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SPACE CIRCUITRY TUNABLE MASS DAMPER DESIGN PARAMETERS SENSITIVITY ANALYSIS

Abstract

Spacecraft electronic equipment are subjected to very severe vibrational mechanical field during all the launcher ascent lift-off phase. Within the first 120-150 seconds, all satellite assemblies and sub-assemblies face the 95% of their entire mechanical life. Differently to other engineering application fields, the space segment is characterized by very high amplitude and very timely short dynamic solicitations. In order to increase electronic components dependability and to avoid any possible anomaly, that could lead to a partial or total functioning interruption, thermal and mechanical devices are included in the assemblies and sub-assemblies design. The main aim of this paper is to focus on mechanical device for vibrations reduction. In particular, passive Tuned Mass Dampers (TMD) have been studied and optimized in order to suppress unwanted dynamic response at circuitry level. The first part of the paper will introduce the topic including a general overview about the available solutions on the market. This section will be followed by a theoretical section where the main governing equations will be introduced and discussed in order to define the functioning principle. Basing on the understanding of the governing relation, a sensibility analysis will be performed in order to identify the design parameters to be considered in a dedicated optimization process. The main goal is to define a set of practice rules to be used during the space equipment design to control, to reduce and, in some cases, to suppress the vibrational field that may affects the EEE parts reliability (f.i. crystal oscillators, relays, etc...) by jeopardizing the hardware nominal functioning. The so obtained set of design parameters will be used, in the third section, for a practice application. A simple sub-system, composed by a metallic chassis and a printed circuit board, will be introduced and an optimal TMD will be identified to reduce the vibrations. Relevant numerical simulation will be presented to identify and to properly dimension the passive device. From preliminary analyses, a reduction up to the 20% is recorded about the accelerations and up to the 45% about the displacements. These numbers will find confirmation in the latter section, the fourth one. In this conclusive paragraph the experimental data about the optimal solution will be presented and discussed by giving evidence of the positive effect of the TMD with respect to EEE parts mechanical reliability.