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

# COURSE DESCRIPTION

## 1. Program identification information

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|---|---|
| 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)<br>(en) | | | | Dispozitive electronice<br>Electronic Devices | | | |
| 2.2 Course Lecturer | | | | Prof. Gheorghe BREZEANU, Prof. Dan NECULOIU, Prof. Lidia DOBRESCU, Prof. Gabriel DIMA, Prof. Cristian RAVARIU, Prof. Florin DRĂGHICI | | | |
| 2.3 Instructor for practical activities | | | | Lect. Dr. Ovidiu Profirescu | | | |
| 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)

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|---|---|---|---|---|---|
| 3.1 Number of hours per week | 5 | Out of which: 3.2 course | 2 | 3.3 seminary/laboratory | 3 |
| 3.4 Total hours in the curricula | 70 | 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<br>Supplemental documentation (library, electronic access resources, in the field, etc)<br>Preparation for practical activities, homework, essays, portfolios, etc. | | | | | 60 |
| Tutoring | | | | | 0 |
| Examinations | | | | | 10 |
| Other activities (if any): | | | | | 10 |

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| 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)

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| 4.1 Curriculum | Basics of Electrical Engineering, Physics |
| 4.2 Results of learning | Knowledge of physics, electricity, mathematics, electrical circuit analysis, solid-state physics |

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

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| 5.1 Course | Room equipped with whiteboard, video projector, and internet connection |
| 5.2 Seminary/ Laboratory/Project | • At least 15 laboratory platforms equipped with general-purpose measuring equipment and setups for measuring and characterizing electronic devices, 15 computers with simulation programs dedicated to electronic devices.<br>• The seminar will be held in a room with specific equipment. |

**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 physical phenomena, electrical behavior, steady-state and dynamic models for basic semiconductor devices: pn junction and Schottky diodes, junction gate field-effect transistor, MOS transistor, bipolar transistor. To explain device operation, basic concepts are introduced regarding semiconductors, the pn junction theory, the metal–semiconductor contact, and the MOS capacitor.

**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.)*

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| **Specific Competences** | • Familiarizing students with the operation of various families of diodes and transistors and with the use of these devices in circuits. Building skills to use model equations and equivalent circuits established for each device studied for the analysis and design of analog and digital circuits; Ability to select devices with optimal parameters for specific circuit structures;<br>• Use of fundamental elements related to devices, circuits, systems, instrumentation, and electronic technology;<br>• Design, measurement, simulation, and testing of electronic devices and circuits using modern software tools;<br>• Modeling and processing of devices and integrated circuits using advanced technologies; |
| **Transversal (General) Competences** | **Teamwork for** coordinating efforts with others to **solve special situations** with various degrees of difficulty<br>**Autonomy and critical thinking:** the ability to think in engineering terms, to search for and analyze data independently, as well as to derive and present new solutions.<br>**Capacity for analysis and synthesis**: presents the knowledge acquired in a synthetic manner, as a result of a systematic analysis process.<br>**Respects the principles of academic ethics.** Correctly cites bibliographic sources used as references in one’s own work. |

**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.)*

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| **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.*<br><br>· **Enumerates** and describes the most important properties of semiconductor materials exploited by electronic devices<br>· **Defines** notions specific to electronic devices<br>· **Describes/classifies** notions/processes/phenomena/models for diodes and transistors<br>· **Defines DC biasing regimes and small-signal dynamic equivalent circuits for the studied electronic devices**<br>· **Develops circuit operation models in DC and small-signal for semiconductor 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).*<br><br>· Teamwork<br>· Solves practical problems using theoretical knowledge<br>· Proposes practical applications for the studied electronic devices<br>· Identifies the electrical behavior of devices in a circuit<br>· Understands the difference between device operation in DC versus small-signal dynamic regime<br>· Distinguishes between linear and nonlinear operating modes of devices<br>· Analyzes elementary electronic circuits with diodes and transistors<br>· Identifies the importance of model parameters in the electrical operation of devices and circuits |

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| **Responsability and autonomy** | *The student's capacity to autonomously and responsably apply their knowledge and skills.*<br>• Selects appropriate bibliographic sources and analyzes them.<br>• Respects the principles of academic ethics, correctly citing the bibliographic sources used.<br>• Demonstrates receptiveness to new learning contexts.<br>• Collaborates with colleagues and teaching staff in conducting teaching activities.<br>• Demonstrates autonomy in organizing the learning situation/context or the problem to be solved.<br>• Contributes with new solutions, specific to the field, to improve the quality of social life.<br>• Becomes aware of the value of one's contribution in engineering for identifying viable/sustainable solutions to solve problems in social and economic life (social responsibility).<br>• Applies principles of ethics/professional deontology in analyzing the technological impact of proposed solutions in the specialty on the environment.<br>• Analyzes and leverages entrepreneurial development opportunities in the specialty field.<br>• Demonstrates management skills for 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 is taught using a chapter-by-chapter presentation (following the contents from point 10), using a PowerPoint video projection. The presentation content is explained in detail and discussed in front of the students. A series of more complex notions and problems are demonstrated on the board. The PowerPoint course support is available on Moodle.

At the seminar, the problematization method is used. Concrete problems with electronic devices are presented and solved on the board. Direct involvement of students in solving the problems is the basic rule of the seminar.

The main materials for the seminar are the course notes and the collection "Electronic Devices — Problems". In addition, the seminars are available on the Moodle platform.

The laboratory is organized in dedicated rooms, equipped with 15 measurement stations that include: a set of standard measuring instruments, setups with the devices to be characterized, and computers for data processing and simulation of various processes that describe the electrical behavior of the devices. All these systems are presented to students at the first laboratory session.

At each laboratory session, the instructor gives a brief presentation of the concepts to be used in that lab, after which students are guided to perform measurements on the setup intended for each device.

The documentation necessary for the laboratory work is included in the laboratory guide "Electronic Devices — Laboratory Guide" and on the website

https://wiki.dcae.pub.ro/index.php/Pagina_principal%C4%83#Platforme_de_aplicatii_sau_laborator

**10. Contents**

| **COURSE** | | |
|---|---|---|
| **Chapter** | **Content** | **No. hours** |
| 1 | 0. Introduction to the course topics<br>1. Notions of semiconductor materials physics<br>1.1 Semiconductors. Insulators. Metals<br>1.2 Electrons and holes<br>1.3 Intrinsic and extrinsic semiconductors<br>1.4 Fermi–Dirac statistics<br>1.4 Transport phenomena in semiconductors, drift and diffusion currents, electrical resistivity,<br>1.5 Generation and recombination<br>1.6 Basic equations of semiconductors<br>1.7 Electrical signals for semiconductor devices<br>1.7.1 Analog signals and rectangular signals<br>1.7.2 Small signal and large signal<br>1.7.3 Steady-state and quasi-stationary regime | 4 |
| 2 | 2. Fundamental semiconductor structures<br>2.1 Introduction<br>2.2 The pn junction at thermal equilibrium<br>2.3 The biased pn junction<br>2.4 Metal–semiconductor contact (Schottky contact)<br>2.5 The MOS capacitor | 3 |
| 3 | 3. Semiconductor diodes<br>3.1 Classes of diodes. Use. Applications<br>3.2 The pn junction<br>3.2.1 Electrostatics of the pn junction<br>3.2.2 Current–voltage relationships<br>3.2.3 Breakdown of the pn junction<br>3.2.4 Small-signal modeling. Internal capacitances<br>3.2.5 Series resistances<br>3.3 Temperature behavior of semiconductor diodes<br>3.4 Applications | 5 |
| 4 | 6. The bipolar transistor (BJT)<br>6.1 BJT structure. npn and pnp transistors<br>6.2 Transistor effect. Operating regimes<br>6.3 Ebers–Moll equations<br>6.4 Operating regimes. Configurations<br>6.5 Simplified modeling<br>6.6 Second-order physical phenomena in BJTs<br>6.7 Advanced modeling in the normal active region (NAR). Small-signal modeling.<br>6.8 Frequency behavior<br>6.9 Limit voltages for BJTs<br>6.10 Thermal regime of the BJT | 8 |

| | | |
|---|---|---|
| 5 | 5. The MOS transistor<br>5.1 General presentation<br>5.2 The induced-channel MOS transistor<br>5.2.1 Structure. Channel formation<br>5.2.2 Threshold voltage. Channel conductance<br>5.2.3 Operating regimes<br>5.2.4 Current–voltage relationships<br>5.2.5 MOS transistor modeling<br>5.3 The depletion-mode (initial-channel) MOS transistor<br>5.4 Applications<br>5.5 Comparisons between the bipolar transistor and the MOS transistor | 8 |
| | **Total:** | 28 |

**Bibliography:**

1. G.Brezeanu, L. Dobrescu, F. Draghici, D. Neculoiu, C. Ravariu, G. Dima, Dispozitive Electronice – suport de curs (electronic) - Moodle, 2025.https://archive.curs.upb.ro/2024/course/view.php?id=599
2. G. Brezeanu, F. Drăghici, Circuite electronice fundamentale, Ed. Niculescu, Bucureşti, 2013.
3. G. Brezeanu, G. Dilimoţ, F. Mitu, F. Drăghici, Dispozitive electronice-Probleme , Ed. Rosetti Educaţional, Bucureşti, 2009
4. R. Muller, T. Kamins, Devices Electronics for Integrated Circuits, Wiley and Sons, New York, 1988
5. R. F. Pierret, G. W. Neudeck, Modular Series on Solid State Devices, Addison – Wesley, New York, 1990
6. P. R. Gray, P. J. Hurst, S. H. Lewis, R. G. Meyer, Analysis and Design of Analog IC’s, ediţia 4, J. Whiley & Sons, 2005.
7. B. Razavi, Design of Analog CMOS Integrated Circuits, McGrawHill, 2001.
8. A. Sedra, K.C. Smith, Microelectronic Circuits,ediţia a 5-a, Oxford University Press, 2004.

**LABORATORY**

| Crt. no. | Content | No. hours |
|---|---|---|
| 1 | Semiconductor diodes<br>1.1 Measurements to determine static and dynamic parameters<br>1.2 Simulation of pn junction operation | 4 |
| 2 | Bipolar transistor<br>2.1 Measurements to determine static and dynamic parameters. CE stage.<br>2.2 Simulation of amplifier stages with bipolar transistor and field-effect transistor using the SPICE program | 4 |
| 3 | MOS and JFET field-effect transistors<br>3.1 Measurements to determine static and dynamic parameters. CS stage.<br>3.2 Extraction (by simulation) of model parameters for diodes, the bipolar transistor, and JFET | 4 |
| 4 | Laboratory colloquium | 2 |
| | **Total:** | 14 |

**SEMINARY**

| Crt. no. | Content | No. hours |
|---|---|---|

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|---|---|---|
| 1 | Circuits with semiconductor diodes<br>Determination of the static operating point by iterative calculation. | 6 |
| 2 | Circuits with bipolar transistors | 6 |
| 3 | Circuits with MOS transistors | 6 |
| 4 | Circuits with JFET transistors | 2 |
| 5 | Circuits with all types of transistors, Final review | 8 |
| | **Total:** | 28 |

**Bibliography:**

1. G.Brezeanu, L. Dobrescu, F. Draghici, D. Neculoiu, C. Ravariu, G. Dima, Dispozitive Electronice – suport de curs (electronic) - Moodle, 2025.https://archive.curs.upb.ro/2024/course/view.php?id=599
2. Dan Dascalu et al Dispozitive si Circuite Electronice, EDP 1982
3. Dan Dascalu et al Dispozitive si Circuite Electronice, Culegere de probleme EDP 1982
4. I. Rusu, F. Babarada, F. Drăghici, “Dispozitive Electronice - Îndrumar de Laborator”, Editura Rosetti Educaţional, Bucureşti, 2011, ISBN 978-973-7881-71-7.
5. S.M. Sze, K.W. Ng, Physics of Semiconductor Devices, 3rd edition, Wiley Interscience, New Jersey, USA, 2007;
6. P.R. Gray, P.J. Hurst, S.H. Lewis, R.G. Meyer, Analysis and Design of Analog Integrated Circuits, 5th edition , Wiley, 2009
7. T.L. Floyd, Electronic Devices- Electron Flow Version, 9th edition, Prentice Hall, 2012;
8. B. Razavi, Fundamentals of Microelectronics, 2nd edition, Wiley Global Education, 2013
9. http://wiki.dcae.pub.ro/index.php/Electronic_Devices(lab)
10. Situl cursului: http://www.dce.pub.ro

**11. Evaluation**

| Activity type | 11.1 Evaluation criteria | 11.2 Evaluation methods | 11.3 Percentage of final grade |
|---|---|---|---|
| 11.4 Course | Iterative analysis of a diode circuit.<br>Semiconductor physics and the pn junction<br>Bipolar transistor | Written test — in-semester assessment | 25% |
| | MOS transistor<br>Elementary amplification stages | Written test — Final exam | 40% |
| 11.5<br>Seminary/laboratory/project | Interpretation of measurement results from the laboratory works | Laboratory colloquium | 10% |
| | Solving simple circuits with diodes, bipolar and MOS transistors | Oral answers at the board during the semester and verification tests | 25% |
| 11.6 Passing conditions | | | |
| Obtaining 50% of the total score for activities during the semester (seminar/laboratory/course)<br>Obtaining 50% of the total score for the in-semester verification and for the final exam.<br>Compliance with the UNSTPB regulations regarding the 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)**

Electronic Devices is a fundamental subject for a specialist in electrical and electronic engineering. The major advances and dynamics of integrated circuits — which explain the unparalleled achievements in the world of computers, mobile communications, or audio and video electronic systems — have been made possible by deep knowledge of the physics and electronics of semiconductor devices.
In this course, using numerical data and commentary, the performance, electrical behavior, models, and equivalent circuits for diodes, field-effect and bipolar transistors, and their use in circuits are illustrated. Special attention is paid to amplification stages.
Through a professional selection of important knowledge, of immediate relevance or timeless value, students are provided with comprehensive scientific and technical training that allows rapid employment, after graduation, in any electronics, telecommunications, or information technology company. Thus, the policy of the Politehnica University of Bucharest is respected, promoting disciplines closely linked to the requirements of a cutting-edge industry such as microelectronics.

| Date | Course lecturer | Instructor(s) for practical activities |
|---|---|---|
| 24.09.2025 | Prof. Dr. Dan Neculoiu, Prof. Gheorghe BREZEANU, Prof. Gabriel DIMA, Prof. Lidia DOBRESCU, Prof. Florin DRĂGHICI, Prof. Cristian RAVARIU | |

| | |
|---|---|
| Date of department approval | Head of department |
| | Prof. Dr. Claudius Dan |
| Date of approval in the Faculty Council | Dean |
| | Prof. Mihnea UDREA |