Attitude Control System and 6DoF Simulator for Microsatellite μSAT-3

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1. Abstract

An **attitude control system** and a **6-DoF simulator** was developed for a microsatellite. The platform must be able **to stabilize in autonomous mode** at a low angular rate and should be controlled within less than one degree pointing accuracy. The attitude control system uses a set of sensors in order to achieve the imposed mission requirements: **gyros**, **sun sensors**, a **fluxgate magnetometer** and an **earth horizon sensor**. **Four reaction wheels** and **three magnetic torquers** are used to complete the space segment control system loop. This work is a summary of all the already completed tasks regarding the satellite control and simulation, and the “know-how” acquired from a previous and successful microsatellite mission, back in the 90’s.

2. Microsatellite μSAT-3

The mission of the vehicle must accomplish a **700 km altitude sun-synchronous orbit** and the earth imaging of the Argentine mainland using two CCD monochromatic cameras, and must be able to ‘take and store, then send’ pictures of the territory.

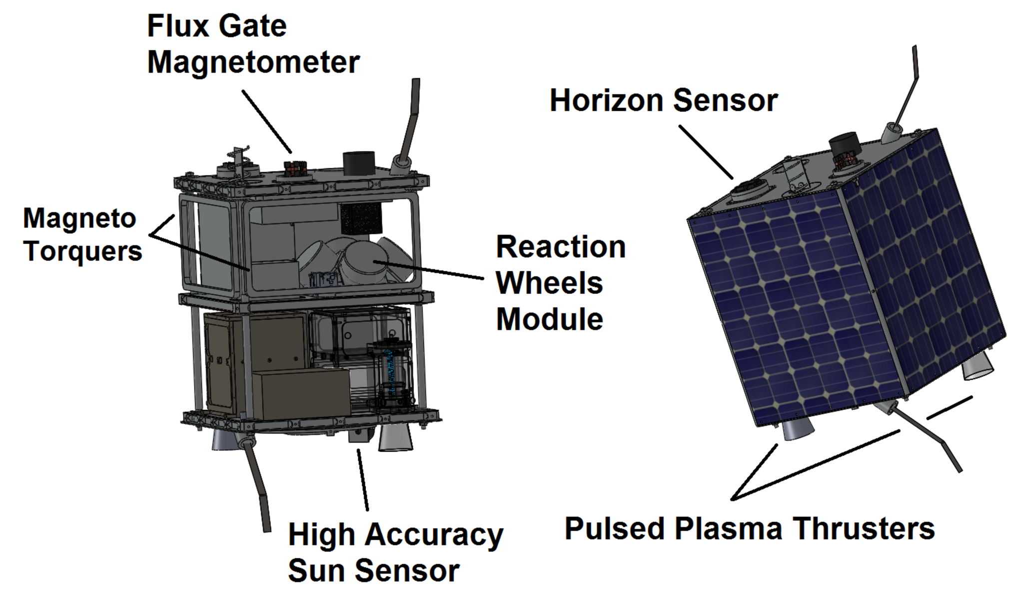

Fig. 1. Vehicle general layout. Outer and inner structure.

Also, the microsatellite should be able to make minor orbit corrections, by means of on-board ablative -solid propellant- pulsed plasma thrusters.

3. 6DoF Simulator

This software provides, among a manifold of state variables, the **orbit dynamics**, **geomagnetic** and **thermal parameters** plotted by means of a friendly user interface. A magnetic field generator allows to simulate the earth magnetic field for any orbital mission. Hence, the **magnetic field generator** is connected as **hardware in the loop** along with the Simulator in order to test the on board magnetometer and the reaction wheels control capacity.

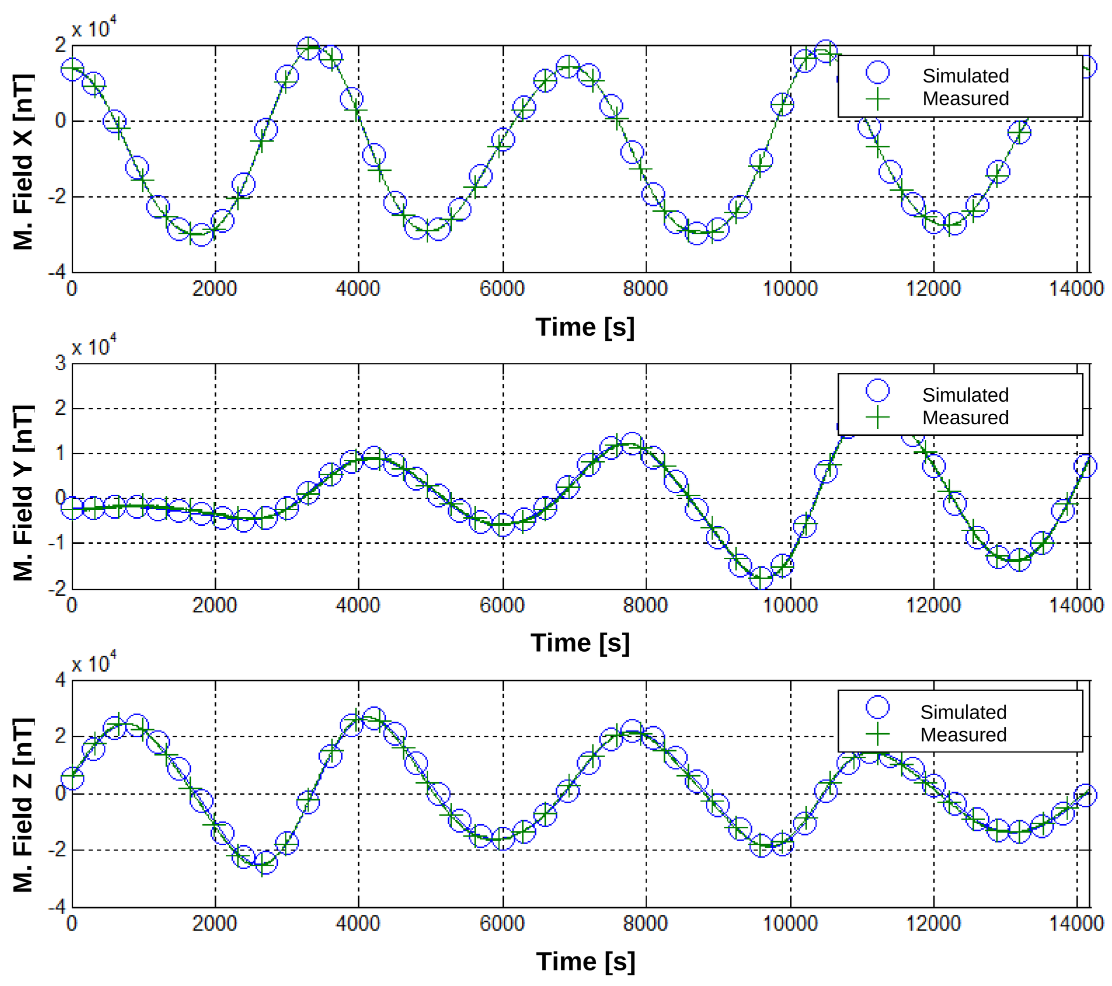

Fig. 2. Helmhotz field generator tests. Simulated and measured earth magnetic field in body reference frame. [1]

4. Sensors and Actuators - Reaction Wheels Module Evolution

The system uses five sensors: gyros -one per axis-, two sensors -one high resolution sensor and a set of low resolution sensors-, a three-axis fluxgate magnetometer and an earth horizon sensor. Three magnetic torquers are used for initial attitude acquisition and for dumping excess angular momentum from reaction wheels. Figure 3 shows the **first reaction wheel module** (left) and the newly design **redundant module** (right). The four-motor configuration allows failure on any single wheel. Some tests have been developed in order to check the ADCS capacity about the z axis [2], as shown below.

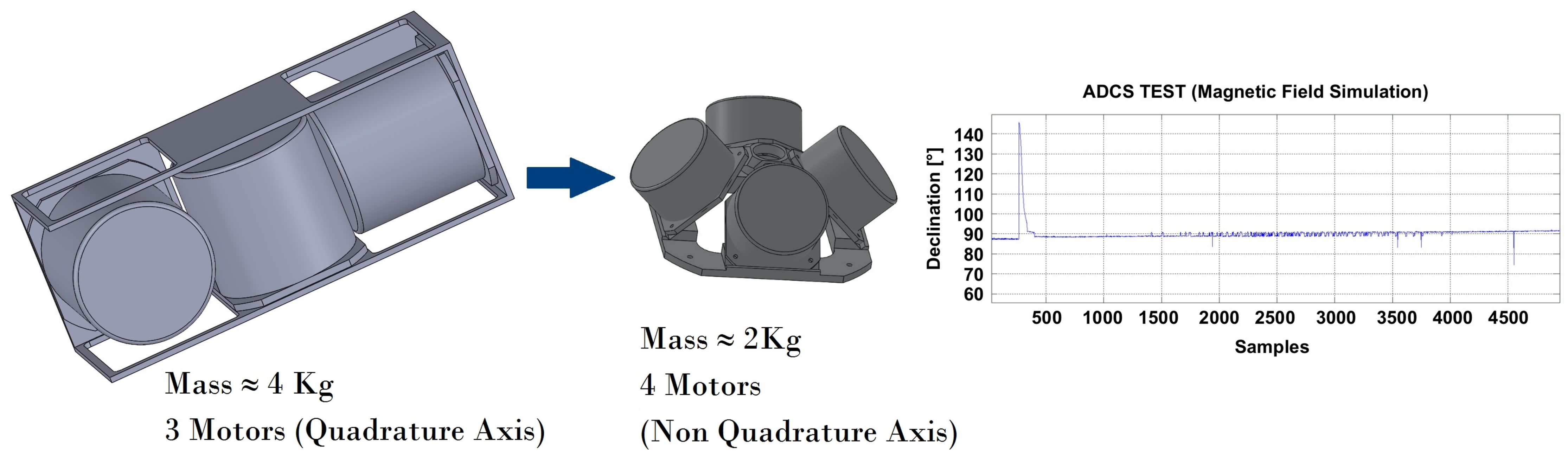

Fig. 3. Structure design configuration changes for reaction wheels module (1996 - 2016).

5. ADCS Interfaces - Space Segment Block Diagram

The PWM signals values are 0-5V at 5 kHz and the motors spin direction signal (DIR) are 0-5V. The magnetic torquers input signal is a 1/2 H-Bridge circuit output placed in the OBC, having a non-regulated bus tension of ≈ 11 V. The earth horizon sensor video signals (V1, V2, V3 and V4) are digital inputs to the OBC (0-5V). START, RST and CLK signals are OBC digital outputs (0-5V) at maximum frequency 1 MHz [3].

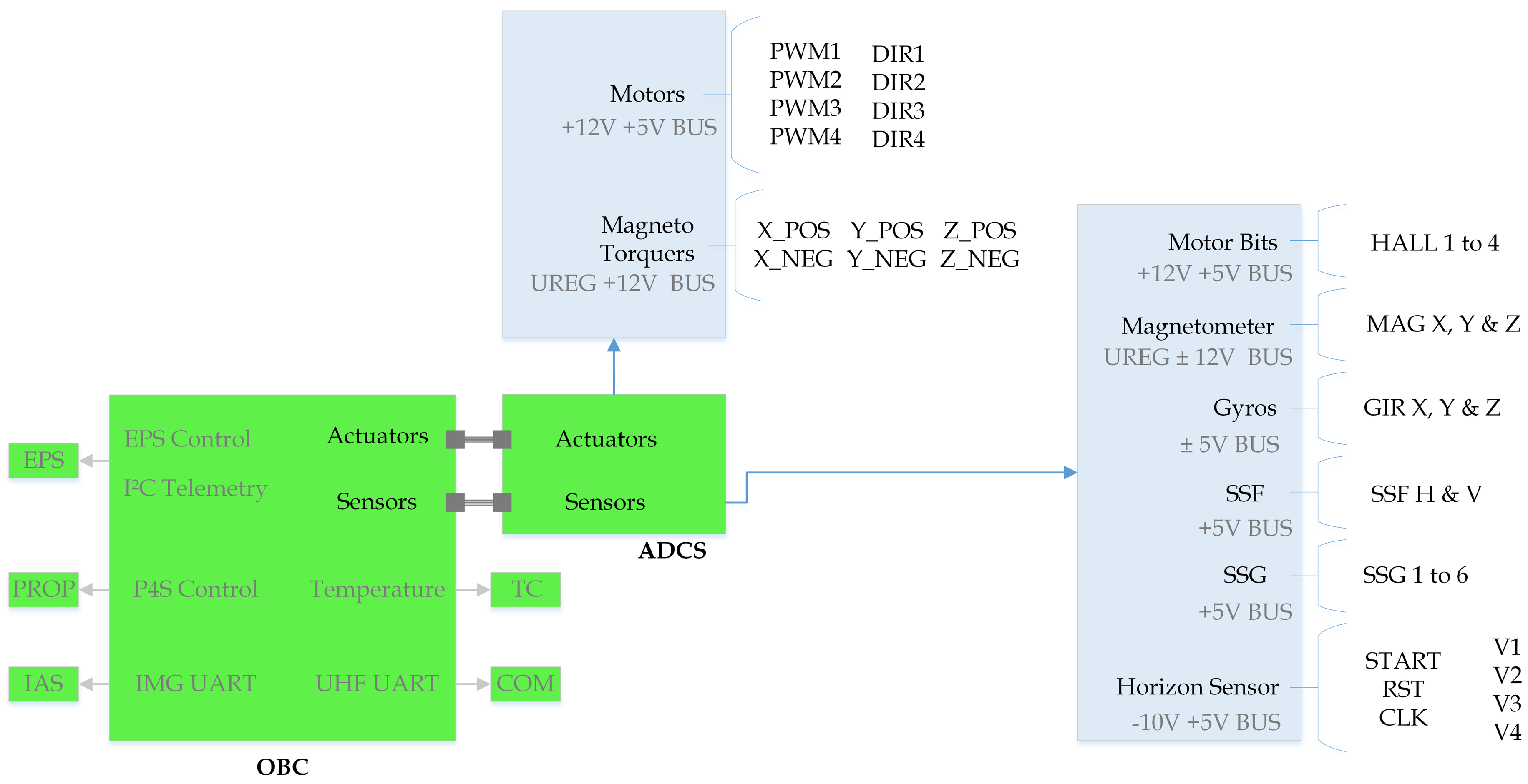

Fig. 4. Hardware signals and power distribution in the space segment block diagram.

6. Conclusions

The Helmholtz coil magnetic field has been verified with the simulated field with a 17% error (≈ 1700 nT). Reaction wheels and magnetic torquers have been succesfully tested in a 1-DoF maneuver about the z body axis (yaw). Based on the "know-how" from the old reaction wheel configuration, the **new configuration** allows to **reducing mass** and chances of a full control failure in one axis. Either mechanical and electrical interfaces designs have passed the **Critical Design Review** and many of them are already constructed and set to be integrated to μSAT-3 engineering model.

7. References

[1] Marcos Brito and Santiago Rodriguez Gonzalez. Simulación en tiempo real del campo magnético terrestre para una misión orbital. *IEEE Argencon Biennial Congress of Argentina*, pages 322–327, 2014.

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[3] Santiago Rodriguez Gonzalez and Marcos Brito. Descripción de los subsistemas del microsatélite. *Nota Técnica 03/16 - Centro de Investigaciones Aplicadas - Dirección General de Investigación y Desarrollo - Fuerza Aérea Argentina*, 2016.