Read-out analog channel with interpolator for signal peak finding

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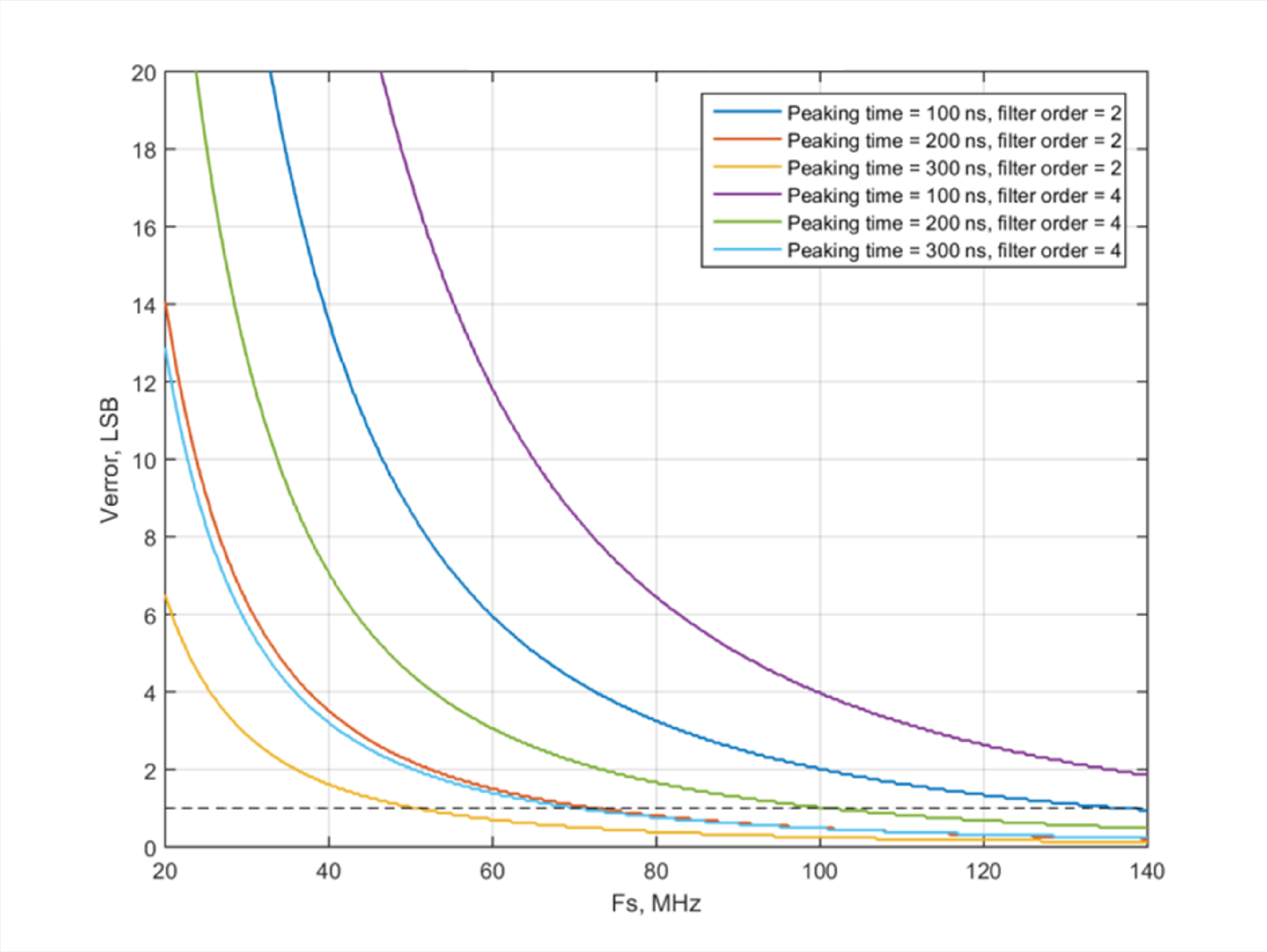
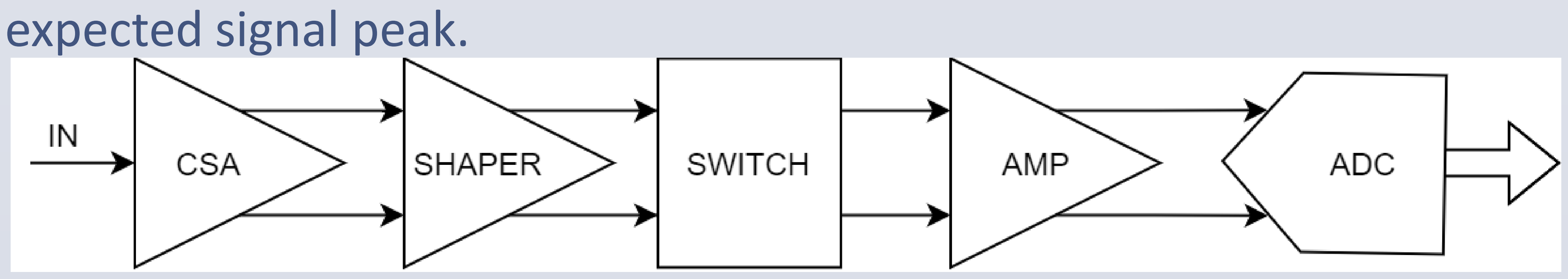
Introduction

Traditionally, an analog peak detector or digital peak detector is used to determine the maximum of signal in the analog channel. When using the digital peak detector, the error in determining the maximum depends on the ratio of the shaper peaking time and the sampling frequency of the ADC. If the signal at the channel output during the ADC sampling period changes more than by 1 LSB, then the peak detector will introduce an error when determining the maximum. Figure bellow shows the error versus sampling frequency for different peaking times and orders of shaper. An approach based on the use of interpolation to increase the signal sampling rate and reduce of the peak error determination is proposed.

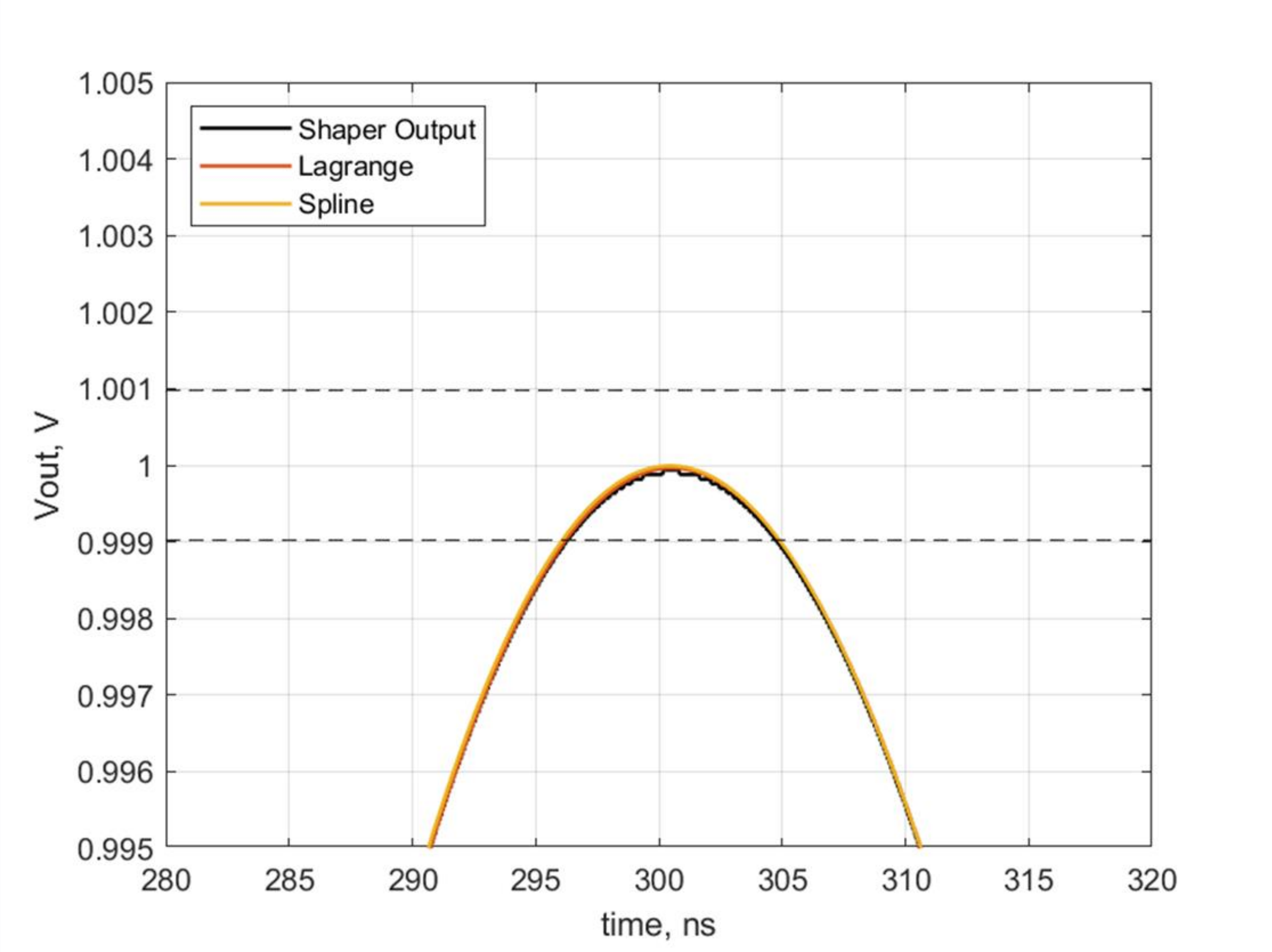


Channel Structure

A prototype analog channel with digital processing system for read-out signals coming from GEM detectors is presented. The channel consists of a CSA, shaper, switch, amplifier followed by a 10-bit ADC. Data from ADC are processed by digital system based on an interpolator for finding the signal peaks in the digital domain. Interpolation allows to find the fit curve function, which passes through a given set of points. Knowing function, it is possible to calculate the intermediate values near the expected signal peak.

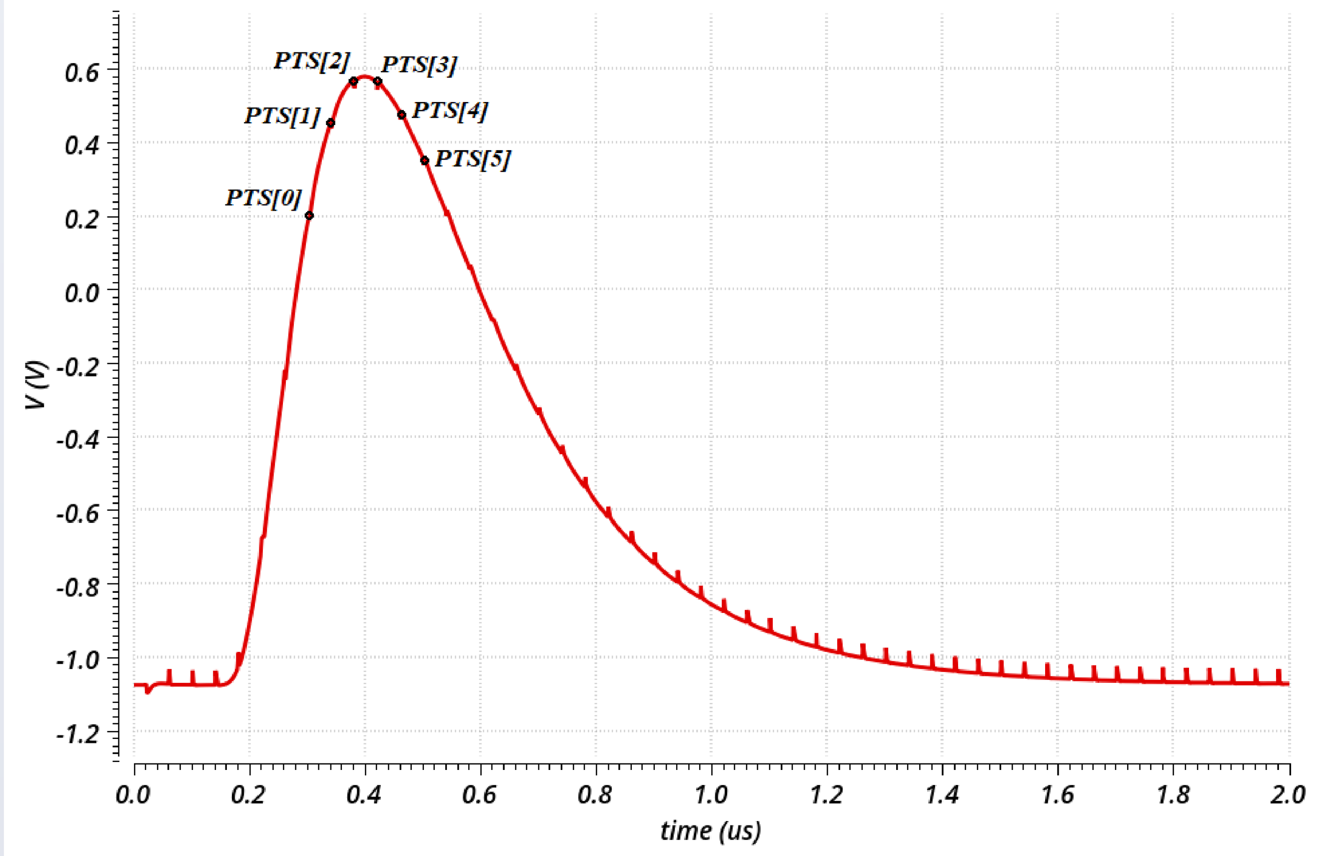


In order to select an interpolation algorithm several known approaches were considered. An interpolation of Lagrange polynomials has been chosen for implementation. The interpolator uses the 6-th order Lagrange interpolation polynomial. It keeps the accuracy of finding the signal peak within 1 LSB of the ADC working at sampling frequency of 25 MHz and 200 ns shaper peaking time in math simulation.



Simulation and implementation

The data coming from the ADC to the interpolator is synchronized and written to a 6-word ring buffer. If the data matches the signal amplitude ratio pattern: PTS [0] <PTS [1] <PTS [2] ≥PTS [3]> PTS [4]> PTS [5], where PTS [i] is the ADC counts, the interpolator calculates values at intermediate points, between samples PTS [1] and PTS [3]. To achieve the required level of accuracy of one LSB, the values are calculated at three intermediate points between adjacent samples. This allows to increase the actual sampling rate of the ADC by 4 times. Further in the cycle, the calculated value is compared with the previous maximum, and in case the current value is less than the previous one, the maximum is fixed and cycle stopped.



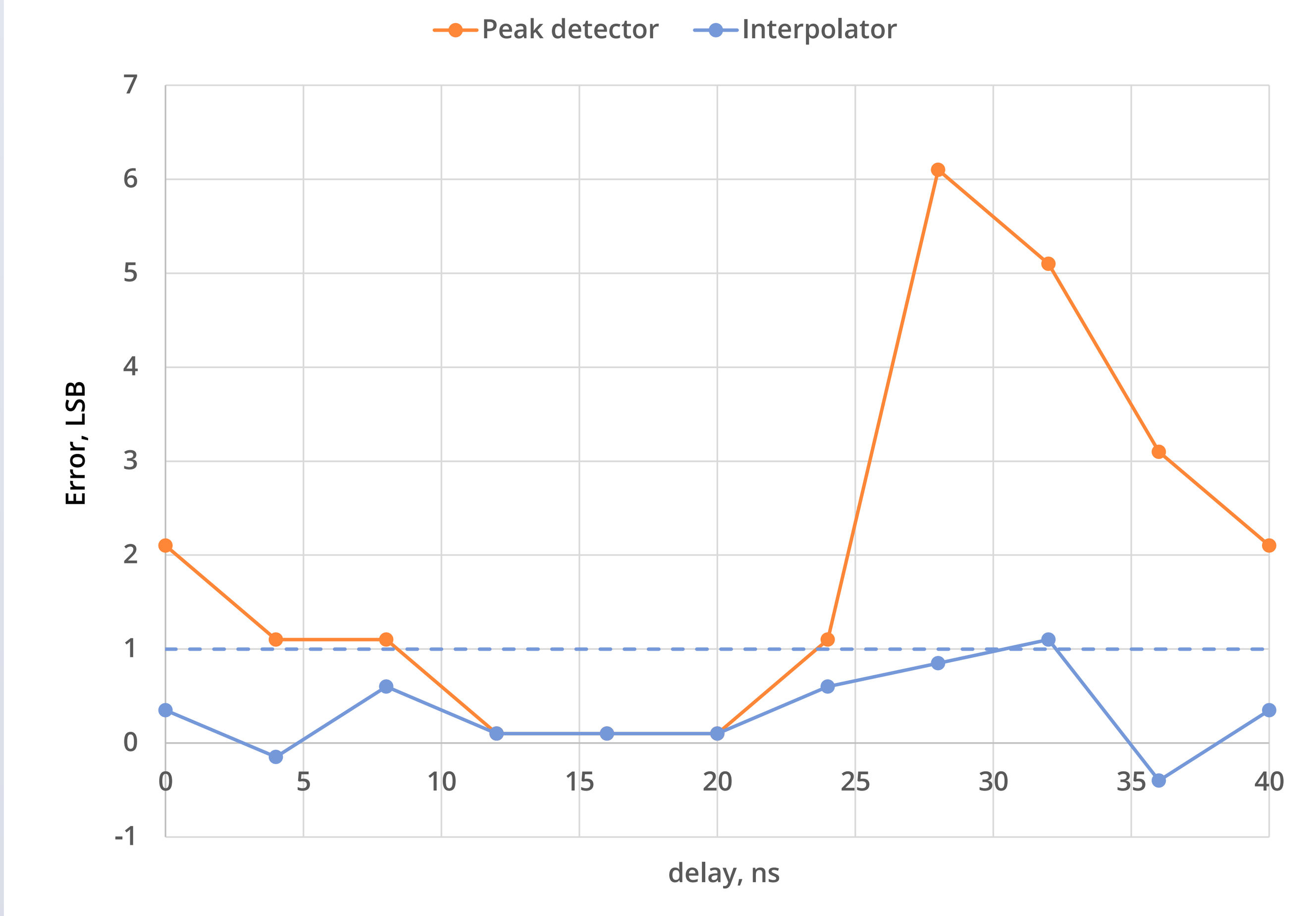


Figure above shows the error of peak determination versus the shift of the signal peak relatively to the ADC start of conversion for digital peak detector (orange line) and interpolator (blue one). For shaper signal with peaking time equal to 270 ns, the maximum error in determining the peak without using the interpolator is 6.1 LSB, whereas with the interpolator – 1.1 LSB.

The analog channel and interpolator were designed in UMC 180 nm CMOS MMRF process.

Conclusion

The read-out analog channel with interpolator for signal peak finding was studied. Using of the interpolator improves the accuracy of determination of the maximum in the analog channel to 1.1 LSB at 25 MHz ADC sampling frequency and 270 ns peaking time of the 2-nd order shaper.

Acknowledgments

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