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)				Instrumente software pentru proiectarea circuitelor integrate CAD for Integrated Circuits Design				
2.2 Course Lecturer				Prof. Dr. Claudius DAN				
2.3 Instructor for practical activities				Prof. Dr. Claudius DAN				
2.4 Year of studies	1	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob	
2.8 Course type		DS	2.9 Course code	UPB.04.M1.O.04-03		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.					0
Tutoring					32
Examinations					1
Other activities (if any):					0

3.7 Total hours of individual study	33.00
3.8 Total hours per semester	75
3.9 Number of ECTS credit points	3

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Graduation of the following courses: Computer Programing • Data Structures and Algorithms • Fundamental Electronic Circuits • Analog Integrated Circuits • Digital Integrated Circuits
4.2 Results of learning	Following knowledge is necessary: • General programing • Analog electronic circuits • Digital electronic circuits

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

5.1 Course	• Course classes will take place in a classron having videoprojector and computer. • For synchronous broadcasting/recording, high speed Internet connection is necessary.
5.2 Seminary/ Laboratory/Project	• Laboratory classes will take place in a classroom having ate least as many computers as the number of students • Computers have tor un a Linux like operating system and the Cadence IC design software suite • Software licenses for the Cadence software.

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 topic is studied in the Electronics, Telecommunication and Information Technology domain / Advanced Microelectronics Master Program and aims to present, analyze and experiment main integrated circuits design techniques using appropriate computer software.

The complexity of now days systems integrated into a chip that may comprise billions of transistors precludes manual design and requires intensive and extensive extremely sophisticated software tools usage. In order to master these techniques, fundamentals of IC design are presented accompanied by specific tools dedicated to solving them.

Algorithms and data structures these software tools are based upon are presented and compared from the user perspective.

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 that the graduate has **basic and advanced knowledge** in the domain of IC design software tools usage and development. **Correlates knowledge** **Applies** knowledge **Applies** standard methods and instruments specific to the domain in order to **evaluate and diagnose** the status of the task to be performed and, based on the conclusions identified/reported **identifies** solutions. **Analizes and arguments** coherently and correctly the base knowledge application context using key concepts and specific methodology. **Oral and written communication in Romanian language**: uses appropriate scientific vocabulary in order to effectively communicate. **Oral and written communication in English language**: demonstrates specific vocabulary mastering.
Transversal (General) Competences	**Works in a team and efficiently communicates**, 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.* • **Enumerates** the most important ages that marked domain development. • **Defines** domain specific terms. • **Describes/classifies** terms/processes/phenomena/structures. • **Points out relations and consequences**.

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 specific context. • **Uses specific principles, based on arguments, in order to effectively design chips and achieve the "first-time-success" goal**. • **Works** productively **in a team**. • **Elaborates scientific texts**. • **Experimentally verifies identified solutions**. • **Solves** practical applications. • Correctly **interprets** de causality connections. • **Analyses and compares different design styles**. • **Identifies solutions** and **elaborates** solution plans/projects. • **Draws conclusions from the experiments**. • **Arguments identified** solutions.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • **Selects** appropriate bibliography and analyses it. • **Follows academic ethics**, correctly citing sources. • **Proves receptivity** for new learning contexts. • **Collaborates** with her/his colleagues and teachers during the didactic process. • **Proves autonomy** in setting up teaching/solving problem context/. • **Proves social responsibility** by actively involving in student social live/implication in academic community events. • **Promotes/contributes** to social live improvement by new solutions in her/his specialization domain • **Is aware of her/his contribution in engineering field**, in identifying viable/sustainable solutions to solve socio-economic issues (social responsibility). • **Applies ethical principles/professional deontology** in analysis of environmental effects of proposed technological solutions. • **Analyzes and exploits business opportunities** /entrepreneurial development in the domain. • **Proves management abilities** in real life situations (time management collaboration vs. conflict).

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.)*

Based on students' study characteristics analysis and their specific needs, the teaching process will explore both exposing methods (lecture, exposition) and interactive dialogs, based pe on discovery teaching methods that are facilitated by direct reality exploration (experiment, demonstration, modelling), and also action based methods like exercises, practical activities and problem solving.

In the teaching activity exposition will be used based on both Power-Point and different recordings that will be available to the students. Each class will debut by reviewing previous chapters pointing out notions in the last previous class.

Presentations use images and graphs in order to facilitate notions understanding and assimilation.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction 1.1 IC design evolution 1.2 Specific IC design problems in the VLSI era 1.3 Design methodologies 1.4 Summary	1
2	IC design process characteristics 2.1 IC design 2.2 Design methodologies/styles 2.3 IC design software tools 2.4 CAD tools classifications 2.5 IC design methodologies history 2.6 Design = Optimization with constraints 2.7 Chip design characteristics 2.8 Hierarchy 2.9 Views 2.10 Connectivity 2.11 Spatial dimension	6
3	Design environment 3.1 Introduction 3.2 System level 3.3 Algorithmic level 3.4 Component level 3.5 Physical level (layout)	2
4	Representation 4.1 Introduction 4.2 General representation problems 4.3 Hierarchy representation 4.4 Views representation 4.5 Connections representation 4.6 Geometry representation	2
5	Analog circuit simulation 5.1 Introduction 5.2 Simulation goal 5.3 Netlists 5.4 Circuit equations formulation 5.5 Modified Nodal Analysis, MNA 5.6 Active device modelling 5.7 Classic analysis 5.8 Simulation acceleration 5.9 Steady-State Analysis – Permanent operation for RF circuits 5.10 Behavioral modelling 5.11 Macro-models 5.12 Verilog-A and Verilog-AMS 5.13 XYCE – Parallel analog simulation	7

6	Digital circuit simulation 6.1 Introduction 6.2 Circuit level simulation 6.3 Logic simulation 6.4 Functional and behavioral simulation 6.5 Simulation problems 6.6 Event-Driven simulation 6.7 Hardware simulation 6.8 Current digital simulators	2
7	Physical Synthesis 7.1 Cell Generation and Modification 7.2 Layout Exterior to the Cells Generation	2
8	Static analysis tools 7.1 Introduction 7.2 Electrical design rule check 7.3 Physical design rule check 7.4 Netlists extraction and comparison	2
9	Interconnections Modelling and Simulation 9.1 Introduction 9.2 Interconnections Modelling	2
10	Power Consumption Estimation and Simulation 10.1 Introduction 10.2 Software Level 10.3 Behavioral Level 10.4 RTL Level 10.5 Gate Level 10.6 Circuit/Transistor Level	2
	Total:	28

Bibliography:
1. DAN Claudius, Handouts of the CAD ICD Course, annually updated, https://curs.upb.ro/2021/mod/folder/view.php?id=240285
2. Chen, W.K., ed., The VLSI Handbook, CRC Press, 2000.
3. Chen, W.K., ed., The VLSI Handbook, CRC Press, 2000.
4. Piguet, C., ed., Low-Power CMOS Circuits, Technology, Logic Design and CAD Tools, CRC Press, 2006
5. Rubin, S.M., Computer Aids for VLSI Design, 2nd ed., 1994
6. Wambacq, P., G. Gielen, J. Gerrits, Low-Power Design Techniques and CAD Tools for Analog and RF Integrated Circuits, Kluwer, 2003
7. Kundert, K.S., The Designer's Guide to SPICE&SPECTRE, Kluwer Academic Publishers, 1998
8. Vladimirescu, A., The SPICE Book, John Wiley & Sons, New York, 1993

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to Unix/Linux operating systems	2
2	Introduction to Cadence IC design environment	2
3	Analog circuit design and simulation in Cadence	2

4	Hierarchical circuit design and simulation in Cadence	2
5	Digital circuit design and simulation	2
6	Mixed signals circuit design and simulation	2
7	Laboratory final test	2
	Total:	14

Bibliography:
1. DAN Claudius, Handouts of the CAD ICD Course, annually updated, https://curs.upb.ro/2021/mod/folder/view.php?id=240285
2. Chen, W.K., ed., The VLSI Handbook, CRC Press, 2000.
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4. Piguet, C., ed., Low-Power CMOS Circuits, Technology, Logic Design and CAD Tools, CRC Press, 2006
5. Rubin, S.M., Computer Aids for VLSI Design, 2nd ed., 1994
6. Wambacq, P., G. Gielen, J. Gerrits, Low-Power Design Techniques and CAD Tools for Analog and RF Integrated Circuits, Kluwer, 2003
7. Kundert, K.S., The Designer's Guide to SPICE&SPECTRE, Kluwer Academic Publishers, 1998
8. Vladimirescu, A., The SPICE Book, John Wiley & Sons, New York, 1993

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Fundamental theoretical notions knowledge	Final grid type written exam	15
	Specific problems solving solutions for each integrated circuit design stage.	Final grid type written exam	15
	Design methodologies and stages mastering,	Final grid type written exam	20
11.5 Seminary/laboratory/project	Good understanding of notions presented during lectures and laboratory activities.	Project, final examination, continous evaluation	10
	Class and lab knowledge application.	Project, final examination, continous evaluation	15
	Independent work abilities using appropriate software tools.	Project, final examination, continous evaluation	25
11.6 Passing conditions			

- Obtaining minimum 50% of the total score.
- Obtaining minimum 50% of the score of activities performed during the semester.
- Obtaining minimum 33% of the final examination score.

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)

- Via the teaching activities, students develop integrated circuits analysis and design abilities that are in high demand due to the unprecedented microelectronics domain development. Engineers for analog, digital and mixed signal integrated circuits design are necessary to sustain this rapid development.

- The software tools studied are in permanent use by all commercial companies active in this field. The Cadence design environment taught in the laboratory is used by virtual all companies active in Romania

- The course curricula is adapted to actual requests and tendencies of the technological evolution. Both classes and application activities provide to the students knowledge and competencies that facilitate fast enrolment into a prestigious company active in the IC design domain.

- Current semiconductor market status highlights major unbalances between offer and demand that generated active, sustained and decisive actions at all decision levels of all states including the European Union.

- In the course development both literature described aspects, knowledge and phenomena and own contributions published or acquired in industrial activities were used.

- The course has similar content to courses taught in: Lodz University of Technology, Poland, THE UNIVERSITY of EDINBURGH, Newcastle, Great Britain etc.

- Via the lab activities practical situation management abilities are formed and developed.

- The course was developed in agreement with microelectronic Romanian companies like Infineon Technologies, Romania, Microchip Romania and On Semiconductor Romania.

Date	Course lecturer	Instructor(s) for practical activities
	Prof. Dr. Claudius DAN	Prof. Dr. Claudius DAN

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