Engineering Tripos Part IIB, 4B21: Analogue Integrated Circuits, 2019-20

Module Leader

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Lab Leader & Lecturer

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Timing and Structure

Michaelmas term. 16 lectures (including examples classes and case studies). Assessment: 100% exam

Prerequisites

3B1, 3B2, 3B5 assumed; 3B3, 3B6 useful

Aims

The aims of the course are to:

- Provide a firm foundation and problem-solving skills for students to design and analyze complementary metal oxide semiconductor (CMOS) analog circuits.

Objectives

As specific objectives, by the end of the course students should be able to:

- Understand the MOSFET: Device, DC Behavior and AC/Small Signal Behavior
- Learn and master techniques for DC and small signal analysis of MOSFET circuits
- Obtain an intuitive understanding of MOSFET voltage amplfiers and their small signal behaviour
- Understand the impact of high frequency operation on MOSFET circuits
- Understand the key parameters for the design of good biasing circuits
- Understand Noise in circuits, the techniques to analyze noise in circuits
- Understand the implication of feedback and its impact on stability, noise and performance.
- Design of OPAMPs

Content

The purpose of this module is to provide firm foundation and problem-solving skills for students to design and analyze complementary metal oxide semiconductor (CMOS) analog circuits. It will cover the major aspects of the design and fabrication of analogue integrated circuits and is intended to make graduates become more competitive to a large industrial segment looking for circuit designers.

4B21: Analogue Integrated Circuits

This course will cover the major aspects of the design and fabrication of analogue integrated circuits. Topics addressed will include:

1. Introduction to MOSFETs (1L)

- MOSFET Current voltage characteristics: Linear and saturation operation, channel length modulation
- Small Signal analysis techniques: transconductance, output impedance due to channel length modulation, small signal resistance, methods to identify impedance at a node, methods to calculate gain, small signal circuit of MOSFETs?
- PMOS, NMOS, CMOS
- Scaling

2. MOSFET as a Switch (1L)

- Operation as a Switch
- Switch-capacitor circuits: Dynamics, Time constants, Parasitics - clock feedthrough and charge injection
- Charge sharing between capacitors

3. Single Stage MOS Voltage Amplifiers (4L)

- Voltage amplifiers: Single stage Topologies: Common source, common source with degeneration, common gate, common drain, cascode.
- CMOS technology and CMOS amplifiers
- Small Signal, Low frequency analysis of MOS Single Stage voltage amplifiers
- Small Signal, High frequency analysis of MOS Single Stage voltage amplifiers: Miller effect, transit frequency, dominant pole

4. MOS Differential amplifiers (2L)

- Concept and operation of Differential Amplifiers
- Analysis of MOS differential amplifiers: Differential gain, Common mode gain, CMRR
- Differential amplifiers with Active CMOS Loads: Differential gain, Common mode gain, CMRR
- Half circuit method

5. Biasing Circuits (1L)

- 2 MOSFET Current mirror
- Impact of channel length modulation
- Cascode current mirror
- Temperature Independent Biasing

6. Noise (1L)

- Noise in circuits: Charasterization of Noise, Noise spectrum
- Types of Noise: thermal noise, flicker noise, shot noise and their noise spectrum
- Noise in RC circuits.
- Noise in MOSFETs: Corner frequency, analysis of noise in MOS voltage amplifiers, calculations of output and input referred noise in MOS circuits, Signal to noise ratio.

7. Feedback (2L)

- Concept of Feedback
- Impact of Feedback on the performance of circuits

8. Operational Amplifiers (2L)

- OPAMP architectures
- Gain boosting
- PSRR, CMRR, Slew Rate

9. Nonlinear Analog Circuits (1L)

- Oscillators

11. Discussion of Example Problems (1L)

Booklists

Please see the Booklist for Group B Courses [2] for references for this module.

Examination Guidelines

Please refer to Form & conduct of the examinations [3].

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