Design and development of miniaturized sweep frequency analyzer using ASIC technology

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Space plasma is essentially collisionless, and its kinetic energy is transferred through plasma waves. Therefore, plasma waves reflect variations of electromagnetic environments in space. Plasma wave receivers, which capture these waves, contribute to the investigation of microscopic electromagnetic phenomena in space. Sweep frequency analyzer (SFA), one of the types of the plasma wave receivers, provides spectral information on plasma waves with good frequency resolutions. General SFA is basically a heterodyne receiving system, and provides the spectrum information with the good signal to noise ratio. The SFA has a PLL, a frequency synthesizer. This PLL makes a number of fine sweep frequency steps. It takes several seconds to complete all sweep steps. Thus, this type of SFA generally has disadvantage in temporal resolution.

We propose a new type of the SFA which is combined double-superheterodyne receiving system with FFT in FPGA (Field Programmable Gate Array). We apply the widen frequency range to each sweep step. This suitably widened frequency range decreases the number of the sweep steps, and improves the temporal resolution. Observed analog signals are converted into digital signals and input to the FPGA. Logic FFT blocks in the FPGA apply the FFT to these digital signals. Thus, we can obtain the frequency resolution which is equal to the widened bandwidth divided by the FFT points. In our system, we achieve low noises, high frequency resolution, and high temporal resolution simultaneously.

Plasma wave receivers, such as SFA, are required to have low noise and wide dynamic range with amplification in wide band. These requirements lead analog circuits in each receiver to be large and heavy and make it difficult to realize small plasma receivers with discrete parts or commercial integrated circuits. General plasma wave observations have been restricted by this problem. We use ASIC (Application Specific Integrated Circuit) technology to make breakthrough in this present state. The ASIC technology enables extreme miniaturization of analog circuit. We have developed several analog circuits in the SFA, such as a differential amp, a low pass filter, PLLs, and band pass filters using ASIC. In the session, we will introduce the new SFA we propose, report our latest developments, and show some performances of our developed circuits.