Abstract

Spacecraft charging remains to be one of the limiting factors of the reliability of the spacecraft electronic systems in the space environment. Spacecraft surfaces interact with the Earth's magnetospheric plasma environment and builds up potential on its surfaces. After exceeding the threshold voltage, it releases uncontrolled Electrostatic Discharge (ESD) on the spacecraft surfaces. The discharge results in transient structural current and radiated electromagnetic energy which modifies the electrical state of the spacecraft systems. The charging induced unwanted currents pose a serious threat to the survivability of the spacecraft in the orbit. The surface potential also affects the scientific measurements in the orbit.

In this thesis, the focus is on the computation of the free space capacitance of the spacecraft surfaces for predicting the charging effects. As, the spacecraft surfaces are covered with conductive and dielectric materials, each surface material has different capacitances with respect to infinity. Due to different value of the capacitance for each surface, the profile of the time dependent potential is different for each surface. This creates the arcing events due to differential charging between the surfaces. The approach is pure theoretical analysis for computing the free space capacitance and time dependent charging potential.

An algorithm based on the method of moments with parametric triangular patch modeling is proposed to compute the free space capacitance of the arbitrarily shaped objects. This algorithm is more general, purely numerical, and capable to model the geometrically complex spacecrafts. This is amenable for the object oriented programming. Based on the proposed approach, capacitance of the planar and curvilinear conducting surfaces such as square, rectangular plates, circular disc, cylinder and truncated cone are analysed. Then, free space capacitance of the metallic surfaces in the presence of dielectric coating such as square plate, circular disk, cylinder and truncated cone, etc. are computed. Subsequently, temporal evolution of the spacecraft structure/surface potential for the various environmental conditions is computed to analyse the spacecraft charging effects.

Keywords: Free space capacitance, geosynchronous orbit, moment method, parametric method of moments, modeling, plasma, spacecraft charging.