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REACTION WHEEL FAILURE ATTENUATION FOR NANO-SPACECRAFTS IN LOW EARTH ORBITS

Abstract

This paper addresses the attitude control design for a nano-spacecraft that is initially actuated by three reaction wheels (RW) and three magnetorquers (MT) in the event of complete failure of one of the reaction wheels. MTs used for de-tumbling and momentum dumping in low Earth orbits are highly reliable (as they do not involve any moving parts), while reaction wheels used for slew manoeuvres and fine pointing are susceptible to wear and tear leading to significant friction, jitter and sometimes failure. Instead of including a redundant RW which adds to the mass and volume of the sub-system, more sophisticated attitude control algorithms are used to maintain 3-axis control performance. Initially, a simple control based on inverse dynamics is used, but this is improved upon using a combination of active disturbance rejection and under-actuation controls for better performance in the event of failure of a RW.

Although the system's stability is almost guaranteed using the proposed control algorithm, the actuators are subject to physical limitations (e.g. the ability to produce torque only in a normal direction to the local magnetic field vector for MTs, and saturation for both, RWs and MTs), that is why they sometimes cannot realize the presumably ideal torque fed to them by the the controller, which leads to attitude instability in some cases (singularities). A singularity avoidance technique is developed to guarantee the stability of the system throughout the mission.

All the controllers are tested by numerical simulations in the presence of environmental disturbing torques, RW noises (i.e. friction, jitter and installation misalignment) and magnetorquer noises.