A Spacecraft Magnetic Dipole Moment Determination Method

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To learn about the magnitude of the magnetic dipole moment of a spacecraft that will orbit under the influence of the Earth magnetic field, is fundamental in terms of predicting the disturbances that will eventually arise from this interaction with the Earth magnetic field due to magnetic forces. Keeping the total residual magnetic dipole moment at tolerable value is of paramount importance to minimize the control subsystem activity regarding the spacecraft attitude correction, as far as this influence is concerned. This paper presents a method for determining the magnetic dipole moment of a spacecraft or a subsystem of it. The magnetic flux density near field measurements are taken in the presence of the Earth magnetic field, in an environment where the induced magnetic field is a significant component of the total measured magnetic field. Once the dipole moment is determined, the result makes it possible to perform the magnetic balance of the satellite. The compensation is implemented by fixing permanent magnets on the spacecraft, with known magnetic moment magnitudes and in opposite directions, with respect to the determined ones, in any of the 3 axis. The method consists in mapping the 3 axis magnetic flux density field around the vertical axis of the spacecraft by monitoring the magnetic field through several fixed probes located in the horizontal equatorial plane. The magnetic field induced on the satellite by the geomagnetic field at the x and y axis are extracted by comparing the flux density at opposite positions of the device under test. The residual magnetic field mapping is promptly obtained at these 2 axis. Regarding the z-axis, one can determine the composition of the residual and magnetic moment induced by the Earth. One can estimate the residual component by considering the homogeneous morphology of the material used to build the spacecraft. The total induced magnetic field would however be in the same orientation as the Earth magnetic field in the test site. Taking this fact into account, allows us to extract with reasonable precision the z-axis induced magnetic field and the residual magnetic dipole component. In order to achieve the goal of performing the magnetic dipole moment determination and compensation, we had to specify a suitable magnetic measuring system composed of 3-axis fluxgate magnetometers with proper resolution and data acquisition to meet our needs. A numerical procedure based on spherical harmonics analysis was implemented in a specific software developed to process the data and evaluate the magnetic dipole moment. This methodology was applied on CBERS satellite, a 2 meters cube structured three-axis stabilized spacecraft, demonstrating its applicability.

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