

Development of a miniaturized search coil magnetometer for cube-satellite experiments

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Since the size of a cube-satellite is very small (e.g, a 1U cube-satellite has a size of 10 cubic centimeters), it is required a miniaturization technique of scientific instruments for probing the plasma waves using cube satellites. We have developed a miniaturized search coil magnetometer for 1U cube-satellite experiments, by using Application Specific Integrated Circuit (ASIC) technology to drastically reduce the system resources (mass, volume and power).

A 6-cm search coil is developed to probe the plasma waves onboard a 1U cube-satellite. The magnetic sensitivity of the search coil depends on its sensor size. Since the effective permeability of a magnetic core decreases with the sensor size, the magnetic sensitivity using a small sensor degrades. It is necessary to compensate for the low effective permeability by using a low noise preamplifier. We have developed a low noise ASIC preamplifier. The size of the ASIC preamplifier is 6.25 mm² and the power is 5.1 mW. The input equivalent noise is 10 nV/sqrt(Hz) at the frequency of 1 kHz. The ASIC preamplifier has a high tolerance against harsh space (radiation and temperature) environments. In the radiation tests, the ASIC preamplifier did not break down for high energy alpha ray incidence (220 MeV, over 5-hour exposure). The input equivalent noise of the ASIC preamplifier did not change before and after the gamma ray (3 Mrad) exposure. The operation temperature range of the ASIC preamplifier is minus 60 to plus 100 degrees Celsius. Additionally, we have developed an ASIC waveform receiver to miniaturize all of the wave measurement systems. The size of the ASIC waveform receiver including a 6th-order Chebyshev anti-aliasing low pass filter is 2.8 mm², the power is 26 mW, and the input equivalent noise is 660 nV/sqrt(Hz) at the frequency of 1 kHz. In the radiation test (alpha ray of 220 MeV), the input equivalent noise of the ASIC waveform receiver increased by up to 10 dB at the frequency of 100 Hz by the effect of the Total Ionizing Dose. However, the ASIC waveform receiver did not break down at the total dose of 400 krad. The operation temperature range of the ASIC waveform receiver is 0 to 60 degrees Celsius. We measured the magnetic sensitivity of a 6-cm search coil connected to the ASIC preamplifier and the ASIC waveform receiver. The magnetic sensitivity of the sensor is 0.2 pT/sqrt(Hz) at the frequency of 1 kHz, with which it is possible to probe the typical plasma waves such as chorus and hiss in the Earth's magnetosphere.

In the presentation, we will present the miniaturized search coil magnetometer designed for 1U cube-satellite experiments in detail.

Keywords: Search coil, Cube satellite, ASIC