300031 - ERF - RF Engineering

Coordinating unit: 300 - EETAC - Castelldefels School of Telecommunications and Aerospace Engineering
Teaching unit: 739 - TSC - Department of Signal Theory and Communications
Academic year: 2019
Degree: BACHELOR'S DEGREE IN AEROSPACE SYSTEMS ENGINEERING/BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2015). (Teaching unit Compulsory)
BACHELOR'S DEGREE IN TELECOMMUNICATIONS SYSTEMS ENGINEERING (Syllabus 2009). (Teaching unit Compulsory)
ECTS credits: 10,5
Teaching languages: Catalan, Spanish, English

Teaching staff
Coordinator: Definit a la infoweb de l'assignatura.
Others: Definido en la infoweb de la asignatura.

Opening hours
Timetable: Schedule appointment with professor

Prior skills
Good capability to operate complex numbers

Requirements
Prerequisite:
- Electromagnetic Waves in Communications Systems

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.)

Generical:
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.
Teaching methodology

This course introduces common design techniques of high frequency networks, different manufacturing technologies, and the terminology used in the industry to define the performance of the networks. With this goal in mind, the methodology includes lectures supported by problems and laboratory simulations. Both, at the classroom and at the lab a professional CAD tool is used for the analysis and design of radiofrequency networks. Lab sessions mainly consider the design and simulation of radiofrequency networks using the knowledge provided during the lectures and the application notes provided by manufacturers. During the lab sessions, the students report their work in order to review the documents when self-studying.

Learning objectives of the subject

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: 262h 30m</th>
<th>Hours large group:</th>
<th>63h</th>
<th>24.00%</th>
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</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>48h</td>
<td>18.29%</td>
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<tr>
<td>Self study:</td>
<td>151h 30m</td>
<td>57.71%</td>
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# Content

## Introduction to distributed circuit design

<table>
<thead>
<tr>
<th>Description:</th>
<th>Learning time: 72h</th>
</tr>
</thead>
<tbody>
<tr>
<td>The topics in this lesson are:</td>
<td>Theory classes: 15h</td>
</tr>
<tr>
<td>• Transmission lines</td>
<td>Laboratory classes: 16h</td>
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<tr>
<td>o Reflection coefficient and Smith chart</td>
<td>Self study: 41h</td>
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<tr>
<td>o Power and losses</td>
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<tr>
<td>• Transmission line design</td>
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<tr>
<td>o Homogeneous and non-homogeneous lines</td>
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<tr>
<td>o Balanced and unbalanced lines</td>
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<tr>
<td>o Coupled lines</td>
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<tr>
<td>• Impedance matching with lumped elements and transmission lines</td>
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<table>
<thead>
<tr>
<th>Related activities:</th>
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<tbody>
<tr>
<td>Activity 1</td>
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<tr>
<td>Activity 2</td>
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<td>Activity 3</td>
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<td>Activity 4</td>
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## Microwave circuits characterization

<table>
<thead>
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<th>Description:</th>
<th>Learning time: 55h 30m</th>
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<tbody>
<tr>
<td>The topics in this lesson are:</td>
<td>Theory classes: 13h 30m</td>
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<tr>
<td>• Parameters used to characterize, measure and simulate microwave networks: Z, Y, ABCD, and S</td>
<td>Laboratory classes: 8h</td>
</tr>
<tr>
<td>• Properties and measurement of scattering parameters S</td>
<td>Self study: 34h</td>
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<tr>
<td>• Calculation of the scattering parameters S of two-port networks</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>
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</tr>
<tr>
<td>• Three or more than three ports networks: power splitters/combiners, directional couplers, 90º hybrid, 180º hybrids, circulators</td>
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<th>Related activities:</th>
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<td>Activity 1</td>
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<td>Activity 2</td>
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<td>Activity 4</td>
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<td>Activity 5</td>
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## Fabrication technologies, instrumentation, and CAD for RF applications

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