U N I V E R S I T Y O F S P L I T

FACULTY OF ELECTRICAL ENGINEERING, MECHANICAL ENGINEERING AND NAVAL ARCHITECTURE

DETAILED PROPOSAL OF THE STUDY PROGRAMME

GRADUATE UNIVERSITY STUDY IN INFORMATION AND COMMUNICATION TECHNOLOGY

SPLIT, February 2022

1.1. List ofmandatory and elective courses

Studyprogramme module: WIRELESS COMMUNICATIONS - 241

List ofcourses								
Year of study:1.								
Semester:I.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
Mandatory	FELJ01	Digital telecommunications	45	0	15	15	0	6
	FELJ28	Radars	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

List ofcourses								
Year of study:1.								
Semester:II.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
Mandatory	FELJ24	Bioelectromagnetics	30	0	0	30	0	5
	FELJ33	Antennas	30	0	15	15	0	6
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

List ofcourses								
Year of study:2.								
Semester:III.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
Mandatory	FELH25	Electromagnetic compatibility	45	0	15	15	0	6
	FELJ26	Electromagnetic ecology and dosimetry	30	0	0	15	0	4
	FELJ22	Measurements in wireless systems	30	0	15	15	0	5
	FELJ36	Systems for wireless transmission of energy	30	0	0	30	0	5
	FELH18	Medical devices	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

Studyprogramme module:: TELECOMMUNICATIONS AND INFORMATICS - 242

List ofcourses								
Year of study:1.								
Semester:I.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
Mandatory	FELJ01	Digital telecommunications	45	0	15	15	0	6
	FELJ28	Radars	30	0	0	30	0	5
	FELJ02	Radio communications	30	0	15	15	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

List ofcourses								
Year of study:1.								
Semester:II.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
	FELJ12	Algorithms	30	0	15	15	0	5
	FELJ14	Mobile communications	30	0	15	15	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

List ofcourses								
Year of study:2.								
Semester:III.								
STATUS	CODE	COURSE	HOURS IN SEMESTER*					ECTS
			L	S	AE	LE	DE	
Mandatory	FELH30	Local and access networks	30	0	0	30	0	5
	FELJ24	Bioelectromagnetics	30	0	0	30	0	5
	FELH18	Medical devices	30	0	0	30	0	5
	FELJ20	Multimedia systems	30	0	0	30	0	5
Elective	FELJ22	Measurements in wireless systems	30	0	15	15	0	5
	FELJ36	Systems for wireless transmission of energy	30	0	0	30	0	5
	* L = lectures, S = seminars, AE = auditoryexcercise, LE = laboratoryexcercise, DE = design excercise							

1.2. Course description

NAME OF THE COURSE	DIGITAL TELECOMMUNICATIONS						
Code	FELJ01	Year of study	1.				
Course teacher	Joško Radić, Ph.D., Associate Professor	Credits (ECTS)	6				
Associate teachers	Petar Šolić, Ph.D., Assistant Professor	Type of instruction (number of hours)	L	S	AE	LE	DE
			45	0	15	15	0
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - Understanding the structure of a digital communication system - Application of analytical models necessary to understand the effects and the design of digital communication systems - Implement and analyse a simple communication system - Acquiring knowledge about the ways of realization of communication networks
Course enrolment requirements and entry competences required for the course	None
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: 1. Compare different systems with redundant coding 2. Analyze the properties of communication systems with redundant coding applied 3. Design transceiver filters for transmission without ISI 4. Explanation of the role of synchronization in a digital communication system 5. Select the corresponding ARQ system with respect to the parameters of the communication channel 6. Identify the topology of the communication network and describe ways of switching in the network 7. Multistage switch design

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Real channelsEqualisation	3	2
	Nyquistfilters, correlationfilters,	3	2
	Linearandnon-linearequalization, Nyquistsignalingfilters,	3	2
	Echocancellation, scrambling,	3	2
	Parallelandserial, synchronousandasynchronous, simplexandduplextransmission,	3	2
	Synchronizationofdigitalsignals (clock, theframeandcarrier)	3	2
	Redundantcoding, block, convolutionsandtrelliscodes,	3	2
	First midterm exam		
	BCH and Reed-Solomon codes, turbo coding		
	ARQ system, FEC systems, encryptionandprotocols,	3	2
	Thetopologyofthe network. networkinggroupsandsignaling	3	2
	Routingandnumbering plan, typesofswitchingsystems	3	2
	Circuitswitching, multistageswitching	3	2
	Spatialandtemporalswitching	3	2

	Second midterm exam	
	List of laboratory exercises	LE hours
	Eye pattern	2
	Equalisation	2
	Scrembling	2
	Channel coding: Block codes	2
	Channel coding: Convolutional codes	2
	Optimum receiver	2

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	1,8	Research		Practical training	
	Experimental work		Report		Individual work	3
	Essay		Seminar essay		Laboratory exercises	0,5
	Tests	0,1	Oral exam		Preparation for laboratory exercises	0,5
	Written exam	0,1	Project		(Other)	

Grading and evaluating student work in class and at the final exam	During the semester there are two mid-term exams and the final exam. Mid-term and final exams consist of questions and tasks. In the final exams students that did not pass the midterm exams take part. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises and 50 % points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula: Grade (%) = 0,8 * (0.5 * M1 + 0,5 * M2) + 0,2 * L; M1, M2 - points at the mid-term expressed as a percentage, and L - points from the laboratory (with completed all lab. Exercises) expressed as a percentage. The final evaluation is determined as follows: percentage Rating 50% to 61% is sufficient (2) 62% to 74% good (3) 75% to 87% of very good (4) 88% 100% Excellent (5)

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• J. Proakis: Digital Communication, IV. Ed.		
	• S. Benedetto: Principlesofdigitaltransmission: with wireless application		
	• L. W. Couch II: Digital and Analog Communication Systems		

Optional literature (at the time of submission of study programme proposal)	
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations
Other (as the proposer wishes to add)	

NAME OF THE COURSE	**RADARS**						
Code	FELJ28	Year of study	1				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Elective	Percentage of application of e-learning	0				
COURSE DESCRIPTION							
Course objectives	– explaining and increasing the knowledge about radiolocation principles, radar operation principle, and the role of all main radar subsystems. – calculating and estimating the basic radar signal parameters – differentiating between specific radar types and perceiving their advantages and disadvantages – visualization of possibilities and characteristics of surveillance and targeting radar operation – considering and investigating modern solutions in radar technology						
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology						
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: – develop competencies in individual and team work in analyzing and designing certain radar subsystems – estimate and calculate radar target parameters – recognize the relation between certain tactical and technical radar requirements – evaluate and perceive advantages and disadvantages of certain radar types – consider and analyze characteristics of surveillance and targeting radars						
	Course content						L hours

Course content broken down in detail by weekly class schedule (syllabus)	Introduction to radar systems.	1
	Basic principles of radar systems.	2
	Parameters of radar signal.	2
	Radio wave propagation, radar equation and maximum range.	3
	Radar cross section.	3
	Estimation of target position parameters by radar signal.	2
	Basic radar hardware.	2
	Moving target indication (MTI) radar.	3
	Doppler impulse radar.	3
	Synthetic aperture radar (SAR).	2
	Meteorological radar.	2
	Ultra wideband (UWB) radar.	2
	Target tracking.	2
	Clutter cancelation in radar systems.	1

	List of laboratory exercises	LE hours
	Transmission and reflection measurements of devices using vector network analyzer.	2
	Radar principles- the measurement of target distance.	6
	Numerical simulation of target radar cross section.	2
	The measurement of bistatic radar cross section.	2
	SAR radar concept- simulation and measurements.	4
	MTI radar concept- simulation and measurements.	2
	UWB radar concept- simulation and measurements.	2
	Group visit to HRM (Croatian Navy) in Lora.	5
	Group visit to Naval centre of electronics (PCE) Split.	5

Format of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☒ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Student responsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	1.5	Research		Practical training	
	Experimental work		Report		Individual work	
	Essay		Seminar essay	2	Laboratory exercises	1
	Tests	0,5	Oral exam		Preparation for laboratory exercises	
	Written exam		Project		(Other)	
Grading and evaluating student work in class and at the final exam	There is one midterm test and seminar essay. The midterm test is after 7 weeks of lecturing and the seminar essays are presented during the next part of the semester. The midterm test consists of theoretical questions and numerical. Seminar essay includes individual work and work in groups, and the presentation of the results. The students that did not pass the test take part In the final exams and the presentation					

<table>
<tr><td></td><td colspan="3">of the seminar essay is obligatory. The midterm test is carried out as written test. Grade (in percentage) is formed according to the formula:
Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M + S)
the activities in percentage:
• NP - attendance at lectures,
• LV – laboratory assessment,
• M - test results,
• S- seminar essay</td></tr>
<tr><td rowspan="4">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>• M. Škiljo:: Radari, predavanja</td><td></td><td>e-learning portal</td></tr>
<tr><td>• Skolnik, M: Introduction to Radar Systems, McGraw-Hill, 1990.</td><td>1</td><td></td></tr>
<tr><td>• Peebles, P. Z: "Radar Principles", John Wiley & Sons, 1998.</td><td>1</td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">• Tait, P: "Introduction to Radar Target Recognition", IEE, 2005.
• Zentner, E.: Antene i radiosustavi, Graphis Zagreb, 2001.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Evaluation of results in accordance with the above learning outcomes
- Feedback from students via surveys
- Self-evaluation of teachers
- Institutional and non-institutional evaluations</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
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NAME OF THE COURSE	BIOELECTROMAGNETICS						
Code	FELJ24	Year of study	1.				
Course teacher	Antonio Šarolić, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Niko Ištuk, Teaching Assistant	Type of instruction (number of hours)	L	S	AE	LE	DE
			30			30	
Status of the course	Elective	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding the human electrophysiology - acquiring knowledge on therapeutic and diagnostic methods - application of specialized interdisciplinary knowledge in biomedical applications		
Course enrolment requirements and entry competences required for the course	None.		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - describe the cell structure - describe the electrophysiology of excitable cells and tissues - apply the electrophysiology knowledge for understanding the brain and heart function - analyze the electric activity of heart and brain with applications in diagnostics - link the electrophysiology principles to the function of other bodily organs and to potential biomedical applications		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction and history.	2	0
	Structure of neuron and muscle cells.	2	0
	Membrane potential.	2	0
	Axon as transmission line (cable).	2	0
	Membrane activation.	2	0
	Synapses, receptors and brain.	2	0
	Heart.	2	0
	Volume source. Volume conductor.	2	0
	Electrocardiography (ECG).	2	0
	Electroencephalograhpy (EEG).	2	0
	Electrophysiology of the eye. Electrodermal reaction.	2	0
	Other diagnostic and therapeutic methods based on applied electromagnetics. Magnetic resonance imaging (MRI).	2	0
	Visit to Medical School of the University of Split. Visit to companies related to the course topics.	2	0
	List of laboratory or design exercises		LE hours
	Membrane potential.		4
	Axon as transmission line (cable).		2

	Membrane activation.	4
	Synapses, receptors and brain.	2
	Electrocardiography (ECG).	2
	Electroencephalograhpy (EEG).	2
	Electrodermal reaction.	2
	Other diagnostic and therapeutic methods based on applied electromagnetics. Magnetic resonance imaging (MRI).	2
	Visit to Medical School of the University of Split. Visit to companies related to the course topics.	6

Format of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Student responsibilities	Student is required to attend the lectures and auditory exercises in the amount of at least 70% of the schedule. Student is required to attend the laboratory exercises in the amount of 100% of the schedule and to complete all tasks associated with laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	1	Research		Practical training	
	Experimental work	0,5	Report		Laboratory exercises	0,5
	Essay		Seminar essay	1	Individual work	1
	Mid-exam	0,5	Oral exam		(Other)	
	Written exam	0,5	Project		(Other)	

Grading and evaluating student work in class and at the final exam	During the semester, two mid-exams will be held. The first mid-exam will be held in the middles of the semester, while the second will be held after the lectures and exercises are completed, schedules to be agreed with the students. The first mid-exam is based on the first half of the course material. The second mid-exam is based on the first second half of the course material. To pass at each mid-exam, min. 50% of points must be earned from the part of the exam containing numerical problems (material from auditory exercises) and min. 50% of points must be earned from the part of the exam containing theory (material from the lectures). To earn the right to approach the second mid-exam, min. 30% of points must be earned from the part of the first mid-exam containing numerical problems (material from auditory exercises) and min. 30% of points must be earned from the part of the first mid-exam containing theory (material from the lectures). If a student earns the positive grades on both mid-exams, he/she is considered to have passed the whole exam with the grade calculated as average from both mid-exams. At the first exam term, students may choose to take the exam containing only that half of the material that they haven't passed at mid-exams. At all other exam terms, students must take the whole exam, containing all the course material. Approaching the exams is subject to fulfilling the requirements on student responsibilities. The overall point percentage defining the overall grade is calculated as the average of points earned in all exam questions, corrected by the result of oral verification: Percentage -> Grade

<table>
<tr><td></td><td colspan="3">50% - 62,4% -> sufficient (2)
62,5% - 74,9% -> good (3)
75% - 87,4% -> very good (4)
87,5% - 100% -> excellent (5)
Final grade can be supplemented by performing practical project work involving individual and experimental work, in agreement with the teacher.
Exam terms: according to the academic year calendar</td></tr>
<tr><td rowspan="4">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>• Jaakko Malmivuo & Robert Plonsey: Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, New York, 1995.</td><td></td><td></td></tr>
<tr><td>• Handbook of biological effects of electromagnetic fields (third edition): Bioengineering and Biophysical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007.</td><td></td><td></td></tr>
<tr><td>• Handbook of biological effects of electromagnetic fields (third edition): Biological and Medical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007.</td><td></td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">• Šantić, A: Biomedicinska elektronika, Školska knjiga, Zagreb, 1995.
• The Biomedical Engineering Handbook (Second Edition), Ed. Joseph D. Bronzino, CRC Press, 2000.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">Surveys providing student feedback</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
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NAME OF THE COURSE	ANTENNAS						
Code	FELJ33	Year of study	1.				
Course teacher	Antonio Šarolić, Ph.D., Full Professor	Credits (ECTS)	6				
Associate teachers	Niko Ištuk, Teaching Assistant	Type of instruction (number of hours)	L	S	AE	LE	DE
			30		15	15	
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding the phenomena of radiation - analysis of antennas as radiating structures - application of antennas in wireless communication systems
Course enrolment requirements and entry competences required for the course	None.
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - utilize the antenna parameters as the basis for antenna application in ICT - elaborately assess the applicability of a certain antenna for specific purpose - calculate the electromagnetic field in the surrounding of simple antenna structures - analyze the parameters of linear antennas - analyze simple uniform antenna arrays

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L or S hours	AE hours
	Introduction. Antenna parameters. Polarization. Radiation pattern.	2	1
	Directivity. Gain. Antenna impedance. Effective area.	2	1
	Effective length. Antenna factor. Relations linking the antenna parameters. Friis equation.	2	1
	Elementary electrical dipole (EED). Field around the EED.	2	1
	Radiated power and radiation resistance of EED. Efficiency of EED.	2	1
	Zones surrounding the antenna – near and far field.	2	1
	Resonant dipoles. Halfwave dipoles. Fullwave dipoles.	2	1
	Electrically short dipole and unipole.	2	1
	Mutual impedance of dipoles.	2	1
	Antenna array. Uniform linear antenna array.	2	1
	Array with uniform amplitude distribution.	2	1
	Arrays with non-uniform amplitude distribution.	2	1
	Practical examples of antenna installations in use – field trip.	2	1
	List of laboratory or design exercises		LE hours
	Introduction. Antenna parameters. Polarization. Radiation pattern. Directivity. Gain. Antenna impedance. Effective area.		2

	Effective length. Antenna factor. Relations linking the antenna parameters. Friis equation. Elementary electrical dipole (EED). Field around the EED.	2
	Radiated power and radiation resistance of EED. Efficiency of EED. Zones surrounding the antenna – near and far field.	2
	Resonant dipoles. Halfwave dipoles. Fullwave dipoles. Electrically short dipole and unipole.	2
	Mutual impedance of dipoles. Antenna array. Uniform linear antenna array.	2
	Array with uniform amplitude distribution. Arrays with non-uniform amplitude distribution.	2
	Practical examples of antenna installations	1

Format of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☒ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	Student is required to attend the lectures and auditory exercises in the amount of at least 70% of the schedule. Student is required to attend the laboratory exercises in the amount of 100% of the schedule and to complete all tasks associated with laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2	Research		Practical training	0,5
	Experimental work	0,5	Report		Laboratory exercises	0,5
	Essay		Seminar essay		Individual work	1
	Mid-exam	0,5	Oral exam		(Other)	
	Written exam	0,5	Project	0,5	(Other)	

Grading and evaluating student work in class and at the final exam	During the semester, two mid-exams will be held. The first mid-exam will be held in the middles of the semester, while the second will be held after the lectures and exercises are completed, schedules to be agreed with the students. The first mid-exam is based on the first half of the course material. The second mid-exam is based on the first second half of the course material. To pass at each mid-exam, min. 50% of points must be earned from the part of the exam containing numerical problems (material from auditory exercises) and min. 50% of points must be earned from the part of the exam containing theory (material from the lectures). To earn the right to approach the second mid-exam, min. 30% of points must be earned from the part of the first mid-exam containing numerical problems (material from auditory exercises) and min. 30% of points must be earned from the part of the first mid-exam containing theory (material from the lectures). If a student earns the positive grades on both mid-exams, he/she is considered to have passed the whole exam with the grade calculated as average from both mid-exams. At the first exam term, students may choose to take the exam containing only that half of the material that they haven't passed at mid-exams. At all other exam terms, students must take the whole exam, containing all the course material.

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The overall point percentage defining the overall grade is calculated as the average of points earned in all exam questions, corrected by the result of oral verification:
Percentage -> Grade
50% - 62,4% -> sufficient (2)
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<tr><td>• Constantine A. Balanis: AntennaTheory: Analysisand Design, Wiley, 1997.</td><td></td><td></td></tr>
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• Handbook of antennas in wireless communications, CRC Press, 2002.</td></tr>
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</table>

NAME OF THE COURSE	ELECTROMAGNETIC COMPATIBILITY						
Code	FELH25	Year of study	2.				
Course teacher	Dragan Poljak, Ph.D., Full Professor Antonio Šarolić, Ph.D., Full Professor	Credits (ECTS)	6				
Associate teachers	Niko Ištuk, Teaching Assistant	Type of instruction (number of hours)	L	S	AE	LE	DE
			45		15	15	
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding the electromagnetic phenomena in circuits, devices and systems - application of acquired knowledge to prevent electromagnetic interference from circuits, devices and systems - application of acquired knowledge to improve immunity of circuits, devices and systems to electromagnetic disturbances
Course enrolment requirements and entry competences required for the course	None.
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - analyze electronic components and circuits from the aspect of electromagnetic compatibility - calculate electromagnetic field around parasitic antenna structures, as well as disturbance voltages induced in such structures - analyze the conducted emissions and susceptibility of electrical devices - design filters for rejection of disturbances - analyze shielding and grounding of electrical devices and circuits - test the electromagnetic compatibility by measurements in accordance with standards and regulations - analyze electromagnetic compatibility of devices and systems using models with concentrated parameters, distributed parameters and transmission lines - analyze wire antennas with the application in electromagnetic compatibility

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction to electromagnetic compatibility.	3	1
	Electronic components and their equivalent circuits.	3	1
	Radiated emissions and susceptibility.	3	1
	Conducted emissions and susceptibility	3	1
	Filtering.	3	1
	Shielding.	3	1
	Grounding.	3	1
	Measurements in electromagnetic compatibility.	3	1
	Electromagnetic compatibility requirements, standards and regu- lations. Electromagnetic compatibility in radiocommunication systems.	3	1

	Historical overview of EMC modelling. Low-frequency models with concentrated parameters.	3	1
	High-frequency models with distributed parameters.	3	1
	Analysis of wire antennas in EMC applications.	3	1
	Transmission line models.	3	1

	List of laboratory or design exercises	LE hours
	Introduction to electromagnetic compatibility.	1
	Electronic components and their equivalent circuits.	1
	Radiated emissions and susceptibility.	1
	Conducted emissions and susceptibility	1
	Filtering.	1
	Shielding.	1
	Grounding.	1
	Measurements in electromagnetic compatibility.	1
	Electromagnetic compatibility requirements, standards and regulations. Electromagnetic compatibility in radiocommunication systems.	1
	Historical overview of EMC modelling. Low-frequency models with concentrated parameters.	1
	High-frequency models with distributed parameters.	1
	Analysis of wire antennas in EMC applications.	1
	Transmission line models.	1

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐*on line* in entirety ☐ partial e-learning ☐ field work	☒ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	Student is required to attend the lectures and auditory exercises in the amount of at least 70% of the schedule. Student is required to attend the laboratory exercises in the amount of 100% of the schedule and to complete all tasks associated with laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	2	Research		Practical training	0,5
	Experimental work	0,5	Report		Laboratory exercises	0,5
	Essay		Seminar essay		Individual work	1
	Mid-exam	0,5	Oral exam		(Other)	
	Written exam	0,5	Project	0,5	(Other)	

Grading and evaluating student work in class and at the final exam	During the semester, two mid-exams will be held. The first mid-exam will be held in the middles of the semester, while the second will be held after the lectures and exercises are completed, schedules to be agreed with the students. The first mid-exam is based on the first half of the course material. The second mid-exam is based on the first second half of the course material. To pass at each mid-exam, min. 50% of points must be earned from the part of the exam containing numerical problems (material from auditory exercises) and min. 50% of points must be earned from the part of the exam containing theory (material from the lectures).

<table>
<tr><td></td><td>To earn the right to approach the second mid-exam, min. 30% of points must be earned from the part of the first mid-exam containing numerical problems (material from auditory exercises) and min. 30% of points must be earned from the part of the first mid-exam containing theory (material from the lectures).
If a student earns the positive grades on both mid-exams, he/she is considered to have passed the whole exam with the grade calculated as average from both mid-exams.
At the first exam term, students may choose to take the exam containing only that half of the material that they haven't passed at mid-exams.
At all other exam terms, students must take the whole exam, containing all the course material.
Approaching the exams is subject to fulfilling the requirements on student responsibilities.
The overall point percentage defining the overall grade is calculated as the average of points earned in all exam questions, corrected by the result of oral verification:
Percentage -> Grade
50% - 62,4% -> sufficient (2)
62,5% - 74,9% -> good (3)
75% - 87,4% -> very good (4)
87,5% - 100% -> excellent (5)
Final grade can be supplemented by performing practical project work involving individual and experimental work, in agreement with the teacher.
Exam terms: according to the academic year calendar</td></tr>
<tr><td>Required literature (available in the library and via other media)</td><td><table>
<tr><th>Title</th><th>Number of copies in the library</th><th>Availability via other media</th></tr>
<tr><td>• Clayton R. Paul: Introduction to ElectromagneticCompatibility, Wiley, 2006.</td><td></td><td></td></tr>
<tr><td>• Dragan Poljak: "Advanced modelingincomputationalelectromagneticcompatibility", WileyInterscience, 2007.</td><td></td><td></td></tr>
</table></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td>• HandbookofElectromagneticCompatibility, ed. R. Perez, Academic Press, 1995.
• Tesche, F.M.: Ianoz, M.V., Karslsson, T.: EMC AnalysisMethodsandComputationalModels, John Wiley&Sons, 1997.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td>Surveys providing student feedback</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td></td></tr>
</table>

<table>
<tr><td>NAME OF THE COURSE</td><td colspan="6">ELECTROMAGNETIC ECOLOGY AND DOSIMETRY</td></tr>
<tr><td>Code</td><td>FELJ26</td><td>Year of study</td><td colspan="4">2</td></tr>
<tr><td>Course teacher</td><td>Dragan Poljak, Ph.D., FullProfessor</td><td>Credits (ECTS)</td><td colspan="4">4</td></tr>
<tr><td rowspan="2">Associate teachers</td><td rowspan="2">Anna Šušnjara, TeachingAssistant</td><td rowspan="2">Type of instruction (number of hours)</td><td>L</td><td>S</td><td>AE</td><td>LE</td><td>DE</td></tr>
<tr><td>30</td><td>0</td><td>0</td><td>15</td><td></td></tr>
<tr><td>Status of the course</td><td>Obligatory</td><td>Percentage of application of e-learning</td><td colspan="4">0</td></tr>
<tr><td colspan="7">COURSE DESCRIPTION</td></tr>
<tr><td>Course objectives</td><td colspan="6">Training students for:
- Understandingandapplyfundamentalprinciplesofelectromagneticandthermaldosimetry,
- Assessmentof human exposure to lowfrequencyandhighfrequencyelectromagneticfields
- Permanentadoptinganddeepeningknowledgeintheareaofbioelectromagnetism
- Applicationofnationalandinternationalregulations for theassessmentof human exposure to non-ionisingradiation</td></tr>
<tr><td>Course enrolment requirements and entry competences required for the course</td><td colspan="6">- Electromagnetic fields, Electromagnetic waves</td></tr>
<tr><td>Learning outcomes expected at the level of the course (4 to 10 learning outcomes)</td><td colspan="6">Students will be able to:
- Definefundamentalnotionsinbioelectromagnetics,
- Applymethods for themeasurementofexternal LF and HF fields
- Applymethods for thecalculationofexternal LF and HF fields
- Analyzethelevelofthe human bodyexposure to non-ionizingradiationusingnationalandinternationalregulations
- Mathematicallyformulatesimplecasesofelectromagneticwaveandradiationfromthinwirestructures.
- Analyzesimpletransmissionlines, groundingsystemsandantennas
- Computefundamentalparametersofinternaldosimetrybymeansofsimplebodymodels.
- Use commercial software packages for applicationofrealisticdosimetrymodelsofthe human body.</td></tr>
<tr><td rowspan="5">Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="3">Course content</td><td>L hours</td><td colspan="2">AE hours</td></tr>
<tr><td colspan="3">Electrosmog: electromagneticpollutionoftheenvironment. Ionisingandnon-ionisingradiation.</td><td>2</td><td colspan="2"></td></tr>
<tr><td colspan="3">Couplingmechanismsofelectromagneticfieldandthe human body. Biologicaleffectsofelectromagneticfields. Lowfrequencyandhighfrequencyeffects. Epidemiologicalandstatisticalstudies.</td><td>2</td><td colspan="2"></td></tr>
<tr><td colspan="3">Fundamentalquantitiesofelectromagneticdosimetry, currentdensity, inducedelectricfield, specificabsorption rate (SAR), specificabsorption(SA), externalfields, powerdensity.</td><td>2</td><td colspan="2"></td></tr>
<tr><td colspan="3">Guidelines for protectionofnon-ionisingradiation. National andinternationalregulations. Basicrestrictionsand referent leves. Protection measures.</td><td>2</td><td colspan="2"></td></tr>
</table>

	Methodsoftheoreticalandexperimentaldosimetry. Incident andinternalfielddosimetry.				2	
	Incident fielddosimetry; Radiationsourcecharacterization. Calculationandmeasurementof LF electricfield. Exposure to powerlinesandsubstationtransformers.				2	
	Incident fielddosimetry; Calculationandmeasurementof HF electromagneticfield. Exposure to RFID antennas, mobilephones, base stations.				2	
	Classificationofmodels for internaldosimetry. Simplifiedandanatomicalbodymodels.				2	
	LF Electromagneticmodeling. LF Electromagneticmodelingofthebody. Wholebodyexposure to lowfrequencies.				2	
	HF Electromagneticmodeling. Theeyeandbrainexposure to non-ionisingradiation.				2	
	The human bodyexposure to transientradiation.				2	
	Thermalresponseofthe human bodyexposed to HF electromagneticradiation visokih frekvencija. Thermalresponse to theeyeandbraindue to plane waveexposure.				2	
	Biomedicalapplicationsofelectromagneticfields. Electricalstimulationofnerves. Laser radiationoftheeye. Methodsofthe human brainstimulation. Transcranialmagneticstimulation.				2	
	List oflaboratoryor design exercises					LEhours
	Human exposure to non-ionising EM radiation (frequenciesup to 10 MHz) – simulationmodels					2
	Human exposure to non-ionising EM radiation (frequenciesabove 10 MHz) – simulationmodels					2
	Measureequipmentandmethods for theassessmentof human exposure to EM fields					3
	Measurementof LF electricfields					2
	Measurementof LF magneticfields					2
	Measurementof HF EM fields					2
	EM fieldcalculationinthevicinityof base stations					2
Format of instruction	☒lectures ☐seminars and workshops ☒exercises ☐*on line*in entirety ☐partial e-learning ☐field work		☐independent assignments ☐multimedia ☒laboratory ☐work with mentor ☐ (other)			
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.					
Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	1,8	Research		Practical training	
	Experimental work		Report		(Other)	1,8
	Essay		Seminar essay		(Other)	0,1
	Tests	0,1	Oral exam		(Other)	0,1
	Written exam	0,1	Project		(Other)	

<table>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="3">There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. Each midterm test (120 min in duration) consists of 3 questions (each containing theoretical part and short numerical problem) and 2 longer numerical problems. The requirement for passing grade is the positive assessment of laboratory exercises and 50 % points on each midterm. Grade (in percentage) is formed according to the formula:

Grade(%) = 0,5 (M1 + M2)

where M1 and M2 are the midterm test results, and is determined through following percentage score:

Percentage score: Grade:

From 50% to 62% sufficient (2)
From 63% to 75% good (3)
From 76% to 88% very good (4)
From 89% to 100% excellent (5)

Students who do not pass midterm exams are obliged to pass final test (150 min in duration) in winter/fall examination period. Final test consists of 4questions(each containing theoretical part and short numerical problem) and 2 longer numerical problems. The requirement for passing grade is 50 % points.Final grade isformedaccording to thedescribed procedure.The midterm and final exams are carried out as written tests.</td></tr>
<tr><td rowspan="3">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>D.Poljak, Teorija elektromagnetskih polja s primjenama u inženjerstvu, Šk. knjiga Zagreb, 2014.</td><td></td><td></td></tr>
<tr><td>D. Poljak: Izloženost ljudi elektromagnetskom zračenju, Kigen, Zagreb, 2007.</td><td></td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">1. D. Poljak, AdvancedModelinginComputationalElectromagneticcompatibility, WileyInterscience, New York 2007.
2. D. Poljak: Human Exposure to Electromagnetic Fields, WIT Press, Southampton- Boston, 2003
3. R.W.Y. Habash, ElectromagneticFieldsandRadiation, Marcel Dekker, 2002.
4. D. Poljak: Exposure of Humans to Electromagnetic Radiation, SoftCOM Library 2002.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Evaluation of results in accordance with the above learning outcomes
- Feedback from students via surveys
- Self-evaluation of teachers
- Institutional and non-institutional evaluations</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
</table>

NAME OF THE COURSE	MEASUREMENTS IN WIRELESS SYSTEMS						
Code	FELJ22	Year of study	2				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	15	15	0
Status of the course	Obligatory: 241 Elective: 242	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - radio-channel measurements and analysis, - statistical modelling of radio propagation in different environments and for various radio systems, - applying empirical and statistical models for radio-channel characterization.
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - calculate radio-channel parameters, - perform measurements and analysis of fixed and mobile radio systems parameters - statistically characterize radio propagation of arbitrary radio-systems on the base of measurements, - Apply various channel models

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction to Measurements in Wireless Systems.	1	1
	Fixed radio-links channel parameters. Fading	2	1
	Ground radio links planning and measurements	2	2
	Fading in mobile radio channels.	2	1
	Mobile radio channel parameters.	2	1
	Propagation path-loss models. Hata-Okumura model.	3	1
	First midterm exam		
	Statistical channel models of ground networks comparison with Maxwell theory based model.	2	1
	Satellite radio-channels. Statistical models based on measurements (Loo model, Suzuki model).	4	1
	Wide-band channel parameters. Wide-band measurements.	4	3
	Wide-band channel models based on measurements.	2	1
	Wide-band indoor radio channel modelling.	3	1
	Second midterm exam		
	List of laboratory exercises		LE hours
	Antenna measurements by Vector Network Analyser measurements. Measurements calibration.		3
	Narrow-band channel measurements at various frequencies.		3

	Wide-band channel measurements	3
	Wide-band indoor channel measurements	3
	Radio-links planning by using measured data and software.	3

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2,0	Research		Practical training	
	Experimental work		Report		Individual work	1.5
	Essay		Seminar essay		Laboratory exercises	0,8
	Tests	0,5	Oral exam		Preparation for laboratory exercises	0,2
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. Each midterm test and final tests consists of theoretical questions and numerical. The students that did not pass the midterm exams take part In the final exams. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises and 40 % points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M1 + M2) the activities in percentage: • NP - attendance at lectures, • LV – laboratory assessment, • M1, M2 – test results.

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• Z. Blažević; Mjerenja u bežičnim sustavima, predavanja		e-learning portal
	• M. Patzold: "Mobile FadingChannels", Wiley, 2002.	1	
	• Doble, J.: "Introduction to Radio Propagation for Fixedand Mobile Communications", Artech House Boston - London, GB, 1996.	1	

Optional literature (at the time of submission of study programme proposal)	• G. H. Bryant: ''Principles of Microwave Measurements'', IEE Publishing, 1993. • Zentner, E.: Antene i radiosustavi, Graphis Zagreb, 2001.
Quality assurance methods that ensure	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers

the acquisition of exit competences	- Institutional and non-institutional evaluations
Other (as the proposer wishes to add)	

NAME OF THE COURSE	**SYSTEMS FOR WIRELESS TRANSMISSION OF ENERGY**						
Code	FELJ36	Year of study	2				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Elective	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding of basic principles of and problemacy of systems for wireless transmission of energy, - designing of radio system for near-field transmission of energy - design of radio system for far-field power transmission - calculation and analysis of wireless energy systems parameters		
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology.		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - analyse power and energy transmission techniques, - calculate and estimate wireless energy transmission system parameters, - designing basic transmission system schemes for given service		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction. Historical perspective of radio and wireless transmission.	2	
	Principles and techniques for radio-transmission of energy. Transformers and resonant transformers (Tesla Coil), and electrically small antennas.	4	
	Antenna scattering matrix. Coupled-Mode Theory and Spherical Mode Theory-Antenna Model application to wireless transmission of energy systems.	4	
	Rectennas.	2	

	Near-field energy and power transmission. Resonant transformer.	4	
	Far-field power transfer.	4	
	Ground energy transfer by far-field systems concept	3	
	Satellite energy transfer system concept	3	
	Norms and standards for wireless energy transfer. Qi standard.	2	
	Electromagnetic Compatibility of wireless energy transfer systems.	2	
	Interference problem between radio-communications systems and radio systems for wireless energy transfer.	2	
	Midterm exam		

	List of laboratory exercises	LE hours
	Measurements and adjustments of inductively fed electrically small antennas	8
	Measurements of transfer performances by Spectrum Analyser, and by Oscilloscope	8
	Measurements of transfer performances by Vector Network Analyser	6
	Tesla Coil Measurements.	8

Format of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☒ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	1.5	Research		Practical training	
	Experimental work		Report		Individual work	2
	Essay		Seminar essay		Laboratory exercises	0,8
	Tests	0,5	Oral exam		Preparation for laboratory exercises	0,2
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are one midterm and one final exam. Both midterm test and final test consist of theoretical questions and numerical problems. The students that did not pass the midterm exams take part In the final exams. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises, 40 % points on the midterm exam or the final exam, and the rest of the grade depends on the seminary work presented by the student. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M + S) the activities in percentage: • NP - attendance at lectures, • LV – laboratory assessment, • M – test results., • S – seminary work results and presentation

	Title	Number of copies in the library	Availability via other media
Required literature (available in the library and via other media)	• Ki Young Kim (editor), "Wireless Power Transfer-PrinciplesandEngineeringExplorations", InTech, January 2012.		e-learning portal
	• Volakis J., C. C. Chen and K. Fujimoto, "Smallantennas: miniaturizationtechniquesandapplications", New York, McGraw-Hill, 2010.		e-learning portal
	• Special issue „Solar Power Satellite and Wireless Power Transmission", IEEE Microwave Magazine, Vol. 3, No. 4, December 2002.	1	
Optional literature (at the time of submission of study programme proposal)	• Lee J. and S. Nam, "Fundamental aspects of near-field coupling small antennas for wireless power transfer", IEEE Trans. Antennas Propag., Vol. 58, No. 12, 3442-3449, 2010. • P. Sample, D. T. Meyer, J. R. Smith: Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer, IEEE Transactions on Industrial Electronics, Vol. 58, No. 2, 2010, p.p 544-554. • N. Tesla, A. Marinčić: Colorado Springs Notes, Nolit, Beograd, 1978. • Carol Gray Montgomery, Robert Henry Dickeand Edward M. Purcell, "Principlesofmicrowavecircuits", McGraw-Hill Book Company, Inc.,USA, 1948.		
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations		
Other (as the proposer wishes to add)			

NAME OF THE COURSE	MEDICAL DEVICES							
Code	FELH18	Year of study	2.					
Course teacher	Antonio Šarolić, Ph.D., Full Professor Ivan Marinović, Ph.D., Full Professor	Credits (ECTS)	5					
Associate teachers	Niko Ištuk, mag. ing. el.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30			30	
Status of the course	Elective	Percentage of application of e-learning	0					

COURSE DESCRIPTION

Course objectives	- learning the types, realizations and application areas of electronic/communication/information technology in medical domain - knowledge on therapeutic, diagnostic and control medical electronic devices - understanding the specifics of functional and safety requirements for medical electronic devices - understanding and application of success criteria for medical device innovation and development
Course enrolment requirements and entry competences required for the course	None.
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - employ their knowledge on electronic/communication/information technology for analysis and development of medical devices - use the knowledge of human physiology, especially electrophysiology, for analysis and development of medical devices - analyze the components of medical electronic devices and their interaction with human body medical electronic devices - conceive the electronic circuits for application in a medical device - characterize a medical electronic device from the aspect of safety - critically assess the success of innovation and development of a medical device

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Basics of human electrophysiology and electrophysiology	2	0
	Measurement medical electronic devices	2	0
	Diagnostic medical electronic devices	2	0
	Therapeutic medical electronic devices	2	0
	Electronic circuits and components in medical devices	6	0
	Circuits and devices for electric and magnetic stimulation at low frequencies	2	0
	Circuits and devices for thermal procedures at high frequencies	2	0
	Electrical safety aspects and electromagnetic compatibility aspects of medical electronic devices	2	0
	Control and auxiliary medical electronic devices. E-Health. Theranostic medical electronic devices – unifying the therapeutics and diagnostics in innovative medical devices and methods	2	0
	Translational resaerch and development of medical devices from lab to clinics (from the workbench to the bedside). Assessment of clinical and economic efficacy of medical technology (Health Technology Assessment - HTA)	2	0

	Clinical studies: principles and implementation of clinical trials of medical devices	2	0
	List of laboratory or design exercises		LE hours
	Basics of human electrophysiology		2
	Amplifier circuits		4
	Electrostimulator circuits		4
	Noise and disturbance suppression in electronic devices		2
	Electromagnetic compatibility testing		2
	Electrical safety testing		2
	Measurements of dielctric properties of tissues		2
	Measurement, diagnostic and therapeutic medical electronic devices – field trip (visit to medical establishments)		8

Format of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	Student is required to attend the lectures and auditory exercises in the amount of at least 70% of the schedule.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	1	Research		Practical training	
	Experimental work	0,5	Report		Laboratory exercises	0,5
	Essay		Seminar essay	1	Individual work	1
	Mid-exam	0,5	Oral exam		(Other)	
	Written exam	0,5	Project		(Other)	

Grading and evaluating student work in class and at the final exam	Lectures are given in collaboration of prof. Šarolić (2/3 of lecture hours) and prof. Marinović (1/3 of lecture hours). Exam: presentation and defense of the seminar essay

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	Ante Šantić: Biomedicinska elektronika, Školska knjiga, Zagreb, 1995.		
	Jaakko Malmivuo & Robert Plonsey: Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, New York, 1995.		

Optional literature (at the time of submission of study programme proposal)	- Handbook of biological effects of electromagnetic fields (third edition): Bioengineering and Biophysical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007. - Handbook of biological effects of electromagnetic fields (third edition): Biological and Medical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007. - The Biomedical Engineering Handbook (Second Edition), Ed. Joseph D. Bronzino, CRC Press, 2000.
Quality assurance methods that ensure the acquisition of exit competences	Surveys providing student feedback
Other (as the proposer wishes to add)	

NAME OF THE COURSE	RADIO COMMUNICATIONS						
Code	FELJ02	Year of study	1.				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	15	15	0
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding and application of basic principles and mechanisms of Earth radio-propagation, - radio-channel physical phenomena modelling, - permanent adoption and deepening of knowledge in the field of radio engineering.		
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - define the fundamental phenomena, the quantities and the laws of Earth radio-propagation, - apply fundamental laws of radio-propagation and model basic radio-channels, - calculate and estimate basic radio-channel parameters, - apply channel models for radio-signal quality estimation - apply basic methods of radio-channel measurements		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction to Radio Communications. History perspective of radio engineering. SI units.	1	-
	Radiowave propagation. Surface Waves. Division of Atmosphere.	2	1
	Radio-antenna parameters and effective isotropic radiated power.	2	2
	Free space radiowave propagation. Radio-gain.	2	1
	Propagation by Troposphere	1	1
	Effective Earth Radius Model and Flat Earth Model. Ducting.	3	1
	Radio-horizon by refraction. Influence of Earth curvature	2	1
	Tropospheric loss by hydrometeors and gasses	1	1
	Propagation by Ionosphere	3	1
	First midterm exam		
	Propagation by diffraction. Fresnel wave theory on diffraction. Knife-Edge Model.	4	1
	Approximate methods for multiple diffraction loss estimation	2	2
	Geometrical Theory of Diffraction. Keller's law of diffraction.	1	1
	Propagation by reflection. Fresnel reflection coefficients. Ground roughness influence. Divergence factor.	4	1

	Interference by direct and ground reflected wave. Power law.	2	1
	Second midterm exam		
	List of laboratory exercises		LE hours
	Introduction to laboratory instruments, devices and other equipment		2
	Reflection parameters measurements		4
	Transmission parameters measurements		4
	Measurements of radio-channels by spectrum analyser		3
	Software estimations of diffraction loss		2

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2,0	Research		Practical training	
	Experimental work		Report		Individual work	1.5
	Essay		Seminar essay		Laboratory exercises	0,8
	Tests	0,5	Oral exam		Preparation for laboratory exercises	0,2
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. Each midterm test and final tests consist of theoretical questions and numerical. The students that did not pass the midterm exams take part In the final exams. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises and 40 % points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M1 + M2) the activities in percentage: • NP - attendance at lectures, • LV – laboratory assessment, • M1, M2 – test results.

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• I. Zanchi, Z. Blažević: Radiokomunikacije, predavanja, FESB		e-learning portal
	• Boithias, L.: Radio WavePropagation, North Oxford Academic 1987.	1	
	• Zentner, E.: Radiokomunikacije, Školska knjiga - Zagreb, 1980.	2	

Optional literature (at the time of submission of study programme proposal)	• Zentner, E.: Antene i radiosustavi, Graphis Zagreb, 2001. • Parsons, J. D.: "The Mobile Radio Propagation Channel", Pentech Press Publishers - London, GB, 1992.

	• Doble, J.: "Introduction to Radio Propagation for Fixed and Mobile Communications", Artech House Boston - London, GB, 1996.
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations
Other (as the proposer wishes to add)	

NAME OF THE COURSE	**ALGORITHMS**						
Code	FELJ12	Year of study	1.				
Course teacher	Matko Šarić, Ph.D., Assistant Professor	Credits (ECTS)	5				
Associate teachers	Ante Topić, TeachingAssistant	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	15	15	0
Status of the course	Obligatory	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - Design of efficient algorithms and analysis of algorithms properties (speed and memory) - Adopting the practical knowledge about sorting algorithms and graph-based algorithms		
Course enrolment requirements and entry competences required for the course	BsC degree.		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - Analyze the execution time of the algorithm - explain and apply different sorting algorithms - explain and apply graph-based algorithms - apply dynamic programming		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L or S hours	AE hours
	Introduction. What are algorithms. Analyzing algorithms in Example D-2 maximum	3	0
	Analyzing of the loops. Solving of summations. Solving 2-D maximum - method of crossing the plane.	3	0
	Asymptotic notation. Limited rule.	3	0

	The technique of divide and rule. Mergesort (pseudocode, execution time analysis).	3	0
	Recursion (search pattern, iteration, recursion tree method). Master theorem.	3	0
	Heap data structure. Heapsort (pseudocode, execution time analysis).	3	0
	Quicksort (pseudocode, execution time analysis)	3	0
	The lower limit of sorting algorithms execution time. Sorting by linear time. (counting sort, radix sort).	3	0
	The algorithms based on graphs (basic concepts and definitions).	3	0
	Graph representation using the adjacency matrix and adjacency list. BFS algorithm.	3	0
	All pairs shortest paths. Dynamic programming. Floyd-Warshall algorithm.	3	0
	Longest common subsequence. Matrix chain multiplication	3	0
	Decision problems. NP-problems and polynomial time verification. NP completeness. Reduction. Hamiltonian path and Hamiltonian cycle.	3	0
	List of laboratory or design exercises		LE hours
	Analysis of typical running times		2
	Solving of summations		2
	Recursions		2
	Merge sort I		2
	Merge sort II		2
	Heap sort		2
	Quicksort		2
	Linear time sorting algorithms		2
	Graph representation		2
	BFS algorithm		2
	Floyd-Warshall algorithm		2
	Longest common subsequence		2
	Matrix chain multiplication		2

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities		

Screening student work *(name the proportion of ECTS credits for eachactivity so that*	Class attendance	2,0	Research		Practical training	
	Experimental work		Report		Individual work	2,2
	Essay		Seminar essay		Laboratory exercises	0,5

the total number of ECTS credits is equal to the ECTS value of the course)	Tests	0,2	Oral exam		Preparation for laboratory exercises	
	Written exam	0,1	Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. Midterm test and final test consist of theoretical questions and numerical problems. In the final exams students that did not pass the midterm exams take part. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises and 50 % points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula: Grade(%) = 0,5 (M1 + M2) the activities in percentage: • M1, M2 – test results. The final grade is defined in the next way: 50% do 63% sufficient (2) 64% do 77% good (3) 78% do 91% very good (4) 92% do 100% excellent (5)

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	Individual work		e-learning portal
	Laboratory exercises		
	Preparation for laboratory exercises		

Optional literature (at the time of submission of study programme proposal)	T.Cormen, C.Leiserson, R.Rivest, C.Stein: „Introduction to Algorithms“, secondedition, thirdprinting, McGraw-Hill, 2002
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Feedback from students who have already obtained BsC degree
Other (as the proposer wishes to add)	

NAME OF THE COURSE	MOBILE COMMUNICATIONS						
Code	FELJ14	Year of study	1.				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	15	15	0
Status of the course	Obligatory: 241 Elective: 242	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding and application of basic principles of radio-networks, - physical OSI layer of cellular radio-networks calculation and analysis, - mobile radio networks analysis.		
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - Calculate optimal radio system configuration in sense of selecting digital modulation and coding, - model and perform basic calculation of cellular networks: base stations power and interference budget - calculate and analyse (narrow- and wide-band) radio-channel parameters, - conduct and analyse radio-channel measurements		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction to Mobile Communications.	1	1
	Classification of digital radio-channels.	2	1
	Digital radio system performances.	2	2
	Systems with bandwidth limitation.	2	1
	Power limited systems.	2	1
	Power limited and bandwidth limited systems. Channel coding.	2	1
	Direct Sequence-Spread Spectrum Systems	2	1
	Cellular radio systems. Cochannel and adjacent channel interference.	2	1
	Path-loss law. Base station ling budget. Multipath reception.	2	2
	First midterm exam		
	Cell radio-coverage calculation.	2	1
	Mobile propagation channel analysis.	2	1
	Radio channel measurements.	2	1
	Propagation channel classification. Delay-spread and channel coherence bandwidth.	2	1
	Second midterm exam		
	List of laboratory exercises		LE hours
	Radio channel characterization by Vector Network Analyser measurements.		5

	Communication systems testing and simulating by Matlab and Simulink	2
	Analog and digital modulation simulations	2
	Multipath fading channels simulations	2
	Adjacent and co-channel interference in cellular systems simulations by Simulink	2
	COST 207 and GSM/EDGE channel models by Matlab	2

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2,0	Research		Practical training	
	Experimental work		Report		Individual work	1.5
	Essay		Seminar essay		Laboratory exercises	0,8
	Tests	0,5	Oral exam		Preparation for laboratory exercises	0,2
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. Each midterm test and final tests consist of theoretical questions and numerical. The students that did not pass the midterm exams take part In the final exams. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises and 40 % points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M1 + M2) the activities in percentage: • NP - attendance at lectures, • LV – laboratory assessment, • M1, M2 – test results.

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• Z. Blažević: Mobilne komunikacije, predavanja, FESB		e-learning portal
	• I. Zanchi, Z. Blažević: Radiokomunikacije, predavanja, FESB		e-learning portal
	• David Parson.: The Mobile Radio Propagation Channel, Pentech Press Pub. London, 1992.	2	

Optional literature (at the time of submission of study programme proposal)	• R. Steele: "Mobile Radio Communications", Pentech Press, London, GB and IEEE Press, Piscataway, USA, 1992. • Vijag, K. Garg, Joseph, E. Wilkes: Wireless and Personal Communications Systems, Prentice Hall PTR, NY 1996.

Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations
Other (as the proposer wishes to add)	

NAME OF THE COURSE	**LOCAL AND ACCESS NETWORKS**						
Code	FELH30	Year of study	2.				
Course teacher	Josip Lörincz, Ph.D., Assistant Professor	Credits (ECTS)	5				
Associate teachers	Dinko Begušić, Ph.D., Full Professor	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	
Status of the course	- Obligatory (university graduate programme, 242)	Percentage of application of e-learning	10%				
COURSE DESCRIPTION							
Course objectives	Training students for: - knowledge and understanding of the fundamental concepts of local and access networks, - knowledge of the characteristics of the medium for the transmission of information in local and access network (metal wires, optical fibre and wireless transmission), - capability to configure local and access networks and network devices, - qualification for participation in the design and maintenance of local and access networks, - permanent acquisition of knowledge in the field of new technologies used in local access networks.						
Course enrolment requirements and entry competences required for the course	Knowledge of basic concepts and technology in the area of data information transfer and communication protocols. Knowledge of basic computer skills. Knowledge of English language.						
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - define basic terms and concepts of local and access networks, - evaluate and implement protocols, systems and techniques for transmission of information in local and access networks based on different transmission medias including metal wires, optical fibre and wireless transmission, - configure local and access networks and network devices, - participate in the design and maintenance of local and access networks, - permanently acquire knowledge about new technologies in the area of local access networks.						

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction. Standards.		2
	The division of the LAN network according to different criteria.		2
	Local area networks of type Ethernet.		2
	Local area networks of type: Token ring, Token bus, FDDI, DQDB		2
	Gigabit Ethernet, switched LAN		2
	Networks: ATM, ATM LAN		2
	Virtual Private Networks-VPN		2
	Wireless Communication Systems-general, cellular (mobile) systems		2
	Wireless LAN (WLAN) networks		2
	Broadband access networks-general		2
	xDSL technology: HDSL, ADSL, VDSL		2
	Fiber optical networks: FTTx technology		2
	HFC technology, WiMAX technology		2
	List of laboratory or design exercises		LEhours
	Exercise 1.: Introduction - basics Riverbed Modeler simulator		2
	Exercise 2.: Local Area Network - The role of Switch in LAN Ethernet network		2
	Exercise 3.: Local Area Network - a network design (planning network with different users, terminals and services)		2
	Exercise 4.: ATM (cell switching technology based on connection oriented connections)		2
	Exercise 5.: RIP protocol (Routing protocol based on an link algorithm state)		2
	Exercise 6.: TCP Transmission Control Protocol (Trusted protocol based on pre-established links)		2
	Exercise 7.: The methods of sorting (queuing, waiting to transmit or discard packets)		2
	Exercise 8.: The wireless local area network (media access control for mobile station)		2
	Exercise 9.: Mobile wireless networks (wireless cellular networks with mobile devices)		2
	Exercise 10.: OSPF routing protocol based on an link-state algorithm		2
	Exercise 11.: Border Gateway Protocol (BGP) - (Routing data traffic between different administrative domains)		2
	Compensation exercises		2

Format of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ *on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☒ work with mentor ☐ (other)

<table>
<tr><td>Studentresponsibilities</td><td colspan="6">Theconditions for overallpositiveassessment are:
• positive assessment of laboratory exercises (above 50 %)
• minimum presence during 70% of overall class teaching time in a semester,
• presence on laboratory exercises during 100% of overall laboratory exercise time in a semester,
• minimum 50% points at each mid-term or final exam (or correctional or commission exam).</td></tr>
<tr><td rowspan="5">Screening student work (name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)</td><td>Class attendance</td><td>1,0</td><td>Research</td><td></td><td>Practical training</td><td></td></tr>
<tr><td>Experimental work</td><td></td><td>Report</td><td></td><td>Independent work</td><td>2,2</td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td></td><td>Laboratory exercises</td><td>1,0</td></tr>
<tr><td>Tests</td><td></td><td>Oral exam</td><td></td><td>Preparation for Laboratory exercises</td><td>0,5</td></tr>
<tr><td>Written exam</td><td>0,3</td><td>Project</td><td></td><td>(Other)</td><td></td></tr>
<tr><td>Grading and evaluating student work in class and at the final exam</td><td colspan="6">During the semester there will be two mid-term exams (tests). The 1st mid-term exam will be after 8 weeks of classes, and the 2nd after 15 weeks of classes. On the 1st and 2nd of the final exams, students take exam of those parts of the curricula which they did not pass on some of the mid-term exams. On the 3rd and 4th of the final (correctional) exam, students take exam of complete course curricula.

Rating (%) = 0.1PL + 0,2LA + 0.35 (M1 + M2)
PL – presence on the lectures (expressed in percentage),
LA- grades from laboratory assessment (expressed in percentage),
M1, M2- the 1st and 2nd mid-term exam grades or final exam grades (expressed in percentage),

The final grade is determined as follows:
percentage Rating
50% to 61% is sufficient (2)
62% to 74% good (3)
75% to 87% of very good (4)
88% 100% Excellent (5)

Independently on results obtained during the 1st or 2nd mid-term exams, on the 3rd and 4th final (correctional) exams students take exam of entire curricula content. In the case of organization of commission exam, students also take exam of entire curricula content. Requirements related to the admission on final and correctional (commission) exam is a positive assessment of laboratory exercises.

Examinations:
1st Final exam
2nd Final exam
3rd Final (correctional) exam
4th Final (correctional) exam
5th Final (commission) exam (organized only based on decision of Faculty council in specific academic year)</td></tr>
<tr><td>Required literature (available in the library and via other media)</td><td colspan="3">Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td></td><td colspan="3">• Milutin Kapov, Josip Lorincz, "Local and Access Networks", FESB-Split, 2015, (2009), internal script</td><td></td><td>e-learning portal</td></tr>
</table>

	• Josip Lorincz, “Instructions for performing laboratory exercises in local and access networks”, FESB Split, internal script, 2015.		e-learning portal
	• Alen Bažant and others: "The basic architecture of the network", ELEMENT, Zagreb, 2004.	5	
	• M. Vrdoljak and others: "New Communication Technologies", FESB Split, HT TKC Split, softcore library Split in 1999.	5	
Optional literature (at the time of submission of study programme proposal)	• M. Jose ., M. Caballero and others, "SDH / SONET, ATM, xDSL and Synchronization Networks", Artech House, Boston, London, 2003. • Alex Gillespie: "Broadband Access Technology Interfaces and Management, Artech House, Boston, London, 2000. • Annabel Z. Dodd, "Telecommunications", Algorithm, Zagreb 2002.		
Quality assurance methods that ensure the acquisition of exit competences	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers - Institutional and non-institutional evaluations - Feedback from graduated students about the relevance of the course content		
Other (as the proposer wishes to add)	/		

NAME OF THE COURSE	**BIOELECTROMAGNETICS**							
Code	FELJ24	Year of study	1.					
Course teacher	Antonio Šarolić, Ph.D., Full Professor	Credits (ECTS)	5					
Associate teachers	Niko Ištuk, Teaching Assistant	Type of instruction (number of hours)	L	S	AE	LE	DE	
			30			30		
Status of the course	Elective	Percentage of application of e-learning	0					
COURSE DESCRIPTION								
Course objectives	Training students for: - understanding the human electrophysiology - acquiring knowledge on therapeutic and diagnostic methods - application of specialized interdisciplinary knowledge in biomedical applications							
Course enrolment requirements and entry competences required for the course	None.							
Learning outcomes expected at the level	Students will be able to: - describe the cell structure							

of the course (4 to 10 learning outcomes)	- describe the electrophysiology of excitable cells and tissues - apply the electrophysiology knowledge for understanding the brain and heart function - analyze the electric activity of heart and brain with applications in diagnostics - link the electrophysiology principles to the function of other bodily organs and to potential biomedical applications					
Course content broken down in detail by weekly class schedule (syllabus)	Course content				L hours	AE hours
	Introduction and history.				2	0
	Structure of neuron and muscle cells.				2	0
	Membrane potential.				2	0
	Axon as transmission line (cable).				2	0
	Membrane activation.				2	0
	Synapses, receptors and brain.				2	0
	Heart.				2	0
	Volume source. Volume conductor.				2	0
	Electrocardiography (ECG).				2	0
	Electroencephalograhpy (EEG).				2	0
	Electrophysiology of the eye. Electrodermal reaction.				2	0
	Other diagnostic and therapeutic methods based on applied electromagnetics. Magnetic resonance imaging (MRI).				2	0
	Visit to Medical School of the University of Split. Visit to companies related to the course topics.				2	0
	List of laboratory or design exercises					LE hours
	Membrane potential.					4
	Axon as transmission line (cable).					2
	Membrane activation.					4
	Synapses, receptors and brain.					2
	Electrocardiography (ECG).					2
	Electroencephalograhpy (EEG).					2
	Electrodermal reaction.					2
	Other diagnostic and therapeutic methods based on applied electromagnetics. Magnetic resonance imaging (MRI).					2
	Visit to Medical School of the University of Split. Visit to companies related to the course topics.					6
Format of instruction	☒ lectures ☒ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work			☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)		
Student responsibilities	Student is required to attend the lectures and auditory exercises in the amount of at least 70% of the schedule. Student is required to attend the laboratory exercises in the amount of 100% of the schedule and to complete all tasks associated with laboratory exercises.					
	Class attendance	1	Research		Practical training	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Experimental work	0,5	Report		Laboratory exercises	0,5
	Essay		Seminar essay	1	Individual work	1
	Mid-exam	0,5	Oral exam		(Other)	
	Written exam	0,5	Project		(Other)	

Grading and evaluating student work in class and at the final exam	During the semester, two mid-exams will be held. The first mid-exam will be held in the middles of the semester, while the second will be held after the lectures and exercises are completed, schedules to be agreed with the students. The first mid-exam is based on the first half of the course material. The second mid-exam is based on the first second half of the course material. To pass at each mid-exam, min. 50% of points must be earned from the part of the exam containing numerical problems (material from auditory exercises) and min. 50% of points must be earned from the part of the exam containing theory (material from the lectures). To earn the right to approach the second mid-exam, min. 30% of points must be earned from the part of the first mid-exam containing numerical problems (material from auditory exercises) and min. 30% of points must be earned from the part of the first mid-exam containing theory (material from the lectures). If a student earns the positive grades on both mid-exams, he/she is considered to have passed the whole exam with the grade calculated as average from both mid-exams. At the first exam term, students may choose to take the exam containing only that half of the material that they haven't passed at mid-exams. At all other exam terms, students must take the whole exam, containing all the course material. Approaching the exams is subject to fulfilling the requirements on student responsibilities. The overall point percentage defining the overall grade is calculated as the average of points earned in all exam questions, corrected by the result of oral verification: Percentage -> Grade 50% - 62,4% -> sufficient (2) 62,5% - 74,9% -> good (3) 75% - 87,4% -> very good (4) 87,5% - 100% -> excellent (5) Final grade can be supplemented by performing practical project work involving individual and experimental work, in agreement with the teacher. Exam terms: according to the academic year calendar

	Title	**Number of copies in the library**	**Availability via other media**
Required literature (available in the library and via other media)	• Jaakko Malmivuo & Robert Plonsey: Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, New York, 1995.		
	• Handbook of biological effects of electromagnetic fields (third edition): Bioengineering and Biophysical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007.		
	• Handbook of biological effects of electromagnetic fields (third edition): Biological		

	and Medical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007.		
Optional literature (at the time of submission of study programme proposal)	• Šantić, A: Biomedicinska elektronika, Školska knjiga, Zagreb, 1995. • The Biomedical Engineering Handbook (Second Edition), Ed. Joseph D. Bronzino, CRC Press, 2000.		
Quality assurance methods that ensure the acquisition of exit competences	Surveys providing student feedback		
Other (as the proposer wishes to add)			

NAME OF THE COURSE	**MEDICAL DEVICES**						
Code	FELH18	Year of study	2.				
Course teacher	Antonio Šarolić, Ph.D., Full Professor Ivan Marinović, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Niko Ištuk, mag. ing. el.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30			30	
Status of the course	Elective	Percentage of application of e-learning	0				
COURSE DESCRIPTION							
Course objectives	- learning the types, realizations and application areas of electronic/communication/information technology in medical domain - knowledge on therapeutic, diagnostic and control medical electronic devices - understanding the specifics of functional and safety requirements for medical electronic devices - understanding and application of success criteria for medical device innovation and development						
Course enrolment requirements and entry competences required for the course	None.						
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - employ their knowledge on electronic/communication/information technology for analysis and development of medical devices - use the knowledge of human physiology, especially electrophysiology, for analysis and development of medical devices - analyze the components of medical electronic devices and their interaction with human body medical electronic devices - conceive the electronic circuits for application in a medical device						

<table>
<tr><td></td><td colspan="4">- characterize a medical electronic device from the aspect of safety
- critically assess the success of innovation and development of a medical device</td></tr>
<tr><td rowspan="20">Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="2">Course content</td><td>L hours</td><td>AE hours</td></tr>
<tr><td colspan="2">Basics of human electrophysiology and electrophysiology</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Measurement medical electronic devices</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Diagnostic medical electronic devices</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Therapeutic medical electronic devices</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Electronic circuits and components in medical devices</td><td>6</td><td>0</td></tr>
<tr><td colspan="2">Circuits and devices for electric and magnetic stimulation at low frequencies</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Circuits and devices for thermal procedures at high frequencies</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Electrical safety aspects and electromagnetic compatibility aspects of medical electronic devices</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Control and auxiliary medical electronic devices. E-Health. Theranostic medical electronic devices – unifying the therapeutics and diagnostics in innovative medical devices and methods</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Translational resaerch and development of medical devices from lab to clinics (from the workbench to the bedside). Assessment of clinical and economic efficacy of medical technology (Health Technology Assessment - HTA)</td><td>2</td><td>0</td></tr>
<tr><td colspan="2">Clinical studies: principles and implementation of clinical trials of medical devices</td><td>2</td><td>0</td></tr>
<tr><td colspan="3">List of laboratory or design exercises</td><td>LE hours</td></tr>
<tr><td colspan="3">Basics of human electrophysiology</td><td>2</td></tr>
<tr><td colspan="3">Amplifier circuits</td><td>4</td></tr>
<tr><td colspan="3">Electrostimulator circuits</td><td>4</td></tr>
<tr><td colspan="3">Noise and disturbance suppression in electronic devices</td><td>2</td></tr>
<tr><td colspan="3">Electromagnetic compatibility testing</td><td>2</td></tr>
<tr><td colspan="3">Electrical safety testing</td><td>2</td></tr>
<tr><td colspan="3">Measurements of dielctric properties of tissues</td><td>2</td></tr>
<tr><td colspan="3">Measurement, diagnostic and therapeutic medical electronic devices – field trip (visit to medical establishments)</td><td>8</td></tr>
<tr><td>Format of instruction</td><td colspan="2">☒ lectures
☒ seminars and workshops
☒ exercises
☐ on line in entirety
☐ partial e-learning
☒ field work</td><td colspan="2">☐ independent assignments
☐ multimedia
☒ laboratory
☐ work with mentor
☐ (other)</td></tr>
<tr><td>Student responsibilities</td><td colspan="4">Student is required to attend the lectures and auditory exercises in the amount of at least 70% of the schedule.</td></tr>
<tr><td rowspan="6">Screening student work (name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)</td><td>Class attendance</td><td>1</td><td>Research</td><td></td><td>Practical training</td><td></td></tr>
<tr><td>Experimental work</td><td>0,5</td><td>Report</td><td></td><td>Laboratory exercises</td><td>0,5</td></tr>
<tr><td>Essay</td><td></td><td>Seminar essay</td><td>1</td><td>Individual work</td><td>1</td></tr>
<tr><td>Mid-exam</td><td>0,5</td><td>Oral exam</td><td></td><td>(Other)</td><td></td></tr>
<tr><td>Written exam</td><td>0,5</td><td>Project</td><td></td><td>(Other)</td><td></td></tr>
<tr><td></td><td colspan="5"></td></tr>
<tr><td>Grading and evaluating student</td><td colspan="5">Lectures are given in collaboration of prof. Šarolić (2/3 of lecture hours) and prof. Marinović (1/3 of lecture hours).</td></tr>
</table>

<table>
<tr><td>work in class and at the final exam</td><td colspan="3">Exam: presentation and defense of the seminar essay</td></tr>
<tr><td rowspan="3">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>Ante Šantić: Biomedicinska elektronika, Školska knjiga, Zagreb, 1995.</td><td></td><td></td></tr>
<tr><td>Jaakko Malmivuo & Robert Plonsey: Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, New York, 1995.</td><td></td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">- Handbook of biological effects of electromagnetic fields (third edition): Bioengineering and Biophysical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007.
- Handbook of biological effects of electromagnetic fields (third edition): Biological and Medical Aspects of Electromagnetic Fields, Ed. Frank S. Barnes and Ben Greenebaum, CRC Press, 2007.
- The Biomedical Engineering Handbook (Second Edition), Ed. Joseph D. Bronzino, CRC Press, 2000.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">Surveys providing student feedback</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
</table>

<table>
<tr><td>NAME OF THE COURSE</td><td colspan="5">MULTIMEDIA SYSTEMS</td></tr>
<tr><td>Code</td><td>FELJ20</td><td>Year of study</td><td colspan="3">2.</td></tr>
<tr><td>Course teacher</td><td>Mladen Russo, Ph.D., Assistant Professor</td><td>Credits (ECTS)</td><td colspan="3">5</td></tr>
<tr><td rowspan="2">Associate teachers</td><td rowspan="2">Jelena Čulić, Teaching Assistant
Martina Bašić, Teaching Assistant</td><td rowspan="2">Type of instruction (number of hours)</td><td>L</td><td>S</td><td>AE</td><td>LE</td><td>DE</td></tr>
<tr><td>30</td><td>0</td><td>0</td><td>30</td><td>0</td></tr>
<tr><td>Status of the course</td><td>Obligatory: 242
Elective: 241</td><td>Percentage of application of e-learning</td><td colspan="3">0</td></tr>
<tr><td colspan="6">COURSE DESCRIPTION</td></tr>
<tr><td>Course objectives</td><td colspan="5">Training students for:
- understanding of multimedia systems and virtual reality
- knowledge of the properties and methods for generating speech, audio, image and video signals (including 3D images and video)
- understanding of the most important algorithms for compressing speech, audio, image and video signals</td></tr>
<tr><td>Course enrolment requirements and entry competences required for the course</td><td colspan="5">None.</td></tr>
<tr><td>Learning outcomes expected at the level of the course (4 to 10 learning outcomes)</td><td colspan="5">Students will be able to:
- describe the basic principles of human speech, hearing and vision
- explain the basic principles of psychoacoustics and their application in compression of audio signals
- demonstrate the frequency masking effect
- define the most important algorithms for compression of speech, audio, image and video signals
- demonstrate the basic mechanisms of JPEG compression</td></tr>
<tr><td rowspan="8">Course content broken down in detail by weekly class schedule (syllabus)</td><td colspan="3">Course content</td><td>L hours</td><td>AE hours</td></tr>
<tr><td colspan="3">Introduction. History of multimedia systems. Basic terms. Overview of multimedia software tools. Design of multimedia applications.</td><td>2</td><td>0</td></tr>
<tr><td colspan="3">Audio signal. How humans hear and speak. Speech modelling.</td><td>2</td><td>0</td></tr>
<tr><td colspan="3">Generic compression techniques for audio signals. Audio specific algorithms (mp3).</td><td>2</td><td>0</td></tr>
<tr><td colspan="3">Speech specific algorithms (LPC, CELP, RELP, MPE, RPE) and applications in mobile telephony. Review of standards for encoding speech and audio signals.</td><td>2</td><td>0</td></tr>
<tr><td colspan="3">Color in images and video signal. The perception of color (how people perceive electromagnetic radiation). Theory of mixing colors.</td><td>2</td><td>0</td></tr>
<tr><td colspan="3">Color models for image signal (RGB, CMY, CMYK). Color models for video signal (YUV, YIQ, YCbCr). Software-oriented color models (HSB, HLS, HSV). Gamma correction. Image signal (resolution, depth, memory requirements). Image formats (gif, tiff, jfif, ps, bmp).</td><td>2</td><td>0</td></tr>
</table>

	Basics of video and television. Analog television and video. Digital television and video. Video formats and memory requirements.	2	0
	Image compression. JPEG modes.	2	0
	Video compression: H.261. H.263.	2	0
	Video compression: MPEG-1. MPEG -2.	2	0
	Video compression: MPEG-4.	2	0
	Video compression: H.264.	2	0
	Fundamentals of virtual reality. History. Stereoscopic (3D) vision. Software and hardware for virtual reality.	2	0
			LE hours
	Sound recording. Searching of voiced and unvoiced speech. Pitch period.		2
	Speech specific algorithms (LPC)		2
	Frequency masking		2
	3D sound		2
	Image compression (JPEG)		2
	Image compression (JPEG)		2
	Image compression (JPEG)		2
	MPEG – influence of I, P, B frames on video quality		2
	Multimedia systems on mobile devices (Android programming)		2
	Multimedia systems on mobile devices (Android programming)		2
	Multimedia systems on mobile devices (Android programming)		2
	3D images		2
	CAVE system		2

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☐ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Studentresponsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all required laboratory exercises.	

Screening student work *(name the proportion of ECTS credits for eachactivity so that the total number of ECTS credits is equal to the ECTS value of the course)*	Class attendance	3	Research		Practical training	
	Experimental work		Report		Individual work	1,7
	Essay		Seminar essay		(Other)	
	Tests	0,2	Oral exam		(Other)	
	Written exam	0,1	Project		(Other)	

Grading and evaluating student work in class and at the final exam	During a semester there are two midterms and final exam. Final exam and midterms are held according to the calendar of classes. At the final exam students take the test from the complete course if they do not have a positive grade on the midterms or take the midterm that they did not pass. At the make-up and commission exam students take the test from the complete course. The requirement for passing grade is 50% points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula:

<table>
<tr><td></td><td colspan="3">Grade(%) = 0,5*M1+0,5*M2; M1, M2 – midterm test results.
The final grade is determined as follows:
Percentage Grade
50% to 61% sufficient (2)
62% to 74% good (3)
75% to 87% very good (4)
88% to 100% excellent (5)</td></tr>
<tr><td rowspan="2">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>• H. Dujmić: Multimedijskisustavi, internal script</td><td>1</td><td>e-learning portal</td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">• Steinmetz, Nahrstedt: "Multimedia Fundamentals: Media CodingandContent Processing", Prentice Hall, 2002
• Rao, Bojkovic, Milovanovic: "Multimedia Communication Systems: Techniques, StandardsandNetworks", Prentice Hall, 2002</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Evaluation of results in accordance with the above learning outcomes
- Feedback from students via surveys
- Self-evaluation of teachers
- Institutional and non-institutional evaluations</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
</table>

NAME OF THE COURSE	MEASUREMENTS IN WIRELESS SYSTEMS						
Code	FELJ22	Year of study	2				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	15	15	0
Status of the course	Obligatory: 241 Elective: 242	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - radio-channel measurements and analysis, - statistical modelling of radio propagation in different environments and for various radio systems, - applying empirical and statistical models for radio-channel characterization.
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - calculate radio-channel parameters, - perform measurements and analysis of fixed and mobile radio systems parameters - statistically characterize radio propagation of arbitrary radio-systems on the base of measurements, - Apply various channel models

Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction to Measurements in Wireless Systems.	1	1
	Fixed radio-links channel parameters. Fading	2	1
	Ground radio links planning and measurements	2	2
	Fading in mobile radio channels.	2	1
	Mobile radio channel parameters.	2	1
	Propagation path-loss models. Hata-Okumura model.	3	1
	First midterm exam		
	Statistical channel models of ground networks comparison with Maxwell theory based model.	2	1
	Satellite radio-channels. Statistical models based on measurements (Loo model, Suzuki model).	4	1
	Wide-band channel parameters. Wide-band measurements.	4	3
	Wide-band channel models based on measurements.	2	1
	Wide-band indoor radio channel modelling.	3	1
	Second midterm exam		
	List of laboratory exercises		LE hours
	Antenna measurements by Vector Network Analyser measurements. Measurements calibration.		3
	Narrow-band channel measurements at various frequencies.		3

	Wide-band channel measurements	3
	Wide-band indoor channel measurements	3
	Radio-links planning by using measured data and software.	3

Format of instruction	☒ lectures ☐ seminars and workshops ☒ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☐ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Student responsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	2,0	Research		Practical training	
	Experimental work		Report		Individual work	1.5
	Essay		Seminar essay		Laboratory exercises	0,8
	Tests	0,5	Oral exam		Preparation for laboratory exercises	0,2
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are two midterms and final exams. The first midterm exam is after 7 weeks of lecturing and the second one is after the next 6 weeks. Each midterm test and final tests consists of theoretical questions and numerical. The students that did not pass the midterm exams take part In the final exams. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises and 40 % points on each midterm exam or the final exam. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M1 + M2) the activities in percentage: • NP - attendance at lectures, • LV – laboratory assessment, • M1, M2 – test results.

Required literature (available in the library and via other media)	**Title**	**Number of copies in the library**	**Availability via other media**
	• Z. Blažević; Mjerenja u bežičnim sustavima, predavanja		e-learning portal
	• M. Patzold: "Mobile Fading Channels", Wiley, 2002.	1	
	• Doble, J.: "Introduction to Radio Propagation for Fixed and Mobile Communications", Artech House Boston - London, GB, 1996.	1	

Optional literature (at the time of submission of study programme proposal)	• G. H. Bryant: ''Principles of Microwave Measurements'', IEE Publishing, 1993. • Zentner, E.: Antene i radiosustavi, Graphis Zagreb, 2001.
Quality assurance methods that ensure	- Evaluation of results in accordance with the above learning outcomes - Feedback from students via surveys - Self-evaluation of teachers

the acquisition of exit competences	- Institutional and non-institutional evaluations
Other (as the proposer wishes to add)	

NAME OF THE COURSE	**SYSTEMS FOR WIRELESS TRANSMISSION OF ENERGY**						
Code	FELJ36	Year of study	2				
Course teacher	Zoran Blažević, Ph.D., Full Professor	Credits (ECTS)	5				
Associate teachers	Maja Škiljo, Ph.D.	Type of instruction (number of hours)	L	S	AE	LE	DE
			30	0	0	30	0
Status of the course	Elective	Percentage of application of e-learning	0				

COURSE DESCRIPTION

Course objectives	Training students for: - understanding of basic principles of and problemacy of systems for wireless transmission of energy, - designing of radio system for near-field transmission of energy - design of radio system for far-field power transmission - calculation and analysis of wireless energy systems parameters		
Course enrolment requirements and entry competences required for the course	Finished the undergraduate study of Communications and Information Technology.		
Learning outcomes expected at the level of the course (4 to 10 learning outcomes)	Students will be able to: - analyse power and energy transmission techniques, - calculate and estimate wireless energy transmission system parameters, - designing basic transmission system schemes for given service		
Course content broken down in detail by weekly class schedule (syllabus)	Course content	L hours	AE hours
	Introduction. Historical perspective of radio and wireless transmission.	2	
	Principles and techniques for radio-transmission of energy. Transformers and resonant transformers (Tesla Coil), and electrically small antennas.	4	
	Antenna scattering matrix. Coupled-Mode Theory and Spherical Mode Theory-Antenna Model application to wireless transmission of energy systems.	4	

	Rectennas.	2	
	Near-field energy and power transmission. Resonant transformer.	4	
	Far-field power transfer.	4	
	Ground energy transfer by far-field systems concept	3	
	Satellite energy transfer system concept	3	
	Norms and standards for wireless energy transfer. Qi standard.	2	
	Electromagnetic Compatibility of wireless energy transfer systems.	2	
	Interference problem between radio-communications systems and radio systems for wireless energy transfer.	2	
	Midterm exam		

	List of laboratory exercises	LE hours
	Measurements and adjustments of inductively fed electrically small antennas	8
	Measurements of transfer performances by Spectrum Analyser, and by Oscilloscope	8
	Measurements of transfer performances by Vector Network Analyser	6
	Tesla Coil Measurements.	8

Format of instruction	☒ lectures ☐ seminars and workshops ☐ exercises ☐ *on line* in entirety ☐ partial e-learning ☒ field work	☒ independent assignments ☐ multimedia ☒ laboratory ☐ work with mentor ☐ (other)
Student responsibilities	The presence on lectures in the amount of at least 70 % of the times scheduled. Performed all laboratory exercises required.	

Screening student work *(name the proportion of ECTS credits for each activity so that the total number of ECTS credits is equal to the ECTS value of the course)*						
	Class attendance	1.5	Research		Practical training	
	Experimental work		Report		Individual work	2
	Essay		Seminar essay		Laboratory exercises	0,8
	Tests	0,5	Oral exam		Preparation for laboratory exercises	0,2
	Written exam		Project		(Other)	

Grading and evaluating student work in class and at the final exam	There are one midterm and one final exam. Both midterm test and final test consist of theoretical questions and numerical problems. The students that did not pass the midterm exams take part In the final exams. The midterm and final exams are carried out as written tests. The requirement for passing grade is the positive assessment of laboratory exercises, 40 % points on the midterm exam or the final exam, and the rest of the grade depends on the seminary work presented by the student. Grade (in percentage) is formed according to the formula: Grade(%) = 0,1 NP + 0,1 LV + 0,4 (M + S) the activities in percentage: • NP - attendance at lectures, • LV – laboratory assessment, • M – test results.,

<table>
<tr><td></td><td colspan="3">• S – seminary work results and presentation</td></tr>
<tr><td rowspan="4">Required literature (available in the library and via other media)</td><td>Title</td><td>Number of copies in the library</td><td>Availability via other media</td></tr>
<tr><td>• Ki Young Kim (editor), “Wireless Power Transfer-Principles and Engineering Explorations”, InTech, January 2012.</td><td></td><td>e-learning portal</td></tr>
<tr><td>• Volakis J., C. C. Chen and K. Fujimoto, “Small antennas: miniaturization techniques and applications”, New York, McGraw-Hill, 2010.</td><td></td><td>e-learning portal</td></tr>
<tr><td>• Special issue „Solar Power Satellite and Wireless Power Transmission“, IEEE Microwave Magazine, Vol. 3, No. 4, December 2002.</td><td>1</td><td></td></tr>
<tr><td>Optional literature (at the time of submission of study programme proposal)</td><td colspan="3">• Lee J. and S. Nam, “Fundamental aspects of near-field coupling small antennas for wireless power transfer”, IEEE Trans. Antennas Propag., Vol. 58, No. 12, 3442-3449, 2010.
• P. Sample, D. T. Meyer, J. R. Smith: Analysis, experimental results, and range adaptation of magnetically coupled resonators for wireless power transfer, IEEE Transactions on Industrial Electronics, Vol. 58, No. 2, 2010, p.p 544-554.
• N. Tesla, A. Marinčić: Colorado Springs Notes, Nolit, Beograd, 1978.
• Carol Gray Montgomery, Robert Henry Dicke and Edward M. Purcell, “Principles of microwave circuits”, McGraw-Hill Book Company, Inc.,USA, 1948.</td></tr>
<tr><td>Quality assurance methods that ensure the acquisition of exit competences</td><td colspan="3">- Evaluation of results in accordance with the above learning outcomes
- Feedback from students via surveys
- Self-evaluation of teachers
- Institutional and non-institutional evaluations</td></tr>
<tr><td>Other (as the proposer wishes to add)</td><td colspan="3"></td></tr>
</table>