ACTIVE DIPOLE ANTENNA MEASUREMENTS ON RPI/IMAGE SATELLITE DETERMINE THE PLASMA SHEAT CHARACTERISTICS

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The Radio Plasma Imager (RPI) aboard the IMAGE satellite was used to determine the characteristics of the plasma sheath around the antenna when transmitting whistler mode signals. Active antenna current measurements were made during three sequential orbits on 29-30 Sept. 2004 while the RPI transmitter systematically changed the transmission frequency from 8 to 23 kHz in steps of 100 Hz. This investigation was directed towards determining the input impedance characteristics of the long thin transmitting dipole (short in terms of free-space wavelengths) as the satellite, in a near polar orbit, moved through the plasmasphere, over the polar cap region and out again through the nighttime plasmasphere at altitudes ranging from 2 R_E to 6 R_E. The plasma frequency at the satellite during this period ranged from 760 kHz to 40 kHz (when over the polar cap) and most of the transmissions during these experiments were in the whistler mode. Continuous antenna current measurements provided the tuning information. The tuning inductance in the feed of the antenna was varied with each frequency step and the location, in frequency, of the current peaks indicated an antenna input capacitance of 550 ± 50 pF over a significant portion of the scanned frequency range. The input capacitance of the RPI antenna (in free space) was calculated to be 370 pF and measured, as the satellite left the plasmasphere into the low-density magnetospheric cavity, to be 450 pF.

To simulate the growth and decay of the plasma sheaths surrounding the antenna, a program was written that calculates the time variation of the charge and current on a dipole antenna embedded in a plasma during each RF cycle. Using the work of Shkarofsky (1972), and Wang and Bell (1969), this program finds the antenna charge as function of applied voltage to calculate the time-dependent radii of the surrounding ion and electron sheaths and the associated sheath capacitance. An equivalent circuit four-capacitor and radiation resistance (Balmain, 1964) model driven by a square-wave voltage was used to calculate the antenna currents and radiated power. The results were compared with the actual antenna current measurements. With this program it is possible to assume that the antenna's wire elements were either insulated or bare. For this data set, the model calculations were carried out at 18.8 kHz, where experimentally, a maximum antenna current of about 300 mA was measured. The calculations indicate a radiated power of 9.8 W. These results are consistent with the known RPI performance.

The good agreement found between these experiments and the model calculations make it possible to use this program to extend the simulations to the design of new satellite transmitter and antenna systems that are planned for flights in Earth's vicinity as well as in other planetary environments.

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