COBEM-2017-2175
NANOSATS' BEHAVIOR HARDWARE IN THE LOOP SIMULATOR UNDER EARTH'S LOW ORBIT MAGNETIC FIELD, LEO.

Cedric Salotto Cordeiro
João Elias Martins Mothé
Instituto Federal de Educação, Ciência e Tecnologia Fluminense, Department of Control and Automation Engineering, Campos dos Goytacazes,RJ, Brazil
cedric.salotto@iff.edu.br
joaoeliasmothe20@gmail.com

William da Silva Vianna
Instituto Federal de Educação, Ciência e Tecnologia Fluminense, Department of Control and Automation Engineering, Campos dos Goytacazes,RJ, Brazil
williamvianna@gmail.com

Abstract. The following research has as main objective to present an space environment simulator in hardware in the loop (HIL) to Nanosats under earth's magnetic field in low orbit, LEO, developed at the Centro de Referência em Sistemas Embarcados e Aeroespaciais' laboratories, CRSEA, from Instituto Federal de Ciência e Tecnologia Fluminense, IFF. The satellites need to have an Attitude Determination and Control System (ADCS) to enable them to make maneuvers and corrections on its position during the flight. This attitude control can be passive or active, depending on the mission's objective. In low orbits, LEO, the earth's magnetic field has enough intensity to generate forces that will result in torque and rotational movement when interacting with the magnetic fields generated by the own satellite. The simulator is composed of a group of six electromagnetic coils, three axis gimbal, support to fix the nanosatellite inside the gimbal, software to control the coils' magnetic field and an interface to view the field vector generated inside the coils that correspond in time to the same point of the satellite's orbit.
Keywords: LEO, Nanosats, ADCS, Hardware in the loop, Simulator.

1. INTRODUCTION

The launch of Nanosats has become increasingly common, once its technology has been dominated all around the world, but one of the most critical points inside its manufacturing is, with no doubt, its attitude control system, which is responsible by keeping it in the correct position on your flight trajectory. Because of the complexibility involved, the ADCS needs to be tested inside an environment that reproduces the space in terms of earth's magnetic field. The simulators are developed to offer external stimuli similar to the ones Nanosats are going to receive when they are in orbit, and because of this they must be as faithful as possible to be able to prove the efficiency of the embedded control system. The attitude control system can be passive or active. In the first case, the spaceship behavior is determined and than tested by the simulator, but during the flight the behavior will stay the same, and in the second one is more complex, because it depends on information acquisition from sensors that after treated by the ADCS algorithm will result in the actuators actions. Thereby, is possible to change the spaceship's behavior during the flight. This work consists on develop an earth's magnetic field simulator to enable tests with the attitude control systems of nanosats or others models in scale, active or passive, and evaluate if they answer to the different stimuli that can occur when they are in orbit.

2. EXPERIMENTAL PROCEDURE (OR COMPUTATIONAL PROCEDURE):

The simulator consists in three pairs of electromagnetic coils disposed orthogonally in the tridimensional space forming inside it a cube volume, electric power control interface, software to generate parameters of magnetic field intensity to each axis, graphic interface to visualize the resultant electromagnetic field inside the coils system, gimbal with three axes inside the coils system to put the nanosat or another model in scale.
The methodology adopted was divided into 4 stages:

1. Generate the resultant magnetic field vector inside the coils system that point to the corresponding direction in relation to the earth's geometric center to each position of the nanosat in orbit.
2. Fix in the interior of the gimbal, the nanosat or its model in scale with the passive or active attitude control to interact with the simulated earth's magnetic field to each point of the orbit.
3. Visualize in the graphic interface the field's generated vector in the coils system and the respective position desired of the nanosat in the hardware in the loop.
4. Compare the real position of the nanosat inside the gimbal with the desired by the simulator software.

Obs: Number 1 is done. Number 2 is in progress.

3. RESULTS AND DISCUSSION

The hardware in the loop resulted in high importance tests to confirm the desired movements of the nanosat when flying in low orbit. Educationally, it was important because of the obtained of a machine where is possible to visualize the attitude control algorithms working.

4. CONCLUSIONS:

Knowing about the importance and complexibility of a good attitude control system, is possible to understand the necessity of being realized a lot of tests before finally launch a nanosat. In this case the simulation is an alternative widely used and important as well, because it permits to test the system in a practice way reducing bad working risks in orbit. One of the ways to realize this simulation is the hardware in the loop technique that permit to create an environment similar to the real in a controlled way.

5. ACKNOWLEDGMENTS:

This hardware in the loop was entirely projected and developed by the Centro de Referência em Sistemas Embarcados e Aeroespaciais (CRSEA), from Instituto Federal Fluminense, localized at the Pólo de Inovação de Campos dos Goytacazes (PICG).

6. REFERENCES:

Hayt, William H. Jr., Eletromagnetismo, 3a. Edição, Rio de Janeiro, 1983.
Wertz, James R., Spacecraft Attitude Determination And Control, Dordrecht, Holland, 1978.
Wertz, James R., Larson, Wiley J., Space Mission Analysis and Design, third ed., New York, 1999.

7. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.