ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (5)

Author: Dr. Shunan Wu
Dalian University of Technology (DUT), China, wushunan@dlut.edu.cn

Mr. kaiming zhang
Dalian University of Technology (DUT), China, 1677042884@qq.com
Prof. Gianmarco Radice
University of Glasgow, United Kingdom, Gianmarco.Radice@glasgow.ac.uk
Prof. Zhigang Wu
Dalian University of Technology (DUT), China, wuzhg@dlut.edu.cn

ROBUST OPTIMAL 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 concept of solar power satellite (SPS) due to it potential for generating large amounts of electrical power. Many different SPS concepts and technologies have been reported by NASA, JAXA, ESA and other organizations. To achieve maximum efficiency, it is paramount to ensure that the SPS is in a stabilized Sun-pointing configuration. Differing from other satellites, the SPS has a very large area and mass, and is expected to be operational for more than 30 years hence the attitude and orbital dynamics could be significantly affected by solar radiation and gravity gradient perturbations. Additionally due to its size, the SPS will have to be assembled in space, therefore the model parameters may not be accurately known. This gives rise to challenging problems to achieve accurate Sun-pointing.

This work focuses on developing a robust Sun-pointing algorithm for the Abacus SPS located in geostationary orbit, with its large solar array perpendicular to the Earth equatorial plane. To address the challenges illustrated above, we make use of optimal linear quadratic regulator (LQR) technique. The solar power satellite is considered as a large rigid body, and the Sun-pointing dynamics of the SPS in a geostationary orbit is introduced. The main orbital perturbations, solar radiation pressure and gravity gradient torques, are then modeled and discussed. The uncertainties in the mass distribution of the SPS are further considered, and the Sun-pointing dynamics is transformed into the nominal state space representation. An optimal LQR controller that performs the Sun-pointing maneuver is then proposed. A quadratic cost function is defined and the gain matrix of the proposed controller can be obtained by minimizing the cost function. It should be noted that the optimal LQR controller is designed in order to account for both the pointing accuracy and the control input. The robustness to perturbations and inertia uncertainties is discussed via the Lyapunov method. Simulation results are finally provided to illustrate the performance of the robust optimal LQR controller by comparing with a PID controller. The results will demonstrate that the proposed controller can achieve higher pointing accuracy, better robustness and lower control torques. Using optimal LQR technique appears to provide a promising solution to attain precise Sun-pointing of a SPS in the presence of model uncertainties and perturbations, while considering the performance and required torques.