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	Bachelor/Undergraduate
1.6 Programme of studies	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Modelarea componentelor microelectronice active			
2.2 Course Lecturer				Prof. Dr. Lidia Dobrescu			
2.3 Instructor for practical activities				Prof. Dr. Lidia Dobrescu			
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.411		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4	Out of which: 3.2 course	3.00	3.3 seminary/laboratory	1
3.4 Total hours in the curricula	56.00	Out of which: 3.5 course	42	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.					30
Tutoring					10
Examinations					20
Other activities (if any):					9

3.7 Total hours of individual study	69.00
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 Course

4.2 Results of learning	General knowledge of physics, electronic devices and software General knowledge of physics, electronic devices and software simulation of electronic circuits simulation

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

5.1 Course	The course will take place in a room equipped with a video projector or using MSTeams platform
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room with specific equipment, which must include: computers, INTERNET connection, SPICE-type electronic circuit simulator or on the MSTeams platform, students having computers with a SPICE-type simulator installed.

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 general objective of the discipline consists in:

Advanced models for bipolar and MOS transistors presentation, highlighting some high-level physical aspects and their reflection in models used for the design of integrated circuits. This general objective is achieved through:

- Highlighting and describing the specific parameters of advanced models for bipolar and MOS transistors.

- Extracting model parameters from electrical meters or catalog sheets

- Exposition of situations resulting from advanced design experience

for the experimental model parameters

- The detailed presentation of some extreme operating regimes such as breakdown through carrier multiplication or through punch through phenomenon and some top technologies in the field of MOS transistors with submicron dimensions.

-Solving simple circuits based on fundamental models and extracting model parameters from specific electrical meters.

- Programs for optimal extraction of model parameters for bipolar and unipolar devices presentation.

- Simulation programs presentation.

- Establishing some physical and technological limits in the construction of devices for integrated circuits on an ultra-large scale.

- Specific parameters of some fundamental models to include the latest developments

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	C1. Fundamentals related to devices, circuits, systems, instrumentation and electronic technology usage. C2 Multiple competencies to practice as a designer of integrated microsystems, of medium complexity, or as a process technologist, using software tools and the latest micro-nanoelectronic technologies C3. Modeling and processing of devices and integrated circuits using modern micro and nanoelectronic technologies
Transversal (General) Competences	CT1 Adaptation to new technologies, professional and personal development, through continuous training using printed documentation sources, specialized software and electronic resources in Romanian and, at least, in one language of international circulation. CT2 Honourable, responsible, ethical behavior in the spirit of the law to ensure the reputation of the profession CT3 Awareness of the need for continuous training; effective use of learning resources and techniques for personal and professional development

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.* • List the fundamental designs of bipolar and MOS transistors • Defines model parameters • Describes/classifies model parameters • Highlights the particularities of special constructive solutions
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).* • Select and group relevant information about construction types of bipolar and MOS transistors. • Reasonably uses specific principles in order to preserve or neglect some model parameters. • Work productively in a team to perform the laboratory. • Elaborate a scientific text in the drafting of the laboratory reports. • Experimentally verify the model parameter extraction solutions. • Solve practical applications in the laboratory, processing data sets from catalog sheets. • Adequately interpret causal relationships between extracted values. • Analyzes and compares the values of the parameters extracted during the laboratory works. • Identifies solutions and prepares laboratory reports. • Formulates conclusions to the experiments carried out • Argue the solutions identified in practical applications.

Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* • Select appropriate bibliographic sources and analyze them. • Respect the principles of academic ethics, correctly citing the bibliographic sources used. • Demonstrates responsiveness to new learning contexts. • Demonstrates collaboration with other colleagues and teaching staff in carrying out teaching activities • Demonstrates autonomy in organizing the learning situation/context or the problem situation to be solved • Promotes/contributes through new solutions related to the specialized field. • Realizes the value of his engineering contribution to the identification of viable/sustainable solutions • Apply ethical principles

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.)*

Starting from the analysis of students' learning characteristics and their specific needs, the teaching process will explore both expository (lecture, exposition) and conversational-interactive teaching methods, based on discovery learning models facilitated by direct exploration and indirect of reality (experiment, demonstration, modelling), but also on action-based methods, such as exercise, practical activities and problem solving.

Lectures will be used in the teaching activity, based on Power Point presentations or different Internet pages that will be made available to students. Each course will start with a recap of the chapters already covered, with an emphasis on the concepts covered in the last course.

Presentations use images and diagrams so that the information presented is easy to understand and assimilate.

This discipline covers information and practical activities designed to support students in their learning efforts and the development of optimal collaborative and communicative relationships in a climate conducive to discovery learning.

It will be considered the practice of active listening and assertive communication skills, as well as feedback construction mechanisms, as ways of regulating behavior in various situations and adapting the pedagogical approach to the students' learning needs.

Teamwork skills will be practiced to solve different learning tasks.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction 1.1. The course subject 1.2. General presentation of specific objectives, general presentation of active component modeling principles 1.3. Overview of lab requirements	3

2	BJT Modeling 2.1. The direct current regime of the bipolar transistor 2.1.1. The fundamental model (Ebers-Moll) 2.1.2. Modeling of generation-recombination currents in empty regions and specific parameters 2.1.3. Modeling the high injection level at the emitter-base junction 2.1.4. Dependence of the gain factor on the collector current 2.1.5. Modeling the Early effect 2.1.6. Modeling series resistors, Verzelessi Method 2.1.7. The Gummel-Poon model 2.2. The dynamic regime of the bipolar transistor 2.2.1. The large signal equivalent circuit 2.2.2. The capacities of transition, diffusion, substrate 2.2.3. Small-signal equivalent circuit 2.2.4. Dynamic parameters	15
3	Modeling the MOS transistor 3.1. General physical model 3.1.1. Constructive and polarizing elements 3.1.2. Gradual approximation 3.1.3. The general expression of the drain current 3.2. Static models in strong inversion 3.2.1. The Ihantola-Moll model 3.2.2. The Merckel-Borel-Cupcea model 3.2.3. The saturation regime 3.2.4. Dependence of mobility on electric field intensity 3.3. Static models in weak inversion (below threshold) 3.4. The dynamic regime of the MOS transistor	18
4	Short Channel Effects Modeling: threshold voltage variation, Drain Induced Barrier Lowering, electrons velocity saturation, electrons mobility decreasing, Reverse short channel effects (RSCE), Punch -through, thin oxide curents,tunneling , Hot carriers effects, series resistances, output conductance.	3
	Total:	42

Bibliography:
1. L. Dobrescu Curs Moodle 04-ELECTRONICA-L-A4-S2: Active Microelectronic Devices Modeling https://archive.curs.upb.ro/2021/course/view.php?id=9167
2. A. Rusu, “Active Microelectronic Devices Modeling”, Romanian Academy Publishing House, 1990.
3. A. Rusu, „Nonlinear Electrical Conduction in Semiconductor Structures ”,Romanian academy Publishing House , 2000;
4. L. Dobrescu, D. Dobrescu, „MOS Devices Advanced Models Printech, Publishing House Bucharest, 2002;
5. L. Dobrescu, D.Dobrescu, "Basics of the Semiconductor Devices Physics", 142 pg., Ed. Printech, ISBN 973-718-364-9, Bucuresti, 2005;.

LABORATORY		
Crt. no.	**Content**	**No. hours**

1	Semiconductor Diodes Modeling in ORCAD CAPTURE CISLITE, including special types of diodes, extracting their parameters and comparing them wih data sheets parameters.	2
2	Modeling bipolar transistors in LTSPICE in order to extract specific parameters using the MICROCAP program and compare them wih data sheets parameters.	4
3	Modeling MOSFET in LTSpice and specific parameters extraction.	6
4	Final revision and Verification	2
	Total:	14

Bibliography:
1. L. Dobrescu Curs Moodle 04-ELECTRONICA-L-A4-S2: Active Microelectronic Devices Modeling

2. D.Dobrescu , L.Dobrescu, “Electronic Devices and Circuits-Activity book ”, 158 pag.,. Printech, Publishing House ISBN 973-652-829-4, Bucharest, 2003;

3. MICROCAP , http://www.spectrum-soft.com/index.shtm

4. LTSpice https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html

5. ORCAD https://www.orcad.com/resources/download-orcad-lite
https://archive.curs.upb.ro/2021/course/view.php?id=9167 Electronic platforms available on Moodle and Teams

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Theoretical knowledge of models for bipolar transistors (BJTs) and their parameters	Homework+ Written Examination+Problems+Moodle quizz	50%
	Theoretical knowledge of MOSFETs models and their parameters	Verification+Final Moodle quizz	30%
11.5 Seminary/laboratory/project	The evaluation is done cumulatively at the end of the laboratory both from the extraction of the model parameters of diodes, bipolar transistors and MOS transistors	Oral and computer verification for the extraction of model parameters from the content of laboratory work	20%
11.6 Passing conditions			

Highlighting important parameters for BJT model MOS model description and highlighting its parameters. Obtaining 50% of the total score of the laboratory; Compliance with the UPB regulation on promotion conditions.

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 content of the subject is largely similar to that of subjects with the same objectives taught in universities in the European Union. The content of the discipline is continuously updated and adapted following consultations with representatives of the business environment in Bucharest.

Date	Course lecturer	Instructor(s) for practical activities
09.09.2022	Prof. Dr. Lidia Dobrescu	Prof. Dr. Lidia Dobrescu

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