



IDENTIFYING DATA

Digital Signal Processing

Subject	Digital Signal Processing			
Code	V05G300V01304			
Study programme	(*)Grao en Enxeñaría de Tecnoloxías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	García Mateo, Carmen			
Lecturers	Abreu Sernández, María Victoria Alonso Alonso, Ignacio García Mateo, Carmen Márquez Flórez, Óscar Willian			
E-mail	carmen.garcia@uvigo.es			
Web	http://fatic.uvigo.es			
General description	<p>Digital signal processing is nowadays a feature of most everyday communications and entertainment devices. The aim of this course is to equip students with a mathematical grounding in general signal and systems analysis. In subsequent course subjects, this knowledge will be applied to specific applications of signals and systems, including audio, image, video and voice signals.</p> <p>Objectives cover the following areas:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Managing signals and systems mathematically and visually, including learning and applying their properties. <input type="checkbox"/> Studying the different domains for signal and systems analysis: time domain, frequency domain and Z domain. <input type="checkbox"/> Learning how to transfer a problem in one domain to a domain in which it is easier to solve. <input type="checkbox"/> Mastering the concept of filter frequency response and learning to interpret the system function. <input type="checkbox"/> Understanding the relationship between the poles and zeros of the system function and the frequency response. <input type="checkbox"/> Acquiring basic notions of filter design in the Z domain. <input type="checkbox"/> Managing specific digital signal processing software. <input type="checkbox"/> Applying the above knowledge to simple and practical laboratory examples. 			

Competencies

Code	
A3	CG3: The knowledge of basic subjects and technologies that capacitates the student to learn new methods and technologies, as well as to give him great versatility to confront and update to new situations
A4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
A57	(CE48/T16) The knowledge of the appropriate techniques to develop and exploit signal processing subsystems .
A58	(CE49/T17) The ability to analyze digital signal processing schemes.

Learning aims

Expected results from this subject	Training and Learning Results
Managing specific software for digital signal processing	A57
Applying mathematical knowledgements for signal filtering	A58
Mastering filtering operations in frequency domain.	A3 A58

Contents

Topic

Subject 1. Introduction to Sampling and Aliasing	Sampling and digital frequency. Analog frequency vs discrete frequency. Aliasing. The sampling theorem.
Subject 2. FIR Filters	Difference equation. Filter Coefficients. Block Diagrams. Causality, linearity and time-invariance. LTI systems and convolution. FIR frequency response. Cascaded LTI systems.
Subject 3. Z Transform	Definition and properties. Linear-phase filters.
Subject 4. IIR Filters	Difference equation. Filter Coefficients. Block Diagrams. Impulse response. Relation between the position of poles and zeros of the system function and the frequency response.
Subject 5. Continuous-Time Signals and Systems	The unit impulse. The unit step. Time delaying. Linearity and time-invariance. Convolution
Subject 6. Continuous-Time Fourier Transform	Definition. Basic pairs. Properties
Subject 7. Sampling and Reconstruction in the Frequency Domain	The sampling theorem in the frequency domain
Subject 8. Windowing and Discrete Fourier Transform (DFT)	Relation of the spectrum of a continuous-time signal to the spectrum of the time-sampled signal. Windowing. DFT and FFT.
Project 1. A/D and D/A Conversion	Digitalisation of Continuous-Time Signals. Aliasing.
Project 2. Digital Filters	Digital filters in the time and frequency domains.
Project 3. Spectral Analysis	Windowing. FFT. Examples

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Master Session	22	44	66
Laboratory practises	11	18	29
Troubleshooting and / or exercises	15	30	45
Forum Index	0	2	2
Multiple choice tests	1.5	0	1.5
Short answer tests	1	0	1
Troubleshooting and / or exercises	4.5	0	4.5

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

Methodologies

	Description
Introductory activities	Course presentation: programme, reading materials, teaching methodology and assessment system
Master Session	Instructor presentation of the main concepts of each subject. Classes do not cover all content that is examination material. The student should take the content indicated in the guidelines for each subject into account as orientation for exams. During the 5 minutes before the lecture, a student will summarize the main concepts presented in the previous session. Students will participate by answering questions during the explanation and by doing exercises. Student will work alone afterwards on the concepts studied in class and on expanding this content using the guidelines provided for each subject. Identification of doubts that need to be resolved in personalized tutorials.
Laboratory practises	Application of Matlab functions and commands for digital signal processing to solve practical exercises. Identification of doubts that need to be resolved in personalized tutorials.
Troubleshooting and / or exercises	Problems and exercises formulated according to the content of the lectures and the guidelines for each subject. Students solve problems and exercises prior to the class in which one or several students explain the solution on the board. Identification of doubts that need to be resolved in personalized tutorials.
Forum Index	The website for the course is included in the TEMA platform (http://fatic.uvigo.es). Subscription to this platform, including a photograph, is mandatory. The website provides all the information related to the course. It also publishes continuous assessment grades and runs forums for students to exchange ideas and discuss doubts.

Personalized attention	
Methodologies	Description
Master Session	Students will have the opportunity to attend personal tutorials in their lecturer's office at times established by lecturers for this purpose at the beginning of the academic year and published on the course website. These tutorials are aimed at resolving student doubts and providing guidance regarding: <ul style="list-style-type: none"> □ The content of the lectures and approaches to study. □ Laboratory projects and the software used. □ Problems and exercises proposed and solved in the classroom as well as other problems and exercises arising during the course.
Laboratory practises	Students will have the opportunity to attend personal tutorials in their lecturer's office at times established by lecturers for this purpose at the beginning of the academic year and published on the course website. These tutorials are aimed at resolving student doubts and providing guidance regarding: <ul style="list-style-type: none"> □ The content of the lectures and approaches to study. □ Laboratory projects and the software used. □ Problems and exercises proposed and solved in the classroom as well as other problems and exercises arising during the course.
Troubleshooting and / or exercises	Students will have the opportunity to attend personal tutorials in their lecturer's office at times established by lecturers for this purpose at the beginning of the academic year and published on the course website. These tutorials are aimed at resolving student doubts and providing guidance regarding: <ul style="list-style-type: none"> □ The content of the lectures and approaches to study. □ Laboratory projects and the software used. □ Problems and exercises proposed and solved in the classroom as well as other problems and exercises arising during the course.

Assessment		
	Description	Qualification
Multiple choice tests	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	0
	In these tests the skill A57 will be evaluated.	
Short answer tests	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	0
	In these tests the skill A53 will be evaluated.	
Troubleshooting and / or exercises	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	100
	In these tests the skills A3, A4 and A58 will be evaluated.	

Other comments on the Evaluation

ASSESSMENT PROCEDURE:

A. Overview

The acquired skills are assessed by a series of tests grouped into three parts, with different requirements:

1. Lab assessment.
2. Basic knowledge test.
3. Problem assessment.

To pass the course it is necessary to pass all three parts.

- For each part one or more tests are performed to obtain an independent grade on each.
- There are tests for each part both during the lecture period and final evaluation periods. In total there are three opportunities to pass each part throughout the academic year.
- A pass grade in any part is valid for the entire academic year.
- The final grade for Basic knowledge test and Lab assessment is Pass or Fail.
- The final grade for the Problem assessment is a numerical mark between 0 and 10.
- The course mark is obtained roughly as follows:
 - If you have passed all three parts, the final grade is the grade of the Problem assessment.
 - If you have not passed any of the three parts, the final grade is the lowest of the three, calculated as specified later on.
 - It is also important to note that:

- The course can be passed with full marks from continuous assessment, with no need to sit the final exam.
- Students who have done continuous assessment and have failed any part, at the end of the term or at the end of the academic year, may need to perform only the failed parts.
- Students who sit any of the tests corresponding to continuous assessment will obtain a mark that will be listed in the academic records.

The following sections explain in detail how each part is graded.

B. Details of the assessment procedure

B1. Lab assessments

- Their goal is to determine whether the student has acquired all the knowledge and/or skills corresponding to the laboratory practice, emphasizing the use of MatLab for digital signal processing.
- Content to be assessed: content of the lab manuals and related theory content.
- Type of test: The test consists of a combination of multiple-choice questions and short questions. Students may use MatLab, lab manuals with personal notes, and text book. Students may not use a calculator for this test.
- Students are graded as pass or fail.
- There are 3 opportunities to pass:
 - Opportunity 1 (Continuous assessment)
 - There will be three mandatory tests in the lab room
 - The test consists of series of questions at the end of each Practice assignment
 - The tests will be graded between 0 and 10. The student will pass this part if he/she gets an average greater than or equal to 5. It is compulsory to sit all three tests.
 - Exact dates will be announced on the web site at the beginning of the lecture period.
 - Opportunities 2 and 3. A test in the End-of-Term exam period, and a test in the End-of-Academic-Year exam period. Students must obtain a pass grade in this test in order to pass the course. The pass mark for this test is 5 out of 10.
- Remarks:
 - Once the pass grade is obtained, this is valid for the entire academic year.
 - While the pass grade is not obtained, it is possible to sit any of the three opportunities.

B2. Basic knowledge test

- The goal of this test is to determine whether the student has acquired the minimum knowledge and skills needed to pass the course.
- Content to be assessed: as specified in the guidelines for each topic in the section "Basic Skills". Knowledge of MatLab is excluded from this test. The test consists of a combination of multiple-choice questions and short theoretical and practical questions. Students may not use books, notes or a calculator for this test.
- Students are graded as pass or fail. Students must obtain a pass grade in this test in order to pass the course. The pass mark for this test is 7 out of 10.
- There are 3 opportunities to pass this test: in an hour of classroom time in the second-last week of the course, in the End-of-Term exam period and in the End-of-Academic-Year exam period. Exact dates will be announced on the web site at the beginning of the lecture period.
- Remarks:
 - Once the pass grade is obtained, this is valid for the entire academic year.
 - While the pass grade is not obtained, it is possible to sit any of the three opportunities.

B3. Problem Assessment

- Their goal is to determine whether the student has acquired all the knowledge and/or skills corresponding to course and knows how to apply them to solve problems.
- Content to be assessed: as specified in the guidelines for each topic in the section "Content to be assessed". MatLab

knowledge is not assessed.

- Type of test: an exam of problems. Students may not use books or notes. The use of calculators may be granted on an exam basis.
- It will be graded between 0 and 10. The pass mark is 5.
- There are 3 opportunities to pass:
 - Opportunity 1 (Continuous assessment)
 - There will be three mandatory tests in the classroom. Each test will be graded between 0 and 10.
 - The mark will be obtained as : $0,25 * \text{Test1Mark} + 0,35 * \text{Test2Mark} + 0,4 * \text{Test3Mark}$
 - Test1: from Subject 1 to Subject 3. It will take place during the sixth week of the course.
 - Test2: from Subject 1 to Subject 6. It will take place during the tenth week of the course.
 - Test3: from Subject 1 to Subject 8. It will take place during the last week of the course.
 - Exact dates will be announced on the web site at the beginning of the lecture period.
 - Opportunities 2 and 3. An exam in the End-of-Term exam period, and an exam in the End-of-Academic-Year exam period. In each exam, all content is evaluated according to the information contained in the guidelines for each subject. The pass mark for this test is 5 out of 10.
 - Remarks:
 - Once the pass mark is obtained, this is valid for the entire academic year.
 - While the pass grade is not obtained, it is possible to sit any of the three opportunities.
 - It is always possible to sit the second opportunity to try to get a better mark.

C. Other comments

- The grade obtained at the end of the term will be part of the academic record of the student. This grade will be final if the mark is above or equal to 5. Otherwise a provisional fail grade will be recorded on their academic record.
- The provisional mark will become definitive fails for students who do not sit at the end of the academic year exam period, or gets a lower mark. Otherwise the better mark will be part of the academic record and becomes final.
- The final mark is computed as:
 - If the student passes all three parts, the mark is that of the problem assessment part.
 - If the student fails any part, the mark is the minimum of:
 - The average mark of the lab assessment.
 - $(5/7) * \text{Mark of the Basic knowledge test}$.
 - Mark of the problem assessment.
 - In case of more than one mark for any part, the highest one will be used.
- Tests performed as continuous assessment may not be rescheduled.
- The grades obtained in the basic knowledge test, the lab assessment, and problem assessment are only valid for the current academic year.
- The use of books, notes or electronic devices such as phones or computers is not permitted in any test or exam. Mobile phones must be turned off and out of reach of the student. If calculator use is permitted, the calculator must be a conventional scientific calculator. Under no circumstances may calculators be used that allow formulas to be saved or that have libraries that automatically perform operations with complex numbers, calculation of roots, etc.

Sources of information

J.H. McClellan y R.W. Schafer, R, **Signal Processing First**, Pearson Prentice Hall,

A. Quarteroni y F. Saleri, **Cálculo científico con Matlab y Octave**, Springer,

M. J. Roberts, **Señales y Sistemas**, McGraw Hill,

A.V. Oppenheim y R.W. Schafer, **Tratamiento de señales en tiempo discreto**, Prentice Hall,

It is recommended to purchase the *Signal Processing First (SPF)* book, as it constitutes the main source of content for the course.

Students will be provided with guidelines for each subject that includes the following sections:

- Theoretical content: The theory that will be evaluated in exams.
- Basic knowledge: Content considered essential for the course and tested by the basic knowledge test described in the section on assessment.
- Problems proposed: A set of problems recommended for each subject.
- SPF vocabulary: A Spanish-English vocabulary with a set of selected terms is included to facilitate reading of the book.

Students will also be provided with a document describing the Matlab content considered essential for the course.

Recommendations

Subjects that continue the syllabus

Fundamentals of Sound and Image/V05G300V01405
 Signal Transmission and Reception Techniques/V05G300V01404
 Fundamentals of Image Processing/V05G300V01632
 Sound Processing/V05G300V01634
 Audio Systems/V05G300V01532
 Imaging Systems/V05G300V01633
 Electronic Systems for Signal Processing/V05G300V01522
 Multimedia Signal Processing/V05G300V01513
 Video and Television/V05G300V01533

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G300V01201
 Mathematics: Linear Algebra/V05G300V01104
 Mathematics: Calculus I/V05G300V01105
 Mathematics: Calculus II/V05G300V01203
