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SPACECRAFT ATTITUDE CONTROL DESIGN USING PENALTY FUNCTION

Abstract

Control moment gyro (CMG) has been widely used for the fast slew maneuver and control of spacecraft attitude. Literature describe single gimbaled control moment gyro (SGCMG) and double gimbaled control moment gyro (DGCMG) for the attitude control of spacecraft. The main control issue for both these types of CMGs boils down to singularity avoidance arising out of gimbal lock condition which drastically cuts down the torque along the output axis of the CMG. Various control design methods have been suggested to avoid the singular condition. In this paper, a penalty function based approach is proposed for the attitude control design of a spacecraft using a variable-speed DGCMG. The aim of this paper is to develop an attitude control system for small spacecraft for fast slew maneuver with short transient settling time. This can provide the required control moment for actuating the spacecraft without much increase in power consumption or mass of the satellite. A nonlinear feedback controller is designed for actuating a single variable-speed DGCMG for large angle maneuvering for target acquisition and pointing maneuvers subject to slew rate limit, control bandwidth, actuator saturation, and disturbances. The singularity avoiding control design is achieved by penalizing the performance index whenever singularity condition is approached. This allows the gimbal angles to be changed to a configuration with less singularity without disturbing the spacecraft orientation. Off-line computations are not required, and therefore the proposed method is carried out in on-line mode. Simulated results are presented to show the efficacy of the proposed method. The results are compared against the null motion steering law found in literature which tries to minimize the condition number of the control influence matrix. The results show the superiority of the proposed control design using penalty function.