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	**Electronic Devices, Circuits and Architectures**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Advanced Computing in Embedded Systems

2. Date despre disciplină

2.1 Course name (ro) (en)				Calcul Reconfigurabil Reconfigurable Computing			
2.2 Course Lecturer				Prof. dr. ing. Gheorghe Ștefan			
2.3 Instructor for practical activities				Prof. dr. ing. Gheorghe Ștefan			
2.4 Year of studies	1	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M1.O.22-05		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	28
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.					60
Tutoring					6
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	69.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Programming courses, Digital Integrated Circuits, Microprocessors Architecture

4.2 Results of learning	Programming in C/C++ and Python, Digital Circuit Design using Verilog/SystemVerilog/VHDL, good know-how of embedded systems (hardware architectures, software programming, interaction between devices)

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

5.1 Course	Room with video projector
5.2 Seminary/ Laboratory/Project	Laboratory room which has PYNQ Z2 boards and work stations with Xilinx Vivado Suite installed

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)*

Developing skills regarding embedded systems on FPGA and designing digital circuits for FPGA implementation

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	1. Defining of the following items: ASIC, CPLD, FPGA, SoC 2. Being capable of listing the principal characteristics of a SoC with FPGA 3. Defining the generic FPGA architecture (elementary cells, connection methods, other peripherals) 4. Being capable of defining the main steps of designing a digital circuit for FPGA (high-level synthesis, hardware definition language design, synthesis, optimization, integration) 5. Knowing the different methods in which the logical reconfigurable block (PL) can be interfaced with the programmable system (PS) and with the peripherals - I/O ports and AXI4 communication protocol.
Transversal (General) Competences	Honorable, responsible and ethical behavior to ensure the reputation of the profession. Team work, task partition and synchronization. Awareness of the need for continuous training. Efficient use of resources (specifications, standards, tutorials, user-guides) for project development and for personal and professional development.

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.* General concepts of using embedded systems with FPGA

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).* Designing and optimizing digital circuits for FPGA and developing applications for integrating the designs in complex systems
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* By applying the knowledge learnt in this course, the students will be capable of evaluating performance criteria of some FPGA systems, to chose the optimal device for a given task.

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.)*

Problem-based learning and case study will be used to raise students' interest in the general objectives of the course. To assess the understanding of new concepts, the conversational method will be employed to evaluate the students' comprehension level. In the process of teaching new notions, exposition and explanation will be used, and evaluation will be conducted individually, in two stages - a written stage in the middle of the semester and an oral stage at the end of the semester.

10. Contents

COURSE

Chapter	Content	No. hours
1	Introductive course in the reconfigurable computing domain	2
2	FPGA devices architecture	4
3	Introduction in digital circuit design with FPGAs	2
4	High Level Synthesis	2
5	Midterm evaluation	2
6	Digital circuit synthesis for FPGA	2
7	Energy consumption analysis and optimization	2
8	Time constraints analysis and optimization	2
9	Implementation of applications on FPGAs	4
10	Complex Applications with FPGAs	4
11	Advanced concepts of reconfigurable computing and the future of the industry	2
	Total:	28

Bibliography:

1. Reconfigurable computing, Scott Hauck and Andre DeHon, Morgan Kaufmann Publishers, 2008
2. Designing with Xilinx FPGAs, Sanjay Churiwala, Springer, 2017

LABORATORY

Crt. no.	Content	No. hours

1	Digital Circuits recap, Verilog HDL recap. How to use Xilinx's Vivado Suite for creating a synthesizable circuit	2
2	Vivado Block Design. Presenting the PYNQ framework and AXI4Lite communication method	4
3	High Level Synthesis. Analysis of digital circuit optimization methods. Presenting the AXI4Stream communication method. Presenting the Direct Memory Access concept	4
4	Presenting AXI4MemoryMapped communication method. Presenting different modes of debugging reconfigurable systems	4
5	Complex applications with reconfigurable systems. Time constraints and energy consumption analysis and optimization	10
6	Help and debugging of projects	4
	Total:	28

Bibliography:

1. High Level Synthesis User Guide - https://docs.xilinx.com/r/en-US/ug1399-vitis-hls
2. Introduction to Digital Systems Design, Giuliano Donzellini, Luca Oneto, Domenico Ponta, Davide Anguita
3. Introduction to Logic Circuits & Logic Design with Verilog, Brock J. LaMeres

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Developing know-how in the specific field	Written midterm exam	20
	Developing know-how in the specific field	Oral exam	30
11.5 Seminary/laboratory/project	Developing of the required tasks	Written evaluation	20
	Project delivery	Oral evaluation	30
11.6 Passing conditions			
At least 50% of the laboratory points, at least 50% of the total grade, at least 80% laboratory presence.			

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)

Throughout the activities, students acquire skills in creating digital circuits using high-level synthesis libraries and become familiar with design and verification methods used in the industry. The gradual complexity of the systems presented in the laboratory sessions and the theoretical concepts introduced in the course facilitate the integration of accumulated knowledge into industrial projects.

Date	Course lecturer	Instructor(s) for practical activities

Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și

Tehnologia Informației

09.09.2022	Prof. dr. ing. Gheorghe Ștefan	Prof. dr. ing. Gheorghe Ștefan

Date of department approval	Head of department
31.10.2024	Prof. Dr. Claudius DAN
Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea