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SUPER-CAPACITOR ENERGY STORAGE FOR MICRO-SATELLITES: DEVELOPMENT AND POTENTIAL MISSION APPLICATIONS

Abstract

Super-capacitors have become a practical alternative to chemical batteries as a rechargeable energy storage medium. For space use, they have the advantage of being able to support high power demanding payloads and subsystems at a much higher specific power than conventional rechargeable batteries. This low mass/ high power capability makes them very attractive for use in space.

Micro-satellites are increasingly being used as a cost-effective means to achieve highly demanding remote sensing and technology demonstration missions. For example, small satellites used in constellations (such as the Disaster Monitoring Constellation – DMC) have enabled global coverage to be achieved with shorter revisit times than is possible with single, larger conventional spacecraft. However, one significant limitation of micro-satellites is their ability to support high power-consumption payloads (such as radars and electric thrusters) due to the constraints on the allowable mass and volume of the battery on-board such spacecraft and to the relatively limited surface area available for body-mounted solar cells.

The energy capacity of recently developed super-capacitors is well matched to the energy generation rate of micro-satellites with body-mounted solar arrays. A typical low-Earth orbiting micro-satellite generates an average power of 30 to 70W in 100 minutes - i.e. an energy of 50 to 120 Wh per orbit, of which typically 50 percent is needed to operate the bus subsystems - leaving 25 to 60 Whr available to any payload. A Lithium-ion based super-capacitor has a specific energy of approximately 15 Wh/kg - which would imply an energy storage mass of 2-4 kg. This is similar to conventional micro-satellite batteries, but the super-capacitor has the great advantage that is can supply 1kW/kg specific power with more than 95 percent energy-efficiency. This is an order of magnitude better than the power delivery capability of conventional batteries, and would enable micro-satellite to operate payloads with 1-2 kW power consumptions for a minute or so.

This paper will present the results of our development of a super-capacitor based power system and will discuss how such systems used directly, or in combination with conventional batteries, can greatly extend the capability of micro-satellites.