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Development of Small Plasma Wave Receiver with a Dedicated Chip for Scientific Spacecraft

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Since space is filled with collisionless plasmas, kinetic energy of each particle of the plasmas is exchanged via electric and magnetic fields, so-called plasma waves. The plasma waves have been observed a number of scientific spacecraft. Plasma wave receivers are classified into two kinds of the receiver, spectrum receivers, and waveform receivers. The spectrum receivers provide an overview of the plasma waves. 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. The dedicated system chip can drastically decrease weight budget of the plasma wave instruments for multi-point observation missions 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, which is realized in a dedicated chip for the analog part. The spectrum receiver is 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 wave. 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.