Course guide
2301217 - RFICD - RF Ic Design

Last modified: 29/05/2025

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

Degree: MASTER'S DEGREE IN SEMICONDUCTOR ENGINEERING AND MICROELECTRONIC DESIGN (Syllabus 2024). (Optional subject).

Academic year: 2025 **ECTS Credits:** 4.0 **Languages:** English

LECTURER

Coordinating lecturer: XAVIER ARAGONES CERVERA

Others: Segon quadrimestre:
XAVIER ARAGONES CERVERA - 11
PEDRO ANTONIO DE PACO SANCHEZ - 11
DIEGO CESAR MATEO PEÑA - 11
JORGE ANDRES VERDU TIRADO - 11

PRIOR SKILLS

Basic concepts on time-domain and frequency-domain representation of signals. Modulations (concept, main types). Analysis and design of analog CMOS circuits (large- and small-signal), basic design trade-offs. Noise and distortion in CMOS circuits. Cadence Virtuoso design environment.

LEARNING RESULTS

Knowledges:
KT01. Identify semiconductor devices, technological processes, the most appropriate microelectronic design tools, and relationships between these elements in order to integrate a given product or system into microelectronic technologies.
KT02. Describe the current state of scientific research and microelectronic industrial technology worldwide and their economic, social and environmental impact.
KT03. Describe the physical principles underlying current semiconductor devices in relation to their application, as well as their emerging trends, modelling and characterisation techniques.
KT04. Identify and describe the different manufacturing and characterisation processes in microelectronics and their applicability according to the functional and cost requirements of the final integrated product.
KT05. Describe the main methods and tools used to design integrated circuits and systems in accordance with the required functional specifications and cost of the final integrated product.
KT06. Identify and describe the main verification and test strategies for integrated circuits and systems according to their application.

Skills:
ST01. Design integrated devices, circuits and systems for new products according to their applications, taking into account sustainability and energy efficiency requirements.
ST02. Apply the manufacturing techniques and processes and design, simulation and characterisation tools of semiconductor engineering and microelectronic design to provide a solution to a specific integrated system proposal.

Competences:
CT01. Design new devices and integrated systems that require the use of manufacturing techniques specific to microelectronic technologies or the use of microelectronic design tools.
CT02. Apply sustainability criteria to projects based on integrated microelectronic products.
CT03. Apply the processes of semiconductor engineering and microelectronic design to fields in diverse areas of science or engineering where integrated systems are required.

TEACHING METHODOLOGY

- Lectures
- Laboratory practical work
- Individual work (distance)
- Exercises
- Written tests

LEARNING OBJECTIVES OF THE SUBJECT

1. Know the main architectures for transmitters and receivers in radiofrequency (RF) communications systems, understand their functionality, figures of merit and main requirements.
2. Know the basic circuit solutions for the different blocks found in RF receiver and transmitter architectures (low-noise amplifiers, power amplifiers, voltage-controlled oscillators and frequency synthesizers, mixers) and be able to design them in microelectronic technologies, mainly CMOS.
3. Use EDA tools to design, analyze and evaluate the performance and figures of merit of RF circuits.
4. Identify the fundamental requirements of an integrated technology to be used in a RF context. Know the desired characteristics and actual behavior at RF of active and passive components in an integrated microelectronic technology, in particular CMOS.

STUDY LOAD

Type	Hours	Percentage
Hours large group	18,0	18.00
Hours small group	12,0	12.00
Self study	70,0	70.00

Total learning time: 100 h

CONTENTS

1. Introduction to RFIC's

Description:
State of the art, main characteristics, performance trends. Technology comparison of RFIC, MMIC and HMIC. Challenges and opportunities in the design of RFIC/MMIC.

Full-or-part-time: 1h
Theory classes: 1h

2. Architectures of RF transceivers

Description:
Multiple access approaches. Receiver and transmitters architectures (heterodyne, direct conversion, image-rejection, low-IF). Band filtering (RF) and channel filtering.

Full-or-part-time: 2h
Theory classes: 2h

3. Fundamental parameters and figures-of-merit in RF receivers and transmitters

Description:
Concepts and definitions for power, ACPR, sensitivity, gain, noise, linearity. Link budget. Relationship between specs of a RF communications standard and figures of merit in receivers and transmitters. Budget analysis.

Full-or-part-time: 4h
Theory classes: 4h

4. Microelectronic technologies for RF

Description:
MOS for RF: physical characteristics, models, fT and fmax. Integrated passive components for RF: inductors, capacitors, varactors, transmission lines. Noise sources, modeling.

Full-or-part-time: 3h 30m
Theory classes: 1h 30m
Practical classes: 2h

5. Power Amplifiers (PA)

Description:
Design of power amplifiers for high power efficiency. Load-pull techniques. Analysis and design of a Class-F power amplifier.

Full-or-part-time: 4h
Theory classes: 4h

6. Low-Noise Amplifiers (LNA)

Description:
Power matching and noise matching. Narrowband amplifiers: analysis and design methodology. Wideband amplifiers.

Full-or-part-time: 6h
Theory classes: 3h
Laboratory classes: 3h

7. Voltage-Controlled Oscillators (VCO)

Description:
Figures of merit. Effects of phase noise and spurs on the signal reception. Resonant circuit solutions: Colpitts, LC-NMOS and LC-CMOS. Quadrature VCOs (QVCOs).

Full-or-part-time: 6h
Theory classes: 3h
Laboratory classes: 3h

8. Introduction to Frequency Synthesizers (FS)

Description:
Figures of merit. Concept of frequency synthesis by means of a phase-locked loop. Type-II PLL's: description, main characteristics, dynamic response. N-Integer frequency synthesizer. Typical circuit implementations of frequency divider, phase detector and charge-pump.

Full-or-part-time: 1h 30m
Theory classes: 1h 30m

9. Mixers

Description:
Active mixers: single-balanced and double-balanced. Passive mixers, polyphase.

Full-or-part-time: 2h
Theory classes: 2h

GRADING SYSTEM

- Lab work: 35%
- Exercises and problems: 25%
- Final written exam: 40%

BIBLIOGRAPHY

Basic:
- Razavi, Behzad. RF microelectronics. 2nd edition. Upper Saddle River, New Jersey: Pearson Education International, 2012. ISBN 9780137134731.
- Lee, Tom H. The design of CMOS radio-frequency integrated circuits. 2nd edition. Cambridge [etc.]: Cambridge University Press, 2004. ISBN 0521835399.
- Cripps, Steve C. RF Power Amplifiers for Wireless Communications. 2nd ed. Boston. MA: Artech House, 2006. ISBN 1596930187.
- Pozar, David M.. Microwave and RF Design of Wireless Systems. 1st Edition. Wiley, 2000. ISBN 978-0471322825.

RESOURCES

Other resources:
Course slides, exercises, tutorials and labs available through the Atenea virtual campus.