

Advanced System Technologies

FPGA-based high-speed ADC without external components

There is a trend to digitize analogue signals earlier in the process to reduce the complexity in analogue signal processing. An analogue-to-digital converter (ADC) is therefore essential and is often integrated directly into FPGAs or microprocessors, but often offers little flexibility. IMES has developed a new FPGA-based ADC that requires no external components, giving it high flexibility. The ADC achieves 9.3 bits resolution and 7 effective number of bits (ENOB) at a sampling rate of 600 MSample/s. An alternative version of the ADC operates at 1.2 GSample/s and achieves 5.3 ENOB.

Basic principle

The implementation is based on the ramp-compare ADC principle. The analogue voltage to be measured is first converted into a time duration and then measured digitally. A reference ramp increases linearly from a start voltage to an end value and is compared to the analogue voltage by a comparator. A time-to-digital converter (TDC) measures the time from the start of the ramp until the input voltage is reached. This time is proportional to the input voltage and is converted into a digital value that represents the original analogue voltage.

Implementation

The FPGA-based ramp-compare ADC was successfully implemented in an UltraScale+ FPGA. The analogue voltage is applied to an LVDS input of the FPGA. The internal LVDS comparator compares the voltage of the reference ramp with the input voltage. The reference ramp is generated by the adjustable output resistance of the output driver and the parasitic capacitance of the I/O pad. The time measurement is performed by an internal TDC. It is based on a delay chain consisting of carry elements. Correction methods improve the linearity and accuracy of the TDC and thus of the ADC.

Versatile applications

Because external components are no longer required, this ADC offers the flexibility to convert almost any digital I/O of the FPGA into an ADC. In particular, the high number of digital I/O ports in today's FPGA systems makes it possible to build massive and powerful ADC arrays directly on the FPGA. Such arrays are particularly useful in measurement systems where real-time digitization of many channels is required.

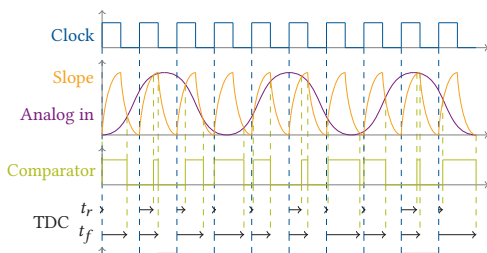


Figure 1: Functionality of the ramp-compare ADC

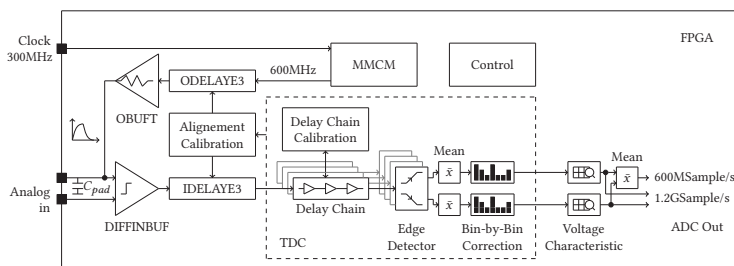


Figure 2: Block diagram of the FPGA-based ADC

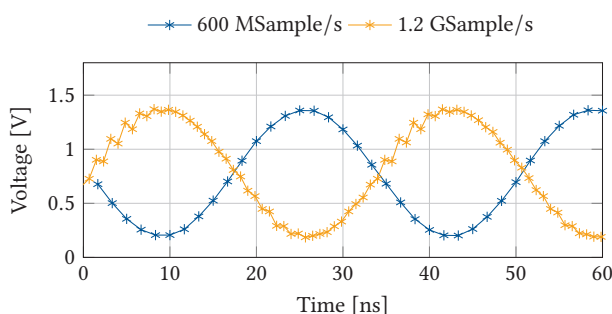


Figure 3: Measurement of a 30MHz sine wave with 600MSample/s (blue) and 1.2GSample/s (yellow)



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