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Author: Mr. Yuki Yamada
Nagoya University, Japan

Dr. Takaya Inamori
Nagoya University, Japan
Dr. Yasutaka Satou
Japan

A FUEL-FREE AND AGILE ATTITUDE MANEUVER OF SPACE MEMBRANE STRUCTURES USING ELECTROMAGNETIC FORCE IN LEO

Abstract

This study proposes an attitude control system of space membrane structures using electromagnetic force. Space membrane structures are large and thin sheet-shaped devices, which provide a large area for satellites without having to increase the size and weight of the satellites. Hence space membrane structures are effective for small satellites that have strict restrictions in size and weight, and they can be used as a large solar panel or deorbit mechanism utilizing air drag in low Earth orbit (LEO). These utilizations require attitude control of the membranes structures. For example, a satellite may have to rotate the membrane solar panel toward the sun. Conventional satellite missions using the membrane structures change its attitude with thrusters or utilizing solar radiation pressure (SRP). Although the use of thrusters allow agile attitude maneuver, thrusters will cause vibration resulting performance degradation on membrane utilization. On the other hand, although utilizing SRP allows the satellite to change the attitude without vibration, the angular velocity is as low as 0.5 deg/day according to flight report of IKAROS launched in 2010 by JAXA. Thus, an agile attitude control system with small membrane vibration is required. In the proposed system, electrical wires attached on the sides of the membrane generates electromagnetic force between the electrical current and the geomagnetic fields, applying control torque to the membrane. Vibration can be reduced using the proposed attitude control system, since the electromagnetic force is directly applied to the membrane. However, this system only can change the satellite attitude and the electrical current as the controllable parameters to control the attitude and to reduce the vibration of the membrane. This study develops the attitude controller of the proposed system, and evaluates the performance. As the membrane dynamics modelling method, this study utilizes unconstrained mode model, which is common method for modelling large space structures such as solar array. To develop attitude controller, linear quadratic regulator (LQR) that takes the vibration reduction into account is used. The performance of the proposed system is evaluated under measures of agility and amplitude of the vibration.