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VIBRATION ISOLATION FOR SOLAR POWER SATELLITE VIA QUASI-ZERO STIFFNESS SYSTEM

Abstract

For a solar power satellites (SPS) in geostationary orbit, a coarse control accuracy is generally needed for pointing to the Sun of the solar panel, in order to collect the solar power. Meanwhile, the antenna, to effectively transmit the energy, is required with higher-accuracy to directly point to a certain ground location. The thermal-induced and actuator-induced vibration are significant for SPS, especially for the main truss where the solar panels and the antenna are resembled. The isolators between the antenna and the main truss are thus required to reduce the vibration transmission, which can therefore improve the attitude control performance. The quasi-zero stiffness (QZS) system is a mechanism with a very low or even zero dynamic stiffness and high-static stiffness, which can be realized by connecting the negative stiffness structure (NSS) with a positive stiffness component. It is profoundly effective for the small magnitude of vibration, which is ideal for the vibration isolation of the SPS.

The main objective of this study is to design a QZS isolator between the main truss and the transmitting antenna of the SPS, and then verify the feasibility of the proposed isolator with the environmental disturbances, including the gravity gradient and the thermal radiation. A simplified model of the multi-joints rotary SPS (MR-SPS) with a QZS isolator is established, and the coupling equations including the attitude motion, structural vibration and the isolator motion is derived using the second Lagrange's equation. The thermal induced bending deformation is considered in the structural vibration equation. Meanwhile, the orbiting thermal dynamic equation is formulated, which is influenced by the attitude motion. Then, the static analysis of the QZS isolator is investigated into the quasi-zero dynamic stiffness at the equilibrium position. Moreover, the isolation performance of the quasi-zero stiffness system is evaluated in the presence of the thermal radiation, and the dynamical response is compared with the model without an isolator. Besides, the QZS characteristic can be improved by appropriately choosing the system's parameters (angle of inclination and ratio of spring stiffnesses). Hence, by introducing the optimization objective that the largest displacement of the isolator can be achieved with a minimum stiffness constraint, the optimization of the QZS isolator is explored by the genetic method.

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