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	**Applied Electronics and Information Engineering**
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			
2.2 Course Lecturer				Prof. Dr. Ing. Cosmin Radu Popa			
2.3 Instructor for practical activities				Prof. Dr. Ing. Cosmin Radu Popa			
2.4 Year of studies	3	2.5 Semester	1	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	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	70	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.					55
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	Electronic devices. Fundamental electronic circuits
4.2 Results of learning	General knowledge of electronic devices and circuits

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

5.1 Course	Understanding of course information.

5.2 Seminary/ Laboratory/Project	Compulsory presence at laboratory classes, according to current PUB 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)*

Analysis, design, applications and performances' optimization of MOS and bipolar analog integrated circuits. Behavior and analysis of various electronic configurations common to many types of analog integrated circuits as: current sources, voltage and current references, small-signal amplifiers, differential amplifiers, output stages, protection circuitry. Presentation of the most widely used internal structures of analog integrated circuits, with a special emphasis on the basic configuration of operational amplifiers. Discussion of the various nonideal characteristics of operational amplifiers. Analysis of circuits' frequency response and study of the stability of feedbacked circuits. Analysis of linear and nonlinear analog computational structures.

Practical applications of the material from the course, such as analysis and design of the various subcircuits common in analog integrated circuits, including differential amplifiers, current sources, internal structures of operational amplifiers, various linear and nonlinear applications of operational amplifiers. Hand calculations and simulations for validating the most important aspects of the analog circuits operation.

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	Obtaining the abilities of using general knowledge relating analog integrated circuits, as well as in designing systems that include these circuits and in the design of final analog integrated circuits. The possibility of evaluating, using the obtained knowledge, what particular type of analog integrated circuits and in what manner they can be used for an efficient solving of concrete requirements.
Transversal (General) Competences	Adequate general behavior.

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.* After studying and mastering the material taught in the "Analog integrated circuits" course, students will acquire a multitude of knowledge related to the functioning of this very important category of current circuits, with a very rapid development perspective in the coming years. "Analog integrated circuit" course studies fundamental blocks of analog circuits, analyzed and designed for their implementation in integrated technologies. This particularity of an integrate realization of analog circuits fundamentaly changes the designed principles, as well as the specific architectures of each circuit class, comparing with the circuit implementation using discrete components. In this sense, it appears additional information that must be analyzed, related to the matching of devices parameters and to the specific errors and limitations associated with the implementation in a particular technology, correlated with the difficulties imposed by the continuous reducing of integrated devices dimensions. Chapter I represents a recap and a synthesis of fundamentals for modeling bipolar and MOS devices, studied in previous disciplines. Linear and nonlinear applications from Chapter II (inverting and non-inverting amplifiers, adding and subtracting amplifiers, rectifiers or circuits for implementing logarithmic and exponential functiuon) use ideal operational amplifiers. The exclusive availability in practice of real operational amplifiers introduces a multitude of errors, in comparison with the operation using ideal circuits. It results the necessity of continuing the course, for analyzing the internal structures of operational amplifiers. In consequence, it is very important to study the constitutive blocks of operational amplifiers, such as current sources (Chapter III), elementary amplifier stages and differential amplifiers (Chapter IV) and output stages (Chapter V). Using all the previous informations, in Chapter VI is analyzed internal architectures of operational amplifiers and are qualitatively and quatitatively evaluated the errors from ideality and also the practical limitations of real circuits, comparing with ideal circuits, analyzed in Chapter II. Starting from the concrete architectures of operational amplifiers studied in Chapter VI, they are re-analyzed the applications with operational amplifiers (presented in Chapter II) and they are evaluated the effects of parameters of real operational amplifiers on the circuits operation. They are proposed methods for improving the performances of operational amplifiers, with a direct impact on maximizing the performances of analyzed applications from Chapter II. Chapter VII studies the circuits frequency response, presenting concrete methods for evaluating analog circuits stability.

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).* Based on the knowledge acquired following the completion and acquisition of knowledge related to the discipline of "Analog integrated circuits", students will be able to understand the operation of the most important categories of analog integrated circuits. Starting from the theoretical notions explained in detail, students will be able to propose concrete solutions to solve a multitude of practical situations, being able to compare the best implementations and choose the optimal implementation option. They will be able to select and group the relevant information in a given context, as well as to use in an argumentative way the specific principles of the analysis of analog integrated circuits in order to design some circuits with the performances required by the applications for which they are intended. Students will experimentally verify the solutions identified for the design of the proposed circuits in order to solve concrete practical applications, capitalizing on the optimal solutions in order to develop plans for solving existing practical problems. In the end, students will be able to formulate conclusions of the studies and experiments carried out, arguing the choice of specific solutions and proposed solutions. Deepening the theoretical and practical notions, students will develop skills related to the study of the latest bibliographic references in the field, as well as the ability to work in a team in order to develop a research project of medium complexity. Students will be able to coherently present and justify the choice of a certain design solution for the studied circuit and present the advantages of this decision.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Students will respect the principles of academic ethics, correctly citing the bibliographic sources used. They will show social responsibility through active involvement in the events of the academic community, a relevant example in this sense being the particularly important involvement of students in the organization and running of the student competition of analysis and design of analog integrated circuits "Tudor Tanasescu". Students will demonstrate receptivity to new learning contexts, achieving a balance between collaboration with other colleagues and teaching staff and demonstrating autonomy in organizing the learning context or the situation to be resolved. They will promote new solutions, related to the specific field of analog integrated circuits, in order to improve social life, realizing the value of their contribution in the field of engineering to the identification of sustainable solutions to solve concrete economic problems. Students will analyze and capitalize on business and entrepreneurial development opportunities in the field of analog integrated circuit design, developing real-life situation management skills.

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 teaching method is based on the utilization of video projections and MS Teams program, the course including a multitude of simulations of analyzed circuits, useful for a good understanding of the discipline and for a concrete evaluation of the limitations of the studied circuits.

Course information are represented by course notes and presentations, available on Moodle and on the following site:

https://curs.upb.ro/2021/course/view.php?id=9052

Teaching at the seminar starts from the explanations of the teacher and it is based on a direct involvement of students in solving problems. Presentations from the seminar lectures and problems are available in printed form (see the References). Theoretical knowledge form the seminar will represent the basis for laboratory.

10. Contents

COURSE

Chapter	Content	No. hours
1	"Modeling of bipolar and MOS devices" - Introduction. Modeling bipolar and MOS devices; analysis of second-order effects.	2
2	"Applications of operational amplifiers" - Linear and nonlinear applications with operational amplifiers. Parameters of operational amplifiers and their errors comparing with ideal circuits. Elementary comparator and comparator with histerezis.	9
3	"Current sources and voltage sources" - Elementary current sources and voltage sources. Cascode and self-biased current sources. Current and voltage references. Techniques for realizing the correction of temperature characteristic of voltage references. Methods for improving the power supply rejection for analyzed circuits.	7
4	"Elementary amplifiers" - Elementary amplifier stages. Study of differential amplifiers - large signal analysis and small signal analysis; determination of the common-mode input voltage range and the rail-to-rail operation. Study of differential amplifiers having an independent-biased current source as load, of differential amplifiers with a current mirror as load, as well as of cascode differential amplifiers. Evaluation and improvement of CMRR and PSRR; particularities depending on the type of the output (simple or differential). Determination of miasmatches effect on the operation of differential amplifiers.	8
5	"Output stages" - Output stages: operation classes, architectures, operation, characterization	2
6	"Operational amplifiers. Internal structures" - Study of internal structures of operational amplifiers. Cascode and folded cascode operational amplifiers. Evaluation of nonidealities of operational amplifiers and methods for improving of their performances. Rail-to-rail operation of operational amplifiers	9
7	"Frequency response of circuits. Stability of circuits" - Bode diagrams. Methods of analysis of frequency response (direct analysis, open circuit and short circuit time constants method, Miller theorem). Evaluation of circuits stability. Frequency compensation of operational amplifier, dominant pole, poles spliting.	5
	Total:	42

Bibliography:

https://curs.upb.ro/2021/course/view.php?id=9052 - cours slides on Moodle

Anca Manolescu, Anton Manolescu, Cosmin Popa, *Analiza şi proiectarea circuitelor integrate analogice VLSI CMOS*, Editura Printech, 2006

Anca Manolescu, Anton Manolescu, Cosmin Popa, *Circuite integrate analogice*, Editura Universităţii Politehnica din Bucureşti, 2005

Cosmin Popa, *Circuite integrate analogice. Indrumar de laborator*, Editura Printech, 2014

LABORATORY

Crt. no.	Content	No. hours

1	Presentation of LT Spice simulation program	2
2	Experimental study of elementary circuits with operational amplifiers	2
3	Simulation of operation of elementary circuits with operational amplifiers	2
4	Evaluation using simulations of operational amplifiers parameters. Experimental study of operational amplifiers parameters and characteristics	2
5	Simulation of current sources operation. Simulation of voltage references operation	2
6	Simulation of differential amplifiers operation	2
7	Laboratory final test	2
	Total:	14

SEMINARY

Crt. no.	**Content**	**No. hours**
1	Linear applications with operational amplifiers	2
2	Nonlinear applications with operational amplifiers	2
3	Recap on on fundamental electronic circuits. Parameters of operational amplifiers	2
4	Current sources. Voltage references	2
5	Differential amplifiers. Output stages	2
6	Internal structures of operational amplifiers	2
7	Frequency response and the analysis of circuits stability. Test for evaluation of the seminar activity	2
	Total:	14

Bibliography:

https://curs.upb.ro/2021/course/view.php?id=9052 - cours slides on Moodle and Teams

Anca Manolescu, Anton Manolescu, Cosmin Popa, *Analiza şi proiectarea circuitelor integrate analogice VLSI CMOS*, Editura Printech, 2006

Anca Manolescu, Anton Manolescu, Cosmin Popa, *Circuite integrate analogice*, Editura Universităţii Politehnica din Bucureşti, 2005

Cosmin Popa, *Circuite integrate analogice. Indrumar de laborator*, Editura Printech, 2014

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Final exam	Knowledge of modality of solving problems specific to analog integrated circuits	50%
11.5 Seminary/laboratory/project	Evaluation of activity from the seminar	Knowledge of theoretical fundamentals and of their modalities of using them for solving specific problems and applications of analog integrated circuits	20%
	Evaluation of the laboratory work	Knowledge of theoretical fundamentals and of theirmodalities of using them for solving specific problems and applications of analog integrated circuits	30%

11.6 Passing conditions
At least 50% from total number of points At least 50% from the points for semester activities

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)

Analysis and design of analog integrated circuits is an area of great interest, there is an important demand for engineers in the design of analog integrated circuits. Studied and designed analog structures present a multitude of practical applications in most areas of electronics, as well as in areas that indirectly uses electronics. The course curricula specifically responds to current trends and technological evoloution. The course and its related applications provide students knowledge and skills that enable quick employment after graduation in a reputed company in the field.

Date	Course lecturer	Instructor(s) for practical activities
	Prof. Dr. Ing. Cosmin Radu Popa	Prof. Dr. Ing. Cosmin Radu Popa

Date of department approval	Head of department
21.10.2025	Conf. Dr. Bogdan Cristian Florea

Date of approval in the Faculty Council	Dean
	Prof.dr.ing. Mihnea Udrea