ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (1)

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MAGNETIC ATTITUDE CONTROL OF A TWO BODY SYSTEM IN DRAG BALANCE INSTRUMENT IMPLEMENTATION

Abstract

An instrument capable of directly measuring the drag force, and hence the atmospheric density, is the Drag Balance Instrument (DBI), which has been flown on the five San Marco satellites, designed, built, launched and operated by the Scuola di Ingegneria Aerospaziale in cooperation with NASA between 1963 and 1988. The original DBI implemented in the San Marco satellite can be modified to fit in a standard Cubesat nanosatellite. Whereas the original implementation consisted of a spherical shell encompassing the whole spacecraft, the Cubesat implementation consist of two plates mounted externally from two faces of the Cubesat. Therefore, the DBI concept adaptation to the Cubesat bus leads to a two body spinning system, with the spin axis aligned to the orbit normal. The two DBI flat plates are mounted on opposite cubesat sides, connected by a rod. The rod is connected to the satellite body by two flexural springs. Beingthe spin axis orthogonal to the rod, the plates are exposed to the incoming atmosphere flux at the spin rate, generating a relative displacement between the DBI and the satellite. The spin frequency component of this displacement is related to the atmospheric drag force and can be evaluated by measuring the displacement itself and isolating the spin frequency content. The whole satellite should be a low cost system, since the lifetime is intrinsically low and the onboard instruments will give useful data for a short time; moreover, benefit would accrue from a mass production unit cost gain. For these kinds of satellites a very simple magnetic control law, based only on magnetometer readings would be preferable, limiting the necessary on-board hardware and computations. The Cubesat attitude dynamics is analyzed, showing how the drag balance and the satellite attitude motions are coupled when the two bodies' center of mass are not exactly coincident. Stability is discussed, determining an upper limit for the static unbalance. A magnetic control law, based only on magnetometer readings, is used for nutation damping, spin rate and spin axis orbit normal pointing control. The attitude acquisition maneuver is described by the method of averaging. It is shown that, though the attitude motion of the two bodies are coupled, there are no coupling effects on the drag balance motion at the spin frequency. This is a very important feature of the proposed attitude control system, not affecting the measurement procedure and the DBI performance.