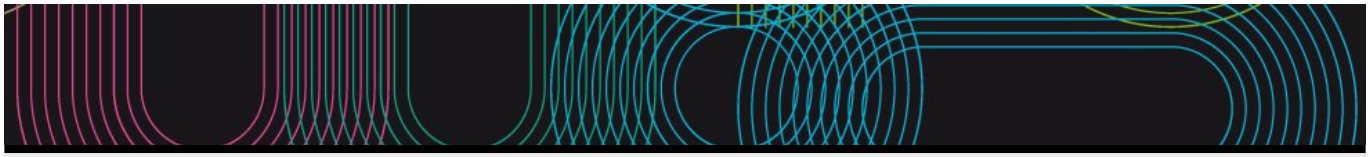

IDENTIFYING DATA				
Integrated Circuits Design and Manufacturing				
Subject	Integrated Circuits Design and Manufacturing			
Code	V05M145V01215			
Study programme	Máster Universitario en Ingeniería de Telecomunicación			
Descriptors	ECTS Credits	Choose	Year	Quadmester
	5	Optional	1st	2nd
Teaching language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

Training and Learning Results	
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
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.
C10	CE10 Ability to design and manufacture integrated circuits.

Expected results from this subject	
Expected results from this subject	Training and Learning Results
Know the design methodologies of electronic integrated circuits	C10
Know the basic topologies used in analog electronic circuits	C10
Can analyze and dimension the devices that form the basic topologies of analog circuits	A5 B8 C10
Know aid software tools integrated circuit design	C10
Know how an electronic circuit is specified for manufacturing	A4 C10

Contents	
Topic	
Chapter 1: Introduction (1h)	Course introduction. Objectives and course planning. Basic concepts of microelectronic design of integrated circuits (ICs).

Chapter 2: Manufacturing sequence for ICs (1h)	Introduction to ICs manufacturing. Planar technology. Manufacturing sequence of ICs in CMOS technology. Structure of MOS transistors. Manufacturing example: CMOS inverter. Masks pattern (layout). Technological design rules. Methodologies and tools for design assistance.
Chapter 3: Physical structure of basic devices and routing strategies (1h)	Specification of the physical structure of MOS transistor. Specification of the physical structure of a resistor. Specification of the physical structure of a capacitor. Strategies for performing transistors with high aspect ratio. Strategies for matched transistors.
Chapter 4: Basic amplifier topologies (2h)	Common source topology. Common drain topology. Common gate topology. Cascode topology. Push_Pull amplifier. Physical design examples.
Chapter 5: Current mirror (3h)	Current sources. Basic structure of a current mirror. Analysis of functioning. Frequency response. Cascode topology. Physical design examples.
Chapter 6: Differential pair (3h)	Differential pair structure. DC analysis. AC analysis. Specifications and design of the physical structure of a self-biased differential amplifier topology. Common mode rejection ratio. Matching of transistors. Slew rate limitations. Physical design examples.
Chapter 7: Operational amplifier (2h)	Two stages operational amplifier. Design parameters. Operational Transconductance Amplifier (OTA). Examples of physical designs.
Chapter 8: Preparing for manufacturing (2h)	Distribution in the base plane. Pad and terminals. Specification formats. Packages.
Laboratory session 1: Introduction to design tools for ICs (2h)	Introduction to design tools for analog ICs. Current mirror example. Electric simulation. Design Rules Check (DRC) and layout extraction.
Laboratory session 2: Design of self-biased differential pair (2h)	Electrical specification. Characterization of DC operating parameters. Characterization of AC operating parameters.
Laboratory session 3: Design of self-biased differential pair II (2h)	DRC and layout extraction. Layout versus schematic (LVS). Post-layout simulation.
Laboratory session 4: Design of a transconductance amplifier (2h)	Electrical Specification. Physical specification. Operation testing.
Laboratory session 5: Preparing for manufacturing (2h)	For the circuit obtained in Laboratory session 4, perform the required steps to create the information needed in order to send the circuit to manufacture.

Planning

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

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

Methodologies

	Description
Lecturing	The professor will present the relevant concepts of the course. Before each lecture, students must carry out a preparation analysis of the topics to be addressed. The aim is to encourage active participation of students, who may ask questions or expose doubts during the session. For a better understanding of certain content, practical examples or case studies will be discussed. Competences A5 and C10 are worked in this methodology.
Mentored work	Students will work in small teams (C-type groups) in the physical design and characterization of a circuit consisting of active devices and passive components, under the close guidance of professors. Attendance will be recorded. The activities to be developed by each team are: - Analysis of possible solutions and design alternatives. - Analysis and monitoring of the proposed solution for the project. - Report with the presentation and analysis of the obtained results. - Presentation and discussion of the results. Competences A4, A5, B8 and C10 are worked in this methodology.
Laboratory practical	Students work with IC CAD tools for IC design, in which they will carried out the definition of an electronic circuit both electrical and physical level, the verification of compliance with specifications and design preparation for manufacturing. Attendance will be recorded and performance of each group in each lab assignment will be evaluated. Competences A5, B8 and C10 are worked in this methodology.

Personalized assistance

Methodologies	Description
Lecturing	The teaching staff will attend doubts and enquiries of the students about the theoretical contents. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331
Laboratory practical	The teaching staff will attend doubts and enquiries of the students about previous preparation of laboratory practices as well as its contents. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331
Mentored work	The teaching staff will attend doubts and enquiries of the students about the doubts and enquiries of students about specifications, theoretical and practical aspects of the assigned project as well as those about the content and structure of the explanatory report. In addition, students will be guided about the structure and contents of the sessions of presentation and defense of the results achieved in the project. Students will have the opportunity to attend personalized or group mentoring. The information to request the personalized assitance can be consulted in the MooVi profile of the teaching team: Ana María Cao Paz: https:// moovi.uvigo.gal/user/view.php?id=11331

Assessment

	Description	Qualification	Training and Learning Results
Problem and/or exercise solving	As part of the continuous evaluation, it will take place in mid-course an individual written test of 60 minutes, in one of the lecture sessions. This test will involve 20% of the final grade. To pass the course, students must achieve a mark of 4 or higher in a 0-10. Competences C10 and A4 will be assessed in these tests.	20	A4 C10
Problem and/or exercise solving	At the end of the theoretical content, students will have a second 60-minute exam, during one of the lectures. This test will represent 20% of the final grade. To pass the subject it will be necessary to obtain at least a score of 4 out of 10. In this test the competences C10, A4 and B8 are evaluated.	20	A4 B8 C10
Laboratory practice	As part of the continuous assessment of the subject, each student will be evaluated for each of the practices. In the evaluation will take into account the work of preparation prior to the realization of the practice, assistance, punctuality and use. The total qualification of the practices will be obtained as an arithmetic average of the qualification of each of them. The internship note is not kept for successive academic courses. In this part the C10, A4, A5 and B8 skills are evaluated.	20	A4 B8 C10 A5

Essay	The evaluation of the work will be performed from memory supporting and public presentation of results. Each group of students you must submit a report of the work has been carried out, indicating expresses the contribution of each to the whole, as well as methodology followed for the distribution and coordination of tasks. The evaluation of the work will be based on the following aspects: - Analysis of alternatives - Correct implementation and design verification - Design compaction - Use of appropriate strategies to minimize the effects of imperfections in the manufacturing process and to ensure good matching of the electrical characteristics between components or devices that like this require it by functional reasons. - Information for integrated circuit manufacturing. - Formal aspects: clarity and order, including figures and appropriate and outstanding data, as well as explanations in a concrete and comprehensive way. Each student will have an individual public exposure of the project has personally performed (including tasks planning and coordination if applicable). The presentations of the students from each group will be out in the same session, 1 hour. Each student will have 5 minutes for their presentation. At the end of the presentation, students must answer questions from teachers and other students present. The evaluation will be based on both the content and formal aspects of the presentation and the answers to questions. It may also assess positively to students who perform relevant questions. The explanatory report should be submitted at least two days before public presentation of work. To pass the course, the student will need obtain at least a score of 5 over 10 in memory, get to least a score of 5 out of 10 in public presentation. In the evaluation of the practical tests, the memory note will weigh 70% and the presentation 30%. In this test the C10, A4, A5 and B8 skills are evaluated.	40	A4 B8 C10 A5

Other comments on the Evaluation

Continuos assessment:

The planning of the different evaluations will be notified to the students on the first day of classes.

In order to pass the course, students must achieve a global mark of 5 or higher in a 0-10 scale. The global mark will be obtained as the weighted summation of the scores obtained in the different parts of the course. A minimum score is required in each of these parts. For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Global assessment:

Students not in continuous evaluation will be evaluated as follows:

- Final test will be 50% of the overall grade of the course. It will consist of two parts: short answer questions and resolution of problems. The part of the questions will represent 50 % of the test qualification and the part of resolution of problems the other 50%. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

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

The deadline to renounce to continuos assessment will be one month before the end date of the semester, according to the calendar of the center. The procedure will be by sending an email to the teaching staff requesting the renounce of continuous assessment.

For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Extraordinary call:

Students who attend this call will be evaluated identically to the global assessment:

- Final test will be 50% of the overall grade of the course. It will consist of two parts: short answer questions and resolution of problems. The part of the questions will represent 50 % of the test qualification and the part of resolution of problems the other 50%. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

- They must develop a project, and deliver the corresponding report and public presentation. Reports are due two days before the public presentation. The project qualification will involve 50% of the overall grade of the course. In the final qualification of the project, the memory report has a corresponding percentage of 70% and the other 30% is obtained from the qualification of the presentation. In order to calculate the grade it is necessary to obtain at least 50 % of the maximum score for each part.

For students not achieving the minimum score in any of the parts, the global mark will be the lower value between 4.5 and the weighted summation of scores.

Sources of information

Basic Bibliography

R. Jacob Baker, **CMOS Circuits desing, Layout and Simulation**, 3º, John Wiley and Sons, 2010

Paul R. Gray, Paul J. Hurst, Stephen H. Lewis, Robert G. Meyer, **Analysis and Design of Analog Integrated Circuits**, 5º, John Wiley and Sons, 2010

Behzad Razavi, **Design of Analog CMOS Integrated Circuits**, 2º, McGraw Hill, 2017

Stephen A. Campbell, **Fabrication Engineering at the micro-and nanoscale**, 4º, Oxford University Press, 2012

Complementary Bibliography

Recommendations

Other comments

All conclusions achieved both in the written tests and in the projects must be adequately justified. Non-trivial concepts cannot be assumed but they have to be explained. The methodologies used by the student will be taken into account in the computation of his/her marks. No auxiliary resources, including but not limited to documentation, can be used in the written tests.

In case of detection of plagiarism in any of the evaluation tests or assignment submissions, the final grade will be SUSPENSE (0) and the fact will be reported to the corresponding academic authorities for prosecution.