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A SPACE POWER SYSTEM FOR ENERGY HARVESTING FROM AN ELECTRODYNAMIC TETHER

Abstract

An electrodynamic tether is a conductive wire, several hundreds of meters long, unreeled from a space probe while under the influence of a planetary magnetic field. The interaction of the free electrons in the wire with the magnetic field follows the basic equation of the Lorenz force and provides either propulsion for orbiting or sling-shoot manoeuvres or even electrical power to the space platform. With growing concerns about the increase of space junk and the incoming regulations to move Earth orbiting satellites out of their nominal orbits, and even de-orbit them, electrodynamic tethers have been proposed as thruster mechanisms for end-of-life orbital operations and related projects have been funded by organisations such as the European Commission, ESA, NASA and JAXA among others.

To make the de-orbiting system completely autonomous from the satellite main power bus, energy harvesters have been studied to provide electrical power for mission control while the operation of the tether. However, these electrical power systems could be as well used as main power systems in space missions to planets with very strong magnetic fields such as Jupiter.

As no detailed proposal for such a power system has been found in the literature this paper makes such a proposal based on electrical topologies already in use in European based space platforms.

The power system is built under the assumption that the power is delivered by a 20km conductive tether in a 600km low Earth orbit in an average solar activity day with three main objectives:

- Provide power to the hollow cathode system and regenerate energy
- Dissipate (dump) the electrical energy injected by the electrodynamic tether
- Use some of the tether incoming energy for powering purposes

To obtain this functionality the tether is directly connected to a hollow cathode, that balances the satellite platform charge by releasing electrons to free space by using a jet of ionised argon, a dissipative load, and a DCDC power supply, which conditions some of the incoming power to the telemetry and telecommand units of the system and the hollow cathode electronics.

The paper presents a detailed system diagram of the proposed electrical power system and gives detailed descriptions of each block, at electronic circuit implementation level, based on European Space Agency missions heritage.