Vibration Isolation for Sensitive Payloads of Spacecrafts Via Stewart Platform With the X-Shape Supporting Structure

Xin Wang[1,*], Xiaokui Yue[1] and Honghua Dai[1]

[1]National Key Laboratory of Aerospace Flight Dynamics, Northwestern Polytechnical University, Xi'an, 710072, China.
[*]Corresponding Author: Xin Wang. Email: wangxin1989@mail.nwpu.edu.cn.

Abstract: With the rapid development of space technologies, the requirements of precise pointing and extreme stability increase a lot for spacecrafts. For some spacecrafts, sensitive payloads, including space telescopes, imaging sensors, space-borne optical interferometers are essential for the missions, which require a relatively quiet working environment. Generally, a spacecraft includes multiple instruments, including reaction wheels, cryogenic coolers, control moment gyroscopes and solar array drives, which can produce micro-vibrations. However, the micro-vibrations from the spacecraft and orbital perturbations both have a serious influence on the performance of sensitive payloads. For the sensitive payloads, performance requirements of low vibration and jitter have become a more and more challenging issue as the vibration sources in the spacecraft increases.

To guarantee the performance of sensitive payloads, multi-degree-of-freedom vibration isolation systems are needed. Stewart platform, as one of the most popular approaches, is excellent for 6-DOF vibration isolation and precise pointing of sensitive payloads. Based on it, a special 6-DOF vibration isolator is designed， whose legs have X-shape structure in a passive manner for improving the vibration isolation performance. Passive isolation control is a reliable, low-cost method which is effective for attenuating high frequency vibrations. However, in general, it is not available for low frequency vibration isolation, especially cannot provide good trade-off between resonant peak and high frequency attenuation, and trade-off between pointing command keeping and disturbance rejection. Therefore, it is necessary to apply active isolation control for the isolation system. Regarding to the time-varying factors and uncertainties of the system, a novel adaptive control strategy is designed as the active control part to keep the sensitive payloads from external interference.

Compared with the simplified linear-stiffness legs, the nonlinearity of the X-shape structure enhances the vibration isolator to have better vibration isolation performances. Besides, the structural parameters of the X-shape structure include layer number, assembly angle and spring stiffness can be tuned arbitrarily, which are beneficial for precise pointing. Numerical simulation demonstrates that the hybrid isolation system can realize good vibration isolation in all six-DOF directions and better vibration isolation performance has been obtained.

DOI: 10.32604/icces.2019.04851