ELECTRONICS
PROF. ALESSANDRO SPINELLI

Objective of the course

This is a course devoted to mastering techniques for signal recovery from noise in modern acquisition systems. In a blend of electronics, physics and signal processing we will study amplifiers, sensors and signal conditioning techniques, keeping an eye on both their physical/theoretical working principles and their real characteristics. Students are expected to gain skills on the design of relatively simple data acquisition systems and on the selection criteria of their various components.

Detailed program

Operation amplifiers (20h): voltage and current amplifiers, input and output impedances. Negative feedback and application to amplifier design. Elementary linear stages and impedances. Real OAs: DC and AC parameters. Instrumentation amplifiers and CMRR. Frequency response of OA circuits, stability of the feedback loop and frequency compensation. Capacitive loading of OA stages.

Sensors (7h): signal readout from resistive sensors: single-ended and differential signals, Wheatstone bridge and balancing, 2-, 3- and 4-wire connections. Temperature compensation.

Noise (8h): signals and noise in time and frequency domains. Autocorrelation and power spectral density. Thermal noise in resistors, Nyquist derivation. Shot noise and Poisson random process model. Flicker noise. Noise in linear circuits and OAs, equivalent input noise. Noise factor and figure, signal-to-noise ratio (S/N). Feedback and noise.

Signal recovery (25h): the case of white noise: low-pass and time-variant filters. Weighting functions. Gated integrators and improvement of S/N. Boxcar averagers and ratemeters. Discrete-time filters and their representation in the frequency domain. Comparison between continuous- and discrete-time filters. Optimum filtering.
The case of low-frequency noise: high-pass filters and effect on pulsed signals. Baseline restorers. Amplitude modulation and synchronous detection. Lock-in amplifiers, analog and digital LIAs.

Textbooks

S. Franco, “Design with OAs and analog ICs”, 4th ed., McGraw Hill, 2015. ISBN 978-0-07-802816-8. Chapters 1-3 and 5-8.
I. Rech, G. Acconcia, "Signal recovery". Chapters 1-18. Available at
https://rech.faculty.polimi.it/wp-content/uploads/LibroCompleto.pdf
Lecture slides are available on the class website (spinelli.faculty.polimi.it/class/ele/ele.html).
You can find these and other updated info in the class Overview file.

Examination

Students are required to pass a written exam. Texts and solutions of previous examinations are available on the instructor’s website.