Paper ID: 15311
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ASTRODYNAMICS SYMPOSIUM (C1)
Guidance, Navigation and Control (3) (3)

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COMPARISON OF TWO CONTROL STRATEGIES FOR UNISAT5 ATTITUDE CONTROL SYSTEM

Abstract

Unisat-5 is a micro satellite designed and built by GAUSS group at the School of Aerospace Engineering of Roma. It is scheduled for launch on Fall 2012 with a Dnepr rocket from the Yasny launch base. The orbit is sun-synchronous, 97 degrees of inclination, 700 km of altitude. The mission requires a large amount of power in order to support the payloads. Hence, a sun pointing attitude has been chosen to keep the solar panels in the best enlightenment conditions. Due to volume and weight constraints on the satellite the only on board actuators are three perpendicular magnetorquers, which can provide a dipole moment up to 4 Am^2.

After being released from the launcher and detumbled, the satellite will have to acquire the desired attitude and then maintain it through the orbit. The initial conditions may result in very large errors in terms of Euler angles, so the chosen algorithm should be capable to cover for it. Anyway, magnetic attitude control can result in under-actuation issues, because magnetic field varies with time and only the torques perpendicular to the magnetic field can be obtained.

Two different control approaches have been studied and tested: the first based on proportional-derivative (PD) quaternion feedback and the latter based on Model Predictive Control (MPC). The quaternion feedback PD controller is a simple and well-known technique, but its achievement only with magnetorquers and without further stabilization methods, can result in a system unable to balance the non-actuated components of the commanded torque. MPC is a suitable technique for complex control problems, such as satellite pointing. In fact, when calculating the actual control it considers the prediction of future trajectories of the system over a finite future horizon. This allows to find a viable control strategy and to minimize the negative effect of under-actuation.

This work describes the design of the MPC and PD attitude control systems for the Unisat-5 mission and their validation on a 6-DOF model, making a comparison between the two controllers in terms of pointing accuracy and power consumption. The simulations take into account all the most important environmental disturbances effects (e.g. gravity gradient, atmospheric drag, solar radiation pressure, residual on-board dipole).