Learning objectives of the subject:

The course objective is two-fold. First, to complement the student VLSI background acquired in the previous core courses on electronics, stressing on important advanced concepts and providing designer insight in the area of VLSI analog and mixed-signal design. Second, to introduce the critical issues to take into account in the full design of a mixed-signal, submicron/nanometer-scale integrated circuit.
Learning results of the subject

Is able to prepare, present and defend individually an original professional exercise in the field of Electronics Engineering as a synthesis and a demonstration of skills acquired during its studies.
- Uses knowledge and strategic skills to create and manage projects with innovative vision, applies systemic solutions to complex problems.
- Plans and uses the information needed for a project or academic work from a critical reflection on the information resources used.
- Applies acquired skills to the execution of a task with independence. Identifies the need for continuous learning and develops its own strategy for doing so.
- Identifies major components and establishes commitments and priorities.
- Designs experiments and measurements to verify hypotheses or validate the operation of equipment, processes, systems or services in the field of Electronic Engineering.
- Selects appropriate equipment or software tools and performs advanced analysis with the data.
- Knows the concept of life-cycle of a product and applies it to the development of ICT products and services, using appropriate standards and legislation.
- Can perform an oral presentation and answer questions from the audience.
- Communicates clearly and efficiently in oral and written presentations on complex topics, being able to adapt to the situation, the type of audience and communication goals.
- Ability to synthesize and solve problems related to the electronic engineering discipline, to apply learning techniques in complex and multiple contexts, to apply previous knowledge to new situations and contexts, as well as the ability to coordinate and work in a team.
- Ability to analyze, design and evaluate microelectronic integrated circuits.
- Ability to identify and model electronic complex systems. Ability to perform qualitative analysis and approximations, establishing the uncertainty of the results.
- Ability to pose hypotheses on microelectronic circuits behavior and experimental methods to validate them.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Guided activities:</th>
<th>Self study:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total learning time: 125h</td>
<td>26h</td>
<td>0h</td>
<td>13h</td>
<td>0h</td>
<td>86h</td>
</tr>
<tr>
<td></td>
<td>20.80%</td>
<td>0.00%</td>
<td>10.40%</td>
<td>0.00%</td>
<td>68.80%</td>
</tr>
</tbody>
</table>
### Content

<table>
<thead>
<tr>
<th>1. Devices</th>
<th><strong>Learning time:</strong> 13h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td></td>
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<tr>
<td>- Advanced transistor models (subthreshold, continuous), second-order effects.</td>
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<tr>
<td>- Noise models and distortion.</td>
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<tr>
<td>- Simulator limits.</td>
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<tr>
<td>- Integrated capacitors and resistors.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Key concepts in analog design</th>
<th><strong>Learning time:</strong> 13h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td></td>
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<tr>
<td>- Differential signaling, (folded, regulated) cascode and follower associated concepts.</td>
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<tr>
<td>- The Miller effect. Pole-splitting.</td>
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<tr>
<td>- High-resistance node analysis, gain-bandwidth product, phase margin.</td>
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<tr>
<td>- Basic stages, advanced current mirrors and references.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Systematic design of transconductors and opamps</th>
<th><strong>Learning time:</strong> 16h</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td></td>
</tr>
<tr>
<td>- General model.</td>
<td></td>
</tr>
<tr>
<td>- Simple OTA. Pole-zero doublet. Linearization techniques.</td>
<td></td>
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<tr>
<td>- Fully differential amplifiers (FDA). Common-mode feedback issues.</td>
<td></td>
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<tr>
<td>- Output stages. Rail-to-rail input and output.</td>
<td></td>
</tr>
</tbody>
</table>
## 4. Mixed-signal circuits

**Learning time:** 17h  
- Theory classes: 5h  
- Laboratory classes: 4h  
- Self study: 8h

**Description:**  
- Current and voltage comparators. Hysteresis.  
- Charge pumps.  
- DLLs.  
- Time-to-digital converters.  
- Digitally-assisted analog circuits.

## 5. Chip-level design

**Learning time:** 16h  
- Theory classes: 6h  
- Laboratory classes: 2h  
- Self study: 8h

**Description:**  
- High-level simulation. Analog and Mixed-Signal (AMS) modeling.  
- Digital synthesis.  
- Digital back-end.  
- Analog and mixed-signal layout techniques. Design rules.  
- Power-supply and clock considerations.  
- Pad characteristics and models. Pad and power rings. Package.

## 6. Design project

**Learning time:** 50h  
- Self study: 50h

**Description:**  
Development of a design project to apply skills developed during the course.

## Qualification system

- Research exercise presentation: 25%  
- Practical lab exercises: 20%  
- Final course exercise: 30%  
- Midterm tests: 25%
Bibliography

Basic:


Complementary:


