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)				Circuite integrate de joasă tensiune şi mică putere			
2.2 Course Lecturer				Prof. Dr. Ing. Gheorghe Brezeanu			
2.3 Instructor for practical activities				Dr. Ing. Vlad Anghel			
2.4 Year of studies	4	2.5 Semester	II	2.6. Evaluation type	V	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.08.O.413		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.					80
Tutoring					0
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	83.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	• Electronic Devices • Fundamental Electronic Circuits • Analog Integrated Circuits • Digital Integrated Circuits, • Microelectronic Technology Fundamentals
4.2 Results of learning	• Knowledge of electronic devices and circuits • Electronic circuit analysis • Microelectronics technology

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

5.1 Course	Room with board, video-projector and internet connection
5.2 Seminary/ Laboratory/Project	Rooms for the project with video-projectors and internet connection. A minimum of 15 computer workstations with dedicated electronic circuit simulation 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)*

The typical architectures for low voltage and low power (LV-LP) circuits such as: rail-to-rail input differential amplifiers and output stages, current mirrors and active loads, constant voltage-gain cells, cascodes, voltage references implemented in MOS, bipolar or BiCMOS technologies are systematically studied.

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	• CIJTMP: requirements, motivation and typical applications • Models for nano-scale MOS and bipolar transistors. • Comparison between CMOS, bipolar and BiCMOS technologies. • Differential amplifiers, inverting and rail-to-rail output stages. • Techniques to reduce power consumption and supply voltage. • Very small current mirrors and low voltage references • CIJTMP practical schematics: current mirrors, amplifiers, invertors, voltage references and LDO voltage regulators

Transversal (General) Competences	• Teamwork for coordinating efforts with the others in order to solve special situations, with varying degrees of difficulty. • Autonomy and critical thinking: the abilty to think in engineering terms, to seek and analyze data independently, as well as identify and present new solutions. • Capacity to analyze and synthesize: Capacitate de analiză și sinteză: presents the acquired knowledge in a synthetic way, as a result of systematic analysis. • Respecting the principles of academic ethics. Correct citations of bibliographic sources used as references in own works.

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.* • Describes and explains the most important techniques for reducing power consumption and supply voltages in CIJTMP. • Defines notions specific to low voltage and low power electronic circuits • Describes/classifies concepts/processes/phenomena/models for amplifiers, current sources and active loads, voltage references, differential and rail-to-rail output stages, inverting gates, etc., implemented in CMOS, bipolar and BiCMOS technologies. • Defines DC bias regimes at low currents for active devices. • Develops behavioral models for electronic circuits used in various applications • Describes techniques for achieving rail-to-rail at the input and output of CIJTMP
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).* • Team work • Practical problem-solving using theoretical knowledge • Proposing practical applications for the studied electronic circuits • Identifying circuit limitations caused by the behavior of electronic devices biased at low currents and power. • Distinguishing between linear and non-linear modes of operation of circuits and between sub and overthreshold conduction, respectively. • CIJTMP analysis • Determining the transfer function of an electronic circuit • Identifying the importance of model parameters in the electrical operation of devices and circuits

Responsability and autonomy	*The student's capacity to autonomously and responsabaly apply their knowledge and skills.* • Selection and analysis of appropriate bibliographic sources. • Respect for the principles of academic ethics, correctly citing the bibliographic sources used. • Demonstrates responsiveness towards new circuit architectures. • Collaborates with other colleagues and teaching staff in undertaking didactic tasks. • Demonstrates autonomy in organizing the learning situation/context or the problem-solving situation. • Contributes, through new solutions related to electronic circuits, to improving the quality of social life. • Realizes the value of personal contributions in the field of engineering for identifying viable/sustainable solutions to solve problems in social and economic life (social responsibility). • Applies principles of professional ethics/deontology in analyzing the technological impact of proposed solutions on the environment. • Analyzes and exploits opportunities for entrepreneurial development in the specialized field. • Demonstrates management skills in real-life situations.

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.)*

The course exposition is based on a chapter-by-chapter presentation (respecting the contents of point 10.) using the video projector in Power point. The content of the presentation is explained in detail, with relevant comments, in front of the students. A number of concepts and problems of greater complexity are specifically demonstrated. Power point slides are available on Moodle.

The project encourages teamwork. The problem-solving method is also used. Each student is assigned to a team that has tasks of conceptualization, design, simulation in a given technological process, management and marketing. The team is assigned the task of developing a specialized low-voltage, low-power circuit. The direct involvement of students in solving tasks related to the process of developing the circuit is the basic rule of the project. Teamwork is an essential condition in completing the project.

The documentation necessary for successful project completion is provided through the collaboration with the multi-national microelectronics company ONSEMI.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Transistor models for CIJTMP 1.1. MOS transistor models 1.2. Models for npn transistors and pnp lateral transistors 1.3. MOS – bipolar comparison 1.4. SPICE parameters of MOS and bipolar transistors	2

2	CMOS CIJTMP 2.1. CMOS technology 2.2. Rail to rail differential input stages 2.3. Rail to rail output stages 2.4. CMOS LV amplifier (<1.5V) 2.5 CMOS Picowatt and very low voltage references (<1.5V) with weak inversion transistors	11
3	Bipolar CIJTMP 3.1. Bipolar technology 3.2 Sample and hold bipolar LV-LP configuration 3.3. Wide bandgap amplifier with gain control 3.4. Temperature compensation bipolar LV references	5
4	BiCMOS CIJTMP 4.1. BiCMOS technology: BiCMOS vs CMOS and Bipolar technologies 4.2. Low power full swing BiCMOS inverters 4.3 Compensation temperature LV references (<1V) 4.4 BiCMOS LDO voltage regulators 4.5 BiCMOS CASCODE amplifiers	10
	Total:	28

Bibliography:

1. G.Brezeanu, Circuite Integrate de joasa tensiune si mica putere - suport de curs (electronic), https://archive.curs.upb.ro/2020/course/view.php?id=10124.
2. G.Brezeanu,Circuite Integrate de joasa tensiune si mica putere - suport de curs (electronic), 2011
3. G. Brezeanu, F. Draghici, Circuite electronice fundamentale, Ed. Niculescu, Bucuresti, 2013.
4. P.R.Gray, P.J. Hurst, S.H.Lewis,R.G.Meyer, Analysis and Design of Analog IC's, editia 4, J.Whiley&Sons, 2001.
5. B. Razavi, Design of Analog CMOS Integrated Circuits, McGrawHill, 2001.
6. T.H. Lee The Design of CMOS Radio Frequency IC ,Cambridge University Press, 1998.
7. A. Sedra, K.C. Smith, Microelectronic Circuits,Oxford University Press, 2004.
8. IEEE Journal of Solid State Circuits, colectia revistei pe perioada 2000- 2019.

PROJECT		
Crt. no.	**Content**	**No. hours**
1	Task 1 – Topic Assignment –design of a low power, low voltage specific circuit	2
2	Task 2 – CAD – Design environment and simulation device model configuration.	2
3	Task 3 -Technology – device technological parameters optimization for Monte Carlo simulations.	2
4	Task 4 – Design – current mirror design according to specifications	2
5	Task 5 – Simulations – chip-level transient simulations.	2
6	Task 6 – Testing – extensive tests by simulations with varying supply values, temperatures and process corners.	2
7	Task 7 – Final evaluation –project presentation and grading.	2

		Total:	14

Bibliography:

1. G. Brezeanu, Circuite Integrate de joasă tensiune și mică putere - suport de curs (electronic), https://archive.curs.upb.ro/2020/course/view.php?id=10124
2. G. Brezeanu, F. Draghici, Circuite electronice fundamentale, Ed. Niculescu, București, 2013
3. P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, Analysis and Design of Analog IC’s, editia 4, J. Whiley&Sons, 2001.
4. B. Razavi, Design of Analog CMOS Integrated Circuits , McGrawHill, 2001.
5. G. Brezeanu, F. Draghici, F. Mitu, G. Dilimot Circuite electronice fundamentale- probleme Ed. Rosetti Educational, București, 2008.
6. IEEE Journal of Solid State Circuits, colecția revistei pe perioada 2000- 2022.

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	1. Knowledge of fundamental concepts to reduce the supply voltage and power consumption of analog integrated circuits. 2. Knowledge of using theory to solve specific problems; 3. Understanding operation, performances and applications of low voltage, low power integrated circuits.	A midterm test, which covers 50% of the lecture, focusing both on analysis and design of low voltage, low power ICs in CMOS technology.	35
	4. Knowledge of fundamental concepts to reduce the supply voltage and power consumption of analog integrated circuits. 5. Knowledge of using theory to solve specific problems; 6. Understanding operation, performances and applications of low voltage, low	Final examination, with the possibility of retaking the midterm test. The exam focuses on analysis and design of low voltage, low power ICs in both bipolar and BiCMOS technologies.	35
11.5 Seminary/laboratory/project	Design, simulation and testing ability of a specific low voltage, low power circuit topology	Grading based on degree of fulfillment of each individual task. Final project evaluation.	30
11.6 Passing conditions			

Obtaining 50% of the score related to the activity during the semester (project/course).

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)

Analog integrated circuits represent a key, fast-growing, branch of microelectronics. Multinational microelectronics companies, well-known producers of analog and mixed signal circuits and systems (Infineon, Microchip, ONSEMI), as well as the expansion to analog design of telecommunications and consumer electronics equipment companies, have considerably increased the demand for qualified engineers, with solid knowledge and competences in the field of integrated circuits. The course provides its graduates with analog and mixed signal circuit analysis, design and testing competences, as well as knowledge of techniques for reducing supply voltage and power consumption. Thus, the strategy of "Politehnica" University of Bucharest, of promoting subjects strongly correlated with both the requirements of present top industry such as microelectronics and the demands of the innovation and design process, is followed.

Date	Course lecturer	Instructor(s) for practical activities
	Prof. Dr. Ing. Gheorghe Brezeanu	Dr. Ing. Vlad Anghel
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	