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	**Telecommunications**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Masters
1.6 Programme of studies	Advanced Wireless Communications

2. Date despre disciplină

2.1 Course name (ro) (en)				Tehnici avansate de transmisiuni de date Advanced Data Transmission Technologies			
2.2 Course Lecturer				Prof. Dr. Calin Vladeanu			
2.3 Instructor for practical activities				Prof. Dr. Calin Vladeanu			
2.4 Year of studies	1	2.5 Semester	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M2.O.21-07		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	3	Out of which: 3.2 course	1.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	42.00	Out of which: 3.5 course	14	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.					54
Tutoring					0
Examinations					4
Other activities (if any):					0

3.7 Total hours of individual study	58.00
3.8 Total hours per semester	100
3.9 Number of ECTS credit points	4

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion and/or promotion of the following disciplines: Mathematics; Theory of circuits; Data communications; Broadband networks.
4.2 Results of learning	Acquiring the following knowledge: basic knowledge of theory of signals and systems, digital signal processing, digital circuits and systems, data communications, and programming in MatLab simulation environment.

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 video projector and computer. Course materials are: bibliographic books, lecture notes and presentations, proposed and solved problems slides and other sources. Lecture digital notes are available in Moodle.
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room with specific equipment, which must include PCs on which the Matlab/Simulink environment is installed. Laboratory meetings are dedicated to theoretical and experimental analysis of several advanced data transmission techniques. Laboratory guide and simulation files are available in Moodle. Attendance at the laboratories is mandatory (according to the regulation of university studies in UNSTPB). Project meetings are dedicated to the presentation, analysis and discussions on the functioning principles, implementation details and testing of the blocks composing the data transmission system defined in the project requirements. The project/homework materials are available in Moodle.

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 discipline is dedicated to the assimilation of knowledge about the latest concepts, techniques and systems of advanced data transmissions. Various data signal processing and transmission techniques are combined with channel coding methods for channel error protection. These coded data transmission schemes represent the optimal solutions in the sense of Shannon's channel capacity. For wireless data communications, advanced MIMO multiple antenna transmission techniques are combined with space-timecoding and channel error coding techniques. All these techniques will be analyzed independently, but also in combined schemes, within the course, laboratory and project activities.

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	The students prove they own basic/advanced knowledge in the field of radio communication systems and equipment. It correlates the specific knowledge of the field of advanced data transmissions with those of other disciplines belonging to the area of electronic engineering, telecommunications and information technologies. Apply in practice the knowledge specific to the field of advanced data transmissions. Apply standardized methods and tools, specific to the field, for carrying out the evaluation and diagnosis process of a situation, depending on the identified/reported problems, and identify solutions. Argue and analyze coherently and correctly the context of application of the basic knowledge of the field, using key concepts of the discipline and the specific methodology. Oral and written communication in Romanian: uses the scientific vocabulary specific to the field, in order to communicate effectively, in writing and orally. Oral and written communication in a foreign language (English): demonstrate understanding of the vocabulary related to the field, in a foreign language.
Transversal (General) Competences	Work in a team and communicate effectively, coordinating his efforts with others to solve problematic situations of medium complexity. Autonomy and critical thinking: the ability to think in scientific terms, search and analyze data independently, and draw and present conclusions/identify solutions. Ability to analyze and synthesize: presents the acquired knowledge in a synthetic way, as a result of a systematic analysis process. Respect the principles of academic ethics: in the documentation activity correctly cite the bibliographic sources used. Put into practice elements of emotional intelligence in the adequate socio-emotional management of real-life/academic/professional situations, demonstrating 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.* Lists the most important stages that marked the development of the field. Defines domain-specific notions. Describes/classifies notions/processes/phenomena/structures. It highlights consequences and relationships.

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. Works productively in the team. Elaborates a scientific text. Experimentally verifies identified solutions. Solves practical application. Interprets appropriately the causal relationships. Identifies solutions and develops resolution/project plans. Formulates conclusions to the experiments carried out. Argues identified solutions/workarounds.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Selects appropriate bibliographic sources and analyzes them. Respects 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 unsolved problem situation. Demonstrates social responsibility through active involvement in student social life/involvement in academic community events. Promotes/contributes through new solutions related to the specialized field to improve the quality of social life. He/she realizes the value of his contribution in the field of engineering to the identification of viable/sustainable solutions to solve problems in social and economic life (social responsibility). Applies principles of professional ethics/deontology in the analysis of the technological impact of the solutions proposed in the specialized field on the environment. Analyzes and capitalizes on business/entrepreneurial development opportunities in the field of specialty. Demonstrates real-life situation management skills (time management, collaboration vs. conflict).

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 the 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 way of reality (experiment, demonstration, modelling), but also on action-based methods, such as exercise, practical activities and problem solving.

In the teaching activity, lectures will be used, with Power Point presentations or different videos that will be made available to the students. Each course will begin with the recapitulation 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 learning through discovery.

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. Baseband and passband data transmissions - Line codes for baseband transmissions; - Pulse shaping for no intersymbol interference (Nyquist criterion); - Modulation techniques: Frequency Shift Keying (FSK), Phase Shift Keying (PSK), Quadrature Amplitude Modulation (QAM); - Channel coding: block codes, convolutional codes; error control strategies: Forward Error Correction (FEC), Automatic Repeat request (ARQ)	4
2	Optimum sequence decoding for convolutional codes: Viterbi algorithm (hard and soft output VA); Maximum A Posteriori (MAP) algorithm.	4
3	Trellis coding: Trellis-coded modulation (TCM), Space-Time Trellis Codes (STTC).	2
4	Concatenated convolutional codes: parallel and serial concatenation, Turbo-codes and iterative decoding, Turbo Trellis Coded Modulation (TTCM).	3
5	Low Density Parity Check (LDPC) codes.	1
	Total:	14

Bibliography:

[1] Sklar B., Harris. F., Digital Communications. Fundamentals and Applications – Third edition, Pearson, Addison-Wesley, 2021.
[2] Proakis J., Salehi M., Digital Communications – Fifth edition, McGraw-Hill, New York, 2007.
[3] Lin S., Costello D. J., Error Control Coding – Second edition, Pearson Education Int., Prentice Hall,2004.
[4] Bănică I., Comunicaţii de date, Politehnica Press Publishing House, 2008.

LABORATORY		
Crt. no.	**Content**	**No. hours**
1	Signal space analysis of 1D and 2D digital modulations. Signal constellations and performance measures: SNR, Euclidian distance, BER, SER, FER.	2
2	Passband data transmissions using M-ary PSK and QAM modulations over band-limited AWGN channel – part I. Block scheme analysis.	2
3	Passband data transmissions using M-ary PSK and QAM modulations over band-limited AWGN channel – part II. Simulink/Matlab simulation. System performance analysis: eye-pattern, BER.	2

4	8PSK Trellis-Coded Modulation – the Ungerboeck trellis design rules; the coding gain.	2
5	Examples of Space-Time coded (STC) MIMO schemes. Combining STC with trellis-coded modulation. Estimation of the coding gain distance (CGD).	2
6	Baseband data transmissions using block-coded Space-Time with Trellis-Coded Modulation over Rayleigh fading AWGN channel – part I. Block scheme analysis.	2
7	Baseband data transmissions using block-coded Space-Time with Trellis-Coded Modulation over Rayleigh fading AWGN channel – part II. Simulink/Matlab simulation. System performance analysis: BER, FER.	2
	Total:	14

PROJECT

Crt. no.	**Content**	**No. hours**
1	Definition of the project/homework subjects and requirements. As a general requirement, the students have to write their own Matlab code to test, both analytically and by simulation, a specific coded data transmission scheme. A different scheme, with different parameters and requirements, is assigned to each project team (maximum 2 students/team).	2
2	Convolutional codes: generation matrix, trellis and polynomial description, Hamming distance.	2
3	Sequence decoding: an example of Viterbi decoding.	2
4	Sequence decoding: an example of MAP decoding.	2
5	An example of parallel-concatenated and punctured Turbo-TCM scheme.	2
6	Scheduled discussions with the project teams to troubleshoot the simulation scripts and discuss on the obtained results.	2
7	Each project team submits the final documents including the results presentation and simulation script files. Each project is evaluated, and the final marks are posted in Moodle.	2
	Total:	14

Bibliography:

[1] – [4].
[5] Vlădeanu C., Bănică I., Popescu S., Data Communications Systems and Networks, Printech Publishing House, 2007.

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. - theoretical description and analysis of advanced data transmission techniques and systems. - differentiated performance analysis of technical and theoretical methods.	The final examination consists of a written test. The subjects will include theory and exercises (similar to those presented at the course). The testing methods will be both in the form of a multiple-choice test, but also with an essay-type description.	40%
11.5 Seminary/laboratory/project	Laboratory - knowledge of fundamental theoretical concepts. - ability to evaluate experimentally several data transmission schemes. - presence and activity of students through laboratory hours.	Two lab reports must be submitted, and two written tests must be taken during 6th and 10thweeks, with both theoretical and practical requirements (one lab report + one lab test represents 20% of final grade).	40%
	Project - ability to apply the theory to solve problems related to data transmissions systems in a specific practical context. - developing personal solutions for designing, implementation, and experimental evaluation of specific data processing and transmission techniques. - writing original code in Matlab, Python, C++, or a similar programming environment to fulfill the required tasks.	Topics are assigned per team (1-2 students) and include theoretical and practical requirements. The deadline for the homework/project is on the 13th week.	20%
11.6 Passing conditions			
Obtaining 50% of the score related to the laboratory activity. Obtaining 50% of the total score.			

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)

Current wireless communication systems use advanced data transmission techniques, which combine signal processing methods with coding/decoding methods for error correction in order to optimize channel capacity in the sense of Shannon's theorem.

Through specific learning activities, students develop skills to solve various engineering problems and propose solutions to improve the performance of advanced wireless communication systems.

The course has a similar content to other courses within similar master's programs organized at the University of Oulu, Finland, but also other universities in the European space.

The course curriculum responds to the current requirements of organization and development, subscribed to the European and global evolution in the field of information and communication technology (ICT).Through laboratory, project and course activities, engineering management skills are developed, considering theoretical and practical situations that students can face in real life, in order to increase their contribution to the improvement of the socio-economic environment.

Date	Course lecturer	Instructor(s) for practical activities
09.09.2022	Prof. dr. ing. Călin VLĂDEANU	Prof. dr. ing. Călin VLĂDEANU

Date of department approval	Head of department
27.10.2024	Conf. Dr. Serban Georgica Obreja

Date of approval in the Faculty Council	Dean
25.10.2024	Prof. Dr. Mihnea Udrea