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EFFECT OF LANGMUIR PROBE MEASUREMENTS ON THE SPACECRAFT POTENTIAL OF SMALL SPACECRAFT

Abstract

Langmuir probes have been used as a plasma diagnostic tool on spacecraft for decades. Traditional spacecraft had current collection areas much larger than the Langmuir probe, such that any change in current collection to the probe had negligible effects on spacecraft electric potential. However, as spacecraft size decreases, the surface area of the probes and the spacecraft become comparable. This leads to drastic changes in the spacecraft's electric potential during probe operation [1].

A spacecraft charging model was created to study the effects of Langmuir probe operations on spacecraft in the ionosphere as a function of area ratios, angle relative to the ion drift, and background plasma properties in support of the MiTEE-I cubesat mission developed at the University of Michigan. This simple model employs two separate analytic current collection schemes for the Langmuir probe and the spacecraft. The Langmuir probe current collection is modeled using a thick sheath approximation for a moving cylindrical probe [2]. The spacecraft is modeled as a series of perpendicular planar probes where ion current collection is preferential to the ram facing side of the spacecraft. Additionally, photoelectron current is emitted from the spacecraft but is assumed to be negligible compared to the effect ofthe Langmuir probe.

In this paper, the results of the model are presented with a focus on the spacecraft potential and the accuracy of electron temperature measurements. As the Langmuir probe enters the electron retardation regime, increased electron collection forces the spacecraft potential to decrease, leading to a measured plasma temperature that is greater than the actual temperature. The decrease in spacecraft potential continues as the probe approaches and enters the electron saturation regime. This leads to a measured spacecraft potential that is more negative than the spacecraft's unperturbed floating potential. Additionally, the current collected to the probe approaches an asymptotic limit as the spacecraft is unable to collect enough ion current to compensate for the probe's electron current collection. This is typically observed in double probes with comparable area ratios.

References

[1] L. H. Brace, "Langmuir probe measurements in the ionosphere," Measurement Techniques in Space Plasmas: Particles Geophysical Monograph, 102.

[2] L. E. Wharton W. R. Hoegy, "Current to moving spherical and cylindrical electrostatic probes," Goddard Space Flight Center, Greenbelt, Maryland, X-621-71-276.