

Course guide

230730 - DAMC - Design of Analogue Microelectronic Circuits

Last modified: 16/05/2025

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). (Compulsory subject).

Academic year: 2025 **ECTS Credits:** 5.0 **Languages:** English

LECTURER

Coordinating lecturer: XAVIER ARAGONES CERVERA

Others: Primer quadrimestre:
XAVIER ARAGONES CERVERA - 21, 23
SERGIO GÓMEZ FERNÁNDEZ - 21

PRIOR SKILLS

The course assumes basic concepts on MOS transistor behavior and modeling, circuit implementation in microelectronic technologies, amplification and analog circuit analysis, as well as circuit simulation and layout edition in Cadence Virtuoso environment or similar, corresponding to the "Introduction to Microelectronic Design" bridge course or similar:

- MOSFET basic behavior: states, equations, curves.
- Characteristics of microelectronic technologies.
- Full-custom design methodology. Basics on layout of custom analog circuits.
- Analog circuit analysis: large signal and small-signal
- Basic 1-transistor amplifier stages. Basic concepts on noise and distortion.
- Circuit simulation at transistor level (.DC, .TRAN, .AC analysis)
- Basic concepts on active-RC filters.
- Basic concepts on DAC and ADC conversion.

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:

CMEE5. Conceive and design electronic circuits for signal amplification, both low and high (radio) frequencies, according to the type of application and objectives of gain, consumption, noise, linearity, stability, impedances, bandwidth.

CMEE6. Understand and apply solutions for analog signal filtering and conversion to/from the digital domain, understand the limitations associated with its microelectronic implementation and select the optimal approach based on specifications, resolution, frequency.

CMEE7. Apply methodologies for the analysis and design of analog circuits in CAD environments for microelectronic design.

Transversal:

CTMEE5. Third language. Know a third language, preferably English, with an adequate oral and written level and in line with the needs that graduates will have.

TEACHING METHODOLOGY

- Lectures
- Individual work (distance)
- Lab design exercises (analysis and simulation)
- Extended answer test (Final Exam)

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The aim of this course is that the student becomes able to design CMOS microelectronic circuits implementing the basic circuits solutions for analog signal acquisition and processing (amplification and filtering). Special attention will be given to understand the non-idealities that limit the dynamic range, resolution, precision, frequency of operation, or power consumption of the circuits, the effects of manufacturing and time variability, and how different circuit solutions can cope with these limitations. Specific design scenarios such as low-power, low voltage, or radio-frequency, will be reviewed in the course. The impact of design decisions will also be assessed from a sustainability perspective, and techniques will be presented to reduce this impact. The student will acquire skills to design these circuits in a microelectronic technology, and know the analysis and verification processes of analog circuits using specific CAD tools for IC design. After this course, the student will be in position to follow specialized courses related to microelectronic design, focused on specific applications (eg. high-frequency communications, signal conditioning, power management...).

Learning results of the subject:

- Know and apply advanced design techniques in analog signal processing circuits in CMOS technology. Low power supply voltage, low consumption, high frequency scenarios.
- Know circuit and design solutions to respond to the limitations of analog circuits linked to their CMOS implementation, such as noise, distortion, manufacturing variability, variability over time.
- Know the methodologies of analysis and design of analog circuits in CAD environments of microelectronic design.

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.- Fundamentals

Description:

- MOS transistor models for analog microelectronic design. From strong to weak inversion.
- Reminder basic analog circuits: common-source stage, common-drain, common-gate, current mirror. The cascode structure.

Full-or-part-time: 12h 48m

Theory classes: 4h

Self study : 8h 48m

2.- Biasing circuits

Description:

- Cascode current mirrors
- Implementation issues: matching, transistor sizing, layout techniques
- Voltage and current references. Bandgap.

Full-or-part-time: 12h 48m

Theory classes: 4h

Self study : 8h 48m

3.- Amplification at high-frequencies

Description:

- Limits in 1-stage amplifier.
- Narrowband amplification.
- Cascaded and distributed solutions.

Full-or-part-time: 6h 24m

Theory classes: 2h

Self study : 4h 24m

4.- Differential amplifiers and OTAs

Description:

- Feedback: open-loop and closed-loop gain, bandwidth, linearity. Stability.
- Differential amplifiers. Common-mode feedback.
- Implementation issues: matching, transistor sizing, layout techniques
- 1-stage OTA solutions. Folded-cascode.
- 2-stage OTA with power-down.

Full-or-part-time: 19h 20m

Theory classes: 6h

Self study : 13h 20m

5.- Circuits for signal acquisition and analog processing

Description:

- Continuous-time feedback amplifiers and filters
- Gm-C. Exploiting weak-inversion for ultra-low power applications.
- Introduction to switched-capacitor amplifiers and filters.
- Sample and hold circuits.
- Comparators.

Full-or-part-time: 32h

Theory classes: 10h

Self study : 22h

6.- Practical design projects

Description:

The student will apply the concepts and skills learned in the course to the design of two circuits implemented in a CMOS microelectronic technology, using the Cadence Virtuoso IC design environment:

- An analog amplifier with large dynamic range, robust against noise and process, temperature and voltage variability.
- 2-stage OTA with power-down.

Full-or-part-time: 41h 40m

Laboratory classes: 13h

Self study : 28h 40m



GRADING SYSTEM

Final examination: 45%

Labs: 30%

Exercises to do at home or in class: 35%

BIBLIOGRAPHY

Basic:

- Allen, P.E.; Holberg, D.R. CMOS analog circuit design. 3rd ed., int. ed. New York: Oxford University Press, 2012. ISBN 9780199937424.
- Gray, P.R. ... [et al.]. Analysis and design of analog integrated circuits. 5th ed. New York: John Wiley, 2010. ISBN 9780470398777.
- Razavi, B. Design of analog CMOS integrated circuits. 2nd ed. Boston: McGraw-Hill, 2017. ISBN 9781259255090.
- Carusone, T.C.; Johns, D.; Martin, K.W. Analog integrated circuit design. Int. stud. version. New York: John Wiley, 2013. ISBN 9781118092330.
- Sansen, Willy M. Analog design essentials [on line]. New York, NY: Springer US, 2006 [Consultation: 27/03/2024]. Available on: <https://link-springer-com.recurtos.biblioteca.upc.edu/book/10.1007/b135984>. ISBN 9780387257471.

Complementary:

- Baker, R.J. CMOS circuit design, layout, and simulation. 4th ed. Hoboken, NJ: IEEE Press : Wiley, 2019. ISBN 9781119481515.

RESOURCES

Other resources:

Course slides, exercises, and tutorials available through the Atenea virtual campus.