Techniques and tools for designing electronic systems

Academic Year: (2024 / 2025) **Review date: 19-04-2024**

Department assigned to the subject: Electronic Technology Department

Coordinating teacher: FERNANDEZ HERRERO, CRISTINA

Type: Compulsory ECTS Credits : 6.0

Year : 1 Semester : 1

REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)

Bachelor courses closely related to the design, modelling and description of electronic systems.

OBJECTIVES

SKILLS
Having the required knowledge and understanding that provide a basis or opportunity for originality in developing and / or applying ideas, often within a research context.

Students should be able to apply their knowledge and shoulod have the ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.

Students should be able to integrate knowledge and handle complexity, and formulate judgments based on information that, being incomplete or limited, includes thoughts about social and ethical responsibilities linked to the application of their knowledge and judgments.

Developing concise, clear and justified documentation and specifing the work to be done for the development, integration and implementation of complex and high added value electronic systems.

Ability to conceive, design, implement and maintain an electronic system in a specific application.

Acquire skills for understanding new technologies in use in electronic systems, and their proper use and integration to solve new problems or applications.

Adopting the scientific method as a fundamental working tool in both professional and research carrers.

Ability to design electronic systems at the behavioral level, from a set of certain specifications, such as at system level, using modeling and simulation tools, such as at subsystem level, using hardware description languages.

Ability to handle tools, techniques and methodologies for designing advanced electronic systems or subsystems

Ability to design a device, system or application that meets a given specification, using a systematic and multidisciplinary approach and integrating modules and advanced tools that are specific to the field of Electronic Engineering .

LEARNING OUTCOMES

The students passing this course should be able to:

- Develop behavioral models of electronic systems and circuits, either for conception and design within a larger system and that can be multidisciplinary, either for experimental verification.
- Capture the specifications of an electronic system capable of implementing the established functionality to a system, device, or application specific, identifying the required electronic subsystems (analog and digital) and specifing each of of them.

- Understand and apply top / down design techniques to Electronic Systems, both the strategies and the techniques in use for digital and analog electronic systems, using MATLAB / SIMULINK.
- Know (in-depth) the modeling and simulation tool MATLAB / SIMULINK , including those advanced utilities such as cosimulation digital architectures described in VHDL or VERILOG with other multidisciplinary systems.
- Skillfully use of signal processing and analysis techniques, including linear system tools, modulation techniques and sampling and quantization processes, in complex electronic systems. In-depth Knowledge and application of automatic control techniques to electronic systems environment.
- Know (in-depth) the description tools for random electronic signals (thermal noise , shot, quantization noise) and to evaluate the influence of noise in electronic systems. Using low noise design techniques.

DESCRIPTION OF CONTENTS: PROGRAMME

Description of Contents:
The existing top-down design methodologies for electronic systems are described in this course, where the electronic system is considered as a part of a whole system, device, or application that can be highly complex and / or multidisciplinary, going from specifications capturing, to subsystems/blocks/circuits identification and specification). The advanced tools and techniques for signal processing and system analysis are required to apply those methodologies: Spectral analysis of signals (DFT , FFT, spectral estimation, windows, power spectral density), discrete to continuous systems conversion (residues, invariance impulse principle) applied to digital signal processing, statistical processing of sampled and continuous signals, quantization error analysis, processing and simulation, shot and thermal noise. Furthermore, the design methodology for the integration of electronic circuits and systems is presented, providing an overview of the available resources and technologies, both general purpose (microprocessors, DSPs) and specific purpose (ASICs, FPGAs), analog, digital and mixed-signal, through specific case studies. The tools supporting the design flow are also presented for different levels of abstraction, including behavioural simulation tools (Matlab / Simulink-specific, such as System Identification Toolbox Toolboxes), high-level synthesis tools (such as Xilinx system Generator), which allow to synthesize a digital circuit from a behavioural model, Hardware -In- the- Loop (HIL) debugging, combining an emulated processing system with other blocks and systems, and the tools that allow the hardware description of digital, analog and mixed-signal circuits (VHDL, Verilog, Verilog A).

Syllabus:
T1. Electronic Systems Overview
- Goals and Strategy, Application examples
- Tools, Partitioning and Testing
T2. Design Flow and Development techniques of an electronic system
- HW Prototyping techniques
- Basic Design Flow. Reference for IC design
and embedded systems
- Modelling, CAD and EDA tools
- Design flows
T3. Review of Electronic Signals and Systems
- Digital Signal Processing Review
- Taxonomy of signals and systems
- Some useful signals
- Common Units
- Introduction to DSP and Applications
- Z Transform
- Nonlinear systems
T4. Power spectrum and Frequency Response
FFT algorithm
- Power Spectrum Estimation
- Digital Signal Processing, frequency domain
T5. Modelling of Sampled systems
- Uniform sampling, decimation, interpolation
- Multirate systems
- Irregular sampling
- Continuous-/Discrete-Time mapping
- Numerical Solvers
T6. Modelling of Noise and Quantization error
- Random Signals and Stochastic Processes.

- Filtered noise
- Quantization error
- Oversampling
- Dithering
T7. Digital Filters
- IIR filters. Analog filter digitalization
- FIR filters.
T8. System Identification
T9. Modelling and Specifying Digital Functions
- Data representation and operation implementation

Final Project: from behavioural to circuit description, practical example of behavioural modelling and high-level synthesis
- Practical project using Matlab and Xilinx System Generator

Bibliography: The bibliography shown below is not complete. Given the variety of topics, specific bibliography will be proposed during the course

LEARNING ACTIVITIES AND METHODOLOGY

LEARNING ACTIVITIES
Lectures
Theoretical and practical classes
Practical classes

TEACHING METHODOLOGIES
Teacher explanations supported with audiovisual media and information technology, in which the main concepts of the subject are developed and the reference literature is provided to supplement student learning.
Demonstration of practical cases, problems, etc.. The cases are posed by the teacher and solved individually or in groups with support of information technology

ASSESSMENT SYSTEM

% end-of-term-examination:	35
% of continuous assessment (assigments, laboratory, practicals…):	65

Continuous Assesment (65%). It is composed of:
- short test (or short questions exam) (15%)
- practices on computer lab (15%)
- Final project (35%)

Final exam (35%, required a minimum grade).

BASIC BIBLIOGRAPHY

- Ingle, Vinay K., Proakis, John G. Digital signal processing using MATLAB , Ed. Brooks/Cole , 2000

- Maloberti, Franco Understanding Microelectronics: A Top-Down Approach, Ed. John Wiley & Sons, 2012

- Oppenheim, Alan V; Schafer, Ronald W. (1938-); Buck, John R Discrete-Time Signal Processing, 2e, Prentice-Hall International , 1999

ADDITIONAL BIBLIOGRAPHY

- Monson H. Hayes Statistical Digital Signal Processing and Modeling, Ed. John Wiley & Sons,, 1996

- Oppenheim, Alan V., Willsky, Alan S., Young, Ian T. Signals and systems , Prentice-Hall International , 1983

BASIC ELECTRONIC RESOURCES

- B. A. Shenoi . Introduction to Digital Signal Processing and Filter Design: https://proquest.safaribooksonline.com/9780471464822