VNIVERSITAT DE VALÈNCIA

# Course Guide
# 43847 Advanced signal processing for communications

## COURSE DATA

| Data Subject | |
|---|---|
| **Code** | 43847 |
| **Name** | Advanced signal processing for communications |
| **Cycle** | Master's degree |
| **ECTS Credits** | 5.0 |
| **Academic year** | 2021 - 2022 |

**Study (s)**

| Degree | Center | Acad. year | Period |
|---|---|---|---|
| 2174 - Master's Degree in Telecommunications Engineering | School of Engineering | 1 | First term |

**Subject-matter**

| Degree | Subject-matter | Character |
|---|---|---|
| 2174 - Master's Degree in Telecommunications Engineering | 1 - Advanced signal processing for communications | Obligatory |

**Coordination**

| Name | Department |
|---|---|
| BOTELLA MASCARELL, CARMEN | 240 - Computer Science |
| SEGURA GARCIA, JAUME | 240 - Computer Science |

## SUMMARY

The focus of the course is to learn the main advanced signal processing techniques used in order to solve different problems encountered nowadays in modern communication systems, covering the design, implementation and fundamental principles of the signal processing blocks, as well as its practical use in several standards.

## PREVIOUS KNOWLEDGE

### Relationship to other subjects of the same degree

There are no specified enrollment restrictions with other subjects of the curriculum.

### Other requirements

No previous knowledge is required apart from the official Master access requirements.

## COMPETENCES (RD 1393/2007) // LEARNING OUTCOMES (RD 822/2021)

### 2174 - Master's Degree in Telecommunications Engineering

- To have critical thinking capabilities to investigate independently and self-critically, and to search and utilize information for documenting ideas.
- To have the ability of standing up for fair criteria with rigor and arguments, reporting them publicly in a clear way and in a multilingual environment.
- To have the ability to participate in diffusion forums, journals, conferences, etc. and to work cooperatively and effectively in transnational teams.
- To have the capability to identify and solve the critical points to conduct an effective technology transfer, transforming theoretical results into products and services that are useful for the society.
- Students should demonstrate self-directed learning skills for continued academic growth.
- Students should possess and understand foundational knowledge that enables original thinking and research in the field.
- Be able to access to information tools in other areas of knowledge and use them properly.
- To be able to assess the need to complete the scientific, historical, language, informatics, literature, ethics, social and human background in general, attending conferences, courses or doing complementary activities, self-assessing the contribution of these activities towards a comprehensive development.
- Ability to apply information theory methods, adaptive modulation and channel coding techniques, as well as advanced signal processing techniques to audiovisual and communication systems.
- Ability to implement cable, transport and satellite systems in wired and mobile environments.

## LEARNING OUTCOMES (RD 1393/2007) // NO CONTENT (RD 822/2021)

At the end of the course, the student should be able to:

- Apply advanced techniques of digital signal processing for communications and audiovisual systems.
- Design and implement statistical signal processing algorithms for communication systems using cable, satellite and mobile communications environments.
- Design and implement advanced algorithms to solve optimization problems of communications, networking and signal processing.
- Establish the fundamental theoretical limits of various estimation problems in different scenarios in

communications.

Apart from the technical contents, this subject also allows to acquire the following skills and social attitudes:

- Promotion of teamwork: collaboration, leadership, planning, interacting, consensus, negotiation, conflict resolution and respect the views of others.
- Promotion of individual working capabilities, organizing the own work efficiently into tasks and subtasks.
- Ability to present a teamwork research project orally in English.
- Making effective presentations.

## DESCRIPTION OF CONTENTS

### 1. Review of signal processing, transmission and detection in Gaussian channels

Base band processing. Transmission and reception techniques in Gaussian channels. Detection, Symbol error probability and Bit error probability. Decission rules (MinMax, Bayes)

### 2. Detection for linear channels with intersymbol interference

Review of optimal linear estimation. MLSE estimation, MAP symbol detection sequence (BCJR).Equalizers based on linear feedback (DFE, FSE). Adaptive equalizers (LMS, RLS). Channel estimation and tracking.

### 3. Advanced transmitter and receiver structures for multi-user communications

Precoding techniques. Multi-carrier transmitter and receiver algorithms. Inter-symbol and inter-carrier interference. Transmission and reception algorithms for spread spectrum communications , Multi-user detection. Standards.

### 4. Synchronization Algorithms

Optimal ML receiver with synchronization errors (in time, phase, or carrier). ML recursive estimation phase. Symbol-level synchronization. Carrier and phase recovery. Synchronization for multi-pulse communications. Algorithms for non-coherent detection.

### 5. Array signal processing for communications

Optimal array processing. Optimal and adaptive beamforming. Estimation of angle of arrival. Kalman filtering applications. Iterative receivers. Processing in MIMO wireless systems. Standards.

## WORKLOAD

| ACTIVITY | Hours | % To be attended |
|---|---|---|
| Theory classes | 25,00 | 100 |
| Tutorials | 10,00 | 100 |
| Laboratory practices | 9,00 | 100 |
| Classroom practices | 6,00 | 100 |
| Development of individual work | 25,00 | 0 |
| Preparation of evaluation activities | 11,00 | 0 |
| Preparing lectures | 20,00 | 0 |
| Preparation of practical classes and problem | 19,00 | 0 |
| **TOTAL** | **125,00** | |

## TEACHING METHODOLOGY

The training activities are conducted in accordance with the following distribution:

a)MD1.- Theoretical activities.

AF1.-Theory classes will provide a global and linked perspective on the different topics covered within the course, analyzing in detail those issues having higher complexity. Student participation will be consistently promoted.

b)MD2.- Practical activities.

They complement the theoretical activities in order to apply the basic concepts and extend them with the acquired knowledge and experience. They include the following types of classroom activities (AF2):

- Problems classes in the classroom
- Labs

c) AF3.- Personal work of the student.

Involves the solution of problems and questions outside the classroom, as well as the preparation of classes and exams (study). This task and tries to promote individual work.

d)AF4.- Evaluation.

The evaluation considers the performance of individual questionnaires in the classroom with the teacher. Labs are also evaluated.

f) AF5.- Scheduled Tutoring (individual or group).

They are aimed at guiding students and solving any arising questions. The student should raise possible questions, thus allowing reviewing the work process.

E-learning platforms (Aula Virtual) will be used to support communication with students. Classroom materials, problems and exercises will be made available through this platform.

## EVALUATION

The final grade will be computed as a weighted average of the following items,

- SE2.- Attending lab sessions and practical work (15% of the final grade)
- SE3.- Problems / exercises (25% of the final grade)
- SE1.- Final exam (60% of the final grade)

The minimum mark required to pass the course is 3.5 over 10 in the final exam. The remaining items are not subjected to a minimum.

If a student is unable to attend the lectures, he/she should contact the lecturer to find an alternative grading method

In any case, the system of evaluation will be ruled by the established in the Regulation of Evaluation and Qualification of the University of Valencia for Degrees and Masters. ( http://www.uv.es/graus/normatives/2017_108_Reglament_avaluacio_qualificacio.pdf ).

## REFERENCES

### Basic

- Fundamentals of Digital Communication, U. Madhow, Cambridge University Press, 2008.
- Course Reader for EE379 Digital Communication: Signal Processing, J. Cioffi, Stanford University (posted at http://aulavirtual.uv.es)
- Course Reader for Advanced Digital Communications at EPFL, S. Diggavi (posted at http://aulavirtual.uv.es)

- Comunicaciones Digitales, A. Artés Rodriguez, F. Pérez González, Prentice Hall, 2007.

**Additional**

- T. K. Moon, W. C. Stirling, Mathematical Methods and Algorithms for Signal Processing, Prentice Hall, 2000.
- S. M. Kay, Fundamentals of Statistical Signal Processing, Volume 1: Estimation Theory, Prentice Hall PTR, 1993
- S. M. Kay, Fundamentals of Statistical Signal Processing, Volume 2: Detection Theory,Prentice Hall PTR, 1993.
- H. V. Poor, An Introduction to Signal Detection and Estimation, Springer, Second Edition, 1994.
- H. Sayed, Adaptive Filters, Wiley-Interscience, 2008
- D. G. Manolakis, V. K. Ingle, S. M. Kogon, Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing, Artech House, 2005.
- J. Choi, Adaptive and Iterative Signal Processing in Communications, Cambridge University Press, 2006.
- D. H. Johnson, D. E. Dudgeon, Array Signal Processing, Prentice Hall, 1993
- H. L. Van Trees, Optimum Array Processing, Wiley-Interscience, 2002
- H. Meyr, M. Moeneclaey, S. Fechtel, Digital Communication Receivers: Synchronization, Channel Estimation and Signal Processing, Wiley-Interscience, 2nd edition, 1997.

## ADDENDUM COVID-19

**This addendum will only be activated if the health situation requires so and with the prior agreement of the Governing Council**

## English version is not available