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DESIGN, MANUFACTURING AND GROUND TEST OF A SMALL AND COST-EFFECTIVE FPGA-BASED CONTROL MOMENT GYRO FOR THE URSA MAIOR NANOSATELLITE

Abstract

The nanosatellite URSA MAIOR (University of Rome la SApienza Micro Attitude In ORbit testing) is scheduled for launch in the near future, as one of the Cubesats selected in the framework of the QB50 mission, leaded by the Von Karman Institute for Fluid Dynamics. On-board this nanospacecraft, in addition to the QB50 scientific payload, a few technological payloads will be boarded. Among these, we find an experimental nanospacecraft variable speed control moment gyro (VSCMG), developed at the Laboratorio di Sistemi Aerospaziali (LSA) of University of Rome "La Sapienza", with the aim to provide nanospacecraft platforms with a high level of attitude maneuvering agility. Fast and accurate spacecraft pointing is required, for example in moving target tracking in the field of space-based space debris observation. In the past, control moment gyros (CMG) were only used in very large spacecraft, such as space stations and Earth-observation platforms, but they are recognized nowadays as a very promising technology, if suitably miniaturized down to the nanospacecraft size. In this paper we show how this can be obtained, thanks to new technical developments and the availability of suitable commercial-off-the-shelf (COTS) components. The URSA MAIOR control moment gyro, as low as 50x50x80 mm3 in volume and about 170 g in weight, described in detail in the paper, was developed and tested on-ground. It is basically composed of a spinning flywheel and a motorized gimbal that tilts the flywheel spin axis. Both flywheel and gimbal motors are based on COTS components. The system compactness and reliability is enhanced by the use of a FPGA-based control electronics, allowing to easily multiply the basic logic blocks inside the device, thus realizing a certain level of redundancy, which permits to make the controller fault tolerant to single event upsets (SEUs). The CMG FPGA, provides for closed loop control for the motors and an I2C interface, allowing the communication with the on-board computer. The device was successfully tested on a specifically developed frictionless supported test-bed, simulating the satellite on-orbit attitude dynamics. The results and system performance in terms of agility and pointing accuracy are discussed in the paper, describing the interface with the satellite.