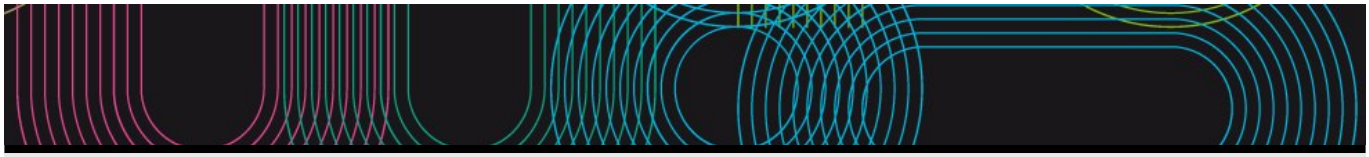

IDENTIFYING DATA				
Principles of Digital Communications				
Subject	Principles of Digital Communications			
Code	V05G300V01613			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	3rd	2nd
Teaching language	Spanish			
Department	Signal Theory and Communications			
Coordinator	Comesaña Alfaro, Pedro			
Lecturers	Comesaña Alfaro, Pedro Pérez González, Fernando			
E-mail	pcomesan@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The basic aims of the subject are the following: - Apply optimisation criteria for the realisation of diagrams of estimate and synchronisation in digital receptors of communications. - Differentiate the blocks and the functionalities of a data transmission system. - Use digital signal processing to transmit and receive analog waveforms. - Apply the basic mechanisms of reduction of the impact of noise in a communications system.			

Competencies	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B11	CG11 To approach a new problem considering first the essential and then the secondary aspects
C26	CE26/ST6 The ability to analyze, codify, process and transmit multimedia information using analogical and digital signal processing techniques.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Apply criteria of optimisation for the realisation of diagrams of estimate and synchronisation in digital receptors of communications	B3	C26	
Differentiate the blocks and the functionalities of a system of transmission of complex data	B11	C26	D2
Use the processed digital of signals to transmit and receive forms of analog wave	B3 B4		D3
Apply the basic mechanisms of reduction of the impact of noise in a system of communications		C26	D2

Contents
Topic

1. Introduction to digital communications	- Historical evolution of wireless communication systems. - Basic blocks of a digital communications system. - Review of impairments in a communications channel. - Introduction to the course.
2. Discrete equivalent channel and Nyquist pulses	- Baseband equivalent channel. - Discrete equivalent channel. - Nyquist pulses. - Square root raised cosine pulses. - Application and implementation of Nyquist pulses. - Introduction to polyphase structures.
3. Symbol synchronization	- Motivation. - Phase Locked Loops (PLL). - PLLs and steepest descent. - Maximum output energy criterion. - Interpolation-based symbol synchronization. - Adaptive symbol synchronization.
4. Frame synchronization	- Review of Least Squares (LS) estimation. - Motivation for frame synchronization. - Data-aided frame synchronization. - Design of training sequences.
5. Phase and carrier recovery	- Decision-directed phase recovery. - Non-decision-directed phase recovery. - Motivation for carrier recovery. - Coarse carrier synchronization. - Fine carrier synchronization.
6. Estimation and equalization in flat channels	- Maximum likelihood detection. - Equalization through estimation. - Direct equalization. - Adaptive equalization. - The LMS algorithm.
7. Frequency selective channel equalization	- Multipath, bandwidth and frequency selectivity. - Zero-forcing equalization. - Least squares equalizer. - LMS algorithm derivation for selective channels. - Unconstrained equalizers.
8. Introduction to advanced digital communications.	- Principles of OFDM. - Introduction to MIMO systems.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	19	28.5	47.5
Problem solving	2	8.5	10.5
Project based learning	7	35	42
Laboratory practices	12	36	48
Essay questions exam	2	0	2

*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.

Methodologies

	Description
Lecturing	Presentation and discussion of the fundamental concepts associated to the different blocks that constitute a digital communications system. This methodology works competencies: CG4, CG11, CT2, CT3.
Problem solving	In A hours the doubts remaining after the publication of the solutions of the proposed problems will be discussed. Furthermore, 3 exercises will be proposed for assessment; some of them will be completed in A hours, while the remaining one(s) will be completed at home. All these 3 exercises will be completed individually. This methodology works competencies: CG3, CG4, CG11, CE26.

Project based learning	In C hours practical projects will be proposed; the students will develop a digital communications system that shows its good operation in the proposed application. The projects will be implemented in small groups. All the members of the group have to understand the operation of all the blocks of the complete system that will be submitted at the end of the course. This methodology works competencies: CG3, CG4, CG11, CE26, CT2, CT3.
Laboratory practices	In B hours the students will work on the lab to create a software defined radio receptor that uses all the basic functionalities studied in the subject. They will be implemented in small groups. This methodology works competencies: CG4, CG11, CE26.

Personalized attention

Methodologies	Description
Lecturing	The teacher will solve the doubts that each student formulates during the presentation realised in the master session.
Laboratory practices	The students will work in small groups and the teacher will solve the doubts that each group might have.
Project based learning	The students will work in small groups and the teacher will solve the doubts that each group might have.

Assessment

	Description	Qualification	Training and Learning Results		
Problem solving	Short exercises (partial tests) related to the contents explained during the masterclasses and in the laboratory. 3 exercises will be proposed for assessment; some of them will be completed in A hours, while the remaining one(s) will be completed at home. All these 3 exercises will be completed individually. The dates of those tests will be approved by the Comisión Académica del Grado (CAG) and will be available at the beginning of the semester. Each exercise will have a weight of 10% in the final mark for the students assessed by continuous evaluation.	30	B3 B4 B11	C26	
Project based learning	Realisation of a practical project in groups, that will be evaluated individually in C hours during the last week of the course. This is a mandatory activity for both those students who choose to follow the continuous evaluation, and those who do not, yielding in both cases the 40% of the final mark.	40	B3 B4 B11	C26	D2 D3
Essay questions exam	Final exam, where the studen will have to solve some exercises; this exam will be the fourth test for those students who chose continuous evaluation. The weight will be 60% for those students that do not follow continuous evaluation, and 30% for those who do.	30	B3 B4 B11	C26	

Other comments on the Evaluation

For those students that choose continuous evaluation the final note will be obtained as:

Npartials + Nproject + Nexam

where Npartials denotes the mark accumulated in the partial tests, up to 3 points; Nproject denotes the mark obtained in the practical project, up to 4 points; and Nexam denotes the mark of the final exam up to 3 points. In order to pass the sbuject, the student has to obtain a minimum mark of 3.5 points (out of 10) in the final exam; if that minimum threshold is not achieved, the final mark of the student will be that obtained in the final exam, although he/she has chosen continuous evaluation. The partial tests will not be repeated.
For those students who did not choose continuous evaluation, the final mark will be obtained as:
Nproject + Nexam

where Nproject denotes the mark obtained in a practical project specifically designed for non-continuous evaluation students, up to 4 points; and Nexam denotes the mark of the final exam up to 6 points. In order to pass the sbuject, the student has to obtain a minimum mark of 3.5 points (out of 10) in the final exam; if that minimum threshold is not achieved, the final mark of the student will be that obtained in the final exam.

The final exam for those students who choose single (non-continuous) evaluation might have more exercises than the exam of those students who chose continuous evaluation.
The student has to choose, after the realisation of the second partial test, if he/she chooses continuous evaluation or single one, informing about it to the teacher within the established period of time. Those students who chose continuous evaluation and did not pass the subject will be assigned the qualification "Failed" independently that they present to the final exam or not.
The mark in the partial exams will be considered for the recovery exam, but not for subsequent courses. In recovery exam the students that choose continuous evalution can decide if they want to keep the mark obtained in the partial tests and the homework/s, or if they want to be evaluated just by considering the final exam (with 60% weight) and the project (40%).
In the case that plagiarism is detected in any of the reports/exams done/taken, the final score for the subject will be 'fail' (0) and the teachers will inform the School authorities of the affaire so that they take the appropriate measures. Besides, the teachers will inform the School authorities of any conduct against ethics by the students, the possibility existing that the School authorities take the appropriate measures.

Sources of information

Basic Bibliography

A. Artés Rodríguez, F. Pérez González y otros,, **Comunicaciones Digitales**, 2007

R. W. Heath Jr., **Introduction to Wireless Digital Communication: A Signal Processing Perspective**, 2017

Complementary Bibliography

J.R. Barry, E. A. Lee y D. G. Messerschmitt, **Digital communication,**, 3rd edition, 2004

Recommendations

Subjects that continue the syllabus

Digital Communications/V05G300V01914

Subjects that it is recommended to have taken before

Signal Transmission and Reception Techniques/V05G300V01404
Multimedia Signal Processing/V05G300V01513