

Academic Year: ( 2022 / 2023 )

Review date: 26-05-2021

Department assigned to the subject: Department of Electronic Technology

Coordinating teacher:

Type: Electives ECTS Credits : 6.0

Year : 4 Semester : 1

**REQUIREMENTS (SUBJECTS THAT ARE ASSUMED TO BE KNOWN)**

Digital Electronics

**OBJECTIVES**

By the end of this content area, students will be able to have:

1. coherent knowledge of integrated circuit design including the use of advanced professional design tools;
2. the ability to apply their knowledge and understanding to identify, formulate and solve design problems using an appropriate methodology based on the use of hardware description languages, simulation and synthesis;
3. the ability to apply their knowledge and understanding to analyse engineering products, evaluating and optimizing the use of hardware resources and the performance of integrated circuits;
4. the ability to apply their knowledge and understanding to develop and realise designs that meet specified requirements;
5. an understanding of design alternatives (structural, behavioural, IP-based, etc.), and an ability to use them;
6. the ability to design and conduct appropriate simulations and tests, interpret the data and draw conclusions to debug a design;
7. workshop and laboratory skills.
8. the ability to select and use appropriate equipment, tools and methods;
9. the ability to combine theory and practice to solve integrated circuit design problems at RT level;
10. an understanding of applicable techniques and methods to integrated circuit design at RT level and of their limitations;

**DESCRIPTION OF CONTENTS: PROGRAMME**

1. Introduction to integrated circuits and microelectronics. Design methodology.
  - Implementation of digital circuits. Integrated circuits and FPGAs. Pros and cons.
  - The design process of an integrated circuit. Design tools. Design flow.
  - Hardware Description Languages (HDLs). Pros and cons.
2. Review and extension of VHDL language concepts
  - Structural design and component instantiation
  - Packages
  - Concurrent and sequential statements. Processes.
  - Objects. Considerations about the use of variables and signals.
  - Data types and operators.
    - + Scalar types
    - + Composite types: ARRAY and RECORD
    - + Subtypes
    - + Operators and conversion functions
    - + Attributes
    - + Synthesis of data types
  - VHDL design of combinational circuits
    - + Conditional statements and combinational circuits
    - + Rules for the design of synthesizable combinational circuits
  - VHDL design of sequential circuits
    - + Synchronous and asynchronous sequential circuits
    - + Rules for the design of synthesizable sequential circuits
    - + Register and flip-flop inference
3. Design validation by simulation

- General structure of a test bench
- Stimuli generation
  - + Waveform generation using concurrent statements
  - + Waveform generation using sequential statements
  - + Application examples
- Output checking. ASSERT statement.
- Use of files for input and output
- 4. Design organization. Generic design.
  - Design organization
  - Generic design
    - + Generic parameters
    - + IP blocks
    - + Types of IP blocks. Configuration and use.
    - + Application examples
  - Iterative statements
    - + Sequential iterative statements. Loops
    - + Concurrent iterative statements
  - Subroutines. Functions and procedures.
- 5. FPGAs
  - Introduction. Types of FPGAs
  - Internal structure of a FPGA
  - Basic resources
    - + Logic cells. Operating modes
    - + Input/Output blocks
    - + Routing resources
  - Advanced resources
    - + Memory blocks
    - + Arithmetic blocks (DSPs)
    - + Clock management and PLLs
    - + Other resources
  - Configuration
  - Examples of FPGA families and devices
  - Applications
- 6. Synthesis and design optimization
  - Digital systems and abstraction levels
  - Synthesis steps
  - Design objectives. Estimation of area and delay.
  - Design optimization techniques at different abstraction levels
  - Design optimization at the RT level. Serial, parallel and pipelined implementations.
  - Clock frequency adjustment. Clock generation.
  - Estimation of power consumption. Low power design.
  - Examples with tools

#### LEARNING ACTIVITIES AND METHODOLOGY

- Lectures: 1 session/week (2 h.)
- Practice: 1 session/week (2 h.). Most sessions in Computer Room to develop practical exercises using design tools
- Lab. Practice: 4 sessions, 3 h. each. Devoted to implement a practical circuit
- Personal assistance, as scheduled by the professor

#### ASSESSMENT SYSTEM

Continuous evaluation system based on:

- Midterm partial exam: 15%
- Design works proposed by the professor, to be carried out in practice sessions and lab sessions: 50%
- Final exam: 35%

It is mandatory to fulfill the design works proposed by the professor.

<b>% end-of-term-examination:</b>	35
<b>% of continuous assessment (assignments, laboratory, practicals...):</b>	65

#### BASIC BIBLIOGRAPHY

- B. Mealy, F. Tappero "Free Range VHDL. The no-frills guide to writing powerful code for your digital implementations", open-source (<http://www.freerangefactory.org/>).

- Ott, Douglas E., Wilderotter, Thomas J. "A designer's guide to VHDL synthesis", Kluwer Academic Publishers, 1994
- Peter J. Ashenden The Designer's Guide to VHDL, Morgan Kaufmann, 2008
- Peter J. Ashenden Digital Design (VHDL): An Embedded Systems Approach, Elsevier, 2007
- SMITH, D.J. HDL chip design, Doone, 1997

#### BASIC ELECTRONIC RESOURCES

- Luis Entrena Arrontes, Celia López Ongil, Mario García Valderas, Enrique San Millán Heredia, Marta Portela García, Almudena Lindoso Muñoz . (OCW) Integrated Circuits and Microelectronics: <http://ocw.uc3m.es/tecnologia-electronica/integrated-circuits-and-microelectronics>