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INVESTIGATION OF DIELECTRIC SURFACE EFFECTS AND APPLIED VOLTAGE ON COMMUNICATION WINDOWS IN DC-ELECTRONEGATIVE PULSING FOR REENTRY BLACKOUT ALLEVIATION

Abstract

A spacecraft entering a dense planetary atmosphere will ionize the background atmosphere along its path by shock formation and frictional heating due to its high speed, thereby creating a plasma layer that surrounds the spacecraft. The plasma layer blocks all incoming and outgoing radio signals, including command, control and telemetry, which is referred to as the reentry blackout problem. Depending on the shape and trajectory of the incoming spacecraft, radio signals of frequencies up to 10 GHz may be attenuated. The blackout period lasts up to several minutes and is a major contributor to the landing error ellipsoid, aside from being a serious safety hazard, especially for human spaceflight. We discuss a new method to create transmission windows in the reentry plasma layer through strong electronegative DC pulses applied to the plasma through electrodes mounted under the vehicle surface. The pulses are repeated with a low duty cycle to reduce power consumption and prevent dielectric breakdown on the surface of the electrodes due to charge accumulation. We discuss selected results from a Particle-in-Cell simulation investigating the interaction of electrodes with the reentry plasma layer. Surface interactions between the plasma and the insulated electrodes are modeled. Simulation results show the creation of pockets of low electron density in the vicinity of the electrodes, which can be utilized for communication. The size and duration of these pockets depend on electrode arrangement and pulse shape. Finally, we present a plan to verify the accuracy of the simulations and efficacy of the blackout alleviation method through experiments in a plasma wind tunnel.