Postgraduate Course
Computational Electromagnetics
(MSc)

Instructor Information

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Course Information

Course Description

This course presents most of the most commonly computational techniques used to solve electromagnetics problems in microwave engineering. These techniques are commonly used to a precise characterization of structures involved in the design and development of devices and antennas. These methods are presented to know their features, advantages and limitations and how or where can be used, as well as their performances against the others.

Prerequisites

Electromagnetic fields Theory
Microwave engineering
Solid knowledge of numerical analysis
Discrete numerical analysis

Course Goal

To reach the understanding of the need of computational electromagnetics in the design of advanced microwave devices, the features of the most common used methods, the ability of developing own codes for these designs and using properly the available tools.

Summary of intended course outcomes

At the conclusion of the course, students should be able to understand the concepts and models used in Computational Electromagnetics and also will be able to apply these to advanced engineering problems, choosing the most suitable method for them, and having the capacity of developing their own methods when required or using the available commercial tools.

By the end of the course the students will reach the abilities of

Understanding the need of computational electromagnetics

Knowing the most common computational techniques and method used to analyse the microwave circuits and antennas

Knowing the basis of these methods and, as consequence, the advantages and drawbacks of each of them

As results of the previous, they will have the capacity to choose the most suitable methods and tools for each problem

Knowing some of the commercial available tools based of these method, the capacity of choosing the most convenient tool and the basic knowledge of their use.

Syllabus

Computational Electromagnetics (60h)

1. Introduction (4h)

   The need of electromagnetic modeling.
   Purpose and scope of application.
   Review of the elecromagnetic problems.
   Equations, boundary conditions and constitutive parameters.

2. Finite differences in the time domain (10h)

   Introduction. Basic concepts. Scope
   Maxwell’s Equations Time Domain
   Yee paper
   Numerical stability

Numerical Dispersion
Incident Wave Source Conditions
Absorbing Boundary Conditions
Introduction to CST Studio. Application examples

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3. The finite element method (10h)

Methods of analysis and design of microwave passive microwave devices and antennas.
Electromagnetic formulation for propagation and radiation problems.
Domain Discretization.
Curl-conforming and div-conforming basis functions.
Methods of Domain Decomposition.
Hybrid numerical-analytical methods.
Electromagnetic Problems based on bodies of revolution, and rectangular waveguide E-plane /H-plane structures.
2-D Formulation.
Axisymmetric Finite Elements.
Microwave filter design
Analysis and design of antennas and arrays.
Introduction to Ansys HFSS. Application examples.

4. The method of moments (10h)

Theory.
Wire antennas.
Introduction to NEC. Examples.
Planar antennas.
Introduction to Ansoft Ensemble. Application examples.

5. The mode-matching technique (10h)

Description of the method.
Relative convergence.
Some examples: H-plane step in rectangular waveguide. E-plane and double-plane step in rectangular waveguide.
Single discontinuity characterization: Generalized Scattering Matrix (GSM).
Multiple discontinuity characterization: GSM, Generalized Admittance Matrix (GAM), Generalized Impedance Matrix (GIM).
Some examples in device analysis.
Introduction to Wapos. Application examples.

6. Physical optics and the general theory of diffraction (10h)

Basic concepts for GO.

Ray tracing GTD definition.
Canonical solutions of GTD over conductors and dielectric surfaces
PO definition. Spectral analysis.
PO projected on apertures.
PTD definition.
Canonical solution on a PTD analysis.
Comparison between GO+GTD & PO+PTD solutions
Example of ray tracing solutions: Reflectors and propagation analysis of a urban environment
Introduction to Ticra GRASP. Application examples.

7. Other commercial software (6h)

Introduction to other software: Keysight EEsof Momentum, Ticra CHAMP, Mician Microwave Wizard, Empire XPU,...

Application examples.

Assignments

During the course each student will select one of the topics, and will have to carry out an analysis or design task with the corresponding commercial software.

Optional. Development of own algorithms for a simple problem to be defined during the course.

Student Assessment Criteria

Final Exam	60%
Work assignments	40%