Linear Systems

Academic Year: (2023 / 2024) **Review date: 24/04/2023 18:09:55**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: KOCH , TOBIAS MIRCO

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

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 frequency domain.

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

1. GENERAL/TRANSVERSAL COMPETENCES:
 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 COMPETENCES:
 2.1. Theoretical knowledge of signals and systems representation in the frequency domain (PO: a, b, e, k)
 2.2. Capacity for analyzing signals and systems in the frequency domain, with emphasis in applications related to Communications (PO: a, b, e, k)
 2.3. Use of fundamental tools for the analysis of signals and systems in the frequency domain, with emphasis in Communications (PO: b, e, k)

DESCRIPTION OF CONTENTS: PROGRAMME

Topic 0. Review of signals and systems in the time-domain

Topic 1. Fourier transforms of continuous-time signals
 1.1. The Fourier series of continuous-time periodic signals: analysis and synthesis equations, properties of the continuous-time Fourier series.
 1.2. The Fourier transform of continuous-time non-periodic signals: analysis and synthesis equations, properties of the continuous-time Fourier transform.
 1.3. Dirac's delta.

Topic 2. Fourier transforms of discrete-time signals
 2.1. The Fourier series of discrete-time periodic signals: analysis and synthesis equations.
 2.2. The Fourier transform for non-periodic signals: analysis and synthesis equations.
 2.3. Properties of the discrete-time Fourier series and the Fourier transform, Parseval's theorem, duality.

Topic 3. Sampling in the time-domain
 3.1. The sampling theorem and ideal reconstruction.

3.2. Discrete-time processing of continuous-time signals.
3.3. Decimation and interpolation.

Topic 4. The discrete Fourier transform
4.1. The discrete Fourier transform (DFT): analysis and synthesis equations, properties.
4.2. The fast Fourier transform (FFT).

Topic 5. The z-transform
5.1. The z-transform: definition and properties.
5.2. The region of convergence.
5.3. The inverse z-transform.

LEARNING ACTIVITIES AND METHODOLOGY

The course comprises four types of activity: lectures, problem solving sessions, group working sessions and laboratory practice.

LECTURES (3 ECTS)
The theoretical lectures provide an overview of the main mathematical and analytical concepts for the analysis of signals and systems in the frequency domain. These lectures will be mostly taught at the blackboard. We will mainly follow the textbook "Signals and Systems" by Oppenheim, Willsky, and Hamid. (PO: a)

PROBLEM SOLVING SESSIONS (2 ECTS)
For each of the topics in the program, students are provided with a problem set together with the corresponding solutions. These are designed to obtain a thorough understanding of the fundamental concepts and to practice algebraic manipulations. The teacher solves a selection of the problems at the blackboard, allowing the students to self-evaluate their solutions. (PO: a, e and k)

LABORATORY EXERCISES (1 ECTS)
The laboratory exercises will be based on MATLAB and are designed to apply the mathematical concepts presented in class. The students learn to model and simulate signals and systems and to interpret the simulated data. (PO: a, b and k)

ASSESSMENT SYSTEM

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

The course is evaluated as follows:

1. Continuous evaluation: Weighted sum of results of mid-term examinations and participation in the laboratory exercises. (PO: a, b, e, k)

2. Final exam: Covering all the topics of the program. (PO: a, e, k)

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

BASIC BIBLIOGRAPHY

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

ADDITIONAL BIBLIOGRAPHY

- Amos Lapidoth A Foundation in Digital Communication. Second edition, Cambridge University Press, 2017

- Simon Haykin and Michael Moher Communication Systems. Fifth edition, John Wiley and Sons, 2009