IDENTIFYING DATA

(*)Instrumentación electrónica e sensores				
Subject	(*)Instrumentación electrónica e sensores			
Code	V05G300V01621			
Study programme	(*)Grao en Enxeñaría de Tecnoloxías de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	6	Mandatory	3rd	2nd
Teaching language	Spanish			
Department				
Coordinator	Mariño Espiñeira, Perfecto			
Lecturers	Costas Pérez, Lucía Mariño Espiñeira, Perfecto Pastoriza Santos, Vicente			
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General description	The main purpose of the subject is to provide the theoretical and practical skills for the design and characterization of electronic instrumentation systems, and the range of sensors which provide analogical and digital signal in the input stage of said instrumentation systems. Course outline: + Analysis of sensor parameters. + Basic concepts about the physical principles of the sensors. + The most important application of sensors in electronic instrumentation. + Electronic instrumentation architectures, from the simplest point to point systems to the most complex distributed systems. International standards for electronic instrumentation are presented. + Design of programmable instrumentation: GPIB, VXI and PXI buses. + Classification of architectures for electronic instrumentation. Introduction of wired and wireless field buses. The main goal of the laboratory sessions (practical work) is to enable the students to acquire sufficient understanding and knowledge to: +Analyze the parameters and main features of the sensors integrated in the electronic instrumentation systems. + Know the applications of each group of sensors. + Manage specific software tools to design (virtual) instruments that allow store, display and analyze recorded data. + Use specific software tools to work with buses of instrumentation programmable. The documentation of the course will be in Spanish. It will be taught and assessed in Spanish.			

Competencies

Code	
A3	CG3: The knowledge of basic subjects and technologies that capacitates the student to learn new methods and technologies, as well as to give him great versatility to confront and update to new situations
A4	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.
A5	CG5: The knowledge to perform measurements, calculations, assessments, appraisals, technical evaluations, studies, reports, task scheduling and similar work to each specific telecommunication area.
A55	(CE46/SE8): The ability to specify and use electronic instrumentation and measurement systems.

Learning aims

Expected results from this subject	Training and Learning Results
Comprehension and command of basic concepts about the physical principles of the sensors.	A3 A55
Comprehension and command of basic concepts about the features and operating modes of the sensors.	A3 A55
Comprehension and command of the signal conditioning settings in sensors and application examples, which form the input stage of the electronic instrumentation systems.	A4 A5 A55
Comprehension and command of basic concepts about the architectures for programmable instrumentation and the standards on programmable instrumentation.	A3 A55
The knowledge of development tools for programmable instrumentation systems	A4 A5
To ability to use development tools to design programmable instrumentation systems connected to wired or wireless field bus.	A4 A5

Contents

Topic	
Unit 1: Introduction to sensors.	Energy conversions. Concepts of sensor, transducer and actuator. Dynamic and static features. Other features. Selection of sensors. Conditioning. Application examples on ICT.
Unit 2: Temperature resistive sensors. Strain gauges.	Temperature resistive sensors: General features. Types. Conditioning . Application examples. Strain gauges: Basic principles. General features. Types of using. Conditioning . Application examples.
Unit 3: Photoresistive and Optoelectronic. Other resistive sensors.	Photoresistive and Optoelectronic: Basic principles. General features. Encoders. Conditioning. Application examples. Other resistive sensors: Gas sensors. Magnetoresistors. Potentiometers. Basic principles. General features. Conditioning . Application examples.
Unit 4: Capacitive sensors. Inductive and magnetic sensors.	Capacitive sensors: Introduction. Measurements principles. Features. Conditioning . Proximity sensors. Application examples . Inductive and magnetic sensors: Introduction. Basic principles. Variable transformer types. Features. Conditioning. Hall effect sensors. Application examples.
Unit 5: Pyrometric sensors and Infrared thermography. Thermocouples. Other sensors.	Pyrometric sensors and infrared thermography: Basic principles . General features . Conditioning. Application examples. Thermocouples: Basic principles. General features. Calibration scales. Conditioning. Application examples Other sensors: Pyroelectric. Ultrasounds. Magnetostrictive. Radar level detection. Biosensors. Chemical sensors. High energy and nuclear sensors.
Unit 6: Programmable instrumentation.	Historical events in electronic instrumentation: Evolution of instrumentation. Instrumentation systems. Definitions. Current needs and future trends. Programmable instrumentation. Switched instrumentation. Hybrid systems on instrumentation. GPIB bus: General features. Configurations and equipment. Standards IEEE 488.1/488.2. Transference procedures. Standard HS488. Command groups. Basic functions. Integrated circuits. Controllers on cards. SCPI Standard. Design environments for ATE systems.
Unit 7: Standard multiprocessor buses.	Systems on cards. Applications of standard buses. Classification. Types of connectors and cards. Multiprocessor systems. Common memory multiprocessor systems. Multiplexing. Bus arbiters. Arbiter techniques. Asynchronous bus concept. Addressing. Data transfer. Interrupts. Electrical design of high speed buses. ECL and TTL signals. Backplane features. Drivers, receivers and transceivers. International standards.
Unit 8: The VME bus.	Introduction . Functional modules. Subbuses and signals. Data transfer. Types of arbitration. System controller. The interrupt chain. Commercial products.
Unit 9: Standards on programmable instrumentation.	Introduction to VXI and PXI buses. Subbuses and signals. Configurations. Types of devices. Products and systems of development. PCI Express and the switched instrumentation. Ethernet and its LXI version for instrumentation. The AXIEe for high features.
Unit 10: Field bus architectures for sensors.	General features. Classification. Practical examples: PROFIBUS and CAN. Intelligent Transportation Systems (ITS). Embedded buses for automotive applications: LIN, MOST, FLEXRAY, JSAE 1939 and others. Standard IEEE 1451 for intelligent sensors. Development tools.

Unit 11:Wireless networks for sensors.	The ISM bands. Basic features of wireless networks. Multiplexing and modulation. The SDR concept. Standards for WLAN and WPAN. IEEE standards 802.15.1/4/3. Wireless sensor networks (WSNs). Other commercial networks.
Practice 1: Introduction to the LabVIEW Application Development Environment	Introduction to LabVIEW environment by means of basic examples of programming.
Practice 2: Temperature sensors. NTC thermistor.	Signal conditioning and virtual instrument development for measurement
Practice 3: Optoelectronic sensors. PIN photodiode.	Spectral response analysis.
Practice 4: Capacitive sensors. Accelerometer.	Signal analysis and post-processing, and virtual instrument developing for tilt measurement.
Practice 5: Programmable Instrumentation I.	Frequency response test of two RC circuits via the programmable control of the laboratory instrumentation. The programmable control will realise through a USB connection from the PC to each instrument.
Practice 6: Programmable Instrumentation II.	To develop an application that verify the frequency response of a RC circuit by means of the programmable control of some of the instruments situated in a VXI chassis. The programmable control of each instrument from the PC will realise through a LAN connection and using a GPIB - Ethernet gateway .

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	2	2	4
Master Session	16	23	39
Laboratory practises	14	12	26
Tutored works	7	28	35
Multiple choice tests	3	43	46

*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.
Master Session	The lecturer will explain in the classroom the main contents of the subject. The students have to manage the proposed bibliography to carry out a self-study process in a way that leads to acquire the knowledge and the skills related to the subject. The lecturer will answer the students questions in the classroom or at the office.
Laboratory practises	Activities designed to apply the main concepts and definitions of the subject. The student will be asked to acquire the basic skills to manage the laboratory instrumentation, software tools and components in order to construct and test electronic circuits. The student has to develop and demonstrate autonomous learning and collaborative skills. He/she is supposed to be able to manage bibliography and recently acquired knowledge. Possible questions can be answered in the laboratory sessions or at the lecturers office.
Tutored works	The students have to manage basic concepts to search and select information in order to get a deeper understanding in some specific fields related to the subject. This is a group activity. The lecturer will propose in the classroom the topic of this group task and monitor the students work in personalized attention sessions.

Personalized attention

Methodologies	Description
Master Session	Master session: The students can go to the lecturers office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will answer the students questions and also give instructions to guide the studying and learning process. Laboratory practises: The students can go to the lecturers office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools). Tutored works: The students can go to the lecturers office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with the monitored work.

Laboratory practises	Master session: The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will answer the students' questions and also give instructions to guide the studying and learning process. Laboratory practises: The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools). Tutored works: The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with the monitored work.
Tutored works	Master session: The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will answer the students' questions and also give instructions to guide the studying and learning process. Laboratory practises: The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students understand the work to be developed in the laboratory (components, circuits, instrumentation and tools). Tutored works: The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with the monitored work.

Assessment

	Description	Qualification
Laboratory practises	The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. They will consider the work of the students carried out before the laboratory session to prepare the proposed tasks and the work in the laboratory. Marks for each session (LSM: Laboratory Session Mark) will be assigned in a 10 points scale. Final mark of laboratory, FML, will be assessed in a 10 points scale. In these practices, the skills A3, A4, A5, and A55 will be assessed.	35
Tutored works	The lecturers will consider the results, the analysis and the quality of the final report, and the classroom presentation. Marks will be assigned in a 10 points scale. In these works, the skills A3, A4, A5, and A55 will be evaluated.	15
Multiple choice tests	The lecturers will check the level of compliance of the students with the goals related to the theory skills. 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. In these tests, the skills A3, A4, A5, and A55 will be evaluated.	50

Other comments on the Evaluation

1. Continuous assessment

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

When the students perform a short answer test or attend at least two laboratory sessions, ***they will be assessed by continuous assessment***.

The subject comprises three different parts: theory (50 %), laboratory (35%) and tutored work (15%). 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

Two short answer tests (SAT) are scheduled. The first test (SAT1) will be performed after unit 5, in the usual weekly scheduling of the theoretical classes. The second test (SAT2) will be performed during the examination period in the date specified in the academic calendar.

The students cannot do the tests at a later date. Marks for each test will be assessed in a 10 points scale. The student who miss a test will be assessed with a mark of 0 for that test. The final mark of theory (FMT) is calculated as the arithmetic mean of the individual marks:

FMT = (SAT1 + SAT2)/2

The minimum mark required to pass this part is of 5 for each test (SATi>=5). If the minimum mark in the first test is not achieved (SAT1 less than 5), the students can repeat this part in the same date of the second test.

1.b Laboratory

Seven laboratory sessions are scheduled. Each session lasts approximately 120 minutes and the students will work in pairs.

This part also will be assessed by continuous assessment. Each session will be only evaluated according to the developed work at the schedule date. The lecturers will consider the work of the students carried out before the laboratory session to prepare the proposed tasks, the work in the laboratory to deal with them as well as the student□s behavior. Marks for each laboratory session (LSM) will be assessed in a 10 points scale. A mark of 0 will be obtained for missing sessions. The final mark of laboratory (FML) is calculated as the arithmetic mean of the individual laboratory session marks:

$$FML = (LSM1 + LSM2 + LSM3 + LSM4 + LSM5 + LSM6 + LSM7)/7$$

In order to pass the laboratory part the students can not miss more than two laboratory sessions and the minimum mark required is of 5 (FML>=5).

1.c Tutored work

In the first session of C hours, lecturers will present the objectives and the schedule of the work. They also assign a specific work to each group. After that, the most important part of the workload will be developed at home.

In order to assess the work, the lecturer will consider the results, their analysis, the quality of the written report and the classroom presentation. Mark for the classroom presentation (CPM) and the written report (WRM) will be assessed in a 10 points scale. The final mark of this part, tutored work mark (TWM), is calculated as the following weighted average:

$$TWM = 0,3*CPM + 0,7*WRM$$

The minimum mark required to pass this part is of 5 (TWM>=5). The students are only allowed to miss one tutored work session.

1.d Final mark of the subject

The weighted points from all assessed parts are added together to calculate the final mark (FM). The following weightings will be applied: 50% theory (FMT), 35% laboratory (FML) and 15% tutored work (TWM). In order to pass the subject, students will be require to pass the theory, laboratory and group project parts. In this case the final mark (FM) will be:

$$FM = (0.5 \cdot FMT + 0.3 \cdot FML + 0.15\ TWM)$$

However, when the students do not pass all parts (FMT, or FML, or TWM less than 5) or do not reach the minimum mark of 5 required to pass each short answer test or miss more than 2 laboratory sessions or miss more than 1 tutored work sessions, the final mark will be the minimum value among them:

$$FM = \min\{ FMT, \cdot FML, TWM \}$$

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

2. Final Exam

The students who prefer a different educational policy can attend an exam on a scheduled date. This exam will comprise three parts (similar to the activities completed by the continuously assessed students): theory exam, laboratory exam and tutored work.

The theory exam will be comprised two short answer tests (SAT). Marks for each test will be assessed in a 10 points scale. will be assessed in a 10 points scale. The final mark of theory (FMT) is calculated as the arithmetic mean of the individual marks:

$$FMT = (SAT1 + SAT2)/2$$

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

The laboratory exam will be assessed in a 10 points scale. The minimum mark required to pass this part is of 5 (FMT>=5).

The tutored workt will be assessed in a 10 points scale. The project will be assigned following the procedure described in advance by the lecturer. The student will prepare a written report to be handed in just before the exam. The final project must be presented within one week of delivery of reports. In order to assess the work, the lecturer will consider the results, their analysis, the quality of the written report and the presentation. Mark for the classroom presentation (CPM) and the written report (WRM) will be assessed in a 10 points scale. The final mark of this part, tutored work mark (TWM), is calculated as the following weighted average:

$$TWM = 0,3*CPM + 0,7*WRM$$

The minimum mark required to pass this part is of 4 (TWM>=5).

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

FM = (0.5·FMT + 0.35·FML + 0.15 TWM)

However, when the students do not reach the minimum mark required (FMT, or FML, or TWM less than 5), the final mark will be the minimum value among them:

FM = min{ FMT, ·FML, TWM }

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

3. Second opportunity to pass the subject

The assessment policy in this call will follow the scheme described in the previous section. Dates will be specified in the academic calendar. This exam consist on a theory exam, a laboratory exam and a tutored workt. In order to attend the laboratory exam and to assign the tutored work, the students have to contact to the lecturer according to an established procedure. The procedure will be published in advance.

The marks obtained in the previous continuous assessment or final exam are kept for those parts in which the student has not attended. The final mark will be calculated as it has described in section 2.

Sources of information

Black, J. (editor), **The system engineering handbook: a guide to building VME bus and VXI bus Systems**,

Mariño, P., **Las comunicaciones en la empresa: normas, redes y servicios**, 2ª Ed.,

Norton, H., **Sensores y analizadores**,

Pérez García, M.A., Álvarez Antón, J.C., Campo Rodríguez, J.C., Ferrero Martín, F.J., y Grillo Orteg, **Instrumentación Electrónica**,

del Río Fernández, J., Shariat-Panahi, S., Sarriá Gandul, S., y Lázaro, A.M., **LabVIEW: Programación para Sistemas de Instrumentación**,

Recommendations

Subjects that are recommended to be taken simultaneously

(*)Circuítos electrónicos programables/V05G300V01502
(*)Electrónica analóxica/V05G300V01624
(*)Sistemas de adquisición de datos/V05G300V01521

Subjects that it is recommended to have taken before

(*)Electrónica dixital/V05G300V01402
(*)Tecnoloxía electrónica/V05G300V01401