# COURSE DESCRIPTION

**1. Program identification information**

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| 1.1 Higher education institution | University POLITEHNICA of Bucharest |
| 1.2 Faculty | Faculty of Electronics, Telecommunications and Information Technology |
| 1.3 Department | Telecommunication Department |
| 1.4 Domain of studies | Electronic Engineering, Telecommunications and Informational Technologies |
| 1.5 Cycle of studies | License |
| 1.6 Program of studies/Qualification | Technologies and Systems for Telecommunications |

**2. Course identification information**

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| 2.1 Name of the course | | | | Microwave Circuits | | | |
| 2.2 Lecturer | | | | Prof. univ. dr. ing. George Lojewski | | | |
| 2.3 Instructor for practical activities | | | | Ş.l. univ. dr. ing. Iulia Mocanu | | | |
| 2.4 Year of studies | III | 2.5 Semester | I | 2.6 Evaluation type | Exam | 2.7 Course choice type | Compulsory |

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

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|---|---|---|---|---|---|
| 3.1 Number of hours per week, out of which | | 3.2 course | 2 | 3.3 practical activities | 1/1 |
| 3.4 Total hours in the curricula, out of which | 56 | 3.5 course | 28 | 3.6 practical activities | 14/14 |

| Distribution of time | Hours |
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| Study according to the manual, course support, bibliography and hand notes | 8 |
| Supplemental documentation (library, electronic access resources, in the field, etc) | 2 |
| Preparation for practical activities, homework, essays, portfolios, etc. | 7 |
| Tutoring | 0 |
| Examinations | 5 |
| Other activities | 0 |

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| 3.7 Total hours of individual study | 22 |
| 3.9 Total hours per semester | 78 |
| 3. 10 Number of ECTS credit points | 3 |

**4. Prerequisites (if applicable)**

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| 4.1 curricular | Analysis and synthesis of circuits<br>Microwaves |
| 4.2 competence-based | Knowledge of the basic concepts referring to the laws of the electromagnetic field, electric and electronic circuits theory |

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**5. Requisites (if applicable)**

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| 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**

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| Professional competences | **C6.** Solving specific problems of broadband communication networks: propagation in various transmission media, high-frequency (microwave and optical) circuits and equipment. |
| Transversal competences | **CT1.** Methodical analysis of the encountered problems during the activity, by identifying the elements for which there are well known solutions, assuring in this manner the fulfillment of the professional tasks<br>**CT3.** Adaptation to newly technologies, personal and professional development, by continuous forming using printed documentation sources , specialized software and electronic resources in Romanian and at least one international language |

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

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| 7.1 General objective of the course | The course provides to the students a thorough training in the knowledge of the fundamental principles and methods utilized in the analysis and synthesis of the microwave circuits. |
| 4.2 Specific objectives | The specific objectives provided by the course refer to the knowledge about the analysis of the microwave structures using the scattering matrix formalism **S**. |

**8. Content**

| **8.1 Lectures** | **Teaching techniques** | **Remarks** |
|---|---|---|
| **1. Basics of linear microwave network theory**<br>1.1. Power waves. The scattering matrix, **S**<br>1.2. Methods for determining the scattering matrix. Properties of the scattering matrix<br>1.3. Reciprocity. Passivity. | 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 | 4 hours |
| **2. Properties of the scattering matrix for some types of devices** | | 4 hours |

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| 2.1. Reciprocal passive lossless two-port devices. Thin two-port device. Measurements of two-port devices. Non-reciprocal two-port device: the ideal isolator.<br>2.2. Properties of three-port devices. Passive, non-dissipative reciprocal or non-reciprocal three-port devices. Ideal three-port circulator. Ideal power splitter.<br>2.3. Properties of four-port devices. Reciprocal, passive, lossless four-port devices. Ideal directional coupler. | 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. | |
| **3. Directional couplers**<br>3.1. The quadrature hybrid branch-line coupler<br>3.2. Ring coupler<br>3.3. Coupled-line directional coupler<br>3.4. Bethe-hole waveguide directional coupler<br>3.5. Multi-hole waveguide directional couplers | | 8 hours |
| **4. Power dividers**<br>4.1. Power-dividers with two and three resistors<br>4.2. Wilkinson power divider | | 4 hours |
| **5. Microwave filters**<br>5.1. Prototype filters, frequency transformations<br>5.2. Microwave filters synthesis<br>5.3. Study of some types of filters. Technological features related to the fabrication of microwave filters in different technologies (microstrip, waveguide, coaxial cable)<br>5.4. The effect of losses on the performances of the microwave filters<br>5.5. Other circuits with filtering behavior. Progressive wave resonator.<br>5.6. Special types of filters | | 8 hours |


Bibliography

1) G. Lojewski, N. Militaru *Circuite de microunde*, Ed. Politehnica Press, Bucureşti 2016

2) G. Lojewski, *Dispozitive şi circuite de microunde*, Ed. Tehnică, Bucureşti 2005.

3) D.M. Pozar, *Microwave Engineering, Fourth Edition*, John Wiley & Sons, Inc., NJ 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 |
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| **Work 1** | Teaching of the necessary | 2 hours |

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| Transmission-line directional couplers | theoretical knowledge needed to understand the measuring methods is done using the classical one, followed by presentations done using the video projector.<br>The oral communication method is the questioning one, frontally utilized.<br>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 that might appear in the measuring process.<br>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 2**<br>Coupled-line directional couplers | | 2 hours |
| **Work 3**<br>Power dividers | | 2 hours |
| **Work 4**<br>Microstrip low-pass filter with cascaded coupled transmission lines | | 2 hours |
| **Work 5**<br>Bandpass filters with edge-coupled transmission lines, in microstrip technology | Teaching of the necessary theoretical knowledge needed to understand the simulation methods is done using the classical one, followed by presentations done using the video projector.<br>The oral communication method is the questioning one, frontally utilized<br>Using professional circuit/electromagnetic simulating tools, the students design and simulate simple microwave circuits and evaluate independently the | 2 hours |
| **Work 6**<br>Non-reciprocal ferrite devices | | 2 hours |
| **Work 7**<br>Final Laboratory Evaluation | | 2 hours |

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| | 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. | |


Bibliography

1) G. Lojewski, N. Militaru *Circuite de microunde*, Ed. Politehnica Press, Bucureşti 2016.

2) G. Lojewski, *Dispozitive şi circuite de microunde*, Ed. Tehnică, Bucureşti 2005.

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 |
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| **Seminary 1** Properties of the scattering matrix, **S** | Teaching of the necessary theoretical knowledge needed to understand the methods for characterization of microwave circuits is done using the classical one (at the 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. | 2 hours |
| **Seminary 2** Characterization of microwave passive circuits using the scattering matrix, **S** | | 2 hours |
| **Seminary 3** Directional couplers | | 2 hours |
| **Seminary 4** Interconnection of *n*-port microwave devices | | 2 hours |
| **Seminary 5** Power dividers | | 2 hours |
| **Seminary 6** The design of the microwave bandpass filters | | 2 hours |
| **Seminary 7** Final Seminary Evaluation | | 2 hours |
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Bibliography

1) G. Lojewski, N. Militaru *Circuite de microunde*, Ed. Politehnica Press, Bucureşti 2016.

2) N. Militaru, G. Lojewski, *Circuite de microunde, Culegere de probleme*, Ed. Matrix Rom, Bucureşti 2013.

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**

In these days microwave applications represent an important market with an increasingly pace. 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 equipments, 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 universitary 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 policy, both from the perspective of content and structure as well as from the perspective of skills and international opportunities offered 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<br>- Knowledge of the way of applying theory to specific problems<br>- Critical and comparative analysis of the theoretical methods and techniques | Programmed exam in session.<br>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% |
| 10.5 Laboratory | - Knowledge of the essential aspects regarding the characterization of the microwave devices | Final laboratory evaluation, containing the design and simulation of a microwave device / | 25% |

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| | and circuits using the scattering matrix.<br>- Knowledge of some specific methods for the design and simulation of microwave circuits.<br>- Microwave circuit analysis through circuit simulation | 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. | |
| 10.6 Seminary | - Knowledge of the essential aspects of propagation phenomena in microwave circuits;<br>- 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 power waves.<br>- Knowledge of the properties of some *n*-port devices.<br>- Knowledge of the important aspects referring to the microwave filters. | | | |

Date

25.09.2017

Lecturer

Prof. univ. dr. ing. George Lojewski

Instructor for practical activities

Ș.l. univ. dr. ing. Iulia Mocanu

Date of department approval

30.10.2017

Department Head,

Conf. univ. dr. ing. Eduard Popovici