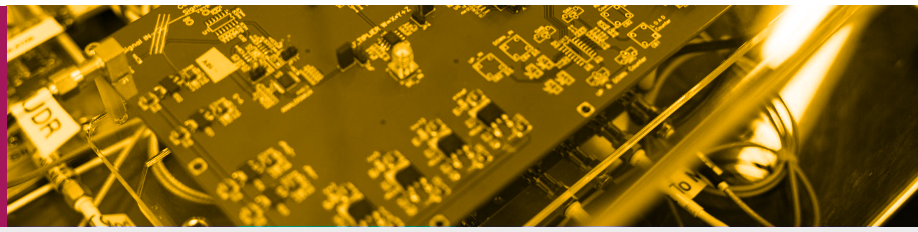
WEIZMANN INSTITUTE OF SCIENCE

SAMPLLAB
Signal Acquisition Modeling Processing and Learning

GREEN **ADC's**

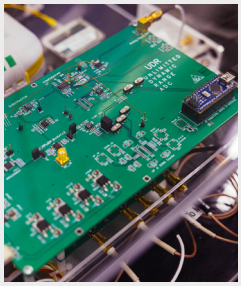


Energy-Efficient Sensing Hardware for Sustainable Information Processing Systems

As the demand for sustainable technology rises, energy-efficient sensing hardware becomes crucial. This project focuses on Analog-to-Digital Converters (ADCs), which are vital for Information Processing Systems (IPS). Our aim is to optimize their design to save power and reduce complexity, enhancing the efficiency and sustainability of IPS applications. We propose three "Green ADCs"—Time-Encoding, Modulo, and Task-Based—designed to enhance energy efficiency and performance.
Time-Encoding-ADCs eliminate global clock dependency, simplifying design and reducing power needs. Modulo-ADCs handle high dynamic ranges with a non-linear operator, minimizing dynamic range demands. Task-Based-ADCs tailor quantization to specific tasks, lowering complexity and power use. Exploiting signal structure, these ADCs enable sub-Nyquist sampling, advancing sustainable IPS technology.

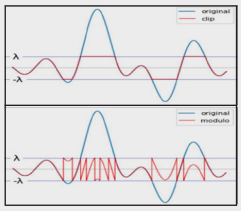
1 Time Encoding Machine (TEM)

By eliminating the need for a global clock, the Time Encoding Machine enables asynchronous ADC operation through irregular sampling based on integral crossings. This design captures signal information while reducing both power usage and bit requirements while preserving all the information needed to recover the signal. We focus on the Integrate and Fire Time Encoding Machine (IF-TEM) method to achieve power savings, especially for structured signals like Finite Rate of Innovation (FRI) and variable-pulse-width (VPW) signals that are popular in biomedical applications.



2 Unlimited Dynamic Range Modulo ADC

To handle High Dynamic Range (HDR) signals efficiently, the Modulo ADC leverages a non-linear modulo operator, converting HDR signals into digital bit sequences while requiring only low dynamic range hardware and reduced number of bits. We are developing robust unfolding algorithms to ensure accurate HDR signal recovery from the samples, even at low sampling rates, thereby reducing the power and bit demands of the ADC.



3 Task-Based Quantization

This initiative introduces task-specific quantization techniques, adjusting quantization rates to the needs of tasks to maintain signal fidelity while minimizing power consumption. Using an analog combiner, this approach performs optimized quantization during sampling, thereby reducing bit usage and memory load in digital signal processing applications.
All the ADCs above can exploit signal structure to enable sub-Nyquist sampling in various signal settings.

SUMMARY

This research seeks to push the boundaries of energy-efficient sensing hardware through three projects: the Time Encoding Machine for asynchronous ADC operation, the Unlimited Dynamic Range Modulo ADC for efficient HDR signal processing, and task-oriented quantization methods. Together, these projects position Green-ADC technology as a key driver in the evolution of sustainable, high-performance IPS solutions.

Prof. Yonina Eldar

Faculty of Math & CS, Weizmann institute of Science
08-9343702 | yonina.eldar@weizmann.ac.il