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Direct pre-amplifier sampling ADC for high- count rate and high-resolution X-ray spectroscopy

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Direct pre-amplifier sampling ADC for high- count rate and high resolution X-ray spectroscopy
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3 CAEN SpA, Viareggio, Italy Abstract**
This study introduces a novel technique for digital signal processing from X-ray detectors, such as silicon drift detectors, aimed at supporting high rates while maintaining excellent resolution.
Traditional high-rate detectors for X-ray or gamma applications, connected to transistor reset preamplifiers, face challenges in signal acquisition due to the large voltage ramp produced, which greatly exceeds the amplitude of the signal of interest. To address this, we utilized a 20-bit SAR ADC capable of sampling the signal directly from the preamplifier with a dynamic range of 1 to 1 million, allowing effective capture even with the presence of a voltage ramp.
We designed a system using four ADCs in interleaving mode to achieve a combined sampling rate of 160 Msps. The readout and control logic were managed by a Zynq SoC, interfacing with the ADCs. The firmware developed includes phase and gain correction for interleaving ADC, trapezoidal filter and readout PC interface logic.
Preliminary measurements were conducted with the Ardesia detector at the Polytechnic University of Milan. The tests, although initial, have shown that the resolution achieved surpasses that of traditional methods using analog reshaping. We performed measurements at both low and medium rates, achieving an optimal resolution (FWHM) of 128 eV at a peaking time of 2μs. A faster peaking time configuration tested for reduced dead time yielded a resolution of 140 eV at 1 Mcps.
These findings highlight the potential of our digital processing approach, which could offer improved resolution and efficiency in X-ray detection systems, especially beneficial for high-count rate applications in scientific environments such as synchrotron facilities.

References

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