IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (2)

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BORESIGHT STABILIZATION OF AN AXISYMMETRIC EARTH-POINTING SATELLITE USING MAGNETORQUERS

Abstract

The objective of boresight stabilization for an Earth-pointing satellite is keeping the boresight axis of an instrument aligned with the nadir direction. It is a common task of many satellites during their operational life. For example, it might be required to a satellite to point a camera or a radar at the Earth or to point an antenna at a ground station. A common approach for boresight stabilization is performing three-axis stabilization with respect to the orbital frame which requires measurements of the full attitude of the satellite. However, in many situations only the pointing direction of the boresight axis is important, and the rotation about it is not relevant. Thus, in those situations measurements of the full attitude can be replaced by measurements of the only nadir direction.

This research proposes a feedback control law that aligns the boresight axis of the instrument to the nadir direction and with no spinning about the boresight axis to avoid blurred measurements. The satellite is inertially symmetric with respect to the boresight axis and uses magnetorquers as only torque actuators. The proposed control law is of the Proportional-Derivative (PD) type and employs measurements of the geomagnetic field, of the angular velocity, and of the nadir direction which can be obtained by using a horizon sensor. Measurements of the full attitude are not required thus eliminating the necessity of additional attitude sensors. Moreover, the proposed law does not require accurate knowledge of the spacecraft inertia parameters. The PD gains are determined by solving a periodic linear-quadratic regulator problem. A numerical study shows the effectiveness of the proposed law. The study also presents a comparison with respect to a three-axis stabilization law in terms of stabilization capabilities with respect to the satellite initial conditions, pointing accuracy, despinning action, and energy consumption.

The proposed research is potentially useful especially for low-cost satellites since for those satellites it is essential to reduce the number of sensing devices so to save cost and weight. Moreover, in low-cost satellites it often occurs that magnetorquers are employed as only torque actuators due to their low cost, low weight, and high reliability with respect to other types of torque actuators. Moreover, many low-cost satellites are of the Cubesat type and often present inertia symmetry with respect to the boresight axis.