ESE 518: Advanced Design of low-noise and low-power analog circuits

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Description: Design of advanced low-noise and low-power analog and mixed-signal integrated circuits for radiation sensors. Students will learn state-of-the-art circuit techniques for low-noise and low-power amplification and processing of signals from sensors. Examples of circuits are low-noise amplifiers, filters, stabilizers, discriminators, peak detectors, and pile-up rejectors. Applications range from medical, to security, safety, industrial measurements and physics research. As a course project, students would develop part of a front-end circuit from transistor level to physical layout using industry-standard CAD tools, and/or would participate in the experimental characterization of those or similar circuits. At the end of the course the student will own a solid background and the basic instruments to design low-noise and low-power amplifiers and processing circuits.

Student Learning Objectives: To provide the student with a solid background and the basic knowledge for enabling the design low noise and low-power front-end circuits. Students will learn how to design a charge amplifier and filter and how to optimize it for the highest signal-to-noise ratio. Students will learn how to analyze the system in the frequency and time domain and how to properly size the active and passive components.

Textbook: Not Required
Recommended reading: Angelo Rivetti
"CMOS: Front-End Electronics for Radiation Sensors"
CRC Press 2015

Outline

1. Overview of radiation detection systems and their applications
2. Radiation sensors
3. Signal formation and processing
4. Noise in sensors, transistors, and amplifiers
5. Front-end
   a. Input transistor optimization
   b. Low-noise and low-power amplifier configurations
   c. Low-noise charge amplification
6. Filtering
   a. Time-variant filters
   b. Time-invariant filters
   c. Baseline stabilizers
7. Processing for extraction
   a. Amplitude discrimination
   b. High-rate photon counting
   c. Peak detection
   d. Time detection
   e. Pile-up rejection
8. Multiplexing and interfaces
9. Scaling and radiation tolerance
10. Examples of front-end ASICs