UAB
Universitat Autònoma de Barcelona

Discrete-Time Signals and Systems

Code: 102712
ECTS Credits: 6

2024/2025

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

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Teachers

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Teaching groups languages

You can view this information at the end of this document.

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 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 engineer's 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 engineer's 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 one's 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

- The Z-transform: definition and properties
- The inverse Z-transform
- Frequency response and transfer function

5. System analysis

- Inverse, minimum-phase and all-pass systems
- Linear phase systems
- Introduction to the design of IR and IIR filters

Activities and Methodology

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Problem-solving lectures	12	0.48	1, 2, 3, 4, 6, 7, 8, 10, 11, 12, 14, 15, 16, 17
Theory lectures	26	1.04	1, 3, 6, 7, 8, 10, 11, 14, 15

Type: Supervised			
Laboratory sessions	12	0.48	1, 2, 6, 7, 8, 12, 13, 16, 17, 18
Tutorship	2	0.08	1, 2, 4, 7
Type: Autonomous			
Individual work of the student: practices preparation	12	0.48	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 16, 17
Individual work of the student: study and exercices resolution	74	2.96	1, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17

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.

Annotation: Within the schedule set by the centre or degree programme, 15 minutes of one class will be reserved for students to evaluate their lecturers and their courses or modules through questionnaires.

Assessment

Continous Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Follow-up Activities	Up to 20%, if it increases the final grade.	1	0.04	1, 2, 5, 6, 7, 9, 12, 13, 14, 15, 16, 18
Partial Exam 1	32%	2	0.08	1, 2, 3, 5, 6, 7, 8, 10, 11, 13, 14, 15, 17
Partial Exam 2	48%	2	0.08	1, 2, 3, 5, 6, 7, 8, 10, 11, 13, 14, 15, 17
Practices	20%	5	0.2	1, 2, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 18
Recovery Exam	80%	2	0.08	1, 2, 3, 5, 6, 7, 8, 10, 11, 13, 14, 15, 17

Principles of evaluation

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

Evaluation elements

There will be the following evaluation elements:

- Follow-up activiites
- Practices
- Partial Exam 1
- Partial Exam 2
- Recovery Exam

The follow-up activities (NS) will consist of participation in class, carrying out problems or tests in class and/or submitting problems outside of class. The follow-up note will only be used to raise the final grade (maximum of 20%).

The grade of practices (NP) will be evaluated based on the reports that must be submitted at the start and / or end of the practice sessions, the work and possible exercices done during or after the sessions, and the possible additional exercises deliveries. It is not necessary to approve each practice individually. Laboratory sessions are an activity that is not recoverable.

The Partial Exam 1 (ExP1) will be held approximately halfway through the course. It does not release matter why the contiguns of this course are cumulative; that is to say, they must master the first issues to be able to follow the last ones.

The Partial Exam 2 (ExP2) will be carried out approximately the last week of face-to-face activities (theoretical classes).

The Recovery Exam (ExR) will be carried out once the face-to-face activities have been finalized, during the time period specifically devoted to examinations.

Calculation of the final grade

- Continuous assessment note: AC = max {0.4*ExP1 + 0.6*ExP2, ExP2}

- Overall note of the exams (NE):

- NE = AC if the recovery exam is not peformed.

- NE = ExR if the recovery exam is performed.

- The final grade (NF) of the subject is: NF = max {0.8 x NE + 0.2 x NP, 0.8 x (0.8 x NE + 0.2 x NP) + 0.2 x NS}

- To approve it is necessary that NF >= 5.

Repeating students

You can keep the Lab Grade from previous years. It is the option that is considered by default if they do not go back to doing the practices.

Honor grades

Granting an Honor qualification is a decision of the faculty responsible for the subject. Honors will be awarded only to students who have shown a great level of excellence in the subject, and not bydefault to those who

have removed the highest marks. The regulations of the UAB indicate that Honors can only be awarded to students who have obtained a final grade of 9.00 or more. It can be granted MH up to 5% of the total number of students enrolled.

Consideration of "Not Evaluable"

The final grade will be "Not Evaluable" only when the student is not present at any exam, neither of the continuous evaluation nor recovery exam.

Consideration in case of copy or plagiarism

Notwithstanding other disciplinary measures that are deemed appropriate, and in accordance with the current academic regulations, the evidenceorreports where the student has committed irregularities (eg plagiarism, deception, copying, the fact to leave copy, etc.) that could lead to a variation of the qualification.

Communication

The Virtual Campus will be the communication platform with the students.

Single evaluation

This subject does not consider a single assessment system.

Bibliography

Recommended bibliography

- Hsu P. Hwei, *Señales y sistemas*, 2a. edición, The McGraw-Hill Companies Inc, 2012.
- John G. Proakis, Dimitris G. Manolakis, T*ratamiento digital de señales*, 4ª edición, Pearson Prentice Hall, 2007.
- Alan V. Oppenheim, Ronald W. Schafer, *Tratamiento de señales en tiempo discreto*, 3ª edición, Pearson, 2012.

Other resources

- John G. Proakis, Dimitris G. Manolakis, *Digital Signal Processing*, Pearson, 2016.
- Alan V. Oppenheim, Ronald W. Schafer, *Discrete-Time Signal Processing*, 3nd edition, Prentice-Hall, 2009.
- S. Haykin, B. Van Veen, *Signals and Systems*, Wiley, 2002.
- S. Haykin, B. Van Veen, *Señales y Sistemas*, Limusa, 2001.
- M. J. Roberts, *Señales y Sistemas*, Mc Graw Hill, 2005.
- 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.

Software

During the practical sessions, MATLAB software will be used.

Likewise, MALTAB will also be used as a support for the theoretical and problem classes.

Language list

Name	Group	Language	Semester	Turn
(PAUL) Classroom practices	311	Spanish	first semester	morning-mixed
(PAUL) Classroom practices	312	Spanish	first semester	morning-mixed
(PAUL) Classroom practices	321	Spanish	first semester	morning-mixed
(PAUL) Classroom practices	322	Spanish	first semester	morning-mixed
(PAUL) Classroom practices	331	Spanish	first semester	afternoon
(PLAB) Practical laboratories	311	Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	312	Spanish	first semester	afternoon
(PLAB) Practical laboratories	313	Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	314	Spanish	first semester	afternoon
(PLAB) Practical laboratories	315	Spanish	first semester	afternoon
(PLAB) Practical laboratories	316	Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	317	Spanish	first semester	afternoon
(PLAB) Practical laboratories	318	Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	319	Spanish	first semester	morning-mixed
(PLAB) Practical laboratories	320	Spanish	first semester	morning-mixed
(TE) Theory	31	Catalan/Spanish	first semester	morning-mixed
(TE) Theory	32	Catalan/Spanish	first semester	morning-mixed
(TE) Theory	33	Catalan/Spanish	first semester	afternoon