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	**Applied Electronics and Information Engineering**
1.4 Domain of studies	Electronic Engineering, Telecommunications and Information Technology
1.5 Cycle of studies	Bachelor/Undergraduate
1.6 Programme of studies	Applied Electronics

2. Date despre disciplină

2.1 Course name (ro) (en)				Microunde Microwaves			
2.2 Course Lecturer				Conf. Dr. Iulia Andreea Mocanu			
2.3 Instructor for practical activities				Conf. Dr. Iulia Andreea Mocanu			
2.4 Year of studies	3	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.05.O.002		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	5	Out of which: 3.2 course	3.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	70.00	Out of which: 3.5 course	42	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.					49
Tutoring					0
Examinations					6
Other activities (if any):					0

3.7 Total hours of individual study	55.00
3.8 Total hours per semester	125
3.9 Number of ECTS credit points	5

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion of the following subjects: • Basics of electrotechnics • Calculus • Signals and systems • Circuit analysis and synthesis
4.2 Results of learning	Basic notions of: theory of electric and electronic circuits, analog signal processing, electromagnetic fields.

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 a video projector and a board.
5.2 Seminary/ Laboratory/Project	The laboratory will take place in a room with specific equipment (slotted lines and PCs with electromagnetic simulation software).

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)*

The Microwaves subject is studied within the field of Electronic Engineering, Telecommunications and Information Technology / specialization Applied Electronics English and aims to familiarize students with the basic principles, models and explanatory theories regarding propagation in different transmission media and circuits/equipment for high frequencies, used in solving practical applications and problems, which aim to stimulate the learning process.

The discipline provides students with a thorough training in the field of guided propagation of electromagnetic waves, as well as knowledge of the basic principles and methods used in the analysis and synthesis of circuits, in the field of microwaves. The specific objectives provided by the discipline refer to the knowledge of the physical phenomena specific to transmission lines and various types of waveguides (rectangular guide, coaxial guide, microstrip lines, etc.). Also, the course provides specific background knowledge related to the analysis of microwave structures using S parameters.

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 basic knowledge of high frequency circuits Correlate the acquired knowledge for various applications Creating skills to solve practical problems using simple microwave circuit design methods. Argues and analyzes coherently and correctly the context of application of the basic knowledge of the field, using key concepts of the discipline and 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): demonstrates understanding of subject-related vocabulary in a foreign language.

Transversal (General) Competences	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. Adaptation to new technologies and professional development, through continuous training using printed documentation sources, specialized software and electronic resources.

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.* • Enumerate and classify the most important types of transmission lines/waveguides. • Defines notions specific to the field of high frequency engineering. • Describes the main physical phenomena specific to transmission lines and waveguides.
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. • Reasonably uses specific principles in order to characterize a simple microwave circuit. • Elaborates a scientific text. • Experimentally verifies the identified solutions. • Solves practical applications. • Adequately interprets causal relationships. • Analyzes and compares microwave circuits. • Formulates conclusions of the performed experiments. • Argues/defends the identified solutions.
Responsability and autonomy	*The student's capacity to autonomously and responsably apply their knowledge and skills.* Selects appropriate bibliographic sources and analyzes them. • 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. • Realizes the value of his contribution in the field of engineering by identifiying viable/sustainable solutions to solve problems in social and economic life (social responsibility). • Demonstrates real-life situation management skills (time management, collaboration vs. conflict in solving a practical problem).

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 and indirect exploration 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 begin with the recapitulation of some elements from the chapters already covered, with an emphasis on the notions covered in the last course.

The lectures use images and diagrams so that the information presented is easy to understand and assimilate.

Active listening and assertive communication skills will be used, as well as feedback construction mechanisms, as ways of regulating behavior in various situations and adapting the pedagogical approach to the students' learning needs.

The ability to work in a team will be practiced to solve different laboratory works.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**
1	Introduction	1
2	Theory of Right-Handed transmission lines -Wave propagation along transmission lines -Particular types of transmission lines (loss-less, with small losses) -Distribution of voltages and currents along loss-less transmission lines -Input impedance of a transmission line. Transmission lines, as circuit elements -The transmitted power along transmission lines, efficiency of a transmission line -The Smith chart. Matching circuits	19
3	Theory of Left-Handed transmission lines -Purely Left-Handed transmission lines -Composite Right-Left Handed trasnmission line: properties, propagation constant, balanced trasnmission line, dual-band transmission line. Bloch impedance; -Comparison with clasical transmission lines: limitations, advantages, practical apliations with improved performances.	6
4	Waveguides: -Plane waves. Plane waves in lossy dielectrics. Plane waves in metals -Wave propagation in uniform waveguides: longitudinal and transversal components of the field, linking relations between them. TEM, TE, TM waves. - Properties of the TEM waves. - Properties of the TE, TM in ideal metallic waveguides. Cutoff frequency, phase and group velocities, wave impedance - Propagation study of the waves in rectangular waveguide: dominant mode TE10, working bandwidth; - Transmitted power along the waveguides, the maximum transmissible power. - Propagation in low-losses waveguides - Planar waveguides. Strip line. Microstrip line. Coplanar waveguide	10

5	Basics of the microwave linear network theory: - Equivalent voltages and currents. Power waves - S matrix of a linear n-port - Determining S matrix, physical significance of the S parameters.	6
	Total:	42

Bibliography:

1. Lojewski G., Militaru N., High Frequencies and Microwaves, Ed. Politehnica Press, Bucuresti 2014
2. Iulia Andreea Mocanu, ”Introducere in studiul metamaterialelor. Linii de transmisiune artificiale de tip „Left Handed”, Editura Matrix Rom, 2018
3. D. M. Pozar, Microwave Engineering, Fourth Edition, John Wiley & Sons, Inc., NJ 2012
4. C. Caloz, T. Itoh, Electromagnetic Metamaterials: Transmission Line Theory and Microwave Applications: The Engineering Approach. Wiley & IEEE Press, Hoboken, NJ, 2006.

LABORATORY

Crt. no.	Content	No. hours
1	Study of Signal’s Amplitude Distribution along the Slotted Line	2
2	Measurement of Frequency and Wavelength in Waveguides	2
3	Measurement of Standing Wave Ratio	2
4	Measurement of the Normalized Impedance. Measurement of the Reflection Coefficient	2
5	Matching circuits	2
6	Recapitulative lab session	2
7	Final lab examination	2
	Total:	14

SEMINARY

Crt. no.	Content	No. hours
1	Determining analytically the distribution of voltage amplitude along a loss-less transmission line	2
2	Input impedance in circuits with transmission lines	2
3	Matching circuits	2
4	Applications on Smith Chart	2
5	Rectangular waveguides	2
6	Scattering parameters	2
7	Final seminary evaluation	2
	Total:	14

Bibliography:

1. I. Mocanu, L. Dogariu, "Microwave problem collection", Editura Printech, 2019

11. Evaluation

Activity type	11.1 Evaluation criteria	11.2 Evaluation methods	11.3 Percentage of final grade
11.4 Course	Knowledge of the basic theoretical notions. -The ability to solve specific problems. -Comparative analysis of theoretical methods/techniques.	Written test (multiple choice, synthesis subject or problem solving).	50 %
11.5 Seminary/laboratory/project	Knowledge of the essential aspects of propagation phenomena in the microwave domain; -Knowledge of some specific investigation methods of these phenomena; -Microwave circuit analysis through circuit simulation.	Ongoing evaluation based on lab activity and reports. - Final laboratory evaluation, containing a theoretical component and a practical one. The theoretical component consists in a set of questions given to each student, while the practical one consists of a measurement performed by each student with the slotted line, using a method presented in the laboratory.	25 %
	Knowledge of the essential aspects of propagation phenomena in transmission lines and waveguides; -The ability to apply general knowledge about microwave propagation to certain problems referring to microwave circuits and systems.	The evaluation of the activity at the seminar takes into account students' activity during seminar classes (homework, solving applications at the blackboard) and a final, written test, during the last class.	25 %
11.6 Passing conditions			
• Obtaining a minimum of 50% (12.5 points) from the score at the laboratory; • Obtaining a minimum of 50% from 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)

Through the course/lab activities, students develop skills to offer solutions to problems and to propose ideas to improve state of the art in the field of high frequency circuits.

- Knowledge / aspects / phenomena described by specialized literature and own research published in prestigious international journals/conferences were both taken into account in the development of the content of the discipline.

- Introducing general aspects about Left-Handed transmission lines with numerous applications in modern dual-band microwave circuits.

- The course has a similar content to the courses held at EPFL (Switzerland) or TU Delft (The Netherlands).

Date	Course lecturer	Instructor(s) for practical activities
	Conf. Dr. Iulia Andreea Mocanu	Conf. Dr. Iulia Andreea Mocanu
Date of department approval	Head of department	
Date of approval in the Faculty Council	Dean	