Subject: Communication Electronics
Code: 18486
Institution: Escuela Politécnica Superior
Degree: Telecommunication Technologies and Services Engineering
Level: Graduate
Type: Specific Technology Training Module in Electronics Systems
ECTS: 6

1. COURSE TITLE

Communication Electronics

1.1. Course number

18464

1.2. Course area

Electronics Systems

1.3. Course type

Specific Technology Training Module in Electronic Systems

1.4. Course level

Graduate

1.5. Year

3rd

1.6. Semester

2nd

1.7. Credit allotment

6 ECTS

1.8. Prerequisites

Communication Electronics belongs to Subject 3.1 "Electronics Systems" from module 3 "Specific Technology Training Module in Electronic Systems" of the Degree of Telecommunication Technologies and Services Engineering. Subject 3.1 consists of eight courses distributed in the 3rd and 4th years of the degree.

To take this course the student must be familiar with basic mathematical tools, analog circuit analysis, communication systems characterization and basic concepts of transmission lines and microwave networks. Contents of this course

are fundamental to provide a global approach to other courses related to the physical level of telecommunication systems. To achieve better performance in *Communication Electronics* (3rd year/2nd semester), it is strongly recommended to have attended *Communication Theory* (2nd year/2nd semester) and *Transmission Media* (3rd year/1st semester). Afterwards, *Communication Electronics* (3/2) is related to *Audio and Video Transmission Systems* (3/2), *Instrumentation and Measurement* (4/1) and *Antennas and Electromagnetic Compatibility* (4/2).

1.9. Minimum attendance requirement

Attendance at theory classes is considered especially useful to achieve the course objectives (see section 1.11) and to participate in continued evaluation tests. However, there are no minimum attendance requirements to take part in the continued evaluation process. Notwithstanding, a small portion of the continued evaluation process will be taken from the handing over of different exercises and problems proposed by the professor without prior warning.

Because of the practical nature of this course, attendance at practice (laboratory) sessions is compulsory. Only the justified and documented absence to two sessions will be allowed (the student will have to make up for these sessions). Unjustified or more absences will mean a NOT PASS grade in the practice part of the course. Both the entrance to the laboratory 10 min after the session has started and leaving out the laboratory before the end of the session will not be allowed.

1.10. Faculty data

Add @uam.es to all email addresses below.

Theory and Practice:

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1.11. Course objectives

The fundamental objectives of this course are to make the student understand and use the basic concepts of the circuits found in radiocommunications, be able to interpret and analyze the characteristics of the main components of communication electronics, and be able to design the simplest devices and transmitting and receiving systems of a radiofrequency chain.

After Part I, where the general context of the radiofrequency systems is presented, two major blocks of circuits are explained: passive ones (Part II) and active ones (Part III). The course ends with the integration of these components in transmitting/receiving chains in Part IV.

The objectives to be achieved by the student are summarized in the following table (divided into different blocks). After taking this course (for the general objectives) and studying each unit (for the unit-by-unit specific objectives) the student should be capable of:

General Objectives	
G.1	Analyzing components and their specifications for communication systems in the radiofrequency (RF) and microwave band.
G.2	Choosing circuits, subsystems and radiofrequency/microwave systems
G.3	Identifying RF circuits and knowing their general features: linear/non-linear regions, active/passive, RF/bias inputs/outputs, figures of merit, …
G.4	Carrying out the whole implementation cycle of a RF device: design, computer simulation and experiments with RF/microwave equipment and components
G.5	Analyzing and interpreting RF measurements and comparing them with theoretical and computer simulated results and identifying the reason for the discrepancies.
Unit-by-Unit Specific Objectives	
Unit 1. Basic Concepts of Communication Electronics	
1.1	Establishing the relationship of this subject with other subjects in the grade
1.2	Identifying the different blocks a communication system in the RF/microwave band is made up of
1.3	Defining, justifying and interpreting S-parameters and making simple calculations with them
1.4	Defining the transfer function, reflection coefficient, loss, gain, coupling, … of a microwave network in terms of S-parameters
1.5	Justifying impedance matching between different blocks
1.6	Quantifying impedance mismatching and power transfer
Unit 2. Noise and Distortion in Communication Systems	
2.1	Defining the effects of perturbations in RF systems
2.2	Analyzing if there is linear (amplitude and phase) and/or non-linear distortion in a RF system and quantifying it (saturation, compression points, intermodulation, …)

2.3	Interpreting and calculating the noise figure and equivalent noise temperature of a RF chain
Unit 3. Radiofrequency Filters	
3.1	Justifying the need for RF filters and knowing when to use the different filter types
3.2	Designing the most simple RF filter types
3.3	Choosing the RF resonator technology depending on the application
3.4	Identifying and designing the main RF filters with transmission lines
Unit 4. Other passive devices	
4.1	Analyzing the features of hybrid circuits (couplers) and power dividers
4.2	Identifying and understanding the function of other devices such as circulators, isolators, …
Unit 5. Amplifiers	
5.1	Identifying the features of an amplifier in the linear/non-linear region
5.2	Relating an amplifier gain to its S-parameters
5.3	Determining the type/class of power amplifier to be used according to the application
5.4	Carrying out the design of a RF amplifier for different objectives
Unit 6. Oscillators and Frequency Synthesizers	
6.1	Understanding how an oscillator works and its characteristic parameters
6.2	Determining the oscillation condition and the oscillation frequency
6.3	Describing phase noise in an oscillator and quantifying it
6.4	Describing the way to use a VCO and the elements it is made up of
6.5	Understanding the elements and mechanisms that make a PLL work
6.6	Designing frequency synthesizers with PLL's
Unit 7. Mixers	
7.1	Understanding the basic models for a diode and a transistor used as a mixer
7.2	Defining frequency conversión and mixer products
7.3	Understanding and quantifying the figures of merit between signals of different frequencies
7.4	Using the mixer in a transmitting or receiving chain
7.5	Identifying the different configurations mixers are used in
Unit 8. Transmitter Architectures – Unit 9. Receiver Architectures	
8/9.4	Using a modulator and a demodulator inside a radiocommunication chain
8/9.5	Distinguishing between the different types of modulators and demodulators (linear/phase or frequency) and the similarities and difference for analogic and digital signals
8/9.6	Identifying the main elements and justifying how block diagrams work in modulators and demodulators
8/9.7	Integrating previously seen circuits to implement modulators and demodulators
8/9.8	Identifying a transmitting/receiving communication chain and its elements in terms of previously seen circuits
8/9.9	Recognizing and justifying the use of the homodyne and superheterodyne scheme
8/9.10	Describing and calculating the characteristic parameters of a transmitter (fidelity, performance) and a receiver (selectivity, sensibility, dynamic range and noise)

8/9.11	Defining and quantifying the gain control in transmitters and receivers
9.12	Calculating the image frequency and identifying solutions to improve the receiver

1.12. Course contents

Contents Outline:

PART I. INTRODUCTION TO ELECTRONIC COMMUNICATION SYSTEMS
- Unit 1. Basic concepts of Communication Electronics
- Unit 2. Noise and Distortion in Communication Systems

PARTE II. PASSIVE CIRCUITS
- Unit 3. Radiofrequency Filters
- Unit 4. Other passive devices

PARTE III. ACTIVE CIRCUITS
- Unit 5. Amplifiers
- Unit 6. Oscillators and frequency synthesizers
- Unit 7. Mixers

PARTE IV. TRANSCEIVER SYSTEMS
- Unit 8. Transmitter Architectures
- Unit 9. Receiver Architectures

Detailed Contents:

PART I. INTRODUCTION TO ELECTRONIC COMMUNICATION SYSTEMS

Unit 1. Basic concepts of Communication Electronics
- 1.1. Blocks of a Communication System
- 1.2. Transmission Lines and Microwave Networks
  - 1.2.1. Transmission Lines
  - 1.2.2. The Smith Chart
  - 1.2.3. Microwave network characterization
  - 1.2.4. Impedance Matching

Unit 2. Noise and Distortion in Communication Systems
- 2.1. Noise
  - 2.1.1. Noise Power
  - 2.1.2. Noise Figure and Noise Equivalent Temperature
  - 2.1.3. Noise Figure of Microwave Networks
- 2.2. Distortion
  - 2.2.1. Linear Distortion
  - 2.2.2. Non-linear Distortion

PART II. PASSIVE CIRCUITS

Unit 3. Radiofrequency Filters
- 3.1. Lumped Filters
  - 3.1.1. Low-Pass Filter Prototype
  - 3.1.2. Impedance and Frequency Transformations

- 3.2. Semi-lumped filters and filters with transmission lines
  - 3.2.1. Richard's and Kuroda's transformations
  - 3.2.2. Stepped-impedance synthesis
  - 3.2.3. Transmission-Line resonator filters

Unit 4. Other passive devices

- 4.1. Two-port circuits
- 4.2. Three-port circuits
- 4.3. Couplers

PART III. ACTIVE CIRCUITS

Unit 5. Amplifiers

- 5.1. Functions and types of amplifiers
  - 5.1.1. Characteristic parameters
  - 5.1.2. Tuned amplifiers
  - 5.1.3. Wideband amplifiers
  - 5.1.4. Power amplifiers
- 5.2. Characterization of two-port networks with transistors
  - 5.2.1. Transistor models
  - 5.2.2. Gain concept in a two-port network
  - 5.2.3. The problem of stability
- 5.3. Amplifier design
  - 5.3.1. Design in terms of gain
  - 5.3.2. Low-noise amplifier design
  - 5.3.3. Power amplifier design

Unit 6. Oscillators and frequency synthesizers

- 6.1. Oscillators
  - 6.1.1. Elements and basic parameters
  - 6.1.2. Design principles
  - 6.1.3. Phase noise: Leeson's model
  - 6.1.4. Types. Voltage controlled oscillators (VCO)
- 6.2. Phase-Locked Loops (PLL)
  - 6.2.1. Basic scheme
  - 6.2.2. Frequency synthesis

Unit 7. Mixers

- 7.1. Mixer parameters
  - 7.1.1. Image frequency, conversion loss and noise
  - 7.1.2. Return loss, isolation and distortion
- 7.2. Mixer circuits
  - 7.2.1. The diode as a mixer
  - 7.2.2. The transistor as a mixer
  - 7.2.3. Balanced mixers and image reject mixers

PART IV. TRANSCEIVER SYSTEMS

Unit 8. Transmitter Architectures

- 8.1. Transmitter system
  - 8.1.1. Types of transmitters
  - 8.1.2. Characteristic parameters
  - 8.1.3. Automatic gain control

8.2. Modulator subsystem
  8.2.1. Linear modulators
  8.2.2. Phase and frequency modulators

Unit 9. Receiver Architectures

9.1. Receiver system
  9.1.1. Types of receivers
  9.1.2. Intermediate Frequency choice
  9.1.3. Characteristic parameters
  9.1.4. Automatic gain control
9.2. Demodulator subsystem
  9.2.1. Linear demodulator
  9.2.2. Phase and frequency demodulators

1.13. Course bibliography

Basic:

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- M. Sierra Pérez, B. Galocha, J.L. Fernandez y M. Sierra Castañer, "Electrónica de Comunicaciones", Editorial Prentice Hall, 2003.

Advanced:

- D. M. Pozar, "Microwave engineering", New York, John Wiley & Sons, 2005.
- R. E. Collin, "Foundations for microwave engineering", IEEE Press, 2001.
- R. Sorrentino, "Microwave and RF engineering", John Wiley & Sons, 2010.
- M. Steer, "Microwave and RF design: a systems approach", SciTech, 2010.
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