DIPLOMA IN ADVANCED APPLIED TECHNOLOGIES FOR INDUSTRY

Module Description

ELECTRONIC CIRCUITS AND DEVICES

Total contact hours	45
ECTS	5 (6 UC credits)
Taught by	Prof. Dr. Salvador Bracho del Pino –Coordinator- Prof. Yolanda Lechuga Solaegui Prof. Román Mozuelos García
Learning goals related to	**Technical Competence:** This course presents theoretical and practical approaches in order to give the basic knowledge to the future engineers to adopt decisions about design, characterization and optimization of electronic systems. The lectures will be analyzed from basic analogue circuits and built-in blocks with increasing complexity up to mixed-signal analogue and digital systems. All the circuits presented are well known and widely used in practical electronic systems design. Not only the different architectures of the circuits are presented, but also their main specifications, optimization, frequency and transient response and, obviously, limitations and optimization techniques. Finally an overview of the different electronic devices and fabrication technologies is presented. Due to the fact that only the electronic engineers that work in advanced design and development of devices are going to use this kind of knowledge, focused learning on electronic devices has not been considered a priority. In short, students completing this course will be able to analyse and design electronic circuits, to understand the principles and operation of the semiconductor devices used in them and to apply this knowledge to solve a wide range of problems that can appear during their professional activities. **Methodological Competence:** The course is based on both theoretical and practical approaches to electronic circuits and systems (from basics to complex systems), with an important laboratory workload, where the students will be able to know the real challenges and limitations of electronic design and characterization. **Social Competence:** Students are encouraged to participate in theoretical classes. Laboratory classes are interactive, and based on practical design cases with more than a single solution, although not all of them will be equally optimal. Finally, students are asked to develop an oral presentation which will be discus at class. **Personal Skills:** The course will consist of theoretical lectures on the basic material coupled with exercises and laboratory examples based on the lectures to develop practical design cases that fulfil specifications. In that sense, students develop the following abilities: • knowledge application of basic science and engineering fundamentals • problem identification, formulation and solution • utilization of a systems approach to design and evaluate performance

	• understanding of the principles of design and characterisation • capacity for independent critical thought, rational inquiry and self-directed learning • intellectual curiosity and creativity, including understanding of the methodological bases of research activity
Content	**A) ELECTRONIC CIRCUITS** **1. Operational Amplifiers** - Opamp and OTA basics - Opamp and OTA macromodels - Basic configurations - Impedance and inductance simulation - Integrator circuits - Fully differential amplifiers - Two-step opamp - Stability **2. Feedback Amplifiers and Stability** - Feedback amplifiers - Frequency response - Stability - Gain and phase margins - Compensate amplifiers and frequency compensation techniques - Reactive feedback and instability - Slew-rate limitations **3. Basic CMOS Built-in blocks with Amplifiers** - nMOS inverters - Miller's equivalent with resistive and active charge - nMOS source follower - Cascode nMOS amplifiers - CMOS amplifiers - DC analysis - Frequency response - Cascode CMOS amplifiers - Current mirrors - Types of CMOS amplifiers biased with current mirrors **4. CMOS OTA Design** - nMOS differential amplifier - DC analysis - Differential mode and common mode gains - Symmetrical CMOS differential amplifier - Transconductance amplifier (OTA) - Frequency response - Two step OTA - OTA stability

5. Non-linear Applications of the Op-amps

- Comparators
- Hysteresis comparators
- Translinear multiplicator and Gilber cell

6. Switched Capacitor (SC) Amplifiers

- Switched resistances
- Passive SC circuits
- SC amplifiers
- SC integrator circuits
- First order SC circuits

7. Continuous and Discrete Filters

- Introduction to filter design
- Active RC filters
- Biquad filters with opamps
- Variable state filters
- Superior order filters
- Cascade connection of biquad cells
- Simulation of cascade filters by element replacement
- Operational simulation of cascade networks

8. Analogue and Mixed-Signal Systems

- Introduction to analogue signal processing
- A/D and D/A conversion
- Sample-and-hold circuits
- D/A converters
- A/D converters: types and classification
- Single and double slope
- Successive approximation (SAR) ADCs and DACs
- Flash ADCs
- Semi flash ADCs
- Pipeline ADCs
- Folded and folded and interpolated ADCs
- Sigma-delta ADCs

B) ELECTRONIC DEVICES

9. Introduction to semiconductors

- Physical basis: energy bands, hole concept, charge transport, diffusion currents…
- PN junction
- Variation of charge region with the voltage
- Currents through PN junction
- Diode models
- Capacity in PN junction
- Dynamic behaviour
- Metal-semiconductor junction

	- Schottky diodes - Ohmic contacts **10. Device Models** - MIS structure - Threshold voltage - MOS description - Substrate effect - BJT description - Voltage/current characteristics - Dynamic parameters **11. Introduction to VLSI Technologies** - nMOS/CMOS fabrication - Capacitors and resistances - Double metal layer - BJT fabrication - Mixed-signal circuits on a single substrate - BiCMOS technologies
Teaching material	▪ **Core Texts:** Allen, E. Ph., Holberg, R. D. CMOS Analog Circuit Design. Oxford University Press (2ndEdition), 2002 Razavi, B. Design of Analog CMOS Integrated Circuits. MacGrw Hill, 2001Sedra, A. S., Smith, K. C. Microelectronic Circuits. Oxford University Press (5thEdition), 2003. Franco, S. Design with Operational Amplifiers and Integrated Circuits. MacGrawHill (3rdEdition), 2002 Gray, P.R., Meyer,R.G. Analysis and Design of analog integrated circuits. Wiley(4thEdition), 2001. Laker,K.,Sansen,W. Design of analog integrated circuits and systems. MacGrawHill, 1994. Maloberti, F.Analog design forCMOS VLSI systems. Kluwer, 2001. Tsividis, Y. Operation and modeling of the MOS transistor. MacGrawHill, 1987 Tsividis, Y. Mixed Analog-Digital VLSI devices and technology. MacGraw Hill, 1996. Singh, J. Semiconductor devices: An introduction. MacGrawHill, 1994
Teaching methods	▪ The class will consist of lectures on the basic material coupled with examples and applied problems for each section. ▪ The contents will be reinforced with practical design examples in the laboratory using powerful simulation tools very well known in the electronic industry.

	▪ Participants will be encouraged to share their ideas and work with others by preparing an oral presentation and further discussion.
Assessment	Student's presentations, laboratory activities and written exam

Workload	Contact hours:	45
	Preparation and follow up of lectures:	30
	Student's paper:	20
	Presentations:	20
	Preparation for a final written assignment:	10
International aspects	▪ Use of international examples and teaching material	
Cross-cultural reference	▪ Participants of international origin. (normally)	
Course language	▪ English	
Integration of business partners	▪	
Particularities	▪	