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STUDY THE EFFECT OF A REAL LAUNCH ENVIRONMENT TESTING THROUGH TRI-AXIS AND SINGLE-AXIS VIBRATION TESTING

Abstract

The satellite launch vibration environment is very harsh, and all satellites and launcher subsystems have to survive without degradation in performance in order to perform their intended function for the success of the mission. The real launch vibration environment induces multi-axis random vibration excitation to the launch vehicles and satellites; however, ground vibration testing of these systems is generally sequential single-axis (SDOF) input vibration testing enveloping flight vibration levels along the axis of vibration. The actual vibration direction depends on the mode shape which may not be exactly along the reference axis of the article. Similarly, acceleration vector also will be along the mode shape direction. The induced acceleration could be in any direction and the resolved components of the acceleration will only be measured by the accelerometer sensors i.e., actual vibration magnitude would be along the resultant (square root of sum of measured acceleration squared) direction of the measured accelerations. To mimic the real launch environment, the resultant acceleration magnitude and direction should be matched in the ground testing. This paper concentrates on the matching of the measured resultant acceleration in SDOF testing and brought out the effect on a package mounted at an angle to the excitation direction. It was found that a very high amplification is needed in SDOF testing to match the resultant response as induced in tri-axis (3DOF) testing. To match the resultant response peak (produced by 3DOF excitation) corresponding to the dominant mode with SDOF excitation, the test article has to be subjected to 45% in SDOF-X, 1.15% in SDOF-Y and 420% in SDOF-Z, higher overall gRMS base input which eventually leads to over-testing of the test article. An exceptionally high overall gRMS base input (almost 100 times compared to 3DOF) was needed in SDOF test to match/envelop the direction of the resultant vector. Further, the stresses induced with resultant magnitude matched input was 30-50% lower in SDOF testing than the 3DOF testing.