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

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Course Description - This course focuses on the design of low-noise and low-power circuits in CMOS for the readout of signals from sensors, with particular attention to capacitive sensors. The student will learn fundamentals and state-of-the-art techniques for low-noise amplification and analog processing. Circuits include low-noise voltage amplifiers and charge pre-amplifiers, optimum semi-Gaussian filters, analog stabilizers, low-noise discriminators, peak amplitude detectors, timing detectors, counters, and pile-up rejectors. The application of the acquired knowledge is relatively broad, ranging from medical imagers to security and safety systems, industrial instruments and physics research. A project will be assigned where student are asked to design a basic front-end circuit from transistor level to partial physical layout. At the end of the course the student will own a solid background and the basic instruments required to design low-noise and low-power front-end amplifiers and high-resolution analog processing circuits.

Course Outline

- Capacitive sensors and radiation sensors
- Signal formation and electronic noise sources
- Low-frequency noise and dielectric noise
- Signal-to-noise ratio and equivalent noise charge
- Frequency-domain noise analysis
- Low-noise voltage amplifiers and charge amplification
- Input transistor optimization and other noise contributions
- Low-noise and high dynamic range filter design
- High-precision analog and mixed-signal processing circuits
- Time-domain noise analysis of time-variant circuits
- The noise weighting function
- Time-variant filters, gated integrators and correlated double sampling
- Low-frequency noise in time domain
- The ideal filter

Recommended textbook Angelo Rivetti
"CMOS Front-End Electronics for Radiation Sensors"
CRC Press 2015

Learning Outcomes - The student will acquire the following abilities

- understand signal and noise, and identify electronic noise sources
- formulate and resolve a low-noise design
- optimize a design for maximum signal-to-noise ratio
- perform frequency-domain and time-domain analysis
- apply knowledge in mathematics to resolve an electronics engineering problem

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