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IAF SPACE POWER SYMPOSIUM (C3)
Space Power System for Ambitious Missions (4)

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THE SPACE ENVIRONMENTAL ELECTRICAL POWER SUBSYSTEM (SEEPS): ENERGY HARVESTING SUPPORTING MICROSATELLITE EXPLORATION OF THE OUTER SOLAR SYSTEM

Abstract

Exploration of the outer solar system has, to date, involved large monolithic spacecraft that take point measurements of the space environment. Missions such as THEMIS and Cluster have demonstrated the value of distributed architectures in determining spatial structures in Earth's magnetosphere. To realize a similar architecture in the outer solar system with similar sized spacecraft would be prohibitively expensive. CubeSats or smaller sized spacecraft provide a potential solution to this problem but powering them is an issue. The distance from the sun necessitates the use of large deployable solar photovoltaic (PV) arrays to capture a minute amount of power. Radioisotope thermoelectric generators (RTGs) are possible, but expensive and dangerous to produce and handle.

We present concepts for harvesting energy from the space environment – space plasmas, dust and debris in particular – through a Space Environmental Electrical Power Subsystem (SEEPS). We estimate the available power in several environments of interest like outer planetary magnetospheres and cometary neighborhoods. Power from spacecraft charging would leverage thermal plasmas and passive electron emitters to pass current through the spacecraft. Harvesting from hypervelocity impact electromagnetic pulses is another potential source, though the underlying physics is far less understood.

Extracting power from the spacecraft charging phenomenon in the Io plasma torus is a promising pursuit, with back-of-the-envelope estimates showing available power on the order of tens to hundreds of mW for a CubeSat sized spacecraft. We use the Spacecraft Plasma Interation System (SPIS) to validate and extend these estimates to more complicated geometries. We also present preliminary results from a recent set of hypervelocity impact experiments in which a prototype rectenna was used along with a suite of RF and plasma sensors.