UNICUSANO
ROME

Code: ING-INF/02 **Credits:** 9
Matter: Antenna theory and design
Main language of instruction: Italian
Other language of instruction: English

Teaching Staff

Head instructor
Prof. Alessio Monti - alessio.monti@unicusano.it

Introduction

1. Objective of the course :

The course is intended to provide the fundamentals about the phenomena of transmission and reception of the electromagnetic field and the related applications to the information technology. The course will focus on the definition of the physical parameters needed to characterize the behavior of an antenna and on the discussion of the main types of antennas currently used in different applicative scenarios. The analysis and synthesis of wireless radio-links are discussed as well.

Objectives

2. Course Structure:

The course is organized in eight subjects. The first subject summarizes the main results of the electromagnetic theory and develop the conceptual tools and the analytical techniques required to rigorously analyze the electromagnetic field radiated by a generic source. The second subject is focused on the description of the physical quantities used to describe the performance of an either transmitting or receiving antenna. The following modules (from three to eight) provide the fundamentals to analyze and design the most common antennas types, such as wire antennas, loop antennas, aperture antennas, parabolic antennas, microstrip antennas and antenna arrays.

Competencies:

• Understanding of the physical phenomena regulating the transmission and reception of the electromagnetic field and of the relative mathematical tools;

• Ability to characterize and to understand the performances of a receiving and a transmitting antenna by using the radiating and electrical parameters;
• Ability to choose and the proper antenna type with respect to the specific application and to the frequency range;
• Ability to design different categories of antennas and antenna arrays satisfying the design specifications.

Syllabus

3. Programme of the course:

Subject 1. Introduction

Fundamentals of electromagnetic theory. Maxwell equations. Constitutive relationships of materials. Electrodynamics potentials. Green function. Infinitesimal electric dipole. Infinitesimal magnetic dipole.

Subject 2. Fundamental parameters of antenna

Introduction. Antenna parameters. Electrical parameters. Radiative parameters. Receiving antennas. Reciprocity theorem. Antenna effective length and effective area. Noise in communication systems and antenna noise temperature. Region separation. Near, intermediate and far-field region. Friis transmission equation and radar range equation.

Subject 3. Wire antennas

Dipole antennas. Short dipole. Half-wavelength dipole. Balun. Linear elements near on infinite perfect conductors. Image theory. Ground effects. Other types of wire antennas.

Subject 4. Loop antennas

Loop antennas. Small circular loop. Circular loop of constant current. Circular loop with non-uniform current. Polygonal loop antennas. Ferrite loop.

Subject 5. Antenna arrays

Array factor. One-dimensional and bi-dimensional uniform arrays. Broadside array.
Endfire array. Hansen-Woodyard condition. Non-uniform arrays. Binomial and polynomial array. Chebyshev array. Parasitic array. Yagi-Uda array. Log-periodic array.

Subject 6. Aperture antennas
Radiation from apertures. Fourier-transform approach. Radiation from rectangular and circular apertures. Uniform field with linear phase variation. Tapered field. Equivalence principles. Love principle. Radiation from rectangular and circular waveguides. Rectangular, circular and pyramidal horn antennas. Corrugated horn. Radiation from slots. Slotted waveguide arrays.

Subject 7. Reflector antennas
Geometrical optics. Microwave lens. Reflector antennas. Reflector antennas losses.
Cross-polarization. Low cross-polarized feeds. Physical optics. Offset reflectors and dual-reflector systems.

Subject 8. Microstrip antennas
Introduction. Characteristics. Radiation mechanism. Surface waves. Feed networks. Rectangular patch. Transmission-line model. Cavity model.

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 in the writing of a technical report containing the results of numerical simulations of relevant structures.

Bibliography and resources

4. Materials to consult:
- Lecture notes
- Recorded and live lectures

5. Recommended bibliography:

- C. Balanis, "Antenna theory, analysis and design", 3rd edition, Wiley-Interscience.
- Robert E. Collin, “Antennas and Radiowave Propagation”, Mcgraw-Hill College.