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VIBRATION SUPPRESSION OF TETHERED SPACE SOLAR POWER SATELLITE BY TETHER TENSION CONTROL

Abstract

Based on the tether tension technology, an active vibration suppression method for tethered flexible space structures as the tethered SSPS (Space Solar Power Satellites) is developed and analyzed both numerically and experimentally. The continuous system model to descript the vibration behavior of the flexible space structure is presented. Using the Mission Function method, a feedback controller for suppressing the structural vibration is developed according to the given continuous system model. In view of the unilateral nonlinearity of the tether, i.e., the tether only can provide the pulling force but not provide pushing force, the tether tension control must manage this kind of the unilateral nonlinearity of the tether to avoid generating negative tension, thereby, the proposed controller is adjusted to adapt to this feature of the tether by making the control force piecewise. In the ground experiment, an aluminum beam is designed as the experimental model to simulate the dynamic behavior of large flexible space structures. Some weights are equipped on the flexible beam in order to ensure the first modal frequency of the flexible beam to be same order of 1 Hz as that of the flexible solar panel. The tether tension actuator is designed to generate arbitrary minute tension for the control of the structural vibration, which consists of the flexible leverage, the strain gauges and the linear motion guide system. This flexible leverage is specially designed in the tether tension actuator for weakening the sharp profile of the tether tension arising from the motion of the actuator which may occur to pull the tether after slack, and a pretension is acted on the tether so as to further eliminate this effect. In order to assess the effects of different flexural rigidity of the flexible leverage on the performance of the tether tension actuator, the flexible leverage in five kinds of dimensions and two kinds of materials is designed and used in the experiment. The experimental results show good agreement with the numerical simulation. The excellent performance of the tether tension actuator is confirmed and the experimental results verified the validity of the proposed control strategy.