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Author: Mr. The Huynh Hoang  
Vietnam National Space Center (VNSC), Vietnam

A TESTBED SYSTEM FOR ATTITUDE DETERMINATION AND CONTROL SYSTEM  
VERIFICATION OF SMALL SATELLITE

**Abstract**

This paper presents a hardware-in-the-loop testbed system that consists of three space environment simulators: zero gravity, Earth's magnetic field and Sun light for attitude determination and control system (ADCS) of nano/micro satellite class at Vietnam National Space Center (VNSC). To meet zero gravity condition, it is essential to be minimized to zero as close as possible the distance between center of mass and the center of rotation of testbed table that rotates freely along three degrees of freedom on the air bearing. The design using two levels of mass distribution control consisting of manual raw adjustment and automatically fine control is proposed. In the automatic mode, a novel approach to use four sliding masses hardware configuration and new control process is implemented. The PID control laws including cascaded PID, fuzzy PID and nonlinear PID are simulated and evaluated. The optimized performance control law is chosen for implementing in the ARM microcontroller. The disturbance moment of testbed table after control process could reach the value of 0.001 Nm. The Earth magnetic field simulator uses the 12th International Geomagnetic Reference Field (IGRF) model and three pair of Helmholtz coils to calculate and generate approximately three axes magnetic field as the similar condition into the orbit. In like manner, the Sun light direction simulator is also designed to simulate Sun light condition affecting to ADCS of satellite. The space environment models of three simulators build in the same platform to ensure the compatibility of system. After fabrication process, the full system is successfully obtained the desired technical requirements. Additionally, to verify the performance of full process, a satellite pointing control law with the accuracy of 0.25 degree using three reaction wheels is also validated on this testbed system. Finally, as a result of comprehensive approach and novel modular hardware design, the experimental results of three simulators are accomplished and presented in this paper. This testbed system is expected to test various ADCS configurations of nano/micro satellites. Early, it will be a test platform for ADCS of NanoDragon satellite at VNSC.