Degree competences to which the subject contributes

**Specific:**
1. CE 23 SIS. Capacidad de análisis de componentes y sus especificaciones para sistemas de comunicaciones guiadas y no guiadas. (CIN/352/2009, BOE 20.2.2009.)
2. CE 24 SIS. Capacidad para la selección de circuitos, subsistemas y sistemas de radiofrecuencia, microondas, radiodifusión, radioenlaces y radiodeterminación. (CIN/352/2009, BOE 20.2.2009.)

**General:**
7. EFFICIENT USE OF EQUIPMENT AND INSTRUMENTATION - Level 3: Design experiments, measurements, subsystems and systems, equipment and tools most appropriate laboratory. Knowing not only benefits but also the limitations of the equipment and resources. Conduct assessments and evaluations critically, making decisions according to the overall system specifications or service.

**Transversal:**
3. SELF-DIRECTED LEARNING - Level 1. Completing set tasks within established deadlines. Working with recommended information sources according to the guidelines set by lecturers.
4. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.
5. TEAMWORK - Level 1. Working in a team and making positive contributions once the aims and group and individual responsibilities have been defined. Reaching joint decisions on the strategy to be followed.
6. EFFECTIVE USE OF INFORMATION RESOURCES - Level 1. Identifying information needs. Using collections, premises and services that are available for designing and executing simple searches that are suited to the topic.

Prior skills
Good capability to operate complex numbers

Requirements
Prerequisite:
- Electromagnetic Waves in Communications Systems
By the end of the term, the student is able to:

- Understand the operating principle of electrically small devices and the main networks that can be designed with them.
- Obtain the equations of voltage and current in an ideal transmission line from an infinitesimal section. Also the student is able to calculate the voltage and current distribution (phasors and time domain) in a transmission line given a source and load.
- Match the impedance of a transmission line using lumped elements, quarter wave impedance transformers, and short-circuited and open-circuited transmission line sections, and to be able to explain the procedures.
- Calculate the attenuation of a transmission line or cable from its primary parameters, and to calculate the attenuation and losses of systems having transmission lines.
- Operate with the scattering parameters (S parameters): to know their definition, how are they measured, and how to shift the reference planes. From these parameters, to infer whether a device is active or passive, and whether it is lossy or lossless.
- Calculate the scattering matrix of a simple two port (made with transmission line sections and/or lumped elements, in series or shunt).
- Regarding two-port, three-port and four-port networks: to explain their mission in a system, to know their scattering matrices, and to solve simple problems involving networks (to compute return losses, insertion losses or gain, coupling, directivity, isolation).
- Identify different manufacturing technologies of high frequency networks (hybrid planar networks, monolithic networks, guided wave networks, MEMS ...) and to know their potential.
- Design microstrip networks from given technical specifications: filters, multiplexors, splitters/combiners, directional couplers, hybrids, switches, mixers, amplifiers, and oscillators.
- Know the main characteristics and manage to use a professional software tool for the design of radiofrequency networks and devices.
- Know the characteristics of common instrumentation in a radiofrequency laboratory: spectrum analyzer, vector network analyzer, signal generator, etc.
- Understand the block diagram of a common RF transceptor and to know some common techniques for subsystem design.

## Study load

<table>
<thead>
<tr>
<th>Total learning time: 265h</th>
<th>Hours large group: 63h</th>
<th>23.77%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td>Hours small group:</td>
<td>39h</td>
<td>14.72%</td>
</tr>
<tr>
<td>Guided activities:</td>
<td>11h 30m</td>
<td>4.34%</td>
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<tr>
<td>Self study:</td>
<td>151h 30m</td>
<td>57.17%</td>
</tr>
</tbody>
</table>
# Content

<table>
<thead>
<tr>
<th>Introduction to distributed circuit design</th>
<th>Learning time: 72h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 15h</td>
</tr>
<tr>
<td>The topics in this lesson are:</td>
<td>Laboratory classes: 16h</td>
</tr>
<tr>
<td>- Transmission lines</td>
<td>Self study: 41h</td>
</tr>
<tr>
<td>- Reflection coefficient and Smith chart</td>
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<tr>
<td>- Power and losses</td>
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<tr>
<td>- Transmission line design</td>
<td></td>
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<tr>
<td>- Homogeneous and non-homogeneous lines</td>
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<tr>
<td>- Balanced and unbalanced lines</td>
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<tr>
<td>- Coupled lines</td>
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<tr>
<td>- Impedance matching with lumped elements and transmission lines</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Microwave circuits characterization</th>
<th>Learning time: 55h 30m</th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 13h 30m</td>
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<tr>
<td>The topics in this lesson are:</td>
<td>Laboratory classes: 8h</td>
</tr>
<tr>
<td>- Parameters used to characterize, measure and simulate microwave networks: Z, Y, ABCD, and S</td>
<td>Self study: 34h</td>
</tr>
<tr>
<td>- Properties and measurement of scattering parameters S</td>
<td></td>
</tr>
<tr>
<td>- Calculation of the scattering parameters S of two-port networks</td>
<td></td>
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<tr>
<td>- Interconnection of two-port networks</td>
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<tr>
<td>- Common two-port networks: attenuators, amplifiers, isolators, and filters</td>
<td></td>
</tr>
<tr>
<td>- Three or more than three ports networks: power splitters/combiners, directional couplers, 90° hybrid, 180° hybrids, circulators</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Related activities:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Activity 1</td>
</tr>
<tr>
<td>Activity 2</td>
</tr>
<tr>
<td>Activity 3</td>
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<tr>
<td>Activity 4</td>
</tr>
</tbody>
</table>

Activity 5
## Fabrication technologies, instrumentation, and CAD for RF applications

**Description:**

The topics in this lesson are:

- Fabrication technologies of radiofrequency devices
  - Planar
  - Waveguides and dielectrics
  - Electro-acoustics
  - Electro-optics
- Components. Encapsulation, tolerances, models, etc
- Instrumentation: spectrum analyzer, vector network analyzer, noise figure analyzer, synthesizer/signal generator, oscilloscope, power detectors
- Instrumentation control software and protocols
- CAD software for the design and analysis of radiofrequency networks and devices
  - Lumped elements simulator
  - 2.5D simulators (method of moments)
  - 3D simulators (frequency and time)
  - Multiphysics

**Related activities:**

Activity 1

<table>
<thead>
<tr>
<th>Learning time: 18h</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theory classes: 8h</td>
</tr>
<tr>
<td>Self study: 10h</td>
</tr>
</tbody>
</table>
### Passive devices

**Learning time:** 57h  
Theory classes: 15h  
Laboratory classes: 8h  
Self study: 34h

**Description:**  
The topics in this lesson are:  
- Reactive elements design using transmission lines  
- Discontinuities  
- Two-port passive components design  
  - Resonators  
  - Filters and multiplexers  
  - Splitters/Combiners  
  - Directional couplers and hybrids  
  - Switches  
  - Phase shifters  
  - Mixers  
  - Circulators and isolators  
- Waveguide networks

**Related activities:**  
Activity 1  
Activity 5

### Active devices

**Learning time:** 60h  
Theory classes: 11h 30m  
Laboratory classes: 16h  
Self study: 32h 30m

**Description:**  
The topics in this lesson are:  
- Amplifying devices  
  - Low noise amplifiers  
  - Power amplifiers  
- Oscillators  
  - RF oscillators  
  - Microwave oscillators

**Related activities:**  
Activity 1  
Activity 6
300031 - ERF - RF Engineering

**Qualification system**

Defined at the course infoweb.

**Regulations for carrying out activities**

A scientific calculator operating with complex numbers is required.
The use of mobile phones is forbidden in any assessment.

**Bibliography**

**Basic:**


**Complementary:**


**Others resources:**

- Application notes
- Manuals