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DEVELOPMENT OF A DUAL GIMBAL CONTROL MOMENT GYRO FOR NANO-SATELLITES

Abstract

The work presented in this article describes the development of an attitude control actuator for use in CubeSats. This actuator uses novel Control Moment Gyro technology to perform slew manoeuvres. The configuration consists of a symmetric pair of counter-rotating gyros mounted in scissoring dual gimbals. The outer gimbals are mechanically constrained using gears driven by a single stepper motor while the inner gimbals are individually actuated using two additional stepper motors. 3-Axis control is obtained by changing the gimbal angles for roll and pitch manoeuvres and varying the wheel speed for yaw rotations. Electronics were designed to control the momentum wheel motors and the gimbal angle actuators. A mathematical model was derived from the mechanical design. The model was used in simulations where a slew manoeuvre was performed in each axis individually in order to match the hardware-in-the-loop test conditions. The average power usage for the 3-axis implementation during a slew manoeuvre was measured at 470 milli-Watt and the volume required for the actuator is only 10 cm x 7 cm x 5 cm, making it suitable for nano-satellite use.

The attitude controllers tested include a Bang-off-Bang and a Quaternion Feedback controller. The controllers are typically combined for large slew manoeuvres: The Bang-off-Bang controller is used first and at the required final attitude, the Quaternion Feedback controller is enabled to accurately track the reference angle. Hardware-in-the-Loop tests were done on a low-friction airbearing platform for ground based attitude control demonstrations. Attitude knowledge was obtained from a MEMS inertial measurement unit and an optical “sun” sensor. Tests were repeated for various platform moments of inertia in order to empirically determine the expected pointing accuracy of the system. Similar tests were also implemented using a conventional reaction wheel configuration to compare the performance. A maximum torque of 0.25 mNm can be achieved by this new actuator and a pointing accuracy of less than 0.2 degrees was demonstrated on the air bearing platform. Initial results show adequate performance to justify further development of a flight actuator module.