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Author: Mr. Andris Slavinskis
University of Tartu, Estonia, andris.slavinskis@gmail.com

Mr. Urmas Kvell
University of Tartu, Estonia, urmas.kvell@estcube.eu
Mr. Erik Kulu
University of Tartu, Estonia, erikkulu@gmail.com
Mr. Tobias Scheffler
Bremen University of Applied Sciences, Germany, tobias.scheffler@estcube.eu
Mr. Silver Lätt
University of Tartu, Estonia, silver.latt@ut.ee
Dr. Mart Noorma
University of Tartu, Estonia, mart.noorma@ut.ee

MAGNETIC ATTITUDE CONTROL ALGORITHMS FOR ESTCUBE-1

Abstract

Attitude Determination and Control System developed for one unit CubeSat ESTCube-1 aims to perform one axis spin-up using only electromagnetic coils. The spin-up is required to deploy an electric solar wind sail (E-sail) tether by centrifugal force. Currently the development is in phase C/D, and the satellite is planned to be launched into low Earth orbit early 2013. ESTCube-1 is mainly developed by students in Estonia and it will be the first satellite performing the E-sail experiment in space. E-sail is a novel space propulsion concept which uses the dynamic solar wind pressure to control the velocity of the satellite. An example E-sail spacecraft structure consists of up to one hundred 25-50 m thick and 20 km long tethers. During the ESTCube-1 mission one 50 m thick and 10-meter long tether will be deployed and E-sail effect will be measured. The effect of plasma break will also be monitored. The orbital decay will be monitored for a longer period of time and compared with other CubeSats from the same launch. After the satellite is deployed from the POD it will be tumbling. For efficient communication and Earth imaging purposes detumbling, nadir and inertial pointing control algorithms are developed. For ESTCube-1 the detumbling algorithm is based on the closed-loop spin-up control algorithm. It is compared with the traditional B-dot detumbling control algorithm. The centrifugal deployment of the tether requires a spin rate about the satellite z-axis of 1 revolution per second and an alignment of the spin axis with the Earth polar axis. A spin-up control algorithm using only magnetic torquers to achieve the desired spin rate is developed. For measuring the E-sail and plasma break effects a precise attitude determination system is developed. The attitude determination system includes magnetometers, sun sensors and gyros; the attitude is controlled by magnetorquers. The Kalman filter is used for the attitude estimation. During the last two decades a considerable amount of theoretical research has been done to develop control algorithms for satellite stabilization and pointing by using only magnetic torquers. Spin-up algorithms using only magnetic coils have been developed previously only for spin stabilization applications which require a low spin rate. This paper presents a high-rate closed-loop spin-up algorithm and discusses the feasibility of an efficient detumbling algorithm based on a spin-up algorithm.