(*)Escola de Enxeñaría de Telecomunicación

(*)Páxina web

(*)

www.teleco.uvigo.es

(*)Presentación

The School of Telecommunication Engineering (EET) is a higher education school of the University of Vigo that offers Bachelor's degrees, Master's degrees and Doctoral programs in the fields of Telecommunications Engineering.

Bachelor's Degree in Telecommunication Technologies Engineering (EUR-ACE®).

The mail goal of the Bachelor's Degree in Telecommunication Technologies Engineering is to form professionals at the forefront of technological knowledge and professional competences in telecommunication engineering. This Bachelor has been recognized with the best quality seals, like the EUR-ACE's. **It has a bilingual option: up to 80% of the degree credits can be taken in English**.

http://teleco.uvigo.es/images/stories/documentos/gett/degree_telecom.pdf

www: http://teleco.uvigo.es/index.php/es/estudios/gett

Master in Telecommunication Engineering

The Master in Telecommunication Engineering is a Master's degree that qualifies to exercise the profession of Telecommunication Engineer, in virtue of the established in the Order CIN/355/2009 of 9 of February.

http://teleco.uvigo.es/images/stories/documentos/met/master_telecom_rev.pdf

www: http://teleco.uvigo.es/index.php/es/estudios/mit

Interuniversity Masters

The current academic offer includes interuniversity master's degrees that are closely related to the business sector:

Master in Cybersecurity: www: https://www.munics.es/

Master in Industrial Mathematics: www: http://m2i.es

International Master in Computer Vision: www: https://www.imcv.eu/

(*)Equipo directivo

MANAGEMENT TEAM

Director: Íñigo Cuíñas Gómez (teleco.direccion@uvigo.es)

Subdirección de Relaciones Internacionales: Enrique Costa Montenegro (teleco.subdir.internacional@uvigo.es)

Subdirección de Extensión: Francisco Javier Díaz Otero (teleco.subdir.extension@uvigo.es)

Subdirección de Organización Académica: Manuel Fernández Veiga (teleco.subdir.academica@uvigo.es)

Subdirección de Calidad: Loreto Rodríguez Pardo (teleco.subdir.calidade@uvigo.es)

Secretaría y Subdirección de Infraestruturas: Miguel Ángel Domínguez Gómez (teleco.subdir.infraestructuras@uvigo.es)

BACHELOR□S DEGREE IN TELECOMMUNICATION TECHNOLOGIES ENGINEERING

General coordinator: Rebeca Díaz Redondo (teleco.grao@uvigo.es)

http://teleco.uvigo.es/images/stories/documentos/comisions/membros_comisions_grao.pdf

MASTER IN TELECOMMUNICATION ENGINEERING

General coordinator: Manuel Fernández Iglésias (teleco.master@uvigo.es)

http://teleco.uvigo.es/images/stories/documentos/comisions/membros_comisions_master.pdf

MASTER IN CYBERSECURITY

General coordinator: Ana Fernández Vilas (camc@uvigo.es)

http://teleco.uvigo.es/images/stories/documentos/comisions/membros_comisions_master_ciberseguridade.pdf

MASTER IN INDUSTRIAL MATHEMATICS

General coordinator: Elena Vázquez Cendón (USC)

UVigo coordinator: José Durany Castrillo (durany@dma.uvigo.es)

http://www.m2i.es/?seccion=coordinacion

INTERNATIONAL MASTER IN COMPUTER VISION

General coordinator: Xose Manuel Pardo López (USC)

UVigo coordinator: José Luis Alba Castro (jalba@gts.uvigo.es)

https://www.imcv.eu/legal-notice/

Telecommunication Engineering

Subjects

Year 1st

Code	Name	Quadmester	Total Cr.
V05M145V01101	A Enxeñaría de Telecomunicación na Sociedade da Información	1st	5
V05M145V01102	Tratamento de Sinal en Comunicacións	1st	5
V05M145V01103	Radio	1st	5
V05M145V01104	Tecnoloxías de Rede	1st	5
V05M145V01105	Tecnoloxías de Aplicación	1st	5
V05M145V01106	Deseño de Circuitos Electrónicos Analóxicos	1st	5

V05M145V01201	Dirección de Proxectos de Telecomunicación	2nd	5
V05M145V01202	Electrónica e Fotónica para Comunicacións	2nd	5
V05M145V01203	Sistemas Electrónicos Dixitais Avanzados	2nd	5
V05M145V01204	Comunicacións Dixitais Avanzadas	2nd	5
V05M145V01205	Procesado de Sinal en Sistemas Audiovisuais	2nd	5
V05M145V01206	Comunicacións Multimedia	2nd	5
V05M145V01207	Comunicacións Ópticas	2nd	5
V05M145V01208	Antenas	2nd	5
V05M145V01209	Laboratorio de Radio	2nd	5
V05M145V01210	Enxeñaría de Internet	2nd	5
V05M145V01211	Redes sen Fíos e Computación Ubicua	2nd	5
V05M145V01212	Enxeñaría Web	2nd	5
V05M145V01213	Circuítos Mixtos Analóxicos e Dixitais	2nd	5
V05M145V01214	Codeseño Hardware/Software de Sistemas Empotrados	2nd	5
V05M145V01215	Deseño e Fabricación de Circuítos Integrados	2nd	5
V05M145V01CFG300301	Comunicación de Datos	1st	6
V05M145V01CFG300303	Transmisión Electromagnética	2nd	6
V05M145V01CFG300304	Procesado Dixital de Sinais	1st	6
V05M145V01CFG300403	Redes de Ordenadores	2nd	6
V05M145V01CFG300404	Técnicas de Transmisión e Recepción de Sinais	2nd	6
V05M145V01CFG300501	Servizos de Internet	1st	6

IDENTIFYING DATA				
Telecommunication Engineering in the Information Society				
Subject	Telecommunication Engineering in the Information Society			
Code	V05M145V01101			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Fernández Iglesias, Manuel José			
Lecturers	Caeiro Rodríguez, Manuel Cuiñas Gómez, Íñigo Fernández Iglesias, Manuel José Mariño Espiñeira, Perfecto			
E-mail	manolo@uvigo.es			
Web	http://faitic.uvigo.es			
General description	This subject looks for motivating the students to practical usage of the most technical concepts of Telecommunication Engineering for solving problems and offer services to the society in which they live: it pretends that they realise that the activity of the engineer is not an isolated fact but it transforms the World (at small and at large scale). This leads to two fundamental ideas: 1) Society, people that conform it, have problems that can be resolved by the engineers: the function of the Engineering is to resolve or mitigate problems of the society in which it frames, not to create them. Knowing how it has resolved situations in the past can help to face problems in the future (this leads to history oriented to future action, no to the contemplation of the past). 2) Engineering activities have direct influence in the own society, in how people live or in how they relate. In fact, the large changes of the last decades have been based directly on contributions of the field of the Engineering of Telecommunication. This influence has to go accompanied of being aware of the ethical responsibility.			

Competencies	
Code	
CB3	CB3 Students must integrate knowledge and handle complexity of formulating judgments based on information that was incomplete or limited, including reflections on social and ethical responsibilities linked to the application of their knowledge and judgments.
CG7	CG7 Capacity for implementation and management of manufacturing processes of electronic and telecommunications equipment; guaranteeing safety for persons and property, the final quality of the products, and their homologation.
CG9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
CG13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.
CE15	CE15/GT1 Ability to integrate technologies and systems of Telecommunication Engineering, with general character, and at broader and multidisciplinary contexts such as bioengineering, photovoltaic conversion, nanotechnology, telemedicine.
CT3	CT3 Understanding Engineering in a framework for sustainable development.
CT4	CT4 Awareness of the need for training and continuous quality improvement, developing values of the dynamics of scientific thought, showing a flexible, open and ethical attitude in front of different opinions or situations, particularly on non-discrimination based on sex, race or religion, respect for fundamental rights, accessibility, etc.

Learning outcomes	
Learning outcomes	Competences
Knowledge of what the profession of Telecommunicationis Engineering is and what represents.	CG7 CG13 CT4
Being aware of the social responsibility, ethical and environmental of Telecommunication Engineering.	CB3 CG9 CT3 CT4
Contact with other disciplines in which the technologies of Telecommunication integrate for the development of the society (i.e. bioengineering, solar energy, nanotechnologies, tele-medicine, teleasistance, teleeducation).	CE15

Contents

Topic	
Seminar on the Engineering in the Society	1. Professional activity and ethic implications. Description of the professional activity of Engineers (preferably with the collaboration of alumni from the School), the ethic implications of their works, and other aspects of professional development. The students interact with speakers. 2. Social implication, by means of Design Thinking. We look for getting familiar with a methodology that moves future engineers to look towards society and try to find solutions or solve problems that directly affect to actual users. Related competencies: CE15, CT4, CB3 and CG9
Professional attributions and their history	Historically, there are eight professional attributions assigned to Telecommunication Engineering within Spanish regulations. Along this item, we will focus on the historical development of systems or applications related with them, as well as on the National and European legislation that applies: * Television * Wire communications (including the small local history: Vigo was the base of German and British cableships) * Radioelectric spectrum (description and management, taking into account National and International legislation) * Internet and its influence in Society * Mobile telephony (including effects on health) * Experts official reports. Related competencies: CG13 and CT3
In a multidisciplinary society	The proposal for the work in groups C is centered in the resolution of problems or situations of the society in which we live, no strictly related with the Telecommunication Engineering, so that the students comprise its implication in multiple fields of the society and how they can influence in giving solutions based on their competencies and engineering skills. Related competencies: CG7, CE15, CT3 and CT4

Planning			
	Class hours	Hours outside the classroom	Total hours
Seminars	14	15	29
Project based learning	5	70	75
Lecturing	9	10	19
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
Seminars	Teaching in seminar format, in which the student participates very actively in the evolution of the classes deepening in a specific subject, expanding it and relating it with contents oriented to the professional practice; including the participation in scientific and/or informative events , organised or not in the own School; the organisation of debates that allow sharing ideas and proposals, guided by lecturers; and the study of cases/analysis of situations (analysis of a problem or real case, with the purpose to knowing it, interpreting it, resolving it, generating hypothesis, diagnosing it and going deep in alternative procedures of solution, to see the application of the theoretical concepts in the real World). These activities can have related a load of autonomous work of the student. The subject "Seminar on Engineering and Society", and related debates, are taught following this methodology. Competencies worked: with this methodology we work the competencies CB3, CG7, CG9, CG13 and CT4

Project based learning	Realisation of works for the resolution of a case or a specific project, as well as the presentation of the results by writing and/or by means of a presentation that may follow different formats: oral, poster, multimedia. They include the integrated Methodologies: problem-based learning, resolution of design problems proposed by lecturers, and project-based learning (PBL) education. Teams of students will be defined, according to the outcomes of a personality test that the students make in the first session. The aim is to attain heterogeneous groups selected externally, as in a real company. The projects in which groups will work are related among them and are focused in a specific field of study familiar tot he students. For this academic course, we are in conversations with AENA so that the study environment could be the Airport of Vigo. The students, in groups, work towards providing a solution to a clear-cut problem according to the Design Thinking methodology, identifying situations of the daily life that a priori may not relate to the Telecommunication. Design Thinking develops through the following phases: discover, interpret, ideate, experience and evolve. The solution achieved will have to consider no only technical questions, but also legal, environmental, social and related with sustainability. By applying the Design Thinking methodology, a specific challenge will be dentified within the field of study, and all the information available relagted to that challenge will be gathered. The students will pose imaginative solutions and will treat to build a proposal that is reasonable, although it may not be still implementable given the current technological development. The aim is not to manufacture or program a solution, but to look for a proposal that is feasible, now or in the future when technology is more developed, and that it is acceptable socially. The groups will begin for locating all relevant information. From that information, they will try to identify the people involved and will try of empathice with them, to identify the actual problem that they feel. From the problem identified, groups will try to produce technological or procedural solutions. They will have to look for technical and scientific information and, finally, elaborate a prototype, a report and a presentation. The result of this activity may be documented through an online service, forum or wiki. Also it will produce a final document and a presentation and/or video that was used in the defence of the work developed in front of the class. Both results will according to the criteria collected in evaluation rubricsm which will be presented to the students at the beginning of the course and will be available at the University's e-learning platform. The interaction with lecturers will be carried out in five 1-hour sessions, and through forums during the research of information, and by email for the exchange of ideas. The groups will have to send to the lecturer in charge the "point of view" before the third session, and three ideas to resolve the challenge before the fourth session. The subject "In a Multidisciplinary Society" corresponds with this educational methodology. Competences worked: CB3, CE15/*GT1, CG9 and CT4.
Lecturing	Explanation of the contents of the subject; it includes explanation of concepts; introduction of practices and exercises; and resolution of problems and/or exercises. The subject "Professional attributions and its history" fits with this methodology. Competencies worked: with this methodology work the competencies CG7, CG9 and CT3

Personalized assistance	
Methodologies	**Description**
Lecturing	Time that group-A lecturers use to meet their students and to solve his/her doubts
Seminars	Time that group-A lecturers use to meet their students and to solve his/her doubts
Project based learning	Time that group-C lecturers use to help their students during their projects development, added to the schedulled meetings
Tests	**Description**
Essay questions exam	Time that lecturers use to help the students to understand the contents of assessment exercises and to review with them, individually, those exercises once corrected.

Assessment		
Description	Qualification	Evaluated Competencess

Seminars	Short answer tests: In the seminars we will value the participation in the debates (with the speakers of the seminar Engineering in the Society). It will be able to support the evaluation in proofs of short answer. With these short answer tests and the observations we will evaluate the competencies CB3, CG7, CG9, CG13 and CT4	20	CB3	CG7 CG9 CG13		CT4
Project based learning	Practical proofs: The realisation of the works in groups will be evaluated in two parts: the own dynamics of the works and the presentations. 25% of the mark is related to the own work; given by the lecturer that directs the work and by the group of lecturers of the matter. Related to the presentation, the mark will represent another 25%, given by his/her mates (evaluation by pairs) according to a rubric that will be approved before the beginning of the works. The mark will be the same for all the group members. With these works we will evaluate the competencies CB3, CE15/GT1, CG9 and CT4	50	CB3	CG9	CE15	CT4
Lecturing	Long answer tests: there will be 2 proofs, of 30 minutes length, that will liberate contents of the previous subjects. In these long proofs we will evaluate the competencies CG7, CG9 and CT3	30		CG7 CG9		CT3
Essay questions exam	The single evaluation exam, in case it would be needed, will consist of questions of development, in which the student will have to show the purchased knowledge, initiative to propose solutions to problems no necessarily of telecommunication, and he/she will also have to expose his opinion on conflicts of professional ethics, showing his capacity to provide opinions on situations that involve to the society.	0	CB3	CG7 CG9 CG13	CE15	CT3 CT4

Other comments on the Evaluation

Thestudents can chose any of the following assessment systems:

1.- The **continuous evaluation** tests allow students to obtain a final grade based solely on their path along the course, and consist of:

1.1. Two long-answer tests, with 15% of the total grade each, totaling 30%.

1.2. Short-answer tests in the seminars, which account for 20%.

1.3. Practical proofs for the evaluation of supervised work (25%) and the presentation of them (25%).

Continuous assessment tasks are not recoverable, and they are only valid for the current year.

A student is assumed to have opted for continuous assessment when he/she has been made one of the long-answer tests and has participated in two debate activities. A student who chooses to continuous assessment is deemed to have been presented to the subject, whether they are present or not to the final exam.

If a student, having submitted to continuous assessment, chooses the final exam, the final grade for the course will be the average of the two.

2.- **Single evaluation exam**. Under the regulations of the University of Vigo, the student who wishes may choose 100% of the final grade by a single final exam. The single evaluation exam is one that is done in the official dates marked on School Board in the months of December or January in first call (or July in the case of second call), and it is mandatory to attend to those students who have not opted for continuous assessment and want to pass the subject.

The final exam will consist of a development test, as described in the evaluation section. All material given in the lectures, lab classes and project presentations is subject to questioning.

The second call exam will have a similar structure to the final exam.

Ethical code

Final exams and quizzes must be worked out on everyone's own. Any infraction will beconsidered a serious breach of ethics and reported to the academic authorities.

Lecturers may decide to fail a student if he has committed a serious ethical breach.

Sources of information

Basic Bibliography

O. Pérez Sanjuán, **De las señales de humo a la Sociedad del Conocimiento**, http://bit.ly/2Rxf9cI, COIT-AEIT,

VV.AA., **Design Thinking Innovation and Research**, https://desire.webs.uvigo.gal, Universidade de Vigo,

VV.AA., **Design Thinking for Educators**, www.designthinkingforeducators.com/toolkit/,

Complementary Bibliography

C. Rico, **Crónicas y testimonios de las Telecomunicaciones españolas**, http://bit.ly/31V3NnF, COIT-AEIT,

O. Pérez Sanjuán, **Detrás de la Cámara. Historia de la televisión y de sus cincuenta años en España**, http://bit.ly/2X0iyBA, COIT-AEIT,

J. Cabanelas, **Vía Vigo: el Cable Inglés el Cable Alemán**, Instituto de Estudios Vigueses,

Recommendations

Subjects that continue the syllabus

Telecommunication Projects Management/V05M145V01201

Contingency plan

Description

In the event that teaching is carried out exclusively online, lectures will be delivered through Campus Remoto, and FaiTIC will serve as a supporting platform to guarantee the accessibility to teaching materials to all students. In case of online tuition, the course planning will be as follows:

A Sessions (Classroom lectures)

Lectures on the topic "Professional powers and their history" will delivered through Campus Remoto. Additionally, the associated presentations will be published in FaiTIC, duly recorded, so that the students can access the explanations of each topic at the most appropriate time, beyond the synchronous sessions.

The conferences of seminar "Engineering in society" will be delivered by videoconference through Campus Remoto. These videoconferences will be recorded and will be made available to the students, in accordance with the precepts of data protection regulations. The speakers will also be asked to provide any material in digital format that they consider appropriate to complement their talks. This material will also be made available to students at FaiTIC.

The means enabled for the resolution of the doubts raised by the students will include: (i) online consultation forums in FaiTIC to give greater visibility to the answers of the teaching staff in relation to the questions asked by each student, and (ii) mentoring sessions in lecturers' virtual offices at Campus Remoto, making an appointment in advance.

C Sessions (Lab sessions)

The scheduled meetings will be held by videoconference through Campus Remoto. Questions related to the practical part will be addressed through online consultation forums and virtual mentoring sessions.

Evaluation

Online assessment will be carried out according to the same provisions as face-to-face assessment, as described in the teaching guide, including the same number of tests with the same weight. Assessment will be organized as follows:

Classroom lectures: Continuous assessment exams and the final exam will be carried out virtually on the scheduled dates using the tools provided by the University.

Lab Sessions: each lab group must deliver a final project report. The content of this report and its organization will be

announced at the beginning of the course, as well as the delivery deadline, in case virtual tuition modality is activate

IDENTIFYING DATA				
Signal Processing in Communications				
Subject	Signal Processing in Communications			
Code	V05M145V01102			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	English			
Department				
Coordinator	López Valcarce, Roberto			
Lecturers	López Valcarce, Roberto			
E-mail	valcarce@gts.uvigo.es			
Web	http://faitic.uvigo.es			
General description	This course presents several of the signal processing techniques most commonly found in the design and implementation of communication systems, with focus on digital processing schemes. Covered aspects include sampling and quantization, block and adaptive estimation, block transform coding, efficient resampling and filtering methods.			

Competencies	
Code	
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE1	CE1 Ability to apply methods of information theory, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing systems and audiovisual communications.
CE2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
CE3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.

Learning outcomes	Competences
Ability to apply multirate processing, adaptive filtering, block-based transform and spectral estimation techniques to communication and multimedia systems	CG4 CE1
Ability to implement advanced signal processing techniques in diverse fields of application: bioengineering, bioinformatics, etc.	CG4 CG8
Ability to apply signal processing techniques to the modeling and simulation of communication systems	CG4 CE1 CE2
Ability to simulate the physical layer of cable, wireline, satellite systems in fixed/mobile communication environments.	CG4 CG8 CE2 CE3

Contents	
Topic	
Sampling and quantization	- Aliasing - Baseband and bandpass sampling - Quantization noise - Converter overload - Spurious-free dynamic range - Sampling jitter
Block-based Transforms in Communications and Multimedia	- DFT: formulation and properties. - Frequency Analysis based on DFT. Windowing. - Power Spectrum Estimation: Welch's periodogram - DFT-based digital modulation schemes: SC-FDE, OFDM.
Multirate Signal Processing	- Sampling rate conversion: decimation, interpolation - Effect in the frequency domain - Polyphase structures - Applications in digital transceivers

Linear estimation	- Least Squares criterion - Minimum Mean Squared Error criterion - Gauss-Markov Theorem - LMMSE properties - State-space description - The Kalman filter

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	18	36
Practices through ICT	20	20	40
Autonomous problem solving	0	30	30
Essay questions exam	2	0	2
Report of practices, practicum and external practices	0	17	17

*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 of main topics, possibly with audiovisual aids. Applied/theoretical problem sessions. Skills involved: CG4, CG8.
Practices through ICT	Under the guidance of the instructor, students will develop the design and/or simulation of a number of signal processing systems involving several of the techniques studied during the course. Skills involved: CE1, CE2, CE3.
Autonomous problem solving	Computer-based simulation of signal processing applications to communications and multimedia. Skills involved: CE1, CE2, CE3.

Personalized assistance

Methodologies	Description
Practices through ICT	Student aid will be provided during office hours by appointment, as well as on-line (email). An on-line discussion forum will be set up for the course, through the usual e-learning platform
Lecturing	Student aid will be provided during office hours by appointment, as well as on-line (email). An on-line discussion forum will be set up for the course, through the usual e-learning platform

Assessment

	Description	Qualification	Evaluated Competencess	
Essay questions exam	Final test in which the student must solve a series of exercises.	40	CG4	CE1 CE2
Report of practices, practicum and external practices	Written reports corresponding to the different lab assignments. In general, they will be carried out in groups of two, and both students will be assigned the same grade. The instructor may require further clarifications in order to check the contribution to the report of all members of the group.	60	CG4 CG8	CE1 CE2 CE3

Other comments on the Evaluation

Students may choose one of the following two assessment options:

1) Continuous assessment: Final grade will consist of a comprehensive test (up to 4 points) and lab reports (up to 6 points)

A minimum grade of 30% in the comprehensive test is required in order to pass the course. If this minimum is not reached, the final grade will be directly the grade obtained in the comprehensive test.

Lab report grades from the first call will be kept for the second call, in which the student will be allowed to take a new comprehensive test.

2) One-shot assessment: The final grade is the one achieved in the comprehensive test, for both the first and second call.

It is assumed that the student chooses the continuous assessment mode as soon as he/she turns in a lab report.

Students are allowed to turn in their reports and exam indistinctly in English, Spanish or Galician.

Sources of information

Basic Bibliography

S. Mitra, **Digital Signal Processing: A Computer Based Approach.**, 4th,

J.G. Proakis and D.G. Manolakis, **Digital Signal Processing**, 4th,

Behrouz Farhang-Boroujeny, **Signal Processing Techniques for Software Radios**, 2nd,

Complementary Bibliography

S. Haykin, **Adaptive Filter Theory**, 5th,

F. Harris, **Multirate Signal Processing for Communication Systems**,

T. K. Moon, W. C. Stirling, **Mathematical methods and algorithms for signal processing**, 1st,

Recommendations

Subjects that continue the syllabus

Real-Time Signal Processing/V05M145V01301
Advanced Digital Communications/V05M145V01204
Multimedia Communications/V05M145V01206
Optical Communications/V05M145V01207
Wireless and Mobile Communications/V05M145V01313
Satellites/V05M145V01311
Communication Advanced Systems/V05M145V01302
Wideband Radio Systems/V05M145V01312

Other comments

It is assumed that students are knowledgeable in the following areas:
- Signal Processing: analog and discrete-time signals, time and frequency domains, Fourier Transform, linear systems (continuous- and discrete-time), convolution, transfer function, FIR and IIR filters, group delay, poles and zeros.
- Probability and statistics: random variables, probability density function, probability distribution function, mean, variance. Gaussian and uniform distributions. Stochastic processes: autocorrelation, crosscorrelation, stationarity, power spectral density.
- Communications: bit rate, baud rate, carrier frequency, PAM and QAM modulation.

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===
Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION OF THE METHODOLOGIES ===
* Teaching methodologies maintained
All of them
* Teaching methodologies modified
None of them
* Remote mechanisms for student attention (tutoring)
Videoconferencing
* Modifications (if applicable) of the contents
N/A
* Additional bibliography to facilitate self-learning
N/A
* Other modifications
N/A
=== ASSESSMENT ADAPTATION ===
No modification of the assessment activities or their corresponding weights is required

IDENTIFYING DATA				
Radiocommunication				
Subject	Radiocommunication			
Code	V05M145V01103			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Arias Acuña, Alberto Marcos			
Lecturers	Arias Acuña, Alberto Marcos González Valdés, Borja Rubiños López, José Óscar			
E-mail	marcos@com.uvigo.es			
Web	http://faitic.uvigo.es			
General description	In this compulsory matter of first semester, the student familiarises with the radiocommunication systems, beginning with the antenna properties, continuing with the study of the noise and interferences and finalising with the calculation of the link budget in different propagation scenarios. These concepts apply to the study of the services of radar and radiolocalization.			

Competencies	
Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CE2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
CE3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
CE5	CE5 Ability to design systems of radio navigation and positioning, as well as radar systems.

Learning outcomes	
Learning outcomes	Competences
Capacity to realise basic antenna designs	CB2 CE2
Capacity to calculate link budgets taking into account both signal and perturbations in distinct stages	CB2 CE2 CE3
Capacity to design radionavegation and positioning systems	CB4 CE3 CE5
Capacity to design radar systems	CB4 CE5

Contents	
Topic	
1. Basic design of antennas	1.1 Fundamental electromagnetic laws 1.2 Trasmitting antenna 1.3 Receiving antenna 1.4 Bands of frequency 1.5 Types of antennas 1.6 Friis Formula 1.7 Transmission losses
2. Models of noise and interferences	2.1 Thermal Noise 2.2 Antenna Noise 2.3 Noise Factor and noise temperature of a receptor 2.4 Concept and types of interferences 2.5 Characterisation of the interference 2.6 Concept of availability, fading and diversity 2.7 Systems limited by noise and by interference

3. Link budget for different propagation modes	3.1 Propagation in low frequencies. Surface and ionospheric waves. Electrical field received. 3.2 Tropospheric propagation. 3.3 Propagtion losses
4. Design of Radionavigation systems	4.1 Fundamentals of radionavigation 4.2 Types of radionavigation systems 4.3 Satellite radionavigation systems 4.4 Design of a radionavigation system
5. Design of radar systems	5.1 Fundamentals of radar systems. Radar cross section 5.2 Types of radar systems 5.3 Design of a radar system

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	20	20	40
Seminars	5	30	35
Laboratory practical	13	13	26
Problem and/or exercise solving	1	11	12
Essay questions exam	1	11	12

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

Methodologies

	Description
Lecturing	Exhibition of the contained of the subject; it includes exhibition of concepts; introduction of practices and exercises; and resolution of problems and/or exercises in common classroom. With this methodology will work the competencies CB2, CE2, CE3 and CE5
Seminars	Teaching in small rooms, in the that the student takes part very actively in the evolution of the kinds deepening in one specific item, enlarging and relating with contents guided to the professional practice; including the participation in scientific events and/or conferences, organized or not in the own School; the organisation of enabling debates compare ideas and proposals, guided by the teacher, both physically and online; and the study of cases/analysis of situations (analysis of a problem or real case, with the aim to know it, interpreted, resolved, generate hypothesis, diagnosed and deepening in alternative procedures of solution, to see the application of the theoretical concepts in the reality). These activities can had related a lot of autonomous work of the student. With this methodology will work the competencies CB4, CE2, CE3 and CE5
Laboratory practical	Application, to practical level, of the knowledges and skills purchased in the theoretical kinds, by means of practices realized with equipment of test and measure, both in the laboratory or of field. Also including practices of laboratory realized on computers (simulation, analysis, processing, etc.), exercises of programming, works realized online, etc. With this methodology will work the competencies CB2, CE2 and CE5

Personalized assistance

Methodologies	Description
Lecturing	In this methodology, all the questions that each student can ask will be answered.
Seminars	Each student will be attended in an individual way.
Laboratory practical	Each student will be attended in an individual way.

Assessment

	Description	Qualification	Evaluated Competencess	
Laboratory practical	Students during the course participate in individual or group practices and perform individual jobs. The individual note for each student of this item is that corresponding to the continuous evaluation and I can be worth up to 30% of the final score.	30	CB2 CB4	CE2 CE3 CE5
Problem and/or exercise solving	Final examination: it consists in a proof for the evaluation of the competencies adquired by the students by means of the resolution of simple problems and short questions of theory.	50	CB2 CB4	CE2 CE5

Essay questions exam	Final exam: it consists in a proof for the evaluation of the competencies adquired by the students. They will have to develop, organise and present the knowledges adquired during the course.	20	CB2 CB4	CE2 CE5

Other comments on the Evaluation

Students during the course participate in individual or group practices and perform individual jobs. The individual note for each student of this item is that corresponding to the continuous evaluation and I can be worth up to 30% of the final score.

All students must assist to the final exam, which consists of a test response and a test of development. The final score in the first and second call is maximum between the score of the exam (single evaluation) and the sum of the note of continuous evaluation with the score of the exam weighted in a 70%.

In case of detection of plariarism in some work/test performed, the final score of the subject will be zero and the teachers will notify this situation to the academic authorities.

Sources of information

Basic Bibliography

Marcos Arias Acuña, Oscar Rubiños López, **Radiocomunicación**, 1a, Andavira Editora, 2011

José María Hernando Rábanos, **Transmisión por Radio**, 6a, Editorial Universitaria Ramón Areces, 2008

John Griffits, **Radio Wave Propagation and Antennas. An Introduction**, 1st, Prentice Hall, 1985

Complementary Bibliography

Robert R. Collin, **Antennas and Radiowave Propagation**, 1st, Mc Graw Hill, 1985

Thomas A.Milligan, **Modern Antenna Design**, 2nd, Wiley, 2005

ngel Cardama, L. Jofre, J.M. Rius, S. Balnch, M. Ferrando, **Antenas**, 2a, Ediciones UPC, 2002

Constantine A. Balanis, **Antenna Theory. Analysis and Design**, 3rd, Wiley, 2005

ITU-R, Recommendations,

Recommendations

Subjects that continue the syllabus

Antennas/V05M145V01208
Radio Laboratory/V05M145V01209
Satellites/V05M145V01311
Wideband Radio Systems/V05M145V01312

Contingency plan

Description

In case of sanitary alert that preclude the assistance to the classrooms and physical laboratories in any moment of the term,
(i) face-to-face learning will be replaced by emergency remote teaching,
(ii) the evaluation will not take into account unrealised laboratory practices that require the use of specific material and cannot be virtualised,
(iii) the assessment shall be carried out virtually through the platform that the University of Vigo will recommend (Faitic, Remote Campus...).

IDENTIFYING DATA				
Network Technologies				
Subject	Network Technologies			
Code	V05M145V01104			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish Galician			
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	López Ardao, José Carlos			
E-mail	jardao@det.uvigo.es			
Web	http://moodle.det.uvigo.es			
General description	This subject covers the competencies in the BOE for the Master degree to achieve those professional attributions of Telecommunications Engineer related to the underlying technologies in the Computer Networks. In any way, it is an advanced course within the scope of these technologies, continuing and intensifying the basic contents studied in the subjects of the GETT.			

Competencies	
Code	
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CE4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
CE6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
CE7	CE7 Capacity for planning, decision making and packaging of networks, services and applications, taking into account the quality of service, direct and operating costs, plan implementation, monitoring, safety procedures, scaling and maintenance, as well as managing and ensuring quality in the development process.
CE12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.

Learning outcomes	
Learning outcomes	Competences
Know how to model mathematically the essential elements of a network of telecommunications	CB5 CG1 CG4 CG8 CG12 CE4 CE6 CE7
Understand the fundamental results on the capacity for different types of networks	CG1 CG4 CG8 CE4 CE6 CE7
Understand, formulate and solve simple models for analyzing the performance of a computer network	CG1 CG4 CG8 CE4 CE6 CE7 CE12

Know how to plan, design and deploy switched networks and IP networks in any application environment	CB5 CG1 CG4 CG8 CG12 CE4 CE6 CE7
Know and understand the internal architecture of the switching equipment, methods of resource allocation and the basic techniques of providing Quality of Service	CB5 CG1 CG4 CG8 CG12 CE4 CE6 CE12

Contents	
Topic	
1. Switching architectures	1.1. Data and control plane. Distributed and centralized control 1.2. Switching architectures. Types of switches 1.3. Queue models for switches and communication networks
2. Network virtualization	2.1. Network virtualisation 2.2. Virtual switches 2.3. Level 2 overlay virtualization 2.4. Ethernet VLANs. VLAN Trunking. 2.5. QinQ and MAC-in-MAC tunnels 2.6. MAC-in-IP tunnels: VXLAN, NVGRE
3. Data Center Networks	3.1. The network of a Data Center 3.2. 3 level hierarchical architecture 3.3. Leaf & Spine Architecture 3.4. Technologies for optimising the use of available bandwidth: MSTP, TRILL, SPB, ECMP
4. Intradomain Internet routing: OSPF	4.1. Hierarchical routing on the Internet. Domains, AS and ISPs 4.2. Protocols for intradomain routing 4.3. OSPF 4.4. Types of OSPF areas
5. Inter-AS routing: BGP	5.1. BGP. 5.2. Attributes and path selection
6. Route filtering	6.1. Route Filtering. Lists and route-maps 6.2. Route filtering in BGP 6.3. BGP Communities 6.4. BGP and Data Centers
7. Traffic engineering. MPLS-TE	7.1. Traffic Engineering 7.2. MPLS-TE
8. QoS architectures in ISPs	8.1. Basic concepts of QoS 8.2. Classification and traffic marking 8.3. Traffic policing and shaping 8.4. Buffer and bandwidth scheduling 8.5. DiffServ Architecture
9. SDN and NFV	9.1. Software Defined Networks (SDN). Key features 9.2. SDN controllers 9.3. OpenFlow 9.4. Network virtualization in SDN. Network Slicing in 5G 9.5. Network Functions Virtualization (NFV) 9.6. SDN and NFV
10. Transport and Access Networks	10.1. Fibre access: Metroethernet. FTTx, GPON 10.2. Radio Access Network. CRAN: Backhaul and Fronthaul. 10.3. Optical transport networks.

Planning			
	Class hours	Hours outside the classroom	Total hours
Autonomous problem solving	0	18	18
Practices through ICT	9	13	22
Problem solving	3	6	9
Gamification	0	12	12

Lecturing	24	36	60
Objective questions exam	2	0	2
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
Autonomous problem solving	Resolution of assignments, exercises, questions and self-assessment tests in the virtual classroom in a individual, autonomous way. These activities have a global weight of 15% in the case of continuous evaluation. With this methodology we will work the competences CB5, CG1, CG4, CG8, CG12, CE4, CE6, CE7, CE12
Practices through ICT	Realization of practices for planning, design, configuration and resolution of problems of network scenarios by means of the emulador GNS3. With this methodology we will work the competences CG1, CG4, CG8, CG12, CE4, CE6, CE7, CE12
Problem solving	Resolution of problems of design, planning and dimensioning of networks. With this methodology we will work the competences CG1, CG4, CG8, CE6, CE7
Gamification	In the virtual classroom, we use a gamification system that employs activity points, mechanics and gamification elements to encourage the performance of online grading activities and to participate meaningfully in discussion forums. This will allow the student to obtain rewards to be used in the exams or in the continuous evaluation. The discussion forums will be the preferred way of answering questions related to the contents of the subject. The gamification will encourage peer support and collaborative resolution of doubts in the forums. Besides contributing to the increase of the motivation, with this methodology there will be worked also the competences CB5, CG12
Lecturing	Explaining of the ideas, concepts, technics and algorithms related to the thematic unities of the course. With this methodology we will work the competences CG1, CG4, CG8, CE4, CE6, CE7, CE12

Personalized assistance

Methodologies	Description
Lecturing	Individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.
Autonomous problem solving	In the case of tasks, the detailed solution will be provided in the virtual classroom. In the case of self-assesmemt tests, suitable feedback for the wrong questions will be provided to the student. In any case, individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.
Practices through ICT	Individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.
Problem solving	Individually personalized attention, face-to-face or by videoconference, will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation must be made through the virtual classroom or by email.
Gamification	In addition to individually personalized face-to-face attention, the professor will be monitor the discussions in the forums making suitable answers when necessary or explaining the answers of the students. The discussion forums are the way to request remote attention for doubts and questions related to the contents of the subject. Private attention about contents by means of messaging or e-mail is not available. In addition to individual attention during the tutorial schedule, the teacher will monitor the discussions in the forums, giving the appropriate response when necessary or explaining the student's answers if necessary. The forums in the virtual classroom are the preferred way of providing asynchronous attention to doubts related to the contents of the subject.

Assessment

	Description	Qualification	Evaluated Competencess		
Autonomous problem solving	During the course, with a roughly weekly periodicity, different tasks, activities, exercises, self-assessment tests must be made in the virtual classroom in an individual and autonomous way. These activities have a global weight of 15%	15	CB5	CG1 CG4 CG8 CG12	CE4 CE6 CE7 CE12
Objective questions exam	Two intermediate one-hour multiple-choice tests will be carried out to check the progress of the subject. Each control test has a weight of 15%.	30		CG1 CG4 CG8	CE4 CE6 CE7 CE12

Essay questions exam	Final exam covering the whole subject. It has a weight of 55% but a minimum score of 3.5 points out of 10 is required to pass the subject.	55	CG1 CG4 CG8	CE4 CE6 CE7 CE12

Other comments on the Evaluation

The students can choose the Assesment method, continuous or exam-only.

Continuous Assesment (CA)

It will consist of:

- Two intermediate one-hour multiple-choice tests (**C1 and C2**) will be carried out to check the progress of the subject. Each control test has a 15% weight in the Final Grade (**FG**). The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Máster (CAM) and will be available at the beginning of each academic semester
- The participation in the online activities in virtual environment, that represent 15% of the Final Grade (**FG**). During the course, with a roughly weekly periodicity, different tasks, activities, exercises, self-assessment tests will be proposed in the virtual classroom. These activities must be realized by all students in an autonomous, individual way. The realization of these activities allows students to obtain "merit points" (**MP**) up to a maximum of 150 points (in case of all activities are evaluated with the maximum grade). The grade of this section will be equal to the **amount of MP divided by 100**. In order to facilitate the achievement of the maximum amount of points, additional optional tasks will be proposed throughout the course.
- The virtual classroom includes a **gamification** system based in other types of points and several gamification elements and mechanisms to motivate students to make the activities and participate in a meaningful way in forums of doubts and discussions. This system allows students get **rewards** to be used in exams and assignments.
- A final exam (**FE**) covering all contents, with a weight of 55% of the Final Grade (**FG**). A minimum qualification of 3.5 points on 10 is required

FG-CA = 0.15x(C1 + C2) + MP/100 + 0,55xFE if FE >= 3.5

FG-CA = FE if FE< 3.5

It is considered that a student chooses CA when presenting to any midterm control test (C1 or C2). If any of these control tests are not made, the grade will be "0". These control tests will be not recoverable.

Exam-only Assesment (EA)

It will only consist of the same FE at the end of the term.

Students who do not take any midterm exam, compulsorily opt for the Exam-only Assesment.

Second call

A new final exam (FE) will be done in the official dates only for students not passing in the first call.

Those students who have failed in the first call by going through Continuous Assesment and wish to renounce it in order to choose the Eventual Assessment, will have to request it in writing to the coordinator before the review date of the first final exam. In this case, any reward obtained by the CA activities carried out in the virtual classroom is also waived.

Other comments

All students taking any final exam are considered to be presented to the subject. The grades for all exams, partial or final, and activities will affect only the actual academic year.

The virtual classroom platform has tools to detect possible anomalous and dishonest behaviors in self-assessment tests (tests carried out among several people, previously known answers, etc.), as well as to detect plagiarism in written works or in software programs.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any works/test/exams, including the activities on the virtual platform, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

In case of any contradiction that may occur between the different versions of the guide, due to some error in the translation, the version that will prevail is the Galician language version.

Sources of information

Basic Bibliography

J.F. Kurose, K.W. Ross, **Computer networking: a top-down approach featuring the Internet**, 7ª,

Diane Teare, **Implementing Cisco IP Routing (ROUTE) Foundation Learning Guide**, Cisco Press,

P. Görason, C. Black, T. Culver, **Software Defined Networks: A comprehensive approach**, 2ª, Morgan Kauffman, 2017

Gary Lee, **Cloud Networking: Understanding Cloud-Based Data Center Networks**, Morgan Kaufmann, 2014

R. Chayapathi, S. Hassan, P. Shah, **Network Functions Virtualization (NFV) with a Touch of SDN**, Addison Wesley, 2016

Complementary Bibliography

Kun I. Park, **QoS in packet networks**, 1ª,

Richard Froom, Balaji Sivasubramanian, Erum Frahim, **Implementing Cisco IP Switched Networks (SWITCH) Foundation Learning Guide**, Cisco Press,

William Stallings, **Foundations of Modern Networking: SDN, NFV, QoE, IoT and Cloud**, Addison Wesley, 2016

Jim Doherty, **SDN and NFV Simplified**, Pearson Education, 2016

Recommendations

Subjects that it is recommended to have taken before

(*)Redes de Ordenadores/V05M145V01403

Contingency plan

Description

The subject is planned in such a way that, in the event of activation of the alert caused by COVID-19 which requires switching to a semi-presential or totally non-presential teaching model, no changes are required in the contents, teaching planning, teaching methodologies, personalised attention mechanisms or evaluation.

IDENTIFYING DATA				
Application Technologies				
Subject	Application Technologies			
Code	V05M145V01105			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	English			
Department				
Coordinator	Fernández Vilas, Ana			
Lecturers	Fernández Vilas, Ana Gil Castiñeira, Felipe José			
E-mail	avilas@det.uvigo.es			
Web	http://faitic.uvigo.es/			
General description	Students will obtain a global picture of the main technological resources to design telematics applications. Basic problems like distributed computing, interoperability and services discovering will be addressed. These concepts will be study in the framework of the cloud computing paradigm.			

Competencies	
Code	
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CE4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
CE8	CE8 Ability to understand and know how to apply the operation and organization of the Internet, new generation Internet technologies and protocols, component models, middleware and services.
CE9	CE9 Ability to solve convergence, interoperability and design of heterogeneous networks with local, access and trunk networks; as well as the integration of telephonic, data, television and interactive services.

Learning outcomes	
Learning outcomes	Competences
Know and apply the different communication techniques for communication and distributed computing	CB5 CG1 CG4 CG12 CE4
Know and apply the techniques for data sharing to enable interoperability among systems and/or services	CB5 CG1 CG8 CG12 CE4 CE9
Know and apply how to specify and discover software services to be integrated in complex telematic solutions	CB5 CG1 CG4 CG8 CG12 CE4 CE9
Know and apply virtualization concepts : cloud computing and content distribution networks.	CB5 CG1 CG12 CE4 CE8

Contents

Topic	
1. Cloud computing: overview	a. Service models (IaaS, PaaS, SaaS) and deployment models b. Reference architectures for cloud applications: virtualization
2. Cloud Computing: AWS	a. Commercial platforms: AWS b. Data Storage
3. Synchronization in distributed systems	a. Modeling & main problems b. Physical clocks c. Logical time & logical clocks d. Global state
4. Taking decisions in distributed systems	a. Mutual exclusion b. Elections c. Group communication d. Consensus
5. Replication and management of groups.	a. System model for replicated objects b. The role of group communication c. Fault-tolerant systems d. The case of high availability: Gossip
6. Distributed Storage & MapReduce	a. Type of data b. Data storage distributed solutions c. Distributed storage systems d. MapReduce programming model e. The Hadoop environment
7. Parallel Computing	a. Technological basis b. Types of parallelism c. Parallel programming d. Big data frameworks e. Parallel performance analysis

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	13	26	39
Lecturing	22	29	51
Laboratory practice	3	30	33
Problem and/or exercise solving	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
Laboratory practical	Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions. We will focus on skills EC9, EC8, EC4, CG12, CG8 and CB5.
Lecturing	Teachers will combine both concepts explanation and toy examples resolution. Resolution of small situations at class will foster debates, especially if it is done in groups. We will focus on skills CG1, CG4, CG12 and CE8

Personalized assistance

Methodologies	Description
Lecturing	Teachers will combine both concepts explanation and toy examples resolution. Resolution of small situations at class will foster debates, especially if it is done in groups
Laboratory practical	Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions.

Assessment

	Description	Qualification		Evaluated Competencess	
Laboratory practice	Students willl design and implement software solutions for different small problems.	50	CB5	CG1 CG8 CG12	CE4 CE8
Problem and/or exercise solving	Written exam wich combines test and short answer questions. No extra material is allowed.	50	CB5	CG4 CG8 CG12	CE8 CE9

Other comments on the Evaluation

Students can follow up a continuous evaluation model or single evaluation. This selection should be done when at the deadline of the first assignement. Once a student selects "continuous evaluation" (having done the first intermediate practical assignment) his/her mark will never be "not taken".

Final mark will be calculated using the arithmetic mean with two partial results: (i) written exam (50%) and(ii) practical assignments (50%).

The **written exam** will take place when and where the official calendar specifies.

Practical assignments:

1- Continuous evaluation: 2 intermediate assignments (deadlines will be detailed in the document that will be published the first day of the semester).

2- Single evaluation: 1 assignment (deadlines will be detailed in the document that will be published the first day of the semester).

The scheme for the second call is exactly the same as the single evaluation.

If any kindof plagiarism is detected, the final mark will be "failed (0)". This fact will be reported to the academic authorities.

Sources of information

Basic Bibliography

George Colouris, Jean Dollimore, Tim Kindberg, Gordon Blair, **Distributed systems: Concepts and design**, Ed. Pearson, 2012

Dan C. Marinescu, **Cloud Computing: Theory & Practice**, Elsevier, 2013

Jimmy Lin , Chris Dyer, Graeme Hirst, **Data-Intensive Text Processing with MapReduce (Synthesis Lectures on Human Language Technologies)**, Morgan and Claypool Publishers, 2010

Victor Eijkhout, Edmond Chow, Robert van de Geijn, **Introduction to High Performance Scientific Computing**, Lulu, 2014

Trobec, R., Slivnik, B., Bulić, P., Robič, B., **Introduction to Parallel Computing From Algorithms to Programming on State-of-the-Art Platforms**, Springer, 2018

Complementary Bibliography

Rajkumar Buyya, James Broberg, Andrzej Goscinski, **Cloud computing: principles and paradigms**, Wiley, 2014

George Reese, **Cloud Application Architectures: Building Applications and Infrastructure in the Cloud**, O'Reilly Media, 2009

Barrie Sosinsky, **Cloud Computing Bible**, John Wiley & Sons, 2010

Kai Hwang, Geoffrey C. Fox andJack J. Dongarra, **Distributed and Cloud Computing**, Elsevier., 2012

Michael J. Kavis, **Architecting the cloud**, Wiley, 2010

Recommendations

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===
Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION OF THE METHODOLOGIES ===
* Teaching methodologies maintained
All.

* Teaching methodologies modified
None.

* Non-attendance mechanisms for student attention (tutoring)

Campus Remoto.

* Modifications (if applicable) of the contents
Without modification.

* Additional bibliography to facilitate self-learning
None.

* Other modifications
None

=== ADAPTATION OF THE TESTS ===
Without modification.

IDENTIFYING DATA				
Analog Electronic Circuits Design				
Subject	Analog Electronic Circuits Design			
Code	V05M145V01106			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Pastoriza Santos, Vicente			
Lecturers	Costas Pérez, Lucía Pastoriza Santos, Vicente			
E-mail	vpastoriza@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The main purpose of this subject is that the student acquires the knowledge and the skills to be able to analyze and design analogue electronic circuits of low frequency, which are most frequently used in data acquisition systems and electronic instrumentation systems. Course outline: +Introduction to electronic systems for signal acquisition: functional block diagrams and architectures. +Feedback: definition and topologies. +Introduction to sensors: definition and classification. +Introduction to signal conditioning circuits. Auxiliary circuits: linearization circuits. Level-shifting circuits. Precision rectifiers. Voltage references. Voltage-to-current conversion. Analog switches and multiplexers. +Amplification in electronic measurement systems: instrumentation amplifiers, programmable amplifiers, and isolation amplifiers. +Active filters. +Sample-and-hold circuits, digital-to-analog and analog-to-digital converters. The main goal of the laboratory sessions (practical work) is to enable the students to acquire sufficient understanding and knowledge to: + Assemble electronics circuits. + Use of laboratory instrumentation to measure of physical variables on circuits. + Detect and correct assembly errors. + Manage specific software tools developed to design, simulation and analysis of analogue electronic system.			

Competencies	
Code	
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.
CE14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Learning outcomes	
Learning outcomes	Competences
Know analyse and design analogue electronic circuits of low frequency.	CB4 CG4 CG8 CE12 CE14
Know the parts that constitute an electronic measurement system.	CB5 CG4 CE12 CE14

Know the principle of operation of sensors and their conditioners.	CB5 CG4 CE12 CE14
Know model an analogue electronic system by means of hardware description languages.	CB4 CG4 CG8 CE12 CE14

Contents	
Topic	
Unit 1: Introduction	Analog systems for signal acquisition: Architectures. Functional block diagrams. Feedback: Definition. Topologies. Series-Parallel feedback. Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Unit 2: Auxiliary circuits	Sensors and signal conditioners: Sensors: Definition and classification. Signal conditioners for resistive sensors: The voltage divider. Wheatstone bridge. Other conditioning circuits. Linearization circuits. Level-shifting circuits: DC level shifter and gain calibration. Precision rectifiers: Half-wave rectifiers and full-wave rectifiers. Voltage references and current sources: Voltage references: Introduction. Performance specifications. Basic circuit. Self-regulated circuit. Thermal stabilization. Voltage-to-current converter circuits: Introduction. Floating-load converters. Grounded-load converters. Analog Switches and Multiplexers Switches: Definition. Types. Applications. Commercial devices. Multiplexers: Definition. Types. Specifications. Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Unit 3: Amplification in signal acquisition systems	Instrumentation amplifiers: Introduction. Definition and ideal characteristics. Real model. Basic configurations. Specifications. Functional block diagram. Applications. Commercial amplifiers and their data sheets. Programmable amplifiers: Introduction. Types. Pin Programmable Gain Amplifier. PGA: Programmable Gain Amplifier. Commercial amplifiers and their data sheets. Isolation amplifiers: Introduction. Classification criteria. Types: capacitive coupled, transformer coupled, and optically coupled. Basic structure. Specifications. Applications and limitations. Examples. Commercial amplifiers and their data sheets. Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

Unit 4: Active filters	Introduction: Fundamentals. Basic filter types. Real parameters. Description by transfer function: Introduction. Transfer function: poles and zeros, stability analysis and frequency response. First order and second order filters. Approximation of filter transfer function: Steps in the realization of active filters. Filter specifications. Mathematical approximation of the characteristic function. Transfer function normalization. Transfer function normalization. Transformation from one type of filter into another. Polynomial approximations. Synthesis: Introduction. Methods. Direct design. Basic topologies of direct synthesis. Cascade design. Comparison of methods. Scaling. Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Unit 5. Sample-and-hold circuits. Digital-to-analog and analog-to-digital converters	Sample-and-hold circuits: Background. Specifications. Architectures. Commercial devices. Analog-to-digital converters: Introduction. Fabrication parameters. Errors. Architectures. Commercial devices. Digital-to-analog converters: Introduction. Fabrication parameters. Errors. Architectures. Commercial devices. Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Practice 1: Auxiliary circuits.	Implementation and testing of certain of the auxiliary circuits developed in the theoretical part. Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Practice 2: Instrumentation amplifier.	Implementation, testing and analysis of an commercial instrumentation amplifier with adjustable gain. Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Practice 3: Active filters.	Implementation of an active filter. Identification of the topology, the order, and the filter type. Theoretical calculation of its cut-off frequency. Frequency response measurement using the waveform generator and the oscilloscope. Plot the magnitude of the frequency response of the filter (Bode magnitude plot). Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Practice 4: Measurement system of a physical variable using commercial sensors.	Implementation and testing of the signal conditioning circuit of a measurement system based on commercial sensors. Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.
Practice 5: Electronic circuit simulation	Simulation of electronic circuits described in the theoretical and/or previous practical part. In this practice will work the competitions CB4, CB5, CG4, CG8, CE12 and CE14.

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	2	3
Lecturing	13	19	32
Problem solving	8	12	20
Project based learning	5	12	17

Laboratory practical	10	10	20
Objective questions exam	3	30	33

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

Methodologies

	Description
Introductory activities	Subject presentation. Presentation of laboratory sessions, instrumentation and software resources to be used. In these sessions, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked.
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or at the office. In these sessions, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked.
Problem solving	Complementary activity to the master sessions. The students will perform exercises and troubleshooting related with the subject. The student should find right solutions to the classroom exercises and other exercises from bibliography. The lecturer will identify issues and resolve students questions in the classroom or at the office. In these sessions, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked.
Project based learning	Complementary activity to the master sessions. Students have to develop a group activity that projects goes on over a period of time and address a specific problem. They have to design, schedule and carry out a set of tasks to achieve a solution. The lecturers will guide and monitor the group work and the individual student work in the C hour sessions. In these sessions, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked.
Laboratory practical	Activities designed to apply the main concepts and definitions of the subject. The student will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The student has to develop and demonstrate autonomous learning and collaborative skills. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in the laboratory sessions or at the lecturer's office. In these practices, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked.

Personalized assistance

Methodologies	Description
Lecturing	The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will answer the students questions and also give instructions to guide the studying and learning process.
Problem solving	The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions, the lecturer will answer the students questions about the problems and/or exercises proposed and/or resolved in the classroom as well as other issues that can appear along the study of the subject.
Laboratory practical	The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools).
Project based learning	The students can attend tutoring sessions (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with issues and questions related with the theoretical and practical project.

Assessment

	Description	Qualification	Evaluated Competencess
Project based learning	The student have to perform a theoretical practical project. In order to assess the project, the lecturer will consider the developed work, the obtained results, their classroom presentation and analysis, and the quality of the final written report if required. The final mark of tutored project (TPM), will be assessed in a 10 points scale. For the evaluation of the project, the lecturer will assess the group work, if this is done in a group (the same mark for each member), the individual student work and the individual oral presentation, if this were to take place. In these practices, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed.	15	CB4 CG4 CE12 CB5 CG8 CE14

Laboratory practical	The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. Final mark of laboratory, FLM, will be assessed in a 10 points scale. For the evaluation of the laboratory sessions, the lecturer will assess the group work (the same mark for each member), the individual preliminary tasks and the answers to personalised questions for each session. In these practices, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed.	25	CB4 CG4 CE12 CB5 CG8 CE14
Objective questions exam	The lecturers will check the level of compliance of the students with the choice tests goals related to the theory skills. Marks for each objective test will be assessed in a 10 points scale. Final mark of objective tests (OTM) will be assessed in a 10 points scale. In these tests, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed.	60	CB4 CG4 CE12 CB5 CG8 CE14

Other comments on the Evaluation

1. Continuous evaluation

According to the guidelines of the degree and the agreements of the academic commission, a continuous evaluation learning scheme will be offered to the students.

When the students perform 1 objective testing (theoretical test) or 1 laboratory session or 1 session of C hours, **they will be assessed by continuous evaluation.**

The subject is divided into the following parts: objective tests (60 %) and practical tests (40%). The marks are valid only for the current academic course. The final grade for the students which have selected this option, may not be "no standing".

1.a Objective tests (multiple choice questionsor short-answer questions)

Two partial testings (OT: objective tests) are scheduled. The first exam will be performed in the usual weekly scheduling of the theoretical classes. The second exam will be performed during the examination period in the date specified in the academic calendar.The students cannot do the exams at a later date.

Each objective test will be comprised multiple choice questions and/or short-answer questions and/or problem-solving exercises. Marks for each objective test (OT) will be assessed in a 10 points scale. The student who miss a test will be assessed with a mark of 0 for that test. The minimum mark required to pass the theoretical part is of 5 for each objective test (OT1 >= 5 and OT2 >= 5). If the minimum mark in the first test is not achieved (OT1 < 5), the students can repeat this part in the same date of the second objective test.

If OT1 >= 5 and OT2 >= 5 the the final mark of objective tests (OTM), will be the arithmetic mean of the two tests:

OTM = (OT1 + OT2)/2

otherwise, the final mark of this part will be:

OTM = 5 -Sum(Ai)/2 where Ai = max({0; 5-OTi}) for i = 1, 2.

1.b Practical tests

1.b.1 Laboratory

Five laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in pairs.This part also will be assessed by continuous evaluation.

The lecturers will assess the individual student work. They will consider the individual work carried out before the laboratory session to prepare the proposed tasks, the participation, as well as the student work in the session. Marks for each laboratory session (LSM) will be assessed in a 10 points scale. A mark of 0 will be obtained for missing sessions. The final mark of laboratory (FLM) is calculated as the arithmetic mean of the individual laboratory session marks.

In order to pass the laboratory part the students can not miss more than one session and the minimum mark required is of 5 (FLM>=5). These absences must be excused with a valid documented reason (medical, bereavement or other) otherwise he/she will be assigned a grade of 0 for the laboratory part (FLM=0).

1.b.2 Tutored project

In the first session of C hours, lecturers will present the objectives and the schedule of the project. They also assign a specific project to each group. The lecturers will monitor the group work and the individual student work in the following sessions of C hours.

In order to assess the project, the lecturer will consider the developed work, the quality of the obtained results, their

classroom presentation and analysis, and the quality of the final written report if required.The final mark of this part, tutored project mark (TPM), will be assessed in a 10 points scale.

The minimum mark required to pass this part is of 5 (TPM>=5) and the students are only allowed to miss one tutored project session. This absence must be excused with a valid documented reason (medical, bereavement or other).

1.c Final mark of the subject

The weighted points from all assessed parts are added together to calculate the final mark (FM). The following weightings will be applied: 60% objective tests (OTM) and 40% practical tests (25% laboratory (FLM) and 15% tutored project (TPM). In order to pass the subject, students will be required to pass the three parts:

- objective tests: OT1>=5 and OT2>=5.
- laboratory: FLM>=5.
- tutored project: TPM>=5.

In this case, the final mark will be the weighted average of the marks obtained by the student in the different parts:

FM = 0.60·OTM + 0.25·FLM + 0.15·TPM

However, when the students do not pass all parts, the final mark will be calculated using the following expression:

FM = 0.60·AM + 0.25·BM + 0.15·CM, where:

AM = 5 -Sum(Ai)/2 where Ai = max({0; 5-OTi}) for i = 1, 2.

BM = min({5; FLM})

CM = min({5; TPM})

A final mark higher than five points (FM >= 5) should be achieved in order to pass the subject.

2. Single evaluation

The students who prefer a different educational policy can attend an exam on a scheduled date. This exam will comprise three parts (similar to the activities completed by the continuously assessed students): two objective test, laboratory exam and tutored project. Dates will be specified in the academic calendar. In order to attend the laboratory exam and to assign the tutored project, the students have to contact to the lecturer according to an established procedure.

The two objective test will be comprised multiple choice questions and/or short-answer questions and/or problem-solving exercises. Marks for each objective test (OT1 and OT2) will be assessed in a 10 points scale.

The laboratory exam will involved a practical test.The laboratory exam will be assessed in a 10 points scale and this mark will be the final mark of laboratory (FLM).

In order to assess the tutored project, the lecturer will consider the developed work, the quality of the the obtained results, their presentation and analysis, and the quality of the final written report if required. This work will be assessed in a 10 points scale and this mark will be the final mark of this part (TPM).

In order to pass the subject, students will be required to pass the three parts:

- objective tests: OT1>=5 and OT2>=5,
- laboratory: FLM>=5.
- tutored project: TPM>=5.

In this case, the final mark (FM) will be:

FM = 0.60·OTM + 0.25·FLM + 0.15·TPM, where:

OTM will be the arithmetic mean of the two objective tests:

OTM = (OT1 + OT2)/2

However, when the students do not pass all parts, the final mark will be calculated using the following expression:

FM = 0.60·AM + 0.25·BM + 0.15·CM, where:

AM = 5 -Sum(Ai)/2 where Ai = max({0; 5-OTi}) for i = 1, 2.

BM = min({5; FLM})

CM = min({5; TPM})

A final mark higher than five points (FM >= 5) should be achieved in order to pass the subject.

3. Second call and extraordinary call

The evaluation policy in this call will follow the scheme described in the previous sections. Dates will be specified in the academic calendar. The lecturer will assign the tutored work and the project to the student. The student has to contact to the lecturer according to an established procedure. The procedure will be published in advance.

Marks obtained in the previous continuous evaluation or single evaluation are kept if the student have got a pass in some parts. Moreover, students cannot take an exam, develop a project or a tutored work task if they have got a pass previously.

The final mark will be the weighted average of the marks obtained by the student as it has described in section 2.

4. About ethical behaviour of students

In the case that plagiarism is detected in any of the reports/tasks/exams done/taken, the final grade for the subject will be 'fail' (0) and the lecturers will inform the School authorities so that they take the actions that they consider appropriate.

Sources of information

Basic Bibliography

Pérez García, M.A., **Instrumentación Electrónica**, 1ª ed., Ediciones Paraninfo, S.A., 2014

Franco, S., **Diseño con amplificadores operacionales y circuítos integrados analógicos**, 3ª ed., McGraw-Hill, 2004

Fraile Mora, J., García Gutiérrez, P., y Fraile Ardanuy, J., **Instrumentación aplicada a la ingeniería**, 3ª ed., Editorial Garceta, 2013

Pallás Areny, R., **Sensores y Acondicionadores de Señal**, 4ª ed., Marcombo D.L., 2003

Pallás Areny, R., Casas, O., y Bragó, R., **Sensores y Acondicionadores de Señal. Problemas resueltos**, Marcombo D.L., 2008

Pérez García, M.A., Álvarez Antón, J.C., Campo Rodríguez, J.C., Ferrero Martín F.C., y Grillo Ortega, **Instrumentación Electrónica**, 2ª ed., Thomson, 2004

Pérez García, M.A., **Instrumentación Electrónica: 230 problemas resueltos**, 1ª ed., Editorial Garceta, 2012

Complementary Bibliography

Recommendations

Subjects that continue the syllabus

Digital and Analog Mixed Circuits/V05M145V01213

Contingency plan

Description

In case of exclusively online teaching, then the planning will be as follows:
*The teaching in groups A, B and C will be taught through classrooms on the Remote Campus.
*In A sessions, the same content described in the guide will be developed. The tasks in B sessions will be adapted to be carried out with simulators, and when this is not possible, they will be replaced by others that are feasible and that also allow obtaining the competences associated with them. In C sessions, the students will carry out a project assigned by the teacher.

In case of exclusively online teaching, the evaluation will be as follows:
*The objective tests will be carried out synchronously in classrooms of the Remote Campus.
*The following weightings will be applied in order to calculate the final mark (FM) : 50% objective tests (OTM) and 50% practical tests (30% laboratory (FLM) and 20% tutored project (TPM).

IDENTIFYING DATA				
Telecommunication Projects Management				
Subject	Telecommunication Projects Management			
Code	V05M145V01201			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	González Castaño, Francisco Javier			
Lecturers	González Castaño, Francisco Javier Lorenzo Rodríguez, María Edita de			
E-mail	javier@det.uvigo.es			
Web	http://faitic.uvigo.es			
General description	A real approach to telecommunications projects management, including knowledge of telecommunications companies and how they are organized, and novel methodologies for project management and human resoruce management. Knowledge of the main operational divisions: executive, technical, commercial and support.			

Competencies	
Code	
CG2	CG2 Capacity for managing projects and telecommunication systems facilities, complying with current legislation, ensuring the quality of service.
CG3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
CG6	CG6 Capacity for general direction, technical direction and management of research, development and innovation projects in companies and technological centers.
CG10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
CG13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.
CE16	CE16/GT2 Capacity for the development, direction, coordination, and technical and financial management of projects on telecommunications systems, networks, infrastructure and services, including supervision and coordination of the accompanying work subprojects; common telecommunications infrastructures in buildings or residential areas, including projects on digital home; telecommunications infrastructure in transport, and environment; with the corresponding energy supply facilities, and evaluation of electromagnetic emissions and electromagnetic compatibility.
CT1	CT1 Being able to predict and control the evolution of complex situations by developing new and innovative working methodologies matched to the specific scientific / research, technological or professional fields, generally multidisciplinary, in which their activities are conducted.
CT5	CT5 Encourage cooperative work, communication skills, management, planning and acceptance of responsibilities in an environment of multilingual and multidisciplinary work, which promotes education for equality, peace and respect for fundamental rights.

Learning outcomes	
Learning outcomes	Competences
- Knowledge of procedures for innovation and creativeness.	CG2 CG3 CG6 CG10 CG13 CE16 CT5
- Tools for telecommunications projects management.	CG3 CT1
- Management of ideas and innovation basics.	CG2 CG3 CG6 CG10 CG13 CE16 CT5

- Knowledge of efficient project management.	CG2 CG3 CG6 CG10 CG13 CE16 CT5

Contents	
Topic	
Telecommunications companies	- A career in the industry - Structure of a telecommunications company - Management roles Related competencies: CG3, CG6, CT5
Human resource management	- Motivational strategies - Performance analysis - Multidisciplinary coordination Related competencies: CG3, CG6, CT5
Work methodology	- Good practice methodologies - Project methodologies - Certifications Related competencies: CT1, CG5
Regulatory issues	- Specific regulations of Telecommunications Engineering - R&D regulations - Other (environmental, ethics, ...) Related competencies: CG2, CG10, CG13, CE16, CG5

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	10	10	20
Mentored work	5	25	30
Seminars	20	40	60
Essay	2	5	7
Essay	2	5	7
Objective questions exam	1	0	1
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	Classroom lectures Related competencies: all
Mentored work	Group work on selected course contents Related competencies: all
Seminars	Invited conferences and discussion on their topics Related competencies: all

Personalized assistance	
Methodologies	**Description**
Lecturing	Lectures on backing topics. Personalized individual attention will take place during official tutoring times or via e-mail at any time.
Mentored work	Work in groups on course topics. Personalized individual attention will take place during official tutoring times or via e-mail at any time.
Seminars	Seminars by industry professionals. Personalized individual attention will take place during official tutoring times or via e-mail at any time.

Assessment

	Description	Qualification	Evaluated Competencess		
Essay	Two assignments of practical work, to be presented as deliverables and defended in public. Assistance to visits to industries and talks by guest speakers and participation in their discussion.	80	CG2 CG3 CG6 CG10 CG13	CE16	CT1 CT5
Objective questions exam	Written exam. Short-answer questions or multiple-choice test	20	CG2 CG3 CG6 CG10 CG13	CE16	CT1 CT5

Other comments on the Evaluation

According to the degree directives, students will be granted two evaluation calls. The first call will consist in continuous evaluation during the course and an exam at the end of the course. Continuous evaluation will include the preparation and defense of two assignments, at the middle and the end of the course, respectively.

The assignments will be performed in groups. In order to score students individually, the professors will meet with the students at class during their work in the assignments.

The first call exam at the official examination date will cover all course content.

In the second call, single evaluation will consist in an exam at the official examination date including all course content, either with multiple-choice test questions or short-answer questions.

Class atendance is mandatory.

Sources of information

Basic Bibliography

Complementary Bibliography

E. Bueno Campos, **Organización de Empresas: estructura, procesos y modelos**, 2ª,

PMI, **PMBOK Guide and Standards**, 5ª,

F. J. Galán, **Coaching Inteligente ACCION**, Junio 2011,

Recommendations

Contingency plan

Description

In case of exceptional circumstances related to COVID 19 there will be no written exam, and 100% of the assessment will be proportionally divided between the two assignments, including their preparation and presentation, the questions for the peers, and the answer to those questions and the professors'.

IDENTIFYING DATA				
Electronics and Photonics for Communications				
Subject	Electronics and Photonics for Communications			
Code	V05M145V01202			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fernández Barciela, Mónica			
Lecturers	Fernández Barciela, Mónica Fraile Peláez, Francisco Javier Isasi de Vicente, Fernando Guillermo			
E-mail	monica.barciela@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The aim of the subject is that the student adquires knowledge on the actual implementation of transceivers for the modern communication systems that transmit in the radiofrequency and optical bands bands. In the case of RF and MW transceivers, the student will learn to evaluate performance, select and design components and analog circuits (active and passive) for them. As an learning aid, the student will use commercial circuit simulators. In the field of the optical communications, the student will learn the operation of the basic transmission and reception components and active optoelectronical subsystems , and will be able to characterise them and select them as function of the optical system to be designed. In this course the student will handle technical and scientific bibliography in English language.			

Competencies	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CE2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
CE3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
CE12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.
CE13	CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics.

Learning outcomes	
Learning outcomes	Competences
Learn to evaluate preformance, select and design components and analog subsystems (active and passive) for communication transceptors in diferent frequency bands (radiofrequency, microwaves). As learning aid, the student will use circuit simulators.	CG1 CG4 CE2 CE3 CE12 CE13
Learn the operation of the components and basic transmission and reception active optoelectronical subsystems in optical communications and photonic processing, and being able to characterise them and select them as function of the optical system to design.	CG1 CG4 CE2 CE3 CE13
Handle technical documentation and scientific bibliography in English	CE13

Contents	
Topic	
1. Introduction to analog circuit design for RF and Microwave transceivers for communications.	a. Communication systems transmitting at RF and microwave frequency bands. b. Semiconductor technologies and design techniques at the different frequency bands. c. Basic tools: S parameters and Impedance matching networks.

2. RF and Microwave passive circuits design.	Couplers, filters and resonators.
3. Design of Microwave linear amplifiers.	a. Design of bias and stabilization networks. b. Stability circles. Power gain circles. Noise circles. c. Amplifier design for maximum transducer gain. d. Low Noise amplifier design. e. Broadband amplifier design.
4. RF and Microwave power amplifier design.	a. Operating Classes. b. Load-line and power contours. b. Design for maximum output power. c. Linearity and energy efficiency.
5. Design of frequency converters.	Modular design of frequency converters.
6. Frequency Synthesizers	a. Synthesizers based on PLLs. b. Direct digital synthesis.
8. Photonics	a. Semiconductors optical properties. b. Fabry-Perot lasers and DFB. c. Photodetectors. Static and dynamic regime. d. Electro-optic and electro-absorbing modulators.

Planning

	Class hours	Hours outside the classroom	Total hours
Practices through ICT	8	20	28
Lecturing	29	58	87
Problem and/or exercise solving	3	4.5	7.5
Problem and/or exercise solving	0	2.5	2.5

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

Methodologies

	Description
Practices through ICT	This practices apply concepts related to the microwaves technologies part of the subject. They will be performed individually or in small teams of 2 students. With the aid of a commercial microwave and RF circuit simulator, the student will analyze various passive (matching networks, filters, couplers, etc.) and active (amplifiers,..) circuits. It will be defined and evaluated different figures of merit and other parameters that will be used for circuits performance evaluation. In Faitic, the student will have available support files and documentation. Through an agreement between UVIGO and the simulator provider, the student may apply for a temporary license of the simulator for his/her PC. The work of the student in these practice classes will be individually evaluated: 1. In continuous Evaluation: by test/s which include short questions/exercises or the design of some circuits, with the aid of the simulator, during or outside practices hours. 2. In Exam-only Evaluation: by means of short questions/exercises and circuit designs (with or without the aid of the simulator) related with the work performed during the practices in computer rooms. In these practices the student with work towards achieving competencies: CE2, CE3, CE12 y CE13
Lecturing	It will take place in a classroom with video projection facilities, blackboard and occasionally CAD tools. During these sessions it will be described in detail the relevant contents in the Subject program. The applications of some of theses concepts will be done thought exercises resolution, with or without CAD tools. In fact, some classes will be fully theoretical while others will include both theory and applications. The student will have available in Faitic support documentation and files. Competencies under work: CE2, CE3, CE12 y CE13

Personalized assistance

Methodologies	Description
Lecturing	During the master sessions the lecturer will answer the questions addressed by the students. The students will be also guided by the lecturer during the time assigned for personalized attention in his/her office, in which he/she will resolve their questions related to the subject theoretical and practical work, as well as the assessment tests and deliverables.

Practices through ICT	During the practice in computer rooms the lecturer will answer the questions addressed by the students and guide his/her assigned work.

Assessment

	Description	Qualification	Evaluated Competences
Practices through ICT	The work of the student in these practices, related to microwave technologies, will be individually evaluated: 1. In Continuous Assessment: through one/several short examinations with questions/exercises and/or performing simple designs, with the aid of the simulator, during or out of the practices schedule. On of these tests may imply a deliverable involving the design of a circuit. 2. In Exam-only Assessment: by means of short questions/exercises and circuit designs (with or without the aid of the simulator) related with the work performed during practices in computer rooms.	30	CE2 CE3 CE12 CE13
Problem and/or exercise solving	In Continuous Assessment: - There will be 2 Short Examinations with exercise solving (may also include short questions), one related to the microwave technologies part, and other related with Photonics. In Exam-only Assessment: -The Final Exam will also include exercises resolution, with or without the aid of the simulator, and may include short questions.	45	CE2 CE3 CE12 CE13
Problem and/or exercise solving	With respect to the part of the subject related to RF technologies, the students will solve, in individual form or in reduced groups, the proposed exercises/designs, with the help of CAD tools. They will deliver a written report that will be evaluated. The evaluation could be complemented by means of an interview about the performed work.	25	CE2 CE3 CE12 CE13

Other comments on the Evaluation

It is convenient that students be present in all practices in computer rooms, since through them the teacher will guide the student practice home work. It is also convenient for the student to perform all the proposed practices and exercises, in order to achieve the skills required to pass the Subject assessment tools.

First Call:

A) In the case that the student opts for *Continuous Assessment*:

1. The evaluation of the practices in computer rooms, related to microwave technologies, will be done through one/several individual Examinations with the support of CAD tools. One of these tests may be replaced by a deliverable report about a proposed circuit design. The total grade achieved in these assessment test corresponds up to 30% of the Subject Qualification (SQ).
2. The evaluation of the subject part related to RF circuit design, will be done through one or several deliverable reports (performed individually or in group) about some proposed designs or exercises, with the aid of CAD tools. This evaluation may include an interview about the work. The total grade achieved will be up to 25% of the SQ.
3. The rest of the assessment with be individually performed through 2 Short Examinations, that may contain exercise resolution and/or short questions:- Exam 1 related to the microwave technologies content, 20 % SQ.- Exam 2 related to Photonics, 25% SQ. It is assumed that students performing Exam 2 choose Continuous Assessment.

The schedule of the midterm/intermediate exams will be available at the beginning of each academic semester. These intermediate exams do not have "second-chance" examinations.

B) If the student opts for *Exam-only Assessment (100% SQ)*, this exam will involve all the subject content (theory and practices) and include: exercises resolutions and/or designs (with or without the aid of the circuit simulator) and/or short questions.

Second Call and *End-of-program call*:

Students who failed the First Call will perform a similar exam as the one in option B. In particular, students that in the First Call chose continuous assessment and want to preserve his/her qualifications obtained in the microwave part practices (30 % SQ) and the RF part deliverables (25% SQ), they must perform a shorted version of the exam in option B (with a total weight of up to 45% SQ), involving most of the subject content, but excluding the RF part and the simulator aid.

In case of plagiarism detection in any of the proposed works/assessment tools performed by the student, his final Subject qualification will be a failure rate of (0), and the coordinator will communicate the school Board this issue so appropriate measures may be taken.

Sources of information

Basic Bibliography

D.M. Pozar, **Microwave Engineering**, 3,

Guillermo González, **Microwave Transistor Amplifiers: Analysis and Design**, 2,

Bahaa E. A. Saleh, Malvin Carl Teich, **Fundamentals of Photonics**, 2,

Guillermo González, **Foundations of Oscillator Circuit Design**, 1,

Rhea, Randall W., **HF filter desing and computer simulation**, 1,

Complementary Bibliography

Enrique Sánchez, **Introducción a los dispositivos y circuitos semiconductores de microondas**, 1,

Steve C. Cripps, **RF Power Amplifiers for Wireless Communications**, 1,

Steve C. Cripps, **Advanced Techniques in RF Power Amplifier Design**, 1,

Amnon Yariv, Pochi Yeh, **Photonics Optical Electronics in Modern Communications**, 6,

S. O. Kasap, **Optoelectronics and Photonics: Principles and Practice**, 2,

Egan, William F., **Phase-lock basics**, 1,

Rhea, Randall W., **Discrete oscillator design : linear, nonlinear, transient, and noise domains**, 1,

Recommendations

Subjects that continue the syllabus

Microwave and Millimetre Wave Circuit Design and CAD/V05M145V01317

Contingency plan

Description

Teaching of Groups A (theoretical content): classes will be online (synchronous or asynchronous), with the support of the documentation in Faitic.

Teaching of Groups B or teaching of Group A (applications): Through on-line classes (synchronous or asynchronous), the students will be provided of a description/explanation of each practice or problem to solve, he/she may ask questions, so that, besides the supporting documentation and files (as well as the simulator licence), he/she can perform the practices or solve the exercises/designs autonomously at home.

Assessment:

In Continuous Assessment: The 2 short examinations scheduled will take place online (with same weight of CTA and characteristics).

The/s assessment tests/s of the practices (TIC) related to microwave technologies will be performed online (with the support of the simulator). Some of them could be replaced by some deliverable reports about the resolution of proposed problems/designs.

The assessment work/s (deliverables report/s) related to content about RF technologies do not change.

In Exam-only Assessment, the exam will be online (with no other change).

IDENTIFYING DATA				
Advanced Digital Electronic Systems				
Subject	Advanced Digital Electronic Systems			
Code	V05M145V01203			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Valdés Peña, María Dolores			
Lecturers	Moure Rodríguez, María José Valdés Peña, María Dolores			
E-mail	mvaldes@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The objective of this course is to provide students with the ability to design complex or high frequency digital systems. Firstly, the electrical characteristics, power consumption, speed and fan-out of digital integrated circuits and the technologies of semiconductor memories are studied. Subsequently, the interface with external peripherals and the methodology for designing synchronous sequential systems are analyzed. Finally, the course focuses on the design of digital communications systems implemented using high density of integration programmable circuits. Meanwhile, throughout all contents, emphasis is placed in the VHDL description of high complexity digital systems.			

Competencies	
Code	
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE10	CE10 Ability to design and manufacture integrated circuits.
CE11	CE11 Knowledge of hardware description languages for high complexity circuits.
CE12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.
CE14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Learning outcomes	
Learning outcomes	Competences
The knowledge of the different technologies of integrated circuits manufacture.	CE10
The ability to analyze and design advanced digital circuits.	CG4 CE12
The knowledge of different input/output technologies of digital circuits.	CE14
The ability to design input/output interface circuits.	CE10 CE12 CE14
The knowledge of the methodologies for the design of complex digital circuits.	CB5 CG8 CE12
The ability to design communication components using programmable logic devices.	CB4 CG8 CE11 CE12
The ability to design complex digital electronic systems using hardware description languages.	CE11

Contents
Topic

Introdution to digital integrated circuits	CMOS technology: NMOS and PMOS technologies, CMOS gates, CMOS fabrication. HW design methodologies: custom, semicustom, cell-based, array-based, programmable logic devices (FPGAs). SW design methodologies: abstraction levels, design methods, design flow, IPs.
Advanced VHDL	VHDL description of complex digital systems: variables, arrays, records, generics, generate, funcion, procedure. VHDL coding of Finite State Machines. Advances synthesis: inference, primitives, IPs.
CMOS integrated circuits	Design Metrics: voltages, noise, fan-in, fan-out, delay, power. Power issues in FPGAs Input/Output: standard levels, package. Timing issues: set-up, hold, metastability, skew, jitter, clock distribution.
Sequential design	Synchronizers: asynchronous inputs, PLLs, DLLs Clocking resources in FPGAs. Sequential Design methods: Moore and Mealy Finite State Machines.
Semiconductor memories	Architecture of semiconductor memories: RAM, CAM, ROM, EEPROM, FLASH. Memory Interfacing: RAM, DRAM, EEPROM, FLASH interfacing. Memory in FPGAs: distributed, blocks, external memory, memory IPs.
Arithmetic in FPGAs	Numeric representations. Overflow. Techniques to mitigate overflow. Precision vs. hardware cost. Arithmetic operations. Low cost hardware implementations. Design arithmetic considerations for HDL coding.
Frequency synthesis for communication applications	Frequency synthesis using numerically controlled oscillators (NCOs). NCO architecture. Design parameters. Spurious Free Dynamic Range (SFDR) characterization. Design techniques. NCO implementation using FPGAs.
Retiming and pipeline techniques	Signal flow graphs (SFGs). Analysis of the critical path of digital systems. Analysis of the input to output latency. Retiming techniques to reduce propagation delay in digital systems: pipelining and time scaling. Applying retiming techniques to the design of digital filters. Hardware cost. Applying the concepts to the implementation of digital filters using FPGAs.
Series vs. parallel implementation issues	Design techniques: fully serial, fully parallel, serial-parallel. Hardware cost and timing issues. Applying the concepts to the implementation of digital filters using FPGAs.
Hardware-in-the-loop	Description, simulation and test of FPGAs based circuits using Matlab/Simulink. Applying the concepts to the design of data acquisition and signal processing circuits. Using tools for hardware-in-the-loop.
Laboratory Practices	Advanced tools for the design and test of complex digital circuits. Design and implementation of ADC/DAC interfaces, sensor interfaces, digital signal processing modules, communications blocks and memory interfaces.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	22	15	37
Laboratory practical	10	15	25
Project based learning	5	10	15
Objective questions exam	1	10	11
Problem and/or exercise solving	0	10	10
Laboratory practice	0	5	5
Project	0	18	18
Presentation	2	2	4
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Lecturing	The professor explains the theoretical contents of the course, encouraging critical discussion and the student involvement. Reading assignments for each session will be previously available via FaiTIC, and students are expected to come to the theoretical class having completed the assigned reading. Through master sessions the outcomes CB5, CE10, CE11, CE12 and CE14 are developed.
Laboratory practical	During laboratory sessions students apply the design methods described in the master sessions. All the sessions are guided and supervised by the professor. Through laboratory practises the outcomes CG4, CE10, CE11, CE12 and CE14 are developed.
Project based learning	This activity focuses on applying the techniques described in the lecture classes and the skills developed at laboratory to a project implementation. Students should obtain well founded solutions, choosing appropriate methods and devices. These projects are planned and tutored in small size groups. Through master sessions the outcomes CB4, CB5, CG4, CG8, CE10, CE11, CE12 and CE14 are developed.

Personalized assistance

Methodologies	**Description**
Lecturing	Students have the opportunity to solve doubts in personalized attention sessions. The appointment with the corresponding professor should be required and agreed by e-mail, preferably in the hours which are published in the faculty website.
Laboratory practical	Students have the opportunity to solve doubts in personalized attention sessions. The appointment with the corresponding professor should be required and agreed by e-mail, preferably in the hours which are published in the faculty website.
Project based learning	Meetings will be planned with each group of students to supervise the progress of the projects.
Tests	**Description**
Problem and/or exercise solving	Students have the opportunity to solve doubts in personalized attention sessions. The appointment with the corresponding professor should be required and agreed by e-mail, preferably in the hours which are published in the faculty website

Assessment

	Description	Qualification	Evaluated Competencess
Objective questions exam	A questions of development type exam will be done at the end of the term. This exam asses all of the contents taught in the theoretical classes.	20	CE10 CE11 CE12 CE14
Problem and/or exercise solving	Students will solve a set of problems and/or system design exercises. It represents 10% of the final score.	10	CE10 CE11 CE12 CE14
Laboratory practice	This evaluation takes place during the practical sessions. The student should complete at least 4 of the 5 sessions. The implementation of the circuits described in the practice guidelines and the reports submitted at the end on each session will deserve the 30% of the final qualification.	30	CG4 CE10 CG8 CE11 CE12 CE14

Project	The students will develop a design project in groups of 4 or more persons, preferably, demonstrating the skills acquired in the master lessons and laboraory practices. The project represents the 35% of the final grade.	35	CB5	CG4 CG8	CE10 CE11 CE12 CE14
Presentation	At the end of the term students must present the results of their pojects both written and orallly. This activity represents 5% of the final grade.	5	CB4		

Other comments on the Evaluation

A pass mark can be achieved in the subject either by continuous evaluation or single evaluation. Both evaluation methods are excluding. Students who assist to more than 2 laboratory sessions are graded using continuous evaluation.

1. Continuous evaluation

Students who opt for the continuous evaluation method will have two assessment opportunities, a first call at the end of the term and a second call at the end of the course (June July).

The first call consists of four different evaluation activities that will be carried out throughout the term. The dates of all evaluations will be published at the beginning of the term. The weighting and content of each continuous assessment part are as follows:

1.1 Objective questions exam and/or questions of development (NExam):

- It covers all of the contents taught in the theoretical classes. Includes short problems or questions, or multiple answer questions.
- The exam will last 1 hour (type A hour).
- The student passes this part if he/she gets a mark greater than or equal to 4 over 10.

1.2 Problem and/or exercise solving (NExerc):

- It consists of a set of problems and/or design exercises that students must solve and deliver on certain previously stipulated dates.
- These activities would be realized outside the classroom hours.
- The student passes this part if he/she gets a mark greater than or equal to 4 over 10.

1.3 Laboratory practices (NPrac):

- The student should correctly implement the circuits described in the guidelines of the practice and submit a report corresponding to each laboratory session. The qualification of each practice depends on these achievements.
- It can be developed individually or by groups of 2 students. In this last case and if both attend the practice, the qualification is the same for the 2 students.

1.4 Project (NPro):

- It should be carried out by collaborative groups of 3 or more students, preferably.
- The 70% of the final mark (NPro) is obtained from the individual tasks assigned to each student and the 30% from the global tasks of the group.
- As part of the individual tasks, each student will be assigned a theoretical work at the begining of the term. This work consists of a preliminary study of the tasks to be carried out in the project. This previous work represents 5% of the final grade of the project.
- In case of plagiarism or abandonment of a member of a work group is detected, his/her score will be fail (0) and will not compute for the score of the rest of the group.
- The student will pass this part if he/she gets an NPro mark greater than or equal to 4 over 10.

1.5 Presentation of the project results (PPro)

Each student must present the results of the project orally and/or in writing. These activities represent 5% of the final grade of the subject.

1.6 Final qualification of continuous evaluation (Final_ac)

The final qualification (Final_ac) of continuous assessment is obtained as follows:

Final_ac = (NExam*0.2 + NExerc*0.1 + NPrac*0.3 + NPro*0.35 + PPro*0.05) if NExam and Npro are greater than or equal to 4;

Final_ca = min [(NExam*0.2 + NExerc*0.1 + NPrac*0.3 + NPro*0.35 + PPro*0.05), 4] in other case;

The student who fails one or more assessments of the continuous evaluation in the first call can recover the following parts in the second call:

- He/she can take the theoretical exam and this mark replaces the previous one (NExam).
- He/she can complete and present his/her project again and these marks replace the previous ones (NPro and PPro).
- He/she can repeat the problems and / or systems design exercises and this mark replaces the previous one (NExerc).

2. Single evaluation

As with continuous evaluation, students who opt for a single evaluation method will have two assessment opportunities, first call and second call. In both cases the single evaluation will consist of the following parts:

- An exam evaluating all the theoretical contents of the subject. It usually consists of several questions of development and short problems and lasts 2 hours. The pass mark for this exam is 4 out of 10 and deserves 40% of the final qualification (NExam).
- A practical exam covering the same aims of the labortory practices developed in continuous evaluation. This exam lasts 2 hours and represents 20% of the final qualification (NPrac).
- An individual project with the same objectives and complexity of the project developed in continuous evaluation. This project deserves 40% of the final qualification (NPro). It is necessary to obtain a mark greater o equal to 4 out of 10 in order to pass the course.

In the case of single evaluation, the final grade (Final_au) is obtained as follows:

Final_au = (NExam*0.4 + NPrac*0.2 + NPro*0.4) if NExam and Npro are greater than or equal to 4;

Final_au = min [(NExam*0.4 + NPrac*0.2 + NPro*0.4), 4] in any other case;

3. Other comments

- The student can use the Spanish, English or Galician for the reports, works, exams or presentations.
- The grades obtained from the continuous or single evaluation are only valid for the current academic year.
- The use of books, notes or electronic devices such as phones or computers is not permitted in any examination. Mobile phones must be turned off and be out of reach of the student.
- In the case that plagiarism is detected in any of the reports/tasks/exams done/taken, the final score for the subject will be fail (0) and the teachers will inform the School authorities so that they take the actions they consider appropriate.

Sources of information

Basic Bibliography

Complementary Bibliography

Weste N., Harris D., **CMOS VLSI Design. A circuits and systems perspective**, 4, 2011

Roth C.H., John L.K., **Digital systems design using VHDL**, 3, 2008

Sharma A.K., **Semiconductor memories : technology, testing, and reliability**, 1997

Kurinec S.K., Iniewski K., **Nanoscale Semiconductor Memories: Technology and Applications (Devices, Circuits, and Systems)**, 2013

Kleitz W., **Digital Electronics: A Practical Approach with VHDL**, 9, 2011

Comer D.J., **Digital logic and state machine design**, 3, 1995

Wakerly J.F., **Digital Design. Principles and Practices**, 4, 2007

Moure M.J., Valdés M.D:, **Apuntes y prácticas de SEDA**, 2017

Recommendations

Subjects that are recommended to be taken simultaneously

Digital and Analog Mixed Circuits/V05M145V01213
Hardware/Software Design of Embedded Systems/V05M145V01214

Contingency plan

Description

In cases of distance or blended learning all the teaching activities will be carried out using the Remote Campus tool together with the support of the FaiTic platform and email. Besides, the following aspects will be taken into account:

* Lecturing (type A hours):

The theoretical contents of the subject will be remotely taught using the "Campus Remoto" platform.

* Laboratory practices and Project based learning (type B and C hours):

The laboratory practices that can be not developed in the specialized laboratories at the University will be replaced by one or more of the following alternatives:

- Demonstration practices in which the students must attend to them and participate remotely.
- Simulation practices that the students must develop and submit results reports.
- Practices developed with electronic circuits that the students can assembly at home and submit a results report.

The project will be replaced by a theoretical and/or experimental work related to the contents of the subject maintaining its weight in the final grade. In this case, it can be done individually or in groups of 2 students according to the its characteristics and/or its length. The work and guidelines will be published by the teaching staff well in advance.

* Assessment:

The assessment criteria will be the same as in case of classroom or face-to-face teaching.

IDENTIFYING DATA				
Advanced Digital Communications				
Subject	Advanced Digital Communications			
Code	V05M145V01204			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Mosquera Nartallo, Carlos			
Lecturers	Gómez Cuba, Felipe Mosquera Nartallo, Carlos			
E-mail	mosquera@gts.uvigo.es			
Web	http://faitic.uvigo.es			
General description	This course presents advanced topics in digital communications with emphasis on modulations, coding and detection. The covered techniques are part of the state of the art in digital communications, and comprise novel aspects as MIMO systems, cognitive radio or dirty paper coding. Contents, teaching and exams are in English. Students may participate in classes and answer to exams preferably in English, but Spanish and Galician are also accepted.			

Competencies	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE1	CE1 Ability to apply methods of information theory, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing systems and audiovisual communications.
CE2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
CE3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.

Learning outcomes	
Learning outcomes	Competences
Handle the mathematical tools needed to model, simulate and evaluate moderns communication systems.	CG1 CG4 CE1 CE2 CE3
Solve problems whose solution does not derive from the application of a standardized procedure.	CG1 CG4 CG8 CE1 CE2 CE3
Understand the principles underlying modern communication standards.	CG1 CG4 CG8 CE1 CE2 CE3
Design transmitters, receivers and measurement equipment for modern communication systems.	CG1 CG4 CG8 CE1 CE2 CE3

Contents

Topic	
Lectures 1-4: MIMO communications	- Introduction. Array, spatial diversity and spatial multiplexing gains. MIMO channel and signal models. - MIMO transmitter design. Principles of precoding for MIMO. Space-time coding. Multiuser MIMO transmitter design. - MIMO receiver design. Multiuser MIMO receiver design. - MIMO channel capacity.
Lecture 5: Synchronization and spectrum sensing in cognitive radio.	- Motivation and requirements. Spectrum management. Synchronization in cognitive radio. Spectrum sensing.
Lecture 6: OFDM and beyond.	- Principles of orthogonal frequency division multiplexing. Filterbanks and multicarrier. Cooperative diversity.
Lecture 7: Dirty paper coding.	- Code design. Costa's theorem. Opportunistic low SNR codes. Applications in downlink channels.

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	14	29.4	43.4
Lecturing	14	57.6	71.6
Objective questions exam	2	0	2
Problem and/or exercise solving	0	8	8

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

Methodologies

	Description
Laboratory practical	Lab practices will cover different aspects of multiple-input multiple-output (MIMO) communications. This will allow students to practically implement and considerably expand some of the concepts seen in the lectures. Competences: CG1, CG4, CE1, CE2, CE3
Lecturing	The course is structured in several advanced topics in digital communications with emphasis on multiple-input multiple-output (MIMO) communications. Competences: CG1, CG4, CG8, CE1, CE2, CE3

Personalized assistance

Methodologies	Description
Lecturing	The instructors will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (during the master session, or during the office hours). Office hours will be given at the beginning of the course and published in the subject's webpage.
Tests	**Description**
Problem and/or exercise solving	The instructors will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (during the work review sessions or during the office hours).

Assessment

	Description	Qualification	Evaluated Competencess	
Objective questions exam	Final exam with short questions and exercises.	50	CG1 CG4 CG8	CE1 CE2 CE3
Problem and/or exercise solving	Every week a homework challenge will be proposed to be solved with the aid of mathematical analysis, software tools or both. If the solution is not turned in within the allocated deadline, the corresponding assignment will not be graded.	50	CG1 CG4 CG8	CE1 CE2 CE3

Other comments on the Evaluation

A minimum score of 35% with respect to the maximum possible score in the final exam is required to pass the course.

In those cases in which the student decides not to carry out the continuous evaluation tasks, the final score will be solely based on the exam with questions of the subject. This applies as well to the second call.

In case the student does not achieve the minimum score in the final written exam, his/her global score will be obtained using the formula: 0.25*REP+0.25*TEST, where REP is the score achieved in the reports and TEST is the score achieved in the final exam.

In case of collective reports, the respective contribution of each student must be clearly stated, and the final score will be personalized as a function of such contribution. An interview with the lecturer may be required in order to assess the individual contributions.

Once the student turns in any of the deliverables, he/she will be considered to be following the continuous evaluation track. Any student that chooses the continuous evaluation track will get a final score, regardless of whether he/she takes the final exam.

Continuous evaluation tasks cannot be redone after their corresponding deadlines, and are only valid for the current year.

Sources of information

Basic Bibliography

Jerry Hampton, **Introduction to MIMO Communications**, First, Cambridge University Press, 2013

Complementary Bibliography

David Tse and Pramod Viswanath, **Fundamentals of Wireless Communication**, First, Cambridge University Press, 2005
Ezio Bliglieri et al., **Principles of Cognitive Radio**, First, Cambridge University Press, 2012
Behrouz Farhang-Boroujeny, **Signal Processing Techniques for Sotware Radios**, Second, Lulu, 2010
Thomas Cover and Joy Thomas, **Elements of Information Theory**, Second, Wiley, 2006
Robert W. Heath Jr. and Angel Lozano, **Foundations of MIMO Communication**, First, Cambridge University Press, 2018

Recommendations

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===
Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION OF THE METHODOLOGIES ===

* Teaching methodologies are maintained, along with monitoring and assessment mechanisms.

* The interaction with the students will be performed on-line, with lectures and office hours offered in synchronous mode.

* The final exam will be given in take-home format

IDENTIFYING DATA				
Signal Processing in Audiovisual Systems				
Subject	Signal Processing in Audiovisual Systems			
Code	V05M145V01205			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Martín Rodríguez, Fernando			
Lecturers	Martín Rodríguez, Fernando			
E-mail	fmartin@uvigo.es			
Web	http://http://faitic.uvigo.es			
General description	In this course we will describe the main compression and coding techniques for audiovisual signals, paying special attention to MPEG4 standard. We will also explain the main characteristics of MPEG-7 standard for multimedia content description and retrieval.			

Competencies	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CE1	CE1 Ability to apply methods of information theory, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing systems and audiovisual communications.

Learning outcomes	
Learning outcomes	Competences
Learning to exploit perceptual effects and spatial/temporal redundancy to compress audiovisual information.	CG1 CG4 CE1
Understanding information structure into the MPEG4 standard and the reasons because it is needed.	CG1
Understanding main processes applied on audio and video signals to guarantee perceptual quality while reducing bitrate. Knowledge of the main algorithms that are part of standards.	CG1 CG4 CE1
Learning to handle audiovisual information to extract metadata and to use them in indexing and retrieval.	CG1
Understanding structure and usefulness of MPEG7 standard.	CG1

Contents	
Topic	
Introduction to audiovisual compression and coding.	Human perception, redundancy and importance. Compression standards history. Analysis and description of spatial/temporal video structure.
Video coding.	Video compression standards: MPEG 1, 2 & 4; H.261, H.263, H.264 (AVC), H.264 extensions, introduction to HEVC (H.265, MPEG-H part 2).
Audio coding.	Audio compression standards: MPEG 1, 2, 4 (MP3, AAC).
Advanced audiovisual description.	MPEG7. Advanced audiovisual description. Multimedia content management. Information retrieval.

Planning			
	Class hours	Hours outside the classroom	Total hours
Practices through ICT	10	30	40
Mentored work	10	50	60
Lecturing	8	8	16
Objective questions exam	1	0	1
Report of practices, practicum and external practices	1	7	8
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Practices through ICT	Working specific concepts from the theory (master) sessions. We will use computer tools. Related competencies: CG1, CG4, CE1.
Mentored work	Work about the explained concepts, sometimes going beyond. Normally, works are initiated in computer lab work and it will spread over more than one week. Students (in pairs), have to discover (on their own or with teacher assistance) what they need to solve the problem. Results (or at least, part of them) will be presented in public. Related competencies: CG1, CG4, CE1.
Lecturing	Basic concepts exposition. Related competencies: CG1, CG4, CE1.

Personalized assistance	
Methodologies	**Description**
Practices through ICT	Query and answer in the classroom and, if necessary, appointment for office work. Query and answer via e-mail.
Mentored work	Query and answer in the classroom and, if necessary, appointment for office work. Query and answer via e-mail.
Lecturing	Query and answer in the classroom and, if necessary, appointment for office work.
Tests	**Description**
Report of practices, practicum and external practices	Answer to questions about laboratory reports. In assessment, a brief report with correct issues and found errors is sent.

Assessment				
	Description	Qualification	Evaluated Competencess	
Objective questions exam	These tests are based on theory classes concepts.	20	CG1 CG4	CE1
Report of practices, practicum and external practices	The qualification of guided works comprises: achievements, documentation and bibliography selection. There may be more than one exercise. Individual and/or in pairs. If a work is done in pairs, qualification will be equal for both team members.	80	CG1 CG4	CE1

Other comments on the Evaluation

There will be a final exam for those students that did not pass under the continuous assesment, the date will be scheduled by the school officials. Students are also allowed to go directly to the final exam skipping all continuous assessment activities.This exam will be assessed between 0 and 10 and includes all concepts in theory classes and also the techniques being explained commonly for the guided works. To pass, students must achieve a minimum of 5 points.

Those students who did not pass in the first call will be allowed to take an exam in the second call. The same rules as those for the exam in the first call will apply.
The "Objective questions exam" may be written or online. If written it will be held on the oficial exam date.

Sources of information

Basic Bibliography

Fernando Pereira and Touradj Ebrahimi, **The MPEG-4 book**, 978-0130616210, 1, MSC Press Multimedia Series, Pearson Education, 2002

Richardson, Iain E. G., **H.264 and MPEG-4 video compression: video coding for next generation multimedia**, 978-0470848371, 1, Wiley, cop., 2003

Complementary Bibliography

Thiagarajan, Jayaraman, **Analysis of the MPEG-1 Layer III (MP3) Algorithm using MATLAB**, 978-1608458028, 1, Morgan and Claypool, 2011

Recommendations

Subjects that are recommended to be taken simultaneously

Multimedia Communications/V05M145V01206

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

Contingency plan

Description

At a first try, all activities are preferred to be done in person but can be done remotely if necessary.

GROUP A:
- Group A classes using the virtual campus.

GROUP B:
- Group B activities would focus on student work and tutoring meetings through the virtual campus.

ASSESSMENT:
- The submission of group B works is already done remotely (using faitic as document delivery place).
- The final evaluation test has two parts:
A) Multiple choice type, compulsory for all students. It can be done without problem through faitic.
B) Long answer (only for students who do not choose continuous assessment). Desirable in person but can be done online using faitic and remote campus.

IDENTIFYING DATA				
Multimedia Communications				
Subject	Multimedia Communications			
Code	V05M145V01206			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Comesaña Alfaro, Pedro			
Lecturers	Comesaña Alfaro, Pedro			
E-mail	pcomesan@gts.uvigo.es			
Web				
General description	In the subject "Multimedia Communications" information theory basic concepts are presented. Then, lattices are presented as both source coding and channel coding tools. After commenting some generalities about another source coding strategy, namely Trellis Code Quantization, more advanced coding problems, as distributed source coding and joint source-channel coding, are considered.			

Competencies	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CE1	CE1 Ability to apply methods of information theory, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing systems and audiovisual communications.
CE4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
CE6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
CE8	CE8 Ability to understand and know how to apply the operation and organization of the Internet, new generation Internet technologies and protocols, component models, middleware and services.

Learning outcomes	
Learning outcomes	Competences
Understanding the fundamental characterisitcs of a lattice, and the properties we must take into account when facing a source coding problem and a channel coding problem.	CG4 CE1
Understand that a trellis code defines a lattice and why this construction is useful for source coding (Trellis-Code Quantization)	CG4 CE1
Understanding of the different distributed source coding schemes.	CG1 CG4 CE1 CE4 CE8
Implementation of a distributed source coding scheme.	CG1 CG4 CE1 CE6 CE8
Understading of the different schemes of joint source and channel coding.	CG4 CE1 CE4 CE6 CE8
Implementation of a joint and source channel coding scheme.	CG1 CG4 CE1 CE4 CE6
Understanding of the characteristics of different ways of multimedia signal distribution, paying special attention to streaming schemes.	CG1 CE4 CE6 CE8

Asessment of the modularity of new video coding standards (e.g., MPEG-7)	CG1 CE4 CE6 CE8

Contents

Topic	
1) Information theory.	1) Discrete case: Entropy. Conditional entropy. Joint entropy. Mutual information. Kullback-Leibler Divergence. 2) Continuous case: Entropy. Conditional entropy. Joint entropy. Mutual information. Kullback-Leibler Divergence. 3) Jensen's inequality. 4) Shaping gain.
2) Lattices	1) Definition 2) Basic properties
3) Advanced source coding	1) Lloyd-Max quantizer. 2) Trellis Code Quantization.
4) Distributed source coding	1) Lossless coding 2) Lossy coding
5) Joint source-channel coding	1) Shannon's separability principle 2) JSCC practical examples

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	13	44	57
Lecturing	15	30	45
Report of practices, practicum and external practices	0	21	21
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
Laboratory practical	13 hours of PC lab. Programming of computational simulations. The student will simulate, by using a numerical calculus programming language (as Matlab) the multimedia communications systems introduced in this subject. Competencies: CG1, CG4, CE1, CE4, CE6, CE8.
Lecturing	15 hours of theoretical lessons, where practical cases will be introduced. Furthermore, autonomous homework exercises will be proposed. Competencies: CG1, CG4, CE1, CE4, CE6, CE8.

Personalized assistance

Tests	Description
Report of practices, practicum and external practices	Individual feedback on the reports will be provided.

Assessment

	Description	Qualification	Evaluated Competencess	
Laboratory practical	Numerical simulation programming.	20	CG1 CG4	CE1 CE4 CE6 CE8
Report of practices, practicum and external practices	Report on lab practises and reports on related topics.	20	CG1	CE1 CE4 CE6
Essay questions exam	Final exam.	60	CG1 CG4	CE1 CE4 CE6

Other comments on the Evaluation

In order to do the weighted average of the different qualifications (corresponding to continuous assessment), the student

should submit all the corresponding tasks. Furthermore, a minimum mark of 40% should be achieved in the final exam, and a minimum mark of 40% should be achieved in each lab practice. In case that those thresholds were not achieved, the final mark will be the minimum of the final exam mark and each lab mark (all of them over 10 points)

All the tests, practices and reports will be done individually.

Those student who choose to be evaluated by single assessment will have to do the final exam (based on long answer and development questions), as well as a practical exam; the complexity of the latter will be similar to the work done by the continuous assessment students.

The same rules are applied to the second call.

Sources of information

Basic Bibliography

Cover and Thomas, **Elements of information theory**, 978-0471241959, 2, Wiley, 2006

Complementary Bibliography

Artículos científicos especificados por el profesorado,

Recommendations

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

Other comments

Even if this subject has not a series of mandatory prerrequisites, it is highly recommended that the student has a minimal background on:

- Statistics.
- Signal Processing.
- Channel coding.
- Source coding.
- Internet networks and protocols.

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===
Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION OF THE METHODOLOGIES ===
* Teaching methodologies maintained
All of them

* Teaching methodologies modified
None of them

* Non-attendance mechanisms for student attention (tutoring)
Videoconference

* Modifications (if applicable) of the contents
N/A

* Additional bibliography to facilitate self-learning
N/A

* Other modifications

None

* Additional Information
Both in the mixed modality and in the non-face-to-face modality, the evaluation scheme contemplated in the corresponding section of this guide will be maintained; the only difference is that the corresponding tests will be done in a non-face-to-face way. Likewise, the planification of the theory and lab lectures will be independent of the modality; in case of mixed or non-face-to-face modalities, IT tools will be used.

In order to enable as much as possible the self-organization of the work by the students, and preventing possible problems of conciliation and/or connectivity, the material used in each session of the subject will be provided to the students well in advance.

IDENTIFYING DATA				
Optical Communications				
Subject	Optical Communications			
Code	V05M145V01207			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Curty Alonso, Marcos			
Lecturers	Curty Alonso, Marcos			
E-mail	mcurty@com.uvigo.es			
Web	http://faitic.uvigo.es			
General description	We review, in the first place, the physical foundations of optical fibre technology: propagation in fibre and both active and passive optical devices. Next, we analyse different advanced systems for fibre transmission and optical networks, and we discuss techniques to evaluate and design them.			

Competencies	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE13	CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics.

Learning outcomes	
Learning outcomes	Competences
1. Functional knowledge of the essential photonic devices for optical communications: LEDs and lasers, photodetectors, optical modulators, couplers, circulators, AWG, fibre amplifiers, semiconductor optical amplifiers, optical filters, single-mode fibres, multi-mode fibres and multicore fibres.	CG4 CE13
2. Knowledge of the noise models used to characterise the optical transmitter subsystems, optical amplifiers and receivers, and capacity to calculate its impact in terms of the signal to noise ratio and error probability.	CG4 CE13
3. Knowledge of the basic formats of digital transmission by optical fibre, and of analog transmission in systems fibre-radio.	CG4 CE13
4. Knowledge of some advanced systems for fibre transmission: new modulation formats, coherent systems, non-linear systems and dispersion management.	CG4 CG8 CE13
5. Knowledge of the specific technologies of optical networks WDM and DWDM, and options to design them.	CG1 CG4 CE13
6. Knowledge of the optical network topologies for long distance transmission, metropolitan and regional networks, and access optical networks.	CG1 CG4 CE13
7. Knowledge of security techniques to protect optical networks.	CG4 CG8 CE13
8. Knowledge of free-space optical systems and visible light communications.	CG4 CG8 CE13

Contents	
Topic	
1. Introduction to optical communication systems	1.1. Reasons for optical transmission
2. Foundations of optical communications	2.1. Non-monochromatic propagation in linear optical fibres. 2.2. Basic active devices: lasers, LEDs, photodetectors, optical modulators and doped fibre amplifiers. 2.3. Basic passive devices: couplers, splitters and filters.

3. Advanced optical devices	3.1. Active devices: SOA, fibre lasers and Raman amplifiers. 3.2. Passive devices: AWG, gratings, circulators, plastic fibres and multicore fibres.
4. Non-linear effects in fibres and dispersion management	4.1. Stimulated Raman Scattering 4.2. Stimulated Brillouin Scattering 4.3. Dispersion management
5. Digital systems ETDM	5.1. Introduction 5.2. ETDM systems with optical amplifiers 5.3. Dispersion compensation in ETDM systems
6. Advanced optical systems	6.1. Systems fibre-radio. 6.2. Coherent links and new formats.
7. Optical networks	7.1. Systems WDM and DWDM 7.2. Switching technologies 7.3. Wavelength conversion. 7.4. Security in optical networks
Laboratory exercise 1. Dispersion in multi-mode fibres	Characterisation of both the intermodal and intramodal dispersion on a graded index fibre
Laboratory exercise 2. Optical modulator	Characterisation of an optical modulator
Laboratory exercise 3. Systems DWDM	Characterisation of DWDM systems working in third telecom window

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	54	72
Laboratory practical	6	6	12
Case studies	2	12	14
Essay questions exam	2	12	14
Problem and/or exercise solving	1	5	6
Case studies	1	6	7

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

Methodologies

	Description
Lecturing	The professor introduces the main contents of each chapter to the students. Note, however, that these lectures do not cover all the contents of each subject. For that reason, the students have to review the supplementary notes provided in class. It is also expected that the students review the concepts introduced in the classroom and expand on their contents using the guide of each chapter, together with the recommended bibliography, as a reference. Through this methodology the competencies CG1, CG4, CG8 and CE13 are developed.
Laboratory practical	The lectures include some exercises in the lab involving different optical devices and optical communication systems. The students have to read the lab notes provided by the professor before the lab starts. At the beginning of each exercise the professor might request that the students summarise the main concepts related to the exercise. Any doubt can be solved using the office hours of the professor. Through this methodology the competencies CG4, CG8 and CE13 are developed.
Case studies	It consists of activities that complement the master sessions and allow a better understanding of the theoretical concepts. Through this methodology the competencies CG1, CG4, CG8 and CE13 are developed.

Personalized assistance

Methodologies	Description

Lecturing	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course.
Laboratory practical	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course.
Case studies	The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course.

Assessment

	Description	Qualification	Evaluated Competencess	
Essay questions exam	At the end of the semester, the students will perform a final test that covers all the contents of the course.	30	CG1 CG4 CG8	CE13
Problem and/or exercise solving	After the last lab session, the student will perform a test (20%) about the exercises done in the lab. Moreover, before the beginning of chapter 5, the students will perform a test (20%) about the contents of the first 4 chapters of the course.	40	CG4 CG8	CE13
Case studies	It evaluates the work realised by the student in the study of cases proposed in class.	30	CG1 CG4 CG8	CE13

Other comments on the Evaluation

First call:

We will offer to the students two possible assessment systems: continuous assessment or exam-only assessment.

Each student has to decide on one of these two options by the third week of the course. In principle, the professor considers that the student decides continuous assessment unless the student explicitly indicates by written statement to the professor that he decides exam-only assessment at the end of the course.

Continuous assessment:

The continuous assessment comprises a series of tasks that the student has to realise along the course (70%), together with a long answer test (30%) that he/she performs at the end of the course. These tasks include (a) the completion of one short answer test about the lab (20%), which will take place after the last lab exercise, and one short answer test about the first four chapters of the subject (20%) that will take place before starting chapter 5, and (b) the assessment of the activities realised by the student related with the 'case studies' (30%) that has to be completed by the end of the course. The activities related to the 'case studies' could be performed in groups of students. In this case, the mark of the students in this task will be the mark of the group. All these tasks may not be retaken at another point in time. That is to say, if a student cannot fulfill them within the time stipulated by the professor, there is no possibility to do them afterwards. Also, they are only valid for the present academic year.

Those students who decide to opt for a continuous assessment will have to fulfill the following conditions in order to pass the course: (a) perform at least 2 out of the 3 lab exercises; (b) obtain, at least, 12 points out of 30 in the 'case studies'; (c) obtain, at least, 12 points out of 30 in the long answer test; and (d) obtain a minimum of 50 points in total (i.e., taking all the activities into account). The final mark of those students who do not fulfill these minimum requirements will be calculated as follows. It will be the minimum between: (i) the total number of points obtained by the student in all the activities of the course, and (ii) 40 points. That is to say, the maximum mark obtainable for these students is 40 points.

The choice of a continuous assessment necessarily implies that the student is counted as present at the final evaluation, independently of whether or not the student has performed the long answer test.

Exam-only assessment:

In addition to the system of continuous assessment described above, the student can opt for a exam-only assessment. This exam-only assessment covers all the contents of the subject. The professor may demand the student to deliver some additional tasks, which will be notified by the fourth week of the course. These tasks have to be delivered on the day of the final exam. To pass the course the student will have to obtain, at least, 50 points out of 100 in the final exam together with the additional tasks.

Second call:

Those students who opted for a continuous assessment in the first call and fulfill the requirements (a) and (b) above, will be able, if they so wish, to keep the mark obtained in the tasks performed during the continuous assessment (70%). In such a case, they will only take a long answer test (30%). To pass the course, these students will have to obtain, at least, 12 points out of 30 in the long answer test, and obtain a minimum of 50 points in total.

Alternatively, these students can also opt for a exam-only assessment, which covers all the contents of the course. In this case, the students will have to inform the professor one month prior to the final exam. Otherwise, it will be understood that the student opts for a long answer test and to keep the mark obtained in the tasks performed during the continuous assessment.

The rest of students (i.e., those that opted for a system of continuous assessment in the first call and do not fulfil the requirements (a) and (b) above, and those students that opted for a exam-only assessment in the first call) will be evaluated by a exam-only assessment, which covers all the contents of the course.

In the case of choosing a exam-only assessment, the professor may demand the student to deliver some additional tasks, which will be notified to the student one month prior to the final exam. These tasks have to be delivered at the day of the final exam. To pass the course the student will have to obtain, at least, 50 points out of 100 in the final exam together with the additional tasks.

Plagiarism is regarded as serious dishonest behaviour. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.

Sources of information

Basic Bibliography

J. Capmany, F. J. Fraile Peláez y J. Martí, **Fundamentos de Comunicaciones Ópticas**, 2a Edición, Síntesis, 2001

J. Capmany, F. J. Fraile Peláez y J. Martí, **Dispositivos de Comunicaciones Ópticas**, 1a Edición, Síntesis, 1999

Complementary Bibliography

G. P. Agrawal, **Fiber-Optic Communication Systems**, 4a Edición, Wiley-Interscience, 2010

G. Keiser, **Optical Fiber Communications**, 5a Edición, McGraw-Hill, 2014

J. Capmany y B. Ortega-Tamarit, **Redes Ópticas**, 1a Edición, Universidad Politécnica de Valencia, 2006

Recommendations

Subjects that it is recommended to have taken before

Electronics and Photonics for Communications/V05M145V01202

Contingency plan

Description

In the case of online teaching, the planning will be as follows:

- Teaching of Group A: The contents will be the same as those corresponding to face-to-face teaching.

- Teaching of Group B: The hardware exercises in the lab will be replaced by detailed theoretical online explanations about them.

- Assessment: The assessment will be online. We will replace the short answer test about the lab with an oral test (10%), and the resolution of exercises (10%).

IDENTIFYING DATA				
Antennas				
Subject	Antennas			
Code	V05M145V01208			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Díaz Otero, Francisco Javier			
Lecturers	Díaz Otero, Francisco Javier Vazquez Alejos, Ana			
E-mail	frdiaz@uvigo.es			
Web				
General description	The subject devotes to the study of antennas and covers from their electromagnetic bases to their practical design, going through the models of analysis and simulation of the behaviour of the antennas.			

Competencies	
Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CE2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
CE3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
CE5	CE5 Ability to design systems of radio navigation and positioning, as well as radar systems.

Learning outcomes	
Learning outcomes	Competences
To understand the phenomena of electromagnetic radiation and receiving signals	CB4 CG4
Know the main parameters that characterise the behaviour of the transmitting and receiving antennas	CB4 CG4 CE2 CE3 CE5
Know the distinct types of antennas according to their applications and operating frequencies	CB4 CG4 CE2 CE3 CE5
To be able to understand and develop models to simulate the behavior of the antennas and predict their characteristic parameters	CB4 CG4 CE2 CE3 CE5
To be able to cope antenna design exercises for certain specifications	CB2 CB4 CG4 CE2 CE3 CE5

Contents
Topic

1. Electromagnetic antennas Basics Competencies related: CE2, CE3, CE5	1.1 Generalities 1.2 Phenomenon of electromagnetic radiation 1.3 Properties of the field of radiation 1.4 The antenna in transmission 1.5 The antenna in reception 1.6 The antenna in systems of communications and in radar
2. Modeling antennas Competencies related: CB4, CG4	2.1 Linear Antennas 2.2 Aperture Antennas 2.3 Arrays
3. Types of antennas CB4, CG4, CE2, CE3, CE5	3.1 Wire Antennas 3.2 Printed and Slot Antennas 3.3 Horns, lens and reflectors

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	15	15	30
Problem solving	3	6	9
Case studies	8	24	32
Practices through ICT	0	26	26
Problem and/or exercise solving	1	6	7
Laboratory practice	1	6	7
Essay questions exam	2	12	14

*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 of the contents on the subject under study, instructions and exercises or projects to be developed by the student. Competencies CB2, CE2, CE3, CE5
Problem solving	Problems and / or exercises related to the subject. The student should develop appropriate or correct solutions through the exercise routines, applying formulas or algorithms, applying transformation methods available and interpretate the results. Complement of the Master session Competencies CB2, CG4, CE2.
Case studies	Analysis of a fact, problem or real event in order to learn, interpret it, solve it, generate hypotheses, compare data, complete knowledges, diagnose it and train in alternative procedures of solution. Competencies CB2, CG4, CE2, CE3, CE5.
Practices through ICT	Activities of applying knowledge in a given context and acquiring basic and procedural skills in relation to the subject, through ICT. Competencies CB2, CB4, CG4, CE2.

Personalized assistance

Methodologies	Description
Lecturing	Personalized attention. Questions and doubts during teaching timetable
Problem solving	Questions and doubts during teaching timetable and in office hours.
Case studies	Questions and doubts during teaching timetable and in office hours.
Practices through ICT	Questions and doubts during teaching timetable, in office hours, Faitic and e-mail.

Assessment

	Description	Qualification	Evaluated Competences
Problem and/or exercise solving	Conceptual questions on the course syllabus.	10	CB2
Laboratory practice	It will value the quality of the homeworks assigned, the participation and attitude showed in the lectures, as well as the oral presentation of the work.	60	CB2 CB4
Essay questions exam	Final examination: Evaluation of the competencie that includes open questions on a subject. The students have to develop, relate, organise and present the knowledges that have on the matter in an extensive answer to a practical situation posed.	30	CB2 CB4

Other comments on the Evaluation

It will be offered to the students enrolled in this class two systems of evaluation: continuous evaluation and single evaluation.

1. CONTINUOUS EVALUATION
The system of continuous evaluation will consist in:

- A short test to be held in class around the mid-teaching period. 10% rating. Rating EC1, with a maximum of 1 point.
- An antenna design for a particular application. It will be held autonomously through the use of software simulation tools. The student will prepare and deliver a report to be presented in class at the end of the semester. Rating EC2, with a maximum of 6 points. The 6 points of this exercise will be distributed as follows: 2 points for active participation in the sessions (in C groups) dedicated to the design, presentation and discussion; 2 points for the quality of the proposed solution; 1 point for the quality of the report submitted; and 1 point for the quality of the oral presentation.
- An extended-response exercise in which problems of analysis and design of antennas for specific applications will be solved. It will be held in the same day fixed for the regular final exam for the course. 30% rating. Rating EC3, with a maximum of 3 points.
- The continuous assessment tests are not recoverable, ie, if a student can not fulfill them within the stipulated period the teacher is not required to repeat them.
- The final score for continuous assessment (EC) was calculated as the sum of the scores on the three planned tests: EC =EC1 + EC2 + EC3.
- The score on the assessable tasks (EC) will be valid only for the academic year in which they are made.

It is understood that a student receives this rating system when he has made the first test,given the results of the second and made the corresponding oral presentation.At this time the student will be considered as well as presented to the exam.

2. SINGLE EVALUATION - FIRST CALL

It involves:

- A final exam that will assess competencies CB2, CG4, CE2, CE3, CE5. 40% rating. EF1 score, with a maximum of 4 points.
- The day of the exam the student will deliver a report on an antenna design previously assigned. The student will give an oral presentation at a public meeting in the shortest possible time respecting the compatibility with other tests of the same course and certification. Rated EF2 with a maximum of 6 points.
- The EF1 and EF2 partial qualifications may be held only until the single evaluation - second call and within the ongoing course.

3. SINGLE EVALUATION - SECOND CALL

It will follow the same procedure as in the single evaluation - first call. Students, communicating it previously to the start of the exam, may retain their previous note EF1 part (or alternatively EC1 EC3 +) or the EF2 (or EC2) part.

COMMENTS:

- Before the completion or delivery date of each test, the procedure and review of scores will be published within a reasonable period of time.
- Every student that comes to the final test is considered as presented. It will also be considered as presented to the test every student who qualifies for the continuous evaluation system in the terms described above.
- It is considered that the subject is approved if the final grade is equal to or greater than 5.

Sources of information
Basic Bibliography
C. A. Balanis, **Advanced Engineering Electromagnetcis**, 2, Wiley, 2005
C. A. Balanis, **Antenna Theory and Design**, 4, Wiley, 2016
W.L.Stutzman,G.A.Thiele, **Antenna Theory and Design**, 3, Wiley, 2013

Complementary Bibliography

R.S.Elliot, **Antenna Theory and Design**, 1, Prentice Hall, 1981

R.E.Collin, **Antennas and Radiowave Propagation**, 1, Mc Graw Hill, 1985

P.S.Kildal, **Foundations of Antenas. A Unified Approach**, 1, Studentlitteratur,

T.A. Milligan, **Modern Antenna Design**, 2, Wiley, 2005

Recommendations

Subjects that continue the syllabus

Wireless and Mobile Communications/V05M145V01313
Satellites/V05M145V01311
Wideband Radio Systems/V05M145V01312

Subjects that are recommended to be taken simultaneously

Radio Laboratory/V05M145V01209

Subjects that it is recommended to have taken before

Radiocommunication/V05M145V01103

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===
Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

In the case that tuition is exclusively remote, then the planning will be the following: lectures will be scheduled at the same time through the Remote Campus of the University of Vigo. Those lectures will be broadcasted online and later recorded to be viewed in asynchronous mode; tutorials will also be in virtual mode through the remote campus and the necessary materials will preferably be sent through the faitic course platform. In addition, the evaluation will be carried out as follows: problems resolution, laboratory exercises (software), homework assignments and evaluation tests will be sent for resolution remotely by the students.

=== ADAPTATION OF THE METHODOLOGIES ===
* Teaching methodologies maintained
All the indicated teaching methodologies are maintained: lectures, problem solving, case studies and laboratory tests with ICT support

* Teaching methodologies modified
There are no relevant modifications in the exposed methodologies.

* Non-attendance mechanisms for student attention (tutoring)
Tutoring hours indicated in the teaching guide will be maintained, but in classroom 643 in the Remote Campus of the University of Vigo. To access, the appropriate indications will be given.
If necessary, tutoring will be enabled through email and videoconference.

* Modifications (if applicable) of the contents
The scheduled visits (anechoic chamber, televes and airport) will be replaced by video exhibitions detailing the contents that were to be explained in person.

* Additional bibliography to facilitate self-learning
Non applicable

* Other modifications
Non applicable

=== ADAPTATION OF THE TESTS ===
* Tests already carried out
Test XX: [Previous Weight 00%] [Proposed Weight 00%]

...

* Pending tests that are maintained
Problem solving [Previous weight 10%] [Proposed Weight 10%]
Laboratory practice and hmework assignments [Previous weight 60%] [Proposed Weight 60%]
Exam of development questions [Previous weight 30%] [Proposed Weight 30%]

* Tests that are modified
Problem solving [Previous weight 10%] [Proposed Weight 10%]
Laboratory practice and homework assignments[Previous weight 60%] [Proposed Weight 60%]
Exam of development questions [Previous weight 30%] [Proposed Weight 30%]

* New tests
Non applicable

* Additional Information
Non applicable

IDENTIFYING DATA				
Radio Laboratory				
Subject	Radio Laboratory			
Code	V05M145V01209			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Torío Gómez, Pablo			
Lecturers	Torío Gómez, Pablo			
E-mail	ptorio@uvigo.es			
Web	http://faitic.uvigo.es			
General description	Intensification in the knowledge of the diverse systems of radius applying a practical methodology of analysis and synthesis			

Competencies	
Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
CE3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
CE5	CE5 Ability to design systems of radio navigation and positioning, as well as radar systems.
CE13	CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics.

Learning outcomes	
Learning outcomes	Competences
* Knowledge of the basic instrumentation for measuring radiofrequency, microwaves, millimeter and sub-millimeter waves	CB1 CB2 CG8 CE2 CE3 CE5 CE13
* Knowledge of the main configurations for measuring characteristic parameters of different subsystems: Measure of impedance, transmission and reflection coefficients, noise factor, dynamic margin, and field strength level.	CB1 CB2 CG8 CE2 CE3 CE5 CE13
* Knowdlege of experimental characterization techniques regarding the mechanisms of signal propagation.	CB1 CB2 CG8 CE2 CE3 CE5 CE13

Contents
Topic

The students will realise some of the following practical: 1. Basic instrumentation. 2. Measures of active elements. · Measure of parameters of transmission and reflection in quadripoles · Measure of the noise factor · Measure of reception parameters (noise, selectivity, sensitivity, dynamic margin....) · Effect of the LNA in the sensitivity of the receptor and with this measured of propagation. · Measure of amplifiers of power of RF: efficiency, gain,... · Measure of parameters of oscillators. 3. Measure of passive elements · Measured of passive filters of RF: losses, selectivity,.... · Measure of the frequency of cut of a wave guide · Measured of antennas: diagrams, gain and join up electromagnetic. · Measure of common elements of microwaves: circulators, directional couplers,... 4. Measures of propagation. · Measure of mitigation with distance · Measured of mitigation with obstacles. Analysis of the phenomena of transmission and reflection. · Statistical study of the variability of the signal 5. Use of a radar. 6. Measures of electromagnetic compatibility. 7. Measures in millimeter and sub-millimeter bands 8. Design, setting and measure of a LNA 9. Design, setting and measure of an oscillator of RF. 10. Analog modulations 11. Digital modulations 11. Network analyzers 12. Software Defined Radio (SDR) 13. Vector signal generators 14. Digital Video Broadcasting Terrestrial (DVB-T) 15. Digital Radio Mondiale (DRM)	All of the tasks will be carried out as Laboratory Practices, using the equipment available at the School.

Planning			
	Class hours	Hours outside the classroom	Total hours
Case studies	2	10	12
Laboratory practical	22	65	87
Lecturing	4	20	24
Problem and/or exercise solving	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
Case studies	Practical demonstrations. CB1, CB2, CG8, CE2, CE3, CE5, CE13.
Laboratory practical	Setting and measure of circuits and telecommunication systems. Employing specific instrumental. In groups. CB1, CB2, CG8, CE2, CE3, CE5, CE13.
Lecturing	Explanation of the theoretical-practical basis of the work to be developed by the students in the laboratory. CB1, CB2, CG8, CE2, CE3, CE5, CE13.

Personalized assistance	
Methodologies	**Description**
Laboratory practical	Doubts may be solved in the tutorial classes. These will take place in the following way: * Individually or in small groups (typically with a maximum of 2-3 people). * Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email. Place and time will preferrably be as officially scheduled.

Lecturing	Doubts may be solved in the tutorial classes. These will take place in the following way: * Individually or in small groups (typically with a maximum of 2-3 people). * Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email. Place and time will preferrably be as officially scheduled.
Case studies	Doubts may be solved in the tutorial classes. These will take place in the following way: * Individually or in small groups (typically with a maximum of 2-3 people). * Unless the contrary is specified, previous appointment with the professor will be required. The appointment will be requested and acknoledged by email. Place and time will preferrably be as officially scheduled.

Assessment

	Description	Qualification	Evaluated Competencess	
Laboratory practical	Laboratory practises	50		CE2 CE3 CE5 CE13
Problem and/or exercise solving	Short answer tests	50	CB1 CB2	CG8

Other comments on the Evaluation

FIRST CALL:

Two assessment systems are offered:

CONTINUOUS ASSESSMENT, that is the ordinary recommended method, around which educational activities are scheduled.SINGLE ASSESSMENT, which is recommended for those situations in which it results impossible to follow the ordinary method
CONTINUOUS ASSESSMENT
It is assumed that students follow continuous assessment whenever they attend any of the laboratory practices.
The continuous assessment consists of the proofs that detail to continuation:* Laboratory practices. Group assessment (Weight: 50%)* Proof of short answer. Individual assessment (Weight: 50%)
Attendance to the laboratory practices is considered as compulsory.
At the end of each practice session the students must hand in a report, reflecting the results obtained, which constitutes the subject of assessment.

The students choose continous assessment whenever they assist to any practice session and hand in the report.

When group assessment, all group components will obtain the same mark, provided that their contribution in the compulsory attendance sessions is reasonably similar.

Missed quizzes and/or lab classes will not be rescheduled.

EXAM-ONLY ASSESSMENTThe exam-only assessment consists of:* Examination on laboratory practice. Individual assessment (Weight: 50%)* Proof of short answer. Individual assessment (Weight: 50%)
SECOND CALL:The student been evaluated by Continuous Assessment can opt between two possibilities the same day of the examination:* Realise again the Proof of short answer in the official date assigned by the Centre and be evaluated according to the stipulated for the system of CONTINUOUS ASSESSMENT* Be evaluated with an only final examination in the official date assigned by the Centre, as the stipulated for the system of EXAM-ONLY ASSESSMENT.
The student not been evaluated by continuous Assessment:* will be evaluated with an only final examination in the official date assigned by the Centre, as the stipulated for the system of EXAM-ONLY ASSESSMENT
In the event of copycatting at any proof or work, the final assessment will be FAIL (0) and the event will be communicated to the Centre headmaster in order to conduct appropriate measures.

Sources of information

Basic Bibliography

Walter Tuttlebee, **Software defined radio : Enabling technologies**,
Fuqin Xiong, **Digital modulation techniques**,

Complementary Bibliography

Ulrich Reimers, **DVB : The family of international standards for digital video broadcasting**,
M. E. Van Valkenburg, **Network analysis**,
Wes Hayward, **Introduction to radio frequency design**,
George Brown, **Radio and electronics cookbook**,
John Davies, **Newnes radio and RF engineer's pocket book**,
Y.T. Lo, S.W. Lee, **Antenna handbook**,
Rajeswari Chatterjee, **Antenna theory and practice**,

Yi Huang, Kevin Boyle, **Antennas : from theory to practice**,
Walter C. Johnson, **Transmission lines and networks**,
Brian C. Wadell, **Transmission line design handbook**,

Recommendations

Subjects that continue the syllabus

Wireless and Mobile Communications/V05M145V01313
Satellites/V05M145V01311
Wideband Radio Systems/V05M145V01312

Subjects that are recommended to be taken simultaneously

Antennas/V05M145V01208
Optical Communications/V05M145V01207
Electronics and Photonics for Communications/V05M145V01202

Subjects that it is recommended to have taken before

Radiocommunication/V05M145V01103
Signal Processing in Communications/V05M145V01102

Contingency plan

Description

=== ADAPTATION OF THE METHODOLOGIES ===
In the event that teaching cannot be in person, on-site sessions will be substituted by remote sessions and by the resolution of exercises.

=== ADAPTATION OF THE TESTS ===
In the event that assessing cannot be in person, it will be carried out remotely, either by oral exams or by written exams. If required, assessing will be complemented by homeworking or home resolution of exercises.

IDENTIFYING DATA				
Internet Engineering				
Subject	Internet Engineering			
Code	V05M145V01210			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fernández Veiga, Manuel			
Lecturers	Fernández Veiga, Manuel			
E-mail	mveiga@det.uvigo.es			
Web	http://faitic.uvigo.es			
General description	Internet Engineering presents and analises the state of the art on the deployment, operations and configuration of large distributed systems in the Internet. The subject covers the study of advanced channel coding techniques, software defined networking, multipath transmission, and also the architecture and main technical challenges of large data centers. A review of network and service virtualization techniques is also included. Students will achieve skills for innovation and research in the field of network engineering.			

Competencies	
Code	
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CE4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
CE6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
CE7	CE7 Capacity for planning, decision making and packaging of networks, services and applications, taking into account the quality of service, direct and operating costs, plan implementation, monitoring, safety procedures, scaling and maintenance, as well as managing and ensuring quality in the development process.
CE8	CE8 Ability to understand and know how to apply the operation and organization of the Internet, new generation Internet technologies and protocols, component models, middleware and services.

Learning outcomes	
Learning outcomes	Competences
Knowledge and know-how about advanced channel coding techniques	CG4 CE4 CE6
To understand the operations and properties of large distributed systems in the Internet. Deep knowledge and insights about advanced communication system	CG1 CG4 CE4 CE6 CE7 CE8
To learn how to analyze and put into use multi path transmission techniques and congestion control algorithms on different types of networks	CB5 CG4 CG8 CE4 CE6 CE7 CE8
To understand the design principles, the operation and performance of large data centers in the Internet	CB5 CG1 CG4 CG12 CE6 CE7 CE8

To command the principles of network & services virtualization. To learn how to perform resource allocation, to compare alternative architectures and comprehend the underlying Internet economic forces.	CB5 CG1 CG4 CG8 CG12 CE4 CE6 CE7 CE8

Contents	
Topic	
1. The Internet ecosystem	1.1 Technology. Normalisation. Prospective 1.2 Service provisioning 1.3 Economy of Internet
2. Coding for distributed storage	2.1 Locally recoverable codes 2.2 Regenerating codes 2.3 Case studies
3. Advanced channel coding	3.1 Capacity-approaching codes: LDPC, turbo 3.2 Capacity-achieving-codes: polar coding, SC-LDPC 3.3 Network coding
4. Resource allocation	4.1 Resource allocation in cloud systems 4.2 Load balancing techniques 4.3 Randomized policies. Optimal allocations 4.4 Auctioning
5. Coded caching	5.1 Centralized and distributed coded caching 5.2 Edge computing 5.3 Index coding
6. Networking technologies for 5G	6.1 SDN, NFV & network slicing 6.2 M2M, URLLC and NB-IoT communications 6.3 Architectures and models for 5G networks
7. Machine learning for networks	7.1 Data-driven network design 7.2 Model-based network design 7.3 Stochastic models: reinforcement and Q-learning 7.4 Stochastic games

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	13	26	39
Laboratory practical	14	56	70
Laboratory practice	1	0	1
Essay questions exam	2	0	2
Problem and/or exercise solving	0	13	13
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	Descriptive exposure of concepts, technical problems and solutions of the state of the art in the discipline. Emphasis on the critical thinking ability to assess the models, the decisions and the operations of the systems under study. Through this methodology, the competencies CB5, CG1, CG4, CG8, CG12, CE4, CE6, CE7 and CE8 are acquired.
Laboratory practical	Development of an engineering project: design, planning, costs, dimensioning, configuration and testing, deployment and maintenance of a cloud-computing infrastructure. Through this methodology, the competencies CB5, CG1, CG4, CG8, CG12, CE4, CE6, CE7 and CE8 are acquired.

Personalized assistance	
Methodologies	**Description**
Lecturing	Problem solving, advising about the material, recommended bibliography, further explanations of concepts and techniques. Individual mentoring about any of the latter matters.

Laboratory practical	Help with the design, installation, configuration and use of any software piece needed for developing the practical project. Individual office hours.

Assessment

	Description	Qualification		Evaluated Competencess	
Laboratory practice	Functional and performance tests of the assigned engineering project. Critical assessment of the technical solutions, the design decisions and the implementation.	30	CB5	CG1 CG4 CG8 CG12	CE4 CE6 CE7 CE8
Essay questions exam	Written examination, closed books, two hours length. The students will answer questions of conceptual and logical character on any one of the systems, components, algorithms or technologies that have been covered in the lectures.	50		CG1 CG4 CG8 CG12	CE4 CE6 CE7 CE8
Problem and/or exercise solving	Written homework, selected problems and exercises.	20	CB5	CG4 CG8	CE8

Other comments on the Evaluation

The student must choose between two alternative, mutually exclusive assessment method: continuous assessment or eventual assessment.

The continuous evaluation option consists in a final written exam (50% of the qualification), the completion of engineering assignments (30% of the qualification) and homework (20%). These assignments will be due the last working day preceding the start of the examination period. The eventual assessment option consists in a final written exam (60% of the qualification) and in the completion of assignments (40% of the qualification). The assignments will be due the last working day preceding the start of the examination period. The examinations of the continuous and the eventual assessment options may not be equal.

The students must declare their preferred assessment type right after the programming assignment is announced. A student will be considered as defective (not active) upon not manifesting any preference at this point.

The students who fail the course will be given a second opportunity at the end of the academic year to do so. Their academic achievements will be re-evaluated, both with a written exam (theoretical knowledge) and a review of their engineering project looking for improvement or changes. The weights are the same they were committed to, according to their choice.

Any assigned grade will only be valid during the academic year where it is awarded.

Sources of information

Basic Bibliography

P. van Mieghem, **Performance analysis of communications networks and systems**, CambridgeUniversity Press, 2014

P. Goransson, C. Black, **Software defined networking: a comprehensive approach**, Morgan Kauffman, 2014

Complementary Bibliography

R. Srikant, L. Ying, **Communication networks. An optimization, control and stochastic networks perspective**, Cambridge University Press, 2013

M. Medard, A. Sprintson, **Network coding. Fundamentals and applications**, Academic Press, 2011

X. Guang, Z. Zhang, **Linear network error correcting coding**, Springer, 2014

Recommendations

Subjects that it is recommended to have taken before

Network Technologies/V05M145V01104

Contingency plan

Description

In the event that the teaching activities have to be suspended or restricted due to a public health situation, all the duties listed in this guide (lectures, projects, homework, exams) will be carried out online without changes, using the systems enabled for this purpose by the university.

IDENTIFYING DATA				
Wireless Networks and Ubiquitous Computation				
Subject	Wireless Networks and Ubiquitous Computation			
Code	V05M145V01211			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Gil Castiñeira, Felipe José			
Lecturers	Gil Castiñeira, Felipe José Rodríguez Pérez, Miguel			
E-mail	felipe@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The subject "Wireless Networks and Ubiquitous Computing" examines mobile communications, the new services that they enable, and the technologies that support them. That is, this subject studies the different wireless communication systems, the more renowned protocols, the predominant architectures, and the new services enabled by the ubiquitous computing paradigm. The subject is taught in Galician and Spanish, but the documentation is written in English.			

Competencies	
Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CE4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
CE6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
CE7	CE7 Capacity for planning, decision making and packaging of networks, services and applications, taking into account the quality of service, direct and operating costs, plan implementation, monitoring, safety procedures, scaling and maintenance, as well as managing and ensuring quality in the development process.
CE9	CE9 Ability to solve convergence, interoperability and design of heterogeneous networks with local, access and trunk networks; as well as the integration of telephonic, data, television and interactive services.
CE24	CE24/TE1 Ability to understand the fundamentals of distributed systems and distributed computing paradigms, and its application in the design, development and management in grid, ubiquitous computing scenarios and cloud systems.

Learning outcomes	
Learning outcomes	Competences
To understand the basic concepts for wireless communications. To understand the basic concepts behind mobile communications. To know the main protocols and architectures used in wireless and mobile networks. Knowledge of the basis and main concepts of ubiquitous/pervasive computing. To understand the relationship/dependence between ubiquitous computing and context information (context-aware computing). To know different pervasive computing systems. Knowledge of recent advances and trends related to ubiquitous computing.	CB1 CB5 CG3 CG8 CG12 CE4 CE6 CE7 CE9 CE24

Contents	
Topic	
Principles of wireless networks.	Channel characteristics; medium access control; mobility management; routing and discovery; etc.

Architectures and standards.	Wireless access/local/personal area networks; wireless sensor networks; cellular networks. Networking issues related with the connectivity/communication of wireless/mobile devices.
Basis of ubiquitous computing.	Context-aware computing; service architecture; data dissemination and management; sinchronization and consistency; service discovery.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	13	24	37
Laboratory practical	10	10	20
Project based learning	4	59	63
Essay questions exam	2	0	2
Report of practices, practicum and external practices	0	2	2
Essay	1	0	1

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

Methodologies

	Description
Lecturing	Professors will present the main theoretical contents related with wireless networks and ubiquitous computing. This methodology will contribute to develop competences CE4, CE6, CE7, CE9, CE24.
Laboratory practical	Students will complete guided and supervised practices. With this methodology students will develop competences CE4, CE6 and CE24.
Project based learning	Students will work in group in the design, implementation and validation of a protocol, system, application or service. With this methodology students will work in the development of competences CB1, CB5, CG8, CG3, CG12, CE7 and CE9.

Personalized assistance

Methodologies	Description
Lecturing	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered during the master sessions or during tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. This schedule will be published on the subject website.
Laboratory practical	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Te professors will guide and help the students to complete the assigned laboratory practises. Questions will be answered during the lab sessions or during tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. This schedule will be published on the subject website.
Project based learning	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. The professors will guide and help the students to complete the assigned project. Questions will be answered during the supervising sessions, group supervising sessions, or during tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. This schedule will be published on the subject website.

Assessment

	Description	Qualification	Evaluated Competencess	
Lecturing	Students will complete one or several exams to asses what they have learned in master sessions. In case there is more than one exam, the result will be the arithmetic mean of the different tests.	40	CB1	CE4 CE6 CE7 CE9 CE24
Laboratory practical	The students will fill questionnaires and/or reports to asses the correct completion and understanding of the laboratory tasks. The concepts studied in the laboratory can be also part of the final exam.	20	CB1 CB5	CE4 CE6 CE7 CE9 CE24

Project based learning	The students will work iin groups in the design, implementation and proof of a protocol, system, application or service. The result will be evaluated after the delivery, having into account key aspects such as the correction, the quality, the performance and the functionalities. In addition, during the implementation of the project, the design and the evolution of the development will be evaluated. If the intermediate results are not satisfactory, a penalization of the 20% of the grade could be applied. The evaluation will be by group and by person: each one of the members of a team must document his/her tasks and answer the questions related to them.	40	CB1 CB5	CG3 CG8 CG12	CE4 CE6 CE7 CE9 CE24

Other comments on the Evaluation

In order to pass the course it is necessary to complete the different parts of the subject (master sessions, practices in labs, and projects). The final grade will be the **weighted geometric mean** of the grades of the different parts. If "x" is the grade obtained for the master sessions, "y" for the practices in labs, and "z" for the project, the final grade will be:

grade = x^0.4 × y^0.2 × z^0.4

During the first month, students must provide a written declaration to opt for final assessment. In other case, it will be considered that they opt for continuous assessment. Students who select continuous assessment and submit the first task or questionnaire may not be listed as "Absent".

Students who opt for the final assessment procedure must pass the short answer test (40%), submit a project (40%) and submit the laboratory practises (20%). These parts will be evaluated as indicated in the tests description section. The final grade will be the **weighted geometric mean** of the grades of the different parts. Besides, they must submit an additional dossier that must be defended in front of the professors, with detailed information about the events and issues that arose during the execution of the different tasks, and especially the project. In addition, during the first month of the course, professors will notify students who opted for final assessment if they have to do the tutored work individually.

Although the project will be developed in groups, the ongoing activities of each student in a group will be monitored individually. In case a student's performance is below his or her group mates, he or she could be expelled from the group or graded on a individual basis.

Intermediate milestones could be required for the project. In case they are not satisfied, a penalization of the 20% of the grade could be applied.

Second call to pass the course

Students can opt to the second call only if they didn't pass the first call.

In order to pass the course it is necessary to complete the different parts of the subject: pass the short answer test (40%), submit a project (40%) and submit the laboratory practises (20%). These parts will be evaluated as indicated in the tests description section. The final grade will be the **weighted geometric mean** of the grades of the different parts. Besides, it will be necessary to submit an additional dossier that must be defended in front of the professors, with detailed information about the events and issues that arose during the execution of the different tasks, and especially the project.

Students that have opted by the continuous assessment procedure, can decide to maintain the grades of the different parts of the subject obtained in the first call or discard them.

Other comments

The grades obtained are only valid for the current academic year.

Although the tutored work will be completed (if possible) in groups, each student should keep a record of his or her activities. In the case in which the performance of a member of the group wouldn't be adequate compared with the performance of his or her team mates, he or she could be excluded from the group and/or qualified individually.

The use of any material during the tests will have to be explicitly authorized.

In case of detection of plagiarism or unethical behavior in any of the tasks/tests done, the final grade will be "failed (0)" and the professors will communicate the incident to the academic authorities to take the appropriate measures.

Sources of information

Basic Bibliography

Cory Beard, William Stallings, **Wireless Communication Networks and Systems**, 1,

Christopher Cox, **An Introduction to LTE**, 2,

Complementary Bibliography

Viajy Garg, **Wireless Communications and Networking**, 1,

Kaveh Pahlavan, Prashant Krishnamurthy, **Networking Fundamentals: Wide, Local and Personal Area Communications**, 1,

Pei Zheng, Larry L. Peterson, Bruce S. Davie, Adrian Farre, **Wireless Networking Complete**, 1,

F. Adelstein, Sandeep K.S. Gupta, Golden G. Richard III, Loren Schwiebert, **Fundamentals of Mobile and Pervasive Computing**, 1,

John Krumm, **Ubiquitous Computing Fundamentals**, 1,

Jean-Philippe vasseur, Adam Dunkels, **Interconnecting smart objects with IP**, 1,

James F. Kurose, Keith W. Ross, **Computer Networking: A Top-Down Approach**, 7,

Recommendations

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===

Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee, at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION OF The METHODOLOGIES ===

Since in the subject uses specific equipment for "laboratory practices" and for "learning based in projects", in case a distance learning scenario is activated we will proceed as follows:

- In case we have sufficient material or of budget to adquire it, devices will be sent to students to complete the tasks at home.
- In any other case, the pending tasks will be substituted by alternative ones that will be completed with simulators.

IDENTIFYING DATA				
Web Engineering				
Subject	Web Engineering			
Code	V05M145V01212			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Santos Gago, Juan Manuel			
Lecturers	Álvarez Sabucedo, Luis Modesto Santos Gago, Juan Manuel			
E-mail	Juan.Santos@det.uvigo.es			
Web	http://faitic.uvigo.es			
General description	The Web, initially conceived as a simple system for the telematic distribution of information, has become, as a whole, in the database more extensive and heterogeneous existing today. Furthermore, the Web has become an important platform for delivery of sophisticated electronic services in very different domains, such as commerce, education, public and private administration, health, leisure, etc. The fundamental objective of this course is to explore some of the main techniques and mechanisms that underlie the development of Web applications, i.e. the software applications that provide services to users through a Web browser. It is not the aim of this course to delve into the technologies for building dynamic Web pages (it is assumed here that the student has previous knowledge of these issues), but to analyse the techniques and acquire the skills necessary, on the one hand, to be able to locate and use the existing implicit "knowledge" on the Web and, on the other hand, to be able to design and develop services accordingly to the software distribution models that dominate the Web. The course will be taught in Spanish or Galician, although the teaching materials (slides, bibliographic documentation, etc.) will be available predominantly in English.			

Competencies	
Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB3	CB3 Students must integrate knowledge and handle complexity of formulating judgments based on information that was incomplete or limited, including reflections on social and ethical responsibilities linked to the application of their knowledge and judgments.
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG5	CG5 Capacity for development, strategic planning, direction, coordination and technical and financial management of projects in all fields of Telecommunication Engineering following quality and environmental criteria.
CG6	CG6 Capacity for general direction, technical direction and management of research, development and innovation projects in companies and technological centers.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
CE8	CE8 Ability to understand and know how to apply the operation and organization of the Internet, new generation Internet technologies and protocols, component models, middleware and services.

Learning outcomes	
Learning outcomes	Competences
Know the evolution of the Web and understand the technologies in use today	CB5 CG8 CE8
Know and be able to use advanced search techniques for both Web documents and other resources accessible through the Web	CB1 CB2 CB4 CB5 CG8 CE8

Know and be able to use mechanisms to represent and manage knowledge on the Web	CB1 CB2 CB3 CB5 CE8
Know to propound, analyze and design innovative Web applications using the models and patterns that predominate in the Web	CB2 CB4 CG5 CG6 CG8 CE6 CE8

Contents	
Topic	
The Web The contents of this topic are related to the achievement of competency CE8	Historical evolution and current state Underlying technologies
Searching information on the Web The contents of this topic are related to the achievement of competencies CB1, CB2, CB4, CB5 and CE8	Algorithms based on Information Retrieval techniques Algorithms based on link analysis Processing large volumes of data
Knowledge Representation on the Web The contents of this topic are related to the achievement of competencies CB1, CB2, CB3, CB4, CB5 and CE8	Metadata and text indexing Computational logic and logical inference The Semantic Web: Knowledge on the Web accessible to machines Semantic Web technologies Folksonomies and social tagging
Models of services and components for the Web The contents of this topic are related to the achievement of competencies CB2, CB5, CE6 and CE8	Reference models and architectures Description of Web services Common development patterns on the Web
Case Studies The contents of this topic are related to the achievement of competencies CB2, CB3, CB4, CB5, CG5, CG6, CG8, CE6 and CE8	Recommendation services Social Web Internet of Things Collective Web intelligence

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	14	5	19
Practices through ICT	8	32	40
Project based learning	4	32	36
Essay questions exam	2	6	8
Report of practices, practicum and external practices	0	10	10
Project	2	10	12
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	The first session of the course is aimed to present the context in which the subject is framed and to describe the specific activities to be undertaken by the student to achieve the predefined learning objectives. In the subsequent sessions the fundamental concepts addressed in the course are presented in class by the faculty, emphasizing the more complex aspects and proposing possible application scenarios. This methodology is mainly focused to the achievement of the competencies CB1, CB5 and CE8.

Practices through ICT	The faculty proposes a number of exercises in order to practice with the concepts and techniques discussed in the theoretic lectures. In particular, it is envisaged the realization, in pairs, of practical exercises about i) search algorithms of general information and ii) mechanisms to access and make use of information available on the Web, mainly information published by means of Knowledge Representation techniques. This methodology is mainly focused to the achievement of the competencies CB3, CB4, CB5 and CE8.
Project based learning	The students, organized in groups of 3 or 4 people, will have to carry out a complete case study, consisting of the proposal, design, development and presentation of a web application that makes use of the technologies and techniques discussed in first part of the course. This methodology is mainly focused to the achievement of the competencies CB2, CB4, CG5, CG6, CG8, CE6 and CE8.

Personalized assistance

Methodologies	Description
Lecturing	In the master classes, lecturers will solve particular doubts and will give guidance on the theoretical and practical contents.
Practices through ICT	During the practice sessions students will be monitored and any questions that may arise will be addressed. Furthermore, lecturers will be available during tutoring hours to solve doubts.
Project based learning	During the project sessions students will be monitored and any questions that may arise will be addressed. Furthermore, lecturers will be available during tutoring hours to solve doubts.

Assessment

	Description	Qualification	Evaluated Competencess		
Essay questions exam	Students will conduct individually, without supporting material, a knowledge test. This test will consist of a written exam in which questions and exercices relating to theoretical concepts covered in the keynote sessions arise.	35	CB1 CB4 CB5		CE8
Report of practices, practicum and external practices	Students must submit a report for each of the practical exercises proposed by the faculty. The reports must describe quantitatively and qualitatively the solutions adopted, justifying its use over other alternatives when relevant.	35	CB2 CB3 CB4	CG8	CE8
Project	In a first phase, students must prepare a proposal for an innovative project that makes use of technologies and techniques discussed in the course. This proposal will be presented in class and analyzed and valued by classmates (peer review) and by the lecturer according to a predefined rubric. The rubric will be made available to students before the start of the project. In a second phase, at project completion, each group must provide a report that documents the design of the proposed solution and the achieved results. This report will be evaluated by the lecturer based on the attainment of the initial objectives and the quality of the solution used to achieve them.	30	CB3 CB4	CG5 CG6 CG8	CE6 CE8

Other comments on the Evaluation

Two evaluation systems will be offered to the students in this course: Continuous Evaluation and Single Evaluation. Regardless of the evaluation system chosen, the pass mark for the course is 5 out of 10. Below the characteristics of both systems are detailed.

Continuous Evaluation

The student must carry out 5 assessment activities that can be divided into 3 groups:

- 2 practical exercises (practical assessment). These exercises are done by pairs, achieving both members the same score. Each exercise has the same weight and their mean corresponds to the Grade of Practice (GPractice).
- 2 assessment activities related to the development of a project (project assessment) carried out by a group of 3-4 students. The first activity involves the presentation of the project proposal and has a relative weight of 0.4. The second activity concerns the evaluation of the project elaboration, for which "work packages", individually coordinated by each group member, will be defined. Each activity is evaluated according to a predefined rubric which includes elements of group evaluation (e.g. level of innovation of the proposal, degree of utilization of techniques discussed in class) and elements of individual assessment (e.g. quality of the exposition, achievements in the

assigned "work package"). The weighted average of these activities corresponds to the Grade of Project (GProject).

- 1 theoretical examination (theory assessment). The score of this exam corresponds to the Grade of Theory (GTheory).

The student must obtain a minimum grade of 3.5 (out of 10) in each of the groups to pass the course. As long as this condition is met, the final Mark (M) of the student is the weighted average of scores in each group, based on the following relation:

M = 0,35 * GTheory + 0,35* GPractice + 0,30 * GProject

If the student has not achieved a score of 3,5 in any of the groups, the final Mark will be the minimum between 4 and the value obtained according to the above relation.

In addition, the following rules must be observed:

- A student who does not submit the report for the first practice will be considered to have chosen the Single Evaluation modality. On the contrary, if he/she presents this report will be deemed to have opted for the Continuous Assessment modality (and he/she may not appear as "No Presented" in the transcripts). At the end of the first practice, the student will have chosen one of the modalities of evaluation, not being able to change it subsequently.
- The continuous assessment activities are not recoverable. That is, if a student does not attend any of them at the scheduled date, the faculty has no obligation to repeat it.

Single Evaluation

Students who choose the Single Evaluation system shall submit the software and the report of a project whose functionality, scope and formats will be agreed upon with the faculty (at least one month prior to the delivery date). In addition, the student must take a written examination that includes both theoretical questions and problems and practical exercises. The date of the examination and delivery of the project will be established on the School Board and officially communicated through appropriate channels.

The final Mark in this evaluation system is the harmonic mean of the scores obtained in the examination and in the project.

Sencond call

The second call will be governed by a procedure similar to the Single Evaluation system. Thus, the student must submit a project and take a written exam. The final Mark is the harmonic mean. However, if the student had a score in the first call higher than 4 in the project (whether by continuous or single evaluation system) he/she would not be required to submit a new project and he/she would keep the previous score. When submitting the project report and software, the valid score will be always the mark of the new submission. Similarly, if the student had a score higher than 4 in the theoretical part of the single evaluation system or a score higher than 4 considering the unweighted arithmetic mean of GTheory and GPractice of the continuous evaluation system, the student may waive the exam, in which case the score of the theoretical part would be the previously obtained (either the single evaluation exam score or the unweighted arithmetic mean of GTheory and GPractice of the continuous evaluation).

None of the marks obtained in the course will be retained for subsequent courses.

Sources of information

Basic Bibliography

R. Baeza-Yates, B. Ribeiro-Neto, **Modern Information Retrieval. The concepts and technology behind search**, 2th Edition, Addison Wesley,

G. Antoniou, P. Groth, F. van Harmele, R. Hoekstra, **A Semantic Web Primer**, 3th Edition, MIT Press,

Complementary Bibliography

G. Shroff, **The Intelligent Web: Search, smart algorithms, and big data**, Oxford University Press,

W.B. Croft, D. Metzler, T. Strohman, **Search Engines: Information Retrieval in Practice**, Pearson,

J. Domingue, D. Fensel, J.A. Hendler, **Handbook of Semantic Web Technologies**, Springer,

S. Casteleyn, F. Daniel, P. Dolog, M. Matera, **Engineering Web Applications**, Springer,

J. Leskovec, A. Rajaraman, J. Ullman, **Mining of Massive Datasets**, Cambridge University Press,

R. Cailliau, J. Gillies, **How the Web was Born: The Story of the World Wide Web**, 978-0-19-286207-5, Oxford University Press, 2000

T. Berners-Lee, **The next web**, 2009

Recommendations

Contingency plan

Description

In the case of online tuition, the planning of the course will be maintained.

Classes will preferably be held synchronously by telematic means, using the tools provided by the University (Campus Remoto and FaiTIC), although some basic content may be made available to students through videos.

Regarding the evaluation:

- The 2 practice reports are not presential activities, so they do not undergo modifications.
- Regarding the project: the presentation of the proposal by the students will be carried out by telematic means and the delivery of the software and associated documentation is not a presential activity, thus maintaining its format.
- The exam will continue to be a written test that will be monitored using the facilities of the Remote Campus. Students must scan the handwritten responses and upload them to FaiTIC.

IDENTIFYING DATA				
Digital and Analog Mixed Circuits				
Subject	Digital and Analog Mixed Circuits			
Code	V05M145V01213			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Quintáns Graña, Camilo			
Lecturers	Quintáns Graña, Camilo			
E-mail	quintans@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The majority of the electronic systems are a mixture of analogic and digital circuits. Due to this fact, besides studying them separately, it is necessary to consider them as a whole and to know their specific characteristics. From a point of view of the electrical signal, the mixed circuits can use both digital signals with analogic information and analogic signals with digital information. Combining the digital data domain with the analogic and temporal is of fundamental importance for designing complex systems. This subject introduces the students in the multidisciplinary study of the different kind of circuits which conform the electronic systems.			

Competencies	
Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE11	CE11 Knowledge of hardware description languages for high complexity circuits.
CE12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.
CE14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Learning outcomes	
Learning outcomes	Competences
To know and to understand the basics of mixed circuits in order to obtain new applications that combine different methods and resources for the design of complex systems	CB1
To know the modeling of mixed electronic systems by using the mathematical basis of the continuous analog systems and discrete systems.	CG4
The ability to combine different methods and resources for the design of complex systems that include analog and digital circuits.	CG8
The knowledge of the characteristics of the description languages modeling the analog and digital mixed electronic circuits. To be able of modeling mixed electronic systems using hardware description languages.	CE11
Knowing how to combine different methods and resources for the design of complex systems that include analog and digital circuits. To design matching circuits from analog to digital signal processors efficiently. Besides of the output signals from analog systems to digital processors.	CE12
To know how to design specific digital filters and modulators for sampling and reconstruction of signals. To know how to use the modulation techniques for conditioning of sensors and for generating electrical signals to actuators.	CE14

Contents	
Topic	
Unit 1: Introduction to mixed analog and digital electronic circuits.	Mixed circuits characteristics. Modeling, simulation and applications of mixed circuits. Introduction to hardware description languages for analog / digital mixed circuits.

Unit 2: Introduction to direct signal coupling techniques from analog to digital processors.	Introduction. Coupling technology in base band and by modulation. Measurement of time constants. PWM modulation. Sigma-Delta Modulation. Phase modulation. Frequency Modulation. Resources for coupling analog signals to digital processors.
Unit 3: Oversampling Techniques for digital processing of analog signals.	Oversampling techniques. Resolution gain. Reshaping of the quantization noise spectrum. First-order modulator. Modeling, simulation and test of sigma-delta modulators.
Unit 4: Sigma-delta modulators circuits.	Design of sigma-delta modulators with different topologies. Operating parameters. Low-pass and band-pass modulators.
Unit 5: Introduction to multistage A/D converters.	Pipelined A/D converters. Basic steps, timing and alignment. Test methods.
Unit 6: Digital filter circuits for signal sampling and reconstruction applications.	VHDL synthesis of digital filters. Decimation filters. Equalizer filters. Data format. Optimization.
Unit 7: Digital synthesis of signals to feed analog systems.	Methods of digital synthesis of analog signals. Direct synthesis. IIR filters. Modeling of digital synthesizers of analog signals with hardware description languages.
Unit 8: Applications of the mixed electronic circuits.	Modelling and implementation of mixed circuits with high level design tools.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	0.5	1	1.5
Lecturing	10.5	21	31.5
Mentored work	4.5	9	13.5
Problem solving	2	4	6
Laboratory practical	7.5	15	22.5
Laboratory practice	1	11	12
Essay	0.5	1	1.5
Essay questions exam	1	15	16
Problem and/or exercise solving	1	15	16
Systematic observation	1	1	2
Report of practices, practicum and external practices	0.5	2	2.5

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

Methodologies

	Description
Introductory activities	Activities aimed at making contact and gathering information about the students, as well as presenting the subject.
Lecturing	Exhibition by the teacher of the reports on the subject matter of study, theoretical bases and / or guidelines of a work, exercise that the student has to develop.
Mentored work	The student, individually or as a group, carries out activities, which can be: - Monographic works, search of information in publications, databases, articles, books ... on a specific topic. - Preparation of seminars, research, reports, essays, conferences, etc. - Reviews on current scientific articles. - Projects (design and develop projects).
Problem solving	Activity in which problems and / or exercises related to the subject are formulated. The student must develop the correct solutions through the exercise of routines, and application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results.
Laboratory practical	Activities of application of knowledge and concrete situations, and acquisition of basic and procedural skills, related to the object of study. They are developed in special spaces with specialized equipment (laboratories, computer rooms, etc.).

Personalized assistance

Methodologies	Description
Lecturing	The professor will attend personally doubts and queries of the students on the study of the theoretical concepts and exercises. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.
Laboratory practical	The professor will attend personally doubts and queries of the students to prepare the practices of laboratory. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.

Mentored work	The professor will attend personally doubts and queries of the students on the upervised works. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.
Problem solving	The professor will attend personally doubts and queries of the students on the resolution of the problems. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.

Tests	**Description**
Report of practices, practicum and external practices	The professor will attend personally doubts and queries of the students on the preparation of the report of practices. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.

Assessment

	Description	Qualification		Evaluated Competencess	
Laboratory practice	Execution practices of real or simulated tasks. These are tests in which the performance of the students will be evaluated on the basis of the knowledge shown, the behavior, organization and planning during the practice, reflection on the results obtained, etc.	20		CG8	CE11 CE12 CE14
Essay	It is a text prepared on a topic and should be written following established rules.	10	CB1	CG4 CG8	
Essay questions exam	Tests that include open questions about a topic. Students must develop, relate, organize and present the knowledge they have about the subject in an extensive response.	20		CG4 CG8	CE11 CE12 CE14
Problem and/or exercise solving	Test in which the student must solve a series of problems and / or exercises in a time / conditions established by the teacher. In this way, students must apply the knowledge acquired.	25	CB1	CG4 CG8	CE11 CE12 CE14
Systematic observation	Attentive, rational, planned and systematic perception to describe and record the manifestations of student behavior.	10		CG8	
Report of practices, practicum and external practices	Preparation of a report by the student in which the characteristics of the work carried out are reflected.	15		CG8	CE11 CE12

Other comments on the Evaluation

1. First call: Continuous assessment

The continuous evaluation consists of the following four parts:

1.-Laboratory (35%), which is divided into:

Development of laboratory practices: Monitoring (10%) plus the practical test (10%).

Report of laboratory practices (15%).

2.-Theory exams (45%), which is divided in an orientation way in:

Development questions (20%).

Problems (25%).

3.-Tutored work (10%), in which the results will be presented in a report of the C group.

4.-Systematic observation (10%). In addition to the aspects mentioned in the description, the participation of the student in carrying out the activities proposed for their autonomous work and the use of personalized attention in the office hours of the teacher will be taken into account.

The final grade, which is scored on a maximum of 10 points, is the sum of the mark of each part if the following conditions are met:

1.-Have carried out a minimum of the 80% of the laboratory practices.

2.-Obtain a minimum mark of the 40% in each part of the assessment.

If it does not fulfill any of the previous requirements, the final mark will be the sum of the marks of each part, but limited to the 40% of the maximum note (4 points). Students who do not reach a minimum score of 40% in the laboratory evaluation, exams and supervised work in the continuous assessment may recover them in the second opportunity tests while maintaining the percentages of the continuous assessment.

To pass, the students have to obtain an equal total mark or upper to the 50% of the maximum mark (5 points).

The practical test will take place near of the last session of laboratory classes. The development questions and problems will can be divided in two sessions spread along the period of teaching.

2. First call: Final exam

Students who fail the course in continuous assessment (have not performed, at least, 80% of the practices) can will take a final exam.

The final exam will consist of a practical and a theoretical test, each corresponding to 50% of the total mark. To pass the student must obtain at least the 40% in each part and must sum a total of at least 5 points.

The students of continuous evaluation that have pending to surpass the minimum of some part will be able to do it in the final examination. If they did not reach the minimum in the supervised work, they will have a deadline to present the proposed improvements until the final exam.

3. Second call

In the second call the assessment will be like the final exam of the first call.

Sources of information

Basic Bibliography

R. Schreier y G.C. Temes, **Understanding Delta-Sigma Data Converters**, IEEE Press, John Wiley & Sons, Inc., 2005

U. Meyer-Base, **Digital Signal Processing with Fiel Programmable Gate Arrays**, 4, Springer, 2014

Charles H. Roth, Lizy Kurian John, **Digital Systems Design using VHDL**, 3, Cengage Learning, 2017

F. Maloberti, **Data Converters**, Springer, 2008

Complementary Bibliography

C. Quintáns, **Simulación de Circuitos Electrónicos con OrCAD 16 DEMO**, 1, Marcombo, 2008

Steven W. Smith, **The Scientist and Engineer□s Guide to Digital Signal Processing**, California Technical Publishing, 1997

G.I. Bourdopoulos, et al, **Delta-Sigma modulators : modeling, design and applications**, Imperial College Press, 2003

S. J. Orfanidis, **Introduction to signal Processing**, Prentice Hall International, Inc., 1997

Alfi Moscovici, **High Speed A/D Converters: Understanding Data Converters Through SPICE**, Kluwer Academic Publishers, 2006

Libin Yao, Michel Steyaert and Willy Sansen, **Low-Power Low-Voltage Sigma-Delta Modulators in nanometer CMOS**, Springer, 2006

Recommendations

Subjects that continue the syllabus

Signal Conditioners/V05M145V01331

Subjects that are recommended to be taken simultaneously

Advanced Digital Electronic Systems/V05M145V01203

Subjects that it is recommended to have taken before

Analog Electronic Circuits Design/V05M145V01106

Contingency plan

Description

In the case to happen to a stage of teaching totally no face-to-face will apply the following extraordinary measures:

Theory
The contents and his distribution in the distinct parts will keep independently of the format of teaching, face-to-face or no face-to-face.

Laboratory
In this part of laboratory, all the practices will make using a simulator of electronic circuits (available in version of free access), except those that require of the use of instrumentation and specific equipment. In case that along the period of teaching alternate with situations of face-to-face teaching and no face-to-face, will be able to adapt the planning as far as possible to carry out in the laboratory those practices that require of the use of instrumentation and specific equipment.

Documentation and bibliography

As in the situation of normal conditions, the no face-to-face teaching will base in the documentation and other didactic resources that the educational team will put to disposal of the students in the FAITIC platform of the University and of the available basic bibliography in the library.

Evaluation
The contents and the distribution of marks in the evaluation, in both continuous and final, will keep independently of the format of teaching, face-to-face or no face-to-face.
As in the no face-to-face teaching, the objective acts of assessment will carry out in a synchronous way and using the remote available tools in CAMPUS REMOTO and FAITIC. In the practical part will be used the same platform and, moreover, the same free access simulator used in the practices.

IDENTIFYING DATA				
Hardware/Software Design of Embedded Systems				
Subject	Hardware/Software Design of Embedded Systems			
Code	V05M145V01214			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician English			
Department				
Coordinator	Poza González, Francisco			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo Poza González, Francisco			
E-mail	fpoza@uvigo.es			
Web	http://www.faitic.uvigo.es			
General description	The documentation of the subject will be in English. The lectures of the subject can be given in any of the three languages of the subject. The main learning goals of this course are: - To learn the codesign methods to design applications based on embedded microprocessors in FPGAs. - To get to know the microprocessors that can be implemented in commercial FPGAs. - To handle the necessary software tools for the development of embedded applications by means of FPGAs. - To design application specific peripherals and their connection to the buses of the embedded microprocessors. - To design real digital applications with embedded microprocessors in FPGAs.			

Competencies	
Code	
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE11	CE11 Knowledge of hardware description languages for high complexity circuits.
CE12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.

Learning outcomes	
Learning outcomes	Competences
To learn the codesign methods to design applications based on embedded microprocessors in FPGAs.	CB5 CE11 CE12
To get to know the microprocessors that can be implemented in commercial FPGAs.	CB5 CE11 CE12
To handle the necessary software tools for the development of embedded applications by means of FPGAs.	CB5 CE11 CE12
To design application specific peripherals and their connection to the buses of the embedded microprocessors.	CB5 CG1 CG8 CE11 CE12
To design real applications with embedded microprocessors in FPGAs.	CB5 CG1 CG8 CE11 CE12

Contents
Topic

LESSON 1 THEORY. INTRODUCTION TO THE DESIGN OF EMBEDDED SYSTEMS. (1 h.)	1.1. Introduction. 1.2. Programmable Systems On Chip (PSOC). 1.3. Hardware/Software Codesign. Codesign phases. 1.4. Xilinx SOC Zynq family introduction. 1.5. Xilinx Vivado and SDK tools for codesign of embedded systems.
LESSON 2 THEORY. MICROPROCESSOR OF THE XILINX ZYNQ FAMILY SOCs. (0'5 h.)	2.1. ARM processor from Zynq SOC family (Zynq Processing Systems (PS)). 2.2. Processor peripherals from Zynq SOC family. 2.3. Clock, reset and processor debugging. 2.4. AXI interface.
LESSON 3 THEORY. FPGA OF THE XILINX ZYNQ FAMILY SOCs. (0'5 h.)	3.1. Introduction to 7 series Xilinx FPGAs. 3.1.1. Logic resources. 3.1.2. Input/output resources. 3.1.3. Memory and signal processing resources. 3.1.4. Analog to digital converter. 3.1.5. Clock resources.
LESSON 4 THEORY. CONNECTION OF PERIPHERAL CIRCUITS TO THE XILINX ARM MICROPROCESSOR. (1 h.)	4.1.- Introduction. 4.2.- Interface for basic peripherals. GPIO. 4.3.- Interface for advanced peripherals. IPIF. 4.4.- Interface for user coprocessors
LESSON 5 THEORY. SOFTWARE DEVELOPMENT FOR THE XILINX ARM MICROPROCESSOR. (1 h.)	5.1.- Introduction. 5.2.- Structure of the routines for handling of peripherals. 5.3.- Interrupt handle. 5.4.- Program debugging.
LESSON 6 THEORY. HARDWARE / SOFTWARE PARTITIONING. (1 h.)	6.1.- Introduction. 6.2.- Examples of hardware / software codesign. 6.3.- Distribution of tasks between hardware and software.
LESSON 7 THEORY. EMBEDDED SYSTEMS ANALISYS PROJECT. (5 h.)	7.1. Design of a software routine for the assigned function. 7.2. Design of a hardware peripheral (coprocessor) for the assigned function. 7.3. Profiling analysis from software routine and hardware peripheral. Comparison of results.
LESSON 1 LABORATORY. XILINX VIVADO ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS. (1.5 h.)	1.1. Introduction. 1.2. Xilinx Vivado environment. 1.3. Design of basic examples of embedded systems. 1.3.1. Addition of predefined peripherals (IP cores). 1.4. Implementation of the developed systems in Digilent evaluation boards.
LESSON 2 LABORATORY. DESIGN OF BASIC PERIPHERAL CIRCUITS. (2 h.)	2.1. Introduction. 2.2. Development of basic user peripherals. GPIO.
LESSON 3 LABORATORY. DESIGN OF ADVANCED PERIPHERAL CIRCUITS. (1.5 h.)	3.1. Introduction. 3.2. Development of advanced user peripherals (Custom IP).
LESSON 4 LABORATORY. XILINX SDK ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS SOFTWARE. (1 h.)	4.1. Introduction. 4.2. Xilinx Software Development Kit (SDK) environment. 4.3. Basic Design Examples.
LESSON 5 LABORATORY. SOFTWARE DEBUGGING OF EMBEDDED APPLICATIONS. (1 h.)	5.1. Introduction. 5.2. Software debugging of embedded systems by means of the GNU debugger from SDK.
LESSON 6 LABORATORY. HARDWARE VERIFICATION OF EMBEDDED APPLICATIONS. (1.5 h)	6.1. Introduction. 6.2. Embedded systems hardware verification using Vivado hardware analyzer.
LESSON 7 LABORATORY. EMBEDDED SYSTEMS PROFILING. (1.5 h)	7.1. Introduction. 7.2. Software profiler.
LESSON 8 LABORATORY. DESIGN PROJECT. DESIGN OF AN APPLICATION BASED IN XILINX 32-BIT MICROPROCESSORS. (10 h.: 5 h. type B + 5 h. type C)	8.1. Design and test of the assigned application.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	5	10	15
Problem solving	5	20	25
Laboratory practical	10	10	20
Mentored work	9	48	57
Presentation	1	7	8

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

Methodologies	
	Description
Lecturing	Conventional lectures. Through this methodology the outcomes CE11 and CE12 are developed.
Problem solving	Problem based learning (PBL): Problem solving. Design of synthesizable circuits in VHDL and software programs in C language. To solve them, the student has to previously develop certain outcomes. Through this methodology the outcomes CB5, CG1, CG8, CE11 and CE12 are developed.
Laboratory practical	VHDL design of digital circuits and circuit implementation in FPGAs and development of software programs in C language. Integration of both to build an embedded system in a FPGA. Through this methodology the outcomes CB5, CG8, CE11 and CE12 are developed.
Mentored work	Project based learning. The students must design an embedded system to solve a problem. In order to that, the students must plan, design and implement the necessary steps. Through this methodology the outcomes CB5, CG1, CG8, CE11 and CE12 are developed
Presentation	Exhibition of the results of the project developed. Through this methodology the outcomes CB5, CE11 and CE12 are developed.

Personalized assistance	
Methodologies	**Description**
Lecturing	In class, the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours, which will be published in the faculty website.
Laboratory practical	In class, the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours, which will be published in the faculty website.
Problem solving	In class, the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours, which will be published in the faculty website.
Mentored work	In class, the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours, which will be published in the faculty website.

Assessment					
	Description	Qualification	Evaluated Competencess		
Problem solving	Problem Based Learning. Resolution of exercises and theoretical problems. The correct application of the theoretical concepts to the problems will be assessed, based on the published criteria.	25	CB5	CG1 CG8	CE11 CE12
Laboratory practical	Design circuits and programs in the laboratory sessions corresponding to the laboratory lessons 1 to 7. It will be necessary to show to the professor the operation of each one of the circuits and programs. It will be necessary to deliver the design source files. The assessment will be based on the operation of the digital system and the correct application of the theoretical concepts, according to the published criteria.	25	CB5	CG8	CE11 CE12
Mentored work	Project Based Learning. Laboratory Project. Design of an embedded system. It will be necessary to deliver the files source of the work realized. It will be necessary to deliver the design source files. The assessment will be based on the operation of the embedded system and the correct application of the theoretical concepts, according to the published criteria.	40	CB5	CG1 CG8	CE11 CE12
Presentation	It will be necessary to do an oral presentation of 15 minutes as a maximum about the work, according to the index supplied by the teacher.	10	CB5		CE11 CE12

Other comments on the Evaluation

The final mark will be expressed in numerical form ranging from 0 to 10, according to the valid regulation (Royal decree 1125/2003 of 5 September; BOE 18 September).

Following the guidelines of the degree the students will be offered two evaluation systems: continuous evaluation and single

evaluation. Students must choose at the start of the subject if they wish to follow the continuous evaluation or prefer to follow the single evaluation at the end of the semester.

CONTINUOUS EVALUATION IN FIRST CALL

The students that have chosen continuous evaluation, but do not pass the course, will have to do the single evaluation in second call.

The different tasks should be delivered in the date specified by the teacher, otherwise they will not be assessed for the continuous evaluation.

If the number of students allows it, the students will develop the theoretical exercises, the laboratory practices and the laboratory projects individually. In case of doing them in groups of two students the mark will be the same for both.

The students who want to be assessed in the continuous evaluation can only miss two sessions as a maximum. If they miss more than 2 sessions, it will be compulsory to do an additional individual task or an examination.

1) Laboratory practices.

Each laboratory practice will be marked from 0 to 10. Its influence in the total mark of the subject will be weighted in function of the number of hours assigned to each lesson. That is, the mark of the practices will be obtained through the following formula:

LAB = (Mark Lesson 1L + ... + Mark Lesson 7L) / 7

2) Theoretical exercises and problems.

Each one of the theoretical exercises and problems proposed in the theoretical sessions will be evaluated. Each exercise will be marked from 0 to 10. Its influence in the total mark of the subject will be weighted according to the difficulty and length of the exercise.

The main exercise will consist in the design of a software routine and a hardware peripheral to perform the function assigned to each student and compare the performance of both, in terms of execution time and logical resources used. The content corresponds to topic 7 of theory. It will be necessary to show the teacher the operation of each one of the circuits and programs. It will be necessary to deliver a brief report explaining the work done.

The total mark will be the sum of the marks of each one of the exercises:

TE = Exercise 1 + ... + Exercise N

3) Tutored works.

This work consists in the design of an embedded system. The correct operation of the developed circuits and programs will be evaluated. This work will be marked from 0 to 10.

4) Presentation.

The work developed during the laboratory project will be presented. The presentation will be marked from 0 to 10.

In case the students pass the theoretical exercises (TE), the laboratory practices (LAB) and the tutored works (TW), that is, the mark of each part >= 5, the final mark (FM) will be the weighted sum of the marks of each part of the subject:

FM = 0,25 * TE + 0,25 * LAB + 0,40 * TW + 0,10 * OP

In case the students do not pass any of the three main parts of the subject, that is, the mark of any task < 5, the final mark (FM) will be:

FM = Minimum [4'5; (0,25 * TE + 0,25 * LAB + 0,40 * TW + 0,10 * OP)]

Where:

TE = Global mark of the theoretical exercises and problems.

LAB = Laboratory Practices.

TW = Tutored Work.

OP = Oral presentation.

SINGLE EVALUATION IN FIRST AND SECOND CALL

The students that opt for the single evaluation in first call or do not pass the subject and have to do the single evaluation in second call must do an exam, which will be divided into two parts: a theoretical part and a practical part.

The theoretical part will consist in the design of a peripheral with a certain functionality that has an AXI-Lite interface, which allows its connection to a Microprocessor. The mark will be from 0 to 10 and its weight in the final grade will be 40%.

The practical part will consist in the design of a embedded system with the necessary peripherals to perform a certain task. The mark will be from 0 to 10 and its weighting in the final grade will be 60%.

In case the students pass each part, that is, the mark of each part >= 5, the final mark (FM) will be the weighted sum of the marks of each part:

NF = 0,40 * TE + 0,60 * PE

In case the students do not pass any of the parts of the exam, that is, the mark of any part < 5, the final mark (FM) will be:

NF = minimum [4,5; (0,40 * TE + 0,60 * PE)]

Where:

TE = Global mark of the theoretical part.

PE = Global mark of the practical part.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the exercises, the final mark will be FAIL (0), and the incident will be reported to the corresponding academic authorities for appropriate action.

Sources of information

Basic Bibliography

ÁLVAREZ RUIZ DE OJEDA, L.J., POZA GONZÁLEZ, F., **Diseño de aplicaciones empotradas de 32 bits en FPGAs con Xilinx EDK 10.1 para Microblaze y Power-PC**, Vison Libros,

Complementary Bibliography

ÁLVAREZ RUIZ DE OJEDA, L.J., **Diseño Digital con FPGAs**, Vision Libros,

Recommendations

Subjects that are recommended to be taken simultaneously

Advanced Digital Electronic Systems/V05M145V01203

Contingency plan

Description

In the case of teaching entirely online because of health and safety recommendations, the same teaching methodologies and the same assessment methods will be maintained. In case of single assessment, the exam will be replaced by the delivery of the same tasks described in the continuous assessment.

IDENTIFYING DATA				
Integrated Circuits Design and Manufacturing				
Subject	Integrated Circuits Design and Manufacturing			
Code	V05M145V01215			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fariña Rodríguez, José			
Lecturers	Cao Paz, Ana María Fariña Rodríguez, José			
E-mail	jfarina@uvigo.es			
Web				
General description	The objectives in mind are: 1) To know and understand the design methodologies of Integrated Circuits (ICs) based on CMOS technology. 2) To know the basic topologies used in analog electronic circuits. 3) To know how to analyze and dimensioning the devices of the basic topologies of analog circuits in CMOS technology. 4) To know and be capable to use software tools for the design of integrated circuits. 5) To know to specify an integrated circuit for manufacturing in CMOS technology.			

Competencies	
Code	
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE10	CE10 Ability to design and manufacture integrated circuits.

Learning outcomes	
Learning outcomes	Competences
Know the design methodologies of electronic integrated circuits	CE10
Know the basic topologies used in analog electronic circuits	CE10
Can analyze and dimension the devices that form the basic topologies of analog circuits	CB5 CG8 CE10
Know aid software tools integrated circuit design	CE10
Know how an electronic circuit is specified for manufacturing	CB4 CE10

Contents	
Topic	
Chapter 1: Introduction (1h)	Course introduction. Objectives and course planning. Basic concepts of microelectronic design of integrated circuits (ICs).
Chapter 2: Manufacturing sequence for ICs (1h)	Introduction to ICs manufacturing. Planar technology. Manufacturing sequence of ICs in CMOS technology. Structure of MOS transistors. Manufacturing example: CMOS inverter. Masks pattern (layout). Technological design rules. Methodologies and tools for design assistance.
Chapter 3: Physical structure of basic devices and routing strategies (1h)	Specification of the physical structure of MOS transistor. Specification of the physical structure of a resistor. Specification of the physical structure of a capacitor. Strategies for performing transistors with high aspect ratio. Strategies for matched transistors.
Chapter 4: Basic amplifier topologies (2h)	Common source topology. Common drain topology. Common gate topology. Cascode topology. Push_Pull amplifier. Physical design examples.
Chapter 5: Current mirror (3h)	Current sources. Basic structure of a current mirror. Analysis of functioning. Frequency response. Cascode topology. Physical design examples.

Chapter 6: Differential pair (3h)	Differential pair structure. DC analysis. AC analysis. Specifications and design of the physical structure of a self-biased differential amplifier topology. Common mode rejection ratio. Matching of transistors. Slew rate limitations. Physical design examples.
Chapter 7: Operational amplifier (2h)	Two stages operational amplifier. Design parameters. Operational Transconductance Amplifier (OTA). Examples of physical designs.
Chapter 8: Preparing for manufacturing (2h)	Distribution in the base plane. Pad and terminals. Specification formats. Packages.
Laboratory session 1: Introduction to design tools for ICs (2h)	Introduction to design tools for analog ICs. Current mirror example. Electric simulation. Design Rules Check (DRC) and layout extraction.
Laboratory session 2: Design of self-biased differential pair (2h)	Electrical specification. Characterization of DC operating parameters. Characterization of AC operating parameters.
Laboratory session 3: Design of self-biased differential pair II (2h)	DRC and layout extraction. Layout versus schematic (LVS). Post-layout simulation.
Laboratory session 4: Design of a transconductance amplifier (2h)	Electrical Specification. Physical specification. Operation testing.
Laboratory session 5: Preparing for manufacturing (2h)	For the circuit obtained in Laboratory session 4, perform the required steps to create the information needed in order to send the circuit to manufacture.

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	13	26	39
Mentored work	4	28	32
Laboratory practical	9	22.5	31.5
Problem and/or exercise solving	1	3	4
Problem and/or exercise solving	1	3	4
Laboratory practice	1	7	8
Essay	1	5.5	6.5
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Lecturing	The professor will present the relevant concepts of the course. Before each lecture, students must carry out a preparation analysis of the topics to be addressed. The aim is to encourage active participation of students, who may ask questions or expose doubts during the session. For a better understanding of certain content, practical examples or case studies will be discussed
Mentored work	Students will work in small teams (C-type groups) in the physical design and characterization of a circuit consisting of active devices and passive components, under the close guidance of professors. Attendance will be recorded. The activities to be developed by each team are: - Analysis of possible solutions and design alternatives.
Laboratory practical	Students work in groups of two people. They will work with IC CAD tools for IC design, in which they will carried out the definition of an electronic circuit both electrical and physical level, the verification of compliance with specifications and design preparation for manufacturing. Attendance will be recorded and performance of each group in each lab assignment will be evaluated.

Personalized assistance

Methodologies	Description
Lecturing	The teaching staff will attend doubts and enquiries of the students about the theoretical contents, previous preparation of laboratory practices as well as its contents. Professors will also resolve the doubts and enquiries of students about specifications, theoretical and practical aspects of the assigned project as well as those about the content and structure of the explanatory report. In addition, students will be guided about the structure and contents of the sessions of presentation and defense of the results achieved in the project. Students will have the opportunity to attend personalized or group mentoring.
Laboratory practical	The teaching staff will attend doubts and enquiries of the students about the theoretical contents, previous preparation of laboratory practices as well as its contents. Professors will also resolve the doubts and enquiries of students about specifications, theoretical and practical aspects of the assigned project as well as those about the content and structure of the explanatory report. In addition, students will be guided about the structure and contents of the sessions of presentation and defense of the results achieved in the project. Students will have the opportunity to attend personalized or group mentoring.

Mentored work	The teaching staff will attend doubts and enquiries of the students about the theoretical contents, previous preparation of laboratory practices as well as its contents. Professors will also resolve the doubts and enquiries of students about specifications, theoretical and practical aspects of the assigned project as well as those about the content and structure of the explanatory report. In addition, students will be guided about the structure and contents of the sessions of presentation and defense of the results achieved in the project. Students will have the opportunity to attend personalized or group mentoring.

Assessment

	Description	Qualification	Evaluated Competencess	
Problem and/or exercise solving	As part of the continuous evaluation, it will take place in mid-course an individual written test of 30 minutes, in one of the lecture sessions. This test will involve 10% of the final grade. This test is the last chance for students to decide whether or not they opt for continuous evaluation. All students completing the test implicitly choose to follow continuous evaluation. The remaining students have to explicitly declare their choice. The lack of declaration from a student means he/she will not follow continuous evaluation. Another written test of 60 minutes will be held in the date of the final exam. This test will have two parts and it is compulsory in whole for students not in continuous evaluation. Students in continuous evaluation can also voluntarily complete the first part since the contents correspond to the first written test. In that case, the score they will receive in this part of the course evaluation will be the one achieved in this second test. The second part of the test is mandatory for all students. Each of the parts will involve 10 % of the final qualification. To pass the course, students must achieve in each part a mark of 4 or higher in a 0-10 scale (or in the intermediate test, where appropriate). Competences CE10 and CB4 will be assessed in these tests.	10	CB4	CE10
Problem and/or exercise solving	At the end of the theoretical content, students will have a second 60-minute exam, during one of the lectures. This test will represent 10% of the final grade. On the date of the final exam there will be another one-hour written test of this kind, compulsory in its entirety for students who do not opt for continuous evaluation. For students in continuous assessment, it will be voluntary, since the contents correspond to those of the second test. Students who voluntarily present themselves will be substituted for the second test grade for which they obtain in this part. The mark of this exam will be 10% of the final grade. To pass the subject it will be necessary to obtain at least a score of 4 out of 10 in each of the parts of the final test (or in the intermediate test, when appropriate). In this test the competences CE10, CB4 and CG8 are evaluated.	10	CB4	CE10
Laboratory practice	As part of the continuous assessment of the subject, each student will be evaluated for each of the practices. In the evaluation will take into account the work of preparation prior to the realization of the practice, assistance, punctuality and use. The previous work will have a maximum weight of 30% of the practice grade. The total qualification of the practices will be obtained as an arithmetic average of the qualification of each of them. To be able to make the average, it is necessary to obtain in each practice a grade equal to or greater than 30% of the maximum score of the practice. For justified reasons you can stop doing one of the practices. The note corresponding to this practice will be zero (0.0). If the criterion of the mean can not be applied, the mark of this part will be calculated multiplying by 0.42 the note obtained with the weighted average and it will not be compensable with the theory mark. The internship note is not kept for successive academic courses.In this test the CE10, CB4, CB5 and CG8 skills are evaluated.	20	CB4 CB5	CG8 CE10

Essay	The evaluation of the work will be performed from memory supporting and public presentation of results. Each group of students you must submit a report of the work has been carried out, indicating expresses the contribution of each to the whole, as well as methodology followed for the distribution and coordination of tasks. The evaluation of the work will be based on the following aspects: - Analysis of alternatives - Correct implementation and design verification - Design compaction - Use of appropriate strategies to minimize the effects of imperfections in the manufacturing process and to ensure good matching of the electrical characteristics between components or devices that like this require it by functional reasons. - Information for integrated circuit manufacturing. - Formal aspects: clarity and order, including figures and appropriate and outstanding data, as well as explanations in a concrete and comprehensive way. Each student will have an individual public exposure of the project has personally performed (including tasks planning and coordination if applicable). The presentations of the students from each group will be out in the same session, 1 hour. Each student will have 5 minutes for their presentation. At the end of the presentation, students must answer questions from teachers and other students present. The evaluation will be based on both the content and formal aspects of the presentation and the answers to questions. It may also assess positively to students who perform relevant questions. The explanatory report should be submitted at least two days before public presentation of work. To pass the course, the student will need obtain at least a score of 5 over 10 in memory, get to least a score of 5 out of 10 in public presentation. In the evaluation of the practical tests, the memory note will weigh 70% and the presentation 30%. In this test the CE10, CB4, CB5 and CG8 skills are evaluated.	60	CB4 CG8 CE10

Other comments on the Evaluation

- Final test will be 50% of the overall grade of the course. It will consist of two parts: short answer questions and resolution of problems. The part of the questions will represent 40 % of the test qualification and the part of resolution of problems the other 60%. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.
- They must develop a project, and deliver the corresponding report and public presentation (in the same sessions and with the same criteria as students in continuous evaluation). Reports are due two days before the public presentation. The project qualification will involve 50% of the overall grade of the course. In the final qualification of the project, the memory report has a corresponding percentage of 70% and the other 30% is obtained from the qualification of the presentation. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

Students not passing the course in the first call will have the opportunity to attend a second call. To pass the course, students must achieve in each part at least 50 % of the maximum score.

Sources of information

Basic Bibliography

R. Jacob Baker, **CMOS Circuits desing, Layout and Simulation**, 978-0-470-88132-3, 3º, John Wiley and Sons, 2010

Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, **Analysis and Design of Analog Integrated Circuits**, 978-0-470-39877-7, 5º, John Wiley and Sons, 2010

Behzad Razavi, **Design of Analog CMOS Integrated Circuits**, 978-0-07-252493-2, 2º, McGraw Hill, 2017

Stephen A. Campbell, **Fabrication Engineering at the micro-and nanoscale**, 978-0-19-986122-4, 4º, Oxford University Press, 2012

Complementary Bibliography

Recommendations

Contingency plan

Description

=== EXCEPTIONAL PLANNING ===

Given the uncertain and unpredictable evolution of the health alert caused by COVID-19, the University of Vigo establishes an extraordinary planning that will be activated when the administrations and the institution itself determine it, considering safety, health and responsibility criteria both in distance and blended learning. These already planned measures guarantee,

at the required time, the development of teaching in a more agile and effective way, as it is known in advance (or well in advance) by the students and teachers through the standardized tool.

=== ADAPTATION OF THE METHODOLOGIES ===
A the same as in the situation of presence, the delivery of classroom teaching will be based on documentation and other teaching resources that team teaching available to students on the platform teleteaching University and the basic literature available in library. In practice, the same environment design, simulation and testing of integrated circuits in open access versions will be used. Theoretical and practical classes and tutorials will be taught through the remote campus of the University.

=== ADAPTATION OF THE TESTS ===
Evaluation methods and their weights are maintained and, in the case of objective evidence, they will be synchronously remotely using the tools available on campus and remote platform teleteaching.

IDENTIFYING DATA				
(*)Comunicación de Datos				
Subject	(*)Comunicación de Datos			
Code	V05M145V01CFG300301			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	1st
Teaching language				
Department				
Coordinator	Herrería Alonso, Sergio			
Lecturers	Herrería Alonso, Sergio			
E-mail	sha@det.uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Transmisión Electromagnética				
Subject	(*)Transmisión Electromagnética			
Code	V05M145V01CFG300303			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	2nd
Teaching language				
Department				
Coordinator	Vera Isasa, María			
Lecturers	Vera Isasa, María			
E-mail	mveraisasa@uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Procesado Dixital de Sinais				
Subject	(*)Procesado Dixital de Sinais			
Code	V05M145V01CFG300304			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	1st
Teaching language				
Department				
Coordinator	Docio Fernández, Laura			
Lecturers	Docio Fernández, Laura			
E-mail	ldocio@gts.uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Redes de Ordenadores				
Subject	(*)Redes de Ordenadores			
Code	V05M145V01CFG300403			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	2nd
Teaching language				
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	López Ardao, José Carlos			
E-mail	jardao@det.uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Técnicas de Transmisión e Recepción de Sinais				
Subject	(*)Técnicas de Transmisión e Recepción de Sinais			
Code	V05M145V01CFG300404			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	2nd
Teaching language				
Department				
Coordinator	López Valcarce, Roberto			
Lecturers	López Valcarce, Roberto			
E-mail	valcarce@gts.uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----

IDENTIFYING DATA				
(*)Servizos de Internet				
Subject	(*)Servizos de Internet			
Code	V05M145V01CFG300501			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	1st
Teaching language				
Department				
Coordinator	Gil Solla, Alberto			
Lecturers	Gil Solla, Alberto			
E-mail	alberto.gil@uvigo.es			

----- UNPUBLISHED TEACHING GUIDE -----