Course guides
230667 - SCPD - System on Chip Physical Design

Unit in charge: Barcelona School of Telecommunications Engineering
Teaching unit: 710 - EEL - Department of Electronic Engineering.
Degree: MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Optional subject).
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).
Academic year: 2021  ECTS Credits: 5.0  Languages: English

LECTURER

Coordinating lecturer: Moll Echeto, Francesc De Borja
Rubio Sola, Jose Antonio
Others: Moll Echeto, Francesc De Borja
Rubio Sola, Jose Antonio

PRIOR SKILLS

Knowledge of CMOS technology and design.
Knowledge of digital design, combinational and sequential.
Basic knowledge of standard cell design flow: synthesis and place and route.

REQUIREMENTS

Graduate studies in Electronic Engineering or equivalent
Micro and Nanoelectronic Design (MND)

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
CEE18. Ability to design CMOS digital and analog integrated circuits of medium complexity.
CEE19. Ability to apply low-power techniques to integrated circuits (ICs).

Transversal:
1. TEAMWORK: Being able to work in an interdisciplinary team, whether as a member or as a leader, with the aim of contributing to projects pragmatically and responsibly and making commitments in view of the resources that are available.

2. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

3. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.
TEACHING METHODOLOGY

- Lectures
- Laboratory activities
- Individual work
- Research topic presentation, individual or groups of two people
- Short answer test and exercises

LEARNING OBJECTIVES OF THE SUBJECT

Learning objectives of the subject:

The aim of this course is to train students in methods of design of digital CMOS integrated circuits from a high level description to a layout in an efficient way using computers so that the resulting layout satisfies topological, geometric, timing and power-consumption constraints of the design.

Learning results of the subject:

- Ability to understand and apply timing and power constraints to a complex integrated circuit.
- Ability to perform the physical implementation of a complex integrated circuit.
- Ability to apply low power design techniques to integrated circuit design.
- Ability to develop techniques for the design, analysis and evaluation of electronic systems in applications such as automation, aerospace, energy distribution and generation, consumer electronics, biomedicine, etc.
- Ability to analyze, design and evaluate microelectronic integrated circuits.
- Ability to implement advanced design techniques of microelectronic integrated circuits.
- Ability to use state of the art computer aided design (CAD) tools for the design of integrated circuits.

STUDY LOAD

<table>
<thead>
<tr>
<th>Type</th>
<th>Hours</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hours large group</td>
<td>13,0</td>
<td>10.40</td>
</tr>
<tr>
<td>Self study</td>
<td>86,0</td>
<td>68.80</td>
</tr>
<tr>
<td>Hours small group</td>
<td>26,0</td>
<td>20.80</td>
</tr>
</tbody>
</table>

Total learning time: 125 h

CONTENTS

Introduction to VLSI design, Technology evolution and state of the art.

Description:
Basis of modern integrated circuits (IC) design and technology. Moore's Law. Evolution of microprocessors and memories during the last decades. Key technology changes in the IC progress. Bulk and 3D technologies, other alternatives. State of the art and foreseen evolution.

Full-or-part-time: 3h
Theory classes: 1h
Self study: 2h

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Full-or-part-time: 3h
Theory classes: 1h
Self study: 2h


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Full-or-part-time: 3h
Theory classes: 1h
Self study: 2h

Digital CMOS circuits power components and models. Dynamic and Static power components models. Voltage and frequency scaling.

Description:

Full-or-part-time: 3h
Theory classes: 1h
Self study: 2h

Low Power Design techniques.

Description:
Gate, Data and Power scaling. Impact of modern design strategies for low power design, examples of modern integrated circuits. Principles of clock gating, data gating and voltage and frequency scaling. Multiple threshold voltage, multiple voltage islands, body bias modulation in FDSOI technology. Optimization of integrated circuit design using multiple threshold voltages strategy. Impact on power and performances. Multiple islands techniques, concept of level shifter cells. Substrate biasing concept, application in FDSOI technology.

Full-or-part-time: 6h
Theory classes: 2h
Self study: 4h
# Thermal power models. Impact on delay and power. Self-heating.

**Description:**
Concept of power dissipation chain, models, parameter calculation, state of the art. Impact of power dissipation in the integrated circuit temperature. Static and dynamic evolution. Self-heating concept.

**Full-or-part-time:** 3h  
Laboratory classes: 1h  
Self study: 2h

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# Technology Scaling impact. Logic circuitry and interconnection models.

**Description:**
Scaling, the key factor of the integrated circuits progress. Moore’s law and scaling. Limits in the photolithographic processes, evolution, state of the art and future prediction. Scaling models for circuitry and interconnections.

**Full-or-part-time:** 3h  
Theory classes: 1h  
Self study: 2h

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**Description:**
Dynamic current signals in digital switching circuits. Distribution of power supply wires, rings. Electrical models and voltage fluctuations due to dynamic and static voltage drops caused by parasitic capacitances. Decoupling capacitance techniques.

**Full-or-part-time:** 3h  
Theory classes: 1h  
Self study: 2h

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# Crosstalk between interconnections. Reliability issues.

**Description:**

**Full-or-part-time:** 3h  
Theory classes: 1h  
Self study: 2h

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# Test of digital integrated circuits

**Description:**
Defects in manufacturing process. Test principles and objectives in the design integrated design and manufacturing. Fault models. Test techniques. Standards related with test, Scan Path and Boundary Scan path techniques.

**Full-or-part-time:** 3h  
Theory classes: 1h  
Self study: 2h
### Alternative design techniques and technologies (emerging devices, neural networks)

**Description:**
- Concept of Neural Networks, memristors as synaptic units. Examples of neural network implementations.

**Full-or-part-time:** 3h  
Theory classes: 1h  
Self study: 2h

### Laboratory: physical implementation of digital IC

**Description:**
- Lab 1 Synthesis with physical information  
- Lab 2 Floorplanning a complete chip  
- Lab 3 Place and route  
- Lab 4 Full Flow: RTL to Place and Route with low power techniques

**Full-or-part-time:** 83h  
Laboratory classes: 57h  
Self study: 26h

### Research topic presentation

**Description:**
- The professors will propose a current topic related to digital design and technology. Each student or groups of two will do some research with current bibliography and present the state of the art on that topic to the rest of the class.

**Full-or-part-time:** 6h  
Theory classes: 1h  
Self study: 5h

### GRADING SYSTEM

**Continuous evaluation (CE):**  
- Two Partial exams: 16.6% each  
- Research topic presentation: 16.6%  
- Laboratory experiences: 50%

**Final score:** maximum (CE, Final exam)

### EXAMINATION RULES

- Final exam: individual  
- Partial exams: individual  
- Research presentation: groups of up to two students  
- Laboratory: groups of up to two students
BIBLIOGRAPHY

Complementary:

RESOURCES

Other resources:
Slides of the course