COURSE DESCRIPTION

1. Program identification information

1.1 Higher education institution	POLITEHNICA University of Bucharest
1.2 Faculty	Faculty of Electronics, Telecommunications and Information Technology
1.3 Department	Dept. of Telecommunications
1.4 Domain of studies	Electronic Engineering, Telecommunications and Informational Technologies
1.5 Cycle of studies	Licence (engineering)
1.6 Program of studies/Qualification	Technologies and Systems for Telecommunications

2. Course identification information

2.1 Name of the course				Microwaves			
2.2 Lecturer				Prof. Dr. Ing. George LOJEWSKI			
2.3 Instructor for practical activities				Ş.L. Dr. Ing. Iulia Mocanu			
2.4 Year of studies	IV	2.5 Semester	8	2.6 Evaluation type	Verification	2.7 Course choice type	Compulsory

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

3.1 Number of hours per week, out of which	5	3.2 course	3	3.3 practical activities	1/1
3.4 Total hours in the curricula, out of which	70	3.5 course	42	3.6 practical activities	14/14

Distribution of time	hours
Study according to the manual, course support, bibliography and hand notes	25
Supplemental documentation (library, electronic access resources, in the field, etc)	4
Preparation for practical activities, homeworks, essays, portfolios, etc.	24
Tutoring	0
Examinations	7
Other activities	0

3.7 Total hours of individual study	60
3.9 Total hours per semester	130
3. 10 Number of ECTS credit points	5

4. Prerequisites (if applicable)

4.1 curricular	Electrotehnics Basics, Mathematics Analysis, Signals and systems, Circuits Analysis and Synthesis
4.2 competence-based	Knowledge of the basic notions for: electric and electronic circuits theory, electrical signal processing, laws of the electromagnetic field

5. Requisites (if applicable)

5.1 for running the course	Amphitheatre multimedia equipped (video projector)
5.2 for running of the applications	Compulsory presence at laboratories (accordingly to the Legislation for the organization and development of the license universitary educational process in University POLITEHNICA of Bucharest)

6. Specific competences

Professional competences	**C1.** Using fundamentals concerning devices, circuits and electronic instrumentation. **C2.** Applying, in typical situations, of the acquisition and signal processing basic methods. **C6.** Solving specific problems of broadband communication networks:

	propagation in various transmission media, high-frequency (microwave and optical) circuits and equipment.
Transversal competences	**CT1.** The methodical analysis of the daily issues, identifying the problems for which well-known solutions are already available, thus accomplishing the professional tasks.

7. Course objectives (as implied by the grid of specific competences)

7.1 General objective of the course	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.
4.2 Specific objectives	The specific objectives provided by the course refer to the knowledge of the physical phenomena specific to transmission lines, different types of waveguides (rectangular waveguide, coaxial waveguide, microstrip lines etc.), resonant cavities. Also, there are provided basic specific knowledge about the analysis of the microwave structures using the scattering matrix formalism S.

8. Content

8.1 Lectures	Teaching techniques	Remarks
1. Transmission lines 1.1. Wave propagation along transmission lines, propagation constant, characteristic impedance 1.2. Distribution of voltages and currents along loss-less transmission lines 1.3. Input impedance of a transmission line. Smith Chart 1.4. The transmitted power, efficiency 1.5. Transmission lines, as circuit elements at high frequencies. Lines as resonators. Matching circuits with transmission lines	Teaching (definitions, demonstration, properties) of the basic theoretical knowledge is done using the classical method (at the blackboard). Physical phenomena, certain characteristics/properties are presented with video projector in order to make them easier to be understood. This is how the demonstrative communication function is achieved. The oral communication methods are the expository method and the questioning one. On the course site, there are available the electronic materials.	18 hours
2. Waveguides 2.1. Plane waves. Plane waves in lossy dielectrics. Plane waves in metals 2.2. 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 2.3. Propagation study of the waves in rectangular waveguide: dominant H_{10}, normal working bandwidth, field's structure, superficial currents,. Wave propagation in circular waveguide. Excitation, detection and filtration of the modes 2.4. Transmitted power along the		12 hours

waveguides, the maximum transmissible power. Propagation in low-losses waveguides 2.5. Coaxial waveguide. Planar waveguides. Microstrip line. Coplanar waveguide		
3. Electromagnetic resonators 3.1. Resonant cavities. Oscillation modes, reflections method 3.2. Computational resonant frequency of an oscillation mode. Quality factor		3 hours
4. Basics of the microwave linear network theory 4.1. Equivalent voltages and currents in waveguides. Power waves 4.2. One-port characterization. **S** matrix of a linear n-port 4.3. Determining **S** matrix 4.4. Properties of the **S** matrix. **S** matrix of the reciprocal devices. **S** matrix of the passive devices. **S** matrix of the conservative devices		9 hours

Bibliography

1) G. Lojewski, N. Militaru, *High Frequencies and Microwaves*, Ed. Politehnica Press, Bucureşti 2014.
2) G. Lojewski, N. Militaru, *Circuite de microunde*, Ed. Politehnica Press, Bucureşti 2016.
3) D.M. Pozar, *Microwave Engineering*, 4th Edition, JohnWiley & Sons, Inc., 2012.
4) D.K. Misra, *Radio-Frequency and Microwave Communication Circuits: Analysis and Design*, JohnWiley & Sons, Inc., 2001.
5) M. Golio, *The RF and Microwave Handbook*, CRC Press LLC, 2001.

8.2 Laboratory	Teaching techniques	Remarks
Work 1 Study of Signal's Amplitude Distribution along the Slotted Line	Teaching of the necessary theoretical knowledge needed to understand the measuring methods is done using the classical one, followed by presentations done using the video projector. The oral communication method is the questioning one, frontally utilized. Using the microwave equipments/installation, the students measure the specific parameters of the lines/guides using different methods and then they evaluate the results obtained experimentally in connection to the fundamental notions presented at the course. There are identified and quantified certain errors	2 hours
Work 2 Measurement of Frequency and Wavelength in Waveguides		2 hours
Work 3 Measurement of Standing Wave Ratio		2 hours
Work 4 Measurement of the Normalized Impedance. Measurement of the Reflection Coefficient		2 hours

	that might appear in the measuring process. The educational materials available to the students are the laboratory platforms included in the laboratory guide which can be found both printed and in electronic version.	
Work 5 Study of Simple Matching Circuits using Circuits Simulation	Teaching of the necessary theoretical knowledge needed to understand the measuring methods is done using the classical one, followed by presentations done using the video projector. The oral communication method is the questioning one, frontally utilized Using professional circuit/electromagnetic simulating tools, the students simulate matching structures with transmission lines and evaluate independently the same problems by continuous utilization both the computer and the software medium. The educational materials available to the students are the laboratory platforms included in the laboratory guide which can be found both printed and in electronic version. .	2 hours
Work 6 The Study of Matching Circuits for Complex Loads		2 hours
Work 7 Final Laboratory Evaluation		2 hours

Bibliography

1) G. Lojewski, N. Militaru, *High Frequencies and Microwaves*, Ed. Politehnica Press, Bucureşti 2014.

2) G. Lojewski (coordonator), *Microunde şi Circuite de microunde. Îndrumar de laborator*, Ed. Electronica2000, Bucureşti, 2004.

3) G. Lojewski, N. Militaru, H. Lupescu, I. Mocanu, A. Bădescu, *Microwave Circuits – Laboratory Guide*, Ed. Politehnica Press, Bucharest, 2014.

4) D.M. Pozar, *Microwave Engineering*, 4th Edition, JohnWiley & Sons, Inc., 2012.

8.3 Seminary	**Teaching techniques**	**Remarks**
Seminary 1 Voltages and Currents along Transmission Lines	Teaching of the necessary theoretical knowledge needed to understand the measuring methods is done using the classical one (at the	2 hours
Seminary 2 Input Impedance in a		2 hours

Transmission Line	blackboard). The oral communication method is the questioning one, frontally utilized. For a better understanding of certain physical phenomena, certain descriptions they are presented using the video projector. The applications are solved through continuous interaction between students and teacher.	
Seminary 3 Applications on Smith Chart		2 hours
Seminary 4 Rectangular Waveguide		2 hours
Seminary 5 Coaxial Cable, Microstrip Line		2 hours
Seminary 6 Scattering Parameters *S* of the n-ports		2 hours
Seminary 7 Final Seminary Evaluation		2 hours

Bibliography

1) G. Lojewski, N. Militaru, *High Frequencies and Microwaves*, Ed. Politehnica Press, Bucureşti 2014.
2) G. Lojewski, N.Militaru, *Microunde, Culegere de probleme*, Ed. Electronica2000, Bucureşti 2005.
3) D.K. Misra, *Radio-Frequency and Microwave Communication Circuits: Analysis and Design*, JohnWiley & Sons, Inc., 2001.

9. Bridging the course content with the expectations of the epistemic community representatives, professional associations and employers representatives for the domain of the program

Nowadays, microwave applications represent an important market with an increasingly pace. Microwave 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 Applied Electronics (ELA). 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 Bucharest Polytechnic University policy, considering both its content and structure, and the skills and international openness it offers to students.

10. Evaluation

Type of activity	10.1 Evaluation criteria	10.2 Evaluation methods	10.3 Weight in the final mark
10.4 Lectures	- Knowledge of fundamental theoretical aspects - Knowledge of the	Programmed exam in session. The subjects cover the whole analytical	50%

	way of applying theory to specific problems - Critical and comparative analysis of the theoretical methods and techniques	programme of the course, realizing a synthesis between comparative theoretical understanding of the course and explaining through exercises and problems of the application methods.	
10.5 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 of distinctive questions; the practical component consists of a measurement done by each student with the slotted line of a specific parameter, using a method presented in the laboratory.	25%
10.6 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 (homeworks, solving applications at the blackboard) and a final, written test during the last class.	25%
10.7 Minimal performance standard			
- Knowledge of the important aspects referring to signals' propagation along transmission lines; - Characterizing a simple microwave circuit using the scattering matrix, **S**.			

Date	Lecturer	Instructor for practical activities
25.09.2017	Prof. univ. dr. ing. G. Łojewski	Ş.L. univ. dr. ing. Iulia Mocanu

Date of department approval

30.10.2017

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Department Head,

Conf. univ. dr. ing. Eduard Popovici