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Development of Miniaturized Plasma Wave Receiver using analog ASIC

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Since space is filled with collisionless plasmas, kinetic energies of plasma particles are exchanged via electric and magnetic fields, so-called plasma waves. The plasma waves have been observed a number of scientific spacecraft with plasma wave receivers. The plasma wave receivers are classified into two types, spectrum receivers, and waveform receivers. The spectrum receivers provide an overview of physical processes in which the plasma waves are excited, grown, and dissipated. The waveform receivers give not only amplitude but also phase of the plasma waves. Phase information between the plasma waves and plasma particle is essential in wave-particle interactions. It is important for understanding physical processes to combine both kinds of data of spectra and waveforms. Since the plasma waves have various intensities in wide-band frequency range, from DC to tens of MHz, the onboard instruments for the plasma wave observation are required to have low noise, high sensitivity, and wide dynamic range in wide-band. The required performances lead to increase the weight budget of the analog part of the instrument since discrete electronics devices and integrated circuits are usually used to implement the instruments. We have developed dedicated chip which can drastically decrease weight budget of the plasma wave instruments for multi-point observation and deep space exploration missions. It is also significant that manufacturing a number of instruments with the same performance becomes easy. In this paper, we demonstrate the miniaturized plasma wave receiver using ASIC (Application Specific Integrated Circuit) technology. The ASIC is a LSI (Large Scale Integrated circuit) for a particular purpose, is commonly developed for a consumer electronics products. For the spectrum receiver, we develop a double super heterodyne receiver, so-called ”Sweep Frequency Analyzer (SFA).” This SFA is improved in the time resolution with keeping good frequency resolution by combining the analog frequency conversion and FFT. The SFA consists of an amplifier, a frequency synthesizer, mixers and band-pass filters. These component circuits are fabricated in chips and their performances are tested. The waveform receiver generally consists of the band-limiting filter, the amplifier, the anti-aliasing filter, and the A/D converter. The developed chip contains these circuits except for the A/D converter, and has six-channel to observe full components of the electric and magnetic fields waves. The chip is connected to A/D converters, a clock generator, and power circuits on the PCB. The sampling frequency is 400 kHz, and the dynamic range of the A/D conversion is 14 bits. The total dimension of the PCB containing waveform receiver chip is 50 mm by 90 mm, similar size of a business-card. By the development of the dedicated chip, the weight per channel of the waveform receiver declines to a tenth of the NOZOMI LFA, which was the onboard instrument of the pas Japanese scientific spacecraft.

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