

# Advanced Analog Integrated Circuits

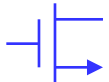
## Overview

Bernhard E. Boser

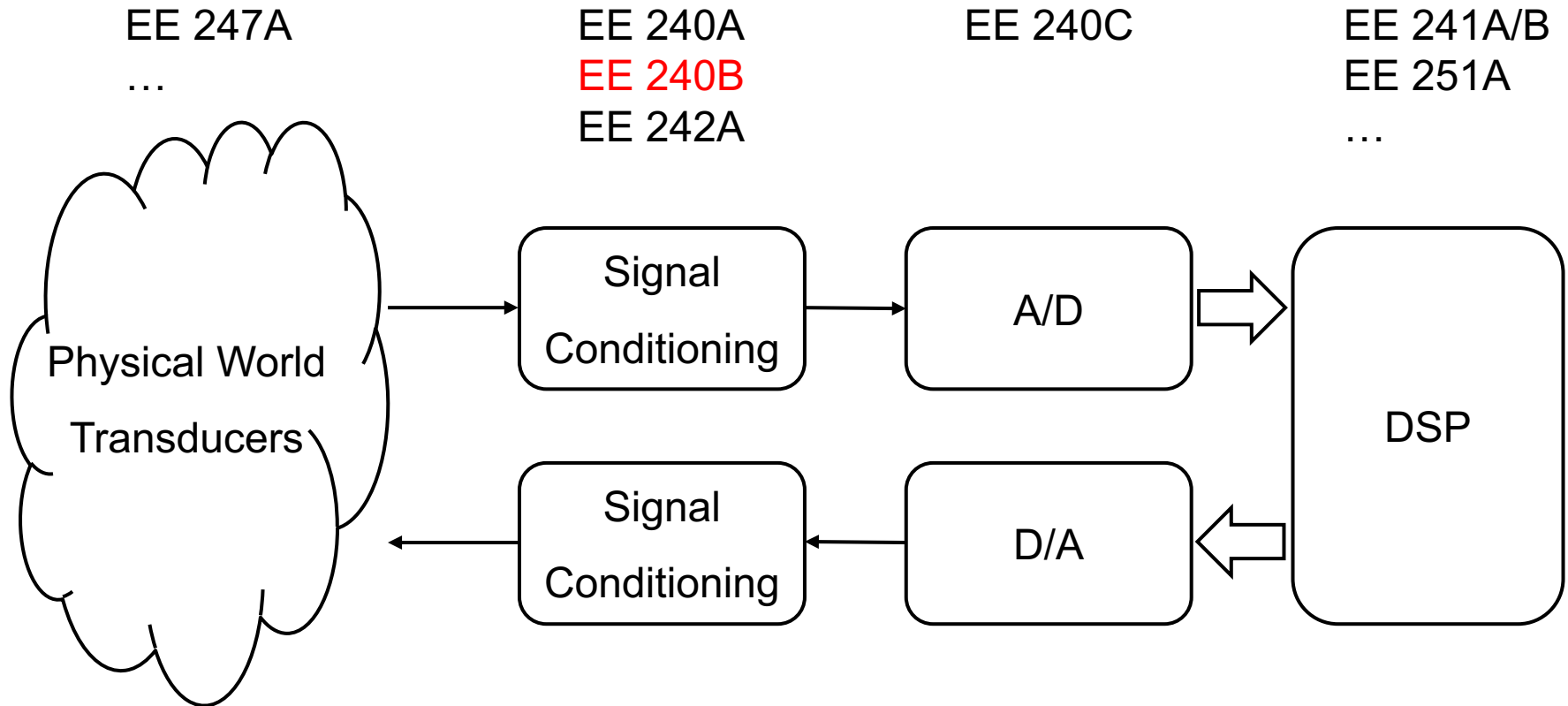
University of California, Berkeley

[boser@eecs.berkeley.edu](mailto:boser@eecs.berkeley.edu)

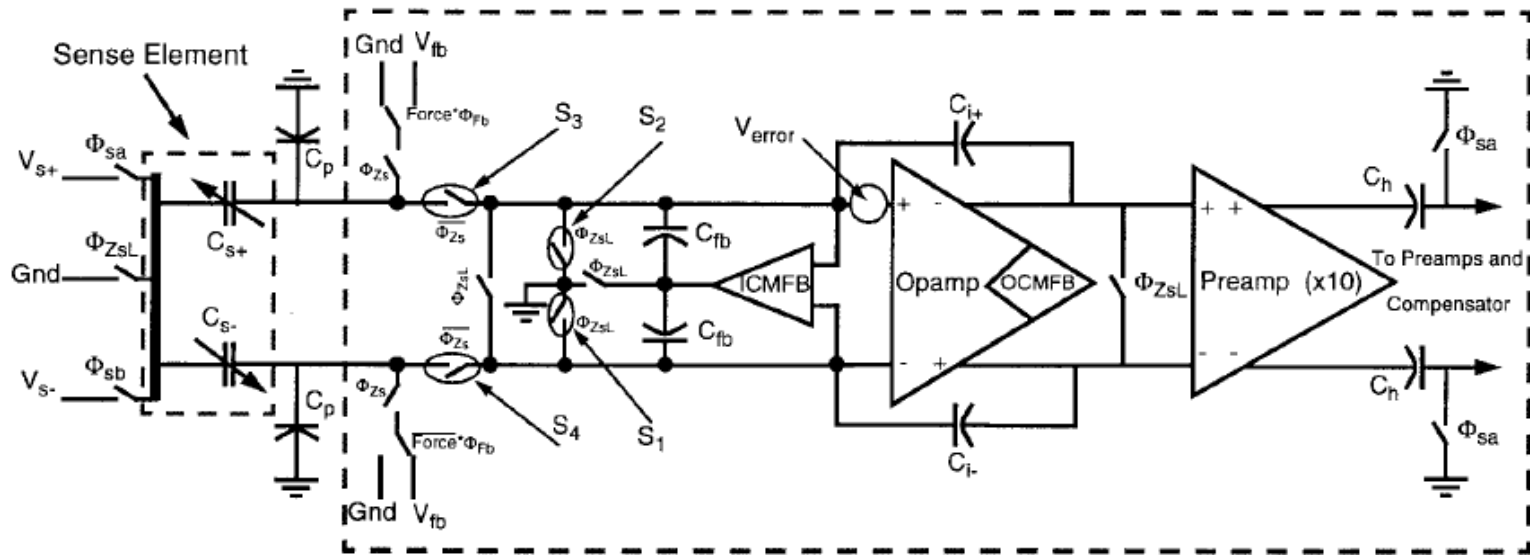
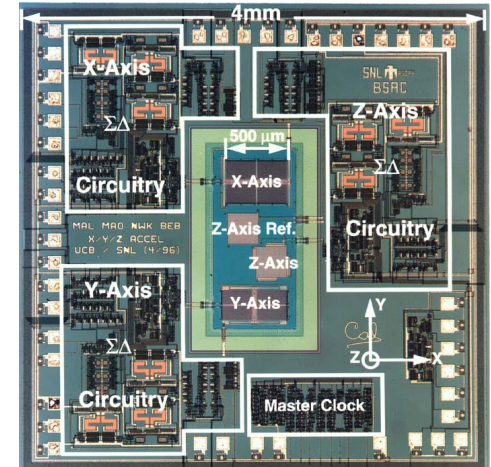
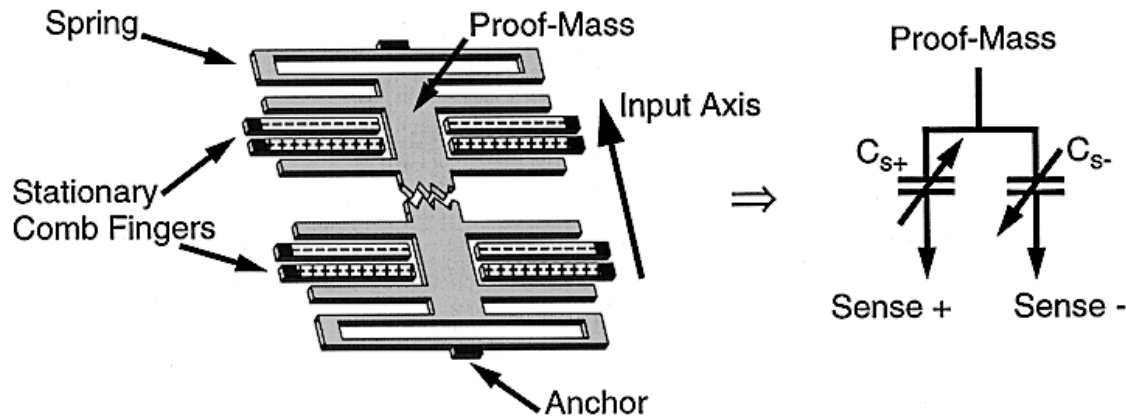
Copyright © 2016 by Bernhard Boser



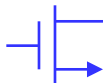
# Mixed Signal Circuits



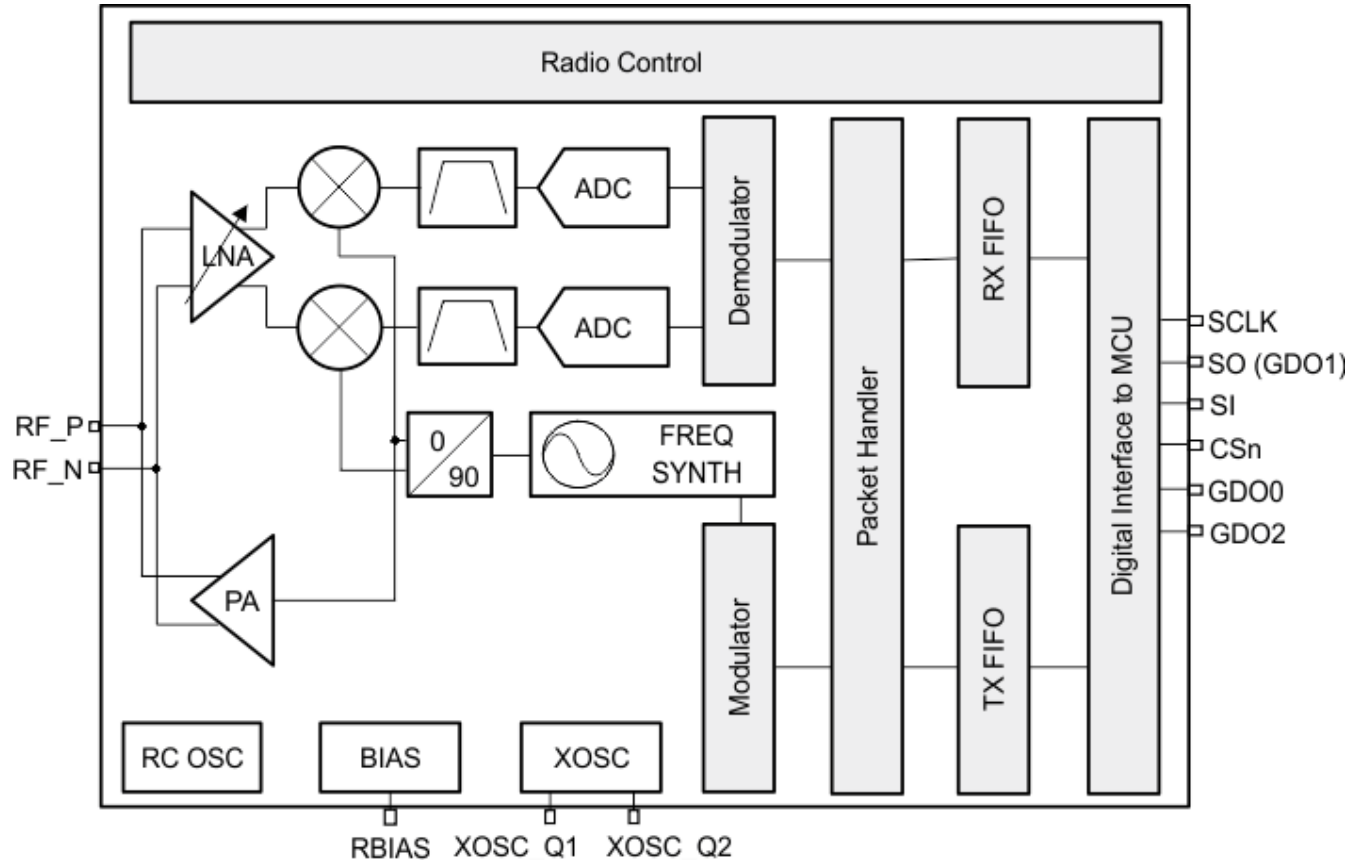
# Example: Accelerometer



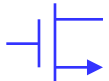
[Lemkin, JSSC 4/1999]



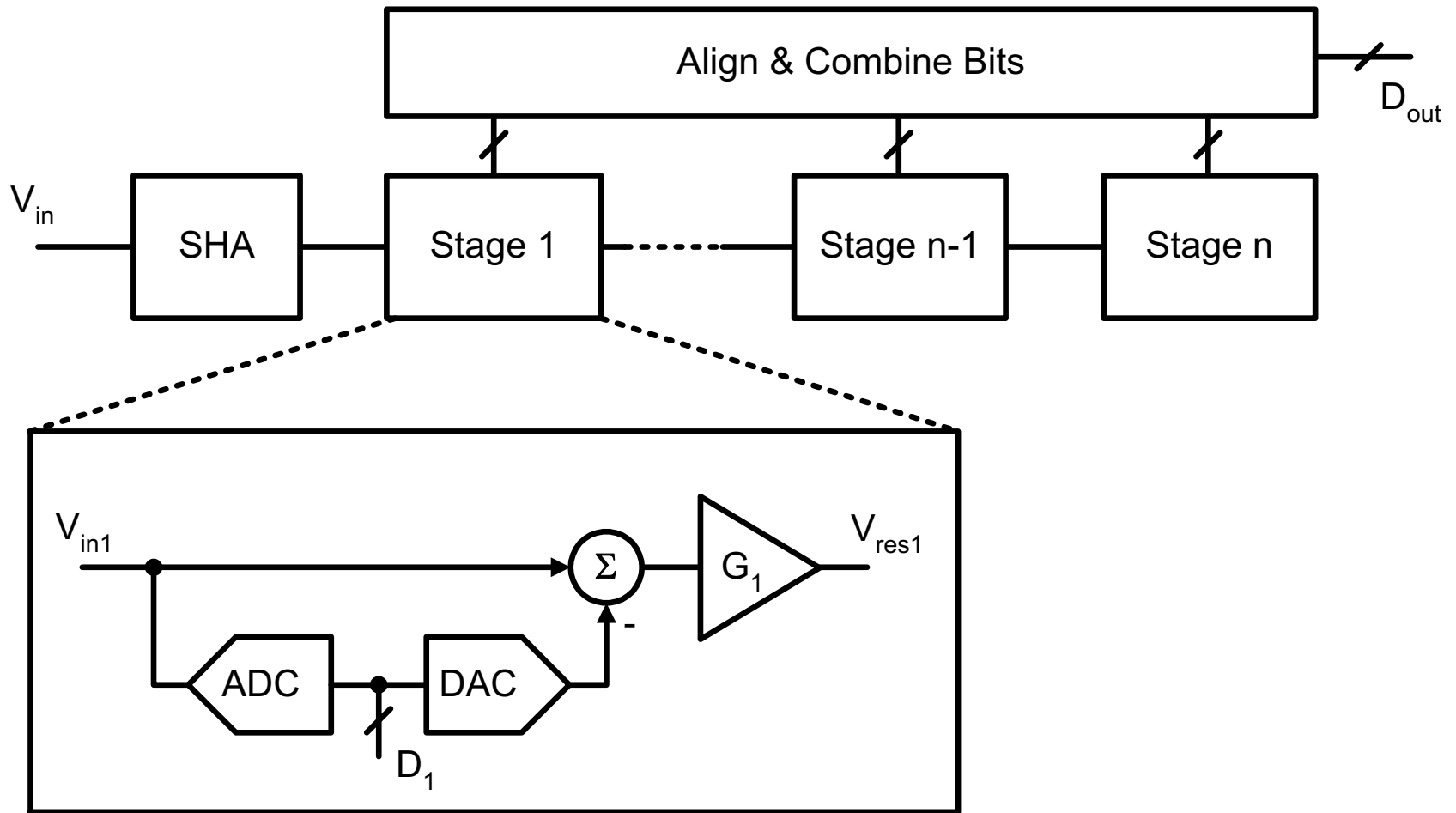
# Example: RF Transceiver



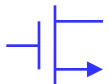
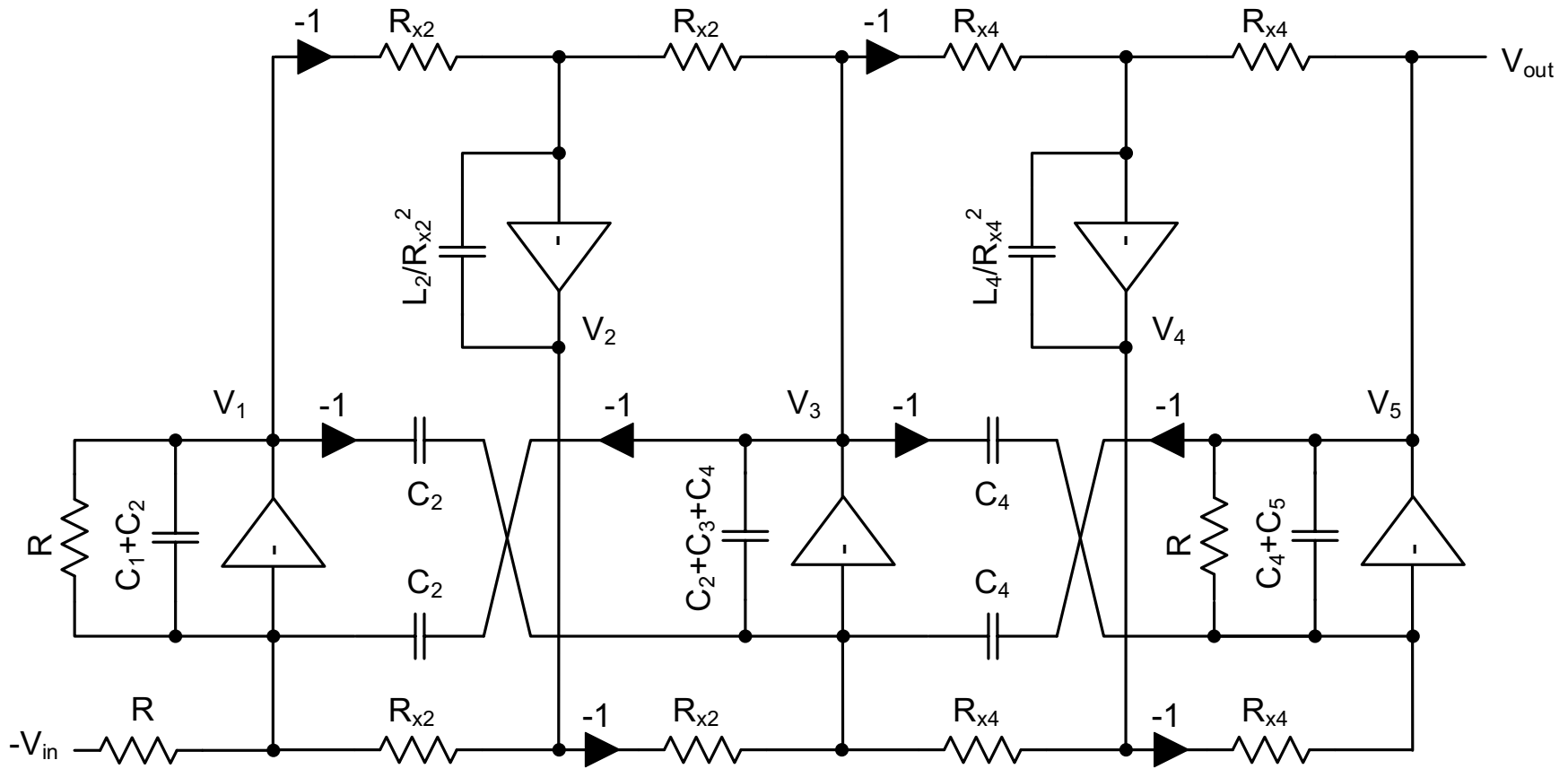
<http://www.ti.com/product/CC110L>



# Example: Pipeline ADC



# Example: Electronic Filter



# Course Overview

---

## EE 240B: Building Blocks

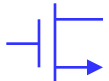
- Amplifiers
- Comparators
- References
- MOS S/H
- Device Models
- Noise
- Feedback

## EE 240C: Analog Functions

- A/D & D/A Converters
- Analog Filters

## EE 241: Digital Circuits

## EE 242: RF Circuits



# Advanced Analog Integrated Circuits

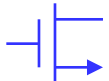
## Amplifier Design

Bernhard E. Boser

University of California, Berkeley

[boser@eecs.berkeley.edu](mailto:boser@eecs.berkeley.edu)

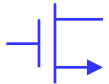
Copyright © 2016 by Bernhard Boser





# Design Considerations

---



# Hierarchical Design

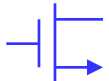
---



# Good Hierarchical Design Strategies

---

- Start from high level abstraction
  - Add details later
- Establish early that specifications are met
  - When architectural changes are still feasible
  - Rework is minimal
- Are predictive
  - No drastic performance degradation during design process
  - Hmm ...

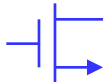


# (Amplifier) Design High Level Objectives

---

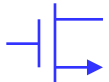
**Specifications**

**Figures-of-Merit**



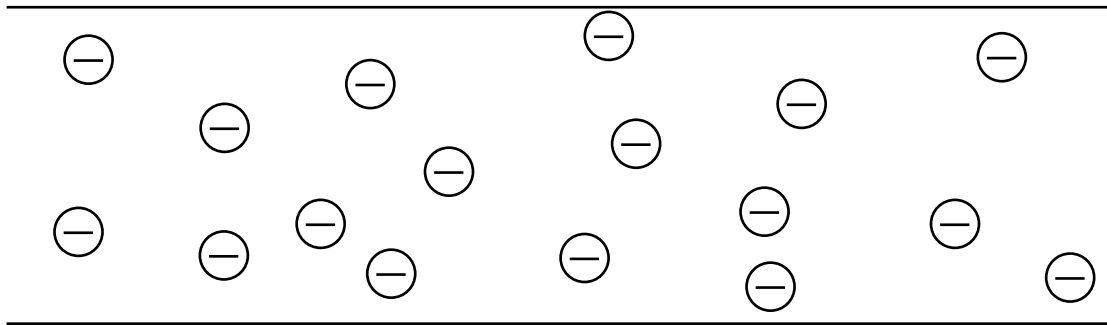
# Dynamic Range Comparison (Example)

---



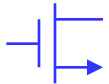
# Electronic Noise

- Random agitation of electrons at finite temperature



# Information

---



# Advanced Analog Integrated Circuits

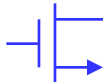
## Administrative

Bernhard E. Boser

University of California, Berkeley

[boser@eecs.berkeley.edu](mailto:boser@eecs.berkeley.edu)

Copyright © 2016 by Bernhard Boser

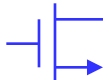




# Administrative

---

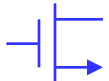
- Instructors:
  - Prof. Bernhard Boser, [boser@eecs.berkeley.edu](mailto:boser@eecs.berkeley.edu)
  - Efthymios Papageorgiou, [epp@berkeley.edu](mailto:epp@berkeley.edu)
- Websites
  - <http://bcourses.berkeley.edu>
  - <http://www.eecs.berkeley.edu/~boser/courses/240B>
- References
  - Gray, Hurst, Lewis, Meyer, *Analysis and Design of Analog Integrated Circuits*, Wiley.
  - Carusone, Johns, Martin, *Analog Integrated Circuit Design*, 2<sup>nd</sup> Edition, Wiley, 2011.
  - Course website



# Schedule Variances

---

- Tuesday, February 7: ISSCC – no class
- Thursday, March 16: Midterm (in-class)
- Thursday, April 27: Final (in-class)
  
- Please inform instructor(s) within two weeks if you have conflicts or need special accommodations

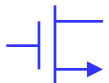


# Prerequisites

---

1. Small signal circuit analysis
2. Feedback analysis, stability criteria, phase margin
3. Bode plots

... such as covered in EECS 240A.



# Advanced Analog Integrated Circuits

## Part I

Bernhard E. Boser

University of California, Berkeley

[boser@eecs.berkeley.edu](mailto:boser@eecs.berkeley.edu)

Copyright © 2016 by Bernhard Boser



# Hierarchical Design

---

- Electronic Noise
- Device Modeling for Design
  - Design metrics:  $g_m/I_D$ ,  $f_T$
- Basic Transistor Amplifiers
  - Bandwidth, Dynamic range, Power dissipation
- Switched-Capacitor Gain Stage
- Single-stage Operational Transconductance Amplifiers
  - Settling time and accuracy
- Multistage Operational Transconductance Amplifiers
  - Frequency compensation

