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	Bachelor/Undergraduate
1.6 Programme of studies	Technologies and Telecommunications Systems

2. Date despre disciplină

2.1 Course name (ro) (en)				Circuite de microunde Microwaves Circuits			
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	II	2.6. Evaluation type	E	2.7 Course regime	Ob
2.8 Course type		S	2.9 Course code	04.S.06.O.213		2.10 Tipul de notare	Nota

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

3.1 Number of hours per week	4	Out of which: 3.2 course	2.00	3.3 seminary/laboratory	2
3.4 Total hours in the curricula	56.00	Out of which: 3.5 course	28	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.					14
Tutoring					0
Examinations					5
Other activities (if any):					0

3.7 Total hours of individual study	19.00
3.8 Total hours per semester	75
3.9 Number of ECTS credit points	3

4. Prerequisites (if applicable) (where applicable)

4.1 Curriculum	Completion of the following disciplines: Fundamentals of Electrical Engineering 1 Signals and Systems Microwaves
4.2 Results of learning	Accumulating the following knowledge: Electromagnetic laws Theory of electric and electronic circuits Transmission lines and waveguides analysis

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

5.1 Course	Amphitheatre multimedia equipped (video projector)
5.2 Seminary/ Laboratory/Project	Room equipped with at least 14 PC's and specific RF/microwave design 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 course provides to the students a thorough training in the knowledge of the fundamental principles and methods utilized in the microwave circuits analysis and synthesis.
The specific objectives provided by the course refer to the knowledge about the analysis of the microwave devices and circuits using the scattering matrix formalism S.

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 in the analysis and design of passive microwave circuits (directive couplers and power dividers, filters, etc.) Apply knowledge 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 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): demonstrates understanding of subject-related vocabulary in a foreign language.

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.* It 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).* Select and group relevant information in a given context. Reasonably uses specific principles in view of abc. Work productively in a team. Elaborate a scientific text. Experimentally verify identified solutions. Solve practical applications. Interpret causal relationships appropriately. Analyze and compare abc. 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.
Blackboard demonstrations and lectures will be used in the teaching activity, 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 the 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 to solve different learning tasks.

10. Contents

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

1	Basics of linear microwave network theory: Power waves. The scattering matrix, S Methods for determining the scattering matrix. Properties of the scattering matrix Reciprocity. Passivity. Conservativity	4
2	Properties of the scattering matrix for some types of devices: Reciprocal passive lossless two-port devices. Thin two-port device. Measurements of two-port devices. Non-reciprocal two-port device: the ideal isolator. Properties of three-port devices. Passive, non-dissipative reciprocal or non-reciprocal three-port devices. Ideal three-port circulator. Ideal power splitter. Properties of four-port devices. Reciprocal, passive, lossless four-port devices. Ideal directional coupler.	4
3	Directional couplers: The quadrature hybrid branch-line coupler Ring coupler Coupled-line directional coupler Directional couplers in rectangular waveguide technology	8
4	Power dividers: Power-dividers with two and three resistors Wilkinson power divider	4
5	Microwave filters: -Prototype filters, frequency transformations -Microwaves filters synthesis -Comparison between the microwaves filters and the artificial transmission lines: common properties, differences, practical applications.	4
6	Multiband passive microwaves devices -Alternatives of transforming the classical couplers (Branch-line, ring, coupled line couplers) into dual band couplers using artificial transmission lines. -Alternatives of transforming the Wilkinson power dividers into dual band ones; -Tehnological particularities to implement the passive microwave devices in different technologies: microstrip, stripline, coplanar, waveguides.	4
	Total:	28

Bibliography:

Iulia Andreea Mocanu, ”Introducere in studiul metamaterialelor. Linii de transmisiune artificiale de tip „Left Handed”, Editura Matrix Rom, 2018

D. M. Pozar, Microwave Engineering, Fourth Edition, John Wiley & Sons, Inc., NJ 2012

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	Wilkinson Power dividers T	2
2	Transmission-line directional couplers	2
3	Coupled-line directional couplers	2
4	Microstrip low-pass filter with cascaded coupled transmission lines	2

5	Bandpass filters with edge-coupled transmission lines, in microstrip technology	2
6	Non-reciprocal ferrite devices	2
7	Final Laboratory Evaluation	2
	Total:	14

SEMINARY

Crt. no.	**Content**	**No. hours**
1	Computation of the scattering matrix, S for two-ports and three-ports	2
2	Computation of the scattering matrix, S for circuits obtained by interconnecting two-ports and three-ports	2
3	Signal flow graphs used to determine the scattering parameters for microwave circuits	2
4	Signal flow graphs used to determine the scattering parameters for microwave circuits with nonreciprocal elements (eg. Circulators)	2
5	Analytical computation of the characteristic parameters of directional couplers.	2
6	Signal flow graphs used to determine the scattering parameters for microwave circuits obtained by interconnecting the directional couplers with other n-ports.	2
7	Final assessment	2
	Total:	14

Bibliography:

1. Lojewski G., Militaru N., Mocanu I., Microwave Circuits, Ed. Politehnica Press, Bucureşti 2021.
2. Lojewski G., Militaru N., Lupescu H., Mocanu I., Bădescu A., Microwave Circuits – Laboratory Guidebook, Ed. POLITEHNICA Press, Bucureşti, România, 2014
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.

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 programme 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 regarding the characterization of the microwave devices and circuits using the scattering matrix. - Knowledge of some specific methods for the design and simulation of microwave circuits. - Microwave circuit analysis through circuit simulation	Final laboratory evaluation, containing the design and simulation of a microwave device / circuit based on an imposed specification. It is assessed: the design correctness, the knowledge of the simulation environment, and the performances of the designed circuit with respect to the specification.	25%
	Seminary: - Knowledge of the essential aspects of propagation phenomena in microwave circuits; - 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 (homeworks, solving applications at the blackboard) and a final, written test during the last class.	25%
11.6 Passing conditions			
Exam: • Obtaining at least 45% (22,5 points) of the score assigned to the exam. (50). **Laboratory**: • Obtaining at least 50% (12.5 points) of the total score allocated to the laboratory activity. The total score 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 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)

The industry has an important demand for qualifies engineers with specialization in designing and operating microwave devices and circuits 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 Microwave Circuits 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 is how there are provided to license university graduate students, the competences accordingly to the necessity of the actual qualifications and also a modern, competitive and quality scientific and technical training which allows a quick hiring after graduation. This aspect is accordingly to University POLITEHNICA of Bucharest strategy, both from the perspective of content and structure as well as from the perspective of skills and international opportunities offered to students.

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	