



# What is the PSD?

THE INNOVATOR IN  
**SOUND & VIBRATION  
TECHNOLOGY**





# CORE VALUES

**COLLABORATION**

**CAPABLE & COMPETENT**

**ACCOUNTABLE & RESPONSIBLE**

**STRONG & DRIVEN WORK ETHIC**

**DO THE RIGHT THING**

**INNOVATION**





# DOWNLOAD DEMO SOFTWARE



PRODUCTS

SUPPORT & SERVICE

RESOURCES



MENU

## FFT ANALYSIS

View frequency changes & highlight harmonics

## MOBILE APPLICATION

Smart setup & interaction with the ObserVR1000

## TEST ACCELERATION

Estimate product life expectancy & potential failures

## ENERGY-SAVING SOLUTIONS

Save energy & cost with an efficient setup

MORE

HOW CAN WE HELP?

SHIPMENT IN LESS THAN 2 WEEKS

## VIBRATION CONTROLLER & DYNAMIC SIGNAL ANALYSIS



VR PRODUCT OFFERINGS

Vibration Research designs and manufactures leading-edge vibration control systems for all brands of electrodynamic and servohydraulic shakers, as well as portable dynamic signal analyzers.

Since 1995, Vibration Research has become the leader and innovator in the field of vibration control. Its success is based on reliable, user friendly software packages for vibration control. Having built a reputation for quality and superior performance, it continues to focus on this objective as the foundation of everything it does.

EXPLORE PRODUCTS

OUR PRODUCTS

VIBRATION CONTROLLER

SHAKER SYSTEMS

PORTABLE DAQ & ANALYZER

DYNAMIC SIGNAL ANALYSIS

DOWNLOAD FREE SOFTWARE DEMO



CLOSE

### PRODUCTS

- Vibration Controllers
- Shaker Systems
- Portable DAQ & Analyzer
- Dynamic Signal Analysis
- Accelerometer Calibration

### SUPPORT & SERVICE

- Upgrades and Support
- Software Updates
- Calibration
- FAQs
- License Key Updates
- Hardware Registration
- Training Classes
- Monthly Webinars
- Test Profile Help

### INDUSTRIES & APPLICATIONS

- Aerospace
- Automotive
- Consumer Goods
- Electronics
- Medical
- Military & Defense
- Packaging & Transportation
- Seismic
- Test Labs
- University

### RESOURCES

- VR University
- Webinar Archives
- Resource Archives
- Experiments & Papers
- Calculator Tools
- Abstracts & Tech Notes
- Quick Tip Videos
- Testing Standards
- The VR Blog

### COMPANY

- About
- VR Innovations
- Careers at VR
- Labs Using VR
- Testimonials
- Mobile App
- Contact

HOW CAN WE HELP YOU?

CONTACT US

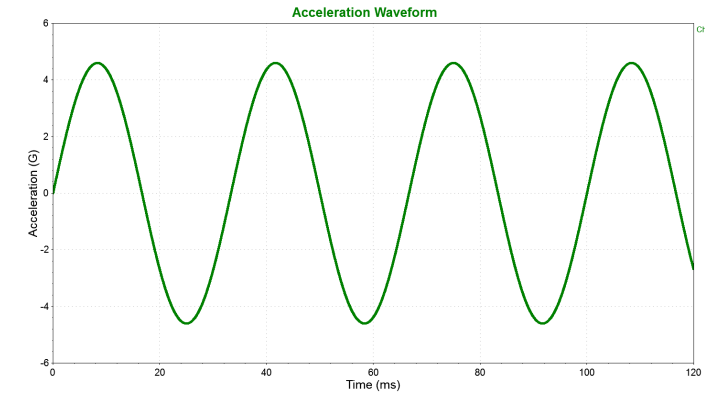
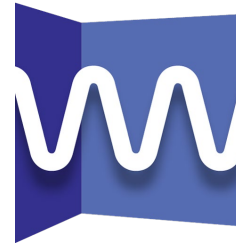
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# RANDOM VIBRATION

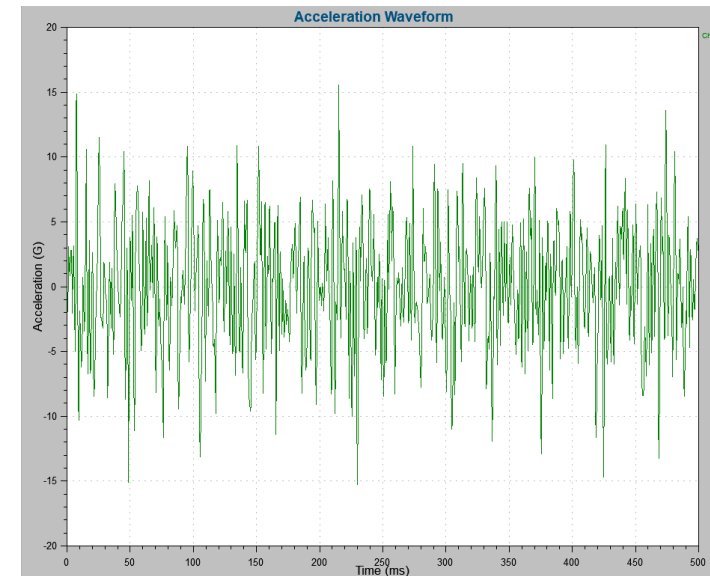
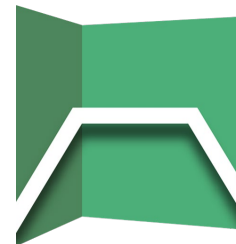
## DEFINITION

- Non-deterministic
  - Non-repetitive
- Stationary vs. Non-Stationary
- Linear vs. Non-Linear



## APPLICATIONS

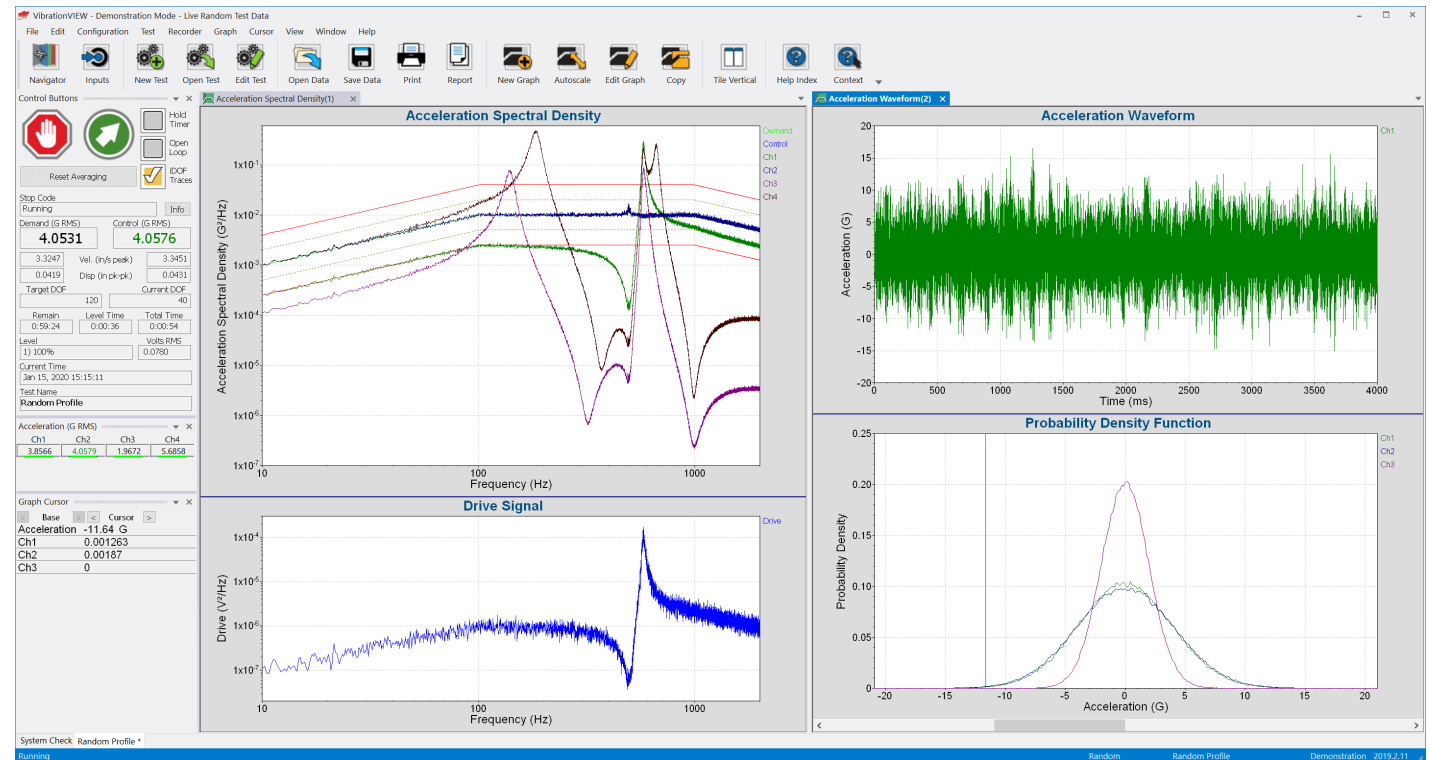
- Most widely used test type
  - “Real World” Vibration
  - Automotive (Road Vibration)
  - Airplane wing in flight
- Product Validation





# KEY TERMS OF THE PSD

- GRMS
- Fast Fourier Transform (FFT)
- Windowing
- Frequency Resolution
- Averaging
- $G^2/Hz$
- $(m/s^2)^2/Hz$





# POWER SPECTRAL DENSITY

## Power

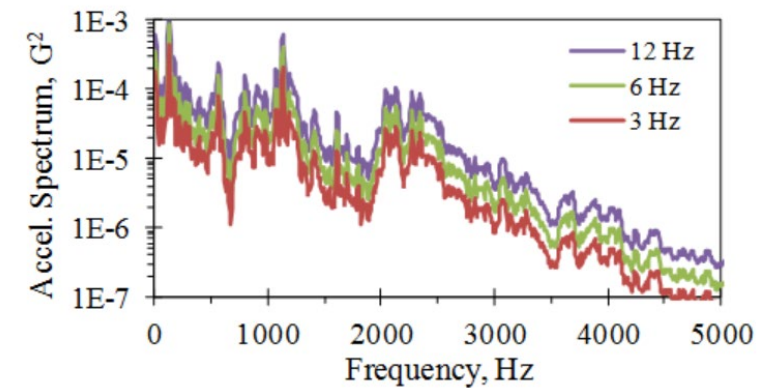
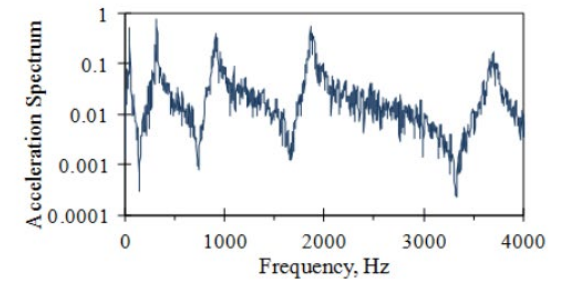
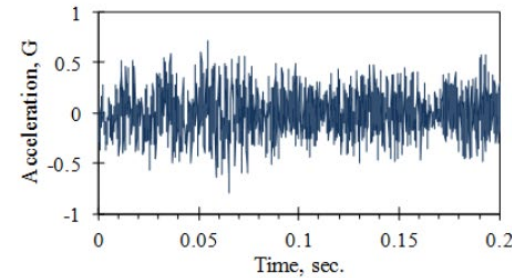
- Magnitude of the PSD
- Mean square value of the signal

## Spectral

- The PSD is a function of frequency
- Representative of signal distribution over a spectrum of frequencies

## Density

- Magnitude is normalized to a single hertz bandwidth



## VIBRATION TESTING THEORY

 INTRODUCTION TO VIBRATION SIGNALS Oct. 12, 2021	 TEST DEVELOPMENT WITH RECORDED DATA Feb. 23, 2021	 SHOCK TESTING Apr. 15, 2020	 SAMPLING & RECONSTRUCTION Jul. 3, 2019
 MATHEMATICS FOR UNDERSTANDING WAVEFORM RELATIONSHIPS Mar. 19, 2019	 SINE TESTING Mar. 5, 2018	 RANDOM TESTING Mar. 5, 2018	

## OBSERVIEW

 FUNDAMENTALS OF SIGNAL PROCESSING Jun. 2, 2021	 GETTING STARTED WITH OBSERVIEW Mar. 31, 2021
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## MY ENROLLED COURSES

**GETTING STARTED WITH VIBRATIONVIEW**  
STATUS: ENROLLED  
ENROLLED: JANUARY 28, 2022

**SAMPLING & RECONSTRUCTION**  
STATUS: ENROLLED  
ENROLLED: APRIL 3, 2020

**SINE TESTING**  
STATUS: ENROLLED  
ENROLLED: AUGUST 28, 2018

**SYSTEM NOISE AND GROUND LOOPS**  
STATUS: ENROLLED  
ENROLLED: APRIL 29, 2020

**VIBRATIONVIEW ANALYZER SOFTWARE PACKAGE**  
STATUS: ENROLLED  
ENROLLED: OCTOBER 26, 2020

## VIBRATIONVIEW

 VIBRATIONVIEW ANALYZER SOFTWARE PACKAGE Jan. 2, 2019	 WINDOW FUNCTIONS FOR SIGNAL PROCESSING Nov. 8, 2018	 SYSTEM CHECK Mar. 29, 2018	 GETTING STARTED WITH VIBRATIONVIEW Mar. 29, 2018
 VIBRATIONVIEW SYLLABUS Mar. 29, 2018			

## TESTING SYSTEM HARDWARE

 SYSTEM NOISE AND GROUND LOOPS Feb. 12, 2020	 PRESERVING VR HARDWARE ACCURACY Jun. 20, 2019	 CALIBRATING A PIEZOELECTRIC ACCELEROMETER IN VIBRATIONVIEW Dec. 28, 2018	 MULTI-SHAKER CONTROL Mar. 29, 2018
 PREVENTATIVE MAINTENANCE Mar. 29, 2018			

## MY CERTIFICATES

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DOWNLOAD CERTIFICATE - ALL



# GENERATING THE PSD

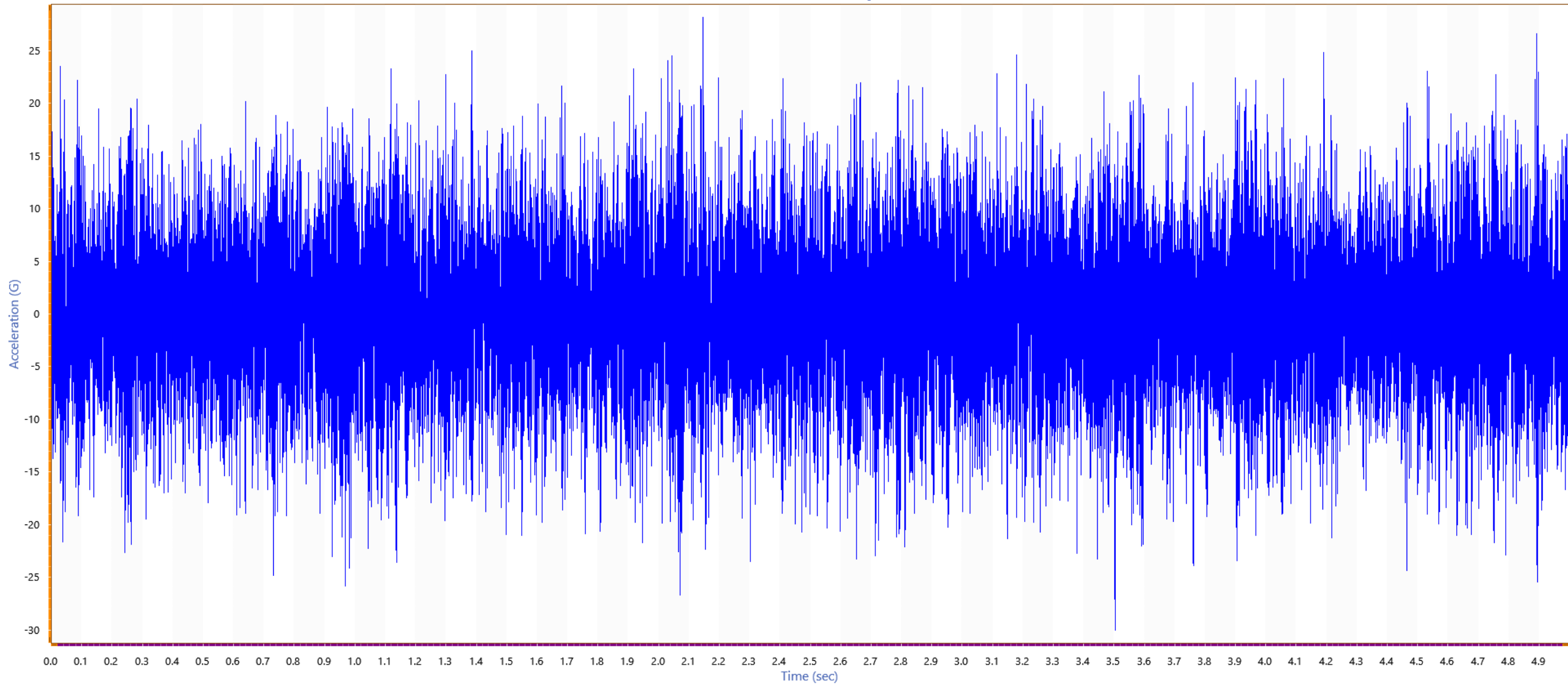
- Gaussian Time-Domain Input Data
- Time-Domain data is partitioned into frames
- Each frame of time domain data is transformed into the frequency domain using the Fast Fourier Transform (FFT)
- Complex Frequency-domain data is converted to power by taking the squared-magnitude of each frequency point
- Squared-magnitudes (power values) of each frame are averaged together
  - Overlapping, windowing, normalizing





# INPUT TIME DATA

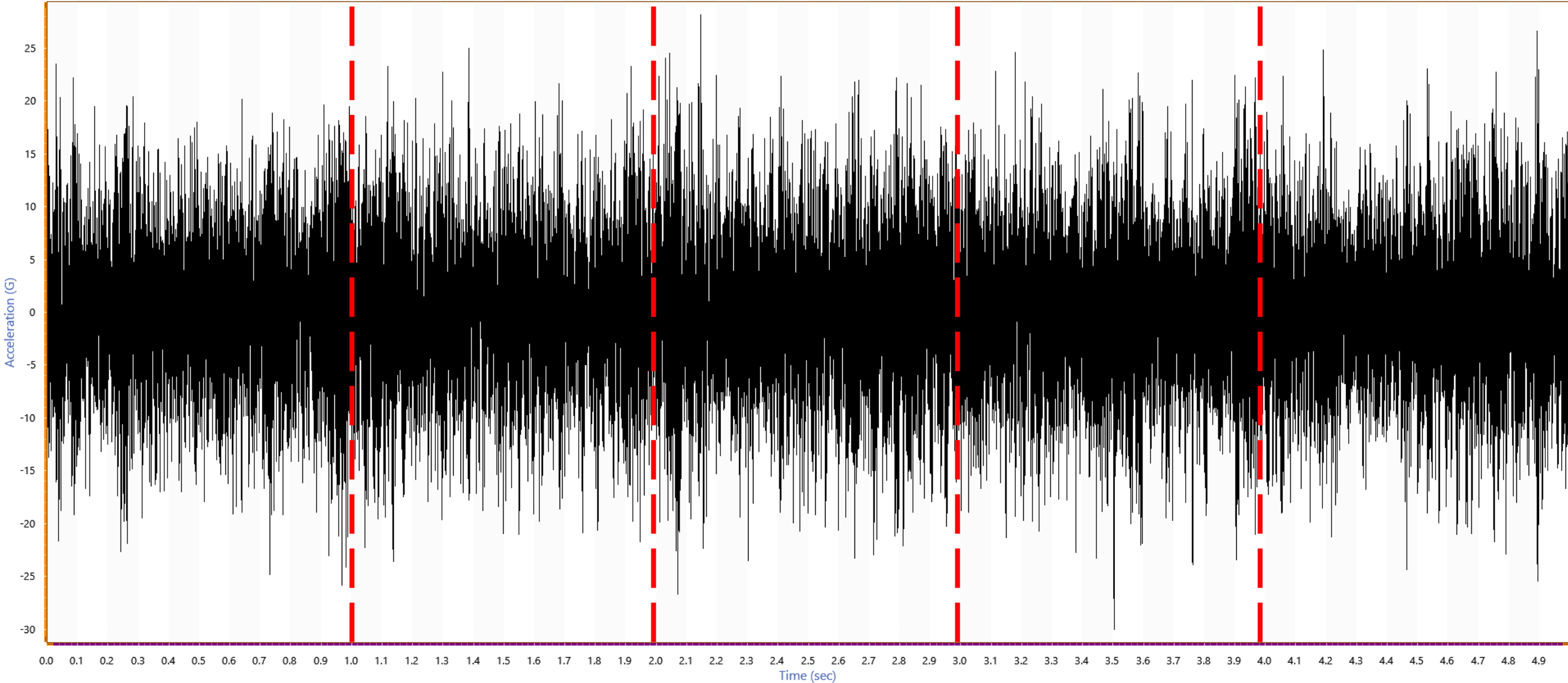
Acceleration Time History





# DIVIDE INTO FRAMES

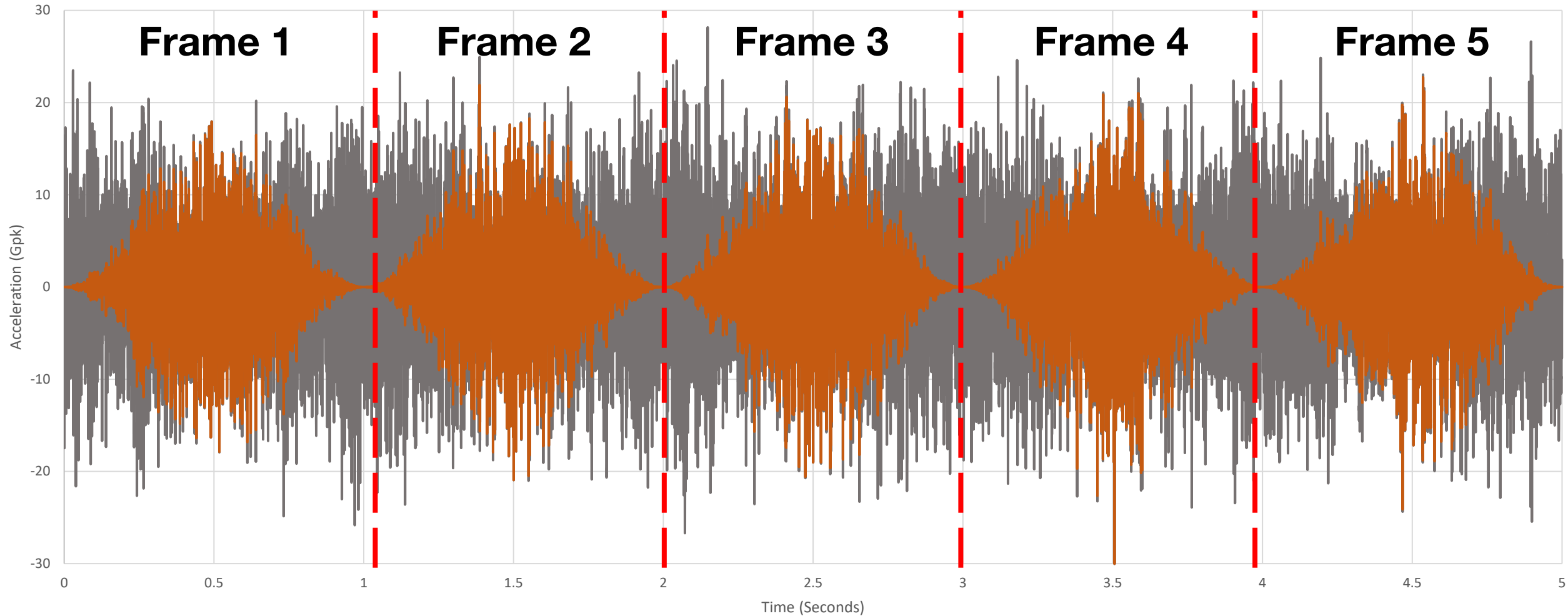
Acceleration Time History





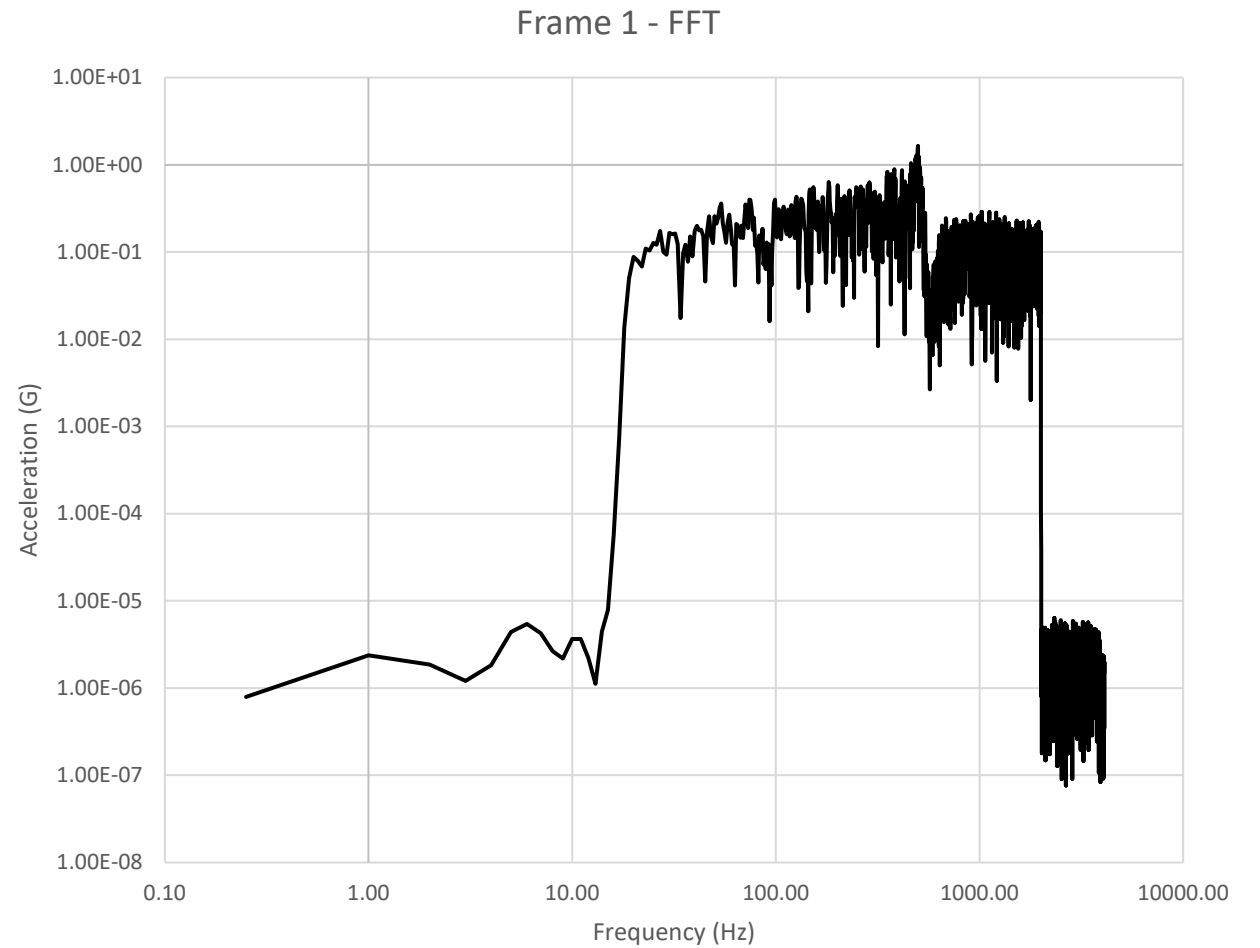
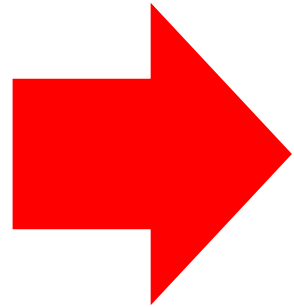
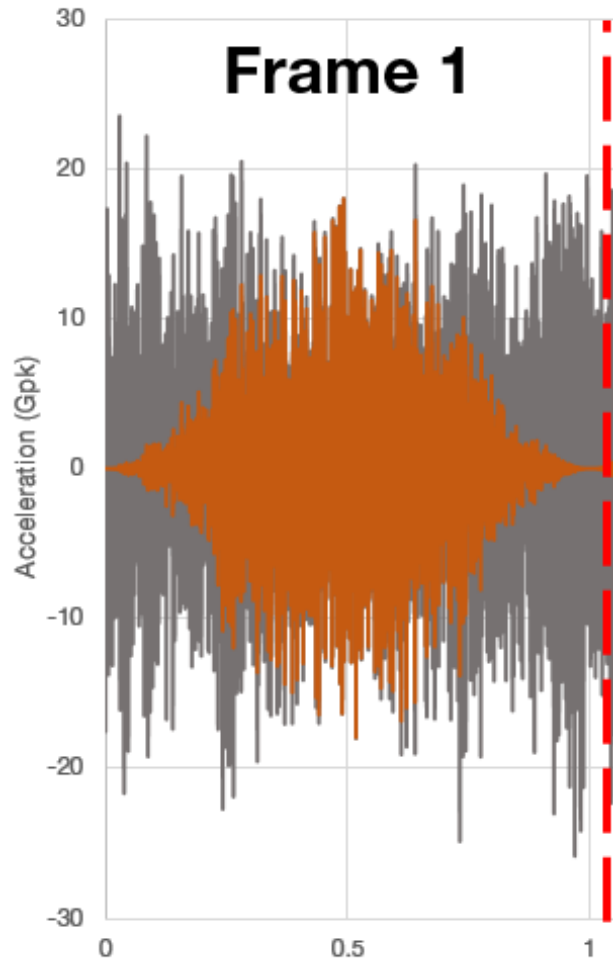
# APPLY WINDOW FUNCTION TO EACH FRAME

Acceleration vs. Time





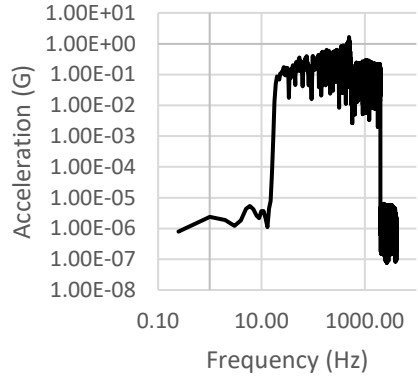
# CALCULATE FFT FOR EACH FRAME



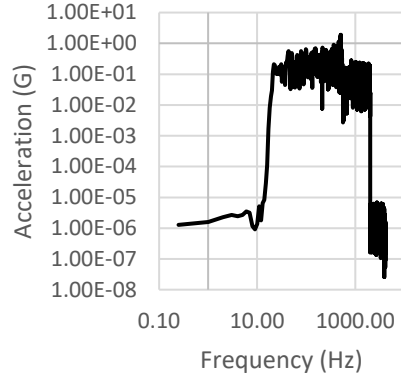


# AVERAGE THE FFT

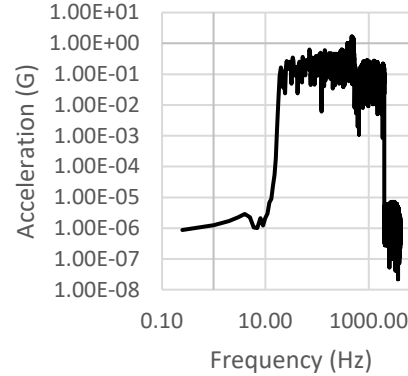
Frame 1 - FFT



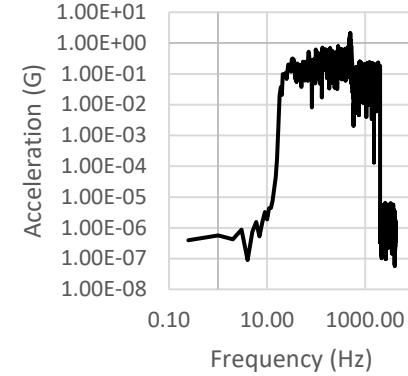
Frame 2 - FFT



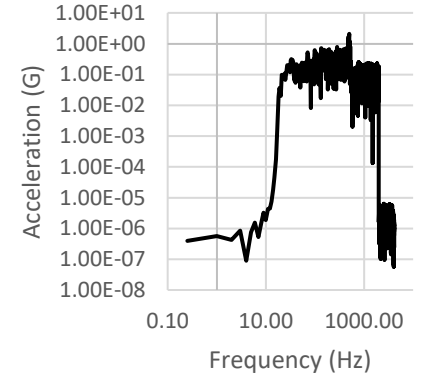
Frame 3 - FFT



Frame 4 - FFT



Frame 5 - FFT



FFT<sup>1/2</sup>

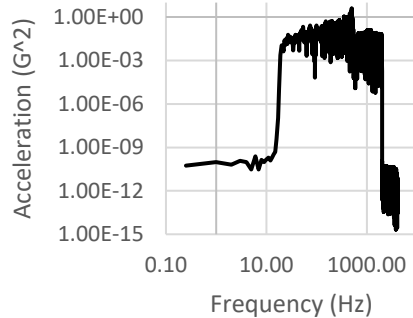
FFT<sup>1/2</sup>

FFT<sup>1/2</sup>

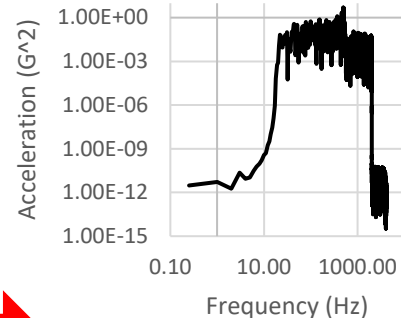
FFT<sup>1/2</sup>

FFT<sup>1/2</sup>

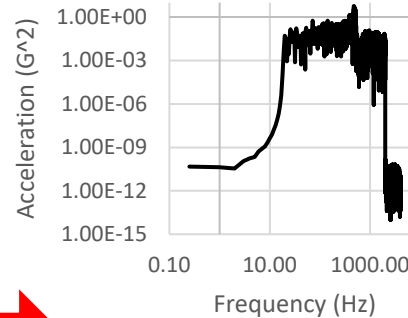
Frame 1 - Power Spectrum



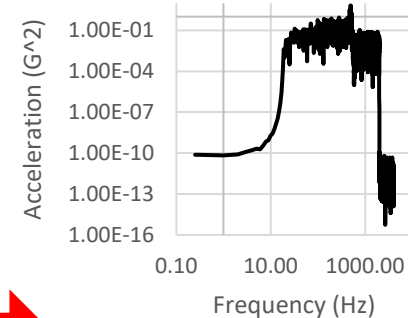
Frame 2 - Power Spectrum



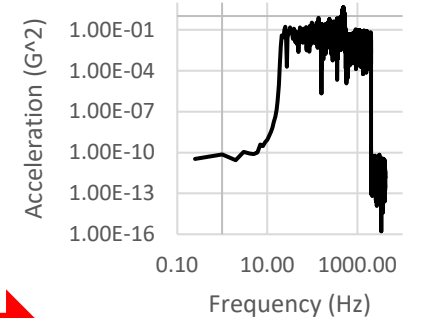
Frame 3 - Power Spectrum



Frame 4 - Power Spectrum



Frame 5 - Power Spectrum



AVG

AVG

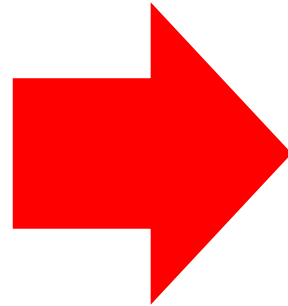
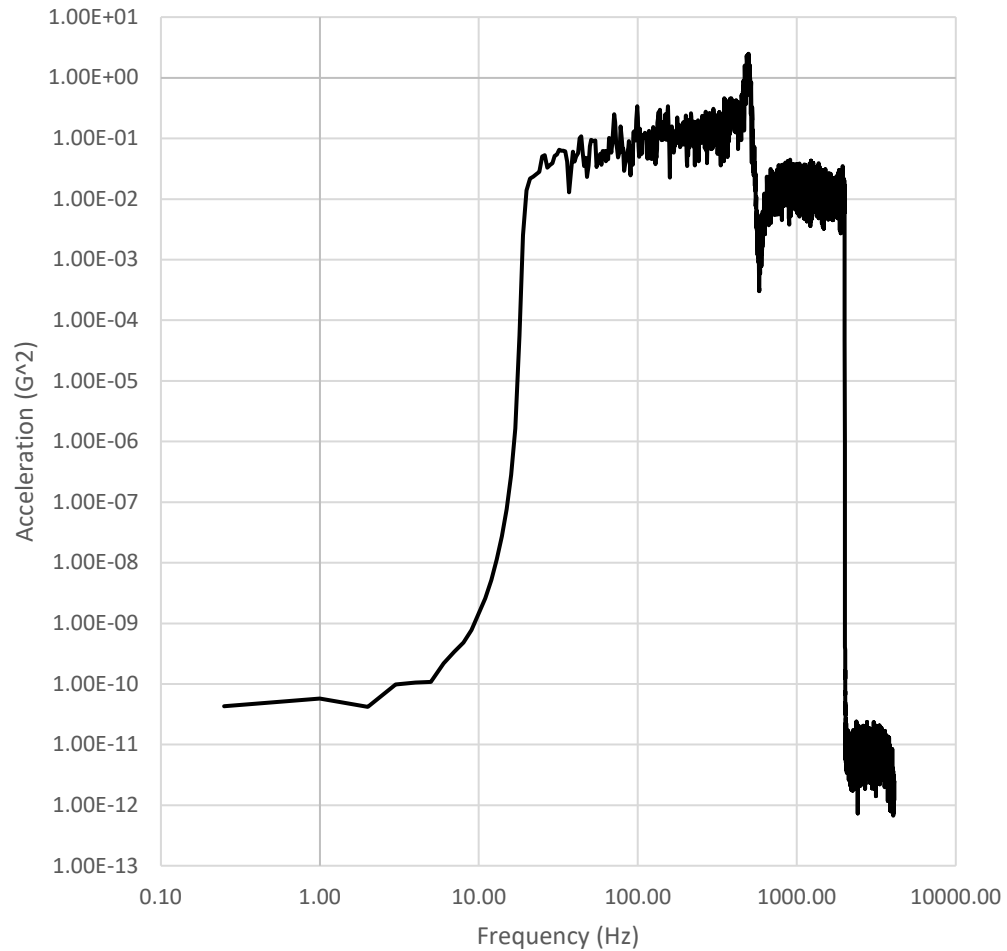
AVG

AVG

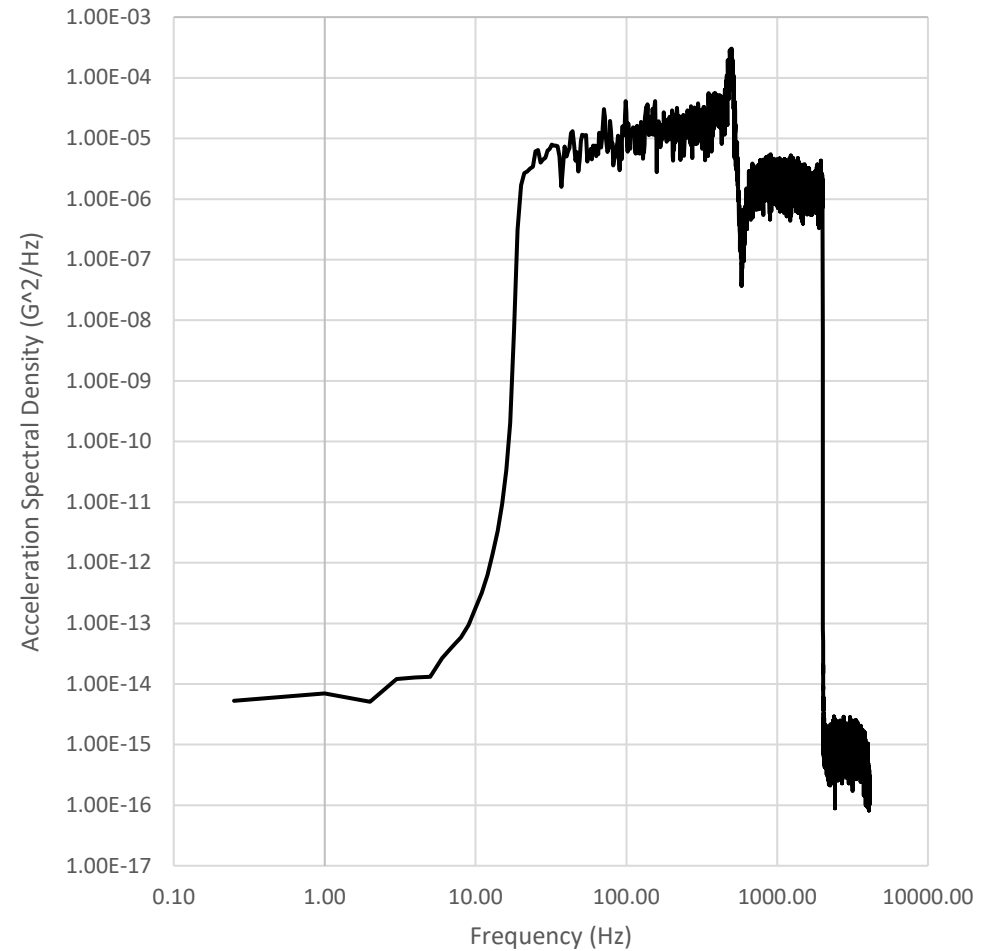


# CONVERT FFT TO POWER

Average - Power Spectrum



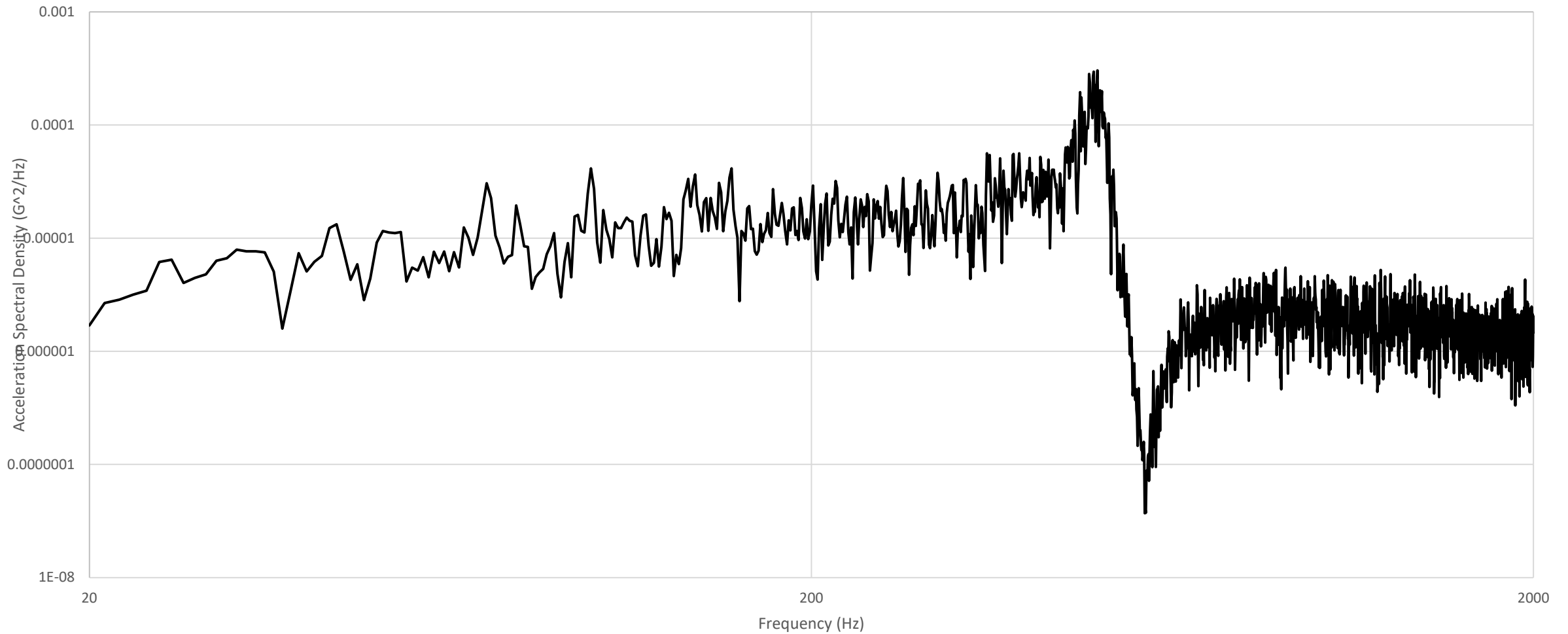
Power Spectral Density





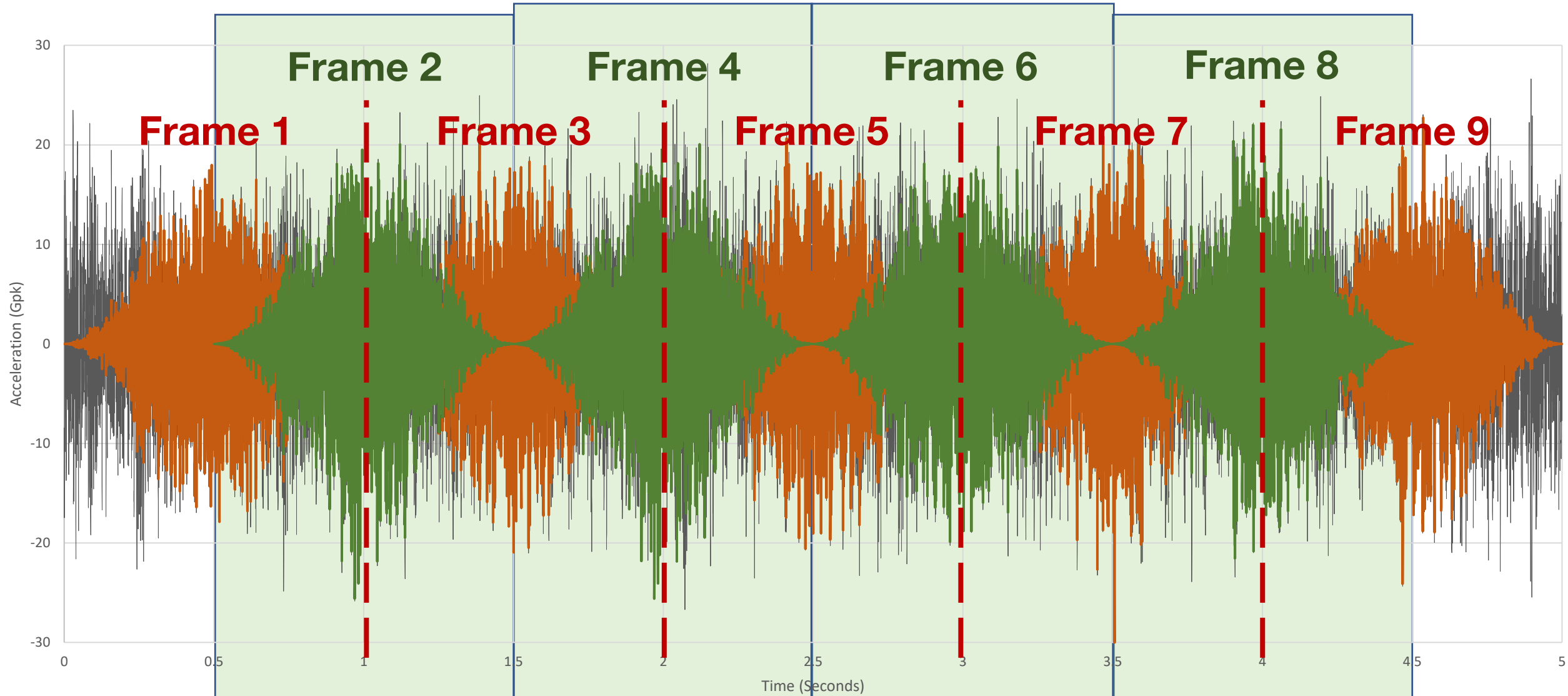
# CREATE A PSD

Power Spectral Density





# OVERLAPPING



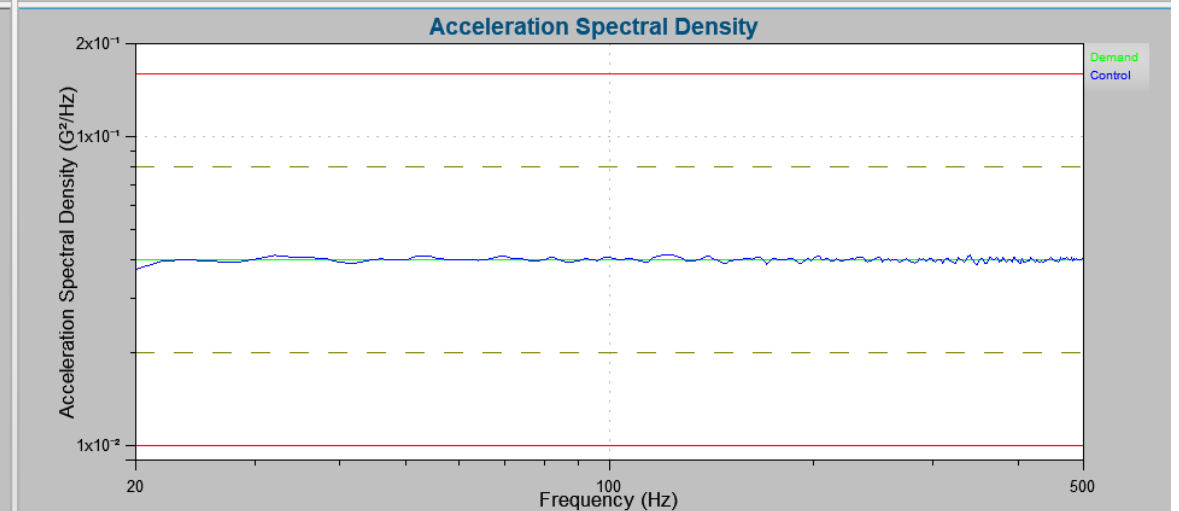
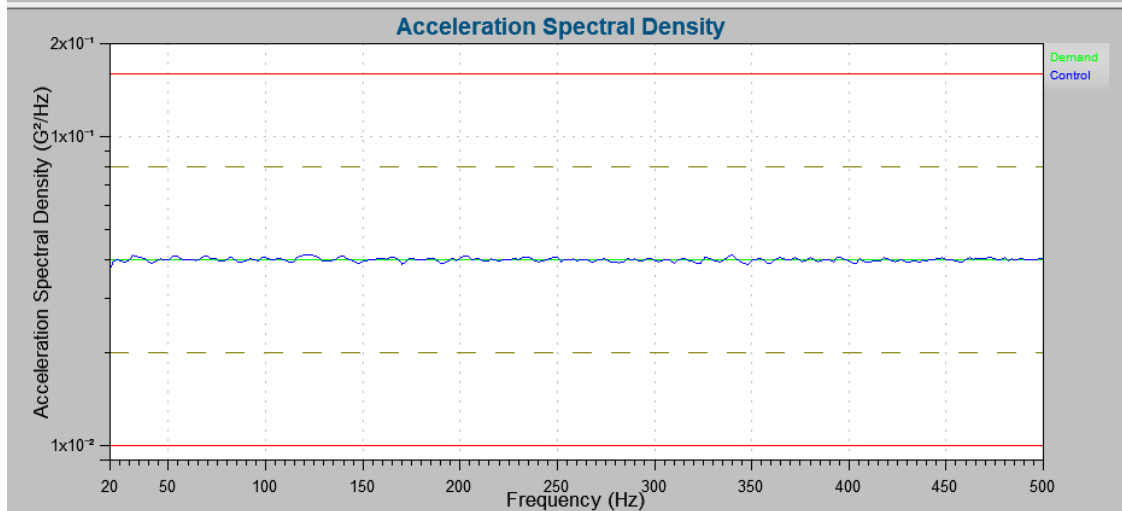
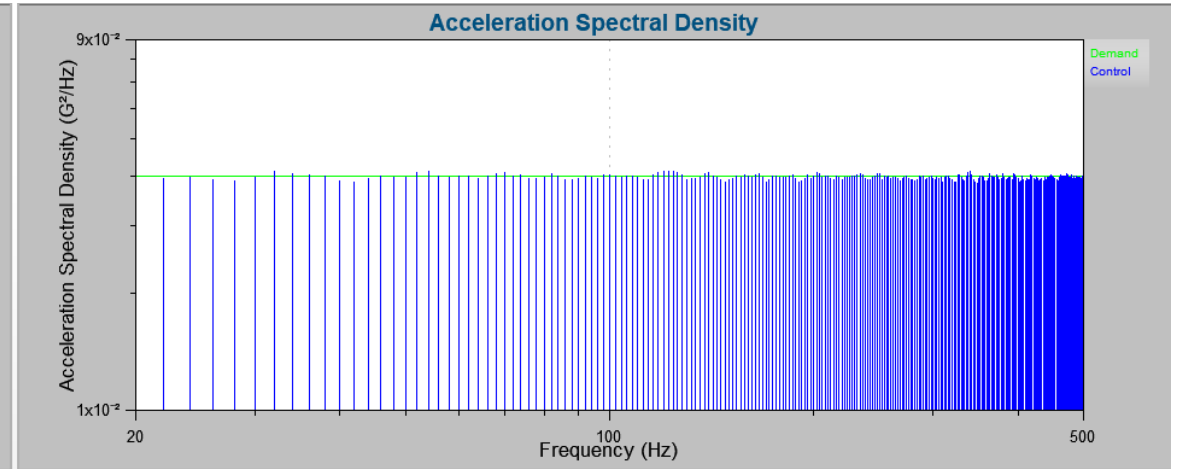
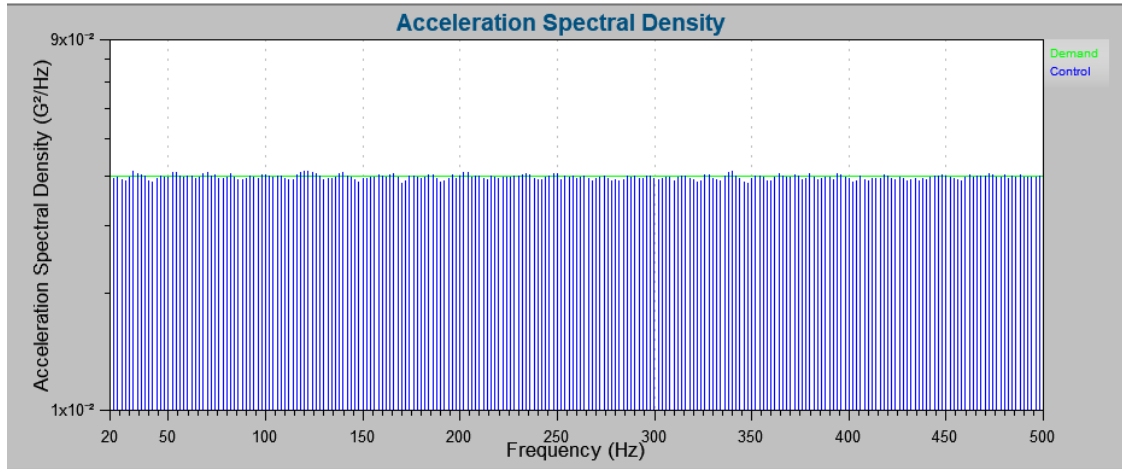




# THE PSD

## Linearly Spaced Lines of Resolution

## Linearly Spaced Lines of Resolution (Log Graph)

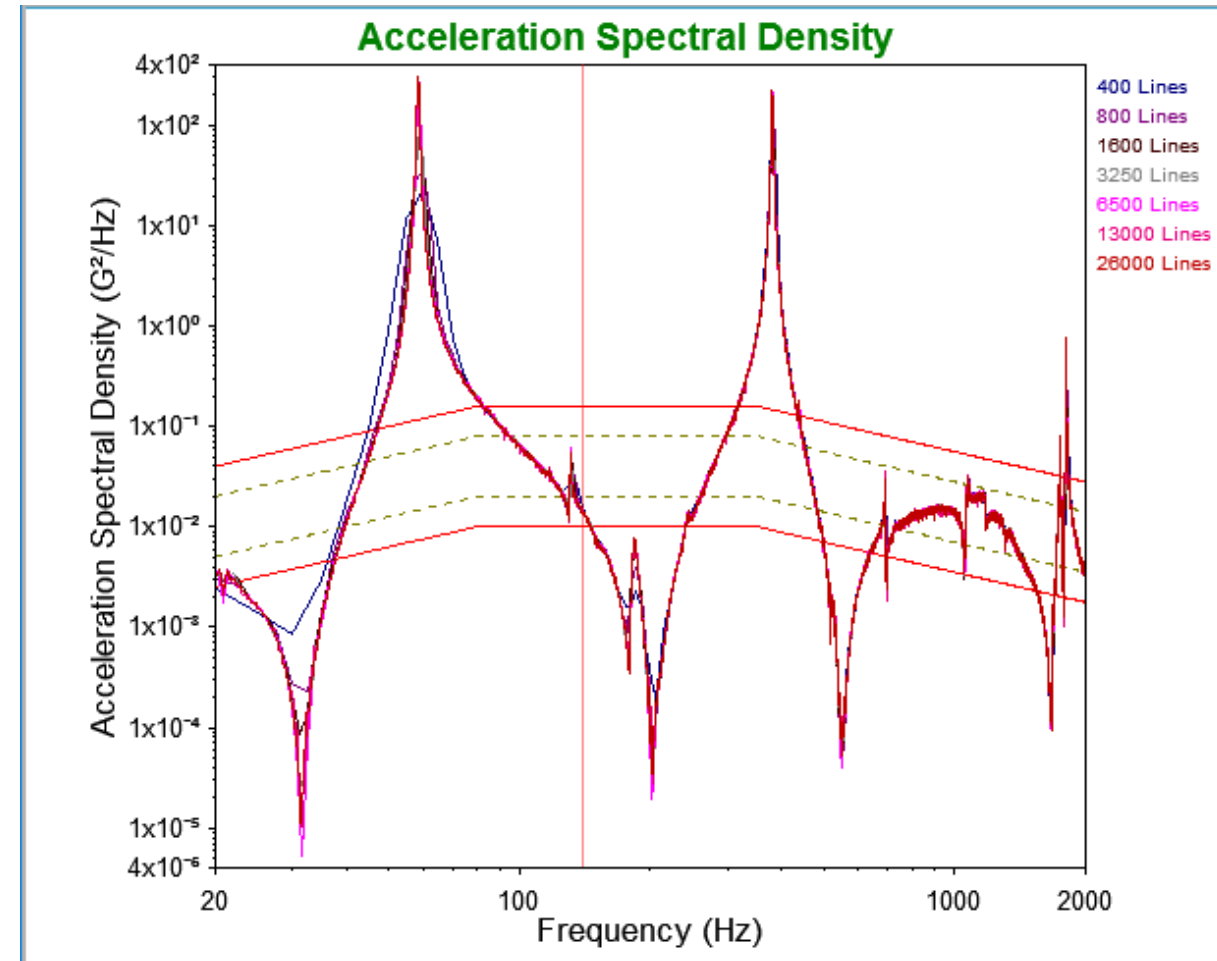




# PSD COMPUTATION

## 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





# STATISTICS AND PROBABILITY

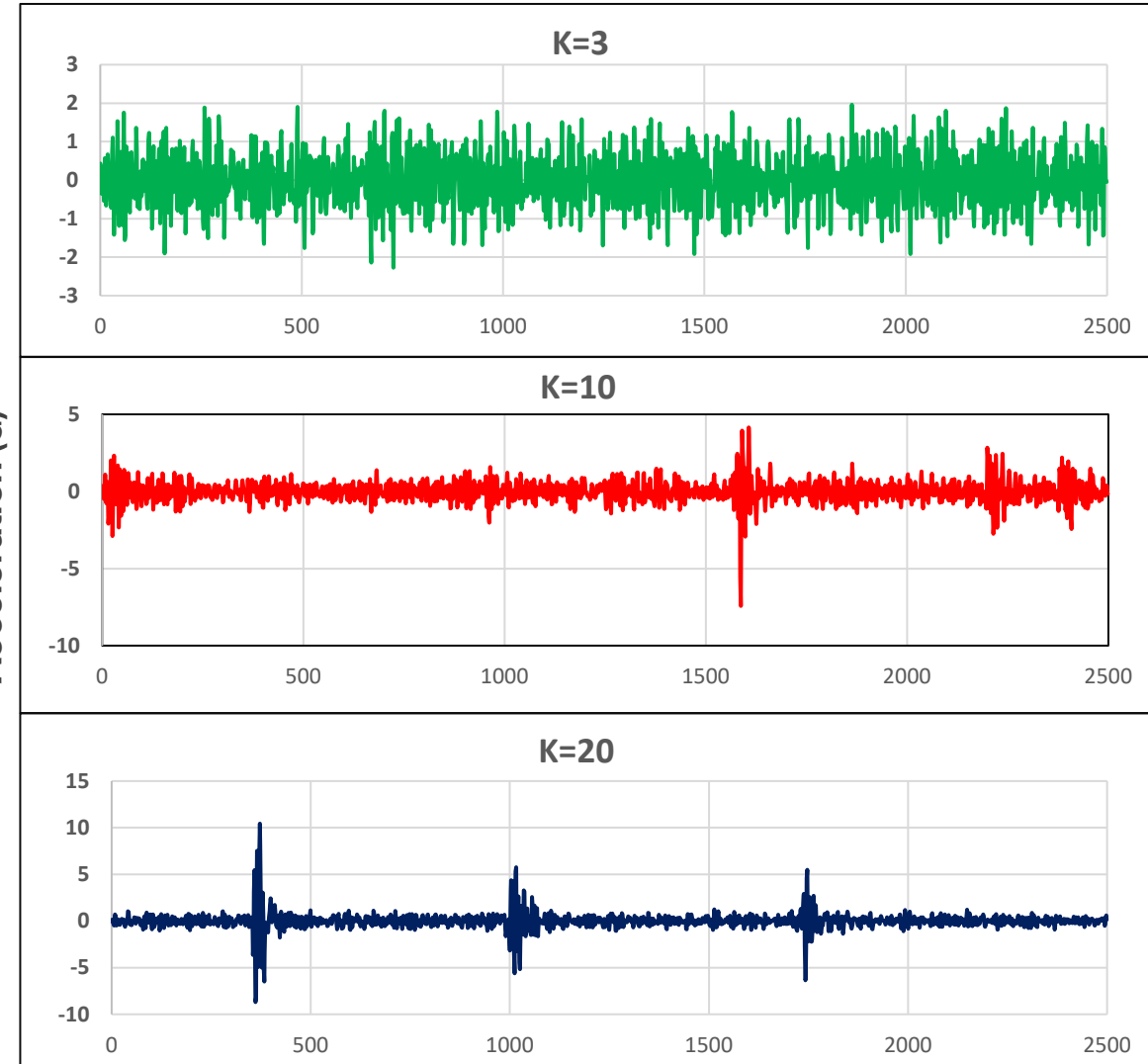
- Mean – 1st Statistical Moment, Arithmetic Average
  - For random vibration, the mean is often at or near 0
  - Mean Square
    - Measures the average strength or power of a signal
- Variance – 2nd Statistical Moment, “Hashiness of Signal”
  - As Degrees of Freedom (DOF) increases, variance decreases
  - Standard Deviation
    - Variability of a signal about its mean value
    - For random vibration, Root Mean Square (RMS) = Standard Deviation
- Skewness - 3rd Statistical Moment, More positive or negative
  - Measure of the asymmetrical spread of a signal about its mean value



# STATISTICS AND PROBABILITY

## KURTOSIS

- Normalized 4th central moment
- Characteristic of the waveform that describes the “peakiness”
- Probabilistic Distribution of peaks in random vibration
- Gaussian Distribution  $K=3$
- For traditional vibration testing the kurtosis will equal 3
- FIELD DATA is often Non-Gaussian





ANY QUESTIONS?

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