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)				Blocuri analogice Analog Blocks			
2.2 Course Lecturer				Dr. ing. Andrei Danchiv			
2.3 Instructor for practical activities				Dr. ing. Andrei Danchiv			
2.4 Year of studies	1	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M1.O.04-00		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.					31
Tutoring					0
Examinations					2
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: • Fundamental Electronic Circuits • Analog Integrated Circuits

4.2 Results of learning	Following knowledge will be acquired: • Electronic Devices • Analog electronic integrated CMOS 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 analog integrated circuits blocks designes.

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.

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 analog IC design. **Correlates knowledge** **Applies** knowledge **Applies** standard methods and instruments specific to the domain in order to **evaluate and diagnoze** 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 mthodology. **Oral and written communication in Romanian language**: uses appropriate scientific vocabulary in order to effectively communicate. **Oral and wiitten 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 analog building blocks types. • **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**. • The student graduating this course will be able to state the specification of an advanced analog building blocks, create a simulation set-up, design the block, layout it and evaluate its characteristics. This course enables the student to work in Advanced Microelectronics area • **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.

This course covers information and practical activities aimed to support students in learning and optimal collaboration and communication relations development in an discovery learning favorable climate.

Active listening and assertive communication abilities practice and feedback will be main means to behavioral adjustment in various situations and for didactic activity adaptation to students' needs.

Team working abilities will be exercised in order to solve various learning tasks.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**

1	Overview of IC manufacturing and design. Process integration. 1.1. Scaling. Moore's law. 1.2. Component isolation. 1.3. CMOS IC process. Latch-Up. 1.4. Bipolar IC and BiCMOS processes. 1.5. Packaging.	2
2	IC devices operation and models. 2.1. Large and small-signal operation of MOS transistors. Strong inversion, weak inversion. Short channel effects. 2.2. SPICE modelling parameters. 2.3. Device model selection for approximate analysis of analog circuits	2
3	Current mirrors, active loads. 3.1. Simple CMOS current mirror 3.2. Source degenerated current mirrors 3.3. High output impedance current mirrors	2
4	Basic MOS gain stages. 4.1. Common source, common-drain and common-gate stages. 4.2. Cascode gain stage. 4.3. Frequency response of single-stage amplifiers. Pole splitting.	2
5	MOS voltage differential stages 5.1. Resistive, active and current mirror load 5.2. Large-signal operation 5.3. Small-signal operation 5.4. Device mismatches effects. Offset voltage. CMRR.	2
6	Two stage Miller opamp 6.1. Basic schematic of two stage Miller opamp 6.2. Basic parameters of the two stage Miller opamp: (a) differential gain, (b) Frequency response at midband frequencies, (c) Slew-rate, (d) Input offset voltage, (e) Output voltage swing, (f) Common-mode input voltage range, (g) n-channel or p-channel input stage, (h) Common-mode rejection ratio, (i) Noise performance. 6.3. Stability of two-stage Miller opamp: (a) Frequency and time response of single and two-pole systems, (b) Differential gain frequency dependence, (c) Opamp compensation, (d) Process and temperature independent compensation.	12
7	Other operational amplifiers 7.1. Folded cascode operational amplifiers 7.2. Transconductance operational amplifiers	2
8	Band-gap reference voltage	2
9	Pulse generators: (a) The Schmitt trigger, (b) Voltage controlled oscillator using Schmitt trigger, (c) Multivibrators.	2
	Total:	2

Bibliography:
1. DANCHIV Andrei, Handouts of the AB Course, annually updated, https://curs.upb.ro/2021/mod/folder/view.php?id=240285
2. R.J. Baker, H.W. Li, and D.E. Boyce, CMOS Circuit Design, Layout, and Simulation, IEEE Press, New York, 1998
3. R.J. Baker, CMOS Mixed-Signal Circuit Design, IEEE Press, New York, 2002
4. C. Dan, Comparatoare, Editura Tehnică, Bucureşti, 2005
5. P.R. Gray, P.J. Hurst, S.H. Lewis and R.G. Meyer, Analysis and Design of Analog Integrated Circuit, 4th ed., John Wiley & Sons, New York, 2001
6. E. Doicaru, M. Bodea. Proiectarea circuitelor integrate analogice orientată spre performanţele de zgomot, Editura Universitaria, Craiova, 2009.
7. R. Gregorian, Introduction to CMOS Op-Amps and Comparators, John Wiley & Sons, New York, 1999
8. D.A. Johns, and K. Martin, Analog Integrated Circuits Design, John Wiley & Sons, New York, 1997
9. K.S. Kundert, The Designer's Guide to SPICE&SPECTRE, Kluwer Academic Publishers, 1998
10. A. Vladimirescu, The SPICE Book, John Wiley & Sons, New York, 1993

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to Lab environment	2
2	Schematic editor. Basic layout (transistor and inverter) 1	2
3	Schematic editor. Basic layout (transistor and inverter) 2	2
4	Simulation of MOS transistor characteristics. Model parameters	2
5	Simulation of current mirrors and single gain stage	2
6	Simulation and layout of differential stage	2
7	Lab examination	2
	Total:	

Bibliography:
1. DANCHIV Andrei, Handouts of the AB Course, annually updated, https://curs.upb.ro/2021/mod/folder/view.php?id=240285
2. R.J. Baker, H.W. Li, and D.E. Boyce, CMOS Circuit Design, Layout, and Simulation, IEEE Press, New York, 1998
3. R.J. Baker, CMOS Mixed-Signal Circuit Design, IEEE Press, New York, 2002
4. C. Dan, Comparatoare, Editura Tehnică, Bucureşti, 2005
5. P.R. Gray, P.J. Hurst, S.H. Lewis and R.G. Meyer, Analysis and Design of Analog Integrated Circuit, 4th ed., John Wiley & Sons, New York, 2001
6. P.R. Gray, P.J. Hurst, S.H. Lewis and R.G. Meyer, Analysis and Design of Analog Integrated Circuit, 4th ed., John Wiley & Sons, New York, 2001
7. R. Gregorian, Introduction to CMOS Op-Amps and Comparators, John Wiley & Sons, New York, 1999
8. D.A. Johns, and K. Martin, Analog Integrated Circuits Design, John Wiley & Sons, New York, 1997
9. K.S. Kundert, The Designer's Guide to SPICE&SPECTRE, Kluwer Academic Publishers, 1998
10. A. Vladimirescu, 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 written exam	15
	Specific problem solving solutions for advanced analog integrated circuits.	Final written exam	15
	Design methodologies and stages mastering,	Final written exam	20
11.5 Seminary/laboratory/project	Good understanding of notions presented during lectures and laboratory activities.	Project, final examination, continuous evaluation	10
	Class and lab knowledge application.	Project, final examination, continuous evaluation	15
	Independent work abilities using appropriate software tools.	Project, final examination, continuous 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 circuit types 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
Sep. 20 2024	Dr. ing. Andrei Danchiv	Dr. ing. Andrei Danchiv

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