A SENSOR TO AVOID ARCING DUE TO GRAPPLING

Luke Goembel[(1)]

[(1)]*Goembel Instruments, 1020 Regester Avenue, Baltimore MD 21239 U.S.A., Email:luke@goembel.biz*

ABSTRACT

It may be useful to measure low spacecraft floating potential (from ~0-100 volts) to aid grappling missions in GEO. Low absolute floating potential (chasis potential) may indicate that environmental conditions are such that arcing would be unlikely to take place during grappling. It might be possible to determine low floating potentials through analysis of charged-particle energy-spectra collected by an electrostatic analyser (ESA) of novel design. The lowest energy ambient ions detected might reveal the spacecraft's negative floating potential (by the 'low energy ion cut-off' method). The energy location of the thermal electron peak might reveal a positive floating potential. Complications to the methods used to determine positive and negative floating potentials include: 1) contamination of ambient particle spectra by spacecraft generated particles and 2) the low fluence of ambient charged particles in some regions of space at some times. A device that might serve as a spacecraft absolute potential monitor prior to and during grappling is described.

1. DETERMINING ABSOLUTE POTENTIAL

The sensor described here (which has not yet been built) would consist of two hemispherical electrostatic analyzers (ESAs) in a nested configuration, one for electron energy analysis and one for ion energy analysis. Spectra collected from the two analyzers could be analyzed in real-time on board the spacecraft to provide guidance for arc-free grappling. It is beyond the scope of this work to determine the maximum absolute potential at which arc-free grappling is assured, so a determination of floating potentials from 0-100 volts has been chosen as a preliminary, likely useful, range of measurement. If analysis of the low energy ion spectrum in the energy range of 0-100 eV reveals an unambiguous cut-off in ambient ions or if there is an unambiguous peak for ambient thermal electrons in the electron spectrum, then the floating potential of the spacecraft would be below 100 volts.

2. LOW ENERGY SPECTRA

The sensor discussed here would collect both ion and electron spectra in high (2%) energy-resolution with an ESA configuration that has been proven both in space [1] and in the laboratory to be ideally suited for very low (down to ~1 eV) charged particle energy analysis. Unusually high energy-resolution and large geometric factor will facilitate the discrimination of ambient charged particles from interfering, spacecraft generated, charged particles. The relatively long, tightly bent path length along the 180˚ arc of hemispherical ESAs offer superior signal-to-noise when compared to currently popular ESA configurations such as that of the top-hat (90˚ spherical sector) ESA with a similar radius of curvature since fewer false counts will be produced by scattered particles and light. The higher energy-resolution (greater information content of the spectrum) and superior signal-to-noise of the proposed sensor at low analysis energies may enable dependable measurements of low floating potentials.

The sensor proposed for use on grappling missions is based on a modification of the flight-qualified, large geometric-factor, high energy-resolution Spacecraft Charge Monitor (SCM) that was delivered to NASA in 2006. It would be modified to energy analyse ions in addition to electrons as shown in Fig. 1.

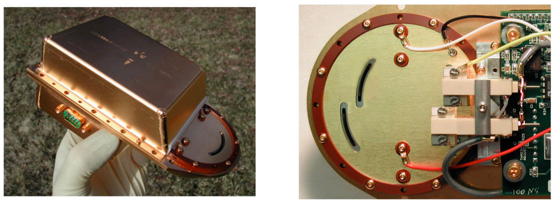

Figure 1. SCM, left, proposed modification, right.

To date, spectra of the sort the proposed instrument would collect in GEO are not available. Lack of such data hinders estimates of the proposed instrument's ability to determine floating potential. Experience with devices that have already flown, such as PES [1] and the Los Alamos National Laboratory Magnetospheric Plasma Analyzer [2], offer guidance on how best to orient the ESA on the spacecraft to limit interference from spacecraft generated charged particles and allow rough estimates of the times needed to make floating potential determinations. However, tests in space are ultimately needed to prove the utility of the novel sensor.

3. REFERENCES

[1] Doering et al. (1973), *Radio Science*, *8*(4), pp. 387-392.

[2] Bame et al. (1993), *Rev. Sci. Instr.*,*64*(4), pp. 1026-1033.