Development of digital to analog converter for the digital fluxgate magnetometer

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We use specific measurement technologies in the fields of satellites and rockets. For example, magnetometers are used for the measurement of the spacecraft attitude. Moreover, we measure the magnetic fields to investigate the phenomena in the space in the space science missions.

To understand the physics of the space plasma, we need to quantitatively investigate the electromagnetic fields and the motion of plasmas. The energy and charge of plasmas are measured by plasma particle instruments and the electric and magnetic fields, which control and accelerate plasmas, are measured by electric field instruments and magnetometers. It is essential to develop the magnetometer having adequate performance for individual missions and satellites.

Magnetometers are categorized in two types; one detects component along the sensitive axis and the other detects the total force. The most typical one of the former type is the fluxgate magnetometer and that of the latter is the proton magnetometer generally used in the ground observatories. Because the fluxgate magnetometers have good accuracy to calculate the attitude in the geomagnetic field, it is often used for spacecraft attitude determination.

A fluxgate magnetometer consists of sensor unit (modulator), signal processing unit (demodulator) and negative feedback system to the sensor. Negative feedback output is controlled to cancel the magnetic field at the sensor. The feedback level corresponds to the external magnetic field. Analog fluxgate magnetometers have following weak points because of analog devices in the circuit.

1 The offset changes for the long term because of the degradation of the analog devices

2 Output characteristics change against the temperature change because of the temperature characteristic of the analog devices

In last 10 years, to solve these problems, Digitized (Digital) Fluxgate Magnetometer (DFG) has been developed. The name DFG is coming from the digital processor in the demodulator which executes digital signal calculation. DFG solves the weak points of the analog fluxgate magnetometer. Followings are the other advantages of DFG:

1 Small and light

2 Low power

3 Small individual differences

Because DFG has many advantages over the analog fluxgate magnetometer, DFG has been developed in U.S. and Austria, and already installed in the launched satellites. In Japan, a 16-bit DFG was developed for the sounding rocket and launched.

DFG needs Digital to Analog Converter (DAC) to feedback the output of the digital processor to the sensor. Because DAC provides feedback value (corresponding to the external magnetic field), the resolution of DFG is determined by the resolution of the DAC. High resolution DAC for spacecraft does not exist and, in the strict sense, DFG having high resolution has not been realized.

Our goal is the development of small, light, low power and high resolution DFG. Here, we report the results of our development of DAC. DAC consists of delta-sigma modulation in a micro computer and the external analog low pass filter.

Delta-sigma modulation consists of integrator, quantizer and delay module. These components constitute a negative feedback loop system. The output of modulator is the pulse density modulation of the input signal. Pulse density modulation is demodulated into analog value through analog low pass filter. Delta-sigma modulation is adopted in high-bits (more than 16 bits) DAC and Analog to Digital Converter. Delta-sigma modulator device for the space use does not exist. We develop a high-bits DAC system which consists of the devices tolerant of the space environment.