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Author: Mrs. Kiyona Miyamoto
Tokyo Institute of Technology, Japan, miyamoto.k.ap@m.titech.ac.jp

Dr. Toshihiro Chujo
Tokyo Institute of Technology, Japan, chujo.t.aa@m.titech.ac.jp
Mr. Kei Watanabe
Tokyo Institute of Technology, Japan, kwatanabe@lss.mes.titech.ac.jp
Prof. Saburo Matunaga
Tokyo Institute of Technology, Japan, Matunaga.Saburo@mes.titech.ac.jp

ATTITUDE CONTROL OF SATELLITES WITH VARIABLE SHAPE FUNCTION UTILIZING ATMOSPHERIC DRAG TORQUE AND MAGNETIC TORQUE

Abstract

In conventional attitude control for Earth-orbiting satellites, magnetorquers are used to cancel disturbances such as atmospheric drag, or to unload accumulated angular momentum of reaction wheels. However, it is difficult to control the attitude to arbitrary direction depending on the position of the satellite because magnetorquers generate torques in plane perpendicular to the geomagnetic field. To solve this problem, we propose a new attitude control method by combining magnetic torque control with atmospheric torque drag control by variable shape function. Variation of the satellite shape can change the equilibrium point of attitude motion under atmospheric drag to arbitrary direction, and vibration around the equilibrium point can be controlled by magnetorquers. Since the control target is the equilibrium point, it has advantages that the control is stable and the control strategy is simple. In this study, we formulate stability analysis according to satellite shape and propose a systematic control method. We used a satellite model which has four movable solar cell paddles, and surveyed the equilibrium point change comprehensively with respect to the paddle angles. As a result, the attitude tends to be stable when the paddles form is convex to the orbital traveling direction, and unstable when the paddles form is convex to the opposite direction. When we investigated in the stable region, we confirmed that the attitude can be controlled to arbitrary direction within the range of about 50 degrees in the orbital traveling direction. One application is to control the relative attitude between satellites in a formation flight. For demonstration of the basis of the technology, we are developing a 50kg-class satellite "HIBARI" at Tokyo Institute of Technology, which will be launched by JAXA's Epsilon rocket in 2021. HIBARI which has four movable solar cell paddles will perform a series of demonstration experiments of a new attitude control system using the variable shape function. Currently, we are developing HIBARI hardware in parallel with theoretical research, and we show the study results considering the on-orbit environment and the actual operation to mount it on the satellite system.