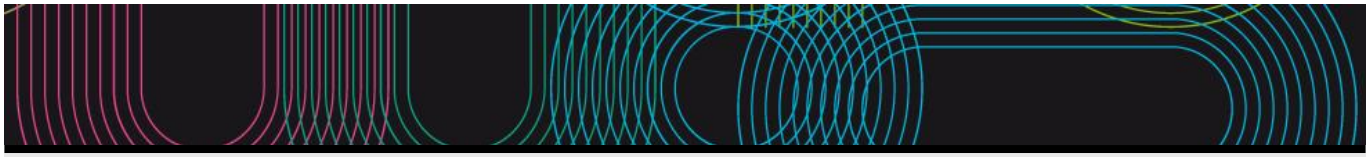

(*)Escola de Enxeñaría de Telecomunicación

(*)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

Directora: Rebeca Pilar Díaz Redondo (teleco.direccion@uvigo.gal)

Secretaría e Subdirección de Novas Titulacións: Pedro Rodríguez Hernández

(teleco.subdir.secretaria@uvigo.gal;teleco.subdir.novastitulacions@uvigo.gal)

Subdirección de Organización Académica: Pedro Comesaña Alfaro (teleco.subdir.academica@uvigo.gal)

Subdirección de Relaciones Internacionais e Subdirección de Infraestructuras: María Verónica Santalla del

Río (teleco.subdir.internacional@uvigo.gal; teleco.subdir.infraestructuras@uvigo.gal)

Subdirección Difusión e Captación: Laura Docio Fernández (teleco.subdir.captacion@uvigo.gal)

Subdirección de Calidade: Ana María Cao Paz(teleco.subdir.calidade@uvigo.gal)

BACHELOR□SDEGREE IN TELECOMMUNICATION TECHNOLOGIES ENGINEERING

Generalcoordinator: Lucía Costas Pérez (teleco.grao@uvigo.gal)

https://teleco.uvigo.es/es/documentos/acordos-es/comisions-academicas-es/miembros-de-la-comision-academica-del-gett/

MASTER IN TELECOMMUNICATION ENGINEERING

Generalcoordinator: Manuel García Sánchez (teleco.master@uvigo.gal)

https://teleco.uvigo.es/es/documentos/acordos-es/comisions-academicas-es/miembros-de-la-comision-academica-del-met/

MASTER INCYBERSECURITY

General coordinator:Ana Fernández Vilas (teleco.munics@uvigo.gal)

https://teleco.uvigo.es/es/documentos/acordos-es/comisions-academicas-es/miembros-de-la-comision-academica-del-munics/

MASTER ININDUSTRIAL MATHEMATICS

Generalcoordinator: Elena Vázquez Cendón (USC)

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

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

INTERNATIONALMASTER 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/

MASTER'S DEGREE IN QUANTUM INFORMATION SCIENCE AND TECHNOLOGIES (MQIST)

General coordinator: Javier Mas (USC)

Coordinador UVIGO: Manuel Fernández Veiga(teleco.mqist@uvigo.es)

https://quantummastergalicia.es/info

Máster Universitario en Ingeniería de Telecomunicación

Subjects			
Year 1st			
Code	Name	Quadmester	Total Cr.
V05M145V01101	Telecommunication Engineering in the Information Society	1st	5
V05M145V01102	Signal Processing in Communications	1st	5
V05M145V01103	Radiocommunication	1st	5
V05M145V01104	Network Technologies	1st	5

V05M145V01105	Application Technologies	1st	5
V05M145V01106	Analog Electronic Circuits Design	2nd	5
V05M145V01201	Telecommunication Projects Management	2nd	5
V05M145V01202	Electronics and Photonics for Communications	2nd	5
V05M145V01203	Digital electronics	1st	6
V05M145V01204	Advanced Digital Communications	2nd	5
V05M145V01205	Signal Processing in Audiovisual Systems	1st 2nd	5
V05M145V01206	Multimedia Communications	2nd	5
V05M145V01207	Optical Communications	2nd	5
V05M145V01208	Antennas	2nd	5
V05M145V01209	Radio Laboratory	2nd	5
V05M145V01210	Internet Engineering	2nd	5
V05M145V01211	Wireless Networks and Ubiquitous Computation	2nd	5
V05M145V01212	Web Engineering	2nd	5
V05M145V01213	Digital and Analog Mixed Circuits	2nd	5
V05M145V01214	Hardware/Software Design of Embedded Systems	2nd	5
V05M145V01215	Integrated Circuits Design and Manufacturing	2nd	5

Year 2nd

Code	Name	Quadmester	Total Cr.
V05M145V01301	Real-Time Signal Processing	1st	5
V05M145V01302	Communication Advanced Systems	1st	5
V05M145V01303	Statistical Signal Processing	1st	5
V05M145V01311	Satellites	1st	5
V05M145V01312	Wideband Radio Systems	1st	5
V05M145V01313	Wireless and Mobile Communications	1st	5
V05M145V01317	Microwave and Millimetre Wave Circuit Design and CAD	1st	5
V05M145V01318	Multimedia Security	1st	5
V05M145V01319	Intelligent Sensors	1st	5
V05M145V01321	Distributed Computing	1st	5
V05M145V01322	Data analysis	1st	5
V05M145V01323	Economical and Social Networks	1st	5
V05M145V01324	Internship in Companies I	1st	5
V05M145V01325	Internship in Companies II	1st	5
V05M145V01326	Internship in Companies III	1st	5
V05M145V01330	Photovoltaic Power Electronics	1st	5
V05M145V01331	Signal Conditioners	1st	5

V05M145V01332	Electronic Equipments Implementation and Exploitation	1st	5
V05M145V01401	Master Thesis	2nd	30

Year 1st

Code	Name	Quadmester	Total Cr.
V05M145V01CFG300301	Data Communication	1st	6
V05M145V01CFG300303	Electromagnetic Transmission	2nd	6
V05M145V01CFG300304	Digital Signal Processing	1st	6
V05M145V01CFG300403	Computers Networks	2nd	6
V05M145V01CFG300404	Signal Transmission and Reception Techniques	2nd	6
V05M145V01CFG300501	Internet services	1st	6
V05M145V01CFG301109	Computer Science: Computer Architecture	2nd	6

IDENTIFYING DATA				
Telecommunication Engineering in the Information Society				
Subject	Telecommunication Engineering in the Information Society			
Code	V05M145V01101			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Cuiñas Gómez, Íñigo			
Lecturers	Cuiñas Gómez, Íñigo			
E-mail	inhigo@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	This subject aims to motivate the students to practical application of the most technical concepts of Telecommunication Engineering for solving problems and offering 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, has problems that can be solved by the engineers: the function of the Engineering is to solve or mitigate problems of the society, not to create them. Knowing how situations have been solved 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 Telecommunication Engineering. This influence has to go accompanied of being aware of the ethical responsibility. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
A3	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.
B7	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.
B9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
B13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.
C15	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.
D3	CT3 Understanding Engineering in a framework for sustainable development.
D4	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.

Expected results from this subject	Training and Learning Results		
Knowledge of what the profession of Telecommunicationis Engineering is and what represents.		B7 B13	D4
Being aware of the social, ethical and environmental responsibility of Telecommunication Engineering.	A3	B9	D3 D4
Contact with other disciplines in which the technologies of Telecommunication integrate for the development of the society (i.e. bioengineering, solar energy, nanotechnologies, remote medicine, remote asistance, or remote education).		C15	

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: C15, D4, A3 and B9
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: B13 and D3
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: B7, C15, D3 and D4

Planning	Class hours	Hours outside the classroom	Total hours
Seminars	0	29	29
Project based learning	0	75	75
Lecturing	0	19	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	Time that group-A lecturers use to meet their students and to solve his/her doubts. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Project based learning	Time that group-C lecturers use to help their students during their projects development, added to the schedulled meetings. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez
Lecturing	Time that group-A lecturers use to meet their students and to solve his/her doubts. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez

Personalized assistance	
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. https://www.uvigo.gal/es/universidad/administracion-personal/pdi/inigo-cuinas-gomez

Assessment			
	Description	Qualification	Training and Learning Results

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 acquired knowledge, initiative to propose solutions to problems no necessarily of telecommunication, and he/she will also have to explain his opinion on conflicts of professional ethics, showing his capacity to provide opinions on situations that involve to the society.	100	A3	B7 B9 B13	C15	D3 D4

Other comments on the Evaluation

The students can only chose for global exam:

Global assessment 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 global assessment exam is one that is done in the official dates marked on School Board in the months of December or January in ordinary 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 extraordinary call exam and, if needed, the end of programme exam will have a similar structure to the final exam (global assessment).

Ethical code

Plagiarism is regarded as serious dishonest behavior. 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

I. Cuiñas, M. J. Fernández Iglesias (editores), **Design Thinking for Engineering. A practical guide**, https://digital-library.theiet.org/content/books/me/pbme024e, The Institute of Engineering and Technology, 2023

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

VV.AA., **Design Thinking. Guía de Iniciación**, https://www.researchgate.net/publication/341803750_Design_Thinking_Guia_de_iniciacion, Universidade de Vigo, 2020

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

IDENTIFYING DATA				
Signal Processing in Communications				
Subject	Signal Processing in Communications			
Code	V05M145V01102			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	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://moovi.uvigo.gal			
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 based modulation, efficient resampling and filtering methods.			

Training and Learning Results	
Code	
B4	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.
B8	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.
C1	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.
C2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
C3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.

Expected results from this subject	Training and Learning Results	
Ability to apply multirate processing, adaptive filtering, block-based transform and spectral estimation techniques to communication and multimedia systems	B4	C1
Ability to implement advanced signal processing techniques in diverse fields of application: bioengineering, bioinformatics, etc.	B4 B8	
Ability to apply signal processing techniques to the modeling and simulation of communication systems	B4	C1 C2
Ability to simulate the physical layer of cable, wireline, satellite systems in fixed/mobile communication environments.	B4 B8	C2 C3

Contents	
Topic	
Sampling and quantization	- Aliasing - Baseband and bandpass sampling - Sampling rate conversion: decimation, interpolation - 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.

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

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	This subject is not taught (the curriculum is being phased out). Documentation is provided.

Personalized assistance

Methodologies	Description
Previous studies	Office hours on demand. Subject not taught due to curriculum discontinuation.

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	Final test in which the student must solve a series of exercises.	100	B4	C1 C2

Other comments on the Evaluation

An exam will be given, whose grade will directly determine the course grade. Questions in this exam can be answered in Spanish, Galician, or English.

Sources of information

Basic Bibliography

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

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

M. S. Grewal and A. P. Andrews, **Kalman filtering: theory and practice using Matlab**, 2nd,

Complementary Bibliography

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

Recommendations

Subjects that continue the syllabus

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

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.

IDENTIFYING DATA				
Radiocommunication				
Subject	Radiocommunication			
Code	V05M145V01103			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish			
Department				
Coordinator	Arias Acuña, Alberto Marcos			
Lecturers	Arias Acuña, Alberto Marcos			
E-mail	marcos@com.uvigo.es			
Web	http://moovi.uvigo.gal			
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.			

Training and Learning Results	
Code	
A2	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.
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
C2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
C3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
C5	CE5 Ability to design systems of radio navigation and positioning, as well as radar systems.

Expected results from this subject	Training and Learning Results	
Capacity to realise basic antenna designs	A2	C2
Capacity to calculate link budgets taking into account both signal and perturbations in distinct stages	A2	C2 C3
Capacity to design radionavegation and positioning systems	A4	C3 C5
Capacity to design radar systems	A4	C5

Contents	
Topic	
1. Basic design of antennas	1.1 Electromagnetic Foundations 1.2 Antennas 1.3 Friis formula Competitions related: A2, C2
2. Models of noise and interferences	2.1 Thermal Noise 2.2 Noise of antenna and receptor 2.3 Interferences 2.4 Availability, fading and diversity 2.5 Radio systems limited by noise and by interference Competitions related: A2, C2, C3
3. Calculation of links in distinct stages of propagation	3.1 Propagation in low frequencies 3.2 Propagation in high frequencies Competitions related: A2,C2
4. Design of systems of *radionavegación	4.1 Radionavegation systems foundations and types 4.2 Satellite radionavegation systems Competitions related: A4, C3, C5
5. Design of systems radar	5.1 Foundations and types of radar system. Radar cross section. 5.2 Design of a radar systems Competitions related: A4, C5

Planning

	Class hours	Hours outside the classroom	Total hours
Problem and/or exercise solving	1	59	60
Essay questions exam	1	64	65

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

Methodologies

	Description

Personalized assistance

Assessment

	Description	Qualification	Training and Learning Results	
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.	60	A2 A4	C2 C5
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.	40	A2 A4	C2 C5

Other comments on the Evaluation

To pass the subject it is necessary to get a minimum of 4 out of 10 in the two written exams. If this minimum is not exceeded, the maximum rating that could be obtained would be 4.9.

Any person enrolled in this subject who receives either of the two written exams will be considered submitted.

The evaluation in the end of career call will be similar to that of the global evaluation.

In the event of detection of plagiarism in any of the work/tests carried out, the final grade for the subject will be "Fail (0)" and the teachers will notify the school management of the matter so that they can take the appropriate measures.

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

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

IDENTIFYING DATA				
Network Technologies				
Subject	Network Technologies			
Code	V05M145V01104			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	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://moovi.uvigo.gal/			
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.			

Training and Learning Results	
Code	
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
C4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
C6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
C7	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.
C12	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.

Expected results from this subject		Training and Learning Results	
Understand the fundamental results on the capacity for different types of networks		B1 B4 B8	C4 C6 C7
Understand, formulate and solve simple models for analyzing the performance of a computer network		B1 B4 B8	C4 C6 C7 C12
Know how to plan, design and deploy switched networks and IP networks in any application environment	A5	B1 B4 B8 B12	C4 C6 C7
Know and understand the internal architecture of the switching equipment, methods of resource allocation and the basic techniques of providing Quality of Service	A5	B1 B4 B8 B12	C4 C6 C12

Contents
Topic

Topic 1: Switch Architecture	1.1. Data and control plane. Distributed and centralized control. 1.2. Software-defined networking (SDN). Fundamental characteristics. 1.3. Switch architecture. Types of switches
Topic 2: Queuing models for switches and communication networks	2.1. Specification and parameters of a queuing system. 2.2. Poisson Processes 2.3. Main queuing models 2.4. Queuing networks
Topic 3: Intradomain routing on the Internet: OSPF	3.1. Hierarchical routing on the Internet. Domains, ASs and ISPs 3.2. Protocols for intradomain routing. 3.3. OSPF 3.4. Types of OSPF Areas
Topic 4: Inter-AS Routing: BGP	4.1. BGP. 4.2. Attributes and path selection.
Topic 5. Route filtering	5.1. Route filtering. access lists and route-maps 5.2. BGP route filtering. 5.3. BGP Communities
Topic 6: Traffic engineering. MPLS-TE	6.1. Traffic engineering. 6.2. MPLS-TE
Topic 7: QoS architectures in ISPs	7.1. QoS Basic Concepts 7.2. Traffic classification and marking 7.3. Traffic Shaping and Policing 7.4. Buffer and bandwidth scheduling 7.5. DiffServ architecture
Topic 8: Network Virtualization	8.1. Network virtualization 8.2. L3 Provider Provisioned Virtual Private Networks (PPVPNs) 8.3. Ethernet VLANs. VLAN Trunking. 8.4. L2 tunnels 8.5. Ethernet VPNs
Topic 9: Data Center Networks	9.1. The network of a Data Center. 9.2. External and internal network virtualization. 9.3. 3-level hierarchical architecture. 9.4. Clos (Leaf & Spine) Architecture 9.5. EVPN in the Data Center 9.6. Alternatives to STP 9.7. Routing Issues in the Data Center

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	123	0	123
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
Previous studies	Study of the subject for the final examination

Personalized assistance

Methodologies	Description
Previous studies	Personalized attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject at https://moovi.uvigo.gal/
Tests	**Description**
Essay questions exam	Personalized attention will be given individually, in a face-to-face meeting or by videoconference, during the tutorial schedule that will be made public at the beginning of the course. Students can ask for tutoring sessions following the instructions provided in the Moovi profile pages of the teacher of this subject at https://moovi.uvigo.gal/

Assessment

Description	Qualification	Training and Learning Results

Essay questions exam	Final exam covering the whole subject. It has a weight of 40% but a minimum score of 4 points out of 10 is required to pass the subject.	100	A5	B1 B4 B8 B12	C4 C6 C7 C12

Other comments on the Evaluation

Global Assessment (GA)

This will consist of an exam covering the entire subject matter.

Extraordinary Opportunity

This will consist of a new EF on the officially established dates, which may only be taken by students who did not pass the subject on the regular exam.

End-of-Year Exam

Students who take this extraordinary exam are subject to exactly the same conditions as those of the Global Assessment.

Other considerations

All students who take any of the Final Exams are considered to have taken the subject.

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

IDENTIFYING DATA

Application Technologies

Subject	Application Technologies			
Code	V05M145V01105			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	English			
Department				
Coordinator	Fernández Vilas, Ana			
Lecturers	Fernández Vilas, Ana			
E-mail	avilas@uvigo.es			
Web	http://moovi.uvigo.gal			
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.			

Training and Learning Results

Code	
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
C4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
C8	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.
C9	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.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Know and apply the different communication techniques for communication and distributed computing	A5	B1 B4 B12	C4
Know and apply the techniques for data sharing to enable interoperability among systems and/or services	A5	B1 B8 B12	C4 C9
Know and apply how to specify and discover software services to be integrated in complex telematic solutions	A5	B1 B4 B8 B12	C4 C9
Know and apply virtualization concepts : cloud computing and content distribution networks.	A5	B1 B12	C4 C8

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	0	39	39
Previous studies	0	49	49
Laboratory practice	2	33	35
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	Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions.
Previous studies	The students will prepare the course content using the material available on the online teaching platform.

Personalized assistance

Methodologies	Description
Laboratory practical	Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions. 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.
Previous studies	Students will be guided in the study of the course contents during office hours by appointment, as well as via email.

Assessment

	Description	Qualification		Training and Learning Results	
Laboratory practice	Laboratory practice	50	A5	B1 B8 B12	C4 C8
Essay questions exam	Essay questions exam	50	A5	B1 B4 B8 B12	C4 C8 C9

Other comments on the Evaluation

The written exam will take place when and where the official calendar specifies; the deadlines for the Lab practice will be detailed in the document that will be published the first day of the semester. If any kind of 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

IDENTIFYING DATA				
Analog Electronic Circuits Design				
Subject	Analog Electronic Circuits Design			
Code	V05M145V01106			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Pastoriza Santos, Vicente			
Lecturers	Pastoriza Santos, Vicente			
E-mail	vpastoriza@uvigo.es			
Web	http://moovi.uvigo.gal			
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.			

Training and Learning Results	
Code	
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B4	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.
B8	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.
C12	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.
C14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Expected results from this subject	Training and Learning Results		
Know analyse and design analogue electronic circuits of low frequency.	A4	B4 B8	C12 C14
Know the parts that constitute an electronic measurement system.	A5	B4	C12 C14
Know the principle of operation of sensors and their conditioners.	A5	B4	C12 C14
Know model an analogue electronic system by means of hardware description languages.	A4	B4 B8	C12 C14

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 competencies CB4, CB5, CG4, CG8, CE12 and CE14.
Tutored project	Realization of one or several laboratory practices (in groups or individually). The theme will be centered on two themes of theoretical-practical planning of the subject. The students will have to present a report of critical results (assessment and comparison with reference data, if applicable). In this practice will work the competencies CB4, CB5, CG4, CG8, CE12 and CE14.

Planning

	Class hours	Hours outside the classroom	Total hours
Objective questions exam	3	72	75
Laboratory practice	3	30	33
Project	1	16	17

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

Methodologies

Description

Personalized assistance

Assessment

	Description	Qualification	Training and Learning Results
Objective questions exam	The lecturers will check the level of compliance of the students with the choice tests goals related to the theory skills. Final mark of objective tests (OTM) will be assessed in a 10 points scale.	60	A4 B4 C12 A5 B8 C14
Laboratory practice	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. The assessment of the practices will be carried out through a practical test in the laboratory, where students will be required to assemble circuits, take measurements, and analyze results from circuits similar to those in the laboratory practices.	25	A4 B4 C12 A5 B8 C14
Project	The student have to perform a theoretical practical project. In order to assess learning 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. The final mark of tutored project (TPM), will be assessed in a 10 points scale.	15	A4 B4 C12 A5 B8 C14

Other comments on the Evaluation

Assessment

This assessment will comprise three parts : 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 = min({ 4.9; (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.

About ethical behaviour of students

Plagiarism is regarded as serious dishonest behavior. 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
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

IDENTIFYING DATA

Telecommunication Projects Management

Subject	Telecommunication Projects Management			
Code	V05M145V01201			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	González Castaño, Francisco Javier			
Lecturers	González Castaño, Francisco Javier			
E-mail	javier@det.uvigo.es			
Web	http://moovi.uvigo.gal/			
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. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results

Code	
B2	CG2 Capacity for managing projects and telecommunication systems facilities, complying with current legislation, ensuring the quality of service.
B3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
B6	CG6 Capacity for general direction, technical direction and management of research, development and innovation projects in companies and technological centers.
B10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
B13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.
C16	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.
D1	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.
D5	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.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
- Knowledge of procedures for innovation and creativeness.	B2 B3 B6 B10 B13	C16	D5
- Tools for telecommunications projects management.	B3		D1
- Management of ideas and innovation basics.	B2 B3 B6 B10 B13	C16	D5
- Knowledge of efficient project management.	B2 B3 B6 B10 B13	C16	D5

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
Objective questions exam	1	124	125

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

Methodologies	
	Description

Personalized assistance

Assessment					
	Description	Qualification	Training and Learning Results		
Objective questions exam	Written exam. Short-answer questions or multiple-choice test	100	B2 B3 B6 B10 B13	C16	D1 D5

Other comments on the Evaluation

Global 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.

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

IDENTIFYING DATA				
Electronics and Photonics for Communications				
Subject	Electronics and Photonics for Communications			
Code	V05M145V01202			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Fernández Barciela, Mónica			
Lecturers	Fernández Barciela, Mónica			
E-mail	monica.barciela@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	The aim of the subject is that students acquire 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, students 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, students 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.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
C2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
C3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
C12	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.
C13	CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics.

Expected results from this subject	Training and Learning Results
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, students will use circuit simulators.	B1 B4 C2 C3 C12 C13
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.	B1 B4 C2 C3 C13
Handle technical documentation and scientific bibliography in English	C13

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. Microwave active circuits design Part I: Linear Amplifiers.	a. Bias and stabilisation networks. b. Circles of stability, power gain and noise. c. Design for maximum transducer gain. d. Design of low noise amplifiers. e. Design of broadband amplifiers.
4. RF and Microwave active circuits design Part II.	a. Power Amplifiers: classes of operation, linearity, dynamic loadline and power contours. Architectures for maximum efficiency. b. Frequency converters. c. Frequency synthesizers.
5. 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	0	28	28
Previous studies	0	87	87
Problem and/or exercise solving	1.5	2	3.5
Problem and/or exercise solving	0	2.5	2.5
Problem and/or exercise solving	1.5	2.5	4

*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 may be performed individually or in small teams of 2 students. With the aid of a commercial microwave and RF circuit simulator, students 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 Moovi, students 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 student work in these practice classes will be individually evaluated 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 these practices, students with work towards achieving competencies: CE2, CE3, CE12 y CE13
Previous studies	In the subject documentation (slides, etc.) 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 of the contents will be fully theoretical while others will include both theory and applications. Students will have available in Moovi support documentation and files. Competencies under work: CE2, CE3, CE12 y CE13

Personalized assistance

Methodologies	Description
Previous studies	Students will be guided by the lecturer team during the time assigned for personalized attention in the office, in which their questions, related to the subject theoretical and practical work as well as the assessment tests, will be solved. To apply for office hours: https://moovi.uvigo.gal/user/profile.php?id=11321
Practices through ICT	During the office hours the lecturer will answer the questions addressed by the students and guide their assigned work. To apply for office hours: https://moovi.uvigo.gal/user/profile.php?id=11321

Assessment

	Description	Qualification	Training and Learning Results

Practices through ICT	The student work in these practices, related to microwave technologies, will be individually evaluated in a 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 the practices.	25	C2 C3 C12
Problem and/or exercise solving	With respect to the part of the subject related to microwave technologies: In Exam-only Assessment, the Final Exam will include exercises resolution, with or without the aid of the simulator, and may also include short questions.	25	C2 C3 C12
Problem and/or exercise solving	With respect to the part of the subject related to RF technologies: In Exam-only Assessment, the examination will include similar exercise solving to the one presented in the theory documentation and guide to design an RF filter, to solve individually.	15	C2 C3 C12
Problem and/or exercise solving	With respect to the part of the subject related to Photonic technologies: In Exam-only Assessment, the Final Exam will also include exercises resolution and may include short questions, related to this part.	35	C2 C3 C12 C13

Other comments on the Evaluation

It is 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:

*Ex*am-only Assessment (100% Subject Qualification), 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 in the First Call.
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,

John L. B. Walker, **Handbook of RF and Microwave Power Amplifiers**, 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

IDENTIFYING DATA				
Digital electronics				
Subject	Digital electronics			
Code	V05M145V01203			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	1st	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Pérez López, Serafín Alfonso Valdés Peña, María Dolores			
Lecturers	Pérez López, Serafín Alfonso Valdés Peña, María Dolores			
E-mail	sperez@uvigo.es mvaldes@uvigo.es			
Web	http://moovi.uvigo.gal/course			
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 integrated programmable circuits. Meanwhile, throughout all contents, emphasis is placed in the VHDL description of high complexity digital systems. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B4	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.
B8	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.
C10	CE10 Ability to design and manufacture integrated circuits.
C11	CE11 Knowledge of hardware description languages for high complexity circuits.
C12	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.
C14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Expected results from this subject	Training and Learning Results		
The knowledge of the integrated circuit manufacturing technologies.			C10
The ability to analyze and design advanced digital circuits.		B4	C12
The knowledge of different input/output technologies of digital circuits.			C14
The ability to design input/output interface circuits.			C10 C12 C14
The knowledge of the design methodologies of complex digital circuits.	A5	B8	C12
The ability to design communication components using programmable logic devices.	A4	B8	C11 C12
The ability to design complex digital electronic systems using hardware description languages.			C11

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. 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

Objective questions exam	1	21.5	22.5
Problem and/or exercise solving	1	21.5	22.5
Laboratory practice	2	43	45
Project	0	60	60

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

Methodologies

	Description

Personalized assistance

Tests	Description
Objective questions exam	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303
Laboratory practice	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303
Project	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303
Problem and/or exercise solving	Students have the opportunity to resolve doubts in personalized attention sessions. The appointment with the corresponding professor must be requested and agreed by email, preferably within the hours published on the faculty website. The links to the contact details of the teachers are: María José Moure Rodríguez - https://moovi.uvigo.gal/user/profile.php?id=11642 María Dolores Valdés Peña - https://moovi.uvigo.gal/user/profile.php?id=11303

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	At the end of the term there will be an exam of short problems and/or development questions. This exam asses all the theoretical contents of the subject.	20			C10 C11 C12 C14
Problem and/or exercise solving	Students will solve a set of problems and/or system design exercises.	20			C10 C11 C12 C14
Laboratory practice	The assessment will be performed in the laboratory. It consists of the design and practical realization of a system.	20		B4 B8	C10 C11 C12 C14
Project	Students will work on a project throughout the course, which they will present at the end of the term.	40	A4 A5	B4 B8	C10 C11 C12 C14

Other comments on the Evaluation

Students will have two opportunities, ordinary and extraordinary calls. In both cases it will consist of the following parts:

- An exam in which all the theoretical contents of the subject are evaluated. It consists of several short problems and/or development questions and lasts 2 hours. To pass the subject it is necessary to obtain a 4 out of 10. This exam represents 40% of the final grade (NExam).

- A practical system design exam. This exam lasts 2 hours. The weight of this evaluation represents 20% of the final grade (Nprac).

- An individual project. This project represents 40% of the final grade (NPro). To pass the subject it is necessary to obtain a grade greater than or equal to 4 out of 10.

Global assessment final grade (Final_GA):

The final grade (Final_GA) is obtained as follows:

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

Final_GA = min [(NExam*0.4 + NPrac*0.2 + NPro*0.4), 4.9] in any other case.

Other comments:

- Students may write their reports, papers, exams or presentations in Spanish, Galician or English.

- The grades obtained in the assessment only apply to the current academic year.

- The use of books, notes or electronic devices such as phones or computers is not permitted in any exam. Mobile phones must be turned off and out of reach of the student.

- Plagiarism is regarded as serious dishonest behavior. In the case that plagiarism is detected in any of the reports/tasks/exams done/taken, 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
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

IDENTIFYING DATA				
Advanced Digital Communications				
Subject	Advanced Digital Communications			
Code	V05M145V01204			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Mosquera Nartallo, Carlos			
Lecturers	Mosquera Nartallo, Carlos			
E-mail	mosquera@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
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 and advanced waveforms. 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.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
C1	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.
C2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
C3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.

Expected results from this subject	Training and Learning Results	
Handle the mathematical tools needed to model, simulate and evaluate moderns communication systems.	B1 B4	C1 C2 C3
Solve problems whose solution does not derive from the application of a standardized procedure.	B1 B4 B8	C1 C2 C3
Understand the principles underlying modern communication standards.	B1 B4 B8	C1 C2 C3
Design transmitters, receivers and measurement equipment for modern communication systems.	B1 B4 B8	C1 C2 C3

Contents
Topic

1. MIMO Communications	1.1 Equivalent discrete channel, multipath and modulation with MIMO and OFDM. MIMO channel and signal models. Statistical characterization. Random fading vs. explicit multipath. 1.2 Constant MIMO channel capacity, with and without CSIT. Ergodic capacity and outage capacity of random MIMO channel. 1.3 Spatial multiplexing. Principles of design of detectors in various dimensions. 1.4 SIMO detectors and MISO beamforming with CSIT. Array gain. Effect of fading on BER and outage. Diversity vs. multiplexing trade-off. 1.5 Principles of transmission with limited CSIT. Time-frequency diversity. ST codes. Limited feedback beamforming.
2. Advanced modulations	2.1 Filtered OFDM 2.2 FBMC 2.3 Beyond multicarrier modulations

Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	0	60	60
Lecturing	0	63	63
Objective 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	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. Matlab will be used for simulation purposes. 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: for contact information, see https://www.uvigo.gal/es/universidad/administracion-personal/pdi/carlos-mosquera-nartallo.

Assessment

	Description	Qualification	Training and Learning Results	
Objective questions exam	Final exam with short questions and exercises.	100	B1	C1
			B4	C2
			B8	C3

Other comments on the Evaluation

Sources of information

Basic Bibliography

Emil Björnson and Özlem Tugfe Demir, **Introduction to Multiple Antenna Communications and Reconfigurable Surfaces**, First, now Publishers Inc., 2024

David Tse and Pramod Viswanath, **Fundamentals of Wireless Communication**, First, Cambridge University Press, 2005

Complementary Bibliography

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

Robert W. Heath Jr. and Angel Lozano, **Foundations of MIMO Communication**, First, Cambridge University Press, 2018

A. Artés, F. Pérez-González, J. Cid, R. López, C. Mosquera, F. Pérez-Cruz, **Principios de comunicaciones digitales**, Versión electrónica, Prentice-Hall, 2012

Recommendations

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

IDENTIFYING DATA				
Signal Processing in Audiovisual Systems				
Subject	Signal Processing in Audiovisual Systems			
Code	V05M145V01205			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	1st 2nd
Teaching language	English			
Department				
Coordinator	Martín Rodríguez, Fernando Márquez Flórez, Óscar Willian			
Lecturers	Márquez Flórez, Óscar Willian Martín Rodríguez, Fernando			
E-mail	omarquez@uvigo.es fmartin@uvigo.es			
Web	http://https://moovi.uvigo.gal/			
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.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
C1	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.

Expected results from this subject	Training and Learning Results
Learning to exploit perceptual effects and spatial/temporal redundancy to compress audiovisual information.	B1 B4 C1
Understanding information structure into the MPEG4 standard and the reasons because it is needed.	B1
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.	B1 B4 C1
Learning to handle audiovisual information to extract metadata and to use them in indexing and retrieval.	B1
Understanding structure and usefulness of MPEG7 standard.	B1

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.
Practical content.	Each year, two practical work assignments will be done on themes related with theory contents.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
Objective questions exam	1	0	1
Problem and/or exercise solving	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
Previous studies	Study of available documentation.

Personalized assistance

Methodologies	Description
Previous studies	Tutoring on demand. Course discontinued due to curriculum extinction.

Assessment

	Description	Qualification	Training and Learning Results	
Previous studies	No classes for this subject (curriculum is being retired). Documentation provided.	0		
Objective questions exam	These tests are associated with the concepts explained in the available documentation.	20	B1 B4	C1
Problem and/or exercise solving	These tests are associated with the concepts explained in the available documentation.	80	B1 B4	C1

Other comments on the Evaluation

Sources of information

Basic Bibliography

Fernando Pereira and Touradj Ebrahimi, **The MPEG-4 book**, 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**, 1, Wiley, cop., 2003

Complementary Bibliography

Thiagarajan, Jayaraman, **Analysis of the MPEG-1 Layer III (MP3) Algorithm using MATLAB**, 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

IDENTIFYING DATA				
Multimedia Communications				
Subject	Multimedia Communications			
Code	V05M145V01206			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	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	http://moovi.uvigo.gal/			
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.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
C1	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.
C4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
C6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
C8	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.

Expected results from this subject	Training and Learning Results
Understand that a trellis code defines a lattice and why this construction is useful for source coding (Trellis-Code Quantization)	B4 C1
Understanding of the different distributed source coding schemes.	B1 B4 C1 C4 C8
Implementation of a distributed source coding scheme.	B1 B4 C1 C6 C8
Understading of the different schemes of joint source and channel coding.	B4 C1 C4 C6 C8
Implementation of a joint and source channel coding scheme.	B1 B4 C1 C4 C6
Understanding of the characteristics of different ways of multimedia signal distribution, paying special attention to streaming schemes.	B1 C4 C6 C8

Asessment of the modularity of new video coding standards (e.g., MPEG-7)	B1 C4 C6 C8

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
Previous studies	0	123	123
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
Previous studies	Study of the indicated bibliography.

Personalized assistance

Methodologies	Description
Previous studies	Subject without teaching due to the discontinuation of the degree. Tutoring on demand.

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Final exam.	100	B1 B4	C1 C4 C6 C8

Other comments on the Evaluation

The assessment will be performed by final exam only.

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the projects, tests or exams, or if extensive use of AI tools is detected in the project, 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

Cover and Thomas, **Elements of information theory**, 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.

IDENTIFYING DATA				
Optical Communications				
Subject	Optical Communications			
Code	V05M145V01207			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	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://https://moovi.uvigo.gal			
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.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
C13	CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics.

Expected results from this subject	Training and Learning Results			
3. Knowledge of the basic formats of digital transmission by optical fibre, and of analog transmission in systems fibre-radio.	A6	B14 B4	C13	
4. Knowledge of some advanced systems for fibre transmission: new modulation formats, coherent systems, non-linear systems and dispersion management.		B14 B14 B14 B4 B8	C13 C37 C37 C37	D7
5. Knowledge of the specific technologies of optical networks WDM and DWDM, and options to design them.	A6	B1 B14 B4	C37 C13	D7
6. Knowledge of the optical network topologies for long distance transmission, metropolitan and regional networks, and access optical networks.		B1 B14 B4	C37 C13	D7 D7 D7 D7
7. Knowledge of security techniques to protect optical networks.		B14 B4 B14 B8	C37 C37 C13	D7
8. Knowledge of free-space optical systems and visible light communications.		B4 B14 B14 B8	C37 C13	D7 D7

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. Spectral characteristics of optical sources and observation of the chirp.	Characterization of various optical sources and chirp observation in an external cavity tunable laser
Laboratory exercise 3. Systems DWDM	Characterisation of DWDM systems working in third telecom window

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	111	111
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
Previous studies	

Personalized assistance

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	At the end of the semester, the students will perform a final test that covers all the contents of the course.	100	B1 B4 B8	C13

Other comments on the Evaluation

Ordinary opportunity:

We will offer to the students one possible assessment system: global assessment.

Global assessment:

This global assessment covers all the contents of the subject. The professor may demand the student to deliver some

additional tasks, which 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.

Extraordinary opportunity:

The students will be evaluated by a global assessment, which covers all the contents of the course. 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.

End-of-Degree Call

The students will be evaluated by a global assessment, which covers all the contents of the course.

Plagiarism is regarded as serious dishonest behaviour. If any form of plagiarism is detected, 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

IDENTIFYING DATA				
Antennas				
Subject	Antennas			
Code	V05M145V01208			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Rodríguez Rodríguez, José Luis			
Lecturers	Rodríguez Rodríguez, José Luis			
E-mail	banner@com.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.			

Training and Learning Results	
Code	
A2	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.
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
B4	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.
C2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
C3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
C5	CE5 Ability to design systems of radio navigation and positioning, as well as radar systems.

Expected results from this subject	Training and Learning Results		
Know the main parameters that characterise the behaviour of the transmitting and receiving antennas	A4	B4	C2 C3 C5
Know the distinct types of antennas according to their applications and operating frequencies	A4	B4	C2 C3 C5
To be able to understand and develop models to simulate the behavior of the antennas and predict their characteristic parameters	A4	B4	C2 C3 C5
To be able to cope antenna design exercises for certain specifications	A2 A4	B4	C2 C3 C5

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

4. Practices	4.1 Design of a single band planar GPS antenna 4.2 Design of a dual band GPS antenna 4.3 Measurement of the final antenna prototype

Planning			
	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
Objective 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
Previous studies	Study of available documentation

Personalized assistance	
Methodologies	**Description**
Previous studies	Mentoring session scheduled on demand.

Assessment					
	Description	Qualification	Training and Learning Results		
Objective questions exam	(*)TEST	100	A2	B4	C2
			A4		C3
					C5

Other comments on the Evaluation

EXTINGUISHED CORUSE (EXAM ONLY)

It will be offered to the students enrolled in this class two systems of evaluation: continuous assesment and exam-only assesment.

1. CONTINUOUS ASSESMENT
The system of continuous assesment will consist on:

- 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, and covers the following competences: CB2, CG4, CE2, CE3, CE5
- The score on the assessable tasks (EC) will be valid only for the academic year in which they are made.
- There is a 1 month period to leave continuous evaluation.
- The participation in practices is voluntary.

2.GLOBAL ASSESMENT - ORDINARY 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 3 points for the report and 3 points for the presentation.
- The EF1 and EF2 partial qualifications may be held only until the single evaluation - second call and within the ongoing course.

3. GLOBAL ASSESMENT - EXTRAORDINARY CALL

It will follow the same procedure as in global assesment - ordinary 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.

4. GLOBAL ASSESMENT - END OF DEGREE CALL

It will follow the same procedure as in global assesment - ordinary 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
Satellites/V05M145V01311
Wireless and Mobile Communications/V05M145V01313
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

IDENTIFYING DATA				
Radio Laboratory				
Subject	Radio Laboratory			
Code	V05M145V01209			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	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://moovi.uvigo.gal			
General description	Deepening in the knowledge of the diverse systems of radius applying a practical methodology of analysis and synthesis			

Training and Learning Results	
Code	
A1	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.
A2	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.
B8	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.
C2	CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning.
C3	CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments.
C5	CE5 Ability to design systems of radio navigation and positioning, as well as radar systems.
C13	CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics.

Expected results from this subject	Training and Learning Results		
* 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.	A1 A2	B8	C2 C3 C5 C13
* Knowdlege of experimental characterization techniques regarding the mechanisms of signal propagation.	A1 A2	B8	C2 C3 C5 C13

Contents
Topic

Theoretical and practical content.	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) 16. Pseudorandom codes 17. Enhanced Spectrum 18. Multiple Input Multiple Output (MIMO)

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	Study of the provided documentation

Personalized assistance

Methodologies	Description
Previous studies	Tutoring available on demand. Subject not covered due to curriculum discontinuation

Assessment

	Description	Qualification	Training and Learning Results	
Previous studies	This subject is not currently offered (the curriculum is being phased out). Documentation will be provided.	0		
Problem and/or exercise solving	Exam	100	A1 A2	B8

Other comments on the Evaluation

ORDINARY CALL:

* Examination on laboratory practice. Individual assessment (Weight: 100%)

SECOND CALL:
Second calls will be assessed as stated in the ordinary call

END OF PROGRAM CALL:

End of program calls will be assessed as stated in the ordinary call

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.
After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

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

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

Subjects that are recommended to be taken simultaneously

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

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102
Radiocommunication/V05M145V01103

IDENTIFYING DATA				
Internet Engineering				
Subject	Internet Engineering			
Code	V05M145V01210			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	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://moovi.uvigo.gal			
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.			

Training and Learning Results	
Code	
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
C4	CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals.
C6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
C7	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.
C8	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.

Expected results from this subject	Training and Learning Results		
Knowledge and know-how about advanced channel coding techniques		B4	C4 C6
To understand the operations and properties of large distributed systems in the Internet. Deep knowledge and insights about advanced communication system		B1 B4	C4 C6 C7 C8
To learn how to analyze and put into use multi path transmission techniques and congestion control algorithms on different types of networks	A5	B4 B8	C4 C6 C7 C8
To understand the design principles, the operation and performance of large data centers in the Internet	A5	B1 B4 B12	C6 C7 C8
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.	A5	B1 B4 B8 B12	C4 C6 C7 C8

Contents

Topic	
1. Coding for distributed storage	1.1 Locally recoverable codes 1.2 Regenerating codes 1.3 Case studies
2. Advanced channel coding	2.1 Capacity-approaching codes: LDPC, turbo 2.2 Capacity-achieving-codes: polar coding, SC-LDPC 2.3 Network coding
3. Networking technologies for 5G	3.1 M2M, URLLC and NB-IoT communications 3.2 Architectures and models for 5G networks
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. MEC & edge computing	5.1 Architecture and services 5.2 Technology: NOMA, CRAN, SWIPT 5.3 Massive multiple access
6. Coded caching	6.1 Centralized and distributed coded caching 6.2 Edge computing 6.3 Index coding
7. Machine learning for networks	7.1 Machine learning & data-driven networks 7.2 Optimization- and model-based machine learning 7.3 Deep learning, reinforcement learning 7.4 Case studies in 5G/6G

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	0	39	39
Laboratory practical	0	70	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	Comprehension 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. Office hours: [https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga]
Laboratory practical	Help with the design, installation, configuration and use of any software piece needed for developing the practical project. Individual office hours. Office hours: [https://www.uvigo.gal/es/universidad/administracion-personal/pdi/manuel-fernandez-veiga]

Assessment

	Description	Qualification	Training and Learning Results		
Laboratory practice	Functional and performance tests of the assigned engineering project. Critical assessment of the technical solutions, the design decisions and the implementation.	30	A5	B1 B4 B8 B12	C4 C6 C7 C8

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.	40		B1 B4 B8 B12	C4 C6 C7 C8
Problem and/or exercise solving	Written homework, selected problems and exercises.	30	A5	B4 B8	C8

Other comments on the Evaluation

The assessment 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 for global assessment right after the programming assignment is announced. A student cannot be considered as defective (not active) if continuous assessment is chosen.

The students who fail the course will be given an extraordinary 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. Goransson, C. Black, **Software defined networking: a comprehensive approach**, Morgan Kauffman, 2014

Complementary Bibliography

Y. Polyanskiy, Y. Wu, **Information theory from coding to learning**, Cambridge University Press, 2023

] I. Maric, S. Shamai, O. Simeone, **Information Theoretic Perspectives on 5G and Beyond**, Cambridge University Press, 2022

] Özlem Tugfe Demir, Emil Björnson and Luca Sanguinetti, **Foundations of User-Centric Cell-Free Massive MIMO**, Foundations and Trends in Signal Processing, 2021

Songze Li and Salman Avestimehr, **Coded Computing**, Foundations and Trends in Communications, 2020

Recommendations

Subjects that it is recommended to have taken before

Network Technologies/V05M145V01104

IDENTIFYING DATA				
Wireless Networks and Ubiquitous Computation				
Subject	Wireless Networks and Ubiquitous Computation			
Code	V05M145V01211			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Gil Castiñeira, Felipe José			
Lecturers	Gil Castiñeira, Felipe José			
E-mail	xil@gti.uvigo.es			
Web	http://moovi.uvigo.gal/			
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. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results
Code

Expected results from this subject	
Expected results from this subject	Training and Learning Results

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	0	37	37
Laboratory practical	0	20	20
Project based learning	0	63	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	Students should study 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	Realization by part of the students of practices. With this methodology will work the competitions CE4, CE6 and CE24. The following software will be used: - Bare metal or virtual Linux environment. - OMNET++ - VMware Player with the Instant Contiki environment.
Project based learning	Students will work 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 tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. Tutorial sessions can be checked or requested on the subject website (https://moovi.uvigo.gal).
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 tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. Tutorial sessions can be checked or requested on the subject website (https://moovi.uvigo.gal).
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 during tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. Tutorial sessions can be checked or requested on the subject website (https://moovi.uvigo.gal).

Assessment

	Description	Qualification	Training and Learning Results
Lecturing	Students will complete one exam to asses what they have learned in master sessions.	40	
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	
Project based learning	The students will design, implement 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.	40	

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

Students 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.

Extraordinary and end-of-program calls to pass the course

Students can opt to the extraordinary call and the end-of-program exam only if they didn't pass the ordinary 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.

Other comments

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

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.

In carrying out the academic activities of this subject, the use of generative artificial intelligence (GAI) is permitted. Its use must be ethical, critical, and responsible. In the event of using GAI, it is essential to critically evaluate any provided results and carefully verify any generated citations or references. Additionally, it is recommended to disclose the use of the employed tools.

Sources of information
Basic Bibliography
Cory Beard, William Stallings, **Wireless Communication Networks and Systems**, 1, Pearson, 2016
Andreas F. Molisch, **Wireless Communications: From Fundamentals to Beyond 5G, 3rd Edition**, 3, Wiley-IEEE Press, 2022
Complementary Bibliography
Christopher Cox, **An Introduction to LTE**, 2, John Wiley & Sons, 2014
Viajy Garg, **Wireless Communications and Networking**, 1, Morgan Kaufmann, 2007
Kaveh Pahlavan, Prashant Krishnamurthy, **Networking Fundamentals: Wide, Local and Personal Area Communications**, 1, Wiley, 2009
Pei Zheng, Larry L. Peterson, Bruce S. Davie, Adrian Farre, **Wireless Networking Complete**, 1, Morgan Kaufmann, 2009
F. Adelstein, Sandeep K.S. Gupta, Golden G. Richard III, Loren Schwiebert, **Fundamentals of Mobile and Pervasive Computing**, 1, McGraw-Hill Professional, 2004
John Krumm, **Ubiquitous Computing Fundamentals**, 1, Chapman and Hall/CRC, 2009
Jean-Philippe vasseur, Adam Dunkels, **Interconnecting smart objects with IP**, 1, Morgan Kaufmann, 2010
James F. Kurose, Keith W. Ross, **Computer Networking: A Top-Down Approach**, 7, Pearson, 2016

Recommendations

IDENTIFYING DATA

Web Engineering

Subject	Web Engineering			
Code	V05M145V01212			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Santos Gago, Juan Manuel			
Lecturers	Santos Gago, Juan Manuel			
E-mail	juan.santos@det.uvigo.gal			
Web	http://moovi.uvigo.gal			
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.			

Training and Learning Results

Code	
A1	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.
A2	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.
A3	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.
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B5	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.
B6	CG6 Capacity for general direction, technical direction and management of research, development and innovation projects in companies and technological centers.
B8	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.
C6	CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents.
C8	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.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Know the evolution of the Web and understand the technologies in use today	A5	B8	C8
Know and be able to use mechanisms to represent and manage knowledge on the Web	A1 A2 A3 A5		C8
Know to propound, analyze and design innovative Web applications using the models and patterns that predominate in the Web	A2 A4	B5 B6 B8	C6 C8

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	0	60	60
Project based learning	0	60	60
Essay questions exam	2	0	2
Project	1	2	3
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	Description
Lecturing	Presentations and other documents covering the various topics addressed in the course will be made available to students. This material, together with the recommended bibliography, will serve as the basis for studying the theoretical part of the course. This methodology is mainly focused to the achievement of the competencies CB1, CB3, CB5 and CE8.
Project based learning	The students, organized in groups of 2 or 3 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. Information about tutoring can be found in: https://moovi.uvigo.gal/user/profile.php?id=11599 and https://moovi.uvigo.gal/user/profile.php?id=11296
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. Information about tutoring can be found in: https://moovi.uvigo.gal/user/profile.php?id=11599 and https://moovi.uvigo.gal/user/profile.php?id=11296

Assessment

	Description	Qualification	Training and Learning Results		
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.	50	A1 A4 A5		C8
Project	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.	50	A3 A4	B5 B6 B8	C6 C8

Other comments on the Evaluation

The student must submit the software and the project report, whose functionality, scope, and formats will be previously agreed upon with the instructor, at least one month before the submission deadline. In addition, the student must take a written exam that will include both theoretical questions and practical problems and exercises. The dates for the exam and project submission will be set by the School Board and officially communicated through the appropriate channels.

The Final Grade will be the harmonic mean of the grades obtained in the exam and the project.

Extraordinary Call and End-of-program exam

The assessment method will follow a procedure similar to that of the First Call.

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

Plagiarism is regarded as serious dishonest behavior. 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

R. Baeza-Yates, B. Ribeiro-Neto, **Modern Information Retrieval: The Concepts and Technology behind Search**, 2, Addison Wesley, 2011

G. Antoniou, P. Groth, F. Van Harmelen, R. Hoekstra, **A Semantic Web Primer**, 3, The MIT Press, 2012

Complementary Bibliography

O. Alonso, R. Baeza-Yates, **Information Retrieval: Advanced Topics and Techniques**, ACM, 2024

G. Shroff, **The Intelligent Web: Search, smart algorithms, and big data**, Oxford University Press, 2015

B. Croft, D. Metzler, T. Strohman, **Search Engines: Information Retrieval in Practice**, Pearson, 2009

Recommendations

IDENTIFYING DATA				
Digital and Analog Mixed Circuits				
Subject	Digital and Analog Mixed Circuits			
Code	V05M145V01213			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Valdés Peña, María Alicia			
Lecturers	Valdés Peña, María Alicia			
E-mail	mavaldesp@yahoo.es			
Web	http://moovi.uvigo.gal			
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. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
A1	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.
B4	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.
B8	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.
C11	CE11 Knowledge of hardware description languages for high complexity circuits.
C12	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.
C14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Expected results from this subject	Training and Learning Results		
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	A1		
To know the modeling of mixed electronic systems by using the mathematical basis of the continuous analog systems and discrete systems.		B4	
The ability to combine different methods and resources for the design of complex systems that include analog and digital circuits.		B8	
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.			C11
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.			C12
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.			C14

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.
Laboratory sessions.	1.- Simulation of a Sigma-Delta ADC modulator. 2.- Assembly of a Sigma-Delta ADC modulator. 3.- Configuration of an FPGA to implement a Sigma-Delta DAC modulator. 4.- Configuration of an FPGA to implement a comb pass-2 filter. 5.- Configuration of an FPGA to implement a DDS circuit. 6.- Configuration of an FPGA to implement a synthesizer circuit based on IIR filter.

Planning

	Class hours	Hours outside the classroom	Total hours
Essay questions exam	1	34	35
Problem and/or exercise solving	1	34	35
Laboratory practice	2	53	55

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

Methodologies

	Description

Personalized assistance

Tests	Description
Laboratory practice	Students have the opportunity to have their questions answered through individual consultation sessions. Appointments with the corresponding instructor must be requested and confirmed by email.
Essay questions exam	Students have the opportunity to have their questions answered through individual consultation sessions. Appointments with the corresponding instructor must be requested and confirmed by email.
Problem and/or exercise solving	Students have the opportunity to have their questions answered through individual consultation sessions. Appointments with the corresponding instructor must be requested and confirmed by email.

Assessment

	Description	Qualification		Training and Learning Results	
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 comprehensive response.	30		B4 B8	C11 C12 C14
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.	30	A1	B4 B8	C11 C12 C14

Laboratory practice	Completion of real or simulated practical tasks. These are tests in which the performance of the students will be evaluated on the basis of their ability to demonstrate their knowledge of the material, their ability to organize and plan during the practice sessions, as well as their reflection on the results obtained, etc.	40	B8	C11 C12 C14

Other comments on the Evaluation

Students will have two assessment opportunities: the ordinary and the extraordinary examination periods. In both cases, the assessment will consist of the following tests:

- **An examination** assessing all the theoretical contents of the course. It consists of several short problems and/or essay-style questions and lasts 2 hours. To pass the examination, a minimum mark of 4 out of 10 must be obtained. This test represents 60% of the final grade (**NExam**).
- **A practical examination on system design.** The duration of the examination will be 2 hours. To pass the examination, a minimum mark of 4 out of 10 must be obtained. This assessment represents 40% of the final grade (**NPrac**).

Final grade (C_Final):

The final grade (**C_Final**) is obtained as follows:

C_Final = (NExam × 0.6 + NPrac × 0.4) if **NExam** and **NPrac** are greater than or equal to 4;

C_Final = min[(NExam × 0.6 + NPrac × 0.4), 4.9] otherwise.

Sources of information

Basic Bibliography

C. Quintáns et al, **Methodology and Resources for the Practical Teaching of Mixed Analog-Digital Circuits**, 1, IEEE, 2024

Shanthi Pavan; Richard Schreier; Gabor C. Temes, **Understanding Delta-Sigma Data Converters**, 2, Wiley-IEEE Press, 2017

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

C. Quintáns, **Simulación de Circuitos Electrónicos con OrCAD PSpice**, 2, Marcombo, 2021

Complementary Bibliography

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

F. Maloberti, **Data Converters**, Springer, 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 it is recommended to have taken before

Digital electronics/V05M145V01203

Analog Electronic Circuits Design/V05M145V01106

IDENTIFYING DATA				
Hardware/Software Design of Embedded Systems				
Subject	Hardware/Software Design of Embedded Systems			
Code	V05M145V01214			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician English			
Department				
Coordinator	Álvarez Ruiz de Ojeda, Luís Jacobo			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo			
E-mail	jalvarez@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Part of this course may be taught and assessed in English. The documentation of the subject will be in English. 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.			

Training and Learning Results	
Code	
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B8	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.
C11	CE11 Knowledge of hardware description languages for high complexity circuits.
C12	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.

Expected results from this subject	Training and Learning Results		
To learn the codesign methods to design applications based on embedded microprocessors in FPGAs.	A5		C11 C12
To get to know the microprocessors that can be implemented in commercial FPGAs.	A5		C11 C12
To handle the necessary software tools for the development of embedded applications by means of FPGAs.	A5		C11 C12
To design application specific peripherals and their connection to the buses of the embedded microprocessors.	A5	B1 B8	C11 C12
To design real applications with embedded microprocessors in FPGAs.	A5	B1 B8	C11 C12

Contents	
Topic	
LESSON 1 THEORY. INTRODUCTION TO THE DESIGN OF EMBEDDED SYSTEMS.	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.	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.	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.	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.	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.	6.1.- Introduction. 6.2.- Examples of hardware / software codesign. 6.3.- Distribution of tasks between hardware and software. 6.4.- Software profiling.
LESSON 7 THEORY. EMBEDDED SYSTEMS ANALISYS PROJECT.	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 8 THEORY. INTERRUPTS IN THE XILINX ARM MICROPROCESSOR.	8.1. Introduction. 8.2. Interrupt Handling. 8.3. Generic Interrupt Controller. 8.4. Interrupt Service Routine.
LESSON 1 LABORATORY. XILINX VIVADO ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS.	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.	2.1. Introduction. 2.2. Development of basic user peripherals. GPIO.
LESSON 3 LABORATORY. DESIGN OF ADVANCED PERIPHERAL CIRCUITS.	3.1. Introduction. 3.2. Development of advanced user peripherals (Custom IP).
LESSON 4 LABORATORY. XILINX VITIS ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS SOFTWARE.	4.1. Introduction. 4.2. Xilinx Vitis environment for software development. 4.3. Basic Design Examples.
LESSON 5 LABORATORY. SOFTWARE DEBUGGING OF EMBEDDED APPLICATIONS.	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.	6.1. Introduction. 6.2. Embedded systems hardware verification using Vivado hardware analyzer.
LESSON 7 LABORATORY. INTERRUPTS IN THE XILINX ARM MICROPROCESSOR.	7.1. Introduction. 7.2. Basic examples with interrupts.
LESSON 8 LABORATORY. DESIGN PROJECT. DESIGN OF AN APPLICATION BASED IN THE XILINX ARM MICROPROCESSOR.	8.1. Design and test of the assigned application. 8.1.1. Design of the required hardware peripherals. 8.1.2. Design of the software program for the application. 8.1.3. Design and test of the complete embedded system.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	4	6	10
Problem solving	4	8	12
Mentored work	6	12	18
Laboratory practical	6	16	22
Mentored work	9	46	55
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 C11 and C12 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 A5, B1, B8, C11 and C12 are developed.
Mentored work	Project based learning. The students must design a software routine and a hardware peripheral of an embedded system to solve a problem. In order to do that, the students must plan, design and implement the necessary steps.
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. Software to be used: Vivado Design Suite from Xilinx. Through this methodology the outcomes A5, B8, C11 and C12 are developed.
Mentored work	Project based learning. The students must design an embedded system to solve a problem. In order to do that, the students must plan, design and implement the necessary steps. Through this methodology the outcomes A5, B1, B8, C11 and C12 are developed
Presentation	Exhibition of the results of the project developed. Through this methodology the outcomes A5, C11 and C12 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 following website: https://moovi.uvigo.gal/user/profile.php?id=11300
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 following website: https://moovi.uvigo.gal/user/profile.php?id=11300
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 following website: https://moovi.uvigo.gal/user/profile.php?id=11300
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 following website: https://moovi.uvigo.gal/user/profile.php?id=11300
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 following website: https://moovi.uvigo.gal/user/profile.php?id=11300

Assessment

	Description	Qualification	Training and Learning Results		
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.	10	A5	B1 B8	C11 C12
Mentored work	Project Based Learning. Theoretical project. Design of a software routine and a hardware peripheral to perform the function assigned. Comparison of the performance of both, in terms of execution time and logical resources used. The assessment will be based on the operation of the system and the correct application of the theoretical concepts, according to the published criteria. It will be necessary to deliver a brief report explaining the work done.	15	A5	B1 B8	C11 C12
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	A5	B8	C11 C12

Mentored work	Project Based Learning. Laboratory Project. Design of a complete embedded system with several peripherals. It will be necessary to deliver the source files of the work realized. 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	A5	B1 B8	C11 C12
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	A5		C11 C12

Other comments on the Evaluation

IMPORTANT:

Due to the discontinuation of the curriculum, this course will not have in-person classes or continuous assessment.

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 assessment and global assessment. Students must choose at the start of the subject if they wish to follow the continuous evaluation or prefer to follow the global assessment at the end of the semester. Students who choose global assessment must notify the subject coordinator in writing within one month from the beginning of the semester.

CONTINUOUS ASSESSMENT IN ORDINARY CALL

The students that have chosen continuous assessment, but do not pass the course, will have to do the global assessment in extraordinary 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 of any type as a maximum. If they miss more than 2 sessions, it will be compulsory to do an additional individual task or an examination.

GLOBAL ASSESSMENT(ordinary or extraordinary call) AND END-OF-PROGRAM CALL

The students that opt for the global assessment (whether it is at the ordinary or extraordinary call) or for the end-of-program call will have to do all the theoretical and practical tasks and the project individually.

The tasks for the single assessment must be delivered before the official date of the examination set by the faculty.

FINAL MARK OF THE COURSE

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 = Lesson 1L + ... + Lesson N L

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

TE = Exercise 1 + ... + Exercise N

3) Tutored works. Theoretical Project.

It will consist of the design of a software routine and a hardware peripheral to perform the function assigned to each student and the comparison of 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.

4) Tutored works. Laboratory Project.

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.

5) 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 part (TE+TTW), the laboratory practices (LAB) and the Laboratory Tutored Work (LTW), 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 = 0,10 * TE + 0,15 * TTW + 0,25 * LAB + 0,40 * LTW + 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 [4'9; (0,10 * TE + 0,15 * TTW + 0,25 * LAB + 0,40 * LTW + 0,10 * OP)]

Where:

TE = Global mark of the theoretical exercises.

TTW = Theoretical Tutored Work.

LAB = Laboratory Practices.

LTW = Laboratory Tutored Work.

OP = Oral presentation.

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

Digital electronics/V05M145V01203

IDENTIFYING DATA

Integrated Circuits Design and Manufacturing

Subject	Integrated Circuits Design and Manufacturing			
Code	V05M145V01215			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish			
Department				
Coordinator	Cao Paz, Ana María			
Lecturers	Cao Paz, Ana María			
E-mail	amcaopaz@uvigo.es			
Web	http://http://moovi.uvigo.gal			
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.			

Training and Learning Results

Code	
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B8	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.
C10	CE10 Ability to design and manufacture integrated circuits.

Expected results from this subject

Expected results from this subject	Training and Learning Results		
Know the design methodologies of electronic integrated circuits			C10
Know the basic topologies used in analog electronic circuits			C10
Can analyze and dimension the devices that form the basic topologies of analog circuits	A5	B8	C10
Know aid software tools integrated circuit design			C10
Know how an electronic circuit is specified for manufacturing	A4		C10

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	0	35	35
Mentored work	0	35	35
Laboratory practical	0	32.5	32.5
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	There are no classes in this subject. The curriculum is in process of extinction.
Mentored work	There are no classes in this subject. The curriculum is in process of extinction. The activities to be developed by each team are: - Analysis of possible solutions and design alternatives. - Analysis and monitoring of the proposed solution for the project. - Report with the presentation and analysis of the obtained results. - Presentation and discussion of the results. Competences A4, A5, B8 and C10 are worked in this methodology.
Laboratory practical	There are no classes in this subject. The curriculum is in process of extinction. Students 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. Competences A5, B8 and C10 are worked in this methodology.

Personalized assistance

Methodologies	Description
Lecturing	The teaching staff will attend doubts and enquiries of the students about the theoretical contents. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331
Laboratory practical	The teaching staff will attend doubts and enquiries of the students about previous preparation of laboratory practices as well as its contents. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331

Mentored work	The teaching staff will attend doubts and enquiries of the students about 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. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331

Assessment

	Description	Qualification	Training and Learning Results
Problem and/or exercise solving	As part of the continuous evaluation, it will take place in mid-course an individual written test of 60 minutes, in one of the lecture sessions. This test will involve 20% of the final grade. To pass the course, students must achieve a mark of 4 or higher in a 0-10. Competences C10 and A4 will be assessed in these tests.	20	A4 C10
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 20% of the final grade. To pass the subject it will be necessary to obtain at least a score of 4 out of 10. In this test the competences C10, A4 and B8 are evaluated.	20	A4 B8 C10
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 total qualification of the practices will be obtained as an arithmetic average of the qualification of each of them. The internship note is not kept for successive academic courses. In this part the C10, A4, A5 and B8 skills are evaluated.	20	A4 B8 C10 A5
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 C10, A4, A5 and B8 skills are evaluated.	40	A4 B8 C10 A5

Other comments on the Evaluation

IMPORTANT: Due to the discontinuation of the curriculum, this course will not have in-person classes or continuous assessment.

Continuos assessment:

The planning of the different evaluations will be notified to the students on the first day of classes.

In order to pass the course, students must achieve a global mark of 5 or higher in a 0-10 scale. The global mark will be obtained as the weighted summation of the scores obtained in the different parts of the course. A minimum score is

required in each of these parts. For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Global assessment:

Students not in continuous evaluation will be evaluated as follows:

- 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 50 % of the test qualification and the part of resolution of problems the other 50%. 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.

The deadline to renounce to continuos assessment will be one month before the end date of the semester, according to the calendar of the center. The procedure will be by sending an email to the teaching staff requesting the renounce of continuous assessment.

For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Extraordinary call:

Students who attend this call will be evaluated identically to the global assessment:

- 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 50 % of the test qualification and the part of resolution of problems the other 50%. 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. 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.

For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Sources of information

Basic Bibliography

R. Jacob Baker, **CMOS Circuits desing, Layout and Simulation**, 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**, 5º, John Wiley and Sons, 2010

Behzad Razavi, **Design of Analog CMOS Integrated Circuits**, 2º, McGraw Hill, 2017

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

Complementary Bibliography

Recommendations

Other comments

All conclusions achieved both in the written tests and in the projects must be adequately justified. Non-trivial concepts cannot be assumed but they have to be explained. The methodologies used by the student will be taken into account in the computation of his/her marks. No auxiliary resources, including but not limited to documentation, can be used in the written tests.

In case of detection of plagiarism in any of the evaluation tests or assignment submissions, the final grade will be SUSPENSE (0) and the fact will be reported to the corresponding academic authorities for prosecution.

IDENTIFYING DATA				
Real-Time Signal Processing				
Subject	Real-Time Signal Processing			
Code	V05M145V01301			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	Martín Rodríguez, Fernando Gil Solla, Alberto			
Lecturers	Álvarez Sabucedo, Luis Modesto Fernández Masaguer, Francisco Gil Solla, Alberto Martín Rodríguez, Fernando			
E-mail	fmartin@uvigo.es alberto.gil@uvigo.es			
Web	http://https://moovi.uvigo.gal/			
General description	In this subject we deal with several architectures and techniques for real-time signal and video processing. Our main focus will be on hands-on, practical work and the capability to adapt to new, emerging, constantly evolving technologies and tools.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B8	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.
C21	CE21/PS1 Manage implementation of signal processing systems options to accelerate computationally complex algorithms.

Expected results from this subject	Training and Learning Results
Understanding the basic principles of real time signal and video processing.	B1 B8 C21
Handling advanced programming tools for real-time signal and video and applications.	B1 B8 C21
Understanding the design and implementation of computationally complex models generated from data (machine learning) and their use in real applications.	B1 B8 C21
Knowing how to design the suitable software-hardware solution for a problem of signal processing with real-time restrictions.	B1 B8 C21

Contents	
Topic	
Fundamentals of real-time signal and video processing	Real-time definitions Real-time processing platforms Software methods and algorithm simplifications
Design and implementation of real-time signal and video processing applications	Real-time constraints: from research to implementation. Practical examples for signal processing Practical examples for video processing
Highly demanding computational models learned from data	Machine learning principles Artificial neural networks and deep learning Typical DNN models and implementation Examples of highly demanding signal and video processing applications.
Practical content.	Work on three practical cases related to theory units.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	Study of available documentation.

Personalized assistance

Methodologies	Description
Previous studies	Tutoring on demand. Course discontinued due to curriculum extinction.

Assessment

	Description	Qualification	Training and Learning Results	
Previous studies	No classes for this subject (curriculum is being retired). Documentation provided.	0		
Essay questions exam	These exam is associated with the concepts explained in the available documentation	100	B1 B8	C21

Other comments on the Evaluation

Teaching and assessment is in english.

Sources of information

Basic Bibliography

Nasser Kehtarnavaz and Mark Gamadia,, **Real-Time Image and Video Processing: From Research to Reality**, 1, Morgan & Claypool publishers, 2006

Gerassimos Barlas, **Multicore and GPU Programming: An Integrated Approach**, 1, Elsevier, 2015

Complementary Bibliography

Nasser Kehtarnavaz, Shane Parris,Abhishek Sehgal, **Smartphone-Based Real-Time Digital Signal Processing**, 1, Morgan & Claypool publishers, 2015

Nasser Kehtarnavaz, Fatemeh Saki, **Anywhere-Anytime Signals and Systems Laboratory: From MATLAB to Smartphones**, 1, Morgan & Claypool publishers, 2016

Recommendations

Subjects that it is recommended to have taken before

Signal Processing in Audiovisual Systems/V05M145V01205
Signal Processing in Communications/V05M145V01102

IDENTIFYING DATA				
Communication Advanced Systems				
Subject	Communication Advanced Systems			
Code	V05M145V01302			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Mosquera Nartallo, Carlos			
Lecturers	Mosquera Nartallo, Carlos			
E-mail	mosquera@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	This course covers the application of advanced mathematical tools to address some challenges in new and emerging satellite and terrestrial communication systems, with special emphasis on lower layers and multiuser systems.			

Training and Learning Results	
Code	
B4	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.
C22	CE22/PS2 Ability to understand the impact of the requirements of the telecommunications systems design services, with special emphasis in the lower layers, while maintaining a global vision of the solutions employed in modern commercial systems of communications.

Expected results from this subject		
Expected results from this subject	Training and Learning Results	
Understand the impact of telecommunication services requirements on system design, with special emphasis on lower layers.	B4	C22
Acquire a global view of the solutions developed for modern commercial communication systems.	B4	C22

Contents	
Topic	
1. Convex optimization	1.1 Basic concepts of convex sets 1.2 Introduction to convex functions 1.3 Quasiconvex functions 1.4 Convex optimization problems 1.5 Duality 1.6 Introduction to non-convex problems 1.7 Practical examples in communications
2. Multi-user fundamentals	2.1 Fundamentals of information theory for multi-user systems, regions of capacity. 2.2 Multiple access channel: rate region, orthogonal and non-orthogonal allocations. Multi-user detection. 2.3 Broadcast channel: rate region, orthogonal assignments, linear precoding and Dirty Paper Coding techniques. 2.4 Network modeling: Interfering Channel and Relay Channel. Interference management and performance. 2.5 Networks and multiple access: planned systems and contention systems. Limitations of IoT systems. Hybrid retransmission. 2.6 Spectrum and interference management. Spectral sensing, cognitive radio, and virtualization. 2.7 Applications in current standards

Planning			
	Class hours	Hours outside the classroom	Total hours

Previous studies	0	123	123
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
Previous studies	No synchronous lectures.

Personalized assistance

Assessment

	Description	Qualification	Training and Learning Results
Essay questions exam		100	

Other comments on the Evaluation

Sources of information

Basic Bibliography

Stephen Boyd, Lieven Vandenberghe, **Convex Optimization**, Cambridge University Press, 2004

Carlos Mosquera, **Class notes**, 2020

David Tse, Pramod Viswanath, **Fundamentals of Wireless Communication**, Cambridge University Press, 2005

Complementary Bibliography

Dimitri P. Bertsekas, **Convex Optimization Theory**, Athena Scientific, 2009

David G. Luenberger, Yinyu Ye, **Linear and Nonlinear Programming**, Fourth, Springer, 2016

Thomas Cover and Joy Thomas, **Elements of Information Theory**, Second, Wiley, 2006

Recommendations

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

Advanced Digital Communications/V05M145V01204

IDENTIFYING DATA				
Statistical Signal Processing				
Subject	Statistical Signal Processing			
Code	V05M145V01303			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	López Valcarce, Roberto			
Lecturers	López Valcarce, Roberto			
E-mail	valcarce@gts.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Statistical Signal Processing, encompassing both estimation and detection theory, can be found at the core of many decision-making and information-extracting systems, including communications, audio and image processing, biomedicine, radar, and big data systems, just to name a few. In this course an introduction to the basics of estimation and detection theory is provided. Since the course is targeted to electrical engineering students, the focus is on the development of practical estimation and detection algorithms amenable to implementation in digital processing systems.			

Training and Learning Results	
Code	
B4	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.
B8	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.
C23	CE23/PS3 Ability to apply methods of statistical processing of signal communications systems and audiovisual.

Expected results from this subject	Training and Learning Results
Ability to apply statistical estimation techniques in communications and multimedia systems	C23
Ability to apply statistical detection techniques in communications and multimedia systems	C23
Ability to determine and interpret fundamental limits in estimation and detection problems	B4 C23
Ability to evaluate the performance of estimation and detection techniques, by analytical as well as by Monte Carlo simulation methods	B8 C23

Contents	
Topic	
Part 1: Parameter Estimation	- The statistical estimation problem. Performance metrics: bias, variance, MSE. Minimum Variance Unbiased Estimator (MVUE). - Fisher Information and Cramer-Rao bound. Slepian-Bangs formula. - Best Linear Unbiased Estimator (BLUE) and Maximum Likelihood Estimator (MLE): definition, properties, and examples.
Part 2: Detection Theory	- Hypothesis tests: types. Performance metrics: false positives and false negatives. ROC curves. - Neyman-Pearson theorem: likelihood ratio. - Detection under the Bayesian philosophy: probability of error, risk, optimum detector. - Examples: deterministic and random signals

Planning	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
Objective 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
Previous studies	Study of the documentation provided.

Personalized assistance	
Methodologies	**Description**
Previous studies	Counseling available on demand during office hours. Course without classes due to the extinction of the study plan.

Assessment				
	Description	Qualification	Training and Learning Results	
Objective questions exam	Related to the concepts covered by the documentation provided.	100	B4 B8	C23

Other comments on the Evaluation

Sources of information

Basic Bibliography

S. M. Kay, **Fundamentals of Statistical Signal Processing, vol. I: Estimation Theory**, 1, Prentice Hall, 1993

S. M. Kay, **Fundamentals of Statistical Signal Processing, vol. II: Detection Theory**, 1, Prentice Hall, 1998

Complementary Bibliography

S Theodoridis, **Machine Learning: A Bayesian and Optimization Perspective**, 1, Elsevier, 2015

L. L. Scharf, **Statistical signal processing: detection, estimation and time series analysis**, 1, Pearson, 1991

IEEE, **http://ieeexplore.ieee.org/**,

Recommendations

Subjects that are recommended to be taken simultaneously

Communication Advanced Systems/V05M145V01302

Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

Advanced Digital Communications/V05M145V01204

IDENTIFYING DATA				
Satellites				
Subject	Satellites			
Code	V05M145V01311			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Aguado Agelet, Fernando Antonio			
Lecturers	Aguado Agelet, Fernando Antonio			
E-mail	faguado@uvigo.gal			
Web	http://moovi.uvigo.gal			
General description	The contents of this course cover the basics of satellite standards, system engineering, the different segments of satellite systems, an introduction to product assurance and assembly, integration and verification procedures as well as an introduction to satellite operations. The course will be entirely conducted in English; the use of Spanish or Galego will be optionally allowed in the last exam.			

Training and Learning Results	
Code	
A2	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.
B3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
B7	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.
C18	CE18/RAD1 Capacity of elaborating, strategic planning, direction, coordination and technical and economic management of spatial projects applying spatial systems engineering standards, with knowledge of the processes a satellite operation.

Expected results from this subject	Training and Learning Results
To know and apply ECSS management space project standards.	C18
To know the basics of the system engineering applied to space projects.	A2 B3 C18
To know the mission life cycle of a space mission.	A2 C18
To know the documentation generated in each engineering phase in a space mission	A2 B3 C18
To know and ellaborate the main technical studies and budgets in a space mission.	B3 B7 C18
To know applicable methodologies and standards to product assurance (PA) and Assembly, Integration and Verification (AIV) procedures in a space project.	A2 B3 C18
To know the basics of satellite operation procedures and standards	C18

Contents	
Topic	
International space project standards (Theoretical and Practical).	ECSS, NASA, INCOSE.
Space project life cycle (Theoretical and Practical).	Documentation and reviews.
Segments of a satellite project (Theoretical).	- Space Segment. - Ground Segment. - User Segment. - Launchers.

Satellite subsystems (Theoretical).	- Communication. - Mechanical & Thermal. - Power. - ADCS. - Propulsion. - On-board computer.
Product Assurance and Assembly, Integration and Verification Procedures in a space project (Theoretical and Practical).	- Product Assurance (PA) in space projects. - Assembly, Integration and Verifications (AIV) plans and procedures in space projects.
Introduction to satellite operations (Theoretical).	- Telemetry and Telecommand definition. - Operation procedures.
Analysis and simulation of two polarization effects, antenna pointing, and tropospheric propagation in satellite communications (Practical)	- Simulation of the pointing and polarization effects. - Effects of the troposphere.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	Study of the provided documentation.

Personalized assistance

Methodologies	Description
Previous studies	Tutorials on demand. Subject without lectures due to the phasing out of the curriculum.

Assessment

	Description	Qualification	Training and Learning Results		
Essay questions exam	(*)Esta proba está asociada aos conceptos explicados na documentación disponible.	100	A2	B3 B7	C18

Other comments on the Evaluation

Sources of information

Basic Bibliography

Course documentation and slides,

James R. Wertz, David F. Everett and Jeffery J. Puschell, **Space Mission Engineering: The New SMAD**, 4,

http://www.ecss.nl,

Transparencias de la asignatura,

Complementary Bibliography

http://www.incose.org/,

NASA Systems Engineering Handbook, SP-2007-6105. Rev 1,

Peter Fortescue (Editor), John Stark (Editor), Graham Swinerd (Editor), **Spacecraft Systems Engineering**, 3,

Recommendations

Subjects that it is recommended to have taken before

Wireless and Mobile Communications/V05M145V01313
Analog Electronic Circuits Design/V05M145V01106

IDENTIFYING DATA				
Wideband Radio Systems				
Subject	Wideband Radio Systems			
Code	V05M145V01312			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	García Sánchez, Manuel			
Lecturers	García Sánchez, Manuel			
E-mail	manuel.garciasanchez@uvigo.es			
Web	http://moovi.uvigo.es			
General description	Wideband radio systems.			

Training and Learning Results	
Code	
C19	CE19/RAD2 Ability to perform theoretical design, experimental band systems measurement and practical implementation broadband for current applications

Expected results from this subject	Training and Learning Results
Theoretical and experimental knowledge of wideband systems	C19
Knowledge of designs of wideband active and passive elements	C19
Fundamentals of wideband signal generation and reception	C19
Fundamentals of wideband signal measurement	C19

Contents	
Topic	
Introduction	Definitions and basic concepts Communicaction systems Radio systems. Antennas. Radioelectric spectrum. Modulation. Radio channel. Propagation channel.
Description of the radio channel	Free space Undistorted transmission Attenuation. Multipath Fading. Doppler spread. Delay spread. Frequency selective channels. Precursors.
Mathematical characterization	Narrowband Statistical amplitude distributions Doppler spectrum Wideband Bello formulation
Channel sounders	Narrowband Doppler. Nyquist limit. Wideband. Frequency domain sounders: VNA Time domain sounders. RF pulse. Sliding correlation sounders. Sounder design and performance assesment. Narrowband sounder with spectrum analyzer 0 span. VNA based sounder. Sliding correlation sounder.
Channel sounders lab	Building a wideband sounder to measure the radio channel.

Wideband modulations	Delay spread. Inter symbol interference. Irreducible BER. Frequency hopping: GSM OFDM. Guard interval. Pilot tones. Equalization. PAPR. Amplifiers. DVB-T. 4G. CDMA. Processing gain. Noise. Adquisition and tracking. RAKE receiver. 3G. Power control. Cellular breathing.
UWB systems	1. Definition. Specificities. Regulation 2. Channel characteristics. 3. Impulse radio UWB. 4. Multiband OFDM approach to UWB. 5. Applications
Wideband and UWB antenna design	1. Wideband antennas. Definition and requirements. 2. Characterization of wideband antennas 3. Examples and applications. 4. UWB antennas. Definition and requirements. 5. Characterization of UWB antennas 6. Examples and applications.
UWB applications	Radar Ground penetrating radar Positioning and location Medical imaging Emerging applications

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
Objective 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
Previous studies	Study of the documentation

Personalized assistance

Methodologies	Description
Previous studies	Subject without lectures. Assitance under request.

Assessment

	Description	Qualification	Training and Learning Results
Objective questions exam	(*)Exame dos conceptos explkicados na documentación	100	C19

Other comments on the Evaluation

We offer the students just one assessment scheme: global assessment.

Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected the exam, 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.D. Parsons, **The Mobile Radio Propagation Channel**, Wiley,

Complementary Bibliography

H. Schulze, **Theory and applications of OFDM and CDMA**, Wiley,

M. Ghavami L.B Michael R. Kohno, **Ultra Wideband signals and systems in communication engineering**, Wiley, 2007

W. Pam Siriwongpairat K.J. Ray Liu, **Ultra-Wideband Communications systems. Multiband OFDM approach**, Wiley, 2008

W. Wiesbeck, G. Adamiuk, C. Sturm, **Basic Properties and Design Principles of UWB Antennas**, 2009

P. Bello, **Theory and applications of OFDM and CDMA**, 1963

J.D. Parsons, D.A. Demery and A.M.D. Turkmani, **Sounding techniques for wideband mobile radio channels: a review**, 1991

Recommendations

IDENTIFYING DATA				
Wireless and Mobile Communications				
Subject	Wireless and Mobile Communications			
Code	V05M145V01313			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Vazquez Alejos, Ana María			
Lecturers	Vazquez Alejos, Ana María			
E-mail	analejos@uvigo.es			
Web				
General description				

Training and Learning Results	
Code	
C20	CE20/RAD3 Ability to analyse and specify the basic parameters of a mobile or wireless radio network, as well as of quality of service.

Expected results from this subject	Training and Learning Results
Dimensioning and capacity planning of mobile and wireless systems.	C20
Ability to carry out a mobile network deployment planning.	C20
Ability to select the radio technology most appropriate to a given application.	C20

Contents	
Topic	
Unit 1. Overview of mobile wireless radio communication systems.	1.1. Introduction to mobile and wireless systems. 1.2. Mobile and wireless radio propagation channel modeling.
Unit 2. Dimensioning and quality of service planning in mobile and wireless radio systems.	2.1. Dimensioning of a mobile radio system. 2.2. Quality of service.
Unit 3. Cellular systems.	3.1. Enabling technologies: from 2G to 4G. 3.2. Next Generation mobile systems: 5G and 6G.
Unit 4. Wireless local and wide area networks.	4.1. Local area wireless systems and services: WLAN, and LPWAN. 4.2. Internet of Things (IoT). 4.3. Vehicular communications. 4.4. Design fundamentals: radio propagation channel modeling, dimensioning and quality of service.
Laboratory practices	1. Behavioral simulation of a transmission link under conditions of Rayleigh fading. 2. Rayleigh radio channel with Jakes-type Doppler spectrum. 3. Link balance and preliminary error estimation. 4. Simulation of different system configurations: no channel coding vs. channel coding and interleaving. 5. Beamforming.

Planning	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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

Previous studies	Study of documentation provided in Moovi.

Personalized assistance	
Methodologies	**Description**
Previous studies	On-demand tutoring. Course without classes due to the phase-out of the curriculum.
Tests	**Description**
Essay questions exam	Test associated with the concepts explained in the documentation available on Moovi.

Assessment			
	Description	Qualification	Training and Learning Results
Previous studies	(*)Non se imparten clases desta materia (o plan de estudios está en proceso de extinción). Proporciónase material de estudio en Moovi.	0	C20
Essay questions exam	(*)Esta proba está asociada aos conceptos explicados na documentación dispoñible en Moovi.	100	C20

Other comments on the Evaluation

After any assessment, teaching staff may call students for oral verification interviews, either at random or where there are indications of cheating, unauthorized use of artificial intelligence, or other fraudulent means in completing the exam. Grades for the assessments shall remain provisional until any such interviews have been completed. During these interviews, students must demonstrate that they possess the knowledge and skills needed to adequately justify the solutions they submitted.

Sources of information

Basic Bibliography

Ana Vazquez Alejos, **Lecture Notes and Powerpoint Slides**,

Andreas F. Molisch, **Wireless Communications: From Fundamentals to Beyond 5G, 3rd Edition**, 978-1-119-11721-6, 3, Wiley, 2022

William Stallings, **5G Wireless: A Comprehensive Introduction**, 978-0-13-676714-5, 1, Addison-Wesley Professional, 2021

Oriol Sallent, **Fundamentos de diseño y gestión de sistemas de comunicaciones móviles celulares**, 978-8-49-880482-9, Iniciativa Digital Politècnica, 2014

Jose María Hernando Rábanos, Luis Mendo Tomás, José Manuel Riera Salís, **Comunicaciones Móviles**, 978-8480042314, 3, Editorial Universitaria Ramón Areces, 2015

Mª Teresa Jiménez Moya, Juan Reig Pascual, Lorenzo Rubio Arjona, **Problemas de comunicaciones móviles**, 9788483630006, Universitat Politècnica de València, 2006

Siva S. Yellampalli, **Wireless Sensor Networks Design, Deployment and Applications**, 9781838809102, 1, InTechOpen, 2021

Complementary Bibliography

Recommendations

Subjects that continue the syllabus

Satellites/V05M145V01311
Communication Advanced Systems/V05M145V01302
Wireless Networks and Ubiquitous Computation/V05M145V01211
Antennas/V05M145V01208

Subjects that are recommended to be taken simultaneously

Wideband Radio Systems/V05M145V01312

Subjects that it is recommended to have taken before

Radio Laboratory/V05M145V01209
Radiocommunication/V05M145V01103

IDENTIFYING DATA				
Microwave and Millimetre Wave Circuit Design and CAD				
Subject	Microwave and Millimetre Wave Circuit Design and CAD			
Code	V05M145V01317			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Fernández Barciela, Mónica			
Lecturers	Fernández Barciela, Mónica			
E-mail	monica.barciela@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	Communications systems are at the mercy of the available technology to fabricate their transceivers. To understand the complexities of modern communications transceivers, their performance requirements and limitations, especially in the microwave and mm-wave frequency bands, it is mandatory to have a closer look to their underlying electronics and fabrication methods. And this look requires not only a theoretical background in active devices and circuit design methodologies or fabrications methods, but most importantly, a practical background in circuit design, fabrication, measurement and performance evaluation. The student has already acquired this theoretical background through previous subjects. The present subject aim to provide the student with some practical background by fully designing, fabricating in hybrid integrated technology and characterizing a circuit prototype, in fact one of the analogue building components of modern transceivers for working in the microwave bands (power amplifier, oscillator or mixer). Most of the presential hours of the course and personal work of the student will be devoted to the design and fabrication of this prototype, in several stages that will be independently evaluated. Besides this practical work, some presential hours will be devoted to describe the design rules and methodologies of advanced transceiver circuit modules working in microwave and mm-wave bands. Among others, we may mention issues related to the design of efficient power amplifiers or the use of X-parameters to characterize and model these nonlinear components.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
C32	CE38/OP8 Ability to design, manufacture (in hybrid technology) and characterize the analog components of transceivers of communications in microwave and millimeter-wave bands

Expected results from this subject	Training and Learning Results	
Learn to design analogue advanced active circuits (linear and nonlinear) for emitters and receivers for communications in the microwave and milimeter wave frequency bands.	B1 B4	C32
Learn to design high frequency circuits for the optoelectronic interface in optical communications systems.	B1 B4	C32
Learn the fabrication techniques of integrated circuits (hybrid and monolithic) for communications in the high frequency bands.	B1 B4 B8	C32
Learn to asses the performance of microwave circuits for communication transceivers.	B1	C32

Contents
Topic

1. Advanced circuit design for communication transceivers in the microwave and millimeter wave bands.	a. Linear and Nonlinear Circuit Design Techniques. -CAD-based design and component models. -Measurement-based design. - S-parameters vs X-parameters b. Advanced Low Noise Amplifier Design c. High Eficiency Power Amplifier Design d. High Frequency Oscillator Design e. Frequency Converter Design
2. High frequency circuit design for optoelectronic transceivers in optical communications systems.	Broadband Amplifier Design Techniques
3. Fabrication techniques for Hybrid and Monolithic Microwave Integrated Circuits	Hybrid MIC processing techniques MMIC technologies and foundry processing techniques.
4. Advanced linear and nonlinear characterization techniques, and corresponding instrumentation, to guide design and evaluate performance.	Device linear characterization techniques and instruments: VNAs. Device nonlinear characterization techniques and instruments: NVNAs, VSAs, etc.
5. A Case Study: CAD-based prototype design, and performance evaluation.	Prototype Design using ADS simulator Prototype simulation to evaluate performance.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	0	15	15
Mentored work	0	35	35
Mentored work	0	50	50
Mentored work	0	25	25
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	Documentation in Moovi describes the main concepts in the most relevant Topics in the Subject. Note: the last Topic is an application work (case study) to be performed by the student, as part of a tutored work. Besides, some of the Topics/sub-topics in the Subject will be individually worked, as part of another tutored work. These lessons are oriented to the acquisition of the competencies: CG1,4,8 and CE38/OP8.
Mentored work	With the aid of his/her personal work, the student will be guided to design - working individually- a circuit prototype using ideal models of the passive components. The student will write one report of the work. The work is designed to help in acquiring competencies: CG1,4,8 and CE38/OP8.
Mentored work	Each student will prepare - working individually- a short written report about one of the topics covered in the subject. This work is designed to aid in acquiring competencies: CG1,4,8 y CE38/OP8.
Mentored work	With the aid of his/her personal work, the student will be guided to design - working individually- a circuit prototype in microstrip hybrid technology. Then, he/she will evaluate its simulated performance. The student will write a report of the work. This work is designed to aid in acquiring competencies: CG1,4,8 y CE38/OP8.

Personalized assistance	
Methodologies	**Description**
Lecturing	The student will be able to consult his doubts, about the different topics described in the master lessons, during the lecturer office hours. Office hours appointments: https://moovi.uvigo.gal/user/profile.php?id=11321
Mentored work	The student will be able to consult his/her technical questions and request suggestions, in the realization of his/her work related to the design of an ideal circuit prototype, by using the lecturer office hours. Office hours appointments: https://moovi.uvigo.gal/user/profile.php?id=11321
Mentored work	The student will be able to consult his/her technical questions and request suggestions, to prepare the presentation of a topic related with the Subject, during the lecturer office hours. Office hours appointments: https://moovi.uvigo.gal/user/profile.php?id=11321

Mentored work	The student will be able to consult his/her technical questions and request suggestions, in the realization of his/her work related to the design of an hybrid microstrip circuit prototype, by using the lecturer office hours. Office hours appointments: https://moovi.uvigo.gal/user/profile.php?id=11321

Assessment

	Description	Qualification	Training and Learning Results	
Mentored work	The student will -individually- design, with ideal passive components, and simulate the performance of a microwave circuit prototype. The assessment will take into account: the circuit design, the simulated performance and the written report. In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32.	30	B1 B4 B8	C32
Mentored work	The student will -individually- write a report about a topic related to the Subject. The assessment will be performed by taking into account the quality of the report. In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32.	30	B1 B4 B8	C32
Mentored work	The student will -individually- design in Hybrid Microstrip Technology and simulate/evaluate the RF performance of a microwave circuit prototype. The assessment will take into account: the circuit layout, the simulated RF performance and the written report. In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32.	40	B1 B4 B8	C32

Other comments on the Evaluation

The subject will be taught and evaluated fully in English. Technical documents, reports and interactions with the students will be performed in English.

A) First Call:

The student work in the subject will be evaluated through the development of the mentored works:

1. The microwave circuit prototype: design (ideal and microstrip), RF performance evaluation (simulated) and written reports. In total, up to 70% of the total Subject qualification.

2. The topic written report. In total, up to 30% of the total subject qualification.

B) Second Call:
Students will have the opportunity to re-design his/her previous prototype and also improve the topic written report. Each of these tasks will be assigned the same qualification percentage as in the First Call
Alternatively: Students who did not opt for improving their previous works, will have four weeks to design, simulate, evaluate performance and write a report of a new circuit prototype, chosen by the lecturer. The assessment of this work will be up to 100% of the subject qualification.
In the End-of-Program Call, evaluations will be similar to the Second Call.

In case of plagiarism detection in any of the student works, the grade obtained by the student in this course will be a failing grade (0) and the course lecturer/s will communicate this issue to the school Board of Directors so they may take those measures deemed appropriate.

Sources of information

Basic Bibliography

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

Complementary Bibliography

Technical papers (journals, application notes, data sheets,...),

Instrumentation and simulator manuals,

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

Guillermo Gonzalez, **Foundations of Oscillator Circuit Design**,

D. Root, **X-Parameters: Characterization, Modeling, and Design of Nonlinear RF and Microwave Components**, 1,

Recommendations

Subjects that it is recommended to have taken before

Electronics and Photonics for Communications/V05M145V01202

IDENTIFYING DATA				
Multimedia Security				
Subject	Multimedia Security			
Code	V05M145V01318			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Pérez González, Fernando			
Lecturers	Pérez González, Fernando			
E-mail	fperez@gts.uvigo.es			
Web	http://faitic.uvigo.es			
General description	Multimedia security is an increasingly important topic as most of the information exchanged nowadays over the Internet is multimedia. Traditional data protection solutions like cryptography only solve the problem partially, because contents, once decrypted, are no longer protected. In addition, there is a rising concern over the integrity of multimedia contents: modern editing tools jeopardize our trust on video, images or audio. Fortunately, a number of research groups and companies have addressed these problems and ingenious solutions exist. This course presents advanced topics in multimedia security, with emphasis on cryptography, watermarking, forensics and signal processing in the encrypted domain. 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.			

Training and Learning Results	
Code	
B4	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.
B8	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.
C31	CE37/OP7 Ability to model, operate, manage, and deal with the full cycle and bagging of networks, services and applications considering the quality of service, direct and costs of operation, the plan of implementation, monitoring, security, scaling and maintenance, managing and ensuring the quality of the development process

Expected results from this subject	Training and Learning Results	
Handle the use of different algorithms in current multimedia communications environments.	B4 B8	C31
Understand technical material in an autonomous way.	B4 B8	C31

Contents	
Topic	
Introduction to cryptography.	Application to multimedia systems. Integration with source and channel coding. Block and stream ciphers. Hashing and MAC codes. Specific algorithms.
Conditional access systems.	Requirements. History and state of the art. Design of a conditional access system.
Secret sharing.	Simple secret sharing systems. Visual cryptography.

Data hiding and watermarking.	Basic concepts. Watermarking versus data hiding. Spread-spectrum watermarking. Quantization-based watermarking. Application to images and video. Application to copyright protection of deep learning models.
Forensic signal processing.	Quantization detection and estimation. Filtering detection and identification. Resampling detection and estimation. Camera attribution.
Signal Processing in the Encrypted Domain.	Privacy metrics and notions. Homomorphic encryption. Garbled cicruits. Signal representation and cipher blowup. Applications.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
Essay questions exam	0	2	2

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

Methodologies

	Description
Previous studies	

Personalized assistance

Methodologies	Description
Previous studies	

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	Final exam with short questions on the contents of the subject.	100	B4 B8	C31

Other comments on the Evaluation

In the case that plagiarism or extensive use of AI tools is detected in any of the reports/exams done/taken, the final score for the subject will be 'fail' (0) and the teachers will inform the School authorities of the affaire so that they take the appropriate measures. Besides, the teachers will inform the School authorities of any conduct against ethics by the students, the possibility existing that the School authorities take the appropriate measures.

Sources of information

Basic Bibliography

A.J. Menezes, **Handbook of Applied Cryptography**, 1996,

Complementary Bibliography

Cox, Miller, Bloom, Fridrich, Kalker, **Digital Watermarking and Steganography**, 2nd,

Troncoso-Pastoriza, Perez-Gonzalez, **Secure Signal Processing in the Cloud: enabling technologies for privacy-preserving multimedia cloud processing**, Signal Processing Magazine,

A. Piva, **An Overview of Image Forensics**, Signal Processing,

Recommendations

IDENTIFYING DATA				
Intelligent Sensors				
Subject	Intelligent Sensors			
Code	V05M145V01319			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Machado Domínguez, Fernando			
Lecturers	Machado Domínguez, Fernando			
E-mail	fmachado@uvigo.es			
Web	http://moovi.uvigo.es			
General description	The overall objective of this course is to provide the theoretical and practical skills for the design and characterization of the electronic instrumentation systems based on smart sensors in wired or wireless topologies. To achieve this, the main intelligent sensors structures, the sensor networks architectures and topologies, the energy harvesting smart sensors systems and the software tools and hardware platforms for designing smart multi-sensor systems will be studied.			

Training and Learning Results	
Code	
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B8	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.
C36	CE43/OP13 Ability to characterize intelligent sensors and their specific characteristics in networks

Expected results from this subject	Training and Learning Results		
Know the different structures of the intelligent sensors.	A5		C36
Know the topologies and architectures of the sensor networks.	A5		C36
Know analyse and design systems of efficient sensors in consumption.	A4	B8	C36
Know software tools and hardware platforms for the design of sensor systems.	A5		C36
Design applications based on data fusion of different sensors.	A4	B8	C36

Contents	
Topic	
Unit 1: Smart Sensors.	Definition. Classification. Architectures. Multisensorial systems. Standard IEEE 1451 for smart sensors. Applications: Internet of Things, Industry 4.0, Machine Learning.
Unit 2: Wired topologies.	General features. Classification. Practical examples. Intelligent Transportation Systems (ITS). Embedded buses for automotive applications. Development tools.
Unit 3: Wireless topologies.	The ISM bands. Basic features of wireless networks. Multiplexing and modulation. The SDR concept. Standards for WLAN and WPAN. IEEE standards 802.15.1/4/3. Wireless sensor networks (WSNs). Other commercial networks.
Laboratory	Laboratory sessions and project.
Unit 1. Wired sensors systems.	Sensor conditioning and data acquisition.
Unit 2. Wireless sensors systems.	Design, implementation and test of a wireless sensor network.
Unit 3. Project: Design and implementation of an electronic instrumentation system with smart sensors.	Design, implementation and test of an electronic instrumentation system with smart sensors, applying theoretical and practical concepts.

Planning	Class hours	Hours outside the classroom	Total hours

Lecturing	0	8	8
Mentored work	0	19.5	19.5
Laboratory practical	0	22.5	22.5
Project based learning	0	60	60
Report of practices, practicum and external practices	0	15	15

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

Methodologies

	Description
Lecturing	As this subject is in a phase-out process with no in-person teaching, the methodology will be based on the students' independent study and autonomous work. The teaching staff will provide the necessary guidelines to follow the contents of the subject under study. 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 personalized attention sessions. In this methodology, the skills A5 and C36 will be developed.
Mentored work	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. The lecturer will propose the topic of this individual task and monitor the student s work in personalized attention sessions. In this methodology, the skills A4, A5, B8 and C36 will be developed.
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. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in personalized attention sessions. In this methodology, the skills A5 and C36 will be developed.
Project based learning	A theoretical-practical project will be carried out individually and autonomously within a specified time to solve a problem through the planning, design, and execution of a series of activities. Students must plan, design, and carry out the necessary activities to solve the proposed problem, following the guidelines of the teaching staff. Finally, they will present the obtained results. Through these tasks, competencies A4, A5, B8, and C36 will be addressed.

Personalized assistance

Methodologies	Description
Lecturing	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The students can go to the lecturer s office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).
Laboratory practical	The lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools). The students can go to the lecturer s office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).
Mentored work	The lecturer will help students to deal with the mentored work. The students can go to the lecturer s office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).
Project based learning	The lecturer will be available to help students in order to deal with the project. The timetable will be available on the school website at the beginning of the term. The timetable and/or the mechanism to request tutoring sessions will be available on the subject's website on the Moovi online-teaching portal (https://moovi.uvigo.gal/).

Assessment

	Description	Qualification	Training and Learning Results
Mentored work	The lecturers will consider the quality of the results obtained, their analysis, the final report, and the classroom presentation. The tutored work mark (TWM) will be assessed in a 10 points scale.	20	A4 B8 C36 A5

Laboratory practical	The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. The final mark of laboratory (FML) 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), as long as it was possible to form groups, the individual preliminary tasks and the answers to personalized questions for each session.	30	A5	C36
Project based learning	The lecturers will consider the work done during the laboratory sessions, the presentation of results and functionality. This mark (FUN) will be assessed in a 10 points scale and will represent 80% of the final mark project (FMP) and 40% of the final mark of the subject (FM). For the evaluation of the project, the lecturer will assess the group work (the same mark for each member) and the individual work during the laboratory sessions and the presentation of the developed project.	40	A4 A5	B8 C36
Report of practices, practicum and external practices	The lecturers will consider the quality of the project report and the presentation and analysis of the results. This mark (REP) will be assessed in a 10 points scale and will represent 20% of the final mark project (FMP) and 10% of the final mark of the subject (FM). For the evaluation of this part, the lecturer will assess the group work (the same mark for each member) and the individual presentation of the developed project. The skills CB4, CB5, CG8 and CE43 will be evaluated in these projects.	10		

Other comments on the Evaluation

Important information: Subject in the phase-out process

Since this subject is part of a degree program that is currently being phased out, no in-person classes will be taught during this academic year. For this reason, as it is not possible to carry out the mandatory in-person tracking of the learning activities, the "Continuous assessment" modality is hereby cancelled. Consequently, all enrolled students will be mandatory assessed through the **"Global assessment"** system, both in the regular and extraordinary opportunities, as well as the end-of-program call, in accordance with the requirements and tests detailed in the corresponding section of this syllabus.

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1. Continuous assessment (ordinary call)

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

In order to **be assessed by continuous evaluation**, the student cannot miss more than one theory session, more than one laboratory session and more than one project session; and only if this absence is duly justified. The final grade of students who have chosen this path cannot be "not presented".

The subject comprises three different parts: theory (20%), laboratory (30%) and project (50%). The marks of the assessed tasks are valid only for the current academic course.

The planning for the different sessions will be available at the beginning of the semester. Students who are occasionally unable to attend any of the assessment tasks could repeat it, whenever it was possible within the subject academic schedule and only if the absence is duly justified.

1.a Theory

Attendance at the theory classes is compulsory. In order to pass the theory part, the student cannot miss more than one theory session and only if this absence is duly justified.

In the first weeks of the course each student will be asked to carry out a task individually with the help of the lecturer about a topic related to the subject. In order to assess the work, the lecturer will consider the results, their analysis and presentation, and the quality of the written report. The students will be informed of the deadline by the lecturer. The tutored work mark (TWM) will be assessed in a 10 points scale. If the students present their works after the deadline the TWM will be 0.

The final mark of theory (FMT) will be: FMT = TWM.

The minimum mark required to pass this part is of 5 (FMT>=5).

1.b Laboratory

Each laboratory session lasts approximately 150 minutes and the students will work in pairs (whenever possible). This part also will be assessed by continuous assessment. Each session will be only evaluated according to the developed work at the

schedule date. The lecturer will consider the work of the students carried out before the laboratory session to prepare the proposed tasks, the work in the laboratory to deal with them as well as the student□s behavior.

Marks for each laboratory session (LSM) will be assessed in a 10 points scale. A mark of 0 will be obtained for missing sessions. In order to pass the laboratory part the students can not miss more than one laboratory sessions and only if this absence is duly justified. The final mark of laboratory (FML) is calculated as the arithmetic mean of the individual laboratory session marks.

1.c Project

In the first session lecturer will present the objectives and the schedule of the project. They also assign a specific project to each group (two students per project whenever possible). After that, the most important part of the workload will be developed in the laboratory: one laboratory session (B hours) and the project sessions (C hours).

In order to assess the project, the lecturer will consider: the work done during the laboratory sessions, functionality and presentation of results (FUN), and the quality of the project report (REP). Each of these parts will be scored on a 10 points scale. The final mark of project (FMP) will be the weighted sum of the marks for each part:

$$FMP = 0.8 \cdot FUN + 0.2 \cdot REP$$

The project will be assessed in a 10 points scale. The minimum mark required to pass this part is of 5 (FMP>=5). The students are only allowed to miss one project session and only if this absence is duly justified.

1.d 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: 20% theory (FMT), 30% laboratory (FML) and 50% project (FMP).

In order to pass the subject, students will be required to pass the theory, laboratory and project parts. In this case the final mark (FM) will be:

$$FM = 0.2 \cdot FMT + 0.3 \cdot FML + 0.5\ FMP.$$

However, when the students do not pass both parts (FML < 5 or FMP < 5), or miss more than 1 theory session, or more than 1 laboratory session, or miss more than 1 project session, the final mark grade can never be higher than 4.9:

$$FM = \min\{4.9\ ;\ (0.2 \cdot FMT + 0.3 \cdot FML + 0.5\ FMP)\}.$$

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

2. Global assessment (ordinary call)

The students who prefer a different educational policy can attend an exam on a scheduled date. The date will be specified in the academic calendar. This exam will comprise three parts: theory exam, laboratory exam and project. The student will prepare a written project report to be handed in just before the exam. The final project must be presented within one week of delivery of reports. In order to assign the project, the student has to contact to the lecturer at least four weeks before the exam.

In order to pass the theory, the student will have to attend to an exam with test questions and/or sort answer questions. The theory exam will be assessed in a 10 points scale and and the final mark of theory (FMT) will be the obtained mark.

In the laboratory exam the student will be asked to deal with some of the electronic circuits developed in the laboratory sessions as well as some short answer questions related to these sessions. The laboratory exam will be assessed in a 10 points scale and the final mark of laboratory (FML) will be the obtained mark.

In order to assess the project, the lecturer will consider the results, their analysis and presentation, and the quality of the written report. The project will be assessed in a 10 points scale and the the final mark of project (FMP) will be the obtained mark.

In order to pass the subject, students will be required to pass each part (FMT>=5, FML>=5 and FMP>=5). In this case the final mark (FM) will be:

$$FM = 0.2 \cdot FMT + 0.3 \cdot FML + 0.5\ FMP.$$

However, when the students do not pass all parts (FMT < 5 or FML < 5 orFMP < 5), the final mark can never be higher than 4.9:

FM = min{4.9 ; (0.2·FMT + 0.3·FML + 0.5 FMP)}.

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

3. Extraordinary call and advance of call

The assessment policy in extraordinary call and advance of call will follow the scheme described in the previous section. Dates will be specified in the academic calendar. This exam consist on a theory exam, a laboratory exam and a project. In order to assign the project, the student has to contact to the lecturer at least four weeks before the exam.

The final mark will be calculated as it has described in:

- section 1 to students with the theory part passed in continuous evaluation, and
- section 2 for all other case.

In extraordinary call, the marks obtained in the previous continuous or global assessment are kept for those parts in which the student has not attended.

Sources of information
Basic Bibliography
Fraden, J., **Handbook of modern sensors**, 5th, Springer, 2016
Gómez, C., Paradells, J. y Caballero, J.E., **Sensors Everywhere: Wireless Network Technologies and Solutions**, Fundación Vodafone España, 2010
Misra, S., Woungang, I. & Chandra, S., **Guide to Wireless sensor networks**, Springer, 2009
Slama, D., Puhlmann, F., Morrish, J. and Bhatnagar R.M, **Enterprise IoT: Strategies and Best Practices for Connected Products and Services**, O'Reilly, 2016
Rogers, L. a& Stanford-Clark, A, **Wiring the IoT: Connecting Hardware with Raspberry Pi, Node-Red, and MQTT**, O'Reilly, 2017
Complementary Bibliography
Mariño-Espiñeira, P., **Las comunicaciones en la empresa; normas, redes y servicios**, 2ª, RAMA, 2006
Faludi, R., **Building wireless sensor networks.**, O´Reilly, 2011
Parallax Inc., **Smart Sensors and Applications**, 3rd, Parallax Inc., 2006

Recommendations

IDENTIFYING DATA				
Distributed Computing				
Subject	Distributed Computing			
Code	V05M145V01321			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Mikic Fonte, Fernando Ariel			
Lecturers	Mikic Fonte, Fernando Ariel			
E-mail	mikic@det.uvigo.es			
Web	http://moovi.uvigo.es			
General description	This course will provide a vision of group of the most usual technologies inside the distributed computing. They will tackle subjects such as the distributed transactions and the replication; the distributed artificial intelligence; and the parallel and evolutionary computing. We will use Spanish and Galician languages in classroom, and English language for the instructional materials.			

Training and Learning Results	
Code	
A2	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.
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B8	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.
C24	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.

Expected results from this subject	Training and Learning Results
To earn skills in the design, development and management of distributed systems.	A2 B8 C24
To understand the functional bases of the distributed systems.	A4 A5 C24
To know the distinct concepts related with the distributed computing.	A5 B8 C24
To earn skills for the application of intelligent systems in the distributed computing.	A2 A5 B8 C24
To learn how to distribute the execution of tasks for the resolution of problems and optimisation by means of evolutionary and parallel computing.	A2 A4 B8 C24

Contents	
Topic	
Theory 1. Distributed artificial intelligence	1. Intelligent agents and multiagent systems 2. Theory of games applied to multiagent systems: coordination, competition, negotiation, auctions, electronic trade 3. Complex distributed systems and auto-organised ones

Theory 2. Parallel and evolutionary computation	1. Distributed Computing and parallelization 2. Algorithms and evolutionary programming: genetics, memetics, differential evolution, intelligence of swarm. 3. Optimisation by means of evolutionary technics and parallelization
Theory 3. Transactions	1. Concurrency problems 2. Recoverability problems 3. Deadlocks 4. Optimistic concurrency control 5. Timestamps
Theory 4. Replication	1. Introduction to replication 2. Case studies of high available services (Bayou and Coda) 3. Transactions with replicated data
Theory 5. Design of distributed systems	1. Google case study
Practice 1. Multi-node cluster with Hadoop Distributed File System.	Part 1: Installation. Part 2: Developing a program analyzing Big Data using distributed Hadoop.
Practice 2: Introducing the basics for using evolutionary algorithms in optimization processes by means of parallel computing on Spark	Part 1: Evolutionary algorithms. Part 2: Decentralized evolutionary algorithms.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	122	122
Objective questions exam	2	0	2
Report of practices, practicum and external practices	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
Previous studies	Study of the documentation provided.

Personalized assistance

Methodologies	Description
Previous studies	Tutoring on demand. Subject without classes due to the discontinuation of the curriculum. https://moovi.uvigo.gal/user/view.php?id=18913

Assessment

	Description	Qualification	Training and Learning Results		
Previous studies	This subject is no longer taught (it belongs to a program being phased out). Documentation will be provided.	0			
Objective questions exam	Series of short answer questions and/or multiple choice.	60	A5		C24
Report of practices, practicum and external practices	Report and documentation on a practical development case associated with the available documentation.	40	A2 A4 A5	B8	

Other comments on the Evaluation

Plagiarism and copying are not allowed. In the event of detection of plagiarism or copying in any of the tests, the final grade will be FAIL (0) and the fact will be communicated to the Center's management for appropriate purposes.

Sources of information

Basic Bibliography

Michael Wooldridge, **An Introduction to Multiagent Systems**, 2, Addison-Wesley, 2009

George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair, **Distributed systems. Concepts and design**, 5, Addison Wesley, 2012

Tom White, **Hadoop: The Definitive Guide**, 4, O'Reilly Media, 2015

A.E. Eiben, J.E. Smith, **Introduction to Evolutionary Computing (Natural Computing Series)**, 2, Springer, 2015

Complementary Bibliography

Thomas Rauber, Gudula Rúnger, **Parallel Programming for Multicore and Cluster Systems**, 2, Springer, 2013

Recommendations

IDENTIFYING DATA				
Data analysis				
Subject	Data analysis			
Code	V05M145V01322			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	García Méndez, Silvia			
Lecturers	García Méndez, Silvia			
E-mail	sgarcia@gti.uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	Data analysis with a practical approach: data extraction and cleansing, data characterization with techniques such as statistical regression, clustering or outlier analysis, and knowledge generation with techniques such as intuitive visualization or automatic classification. The course is taught in Spanish. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
A2	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.
A3	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.
B4	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.
B8	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.
C25	CE25/TE2 Ability to manage the acquisition, structuring, analysis and visualization of data, extracting information and underlying knowledge, critically assessing the results, and applying it to strategic decision-making and innovation in different areas.

Expected results from this subject	Training and Learning Results		
- Knowledge of the importance of the preparation of the data and how to apply the main pre-processing techniques.	A2	B4 B8	C25
- Knowledge of the main techniques of data mining as well as the necessary premises for its application to a particular stage.	A2 A3	B4 B8	
- Knowldge of the different types of data mining results evaluation and how to apply them.			C25
- Knowledge of statistical software and how to apply it to on-line and off-line data mining.		B4	C25
-Ability to to schedule, develop and evaluate a data analysis process.		B4 B8	C25

Contents	
Topic	
Statistical analysis of data	- Correlation and causation. - Regressions. - Intervals of confidence and error. Hypothesis tests.
Data mining	- Cleaning, integration, reduction and transformation of data. - Classification and clustering.
Computational analysis of data	- Large-scale data analysis. - Visualisation of data and results. - Application scenarios.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	121	121
Problem and/or exercise solving	2	0	2
Essay	0	1	1
Essay	0	1	1
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Previous studies	(*)Estudo da documentación proporcionada.

Personalized assistance

Methodologies	Description
Previous studies	

Assessment

	Description	Qualification	Training and Learning Results		
Problem and/or exercise solving	Short-answer written exam.	40			C25
Essay	Deliverable reporting work on a dataset that will be handed at the beginning on the course.	30	A2 A3	B4 B8	C25
Essay	Deliverable reporting work on a dataset that will be handed at the beginning on the course.	30	A2 A3	B4 B8	C25

Other comments on the Evaluation

ORDINARY OPPORTUNITY

The student will have to choose between continuous and global evaluation.

Continuous evaluation will consist in the following::

1. Short answer test (4 points maximum).
2. Two deliverables of the work on a common dataset (6 points maximum, 3 points each)

To pass the course, the student must obtain 1,5/4 points at least in the short answer test and an overal score (across all possible activities) above 5 points. Failure to reach the minimum grade in the short answer test limits the maximum achievable grade to 4.9. The maximum score is 10 points.

The contents of the short answer test and the deliverables will be balanced for a reasonable preparation effort.

Global evaluation will consist on a single exam covering the whole theoretical and practical course content (the maximum score of this exam will be 5 points. A minimum score of 2 is necessary to pass the course) and a deliverable based on a dataset selected by the professor (maximum score of 5 points). The minimum score to pass the course is 5 points overall. Failure to reach the minimum grade in the exam limits the maximum achievable grade to 4.9. The maximum score is 10 points.

EXTRAORDINARY AND FINAL DEGREE OPPORTUNITIES

The only possibility will be global evaluation, as previously described.

Sources of information

Basic Bibliography

Complementary Bibliography

Zummel, N., Mount, J., **Practical Data Science with R**, ISBN 9781617291562, Manning Publications,

James, G., Witten, D., Hastie, T., Tibshirani, R., **An Introduction to Statistical Learning with Applications in R**, ISBN 9781461471387, Springer,

Recommendations

IDENTIFYING DATA				
Economical and Social Networks				
Subject	Economical and Social Networks			
Code	V05M145V01323			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Sousa Vieira, Estrella			
Lecturers	Sousa Vieira, Estrella			
E-mail	estela@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	Social and Economic networks tackles the structural and dynamic study of networks of relationship between agents that arise in the fields of telecommunications, society and economy. We study, in particular, models of generation, of diffusion of information, of contagion, of learning and of training of coalitions. The theoretical contents are applied to practical study cases.			

Training and Learning Results	
Code	
A1	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.
A3	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.
B4	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.
B8	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.
C26	CE26/TE3 Ability to understand and know to exploit the processes of training and dissemination of information in social networks, applying them to the improvement of Internet
C27	CE27/TE4 Ability to design and manage distributed systems based on learning and incentive

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Understand the static and dynamic phenomena that explain the structure of the networks	B4 C26
Know how to analyse the mechanisms of training of networks in strategic terms	B4 B8 C26 C27
Know how to model and apply to real data the processes of diffusion of information in networks	A1 A3 C26 C27
Know how apply the procedures of structural and dynamic analysis of the networks to analyse complex systems in the technological fields, biological, economic and social.	A1 A3 B4 B8 C26 C27
Know how to use the dynamics of learning in networks to characterise phenomena	A1 A3 B4 C27

Contents
Topic

1. Basic concepts	a. Empirical evidence b. Descriptive parameters c. Scaling laws
2. Training of networks	a. Random models: static training b. Random models: dynamic training c. Strategic training: stability, efficiency and incentives
3. Diffusion and learning in networks	a. Simple diffusion SIR, SIS and others b. Learning and reinforcement in networks c. Games in networks: strategic complements and strategic substitutes
4. Applications	a. Meritocracy. b. Trending topics c. Recommendations/punctuations d. Virality e. Origins of rumours

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	Study of the provided documentation.

Personalized assistance

Methodologies	Description
Previous studies	Tutoring on demand. Subject without classes due to the discontinuation of the curriculum.

Assessment

	Description	Qualification	Training and Learning Results		
Previous studies		0			
Essay questions exam	Written exam of essay questions about the contents of the subject.	100	A1 A3	B4 B8	C26 C27

Other comments on the Evaluation

The assessment will consist in the realisation of a written final exam

Sources of information

Basic Bibliography

A.-L. Barabasi, **Network science**, Cambridge University Press, 2016

M. O. Jackson, **Social and economic networks**, Princeton University Press, 2010

M. Newman, **Networks**, OUP Oxford, 2018

Complementary Bibliography

B. Bollobas, **Random Graphs**, Cambridge University Press, 20011

G. Chen, X. Wang, X. Li, **Fundamentals of complex networks: models, structures and dynamics**, Wiley, 2015

R. van der Hofstad, **Random graphs and complex networks**, Cambridge University Press, 2024

Recommendations

IDENTIFYING DATA				
Internship in Companies I				
Subject	Internship in Companies I			
Code	V05M145V01324			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers	Marcos Acevedo, Jorge			
E-mail	acevedo@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The student develops own functions in a company as an Telecommunication Engineer with determinate profile by the technology that the student have studied (Electronics, Processed of signal for communications, Radiocommunication and Telematic) and supervised by the University adviser and the company adviser.			

Training and Learning Results	
Code	
A2	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.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B8	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.
B9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
B10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
B13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.

Expected results from this subject	Training and Learning Results
Experience in the practice of the profession of engineering of Telecommunication and his/her usual functions in some real company environment.	A2 A5 B8 B9 B10 B12 B13

Contents	
Topic	
General content	To define by the tutor in the company and the academic tutor
Integration in the company and in his surroundings of work	During his stay the student will be integrated into the organization of the company and must coordinate with the rest of members of the work team to he was assigned.
Development of his professional activity	The student will make the tasks entrusted, in accordance with his knowledges and competences.

Planning	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	120	5	125
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Practicum, External practices and clinical practices	Stay in a company developing functions of a Telecommunications Technical Engineer so that they can put into practice the knowledge and skills acquired, to complete their academic training.

Personalized assistance

Methodologies	Description
Practicum, External practices and clinical practices	The student will have a tutor inside the company that will guide him and will supervise in the specific tasks that it will have to develop inside the same; and an academic tutor - professor of the E.E.T. of the University of Vigo- that will define together with the tutor of the company, the general frame of the activity of the student, checking that it adjusts to the profile studied by the student.

Assessment

	Description	Qualification	Training and Learning Results	
Practicum, External practices and clinical practices	The evaluation will realise in function of: 1) The memory of activities 2) The evaluation of the company tutor	100	A2 A5	B8 B9 B10 B12 B13

Other comments on the Evaluation

REPORT OF ACTIVITIES: The student must submit a report explaining the activities undertaken during practices, specifying its duration, departments of the company that were conducted, training received (courses, software, etc.), the level of integration within the company and personal relationships.
The report must also include a section of conclusions, containing a reflection on the adequacy of the lessons learned during the university studies to performance practice (negative and positive aspects significant related to the development of practices). It also assessed the inclusion of information on the professional and personal experience with the practices (personal assessment of learning achieved over practices or own contributions and suggestions on the structure and operation of the company visited).
The assessment of memory will be 60% of the final qualification.
COMPANY TUTOR EVALUATION: The company tutor will submit a report assessing aspects with the practices carried out by students: punctuality, attendance, responsibility, teamwork ability and integration in the enterprise, quality of work done, etc.
The assessment of the tutor in the company will be 40% of the final qualification.

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

Other comments

It is recommended that the student have the greatest possible number of subjects studied and / or passed.

IDENTIFYING DATA				
Internship in Companies II				
Subject	Internship in Companies II			
Code	V05M145V01325			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers	Marcos Acevedo, Jorge			
E-mail	acevedo@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The student develops own functions in a company as an Telecommunication Engineer with determinate profile by the technology that the student have studied (Electronics, Processed of signal for communications, Radiocommunication and Telematic) and supervised by the University adviser and the company adviser.			

Training and Learning Results	
Code	
A2	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.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B8	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.
B9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
B10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
B13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.

Expected results from this subject	Training and Learning Results
Experience in the practice of the profession of ingineering of Telecommunication and his usual functions in some real company environment.	A2 A5 B8 B9 B10 B12 B13

Contents	
Topic	
General content	To define by the tutor in the company and the academic tutor.
Integration in the company and in his surroundings of work	During his stay the student will be integrated into the organization of the company and must coordinate with the rest of members of the work team to he was assigned.
Development of his professional activity	The student will make the tasks entrusted, in accordance with his knowledges and competences.

Planning	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	120	5	125
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Practicum, External practices and clinical practices	Stay in a company developing functions of a Telecommunications Engineer so that they can put into practice the knowledge and skills acquired, to complete their academic training.

Personalized assistance

Methodologies	Description
Practicum, External practices and clinical practices	The student will have a tutor inside the company that will guide him and will supervise in the specific tasks that it will have to develop inside the same; and an academic tutor - professor of the E.E.T. of the University of Vigo- that will define together with the tutor of the company, the general frame of the activity of the student, checking that it adjusts to the profile studied by the student.

Assessment

	Description	Qualification	Training and Learning Results	
Practicum, External practices and clinical practices	The evaluation will realise in function of: 1) The memory of activities 2) The evaluation of the tutor in the company	100	A2 A5	B8 B9 B10 B12 B13

Other comments on the Evaluation

REPORT OF ACTIVITIES: The student must submit a report explaining the activities undertaken during practices, specifying its duration, departments of the company that were conducted, training received (courses, software, etc.), the level of integration within the company and personal relationships.
The report must also include a section of conclusions, containing a reflection on the adequacy of the lessons learned during the university studies to performance practice (negative and positive aspects significant related to the development of practices). It also assessed the inclusion of information on the professional and personal experience with the practices (personal assessment of learning achieved over practices or own contributions and suggestions on the structure and operation of the company visited).
The assessment of memory will be 60% of the final qualification.
COMPANY TUTOR EVALUATION: The company tutor will submit a report assessing aspects with the practices carried out by students: punctuality, attendance, responsibility, teamwork ability and integration in the enterprise, quality of work done, etc.
The assessment of the tutor in the company will be 40% of the final qualification.

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

Other comments

It is recommended that the student have the greatest possible number of subjects studied and / or passed.

IDENTIFYING DATA				
Internship in Companies III				
Subject	Internship in Companies III			
Code	V05M145V01326			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers	Marcos Acevedo, Jorge			
E-mail	acevedo@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The student develops own functions in a company as an Telecommunication Engineer with determinate profile by the technology that the student have studied (Electronics, Processed of signal for communications, Radiocommunication and Telematic) and supervised by the University adviser and the company adviser.			

Training and Learning Results	
Code	
A2	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.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B8	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.
B9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
B10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
B13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.

Expected results from this subject	Training and Learning Results
Experience in the practice of the profession of ingineering of Telecommunication and his usual functions in some real company environment.	A2 A5 B8 B9 B10 B12 B13

Contents	
Topic	
General content	To define by the tutor in the company and the academic tutor.
Integration in the company and in his surroundings of work	During his stay the student will be integrated into the organization of the company and must coordinate with the rest of members of the work team to he was assigned.
Development of his professional activity	The student will make the tasks entrusted, in accordance with his knowledges and competences.

Planning	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	120	5	125
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Practicum, External practices and clinical practices	Stay in a company developing functions of a Telecommunications Engineer so that they can put into practice the knowledge and skills acquired, to complete their academic training.

Personalized assistance

Methodologies	Description
Practicum, External practices and clinical practices	The student will have a tutor inside the company that will guide him and will supervise in the specific tasks that it will have to develop inside the same; and an academic tutor - professor of the E.E.T. of the University of Vigo- that will define together with the tutor of the company, the general frame of the activity of the student, checking that it adjusts to the profile studied by the student.

Assessment

	Description	Qualification	Training and Learning Results	
Practicum, External practices and clinical practices	The evaluation will realise in function of: 1) The memory of activities 2) The evaluation of the tutor in the company	100	A2 A5	B8 B9 B10 B12 B13

Other comments on the Evaluation

REPORT OF ACTIVITIES: The student must submit a report explaining the activities undertaken during practices, specifying its duration, departments of the company that were conducted, training received (courses, software, etc.), the level of integration within the company and personal relationships.
The report must also include a section of conclusions, containing a reflection on the adequacy of the lessons learned during the university studies to performance practice (negative and positive aspects significant related to the development of practices). It also assessed the inclusion of information on the professional and personal experience with the practices (personal assessment of learning achieved over practices or own contributions and suggestions on the structure and operation of the company visited).
The assessment of memory will be 60% of the final qualification.
COMPANY TUTOR EVALUATION: The company tutor will submit a report assessing aspects with the practices carried out by students: punctuality, attendance, responsibility, teamwork ability and integration in the enterprise, quality of work done, etc.
The assessment of the tutor in the company will be 40% of the final qualification.

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

Other comments

It is recommended that the student have the greatest possible number of subjects studied and / or passed.

IDENTIFYING DATA				
Photovoltaic Power Electronics				
Subject	Photovoltaic Power Electronics			
Code	V05M145V01330			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Doval Gandoy, Jesús			
Lecturers	Doval Gandoy, Jesús			
E-mail	jdoval@uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The subject describes the basic concepts of control and power electronic converters used in photovoltaic systems.			

Training and Learning Results	
Code	
A2	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.
B4	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.
B8	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.
C28	CE28/SE1 Capacity of technology integration of photovoltaic conversion for power systems of Telecommunication Engineering.

Expected results from this subject	Training and Learning Results
Knowledge of power conversion technologies used in photovoltaic systems.	A2 B4 B8 C28
Knowledge of control techniques of electronic power converters used in photovoltaic systems.	A2 B4 B8 C28

Contents	
Topic	
Chapter 1: Introduction to photovoltaic systems	Photovoltaic effect. Electrical characteristics of photovoltaic cells. Temperature dependence. Irradiation dependence. Electrical connection. Shadow effect.
Chapter 2: Topologies of power electronics converters in photovoltaics.	Electrical configuration photovoltaic cells. Topologies of power electronics converters.
Chapter 3: Control of photovoltaic inverters.	Control of stand-alone photovoltaic inverters. Control of grid-connected photovoltaic inverters. Synchronisation. Maximum power point tracking.
Chapter 4: Regulations and Standards in power electronics photovoltaics systems.	International regulations: IEEE, IEC, VDE, EN. Power quality, ride-through, anti-islanding.

Planning			
	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	Study of the documentation

Personalized assistance

Methodologies	Description
Previous studies	On-demand tutoring. Subject without class due to the extinction of the curriculum.

Assessment

	Description	Qualification	Training and Learning Results		
Previous studies	There are no classes for this subject. The curriculum is in the process of being phased out. Documentation is provided.	0			
Essay questions exam	This test is associated with the concepts explained in the available documentation.	100	A2	B4 B8	C28

Other comments on the Evaluation

Sources of information

Basic Bibliography

Remus Teodorescu, Marco Liserre, Pedro Rodríguez, **Grid Converters for Photovoltaic and Wind Power Systems**, John Wiley & Sons, Ltd.,

Complementary Bibliography

Ned Mohan, Tore M. Undeland, William P. Robbins, **Power Electronics: Converters, Applications, and Design**, John Wiley & Sons, Ltd.,

Andrés Barrado Bautista, Antonio Lázaro Blanco, **Problemas de electrónica de potencia**, Pearson Educación,

Recommendations

IDENTIFYING DATA				
Signal Conditioners				
Subject	Signal Conditioners			
Code	V05M145V01331			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	#EnglishFriendly Spanish			
Department				
Coordinator	Valdés Peña, María Alicia			
Lecturers	Valdés Peña, María Alicia			
E-mail	mavaldesp@yahoo.es			
Web	http://moovi.uvigo.gal			
General description	In this subject the electronic circuits that condition the signals generated by sensors to be efficiently coupled to a data acquisition system or to a digital processor are studied. It is a subject that follows the Design of Analog Electronic Circuits, which is coursed in the first course of the master. Thus, in this new subject the basic conditioning circuits are expanded by including measuring active bridges, alternating current conditioning circuits, etc. Another important aspect that is included in the study is the evaluation of the measurement uncertainty. Student learns to characterize a measure provided by a sensor through the calibration curve and the uncertainty. The theory is complemented by laboratory practices that focus on providing students with the skills needed to address the realization of a complete measurement system, from the physical system up to the user interface. The key points of the laboratory work are: -The followed methodology to measure physical variables to the calculation of uncertainties. -Characterization of transducers. -Topologies of conditioning circuits. -The connection of the conditioned signals to a digital processor. -Instrumentation software for digitally conditioning and user interfaces. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B4	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.
B8	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.
C29	CE29/SE2 Ability to build a system of a physical variable measured from the transducer to the user interface, including knowledge of methodology, basic topologies of conditioning signal and instrumentation software

Expected results from this subject	Training and Learning Results	
To know the modeling and simulationing of analogic electronic systems by means of the hardware description language SPICE.	B1 B4 B8	C29
To know the evaluationing of the uncertainties in the measuring processes following the standards.	B4	
To know how to handle and to program data acquisition systems.	B1	C29
To know the developing of complex electronic circuits for conditioning the sensors.	B1 B4 B8	C29
To konw to analyse and to design circuits for interfaces between the sensors and digital processors.	B1	C29
To know how to develop an instrumentation electronic systems.	B1 B4 B8	C29

Contents

Topic	
Unit 1: Introduction to the measuring systems of physical variables.	Functional and working characteristics of sensors. Evaluation of measurement data. Sensor calibration. Measurement uncertainties. Parts of a conditioning circuit. Types of conditioners.
Unit 2: Introduction to the metrology. Evaluation of measurement uncertainty.	Methodology to measure and to calibrate sensors. Terminology. Statistical method.
Unit 3. Circuits to conditioning signal from measured sensors.	Active measuring bridges in direct and alternating current. Ac/dc converters. Selection and design of filtering stages. Frequency to voltage converters. Conditioners for output stages.
Unit 4: Interfaces between on-off sensors and digital processors.	Basic concepts of local interfaces of on-off sensors. Interfaces with and without galvanic isolation. Coupling in alternating and continuous current.
Unit 5: Conditioning circuits for inductive and magnetic measure sensors.	Study of the conditioners for several inductive and magnetic sensors according to his application.
Unit 6: Conditioning circuits for capacitive measureing sensors.	Study of the conditioners for capacitive sensors.
Unit 7: Conditioning circuits for generators sensors.	Study of the conditioning circuits for generators sensors according to his physical working principle.
Unit 8: Practical cases of conditioning circuits for measuring sensors.	Study of real cases with commercial sensors and circuits.
Laboratory sessions.	Two projects will be carried out, each one corresponding to a complete measurement system, from the sensor to the user interface, including conditioning and programming a data acquisition system. The evaluation of uncertainties will be included.

Planning

	Class hours	Hours outside the classroom	Total hours
Essay questions exam	1	34	35
Problem and/or exercise solving	1	34	35
Laboratory practice	2	53	55

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

Methodologies

	Description

Personalized assistance

Tests	Description
Laboratory practice	Students have the opportunity to have their questions answered through individual consultation sessions. Appointments with the corresponding instructor must be requested and confirmed by email.
Problem and/or exercise solving	Students have the opportunity to have their questions answered through individual consultation sessions. Appointments with the corresponding instructor must be requested and confirmed by email.
Essay questions exam	Students have the opportunity to have their questions answered through individual consultation sessions. Appointments with the corresponding instructor must be requested and confirmed by email.

Assessment

	Description	Qualification	Training and Learning Results	
Essay questions exam	A written examination consisting of essay-style questions and/or short problems will be held at the end of the semester. This examination assesses all the theoretical content covered in the course.	30	B1 B4 B8	C29
Problem and/or exercise solving	Students will solve a set of problems and/or system design exercises.	30	B1 B4 B8	C29
Laboratory practice	This assessment will be conducted in the laboratory. It consists of the design and practical implementation of a system.	40	B1 B4 B8	C29

Other comments on the Evaluation

Students will have two assessment opportunities: the ordinary and the extraordinary examination periods. In both cases, the

assessment will consist of the following tests:

- **An examination** assessing all the theoretical contents of the course. It consists of several short problems and/or essay-style questions and lasts 2 hours. To pass the examination, a minimum mark of 4 out of 10 must be obtained. This test represents 60% of the final grade (**NExam**).
- **A practical examination on system design.** The duration of the examination will be 2 hours. To pass the examination, a minimum mark of 4 out of 10 must be obtained. This assessment represents 40% of the final grade (**NPrac**).

Final grade (C_Final):

The final grade (**C_Final**) is obtained as follows:

C_Final = (NExam × 0.6 + NPrac × 0.4) if **NExam** and **NPrac** are greater than or equal to 4;

C_Final = min[(NExam × 0.6 + NPrac × 0.4), 4.9] otherwise.

Sources of information

Basic Bibliography

Pallás Areny, Ramón, **Sensors and signal conditioning**, Second Edition, John Wiley & Sons, inc., 2001

European co-operation for Accreditation, **Expression of the Uncertainty of Measurement in Calibration**, September 2013 rev 02, EA-4/02 M, 2013

C. Quintáns, **Simulación de Circuitos Electrónicos con OrCAD PSpice**, 2, Marcombo, 2021

Complementary Bibliography

Philip R. Bevington and D. Keith Robinson, **Data Reduction and Error Analysis for the Physical Sciences**, McGraw Hill, 2003

Grupo de Trabajo 1 del Comité Conjunto de Guías en Metrología (JCGM / WG 1), **Guía para la Expresión de la Incertidumbre de Medida**, 2008

Recommendations

Subjects that it is recommended to have taken before

Digital and Analog Mixed Circuits/V05M145V01213
Digital electronics/V05M145V01203
Analog Electronic Circuits Design/V05M145V01106

IDENTIFYING DATA				
Electronic Equipments Implementation and Exploitation				
Subject	Electronic Equipments Implementation and Exploitation			
Code	V05M145V01332			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	López Sánchez, Óscar			
Lecturers	López Sánchez, Óscar			
E-mail	olopez@uvigo.es			
Web	http://moovi.uvigo.gal/			
General description	This subject provides the main concepts related with the analysis of reliability of complex electronic systems, as well the modelling of these, from the point of view of the reliability. It includes methodologies of design of electronic systems for applications of safety, and also the EMC analysis. Also provides insight of the relation with the management of the equipment inventory and the human capital. English Friendly subject: International students may request from the teachers: a) resources and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English. This is a translation of the subject. In case of any discrepancy, the only valid guide is the one written in Spanish.			

Training and Learning Results	
Code	
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
B7	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.
C15	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.
C30	CE30/SE3 Capacity planning, evaluation and decision-making in new environments relating to the packaging of networks, services and applications in the electromagnetic field, with knowledge of reliability and life cycle costing
D3	CT3 Understanding Engineering in a framework for sustainable development.
D5	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.

Expected results from this subject	Training and Learning Results
Ability to make an analysis of electromagnetic compatibility of an electronic system according the standards	B1 B3 B7
Ability to design electronic equipment that includes specifications of maintainability and availability	B7 C15 C30 D3
Ability to specify the stocks level required for a given equipment maintainability	B7 C30
Ability to determine the life cycle cost of a product	C30 D3
Capacity to implement and manage the operation of electronic equipment	B7 C30
Ability to the assets management of an organization, related to the subject	B3 D5

Ability to understand the impact of risks, human reliability and knowledge management, in an organization	B3 B7 D3

Contents	
Topic	
Electromagnetic Interferences	Noise and interference. Design for electromagnetic compatibility (ECM). Path of electromagnetic noise. Coupling methods.
Design techniques for EMC	Analysis of conducted emissions. Analysis of radiated emissions. Common impedance coupling. Cabling. Ground system. Shielding.
EMC standards for telecommunications equipment	EMC directive 2014/30/UE. EMC basic publications. EMC generic standards. Product family standards. Emission and immunity standards, conducted and radiated. Harmonic currents standards. Grid disturbances standards. Pre-compliance EMC tests.
Introduction to the reliability of electronic systems	Definitions and basic concepts. RAMS Technologies. Parameters of the reliability of electronic components. Prediction of the reliability. Applicable technical standards. Systems in series, parallel and redundant.
Design and optimization of electronic systems	Optimization of redundancies. Analysis for mantenibilidad and availability.
Analysis of failures	Modelling by Markov and by Petri networks. Failure modes of electronic components. Determination of mechanism and ways of failures.
Fail-safe systems	Specifications for safe systems against failures. Design methodologies for fail-safe systems.

Planning	Class hours	Hours outside the classroom	Total hours
Previous studies	0	123	123
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
Previous studies	Study of the documentation provided.

Personalized assistance	
Methodologies	**Description**
Previous studies	Office hours on request. Course without classes due to the phase-out of the curriculum.

Assessment	Description	Qualification	Training and Learning Results		
Essay questions exam	Individual written test with theoretical questions, problems and exercises that will evaluate all the content of the subject (85%) and a practical exam that will be carried out in the laboratory (15%).	100	B1 B3 B7	C15 C30	D3 D5

Other comments on the Evaluation

Choosing of global assessment must be communicated in writing to the coordinator within one month of the start of the semester.

The end-of-program exam will be by global assessment.

The global assessment will consist of an individual written test with theoretical questions, problems and exercises that will evaluate all the content of the subject (85%) and a practical exam that will be carried out in the laboratory (15%).

In case of detection of copying or 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

Henry W. Ott, **Electromagnetic Compatibility Engineering**, 1ª, Wiley, 2011

López Veraguas, Joan Pere, **Compatibilidad electromagnética y seguridad funcional en sistemas electrónicos**, Marcombo, 2010

David J. Smith, **Reliability, Maintainability and Risk**, 8ª, Butterworth Heinemann, 2011
I. Fernández, A. Camacho, C. Gasco, A.M. Macías, M.A. Martín, G. Reyes, J. Rivas, **Seguridad Funcional en Instalaciones de Proceso: Sistemas Instrumentados de Seguridad y Análisis SIL**, ISA, 2012
M. Goble, H. Cheddie, **Safety Instrumented Systems Verification**, ISA, 2005
M. Goble, **Control Systems Safety Evaluation and Reliability**, 3ª, ISA, 2010
Michael D. Medoff Rainer and I. Faller, **Functional Safety: An IEC 61508 SIL 3 Compliant Development Process**, 3ª, Exida, 2014

Complementary Bibliography

T.I. Bajenescu, M.I. Bâzu, **Reliability of Electronic Components**, Springer-Verlag, 1999
P. Kales, **Reliability**, Prentice-Hall, 1998
B. R. Mehta Y. J. Reddy, **Industrial Process Automation Systems Design and Implementation**, Elsevier, 2015
ISO, **UNE-ISO 55000:2015: Gestión de activos. Aspectos generales, principios y terminología**, AENOR, 2015
Milton Ohring, **Reliability and Failure of Electronic Materials and Devices**, 2ª, Elsevier, 2015
Chris J. O´Brien, **Final Elements in Safety Instrumented Systems**, 1ª, Exida, 2018
Shahriyar Kaboli, **Reliability in Power Electronics and Electrical Machines: Industrial Applications and Performance Models**, 1ª, IGI Global, 2016
Francesco Flammini, **Railway Safety, Reliability, and Security: Technologies and Systems Engineering**, 1ª, 2012

Recommendations

Subjects that are recommended to be taken simultaneously

Signal Conditioners/V05M145V01331
Photovoltaic Power Electronics/V05M145V01330

Subjects that it is recommended to have taken before

Digital and Analog Mixed Circuits/V05M145V01213
Hardware/Software Design of Embedded Systems/V05M145V01214
Integrated Circuits Design and Manufacturing/V05M145V01215

Other comments

This version in English of the guide is a translation of the original one in Galician. In the case that, by mistake, there exists differences between them the original one in Galician is what prevails.

IDENTIFYING DATA				
Master Thesis				
Subject	Master Thesis			
Code	V05M145V01401			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	30	Mandatory	2nd	2nd
Teaching language	English			
Department				
Coordinator	Herrería Alonso, Sergio			
Lecturers	Herrería Alonso, Sergio			
E-mail	sha@det.uvigo.es			
Web	http://moovi.uvigo.gal			
General description	The Master Thesis (TFM) forms part, like module, of the plan of studies of the title of Master in Engineering of Telecommunication. It is an original and personal work that each student realises of autonomous form under educational permission, and has to allow him show of form integrated the acquisition of the formative contents and the competitions associated to the title. His definition and contents are explained of form more extensive in the rule for the realisation of the TFM, whose content can consult in the web of the School of Telecommunication Engineering.			

Training and Learning Results	
Code	
A1	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.
B1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
B5	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.
B8	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.
B11	CG11 Ability to communicate (oral and written) conclusions, and the knowledge and reasons supporting them, to specialists and non-specialists in a clear and unambiguous way.
B12	CG12 Skills for lifelong, self-directed and autonomous learning.
C17	CE17/TFM Embodiment, presentation and defense, once all credits of the curriculum are passed, of an original exercise performed individually in front of a university jury, consisting of a comprehensive project of Telecommunication Engineering with professional nature, in which skills acquired in the teachings are synthesized.

Expected results from this subject	Training and Learning Results
Research, classification and structuring of information on some topic relevant to Telecommunications engineering.	A1 B8 B12
Dissertation containing the fundamentals, the solution and an analysis of the results about the problem addressed. It should include a review of the state of the art, an explanation of the methodology or approach, and a discussion of the obtained results.	B1 B8 B11 C17
Design of prototypes, computer programs, circuits, procedures, algorithms, methods, etc, complying to specifications.	A1 B1 B5 B8 B12

Contents	
Topic	
The contents of the Master's Thesis are established in the individual proposals offered by the advisors, according to the rules issued by the Academic Commission of the Master Programme.	The subject of each work is specific, given the individual character of the work.

Planning

	Class hours	Hours outside the classroom	Total hours
Previous studies	0	60	60
Case studies	0	30	30
Project based learning	0	630	630
Problem solving	0	30	30

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

Methodologies

	Description
Previous studies	Research, reading and work of documentation carried out by the students autonomously.
Case studies	Critical analysis of similar problems to that posed in the TFM, with the objective of extracting ideas, analogies, methods or partial results that help in the resolution of the problem posed in the TFM.
Project based learning	Development of an original solution to the technical problem of interest in a individual and autonomous form. Writing a report with the hypotheses, the solution and the conclusions of the work.
Problem solving	Study of the possible solutions to the technical problem proposed. Development of a solution (analytical, methodological, experimental or combined) that allows to reach the planned aims.

Personalized assistance

Methodologies	Description
Project based learning	Each student will meet his/her advisors to receive guidance, orientation or academic assistance on the objectives, the methodology, the analysis of results and the presentation of the thesis. The TFM coordinator will establish tutoring hours at the beginning of the term. These hours could be checked at the subject web page https://moovi.uvigo.gal/.

Assessment

	Description	Qualification	Training and Learning Results		
Project based learning	The assessment is done after an oral presentation and defence in front of an examining committee. In the evaluation, the Committee might take into account the opinions or the report issued by the advisor, as well as the quality of the presentation, the review of the state of the art, the quality of the technical proposal, the novelty and importance of the results, the capacity of initiative of the student, etc. System of qualifications: numerical final qualification (from 0 to 10) according to the valid legislation.	100	A1	B1 B5 B8 B11 B12	C17

Other comments on the Evaluation

Generative AI

In the performance of the academic activities of this subject, the use of generative artificial intelligence (GAI) is allowed. Its use must be done ethically, critically and responsibly. In the case of using GAI, any results provided by GAI should be critically evaluated, and any citations or references generated should be carefully checked. It is also mandatory to declare the use of these tools.

Sources of information

Basic Bibliography

Complementary Bibliography

Recommendations

IDENTIFYING DATA				
Data Communication				
Subject	Data Communication			
Code	V05M145V01CFG300301			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	1st
Teaching language	Spanish			
Department				
Coordinator	López García, Cándido Antonio			
Lecturers	López García, Cándido Antonio			
E-mail	candido@det.uvigo.es			

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IDENTIFYING DATA				
Electromagnetic Transmission				
Subject	Electromagnetic Transmission			
Code	V05M145V01CFG300303			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	2nd
Teaching language				
Department				
Coordinator	Vera Isasa, María			
Lecturers	Vera Isasa, María			
E-mail	mirentxu@uvigo.gal			

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IDENTIFYING DATA				
Digital Signal Processing				
Subject	Digital Signal Processing			
Code	V05M145V01CFG300304			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	1st
Teaching language				
Department				
Coordinator	Márquez Flórez, Óscar Willian			
Lecturers	Márquez Flórez, Óscar Willian			
E-mail	omarquez@uvigo.es			

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IDENTIFYING DATA				
Computers Networks				
Subject	Computers Networks			
Code	V05M145V01CFG300403			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	López Ardao, José Carlos			
E-mail	jardao@det.uvigo.es			

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IDENTIFYING DATA				
Signal Transmission and Reception Techniques				
Subject	Signal Transmission and Reception Techniques			
Code	V05M145V01CFG300404			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	2nd
Teaching language	English			
Department				
Coordinator	Gómez Cuba, Felipe Rodríguez Banga, Eduardo			
Lecturers	Gómez Cuba, Felipe Rodríguez Banga, Eduardo			
E-mail	erbanga@uvigo.es gomezcuba@gts.uvigo.es			

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IDENTIFYING DATA				
Internet services				
Subject	Internet services			
Code	V05M145V01CFG300501			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	1st
Teaching language				
Department				
Coordinator	Gil Solla, Alberto			
Lecturers	Gil Solla, Alberto			
E-mail	alberto.gil@uvigo.es			

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IDENTIFYING DATA				
Computer Science: Computer Architecture				
Subject	Computer Science: Computer Architecture			
Code	V05M145V01CFG301109			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Optional	1st	2nd
Teaching language	#EnglishFriendly Spanish Galician			
Department				
Coordinator	Llamas Nistal, Martín Fernández Iglesias, Manuel José			
Lecturers	Fernández Iglesias, Manuel José Llamas Nistal, Martín			
E-mail	manolo@uvigo.es martin@uvigo.es			

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