Universitatea Naţională de Ştiinţă şi Tehnologie Politehnica Bucureşti
Facultatea de Electronică, Telecomunicaţii şi
Tehnologia Informaţiei

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	Applied Electronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Circuite integrate analogice Analogic Integrated Circuits			
2.2 Course Lecturer				Ş.L. dr. ing. Şerban MIHALACHE			
2.3 Instructor for practical activities				Ş.L. dr. ing. Şerban MIHALACHE			
2.4 Year of studies	3	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		D	2.9 Course code	04.D.05.O.003		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	5	Out of which: 3.2 course	3.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	70.00	Out of which: 3.5 course	42	3.6 seminary/laboratory	28
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.					50
Tutoring					0
Examinations					5
Other activities (if any):					0

3.7 Total hours of individual study	55.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Finishing the following courses: – Electronic Devices; – Basic Electronic Circuits.

4.2 Results of learning	General knowledge of: – fundamental principles of electronic circuit analysis; – modeling of analog electronic signals and systems.

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

5.1 Course	– The lectures will take place in a room equipped with a video projector.
5.2 Seminary/ Laboratory/Project	– The tutorials will take place in a room equipped with a video projector. – The laboratory will take place in a room with specific equipment, which must include: computers, experimental hardware platforms, specialized software (LTSpice). – Mandatory attendance of laboratory sessions (in accordance with the NUSTPB undergraduate studies regulations).

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 course is studied within the “Electronic Engineering, Telecommunications, and Information Technologies” domain / “Applied Electronics” and “Telecommunications Technologies and Systems” specializations (English language course), and aims to familiarize students with the fundamental aspects underlying the analysis, design, performance optimization, and applications of analog CMOS and bipolar integrated circuits. The operation and analysis of the main sub-circuits are studied: current sources, voltage references, small-signal amplifiers, differential amplifiers, output stages, and protection circuits. The internal structures of analog integrated circuits are presented, with a focus on the most important operational amplifier topologies. The analysis of various non-idealities of the studied operational amplifiers is carried out. The frequency response of circuits and the analysis of the stability of feedback circuits are studied, as well as linear and non-linear analog computing structures.
Practical seminar and laboratory applications aim to provide practical experience with the main circuits studied in the course and the techniques for analyzing and designing various sub-circuits with wide applicability in the area of analog integrated circuits, through manual calculations and simulation validation of significant elements of the operation of the studied analog circuits.
All of these contribute to conveying to students an overall view of the methodological and procedural benchmarks related to the field of analog integrated circuits.

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 a basic understanding of analog circuit analysis and design methods, characterization of time-domain and frequency-domain behavior, design of analog electronic systems based on operational amplifiers, and description of the operation and basic principles of linear and nonlinear applications using operational amplifiers. – Applies the acquired theoretical knowledge practically, uses simulation tools, and builds experimental setups for the analysis and design of analog circuits. – Applies standardized methods and tools specific to the field to carry out the evaluation process of a situation, depending on the identified problems, and identifies solutions. – Justifies and analyzes coherently and correctly the context of applying the basic knowledge of the domain, using key concepts of the course and the specific methodology. – Oral and written communication in Romanian: uses the specific scientific vocabulary of the domain to communicate effectively and accurately, both in writing and orally. – Oral and written communication in a foreign language (English): demonstrates understanding and correct application of the vocabulary related to the design of analog circuits, in a foreign language.
Transversal (General) Competences	– Communicates effectively, especially during practical sessions, coordinating their efforts with others to solve medium-complexity problems. – Autonomy and critical thinking: The ability to think scientifically, to independently search for and analyze data, to identify solutions, and to draw and present conclusions. – Analytical and synthesis skills: Presents acquired knowledge in a concise manner, following a systematic analysis process. – Respects academic ethics: Correctly cites bibliographic sources in research activities. – Applies elements of emotional intelligence in the appropriate socio-emotional management of academic situations, demonstrating self-control and objectivity in decision-making or 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 correctly the basic concepts of analog integrated circuit analysis and design: operating point, AC analysis, small-signal model, superposition, common mode, differential mode, transfer function, frequency response, stability criteria, etc. – Describes appropriately the fundamental concepts and characteristic quantities that describe the operation and performance of analog integrated circuits. – Highlights the methods for analyzing the frequency response of an analog electronic system and investigating its stability. – Correctly identifies the role of devices in the operation of analog integrated circuits. – Understands the techniques for compensating the temperature dependence of current sources and voltage references. – Understands the modeling techniques of amplification stages, their role in the design of operational amplifiers, and the associated advantages and disadvantages. – Understands and describes appropriately the effect of device tolerances and the pairing techniques for reducing the sensitivity of circuits to them.
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 of the analysis and design of analog integrated circuits. – Uses the concepts of analysis and design of analog integrated circuits argumentatively in order to correctly address problems. – Verifies experimentally the identified solutions for the practical resolution of applications of analog integrated circuits. – Formulates correct conclusions about the results of the conducted experiments. – Justifies the methods and the solutions used to solve problems.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* – Selects appropriate bibliographic sources and analyzes them. – Respects academic ethics by correctly citing the bibliographic sources used. – Demonstrates receptiveness to new learning contexts. – Collaborates with peers and faculty in conducting educational activities. – Demonstrates autonomy in organizing the learning context and problems to be solved. – Recognizes the value of their contribution to the engineering field in identifying viable solutions to address social and economic problems. – Analyzes business opportunities or entrepreneurial development based on the knowledge acquired in the field. – Demonstrates time management skills and other real-life situation management abilities.

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 coursework is approached in an interactive manner, encouraging active student participation. Both classical teaching methods are used (lecture and exposition), using PowerPoint presentations through multimedia means, as well as interactive ones, based on question-and-answer sessions and student feedback, constantly adapting the pedagogical approach to the students' assimilation and learning possibilities (through additional review of certain notions and concepts, if this proves necessary).
Each meeting begins with a brief recap of the previous chapters, with an emphasis on the concepts covered in the last meeting. The presentations use numerous images and diagrams, so that the information presented is as easy to understand and assimilate as possible. A number of exercises or problems are worked with the students and the homework related to the course chapters is discussed with them.
Complete course materials are available in electronic form on the faculty's Moodle platform.
– Teaching in the tutorial and laboratory sessions is based on oral communication and detailed explanation of the methods used and the results obtained, in a constantly interactive manner. Students independently implement and evaluate the same problems using the computer and software and/or hardware environment. The developed applications help students in developing optimal communication relationships in a climate conducive to learning through discovery.
All tutorial and laboratory materials are available in electronic form on the faculty's Moodle platform.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	"Introduction" – General overview, history. Areas of application, performance, limitations	4
2	"CMOS Technology" – Physics and modeling of MOS and bipolar devices. Analysis of second-order effects	8
3	"Operational Amplifiers" – Modeling analog systems with and without feedback. Parameters of operational amplifiers and deviations from ideality	2
4	"Operational Amplifiers" – Linear and non-linear applications of ideal operational amplifiers. Basic comparator and hysteresis comparator. Effects of non-idealities on performance	8
5	"Operational Amplifiers" – Frequency response analysis, Bode plots, stability analysis. Miller's theorem	6
6	"Current Sources and Voltage References" – Elementary and advanced current sources (CASCOD, Wilson, Widlar). Voltage references and techniques for correcting their temperature characteristics. Methods for improving power supply rejection ratio	6
7	"Internal Structures of Operational Amplifiers" – Elementary amplification stages. Study of differential stages with resistive and active loads (large-signal operation, small-signal analysis, common-mode input voltage range and output voltage swing). Evaluation and improvement of CMRR and PSRR	4
8	"Internal Structures of Operational Amplifiers" – Two-stage Miller amplifiers. Amplifiers with increased output voltage swing. CASCOD and folded CASCOD amplifiers. Output stages and classes of operation. Frequency compensation techniques	4
	Total:	42

Bibliography:
1. Ş. Mihalache, M. Enăchescu, *Analog Integrated Circuits*, lecture notes available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. B. Razavi, *Design of Analog CMOS Integrated Circuits*, 2nd Ed., McGraw-Hill, 2017.
3. A.S. Sedra, K.C. Smith, *Microelectronic Circuits* (*The Oxford Series in Electrical and Computer Engineering*), 7th Ed., Oxford University Press, 2014.
4. R.J. Baker, *CMOS Circuit Design, Layout, and Simulation*, 4th Ed., IEEE Press, Wiley, 2019.
5. P.R. Gray, P.J. Hurst, S.H. Lewis, R.G. Meyer, *Analysis and Design of Analog Integrated Circuits*, 4th Ed., John Wiley & Sons, 2001.

LABORATORY

Crt. no.	Content	No. hours
1	Introduction to the LTSpice design and simulation environment	2
2	Experimental study of basic circuits using operational amplifiers	2
3	Simulation of the functionality of basic circuits using operational amplifiers	2
4	Evaluating operational amplifier parameters through simulation. Experimental study of operational amplifier parameters and characteristics	2
5	Simulation of the functionality of current sources and voltage references	2
6	Simulation of the functionality of differential amplifiers	2
7	Final colloquium	2
	Total:	14

SEMINARY

Crt. no.	Content	No. hours
1	Linear applications of ideal operational amplifiers	2
2	Non-linear applications of ideal operational amplifiers	2
3	Frequency response of analog systems and stability analysis	2
4	Current sources and voltage references	2
5	Differential amplifiers	2
6	Internal structures of operational amplifiers. Output stages	2
7	Final colloquium	2
	Total:	14

Bibliography:
1. Ş. Mihalache, *Analog Integrated Circuits – Tutorial notes and support*, available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. M. Enăchescu, F.S. Dumitru, Ş. Mihalache, *Analog Integrated Circuits – Lab tutorial*, available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
3. A. Manolescu, A. Manolescu, C. Popa, *Analiza şi proiectarea circuitelor integrate analogice VLSI CMOS*, Printech, 2006.

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of fundamental theory and concepts relating to analog integrated circuit analysis and design. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Exam during the exam session (written evaluation)	50%
11.5 Seminary/laboratory/project	Knowledge of fundamental theory and concepts relating to analog integrated circuit analysis and design. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Tests during the tutorial sessions (written evaluations) Final tutorial colloquium (written evaluation)	20%
	Knowledge of fundamental theory and concepts relating to analog integrated circuit analysis and design. Understanding how to simulate and implement (software and hardware) the studied circuits using an advanced development environment (LTSpice) and the hardware platforms.	Continuous evaluation (practical and oral evaluation) Final laboratory colloquium (practical and oral evaluation)	30%
11.6 Passing conditions			
– Obtaining a grade of at least 50%. – Meeting the general laboratory activity requirements (attending the lab sessions and attempting the final colloquium).			

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 analysis and design of analog integrated circuits is a highly relevant field today, with a significant demand for engineers in the field of analog integrated circuit design. The analog structures studied have a multitude of practical applications in most areas of electronics, as well as in fields that indirectly use electronic circuits. The course program directly addresses current requirements and technological trends. The course and its associated applications provide students with the knowledge and skills that enable them to find rapid employment after graduation in a prestigious company in the field.

Date	Course lecturer	Instructor(s) for practical activities

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26.09.2025	Ş.L. dr. ing. Şerban MIHALACHE	Ş.L. dr. ing. Şerban MIHALACHE

Date of department approval	Head of department Prof. dr. ing. Claudius DAN
Date of approval in the Faculty Council	Dean Prof. dr. ing. Radu Mihnea UDREA