Miniaturization of a plasma wave receiver system towards future space missions based on micro-/nano-satellites

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Plasma waves sensitively reflect dynamic variations of in-situ environments in space, because space plasmas are basically collisionless. The environment in space is controlled by wave-particle interactions. The Langmuir wave is a good example in the meaning of showing the existence of energetic electron beam which energies are much higher than thermal velocities of background electrons. Such electrostatic waves well thermalize local plasmas along the direction to their electric field oscillations. On the other hand, some of plasma wave modes are electromagnetic. They propagate far from their source region. One can identify the dynamics of their source region as well as the magnetic field structure by conducting the analysis of time variations of their intensities and their propagation features. Thus, observation of plasma waves provide us of a plenty of information of electromagnetic behaviors in space. In particular, the multiple point observations of plasma waves via plural satellites lead to understanding of spatial variations of space environments. Furthermore, continuous observations are the best in the meaning of monitoring the space environment. Such observations of plasma waves can be realized only by micro- or nano-satellites.

Plasma wave receiver system onboard satellites typically observe plasma waves with their frequencies from 0 Hz to a few MHz. It consists of electric field sensors, magnetic field sensors and receivers. Unfortunately, a conventional type of plasma wave receivers does not fit micro- or nano- satellites, because their size and weight is relatively larger than that of an optical camera, which is frequently carried by micro- or nano-satellites. Miniaturizing plasma wave receiver system is essential in realizing missions using micro- or nano-satellites. In order to make plasma wave receiver systems fit micro- or nano-satellites, we have been attempting the miniaturization of plasma wave receiver system using ASIC (ASIC: Application Specific Integrated Circuit). The ASIC is an electronic device which is designed for a specific application. We succeeded in developing the ASIC chip which is dedicated to the plasma wave receiver system. The size of the chip we designed is 5mm x 5mm. It contains six-channels of waveform type receivers which can observe waveforms of plasma wave with their frequencies up to 100 kHz. The chip consists of analogue components such as low noise amplifiers and filters. By using this ASIC chip, we developed the small plasma wave receiver with other necessary peripheral components. The size of the board is 40mm x 50mm and its weight is 24.9g. This plasma wave receiver system is almost one-order smaller than conventional ones. We also succeeded in developing the small sensor preamplifiers using ASIC. Furthermore, we have just started to implement the digital part of the plasma wave receiver system into the same chip so-called the analogue-digital mixed signal chip. In the present paper, we show our attempts in miniaturizing plasma wave receiver system and discuss plausible missions using our small plasma wave receiver system under international collaborations with the Asian and Oceanian countries.