

PCG008-P06

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Development of high-resolution digital fluxgate magnetometer for the SCOPE mission

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The main subject of the SCOPE (Scale COupling in the Plasma universE) project is to investigate the cross-scale coupling physics of the plasma in the magnetosphere and in the interplanetary space. The magnetic field should be measured with higher time resolution than 10 msec, to investigate the electron-scale process of the plasma. The performance requirements of the SCOPE mission are shown below.

Dynamic range : +/-4000 nT

Frequency range : DC-128 Hz

Resolution : 20 bits (Quantization step corresponds to 8 pT.)

We have developed a digital-type fluxgate magnetometer for S310-40, a sounding rocket mission, as a preliminary experimental step for the SCOPE spacecraft. The digital-type has the advantage of being small, lightweight and low power. The performance requirements for the S310-40 mission are shown below.

Dynamic range: +/-65000 nT

Frequency range: DC-60 Hz

Resolution: 16 bits (corresponding to 2 nT)

When we keep the 16-bit resolution and change the dynamic range from +/- 65000 nT to +/- 4000 nT, the quantization step corresponds to 128 pT.

The accuracy of the digital-type fluxgate is determined by the resolution of the Digital-to-Analog Converter (DAC) in the electronics package. DACs having a resolution > 12 bits are not available for the space applications. We developed a sigma-delta type DAC, in order to improve the accuracy of the digital-type fluxgate magnetometer. The resolution of the sigma-delta DAC is determined by the topology of the sigma-delta modulator and analog filter. First, we designed the topology of the modulator and analog filter by numerical simulation. In the most optimized solution, they are 2nd-order 1-bit sigma-delta modulator and 4th-order analog low-pass filter, respectively. Second, we experimentally evaluated the performance of the DAC circuit build by a Field Programmable Gate Array (FPGA) and OP-amps which are tolerant of the space environment. We examined the errors in the output signal of the DAC circuit against the varying input signal. We found that the DAC circuit satisfied 16-bit resolution when the over sampling ratio is 676. The linearity error was 0.006 %, which corresponds to 4.8 nT for +/- 40000 nT range. These results showed that this DAC circuit satisfied the requirements for the S310-40 mission. We report the examination results of the fluxgate magnetometer developed for the S310-40 rocket experiment.

Keywords: SCOPE, magnetometer, digital fluxgate, sigma-delta modulation technique, Digital-to-Analog Converter