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CUBESAT MAGNETIC ATLAS AND IN-ORBIT COMPENSATION OF RESIDUAL MAGNETIC DIPOLE

Abstract

Magnetic control is a frequent choice for CubeSat missions when pointing requirements are not very demanding. Magnetic actuators are admittedly low cost, relatively simple to manufacture, and the research on their use in the attitude control loop is abundant. It has been shown, however, that for spacecraft with small moments of inertia a major disturbance that significantly degrades attitude control accuracy is the residual magnetic moment. Furthermore, prior research indicates that even perfect identification of the residual magnetic dipole does not allow its full compensation for larger values of the magnetic dipoles in CubeSats that are reported in the literature.

While implementing a Skoltech University CubeSat mission, we developed a method to mitigate the residual magnetization problem, while still on the ground, and provide the means to identify and compensate the magnetic disturbances in orbit. The routine starts from accurate measurements of all the components' and subsystems' magnetic fields at the stage when the electrical model of the spacecraft is ready. This allows making a map of the assembled CubeSat's internal magnetic fields using electromagnetic simulation and analysis software. Such maps can be produced for each operational regime of the spacecraft and compose a magnetic atlas in accordance with the concept of operations. Firstly, the atlas can be employed to optimize the CubeSat components layout to reduce the residual magnetization level. Secondly, it can help pinpointing the best locations for magnetometers in terms of lower bias due to internal magnetic dipoles.

This study demonstrates the use of such magnetic atlas with a focus on its in-flight application. By feeding the maps to the extended Kalman filter, which processes the magnetometer data and estimates the residual magnetic dipole and the magnetometer bias along with the state variables, we ensure a better initial guess for the disturbances, which is crucial for the filter's convergence. It is shown to be of importance, whenever the internal magnetic dipole abruptly changes when the spacecraft switches between the regimes. For larger values of the residual dipole, when conventional compensation technique does not provide satisfactory results, we propose to change the control loop duty-cycle. Thus, after a certain threshold in the magnetization level, the magnetorquers are never switched off, which entails a better compensation of the residual dipole given that we can properly process the magnetometer bias. We present our simulation results that show an overall improvement in residual dipole compensation as compared with the prior research.