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IMPLEMENTATION AND TESTING OF A PASSIVE MAGNETIC ATTITUDE CONTROL SYSTEM FOR THE 3U ASTROBIO CUBESAT ORBITING IN THE VAN ALLEN BELT

Abstract

AstroBio CubeSat (ABCS) is a mission funded by the Italian Space Agency (ASI) aimed at validating novel lab-on-chip technology that would enable the use of micro- and nano-satellites as autonomous orbiting laboratories for research in astrobiology. The 3U CubeSat ABCS will be deployed by Vega-C launch system in a circular orbit with altitude of 5900 km and inclination of 70 degrees which crosses the inner Van Allen belt, collecting a total ionizing dose (TID) orders of magnitude greater than the one experienced in any Low Earth Orbit (LEO). Because of the effects of TID onto on-board electronic devices, ABCS is expected to have an operative life significantly shorter than LEO CubeSats.

The implementation of an attitude control system (ACS) capable of (i) detumbling the satellite, (ii) rotating it such that the body-mounted solar panels can face the Sun with optimal exposure and (iii) allowing a uniform distribution of the radiative thermal load, can increase the reliability of ABCS. In fact, both the payload and the on-board systems set strict constraints on the power requirement and the allowed temperature range. Given the short operative life expected for ABCS, the faster and the longer these operative conditions are established after the deployment, the higher the chance to collect data from the payload and validate the lab-on chip.

Limits on the power budget dictate the use of a passive magnetic attitude control system (PMACS), consisting of permanent magnets, rotating the satellite in the direction of the geomagnetic field vector, and soft magnetic alloy tapes, performing the detumbling and stabilization of the satellite. The characterization of the mentioned devices is not trivial and pivotal for estimating the performance of the PMACS. The magnetic dipole moments and the hysteresis loop for the soft magnetic tapes were determined experimentally, in a laboratory facility including a spherical air-bearing, allowing friction-less rotation, and a Helmholtz cage, recreating the geomagnetic field that ABCS will experience during the mission. Because the magnetosphere is strongly perturbed in the Van Allen belt region the IGRF model may lack of accuracy, therefore it was used the Tsyganenko model, which includes the contributions from major external

magnetospheric sources inferred by satellite data. Once characterized the magnetic devices, the PMACS was tested on the engineering unit of ABCS, and the optimal configuration to achieve the desired attitude and stability within one day from the deployment was determined.