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	Mobile Communications

2. Date despre disciplină

2.1 Course name (ro) (en)				Sisteme cu acces dinamic la spectru Dynamic Spectrum Access Systems			
2.2 Course Lecturer				Prof. Dr. Alexandru Martian			
2.3 Instructor for practical activities				Prof. Dr. Alexandru Martian			
2.4 Year of studies	2	2.5 Semester	I	2.6. Evaluation type	E	2.7 Course regime	Op
2.8 Course type		DA	2.9 Course code	UPB.04.M3.A.08-36		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	2	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	0
3.4 Total hours in the curricula	28.00	Out of which: 3.5 course	28	3.6 seminary/laboratory	0
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.					39
Tutoring					4
Examinations					3
Other activities (if any):					0

3.7 Total hours of individual study	47.00
3.8 Total hours per semester	75
3.9 Number of ECTS credit points	3

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Signals and Systems Analogic and Digital Communications Radio Communications: Systems and Equipment Digital Signal Processing
4.2 Results of learning	General knowledge regarding analogic and digital signals, the capacity of understanding the functioning of a principle or block diagram of a radio communication equipment, basic knowledge regarding information transmission, basic knowledge of digital signal processing.

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 whiteboard.
5.2 Seminary/ Laboratory/Project	-

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)*

Getting the student familiar with the dynamic spectrum access (DSA) concept. The reasons for which the concept appeared are cleared. Details regarding several existing and upcoming standards based on dynamic spectrum access are presented.

One of the key elements of a DSA equipment, namely the spectrum sensing process, is analyzed in detail. Several spectrum sensing methods are discussed, with focus on the most popular one, energy detection. Cooperative spectrum sensing approaches are also presented.

In order to also have a practical view of the subject, implementation aspects are also being given, both from the hardware and from the software points of view.

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	- Knowledge of the specific architectures for dynamic spectrum access systems and devices; - Knowledge about current and upcoming standards that are based on dynamic spectrum access principles; - Knowledge regarding different spectrum sensing methods.
Transversal (General) Competences	Works in a team and communicates effectively, coordinating efforts with others to solve problem 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 process of systematic analysis. Respect the principles of academic ethics: correctly cite the bibliographic sources used in the documentation activity. Puts elements of emotional intelligence into practice in the appropriate social-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. • 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	Introduction 1.1 What is dynamic spectrum access (DSA)? 1.2 Why is dynamic spectrum access necessary? 1.3 RF Spectrum occupancy measurement campaigns 1.4 Evolution of software defined radio (SDR) towards cognitive radio (CR) 1.5 Worldwide commercial deployments, pilots and trials	4
2	Standards based on dynamic spectrum access elements 2.1 IEEE 802.22 (WRAN) 2.2 IEEE 1900.1-7 2.3 IEEE 802.11af and 802.11h 2.4 IEEE 802.16h 2.5 LTE-U and LAA 2.6 DSA elements for 5G	4
3	Generic architecture of a DSA equipment 3.1 The cognitive cycle 3.2 Necessary signal processing blocks	2

4	Spectrum sensing 4.1 Problem definition 4.2 Classification of spectrum sensing methods 4.3 Spectrum databases	3
5	Energy detection (ED) 5.1 Classical energy detection algorithm 5.2 Improved energy detection algorithms 5.3 Performance evaluation for ED algorithms	4
6	Feature-based spectrum sensing 6.1. Cyclostationary feature detection 6.2. Matched filtering detection 6.3. Wavelet detection 6.4. Covariance based spectrum sensing	4
7	Cooperative spectrum sensing 7.1. Benefits of cooperative spectrum sensing 7.2. Centralized cooperative spectrum sensing 7.3. Distributed cooperative spectrum sensing 7.4. Relay-assisted cooperative spectrum sensing	3
8	Implementation of DSA equipment 8.1. How to choose an SDR platform? 8.2. The Universal Software Radio Peripheral (USRP) platform families 8.3. Other SDR platforms 8.4. The GNU Radio Environment	4
	Total:	28

Bibliography:

A. Marțian, “Utilizarea eficientă a spectrului de radiofrecvență. Evaluarea stadiului actual și perspective”, Ed. Politehnica Press, 2017.
O. Holland, H. Bogucka and A. Medeisis, “Opportunistic Spectrum Sharing and White Space Access: The Practical Reality”, Wiley, 2015.
A.M. Wyglinski, M. Nekovee and T. Hou, “Cognitive Radio Communications and Networks: Principles and Practice”, Academic Press, 2009.
B. Fette, “Cognitive Radio Technology”, Academic Press, 2009.

Bibliography:

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	- knowledge of the fundamental teoretic notions; - knowledge of applying theory in specific practical applications; - differential analysis of teoretical techniques and methods.	One final exam during the session (100 points).	100

11.5 Seminary/laboratory/project			
11.6 Passing conditions			
• 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)

Wireless communication systems are and will be an important component in the global communication systems. However, as the number of radio communication systems increased significantly in the last decades, one of the key necessary resources which is the frequency spectrum became overcrowded. Different measurement campaigns performed recently revealed the fact that several frequency bands are actually used in a very low degree.

The apparent contradiction that rises from the previous remarks can be explained by taking into account the current spectrum licensing model, which is a static one. That means that most of the frequency bands are owned by network operators which have the exclusive right of transmitting in that bands. Such an approach leads in most cases to an extremely inefficient use of the frequency resource.

A possible solution to this problem is the dynamic spectrum access (DSA) approach, which assumes that secondary (unlicensed) users (SU) are allowed to use frequency resources as long the primary (licensed) users (PU) are not actively using them. This kind of approach has already been integrated into different existing standards and is foreseen to be one of the key technologies for the fore coming 5G networks.

The lecture introduces elements like standards based on DSA elements, the generic architecture of a DSA equipment and details one of the key blocks of a DSA device, the spectrum sensing block. Practical concepts regarding the implementation of DSA equipment are also being given.

The course curriculum corresponds to the current development and evolution of wireless communication systems, including theoretical aspects regarding the architecture and the functions that such equipment has to fulfil, along with practical aspects regarding the design and implementation of dynamic spectrum access equipment.

The graduates are provided with competences adequate to the current necessities and a scientific and technical training, competitive and of good quality, which will allow them a fast employment after graduation, being perfectly suited to the politics of the University “Politehnica” of Bucharest, both from the structure and contents point of view, and from the international opening and abilities offered to the students.

Date	Course lecturer	Instructor(s) for practical activities
01.10.2024	Prof. Dr. Alexandru Martian	Prof. Dr. Alexandru Martian

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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