

EE-424

**Fundamentals of analog & mixed signal VLSI design**

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Cursus	Sem.	Type
Data and Internet of Things minor	H	Opt.
Electrical and Electronical Engineering	MA1, MA3	Obl.
Microtechnics	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Courses	2 weekly
Exercises	2 weekly
<b>Number of positions</b>	

**Summary**

This course provides the foundation for entry-level analog/mixed-signal IC designers. This course will layer advanced circuit design concepts (such as noise and distortion) over a broad range of contemporary/practical circuits. It is an expansion of EE520 and links to more advanced circuit courses.

**Content****Understanding the Device and Design Methodology**

- Technology Roadmap
- Modeling of the MOS Transistor
- The Concept of Inversion Coefficient and Gm/ID Design Methodology
- Understanding Process Variations and Reliability

**Deeper Dive into Continuous/Discrete-time Amplifiers**

- Introduction to Noise
- Basic Building Blocks
- Amplifiers (OTAs and OPAMPs)
- Comparators
- Offset and 1/f Noise Reduction Techniques

**Applied Analog/Mixed-Signal Circuits**

- Power Converter Circuits
- Continuous-time (CT) Filters Design
- Switched-capacitors (SC) Filters Design

- Phase Locked Loop
- Analog-to-digital / Digital-to-Analog Circuits
- Sensor Interface

### Keywords

CMOS, Integrated Circuits, Analog Circuit, Mixed-Signal Circuit, Device Model, Noise, Amplifiers, Filters, Sensors, Oscillators

### Learning Prerequisites

#### Important concepts to start the course

- Transistor operation (as a switch or a current source)
- Laplace-domain analysis of continuous-time domain circuits and their frequency response
- Feedback

### Learning Outcomes

By the end of the course, the student must be able to:

- Choose appropriate design methodology for amplifier design
- Assess / Evaluate the impact of noise/variation/distortion in continuous/discrete-time circuits
- Critique on the pros/cons of various analog/mixed-signal circuit structures
- Contextualise circuit design with the characteristics of the device and the focus of the application
- Elaborate on energy-efficiency
- Elaborate on robustness

### Transversal skills

- Demonstrate the capacity for critical thinking
- Access and evaluate appropriate sources of information.
- Use a work methodology appropriate to the task.

### Teaching methods

Four hours per week:

alternating between weeks with two 2 hour lecture and with one 2 hour lecture and one 2 hour exercise

### Expected student activities

In addition to following the lectures and the exercise, the students are expected to do some home work based on the exercises.

### Assessment methods

Written exam

### Resources

## Bibliography

### Device modeling:

- [1] C. C. Enz and E. A. Vittoz, Charge-based MOS Transistor Modeling, Wiley, 2006.
- [2] Y. Tsvividis and C. Mc Andrew, Operation and Modeling of the MOS Transistor, 3rd ed., Oxford University Press, 2001.

### CMOS IC design:

- [3] T. C. Carusone, D. A. Johns, K. W. Martin, Analog Integrated Circuit Design, 2nd edition, Wiley, 2012.
- [4] B. Razavi, Design of Analog CMOS Integrated Circuits, 2nd ed., Mc Graw Hill, 2017.
- [5] W. Sansen, Analog Design Essentials, Springer, 2013.
- [6] A. Sedra, K. Smith, Microelectronic Circuits, 7th edition, Oxford University Press, 2015.
- [7] P. R. Gray, P. J. Hurst, S. H. Lewis and R. G. Meyer, Analysis and Design of Analog Integrated Circuits, 5th ed., Wiley, 2009.

### Gm/ID design methodology:

- [8] David Binkley, Tradeoffs and Optimization in Analog CMOS Design, Wiley, 2008.
- [9] P. Jespers, B. Murmann, Systematic Design of Analog CMOS Circuits, Cambridge, 2017.
- [10] P. Jespers, The Gm over ID Methodology, Springer, 2010.

## Ressources en bibliothèque

- [4] B. Razavi, Design of Analog CMOS Integrated Circuits
- [1] C. C. Enz and E. A. Vittoz, Charge-based MOS Transistor Modeling
- [3] T. C. Carusone, D. A. Johns, K. W. Martin, Analog Integrated Circuit Design
- [2] Y. Tsvividis and C. Mc Andrew, Operation and Modeling of the MOS Transistor
- [7] P. R. Gray, P. J. Hurst, S. H. Lewis and R. G. Meyer, Analysis and Design of Analog Integrated Circuits
- [6] A. Sedra, K. Smith, Microelectronic Circuits
- [8] David Binkley, Tradeoffs and Optimization in Analog CMOS Design
- [9] P. Jespers, B. Murmann, Systematic Design of Analog CMOS Circuits
- [10] P. Jespers, The Gm over ID Methodology
- [5] W. Sansen, Analog Design Essentials

## Moodle Link

- <https://go.epfl.ch/EE-424>