



## **Miniaturization of plasma wave receivers onboard scientific satellites and its application to the sensor network system for monitoring the electromagnetic environment in space**

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A plasma wave receiver onboard a scientific satellite has a role of observing electromagnetic/electrostatic waves in space. Since space plasmas are essentially collisionless, kinetic energies are transferred via plasma waves. Therefore, the observation of plasma waves is very significant in studying the energy transportation in space plasmas.

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 problem on the lack of resources of spacecraft in planetary missions. Therefore, the breakthrough of plasma wave observations via spacecraft needs the extreme miniaturization of onboard plasma wave receivers. One of the characteristics of plasma wave receivers is the large occupation of circuit boards by analogue circuits such as differential amplifiers, operational amplifiers, and filters. Therefore, the miniaturization of their analogue circuits leads to the realization of the compact plasma wave receiver, effectively. Therefore, we attempt to develop the very small analogue part of the receiver using the ASIC (analogue specific integrated circuits) technology.

In the current phase, we succeeded in developing the ASIC chip, which contains six channels of fifth-order switched-capacitor filters as well as amplifiers with 20dB gain. The chip size is 3mm x 3mm. If we develop the similar circuit using discrete electrical parts, the size of the board is hundreds of times larger than this chip. We have checked its function and performance in the view point of using for plasma wave receivers and found it can be promising after conducting slight modification of the design.

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 observed data are transferred to the centre station such as space stations or satellites/rockets through the ad-hoc network system. The objective of the MSEE is to observe plasma wave activities in multiple-points. As stated above, since space plasmas are collisionless, kinetic energies of plasmas are exchanged through plasma waves. This means the plasma wave activities well reflect the variation of the environments in space which is filled with space plasmas. The targets of the MSEE are the artificial disturbances due to human activities in space as well as natural plasma waves. The MSEE provides us with the information on the three dimensional variation of the space electromagnetic environment in the target area. Recently, we have developed the prototype of the sensor node. In the prototype sensor node, small electric and magnetic field sensors with enough sensitivities and their small preamplifiers are installed. We also developed the small analogue circuits dedicated to monitoring of plasma waves using the analogue ASIC technology. The necessary analogue components of plasma wave monitors are

realized in one-chip ASIC with the size of 3mm x 3mm. The system of the sensor node is controlled by the one-chip computer. Under its control, communications and location identification are done using the wireless network technology.

In the present paper, we report our development of the miniaturized plasma wave receivers and also show its application to the sensor network system for monitoring the electromagnetic environment in space.