

Miniaturization of energetic electron sensor for future planetary explorations using ASIC

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In our solar system, the outer space is filled with plasma, a gas made up of charged particles. The origins of plasma in our solar system are the Sun and the ionized atmosphere of planets and satellites, and their energy is typically less than 10 eV. Nevertheless, high energy electrons (> keV) are observed in all planetary magnetospheres in our solar system. Some of these electrons precipitate into the atmosphere and deposit their energy. To clarify the acceleration mechanism of high energy electrons and to evaluate the effects of energetic electrons on the planetary environment are the important issues in planetary science. ~10-100 keV is key energy range because this is transition energy from thermal to non-thermal distributions of energy spectrum. Recently, APDs (Avalanche PhotoDiodes), which are detectors with high detection efficiency for ~10-100 keV electrons, have been applied to an energetic electron sensor. In this research, we aim to apply APDs to an energetic electron sensor for future planetary explorations. For planetary explorations, which place stringent limitation on payload mass, we aim to miniaturize the sensor by applying the ASIC (Application Specific Integrated Circuit) technology to analog signal processing circuits for APDs. It is composed of preamplifiers, shaping amplifiers, peak holders, and Analog-to-digital converters. We optimized ASIC to process signals from APDs and designed an ASIC so that its dynamic range and the wave form peaking time to be $\sim 10^6 e^-$ and $\sim 1 \mu s$, respectively, in consideration of the gain and the noise characteristics of the assumed detector (APD). The performance was confirmed in the simulation. We conducted layout design of the circuit to fit 5 mm×5 mm chip, which is about 100 times smaller than analog circuit board before ASIC. Furthermore, we developed the circuit to control the ASIC chip and confirmed its operation in simulation.