UNICUSANO
ROME

Code: ING-INF/02 **Credits:** 6
Matter: Wireless Systems Technologies
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Michela Longhi - michela.longhi@unicusano.it

Introduction

1. *Objective of the course:*

The course is designed to provide the methodologies and skills necessary for understanding the technologies underlying modern wireless systems. In particular, the course provides theoretical and practical information on the main wireless systems and on enabling electronic and electromagnetic technologies. Knowledge and skills are provided on noise in telecommunications systems, on antennas and radio propagation, as well as on the operation of major microwave systems. Particular emphasis is placed on the physical understanding of the phenomena that characterize the transmission and reception of information on the radio carrier. This course is part of the disciplines of electromagnetic fields and expands and deepens the knowledge acquired in the teachings of Electromagnetic Fields and Guided Propagation and microwave circuits.

Objectives

2. *Course Structure:*

- Illustrate the main wireless communication systems and their specificities
- Describe the enabling technologies for modern wireless systems
- Describe the issues of noise and distortion in wireless systems
- Illustrate the fundamentals of antenna theory and radio propagation
- Illustrate the main microwave systems, their operation, and the related design criteria

Competencies:

Knowledge and understanding
At the end of the course, the student will know the terminology, properties and characteristics of modern wireless systems. He will know the sources of noise that affect the performance of a wireless system. He will also know the fundamentals of antennas and the physical quantities used for their characterization. Finally, the student will know the fundamentals of the free propagation of the electromagnetic field, the effects of the ground and the atmosphere and the problem of multiple paths.

Applying knowledge and understanding
At the end of the course, the student will have developed the ability to analyze and synthesize a wireless communication system and related propagation scenarios.
Making judgments
At the end of the course, the student will have the ability to choose the components necessary to size a wireless system that meets certain design specifications. He will also have acquired the ability to determine the effects of the environment on the propagation of the electromagnetic field and to take them into account in the design phase. Finally, the student will have developed a critical ability to interpret the results obtained during a numerical exercise and a simulation both in terms of physical consistency of the results obtained and in terms of engineering feasibility of the solution identified.

Communication skills
At the end of the course, the student will have developed a correct and understandable scientific language that will allow him to express in a clear and unambiguous way the technical knowledge acquired in the field of wireless systems theory, antennas and radio propagation.

Learning skills
At the end of the course, the student will have developed the ability to apply the knowledge acquired for solving unfamiliar problems that have as their object the transmission and reception of information on a radio carrier.

Syllabus

3. *Programme of the course:*

Module 1 - Recall of Electromagnetic Fields

Maxwell's equations. Electromagnetic waves. Continuity equation. Constitutive relations. Kramers-Kronig relations. Boundary conditions.

Module 2 - Antenna Basics
Electrodynamic potentials. Green's function: Green's function for free space. Radiation from an arbitrary current distribution. Radiation from elementary antennas. Electrical and radiative characteristics of the antennas. Effective area and noise temperature of an antenna. Separation between the field regions. Friis formula. Notes on the main types of antennas.

Module 3 - Receiving antennas and noise
Power received by an antenna in a condition of polarization adaptation. Power received by an antenna in a condition of polarization mismatch. Antenna noise.

Module 4 - Free Space Propagation
Field in the distant area. Friis formula. Radar equation.

Module 5 - Introduction to microwave systems
Noise temperature and background noise. Wireless communication systems. Architecture of a radio receiver. Digital modulation and bit error rate. Radar systems. Radiometric systems. Microwave propagation. Microwave heating.

Module 6 - Electromagnetic Simulation (CST) Software
Introduction to electromagnetic simulation. Generic electromagnetic simulation process. Main electromagnetic simulation software. Using the CST Microwave Studio software.

Evaluation system and criteria

The exam usually consists in carrying out a written test aimed at ascertaining the ability to analyze and rework the concepts acquired.
The written test includes 2 numerical exercises and 2 theory questions to be completed in 90 minutes. Each of the questions has a maximum score of 7.5 points.
The exercises present in the exams will concern the modules for which there are exercises on the platform (uploaded as a single file within the corresponding module).
The exercises, therefore, will cover the following modules:
Fundamentals of antennas; Free space propagation.

The student who must take the exam on the entire 6 CFU program can choose, indicating his choice during the exam, to take the exam through TWO PARTIAL EXAMS (see facsimile task uploaded on the platform).

- Partial exam 1 (3 CFU) will cover the following modules: Module 1, Module 2, Module 3. Partial exam 1 will be evaluated up to a maximum of 15 points.
- Partial exam 2 (3 CFU) will cover the following modules: Module 4, Module 5, Module 6. Partial exam 2 will be evaluated up to a maximum of 15 points.

Bibliography and resources

4. *Materials to consult:*

The didactic material on the platform is divided into 6 modules. They cover the entire program and each of them contains handouts, exercises, slides, video lessons in which the teacher comments on the slides. This material contains all the tools necessary to tackle the study of the subject.

5. *Recommended bibliography:*

- David M. Pozar, “Microwave and RF Design of Wireless Systems”, John Wiley & Sons, Inc.
- Kai Chang, “RF and Microwave Wireless Systems”, John Wiley & Sons, Inc.
- Aldo Paraboni e Michele D’Amico, “Radiopropagazione”, McGraw-Hill Education Italy.