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DESIGN CRITERIA FOR REDUCED ACOUSTIC EMISSIONS IN PAYLOADS FOR ISS OPERATIONS

Abstract

The University of Alabama at Birmingham (UAB) Engineering Innovation and Technology Development (EITD) team produces powered payloads for the ISS under contract with the NASA Cold Stowage Group. Our units have been a part of over 120 flight missions with 12 units currently operating on station. NASA limits the continuous noise exposure of the crew on ISS. Our units have proved to be critical for science missions, but, the noise produced by our payloads has been above traditionally acceptable levels. Most of our payloads employ single piston sterling engines (cryocoolers) for heat lift. The noise of our units is 'structure borne' as vibration produced at the cryocooler transmits to the exterior panels. Cryocoolers traditionally employ a passive spring damper to mitigate vibration. Our design considerations limit us to spider springs. The performance trade-offs of three COTS design options are explored. Acoustic noise in our payloads is a complex, mechatronic problem. Breaking the transmission path to exterior panels and mass balancing dampers on the cryocooler have been two fruitful mechanical approaches to vibration control. The electrical drive signal frequency of the cryocooler piston is 60 Hz. This signal excites a fundamental frequency at 60 Hz and harmonic frequencies at multiples of 60 Hz. These harmonics cause acoustic emissions far exceeding NC-34, particularly in the 63 - 1000 Hz octave bands. The drive signal can be manipulated via Selective Harmonic Elimination (SHE) to target specific harmonics and reduce their impact. SHE was used successfully to drastically reduce the vibrations at 180 Hz (250 Hz Band) on flight units that are currently on station. The payload cryocoolers reject their heat with the aid of a AAA fan inside the units. The mechanical vibration and air turbulence produced by this fan results in significant acoustic emissions at 500 and 1000 Hz bands. Various methods for addressing this noise source are evaluated. The use of Principal Components Analysis (PCA) to determine the dominant direction of its vibration, while varying various parameters like power levels, types of passive spring dampers, etc. is discussed. The parameters explored during acoustic noise testing include different spring damper designs, mounting orientation of a mass balanced damper, interactions between two coupled cryocoolers, and SHE. Through our studies, the acoustic emissions of our payloads have been reduced by at least 10 dB in the 63 Hz and 125 Hz bands. Our units are now on the verge of meeting NC-34.