Communication Theory
(Teoría de la Comunicación)

Degree in Telecommunication Technologies Engineering
Degree in Communication Electronics Engineering
Degree in Telematics Engineering
Degree in Telecommunication Systems Engineering

Universidad de Alcalá
2016 / 2017
2nd Year – 2nd Semester
1. INTRODUCTION

A Communication Theory course intends to show to the students the development and functioning of a complete telecommunications system, starting with the information input at the transmitter, and ending with the reception and interpretation of said information at the receiver. The fundamentals of both analog and digital communication systems will be addressed. For both kinds of communication systems, not only the sort of information to be transmitted will be taken into account, but also how it is actually transmitted, along with the effects of alien impairments on the transmitted signal, such as noise, attenuation or the band limitation of the transmission channel.

This course casts the basic foundations in order to understand any other subsequent course closely related to the Telecommunications domain (Digital Communications, Communication Networks, Mobile Communications, Telecommunication Systems, Optical Communications, and so on).
This course will thus be a basic asset for any telecommunication engineer working in any field related to communications.

To take full advantage and better understanding of the course, it would be convenient for the student to have previous and sound knowledge of the courses of Signal and Systems, and Statistics, taken during the first semester of the second year.

2. COMPETENCES

This course contributes to the acquisition of the following professional competences, as defined in Paragraph 5 of the Annex from Order CIN/352/2009, and contributes to acquire the generic competences as defined in Paragraph 3 of said Annex.

Generic competences:

   TRU1. Capacity for analysis and synthesis.

Professional competences:

   CT1. Competence for individual acquisition of new knowledge and suitable techniques for the conception, development or exploitation of telecommunication systems and services.
   CT2. Competence for using communication and computer based applications (office, databases, advanced calculus, project management, visualization, and so on) to support the development and exploitation of telecommunication and electronics networks, services and applications.
   CT4. Competence to analyze and specify the fundamental parameters of a telecommunication system.
   CT5. Competence to evaluate the advantages and disadvantages of different technological alternatives in order to deploy or implement telecommunication systems, from the point of view of the signal space, perturbations and noise, and of either analog or digital modulation systems.

Learning outcomes:

   LO1. Knowledge and understanding of the basic concepts and techniques for telecommunications, analog and digital: modulation process, noise, demodulation process. It contributes to the acquisition of competence CT1.
   LO2. Ability to perform bibliographical or information searches related to telecommunications. It contributes to the acquisition of competence CT1.
LO3. Ability to perform communication systems’ computer simulations, in order to support the development and exploitation of networks, services and applications in telecommunications. It contributes to the acquisition of competence CT2.

LO4. Ability to analyze and specify the basic parameters of any communication system, along with the ability to develop technical skills in the field of telecommunication technologies, emphasizing the analysis and mathematical characterization of the communication systems. It contributes to the acquisition of competence CT4.

LO5. Ability to describe the communication signals in the signal space, and to characterize the perturbations and noise affecting analog or digital modulation systems. It contributes to the acquisition of competence CT5.

3. CONTENTS

<table>
<thead>
<tr>
<th>Content blocks</th>
<th>ECTS credits or hours</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Block 1. Preliminary concepts</strong></td>
<td></td>
</tr>
<tr>
<td>Study of a complete communication system, including all possible processing blocks.</td>
<td>• 4 hours</td>
</tr>
<tr>
<td><strong>Block 2. Analog communications</strong></td>
<td></td>
</tr>
<tr>
<td>Presentation and study of the different analog communication technique. Amplitude and angular modulations. Noise in communication systems. Effects of noise in analog modulations. Problems solving.</td>
<td>• 16 hours</td>
</tr>
<tr>
<td><strong>Block 3. Optimal detection.</strong></td>
<td></td>
</tr>
<tr>
<td>Signals’ geometrical representation. Modulation and detection in Gaussian channels. Error probability calculation. Correlation receiver. Matched filter receiver. Problems solving.</td>
<td>• 14 hours</td>
</tr>
<tr>
<td><strong>Block 4. Baseband Digital Transmission</strong></td>
<td></td>
</tr>
<tr>
<td>Baseband pulse transmission. Pulse amplitude modulations (PAM). Line codes’ power spectral density. Intersymbol interference (ISI). Frequency and time zero-ISI conditions. Problems solving.</td>
<td>• 10 hours</td>
</tr>
<tr>
<td><strong>Block 5. Passband digital transmission.</strong></td>
<td></td>
</tr>
<tr>
<td>PSK, FSK, MSK, ASK and QAM modulations. Error probabilities for each modulation. Power spectral density in passband signals. Problems solving.</td>
<td>• 14 hours</td>
</tr>
</tbody>
</table>
4. TEACHING-LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES

4.1. Credits distribution (specified in hours)

<table>
<thead>
<tr>
<th>Number of on-site hours:</th>
<th>28 hours in large group</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>28 hours in small group</td>
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<tr>
<td></td>
<td>2 hours for examinations</td>
</tr>
</tbody>
</table>

| Number of hours for individual student work:     | 92 hours                |
| Total hours                                      | 150                     |

4.2. Methodological strategies, teaching materials and didactic resources

The formative activities that are going to be considered during the teaching process are the following:

1. Theoretical lesson.
2. Problems solving lesson.
3. Lessons focusing on software simulations.
4. Individual or group tuitions.

The theoretical lessons (3 ECTS) are expositive lessons performed using means like the blackboard or adhoc slides. These theoretical lessons will be complemented with examples clarifying the concepts explained.

In these theoretical lessons, the student will acquire the course’s specific competences. It is most convenient that the students contribute with their own personal or group effort in order to complement the knowledge presented during the lessons (e.g. particular cases study or of hints made by the teacher).

For the problems solving lessons and software simulations (3 ECTS) the teacher will provide a set of reference problems, and a maximum of 50% of those problems will be selected to be solved during the classes. The teacher will let the students know which problems will be solved during the next lesson, so that the student can try to solve them in advance. The student should strive to solve any doubt that could have arisen when trying to solve the problems.

For a better understanding of the mental procedure followed while solving the problems, it would be convenient that the students themselves in the blackboard, under the teacher’s guidance, rather than the opposite, perform the solving process. This will foster the interchange of critical opinions about the resolution process and about the results obtained.
Moreover, software simulation lessons will use didactic equipment or personal computers. The teacher may provide guidelines in advance, so the student can prepare the practical work. During these lessons, the student will be able to compare between the expected theoretical results and the obtained simulated results, and this could lead to a discussion.

In both individual or group tuitions, the teacher could solve doubts, or brainstorm matters related to the course. The students will have the possibility to establish a more personal relationship, so that they could address questions impossible to discuss in a greater group.

5. ASSESSMENT: procedures, assessment and marking criteria

Assessment is a polyedric activity and this section aims to describe only the facet devoted to verify the student’s competence acquisition. Provided that the assessment unavoidably modifies the teaching-learning process, we understand that it should favor the student's progressive and continuous study.

Assessment procedures:
The student has two assessment periods: a regular assessment period and an extra assessment period, each using different assessment procedures:

1. Regular assessment period. According to current UAH regulations approved by the Governing Council in document Normativa de Evaluación de los Aprendizajes, NEA, Article 3, regular assessment must be inspired in continuous assessment criteria.
   a) Continuous assessment. Consisting on two mid-term tests and a final exam.
   b) Final exam assessment. Consisting on one final exam.

2. Extra assessment period. Consisting on one final exam.

Assessment criteria:
In those written tests, no matter if the student is following regular or extra assessment, the following criteria will be valued:
   AC2. Autonomous ability to learn new concepts and adequate techniques related to Communication Theory (CT1).
   AC3. Ability to interpret the software simulations (CT2).
   AC4. Ability to analyze and specify basic parameters of baseband or passband communication systems (CT4).
   AC5. Ability to represent signals in the signal space to characterize and assess the effect of noise in both analog and digital modulations (CT5).

Grading tools:
Continuous assessment marks will be determined using the following tools:
1. Mid-term test (MT). Consisting of the resolution of theory applied problems or theoretical questions.
2. Final exam (FE). Consisting of the resolution of theory applied problems or theoretical questions.

**Marking criteria:**
For each assessment period and type, grading will follow these criteria:

### Regular assessment period, continuous assessment.

<table>
<thead>
<tr>
<th>Competence</th>
<th>Learning outcome</th>
<th>Assessment criteria</th>
<th>Grading tool</th>
<th>Percentage of the student's final grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRU1, TRU4, CT1, CT4.</td>
<td>LO1, LO2, LO3, LO4.</td>
<td>AC1, AC4, AC5.</td>
<td>MT 1</td>
<td>30 %</td>
</tr>
<tr>
<td>TRU1, TRU4, CT1, CT4, CT5.</td>
<td>LO2, LO3, LO4, LO5.</td>
<td>AC1, AC4, AC5.</td>
<td>MT 2</td>
<td>30 %</td>
</tr>
<tr>
<td>TRU1, TRU4, CT1, CT2, CT4, CT5.</td>
<td>LO1, LO2, LO3, LO4, LO5.</td>
<td>AC1, AC2, AC3, AC4, AC5.</td>
<td>FE</td>
<td>40 %</td>
</tr>
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</table>

As a general criterion, those students taking at least one mid-term test (MT) will be considered as *presented* in the regular assessment period. Students not undergoing any of these mid-term tests will get a 0 grade in that particular test. Structure and timing of these tests will be set at the beginning of the semester.

For those students that prove in the final exam evidences that they have complemented the partially credited competences obtained in the mid-term exams, those competences will be considered achieved in the regular assessment period.

### Regular assessment period, final exam assessment.

<table>
<thead>
<tr>
<th>Competence</th>
<th>Learning outcome</th>
<th>Assessment criteria</th>
<th>Grading tool</th>
<th>Percentage of the student's final grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRU1, TRU4, CT1, CT2, CT4, CT5.</td>
<td>LO1, LO2, LO3, LO4, LO5.</td>
<td>AC1, AC2, AC3, AC4, AC5.</td>
<td>FE</td>
<td>100 %</td>
</tr>
</tbody>
</table>

### Extra assessment period.

<table>
<thead>
<tr>
<th>Competence</th>
<th>Learning outcome</th>
<th>Assessment criteria</th>
<th>Grading tool</th>
<th>Percentage of the student's final grade</th>
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6. BIBLIOGRAPHY

Basic bibliography:

COMMUNICATION SYSTEMS
Author: S. Haykin
Ed.: Wiley

COMMUNICATION SYSTEMS
Author: A.B. Carlson y otros
Ed.: McGraw-Hill

COMMUNICATION SYSTEMS ENGINEERING
Author: J.G. Proakis y otros
Ed.: Prentice Hall

THEORY AND PROBLEMS OF ANALOG AND DIGITAL COMMUNICATIONS
Author: Hwei P. Hsu

Additional bibliography:

COMUNICACIONES DIGITALES.
Author: A. Artés, F. Pérez y otros
Ed.: Prentice Hall

DIGITAL COMMUNICATION
Author: Bernard Sklar
Ed.: Prentice-Hall

PRINCIPLES OF COMMUNICATIONS
Author: R.E. Ziener y W.H. Tranter
Ed.: Wiley

CONTEMPORARY COMMUNICATION SYSTEMS USING MATLAB
Author: J.G. Proakis y otros
Ed.: Thompson-Brooks/Cole