Italian code: ING-INF/02 (old) – IINF-02/A (new) **Credits: 6**
Course: Wireless Systems Technologies
Main language of instruction: Italian
Other language of instruction: English

Head instructor
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Objectives

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

Course structure

- Module 1 – Electromagnetic Field Reminders
- Module 2 – Fundamentals of Antennas
- Module 3 – Receiving antennas and noise
- Module 4 – Propagation in free space
- Module 5 – Introduction to Microwave Systems
- Module 6 – Electromagnetic Simulation Software (CST)

Competencies

A. Knowledge and understanding:

At the end of the course, the student will know the terminology, properties and characteristics of modern wireless systems. You will know the noise sources 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.

B. 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 its propagation scenarios.

C. Making judgements:

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 developed 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 the performance of a numerical exercise and a simulation both in terms of physical coherence of the results obtained and in terms of engineering feasibility of the identified solution.

D. 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 the theory of wireless systems, antennas and radio propagation.

E. Learning skills:

At the end of the course, the student will have developed the ability to apply the acquired knowledge to the resolution of unfamiliar problems concerning the transmission and reception of information on a radio carrier.

Syllabus

Module 1 – Electromagnetic Field Reminders

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

Module 2 – Fundamentals of Antennas

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

Module 3 – Receiving antennas and noise
Power received from an antenna in polarization matching condition.
Power received from an antenna in a polarization mismatch condition.
Antenna noise.

Module 4 – Propagation in free space
Field in a 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 Software (CST)
Introduction to electromagnetic simulation.
Generic electromagnetic simulation process.
Main electromagnetic simulation software.
Use of CST Microwave Studio software.

Evaluation system and criteria

The exam usually consists of 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 carried out in 90 minutes. Each of the questions has a maximum score of 7.5 points.
The exercises in the exams will concern the modules for which there are exercises in the platform (uploaded as a single file within the corresponding module).

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

- The 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.
- The 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

1. *Materials to consult*

The teaching 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 deal with the study of the subject.

2. *Recommended bibliography*

Suggested readings are:

- 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 and Michele D'Amico, "Radiopropagazione", McGraw-Hill Education Italy