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ATTITUDE DETERMINATION & CONTROL SYSTEM (ADCS) OF PICO-SATELLITE

Abstract

In the development of 21st century satellites, miniaturization plays a vital role with respect to short development time and reduced launch cost. In specific the Pico-satellite missions are more attractive for student education programs and demonstration of new technologies. This paper describes the design and analysis of Attitude Determination and Control System (ADCS) of STUDSAT-India's first Pico-satellite program designed and developed by a group of undergraduate students and be launched by ISRO. It elaborates the different steps involved in the development of ADCS with the results obtained from its implementation in STUDSAT. Studsat is a nadir-pointing satellite.

As we approach the miniaturization, along with the advantages it is challenging to design the ADCS within the defined constraints of power, mass and size defined of the order 150 mWatt, 200 gms and 100 mm x 100 mm x 50 mm respectively for a Pico-satellite.

Studsat is a closed loop 3 axes stabilised system with magnetometer as sensing element and actuated by magnetic torquers. The magnetometer is a COTS component of accuracy 1degree for attitude determination, having UART interface with on-board computer. The B.dot law is implemented for the initial detumbling of the satellite. The magnetic field data measured by the magnetometer along with the International Geomagnetic Reference Field (IGRF) model implemented onboard is fed to Extended Kalman Filter which provides an optimal state estimate from noisy measurements. The estimated states are sent to controller which calculates the current to be sent to the coils for the attitude correction. A periodic gain controller is designed by Asymptotic Linear Quadratic Regulator (ALQR) technique. The control law includes the actuator saturation logic. The performance analysis has been done by various simulations. SGP4 algorithm is implemented onboard for the determination of position of satellite in space.

The magnetic torquers are insulated copper coils wound in rectangular shape with the help of pulleys at four corners. The on-board computer generates PWM signal as an input to H-bridge circuitry, used to drive the current to the coils. The integrated ADCS hardware is space qualified by subjecting the system to thermo-vacuum and vibration tests.

The stringent constraints in the implementation of the system limited the pointing accuracy to 3 degree which is sufficient for the current mission. Over all being undergraduate students it was an excellent experience to develop space based system.