

# Fundamentals of Analog & Mixed Signal VLSI Design

## Introduction

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The logo of the Swiss Federal Institute of Technology, Lausanne (EPFL), consisting of the letters 'EPFL' in a bold, red, sans-serif font.

# Summary, Aims and Objectives

- Summary
  - ▶ This course presents the **design of low-power analog CMOS integrated circuits**. The techniques are based on the concept of **inversion coefficient** that can be used as the main design parameter for the optimization of figures-of-merit applied to circuits including amplifiers, filters and oscillators
- Course aims
  - ▶ To understand what conditions the **power consumption of analog circuits**
  - ▶ To present a **methodology** for the design of low-power analog CMOS ICs
  - ▶ To explain the concept of **inversion coefficient** and how it can be applied for the design of low-power analog circuits
- Learning objectives
  - ▶ To learn how to design basic analog CMOS integrated circuits
  - ▶ To design simple analog building blocks according to specs
  - ▶ To verify by circuit simulations that the specs have been achieved

# Syllabus

- 1) Introduction
- 2) Technology roadmap
- 3) Modeling of the MOS transistor for low-power design
- 4) The concept of inversion coefficient and  $G_m/I_D$  design methodology
- 5) Optimization of basic figures-of-merit
- 6) Amplifiers (OTAs and OPAMPs)
- 7) Offset and  $1/f$  noise reduction techniques
- 8) Continuous-time (CT) filters design
- 9) Switched-capacitors (SC) filters design
- 10) Oscillators

# Program

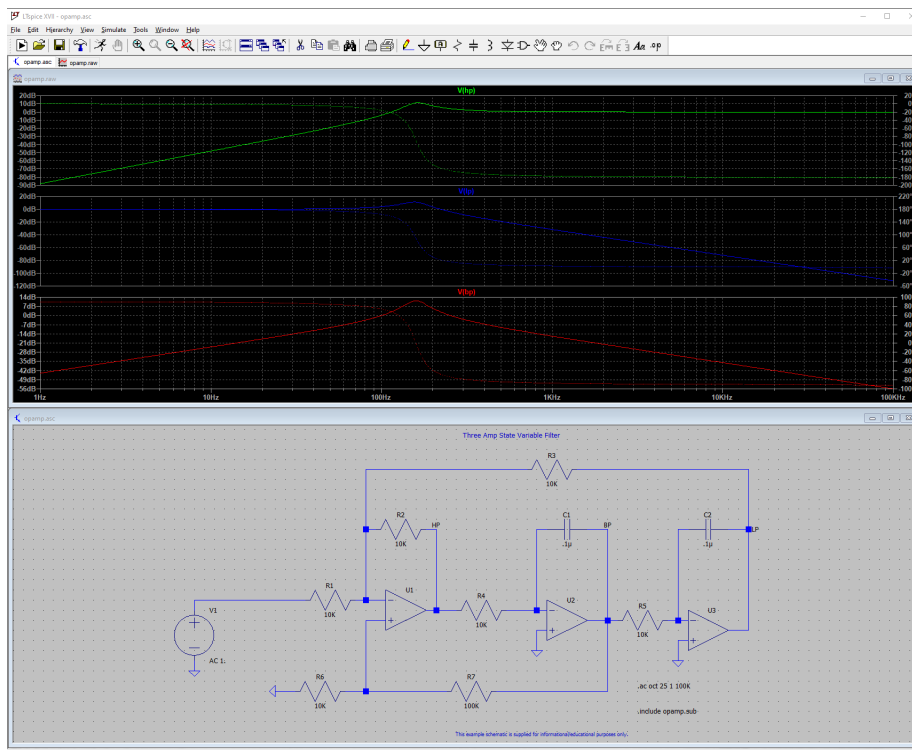
Lecture #	Date	Topic
1	10.09.2025	Introduction Technology roadmap
2	17.09.2025	Modeling of the MOS transistor for low-power design (long-channel)
3	24.09.2025	Modeling of the MOS transistor for low-power design (short-channel)
4	01.10.2025	Noise in circuits and systems
5	08.10.2025	The concept of inversion coefficient and Gm/ID design methodology
6	15.10.2025	Basic building blocks
	22.10.2025	Fall break
7	29.10.2025	Amplifiers (OTAs and OPAMPs) Part 1
8	05.11.2025	Amplifiers (OTAs and OPAMPs) Part 2
9	12.11.2025	Offset and 1/f noise reduction techniques
10	19.11.2025	Continuous-time filters (CTFs)
11	26.11.2025	Switched-capacitors circuits and filters (SCF)
12	03.12.2025	Reference circuits
13	10.12.2025	Oscillators
14	17.12.2025	Comparators

# Teaching Methods

- Two hours **lectures** based on the slides accessible from the corresponding moodle site
- The lecture will be given in person
- Computer tools will be used for
  - ▶ **Analysis** and the **design** with Jupyter or Quarto Notebooks
  - ▶ **Verification** will be done with ngspice or LTspice circuit **simulators**
  - ▶ **Schematic capture** with Qucs-S
- **Homework** to prepare and validate the work done during the exercise and simulation sessions

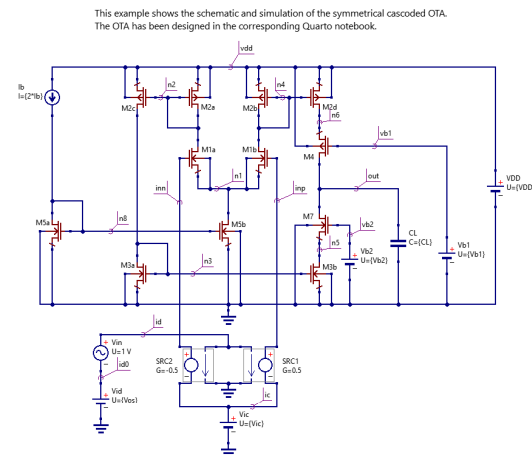
# Tools

- **Analysis** and **design** will be carried out with **Jupyter** or **Quarto Notebooks**
- Circuit **simulation** will be carried out with **ngspice** or **LTSpice**
- Schematic capture can be done in **LTSpice** or preferably in **Qucs-S**

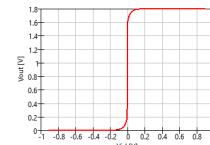


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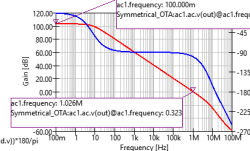
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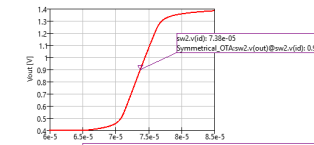
dc simulation



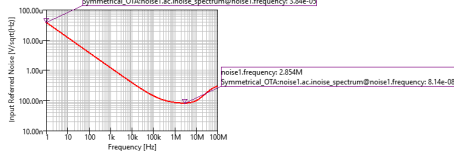
Parameter sweep



dc simulation







Parameter sweep



# Moodle Site

- Information on the course, slides, exercises, homework can be found on the moodle site



FR | EN | DE   ChristianENZ 

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## General

### Welcome to the course on Low-power Analog IC Design

#### Summary

This course presents the design of low-power analog CMOS integrated circuits. The techniques are based on the concept of inversion coefficient that can be used as the main design parameter for the optimization of figures-of-merit applied to circuits including amplifiers, filters and oscillators.

#### Course book

You can find more information about this course by looking at the [course book](#).

#### Contents

1. Introduction
2. Technology Roadmap
3. Modeling of the MOS Transistor for Low-power Design
4. The Concept of Inversion Coefficient and Gm/ID Design Methodology
5. Optimization of Basic Figures-of-merit
6. Amplifiers (OTAs and OPAMPs)
7. Offset and 1/f Noise Reduction Techniques
8. Continuous-time (CT) Filters Design
9. Switched-capacitors (SC) Filters Design
10. Oscillators

#### Program

Lecture #	Date	Topic
1	17.09.2020	Introduction, Technology roadmap
2	24.09.2020	Technology roadmap
3	01.10.2020	Modeling of the MOS transistor for low-power design
4	08.10.2020	Modeling of the MOS transistor for low-power design
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10	19.11.2020	Offset and 1/f noise reduction techniques
11	26.11.2020	Continuous-time (CT) filters design
12	03.12.2020	Switched-capacitors (SC) filters design
13	10.12.2020	Switched-capacitors (SC) circuits design
14	17.12.2020	Oscillators

# GitHub Site

- Many examples will be available from my GitHub site

<https://github.com/chrisenz>

- There are mainly two repositories:

- ▶ <https://github.com/chrisenz/Analog-Circuit-Design>

Includes many circuit examples designed in a generic 180nm bulk CMOS technology and simulated in ngspice with EKV 2.6 compact model

- ▶ <https://github.com/chrisenz/sEKV-Design-in-IHP-SG13G2>

Includes many design circuit examples designed in the IHP 130nm BiCMOS technology and simulated in ngspice with the PSP compact model

# Evaluation

- There will be no mid-term
- Final open book exam will be a MCQ done in Moodle