Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

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We have been measuring electric fields of the plasma waves (a few Hz to several hundred Hz) to understand the magnetospheric dynamics. The spatial resolutions of electric field measurements are not enough because we cannot launch a lot of satellites due to the large size and mass of satellites. Demands of micro satellites like a 1U (10 cubic centimeters) cube satellites are increasing. We need to miniaturize measurement instruments for probing the plasma waves.

This study deals with an electric field instrument in plasma wave observations. We use the electric field instrument for capturing the electric fields detected by wire probe antennas. In this study, the purpose is to miniaturize the electric field instrument with a high radiation tolerance (300 krad) using Application Specific Integrated Circuit (ASIC) technology.

We designed a based amplifier for a new electric field instrument. In the new based amplifier, the equivalent input noise is 50 nV/sqrt(Hz) at 1 kHz, which is 3.9 dB-larger than that of conventional based amplifier (OP-41). The noise performance of new based amplifier is acceptable for capturing the plasma waves. To confirm the radiation tolerance of new based amplifier, we did the radiation tests up to 300 krad using the gamma ray. From the radiation test results, the gain was no change before and after the radiation tests. The output noise was degraded with 5.05 dB at 100 Hz by total ionizing dose effects. However, the based amplifier was not breakdown by the gamma ray. The electric field instrument consisted of new based amplifier could operate with a high radiation tolerance.

We conducted the transient analysis for the new electric field instrument by a circuit simulator (Tanner EDA). In the simulation, rectangular waves of 1 Vpp with 10 Hz input to the new electric field instrument via a sheath impedance (10 MOhms and 100 pF). From the simulation results, the output waveforms of new electric field instrument showed similar output waveforms in comparison with the conventional electric field instrument. The power consumption of new electric field instrument can decrease with approximately 67% than that of the conventional electric field instrument. From the simulation results, we confirmed the basic operations as the electric field instrument for detecting the plasma waves. In the future work, we will need to improve the temperature operating range because the new electric field instrument cannot operate at minus 60 Celsius degrees from the temperature simulation results.

In this presentation, we will present the basic study on electric field instrument for plasma wave observation by ASIC technology in detail.

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