Universitatea Națională de Știință și Tehnologie Politehnica București
Facultatea de Electronică, Telecomunicații și Tehnologia Informației

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 Microelectronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Proiectare digitală avansată Advanced Digital Design			
2.2 Course Lecturer				Lect. Zoltan HASCSI, PhD			
2.3 Instructor for practical activities				Lect. Zoltan HASCSI, PhD			
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.M2.O.04-09		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	3	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	42.00	Out of which: 3.5 course	28	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.					56
Tutoring					0
Examinations					2
Other activities (if any):					0

3.7 Total hours of individual study	58.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Digital Integrated Circuits Microprocessors and Microcontrollers Algorithms and Data Structures

4.2 Results of learning	Accumulation of the following knowledge at the base level: - digital circuits - Verilog HDL, design flow and IDE tools

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

5.1 Course	Classroom with video-projector
5.2 Seminary/ Laboratory/Project	Room with computers and a video-projector. Personal computers on which Xilinx Vivado IDE Suite is 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)*

This course answers the following questions:When and for what reason a recursive description for a digital circuit/system makes sense? What is a hybrid computational system? How is designed a hybrid computational system? Functional diversity and complexity approached will allow the student to design a hybrid computational system. The student is therefore prepared to approach systems in which the functionality is obtained through physical and informational structuring.

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	Design, verification, implementation and testing of digital circuits. Use of specific software and hardware tools. Analysis of schematics/descriptions of digital circuits. Understanding/inferring their behavior.
Transversal (General) Competences	Works in a team and communicates efficiently, coordinating her/his efforts to others efforts in order to solve medium size/complexity issues. Autonomy and critical thinking: ability to think using appropriate scientific terms, to independently search and analyze data and to draw and present conclusions / identify solutions. Analysis and synthesis ability: synthetically presents acquired knowledge via systematic analysis. Follows academic ethics: in the documentation activity properly cites the bibliographical sources.

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.* • **Define** the basic concepts of binary arithmetic and Boolean algebra. • **Describe** logical functions using algebraic/tabular/graphical representations. • **Describe** methods for automata description with graphs/flowcharts/state diagrams. • **Exemplify** and **characterize** digital circuit implementation technologies. • **Describe** the basic structures of digital circuits and **explain** their operation. • **Define** metrics for digital circuit characterization and **describe** measurement/estimation methods for them. • **Exemplify** digital circuit analysis/design methodologies. **Enumerate** and **describe** their stages. • **Understand** the terms, abbreviations, acronyms and symbols used in the field of digital circuits.
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).* • **Draw** the diagram of a digital circuit, at the level of transistors/logic gates/function blocks. • Behaviorally/structurally **describe** a logic circuit using verilog language. • **Interpret** the waveforms of a digital circuit simulation. • **Identify** functional blocks in a digital circuit and **infer** its behavior to different input stimuli. • **Analyze** a digital circuit diagram and **deduce** the logic function in the form of logic expression/diagram/graph. • **Design** a combinational logic circuit using logic expressions/truth tables/VK diagrams. • **Design** an automaton using state diagrams/graphs/flowcharts. • **Design** a digital circuit combining generic functional blocks (mux, dmux, encoder, decoder, adder, comparator, register, counter, etc.). • **Define** scenarios for generating input stimuli for a digital circuit and **predict** its response. • **Find** and **correct** errors in the design and/or description of a non-functional circuit.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Effectively **use** software tools and hardware resources in the learning, analysis and design process. • **Select** appropriate documentation sources. • **Demonstrate** autonomy in planning and implementing solutions to given problems, as well as identifying and correcting errors/mistakes. • **Demonstrate** collaboration with other colleagues and teaching staff in carrying out teaching activities. • **Responsibly** apply the principles, norms and values of professional ethics in completing homework and laboratory assignments. • **Self-evaluate** objectively, **identifying** gaps and needs, provide proactive feedback.

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.)*

Teaching is based on the use of the video-projector (covering communication and demonstration function). The oral communication methods are expository method and problem-solving method. All materials are available online (direct or via links) on the project's site and on the faculty's "Moodle" platform.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction •Circuit & information •Size vs. complexity •Recursively defined circuits •Hybrid computational systems	2
2	Combinational systems •Shifters •Priority encoder •Prefix computational network •Carry-Save-Adder •Multiplier •Sorting network •First detection network •Spira's theorem	6
3	Applications for memory systems •FPGA •Content Addressable Memory •Associative memory •Benes-Waxman permutation network •First-order systolic systems	5
4	Automata systems •Serial arithmetic (Hillis Cell) •Functional automata •LIFO memory system •FIFO memory system •Multiply-Accumulate circuit •Automata vs. Combinational circuits •Circuit complexity of a binary string	5
5	Processing systems •Loops and the control's complexity •Push-down automata •Interpreting vs. executing processors •Stack processor •Computational accelerators	5

6	Self-organizing systems •Cellular automata •Systolic systems •Neural networks •Global loops in self-organizing systems	5
	Total:	28
Bibliography: http://curs.upb.ro/ Gheorghe Ștefan. Loops & Complexity in Digital Systems. Lecture Notes on Digital Design in the Giga-Gate per Chip Era		

LABORATORY		
Crt. no.	**Content**	**No. hours**
1	Iterative HDL descriptions	2
2	Recursive HDL descriptions	2
3	Efficient implementations of advanced arithmetic circuits through iterative/recursive descriptions: Carry-Select Adder. Carry-Lookahead Adder. Array Multiplier. Parallel Sorter	8
4	Colloquium	2
	Total:	14
Bibliography:		

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 - choosing the correct solutions for solving some exercises	Homework	20%
	- knowledge of fundamental theoretical notions - choosing the correct solutions for solving some exercises	Final Exam	30%
11.5 Seminary/laboratory/project	Activity during lab	Lab activity	10%
	Iterative/recursive description for a parallel implementation of a given arithmetic function	Colloquium	40%
11.6 Passing conditions			
At least 50% of the total marks At least 50% of the marks alloted to laboratory			

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)

Through the activities carried out, students develop skills in the design and verification of digital systems and become familiar with the design tools and methodologies used in the industry. The gradual increase of the project complexity facilitates the development of skills to manage practical challenges that can be encountered in real industrial projects. All technical university teach a similar course

Date	Course lecturer	Instructor(s) for practical activities
09.09.2022	Lect. Zoltan HASCSI, PhD	Lect. Zoltan HASCSI, PhD
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	