Course guide
300037 - CSF - Wireless Communications

Last modified: 01/06/2023

Unit in charge: Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications.

Degree: BACHELOR'S DEGREE IN NETWORK ENGINEERING (Syllabus 2009). (Optional subject).
BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).
BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING (Syllabus 2015). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, Spanish, English

LECTURER

Coordinating lecturer: Definit a la infoweb de l'assignatura.

Others: Definit a la infoweb de l'assignatura.

PRIOR SKILLS

Operability with complex numbers, arrays, variables and random processes.
Analysis of signals and systems, both analogue and digital, in the time and frequency domains.
Both linear and logarithmic (dB) scales.
Basic knowledge of communications, antennas, transmitters and receivers

REQUIREMENTS

RADIO SOFTWARE ENGINEERING - Corequisite
WIRELESS COMMUNICATIONS LABORATORY - Irequisite

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. CE 21 SIS. Capacidad para construir, explotar y gestionar las redes, servicios, procesos y aplicaciones de telecomunicaciones, entendidas éstas como sistemas de captación, transporte, representación, procesado, almacenamiento, gestión y presentación de información multimedia, desde el punto de vista de los sistemas de transmisión.(CIN/352/2009, BOE 20.2.2009.)

Transversal:
2. SELF-DIRECTED LEARNING - Level 2: Completing set tasks based on the guidelines set by lecturers. Devoting the time needed to complete each task, including personal contributions and expanding on the recommended information sources.
3. EFFICIENT ORAL AND WRITTEN COMMUNICATION - Level 2. Using strategies for preparing and giving oral presentations. Writing texts and documents whose content is coherent, well structured and free of spelling and grammatical errors.
4. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
5. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
6. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 2. Designing and executing a good strategy for advanced searches using specialized information resources, once the various parts of an academic document have been identified and bibliographical references provided. Choosing suitable information based on its relevance and quality.

TEACHING METHODOLOGY

The methodology used in the subject is made up of a combination of elements, in which both lectures and practical activities are used, which include solving exercises and problems about the different topics. The practical activities are carried out in groups of students, who must write reports that will be evaluated.

Students have didactic materials of different nature: class notes, slides of theoretical content, list of exercises and their results, complementary documents, bibliography, etc.

Theoretical sessions are based on formal lectures, ensuring that their added value is the possibility of interacting with the professor so that the learning of the concepts by the student is as solid as possible. This interactivity is intended to be complementary to the formal bibliographic references and therefore contains informal elements with the aim of favoring the questioning, understanding and establishment of the fundamental concepts in a more dynamic way, especially thinking about the acquisition of new knowledge and not so much as a reference for experts in the field.

Students work in groups of a maximum of 3 people to carry out practical activities and develop cooperative work. The teams must write technical reports on the activities carried out. These reports are discussed in later classes with the aim of consolidating the concepts.

In the practical sessions, the professor solves exercises and comments on the ideas and concepts with the students, as well as the difficulties that the students have encountered in their autonomous learning time.

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course the student of Wireless Communications must be able to:

- Know the main features, uses and functionality of the most used radio communication standards, as well as future trends and techniques under development with prospects of being incorporated into standards and equipment for general and commercial use.

- Know the main characteristics of the regulation of the different radio communications systems (broadcasting, mobile communications, satellite positioning signals, terrestrial links, etc.)

- Know, design and choose the most appropriate engineering techniques to achieve a high quality radio communication system: coding, differential modulations, interleaving, channel equalization, diversity, repeaters, antennas, etc.

- Analyze and design radio communication systems that use the techniques described in the previous point.

- Know and understand the main multiple access techniques used in radiocommunication environments (TDMA, FDMA, CDMA, OFDMA). In all cases, be able to dimension, design, and evaluate a system that works with any of these access techniques.

- Know and understand OFDM transmission techniques (orthogonal multi-carrier communications), in particular their technical features, parameters, advantages, limitations and complexities. Being able to correctly dimension and design systems based on these techniques, as well as properly evaluate their performance parameters.

- Define the main characteristics of a satellite communication system and make a power budget of the uplink and downlink considering the effect of interference.

From a general point of view and as an academic synthesis, it can be concluded that the main objective is to acquire an overview of wireless communication systems with sufficient technical detail to be able to design any system that allows create any new service based on these communications or improve the efficiency of any existing process of any company in any sector based on a radio communications system.

It should be noted that currently wireless communication systems are present in all areas of society and in all business sectors, without any exceptions. This fact allows the telecommunications systems engineer to add value to any new or existing company, product development or service. The Wireless Communications course should provide solid elements for the future engineer that allow to make these contributions with solvency, and prepare them for the continuous acquisition of new knowledge in such a strongly changing technology environment.

Therefore, beyond the specific details provided by the subject, the fundamental objective is for the student to establish a solid foundation of knowledge, which we could call a good background on which to be prepared for any present or future challenge. All of this makes the subject one of the fundamental bases of the degree.

STUDY LOAD

Type	Hours	Percentage
Hours medium group	16,0	10.67
Guided activities	24,0	16.00
Hours large group	26,0	17.33
Self study	84,0	56.00

Total learning time: 150 h

CONTENTS

Introduction and Regulation

Description:
Fundamental concepts of wireless communications, scopes and applications, standards, classification of systems, trends and forecasts, innovative concepts and techniques. Basic description of advanced techniques such as cooperative communications, Network Coding, Space Modulations, Massive MIMO and VLC. Basic description of the main features of 5G technology. Regulation of radio communications, basic concepts of regulation, regulatory bodies, legislation and recommendations, market regulation, universal service.

Related activities:
Activity 1: Study of the coverage of basic services, analysis of problems and proposal of solutions.

Activity 2: Consultation of regulations of a specific communications system. Electromagnetic spectrum management policy.

Full-or-part-time: 12h
Theory classes: 2h
Laboratory classes: 2h
Self study : 8h

Advanced Modulations

Description:
In this block the most appropriate digital modulations for wireless transmission systems are studied and analyzed, completing the study carried out in other subjects by introducing the concept of constant envelope modulations and differential coding. A review of all the fundamental concepts of signal theory and communications is made. Emphasis is placed on concepts especially relevant for radio communications such as the construction of the baseband signal, decomposition into in-phase and quadrature components, band pass signals, constellations, PAPR, ACP, relationship between SNR, BER and spectral efficiency, etc.

Related activities:
Activity 3: Study with WinIQSim of digital radiocommunications signals: analysis of the PAPR of the signal.

Activity 4: Study with WinIQSim of digital signals: analysis of the ACP of the signal.

Solving exercises and problems

Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 4h
Self study : 12h

Multiple Access Techniques, spread spectrum, CDMA

Description:
In this block, multiple access techniques (FDMA, TDMA, CDMA, SDMA, OFDMA) applicable to wireless transmission systems are studied and analyzed. Special emphasis is placed on spread spectrum signal transmission techniques (FH-CDMA and DS-CDMA). The entire transmission and reception chain of this type of systems will be studied, as well as the generation and characteristics of the spreading codes, the design, dimensioning and evaluation of a CDMA-based transmission system.

Related activities:
Exercice resolution

Full-or-part-time: 28h
Theory classes: 8h
Laboratory classes: 4h
Self study : 16h

Channel Equalisation

Description:
This block explains channel equalization techniques to compensate for distortion and ISI effects that are generated in broadband transmissions, which appear more frequently when the need for transmission rates increases and when spread spectrum techniques are used. The different types of channel equalizers are described, the LMS algorithm and the design, calculation of coefficients and performance analysis of some types of equalizers are carried out.

Related activities:
Exercice resolution

Full-or-part-time: 26h
Theory classes: 6h
Laboratory classes: 4h
Self study : 16h

Multicarrier transmissions, OFDM

Description:
In this section, multicarrier transmission techniques are studied, focusing on the OFDM transmission technique, as well as DMT modulation. All the theoretical details and the implementation characteristics in real systems will be described. Dynamic adaptation mechanisms and a bitloading algorithm called water filling are included.
This technique is presented as a high-efficiency alternative to channel equalizers in order to be able to use broadband signals without suffering the distortion and ISI effects due to the limitations of the channel's coherence bandwidth.

Related activities:
Exercice resolution

Full-or-part-time: 40h
Theory classes: 10h
Laboratory classes: 8h
Self study : 22h

Radio Engineering Techniques

Description:
In this block, some of the most used techniques in wireless communication systems to combat the harmful effects of the radio channel are studied and analyzed, such as channel coding, hybrid retransmission techniques (HARQ), soft combining, incremental redundancy and interleaving schemes.

Related activities:
Activity 5: Study of the effects of multipath propagation in radiofrequency signals.

Exercise resolution

Full-or-part-time: 17h
Theory classes: 2h 30m
Laboratory classes: 2h 30m
Self study : 12h

Terrestrial Radio Links

Description:
This block provides a description of the principles of operation of point-to-point digital radio links using different technologies and broadcasting systems for audio and television signals. In all cases, the main link design parameters, link budget, services, types of data and capacity calculations will be analyzed. An introduction to wireless sensor networks is also made.

Related activities:
Exercice resolution

Full-or-part-time: 7h
Theory classes: 2h
Laboratory classes: 1h
Self study : 4h

ACTIVITIES

Study of coverage of basic services, analysis of problems and proposal of solutions.

Description:
Study of coverage of basic services, analysis of problems and proposal of solutions.

Full-or-part-time: 3h
Self study: 3h

Consultation of regulations of a specific communications system. Electromagnetic Spectrum Management Policy

Description:
Consultation of regulations of a specific communications system. Electromagnetic Spectrum Management Policy

Full-or-part-time: 3h
Self study: 3h

Study with WinIQSim of digital radiocommunications signals: analysis of the PAPR of the signal.

Description:
Study with WinIQSim of digital radiocommunications signals: analysis of the PAPR of the signal.

Full-or-part-time: 5h
Self study: 5h

Study with WinIQSim of digital signals: analysis of the signal ACP

Description:
Study with WinIQSim of digital signals: analysis of the signal ACP

Full-or-part-time: 5h
Self study: 5h

Study of the effects of multipath propagation in radio frequency signals.

Description:
Study of the effects of multipath propagation in radio frequency signals.

Full-or-part-time: 5h
Self study: 5h

Channel equalisers test

Description:
The student will have to carry out a test where he/she will be asked to demonstrate the knowledge that he/she should have acquired in the theory classes and problems prior to the test.

Delivery:
It has 15% weight in the final mark

Full-or-part-time: 1h 30m
Theory classes: 1h 30m

GRADING SYSTEM

Exams: 50%. Mid-term and final
Test: 15%
Group practical activities and reports: 30%
Attitude and participation: 5%

EXAMINATION RULES.

The completion and delivery of reports is mandatory in order to pass the course.

BIBLIOGRAPHY

Basic:
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- Artés Rodríguez, A.. Comunicaciones digitales. Madrid: Prentice Hall, 2007. ISBN 9788483223482.
- Hernando Rábanos, José María. Transmisión por radio. 6a ed.. Madrid: Centro de Estudios Ramon Areces, 2008. ISBN 9788480048569.
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