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Linear Systems

Academic Year: (2019 / 2020) **Review date: 19-03-2019**

Department assigned to the subject: Signal and Communications Theory Department

Coordinating teacher: GALLARDO ANTOLIN, ASCENSION

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
Systems and Circuits

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

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

Unit 1. Fourier Series Representation
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
1.5. Fourier Series Representation of Discrete-Time Periodic Signals: Analysis and Synthesis Equations
1.6. Properties of Discrete-Time Fourier Series. Comparison with the Continuous Case. Examples.

Unit 2. The 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. Parseval's Theorem.
2.5. Frequency Response of Systems Characterized by Linear Constant-Coefficient Differential Equations
2.6. The Discrete-Time Fourier Transform for Aperiodic Signals
2.7. The Discrete-Time Fourier Transform for Periodic Signals
2.8. Properties of the Continuous-Time Fourier Transform. Parseval's Theorem. Duality
2.9. Frequency Response of Systems Characterized by Linear Constant-Coefficient Difference Equations

Unit 3. Sampling in the Time-Domain
3.1. Introduction
3.2. The Sampling Theorem
3.3. Reconstruction of Continuous-Time Signals from Its Samples Using Interpolation
3.4. Discrete-Time Processing of Continuous-Time Signals
3.5. Decimation and Interpolation

Unit 4. Sampling in the Frequency-Domain: Discrete Fourier Transform
4.1. Introduction
4.2. Sampling of the Fourier Transform
4.3. Discrete Fourier Transform
4.4. Properties
4.5. Circular Convolution and Linear Convolution

Unit 5. The z-Transform
5.1. Introduction
5.2. The z-Transform
5.3. The Region of Convergence. Properties
5.4. The Inverse z-Transform
5.5. Properties of the z-Transform
5.6. Evaluation of the Frequency Response from the Pole-Zero Plot
5.7. Analysis and Characterization of LTI Systems Using the z-Transform
5.8. Block Diagram Representation

LEARNING ACTIVITIES AND METHODOLOGY

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

LECTURES (3 ECTS)
Lectures provide an oveview 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. (PO: a)

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 (PO: a, e and k).

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 mere demonstrations to more open problems. (PO: a, b and k)

ASSESSMENT SYSTEM

Assessment is broken up into the following evaluation procedures:
1. Continuous evaluation: Two block exams plus and laboratory questionnaires. (PO: a, b, e and k)
2. Final exam: covering all the topics of the program. (PO: a, e and k)

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

- A. V. Oppenheim and R. W. Schafer "Discrete-Time Signal Processing", Prentice-Hall, Englewood Cliffs, NJ, 1989..

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

(August 16, 1996).

- S. S. Soliman and M. D. Srinath "Continuous and Discrete Time Signals and Systems", Prentice Hall, Upper Saddle River, NJ, Second Edition, 1998..

ADDITIONAL BIBLIOGRAPHY

- A. Bracewel "The Fourier Transform and Its Applications", McGraw-Hill, New York, Second Edition. 1986..

- A. Papoulis "The Fourier Integral and Its Applications", McGraw-Hill, New York, 1962..

- A. Papoulis "Signal Analysis", McGraw-Hill, New York, 1977..

- J. G. Proakis and D. G. Manolakis "Digital Signal Processing: Principles, Algorithms and Applications", Prentice-Hall, Upper Saddle River, NJ, 1996..

- J. R. Buck, M. M. Daniel and A. C. Singer "Computer Explorations in Signals and Systems Using MATLAB", Prentice-Hall, Upper Saddle River, NJ, 1997..

- R. A. Gabel and R. A. Roberts "Signals and Linear Systems", John Wiley & Sons, New York, NY, Third Edition, 1987..