

Development of miniaturized pick-up amplification circuit for plasma particle detectors on board satellites

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Since space plasmas show a collision-less feature, wave-particle interaction dominates the electromagnetic environment. Observation of both particles and waves is essential to understand energy and momentum transfer mechanisms. For observations of spatially non-uniform space plasmas, it is critical to perform the formation flight consisting of multiple satellites. Recent trends of spacecraft fleet missions in the terrestrial magnetosphere such as Cluster II [Escoubet et al., 2001], THEMIS [Angelopoulos, 2008], and MMS missions [Burch et al., 2015] consist of 4-5 satellites. These multiple-satellite missions require a lot of resources. Thus, opportunities for conducting these missions have been limited. The use of small satellites is a quite effective way to increase such opportunities. To conduct space missions consisting of small satellites, onboard instruments also need to be miniaturized. Some attempts to develop miniaturized instruments for observing plasma waves have been made using application-specific integrated circuit (ASIC) technology [Ozaki et al., 2016; Zushi et al., 2019]. In this session, we focus on the miniaturization of particle instruments. A time-of-flight (TOF) technique is commonly used for mass discrimination of incoming particles. Typical TOF measures speed of incoming particles using a timing difference between their passages at two points inside a sensor. TOF sensors require incredibly high resolution of the elapsed time measurement, for example, the low-energy particle experiment-ion mass analyzer (LEPi) onboard Arase satellite has a resolution of more than 1.6 ns [Asamura et al., 2018]. Thus a high-speed amplifier for a TOF sensor that operates at around 1 ns is necessary to perform TOF measurements. A conventional amplifier consumes a volume of more than 1400 cm³. Here we are developing an ASIC-based fast amplifier for satellite-borne plasma particle sensors. A developed chip is a size of less than 5 mm×5 mm that includes more than 3 channels of the amplifiers. Each amplifier can detect output signals of a micro-channel-plate (MCP) within a timing fluctuation of 1.6 ns, which can be applied for typical TOF-based ion energy-mass spectrometers. We introduce the design and performances of the developed amplifiers using results of TOF experimental measurements.

Keywords: ASIC, wave-particle interaction, amplifier for TOF measurements