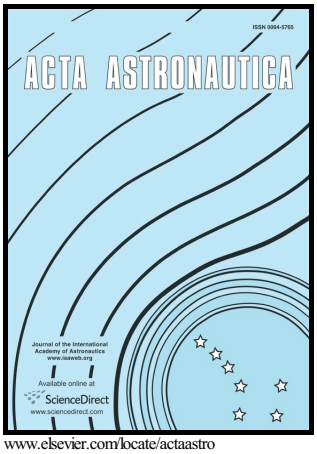

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Fault Tolerant Attitude Control for Spacecraft with SGCMGs under actuator partial failure and actuator saturation ☆

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Abstract

A Fault Tolerant Attitude Control algorithm for the spacecraft using Single Gimbal Control Moment Gyros (SGCMGs) as actuator is proposed. The controller is designed using the sliding mode control theory to control the gimbal rate directly and there is no singular point in the control algorithm, which means that we don't need to design the steering laws again and the singularity problems can be avoided. Also the gimbal rate saturation is considered when designing the control method. The adaptive control algorithm is used to estimate the disturbance and the boundary of the fault and saturation, which means that no prior information of the fault is needed. Although the controller is designed based on the SGCMGs, it can also be employed when reaction wheels work as the actuator of the spacecraft. Also the complete failure of several SGCMGs is allowed. It is proved based on the Lyapunov stability theorem that the designed control algorithm can achieve the attitude asymptotic stability both on the fault or fault-free condition. The simulation results show that the proposed method has a strong robustness.

Keywords: spacecraft; fault tolerant control method; single gimbal control moment gyros; gimbal rate saturation; sliding mode control.

1. Introduction

The attitude control system has been designed more and more complicated to cope with the complex space missions, followed by the greater probability of faults or failures due to the aging or damage of the sensors or/and actuators. The faults or the failures may lead to the failure of the space missions, even the crash of the spacecraft. The Mars Odyssey (launched in 2001) came into the protective standby mode in 2014 due to the failure of a reaction wheel. How to avoid the failure of the space mission and the economic losses has become an important matter in the field of spacecraft control. The fault tolerant control (FTC) method was proposed to increase the robustness of the attitude control system.

Angular momentum exchange devices including Reaction Wheels (RWs) and Control Moment Gyros (CMGs) have been wildly used in the field of three-axis stabilized attitude control. As for the spacecraft with RWs, numerous research achievements on the field of FTC have been

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