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DYNAMIC CLOSED LOOP ATTITUDE CONTROL SIMULATION AND VERIFICATION ENVIRONMENT FOR MICRO-SATELLITES

Abstract

Tohoku University has been developing multiple micro-satellites for years. The most recent 50-kg class micro-satellite “RISESAT” is equipped with a high-resolution multi-spectral Cassegrain telescope with 5 m GSD, as well as an optical communication terminal named “VSOTA.” VSOTA requires high-performance attitude control of less than 0.04 deg angle error to keep communication link with the optical ground station because the transmitting laser direction is fixed on the satellite body.

Although main methods of testing attitude control system (ACS) before launch are mathematical simulation or static closed loop tests, it is difficult to reproduce sensor noises and actuator errors in mathematical models perfectly. Furthermore, the more severe the attitude determination and control requirements are, the more important it is that the assembled ACS is tested in motion before the launch. Due to these reasons, Tohoku University has started development of a dynamic closed loop test environment. This environment is based on a low friction 3-axis motion table using spherical air bearing. Each sensors and actuators, as well as the total performance of the ACS of RISESAT will be evaluated using this environment.

This test environment is designed to be able to evaluate attitude control accuracy of down to 0.04 deg. The table size is 1.2 x 1.0 x 1.0 m including air bearing stand. The floating mass is less than 70 kg with a 10 cm spherical bearing ball. The table is allowed full-freedom of spin in the yaw axis, and pitch and roll motions are constrained to angles of less than 10 deg. The attitude angle of the test table is measured by IR camera tracking system, and the gyroscope on the table measures angular velocity of thetable. The resolution of attitude angle measurement is 0.005 deg and that of angular velocity is 0.004 deg/s. The components on the table communicate with a PC and other components via wireless communication in order not to disturb the motion by cables. Also the center of gravity can be auto-adjusted by newly developed linear mass displacement mechanism in three axes so that the residuals gravity gradient torque can be neglected.

In this paper, the details of designed specification and the results of system integration of this dynamic closed loop simulation environment will be described. In addition, the experiments of attitude control using the test table and evaluation results of attitude control components of RISESAT are described.