# 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:** 2020  
**Degree:**  
- MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Optional)  
- MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Teaching unit Optional)  
**ECTS credits:** 5  
**Teaching languages:** English

## Teaching staff

**Coordinator:** 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

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group:</th>
<th>26h</th>
<th>20.80%</th>
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<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Hours small group:</td>
<td>13h</td>
<td>10.40%</td>
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<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>86h</td>
<td>68.80%</td>
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# Content

## 1. System-level design

<table>
<thead>
<tr>
<th>Description:</th>
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<tbody>
<tr>
<td>- Reminder front-end architectures, basic concepts on modulations.</td>
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<tr>
<td>- System-level parameters: error probability, SNR, tolerance to interferers, ACPR, sensitivity</td>
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<tr>
<td>- Circuit-level parameters: gain, linearity, noise figure, power</td>
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<tr>
<td>- From communication standard definitions to circuit specs. Case study: The Bluetooth receiver design.</td>
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<tr>
<td>- Lab, practical exercise.</td>
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<table>
<thead>
<tr>
<th>Related activities:</th>
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</thead>
<tbody>
<tr>
<td>- Exercises, to be delivered</td>
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<tr>
<td>- Pre-lab</td>
</tr>
<tr>
<td>- Lab</td>
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<table>
<thead>
<tr>
<th>Learning time: 38h</th>
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<tbody>
<tr>
<td>Theory classes: 10h</td>
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<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Guided activities: 14h</td>
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<tr>
<td>Self study : 12h</td>
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## 2. The CMOS technology for RF

<table>
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<th>Description:</th>
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<tbody>
<tr>
<td>- MOS models for RF.</td>
</tr>
<tr>
<td>- Passive components integrated in CMOS technology</td>
</tr>
<tr>
<td>- Lab, characterization of a MOS transistor for RF</td>
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<table>
<thead>
<tr>
<th>Related activities:</th>
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</thead>
<tbody>
<tr>
<td>- Exercises, to be delivered</td>
</tr>
<tr>
<td>- Lab</td>
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<table>
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<tr>
<th>Learning time: 19h</th>
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<tbody>
<tr>
<td>Theory classes: 4h</td>
</tr>
<tr>
<td>Laboratory classes: 2h</td>
</tr>
<tr>
<td>Guided activities: 7h</td>
</tr>
<tr>
<td>Self study : 6h</td>
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</tbody>
</table>
### 3. Design of Low-Noise Amplifiers (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:**  
- Resonant LC-CMOS VCO design. Analysis and design procedure.  
- Other VCO topologies. 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
### 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
- Guided activities: 12h
- Theory classes: 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 analytical methods, with the aim to strengthen the theoretical knowledge.

#### ORAL PRESENTATION

**Hours:** 8h
- Self study: 4h
- Theory classes: 4h

**Description:**
Presentation of a RF circuit/system
Qualification system

The basic qualification system of the course is through continuous 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:


Others resources:

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