

Course guide

270070 - PDS - Digital Signal Processing

Last modified: 13/07/2023

Unit in charge: Barcelona School of Informatics
Teaching unit: 707 - ESAII - Department of Automatic Control.

Degree: BACHELOR'S DEGREE IN INFORMATICS ENGINEERING (Syllabus 2010). (Optional subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan

LECTURER

Coordinating lecturer: ANTONI GRAU SALDES

Others: Primer quadrimestre:
ANTONI GRAU SALDES - 10

PRIOR SKILLS

Programming in language C.
To know how numbers are represented on a computer, and know how to perform arithmetic-logical operations.
To know the operation and structure of the processor.
To know the architecture and operation of a computer.
To understand written documentation in English correctly.

REQUIREMENTS

- Prerequisite CI

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CEC1.1. To design a system based on microprocessor/microcontroller.

CEC1.2. To design/configure an integrated circuit using the adequate software tools.

CEC2.3. To develop and analyse software for systems based on microprocessors and its interfaces with users and other devices.

CEC3.1. To analyse, evaluate and select the most adequate hardware and software platform to support embedded and real-time applications.

CEC3.2. To develop specific processors and embedded systems; to develop and optimize the software of these systems.

CT1.1B. To demonstrate knowledge and comprehension about the fundamentals of computer usage and programming. Knowledge about the structure, operation and interconnection of computer systems, and about the fundamentals of its programming.

CT1.2A. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to solve the mathematical problems presented in engineering. Talent to apply the knowledge about: algebra, differential and integral calculus and numeric methods; statistics and optimization.

CT1.2B. To interpret, select and value concepts, theories, uses and technological developments related to computer science and its application derived from the needed fundamentals of mathematics, statistics and physics. Capacity to understand and dominate the physical and technological fundamentals of computer science: electromagnetism, waves, circuit theory, electronics and photonics and its application to solve engineering problems.

CT1.2C. To use properly theories, procedures and tools in the professional development of the informatics engineering in all its fields (specification, design, implementation, deployment and products evaluation) demonstrating the comprehension of the adopted compromises in the design decisions.

CT2.3. To design, develop, select and evaluate computer applications, systems and services and, at the same time, ensure its reliability, security and quality in function of ethical principles and the current legislation and normative.

CT5.5. To use the tools of a software development environment to create and develop applications.

CT5.6. To demonstrate knowledge and capacity to apply the fundamental principles and basic techniques of parallel, concurrent, distributed and real-time programming.

CT6.2. To demonstrate knowledge, comprehension and capacity to evaluate the structure and architecture of computers, and the basic components that compound them.

CT7.2. To evaluate hardware/software systems in function of a determined criteria of quality.

Generical:

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

TEACHING METHODOLOGY

No distinction will be made between theory classes and problems, the theoretical classes will be reinforced with examples showing possible alternatives and solutions to problems in the field of DSP (both components of a DSP system and applications).

The lab sessions will be held 'in situ' in the teaching laboratory of the department at the FIB. It is an unavoidable requirement to have carried out a previous work that will be specified by each one of the practices.

LEARNING OBJECTIVES OF THE SUBJECT

1. Differentiate the different types of systems, and define their characteristics
2. Understand the specific characteristics of a DSP processor over a general purpose processor
3. Differentiate the different types of signals, and define their characteristics
4. Understand the meaning and benefits of digital signal processing (PDS), and what are the most common areas of application
5. Understand the basics of the analog-to-digital conversion process, the interface needed in a DSP system, and the inherent limitations of this process.
6. Specify, analyze, and determine the basic parameters of an analog input or output interface (acquisition and reconstruction).
7. Know and apply the duality of the time-frequency domain of the signal. Understand the relationships between the two domains
8. Master the various alternatives for the implementation of the Fourier transform by discrete signals
9. Recognize the usefulness of discrete transformations in the field of PDS, and know how to apply these techniques
10. Use the z-transform for the representation, analysis and design of signals and discrete systems
11. Define the most common applications of the z transform in PDS systems
12. Know and be able to apply the correlation technique in the field of PDS
13. Know the areas of application of filters in DSP systems
14. Design filters according to the requirements of the application
15. Know how to apply FIR filters and IIR filters according to the requirements of the application
16. Know the differences in the architecture of floating point and fixed point DSPs
17. Analitzar els errors inherents en els sistemes DSP deguts a la quantificació i la resolució finita
18. Know how to use DSP-based development environments for rapid prototype development
19. Know how to use numerical computing packages for simulation, analysis and development of algorithms in the field of DSP
20. Know how to apply DSP techniques in audio systems
21. Know how to apply DSP techniques in the field of imaging
22. Know how to apply DSP techniques in the field of video
23. Apply information compression techniques (JPEG, MPEG, ...)
24. Know the basic components of a digital signal processing system
26. Know and be able to apply the convolution technique in the field of PDS

STUDY LOAD

| Type | Hours | Percentage |
|--------------------|-------|------------|
| Hours small group | 30,0 | 20.00 |
| Guided activities | 6,0 | 4.00 |
| Hours medium group | 12,0 | 8.00 |
| Hours large group | 18,0 | 12.00 |
| Self study | 84,0 | 56.00 |

Total learning time: 150 h

CONTENTS

Introduction

Description:

- Senyals, sistemes i processat del senyal.
- Aplicacions del PDS
- Operadors bàsics en el PDS
- Arquitectura dels microprocessadors DSP
- Estructura dels sistemes PDS

Signal discretization

Description:

- Mostreig de senyals. Sinusoide mostrejada.
- Teorema del mostreig.
- Espectre dels senyals mostrejats.
- Relació de freqüències continu-discret.
- Conversió analògic a digital. Quantificacions.
- Conversió digital a analògic. Reconstrucció.

Fourier Transform

Description:

- Applications. Equalization, filtering and audio, image and video compression.
- Discrete Fourier Transform (DFT).
- Fast Fourier Transform (FFT).
- Inverse Fourier Transform

Z-transform and signal processing

Description:

- Transformada Z.
- Transformada Inversa Z.
- Propietats de la transformada Z.
- Aplicacions de la transformada Z en el PDS

Correlation and convolution

Description:

- Correlació creuada i autocorrelació
- Fast correlation.
- Convolució. Circular. Deconvolució. Fast linear convolution.
- Exemples d'aplicacions.

Digital Filters

Description:

- Introducció
- Funció de transferència.
- Resposta impulsional.
- Estabilitat.
- Resposta freqüencial.
- Estructures.
- Criteris i procediment pel disseny de filtres digitals
- Disseny de filtres de resposta impulsional finita
- Disseny de filtres de resposta impulsional infinita
- Exemples

Processors for signal processing

Description:

- Arquitectura i tipus
- Criteris de selecció.
- Implementació dels algorismes en PDS de propòsit general.
- PDS de propòsit específic.
- Sistemes de desenvolupament pel PDS.

Audio signal processing

Description:

Equalització
Efectes de so
Compressió
Sintetitzador de so i veu

Image and video signal processing

Description:

Formats d'imatges. Compressió
Efectes d'imatge
Equalització
Compressió de vídeo

ACTIVITIES

Topic 1. What is Digital Signal Processing

Description:

Participate actively in the face-to-face session. Autonomous study of the proposed materials. Solving the proposed problems. Search for information and systems in which PDS is key.

Specific objectives:

4, 24

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 5h

Theory classes: 2h

Self study: 3h

Topic 2. Discretization of signals

Description:

Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems.

Specific objectives:

1, 3, 5, 6

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 11h 30m

Theory classes: 3h

Practical classes: 0h 30m

Self study: 8h

Topic 3. Frequency analysis of the signal. Fourier transform

Description:

Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems. Search for information regarding the different discrete transforms: concept, properties, implementation and application in the PDS.

Specific objectives:

4, 7, 8, 9, 20, 21, 22

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 10h

Theory classes: 3h

Practical classes: 1h

Self study: 6h

Topic 4. Z transform. Use for signal processing

Description:

Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems

Specific objectives:

10, 11

Full-or-part-time: 16h

Theory classes: 3h

Practical classes: 1h

Self study: 12h

Topic 5. FIR digital filters

Description:

Actively participate in the face-to-face session. Independent study of the proposed materials. Resolution of the proposed problems

Specific objectives:

12, 26

Full-or-part-time: 18h

Theory classes: 4h

Practical classes: 2h

Self study: 12h

Topic 6. IIR digital filters

Description:

Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems

Specific objectives:

7, 13, 14, 15

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 18h

Theory classes: 4h

Practical classes: 2h

Self study: 12h

Topic 7. Audio processing

Description:

Actively participate in face-to-face sessions. Independent study of the proposed materials. Resolution of the proposed problems

Specific objectives:

2, 4, 16, 17, 18, 20, 21, 24

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 13h 30m

Theory classes: 3h 30m

Practical classes: 1h

Self study: 9h

Practice 1. Systems and signals

Description:

Comprehensive reading of the statement of the practice, and of the rest of the materials indicated in the statement.
Carrying out the previous activities indicated in the statement.
Completion of the exercises that must be handed in at the beginning of the laboratory session.

Specific objectives:

1, 2, 3, 4, 5, 6, 17, 18, 20, 24

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 10h

Laboratory classes: 6h

Self study: 4h

Practice 2. Sampling

Description:

Comprehensive reading of the statement of the practice, and of the rest of the materials indicated in the statement.
Carrying out the previous activities indicated in the statement.
Completion of the exercises that must be handed in at the beginning of the laboratory session.

Specific objectives:

2, 4, 7, 8, 9, 10, 11, 12, 20, 24, 26

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 12h

Laboratory classes: 6h

Self study: 6h

Practice 3. DSP processor

Description:

Comprehensive reading of the statement of the practice, and of the rest of the materials indicated in the statement.
Carrying out the previous activities indicated in the statement.
Completion of the exercises that must be handed in at the beginning of the laboratory session.

Specific objectives:

1, 2, 3, 4, 13, 14, 15, 19

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 10h

Laboratory classes: 6h

Self study: 4h

Practice 4. FIR Filters with DSP

Description:

Comprehensive reading of the statement of the practice, and of the rest of the materials indicated in the statement.
Carrying out the previous activities indicated in the statement.
Completion of the exercises that must be handed in at the beginning of the laboratory session.

Specific objectives:

16, 17, 18, 19, 20, 23

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 12h

Laboratory classes: 6h

Self study: 6h

Practice 5. IIR Filters with DSP

Description:

Comprehensive reading of the statement of the practice, and of the rest of the materials indicated in the statement.
Carrying out the previous activities indicated in the statement.

Specific objectives:

17, 19, 21, 22, 23

Related competencies :

G6. SOLVENT USE OF THE INFORMATION RESOURCES: To manage the acquisition, structuring, analysis and visualization of data and information of the field of the informatics engineering, and value in a critical way the results of this management.

Full-or-part-time: 14h

Laboratory classes: 6h

Self study: 8h

GRADING SYSTEM

The grade of the subject is obtained from two components: the teamwork project (NT) and the laboratory grade (NL). Both components weigh 50% of the final grade.

NT is obtained from a teamwork project which has a weight of 90% in the NT, and the evaluation of activities directly related to transversal competence (ACT), which has a weight of 10% in the NT.

ACT is obtained from the realization of a work related to the content of the subject, where the student will look for information to complete the aspects worked. Special attention is paid to the quality of the references used, their obtaining and critical assessment, and their correct citation.

The NL laboratory mark is obtained from the average of the individual evaluations of the practices There will be 5 evaluable practices during the course.

BIBLIOGRAPHY

Basic:

- Ifeachor, E.C.; Jervis, B.W. Digital signal processing: a practical approach. 2nd ed. Addison Wesley, 2002. ISBN 0201596199.
- Proakis, J.G.; Manolakis, D.G. Digital signal processing. 4th ed. Prentice-Hall International, 2007. ISBN 0131873741.



Complementary:

- Chassaing, R. Digital signal processing and applications with the TMS320C6713 and TMS320C6416 DSK. 2nd ed. John Wiley & Sons, 2008. ISBN 9780470138663.
- Texas Instrument. C5515 eZDSP USB stick development tool.