Time-to-Digital Converters in Sigma-Delta Modulators

Analog-to-Digital Conversion (ADC) is usually performed by quantizing the voltage amplitude of the analog signal. For an N-bit resolution ADC: $2^N$ quantization levels are required. Knowing that in recent CMOS technologies, the supply voltage is about 1.0 V, there are currently two major problems in realizing conventional voltage amplitude quantizers: - It is very difficult to achieve comparison levels with a precision of (supply voltage) / $2^N$. - It is very difficult to achieve comparators sensitive to voltage variations in the order of (supply voltage) / $2^N$. To overcome these problems, we propose the use of Time-to-Digital Converters (TDC). The idea of these converters is to make a Time-quantization using Voltage-Controlled Oscillators (VCO). In fact, the VCO output is a time-domain signal whose frequency depends on the VCO analog input voltage. A quantized output may be obtained by counting the number of transitions in a given clock period. There has been very compact and low-power implementations of this type of ADCs [Daniels2010]. In this Ph.D., we are mainly interested in including this type of ADC as a multi-bit quantizer inside a Sigma-Delta modulator [Gaber2010]. This Ph.D. work will include: - A theoretical part on the mathematical model of Continuous-Time Sigma-Delta with a VCO-based quantizer - A practical part on the design and implementation of this ADC in an advanced CMOS process. - Measurement of the fabricated chip [Daniels2010] J. Daniels, W. Dehaene, M. Steyaert, A. Wiesbauer, "A 0.02mm2 65nm CMOS 30MHz BW all-digital differential VCO-based ADC with 64dB SNDR", IEEE VLSI Circuits Symposium, VLSIC, 2010. [Gaber2010] W. Gaber, M. Allam, H. Aboushady, M.M. Louerat and E. Eid, "Systematic Design of Continuous-Time Sigma-Delta Modulators with VCO-Based Quantizers", IEEE International Symposium on Circuits & Systems, ISCAS, 2010.

This work requires deep understanding of the following topics: - Voltage-Controlled-Oscillators - Sigma-Delta Analog-to-Digital Converters - Integrated circuits design in advanced CMOS technologies (65nm and beyond)

In this topic, we collaborate with the Brazilian Space Agency (INPE) and the Federal University of Rio Grande do Norte, Natal, Brazil.