# Summary:

In early Dec 2011, Dr. Kazue Takahashi, the member of the RBSP Science Team at APL responsible for review of the RBSP-EFW V&V Matrices contacted Dr. John Bonnell with a request for some additional clarifying information regarding several of the EFW instrument requirements and how compliance with those requirements was verified by the testing performed to-date. In particular, Dr. Takahashi wanted clarification of how the analog E-field interface between the EFW and EMFISIS instruments was verified (EFW-36 and EFW-208), as well as the ability of the EFW instrument to make cold plasma density measurements (EFW-47).

Dr. Bonnell agreed to provide this information. Late fall proceeded into winter, and winter into the early hints of spring, and finally Dr. Bonnell collected the necessary supporting information and created this document.

# EFW-36 and EFW-208, ‘EFW On-Board Delivery of Signals to EMFISIS – Spin Plane Sensor Pairs and Single Pair Axial”.

The verification of these two requirements at the instrument level occurred via the bench testing in support of the EFW SciCal; Noise, Phasing and Timing; and Full-Up Science Tests (RBSP\_EFW\_TR\_026, \_027, and \_028, respectively).

Some aspects of these two requirements are dependent upon EMFISIS-side analog and digital signal processing (bandwidth, dynamic range), and so are not verified by these tests, but have been subsequently verified at the Observatory level as part of the Limited and Comprehensive Interface Tests conducted in July 2011 (LIT) and Jan 2012 (CIT).

The remaining aspects of these two requirements (total bandwidth; sensitivity, interpreted as noise floor at S/N=1; and maximum signal amplitude) translated directly into quantities measured in the bench tests. These include:

1. The gain vs. frequency of the EMFISIS E-field interface for all three channels (SciCal report (TR\_026); beb\_scical\_ac\_freq\_response\_FM2\_chan??-analysis-Rev?.pdf, “PLOTS-Gain” tab, “EMFISIS vs. VSPHERE” panel), which is adequate to support the required 10-Hz to 400-kHz frequency range.
2. The measured noise floor shown in TR\_027, with required upper limits indicated on the plots.
3. The measured dynamic range of the EMFISIS E-field interface channels (BEB board-level functional test).

# EFW-47, ‘EFW Spin Plane Cold Plasma Density Measurements.”

The verification of this requirement occurred via the bench testing in support of the EFW SciCal test (RBSP\_EFW\_TR\_026). EFW makes cold plasma density measurements by measuring the potential difference between a suitably-averaged collection of the EFW sensors and the Observatory ground potential (often called the spacecraft potential, or VSC), and then inverting that measured potential difference into an estimate of the ambient plasma density using either an empirically-determined relationship derived from on-orbit plasma or wave observations, or via probe-plasma modeling for the given EFW bias current settings.

The sensor and spacecraft potentials relative to the ambient plasma are different because of the bias current driven to the EFW sensors in order to optimize their DC and AC coupling to electric fluctuations in the plasma. This current biasing drives the EFW sensor potentials closer to the ambient plasma potential, while simultaneously driving the spacecraft potential relative to the plasma to larger magnitudes. This also results in the spacecraft potential relative to the plasma potential being more sensitive to fluctuations in the ambient plasma density (actually number flux), and produces an observable that can be used as a calibrated proxy for the ambient plasma density in many situations.

The relationship between ambient density and the spacecraft potential is roughly logarithmic, with VSC ~ loge(ne). The typical range of VSC (Vsensor – Vground) for ambient densities from 0.01 to 100 cm-3 is roughly -40 V to near 0 V based on experience with the Polar, Cluster-2, and THEMIS electric field instruments, giving roughly 10 V/decade of density variation.

The EFW sensor potentials have a dynamic range of +/- 225-V (450 Vpp) with 16-bit resolution, giving a resolution of ~6.9 mV/ADC count.

The dynamic range of the sensor potential measurement (-225 V to + 225 V) easily encompasses that required by past experience (-40 to 0 V).

For 50% resolution, one has to have better than 0.3-decade (log10(2)) resolution, which would be 3-V resolution; the measurement has a resolution of far better than that, and so the 50% resolution requirement is easily achieved.

# Revision History:

* Rev A, John Bonnell, UCB SSL, 6 March 2012.
  + Initial version, incorporating additional narrative on EFW-36, EFW-208, and EFW-47.