

Course guide

300024 - FC - Fundamentals of 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). (Compulsory subject). BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Compulsory subject).	
Academic year: 2023	ECTS Credits: 6.0	Languages: Catalan, Spanish

LECTURER

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

Others: Definit a la infoweb de l'assignatura.

PRIOR SKILLS

- Operations with complex numbers. Product and sum, rationalisation, inversion, calculation of the module and phase of a complex number.
- Operations with trigonometric functions.
- Operations with matrices.
- Knowledge of probability.
- Operations with signals and systems in the frequency domain based on Fourier series and transform, and application of their main properties.
- Operations with convolutions of functions.
- Knowledge of the concept of signal filtering.
- Operations in the linear and logarithmic scales (dB).

REQUIREMENTS

- Pre-requisites:
 - o Calculus
 - o Mathematics for Telecommunications
 - o Electronics for Telecommunications
 - o Linear Algebra and Applications
 - o Linear Circuits and Systems
- Particular importance is given to knowledge of the Fourier transform and Fourier series, probability and trigonometric calculation.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

1. CE 10 TELECOM. Capacidad para evaluar las ventajas e inconvenientes de diferentes alternativas tecnológicas de despliegue o implementación de sistemas de comunicaciones, desde el punto de vista del espacio de la señal, las perturbaciones y el ruido y los sistemas de modulación analógica y digital. (CIN/352/2009, BOE 20.2.2009.)
2. CE 9 TELECOM. Capacidad de analizar y especificar los parámetros fundamentales de un sistema de comunicaciones.(CIN/352/2009, BOE 20.2.2009.)

Transversal:

3. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.
4. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.
5. 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.

TEACHING METHODOLOGY

The materials prepared by the teaching staff (slides, class notes, model exercises, etc.) are available on the digital campus and should provide students with sufficient material for self-directed work, either individually or in groups. By working through this material before each class, students will be able to use the face-to-face sessions to consolidate their understanding of the course content and resolve any doubts.

Lectures (groups of no more than 40 students) are essentially expository sessions combining formal presentation of the course content and informal questions for students to discuss. This approach is designed to facilitate the understanding and assimilation of basic concepts. The course materials enable students to prepare for lectures in advance so that they can take a more active role in each session (rather than simply focusing on note-taking).

In the problem-solving sessions (groups of no more than 20 students) students work in pairs or groups of three to complete exercises related to the theory covered in the lectures. Once students have solved the problems set for the session, the teacher will work through some of the exercises with the whole group and may set additional work to be completed as self-directed learning.

LEARNING OBJECTIVES OF THE SUBJECT

On completion of Fundamentals of Communications, students will be able to:

- recognise the functional blocks that make up a communication system;
- perform operations with modulated signals in the time and frequency domains;
- study and calculate the parameters of analogue and digital communications;
- understand the basic quality criteria for communication systems (signal-to-noise ratio and probability of error);
- understand multiplexing techniques;
- understand multiple access techniques;
- understand the basic techniques for channel encoding (error detection and correction).

STUDY LOAD

Type	Hours	Percentage
Guided activities	14,0	9.33
Hours medium group	13,0	8.67
Self study	84,0	56.00
Hours large group	39,0	26.00

Total learning time: 150 h

CONTENTS

Introduction to Communication Systems

Description:

This topic introduces the main concepts of the subject by providing an overview of telecommunications systems and establishing the links between these systems and the topics covered in other subjects. Students first learn the basic elements that must be considered in the design of any type of communications system. This is followed by an introduction to the concept of modulation and, finally, a general overview of a complete communication system (information source, source encoding, channel encoding, modulation, multiplexing, multiple access, transmission, reception, demodulation, equalisation, synchronisation, etc.).

Full-or-part-time: 8h

Theory classes: 3h

Practical classes: 1h

Self study : 4h

Analogue Communication

Description:

The second topic focuses on basic aspects of analogue amplitude and frequency modulation such as bandwidth, power, information signal recovery and the signal-to-noise ratio. Students are given a brief presentation of the main characteristics of analogue communication systems.

Related activities:

Class test.

Full-or-part-time: 29h

Theory classes: 6h

Practical classes: 3h

Self study : 20h

Digital Communication

Description:

The third topic introduces the fundamental concepts in digital signal transmission.

Baseband digital transmission. Pulse-amplitude modulation (PAM). Signal model. Rectangular pulses (line coding).

NRZ, RZ, etc. PAM signal spectrum. Detection of binary PAM signals in an AWGN channel. Receiver scheme.

Adaptive filter and eye diagram. ML and MAP detection. Probability of error. Transmission in band-limited channels. Pole distribution. Bandpass digital transmission. Digital modulations. Signal model.

In-phase and quadrature components. Constellation.

Amplitude modulations (M-ASK).

Phase modulations (QPSK, M-PSK).

Frequency modulations (M-FSK).

Amplitude-phase modulations (QAM, APSK).

Advanced modulations:

Continuous phase modulation (CPM: MSK, GMSK).

Note: For each modulation, students will learn about the constellation, the spectrum of the equivalent lowpass signal and the spectrum efficiency, consider possible schemes for signal detection in an AWGN channel, and evaluate the probability of error.

Related activities:

Practical activities using the WinIQSIM software.

Class test.

Full-or-part-time: 78h

Theory classes: 18h

Practical classes: 6h

Guided activities: 14h

Self study : 40h

Media Access Multiplexing

Description:

This topic provides an overview of the techniques for shared use of a transmission medium by different TDM, FDM, CDM and OFDM connections (multiplexing) and management of simultaneous access to the shared transmission medium by different terminals (media access management). TDMA, FDMA, CDMA (DS-CDMA and FH-CDMA), OFDMA, SDMA.

Related activities:

Class test.

Full-or-part-time: 17h

Theory classes: 6h

Practical classes: 1h

Self study : 10h

Channel Encoding

Description:

Introduction. ARQ vs. FEC. Classification of FEC codes and notation uses. Block codes. Convolutional codes.

Concatenated codes. Note: For each type of code, students will be given a general description and a range of examples. The complexity and performance of each type of code will be described. Interleaved turbo codes. LDPC codes (despite their complexity, these codes are widely used and can therefore be described generically for the purposes of this topic).

Full-or-part-time: 18h

Theory classes: 6h

Practical classes: 2h

Self study : 10h

ACTIVITIES

CLASS TEST ON CONTENT UP TO TOPIC 2

Description:

Students must complete a test to demonstrate their understanding of the content covered in the lectures and problem-solving sessions up to this point in the course.

Specific objectives:

The test is designed to monitor the progress of each student up to this point in the course. Specifically, students should demonstrate that they are able to:

- understand the advantages and disadvantages of different analogue frequency modulations;
- use the required notation and units for communication systems analysis;
- formulate and interpret time signals in the frequency domain.

Material:

None. Students may not consult reference material.

Delivery:

The test counts for 15% of the final mark for the subject.

Full-or-part-time: 1h

Practical classes: 1h

PRACTICAL ACTIVITY 1, DIGITAL COMMUNICATIONS USING WINIQSIM SOFTWARE

Description:

Three 2-hour sessions and one 1-hour session. Students work individually.

- Use a digital transmission simulation tool for in-depth study of the operation of a digital transmission system and the impact of different real-world phenomena that affect the operation of these types of systems. In the first session the lecturer will give a practical explanation of the WinIQSIM software and its basic operating parameters. In the following sessions, students will develop practical solutions to the problems set.

Specific objectives:

On completion of the practical activity, students will be able to:

- characterise a digital communication system using WinIQSIM, analyse the system dynamics and discuss the system's performance;
- use the analytical skills and laboratory techniques acquired to design and analyse the basic performance parameters of a digital communication system;
- write a report or scientific paper containing a synthesis and critical appraisal of the laboratory work carried out.

Material:

WinIQSIM. Software developed by Rohde & Schwarz that offers simulation capabilities for a large number of digital transmission systems and configurations. Offers connectivity with other equipment developed by the same manufacturers for working with RF frequencies, in particular I/Q Modulation Generator AMIQ and the SMIQB60 arbitrary waveform generator.

Students' personal computers.

Delivery:

Attendance is compulsory. Assessment of students' laboratory skills will be based on:

- Attendance and completion of the practical sessions.
- Individual preparatory work.
- Individual report or scientific paper outlining and explaining the results of the activity and offering a critical analysis based on the theoretical knowledge acquired during the course. Assessment will be based on the report/paper and a question sheet that must be completed during the activity.

Full-or-part-time: 21h

Guided activities: 7h

Self study: 14h

PRACTICAL ACTIVITY 2, DIGITAL COMMUNICATIONS USING THE WINIQSIM SOFTWARE

Description:

Three 2-hour sessions and one 1-hour session. Students work individually.

- Use a digital transmission simulation tool for in-depth study of the operation of a digital transmission system and the impact of different real-world phenomena that affect the operation of these types of systems. In the first session the lecturer will give a practical explanation of the WinIQSIM software and its basic operating parameters. In the following sessions, students will develop practical solutions to the problems set.

Specific objectives:

On completion of the practical activity, students will be able to:

- analyse and solve academic problems based on real communication situations to verify the practical usefulness of the theory covered in the course;
- analyse the effect of multipath propagation on communication systems;
- represent and analyse constellations, eye diagrams and impulse responses in communication systems with multipath propagation;
- calculate, identify and evaluate the effects of phase and frequency desynchronisation;
- write a report or scientific paper containing a synthesis and critical appraisal of the laboratory work carried out.

Material:

WinIQSIM. Software developed by Rohde & Schwarz that offers simulation capabilities for a large number of digital transmission systems and configurations. Offers connectivity with other equipment developed by the same manufacturers for working with RF frequencies, in particular I/Q Modulation Generator AMIQ and the SMIQB60 arbitrary waveform generator.

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Delivery:

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Full-or-part-time: 21h

Guided activities: 7h

Self study: 14h

CLASS TEST ON CONTENT UP TO TOPIC 3

Description:

Students must complete a test to demonstrate their understanding of the content covered in the lectures and problem-solving sessions up to this point in the course.

Specific objectives:

The test is designed to monitor the progress of each student up to this point in the course. Specifically, students should demonstrate that they are able to:

- understand the advantages and disadvantages of different digital modulations;
- use the required notation and units for digital communication systems analysis;
- formulate and interpret time signals in the frequency domain.

Material:

None. Students may not consult reference material.

Delivery:

The test counts for 15% of the final mark for the subject.

Full-or-part-time: 1h

Practical classes: 1h



GRADING SYSTEM

- Examinations - 50%. Mid-semester examination (20%) and final examination (30%).
- Class tests - 30%. Two class tests.
- Directed activities - 20%. Two reports on practical sessions + completed question sheet, each worth 10%.

EXAMINATION RULES.

- Students work individually in directed activity sessions.
- Any student who fails to complete an activity or submit the corresponding report will be awarded a mark of 0 for the activity in question.

BIBLIOGRAPHY

Basic:

- Stacey, Dale. Aeronautical radio communication systems and networks [Rekurs electrònic] [on line]. Chichester, England ; Hoboken, NJ: Wiley, 2008 [Consultation: 26/07/2022]. Available on: <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=350916>. ISBN 0070111278.
- Faúndez Zanuy, Marcos. Sistemas de comunicaciones. Barcelona: Marcombo Boixareu, 2001. ISBN 8426713041.
- Proakis, John G.; Salehi, Masoud. Communication systems engineering. 2nd ed. Upper Saddle River, New Jersey: Prentice Hall, 2002. ISBN 0130617938.
- Sklar, Bernard. Digital communications : fundamentals and applications. 2nd ed. Upper Saddle River: Prentice Hall, 2001. ISBN 0130847887.

Complementary:

- Proakis, John G.; Salehi, Masoud. Digital communications. 5th. ed. Boston [etc.]: McGraw-Hill, 2008. ISBN 9780072957167.