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ENERGY EFFICIENT SAMPLING AND CONVERSION OF BIO-SIGNALS USING TIME-MODE CIRCUITS

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ABSTRACT

With the continuous developments in science and engineering, specifically in the fields of electronics and manufacturing, implantable electronic devices have become a reality during the last decades. Implantable electronic devices have hard design constraints: 1) As small size as possible to reduce tissue damage, 2) Minimum heat generation to protect the surrounding tissue, and 3) Minimum energy dissipation as these devices are mostly operated using a small battery or wireless power transfer.

The advancement and scaling of CMOS technologies has always been based on improving the performance of digital systems. With each new technology node, the threshold voltages of the available MOS transistors and the supply voltage of the process node is scaled as well. Scaling of the supply voltage reduces the headroom that is available to the transistors for operating in the region. Even though reducing the supply voltage reduces the energy dissipation, without transistors operating in the saturation region, it is very hard to realize signal processing and amplification functions in the analogue domain.

To address the mentioned hard constraints of implantable electronic device design, we propose time-mode circuits for energy efficient sampling and conversion of bio-signals in advanced process technologies. The types of circuits we are proposing benefit both from voltage scaling and smaller size of advanced process nodes while being able to process digital signals with analogue accuracy, i.e., time-mode circuits represent an analogue signal by the time difference between two binary switching events. For example, when compared to standard digital CMOS circuit operation, to transfer N bits of data in parallel, the number of switchings required may change from 0 to N in standard CMOS, while it always takes time-mode circuits two switching if the rising and falling edges of a pulse is used for signal representation.

Based on these observations, we designed a bio-signal sampling and conversion system that consists of an analogue-to-time converter (ATC) followed by an asynchronous time-to-digital converter (A-TDC). The ATC converts the sampled bio-signal to a time-pulse with a high analogue-to-time conversion gain, and the A-TDC resolves this generated pulse to a digital value, completing the sampling and conversion process. We will present the design process and simulation results of such an implementation that operates with a supply voltage of 0.6V in a standard 0.18um process.

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