

Course guide

230600 - DC - Digital Communications

Last modified: 11/04/2025

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

Degree: MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: JAUME RIBA SAGARRA - GREGORIO VAZQUEZ GRAU

Others: Primer quadrimestre:
GREGORIO VAZQUEZ GRAU - 10

PRIOR SKILLS

Students are required to certify that they have previously followed an introductory course on communications with a similar content as the undergraduate subject 'Introduction to Communications' (<https://www.upc.edu/content/grau/guiadocent/pdf/ing/230018>)

Basic concepts on signal and systems:

- Time domain and frequency domain analysis of deterministic and random signals and linear systems.
- Characterization of random signals (stochastic processes).
- Stationarity and Ergodicity.
- Real and complex Gaussian processes. Thermal noise.
- Power spectral density.
- Pass-band random signals. Base-band equivalent representation. In-phase and quadrature components.

Basic concepts on digital communications:

- Additive White Gaussian Noise (AWGN) channel.
- Matched filter and signal detection.
- Time and frequency domain Nyquist's criterions.
- Band-limited pulse shaping. Nyquist's pulses.
- Symbol and bit error probabilities in PAM modulations.
- Frequency selective channels and inter-symbol interferences.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.

Transversal:

2. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
3. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

TEACHING METHODOLOGY

- Lectures
- Application classes
- Individual work (distance)
- Exercises
- Mid-Term Exam
- Final Exam

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The objective of this course is to provide the fundamental concepts on advanced digital communications systems, including diversity and coding techniques as methodologies to adapt the signal to the characteristics of the physical channel.

The course must habilitate students coming from heterogeneous different disciplines for being able to follow advanced studies in this field.

In the first part of the subject, tools will be provided to understand the most sophisticated modulations based on the signal space concept and on the MAP/ML optimal detection theory. As case of study, the most important band-pass modulations (ASK, PSK, QAM) will be analysed when transmitted over an ideal and stationary channel with Additive White Gaussian Noise (AWGN).

In the second part of the course, the physical communication channel will be characterized in terms of the most important parameters such as the delay spread, coherence time, Doppler spread and coherence bandwidth. In particular, temporal and spatial diversity techniques will be presented as measures to face flat frequency fading channels.

Finally, in the third part of the subject, multi-carrier modulations will be presented, with emphasis on OFDM modulation as the most suitable type of modulation for frequency-selective channels. Different multiple access techniques will be introduced.

Learning results of the subject:

- Ability to use and to understand a vectorial and matrix representation of signals and multidimensional modulations.
- Ability to characterize the physical channel and its influence on the design of a communications system.
- Ability to use diversity techniques and coding techniques appropriate to the physical channel.
- Ability to analyse the performance of communication systems with frequency, time and space multiplexing.

STUDY LOAD

Type	Hours	Percentage
Self study	86,0	68.80
Hours large group	39,0	31.20

Total learning time: 125 h

CONTENTS

1. Signal Space and Optimal Detection

Description:

1. Transmission in AWGN channels

- Signal Space
- Optimal MAP receiver
- Union Bound.
- Basic modulations (ASK, PSK, FSK, QAM).

Full-or-part-time: 45h

Theory classes: 15h

Self study : 30h

2. Frequency Flat-Fading Channels

Description:

- Channel models. Bello's model.
- Delay-spread and coherence-bandwidth. Doppler-spread and coherence-time.
- Rayleigh and Rice fading channels.
- Diversity concept. Case study: repetition code and the Maximum Ratio Combiner (MRC).
- Spatial Diversity: SIMO, MISO, MIMO. Diversity gain vs array gain.
- Temporal diversity: Interleaving, time-codes and maximum product distance.
- Case study: Rotational codes.
- Space-Time coding: Alamouti's scheme.

Full-or-part-time: 57h

Theory classes: 15h

Self study : 42h

3. Frequency-Selective Channels: Orthogonal Frequency Division Multiplexing (OFDM)

Description:

- Bello's channel model and the channel matrix.
- Block transmission and SVD solution.
- OFDMA: Orthogonal Frequency Division Multiple Access.

Full-or-part-time: 23h

Theory classes: 9h

Self study : 14h

ACTIVITIES

EXERCISES

Description:

Exercises to strengthen the theoretical knowledge.

Full-or-part-time: 1h

Theory classes: 1h

EXTENDED ANSWER TEST (MID TERM EXAMINATION)

Description:

Mid term control.

Full-or-part-time: 1h

Theory classes: 1h

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Description:

Final examination.

Full-or-part-time: 1h

Theory classes: 1h



GRADING SYSTEM

Final examination: 40 %

Mid-Term examination: 60 %

Final Grade: The final grade is the maximum between the Final Exam mark and the weighted former mark.

BIBLIOGRAPHY

Basic:

- Proakis, J.G.; Salehi, M. Digital communications. 5th ed. Boston: McGraw-Hill, 2008. ISBN 9780072957167.
- Gallager, R.G. Principles of digital communication [on line]. Cambridge ; New York: Cambridge University Press, 2008 [Consultation: 08/07/2025]. Available on : <https://ebookcentral-proquest-com.recursos.biblioteca.upc.edu/lib/upcatalunya-ebooks/detail.action?pq-origsite=primo&docID=336113>. ISBN 9780521879071.
- Benedetto, S.; Biglieri, E. Principles of digital transmission: with wireless applications [on line]. New York: Kluwer Acad./Plenum PWB, 1999 [Consultation: 22/09/2020]. Available on: <http://link.springer.com/book/10.1007/b117711/page/1>. ISBN 0306457539.
- Artés, A.; Pérez, F.; Cid, J.; López, R.; Mosquera, C.; Pérez, F. Comunicaciones digitales. Madrid: Pearson Educación/Prentice Hall, 2007. ISBN 9788483223482.