Development of the Langmuir Probe for the Spacecraft with Charged Potential

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The floating potential of a spacecraft in space varies with the number flux of charged particles incident to and emitting from its surface. A low earth orbit (LEO) satellites is known to be negatively charged due to incidence of thermal electrons, and its potential can be negatively charged up to several volts. In addition, it is known that the ion sheath with a thickness of several centimeters is formed on the spacecraft surface. In the case of spacecraft on which active experiments are carried out, it is possible for the potential to be much larger and then the sheath thickness on the spacecraft surface will be more the n ten centimeters. This situation is unacceptable for measurements by a Langmuir probe because an amplitude of the sweep voltage to obtain the voltage versus current (V-I) relationship in the Langmuir probe measurements is typically a few volts, and therefore the sweep with respect to the floating potential cannot cover the voltage range necessary for the electron temperature and density estimation. Furthermore, the probe measurement may be adversary affected by the ion sheath formed on the spacecraft surface. We are developing an electric circuit for the Langmuir probe which can be used on spacecraft with large floating potential so as to avoid such unfavorable situation. In the developed circuit, the voltage sweep to get the V-I relationship consists of two steps; 1) coarse sweep for wide voltage range and 2) fine sweep for narrow voltage range. A voltage from 0 to 100V is applied to the probe to find the space potential on the spacecraft in the first step. In actual measurement, the circuit is designed to find the potential on which the gradient of logarithmic probe current with the voltage becomes maximum in a wide range of the voltage sweep. In the second step, the probe voltage is determined with respect to this space potential so that one can obtain the V-I relationship with a fine step which is necessary for the electron temperature and density estimates. Such a circuit for Langmuir probe measurement was first developed a few years ago. However, the circuit did not work properly. In this study, we try to modify the logic of the FPGA program in the circuit to overcome the problem. Then, the performance was tested by confirming whether the reference potential with respect to the plasma could be determined. As a result, it was confirmed that the circuit can successfully determine the potential. Thurs, it can be concluded that the present modification of the in-circuit logic for the Langmuir probe greatly improves its performance and the newer circuit can properly determine the potential with respect to the plasma. We will also examine how the ion sheath affects the plasma parameter estimation when the measurement is made within the expanded ion sheath around the spacecraft with a large negative potential.

Keywords: Langmuir probe, Plasma parameter, Spacecraft, Floating potential

