Course guides
230663 - RICS - Radiofrequency Integrated Circuits and Systems

Last modified: 28/05/2020

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: XAVIER ARAGONES CERVERA

Others: XAVIER ARAGONES CERVERA, DIEGO MATEO PEÑA

PRIOR SKILLS

Basic concepts on modulations (concept, types), up- and down-conversion. MOSFET transistor (core courses MND and MNT). Analog circuit analysis and design; performance trade-offs (core courses AACT and MND). Basic RF circuit topologies and figures of merit (bridge course ECS). Cadence design environment (bridge course ECS, core course MND).

REQUIREMENTS

Basic concepts on modulations (concept, types), up- and down-conversion. MOSFET transistor (core courses MND and MNT). Analog circuit analysis and design; performance trade-offs (core courses AACT and MND). Basic RF circuit topologies and figures of merit (bridge course ECS). Cadence design environment (bridge course ECS, core course MND).

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 practical work
- Individual work (distance)
- Exercises
- Oral presentations
- Written tests

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The aim of this course is to train students in methods of design, analysis and specification of analog circuits for RF (radiofrequency) communication systems, integrated in microelectronic CMOS technology. In the first part of the course, system-level analysis will link specifications of communication systems with the figures of merit of the electronic circuits that implement the receivers/transmitters in those systems. A comprehensive analysis of the different specs will be done, and a specification procedure of the circuits using software tools will be described. Next, the major circuits in a RF communication receiver front-end will be described, for the particular target of integration in CMOS technology. Performance trade-offs will be analyzed and for each of the circuits, design procedures will be described and practiced in specific exercises using professional EDA tools for microelectronic design (Cadence). Basic knowledge of the microelectronic CMOS technology is assumed, although the possibilities, limitations and particularities of this technology for RF will be also discussed in the course.

STUDY LOAD

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

Total learning time: 125 h

CONTENTS

1. System-level design

Description:
- Reminder front-end architectures, basic concepts on modulations.
- System-level parameters: error probability, SNR, tolerance to interferers, ACPR, sensitivity
- Circuit-level parameters: gain, linearity, noise figure, power
- From communication standard definitions to circuit specs. Case study: The Bluetooth receiver design.
- Lab, practical exercise.

Related activities:
- Exercises, to be delivered
- Pre-lab
- Lab

Full-or-part-time: 38h
Theory classes: 10h
Laboratory classes: 2h
Guided activities: 14h
Self study : 12h

2. The CMOS technology for RF

Description:
- MOS models for RF.
- Passive components integrated in CMOS technology
- Lab, characterization of a MOS transistor for RF

Related activities:
- Exercises, to be delivered
- Lab

Full-or-part-time: 19h
Theory classes: 4h
Laboratory classes: 2h
Guided activities: 7h
Self study : 6h

3. Design of Low-Noise Amplfiers (LNA)

Description:
- Tuned Low-Noise Amplifiers. Analysis and design procedure.
- Other LNA topologies.
- Specific analysis for RF using SpectreRF.
- Lab, design of a tuned LNA and performance analysis using SpectreRF

Related activities:
- Exercises, to be delivered
- Pre-lab
- Lab

Full-or-part-time: 30h
Theory classes: 7h
Laboratory classes: 2h
Guided activities: 11h
Self study : 10h

4. Design of Voltage-Controlled Oscillators (VCO)

Description:
- Ressonant LC-CMOS VCO design. Analysis and design procedure.
- Other VCO topopologies. QVCOs.
- Introduction to PLLs and frequency synthesizers.
- Lab, design of a VCO and performance analysis using SpectreRF

Related activities:
- Exercises, to be delivered
- Pre-lab
- Lab

Full-or-part-time: 19h
Theory classes: 4h
Laboratory classes: 2h
Guided activities: 7h
Self study : 6h

5. Design of Mixers

Description:
- Active mixers. Analysis and design procedure.
- Other mixers: passive, polyphase filters
- Lab, design of a mixer based on a Gilbert cell, using SpectreRF

Related activities:
- Exercises, to be delivered
- Lab

Full-or-part-time: 19h
Theory classes: 4h
Laboratory classes: 2h
Guided activities: 7h
Self study : 6h

ACTIVITIES

LABORATORY

Description:
All lab practices will be partly done with the assistance of a professor during regular class sessions, and partly done individually by the students as part of their guided study.
- System-level budget analysis
- Characterization of a MOS transistor for RF
- Design of a tuned LNA and performance analysis using SpectreRF
- Design of a VCO and performance analysis using SpectreRF
- Design of a mixer based on a Gilbert cell, using SpectreRF

Full-or-part-time: 24h
Theory classes: 12h
Guided activities: 12h

EXERCISES

Description:
Exercises using analythical methods, with the aim to strengthen the theoretical knowledge.

Full-or-part-time: 13h
Self study: 13h

ORAL PRESENTATION

Description:
Presentation of a RF circuit/system

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

GRADING SYSTEM

The basic qualification system of the course is through continous assessment, obtained from the following components:

- Exercises and problems, personal solving: 35%
- Laboratory assessments: 40%
- Written test: 25%

In order to be qualified through continuous assessment, regular attendance to the classes/lab practices and regular delivery of exercises/laboratory reports is expected.
In case a minimum of attendance and deliveries is not fulfilled, the student can be qualified through a single final written examination.

BIBLIOGRAPHY

Basic:

- Razavi, B. RF microelectronics. 2nd ed. int. Upper Saddle River: Pearson Education International, 2012. ISBN 978-0-12-283941-9.
- Lee, T.H. The design of CMOS radio-frequency integrated circuits. 2nd ed. Cambridge: Cambridge University Press, 2004. ISBN 0521835399.

RESOURCES

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