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ON GROUND CHARACTERIZATION OF MICRO-VIBRATIONAL DISTURBANCES GENERATED BY SINGLE GIMBAL CONTROL MOMENT GYRO

Abstract

Control Moment Gyros (CMGs) are inertial actuators used for spacecraft attitude control. A Single Gimbal CMG (SGCMG) consists of a spinning flywheel, which generates angular momentum, and a gimbal servo system which is used to swivel the angular momentum vector to produce the output gyric torque. CMGs are a major source of micro-vibrations, which are low amplitude vibrational disturbances with broadband frequency content which severely affect the pointing performance of highly sensitive imaging payloads. Though earlier studies identified the spinning flywheel as the major micro-vibration source, studies on how flywheel generated disturbances are affected by gimbal flexibility & the effect of gimbal servo system on micro-vibrations are very few. To this end, this paper aims to carry out a comprehensive and systematic characterization of SGCMG micro-vibrations, to measure SGCMG generated disturbances across all modes of operation, identify the sources of these disturbances, characterize micro-vibrations across the required flywheel speed ranges, and understand the effect of gimbal flexibility and gimbal servo system on micro-vibrations. Micro-vibrations are characterized by measuring the transmitted forces and moments using a standard Kistler dynamometer.

Firstly, the flywheel assembly was hard mounted on the test set-up and disturbances were characterized across wheel speed range. These measurements were repeated with SGCMG fixed on Kistler and with the gimbal servo off. Comparison of these two studies shows that the flexibilities of the gimbal assembly modifies the flywheel micro-vibrations. Critical flywheel spin speeds at which flywheel bearing sub & super harmonics interact with gimbal structural modes were identified. Next, with the gimbal servo on, at specific gimbal angles, the measurements are repeated and it is seen that gimbal servo errors are contributing to the micro-vibrations. Measurements are also carried out with the gimbal slewing at constant wheel speeds. Thus, SGCMG micro-vibrations are characterized across the required wheel speed ranges, gimbal angular positions and gimbal angular rates. These studies show that apart from flywheel unbalance, bearing imperfections and flywheel structural modes, the gimbal flexibility and gimbal angular position significantly affect the SGCMG generated micro-vibrations. The studies helped in identifying flywheel speed range & selection of gimbal servo control parameters for minimizing micro-vibrations. This comprehensive SGCMG micro-vibration characterization can be used as an input for the design of a micro-vibration isolator, to carry out interaction studies with payload and for spacecraft jitter predictions.