Universitat Autònoma de Barcelona

2020/2021

Integrated Analogical and Mixed Circuits and Systems Design

Code: 102726
ECTS Credits: 6

Degree	Type	Year	Semester
2500895 Electronic Engineering for Telecommunication	OT	4	0

The proposed teaching and assessment methodology that appear in the guide may be subject to changes as a result of the restrictions to face-to-face class attendance imposed by the health authorities.

Contact

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Use of Languages

Principal working language: catalan (cat)
Some groups entirely in English: No
Some groups entirely in Catalan: Yes
Some groups entirely in Spanish: No

Teachers

Francesc Serra Graells

Prerequisites

The following backgrund is advised:

- Circuit theory and electronics
- Electronic devices
- Microelectronic design

Objectives and Contextualisation

The overall goal of this syllabus is double:

- Introduction to the design techniques for analog and mixed-signal integrated circuits in CMOS technologies.
- Hands-on-experience on the methodology and EDA tools for the design of full-custom integrated circuits through the free environment APDK (http://www.cnm.es/~pserra/apdk).

Competences

- Communication
- Design components and electronic circuits in accordance with specifications
- Design, analyse and propose specialised radiofrequency and microwave components, devices, circuits and systems for telecommunication systems.
- Develop personal attitude.
- Develop personal work habits.
- Develop thinking habits.
- Work in a team.

Learning Outcomes

1. Communicate efficiently, orally and in writing, knowledge, results and skills, both professionally and to non-expert audiences.
2. Demonstrate an integrated overview of the main challenges and trends in integrated system design based on technological developments and applications.
3. Design analogue and mixed integrated circuits and systems defining specifications to optimize the final product and depending on its final application.
4. Design communication circuits and components for specific applications using professional simulation tools.
5. Develop curiosity and creativity.
6. Develop systemic thinking.
7. Generate innovative and competitive proposals in professional activity.
8. Maintain a proactive and dynamic attitude with regard to ones own professional career, personal growth and continuing education. Have the will to overcome difficulties.
9. Make ones own decisions.
10. Manage information by critically incorporating the innovations of ones professional field, and analysing future trends.
11. Provide solutions to problems related to the practical implementation of communications components, such as interference, radiation loss, generation of parasitic modes, size, presence of spurious elements, etc.
12. Work cooperatively.
13. Work in complex or uncertain surroundings and with limited resources.

Content

Chapter 1. Introduction to the design of analog integrated circuits
1.1. From the Idea to the Chip
1.2. Microelectronic vs Electronic Design
1.3. CMOS Technologies
1.4. Device Modeling
1.5. The Operational Amplifier and its FoMs
1.6. Lab Proposal: My OpAmp in CNM 2.5um CMOS Technology (CNM25)

Chapter 2. Single Stage OpAmps
2.1. The Mono-Transistor Amplifier
2.2. Differential Topologies
2.3. Common Mode Feedback
2.4. Folded Amplifiers
2.5. Cascode Topologies
2.6. Gain Enhancement Techniques

Chapter 3. Multi-Stage OpAmps
3.1. Two-Stage Topologies
3.2. Miller Effect
3.3. Frequency Compensation
3.4. Design Space

Introduction to the CNM25 APDK (http://www.cnm.es/~pserra/apdk)

Chapter 4. Full-Custom Analog Design Methodology
4.1. Device Sizing
4.2. Process and Mismatching Simulation
4.3. The Art of Analog Layout
4.4. Physical Verification
4.5. Parasitics Extraction
4.6. DFM Techniques

Chapter 5. Low-Power OpAmps
5.1. Low-Voltage vs Low-Current
5.2. Subthreshold Operation
5.3. Class-AB Output Stages
5.4. Rail-to-Rail Topologies
5.5. Inverted-Based Pseudo-Differential Multi-Stage Architectures

Chapter 6. OpAmp Application Examples
6.1. Pre-Amplification
6.2. MRC-Amplifiers for AGC
6.3. Continuous-Time Gm-C Filters
6.4. Switched-Capacitor Filters

Chapter 7. Integrated Data Converters
7.1. ADC vs DAC
7.2. Flash Architectures
7.3. SAR Topologies
7.4. Integrating Solutions
7.5. Delta-Sigma Modulators

Methodology

- Directed activities: lectures, case studies and exercises, lab sessions and seminars
- Supervised activities: tutorials
- Non-supervised activities: study, lab pre-work, writing reports and oral presentations

Activities

Title	Hours	ECTS	Learning Outcomes
Type: Directed			
Case studies and exercises	12	0.48	2, 6, 3
Lab sessions	12	0.48	2, 3, 9, 12, 13
Lectures	26	1.04	2, 6, 3
Type: Supervised			
Tutorials	12	0.48	2, 6, 5, 3
Type: Autonomous			
Lab pre-work	8	0.32	1, 2, 6, 5, 3, 7, 10, 8, 9, 12, 13
Study	68	2.72	11, 2, 6, 5, 4, 3

Assessment

progressive evaluation of the overall mark is based on the following weights:

- Individual work (50%)
- Lab report (40%)
- Solved exercises (10%)

Lab work (including sessions and report) is mandatory to pass evaluation. The above evaluation scheme is only applicable when individual marks are greater or equal to 3/10. Otherwise, students must take de remedial exam.

In case the student applies for the remedial exam, its weight will be 50% of the overall mark, together with the lab report (40%) and solved exercises (10%).

Any student not compliant with the above criterias will be considered "Non Evaluable",

Any change on the above evaluation method will be communicated in advance to the affected students.

Assessment Activities

Title	Weighting	Hours	ECTS	Learning Outcomes
Individual work	50%	4	0.16	11, 1, 2, 6, 5, 3, 7, 10, 8, 9, 12
Lab report	40%	4	0.16	1, 2, 6, 4, 3, 9, 12, 13
Remedial exam	50%	2	0.08	2, 6, 3, 9
Solved exercises	10%	2	0.08	2, 6, 5, 3, 9

Bibliography

Teachin materials supplied during lecture sessions are almost self-explanatory. For a deeper understanding of both theoretical and practical contents, the following readings are recommended:

- P. E. Allen and D. R. Holberg, CMOS Analog Circuit Design, Oxford University Press, http://www.aicdesign.org
- B. Razavi, Design of Analog CMOS Integrated Circuits, McGraw-Hill Education
- F. Maloberti, Analog Design for CMOS VLSI Systems, Kluwer Academic Publishers
- T. Tuma and A. Burmen, Circuit Simulation with SPICE OPUS: Theory and Practice, Modeling and Simulation Science,
- Engineering andTechnology, Birkhäuser Boston
- A. Hastings, The Art of Analog Layout, Pearson Prentice Hall