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	Microelectronics, Optoelectronics and Nanotechnologies

2. Date despre disciplină

2.1 Course name (ro) (en)				Tehnici avansate de prelucrare digitală a semnalelor Advanced Techniques in Digital Signal Processing			
2.2 Course Lecturer				Prof. dr. ing. Dragoș BURILEANU			
2.3 Instructor for practical activities				Ș.L. dr. ing. Șerban MIHALACHE			
2.4 Year of studies	4	2.5 Semester	1	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.07.O.401		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4.5	Out of which: 3.2 course	3	3.3 seminary/laboratory	1.5
3.4 Total hours in the curricula	63	Out of which: 3.5 course	42	3.6 seminary/laboratory	21
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.					58
Tutoring					0
Examinations					4
Other activities (if any):					0

3.7 Total hours of individual study	62.00
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: – Digital Signal Processing; – Computer Programming.

4.2 Results of learning	General knowledge of: – fundamental knowledge of digital signal processing (basic algorithms and techniques); – knowledge of the MATLAB development environment.

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 and a computer.
5.2 Seminary/ Laboratory/Project	– The laboratory will take place in a room with specific equipment, which must include: computers, video projector, specialized software (the MATLAB software suite). – 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 / “Microelectronics, Optoelectronics and Nanotechnologies” specialization, and aims to present advanced topics in digital signal processing (statistical processing of random signals, spectral estimation, adaptive filtering, multirate systems, VLSI architectures), with applications in communications, speech technology, and audio signal processing.
The primary goal is to understand the phenomena underlying the studied techniques and their use in various current fields. Numerous examples and detailed explanations in the lectures help to clarify more difficult theoretical aspects and to solve practical applications and problems, with relevance for stimulating the students’ learning process. Additionally, laboratory applications aim to provide practical experience in the main concepts taught in the lectures. The implemented applications include various software simulations using the MATLAB development environment.
The course covers the following basic concepts and specific topics: discrete random signals and the response of digital filters to random signals, nonparametric and parametric methods of spectral analysis, modeling of random signals, linear estimation and the Wiener filter, adaptive filtering, processing of signals with multiple sampling, analysis and processing of speech signals, applications of speech technology, digital processing techniques for audio applications, concepts related to finite arithmetic in DSP, VLSI structures used for hardware implementation of DSP systems. All of these contribute to providing students with an overview of the methodological and procedural benchmarks of the studied field.

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 statistical signal processing, spectral analysis, adaptive filtering, analysis and processing techniques for speech and audio signals, and the basic operation and principles of general-purpose digital signal processors. – Applies the acquired theoretical knowledge practically and uses simulation environments for digital signal analysis and processing. – Applies standardized methods and tools specific to the DSP field to carry out the evaluation process of a situation, depending on the problems to be solved, and identify solutions. – Justifies and analyzes coherently and correctly the context of applying advanced knowledge of the DSP field, using key concepts of the course and the specific methodology. – Oral and written communication in Romanian: uses the specific scientific vocabulary of the DSP field 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 signal processing in a foreign language.
Transversal (General) Competences	– Communicates effectively, especially during practical sessions, coordinating 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 synthetic ability: presents acquired knowledge in a synthetic manner as a result of a systematic analysis process. – Adheres to academic ethics: accurately cites bibliographic sources used in research activities. – Practical application of emotional intelligence: demonstrates appropriate socio-emotional management of academic situations, showing 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 the studied field. – Describes appropriately the fundamental concepts and specific measures for statistical processing of discrete random signals. – Highlights and applies correctly the studied methods of spectral analysis and linear estimation. – Understands the main problem classes of adaptive filtering and applies them to solve various practical problems. – Defines and uses appropriately the concepts of decimation and interpolation. – Understands the concepts relating to characterizing speech signals at the acoustic and phonetic levels and representing it in the time and frequency domains. – Understands and describes correctly various contemporary applications of speech technology. – Describes various digital processing techniques used in professional audio recording studios, being able to correctly highlight how to implement them. – Understands the basic concepts related to the use of finite arithmetic in the implementation of DSP algorithms, being able to correctly highlight the main effects of using fixed-point and floating-point arithmetic. – Describes the main characteristics and features of digital signal processors.
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 DSP. – Uses DSP concepts justifiably to address problems correctly. – Experimentally verifies the identified solutions for the practical resolution of a DSP application. – Formulates correct conclusions about the results of the experiments performed. – 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 of DSP. – 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 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 environment. The developed applications help students in developing optimal communication relationships in a climate conducive to learning through discovery.
All laboratory materials are available in electronic form on the faculty's Moodle platform.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	"Statistical signal processing" – Introduction. Continuous-time random signals; basic statistical parameters. Discrete-time random signals; the Wiener–Khintchine theorem. Digital filter response to random signals	4
2	"Spectral analysis and parametric estimation for random signals" – Spectral analysis: nonparametric power spectrum estimation; signal modeling and parametric spectral estimation. Optimization algorithms. Linear estimation; Wiener filters	6
3	"Adaptive filters" – Basic concepts. Adaptive algorithms: LMS, NLMS. Adaptive filter configurations: system identification, inverse modeling, linear prediction, interference cancelation; applications. Acoustic echo cancelation in distance talking communication systems	6
4	"Multirate signal processing" – Generalities. Decimation by an integer factor. Interpolation by an integer factor. Sampling rate conversion by a rational factor	4
5	"Speech analysis and processing" – Speech production and perception. Acoustic and phonetic level descriptions; representations in the time and frequency domains. Speech signal variability. The principle of linear prediction in speech technology; the LPC vocoder. Other applications of speech technology: intelligent dialogue systems; speaker recognition; forensic expertise of speech in audio recordings	8
6	"Digital processing techniques and signal processors for audio applications" – Digital recording / playback systems on compact disk. Digital processing techniques used in professional audio studios: volume control and mixing, dynamic range modification, filtering and equalization, special effects. Audio digital techniques implementation using signal processors	6
7	"Finite-precision arithmetic in digital signal processing" – Numerical issues and data formats. Fixed-point representation in digital signal processors. Floating-point representation in digital signal processors. Comparison between numerical implementations. Finite word-length effects in digital filter implementation	4

8	"Hardware implementation of DSP systems. VLSI architectures" – Generalities: hardware implementations, objectives and performance; applications. Digital signal processors (DSPs): general characteristics; Harvard and Super-Harvard architectures; performance, levels of integration; processor families, typical examples. Development systems and practical considerations of DSP algorithm implementation	4
	Total:	42

Bibliography:

1. D. Burileanu, *Tehnici avansate de prelucrare digitală a semnalelor*, lecture notes available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. D. Burileanu, Ş. Mihalache, *Prelucrarea digitală a semnalelor: concepte fundamentale, tehnici avansate, aplicaţii*, MATRIX ROM, Bucureşti, 2022, ISBN: 978-606-25-0767-1.
3. D.G. Manolakis, V.K. Ingle, *Applied Digital Signal Processing: Theory and Practice*, Cambridge University Press, 2011.
4. S.V. Vaseghi, *Advanced Digital Signal Processing and Noise Reduction*, 4th Ed., John Wiley & Sons, 2008.
5. Z.M. Hussain, A.Z. Sadik, P. O'shea, *Digital Signal Processing: An Introduction with MATLAB and Applications*, Springer, 2014.
6. U. Zolzer, *Digital Audio Signal Processing*, 3rd Ed., John Wiley & Sons, 2022.
7. G. Ruiz, J.A. Michell (Eds.), *Design and Architectures for Digital Signal Processing*, IntechOpen, 2013.

LABORATORY

Crt. no.	Content	No. hours
1	Discrete deterministic signals: DFT, digital filtering. Discrete random signals: representations, statistical measures	3
2	Spectral analysis fundamentals for random signals. Linear estimation: the Wiener filter	3
3	Adaptive filters: the LMS and NLMS algorithms, applications	3
4	Multirate systems: decimation, interpolation, sampling rate conversion by a rational factor, applications	3
5	Digital signal processing techniques for the audio: audio and speech signal processing applications	3
6	Additional problems for advanced digital signal processing applications	3
7	Final colloquium	3
	Total:	21

Bibliography:

1. Ş. Mihalache, D. Burileanu, *Tehnici avansate de prelucrare digitală a semnalelor – Platforme de laborator*, lab tutorials available in electronic form on the Moodle platform of the ETTI faculty: https://curs.upb.ro/
2. Ş. Mihalache, D. Burileanu, *Prelucrarea digitală a semnalelor: aplicaţii fundamentale şi avansate folosind MATLAB*, MATRIX ROM, Bucureşti, 2024, ISBN: 978-606-25-0933-0.
3. D. Burileanu, Ş. Mihalache, *Prelucrarea digitală a semnalelor: concepte fundamentale, tehnici avansate, aplicaţii*, MATRIX ROM, Bucureşti, 2022, ISBN: 978-606-25-0767-1.

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 advanced DSP techniques. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Exam during the exam session (written evaluation)	50%
	Knowledge of fundamental theory and concepts relating to advanced DSP techniques. Understanding how to apply theoretical knowledge to solve domain-specific problems.	Test during the semester (written evaluation)	10%
11.5 Seminary/laboratory/project	Understanding DSP algorithms and techniques. Understanding how to simulate and implement (software) the studied methods using an advanced development environment (MATLAB).	Continuous evaluation (practical and oral evaluation) Final colloquium (practical and written evaluation)	40%
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)

Over the last two decades, the field of digital signal processing (DSP) has undergone a remarkable development, both theoretically and technologically. The increasing market demand for products utilizing DSP techniques can be attributed to the fundamental advantage of using the power of numerical computation for the mathematical manipulation of signals, and to the fact that manufacturers of digital integrated circuits now offer inexpensive and highly performant circuits capable of efficiently implementing complex processing functions. Considered a cutting-edge field at the turn of the century and millennium, DSP consistently demands engineers with solid theoretical and practical knowledge.
This course directly addresses the current development and evolution needs of the European economy in the field of Electronic Engineering, providing advanced knowledge of digital signal processing: modern methods used in the statistical processing of random signals, adaptive filtering, artificial neural networks and machine learning methods, techniques for processing audio and speech signals, etc. In the context of the current progress of information technology and electronic devices, the target areas of activity are extremely numerous: communications, medical engineering, instrumentation, space research, multimedia technologies, consumer electronics, robotics and intelligent human-machine interfaces, autonomous machines, biometric technologies, forensic expertise of digital audio/video recordings, etc.

Thus, students are provided with competencies that are adequate to the needs of current qualifications and a modern, quality, and competitive scientific and technical training, which allows them to be quickly employed after graduation. The course is perfectly integrated into the policy of the National University of Science and Technology POLITEHNICA Bucharest, both in terms of content and structure, and in terms of the skills and international openness offered to students. Potential employers target both the academic environment (teaching and research profile) and the research and development environment in state and private institutions that utilize advanced methods and techniques of digital signal processing.
The content of the course is largely similar to that of others with the same objectives taught in universities in the European Union and is continuously updated and adapted following consultations with representatives of the business environment.

Date	Course lecturer	Instructor(s) for practical activities
26.09.2025	Prof. dr. ing. Dragoş BURILEANU	Ş.L. dr. ing. Şerban MIHALACHE

Date of department approval	Head of department
22.10.2025	Prof. Dr. Claudius Dan

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