Low Power CMOS Interface Circuitry for Sensors and Actuators

This thesis is concerned with the design of integrated CMOS circuits applicable for transducer interfacing. The project entry-point is the development of circuitry suitable for biomedical implantable sensors/actuators for neural prosthesis. Implantable sensor outputs are characterized by very weak signals at a relatively low bandwidth. Typically for the nerve-cuff electrode, these signals have a magnitude of only a few µV over a 4 kHz bandwidth, making pre-amplification an absolute necessity prior to any further processing. To this end, we have developed two prototype nerve signal instrumentation amplifiers characterized by high, well-controlled gain and low noise performance. The first version achieves low noise performance, comparable to bipolar designs, by careful dimensioning of the input stage. The second version addresses some drawbacks of the first design and employs more advanced design solutions for improved noise performance (chopper modulation of the amplifier input stage).

Prior to further processing of the nerve signals, quantization is done. To accommodate quantization, a data converter of the sigma-delta type has been analyzed, optimized and implemented according to the specifications put forth by the recorded nerve signals. The main concern in the optimization task was the required low power consumption of the data converter. For nerve stimulation, current pulses are used. For this purpose, current-steering digital to analog converters are useful due to their ability to directly convert a digital input word to an output current for stimulation. The D/A circuit implemented in this work, was however not aimed at implanted actuator applications, but rather high-speed, high-accuracy demonstration purposes. Although not intended for implantable circuits, the current-steering D/A principle is easily scaled for other requirements and the developed design techniques remain valid.

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