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ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics - Part 2 (6)

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HARDWARE-IN-THE-LOOP TESTING OF A REACTION WHEEL VIA SLIDING MODE SPEED CONTROLLER

Abstract

Modern small satellite need to point more precisely than in the past, in order to accomplish their missions. The main reason for maintaining high pointing accuracy is so that a payload, such as an antenna or an optical instrument, may be accurately directed toward a particular feature or location. As the actuator, the reaction wheel is one of the key components of the high accuracy stabilization loop. That is because it will not only offer the control torque to the satellite, but also produce disturbance torque for the satellite attitude control. In the attitude control loop, the major reaction disturbances are static friction and sliding friction torque which must be considered seriously because high accuracy stabilization couldn't be achieved otherwise. For nadir-pointing mode, in order to constrain the influence of this static friction around zero speed; the reaction wheel should operate under speed mode to achieve high accuracy stabilization. To improve the low-speed performance of reaction wheel, some methods are introduced as a friction Compensation. Although these methods can reduce the uncompensated attitude error, their usefulness is limited by their dependence upon the characteristic of friction. Variable-structure control theory is used in literature as a method for decreasing the disturbance of reaction wheels static friction to the attitude of a small satellite. However, the robustness property of variable-structure controller involves high control activity and so for implementing this controller on a satellite, dynamic and high sample rate attitude sensor is needed. The maximum update rate of fine sun sensor is less than 10 Hz, which means that the sensor updates every 0.1 second or slower. Such sample rates are not convenient for variable-structure control theory due to the fact that implementing these controller need high frequency control loop. Hence in the other way, fine attitude control can be achieved by a conventional PD torque controller for sun sensor feedback loop and the variable-structure control theory can be implemented on the reaction wheel as a speed driver. The real time hardware-in-the-loop simulation studies demonstrated that the proposed fine attitude controller can produce a better speed response for different speed commands, load disturbances, and parameter uncertainties and evidently improve attitude performance. The mass computation of this synthetic algorithm is in low level compared with the other fine attitude approaches and on top of that the output rate of fine sun sensors are also take into account.