Universidad de Navarra

Antenas y Propagación (Ing.Gr.)

Guía docente 2023-24

PRESENTACIÓN

Breve descripción:

This subject builds on the point where the Electromagnetic Fields subject ended, as it introduces concepts related to the interface between a guided wave and a radiated wave in free space. After studying the basic mathematical concepts of electromagnetic radiation, main antenna types are described, ranging from wire antennas, to aperture, microstrip and reflector antennas. The syllabus finalizes with an overview of the main physical factors that affect ideal wave propagation. Graphical animations and computer simulations contribute to visualize the intriguing phenomenon of wireless electromagnetic radiation.

Titulación (Módulo/Materia):

- Ingeniería en Sistemas de telecomunicación (Bloque Especializado de Sistemas de Telecomunicación/Sistemas de Comunicación)

Detalles:

- **ECTS**: 6 ECTS
- **Curso, semestre**: 3.º curso, 1.º semestre
- **Carácter**: Obligatorio
- **Idioma**: English topics 1-7; Castellano tema 8

Profesores de la asignatura:

- García Muñoz, Francisco Javier / Colaborador docente
- Sancho Seuma, Juan Ignacio / Profesor titular
- Valderas Gázquez, Daniel / Profesor titular

COMPETENCIAS

INGENIERÍA EN SISTEMAS DE TELECOMUNICACIÓN

CE23 - Capacidad de análisis de componentes y sus especificaciones para sistemas de comunicaciones guiadas y no guiadas.

CE24 - Capacidad para la selección de circuitos, subsistemas y sistemas de radiofrecuencia, microondas, radiodifusión, radioenlaces y radio determinación.

CE25 - Capacidad para la selección de antenas, equipos y sistemas de transmisión, propagación de ondas guiadas y no guiadas, por medios electromagnéticos, de radiofrecuencia u ópticos y la correspondiente gestión del espacio radioeléctrico y asignación de frecuencias.

PROGRAMA

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Topic 1 Electromagnetic Radiation

1. How is EM radiation possible?: antenna definition
2. Mathematical approach: Magnetic Vector Potential
3. Far Field Conditions

Topic 2 Array Factor

1. Array Factor of discrete distributions
2. Array Factor of continuous distributions
3. Scaling up the Array Factor
4. Array Factor calculation of discrete distributions
5. Array Factor representation of discrete distributions
6. Broadside and endfire uniform arrays

Topic 3 Antenna Parameters

1. Antenna types
2. Reflection Coefficient, Impedance bandwidth and Input impedance
3. Radiated power and Efficiency
4. Radiation Pattern, Directivity and Gain
5. Antenna Polarization
6. Effective aperture and Radar Cross Section
7. Available and Accepted power
8. Friis equation
9. Reciprocity principle

Topic 4 Wire Antennas

1. Introduction
2. Elemental Dipole
3. Small Dipole
4. Finite Length Dipole
5. Half-wavelength Dipole
6. Mutual Impedance
7. Folded Dipoles and Yagi-Uda Antenna

8. Monopole
9. Loop Antenna

Topic 5 Microstrip Antennas

1. Introduction
2. Radiation principle
3. Design of rectangular microstrip antennas
4. Feeding Networks
5. Compact and broadband microstrip antennas

Topic 6 Aperture Antennas

1. Introduction
2. Mathematical approach
3. Elemental aperture
4. Finite aperture
5. Horns

Topic 7 Reflector Antennas

1. Introduction
2. Types of reflectors
3. Parabolic Reflector: geometrical description
4. Directivity

Topic 8 Propagation

1. Free space losses
2. Factors affecting propagation
3. Ground reflection
4. Diffraction
5. Surface waves
6. Atmospheric effects
7. Empirical and physical models of propagation

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Programa (castellano)

Tema 1: Radiación electromagnética

1. ¿Cómo es posible la radiación electromagnética?: definición de antena
2. Enfoque matemático: Potencial Vector Magnético
3. Condiciones de Campo Lejano

Tema 2: Factor de array

1. Factor de array de distribuciones discretas
2. Factor de array de distribuciones continuas
3. Generalización del factor de array
4. Cálculo del factor de array de distribuciones discretas
5. Representación de factores de array de distribuciones discretas
6. Agrupaciones uniformes tipo broadside y endfire

Tema 3 Parámetros de antenas

1. Tipos de antenas
2. Coeficiente de reflexión, ancho de banda de impedancia e impedancia de entrada
3. Energía radiada y eficiencia
4. Patrón de radiación, directividad y ganancia
5. Polarización de una antena
6. Apertura efectiva y Sección Radar Equivalente
7. Energía disponible y aceptada
8. Ecuación de Friis
9. Principio de reciprocidad

Tema 4: Antenas de hilo

1. Introducción

2. Dipolo elemental

3. Dipolo pequeño

4. Dipolo de longitud finita

5. Dipolo de media longitud de onda

6. Impedancia mutua

7. Dipolos plegados y antena Yagi-Uda

8. Antena Monopolo

9. Antena espira

Tema 5 Antenas parche

1. Introducción

2. Principio de radiación

3. Diseño antenas parche rectangulares

4. Redes de alimentación

5. Antenas parche de banda ancha y compactas

Tema 6 Antenas de apertura

1. Introducción

2. Enfoque matemático

3. Apertura elemental

4. Apertura finita

5. Antena de bocina

Tema 7 Antenas reflector

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1. Introducción

2. Tipos de reflectores

3. Reflector parabólico: descripción geométrica

4. Directividad

Tema 8 Propagación

1. Pérdidas en el espacio libre

2. Principio de superposición

3. Pérdidas por reflexión en el suelo

4. Difracción

5. Ondas de superficie

6. Efectos atmosféricos

7. Modelos empíricos de propagación

ACTIVIDADES FORMATIVAS

In the context of the present subject, the student should:

1. Take on basic concepts of antenna theory and propagation from a mathematical point of view

2. Obtain general knowledge about the electromagnetic simulation tools that make it possible to solve real design problems: relate the theoretical concepts to the outcomes of electromagnetic simulation

3. Conduct a comprehensive antenna project through specifications, design, simulation, fabrication and testing.

4. Be able to select an appropriate antenna for a wireless application using information from an industrial portfolio.

For that purpose,

1. Theoretical classes will explain main antenna concepts. Lecture slides will be available to students as supporting material. Taking personal notes is recommended.

2. Exercises on paper will illustrate theory, either within lectures or via on-line videos.

    1. Practical sessions will be held inthe computer as a virtual-lab. Realantenna designs and examples will make up the 20% of the classes by simulation tools(CST Microwave Studio).
    2. An antenna design contest will be held in order to have hands-on experience of the explained concepts.

3. Stress will be put on the understanding of the subject content and not on learning formulas by heart.

Introductory and explicative videos will be proposed to the students to prepare the lectures and study/review concepts that are not advanced.

SESIONES PRACTICAS

The practical section of the subject is divided into two parts: Computer sessions and Design Contest.

Computer Sessions

The objectives of the practical computer sessions are to get familiar with the visualization of electromagnetic fields, employ numerical methods for complex problems and apply the theoretical concepts in a virtual environment by simulation.

CST Studio Suite in will be the main set of tools.

The content of these computer exercises will be part of the exams.

Design Contest

The students will participate in a Design contest. In groups of two, they will design, get fabricated and measure a real antenna according to the provided specifications. The Design contest will have three phases:

- Design with CST Studio Suite.
- Fabrication on a PCB ComputerNumerical Control (CNC) machine.
- Characterization with Vector NetworkAnalyzer, reflection and transmission in a wireless link.

As mentioned in the assessment section, the contest takes 2,5 out of 10 points

EVALUACIÓN

CONVOCATORIA ORDINARIA

Students will be evaluated based on:

- A mid-term exam for topics 1-4.
- A Design Contest.
- The final exam.
- On-line tests.

To pass the subject, the student must obtain a total mark that is equal to or higher than 5 (over 10).

The final exam covers the entire subject. However, those who receive a mark over 5 points out of 10 on the mid-term exam will not have to do the part of the final exam that covers

Topics 1-4 unless they wish. Otherwise, the whole subject will be compulsory taken in the final exam. If students do repeat the part of the exam that covers those topics, the latest score will count in any case.

There will be on-line tests to evaluate 20 videos for preparation of the classes. Each video takes 0.05 p what makes 1 p in total. The tests will be done individually at the student convenience before class. A selection of questions will be done the day of the exam. If this latter test is passed (5 out of 10) then the mark will be the highest one. Otherwise, the last mark will be kept. In the mid-term exam, the corresponding test part will be done and its mark kept for the final exam.

The mark for the Design Contest will consist of a maximum of 1 point based on prototype intrinsic quality. Another 1,5 points will be granted based on competitive criteria.

The mid-term exam is worth 3.8 points, the Design Contest 2.5 points, the video tests 1 point and the final exam 2.7 points (not including Topics 1-4). A minimum mark of 2.5 over 10 should be achieved in Topics 5-8 in order to pass the whole subject.

CONVOCATORIA EXTRAORDINARIA

Students who do not pass in December must re-sit the exam in January. In that case, the mark for the mid-term exam will not be kept whereas and the Design Contest will be kept for this particular re-sit, but not for the possible following ones . However, there is the chance to repeat individually the design contest project. It is possible to take the exam again in January even if the subject was passed, being the final grade the last obtained.

HORARIOS DE ATENCIÓN

Dr Daniel Valderas (dvalderas@tecnun.es)

- Office in Urdaneta building. Floor 0
- Hours: Mondays 16.30-17.30
- Please book by mail

BIBLIOGRAFÍA

1. **CARDAMA, A.** *Antenas,* Ediciones UPC Localízalo en la biblioteca
2. **BALANIS, C.A.** *Antenna Theory: Analysis and design*, Wiley Localízalo en la biblioteca
3. **STUTZMAN, W.L.** *Antenna Theory and Design,* Wiley Localízalo en la biblioteca
4. **COLLIN, R.E.** *Antennas and Radiowave Propagation*, McGraw-Hill Localízalo en la biblioteca