Miniaturization and Integration of the System for measuring Space Electromagnetic Environments

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Since space plasmas are essentially collisionless, kinetic energies of plasma particles are exchanged through the plasma waves. These interactions among the space plasmas and the plasma waves are called the wave-particle interactions. The wave-particle interactions are very important in analyzing electromagnetic phenomena occurring in space. A number of scientific satellites have been launched to measure space electromagnetic environments. We address two themes in the present paper as follows: (i) development of the one-chip type of a new system for measuring the wave-particle interactions, (ii) miniaturization of analog parts of the plasma wave receivers.

The Wave-Particle Interaction Analyzer (WPIA) is a novel instrument to observe wave-particle interactions directly by calculating the inner product between the electric field of plasma waves and of plasma particles. The WPIA has four fundamental functions: waveform calibration, coordinate transformation, time correction, and interaction calculation. We demonstrate the feasibility of One-chip WPIA (O-WPIA) using a Field Programmable Gate Array (FPGA) as a test model for future science missions. The O-WPIA is capable of real-time processing with low power consumption. We validate the performance of the O-WPIA including determination of errors in the calibration and power consumption.

We also develop a tiny chip using analog ASIC (Application Specific Integrated Circuit) technology for scientific and extra objectives [1]. The package size is 15 mm times 15 mm, and it contains the bare chip with the size of 3 mm £ 3 mm shown in figure 1. The chips are manufactured with CMOS 0.25 μm process by TSMC Co., Ltd. Several types of analog filters and amplifiers are implemented in the chip. We design the Gm-C filter, the SC (Switched Capacitor) filters, and the differential amplifier. The Gm-C filter is realized with OTA (Operational Transconductance Amplifier) and capacitors. The frequency response of the Gm-C filter is compensated within ±1 % in the -30 to 60 degrees C range by the compensation circuits [2]. We design six channels of waveform receivers inside a single chip. Figure 2 shows a mask pattern layout of the six-channel waveform receiver. The circuits and I/O pad are implemented inside the size of 3 mm times 3 mm.

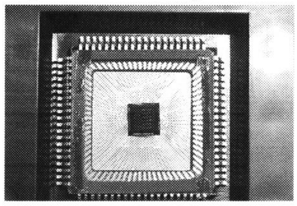

Figure 1. The photograph of the ASIC.

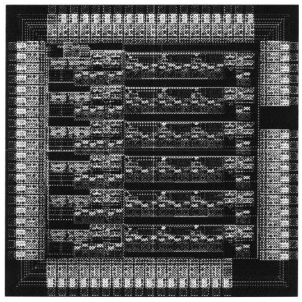

Figure 2. The layout of the waveform receiver.

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References

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