# Voltage Sensing, Voltage Monitoring

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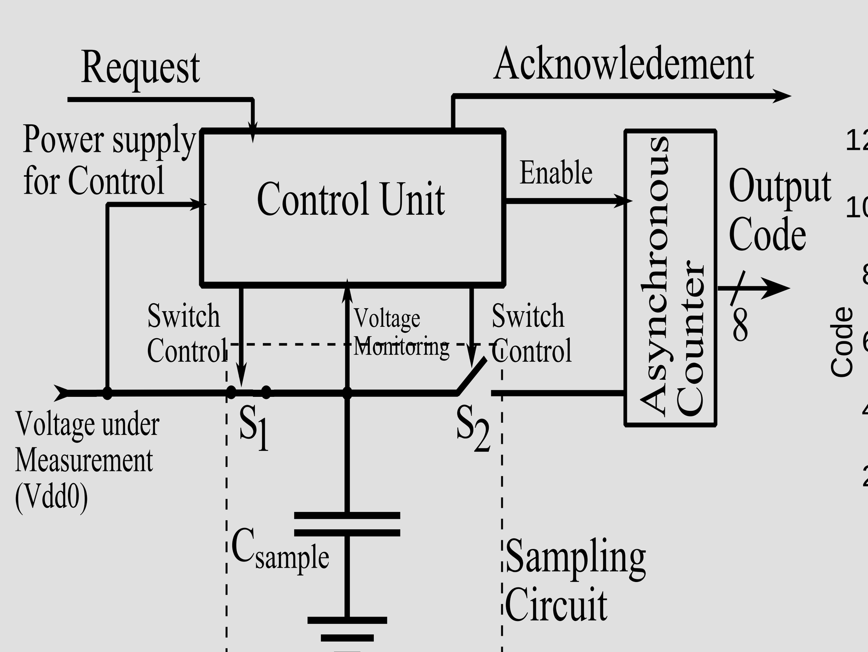
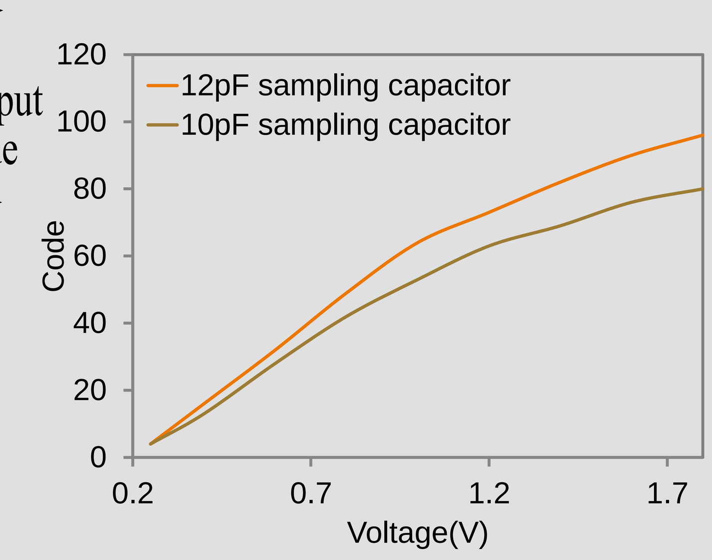
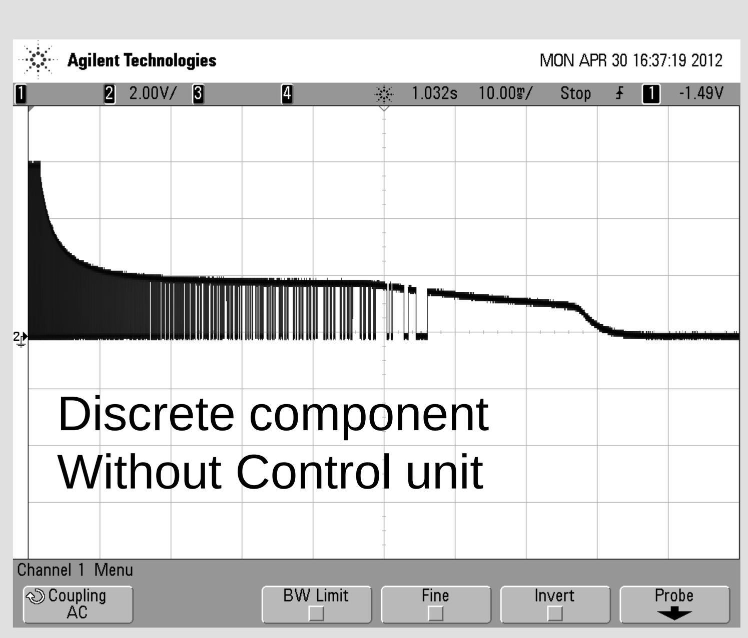
***We propose a range of on-chip solutions for sensing and monitoring, such as highly variation-robust and non-invasive voltage sensors and monitors.***

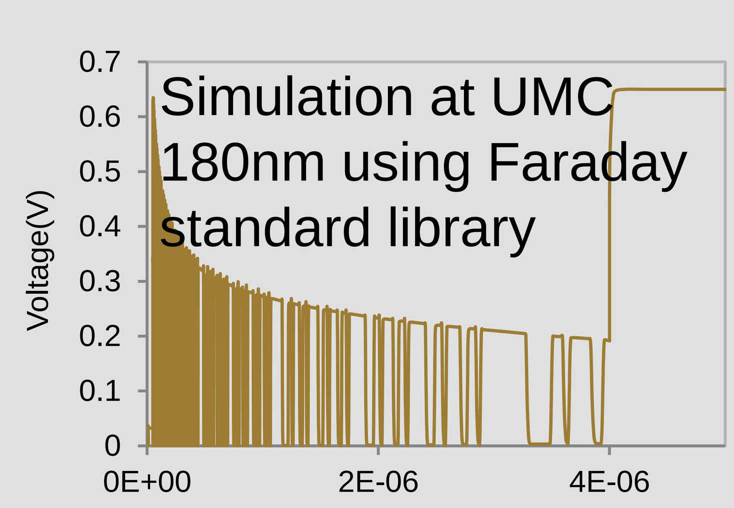
## How we sense?

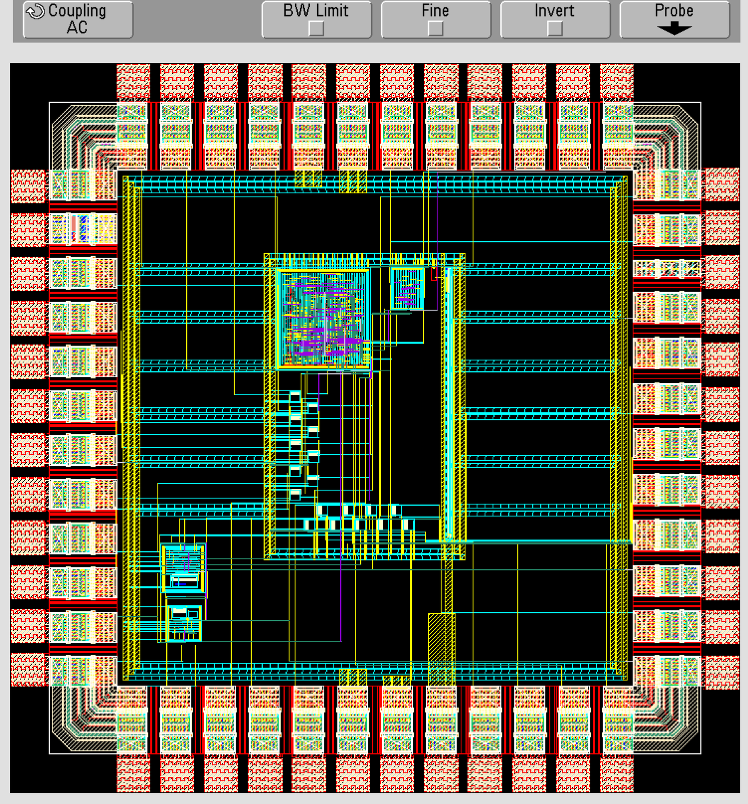
Our approach to voltage sensing is based on the use of the principle of power-modulated computing [1]. This principle is essentially based on the fundamental ways of converting electrical energy into computational activity in a maximally proportional way. Our voltage sensors and monitors avoid using conventional A-to-D converters. Why? First of all, conventional ADCs are usually designed to deliver high accuracy measurements of electric signals in order to perform high quality signal processing. For on chip measurement of voltages is an over-kill because the decisions about resource management do not require that level of accuracy of measurement. Secondly, conventional ADCs require almost perfect conditions for their operation, such as stable power sources, timing and voltage references. Thirdly, conventional ADCs occupy large area, power costly and slow in response for the needs of on-chip use.
Foundation of our proposed sensing method is established on two bases; sampling energy into storage and mapping this energy into a code [2].



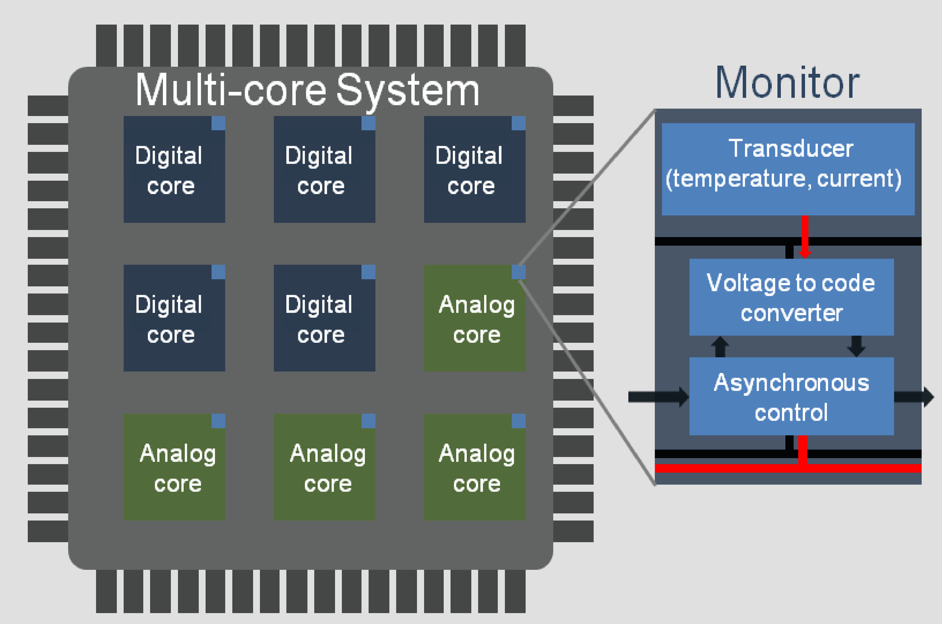



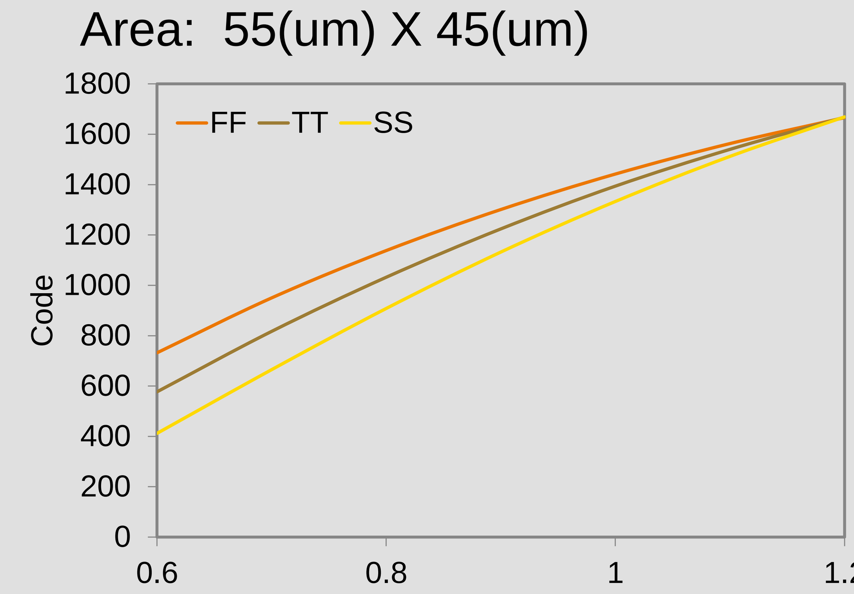
(Mixed-signal design operating at subthreshold region), taped out on 16th of April**.**
Contains a reference free voltage sensor [2], Asynchronous PWM generator, voltage shifters and an intelligent power unit in order to design a reference free buck converter. The system has been specially characterized to operate under unstable energy conditions. The chip has been taped out using Faraday 180nm technology node.

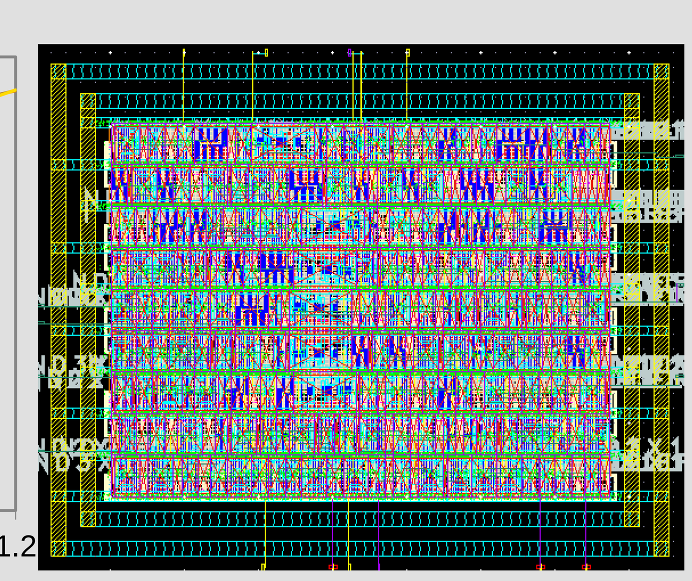
The main criteria for on-chip measurements are *levels of accuracy that are good enough to make decisions, high robustness to PVT variations, low area and power costs, fast response.* All these criteria are satisfied by our voltage sensing solutions.




They are based on the careful use of elastic digital circuits. These circuits present a natural way of proportional conversion from their supplied voltage to their switching activity for a wide range of voltages. The proportionality can vary from linear to nearly linear, depending on the required voltage ranges, and with suitable calibration can produce sufficient levels of accuracy. The solutions are non-invasive because they draw very little current and occupy small area, and can be placed anywhere on chip to monitor the conditions of processing IPs. The solutions are robust due to their inherent delay-insensitivity - their switching behavior is hazard-free and invariant to the values of delays in gates and many interconnects, which themselves change in response to changing supply voltages. The solutions are low energy because they only consume power when they actively perform conversion. The circuits can be implemented from standard cells available in common design libraries. The essential part of these sensors is a self-timed counter, which combines the functionality of a voltage-modulated oscillator and counter. Oscillation is performed by a closed loop embedded in the least significant bit whose pulses are passed through the frequency-dividing stages in an elastic way based on handshakes, thereby achieving accumulation of the voltage-proportional switching activity into a high density binary code.

Using UMC 90nm technology node
Conversion time 1.2us!
Dynamic power consumption: 76 uW
Cell leakage power: 7 uW
Area: 55(um) X 45(um)



## References

1. A. Yakovlev, "Energy-Modulated Computing," in *DATE'11*, Grenoble, March 2011, EDAA, pp. 1340-1345.
2. "Apparatus and method for voltage sensing," in *UK Patent Application No. 1 005 372.6*: Newcastle University, March 2010.