

Course Guide

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Integrated Circuits and Systems
IMB-CNM(CSIC)

- 1 Basic Information
- 2 Objectives and Prerequisites
- 3 Theoretical Contents
- 4 Lab Exercises
- 5 Evaluation Methodology
- 6 Recommended Bibliography

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Basic Info

Who:

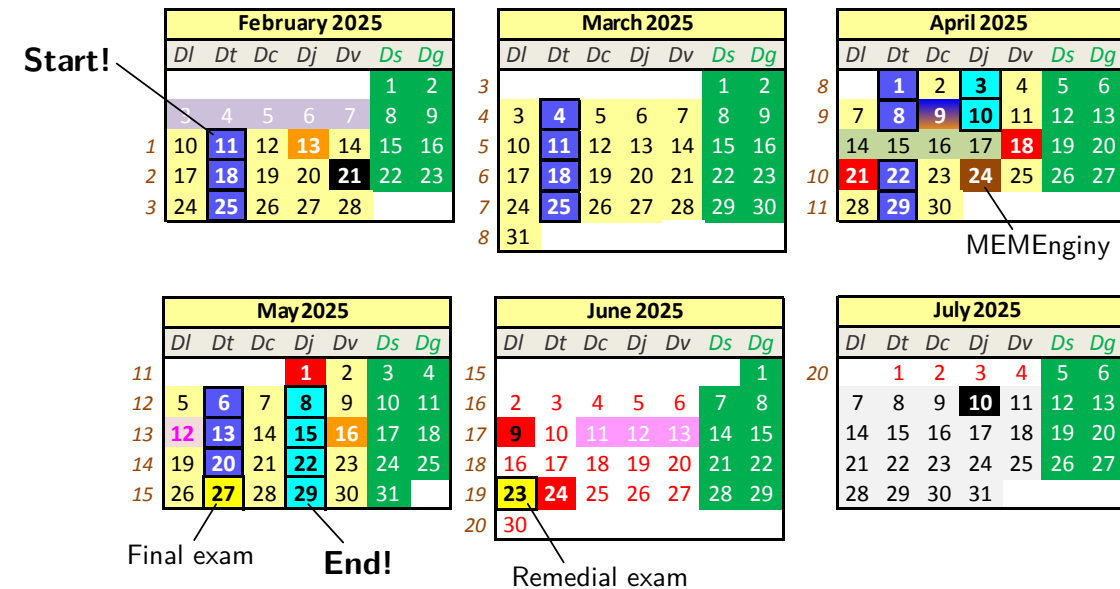
- Francesc Serra Graells
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tel. 935 947 700

- Stepan Sutula

Where:

- Classroom: Seminari B
- Laboratory: Q5/2005
- <https://cv.uab.cat>
- <http://www.cnm.es/users/pserra/uab/ihsd>

When:

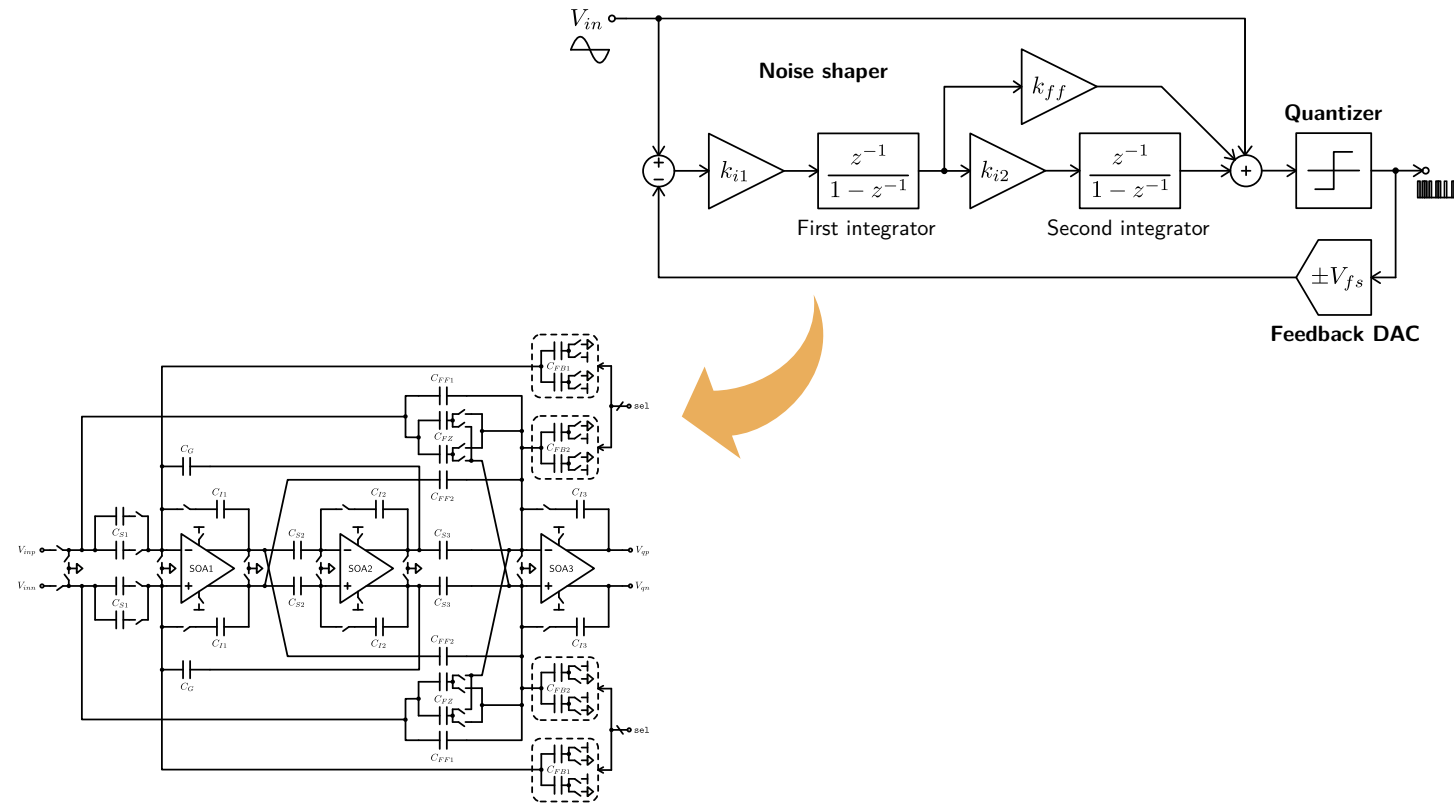


- Classroom Tuesdays 15:00h-17:00h
- Laboratory Thursdays 17:00h-19:00h
- Final exam May 27th 15:00h
- Remedial exam June 23rd 15:00h

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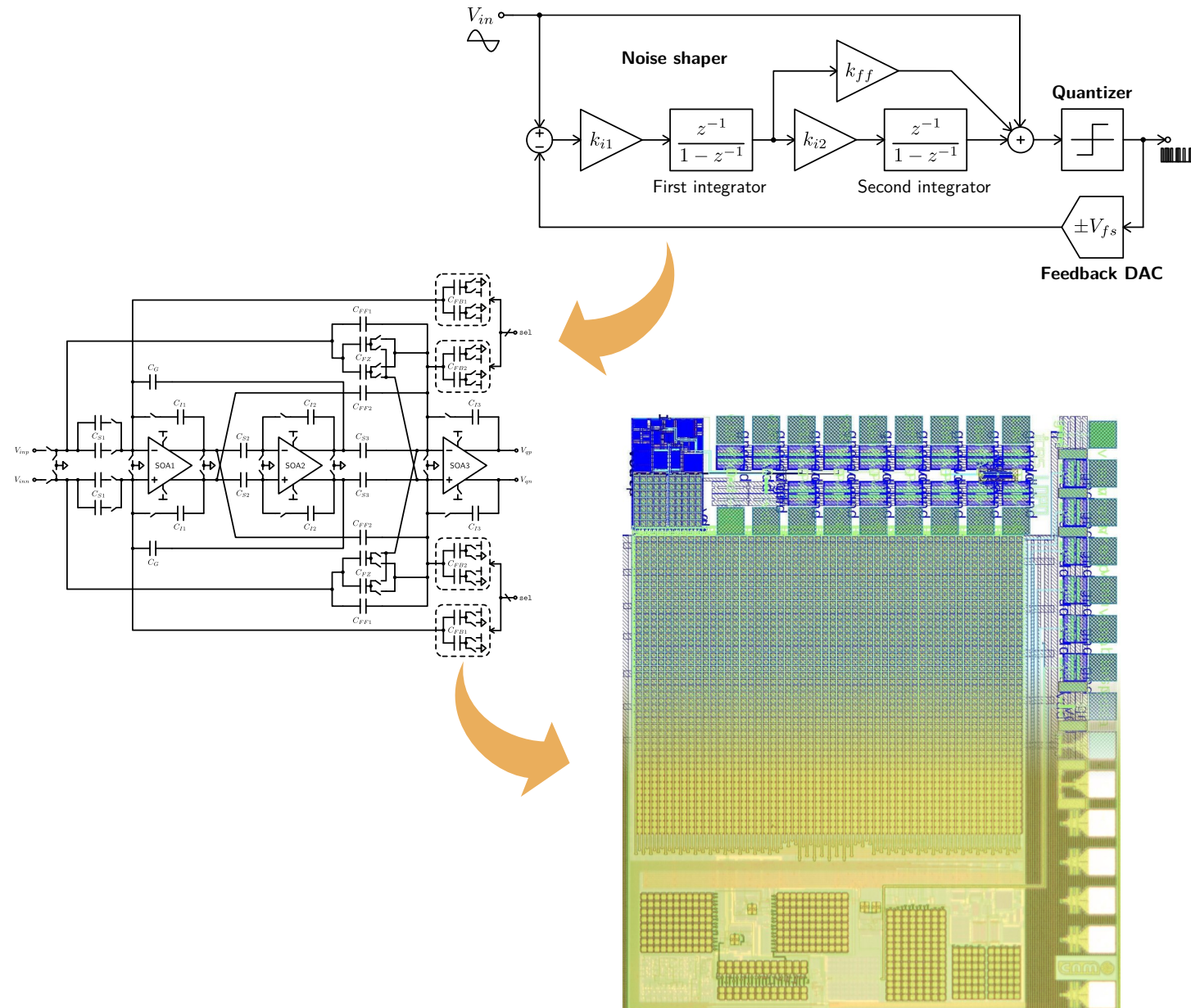
Objectives

- Design techniques for **A/D** and **D/A** converters in **CMOS** technologies



Objectives

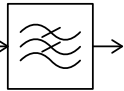
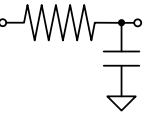
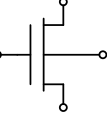
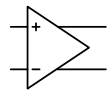
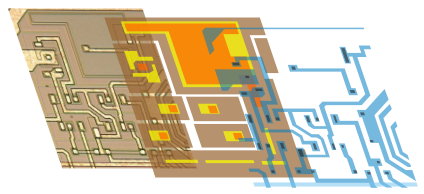
- ▶ Design techniques for **A/D** and **D/A converters** in **CMOS** technologies
- ▶ Design methodology and EDA tools for **mixed-signal** and **full-custom ASICs**

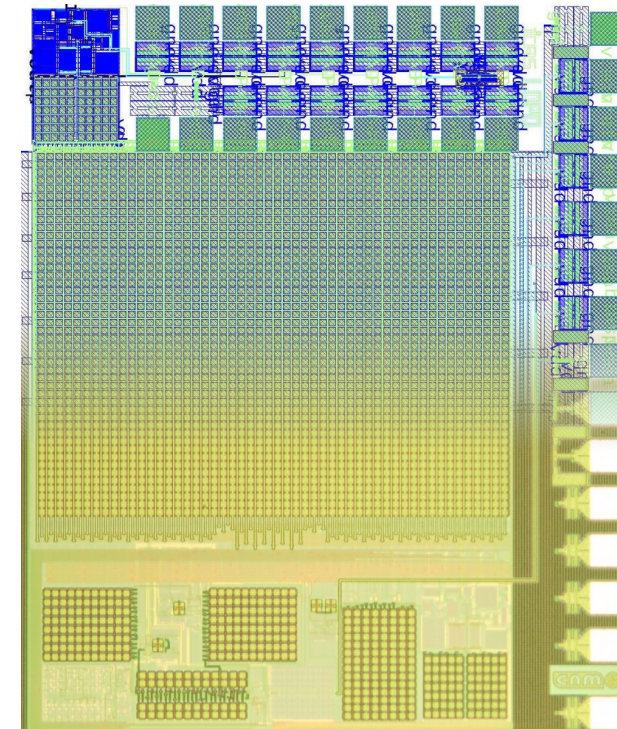
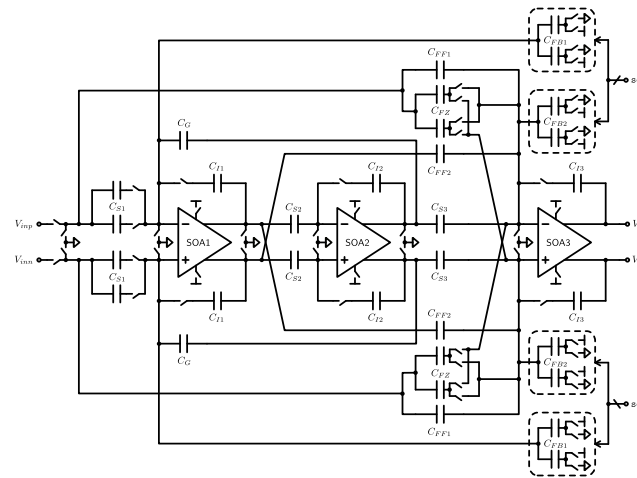
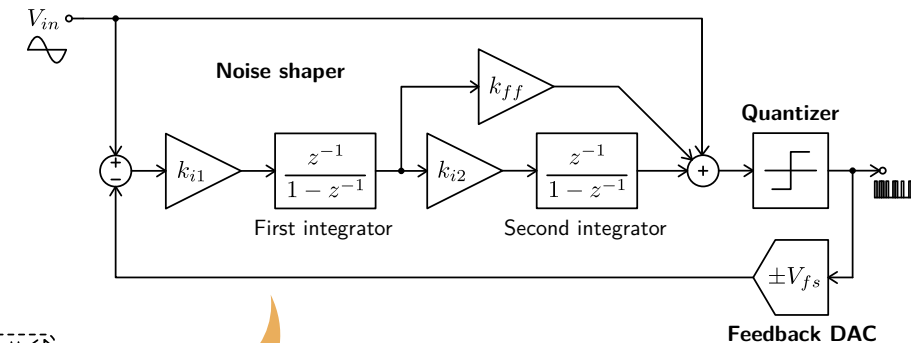


Objectives

- ▶ Design techniques for **A/D** and **D/A** converters in **CMOS** technologies
- ▶ Design methodology and EDA tools for **mixed-signal** and **full-custom ASICs**

Prerequisites

- ▲ Signal processing 
- ▲ Circuit theory 
- ▲ Electronic devices 
- ▲ Analog CMOS design 
- ▲ Microelectronics technology 



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Theory Contents

1 Introduction to Integrated Heterogeneous Systems

- 1.1 Evolution of CMOS Technologies
- 1.2 Trends in Analog and Mixed IC Design
- 1.3 A/D and D/A Conversion Principles
- 1.4 ADC and DAC Figures of Merit
- 1.5 Lab Proposal: My Delta-Sigma ADC in 2.5 μ m CMOS Technology (CNM25)

4 Full-Custom IC Design Methodology

- 4.1 Mixed-Signal Design Flow
- 4.2 AMS Hardware Description Languages
- 4.3 Device Sizing
- 4.4 Process and Mismatching Simulation
- 4.5 The Art of Analog Layout
- 4.6 Physical Verification
- 4.7 Parasitics Extraction
- 4.8 DFM Techniques

2 ADC Architectures and CMOS Circuits

- 2.1 ADC Classification
- 2.2 Flash Converters
- 2.3 Sub-Ranging, Time-Interleaving and Pipelining
- 2.4 Successive-Approximation Converters
- 2.5 Integrating Techniques
- 2.6 Delta-Sigma Modulation
- 2.7 Time-Domain Converters

3 DAC Architectures and CMOS Circuits

- 3.1 DAC Classification
- 3.2 Flash Converters
- 3.3 Pulse-Width Modulation
- 3.4 Delta-Sigma Modulation

(Seminar: **Lab Exercises in CNM25**)

Theory Contents

5 CMOS OpAmps

- 5.1 OpAmp Figures of Merit
- 5.2 The Mono-Transistor Amplifier
- 5.3 Differential Circuits with CMFB
- 5.4 Folded Amplifiers
- 5.5 Cascode Topologies
- 5.6 Gain Enhancement Techniques
- 5.7 Multi-Stage OpAmps

6 Delta-Sigma Modulators for ADC

- 6.1 Oversampling and Noise Shaping Principles
- 6.2 Architecture Selection Based on Quantization Error
- 6.3 Switched-Capacitor CMOS Implementations
- 6.4 Modeling Circuit Second Order Effects
- 6.5 Digitally Assisted Techniques
- 6.6 Low-Power Circuit Topologies

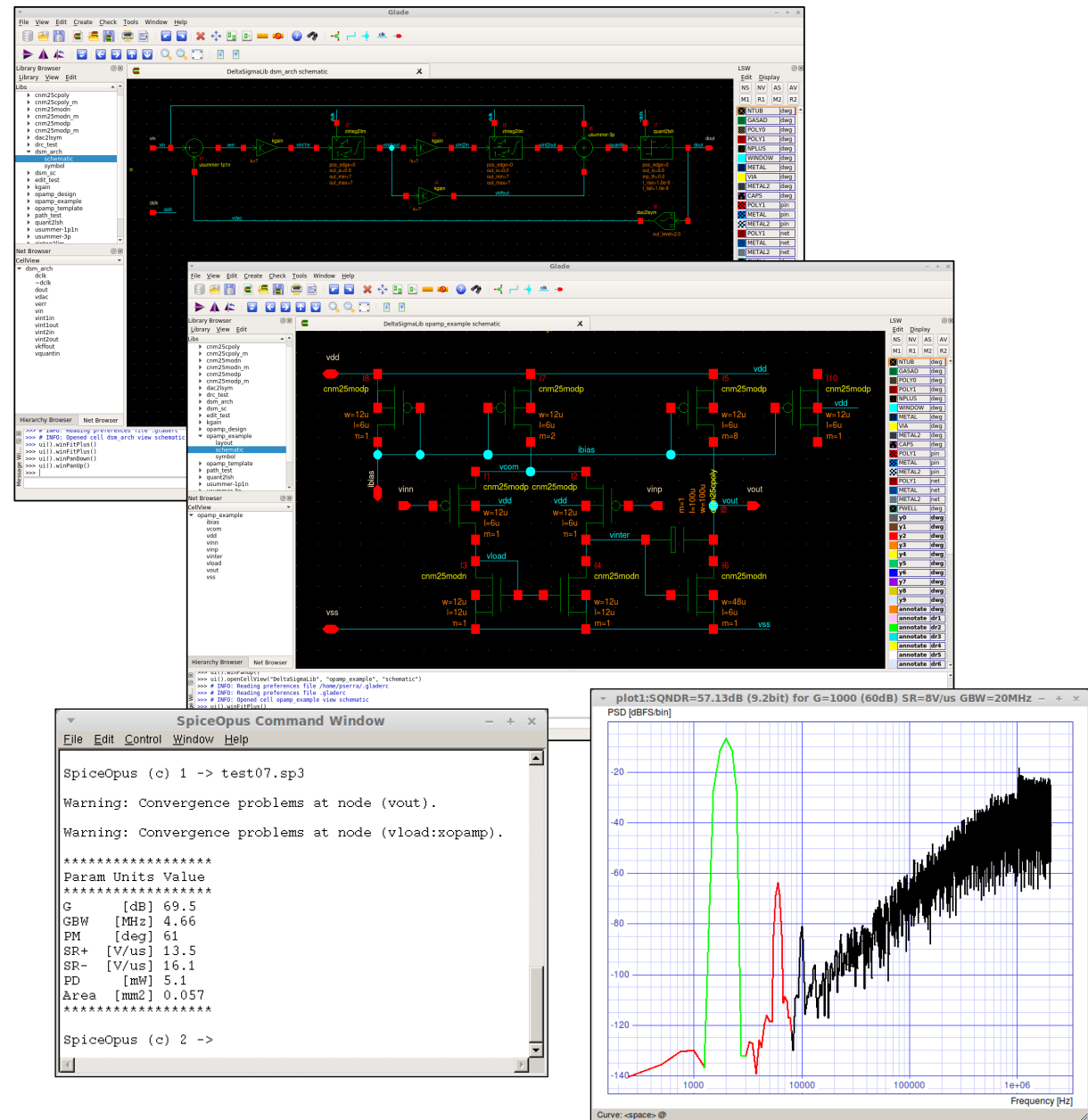
7 Application Specific ROICs for Smart Sensors

- 7.1 High-Resolution SC Delta-Sigma ADC for Space Applications
- 7.2 Compact Pixel Integrating ADC for Infrared and X-Ray Imagers
- 7.3 Low-Power Potentiostatic CT Delta-Sigma ADC for Electrochemical Integrated Sensors

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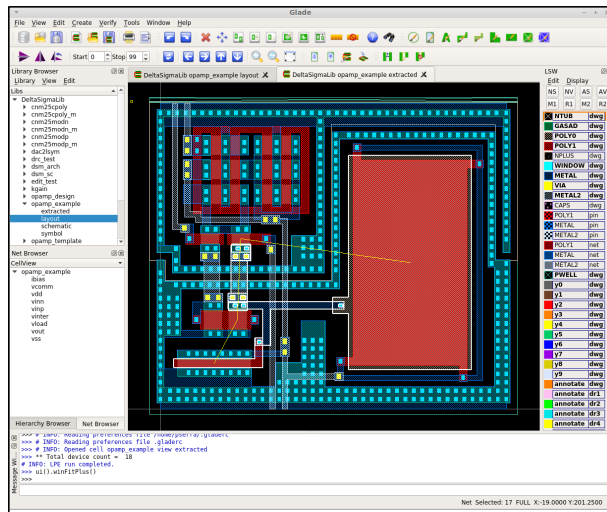
Lab Exercises

- ▶ Second-order single-bit A/D $\Delta\Sigma$ modulator design case
- ▲ Simple 2.5 μm 2P2M CMOS technology (CNM25)

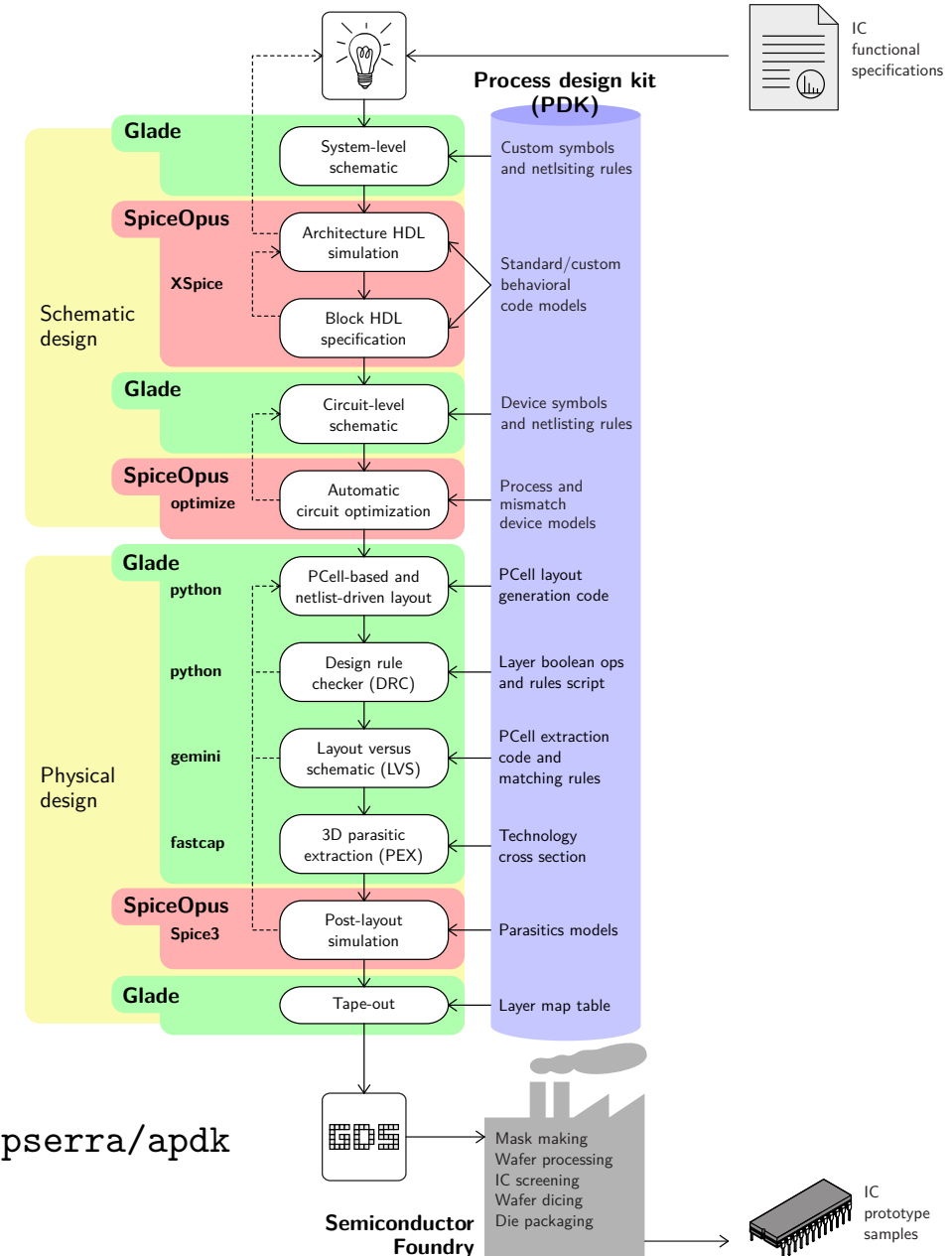


Lab Exercises

- ▶ Second-order single-bit A/D $\Delta\Sigma$ modulator design case
- ▲ Simple 2.5 μm 2P2M CMOS technology (CNM25)
- ▲ Freeware and multi-OS (MS Windows, Linux) EDA tools
- ▲ Work at **home** and tutorial at **lab**...



■ <http://www.cnm.es/users/pserra/apdk>



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Evaluation Methodology

► If $Q_{\text{exams,lab}} \geq \frac{4}{10}$:

$$Q_{\text{overall}} = 0.1Q_{\text{exercises}} + 0.4Q_{\text{lab}} + 0.5Q_{\text{exams}}$$

$Q_{\text{exams}} = \max(Q_{\text{exam1}}, 0.8Q_{\text{exam2}})$

The diagram illustrates the evaluation methodology. It shows the overall grade calculation and the exam grade calculation. The overall grade is calculated as a weighted sum of homework exercises, lab, and exams. The exam grade is the maximum of the first exam and 80% of the second exam. The second exam is a remedial exam.

▲ **Distributed** weights

▲ **Continuous** evaluation

▲ **Second** opportunity to pass exam

▼ **Hard work** to obtain top marks

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Recommended Bibliography

▲ Self-contained theory in slides

▲ Practical problems solved at classroom

▲ Hands-on lab exercises

► **Reference** material:

- R. van de Plassche, *CMOS Integrated Analog-to-Digital and Digital-to-Analog Converters*, Kluwer Academic Publishers
- R. Schreier and G. C. Temes, *Understanding Delta-Sigma Data Converters*, John Wiley & Sons
- V. Peluso, M. Steyaert and W. Sansen, *Design of Low-Voltage and Low-Power CMOS Delta-Sigma A/D Converters*, Kluwer Academic Publishers
- F. Medeiro, A. Pérez-Verdú and A. Rodríguez-Vázquez, *Top-Down Design of High-Performance Sigma-Delta Modulators*, Kluwer Academic Publishers
- T. Tuma and A. Burmen, *Circuit Simulation with SPICE OPUS: Theory and Practice*, Modeling and Simulation Science, Engineering and Technology, Birkhäuser Boston
- A. Hastings, *The Art of Analog Layout*, Pearson Prentice Hall

Recommended Bibliography

► **Additional** references for those students lacking of some background:

Signal Processing

- A.V. Oppenheim, *Signals and Systems*, Prentice Hall
- A.B. Carlson, *Communication Systems*, McGraw Hill
- H. Baher, *Analog & digital signal processing*, John Wiley

Circuit Theory & Electronic Devices

- A.B. Carlson, *Teoría de circuitos*, Thomson-Paraninfo
- D.E. Scott, *Introducción al análisis de circuitos*, McGraw Hill
- J.D. Irwin, *Análisis básico de circuitos en Ingeniería*, Prentice Hall Hispanoamericana
- L.O. Chua, *Linear and non linear circuits*, McGraw Hill
- R.C. Dorf, J.A. Svoboda, *Introduction to electric circuits*, John Wiley & Sons
- A.R. Hambley, *Electrónica*, Prentice Hall
- C.J. Savant Jr., M.S. Roden, G.L. Carpenter, *Diseño Electrónico, Circuitos y sistemas*, Prentice Hall
- R. Boylestad, L. Nashelsky, *Electronic Devices and Circuit Theory*, Prentice Hall

Microelectronics Technology & VLSI Design

- P.E. Allen, D.R. Holberg, *CMOS analog circuit design*, HRW Series in Electrical and Computer Engineering
- B. Razavi, *Design of analog CMOS integrated circuits*, McGraw-Hill
- M. N. Horenstein, *Microelectrónica: circuitos y dispositivos*, Prentice-Hall
- J. Millman, A. Grabel, *Microelectrónica*, Ed. Hispano Europea
- R.J.Baker, H.W. Li, D.E. Boyce, *CMOS circuit design, layout, and simulation*, IEEE Press Series on Microelectronic Systems
- R.L. Geiger, P.E. Allen, N.R. Strader, *VLSI design techniques for analog and digital circuits*, McGrawHill
- N.H.E. Weste, K. Eshraghian, *Principles of CMOS VLSI design a systems perspective*, Addison-Wesley
- J.P.Uyemura, *Introduction to VLSI circuits and systems*, John Wiley and Sons