COURSE GUIDE: High-Frequency Technologies for Communication Systems (HFTC)

Academic year:	2014-2015
Program:	Master's program in Research and Innovation in Information and Communications Technologies (i^2-ICT)
Center:	Escuela Politécnica Superior
University:	Universidad Autónoma de Madrid
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1. ASIGNATURA / COURSE (ID)

Tecnologías de alta frecuencia para sistemas de comunicaciones
High-frequency technologies for communication systems (HFTC)

1.1. Programa / program

Máster Universitario en Investigación e Innovación en Tecnologías de la Información y las Comunicaciones (i^2-TIC)

Master in Research and Innovation in Information and Communications Technologies (i^2-ICT) [Officially certified]

1.2. Course code

32445

1.3. Course areas

Teoría de la señal y Comunicaciones
Signal theory and Communications

1.4. Tipo de asignatura / Course type

Optativa [itinerario: Seguridad biométrica y videovigilancia]
Elective [itinerary: Biometric Security and Video Surveillance]

1.5. Semester

Second semester

1.6. Credits

6 ETCS

1.7. Language of instruction

The lecture notes are in Spanish. The lectures are mostly in Spanish. Some of the lectures and seminars can be in English.

1.8. Recommendations / Related subjects

Knowledge of basic radiofrequency and communication systems is recommended. Good handling of mathematics and computer mathematical programs is also useful to follow the course.

Related subjects are:

- Comunicaciones inalámbricas de banda ancha [Wideband Wireless Communications]

1.9. Lecturers

Add @uam.es to all email addresses below.

Lectures and labs:

Dr. Juan Córcoles (Coordinator)
Departamento de Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-209
Tel.: +34 914972425
e-mail: juan.corcoles

Dr. Jorge A. Ruiz-Cruz
Departamento de Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-218
Tel.: +34 914972801
e-mail: jorge.ruizcruz

1.10. Objetivos de la asignatura / Course objectives

OBJETIVOS GENERALES	
G1	Comprender y utilizar los dispositivos que constituyen la cadena de radiofrecuencia (RF) de un sistema de comunicaciones típico, desde la antena a los subsistemas de RF (acopladores, filtros, multiplexores, mezcladores, amplificadores,…)
G2	Utilizar las reglas de análisis y diseño de circuitos en las principales tecnologías usadas en RF (planar, cable coaxial, guía de onda,...)
G3	Comprender y utilizar las reglas de análisis y diseño de los principales dispositivos de RF utilizados para la distribución de potencia y alimentación de arrays de antenas

OBJETIVOS GENERALES	
G4	Comprender y utilizar las principales reglas de análisis y diseño para sintetizar diagramas de radiación utilizados en radiocomunicaciones
G5	Comprender y utilizar las reglas de análisis y diseño de los principales dispositivos de RF utilizados para la discriminación en frecuencia
G6	Utilizar el concepto de discriminación de polarización en sistemas de radiocomunicaciones

GENERAL OBJECTIVES	
G1	Know and understand the devices the radiofrequency (RF) chain of a typical communication system is made up of, from the antenna to the RF subsystems (couplers, filters, multiplexors, mixers, amplifiers, …)
G2	Use the analysis and design rules of circuits in the main technologies used in RF (planar, coaxial cable, waveguide, …)
G3	Understand and use the analysis and design rules of the main RF devices used for power distribution and antenna array feeding
G4	Understand and use the main analysis and design rules to synthesize radiation diagrams used in radiocommunications
G5	Understand and use the analysis and design rules of the main RF devices used por frequency discrimination
G6	Use the concept of polarization discrimination in radiocommunication systems

At the end of each unit, the student should be able to:

UNIT BY UNIT SPECIFIC OBJECTIVES	
UNIT 1.- Signal processing and technologies in radiocommunication devices	
1.1.	Know the different blocks a RF communication system is made up of and their function in the overall system
1.2.	Know and choose the different RF technologies according to the application and the frequency band
UNIT 2.- Circuit theory for radiofrequency devices	
2.1.	Know the physical meaning of the scattering matrix, its properties and its value for the most simple circuits
2.2.	Carry out basic operations with the scattering matrix to characterize passive devices
2.3.	Use home-made and specific computer software to analyze and obtain the scattering matrix of a RF device
UNIT 3.- Impedance transformation	
3.1.	Justify the need to transform impedances between different stages in a radiocommunication device
3.2.	Quantify the mismatching between impedances and the power transfer
3.3.	Know and use strategies based on multisection transformers to obtain different frequency responses in impedance matching

UNIT 4.- Power division and combination	
4.1.	Know and identify the properties and limitations of radiofrequency circuits with more than two ports
4.2.	Know the analysis and design rules of radiofrequency divisors
4.3.	Know the analysis and design rules, as well as the different architectures, of couplers
UNIT 5.- Radiation diagram synthesis in antenna arrays	
5.1.	Know the advantages of an array antenna against an isolated antenna
5.2.	Represent the array factor, identifying the most relevant features: nulls, sidelobes, directivity, beamwidth
5.3.	Calculate the array feeding to achieve a null field in the desired directions
5.4.	Understand the need for shaped-beam diagrams and be able to calculate the necessary feeding in the array to achieve them
5.5.	Know the synthesis strategies to control sidelobes and their effect in other parameters in the array radiation diagram
UNIT 6.- Filter synthesis theory	
6.1.	State the problem of the approximation and the prototype transfer functions
6.2	Write the relation between poles and zeros of the transfer function and S-parameters
6.3.	Describe the process to obtain a circuit with a prefixed response
6.4.	Describe the process to obtain a microwave network with distributed elements with a prefixed response
UNIT 7.- Microwave resonators	
7.1	Know the parameters that define a generic resonator and obtain its values for lumped and distributed resonators
7.2.	Write the field inside a cavity resonator and relate it to the resonance frequency
7.3.	Calculate the excitation and coupling in resonators for simple cases
7.4.	Know how to design simple band pass filters
UNIT 8.- Frequency and polarization discrimination	
9.1	State structures able to discriminate signals according to frequency bands using filters
9.2.	Understand the concept of filter load in and out of its pass band
9.3.	Stata structures able to discriminate signals according to their polarization

1.11. Course contents

MODULE I: THEORETICAL AND TECHNOLOGICAL FOUNDATIONS FOR RADIOCOMMUNICATION DEVICES

1. **Signal processing and technologies in radiocommunication devices**
   1.1. Blocks and devices in a radiocommunication systema
   1.2. Transmission Lines
   1.3. Radiofrequency technologies

2. Circuit theory for radiofrequency devices
- 2.1. Power waves and S-parameter matrix
- 2.2. Properties of the scattering matrx. Bartlett's theorem.
- 2.3. Reference plane shift and reference impedance change
- 2.4. Other parameters to characterize two-port networks and their cascading
- 2.5. Calculation of the scattering matrix in radiofrequency circuits

MODULE II: POWER DISTRIBUTION AND FEEDING IN ANTENNA ARRAYS

3. Impedance transformation
- 3.1. Matching a complex load and a real load.
- 3.2. Small reflection theory and multisection transformers.

4. Power división and combination
- 4.1. S-parameters in 3-port and 4-port circuits
- 4.2. Divisors: simple, resistive, Wilkinson
- 4.3. Couplers: branch-line, hybrid, coupled lines

5. Radiation diagram synthesis in antenna arrays
- 5.1. Concept and types of antenna arrays
- 5.2. Analysis of the most significant features
- 5.3. Synthesis with field null directions
- 5.4. Shaped-beam synthesis
- 5.5. Synthesis with sidelobe control

MODULE III: CHANNEL AND FREQUENCY BAND SELECTION

6. Filter synthesis theory
- 6.1. The problema of the approximation
- 6.2. Circuital synthesis

7. Microwave resonators
- 7.1. Lumped and distributed resonators
- 7.2. Cavity resonators
- 7.3. Excitation of resonators
- 7.4. Coupling between resonators
- 7.5. Bandpass filter examples

8. Frequency and polarization discrimination
- 8.1. Multiplexors
- 8.2. Antenna feeders with polarization control

1.12. Course bibliography

Microwave circuits:
- D. M. Pozar, "Microwave engineering", New York, John Wiley & Sons, 2005
- R. E. Collin, "Foundations for microwave engineering", IEEE Press, 2001
- D. M. Pozar, "Microwave and RF wireless systems", John Wiley & Sons, 2001
- J-S. Hong, M. J. Lancaster, "Microstrip filters for RF/microwave applications", John Wiley & Sons, 2001

Antennas:
- A. Cardama y otros, "Antenas", Edicions UPC 2002.
- C. Balanis, "Antenna Theory. Analysis and Design", John Wiley & Sons 1997.
- R. S. Elliot, "Antenna theory and Design", IEEE press, 2003.
- W.L. Stutzman, "Antenna Theory and Design", Wiley. 1981.

Advanced bibliography:
- S. Ramo, "Fields and waves in communications electronics", J. Wiley & Sons 1994.
- R. E. Collin, "Field theory of guided waves ", IEEE Press, 1991
- C. Balanis, "Advanced engineering electromagnetics", John Wiley & Sons 1989.
- J. Uher, J. Bornemann, U. Rosenberg, "Waveguide components for antenna feed systems: theory and CAD", Artech House, 1993
- G. L. Matthaei, L. Young, E. M. T. Jones, "Microwave filters, impedance-matching networks, and coupling structures", Artech House, 1980
- R. J. Cameron, C. M. Kudsia, R. R. Mansour, "Microwave filters for communication systems fundamentals, design, and applications", Wiley-Interscience, 2007

1.13. Coursework and evaluation

In both the ordinary and the extraordinary exam period it is necessary to have a pass grade (≥ 5) to pass the course.

The final grade (FG) will depend on the grade for the theoretical part (TG) and the grade for the laboratory part (LG), according to the following proportion:

$$FG = 35\% \cdot TG + 65\% \cdot LG$$

Both grades should be higher than 4,5 have a pass.

The grade for the theoretical part will be obtained from the final exam of the subject. The grade for the laboratory part has a recommended method: continuous evaluation, where the grade will be obtained through the realization of various designs which will be proposed throughout the course. Exceptionally, the student can attend a laboratory exam to obtain his/her grade for the laboratory part.