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NONLINEAR FAULT TOLERANT ATTITUDE CONTROL FOR FAST-D SPACECRAFTR

Abstract

The Formation for Atmospheric Science and Technology demonstration (FAST) is a formation flying mission consisting of two micro-satellites, FAST-T from Tsinghua University, China and FAST-D from Delft University of Technology, The Netherlands. This paper concerns a nonlinear fault tolerant attitude control system design for the FAST-D spacecraft.

Conventional attitude control of satellites has been based on classical techniques which together with a conservative trend of thought form bottlenecks for ADCS to achieve a higher performance rating, flexibility in mode switching and fault tolerance. For FAST, being an educational and scientific mission, it allows applications of innovative ADCS technologies aiming for solving these bottlenecks. The FAST-D ACDS utilizes the following attitude sensors: 2 earth horizon sensor, 1 fine sun sensor, 2 autonomous star trackers, 3 axis magnetometers and 3 axis rate sensors. The attitude control system also consists of 4 reaction wheels in a Tetrahedron configuration together with 3 magnetic coils for de-saturating these reaction wheels.

An integrated attitude determination system combines the rate and vector sensors in an extended Kalman filter to obtain highly accurate attitude and rate estimates for the entire mission duration. Furthermore, the ADCS system utilizes a double-loop Non-linear Dynamic Inversion (NDI) technique with the time scale separation concept. The kinematic model of the spacecraft is formulated in terms of Modified Rodrigues Parameters (MRP) in the outer-loop of the NDI control system. This allows flexible control of a non-linear system in different flying modes, separating spacecraft dynamics from its kinematics, and providing high pointing accuracy in a dynamic environment.

Fault detection of control actuators is discussed after the control allocation algorithms and reconfiguration of the control system are presented when actuator failure has occurred. Simulation results show that the control system design is fault tolerant, flexible, and suitable for the entire mission flight of the spacecraft.