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Author: Mr. Aleksandr Zykov
S.P. Korolev Rocket and Space Corporation Energia, Russian Federation

CONTROL ALGORITHMS DEVELOPMENT FOR SPACE PLATFORM WITH A ROTATING SOLAR SAIL

Abstract

The objective of this study is to develop control algorithms for a space platform used for various purposes without the need to spend fuel on such operations as orbit reboosts, angular maneuvers, and desaturation of accumulated angular momentum. Principles of spacecraft angular motion control are demonstrated using a base structure consisting of an instrument module, a solar sail which is representing by a large rotating membrane disk, and a compensating powered gyroscope (Hooke's gyroscope). The solar sail is used for transferring the momentum to the instrument module, while its central rigid insert – for transferring angular momentum. The membrane disk of a solar sail is in a stress-strained state due to centrifugal forces and the gyroscope-generated momentum. The gyroscope-generated momentum occurs when the rotational axis of the hard insert, located in the center of the membrane disk, turns during angular maneuvers performed by the spacecraft. Lyapunov's method is used to prove the stability of the sail's stationary form at regular precession of the membrane rotation axis. Desaturation of the accumulated angular momentum of the Hooke's gyroscope is accomplished using solar pressure torque. Control algorithms with adaptive observation system were developed for the solar sail deployment, active damping of flex vibrations of the solar sail membrane disk, as well as for the angular and trajectory maneuvers of space platform. The research paper presents the results of the analytical and numerical study of the dynamic task of solar sail deployment and dynamic behavior of the spacecraft with a rotating solar sail in two modes: planned maneuvers and damping of initial angular rates.