Systems and Signals

Academic Year: (2023 / 2024) **Review date: 19/12/2023 13:54:13**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: LÓPEZ SANTIAGO, JAVIER

Type: Compulsory ECTS Credits : 6.0

Year : 2 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus I
Calculus II
Linear Algebra

LEARNING OUTCOMES

RA3: Be able to carry out conceptual designs for bioengineering applications according to their level of knowledge and understanding, working in a team. Design encompasses devices, processes, protocols, strategies, objects and specifications broader than strictly technical, including social awareness, health and safety, environmental and commercial considerations.
RA4: Be able to use appropriate methods to carry out studies and solve problems in the biomedical field, commensurate with their level of knowledge. Research involves conducting literature searches, designing and carrying out experimental practices, interpreting data, selecting the best approach and communicating knowledge, ideas and solutions within their field of study. May require consultation of databases, safety standards and procedures.
CB1: Students have demonstrated possession and understanding of knowledge in an area of study that builds on the foundation of general secondary education, and is usually at a level that, while relying on advanced textbooks, also includes some aspects that involve knowledge from the cutting edge of their field of study.
CB2: Students are able to apply their knowledge to their work or vocation in a professional manner and possess the competences usually demonstrated through the development and defence of arguments and problem solving within their field of study.
CB3: Students have the ability to gather and interpret relevant data (usually within their field of study) in order to make judgements which include reflection on relevant social, scientific or ethical issues.
CB4: Students should be able to communicate information, ideas, problems and solutions to both specialist and non-specialist audiences.
CG2: Ability to design, draft and develop scientific-technical projects in the field of biomedical engineering.
CG4: Ability to solve problems with initiative, decision-making, creativity, and to communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the biomedical engineer's activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG7: Drafting, representing and interpreting scientific-technical documentation.
CG9: Ability to analyse and conceptually design electronic devices to solve problems in biology and medicine.
ECRT26: Understanding of existing signal processing techniques to obtain information from them.
CT1: Ability to communicate knowledge orally and in writing to both specialised and non-specialised audiences.
CT2: Ability to establish good interpersonal communication and to work in multidisciplinary and international teams.
CT3: Ability to organise and plan their work, making the right decisions based on the information available, gathering and interpreting relevant data in order to make judgements within their area of study.

OBJECTIVES

The goal of the course is to provide the students with the theoretical and methodological knowledge necessary to work with continuous and discrete-time signals and LTI (linear and time-invariant) systems in the time and frequency domain.

Upon successful completion of the course a student will meet the following ABET Program Outcomes (PO): a, b, e, k.

1.1. Individual-work skills (PO: a, b, e, k)
1.2. Capacity for analysis and synthesis (PO: b, e)
1.3. Ability to apply theoretical concepts to practice (PO: a, b, e, k)
1.4. Skills related to group work, collaboration and coordination with other students (PO: a, e, k)
2. SPECIFIC OBJECTIVES:
2.1. Theoretical knowledge of signals and systems representation in the time domain (PO: a, b, e, k)
2.2. Theoretical knowledge of signals and systems representation in the frequency domain (PO: a, b, e, k)
2.3. Capacity for analyzing signals and systems in the frequency domain, with emphasis in applications related to Bioengineering (PO: a, b, e, k)
2.4. Use of fundamental tools for the analysis of signals and systems in the frequency domain, with emphasis in Bioengineering (PO: b, e, k)

DESCRIPTION OF CONTENTS: PROGRAMME

Unit 1. Signals
1.1. Definition and introduction to biomedical signals
1.2. Properties of the signals: regularity, symmetry, etc.
1.3. Characterization of signals: energy and average power.
1.4. Basic operations with signals: time reversal, scaling, shifting.

Unit 2. Systems
2.1. Properties of the systems: causality, stability, time invariance, linearity.
2.2. Linear Time-Invariant Systems (LTI).
2.3. Convolution.
2.4. Properties of LTI systems.

Unit 3. Fourier Series Representation of Continuous-Time Periodic Signals and sequences
3.1. Introduction: Response of LTI Systems to Complex Exponentials.
3.2. Fourier Series Representation of Continuous-Time Periodic Signals: Analysis and Synthesis Equations.
3.3. Properties of Continuous-Time Fourier Series. Examples.
3.4. Fourier Series Representation of Discrete-Time Periodic Signals: Analysis and Synthesis Equations.
3.5. Properties of Discrete-Time Fourier Series and comparisons with the Continuous Case. Examples.

Unit 4. The Continuous-Time Fourier Transform
4.1. The Continuous-Time Fourier Transform for Aperiodic Signals.
4.2. The Continuous-Time Fourier Transform for Periodic Signals.
4.3. Properties of the Continuous-Time Fourier Transform. Examples. Parseval's Theorem.
4.4. The Discrete-Time Fourier Transform. Properties.

Unit 5. Sampling
5.1. The Sampling Theorem.
5.2. Reconstruction of Continuous-Time Signals from Its Samples Using Interpolation.
5.3. Discrete-Time Processing of Continuous-Time Signals.
5.4. Decimation and Interpolation.

Unit 6. The Laplace transform and the z-Transform
6.1. The Laplace transform.
6.2. The z-Transform.
6.3. The Region of Convergence. Properties.
6.4. The Inverse Transforms.
6.5. Properties of the Transforms.
6.6. Evaluation of the Frequency Response from the Pole-Zero Plot.
6.7. Analysis and Characterization of LTI Systems Using transforms.

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LEARNING ACTIVITIES AND METHODOLOGY

The course will be taught in three types of classes: theory, exercises and laboratory practice.

THEORY (2.5 ECTS)
The sessions will explain the basic fundamentals and analysis tools corresponding to the core of the course. Numerous examples of signals, systems, their properties and their behaviour, both in the time domain and in the frequency domain, will be given. For this purpose, a blackboard and audiovisual media (slides, video, ...) will be used. The main objective is that the student qualitatively understands the basic tools of linear systems.

EXERCISES (2.5 ECTS)
For the exercises class, students will be provided in advance with the corresponding statements. Likewise, the detailed solution of different proposed exercises will be provided so that the student acquires a practical knowledge of the subject.

LABORATORIES (1 ECTS)
The laboratories provide students with a hands-on experience to understand the fundamentals of signals, systems and, most particularly, signal analysis and signal processing. Students will also learn how to use Matlab for signal processing. Students should come prepared for the lab sessions. A paper on a particular application of signal processing in the area of Biomedicine will be proposed and carried out in groups.

TUTORIALS
Tutorials will be held weekly in several sessions spread throughout the week in order to give students more options to attend. Group tutorials will be held when required by the students, at the times scheduled for this purpose.

ASSESSMENT SYSTEM

% end-of-term-examination/test:	50
% of continuous assessment (assigments, laboratory, practicals…):	50

The final exam will determine 50% of the total course grade (5 points). (PO a, PO c, PO e, PO g, and PO k)

Quizzes, homework and lab sessions will be used to award the remaining 5 points (50% of the final grade).

1. At the end of each unit or couple of units there will be a. The total maximum grade for these exercises will be 2-4 points. (PO a, PO c, PO e, PO g, and PO k)

2. Laboratory sessions. There are 3 sessions, the total grade here is 1-3 points (PO b y PO k). This block is evaluated by the presentation of a practical case designed by the teacher.

The students need 3.5 out 10 points in the final exam to successfully pass the course.

BASIC BIBLIOGRAPHY

- Alan Oppenheim and Alan Willsky Signal and Systems, Prentice Hall, 1997

- Alan Oppenheim, Ronald W Schafer and John R Buck Discrete-time signal processing, Prentice-Hall International, 1999

- B. . Lathi Linear Systems and Signals, Oxford University Press, 2005

- Hwei Hsu Signals and Systems, Schaum's Outlines, 2011