Universitatea Naţională de Ştiinţă şi Tehnologie Politehnica Bucureşti
Facultatea de Electronică, Telecomunicaţii şi
Tehnologia Informaţiei

COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	**National University of Science and Technology Politehnica Bucharest**
1.2 Faculty	**Electronics, Telecommunications and Information Technology**
1.3 Department	**Telecommunications**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Advanced Wireless Communications

2. Date despre disciplină

2.1 Course name (ro) (en)			Sisteme radio definite software şi proiectarea circuitelor programabile Software Defined Radio and Programmable Circuits Design				
2.2 Course Lecturer			Prof. Dr. Alexandru Martian, Prof. Dr. Cristian Anghel				
2.3 Instructor for practical activities			Prof. Dr. Alexandru Martian, Prof. Dr. Cristian Anghel				
2.4 Year of studies	1	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		F	2.9 Course code	3		2.10 Tipul de notare	Nota

3. Total estimated time (hours per semester for academic activities)

3.1 Number of hours per week	2.5	Out of which: 3.2 course	1.50	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	35.00	Out of which: 3.5 course	21	3.6 seminary/laboratory	14
Distribution of time:					hours
Study according to the manual, course support, bibliography and hand notes Supplemental documentation (library, electronic access resources, in the field, etc) Preparation for practical activities, homework, essays, portfolios, etc.					55
Tutoring					5
Examinations					3
Other activities (if any):					2

3.7 Total hours of individual study	65.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Attending and/or passing the following lectures: Signals and Systems Analogic and Digital Communications Radio Communications: Systems and Equipment Digital Signal Processing
4.2 Results of learning	Accumulation of the following knowledge: • general knowledge regarding analog and digital signals, • the capacity of understanding the functioning of a principle or block diagram of a radio communication equipment, • basic knowledge regarding information transmission, • basic knowledge of digital signal processing.

5. Necessary conditions for the optimal development of teaching activities (where applicable)

5.1 Course	The course will take place in a room equipped with video projector and computer.
5.2 Seminary/ Laboratory/Project	• The laboratory will take place in a room with specific equipment, which must include: PCs on which the Matlab/Simulink and Xilinx FPGA programming environments will be installed. • Attendance at the laboratories is mandatory (according to the regulation of university undergraduate studies in UPB).

6. General objective *(Reffering to the teachers' intentions for students and to what the students will be thought during the course. It offers an idea on the position of course in the scientific domain, as well as the role it has for the study programme. The course topics, the justification of including the course in the currcula of the study programme, etc. will be described in a general manner)*

This discipline is studied within the Advanced Wireless Communications master study program and aims to familiarize students with the main approaches, models and explanatory theories in the field of software defined and programmable circuit design, used in solving practical applications and problems, with relevance for stimulating the learning process in students.
The discipline addresses as a specific topic general notions related to software defined radio (ideal concept, general architecture, baseband processing aspects and digital front end aspects) and programmable circuit design (SPLD, CPLD and FPGA circuits, VHDL language, physical and logical dedicated components instantiation, VHDL code verification). All of this contributes to conveying/training to/to students an overview of the methodological and procedural benchmarks related to the field.

7. Competences *(Proven capacity to use knowledge, aptitudes and personal, social and/or methodological abilities in work or study situations and for personal and proffesional growth. They refflect the empolyers requirements.)*

Specific Competences	Demonstrates basic/advanced knowledge of software defined radio and programmable circuit design. Correlate knowledge Apply knowledge in practice It applies standardized methods and tools, specific to the field, to carry out the evaluation and diagnosis process of a situation, depending on the identified/reported problems, and identifies solutions. It argues and analyzes coherently and correctly the context of application of the basic knowledge of the field, using key concepts of the discipline and the specific methodology. Oral and written communication in Romanian: uses the scientific vocabulary specific to the field, in order to communicate effectively, in writing and orally. Oral and written communication in a foreign language (English): demonstrates understanding of subject-related vocabulary in a foreign language.
Transversal (General) Competences	Works in a team and communicates effectively, coordinating efforts with others to solve problem situations of medium complexity. Autonomy and critical thinking: the ability to think in scientific terms, search and analyze data independently, and draw and present conclusions / identify solutions. Ability to analyze and synthesize: presents the acquired knowledge in a synthetic way, as a result of a process of systematic analysis. Respect the principles of academic ethics: correctly cite the bibliographic sources used in the documentation activity. Puts elements of emotional intelligence into practice in the appropriate social-emotional management of real-life/academic/professional situations, demonstrating self-control and objectivity in decision-making or stressful situations.

8. Learning outcomes *(Synthetic descriptions for what a student will be capable of doing or showing at the completion of a course. The learning outcomes reflect the student's acomplishments and to a lesser extent the teachers' intentions. The learning outcomes inform the students of what is expected from them with respect to performance and to obtain the desired grades and ECTS points. They are defined in concise terms, using verbs similar to the examples below and indicate what will be required for evaluation. The learning outcomes will be formulated so that the correlation with the competences defined in section 7 is highlighted.)*

Knowledge	*The result of knowledge aquisition through learning. The knowledge represents the totality of facts, priciples, theories and practices for a given work or study field. They can be theoretical and/or factual.* • Lists the most important stages that marked the development of the field. • Defines domain-specific notions. • Describes/classifies notions/processes/phenomena/structures. • Highlights consequences and relationships.

Skills	*The capacity to apply the knowledge and use the know-how for completing tasks and solving problems. The skills are described as being cognitive (requiring the use of logical, intuitive and creative thinking) or practical (implying manual dexterity and the use of methods, materials, tools and intrumentation).* Selects and groups relevant information in a given context. • Work productively in a team. • Elaborate a scientific text. • Experimentally verifies identified solutions. • Solve practical applications. • Adequately interpret causal relationships. • Identifies solutions and develops solution/project plans. • Formulates conclusions to the experiments carried out. • Argue the identified solutions/solutions.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Select appropriate bibliographic sources and analyze them. • Respect the principles of academic ethics, correctly citing the bibliographic sources used. • Demonstrates responsiveness to new learning contexts. • Demonstrates collaboration with other colleagues and teaching staff in carrying out teaching activities • Demonstrates autonomy in organizing the learning situation/context or the problem situation to be solved • Demonstrates social responsibility through active involvement in student social life/involvement in academic community events • Promotes/contributes through new solutions related to the specialized field to improve the quality of social life. • Realizes the value of his contribution in the field of engineering to the identification of viable/sustainable solutions to solve problems in social and economic life (social responsibility). • Apply principles of professional ethics/deontology in the analysis of the technological impact of the proposed solutions in the specialized field on the environment. • Analyzes and capitalizes on business/entrepreneurial development opportunities in the specialized field. • Demonstrates real-life situation management skills (collaborative vs. conflict time management).

9. Teaching techniques *(Student centric techniques will be considered. The means for students to participate in defining their own study path, the identification of eventual fallbacks and the remedial measures that will be adopted in those cases will be described.)*

Starting from the analysis of students' learning characteristics and their specific needs, the teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct exploration and indirect of reality (experiment, demonstration, modelling), but also on action-based methods, such as exercise, practical activities and problem solving.
In the teaching activity, lectures will be used, based on Power Point presentations or different videos that will be made available to the students. Each course will start with a recap of the chapters already covered, with an emphasis on the concepts covered in the last course.
Presentations use images and diagrams so that the information presented is easy to understand and assimilate.
This discipline covers information and practical activities designed to support students in their learning efforts and the development of optimal collaborative and communicative relationships in a climate conducive to discovery learning.

It will be considered the practice of active listening and assertive communication skills, as well as feedback construction mechanisms, as ways of regulating behavior in various situations and adapting the pedagogical approach to the students' learning needs.
Teamwork skills will be practiced to solve different learning tasks.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	1. Introduction 1.1 Definition 1.2 Ideal Concept 1.3 History, Benefits and Drawbacks 1.4 General Hardware and Software Architecture 1.5 Evolution towards Cognitive Radio	1
2	2. Baseband processing 2.1 General Aspects 2.2 Bit-level Processing (Encryption, Error-Detecting Codes, Randomization, Channel Coding, Rate Adaptation) 2.2 Modulation (QAM and PSK modulation techniques) 2.3 Pulse-shape Filtering	2
3	3. Digital Front End (DFE): Transmit Side 3.1 General Aspects 3.2 Generic Block Diagram 3.3 DFE Tx Architectures (Digital Intermediate Frequency, Direct Conversion) 3.4 Cascaded Integrator Comb (CIC) Filters	2.5
4	4. Digital Front End (DFE): Receive Side 4.1 General Aspects 4.2 Perturbations in a radio receiver (Noise, Distortions) 4.3 Generic Block Diagram 4.3 DFE Rx Architectures (Digital Intermediate Frequency, Zero IF) 4.4 Multiband Architectures 4.5 Receiver Synchronization	3
5	5. Example of SDR Platforms: the USRP family 5.1 General Aspects, Applications 5.2 USRP families pconverters architectures 5.3 USRP N210 architecture 5.4 WBX RF daughterboard 5.5 Software Environments (GNU Radio, Matlab, LabView)	2
6	Programmable logic circuits 6.1. SPLD circuits (PLA and PAL) 6.2. CPLD circuits 6.3. FPGA circuits	2.5

7	VHDL language 7.1 Numerical representations 7.2 Main concepts 7.3 VHDL language syntaxis 7.4Compartmental description 7.5 Structural description	3
8	Physical and logical dedicated components instantiation 8.1. Physical components 8.1.1. Memory blocks 8.1.2.Arithmetical blocks 8.2. Logical components	3
9	VHDL code verification 9.1. Verification at module level 9.1.1.Functional verification 9.1.2.Timing verification 9.2. Verification at system level	2.5
	Total:	21
Bibliography:		

LABORATORY		
Crt. no.	**Content**	**No. hours**
1	Digital modulation techniques: comparison of performances for BPSK/4QAM/16/QAM. RC/RRC shaping filter	2
2	Up/Down conversion and RF Impairments: frequency/phase offset, amplitude/phase imbalance, phase noise. CIC Filters.	2
3	Carrier recovery techniques: Costas Loop for BPSK and QPSK signals Timing recovery techniques: Early-Late timing recovery.	2
4	VHDL language	2
5	VHDL source code verification (Modelsim)	2
6	Memory blocks	2
7	Final lab test	2
	Total:	14

Bibliography:

1.Marţian Alexandru, Anghel Cristian, Software Defined Radio and Programmable Circuit Design, suport de curs electronic, https://curs.upb.ro/2021/course/view.php?id=9458.
2.Software-Defined Radio for Engineers, by Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinski, Artech House, 2018.
3.E. Grayver, Implementing Software Defined Radio, Springer, 2012.
4.Gheorghe Stefan, Circuite si sisteme digitale, Editura Tehnica 2000
5.Gheorghe Toacse, Dan Nicula, Electronica Digitala vol. 1 & 2, Editura Tehnica 2005

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	- knowledge of fundamental theoretical notions;	One final exam during the session	20
	- knowledge of applying theory in specific practical applications;	One final exam during the session	10
	- differential analysis of teoretical techniques and methods.	One final exam during the session	10

11.5 Seminary/laboratory/project	- ability of simulating radio communication systems - ability of implementing various blocks from a software defined radio equipment. - the capacity of simulating radiocommunication systems based on block diagrams.	Marks for each laboratory based on tests comprising of questions regarding the aspects discussed in each of the laboratories.	25
	- ability of implementing various blocks from a software defined radio equipment. - the capacity of simulating radiocommunication systems based on block diagrams.	Final test with VHDL code examples	25
	- the capacity of simulating radiocommunication systems based on block diagrams.		
	- ability to write VHDL source code based on specifications - ability to test the written VHDL source code - ability to use dedicated components		
	- ability to write VHDL source code based on specifications - ability to test the written VHDL source code - ability to use dedicated components		
11.6 Passing conditions			
• Obtaining 50% of the total score. • Obtaining 50% of the score related to the activity during the semester. **Atenţie la Regulamentul de studii aplicabil, se pot include aici referinţe în acest sens!**			

12. Corroborate the content of the course with the expectations of representatives of employers and representative professional associations in the field of the program, as well as with the current state of knowledge in the scientific field approached and practices in higher education institutions in the European Higher Education Area (EHEA)

Wireless communication systems are and will be an important component in the global communication systems. Together with the technological progress of communication equipment, more and more of these devices need an internet connection, and therefore the need of a data connection (of higher and higher speed) in parallel with the classical voice one arises. Moreover, an ever larger number of communication standards coexist, which in most of the times implies the existence of several dedicated equipment.

In a software defined radio (SDR) equipment, most of the signal processing blocks necessary in a wireless device are implemented in the digital domain by software (using various hardware circuits, like programmable logic devices (FPGA), digital signal processors (DSP), application specific integrated circuits (ASIC), etc.). The advantages offered by such devices compared to classical equipment are the possibility of reconfiguration, which allows improvements and the addition of new standards without hardware changes, and also the capability of using several different radio access technologies, depending on specific needs.

The course curriculum responds to the current development and evolution requirements, subscribed to the European and world evolution in the field of communications and information technology (ICT).

In this way, the graduates are provided with adequate competences with the needs of the current qualifications and a modern, quality and competitive scientific and technical training, which will allow them to be employed quickly after graduation, being perfectly framed in the policy of the Politehnica University of Bucharest, both from the point of view of the content and structure, as well as from the point of view of the skills and international openness offered to students.

Through the activities carried out in this discipline, students develop skills to offer solutions to problems and to propose ideas for improving the existing situation in the field of radio communication systems and equipment. It is also considered the development of the graduate's skills to manage practical situations that he may face in real life in order to increase his contribution to the improvement of the socio-economic environment.

Date	Course lecturer	Instructor(s) for practical activities
	Prof. Dr. Alexandru Martian, Prof. Dr. Cristian Anghel	Prof. Dr. Alexandru Martian, Prof. Dr. Cristian Anghel

Date of department approval	Head of department

Date of approval in the Faculty Council	Dean

Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și

Tehnologia Informației