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Author: Dr. Shunan Wu
Dalian University of Technology (DUT), China

Mr. kaiming zhang
Dalian University of Technology (DUT), China
Mr. yuliang liu
Dalian University of Technology (DUT), China
Prof. Zhigang Wu
Dalian University of Technology (DUT), China
Prof. Gianmarco Radice
University of Glasgow, United Kingdom

ROBUST COLLOCATED SUN-POINTING CONTROL OF A LARGE SOLAR POWER SATELLITE

Abstract

Recent years have witnessed the resurgence of space-based solar power research, and in particular the solar power satellite (SPS) paradigm has received much attention due to its potential for generating clean electrical power. Many different SPS concepts and technologies have been proposed by different organizations. To achieve maximum generating efficiency, it is paramount to ensure that the SPS is in a stabilized Sun-pointing configuration. Unlike other satellites, the SPS has a very large area and mass, and also has a planned mission lifetime of more than 30 years. The scale of the satellite and the duration of the mission mean that Sun-pointing maneuvers could be significantly affected by perturbations caused by solar radiation and gravity gradients. Meanwhile, the large area and mass property could lead to very low and closely distributed structure frequencies, which will cause a significant problem of control-structure interaction. This gives rise to challenging problems to achieve accurate sun-pointing control.

This paper presents the robust collocated sun-pointing control design of the Abacus SPS in the presence of model uncertainties, perturbations and bandwidth constraint. The decoupled linearized dynamic equations that describe attitude motion and vibration of the SPS, are firstly derived in the body-reference frame, in which the unconstrained free vibration modes are used. The dynamic equations are then transformed into a Lagrange representation for the design of the controller. Due to the limitation of current angular-momentum-exchange devices, electric thrusters are used as actuators for SPS attitude control. Through collocated placement of the electric thrusters, displacement and rate sensors, a symmetric output feedback controller that can achieve the necessary sun-pointing requirements in the presence of model uncertainties, is proposed. It should be noted that the controller gain is obtained by solving the desired reference model of the closed-loop system. An integrator and a disturbance rejection filter are then integrated into the above controller to reduce sun-pointing errors caused by perturbations. The proposed dynamic model, including three attitude angles and all structure modes under 0.1 Hz, is finally used to assess the control performances under different system bandwidths by means of numerical simulations. The results demonstrate that the proposed controller can achieve higher pointing accuracy, better robustness, and can effectively suppress vibration than PID control. Using the proposed symmetric output feedback control technique appears to be a promising solution to achieve precise Sun-pointing of a SPS in the presence of model uncertainties and perturbations, while considering performance and bandwidth.