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Development of the ASIC for miniaturizing the digital fluxgate magnetometer onboard future magnetospheric satellites

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The main subject of the SCOPE (cross-Scale COupling in the Plasma universE) mission examined by ISAS/JAXA is to investigate the cross-scale coupling physics of the plasma in the magnetosphere and interplanetary space by using 5 spacecrafts. The total weight of the spacecrafts is severely limited due to the limitation of the capability of the launch vehicle. It is required to further reduce the resources of the payload instruments to achieve the mission.

Fluxgate magnetometers have many advantages as a method to measure the magnetic field by spacecraft; relatively simple principle, good accuracy, and low power consumption. Therefore they have been most often used for the magnetospheric observation missions since the 1950s. Because the electronics of conventional fluxgate magnetometer mostly consisted of analog devices, it was hard to reduce the resources. On the other hand, so-called digital-type fluxgate magnetometers have been developed since 1990s. For the digital-type fluxgate magnetometer, digital signal processors, e.g. FPGA (Field Programmable Gate Array), undertake the signal processing, which has been performed by analog devises for the conventional type. In previous studies, digital-type fluxgate magnetometers have been successfully reduced the size, mass, and power consumption with keeping good measurement accuracy. However, the preamplifier (AMP) and the Band-Pass Filter (BPF) in the electronics circuit of the digital types should be built by discrete analog devices. Moreover, digital-to-analog and analog-to-digital converters are built by the commercial IC chips, and hard to be reduced in size.

Application Specific Integrated Circuit (ASIC) chip is a device which can be designed for specific function. Using ASIC in the analog part of the digital-type fluxgate magnetometer would enable the further reduction of the resource keeping good performance.

We designed an ASIC chip which contains an AMP and a BPF. The gain of the amplifier is controlled (2, 3, ... ,10 times) by the external signals given to the ASIC. The BPF is the second-order Butterworth filter and the center frequency can be precisely adjusted to 22 kHz, the frequency of the fluxgate sensor output signal, by adjusting the external resistor.

The performance and the temperature dependence of the designed circuit were evaluated by the circuit simulator. The output dynamic range is 0.24 F.S.(corresponding to 1.2 V). The frequency characteristic of the BPF satisfies the requirement. The noise density in the output signal is less than 600 $nV/Hz^{1/2}$ at 1 Hz(corresponding to 2 $pT/Hz^{1/2}$) in the temperature range between -30 degrees C and 50 degrees C. The simulation results indicated that the overall performance of the designed ASIC satisfies the requirements.

We experimentally examined the characteristic performance of the ASIC chip. In our presentation, we will focus on the evaluation results of the ASIC performance.

Keywords: Space plasma, Magnetosphere, The SCOPE mission, Fluxgate magnetometer, ASIC