Last update: 30-06-2017

230663 - RICS - Radiofrequency Integrated Circuits and Systems

Coordinating unit: 230 - ETSETB - Barcelona School of Telecommunications Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering
Academic year: 2017
Degree: DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 1992). (Teaching unit Optional)
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2009). (Teaching unit Optional)
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Teaching unit Optional)
DEGREE IN ELECTRONIC ENGINEERING (Syllabus 1992). (Teaching unit Optional)
ECTS credits: 5 Teaching languages: English

Teaching staff

Coordinator: DIEGO MATEO PEÑA

Others: XAVIER ARAGONES CERVERA, DIEGO MATEO PEÑA

Prior skills

Basic concepts on modulations (concept, types), up- and down-conversion. Basic concepts on transceiver architectures (heterodyne, homodyne: block diagrams). 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. Basic concepts on transceiver architectures (heterodyne, homodyne: block diagrams). 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 classes
- Laboratory practical work
- Individual work (distance)
- Exercises
- Oral presentations
- Written tests

Learning objectives of the subject

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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 the communication system with the figures of merit of the electronic circuits that implement the system. 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

Total learning time: 125h	Hours large group:	26h	20.80%
	Hours medium group:	0h	0.00%
	Hours small group:	13h	10.40%
	Guided activities:	0h	0.00%
	Self study:	86h	68.80%

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Content

1. System-level design

Learning time: 38h

Theory classes: 10h
Laboratory classes: 2h
Guided activities: 14h
Self study : 12h

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

2. The CMOS technology for RF

Learning time: 19h

Theory classes: 4h
Laboratory classes: 2h
Guided activities: 7h
Self study : 6h

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

3. Design of Low-Noise Amplfiers (LNA)	Learning time: 30h Theory classes: 7h Laboratory classes: 2h Guided activities: 11h Self study : 10h

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

4. Design of Voltage-Controlled Oscillators (VCO)	Learning time: 19h Theory classes: 4h Laboratory classes: 2h Guided activities: 7h Self study : 6h

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

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

5. Design of Mixers	Learning time: 19h Theory classes: 4h Laboratory classes: 2h Guided activities: 7h Self study : 6h

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

Planning of activities

LABORATORY	Hours: 24h Theory classes: 12h Guided activities: 12h

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

EXERCISES	Hours: 13h Self study: 13h

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

ORAL PRESENTATION	Hours: 8h Theory classes: 4h Self study: 4h

Description:
Presentation of a RF circuit/system

Qualification system

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

- Exercises and problems, personal solving: 30%
- Individual presentation of a RF circuit/system: 20%
- Laboratory assessments: 30%
- Written test: 20%

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.

Others resources:

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