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## Development of high-resolution digital fluxgate magnetometer using delta-sigma DAC

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Fluxgate magnetometers have good accuracy and are very small, lightweight and low power. Therefore they are most widely used for space science missions to measure the earth, planetary and interplanetary magnetic field.

Our objective is the development of the Digital FluxGate magnetometers (DFG) for the SCOPE mission. As a first step, we are developing the DFG onboard the sounding rocket (S310-40th). Since 1990s, DFGs are developed by Austria and U.S. teams. Their DFG has more advantage in the weight, size and power consumption than conventional types. Accuracy of magnetic field measurement is determined by the resolution of Digital to Analog Converter (DAC) in the electronics part.

High-bits delta-sigma DAC for space applications is not available currently. It means that high-resolution DFGs have not developed until now. We adopted delta-sigma modulation and developed a high-bits delta-sigma DAC system which consists of the devices tolerant of the space environment. To install fluxgate magnetometer in S310-40th, we aim for high resolution (2 nT/bit, 16bits at +/-60000 nT range) to satisfy the requirement.

Delta-sigma modulation techniques are used in high-bits (more than 16 bits) DAC in many fields. Input value is modulated to pulse density signal. Pulse density is demodulated into analog value through analog low-pass filter. Delta-sigma modulator consists of simple modules (integrator, quantizer and delay module). The delta-sigma DAC can be made of micro controller and analog low-pass filter.

We developed a 2nd-order delta-sigma modulator and examined the errors in the output signal of DAC against the varying input signal. When the over sampling ratio is 637, resolution of DAC is around 16 bits in the case of dc input. We designed a 4th-order analog low-pass filter. Developed DAC consists of FPGA and 4th-order analog low-pass filter using OP-amp. We report the result of developed delta-sigma DAC and characteristics of DFG test model in which that DAC is installed.

Keywords: digital fluxgate magnetometer, digital to analog converter, delta-sigma modulator, SCOPE