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	Microsystems

2. Date despre disciplină

2.1 Course name (ro) (en)	Circuite micro- si –nanoelectronice CMOS şi BiCMOS pentru microsisteme
2.2 Course Lecturer	Prof. Dr. Ing. Gheorghe Brezeanu
2.3 Instructor for practical activities	Conf. Dr. Ing. Gheorghe Pristavu

2.4 Year of studies	1	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type	DS	2.9 Course code	UPB.04.M2.O.03-10			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 · Low Voltage Low Power Integrated Circuits
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 laboratory 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 main techniques to reduce power consumption and supply voltage in fundamental analog circuits such as: amplifiers, current sources and active loads, voltage references, rail-to-rail differential and output stages, inverting gates, etc., made in technology CMOS, bipolar and BiCMOS 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	· Design of CMNMs with nanometric MOS transistors, low operating voltages and low power consumption: requirements, motivation and typical applications • Use of circuit simulation programs for the analysis and design of complex schemes • The ability to select and use models for MOS devices with degrees of complexity depending on the specific application • Differential amplifiers, inverters and rail-to-rail output stages • Low current sources and low voltage references
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.* · Knows the evolution of integrated circuits and fabrication technologies; the implications of Moore's law. · Use of models for MOS transistors in weak inversion and with dynamic threshold. · Describes/classifies concepts/processes/phenomena/models for amplifiers, current sources and active loads, voltage references, differential and rai-to-rail output stages, inverting gates, etc., made in CMOS, bipolar and BiCMOS technology. · Develop behavioral models for electronic circuits used in various applications. · Describes complex techniques for achieving rail-to-rail swing at the input and output of micro-nanoelectronic circuits. · Designs practical schematics of MOS and BiCMOS microelectronic circuits: DC-DC converters, log-domain 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).* · Team work · Practical problem-solving using theoretical knowledge · Proposing practical applications for the studied electronic circuits · Identifying circuit limitations caused by the behavior of micro-nanometric electronic devices. · CMNMs analysis · Identifying the importance of model parameters in the electrical operation of devices and circuits
Responsability and autonomy	*The student's capacity to autonomously and responsably 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.

Creativity is stimulated in the laboratory. The problematization method is also used. Each student is assigned a complex circuit simulation task from the course chapters. The essential blocks in the structure of the circuit to be simulated are detailed and analyzed successively: switches, current sources, voltage references, comparators.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	1. Scaling of integrated circuits to nanometric dimensions. Implications. limitations 1.1 Evolution of submicron ICs. Scaling 1.2 Specific design techniques 1.3 Power / supply voltage limitations in integrated circuits.	2
2	2. Physics and modeling of nanometric MOS transistors. Nanometric CMOS and BiCMOS technologies 2.1 The MOS transistor in weak inversion 2.2 The Dynamic Threshold Transistor (DTMOS) 2.3 Speed saturation and mobility decrease in nanometric channels 2.4 The structure of the nanometer-sized MOS transistor 2.6 High permittivity dielectrics. The equivalent thickness of the oxide 2.7 Metals for electrodes and interconnections 2.8. Noise isolation. Protection against electrostatic discharges.	6
3	3. Rail-to-rail low-voltage amplifiers 3.1 OAs with complementary transistor input stage 3.2 OAs with nMOS transistor input stages.	2
4	4. CMOS circuits with adjustable threshold transistors 4.1 OAs with low voltage DTMOS 4.2 Low voltage reference with DTMOS. 4.3 OAs with current controlled threshold MOS transistors.	4
5	5. Current sources and voltage references 5.1 Parameters of current sources 5.2 Small current sources 5.3 High-swing cascode sources 5.4 Sources with high output resistance 5.5 Sources with high output swing and resistance 5.6 Sources with self-bias 5.7 Voltage references lower than 1V 5.8 LDO stabilizers	6

6	6. DC-DC converters 6 6.1 Block diagram 6.2 The flyback converter 6.3 The direct converter 6.4 Push-pull converter	4
7	7. Log-domain integrators 7.1 The log-domain concept 7.2 The principle of non-linearity 7.3 Bipolar log-domain integrator 7.4 CMOS log-domain integrator 7.5 BiCMOS log-domain integrator.	4
	Total:	28

Bibliography:

1. G.Brezeanu, *Circuite nanoelectronice CMOS si BiCMOS* - suport de curs (electronic), 2022.
2. G. Brezeanu, F. Draghici, Circuite electronice fundamentale, Ed. Niculescu, Bucuresti, 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. T.H. Lee The Design of CMOS Radio Frequency IC ,Cambridge University Press, 1998.
6. A. Sedra, K.C. Smith, Microelectronic Circuits,Oxford University Press, 2004.
7. IEEE Journal of Solid State Circuits, collection during 2000-2022.

LABORATORY

Crt. no.	Content	No. hours
1	1. Simulation environment, configuration (Cadence, Mentor Graphics, etc.)	2
2	2. Task assignment. Identifying the basic blocks of the complex circuit.	2
3	3. Selection of the micro-nanoelectronic technology in which the circuit is simulated. Analysis of device parameters.	2
4	4. Simulation of component blocks: MOS switch, current sources.	2
5	5. Simulation of component blocks: voltage references, comparator.	2
6	6. Complex circuit level simulation.	2
7	7. Functional Validation. Evaluation.	2
	Total:	14

Bibliography:

1. G. Brezeanu, F. Draghici, Circuite electronice fundamentale, Ed. Niculescu, București, 2013
2. 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.
3. B. Razavi, Design of Analog CMOS Integrated Circuits , McGrawHill, 2001.
4. G. Brezeanu, F. Draghici, F. Mitu, G. Dilimot Circuite electronice fundamentale- probleme Ed. Rosetti Educational, București, 2008.
5. IEEE Journal of Solid State Circuits, collection during 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 design concepts for CMNMs. 2. Knowledge of using theory to solve specific problems; 3. Understanding operation, performances and applications of CMNMs	Questions addressed to the students during the course regarding the operation of the presented circuits and the role of the component blocks	20%
	Knowledge of fundamental design concepts for CMNMs. 5. Knowledge of using theory to solve specific problems; 6. Understanding operation, performances and applications of CMNMs	Final examination, focusing on schematic analysis questions and exercises for CMNMs in both bipolar and BiCMOS technologies.	50%
11.5 Seminary/laboratory/project	Simulation and testing abilities of fundamental CMNMs blocks	Grading based on degree of fulfillment of each individual task. Final project evaluation.	30%
11.6 Passing conditions			
btaining 50% of the total score related to the activity during the semester (course/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)

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 CMNMs 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
17.10.2024	Prof. Dr. Ing. Gheorghe Brezeanu	Conf. Dr. Ing. Gheorghe Pristavu
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	