Chapter 5
Control and Monitoring Techniques

5.1 Active Spacecraft Charge Control

Charge control devices are a means of controlling spacecraft potential. Various active charged-particle emitters have been and are being developed and show promise of controlling spacecraft potential in the space plasma environment. At this time, only neutral plasma devices (both ion and electron emitters) have demonstrated the ability to control spacecraft potential in geomagnetic substorms. These devices are sometimes recommended for charge control purposes [1,2]. Plasma contactors are currently the most widely used charge control devices.

Emitted particles constitute an additional term in the current balance of a spacecraft. Because the ambient current densities at geosynchronous altitude are quite small, emitting small currents from a spacecraft can have a strong effect on its potential, as has been demonstrated on ATS-5, ATS-6, SCATHA, and other spacecraft. However, devices that emit particles of only one electric charge (e.g., electrons) are not suitable for active potential control applications unless all spacecraft surfaces are conducting. Activation of such a device will result in a rapid change of spacecraft potential. Differential charging of any insulating surfaces will occur, however, and cause potential barrier formation near the emitter. Emission of low-energy particles can then be suppressed. Higher energy particles can escape, but their emission could result in the buildup of large differential potentials. Conversely, devices that emit neutral plasmas or neutralized beams, e.g., hollow cathode plasma sources or ion engines, can maintain spacecraft potentials near plasma ground and suppress differential charging. These are, therefore, a possible type of charge control devices at the cost of reliability and complexity.
5.2 Environmental and Event Monitors

The occurrence of environmentally induced discharge effects in spacecraft systems is usually difficult to verify. Often the only thing known about an anomaly is that it occurred at some spacecraft time. Since most spacecraft are not well instrumented for environmental effects, the state of the environment at the time of the anomaly typically has to be inferred from ground observatory data. These environmental data are not necessarily representative of the environment at the spacecraft location; in fact, the correlation is generally poor.

This problem could be addressed if spacecraft carried a set of environmental monitors, e.g., a simple monitor set designed to measure the characteristic energy and current flux as well as to determine transients on harness positions within the spacecraft [3]. This would allow correlation between the onset of the charging environment and possible transients induced on the electronic systems. Representative packages weigh about 1 kg and use 2–3 W of power. One commercially available system is the Amptek Compact Environmental Anomaly SEnsor (CEASE) package that measures total radiation dose, radiation dose rate, surface dielectric charging, deep dielectric charging, single event effects (http://www.amptek.com/pdf/cease.pdf). Such environmental sensors would be on outside surfaces and preferably in shade. Even more sophisticated packages are available that make detailed scientific measurements of the environment. For example, ion particle detectors in the range of 10 to 50 keV are used to sense the onset of geomagnetic substorms. Transient monitors capable of measuring the pulse characteristics have also been used [4]. These systems require larger weight and power budgets, but they do provide better data.

Spacecraft charging effect monitors require data analysis support to produce the desired results. If they were carried on a number of operational satellites, the technology community would be able to obtain a statistical base relating charging to induced transients. The operational people, on the other hand, would be able to tell when charging is of concern, to establish operational procedures to minimize detrimental effects, and to separate system malfunctions from environmentally induced effects.

It is recommended that monitor packages be carried on all geosynchronous spacecraft. These packages should consist, at a minimum, of a dosimeter, energetic plasma environment detector, surface potential monitor, and transient voltage pulse detector. Various types of IESD monitors are currently in development and should be seriously considered also.
References


