High-Voltage Power Switching for a Conducting Tether

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Abstract

The ElectroDynamic Delivery Express (EDDE) is an autonomous space vehicle that can maneuver throughout low earth orbit without using fuel. EDDE uses solar power to drive multi-ampere currents through a kilometers-long aluminum conductor, creating a force normal to both the conductor and the local magnetic field that drives the space vehicle. The current circuit is completed through the ambient plasma around the conductor. To provide complete control of the orbit, the high-voltage current must be switched repeatedly as a function of the orbital position, to modulate the force on the conductor. This paper describes our solution to this power switching and control problem. Arcing from the conductor to the ambient plasma is a potentially serious problem. To reduce the possibility of arcing, the solar arrays are distributed along the conductor length to reduce the peak potential between the conductor and the local plasma. If arcing does start, it can be quenched by electrically isolating the tether segments upstream of the arcing section, using high-voltage control switches in each power module. This makes it feasible to pull the arcing segment positive to quench the arc. Each power module includes an “H-bridge” so the solar array can drive current through the tether in either direction. Turning the bridge off isolates the conductor segments and array from each other, to help quench arcs from either the array or the conductor. The bridge also includes a shunt switch so tether current can bypass the solar array. This lets EDDE continue operating despite failed power switches or mis-aimed solar arrays. Effective current control and arcing control requires communication between the modules. This could be provided with an optical system, or with RF signals transmitted along the conductor, superimposed on the drive current. The entire space vehicle electrical system and switching circuitry are simulated on the “Virtual Test Bed” at the University of South Carolina to demonstrate system performance and design optimization.