SPACE SYSTEMS SYMPOSIUM (D1)
Enabling Technologies for Space Systems (2)

Author: Dr. Krishna Kumar
Ryerson University, Canada

ATTITUDE CONTROL OF SOLAR POWER SATELLITES USING FLUID-RING ACTUATORS

Abstract

The space-based power generation using a solar power satellite (SPS) represents one of the promising solutions to current energy crisis worldwide. In 1968, Glaser proposed this concept of a solar power satellite (SPS) in geostationary orbit (GEO). Thereafter, several studies have been conducted on the SPS and several configurations and architectures of the SPS have been proposed. Recently, California's biggest energy utility, Pacific Gas Electric signed a deal to purchase 200 MW of electricity from Solaren Corporation that plans to beam the power down to Earth from outer space, beginning in 2016. Japan's space agency, JAXA, is also actively working on this project and has planned to launch a constellation of SPS, each beaming power to a 1.8-mile wide receiving station that will produce 1 GW of electricity and power 500,000 homes. However, the attitude control of the SPS poses significant challenges owing to its large size (typical size greater than 1 square km and mass greater than 1e6 kg) and the requirement of precisely controllable wireless power transmission. The present paper will examine these issues and proposes a novel method for attitude control of the SPS.

In the present paper, we propose fluid rings as actuators for a three-axis attitude control of a SPS. The present investigation makes several contributions. First, the nonlinear system model that include the SPS and fluid rings is developed. Second, nonlinear control laws based on sliding mode control techniques are developed for fluid control torques. Third, several cases including uncertainties in system parameters, high attitude disturbance torques, and intermittent actuators' faults are examined to assess the efficacy of the proposed control method.

The system model comprises a SPS and three/four fluid rings. Each fluid ring is fitted with a pump to regulate the flow of the fluid. The system equations of motion are derived through Euler's moment equations. Nonlinear control laws for the required fluid control torques are developed using sliding mode control technique. The numerical simulation of the governing nonlinear equations of the motion of the system establishes the feasibility of achieving desired attitude control of the SPS. The fluid controllers are successful in stabilizing the attitude of the SPS in presence of high attitude disturbance torques and intermittent actuators' failures. Furthermore, the SPS attitude response virtually remains unaffected for all the cases considered. The proposed attitude control method may find applications in future SPS missions.