A basic study of search coil with a built-in ASIC preamplifier

*Yuya Tokunaga[1], Mitsunori Ozaki[2], Satoshi Yagitani[2], Hirotsugu Kojima[3]

1.School of Electrical and Computer Engineering, College of Science and Engineering, Kanazawa University, 2.Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University, 3.RISH, Kyoto University

Multipoint plasma wave observations by miniaturized scientific satellites in the magnetosphere are important to understand the magnetospheric dynamics. Physical limitations (mass, volume, and power) of scientific instruments become more severe in miniaturized satellites. We have been developing compact plasma wave instruments to reduce the system resources by using application specific integrated circuit (ASIC) technology. Search coil magnetometers based on Faraday's law are commonly used for AC magnetic field observations of plasma waves. A typical search coil sensor consists of a single set of solenoidal coil and magnetic core. The sensor is placed at a tip of a mast away from a satellite body to prevent the noise generated from the body. The sensor is connected to a preamplifier installed in the satellite body with a long cable, then the electrical characteristics are degraded due to the effect of long cable's capacitance component. In this study, we propose a new search coil with a built-in an ASIC preamplifier to improve the electrical characteristics. We have especially studied the following items. The first is the effect of effective permeability of the magnetic core. There is no space for putting the ASIC preamplifier in a traditional rod core. To make a space for putting the ASIC preamplifier in the sensor, the core is divided into a couple of thinner rod cores. To evaluate the effect of effective permeability for the divided the cores, we performed the electromagnetic field simulations. The simulation and measurement results show that the effective permeability of the divided cores are larger than that for the previous rod core. Next, the second item is the effect of the radiation environment. It is necessary to consider the effects of radiation, because the ASIC preamplifier is directly exposed in space environment. Degradation of electrical performance and latch-up of the ASIC preamplifier will be caused by the strong radiation as in the radiation belts. The radiation simulation result shows that a Copper plate (thickness : 5 mm) representing a dense coil winding acts as a radiation shield for alpha ray (60 MeV/(mg/cm2) or less) and gamma ray (0.05 MeV/(mg/cm2) or less). Thus, it is possible to shield the ASIC preamplifier in the coil from the radiation. The third item is the crosstalk problem. The AC magnetic field vectors are measured by using 3-axis search coil. The magnetic field is distorted by the 3-axis magnetic core. As a result, the crosstalk problem will be expected to occur. An optimal placement of the 3-axis magnetic core is evaluated by using the electromagnetic simulation. The simulation results show that the crosstalk becomes -40 dB or less (vector angle measurement error less than 1 degree) when the intervals between each core are less than 35 mm. In this presentation, we will present the analysis results for a proposed search coil with a built-in ASIC preamplifier in detail.

Keywords: ASIC preamplifier, Plasma wave observations, Search coil

