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Author: Prof. Arun Misra
McGill University, Canada, arun.misra@mcgill.ca

Ms. Nona Abolfathi Nobari
McGill University, Canada, nona.abolfathinobari@mail.mcgill.ca

A NOVEL ACTIVE CONTROLLER FOR SPIN STABILIZED SATELLITES USING FLUID RINGS

Abstract

A satellite is required to maintain a specific orientation to accomplish its mission objectives, such as imaging, communication, and power generation. To this end, several satellite stabilization methods have been proposed and tested so far, which can be generally categorized into two groups of controllers, namely, passive and active. Satellite designers usually do not completely rely on passive stabilization. For instance, the well-known gravity gradient stabilization is usually accompanied by other kind of active controllers, such as reaction wheels, CMGs as the secondary means of controlling the satellite attitude angles. In this paper, a novel complementary active controller for spin stabilized satellites is proposed as an alternate to the commonly used micro thrusters. The controller utilizes two circular fluid rings in roll and yaw directions. The flow inside each fluid ring is regulated by a space-qualified pump, which produces the required torque. This control torque has two components: one resulting from the pump pressure, the other from the shear stress acting on the wall of the ring. The merits of this novel method lies in reduction of the system total mass and the energy consumption, thereby reducing the total cost of the satellite, the downside being the difficulty of fluid modeling and possible fluid leakage. To verify the feasibility of the proposed system, a dynamical model of the spin stabilized satellite with two fluid rings is first formulated. To asymptotically stabilize the satellite orientation, a control law is then designed to calculate the control torque required. The desired fluid angular velocity can be calculated by substituting this control torque in the equations of motion of the fluid rings. The simulation results of the dynamical model of the system show that the satellite becomes asymptotically stable in a fairly short period of the time, about five minutes, while the required fluid angular velocity is as small as 0.1 rad/s, which can easily be produced with low energy consumption. These results show that fluid rings can be attractive alternates to other kind of active controllers for spin stabilized satellites; indeed, they are worth further investigation for real applications because of their cost-saving advantages.