Subject: Communication Theory
Code: 18481
Institution: Escuela Politécnica Superior
Degree: Telecommunication Technologies and Services Engineering
Level: Graduate
Type: Training Module Common to the Telecommunications Branch
ECTS: 6

1. COURSE TITLE

Communication Theory

1.1. Course number

18481

1.2. Course area

Communication Signal Treatment

1.3. Course type

Training Module Common to the Telecommunications Branch

1.4. Course level

Graduate

1.5. Year

2º

1.6. Semester

2º

1.7. Credit allotment

6

1.8. Prerequisites

Communication Theory belongs to the *Area 2.3* (*Communication Signal Treatment*) from the *Training Module Common to the Telecommunications Branch* of the Degree of Telecommunication Technologies and Services Engineering.

This area contains three related subjects: Communication Theory, Filter Design, and Digital Signal Treatment.

Communication Theory is based in concepts studied in the course *Linear Systems* from *Area 1.5* (*Circuits and Systems*) of the *Core Module*. Also, but to a less extent,

Communication Theory is based on concepts studied in the course *Probability and Statistics* from *Area 1.1* (*Mathematic Subjects*) of the *Core Module*.

Specifically, basic prerequisites for *Communication Theory* include: operation with mathematical tools such as trigonometric functions, complex numbers, and basic integration. From *Probability and Statistics* the main prerequisites are: operation with random variables and statistical distributions. From *Linear Systems* the main prerequisites are: characterization and operation with linear time-invariant systems through impulse and frequency responses, continuous Fourier transforms, sampling, reconstruction, and conversion between continuous and discrete time.

1.9. Minimum attendance requirement

Attendance to theory sessions is strongly recommended but not required.

Attendance to laboratory sessions is required. Only two absences will be permitted if they are properly justified and documented. In this case, each missed session will have to be done in one week from the absence, in a time slot to be scheduled with the laboratory teacher. If these rules are not followed, the laboratory part of the course will be FAILED, which will imply that the full course will be FAILED. No access will be given to the laboratory 10 minutes after the session beginning. Also, the laboratory cannot be left, unless justified reason, until the end of the session.

1.10. Faculty data

Add @uam.es to all email addresses below.

Theory :

Dr. Julián Fiérrez Aguilar (Coordinator)
Departamento de Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-206 Edificio C – 2ª Planta
Tel.: +34 914976205
e-mail: julian.fierrez
Web: http://atvs.ii.uam.es/

Laboratory:

Dr. Julián Fiérrez Aguilar (Coordinator)
Departamento de Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-206 Edificio C – 2ª Planta
Tel.: +34 914976205
e-mail: julian.fierrez
Web: http://atvs.ii.uam.es/

Dr. Daniel Tapias Merino
Departamento de Tecnología Electrónica y de las Comunicaciones
Escuela Politécnica Superior
Office: C-213 Edificio C – 2ª Planta
Tel.: +34 914977558
e-mail: daniel.tapias
Web: http://www.eps.uam.es/esp/personal/ficha2.php?empid=658

1.11. Course objectives

Communication Theory is an introductory course to analog and digital communications. It is divided into 4 Units: 1) introduction to the course and generalities; 2) concepts in signals, systems, and perturbations in telecommunication systems; 3) analog communications; and 4) digital communications.

Units 1 and 2 provide introductory information and generalities required for understanding the core material of the course, developed in Units 3 and 4, which are focused in analog and digital communication methods, respectively.

In parallel to the theory sessions, six laboratory sessions will be conducted, with the purpose of strengthening the understanding of the theory, and also let the students know the computational tools available for designing and analyzing communication systems.

The **competencies** intended to be developed in this course are the following:

CO4 Capability to analyze and specify the fundamental parameters of a communication system.
CO5 Capability to evaluate the advantages and disadvantages of different technological alternatives for the deployment and implementation of communications systems, from the point of view of the signals, perturbations, noise, and analog and digital modulations.

At the end of each unit, the student should be capable of:

UNIT BY UNIT SPECIFIC OBJECTIVES	
UNIT 1.- Introduction	
1.1.	History of main advances in telecommunication systems (STs).
1.2.	Knowing the elements of a ST.
1.3.	Knowing the quality parameters of a ST.
1.4.	Knowing the types of STs.
1.5.	Knowing the methods for information multiplexing in communications.

UNIT 2.- Signals, Systems, and Perturbations	
2.1.	Knowing the main signal types in communications.
2.2.	Operating with logarithmic units.
2.3.	Operating with main continuous Fourier transforms.
2.4.	Operating with energy and power spectral densities.
2.5.	Working with the concepts: delay, attenuation, perturbation, carrier, amplitude and phase modulation, phase and group velocity, linear and non-linear distortion, crosstalk and interference, noise and its characterization (with emphasis in white Gaussian noise).
2.6.	Working with band-pass signals and noise (including phase and quadrature components and complex envelope).
UNIT 3.- Analog Communications	
3.1.	Characterizing base-band communications.
3.2.	Understanding modulation and example analog modulations.
3.3.	Characterizing without noise the following analog linear modulations: DBL, AM, BLU, BLV, and QAM.
3.4.	Characterizing with noise the following analog linear modulations: DBL, BLU, and AM.
3.5.	Characterizing with and without noise the following analog angular modulations (including spectral analysis and basic generation and demodulation): PM and FM.
3.6.	Addressing advantages and disadvantages of main analog modulations.
UNIT 4.- Digital Communications	
4.1.	Knowing the general model of digital communications, including: digitalization, source coding, encrypting, channel coding, multiplexing, and modulation.
4.2.	Characterizing digital communications based on PCM.
4.3.	Understanding modulation in digital communications.
4.4.	Characterizing with and without noise base-band digital transmission based on PAM (binary and M-ary).
4.5.	Characterizing with noise basic digital receivers based on sampling and optimal.
4.6.	Operating in signal vector spaces.
4.7.	Characterizing digital modulation constellations.
4.8.	Understanding the optimal reception of M signals in relation with their constellation.
4.9.	Characterizing with and without noise digital band-pass transmissions: ASK, QAM, PSK, and FSK.
4.10.	Understanding digital transmission in bandwidth-limited channels and its relation to Inter-Symbol Interference (ISI).
4.11.	Characterizing ISI analytically in PAM systems.
4.12.	Interpreting ISI in practice through eye diagrams.
4.13.	Knowing the design principles for the optimal receiver considering ISI.
4.14.	Addressing advantages and disadvantages of main digital modulations.

1.12. Course contents

1. **Introduction.**
   - 1.1. Basic concepts and history.
   - 1.2. Telecommunication systems and transmission systems.

2. **Signals, Systems, and Perturbations.**
   - 2.1. Introduction. Signal characterization.
   - 2.2. Perturbations in transmission systems.
   - 2.3. Bandwidth-limited band-pass signals.

   LABORATORY SESSION 1: Perturbations: distortion and noise.

3. **Analog Communications.**
   - 3.1. Introduction.
   - 3.2. Linear modulations (DBL, AM, BLU, BLV, QAM).
   - 3.3. Noise in linear modulations.
   - 3.4. Angular modulations (PM, FM).
   - 3.5. Noise in angular modulations.
   - 3.6. Comparative of analog modulations.

   LABORATORY SESSION 2: Analog modulations.
   LABORATORY SESSION 3: Noise in linear modulations.
   LABORATORY SESSION 4: Angular modulations.

4. **Digital Communications.**
   - 4.1. Introduction.
   - 4.2. Base-band digital transmission with AWGN.
   - 4.3. Analysis in signal space.
   - 4.4. Band-pass digital transmission with AWGN (ASK, QAM, PSK, FSK).
   - 4.5. Comparative of digital modulations.
   - 4.6. Digital transmission in bandwidth-limited channels (ISI).

   LABORATORY SESSION 5: Digital modulations.
   LABORATORY SESSION 6: Eye diagrams.

1.13. Course bibliography

Basic:

1. J.G. Proakis, M. Salehi, "Communication systems engineering", 2nd ed., Prentice-Hall, 2002.

Intermediate:

2. S. Haykin, "Communication Systems", 4th ed., John Willey & Sons, 2001.
3. B. Sklar, "Digital Communications: Fundamentals and Applications", 2nd ed., Prentice-Hall, 2001
4. R. E. Ziemer, W. H. Tranter, "Principles of Communications", John Wiley and Sons, 2002
5. M. B. Pursley, "Introduction to Digital Communications", Prentice Hall, 2005
6. M. Burgos, F. Pérez, M. Salazar, "Apuntes de la asignatura Teoría de la Comunicación". Dpto. de Publicaciones de la ETSIT-UPM, 1999.

Advanced:

7. J.G. Proakis, "Digital Communications", 3rd ed., McGraw-Hill, 1995.
8. A. Goldsmith, "Wireless Communications", 1ª ed., Cambridge University Press, 2005
9. A.B. Carlson, P.B. Crilly, J.C. Rutledge, "Communication Systems", 4th ed., McGraw-Hill, 2002.
10. W. Tomasi, "Sistemas de Comunicaciones Electrónicas", 4ª ed., Prentice-Hall/Pearson Education, 2003.

Slides:

Although the basic text indicated above covers the full course, the level of detail to be followed is not the same. The students will be provided with slides summarizing the main concepts developed in the course, in which the related sections of the basic text will be noted for further study.