Linear systems

Academic Year: (2023 / 2024) **Review date: 12/02/2024 12:39:59**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: LÓPEZ SANTIAGO, JAVIER

Type: Electives ECTS Credits : 6.0

Year : Semester :

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Calculus II
Signals, Systems and Circuits

LEARNING OUTCOMES

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.
CB5. Students will have developed the learning skills necessary to undertake further study with a high degree of autonomy.
CG2. Learn new methods and technologies from basic scientific and technical knowledge, and being able to adapt to new situations.
CG3. Solve problems with initiative, decision making, creativity, and communicate and transmit knowledge, skills and abilities, understanding the ethical, social and professional responsibility of the engineering activity. Capacity for leadership, innovation and entrepreneurial spirit.
CG4. Solve mathematical, physical, chemical, biological and technological problems that may arise within the framework of the applications of quantum technologies, nanotechnology, biology, micro- and nano-electronics and photonics in various fields of engineering.
CG5. Use the theoretical and practical knowledge acquired in the definition, approach and resolution of problems in the framework of the exercise of their profession.
CG6. Develop new products and services based on the use and exploitation of new technologies related to physical engineering.
CG7. Undertake further specialized studies, both in physics and in the various branches of engineering.
CE4. Analyze and manipulate analog and digital signals in the temporal and frequency domains, and understand and master the basic concepts of linear systems and related functions and transforms, as well as apply them to circuit design.
CT1. Work in multidisciplinary and international teams as well as organize and plan work making the right decisions based on available information, gathering and interpreting relevant data to make judgments and critical thinking within the area of study.

RA1. To have acquired sufficient knowledge and proved a sufficiently deep comprehension of the basic principles, both theoretical and practical, and methodology of the more important fields in science and technology as to be able to work successfully in them.
RA2. To be able, using arguments, strategies and procedures developed by themselves, to apply their knowledge and abilities to the successful solution of complex technological problems that require creating and innovative thinking.
RA3. To be able to search for, collect and interpret relevant information and data to back up their conclusions including, whenever needed, the consideration of any social, scientific and ethical aspects

relevant in their field of study.
RA4. To be able to successfully manage themselves in the complex situations that might arise in their academic or professional fields of study and that might require the development of novel approaches or solutions.
RA6. To be aware of their own shortcomings and formative needs in their field of specialty, and to be able to plan and organize their own training with a high degree of independence.

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

BLOCK 0: Introduction
Unit 0. Review of Signals and Systems in the Time-Domain
BLOCK 1: The Fourier Transform of Continuous-Time Signals
Unit 1. Fourier Series Representation of Continuous-Time Periodic Signals
1.1. Introduction: Response of LTI Systems to Complex Exponentials
1.2. Fourier Series Representation of Continuous-Time Periodic Signals: Analysis and Synthesis Equations
1.3. Convergence
1.4. Properties of Continuous-Time Fourier Series. Examples
Unit 2. The Continuous-Time Fourier Transform
2.1. Introduction
2.2. The Continuous-Time Fourier Transform for Aperiodic Signals
2.3. The Continuous-Time Fourier Transform for Periodic Signals
2.4. Properties of the Continuous-Time Fourier Transform. Examples.
BLOCK 2. The Fourier Transform of Discrete-Time Signals
Unit 3. Fourier Series Representation of Discrete-Time Periodic Signals
3.1. Fourier Series Representation of Discrete-Time Periodic Signals: Analysis and Synthesis Equations
3.2. Properties of Discrete-Time Fourier Series. Comparison with the Continuous Case. Examples.
Unit 4. The Discrete-Time Fourier Transform
4.1. Introduction
4.2. The Discrete-Time Fourier Transform for Aperiodic Signals
4.3. The Discrete-Time Fourier Transform for Periodic Signals
4.4. Properties of the Continuous-Time Fourier Transform. Parseval¿s Theorem. Duality
Unit 5. Systems
5.1. Introduction
5.2. Frequency Response of Systems Characterized by Linear Constant-Coefficient Differential Equations
5.3. Frequency Response of Systems Characterized by Linear Constant-Coefficient Difference Equations
BLOCK 3. Sampling
Unit 6. Sampling in the Time-Domain
6.1. Introduction
6.2. The Sampling Theorem

6.3. Reconstruction of Continuous-Time Signals from Its Samples Using Interpolation
6.4. Discrete-Time Processing of Continuous-Time Signals
6.5. Decimation and Interpolation
Unit 7. Sampling in the Frequency-Domain: Discrete Fourier Transform
7.1. Introduction
7.2. Sampling of the Fourier Transform
7.3. Discrete Fourier Transform
7.4. Properties
BLOCK 4. The z-Transform
Unit 8. The z-Transform
8.1. Introduction
8.2. The z-Transform
8.3. The Region of Convergence. Properties
8.4. The Inverse z-Transform
8.5. Properties of the z-Transform
8.6. Evaluation of the Frequency Response from the Pole-Zero Plot
8.7. Analysis and Characterization of LTI Systems Using the z-Transform
8.8. Block Diagram Representation

LEARNING ACTIVITIES AND METHODOLOGY

AF1. THEORETICAL-PRACTICAL CLASSES. Knowledge and concepts students mustacquire. Receive course notes and will have basic reference texts.Students partake in exercises to resolve practical problems
AF2. TUTORING SESSIONS. Individualized attendance (individual tutoring) or in-group (group tutoring) for students with a teacher.Subjects with 6 credits have 4 hours of tutoring/ 100% on- site attendance.
AF3. STUDENT INDIVIDUAL WORK OR GROUP WORK.Subjects with 6 credits have 98 hours/0% on-site.
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction.
AF9. FINAL EXAM. Global assessment of knowledge, skills and capacities acquired throughout the course. It entails 4 hours/100% on-site
AF8. WORKSHOPS AND LABORATORY SESSIONS. Subjects with 3 credits have 4 hours with 100% on-site instruction. Subjects with 6 credits have 8 hours/100% on-site instruction.
MD1. THEORY CLASS. Classroom presentations by the teacher with IT and audiovisual support in which the subject`s main concepts are developed, while providing material and bibliography to complement student learning
MD2. PRACTICAL CLASS. Resolution of practical cases and problem, posed by the teacher, and carried out individually or in a group
MD3. TUTORING SESSIONS. Individualized attendance (individual tutoring sessions) or in-group (group tutoring sessions) for students with teacher as tutor. Subjects with 6 credits have 4 hours of tutoring/100% on-site.
MD6. LABORATORY PRACTICAL SESSIONS. Applied/experimental learning/teaching in workshops and laboratories under the tutor's supervision.

ASSESSMENT SYSTEM

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

Assessment includes:
- Lab exercises (10 %)
- Partial exams (40%)
- Final examination (50%)

A mark of at least 4 out of 10 in the final exam will be required in order to be able to take the average with the continuous assessment.

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