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DESIGN, DEVELOPMENT AND ANALYSIS OF GEAR BASED VARIABLE SPEED CONTROL MOMENT GYROS

Abstract

The current study proposes a novel design of gear based Variable Speed Control Moment Gyros (VSCMG). VSCMG is a recent actuation system, which is being used for spacecraft attitude control. It is a single-gimbal Control Moment Gyroscope (CMG) with a flywheel, which is allowed to have variable spin speed. CMGs can generate much higher torque than conventional spacecraft reaction wheel actuators. The presented VSCMG design has many advantages over the traditional VSCMG design. Complex gear configuration is utilized for designing the fault-tolerant system for both flywheel control and gimbal rate control. The implementation of gear system provides the mechanical advantage as it combines the incoming torque from the different motors hence, it can increase the torque produced. For the proposed design, a complete physical model is developed and the dynamics equations incorporating gear variables are developed to study the stability and control characteristics for spacecraft attitude control. The VSCMG can be considered as two-loop system, including a closed-loop control system for flywheel speed and a closed loop control for gimbal rate. The proportional-derivative closed-loop control model is considered for finding the desired control output. Apart from normal functioning, the controller is designed in such a way that, it can reconfigure itself during failure to provide desired control output. The stability analysis of closed-loop control system is performed using Lyapunov approach. Simulations are carried out based on the presented dynamics and control algorithms to demonstrate the effectiveness of proposed design for conventional and fault-tolerant attitude control.