

Study on Miniaturization of Plasma Wave Receiver Using Analog ASIC

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Plasma filling the space is very rarefied. Ions and electrons in space plasma don't exchange their kinetic energy through their collision but through plasma waves. Hence observing plasma wave is essential for measuring space electromagnetic environment. The characteristics of plasma waves appear especially in the frequency range below electron plasma frequencies, which are typically a few tens of MHz at maximum in the terrestrial magnetosphere. On the other hand, the signal dynamic range of plasma waves is very wide. There exist plasma waves with their intensities of a few $\mu\text{V/m}$ to a few hundreds of mV/m . Then the plasma observation device should have high sensitivity as well as a wide dynamic range in wide frequency bands. The device of observing plasma waves is so-called plasma wave receiver. In order to achieve the above requirements to the frequency range, the sensitivity, and the dynamic range, typical plasma wave receivers tend to be large because they need large analog circuits such as filters and amplifiers. However, recent space missions require miniaturization of onboard observation device in order to reduce mass and power budgets. Plasma wave receivers cannot run away from the miniaturization of their analogue circuits. In this study, we will try to miniaturize the plasma observation receiver using ASIC(Application Specific Integrate Circuit).

SFA(Sweep Frequency Analyzer) and WFC(Wave Form Capture) are used in plasma observation device. The SFA is one type of spectrum analyzer, which has poor time resolution and fine frequency resolution. The SFA is a double super heterodyne receiver and operate frequency conversion two times. In usual SFA, we swept the frequency very finely, so it takes long time to sweep all frequency and time resolution becomes worse. However, SFA which we design operate A/D conversion and FFT after sweeping frequency roughly. By using this method, we can realize both good frequency resolution and good time resolution. Thus we need to implement a frequency synthesizer, mixer, and band pass filter inside an ASIC chip. We developed test circuits of the each component and evaluated their performance. On the other hand, the WFC observes plasma waves in the time domain. It provides phase information of the observed plasma waves. Then the WFC should be calibrated in its phase as well as its gain. The transfer functions of the electric field sensors strongly depend on the surrounding plasma conditions. Because the change of transfer functions affect observed waveforms, we need to measure transfer function by onboard system in space. We realized miniaturization of waveform receiver, measurement system and preamplifier using analog ASIC and developed the miniaturized waveform receiver with the built-in preamplifier and onboard measurement system.

In the present paper, we show our attempts in developing both types of ASIC, i.e., SFA chip and WFC chip.

Keywords: Plasma Wave, Downsizing, Integrate Circuit, ASIC, Sweep Frequency Analyzer, Waveform Capture