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Design and optimization of the read-out electronics for high energy resolution X-ray strip detectors

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Semiconductor strip sensors applied as solid-state radiation or particle detectors can be used in radiation detection and measurement for various applications in particle physics experiments, X-ray imaging (e.g. medical), or material science. The X-ray imaging devices with spectroscopic and position resolution features are a very important research topic at many research institutes and companies worldwide [1-3]. Short strip silicon detectors are good candidates for X-ray spectroscopy, because of their relatively small capacitance and leakage current. If additionally, strip pitch is below 100 µm, then the high spatial resolution is also possible.
In this paper, the analysis and design of the read-out electronics for short silicon strip detectors with Charge Sensitive Amplifier and shaper are presented. The CSA is optimized for the detector capacitance of around 1.5 pF, and the shaper peaking time is about 1 µs (controlled by the sets of switches). We take into account the sources of noise in a radiation imaging system (current parallel noise, voltage series noise, and 1/f or flicker series noise) both internal (related to the front-end electronics itself) but also external, stemming from a sensor, interconnect, or printed circuit board parasitic components [4]. We target the noise level below 30 el. rms, considering low power consumption (a few mW) and limited channel area. To increase the speed of analog front-end electronics we take into account both continuous-time resistive CSA feedback and the application of digitally assisted analog techniques such as a digital feedback reset.

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