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Development of Low-noise High-speed Analog ASIC for X-ray CCD Cameras and Wide-band X-ray Imaging Sensors

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We report on the performance evaluation of the readout ASIC developed for onboard X-ray CCD cameras in astrophysics. The quick and low-noise readout is essential for the pile-up free imaging spectroscopy with the future highly sensitive telescope. Our goal is the readout noise of 5e- rms at the pixel rate of 1Mpix/sec, which is about 10 times faster than those of the currently working detectors. We had successfully developed a low-noise mixed-signal Application Specific Integrated Circuit (ASIC) as the front-end electronics of Soft X-ray Imager (Nakajima et al. 2013, NIMA, 731, 166; Nakajima et al. 2014, JAXA-RR-14-007) onboard the ASTRO-H satellite that will be launched in this Japanese fiscal year. However, the noise performance was limited at the pixel rate higher than 250 kpix/sec. Then we have designed and developed the new ASIC with the fourth-order Delta Sigma modulators to enhance its inherent noise-shaping performance. It was fabricated through Taiwan Semiconductor Manufacturing Company (TSMC) 0.35 um CMOS process. It consists of four identical circuits that process the CCD signal simultaneously. The input signal range of ±20 mV covers the effective energy range of the typical X-ray photon counting CCD (up to 30 keV). Our Delta Sigma circuit can also be applied to the other X-ray wide-band imaging sensors such as SOIPIX (Arai et al. 2011, NIMA, 58, 2528). We present the obtained performances of the new ASIC such as the input equivalent noise, integrated non-linearity, as well as the radiation tolerance against the single event latch-up and total ionizing dose. We also briefly report the results obtained from the integrated test with a fully-depleted P-channel X-ray CCD.

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