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DESIGN OF THE ACTIVE ATTITUDE DETERMINATION AND CONTROL SYSTEM FOR THE E-ST@R CUBESAT

Abstract

One of the most limiting factors which affects pico/nano satellites capabilities is the poor accuracy in attitude control. To improve mission performances of this class of satellites, the capability of controlling satellite's attitude shall be enhanced. The paper presents the design, development and verification of the Active Attitude Determination and Control System (A-ADCS) of the e-st@r cubesat developed at Politecnico di Torino. The heart of the system is an ARM9 microcontroller that manages the interfaces with sensors, actuators and the on-board computer and performs the control tasks. The attitude manoeuvres are guaranteed by three magnetic torquers that contribute to control the satellite in all the mission phases. The satellite attitude is determined elaborating the data provided by a COTS Inertial Measurement Unit, a Magnetometer and the telemetries of the solar panels, used as coarse Sun sensor. Different algorithms have been studied and then implemented on the microprocessor in order to determine the satellite attitude. Robust and optimal techniques have been used for the controller design, while stability and performances of the system are evaluated to choose the best control solution in every mission phase. A mathematical model of the A-ADCS and the external torques acting on the satellite, its dynamics and kinematics, is developed in order to support the design. After the design is evaluated and frozen, a more detailed simulation model is developed. It contains non-ideal sensors and actuators models and more accurate system disturbances models. New numerical simulations permit to evaluate the behaviour of the controller under more realistic mission conditions. This model is the basic element of the Hardware In The Loop (HITL) simulator that is developed to test the A-ADCS hardware (and also the whole satellite). Testing an A-ADCS on Earth poses some issues, due to the difficulties of reproducing real orbit conditions (i.e. apparent sun position, magnetic field, etc). This is especially true in the case of low cost projects, for which complex testing facilities are usually not available. Thanks to a good HITL simulator it is possible to test the system and its "real in orbit" behaviour to a certain grade of accuracy saving money and time for verification. The paper shows the results of the verification of the ADCS by means of the HITL strategy, which are consistent with the expected values.