Paper ID: 50899
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IAF ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (2) (6)

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SLIDING MODE TECHNIQUES FOR PRECISE ATTITUDE CONTROL

Abstract

Small satellites have begun to play an important role in the space researches, especially about new technology development and attitude control. The main idea of this research is related to the design of Attitude Determination and Control System (ADCS) for small satellites. These ADCS systems should be compliant with strict pointing requirements and should be able to guarantee robustness against uncertainties and external disturbances. To accomplish the desired mission task and to design a robust flight software, two second-order Sliding Mode Controllers (SMCs) are taken into account: (i) a super twisting and (ii) a variable gain continuous twisting (CT) SMC. These approaches are able to provide finite-time theoretically exact convergence of the system states to the desired configuration. Moreover, the STW algorithm steers to zero in finite time the first time derivative of the sliding variable in the presence of smooth matched disturbances with known bound and it contains a term that is obtained as the integral of a discontinuous component. The adaptive CT SMC is a homogeneous control algorithm for uncertain second order plants, for which the chattering phenomenon is strongly attenuated. The selected SMC control laws are continuous and can guarantee that the system trajectories reach and maintain a motion on the desired sliding manifold in finite time. The objective of this research is to design of a robust flight software, in which hardware constraints are also included, for different Low Earth Orbit (LEO) missions. Moreover, the control signal compensates perturbations in finite time and these controllers significantly mitigate chattering with respect to classical first order SMC (if designed properly). Furthermore, a third-order sliding mode differentiator is combined with the proposed SMC systems to detect and reconstruct actuator faults in order to obtain a sensorless FDIR procedure, which can achieve tolerance to a wide class of additive failures. Extensive simulations are performed to prove the effectiveness of the proposed control system in different scenarios, including uncertainties of the spacecraft configuration, measurement errors and errors in torque actuation. Performance are evaluated in terms of pointing stability and accuracy. A pyramidal configuration of the reaction wheels is considered as baseline, and a fault analysis is included, to prove the performance of the controllers, to guarantee global stability and ensure insensitivity and robustness to system uncertainties.