Specification for the book of courses

Study program	Communications and Information Technologies / Communications and Information Processing Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	DSP Algorithms and Programming		
Lecturer (for lectures)	Nikolić R. Tatjana		
Lecturer/associate (for exercises)	Nikolić R. Tatjana		
Lecturer/associate (for OFE)	Nikolić R. Tatjana		
Number of ECTS 5	**Course status (obligatory/elective)**	Obligatory / Elective	

Prerequisites	None
Course objectives	The objective of the course is to enable students to master the theoretical and practical knowledge necessary for the implementation of fundamental digital signal processing algorithms using digital signal processors (DSP). The studied material includes the design, simulation, and implementation of key signal processing algorithms using the C programming language and MATLAB tools, as well as their integration into real systems.
Course outcomes	After successful completion of the course, the student will be able to: a) explain the basic concepts and mathematical foundations of digital signal processing, b) analyze and apply signal processing techniques, c) develop and optimize DSP algorithms in the C programming language, d) implement algorithms on DSP platforms or via simulators, e) use MATLAB for signal analysis, system simulation, and verification of implementation accuracy, f) realize practical solutions in applications such as sensor signal processing.
Course outline	
Theoretical teaching	Overview of digital signal processing theory. Signal discretization. Sampling, quantization, and codec operations. A/D and D/A converters. Frequency-domain signal analysis. Specific features and architectures of DSP processors. Data representation in fixed-point and floating-point formats and arithmetic; effects of finite word length. Instruction set. Development and implementation of computationally efficient algorithms on DSP platforms: convolution, correlation, digital filters (IIR, FIR, LMS, DFT, FFT, IFFT). Audio, speech, and image processing using DSP processors. Programming DSP processors in assembly and high-level languages. Development tools: assembler, linker, simulator, debugger. Efficient code creation: optimization, data type effects, memory mapping. Implementation in embedded environments.
Practical teaching (exercises, OFE, study and research work)	1) Signal generation and analysis in MATLAB. 2) Manipulation of fixed-point and floating-point numbers. 3) Introduction to the capabilities of modern development tools for design – using the Code Composer Studio software and DSP development system. 4) Implementation of FIR and IIR filters using MATLAB and FDATool. 5) Implementation of the FFT algorithm in the C programming language. 6) Generation of sinusoidal and noise signals, DTMF generator and tone detector. 7) Audio signal processing, sound source localization, and application in speech recognition. 8) Echo cancellation. 9) Digital image processing, histogram, filtering, application of JPEG standard and DCT. 10) Medical image processing, filtering of electrocardiogram (ECG) and electroencephalogram (EEG) signals.
Textbooks/references	
1	Kuo, S., Lee, B., Tian, W., Real-Time Digital Signal Processing: Fundamentals, Implementations and Applications, 3rd Edition, John Wiley & Sons Ltd., 2013.
2	T. B. Welch, C. H.G. Wright, M. G. Morrow, Real-Time Digital Signal Processing from MATLAB to C with the TMS320C6x DSPs, 3th Edition, CRC Press, 2017.
3	Kuo, S., Gan, W. S., Digital Signal Processors: Architectures, Implementations, and Applications, Pearson Educaton Inc., 2005.
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Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures; classroom exercises; laboratory exercises; homework assignments; project work; consultations

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points

Activity during lectures		**Written exam**	20
Exercises	20	**Oral exam**	20
Colloquia	20		
Projects	20		

Specification for the book of courses

Study program	Communications and Information Technologies / Communications and Information Processing Electronics and Embedded Systems
Type and level of studies	Master Academic Studies
The name of the course	Embedded System Design
Lecturer (for lectures)	Jovanović D. Milica, Đorđević Lj. Goran
Lecturer/associate (for exercises)	Đošić M. Sandra
Lecturer/associate (for OFE)	Jovanović D. Milica

Number of ECTS	5	**Course status (obligatory/elective)**	Obligatory / Elective

Prerequisites	None
Course objectives	Aim of this course is ability to design embedded system according to the application requirements and implementation limitations, focusing on the fundamental principles of embedded designing. Introduction to advanced methods and tools for embedded system design with emphasis on hardware/software co-design for FPGA platforms: modeling techniques, specification and analysis of alternative solutions, hardware/software partitioning with synthesis, understanding trade-offs between performance, consumption and resource utilization.
Course outcomes	By the end of the course a student should be able to: a) model and specify embedded systems at high level of abstraction using standard methods and tools; b) design hardware/software system on FPGA platform; c) analyze hardware/software tradeoffs, algorithms and architectures to optimize the embedded systems based on requirements and implementation constraints; d) analyze modern embedded design trends
Course outline	
Theoretical teaching	Introduction to embedded system design: application areas and examples, common characteristics, and challenges in embedded systems; traditional design flow, platform-based design. Specifications and modeling: requirements, models of computation, communicating finite state machines, data flow models, process networks, discrete-event based languages, levels of hardware modeling; comparison of models of computation. Evaluation and validation: performance evaluation, energy and power models, simulation, emulation, formal verification. Application mapping: problem definition, scheduling in real-time systems, hardware/software partitioning, mapping to heterogeneous multi-processors.
Practical teaching (exercises, OFE, study and research work)	Practical classes cover work with the FPGA development platforms. Several laboratory exercises and small-scale projects focus on unified designing of hardware and software as well as performance evaluation. Practical classes include the following activities: a) designing a complete microprocessor based on the available IP core of standard peripheral units, b) developing software under the operating system using available device drivers, c) designing a dedicated IP core, and d) developing a software driver for the projected IP core and its integration into the microprocessor system
Textbooks/references	
1	P. Marwedel, Embedded System Design: Foundations of Cyber-Physical Systems, and the Internet of Things, Springer, 2018.
2	M. Wolf, High-Performance Embedded Computing: Applications in Cyber-Physical Systems and Mobile Computing, Morgan Kaufmann, 2014.
3	L. H. Crockett, R. A. Elliot, M. A. Enderwitz, R. W. Stewart, The Zynq Book : Embedded Processing with the Arm Cortex-A9 on the Xilinx Zynq-7000 All Programmable SoC, Strathclyde Academic Media, 2014
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Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures, exercises, labs, homework, colloquia, consultations.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	25

Exercises	30	**Oral exam**	25
Colloquia	20		
Projects			

Specification for the book of courses

Study program		Electronics and Embedded Systems	
Type and level of studies		Master Academic Studies	
The name of the course		Adaptive Signal Processing	
Lecturer (for lectures)		Stančić Z. Goran	
Lecturer/associate (for exercises)		Đorđević Z. Ivana	
Lecturer/associate (for OFE)		Đorđević Z. Ivana	
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	Acquisition of fundamental knowledge in adaptive digital signal processing. Introduction to methods for practical implementation of filtering functions. Introduction to MATLAB commands for analysis, processing, and visualization of digital signals.
Course outcomes	Acquisition of theoretical and practical knowledge in adaptive filter design methods. Mastery of techniques for designing non-recursive adaptive filters. Understanding of the mathematical framework necessary for the design of non-recursive adaptive systems.
Course outline	
Theoretical teaching	Least squares approximation. Correlation. Discrete Fourier Transform. Random signals. Spectrum estimation and power spectral density. Properties of power spectra. Wiener filter. Kalman filter. System design through error minimization. Implementation of linear predictors. System identification. Inverse modeling. Interference cancellation. Covariance. Time constant of coefficient convergence. Convergence under ideal conditions. Steepest descent algorithm. LMS algorithm. Modified LMS algorithms. RLS algorithm. Performance measures of adaptive systems. Learning curve.
Practical teaching (exercises, OFE, study and research work)	Computation of least squares approximation of a continuous signal in MATLAB. Least squares approximation of a digital signal. Orthogonality. Discrete Fourier series. Correlation. Covariance. Analysis and design of linear predictors. System identification, inverse modeling, and interference cancellation implemented in MATLAB.
Textbooks/references	
1	Paulo S. R. Diniz: Adaptive filtering - Algoritms and practical implementation, Springer, Rio de Janeiro, Brazil, 2008
2	Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon: Statistical and adaptive signal processing, Artech house Inc., Norwood,MA, 2005
3	Samuel D. Stearns, Digital signal processing with examples in Matlab, CRC Press Washington, 2003.
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Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures and problem-solving classes, consultations,demonstrations in Matlab

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	30
Exercises		Oral exam	30
Colloquia			
Projects	40		

Specification for the book of courses

Study program	Electron Devices and Microsystems Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Open Source Operating Systems		
Lecturer (for lectures)	Dimitrijević A. Marko		
Lecturer/associate (for exercises)	Dimitrijević A. Marko		
Lecturer/associate (for OFE)	Dimitrijević A. Marko		
Number of ECTS 5	**Course status (obligatory/elective)**	Obligatory / Elective	

Prerequisites	None
Course objectives	Acquiring the necessary knowledge for advanced using open source operating systems: Linux/Unix.
Course outcomes	Mastering the knowledge and skills of using and administering open source operating systems (OOS), application installation on OOS and OOS networking. Learning user interface (shell) and script programming.
Course outline	
Theoretical teaching	The history of open source system (OOS) development. OOS architectures. Kernel. Working with files and file systems. Shell and shell script programming (regular expressions, variables). Processes and jobs. Working with users and security models. Working with hardware and hardware diagnostics. Working with text files, standard I/O, pipes. Installing and maintaining software on OOS. Computer networks and network services. Graphical user interface.
Practical teaching (exercises, OFE, study and research work)	The login procedure. General purpose commands (passwd, cal, clear, date, man, find, grep,...). Working with files and directories (commands: cat, chmod, umask, chown, chgrp, cmp, diff, cp, more, mv, rm, ln, ...). Working environment and corresponding commands (env, set). Archiving (tar, gzip, bzip,...). Process control (jobs, ps, top, kill, killall,...). Text editors (VI editor). Shell (bash, tcsh, zsh) and script programming. Regular expressions. Working with a file system (commands df, du, dd, fdisk, gdisk). Graphical user interface. System administration basics. Applications installation and maintenance (rpm, make,...). Basic network services and commands for working in the computer network environment (ping, traceroute, arp, netstat, nslookup,...).
Textbooks/references	
1	Evi Nemeth, Garth Snyder, Trent Hein, Ben Whaley, Dan Mackin, UNIX and Linux System Administration Handbook 5th Edition, Addison-Wesley Professional, 2017, ISBN: 978-0-134-27755-4.
2	William Shotts, The Linux Command Line: A Complete Introduction, 2nd Edition, No Starch Press, 2019, ISBN: 978-1-59327-389-7.
3	Abraham Silberschatz, Peter Galvin, Greg Gagne, Operating System Concepts 10th Edition, John Wiley & Sons, Inc., 2018, ISBN 978-1-118-06333-0.
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Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	2	0	0

Teaching methods	lectures, excercises, laboratory work, consultations

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	70
Exercises	30	Oral exam	
Colloquia			
Projects			

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	RF Systems		
Lecturer (for lectures)	Marinković D. Zlatica, Stanković Ž. Zoran		
Lecturer/associate (for exercises)	Stošić P. Biljana		
Lecturer/associate (for OFE)	Atanasković S. Aleksandar		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	
Prerequisites	None		
Course objectives	Introduction to modern radio systems, their operating principles, and characteristics. Familiarization with the basics of radio wave propagation and components of radio links. Training in antenna design and design of typical RF system circuits through the use of specialized electromagnetic software tools and RF circuit design software tools.		
Course outcomes	Knowledge of the basic types and operating principles of RF systems and their components. Understanding of radio signal characteristics and the ability to plan RF systems. Proficiency in performing electromagnetic simulations and applying them in the design of planar antennas and other RF circuits.		
Course outline			
Theoretical teaching	Fundamentals of radio wave propagation. Components of RF links. Antennas – characteristics and basic types. Design of planar antennas. Design of RF components (power dividers, directional couplers, etc.). Software-defined radio and cognitive radio. Radio Frequency Identification (RFID) – readers and tags. Global positioning systems, terrestrial/maritime navigation systems. Radar systems. Electromagnetic simulation of RF components.		
Practical teaching (exercises, OFE, study and research work)	Solving problems related to signal propagation, calculating charcteristics of antennas and RF system components. Performing calculations necessary for radio link design. Working with software packages for RF system and component design. Implementation and measurement of selected RF system components.		

Textbooks/references

1	J. S. Seybold, Introduction to RF Propagation, Wiley, 2005.
2	C. Balanis, Antenna theory: Analysis and Design, 4rd edition, Wiley, 2016.
3	David M. Pozar, Microwave Engineering, 4th ed., John Wiley & Sons, Inc., 2012.
4	David M. Pozar, Microwave Engineering, 4th ed., John Wiley & Sons, Inc., 2012.
5	Albert Lozano-Nieto, RFID Design Fundamentals and Applications, CRC Press, 2018.

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	1	0	0

Teaching methods	Lectures. Exercises. Laboratory exercises.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	5	Written exam	25
Exercises	10	Oral exam	25
Colloquia			
Projects	35		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Mixed Signal Integrated Circuits Design		
Lecturer (for lectures)	Mirković D. Dejan		
Lecturer/associate (for exercises)	Mirković D. Dejan		
Lecturer/associate (for OFE)	Radivojević S. Novak		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	Acquiring and systematizing knowledge related to electronic circuits with digital and analog signals, with special emphasis on parts where conversion from one signal form to another occurs.
Course outcomes	Acquisition of competencies for the design of mixed-signal integrated circuits. Students are expected to learn to dimension transistors in analog and digital parts of mixed-signal circuits, use programs for simulation and physical design of integrated circuits, and learn how to present the results of their work.
Course outline	
Theoretical teaching	Architectures and models of A/D and D/A converters. Quantization noise. Converter performance. Effective number of bits. Improving the signal-to-noise ratio using feedback, averaging and oversampling. Noise shaping circuits. Signal sampling circuits (track/sample and hold). SD modulator. SC/SI circuits and clock generation circuits. Topologies of operational, transconductance amplifiers (OTA) and comparators. Decimation filters for A/D converters.
Practical teaching (exercises, OFE, study and research work)	Students deepen the knowledge acquired in lectures by acquiring design skills using professional software packages for designing integrated circuits, such as Cadence and Mentor Graphics (Seiemens EDA).
Textbooks/references	
1	R. Jacob Baker, CMOS: Mixed-Signal Circuit Design, 2nd Edition, Wiley-IEEE Press, 2008, 352 pp., ISBN: 978-0-470-29026-2
2	Pavan Shanthi, Schreier Richard, Temes C. Gabor, Understanding Delta-Sigma Data Converters, Wiley-IEEE Press, 2017, 584 pp., ISBN: 978-1-119-25827-8
3	T. C. Carusone, D. A. Johns and K. W. Martin, ANALOG INTEGRATED CIRCUIT DESIGN, John Wiley & Sons, Inc., 2012, 794 pp., ISBN: 978-0-470-77010-8
4	P. E. Allen, D. R. Hodberg, CMOS Analog Circuit Design, Third Edition, Oxford University Press, 2012., 725 pp., ISBN: 978-0-19-976507-2
5	M. J. M. Pelgrom, Analog-to-Digital Conversion, Second Edition, Springer, 2013, 556 pp., ISBN: 978-1-4614-1370-7

Number of classes of active education per week during semester/trimester/year

Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	1	2	0	0

Teaching methods	Lectures, auditory exercises, computer laboratory exercises, consultations, individual and group projects.

Grade (maximum number of points 100)

Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	10	**Written exam**	
Exercises	20	**Oral exam**	30
Colloquia			
Projects	40		

Specification for the book of courses

Study program		Electrical Power Engineering Electronics and Embedded Systems	
Type and level of studies		Master Academic Studies	
The name of the course		Electronic Control Circuits for Converters	
Lecturer (for lectures)		Mančić D. Dragan, Jovanović D. Igor	
Lecturer/associate (for exercises)		Jovanović D. Igor	
Lecturer/associate (for OFE)			
Number of ECTS	5	**Course status (obligatory/elective)**	Obligatory / Elective

Prerequisites	None
Course objectives	Acquiring the fundamental knowledge about the control principles for power converters, methods of their realisation and practical application.
Course outcomes	Theoretical knowledge on the control of power converters. Mastering the techniques of development, realisation and application of the various control methods for power converters.
Course outline	
Theoretical teaching	Driver circuits for power electronic components (thyristor, bipolar transistor, MOSFET, IGBT, GTO). Control circuits with phase control. Control circuits for AC voltage controllers. Control circuits for rectifiers. Control circuits for choppers. Control circuits for inverters. Control circuits for cycloconverters. Professional systems in power electronics. Electromagnetic compatibility of power electronic devices.
Practical teaching (exercises, OFE, study and research work)	Drivers. Control of rectifiers. Control of choppers. Control of inverters. Control of a system for speed regulation of an asynchronous motor.
Textbooks/references	
1	N.Mohan, T.M.Undeland, W.P.Robbins, "Power electronics: Converters, Applications, and Design", John Wiley & Sons., New York, 2007.
2	R.W.Erickson, D. Maksimovic, "Fundamentals of Power Electronics, Third Edition", Springer, 2020.
3	M.H.Rashid, "Power Electronics Handbook", Elsevier Science, 2017.
4	L.A.Kumar, A. Kalaiarasi, YUMaheswari, “Power Electronics with MATLAB”, Cambridge University Press, Cambridge, 2018.
5	Lectures; Auditorial exercises; Laboratory exercises; Computer exercises; Consultations.

Number of classes of active education per week during semester/trimester/year

Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	2	0	0	0

Teaching methods	Lectures; Auditorial exercises; Computer exercises; Consultations.

Grade (maximum number of points 100)

Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	10	**Written exam**	20
Exercises	15	**Oral exam**	20
Colloquia	20		
Projects	15		

Specification for the book of courses

Study program	Control Systems / Automatic Control Electrical Power Engineering Electron Devices and Microsystems Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Methods of mathematical optimization		
Lecturer (for lectures)	Marinković D. Slađana, Rančić Z. Lidija		
Lecturer/associate (for exercises)	Rajković P. Jovan		
Lecturer/associate (for OFE)			
Number of ECTS	5	**Course status (obligatory/elective)**	Obligatory / Elective

Prerequisites	None
Course objectives	Mastering basic mathematical knowledge from optimization theory and getting acquainted with various optimization methods. Training for forming mathematical models of problems from practice and solving them.
Course outcomes	Students' capability to apply acquired knowledge in the profession. Ability to recognize optimization problems from practice, define them, form mathematical models, select appropriate methods for their solution and apply methods using software tools.
Course outline	
Theoretical teaching	Defining a general optimization problem. Theoretical foundations of optimization. Elements of convex analysis. Linear programming. Geometric interpretation of linear programming problems. Duality principle. Simplex method. One-dimensional optimizations. Unconstrained multidimensional optimizations. Search methods. Gradient methods. Constrained multidimensional optimizations. Kuhn-Tucker conditions. Method of Lagrange multipliers. Penalty function methods. Fundamentals of multiobjective optimization.
Practical teaching (exercises, OFE, study and research work)	Solving tasks that follow the content presented in the theoretical classes. Implementation of optimization algorithms through software packages for symbolic computation. Through the preparation of homework assignments and the analysis of their solutions, the application of mathematical and software tools in the context of optimization is gradually mastered.
Textbooks/references	
1	E.K.P. Chong, S.H. Zak, An Introduction to Optimization, John Wiley & Sons, 2001.
2	X.S. Yang, Introduction to Mathematical Optimization, Cambridge International Science Publishing, 2008.
3	M.J. Kochenderfer, T.A. Wheeler, Algorithms for Optimization, second edition, The MIT Press, 2025.
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Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	0	0	0

Teaching methods	Lectures, computational exercises, computer exercises, project.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	40
Exercises	10	Oral exam	10
Colloquia			
Projects	40		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Medical Electronic Systems		
Lecturer (for lectures)	Jovanović D. Borisav		
Lecturer/associate (for exercises)	Jovanović D. Borisav		
Lecturer/associate (for OFE)	Jovanović D. Borisav		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	
Prerequisites	None		
Course objectives	Acquiring practical knowledge about the function and design of electronic systems for medical diagnostics and physical therapy		
Course outcomes	Gaining competencies in the design of electronic systems used in physical therapy and medical diagnostics		
Course outline			
Theoretical teaching	Membrane and action potential, generation and transmission of electrical impulses in the body. Systems for monitoring patients' vital parameters: a system for monitoring heart activity, construction of a device for measuring oxyhemoglobin concentration in the blood, construction of a device for detecting the respiration curve. Medical electrotherapy devices. Stimulation of nerves and muscles. Design of pacemaker devices. Impedance plethysmography. Design of defibrillator devices and cardioverter defibrillators. Patient telemetry monitoring systems		
Practical teaching (exercises, OFE, study and research work)	The knowledge acquired during lectures is complemented by hands-on laboratory exercises. These exercises begin with the simulation of basic analog circuits used in diagnostic devices. In practical tasks, students program PIC microcontrollers, which are integral components of systems that monitor vital parameters: a pulse oximeter for determining blood oxyhemoglobin concentration (SpO_2), a device for measuring the respiration waveform, and a standard ECG device. For the purpose of these exercises, printed circuit boards were developed to implement real medical devices: an ECG device, a pulse oximeter, and a respiration waveform detector. A dedicated application was also created to run on the Linux operating system, featuring most of the functions of a patient monitoring system.		
Textbooks/references			
1	D. Prutchi, M. Norris, Design and Development of Medical Electronic Intrumentation, John Willey and Sons, Inc. 2005		
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3			
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Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures with the use of a projector, audio-based exercises, computer-based laboratory work, consultations, and individual projects.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	10	Written exam	
Exercises	20	Oral exam	30
Colloquia	20		
Projects	20		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Simulation and Optimization of Electronic Circuits		
Lecturer (for lectures)	Milić Lj. Miljana		
Lecturer/associate (for exercises)	Milić Lj. Miljana		
Lecturer/associate (for OFE)	Milić Lj. Miljana		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	Acquisition and systematisation of knowledge on algorithms for the analysis and optimization of analog circuits, as well as the simulation of digital and mixed-signal circuits
Course outcomes	By the end of this course, students will be able to apply advanced simulation techniques to analyze and optimize analog, digital, and mixed-signal electronic circuits. They will also develop skills in using optimization algorithms and tolerance analysis to improve circuit performance and reliability in practical applications.
Course outline	
Theoretical teaching	Analog Circuit Simulation: Abstraction domains: DC (direct current), steady-state, and time domain; Simulation algorithms; Simulation of linear resistive and reactive circuits; Simulation of nonlinear resistive circuits; Simulation of nonlinear reactive circuits; Models of basic passive and active electronic components. Digital Circuit Simulation: Path selection and event-driven simulation principles; Discrete-event simulation techniques. Mixed-Signal Circuit Simulation: Simulation of circuits with mixed analog and digital signals; Methods for estimating power consumption and timing delays. Circuit Optimization: Importance of weighting functions; Optimization algorithms; Simulated annealing; Evolutionary algorithms; Constrained optimization; Deterministic and statistical tolerance analysis; Optimization techniques in machine learning applications.
Practical teaching (exercises, OFE, study and research work)	Algorithms for the analysis of linear and nonlinear circuits across different domains. Algorithms for digital circuit simulation. Optimization of electronic circuits without the use of computer programs. This course includes laboratory exercises focused on the application of the Spice simulator and optimization tools. Additionally, the use of the Python programming language in machine learning is covered.
Textbooks/references	
1	Vanco Litovski, Mark Zwoliński, VLSI Circuit Simulation and Optimization, Springer, 1996.
2	Mark Zwoliński, Digital System Design with VHDL, 2004.
3	Sebastian Raschka, Vahid Mirjalili: Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2, 3rd Edition, Packt, 2015.
4	
5	

Number of classes of active education per week during semester/trimester/year				
Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	2	1	0	0

Teaching methods	Lectures utilizing multimedia projectors; classroom-based practical exercises; computer laboratory sessions; academic consultations; individual project work.

Grade (maximum number of points 100)			
Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	10	**Written exam**	
Exercises	30	**Oral exam**	30
Colloquia			
Projects	30		

Specification for the book of courses

Study program	Electronics and Embedded Systems
Type and level of studies	Master Academic Studies
The name of the course	Ultrasonic Technique
Lecturer (for lectures)	Mančić D. Dragan, Jovanović D. Igor
Lecturer/associate (for exercises)	Jovanović D. Igor
Lecturer/associate (for OFE)	Jovanović D. Igor

Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	Acquiring the fundamental knowledge about ultrasonic technique, methods of realisation and practical applications of ultrasonic devices.
Course outcomes	Theoretical knowledge on ultrasonic technique. Mastering the techniques of development, realisation and application of ultrasonic transducers and generators.
Course outline	
Theoretical teaching	Introduction to ultrasonic technique. Application areas of ultrasound. Theoretical aspects on application of ultrasound. Generation and propagation of ultrasonic waves. Ultrasonic waveguides and transducers. Detection and measurement of ultrasound. Nondestructive testing of materials. Application of ultrasound in signal processing and measurements. Ultrasound in medicine. Methods of ultrasonic scanning. Application of power ultrasound.
Practical teaching (exercises, OFE, study and research work)	Measurement of the parameters of piezoelectric ceramics. Construction and measurement of the parameters of ultrasonic sandwich transducers. Construction and measurement of the parameters of ultrasonic sonotrode. Ultrasonic generator. System for ultrasonic cleaning.
Textbooks/references	
1	M.Radmanovic, D.Mancic, "Design and modelling of power ultrasonics transducers", MP Interconsulting, Le Lockle, Switzerland, 2004.
2	D.Ensminger, L.J.Bond, "Ultrasonics: Fundamentals, Technologies, and Applications", CRC Press, 2011.
3	J.David, N.Cheeke, "Fundamentals and Applications of Ultrasonic Waves", CRC Press, 2012.
4	J.A.Gallego-Juarez, KF Graff, "Power Ultrasonics: Applications of High-Intensity Ultrasound", Elsevier, 2015.
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures; Auditorial exercises; Laboratory exercises; Computer exercises; Consultations.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	10	**Written exam**	20
Exercises	15	**Oral exam**	20
Colloquia	20		
Projects	15		

Specification for the book of courses

Study program	Electronics and Embedded Systems
Type and level of studies	Master Academic Studies
The name of the course	Artificial Intelligence in Engineering
Lecturer (for lectures)	Andrejević-Stošović V. Miona, Cvetković S. Stevica
Lecturer/associate (for exercises)	Radivojević S. Novak
Lecturer/associate (for OFE)	Radivojević S. Novak
Number of ECTS	5
Course status (obligatory/elective)	Elective
Prerequisites	None
Course objectives	To equip engineering students with comprehensive knowledge of artificial intelligence and practical skills necessary for the integration of artificial intelligence algorithms in various electronic systems. To enable them to apply modern machine and deep learning techniques to solve complex engineering problems.
Course outcomes	Upon completion of the course, students will demonstrate expertise in data preparation and analysis, implement classical machine learning models and deep neural network models using standard software tools. They will also be able to use generative artificial intelligence to improve engineering processes and decision-making.
Course outline	
Theoretical teaching	Artificial intelligence concepts, starting from data preparation, exploratory data analysis (EDA) and preprocessing techniques. Classical machine learning approaches including supervised learning methods for classification and regression problems. Unsupervised learning techniques with clustering as a basic example. Neural networks, training and error function. Deep neural networks. Convolutional neural networks for signal processing. Transformer models for sequential data. Generative artificial intelligence. Modern image generation techniques and large language models.
Practical teaching (exercises, OFE, study and research work)	Principles of Python programming for artificial intelligence, using the NumPy library for numerical computation and scikit-learn for implementing classical machine learning algorithms. Data preprocessing through data analysis and visualization (EDA). PyTorch library for implementing deep neural networks, construction and training of deep neural networks, convolutional architectures. Generative artificial intelligence (GenAI) programming interfaces for engineering applications, automatic content generation, data augmentation, and intelligent systems integration.
Textbooks/references	
1	Sebastian Raschka, Yuxi Liu, Vahid Mirjalili, Machine Learning with PyTorch and Scikit-Learn: Develop machine learning and deep learning models with Python, Pack Publishing, 2022.
2	Abhishek Thakur, Approaching Almost Any Machine Learning Problem, Amazon Digital Services, 2020.
3	Andriy Burkov, Machine Learning Engineering, Amazon Digital Services, 2020.
4	Numa Dhamani and Maggie Engler, Introduction to Generative AI, Manning, 2024.
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	2	0	0

Teaching methods	Lectures, computer exercises, consultations, individual and group projects.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	10	Written exam	30
Exercises	20	Oral exam	20
Colloquia			
Projects	20		

Specification for the book of courses

Study program		Electronics and Embedded Systems	
Type and level of studies		Master Academic Studies	
The name of the course		Hardware Modeling Languages	
Lecturer (for lectures)		Andrejević-Stošović V. Miona, Mirković D. Dejan	
Lecturer/associate (for exercises)		Mirković D. Dejan	
Lecturer/associate (for OFE)		Radivojević S. Novak	
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	Mastering hardware description languages (HDL) used in the design and verification of integrated circuits: Verilog, System Verilog, Verilog-AMS.
Course outcomes	Acquiring competence in modeling digital and analog electronic circuits using HDL language. Students are expected to learn to correctly describe an electronic circuit according to given specifications and to verify the functionality of the model with appropriate simulations. Students should learn how to write and present the results of their work.
Course outline	
Theoretical teaching	SystemVerilog as HDL. Structural and numeric data types. Operators. Enumeration and definition of new types. Flow and loop control statements. Concurrent processes. Statements for modeling combinational and sequential circuits. Blocking and non-blocking assignment. Module instantiation. Interface structures. Time representation. Module parameterization. Compiler directives. Testbenches. Rules for writing synthesizable code. Introduction to design verification. Fundamentals of the Verilog-AMS language for modeling and verifying analog blocks in a digital environment. Behavioral description. Description of conservative (Kirchhoff's laws) and non-conservative (signal flow) systems. Examples of Verilog-A models.
Practical teaching (exercises, OFE, study and research work)	Students deepen the knowledge acquired in lectures by developing the skills of writing and validating Verilog models using compilers and simulators from professional software packages Cadence and Mentor Graphics (Siemens EDA).
Textbooks/references	
1	Sutherland, S., et al., SystemVerilog for Design: A Guide to Using SystemVerilog for Hardware Design and Modeling, 2013. ISBN 1475766823, 9781475766820.
2	Writing testbenches using SystemVerilog. Springer Science & Business Media, 2007. ISBN 1475766823, 9781475766820.
3	Kundert, Ken, and Olaf Zinke. The designer's guide to Verilog-AMS. Springer Science & Business Media, 2006. ISBN 140208045X, 9781402080456.
4	Verilog-AMS Language Reference Manual, Version 2.4.0, Accellera Systems Initiative 2014.
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	2	0	0

Teaching methods	Lectures, computer exercises, consultations, individual and group projects.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	10	**Written exam**	
Exercises	20	**Oral exam**	30
Colloquia			
Projects	40		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Open-source Hardware		
Lecturer (for lectures)	Dimitrijević A. Marko, Jovanović D. Borisav		
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)	Dimitrijević A. Marko, Jovanović D. Borisav		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	System on Chip
Course objectives	Gaining advanced and practical knowledge of system-on-chip developed with open-source hardware.
Course outcomes	Students will deepen the knowledge gained in the System on Chip course. By implementing a prototype using open-source hardware, they will acquire practical knowledge and skills in applying design, simulation, and programming tools.
Course outline	
Theoretical teaching	The concept of open source hardware and comparison with commercial solutions. Introduction to the open RISC-V architecture and instruction set. Peripherals, interfaces and connectivity. Open real-time operating systems. Optimization and modification of systems on a chip, constraint analysis. Design tools in Verilog and VHDL languages for hardware description, implementation of prototypes on FPGA. Basic RISC-V core instruction set, tools for programming RISC-V systems on a chip in assembler, C/C++ compilers.
Practical teaching (exercises, OFE, study and research work)	Analysis and modification of RISC-V cores, instruction sets and memory. Configuration of the SweRV EH1 RiscV core, arithmetic/logic/memory instructions, resolution of structural hazards and control deadlocks, superscalar execution – simultaneous execution of two instructions, adding new functionality – extension with new instructions or hardware counters for monitoring core performance, memory hierarchy, usage of instruction caches to speed up memory access and reduce latency. Usage of ICCM and DCCM memories that enable fast access to instructions and data.
Textbooks/references	
1	S. Harris, D. Harris, Digital Design and Computer Architecture: RISC-V Edition, Morgan Kaufmann 2022, ISBN: 978-0-12-820064-3.
2	
3	
4	
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	0	2	0	0

Teaching methods	Lectures, laboratory exercises, consultations, project assignment

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises	50	Oral exam	50
Colloquia			
Projects			

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Digital System Design		
Lecturer (for lectures)	Jovanović D. Milica, Đorđević Lj. Goran		
Lecturer/associate (for exercises)	Đošić M. Sandra		
Lecturer/associate (for OFE)	Đošić M. Sandra		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	

Prerequisites	None
Course objectives	The course objective is to teach students with principles and techniques of digital system design at register transfer level (RTL) of abstraction, with emphasis on a hardware description language approach. This includes: RTL design methodology, building blocks of digital system modeling and basics of high-level synthesis.
Course outcomes	At the end of this course, students are expected to use techniques, skills and modern engineering tools for digital systems design including: a) synthesis and implementation of digital systems designs suitable for implementation on programmable device, b) simulation of hardware description language-based digital systems designs; c) design datapath and control unit of digital systems according to a stated functional behavior; d) transformation of algorithm into digital hardware; e) integration of existing IP cores into larger, more complex design.
Course outline	
Theoretical teaching	Introduction to principles of digital circuits and systems design. Programmable devices: FPGA architecture, design flow and development tools. Introduction to VHDL: VHDL code structure, lexical elements and objects, concurrent statements, sequential code, finite state machines, package and components, structural and hierarchical design, functions and procedures. RTL design: control/datapath model of digital system, datapath organization, control unit design techniques, optimization of ASM diagram, VHDL description of RTL system. Introduction to system on-chip design and IP core based design. Introduction to hardware/software co-design.
Practical teaching (exercises, OFE, study and research work)	Practical teaching includes: 1) VHDL simulation and synthesis; 2) using concurrent statements; 3) using sequential statements; 4) VHDL design of finite state machines; 5) structural design in VHDL; 6) using packages and libraries; 7) using functions and procedures, 8) RTL design (design and optimization of datapath), 9) RTL design (design and optimization of control unit), 10) design and implementation of simple RTL system, 11) IP design and integration into larger system, 12) design and implementation of simple embedded system using hardware/software co-design. In addition, a larger design project will be assigned as the course project.
Textbooks/references	
1	P.P. Chu, „RTL Hardware Design Using VHDL, Coding for Efficiency, Portability, and Scalability“, John Wiley & Sons, Inc. Hoboken, New Jersey, 2006
2	P.P. Chu, „FPGA prototyping by VHDL examples“, John Wiley & Sons, Inc. Hoboken, New Jersey, 2008
3	D. Gajski, Principles of Digital Design, Prentice-Hall, Inc. Upper Saddle River, NJ, 1997.
4	
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures, exercises, laboratory exercises, homework, consultations

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	25
Exercises	30	Oral exam	25
Colloquia	20		
Projects			

Specification for the book of courses

Study program	Communications and Information Technologies / System Engineering and Radio-Communications Electronics and Embedded Systems
Type and level of studies	Master Academic Studies
The name of the course	Distributed Embedded Systems
Lecturer (for lectures)	Đorđević Lj. Goran, Đošić M. Sandra, Jovanović D. Milica
Lecturer/associate (for exercises)	Jovanović D. Milica
Lecturer/associate (for OFE)	Đorđević Lj. Goran
Number of ECTS	5
Course status (obligatory/elective)	Obligatory / Elective
Prerequisites	None
Course objectives	Understand the principles of distributed embedded systems, with a special emphasis on wireless communication. Master key wireless technologies and protocols used in embedded systems (e.g., Bluetooth Low Energy, Zigbee, LoRa). Explore advanced topics, including wireless localization, time synchronization, and the design of low-power networked embedded systems. Develop practical skills in designing, implementing, and evaluating wireless embedded systems. Analyze typical applications and contemporary trends in distributed embedded systems (e.g., IoT, sensor networks).
Course outcomes	By the end of this course, students will be able to acquire theoretical knowledge and practical skills necessary for: a) understanding the principles of design, analysis, and implementation of distributed embedded systems, b) designing and developing real-world distributed embedded systems based on wireless communication, c) evaluating the advantages and limitations of different technologies used in the design and implementation of wireless embedded systems.
Course outline	
Theoretical teaching	Introduction to distributed embedded systems: definition, architecture, challenges. Wireless communication protocols: short-range protocols (IEEE 802.11, Bluetooth Low Energy, Zigbee), long-range protocols (LoRa/LoRaWAN, NB-IoT). Time synchronization in distributed embedded systems: clock drift , synchronization protocols (NTP, PTP, TSN). Wireless localization : principles (RSSI, ToA, TDoA, AoA), algorithms (trilateration, multilateration, fingerprinting), technologies (UWB, BLE, GPS, WiFi). Energy management: low-power design and energy-efficient communication protocols. Applications: smart cities, Industrial IoT, healthcare, autonomous systems. Modern trends and emerging technologies: 5G/6G , AI and Machine Learning in wireless embedded systems, Edge and Fog computing for distributed processing.
Practical teaching (exercises, OFE, study and research work)	Practical teaching is organized through several mini-projects focused on: 1) Establishing a simple wireless communication link via Wi-Fi, and implementing basic client-server communicatio; 2) Sensor data transmission using BLE: setting up BLE-enabled sensors, transmitting and receiving sensor data; 3) Implementation of a simple TDMA-based communication protocol: designing a basic TDMA scheme, testing multi-node communication with synchronized time slots; 4) Time synchronization using NTP: configuring NTP on embedded systems, measuring and compensating for clock drift: 5) RSSI-based localization using BLE technology: estimating distance from RSSI, implementing trilateration for position tracking; 6) Experimentation with UWB for high-precision localization: setting up UWB modules, testing ToA and TDoA methods; 7) Energy consumption measurement & optimization of a wireless sensor node: profiling power usage, implementing sleep modes and duty cycling.
Textbooks/references	
1	H. Karl and A. Willig, Protocols and Architectures for Wireless Sensor Networks, Wiley, 2007.
2	I. Sharp and K. Yu, Wireless Positioning: Principles and Practice, Springer, 2019
3	Additional course materials, such as lecture notes and tutorial documents, will be available on the faculty website
4	
5	
Number of classes of active education per week during semester/trimester/year	

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	2	0	0
Teaching methods	Lectures, tutorial sessions, laboratory exercises, homework assignments, mini-projects, and consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		**Points**	**Final exam**	**Points**
Activity during lectures			**Written exam**	35
Exercises		30	**Oral exam**	35
Colloquia				
Projects				

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Advanced Microprocessor Systems		
Lecturer (for lectures)	Nikolić R. Tatjana		
Lecturer/associate (for exercises)	Nikolić R. Tatjana		
Lecturer/associate (for OFE)	Nikolić R. Tatjana		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	

Prerequisites	None
Course objectives	Introducing students to current trends and future directions in the development of microprocessor architectures, as well as the utilization of hardware capabilities of multiprocessor platforms for software development. The subject matter covers the architecture and organization of high-performance processors and various parallelism techniques implemented in code at the thread and process levels.
Course outcomes	By acquiring knowledge from this course, the student will be able to: a) understand the operating principles of modern multicore microprocessors on a chip; b) classify and analyze components of modern parallel systems, including multicore processors, cache hierarchies, shared and distributed memories, interconnection subsystems, and hardware accelerators (GPU, TPU, FPGA); c) design and program homogeneous and heterogeneous multiprocessor systems on a chip; d) create multithreaded programs using various parallel programming models; e) evaluate performance using code profilers and debug code; f) design the architecture and software for application-specific processors.
Course outline	
Theoretical teaching	Trends in scaling technology. Techniques for performance improvement. Power consumption reduction. Power-saving modes in microprocessors. Architectures of multicore processors. Memory hierarchy. Physical and logical interconnection of computing resources. Basic concepts of parallel programming. Program structure. Process. Thread. Communication between threads and synchronization. Development and optimization of parallel algorithms. Principles of synchronization, race condition avoidance, mutual exclusion control, barriers, and deadlock prevention techniques. Programming parallel and heterogeneous systems – parallel models (OpenMP, Pthreads), GPU programming (CUDA/OpenCL). Application-specific processors. Architectures specialized for high-performance computing and machine learning.
Practical teaching (exercises, OFE, study and research work)	1) Introduction to multicore architecture using simulators. 2) Implementation and performance measurement of OpenMP programs. 3) Performance evaluation of systems through parallelization of program segments. 4) Thread synchronization – implementation and analysis of various mechanisms (mutex, spinlock, atomic operations). 5) Development of parallel-sequential programs. 6) Creation of multithreaded code by modifying serial programs. 7) Implementation of software considering memory hierarchy. 8) Development of complex programs using parallel processing techniques and testing software in a multicore environment.
Textbooks/references	
1	J. L. Hennessy, D. A. Patterson, Computer Architecture: A Quantitative Approach, 6th Edition, Morgan Kaufmann, 2017.
2	Herlihy, M., Nir Shavit, N., Luchangco, L., Spear, M., The Art of Multiprocessor Programming, 2nd Edition, Morgan Kaufman Publishing, 2020.
3	Michel Dubois, Murali Annavaram, Per Stenstrom, Parallel Computer Organization and Design, Cambridge University Press, 2012.
4	
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures; classroom exercises; laboratory exercises; homework assignments; project work; consultations

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points

Activity during lectures		**Written exam**	20
Exercises	20	**Oral exam**	20
Colloquia	20		
Projects	20		

Specification for the book of courses

<table>
<tr><td colspan="3">Study program</td><td colspan="2">Electron Devices and Microsystems
Electronics and Embedded Systems</td></tr>
<tr><td colspan="3">Type and level of studies</td><td colspan="2">Master Academic Studies</td></tr>
<tr><td colspan="3">The name of the course</td><td colspan="2">Nanoelectronics</td></tr>
<tr><td colspan="3">Lecturer (for lectures)</td><td colspan="2">Davidović S. Vojkan</td></tr>
<tr><td colspan="3">Lecturer/associate (for exercises)</td><td colspan="2">Davidović S. Vojkan</td></tr>
<tr><td colspan="3">Lecturer/associate (for OFE)</td><td colspan="2"></td></tr>
<tr><td colspan="2">Number of ECTS</td><td>5</td><td>Course status (obligatory/elective)</td><td>Obligatory / Elective</td></tr>
<tr><td>Prerequisites</td><td colspan="4">None</td></tr>
<tr><td>Course objectives</td><td colspan="4">The aim of the course is for the student to acquire the necessary level of knowledge about trends in the field of development of state-of-the-art nanoelectronic components and systems, about new operating principles of components, new materials used for the production of nano-components, technological processes used to realize nano-components and models used to describe their functioning. The knowledge acquired in this subject should enable the student to easily fit into the modern semiconductor industry and understand new developments in the field of information technology.</td></tr>
<tr><td>Course outcomes</td><td colspan="4">The student knows the scaling rules and trends in the development of nanocomponents. He knows the specifics of technological processes for the realization of very thin and well-controlled layers of materials, material removal techniques and adequate measurement methods. He understands the application of High-k dielectric materials, strained silicon, metal gate, understands the structure and functioning of FD and SOI transistors, FinFET model. He understands ferroelectric FET, RTD and Single electron transistor principles. He understands superconductivity and its applications in electronics, the potential of carbon nanotubes for component realization, components based on organic molecules, memory components for RAM or HDD and sensor components. In general, his way of thinking has shifted from the macro level to the level of very thin layers, the interaction of a small number of molecules, the importance of interfaces, and new materials.</td></tr>
<tr><td colspan="5">Course outline</td></tr>
<tr><td>Theoretical teaching</td><td colspan="4">Scaling theory, Moore's law. Materials in nanoelectronics (semiconductors, dielectrics, superconductors, ferroelectrics, organic molecules). Quantum effects. Methods of deposition of thin layers of materials. Lithography. Etching and chemical mechanical polishing. Measurement techniques in nanotechnology. Si MOSFET - new materials and alternative concepts (High-k dielectrics, strained Si). FinFETs, structure and modeling. Ferroelectric FET transistors. RTD components. Single-electron transistors. Superconducting electronics and quantum computers. Graphene, carbon nanotubes and components. Nanocomponents based on organic molecules. Nanoelectronic RAM memories. Ferroelectric RAM components. Concept of high-density memory disks - AFM. Sensor nanocomponents.</td></tr>
<tr><td>Practical teaching (exercises, OFE, study and research work)</td><td colspan="4">Defining and solving a certain number of tasks related to the physical phenomena and functioning of nanoelectronic components, modeling and computer simulations. Organization of seminars with current issues and with an emphasis on teamwork.
In the form of consultations, analyzing of a certain number of scientific papers (of the student's choice and affinity) in the field of nanoelectronic components.</td></tr>
<tr><td colspan="5">Textbooks/references</td></tr>
<tr><td>1</td><td colspan="4">Vijay Kumar Arora, NANOELECTRONICS: Quantum Engineering of Low-Dimensional Nanoensembes, CRC Press, 2020, ISBN: 978-0367575922</td></tr>
<tr><td>2</td><td colspan="4">Brajesh Kumar Kaushik, NANOELECTRONICS, Devices, Circuits and Systems, Elsevier, 2018, ISBN 9780128133538</td></tr>
<tr><td>3</td><td colspan="4">K. Goel, NANOELECTRONICS AND NANOSYSTEMS, From Transistors to Molecular Quantum Devices, Springer 2004, ISBN 978-3-662-05421-5</td></tr>
<tr><td>4</td><td colspan="4">IEEE Electron Device / Solid State Circuits - selection of the latests publications from the journals and conferences.</td></tr>
<tr><td>5</td><td colspan="4">Rainer Waser (Ed.), NANOELECTRONICS AND INFORMATION TECHNOLOGY, Advanced Electronic Materials and Novel Devices, Wiley-VCH, 2012 (Third Edition), ISBN: 978- 3-527-409273</td></tr>
<tr><td colspan="5">Number of classes of active education per week during semester/trimester/year</td></tr>
<tr><td>Lectures</td><td>Exercises</td><td>OFE</td><td>Study and research work</td><td>Other classes</td></tr>
</table>

2	2	0	0	0
Teaching methods	Lectures using PowerPoint presentations, problem solving, seminars with papers on current topics, homework, and consultative teaching.			
Grade (maximum number of points 100)				
Pre-exam duties		**Points**	**Final exam**	**Points**
Activity during lectures		20	**Written exam**	20
Exercises		0	**Oral exam**	30
Colloquia		10		
Projects		20		

Specification for the book of courses

Study program	Electron Devices and Microsystems Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Real Time Operating Systems		
Lecturer (for lectures)	Nikolić S. Goran		
Lecturer/associate (for exercises)	Nedeljković N. Jelena		
Lecturer/associate (for OFE)	Nedeljković N. Jelena		
Number of ECTS 5	**Course status (obligatory/elective)**	Obligatory / Elective	

Prerequisites	None
Course objectives	Acquiring knowledge of the fundamental concepts and principles of modern operating systems, with a particular focus on their structure, functions, and components. Special attention is given to real-time operating systems, including an understanding of their specific requirements, as well as the importance of timing constraints and guarantees during program execution in such systems.
Course outcomes	Students will acquire theoretical and practical knowledge about the concepts, internal design, and implementation of modern operating systems, with a focus on systems intended for embedded applications. They will gain proficiency in the practical use of the Real-Time Linux operating system API functions, as well as a detailed understanding of the structure and functions of the Linux kernel, including the possibilities for its modification and extension in real-time operating environments.
Course outline	
Theoretical teaching	Covers the history and development of embedded Linux systems, as well as an overview of popular distributions and architectures. It examines the structure of the Linux operating system, including the kernel, user space, startup sequences, and the boot loader interface. Special emphasis is placed on system resource management—memory, interrupts, timers, interfaces, and power consumption. Embedded memory technologies are analyzed along with methods for memory and kernel space optimization. The course covers driver development for serial and communication interfaces, as well as application porting, multithreaded programming, and integration with the kernel API. Special attention is given to Real-Time Linux as an operating system for real-time operation, including analysis of interrupt and scheduler latency, memory management, and synchronization mechanisms.
Practical teaching (exercises, OFE, study and research work)	Practical instruction includes working in a Linux environment on embedded platforms such as Raspberry Pi or ARM devices. Through the command line and shell scripts, students will master working with files, directories, and basic system commands. The course covers the fundamentals of shell programming, network configuration (TCP/IP), process and thread administration, as well as their synchronization. Special focus is placed on the boot process, configuration, and compilation of the Linux kernel, as well as working with modules. Programs will be developed in C, C++, and Python, with direct application to embedded hardware, providing students with hands-on experience in developing real-time Linux systems.
Textbooks/references	
1	Operating Systems: Internals and Design Principles 9th Edition by William Stallings, ISBN-10:0134670957, ISBN-13:978-0134670959, Pearson, 2017, https://www.amazon.com/Operating-Systems-Internals-Design-Principles/dp/0134670957
2	Modern Operating Systems 4th Edition by Andrew Tanenbaum, Herbert Bos, ISBN-10: 013359162X, ISBN-13: 978-0133591620, Pearson, 2014, https://www.amazon.com/Modern-Operating-Systems-Andrew-Tanenbaum/dp/013359162X
3	Operating System Concepts 10th Edition by Abraham Silberschatz, Peter B. Galvin, Greg Gagne, SBN-10: 1119800366, ISBN-13:978-1119800361, Wiley, 2021, https://www.amazon.com/Operating-System-Concepts-Abraham-Silberschatz/dp/1119800366
4	Embedded Linux Primer: A Practical, Real-World Approach 2nd Edition by Christopher Hallinan, ISBN-10: 0137017839, ISBN-13:978-0137017836, Prentice Hall, 2010, https://www.amazon.com/Embedded-Linux-Primer-Practical-Real-World/dp/0137017839
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	1	0	0

Teaching methods	Lectures with the use of computers and a projector. Lectures. Auditory exercises. Laboratory exercises. Homework assignments. Seminar paper. Consultations.		
Grade (maximum number of points 100)			
Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	10	**Written exam**	20
Exercises	15	**Oral exam**	20
Colloquia	20		
Projects	15		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Video Signals Processing		
Lecturer (for lectures)	Nikolić V. Saša, Cvetković S. Stevica		
Lecturer/associate (for exercises)	Nikolić V. Saša		
Lecturer/associate (for OFE)	Cvetković S. Stevica		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	The goal of the course is to introduce students to basic algorithms for digital video signal processing, including quality improvement, sharpening, filtering, segmentation, and tracking of moving objects. Students will master the necessary mathematical apparatus for the formalization and application of these operations in the analysis of video content. Special emphasis is placed on the practical application of acquired knowledge through the software implementation of algorithms.
Course outcomes	To enable students to understand and independently implement the most important algorithms of digital video signal processing in the Matlab or Python environment. Students will also be able to use software tools for video analysis and solving practical tasks, as well as to assess the applicability of different methods in the context of specific technical problems.
Course outline	
Theoretical teaching	Loading, decompression and display of video signals. Filtering and noise removal in video sequences. Video compression – principles and standards (MPEG, H.264/AVC, H.265/HEVC). Video stabilization and camera motion correction. Superresolution and quality enhancement. Mosaicking and panorama creation. Optical flow and block motion estimation. Object detection and tracking in video. Scene segmentation and keyframe extraction. Content-based video search. Modern video processing methods based on deep neural networks.
Practical teaching (exercises, OFE, study and research work)	The exercises follow the theoretical part of the course through the practical application of video processing algorithms in environments such as Python (OpenCV), MATLAB, or similar tools. Students will work on removing noise from video sequences, applying filters in space and time, and stabilizing video recordings. Basic algorithms for optical flow and moving object tracking are covered. Special attention is paid to the application of deep neural networks for video content analysis. Students will experiment with automatic keyframe detection and content-based video search. Exercises are implemented through individual or team mini-projects.
Textbooks/references	
1	Oge Marques, Practical image and video processing using Matlab, Wiley, 2011.
2	A, Elhanashi, S. Saponara: Deep learning in action: Image and Video Processing for Practical Use, Elsevier 2025
3	Rafael C. Gonzalez, Richard E. Woods, Digital Image Processing, 3rd edition, Prentice-Hall, 2008.
4	M.D. Patil, G.K. BirajdarS.S. Chaudhari: Computational Intelligence in Image and Video Processing, CRC Press, 2023
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	1	0	0

Teaching methods	Lectures, laboratory exercises.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	5	Written exam	20
Exercises	15	Oral exam	20
Colloquia	20		
Projects	20		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	System on Chip		
Lecturer (for lectures)	Dimitrijević A. Marko, Jovanović D. Borisav		
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)	Dimitrijević A. Marko, Jovanović D. Borisav		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	
Prerequisites	None		
Course objectives	Acquiring knowledge about the fundamental features, architecture, and design techniques of system-on-chip.		
Course outcomes	Acquiring competencies for designing integrated circuits that integrate all the elements of the entire system. Students will learn the basic properties of systems-on-chip, design procedures, and methods for overcoming fundamental and specific problems for the implementation and production of such systems.		
Course outline			
Theoretical teaching	Concept and properties of system-on-chip. Elements of system-on-a-chip: processor, memory, interfaces and peripherals. Basic architectures. Hardware and software components of the system, operating systems for working in the system-on-a-chip environment. Performance analysis. System simulation and verification, hardware and software co-simulation. Examples of applications and systems for implementing system-on-a-chip. FPGA properties and prototype implementation process.		
Practical teaching (exercises, OFE, study and research work)	Creating a system-on-chip (SoC) based on the open-source RISC-V core and implementing a prototype of the created system on an FPGA board. Programming RISC-V. Using and modifying the RISC-V input/output subsystem (includes creating a basic Vivado project of a RISC-V system, programming RISC-V in C, RISC-V assembly language, function calls, example programs in C and assembly language, setting up RISC-V interrupts, programming input/output, peripherals – displays, timers, serial communication controllers).		
Textbooks/references			
1	D. Black, J. Donovan, SystemC: From the Ground Up, 2nd Edition, Springer, 2010, ISBN: 978-0-387-69957-8.		
2	M. Zwolinski, Digital System Design with SystemVerilog, Upper Saddle River, US. Prentice Hall, 2009, ISBN: 978-0-13-704579-2		
3	M. J. Flynn, W. Luk, Computer System Design: System-on-Chip, Wiley, 2011, ISBN: 978-0-470-64336-5.		
4	S. Harris, D. Harris, Digital Design and Computer Architecture: RISC-V Edition, Morgan Kaufmann, 2022, ISBN: 978-0-12-820064-3.		
5			

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	0	2	0	0

Teaching methods	Lectures, laboratory exercises, consultations, project assignment

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises	50	Oral exam	50
Colloquia			
Projects			

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Methodology in Verification		
Lecturer (for lectures)	Andrejević-Stošović V. Miona		
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)	Radivojević S. Novak		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	
Prerequisites	None		
Course objectives	Acquiring knowledge related to various methodologies for verifying digital systems with an emphasis on functional verification.		
Course outcomes	Acquiring competence for design verification at different levels and of varying complexity.		

Course outline

Theoretical teaching	Functional verification using the universal methodology. Data transfer modeling (transactions). Interfaces. Agents - driver, sequencer and monitor. Transaction sequences. Verification environment. Reference model (scoreboard). Virtual sequencer. Configuration objects. Simulation phases. Test creation. Connecting the verification environment to the design (testbench module). Functional and code coverage. System-on-chip verification. Gate Level Simulation. Formal verification (assertions). Emulation and prototyping.
Practical teaching (exercises, OFE, study and research work)	Students are introduced to the SystemVerilog language and UVM through a series of practical examples using professional tools and software packages for electronic design (Cadence). Through the examples, students have the opportunity to apply the knowledge acquired from object-oriented programming to create an abstract model of a digital system, and then develop a UVC according to the universal methodology for simpler protocols based on the valid-ready handshake concept.

Textbooks/references

1	Chris Spear, Greg Tumbush: SystemVerilog for Verification - A Guide to Learning the Testbench Language Features, 3rd edition, Springer, 2012, ISBN: 978-1-4614-0714-0.
2	IEEE Standard for Universal Verification Methodology Language Reference Manual, in IEEE Std 1800.2-2020 (Revision of IEEE Std 1800.2-2017) , vol., no., pp.1-458, 14 Sept. 2020, doi: 10.1109/IEEESTD.2020.9195920.
3	IEEE Standard for SystemVerilog-Unified Hardware Design, Specification, and Verification Language, in IEEE Std 1800-2017 (Revision of IEEE Std 1800-2012) , vol., no., pp.1-1315, 22 Feb. 2018 doi: 10.1109/IEEESTD.2018.8299595.
4	
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	0	2	0	0

Teaching methods	Lectures, auditory exercises, computer laboratory exercises, consultations, individual and group projects.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	25	Written exam	
Exercises	25	Oral exam	50
Colloquia			
Projects			

Specification for the book of courses

Study program	Electronics and Embedded Systems			
Type and level of studies	Master Academic Studies			
The name of the course	Embedded Operating Systems			
Lecturer (for lectures)	Nikolić R. Tatjana			
Lecturer/associate (for exercises)	Nikolić R. Tatjana			
Lecturer/associate (for OFE)	Nikolić R. Tatjana			
Number of ECTS	5	**Course status (obligatory/elective)**	Elective	
Prerequisites	None			
Course objectives	The course aims to enable students to understand the architecture, operation, and design of operating systems tailored for embedded platforms. Special emphasis is placed on Linux, real-time operating systems, as well as system software for hardware resource management, process control, synchronization, and security.			
Course outcomes	Upon successful completion of the course, the student will be able to: a) understand the architecture and components of embedded operating systems; b) configure and customize embedded Linux for specific hardware platforms; c) develop and integrate kernel modules and device drivers; d) analyze and optimize real-time operating system performance; e) apply security and stability concepts in embedded operating system development.			
Course outline				
Theoretical teaching	Introduction to embedded operating systems - requirements, challenges, and architecture. Process and thread management in embedded systems. Synchronization mechanisms and resource management. File systems in embedded environments. Embedded Linux - structure and init systems. Real-time operating systems. Development of embedded operating systems and customization of available OS platforms. Development and integration of kernel modules. Creation of drivers for real hardware components - character, block, and network devices. System-level programming in assembly and C languages. Kernel mechanisms necessary for driver development. Processes managing interaction between processor and memory. User space interfaces. Integration and testing of complex Linux drivers. Support for system security.			
Practical teaching (exercises, OFE, study and research work)	1) Installation and configuration of an embedded Linux distribution. 2) Configuring and compiling the operating system kernel for the target platform. 3) Creating, compiling, and loading Linux kernel modules. 4) Developing character and block device drivers. 5) Working with interprocess communication mechanisms. 6) Handling interrupts within kernel modules. 7) Development of a sensor driver.			
Textbooks/references				
1	K. Yaghmour, J. Masters, G. Ben-Yossef, P. Gerum, Building Embedded Linux Systems: Concepts, Techniques, Tricks, and Traps, 2nd Edition, O'Reilly Media, 2008.			
2	Frank Vasquez, Chris Simmonds, Mastering Embedded Linux Programming, Packt Publishing, 2021.			
3	A. Holt , C. Y. Huang, Embedded Operating Systems: A Practical Approach, Springer, 2018.			
4	J. Corbet, A. Rubini, G. Kroah-Hartman, Linux Device Drivers: Where the Kernel Meets the Hardware, 3rd Edition, O'Reilly Media, 2005.			
5				
Number of classes of active education per week during semester/trimester/year				
Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	2	1	0	0
Teaching methods	Lectures; classroom exercises; laboratory exercises; homework assignments; project work; consultations			
Grade (maximum number of points 100)				
Pre-exam duties	**Points**	**Final exam**	**Points**	
Activity during lectures		**Written exam**	20	
Exercises	20	**Oral exam**	20	
Colloquia	20			
Projects	20			

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Power Supplies		
Lecturer (for lectures)	Mančić D. Dragan, Jovanović D. Igor		
Lecturer/associate (for exercises)	Jovanović D. Igor		
Lecturer/associate (for OFE)	Jovanović D. Igor		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	Acquiring the fundamental knowledge about power supplies, methods of their realisation and practical application.
Course outcomes	Theoretical knowledge on power supplies. Mastering the techniques of development, realisation and application of power supplies.
Course outline	
Theoretical teaching	Types of power supplies. Linear power supplies. Switching power supplies. Direct converters (buck, boost, inverting converter, Ćuk converter, SEPIC converter, reverse converters). Isolated converters (forward and flyback converters, Ćuk converter). Two-pulse converters. Control methods for switching sources. Power supply systems. Centralized and decentralized power supplies. Grounding of a system. Voltage balance. Uninterruptible power supplies (UPS). Elements of a system. Batteries and accumulators. Methods of implementation. Methods of regulation and control.
Practical teaching (exercises, OFE, study and research work)	Linear voltage regulator. Switching voltage regulator. The switching flyback converter. Switching half-bridge converter. An uninterruptible power supply system.
Textbooks/references	
1	A. Pressman, K.Billings, T.Morey, "Switching Power Supply Design", McGraw-Hill, 2009.
2	R.W.Erickson, D. Maksimovic, "Fundamentals of Power Electronics, Third Edition", Springer, 2020.
3	S.Maniktala, "Switching Power Supply Design and Optimization", McGraw-Hill, 2014.
4	S.M.Sandler, "Switched-Mode Power Supply Simulation with SPICE", Faraday Press, 2018.
5	L.A.Kumar, A.Kalaiarasi, Y.U.Maheswari, “Power Electronics with MATLAB”, Cambridge University Press, Cambridge, 2018.

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0

Teaching methods	Lectures; Auditorial exercises; Laboratory exercises; Computer exercises; Consultations.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures	10	**Written exam**	20
Exercises	15	**Oral exam**	20
Colloquia	20		
Projects	15		

Specification for the book of courses

Study program	Electrical Power Engineering Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Photovoltaic Systems		
Lecturer (for lectures)	Petronijević P. Milutin, Jovanović D. Igor		
Lecturer/associate (for exercises)	Jovanović D. Igor, Filipović R. Filip		
Lecturer/associate (for OFE)	Jovanović D. Igor, Filipović R. Filip		
Number of ECTS 5	**Course status (obligatory/elective)**	Obligatory / Elective	

Prerequisites	None
Course objectives	Acquiring knowledge about the concepts and elements of photovoltaic energy conversion systems. Familiarization with the specific structure of energy converters for this purpose, with the basic characteristics and functions of measuring, control and protection circuits.
Course outcomes	Theoretical and practical knowledge of photovoltaic systems and associated control, monitoring and measurement systems; mastery of the techniques of design, implementation and application of photovoltaic on-grid and off-grid systems; assessment of the cost-effectiveness of the system.
Course outline	
Theoretical teaching	Types and characteristics of solar panels. Estimation of expected energy using a solar calculator and selection of basic system components. Algorithms and devices for tracking the maximum power point. Inverters for photovoltaic systems. Hybrid systems. Principles of system design and accompanying control, protection, measurement and monitoring equipment. Selection of protection and switching devices in photovoltaic systems. Safety functions: detection of network outages, protection against overloading. Selection of lightning protection devices. Techno-economic analysis of the investment. Optimization of hybrid systems. Compliance with the conditions for connection to the distribution network. Content of the project documentation of the photovoltaic system.
Practical teaching (exercises, OFE, study and research work)	Computational exercises: Analysis of the operation of DC-DC converters of various configurations. Modeling a photovoltaic panel with a maximum power point tracking circuit. Implementation of an algorithm for maximum power point tracking. Determination of DC-DC converter parameters when supplying power to consumers via a photovoltaic module with and without maximum power point tracking. Determination of the number of photovoltaic modules in a series. Calculation of expected electricity production and capacity factor of a photovoltaic system. Selection of conductor cross-section in a DC circuit. Selection of protective devices in a DC circuit. Selection of conductor cross-section in an AC circuit. Selection of protective devices in an AC circuit. Selection of switching devices and devices for protection against atmospheric discharge. Calculation of compliance with prescribed technical conditions by the distribution system operator. Laboratory exercises accompany the lectures and, through the use of specific simulation software, illustrate all the steps in designing a solar power plant: calculation of energy yield, selection of equipment on the DC side, selection of inverters, selection of switching and protective equipment on the AC side, techno-economic analysis of the profitability of a solar power plant.
Textbooks/references	
1	P. Gevorkian, Large-Scale Solar Power System Design (GreenSource Books) : An engineering guide for Grid-Connected Solar Power Generation: An Engineering Guide for Grid-Connected Solar Power Generation. Mcgraw-hill, 2011.
2	M. Boxwell, Solar electricity handbook: A Simple Practical Guide to Solar Energy : how to Design and Install Photovoltaic Solar Electric Systems. 2015.
3	A. Keyhani, "Design of Smart Power Grid Renewable Energy Systems", Wiley, 2019.
4	Schneider Electric, ""Electrical Installation Guide, IEC Standards"", 2018"
5	Seip, Günter G., and Werner Sturm, eds. Electrical installations handbook. Erlangen: Publicis MCD Verlag, 2000.

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
2	1	1	0	0

Teaching methods	Lectures are conducted using slides, animations and simulations. Numerical exercises include solving examples to illustrate lectures and solve specific engineering problems. Exercises are conducted in the laboratory - simulations in SYSTEM ADVISOR MODEL software. Student seminar paper.		
Grade (maximum number of points 100)			
Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	5	**Written exam**	20
Exercises	15	**Oral exam**	20
Colloquia	20		
Projects	20		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Advanced Embedded Systems Design		
Lecturer (for lectures)	Đošić M. Sandra, Đorđević Lj. Goran, Jovanović D. Milica		
Lecturer/associate (for exercises)	Jovanović D. Milica		
Lecturer/associate (for OFE)	Jovanović D. Milica		
Number of ECTS 5	**Course status (obligatory/elective)**	Elective	

Prerequisites	None
Course objectives	The objectives of this course are: a) To master advanced techniques for hardware and software design for SoC platforms based on FPGA (SoC FPGA), which includes high-level synthesis (HLS), integration of operating systems in SoC FPGA software development, and the design of complex embedded systems through hardware-software co-design using modern tools and methodologies; b) To become familiar with typical application areas of SoC FPGA, such as signal processing, machine learning, and real-time systems; c) To acquire skills for analyzing performance, power consumption, and resource utilization in SoC FPGA.
Course outcomes	The outcome of this course is for students to gain the ability to: a) Design hardware accelerators on SoC FPGA platforms using HLS and apply optimization techniques; b) Launch and configure an operating system on an SoC FPGA platform, as well as develop and integrate drivers for HLS accelerators; c) Identify bottlenecks in various components of an SoC FPGA system, analyze the requirements and constraints of target applications; d) Design, implement, and test a complete SoC FPGA system (e.g., for applications in machine learning, digital signal processing, or network communication) through the integration of HLS accelerators and the operating system via hardware-software co-design.
Course outline	
Theoretical teaching	Introduction to SoC FPGA: Architecture and standard design flow. High-Level Synthesis (HLS): Theoretical foundations, development tools, design flow (coding, synthesis, optimization, verification), optimization techniques (loop unrolling, pipelining, array partitioning), data exchange via AXI interface. Operating Systems for SoC FPGA: "Bare-metal" and "OS-based" configurations, operating systems for SoC FPGA, the boot process, task management, and interrupt handling. Hardware-Software Co-Design: Functional partitioning between software (OS) and hardware (HLS), AXI communication, and device driver development for HLS accelerators. Advanced Design Techniques: Partial dynamic reconfiguration, power optimization, and error detection techniques. Application Areas: Signal processing, machine learning, networking, and vision.
Practical teaching (exercises, OFE, study and research work)	Practical instruction is conducted on FPGA SoC platforms, using advanced software tools for integrated hardware and software design. It is organized into the following units: a) Development of hardware accelerators using HLS: implementation and optimization of hardware modules with HLS techniques, focusing on parallelism and throughput, along with analysis of trade-offs between performance, power consumption, and resource utilization; b) Configuration and use of operating systems: booting and customizing an operating system (OS) on an FPGA SoC platform, including development of software tailored to the OS environment; c) Hardware-software co-design in an OS environment: system design with integrated hardware and software, exploring efficient methods for data exchange between the processing system and programmable logic; d) Application-domain implementation and optimization: design and integration of HLS accelerators with the operating system for applications in signal processing, machine learning, and networking, with an understanding of each domain's specific requirements and constraints.
Textbooks/references	
1	Uwe Meyer-Baese, Embedded Microprocessor System Design using FPGAs, Springer, 2025
2	M. Fingeroff, High-Level Synthesis Blue Book, 2010, Xlibris Us
3	Advanced Digital System Design using SoC FPGAs: An Integrated Hardware/Software Approach, Springer, 2023
4	Peter Athanas, Dionisios Pnevmatikatos, Nicolas Sklavos (yp.), Embedded Systems Design with FPGAs, Springer, 2013
5	Design of Complex Embedded Systems, course notes and PowerPoint presentations for lectures, problem-solving sessions, and laboratory exercises, available on the course website.
Number of classes of active education per week during semester/trimester/year	

Lectures	Exercises	OFE	Study and research work	Other classes
2	2	1	0	0
Teaching methods	Lectures, tutorial sessions, laboratory exercises, homework assignments, mini-projects, and consultations.			
Grade (maximum number of points 100)				
Pre-exam duties		**Points**	**Final exam**	**Points**
Activity during lectures			**Written exam**	25
Exercises		50	**Oral exam**	25
Colloquia				
Projects				

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Academic Studies		
The name of the course	Applications of Machine Learning in Electronic Circuit Design		
Lecturer (for lectures)	Đorđević D. Srđan, Andrejević-Stošović V. Miona		
Lecturer/associate (for exercises)	Đorđević D. Srđan, Andrejević-Stošović V. Miona		
Lecturer/associate (for OFE)	Đorđević D. Srđan, Andrejević-Stošović V. Miona		
Number of ECTS	5	**Course status (obligatory/elective)**	Elective

Prerequisites	None
Course objectives	The aim of the course is to introduce students to the applications of machine learning at various stages of electronic design automation.
Course outcomes	Upon completing the course, students will know how to use machine learning techniques to improve the automation of a circuit design. Students will have developed the necessary knowledge to build an effective machine learning model for automating and optimizing specific task in electronic circuit design.
Course outline	
Theoretical teaching	Supervised and unsupervised machine learning algorithms, reinforcement learning, Generative Adversarial Networks (GAN). Applications of machine learning in High-Level Synthesis (HLS): Design Space Exploration (DSE), predicting of timing, resource consumption and operation delay. Machine learning based surrogate models for optimization at logical level. Applications in physical design: clock network synthesis, IR drop estimation, power delivery network synthesis, placement of components as a reinforcement learning problem. Optimization-based synthesis of analog circuits using machine learning. Machine learning algorithms for analog IC fault testing and diagnosis.
Practical teaching (exercises, OFE, study and research work)	The exercises provide an insight into the structure and usage of machine learning based tools for the physical design of integrated circuits. Students must learn basics of the Python programming language in order to complete this assignment.
Textbooks/references	
1	H. Ren, J. Hu, Machine Learning Applications in Electronic Design Automation, 1st ed., Springer International Publishing, 2022, ISBN 978-3-031-13073-1
2	S. Raschka, V. Mirjalili, Python Machine Learning, 2nd ed., Packt Publishing, 2018, ISBN 978-1787125933
3	
4	
5	

Number of classes of active education per week during semester/trimester/year

Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	1	1	0	0

Teaching methods	Lectures, laboratory exercises, consultations, project assignment

Grade (maximum number of points 100)

Pre-exam duties	**Points**	**Final exam**	**Points**
Activity during lectures	5	**Written exam**	
Exercises	10	**Oral exam**	40
Colloquia	20		
Projects	25		

Specification for the book of courses

Study program		Electronics and Embedded Systems		
Type and level of studies		Master Academic Studies		
The name of the course		Measurement Systems in Industry 5.0		
Lecturer (for lectures)		Dinčić R. Milan, Jovanović R. Jelena		
Lecturer/associate (for exercises)		Pešić T. Miroljub, Ranđelović S. Ivana		
Lecturer/associate (for OFE)		Pešić T. Miroljub, Ranđelović S. Ivana		
Number of ECTS	5	**Course status (obligatory/elective)**		Elective
Prerequisites	None			
Course objectives	Empowering students to apply modern industrial measurement systems by integrating advanced technologies such as artificial intelligence, IoT/IIoT, and predictive maintenance — with a strong emphasis on improving the reliability, accuracy, and energy efficiency of these systems.			
Course outcomes	Students will gain comprehensive theoretical and practical knowledge essential for the implementation of modern measurement systems in industrial settings. They will be equipped to integrate artificial intelligence, IoT/IIoT technologies, and predictive maintenance into advanced measurement solutions. Additionally, they will learn to apply smart sensors, digital twins, and sensor fusion techniques. Students will also master methods for enhancing the accuracy, reliability, and energy efficiency of measurement systems, thereby preparing them to work effectively in cutting-edge industrial environments.			
Course outline				
Theoretical teaching	The course explores modern measurement systems with applications in industry, including the fundamental principles of Industry 4.0 and 5.0, measurement systems based on artificial intelligence, as well as the basic concepts of the Internet of Things (IoT) and the Industrial Internet of Things (IIoT). Students will also become familiar with smart sensors, digital twins, predictive maintenance techniques, sensor fusion, and energy harvesting techniques for powering autonomous sensor modules. Through this approach, students gain the knowledge necessary to apply the latest technologies in modern industrial environments.			
Practical teaching (exercises, OFE, study and research work)	Problem-solving exercises, laboratory sessions, project assignments, and seminar papers designed to equip students with practical skills and knowledge for the application of modern measurement systems in industrial environments.			
Textbooks/references				
1	Dan Zhang (editor), Xuechao Duan (editor), "Smart Sensors and Devices in Artificial Intelligence", Mdpi AG, 2021.			
2	Halit Eren, "Artificial Intelligence in Wireless Sensors and Instruments: Networks and Applications", CRC Press, 2024.			
3	Bhagirathi Nayak, Monika Mangla, Sachi Nandan Mohanty, Suneeta Satpathy, "Integration of Cloud Computing with Internet of Things: Foundations, Analytics and Applications", Wiley, 2021.			
4	Guangrui Wen, Zihao Lei, Xuefeng Chen, Xin Huang, "New Generation Artificial Intelligence-Driven Diagnosis and Maintenance Techniques: Advanced Machine Learning Models, Methods and Applications", Springer, 2024.			
5	Alice James, Avishkar Seth, Subhas Chandra Mukhopadhyay, "Smart Sensors, Measurement and Instrumentation: Iot System Design: Project Based Approach", Springer, 2022.			
Number of classes of active education per week during semester/trimester/year				
Lectures	**Exercises**	**OFE**	**Study and research work**	**Other classes**
2	1	2	0	0
Teaching methods	Lectures, problem-solving and laboratory exercises, consultations, project work, real-world industrial case studies, teamwork, educational games and simulations — all delivered through personalized learning approaches tailored to students' individual needs and interests.			
Grade (maximum number of points 100)				
Pre-exam duties	**Points**	**Final exam**		**Points**
Activity during lectures	5	**Written exam**		25
Exercises	25	**Oral exam**		25

Colloquia	20		
Projects			

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Doctoral Studies		
The name of the course	Professional Practice		
Lecturer (for lectures)			
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS	3	**Course status (obligatory/elective)**	Obligatory

Prerequisites	
Course objectives	Introduction to the work process in the company where the professional practice is carried out, its goals and organizational units. Introduction to the team and project that the student joins as part of their professional practice, which is selected in accordance with the study electives that the student has chosen. Understanding the work process in the company, business processes, understanding work risks, participation in design, documentation or quality control, in accordance with the work process and the possibilities of the work environment.
Course outcomes	Improving the student's ability to engage in the work process after completing their studies. Developing responsibility, a professional approach to work, and communication skills in a team. Supplementing the theoretical knowledge acquired within the study program and gaining practical knowledge of the issues studied within the studies that the student is attending. Using the experience of experts employed at the institution where the internship is conducted to expand the practical knowledge and motivation of students. Gaining a clear insight into the possibility of applying the acquired knowledge and skills covered by the study program in practice.
Course outline	
Theoretical teaching	
Practical teaching (exercises, OFE, study and research work)	The content of the internship is in full accordance with the goals of the internship. The student learns about the structure of the company and its business goals, adapts his/her own engagement to the field of study he/she has chosen, and duly fulfills work obligations in accordance with the duties of employees in the company. The student describes his/her own engagement during the internship and gives a critical review of his/her own experience, knowledge, and skills acquired during the internship.
Textbooks/references	
1	
2	
3	
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5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
				6

Teaching methods	The student independently chooses a company from the state, private or public sector or a laboratory of the Faculty of Electronics in Niš in which he will complete his professional internship. Professional internship can also be completed abroad, in which case the student, among other things, improves his foreign language skills. At the student's proposal, the head of the elective area-module approves that the internship be completed in the desired institution and, upon request, issues a written instruction for professional internship to the person responsible for carrying out the internship in the given institution. After the completed internship, and based on the student's report and the confirmation of the responsible person who confirms with the signature and seal of the company that the internship has been completed, the student is awarded 3 ECTS credits for the completed professional internship.

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises	70	Oral exam	30

Colloquia			
Projects			

Specification for the book of courses

Study program		Electronics and Embedded Systems	
Type and level of studies		Doctoral Studies	
The name of the course		Master Thesis – Study and Research Work	
Lecturer (for lectures)			
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS	6	**Course status (obligatory/elective)**	Obligatory

Prerequisites	
Course objectives	Application of basic, theoretical-methodological, scientific-professional and professional-applied knowledge and methods to solve specific problems. The student studies the problem, its structure and complexity and, based on the conducted analyses, draws conclusions about possible ways of solving it. By studying the literature, the student becomes familiar with the methods intended for solving similar tasks and engineering practice in solving them.
Course outcomes	Enabling students to independently apply previously acquired knowledge from various areas they have studied, in order to observe the structure of a given problem and its systemic analysis in order to draw conclusions about possible directions for its solution. Through the independent use of literature, students expand their knowledge by studying various methods and works related to similar issues. In this way, students develop the ability to conduct analyses and identify problems within the given issue. Through the practical application of acquired knowledge, students develop the ability to perceive the place and role of engineers in the chosen area, the need for cooperation with other professions and teamwork.
Course outline	
Theoretical teaching	It is formed individually in accordance with the needs of a specific master's thesis, its complexity and structure. The student, according to his or her affinities and preferences, chooses the field of study work, or rather the subject teacher from the list of teachers in the study program who defines a specific task for him or her. The student studies professional literature, professional and scientific papers dealing with similar topics, performs analyses in order to find a solution to a specific task or performs certain experiments in the laboratory. The study work also includes active monitoring of primary knowledge, organization and performance of experiments, numerical simulations and statistical data processing, and preparation of a seminar paper in a narrow scientific and educational field to which the topic of the independent research work belongs.
Practical teaching (exercises, OFE, study and research work)	
Textbooks/references	
1	University of Niš, Faculty of Electronic Engineering, Guidelines and Template for the Preparation of Final, Diploma and Master's Theses, Niš, available at: https://sip.elfak.ni.ac.rs/downloads/obrasci/forma-diplomski-rad.pdf
2	T. M. Young, Technical Writing A-Z: A Commonsense Guide to Engineering Reports and Theses, ASME Press, New York, 2005, ISBN 978-0-7918-0236-6.
3	E. J. Rothwell and M. J. Cloud, Engineering Writing by Design: Creating Formal Documents of Lasting Value, CRC Press, 2017, ISBN 9781482234329.
4	H. El Chaarani and Z. El Abiad, How to Write a Master Thesis: The Easy Handbook Guide, New Edition, Journal of Contemporary Research in Business Administration and Economic Sciences, 2021.
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
			12	

Teaching methods	Mentoring and individual consultations.
Grade (maximum number of points 100)	

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	
Exercises		Oral exam	50
Colloquia			
Projects	50		

Specification for the book of courses

Study program	Electronics and Embedded Systems		
Type and level of studies	Master Studies		
The name of the course	Master Thesis		
Lecturer (for lectures)			
Lecturer/associate (for exercises)			
Lecturer/associate (for OFE)			
Number of ECTS	11	**Course status (obligatory/elective)**	Obligatory

Prerequisites	
Course objectives	The Master's thesis aims to consolidate, confirm and practically apply the knowledge acquired during the Master's academic studies. The student is given the opportunity to demonstrate the ability to independently carry out a project, which can be of a practical, research or theoretical-methodological nature. The student also gains experience in presenting his/her work through a written form and an oral presentation during the thesis defense.
Course outcomes	Ability to lead an independent project, ability to formulate and analyze problems, critically review possible solutions, review literature in a given field. Application of acquired engineering and design knowledge and skills to solve problems, taking into account the complexity, costs, reliability and efficiency of the solution. Ability to write a paper in a given form. Ability to clearly explain the completed project through an oral defense of the paper.
Course outline	
Theoretical teaching	A master's thesis is an independent research, practical or theoretical methodological work of a student in accordance with the level of study, in which he becomes acquainted with a narrow field through a literature review and adopts the research methodology, or design, necessary for the preparation of the thesis. Through the preparation of the thesis, the student applies practical and theoretical knowledge acquired during his studies. The written thesis usually contains an introductory chapter, a definition of the problem, a review of the field and existing solutions, a proposal and description of the solution, a conclusion and literature. A public oral defense of the thesis is organized in front of a commission of three members, one of whom is the thesis mentor. During the oral defense, the candidate explains the results of his work, and then answers questions from the commission members, thereby demonstrating the candidate's ability to orally present his project.
Practical teaching (exercises, OFE, study and research work)	
Textbooks/references	
1	
2	
3	
4	
5	

Number of classes of active education per week during semester/trimester/year

Lectures	Exercises	OFE	Study and research work	Other classes
				2

Teaching methods	

Grade (maximum number of points 100)

Pre-exam duties	Points	Final exam	Points
Activity during lectures		Written exam	70
Exercises		Oral exam	30
Colloquia			
Projects			