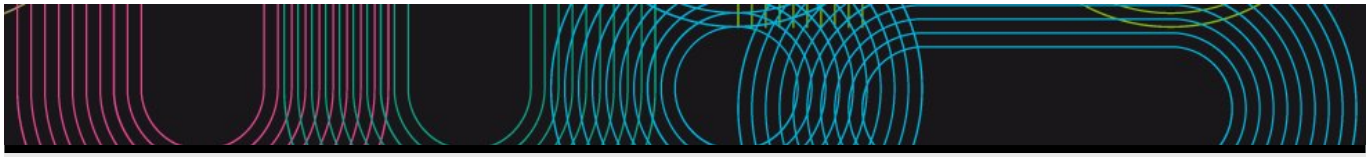

IDENTIFYING DATA				
Analog Electronic Circuits Design				
Subject	Analog Electronic Circuits Design			
Code	V05M145V01106			
Study programme	Telecommunication Engineering			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Mandatory	1st	1st
Teaching language	Spanish Galician			
Department				
Coordinator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

Competencies	
Code	
A4	CB4 Students must communicate their conclusions, and the knowledge and reasons stating them-, to specialists and non-specialists in a clear and unambiguous way.
A5	CB5 Students must have learning skills to allow themselves to continue studying in largely self-directed or autonomous way
B4	CG4 Capacity for mathematical modeling, calculation and simulation in technological centers and engineering companies, particularly in research, development and innovation tasks in all areas related to Telecommunication Engineering and associated multidisciplinary fields.
B8	CG8 Ability to apply acquired knowledge and to solve problems in new or unfamiliar environments within broader and multidiscipline contexts, being able to integrate knowledge.
C12	CE12 Ability to use programmable logic devices, as well as to design advanced electronic systems, both analog and digital. The ability to design communications components such as routers, switches, hubs, transmitters and receivers in different bands.
C14	CE14 Ability to develop electronic instrumentation, as well as transducers, actuators and sensors.

Learning outcomes

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

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

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

Planning

	Class hours	Hours outside the classroom	Total hours
Introductory activities	1	2	3
Lecturing	13	19	32
Problem solving	8	12	20
Project based learning	5	12	17
Laboratory practices	10	10	20
Objective questions exam	3	30	33

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

Methodologies

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

Personalized attention

Methodologies	Description
Lecturing	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.
Problem solving	The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions, the lecturer will answer the students questions about the problems and/or exercises proposed and/or resolved in the classroom as well as other issues that can appear along the study of the subject.
Laboratory practices	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).
Project based learning	The students can go to the lecturer's office (individually or in a group). The timetable will be available on the subject website at the beginning of the term. In these sessions the lecturer will help students to deal with issues and questions related with the theoretical and practical project.

Assessment

Description	Qualification	Training and Learning Results

Project based learning	The student have to perform a theoretical practical project. In order to assess the project, the lecturer will consider the developed work, the obtained results, their classroom presentation and analysis, and the quality of the final written report if required.The final mark of tutored project (TPM), will be assessed in a 10 points scale. For the evaluation of the laboratory sessions, the lecturer will assess the group work (the same mark for each member), the individual student work and the individual oral presentation. In these practices, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed.	10	A4 B4 C12 A5 B8 C14
Laboratory practices	The lecturers will check the level of compliance of the students with the goals related to the laboratory skills. Final mark of laboratory, FLM, will be assessed in a 10 points scale. For the evaluation of the laboratory sessions, the lecturer will assess the group work (the same mark for each member), the individual preliminary tasks and the answers to personalised questions for each session. In these practices, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed.	30	A4 B4 C12 A5 B8 C14
Objective questions exam	The lecturers will check the level of compliance of the students with the choice tests goals related to the theory skills. Marks for each objective test will be assessed in a 10 points scale. Final mark of objective tests (OTM) will be assessed in a 10 points scale. In these tests, the skills CB4, CB5, CG4, CG8, CE12 and CE14 will be assessed.	60	A4 B4 C12 A5 B8 C14

Other comments on the Evaluation

1. Continuous evaluation

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

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

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

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

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

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

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

OTM = (OT1 + OT2)/2

otherwise, the final mark of this part will be:

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

1.b Practical tests

1.b.1 Laboratory

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

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

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

In order to pass the laboratory part the students can not miss more than oe laboratory session and the minimum mark

required is of 5 (FLM>=5). These absences must be excused with a valid documented reason (medical, bereavement or other) otherwise he/she will be assigned a grade of 0 for the laboratory part (FLM=0).

1.b.2 Tutored project

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

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

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

1.c Final mark of the subject

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

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

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

FM = 0.60·OTM + 0.30·FLM + 0.10·TPM

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

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

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

BM = min({5; FLM})

CM = min({5; TPM})

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

2. Single evaluation

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

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

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

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

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

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

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

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

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

OTM = (OT1 + OT2)/2

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

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

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

BM = min({5; FLM})

CM = min({5; TPM})

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

3. Second call and extraordinary call

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

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

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

4. About ethical behaviour of students

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

Sources of information

Basic Bibliography

Pérez García, M.A., **Instrumentación Electrónica**, 1ª ed., Ediciones Paraninfo, S.A., 2014

Franco, S., **Diseño con amplificadores operacionales y circuítos integrados analógicos**, 3ª ed., McGraw-Hill, 2004

Fraile Mora, J., García Gutiérrez, P., y Fraile Ardanuy, J., **Instrumentación aplicada a la ingeniería**, 3ª ed., Editorial Garceta, 2013

Pallás Areny, R., **Sensores y Acondicionadores de Señal**, 4ª ed., Marcombo D.L., 2003

Pallás Areny, R., Casas, O., y Bragó, R., **Sensores y Acondicionadores de Señal. Problemas resueltos**, Marcombo D.L., 2008

Pérez García, M.A., Álvarez Antón, J.C., Campo Rodríguez, J.C., Ferrero Martín F.C., y Grillo Ortega, **Instrumentación Electrónica**, 2ª ed., Thomson, 2004

Pérez García, M.A., **Instrumentación Electrónica: 230 problemas resueltos**, 1ª ed., Editorial Garceta, 2012

Complementary Bibliography

Recommendations

Subjects that continue the syllabus

Digital and Analog Mixed Circuits/V05M145V01213