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DYNAMIC ANALYSIS OF A NOVEL HEXAPOD PLATFORM WITH EMBEDDED ELECTROMAGNETIC SHUNT DAMPERS

Abstract

A hexapod platform is often considered as a solution for space missions in which more-established isolators (e.g. viscoelastic mounts) are not adequate to achieve the required high-performance isolation. Nevertheless, these platforms are rarely actually integrated on a spacecraft due to several drawbacks they still present such as system complexity, considerable amount of added mass and need for control algorithm. For these reasons, extensive research has been dedicated in improving the damping methods embedded within the strut elements so to balance those drawbacks with unprecedented performance. Among other recent developments, Electromagnetic Shunt Dampers (EMSD) are gaining an increasing attention. In particular, with the use of a negative-resistance converter, EMSDs have been proved to operate as semi-active dampers capable of combining the advantages of passive dampers (roll-off slope of -40 dB/decade) and active dampers (elimination of the resonance peak) without requiring either an active control algorithm or high input power. This technology was embedded in a 2-DoF strut and its improved performance as a single strut or as a bipod system was previously tested and verified by the authors. This paper focuses on the design and analysis of a novel hexapod platform formed by six of the aforementioned 2-DoF struts. By combining the extra internal degree of freedom with the strut low longitudinal stiffness it is possible to achieve considerable micro-vibration attenuation already at 100Hz. However, the performance of the isolation platform is determined not only by the damping property of the struts, but also by the design of the platform itself and the dynamic interaction between all its constitutive elements. This paper tackles this aspect by analysing the effect of the platform geometry and its boundary conditions on the overall isolation performance. This work proposes new boundary conditions of the platform (with respect to the well-established all-spherical-joint boundary conditions) to overcome the inherent limitation of the platform due to the strut inertia and restore the isolation performance to be as close as possible to the ideal case (i.e. the struts are considered massless). The results relative to the proposed hexapod platform are obtained through the comparison of an analytical model with a numerical model. The design and experimental validation of a novel planar joint specifically designed for micro-vibration application are also presented. This paper is intended as a first step toward the development of a new class of platforms that are specifically designed for micro-vibration mitigation.