Code: ING-INF/02 **Credits:** 9
Matter: Microwave Systems and Components
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Mirko Barbuto - mirko.barbuto@unicusano.it

Introduction

1. Objective of the course :

The course aims to provide fundamentals about the main microwave systems (i.e. radar systems, wireless communication systems, microwave heating systems, etc.) and their main constituting components. Some of the elements of a microwave system, already introduced in the previous courses of the same scientific-disciplinary area (antennas, transmission lines, etc.), will be further investigated to highlight the systemic aspects.
Particular emphasis will also be given to understanding the fundamental design principles of a microwave system and of its main individual components.

Objectives

2. Course Structure:

The course is organized in five subjects. The first subject is an introduction to microwave systems while the second one is focused on the use of full-wave numerical simulators for the analysis and synthesis of microwave components. The third subject is related to transmission lines and the use of the Smith Chart. Subject four is referring to impedance matching. Finally, subject five deals with the synthesis of microwave filters.
The course of Microwave Systems and Components provides 6 credits. The total study load for this teaching module is around 150 hours, divided as follows: about 110 hours for viewing and studying the video recorded materials; about 40 hours of Interactive Teaching for the elaboration of 3 E-tivity and for the execution of self-assessment tests.

We suggest to uniformly distribute the course study over a period of 8 weeks, devoting 18-22 hours of study a week.
For attending the course, knowledge of fundamental concepts of electromagnetic field theory is required.

Competencies:

At the end of the course the student will have knowledge of the main microwave systems and of their main constitutive components. In particular, the student will know the effects of the different components on the performance of the overall system. Moreover, through the E-tivity, students will acquire ability to formulate electromagnetic problems within the software CST Microwave Studio.
The student will be able to design the main components and devices that constitute a microwave system. Therefore, he will be able to approach the project of a simple radio frequency transmission and reception system, using the simulation tools available on the market.
Furthermore, the student will be able to identify the most appropriate models to describe and design the individual functional blocks of a complex microwave system (e.g. generator, transmission line, radiating element, etc.) and to apply critical verification methods to evaluate the effectiveness of the project itself. Thanks to the e-tivity and the interaction with colleagues and the head instructor, the student will be able to present the project results through discussion in technical language or written technical reports.

Finally, at the end of the course, the student will be able to read technical documents for deriving the necessary information for the design of various microwave components and to apply the acquired knowledge for the resolution of unfamiliar problems related to the design of microwave systems.

Syllabus

3. Programme of the course:

Subject 1. Introduction to microwave systems

Fundamentals of antennas and their systemic aspects (radiation diagram, noise temperature,…); wireless communication systems (Friis formula, link budget, radio receiver architecture, examples,…);

radar systems (radar range equation, radar cross section, radar types); radiometric systems; microwave propagation (atmosphere effects, soil effects, plasma effects); other applications (microwave heating; wireless power transfer, biological effects and security).

Subject 2. Electromagnetic simulation software
Introduction to electromagnetic simulation; generic process of an electromagnetic simulation; electromagnetic solvers (method of moments, FEM method, finite difference time domain, comparison between the different methods); main electromagnetic software simulators (Momentum, FEKO, HFSS, CST Microwave Studio,...); tutorial for the use of CST Microwave Studio.

Subject 3. Transmission lines and Smith Chart
From Maxwell equations to telegraphist equations; their solutions; reflection coefficient and impedance matching of transmission lines; Smith Chart; frequency behavior of simple circuits; basic operations on Smith Chart.

Subject 4. Impedance matching
Lumped elements impedance matching; single stub technique; double stub matching; quarter-wave impedance transformer; small reflection theory.

Subject 5. Microwave filters
Periodic structures; filters design with the insertion loss method; filters transformations; filters implementation; stepped-impedance pass-band filter; coupled lines filters; coupled resonators filters.

Evaluation system and criteria

The exam consists of a written test aimed at assessing the abilities to analyze and re-elaborate the theoretical concepts and a series of activities (E-tivity) carried out during the course in virtual classes.
The evaluation of the E-tivity from 0 to 5 points, is carried out during the course. The final test is evaluated from 0 to 26 points.
The written test (lasting 90 minutes) involves the theoretical discussion, in written form, of two topics of the course. Each answer will be evaluated (from a minimum of 0 to a maximum of 13 points) based on the following parameters: relevance to the question (4

points), completeness of information (5 points), quality of the presentation (4 points).
The expected learning outcomes regarding the knowledge of the subject and the ability to apply this knowledge are evaluated by the written test, while the communication skills, the ability to draw conclusions and the capacity for self-learning are evaluated through the E-tivity.

Bibliography and resources

4. *Materials to consult:*
   The teaching material on the platform is divided into 5 modules. They completely cover the program and each of them contains lecture notes, slides and video lessons. This material contains all the elements necessary to study the course subjects.

5. *Recommended bibliography:*

- David M. Pozar, “Microwave Engineering”, John Wiley & Sons, Inc., 4rd edition.
- Robert E. Collin, “Foundations for Microwave Engineering”, Wiley-IEEE Press, 2nd edition