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

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 linked to the spacecraft actuators output torque. It has been shown that for high torque inertial actuators (¿0.3Nm), Control Moment Gyroscope (CMG) exhibits better performances in terms of mass and power than reaction wheels. However, 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 project, an innovative two-stage viscoelastic damping system has been designed and implemented in a new low micro-vibration CMG. The mini-CMG has been designed for mini satellite applications and has an output torque greater than 0.5Nm with a mass lower than 5kg while maintaining a low micro-vibration signature. The innovative passive damping system aims at minimising the amount of micro-vibrations transmitted to the spacecraft. The first stage of the damping system acts at bearing level to reduce bearing and unbalance disturbances before any amplification occurred due to structural resonance modes. In addition, the second stage of the damping system acts at mechanism level to attenuate structural resonances and motor noise. The attractiveness of viscoelastic materials comes from their high damping properties and their ability to act as passive damper to reduce micro-vibrations. The design of the damping system has been performed into two phases: at viscoelastic material level (material characterisation and selection) and at viscoelastic damper level (Damper design and characterisation). The developed CMG design enables to combine high actuator output torque with a low micro-vibration signature. The developed 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.