UNICUSANO ROME

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

Teaching Staff

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

Objectives

The main objective of the course is to provide knowledge on the operation of major microwave systems (radar systems, wireless communication systems, microwave heating systems, etc.) and the primary hardware components that comprise them. Some of the elements in a microwave system, previously introduced in earlier courses in the same scientific-disciplinary sector (antennas, transmission lines, etc.), will be revisited to emphasize their systemic aspects. Particular emphasis will also be given to understanding the fundamental design criteria of a microwave system and its individual components.

Course structure

The course is organized into five sections. The first section introduces the fundamentals of microwave systems and their main components. The second section reviews concepts related to antennas and transmission lines, with a particular focus on systemic aspects. The third and fourth sections cover design techniques commonly used for impedance matching networks and microwave filters, respectively. Finally, the fifth section provides the tools necessary for designing microwave components and circuits.

Competencies:

A. Knowledge and understanding:

Upon completion of the course, the student will have knowledge of the main microwave systems and the components that typically comprise them. In particular, the student will be able to understand the implications of different components on the performance of the overall system.

B. Applying knowledge and understanding:

The student will be able to design the main devices and components that constitute a microwave system. They will be capable of approaching the design of a simple RF transmission and reception system, using commercially available simulation tools.

C. Making judgements:

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 assess the quality of the design.

D. Communication skills:

The student will be able to present design results through technical discussions or written reports on the activities performed.

E. Learning skills:

At the end of the course, the student will be able to read technical documents to extract the necessary information for designing various microwave components and to apply the acquired knowledge to solve unfamiliar problems related to microwave system design.

Syllabus

Subject 1 – Introduction

Recalls of antennas with particular emphasis on systemic aspects (radiation pattern, noise temperature...); wireless communication systems (Friis formula, link budget, radio receiver architecture, noise characterization, examples...); radar systems (radar equation, radar cross section; radar types); radiometric systems; microwave propagation (atmospheric effects, ground effects, plasma effects); other applications (microwave heating, power transfer, biological effects and safety).

Subject 2 – Recalls on transmission lines theory

From Maxwell's equations to the telegrapher's equations; solution of the telegrapher's equations; reflection coefficient and impedance matching in transmission lines; Smith chart: introduction and operation; frequency behavior of simple circuits; basic operations on the Smith chart.

Subject 3 - Impedance matching techniques

Matching with lumped elements (L-networks, analytical solution and with Smith chart); single stub matching (series and parallel connection); double stub matching (analytical solution and with Smith chart); quarter-wave transformer; small reflection theory; binomial multi-section transformer; Chebyshev multi-section transformer (Chebyshev polynomials and transformer design); tapered lines (exponential, triangular, and Klopfenstein tapering); Bode-Fano criterion.

Subject 4 – Microwave filters

Periodic Structures (analysis of infinite periodic structures, finite periodic structures, dispersion diagrams); filter design using the insertion loss method (characterization through power loss ratio, maximally flat low-pass prototype, equal-ripple low-pass prototype, linear phase low-pass prototype); filter transformations (impedance and frequency scaling, bandpass and band-stop transformations); filter implementation (Richards transformations, Kuroda identities, impedance and admittance inverters); stepped-impedance low-pass filter; coupled-line filters (filtering properties of a coupled-line section, bandpass filter design using coupled lines); filters with coupled resonators (band-stop and bandpass filters with quarter-wave resonators; bandpass filter with capacitively coupled series resonator, bandpass filter with capacitively coupled parallel resonator).

Subject 5 – Electromagnetic simulators

Introduction to Electromagnetic Simulation; generic electromagnetic simulation process (Method of Moments, FEM, Finite Difference Time Domain, comparison between different simulators); main electromagnetic simulation software (Momentum, FEKO, HFSS, CST Microwave Studio,…); tutorial for using CST Microwave Studio.

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.