Wire Probe Antenna and Electric Field Detector of Plasma Wave Experiment aboard ARASE: Specifications and Evaluation results

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This paper summarizes the specifications and the evaluation results of Wire Probe Antenna (WPT) and Electric Field Detector (EFD), which are the key parts of Plasma Wave Experiment (PWE) aboard the ARASE (ERG) Satellite, in their initial operations and the beginning phase of the full observations.

WPT consists of the two sets of dipole antennas as electric field sensors with 32m tip-to-tip length, with a sphere probe (6cm diameter) attached at each end of wires (length: 15-m). They are extended orthogonally in the spin plane of the spacecraft which is roughly perpendicular to the Sun. WPT enables the PWE to measure the E-field in the frequency range from DC to 10 MHz. This system is almost compatible to the WPT of the Plasma Wave Investigation (PWI) aboard BepiColombo Mercury Magnetospheric Orbiter, except the material of the spherical probe (ERG: Aluminium alloy, MMO: Titanium-alloy). For the ISAS and JAXA spacecraft, there was a long time gap in the history of the development of wire antenna systems after the Geotail mission launched in 1992 (WPT aboard the Nozomi Mars orbiter was not extended in space.), its physical, mechanical, electrical, and operational establishments were critically important not only for this mission but also for the preparation of BepiColombo. Thanks to the engineers of the NIPPI cooporation and JAXA, its full deployment operation on 14-16 January 2017 was succeeded. This paper shows the length of the deployed antenna independently evaluated by the Lorentz force (spacecraft velocity x B-field), the antenna impedance in low frequency (˜0.1-10Hz, registive) and high frequency (several 10s-100s Hz, capacitive), as the basic information of the E-field measurement capability of the PWE E-field receivers, EWO-E (EFD, WFC-E, OFA-E) and HFA. We also discuss the evaluation results for the possible degradation of the spherical probe surface coated by TiAlN as the BepiColombo WPT.

EFD is the 2-channel low frequency electric receiver as a part of EWO (EFD/WFC/OFA), for the measurement of 2ch electric field in the spin-plane with the sampling rate of 512 Hz (dynamic range: +-200 mV/m, +-3 V/m) and the 4ch spacecraft potential with the sampling rate of 128 Hz (dynamic range: +-100 V), respectively, with the the bias control capability for the WPT probes. The electric field in DC - 232Hz provides the capability to detect (1) the fundamental information of the plasma dynamics and accelerations and (2) the characteristics of MHD and ion waves with their Poynting vectors with the data measured by MGF and PWE/WFC-B connected to PWE/SCM (Search Coil Magnetometer) in stable and active magnetosopheric status. The spacecraft potential provides the basic electron density information with the upper hybrid resonance (UHR) frequency provided by PWE-HFA.

The EFD has two data modes: The normal (Medium-mode) data are provided continuously with OFA-E/B data sets, as (1) 2-ch waveforms with 64 Hz (in Apoapsis mode, in L less than 4) or 256 Hz (in Periapsis mode, in L larger than 4), (2) 1-ch spectrum in 1-232 Hz with 1-sec resolution, and (3) 4-ch spacecraft potential with 8 Hz. The burst (High-mode) data are intermittently obtained, and downloaded with WFC-E/B data sets after the selection, as (4) 2-ch waveforms with 512 Hz and (5) 4-ch spacecraft potential with 128 Hz. This paper will show the status of their calibrations after the subtraction of spacecraft Velocity x B field. We also discuss some potential problems for data analyses caused by the effects of surrounding electron plasma characteristics on the spacecraft potential, wake effect by the spacecraft motions, and possible artificial contaminations. They are common problems in the electric field measurements by the biased-probe method.