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ANALYSIS OF SUN-ACQUISITION MAGNETIC ATTITUDE CONTROL FOR NANOSATELLITE USING A HARDWARE-IN-THE-LOOP SATELLITE SIMULATOR

Abstract

Many nanosatellite missions based on CubeSats require special attitude motion according to demands of their payload. In some cases, there is no strict requirements on angular velocity or orientation of the satellite, that is why for satellites in LEO it is enough to use active magnetic attitude control system with minimal set of sensors for attitude motion determination. Usually, it is used for angular velocity damping after the launch: onboard magnetorquers produce the magnetic dipole moment according to the well-known Bdot algorithm. Afterwards, the satellite attitude motion is random, and it is determined by initial conditions and orbital disturbance torques. This random motion can lead to low effectiveness of solar panels due to high angles between the normal to the high-area side of the 3U CubeSat and Sun direction. It results in low power onboard that could be not enough for the payload. That is why for such a mission with low attitude motion requirements the magnetic control algorithm for Sun acquisition should be applied.

In the framework of joint project between the University of Brasilia and the Keldysh Institute of Applied Mathematics the Sun acquisition magnetic attitude control algorithm is developed and tested on the laboratory facility with Earth magnetic field imitator and nanosatellite mock-up suspended on the air-cushion. The main feature of the algorithm is that it does not require the Sun sensors, the direction to the Sun in body reference frame is calculated using magnetometer measurements processed by the extended Kalman filter and Sun direction model onboard. Two-line elements provide the satellite position according to SGP4 model that is used for magnetic field calculation using IGRF model, the estimated local geomagnetic induction vector in body reference frame is compared to the magnetometer measurements, the current attitude quaternion and angular velocity are estimated in real-time. The developed control law is proportional to the unit sun-direction derivative in the body reference frame. The calculated magnetic dipole is implemented by magnetorquers, the dipole interaction with local magnetic field provides the required control torque. As the result, the defined normal to the solar panels is aligned with the Sun direction and the satellite rotates around this axis. The main difference between the attitude motion of the satellite in orbit and its mock-up is the disturbance torque due to inevitable shift between the suspension point and center of mass. The performance of the algorithm considering this difference is studied in the paper.