Course guide
2301200 - MD - Microelectronic Design

Last modified: 30/05/2025

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 701 - DAC - Department of Computer Architecture.

Degree: MASTER'S DEGREE IN SEMICONDUCTOR ENGINEERING AND MICROELECTRONIC DESIGN (Syllabus 2024). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 6.0 **Languages:** English

LECTURER

Coordinating lecturer: JORDI COSP VILELLA

Others: Primer quadrimestre:
JORDI COSP VILELLA - 11, 13
RAFEL MANERA ESCALERO - 11, 13

PRIOR SKILLS

General concepts on electronics, solid state technology and digital systems
- MOSFET behavior
- Digital electronics
- DC and transient analysis of circuits

LEARNING RESULTS

Knowledges:
KT01. Identify semiconductor devices, technological processes, the most appropriate microelectronic design tools, and relationships between these elements in order to integrate a given product or system into microelectronic technologies.
KT02. Describe the current state of scientific research and microelectronic industrial technology worldwide and their economic, social and environmental impact.
KT05. Describe the main methods and tools used to design integrated circuits and systems in accordance with the required functional specifications and cost of the final integrated product.
KT06. Identify and describe the main verification and test strategies for integrated circuits and systems according to their application.
KT07. Identify gender stereotypes and roles and how they may impact professional practice.

Skills:
ST01. Design integrated devices, circuits and systems for new products according to their applications, taking into account sustainability and energy efficiency requirements.
ST02. Apply the manufacturing techniques and processes and design, simulation and characterisation tools of semiconductor engineering and microelectronic design to provide a solution to a specific integrated system proposal.
ST03. Critically analyse the principles, values and procedures that govern the practice of the profession.
ST04. Select appropriate sources of information from the scientific and technical literature, using appropriate channels, and integrate this information, demonstrating the ability to synthesise information, analyse alternatives and engage in critical debate.
ST05. Communicate the results of one's work, the conclusions reached and the knowledge and reasoning underlying them clearly, concisely and unambiguously to specialist and non-specialist audiences, both orally and in written technical and/or scientific documents.
ST06. Plan the different activities involved in successfully carrying out an assigned task within a team, managing time and resources appropriately.
ST07. Work as part of a heterogeneous team that includes supervisors and specialist and non-specialist members.

Competences:
CT01. Design new devices and integrated systems that require the use of manufacturing techniques specific to microelectronic technologies or the use of microelectronic design tools.
CT02. Apply sustainability criteria to projects based on integrated microelectronic products.
CT03. Apply the processes of semiconductor engineering and microelectronic design to fields in diverse areas of science or engineering where integrated systems are required.

TEACHING METHODOLOGY

- Lectures
- Practical lab exercises
- Final test
- Autonomous work of the student

LEARNING OBJECTIVES OF THE SUBJECT

Analyze and design the basic elements that constitute a digital microelectronic circuit from schematics to layout.
Use commercial Electronic Design Automation (EDA) tools for VLSI analysis and design.
Use advanced design techniques to optimize power consumption on IC's.
Introduction to VLSI technology independent high-level design methodologies and hardware description languages.

STUDY LOAD

Type	Hours	Percentage
Self study	102,0	68.00
Hours small group	12,0	8.00
Hours large group	36,0	24.00

Total learning time: 150 h

CONTENTS

Introduction

Description:
Moore's Law. Evolution of VLSI technology.
Types of transistors for VLSI technology: planar MOSFET, FDSOI and FinFET. Principal characteristics and models for digital design.
Methodology and design flux. Hardware description languages.

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Design of combinational blocks

Description:
The static CMOS logic gate.
Layout of static CMOS logic gates.
Logic gate characterization.
RC delay model.
Logical effort. Delay of digital blocks and paths.
Power consumption. Dynamic and static power.

Related activities:
Design and characterization of standard combinational cells

Full-or-part-time: 37h 30m
Theory classes: 8h
Laboratory classes: 4h
Self study : 25h 30m

Design of sequential blocks

Description:
Latches and flip-flops. Characterization. Setup and hold time.
Design, layout and analysis of flip-flops. D-type and T-type flip-flops. Reset and enable signals.
Analysis and timing of digital circuits. Clock skew.
Synchronizers and timing analysis. Slack.
Memories. Structure and layout of memories ROM, SRAM, DRAM and Flash.content english

Related activities:
Design and characterization of standard sequential cells

Full-or-part-time: 31h 15m
Theory classes: 6h
Laboratory classes: 4h
Self study : 21h 15m

Datapath subsystems

Description:
Adders and subtractors.
Comparators.
Counters.
Coders.
Shifters.
Multipliers.

Related activities:
Design and simulation of a datapath subsystem

Full-or-part-time: 25h
Theory classes: 6h
Laboratory classes: 2h
Self study : 17h

Interconnect

Description:
Interconnect modeling.
Interconnect impact on circuit performance.
Interconnect engineering.

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Low-power consumption techniques

Description:
Low-power architectures. Clock gating and power gating.
Dynamic voltage and frequency scaling (DVFS)
Low-power technologies and techniques.

Full-or-part-time: 12h 30m
Theory classes: 4h
Self study : 8h 30m

Special purpose subsystems

Description:
Power distribution.
Generation and distribution of clock signals.
Input/output pads.
Test and characterization.
Packaging and cooling.
Latchup, electromigration, antenna effect and parasitics.

Related activities:
Input/output PADs

Full-or-part-time: 18h 45m
Theory classes: 4h
Laboratory classes: 2h
Self study : 12h 45m

GRADING SYSTEM

Lab exercices: 25%
Class exercises: 25%
Final test: 50%

BIBLIOGRAPHY

Basic:
- Weste, N.H.E.; Harris, D.M. CMOS VLSI design: a circuits and systems perspective. 4th ed. Boston: Addison Wesley, 2011. ISBN 9780321547743.
- Rabaey, J.M.; Chandrakasan, A.P.; Nikolic, B. Digital integrated circuits: a design perspective. 2nd ed. Upper Saddle River: Pearson Education, 2003. ISBN 9788131709146.
- Taraate, V. Digital logic design using Verilog: coding and RTL synthesis [on line]. 2nd ed. Singapore: Springer, 2022 [Consultation: 17/05/2024]. Available on: https://link-springer-com.recursos.biblioteca.upc.edu/book/10.1007/978-981-16-3199-3. ISBN 9789811631986.

Complementary:
- Baker, R.J. CMOS circuit design, layout, and simulation. Fourth edition. Hoboken, New Jersey: IEEE Press, 2019. ISBN 9781119481515.
- Tsividis, Y.; McAndrew, C. Operation and modeling of the MOS transistor. 3rd ed. New York : Oxford: Oxford University Press, 2011. ISBN 9780195170153.