Universidad de Alcalá

TEACHING GUIDE

Digital Communications

Degree in
Telecommunication Technologies Engineering (GITT)
Telecommunication Systems Engineering (GIST)

Universidad de Alcalá

Academic Year 2021/2022

3rd Year - 2nd Semester (GITT)

3rd Year - 1st Semester (GIST)

Approved by the School Board on July 6, 2021

TEACHING GUIDE

Course Name:	**Digital Communications**
Code:	**350025 (GITT+GIST)**
Degree in:	**Telecommunication Technologies Engineering (GITT)** **Telecommunication Systems Engineering (GIST)**
Department and area:	**Teoría de la Señal y Comunicaciones** **Signal Theory and Communications**
Type:	**Compulsory (GITT+GIST)**
ECTS Credits:	**6.0**
Year and semester:	**3rd Year - 2nd Semester (GITT)** **3rd Year - 1st Semester (GIST)**
Teachers:	Check Department webpage
Tutoring schedule:	Check subject website
Language:	Spanish/English friendly

1. COURSE SUMMARY

The subject of Digital Communications intends to delve deeper in, and extend, the knowledge about communication systems acquired throughout the subject of Communication Theory. To this purpose, after having illustrated the structure of modern digital communication systems, the essential concepts about Information Theory are motivated and explained, since they provide the conceptual framework, along with the performance limits, for said systems. These concepts and tools provide the grounds to understand the most usual channel coding techniques. The subject and its related concepts are completed with the study of the medium access techniques.This subject is essential (along with Communication Theory) in order to understand the subjects that will be taken in subsequent courses, and that are closely related with the communications field. Moreover, this subject is an asset for any engineer working in the telecommunications sector, since it provides the necessary basis to better understand the present and future innovations in communication systems.To get the best from this subject, it is mandatory to have a sound background on the subjects of Signals and Systems and Communication Theory, together with their prerequisites, studied during the first and second academic years.

2. SKILLS

Basic, Generic and Cross Curricular Skills.

This course contributes to acquire the following generic skills, which are defined in the Section 3 of the Annex to the Law CIN/352/2009:

en_TR8 - Capacity of working in a multidisciplinary and multilingual team and of communicating, both in spoken and written language, knowledge, procedures, results and ideas related to telecommunications and electronics.

en_TRU1 - Capacity of analysis and synthesis.

en_TRU4 - Autonomous learning skills.

Professional Skills

This course contributes to acquire the following professional skills, which are defined in the Section 5 of the Annex to the Law CIN/352/2009:

en_CST2 - Ability to apply the techniques on which telecommunication networks, services and applications are based, both in fixed and mobile environments, personal, local or at a great distance, with different bandwidths, including telephony, broadcasting, television and data, from the point of view of transmission systems.

en_CST6 - Ability to analyze, encode, process and transmit multimedia information using analog and digital signal processing techniques.

Learning Outcomes

After succeeding in the learning/teaching process of this subject the students will be able to:

RA1. Master the Matlab software (or any other of similar characteristics that the teachers choose in order to deliver the laboratory practices), with the aim of carrying on the computer simulations about communications in the context of development and exploitation of networks, services and telecommunication services. Moreover, the student is able to analyze/interpret the results obtained. Skills TR8, TRU1, TRU4 y CST6.

RA2. Gather and synthesize information related with telecommunications, obtained using bibliographic search computer tools. Skill TRU4.

RA3. Describe the concepts and basic techniques about information theory: concepts of amount of information, entropy and channel capacity. Skills CST2, CST6.

RA4. Identify the main techniques for channel coding, as well as their applications. Skills CST2, CST6.

RA5. Explain the man techniques for medium access in digital communications. Skills CST2, CST6.

3. CONTENTS

Contents Blocks	Total number of hours
Block 1. Introduction Digital communications system model. Design and performance criteria.	2 hours
Block 2. Information Theory. Information, uncertainty and entropy. Memoryless discrete source. Extended source. Source coding theorem. Joint and conditional entropy, relative entropy and mutual information. Noisy channel coding theorem. Differential entropy and mutual information for continuous RRVV. Absolute capacity: Shannon-Hartley theorem. Exercises.	16 hours
Block 3. Channel coding. Fundamentals of channel coding (code types, Hamming distance). Block codes. Convolutional codes. Iterative codes (turbocodes). LDPC. Exercises.	20 hours
Block 4. Medium access techniques. Physical layer and medium access. FDMA. TDMA. SDMA. CDMA. OFDMA. Exercises.	18 hours

4. TEACHING - LEARNING METHODOLOGIES. FORMATIVE ACTIVITIES.

4.1. Credits Distribution

Number of on-site hours:	58 hours (28 big group + 28 small group +2 exams hours)
Number of hours of student work:	92
Total hours	150

4.2. Methodological strategies, teaching materials and resources

The formative activities that will be made use of during the learning process are as follows:

Theoretical lessons (3 ECTS)

They consist in magistral lessons delivered using means like the blackboard or appropriate presentations. These theoretical lessons will be complemented with examples clarifying the concepts explained. During these theoretical lessons, the student will acquire the course specific skills, excepting those explicitly involving practical or laboratory work. It is convenient that the student contributes with his/her personal or collective work in order to complement the knowledge introduced during lesson delivery (particular cases study, or hints provided by the teacher).

Problem solving lessons (2,5 ECTS)

During the problem solving lessons, the teacher will provide the student with a typical problem set. The teacher will inform the students about which problems from the set will be solved during the ensuing session, so that the student may try to solve them in advance. For a better comprehension of the mental procedure followed to solve the problems, it would be convenient that the resolution in the blackboard is faced by the students themselves under the teacher's supervision, instead the opposite case, excepting for some particular situations. This would improve the interchange of critical opinions about the resolution process, as well as the final outcome.

Practical demonstrations (0,5 ECTS)

These demos will be made using PC simulations. The teacher will provide guidelines and software for the demos, so that the students may prepare them in advance. Each demo will be performed publicly by the lecturer during the corresponding sessions, so that the students may compare the expected theoretical results and the results obtained by simulation, and openly discuss about their background and particularities, reaching at the end suitable and illustrative conclusions. The final objective of these demos is to illustrate the concepts worked out during the theoretical and problem solving sessions from a practical point of view, for a better understanding of the subject and its contents.

Tutoring sessions

In the individual or collective tutoring sessions, the teacher could solve doubts, or clarify points about the subject. The students will have the possibility to establish a more personal communication, so that they can pose questions that may not be addressed practically in a larger group.

5. ASSESSMENT: procedures, evaluation and grading criteria

Preferably, students will be offered a continuous assessment model that has characteristics of formative assessment in a way that serves as feedback in the teaching-learning process.

5.1. PROCEDURES

The evaluation must be inspired by the criteria of continuous evaluation (Regulations for the Regulation of Teaching Learning Processes, NRPEA, art 3). However, in compliance with the regulations of the University of Alcalá, an alternative process of final evaluation is made available to the student in accordance with the Regulations for the Evaluation of Apprenticeships (approved by the Governing Council on March 24, 2011 and modified in the Board of Directors). Government of May 5, 2016) as indicated in Article 10, students will have a period of fifteen days from the start of the course to request in writing to the Director of the Polytechnic School their intention to take the non-continuous evaluation model adducing the reasons that they deem convenient. The evaluation of the learning process of all

students who do not apply for it or are denied it will be done, by default, according to the continuous assessment model. The student has two calls to pass the subject, one ordinary and one extraordinary.

In the extraordinary call, the evaluation of all students will be obtained from a final test.

The Continuous evaluation may use the following tools:

- Midterm written tests consisting in solving exercises of the kind developed during the problem solving sessions. (PEIx)
- Final written test consisting in solving exercises of the kind developed during the problem solving sessions, and an open question related to the demos. (PEF)

5.2. EVALUATION

EVALUATION CRITERIA

The evaluation criteria measure the level in which the competences have been acquired by the student. For that purpose, the following are defined:

CE1. The student is able to communicate in writing knowledge, procedures and examine / evaluate results and ideas related to telecommunications and electronics (TR8 y TRU1).

CE2. The student shows the ability to learn independently new knowledge and appropriate techniques related to Digital Communications (CST2, TRU4).

CE3. The student can interpret and modify the code in Matlab (or corresponding to other software tools, if applicable) of the exercises similar to those proposed in the classroom (CST6).

CE4. The student correctly identifies the fundamental parameters of a Digital Communications System. The student demonstrates the ability to characterize the modulations, the access techniques and the main commitments of a Digital Communications System (CST2, CST6).

CE5. The student is able to apply the principles of Digital Communications in different applications and different environments(CST2, CST6).

GRADING TOOLS

The work of the student is graded in terms of the evaluation criteria above, through the following tools:

1. Ordinary call: The student who attend grading tests over the 20% of the total grade will be considered assessed in the ordinary call.
   a. Continuous evaluation. The grading in the continuous evaluation will be determined by the grading of two midterm tests. This part will account for 60% of the final grade for the subject. Students who do not attend these tests will have a score of 0 points corresponding to the test in question. The nature and dates of said tests will be made public at the beginning of the course. The 40% of the student's final grade will be obtained from a final written test in which the student must show her/his knowledge of the subject, including the demo part. Students who do not attend the final test will have a score of 0 points corresponding to this test.
   b. Final evaluation. The students included in the extraordinary call will obtain 100% of the grade through a final test (PEF).
2. Extraordinary call. Final assessment (PEF). Students who do not pass the ordinary call (either continuous assessment or final test) will be entitled to an extraordinary call consisting of a written test of the same characteristics as that performed by the students evaluated through the final written test in the ordinary call, of the which will obtain 100% of the grade.

GRADING CRITERIA

In the ordinary call-continuous evaluation the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skills	Learning Outcomes	Evaluation criteria	Grading tool	Contribution to the final mark
TR8, TRU1, TRU4, CST6, CST2	RA1, RA2, RA3.	CE1, CE3, CE4	PEI1	30%
	RA1, RA3, RA4, RA5		PEI2	30%
	RA1-RA5	CE1-CE5	PEF	40%

The students who are included in the final evaluation system will obtain 100% of the grade by a final test that will be the same as the final test of the continuous assessment students. In the ordinary call-final evaluation, the relationship between the competences, learning outcomes, criteria and evaluation instruments is as follows.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR8, TRU1, TRU4, CST2, CST6	RA1-RA5	CE1-CE5	PEF	100%

Students who do not pass the ordinary call (either continuous assessment or final test) will be entitled to an extraordinary call consisting of a written test of the same characteristics as final test in the ordinary call, of the which will obtain 100% of the grade.

In the case of the extraordinary call, the same percentages that have been established in the case of the evaluation by means of a final exam will be maintained.

Skill	Learning Outcomes	Evaluation criteria	Grading Tool	Contribution to the final mark
TR8, TRU1, TRU4, CST2, CST6	RA1-RA5	CE1-CE5	PEF	100%

6. BIBLIOGRAPHY

6.1. Basic Bibliography

- S. Haykin; Communication Systems; Wiley; 4th. ed., 2001.
- B. Sklar; Digital Communications: Fundamentals and applications; Prentice Hall.
- J. G. Proakis et all; Communication Systems Engineering; Prentice Hall.
- S. Lin, D. Costello; Error Control Coding; Prentice Hall, 2nd. ed., 2004.
- J. G. Proakis, M. Salehi; Contemporary Communication Systems using Matlab; Thompson-Brooks/Cole, 1998.
- J. Castiñeira, P. Guy; Essentials of Error-Control Coding; Wiley, 2006.

6.2. Additional Bibliography

- S. B. Wicker; Error Control Systems for Digital Communication and Storage; Prentice Hall.
- E. Lee et all; Digital Communications; Kluwer Academic.

Disclosure Note

The University of Alcalá guarantees to its students that, if due to health requirements the competent authorities do not allow the total or partial attendance of the teaching activities, the teaching plans will achieve their objectives through a teaching-learning and evaluation methodology in online format, which will return to the face-to-face mode as soon as these impediments cease.