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“Optimization of cushioning material for low impact shock tests for Lean satellites”

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Increasing number of small satellites especially CubeSats are launched on dedicated launch vehicles in large number, being separated from the launch vehicle in different phase of a rocket launch. The satellites need to withstand and be successfully launched from the launch vehicle and survive the shock environment of very high frequencies, very short duration, and high accelerations generated by various separation events using pyro devices during launch. CubeSats are not separated with shock. The shock experienced during the separation events at other places of launch vehicles, such fairing separation, main satellite separation, etc. that use pyro devices which may be explosive that led to very high accelerations (order of 10^4m/s^2) at very short duration (~10msec). Micro components or sensors are located at or near the source of this explosive release of energy (pyro shock) may fail, jeopardizing the entire mission. Pyrotechnic shock environments are difficult to replicate in the laboratory but there is a need to accurately simulate the shock generated during the satellite separation in a laboratory test prior to satellite launch.

Generally, there are various types of shock machine which are a large mechanical shock machine, medium-weight shock machine, light-weight shock machine, free-fall drop shock machine, a Hopkinson bar, and an air gun shock machine. These are used in an industrial and laboratory environment. All types of shock machine are used for recreating accurate and repeatable shock level. The mechanism of shock generation on the air gun shock machine is elaborated in our laboratory. A projectile energized by compressed air impacts a shock table. The measured shock response is affected by the impact force, the material between the impacting surfaces, and the dynamics of the shock table. Simultaneous measurement of shock response on the corresponding x, y, and z axes require thicker plates as the interface jig. The shock response measured from the accelerometers attaching on the interface can satisfy the target shock specification simultaneously along three axes. The measured SRS was characterized by establishing statistical and probabilistic normal to tolerance limits. The SRS analysis from the acquired accelerometer data was done using a software designated in the LabVIEW™ environment. The magnitude of shock response increases with the impact pressure (velocity) and generally reduces when a soft material like natural rubber is placed between the impacting surfaces.

Launching the great numbers of satellite from the various launchers increase the use of testing equipment in the laboratory. While the testing in the laboratory needs the use of enormous amount of damper and all these used dampers cannot be used again after using one time of shock environment simulation. The purpose of this research is to reduce the use of the number of dampers, to get the replicable results of SRS by using one damper in multiple tests, and to be cost effective in the laboratory environment in the future. And then, improving the reliability and reusability of the dampers used in shock simulation on an air gun shock machine by reducing the number of dampers usage on each test which required to generate a required and repeatable shock response for the launching environment. Improving the reusability of launcher parts by rocket company such as recapturing and reusing of fairing and first rocket stage of their launcher, and they also tend to use the other types of releasing mechanism such as separation with low acceleration shock mechanism.

Master Thesis

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