

# Number of Oscillation Cycles (NOC): A New Paradigm for VCO-based Comparison

*Abstract*—SAR ADCs are coming of age due to the mostly digital implementations where the benefit of advanced CMOS technologies can be generally brought into ADC designs. Time-domain signaling is also promising since the speed and time resolution are both scaling favorable. Therefore, the SAR ADCs with time-based comparator have attracted significant interest in recent years. Nevertheless, comparing with oversampled converters where the unique property of VCO, the first-order noise shaping, has been used to enhance the system, Nyquist converters uses only the bit decision of time-base comparison. This talk introduces the concept of oscillation-cycle information in VCO-based comparators. With rigorous analysis, the number of oscillation cycles (NOC) can be generally exploited as a parallel coarse quantization with a large signal, and/or as a quantitative indication of metastability with a small signal. Moreover, the NOC is inherent and of little cost in hardware, power and area. The demonstrated VCO ADCs exhibit significantly enhanced linearity and robustness, comparing with their voltage-domain counterparts. This talk discusses also a closed-form metastability analysis of VCO-based comparator, introducing the metastability depth as a quantitative measure of metastability.