



## (\*)Escola de Enxeñaría de Telecomunicación

### (\*)Páxina web

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[www.teleco.uvigo.es](http://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 main 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](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](http://teleco.uvigo.es/images/stories/documentos/met/master_telecom_rev.pdf)

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

#### **Interuniversity Masters**

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

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

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

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

### (\*)Equipo directivo

#### MANAGEMENT TEAM

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

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

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

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

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

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

#### BACHELOR'S DEGREE IN TELECOMMUNICATION TECHNOLOGIES ENGINEERING

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

[http://teleco.uvigo.es/images/stories/documentos/comisions/membros\\_comisions\\_grao.pdf](http://teleco.uvigo.es/images/stories/documentos/comisions/membros_comisions_grao.pdf)

#### MASTER IN TELECOMMUNICATION ENGINEERING

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

[http://teleco.uvigo.es/images/stories/documentos/comisions/membros\\_comisions\\_master.pdf](http://teleco.uvigo.es/images/stories/documentos/comisions/membros_comisions_master.pdf)

#### MASTER IN CYBERSECURITY

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

[http://teleco.uvigo.es/images/stories/documentos/comisions/membros\\_comisions\\_master\\_ciberseguridade.pdf](http://teleco.uvigo.es/images/stories/documentos/comisions/membros_comisions_master_ciberseguridade.pdf)

#### MASTER IN INDUSTRIAL MATHEMATICS

General coordinator: Elena Vázquez Cendón (USC)

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

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

#### INTERNATIONAL MASTER IN COMPUTER VISION

General coordinator: Xose Manuel Pardo López (USC)

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

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

## Telecommunication Engineering

### Subjects

#### Year 1st

Code	Name	Quadmester	Total Cr.
V05M145V01101	A Enxeñaría de Telecomunicación na Sociedade da Información	1st	5
V05M145V01102	Tratamento de Sinal en Comunicaci3ns	1st	5
V05M145V01103	Radio	1st	5
V05M145V01104	Tecnoloxías de Rede	1st	5
V05M145V01105	Tecnoloxías de Aplicaci3n	1st	5
V05M145V01106	Deseño de Circuitos Electr3nicos Anal3xicos	1st	5

V05M145V01201	Dirección de Proxectos de Telecomunicación	2nd	5
V05M145V01202	Electrónica e Fotónica para Comunicacions	2nd	5
V05M145V01203	Sistemas Electrónicos Dixitais Avanzados	2nd	5
V05M145V01204	Comunicacións Dixitais Avanzadas	2nd	5
V05M145V01205	Procesado de Sinal en Sistemas Audiovisuais	2nd	5
V05M145V01206	Comunicacións Multimedia	2nd	5
V05M145V01207	Comunicacións Ópticas	2nd	5
V05M145V01208	Antenas	2nd	5
V05M145V01209	Laboratorio de Radio	2nd	5
V05M145V01210	Enxeñaría de Internet	2nd	5
V05M145V01211	Redes sen Fíos e Computación Ubicua	2nd	5
V05M145V01212	Enxeñaría Web	2nd	5
V05M145V01213	Circuitos Mixtos Analóxicos e Dixitais	2nd	5
V05M145V01214	Codeño Hardware/Software de Sistemas Empotrados	2nd	5
V05M145V01215	Deseño e Fabricación de Circuitos Integrados	2nd	5

### Year 2nd

Code	Name	Quadmester	Total Cr.
V05M145V01301	Procesado de Sinal en Tempo Real	1st	5
V05M145V01302	Sistemas Avanzados de Comunicación	1st	5
V05M145V01303	Procesado Estatístico do Sinal	1st	5
V05M145V01304	Optimización Numérica en Telecomunicacións	1st	5
V05M145V01305	Modelos Matemáticos e Simulación Numérica	1st	5
V05M145V01306	Técnicas Criptográficas de Protección de Datos	1st	5
V05M145V01307	Machine Learning	1st	5
V05M145V01308	Administración de Redes e Sistemas	1st	5
V05M145V01309	Tecnoloxías para o Desenvolvemento Web	1st	5
V05M145V01310	Desenvolvemento de Aplicacións Móviles	1st	5
V05M145V01311	Satélites	1st	5
V05M145V01312	Sistemas de Radio en Banda Larga	1st	5
V05M145V01313	Comunicacións Móviles e sen Fíos	1st	5
V05M145V01314	Radionavegación	1st	5
V05M145V01315	Redes Ópticas	1st	5

V05M145V01316	Radar	1st	5
V05M145V01317	Deseño de Circuitos de Microondas e Ondas Milimétricas e CAD	1st	5
V05M145V01318	Seguridade Multimedia	1st	5
V05M145V01319	Sensores Intelixentes	1st	5
V05M145V01320	Laboratorio de Electrónica Dixital para Comunicacións	1st	5
V05M145V01321	Computación Distribuída	1st	5
V05M145V01322	Análise de Datos	1st	5
V05M145V01323	Redes Sociais e Económicas	1st	5
V05M145V01324	Prácticas en Empresas I	1st	5
V05M145V01325	Prácticas en Empresa II	1st	5
V05M145V01326	Prácticas en Empresas III	1st	5
V05M145V01327	Network Information Theory	1st	5
V05M145V01328	Aprendizaxe en Rede e Traballo Colaborativo	1st	5
V05M145V01329	Human-Computer Interaction	1st	5
V05M145V01330	Electrónica de Potencia en Fotovoltaica	1st	5
V05M145V01331	Acondicionadores de Sinal	1st	5
V05M145V01332	Implementación e Explotación de Equipos Electrónicos	1st	5
V05M145V01333	Laboratorio de Equipos Electrónicos	1st	5
V05M145V01334	Seminario de Telecomunicacións	1st	5
V05M145V01335	Transdutores Piezoeléctricos e Aplicacións	1st	5
V05M145V01336	Álgebra Lineal Numérica en Enxeñaría de Telecomunicación	1st	5
V05M145V01401	Traballo Fin de Máster	2nd	30

### Year 1st

Code	Name	Quadmester	Total Cr.
V05M145V01CFG300301	Comunicación de Datos	1st	6
V05M145V01CFG300303	Transmisión Electromagnética	2nd	6
V05M145V01CFG300304	Procesado Dixital de Sinais	1st	6
V05M145V01CFG300403	Redes de Ordenadores	2nd	6
V05M145V01CFG300404	Técnicas de Transmisión e Recepción de Sinais	2nd	6
V05M145V01CFG300501	Servizos de Internet	1st	6

**IDENTIFYING DATA****Telecommunication Engineering in the Information Society**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

## Topic

Seminar on the Engineering in the Society	<p>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.</p> <p>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.</p> <p>Related competencies: CE15, CT4, CB3 and CG9</p>
Professional attributions and their history	<p>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:</p> <ul style="list-style-type: none"><li>* Television</li><li>* Wire communications (including the small local history: Vigo was the base of German and British cables)</li><li>* Radioelectric spectrum (description and management, taking into account National and International legislation)</li><li>* Internet and its influence in Society</li><li>* Mobile telephony (including effects on health)</li><li>* Experts official reports.</li></ul> <p>Related competencies: CG13 and CT3</p>
In a multidisciplinary society	<p>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.</p> <p>Related competencies: CG7, CE15, CT3 and CT4</p>

## Planning

	Class hours	Hours outside the classroom	Total hours
Seminars	14	15	29
Project based learning	5	70	75
Lecturing	9	10	19
Essay questions exam	2	0	2

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

## Methodologies

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

**Project based learning** Realisation of works for the resolution of a case or a specific project, as well as the presentation of the results by writing and/or by means of a presentation that may follow different formats: oral, poster, multimedia. They include the integrated Methodologies: problem-based learning, resolution of design problems proposed by lecturers, and project-based learning (PBL) education.

Teams of students will be defined, according to the outcomes of a personality test that the students make in the first session. The aim is to attain heterogeneous groups selected externally, as in a real company. The projects in which groups will work are related among them and are focused in a specific field of study familiar to the students. For this academic course, we are in conversations with AENA so that the study environment could be the Airport of Vigo.

The students, in groups, work towards providing a solution to a clear-cut problem according to the Design Thinking methodology, identifying situations of the daily life that a priori may not relate to the Telecommunication. Design Thinking develops through the following phases: discover, interpret, ideate, experience and evolve. The solution achieved will have to consider not only technical questions, but also legal, environmental, social and related with sustainability.

By applying the Design Thinking methodology, a specific challenge will be identified within the field of study, and all the information available related to that challenge will be gathered. The students will pose imaginative solutions and will try to build a proposal that is reasonable, although it may not be still implementable given the current technological development.

The aim is not to manufacture or program a solution, but to look for a proposal that is feasible, now or in the future when technology is more developed, and that it is acceptable socially.

The groups will begin for locating all relevant information. From that information, they will try to identify the people involved and will try to empathize with them, to identify the actual problem that they feel. From the problem identified, groups will try to produce technological or procedural solutions. They will have to look for technical and scientific information and, finally, elaborate a prototype, a report and a presentation.

The result of this activity may be documented through an online service, forum or wiki. Also it will produce a final document and a presentation and/or video that was used in the defence of the work developed in front of the class. Both results will be according to the criteria collected in evaluation rubrics which will be presented to the students at the beginning of the course and will be available at the University's e-learning platform.

The interaction with lecturers will be carried out in five 1-hour sessions, and through forums during the research of information, and by email for the exchange of ideas. The groups will have to send to the lecturer in charge the "point of view" before the third session, and three ideas to resolve the challenge before the fourth session.

The subject "In a Multidisciplinary Society" corresponds with this educational methodology.

Competences worked: CB3, CE15/\*GT1, CG9 and CT4.

**Lecturing** Explanation of the contents of the subject; it includes explanation of concepts; introduction of practices and exercises; and resolution of problems and/or exercises.

The subject "Professional attributions and its history" fits with this methodology.

Competencies worked: with this methodology work the competencies CG7, CG9 and CT3

### Personalized assistance

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

### Assessment

Description	Qualification	Evaluated Competences

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

### Other comments on the Evaluation

The students can choose any of the following assessment systems:

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

- 1.1. Two long-answer tests, with 15% of the total grade each, totaling 30%.
- 1.2. Short-answer tests in the seminars, which account for 20%.
- 1.3. Practical proofs for the evaluation of supervised work (25%) and the presentation of them (25%).

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

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

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

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

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



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

### **Ethical code**

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

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

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### **Sources of information**

#### **Basic Bibliography**

O. Pérez Sanjuán, **De las señales de humo a la Sociedad del Conocimiento**, <http://bit.ly/2Rxf9cl>, COIT-AEIT,

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

VV.AA., **Design Thinking for Educators**, [www.designthinkingforeducators.com/toolkit/](http://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 y el Cable Alemán**, Instituto de Estudios Vigüeses,

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### **Recommendations**

#### **Subjects that continue the syllabus**

Telecommunication Projects Management/V05M145V01201

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### **Contingency plan**

#### **Description**

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

#### A Sessions (Classroom lectures)

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

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

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

#### C Sessions (Lab sessions)

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

#### Evaluation

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

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

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

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

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**IDENTIFYING DATA****Signal Processing in Communications**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

Topic	
Sampling and quantization	<ul style="list-style-type: none"> <li>- Aliasing</li> <li>- Baseband and bandpass sampling</li> <li>- Quantization noise</li> <li>- Converter overload</li> <li>- Spurious-free dynamic range</li> <li>- Sampling jitter</li> </ul>
Block-based Transforms in Communications and Multimedia	<ul style="list-style-type: none"> <li>- DFT: formulation and properties.</li> <li>- Frequency Analysis based on DFT. Windowing.</li> <li>- Power Spectrum Estimation: Welch's periodogram</li> <li>- DFT-based digital modulation schemes: SC-FDE, OFDM.</li> </ul>
Multirate Signal Processing	<ul style="list-style-type: none"> <li>- Sampling rate conversion: decimation, interpolation</li> <li>- Effect in the frequency domain</li> <li>- Polyphase structures</li> <li>- Applications in digital transceivers</li> </ul>

Linear estimation

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

## Planning

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

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

## Methodologies

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

## Personalized assistance

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

## Assessment

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

## Other comments on the Evaluation

Students may choose one of the following two assessment options:

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

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

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

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

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

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

## Sources of information

## Basic Bibliography

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

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

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

## Complementary Bibliography

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

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

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

## Recommendations

### Subjects that continue the syllabus

Real-Time Signal Processing/V05M145V01301

Advanced Digital Communications/V05M145V01204

Multimedia Communications/V05M145V01206

Optical Communications/V05M145V01207

Wireless and Mobile Communications/V05M145V01313

Satellites/V05M145V01311

Communication Advanced Systems/V05M145V01302

Wideband Radio Systems/V05M145V01312

## Other comments

It is assumed that students are knowledgeable in the following areas:

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

## Contingency plan

### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

All of them

\* Teaching methodologies modified

None of them

\* Remote mechanisms for student attention (tutoring)

Videoconferencing

\* Modifications (if applicable) of the contents

N/A

\* Additional bibliography to facilitate self-learning

N/A

\* Other modifications

N/A

=== ASSESSMENT ADAPTATION ===

No modification of the assessment activities or their corresponding weights is required

**IDENTIFYING DATA****Radiocommunication**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

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

## Planning

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

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

## Methodologies

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

## Personalized assistance

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

## Assessment

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

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

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

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

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

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### 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 Griffiths, **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,

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### Recommendations

#### Subjects that continue the syllabus

Antennas/V05M145V01208

Radio Laboratory/V05M145V01209

Satellites/V05M145V01311

Wideband Radio Systems/V05M145V01312

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### Contingency plan

#### Description

In case of sanitary alert that preclude the assistance to the classrooms and physical laboratories in any moment of the term,

(i) face-to-face learning will be replaced by emergency remote teaching,

(ii) the evaluation will not take into account unrealised laboratory practices that require the use of specific material and cannot be virtualised,

(iii) the assessment shall be carried out virtually through the platform that the University of Vigo will recommend (Faitic, Remote Campus...).



**IDENTIFYING DATA****Network Technologies**

Subject	Network Technologies			
Code	V05M145V01104			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish Galician			
Department				
Coordinator	López Ardao, José Carlos			
Lecturers	López Ardao, José Carlos			
E-mail	jardao@det.uvigo.es			
Web	http://moodle.det.uvigo.es			

General description This subject covers the competencies in the BOE for the Master degree to achieve those professional attributions of Telecommunications Engineer related to the underlying technologies in the Computer Networks.

In any way, it is an advanced course within the scope of these technologies, continuing and intensifying the basic contents studied in the subjects of the GETT.

**Competencies**

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

**Learning outcomes**

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

Know how to plan, design and deploy switched networks and IP networks in any application environment CB5  
CG1  
CG4  
CG8  
CG12  
CE4  
CE6  
CE7

Know and understand the internal architecture of the switching equipment, methods of resource allocation and the basic techniques of providing Quality of Service CB5  
CG1  
CG4  
CG8  
CG12  
CE4  
CE6  
CE12

## Contents

### Topic

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

## Planning

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

Lecturing	24	36	60
Objective questions exam	2	0	2
Essay questions exam	2	0	2

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

### Methodologies

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

### Personalized assistance

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

### Assessment

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

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

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

#### Continuous Assessment (CA)

It will consist of:

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

$$FG-CA = 0.15x(C1 + C2) + MP/100 + 0,55xFE \text{ if } FE \geq 3.5$$

$$FG-CA = FE \text{ if } FE < 3.5$$

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

#### Exam-only Assessment (EA)

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

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

#### Second call

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

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

#### Other comments

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

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

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

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

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**Sources of information**

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**Basic Bibliography**

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

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

P. Görason, C. Black, T. Culver, **Software Defined Networks: A comprehensive approach**, 2<sup>a</sup>, Morgan Kaufman, 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

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**Complementary Bibliography**

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Kun I. Park, **QoS in packet networks**, 1<sup>a</sup>,

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

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**Recommendations**

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**Subjects that it is recommended to have taken before**

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(\*)Redes de Ordenadores/V05M145V01403

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**Contingency plan**

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**Description**

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

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**IDENTIFYING DATA****Application Technologies**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

## Planning

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	13	26	39
Lecturing	22	29	51
Laboratory practice	3	30	33
Problem and/or exercise solving	2	0	2

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

## Methodologies

	Description
Laboratory practical	Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions.  We will focus on skills EC9, EC8, EC4, CG12, CG8 and CB5.
Lecturing	Teachers will combine both concepts explanation and toy examples resolution. Resolution of small situations at class will foster debates, especially if it is done in groups.  We will focus on skills CG1, CG4, CG12 and CE8

## Personalized assistance

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

## Assessment

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

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## Other comments on the Evaluation

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

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

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

### Practical assignments:

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

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

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

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

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## Sources of information

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### 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., Buli&#263;, P., Robi&#269;, 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 and Jack J. Dongarra, **Distributed and Cloud Computing**, Elsevier., 2012

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

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## Recommendations

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## Contingency plan

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### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

All.

\* Teaching methodologies modified

None.

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

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Campus Remoto.

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

\* Additional bibliography to facilitate self-learning  
None.

\* Other modifications  
None

=== ADAPTATION OF THE TESTS ===

Without modification.

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<b>IDENTIFYING DATA</b>				
<b>Analog Electronic Circuits Design</b>				
Subject	Analog Electronic Circuits Design			
Code	V05M145V01106			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Pastoriza Santos, Vicente			
Lecturers	Costas Pérez, Lucía Pastoriza Santos, Vicente			
E-mail	vpastoriza@uvigo.es			
Web	http://faitic.uvigo.es			
General description	<p>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.</p> <p>Course outline:</p> <ul style="list-style-type: none"> <li>+ Introduction to electronic systems for signal acquisition: functional block diagrams and architectures.</li> <li>+ Feedback: definition and topologies.</li> <li>+ Introduction to sensors: definition and classification.</li> <li>+ Introduction to signal conditioning circuits. Auxiliary circuits: linearization circuits. Level-shifting circuits. Precision rectifiers. Voltage references. Voltage-to-current conversion. Analog switches and multiplexers.</li> <li>+ Amplification in electronic measurement systems: instrumentation amplifiers, programmable amplifiers, and isolation amplifiers.</li> <li>+ Active filters.</li> <li>+ Sample-and-hold circuits, digital-to-analog and analog-to-digital converters.</li> </ul> <p>The main goal of the laboratory sessions (practical work) is to enable the students to acquire sufficient understanding and knowledge to:</p> <ul style="list-style-type: none"> <li>+ Assemble electronics circuits.</li> <li>+ Use of laboratory instrumentation to measure of physical variables on circuits.</li> <li>+ Detect and correct assembly errors.</li> <li>+ Manage specific software tools developed to design, simulation and analysis of analogue electronic system.</li> </ul>			

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

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

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

## Contents

Topic	
Unit 1: Introduction	<p>Analog systems for signal acquisition: Architectures. Functional block diagrams.</p> <p>Feedback: Definition. Topologies. Series-Parallel feedback.</p> <p>Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.</p>
Unit 2: Auxiliary circuits	<p>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.</p> <p>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.</p> <p>Analog Switches and Multiplexers Switches: Definition. Types. Applications. Commercial devices. Multiplexers: Definition. Types. Specifications.</p> <p>Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.</p>
Unit 3: Amplification in signal acquisition systems	<p>Instrumentation amplifiers: Introduction. Definition and ideal characteristics. Real model. Basic configurations. Specifications. Functional block diagram. Applications. Commercial amplifiers and their data sheets.</p> <p>Programmable amplifiers: Introduction. Types. Pin Programmable Gain Amplifier. PGA: Programmable Gain Amplifier. Commercial amplifiers and their data sheets.</p> <p>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.</p> <p>Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.</p>

#### Unit 4: Active filters

Introduction:  
Fundamentals. Basic filter types. Real parameters.

Description by transfer function:  
Introduction. Transfer function: poles and zeros, stability analysis and frequency response. First order and second order filters.

Approximation of filter transfer function:  
Steps in the realization of active filters. Filter specifications. Mathematical approximation of the characteristic function. Transfer function normalization. Transfer function normalization. Transformation from one type of filter into another. Polynomial approximations.

Synthesis:  
Introduction. Methods. Direct design. Basic topologies of direct synthesis. Cascade design. Comparison of methods. Scaling.

Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

#### Unit 5. Sample-and-hold circuits. Digital-to-analog and analog-to-digital converters

Sample-and-hold circuits:  
Background. Specifications. Architectures. Commercial devices.

Analog-to-digital converters:  
Introduction. Fabrication parameters. Errors. Architectures. Commercial devices.

Digital-to-analog converters:  
Introduction. Fabrication parameters. Errors. Architectures. Commercial devices.

Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

#### Practice 1: Auxiliary circuits.

Implementation and testing of certain of the auxiliary circuits developed in the theoretical part.

Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

#### Practice 2: Instrumentation amplifier.

Implementation, testing and analysis of an commercial instrumentation amplifier with adjustable gain.

Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

#### Practice 3: Active filters.

Implementation of an active filter. Identification of the topology, the order, and the filter type. Theoretical calculation of its cut-off frequency. Frequency response measurement using the waveform generator and the oscilloscope. Plot the magnitude of the frequency response of the filter (Bode magnitude plot).

Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

#### Practice 4: Measurement system of a physical variable using commercial sensors.

Implementation and testing of the signal conditioning circuit of a measurement system based on commercial sensors.

Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed.

#### Practice 5: Electronic circuit simulation

Simulation of electronic circuits described in the theoretical and/or previous practical part.

In this practice will work the competitions CB4, CB5, CG4, CG8, CE12 and CE14.

### Planning

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

Laboratory practical	10	10	20
Objective questions exam	3	30	33

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

### Methodologies

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

### Personalized assistance

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

### Assessment

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

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

## Other comments on the Evaluation

### 1. Continuous evaluation

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

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

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

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

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

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

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

$$OTM = (OT1 + OT2)/2$$

otherwise, the final mark of this part will be:

$$OTM = 5 - \text{Sum}(A_i)/2 \text{ where } A_i = \max\{0; 5 - OT_i\} \text{ for } i = 1, 2.$$

#### 1.b Practical tests

##### 1.b.1 Laboratory

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

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

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

##### 1.b.2 Tutored project

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

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

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

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

### 1.c Final mark of the subject

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

- objective tests:  $OT1 \geq 5$  and  $OT2 \geq 5$ .
- laboratory:  $FLM \geq 5$ .
- tutored project:  $TPM \geq 5$ .

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

$$FM = 0.60 \cdot OTM + 0.25 \cdot FLM + 0.15 \cdot TPM$$

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

$$FM = 0.60 \cdot AM + 0.25 \cdot BM + 0.15 \cdot CM, \text{ where:}$$

$$AM = 5 - \frac{\sum(A_i)}{2} \text{ where } A_i = \max(\{0; 5 - OT_i\}) \text{ for } i = 1, 2.$$

$$BM = \min(\{5; FLM\})$$

$$CM = \min(\{5; TPM\})$$

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

## 2. Single evaluation

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

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

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

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

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

- objective tests:  $OT1 \geq 5$  and  $OT2 \geq 5$ ,
- laboratory:  $FLM \geq 5$ .
- tutored project:  $TPM \geq 5$ .

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

$$FM = 0.60 \cdot OTM + 0.25 \cdot FLM + 0.15 \cdot TPM, \text{ where:}$$

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

$$OTM = \frac{OT1 + OT2}{2}$$

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

$$FM = 0.60 \cdot AM + 0.25 \cdot BM + 0.15 \cdot CM, \text{ where:}$$

$$AM = 5 - \frac{\sum(A_i)}{2} \text{ where } A_i = \max(\{0; 5 - OT_i\}) \text{ for } i = 1, 2.$$

BM = min( {5; FLM} )

CM = min( {5; TPM} )

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

### 3. Second call and extraordinary call

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

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

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

### 4. About ethical behaviour of students

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

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#### 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 circuitos 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

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#### Recommendations

##### Subjects that continue the syllabus

Digital and Analog Mixed Circuits/V05M145V01213

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#### Contingency plan

##### Description

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

\*The teaching in groups A, B and C will be taught through classrooms on the Remote Campus.

\*In A sessions, the same content described in the guide will be developed. The tasks in B sessions will be adapted to be carried out with simulators, and when this is not possible, they will be replaced by others that are feasible and that also allow obtaining the competences associated with them. In C sessions, the students will carry out a project assigned by the teacher.

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

\*The objective tests will be carried out synchronously in classrooms of the Remote Campus.

\*The following weightings will be applied in order to calculate the final mark (FM) : 50% objective tests (OTM) and 50% practical tests (30% laboratory (FLM) and 20% tutored project (TPM)).

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**IDENTIFYING DATA****Telecommunication Projects Management**

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

**Competencies**

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

**Learning outcomes**

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

- Knowledge of efficient project management.

CG2  
CG3  
CG6  
CG10  
CG13  
CE16  
CT5

## Contents

Topic	
Telecommunications companies	<ul style="list-style-type: none"> <li>- A career in the industry</li> <li>- Structure of a telecommunications company</li> <li>- Management roles</li> </ul> <p>Related competencies: CG3, CG6, CT5</p>
Human resource management	<ul style="list-style-type: none"> <li>- Motivational strategies</li> <li>- Performance analysis</li> <li>- Multidisciplinary coordination</li> </ul> <p>Related competencies: CG3, CG6, CT5</p>
Work methodology	<ul style="list-style-type: none"> <li>- Good practice methodologies</li> <li>- Project methodologies</li> <li>- Certifications</li> </ul> <p>Related competencies: CT1, CG5</p>
Regulatory issues	<ul style="list-style-type: none"> <li>- Specific regulations of Telecommunications Engineering</li> <li>- R&amp;D regulations</li> <li>- Other (environmental, ethics, ...)</li> </ul> <p>Related competencies: CG2, CG10, CG13, CE16, CG5</p>

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	10	20
Mentored work	5	25	30
Seminars	20	40	60
Essay	2	5	7
Essay	2	5	7
Objective questions exam	1	0	1

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

## Methodologies

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

## Personalized assistance

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

## Assessment

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

### Other comments on the Evaluation

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

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

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

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

Class attendance is mandatory.

### Sources of information

#### Basic Bibliography

#### Complementary Bibliography

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

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

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

### Recommendations

### Contingency plan

#### Description

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

**IDENTIFYING DATA****Electronics and Photonics for Communications**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

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

## Planning

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

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

## Methodologies

	Description
Practices through ICT	<p>This practices apply concepts related to the microwaves technologies part of the subject. They will be performed individually or in small teams of 2 students. With the aid of a commercial microwave and RF circuit simulator, the student will analyze various passive (matching networks, filters, couplers, etc.) and active (amplifiers,..) circuits. It will be defined and evaluated different figures of merit and other parameters that will be used for circuits performance evaluation.</p> <p>In Faitic, the student will have available support files and documentation. Through an agreement between UVIGO and the simulator provider, the student may apply for a temporary license of the simulator for his/her PC.</p> <p>The work of the student in these practice classes will be individually evaluated:</p> <ol style="list-style-type: none"> <li>1. In continuous Evaluation: by test/s which include short questions/exercises or the design of some circuits, with the aid of the simulator, during or outside practices hours.</li> <li>2. In Exam-only Evaluation: by means of short questions/exercises and circuit designs (with or without the aid of the simulator) related with the work performed during the practices in computer rooms.</li> </ol> <p>In these practices the student with work towards achieving competencies: CE2, CE3, CE12 y CE13</p>
Lecturing	<p>It will take place in a classroom with video projection facilities, blackboard and occasionally CAD tools.</p> <p>During these sessions it will be described in detail the relevant contents in the Subject program. The applications of some of these concepts will be done through exercises resolution, with or without CAD tools. In fact, some classes will be fully theoretical while others will include both theory and applications.</p> <p>The student will have available in Faitic support documentation and files.</p> <p>Competencies under work: CE2, CE3, CE12 y CE13</p>

## Personalized assistance

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

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

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

#### **Other comments on the Evaluation**

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

First Call:

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

1. The evaluation of the practices in computer rooms, related to microwave technologies, will be done through one/several individual Examinations with the support of CAD tools. One of these tests may be replaced by a deliverable report about a proposed circuit design. The total grade achieved in these assessment test corresponds up to 30% of the Subject Qualification (SQ).

2. The evaluation of the subject part related to RF circuit design, will be done through one or several deliverable reports (performed individually or in group) about some proposed designs or exercises, with the aid of CAD tools. This evaluation may include an interview about the work. The total grade achieved will be up to 25% of the SQ.

3. The rest of the assessment will be individually performed through 2 Short Examinations, that may contain exercise resolution and/or short questions:- Exam 1 related to the microwave technologies content, 20 % SQ.- Exam 2 related to Photonics, 25% SQ. It is assumed that students performing Exam 2 choose Continuous Assessment.

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

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

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

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

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

#### **Sources of information**

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**Basic Bibliography**

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

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

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

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

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

**Complementary Bibliography**

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

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

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

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

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

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

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

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**Recommendations****Subjects that continue the syllabus**

Microwave and Millimetre Wave Circuit Design and CAD/V05M145V01317

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**Contingency plan****Description**

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

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

Assessment:

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

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

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

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

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**IDENTIFYING DATA****Advanced Digital Electronic Systems**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	22	15	37
Laboratory practical	10	15	25
Project based learning	5	10	15
Objective questions exam	1	10	11
Problem and/or exercise solving	0	10	10
Laboratory practice	0	5	5
Project	0	18	18
Presentation	2	2	4

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

### Methodologies

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

### Personalized assistance

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

Tests	Description
Problem and/or exercise solving	Students have the opportunity to solve doubts in personalized attention sessions. The appointment with the corresponding professor should be required and agreed by e-mail, preferably in the hours which are published in the faculty website

### Assessment

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

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

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### Other comments on the Evaluation

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

#### 1. Continuous evaluation

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

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

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

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

##### 1.2 Problem and/or exercise solving (NExerc):

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

##### 1.3 Laboratory practices (NPrac):

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

##### 1.4 Project (NPro):

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

##### 1.5 Presentation of the project results (PPro)

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

##### 1.6 Final qualification of continuous evaluation (Final\_ac)

The final qualification (Final\_ac) of continuous assessment is obtained as follows:

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

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

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

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

## 2. Single evaluation

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

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

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

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

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

## 3. Other comments

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

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### 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

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### Recommendations

#### Subjects that are recommended to be taken simultaneously

Digital and Analog Mixed Circuits/V05M145V01213

Hardware/Software Design of Embedded Systems/V05M145V01214

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## Contingency plan

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### Description

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

\* Lecturing (type A hours):

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

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

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

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

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

\* Assessment:

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

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**IDENTIFYING DATA****Advanced Digital Communications**

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

Contents, teaching and exams are in English. Students may participate in classes and answer to exams preferably in English, but Spanish and Galician are also accepted.

**Competencies**

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

**Learning outcomes**

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

**Contents**

## Topic

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

## Planning

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

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

## Methodologies

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

## Personalized assistance

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

## Assessment

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

## Other comments on the Evaluation

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

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

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

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

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

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

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## Sources of information

### Basic Bibliography

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

### Complementary Bibliography

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

Ezio Bliglieri et al., **Principles of Cognitive Radio**, First, Cambridge University Press, 2012

Behrouz Farhang-Boroujeny, **Signal Processing Techniques for Software Radios**, Second, Lulu, 2010

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

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

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## Recommendations

### Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

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## Contingency plan

### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

- \* Teaching methodologies are maintained, along with monitoring and assessment mechanisms.
- \* The interaction with the students will be performed on-line, with lectures and office hours offered in synchronous mode.
- \* The final exam will be given in take-home format



**IDENTIFYING DATA****Signal Processing in Audiovisual Systems**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

**Planning**

	Class hours	Hours outside the classroom	Total hours
Practices through ICT	10	30	40
Mentored work	10	50	60
Lecturing	8	8	16
Objective questions exam	1	0	1
Report of practices, practicum and external practices 1		7	8

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

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

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

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

### **Other comments on the Evaluation**

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

Those students who did not pass in the first call will be allowed to take an exam in the second call. The same rules as those for the exam in the first call will apply.

The "Objective questions exam" may be written or online. If written it will be held on the oficial exam date.

### **Sources of information**

#### **Basic Bibliography**

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

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

#### **Complementary Bibliography**

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

### **Recommendations**

#### **Subjects that are recommended to be taken simultaneously**

Multimedia Communications/V05M145V01206

#### **Subjects that it is recommended to have taken before**

Signal Processing in Communications/V05M145V01102

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## **Contingency plan**

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### **Description**

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

GROUP A:

- Group A classes using the virtual campus.

GROUP B:

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

ASSESSMENT:

- The submission of group B works is already done remotely (using faitic as document delivery place).

- The final evaluation test has two parts:

A) Multiple choice type, compulsory for all students. It can be done without problem through faitic.

B) Long answer (only for students who do not choose continuous assessment). Desirable in person but can be done online using faitic and remote campus.

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**IDENTIFYING DATA****Multimedia Communications**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

**Planning**

	Class hours	Hours outside the classroom	Total hours
Laboratory practical	13	44	57
Lecturing	15	30	45
Report of practices, practicum and external practices	0	21	21
Essay questions exam	2	0	2

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

**Methodologies**

	Description
Laboratory practical	13 hours of PC lab. Programming of computational simulations. The student will simulate, by using a numerical calculus programming language (as Matlab) the multimedia communications systems introduced in this subject.  Competencies: CG1, CG4, CE1, CE4, CE6, CE8.
Lecturing	15 hours of theoretical lessons, where practical cases will be introduced. Furthermore, autonomous homework exercises will be proposed.  Competencies: CG1, CG4, CE1, CE4, CE6, CE8.

**Personalized assistance**

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

**Assessment**

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

**Other comments on the Evaluation**

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

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

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

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

The same rules are applied to the second call.

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### Sources of information

#### Basic Bibliography

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

#### Complementary Bibliography

**Artículos científicos especificados por el profesorado,**

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### Recommendations

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### Subjects that it is recommended to have taken before

Signal Processing in Communications/V05M145V01102

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### Other comments

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

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

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### Contingency plan

#### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

All of them

\* Teaching methodologies modified

None of them

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

Videoconference

\* Modifications (if applicable) of the contents

N/A

\* Additional bibliography to facilitate self-learning

N/A

\* Other modifications

None

\* Additional Information

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

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

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**IDENTIFYING DATA****Optical Communications**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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



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

### Planning

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

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

### Methodologies

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

### Personalized assistance

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

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

### **Other comments on the Evaluation**

First call:

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

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

Continuous assessment:

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

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

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

Exam-only assessment:

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

Second call:

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

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

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

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

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

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### 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

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### Recommendations

#### Subjects that it is recommended to have taken before

Electronics and Photonics for Communications/V05M145V01202

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### Contingency plan

#### Description

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

- Teaching of Group A: The contents will be the same as those corresponding to face-to-face teaching.
- Teaching of Group B: The hardware exercises in the lab will be replaced by detailed theoretical online explanations about them.
- Assessment: The assessment will be online. We will replace the short answer test about the lab with an oral test (10%), and the resolution of exercises (10%).

**IDENTIFYING DATA****Antennas**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

### Planning

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

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

### Methodologies

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

### Personalized assistance

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

### Assessment

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

### Other comments on the Evaluation

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

### 1. CONTINUOUS EVALUATION

The system of continuous evaluation will consist in:

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

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

### 2. SINGLE EVALUATION - FIRST CALL

It involves:

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

### 3. SINGLE EVALUATION - SECOND CALL

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

COMMENTS:

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

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#### Sources of information

##### Basic Bibliography

C. A. Balanis, **Advanced Engineering Electromagnetics**, 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

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## Complementary Bibliography

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

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

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

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

## Recommendations

### Subjects that continue the syllabus

Wireless and Mobile Communications/V05M145V01313

Satellites/V05M145V01311

Wideband Radio Systems/V05M145V01312

### Subjects that are recommended to be taken simultaneously

Radio Laboratory/V05M145V01209

### Subjects that it is recommended to have taken before

Radiocommunication/V05M145V01103

## Contingency plan

### Description

=== EXCEPTIONAL PLANNING ===

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

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

=== ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

All the indicated teaching methodologies are maintained: lectures, problem solving, case studies and laboratory tests with ICT support

\* Teaching methodologies modified

There are no relevant modifications in the exposed methodologies.

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

Tutoring hours indicated in the teaching guide will be maintained, but in classroom 643 in the Remote Campus of the University of Vigo. To access, the appropriate indications will be given.

If necessary, tutoring will be enabled through email and videoconference.

\* Modifications (if applicable) of the contents

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

\* Additional bibliography to facilitate self-learning

Non applicable

\* Other modifications

Non applicable

=== ADAPTATION OF THE TESTS ===

\* Tests already carried out

Test XX: [Previous Weight 00%] [Proposed Weight 00%]

...

\* Pending tests that are maintained

Problem solving [Previous weight 10%] [Proposed Weight 10%]

Laboratory practice and homework assignments [Previous weight 60%] [Proposed Weight 60%]

Exam of development questions [Previous weight 30%] [Proposed Weight 30%]

\* Tests that are modified

Problem solving [Previous weight 10%] [Proposed Weight 10%]

Laboratory practice and homework assignments [Previous weight 60%] [Proposed Weight 60%]

Exam of development questions [Previous weight 30%] [Proposed Weight 30%]

\* New tests

Non applicable

\* Additional Information

Non applicable

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**IDENTIFYING DATA****Radio Laboratory**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

Topic	
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The students will realise some of the following practical:

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

All of the tasks will be carried out as Laboratory Practices, using the equipment available at the School.

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Case studies	2	10	12
Laboratory practical	22	65	87
Lecturing	4	20	24
Problem and/or exercise solving	2	0	2

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

<b>Methodologies</b>	
	Description
Case studies	Practical demonstrations. CB1, CB2, CG8, CE2, CE3, CE5, CE13.
Laboratory practical	Setting and measure of circuits and telecommunication systems. Employing specific instrumental. In groups. CB1, CB2, CG8, CE2, CE3, CE5, CE13.
Lecturing	Explanation of the theoretical-practical basis of the work to be developed by the students in the laboratory. CB1, CB2, CG8, CE2, CE3, CE5, CE13.

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

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

<b>Assessment</b>				
	Description	Qualification	Evaluated Competences	
Laboratory practical	Laboratory practises	50		CE2 CE3 CE5 CE13
Problem and/or exercise solving	Short answer tests	50	CB1 CB2	CG8

### **Other comments on the Evaluation**

FIRST CALL:

Two assessment systems are offered:

CONTINUOUS ASSESSMENT, that is the ordinary recommended method, around which educational activities are scheduled. SINGLE ASSESSMENT, which is recommended for those situations in which it results impossible to follow the ordinary method

CONTINUOUS ASSESSMENT

It is assumed that students follow continuous assessment whenever they attend any of the laboratory practices.

The continuous assessment consists of the proofs that detail to continuation: \* Laboratory practices. Group assessment (Weight: 50%)\* Proof of short answer. Individual assessment (Weight: 50%)

Attendance to the laboratory practices is considered as compulsory.

At the end of each practice session the students must hand in a report, reflecting the results obtained, which constitutes the subject of assessment.

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

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

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

EXAM-ONLY ASSESSMENT The exam-only assessment consists of: \* Examination on laboratory practice. Individual assessment (Weight: 50%)\* Proof of short answer. Individual assessment (Weight: 50%)

SECOND CALL: The student been evaluated by Continuous Assessment can opt between two possibilities the same day of the examination: \* Realise again the Proof of short answer in the official date assigned by the Centre and be evaluated according to the stipulated for the system of CONTINUOUS ASSESSMENT\* Be evaluated with an only final examination in the official date assigned by the Centre, as the stipulated for the system of EXAM-ONLY ASSESSMENT.

The student not been evaluated by continuous Assessment: \* will be evaluated with an only final examination in the official date assigned by the Centre, as the stipulated for the system of EXAM-ONLY ASSESSMENT

In the event of copycatting at any proof or work, the final assessment will be FAIL (0) and the event will be communicated to the Centre headmaster in order to conduct appropriate measures.

### **Sources of information**

#### **Basic Bibliography**

Walter Tuttlebee, **Software defined radio : Enabling technologies,**

Fuqin Xiong, **Digital modulation techniques,**

#### **Complementary Bibliography**

Ulrich Reimers, **DVB : The family of international standards for digital video broadcasting,**

M. E. Van Valkenburg, **Network analysis,**

Wes Hayward, **Introduction to radio frequency design,**

George Brown, **Radio and electronics cookbook,**

John Davies, **Newnes radio and RF engineer's pocket book,**

Y.T. Lo, S.W. Lee, **Antenna handbook,**

Rajeswari Chatterjee, **Antenna theory and practice,**

Yi Huang, Kevin Boyle, **Antennas : from theory to practice,**

Walter C. Johnson, **Transmission lines and networks,**

Brian C. Wadell, **Transmission line design handbook,**

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### **Recommendations**

#### **Subjects that continue the syllabus**

Wireless and Mobile Communications/V05M145V01313

Satellites/V05M145V01311

Wideband Radio Systems/V05M145V01312

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#### **Subjects that are recommended to be taken simultaneously**

Antennas/V05M145V01208

Optical Communications/V05M145V01207

Electronics and Photonics for Communications/V05M145V01202

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#### **Subjects that it is recommended to have taken before**

Radiocommunication/V05M145V01103

Signal Processing in Communications/V05M145V01102

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### **Contingency plan**

#### **Description**

=== ADAPTATION OF THE METHODOLOGIES ===

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

=== ADAPTATION OF THE TESTS ===

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

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**IDENTIFYING DATA****Internet Engineering**

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

**Competencies**

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

**Learning outcomes**

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

To command the principles of network & services virtualization. To learn how to perform resource allocation, to compare alternative architectures and comprehend the underlying Internet economic forces.

CB5  
CG1  
CG4  
CG8  
CG12  
CE4  
CE6  
CE7  
CE8

## Contents

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

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	13	26	39
Laboratory practical	14	56	70
Laboratory practice	1	0	1
Essay questions exam	2	0	2
Problem and/or exercise solving	0	13	13

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

## Methodologies

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

## Personalized assistance

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

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

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

### **Other comments on the Evaluation**

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

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

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

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

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

### **Sources of information**

#### **Basic Bibliography**

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

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

#### **Complementary Bibliography**

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

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

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

### **Recommendations**

#### **Subjects that it is recommended to have taken before**

Network Technologies/V05M145V01104

### **Contingency plan**

#### **Description**

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

**IDENTIFYING DATA****Wireless Networks and Ubiquitous Computation**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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



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

### Planning

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

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

### Methodologies

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

### Personalized assistance

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

### Assessment

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

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

$$\text{grade} = x^{0.4} \times y^{0.2} \times z^{0.4}$$

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

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

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

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

### Second call to pass the course

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

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

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

### Other comments

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

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

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

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

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### Sources of information

#### Basic Bibliography

Cory Beard, William Stallings, **Wireless Communication Networks and Systems**, 1,  
 Christopher Cox, **An Introduction to LTE**, 2,

## Complementary Bibliography

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

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

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

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

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

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

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

## Recommendations

## Contingency plan

### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF The METHODOLOGIES ===

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

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

<b>IDENTIFYING DATA</b>				
<b>Web Engineering</b>				
Subject	Web Engineering			
Code	V05M145V01212			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	1st	2nd
Teaching language	Spanish Galician			
Department				
Coordinator	Santos Gago, Juan Manuel			
Lecturers	Álvarez Sabucedo, Luis Modesto Santos Gago, Juan Manuel			
E-mail	Juan.Santos@det.uvigo.es			
Web	<a href="http://fatic.uvigo.es">http://fatic.uvigo.es</a>			
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.			
	<p>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.</p> <p>The course will be taught in Spanish or Galician, although the teaching materials (slides, bibliographic documentation, etc.) will be available predominantly in English.</p>			

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

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

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

## Contents

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

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	14	5	19
Practices through ICT	8	32	40
Project based learning	4	32	36
Essay questions exam	2	6	8
Report of practices, practicum and external practices	0	10	10
Project	2	10	12

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

## Methodologies

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

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

### Personalized assistance

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

### Assessment

Description	Qualification	Evaluated Competences
Essay questions exam	35	CB1 CB4 CB5 CE8
Report of practices, practicum and external practices	35	CB2 CB3 CB4 CG8 CE8
Project	30	CB3 CB4 CG5 CG6 CG8 CE6 CE8

In a second phase, at project completion, each group must provide a report that documents the design of the proposed solution and the achieved results. This report will be evaluated by the lecturer based on the attainment of the initial objectives and the quality of the solution used to achieve them.

### Other comments on the Evaluation

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

#### Continuous Evaluation

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

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

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

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

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

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

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

In addition, the following rules must be observed:

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

### Single Evaluation

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

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

### Second call

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

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

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### Sources of information

#### Basic Bibliography

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

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

#### Complementary Bibliography

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

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

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

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

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

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

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### Recommendations

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## **Contingency plan**

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### **Description**

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

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

Regarding the evaluation:

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

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

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

## Planning

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

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

## Methodologies

	Description
Introductory activities	Activities aimed at making contact and gathering information about the students, as well as presenting the subject.
Lecturing	Exhibition by the teacher of the reports on the subject matter of study, theoretical bases and / or guidelines of a work, exercise that the student has to develop.
Mentored work	The student, individually or as a group, carries out activities, which can be: <ul style="list-style-type: none"> <li>- Monographic works, search of information in publications, databases, articles, books ... on a specific topic.</li> <li>- Preparation of seminars, research, reports, essays, conferences, etc.</li> <li>- Reviews on current scientific articles.</li> <li>- Projects (design and develop projects).</li> </ul>
Problem solving	Activity in which problems and / or exercises related to the subject are formulated. The student must develop the correct solutions through the exercise of routines, and application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results.
Laboratory practical	Activities of application of knowledge and concrete situations, and acquisition of basic and procedural skills, related to the object of study. They are developed in special spaces with specialized equipment (laboratories, computer rooms, etc.).

## Personalized assistance

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

Mentored work	The professor will attend personally doubts and queries of the students on the supervised works. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.
Problem solving	The professor will attend personally doubts and queries of the students on the resolution of the problems. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.
<b>Tests</b>	<b>Description</b>
Report of practices, practicum and external practices	The professor will attend personally doubts and queries of the students on the preparation of the report of practices. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.

## Assessment

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

## Other comments on the Evaluation

### 1. First call: Continuous assessment

The continuous evaluation consists of the following four parts:

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

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

Report of laboratory practices (15%).

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

Development questions (20%).

Problems (25%).

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

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

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

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

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

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

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

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

## 2. First call: Final exam

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

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

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

## 3. Second call

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

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### Sources of information

#### Basic Bibliography

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

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

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

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

#### Complementary Bibliography

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

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

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

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

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

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

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### Recommendations

#### Subjects that continue the syllabus

Signal Conditioners/V05M145V01331

#### Subjects that are recommended to be taken simultaneously

Advanced Digital Electronic Systems/V05M145V01203

#### Subjects that it is recommended to have taken before

Analog Electronic Circuits Design/V05M145V01106

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### Contingency plan

#### Description

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

##### Theory

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

##### Laboratory

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

Documentation and bibliography

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

#### Evaluation

The contents and the distribution of marks in the evaluation, in both continuous and final, will keep independently of the format of teaching, face-to-face or no face-to-face.

As in the no face-to-face teaching, the objective acts of assessment will carry out in a synchronous way and using the remote available tools in CAMPUS REMOTO and FAITIC. In the practical part will be used the same platform and, moreover, the same free access simulator used in the practices.

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**IDENTIFYING DATA****Hardware/Software Design of Embedded Systems**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

Topic	
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LESSON 1 THEORY. INTRODUCTION TO THE DESIGN OF EMBEDDED SYSTEMS. (1 h.)	<ul style="list-style-type: none"> <li>1.1. Introduction.</li> <li>1.2. Programmable Systems On Chip (PSOC).</li> <li>1.3. Hardware/Software Codesign. Codesign phases.</li> <li>1.4. Xilinx SOC Zynq family introduction.</li> <li>1.5. Xilinx Vivado and SDK tools for codesign of embedded systems.</li> </ul>
LESSON 2 THEORY. MICROPROCESSOR OF THE XILINX ZYNQ FAMILY SOCs. (0'5 h.)	<ul style="list-style-type: none"> <li>2.1. ARM processor from Zynq SOC family (Zynq Processing Systems (PS)).</li> <li>2.2. Processor peripherals from Zynq SOC family.</li> <li>2.3. Clock, reset and processor debugging.</li> <li>2.4. AXI interface.</li> </ul>
LESSON 3 THEORY. FPGA OF THE XILINX ZYNQ FAMILY SOCs. (0'5 h.)	<ul style="list-style-type: none"> <li>3.1. Introduction to 7 series Xilinx FPGAs. <ul style="list-style-type: none"> <li>3.1.1. Logic resources.</li> <li>3.1.2. Input/output resources.</li> <li>3.1.3. Memory and signal processing resources.</li> <li>3.1.4. Analog to digital converter.</li> <li>3.1.5. Clock resources.</li> </ul> </li> </ul>
LESSON 4 THEORY. CONNECTION OF PERIPHERAL CIRCUITS TO THE XILINX ARM MICROPROCESSOR. (1 h.)	<ul style="list-style-type: none"> <li>4.1.- Introduction.</li> <li>4.2.- Interface for basic peripherals. GPIO.</li> <li>4.3.- Interface for advanced peripherals. IPIF.</li> <li>4.4.- Interface for user coprocessors</li> </ul>
LESSON 5 THEORY. SOFTWARE DEVELOPMENT FOR THE XILINX ARM MICROPROCESSOR. (1 h.)	<ul style="list-style-type: none"> <li>5.1.- Introduction.</li> <li>5.2.- Structure of the routines for handling of peripherals.</li> <li>5.3.- Interrupt handle.</li> <li>5.4.- Program debugging.</li> </ul>
LESSON 6 THEORY. HARDWARE / SOFTWARE PARTITIONING. (1 h.)	<ul style="list-style-type: none"> <li>6.1.- Introduction.</li> <li>6.2.- Examples of hardware / software codesign.</li> <li>6.3.- Distribution of tasks between hardware and software.</li> </ul>
LESSON 7 THEORY. EMBEDDED SYSTEMS ANALISYS PROJECT. (5 h.)	<ul style="list-style-type: none"> <li>7.1. Design of a software routine for the assigned function.</li> <li>7.2. Design of a hardware peripheral (coprocessor) for the assigned function.</li> <li>7.3. Profiling analysis from software routine and hardware peripheral. Comparison of results.</li> </ul>
LESSON 1 LABORATORY. XILINX VIVADO ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS. (1.5 h.)	<ul style="list-style-type: none"> <li>1.1. Introduction.</li> <li>1.2. Xilinx Vivado environment.</li> <li>1.3. Design of basic examples of embedded systems. <ul style="list-style-type: none"> <li>1.3.1. Addition of predefined peripherals (IP cores).</li> </ul> </li> <li>1.4. Implementation of the developed systems in Digilent evaluation boards.</li> </ul>
LESSON 2 LABORATORY. DESIGN OF BASIC PERIPHERAL CIRCUITS. (2 h.)	<ul style="list-style-type: none"> <li>2.1. Introduction.</li> <li>2.2. Development of basic user peripherals. GPIO.</li> </ul>
LESSON 3 LABORATORY. DESIGN OF ADVANCED PERIPHERAL CIRCUITS. (1.5 h.)	<ul style="list-style-type: none"> <li>3.1. Introduction.</li> <li>3.2. Development of advanced user peripherals (Custom IP).</li> </ul>
LESSON 4 LABORATORY. XILINX SDK ENVIRONMENT FOR THE DESIGN OF EMBEDDED SYSTEMS SOFTWARE. (1 h.)	<ul style="list-style-type: none"> <li>4.1. Introduction.</li> <li>4.2. Xilinx Software Development Kit (SDK) environment.</li> <li>4.3. Basic Design Examples.</li> </ul>
LESSON 5 LABORATORY. SOFTWARE DEBUGGING OF EMBEDDED APPLICATIONS. (1 h.)	<ul style="list-style-type: none"> <li>5.1. Introduction.</li> <li>5.2. Software debugging of embedded systems by means of the GNU debugger from SDK.</li> </ul>
LESSON 6 LABORATORY. HARDWARE VERIFICATION OF EMBEDDED APPLICATIONS. (1.5 h)	<ul style="list-style-type: none"> <li>6.1. Introduction.</li> <li>6.2. Embedded systems hardware verification using Vivado hardware analyzer.</li> </ul>
LESSON 7 LABORATORY. EMBEDDED SYSTEMS PROFILING. (1.5 h)	<ul style="list-style-type: none"> <li>7.1. Introduction.</li> <li>7.2. Software profiler.</li> </ul>
LESSON 8 LABORATORY. DESIGN PROJECT. DESIGN OF AN APPLICATION BASED IN XILINX 32-BIT MICROPROCESSORS. (10 h.: 5 h. type B + 5 h. type C)	<ul style="list-style-type: none"> <li>8.1. Design and test of the assigned application.</li> </ul>

## Planning

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

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

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

### **Personalized assistance**

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

### **Assessment**

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

### **Other comments on the Evaluation**

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

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



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

### **CONTINUOUS EVALUATION IN FIRST CALL**

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

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

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

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

#### 1) Laboratory practices.

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

$$LAB = ( \text{Mark Lesson 1L} + \dots + \text{Mark Lesson 7L} ) / 7$$

#### 2) Theoretical exercises and problems.

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

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

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

$$TE = \text{Exercise 1} + \dots + \text{Exercise N}$$

#### 3) Tutored works.

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

#### 4) Presentation.

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

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

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

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

$$FM = \text{Minimum} [4,5; (0,25 * TE + 0,25 * LAB + 0,40 * TW + 0,10 * OP) ]$$

Where:

TE = Global mark of the theoretical exercises and problems.

LAB = Laboratory Practices.

TW = Tutored Work.

OP = Oral presentation.

### **SINGLE EVALUATION IN FIRST AND SECOND CALL**

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

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

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

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

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

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

$$NF = \text{minimum} [4,5; (0,40 * TE + 0,60 * PE)]$$

Where:

TE = Global mark of the theoretical part.

PE = Global mark of the practical part.

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

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### 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**, Vision Libros,

#### Complementary Bibliography

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

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### Recommendations

#### Subjects that are recommended to be taken simultaneously

Advanced Digital Electronic Systems/V05M145V01203

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### Contingency plan

#### Description

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

**IDENTIFYING DATA****Integrated Circuits Design and Manufacturing**

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

**Competencies**

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

**Learning outcomes**

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

**Contents**

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

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

### Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	13	26	39
Mentored work	4	28	32
Laboratory practical	9	22.5	31.5
Problem and/or exercise solving	1	3	4
Problem and/or exercise solving	1	3	4
Laboratory practice	1	7	8
Essay	1	5.5	6.5

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

### Methodologies

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

### Personalized assistance

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

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

Essay	<p>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:</p> <ul style="list-style-type: none"> <li>- Analysis of alternatives</li> <li>- Correct implementation and design verification</li> <li>- Design compaction</li> <li>- 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.</li> <li>- Information for integrated circuit manufacturing.</li> <li>- Formal aspects: clarity and order, including figures and appropriate and outstanding data, as well as explanations in a concrete and comprehensive way.</li> </ul> <p>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.</p> <p>To pass the course, the student will need obtain at least a score of 5 over 10 in memory, get to least a score of 5 out of 10 in public presentation. In the evaluation of the practical tests, the memory note will weigh 70% and the presentation 30%. In this test the CE10, CB4, CB5 and CG8 skills are evaluated.</p>	60	CB4 CG8 CE10
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### Other comments on the Evaluation

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

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

### Sources of information

#### Basic Bibliography

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

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

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

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

#### Complementary Bibliography

### Recommendations

### Contingency plan

#### Description

=== EXCEPTIONAL PLANNING ===

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

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

=== ADAPTATION OF THE METHODOLOGIES ===

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

=== ADAPTATION OF THE TESTS ===

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

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<b>IDENTIFYING DATA</b>				
<b>Real-Time Signal Processing</b>				
Subject	Real-Time Signal Processing			
Code	V05M145V01301			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Martín Rodríguez, Fernando			
Lecturers	Martín Rodríguez, Fernando			
E-mail	fmartin@uvigo.es			
Web				
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.			

<b>Competencies</b>	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE21CE21/PS1	Manage implementation of signal processing systems options to accelerate computationally complex algorithms.

<b>Learning outcomes</b>	
Learning outcomes	Competences
Understanding the basic principles of real time signal and video processing.	CG1 CG8 CE21
Handling advanced programming tools for real-time signal and video and applications.	CG1 CG8 CE21
Understanding the design and implementation of computationally complex models generated from data (machine learning) and their use in real applications.	CG1 CG8 CE21
Knowing how to design the suitable software-hardware solution for a problem of signal processing with real-time restrictions.	CG1 CG8 CE21

<b>Contents</b>	
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.

<b>Planning</b>			
	Class hours	Hours outside the classroom	Total hours
Lecturing	12	0	12
Practices through ICT	8	25	33
Case studies	5	70	75
Report of practices, practicum and external practices	3	0	3
Problem and/or exercise solving	1.5	0	1.5
Presentation	0.5	0	0.5



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

<b>Methodologies</b>	
	Description
Lecturing	Description of the fundamental concepts and practical considerations for signal and video processing applications with real-time constraints. CG1
Practices through ICT	Individual practice work using computing platforms and/or simulators to implement and compare software solutions. CG1, CG8, CE21
Case studies	Individual or group practice work using computing platforms and/or simulators to study and implement specific applications. CG1, CG8, CE21

<b>Personalized assistance</b>	
Methodologies	Description
Practices through ICT	The instructor will propose practical exercises to grasp the concepts explained in class and related to the case studies. The professor will review with the student the design and the code of the student in each session.
Case studies	The instructor will propose a couple of case studies and the students will need to study them and implement different solutions. The students will need to make a written report and present the results to their classmates. The professor will guide the students but the work is mainly done by them.

<b>Assessment</b>				
	Description	Qualification	Evaluated Competences	
Report of practices, practicum and external practices	Report on the study of the practical case and solution adopted	70	CG1 CG8	CE21
Problem and/or exercise solving	Computer-based tests regarding the explained contents in master classes and concepts appearing in the case studies.	20	CG1 CG8	
Presentation	The students will present, individually, their work related to the case studies	10	CG8	CE21

### **Other comments on the Evaluation**

Teaching and assessment is in english.

Attendance is compulsory in continuous assessment, unless special circumstances are alleged. Continuous assessment will be based on short answer tests, case study reports and presentations.

There will be an official first-call exam scheduled by the "Xunta de Escola" that the students that didn't pass the continuous assessment will have to take if they want to pass the course. This final exam will be scored from 0 to 10 points and covers all the topics explained during the course and also concepts and techniques explained for the case studies. To pass this exam the student has to score, at least, 5 points.

Delivering any of the reports or sitting at any test will automatically mean that the student is following the course in the continuous assessment mode. That means that he/she will appear as "presented" in the records of the subject even if the first-chance exam is not taken.

There will be a second-call exam at the end of the course for students who failed the course both in continuous assessment mode and/or first-chance exam. The score of the subject will be the score of this exam. The exam will be scored between 0 and 10. To pass the subject, at least 5 points are needed.

### **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

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**Recommendations**

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**Subjects that it is recommended to have taken before**

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Signal Processing in Audiovisual Systems/V05M145V01205

Signal Processing in Communications/V05M145V01102

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**Contingency plan**

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**Description**

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

**GROUP A:**

- Group A classes using the virtual campus.

**GROUP B:**

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

**ASSESSMENT:**

- The submission of group B works is already done remotely (using faitic as document delivery place).

- The problem solving exam can be done online using faitic and remote campus.

- Presentations can be done online through virtual campus.

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**IDENTIFYING DATA****Communication Advanced Systems**

Subject	Communication Advanced Systems			
Code	V05M145V01302			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Mosquera Nartallo, Carlos			
Lecturers	Gómez Cuba, Felipe Mosquera Nartallo, Carlos			
E-mail	mosquera@gts.uvigo.es			
Web				
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.			

**Competencies**

Code	
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CE22CE22/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.

**Learning outcomes**

Learning outcomes	Competences
Understand the impact of telecommunication services requirements on system design, with special emphasis on lower layers.	CG4 CE22
Acquire a global view of the solutions developed for modern commercial communication systems.	CG4 CE22

**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 Multi-user channels and bounds 2.2 Multiple-access channel: coordinated and uncoordinated access, rate regions, multiuser detection techniques, random access schemes. 2.3 Broadcast channel: rate regions, precoding, non-orthogonal techniques.

**Planning**

	Class hours	Hours outside the classroom	Total hours
Seminars	6	15	21
Problem solving	0	25	25
Lecturing	24	53	77
Problem and/or exercise solving	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

Seminars	Different communication systems will be presented with special emphasis on those challenges which are at the core of modern solutions and require advanced mathematical tools. Skills CG4 and CE22 are developed here.
Problem solving	Every week a homework challenge will be proposed to be solved with the aid of mathematical analysis, software tools or both. Skills CG4 and CE22 are developed here.
Lecturing	Advanced mathematical tools will be introduced as background material to address practical solutions in modern communication systems. Skills CG4 and CE22 are developed here.

### Personalized assistance

Methodologies	Description
Lecturing	Student support will be provided during office hours and by e-mail.
Seminars	Student support will be provided during office hours and by e-mail.
Problem solving	Student support will be provided during office hours and by e-mail.

### Assessment

	Description	Qualification	Evaluated Competences	
Problem solving	Every week a homework challenge will be proposed to be solved with the aid of mathematical analysis, software tools or both. If the solution is not turned in within the allocated deadline, the corresponding assignment will not be graded.	50	CG4	CE22
Problem and/or exercise solving	Final exam with short questions and exercises.	50	CG4	CE22

### Other comments on the Evaluation

The students need to obtain 50 out of 100 points to pass the course. In addition, a minimum grade of 30% is required in the final exam; if this grade is not achieved, the final grade will be that obtained in the final exam. This applies also to the second call.

The grades obtained from the weekly assignments are only valid for the current academic year, and cannot be redone after the corresponding deadline. A student can decide to opt out the evaluation of the weekly assignments; in such a case, his/her final score will be fully based on the final exam. This applies also to the second call. Once the student turns in any of the deliverables, he/she will be considered to be following the continuous evaluation track.

Any student that chooses the continuous evaluation track will get a final score, regardless of her/his taking the final exam.

All the homeworks and exam will be given in English.

### 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

### Recommendations

#### Subjects that it is recommended to have taken before

Advanced Digital Communications/V05M145V01204

Signal Processing in Communications/V05M145V01102

#### Other comments

Attendance to physical classes is mandatory. If a minimum 80% attendance is not fulfilled, the grade will be entirely based on the final exam.

### Contingency plan

#### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

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

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

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## IDENTIFYING DATA

### Statistical Signal Processing

Subject	Statistical Signal Processing			
Code	V05M145V01303			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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://fatic.uvigo.es			
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.			

## Competencies

Code	
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE23CE23/PS3	Ability to apply methods of statistical processing of signal communications systems and audiovisual.

## Learning outcomes

Learning outcomes	Competences
Ability to apply statistical estimation techniques in communications and multimedia systems	CE23
Ability to apply statistical detection techniques in communications and multimedia systems	CE23
Ability to determine and interpret fundamental limits in estimation and detection problems	CG4 CE23
Ability to evaluate the performance of estimation and detection techniques, by analytical as well as by Monte Carlo simulation methods	CG8 CE23

## Contents

Topic	
Part 1: Parameter Estimation	<ul style="list-style-type: none"><li>- The statistical estimation problem. Performance metrics: bias, variance, MSE. Minimum Variance Unbiased Estimator (MVUE).</li><li>- Fisher Information and Cramer-Rao bound. Slepian-Bangs formula.</li><li>- Best Linear Unbiased Estimator (BLUE) and Maximum Likelihood Estimator (MLE): definition, properties, and examples.</li></ul>
Part 2: Detection Theory	<ul style="list-style-type: none"><li>- Hypothesis tests: types. Performance metrics: false positives and false negatives. ROC curves.</li><li>- Neyman-Pearson theorem: likelihood ratio.</li><li>- Detection under the Bayesian philosophy: probability of error, risk, optimum detector.</li><li>- Examples: deterministic and random signals</li></ul>

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	21	23	44
Practices through ICT	7	0	7
Autonomous problem solving	0	28	28
Simulation	0	25	25
Project	0	21	21

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

<b>Methodologies</b>	
	Description
Lecturing	Presentation of main topics, possibly with audiovisual aids. Skills involved: CG4, CG8
Practices through ICT	Computer-based simulation in the lab of statistical signal processing applications to communications and multimedia, via Monte Carlo methods. Performance analysis. Skills involved: CG8, CE23
Autonomous problem solving	Students will be given a series of short homework assignments throughout the course that they should turn in by the set deadline. Skills involved: CG4, CG8, CE23
Simulation	Computer-based simulation of statistical signal processing applications to communications and multimedia, via Monte Carlo methods. Performance analysis. Skills involved: CG8, CE23

<b>Personalized assistance</b>	
<b>Methodologies</b>	<b>Description</b>
Lecturing	Student aid will be provided during office hours by appointment, as well as on-line (email).
Practices through ICT	Student aid will be provided during lab hours and office hours by appointment, as well as on-line (email).

<b>Assessment</b>			
	Description	Qualification	Evaluated Competences
Autonomous problem solving	Students will be given a series of short homework assignments throughout the course that they should turn in by the set deadline.	40	CG4 CG8 CE23
Project	Development of an individual final project in which students will apply the acquired tools and techniques to a practical problem.	60	CG4 CG8 CE23

### **Other comments on the Evaluation**

Students may choose one of the following two assessment options:

1) Continuous assessment: Final grade will consist of:

- final project (up to 6 points)
- homework assignments (up to 4 points)

A minimum grade of 30% in the final project is required in order to pass the course. Otherwise, the overall grade will directly be that of the final project.

Homework grades from the first call will be kept for the second call, in which the student will be allowed to resubmit the final project. Students assume continuous assessment with the submission of any homework assignment.

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

### **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**

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

T. K. Moon, W. C. Stirling, **Mathematical Methods and Algorithms for Signal Processing**, 1, Pearson, 1999

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**

Advanced Digital Communications/V05M145V01204

Signal Processing in Communications/V05M145V01102

### **Contingency plan**

## Description

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### === EXCEPTIONAL PLANNING ===

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

### === ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

All of them

\* Teaching methodologies modified

None of them

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

Videoconferencing

\* Modifications (if applicable) of the contents

N/A

\* Additional bibliography to facilitate self-learning

N/A

\* Other modifications

N/A

### === ADAPTATION OF THE TESTS ===

There are no modifications of the assessment mechanisms, or the corresponding weights

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**IDENTIFYING DATA**

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**Numerical Optimisation in Telecommunications**

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Subject Numerical  
Optimisation in  
Telecommunications

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Code V05M145V01304

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Study Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

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Teaching  
language

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Department

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Coordinator

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Lecturers

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E-mail

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

**IDENTIFYING DATA****Mathematical Modelling and Numerical Simulation**

Subject	Mathematical Modelling and Numerical Simulation			
Code	V05M145V01305			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language				
Department				
Coordinator				
Lecturers				
E-mail				

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

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**IDENTIFYING DATA**

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**Data Protection Cryptographic Techniques**

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Subject Data Protection  
Cryptographic  
Techniques

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Code V05M145V01306

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Study Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

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Teaching  
language

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Department

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Coordinator

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Lecturers

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E-mail

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

**IDENTIFYING DATA****Machine Learning**

Subject Machine Learning

Code V05M145V01307

Study programme Telecommunication Engineering

Descriptors ECTS Credits

5

Type

Optional

Year

2nd

Quadmester

1st

Teaching language

Department

Coordinator

Lecturers

E-mail

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

**IDENTIFYING DATA****Administration of Networks and Systems**

Subject	Administration of Networks and Systems			
Code	V05M145V01308			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language				
Department				
Coordinator				
Lecturers				
E-mail				

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

**IDENTIFYING DATA****Web Development Technologies**

Subject	Web Development Technologies			
Code	V05M145V01309			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	López Nores, Martín			
Lecturers	López Nores, Martín			
E-mail	mlnores@det.uvigo.es			
Web	http://fatic.uvigo.es			
General description	Description of the most current techniques applications for the development of Web applications. The course will tech the students to develop multiplatform applications based on the HTML5 foundation.			

**Competencies**

Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG12CG12	Skills for lifelong, self-directed and autonomous learning.
CE35 CE50/OP20	Ability to deploy and manage server software application logic of a web service managers, to design and manage non-relational data bases , and understand the functional division of an existing Web application between the client and the server itself

**Learning outcomes**

Learning outcomes	Competences
The students will be able to design, develop and manage the whole infrastructure of a web application.	CB1
Besides, they will be able to develop the application logic and to create responsive user interfaces using web technologies.	CB5 CG12 CE35

**Contents**

Topic	
The current ecosystem of web development	Introduction to HTML5, CSS3 and Javascript.  Architectures of web and mobile applications.  Concepts and frameworks of multi-platform development.
Markup with HTML5 and Angular	Structural elements of an application.  Semantic markup.  Forms.  Programming interfaces.  Data binding and structural directives.
Presentation with CSS3 and SaaS	The box model.  Adaptable design.  Selectors.  Extensions of the SaaS metalanguage.

Application logic with Javascript and TypeScript Evolution of scripting languages for the web.

CRUD applications and REST interfaces.

Objects and arrays in Javascript.

Processing of JSON and XML content.

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	9	18	27
Problem solving	5	14	19
Project based learning	11	66	77
Essay questions exam	2	0	2

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

## Methodologies

	Description
Lecturing	Presentation of the main concepts and technologies, predominantly through practical examples of use. It will work mainly the competency CE35.
Problem solving	Practices of the concepts presented in the lectures. It will work the CB5 and CE35 competencies.
Project based learning	Development in group of a practical project, consisting in a functional version of a web service that incorporates the main mechanisms presented in the course. It will work the CB5 and CE35 competencies.

## Personalized assistance

### Methodologies Description

Lecturing	During the tutoring hours, the professors will deliver personalised attention, to guide the student in the understanding of the theoretical concepts explained in the lecturing sessions or in the practical ones. In these hours, the professors will also follow up on the work linked to the practical project. In the group tutoring hours, the professors will conduct the debate on the solutions proposed by the members of the working groups, and also check the uniform participation of the members in the final development.
Problem solving	During the tutoring hours, the professors will deliver personalised attention, to guide the student in the understanding of the theoretical concepts explained in the lecturing sessions or in the practical ones. In these hours, the professors will also follow up on the work linked to the practical project. In the group tutoring hours, the professors will conduct the debate on the solutions proposed by the members of the working groups, and also check the uniform participation of the members in the final development.

## Assessment

	Description	Qualification	Evaluated Competences		
Project based learning	Practical project.	70	CB1 CB5	CE35	
Essay questions exam	Final exam.	30	CB5	CG12	CE35

## Other comments on the Evaluation

### Continuous Assessment:

To opt to continuous assessment, it is necessary to attend 80% of the practical lab sessions and make the corresponding deliveries, and also to make the partial deliveries requested for the group development project.

Each one of the deliveries will be evaluated separately. The final practical mark will be the result of averaging the mark obtained in the last delivery of the development project (70%) and the arithmetical average of the previous deliveries (30%). All the marks associated to the work done in group will be shared by all of its members.

The final mark will be the obtained by averaging the practical mark (70%) and the mark obtained in the exam (30%).

### One-step Assessment:

The student who prefers one-step assessment must tell the professor before the date of the first partial delivery of the development project. In this case, his/her partial deliveries will not be taken into account for his/her mark, but they will for the marks of the other group members who opt to continuous assessment. The final mark will be calculated by averaging the mark obtained in the final delivery of the project (70%) and that of the final examination (30%).

## Second Opportunity:

In the second opportunity, the students have to deliver (individually) a set of modifications to the project developed during the course. In the case of the students of one-step assessment, this delivery will account for 70% of the final mark, and the remaining 30% will correspond to the final exam.

For the students who chose continuous assessment, the practical note will be the maximum between (i) the weighted average of the marks of new delivery (70%) and the marks of the partial deliveries (30%) and (ii) the mark corresponding only to the new delivery.

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### Sources of information

#### Basic Bibliography

Mark Pilgrim, **HTML5: Up and Running**, 1ª, O'Reilly, 2010

Wesley Hales, **HTML5 and JavaScript Web Apps**, 1ª, O'Reilly, 2012

Chris Griffith, **Mobile App Development with Ionic, Revised Edition**, 1ª, revisada, O'Reilly, 2017

<https://developer.mozilla.org/en/docs/Web>, **Web technology for developers**,

#### Complementary Bibliography

Peter Gasston, **The book of CSS3**, 2ª, No Starch Press, 2014

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### Recommendations

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### Contingency plan

#### Description

=== EXCEPTIONAL MEASURES SCHEDULED ===

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

=== ADAPTATION OF METHODOLOGIES ===

All the teaching methodologies will be kept, although they will be implemented through telematic tools, without modifications of the course contents. The tutoring hours will also take place by videoconference.

=== ADAPTATION OF THE EVALUATION ===

No modifications; all the demonstrations, proofs and code reviews will take place through videoconference.

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## IDENTIFYING DATA

### Mobile Applications Development

Subject	Mobile Applications Development			
Code	V05M145V01310			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Costa Montenegro, Enrique			
Lecturers	Costa Montenegro, Enrique Gil Castiñeira, Felipe José López Bravo, Cristina			
E-mail	kike@gti.uvigo.es			
Web	http://fatic.uvigo.es			
General description	The course "Development of Mobile Applications" shows an overview of the ubiquitous panorama, in particular of the mobile applications and of the different operating systems in which they run.			

Mobile applications market has big growth expectations due to the huge number of active mobile devices around the world (several millions), the deployment of smart cities or the evolution of the Internet to the Internet of Everything (people, processes, data and objects).

Along the course, an example mobile application (a game) will be developed, through which the different characteristic and functionalities of the Android platform will be introduced: user interfaces, activities, services, context integration, data sharing and security.

Besides, those who join the course have to develop their own project, which should include all the phases of development of a mobile application, from the initial design to the publication in online software shops such as Google Play.

The documentation of the course will be available in English. The master sessions, the laboratory practises and the follow-up of the tutored works will be in English, as well.

## Competencies

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE33CE46/OP16	Ability to understand the current development of mobile and ubiquitous services and market developments
CE34CE47/OP17	Ability to design, create, integrate sources of context, and working group on the development of a mobile application

## Learning outcomes

Learning outcomes	Competences
Acquire an overview of the ubiquitous panorama, in particular of the mobile applications and of the different operating systems in which they run.	CE33
Learn how to build mobile applications including different elements (interaction with the user, context integration, interconnection with other devices, notifications, ...)	CB2 CB5 CG8 CE34
Work in group to propose, build and defend a mobile application.	CB2 CB5 CG8 CE33 CE34

## Contents

Topic

Mobile Operating Systems	<ul style="list-style-type: none"> <li>- Overview of the leading operating systems for mobile devices (Android, IOS, Windows Phone).</li> <li>- Versions.</li> <li>- Market evolution.</li> </ul>
Android Operating System	<ul style="list-style-type: none"> <li>- Android architecture.</li> <li>- Components of an Android application: activities, services, content providers and broadcast receivers.</li> <li>- Applications life cycle.</li> </ul>
Mobile applications in the market	<ul style="list-style-type: none"> <li>- Planning the development of an application.</li> <li>- Publication of applications.</li> <li>- Description of mobile applications available in the market.</li> </ul>
Building Android applications	<ul style="list-style-type: none"> <li>- Android Studio SDK</li> <li>- Android emulator</li> <li>- Activities, actions and intents</li> <li>- Services and notifications</li> <li>- Menus, preferences and dialogs</li> <li>- User interfaces with views</li> <li>- Fragments</li> <li>- Concurrency</li> <li>- Permissions</li> <li>- Data persistence</li> <li>- Context integration: localization, sensors</li> <li>- Interconnection: bluetooth, wifi</li> </ul>

### Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	4	4	8
Laboratory practical	12	36	48
Mentored work	4.5	49.5	54
Presentation	0.5	0.5	1
Objective questions exam	1	1	2
Laboratory practice	3	9	12

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

### Methodologies

	Description
Lecturing	The professors of the course present the main theoretical contents related to the development of applications for mobile devices. Through this methodology the competency CE33 (CE46/OP16) is developed.
Laboratory practical	Students will complete guided and supervised practices about the basic aspects of Android mobile applications. Through this methodology the competencies CB2, CG8, CE33 (CE46/OP16) and CE34(CE7/OP17) are developed.
Mentored work	In groups, design, development and test of a mobile application. Students and professors will have regular meetings to check the correct evolution of the tutored works. Through this methodology the competencies CB2, CB5, CG8, CE33 (CE46/OP16) and CE34(CE7/OP17) are developed.
Presentation	Presentation and defense of the mobile application that has been developed throughout the course. Through this methodology the competencies CG8, CE33 (CE46/OP16) and CE34(CE7/OP17) are developed.

### 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 face-to-face or online (during the master session itself or during the tutoring hours). The tutoring hours will be agreed with the students by appointment. The tutoring sessions may be carried out by telematic means (email, videoconference, FAITIC forums, ...) under the modality of prior agreement.
Laboratory practical	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered face-to-face or online (during the lab session itself or during the tutoring hours). The tutoring hours will be agreed with the students by appointment. The tutoring sessions may be carried out by telematic means (email, videoconference, FAITIC forums, ...) under the modality of prior agreement.

Mentored work	The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Questions will be answered face-to-face or online (during the supervising session itself or during the tutoring hours). The tutoring hours will be agreed with the students by appointment. The tutoring sessions may be carried out by telematic means (email, videoconference, FAITIC forums, ...) under the modality of prior agreement.
Presentation	The professors of the course will guide the students during the preparation of the presentation of the results of the guided work, mostly during the last sessions of the supervising sessions or during tutorial sessions.

<b>Assessment</b>					
	Description	Qualification	Evaluated Competences		
Mentored work	Whenever possible, the students will be divided in groups, to design, build and test an application for mobile devices. The result will be evaluated after the delivery, taking into account key aspects such as correction, quality, performance and functionalities of the developed application. Likewise, during the development of the project, professors will make a continuous follow-up of the design and the evolution of the implementation, which may include intermediate assessment tests.	45	CB2 CB5	CG8	CE33 CE34
Presentation	At the end of the course, each group of students has to present and defend in English the developed application for mobile devices. The defence has to include a practical demonstration of the use of the application.	10		CG8	CE33 CE34
Objective questions exam	After each master session, students will make a multiple choice test (in English) to evaluate the understanding of the presented topics.	20			CE33
Laboratory practice	In each practice session students will demonstrate the proper functioning of the developments carried out during the session.	25	CB2	CG8	CE33 CE34

### **Other comments on the Evaluation**

#### **FIRST CALL**

Following the guidelines of the degree, two evaluation systems will be offered to students attending this course: continuous evaluation and single evaluation. Before the end of the second week of the course, students must declare if they opt for the continuous evaluation or the single evaluation. Those who opt for the continuous evaluation system may not be listed as "not presented" if they make a delivery or an assessment test after the communication of their decision.

#### **Continuous evaluation system**

Those students who opt for continuous evaluation system must:

- Take a set of tests with multiple choice questions. These partial tests will be done at the end of each master session. These tests will account for 20 % of the overall grade of the course.
- Take a set of practical tests in the laboratory. These tests will be performed at the end of each practice session. These tests will account for 25 % of the overall grade of the course.
- Design, build and defend a mobile application (tutored work). This task will account for 55 % of the overall grade of the course. A 10 % is reserved for the presentation and defence of the developed mobile application. Though this task will be developed in groups (whenever possible), professors will make a continuous follow-up of the activities performed by each student of a group. If the performance of a student is not in line with the rest of his/her teammates, his/her expulsion of the group might be considered, or he or she might be assessed individually.

The final grade of the course will be equal to the weighted arithmetic mean of the three indicated tasks. To pass the course the final grade must be greater or equal to five.

#### **Single evaluation system**

Those students who opt for the single evaluation system must:

- Take a final test with short answer or multiple choice questions (a 20 % of the overall grade of the course).
- Make and demonstrate the proper functioning of the practices in the laboratory (a 25 % of the overall grade of the course).
- Design, build and defend a mobile application (tutored work), individually or if it is possible in groups (a 55 % of the overall grade of the course, with a 10 % reserved for the presentation and defence of the developed mobile application).
- Deliver a *dossier* that includes all the details about the development of the practices in the laboratory and, especially, about the tutored work.

The final grade of the course will be equal to the weighted arithmetic mean of the three indicated tasks, if the *dossier* is delivered, or zero otherwise. To pass the course the final grade must be greater or equal to five.

## SECOND CALL

The course final exam will only be held for students who failed the course in the first call.

The assessment will consist in doing one, two or three of the following tasks, depending on the marks achieved in the equivalent tasks during the first opportunity:

- Make a final test with short answers or multiple choice questions (a 20 % of the overall grade of the course).
- Make and demonstrate the proper functioning of the practices in the laboratory (a 25 % of the overall grade of the course).
- Design, build and defend a mobile application (tutored work), individually or if it is possible in groups (a 55 % of the overall grade of the course, with a 10 % reserved for the presentation and defence of the developed mobile application).
- In addition, those who opt for the final assessment system should deliver a *dossier* that includes all the details about the development of the practices in the laboratory and, especially, about the tutored work.

If the mark of any of the tasks in the first opportunity, equivalent to these, is greater or equal to five, the student can choose between keeping his/her marks of the first opportunity or repeating the assessments again.

## OTHER COMMENTS

- The obtained grades are only valid for the current academic year.
- Although the tutored work will be completed (if possible) in groups, the performance of each student in his or her group will be monitored continuously. In the case in which the performance of a member of the group wouldn't be adequate compared with the performance of his or her team mates, he or she could be excluded from the group and/or qualified individually. This criteria will be also apply to the presentation of the developed application.
- The use of any material during the tests will have to be explicitly authorized.
- In case of detection of plagiarism in any of the tasks/tests done, the final grade will be "failed (0)" and the professors will communicate the incident to the head of the school to take the measures that they consider appropriate.

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## Sources of information

### Basic Bibliography

Joshua J. Drake, **Android hackers's handbook**, 1ª,

Wei-Meng Lee, **Beginning Android 4 Application Deveolment**, 1ª,

Jesús Tomás Gironés, **El gran libro de Android**, 5ª,

### Complementary Bibliography

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## Recommendations

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## Other comments

It is recommended to have Java programming skills

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## Contingency plan

### Description

Tutoring sessions:

Tutoring sessions may be carried out online: either asynchronously (e-mail, FAITIC forums, etc.) or by videoconference, in this case by appointment.

Elearning platforms/tools

Online tuition will be supported by Campus Remoto and FAITIC. Other supplementary platforms may be used to guarantee the accessibility to teaching content.

Classes and assessment

In the case that the teaching is exclusively non-face-to-face, the classes of the subject and its evaluation will be developed in

a similar way, but using the platforms provided by the University.

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**IDENTIFYING DATA****Satellites**

Subject	Satellites			
Code	V05M145V01311			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Aguado Agelet, Fernando Antonio			
Lecturers	Aguado Agelet, Fernando Antonio Pérez Fontán, Fernando			
E-mail	faguado@tsc.uvigo.es			
Web	http://fatic.uvigo.es			
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.			

**Competencies**

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CG3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
CG7	CG7 Capacity for implementation and management of manufacturing processes of electronic and telecommunications equipment; guaranteeing safety for persons and property, the final quality of the products, and their homologation.
CE18	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.

**Learning outcomes**

Learning outcomes	Competences
To know and apply ECSS management space project standards.	CE18
To know the basics of the system engineering applied to space projects.	CB2 CG3 CE18
To know the mission life cycle of a space mission.	CB2 CE18
To know the documentation generated in each engineering phase in a space mission	CB2 CG3 CE18
To know and elaborate the main technical studies and budgets in a space mission.	CG3 CG7 CE18
To know applicable methodologies and standards to product assurance (PA) and Assembly, Integration and Verification (AIV) procedures in a space project.	CB2 CG3 CE18
To know the basics of satellite operation procedures and standards	CE18

**Contents**

Topic	
International space project standards	ECSS, NASA, INCOSE.
Space project life cycle	Documentation and reviews.
Segments of a satellite project	- Space Segment. - Ground Segment. - User Segment. - Launchers.
Satellite subsystems	- Communication. - Mechanical & Thermal. - Power. - ADCS. - Propulsion. - On-board computer.

Product Assurance and Assembly, Integration and Verification Procedures in a space project.	- Product Assurance (PA) in space projects. - Assembly, Integration and Verifications (AIV) plans and procedures in space projects.
Introduction to satellite operations	- Telemetry and Telecommand definition. - Operation procedures.

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	13	39	52
Mentored work	6	18	24
Seminars	10	20	30
Problem and/or exercise solving	1	18	19

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

## Methodologies

	Description
Lecturing	The different aspects of the subject are described, including the possibility of using the flipped learning methodology  With this methodology CB2, CG3 and CE18 competencies are covered.
Mentored work	Each student will apply the theoretical knowledge to evaluate the technical feasibility of a small satellite project proposed by the student.  With this methodology CB2, CG3 and CE18 competences are covered.
Seminars	Each student will apply the theoretical knowledge to different practical tasks that cover the main part of the contents of the subject with the help of specific software.  With this methodology CB2, CG7 and CE18 competences are worked.

## Personalized assistance

### Methodologies Description

Lecturing	The students will have the opportunity to attend tutorial hours with the university lecturers in the schedule that will be established and published in the subject web-page. They may also send their queries by email.
Seminars	The students will have the opportunity to attend tutorial hours with the university lecturers in the schedule that will be established and published in the subject web-page. They may also send their queries by email.
Mentored work	The students will have the opportunity to attend tutorial hours with the university lecturers in the schedule that will be established and published in the subject web-page. They may also send their queries by email.

## Assessment

	Description	Qualification	Evaluated Competences		
Mentored work	The students will write 2 intermediate reports and a final report including the results obtained to justify the technical feasibility of the proposed small satellite mission.  The evaluation will be based on the students' assistance to the master lessons, his or her participation on the seminars as well as the presented reports and oral presentations showing the obtained results.	45	CB2	CG3	CE18
Seminars	The students will perform simulations using specific software.  The evaluation will be based on the students' assistance to the seminars, his or her participation on the seminars and a final report.	35	CB2		CE18
Problem and/or exercise solving	A final test to complement the evaluation of the contents presented in the master sessions.  The test will be individual with time limit.	20			CE18

## Other comments on the Evaluation

In case of detection of plagiarism in some of the works or tests, the final qualification of the subject will be "suspended (0)" and the lecturers will communicate to the direction of the School the matter in order to take the measures it deems appropriate.

**At the beginning of the term, the student will choose the assessment methodology for the first call: single evaluation or continuous evaluation. The second call will be always assessed by single evaluation.**

**The teaching language will be English.**

**Both, documentation and presentations of this subject will be exclusively in English.**

**English shall be used for writing the reports to evaluate the laboratory practices and the tutored works.**

**The students can use English, Spanish or Galego to respond the final short answer test.**

### **First call**

The subject will be evaluated through one of the following mechanisms:

#### **Single evaluation:**

- The exam will include questions, numerical problems and/or development of simulations, related with the contents presented in master sessions, seminars and tutored works. It will be necessary to obtain 5 points over 10 to pass the exam.

**Continuous evaluation.** The subject will be assessed throughout the entire term:

- **Seminars:** each student will have to perform different tasks with a total weight of 35% of the final mark.
- **Tutored works:** each student will participate in different tutored works proposed during the lecture period. This part will be evaluated by written reports as well as oral presentatios. This activity will have a total weight of 45% of the final mark.
- **Short answer test:** This exam will be the final assessment of the continuous evaluation, and it will have a total weight of 25% of the final mark.

**Second call:** the student will have to take an exam which will include questions and/or numerical problems related with the contents presented in the master sessions, seminars and the tutored works (100% of the final mark). Those students following the continuous evaluation, during the first call, can optionally take this exam for the 65% of the final grade.

**All the different grades are only valid for the current course, and will expire after the second call in case someone needs to take the course again.**

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### **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>,

#### **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,

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### **Recommendations**



## Subjects that it is recommended to have taken before

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Analog Electronic Circuits Design/V05M145V01106

Wireless and Mobile Communications/V05M145V01313

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## Contingency plan

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### Description

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=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

Synchronous classes at the same time slots than the in-class teaching activities, supported by Campus Remoto and FAITIC. Other supplementary platforms may be used to guarantee the accessibility to teaching content.

\* Teaching methodologies modified

In the case of a lockdown, more extensive use of a flipped learning methodology will be used, uploading to faitic support multimedia resources for selected lessons, including recorded video classes, podcast, quizzes as well as weekly activities to be completed by the students.

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

Tutoring sessions may be carried out online: either asynchronously (e-mail, FAITIC forums, etc.) or by videoconference, in this case by appointment

\* Modifications (if applicable) of the contents

The contents will be maintained in case of a health alert.

\* Additional bibliography to facilitate self-learning

- 1.- Documentation for the audio opensource software Audacity: <https://manual.audacityteam.org>
- 2.- Documentation for the multimedia (video and audio) software OBS: <https://obsproject.com/wiki/>
- 3.- Documentation for python: <https://www.python.org/doc/>
- 4.- How to install a virtual machine using VirtualBox: <https://www.virtualbox.org/wiki/Documentation>
- 5.- GNURadio documentation: <https://www.gnuradio.org/docs/>

\* Other modifications

No further modifications are expected since for the development of the activities for the mentoring work and seminars; the students will be used open-source or licensed software by UVIGO.

=== ADAPTATION OF THE TESTS ===

\* Tests already carried out

Since the number of expected students in the subject is reduced, all the assessment will follow the same methodology than in case of in-class teaching activities. Only a final test is scheduled.

Final Test: [Previous Weight 20%] [Proposed Weight 20%]

\* Pending tests that are maintained

Final Test: [Previous Weight 20%] [Proposed Weight 20%]

\* Tests that are modified

No modifications of the tests are contemplated.

\* New tests

No modifications of the tests are contemplated.

\* Additional Information

In case of a lockdown, the students will present the results of the project reports (2 intermediate and a final), using a videoconference system.

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**IDENTIFYING DATA****Wideband Radio Systems**

Subject	Wideband Radio Systems			
Code	V05M145V01312			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	García Sánchez, Manuel			
Lecturers	García Sánchez, Manuel Santalla del Río, María Verónica			
E-mail	manuel.garciasanchez@uvigo.es			
Web	<a href="http://www.faitic.uvigo.es">http://www.faitic.uvigo.es</a>			
General description	Wideband radio systems.			

**Competencies**

Code	CE19CE19/RAD2
	Ability to perform theoretical design, experimental band systems measurement and practical implementation broadband for current applications

**Learning outcomes**

Learning outcomes	Competences
Theoretical and experimental knowledge of wideband systems	CE19
Knowledge of designs of wideband active and passive elements	CE19
Fundamentals of wideband signal generation and reception	CE19
Fundamentals of wideband signal measurement	CE19

**Contents**

Topic	
Introduction	Definitions and basic concepts Communication 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
Seminars	2	6	8
Laboratory practical	20	60	80
Flipped Learning	6	18	24
Problem and/or exercise solving	1	5	6
Laboratory practice	1	6	7

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

### Methodologies

	Description
Seminars	Activities designed to work on a specific topic , which allow deepen or complement the contents of the subject.
Laboratory practical	Building and testing wideband radio channel sounders
Flipped Learning	Theoretical foundations of wideband systems

### Personalized assistance

Methodologies	Description
Laboratory practical	The students could ask questions during classes, during sheduled hours for the professors to atend the students or by email.
Flipped Learning	The students could ask questions during classes, during sheduled hours for the professors to atend the students or by email.

### Assessment

	Description	Qualification	Evaluated Competences
Laboratory practical	Practice written and oral reports.	40	CE19
Flipped Learning	Exam	60	CE19

### Other comments on the Evaluation

First call: We offer the students two schemes of assessment: continuous assessment and final assessment. The students will have to opt by one of the two schemes before a given date.

Second call: just final exam.

**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.**

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**Sources of information**

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**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

David D. Wentzloff,, **System Design Considerations for Ultra-Wideband Communication**, 2005

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**Recommendations**

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**Contingency plan**

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**Description**

If due to exceptional circumstances the experimental part of the laboratory practices is not carried out, then the learning outcome "Theoretical and experimental knowledge of wideband systems" should be changed to "Theoretical knowledge of wideband systems"

No other changes will be needed under exceptional circumstances

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**IDENTIFYING DATA****Wireless and Mobile Communications**

Subject	Wireless and Mobile Communications			
Code	V05M145V01313			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	English			
Department				
Coordinator	Vazquez Alejos, Ana			
Lecturers	Pérez Fontán, Fernando Vazquez Alejos, Ana			
E-mail	ana.vazquez.alejos@gmail.com			
Web	http://http://faitic.uvigo.es			
General description	This subject introduces the student in the technology of the main present mobile and wireless communication systems, with training in analysis of coverage and quality planning at radio interface level.			

**Competencies**

Code	CE20CE20/RAD3
	Ability to analyse and specify the basic parameters of a mobile or wireless radio network, as well as of quality of service.

**Learning outcomes**

Learning outcomes	Competences
Ability to compute the coverage and capacity of a mobile communications site and estimate the cellular radius.	CE20
Dimensioning and capacity planning of mobile and wireless systems.	CE20
Ability to carry out a mobile network deployment planning.	CE20
Ability to select the radio technology most appropriate to a given application.	CE20

**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. Review of the standards of current cellular systems.	3.1. Introduction to mobile phone systems 1G and 2G. 3.2. 3G mobile phone systems: CDMA, UMTS, 3G. 3.3. 4G mobile phone systems: LTE. 3.4. Next Generation mobile phone systems: 5G and B5G.
Unit 4. Review of the standards of current wireless systems.	4.1. Introduction to wireless systems and services WLAN, sensor networks, vehicular communications, Internet of Things (IoT). 4.2. Design fundamentals: radio propagation channel modeling, dimensioning and quality of service. 4.3. Other wireless systems: DECT, TETRA.

**Planning**

	Class hours	Hours outside the classroom	Total hours
Lecturing	10	30	40
Case studies	3	3	6
Problem solving	4	6	10
Practices through ICT	5	5	10
Mentored work	10	10	20
Autonomous problem solving	0	10	10
Problem and/or exercise solving	3	3	6
Self-assessment	0	10	10
Essay	0	3	3
Laboratory practice	0	10	10

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

<b>Methodologies</b>	
	Description
Lecturing	Presentation of the theoretical contents of the subject by teachers.
Case studies	Conducting case studies in laboratory with delivery of a memory/report to be assessed.
Problem solving	Theoretical contents taught in the master lessons will be complemented with the resolution of problems and/or exercises during class time.
Practices through ICT	During the master lessons, practical cases will be realized with delivery of evaluable result at the end of the session.
Mentored work	In group C classes, the development of two works will be proposed that covers any of the subjects considered in master lessons and practices.
Autonomous problem solving	Solving by the student of problems related with the subject applied to specific cases. The student must develop the analysis and resolution of the problems in an autonomous form. These exercises are proposed weekly in attendance hours and they are guided by the professor on the resolution.

### **Personalized assistance**

<b>Methodologies</b>	<b>Description</b>
Lecturing	Time scheduled by professors to attend and resolve doubts of the students.
Autonomous problem solving	Time that the lecturer of group A will use to attend the students that need some support in doing their autonomous work.
Case studies	Time scheduled to help the students in preparing their work.
Problem solving	Time that the lecturer can use to help the students in preparing their work.
Practices through ICT	Time devoted to attend and resolve doubts of the students in the resolution of the proposed practices.
Mentored work	Time devoted to attend and resolve doubts of the students in the realization of the tasks proposed in the C group class.
<b>Tests</b>	<b>Description</b>
Problem and/or exercise solving	Time that the lecturer can use to help the students in preparing their tests.
Self-assessment	Time that the lecturer can use to help the students in preparing their tests.
Essay	Time devoted to attend and resolve doubts of the students in preparing the memory of the tutored work.
Laboratory practice	Time devoted to attend and resolve doubts of the students in preparing the memory of the laboratory practices.

### **Assessment**

	Description	Qualification	Evaluated Competences
Autonomous problem solving	It will evaluate the resolution of problems delivered to each student for troubleshooting in an autonomous form.	10	CE20
Problem and/or exercise solving	Final examination consists of a multiple choice test for assessing the skills acquired by students by solving simple problems and questions of theory. This test includes closed questions with different alternative of answer. Students select an answer from a limited number of possibilities.	35	CE20
Self-assessment	Multiple choice questions tests for each unit of the subject content. The questionnaires are performed through Fatic platform that shows the results after completing each test. Students perform the tests in an autonomous form, and indications are given during attendance and office hours.	10	CE20
Essay	Tutored works performed in group C classes will be evaluated by means of the realization of an individual report by each student.	15	CE20
Laboratory practice	For each lab practice (case studies / analysis of situations) an individual report of results must be presented for assessment.	30	CE20

### **Other comments on the Evaluation**

Students enrolled in the subject can choose one of the two proposed assessment systems: continuous assessment or exam-only assessment. The student must communicate the selected evaluation to the teacher during the first session of type A classes.

#### **Continuous assessment (first call)**

Continuous assessment involves performing throughout the semester of the paragraphs disaggregated in the above table.

Each of the blocks is of mandatory fulfillment in the form of continuous and individual assessment, and to pass the subject a minimum of 1/3 of the note assigned to each of the sections and the total mark accumulated within the five sections to be achieved must overcome at least 50% of the final grade.

The short answer test is multiple choice and is done the day indicated in the official exam schedule. Regarding the block of laboratory practices, one report is required per practice and per student, made in a individual way. Evidences of report copying or cloning will drive to fail the related task.

Continuous assessment involves making 100% of all proposed tasks: active participation in the sessions of classroom and laboratory practices, autonomous work as solving exercises and online/in-class self-assessment tests (questionnaires), C-classes works, as well as performing the final short answer test.

These tasks are not recoverable, that is, if a student does not satisfy the scheduled tasks, the teacher has no obligation to repeat any of them, and also they will be only valid for the academic year in which they are completed.

The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Máster (CAM) and will be available at the beginning of each academic semester.

It is considered that the subject is passed if the total grade is equal to or greater than 5. In case of leaving the modality of continuous assessment, the final grade will be "no presentado".

### **Exam-only assessment (first call)**

A student who does not opt for continuous assessment should be eligible for the highest grade by a final exam, which will consist of three parts:

- Part 1: realization of laboratory practices and delivery of reports due (30% of the final grade). One report is required per practice and per student, made in a individual way. Evidences of report copying or cloning will drive to grade as zero the related practice.
- Part 2: test exam (50% of the final grade).
- Part 3: troubleshooting (20% of the final grade).

It is considered that the subject is passed by eventual assessment if the total grade is equal to or greater than 5.

### **Second call evaluation**

For students who followed the continuous assessment, those ones who want to retain the mark obtained in the first part of the continuous assessment (70%) may choose to perform only the test (30%) provided they have exceeded the minimum requirement in each block .

For students who chose the exam-only assessment, the grade will be given by a final exam that will consist of three parts: a practical examination (pass /non-pass) (20%), a standard test exam (40%) and an examination of problems (40%) .

It is considered that the subject is approved in second call if the total grade is equal to or greater than 5.

### **End-of-program call**

It will consist of an exam with three parts: a practical examination (pass /non-pass)(20%), a standard test exam (40%) and an examination of problems (40%). It is considered that the subject is approved if the total grade is equal to or greater than 5.

### **Ethical code and plagiarism**

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.

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### **Sources of information**

#### **Basic Bibliography**

Ana Vazquez Alejos, **Lecture Notes and Powerpoint Slides**, 2017,

Oriol Sallent, **Fundamentos de diseño y gestión de sistemas de comunicaciones móviles celulares**, 2014,

#### **Complementary Bibliography**

Jose María Hernando Rábanos, **Comunicaciones Móviles**, 2004,

M<sup>a</sup> Teresa Jiménez Moya, Juan Reig Pascual, Lorenzo Rubio Arjona, **Problemas de comunicaciones móviles**, 2006,



José Manuel Huidobro Moya, **Comunicaciones móviles : sistemas GSM, UMTS Y LTE**, 2012,  
Martin Sauter, **From GSM to LTE: An Introduction to Mobile Networks and Mobile Broadband**, 2011,  
Maciej Stasiak et al., **Modelling and Dimensioning of Mobile Wireless Networks: From GSM to LTE**, 2010,  
W. Dargie, C. Poellabauer, **Fundamentals of Wireless Sensor Networks: Theory and Practice**, 2010,

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### **Recommendations**

#### **Subjects that continue the syllabus**

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

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#### **Subjects that are recommended to be taken simultaneously**

Wideband Radio Systems/V05M145V01312

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#### **Subjects that it is recommended to have taken before**

Radio Laboratory/V05M145V01209  
Radiocommunication/V05M145V01103

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### **Contingency plan**

#### **Description**

In case of online tuition, then the planning will be as follows: classes will be scheduled (group A, B and C) at the same time via the Remote Campus of the University of Vigo. These classes will be broadcast online and recorded to be viewed later in asynchronous mode. The necessary materials will preferably be available on the course platform at Faitic.

In addition, the evaluation will be carried out as follows: problem solving, laboratory practices (software), self-assessment, mentored work and evaluation tests will be arranged in a format for remote resolution by the students, without it being necessary modifying its normal operation.

The test calendar and the weight of the tests in the total evaluation will be maintained.

The tutoring hours will be maintained, but they will take place in the virtual classroom of the teaching staff at the Remote Campus of the University of Vigo. To access, the appropriate indications will be given.

If necessary, tutoring will be enabled through email and videoconference.

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**IDENTIFYING DATA****Radio Navigation**

Subject Radio Navigation

Code V05M145V01314

Study programme Telecommunication Engineering

Descriptors ECTS Credits

5

Type

Optional

Year

2nd

Quadmester

1st

Teaching language

Department

Coordinator

Lecturers

E-mail

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

**IDENTIFYING DATA****Optical Networks**

Subject Optical Networks

Code V05M145V01315

Study Telecommunication

programme Engineering

Descriptors ECTS Credits

5

Type

Optional

Year

2nd

Quadmester

1st

Teaching

language

Department

Coordinator

Lecturers

E-mail

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

**IDENTIFYING DATA****Radar**

Subject Radar

Code V05M145V01316

Study programme Telecommunication Engineering

Descriptors ECTS Credits

5

Type

Optional

Year

2nd

Quadmester

1st

Teaching language

Department

Coordinator

Lecturers

E-mail

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

**IDENTIFYING DATA****Microwave and Millimetre Wave Circuit Design and CAD**

Subject	Microwave and Millimetre Wave Circuit Design and CAD			
Code	V05M145V01317			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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	<a href="http://faitic.uvigo.es">http://faitic.uvigo.es</a>			
General description	<p>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.</p>			

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. 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.

The subject will be taught fully in english, both in oral and written communications with the students, and in provided technical documents and reports.

**Competencies**

Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE32CE38/OP8	Ability to design, manufacture (in hybrid technology) and characterize the analog components of transceivers of communications in microwave and millimeter-wave bands

**Learning outcomes**

Learning outcomes	Competences
Learn to design analogue advanced active circuits (linear and nonlinear) for emitters and receivers for communications in the microwave and millimeter wave frequency bands.	CG1 CG4 CE32
Learn to design high frequency circuits for the optoelectronic interface in optical communications systems.	CG1 CG4 CE32
Learn the fabrication techniques of integrated circuits (hybrid and monolithic) for communications in the high frequency bands. Learn how to apply one of these techniques in circuit prototype fabrication.	CG1 CG4 CG8 CE32
Learn to characterize and asses the performance of microwave circuits for communication transceivers.	CG1 CE32

**Contents**

## Topic

1. Advanced circuit design for communication transceivers in the microwave and millimeter wave bands.	<p>a. Linear and Nonlinear Circuit Design Techniques. -CAD-based design and component models. -Measurement-based design. - S-parameters vs X-parameters</p> <p>b. Advanced Low Noise Amplifier Design</p> <p>c. High Efficiency Power Amplifier Design</p> <p>d. High Frequency Oscillator Design</p> <p>e. Frequency Converter Design</p>
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, fabrication and performance evaluation.	Prototype Design using ADS simulator  Prototype fabrication in Hybrid-MIC technology using microstrip transmission lines  Prototype characterization to evaluate performance.

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	5	10	15
Practices through ICT	14	56	70
Laboratory practical	4	0	4
Mentored work	0	22	22
Mentored work	2	12	14

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

## Methodologies

	Description
Lecturing	<p>It will be given in a classroom with the aid of a slate board and a video projector. Main concepts in the relevant Chapters will be described. The student will have available in Fatic support documentation.</p> <p>Note: the last Chapter it is an application work (case study) to be performed by the student, as part of a tutored work. Besides, some of the Topics/sections in the Subject will be individually worked and presented by the students, as part of another tutored work.</p> <p>These lessons are oriented to the acquisition of the competencies: CG1,4,8 and CE38/OP8.</p>
Practices through ICT	<p>During these classes, with the aid of a commercial microwave circuits simulator, the student will design a circuit prototype, among those described in the subject. This work will also continue at home hours through tutored personal work.</p> <p>The student will have available in Fatic support documentation and files. He/she will be able to obtain a circuit simulator student licence for his/her PC, thanks to an agreement between UVIGO and the simulator provider company.</p> <p>These classes are designed to aid in acquiring competencies: CG1,4,8 and CE38/OP8.</p>
Laboratory practical	<p>The previously designed prototype by the student, during the practices in computer rooms and his/her personal work, will be fabricated in hybrid MIC technology and characterized using adequate instrumentation.</p> <p>These classes are designed to help in acquiring competencies: CG1,4,8 and CE38/OP8.</p>
Mentored work	<p>With the aid of the hours of practice in computer rooms, and through his/her personal work, the student will be guided to fully design - working individually- a circuit prototype. Then, he/her will fabricate this prototype and evaluate its performance during the laboratory practices. The student will write a final report of his/her work. This work will require most of the student effort in the subject.</p> <p>These classes are designed to help in acquiring competencies: CG1,4,8 and CE38/OP8.</p>

Mentored work	Each student will prepare - working individually- a short written report about one of the topics covered in the subject. This work will also be assessed by an oral presentation in which he/she will answer questions about the work. These classes are designed to help in acquiring competencies: CG1,4,8 y CE38/OP8.
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### 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.
Practices through ICT	During these classes, students -individually- will perform the assigned tasks related to CAD design with the aid and personalized guidance of the lecturer.
Laboratory practical	During these classes, students -individually- will perform the assigned tasks related to prototyping and measurements with the aid and personalized guidance of the lecturer.
Mentored work	The student will be able to consult his doubts and request suggestions in the realization of his work of design/manufacture and measure of the prototype using the lecturer office hours.
Mentored work	The student will be able to consult his doubts and request suggestions in the realization of the work/presentation of a topic, related to the Subject, during the lecturer office hours.

### Assessment

	Description	Qualification	Evaluated Competences	
Mentored work	The student -individually- will design, fabricate in Hybrid Technology and evaluate the performance of a microwave circuit prototype. The assesment will be performed through the circuit design, the quality of the fabricated prototype, the final measured prototype performance and a written report. In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32.	90	CG1 CG4 CG8	CE32
Mentored work	The student -individually, will write a report about a topic related to the subject. The assesment will be performed taking into account the quality of the report and the answers to short questions during the oral presentation of the work. In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32.	10	CG1 CG4 CG8	CE32

### Other comments on the Evaluation

The subject will be taught fully in English, both in oral and written communications with the students, and in provided technical documents and reports.

A) First Call: The student work in the subject will be evaluated through the development of the two mentored works:

1. The circuit prototype: design, fabrication in hybrid integrated technology, performance evaluation (simulated and experimental), and written report (90% of the total subject qualification).
2. The written report and its presentation, about a given topic, and his/her answers to the presented questions. (10% of the total subject qualification).

B) Second Call:

Those students who have been present at least in 80% of the presential hours will have the opportunity to re-design his/her previous prototype design and also improve the written report of the topic. Each of these tasks will be assigned the same qualification percentage as in the first call. Those students who have not been present in at least 80% of the presential hours, or did not opt for improving their previous works, will have four weeks to design, fabricate, measure, evaluate performance and write a report of a circuit prototype chosen by the lecturer. The assessment of this work will be 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,

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## **Recommendations**

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### **Subjects that it is recommended to have taken before**

Electronics and Photonics for Communications/V05M145V01202

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## **Contingency plan**

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### **Description**

Teaching Group A: Lectures will be online (synchronous or asynchronous).

Teaching Group A: On-line classes (synchronous or asynchronous) will provide the students with descriptions/explanations of the work to be done and aid him to solve his/her doubts, so that, beside the provided supporting documentation and files, as well as the simulator license and online office hours, he/she can performed the assigned work autonomously at home.

The mentored work corresponding to the design of an electronic prototype will not include those parts related to the manufacture and measurement of this prototype. This experimental work will be replaced by the development of an additional report, on another subject topic, or the design of another circuit. The prototype work will correspond in this case to 75% of the subject grade, the extra report/design to 15%.

Evaluation:

First Call:

The mentored works will be evaluated through the delivered written reports, the designs simulations results (prototype or additional circuit) and the oral presentations, which will be performed on-line during the classes of groups B.

Second and End-of-Program Call:

Those students who have been present at least in 80% of the presential hours will have the opportunity to improve their previous deliverables (mentored works). Each of these tasks will be assigned the same qualification percentage as in the First Call.

Otherwise, the student will have 4 weeks to: design, with the aid of the simulator, evaluate performance through simulations and deliver a written report of circuit prototype, suggested by the professor. This work grades up to 80% of the total subject grade. For the remaining 20%, the student will have to deliver a written report on a subject related with one of the subject topics. For performing this report the student will have 1 week.

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**IDENTIFYING DATA****Multimedia Security**

Subject	Multimedia Security			
Code	V05M145V01318			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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://fatic.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.

**Competencies**

Code	
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE31CE37/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

**Learning outcomes**

Learning outcomes	Competences
Handle the most advanced information protection methods.	CG4 CG8 CE31
Understand the potential and limitations of the different methods.	CG4 CG8 CE31
Handle the use of different algorithms in current multimedia communications environments.	CG4 CG8 CE31
Understand technical material in an autonomous way.	CG4 CG8 CE31

**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.
Forensic signal processing.	Quantization detection and estimation. Filtering detection and identification. Resampling detection and estimation. Source ballistics.
Signal Processing in the Encrypted Domain.	Privacy metrics and notions. Homomorphic encryption. Garbled circuits. Signal representation and cipher blowup. Applications.

## Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	14	28	42
Laboratory practical	9	42	51
Report of practices, practicum and external practices	0	30	30
Essay questions exam	2	0	2

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

## Methodologies

	Description
Lecturing	The course is structured in several topics in multimedia security, including cryptography, watermarking, forensics and signal processing in the encrypted domain.  Competences: CG4, CG8, CE31
Laboratory practical	Lab practices will cover different aspects of multiple-input data hiding, watermarking and forensics. This will allow students to practically implement and considerably expand some of the concepts seen in the lectures.  Competences: CG4, CG8, CE31

## Personalized assistance

Methodologies	Description
Lecturing	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the master session, or during the office hours. Office hours will be given at the beginning of the course and published in the subject's webpage.
Tests	Description
Report of practices, practicum and external practices	The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered during the work review sessions or during the office hours.

## Assessment

	Description	Qualification	Evaluated Competences	
Report of practices, practicum and external practices	Reports of the practices and additional personal work that employ the techniques seen in the classroom. Quality of the reports and correctness of the results will be evaluated. Reports will be individual or collective, depending on the size of the unit that carried out the practices.	70	CG4 CG8	CE31
Essay questions exam	Final exam with short questions on the contents of the subject.	30	CG4 CG8	CE31

## Other comments on the Evaluation

A minimum score of 30% with respect to the maximum possible score in the final exam is required to pass the course.

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

In case the student does not achieve the minimum score in the final written exam, his/her global score will be obtained using the formula:  $0.35*REP+0.15*TEST$ , where REP is the score achieved in the reports and TEST is the score achieved in the final exam.

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

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

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

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

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### 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,

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### Recommendations

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### Contingency plan

#### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION OF THE METHODOLOGIES ===

In such case, teaching and evaluation will take place fully or partially online.

<b>IDENTIFYING DATA</b>				
<b>Intelligent Sensors</b>				
Subject	Intelligent Sensors			
Code	V05M145V01319			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Mariño Espiñeira, Perfecto			
Lecturers	Machado Domínguez, Fernando Mariño Espiñeira, Perfecto			
E-mail	pmarino@uvigo.es			
Web	http://fatic.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.			

<b>Competencies</b>	
Code	
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE36	CE36 Ability to characterize intelligent sensors and their specific characteristics in networks

<b>Learning outcomes</b>	
Learning outcomes	Competences
Know the different structures of the intelligent sensors.	CB5 CG8 CE36
Know the topologies and architectures of the sensor networks.	CB5 CG8 CE36
Know analyse and design systems of efficient sensors in consumption.	CB4 CG8 CE36
Know software tools and hardware platforms for the design of sensor systems.	CB5 CG8 CE36
Design applications based on data fusion of different sensors.	CB4 CG8 CE36

<b>Contents</b>	
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: PROFIBUS and CAN. Intelligent Transportation Systems (ITS). Embedded buses for automotive applications: LIN, MOST, FLEXRAY, JSAE 1939 and others. 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	

Unit 1. Wired smart sensors systems.	Analysis and test of smart sensors.
Unit 2. Wireless smart 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	4	4	8
Mentored work	1	18.5	19.5
Laboratory practical	7.5	15	22.5
Project based learning	12.5	62.5	75

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

## Methodologies

	Description
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students' questions in the classroom or at the office. In these sessions, the skills CB4, CB5, CG8, and CE43 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 in the classroom the topic of this individual task and monitor the student's work in personalized attention sessions. In these sessions, the skills CB4, CB5, CG8 and CE43 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 and collaborative skills. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in the laboratory sessions or at the lecturer's office. In these sessions, the skills CB4, CB5, CG8, and CE43 will be developed.
Project based learning	Students have to develop a group activity that goes on over a period of time and address a specific problem. They have to design, schedule and carry out a set of tasks to achieve a solution. The assessment will be based on the quality of the proposed solution, the depth of content understanding demonstrated and the final presentation. In these sessions, the skills CB4, CB5, CG8, and CE43 will be developed.

## Personalized assistance

Methodologies	Description
Lecturing	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. Tutoring sessions also may be carried out online: either asynchronously (e-mail, FAITIC forums, etc.) or by videoconference, in this case by appointment. In these sessions the lecturer will answer the students' questions and also give instructions to guide the studying and learning process.
Laboratory practical	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. Tutoring sessions also may be carried out online: either asynchronously (e-mail, FAITIC forums, etc.) or by videoconference, in this case by appointment. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools).
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. Tutoring sessions also may be carried out online: either asynchronously (e-mail, FAITIC forums, etc.) or by videoconference, in this case by appointment. In these sessions the lecturer will help students to deal with the monitored work.
Project based learning	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. Tutoring sessions also may be carried out online: either asynchronously (e-mail, FAITIC forums, etc.) or by videoconference, in this case by appointment. The lecturers will be available to help students in order to deal with the project as well as the monitored work.

## Assessment

Description	Qualification	Evaluated Competences
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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. In these works, the skills CB4, CB5, CG8 and CE43 will be evaluated.	20	CB4 CB5	CG8	CE36
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. In these practices, the skills CB4, CB5, CG8 and CE43 will be assessed.	20	CB4 CB5	CG8	CE36
Project based learning	The lecturers will consider the quality of the results obtained, their presentation and analysis, and the final oral presentation. The final mark of the project (FMP) will be assessed in a 10 points scale. For the evaluation of the project, the lecturer will assess the group work (the same mark for each member), as long as it was possible to form groups, and the individual oral presentation of the developed project. The skills CB4, CB5, CG8 and CE43 will be evaluated in these projects.	60	CB4 CB5	CG8	CE36

## Other comments on the Evaluation

### 1. Continuous evaluation (first 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 subject comprises three different parts: theory (20%), laboratory (20%) and project (60%). Once a task has been assessed, the students can not do/repeat the task at a later date. The marks are valid only for the current academic course.

#### 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 ( $FMT \geq 5$ ).

#### 1.b Laboratory

Three laboratory sessions are scheduled. Each 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:

$$FML = (LSM1 + LSM2 + LSM3)/3$$

#### 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 results, their analysis and presentation, and the final oral presentation. The final mark of project (FMP) will be assessed in a 10 points scale. The minimum mark required to pass this part is of 5 ( $FMP \geq 5$ ). 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), 20% laboratory (FML) and 60% 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:

$$FM = 0.2 \cdot FMT + 0.2 \cdot FML + 0.6 \cdot FMP.$$

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 will be:

$$FM = \min\{4 ; (0.2 \cdot FMT + 0.2 \cdot FML + 0.6 \cdot FMP)\}.$$

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

### **2. Single evaluation (first 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 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 ( $FMT \geq 5$ ,  $FML \geq 5$  and  $FMP \geq 5$ ). In this case the final mark (FM) will be:

$$FM = 0.2 \cdot FMT + 0.2 \cdot FML + 0.6 \cdot FMP.$$

However, when the students do not pass all parts ( $FMT < 5$  or  $FML < 5$  or  $FMP < 5$ ), the final mark will be:

$$FM = \min\{4 ; (0.2 \cdot FMT + 0.2 \cdot FML + 0.6 \cdot FMP)\}.$$

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

### **3. Second call evaluation**

The assessment policy in this 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. 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.

The marks obtained in the previous continuous or single evaluation are kept for those parts in which the student has not

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

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

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### 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

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### Recommendations

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### Contingency plan

#### Description

In case of online tuition, then the planning and the evaluation will be carried out as follows:

\* Theory: the theory classes will be performed through electronic means and the contents will be available online.

\* Practices: depending on the contents developed in each laboratory practice and the availability of material, the session will be performed in a virtual way, in the students home (using provided basic equipment) or by simulation (using free software or University licensed software). The details of each practices session will be available online in FAITIC. In this scenario, the practices will be individually developed and evaluated.

\* Project: depending on the proposed project and the availability of material, the work will be performed in a virtual way, in the students home (using provided basic equipment) or by simulation (using free software or University licensed software). The details of each project session will be available online in FAITIC. In this scenario, the project will be individually developed and evaluated.

\* Assessment: the assessment will supported by FAITIC and Campus Remoto.

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**IDENTIFYING DATA**

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**Practicals in Digital Electronics for Communications**

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Subject   Practicals in Digital  
          Electronics for  
          Communications

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Code       V05M145V01320

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Study      Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

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Teaching  
language

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Department

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Coordinator

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Lecturers

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E-mail

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

**IDENTIFYING DATA****Distributed Computing**

Subject	Distributed Computing			
Code	V05M145V01321			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Mikic Fonte, Fernando Ariel			
Lecturers	Burguillo Rial, Juan Carlos Mikic Fonte, Fernando Ariel Rodríguez Hernández, Pedro Salvador			
E-mail	mikic@gist.uvigo.es			
Web	http://fatic.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 grid computing, cloud computing, and cluster computing; 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.			

**Competencies**

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE24CE24/TE1	Ability to understand the fundamentals of distributed systems and distributed computing paradigms, and its application in the design, development and management in grid, ubiquitous computing scenarios and cloud systems.

**Learning outcomes**

Learning outcomes	Competences
To earn skills in the design, development and management of distributed systems.	CB2 CG8 CE24
To understand the functional bases of the distributed systems.	CB4 CB5 CE24
To know the distinct concepts related with the distributed computing: clustering, grids, cloud computing and ubiquitous computing.	CB5 CG8 CE24
To earn skills for the application of intelligent systems in the distributed computing.	CB2 CB5 CG8 CE24
To learn how to distribute the execution of tasks for the resolution of problems and optimisation by means of evolutionary and parallel computing.	CB2 CB4 CG8 CE24

**Contents**

Topic	
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

2. Parallel and evolutionary computation	<ol style="list-style-type: none"> <li>1. Distributed Computing and parallelization</li> <li>2. Algorithms and evolutionary programming: genetics, memetics, differential evolution, intelligence of swarm.</li> <li>3. Optimisation by means of evolutionary technics and parallelization</li> </ol>
3. Transactions	<ol style="list-style-type: none"> <li>1. Concurrency problems</li> <li>2. Recoverability problems</li> <li>3. Deadlocks</li> <li>4. Optimistic concurrency control</li> <li>5. Timestamps</li> </ol>
4. Replication	<ol style="list-style-type: none"> <li>1. Introduction to replication</li> <li>2. Case studies of high available services (Bayou and Coda)</li> <li>3. Transactions with replicated data</li> <li>4. Design of distributed systems: Google case study</li> </ol>
5. Grid and Cluster	<ol style="list-style-type: none"> <li>1. Basic concepts of grid computing</li> <li>2. Basic concepts of cluster computing.</li> </ol>

### Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	17	0	17
Practices through ICT	9	0	9
Autonomous problem solving	0	92	92
Problem and/or exercise solving	3	0	3
Report of practices, practicum and external practices	0	3	3
Laboratory practice	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	Theoretical classes with practical cases. Besides, problems will be proposed for solving them in autonomous way.
	Competencies related to this activity: CB5 and CE24
Practices through ICT	Practices by means of computers connected in network and/or virtual machines.
	Competencies related to this activity: CB2, CB4, and CG8
Autonomous problem solving	Study work on the contents of theoretical classes, as well as support for the achievement of practices through ICT.
	Competencies related to this activity: CB5 and CG8

### Personalized assistance

Methodologies	Description
Practices through ICT	The personalised attention will carry out in the practical part of the course, as in the tutorial time. The tutorials may be carried out by telematic means (email, videoconference, FAITIC forums, etc.) and an appointment may be required.

### Assessment

	Description	Qualification	Evaluated Competences		
Problem and/or exercise solving	Examinations composed by a series of short answer questions and/or test type ones that the student will have to answer in the classroom individually.	60	CB2 CB4 CB5	CG8	CE24
Report of practices, practicum and external practices	Detailed report of the tasks during the practices of laboratory carried out in group.	5	CB2 CB4	CG8	CE24
Laboratory practice	Assessment of the work carried out by the students during the laboratory practices carried out in group. Level of involvement, participation in the practices, and performance of the work	35	CB2 CB4 CB5	CG8	CE24

### Other comments on the Evaluation

Students can, at first call, decide to be assessed according to a continuous assessment model or by an exam-only assessment. The fact of presenting to the first continuous assessment exam involves opting for this assessment model

(otherwise opting for the exam-only assessment model). Once the students choose the continuous assessment model, their grade can never be "Not Submitted". For second call the students will be evaluated using the modality of "exam-only assessment" (some modifications over the original practices can be required). The scores obtained in first call are not preserved for second call.

Plagiarism and copy are not allowed.

## 1- CONTINUOUS ASSESSMENT

To pass the course requires a minimum score of 5 points. The score will be the result to add the scores received in each one of the following parts:

- Exam 1:
  - Dates: Before the middle of the semester
  - Individually
  - Contents: Theoretical content given until this moment
  - Type: Series of short answer questions and/or test type ones
  - Maximum score = 2 points
- Exam 2:
  - Dates: Official calendar (coinciding with the exam-only assessment for those that opted by this modality)
  - Individually
  - Contents: Theoretical content given until this moment excepting those that already were assessed in the Exam 1.
  - Type: Series of short answer questions and/or test type ones
  - Maximum score = 4 points
- Practices:
  - Dates: Since week 3 to week 11
  - In group:
    - Reports / memories of practice and Laboratory practice: A personalized score is assigned to each member of the group according to the following:
    - Final score of practices = (Memory + Practice) \* Weighting factor
      - Memory maximum score = 0.5 points
      - Practice maximum score = 3.5 points (verification of the correct operation of the practice and of possible changes to be made in it, in group or individually).
      - Weighting factor = (Follow-up by the teacher + Peers assessment) / 20
        - Follow-up by the teacher: About the work carried out by each student observed by the teacher (0-10)
        - Peers assessment: Within each group. Each student assesses his/her partners about the work they did (0-10). Then, an arithmetic average is calculated for each student.
  - Maximum score= 4 points

## 2- EXAM-ONLY ASSESSMENT

To pass the course requires a minimum score of 5 points.

- Theoretical exam:
  - Dates: Official calendar
  - Individually
  - Contents: Given in the whole theoretical part of the course.
  - Type: Series of short answer questions and/or test type ones
  - Maximum score= 6 points

- Practice exam and delivery of practice:
  - Dates of the exam: Official calendar
  - Dates of the delivery of practice: Before the exam.
  - Individually.
  - Contents: Related to the practice and its performance.
  - Type: Series of short answer questions and/or test type ones, and verification of the correct operation of the practice and of possible changes to be made in it.
  - Maximum score= 4 points

## Sources of information

### Basic Bibliography

George Coulouris, Jean Dollimore, Tim Kindberg, Gordon Blair, **Distributed systems. Concepts and design**, 5, Addison Wesley, 2011

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

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

Tom White, **Hadoop: The Definitive Guide**, 3, O'Reilly Media, 2012

### Complementary Bibliography

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

## Recommendations

### Subjects that it is recommended to have taken before

Application Technologies/V05M145V01105

## Contingency plan

### Description

=== EXCEPTIONAL PLANNING ===

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

=== ADAPTATION ===

Those methodologies used and tests to be carried out in person will respectively be used and carried out online through the Remote Campus and the Fatic platform (without prejudice to other measures that can be adopted to guarantee the accessibility of the students).

**IDENTIFYING DATA****Data analysis**

Subject	Data analysis			
Code	V05M145V01322			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	González Castaño, Francisco Javier			
Lecturers	González Castaño, Francisco Javier			
E-mail	javier@det.uvigo.es			
Web	<a href="http://http://fatic.uvigo.es">http://http://fatic.uvigo.es</a>			
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.			

**Competencies**

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB3	CB3 Students must integrate knowledge and handle complexity of formulating judgments based on information that was incomplete or limited, including reflections on social and ethical responsibilities linked to the application of their knowledge and judgments.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE25	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.

**Learning outcomes**

Learning outcomes	Competences
- Knowledge of the different stages of knowledge extraction and the areas of application of data mining.	CB2 CB3 CG4 CG8 CE25
- Knowledge of the importance of the preparation of the data and how to apply the main pre-processing techniques.	CB2 CG4 CG8 CE25
- Knowledge of the main techniques of data mining as well as the necessary premises for its application to a particular stage.	CB2 CB3 CG4 CG8
- Knowledge of the different types of data mining results evaluation and how to apply them.	CE25
- Knowledge of statistical software and how to apply it to on-line and off-line data mining.	CG4 CE25
-Ability to to schedule, develop and evaluate a data analysis process.	CG4 CG8 CE25
New	

**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
Project based learning	2	36	38
Laboratory practical	5	19	24
Lecturing	20	40	60
Problem and/or exercise solving	2	0	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
Project based learning	Arranged in groups, the students will solve a practical case of data analysis in an application scenario. CB2 CB3 CG4 CG8 CE25
Laboratory practical	During the course, students will develop solutions in laboratory sessions to grasp the course content. CB2 CB3 CG4 CG8 CE25
Lecturing	Lectures that will illustrate the course content with small exercises. These will be solved by the lecturer or the students themselves, alone or in groups. The goal is to foster discussion and knowledge of course competencies. CB2 CB3 CG4 CG8.

## Personalized assistance

Methodologies	Description
Lecturing	Individual attention will take place during official tutoring times or via e-mail at any time.
Project based learning	Individual attention will take place during official tutoring times or via e-mail at any time.
Laboratory practical	Individual attention will take place during official tutoring times or via e-mail at any time.

## Assessment

	Description	Qualification	Evaluated Competences		
Problem and/or exercise solving	Short-answer written exam.	40			CE25
Essay	Each student will present two deliverables reporting his/her work on a dataset that will be handed at the beginning of the course.	60	CB2 CB3	CG4 CG8	CE25

## Other comments on the Evaluation

### FIRST CALL

At the beginning of the course the student will have to choose between continuous and single evaluation. No change of decision will be allowed.

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)

To pass the course, the student must obtain 1,5/4 points at least in the short answer test and an overall 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. The maximum score is 10 points.

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

Single 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. The maximum score is 10 points.

## **SECOND CALL**

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

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### **Sources of information**

#### **Basic Bibliography**

#### **Complementary Bibliography**

Zumel, 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,

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### **Recommendations**

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### **Contingency plan**

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#### **Description**

In case of exceptional circumstances related to COVID 19 there will be no written exam. Assessment will be totally based on the two assignments.

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**IDENTIFYING DATA****Economical and Social Networks**

Subject	Economical and Social Networks			
Code	V05M145V01323			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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://fatic.uvigo.es			
General description	Social and Economic networks tackles the dynamic and structural study of networks of relationship between agents that arise in the fields of telecommunications, economy and sociology. We study, in particular, dynamic models of diffusion of information, of contagion, of strategic balance and of training of coalitions. The theoretical contents are applied to a practical study case.			

**Competencies**

Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CB3	CB3 Students must integrate knowledge and handle complexity of formulating judgments based on information that was incomplete or limited, including reflections on social and ethical responsibilities linked to the application of their knowledge and judgments.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE26CE26/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
CE27CE27/TE4	Ability to design and manage distributed systems based on learning and incentive

**Learning outcomes**

Learning outcomes	Competences
Understand the static and dynamic phenomena that explain the structure of the social networks	CG4 CE26
Know how to analyse the mechanisms of training of networks in strategic terms	CG4 CG8 CE26 CE27
Know how to model and apply to real data the processes of diffusion of information in social networks	CB1 CB3 CE26 CE27
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.	CB1 CB3 CG4 CG8 CE26 CE27
Know how to use the dynamics of learning in networks to characterise phenomena	CB1 CB3 CG4 CE27

**Contents**

Topic	
1. Basic models	a. Empirical evidence b. Descriptive parameters, centrality and importance 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 social 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. Identification of experts and leaders b. Trending topics c. Recommendations/punctuations d. Virality e. Origins of rumours

### Planning

	Class hours	Hours outside the classroom	Total hours
Project based learning	6	36	42
Autonomous problem solving	4.5	21	25.5
Lecturing	18.5	36	54.5
Essay questions exam	2	0	2
Objective questions exam	1	0	1

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

### Methodologies

	Description
Project based learning	Development of a practical project of analysis and modeling of a technological, social, biological or economic network. It will consist in the structural and dynamic explanation of the observable phenomena in the data that describe the network.  Through this methodology, competencies CB1, CB3, CG4, CG8, CE26 and CE27 are developed.
Autonomous problem solving	Autonomous resolution of problems and exercises related to the contents taught in the lectures.  Through this methodology, competencies CB1, CB3, CG4, CG8, CE26 and CE27 are developed.
Lecturing	Synthetic exposition of the basic concepts that support the subject.  Through this methodology, competencies CB1, CB3, CG4, CG8, CE26 and CE27 are developed.

### Personalized assistance

Methodologies	Description
Lecturing	Individual attention to the students to solve the doubts that may arise in the study of the material of the lectures.
Project based learning	Individual attention to students to solve the doubts that may arise in the development of the project.
Autonomous problem solving	Individual attention to students to solve the doubts that may arise in the autonomous resolution of the problems.

### Assessment

	Description	Qualification	Evaluated Competences		
Project based learning	Functional test of the project and quality of the conclusions.	30	CB1 CB3	CG4 CG8	CE26 CE27
Autonomous problem solving	Correction of the proposed exercises.	30	CB1 CB3	CG4 CG8	CE26 CE27
Essay questions exam	Written exam of essay questions about the contents of the subject.	30	CB1 CB3	CG4 CG8	CE26 CE27
Objective questions exam	Written exam of objective questions about the contents of the subject.	10	CB1 CB3	CG4 CG8	CE26 CE27

### Other comments on the Evaluation

We leave to discretion of the students two methods of alternative assessment in the subject: continuous assessment and single assessment.

The continuous assessment will consist in the realisation of a written final exam (40% of the qualification), the development of a practical project (30% of the qualification) and the written resolution of problems and exercises along the course (30%

of the qualification). The single assessment will consist in the realisation of a written final exam (60% of the qualification) and in the development of a practical project (40% of the qualification) that will be delivered before the last day of the official period of exams.

The students will choose one or another modality of assessment at the time when the development projects are announced.

All those students who attend the written final exam and/or deliver the project will be considered as presented.

Those students who do not pass the subject at the first call have a second call in the month of July in which his/her knowledge will be re-evaluated with a written exam and/or his/her project will be re-evaluated if it had been improved or modified. The weights of each one of the tests (exam and project) will be the same that in the ordinary period of exams according to the modality that had been chosen.

The qualifications of the tests have only effects in the academic course in that they were awarded, with independence of the itinerary of evaluation chosen.

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### Sources of information

#### Basic Bibliography

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

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

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

#### Complementary Bibliography

R. van der Hofstad, **Random graphs and complex networks**, Cambridge University Press, 2016

D. Easley, J. Kleinberg, **Networks, Crowds, and Markets: Reasoning About a Highly Connected World**, Cambridge University Press, 2010

B. Bollobas, **Random Graphs**, Cambridge University Press, 2001

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### Recommendations

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### Contingency plan

#### Description

In case of online tuition, the same methodologies will be used and the same proofs will be carried out that would have been developed in classroom at School.

Online tuition will be supported by Campus Remoto and Faitic.

**IDENTIFYING DATA****Internship in Companies I**

Subject	Internship in Companies I			
Code	V05M145V01324			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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://fatic.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.			

**Competencies**

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
CG10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CG13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.

**Learning outcomes**

Learning outcomes	Competences
Experience in the practice of the profession of engineering of Telecommunication and his/her usual functions in some real company environment.	CB2 CB5 CG8 CG9 CG10 CG12 CG13

**Contents**

Topic	
Item	The student will realise a stay in the company developing own functions of a/to Engineer/to of Telecommunication.

**Planning**

	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	120	0	120
Report of practices, practicum and external practices(Repetida non usar)	5	0	5

\*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 an Telecommunication Engineer.

## Personalized assistance

Methodologies	Description
Practicum, External practices and clinical practices	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).

## Assessment

	Description	Qualification	Evaluated Competences
Report of practices, practicum and external practices(Repetida non usar)	Activities memory Company tutor evaluation	100 CB2 CB5	CG8 CG9 CG10 CG12 CG13

## 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.

## Contingency plan

### Description

#### === EXCEPTIONAL PLANNING ===

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

#### === ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

\* Teaching methodologies modified

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

\* Modifications (if applicable) of the contents

\* Additional bibliography to facilitate self-learning

\* Other modifications

=== ADAPTATION OF THE TESTS ===

\* Tests already carried out

Test XX: [Previous Weight 00%] [Proposed Weight 00%]

...

\* Pending tests that are maintained

Test XX: [Previous Weight 00%] [Proposed Weight 00%]

...

\* Tests that are modified

[Previous test] => [New test]

\* New tests

\* Additional Information

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**IDENTIFYING DATA****Internship in Companies II**

Subject	Internship in Companies II			
Code	V05M145V01325			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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://fatic.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.			

**Competencies**

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
CG10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CG13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.

**Learning outcomes**

Learning outcomes	Competences
Experience in the practice of the profession of engineering of Telecommunication and his usual functions in some real company environment.	CB2 CB5 CG8 CG9 CG10 CG12 CG13

**Contents**

Topic	
Item	The student will realise a stay in the company developing own functions of a/to Engineer/to of Telecommunication.

**Planning**

	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	120	0	120
Report of practices, practicum and external practices(Repetida non usar)	5	0	5

\*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 an Telecommunication Engineer.

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**Personalized assistance**

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Methodologies	Description
Practicum, External practices and clinical practices	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).

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**Assessment**

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	Description	Qualification	Evaluated Competences
Report of practices, practicum and external practices(Repetida non usar)	Activities memory Company tutor evaluation	100 CB2 CB5	CG8 CG9 CG10 CG12 CG13

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**Other comments on the Evaluation**

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**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.

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**Sources of information**

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**Basic Bibliography****Complementary Bibliography**

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**Recommendations**

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**Other comments**

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

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**Contingency plan**

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**Description**

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=== ADAPTATION OF THE METHODOLOGIES ===

\* Educational Methodologies that keep

Any because the subject consists of the permanence in a company developing activities adapted to the degree

\* Educational Methodologies that modify

All. The subject sewed in the stay in the company of the student during a time. In the case that the teaching was exclusively no face-to-face, the practice in the company only will be able to make if it does in the remote.

\* Modifications (if they proceed) of the contents to give

There are no changes

\* Additional Bibliography to facilitate the self-learning

There are not

\* Other modifications

There are not more modifications

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=== ADAPTATION OF THE EVALUATION ===

Unchanged

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**IDENTIFYING DATA****Internship in Companies III**

Subject	Internship in Companies III			
Code	V05M145V01326			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	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://fatic.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.			

**Competencies**

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CB5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG9	CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering.
CG10	CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CG13	CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering.

**Learning outcomes**

Learning outcomes	Competences
Experience in the practice of the profession of engineering of Telecommunication and his usual functions in some real company environment.	CB2 CB5 CG8 CG9 CG10 CG12 CG13

**Contents**

Topic	
Item	The student will realise a stay in the company developing own functions of a/to Engineer/to of Telecommunication.

**Planning**

	Class hours	Hours outside the classroom	Total hours
Practicum, External practices and clinical practices	120	0	120
Report of practices, practicum and external practices(Repetida non usar)	5	0	5

\*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 an Telecommunication Engineer.

<b>Personalized assistance</b>	
<b>Methodologies</b>	<b>Description</b>
Practicum, External practices and clinical practices	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).

<b>Assessment</b>			
	Description	Qualification	Evaluated Competences
Report of practices, practicum and external practices(Repetida non usar)	Activities memory Company tutor evaluation	100 CB2 CB5	CG8 CG9 CG10 CG12 CG13

### **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.

### **Contingency plan**

#### **Description**

=== ADAPTATION OF THE METHODOLOGIES ===

\* Educational Methodologies that keep

Any because the subject consists of the permanence in a company developing activities adapted to the degree

\* Educational Methodologies that modify

All. The subject sewed in the stay in the company of the student during a time. In the case that the teaching was exclusively no face-to-face, the practice in the company only will be able to make if it does in the remote.

\* Modifications (if they proceed) of the contents to give

There are no changes

\* Additional Bibliography to facilitate the self-learning

There are not

\* Other modifications

There are not more modifications

=== ADAPTATION OF THE EVALUATION ===

Unchanged

**IDENTIFYING DATA****Network Information Theory**

Subject Network  
Information Theory

Code V05M145V01327

Study Telecommunication  
programme Engineering

Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

Teaching  
language

Department

Coordinator

Lecturers

E-mail

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

**IDENTIFYING DATA****Learning in Networks and Collaborative Work**

Subject	Learning in Networks and Collaborative Work			
Code	V05M145V01328			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language				
Department				
Coordinator				
Lecturers				
E-mail				

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

**IDENTIFYING DATA****Human-Computer Interaction**

Subject Human-Computer  
Interaction

Code V05M145V01329

Study Telecommunication  
programme Engineering

Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

Teaching  
language

Department

Coordinator

Lecturers

E-mail

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

## IDENTIFYING DATA

### Photovoltaic Power Electronics

Subject	Photovoltaic Power Electronics			
Code	V05M145V01330			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish Galician			
Department				
Coordinator	Doval Gandoy, Jesús			
Lecturers	Doval Gandoy, Jesús Martínez-Peñalver Freire, Carlos			
E-mail	jdoval@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The subject describes the basic concepts of control and power electronic converters used in photovoltaic systems.			

## Competencies

Code	
CB2	CB2 Students must apply their knowledge and ability to solve problems in new or unfamiliar environments within broader (or multidisciplinary) contexts related to their field of study.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE28	CE28/SE1 Capacity of technology integration of photovoltaic conversion for power systems of Telecommunication Engineering.

## Learning outcomes

Learning outcomes	Competences
Knowledge of power conversion technologies used in photovoltaic systems.	CB2 CG4 CG8 CE28
Knowledge of control techniques of electronic power converters used in photovoltaic systems.	CB2 CG4 CG8 CE28

## 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
Laboratory practical	10	31	41
Problem solving	5	16	21
Lecturing	15	48	63

\*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	Application of the knowledge to particular situations and acquisition of basic skills related with the topic. Competencies: CB2, CG4, CG8, CE28/SE1.
Problem solving	Formulation of problems and/or exercises related with the topic. The student has to develop the correct solutions by means of applying routines, the application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results. Competencies: CB2, CG4, CG8, CE28/SE1.
Lecturing	The professor presents the contents on the subject: theoretical basis and/or guidelines of the work to be developed by the students. Competencies: CB2, CG4, CG8, CE28/SE1.

### Personalized assistance

Methodologies	Description
Lecturing	The professor will attend personally doubts and queries of the students, on the study of theoretical concepts, on exercises or on practices of laboratory. The students will have occasion to attend personal tutorials at the professor office. The tutorial hours will be published at the beginning of the semester in the website of the subject.
Laboratory practical	The professor will attend personally doubts and queries of the students, on the study of theoretical concepts, on exercises or on practices of laboratory. The students will have occasion to attend personal tutorials at the professor office. The tutorial hours will be published at the beginning of the semester in the website of the subject.
Problem solving	The professor will attend personally doubts and queries of the students, on the study of theoretical concepts, on exercises or on practices of laboratory. The students will have occasion to attend personal tutorials at the professor office. The tutorial hours will be published at the beginning of the semester in the website of the subject.

### Assessment

	Description	Qualification	Evaluated Competences		
Laboratory practical	Development of the practices of laboratory.	33	CB2	CG4 CG8	CE28
Problem solving	Resolution of exercises proposed	33	CB2	CG4 CG8	CE28
Lecturing	Theoretical concepts.	34	CB2	CG4 CG8	CE28

### Other comments on the Evaluation

There are two ways to evaluate the students: continuous evaluation or single evaluation.

#### 1. Continuous evaluation

The continuous evaluation consists in the evaluation of the tasks proposed by the professor along the course. The students will execute the tasks and will deliver a report of each one of the tasks. The professor may ask students questions about the tasks carried out in order to assess the knowledge acquired.

The professor will score the students from their work in the developed tasks and from the reports.

The marks will be valid only for the current academic course. It is understood that the student chooses the continuous evaluation when he/she presents at least one task. His/her qualification will be the one of continuous evaluation.

#### 2. Single evaluation

The final examination is for students that do not participate in the continuous evaluation. It consists of theoretical questions, problems and exercises that will evaluate the knowledge of the student in the topic. The examination date will be established by the head of the Faculty.

#### 3. Second call

There is a second opportunity to pass the subject. The student will have to pass an exam with questions, problems and exercises that will evaluate the knowledge of the student in the topic. The examination date will be established by the head of the Faculty. This examination is the same for all the students, have followed or no the continuous evaluation.

### Sources of information

#### Basic Bibliography



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

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### **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,

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### **Recommendations**

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### **Contingency plan**

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#### **Description**

=== MEDIDAS EXCEPCIONALES PLANIFICADAS ===

Ante la incierta e imprevisible evolución de la alerta sanitaria provocada por el COVID-19, la Universidad de Vigo establece una planificación extraordinaria que se activará en el momento en que las administraciones y la propia institución lo determinen atendiendo a criterios de seguridad, salud y responsabilidad, y garantizando la docencia en un escenario no presencial o parcialmente presencial. Estas medidas ya planificadas garantizan, en el momento que sea preceptivo, el desarrollo de la docencia de un modo más ágil y eficaz al ser conocido de antemano (o con una amplia antelación) por el alumnado y el profesorado a través de la herramienta normalizada e institucionalizada de las guías docentes.

=== ADAPTATION OF THE METHODOLOGIES ===

Lecturing: it can be taught virtually through campusvirtual from UVigo.

Laboratory practical: it can be taught virtually through campusvirtual from UVigo.

Problem solving: it can be taught virtually through campusvirtual from UVigo.

Tutorship: the teacher can tutor students virtually through the campusvirtual from Uvigo.

No need to modify contents.

No need to add additional bibliography.

=== ADAPTATION OF THE TESTS ===

The evaluation mechanism is maintained.

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<b>IDENTIFYING DATA</b>				
<b>Signal Conditioners</b>				
Subject	Signal Conditioners			
Code	V05M145V01331			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Quintáns Graña, Camilo			
Lecturers	Quintáns Graña, Camilo			
E-mail	quintans@uvigo.es			
Web	<a href="http://fatic.uvigo.es">http://fatic.uvigo.es</a>			
General description	<p>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.</p> <p>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.</p> <p>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.</p> <p>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:</p> <ul style="list-style-type: none"> <li>-The followed methodology to measure physical variables to the calculation of uncertainties.</li> <li>-Characterization of transducers.</li> <li>-Topologies of conditioning circuits.</li> <li>-The connection of the conditioned signals to a digital processor.</li> <li>-Instrumentation software for digitally conditioning and user interfaces.</li> </ul>			

<b>Competencies</b>	
Code	
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CE29	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

<b>Learning outcomes</b>	
Learning outcomes	Competences
To know the modeling and simulation of analogic electronic systems by means of the hardware description language SPICE.	CG1 CG4 CG8 CE29
To know the evaluation of the uncertainties in the measuring processes following the standards.	CG4
To know how to handle and to program data acquisition systems.	CG1 CE29
To know the developing of complex electronic circuits for conditioning the sensors.	CG1 CG4 CG8 CE29
To know to analyse and to design circuits for interfaces between the sensors and digital processors.	CG1 CE29
To know how to develop an instrumentation electronic systems.	CG1 CG4 CG8 CE29

<b>Contents</b>
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 measuring 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.

## Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	0.5	1	1.5
Lecturing	7	14	21
Mentored work	4.5	9	13.5
Problem solving	6	12	18
Laboratory practical	7	14	21
Laboratory practice	1	12	13
Essay	0.5	1	1.5
Essay questions exam	1	15	16
Problem and/or exercise solving	1	15	16
Report of practices, practicum and external practices	0.5	2	2.5
Systematic observation	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
Introductory activities	Activities aimed at making contact and gathering information about the students, as well as presenting the subject.
Lecturing	Exhibition by the teacher of the reports on the subject matter of study, theoretical bases and / or guidelines of a work, exercise that the student has to develop.
Mentored work	The student, individually or as a group, carries out activities, which can be: <ul style="list-style-type: none"> <li>- Monographic works, search of information in publications, databases, articles, books ... on a specific topic.</li> <li>- Preparation of seminars, research, reports, essays, conferences, etc.</li> <li>- Reviews on current scientific articles.</li> <li>- Projects (design and develop projects).</li> </ul>
Problem solving	Activity in which problems and / or exercises related to the subject are formulated. The student must develop the correct solutions through the exercise of routines, and application of formulas or algorithms, the application of procedures of transformation of the available information and the interpretation of the results.
Laboratory practical	Activities of application of knowledge and concrete situations, and acquisition of basic and procedural skills, related to the object of study. They are developed in special spaces with specialized equipment (laboratories, computer rooms, etc.).

## Personalized assistance

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

Mentored work	The professor will attend personally doubts and queries of the students on the supervised works. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.
Problem solving	The professor will attend personally doubts and queries of the students on the resolution of the problems. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.
<b>Tests</b>	<b>Description</b>
Report of practices, practicum and external practices	The professor will attend personally doubts and queries of the students on the preparation and presentation of the memories of the results of the laboratory practices. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject.

<b>Assessment</b>				
	Description	Qualification	Evaluated Competences	
Laboratory practice	Execution practices of real or simulated tasks. These are tests in which the performance of the students will be evaluated on the basis of the knowledge shown, the behavior, organization and planning during the practice, reflection on the results obtained, etc.	20	CG1 CG4 CG8	CE29
Essay	It is a text prepared on a topic and should be written following established rules.	10	CG1 CG4 CG8	CE29
Essay questions exam	Tests that include open questions about a topic. Students must develop, relate, organize and present the knowledge they have about the subject in an extensive response.	20	CG1 CG4 CG8	CE29
Problem and/or exercise solving	Test in which the student must solve a series of problems and / or exercises in a time / conditions established by the teacher. In this way, students must apply the knowledge acquired.	25	CG1 CG4 CG8	CE29
Report of practices, practicum and external practices	Preparation of a report by the student in which the characteristics of the work carried out are reflected.	15	CG1 CG4 CG8	CE29
Systematic observation	Attentive, rational, planned and systematic perception to describe and record the manifestations of student behavior.	10	CG8	

### **Other comments on the Evaluation**

#### **1. First call: Continuous assessment**

The continuous evaluation consists of the following four parts:

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

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

Report of laboratory practices (15%).

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

Development questions (20%).

Problems (25%).

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

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

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

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

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

If it does not fulfill any of the previous requirements, the final mark will be the sum of the marks of each part, but limited to the 40% of the maximum note (4 points). Students who do not reach a minimum score of 40% in the laboratory evaluation,

exams and supervised work in the continuous assessment may recover them in the second opportunity tests while maintaining the percentages of the continuous assessment.

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

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

## 2. First call: Final exam

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

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

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

## 3. Second call

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

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### 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

#### 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

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

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### Recommendations

#### Subjects that it is recommended to have taken before

Digital and Analog Mixed Circuits/V05M145V01213

Analog Electronic Circuits Design/V05M145V01106

Advanced Digital Electronic Systems/V05M145V01203

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### Contingency plan

#### Description

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

##### Theory

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

##### Laboratory

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

##### Documentation and bibliography

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

## Evaluation

The contents and the distribution of marks in the evaluation, in both continuous and final, will keep independently of the format of teaching, face-to-face or no face-to-face.

As in the no face-to-face teaching, the objective acts of assessment will carry out in a synchronous way and using the remote available tools in CAMPUS REMOTO and FAITIC. In the practical part will be used the same platform and, moreover, the same free access simulator used in the practices.

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**IDENTIFYING DATA****Electronic Equipments Implementation and Exploitation**

Subject	Electronic Equipments Implementation and Exploitation			
Code	V05M145V01332			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language	Spanish			
Department				
Coordinator	Marcos Acevedo, Jorge			
Lecturers	López Sánchez, Óscar Marcos Acevedo, Jorge			
E-mail	acevedo@uvigo.es			
Web	<a href="http://fatic.uvigo.es/">http://fatic.uvigo.es/</a>			
General description	This subject includes concepts related with dependability analysis of complex electronic systems as well as their models. Also includes methodologies for electronic systems design for safety applications and EMC analysis. Finally it includes asset management and human resources.			

**Competencies**

Code	
CG3	CG3 Ability to lead, plan and monitor multidisciplinary teams.
CG7	CG7 Capacity for implementation and management of manufacturing processes of electronic and telecommunications equipment; guaranteeing safety for persons and property, the final quality of the products, and their homologation.
CE30	CE30 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

**Learning outcomes**

Learning outcomes	Competences
Ability to make an analysis of electromagnetic compatibility of an electronic system according the standards	CG7
Ability to design electronic equipment that includes specifications of maintainability and availability	CG7 CE30
Ability to specify the stocks level required for a given equipment maintainability	CG7
Ability to determine the life cycle cost of a product	CE30
Capacity to implement and manage the operation of electronic equipment	CG7
Ability to the assets management of an organization, related to the subject	CG3
Ability to understand the impact of risks, human reliability and knowledge management, in an organization	CG3

**Contents**

Topic	
Item 1: Dependability analysis of electronic systems.	Reliability allocation and optimization. Maintainability and availability analysis. Product life cycle.
Item 2: Modeling of electronic systems for dependability applications.	Markov models and Petri Nets.
Item 3: Failure analysis.	Failure modes of electronic components. Analysis of failure mechanisms and causes of the failure modes. Standards.
Item 4: Fail-safe systems.	Fault-safe systems specification. Design methodologies. Validation. Practical examples.
Item 5: Production and assembly of equipment electronic.	Materials and manufacturing processes. Mounting technologies. Lifetime assays. Installation cautions.
Item 6: Electromagnetic compatibility.	Analysis of EMC in circuits, systems and electronic equipments. Circuits and systems in living areas. Circuits and equipment systems of information technologies. Circuits and systems in automotive systems. Applications.
Item 7: Asset Management.	Asset management types. Management of physical assets: The Standard. Competence frames.
Item 8: The intellectual capital in organizations.	Intangible assets: Management. Human capital. Decision making.

**Planning**

	Class hours	Hours outside the classroom	Total hours
Lecturing	18	0	18
Laboratory practical	10	15	25
Problem solving	0	10	10
Mentored work	0	40	40
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

Methodologies	Description
Lecturing	It will develop in the schedules fixed by the direction of the engineering school. It consist of a presentation by the teacher, of the contents of the subject. Also proceed to solving examples and/or problems that illustrate the problems to be solved adequately. The student may submit all doubts and questions deemed appropriate, during the session. We will promote the more active participation of the student possible.  Competencias CG7, CG3 and CE30/SE3 are used
Laboratory practical	Students will perform practical examples of dependability analysis of electronic control systems, according to standards. The analysis will performed with specific software application.  Competencies CG7 and CG3 are used
Problem solving	In this educational activity we will propose problems and/or exercises subject related. They are also used to highlight the doubts and also for feedback to teachers on this aspect.  Competencias CG7, CG3 and CE30/SE3 are used
Mentored work	It consists in carrying out specific tasks that are elated to the subject and in collaboration with xternal entities, provided that this is possible.  Competencias CG7, CG3 and CE30/SE3 are used

### Personalized assistance

Methodologies	Description
Lecturing	The teacher will personally attend doubts and queries of students, on the study of theoretical, laboratory or projects. Students will have opportunity to attend individual tutorials or in groups in the teacher's office on schedule to be established for this purpose at the beginning of the course and to be published on the page of the subject.
Laboratory practical	The teacher will personally attend doubts and queries of students, on the study of theoretical, laboratory or projects. Students will have opportunity to attend individual tutorials or in groups in the teacher's office on schedule to be established for this purpose at the beginning of the course and to be published on the page of the subject.
Problem solving	The teacher will personally attend doubts and queries of students, on the study of theoretical, laboratory or projects. Students will have opportunity to attend individual tutorials or in groups in the teacher's office on schedule to be established for this purpose at the beginning of the course and to be published on the page of the subject.
Mentored work	The teacher will personally attend doubts and queries of students, on the study of theoretical, laboratory or projects. Students will have opportunity to attend individual tutorials or in groups in the teacher's office on schedule to be established for this purpose at the beginning of the course and to be published on the page of the subject.

### Assessment

	Description	Qualification	Evaluated Competencess	
Problem solving	Deliverables, problems and exercises will be assess.	40	CG3 CG7	CE30
Mentored work	They will evaluate the contents (methodology of development, conclusions obtained, exhibition of results and capacity of work in team)  For works in team the individual note will be the same for all members of the team	50	CG3 CG7	CE30
Objective questions exam	Exam of theory questions and / or exercises	10	CG3 CG7	CE30



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## Other comments on the Evaluation

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The deliverables of the troubles and exercises are provide for guidance, for weeks 2, 4, 6 and 8.

Following the own guidelines of the degree and the agreements of the academic commission, offers to the students the option of continuous evaluation or single evaluation in the date established by the centre.

The students that choose continuous evaluation will have to communicate it to the professor during the first week of class. The continuous evaluation supposes:

- a) The students realise the problems and exercises proposed by the professor and deliver them in time and form. Maximum assessment 4 points (40% of the final note). Will have to obtain a minimum note of 2 points. These tasks will not be recoverable later.
- b) The students realise a supervised work, in group. This work will procure, whenever it was possible, that realise with a company or external institution to the University. In this case the students will go to the company when it was necessary, for the realisation of the work. Maximum assessment 5 points (50% of the final note). Will have to obtain a minimum note of 2,5 points.
- c) The students realise a exam of theory questions and/or exercices. Maximum assessment 1 point (10%).

Students do not exceed any of the two minimum requirements, the rating will be the lower of the average grade of the two scores and 4.5 points.

Students working in groups will have the same grade.

The single evaluation by first call or second call, involves:

- a) That the students perform and deliver on exam day, the exercises and problems posed in the subject, which is referred to in paragraph a) above. Maximum rating 4 points (40% of the final mark). The students must obtain a minimum of 2 points.
- b) That the students to take an exam with questions and problems 2h corresponding to both the theoretical and laboratory. Maximum rating 6 points (60% of the final grade). The students must obtain a minimum of 3 points.

Students in single evaluation do not exceed any of the two minimum requirements, the rating will be the lower of the average grade of the two scores and 4.5 points.

It demands an ethical behaviour by part of the students. In case of plagiarism detection in any of the works/test realised the final qualification of the matter will be "suspense (0)" and the professors will communicate to the school direction the problem so that it take the measures that consider timely.

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## Sources of information

### Basic Bibliography

David J. Smith, **Reliability, Maintainability and Risk**, 8ª, Butterworth Heinemann, 2011

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

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

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## Recommendations

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**Subjects that are recommended to be taken simultaneously**

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Signal Conditioners/V05M145V01331

Photovoltaic Power Electronics/V05M145V01330

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**Subjects that it is recommended to have taken before**

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Digital and Analog Mixed Circuits/V05M145V01213

Hardware/Software Design of Embedded Systems/V05M145V01214

Integrated Circuits Design and Manufacturing/V05M145V01215

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**Contingency plan**

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**Description**

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=== ADAPTATION OF THE METHODOLOGIES ===

\* Teaching methodologies maintained

All methodologies are maintained except for the practices of the laboratory. The other methodologies carried out in remote.

\* Teaching methodologies modified

The practices of the laboratory will see modified of the following form: Of the 5 planned practices, 4 could be made of remote form since they base in the utilization of a PC and specific software. In the case of online tuition, we would look for an alternative so that the students can use it also in the remote. The other practice would do in the remote. The professor shows by means of a video the operation of the place of work and of his equipment takes the measures and the students treat said information and elaborate the corresponding memory.

\* Modifications (if applicable) of the contents

There are no changes.

\* Additional bibliography to facilitate self-learning

There are no changes. It will follow using the included bibliography in point 8, in addition to the additional documentation that is in FAITIC.

\* Other modifications

There are not more modifications.

=== ADAPTATION OF THE TESTS ===

The continuous evaluation does not change since it bases on the realization of tasks and works, so much individual how in a group, in addition to the realization of the practices of the laboratory. In the case of teaching, a non-face-to-face exam the presentation of the works will be in a remote.

If any student opts by the only evaluation, so much in first how in the second opportunity, the evaluation neither changes, excepting that the examination will be realized also in a remote.

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**IDENTIFYING DATA**

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**Electronic Equipment Practicals**

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Subject Electronic  
Equipment  
Practicals

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Code V05M145V01333

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Study Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

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Teaching  
language

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Department

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Coordinator

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Lecturers

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E-mail

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**IDENTIFYING DATA**

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**Telecommunications Seminar**

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Subject Telecommunications  
Seminar

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Code V05M145V01334

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Study Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

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Teaching  
language

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Department

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Coordinator

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Lecturers

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E-mail

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**IDENTIFYING DATA**

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**Piezoelectric Transducers and Applications**

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Subject Piezoelectric  
Transducers and  
Applications

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Code V05M145V01335

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Study Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st

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Teaching  
language

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Department

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Coordinator

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Lecturers

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E-mail

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

**IDENTIFYING DATA****Numerical Linear Algebra in Telecommunications Engineering**

Subject	Numerical Linear Algebra in Telecommunications Engineering			
Code	V05M145V01336			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	5	Optional	2nd	1st
Teaching language				
Department				
Coordinator				
Lecturers				
E-mail				

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

**IDENTIFYING DATA****Master Thesis**

Subject	Master Thesis			
Code	V05M145V01401			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Type	Year	Quadmester
	30	Mandatory	2nd	2nd
Teaching language	Spanish English			
Department				
Coordinator	Fernández Veiga, Manuel			
Lecturers	Fernández Veiga, Manuel			
E-mail	mveiga@det.uvigo.es			
Web	http://faticuvigo.es			
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.			

**Competencies**

Code	
CB1	CB1 Knowledge and understanding needed to provide a basis or opportunity for being original in developing and/or applying ideas, often within a research context.
CG1	CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas.
CG5	CG5 Capacity for development, strategic planning, direction, coordination and technical and financial management of projects in all fields of Telecommunication Engineering following quality and environmental criteria.
CG8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
CG11	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.
CG12	CG12 Skills for lifelong, self-directed and autonomous learning.
CE17	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.

**Learning outcomes**

Learning outcomes	Competences
Research, classification and structuring of information on some topic relevant to Telecommunications engineering.	CB1 CG8 CG12
Dissertation containing the fundamentals, the solution and an analysis of 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 results.	CG1 CG8 CG11 CE17
Design of prototypes, computer programs, circuits, procedures, algorithms, designs, methods, etc, complying to specifications	CB1 CG1 CG5 CG8 CG12

**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, which is published in the website of the School of Telecommunications Engineering	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	20	20
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, proposals of resolution of problems and/or exercises that will realise in the classroom or the laboratory of autonomous form by the students.
Case studies	It carries out a critical analysis of similar problems to the posed in the thesis, with the goal of extracting ideas, analogies, methods or partial results that help in the resolution of the problem posed in the thesis.
Project based learning	The student, individually, solves a scientific problem, originally and independently, within the thematic area of his/her interest, and is able to write a dissertation with the hypotheses, the solution and the conclusions of his work.
Problem solving	The student analyzes the possible solutions to a scientific problem proposed for the thesis, and elaborates a synthesis solution (analytical, meteorological, experimental or combined) that allow him to fulfill the stated goals.

## 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.

## Assessment

	Description	Qualification	Evaluated Competences
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 questions like 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: it will express by means of numerical final qualification of 0 to 10 according to the valid legislation.	100	CB1 CG1 CG5 CG8 CG11 CG12 CE17

## Other comments on the Evaluation

All the information related with the Master's Thesis can be accessed on the web of the School of Engineering of Telecommunication. Students and professors can also see individual information about the Master's Thesis in their online administrative office.

## Sources of information

### Basic Bibliography

### Complementary Bibliography

## Recommendations

## Contingency plan

### Description

In the event that the teaching activities have to be suspended or restricted due to a public health situation, all the activities spanned by the Master's thesis will be carried out online through the tools enabled by the University of Vigo. Eventually, the public defense of the thesis will take place online, too. The laboratory duties will be replaced by other equivalent activities, agreed between advisors and their students, which guarantee the fulfillment of the competences and can be executed online.



**IDENTIFYING DATA****(\*)Comunicación de Datos**

Subject (\*)Comunicación de  
Datos

Code V05M145V01CFG300301

Study Telecommunication  
programme Engineering

Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	1st

Teaching  
language

Department

Coordinator Herrería Alonso, Sergio

Lecturers Herrería Alonso, Sergio

E-mail sha@det.uvigo.es

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**IDENTIFYING DATA****(\*)Transmisión Electromagnética**

Subject (\*)Transmisión  
Electromagnética

Code V05M145V01CFG300303

Study Telecommunication  
programme Engineering

Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	2nd

Teaching  
language

Department

Coordinator Vera Isasa, María

Lecturers Vera Isasa, María

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**IDENTIFYING DATA**

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**(\*)Procesado Dixital de Sinais**

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Subject (\*)Procesado Dixital de Sinais

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Code V05M145V01CFG300304

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Study Telecommunication programme Engineering

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Descriptors ECTS Credits	Type	Year	Quadmester
6	Optional	1st	1st

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Teaching language

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Department

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Coordinator Docio Fernández, Laura

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**IDENTIFYING DATA****(\*)Redes de Ordenadores**

Subject (\*)Redes de  
Ordenadores

Code V05M145V01CFG300403

Study Telecommunication  
programme Engineering

Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	2nd

Teaching  
language

Department

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**IDENTIFYING DATA**

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**(\*)Técnicas de Transmisión e Recepción de Sinais**

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Subject (\*)Técnicas de  
Transmisión e Recepción  
de Sinais

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Code V05M145V01CFG300404

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Study Telecommunication  
programme Engineering

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Descriptors	ECTS Credits	Type	Year	Quadmester
	6	Optional	1st	2nd

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Teaching  
language

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Department

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**IDENTIFYING DATA****(\*)Servizos de Internet**

Subject (\*)Servizos de Internet

Code V05M145V01CFG300501

Study Telecommunication

programme Engineering

Descriptors ECTS Credits

6

Type

Optional

Year

1st

Quadmester

1st

Teaching

language

Department

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