



## IDENTIFYING DATA

### (\*)Sistemas electrónicos de procesamiento de señal

Subject	(*)Sistemas electrónicos de procesamiento de señal			
Code	V05G300V01522			
Study programme	(*)Grao en Enxeñaría de Tecnoloxías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	3rd	1st
Teaching language	Spanish English			
Department				
Coordinator	Valdés Peña, María Dolores			
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General description	This course introduces the basic concepts of digital signal processing systems from the point of view of its hardware implementation. Emphasis is put on FPGAs-based solutions, using professional software design tools and hardware supports. The nature of the course is mainly practical. It enhances the development of collaborative projects whose ultimate goal is the design of electronic signal processing systems.			

## Competencies

Code	
A1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
A6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
A9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
A48	(CE39/SE1): The ability to construct, exploit and manage the receiving, transporting, representation, processing, storage, manage and presentation multimedia information from the electronic systems point of view.
A54	(CE45/SE7): The ability to design interface, data capturing and storage devices, and terminals for services and telecommunication systems.
B4	The ability to use software tools that support problem solving in engineering

## Learning aims

Expected results from this subject	Training and Learning Results	
Understand the fundamental design principles of the signal processing hardware systems.	A48 A54	
Ability to decide different design strategies depending on the application.	A48 A54	
Ability to choose the most suitable hardware architecture for each application.	A48 A54	
Ability to design basic circuits for audio and image processing.	A6 A9 A48 A54	
Acquire skills in the use of design, simulation and implementation tools of signal processing systems.	A48 A54	B4
Acquire skills to verify the proper operation of complex hardware systems.	A48 A54	

Acquire skills to combine different software tools and hardware platforms.

A48

A54

Ability to document hardware design projects.

A1

## Contents

### Topic

Theory: Theme 1. Introduction	- Basic architecture of electronic signal processing systems: signal conditioning, sampling, conversion, and reconstruction.
Theory: Theme 2. Types of signal processing	-Different hardware and software solutions: DSP and FPGAs. -Processing forms: Serial/Parallel, Hardware/Software. -Hardware cost of regular signal processing circuits. Logical resources used. Processing rate. Power consumption.
Theory: Theme 3. Arithmetic in DSP	-Data types. -Data modification: quantification and overflow. -Arithmetic operations and associated circuits. -Associated concepts: critical path, pipeline and latency. -Design examples.
Theory: Theme 4. Introduction to digital filtering	- Example of a real system for signal conditioning and sampling using the Spartan-3AN development board from Xilinx. - Example of basic digital filter design.
Theory: Theme 5. Design and Implementation of Digital Filters	- Implementation of FIR and IIR filters in FPGA. - Analysis of full 6 parallel and semi-parallel solutions: hardware costs, operation rates.
Theory: Theme 6. Software design tools	- Introduction to the System Generator: design flow, data format, sampling frequency, implementation options, system verification, and multi-rate systems.
Theory: Theme 7. Design of image processing systems	- Examples of basic image processing systems. Analysis of hardware resources required. - Implementation and performance analysis.
Theory: Theme 8. Design of audio processing systems	- Examples of audio processing systems. - Analysis of required hardware resources. - Implementation and performance analysis.
Theory: Theme 9. Design of signal processing systems for communications	- Examples of signal processing systems for communication applications. - Implementation and performance analysis.
Labs: Theme 1. Design of signal processing systems using VHDL.	- Design, implementation and verification of basic signal processing described using VHDL. Design of lowpass, highpass, bandpass and bandstop FIR and IIR filters. Direct-form and transpose-form structures. - Using the ISE design tool from Xilinx.
Labs: Theme 2. Design of signal processing systems using System Generator	- Design, implementation and verification of signal processing systems for communication applications, image and audio processing. - Using the System Generator design tool from Xilinx.

## Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practises	8	16	24
Projects	12	60	72
Master Session	18	18	36
Short answer tests	2	6	8
Jobs and projects	2	8	10

\*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

## Methodologies

	Description
Laboratory practises	Basic signal processing systems will be implemented using FPGAs.

Projects	<p>Working groups of two or three students will be established. Each group will develop two projects along the course. These projects will address the design of signal processing systems of low and medium complexity, respectively. The implementation of the projects will be mainly in laboratory hours (hours type B).</p> <p>Additionally, small groups (Groups Type C) will be available allowing monitoring the projects to be developed in the course. Activities to be developed in groups C:</p> <p>Activity 1. Description, analysis and discussion of the systems designed in the first project of the course. Presentation of results. Discussion of design alternatives.</p> <p>Activity 2. Analysis and monitoring of the proposed solution for the second project.</p> <p>Activity 3. Demonstration of the behavior of systems designed in the second project. Analysis and discussion of results.</p>
Master Session	The theoretical content of the course will be presented by the teacher.

### Personalized attention

Methodologies	Description
Master Session	The teacher will personally attend student's doubts and queries related to theoretical contents, laboratory practices and projects. Students will have the opportunity to attend to individual or group tutorials, which will be held at the teacher's office following the schedule to be established at the beginning of the course, to be published at the course's website.
Laboratory practises	The teacher will personally attend student's doubts and queries related to theoretical contents, laboratory practices and projects. Students will have the opportunity to attend to individual or group tutorials, which will be held at the teacher's office following the schedule to be established at the beginning of the course, to be published at the course's website.
Projects	The teacher will personally attend student's doubts and queries related to theoretical contents, laboratory practices and projects. Students will have the opportunity to attend to individual or group tutorials, which will be held at the teacher's office following the schedule to be established at the beginning of the course, to be published at the course's website.

### Assessment

	Description	Qualification
Short answer tests	There will be a short-answer test on the theoretical issues of the course. More information is provided in the "Other Comments" section below.	20
	This test will assess competencies A48 and A54.	
Jobs and projects	There will be two projects during the course. In the first project the student will design a basic signal processing system. The weight of this assessment is 35% of the total grade for the course. The second project will involve the design of a signal processing system of medium complexity and its evaluation will be a 45% of the final grade. More information is provided in the "Other Comments" section that follows.	80
	These projects will assess competencies A1, A6, A9, B4, A48 and A54.	

### Other comments on the Evaluation

According to the guidelines for the degree programme, two evaluation systems will be offered to students: continuous assessment and a final exam.

#### 1.- Continuous assessment

The evaluation of the course is done through continuous assessment, which consists of a theory test and the delivery of two theoretical-practical works (projects). However, the realization of a final test is also included as an alternative.

The theoretical examination will include the contents of the first three topics of the course and will take place in the fourth week of classes. The examination will take place during lecture hours (Type A hours). The weight of this examination will be 2 points out of 10.

The first theoretical-practical work will include themes 1 to 5. It will consist of the design of a basic signal processing system. This work will be conducted in laboratory hours (Type B hours) in groups of two or three students. The content of the work is indicated in week 2 of classes and the delivery will take place on week 7. As a result of the work a descriptive report is

produced for the designed system. The weight of this assessment is 3.5 points out of 10.

The second theoretical-practical work will include themes 6 to 9. This work will be conducted in laboratory hours (Type B hours) in groups of two or three students. The content of the work is indicated in week 6 of classes and delivery will take place in week 13. The weight of this assessment is 4.5 points out of 10.

The final grade for the course will be the sum of the three assessments. To pass the course a student must meet the following conditions:

- Get at least 5 out of 10 in the overall evaluation
- Get at least 40% of the maximum score for each of the evaluation activities.

Students who fail any of the assessments shall be submitted to the corresponding final exam. Similarly, students who want to improve the grade obtained in any of the assessments may be submitted to final exam.

In the case a student fails to obtain at least 40% of the maximum score in any of the assessment activities, but has above the minimum of 5 out of 10 in the overall assessment, the student will be considered suspended and the note 4.5 will appear in the minutes.

It is understood that the student chooses continuous assessment if he/she conducts the first theoretical-practical work, and since then will be considered submitted to this evaluation alternative.

## **2.- Assessment by final exam.**

The final exam will consist of the same evaluative activities covered by continuous assessment. This means that on the date scheduled for the final exam students who have not opted for the continuous assessment should make the theoretical examination of the themes 1 to 3 of the course and deliver the reports of both theoretical and practical work equivalent to that performed by continuous assessment. Such works will be indicated in class week 8. The theoretical and practical work will be discussed in the week following delivery.

As noted above, those students who have opted for continuous assessment and not passed any assessment activities or want to improve their grade may also pass a final exam only with the theme (or themes) to be considered. In this case the grade will be the highest between the final examination and continuous assessment.

## **3.- Second call (July)**

The second call assessment exam will be similar to the final examination described in item 2 above.

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### **Sources of information**

U. Meyer-Baese, **Digital signal processing with Field Programmable Gate Arrays**, 3th ed.,  
James H. McClellan, Ronald W. Schafer, Mark A. Yoder, **Signal processing first**,  
John G. Proakis, Dimitris G. Manolakis, **Digital signal processing**, 4th ed.,  
XUP, University of Strathclyde and Steepest Ascent, **DSP for FPGA Primer**,

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### **Recommendations**

#### **Subjects that are recommended to be taken simultaneously**

- (\*)Circuitos electrónicos programables/V05G300V01502
  - (\*)Sistemas de adquisición de datos/V05G300V01521
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#### **Subjects that it is recommended to have taken before**

- (\*)Electrónica digital/V05G300V01402
  - (\*)Procesado digital de sinais/V05G300V01304
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