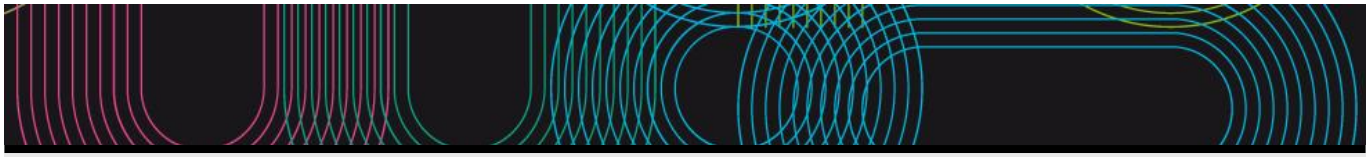

(*)Escola de Enxeñaría de Telecomunicación

(*)Páxina web

(*)

www.teleco.uvigo.es

(*)Presentación

(*)

A Escola Enxeñaría de Telecomunicación oferta para o curso académico 2017-18 un grao e dous másteres totalmente adaptados ao Espacio Europeo de Educación Superior, verificados pola ANECA axustándose á Orde Ministerial CIN/352/2009. A continuación indícanse os enlaces de acceso aos dípticos informativos dos tres títulos.

Grao en Enxeñaría de Tecnoloxías de Telecomunicación

http://teleco.uvigo.es/images/stories/documentos/gett/diptico-uvigo-eet-grao-gal.pdf

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

Máster en Enxeñaría de Telecomunicación

http://teleco.uvigo.es/images/stories/documentos/met/diptico-uvigo-eet-master-gal.pdf

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

Máster Interuniversitario en Matemática Industrial

http://teleco.uvigo.es/images/stories/documentos/promocion/M2i_Presentacion.pdf

www: http://m2i.es

(*)Equipo directivo

(*)

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COORDINACIÓN DO MESTRADO INTERUNIVERSITARIO EN MATEMÁTICA INDUSTRIAL

Coordinador Xeral: José Durany Castrillo (durany@dma.uvigo.es)

Degree in Telecommunications Technologies Engineering

Subjects

Year 2nd

Code	Name	Quadmester	Total Cr.
V05G306V01201	Physics: Fundamentals of electronics	1st	6
V05G306V01202	Physics: Fields and Waves	1st	6
V05G306V01203	Digital electronics	1st	6
V05G306V01204	Data Communication	1st	6
V05G306V01205	Digital Signal Processing	1st	6
V05G306V01206	Electronic technology	2nd	6
V05G306V01207	Electromagnetic Transmission	2nd	6
V05G306V01208	Signal Transmission and Reception Techniques	2nd	6
V05G306V01209	Fundamentals of Sound and Image	2nd	6
V05G306V01210	Computer Networks	2nd	6

IDENTIFYING DATA				
Physics: Fundamentals of electronics				
Subject	Physics: Fundamentals of electronics			
Code	V05G306V01201			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	2nd	1st
Teaching language	#EnglishFriendly English			
Department				
Coordinator	Domínguez Gómez, Miguel Ángel Raña García, Herminio José			
Lecturers	Domínguez Gómez, Miguel Ángel Raña García, Herminio José			
E-mail	hrana@uvigo.es mdgomez@uvigo.es			
Web	http://faitic.uvigo.es			
General description	The main purpose of this course is to provide students the basis for understanding and mastery of the principles of operation of devices and electronic circuits. It begins with a brief introduction to electronics in order to provide students with a global vision. After, basic concepts about devices and electronic circuits are taught: · Diodes and circuits with diodes, including concepts such as load line, ideal diodes, rectifiers, shaping circuits, logic circuits, voltage regulators and devices physics. · Characteristics of bipolar transistors, analysis of load line, large-signal models, polarization, amplification and small-signal equivalent circuits. · Study of the FET similar to the previous highlighting the MOSFET. · Check the circuit designs studied using SPICE. Mounting and verification using laboratory electronic instrumentation. · Basic concepts about logic digital circuits. On the other hand, in the framework of the course it takes place the first contact of students with the electronics labs. Therefore, the main objective of the practical part of the course is for students to acquire the bases for a correct management of the most common instruments in the laboratories of electronics. At the end of the course the student must know how to handle the laboratory instruments, distinguish and characterize the different components, and have practical skills in assembly and measurement. Students will also start with simulation of circuits, in order to introduce them to computer-aided design. International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Competencies	
Code	
B13	CG13 The ability to use software tools that support problem solving in engineering.
C4	CE4/FB4: Comprehension and command of basic concepts in linear systems and their related functions and transforms; electric circuits theory, electronic circuits, physical principles of semiconductors and logical families, electronic and photonic devices, materials technology and their application to solve Engineering problems.

Learning outcomes		
Expected results from this subject		Training and Learning Results
Understanding and control of the basic concepts of the physical principles of semiconductors.		C4
Understanding and control of the basic concepts of operation of the electronic and photonic devices.		C4
Understanding and control of simple electronic circuits based on the electronic and photonic devices and their applications.		C4
Understanding and control of the basic concepts of the logic families.		C4
Basic knowledges on CAD (Computer Aided Design) tools for the simulation of electronic circuits.	B13	
Capacity utilization of CAD tools for designing simple electronic circuits.	B13	

Contents	
Topic	
Subject 1: Introduction	Electronic systems. Design process. Integrated circuits.

Subject 2: Diodes and circuits with diodes	Characteristics of the diode. Zeners. Analysis of the load line. Ideal model of the diode. Circuits with diodes (rectifiers, clipping and voltage regulator circuits). Small signal equivalent linear circuits. Basic concepts of semiconductors. Physics of the diode. Capacity effects. LED and laser diodes. Photodiodes.
Subject 3: Principles of amplification	General aims: Voltage, current and power gains. Ideal amplifier. Amplifier Models. Limits. Introduction to amplifier frequency response.
Subject 4: Bipolar Junction Transistors (BJT)	Operation of the npn Bipolar Junction Transistor (BJT). Load-Line Analysis of a Common-Emitter Amplifier. The pnp Bipolar Junction Transistor. Models of circuits. Analysis of circuits with BJTs. Phototransistors and optocouplers.
Subject 5: Analysis of amplifiers with Bipolar Junction Transistors	Small-Signal Equivalent Circuits. Analysis in medium frequencies: the Common-Emitter amplifier, the Emitter-Follower amplifier, the Common-Collector amplifier and the Common-Base amplifier.
Subject 6: Field Effect Transistors (FET)	NMOS Transistor. Analysis of the load line of a simplified NMOS amplifier. Polarization circuits. JFET and depletion MOSFET transistors and channel p devices.
Subject 7: Analysis of amplifiers with Field Effect Transistors	Small-Signal Equivalent Circuits. Analysis in medium frequencies: the Common-Source amplifier and the Source Follower amplifiers.
Subject 8: Digital logic circuits	Digital logic circuits. Basic concepts. Electrical specifications of the logic gates. The inverter CMOS. CMOS gates NOR and NAND.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	4	6
Lecturing	13	24	37
Problem solving	14	33	47
Laboratory practical	14	30	44
Problem and/or exercise solving	8	0	8
Laboratory practice	5	0	5
Self-assessment	0	3	3

*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	Presentation of the subject. Presentation of the laboratory practices and the instrumentation and software to be used.Through this methodology the competencies CG13 and CE4 are developed.
Lecturing	Exposition of contents. Later personal work of the student reviewing the concepts seen in the classroom and preparing the subjects using the proposed bibliography. Identification of doubts that require to be resolved in personal tutorships. Through this methodology the competency CE4 is developed.
Problem solving	Activity to formulate and resolve problems and/or exercises related with the subject. Complement of the theoretical sessions. Personal work of the student with resolution of problems and/or exercises proposed in the classroom and extracted of the bibliography. Identification of doubts that require to be resolved in personal tutorships. Through this methodology the competency CE4 is developed.
Laboratory practical	Activities of application of the theoretical knowledges. It will learn to handle the typical instrumentation of an electronic laboratory and it will implement basic electronic circuits seen in the theoric sessions. Also they will purchase skills of handle of simulation tools. Personal work of the student preparing the practices using the available documentation and reviewing the theoretical concepts related. Development and analysis of results. Identification of doubts that require to be resolved in personal tutorships.Through this methodology the competency CG13 is developed.

Personalized assistance

Methodologies	Description
Lecturing	The students will be able to attend to personalised tutorials in the professor´s office in the schedule that the professors will establish and will publish in the web page of the subject. Here, they will be able to resolve their doubts about the contents given in the Master Sessions and will be oriented about how to deal with them.
Problem solving	The students will be able to attend to personalised tutorials in the professor's office in the schedule that the professors will establish and will publish in the web page of the subject. Here, they will be able to resolve their doubts about the problems and/or exercises proposed and resolved in the classroom as well as other problems and/or exercises that can appear along the study of the subject.

Laboratory practical	The students will be able to attend to personalised tutorials in the professor's office in the schedule that the professors will establish and will publish in the web page of the subject. Here, they will be able to resolve their doubts about the development of the laboratory practices, the handle of the instrumentation, the setting of the electronic circuits and the software of simulation.

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Tests will be carried out in the classroom throughout the year to evaluate the competencies of the student to resolve problems and/or the exercises over a part of the contents of the subject.	60		C4
Laboratory practice	Tests will be carried out in the laboratory along the course about management of instrumentation, mounting of electronic circuits and simulation. The skills acquired by the student about the contents of the subject laboratory practices will be evaluated.	35	B13	C4
Self-assessment	Techniques aimed to collect data about the participation of the student in the proposed self-assessment tests.	5		

Other comments on the Evaluation

1. First call (continuous assessment)

A system of continuous assessment will be offered to the students following the guidelines of the bachelor and the agreements of the academic commission. Students who take the first test of resolution of problems and/or exercises deem to opt for continuous assessment. Those students who do not take the first test of resolution of problems and/or exercises deem to renounce to the continuous assessment and they will only have the possibility to take the exam-only assessment. Students who do not follow the continuous assessment and do not take the exam-only assessment will be considered "not presented".

1.a Self-assessment tests

The professors will evaluate the execution of the proposed self-assessment tasks, getting the student a rating from 0 to 10 (AE).

The final mark of self-assessment tests (NAE) will be:

NAE = 0.05*AE

1.b Theory

Students will carry out 3 exams (multiple choice test and/or short answer test and/or resolution of problems and/or exercises) properly programmed along the course (PT1, PT2 and PT3). The schedule of these exams will be approved in "CAG" (Degree Academic Commission) and will be made public at te beginning of the corresponding term. PT1 will be about themes 1 and 2 (block 1), PT2 about themes 3, 4 and 5 (block 2) and PT3 about themes 6, 7 and 8 (block 3). These exams will be valued from 0 up to 10 and the final mark will be the average (NPT -> Mark of theory exams):

NPT = (NPT1 + NPT2 + NPT3)/3

It is necessary to obtain a minimum of 3 points out of 10 in each of these exams (NPT1 >= 3, NPT2 >= 3 and NPT3 >= 3) to pass the subject.

The final mark of theory (NT) will be:

NT = 0.6*NPT

The exams are not recoverable, that is to say, if a student cannot assist the day they are scheduled, the professors do not have obligation to repeat them. The mark of the missed exams will be 0.

1.c Practical

Students will carry out 2 practical tests properly programmed along the course. The schedule of these tests will be approved in "CAG" (Degree Academic Commission) and will be made public at te beginning of the corresponding term. These tests will be valued from 0 up to 10 and the final mark of the practical (NP) will be:

NP = 0.35*[(NP1 + NP2)/2]

The practical tests are not recoverable, that is to say, if a student cannot assist the day they are scheduled, the professors do not have obligation to repeat them. The mark of the missed tests will be 0.

1.d Final mark of the subject

It must get a minimum of 4 points out of 10 in theory (NT >= 2.4) and practices (NP >= 1.4) to pass the subject. Also it is necessary to get a minimum of 3 points out of 10 in each of the 3 theory exams (NPT1 >= 3, NPT2 >= 3 and NPT3 >= 3).

The final mark (NF) will be:

If NT >= 2.4 and NP >= 1.4 and NPT1 >= 3 and NPT2 >= 3 and NPT3 >= 3 => NF = NAE + NT + NP

If NT < 2.4 or NP < 1.4 or NPT1 < 3 or NPT2 < 3 or NPT3 < 3 => NF = min {4.5; NAE + NT + NP}

2. First call (exam-only assessment)

The students who do not follow the continuous assessment or had a final mark lower than 5 (failed) in the continuous assessment, will be able to present to a final exam.

The final exam will have a theoretical part and a practical one. The theoretical part will be carried out in the dates established by the School and it will consist in an exam (multiple choice test and/or short answer test and/or resolution of problems and/or exercises). This exam will have 3 parts, one for each block specified in section 1.b. Each part will be evaluated from 0 up to 10 and the final mark of theory (NT) will be the average multiplied by 0.6. It is necessary to get a minimum of 3 points in each of these parts (NPT1 >= 3, NPT2 >= 3 and NPT3 >= 3) and a minimum of 4 points out of 10 in theory (NT >= 2.4) to pass the subject.

The practical exam will be carried out in the laboratory in the dates established by the School and it will consist in a practical test which will be evaluated from 0 up to 10 and the final mark of practices (NP) will be the points of the test multiplied by 0.4. It must get a minimum of 4 points out of 10 in the practical exam (NP >= 1.6) to pass the subject.

By reasons of organisation of the groups of examination, the professors will open a period so that the students could enroll for the final practice exam. Only those students who have inscribed in due time and form, according to the rules indicated by the professors in the corresponding announcement, will be able to take the final practice exam.

The students who have opted for the continuous assessment and have failed and present to the final exam, can only do the theoretical part or to the practical one or both. They will keep the mark got in the continuous assessment of the missed part if the minimums specified in the continuous assessment process were achieved. The students who take the theoretical part will be able to carry out the blocks they want. The mark of the continous assessment of the missed blocks (NPT1, NPT2 and NPT3) will be kept. If they do not take the practical part, the practice note (NP) of the continuous assessment is recalculated multiplying by 0.4 instead of by 0.35.

The final mark (NF) will be:

If NT >= 2.4 and NP >= 1.6 and NPT1 >= 3 and NPT2 >= 3 and NPT3 >= 3 => NF = NT + NP

If NT < 2.4 or NP < 1.6 or NPT1< 3 or NPT2 < 3 or NPT3 < 3 => NF = min {4.5; NT + NP}

3. Second call

It will have a theoretical part and practical one with the same format as the exam-only assessment.

The students who take this call can only do the theoretical part, the practical one or both. They will keep the mark got in the first call (continuous or exam-only assessment). The students who take the theoretical part will be able to carry out the blocks they want. The mark of the first call (continuous or exam-only assessment) of the missed blocks will be kept. The calculation of the final mark of the subject will be as described in section 2.

The final mark of the subject will be the best of the first call and the second call.

By reasons of organisation of the groups of examination, the professors will open a period so that the students could enroll for the second call of practices. Only those students who have inscribed in due time and form , according to the rules indicated by the professors in the corresponding announcement, will be able to take this exam.

4. End-of-program call

This call will be the same as the second call.

5. Validity of the marks

The marks of the student in the theoretical and practical parts of the subject will be valid only for the academic course in which they was got.

If a cheating case is detected, the final mark will be FAIL (0) and the case will be communicated to the School Management.

Sources of information
Basic Bibliography
Hambley, A. R., **Electrónica**, 2ª ed., Prentice Hall, 2001
Quintáns, C., **Simulación de circuitos electrónicos con OrCAD 16 Demo**, Marcombo, 2008
Hambley, Allan R., **Electronics**, 2nd ed., Prentice Hall, 2000
Complementary Bibliography

Recommendations
Subjects that continue the syllabus
Digital Electronics/V05G300V01402
Electronic Technology/V05G300V01401

Subjects that it is recommended to have taken before
Physics: Analysis of Linear Circuits/V05G301V01108

IDENTIFYING DATA				
Physics: Fields and Waves				
Subject	Physics: Fields and Waves			
Code	V05G306V01202			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Basic education	2nd	1st
Teaching language	#EnglishFriendly English			
Department				
Coordinator	Pino García, Antonio			
Lecturers	Lorenzo Rodríguez, María Edita de Pino García, Antonio Vazquez Alejos, Ana			
E-mail	agpino@uvigo.es			
Web	http://faitic.uvigo.es			
General description	Fields and Waves presents the first contact in the student's degree with the phenomena of electromagnetic waves, which are the physical medium for transmission of information at almost instantaneous speed. Mathematical modeling of electromagnetic fields that provide insights into the behavior of electromagnetic waves in real environments will be introduced. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Competencies	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
C1	CE1/FB1: The ability to solve mathematical problems in Engineering. The aptitude to apply knowledge about linear algebra, geometry, differential geometry, differential and integral calculus, differential and partial differential equations; numerical methods, numerical algorithms, statistics and optimization
C3	CE3/FB3: Comprehension and command of basic concepts about the general laws of mechanics, thermodynamics, electromagnetic fields and waves and electromagnetism and their application to solve Engineering problems.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Solve problems of applied electromagnetism by applying the laws of Maxwell, the properties of the electric and magnetic fields and the constitutive electromagnetic relations of matter.	B3	C1 C3	D3
Solve electrostatic and magnetostatic problems: capacity and self-induction.	B3	C1 C3	D3
Calculate the main parameters of electromagnetic waves: frequency, wavelength, propagation constant, polarization, Poynting vector, phase constant, attenuation constant	B3	C1 C3	D3
Analyze the propagación of waves in media with and without losses.	B3	C1 C3	D3
Analyze the incidence of waves over obstacles or discontinuities: decomposition in incident, reflected and transmitted waves.	B3	C1 C3	D3

Contents	
Topic	
1. Vector and differential analysis of fields	1.1 Scalar and vector fields 1.2 Systems of coordinates in space 1.3 Vector Algebra 1.4 Integral Operators 1.5 Differential operators 1.6 Properties of operators

2. Electrostatic fields	2.1 Sources of the electrostatic field 2.2 Equations of the electrostatic field, electric potential 2.3 Electrostatic fields produced by charge distributions 2.4 Equations of Poisson and Laplace 2.5 Electrostatic field in material media
3. Magnetostatic fields	3.1 Sources of magnetostatic field 3.2 Magnetostatic field equations 3.3 Magnetostatic field produced by current distributions 3.4 Magnetostatic filed in material media
4. Maxwell Model	4.1 Maxwell's equations in integral form 4.2 Differential form of Maxwell's equations 4.3 Boundary conditions. 4.4 Energy balance of the electromagnetic field 4.5 Harmonic time variation 4.6 Harmonic time variation in material media
5. Wave equation and its solutions	5.1 Wave equation for time harmonic fields 5.2 Propagation, attenuation and phase constants 5.3 Solutions in rectangular coordinates 5.4 Progressive, stationary and evanescent waves in lossy and losseless media
6. Uniform plane waves	6.1 Expressions of the fields 6.2 Characteristic impedance 6.3 Poynting Vector 6.4 Polarization
7. Waves in the presence of obstacles	7.1 Incident wave, scattered wave and transmitted wave 7.2 Standing waves 7.3 Standing wave pattern 7.4 Polarization and power

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	16	24	40
Case studies	20	30	50
Problem solving	14	21	35
Essay questions exam	2	10	12
Case studies	2	4	6
Problem and/or exercise solving	2	5	7
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies

	Description
Lecturing	Exhibition by the professor of the contents on the matter object of study, theoretical bases and/or guidelines of a work, exercise or project to develop by the student. Through this methodology the competencies CG3, CE1, CE3 and CT3 are developed.
Case studies	Analysis of a fact, problem or real event with the purpose to know it, interpret it, resolve it, generate hypothesis, contrast data, think about it, complete knowledges, diagnose it and train in alternative procedures of solution. This metodology will be used both in large and medium size groups. Through this methodology the competencies CG3, CE1, CE3 and CT3 are developed.
Problem solving	Activities application of knowledge to specific situations, and the acquisition of basic skills and procedural matters related to the object of study, which are held in computer rooms. Electromagnetic simulators will be used. Through this methodology the competencies CG3, CE1, CE3 and CT3 and are developed.

Personalized assistance

Methodologies	**Description**
Lecturing	The student will receive personalized attention during the tutoring hours.
Problem solving	The student will receive personalized attention during the tutoring hours.
Case studies	The student will receive personalized attention during the tutoring hours.
Tests	**Description**
Essay questions exam	The student will receive personalized attention during the tutoring hours.
Case studies	The student will receive personalized attention during the tutoring hours.

Problem and/or exercise solving	The student will receive personalized attention during the tutoring hours.

Assessment

	Description	Qualification	Training and Learning Results
Essay questions exam	Proof for individual evaluation of the skills that includes open questions on a subject. The students have to develop, relate, organise and present their knowledge about the subject in an extensive answer.	40	B3 C1 C3 D3
Case studies	Test for individual evaluation of the competences that includes the approach of a practical case. Students develop the analysis of the situation in order to know it, interpret it, solve it, generate hypothesis, contrast data, reflect, complete knowledge, diagnose it and train in alternative solution procedures.	40	B3 C1 C3 D3
Problem and/or exercise solving	Individual proof where students must develop appropriate or correct solutions through the exercise of routines, the application of formulas or algorithms, the application of procedures for transforming available information and the interpretation of results	20	B3 C1 C3 D3

Other comments on the Evaluation

Following the policy guidelines of the Center, the students can choose between two systems of evaluation: continuous evaluation and evaluation at the end of the term.

In all the evaluation tests, the competences CG3, CE1, CE3 and CT3 will be evaluated.

1. CONTINUOUS ASSESSMENT.

- The system of continuous assessment (EC) will consist of:
  - a) A problem solving test. The qualification will be ECa, with maximum score of 1 points.
  - b) A problem solving session on topics 1, 2 and 3. The score will be ECb, and the subtotal EC1 = ECa + ECb can have a maximum value of 5 points.
  - c) A problem solving test. The qualification will be ECc, with maximum score of 1 poins.
  - d) A problem solving session on topics 4 to 7. The score will be ECd, and the subtotal EC2 = ECc + ECd can have a maximum value of 5 points. This last test will coincide in the calendar and schedule with the official exam date in the first opportunity evaluation.
- The final score of the first opportunity for students who follow continuous assessment (CE) is obtained by adding the two previous subtotals: EC = EC1 + EC2.
- The planning of the different intermediate assessment tests will be approved by an Academic Committee of Degree (CAG) and will be available at the beginning of the semester.
- Before the completion or delivery of each test, the date and procedure for reviewing the grades obtained will be indicated, which will be public within a reasonable period of time.
- The continuous assessment tests are not recoverable, that is, if a student cannot meet them within the stipulated period, the teacher does not have to repeat them.
- The qualification obtained in the continuous assessment tests (EC1 and EC2) will be valid only for the current academic year.
- It will be understood that a student accepts this system if he/she presents to take the "b" test for continuous assessment.

2. EXAM-ONLY ASSESSMENT

- It will be mandatory for students who do not follow continuous assessment to be able to pass the subject at first opportunity.
- It will consist of a problem solving session on topics 1 to 7. The score will be EF.

3. SECOND OPPORTUNITY EVALUATION.

- Students who followed the continuous assessment:
  - The second oportunity exam will be divided into two parts: EX1 (items 1 to 3) with a maximum value of 5 points, and EX2 (items 4 to 7) with a maximum value of 5 points.

    - The students who followed the continuous evaluation will choose if to do: only EX1, only EX2 or both parties. The final note will be: EF = max (EX1, EC1) + max (EX2, EC2).

- Students who did not follow the continuous evaluation. It consists of a single evaluation with the same format as the first opportunity (a problem solving session on topics 1 to 7). The score will be EF.

4. END OF PROGRAM CALL

- It will have the same format as the exam-only assesment.

5. OBSERVATIONS.

- Student who chose continuous assessment or takes any of the two final global exams of first or second opportunity are considered as presented.
- It is considered that the subject is approved if the final grade is equal to or greater than 5.
- In case of detection of plagiarism in any of the tests, the final grade will be SUSPENSE (0) and the fact will be communicated to the Center Head for the appropriate purposes.

Sources of information
Basic Bibliography
F. T. Ulaby, U. Ravaioli, **Fundamentals of Applied Electromagnetics**, Global Edition 7/e, Pearson Education Limited, 2015
D. K. Cheng, **Fundamentos de Electromagnetismo para Ingeniería**, Addison Wesley, 1998
Complementary Bibliography
D. K. Cheng, **Fundamentals of Engineering Electromagnetics**, New International Edition, Pearson, 2013
J. R. Reitz, F. J. Milford, R. W. Christy, **Fundamentos de la Teoría Electromagnética**, 4ª Edición, Addison Wesley, 1996
David J. Griffiths, **Introduction to Electrodynamics**, 4ª Edición, Pearson Education Limited, 2012
F. Dios, D. Artigas, et all., **Campos Electromagnéticos**, Ediciones UPC, 1998
W. H. Hayt, J. A. Buck, **Teoría Electromagnética**, 8ª Edición, Mc Graw Hill, 2012
D. K. Cheng, **Field and Wave Electromagnetics**, 2ª Edición, Addison Wesley, 1998
M. F. Iskander, **Electromagnetic Fields and Waves**, 2ª Edición, Prentice Hall, 2012

Recommendations
Subjects that continue the syllabus
Electromagnetic Transmission/V05G300V01303

Subjects that it is recommended to have taken before
Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106

IDENTIFYING DATA				
Digital electronics				
Subject	Digital electronics			
Code	V05G306V01203			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	Machado Domínguez, Fernando Nogueiras Meléndez, Andres Augusto			
Lecturers	Álvarez Ruiz de Ojeda, Luís Jacobo Machado Domínguez, Fernando Nogueiras Meléndez, Andres Augusto			
E-mail	fmachado@uvigo.es aaugusto@uvigo.es			
Web	http://faitic.uvigo.es			
General description	This course is an introduction to the basic principles of digital design and the analysis and design of digital circuits and systems. First, logic circuits, basic digital devices and logic gates representation will be introduced. Then, hardware description languages (HDL) based design, description and simulation methods will be described. Combinational and sequential logic design will be explained using the top-down design paradigm. Finally, the common combinational and sequential logic circuits will be described: operation, diagrams, symbols and VHDL description and simulation.			

Competencies	
Code	
B13	CG13 The ability to use software tools that support problem solving in engineering.
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C14	CE14/T9: The ability to analyze and design combinatory and sequential, synchronous and asynchronous circuits and the usage of integrated circuits and microprocessors.
C15	CE15/T10: The knowledge and application of the fundamentals of description languages for hardware devices.

Learning outcomes		
Expected results from this subject		Training and Learning Results
Knowledge of the concepts, components and basic tools of digital design.	B13 B14	C14 C15
Ability to analyse and design combinational systems.	B13	C14 C15
Knowledge of the combinational functional blocks and their aplications.	B14	C14
Knowledge of the basic storage elements, the sequential blocks and their aplications.	B14	C14
Ability to analyse and design synchronous sequential systems.	B13	C14 C15
Knowledge of description and simulation methods based on hardware description languages (HDL).	B13	C14 C15

Contents	
Topic	
Unit 1: Introduction to digital electronics	Introduction to Digital Electronics. Number systems and digital codes. Boolean Algebra. Truth Tables. Logic Gates. Boolean Funtions Simplification.
Unit 2: Introduction to VHDL	Introduction to hardware description languages. Basic VHDL syntax. Data types and objects. Operators. Concurrent and sequential sentences. Component instantiation.
Unit 3: Basic combinational systems	Functional blocks. Technologies and output types of the digital circuits. Decoders. Encoders. Multiplexers. Demultiplexers. Application examples. VHDL description.
Unit 4: Programmable gate arrays	Introduction to the programmable circuits. Application examples.
Unit 5: Arithmetic combinational systems	Comparators. Parity detection and generation. Arithmetic circuits. Application examples. VHDL description.

Unit 6: Sequential logic systems principles	Definition and classification. Latches and flip-flops. Application examples. VHDL description.
Unit 7: Synchronous sequential systems	General theory. Counters. Multibit registers. Shift registers. Application examples. VHDL description.
Unit 8: Synchronous sequential logic design	Synchronous sequential systems design. Application examples. VHDL description.
Unit 9: Memory units	Classification. Active and pasive random access memories. Random access memories. Sequential acces memories. Associative memories.
Unit 10: Programmable logical devices	Introduction to the programmable logical devices.
PRACTICE 1. INTRODUCTION TO SYNTHESIS AND ANALYSIS OF HDL DESIGNS TOOL	General flow diagram. Block description. Practical examples.
PRACTICE 2. INTRODUCTION TO VHDL DESIGN	Description and synthesis of combinational systems using VHDL. Practical examples.
PRACTICE 3. DIGITAL SYSTEMS TEST: FUNCTIONAL SIMULATION	Obtaining symbols from schematic. Component instantiation. Stimulus definition. Test-bench Functional simulation. Practical examples.
PRACTICE 4. DIGITAL SYSTEMS COMPILATION AND IMPLEMENTATION. TEMPORAL SIMULATION	Programmable logic device architecture. Compilation and implementation. Temporal simulation. Practical examples.
PRACTICE 5. TESTING DIGITAL SYSTEMS TEST IN THE DEVELOPMENT BOARD	Development board. Configuration file. Programmble logic devices technology and configuration methods. Device programming. Digital systems test in the development board. Implementation examples.
PRACTICE 6. COMBINATIONAL CIRCUITS	Design and implementation of combinational circuits using VHDL: truth table, logic function and behavioural descriptions.
PRACTICE 7. ARITHMETIC CIRCUITS	Design and implementation of arithmetic circuits usign VHDL: truth table, logic function and behavioural descriptions.
PRACTICE 8. ARITHMETIC SYSTEMS	Design and implementation of arithmetic systems usign VHDL. Arithmetic and logic unit (ALU).
PRACTICE 9. SEQUENTIAL CIRCUITS I	Design and implementation of sequential circuits usign VHDL (flip-flops, registers and counters).
PRACTICE 10. SEQUENTIAL CIRCUITS II	Design and implementation of sequential circuits usign VHDL (counters, shift registers). Design and implementation of synchronous sequential logic systems usign VHDL (state machines).
PRACTICE 11. COMPONENT ASSEMBLY AND CONNECTION. DIGITAL INSTRUMENTATION.	Logic analyser. Connection of external push-buttons, switches, LEDs, 7-segments displays. Test of sequential circuits using the logic analyser.
PRACTICE 12. SEQUENTIAL SYSTEMS I	Design and implementation of a sequential system based on functional blocks usign VHDL. Dynamic controller of a 4-digit, 7-segment display.
PRACTICE 13. SEQUENTIAL SYSTEMS II	Design and implementation of a complex sequential system. Reading system of a row and column based button keypad .

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	1	2
Lecturing	13	21	34
Laboratory practical	26	26	52
Problem solving	8	20	28
Laboratory practice	2	2	4
Problem and/or exercise solving	6	24	30
*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.
Lecturing	The lecturer will explain in the classroom the main contents of the subject. The students have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or in the office. In these sessions the students will develop the skils CE14 and CE15 ("know").
Laboratory practical	Activities designed to apply the main concepts and definitions of the subject. The students 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 students have to develop and demonstrate autonomous learning and collaborative skills. Possible questions can be answered in the laboratory sessions or in the lecturers office. In these sessions the students will develop the skils CE15, CG13 and CG14 ("know how").

Problem solving	Activities designed to apply the main concepts of the subject to solve problems and exercices. The lecturer will explain a set of problems and the students have to solve diferent take-home sets of problems. The answers to selected problems will be provided later on. The lecturer will answer the students questions in the classroom or at the office. In these sessions the students will develop the skils CE14 and CG15 ("know how").

Personalized assistance

Methodologies	Description
Lecturing	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The students can go to the lecturers office. The timetable will be available on the subject website at the beginning of the term.
Problem solving	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The students can go to the lecturers office. The timetable will be available on the subject website at the beginning of the term.
Laboratory practical	The lecturer will answer the students questions and also give instructions to guide the studying and learning process. The students can go to the lecturers office. The timetable will be available on the subject website at the beginning of the term.

Assessment

	Description	Qualification	Training and Learning Results	
Laboratory practical	The lecturer will check the level of compliance of the students with the goals related to the laboratory skills. 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) and the individual answers to personalized questions for each session (individual mark).	20	B13 B14	C15
Problem and/or exercise solving	The lecturer will check the students' skills to solve exercices and troubleshooting. Marks for each test will be assessed in a 10 points scale. Final mark of theory, FMT, will be assessed in a 10 points scale.	80		C14 C15

Other comments on the Evaluation

1. Continuous assessment (first call)

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 troubleshooting test or attend at least two laboratory sessions, ***they will be assessed by continuous assessment***.

The subject comprises two different parts: theory and laboratory. 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

Three exercises and troubleshooting tests (ETT) are scheduled. The first and second intermediate tests (ETT1 and ETT2) will be performed during the classes. The scheduling of the intermediate tests will be approved by the Academic Committee of the Degree (CAG) and will be available at the beginning of the semester. The final test (FETT) will be performed during the examination period in the date specified in the academic calendar. Marks for each test will be assessed in a 10 points scale. In order to pass this part, students will be require to obtain at least a mark of 4 in the final test (FETT>=4). In this case the final mark of theory (FMT) will be:

$$FMT = \max\{FETT ; (0.2\cdot ETT1 + 0.2\cdot ETT2 + 0.6\cdot FETT)\}.$$

However, when the students do not pass the final test (FETT less than 4), the final mark of theory will be:

$$FMT = \min\{4 ; \max\{FETT ; (0.2\cdot ETT1 + 0.2\cdot ETT2 + 0.6\cdot FETT)\}\}.$$

The students cannot do the tests at a later date. The student who miss a test will be assessed with a mark of 0 for that test.

1.b Laboratory

Thirteen laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in pairs whenever possible. The first five sessions are guided practices. In these sessions, the instrumentation and software resources will be presented and the students will configure a programmable logic device following the design flow. These five sessions are mandatory but will not be assessed. The following seasons will be assessed by continuous assessment. Each session will be only evaluated according to the developed work at the schedule date. The marks for these laboratory sessions (LSM) will be assessed in a 10 points scale. 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. Only sessions 6 to 13 will be assessed. A mark of 0 will be obtained for missing sessions. In order to pass the laboratory part, the students can not miss more than two laboratory sessions. In this case, the weighted points from all assessed sessions are added together to calculate the final mark of laboratory (FML):

FML = (LSM6 + LSM7 + LSM8 + LSM9 + LSM10 + LSM11 + LSM12 + LSM13) / 8.

For the students who miss more than two laboratory sessions, the with a final mark of laboratory will be:

FML = min{4 ; (LSM6 + LSM7 + LSM8 + LSM9 + LSM10 + LSM11 + LSM12 + LSM13) / 8}.

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: 80% theory (FMT) and 20% laboratory (FML). In order to pass the subject, students will be require to obtain at least a mark of 5 in each part (FMT>=5 and FML>=5). In this case the final mark (FM) will be:

FM = (0.8·FMT + 0.2·FML).

However, when the students do not pass both parts (FMT or FML less than 5), the final mark will be:

FM = min{4, (0.8·FMT + 0.2·FML)}.

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

2. Exam-only assessment (first call)

The students who prefer a different educational policy can attend an exam on a scheduled date. This assessment consist on a theory exam and laboratory exam. In order to attend the laboratory exam, the students have to contact to the lecturer at least two weeks before the exam. This way, the organization of the laboratory exam will be simpler.

The theory exam will consist on an exercises and troubleshooting test (FETT). Mark for this test will be assessed in a 10 points scale. The final mark of theory (FMT) will be:

FMT = FETT.

The laboratory exam will consist on the resolution of a practical exercise in the laboratory. This practical exercise will be similar to those made in the laboratory sessions. The final mark of laboratory (FML) will be assessed in a 10 points scale.

In order to pass the subject, students will be required to pass the laboratory and theory exams. The minimum mark required to pass each part is of 5 (FMT>=5 and FML>=5). In this case the final mark (FM) will be:

FM = (0.8·FMT + 0.2·FML).

However, when the students do not pass both parts (FMT or FML less than 5), the final mark will be:

FM = min{4 ; (0.8·FMT + 0.2·FML)}.

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

3. Second call assessment and end-of-program call assessment

These assessments consist on a theory exam and a laboratory exam. Dates will be specified in the academic calendar. In order to attend the laboratory exam, the students have to contact to the lecturer at least two weeks before the final exam.

In second call assessment, the marks obtained in the first chance assesment, continuous assessment or semester assessment, are kept for those parts in which the student has not attended (FMT or FML). The final mark will be calculated as it has described in section 2 (semester assessment).

Sources of information

Basic Bibliography

L. J. Álvarez, F. Machado, M.J. Moure, A.A. Nogueiras, S. Pérez, **Electrónica Digital**, Curso 2019-2020,

Wakerly J. F., **Digital Design. Principles and Practices**, 4th, Pearson/Prentice Hall, 2007

E. Mandado, **Sistemas Electrónicos Digitales**, 10ª, Marcombo, 2015

Douglas L. Perry, **VHDL : programming by example**, 4th, McGraw-Hill, 2002

Complementary Bibliography

Thomas L. Floyd, **Digital Fundamentals**, 11th, Pearson, 2014

L.J. Álvarez, E. Mandado, M.D. Valdés, **Dispositivos Lógicos Programables y sus aplicaciones**, 1ª, Thomson-Paraninfo, 2002

S. Pérez, E, Soto, S. Fernández, **Diseño de sistemas digitales con VHDL**, Thomson-Paraninfo, 2002

L.J. Álvarez, **Diseño Digital con Lógica Programable**, 1ª, Tórculo, 2004

J. Bhasker, **A VHDL primer**, 3rd, Prentice Hall, 1999

Recommendations

Subjects that are recommended to be taken simultaneously

Physics: Fundamentals of electronics/V05G301V01201

Subjects that it is recommended to have taken before

Informatics: Computer Architecture/V05G301V01109

IDENTIFYING DATA

Data Communication

Subject	Data Communication			
Code	V05G306V01204			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	Díaz Redondo, Rebeca Pilar López García, Cándido Antonio			
Lecturers	Díaz Redondo, Rebeca Pilar Fernández Veiga, Manuel López García, Cándido Antonio			
E-mail	candido@det.uvigo.es rebeca@det.uvigo.es			
Web	http://faitic.uvigo.es			
General description	In this subject the efficiency and reliability of data transmission using discrete memoryless channels will be analyzed, and the next issues will be introduced: * lossless data compression methods, * linear error control codes, * data link layer protocols, and * multiple access channels protocols and technologies.			

Competencies

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C11	CE11/T6: The ability to conceive, deploy, organize and manage networks, systems, services and Telecommunication infrastructures in residential (home, city, digital communities), business and institutional environments, being responsible for launching of projects and continuous improvement like knowing their social and economical impact.
C17	CE17/T12: The knowledge and usage of concepts of communication network architecture, protocols and interfaces.
C18	CE18/T13: The ability to differentiate the concepts of access and transport networks, packet and circuit switched networks, mobile and fixed networks, as well as distributed newtwork application and systems, voice, data, video, audio, interactive and multimedia services.
C20	CE20/T15: The knowledge of national, European and international telecommunication regulations and laws.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes

Expected results from this subject	Training and Learning Results		
Understanding the basics of digital transmission of information processes, the mathematical models of channels and the concept of capacity.	B3	C17	
Knowledge and ability to analyze the ways of achieving reliable data transmission.	B3 B4	C17 C20	D2 D3
Understanding the methods of sharing multiple access channels, their limits and the factors that affect their performance.	B3	C11 C18	D3
Master the main technical standards, interfaces and protocols in the field of data transmission and local networks.	B3	C20	D3
Practice with interfaces and protocols in the laboratory, as well as in the development of basic transmission solutions.	B3	C20	D3

Contents

Topic

Unit 1. Fundamentals of discrete Information Theory	1.1. A basic model of data communication systems 1.1.1. Discrete sources: discrete memoryless sources 1.1.2. Discrete channels: discrete memoryless channels 1.1.3. Source coding and channel coding 1.2. Information measures 1.2.1. Entropy. Joint entropy 1.2.2. Conditional entropy 1.2.3. Mutual information 1.3. Shannon's source coding theorem 1.3.1. Uniquely decodable codes: instantaneous codes 1.3.2. Kraft's theorem. McMillan's theorem 1.3.3. Optimal codes. Code redundancy 1.3.4. Shannon's source coding theorem 1.3.5. Compact codes. Huffman's algorithm 1.4. Shannon's noisy channels coding theorem 1.4.1. Channel capacity 1.4.2. Symmetric channels 1.4.3. Shannon's noisy channels coding theorem
Unit 2. Data transmission error control	2.1. Linear codes 2.1.1. Definition and matrix description 2.1.2. Syndrome decoding 2.1.3. Error detection and correction properties 2.1.4. Hamming codes 2.1.5. Cyclic codes 2.2. ARQ protocols 2.2.1. Stop and wait 2.2.2. Go-back n 2.2.3. Selective repeat
Unit 3. Multiple access channels and local area networks	3.1. Multiple access channels 3.1.1. The multiple access channel: definition and types 3.1.2. MAC protocols: Aloha, CSMA and variants 3.1.3. Performance of MAC protocols 3.2. Local area networks 3.2.1. Wi-Fi networks 3.2.2. Ethernet networks 3.2.3. Switching ethernet 3.2.4. Virtual local networks

Planning

	Class hours	Hours outside the classroom	Total hours
Lecturing	26	0	26
Previous studies	0	47	47
Problem solving	24	0	24
Autonomous problem solving	0	47	47
Essay questions exam	4	0	4
Problem and/or exercise solving	2	0	2

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

Methodologies

	Description
Lecturing	Systematic exposition of the theoretical contents of the subject, emphasizing the aims, fundamental concepts and relationships between the different units. Through this methodology the competencies CE11, CE17, CE18, CE20, CG3 and CT2 are developed.
Previous studies	Students will study the theoretical contents of the subject using the textbook and/or further material. Through this methodology the competencies CE11, CE17, CE18, CE20, CG3 and CT2 are developed.

Problem solving	Selected problems and/or exercises will be solved in detail, emphasizing the theoretical concepts involved and the methodology of resolution. Through this methodology the competencies CE11, CE17, CE18, CE20, CG4 and CT3 are developed.
Autonomous problem solving	Students will try to autonomously solve a problems and/or exercises from a proposed collection. Through this methodology the competencies CE11, CE17, CE18, CE20, CG4 and CT3 are developed.

Personalized assistance

Methodologies	Description
Previous studies	Students will receive personalized attention (in the professor's office, during the office hours) to resolve doubts that can arise in the autonomous study of the subject.
Autonomous problem solving	Students will receive personalized attention (in the professor's office, during the office hours) to resolve doubts that can arise in the autonomous resolution of exercices.

Assessment

	Description	Qualification	Training and Learning Results		
Essay questions exam	Two partial examinations. In each one of them we will evaluate all the competencies corresponding to the contents we have seen in class to date of the examination.	70	B3 B4	C11 C17 C18 C20	D2 D3
Problem and/or exercise solving	They will be realised with periodicity roughly twice-weekly.	30	B3	C17 C18	D3

Other comments on the Evaluation

A continuous assessment of the learning will be practised. Continuous assessment will consist of two types of tests: short tests, every two weeks; and two partial exams, the first one in the midterm and the second one at the end of the class period. All these tests will not be repeatable and will only be accountable for the first call in the current course. The schedule of the midterm/intermediate exams will be approved in the Comisión Académica de Grado (CAG) and will be available at the beginning of each academic semester.

The continuous assessment grade will be obtained as the weighted average of the grades of all the mentioned tests: 30% due to all the short tests (equally weighted) and 35% of each one of the partial exams, whenever the average grade of partial exams was not less than 3,5. In other case, the grade of the continuous assessment will be the average grade obtained in the partial exams.

All the students that have not reached at least a grade of 5 in the continuous assessment (included the students not evaluated) can do a final exam, that will include ALL the contents of the subject and that will take place in the exam period scheduled by the Centre. In this case, the final grade of the subject will be the exam grade.

All the students following continuous assessment or taking the final exam will be graded. The students that attend to the second partial exam will be considered following continuous assessment.

Those students who do not pass the subject at the first call have a second one consistent in the realisation of a new final exam.

In extraordinary calls the assessment will just consist in the realisation of a written exam including ALL the contents of the subject.

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

Sources of information

Basic Bibliography

C. López García, M. Fernández Veiga, **Teoría de la Información y Codificación, 2/e**, 2013,

Complementary Bibliography

C. López García, M. Fernández Veiga, **Cuestiones de Teoría de la Información y Codificación**, 2003,

J. F. Kurose, K. W. Ross, **Computer Networking, 6/e**, 2012,

Recommendations

Subjects that continue the syllabus

Subjects that it is recommended to have taken before

Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101
Mathematics: Probability and Statistics/V05G301V01107

IDENTIFYING DATA				
Digital Signal Processing				
Subject	Digital Signal Processing			
Code	V05G306V01205			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	1st
Teaching language	English			
Department				
Coordinator	Alonso Alonso, Ignacio			
Lecturers	Alonso Alonso, Ignacio			
E-mail	ignacio.alonso@uvigo.es			
Web	http://faitic.uvigo.es			
General description	Digital signal processing is nowadays a feature of most everyday communications and entertainment devices. The aim of this course is to equip students with a mathematical grounding in general signal and systems analysis. In subsequent course subjects, this knowledge will be applied to specific applications of signals and systems, including audio, image, video and voice signals. Objectives cover the following areas: Managing signals and systems mathematically and visually, including learning and applying their properties. Studying the different domains for signal and systems analysis: time domain, frequency domain and Z domain. Learning how to transfer a problem in one domain to a domain in which it is easier to solve. Mastering the concept of filter frequency response and learning to interpret the system function. Understanding the relationship between the poles and zeros of the system function and the frequency response. Acquiring basic notions of filter design in the Z domain. Managing specific digital signal processing software. Applying the above knowledge to simple and practical laboratory examples.			

Competencies	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
C48	(CE48/T16) The knowledge of the appropriate techniques to develop and exploit signal processing subsystems.
C49	(CE49/T17) The ability to analyze digital signal processing schemes.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Managing specific software for digital signal processing	B3	C48	D3
Applying mathematical knowledge for signal filtering	B4	C49	D2
Mastering filtering operations in frequency domain.	B4	C49	D2
Learning mathematical issues for understanding the processes of sampling and windowing of analog signals.	B3	C48	D3
Analysis of simple processing systems.	B4	C49	D2

Contents	
Topic	
Subject 1. Introduction	Concept of signal and system. Mathematical representation
Subject 2. Sinusoids	Sinusoidal signals: Frequency, amplitude and phase. Complex exponentials and phasors. Phasor addition rule.
Subject 3. Spectrum representation	Spectrum of a sum of sinusoids. Mathematical expression and graphical plot. Fourier Series analysis of periodic signals.

Subject 4. Introduction to Sampling and Aliasing	Sampling and digital frequency. Analog frequency vs discrete frequency. Aliasing. The sampling theorem.
Subject 5. FIR Filters	Introduction to discrete-time systems. Difference equation. Filter Coefficients. Block Diagrams. Causality, linearity and time-invariance. LTI systems and convolution. FIR frequency response. Cascaded LTI systems.
Subject 6. Frequency response of FIR filters	Sinusoidal response of FIR systems. Frequency response. Properties. Graphical representation.
Subject 7. Z Transform	Definition and properties. Linear-phase filters.
Subject 8. IIR Filters	Difference equation. Filter Coefficients. Block Diagrams. Impulse response. Relation between the position of poles and zeros of the system function and the frequency response.
Subject 9. Continuous-Time Signals and Systems	Introduction to continuous-time systems. The unit impulse. The unit step. Time delaying. Linearity and time-invariance. Convolution
Subject 10. Continuous-Time Fourier Transform	Definition. Basic pairs. Properties
Subject 11. Sampling and Reconstruction in the Frequency Domain	The sampling theorem in the frequency domain
Project 1. A/D and D/A Conversion	Digitalisation of Continuous-Time Signals. Aliasing.
Project 2. Digital Filters	Digital filters in the time and frequency domains.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	23	40	63
Laboratory practical	11	22	33
Problem solving	15	30	45
Discussion Forum	0	2	2
Objective questions exam	1.5	0	1.5
Problem and/or exercise solving	4.5	0	4.5

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

Methodologies

	Description
Introductory activities	Course presentation: programme, reading materials, teaching methodology and assessment system
Lecturing	Instructor presentation of the main concepts of each subject. During the 5 minutes before the lecture, a student will summarize the main concepts presented in the previous session. Students will participate by answering questions during the explanation and by doing exercises. Student will work alone afterwards on the concepts studied in class and on expanding this content using the guidelines provided for each subject. Identification of doubts that need to be resolved in personalized tutorials. Through this methodology the competencies CE48, CG3, and CT3 are developed.
Laboratory practical	Application of Matlab functions and commands for digital signal processing to solve practical exercises. Identification of doubts that need to be resolved in personalized tutorials. Through this methodology the competencies CE49, CG4 and CT2 are developed.
Problem solving	Problems and exercises formulated according to the content of the lectures and the guidelines for each subject. Students solve problems and exercises prior to the class in which one or several students explain the solution on the board. Identification of doubts that need to be resolved in personalized tutorials. Through this methodology the competencies CE49, CG4 and CT2 are developed.
Discussion Forum	The website for the course is included in the TEMA platform (http://faitic.uvigo.es). Subscription to this platform, including a photograph, is mandatory. The website provides all the information related to the course. It also publishes continuous assessment grades and runs forums for students to exchange ideas and discuss doubts. Through this methodology the competencies CE48, CE49, CG3, CG4 , CT2 and CT3 are developed.

Personalized assistance

Methodologies	Description
Lecturing	Students will have the opportunity to attend personal tutorials in their lecturer□s office at times established by lecturers for this purpose at the beginning of the academic year and published on the course website. These tutorials are aimed at resolving student doubts and providing guidance regarding: □ The content of the lectures and approaches to study. □ Laboratory projects and the software used. □ Problems and exercises proposed and solved in the classroom as well as other problems and exercises arising during the course.
Laboratory practical	The same as in the previous section.
Problem solving	The same as in the previous section.

Assessment

	Description	Qualification	Training and Learning Results		
Objective questions exam	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	0	B3	C48 C49	D3
Problem and/or exercise solving	These tests are a requirement to pass the subject. See details in the "Other comments and second call" section.	100	B3 B4	C48 C49	D2 D3

Other comments on the Evaluation

ASSESSMENT PROCEDURE:

A. Overview

The acquired skills are assessed by a series of tests grouped into two parts, with different requirements:

1. **Lab assessment**.
2. **Problems assessment**.

To pass the course it is necessary to pass all two parts.

- For each part one or more tests are performed to obtain an independent grade on each.
- There are tests for the two parts both in continuous assessment and in final exam assessment.
- A pass grade in any part is valid for the entire academic year.
- The final grade for Lab assessment is a numerical mark between 0 and 10. A student needs a grade greater than or equal to 5 to pass the Lab. If the Lab grade is greater than 7, the Lab grade will increase the Course mark (see details below).
- The final grade for the Problem assessment is a numerical mark between 0 and 10.
- The **Course mark** is obtained as follows (for both continuous and final exam assessment):
    - If you have passed all two parts and the Lab grade is not greater than 7:
        - Course mark=Problem assessment grade.
    - If you have passed all two parts and the Lab grade is greater than 7:
        - Course mark=minimum [10 , Problem assessment grade + [(Lab grade-7)/3]]
    - If you have not passed any of the two parts:
        - Course mark=minimum [Problem assessment grade, Lab grade]
    - In case the student has more than one mark for any part, the highest one will be used.

It is also important to note that:

- The course can be passed with full marks from continuous assessment, with no need to sit the final exam.
- Students who have done continuous assessment and have failed any part, in the final exam, only have to sit the part they failed (Lab or Problems).
- Students who sit any of the tests corresponding to Problem assessment will obtain a mark that will be listed in the academic records.

The following sections explain in detail how each part is graded.

B. Details of the assessment procedure

B1. Lab assessment

- Its goal is to determine whether the student has acquired all the knowledge and/or skills corresponding to the laboratory practice, emphasizing the use of MatLab for digital signal processing.
- Content to be assessed: content of the lab manuals and related theory content.
- Type of test: The test consists of a combination of multiple-choice questions and short questions. Students may use MatLab, lab manuals with personal notes, and text book. Students may not use a calculator for this test.
- The final grade for Lab assessment is a numerical mark between 0 and 10. A student needs a grade greater than or equal to 5 to pass the Lab. If the Lab grade is greater than 7, the Lab grade will increase the Course mark.
- Assessment method:
    - **First call**: Students will have two nonexclusive ways to pass the Lab part.
        1. Two tests in the lab room during the class period (continuous assessment)
            - The test consists of a series of questions at the end of each Lab assignment
            - The tests will be graded between 0 and 10. The student will pass this part if he/she gets an average greater than or equal to 5. It is compulsory to sit the two tests.
            - Tests dates will be announced on the subject web site at the beginning of the lecture period.
        1. A final exam (final exam assessment). The pass mark for this test is 5 out of 10.
    - **Second call and end-of-program call**: A final exam (final exam assessment). The pass mark for this test is 5 out of 10.
- Remarks:
    - Once the Lab part has been passed, the Lab grade will be valid for the entire academic year.

B2. Problems assessment

- Its goal is to determine whether the student has acquired all the knowledge and/or skills corresponding to the course and knows how to apply them to solve problems.
- Content to be assessed: as specified in the guidelines document for each topic (available on the subject web) in the section "Content to be assessed". MatLab knowledge is not assessed.
- Type of test: A problem solving test. Students are not allowed to use books or notes. The use of calculators may be granted on an exam basis.
- It will be graded between 0 and 10. The pass mark is 5.
- Assessment method:
    - **First call**: Students will have two nonexclusive ways to pass the Problems part.
        1. Three tests in the classroom during the class period (continuous assessment). Each test will be graded between 0 and 10.
            - The mark will be obtained as : 0,15* Test1Mark+ 0,35*Test2Mark + 0,5*Test3Mark
            - Test1: Units 1 to 4. Test2: Units 1 to 8. Test3: Units 1 to 11.
            - Tests dates will be announced on the web site at the beginning of the lecture period.
        2. A final exam (final exam assessment). The pass mark for this test is 5 out of 10.
    - **Second call and end-of-program call**: A final exam (final exam assessment). The pass mark for this test is 5 out of 10.
- Remarks:
    - Once the Problems part has been passed, the Problems grade will be valid for the entire academic year.
    - A student who has passed the Problems part during the First call through the continuous assessment method is allowed to sit the final exam of the First call to try to get a better mark.
    - A student who has passed the Problems part during the First call is NOT allowed to sit the Problems Part of the

final exam of the Second call.

C. Other comments

- After the end of the course students will have a single grade of the subject in their academic record:
    - After the First call their corresponding grade is registered. If this grade is greater than or equal to 5, it will be the student final grade
    - If a student who has not passed the subject in the First call, gets a better grade in the Second call, this new grade will be the one that will be included in his academic record. If it is not better the academic record will stay unchanged. In any of these cases, this grade becomes the final grade.
- Continuous assessment tests may not be rescheduled.
- Lab or Problems grades 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 out of reach of the student. If calculator use is permitted, the calculator must be a conventional scientific calculator. Therefore, calculators that allow formulas to be saved or that have libraries that automatically perform operations with complex numbers, calculation of roots, etc. are not allowed under no circumstances.
- Plagiarism is regarded as serious dishonest behavior. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the incident will be reported to the corresponding academic authorities for prosecution.
- Throughout the course, during the celebration of the lectures, the teachers of the subject will eventually propose activities or exercises in which students can be rewarded with up to 1 point out of 10. If they receive it, this bonus will be added to the final grade that the students have obtained following the assessment methods previously described.

Sources of information
Basic Bibliography
J.H. McClellan y R.W. Schafer, R, **Signal Processing First**, Pearson Prentice Hall,
Complementary Bibliography
A. Quarteroni y F. Saleri, **Cálculo científico con Matlab y Octave**, Springer,
M. J. Roberts, **Señales y Sistemas**, McGraw Hill,
A.V. Oppenheim y R.W. Schafer, **Tratamiento de señales en tiempo discreto**, Prentice Hall,

Recommendations
Subjects that continue the syllabus
Fundamentals of Sound and Image/V05G300V01405
Signal Transmission and Reception Techniques/V05G300V01404
Fundamentals of Image Processing/V05G300V01632
Sound Processing/V05G300V01634
Audio Systems/V05G300V01532
Imaging Systems/V05G300V01633
Electronic Systems for Signal Processing/V05G300V01522
Multimedia Signal Processing/V05G300V01513
Video and Television/V05G300V01533

Subjects that it is recommended to have taken before
Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Linear algebra/V05G301V01102
Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106

IDENTIFYING DATA				
Electronic technology				
Subject	Electronic technology			
Code	V05G306V01206			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	English			
Department				
Coordinator	Raña García, Herminio José Quintáns Graña, Camilo			
Lecturers	Quintáns Graña, Camilo Raña García, Herminio José			
E-mail	hrana@uvigo.es quintans@uvigo.es			
Web	http://faitic.uvigo.es			
General description	This course is dedicated to the utilisation of integrated circuits, in particular operational amplifiers, as well as to the following fields: Electronics of Power, Electrotechnics in the aspects of electrical installations and to the conversion of photovoltaic solar energy and thermal.			

Competencies	
Code	
B13	CG13 The ability to use software tools that support problem solving in engineering.
B14	CG14 The ability to use software tools to search for information or bibliographical resources.
C14	CE14/T9: The ability to analyze and design combinatory and sequential, synchronous and asynchronous circuits and the usage of integrated circuits and microprocessors.
C16	CE16/T11: The ability to use different energy sources, especially photovoltaic and thermal ones, as well as the fundamentals of power electronics and electronics

Learning outcomes		
Expected results from this subject	Training and Learning Results	
To know how to analyse and use circuits with operational amplifiers and with other integrated circuits.	B13 B14	C14
To know the foundations of Electrotechnics.		C16
To know the foundations of the Power Electronics and the basic topologies of the power electronic converters.	B13 B14	C16
Ability to use distinct sources of energy and especially photovoltaic solar energy and thermal solar energy.	B13	C16

Contents	
Topic	
Operational amplifiers and other integrated circuits	Introduction to amplifiers: Aspects of frequency response in amplifiers. Bode diagrams. Principles of operation of an operational amplifier. Application circuits for operational amplifiers. Other integrated circuits of general application.
Power Electronics (I)	Introduction to Power Electronics. Power electronic devices .
Power Electronics (II)	DC power supplies. DC-DC converters.
Power Electronics (III)	Single-phase rectifiers. Single-phase inverters.
Electrotechnics	Electrical installations. Protections.
Photovoltaic and thermal solar energy	Photovoltaic and thermal solar installations. Photovoltaic cells. Photovoltaic panels. Photovoltaic systems of energy conversion.

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	18	18	36
Laboratory practical	22	22	44
Problem solving	6	12	18

Essay questions exam	3	15	18
Problem and/or exercise solving	3	15	18
Laboratory practice	4	12	16

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

Methodologies

	Description
Lecturing	The teacher exposes the theoretical contents. This activity is individual. In these activities skills CE14 and CE16 are developped.
Laboratory practical	They include circuit mounting and testing and computer electronic circuits simulation. Some practical classes will also include some web search made by the student, about some technical information about some specific electronic devices used in the practical classes (e.g. some kind of transistors or operational amplifiers). This activity is collective. The students work in teams of two persons in each laboratory position. Through this methodology the competencies CE14, CE16, CG13 and CG14 are developed.
Problem solving	The teacher will solve exercises about most of the chapters. This activity is individual. Through this methodology the competencies CE14 and CE16 are developed.

Personalized assistance

Methodologies	Description
Lecturing	The students may attend to the professor office in the office hours published in the course webpage. Doubts about the contents of the master classes will be resolved in this tutorship time as well as doubts about how to prepare their study.
Laboratory practical	The students may attend to the professor office in the office hours published in the course webpage. Doubts arisen to the students about the practices of laboratory, about how to use the instrumentation or about the implementation of the electronic circuits and the simulation software will be resolved in this sessions.
Problem solving	The students may attend to the professor office in the office hours published in the course webpage. Doubts arisen to the students on the problems and/or exercises proposed and resolved in the classroom will be resolved in this tutorship time as well as other problems and/or exercises that can appear along the study of the subject.

Assessment

	Description	Qualification	Training and Learning Results
Essay questions exam	They make part of each partial examination of theory, in which they are half of its value.The number of tests and how they work are detailed in 'Other comments and July evaluation'.	35	C14 C16
Problem and/or exercise solving	They make part of each partial examination of theory, in which they are half of its value.The number of tests and how they work are detailed in 'Other comments and July evaluation'.	35	C14 C16
Laboratory practice	They are made in the laboratory. They consist of the kind of tasks made or prepared during the practices of the course: the practical exams consist of: 1) mounting of circuits, making measures on them and answering questions related with these circuits and 2) simulation of circuits equal or similar to the ones studied in the practices and answering questions related with this simulation. In the laboratory practice exams the student will be allowed to use some especific technical information collected by the student during the practices (e.g. datasheets from manufacturers).	30	B13 C14 B14 C16

Other comments on the Evaluation

A process of continuous assessment based on midterms is established, but the student may choose alternatively an exam-only assessment.

Partial exams are not recoverable, i.e., if a student can not attend the day they are scheduled, teachers do not have

obligation to repeat them. The grades for the partial exams are valid only for the academic year in which they are made.

Note 1: During exams mobile phones must be turned off and kept away. It is not allowed to use them as calculators. The student must have a calculator.

Note 2: It is not allowed to enter the classroom after an exam begins.

Continuous assessment:

For continuous assessment, the contents of theory are divided into three blocks and the contents of laboratory are divided into two blocks.

The student joins continuous evaluation if and only if he/she attends to any of the partial exams (either theoretical or laboratory ones) . From that moment, the student is considered as presented, and if he/she doesn't attend to any other partial exams, his/her mark on them will be zero.

As specified below, 4 points (out of 10) is considered as minimum grade in each block, as well as minimum theory grade, laboratory grade or grade of each block (grade of a partial examination or grade of that block in the final examination, in theory or practice, as well).

Regarding theory:

There are two partial exams, for the first two blocks. The student must repeat each partial exam in the final exam if the grade on any of them is less than 4. The exam of the third block is done by all students in the final exam.

If a student gets a grade of at least 4 points in a partial exam, he/she can try to improve the mark of that block in the final exam, but the grade in that block will be the one obtained in the final exam, even though it is less than the grade obtained in the partial exam.

The theory grade NT is the average grade of the three blocks, if the three student's grades exceed 4 point. If in any of the three blocks, the student does not reach 4 points, his/her theory grade is the minimum between 3.5 and the average of the three blocks.

The partial exams take place on the usual weekly scheduling of the classes and last 1 hour and 50 minutes each.

They include both one half (in time and in mark) of development questions and one half exercises.

The duration of each block of the final theory exam (first, second and third) is one hour.

Regarding practices:

Laboratory practices are assessed through practical exams described above (laboratory exams).

The practices of the two blocks are examined in two partial laboratory exams. The student must repeat a lab exam in the final exam if his/her mark in it is less than 4.

To participate in the partial exams of laboratory practices the student must attend to all the laboratory practices. Nevertheless, the students that do not fulfil this requirement can attend to the partial exams of theory and liberate themselves from its contents for the final theory exam.
If a student gets a grade of at least 4 points in a partial laboratory exam, he/she may try to improve the grade of that block in the final exam, but the grade in that block will be the one obtained in the final exam, even though it is less than the grade obtained in the partial exam.

The practice note NP is the average grade of the two blocks, if the grade of the student in both partial exams exceeds 4 points. If the student doesn't reach 4 points in any of the two blocks, his/her practice grade is the minimum between 3.5 and the average of the two blocks.

Material for practical exams:

The student must take to the practical exams the datasheets of the semiconductors used during the practices, which the student must gather as the practices are carried out. The student can also take to the practical exams the practices printed, bound or stapled, along with annotations added by the student during the realization of the practices, according to rules that will be detailed on the web of the subject.

VERY IMPORTANT: The students who want to attend to the lab final exam of the course must enroll for it, prior to the exam, via the subject web (section'Inscripciones'). The teachers of the subject will communicate through an announcement on that website a deadline for such preinscription. This preinscription is necessary to schedule the shifts for the lab exam. Only the students enrolled before that date will have right to do the lab exam.

Final grade:

The final grade NF is NT x 0.7 + NP x 0.3, if NT and NP are both at least 4 points. Otherwise NF is the minimum between 4.5 and NT x 0.7 + NP x 0.3 . NT and NP are calculated as indicated above. The student passes the subject in May session (first call) if the final grade NF is greater than or equal to 5.

Exam-only assessment

The students who choose exam-only assessment do the same final exam as those other who are assessed by continuous assessment and who have reached the minimum grade in no partial exam, i.e., they have to make all the final examination, both the three blocks of theory and the two blocks of lab practices.

The theory grade NT, the practice grade NP and the final grade NF are calculated in the same way as indicated above, for students assessed by continuous assessment.

Second call

The second call exam consists of two parts:

- A theory exam, 3 hours long. Its grade is NT.

- A laboratory exam, 1 hour 50 minutes long. Its mark is NP.

Unlike the final exam (first call), this exams are not divided into blocks.

The grade in this second call exam, NR, is NT x 0,7 + NP x 0,3, where NT is the theory exam grade and NP is the laboratory exam grade, provided that NT and NP are both greater or equal to 4 points. Otherwise, the grade in this second call is the minimum between 4.5 and NT x 0,7 + NP x 0,3.

In the second call, all the students can attend to both sections (theory and practice). The rule of 'highest grade' which is compulsory for the total grade of all the subjects, will apply in this subject also extended to each section; i.e., the theory grade of each student to calculate the grade for the second call will be the highest between the May theory mark (first call) and the mark in the second call theory exam. The same for the laboratory grade.

VERY IMPORTANT: In the same way as stated for the May final proof, the students who want to attend to the second call laboratory exam must enroll to attend to it, via the subject web. The teachers of the subject will communicate through an announcement on that website a deadline for such preinscription. This preinscription is necessary to schedule the shifts for the laboratory exam. Only the students who enroll before that date will cahave right to do the laboratory exam.

END OF CAREER EXAM

The end of career (E.C.) exam has the same structure as the second call exam and its grade is calculated the same way as in the second call exam, except that no grade of a previous opportunity is retained (neither from partial exams nor from final nor second call exam): the grade of a student in the E.C. act depends for all students only upon the E.C. exam itself.

Sources of information
Basic Bibliography
Hambley, A. R., **Electrónica**, 2ª ed. en español, Prentice-Hall,
Hart, D. W., **Electrónica de potencia**, Prentice-Hall,
Quintáns Graña, C., **Simulación de circuitos con OrCAD 16 DEMO**, Marcombo,
Hambley, Allan R., **Electronics**, 2nd ed., Prentice Hall,
Hart, Daniel W., **Power Electronics**, McGraw-Hill,
Complementary Bibliography
Rashid, Muhammad H., **Electrónica de potencia: circuitos, dispositivos y aplicaciones**, Pearson Education,
Reglamento Electrotécnico para Baja Tensión (REBT) e Instrucciones Técnicas Complementarias (ITC),
Schneider Electric España, S.A., **Guía de diseño de instalaciones eléctricas (PDF de uso libre disponible en www.schneiderelectric.es)**, Schneider Electric España, S.A,
Guirado, R., **Tecnología eléctrica**, McGraw-Hill,
AENOR, **Norma UNE 60617 de Símbolos gráficos para esquemas eléctricos**,
Carta, J. A. y otros, **Centrales de energías renovables. Generación eléctrica con energías renovables**, Pearson-UNED,

Recommendations
Subjects that continue the syllabus
Analogue Electronics/V05G300V01624

Subjects that it is recommended to have taken before

Physics: Fundamentals of Electronics/V05G300V01305
Physics: Analysis of Linear Circuits/V05G301V01108

IDENTIFYING DATA				
Electromagnetic Transmission				
Subject	Electromagnetic Transmission			
Code	V05G306V01207			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	#EnglishFriendly English			
Department				
Coordinator	Vera Isasa, María Lorenzo Rodríguez, María Edita de			
Lecturers	Lorenzo Rodríguez, María Edita de Vazquez Alejos, Ana Vera Isasa, María			
E-mail	mveraisasa@uvigo.es edita.delorenzo@uvigo.es			
Web	http://faitic.uvigo.es			
General description	Fundamentals of electromagnetic guided and unguided transmission. Analysis of the operating principles of different transmission media models and their characterization in telecommunication engineering. English Friendly subject: International students may request from the teachers: a) materials and bibliographic references in English, b) tutoring sessions in English, c) exams and assessments in English.			

Competencies	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C9	CE9/T4: The ability to analyze and specify the main parameters of a communications system.
C13	CE13/T8: The ability to understand the electromagnetic and acoustic wave mechanisms of propagation and transmission, and their corresponding receiving and transmitting devices.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Transmissionm line specification: two-wire line, coaxial wire, coaxial models, twisted pair, optical fibre.	B3	C9	
Tension and current waves, E-H fields and stationary wave analysis.	B5	C13	
Proposing impedance matching solutions.	B4		
Antenna radiated field calculation and related parameters: radiation pattern, gain, beam-width, impedance, polarisation, effective area.	B5	C9 C13	
Resolving problems of propagation and reception of electromagnetic waves.	B3 B4		D2 D3

Contents	
Topic	
Introduction	Types of transmission media, advantages and disadvantages, characterisation.

Transmission lines	Getting started with some of the most commonly used transmission lines: two-wire, coaxial cable, twisted pair. Circuit model of distributed parameters ,general equations, characteristic parameters (characteristic impedance, propagation velocity, attenuation and phase coefficients). Attenuation, dispersion and crosstalk. Transmission line in a circuit (reflection coefficient, standing wave ratio, input impedance). Smith Chart.
Waveguides	Transmission modes, cutoff frequency, guided wavelength, wave impedance. Rectangular waveguide.
Optical fiber.	Structure and types. Numerical aperture and acceptance cone. Attenuation and dispersion. Optical sources and receivers.
Radiowaves and antennas	Characteristics of radiowaves: far field, radiation integral. Antenna concept and fundamental parameters (radiation pattern, secondary lobe level, beamwidth, directivity, gain, polarisation, impedance). Reception: power balance in free space (Friis equation), polarization loss factor. Antenna arrays.
Labs	- Measurement and analysis of voltage and current waves and standing waves. - Optical fiber transmission fundamentals. - Basic impedance matching technics. - Radiation pattern plots. - Measurement of antenna basic parameters. - Problem resolution.

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	18	27	45
Autonomous problem solving	7	28	35
Laboratory practical	20	4	24
Problem solving	6	18	24
Problem and/or exercise solving	3	9	12
Objective questions exam	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
Introductory activities	Activities focused to take contact and get information about the students and to introduce the subject.
Lecturing	Presentation by the teacher of the contents of the subject of study (theoretical basis). Through this methodology the competencies CG3, CE9,CE13 and CT2 are developed.
Autonomous problem solving	Activity in which problems are formulated related to the subject. The student must develop the analysis and solving problems independently. The solutions are provided in ordinary class hours. Through this methodology the competencies CG4, CE9 and CE13 are developed.
Laboratory practical	Application of knowledge to specific situations and acquisition of basic skills and procedures. They are developed in laboratories with specialized equipment. Through this methodology the competencies CG5 and CT3 are developed.
Problem solving	Activity in which problems are formulated related to the subject. The student must develop the analysis and solving problems with the advisor help. Through this methodology the competencies CG4, CE9 and CE13 are developed.

Personalized assistance

Methodologies	Description
Lecturing	In the tutorial schedule, teaching staff will attend the needs and queries of the students related with the study of the subject.
Laboratory practical	The teaching staff will set the time of the session and will resolve the questions about the practical implementation.

Autonomous problem solving	In the tutorial schedule, teaching staff will attend the needs and queries of the students related with the study of the subject.
Problem solving	In the tutorial schedule, teaching staff will attend the needs and queries of the students related with the study of the subject.

Assessment

	Description	Qualification	Training and Learning Results	
Problem and/or exercise solving	Proof in which the student has to solve a series of problems in a time and conditions established by the teacher, applying the acquired knowledge.	75	B3 B4	C9 C13
Objective questions exam	Proofs of short length (see other comments)	25	B3 B5	C9 C13

Other comments on the Evaluation

Following the guidelines of the degree, two evaluation systems will be offered: continuous assessment or single assessment.

Continuous assessment

Continuous assessment includes the following tasks (with its time length and weight in the final grade):

- T1: Exercises of decibels (30 minutes, 5%).
- T2: Problems of transmission lines (1 hour, 30%).
- T3: Questions about guided transmission labs (1 hour, 15%).
- T4: Questions about radiotransmission labs (30 minutes, 10%).
- T5: Problems of radiotransmission (2 hours, 40%).

The time schedule of these tasks, approved by the CAG, will be available at the beginning of the semester.

These tasks are **not recoverable**, ie if a student cannot fulfill on time the teacher has no obligation to repeat them and they are **valid only for the academic year in which they are made**.

To pass the subject by this assesment system, it is necessary to obtain 30% of the maximum qualification in each one of the following thematic blocks:

Guided transmission: T1 + T2 + T3.

Radiotransmission: T4 + T5

If the minimum 30% required is not obtained in any of the blocks defined, the final mark will never be higher than 4.5

After the first problem solving exam the student must decide between continuous assesment or single assesment, in which case they receive a mark, independently that they assist or not to the other tasks. A failure to attend to this test implies that the choice is single assessment.

Exam-only assessment

In addition to the continuous assessment described above, the student may choose to perform one final exam with two parts:

- Part I: questions about labs (30%).

- Part II: problem solving (70%).

Second call

It consists of a final exam with the same characteristics and weights as indicated in the single assessment section.

Students who have chosen continuous assessment may keep the mark of one of the thematic blocks (guided or radio transmission) if it has exceeded the required minimum.

End-of-program call

The system described in the single assessment section will be applied.

Copy

In case of detecting any student copying or not respecting the instructions of any of the evaluation tests, he/she will be urged to leave the classroom/laboratory, the final grade will be FAIL (0 points), and this incident will be reported to the corresponding academic authorities to take the appropriate consecuences.

At least 50% in the total qualification must be obtained in any of the assessment systems and calls to pass the subject.

Sources of information

Basic Bibliography

F.T. Ulaby, **Fundamentals of Applied Electromagnetics**, 7ª,

S.M. Wentworth, **Applied electromagnetics. Early transmission line approach**, 1ª,

D. K. Cheng, **Fundamentos de electromagnetismo para ingeniería**,

Complementary Bibliography

B.M. Notaros, **Electromagnetics**, Pearson, 2011

N.N.Rao, **Elements of engineering electromagnetics**, 6ª, Pearson, 2004

J.D. Krauss, **Electromagnetismo con aplicaciones**, McGraw-Hill, 2000

D. K. Cheng, **Field and Wave Electromagnetics**, 2ª, Addison-Wesley, 1989

Recommendations

Subjects that continue the syllabus

Fundamentals of Sound and Image/V05G300V01405
Signal Transmission and Reception Techniques/V05G300V01404
Microwave Circuits/V05G300V01611
Radio Frequency Circuits/V05G300V01511
Optical Telecommunication Infrastructures/V05G300V01614
Wireless Systems and Networks/V05G300V01615
Radio Communication Systems/V05G300V01512

Subjects that are recommended to be taken simultaneously

Digital Signal Processing/V05G300V01304

Subjects that it is recommended to have taken before

Mathematics: Calculus 1/V05G301V01101
Mathematics: Calculus 2/V05G301V01106
Physics: Fields and Waves/V05G301V01202

IDENTIFYING DATA

Signal Transmission and Reception Techniques

Subject	Signal Transmission and Reception Techniques			
Code	V05G306V01208			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	English			
Department				
Coordinator	López Valcarce, Roberto			
Lecturers	López Valcarce, Roberto Rodríguez Banga, Eduardo			
E-mail	valcarce@gts.uvigo.es			
Web	http://faitic.uvigo.es			
General description	The course "Techniques for Signal Transmission and Reception" is an introduction to the different existent methods for the exchange of information in digital format at the physical layer level. Its main focus is on pulse amplitude modulation (PAM) as illustrative example. The main components of a digital transmitter and receiver are described, as well as the different effects caused by the communication channel and the different performance parameters of a digital system.			

Competencies

Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
C7	CE7/T2: The ability to use communication and software applications (ofimatics, databases, advanced calculus, project management, visualization, etc.) to support the development and operation of Electronics and Telecommunication networks, services and applications.
C9	CE9/T4: The ability to analyze and specify the main parameters of a communications system.
C10	CE10/T5: The ability to evaluate the advantages and disadvantages of different technological alternatives in the implementation and deployment of communication systems from the point of view of signals, perturbations, noise and digital and analogical modulation systems.
C20	CE20/T15: The knowledge of national, European and international telecommunication regulations and laws.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes

Expected results from this subject	Training and Learning Results		
Differentiate the blocks and functionalities of a complete data transmission sytem	B3	C9 C10	
Identify the minimum requirements for a reliable data communication.	B3 B4	C9 C10	
Distinguish the fundamental parameters of a complete communications system oriented to data transmission.	B3 B4	C9 C10	
Describe, develop and analyse the different blocks of a data transmission system.	B3 B6	C9 C10 C20	D3
Develop and implement basic circuits for modulation and demodulation of signals.	B4 B6	C9 C10 C20	D2
Use applications of communication and computer (text processing, databases, advanced calculus, management of projects, visualisation, etc.) to support the design of data transmission systems.	B4	C7	D2 D3
Recognise the different quality assessment measures of a digital signal.		C9 C10	

Statistically analyse the noise and understand its effects.	B3	C9 C10

Contents	
Topic	
1. Introduction to digital communication systems	-Basic elements and general description of a communication system. -Analog and digital communications -Description of a digital transmitter -Description of a digital receiver
2. Signals, systems and stochastic processes in communications	-Review of basic concepts: signals, systems, transforms. -Autocorrelation function of a stochastic process. -Power spectral density. Transmitted power, transmission bandwidth. -Noise characterization
3. Frequency conversion and analog processing	-Amplitude modulation (AM) with suppressed carrier -I/Q Modulation and demodulation. - Transceiver requirements and specifications -Receiver architectures: direct conversion, intermediate frequency. Analog and digital stages.
4. Pulse amplitude modulation (PAM)	- Baseband PAM - Bandlimited channels and intersymbol interferences (ISI) - Nyquist criterion, raised cosine pulses, eye diagram - Bandpass PAM
5. Modulation and detection in Gaussian channels	-Introduction to the Signal Space -Derivation of the Matched Filter -Maximum A Posteriori (MAP) and Maximum Likelihood (ML) detectors -Probability of error
6. The communication channel	-Transmission media -Signal to noise ratio -Multipath and frequency selectivity -Fading -Doppler effect

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	24	24	48
Computer practices	21	31.5	52.5
Problem solving	2	8	10
Laboratory practical	6	9	15
Essay questions exam	2	16	18
Problem and/or exercise solving	1	5.5	6.5
*The information in the planning table is for guidance only and does not take into account the heterogeneity of the students.			

Methodologies	
	Description
Lecturing	Presentation and discussion of the fundamental theory. Through this methodology, skills CE9, CE10, CE20, CG3, CG4, CG6, CT2, CT3 are developed
Computer practices	The concepts presented in class will be further illustrated and developed by means of Matlab-based simulation and signal processing tools. Through this methodology, skills CE7, CE9, CE10, CG3, CG4, CT2 are developed
Problem solving	A simple problem will be solved after each batch of slides. This problem will help to understand the concepts introduced in that batch of slides. Through this methodology, skills CE9, CE10, CG4 are developed
Laboratory practical	Experimental study with real communication signals by means of Software-Defined Radio tools. This year a new practice, dealing with the modulation and demodulation of digital communications signals, will be introduced. Through this methodology, skills CE9, CE10, CG3, CG6, CT2 are developed

Personalized assistance	
Methodologies	**Description**

Laboratory practical	Beyond the initial explanation to the group, the teachers will resolve the individual doubts of the students.
Lecturing	The personalized attention will be done at the office hours.
Computer practices	Beyond the initial explanation to the group, the teachers will resolve the individual doubts of the students.
Problem solving	The personalized attention will be done at the office hours. Special group sessions will be organized for solving the proposed problems; in those sessions the students will try to resolve the problems, so questions on the subject will be arised, and will be solved by the teachers.

Assessment

	Description	Qualification	Training and Learning Results		
Essay questions exam	Final examination. It will cover all of the material covered during the course and will take place during the exam period as established by the Center.	60	B3 B4 B6	C9 C10 C20	D2 D3
Problem and/or exercise solving	Three short tests will be given during the semester.	40	B3 B4 B6	C7 C9 C10 C20	

Other comments on the Evaluation

For those students who choose the continuous assesment track. Four tests: 10% the first, 15% the second, 15% the third, and 60% the fourth.

The first three tests will take place following the schedule to be approved by the Academic Committee, which will be published by the beginning of the semester. These tests are not recoverable, that is to say, if a student does not show up when they take place, the instructors do not have the obligation to repeat them. In each test, the material covered from the start of the course until the previous week (inclusive) will be evaluated. The fourth test will be a shorter version of the exam that students who do not choose the continuous assesment track will have to take.

For those students who do not choose the continuous assessment track. Final examination: 100%

Students will be graded as long as they take any test (either the short-answer tests, or the final exam). Students will be assumed to choose the continuous assesment track as soon as they take any two of the short-answer tests. Students taking at most one of the short answer tests and the final exam will be assumed to choose the final assesment track.

Students choosing the continuous assesment track and not passing the subject will receive the "fail" mark, regardless of whether they took the final exam or not.

The mark achieved in the first three short-answer tests will be kept for the second call, but not for subsequent years.

Regarding the second call, students in the continuous assessment track will be allowed to choose if they wish to keep the mark achieved in the short-answer tests, or if they want to be assessed only by the final exam.

For the end-of-program call. Final examination: 100%.

Plagiarism is regarded as serious misconduct. If any form of plagiarism is detected in any of the tests or exams, the final grade will be FAIL (0), and the corresponding academic authorities will be informed about the fact, in order to take adequate measures.

Sources of information

Basic Bibliography

A. Artés, F. Pérez González et al., **Comunicaciones Digitales**, 1,

J. G. Proakis, M. Salehi, **Fundamentals of Communication Systems**, 1,

Complementary Bibliography

C.R. Johnson Jr., W.A. Sethares, **Telecommunication Breakdown**, 1,

Bernard Sklar, **Digital Communications: Fundamentals and Applications**, 2,

B. Razavi, **RF Microelectronics**, 1,

Recommendations

Subjects that continue the syllabus

Principles of Digital Communications/V05G300V01613

Subjects that it is recommended to have taken before

Physics: Analysis of Linear Circuits/V05G301V01108
Mathematics: Probability and Statistics/V05G301V01107
Digital Signal Processing/V05G301V01205

Other comments

It is assumed that the student has basic knowledge of analog and digital signal processing, as well as of probability and statistics.

IDENTIFYING DATA				
Fundamentals of Sound and Image				
Subject	Fundamentals of Sound and Image			
Code	V05G306V01209			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	English			
Department				
Coordinator	Martín Rodríguez, Fernando González Valdés, Borja			
Lecturers	González Valdés, Borja Martín Rodríguez, Fernando Sobreira Seoane, Manuel Ángel			
E-mail	fmartin@uvigo.es bgvaldes@com.uvigo.es			
Web	http://faitic.uvigo.es			
General description	"Sound & image fundamentals" presents some basic concepts on sound & image nature, the course also deals with some basic processing of these signals.			

Competencies	
Code	
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
C13	CE13/T8: The ability to understand the electromagnetic and acoustic wave mechanisms of propagation and transmission, and their corresponding receiving and transmitting devices.
C48	(CE48/T16) The knowledge of the appropriate techniques to develop and exploit signal processing subsystems.
C49	(CE49/T17) The ability to analyze digital signal processing schemes.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Acquire mathematical tools that allow the understanding of the practical effects of sampling, windowing and time-frequency analysis of sound and image signals.	B3	C48 C49	D3
Apply quantification techniques	B3	C48 C49	D3
Understand the nature, basic properties, generation and capture of sound and image.		C13	D3
Understand and interpret the different levels of measurement present in sound systems.	B5		D3
Review the different processes and systems associated with the treatment of sound and image	B3 B5	C48 C49	D3
Apply the basic rules of the colorimetry.	B3		D3

Contents	
Topic	
Sampling, windowing and quantification of one-dimensional and two-dimensional signals.	- Sampling, Nyquist theorem, reconstruction filter. - 2D sampling, concept of resolution vs. sampling frequency. 2D reconstruction. - Windowing in 1D and 2D. - Uniform quantization. A/D conversion . Quantization noise.
Time-frequency analysis of sound and image signals.	- Sound and image characteristics in time and double spatial dimension, respectively. - Windowing and Discrete Fourier Transform (DFT). DFT in 2D. - Frequency characteristics. Spatial frequencies, physical interpretation.
Basic concepts of light and color.	- The image: numerical nature, colorimetry, visual system basics.

Acoustics: basics. Measurement of acoustic signals.	- The sound: acoustic variables, generation, combination of sources, sound sensations - Measurement levels. - Sound level meter
Sound and image systems and processes: basics.	Filter banks. - Sound capture and calibration. - Specifications and objective quality. - 1D filtering. FIR and IIR filters. Relation between windowing and filtering. - 2D filtering. Separable filters. Point operations and spatial filtering on images.

Planning			
	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	0	1
Lecturing	25	50	75
Problem solving	6	12	18
Computer practices	19	19	38
Discussion Forum	0	1	1
Objective questions exam	0	2	2
Essay questions exam	4	0	4
Problem and/or exercise solving	1	0	1
Practices report	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
Introductory activities	Course presentation: programme, reading materials, teaching methodology and assessment system. Developed capabilities: CG3, CG5, CE13, CT3, CE48, CE49.
Lecturing	Instructor presentation of the main concepts of each subject. The student should take the contents of the guiding documents provided for each section. Student will work alone afterwards on the concepts studied in class and on expanding this content using the documents provided for each subject. Identification of doubts that need to be resolved in personalized tutorials. Developed capabilities: CG3, CG5, CE13, CT3, CE48, CE49.
Problem solving	Problems and exercises formulated according to the content of the lectures and the documents for each subject. Students solve problems and exercises prior to the class. Identification of doubts that need to be resolved in personalized tutorials. Developed capabilities: CG3, CG5, CE13, CT3, , CE48, CE49.
Computer practices	Handling of analysis tools and algorithms. Identifying which one must to be used to solve each specific problem. Identification of doubts that need to be resolved in personalized tutorials. Developed capabilities: CG3, CG5, CE13, CT3, , CE48, CE49.
Discussion Forum	The website for the course is included in the TEMA platform (http://faitic.uvigo.es). Subscription to this platform, including a photograph, is mandatory. The website provides all the information related to the course. It also publishes continuous assessment grades and runs forums for students to exchange ideas and discuss doubts. Developed capabilities: CG3, CG5, CE13, CT3, CE48, CE49.

Personalized assistance	
Methodologies	**Description**
Problem solving	Help with problem solving, in the classroom and/or at the office.
Computer practices	Help in the classroom and, if necessary at the office or via e-mail.
Lecturing	Querry and answer in the classroom and, if necessary, at the office.
Tests	**Description**

Practices report	Querry and answer about report writing. Report correction consists in a brief remark being sent to students (via faitic).

Assessment				
	Description	Qualification	Training and Learning Results	
Objective questions exam	On the faitic website.	8	B3	C48 C49
Essay questions exam	To evaluate theoretical knowledge and problem resolution.	60	B3 B5	C13 C48 C49
Problem and/or exercise solving	Exam with questions and problems.	14	B3	C48 C49
Practices report	Report about the work perfomed during several weeks in the computer classroom. This is the only methodology where team work is assessed (teams of two). The qualification is the same for both students.	18	B5	

Other comments on the Evaluation

On detecting any kind of plagiarism in any of the tests (short test, partial or final exam, lab reports) the final qualification will be FAIL (0) and the fact will be transmitted to school regents for taking the appropriate actions.
There are two kinds of assesment: continuous assesment and exam-only assesment.

The schedule for intermediate evaluation tests will be approved by the CAG (DEGREE ACADEMIC COMMITTEE) and will be published at the beginning of four month period in which this course is delivered.

CONTINUOUS ASSESSMENT

The continuous assessment consists of several activities. If the student can not do them in the fixed date, this activity will not be evaluated. The grades of these activities will be valid only for the present academic course.
If the student sits for "Test 1" (see below), she/he will be evaluated by continuous assessment. Furthermore, once the student has taken this exam, she/he will be considered to have attended this examination call. Qualification will be computed using the following criteria with no consideration if she/he takes the final exam or not.

Types and assessment of activities:
1. Individual evaluation tests of group B (Test 1 and Test 2, Weight: 14%). Written and short answer test about the work done in group B.
2. Resolution of tests (Weight: 8%): they are developed throughout the course on the faitic platform.
3. Deliverables (Reports) of practices (Weight: 18%).
4. Test 3: Final written test (of development, Weight: 60%): it coincides with the date of the final exam of the subject. Includes all topics.
In order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet these two conditions:

1) get a score equal or greater than 3.5/10 in Test 3 (final written test).

2) get equal or greater than 5/10 in the individual group B score (Test A and B)

If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value "4".

To participate in the Continuous Assessment, an 80% attendance to group A and B is required. In case of non-compliance, the student will be evaluated in the single assessment option.

Any student can be called at any time by teachers to review the work done to date in group B.

EXAM-ONLY ASSESSMENT

If the student does not sit for Test 1, he/she will be evaluated by means of an only exam, in the official date. The grades for this final exam are between 0 and 10 points. It includes all the subjects of the course, including the laboratory works.

In order to ensure that students acquire a balanced minimum on the subject competences, they will pass the course if they meet these two conditions:

1) get a final mark equal to or greater than 5 (on a ten-points scale)

2) and a score equal to or greater than 4 in the questions related with the group B activities.

If some of these conditions are not fulfilled, then the final grade (on a ten-points scale) will be the minimum between the final mark and the value "4".

Second call exam:

⇒ Students evaluated by Continuous Assessment in the first opportunity can opt between two possibilities the same day of the exam:

1. Do again Test 3 and be evaluated according what is stipulated for the system of Continuous Assessment. The test includes all subjects not evaluated in Test 1.
2. Be evaluated with a single final exam in the official date assigned by the Centre. The grades for this final exam are between 0 and 10 points. It includes all the subjects of the course, including the laboratory works. Non Continuous Assessment rules apply.

⇒ Students not evaluated by Continuous Assessment:

The grades for this final exam are between 0 and 10 points. It includes all the subjects of the course, including the laboratory works. Non Continuous Assessment rules apply. No other activities are assessed.

End of program Exam:

In special call exam (end of degree), we will proceed as in the case of students that have not completed the continous assesment.

Sources of information

Basic Bibliography

Finn Jacobsen et al., **FUNDAMENTALS OF ACOUSTICS AND NOISE CONTROL**, Technical University

R. J. Clarke, **Digital Compression of Still Images and Video**, Academic Press.

Complementary Bibliography

Lawrence Kinsler, Austin Frey, Alán Coppens, James Sanders, **FUNDAMENTALS OF ACOUSTICS**, John Wiley &

T. Perales Benito, **Radio y Televisión Digitales: Tecnología de los Sistemas DAB, DVB, IBUC y ATSC**, Creaciones Copyright

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

Recommendations

Subjects that continue the syllabus

Room Acoustics/V05G300V01635
Fundamentals of Acoustics Engineering/V05G300V01531
Fundamentals of Image Processing/V05G300V01632
Sound Processing/V05G300V01634
Audio Systems/V05G300V01532
Imaging Systems/V05G300V01633
Audiovisual Technology/V05G300V01631
Video and Television/V05G300V01533

Subjects that are recommended to be taken simultaneously

Signal Transmission and Reception Techniques/V05G300V01404

Subjects that it is recommended to have taken before

Digital Signal Processing/V05G300V01304
Electromagnetic Transmission/V05G300V01303
Physics: Fundamentals of Mechanics and Thermodynamics/V05G301V01103

IDENTIFYING DATA				
Computer Networks				
Subject	Computer Networks			
Code	V05G306V01210			
Study programme	Degree in Telecommunications Technologies Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	2nd	2nd
Teaching language	English			
Department				
Coordinator	López Ardao, José Carlos Rodríguez Pérez, Miguel			
Lecturers	López Ardao, José Carlos Rodríguez Pérez, Miguel			
E-mail	jardao@det.uvigo.es miguel@det.uvigo.gal			
Web	http://moodle.det.uvigo.es			
General description	Operating principles, architecture, technology and norms of computer networks, especially of Internet. Design-oriented course, complemented by practical skills			

Competencies	
Code	
B1	CG1: The ability to write, develop and sign projects in the field of Telecommunication Engineering, according to the knowledge acquired as considered in section 5 of this Law, the conception and development or operation of networks, services and applications of Telecommunication and Electronics.
B3	CG3: The knowledge of basic subjects and technologies that enables the student to learn new methods and technologies, as well as to give him great versatility to confront and adapt to new situations
B4	CG4: The ability to solve problems with initiative, to make creative decisions and to communicate and transmit knowledge and skills, understanding the ethical and professional responsibility of the Technical Telecommunication Engineer activity.
B6	CG6: The aptitude to manage mandatory specifications, procedures and laws.
B9	CG9: The ability to work in multidisciplinary groups in a Multilanguage environment and to communicate, in writing and orally, knowledge, procedures, results and ideas related with Telecommunications and Electronics.
C11	CE11/T6: The ability to conceive, deploy, organize and manage networks, systems, services and Telecommunication infrastructures in residential (home, city, digital communities), business and institutional environments, being responsible for launching of projects and continuous improvement like knowing their social and economical impact.
C17	CE17/T12: The knowledge and usage of concepts of communication network architecture, protocols and interfaces.
C18	CE18/T13: The ability to differentiate the concepts of access and transport networks, packet and circuit switched networks, mobile and fixed networks, as well as distributed newtwork application and systems, voice, data, video, audio, interactive and multimedia services.
C19	CE19/T14: The knowledge of methods of networking and routing, as well as the fundamentals of planning and network evaluation based on traffic parameters.
D2	CT2 Understanding Engineering within a framework of sustainable development.
D3	CT3 Awareness of the need for long-life training and continuous quality improvement, showing a flexible, open and ethical attitude toward different opinions and situations, particularly on non-discrimination based on sex, race or religion, as well as respect for fundamental rights, accessibility, etc.
D4	CT4 Encourage cooperative work, and skills like communication, organization, planning and acceptance of responsibility in a multilingual and multidisciplinary work environment, which promotes education for equality, peace and respect for fundamental rights.

Learning outcomes			
Expected results from this subject	Training and Learning Results		
Comprise the general organization and the basic aspects of operation of communication networks, and particularly of computer networks	B3	C17	D2
Identify and know employ the concepts of switching, access and transport networks and wired and wireless networks	B3	C18	
Comprise the principles and the organization of distributed applications and services, either data or media oriented	B3	C17	
Comprise and know how to analyze the operation of the Internet: the architecture, the service model, the data transport, the routing methods and inter-networking, error control and congestion control	B3 B6	C11 C17 C19	D2 D3

Dominate the technical standards and the fundamental protocols of the Internet	B3 B4 B6	C17 C18 C19	
Practical capacity to design, handle and configure computer networks, from the point of view of data switching and transport	B1 B9	C11	D4
Specify common telecommunications infrastructures and structured cabling in buildings	B1 B6	C11	

Contents	
Topic	
1. Introduction	1.1. Network elements, types of links, services and protocols 1.2. Switching techniques: circuits, messages and packets 1.3. Reference models and service modes
2. Packet switching (I): Link Transmission	2.1. Packet framing and Frame transmission 2.2. Forwarding techniques. 2.3. Generalized forwarding. Correspondence and action 2.4. Statistical multiplexing 2.5. ARQ Techniques 2.6. Flow control
3. Packet switching (II): Path Transmission	3.1. Fundamental performance: delay, losses, equivalent capacity 3.2. Reliability (hop-by-hop vs. end-to-end)
4. The data plane (I): IEEE 802.x networks	4.1. Flat architecture of the data plane 4.2. Bridges and switches 4.3. Forwarding tables 4.4. Frame Formats 4.5. Practical limits
5. The data plane (II): IP networks	5.1. Hierarchical architecture of the data plane 5.2. Structure of IP addresses 5.3. Routers and forwarding tables 5.4. Correspondence in IP (longest prefix match) 5.5. The IP protocol. IPv4 and IPv6 5.6. Addressing scopes. Private networks 5.7. NAT
6. Interconnection of link networks	6.1. IP as interconnection network 6.2. Routers vs. switches 6.3. Translation between link and network addresses: ND/ARP 6.4. Fragmentation
7. The control plane (I): Distributed control	7.1. Flat Networks (Bridged IEEE 802.1 LANs): Backward Learning and STP 7.2. Hierarchical networks (IP): RIB, IGPs, ASs, BGP
8. The control plane (II): Centralized control	8.1. Programmable switches 8.2. Software Defined Networks (SDN)
9. The Transport Layer	9.1. Multiplexing, reliability and transmission modes 9.2. Transport protocols 9.3. UDP 9.4. TCP: Connection management. Ordered delivery. ARQ and flow control in TCP
10. Congestion control	10.1. The AIMD algorithm 10.2. Classic implementations: Tahoe, Reno 10.3. Delay-based mechanisms. Vegas
11. Internet Security	11.1. Secure communication systems 11.2. Confidentiality. Symmetric and asymmetric cryptography 11.3. Authenticity and integrity. Hash functions. Digital signatures 11.4. Availability. DDoS Attacks 11.5. Secure Transport: TLS over TCP

Planning			
	Class hours	Hours outside the classroom	Total hours
Lecturing	28	28	56
Problem solving	10	15	25
Autonomous practices through ICT	6	24	30
Autonomous problem solving	0	15	15
Discussion Forum	0	4	4
Computer practices	8	8	16
Essay questions exam	2	0	2
Objective questions exam	2	0	2

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

Methodologies	
	Description
Lecturing	Exposition of the ideas, concepts, technics and algorithms related to the thematic units of the course. With this methodology we will work the competences CT2, CT3, CG3, CG4, CE11, CE17, CE18 and CE19.
Problem solving	Resolution in the classroom by the professor of problems and exercises related with the contents of the master lessons. With this methodology students work the competences CG3, CG4, CE11, CE17, CE18 and CE19.
Autonomous practices through ICT	Students have to develop a network program in an autonomous and individual way. There will be several classroom sessions to explain related programming concepts (sockets, threads), to explain with all detail the program and his implementation, to solve doubts with the professor, and to test and debug the program in the laboratory where this will be tested and evaluated. With this methodology work the competences CG1, CG6, CG9, CE11, CE17 and CE19.
Autonomous problem solving	Completion and delivery, more or less weekly, of online activities. These are self-evaluation tests and small tasks or problems to be carried out before or after the practical classes. It also includes the delivery of a small basic network program, as a training for the final network program. With this methodology we will work the competencies CG4, CG6, CG9, CE11, CE17, CE18, CE19, CT2, CT3, CT4
Discussion Forum	The discussion forums will be necessarily the way to request remote attention for doubts and questions related to the contents of the subject. This discussion and collaborative help will be promoted in the virtual classroom. With this methodology we will work the competences CT3 and CT4
Computer practices	Instructor-led practices on computer labs, using various network tools and utilities (GNS3, WireShark, ping, traceroute, dig, etc.) to reinforce the content presented in the master classes. CG1, CG9, CE17 and CE19 competencies are worked with this methodology.

Personalized assistance	
Methodologies	**Description**
Lecturing	Individually personalized face-to-face attention will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation in the virtual platform is recommended
Problem solving	Individually personalized face-to-face attention will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation in the virtual platform is recommended
Computer practices	Individually personalized face-to-face attention will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation in the virtual platform is recommended
Autonomous practices through ICT	Individually personalized face-to-face attention will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation in the virtual platform is recommended. Please, in this case, contact your practice professor
Autonomous problem solving	In the case of tasks, the detailed solution will be provided in the virtual classroom. In the case of self-assesmemt tests, suitable feedback for the wrong questions will be provided to the student. In any case, individually personalized face-to-face attention will be dispensed. The tutorial schedule will be announced at the beginning of the course. Reservation in the virtual platform is recommended
Discussion Forum	In addition to individually personalized face-to-face attention, the professor will be monitor the discussions in the forums making suitable answers when necessary or explaining the answers of the students. The discussion forums are the way to request remote attention for doubts and questions related to the contents of the subject. Private attention about contents by means of messaging or e-mail is not available.

Assessment			
	Description	Qualification	Training and Learning Results
Autonomous practices through ICT	The student must develop a network program. This program must be made and delivered individually. There will be several classroom sessions for the explanation of the practice, tutoring with the teacher and for the development, testing and debugging of the program in the laboratory, where it will be tested and evaluated. It supposes a weight of 20% but a minimum mark of 3.5 points is required to pass the subject.	20	B1 C11 B6 C17 B9 C19

Autonomous problem solving	During the course, with an approximately weekly periodicity, tasks, resolution of exercises, questions and self-evaluation tests will be proposed in the virtual classroom that must be carried out by the students individually, autonomously and not presencially, always with a deadline. These tasks have an overall weight of 10% for the student who chooses option B of continuous assessment. Those who choose option A of continuous assessment can do the tasks but the score does not count for the final mark, being only indicative for their self-assessment.	0-10	B4 C11 D2 B6 C17 D3 B9 C18 D4 C19
Essay questions exam	Final exam covering the whole subject. It has a weight of 50% but a minimum mark of 3.5 out of 10 is required to pass the subject.	50	B3 C11 D2 B4 C17 C18 C19
Objective questions exam	Two intermediate one-hour multiple-choice tests will be carried out to check the progress of the subject. Each control test has a weight of 10% for the students who choose option B of continuous evaluation and 15% for the students who choose option A.	30-20	B3 C11 D2 B4 C17 C18 C19

Other comments on the Evaluation

Students can choose the method of Assessment: **Continuous or Exam-Only Assessment.**

Continuous Assessment (CA)

There will be two possible ways or options to go through Continuous Assessment, which we call A and B. Student must choose the option in the subject virtual classroom during first month. The deadline for making the choice will be communicated sufficiently in advance in the official News Forum of the virtual classroom. After this deadline, the chosen continuous assessment option cannot be changed. Students who do not make any explicit choice follow the exam-only assessment.

Given the necessary collaborative and social character of option B, groups that do not reach a minimum of 30 students, will only have option A for continuous assessment.

Continuous Assessment consists of four types of activities or tests:

- **Qualifying activities in the virtual classroom**. During the course, with an approximately weekly periodicity, tasks, resolution of exercises, questions and self-evaluation tests will be proposed in the virtual classroom for the students to carry out after school hours individually, autonomously. All activities will have a strict deadline. The completion of these activities allows students to obtain merit points (**MP**) up to a maximum of 100 points (in the case of the correct completion of all of them). **The mark in this part will be calculated as the amount of MP divided by 100**. In order to facilitate to get the maximum number of points, there will be additional optional tasks will proposed throughout the course.

  The Merit Points only count for students who have chosen option B of continuous assessment. Those who chose option A of continuous assessment can also do the tasks and tests, but the MP obtained do not count for the final mark, being only indicative of their self-assessment.

  A gamification system will be employed in the virtual classroom using other types of points, mechanics and elements of gamification to motivate the completion of the activities and the meaningful participation in forums for help, doubts and discussions. This will allow students to earn rewards for use in the subject exams and homework.

- **Two intermediate one-hour multiple-choice tests to assess the progress of the subject (C1 and C2)**. Each control test has a weight of 15% on the final mark (FG) for students who chose option A of continuous assessment and 10% for those who opt for option B. The schedule of the different intermediate evaluation tests will be approved by the Comisión Académica de Grado (CAG) and will be available at the beginning of the term.

- **The development of a network program (NP)**. The deadline will be published together with its specifications. Compliance with the prescriptions and software quality will determine the qualification of this program. An assessment guide will be published along with the program specifications. This program must be coded and submitted individually. The NP will account for 20% of the Final Grade (FG), and it is required to reach 3.5 points to be able to pass the subject.

- **A final exam (FE) covering all contents,** has a weight of 50% of the Final Grade (FG). A minimum qualification of

3.5 points over 10 is required

FG-CA-A = 0.15 × (C1+C2) + 0.2 · NP + 0.5 × FE, if FE ≥ 3,5 and NP ≥ 3.5

FG-CA-A = 0.1 × (C1+C2) + MP/100 + 0.2 × NP + 0. 5 · FE, if FE ≥ 3,5 and NP ≥ 3.5

If either FE or NP does not reach the minimum mark of 3.5 => FG-CA-A =FG-CA-B = min(3.5, FE)

As said above, it is mandatory to choose the CA option, A or B, in the established period, that will be until the day before the C1 control test. Students that do not make any explicit choice will be subjected to exam-only assessment (EA).

Failure to take any of the control tests, C1 or C2, implies a mark of "0" on the test. These tests are not recoverable.

Exam-Only Assessment (EA)

Students who do not made any choice of continuous assessment within the stipulated time period are required to take the Exam-Only Assessment (EA)

The Exam-Only Assessment will consist of the same FE at the end of the term, and the submission of the same network program (NP) proposed for those going through CA. The submission deadlines will also be the same.

The grade of the NP in this case will be simply APPT (with an equivalent numeric value of "1"), if the qualification obtained in the NP is equal to or greater than 5, or NOT APPT (with a numeric value of "'0") if it is less than 5 or not delivered. In this case the final mark will correspond to the 40% of the FE. That is to say,

FG-EA = (0.4 + 0.6 · NP) × FE

Second call

In the official dates, a new final exam (FE) will be done only for students that failed in the first call. Students will also be allowed to deliver a new NP consisting of a modified version of the program of the first call, and whose specifications will be published with at least 3 weeks of advance with respect to the deadline. This deadline will never be later than this second final exam.

For students who chose CA, these FE and NP represent an opportunity to improve the mark in these with respect to the first call, and so the calculation of the final grade considers the best grade obtained.

For students who chose EA, the FE and the NP are considered joint and inseparable, that is,

FG-EA = Max{(0.4 + 0.6 × NP-1st) × FE-1st, (0.4 + 0.6 × NP-2nd) × FE-2nd}

Those students who have failed in the first call by going through Continuous Assessment and wish to renounce it in order to choose the Eventual Assessment, will have to request it in writing to the subject coordinator before the review date of the first final exam. In this case, the conditions to pass the subject are exactly the same as those of the rest of the students that have chosen EA, being therefore compulsory the delivery of a new NP with the second call specifications. In this case, any reward obtained by the CA activities in the virtual classroom is also waived.

End-of-program call

Students participating in the extraordinary call must pass the FE, to be carried out at the officially established dates and obtain an APT grade in the NP, that must be delivered before the date of this FE. The specifications of this program are the same as those of the second call. It is mandatory to deliver this program on time, even if it has already been delivered in the second call.

The final mark of this call will be that of the EF if the NP is APT, and 40% of the EF if the NP is NOT APT

Other comments

All students presenting to any FE are considered to be presented to the subject. The marks for all exams, intermediate or final, and activities will only have effects on the current academic year.

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

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

All the official communications of the Subject will be published in the News Forum of the virtual classroom, to which all the students are necessarily subscribed by email. It is assumed that all students reads these messages and are properly informed of their content.

In the event of any contradiction that may have occurred between the different versions of this guide, due to any error in the translation, the prevailing version will be the Galician language version, with the exception of the English teaching group, for which the English version of the Guide will be considered.

Sources of information

Basic Bibliography

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

L. Peterson, B. Davie, **Computer networks: a systems approach**, 5,

Complementary Bibliography

A. Leon-Garcia, I. Widjaja, **Communication networks: fundamental concepts and key architectures**, 2,

C. López, M. Rodríguez, S. Herrería, M. Fernández, **Cuestiones de redes de datos: principios y protocolos**, 1,

Recommendations

Subjects that continue the syllabus

Data Networks: Technology and Architecture/V05G300V01542
Multimedia Networks/V05G300V01643
Network Security/V05G300V01543
Internet Services/V05G300V01501
Network and Switching Theory/V05G300V01642

Subjects that are recommended to be taken simultaneously

Data Communication/V05G300V01301

Subjects that it is recommended to have taken before

Programming II/V05G300V01302

Other comments

To take the course, in order to carry out the network program, it is very important to have a certain programming skills in an object-oriented language such as Java (or C ++). The skill level obtained after passing the Programming II course is enough.