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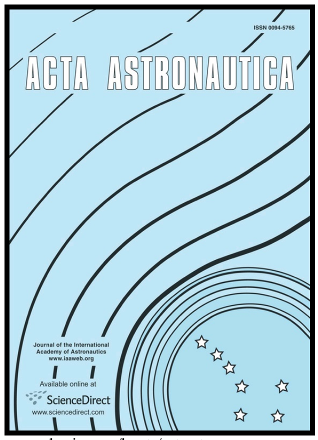

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DEVELOPMENT OF A LOW-COST, LOW MICRO-VIBRATION CMG FOR SMALL AGILE SATELLITE APPLICATIONS

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Abstract

The agility of the spacecraft which refers to the spacecraft's ability to execute fast and accurate manoeuvres within a fixed period of time, is a key satellite parameter. The spacecraft agility is directly proportional to the spacecraft actuators' output torque. For high torque inertial actuators (>0.5Nm), Control Moment Gyroscope (CMG) exhibits better performances in terms of mass and electrical power consumption than reaction wheels. However, in addition to the complex steering law required to avoid CMG singularities, one of the reasons why CMGs are not widely used is due to their high micro-vibration emission which may interfere and disrupt spacecraft sensitive instruments such as optical payload. In this paper, an innovative two-stage viscoelastic damping system has been designed and implemented in a new low micro-vibration CMG prototype. The first stage of the damping system acts at bearing level while the second stage of the damping system acts at mechanism level to attenuate structural resonances and motor noise. The developed CMG enables to combine high actuator output torque with a low micro-vibration signature. The viscoelastic damping system is cost effective as this is a fully passive system which requires no thermal control and no electronics. Furthermore, the attenuation provided by this innovative two stage damping system can reach a slope up to -80dB/dec which leads to a Mini-CMG micro-vibration signature lower than similar output torque reaction wheels not equipped with a damping system.

Keywords
Control Moment Gyroscope, CMG, Micro-vibration, Reaction wheel, viscoelastic isolator

1. LITERATURE REVIEW OF ACS ACTUATORS FOR SMALL SATELLITES

Nowadays, most of Earth Observation satellite end-user applications such as 2D cartography, high resolution 2D/3D pictures, agriculture monitoring, natural disaster management or military use, require highly accurate and agile satellites.

The current state of the art of spacecraft's Attitude Control System (ACS), subsystem in charge of controlling and slewing the satellite, uses angular momentum exchange mechanisms such as Reaction Wheels (RW) or Control Moment Gyroscope (CMG). Both actuators are presented in the following sections.

1.1 Introduction to Reaction Wheels

The majority of satellites uses reaction wheels as primary ACS actuator. This technical decision can be explained by the simplicity of the RW ACS controller and a significant space heritage. The output torque of a RW is generated by a modification of the angular momentum (either by increasing or by decreasing the speed of the RW's inertia disk). Figure 1 presents a schematic view of the SSTL© 200-SP reaction wheel. In addition, the torque of a reaction wheel can be computed as per Eq 1.

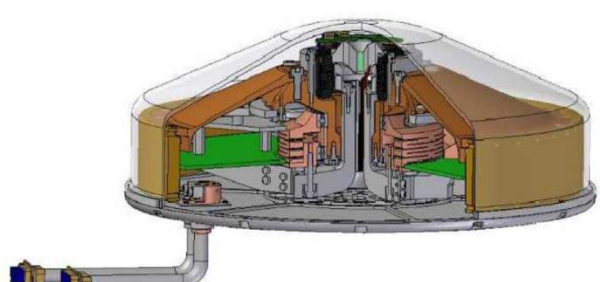

Figure 1: Schematic view of the SSTL© 200-SP reaction wheel [1]

$$N_{wheel} = I_{disk}\ddot{\theta}_{disk} \qquad (1)$$