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

2. Date despre disciplină

2.1 Course name (ro) (en)				Microunde			
2.2 Course Lecturer				Conf. Dr. Nicolae Gheorghe Militaru			
2.3 Instructor for practical activities				Conf. Dr. Nicolae Gheorghe Militaru			
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.005		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.					48
Tutoring					0
Examinations					7
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 disciplines: Physics 1 Mathematical Analysis Fundamentals of Electrical Engineering 1 Signals and Systems
4.2 Results of learning	Gain of knowledge regarding: Guided propagation of the electromagnetic field Matrix computation Vector analysis Definite integrals Partial derivatives Harmonic signals

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

5.1 Course	Room equipped with a blackboard and video-projector.
5.2 Seminary/ Laboratory/Project	Room equipped with computers and specific microwave equipment.

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 studied within the field of Electronic Engineering, Telecommunications and InformationTechnologies, specialization Technologies and Telecommunication Systems, and aims to familiarize studentswith the main approaches, models and explanatory theories of the field, used in solving practicalapplications and problems, with relevance to stimulating the learning process for students.

The course provides to the students a thorough training in the domain of the electromagnetic waves guided propagation, of the electromagnetic resonators and also in the knowledge of the fundamental principles and methods utilized in the analysis and synthesis of the circuits in microwave domain.

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 unguided and guided electromagnetic field propagation through various media (free space, waveguides) Apply the knowledge obtained in the course in practice. It applies standardized methods and tools, specific to the field, to carry out the evaluation and diagnosis process of a situation, depending on the identified/reported problems, and identifies solutions. It argues and analyzes coherently and correctly the context of application of thebasic knowledge of the field, using key concepts of the discipline and the specificmethodology. Oral and written communication in Romanian: uses the scientific vocabularyspecific 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	Works in a team and communicates effectively, coordinating efforts with others tosolve problem situations of medium complexity. Autonomy and critical thinking: the ability to think in scientific terms, search andanalyze 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.* It lists the most important properties related to the physical phenomena characteristic of transmission lines, waveguides of various types (rectangular guide, coaxial guide, flat lines, etc.),resonant cavities. Defines specific notions related to the analysis of microwave structures using the scattering matrix formalism, [S]. Describe/classify waveguides in terms of their main properties and their potential in civil/military applications.
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).* Select and group relevant information in a given context. Uses specific principles in a reasoned manner in order to address a particular problem related to the propagation of the electromagnetic field through a given waveguide. Work productively in a team. Elaborate a scientific text. Experimentally verify identified solutions. It solves practical applications in various technologies (planing, rectangular/circular waveguide). Identifies solutions and develops resolution/project plans. Formulate conclusions to the experiments carried out. Argue the identified solutions/workarounds.

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 its 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 solutions proposed in the specialized field on the environment. Analyzes and capitalizes on business/entrepreneurial development opportunities in the specialty area. 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.

Lectures with blackboard demonstrations will be used in the teaching activity and, in particular situations, Power Point presentations or different videos that will be made available to students in the Moodle environment. 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 andassimilate.

This discipline covers information and practical activities designed to support students in their learningefforts and the development of optimal collaborative and communicative relationships in a climateconducive 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.

10. Contents

COURSE		
Chapter	**Content**	**No. hours**

1	Transmission lines: Wave propagation along transmission lines, propagation constant, characteristicimpedance Distribution of voltages and currents along loss-less transmission lines Input impedance of a transmission line. Smith Chart The transmitted power, efficiency 1.5. Transmission lines, as circuit elements at high frequencies. Lines as resonators. Matching circuits with transmission lines	18
2	Waveguides: Plane waves. Plane waves in lossy dielectrics. Plane waves in metals Wave propagation in uniform waveguides: longitudinal and transversal components ofthe field, linking relations between them. TEM, TE, TM waves. Properties of the TEMwaves. Properties of the TE, TM in ideal metallic waveguides. Cutoff frequency, phaseand group velocities, wave impedance Propagation study of the waves in rectangular waveguide: dominant TE10, normal operating bandwidth, field's structure, superficial currents,. Wave propagation incircular waveguide. Excitation, detection and filtration of the modes Transmitted power along the waveguides, the maximum transmissible power.Propagation in low-losses waveguides Coaxial waveguide. Planar waveguides. Strip line. Microstrip line. Coplanar waveguide	15
3	Electromagnetic resonators: Resonant cavities. Oscillation modes, reflections method Computational resonant frequency of an oscillation mode. Quality factor	6
4	Basics of the microwave linear network theory: Equivalent voltages and currents in waveguides. Power waves One-port characterization. S matrix of a linear n-port 4.3. Determining S matrix Properties of the S matrix. S matrix of the reciprocal devices. S matrix of the passive devices. S matrix of the conservative devices	3
	Total:	42

Bibliography:

Lojewski G., Militaru N., High Frequencies and Microwaves, Ed. Politehnica Press, Bucuresti 2014
Petrescu T., Militaru N., Microunde, Ed. Politehnica Press, Bucuresti 2021
Pozar D.M., Microwave Engineering, 4th Edition, JohnWiley & Sons, Inc., 2012

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	Study of Matching Circuits for Resistive Loads	2
6	The Study of Matching Circuits for Complex Loads	2
7	Laboratory assessment (theory and practice)	2
	Total:	14

SEMINARY		
Crt. no.	**Content**	**No. hours**
1	Voltages and Currents along Transmission Lines	2
2	Input Impedance of a Transmission Line	2
3	Applications on Smith Chart	2
4	Written assessment #1 Rectangular Waveguide	2
5	Power transmission, attenuation constant	2
6	Coaxial Cable, Planar waveguides	2
7	Scattering Parameters S of the n-ports Written assessment #2	2
	Total:	14

Bibliography:

Lojewski G., Militaru N., Microunde. Culegere de probleme, Ed. Electronica2000, Bucureşti 2005
Lojewski G. (coordonator), Microunde şi Circuite de microunde. Îndrumar de laborator, Ed.Electronica2000, Bucureşti 2004
Pozar D.M., Microwave Engineering, Fourth Edition, John Wiley &Sons, Inc., NJ 2012

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 aspects - Knowledge of the way of applying theory to specific problems - Critical and comparative analysis of the theoretical methods and techniques.	Programmed exam in session. The subjects cover the whole analytical programe of the course, realizing a synthesis between comparative theoretical understanding of the course and explaining through exercises and problems of the application methods.	50%

11.5 Seminary/laboratory/project	Laboratory: - Knowledge of the essential aspects of propagation phenomena in microwave domain - Knowledge of some specific investigation methods of these phenomena - Microwave circuit analysis through circuit simulation.	Final laboratory evaluation, containing a theoretical component and a practical one. The theoretical component consists of the given answer by each student to a set ofdistinctive questions; the practicalcomponent consists of ameasurement done by each studentwith the slotted line of a specificparameter, using a method presentedin the laboratory.	25%
	Seminary: - Knowledge of the essential aspects of propagation phenomena in microwave domain - Create the ability to apply general knowledge about microwave propagation to certain problems referring to circuits and systems in which microwaves are used.	The evaluation of the activity at the seminar takes into account students' activity during seminar classes (home works, solving applications at the blackboard) and two written assessments during the semester.	25%
11.6 Passing conditions			
Exam: • Obtaining at least 45% (min. 22 points) of the points assigned to the exam (50). **Seminary**: • Obtaining at least 50% (12,5 points) of the score allocated to the seminary activity (25). **Laboratory**: • Obtaining at least 50% (min. 12.5 points) of the total score allocated to the laboratory activity. The totalscore for the laboratory activity has two components: the grade obtained at the colloquium (weight of 50%of the total score) and the arithmetic mean of the written reports corresponding to the laboratory works(weight of 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)

Nowadays, microwave applications represent an important market with an increasingly pace. Microwaves and Microwave Circuits have an essential role both in mobile communication systems and/or satellite ones and in other scientific or consumer applications.

The industry has an important demand for qualifies engineers with specialization in microwaves domain and with a solid base in electronics, systems and information technology so it can maintain he growing pace of new products and applications/services.

The curriculum of the course responds objectively to these novel demands of development and evolution, subscribed to European Economy off Services in Electronics and Telecommunication Engineering domain, the study program Technologies and Systems for Telecommunications (TST). In the present technological progress of the RF/Microwaves equipment, the activity domains are practically unlimited such as applications and consumers (microwave ovens, smart phone mobile terminals), medical domain (treatment, screening), military domain (special integrated communications systems, radiolocation systems), security domain (surveillance systems), professional communication domain and others.

This provides graduates with the appropriate skills and training requirements according to current qualifications, and a modern, high quality and competitive scientific and technical training, enabling them acquiring a working place after the graduation. The course fits therefore perfectly to the POLITEHNICA Bucharest university policy, considering both its content and structure, and the skills and international openness it offers to students.

Date	Course lecturer	Instructor(s) for practical activities
17.09.2025	Conf. Dr. Nicolae Gheorghe Militaru	Conf. Dr. Nicolae Gheorghe Militaru
Date of department approval	Head of department Conf. dr. ing. Șerban Georgică Obreja	
Date of approval in the Faculty Council	Dean Prof. dr. ing. Mihnea Udrea	