Universitat Autònoma de Barcelona

2021/2022

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

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

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

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Rafael Terris Gallego

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

- 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

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.

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.

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 exercices 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:

- 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 10%).

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. It is mandatory to perform the laboratory practices. Laboratory sessions are an activity that is not recoverable.

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= max{0.4*ExP1 + 0.6*ExP2; ExP2}

- Global test score (NE):

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

    - If AC> = 4.5 and the recovery exam is done, then NE= ExR (AC mark is discarted).

- To approve is a necessary condition that NE >= 4.5 and that practice grade (NP) >= 4.5. It should benoted that if AC >= 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 >= 4.5 and NP < 4.5, then NF = min {4.5, 0.8 x NE +0.2 x NP}.

    - If NE >= 4.5 and NP >= 4.5, NF = max{0.8 x NE + 0.2 x NP, 0.9 x (0.8 x NE + 0.2 x NP) + 0.1 x NS}.

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

Repeating students

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.

Honor grades

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.

Consideration of "Not Evaluable"

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

Consideration in case of copy or plagiarism

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 ofthe rating.

Communication

The Virtual Campus is the platform that wil lbe usedto communicatewith students.

Assessment Activities

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

Bibliography

Recommended bibliography

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- 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.