Vibration Control of Tension Aligned Structures

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Large space structures are being considered to support radar antennas for imagery and moving object identification and tracking, solar arrays for energy collection, and platforms for large mirrors and telescopes. In these applications such structures have stringent design requirements in terms of precision, environmental stability and durability, high deployment reliability, manufacturability, and cost. In particular, high precision is particularly difficult to achieve since these structures are sensitive to vibration sources located on the structure. Vibration sources can transmit vibration from one location in the structure to another and cause misalignment of sensitive instruments. Vibration suppression in large space structures is a challenging task for engineers.

Recently, tension-aligned structures have been proposed for space applications where high precision is an important consideration. A tension-aligned structure, analogous to a bow with a string, consists of a supporting structure in compression and a sensor array in tension. By providing larger stiffness for a lower mass, tension-aligned structures have better packaging efficiency and maintain flatness of the sensor surface. This work presents an efficient method for vibration suppression in a tension-aligned array structure using constraint actuators. The primary role of constraint actuators is to cyclically apply and remove constraints such that vibration energy is efficiently funneled into high-frequency modes of the structure, where it can be dissipated quickly and naturally due to high rates of damping. A cycle of constraint application and removal can never add energy and hence the method can potentially achieve vibration control without accurate knowledge of the system states. The vibration control methodology is applied to a tension-aligned array structure supported by a structure in compression. This approach for vibration suppression has the potential to positively influence the development of tension-aligned architectures which are contemplated for large precision apertures in space.