The July 2004 Event and Simulation of its IDC Effect on Spacecraft

Y.-Q. Hao, W.-X. Jiao, H.-F. Chen, X.-S. Li

Institute of Space Physics and Applied Technology, Peking University, Beijing 100871
(jiao@pku.edu.cn)

Internal dielectric charging (IDC) is a significant hazard to the spacecraft exposed to the space radiation environment, especially to those passing through the Earth-ąŕs radiation belts. As known, solar events, such as flares, CMEs, SPEs and electron storms, are usually the causes of IDC and lead to spacecraft anomalies. During the event of July 2004, the GOES satellite data showed that the flux of >0.6 MeV electrons increased dramatically, and reached about $10^6 cm^{-2} \cdot Sr^{-1}$. This event lasted for several days and was possibly a serious threat to spacecrafts at that time. In this paper, a generalized cubic onboard subsystem is constructed to examine the effect of IDC and its relation to space events. This subsystem has shields on each side and 10 Printed Circuit Boards (PCB) inside. Utilizing GEANT4 toolkit based on Monte Carlo method, we simulate the interaction of injecting elections with the shields and PCBsąŕ dielectric to calculate the electron deposition. The maximum electron field inside these PCBs is calculated, and the effect of IDC and its relation to solar events are evaluated quantitatively.

According to the assumption of exponential spectrum of space electrons and its corresponding empirical formula $J(>E) = J_0 \cdot e^{-1.57E}$, the electron spectrum is calculated from GOES data, and input into the GEANT4 as injecting particles. The simulation result gives the dose rate, and from which the radiation-induced conductivity (RIC) can be calculated with $\sigma = \sigma_0 + k_p \dot{D}^{\Delta}$. These calculations help us to determine the maximum electron field inside the dielectric finally.

Given the severe space environment during the event of July 2004, we get a strong field of $10^6 V \cdot m^{-1}$, which leads to a 'potential hazard' of breakdown. The study on IDC effect can help us to assess the vulnerability while designing the shield, and reduce the risk of operational spacecraft systems from IDC.