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19901 - ADSPAA - Analog and Digital Signal Processing in Aerospace Applications

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering

Teaching unit: 739 - TSC - Department of Signal Theory and Communications

Academic year: 2018

Degree: MASTER'S DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2015). (Teaching unit Compulsory)
DOCTORAL DEGREE IN AEROSPACE SCIENCE AND TECHNOLOGY (Syllabus 2007). (Teaching unit Optional)

ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: Defined in the course webpage at the EETAC website.

Others: Defined in the course webpage at the EETAC website.

Prior skills

- Basic operational capacity of infinitesimal calculation including derivation, integration and series.
- Operations with complex numbers. Product and summation of complex numbers, calculation of module and phase of a complex number.
- Probability and statistics: Probability concepts, random variables, probability density function.
- Operations with matrices.
- Operations with trigonometric functions.
- Basic circuit analysis.

Degree competences to which the subject contributes

Basic:

CB6. (ENG) CB6 - Poseer y comprender conocimientos que aporten una base u oportunidad de ser originales en el desarrollo y/o aplicación de ideas, a menudo en un contexto de investigación.

CB7. (ENG) CB7 - Que los estudiantes sepan aplicar los conocimientos adquiridos y su capacidad de resolución de problemas en entornos nuevos o poco conocidos dentro de contextos más amplios (o multidisciplinares) relacionados con su área de estudio.

CB9. (ENG) CB9 - Que los estudiantes sepan comunicar sus conclusiones y los conocimientos y razones últimas que las sustentan a públicos especializados y no especializados de un modo claro y sin ambigüedades.

CB10. (ENG) CB10 - Que los estudiantes posean las habilidades de aprendizaje que les permitan continuar estudiando de un modo que habrá de ser en gran medida autodirigido o autónomo.

Specific:

CE2 MAST. (ENG) CE2: Utilizar las herramientas, dispositivos, y sistemas que permiten realizar el acondicionamiento tanto analógico como digital de señal.

Generical:

CG1 MAST. (ENG) CG1: Identificar y conocer las principales actividades de I+D+i en el campo aeroespacial que se llevan a cabo actualmente a nivel internacional en el ámbito académico, la industria y las mayores agencias espaciales.

CG2 MAST. (ENG) CG2: Identificar y aplicar los análisis teóricos, experimentales y numéricos fundamentales de uso actual en ingeniería aeroespacial.

CG4 MAST. (ENG) CG4: Participar en un proyecto de I+D+i del ámbito aeroespacial aportando una visión y conocimientos novedosos asociados con las técnicas de uso más puntero en el campo.

Transversal:

CT3. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim

of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.
CT4. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

Teaching methodology

Thanks to the work material prepared by the lecturers, i.e. slides, class notes, solved exercises, etc. available at the digital campus (ATENEA), the student has enough available tools to work autonomously, both individually and in group. The student will take advantage of this material to consolidate in class the main concepts of the subject and solve doubts that he/she may have.
The course is divided in two kinds of sessions: Sessions done at the theory class (theory and exercises) and lab sessions. Theoretical/exercise classes combine formal explanations done by the lecturer and informal questions made to the students which favours the comprehension of the basic concepts of the subject. The work material prepared for the student allows him to stay in class focusing on learning the subject concepts instead of just taking notes. Moreover, several proposed exercises will be solved in these sessions to illustrate the concepts presented at the theoretical sessions. The lecturer will propose exercises to be solved by the students in the hours of autonomous learning.

In the lab sessions, the activity will be done in groups of two students. Each group will have to do a previous work before the beginning of the lab exercise. After the lab work, the students will have to elaborate and present a document that should briefly describe the work developed in the lab and highlight the relationship between the lab work and the concepts previously seen in the theoretical classes. The main conclusions of the lab work should also be included in the final document.

Learning objectives of the subject

- Understand the advantages and disadvantages of digital signal processing compared to the analog tehcniques. Know the applications of digital signal processing.
- Understand the concepts of signal and systems and its characterization.
- Know the processes of A/D and D/A conversion.
- Understand the concept of transfer function in a discrete linear and invariant system. Calculate poles and zeros.
- Understand the concepts related to Laplace transform, Z-transform and Fourier transform.
- Know the concepts of correlation and spectral density.
- Know some applicability examples of the correlation and spectrum concepts, such as the Wiener filtering.
- Know the Least Squares methodology for system identification.
- Know the Least Mean Squares algorithm for system identification.
- Know the funcitonal blocks of a communications system.
- Operate with modulated signals in the time and frequency domain.
- Study and calculate the main parameters of a communication system.
- Study the main quaility criteria in communications system (signal to noise ratio and error probability).
- Know the basic channel coding techniques (error detection and correction systems).

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Study load

Total learning time: 125h	Hours large group:	45h	36.00%
	Hours medium group:	0h	0.00%
	Hours small group:	0h	0.00%
	Guided activities:	0h	0.00%
	Self study:	80h	64.00%

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Content

Analog and Digital Signal Processing

Learning time: 34h 20m

Theory classes: 12h 20m
Self study : 22h

Description:
An overview of the basic concepts related to analog and digital signal processing is provided.

Related activities:
1 Individual deliverables/exercises
2 Laboratory Sessions:
- Simulation of Acoustic Echoes
- Dual Tone Multi-Freq. (DTMF) Detect.
- Interfering Tone Suppression

Specific objectives:
In this sessions we provide an overview of the following topics:
- Signals and Systems
- Laplace Transform
- Fundamental of Analog Linear Systems
- Sinusoidal Steady State Responses
- Fourier Series-Transform
- Analog Filtering
- Sampling Theorem/Nyquist
- Discrete Linear Systems
- Z-Transform
- Discrete-time Fourier Transform
- Windowing

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Optimum and Adaptive Filters for System Identification	Learning time: 34h Theory classes: 12h Self study : 22h

Description:
An overview of optimum and adaptive filter is provided and the basic concepts of system identification are explained.

Related activities:
1 Individual deliverables/exercises
2 Laboratory Sessions:
- Echoes Identifier
- The Wiener Filter (unknown disturbance)
- Technical paper on a noise canceller estimated using the LMS algorithm.

Specific objectives:
In this sessions we provide an overview of the following topics:
- Deterministic and stocastic signal filtering.
- Digital FIR and IIR signal desing.
- Linear phase filtering.
- Cross correlation and autocorrelation of deterministic and stocastic signals. Signal power and energy.
- Energy and power spectral densitiy. Example: White noise.
- Cross correlation and autocorrelation of a signal at the input/output of a linear filter.
- Optimum Wiener filtering. Application examples (identifying systems and correlation receivers).
- Least Squares methodology.
- Least Mean Squares methodology.

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Analog and digital communications

Learning time: 34h

Theory classes: 12h
Self study : 22h

Description:
- Initially, an introduction of the concept of communications system is provided, highlitghting the main sub-systems that belong to the transmitter and receiver, and a characterization of the propagation channel (delay, attenuation, interference, noise, distortion). Then, an overview of the main quality parameters in a communication system is presented.
On the other hand, the main amplitude analog modulations (AM, DSB, SSB) and angular analog modulations (PM and FM) are described, highlighting aspects such as signal bandwidth, transmit power, demodulator scheme, signal to noise ratio, etc.
Moreover, an overview of the main concepts of digital signal transmission is provided. These topics will be presented: Baseband digital transmission, PAM modulation. Line coding (NRZ, RZ, etc.). Pulse shaping. PAM signal spectrum. Detection of PAM signal in presence of AWGN noise. Receiver scheme. Matched filter. Error probability. In-phase and quadrature components in band pass modulated signals. Digital modulations (ASK, FSK, PSK, QAM). Constellation.
Finally, the main concepts concerning channel coding will be presented. ARQ and FEC techniques. Block and convolutional coding.

Related activities:
Exercise/exam done in a class sesison.

Specific objectives:
- Know the funcitonal blocks of a communications system.
- Operate with modulated signals in the time and frequency domain.
- Study and calculate the main parameters of a communication system.
- Study the main quaility criteria in communications system (signal to noise ratio and error probability).
- Know the basic channel coding techniques (error detection and correction systems).

Digital Radio

Learning time: 22h 40m

Theory classes: 8h
Self study : 14h 40m

Description:
The explained theoretical concepts are used to explaing the performance of a digital communications transmitter and receiver.
An overview of the basics of Green Radio will be provided, i.e. techniques that reduce the energy consumption in a communication system.

Related activities:
Activity 3: Experimentation with a digital communications transceiver.

Specific objectives:
- Block diagram of a transmitter.
- Block diagram of a receiver.
- Hardware components for implementing a digital communication system.
- Energy efficient RF amplifiers.

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Qualification system

Defined in the course webpage at the EETAC website.

Regulations for carrying out activities

Attendance to the lab sessions, realization of the previous work and the final document of the lab work is mandatory. Not doing all of this will represent a zero mark in the corresponding activity.

Bibliography

Basic:

Proakis, John G.; Manolakis, Dimitris G. Introduction to digital signal processing. New York : London: MacMillan ; Collier MacMillan, 1988. ISBN 0023968109.

Oppenheim, Alan V.; Schafer, Ronald W. Discrete-time signal processing. 3rd. Upper Saddle River (N.J.): Prentice-Hall, 2010. ISBN 9780131988422.

Carlson, A. Bruce; Rutledge, Janet C.; Crilly, Paul B. Communication systems : an introduction to signals and noise in electrical communication. 4th. New York [etc.]: McGraw-Hill, 2002. ISBN 0070111278.

Proakis, John G.; Salehi, Masoud. Communication systems engineering. 2nd. Upper Saddle River, New Jersey: Prentice Hall, 2002. ISBN 0130617938.

Sklar, Bernard. Digital communications : fundamentals and applications. 2nd. Upper Saddle River: Prentice Hall, 2001. ISBN 0130847887.

Haykin, Simon S.; Van Veen, Barry. Signals and systems. 2nd. New York ; [Chichester]: Wiley, 2003. ISBN 0471378518.

Oppenheim, Alan V.; Willsky, Alan S.; Nawab, Syed Hamid. Signals and systems. 2nd. Essex: Pearson, 2014. ISBN 9781292025902.

Others resources:

Audiovisual material

Transparències

Slides

Col·lecció d'exercicis

Resource

Computer material

Matlab

Matlab to carry out the lab exercises