Course guide
330246 - MIC - Microelectronics

Last modified: 28/04/2025

Unit in charge: Manresa School of Engineering
Teaching unit: 750 - EMIT - Department of Mining, Industrial and ICT Engineering.

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

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

LECTURER

Coordinating lecturer: FRANCESC XAVIER MONCUNILL GENIZ

Others:

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge and understanding of the structure of integrated circuits, including the identification of the elements that components and their interaction, with emphasis on the most common devices and blocks in analog and digital circuits.
2. The ability to use CAD tools for integrated circuit design and verification
3. The ability to analyze, design and implement, select and use real-time data processing, control and automation systems, especially in embedded systems.
4. The ability to define, program, and use embedded devices with global connectivity.
5. The ability to define, analyze, design, develop, evaluate, document and launch systems that include electronic, computer and communications subsystems.
6. The ability to understand and use systems designed to perform a given task based on stimuli captured from their environment, including systems

Transversal:
7. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
8. TEAMWORK - Level 3. Managing and making work groups effective. Resolving possible conflicts, valuing working with others, assessing the effectiveness of a team and presenting the final results.
9. SELF-DIRECTED LEARNING - Level 3. Applying the knowledge gained in completing a task according to its relevance and importance. Deciding how to carry out a task, the amount of time to be devoted to it and the most suitable information sources.
10. EFFECTIVE USE OF INFORMATI0N RESOURCES - Level 3. Planning and using the information necessary for an academic assignment (a final thesis, for example) based on a critical appraisal of the information resources used.

TEACHING METHODOLOGY

The course consists of face-to-face activities consisting of 2 hours per week of lectures and participatory classes in the classroom and 2 hours per week in the laboratory.

In the lectures and participative classes in the classroom the contents of the subject are presented and the interaction between students and the teacher is facilitated. Individual / group personal work activities are also proposed that should contribute to the understanding of the subject.

In the laboratory classes some circuits of special interest will be studied in detail and a design proposed by the teacher will be made. The teacher will be available to answer questions and help properly plan the design, a part of which will be done outside the classroom.

A part of the activities will be carried out in English, including some of the lectures and laboratory classes. Much of the support material will be in English.

LEARNING OBJECTIVES OF THE SUBJECT

Upon completion of the Microelectronics course, the student will:

- Have basic notions about semiconductor materials and their properties.
- Know the principles of operation of the main devices and blocks that are part of integrated circuits.
- Be able to design simple digital and analog integrated circuits, from the schematic level to the monolithic arrangement (layout).
- Know the main techniques of design, manufacture and verification of microelectronic circuits.
- Know the technical-scientific terminology in English related to microelectronics.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours small group	30,0	20.00
Hours large group	30,0	20.00

Total learning time: 150 h

CONTENTS

1. INTRODUCTION TO INTEGRATED CIRCUITS AND MICROELECTRONICS

Description:
This topic presents a historical perspective and the current state of the art of microelectronics.
An introduction to semiconductor materials and their fundamental properties is also made:
- Crystalline structure and current carriers.
- Model of energy bands in a semiconductor.
- Intrinsic and P and N extrinsic semiconductor.
· Generation and recombination of carriers. Diffusion and drag currents.
· The PN junction.

Related activities:
A1, A3, A4.

Full-or-part-time: 15h
Theory classes: 6h
Self study : 9h

2. INTEGRATED CIRCUIT MANUFACTURING TECHNOLOGY

Description:
This topic presents the main integrated circuit manufacturing techniques and processes, including:
- Oxidation, photolithography, etching, diffusion, ion implantation, layer deposition, metallization, epitaxy, encapsulation.
- CMOS and bipolar manufacturing processes.
- Verification and testing: parametric testing, fault modeling and simulation, design for verifiability.
- Protection against electrostatic discharge (ESD).

The main types of integrated circuit are described subsequently:
- Monolithic and Hybrid Circuits, Programmable Devices (CPLD and FPGA), General Purpose Integrated Circuits, Application Specific (ASIC) and Standard Products (ASSP), Systems on a Single Chip (SoC).

Various designs made by the Communication Circuits and Systems Research Group (CIRCUIT) of the Universitat Politècnica de Catalunya are also presented.

Additionally, a visit to a research center in technologies, devices and integrated circuits is planned, such as the Barcelona Institute of Microelectronics (National Microelectronics Center).

Full-or-part-time: 20h
Theory classes: 4h
Laboratory classes: 4h
Self study : 12h

3. ACTIVE AND PASSIVE DEVICES IN INTEGRATED CIRCUITS

Description:
This topic presents the main devices used in integrated circuits, specifically:
- The MOS transistor: physical structure, characteristic curves, operating zones, models. Circuit analysis with MOS transitors. Applications. CMOS technology.
- The bipolar transistor: physical structure, characteristic curves, operating zones, models. Circuit analysis with bipolar transistors. Applications.
- Comparison between CMOS, bipolar and BiCMOS technologies.
- Integrated passive elements: resistors, capacitors, inductors, diodes.

Related activities:
All.

Full-or-part-time: 35h
Theory classes: 6h
Laboratory classes: 8h
Self study : 21h

4. INTEGRATED DIGITAL CIRCUITS

Description:
This topic presents basic blocks used in digital integrated circuits, and their properties:
- CMOS logic gates: inverter, NAND and NOR.
- Complex logical functions: analysis and design.
- Dynamic response of CMOS technology. Fan-in and fan-out. Power consumption.
- Pass transistors, transmission gates.
- Flip-flops. Memories.
- Flash memories. Floating gate transistor. NOR and NAND topologies. Single-level and multi-level cells.

Additionally, the process of synthesis of digital circuits using standard cells is presented from the description in VHDL language to the monolithic arrangement (layout).

Related activities:
All.

Full-or-part-time: 55h
Theory classes: 8h
Laboratory classes: 14h
Self study : 33h

5. ANALOG INTEGRATED CIRCUITS

Description:
This topic presents basic blocks used in analog integrated circuits, and their properties:
- Small signal models of MOS and bipolar transistors.
- Amplifiers.
- Active loads.
- Power sources.
- Voltage references.

Related activities:
All.

Full-or-part-time: 25h
Theory classes: 6h
Laboratory classes: 4h
Self study : 15h

ACTIVITIES

TITLE OF ACTIVITY 1: MASTER AND PARTICIPATORY CLASSES

Description:
In the classes the theoretical aspects of the subject will be developed. These will allow the interaction between the students and the teacher.

Specific objectives:
All of the subject.

Material:
Published teaching material.
Recommended bibliography.

Delivery:
Occasionally, assessable activities will be carried out, which will contribute in a proportional part to the grade.

Full-or-part-time: 25h
Theory classes: 25h

TITLE OF ACTIVITY 2: LABORATORY SESSIONS

Description:
There will be 5 laboratory practices, where part of the knowledge explained in the theory sessions will be put into practice. The face-to-face sessions will be held in the laboratory for two hours a week, in groups. Students will have information in the appropriate format. The laboratory will have a computer with the necessary software to carry out the proposed work.

Specific objectives:
- Edition and simulation of integrated circuits at the schematic and layout levels using Ngspice and Magic VLSI Layout Tool.
- Analysis of the CMOS inverter at the schematic and layout levels.
- Design and verification of a complex CMOS logic gate at the schematic and layout levels.
- Alternatively, design and verification of an analog amplifier at the schematic and layout levels.
- Synthesis of a digital circuit based on its description in VHDL language.

Material:
Electronic equipment and instrumentation, computer with suitable software.
Documentation and information to support the performance of the work.

Delivery:
Students will deliver a report on the work developed in each of the practices. The evaluation will take into account the documentation, as well as the presentation and an assessment of the work carried out regularly.

Full-or-part-time: 70h
Self study: 40h
Laboratory classes: 30h

TITLE OF ACTIVITY 3: INDIVIDUAL / GROUP PERSONAL WORK

Description:
The student must develop certain activities personally to achieve the objectives of the subject.

Specific objectives:
All of the subject.

Material:
Published teaching material.
Recommended bibliography.

Delivery:
Individual / group personal work will be translated, in part, into exercises during the course. The qualification of these exercises will contribute to the evaluation of the subject as described later.

Full-or-part-time: 35h
Self study: 35h

TITLE OF ACTIVITY 4: EXAMS

Description:
During the course there will be an individual control test. At the end of the course, a final globalizing test of the acquired knowledge will be carried out.

Specific objectives:
All of the subject.

Material:
Test statements.

Delivery:
The qualification of the tests will contribute to the evaluation of the subject as described below.

Full-or-part-time: 20h
Self study: 15h
Theory classes: 5h

GRADING SYSTEM

The final grade of the course will be obtained as follows:
- 40%: Laboratory practices (Activity 2)
- 10%: Personal and team work (Activity 3)
- 15%: Control test (Activity 4)
- 35%: Final exam (Activity 4)

Note. When the results of the evaluation of individual activities are substantially lower than those obtained in group activities, the execution of activities similar to those carried out in groups may be required individually. The rating of the latter will replace the originals.

Reassessment:

Students who have obtained the grade of 'failed' in the regular assessment period can access the re-assessment process.

Students who have a 'not presented' or have passed the subject in the ordinary evaluation period cannot access the re-evaluation process.

The result of the reassessment is a grade that replaces the grade obtained in the ordinary assessment process, which is higher than this and, in any case, will be at most a 'pass' 5.

If RR is the result of the re-assessment process and NER is the mark of the re-assessment examination, then:

RR = minimum { 5, (40%·Activity 2 + 10%·Activity 3 + 50%·NER) }

EXAMINATION RULES.

Those activities that are explicitly declared as individual, whether in person or not, will be carried out without any collaboration from other people.
The dates, formats and other delivery conditions that are established will be mandatory.

BIBLIOGRAPHY

Basic:
- Baker, R. J. CMOS circuit design, layout, and simulation [on line]. 4th ed. Hoboken: IEEE Press, 2019 [Consultation: 13/06/2024]. Available on: https://onlinelibrary-wiley-com.recursos.biblioteca.upc.edu/doi/book/10.1002/9780470891179. ISBN 9781119481515.
- Castañer, L.; Jiménez, V.; Bardés, D. Fundamentos de diseño microelectrónico [on line]. Barcelona: Edicions UPC, 2002 [Consultation: 17/12/2020]. Available on: http://hdl.handle.net/2099.3/36783. ISBN 9788483016138.

RESOURCES

Other resources:
- Teaching and support material published on the ATENEA platform.
- Open Courseware portal of the iTIC degree http://ocw.itic.cat. />- CAD tools and support material available at http://opencircuitdesign.com. />