Correction of Aliased NTS Shock Data for Delta II S&A Detonators

NASA/KSC Structural Dynamics

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Overview

Recent pyroshock testing at NTS Santa Clarita has revealed differences in SRS magnitudes when using unfiltered 250 KHz and 1 MHz sampling rate acquisition. Analysis of data shows aliasing of high frequency pyroshock energy above the Nyquist frequency of 125 kHz and below the standard NTS sampling rate of 250 kHz. Through the Orbital Sciences Corporation study and discussions with NTS Santa Clarita, it has been shown that NTS as standard practices does not employ low-pass filtering as a technique to prevent aliasing of high frequency data into the frequency range of interest, 10-10,000 Hz. Rather, it is their standard practice to rely on customer specification of desired filtering methods to match customer requirements. Organizations that have not specified filtering requirements to NTS for pyroshock testing at Santa Clarita have received testing that may not meet their intended requirements. The ULA, Delta II program has not previously specified pyroshock data acquisition filtering techniques to NTS, and as a result has received test results viewed as suspect for existing components.

Aliasing of data in the case of NTS pyroshock testing results in artificially high SRS results where anti-aliasing filter techniques are not employed. As a result, efforts have attempted to quantify the bias in unfiltered SRS results as a tool to establish accurate representations of previous unfiltered NTS pyroshock testing. Testing at both Orbital Sciences Corporation and ULA has recreated the conditions leading to artificially high SRS results as well as correct filtered test setups. Analysis of 6 pyroshock tests at NTS for OSC, under similar test setups and conditions to the aforementioned results, varying pyroshock intensity, shows the impact of aliasing on unfiltered data, and as a result provides a guideline for correctly evaluating previous NTS pyroshock testing against requirements.

Due to the recent discovery of these phenomena as they pertain to NTS customers, investigation is ongoing. Nevertheless, the existing body of work developed by NTS, OSC, ULA, and NASA is believed to accurately portray both the cause, and appropriate corrective actions. Moreover, it is believed that analysis of characterization tests provides a reasonable and conservative estimate of bias due to aliasing of unfiltered data.

NASA and ULA have reviewed the pyroshock test data resulting from OSC characterization testing. Additionally, NASA has reviewed NTS test reports for Detonator P/N 107800 for comparison of test configuration to OSC characterization testing. Results show that it is conservative to apply a -

20 dB reduction in unfiltered aliased NTS pyroshock test data for S&A Detonators as an accurate representation of data for comparison against requirements.

Bias Correction Methodology

Data from the Orbital Sciences Corporation testing discussed in OSC analyses, and provided to NASA/KSC for review shows the difference in achieved levels between incorrectly acquired unfiltered aliased data, and correctly acquired filtered data. Six pyroshock tests were performed, with test setup detonator cord varying from 1 ft of 7.5 gr/ft to 50 ft of 15 gr/ft cord in varying but typical/standard configurations. In comparison, review of actual NTS pyroshock test data for S&A detonators shows test setup detonator cord achieving desired levels at 20 ft of 25 gr/ft. While existing tests represent a limited set of data, review of OSC characterization testing shows a general trend where increasing length and gr/ft of test setup detonator cord corresponds to a decreased bias between unfiltered and filtered data.

Figure 1 represents the dB difference between unfiltered sampled data and filtered sampled data for 5 of the 6 data tests performed by OSC. (The remaining set used anti-alias filters on both sets of data.) Results show that increased charge tests (15 gr/ft) are below the average of all tests, and show a general trend of decreased bias as a function of charge (compare Figures 1 and 2). While a limited data set does not provide definitive conclusions regarding such trends, comparison of both the average of all sets, and the 15 gr/ft tests versus similar NTS S&A detonator test setups shows that 20 dB is a conservative bias to be applied to improperly sampled data. Furthermore, review of S&A Detonator testing shows that the 7.5gr/ft test setup does not achieve required levels and was therefore not incorporated into the final bias correction applied in Figure 3, which compares MPE vs. corrected demonstrated test levels.

Conclusion

Previously demonstrated S&A Detonator ELAT levels were bias corrected (in a frequency dependent manner) per Figure 2 with the addition of +3 dB over testing that was consistently demonstrated through previous testing. Results in Figure 3 show greater than 6 dB margin across frequencies. Additionally, per MIL-STD-1540C Table 3, a - 6 dB test tolerance is allowed for narrowband deficiencies, or -3 dB tolerance per EWR-127-1. The use of these tolerances was not incorporated in this analysis but could provide additional acceptance rationale. Therefore, NASA KSC Dynamics asserts that the S&A Detonators for DII GLAST have shown adequate margin versus predicted MPE to be considered qualified for flight.

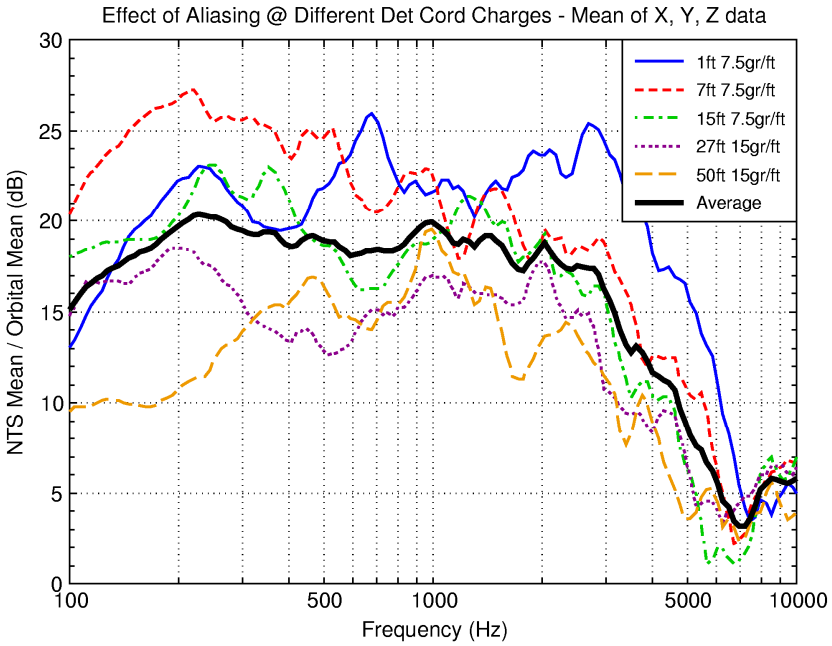

Figure 1

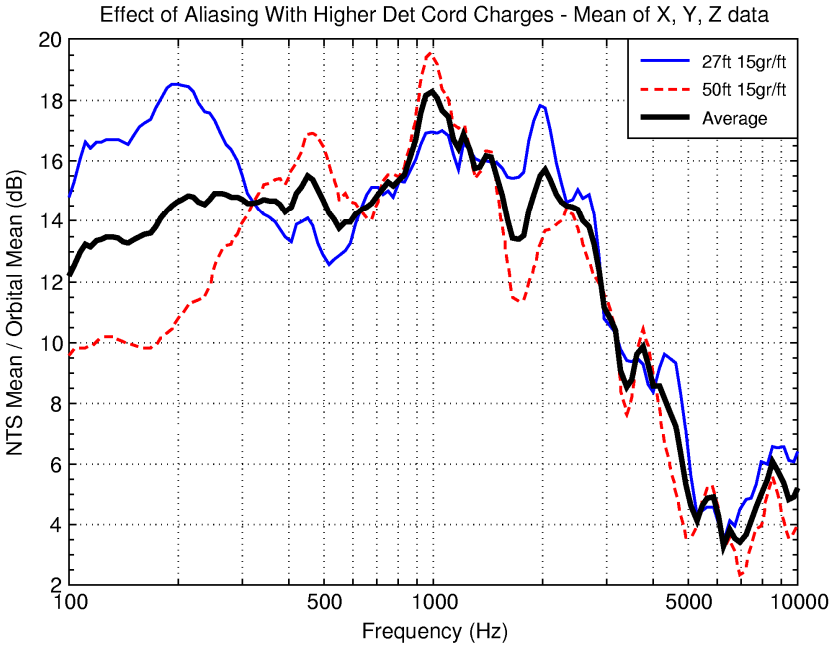

Figure 2

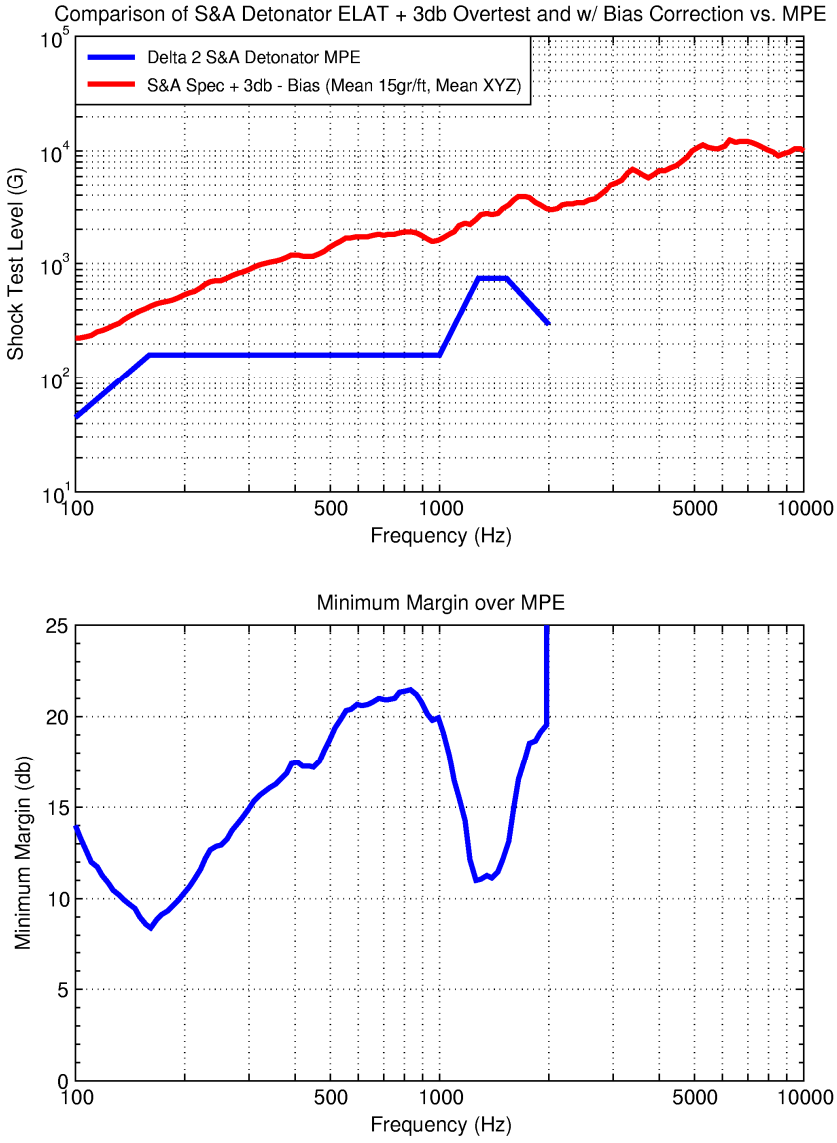
Comparison of S&A Detonator ELAT + 3db Overtest and w/ Bias Correction vs. MPE
Delta 2 S&A Detonator MPE
S&A Spec + 3db - Bias (Mean 15gr/ft, Mean XYZ)
Shock Test Level (G)
Frequency (Hz)
Minimum Margin over MPE
Minimum Margin (db)
Frequency (Hz)

Figure 3