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	Bachelor/Undergraduate
1.6 Programme of studies	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Tehnici de proiectare pentru structuri VLSI			
2.2 Course Lecturer				S.l./Lect. Dr. Marius Enachescu			
2.3 Instructor for practical activities				As. Drd. Florin-Silviu Dumitru			
2.4 Year of studies	4	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.07.O.402		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4.5	Out of which: 3.2 course	3.00	3.3 seminary/laboratory	1.5
3.4 Total hours in the curricula	63.00	Out of which: 3.5 course	42	3.6 seminary/laboratory	21
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.					57
Tutoring					3
Examinations					2
Other activities (if any):					0

3.7 Total hours of individual study	62.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion and/or promotion of the following subjects: · Physics, · Electronic devices, · Fundamental electronic circuits, · Analog integrated circuits, · Digital Integrated Circuits Virtual instrumentation for microelectronics

4.2 Results of learning	General knowledge of mathematics, general knowledge of microprocessors as well as the SPICE language.

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

5.1 Course	N/A
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room with specific equipment, which must include: access to the software and/or hardware resources necessary for the development of mixed signal circuits (Cadence and/or Synopsys Suite for the design of integrated circuits).

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 field of Electronic Engineering, Telecommunications and Information Technologies / specialization Microelectronics, optoelectronics and nanotechnologies.

The purpose of this course is for students to understand key components of a VLSI system, to familiarize themselves with the "tools" for designing VLSI structures, at the level of algorithms and data structures, and to familiarize themselves with behavioral, structural and physical specifications. At the end of the course, students will be able to (1) build design tools for VLSI, (2) design VLSI chips, (3) master algorithms for solving complex problems involving "bits", "gates", "geometry", "graphs", "matrices", "time", etc.

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	- Analysis of the various circuits presented at each course in order to acquire the knowledge taught. - Familiarize yourself with the operation, performances and specific limitations of a general mixed signal design. – Demonstrates understanding design specifications and structuring of a mixed signal electronic systems into functional blocks. – Argue and analyze coherently and correctly VLSI applications, using key concepts of related disciplines and their specific methodologies. – Oral and written communication in Romanian: uses the scientific vocabulary specific to the chosen field of study, in order to communicate effectively and correctly, in writing and orally. – Oral and written communication in a foreign language (English): demonstrates the correct understanding and application of the vocabulary related to the chosen field of study, 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, to search and analyze data independently, to identify solutions, and to draw and present conclusions. – Ability to analyze and synthesize: presents the acquired knowledge in a synthetic way, as a result of a systematic analysis process. - Respect the principles of academic ethics: correctly cite the bibliographic sources used in the documentation activity. – Put into practice elements of emotional intelligence in the adequate socio-emotional management of some situations in academic life, demonstrating self-control and objectivity in decision-making or in 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.* – Defines notions and concepts specific to VLSI analog-digital mixed signal systems. – Appropriately describes the design and analysis techniques used to develop the system. – Understands and describes the phenomena involved in the operation of the component blocks of the system and their impact at the system level. – Lists the most important stages of the technological processes involved and/or of the adopted solutions, highlighting their limitations, advantages, disadvantages and their applicability in system design. – Understands and properly describes the stages of making a VLSI system according to the organization, requirements and way of working used in the industry.
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, thus being able to adequately describe various theoretical or practical aspects relevant to VLSI systems. - Uses specific concepts and principles of VLSI systems in order to correctly approach some problems. – Correctly identifies and interprets causal relationships in system operation. - Formulate correct conclusions on the experimental results obtained. – Argues the way of solving and the solutions used to solve some problems.

Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* – Selects appropriate bibliographic sources and analyze them. - Respects the principles of academic ethics, correctly citing the bibliographic sources used. – Demonstrates responsiveness to new learning contexts. - Demonstrates team spirit and collaboration with other colleagues and teaching staff in carrying out teaching activities. – Demonstrates autonomy in organizing the learning context and the problems to be solved. – Realizes the value of its contribution in the field of engineering to the identification of viable solutions to solve problems in social and economic life. – Analyze business or entrepreneurial development opportunities, starting from the knowledge acquired in the field studied. – Demonstrates management skills for real-life situations (eg proper project 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.)*

- Respect the principles of academic ethics, correctly citing the bibliographic sources used.

– Demonstrates responsiveness to new learning contexts.

- Demonstrates team spirit and collaboration with other colleagues and teaching staff in carrying out teaching activities.

– Demonstrates autonomy in organizing the learning context and the problems to be solved.

– Realizes the value of its contribution in the field of engineering to the identification of viable solutions to solve problems in social and economic life.

– Analyze business or entrepreneurial development opportunities, starting from the knowledge acquired in the field studied.

– Demonstrates management skills for real-life situations (e.g., proper project time management).

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	VLSI Introduction	2
2	CMOS 1. CMOS Background 2. CMOS 3. CMOS Logic 4. CMOS logic design and fabrication 5. CMOS processing technology	6
3	MOS Transistor Theory 1. Introduction 2. Non-ideal V-I effects 3. DC transfer characteristics 4. CMOS inverter	6

4	Delay 1. Introduction 2. RC delay model 3. Linear delay model 4. Logical effort of paths 5. Timing analysis delay models	8
5	Power 1. Introduction 2. Dynamic Power 3. Static Power 4. Power-Delay Product 5. Low-power architectures	6
6	Wires 1. Introduction 2. Wire RC models in VLSI circuits 3. Wire impact in delay and power of VLSI circuits. 4. Critical paths logical effort when considering wire influence.	4
7	Semiconductor memories: structure at the transistor level and how to write and read in cells of the type: 1. SRAM 2. DRAMA	0
	Total:	42

Bibliography:

M. Enachescu, TPSVLSI, suport de curs electronic pe platforma Moodle a facultății de ETTI: https: https://archive.curs.upb.ro/2021/course/view.php?id=9163

N. WESTE, D. HARRIS, CMOS VLSI Design: A Circuits and Systems Perspective (4th Edition). Addison-Wesley Publishing Company, 2010, ISBN-10: 0-321-54774-8, ISBN-13: 978-0-321-54774-3

R.J. Baker, CMOS: Circuit Design, Layout, and Simulation, 4th Ed., IEEE Press, Wiley, 2019.

Behzad Razavi, „Design of Analog CMOS Integrated Circuits”, McGraw-Hill, Inc., 2017.

LABORATORY

Crt. no.	Content	No. hours
1	Cadence Virtuoso tutorial	3
2	Transistor level combinational logic circuit design using CMOS nanotechnologies	3
3	Combinational logic circuits: performance evaluation.	3
4	Transistor level sequential logic circuit design and analysis using CMOS nanotechnologies. Applications	3
5	SRAM 6T design and read/write functionality analysis.	3
6	SRAM array system analysis.	3
7	Final grading (oral/written/practical evaluation)	3
	Total:	

Bibliography:

M. Enachescu, TPSVLSI, suport de laborator lectronic pe platforma Moodle a facultății de ETTI: https: https://archive.curs.upb.ro/2021/course/view.php?id=9163

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Midterm	Written	20
	Final Examination	Written/Oral	50
11.5 Seminary/laboratory/project	Tests during each session	Written	15
	Final test	Written/Practical	15
11.6 Passing conditions			
• Obtaining 50% of the total score. • Obtaining 50% of the score related to the activity during the semester.			

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)

The discipline content and gained knowledge are aligned with the professional organizations, e.g., ARIES, and VLSI circuit design companies where students can start their tenureship as engineers or as new college graduates. Also, it is aligned with national and international quality assurance entities, e.g., ARACIS.

This provides graduates with the appropriate skills and training requirements according to current qualifications, and a modern, high quality and competitive scientific and technical training, enabling them acquiring a working place after the graduation. The course fits therefore perfectly to the Bucharest Polytechnic University policy, considering both its content and structure, and the skills and international openness it offers to students.

Date	Course lecturer	Instructor(s) for practical activities
09.09.2022	S.l./Lect. Dr. Marius Enachescu	As. Drd. Florin-Silviu Dumitru

Date of department approval	Head of department
31.10.2024	Prof. Dr. Claudius DAN

Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și

Tehnologia Informației

Date of approval in the Faculty Council	Dean
01.11.2024	Prof. Dr. Mihnea Udrea