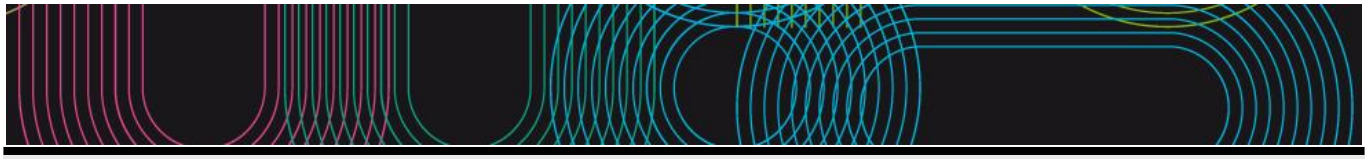

# (*)Escola de Enxeñaría de Telecomunicación

## Telecommunication Engineering

**Subjects**

**Year 1st**

| Code | Name | Quadmester | Total Cr. |
|---|---|---|---|
| V05M145V01101 | A Enxeñaría de Telecomunicación na Sociedade da Información | 1st | 5 |
| V05M145V01102 | Tratamento de Sinal en Comunicacións | 1st | 5 |
| V05M145V01103 | Radio | 1st | 5 |
| V05M145V01104 | Tecnoloxías de Rede | 1st | 5 |
| V05M145V01105 | Tecnoloxías de Aplicación | 1st | 5 |
| V05M145V01106 | Deseño de Circuitos Electrónicos Analóxicos | 1st | 5 |
| V05M145V01201 | Dirección de Proxectos de Telecomunicación | 2nd | 5 |
| V05M145V01202 | Electrónica e Fotónica para Comunicacións | 2nd | 5 |
| V05M145V01203 | Sistemas Electrónicos Dixitais Avanzados | 2nd | 5 |
| V05M145V01204 | Comunicacións Dixitais Avanzadas | 2nd | 5 |
| V05M145V01205 | Procesado de Sinal en Sistemas Audiovisuais | 2nd | 5 |
| V05M145V01206 | Comunicacións Multimedia | 2nd | 5 |
| V05M145V01207 | Comunicacións Ópticas | 2nd | 5 |
| V05M145V01208 | Antenas | 2nd | 5 |
| V05M145V01209 | Laboratorio de Radio | 2nd | 5 |
| V05M145V01210 | Enxeñaría de Internet | 2nd | 5 |
| V05M145V01211 | Redes sen Fíos e Computación Ubicua | 2nd | 5 |
| V05M145V01212 | Enxeñaría Web | 2nd | 5 |
| V05M145V01213 | Circuítos Mixtos Analóxicos e Dixitais | 2nd | 5 |
| V05M145V01214 | Codeseño Hardware/Software de Sistemas Empotrados | 2nd | 5 |
| V05M145V01215 | Deseño e Fabricación de Circuítos Integrados | 2nd | 5 |

**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 | Ténicas 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 Móbiles | 1st | 5 |
| V05M145V01311 | Satélites | 1st | 5 |
| V05M145V01312 | Sistemas de Radio en Banda Larga | 1st | 5 |
| V05M145V01313 | Comunicacións Móbiles e sen Fíos | 1st | 5 |
| V05M145V01314 | Radionavegación | 1st | 5 |
| V05M145V01315 | Redes Ópticas | 1st | 5 |
| V05M145V01316 | Radar | 1st | 5 |
| V05M145V01317 | Deseño de Circuítos 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 | Álxebra Lineal Numérica en Enxeñaría de Telecomunicación | 1st | 5 |
| V05M145V01401 | Traballo Fin de Máster | 2nd | 30 |

**Year 1st**

| Code | Name | Quadmester | Total Cr. |
|---|---|---|---|
| V05M145V01403 | Redes de Ordenadores | 2nd | 6 |
| V05M145V01404 | Técnicas de Transmisión e Recepción de Sinais | 2nd | 6 |
| V05M145V01501 | 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<br>Galician | | | |
| Department | | | | |
| Coordinator | Cuiñas Gómez, Íñigo | | | |
| Lecturers | Caeiro Rodríguez, Manuel<br>Cuiñas Gómez, Íñigo<br>Fernández Iglesias, Manuel José<br>Mariño Espiñeira, Perfecto | | | |
| E-mail | inhigo@uvigo.es | | | |
| Web | http://faitic.uvigo.es | | | |
| General description | This subject looks for proposing 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 take consciousness 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:<br>1) The 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 (history oriented to future action, no to the contemplation of the past).<br>2) The engineering activities have direct influence in the own society, in how people live or in how they relate. In fact, the big changes of the last decades have been starred directly by contributions of the field of the Engineering of Telecommunication. This influence has to go accompanied of taking of consciousness of the ethical responsibility. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know be |
| 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. | - know |
| CG9 | CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering. | - Know be |
| CG13 | CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering. | - know<br>- Know How |
| 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. | - Know How |
| CT3 | CT3 Understanding Engineering in a framework for sustainable development. | - Know be |
| 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. | - know<br>- Know be |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Knowledge of what the profession of Telecommunicationis Engineering is and what represents. | CG7<br>CG13<br>CT4 |

| | |
|---|---|
| Taking of consciousness of the social responsibility, ethical and environmental of Telecommunication Engineering. | CB3<br>CG9<br>CT3<br>CT4 |
| Contact with other disciplines in which the technologies of Telecommunication integrate for the development of the society: bioengineering, solar energy, nanotechnologies, tele-medicine, teleasistance, teleeducation. | CE15 |

| **Contents** | |
|---|---|
| Topic | |
| Seminar on the Engineering in the Society | 1. Professional activity and ethic implications.<br>Description of the professional activity of Engineers (to be possible former students at the School), the thic implications of their works, and other aspects of professional development (EuroPass, professional association, activity ambits). The students interact with speakers.<br><br>2. Social implication by means of Design Thinking.<br>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.<br><br>Related competencies: CE15, CT4, CB3 and CG9 |
| Professional attributions and their history | Historically, there are eight historical professional attributions assigned to Telecommunication Engineering. Along this item, we will center on the historical development of systems or applications related with tem, as well as on the National and European legislation that applies:<br>* Television<br>* Wire communications (including the small local history: Vigo was the base of German and British cableships)<br>* Radioelectric spectrum (description and management, taking into account National and International legislation)<br>* Internet and its influence in Society<br>* Mobile telephony (including effects on health)<br>* Experts official reports.<br><br>Related competencies: CG13 and CT3 |
| In a multidisciplinary society | The proposal for the work in groups C is centered in the resolution of problems or situations of the society in which we live, no strictly related with the Telecommunication Engineering, so that the students comprise his implication in multiple fields of the society and how can influence in her with solutions posed from his competencies and engineering skills.<br><br>Related competencies: CG7, CE15, CT3 and CT4 |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Seminars | 14 | 15 | 29 |
| Projects | 5 | 70 | 75 |
| Master Session | 9 | 10 | 19 |
| Long answer tests and development | 2 | 0 | 2 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| **Methodologies** |
|---|
| Description |

| | |
|---|---|
| Seminars | Teaching in seminar format, in which the student participates very actively in the evolution of the classes deepening in a specific subject, expanding it and relating it with contents oriented to the professional practice; including the participation in scientific events and/or informative, organised or no in the own School; the organisation of debates that allow sharing ideas and proposals, guided by lecturers, both face-to-face or on-line; and the study of cases/analysis of situations (analysis of a problem or real case, with the purpose to know it, interpret it, resolve it, generate hypothesis, diagnose it and going deep in alternative procedures of solution, to see the application of the theoretical concepts in the reality). These activities can have related a load of autonomous work of the student.<br><br>The subject "Seminar on Engineering and Society", and related debates, are taught following this methodology.<br><br>Competencies worked: with this methodology we work the competencies CB3, CG7, CG9, CG13 and CT4 |
| Projects | Realisation of works, individual or in group, for the resolution of a case or a concrete project, as well as the presentation of the results by writing and/or by means of a presentation that can follow different formats: oral, poster, multimedia. They include the integrated Methodologies: learning based in problems (LBP), resolution of problems of design proposed by the professor, and education based in projects of learning (PBL).<br><br>Teachers will create groups, using as selection criteria the results of a personality test done by the students at first session. The objective is to obtain heterogeneous groups, and externally selected, as at an actual company.<br><br>The student, in group, prepares a work providing a solution to a clear-cut problem according to the methodology Design Thinking, identifying situations of the daily life that a priori do not relate with the Telecommunication. Design Thinking methodology develops with the following steps: finding, interpreting, thinking, experimenting, and evolving.<br>The solution has to take into account both technical and legal, environmental, social and sustainability aspects.<br><br>Following Design Thinking methodology, an area of actuation will be identified and the first step will be searching for news on a subject proposed by each group (for example location of missing aeroplanes in the sea, integration vs. exclusion of communities in risk of vulnerability -elderly, third world, rural-, etc.). Students will pose imaginative solutions and will treat to find a proposal that would be reasonable, although it can not being still implementable given the current technological development.<br>The final objective is not to build or program a solution, but it is to look for a proposal that is valid, today or in the future, and would be socially acceptable.<br><br>The groups will begin for locating real news related. From them, they will treat to identify people implied in similar situations and they will try to empathy with them, in order to explain the problem they feel (and not the problem that we seem to identify from outside). From this explained problem groups will ideate technological or procedural solutions . They will have to look for technical and scientific information on these and, finally, elaborate a prototype, a report and a presentation.<br>The result of this activity could be documented through a service on line type forum or wiki. Also, a document of presentation or video will produce to be used in the final presentation of the work developed to the class. Both results will be evaluated based on previously known rubrics.<br>The interaction with the lecturers will be face-to-face with five meetings of one hour, and through forums during the research of information, and by email for the exchange of ideas.<br><br>The subject "At a Multidisciplinary Society" fits with this methodology.<br><br>Competencies worked: with this methodology work the competencies CB3, CE15/GT1, CG9 and CT4 |
| Master Session | Explanation of the contents of the subject; it includes explanation of concepts; introduction of practices and exercises; and resolution of problems and/or exercises in ordinary classroom.<br><br>The subject "Professional attributions and its history" fits with this methodology.<br><br>Competencies worked: with this methodology work the competencies CG7, CG9 and CT3 |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| Master Session | 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 |

| | |
|---|---|
| Projects | Time that group-C lecturers use to help their students during their projects development, added to the schedulled meetings |

| **Tests** | Description |
|---|---|
| Long answer tests and development | Time that lecturers use to help the students to understand the contents of assessment exercises and to review with them, individually, those exercises once corrected. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Master Session | Long answer tests: there will be 2 proofs, of 30 minutes length, that will liberate contents of the previous subjects.<br><br>In these long proofs we will evaluate the competencies CG7, CG9 and CT3 | 30 | CG7<br>CG9<br>CT3 |
| 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.<br><br>With these short answer tests and the observations we will evaluate the competencies CB3, CG7, CG9, CG13 and CT4 | 20 | CB3<br>CG7<br>CG9<br>CG13<br>CT4 |
| Projects | Practical proofs: The realisation of the works in groups will be evaluated in two parts: the own dynamics of the works and the presentations. The student will receive 25% of the note by the own work; evaluated to 50% by the lecturer that directs the work and by the group of professors of the matter.<br>Related to the presentation, the student will receive another 25%, evaluated by his/her mates (evaluation by pairs) according to a rubric that will be approved before the beginning of the works.<br><br>With these works we will evaluate the competencies CB3, CE15/GT1, CG9 and CT4 | 50 | CB3<br>CG9<br>CE15<br>CT4 |
| Long answer tests and development | The final examination, 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<br>CG7<br>CG9<br>CG13<br>CE15<br>CT3<br>CT4 |

**Other comments and July evaluation**

Thestudents can chose any of the following assessment systems:

1.- The **continuous assessment** 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.- **FInal 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 final exam is one that is done in the official dates marked on School Board in the months of December or January (or July in the case of special consideration), and who are obliged to attend 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 resit exam will have a similar structure to the final exam.

**Ethical code**

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

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

| **Sources of information** |
|---|
| **Basic Bibliography** |
| O. Pérez Sanjuán, De las señales de humo a la Sociedad del Conocimiento, COIT-AEIT, 2006 |
| VV.AA., Design Thinking for Educators, www.designthinkingforeducators.com/toolkit/, 2012 |
| **Complementary Bibliography** |
| C. Rico, Crónicas y testimonios de las Telecomunicaciones españolas, COIT-AEIT, 2006 |
| O. Pérez Sanjuán, Detrás de la cámara, COIT-AEIT, 2008 |
| J. Cabanelas, Vía Vigo: el Cable Inglés – el Cable Alemán, Instituto de Estudios Vigueses, 2013 |

| **Recommendations** |
|---|
| **Subjects that continue the syllabus** |
| Telecommunication Projects Management/V05M145V01201 |

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know<br>- Know How |
| 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. | - Know How<br>- Know be |
| 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. | - know<br>- Know How |
| CE2 | CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning. | - know<br>- Know How |
| CE3 | CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments. | - know |

| 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<br>CE1 |
| Ability to implement advanced signal processing techniques in diverse fields of application: bioengineering, bioinformatics, etc. | CG4<br>CG8 |
| Ability to apply signal processing techniques to the modeling and simulation of communication systems | CG4<br>CE1<br>CE2 |
| Ability to simulate the physical layer of cable, wireline, satellite systems in fixed/mobile communication environments. | CG4<br>CG8<br>CE2<br>CE3 |

| Contents | |
|---|---|
| Topic | |
| Chapter 1: Block-based Transforms in Communications and Multimedia | - DFT: formulation and properties.<br>- Frequency Analysis based on DFT. Windowing.<br>- Power Spectrum Estimation: Welch's periodogram<br>- DFT-based digital modulation schemes: DMT, OFDM.<br>- DCT: formulation and properties.<br>- Transform domain coding. |

| | |
|---|---|
| Lab Assignment 1: Sampling and quantization | - Aliasing<br>- Baseband and bandpass sampling<br>- Quantization noise<br>- Converter overload<br>- Spurious-free dynamic range<br>- Sampling jitter |
| Lab Assignment 2: Simulation of a multicarrier-based digital communication system | -Experimental study of the diverse effects and tradeoffs involved in the design of the transmitter and receiver of a multicarrier communication system. |
| Chapter 2: Adaptive Filtering and Estimation | - Minimum Mean Squared Error criterion<br>- Wiener filter<br>- LMS adaptive filters<br>- Least Squares criterion |
| Lab Assignment 3: Adaptive Filtering | - LMS and NLMS Algorithms<br>- Simulation in a channel equalization context<br>- Simulation in an echo/interference cancellation context |
| Chapter 3: Multirate Processing and Filter Banks | - Sampling rate conversion: decimation, interpolation<br>- Multirate filters: polyphase decomposition<br>- Applications: digital transceivers, filter banks |
| Final Project | - The student will develop the design of a signal processing system involving several aspects covered during the course, and meeting a series of specifications/requirements. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 18 | 18 | 36 |
| Laboratory practises | 20 | 20 | 40 |
| Autonomous practices through ICT | 0 | 40 | 40 |
| Long answer tests and development | 2 | 0 | 2 |
| Reports / memories of practice | 0 | 5 | 5 |
| Jobs and projects | 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 |
|---|---|
| Master Session | Presentation of main topics, possibly with audiovisual aids. Applied/theoretical problem sessions. Skills involved: CG4, CG8. |
| Laboratory practises | Under the guidance of the instructor, students will develop the design and/or simulation of a signal processing system involving several of the techniques studied during the course. Skills involved: CE1, CE2, CE3. |
| Autonomous practices through ICT | Computer-based simulation of signal processing applications to communications and multimedia. Skills involved: CE1, CE2, CE3. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Laboratory practises | Student aid will be provided during office hours as well as on-line (email). An on-line discussion forum will be set up for the course, through the usual e-learning platform |
| Master Session | Student aid will be provided during office hours as well as on-line (email). An on-line discussion forum will be set up for the course, through the usual e-learning platform |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Long answer tests and development | Final test in which the student must solve a series of exercises. | 40 | CG4<br>CE1<br>CE2 |

| | | | |
|---|---|---|---|
| Reports / memories of practice | 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. | 40 | CG4<br>CG8<br>CE1<br>CE2 |
| Jobs and projects | Written report describing the developed design and obtained results for the final project. In general, they will be carried out in groups of three, and all three members 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. | 20 | CG4<br>CG8<br>CE1<br>CE2<br>CE3 |

## Other comments and July evaluation

Students may choose one of the following two assessment options:

1) Continuous assessment: Final grade will consist of:

- comprehensive test (up to 4 points)

- lab reports (up to 4 points)

- final project (up to 2 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 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 resubmit the final project and/or 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.

Any kind of plagiarism will result in automatically failing the course.

It is assumed that the student chooses the continuous assessment mode as soon as he/she turns in a lab report and/or final project 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, 2011

J.G. Proakis and D.G. Manolakis, Digital Signal Processing, 4th, 2006

### Complementary Bibliography

Behrouz Farhang-Boroujeny, Signal Processing Techniques for Software Radios, 2nd, 2010

S. Haykin, Adaptive Filter Theory, 4th, 2001

P.P. Vaidyanathan, Multirate systems and Filter Banks, 1993

F. Harris, Multirate Signal Processing for Communication Systems, 2004

T. K. Moon, W. C. Stirling, Mathematical methods and algorithms for signal processing, 1st, 2000

## 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.

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Radiocommunication** | | | | |
| Subject | Radiocommunication | | | |
| Code | V05M145V01103 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Mandatory | 1st | 1st |
| Teaching language | Spanish | | | |
| Department | | | | |
| Coordinator | Arias Acuña, Alberto Marcos | | | |
| Lecturers | Arias Acuña, Alberto Marcos<br>Rubiños López, José Óscar<br>Vazquez Alejos, Ana | | | |
| 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.<br>These concepts apply to the study of the services of radar and radiolocalization. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How |
| 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. | - Know How |
| CE2 | CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning. | - Know How |
| CE3 | CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments. | - Know How |
| CE5 | CE5 Ability to design systems of radio navigation and positioning, as well as radar systems. | - Know How |

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

| Contents | |
|---|---|
| Topic | |
| 1. Basic design of antennas | 1.1 Fundamental electromagnetic laws<br>1.2 Trasmitting antenna<br>1.3 Receiving antenna<br>1.4 Bands of frequency<br>1.5 Types of antennas<br>1.6 Friis Formula<br>1.7 Transmission losses |

| | |
|---|---|
| 2. Models of noise and interferences | 2.1 Thermal Noise<br>2.2 Antenna Noise<br>2.3 Noise Factor and noise temperature of a receptor<br>2.4 Concept and types of interferences<br>2.5 Characterisation of the interference<br>2.6 Concept of availability, fading and diversity<br>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.<br>3.2 Tropospheric propagation.<br>3.3 Propagtion losses |
| 4. Design of Radionavigation systems | 4.1 Fundamentals of radionavigation<br>4.2 Types of radionavigation systems<br>4.3 Satellite radionavigation systems<br>4.4 Design of a radionavigation system |
| 5. Design of radar systems | 5.1 Fundamentals of radar systems. Radar cross section<br>5.2 Types of radar systems<br>5.3 Design of a radar system |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 20 | 20 | 40 |
| Seminars | 4 | 24 | 28 |
| Laboratory practises | 13 | 13 | 26 |
| Short answer tests | 1 | 10 | 11 |
| Long answer tests and development | 1 | 10 | 11 |
| Other | 1 | 8 | 9 |

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

**Methodologies**

| | Description |
|---|---|
| Master Session | Exhibition of the contents of the subject; it includes exhibition of concepts; introduction of practices and exercises; and resolution of problems and/or exercises in ordinary classroom. |
| Seminars | Teaching for few students; they 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. These activities can have related a load of autonomous work of the student. |
| Laboratory practises | Application, to practical level, of the knowledges and skills adquired in the theoretical classes, by means of practices realised with equipment of test and measure. Also including practical of laboratory realised on computers (simulations, analysis, processed, etc.), exercises of programming, on-line realised works, etc. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | 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 practises | Each student will be attended in an individual way. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Short answer tests | 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<br>CB4<br>CE2<br>CE5 |

| | | | |
|---|---|---|---|
| Long answer tests and development | Final exam: it consists in a proof for the evaluation of the competencies adquired by the students. They will have to develop, organise and present the knowledges adquired during the course. | 20 | CB2<br>CB4<br>CE2<br>CE5 |
| Other | Participation in activities by part of the students, especially of the practices. This section corresponds to the continuous evaluation of the student. | 30 | CB2<br>CB4<br>CE2<br>CE5 |

**Other comments and July evaluation**

The final examination, that will consist of the proof of short answer and the proof of development will represent 70% for the students that opt by continuous evaluation and 100% of the final note in case of not opting by the continuous evaluation.

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

**Sources of information**

**Basic Bibliography**

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

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

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

**Complementary Bibliography**

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

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

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

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

ITU-R, Recommendations,

**Recommendations**

**Subjects that continue the syllabus**

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

| 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 | Galician | | | |
| Department | | | | |
| Coordinator | López Ardao, José Carlos | | | |
| Lecturers | López Ardao, José Carlos | | | |
| E-mail | jardao@det.uvigo.es | | | |
| Web | http://www.socialwire.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.<br><br>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 | | Typology |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - know |
| CE4 | CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals. | - know<br>- Know How |
| CE6 | CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Know how to model mathematically the essential elements of a network of telecommunications | CB5<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>CE7 |

| | |
|---|---|
| Understand the fundamental results on the capacity for different types of networks | CG1<br>CG4<br>CG8<br>CE4<br>CE6<br>CE7 |
| Understand, formulate and solve simple models for analyzing the performance of a computer network | CG1<br>CG4<br>CG8<br>CE4<br>CE6<br>CE7<br>CE12 |
| Know how to plan, design and deploy switched networks and IP networks in any application environment | CB5<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>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<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>CE12 |

| **Contents** | |
|---|---|
| Topic | |
| 1. Network modeling (I) | a) Links: Statistical Multiplexing and queues<br>b) Analysis of delays and losses in queues |
| 2. Network modeling (II) | a) Modeling of queues<br>b) Networks of queues |
| 3. Network modeling (III) | a) Flow Networks<br>b) Resoure Allocation<br>c) Switching Architectures<br>d) Scheduling in switches |
| 4. Design and planning of Ethernet networks (I) | a) Management and planning of VLANs.<br>b) VLAN Trunking. QinQ<br>c) VTP |
| 5. Design and planning of Ethernet networks (II) | a) Advanced STP<br>b) Link Aggregation<br>c) Guidelines for network planning |
| 6. Interdomain Routing in Internet (I) | a) Hierarchical Routing in Internet. Domains and ASes<br>b) Algorithms for Interdomain Routing<br>c) EIGRP |
| 7. Interdomain Routing in Internet (II) | a) OSPF |
| 8. Inter-AS Routing | a) BGP |
| 9. Design and planning of IP networks | a) Access Lists, route maps and prefix lists<br>b) Route Filtering<br>c) Traffic Filtering<br>d) NAT<br>e) DHCP |
| 10. Traffic Engineering and MPLS | a) Traffic Engineering<br>b) Basic Concepts about MPLS<br>c) Label Distribution: LDP<br>d) MPLS-TE |

| | |
|---|---|
| 11. Quality of service | a) Basic Concepts of QoS<br>b) Traffic Classification and marking<br>c) Traffic Shaping and Policing<br>d) Active Queue Management (AQM)<br>e) Bandwidth Scheduling<br>f) DiffServ Architecture |
| 12. Multimedia and Internet | a) Multimedia Applications: Types (VoIP, IPTV vs OTT, VoD, etc.) and requirements<br>b) Impact of the delay and losses in multimedia applications<br>c) Systems of Streaming Multimedia: UDP/RTP and HTTP<br>d) Multicast. IGMP<br>e) Access Networks for IPTV |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Laboratory practises | 9 | 13.5 | 22.5 |
| Autonomous troubleshooting and / or exercises | 0 | 17.5 | 17.5 |
| Master Session | 27 | 54 | 81 |
| Long answer tests and development | 2 | 0 | 2 |
| Long answer tests and development | 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 practises | Practices of design, planning and architecture in different network scenarios and with different protocols, using GNS3 emulator. This methodology is related to the competencies CG1, CG4, CG8, CE4, CE6, CE7, CE12 |
| Autonomous troubleshooting and / or exercises | This activities will entail the development of autonomous exercises, tasks, tests, etc. by the student. With this methodology will work the competitions CB5, CG1, CG4, CG8, CG12, CE4, CE6, CE7, CE12 |
| Master Session | Exposition of the ideas, concepts, technical and algorithms belonging to the lessons of the course. This also includes the resolution of problems and theoretical questions in the classroom, and two sessions of an hour for midterm exams, and a session of two hours for the final exam. With this methodology will work the competitions CG1, CG4, CG8, CE4, CE6, CE7, CE12 |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | Individually personalized attention and attendance will be dispensed. The tutorial schedule will be announced at the beginning of the course. No appointment is necessary. |
| Laboratory practises | Individually personalized attention and attendance will be dispensed. The tutorial schedule will be announced at the beginning of the course. No appointment is necessary. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Autonomous troubleshooting and / or exercises | Along the term, exercises, questions and tests must be done in the virtual classroom by all the students in an autonomous way. These tasks have a global weight of 10% | 10 | CB5<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>CE7<br>CE12 |

| | | | |
|---|---|---|---|
| Long answer tests and development | Two exams will be done. The first one will cover lessons 1 to 5 and the second one lessons 6 to 9. Each partial exam has a 20% weight. | 40 | CG1<br>CG4<br>CG8<br>CE4<br>CE6<br>CE7<br>CE12 |
| Long answer tests and development | Final exam covering all the lessons. It supposes a weight of 50% but a minimum qualification of 3.5 points on 10 is required | 50 | CG1<br>CG4<br>CG8<br>CE4<br>CE6<br>CE7<br>CE12 |

**Other comments and July evaluation**

The students can choose the evaluation method, continuous or single.

Continuous Evaluation (CE) will consist of:

- Two midterm exams (ME1 and ME2) in weeks 7 and 11, covering, respectively, the contents of the lessons 1 to 5, and 6 to 9. Each midterm exam has a 20% weight in the Final Qualification (FQ).
- Participation in the online activities (OA) in virtual environment, that represent 10% of the Final Qualification (FQ).
- A final exam (FE) covering all contents, with a weight of 50% of the Final Qualification (FQ). A minimum qualification of 3.5 points on 10 is required

FQ-CE = 0.2x(ME1 + ME2) + 0.1xOA + 0,5xFE if FE >= 3.5

FQ-CE = FE if FE< 3.5

Single evaluation (SE) will only consist of the same FE at the end of the term.

It is considered that a student chooses CE when presenting to any midterm exam, election to be held until end of course.

Students who do not present to any midterm exam, compulsorily opt for the Single Evaluation.

A new final exam (FE) will be done in the official dates in July, in order to improve the qualification with respect to May,

The qualifications for all exams, partial or final, and activities will affect only the actual academic year.

In case of detection of plagiarism in any of the works/test/exams, the final qualification will be Suspense (0) and this case will be communicated to the School Head.

**Sources of information**

**Basic Bibliography**

J.F. Kurose, K.W. Ross, Computer networking: a top-down approach featuring the Internet, 7ª, 2016

**Complementary Bibliography**

R. Srikant & Lei Ying, Communication Networks, Cambridge University Press, 2014

Villy B. Iversen, Teletraffic Engineering Handbook, Web, 2011

Villy B. Iversen, Teletraffic Engineering and Network Planning, Web, 2010

Kun I. Park, QoS in packet networks, 1ª, 2005

Pazos Arias, J.J., Suárez González, A., Díaz Redondo, R.P., Teoría de colas y simulación de eventos discretos, 2003

M.J. Newman, Networks, Oxford Univ. Press, 2012

Diane Teare, Implementing Cisco IP Routing (ROUTE) Foundation Learning Guide, Cisco Press, 2015

Richard Froom, Balaji Sivasubramanian, Erum Frahim, Implementing Cisco IP Switched Networks (SWITCH) Foundation Learning Guide, Cisco Press, 2015

**Recommendations**

**Subjects that continue the syllabus**

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

(*)Redes de Ordenadores/V05M145V01403

| 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 | Spanish | | | |
| Department | | | | |
| Coordinator | Díaz Redondo, Rebeca Pilar | | | |
| Lecturers | Díaz Redondo, Rebeca Pilar<br>Fernández Vilas, Ana | | | |
| E-mail | rebeca@det.uvigo.es | | | |
| Web | http://faitic.uvigo.es/ | | | |
| General description | Students will obtain a global picture of the main technological resources to design telematics applications. Basic problems like distributed computing, interoperability and services discovering will be addressed. These concepts will be study in the framework of the cloud computing paradigm. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - know<br>- Know How |
| CE4 | CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals. | - Know How |
| 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. | - Know How |
| 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. | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Know and apply the different communication techniques for communication and distributed computing | CB5<br>CG1<br>CG4<br>CG12<br>CE4 |
| Know and apply the techniques for data sharing to enable interoperability among systems and/or services | CB5<br>CG1<br>CG8<br>CG12<br>CE4<br>CE9 |

| | |
|---|---|
| Know and apply how to specify and discover software services to be integrated in complex telematic solutions | CB5<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE9 |
| Know and apply virtualization concepts : cloud computing and content distribution networks. | CB5<br>CG1<br>CG12<br>CE4<br>CE8 |

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

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Laboratory practises | 13 | 26 | 39 |
| Master Session | 22 | 29 | 51 |
| Practical tests, real task execution and / or simulated. | 3 | 30 | 33 |
| Short answer tests | 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 practises | Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions.<br><br>We will focus on skills EC9, EC8, EC4, CG12, CG8 and CB5. |
| Master Session | Teachers will combine both concepts explanation and toy examples resolution.<br>Resolution of small situations at class will foster debates, especially if it is done in groups.<br><br>We will focus on skills CG1, CG4, CG12 and CE8 |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |

| | |
|---|---|
| Master Session | 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 practises | Students will design and develop small prototypes and software solutions to reinforce the theoretical concepts explained in master sessions. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Practical tests, real task execution and / or simulated. | Students willl design and implement software solutions for different small problems. | 40 | CB5<br>CG1<br>CG8<br>CG12<br>CE4<br>CE8 |
| Short answer tests | Written exam wich combines test and short answer questions. No extra material is allowed. | 60 | CB5<br>CG4<br>CG8<br>CG12<br>CE8<br>CE9 |

**Other comments and July evaluation**

Students can follow up a continuous assessment model or decide to do a final exam. This selection should be done by 7th week. 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 weighted geometric mean formula with two partial results: (i) written exam (60%) and (ii) practical assignments (40%).

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

**Practical assignments**:

1- Continuous assessment: 2 intermediate assignments on 7th week and 13th week.

2- Final assessment: 1 assignment on 13th week.

Extraordinary assessment scheme is exactly the same as the final assessment.

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

**Sources of information**

**Basic Bibliography**

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

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

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

**Complementary Bibliography**

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

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

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

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

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

**Recommendations**

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know |
| 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. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| CE14 | CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors. | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Know analyse and design analogue electronic circuits of low frequency. | CB4<br>CG4<br>CG8<br>CE12<br>CE14 |

| | |
|---|---|
| Know the parts that constitute an electronic measurement system. | CB5<br>CG4<br>CE12<br>CE14 |
| Know the principle of operation of sensors and their conditioners. | CB5<br>CG4<br>CE12<br>CE14 |
| Know model an analogue electronic system by means of hardware description languages. | CB4<br>CG4<br>CG8<br>CE12<br>CE14 |

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

| | |
|---|---|
| Unit 4: Active filters | Introduction:<br>Fundamentals. Basic filter types. Real parameters.<br><br>Description by transfer function:<br>Introduction. Transfer function: poles and zeros, stability analysis and frequency response. First order and second order filters.<br><br>Approximation of filter transfer function:<br>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: Butterworth and Chebyshev.<br><br>Synthesis:<br>Introduction. Methods. Direct design. Basic topologies of direct synthesis: voltage control voltage source (KRC or Sallen-Key) and Multiple Feedback (MFB). Cascade design. Comparison of methods. Scaling.<br><br>Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed. |
| Unit 5. Sample-and-hold circuits.<br>Digital-to-analog and analog-to-digital converters | Sample-and-hold circuits:<br>Background. Specifications. Architectures. Commercial devices.<br><br>Analog-to-digital converters:<br>Introduction. Fabrication parameters. Errors. Full-flash converters. Semi-flash converters (sub-ranging). Pipeline converters. Integrating converters: single or double analogue slope. Successive approximation converters. Commercial devices.<br><br>Digital-to-analog converters:<br>Introduction. Fabrication parameters. Errors. Linear resistive network. Weighted resistive network. R-2R resistor ladder network.<br><br>Through this unit the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed. |
| Practice 1: Auxiliary circuits. | Assembly and testing of a voltage reference. Assembly and testing of a current source.<br><br>Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed. |
| Practice 2: Instrumentation amplifier. | Assembly and testing of and three-op-amp based instrumentation amplifier from discreet components. Assembly and testing of an commercial instrumentation amplifier with adjustable gain by potentiometer.<br><br>Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed. |
| Practice 3: Active filters. | Assembly 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).<br><br>Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed. |
| Practice 4: Digital-to-analog conversion. | Assembly and testing of a discrete converter of 3 bits based on R-2R resistor ladder network. Calculation of ideal characteristic parameters. Measurement of real parameters. Plot the converter transfer function.<br><br>In this practice will work the competitions CB4, CB5, CG4, CG8, CE12 and CE14. |
| Practice 5: Measurement system of a physical variable using a commercial sensor. | Design of the signal conditioning circuit of a measurement system based on a commercial sensor and some circuits used in previous practices.<br><br>Through this practice the competencies CB4, CB5, CG4, CG8, CE12 and CE14 are developed. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Introductory activities | 1 | 2 | 3 |
| Master Session | 13 | 19 | 32 |
| Troubleshooting and / or exercises | 8 | 12 | 20 |
| Others | 5 | 12 | 17 |
| Laboratory practises | 10 | 10 | 20 |
| Multiple choice tests | 3 | 30 | 33 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Introductory activities | Subject presentation. Presentation of laboratory sessions, instrumentation and software resources to be used. In these sessions, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked. |
| Master Session | 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. |
| Troubleshooting and / or exercises | 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. |
| Others | Complementary activity to the master sessions. 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 lecturers will guide and monitor the group work and the individual student work in the C hour sessions. The sessions will be performed in the laboratory. In these sessions, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked. |
| Laboratory practises | 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 practises, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be worked. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | The students can go to the lecturer's office (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. |
| Troubleshooting and / or exercises | The students can go to the lecturer's office (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 practises | The students can go to the lecturer's office (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). |
| Others | The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with issues and questions related with the theoretical and practical project. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |

| | | | |
|---|---|---|---|
| Laboratory practises | 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. | 30 | CB4<br>CB5<br>CG4<br>CG8<br>CE12<br>CE14 |
| Others | 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 laboratory sessions, the lecturer will assess the group work (the same mark for each member), the individual student work and the individual oral presentation. In these practices, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed. | 10 | CB4<br>CB5<br>CG4<br>CG8<br>CE12<br>CE14 |
| Multiple choice tests | 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<br>CB5<br>CG4<br>CG8<br>CE12<br>CE14 |

## Other comments and July evaluation

**1. Continuous assessment**

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

When the students perform a objective testing (theoretical test) or miss at most one laboratory session, **they will be assessed by continuous assessment.**

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.

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

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

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

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

OTM = (OT1 + OT2)/2

otherwise, the final mark of this part will be:

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

**1.b Practical tests**

**1.b.1 Laboratory**

Five laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in pairs.This part also will be assessed by continuous assessment. Each session will be only evaluated according to the developed work at the schedule date.

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 laboratory attendance, as well as the student work in the laboratory. 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:

FLM = Sum(LSMi)/5; i = 1, 2, ..., 5.

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

**1.b.2 Tutored project**

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

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

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

**1.c Final mark of the subject**

The weighted points from all assessed parts are added together to calculate the final mark (FM). The following weightings will be applied: 60% objective tests (OTM) and 40% practical tests (30% laboratory (FML) and 10% tutored project (TPM). In order to pass the subject, students will be required to pass the three parts:

- objective tests: OT1>=5 and OT2>=5,
- laboratory: FLM>=5 and don't miss more than 1 laboratory sessions.
- tutored project: TPM>=5 and don't miss more than 1 tutored work session.

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

FM = 0.60·OTM + 0.30·FLM + 0.10·TPM

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

FM = 0.60·AM + 0.30·BM + 0.10·CM, where:

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

BM = min( {5; FLM} )

CM = min( {5; TPM} )

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

**2. Final exam**

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

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

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

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

- tutored project: TPM>=5.

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

FM = 0.60·OTM + 0.30·FLM + 0.10·TPM, where:

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

OTM = (OT1 + OT2)/2

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

FM = 0.60·AM + 0.30·BM + 0.10·CM, where:

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

BM = min( {5; FLM} )

CM = min( {5; TPM} )

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

**3. Second opportunity to pass the subject.**

The assessment policy in this call will follow the scheme described in the previous section. 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 assessment or final exam are kept if the student have got a pass in some parts. Moreover, students cannot take an exam, develop a project or a tutored work task if they have got a pass previously.

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

**4. About ethical behaviour of students**

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

| Sources of information |
|---|
| **Basic Bibliography** |
| Pérez García, M.A., Instrumentación Electrónica, 1ª ed., Ediciones Paraninfo, S.A., 2014, Madrid |
| Franco, S., Diseño con amplificadores operacionales y circuítos integrados analógicos, 3ª ed., McGraw-Hill, 2004, México D.F. |
| Fraile Mora, J., García Gutiérrez, P., y Fraile Ardanuy, J., Instrumentación aplicada a la ingeniería, 3ª ed., Editorial Garceta, 2013, Madrid |
| Pallás Areny, R., Sensores y Acondicionadores de Señal, 4ª ed., Marcombo D.L., 2003, Barcelona |
| Pallás Areny, R., Casas, O., y Bragó, R., Sensores y Acondicionadores de Señal. Problemas resueltos, Marcombo D.L., 2008, Barcelona |
| 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, Madrid |
| Pérez García, M.A., Instrumentación Electrónica: 230 problemas resueltos, 1ª ed., Editorial Garceta, 2012, Madrid |
| **Complementary Bibliography** |

| Recommendations |
|---|
| **Subjects that continue the syllabus** |
| Digital and Analog Mixed Circuits/V05M145V01213 |

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Telecommunication Projects Management** | | | | |
| Subject | Telecommunication Projects Management | | | |
| Code | V05M145V01201 | | | |
| Study programme | 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<br>Lorenzo Rodríguez, María Edita de | | | |
| E-mail | javier@det.uvigo.es | | | |
| Web | http://faitic.uvigo.es | | | |
| General description | A real approach to telecommunications projects management, including knowledge of telecommunications companies and how they are organized, and novel methodologies for project management and human resoruce management. Knowledge of the main operational divisions: executive, technical, commercial and support. | | | |

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

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| - Knowledge of procedures for innovation and creativeness. | CG2<br>CG3<br>CG6<br>CG10<br>CG13<br>CE16<br>CT5 |
| - Tools for telecommunications projects management. | CG3<br>CT1 |

| | |
|---|---|
| - Management of ideas and innovation basics. | CG2<br>CG3<br>CG6<br>CG10<br>CG13<br>CE16<br>CT5 |
| - Knowledge of efficient project management. | CG2<br>CG3<br>CG6<br>CG10<br>CG13<br>CE16<br>CT5 |

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

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 10 | 10 | 20 |
| Tutored works | 5 | 25 | 30 |
| Seminars | 20 | 40 | 60 |
| Reports / memories of practice | 2 | 6 | 8 |
| Jobs and projects | 2 | 4 | 6 |
| Multiple choice tests | 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 |
| Master Session | Classroom lectures<br><br>Related competencies: all |
| Tutored works | Group work on selected course contents<br><br>Related competencies: all |
| Seminars | Invited conferences and discussion on their topics<br><br>Related competencies: all |

| **Personalized attention** |
|---|

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

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Reports / memories of practice | Practical cases, to be presented as deliverables. | 50 | CG2<br>CG3<br>CG6<br>CG10<br>CG13<br>CE16<br>CT1<br>CT5 |
| Jobs and projects | Practical work, to be presented as deliverables and defended in public | 30 | CG2<br>CG3<br>CG6<br>CG10<br>CG13<br>CE16<br>CT1<br>CT5 |
| Multiple choice tests | Written exam | 20 | CG2<br>CG3<br>CG6<br>CG10<br>CG13<br>CE16<br>CT1<br>CT5 |

**Other comments and July evaluation**

According to the degree directives, students will be granted two evaluation methodologies, continuous evaluation and evaluation at the end of the course. The former will consist in 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 during their work in the assignments.

Evaluation at the end of the course will consist in an exam at the official examination date including all course content.

In the second evaluation option, overall evaluation will consist in an exam at the official examination date including all course content.

Class atendance is mandatory.

**Sources of information**

**Basic Bibliography**

**Complementary Bibliography**

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

**Recommendations**

| 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<br>English | | | |
| Department | | | | |
| Coordinator | Fernández Barciela, Mónica | | | |
| Lecturers | Fernández Barciela, Mónica<br>Fraile Peláez, Francisco Javier<br>Isasi de Vicente, Fernando Guillermo | | | |
| E-mail | monica.barciela@uvigo.es | | | |
| Web | http://faitic.uvigo.es | | | |
| General description | The aim of the subject is that the student adquires knowledge on the actual implementation of transceivers for the modern communication systems that transmit in the radiofrequency and optical bands bands. In the case of RF and MW transceivers, the student will learn to evaluate performance, select and design components and analog circuits (active and passive) for them. As an learning aid, the student will use commercial circuit simulators.<br>In the field of the optical communications, the student will learn the operation of the basic transmission and reception components and active optoelectronical subsystems , and will be able to characterise them and select them as function of the optical system to be designed.<br>In this course the student will handle technical and scientific bibliography in English language. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - Know How |
| CE2 | CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning. | - Know How |
| CE3 | CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments. | - Know How |
| 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. | - Know How |
| CE13 | CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics. | - know<br>- Know How |

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

| Contents | |
|---|---|
| Topic | |
| 1. Introduction to circuit design for RF and Microwave transceptors | a. Analog circuits for communication transceptors.<br>b. Transceptor technologies for communication systems transmitting at different frequency bands. Applications.<br>c. Basic concepts. Transmission lines. S parameters. Smith Chart. Impedance matching. |
| 2. Passive circuit design | Couplers, filters and phase shifters. |
| 3. Introduction to microwave linear amplifier design | a. Power and power gain definitions. Gain and noise circles.<br>b. Stability. Stability circles. Bias and stabilization networks. |
| 4. Microwave linear amplifier design | a. Maximum transducer gain design<br>b. Low noise ampliifiiers<br>c. Broadband amplifiers |
| 5. Power amplifier design | a. Loadline and power contours.<br>b. Operating Classes.<br>c. Designing for linearity and efficiency. |
| 6. Frequency converters design | Frequency multipliers and mixers. |
| 7. Signal generators | a. Oscillator design. VCOs<br>b. PLL basics<br>c. PLL based synthesiers.<br>d. Direct digital synthesis. |
| 8. Photonics | a. Semiconductors optical properties.<br>b. Fabry-Perot lasers and DFB.<br>c. Photodetectors. Static and dynamic regime.<br>d. Electro-optic and electro-absorbing modulators. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Practice in computer rooms | 8 | 0 | 8 |
| Master Session | 29 | 72.5 | 101.5 |
| Short answer tests | 1 | 0 | 1 |
| Troubleshooting and / or exercises | 2 | 4 | 6 |
| Practical tests, real task execution and / or simulated. | 0 | 8.5 | 8.5 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Practice in computer rooms | 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, oscillators) circuits. It will be defined and evaluated different figures of merit and other parameters that will be used for circuits performance evaluation.<br>The work of the student in these practice classes will be evaluated:<br>1. In continuous evaluation: by answering -in writting form- short questions and performing simple designs during some/one of the practices.<br><br>2. In evaluation performed only in a final examination: by means of short questions and circuit designs related with the work performed during the practice in computer rooms.<br>In these practices the student with work towards achieving competencies: CE2, CE3, CE12 y CE13 |
| Master Session | It will take place in a classroom with video projection facilities and blackboard.<br>During these sessions it will be described in detail most of the contents in the subject programme.<br>Competencies under work: CE2, CE3, CE12 y CE13 |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | 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 theoretical and practical work, as well as the design work. |

| | |
|---|---|
| Practice in computer rooms | During the practice in computer rooms the lecturer will answer the questions addressed by the students and guide his/her assigned work. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Practice in computer rooms | The work of the student in these practice classes will be evaluated:<br>1. In continuous evaluation: by answering -in writting form- short questions and performing simple designs during some/one of the practices.<br><br>2. In evaluation performed only in a final examination: by means of short questions and circuit designs related with the work performed during the practice in computer rooms. | 10 | CE2<br>CE3<br>CE12<br>CE13 |
| Short answer tests | There will be 2 short examinations, one of them in the same date as the final examination of the students that do not follow continuous evaluation. The two short examinations and the final examination will include both short answer tests and exercises. | 30 | CE2<br>CE3<br>CE12<br>CE13 |
| Troubleshooting and / or exercises | The 2 short examinations, mentioned above, and the Final Exam will include exercises resolution. | 40 | CE2<br>CE3<br>CE12<br>CE13 |
| Practical tests, real task execution and / or simulated. | For students following continous evalutation, it will be mandatory to perform a circuit desing using the circuit simulator, work proposed by the lecturer.<br>This work will be evaluated by a written report and answers to short questions addressed by the lecturer. | 20 | CE2<br>CE3<br>CE12<br>CE13 |

**Other comments and July evaluation**

A) If the student chooses continuous evaluation:

1. It will be compulsory the assistance to the practises in the computer room, as well as the realisation of a design of a microwave circuit by means of the circuit simulator. This design will be proposed by the lecturer and it will be an autonomous work of the student.
The evaluation of the practises will be a 10% of the total subject qualification, and the evaluation of the circuit design will be a 20%. That is to say, the sum of the evaluation of the practical classes and the design will add up to a 30% of the subject qualification.
2. The rest of the subject assessment (up to a 70% of the subject qualification) will be performed by two short exams that will contain exercises resolution, and/or short answers tests. The first short exam will assess up to a 30%, and the second up to a 40%, of the subject qualification. Before performing the second short exam, the student must inform the lecturers about his choice of the method of evaluation.

B) If the student chooses a final exam:

It will only be considered the score he/she obtained in the final examination: in the exercises resolution (in the extensive version) and in the short question test related to: the theoretical part, and the practices in the computer room.
Second Assessment (July):
In July the students who did not pass the subject in May, will be assessed by an similar exam as that described in previous B option. In particular, the students that in May chose continuous evaluation and declare the want to keep the scores obtained in the practises and in the design (that will add up to a 30% of the subject qualification), will perform a reduced version of the final examination described in the previous paragraph (and will add up to a 70% of the subject qualification).

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 |
| --- |
| D.M. Pozar, Microwave Engineering, 3, Addison-Wesley Pub. Co |
| Guillermo González, Microwave Transistor Amplifiers: Analysis and Design, 2, Prentice-Hall |
| Bahaa E. A. Saleh, Malvin Carl Teich, Fundamentals of Photonics, 2, Wiley |
| Guillermo González, Foundations of Oscillator Circuit Design, 1, Artech House |
| Rhea, Randall W., HF filter desing and computer simulation, 1, Noble Publishing |
| **Complementary Bibliography** |
| Enrique Sánchez, Introducción a los dispositivos y circuitos semiconductores de microondas, 1, Pearson Educacion |
| Steve C. Cripps, RF Power Amplifiers for Wireless Communications, 1, Artech House |
| Steve C. Cripps, Advanced Techniques in RF Power Amplifier Design, 1, Artech House |
| Amnon Yariv, Pochi Yeh, Photonics Optical Electronics in Modern Communications, 6, Oxford University Press |
| S. O. Kasap, Optoelectronics and Photonics: Principles and Practice, 2, International ed. Pearson |
| Egan, William F., Phase-lock basics, 1, John Wiley & Sons |
| Rhea, Randall W., Discrete oscillator design : linear, nonlinear, transient, and noise domains, 1, Artech House |

| Recommendations |
| --- |
| **Subjects that continue the syllabus** |
| Microwave and Millimetre Wave Circuit Design and CAD/V05M145V01317 |

| 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 | Moure Rodríguez, María José | | | |
| Lecturers | Moure Rodríguez, María José<br>Valdés Peña, María Dolores | | | |
| E-mail | mjmoure@uvigo.es | | | |
| Web | http://faitic.uvigo.es | | | |
| General description | The objective of this course is to provide students with the ability to design complex or high frequency digital systems. Firstly, the electrical characteristics, power consumption, speed and fan-out of digital integrated circuits and the technologies of semiconductor memories are studied. Subsequently, the interface with external peripherals and the methodology for designing synchronous sequential systems are analyzed. Finally, the course focuses on the design of digital communications systems implemented using high density of integration programmable circuits. Meanwhile, throughout all contents, emphasis is placed in the VHDL description of high complexity digital systems. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How<br>- Know be |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know be |
| 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. | - Know How |
| 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. | - Know How<br>- Know be |
| CE10 | CE10 Ability to design and manufacture integrated circuits. | - Know How |
| CE11 | CE11 Knowledge of hardware description languages for high complexity circuits. | - Know How |
| 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. | - know<br>- Know How |
| CE14 | CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors. | - Know How |

| 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<br>CE12 |
| The knowledge of different input/output technologies of digital circuits. | CE14 |
| The ability to design input/output interface circuits. | CE10<br>CE12<br>CE14 |
| The knowledge of the methodologies for the design of complex digital circuits. | CB5<br>CG8<br>CE12 |
| The ability to design communication components using programmable logic devices. | CB4<br>CG8<br>CE11<br>CE12 |

| | |
|---|---|
| The ability to design complex digital electronic systems using hardware description languages. | CE11 |

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

| | |
|---|---|
| Laboratory Practices | Advanced tools for the design and test of complex digital circuits.<br><br>Design and implementation of ADC/DAC interfaces, sensor interfaces, digital signal processing modules, communications blocks and memory interfaces. |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 18 | 20 | 38 |
| Laboratory practises | 14 | 10 | 24 |
| Projects | 5 | 30 | 35 |
| Short answer tests | 2 | 20 | 22 |
| Practical tests, real task execution and / or simulated. | 0 | 5 | 5 |
| Jobs and projects | 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 |
| Master Session | 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.<br><br>Through master sessions the outcomes CB5, CE10, CE11, CE12 and CE14 are developed. |
| Laboratory practises | During laboratory sessions students apply the design methods described in the master sessions. All the sessions are guided and supervised by the professor. The in-person sessions are developed in a laboratory with skilled equipment.<br><br>Through laboratory practises the outcomes CG4, CE10, CE11, CE12 and CE14 are developed. |
| Projects | This activity focuses on applying the techniques described in the lecture classes and the skills developed at laboratory to a project implementation. The in-person sessions are developed in a laboratory with skilled equipment. Students should obtain well founded solutions, choosing appropriate methods and devices. These projects are planned and tutored in small size groups.<br><br>Through master sessions the outcomes CB4, CB5, CG4, CG8, CE10, CE11, CE12 and CE14 are developed. |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| Master Session | 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 practises | 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. |
| **Tests** | Description |
| Jobs and projects | Each group of students developing a project will attend periodic follow-up meetings. |

| **Assessment** | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Short answer tests | An objective evaluation will be realized at the end of the term. This exam asses all of the contents taught in the theoretical classes. | 30 | CE10<br>CE11<br>CE12<br>CE14 |

| | | | |
|---|---|---|---|
| Practical tests, real task execution and / or simulated. | This evaluation are realized during the practical sessions. The assistance to the laboratory practices is mandatory and 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 20% of the final qualification. | 20 | CG4<br>CG8<br>CE10<br>CE11<br>CE12<br>CE14 |
| Jobs and projects | During the fisrt weeks of the term a job will be assigned to each student individually. This task will be related to any topics of the course and deserves the 20% of the final qualification.<br>Besides at the end of the term the students should also present a tutored project which deserves the 30% of the final qualification. The progress of this job will be supervised from continuous assessment but the final work should be oral presented by the authors. | 50 | CB4<br>CB5<br>CG4<br>CG8<br>CE10<br>CE11<br>CE12<br>CE14 |

**Other comments and July evaluation**

**1. Continuous assessment**

The course can be passed with full marks from continuous assessment, with no need to sit the final exam. Students who assist to more than 2 laboratory sessions are graded using continuous assessment.

The weighting and content of each continuous assessment part are as follows:

**1.1 Test (NExam):**

- It covers all of the contents taught in the theoretical classes and includes short exercises or problems.
- The date of this test will be the same of the final exam.
- The student pass this part if he/she gets a mark greater than or equal to 5 over 10.

**1.2 Laboratory practices (NPrac):**

- The student should complete 4 of the 5 sessions in order to pass this part.
- 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.

**1.3 Job (NTask):**

- This task will be assigned to each student individually.
- The student should present a written report of this task**.**

**1.4 Project (NPro):**

- It should be oral presented by each of the authors.
- It should be carried out by collaborative groups of 2 or more students. The 60% of the final mark (NPro) is obtained from the individual tasks assigned to each student, the 20% from the global tasks of the group, the 10% from the oral presentation of each student and the 10% from the report 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 a mark greater than or equal to 5 over 10.

**1.5 Final qualification of continuous assessment (Final_ca)**

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

Final_ca: = (NExam*0.3 + NPrac*0.2 + NTask*0.2 + NPro*0.3) if NExam and Npro are greater than or equal to 5;

Final_ca = min [(NExam*0.3 + NPrac*0.2 + NTask*0.2 + NPro*0.3), 4] in other case;

The student who fails one or more of the parts of continuous assessment has another opportunity to pass the following parts in the final exam:

- He/she can improve his/her assigned job and this mark replaces the previous one (NTask).
- He/she can repeat the theoretical examination and this mark replaces the previous one (NExam).
- He/she can complete and present his/her project and this mark replaces the previous one (NPro).

**2. Final exam and qualification**

There is a final exam at the end of the term and in July.

- In the final exam, all content is evaluated. It usually consists of several questions and problems and lasts 2 hours. The pass mark for this exam is 4 out of 10 and deserves 50% of the final qualification (NExam).
- The students must present the results and reports of the same practices developed in continuous assessment. This practices represent 20% of the final qualification (NPrac).
- In order to pass the subject the students should present an individual project with the same objectives and complexity of the project developed in continuous assessment. This project deserves 30% of the final qualification (NPro) and it is necessary to obtain a mark greater o equal to 5 out of 10 in order to pass the course.

Final_ex = (NExam*0.5 + NPrac*0.2 + NPro*0.3) if NExam and Npro are greater than or equal to 5;

Final_ex = min [(NExam*0.5 + NPrac*0.2 + NPro*0.3), 4] in 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 assessment and final exams 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 test or exam. 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 that they consider appropiate.

| **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, FaiTIC (http://faitic.uvigo.es) |

| **Recommendations** |
|---|

| 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 | Pérez González, Fernando | | | |
| Lecturers | Mosquera Nartallo, Carlos<br>Pérez González, Fernando | | | |
| E-mail | fperez@gts.uvigo.es | | | |
| Web | http://faitic.uvigo.es | | | |
| General description | This course presents advanced topics in digital communications with emphasis on modulations, coding and detection. The covered techniques are part of the state of the art in digital communications, and comprise novel aspects as MIMO systems, cognitive radio or dirty paper coding.<br><br>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 | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CE2 | CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning. | - know<br>- Know How |
| CE3 | CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Handle the mathematical tools needed to model, simulate and evaluate moderns communication systems. | CG1<br>CG4<br>CE1<br>CE2<br>CE3 |
| Solve problems whose solution does not derive from the application of a standardized procedure. | CG1<br>CG4<br>CG8<br>CE1<br>CE2<br>CE3 |
| Understand the principles underlying modern communication standards. | CG1<br>CG4<br>CG8<br>CE1<br>CE2<br>CE3 |

| | |
|---|---|
| Design transmitters, receivers and measurement equipment for modern communication systems. | CG1<br>CG4<br>CG8<br>CE1<br>CE2<br>CE3 |

| **Contents** | |
|---|---|
| Topic | |
| Lectures 1-4: MIMO communications | - Introduction. Array, spatial diversity and spatial multiplexing gains. MIMO channel and signal models.<br>- MIMO transmitter design. Principles of precoding for MIMO. Space-time coding. Multiuser MIMO transmitter design.<br>- MIMO receiver design. Multiuser MIMO receiver design.<br>- 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: Dirty paper coding. | - Code design. Costa's theorem. Opportunistic low SNR codes. Applications in downlink channels. |
| Lecture 7: OFDM and beyond. | - Principles of orthogonal frequency division multiplexing. Filterbanks and multicarrier. Cooperative diversity. |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Laboratory practises | 14 | 29.4 | 43.4 |
| Master Session | 14 | 57.6 | 71.6 |
| Long answer tests and development | 2 | 0 | 2 |
| Reports / memories of practice | 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 practises | 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.<br><br>Competences: CG1, CG4, CE1, CE2, CE3 |
| Master Session | The course is structured in several advanced topics in digital communications with emphasis on multiple-input multiple-output (MIMO) communications.<br><br>Competences: CG1, CG4, CG8, CE1, CE2, CE3 |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| Master Session | The teachers 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 |
| Reports / memories of practice | The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (during the work review sessions or during the office hours). |

| **Assessment** | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |

| | | | |
|---|---|---|---|
| Long answer tests and development | Final exam with short questions on the contents of the subject. | 50 | CG1<br>CG4<br>CG8<br>CE1<br>CE2<br>CE3 |
| Reports / memories of practice | Reports of the practices that employ the techniques seen in the classroom. | 50 | CG1<br>CG4<br>CG8<br>CE1<br>CE2<br>CE3 |

**Other comments and July evaluation**

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

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

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

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

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

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

**Sources of information**

**Basic Bibliography**

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

**Complementary Bibliography**

Ezio Biglieri et al., MIMO Wireless Communications, First, Cambridge University Press, 2007

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, 2013

Behrouz Farhang-Boroujeny, Signal Processing Techniques for Sotware Radios, Second,

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

**Recommendations**

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

Signal Processing in Communications/V05M145V01102

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Signal Processing in Audiovisual Systems** | | | | |
| Subject | Signal Processing in Audiovisual Systems | | | |
| Code | V05M145V01205 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Optional | 1st | 2nd |
| Teaching language | English | | | |
| Department | | | | |
| Coordinator | Martín Rodríguez, Fernando | | | |
| Lecturers | Martín Rodríguez, Fernando | | | |
| E-mail | fmartin@uvigo.es | | | |
| Web | http://http://faitic.uvigo.es | | | |
| General description | In this course we will describe the main compression and coding tecniques 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 | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Learning to exploit perceptual effects and spatial/temporal redundancy to compress audiovisual information. | CG1<br>CG4<br>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<br>CG4<br>CE1 |
| Learning to handle audiovisual information to extract metadata and to use them in indexing and retrieval. | CG1 |
| Understanding strcuture and usefulness of MPEG7 standard. | CG1 |

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

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Practice in computer rooms | 10 | 30 | 40 |

| | | | |
|---|---|---|---|
| Tutored works | 10 | 50 | 60 |
| Master Session | 8 | 8 | 16 |
| Multiple choice tests | 1 | 0 | 1 |
| Reports / memories of practice | 1 | 7 | 8 |

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

## Methodologies

| | Description |
|---|---|
| Practice in computer rooms | Working specific concepts from the theory (master) sessions. We will use computer tools.<br>Related competencies: CG1, CG4, CE1. |
| Tutored works | 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.<br>Related competencies: CG1, CG4, CE1. |
| Master Session | Basic concepts exposition. Related competencies: CG1, CG4, CE1. |

## Personalized attention

| Methodologies | Description |
|---|---|
| Practice in computer rooms | Querry and answer in the classroom and, if necessary, appointment for office work. Query and answer via e-mail. |
| Tutored works | Querry and answer in the classroom and, if necessary, appointment for office work. Query and answer via e-mail. |
| Master Session | Querry and answer in the classroom and, if necessary, appointment for office work. |
| **Tests** | Description |
| Reports / memories of practice | Answer to questions on writing them. In assessment, a brief report with correct issues and and errors is sent. |

## Assessment

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Multiple choice tests | These tests are based on theory classes concepts. | 20 | CG1<br>CG4<br>CE1 |
| Reports / memories of practice | The qualification of guided works comprises: achievemnts, documentation, bibliography selection and oral presentation. Normally individual work. If team work is done, most of the qualification will be equal for different team members. Presentation assesment may cause slight diferences in individual qualification. | 80 | CG1<br>CG4<br>CE1 |

## Other comments and July 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 assesment activities.This exam will be assesed 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.

Extraordinary exam in July will consist of another exam for students failing to pass in may (after continuous evaluation and final exam). This new exam will be governed by the same rules of final exam in may.

## Sources of information

### Basic Bibliography

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

Richardson, Iain E. G., H.264 and MPEG-4 video compression: video coding for next generation multimedia, Wiley, cop., 2004

### Complementary Bibliography

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

## Recommendations

### Subjects that are recommended to be taken simultaneously

Multimedia Communications/V05M145V01206

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

Signal Processing in Communications/V05M145V01102

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Multimedia Communications** | | | | |
| Subject | Multimedia Communications | | | |
| Code | V05M145V01206 | | | |
| Study programme | 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@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 | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| CE4 | CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals. | - Know How |
| CE6 | CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents. | - Know How |
| 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. | - know |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Understanding the fundamental characterisitcs of a lattice, and the properties we must take into account when facing a source coding problem and a channel coding problem. | CG4<br>CE1 |
| Understand that a trellis code defines a lattice and why this construction is useful for source coding (Trellis-Code Quantization) | CG4<br>CE1 |
| Understanding of the different distributed source coding schemes. | CG1<br>CG4<br>CE1<br>CE4<br>CE8 |
| Implementation of a distributed source coding scheme. | CG1<br>CG4<br>CE1<br>CE6<br>CE8 |
| Understading of the different schemes of joint source and channel coding. | CG4<br>CE1<br>CE4<br>CE6<br>CE8 |

| | |
|---|---|
| Implementation of a joint and source channel coding scheme. | CG1<br>CG4<br>CE1<br>CE4<br>CE6 |
| Understanding of the characteristics of different ways of multimedia signal distribution, paying special attention to streaming schemes. | CG1<br>CE4<br>CE6<br>CE8 |
| Asessment of the modularity of new video coding standards (e.g., MPEG-7) | CG1<br>CE4<br>CE6<br>CE8 |

## Contents

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

## Planning

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Laboratory practises | 13 | 44 | 57 |
| Master Session | 15 | 30 | 45 |
| Reports / memories of practice | 0 | 21 | 21 |
| Long answer tests and development | 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 practises | 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.<br><br>Competencies: CG1, CG4, CE1, CE4, CE6, CE8. |
| Master Session | 15 hours of theoretical lessons, where practical cases will be introduced. Furthermore, autonomous homework exercises will be proposed.<br><br>Competencies: CG1, CG4, CE1, CE4, CE6, CE8. |

## Personalized attention

| **Tests** | Description |
|---|---|
| Reports / memories of practice | Individual feedback on the reports will be provided. |

## Assessment

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Laboratory practises | Numerical simulation programming. | 30 | CG1<br>CG4<br>CE1<br>CE4<br>CE6<br>CE8 |
| Reports / memories of practice | Report on lab practises and reports on related topics. | 10 | CG1<br>CE1<br>CE4<br>CE6 |
| Long answer tests and development | Final exam. | 60 | CG1<br>CG4<br>CE1<br>CE4<br>CE6 |

**Other comments and July evaluation**

In order to do the weighted average of the different qualifications (corresponding to continual assessment), the student should submit all the mentioned tasks. Furthermore, a minimum mark of 40% should be achieved in the final exam, and a minimum mark of 40% should be achieved in the lab practice. In case that those thresholds were not achieved, the final mark will be the minimum of the final exam mark and the lab mark (both of them over 10 points)

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

Those student who choose to be evaluated by final 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.

Plagiarism/copy in any of the tasks described above implies automatic failure.

**Sources of information**

**Basic Bibliography**

Cover and Thomas, Elements of information theory, Wiley, 2006

**Complementary Bibliography**

Artículos científicos especificados por el profesorado,

**Recommendations**

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

Signal Processing in Communications/V05M145V01102

**Other comments**

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

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

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CE13 | CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics. | - know<br>- Know How |

| 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<br>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<br>CE13 |
| 3. Knowledge of the basic formats of digital transmission by optical fibre, and of analog transmission in systems fibre-radio. | CG4<br>CE13 |
| 4. Knowledge of some advanced systems for fibre transmission: new modulation formats, coherent systems, non-linear systems and dispersion management. | CG4<br>CG8<br>CE13 |
| 5. Knowledge of the specific technologies of optical networks WDM and DWDM, and options to design them. | CG1<br>CG4<br>CE13 |
| 6. Knowledge of the optical network topologies for long distance transmission, metropolitan and regional networks, and access optical networks. | CG1<br>CG4<br>CE13 |
| 7. Knowledge of security techniques to protect optical networks. | CG4<br>CG8<br>CE13 |
| 8. Knowledge of free-space optical systems and visible light communications. | CG4<br>CG8<br>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.<br><br>2.2. Basic active devices: lasers, LEDs, photodetectors, optical modulators and doped fibre amplifiers.<br><br>2.3. Basic passive devices: couplers, splitters and filters. |
| 3. Advanced optical devices | 3.1. Active devices: SOA, fibre lasers and Raman amplifiers.<br><br>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<br><br>4.2. Stimulated Brillouin Scattering<br><br>4.3. Dispersion management |
| 5. Digital systems ETDM | 5.1. Introduction<br><br>5.2. ETDM systems with optical amplifiers<br><br>5.3. Dispersion compensation in ETDM systems |
| 6. Advanced optical systems | 6.1. Systems fibre-radio.<br><br>6.2. Coherent links and new formats. |
| 7. Optical networks | 7.1. Systems WDM and DWDM<br><br>7.2. Switching technologies<br><br>7.3. Wavelength conversion.<br><br>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 |
| Master Session | 18 | 54 | 72 |
| Laboratory practises | 6 | 6 | 12 |
| Case studies / analysis of situations | 2 | 12 | 14 |
| Long answer tests and development | 2 | 12 | 14 |
| Short answer tests | 1 | 5 | 6 |
| Case studies / analysis of situations | 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 |
| Master Session | 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.<br><br>Through this methodology the competencies CG1, CG4, CG8 and CE13 are developed. |

| | |
|---|---|
| Laboratory practises | 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.<br><br>Through this methodology the competencies CG4, CG8 and CE13 are developed. |
| Case studies / analysis of situations | It consists of activities that complement the master sessions and allow a better understanding of the theoretical concepts.<br><br>Through this methodology the competencies CG1, CG4, CG8 and CE13 are developed. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | 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 practises | 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 / analysis of situations | The students can use the office hours of the professor to solve doubts related to the subject. The timetable of these office hours will be available at the beginning of the semester and is published on the website of the course. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Long answer tests and development | At the end of the semester, the students will perform a final test that covers all the contents of the course. | 30 | CG1<br>CG4<br>CG8<br>CE13 |
| Short answer tests | 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 (30%) about the contents of the first 4 chapters of the course. | 50 | CG4<br>CG8<br>CE13 |
| Case studies / analysis of situations | It evaluates the work realised by the student in the study of cases proposed in class. | 20 | CG1<br>CG4<br>CG8<br>CE13 |

**Other comments and July evaluation**

We will offer to the students two possible assessment systems: continuous evaluation or final evaluation at the end of the course.

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 evaluation unless the student explicitly indicates by written statement to the professor that he decides final evaluation at the end of the course.

Continuous evaluation:

The continuous evaluation 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 first four chapters of the subject (30%) and that it will take place the fourth week of the course, and the completion of one short answer test about the lab (20%) and that it will take place after the last lab exercise, and (b) the assessment of the activities realised by the student related with the 'case studies' (20%) that has to be completed by the seventh week 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 evaluation 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, 8 points out of 20 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 evaluation 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.

Evaluation at the end of the semester:

In addition to the system of continuous evaluation described above, the student can opt for a final examination only. This final evaluation 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 examination. 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.

Evaluation in July:

Those students who opted for a continuous evaluation 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 evaluation (70%). In such a case, they will only take a long answer test (30%). To pass the course, these students will have to obtain, at least, 12 points out of 30 in the long answer test, and obtain a minimum of 50 points in total.

Alternatively, these students can also opt for a final examination only, 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 continuous evaluation.

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

In the case of choosing a final exam only, 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 examination. 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.

In case of detection of plagiarism in any of the works/tasks mentioned in the evaluations above, the final mark will be "fail (0)" and the professors will communicate this fact to the direction of the school such that it can take the measures that it considers appropriate.

| **Sources of information** |
|---|
| **Basic Bibliography** |
| J. Capmany, F. J. Fraile Peláez y J. Martí, Fundamentos de Comunicaciones Ópticas, 2a Edición, Síntesis, 2001, |
| J. Capmany, F. J. Fraile Peláez y J. Martí, Dispositivos de Comunicaciones Ópticas, 1a Edición, Síntesis, 1999, |
| **Complementary Bibliography** |
| G. P. Agrawal, Fiber-Optic Communication Systems, 4a Edición, Wiley-Interscience, 2010, |
| G. Keiser, Optical Fiber Communications, 5a Edición, McGraw-Hill, 2014, |
| J. Capmany y B. Ortega-Tamarit, Redes Ópticas, 1a Edición, Universidad Politécnica de Valencia, 2006, |

| **Recommendations** |
|---|

| **Subjects that it is recommended to have taken before** |
|---|
| Electronics and Photonics for Communications/V05M145V01202 |

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Antennas** | | | | |
| Subject | Antennas | | | |
| Code | V05M145V01208 | | | |
| Study programme | 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 | | | |
| E-mail | fjdiaz@com.uvigo.es | | | |
| Web | | | | |
| General description | The subject devotes to the study of antennas and covers from their electromagnetic bases to their practical design, going through the models of analysis and simulation of the behaviour of the antennas. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CE2 | CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning. | - know<br>- Know How |
| CE3 | CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments. | - know<br>- Know How |
| CE5 | CE5 Ability to design systems of radio navigation and positioning, as well as radar systems. | - know<br>- Know How |

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

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

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 15 | 15 | 30 |
| Troubleshooting and / or exercises | 3 | 6 | 9 |
| Case studies / analysis of situations | 8 | 24 | 32 |
| Autonomous practices through ICT | 0 | 26 | 26 |
| Short answer tests | 1 | 6 | 7 |
| Practical tests, real task execution and / or simulated. | 1 | 6 | 7 |
| Long answer tests and development | 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 |
| Master Session | Presentation of the contents on the subject under study, instructions and exercises or projects to be developed by the student.<br>Competencies CB2, CE2, CE3, CE5 |
| Troubleshooting and / or exercises | 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<br>Competencies CB2, CG4, CE2. |
| Case studies / analysis of situations | 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.<br>Competencies CB2, CG4, CE2, CE3, CE5. |
| Autonomous practices through ICT | Activities of application of the knowledges to concrete situations and of acquisition of basic skills related with the matter object of study. They will be developed through ICT in an autonomous way.<br>Competencies CB2, CB4, CG4, CE2. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | Personalized attention. Questions and doubts during teaching timetable |
| Troubleshooting and / or exercises | Questions and doubts during teaching timetable and in office hours. |
| Case studies / analysis of situations | Questions and doubts during teaching timetable and in office hours. |
| Autonomous practices through ICT | Questions and doubts during teaching timetable, in office hours, Faitic and e-mail. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Short answer tests | Conceptual questions on the course syllabus. | 10 | CB2 |
| Practical tests, real task execution and / or simulated. | It will value the quality of the homeworks assigned, the participation and attitude showed in the classes, as well as the oral presentation of the work. | 60 | CB2<br>CB4 |

| | | | |
|---|---|---|---|
| Long answer tests and development | Final examination: Evaluation of the competencie that includes open questions on a subject. The students have to develop, relate, organise and present the knowledges that have on the matter in an extensive answer to a practical situation posed. | 30 | CB2<br>CB4 |

**Other comments and July evaluation**

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

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 exercise about 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 and 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 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 memory 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. FINAL EVALUATION OF SEMESTER

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 examination 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 call of July and within the ongoing course.

3. RECOVERY IN THE CALL OF JULY

It will follow the same procedure as the evaluation at the end of the semester. 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 assessment system in the terms described above.
- It is considered that the subject is approved if the final grade is equal to or greater than 5.

**Sources of information**

**Basic Bibliography**

C. A. Balanis, Advanced Engineering Electromagnetcis, 2, Wiley, 2005, USA

C. A. Balanis, Antenna Theory and Design, 4, Wiley, 2016, USA

W.L.Stutzman,G.A.Thiele, Antenna Theory and Design, 3, Wiley, 2013, USA

**Complementary Bibliography**

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

R.E.Collin, Antennas and Radiowave Propagation, 1, Mc Graw Hill, 1985, USA
P.S.Kildal, Foundations of Antenas. A Unified Approach, 1, Studentlitteratur, Sweden
T.A. Milligan, Modern Antenna Design, 2, Wiley, 2005, USA

## 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

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CE2 | CE2 Ability to develop radio communication systems: antenna, equipment and subsystems design; channel modeling; link budgeting; and planning. | - know<br>- Know How |
| CE3 | CE3 Ability to implement systems by cable, line, satellite, in fixed and mobile communication environments. | - know<br>- Know How |
| CE5 | CE5 Ability to design systems of radio navigation and positioning, as well as radar systems. | - know<br>- Know How |
| CE13 | CE13 Ability to apply advanced knowledge of photonics, optoelectronics and high-frequency electronics. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| * Knowledge of the basic instrumentation for measuring radiofrequency, microwaves, millimeter and sub-millimeter waves | CB1<br>CB2<br>CG8<br>CE2<br>CE3<br>CE5<br>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<br>CB2<br>CG8<br>CE2<br>CE3<br>CE5<br>CE13 |
| * Knowdlege of experimental characterization techniques regarding the mechanisms of signal propagation. | CB1<br>CB2<br>CG8<br>CE2<br>CE3<br>CE5<br>CE13 |

| Contents |
|---|

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

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Case studies / analysis of situations | 2 | 10 | 12 |
| Laboratory practises | 22 | 65 | 87 |
| Master Session | 4 | 20 | 24 |
| Short answer tests | 2 | 0 | 2 |

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

**Methodologies**

| | Description |
|---|---|
| Case studies / analysis of situations | Practical demonstrations. CB1, CB2, CG8, CE2, CE3, CE5, CE13. |
| Laboratory practises | Setting and measure of circuits and telecommunication systems. Employing specific instrumental. CB1, CB2, CG8, CE2, CE3, CE5, CE13. |
| Master Session | Explanation of the theoretical-practical basis of the work to be developed by the students in the laboratory. CB1, CB2, CG8, CE2, CE3, CE5, CE13. |

**Personalized attention**

| Methodologies | Description |
|---|---|

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

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Laboratory practises | Laboratory practises | 50 | CE2<br>CE3<br>CE5<br>CE13 |
| Short answer tests | Short answer tests | 50 | CB1<br>CB2<br>CG8 |

**Other comments and July evaluation**

Two evaluation systems are offered:

CONTINUOUS EVALUATION, that is the ordinary recommended method, around which educational activities are scheduled.NOT CONTINUOUS EVALUATION, which is recommended for those situations in which it results impossible to follow the ordinary method
CONTINUOUS EVALUATIONThe continuous evaluation 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.

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

NOT CONTINUOUS EVALUATIONThe not continuous evaluation consists of:* Examination on laboratory practice. Individual assessment (Weight: 50%)* Proof of short answer. Individual assessment (Weight: 50%)
RETAKE:The student been evaluated by Continuous Evaluation 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 EVALUATION”* Be evaluated with an only final examination in the official date assigned by the Centre, as the stipulated for the system of “NOT CONTINUOUS EVALUATION”.
The student not been evaluated by continuous Evaluation:* will be evaluated with an only final examination in the official date assigned by the Centre, as the stipulated for the system of “NOT CONTINUOUS EVALUATION”

**Sources of information**

**Basic Bibliography**

Walter Tuttlebee, Software defined radio : Enabling technologies, John Wiley & Sons
Fuqin Xiong, Digital modulation techniques, Artech House

**Complementary Bibliography**

Ulrich Reimers, DVB : The family of international standards for digital video broadcasting, Springer
M. E. Van Valkenburg, Network analysis, Prentice-Hall
Wes Hayward, Introduction to radio frequency design, American Radio Relay League
George Brown, Radio and electronics cookbook, Oxford : Newnes
John Davies, Newnes radio and RF engineer's pocket book, Oxford : Newnes
Y.T. Lo, S.W. Lee, Antenna handbook, Van Nostrand Reinhold
Rajeswari Chatterjee, Antenna theory and practice, John Wiley and Sons
Yi Huang, Kevin Boyle, Antennas : from theory to practice, Wiley

Walter C. Johnson, Transmission lines and networks, Mac Graw-Hill

Brian C. Wadell, Transmission line design handbook, Artech House

**Recommendations**

**Subjects that continue the syllabus**

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

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

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

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

Radiocommunication/V05M145V01103
Signal Processing in Communications/V05M145V01102

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know How |
| CE4 | CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals. | - Know How |
| CE6 | CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents. | - Know How |
| 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. | - Know How |
| 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. | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Knowledge and know-how about advanced channel coding techniques | CG4<br>CE4<br>CE6 |
| To understand the operations and properties of large distributed systems in the Internet. Deep knowledge and insights about advanced communication system | CG1<br>CG4<br>CE4<br>CE6<br>CE7<br>CE8 |

| | |
|---|---|
| To learn how to analyze and put into use multi path transmission techniques and congestion control algorithms on different types of networks | CB5<br>CG4<br>CG8<br>CE4<br>CE6<br>CE7<br>CE8 |
| To understand the design principles, the operation and performance of large data centers in the Internet | CB5<br>CG1<br>CG4<br>CG12<br>CE6<br>CE7<br>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<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>CE7<br>CE8 |

| **Contents** | |
|---|---|
| Topic | |
| 1. The Internet ecosystem | 1.1 Technology. Normalisation. Prospective<br>1.2 Service provisioning<br>1.3 Economy of Internet |
| 2. Advanced channel coding | 2.1 Capacity-approaching codes<br>2.2 Capacity-achieving-codes<br>2.3 Network coding<br>2.4 Erasure coding |
| 3. Datacenter architectures | 3.1 Datacenter structure and architecture<br>3.2 Advanced & efficient switching systems |
| 4. Datacenter networking | 4.1 Ethernet bridging & virtual bridging<br>4.2 VLAN partitioning and extension<br>4.3 Other tunneling technologies |
| 5.Software defined networking | 5.1 Software defined networking: concepts, elements and products<br>5.2 Network function virtualization |
| 6. Resource allocation | 6.1 Resource allocation in cloud systems<br>6.2 Load balancing techniques<br>6.3 Randomized policies. Optimal allocations<br>6.4 Auctioning |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 13 | 26 | 39 |
| Laboratory practises | 14 | 56 | 70 |
| Long answer tests and development | 2 | 0 | 2 |
| Practical tests, real task execution and / or simulated. | 1 | 0 | 1 |
| Troubleshooting and / or exercises | 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 |

| | |
|---|---|
| Master Session | 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.<br><br>Through this methodology, the competencies CB5, CG1, CG4, CG8, CG12, CE4, CE5, CE7 and CE8 are acquired. |
| Laboratory practises | Development of an engineering project: design, planning, costs, dimensioning, configuration and testing, deployment and maintenance of a cloud-computing infrastructure.<br><br>Through this methodology, the competencies CB5, CG1, CG4, CG8, CG12, CE4, CE5, CE7 and CE8 are acquired. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | Problem solving, advising about the material, recommended bibliography, further explanations of concepts and techniques. Individual mentoring about any of the latter matters. |
| Laboratory practises | Help with the design, installation, configuration and use of any software piece needed for developing the practical project. Individual office hours. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Long answer tests and development | 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<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>CE7<br>CE8 |
| Practical tests, real task execution and / or simulated. | Functional and performance tests of the assigned engineering project. Critical assessment of the technical solutions, the design decisions and the implementation. | 30 | CB5<br>CG1<br>CG4<br>CG8<br>CG12<br>CE4<br>CE6<br>CE7<br>CE8 |
| Troubleshooting and / or exercises | Written homework, selected problems and exercises. | 20 | CB5<br>CG4<br>CG8<br>CE8 |

**Other comments and July evaluation**

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

The continuous evaluation options consists in a final written exam (50% of the qualification), the completion of an engineering project  (30% of the qualification) and homework (20%). This project will be due the last working day preceding the start of the examination period. The final assessment option consists in a final written exam (60% of the qualification) and in the completion of an engineering project (40% of the qualification). This project will be due the last working day preceding the start of the examination period. The examinations of the continuous and the final 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.

Should any form of plagiarism be detected in any project or test submitted, the final grade in the subject will be FAIL (0) and the event will be reported to the academic officers so that the appropriate sanctions can be taken.

| Sources of information |
| --- |
| **Basic Bibliography** |
| P. van Mieghem, Performance analysis of communications networks and systems, CambridgeUniversity Press, 2014, |
| P. Goransson, C. Black, Software defined networking: a comprehensive approach, Morgan Kauffman, 2014, |
| **Complementary Bibliography** |
| R. Srikant, L. Ying, Communication networks. An optimization, control and stochastic networks perspective, Cambridge University Press, 2013, |
| M. Medard, A. Sprintson, Network coding. Fundamentals and applications, Academic Press, 2011, |
| X. Guang, Z. Zhang, Linear network error correcting coding, Springer, 2014, |
| W. Stallings, Foundations of modern networking, Addison-Wesley, 2015, |

| Recommendations |
| --- |

| Subjects that it is recommended to have taken before |
| --- |
| Network Technologies/V05M145V01104 |

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How |
| CG3 | CG3 Ability to lead, plan and monitor multidisciplinary teams. | - Know How |
| 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. | - Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know How |
| CE4 | CE4 Ability to design and plan networks for transporting, broadcasting and distribution of multimedia signals. | - know<br>- Know How |
| CE6 | CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |

| | |
|---|---|
| To understand the basic concepts for wireless communications. | CB1<br>CB5 |
| To understand the basic concepts behind mobile communications. | CG3<br>CG8 |
| To know the main protocols and architectures used in wireless and mobile networks. | CG12<br>CE4 |
| Knowledge of the basis and main concepts of ubiquitous/pervasive computing. | CE6<br>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<br>CE24 |

| **Contents** | |
|---|---|
| Topic | |
| Principles of wireless networks. | Channel characteristics; medium access control; mobility management; routing and discovery; securiry issues. |
| Architectures and standards. | Wireless access/local/personal area networks; wireless sensor networks; TCP/IP issues related with the connectivity/communication of wireless/mobile devices. |
| Basis of ubiquitous computing. | Context-aware computing; service architecture; data dissemination and management; sinchronization and consistency; service discovery. |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 15 | 22.5 | 37.5 |
| Laboratory practises | 10 | 10 | 20 |
| Integrated methodologies | 5 | 57.5 | 62.5 |
| Long answer tests and development | 2 | 0 | 2 |
| Reports / memories of practice | 0 | 2 | 2 |
| Jobs and projects | 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 |
| Master Session | Professors will present the main theoretical contents related with wireless networks and ubiquitous computing. This methodology will contribute to develop the competitions CE4, CE6, CE7, CE9, CE24. |
| Laboratory practises | Students will complete guided and supervised practices in the laboratory. With this methodology students will develop competences CE4, CE6 and CE24. |
| Integrated methodologies | 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 attention** | |
|---|---|
| Methodologies | Description |
| Master Session | 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 practises | The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. Te professors will guide and help the students to complete the assigned laboratory practises. Questions will be answered during the lab sessions or during tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. This schedule will be published on the subject website. |
| Integrated methodologies | The professors of the course will provide individual attention to the students during the course, solving their doubts and questions. The professors will guide and help the students to complete the assigned project. Questions will be answered during the supervising sessions, group supervising sessions, or during tutorial sessions. Teachers will establish timetables for this purpose at the beginning of the course. This schedule will be published on the subject website. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Master Session | Students will complete an exam to asses what they have learned in master sessions. | 40 | CB1<br>CE4<br>CE6<br>CE7<br>CE9<br>CE24 |
| Laboratory practises | The students will fill questionnaires and/or reports to asses the correct completion and understanding of the laboratory tasks.<br><br>The concepts studied in the laboratory can be also part of the final exam. | 20 | CB1<br>CB5<br>CE4<br>CE6<br>CE7<br>CE9<br>CE24 |
| Integrated methodologies | The students will work iin groups in the design, implementation and proof of a protocol, system, application or service. The result will be evaluated after the delivery, having into account key aspects such as the correction, the quality, the performance and the functionalities. In addition, during the implementation of the project, the design and the evolution of the development will be evaluated. If the intermediate results are not satisfactory, a penalization of the 20% of the grade could be applied. The evaluation will be by group and by person: each one of the members of a team must document his/her tasks and answer the questions related to them. | 40 | CB1<br>CB5<br>CG3<br>CG8<br>CG12<br>CE4<br>CE6<br>CE7<br>CE9<br>CE24 |

## Other comments and July evaluation

In order to pass the course it is necessary to complete the different parts of the subject (master sessions, practices in labs, and projects). The final grade will be the **weighted geometric mean** of the grades of the different parts. If "x" is the grade obtained for the master sessions, "y" for the practices in labs, and "z" for the project, the final grade will be: grade = x^0.4 × y^0.2 × z^0.4

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

Students who opt for the final assessment procedure must pass the short answer test (40%), submit a project (40%) and submit the laboratory practises (20%). These parts will be evaluated as indicated in the tests description section. The final grade will be the **weighted geometric mean** of the grades of the different parts. Besides, they must submit an additional dossier that must be defended in-person 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 opportunity to pass the course**

The end of course exam will only be held by students who failed the end of semester exams.

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-person 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 parts they have already passed in the first opportunity or discard them.

**Other comments**

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

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

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

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

| **Sources of information** |
|---|
| **Basic Bibliography** |
| Cory Beard, William Stallings, Wireless Communication Networks and Systems, 1, 2016 |
| Christopher Cox, An Introduction to LTE, 2, 2014 |
| **Complementary Bibliography** |
| Viajy Garg, Wireless Communications and Networking, 1, 2007 |
| Kaveh Pahlavan, Prashant Krishnamurthy, Networking Fundamentals: Wide, Local and Personal Area Communications, 1, 2009 |
| Pei Zheng, Larry L. Peterson, Bruce S. Davie, Adrian Farre, Wireless Networking Complete, 1, 2009 |
| F. Adelstein, Sandeep K.S. Gupta, Golden G. Richard III, Loren Schwiebert, Fundamentals of Mobile and Pervasive Computing, 1, 2005 |
| John Krumm, Ubiquitous Computing Fundamentals, 1, 2010 |
| Jean-Philippe vasseur, Adam Dunkels, Interconnecting smart objects with IP, 1, 2010 |
| James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 7, 2017 |

| **Recommendations** |
|---|

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Web Engineering** | | | | |
| Subject | Web Engineering | | | |
| Code | V05M145V01212 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Optional | 1st | 2nd |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Santos Gago, Juan Manuel | | | |
| Lecturers | Álvarez Sabucedo, Luis Modesto<br>Santos Gago, Juan Manuel | | | |
| E-mail | Juan.Santos@det.uvigo.es | | | |
| Web | http://faitic.uvigo.es | | | |
| General description | The Web, initially conceived as a simple system for the telematic distribution of information, has become, as a whole, in the database more extensive and heterogeneous existing today. Furthermore, the Web has become an important platform for delivery of sophisticated electronic services in very different domains, such as commerce, education, public and private administration, health, leisure, etc.<br><br>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.<br><br>The course will be taught in Spanish or Galician, although the teaching materials (slides, bibliographic documentation, etc.) will be available predominantly in English. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know |
| 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. | - know<br>- Know How |
| 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. | - know |
| 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. | - Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How |
| 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. | - Know How |
| CG6 | CG6 Capacity for general direction, technical direction and management of research, development and innovation projects in companies and technological centers. | - Know How |
| 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. | - know<br>- Know How |
| CE6 | CE6 Ability to model, design, implement, manage, operate, and maintain networks, services and contents. | - Know How |
| 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. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |

| | |
|---|---|
| Know the evolution of the Web and understand the technologies in use today | CB5<br>CG8<br>CE8 |
| Know and be able to use advanced search techniques for both Web documents and other resources accessible through the Web | CB1<br>CB2<br>CB4<br>CB5<br>CG8<br>CE8 |
| Know and be able to use mechanisms to represent and manage knowledge on the Web | CB1<br>CB2<br>CB3<br>CB5<br>CE8 |
| Know to propound, analyze and design innovative Web applications using the models and patterns that predominate in the Web | CB2<br>CB4<br>CG5<br>CG6<br>CG8<br>CE6<br>CE8 |

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

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 14 | 5 | 19 |
| Practice in computer rooms | 8 | 32 | 40 |
| Projects | 4 | 32 | 36 |
| Short answer tests | 2 | 6 | 8 |
| Reports / memories of practice | 0 | 10 | 10 |
| Jobs and projects | 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 |

| | |
|---|---|
| Master Session | 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.<br><br>This methodology is mainly focused to the achievement of the competencies CB1, CB5 and CE8. |
| Practice in computer rooms | 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.<br><br>This methodology is mainly focused to the achievement of the competencies CB3, CB4, CB5 and CE8. |
| Projects | 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.<br><br>This methodology is mainly focused to the achievement of the competencies CB2, CB4, CG5, CG6, CG8, CE6 and CE8. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | In the master classes, lecturers will be solve particular doubts and will give guidance on the theoretical and practical contents. |
| Practice in computer rooms | During the in-classroom 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. |
| Projects | During the in-classroom project sessions students will be monitored and any questions that may arise will be addressed. Furthermore, lecturers will be available during tutoring hours to solve doubts. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Short answer tests | Students will conduct individually, without supporting material, a knowledge test. This test will consist of a written exam in which questions relating to theoretical concepts covered in the keynote sessions arise. | 35 | CB1<br>CB4<br>CB5<br>CE8 |
| Reports / memories of practice | Students must submit a report for each of the practical exercises proposed by the faculty. The reports must describe quantitatively and qualitatively the solutions adopted, justifying its use over other alternatives when relevant. | 30 | CB2<br>CB3<br>CB4<br>CG8<br>CE8 |
| Jobs and projects | In a first phase, students must prepare a proposal for an innovative project that makes use of technologies and techniques discussed in the course. This proposal will be presented in class and analyzed and valued by classmates (peer review) and by the lecturer according to a predefined rubric. The rubric will be made available to students before the start of the project.<br><br>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. | 35 | CB3<br>CB4<br>CG5<br>CG6<br>CG8<br>CE6<br>CE8 |

**Other comments and July evaluation**

Two evaluation systems will be offered to the students in this course: Continuous Evaluation and Single Evaluation (at the

end of the semester). The student must choose, in the first week of class, the modality that will continue. Once the choice is made, the student may not change the system.

Regardless of the evaluation system chosen, the pass mark for the course is 5 out of 10. Below the characteristics of both systems and the particularities of the subsequent calls are detailed.

**Continuous Evaluation**

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

- 1 theoretical exam (theory assessment). The score of this test corresponds to the Grade of Theory (GTheory)
- 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 mainly includes elements of group evaluation (e.g. level of innovation of the proposal, degree of utilization of techniques discussed in class), but also 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)

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:

$$M = 0{,}35 * GTheory + 0{,}3* GPractice + 0{,}35 * GProject$$

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 attending any scheduled activity of the continuous evaluation modality is considered he/she definitely has chosen that evaluation system, and he/she may not appear as "No Presented" in the transcripts.
- 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 chooses 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.

**Evaluation of subsequent calls**

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 higher than 4 in the project (whether by continuous or single evaluation system) he/she would not be required to submit the 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 mean score over 4 between the scores of theory and practice 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 (score of the theoretical part in the single evaluation or the mean of theory and practice in the continuous evaluation).

None of the marks obtained in the course, regardless of the chosen system of evaluation will be retained for subsequent courses.

## Sources of information

### Basic Bibliography

R. Baeza-Yates, B. Ribeiro-Neto, Modern Information Retrieval. The concepts and technology behind search, 2th Edition, Addison Wesley, 2011

G. Antoniou, P. Groth, F. van Harmele, R. Hoekstra, A Semantic Web Primer, 3th Edition, MIT Press, 2012

**Complementary Bibliography**

G. Shroff, The Intelligent Web: Search, smart algorithms, and big data, Oxford University Press, 2014

W.B. Croft, D. Metzler, T. Strohman, Search Engines: Information Retrieval in Practice, Pearson, 2010

J. Domingue, D. Fensel, J.A. Hendler, Handbook of Semantic Web Technologies, Springer, 2011

S. Casteleyn, F. Daniel, P. Dolog, M. Matera, Engineering Web Applications, Springer, 2009

J. Leskovec, A. Rajaraman, J. Ullman, Mining of Massive Datasets, Cambridge University Press, 2014

T. Berners-Lee, The next web, 2009, https://www.ted.com/talks/tim_berners_lee_on_the_next_web

**Recommendations**

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

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know |
| 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. | - know |
| 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. | - Know How |
| CE11 | CE11 Knowledge of hardware description languages for high complexity circuits. | - Know How |
| 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. | - Know How |
| CE14 | CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors. | - know |

| 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.<br>To design matching circuits from analog to digital signal processors efficiently. Besides of the output signals from analog systems to digital processors. | CE12 |
| To know how to design specific digital filters and modulators for sampling and reconstruction of signals.<br>To know how to use the modulation techniques for conditioning of sensors and for generating electrical signals to actuators. | CE14 |

| Contents |
|---|
| Topic |

| | |
|---|---|
| Unit 1: Introduction to mixed analog and digital electronic circuits. | Mixed circuits characteristics. Modeling, simulation and applications of mixed circuits. Introduction to hardware description languages for analog / digital mixed circuits. |
| Unit 2: Introduction to direct signal coupling techniques from analog to digital processors. | Introduction. Coupling technology in base band and by modulation. Measurement of time constants. PWM modulation. Sigma-Delta Modulation. Phase modulation. Frequency Modulation. Resources for coupling analog signals to digital processors. |
| Unit 3: Oversampling Techniques for digital processing of analog signals. | Oversampling techniques. Resolution gain. Reshaping of the quantization noise spectrum. First-order modulator. Modeling, simulation and test of sigma-delta modulators. |
| Unit 4: Sigma-delta modulators circuits. | Design of sigma-delta modulators with different topologies. Operating parameters. Low-pass and band-pass modulators. |
| Unit 5: Introduction to multistage A/D converters. | Pipelined A/D converters. Basic steps, timing and alignment. Test methods. |
| Unit 6: Digital filter circuits for signal sampling and reconstruction applications. | VHDL synthesis of digital filters. Decimation filters. Equalizer filters. Data format. Optimization. |
| Unit 7: Digital synthesis of signals to feed analog systems. | Methods of digital synthesis of analog signals. Direct synthesis. IIR filters. Modeling of digital synthesizers of analog signals with hardware description languages. |
| Unit 8: Applications of the mixed electronic systems to the instrumentation. | Analogical-and-digital measurement electronic systems. Direct converting circuits of physical variables to digital signals. Resistance-to-digital, capacity-to-digital and inductance-to-digital converters. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 13 | 26 | 39 |
| Tutored works | 5 | 10 | 15 |
| Laboratory practises | 8 | 16 | 24 |
| Short answer tests | 1 | 13 | 14 |
| Practical tests, real task execution and / or simulated. | 2 | 20 | 22 |
| Multiple choice tests | 1 | 10 | 11 |

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

**Methodologies**

| | Description |
|---|---|
| Master Session | Exhibition of the contents of the subject; it includes exhibition of concepts; introduction of practices and exercises; and resolution of problems and/or exercises in ordinary classroom. |
| Tutored works | The student, of individual way or in group, elaborates a document on the thematic of the matter or prepares seminars, investigations, memories, essays, summaries of reading, conferences, etc. |
| Laboratory practises | Application, at a practical level, of the knowledge and skills acquired in the lectures by mean of practices undertaken with test and measurement equipment, either in the laboratory or in other place. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | 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 practises | 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. |
| Tutored works | The professor will attend personally doubts and queries of the students on the upervised works. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject. |

**Assessment**

| Description | Qualification | Evaluated Competencess |
|---|---|---|

| | | | |
|---|---|---|---|
| Laboratory practises | It values the participation of the student in the practices of laboratory: preparation of previous tasks, fulfillment of the aims posed in each practice and back tasks in which the student analyses the results, compares them with the expected and presents the conclusions. They can apply to the tests of continuous or final assessment. | 15 | CG8<br>CE12<br>CE14 |
| Tutored works | he student, individually or in group, elaborates a document on the thematic of the matter or prepares seminars, investigations, memories, essays, summaries of reading, conferences, etc. | 10 | CB1<br>CG4<br>CG8<br>CE11<br>CE12<br>CE14 |
| Short answer tests | Tests that include direct questions about an specific topic. The student has to answer of direct form in virtue of the knowledge that has on the subject. The answer is brief. They can apply to the tests of continuous evaluation or to the final examination. | 25 | CB1<br>CG4<br>CE11<br>CE14 |
| Practical tests, real task execution and / or simulated. | Tests that include activities of laboratory and/or TIC, problems or cases to resolve. The students have to give answer to the activity formulated by reflecting, in a practical way, the theoretical and practical knowledge that have been learnt in the subject, using, if it is necessary, the equipment or instrumentation of the practices carried out in the course. They can apply to the tests of continuous or final assessment. | 25 | CG8<br>CE11<br>CE12<br>CE14 |
| Multiple choice tests | Tests that include direct questions about an specific topic with answers of multiple selection. They can apply to the tests of continuous or final assessment. | 25 | CB1<br>CG4<br>CE14 |

## Other comments and July evaluation

### 1. Continuous evaluation

The continuous evaluation is divided in five parts (with their respective weights): the progress in the practices in the laboratory (15%), tutored works (10%), the practical test (25%), a test of short answers (25%) and a test of multiple choices (25%). The final mark is on a maximum of 10 points.

The final mark is the sum of the partial marks obtained in each part, if the students fulfill the following conditions:

- Have carried out a minimum of the 80% of the practices of laboratory.
- Obtain a minimum mark of the 40% in each part of the evaluation.

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).

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

The practical test will take place in the last session of laboratory classes. The tests of multiple choice and the short answers will can be divided in two sessions spread along the period of teaching.

### 2. Final exam

Students who fail the course in continuous assessment 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.

### 3. Call for recovery

The call for recovery will be like the final exam.

## Sources of information

### Basic Bibliography

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

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, Dordrecht, The Netherlands

**Complementary Bibliography**

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

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

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

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

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

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

## Recommendations

**Subjects that continue the syllabus**

Signal Conditioners/V05M145V01331

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

Advanced Digital Electronic Systems/V05M145V01203

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

Analog Electronic Circuits Design/V05M145V01106

| 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 | Galician<br>English | | | |
| Department | | | | |
| Coordinator | Poza González, Francisco | | | |
| Lecturers | Álvarez Ruiz de Ojeda, Luís Jacobo<br>Poza González, Francisco | | | |
| E-mail | fpoza@uvigo.es | | | |
| Web | http://www.faitic.uvigo.es | | | |
| General description | The documentation of the subject will be in English. Half of lectures will be given in English, another half in galician.<br>The main learning goals of this course are:<br>• To learn the codesign methods to design applications based on embedded microprocessors in FPGAs.<br>• To get to know the microprocessors that can be implemented in commercial FPGAs.<br>• To handle the necessary software tools for the development of embedded applications by means of FPGAs.<br>• To design application specific peripherals and their connection to the buses of the embedded microprocessors.<br>• To design real digital applications with embedded microprocessors in FPGAs. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - know<br>- Know How |
| CE11 | CE11 Knowledge of hardware description languages for high complexity circuits. | - know |
| 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. | - Know How |

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

| | |
|---|---|
| To design real applications with embedded microprocessors in FPGAs. | CB5<br>CG1<br>CG8<br>CE11<br>CE12 |

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

| | |
|---|---|
| LESSON 8 LABORATORY. DESIGN PROJECT. DESIGN OF AN APPLICATION BASED IN XILINX 32-BIT MICROPROCESSORS. (10 h.: 5 h. type B + 5 h. type C) | 8.1. Design and test of the assigned application. |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 5 | 10 | 15 |
| Troubleshooting and / or exercises | 5 | 20 | 25 |
| Laboratory practises | 10 | 10 | 20 |
| Tutored works | 9 | 48 | 57 |
| Presentations / exhibitions | 1 | 7 | 8 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| **Methodologies** | |
|---|---|
| | Description |
| Master Session | Conventional lectures.<br><br>Through this methodology the outcomes CE11 and CE12 are developed. |
| Troubleshooting and / or exercises | 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.<br><br>Through this methodology the outcomes CB5, CG1, CG8, CE11 and CE12 are developed. |
| Laboratory practises | 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.<br><br>Through this methodology the outcomes CB5, CG8, CE11 and CE12 are developed. |
| Tutored works | 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.<br><br>Through this methodology the outcomes CB5, CG1, CG8, CE11 and CE12 are developed |
| Presentations / exhibitions | Exhibition of the results of the project developed.<br><br>Through this methodology the outcomes CB5, CE11 and CE12 are developed. |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| Master Session | 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 practises | 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. |
| Troubleshooting and / or exercises | 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. |
| Tutored works | In class, the teacher will assist the students. Besides, the students will have the opportunity to consult with the teacher in office hours, which will be published in the faculty website. |

| **Assessment** | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Presentations / exhibitions | 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<br>CE11<br>CE12 |

| | | | |
|---|---|---|---|
| Laboratory practises | Design circuits and programs in the laboratory sessions corresponding to the laboratory lessons 1 to 5.<br>It will be necessary to show to the professor the operation of each one of the circuits and programs.<br>It will be necessary to deliver the design source files.<br>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<br>CG8<br>CE11<br>CE12 |
| Troubleshooting and / or exercises | Problem Based Learning.<br>Resolution of exercises and theoretical problems. They will be focused on the development of a software routine and a hardware peripheral for the assigned function to each student and compare the profiling of both in terms of execution time and used logical resources.<br>The content corresponds to theoretical lesson 7.<br>It will be necessary to show to the professor the operation of each one of the circuits and programs.<br>The correct application of the theoretical concepts to the problems will be assessed, based on the published criteria.<br>It will be necessary to deliver a short report explaining the work done. | 25 | CB5<br>CG1<br>CG8<br>CE11<br>CE12 |
| Tutored works | Project Based Learning.<br>Laboratory Project. Design of an embedded system.<br>It will be necessary to deliver the files source of the work realized. It will be necessary to deliver the design source files.<br>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<br>CG1<br>CG8<br>CE11<br>CE12 |

**Other comments and July evaluation**

The total mark will be the sum of the marks obtained in the different tasks of the subject.

All the students, both those who follow the subject continuously and those who want to be assessed in the final exam at the end of the term or in the extraordinary exam in July, will have to do the tasks described in the previous section. The students that do not attend classes regularly will also have to do the same tasks as the students who attend classes.

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 assessment systems: continuous assessment and final assessment.

CONTINUOUS ASSESSMENT:

• The students are considered to have chosen the continuous assessment when they have done 2 laboratory practices and/or 2 reports of theoretical exercises.

• The students that have chosen continuous assessment, but do not pass the course, will have to do the final assessment in July.

• The students that pass the course by means of continuous assessment will not be allowed to repeat any task in the final assessment in order to improve the mark.

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

• Preferably 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 assessment 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.

FINAL ASSESSMENT:

• The students that opt for the final assessment will have to do all the theoretical and practical tasks and the project individually.

• The tasks for the final assessment have to be delivered before the official date of the examination set by the faculty.

COMMON FOR ALL THE STUDENTS

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

FM = 0'25 * TE + 0'25 * LAB + 0'40 * LP + 0'10 * OP

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

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

Where:

TE = Global mark of the theoretical exercises and problems.

LAB = Guided Laboratory Practices.

LP = Laboratory Project.

OP = Oral presentation.

ASSESSMENT CRITERIA.

1) Realization of guided laboratory practices.

It will evaluate the correct operation of the circuits and programs developed in the laboratory sessions. Each laboratory lesson 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 corresponding to the laboratory lessons 1 to 5 will be obtained through the following formula:

LAB = ( Lesson 1L + Lesson 2L + Lesson 3L + Lesson 4L + Lesson 5L ) / 5

The total mark of the guided laboratory practices (LAB) will correspond to 25% of the total mark of the subject. It will be necessary to deliver the required source files. The assessment criteria refer only to the functionality of the circuits and programs developed, that is, the circuits and programs have to work perfectly to obtain the maximum mark.

2) Theoretical exercises and problems.

Each one of the theoretical exercises and problems proposed in the theoretical sessions 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 exercises assigned.

The majority of the exercises will consist in the design of a peripheral for an embedded system and the approach to the design of a complete embedded system with its peripherals.

The assessment criteria are the following:

2.1) Suitable distribution of tasks between “hardware” and “software".

2.2) Suitable organization of the “hardware” and suitable structure of the C program.

2.3) Correct design (CORR).

Optimization of the VHDL description and the C programs. Synchronous design. Reusable design.

2.4) Functionality (FUNC).

If the exercise asks for it, the behavioral simulation and synthesis of the VHDL, as well as the simulation of the C programs have to work perfectly.

2.5) Documentation (DOC).

i. Design source files. Enough comments in the VHDL and C files to explain the sentences used.

It will be necessary to deliver the required source files. The total mark will be the sum of the marks of each one of the exercise reports divided by the number of reports:

TE = (Exercise 1 + … + Exercise N) / N

3) Autonomous Laboratory Project.

This project consists in the design of an embedded system. The assessment criteria are the following:

3.1) Suitable distribution of tasks between “hardware” and “software".

3.2) Suitable organization of the hardware system and suitable structure of the C program.

3.3) Correct design (CORR). System entirely synthesizable. Suitable hierarchy arrangement. Design totally synchronous. Technology independent design. Reusable design.

3.4) Analysis of the design and the implementation in FPGAs (ANA). Analysis of the FPGA logical resources used and their justification. Analysis of the internal system delays. Analysis of the chosen implementation options. Optimal utilization of the FPGA logical resources. Achievement of an optimal processing speed. Verification with Chipscope.

3.5) Functionality (FUNC). Software Simulation. Software Debugging. Behavioral and Timing Simulation of the different hardware circuits. Simulation of the complete embedded system (hardware + software). Debugging of the complete embedded system (hardware + software). Board test of the complete embedded system (hardware + software). All the sections have to work perfectly to obtain the maximum mark.

6) Documentation of the design and the implementation with FPGAs (DOC).

3.6.1) Document.

i. Clear structure and order.

ii. Clear and sufficient explanations for the understanding of the work developed.

iii. Include suitable figures.

iv. Include important data.

3.6.2) Source design files.

i. Sufficient comments in the VHDL files for its understanding.

ii. Sufficient comments in the C files for its understanding.

For the Autonomous Laboratory Project (LP), it will be necessary to do an oral presentation.

3.7) Laboratory Project Oral Presentation.

The work developed during the laboratory project will be presented. The assessment criteria are the following:

i. Clear structure and presentation order.

ii. Clear explanations.

iii. Enough explanations to understand the project.

iv. Suitable figures.

v. Relevant data.

## Sources of information

### Basic Bibliography

ÁLVAREZ RUIZ DE OJEDA, L.J., POZA GONZÁLEZ, F., Diseño de aplicaciones empotradas de 32 bits en FPGAs con Xilinx EDK 10.1 para Microblaze y Power-PC, Vison Libros, 2012

### Complementary Bibliography

ÁLVAREZ RUIZ DE OJEDA, L.J., Diseño Digital con FPGAs, Vision Libros, 2013

## Recommendations

### Subjects that are recommended to be taken simultaneously

Advanced Digital Electronic Systems/V05M145V01203

| 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<br>Fariña Rodríguez, José | | | |
| E-mail | jfarina@uvigo.es | | | |
| Web | | | | |
| General description | The objectives in mind are:<br>1) To know and understand the design methodologies of Integrated Circuits (ICs) based on CMOS technology.<br>2) To know the basic topologies used in analog electronic circuits.<br>3) To know how to analyze and dimensioning the devices of the basic topologies of analog circuits in CMOS technology.<br>4) To know and be capable to use software tools for the design of integrated circuits.<br>5) To know to specify an integrated circuit for manufacturing in CMOS technology. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How |
| 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. | - Know How |
| CE10 | CE10 Ability to design and manufacture integrated circuits. | - know<br>- Know How |

| 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<br>CG8<br>CE10 |
| Know aid software tools integrated circuit design | CE10 |
| Know how an electronic circuit is specified for manufacturing | CB4<br>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 |
| Master Session | 14 | 28 | 42 |
| Troubleshooting and / or exercises | 4 | 28 | 32 |
| Laboratory practises | 9 | 22.5 | 31.5 |
| Short answer tests | 1 | 4 | 5 |
| Troubleshooting and / or exercises | 1 | 5.5 | 6.5 |
| Practical tests, real task execution and / or simulated. | 1 | 7 | 8 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| **Methodologies** | |
|---|---|
| | Description |
| Master Session | 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 |
| Troubleshooting and / or exercises | 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:<br>- Analysis of possible solutions and design alternatives. |
| Laboratory practises | 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 attention** | |
|---|---|
| Methodologies | Description |

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

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Short answer tests | 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.<br>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.<br>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).<br>Competences CE10 and CB4 will be assessed in these tests. | 20 | CB4<br>CE10 |
| Troubleshooting and / or exercises | 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.<br>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.<br>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).<br>Competences CE10 and CB4 will be assessed in these tests. | 20 | CB4<br>CG8<br>CE10 |

| | | | |
|---|---|---|---|
| Practical tests, real task execution and / or simulated. | The evaluation of the practical tests 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:<br>- Analysis of alternatives<br>- Correct implementation and design verification<br>- Design compaction<br>- 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.<br>- Information for integrated circuit manufacturing.<br>- Formal aspects: clarity and order, including figures and appropriate and outstanding data, as well as explanations in a concrete and comprehensive way.<br>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.<br>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%.<br>In this test the CE10, CB4, CB5 and CG8 skills are evaluated. | 60 | CB4<br>CB5<br>CG8<br>CE10 |

**Other comments and July 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, John Wiley & Sons, 2010

Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, Analysis and Design of Analog Integrated Circuits, John Wiley & Sons, 2009

Behzad Razavi, Design of Analog CMOS Integrated Circuits, McGraw Hill, 2000

Stephen A. Campbell, Fabrication Engineering at the micro-and nanoscale, Oxford University Press, 2013

**Complementary Bibliography**

**Recommendations**

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Real-Time Signal Processing** | | | | |
| 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 Herrero, Julio | | | |
| Lecturers | Martín Herrero, Julio | | | |
| E-mail | julio@uvigo.es | | | |
| Web | | | | |
| General description | We deal with different architectures and techniques for realtime signal processing, including digital signal processors (DSP) and multicore computing platforms (CPUs and massively parallel GPUs). Standards such as OpenCL, OpenMP, PPL and AMP will be addressed. Our main focus will be on hands-on, practical work and the capability to adapt to new, emerging, constantly evolving technologies and tools. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - know<br>- Know How<br>- Know be |
| 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. | - know<br>- Know How<br>- Know be |
| CE21 | CE21/PS1 Manage implementation of signal processing systems options to accelerate computationally complex algorithms. | - know<br>- Know How<br>- Know be |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| To handle advanced architectures for realtime signal and video processing | CG1<br>CG8<br>CE21 |
| To apply advanced techniques of DSP programming in realtime signal applications | CG1<br>CG8<br>CE21 |
| To understand the basic principles of realtime signal and video processing on standard GPUs and general purpose GPU | CG1<br>CG8<br>CE21 |
| To understand and apply the fundamentals of realtime application programming on graphic processing units, using multiplatform programming interfaces (OpenCL) | CG1<br>CG8<br>CE21 |

| Contents | |
|---|---|
| Topic | |
| High and low level DSP programming | High and low level DSP programming |
| GPU programming fundamentals | GPU programming fundamentals |
| General purpose programming of GPUs (GPGPU) | General purpose programming of GPUs (GPGPU) |
| OpenCL programming and integration in different architectures | OpenCL programming and integration in different architectures |

| Planning |
|---|

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 8 | 0 | 8 |
| Practice in computer rooms | 17 | 0 | 17 |
| Projects | 0 | 95 | 95 |
| Long answer tests and development | 2 | 0 | 2 |
| Practical tests, real task execution and / or simulated. | 3 | 0 | 3 |

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

## Methodologies

| | Description |
|---|---|
| Master Session | General introductions to fundamental concepts. All competencies are addressed. |
| Practice in computer rooms | Individual hands-on work on computing platforms and/or simulators to implement and compare study cases. All competencies are addressed. |
| Projects | In-depth practical development of an application/algorithm according to the specific interests of each student. All competencies are addressed. |

## Personalized attention

| Methodologies | Description |
|---|---|
| Projects | The professor will review with the student the design and the code of the student in each class session, and in individual office hours. |
| Practice in computer rooms | The professor will review with the student the design and the code of the student in each session. |

## Assessment

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Long answer tests and development | Questions on general fundamental concepts of realtime signal processing | 30 | CG1<br>CG8<br>CE21 |
| Practical tests, real task execution and / or simulated. | Programming of realtime algorithms | 70 | CG1<br>CG8<br>CE21 |

## Other comments and July evaluation

The assessment is continuous by default, based on the work carried on by the students during the lab classes and in their personal project. This can provide up to 100% of the final mark. There is an optional written final exam at the end of the period of classes, which can be used to raise the continuous evaluation mark, or as 100% of the qualification for those students not willing to follow the continuous assessment. Those students not succeeding in the first call will have access to a second call, where the whole mark will come out from the final written exam.

## Sources of information

### Basic Bibliography

Sen M. Kuo, Bob H. Lee, Wenshun Tian, Real-Time Digital Signal Processing, 3, Wiley, 2013,

Matthew Scarpino, OpenCL in Action, 1, Manning, 2012,

### Complementary Bibliography

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

Khronos Group, The OpenCL specifications https://www.khronos.org/registry/cl/, 2.2, 2016,

Raymond Tay, OpenCL Parallel Programming Development Cookbook, 1, Packt Publishing, 2013,

## Recommendations

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

Signal Processing in Communications/V05M145V01102

**Other comments**

For a suitable progress in the course, proficiency in C and C++ programming is required.

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Communication Advanced Systems** | | | | |
| Subject | Communication<br>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 | 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 | | Typology |
| 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. | - know<br>- Know How |
| CE22 | CE22/PS2 Ability to understand the impact of the requirements of the telecommunications systems design services, with special emphasis in the lower layers, while maintaining a global vision of the solutions employed in modern commercial systems of communications. | - know<br>- Know How<br>- Know be |

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

| Contents | |
|---|---|
| Topic | |
| 1. Convex optimization | 1.1 Basic concepts of convex sets<br>1.2 Introduction to convex functions<br>1.3 Quasiconvex functions<br>1.4 Convex optimization problems<br>1.5 Duality<br>1.6 Practical examples in communications |
| 2. Multiple-access channels | 2.1 Capacity regions: coordinated and uncoordinated access<br>2.2 Multiuser detection techniques<br>2.3 Random access schemes |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Seminars | 4 | 10 | 14 |
| Troubleshooting and / or exercises | 0 | 25 | 25 |
| Master Session | 24 | 60 | 84 |
| Short answer tests | 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 | 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. |
| Troubleshooting and / or exercises | 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. |
| Master Session | 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 attention**

| Methodologies | Description |
|---|---|
| Master Session | 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. |
| Troubleshooting and / or exercises | Student support will be provided during office hours and by e-mail. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Troubleshooting and / or exercises | 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<br>CE22 |
| Short answer tests | Final exam with short questions and exercises. | 50 | CG4<br>CE22 |

**Other comments and July 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, 2017, Vigo

**Complementary Bibliography**

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

**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.

| 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://faitic.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 | | Typology |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CE23 | CE23/PS3 Ability to apply methods of statistical processing of signal communications systems and audiovisual. | - know<br>- Know How |

| 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<br>CE23 |
| Ability to evaluate the performance of estimation and detection techniques, by analytical as well as by Monte Carlo simulation methods | CG8<br>CE23 |

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

| Planning |
|---|

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 21 | 23 | 44 |
| Practice in computer rooms | 7 | 0 | 7 |
| Autonomous troubleshooting and / or exercises | 0 | 28 | 28 |
| Autonomous practices through ICT | 0 | 25 | 25 |
| Jobs and projects | 0 | 21 | 21 |

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

**Methodologies**

| | Description |
|---|---|
| Master Session | Presentation of main topics, possibly with audiovisual aids. Skills involved: CG4, CG8 |
| Practice in computer rooms | Computer-based simulation in the lab of statistical signal processing applications to communications and multimedia, via Monte Carlo methods. Performance analysis. Skilss involved: CG8, CE23 |
| Autonomous troubleshooting and / or exercises | 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 |
| Autonomous practices through ICT | Computer-based simulation of statistical signal processing applications to communications and multimedia, via Monte Carlo methods. Performance analysis. Skills involved: CG8, C23 |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | Student aid will be provided during office hours as well as on-line (email). |
| Practice in computer rooms | Student aid will be provided during lab hours and office hours, as well as on-line (email). |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Autonomous troubleshooting and / or exercises | Students will be given a series of short homework assignments throughout the course that they should turn in by the set deadline. | 40 | CG4<br>CG8<br>CE23 |
| Jobs and projects | Development of an individual final project in which students will apply the acquired tools and techniques to a practical problem. | 60 | CG4<br>CG8<br>CE23 |

**Other comments and July 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.

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

Any kind of plagiarism will result in automatically failing the course.

**Sources of information**

**Basic Bibliography**

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

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

**Complementary Bibliography**

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

T. K. Moon, W. C. Stirling, Mathematical Methods and Algorithms for Signal Processing, 1, 2000

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

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Numerical Optimisation in Telecommunications** | | | | |
| Subject | Numerical Optimisation in Telecommunications | | | |
| Code | V05M145V01304 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **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 -----

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Data Protection Cryptographic Techniques** | | | | |
| Subject | Data Protection Cryptographic Techniques | | | |
| Code | V05M145V01306 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **Machine Learning** | | | | |
| Subject | Machine Learning | | | |
| Code | V05M145V01307 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **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 | Rodríguez Pérez, Miguel | | | |
| Lecturers | Rodríguez Pérez, Miguel | | | |
| E-mail | Miguel.Rodriguez@det.uvigo.es | | | |
| Web | http://faitic.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 | | Typology |
| 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. | - know |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know be |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know be |
| 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 | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| The students will be able to design, develop and manage the whole infrastructure of a web application. Besides, they will be able to develop the application logic and to create responsive user interfaces using web technologies. | CB1<br>CB5<br>CG12<br>CE35 |

| Contents | |
|---|---|
| Topic | |
| Web applications architecture | |
| HTML5: A tagged language in permanent evolution | Introduction to the WHATWG<br>New HTML tags<br>Semantic Markup<br>Forms<br>New APIs |
| Content presentation: CSS3 | A new box model<br>Responsive design<br>New CSS modules and standardization process<br>Images and gradients<br>New selectors |

| | |
|---|---|
| Web applications | The javascript language |
| | Web applications frameworks |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 9 | 18 | 27 |
| Laboratory practises | 9 | 18 | 27 |
| Autonomous practices through ICT | 5 | 64 | 69 |
| Long answer tests and development | 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 |
| Master Session | Presentation of the main concepts treated in the subject, and description of the technologies employed. The presentation will be based, most of the time, practical examples. Most work will be focused on the competence CE35. |
| Laboratory practises | In the labs the students will face several practical sessions –supervised by the professors– where they will settle the concepts learnt in the theoretical classes. The work will be focused in competencies CB5 and CE35. |
| Autonomous practices through ICT | A project with a fairly large magnitude will be posed to be developed as a teamwork during all the semester. The work will focus on competencies CB1, CB5, CG12 and CE35. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | During the hours of tutoring, teachers will conduct a personalized attention, either individually to strengthen or guide the student na understanding of theoretical concepts explained in the sessions demonstrative lectures or practical sessions. In these hours also monitoring associated with the project of a certain size to be undertaken with colleagues work is done. In the group tutorials solutions raised by the group are discussed and reviewed the uniform participation of members in the final development. |
| Autonomous practices through ICT | During the hours of tutoring, teachers will conduct a personalized attention, either individually to strengthen or guide the student na understanding of theoretical concepts explained in the sessions demonstrative lectures or practical sessions. In these hours also monitoring associated with the project of a certain size to be undertaken with colleagues work is done. In the group tutorials solutions raised by the group are discussed and reviewed the uniform participation of members in the final development. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Autonomous practices through ICT | Implementation of a small demonstration of a web application with the technologies exposed in the subject. | 50 | CB1<br>CB5<br>CG12<br>CE35 |
| Long answer tests and development | Final exam. | 50 | CB5<br>CG12<br>CE35 |

**Other comments and July evaluation**

**Continuous evaluation:**

To opt to the continuous evaluation, it is necessary to attend at least to 80% of the practical laboratory sessions and produce the partial deliveries of the group project.

Each delivery will be evaluated individually, being the total mark of the practice the result to ponder 50% of the note obtained in the last delivery with the average of the previous deliveries. Each mark will be shared by all the members of the group.

The final mark of the subject will be the pondered average among the practical mark (50%) and the mark of the final exam (50%).

**Final evaluation:**

The students that prefer the final evaluation will have to indicate so to the professor before the date of the first partial delivery of the group project. In such case, his partial deliveries will not be taken into account for his mark, (although they are taken into consideration for those group members that had chosen the continuous evaluation). The final mark will be 50% of the mark obtained in the final delivery of the work and 50% of the final exam mark.

**Second evaluation:**

In the extraordinary evaluation students will be requested make some small modifications to the group project individually. For those students that had chosen final evaluation, this delivery will represent 50% of the final mark while the remaining 50% corresponds with a new final exam.
In the case of the students of continuous evaluation, the mark of the practice will be the largest of: 50% of the new delivery and the previous partial deliveries (50%) or 100% of the new delivery.

| Sources of information |
| --- |
| **Basic Bibliography** |
| Mark Pilgrim, HTML5: Up and Running, 1ª, O'Reilly, 2010, |
| https://developer.mozilla.org/en/docs/Web, Web technology for developers, |
| Wesley Hales, HTML5 and JavaScript Web Apps, 1ª, O'Reilly, 2012, |
| **Complementary Bibliography** |
| Peter Gasston, The book of CSS3, 2ª, No Starch Press, 2014, |

| Recommendations |
| --- |

| 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<br>Gil Castiñeira, Felipe José<br>López Bravo, Cristina | | | |
| E-mail | kike@gti.uvigo.es | | | |
| Web | http://faitic.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.<br><br>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).<br><br>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.<br><br>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.<br><br>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 | | Typology |
| 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. | - know<br>- Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - Know How<br>- Know be |
| 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. | - Know How |
| CE33 | CE46/OP16 Ability to understand the current development of mobile and ubiquitous services and market developments . | - know |
| CE34 | CE47/OP17 Ability to design, create, integrate sources of context, and working group on the development of a mobile application | - Know How<br>- Know be |

| 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<br>CB5<br>CG8<br>CE34 |

| | |
|---|---|
| Work in group to propose, build and defend a mobile application. | CB2<br>CB5<br>CG8<br>CE33<br>CE34 |

| Contents | |
|---|---|
| Topic | |
| Movile Operating Systems | - Overview of the leading operating systems for mobile devices (Android, IOS, Windows Phone).<br>- Versions.<br>- Market evolution. |
| Android Operating System | - Android architecture.<br>- Components of an Android application: activities, services, content providers and broadcast receivers.<br>- Applications life cycle. |
| Mobile applications in the market | - Planning the development of an application.<br>- Publication of applications.<br>- Description of mobile applications available in the market. |
| Building Android applications | - Android Studio SDK<br>- Android emulator<br>- Activities, actions and intents<br>- Services and notifications<br>- Menus, preferences and dialogs<br>- User interfaces with views<br>- Fragments<br>- Concurrency<br>- Permissions<br>- Data persistence<br>- Context integration: localization, sensors<br>- Interconnection: bluetooth, wifi |

| Planning | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 4 | 4 | 8 |
| Laboratory practises | 12 | 36 | 48 |
| Tutored works | 4.5 | 49.5 | 54 |
| Presentations / exhibitions | 0.5 | 0.5 | 1 |
| Multiple choice tests | 1 | 1 | 2 |
| Practical tests, real task execution and / or simulated. | 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 |
|---|---|
| Master Session | 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 practises | Students will complete guided and supervised practices in the laboratory about the basic aspects of Android mobile applications. Through this methodology the competencies CB2, CG8, CE33 (CE46/OP16) and CE34(CE7/OP17) are developed. |
| Tutored works | 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. |
| Presentations / exhibitions | 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 attention | |
|---|---|
| Methodologies | Description |

| | |
|---|---|
| Master Session | 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 practises | 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 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. |
| Tutored works | 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 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. |
| Presentations / exhibitions | 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. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Tutored works | 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<br>CB5<br>CG8<br>CE33<br>CE34 |
| Presentations / exhibitions | 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<br>CE33<br>CE34 |
| Multiple choice tests | After each master session, students will make a multiple choice test (in English) to evaluate the understanding of the presented topics. | 20 | CE33 |
| Practical tests, real task execution and / or simulated. | In each practice session students will demonstrate the proper functioning of the developments carried out during the session. | 25 | CB2<br>CG8<br>CE33<br>CE34 |

**Other comments and July evaluation**

**FIRST OPPORTUNITY**

Following the guidelines of the degree, two assessment systems will be offered to students attending this course: continuous assessment and final assessment. Before the end of the second week of the course, students must declare if they opt for the continuous assessment or the final assessment. 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 assessment system**

Those students who opt for continuous assessment 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.

**Final assessment system**
Those students who opt for the final assessment 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 OPPORTUNITY**
The course final exam will only be held for students who failed the course in the first opportunity.
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 presententaion of the developd 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.

| **Sources of information** |
|---|
| **Basic Bibliography** |
| Joshua J. Drake, Android hackers's handbook, 1ª, John Wiley & Sons |
| Wei-Meng Lee, Beginning Android 4 Application Develeoment, 1ª, Wrox |
| Jesús Tomás Gironés, El gran libro de Android, 5ª, Marcombo |
| **Complementary Bibliography** |

| **Recommendations** |
|---|

| **Other comments** |
|---|
| It is recommended to have Java programming skills |

| 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<br>Pérez Fontán, Fernando | | | |
| E-mail | faguado@tsc.uvigo.es | | | |
| Web | http://faitic.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 | | Typology |
| 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. | - Know How |
| CG3 | CG3 Ability to lead, plan and monitor multidisciplinary teams. | - Know How |
| 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. | - Know How |
| 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. | - Know How |

| 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<br>CG3<br>CE18 |
| To know the mission life cycle of a space mission. | CB2<br>CE18 |
| To know the documentation generated in each engineering phase in a space mission | CB2<br>CG3<br>CE18 |
| To know and ellaborate the main technical studies and budgets in a space mission. | CG3<br>CG4<br>CE18 |
| To know applicable methodologies and standards to product assurance (PA) and Assembly, Integration and Verification (AIV) procedures in a space project. | CB2<br>CG3<br>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.<br>- Ground Segment.<br>- User Segment.<br>- Launchers. |
| Satellite subsystems | - Communication.<br>- Mechanical & Thermal.<br>- Power.<br>- ADCS.<br>- Propulsion.<br>- On-board computer. |
| Product Assurance and Assembly, Integration and Verification Procedures in a space project. | - Product Assurance (PA) in space projects.<br>- Assembly, Integration and Verifications (AIV) plans and procedures in space projects. |
| Introduction to satellite operations | - Telemetry and Telecommand definition.<br>- Operation procedures. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 19 | 57 | 76 |
| Seminars | 10 | 20 | 30 |
| Short answer tests | 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 |
|---|---|
| Master Session | We describe the different aspects of the subject providing all the necessary educational material.<br><br>Through this methodology the competencies CB2, CG3 and CE18 are developed. |
| Seminars | Every student will apply the theoretical knowledge to different practical tasks covering the main part of the contents of the subject with the help of the software suites.<br><br>Through this methodology the competencies CB2, CG4 and CE18 are developed. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | 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. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Master Session | The evaluation will be based on the documentation written by the student for a proposed project. | 45 | CB2<br>CG3<br>CE18 |
| Seminars | The students will perform simulations using specific software.<br><br>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<br>CG4<br>CE18 |
| Short answer tests | A final test to complement the evaluation of the contents presented in the master sessions.<br><br>The test will be individual with time limit. | 20 | CE18 |

**Other comments and July 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.

| Sources of information |
| --- |
| **Basic Bibliography** |
| James R. Wertz, David F. Everett and Jeffery J. Puschell, Space Mission Engineering: The New SMAD, 4, Microcosm Press |
| http://www.ecss.nl, |
| **Complementary Bibliography** |
| http://www.incose.org/, |
| NASA Systems Engineering Handbook, SP-2007-6105. Rev 1, NASA |
| Peter Fortescue (Editor), John Stark (Editor), Graham Swinerd (Editor), Spacecraft Systems Engineering, 3, Wiley |

| Recommendations |
| --- |

| Subjects that it is recommended to have taken before |
| --- |
| Analog Electronic Circuits Design/V05M145V01106 |
| Wireless and Mobile Communications/V05M145V01313 |

| 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<br>Santalla del Río, María Verónica | | | |
| E-mail | manuel.garciasanchez@uvigo.es | | | |
| Web | http://www.faitic.uvigo.es | | | |
| General description | Wideband radio systems. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CE19 | CE19/RAD2 Ability to perform theoretical design, experimental band systems measurement and practical implementation broadband for current applications | - know<br>- Know How |

| 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<br>Communicaction systems<br>Radio systems. Antennas. Radioelectric spectrum. Modulation.<br>Radio channel. Propagation channel. |
| Description of the radio channel | Free space<br>Undistorted transmission<br>Attenuation.<br>Multipath<br>Fading. Doppler spread.<br>Delay spread. Frequency selective channels.<br>Precursors. |
| Mathematical characterization | Narrowband<br>Statistical amplitude distributions<br>Doppler spectrum<br>Wideband<br>Bello formulation |

| | |
|---|---|
| Channel sounders | Narrowband<br>Doppler. Nyquist limit.<br>Wideband.<br>Frequency domain sounders: VNA<br>Time domain sounders.<br>RF pulse.<br>Sliding correlation sounders.<br>Sounder design and performance assesment.<br>Narrowband sounder with spectrum analyzer 0 span.<br>VNA based sounder.<br>Sliding correlation sounder. |
| Channel sounders lab | Building a wideband sounder to measure the radio channel. |
| Wideband modulations | Delay spread. Inter symbol interference. Irreducible BER.<br>Frequency hopping: GSM<br>OFDM. Guard interval. Pilot tones. Equalization. PAPR. Amplifiers. DVB-T. 4G.<br>CDMA. Processing gain. Noise. Adquisition and tracking. RAKE receiver. 3G.<br>Power control. Cellular breathing. |
| UWB systems | 1. Definition. Specificities. Regulation<br>2. Channel characteristics.<br>3. Impulse radio UWB.<br>4. Multiband OFDM approach to UWB.<br>5. Applications |
| Wideband and UWB antenna design | 1. Wideband antennas. Definition and requirements.<br>2. Characterization of wideband antennas<br>3. Examples and applications.<br>4. UWB antennas. Definition and requirements.<br>5. Characterization of UWB antennas<br>6. Examples and applications. |
| UWB applications | Radar<br>Ground penetrating radar<br>Positioning and location<br>Medical imaging<br>Emerging applications |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Seminars | 2 | 6 | 8 |
| Laboratory practises | 20 | 60 | 80 |
| Master Session | 6 | 18 | 24 |
| Short answer tests | 1 | 5 | 6 |
| Practical tests, real task execution and / or simulated. | 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 practises | Building and testing wideband radio channel sounders |
| Master Session | Master lecture given by the teacher |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | The students could ask questions during classes, during sheduled hours for the professors to atend the students or by email. |
| Laboratory practises | The students could ask questions during classes, during sheduled hours for the professors to atend the students or by email. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Master Session | Short answer test | 60 | CE19 |
| Laboratory practises | Practice written and oral reports. | 40 | CE19 |

**Other comments and July evaluation**

First call:

Following the guidelines of the master we offer to the students  two schemes of evaluation: 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.

**Sources of information**

**Basic Bibliography**

J.D. Parsons, The Mobile Radio Propagation Channel,

**Complementary Bibliography**

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

**Recommendations**

| 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<br>Vazquez Alejos, Ana | | | |
| E-mail | analejos@uvigo.es | | | |
| 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 | | Typology |
| CE20 | CE20/RAD3 Ability to analyse and specify the basic parameters of a mobile or wireless radio network, as well as of quality of service. | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Know the reference architectures of the 2G/3G/4G cellular systems, and also for short range radio systems and standards: WLAN, WPAN and others. | CE20 |
| 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, cellular, WLAN, WPAN, and other wireless radio communication systems. | 1.1. Introduction to mobile and wireless systems.<br>1.2. Mobile and wireless radio propagation channel. |
| Unit 2. Dimensioning and quality of service planning in mobile and wireless radio systems. | 2.1. The cellular concept.<br>2.2. Cellular design fundamentals.<br>2.3. Dimensioning of a mobile radio system.<br>2.4. Quality of service. |
| Unit 3. Review of the standards of current cellular systems. | 3.1. 2G mobile phone systems: GSM and GPRS.<br>3.2. 3G mobile phone systems: CDMA, UMTS, 3G, 3G+.<br>3.3. Next Generation Mobile phone systems: LTE 5G.<br>3.4. Security vulnerability in mobile communications systems. |
| Unit 4. Review of the standards of current wireless systems. | 4.1. Introduction to wireless systems and services: WLAN, WPAN, BAN.<br>4.2. Design fundamentals: dimensioning and quality of service.<br>4.3. Security vulnerability in wireless communications systems. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 22 | 22 | 44 |
| Case studies / analysis of situations | 4 | 40 | 44 |
| Troubleshooting and / or exercises | 4 | 2 | 6 |
| Autonomous troubleshooting and / or exercises | 0 | 10 | 10 |

| | | | |
|---|---|---|---|
| Short answer tests | 0 | 1 | 1 |
| Practical tests, real task execution and / or simulated. | 0 | 10 | 10 |
| Self-assessment tests | 0 | 10 | 10 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| **Methodologies** | |
|---|---|
| | Description |
| Master Session | Presentation of the contents of the subject by teachers; it includes explaining the theoretical concepts; introduction of lab practices, on-line tests and exercises/problems of autonomous realisation. |
| Case studies / analysis of situations | Conducting case studies in laboratory with delivery of a memory/report to be assessed. |
| Troubleshooting and / or exercises | Resolution of problems and/or exercises in ordinary classroom. |
| Autonomous troubleshooting and / or exercises | 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 attention** | |
|---|---|
| Methodologies | Description |
| Master Session | Time scheduled by professors to attend and resolve doubts of the students. |
| Autonomous troubleshooting and / or exercises | Time that the lecturer of group A will use to attend the students that need some support in doing their autonomous work. |
| Case studies / analysis of situations | Time scheduled to help the students in preparing their work. |
| Troubleshooting and / or exercises | Time that the lecturer can use to help the students in preparing their work. |
| **Tests** | Description |
| Short answer tests | Time that the lecturer can use to help the students in preparing their tests. |
| Practical tests, real task execution and / or simulated. | Time to be used by professors to help the students to understand the lab practices and to resolve doubts. |
| Self-assessment tests | Time that the lecturer can use to help the students in preparing their tests. |

| **Assessment** | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Autonomous troubleshooting and / or exercises | It will evaluate the resolution of problems delivered to each student for troubleshooting in an autonomous form. | 15 | CE20 |
| Short answer tests | 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 |
| Practical tests, real task execution and / or simulated. | For each lab practice (case studies / analysis of situations) an individual report of results must be presented for assessment. | 35 | CE20 |
| Self-assessment tests | Multiple choice questions tests for each unit of the subject content. The questionnaires are performed through Faitic 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. | 15 | CE20 |

**Other comments and July evaluation**

According to the specific guidelines of the degree, students enrolled in the subject can choose one of the two proposed assessment systems: continuous assessment or final evaluation.

**Continuous assessment**

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 final 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 practice.

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), and performing the final short answer test.

These tasks are not recoverable, that is, if a student does not satisfy the stipulated timing the teacher has no obligation to repeat, and also they will be only valid for the academic year in which they are made.

**Evaluation by final exam**

In compliance with the regulations of the University of Vigo, a student who does not opt for continuous assessment should be eligible for the highest rating by the final exam, which will consist of three parts:

- Part 1: realization of laboratory practices and delivery of reports due (35% 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 if the final grade is equal to or greater than 5.

**Extraordinary exam (July)**

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 final evaluation, the note will be the final exam that will consist of three parts: a practical examination (pass /non-pass), a standard test exam (50%) and an examination of problems (50%) .

It is considered that the subject is approved if the final grade is equal to or greater than 5.

| **Sources of information** |
|---|
| **Basic Bibliography** |
| Ana Vazquez Alejos, Lecture Notes and Powerpoint Slides, 2017, Faitic |
| Oriol Sallent, Fundamentos de diseño y gestión de sistemas de comunicaciones móviles celulares, 2014, Publicacions Acadèmiques Digitals de la UPC |
| **Complementary Bibliography** |
| Jose María Hernando Rábanos, Comunicaciones Móviles, 2004, Editorial Universitaria Ramón Areces |
| Mª Teresa Jiménez Moya, Juan Reig Pascual, Lorenzo Rubio Arjona, Problemas de comunicaciones móviles, 2006, Universidad Politécnica de Valencia |
| José Manuel Huidobro Moya, Comunicaciones móviles : sistemas GSM, UMTS Y LTE, 2012, RA-MA |
| Qualcomm, 2014, https://www.qualcomm.com/ |
| Martin Sauter, From GSM to LTE: An Introduction to Mobile Networks and Mobile Broadband, 2011, Wiley Online Library |
| Maciej Stasiak et al., Modelling and Dimensioning of Mobile Wireless Networks: From GSM to LTE, 2010, Wiley |
| W. Dargie, C. Poellabauer, Fundamentals of Wireless Sensor Networks: Theory and Practice, 2010, Wiley |

| **Recommendations** |
|---|
| **Subjects that continue the syllabus** |
| Antennas/V05M145V01208 |
| Radio Laboratory/V05M145V01209 |
| Wireless Networks and Ubiquitous Computation/V05M145V01211 |

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

Radiocommunication/V05M145V01103

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Radio Navigation** | | | | |
| Subject | Radio Navigation | | | |
| Code | V05M145V01314 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **Optical Networks** | | | | |
| Subject | Optical Networks | | | |
| Code | V05M145V01315 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **Radar** | | | | |
| Subject | Radar | | | |
| Code | V05M145V01316 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **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 | http://faitic.uvigo.es | | | |
| General description | Communications systems are at the mercy of the available technology to fabricate their transceivers. To understand the complexities of modern communications transceivers, their performance requirements and limitations, especially in the microwave and mm-wave frequency bands, it is mandatory to have a closer look to their underlying electronics and fabrication methods. And this look requires not only a theoretical background in active devices and circuit design methodologies or fabrications methods, but most importantly, a practical background in circuit design, fabrication, measurement and performance evaluation. The student has already acquired this theoretical background through previous subjects.<br><br>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.<br><br>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 | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - Know How |
| CE32 | CE38/OP8 Ability to design, manufacture (in hybrid technology) and characterize the analog components of transceivers of communications in microwave and millimeter-wave bands | - know<br>- Know How |

| 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 milimeter wave frequency bands. | CG1<br>CG4<br>CE32 |
| Learn to design high frequency circuits for the optoelectronic interface in optical communications systems. | CG1<br>CG4<br>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<br>CG4<br>CG8<br>CE32 |
| Learn to characterize and asses the performance of microwave circuits for communication transceivers. | CG1<br>CE32 |

| **Contents** | |
|---|---|
| Topic | |
| 1. Advanced circuit design for communication transceivers in the microwave and millimeter wave bands. | a. Linear and Nonlinear Circuit Design Techniques.<br>-CAD-based design and component models.<br>-Measurement-based design.<br>- S-parameters vs X-parameters<br>b. Advanced Low Noise Amplifier Design<br>c. High Eficiency Power Amplifier Design<br>d. High Frequency Oscillator Design<br>e. Frequency Converter Design |
| 2. High frequency circuit design for optoelectronic transceivers in optical communications systems. | Broadband Amplifier Design Techniques |
| 3. Fabrication techniques for Hybrid and Monolithic Microwave Integrated Circuits | Hybrid MIC processing techniques<br><br>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.<br><br>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<br><br>Prototype fabrication in Hybrid-MIC technology using microstrip transmission lines<br><br>Prototype characterization to evaluate performance. |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 5 | 10 | 15 |
| Practice in computer rooms | 14 | 0 | 14 |
| Laboratory practises | 4 | 0 | 4 |
| Tutored works | 0 | 78 | 78 |
| Tutored works | 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 |
| Master Session | It will be given in a classroom with the aid of a slate board and a video projector.<br>Main concepts in the Chapters will be described, with the exception of the last Chapter that it will not be covered here, since it is an application work (case study) by the student.<br>These classes are designed to aid in adquiring competencies: CG1,4,8 and CE38/OP8. |
| Practice in computer rooms | During these classes, with the aid of a commercial microwave circuits simulator, it will be designed by the student a circuit prototype, among those described in the subject. This work will be completed with through tutorized personal work by the student.<br>These classes are designed to aid in adquiring competencies: CG1,4,8 and CE38/OP8. |
| Laboratory practises | 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.<br>These classes are designed to help in adquiring competencies: CG1,4,8 and CE38/OP8. |

| | |
|---|---|
| Tutored works | 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 project with require most of the student effort in the subject.<br>These classes are designed to help in adquiring competencies: CG1,4,8 and CE38/OP8. |
| Tutored works | Each student will prepare - working individually- a short writen report about one of the topics covered in the subject. This work will by assesed by an oral presentation in which he/she will answer short questions about the work.<br>These classes are designed to help in adquiring competencies: CG1,4,8 y CE38/OP8. |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Practice in computer rooms | During these classes, students -individually- will perform the assigned tasks related to CAD design with the aid and personalized guidance of the lecturer. |
| Laboratory practises | During these classes, students -individually- will perform the assigned tasks related to prototyping and measurements with the aid and personalized guidance of the lecturer. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Tutored works | 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.<br>In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32. | 90 | CG1<br>CG4<br>CG8<br>CE32 |
| Tutored works | 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.<br>In this work, it will be evaluated competencies CG1, CG4, CG8 and CE32. | 10 | CG1<br>CG4<br>CG8<br>CE32 |

**Other comments and July 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 summons : The work of the student in the subject will be evaluated through the development of the two tutorized works:

1. The circuit prototype: design, fabrication in hybrid integrated technology, performance evaluation, and written report (90% of the total subject qualification).

2. The written report about a given topic and his/her answers to the short questions. (10% of the total subject qualification).

If the student does not obtain the minimum qualification to pass the subject in the first summons and has been present at least in 80% of the presential hours, the lecturer will suggest changes/improvements to the prototype design and written report about the topic, for the second summons.

B) The second summons: 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 improve the written report of the topic. Each of these tasks will be assigned the same qualification percentage as in the first summons Those students who have not been present in at least 80% of the presential hours, will have two 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 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, Prentice Hall

**Complementary Bibliography**

| |
|---|
| Technical papers (journals, application notes, data sheets,...), |
| Instrumentation and simulator manuals, |
| Steve C. Cripps, Advanced Techniques in RF Power Amplifier Design, 1, Artech House |
| Guillermo Gonzalez, Foundations of Oscillator Circuit Design, Artech House |
| D. Root, X-Parameters: Characterization, Modeling, and Design of Nonlinear RF and Microwave Components, 1, Cambridge |

## Recommendations

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

| |
|---|
| Electronics and Photonics for Communications/V05M145V01202 |

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Multimedia Security** | | | | |
| Subject | Multimedia Security | | | |
| Code | V05M145V01318 | | | |
| Study programme | 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://faitic.uvigo.es | | | |
| General description | Multimedia security is an increasingly important topic as most of the information exchanged nowadays over the Internet is multimedia. Traditional data protection solutions like cryptography only solve the problem partially, because contents, once decrypted, are no longer protected. In addition, there is a rising concern over the integrity of multimedia contents: modern editing tools jeopardize our trust on video, images or audio. Fortunately, a number of research groups and companies have addressed these problems and ingenious solutions exist.<br><br>This course presents advanced topics in multimedia security, with emphasis on cryptography, watermarking, forensics and signal processing in the encrypted domain.<br><br>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 | | Typology |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CE31 | CE37/OP7 Ability to model, operate, manage, and deal with the full cycle and bagging of networks, services and applications considering the quality of service, direct and costs of operation, the plan of implementation, monitoring, security, scaling and maintenance, managing and ensuring the quality of the development process | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Handle the most advanced information protection methods. | CG4<br>CG8<br>CE31 |
| Understand the potential and limitations of the different methods. | CG4<br>CG8<br>CE31 |
| Handle the use of different algorithms in current multimedia communications environments. | CG4<br>CG8<br>CE31 |
| Understand technical material in an autonomous way. | CG4<br>CG8<br>CE31 |

| Contents |
|---|
| Topic |

| | |
|---|---|
| Introduction to cryptography. | Application to multimedia systems.<br>Integration with source and channel coding.<br>Block and stream ciphers.<br>Hashing and MAC codes.<br>Specific algorithms. |
| Conditional access systems. | Requirements.<br>History and state of the art.<br>Design of a conditional access system. |
| Secret sharing. | Simple secret sharing systems.<br>Visual cryptography. |
| Data hiding and watermarking. | Basic concepts.<br>Watermarking versus data hiding.<br>Spread-spectrum watermarking.<br>Quantization-based watermarking.<br>Application to images and video. |
| Forensic signal processing. | Quantization detection and estimation.<br>Filtering detection and identification.<br>Resampling detection and estimation.<br>Source ballistics. |
| Signal Processing in the Encrypted Domain. | Privacy metrics and notions.<br>Homomorphic encryption.<br>Garbled cicruits.<br>Signal representation and cipher blowup.<br>Applications. |

**Planning**

| | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Master Session | 14 | 28 | 42 |
| Laboratory practises | 9 | 42 | 51 |
| Reports / memories of practice | 0 | 30 | 30 |
| Long answer tests and development | 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 |
|---|---|
| Master Session | The course is structured in several topics in multimedia security, including cryptography, watermarking, forensics and signal processing in the encrypted domain.<br><br>Competences: CG4, CG8, CE31 |
| Laboratory practises | 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.<br><br>Competences: CG4, CG8, CE31 |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | The teachers 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 |
| Reports / memories of practice | The teachers will provide individualized and personalized attention to students during the course, solving their doubts and questions. Doubts will be answered in presential form (during the work review sessions or during the office hours). |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Reports / memories of practice | 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<br>CG8<br>CE31 |
| Long answer tests and development | Final exam with short questions on the contents of the subject. | 30 | CG4<br>CG8<br>CE31 |

## Other comments and July 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.

## Sources of information

### Basic Bibliography

### Complementary Bibliography


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

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

A.J. Menezes, Handbook of Applied Cryptography, 1996, CRC Press

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


## Recommendations

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

Statistical Signal Processing/V05M145V01303

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Intelligent Sensors** | | | | |
| Subject | Intelligent Sensors | | | |
| Code | V05M145V01319 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Optional | 2nd | 1st |
| Teaching language | Spanish<br>Galician | | | |
| Department | | | | |
| Coordinator | Mariño Espiñeira, Perfecto | | | |
| Lecturers | Machado Domínguez, Fernando<br>Mariño Espiñeira, Perfecto<br>Pastoriza Santos, Vicente | | | |
| E-mail | pmarino@uvigo.es | | | |
| Web | http://faitic.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. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know |
| 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. | - Know How |
| CE36 | CE43/OP13 Ability to characterize intelligent sensors and their specific characteristics in networks | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Know the different structures of the intelligent sensors. | CB5<br>CG8<br>CE36 |
| Know the topologies and architectures of the sensor networks. | CB5<br>CG8<br>CE36 |
| Know analyse and design systems of efficient sensors in consumption. | CB4<br>CG8<br>CE36 |
| Know software tools and hardware platforms for the design of sensor systems. | CB5<br>CG8<br>CE36 |
| Design applications based on data fusion of different sensors. | CB4<br>CG8<br>CE36 |

| Contents | |
|---|---|
| Topic | |
| Unit 1: Smart Sensors. | Definition. Classification. Architectures. Multisensorial systems. Standard IEEE<br>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 |
|---|---|---|---|
| Master Session | 4 | 4 | 8 |
| Tutored works | 1 | 18.5 | 19.5 |
| Laboratory practises | 7.5 | 15 | 22.5 |
| Integrated methodologies | 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 |
|---|---|
| Master Session | 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. |
| Tutored works | 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 practises | 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. |
| Integrated methodologies | 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 attention**

| Methodologies | Description |
|---|---|
| Master Session | 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. In these sessions the lecturer will answer the students' questions and also give instructions to guide the studying and learning process. |
| Laboratory practises | 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. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools). |
| Integrated methodologies | The students can go to the lecturer's office (individually or in a group). The timetable will be available on the school website at the beginning of the term. The lecturers will be available to help students in order to deal with the project as well as the monitored work. |

| | |
|---|---|
| Tutored works | 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. In these sessions the lecturer will help students to deal with the monitored work. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Laboratory practises | 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), 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<br>CB5<br>CG8<br>CE36 |
| Integrated methodologies | 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) and the individual oral presentation of the developed project. The skills CB4, CB5, CG8 and CE43 will be evaluated in these projects. | 60 | CB4<br>CB5<br>CG8<br>CE36 |
| Tutored works | 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<br>CB5<br>CG8<br>CE36 |

**Other comments and July evaluation**

**1. Continuous assessment**

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 assessment***, 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>=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>=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:

$$FM = 0.2 \cdot FMT + 0.2 \cdot FML + 0.6\ FMP.$$

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:

$$FM = \min\{4\ ;\ (0.2 \cdot FMT + 0.2 \cdot FML + 0.6\ FMP)\}.$$

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

**2. Final Exam**

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

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

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

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

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

$$FM = 0.2 \cdot FMT + 0.2 \cdot FML + 0.6\ FMP.$$

However, when the students do not pass all parts (FMT < 5 or FML < 5 orFMP < 5), the final mark will be:

$$FM = \min\{4\ ;\ (0.2 \cdot FMT + 0.2 \cdot FML + 0.6\ FMP)\}.$$

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

**3. Second opportunity to pass the subject**

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 assessment or final exam 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 assessment.
- section 2  for all other case.

| Sources of information |
|---|
| **Basic Bibliography** |
| Fraden, J., Handbook of modern sensors, 5th, Springer, 2016, New York |
| Gómez, C., Paradells, J. y Caballero, J.E., Sensors Everywhere: Wireless Network Technologies and Solutions, Fundación Vodafone España, 2010, http://www.fundacionvodafone.es/sites/default/files/libro_sensores.pdf |
| 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, Upcomming, |
| **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, https://www.parallax.com/sites/default/files/downloads/28029-Smart-Sensors-Text-v1.0.pdf |

| Recommendations |
|---|

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Practicals in Digital Electronics for Communications** | | | | |
| Subject | Practicals in Digital Electronics for Communications | | | |
| Code | V05M145V01320 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **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<br>Mikic Fonte, Fernando Ariel<br>Rodríguez Hernández, Pedro Salvador | | | |
| E-mail | mikic@det.uvigo.es | | | |
| Web | http://faitic.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.<br><br>We will use Spanish language in classroom, and English language for the instructional materials. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know<br>- Know How |
| 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. | - know<br>- Know How |
| 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. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| To earn skills in the design, development and management of distributed systems. | CB2<br>CG8<br>CE24 |
| To undertand the functional bases of the distributed systems. | CB4<br>CB5<br>CE24 |
| To know the distinct concepts related with the distributed computing: clustering, grids, cloud computing and ubiquitous computing. | CB5<br>CG8<br>CE24 |
| To earn skills for the application of intelligent systems in the distributed computing. | CB2<br>CB5<br>CG8<br>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<br>CB4<br>CG8<br>CE24 |

| Contents |
|---|

| Topic | |
|---|---|
| 1. Transactions | 1. Concurrency problems<br>2. Recoverability problems<br>3. Deadlocks<br>4. Optimistic concurrency control<br>5. Timestamps |
| 2. Replication | 1. Introduction to replication<br>2. Case studies of high available services (Bayou and Coda)<br>3. Transactions with replicated data<br>4. Design of distributed systems: Google case study |
| 3. Grid and Cluster | 1. Basic concepts of grid computing<br>2. Basic concepts of cluster computing. |
| 4. Distributed artificial intelligence | 1. Intelligent agents and multiagent systems<br>2. Theory of games applied to multiagent systems: coordination, competition, negotiation, auctions, electronic trade<br>3. Complex distributed systems and auto-organised ones |
| 5. Parallel and evolutionary computation | 1. Distributed Computing and parallelization<br>2. Algorithms and evolutionary programming: genetics, memetics, differential evolution, intelligence of swarm.<br>3. Optimisation by means of evolutionary technics and parallelization |

| **Planning** | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Master Session | 17 | 0 | 17 |
| Autonomous practices through ICT | 7.5 | 0 | 7.5 |
| Autonomous troubleshooting and / or exercises | 0 | 92.5 | 92.5 |
| Short answer tests | 3 | 0 | 3 |
| Reports / memories of practice | 0 | 2.5 | 2.5 |
| Systematic observation | 2.5 | 0 | 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 |
| Master Session | Theoretical classes with practical cases. Besides, problems will be proposed for solving them in autonomous way.<br><br>Competencies related to this activity: CB5 and CE24 |
| Autonomous practices through ICT | Practices in laboratory realised by means of computers connected in network and/or virtual machines.<br><br>Competencies related to this activity: CB2, CB4, and CG8 |
| Autonomous troubleshooting and / or exercises | Work of study on the contents of the theoretical classes, as well as of support to the realisation and achievement of the practices of laboratory.<br><br>Competencies related to this activity: CB5 and CG8 |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| Autonomous practices through ICT | The personalised attention will carry out in the practical part of the course, as in the tutorial time. |
| **Tests** | Description |
| Systematic observation | The personalised attention will carry out in the practical part of the course, as in the tutorial time. |

| **Assessment** | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |

| | | | |
|---|---|---|---|
| Short answer tests | 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. | 70 | CB2<br>CB4<br>CB5<br>CG8<br>CE24 |
| Reports / memories of practice | Detailed report of the tasks during the realisation of the practices of laboratory carried out in group. | 10 | CB2<br>CB4<br>CG8<br>CE24 |
| Systematic observation | Observation by the professor of the work carried out by the students in the classroom during the realisation of the practices of laboratory carried out in group. Level of participation in those practices and functioning of the work carried out. | 20 | CB2<br>CB4<br>CB5<br>CG8<br>CE24 |

**Other comments and July evaluation**

The students can decide being evaluated according to a model of continuous evaluation (reviewed previously) or realise a final examination. The fact a student answer the first examination of continuous evaluation means he/she opts by this model of evaluation (in contrary case he/she opts by the model of final examination). Once the students opt by the model of continuous evaluation their qualification will not be able to be never "No presented".

Plagiarism and copy are not allowed.

1- CONTINUOUS EVALUATION

To surpass the course requires a minimum qualification of 5 points. The qualification will be the result to add the qualifications received in each one of the following parts:

- Written exam 1:
  - Dates: On the fourth week of the course
  - Individually
  - Contents: Given until this moment
  - Type: Series of short answer questions and/or test type ones
  - Maximum punctuation = 5 points
- Written exam 2:
  - Dates: Official calendar (coinciding with the final examination for those that opted by this modality)
  - Individually
  - Contents: Given until this moment excepting those that already were evaluated in the written exam 1.
  - Type: Series of short answer questions and/or test type ones
  - Maximum punctuation = 2 points
- Practices:
  - Dates: Weeks 6, 7, and 8
  - In group:
    - Reports / memories of practice: The same mark is asigned to each member of the group.
    - Systematic observation: A personalized mark is asigned to each member of the group. This mark is based on the observation by the professor of the work carried out by each student in the classroom during the realisation of the practices of laboratory.
  - Maximum punctuation = 3 points

2- FINAL EXAMINATION

To surpass the course requires a minimum qualification of 5 points.

- Written exam:
  - Dates: Official calendar
  - Individually
  - Contents: Given in the whole course (including practical).
  - Type: Series of short answer questions and/or test type ones
  - Maximum punctuation = 10 points

3- EXTRAORDINARY EVALUATION

The students will be evaluated using the modality of "final examination"

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

| Recommendations |
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| 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 | Fernández Vilas, Ana<br>González Castaño, Francisco Javier | | | |
| E-mail | javier@det.uvigo.es | | | |
| Web | http://http://faitic.uvigo.es | | | |
| 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 | | Typology |
| 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. | - know<br>- Know How |
| 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. | - know |
| 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. | - know<br>- Know How |
| 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. | - know |
| 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. | - know<br>- Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| - Knowledge of the different stages of knowledge extraction and the areas of application of data mining. | CB2<br>CB3<br>CG4<br>CG8<br>CE25 |
| - Knowledge of the importance of the preparation of the data and how to apply the main pre-processing techniques. | CB2<br>CG4<br>CG8<br>CE25 |
| - Knowledge of the main techniques of data mining as well as the necessary premises for its application to a particular stage. | CB2<br>CB3<br>CG4<br>CG8 |
| - Knowldge 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<br>CE25 |
| -Ability to to schedule, develop and evaluate a data analysis process. | CG4<br>CG8<br>CE25 |
| New | |

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

| Planning | Class hours | Hours outside the classroom | Total hours |
|---|---|---|---|
| Projects | 2 | 36 | 38 |
| Laboratory practises | 8 | 16 | 24 |
| Master Session | 20 | 40 | 60 |
| Short answer tests | 2 | 0 | 2 |
| Jobs and projects | 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 |
|---|---|
| Projects | Arranged in groups, the students will solve a practical case of data analysis in an application scenario. CB2 CB3 CG4 CG8 CE25 |
| Laboratory practises | During the course, students will develop solutions in laboratory sessions to grasp the course content. CB2<br>CB3 CG4 CG8 CE25 |
| Master Session | Lectures that will illustrate the course content with small exercises. These will be solved by the lecturer of the students themselves, alone or in groups. The goal is to foster discussion and knowledge of course competencies. CB2 CB3 CG4 CG8. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | Individual atention will take place during official tutoring times or via e-mail at any time. |
| Projects | Individual atention will take place during official tutoring times or via e-mail at any time. |
| Laboratory practises | Individual atention will take place during official tutoring times or via e-mail at any time. |

| Assessment | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Short answer tests | Short-answer written exam. | 40 | CE25 |
| Jobs and projects | Working groups will generate two deliverables reporting their work on a dataset that will be handed to them at the beginning on the course. | 60 | CB2<br>CB3<br>CG4<br>CG8<br>CE25 |

**Other comments and July evaluation**

During the bimester, the evaluation of the course will only take place according to the continuous evaluation system.

**CONTINUOUS EVALUATION**

It will be based on the aforementioned methodologies. The grading of the activities is as follows:

1. Short answer test (4 points maximum).
2. Two deliverables on 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 overal mark (across all possible activities) above 5 points. The maximum mark is 10 points.

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

**FINAL COURSE EVALUATION**

Final course evaluation, as an alternative to continuous evaluation, will consist on a single exam covering the whole course content, theoretical and/or practical. The maximum mark of this exam will be 10 points. The minimum mark to pass the exam is 5 points.

| **Sources of information** |
| --- |
| **Basic Bibliography** |
| **Complementary Bibliography** |

| **Recommendations** |
| --- |

| 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 | Fernández Veiga, Manuel | | | |
| Lecturers | Fernández Veiga, Manuel | | | |
| E-mail | mveiga@det.uvigo.es | | | |
| Web | http://faitic.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 | | Typology |
| 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. | - know |
| 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. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| CE26 | CE26/TE3 Ability to understand and know to exploit the processes of training and dissemination of information in social networks, applying them to the improvement of Internet | - Know How |
| CE27 | CE27/TE4 Ability to design and manage distributed systems based on learning and incentive | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Understand the static and dynamic phenomena that explain the structure of the social networks | CG4<br>CE26 |
| Know how to analyse the mechanisms of training of networks in strategic terms | CG4<br>CG8<br>CE26<br>CE27 |
| Know how to model and apply to real data the processes of diffusion of information in social networks | CB1<br>CB3<br>CE26<br>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<br>CB3<br>CG4<br>CG8<br>CE26<br>CE27 |
| Know how to use the dynamics of learning in networks to characterise phenomena | CB1<br>CB3<br>CG4<br>CE27 |

| Contents | |
|---|---|
| Topic | |
| 1. Basic models | a. Empirical evidence<br>b. Random networks<br>c. Descriptive parameters, centrality and importance<br>d. Scaling laws |
| 2. Training of networks | a. Random models: static training<br>b. Random models: dynamic training<br>c. Strategic training: stability, efficiency and incentives |
| 3. Diffusion and learning in social networks | a. Simple diffusion SIR, SIS and others<br>b. Learning and reinforcement in networks<br>c. Games in networks: strategic complements and strategic substitutes |
| 4. Applications | a. Recommendations/punctuations<br>b. Virality<br>c. Origins of rumours<br>d. Trending topics<br>d. Meritocracy. Identification of experts and leaders |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Projects | 14 | 45 | 59 |
| Master Session | 14 | 35 | 49 |
| Troubleshooting and / or exercises | 0 | 11 | 11 |
| Long answer tests and development | 1 | 2 | 3 |
| Practical tests, real task execution and / or simulated. | 1 | 2 | 3 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Projects | Development of a practical project of analysis and modeling of a network of diffusion: technological, social, biological or economic. It will consist in the structural and dynamic explanation of the observable phenomena in the data that describe the network.<br><br>Through this methodology, competencies CB1, CB3, CG4, CG8, CE26 and CE27 are developed. |
| Master Session | Synthetic exposition in the classroom of the basic concepts that support the subject.<br><br>Through this methodology, competencies CB1, CB3, CG4, CG8, CE26 and CE27 are developed. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | Resolution of doubts, bibliographic recommendations, proposals of exercises or explanation of concepts and technical on any part of the program of the *asignatura. Individual attention to the students. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Troubleshooting and / or exercises | Correction of the exercises proposed. Written submission. | 30 | CB1<br>CB3<br>CG4<br>CG8<br>CE26<br>CE27 |

| | | | |
|---|---|---|---|
| Long answer tests and development | Written examination paper. | 50 | CB1<br>CB3<br>CG4<br>CG8<br>CE26<br>CE27 |
| Practical tests, real task execution and / or simulated. | Functional test of the practical project. | 20 | CB1<br>CB3<br>CG4<br>CG8<br>CE26<br>CE27 |

**Other comments and July evaluation**

We leave to discretion of the students two methods of alternative evaluation in the subject: continuous evaluation and single evaluation. The continuous evaluation will consist in the realisation of a written exam (50% of the qualification), a laboratory project (30%) and in the resolution written of problems along the course (20% of the qualification). The single evaluation will consist in the realisation of a final examination writing (60% of the qualification) and in the development of a practical project (40% of the qualification) that will be due before the last day of the official period of examinations.

The students will choose one or another modality of evaluation in the moment in that the project is announced. They will be considered not presented in case no explicit election is made at in this moment. Those who do not pass the subject at the earliest opportunity of the announcement have of a second opportunity in the month of July in which his knowledge will be tested with a written examination or his project will be assessed again if it had been improved or modified. The weights of each one of the tests (examination and project) will be the same that in the ordinary period of evaluation according to the modality that had chosen.

The qualification of the test has only effects in the academic course in that they were awarded, with independence of the itinerary of evaluation chosen.

Should any form of plagiarism be detected in a project or test, the final grade in the subject will be FAIL (0) and the event will be reported to the academic officers so that appropriate sanctions could be taken.

**Sources of information**

**Basic Bibliography**

B. Bollobas, Random Graphs, 2ª, Cambridge University Press, 2001,

D. Easley, J. Kleinberg, Networks, Crowds, and Markets: Reasoning About a Highly Connected World, Cambridge University Press, 2010,

**Complementary Bibliography**

A. D. Barbour, L. Holst and S. Janson, Poisson Approximation, 2ª, Oxford Science Publications, 1992,

R. Durrett, Random Graph Dynamics, Cambridge University Press, 2010,

G. Grimmett, Percolation, 2ª, Springer, 1999,

S. Janson, T. Luczak, A. Rucinski, Random Graphs, Wiley, 2000,

R. Meester and R. Roy, Continuum Percolation, Cambridge University Press, 2008,

R. van der Hofstad, Random graphs and complex networks, Cambridge University Press, 2016,

**Recommendations**

| 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://faitic.uvigo.es | | | |
| General description | The student develops own functions in a company as an Telecommunication Engineer with determinate profile by the technology that the student have studied (Electronics, Processed of signal for communications, Radiocommunication and Telematic) and supervised by the University adviser and the company adviser. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know |
| 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. | - Know How |
| CG9 | CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering. | - Know be |
| CG10 | CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications. | - Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know be |
| CG13 | CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering. | - know |

| 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<br>CB5<br>CG8<br>CG9<br>CG10<br>CG12<br>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 |
| External practises | 125 | 0 | 125 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies |
|---|

| | Description |
|---|---|
| External practises | Stay in a company developing functions of an Telecommunication Engineer. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| External practises | 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 Competencess |
| External practises | The evaluation will realise in function of:<br>1) The memory of activities<br>2) The evaluation of the company tutor | 100 | CB2<br>CB5<br>CG8<br>CG9<br>CG10<br>CG12<br>CG13 |

**Other comments and July evaluation**

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

**Sources of information**

**Basic Bibliography**

**Complementary Bibliography**

**Recommendations**

**Other comments**

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

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Internship in Companies II** | | | | |
| Subject | Internship in Companies II | | | |
| Code | V05M145V01325 | | | |
| Study programme | 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://faitic.uvigo.es | | | |
| General description | The student develops own functions in a company as an Telecommunication Engineer with determinate profile by the technology that the student have studied (Electronics, Processed of signal for communications, Radiocommunication and Telematic) and supervised by the University adviser and the company adviser. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know |
| 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. | - Know How |
| CG9 | CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering. | - Know be |
| CG10 | CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications. | - Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know be |
| CG13 | CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering. | - know |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Experience in the practice of the profession of ingineering of Telecommunication and his usual functions in some real company environment. | CB2<br>CB5<br>CG8<br>CG9<br>CG10<br>CG12<br>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 |
| External practises | 125 | 0 | 125 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies |
|---|

| | Description |
|---|---|
| External practises | Stay in a company developing functions of an Telecommunication Engineer. |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| External practises | 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 Competencess |
| External practises | The evaluation will realise in function of:<br>1) The memory of activities<br>2) The evaluation of the tutor in the company | 100 | CB2<br>CB5<br>CG8<br>CG9<br>CG10<br>CG12<br>CG13 |

**Other comments and July evaluation**

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

**Sources of information**

**Basic Bibliography**

**Complementary Bibliography**

**Recommendations**

**Other comments**

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

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Internship in Companies III** | | | | |
| Subject | Internship in Companies III | | | |
| Code | V05M145V01326 | | | |
| Study programme | 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://faitic.uvigo.es | | | |
| General description | The student develops own functions in a company as an Telecommunication Engineer with determinate profile by the technology that the student have studied (Electronics, Processed of signal for communications, Radiocommunication and Telematic) and supervised by the University adviser and the company adviser. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| 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. | - Know How |
| CB5 | CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way | - know |
| 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. | - Know How |
| CG9 | CG9 Ability to understand the responsibility and professional ethics in the activity of the profession of Telecommunications Engineering. | - Know be |
| CG10 | CG10 Ability to apply principles of economics and human resources and projects management, as well as legislation, regulation and standardization of telecommunications. | - Know How |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know be |
| CG13 | CG13 Knowledge, understanding and ability to implement the necessary legislation in the exercise of the profession of Telecommunication Engineering. | - know |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Experience in the practice of the profession of ingineering of Telecommunication and his usual functions in some real company environment. | CB2<br>CB5<br>CG8<br>CG9<br>CG10<br>CG12<br>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 |
| External practises | 125 | 0 | 125 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies |
|---|

| | Description |
|---|---|
| External practises | Stay in a company developing functions of an Telecommunication Engineer. |

| **Personalized attention** | |
|---|---|
| Methodologies | Description |
| External practises | 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 Competencess |
| External practises | The evaluation will realise in function of:<br>1) The memory of activities<br>2) The evaluation of the tutor in the company | 100 | CB2<br>CB5<br>CG8<br>CG9<br>CG10<br>CG12<br>CG13 |

**Other comments and July evaluation**

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

**Sources of information**

**Basic Bibliography**

**Complementary Bibliography**

**Recommendations**

**Other comments**

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

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Network Information Theory** | | | | |
| Subject | Network Information Theory | | | |
| Code | V05M145V01327 | | | |
| 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 | | | | |
|---|---|---|---|---|
| **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 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 | | | | |
|---|---|---|---|---|
| **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<br>Galician | | | |
| Department | | | | |
| Coordinator | Doval Gandoy, Jesús | | | |
| Lecturers | Doval Gandoy, Jesús | | | |
| 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 | | Typology |
| 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. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| CE28 | CE28/SE1 Capacity of technology integration of photovoltaic conversion for power systems of Telecommunication Engineering. | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Knowledge of power conversion technologies used in photovoltaic systems. | CB2<br>CG4<br>CG8<br>CE28 |
| Knowledge of control techniques of electronic power converters used in photovoltaic systems. | CB2<br>CG4<br>CG8<br>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 practises | 10 | 31 | 41 |

| | | | |
|---|---|---|---|
| Troubleshooting and / or exercises | 5 | 16 | 21 |
| Master Session | 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 practises | Application of the knowledge to particular situations and acquisition of basic skills related with the topic. Competencies: CB2, CG4, CG8, CE28/SE1. |
| Troubleshooting and / or exercises | 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. |
| Master Session | 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 attention

| Methodologies | Description |
|---|---|
| Master Session | 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 practises | 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. |
| Troubleshooting and / or exercises | 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 Competencess |
|---|---|---|---|
| Master Session | Theoretical concepts. | 34 | CB2<br>CG4<br>CG8<br>CE28 |
| Laboratory practises | Development of the practices of laboratory. | 33 | CB2<br>CG4<br>CG8<br>CE28 |
| Troubleshooting and / or exercises | Resolution of exercises proposed | 33 | CB2<br>CG4<br>CG8<br>CE28 |

## Other comments and July evaluation

There are two ways to evaluate the students: continuous evaluation or evaluation by final examination.

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 students will present the tasks in the classroom and they will have to answer quesions.

The professor will score the students from their work in the developed tasks, the reports and the oral presentation.

The marks will be valid only for the current academic course. It is understood that the student chooses the continuous

assessment when it presents at least one task. His qualification will be the one of continuous evaluation.

2. Evaluation by final examination

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. Extraordinary examination (June-July)

The extraordinary examination 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.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., 2011 |
| **Complementary Bibliography** |
| Ned Mohan, Tore M. Undeland, William P. Robbins, Power Electronics: Converters, Applications, and Design, John Wiley & Sons, Ltd., 2002 |
| Andrés Barrado Bautista, Antonio Lázaro Blanco, Problemas de electrónica de potencia, Pearson Educación, 2007 |

| **Recommendations** |
|---|

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Signal Conditioners** | | | | |
| 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 | http://http://faitic.uvigo.es | | | |
| General description | In this subject the electronic circuits that condition the signals generated by sensors to be efficiently coupled to a data acquisition system or to a digital processor are studied.<br>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.<br>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.<br>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.<br>The key points of the laboratory work are:<br>-The followed methodology to measure physical variables to the calculation of uncertainties.<br>-Characterization of transducers.<br>-Topologies of conditioning circuits.<br>-The connection of the conditioned signals to a digital processor.<br>-Instrumentation software for digitally conditioning and user interfaces. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - Know How<br>- Know be |
| 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. | - Know How |
| 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 | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| To know the modeling and simulationing of analogic electronic systems by means of the hardware description language SPICE. | CG1<br>CG4<br>CG8<br>CE29 |
| To know the evaluationing of the uncertainties in the measuring processes following the standards. | CG4 |
| To know how to handle and to program data acquisition systems. | CG1<br>CE29 |
| To know the developing of complex electronic circuits for conditioning the sensors. | CG1<br>CG4<br>CG8<br>CE29 |
| To konw to analyse and to design circuits for interfaces between the sensors and digital processors. | CG1<br>CE29 |

| | |
|---|---|
| To know how to develop an instrumentation electronic systems. | CG1<br>CG4<br>CG8<br>CE29 |

| Contents | |
|---|---|
| Topic | |
| Unit 1: Introduction to the measuring systems of physical variables. | Functional and working characteristics of sensors. Evaluation of measurement data. Sensor calibration. Measurement uncertainties. Parts of a conditioning circuit. Types of conditioners. |
| Unit 2: Introduction to the metrology. Evaluation of measurement uncertainty. | Methodology to measure and to calibrate sensors. Terminology. Statistical method. |
| Unit 3. Circuits to conditioning signal from measured sensors. | Active measuring bridges in direct and alternating current. Ac/dc converters. Selection and design of filtering stages. Frequency to voltage converters. Conditioners for output stages. |
| Unit 4: Interfaces between on-off sensors and digital processors. | Basic concepts of local interfaces of on-off sensors. Interfaces with and without galvanic isolation.<br>Coupling in alternating and continuous current. |
| Unit 5: Conditioning circuits for inductive and magnetic measure sensors. | Study of the conditioners for several inductive and magnetic sensors according to his application. |
| Unit 6: Conditioning circuits for capacitive measureing sensors. | Study of the conditioners for capacitive sensors. |
| Unit 7: Conditioning circuits for generators sensors. | Study of the conditioning circuits for generators sensors according to his physical working principle. |
| Unit 8: Practical cases of conditioning circuits for measuring sensors. | Study of real cases with commercial sensors and circuits. |

| Planning | | | |
|---|---|---|---|
| | Class hours | Hours outside the classroom | Total hours |
| Laboratory practises | 7 | 14 | 21 |
| Tutored works | 5 | 25 | 30 |
| Master Session | 13 | 26 | 39 |
| Reports / memories of practice | 1 | 10 | 11 |
| Practical tests, real task execution and / or simulated. | 2 | 10 | 12 |
| Short answer tests | 1 | 5 | 6 |
| Troubleshooting and / or exercises | 1 | 5 | 6 |
| *The information in the planning table is for guidance only and does not take into account the heterogeneity of the students. | | | |

| Methodologies | |
|---|---|
| | Description |
| Laboratory practises | Application, at a practical level, of the knowledge and skills acquired in the lectures by mean of practices undertaken with test and measurement equipment, either in the laboratory or in other place. |
| Tutored works | The student, of individual way or in group, elaborates a document on the thematic of the matter or prepares seminars, investigations, memories, essays, summaries of reading, conferences, etc. |
| Master Session | Exhibition of the contents of the subject; it includes exhibition of concepts; introduction of practices and exercises; and resolution of problems and/or exercises in ordinary classroom. |

| Personalized attention | |
|---|---|
| Methodologies | Description |
| Master Session | 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 practises | 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. |

| | |
|---|---|
| Tutored works | The professor will attend personally doubts and queries of the students on the upervised works. The tutorships will do in the office of the professor in the schedule that establish at the beginning of the course and that will publish in the page Web of the subject. |

| **Tests** | Description |
|---|---|
| Reports / memories of practice | 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. |

**Assessment**

| | Description | Qualification | Evaluated Competencess |
|---|---|---|---|
| Laboratory practises | It values the participation of the student in the practices of laboratory: preparation of previous tasks, fulfillment of the aims posed in each practice and back tasks in which the student analyses the results, compares them with the expected and presents the conclusions. They can apply to the tests of continuous or final assessment. | 15 | CG1<br>CG4<br>CG8<br>CE29 |
| Tutored works | The student, individually or in group, elaborates a document on the thematic of the matter or prepares seminars, investigations, memories, essays, summaries of reading, conferences, etc. | 10 | CG1<br>CE29 |
| Reports / memories of practice | Preparation of a document by part of the student in which they reflect the characteristics of the work carried out. The students have to describe the tasks and procedures developed, show the results obtained and observations realised, as well as the analysis and treatment of data. | 15 | CG1<br>CG4<br>CG8<br>CE29 |
| Practical tests, real task execution and / or simulated. | Tests that include activities of laboratory and/or TIC, problems or cases to resolve. The students have to give answer to the activity formulated by reflecting, in a practical way, the theoretical and practical knowledge that have been learnt in the subject, using, if it is necessary, the equipment or instrumentation of the practices carried out in the course. They can apply to the tests of continuous or final assessment. | 20 | CG1<br>CG4<br>CG8<br>CE29 |
| Short answer tests | Tests that include direct questions about an specific topic. The student has to answer of direct form in virtue of the knowledges that has on the subject. The answer is brief. They can apply to the tests of continuous evaluation or to the final examination. | 20 | CG1<br>CG4<br>CE29 |
| Troubleshooting and / or exercises | Proof in which the student has to solve a series of problems and/or exercises in a time/condition established/ace by the professor. Of this form, the student has to apply the knowledges that purchased. The application of this technique can be face-to-face or not. You can use different tools to apply this technique as, for example, chat, run or forum, audio, video, etc. | 20 | CG1<br>CG4<br>CG8<br>CE29 |

**Other comments and July evaluation**

1. Continuous evaluation

The practical part (50% of the note) and the part of theory (50% of the note) are evaluated by continuous assessment. Each one of these parts are evaluated following the methodologies described before with his respective weights in the following way:

-Practical part: it is divided in the progress of the practices in the laboratory (15%), the report of practices (15%) and a practical exam (20%).

-Part of theory: it is divided in one exam with questions of short answer (20%), the supervised work (10%) and the exam with resolution of problems (20%).

The final mark, which is on a maximum of 10 points, is the sum of the notes of each part, if the students fulfill the following conditions:

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

-Obtain a minimum mark of 40% in each one of the two parts of the evaluation (theory and practice).

If it does not fulfill some of the previous requirements, the final mark will be the sum of the notes of each part, but limited to 40% of the maximum mark (4 points).

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 in the last session of the laboratory classes. The tests of resolution of problems and of short answer can be divided in two sessions spread along the period of teaching.

The reports of the supervised work and of the practices have to be delivered before finalizing the period of final exams established for the term.

The assessment is particular for each student and the practices of laboratory will be done preferably by individual form. If it is the case, the marks of the activities that the students do in groups will be the same for all the students that compose it.

2. Final exam

The students that do not opt by the continuous evaluation (have not carried out, at least, 80% of the practices) or have obtained a total mark below 5 (suspense), will be able to do to the final exam.

The final exam will consist of a practical exam at the laboratory and in an exam of theory with questions of short answer and resolution of problems, each one corresponding to 50% of the total mark. To pass the student must obtain a minimum of 40% in each part and sum in total, at least, 5 points.

3. Call for recovery

The call for recovery will be like the final exam.

## 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, Barcelona

## 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

| 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 | Marcos Acevedo, Jorge<br>Sánchez Real, Francisco Javier | | | |
| E-mail | acevedo@uvigo.es | | | |
| Web | http://faitic.uvigo.es/ | | | |
| General description | This subject includes concepts related with dependability analysis of complex electronic systems as well as their models. Also includes metodologies for electronic systems design for safety applications and EMC analysis. Finally it includes asset management and human resources. | | | |

| Competencies | | |
|---|---|---|
| Code | | Typology |
| CG3 | CG3 Ability to lead, plan and monitor multidisciplinary teams. | - Know be |
| 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. | - Know How |
| CE30 | CE30/SE3 Capacity planning, evaluation and decision-making in new environments relating to the packaging of networks, services and applications in the electromagnetic field, with knowledge of reliability and life cycle costing | - Know How |

| 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<br>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 |
|---|---|---|---|
| Master Session | 18 | 0 | 18 |
| Laboratory practises | 10 | 15 | 25 |
| Troubleshooting and / or exercises | 0 | 10 | 10 |
| Tutored works | 0 | 40 | 40 |
| Short answer tests | 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 |
|---|---|
| Master Session | 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.<br><br>Competencias CG7, CG3 and CE30/SE3 are used |
| Laboratory practises | Students will perform practical examples of dependability analysis of electronic control systems, according to standards. The analysis will performed with specific software application.<br><br>Competencies CG7 and CG3 are used |
| Troubleshooting and / or exercises | 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.<br><br>Competencias CG7, CG3 and CE30/SE3 are used |
| Tutored works | It consists in carrying out specific tasks that are elated to the subject and in collaboration with xternal entities, provided that this is possible.<br><br>Competencias CG7, CG3 and CE30/SE3 are used |

**Personalized attention**

| Methodologies | Description |
|---|---|
| Master Session | 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 practises | 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. |
| Troubleshooting and / or exercises | 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. |
| Tutored works | 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 |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Troubleshooting and / or exercises | Deliverables, problems and exercises will be assess. | 40 | CG3<br>CG7<br>CE30 |
| Tutored works | They will evaluate the contents (methodology of development, conclusions obtained, exhibition of results and capacity of work in team)<br><br>For works in team the indivual note will be the same for all members of the team | 50 | CG3<br>CG7<br>CE30 |
| Short answer tests | It will realise a proof with 10 questions of theory or exercises on the matter. | 10 | CG3<br>CG7<br>CE30 |

**Other comments and July evaluation**

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 do the final examination 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 examf of 10 short questions. 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 final exam assessment by the end of the semester or in the extraordinary (June-July), 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 the final examination 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.

**Sources of information**

**Basic Bibliography**

David J. Smith, Reliability, Maintainability and Risk, 8ª, Butterworth Heinemann, 2011, USA

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

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, España

M. Goble, H. Cheddie, Safety Instrumented Systems Verification, ISA, 2005, USA

M. Goble, Control Systems Safety Evaluation and Reliability, 3ª, ISA, 2010, USA

**Complementary Bibliography**

T.I. Bajenescu, M.I. Bâzu, Reliability of Electronic Components, Springer-Verlag, 1999, Alemania

P. Kales, Reliability, Prentice-Hall, 1998, USA

B. R. Mehta Y. J. Reddy, Industrial Process Automation Systems Design and Implementation, Elsevier, 2015, USA

ISO, UNE-ISO 55000:2015: Gestión de activos. Aspectos generales, principios y terminología, AENOR, 2015, España

## Recommendations

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

Signal Conditioners/V05M145V01331
Photovoltaic Power Electronics/V05M145V01330

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

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

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Electronic Equipment Practicals** | | | | |
| Subject | Electronic Equipment Practicals | | | |
| Code | V05M145V01333 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Optional | 2nd | 1st |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | | | | |
| Lecturers | | | | |
| E-mail | | | | |

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| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Telecommunications Seminar** | | | | |
| Subject | Telecommunications Seminar | | | |
| Code | V05M145V01334 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Optional | 2nd | 1st |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | | | | |
| Lecturers | | | | |
| E-mail | | | | |

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| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **Piezoelectric Transducers and Applications** | | | | |
| Subject | Piezoelectric Transducers and Applications | | | |
| Code | V05M145V01335 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 5 | Optional | 2nd | 1st |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | | | | |
| Lecturers | | | | |
| E-mail | | | | |

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| 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 | | | | |

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| 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<br>English | | | |
| Department | | | | |
| Coordinator | Fernández Veiga, Manuel | | | |
| Lecturers | Fernández Veiga, Manuel | | | |
| E-mail | mveiga@det.uvigo.es | | | |
| Web | http://faiticuvigo.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 | | Typology |
| 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. | - know |
| CG1 | CG1 Ability to project, calculate and design products, processes and facilities in telecommunication engineering areas. | - Know How |
| 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. | - Know How |
| 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. | - Know How |
| 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. | - Know How<br>- Know be |
| CG12 | CG12 Skills for lifelong, self-directed and autonomous learning. | - Know How<br>- Know be |
| 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. | - Know How |

| Learning outcomes | |
|---|---|
| Learning outcomes | Competences |
| Research, classification and structuring of information on some topic relevant to Telecommunications engineering. | CB1<br>CG8<br>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<br>CG8<br>CG11<br>CE17 |
| Design of prototypes, computer programs, circuits, procedures, algorithms, designs, methods, etc, complying to specifications | CB1<br>CG1<br>CG5<br>CG8<br>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 / activities | 0 | 60 | 60 |
| Case studies / analysis of situations | 0 | 20 | 20 |
| Others | 10 | 0 | 10 |
| Projects | 0 | 630 | 630 |
| Troubleshooting and / or exercises | 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 / activities | 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 / analysis of situations | 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. |
| Others | The student receives personalised attention of his advisor about the general approach, the definition of aims and the plan of development of his/her thesis, as well as orientation more specific and guidance about the particular technical problems that involves. |
| Projects | 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. |
| Troubleshooting and / or exercises | 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 attention | |
|---|---|
| Methodologies | Description |
| Others | Each student will gather regulate and periodically with his tutor or tutor to receive academic help on the realisation of his specific work. |

| Assessment | | | |
|---|---|---|---|
| | Description | Qualification | Evaluated Competencess |
| Projects | The assessment is done after an oral presentation and defence in front of an examining committee.<br><br>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.<br><br>System of qualifications: it will express by means of numerical final qualification of 0 to 10 according to the valid legislation. | 100 | CB1<br>CG1<br>CG5<br>CG8<br>CG11<br>CG12<br>CE17 |

**Other comments and July evaluation**

All the information related with the Master's Thesis can be accessed on the web of the School of Engineering of Telecommunication.

**Sources of information**

**Basic Bibliography**

## Complementary Bibliography

## Recommendations

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Redes de Ordenadores** | | | | |
| Subject | (*)Redes de Ordenadores | | | |
| Code | V05M145V01403 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 6 | Optional | 1st | 2nd |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | | | | |
| Lecturers | | | | |
| E-mail | | | | |

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| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Técnicas de Transmisión e Recepción de Sinais** | | | | |
| Subject | (*)Técnicas de Transmisión e Recepción de Sinais | | | |
| Code | V05M145V01404 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 6 | Optional | 1st | 2nd |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | | | | |
| Lecturers | | | | |
| E-mail | | | | |

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

| IDENTIFYING DATA | | | | |
|---|---|---|---|---|
| **(*)Servizos de Internet** | | | | |
| Subject | (*)Servizos de Internet | | | |
| Code | V05M145V01501 | | | |
| Study programme | Telecommunication Engineering | | | |
| Descriptors | ECTS Credits | Type | Year | Quadmester |
| | 6 | Optional | 1st | 1st |
| Teaching language | | | | |
| Department | | | | |
| Coordinator | | | | |
| Lecturers | | | | |
| E-mail | | | | |

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