Program Overview - Electronics

Year I							
Semester I			Hours/Week				
Nr.	M/E	Courses	L	NE	Lab	ECTS	Teacher
1.	M	Multimedia communications	2	2	0	6	Myzafere Limani
2.	M	VLSI technology	2	2	0	6	Sabrije Osmanaj, Nebi Caka
3.	M	Digital Processing of Audio Signals	2	2	0	6	Ilir Limani
4.	E	Elective courses (2 courses)					
		1. Microwave Engineering	2	2	0	6	1.Enver Hamiti
		2. Electronic instrumentation	2	2	0	6	2.Qamil Kabashi
		3. Numerical techiques in electromanetics	2	2	0	6	3.Luan Ahma
		4. Biomedical Informatics	2	2	0	6	4.Sabrije Osmanaj
		5. Digital image processing	2	2	0	6	5.Rexhep Hasani
Semester II							
1.	M	Acoustics and hearing process	2	2	0	6	Myzafere Limani
2.	M	Biomedical Signals and Systems	2	2	0	6	Sabrije Osmanaj
3.	M	Digital filters	2	2	0	6	Ilir Limani
4.	E	Elective courses: (2 courses)					
		1. Optical communication systems	2	2	0	6	1.Nebi Caka, Milaim Zabeli
		2.Digital Microelectronic Circuits	2	2	0	6	2.Nebi Caka
		3.Design of Radio Frequency and Microwave Circuits	2	2	0	6	3.Enver Hamiti
		4.Random Processes in Systems	2	2	0	6	4.Ilir Limani
		5.Power sources for electronic devices	2	2	0	6	5.Myzafere Limani
		6. Methodology of scientific research	2	2	0	6	6. Lule Ahmedi

Year II							
Semester III			Hours/Week				
Nr.	M/E	Courses	L	NE	Lab	ECTS	Teacher
1.	M	Acoustics of speech and music	2	2	0	6	Myzafere Limani

2.	M	Computer Modeling of Physiological Systems	2	2	0	6	Mimoza Ibrani
3.	M	System Modeling and Identification	2	2	0	6	Ilir Limani
4.	E	Elective courses (2 courses)					
		1.Biomedical Instrumentation	2	2	0	6	1.Sabrije Osmanaj
		2.Process controlsystems and Measurement	2	2	0	6	2.Nga Industria
		3.Design of Interleaving systems	2	2	0	6	3.Astrit Ademaj
		4.Adaptive Filters	2	2	0	6	4.Ilir Limani
		5. Radio-Frequency Electronics	2	2	0	6	5.Enver Hamiti

Semester IV							
1.	M	Master Thesis				30	

1.1.1. Course descriptions

Course title: Multimedia communications (Mandatory, Sem. I , 6 ECTS)
The goals: This course introduces technologies for multimedia communications. We will address how to efficiently represent multimedia data, including video, image, and audio, and how to deliver them over a variety of networks. In the coding aspect, state-of-the art compression technologies will be presented. Emphasis will be given to a number of standards, including H.26x, MPEG and JPEG. In th networking aspect, special considerations will be given for sending multimedia over ATM, wireless, and IP networks, such as error resilience and quality of services. The H.32x series, standards for audiovisual communication systems in various network environments, will be described. Current research results in multimedia communications will be reviewed through student seminars in the last weeks of course.
Learning outcomes: At the end of the course the student will be able to: have an excellent understanding of multimedia enabling technologies, services and applications;master basic Internet concepts and protocols; analyze analog and digital video signals and systems; know the fundamental video processing techniques; acquire the basic skill of designing video compression; familiarize himself/herself with video compression standards; know the basic techniques in designing video transmission systems: error control and rate control.
Course content: Introduction of international standards. Image coding: DCT/subband/VQ. Image coding: JPEG. Video coding: ITU-T H.261, H.263, H.263 Version 2. Video coding: ISO MPEG-1, MPEG-2. MPEG audio coding. ITU-T speech coding: G.72x. MPEG-4 Video. Systems: ITU-T H.320, H.323, H.324, etc. MPEG-4 Systems. Networking issues: error resilience, network characteristics, Quality of Service (QoS). Error resilience in video codecs: H.26x and MPEG. Multimedia over IP: Multimedia over ATM. Multimedia over wireless/mobile networks
Methods of teaching: 30 hours lectures, 30 hours exercise. Approximately 100 hours of personal study and exercise.
Grading System: Seminar 50%, final exam 60 %.
Literature:

1. R. Steinmetz and K. Nahrstedt, Media Coding and Content Processing, Prentice Hall, 2002,
2. G. Lu, "Communication and Computing for Distributed Multimedia Systems", Artech House, 1996,
3. R. Steinmetz and K. Nahrstedt, Multimedia: Computing, Communications and Applications, Prentice Hall, 1995,
4. P. K. Andleigh and K. Thakrar, Multimedia Systems Design, Prentice Hall, 1996.

Course title: VLSI technology (Mandatory, Sem. I, 6 ECTS)
The goal : Principles of semiconductor technology and advanced micro- and nano- electron devices. Technology of modern VLSI chip design.
Learning outcomes: On successful completion of the course, students will be able to:
Describe the scaling of semiconductor electron devices. Explain the silicon crystal structure. Explain the process steps in semiconductor fabrication technology. Analyze the cross-sections of transistor structures. Identify physical principles of fabrication steps in semiconductor technology. Point out the limitations of modern semiconductor technology. Integrate the process steps for the MOS and bipolar transistor fabrication.
Course content: Progress and development of electronics and semiconductor technology. Principles and implication of scaling and Moore's law. Silicon crystal structure. Crystal growth and production of silicon wafers. Planar technology. Principles of process integration. Modern CMOS technology. Integration of fabrication steps in planar technology. Semiconductor doping methods: diffusion and ion implantation. Doping distributions in silicon. Physical mechanisms of doping. Selectivity in semiconductor technology, lithography. Principles of isolation and passivization, thermal oxidation. Material removal in semiconductor technology, etching. Deposition of materials in semiconductor technology. Methods of on-

chip interconnections of devices and circuit blocks. Metallization systems. Limitations of semiconductor technology. Advanced materials. Nano-technology.

Methods of teaching: Lectures, Exams, Exercises, Experimental Exercises, Consultations

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. James D. Plummer, Michael Deal, Peter B. Griffin (2000). Silicon VLSI Technology: Fundamentals, Practice, and Modeling, Prentice Hall
2. Stanley Wolf, Richard N. Tauber (2000). Silicon Processing for the VLSI Era, Vol. 1: Process Technology, Lattice Press.
3. P. Biljanović (2001). Mikroelektronika Integrirani elektronički sklopovi, Školska knjiga,

Course title: Digital Processing of Audio Signals (Mandatory, Sem I., 6 ECTS)

Course objectives: Course gives fundamentals of digital speech processing and its applications in communications and multimedia.

Learning outcomes: Student will understand basic algorithms of speech analysis common to many applications. They will be given an overview of applications (recognition, synthesis, coding) and be informed about practical aspects of speech algorithms implementation.

Course content: Digital speech modeling, parametric models. Speech analysis, parameter estimation for vocal tract model and excitation model. Most important speech models and their properties. Speech coding and applications. Automatic speech and speaker recognition, language detection. Speech feature vectors, Cepstral analysis. Statistical models for speech recognition, Hidden Markov Model, Gaussian Mixture Model, training procedures for statistical models. Acoustical and lexical models. Speech synthesis, diaphonic, three phonic. Speech normalization and modification. Examples of systems for speech coding, recognition and synthesis.

Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.

Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. Rabiner, L., Juang, B.H.: "*Fundamentals of Speech Recognition, Signal Processing*", Prentice Hall, Engelwood Cliffs, NJ, 1993.
2. Zölzer, U.: "*Digital Audio Signal Processing*", Wiley, 2008.
3. Gold, B., Morgan, N.: "*Speech and Audio Signal Processing*", John Wiley & Sons, 2011,

Course title: Microwave Engineering (Elective, Sem. I, 6 ECTS)

The goal : The purpose of the course is to provide students with advanced theoretical and practical survey of microwaves, microwave circuits and system design.

Learning outcomes: On completion of this course, students will be able to: 1. Have advanced knowledge about microwaves, microwave circuits and systems. 2. Use advanced software tools to analyze and design microwave circuits and systems, 3. Analyze and design of practical microwave systems.

Course content: Transmission Lines. Waveguides. Smith Charts and Scattering Parameters applications . CAD tools- Microwave office, ect. Microwave Filters. Impedance-Matching Networks, and Coupling Structures. Microwave Amplifiers. Oscillators and Frequency Synthesizers . Microwave planning systems. Noise and distortion in Microwave systems .

Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises. Approximately 100 hours of personal study and exercise, including seminars.

Grading System

Seminar 10%, Project 30 %, Final Exam 60 %

Literature:

1. David M. Pozar, Microwave Engineering, 3rd Edition; Wiley; 2005; ISBN:0-471-44878-8
2. David M. Pozar, Microwave and RF Design of Wireless Systems, John Wiley & Sons, 2001
3. E. da Silva, “High Frequency and Microwave Engineering “ Lineacre House, Jordan Hill, OXFORD OX2 8DP, First publish 2001.

Course title: Electronic instrumentation (Elective, Sem. I, 6 ECTS)
Course objectives*:* Successful completion of the course will enable the students to:
Understand the fundamentals of Measurements and Transducers
Relevance of digital instruments in measurements, digital voltmeter, Digital ohm meter, Digital capacitance meter, Digital modulation index meter, Digital quality factor meter, Digital tan delta meter, Digital IC tester , Digital storage oscilloscopes, spectrum analyzer, Logic analyzer etc.
Learning outcomes: Upon completion of the subject, students will be able to
Understand the fundamentals of an instrumentation measurement system;
Evaluate the static and dynamic characteristics of instrumentation measurement systems;
Evaluate the test method and measuring instruments to ensure measurement accuracy;
Course Content: I-Measurements and Transducers: Fundamentals of Measurements: General Concepts on Instruments; Introduction to Portable Instruments; Errors, Controlling and Networking of Instruments; Signals and Signal Conditioning; Noise and Interference. Transducers: Classification of transducers, characteristics and choice of transducers; Resistance, Capacitance, Piezoelectric, Thermoelectric, Hall Effect, Photoelectric, Tachogenerators, Measurement of displacement, velocity, acceleration, force, torque, strain, speed, and sound, temperature, pressure, flow, humidity, thickness, pH, position.
II - Digital Measurements Counters, Digital frequency and time meters, Universal counter timer. DigitalVoltmeter: General Characteristics, Ramp type DVM, Staircase ramp DVM, Successive approximation type DVM, Integrating type DVM Dual slope A/D DVM, Digital ohm meter, Digital capacitance meter, Digital modulation index meter, Digital quality factor meter, Digital tan delta meter, Digital IC tester. III- Measurement Instruments Oscilloscopes: The basic operation of an oscilloscope, advanced techniques: Multiple time bases, Oscilloscopes with dual channels and dual time bases, Use of low cost microprocessor blocks, Digital storage oscilloscopes (DSOs): Sampling techniques, DSO characteristics, Recent developments on DSO techniques. Spectrum analyzers: Spectrum Analysis, Types of spectrum analyzer: Real time technique, Fourier transform analyzer, swept tuned analyzer, Super heterodyne spectrum analyzer. Logic analyzers: Basic operation of Logic analyzer, Digital circuit testing and logic analysis, Types of analysis.
Literature*:*

1. Digital and Analogue Instrumentation testing and measurement, Nihal Kularatna, The Institution of Electrical Engineers, 2003
2. Measurement, Instrumentation and Sensors Handbook, J. G. Webster, CRC Press, 1999.

Course title: Numerical techniques in electromagnetics (Elective, Sem I, 6 ECTS)
The goal: Understanding of theoretical foundations of electromagnetism, and of numerical approach to solution of practical problems.
Learning outcomes: On successful completion of the course, students will be able to: 1. Understand electromagnetic field theory 2. Explain fundamental properties of finite element method 3. Explain fundamental properties of method of moments 4. Develop models for application of numerical methods 5. Apply numerical methods to solution of practical problems 6. Asses applicability of results of numerical calculations

Course content: Maxwell's equations in time and frequency domain. Electromagnetic potentials, wave equations. Integrals of potentials and fields. Finite element method, functional. Weighted residual method. Poisson's equation. Approximation of potential function. Solving of static electric fields in electrical devices (calculation of capacitances, shielding). Non-linear problems, calculation of magnetic field (calculation of inductances, shielding). Quasistatic problems (eddy currents, skin effect, shielding). Method of moments. Integral formulation of electric and magnetic field problems. Calculation of low-frequency electric and magnetic field.

Teaching methodology: 45 hours lectures, 45 hours tutorial, and 40 hours independent work.

Assesment: Firsa assesment:30%, Second assesment: 25%, Home work 10%, Attendance: 5%, Final exam, 30%, Total:100%

Literature :

1. M.N .Sadiku, *Numerical tecniques nin elektromagnetics*, CRC Press, L.L.C, 2001
2. M.N. *Sadiku, Elements of electromagnetic*, Oxford University Press, New York, 2001

Course title: Biomedical Informatics (Elective, Sem. I, 6 ECTS)

The goal : By attending the Biomedical Informatics course students will get an opportunity to learn about key concepts and definitions in the growing and expanding domain of biomedical informatics and e-Health. The course encompasses many aspects of this domain, including state of the world when it comes to definitions, research and developments in the field; biomedical data collection and processing techniques; adoption of IT technologies in the healthcare delivery systems; electronic healthcare records; aspects, benefits and challenges in the field of telemedicine and, other related topics.

Learning outcomes: On successful completion of the course, students will be able to: Explain health policy organization and influence of ICT. Explain Health Technology Assessment (HTA). Explain origin and basic characteristics of biomedical signals. State characteristics and signal processing methods of ECG, EMG and EEG signals. Define benefits of e-Health adoption. Explain problems of the interoperability and communication protocols. Explain benefits and problems of electronic healthcare record. Explain benefits and problems of the telemedicine

Course content: Introduction into biomedical informatics - terms and concepts definitions. Properties and scope of medical and biomedical informatics. Health policy and structure of care delivery systems in Croatia and worldwide. Collection, processing and transport of patient medical data. Biomedical signal processing - basic concepts, features and characteristics. Examples of patient biomedical data processing - ECG, EEG, EMG. IT solutions in the domain of e-Health - examples, characteristics, key functional and technical criteria. Electronic healthcare record, integration and interoperability. Certification process. Standards for achieving full scope of e-Health solutions interoperability. Telemedicine.

Methods of teaching: Lectures, Exams, Consultations, Seminars, Internship visits.

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. H. Van Bemmel, M.A. Musen (1997). Handbook of Medical Informatics, Springer Verlag
2. E.H. Shortliffe, L.E. Perreault (Eds.); (2001). Medical Informatics: Computer Applications in Health Care and Biomedicine, 2nd Ed., Springer Verlag
3. Amine Nait-Ali (Ed.) (2009). Advanced Biosignal Processing, Springer Verlag

Course title: Digital image processing (Elective, Sem. I. 6 ECTS)

Course objectives: The ultimate goal is to develop a thorough understanding of the subject and familiarity with the most common techniques.

Learning outcomes: After completing this course the student will be able:to provide development of skills to effectively integrate new concepts in digital image processing;to study computer algorithms and data structures which are important to represent 2-D data.
Contents: Genesis and applications of digital image processing; Digital image processing an analysis; Complexity of operations in the image; The basic notions of the image; The main problems of digital image processing; Presentation of the image; Image restoration and registration; Reconstruction of the image from the projection; The image and video compression; Elements of visual perception; The physical characteristics of light; The properties of the visual system; Time characteristics of the visual system; Objective and subjective measures of image quality; Spectrum of the colors; The image sensors with electron beam; Image scanning methods; Semiconductor image sensors; Image sampling; Quantization of the image; Digitalization of the color image; The need for compression of image and tips redundancy; Different compression methods; Image enhancement; Linear filtering.
Teaching methodology: lecture, discussion, seminar paper.
Evaluation Methods: Seminar paper: 40%. Attendance 5%, Final Exam: 55%
Literature:

1. Rafael C. Gonzalez and Richard E. *Woods, Digital Image Processing.*
2. William K. Pratt*, Digital Image Processing.*
3. Roger L. Easton, *Fundamentals of Digital Image Processing.*

Course title: Acoustics and hearing process (Mandatory, Sem II., 6 ECTS)
The goals: To present the fundamental concepts of acoustics and the analytical techniques required to solve a range of engineering problems in acoustics. This course provides an introduction to the physical principles of acoustics and their application. Fundamental topics include the generation, transmission, and reception of acoustic waves. Applications covered are selected from underwater acoustics, architectural acoustics, remote sensing, and nondestructive testing.
Learning outcomes: On completion of the course the student should be able to effectively use the basic concepts of physical acoustics, to analyze the characteristics of acoustic fields, to recognize and apply basic laws of acoustics of closed spaces. To have essential knowledge in speech, music and psycho-physiological acoustics. To know and apply modern technologies of ultrasound in medicine and technology.
Course content: Fundamentals of physical acoustics. Sound. Theory of acoustic signals and field characteristics. Sounds and waves in enclosed spaces. Music and speech. Propagation of acoustic waves. Electrical, mechanical and acoustical analogies. Sound sources (spherical dipole). Resonators, absorbers, filters. Physiological Acoustics. Psychoacoustics. Architectural and building acoustics. Noise and vibrations. Electroacoustic transducers, microphones, loudspeakers, headphones. Sound reinforcement. Ultrasound and its applications in medicine and technology. Electro-acoustic measurements.
Methods of teaching: 30 hours lectures, 30 hours exercise. Approximately 100 hours of personal study and exercise.
Grading System: Writen exam 50%, final exam 50 %.
Literature:

1. T. Jelaković , Zvuk, sluh i arhitektonska akustika Zagreb, 1978,
2. Marshall Long, Architectural Acoustics; Elsevier, San Diego; 2006,
3. D.T. Blackstock, Fundamentals of physical acoustics; Wiley Interscience publication; 2000,
4. W. M. Hartmann, Signals, Sound and Sensation (Modern Acoustics and Signal Processing), Amazon 1997,
5. M. Limani, Bazat e akustikës teknike, Prishtinë, 2005.

Course title: Biomedical Signals and Systems (Mandatory, Sem. II, 6 ECTS)
The goal: The purpose of this course is to serve as an introduction to and an overview of the field of biomedical engineering. Considering this purpose, a link between biomedicine and electrical engineering will be given. Students should be able to understand and define the discipline of biomedical engineering, basic physiological and electrophysiological mechanisms, basic bioelectric signals, electrodes and registration techniques. They will also acquire an introductory knowledge about the most important diagnostic and therapeutic electromedical equipment and safety assurance in medical facilities.
Learning outcomes: On successful completion of the course, students will be able to: Describe physiological systems in the human body. Distinguish main features of biomedical signals. Describe biomedical signal registration techniques. Compare biomedical signals registration and analysis methods for the particular problem solving. Explain functioning of diagnostic medical imaging systems. Appraise applicability of the particular medical imaging method.
Course content: The discipline of biomedical engineering, a historical perspectives and contemporary trends. The human body: an overview. Basic electrophysiology. Cell and cellular mechanisms. Bioelectricity. Physiologic systems. Nervous system. Muscular system. Circulatory system. Respiratory system. Sensing systems. Homeostasis. Body as a control system. Bioelectric potentials and their main features (ECG, EEG, EMG, ENG and ERG). Registration techniques and problems. Electrodes. Overview of other biomedical signals. Therapeutic electromedical equipment. The most important techniques and devices. Diagnostic medical imaging. Equipment and techniques. Fundamental physical and medical limitations. Methods for quality evaluation processing. Estimation of diagnostic value processing. Patient safety and safety assurance in modern medical facilities.
Methods of teaching: Lectures, Exams, Consultations, Seminars, Internship visits
Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. A. Šantić (1995). Biomedicinska elektronika, Školska knjiga, Zagreb
2. A.J. Vander, J.H. Sherman, D.S. Luciano (2001). Human Physiology: The Mechanisms of Body F unction, Mc Graw Hill, N.Y., USA
3. J.J.Carr, J.M.Brown (1998). Introduction to Biomedical Equipment Technology, Prentice Hall
4. John Denis Enderle, Joseph D. Bronzino, Susan M. Blanchard (2005). Introduction to Biomedical Engineering, Academic Press

Course title: Digital filters (Mandatory, Sem. II, 6 ECTS)
Course objectives: Students will be introduced in basic concepts of digital filters design, mathematical models and software applications for the analysis and implementation of digital filters.
Learning outcomes: This course concerns the description of digital filter design techniques; at the end of the course the students should achieve the capability of using digital filter design tools and evaluating the properties of obtained design results.
Course content: Discrete signals and systems, Important transforms, Transfer function and frequency response; Analysis of finite word length; Digital filters of finite impulse response (FIR); Design of FIR filters and realization structures; Optimal design methods of FIR filters; Digital filters of infinite impulse response (IIR); Elliptic transfer function of minimal Q factors; Half-band filters; IIR filters design without multipliers; Digital signal processing with different sampling frequencies; Digital filter-banks (QMF banks).
Teaching methodology: 30 hours of lectures+20 hours of supervised exercises +10 hours of laboratory. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Antoniou A., "*Digital Signal Processing: Signals, Systems, and Filters*", McGraw-Hill, 2005.
2. Alan V. Oppenheim, et al, "*Discrete -Time Signal Processing*", 2nd ed., 1998, Prentice Hall.

3. Mitra S. K., "*Digital Signal Processing: A Computer-Based Approach*", 4th Edition, McGraw-Hill, 2011.

Course title: Optical communication systems (Elective, Sem. II, 6 ECTS)
The goal: This course introduces students into optical communication systems.
Learning outcomes: On successful completion of the course, students will be able to:
1. explain the phenomena and laws of propagation of light through optical fibers; 2. describe the construction and working principle of photo-emitters and photo-detectors used in optical communications systems: LEDs, photodiodes (pin and avalanche, APD), phototransistors; semiconductor lasers (laser diodes). 3. describe the construction of optical fibers and optical cables and main methods/techniques of their fabrication; 4. explain the problems that arise during the course of optical fibers and in their coupling with photo-emitters and photo-detectors; 5. describe digital and analog transmission systems with optical fiber; 6. describe multichannel WDM systems; 7. explain the working principle and characteristics of optical amplifiers; 8. describe the topologies and the main features of optical networks; 9. perform measurements in fiber optic systems.
Course content: 1. Introduction (the history and actual state of optical communication systems). 2. Optical fibers (structure and fabrication). 3. Signal degradation in optical fibers (attenuation and , dispersion). 4. Optical sources and transmitters (LEDs, laser diodes). 5. Power launching and coupling and fiber-to-fiber joints. 6. Photodetectors and optical receivers (pin and avalanche photodiodes; noises; preamplifiers). 7. Digital transmission systems (link power budget and rise-time budget; NRZ and RZ line coding). 8. Analog transmission systems. 9. Wavelength-division multiplexing (WDM) concepts and components. 10. Optical amplifiers. 11. Optical networks (SONET/SDH). 12. Measurements in fiber-optic communication systems. 13. Optical fiber transmission systems in Kosovo and in the region
Methods of teaching: 30 hours of lectures + 30 hours of auditorial and laboratory exercises. Approximately 100 hours of personal study and exercise including home-works.
Grading System: 1st Exam: 25%; 2nd Exam: 25%; 50%, Home-work: 25 %, Final exam: 25 %
Literature:

1. Gerd Keiser, *Optical Fiber Communications*, 4th ed., McGraw-Hill, 2008.
2. Govind P. Agrawal, *Fiber-Optic Communication Systems*, 3rd ed., John Wiley & Sons, 2002.
3. Nebi Caka, *Optoelektronika*, Universiteti i Prishtinës, 1996.

Course title: Digital Microelectronic Circuits (Elective, Sem II, 6 ECTS)
The goal: *The goal of this course*is to provide the basic principles of*digital microelectronic circuits.*
Learning outcomes: On successful completion of the course, students will be able to:
1. describe the MOS transistor models; 2. present the main characteristics of CMOS inverter; 3. describe the main features of combinational CMOS logic circuits; 4. describe the main features of sequential CMOS circuits; 5. explain the problems with distribution lines; 6. analyze arithmetic CMOS circuits; 7. present the main memory circuits; 8. outline Input/output circuits; 9. draft a paper on a particular issue or issues in the field of digital microelectronic circuits.
Course content: Introduction. CMOS digital circuits devices. MOS transistor models. CMOS process layout rules. CMOS inverter - static and dynamic characteristics, power. Combinational CMOS logic circuits - complementary, rationed, pass-transistor, dynamic circuits. Sequential CMOS circuits - latches and flip-flops. Wires and interconnections - parameters and models, lines distribution problems. Arithmetical CMOS circuits - adders, multipliers, shifters. Memory CMOS circuits - layout organization, memory core circuit implementations, peripheral circuits. Input/output circuits.
Methods of teaching: 30 hours of lectures + 30 hours of auditorial and laboratory exercises. Approximately 100 hours of personal study and exercise including home-work.

Grading System: 1st Exam: 25%; 2nd Exam: 25%; 50%, Home-work: 25 %, Final exam: 25 %

Literature:

1. J.M. Rabaey, A. Chandrakasan, B. Nikolic, *Digital Integrated Circuits - A Design Perspective*, 2nd ed.;; Prentice Hall; 2003; ISBN: 0-13-120764-4
2. R.J. Baker, *CMOS - Circuit Design, Layout, and Simulation*, 2nd ed.; IEEE Press & Wiley-Interscience; 2005; ISBN: 0-471-70055-X
3. N.H. E. Weste, D. Harris, *CMOS VLSI Design - A Circuit Perspective and Systems Perspective*, 3rd ed.;; Pearson Education; 2005; ISBN: 0-321-26977-2

Course title: Design of Radio Frequency and Microwave Circuits (Elective, Sem.II, 6 ECTS)

The goal : The purpose of the course is to provide students with fundamental treatment about theoretical and practical design of radio frequency and microwave circuits.

Learning outcomes: On completion of this course, students will be able to: 1. Have fundamental knowledge about radio frequency and microwave circuits 2. Use advanced CAD in practical design 3. Analyze and design in radio frequency and microwave and propose solutions.

Course Description: Introduction. Integrated circuit technology. Modeling of passive and active components. Planar transmission lines: microstrip, slotline and coplanar. Passive circuits: matching networks, filters and directional couplers. PIN-switches, detectors, mixers and frequency multipliers. Small signal and large signal amplifiers. Low noise amplifiers. Power amplifiers. Balanced amplifiers and parallel amplifier operation. RF and microwave oscillators. PLL. Integrated circuits for optical and wireless communication systems.

Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises . Approximately 100 hours of personal study and exercise, including seminars

Grading System

Seminar 10%, Project 30 %, Final Exam 60 %

Literature:

1. David M. Pozar; “Microwave Engineering”, 3rd Edition; Wiley;2005; ISBN:0-471-44878-8
2. Thomas H. Lee; “The Design of CMOS Radio-Frequency Integrated Circuits”; Cambridge; 2004; ISBN: 0-521-83539-9
3. G. D. Vendelin, A. M. Pavio, U. L. Rohde; “Microwave Circuit Design”; Wiley; 1990; ISBN: 0-471-60276-0

Course title: Random Processes in Systems (Elective, Sem. II, 6 ECTS)

Course objectives: The course gives knowledge of the theory of random processes and applications in the systems for signal processing and analysis.

Learning outcomes: Upon completion of the course student will: understand how random variables and stochastic processes can be analyzed and described, be able to analyze the output signal of linear systems with stochastic input signals, be able to implement and simulate random experiments on a computer by using MATLAB, have acquired competence in applying statistical methods to solve basic problems in electrical engineering.

Course content: Continuous and discrete random signals. Random processes. Stationarity and independence. Correlation functions and power spectral density. Random process in linear systems. Signal parameter estimation. Detection. System identification using cross correlation. Noise modeling and characterization. Noise factor. Optimum linear systems. Wiener filters. Matched filter. Realization of the optimum systems. Signal extraction from the noise by correlation and using matched filter. Signal quantization. Applications in communication, electronics and measurements.

Teaching methodology: 30 hours of lectures+30 hours of supervised exercises laboratory. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Papoulis, A., Pillai, U.: "*Probability, Random Variables and Stochastic Processes*", McGraw-Hill Europe, 2002.
2. Gubner, J.: "*Probability and Random Processes for Electrical and Computer Engineers*", Cambridge University Press 2006.
3. Hsu, H.: "*Schaum's Outline of Probability, Random Variables, and Random Processes*", McGraw-Hill, 2010.

Course title: Power sources for electronic devices (Elective, Sem II, 6 ECTS)
The goals: The primary goal of the course is to give students a foundation for analysis and design of electronic circuits for conversion and control of electrical energy. The work is placed in the context of modern energy challenges, including alternative electricity resources and efficient energy applications for low power sources for electronic devices applications. An additional goal is to help students to fit together their complete electrical engineering background to tackle practical design problems. The course present concepts, fundamental analysis tools, practical considerations for design, and a range of power electronics applications.
Learning outcomes: Students need to assemble their body of knowledge to address diverse energy applications. The course emphasizes applications as solar panels, high-performance power supplies for low-voltage digital circuits, solid-state lighting, battery charging, grid interfaces. Students are taught professionalism aspects, such as learning how to establish detailed specifications from a general set of user requirements, how to look beyond basic requirements to understand user needs, how attributes of a design may meet literal requirements but still lead to an unacceptable solution, how to understand cross-disciplinary team strategies from addressing major application challenges, and learning how to consider broad aspects and implications of global energy challenges.
Course content: Low power energy sources, with the main sources of energy: electromechanical sources, fuel cells, solar cells, ultracapacitors, wind power equipment. Properties of the individual sources of energy. Optimizations of power sources. Power semiconductors devices: MOSFET, IGBT, diodes. Passive components for power sources. Heat transfer. Uninteruptble power sources. Integrated circuits power sources. Sources for mobile devices. Power factor correction. Standards for energy resources.
Methods of teaching: 30 hours lectures, 15 hours of auditorial exercises + 15 hours of laboratory exercises. Approximately 100 hours of personal study and exercise.
hours exercise. Approximately 100 hours of personal study and exercise.
Grading System: Project 30%, final exam 60 %.
Literature:

1. Issa Batarseh, Power Electronic Circuits, Wiley, 2004,
2. Daniel Hart, Power Electronics, 2nd. Ed., McGraw-Hill, 2011,
3. Myzafere Limani, Elektronika energjetike, Universiteti i Prishtinës, 2001.

Course title: Methodology of scientific research (Elective, Sem II., 6 ECTS)
Course objectives: To introduce some key elements of research methodology to first time research students.
Learning outcomes: At the end of this course, the students should be able to: understand some basic concepts of research and its methodologies, identify appropriate research topics, select and define

appropriate research problem and parameters, prepare a project proposal (to undertake a project), organize and conduct research (advanced project) in a more appropriate manner, write a research report and thesis, write a research proposal (grants).
Course content: Overview of experimental and engineering methodological approaches to research; Basics of research design (e.g., hypothesis formulation); The research process: documenting research, sources of information, research funding, creativity and intellectual discovery; Guidelines and a framework for efficient development of research; legal and ethical issues; protecting and exploiting research; Intellectual Property rights; Managing the research project: supervision, planning and organization; problems and pitfalls; Presentation skills (written, oral); Use of relevant research tools (technology, experimental infrastructure, mathematical methods, etc.).
Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.
Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %
Literature:

1. Kothari B.L., "*Research Methodology: Tools and Techniques*", New Age International Publishers, 2009.
2. Boot C. W., "*The Craft of Research*", University Of Chicago Press, 2008.

Course title: Acoustics of speech and music (Mandatory, Sem III., 6 ECTS)
The goals: The present characteristics of speech and music, analysis, processing and synthesis of speech and music. Particular emphasis is given to encoding and equipment for speech recognition and music.
Learning outcomes: On completion of the course the student should be able to effectively use the basic concepts of physical acoustics, to analyze the characteristics of acoustic fields, to recognize and apply basic laws of acoustics of closed spaces. To have essential knowledge in speech, music and psycho-physiological acoustics. To have fundamental knowledge of modern technologies of ultrasound applied in medicine and technology.
Course content: Acoustic characteristics of the speech system. Mechanism of speech production. Elements of speech and its characteristics relevant to the transfer and processing of speech. Analysis of speech (articulation, analytical, experimental). Mechanical and electronic speech synthesizers. Digital processing of speech and music. Transfer systems using speech analysis-synthesis method (channel, causing voice, formants, prediction). Speech coding. Text and speech synthesis. Equipment for speech recognition. Recognition of speakers. The main features of musical tone. Digital audio encoding. Digital audio coding standards. Musical instruments.
Methods of teaching: 30 hours lectures, 30 hours exercise. Approximately 100 hours of personal study and exercise.
Grading System: Seminar 50%, final exam 50 %.
Literature:

1. Huang, X., Acero, A., Hon, H.-W. Spoken Language Processing – A Guide to Theory, Algorithm and System Development, Prentice Hall, 2001,
2. Lawrence Rabiner, B H Juang, Fundamentals of Speech Recognition,
3. John N. Holmes, Wendy J. Holmes, Speech Synthesis and Recognition, 2nd Edition,
4. Ben Gold, Nelson Morgan, Dan Ellis, Processing and Perception of Speech and Music, 2nd Edition.

Course title: Computer Modeling of Physiological Systems *(*Mandatory, Sem. III, 6 ECTS)
The goal: To provide computer and electromagnetic modeling approaches for physiological systems

Learning outcomes: On successful completion of the course, students will be able to:
1. Synthesise knowledge in electromagnetics, mathematics, theory of signals and systems, modeling techniques, physiology and anatomy; 2 Develop computational electromagnetic equations to describe the dynamic behavior of physiological systems; 3. Simulate and visualize dynamic responses of physiological models; 4. Apply physical properties of bio tissue (electrical, mechanical, thermal, optical); 5. Solve problems related to electrical modeling of physiological models

Course content: Modeling approaches for physiological systems: levels of modeling, classification of models, descriptive models, explanatory models. Physiome. Relations to genomics, bioinformatics and computational biology. Fundamental principles, processes and tools in model development. Models of linear systems. Models of nonlinear systems: Volterra and Wiener series. Application of fundamental laws of electromagnetism, mechanics and themodynamics to physiological systems.
Physical properties of tissue (electrical, mechanical, thermal, optical etc.).Examples and applications.

Methods of teaching: 30 hours of lectures + 30 hours exercises. Approximately 80-90 hours of personal study and exercise including assignments.

Grading System:
Assignments and seminar 60%, Final Exam 40 % .

Literature:

1. James W. Haefner, "Modeling Biological Systems:Principles and Applications, Springer; 2nd edition (May 6, 2005)
2. Few research articles on the topic
3. Robert Plonsey, Roger C. Barr, " Bioelectricity: A Quantitative Approach, Plenum US, 2000

Course title: System Modeling and Identification (Mandatory, Sem III., 6 ECTS)

Course objectives: This course aims to introduce students to the fundamentals of continuous and discrete dynamic system modeling and main identification methods.

Learning outcomes: Students should be able to do the following upon completion of this course: express a system dynamics in terms of differential equation, transfer function, and state-space, should achieve the capability of using identification methods in real processes and in evaluating the quality of the obtained models.

Course content: The basic principles of dynamic system modeling. Transition from one model to another model. Black box model representation. Nonparametric identification: time domain identification by correlation analysis, frequency response analysis, frequency response analysis by the correlation method, Fourier analysis, persistency of excitation. Parametric identification: prediction error methods, prediction models, least-squares method, analysis of the linear LS estimate, convergence and consistency. Model structure selection. Model validation.

Teaching methodology: 30 hours of lectures+30 hours of supervised exercises laboratory. Approximately 75 hours of personal study, including homework exercises.

Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. *"Simulation of Dynamic Systems with MATLAB and Simulink", Klee, H., CRC Press, Boca Raton, FL., 2007.*
2. R. Isermann, "*Identification of Dynamic Systems: An Introduction with Applications*", Springer, 2005.
3. L. Ljung, "*System Identification: Theory for the User*", Prentice Hall, 1999.

Course title: Biomedical Instrumentation (Elective, Sem. III, 6 ECTS)

The goal: Main purpose of this course is to give the students a basic knowledge in the field of electromedical equipment manufacturing and design, including an outline of characteristics and types of modern electromedical diagnostic and therapeutic equipment. An overview of specific requirements for this equipment, including designing principles and standards, is presented. After the completion of obligations within the course, students should be able to understand and define

basic performances of most important electromedical diagnostic and therapeutic equipment, including some practical skills of its use. It could be expected that, with the acquired knowledge, they could be working as clinical or biomedical engineers.

Learning outcomes: On successful completion of the course, students will be able to: Classify Biomedical sensors and transducers. Design bioelectric amplifiers. Use Electromagnetic interference suppression techniques. Design electrocardiographs. Physiological pressure and other cardiovascular measurements and devices. Design of biological impedance measurement and respiratory system parameters. Compare pacemakers and defibrillators, understand principles of operation of electrosurgery and laser operating modes. Compare medical imaging methods and equipment in radiology, nuclear medicine and medical ultrasound and MRI.

Course content: Biomedical sensors and transducers. Bioelectric amplifiers. Electromagnetic interference suppression techniques. Electrocardiographs. Physiological pressure and other cardiovascular measurements and devices. Instrumentation for measurement brain parameters. Biological impedance measurement. Respiratory system and its measurement. Intensive and coronary care units. Pacemakers and defibrillators. Electrosurgery. Lasers. Medical imaging equipment. Radiology and nuclear medicine equipment. Medical ultrasound. Magnetic resonance imaging.

Methods of teaching: Lectures, Exams, Consultations, Seminars, Internship visits

Grading System: Seminar 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. A. Šantić (1995). Biomedicinska elektronika, Školska knjiga, Zagreb
2. J.J.Carr, J.M.Brown (1998). Introduction to Biomedical Equipment Technology, Prentice Hall
3. J. G. Webster (1995). Medical Instrumentation: Application and Design, John Wiley&Sons, N.Y.
4. E. Krestel (1990). Imaging Systems for Medical Diagnostics, Siemens Akt.
5. Richard C. F ries (2001). Handbook of Medical device design, Marcel Dekker, Inc.

Course title: Adaptive Filters (Elective, Sem. III, 6 ECTS)

Course objectives: Student will learn basic adaptive signal processing methods, especially linear adaptive filters and non-linear filters.

Learning outcomes: After completing the course, the student will be familiar with the most important adaptive filter generic problems: optimal design, convergence, recursiveness in time, frequency domain implementations; will be able to start from the formulation of a problem formulation and utilize a number of typical algorithmic tools to derive the solution; and will know what are the most important structures for adaptive filters: LMS, RLS etc.

Course content: Optimal filtering and estimation, Wiener filters, linear prediction. Steepest descent and stochastic gradient algorithms. Frequency-domain adaptive filters. Method of least squares, recursive least squares, fast fixed-order and order-recursive (lattice) filters. Misadjustment, convergence and tracking analyses, stability issues, finite precision effects. Connections with Kalman filtering. Nonlinear adaptive filters.

Teaching methodology: 30 hours of lectures+30 hours of supervised exercises. Approximately 75 hours of personal study, including homework exercises.

Grading System: Homework 10%, Mid-term exams 30 %, Final Exam 60 %

Literature:

1. Haykin, S. "*Adaptive Filter Theory*", Prentice-Hal, 2002.

2. Manolakis D., Ingle V., and Kogon S.; "*Statistical and Adaptive Signal Processing*", McGraw-Hill Inc., 2000.
3. Hayes M.; "*Statistical Digital Signal Processing and Modeling*", John Wiley & Sons, Inc., 1996

Course title: Radio-Frequency Electronics (Elective, Sem. III, 6 ECTS)
The goal : The purpose of the course is to provide students with fundamental concepts and key circuits of radio-frequency systems.
Learning outcomes: On completion of this course, students will be able to: 1. Have advanced knowledge about fundamental principles applied to all radio devices, from wireless single-chip data transceivers to high-power broadcast transmitters 2. Solve theoretical and practical problems 3. Analyze different aspects of design in radio-frequency systems and propose solutions.
Course content: Introduction. Impedance matching. Linear power amplifiers. Basic filters. Frequency converters. Amplitude and frequency modulation. Radio receivers. Suppressed-carrier AM and quadrature AM (QAM). Class-C, D, and E Power RF amplifiers. Oscillators. Phase lock loops and synthesizers. Coupled-resonator bandpass filters. Hybrid couplers. Small-signal RF amplifiers. Demodulators and detectors. Digital modulation techniques. Modulation, noise, and information. Amplifier and oscillator noise analysis. S-parameter circuit analysis
Methods of teaching: 30 hours of lectures + 30 hours of auditorial exercises . Approximately 100 hours of personal study and exercise, including seminars.
Grading System
Seminar 10%, Project 30 %, Final Exam 60 %
Literature:
1. Jon B. Hagen, " Radio-Frequency Electronics", Circuits and Applications Second Edition, © Cambridge University Press 2009
2. Kai Chang, **Radio Frequency Circuit Design**, John Wiley & Sons, 2001
3. Rohde, U. and Whitaker, J., " Communications Receivers", Third Edition, New York, McGraw-Hill, 2001.

Course title: Master Thesis (Mandatory, Sem. IV, 30 ECTS)
The goal: Master thesis is the final scientific work that will prove the student capability to work on a scientific topic independently by using methodologically sound approaches.
Learning outcomes: At the end of this course, students will be capable to: 1. Read and understand state-of-the-art literature. 2. Independently specify, analyze and propose solutions. 3. Explain and discuss critically results. 4. Present and defend the thesis in a written and oral form.
Course content: The thesis could be proposed by the supervisor or can be chosen by the student, and should be in the accordance with the qualification profile. 1. Reading of the state of the art. 2. Understanding and specifying the problem. 3. Design and implement different solutions. 4. Analyze and discuss critically the results.
Methods of teaching: Compliant with the actual regulation at the faculty level on how to conduct a master thesis.
Literature:
1. Jean-Luc LeBrun. Scientific Writing. World Scientific, 2007.
2. Depending on the topic covered in thesis, different bibliographic resources will be recommended by the teachers.