UNICUSANO
ROME

Code: ING-INF/02 **Credits: 9**
Course: Waveguide propagation and microwave circuits
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Stefano VELLUCCI - stefano.vellucci@unicusano.it

Objectives

The course provides the fundamentals on waveguided propagation of the electromagnetic field and the basic knowledge of passive microwave components and of the electromagnetic theory behind their operation. Emphasis is given to the methods required to understand the behavior and the design of the most common waveguiding structures working at microwave frequencies. The fundamentals for the design of microwave components and networks are also provided.

Course structure

The course is organized into six subjects. The first subject summarizes the main results of the electromagnetic theory and introduces the classification and the main uses of microwaves. The second subject focuses on the analytical tools required for the characterization of the electromagnetic guiding structures. The third and fourth subjects analyze the most common guiding structures constituted by one or more conductors and provide the respective design tools. The fifth subject is aimed at the analysis and the design of microwave and millimeter-wave networks. Finally, the sixth subject is devoted to the introduction to the use of commercial full-wave electromagnetic simulators.

Competencies:

A. Knowledge and understanding:

At the end of the course, the student will know the terminology, properties and physical quantities used to characterize a mode of propagation. Furthermore, he will

know the characteristics of the propagation of electromagnetic fields inside the guiding structures in relation to the frequency band used, the operating principles of the main types of guiding structures, the analytical formulation necessary for their analysis, their characteristics and the respective advantages and disadvantages. Finally, the student will know the transmission line model of the guided modes, the analytical techniques and tools necessary to characterize a microwave circuit and will understand the functions and the operating principle of the main microwave components in waveguide and microstrip structures.

B. Applying knowledge and understanding:

At the end of the course, the student will have developed the ability to analyze and synthesize single and multi-conductor guiding structures and will be able to calculate the electromagnetic field that propagates within a generic guiding structure, once the geometry and characteristics of the structure are known. In addition, the student will have the ability to analyze and synthesize microwave components with one, two, three and four ports.

C. Making judgements:

At the end of the course, the student will have the ability to choose a specific type of guiding structure based on project specifications. He will also have acquired the ability to identify the components necessary to perform a pre-assigned complex function as well as the related interconnections. Finally, the student will have developed a critical ability to interpret the results obtained during the performance of a numerical exercise or a simulation both in terms of the physical consistency of the results obtained and in terms of the engineering feasibility of the solution identified.

D. Communication skills:

At the end of the course, the student will have developed a correct and understandable scientific language, which will allow him to express clearly and unambiguously the technical knowledge acquired in the field of guided propagation theory and microwave circuits.

E. Learning skills:

At the end of the course, the student will be able to apply the knowledge acquired for solving unfamiliar problems that have as their object the transmission of the electromagnetic field through an appropriate guiding structure and its processing using microwave circuits.

Syllabus

Subject 1 – Introduction
Fundamentals of electromagnetic theory. Maxwell equations. Constitutive relationships of materials. Introduction to microwave engineering. Electromagnetic spectrum. Examples of guiding structures.

Subject 2 – Supply models
Maxwell equations in transverse form. TE, TM and TEM waves. Boundary conditions. Eigenvalues and eigensolutions. Phase, energy and group velocities. Waves Attenuation. Waves orthogonality.

Subject 3 - Statistics and econometrics
TE and TM waves in rectangular waveguide. Dominant and high-order modes in rectangular waveguide. Bessel functions. TE and TM waves in circular waveguide. Dominant and high-order modes in circular waveguide.

Subject 4 – Demand models
Guiding structures with more than one conductor and closed metal cladding. Coaxial cable. Stripline. Microstrip transmission-line.

Subject 5 – Assignment models
Introduction. Transmission-line model of the guided modes. Microwave networks. Matrices for microwave networks. Passive microwave components.

Subject 6 – Assessment models
Introduction to the electromagnetic simulation software CST Studio Suite (Basic interface; Using the program help; Definition of a simulation setup; Types of solvers available; Definitions of materials; Definitions of the frequency range, boundary conditions and symmetry planes; Types of electromagnetic excitation; Definition of field monitor). Simulation of a lambda/2 electromagnetic dipole and display of its characteristics. Simulation of a waveguide and display of its characteristics. Simulation of a magic T and its characteristics.

Evaluation system and criteria

The assessments of course is based on the following criteria:
I) Final exam (84 %)
II) Homework (16 %)

The final exam consists of three parts: two numerical exercises and one open question. The homework consists of the writing of a technical report containing the results of numerical simulations of relevant structures.

Bibliography and resources

1. *Materials to consult*

- Lecture notes
- Recorded and live lectures

2. *Recommended bibliography*

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