

Comparison of Two CMOS readout chains for a 330x330 μm^2 pixel aiming at spectral CT medical applications

Spectral Computed Tomography (CT) based on Photon-Counting Detectors (PCDs) is an emerging technology [1] that provides 3D images on multiple energy channels (typically between 2 and 8 energy bands). The main challenge for PCDs is to achieve good spectral accuracy while maintaining reliable performance at high-count rate.

The classic architecture of a PCD utilizes a CdTe crystal hybridized to a CMOS readout ASIC. Each pixel readout chain contains an analog front-end that transforms the incoming charge into a voltage pulse whose amplitude is an image of the detected photon energy. This amplitude is digitally converted at the pixel level thanks to several comparators, each comparator having its own threshold and feeding its own counter.

This paper focuses on the comparison between 2 readout chains that can be implemented in a 330x330 μm^2 CMOS pixel.

Two types of analog front-end are considered: one with our previously described Capacitive Transimpedance Amplifier (CTIA) with a “hard-reset” [2] and one with a Resistive Transimpedance Amplifier (RTIA). We will give a performance comparison of the front-end circuit variants, and discuss the impact of the choice of amplifier type on the remaining blocks of the readout chain, such as the leakage current compensation technique (BaseLine Holder or BaseLine Restoration) and the charge sharing correction (Analog Summing or Digital Summing). Moreover, thanks to a test-chip using the TSMC 0.13 μm process, some experimental results are given. A good performance of the circuit in terms of speed and low power consumption is obtained. For a steady equivalent flux of 20Mcps, we evaluated the power consumption at 2.8mW/mm² and a deadtime of 26ns (CTIA) and 23ns (RTIA) for an input capacitance in the order of 200fF.

Given these positive results, we plan to connect the circuit to a CdTe crystal sensor and characterize the detector under X-ray condition.

References

- [1] R. Ballabriga et al., “Photon Counting Detectors for X-Ray Imaging With Emphasis on CT,” IEEE Trans. Radiat. Plasma Med. Sci., Jul. 2021, doi: 10.1109/TRPMS.2020.3002949.
- [2] D. Tran, A. Peizerat, and A. Brambilla, “A CMOS Readout Pixel Circuitry for Spectral-CT Applications,” in 2024 19th Conference on Ph.D Research in Microelectronics and Electronics (PRIME), Jun. 2024, doi: 10.1109/PRIME61930.2024.10559715.

Workshop topics

Front-end electronics and readout

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