Geophysical Research Abstracts
Vol. 12, EGU2010-5695-2, 2010
EGU General Assembly 2010

Small sensor probe for monitoring the space electromagnetic environments by the application of the miniaturized plasma wave receiver

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Plasma waves act as the medium in the transport of kinetic energies through wave-particle interactions in space plasmas. Therefore, most of the space missions to investigate space plasmas carry the onboard plasma wave receivers, which is a kind of radio receivers with very high sensitivities.

Recently, the downsized satellites in science missions such as formation flights and small satellites require the further reduction of power and mass budget for onboard instruments. We also face the similar requirement from the lack of the spacecraft resources in planetary missions. To meet the requirement, we developed the very small plasma wave receiver using the analogue ASIC (Application Specific Integrated Circuit) technology. Since the plasma wave receiver needs to receive very weak signals in the various frequency ranges, it accommodates filters with different frequency responses, low noise amplifiers with high gains and oscillators. This leads to the large occupation of the board by the analogue circuits. Therefore, the breakthrough to the extreme miniaturization of the plasma wave receiver does not occur without the miniaturization of the analogue electronic circuit.

We have already confirmed the feasibility in realizing six channels (three for electric fields and three for magnetic fields) of waveform receivers inside the small chip with the size of 3mm x 3mm. The developed waveform receiver shows the good feature enough for the use in scientific missions. This success in the miniaturization of plasma wave receivers allow us to develop a new system measuring plasma waves in multiple points.

Based on the technology of the miniaturization of plasma wave receivers, we propose a new system for monitoring the electromagnetic environment in space. We address it MSEE (Monitor System for space Electromagnetic Environments). The MSEE is a kind of the sensor network system in space. It consists of palm-sized sensor nodes, which are randomly distributed in the target area. The sensor node carries a compact plasma wave receiver as well as other necessary components such as communications and digital processing units. The MSEE system resolves the disadvantage of the single-point (or a few points) observation in space missions. This is a very new concept for measuring the space electromagnetic environments.
The important issue in the development of the MSEE is the design and development of the small sensor node. We developed the first prototype of the sensor node system. It contains the analogue ASIC of plasma wave receiver with small electric and magnetic sensors, small digital processing unit using the one-chip computer, small fluxgate sensor for the attitude detection, and GPS receiver for the location estimation. The system is controlled by the software running on the onboard one-chip computer.

In the present paper, we report our design of the MSEE sensor node system as well as the development of the miniaturized plasma wave receivers. We also show the performance of our first prototype of the sensor node.