

**Discrete-Time Signals and Systems**

Code: 102712  
ECTS Credits: 6

Degree	Type	Year	Semester
2500895 Electronic Engineering for Telecommunication	OB	2	1
2500898 Telecommunication Systems Engineering	OB	2	1

**Contact**

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**Use of Languages**

Principal working language: catalan (cat)  
Some groups entirely in English: No  
Some groups entirely in Catalan: No  
Some groups entirely in Spanish: No

**Other comments on languages**

En clase también se podrá usar el castellano indistintamente.

**Teachers**

Jose Antonio del Peral Rosado  
Antonio Fuentes Cejudo

**Prerequisites**

This subject can be considered as the continuation of the subject 'Fundamentals of Signals and Systems'; therefore, it is recommended to have completed and passed 'Fundamentals of Signals and Systems'.

**Objectives and Contextualisation**

The processing of sequences of numbers, also known as discrete signals, is a task present in virtually all information transmission, processing and storage systems, even when the source signals can be analog. The aim of the course is to provide the student with the fundamental knowledge to describe the discrete signals and the systems that deal with them, both in the temporal domain and in the frequency or transformed domains.

The specific goals are:

- To understand the representation of discrete signals over time, as well as their properties.
- To analyze the systems for the discrete signals processing over time and propose alternative ways of describing them.
- To represent signals and systems in transformed domains: in the frequency domain and in the Z domain.
- To design basic digital filters.
- To relate discrete signals with the periodic sampling of analog signals and with their reconstruction.
- To apply the Matlab programming environment to solve digital signal processing problems.
- To characterize random discrete signals.

## Competences

### Electronic Engineering for Telecommunication

- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Draft, develop and sign projects in the field of telecommunications engineering designed to conceive, develop or exploit electronic systems
- Learn new methods and technologies, building on basic technological knowledge, to be able to adapt to new situations.
- Resolve problems with initiative and creativity. Make decisions. Communicate and transmit knowledge, skills and abilities, in awareness of the ethical and professional responsibilities involved in a telecommunications engineers work.
- Work in a multidisciplinary group and in a multilingual environment, and communicate, both in writing and orally, knowledge, procedures, results and ideas related with telecommunications and electronics
- Work in a team.

### Telecommunication Systems Engineering

- Communication
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Draft, develop and sign projects in the field of telecommunications engineering that, depending on the speciality, are aimed at the conception, development or exploitation of telecommunication and electronic networks, services and applications.
- Learn new methods and technologies, building on basic technological knowledge, to be able to adapt to new situations.
- Resolve problems with initiative and creativity. Make decisions. Communicate and transmit knowledge, skills and abilities, in awareness of the ethical and professional responsibilities involved in a telecommunications engineers work.
- Work in a multidisciplinary group and in a multilingual environment, and communicate, both in writing and orally, knowledge, procedures, results and ideas related with telecommunications and electronics.
- Work in a team.

## Learning Outcomes

1. Analyse and design digital signal processing diagrams.
2. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
3. Develop and seek basic signal processing applications other than for communications.
4. Develop curiosity and creativity.
5. Develop independent learning strategies.
6. Develop systemic thinking.
7. Develop the capacity for analysis and synthesis.
8. Devise and seek basic applications for signal processing other than communications.
9. Efficiently use ICT for the communication and transmission of ideas and results.
10. Illustrate signal and communication processing algorithms using a basic mathematical formalism.
11. Illustrate the algorithms of signal processing and communications using a basic mathematical formalism.
12. Make basic use of computer applications in digital processing.
13. Make ones own decisions.
14. Transfer concepts of discreet mathematics to telecommunications, in the field of the processing of numerical series by means of digital filters.
15. Transfer concepts of discrete mathematics to telecommunications, in the area of numerical series processing using digital filters

16. Use computer applications for basic digital processing.
17. Work autonomously.
18. Work cooperatively.

## **Content**

### 1. Signals and discrete systems

- Signals: properties, transformations and basic signals
- Systems: properties, basic systems
- Convolution
- Description of systems using finite difference equations

### 2. Frequency representation

- Fourier transform (FT): definition, properties, convolution theorem
- Discrete Fourier Transform (DFT): definition, properties, circular convolution
- Correlation and spectrum
- Decimation and interpolation

### 3. Sampling and reconstruction

- Periodic sampling
- Sampling representation in the frequency domain
- Reconstruction of limited band signals: Nyquist Theorem
- Modification of the sampling frequency

### 4. Representation of signals and systems in the Z domain

- Transformation Z: definition, properties
- Frequency response and transfer function
- All-pass systems, minimum phase systems and linear phase systems

### 5. Introduction to the design of FIR and IIR filters

## **Methodology**

#### Class activities:

- Theory lectures: presentation of the theoretical contents
- Problem-solving lectures: solving problems related to the theory, with the participation of the students themselves.
- Laboratory sessions: application of the techniques shown in the theory lectures to different representative cases of real systems and implementation with standard software for digital signal processing (Matlab).
- Partial and final exams (recovery).

#### Autonomous activities:

- Study of the theoretical and practical contents of the subject. Problem solving and preparation of deliveries with solutions of some sets of problems. Preparation of the exams.
- Practical works: realization and deepening of laboratory sessions. Preparation of the laboratory sessions report.

In addition, students can attend sessions of individual or group tutoring to resolve questions that may arise during the course.

## **Activities**

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem-solving lectures	12	0.48	1, 2, 6, 7, 4, 3, 8, 11, 10, 15, 14, 17, 12, 16
Theory lectures	26	1.04	1, 6, 7, 3, 8, 11, 10, 15, 14
Type: Supervised			
Laboratory sessions	12	0.48	1, 2, 6, 7, 8, 13, 18, 17, 12, 16
Tutorship	2	0.08	1, 2, 7, 4
Type: Autonomous			
Individual work of the student: practices preparation	12	0.48	1, 2, 6, 5, 7, 4, 9, 3, 8, 11, 10, 13, 17, 12, 16
Individual work of the student: study and exercises resolution	74	2.96	1, 6, 5, 7, 4, 9, 3, 8, 13, 15, 14, 17, 12, 16

## Assessment

### Principles of evaluation

The evaluation is structured so that students can choose a continuous assessment format or a format where most of the weight of the evaluation is concentrated at the end of the course (which can also serve as a recovery mechanism for ongoing evaluation). This allows the student to adapt the rhythm of realization of the evaluative elements to their needs and preferences.

### Evaluative elements

There will be the following evaluative elements:

- Laboratory Sessions
- Partial Exam 1
- Partial Exam 2
- Recovery Exam

The partial exam 1 (EXP1) will be held approximately in the middle of the course. The contents of this course are cumulative, so that the first topics have to be mastered in order to be able to follow the last ones.

The partial exam 2 (EXP2) will take place approximately to the last week of the theoretical classes.

The recovery exam (EXR) will be carried out once the theoretical classes are finished, during the period of time specifically dedicated to exams.

The exams can be composed by test questions or problem-solving type, or include both types.

### Calculation of the final grade

- Continuous evaluation note:  $AC = 0.4 * EXP1 + 0.6 * EXP2$

- Global test score (NE):

- If the continuous evaluation or  $AC < 4.5$  has not been done, then  $NE = \max \{EXR, AC\}$ .

- If  $AC \geq 4.5$  and the recovery exam is done, then  $NE = EXR$  (AC mark is discarded).
- To approve is a necessary condition that  $NE \geq 4.5$  and that Practical Note (NP)  $\geq 4.5$ . It should be noted that if  $AC \geq 4.5$ , it is not mandatory to take the final exam.
- The final grade of the subject is:
  - If  $NE < 4.5$ ,  $NF = NE$ .
  - If  $NE \geq 4.5$  and  $NP < 4.5$ , then  $NF = \min \{4.5, 0.8 \times NE + 0.2 \times \text{Practical Note}\}$ .
  - If  $NE \geq 4.5$  and  $NP \geq 4.5$ ,  $NF = 0.8 \times NE + 0.2 \times \text{Practice Note}$
- To approve it is necessary that  $NF \geq 5$ .

The practices will be evaluated based on the reports that must be submitted at the start and / or end of the practice sessions, the work done during the sessions and any additional tests that may be carried out during the sessions. It is not necessary to approve each practice individually. Attendance at all laboratory practices is mandatory.

#### Other general considerations

You can keep the practice mark of previous years. This is the default option that is applied if the repeating students do not return to do the practices.

Granting a MH grade is a decision of the responsible professor. The regulations of the UAB indicate that the MH can only be granted to students who have obtained a final grade equal to or greater than 9.00. It can be granted up to 5% of MH of the total number of students enrolled. MH grades will be awarded only when the student has demonstrated a high degree of excellence in the subject, and the fact of having one of the highest marks does not imply that MH is granted automatically.

The final grade will be "Not Evaluable" only when the student does not appear for any exam, neither the continuous evaluation nor the recovery.

Notwithstanding other disciplinary measures deemed appropriate, and in accordance with current academic regulations, will be scored with a zero evidence or delivery where the student has committed the irregularities (eg plagiarism, copy, cheating, the fact of allowing copy, etc. ) that may lead to a variation of the rating.

The Virtual Campus is the platform that will be used to communicate with students.

## Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Final Exam	50%	3	0.12	1, 2, 6, 5, 7, 3, 8, 11, 10, 13, 15, 14, 17
Partial Exam 1	20%	2	0.08	1, 2, 6, 5, 7, 3, 8, 11, 10, 13, 15, 14, 17
Partial Exam 2	30%	2	0.08	1, 2, 6, 5, 7, 3, 8, 11, 10, 13, 15, 14, 17
Work during practical sessions and reports preparation	25%	5	0.2	1, 2, 6, 7, 4, 9, 3, 8, 11, 10, 13, 15, 14, 18, 12, 16

## Bibliography

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- S. Haykin, B. Van Veen, *Signals and Systems*, Wiley, 2002.
- M. J. Roberts, *Señales y Sistemas*, Mc Graw Hill, 2005.
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- J. Proakis, D. Manolakis, *Digital Signal Processing: Principles, Algorithms and Applications*, 3rd edition, Prentice-Hall, 1996.
- J. Proakis, D. Manolakis, *Digital Signal Processing*, Pearson, 2016
- J.B. Mariño Acebal, F. Vallverdú Bayés, J.A. Rodríguez Fonollosa, A. Moreno Bilbao, *Tratamiento Digital de la Señal: Una introducción experimental*, Edicions UPC, 1999.
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