

Random Theory

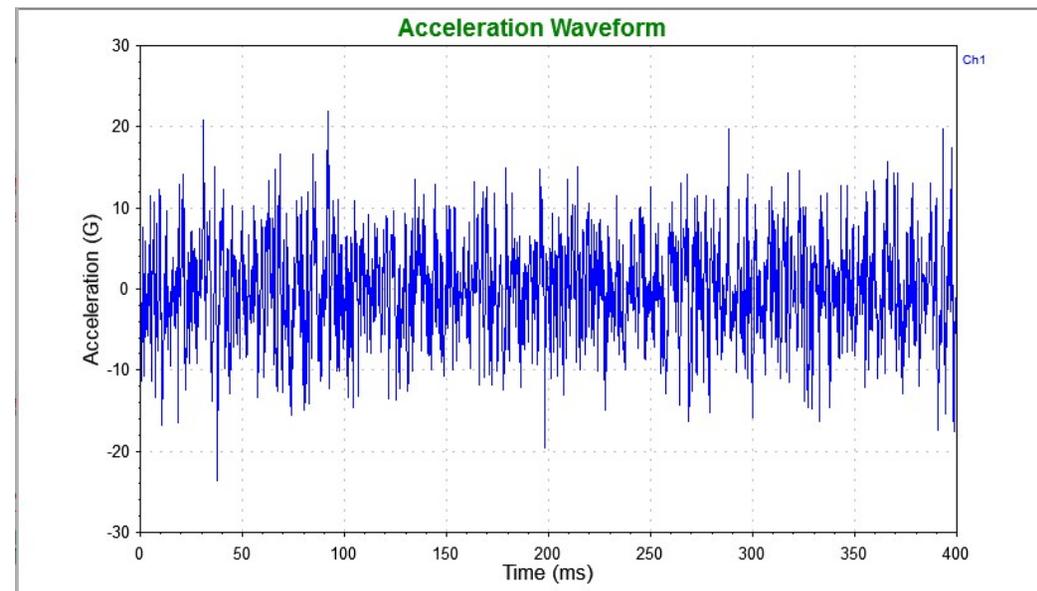


November 2017 Webinar
Jade Vande Kamp
Quality Manager



What is Random Vibration?

- Non-deterministic motion
 - Non-repetitive, non-predictable
- Applications:
 - Most widely used test type
 - “Real World” Vibration



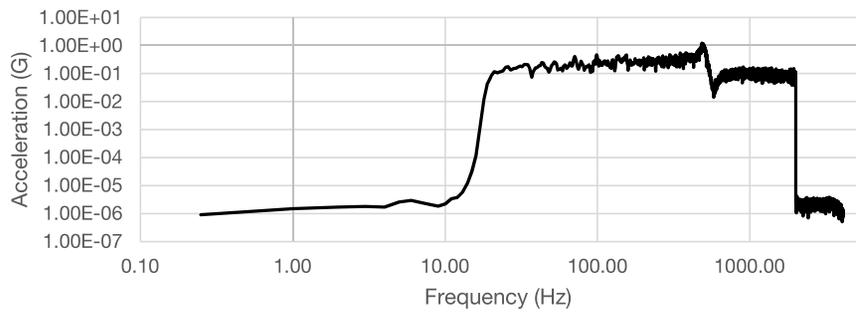
Random Key Terms

- Power Spectral Density (PSD)
 - Fourier Series
 - Fast Fourier Transform (FFT)
 - Digital Sampling
 - Windowing
 - Frequency Resolution
 - Averaging
 - G^2/Hz
 - $(\text{m/s}^2)^2/\text{Hz}$

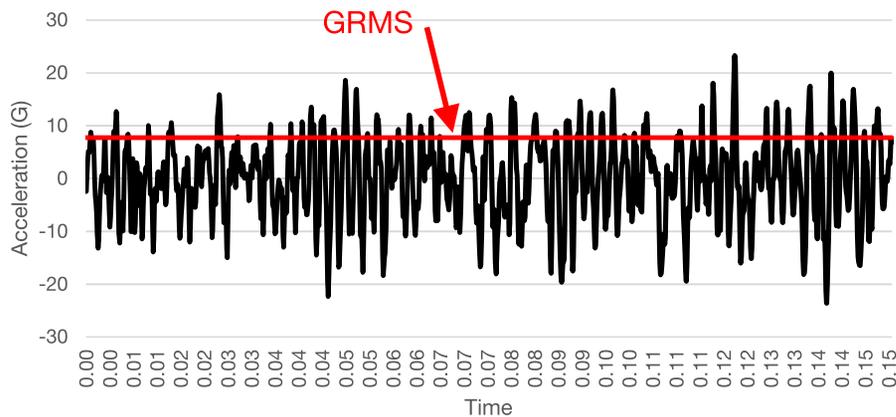


Why Power?

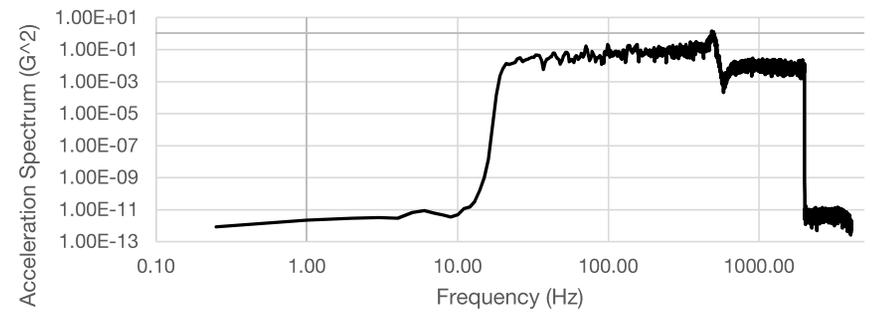
Average - FFT



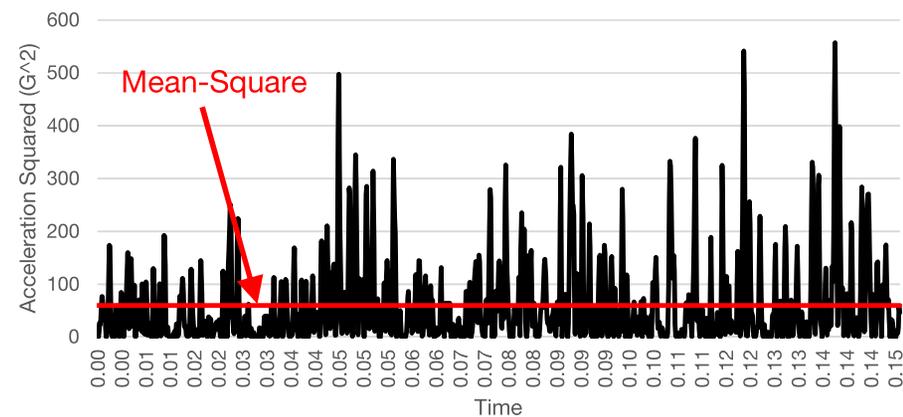
Acceleration vs. Time



Power Spectrum

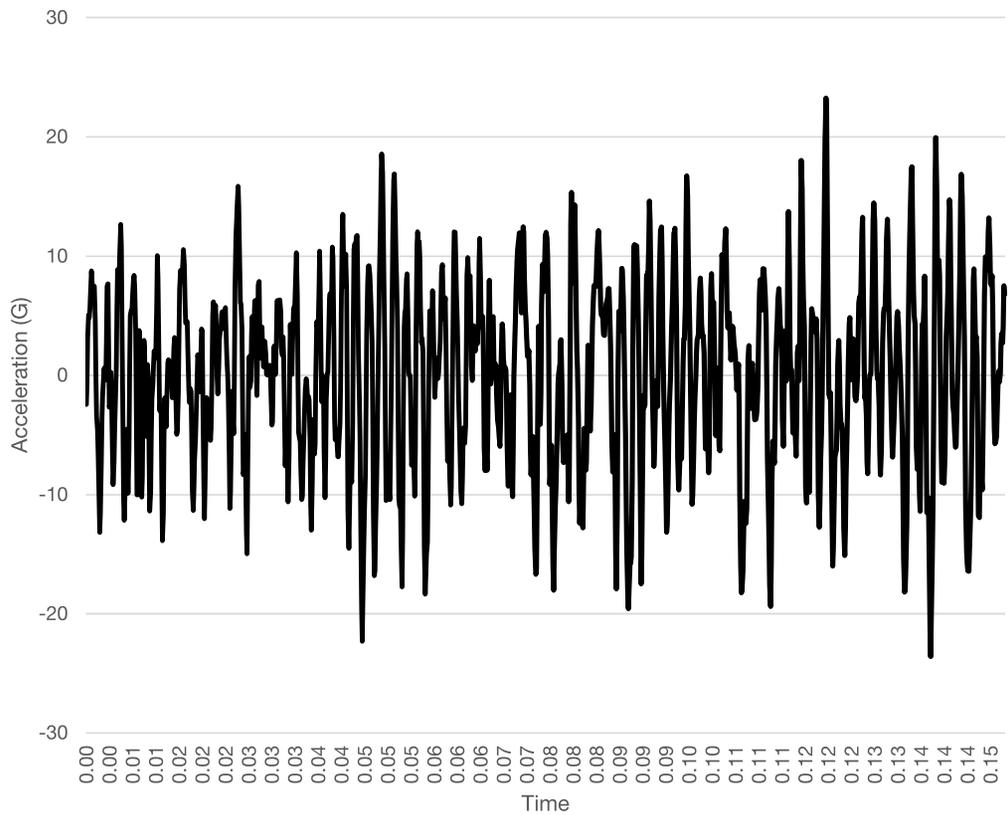


Acceleration Squared vs. Time

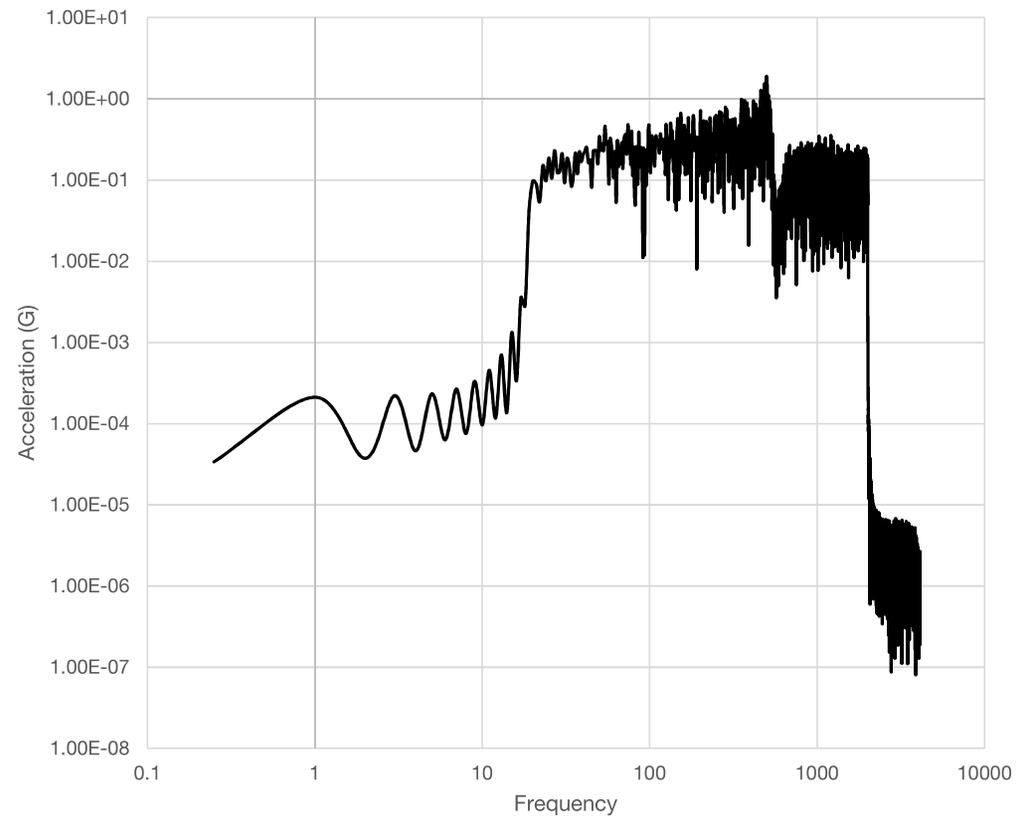


Why Spectral?

Acceleration vs. Time



0-1 Second FFT, 4096 Lines

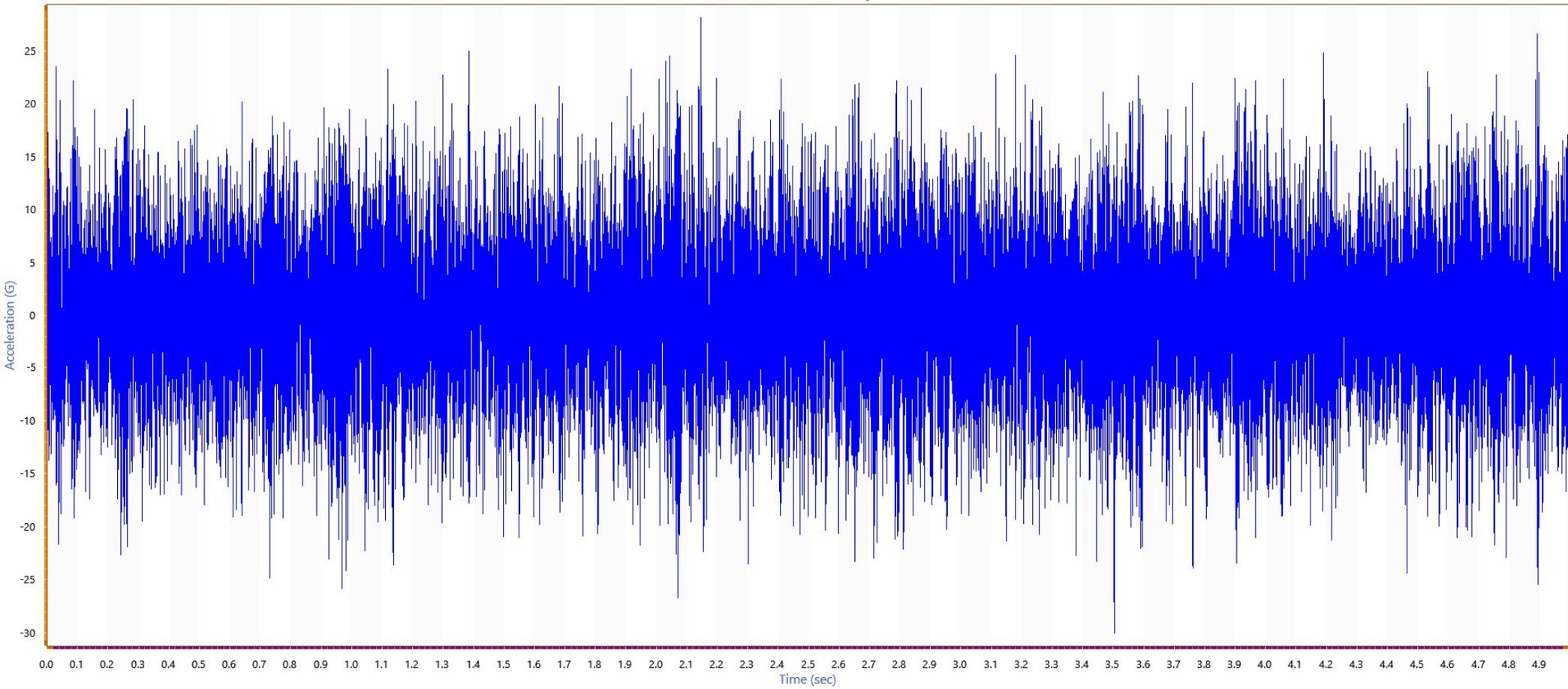


Why Density?

Frequencies	Bandwidth	RMS Meter Reading	Filtered Mean Square	Spectral Density
495 – 505 Hz	10 Hz	1 GRMS	1 G ²	0.1 G ² /Hz
480 - 520	40 Hz	2 GRMS	4 G ²	0.1 G ² /Hz
420 - 580	160 Hz	4 GRMS	16 G ²	0.1 G ² /Hz

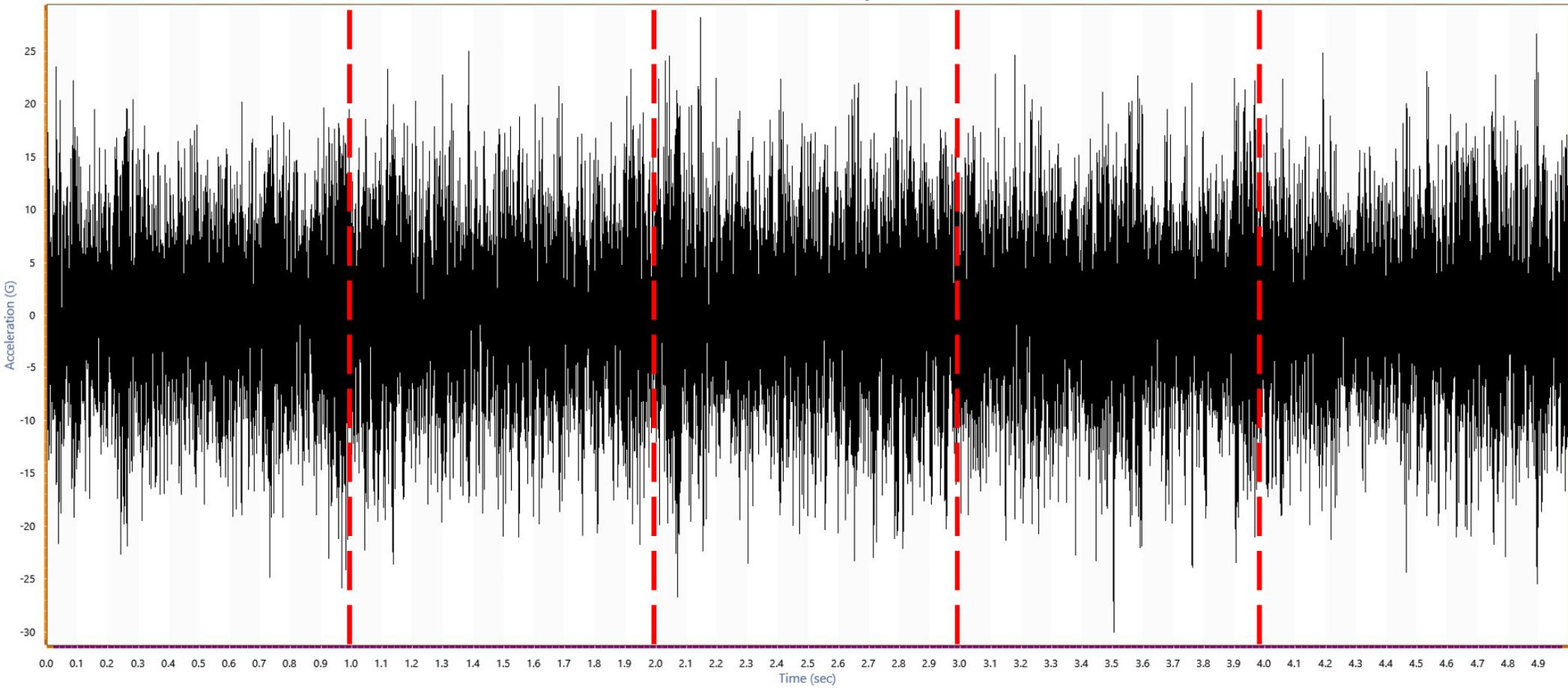
Input Time Data

Acceleration Time History



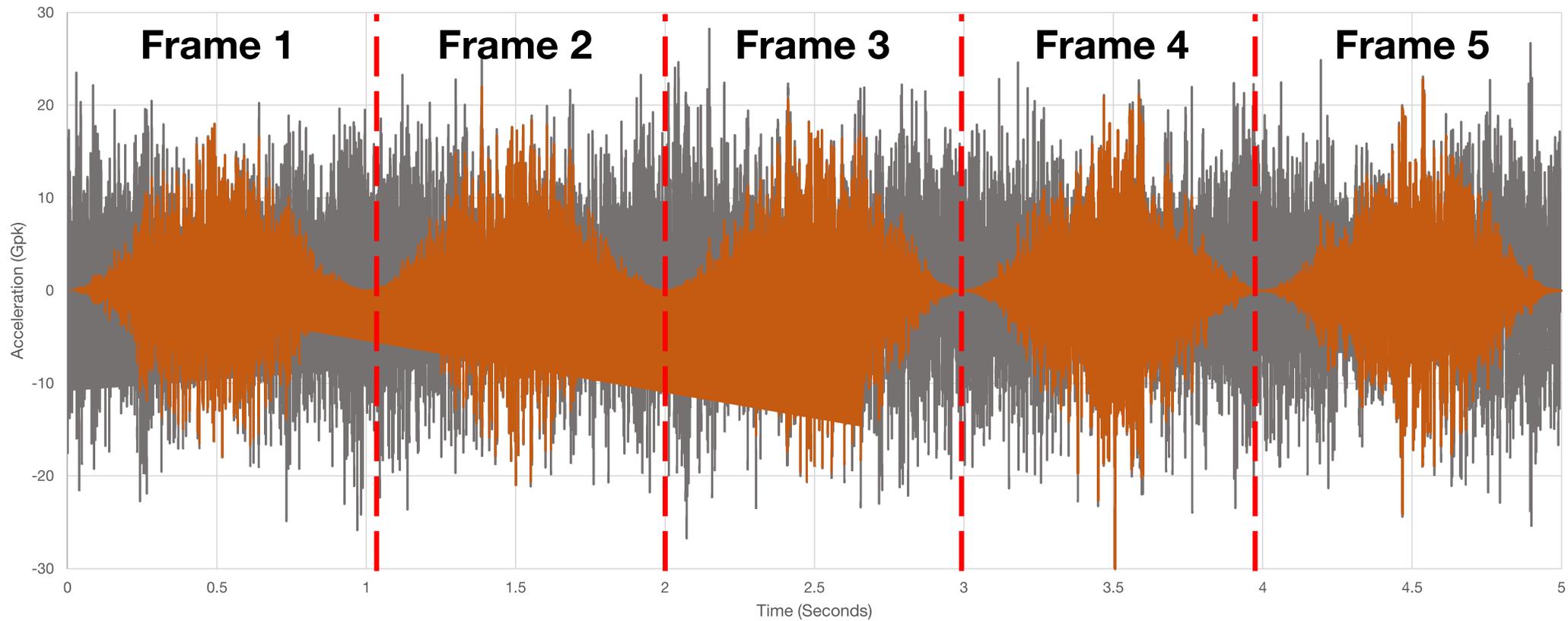
Divide into Frames

Acceleration Time History

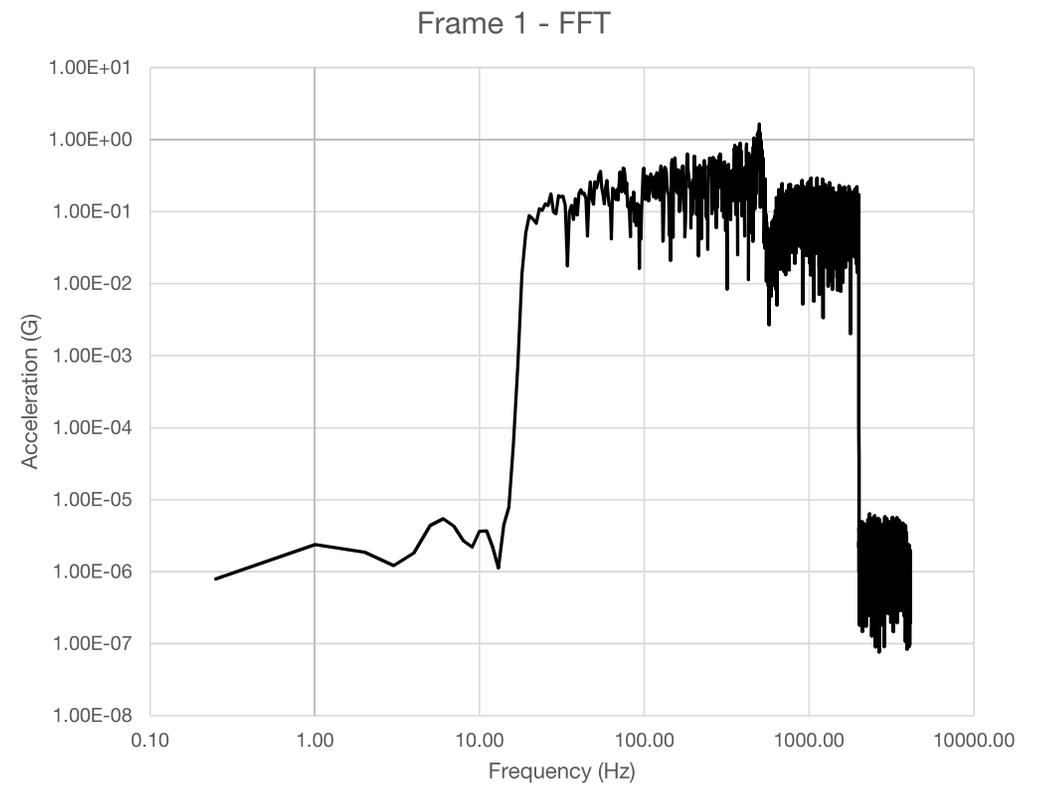
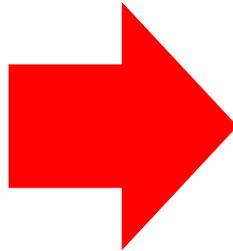
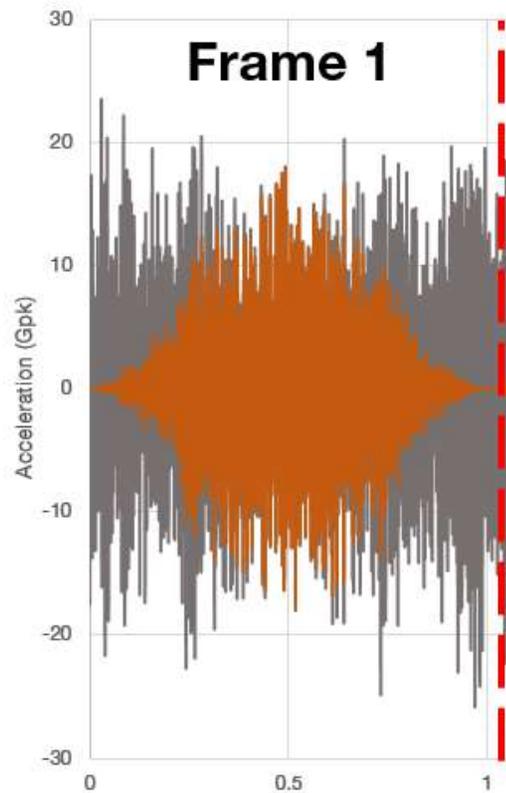


Apply Window Function to Each Frame

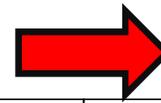
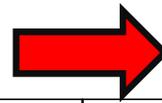
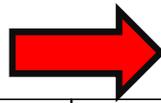
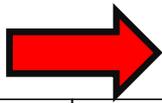
Acceleration vs. Time



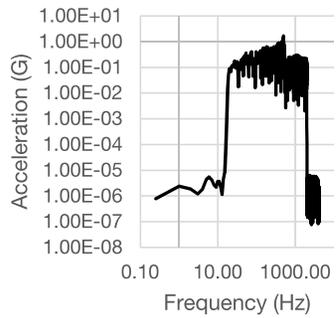
Calculate FFT for Each Frame



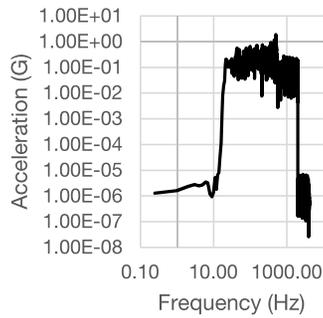
Average the FFT's



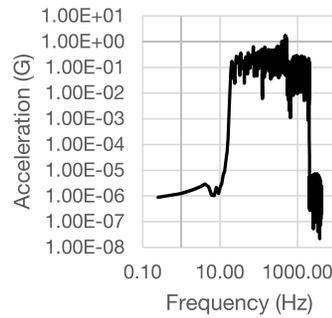
Frame 1 - FFT



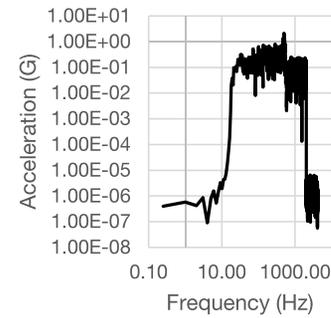
Frame 2 - FFT



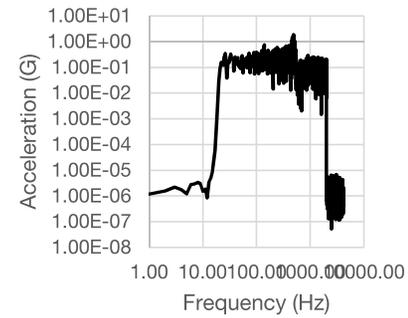
Frame 3 - FFT



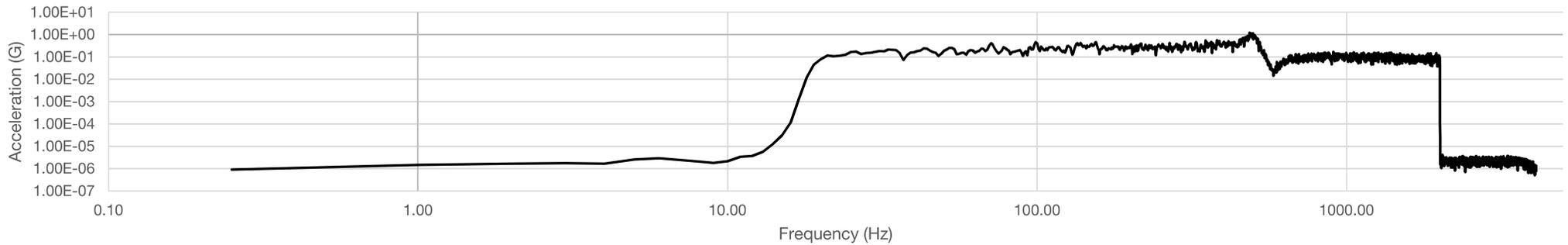
Frame 4 - FFT



Frame 5 - FFT

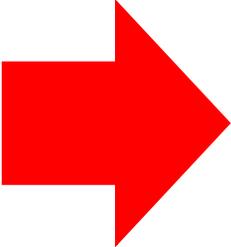
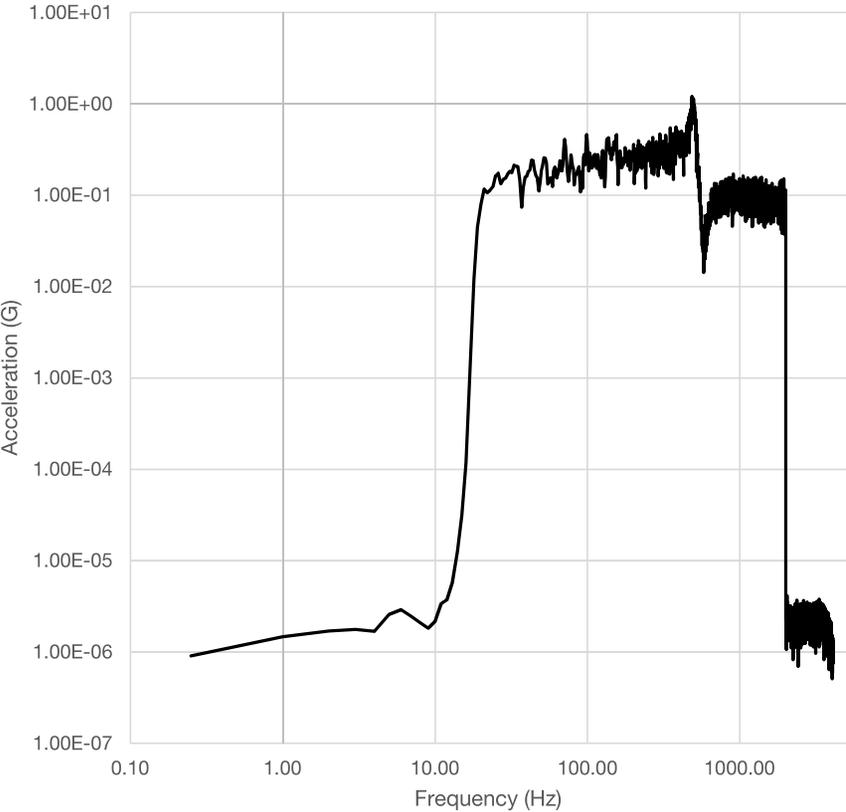


Average - FFT

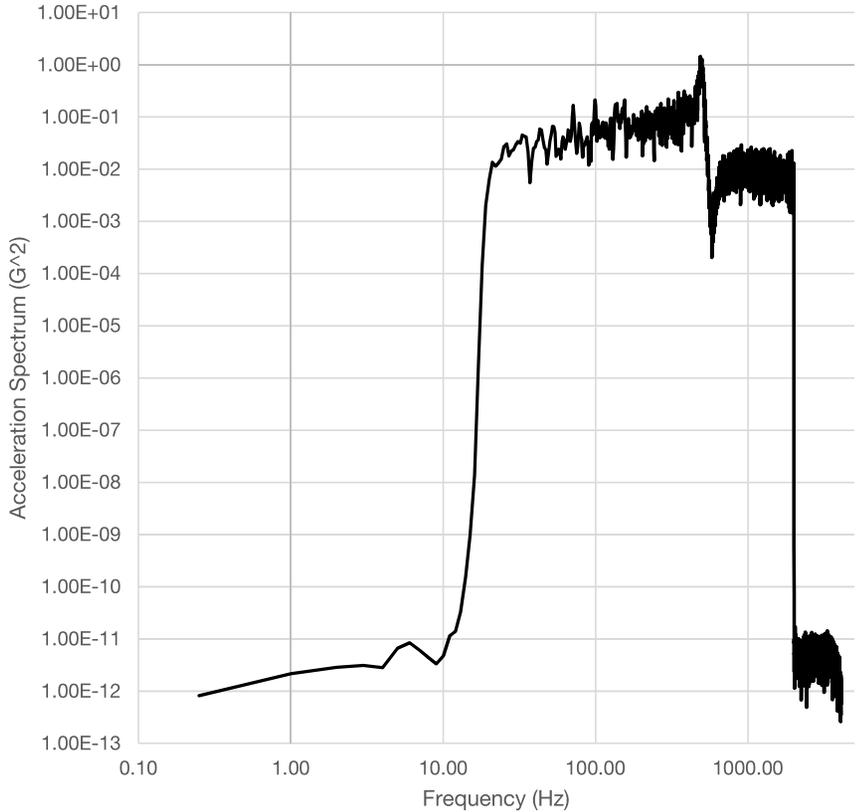


Convert FFT to Power

Average - FFT

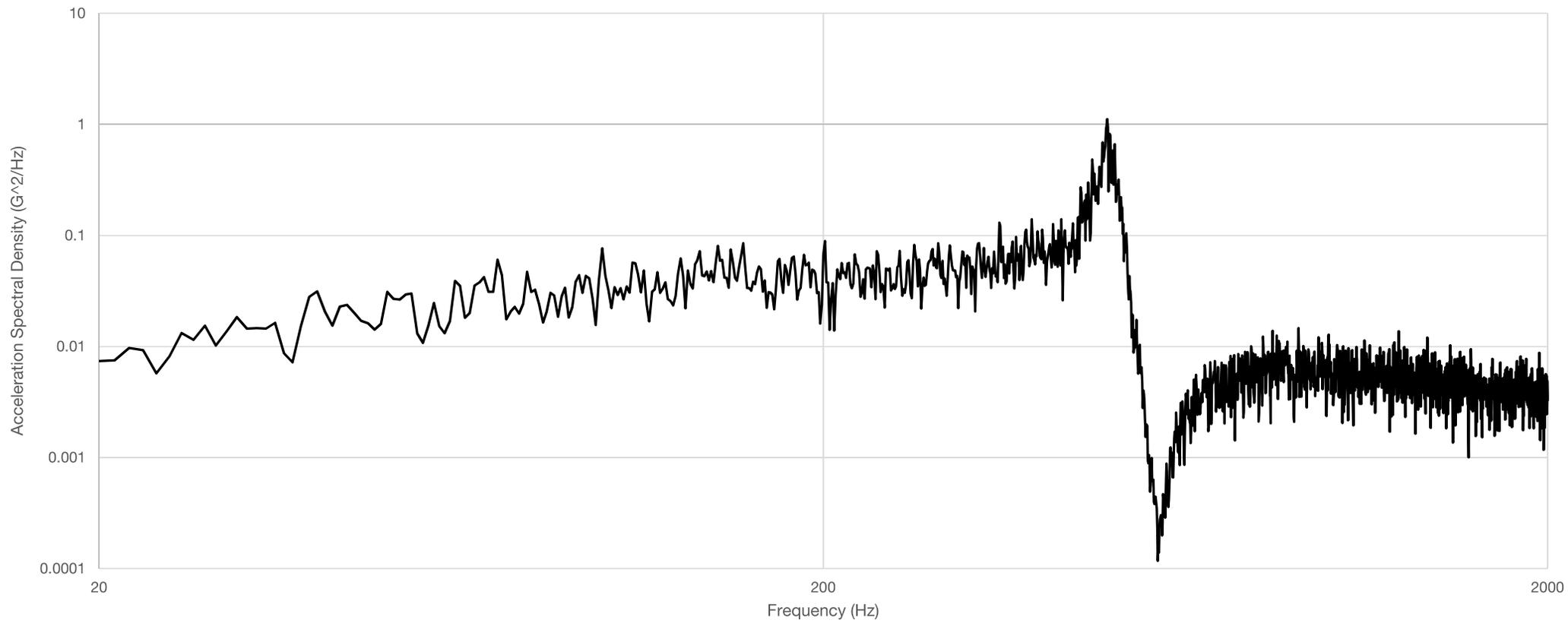


Power Spectrum

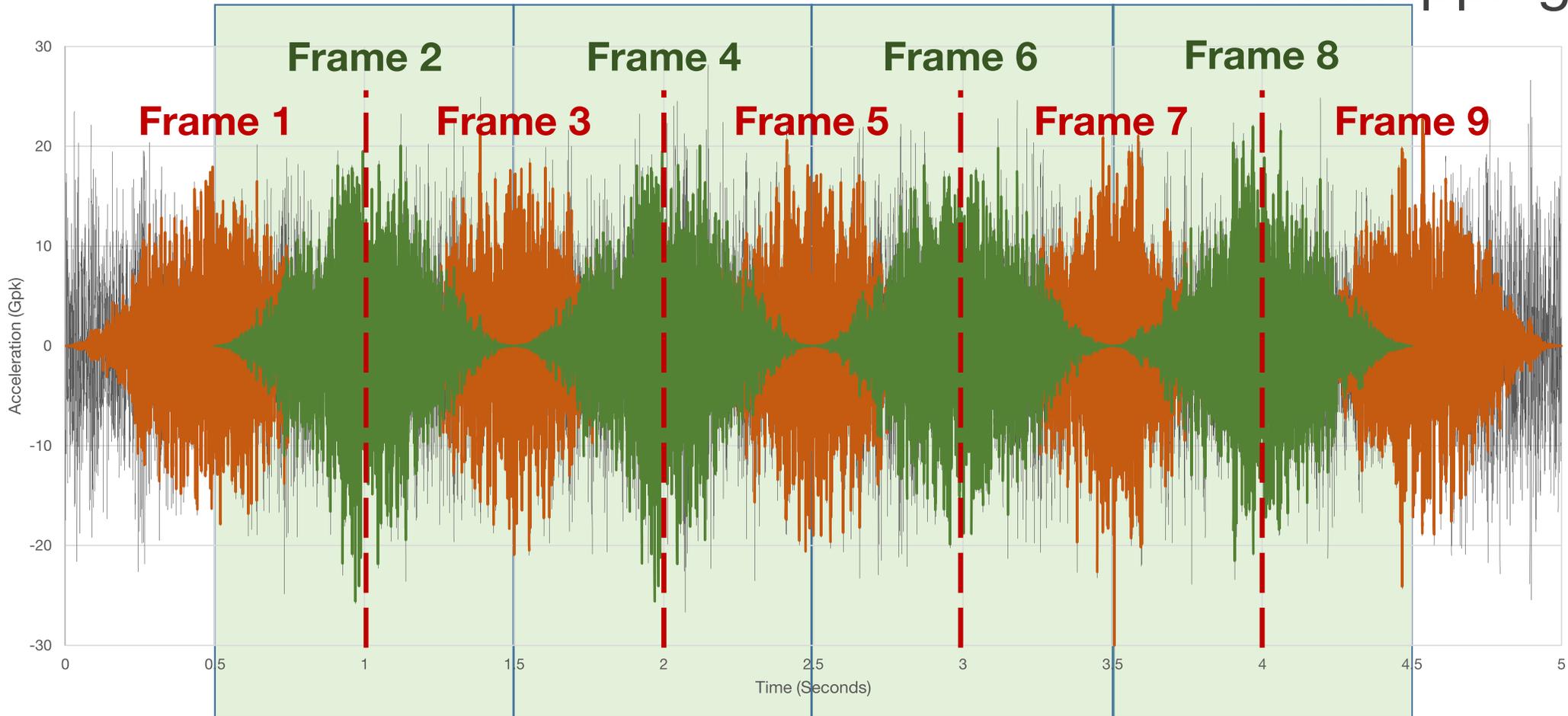


Create a PSD

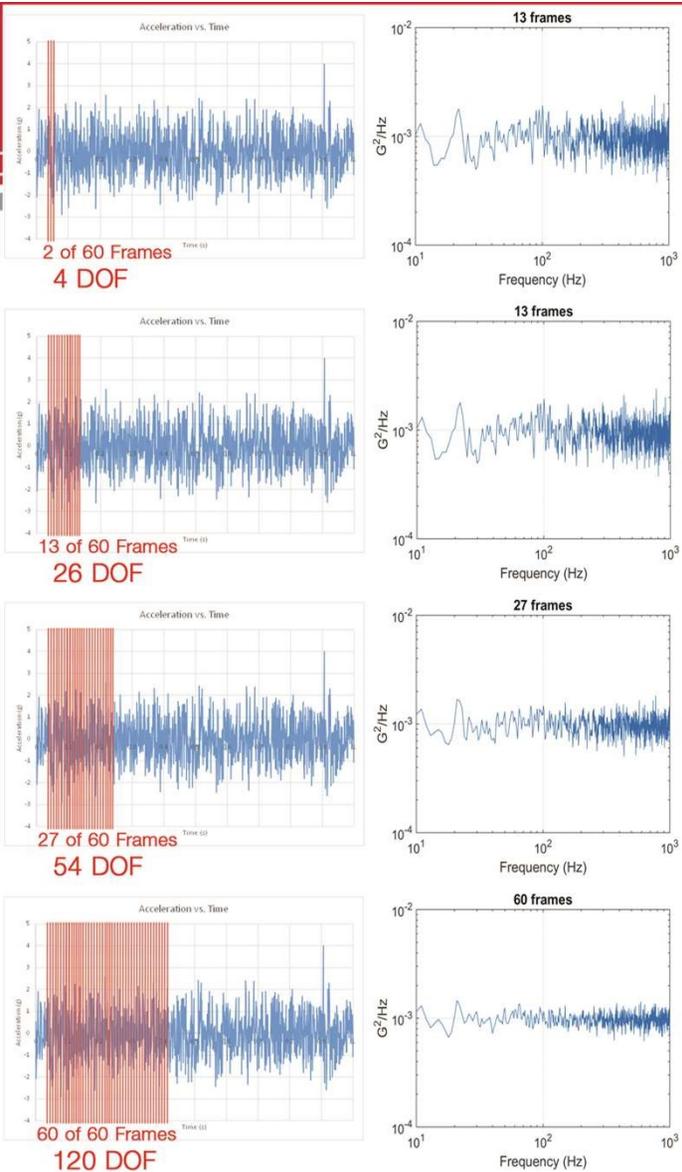
Power Spectral Density



Overlapping



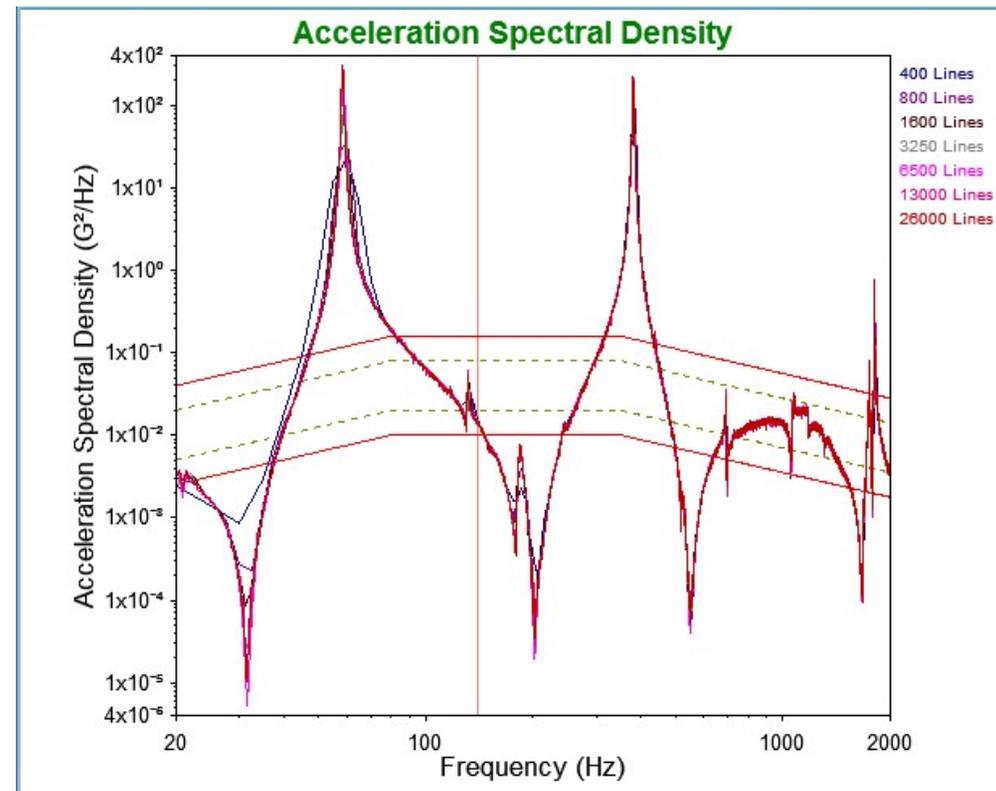
Degrees of Freedom



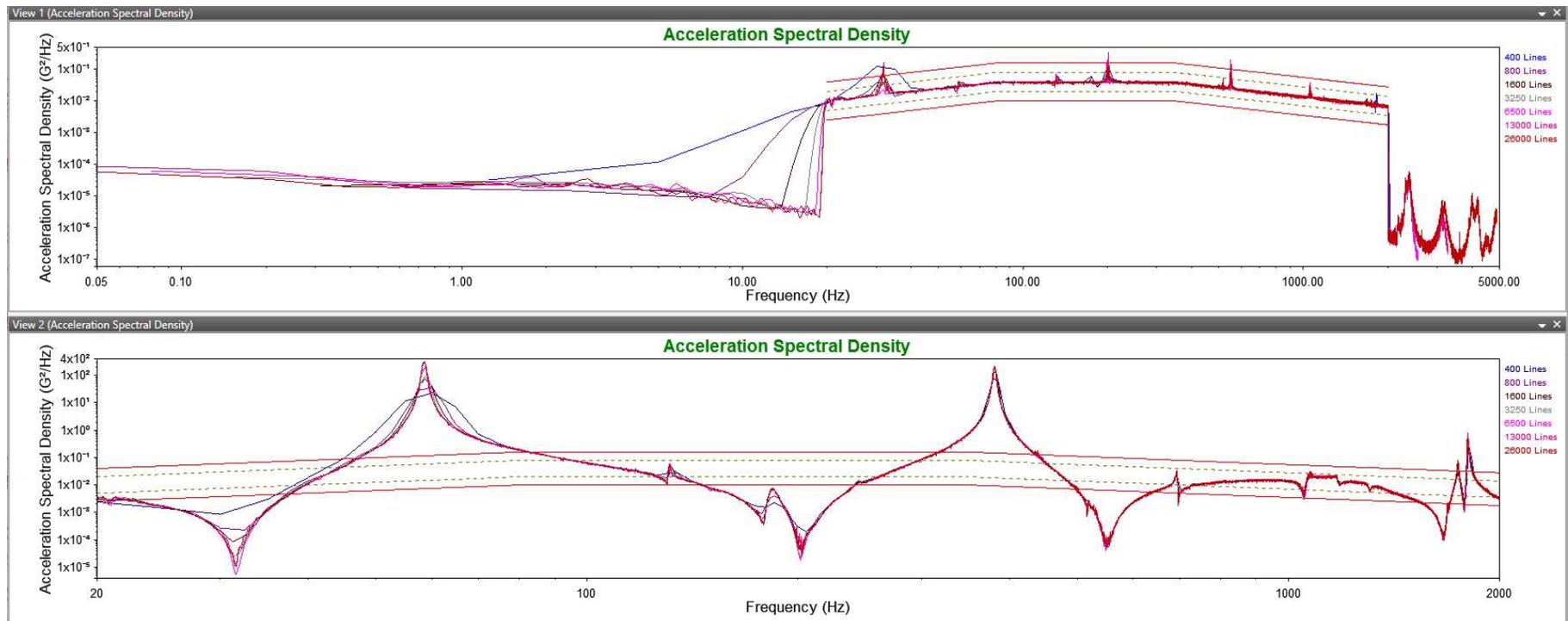
DOF=	120	200	300
± 3 dB	99.92%	100.00%	100.00%
± 2 dB	62.49%	99.10%	99.99%
± 1.5 dB	0.11%	56.01%	96.94%

Lines of Resolution

- Frequency Resolution
 - Determines Bin Width of the PSD
 - Single point amplitude/bin
 - High Lines = Small Bin Width
 - Higher resolution will create a single point amplitude that more closely represents the energy of that particular frequency range
 - 3+ lines of resolution in a resonance to properly resolve the peak



Lines of Resolution



Overview

- Random Vibration
- Terminology
- What is a FFT?
- What is a PSD?

Any
Questions

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