Course guides
230665 - AMS - Analog and Mixed-Signal System-On-Chip Design

Last modified: 29/04/2020

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

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

Academic year: 2020 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: JORDI COSP VILELLA

Others: JORDI MADRENAS BOADAS

PRIOR SKILLS

Knowledge on:
* Electronic devices (diodes, BJT and MOSFET)
* Analysis and design of basic MOSFET analog circuits (W/L and ID sizing) as single-transistor and differential amplifier stages, current mirrors, cascoded circuits.
* Linear and nonlinear OpAmp based circuits
* Stability analysis of second order circuits.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Transversal:
1. 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.

2. 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

- Lectures
- Laboratory classes
- Laboratory practical work
- Oral presentations
- Other activities
- Short answer tests (Control)

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The course objective is two-fold. First, to complement the student VLSI background acquired in the previous core courses on electronics, stressing on important advanced concepts and providing designer insight in the area of VLSI analog and mixed-signal design. Second, to introduce the critical issues to take into account in the full design of a mixed-signal, submicron/nanometer-scale integrated circuit.

Learning results of the subject

Is able to prepare, present and defend individually an original professional exercise in the field of Electronics Engineering as a synthesis and a demonstration of skills acquired during its studies.
- Uses knowledge and strategic skills to create and manage projects with innovative vision, applies systemic solutions to complex problems.
- Plans and uses the information needed for a project or academic work from a critical reflection on the information resources used.
- Applies acquired skills to the execution of a task with independence. Identifies the need for continuous learning and develops its own strategy for doing so.
- Identifies major components and establishes commitments and priorities.
- Designs experiments and measurements to verify hypotheses or validate the operation of equipment, processes, systems or services in the field of Electronic Engineering.
- Selects appropriate equipment or software tools and performs advanced analysis with the data.
- Knows the concept of life-cycle of a product and applies it to the development of ICT products and services, using appropriate standards and legislation.
- Can perform an oral presentation and answer questions from the audience.
- Communicates clearly and efficiently in oral and written presentations on complex topics, being able to adapt to the situation, the type of audience and communication goals.
- Ability to synthesize and solve problems related to the electronic engineering discipline, to apply learning techniques in complex and multiple contexts, to apply previous knowledge to new situations and contexts, as well as the ability to coordinate and work in a team.
- Ability to analyze, design and evaluate microelectronic integrated circuits.
- Ability to identify and model electronic complex systems. Ability to perform qualitative analysis and approximations, establishing the uncertainty of the results.
- Ability to pose hypotheses on microelectronic circuits behavior and experimental methods to validate them.

STUDY LOAD

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

Total learning time: 125 h

CONTENTS

1. Devices

Description:
- Advanced transistor models (subthreshold, continuous), second-order effects.
- Noise models and distortion.
- Simulator limits.
- Integrated capacitors and resistors.

Full-or-part-time: 13h
Theory classes: 5h
Laboratory classes: 2h
Self study : 6h

2. Key concepts in analog design

Description:
- Differential signaling, (folded, regulated) cascode and follower associated concepts.
- The Miller effect. Pole-splitting.
- High-resistance node analysis, gain-bandwidth product, phase margin.
- Basic stages, advanced current mirrors and references.

Full-or-part-time: 13h
Theory classes: 5h
Laboratory classes: 2h
Self study : 6h

3. Systematic design of transconductors and opamps

Description:
- General model.
- Simple OTA. Pole-zero doublet. Linearization techniques.
- Fully differential amplifiers (FDA). Common-mode feedback issues.
- Output stages. Rail-to-rail input and output.

Full-or-part-time: 16h
Theory classes: 5h
Laboratory classes: 3h
Self study : 8h

4. Mixed-signal circuits

Description:
- Current and voltage comparators. Hysteresis.
- Charge pumps.
- DLLs.
- Time-to-digital converters.
- Digitally-assisted analog circuits.

Full-or-part-time: 17h
Theory classes: 5h
Laboratory classes: 4h
Self study : 8h

5. Chip-level design

Description:
- High-level simulation. Analog and Mixed-Signal (AMS) modeling.
- Digital synthesis.
- Digital back-end.
- Analog and mixed-signal layout techniques. Design rules.
- PVT issues. Matching techniques. Noise and crosstalk reduction.
- Power-supply and clock considerations.
- Pad characteristics and models. Pad and power rings. Package.

Full-or-part-time: 16h
Theory classes: 6h
Laboratory classes: 2h
Self study : 8h

6. Design project

Description:
Development of a design project to apply skills developed during the course.

Full-or-part-time: 50h
Self study : 50h

GRADING SYSTEM

Research exercise presentation: 25%
Practical lab exercises: 20%
Final course exercise: 30%
Midterm tests: 25%

BIBLIOGRAPHY

Basic:
- Baker, R.J. CMOS circuit design, layout and simulation. 4th ed. Hoboken, NJ: IEEE Press : Wiley, 2019. ISBN 9781119481515.
- Laker, K.R.; Sansen, W.M.C. Design of analog integrated circuits and systems. New York: McGraw-Hill, 1994. ISBN 007036060X.

Complementary:
- Tsidivis, Y.P. Operation and modeling of the MOS transistor. New York: McGraw-Hill, 1987. ISBN 007065381X.
- Toumazou, C.; Moschytz, G.; Gilbert, B. (eds.). Trade-offs in analog circuit design: the designer's companion [on line]. Boston: Kluwer Academic Publishers, 2002 [Consultation: 10/03/2015]. Available on: http://link.springer.com/book/10.1007/b117184. ISBN 1402070373.
- Ismail, M.; Fiez, T. Analog VLSI: signal and information processing. New York: McGraw-Hill, 1994. ISBN 0070323860.
- Razavi, B. Design of analog CMOS integrated circuits. 2nd ed. Boston: McGraw-Hill, 2017. ISBN 9781259255090.
- Sánchez-Sinencio, E.; Andreou, A.G. Low-voltage/low-power integrated circuits and systems: low-voltage mixed-signal circuits. New York: IEEE Press, 1998. ISBN 0780334469.
- Hastings, A. The art of analog layout. 2nd ed. Upper Saddle River: Prentice Hall, 2006. ISBN 0131464108.