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DEVELOPMENT AND VERIFICATION OF MICROSATELLITE ATTITUDE CONTROL SYSTEM BY PROCESSOR-IN-THE-LOOP METHOD

Abstract

The paper describes the development of a microsatellite attitude control system and verification of its functionality and performance by processor-in-the-loop (PIL) method. At NCKU, Taiwan, a 30 kg experimental satellite named CKUTEX is being developed. To verify the in-orbit performance of the attitude determination and control subsystem (ADCS), a PIL simulation capability is established. The role of the ADCS is to provide attitude control functions such that detumbling the angular velocity and stabilize the satellite, as well as estimate orbit and attitude information for satellite operation. For the CKUTEX, the operation of the ADCS consists of three states: initialization, detumbling, and normal operation. During the initialization state, the ADCS estimates the attitude from the measurements obtained by various sensors to establish early-orbit data. During the detumbling state, magnetic control is used to decrease the satellite's angular velocity. In the normal operation state, the ADCS maintains the angular velocity and provides the satellite attitude determination capability. To fully develop and verify the attitude control and determination algorithms, a PIL simulation is developed. The simulation facility contains a dynamic simulator and real-time controller, as well as some interfacing circuitry. The dynamic simulator is capable of performing simulation of the space environment, orbit dynamic, attitude dynamic, and sensor/actuator models. The real-time controller is a realization of the embedded controller for attitude determination and control. The CKUTEX employs five sensors including magnetometer, sun sensor, IMU, GPS receiver, and DSS payload for orbit and attitude determination. The control actions of the CKTEX are provided by magnetic torquers. Specifically, an NI-PXI platform is used to facilitate the simulation of the dynamics and a microchip processor is used to realize the real-time attitude determination and control functions. In the paper, the control requirements of the CKUTEX are briefly discussed. The PIL simulation facility is then described. Different simulation and test results are then provided to illustrate the capability of the PIL simulation in developing and verifying various functions and operations of the CKUTEX ADCS. The hard real-time performance requirement and computation throughput are then assessed to verify the embedded processor. The paper also outlines some future extension of the facility in ground test support as well as hardware-in-the loop simulation.