

Generating Accelerated Loading Profiles from Measured Time Series Data



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BACKGROUND



Typically durability tests require that a motor coach drives a set number of miles on a durability test track. The number of miles necessary to complete a road test amounts to months of time spent at a test track. This large time investment is also accompanied by a large investment of money. The large investment of money arises from the transport costs of the vehicle and the cost of personnel necessary to complete the test. This commitment of time and money increases considerably if a component on the motor coach fails during testing. To help avoid failures during road tests, accelerated lab tests can be done to test components before the motor coach is subjected to a road test. Lab tests can be used to spot failures before road tests because lab tests are accelerated to have a lower time commitment when compared to road tests.

Synthesis of an accelerated test by use of frequency domain method requires a mission profile that describes the damage and maximum response of the intended test. The accuracy of the mission profile determines the accuracy of the generated accelerated test. To generate a mission profile, the event data from a continuous time series of road data must first be extracted.

The method of identifying events to be extracted from a continuous time series of road data effects the accuracy of the mission profile. As the extracted events are used to generate an accelerated test, missing any pertinent event data will effect the accuracy of the accelerated test. In addition, if extra time is added to events to ensure no pertinent data is missed, the final accelerated test will take a longer time duration to complete than necessary.

OBJECTIVES

- > Separate events in time series data by visual inspection
- > Generate an accelerated test using separated event data by using a frequency domain method

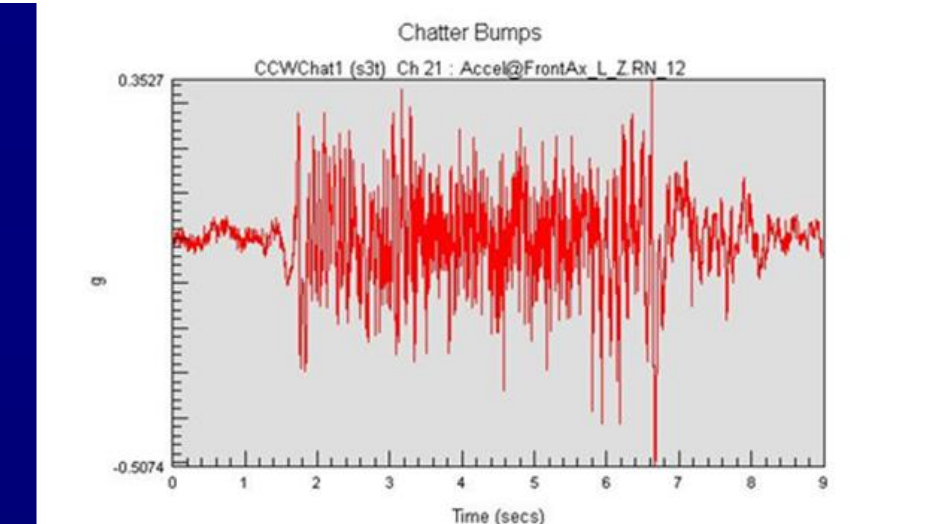
DEFINITIONS

Shock response spectrum (SRS) – Represents the maximum response of a time series event in the frequency domain.

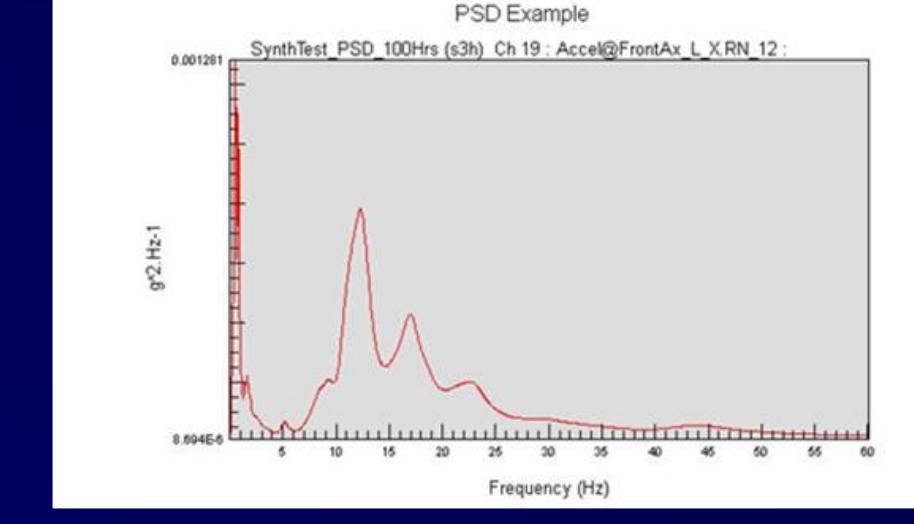
Fatigue Damage Spectrum (FDS) – Represents the damage content of a time series event in the frequency domain.

Extreme Response Spectrum (ERS) – Represents the expected maximum response of a frequency domain power spectral density (PSD) function in the frequency domain.

Example Event Time Series Data



Example of Accelerated Test PSD



METHODOLOGY

Generation of Mission Profile

1. Events separated by visual inspection in the time series domain,
2. Fatigue damage spectrum (FDS) and shock response spectrum (SRS) of each separated event generated,
3. Mission profile created using following formula for n events.

$$\text{Lifetime Damage} = \sum \text{FDS} = (\text{FDS}_1 \times \text{repeats}) + (\text{FDS}_2 \times \text{repeats}) + \dots + (\text{FDS}_{(n-1)} \times \text{repeats}) + (\text{FDS}_n \times \text{repeats})$$

$$\text{Maximum Response} = \text{MAX}(\text{SRS}_1, \text{SRS}_2, \text{SRS}_3, \dots, \text{SRS}_{(n-1)}, \text{SRS}_n)$$

Generation of Accelerated Test

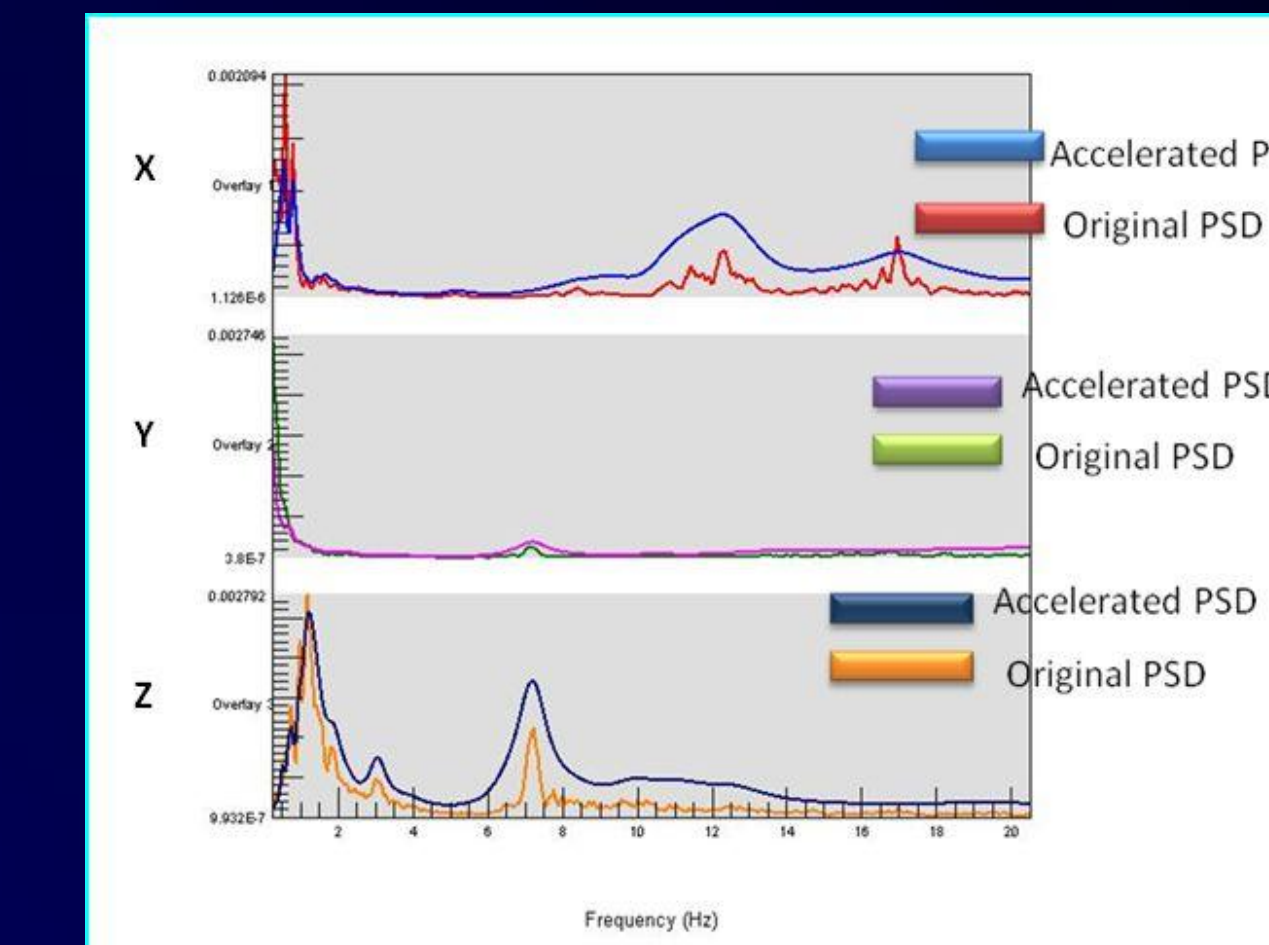
1. Generate an accelerated test power spectral density (PSD) function using the lifetime damage from mission profile and various selected test parameters.
2. Generate extreme response spectrum (ERS) of accelerated test PSD,
3. Compare maximum response function from mission profile with accelerated test ERS,
 - a) If maximum response function is below the accelerated test's ERS function, then test is invalid. Test is invalid as accelerated test PSD generates unrealistic responses. Return to step one and repeat procedure using different test parameters.
 - b) If maximum response function is above the accelerated test's ERS function, then accelerated test PSD is valid.

Selected Test Parameters

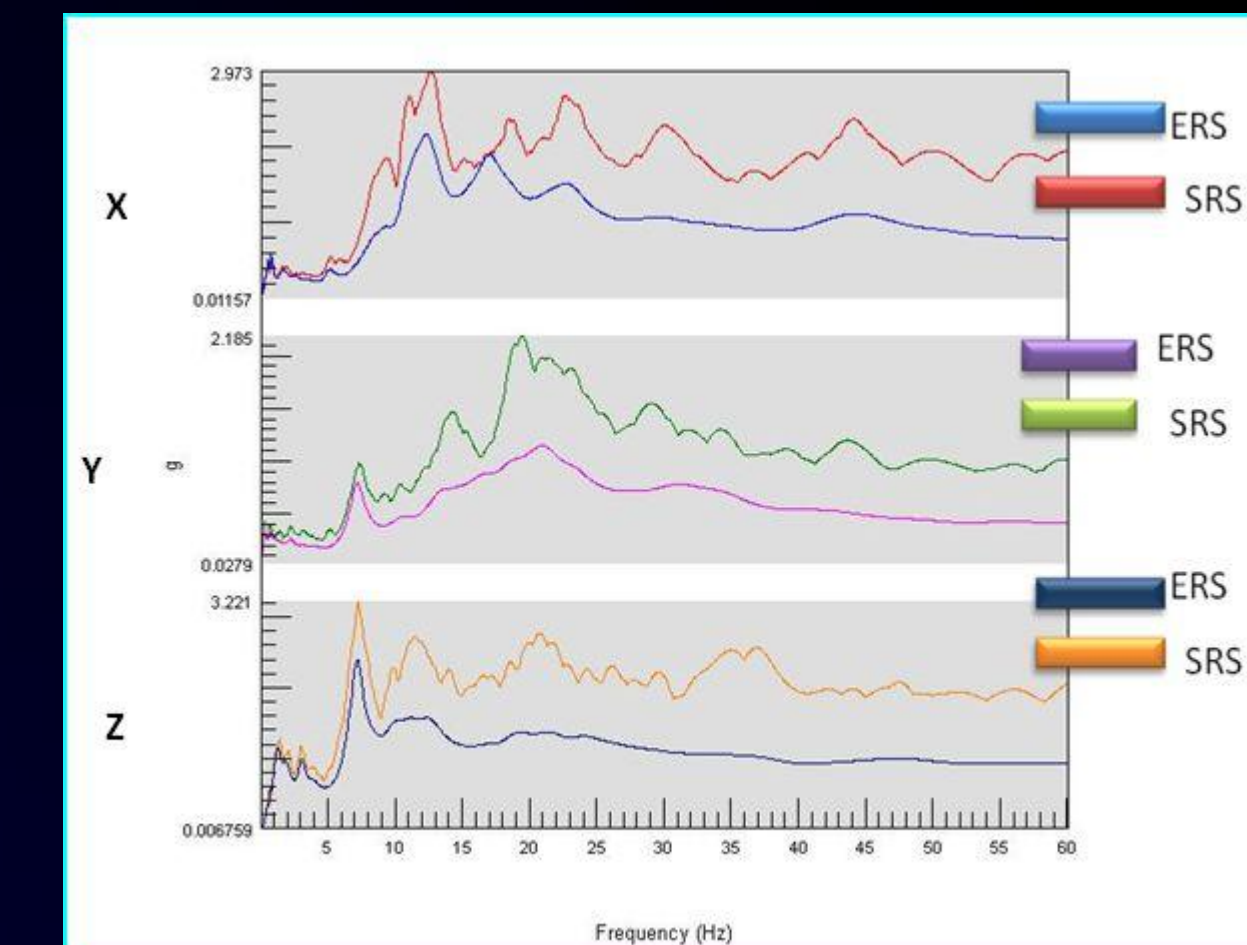
Test Parameter	Value
Variability of Strength	8%
Variability of Loading Environment Damage	30%
Confidence Level	44%
Number of Tests	1
Safety Factor	1 (Set to value)
Test Factor	0.151052 (Calculated)
Test Distribution	log-normal
Accelerated Test Duration	100 Hours
Time Reduction	83.40%
Basquin Curve Slope	4

RESULTS

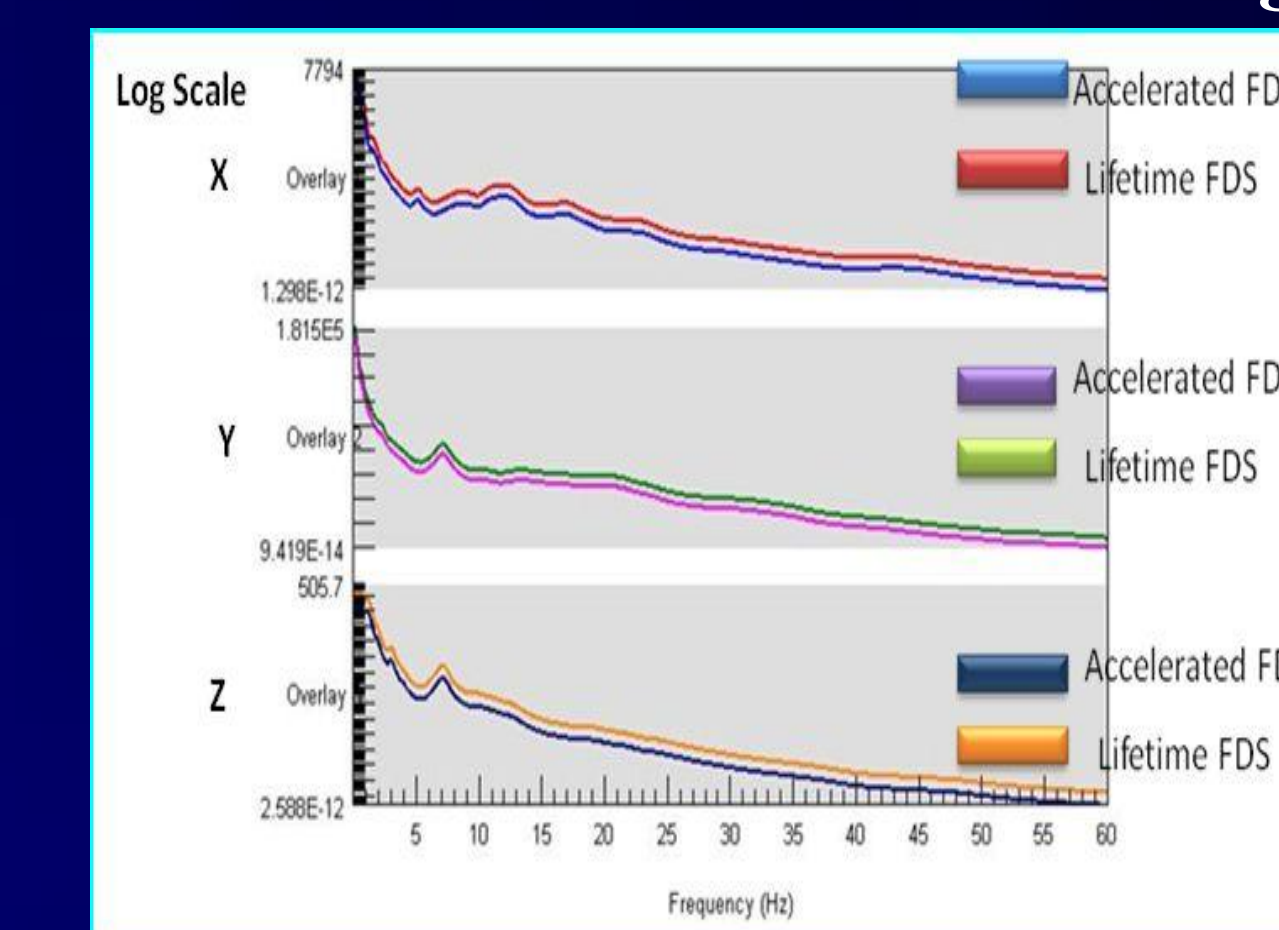
Comparison of Generated Accelerated Test PSD and PSD of Original Test Data



Comparison of Generated Accelerated Test ERS and Maximum SRS of Original Test Data



Comparison of Generated Accelerated Test FDS and Lifetime Damage FDS



- Accelerated Test ERS kept below Original Data SRS
- Confidence Level below 50% to keep ERS below SRS

- Accelerated Test PSD contains similar frequency content as PSD of Original Data
- Safety Factor was not used

CONCLUSIONS

From an original test of over 600 hours it is possible to generate a 100 hour test using a frequency domain method. The frequency content of the original test data is not lost when generating the accelerated test. By keeping the frequency content of the original test, the lab test becomes a better representation of the actual road test. While it is possible to generate an accelerated test, more research is needed to determine a valid selection method for test parameters. In addition, the method of identifying events needs to be improved due to uncertainty in visual identification. Improvements in identifying events can be made by using a frequency domain method instead of a time domain method.