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	Technologies and Telecommunications Systems

2. Date despre disciplină

2.1 Course name (ro) (en)				Dispozitive electronice Electronic Devices			
2.2 Course Lecturer				Prof. Dr. Gabriel Dima			
2.3 Instructor for practical activities				Prof. Dr. Gabriel Dima			
2.4 Year of studies	2	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.03.O.002		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	2.00	3.3 seminary/laboratory	3
3.4 Total hours in the curricula	70.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	42
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.					64
Tutoring					0
Examinations					6
Other activities (if any):					0

3.7 Total hours of individual study	80.00
3.8 Total hours per semester	150
3.9 Number of ECTS credit points	6

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Mathematics, Physics 1 & 2, Fundamentals of Electrical Engineering, Measurements in Electronics and Telecommunications.

4.2 Results of learning	General principles of solid state physics, electricity, mathematics, electric circuits analysis and able to use general purpose measurement equipment.

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

5.1 Course	Lecture room equipped with multimedia projector, white or chalkboard and internet connection.
5.2 Seminary/ Laboratory/Project	Seminar room/Laboratory equipped with multimedia projector, white or chalkboard and internet connection. Minimum 15 experimental platforms that includes measurement boards and general purpose measurement equipment for the measurement and characterization of electron devices. 15 personal computers running device and 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)*

Study of semiconductors' solid state physics with regards to pn-junction, metal-semiconductor interface and MOS capacitor together with the electrical behaviour and steady state and dynamic models for basic electron devices: pn junction diode, Schottky diode, Junction Field Effect Transistor (J-FET), Metal Oxide Semiconductor Transistors (MOS-FET) and Bipolar Junction Transistor (BJT).

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	Basic knowledge related to solid state physics with special regards to semiconductor physics. Advanced knowledge related to device physics, operation modes and steady state and dinamic modelling for pn junction, Schottky diode, JFET, MOSFET and BJT. Ability to apply the knowledge acquired related to device modelling and equivalent circuits for analysis and design on analog as well as digital circuitry. Ability to extract optimal parameters for devices for given circuit topologies.
Transversal (General) Competences	Team work, efficient communication: ability to efficient cooperate with the other member of the team to solve problems of medium complexity. Critical thinking: ability to think scientifically, to inquire and to analyze data independently and to draw conclusions as well as to identify solutions. Capacity of analyse and synthesise: ability of presenting the acquired knowledge following a systematic analysis. Follow the academic ethical principles: during the desk research, cite correctly the reference sources.

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.* Ability to list and describe the most important properties of semiconductor materials used in the production of semiconductor devices. Ability to define specific characteristics of studied electron devices. Ability to describe/classify concepts/phenomena/models for diodes and transistors. Ability to define DC biasing modes and dynamic circuit models for studied electron devices.
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).* Ability of working in teams. Ability to solve practical exercises using the acquired knowledge. Ability to propose practical schemes for circuits incorporating studies electronic devices. Ability to identify the electrical behaviour of electron devices within given circuits. Ability to differentiate between the electron devices behaviour in DC and small-signal dinamic modes. Ability to differentiate between the linear and non-linear behaviour of electron devices. Ability to analyse elementary circuits with diodes and transistors. Ability to acknowledge the importance of model parameters for electrical behaviour of studies electron devices.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Ability to undertake a proper desk research and analysis of references. Respect the academic ethical principles, by correct citing the used references. Prove openness for new learning contexts. Cooperate with other colleagues and academic staff in the implementation of academic activities. Prove autonomy in setting-up the learning context or of the problem to be solved. Contribute through new solutions related to its field of study for the improvement of the quality of life. Be aware of its contribution within the engineering through identification of solutions for reallife problems from the society (social responsibility). Apply the ethical principles in analysing the impact the proposed solutions on the environment. Analise and take advantage of opportunities of personal entrepreneurial development. Prove management abilities in real life settings.

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 laboratory activities are divided in two rooms: the first one is equipped with 15 experimental platforms that includes measurements boards and general purpose measurement equipment for the measurement and characterisation of electron devices while the second one is equipped with 15 personal computer having installed different devices and circuit simulation software. In the beginning of each laboratory, the students are introduced to the given topic by the tutors that afterwards guide them during the whole time – the laboratory notes consist in all the needed information in terms of theoretical background, measurement settings, practical steps as well as hints in order that the students to successfully finalize the required tasks (the laboratory notes are available within the laboratory book „Dispozitive electronice-Îndrumar de laborator” and online at

https://wiki.dcae.pub.ro/index.php/Pagina_principal%C4%83#Platforme_de_aplicatii_sau_laborator).
Within the first meeting, the students are introduced to the lab rules and procedures (working security included), equipment operation hands-on and measurements boards.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Semiconductors Fundamentals 1.1 Semiconductors. Insulators. Metals 1.2 Electrons and holes 1.3 Intrinsic and extrinsic semiconductors 1.4 Drift and diffusion 1.5 Generation and recombination 1.6 Semiconductor equations 1.7 Electrical signals for semiconductor devices 1.7.1 Analog and digital signals 1.7.2 Small signal and large signal 1.73 Stationary and Quasi-Stationary Signals. Operation at high frequencies. The effect of internal capacities	2
2	Semiconductor Diodes 2.1 Diodes applications 2.2 pn Junction 2.2.1 Electrostatics of pn junction 2.2.2 Current voltage relationships 2.2.3 pn junction breakdown 2.2.4 Small signal modeling 2.3 pn Junction diode 2.4 Metal-semiconductor contact 2.5 Light-emitting diode (LED) 2.6 Thermal behavior of semiconductor diodes 2.7 Applications	10
3	Metal Oxide Semiconductor (MOS) Field Effect Transistor 3.1 Field effect transistor concept. Classification 3.2 MOS capacitor 3.3 Enhancement MOS. 3.3.1 Structure. Channel inducing 3.3.2 Threshold voltage. Channel conductance 3.3.3 Operation modes 3.3.4 Current voltage relationships. 3.3.5 MOS transistor models 3.4 Depletion MOS. Structure and operation 3.5 Applications	8

4	Bipolar transistor 4.1 Device structure. npn and pnp transistors 4.2 Transistor effect 4.3 Ebers-Moll equations 4.4 Operating modes. Configurations 4.5 Simplified modeling 4.6 Second order characteristics of transistor 4.7 Full modeling in forward active mode 4.8 High frequency transistor response 4.9 Transistor breakdown voltages 4.10 Transistor temperature behavior 4.11 Comparison between bipolar junctions transistor and MOS transistor	8
	Total:	28

Bibliography:

1. G. Dima, Electronic Devices – Lecture notes (electronic/Moodle), 2011.
2. D. Dascălu et al., Dispozitive şi Circuite Electronice, Ed. Didactica şi Pedagogică, 1982.
3. R. Muller, T. Kamins, Devices Electronics for Integrated Circuits, Wiley and Sons, New York, 1988.
4. R. F. Pierret, G. W. Neudeck, Modular Series on Solid State Devices, Addison – Wesley, New York, 1990.
5. C.G. Fonstad, Microelectronic Devices and Circuits, McGraw-Hill, 1994.
6. A. Sedra, K.C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.
7. S.M. Sze, K.W. Ng, Physics of Semiconductor Devices, 3rd edition, Wiley Interscience, New Jersey, USA, 2007.
8. P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, Analysis and Design of Analog IC's, 5th Edition, J. Whiley & Sons, 2009.
9. T.L. Floyd, Electronic Devices- Electron Flow Version, 9th edition, Prentice Hall, 2012.
10. B. Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, McGrawHill, 2013.

LABORATORY

Crt. no.	Content	No. hours
1	Semiconductor Diodes 1.1 - Measuring of static and dynamic parameters. 1.2 - Simulation of a pn junction using a simulator.	4
2	Bipolar transistor 2.1 - Measuring of static and dynamic parameters. Common emitter amplifier stage. 2.2 - Spice simulations of basic amplifier stage	4
3	nMOS and junction field effect transistor 3.1 - Measuring of static and dynamic parameters. Common source amplifier stage. 3.2 Parameter extraction for diodes, bipolar and FET transistors	4
4	Final verification – practical test	2
	Total:	14

SEMINARY

Crt. no.	Content	No. hours
1	Electrons and holes. Extrinsic semiconductors. Semiconductor resistivity.	2

2	PN junction. Depletion region. Semiconductor diodes. Diode DC operating point using an iterative method. Diode circuits - DC and Small signal analysis.	2
3	JFET. Current sources and single stage amplifiers involving J-FETs (common source and degenerated source)	2
4	Single stage amplifiers involving J-FETs (common gate and common drain).	2
5	Single stage amplifiers involving J-FETs (cont').	2
6	MOSFET. Current sources and single stage amplifiers involving MOSFETs (common source and degenerated source)	2
7	Single stage amplifiers involving MOSFETs (common gate and common drain).	2
8	Single stage amplifiers involving MOSFETs and FETs.	2
9	Single stage amplifiers involving MOSFETs and FETs (cont').	2
10	BJT. Current sources and single stage amplifiers involving BJTs (common emitter and degenerated emitter).	2
11	Single stage amplifiers involving BJTs (common base and common collector).	2
12	Single stage amplifiers involving BJTs, MOSFETs and FETs.	2
13	Single stage amplifiers involving BJTs, MOSFETs and FETs (cont').	2
14	Single stage amplifiers involving BJTs, MOSFETs and FETs (cont').	2
	Total:	28

Bibliography:
1. G. Dima – Electron Devices, Seminar notes (electronic / Moodle), 2011.
2. D. Dascălu et al., Dispozitive şi Circuite Electronice – Probleme, Ed. Didactica şi Pedagogică, 1982.
3. G. Brezeanu, G. Dilimoţ, F. Mitu, F. Drăghici, Dispozitive electronice-Probleme , Ed. Rosetti Educaţional, Bucureşti, 2009.
4. I. Rusu, F. Babarada, F. Drăghici, Dispozitive Electronice - Îndrumar de Laborator, Editura Rosetti Educațional, București, ISBN 978-973-7881-71-7, 2011.
5. R. Muller, T. Kamins, Devices Electronics for Integrated Circuits, Wiley and Sons, New York, 1988.
6. R. F. Pierret, G. W. Neudeck, Modular Series on Solid State Devices, Addison – Wesley, New York, 1990.
7. C.G. Fonstad, Microelectronic Devices and Circuits, McGraw-Hill, 1994.
8. A. Sedra, K.C. Smith, Microelectronic Circuits, 5th Edition, Oxford University Press, 2004.
9. S.M. Sze, K.W. Ng, Physics of Semiconductor Devices, 3rd edition, Wiley Interscience, New Jersey, USA, 2007.
10. P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, Analysis and Design of Analog IC's, 5th Edition, J. Whiley & Sons, 2009.
11. T.L. Floyd, Electronic Devices- Electron Flow Version, 9th edition, Prentice Hall, 2012.
12. B. Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, McGrawHill, 2013.
13. Elettronica Veneta SPA, Power Supply Unit, mod. PSLC/EV, Teacher/Student handbook, Treviso, Italy, 2008.
14. Elettronica Veneta SPA, Electronic Devices and Circuits Mod. MCM3/EV, Volume 1/2, Theory and Experiments, Teacher/Student manual, "Final English version provided by Cambridge Open Learning", Treviso, Italy, 2008.
15. Elettronica Veneta SPA, Electronic Devices and Circuits Mod. MCM3/EV, Volume 2/2, Service Manual, Teacher manual, Treviso, Italy, 2008.
16. Elettronica Veneta SPA, Electronic Devices and Circuits Mod. MCM4/EV, Volume 1/2, Theory and Experiments, Teacher/Student manual, "Final English version provided by Cambridge Open Learning" Treviso, Italy, 2008.
17. Elettronica Veneta SPA, Electronic Devices and Circuits Mod. MCM4/EV, Volume 2/2, Service Manual, Teacher manual, Treviso, Italy, 2008.

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade

11.4 Course	Knowledge of fundamental theoretical concepts, of using theory to solve especific problems and understanding and use of model parameters and equivalent circuits for diodes.	A written midterm test, that covers 50% of the content, focusing both on theoretical knowledge evaluation and solving problems that illustrate semiconductors use in devices fabrication and the operation of pn junction and diodes in specific electronic circuits.	30%
	Knowledge of fundamental theoretical concepts, of using theory to solve specific problems and understanding and use of model parameters and equivalent circuits for field effect and bipolar transistors.	Final examination, with the possibility of retaking the midterm test. This exam is focused both on theoretical knowledge evaluation and solving problems that illustrate operation and parameters of field effect and bipolar transistors, in specific single transistor amplifiers.	40%
11.5 Seminary/laboratory/project	Seminar - Understanding and use of established models for diodes, field effect and bipolar transistors in specific circuits.	Two written tests of equal weight, at dates fixed at the beginning of the semester; test topics are based on problems with numerical data on semiconductor physics and specific circuits with diodes, field effect and bipolar transistors.	20%
	Laboratory - Knowledge of measurement methods and characterization of fundamental electronic devices: diodes and transistors. Knowledge of analysis and characterization software for electronic devices.	Evaluation over the semester of practical activities undertaken. Grading based on the understanding of measurement methods and elaboration of main electrical characteristics of studied electronic devices. Final laboratory examination, evaluating both theoretical knowledge (questions) and practical abilities (implementation and testing of a specific electronic circuit).	10%
11.6 Passing conditions			
Acquiring a minimum score of 50% for all activities: for seminar - 10 points out of 100, for laboratory - 5 points out of 100, for the midterm test - 15 points out of 100 and for the final examination - 20 points out of 100.			

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)

Universitatea Națională de Știință și Tehnologie Politehnica București

Facultatea de Electronică, Telecomunicații și Tehnologia Informației

Electronic Devices subject represents a fundamental topic for an electrics and electronics engineering engineer. Deep knowledge of physics and semiconductor electronics devices have made possible major progress, explaining the unparalleled achievements in mobile communications, computers or audio and video electronic systems. This course presents the electrical behavior, models and equivalent circuits of diodes, field effect and bipolar transistors, as well as their uses within different purpose circuit with special regards to amplifier stages. By selection of important knowledge, of immediate or timeless topicality, the students are offered complete scientific and technical training, allowing employment opportunities after graduation in any electronics, telecommunications or information technology entity. Thus, the policy of National University of Science and Technology POLITEHNICA Bucharest, of promoting subjects strongly correlated with the actual demand of the labour market, is followed.

Date	Course lecturer	Instructor(s) for practical activities
21.09.2025	Prof. Dr. Gabriel DIMA	Prof. Dr. Gabriel DIMA
		Sl.Dr. Laurentiu TEODORESCU

Date of department approval	Head of department
	Prof. Dr. Claudius DAN

Date of approval in the Faculty Council	Dean
	Prof. Dr. Mihnea UDREA