Linear Systems

Academic Year: (2023 / 2024) **Review date: 26-04-2023**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: VAZQUEZ VILAR, GONZALO

Type: Basic Core ECTS Credits : 6.0

Year : 2 Semester : 1

Branch of knowledge: Engineering and Architecture

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

'Calculus II' and 'Circuits and Systems'

OBJECTIVES

Linear systems, or systems defined by a linear operator, can be used to model many real-world systems, and find applications in control theory, signal processing, and telecommunication technologies, among other areas. The goal of this 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 both time and frequency domains.

Upon attending this course students will acquire:
- Theoretical knowledge of signals and systems representation in the frequency domain.
- Capacity for analyzing signals and systems in the frequency domain, with emphasis in applications related to communications.
- Use of fundamental tools for the analysis of signals and systems in the frequency domain, with emphasis in communications.

DESCRIPTION OF CONTENTS: PROGRAMME

Unit 0. Review of Signals and Systems in the Time-Domain

Unit 1. Fourier Transform: continuous-time signals
1.1. Periodic signals: Fourier series representation
1.2. The continuous-time Fourier transform and its properties
1.3. Analysis of linear time-invariant systems
1.4. Applications: Filtering and systems described by linear differential equations

Unit 2. Fourier Transform: discrete-time sequences
2.1. Discrete-time complex exponentials
2.2. Fourier series representation of discrete-time periodic signals
2.3. The Fourier transform of sequences and differences with continuous-time
2.4. Applications: Filtering. Systems characterized by linear difference equations

Unit 3. Sampling in the time-domain
3.1. The sampling theorem and optimal signal reconstruction
3.2. Discrete-time processing of continuous-time signals
3.3. Decimation and interpolation

Unit 4. Discrete Fourier Transform (DFT)
4.1. Finite-length signals and periodic signals: DFT
4.2. Connection between Discrete Fourier Transform and the Fourier Transform
4.3. Efficient implementation and applications

Unit 5. The z-transform
5.1. Definition and connection with Fourier Transform
5.2. The region of convergence and its properties: zero-pole diagrams
5.3. Analysis and characterization of unstable LTI systems

LEARNING ACTIVITIES AND METHODOLOGY

The course comprises three types of activities: lectures, problem solving sessions, and laboratory sessions.

LECTURES (3 ECTS)
Lectures provide an overview of the main mathematical and analytical tools for analysis of signals and systems in the frequency domain mainly using the board and aided by slides and other audiovisual media for the illustration of certain topics. Recommended readings and self-evaluation quizzes are provided for homework.

PROBLEM SOLVING SESSIONS (2 ECTS)
Students are provided with problem sets for each of the units of the program together with the answers (but not the solving procedures). These are designed to probe a thorough understanding of fundamental concepts and to encourage practice on algebraic manipulations. The instructor solves on the board a selection of the problems allowing students self-evaluation by comparison with their answers. During these sessions students are encouraged to ask questions and suggest alternative answers.

LABORATORY EXERCISES (1 ECTS)
Laboratory exercises using MATLAB are designed for applying the mathematical tools presented in the lecture. The students learn to model and simulate signals and systems, and to interpret data from their computational work. The degree of freedom is increased from the first towards the fourth session, progressing from guided exercises to more open problems.

ASSESSMENT SYSTEM

Assessment is broken up into the following evaluation procedures:

1. Continuous evaluation: Intermediate assessments plus laboratory questionnaires.

2. Final exam: covering all the topics of the program.

A minimum grade of 4 (over 10) will be required in the final exam to pass the course.

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

BASIC BIBLIOGRAPHY

- Alan V. Oppenheim, Alan S. Willsky, with S. Hamid Signals and Systems. 2nd edition, Prentice Hall, 1996