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)				Proceduri Avansate în Comunicțiile Wireless Advanced Procedures in Wireless Communications			
2.2 Course Lecturer				Prof. Dr. Cristian Anghel			
2.3 Instructor for practical activities				Prof. Dr. Cristian Anghel			
2.4 Year of studies	2	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		DA	2.9 Course code	UPB.04.M3.O.21-26		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	1.50	3.3 seminary/laboratory	1.5
3.4 Total hours in the curricula	42.00	Out of which: 3.5 course	21	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.					
Tutoring					
Examinations					
Other activities (if any):					

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	Digital Signal Processing Antenna and Propagation Mathematical Analysis

4.2 Results of learning	Knowledge of propagation modes, vectorial calculus, coordinate

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

5.1 Course	NA
5.2 Seminary/ Laboratory/Project	Compulsory lab activities (according to the internal regulations of UNSTPB of Bucharest)

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)*

To apply the general and specific knowledge about the modern wireless communication systems theory in different projects.

To be able to decide about a solution feasibility based on the performance criteria obtained during the course.

To understand the particularities of each type of application and to evaluate the impact of the operating conditions on the wireless communication systems' performances.

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	To apply the general and specific knowledge about the modern wireless communication systems theory in different projects. To be able to decide about a solution feasibility based on the performance criteria obtained during the course. To understand the particularities of each type of application and to evaluate the impact of the operating conditions on the wireless communication systems' performances.
Transversal (General) Competences	Methodical analysis of the problems encountered in work, identifying the items for which known solutions are established.

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. • 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. • Work productively in a team. • Elaborate a scientific text. • Experimentally verifies identified solutions. • Solve practical applications. • Adequately interpret causal relationships. • Identifies solutions and develops solution/project plans. • Formulates conclusions to the experiments carried out. • Argue the identified solutions/solutions.
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 • 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. • 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). • Apply principles of professional ethics/deontology in the analysis of the technological impact of the proposed solutions in the specialized field on the environment. • Analyzes and capitalizes on business/entrepreneurial development opportunities in the specialized field. • Demonstrates real-life situation management skills (collaborative vs. conflict time management).

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.

In the teaching activity, lectures will be used, based on Power Point presentations or different videos that will be made available to the 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	1. Introduction 1.1. The goal of the course 1.2. The course content 1.3. The evaluation methods	1
2	2. Multiple access techniques 2.1. TDMA 2.1.1. MF-TDMA 2.1.2. STDMA 2.2. FDMA 2.2.1.OFDMA 2.2.2. WDMA 2.2.3. SC-FDMA 2.3. CDMA 2.3.1.W-CDMA 2.3.2. TD-CDMA 2.3.3. TD-SCDMA 2.3.4. DS-CDMA 2.3.5. FH-CDMA 2.3.6. OFHMA 2.3.7. MC-CDMA 2.4. SDMA 2.4.1. HC-SDMA 2.5. PDMA 2.6. PAMA	3
3	3. Duplexing methods 3.1. TDD 3.2. FDD 3.3. In band full duplex	3

4	4. High spectral efficiency methods 4.1. Link adaptation 4.1.1. Channel coding rate 4.1.2. Digital modulation type 4.1.3. Modulatin and coding schemes 4.2. Diversity techniques in wireless communication systems 4.2.1. Time diversity 4.2.2. Frequency diversity 4.2.3. Multi-user diversity 4.2.4. Spatial diversity 4.2.5. Polarization diversity 4.3. Diversity combining techniques at receiver 4.3.1. SC (Selection Combining) 4.3.2. FSC (Feedback or Scanning Combining) 4.3.3. MRC (Maximum Ratio Combining) 4.3.4. EGC (Equal Gain Combining) 4.3.5. ZF (Zero Forcing) 4.3.6.MMSE (Minimum Mean Square Error)	7
5	5. Interference cancellation techniques 5.1. Cognitive networks 5.2. Interferences cancellation 5.3. Inter-cell interference coordination (ICIC) – LTE systems, Release 8/9 5.4. Enhaned Inter-cell interference coordination (eICIC) – LTE systems, Release 10 5.5.Further Enhanced Inter-cell interference coordination (feICIC) – LTE systems, Release 11	4
6	6. Smart antennas 6.1. Switched lobes 6.2. Dynamically phased array 6.2.1. Direction of Arrival detection algorithm for signal 6.3. Adaptive array 6.3.1.Additional Direction of Arrival detection algorithm for interferences	2
7	7. Ultra wide band systems 7.1. Proprieties of UWB systems 7.2. Applications for UWB systems	1
	Total:	21

Bibliography:

1. Note de curs. On Moodle each year
2. 3GPP specifications http://www.3gpp.org/specifications/specification-numbering

LABORATORY

Crt. no.	Content	No. hours
1	Laboratory 1 Matlab: Link adaptation – simulator for WiMAX systems Matlab: Transmit power control – simulator for WCDMA systems	2
2	Laboratory 2 Matlab: Diversity techniques – 1st part: space time coding (Alamouti scheme) Matlab: Diversity techniques – 2nd part: polarization diversity	2

3	Laboratory 3 Matlab: Diversity combining techniques at receiver – 1st part: MRC Matlab: Diversity combining techniques at receiver – 2nd part: MMSE	2
4	Laboratory 4 Matlab: Inter-cell interference coordination techniques: ICIC	2
5	Laboratory 5 Matlab: Smart antennas – performances simulation	2
6	Laboratory 6 Matlab: Ultra wide band systems – performances simulation	2
7	Laboratory 7 Final laboratory test	2
	Total:	14
PROJECT		
Crt. no.	**Content**	**No. hours**
1	Massive MIMO systems	2
2	5G NR systems	2
3	High order modulation (256 QAM)	3
	Total:	7
Bibliography:		

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	- The knowledge of the fundamental theoretical notions	Exam scheduled session. Topics cover all the syllabus of the subject, making a synthesis of comparative theoretical completion of the course and explaining patterns of application exercises.	20
	- The ability to apply the theoretical knowledge in solving specific problems	Exam scheduled session. Topics cover all the syllabus of the subject, making a synthesis of comparative theoretical completion of the course and explaining patterns of application exercises.	20
	- Critical and comparative analysis performed over the theoretical models	Exam scheduled session. Topics cover all the syllabus of the subject, making a synthesis of comparative theoretical completion of the course and explaining patterns of application exercises.	10

11.5 Seminary/laboratory/project	- The knowledge of the fundamental parameters of a link adaptation/ transmit power control algorithms and their usage methods - The knowledge of the diversity techniques and their advantages in specific applications	Oral laboratory examination comprises a theoretical and practical component. Theoretical component consists of each student response to a separate set of questions; the practical component is to determine the fundamental parameters of wireless communication systems	20
	- The diversity combing techniques at receiver comparison - The understanding of different types of smart antennas and the knowledge of their corresponding parameters	Oral laboratory examination comprises a theoretical and practical component. Theoretical component consists of each student response to a separate set of questions; the practical component is to determine the fundamental parameters of wireless communication systems	20
	- The knowledge of the ultra wide band systems parameters	Oral laboratory examination comprises a theoretical and practical component. Theoretical component consists of each student response to a separate set of questions; the practical component is to determine the fundamental parameters of wireless communication systems	10
11.6 Passing conditions			
The knowledge of multiple access techniques and diversity techniques and the ability to select one of them in a specific application The knowledge of smart antennas types - The knowledge of interference cancellation techniques			

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)

This course, by its own content, refers to the news principles and techniques characterizing the wireless communication systems. The growth of this systems in the last decades, discussing about WiFi, WiMAX, GSM/GPRS/EDGE/UMTS or LTE and LTE-A, obliges the engineers from today to be up to date with all the news from this domain. And since the wireless mobile communications are characterized by a continuous dynamic and a fast evolution of their features, the basic principles presentation for these systems represents one of the major targets of this course. On the other hand, it is important to present also some specific aspects, as examples, in order to better understand the above mentioned principles.

This provides the master graduates skills in line with current needs, a technical and scientific training, enabling rapid employment after graduation. This policy is in accordance with the Polytechnic University of Bucharest, both in terms of content and structure and in terms of skills and international openness offered to graduates.

Date	Course lecturer	Instructor(s) for practical activities
14.10.2024	Prof. Dr. Cristian Anghel	Prof. Dr. Cristian Anghel

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