

## Course guide

### 230736 - IMD - Introduction to Microelectronic Design

Last modified: 25/05/2023

**Unit in charge:** Barcelona School of Telecommunications Engineering  
**Teaching unit:** 710 - EEL - Department of Electronic Engineering.

**Degree:** MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).  
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).  
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2022). (Optional subject).

**Academic year:** 2023    **ECTS Credits:** 5.0    **Languages:** English

#### LECTURER

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**Coordinating lecturer:** Consultar aquí / See here:  
<https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/responsables-assignatura>

**Others:** Consultar aquí / See here:  
<https://telecos.upc.edu/ca/estudis/curs-actual/professorat-responsables-coordinadors/professorat-assignat-idioma>

#### PRIOR SKILLS

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The MOS transistor - Physical structure and Modeling (DC equations). Fundamentals of digital circuits: combinational (logic functions) and synchronous. MOSFET small-signal model. Concepts of operation point (quiescent point) and response to the small signal. DC and Small-signal analysis of basic analog circuits - the common-source amplifier. Circuit analysis in the Laplace domain.

#### DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

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##### Specific:

1. Ability to design and manufacture integrated circuits
2. Ability to use programmable logical devices, as well as to design analog and digital advanced electronics systems. Ability to design communication devices, such as routers, switches, hubs, transmitters and receivers in different bands.
3. Ability to apply advanced knowledge in photonics, optoelectronics and high-frequency electronic
4. Ability to implement wired/wireless systems, in both fix and mobile communication environments.

##### Transversal:

5. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
6. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

#### TEACHING METHODOLOGY

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- Lectures
- Laboratory classes
- Laboratory practical work
- Individual work (distance)
- Exercises
- Extended answer test (Final Exam)

## LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The main objective of the course is to provide basic knowledge and skills related to the design of circuits integrated in microelectronic CMOS technologies. Based on the analysis and design of both basic analog circuit stages (amplifiers) and digital (basic gates), the student will delve into the physical design (layout) of these circuits in CMOS integrated technologies, and will execute the physical and functional verification processes of the circuits designed, using EDA design tools. The student will know the physical aspects that affect the performance of the circuits (parasitic capacitances, process variability, noise), as well as other non-idealities, and will finally be introduced to the particularities of microelectronic circuit design for radio-frequency signals.

Learning results of the subject

Design basic circuits integrated in CMOS technologies (IC design), including their physical implementation.

Analyze basic logic gates and simple analog CMOS amplifier circuits and be able to design them to fulfill specification targets.

Understand and assess the most important non-idealities in these circuits, and how they affect their performance.

## STUDY LOAD

Type	Hours	Percentage
Self study	86,0	68.80
Hours large group	13,0	10.40
Hours small group	26,0	20.80

**Total learning time:** 125 h

## CONTENTS

### 1. CMOS circuits and technology

#### Description:

Reminder on the MOS transistor: physical structure, qualitative behavior, models.

DC analysis of circuits with MOS transistors.

Microelectronic implementation of CMOS circuits: parts of an integrated circuit; twin-well and triple-well technologies; layers; transistors; contacts; metal connections.

#### Related activities:

Lab1: Introduction to schematic capture, circuit simulation and layout edition using Cadence Virtuoso.

#### Full-or-part-time: 20h 18m

Theory classes: 3h

Practical classes: 6h

Self study : 11h 18m

## 2. Basic CMOS digital gates

### Description:

Physical structure, DC analysis.  
Delay models and estimation; design for speed.  
Power consumption: dynamic, static (leakage).  
Fanout and driving force. Scaled drivers.

### Related activities:

Lab2: Design and analysis of digital CMOS circuits. Sizing digital gates.

**Full-or-part-time:** 20h 18m

Theory classes: 3h

Laboratory classes: 6h

Self study : 11h 18m

## 3. Basic CMOS analog amplifiers

### Description:

Reminder small-signal concept (operating point, linearity assumption) and small-signal models.  
The common-source amplifier (single-ended).  
Biasing. The current mirror.  
Frequency response. Pole identification. Bandwidth estimation.  
Differential common-source amplifier (fully-differential).  
Differential amplifier with current-mirror load (simple OTA).

### Related activities:

Lab3: Design of basic CMOS amplifier circuits

**Full-or-part-time:** 27h 06m

Theory classes: 4h

Laboratory classes: 8h

Self study : 15h 06m

## 4. Introduction to amplifiers for RF: a narrowband LNA

### Description:

A receiver for RF communications. Requirements for a LNA.  
The common-source amplifier with inductive degeneration.  
Inductive loads. Quality factor.  
Noise in analog CMOS circuits. Noise metrics in RF amplifiers. Noise metrics in low-frequency amplifiers.  
Non-linearity in analog CMOS amplifiers. Linearity metrics in RF amplifiers. Linearity metrics in low-frequency amplifiers.

**Full-or-part-time:** 20h 18m

Theory classes: 3h

Laboratory classes: 6h

Self study : 11h 18m

## GRADING SYSTEM

Final examination: 40 %

Partial examinations and exercises: 20 %

Laboratory assessments: 40 %



## BIBLIOGRAPHY

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### Basic:

- Razavi, B. Fundamentals of microelectronics. Hoboken: John Wiley & Sons, 2008. ISBN 9780471478461.
- Weste, Neil H.E; Harris, David Money. CMOS VLSI design : a circuits and systems perspective. 4th ed. Boston: Addison Wesley, cop. 2011. ISBN 9780321547743.

### Complementary:

- Carusone, T.C.; Johns, D.; Martin, K.W. Analog integrated circuit design. International student version. New York: John Wiley, 2013. ISBN 9781118092330.

## RESOURCES

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### Other resources:

Notes, exercises, tutorials and labs available through the Atenea virtual campus.