Random Averaging

An Exploration of Power Spectral Density Estimation

VIBRATION RESEARCH

Questions

- How should we deal with a change in level?
- How can we meet tolerance at a change in level?

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iDOF Truisms:

1. *"You don't know what you don't know"*
2. *"The smoothest control lines display in the industry"*
3. *"The world is not linear"*

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Experience:

- *How to run the test*
- *AND get the report you need*

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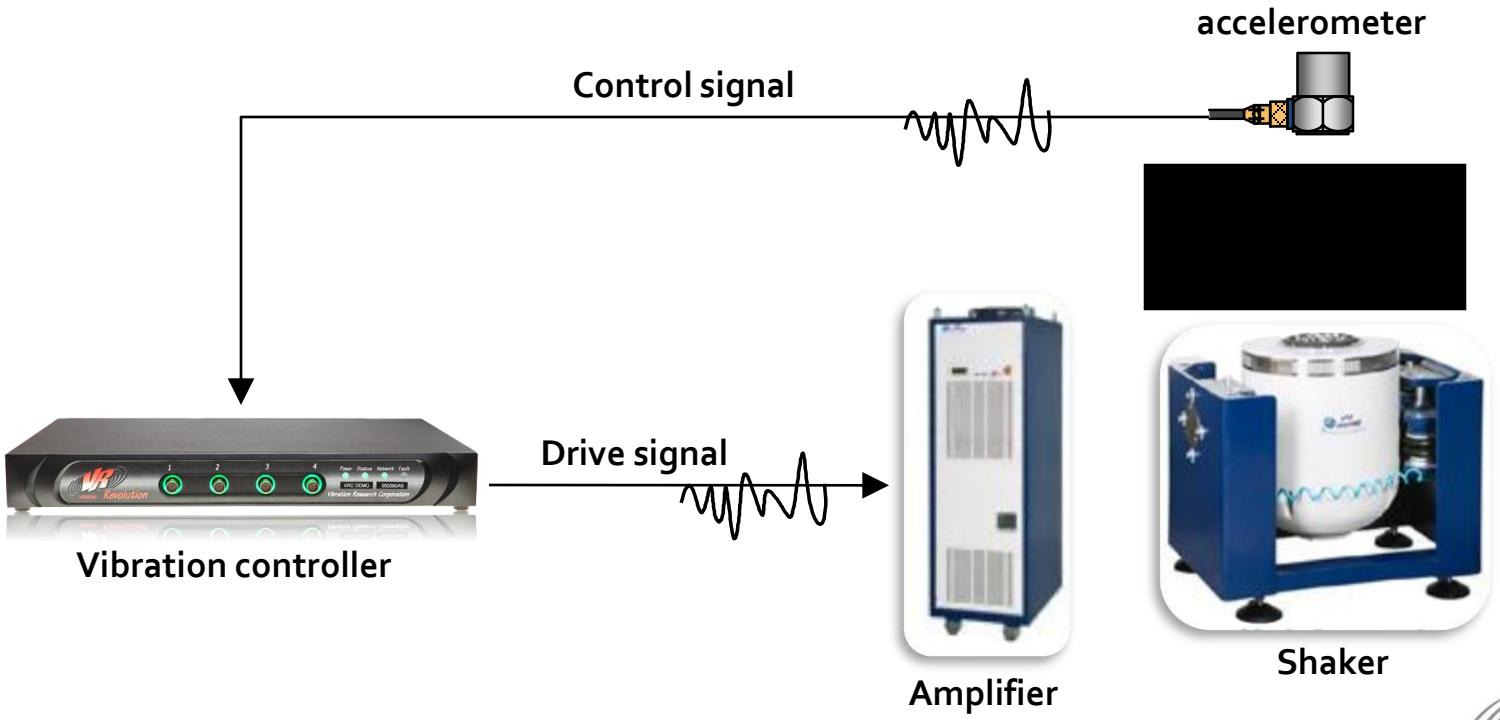
- The purpose of the controller is to ensure the actual vibration measured meets the programmed vibration of the test profile.

- The controller does this by monitoring the input response from the accelerometer and making adjustments to the drive voltage.



VIBRATION RESEARCH

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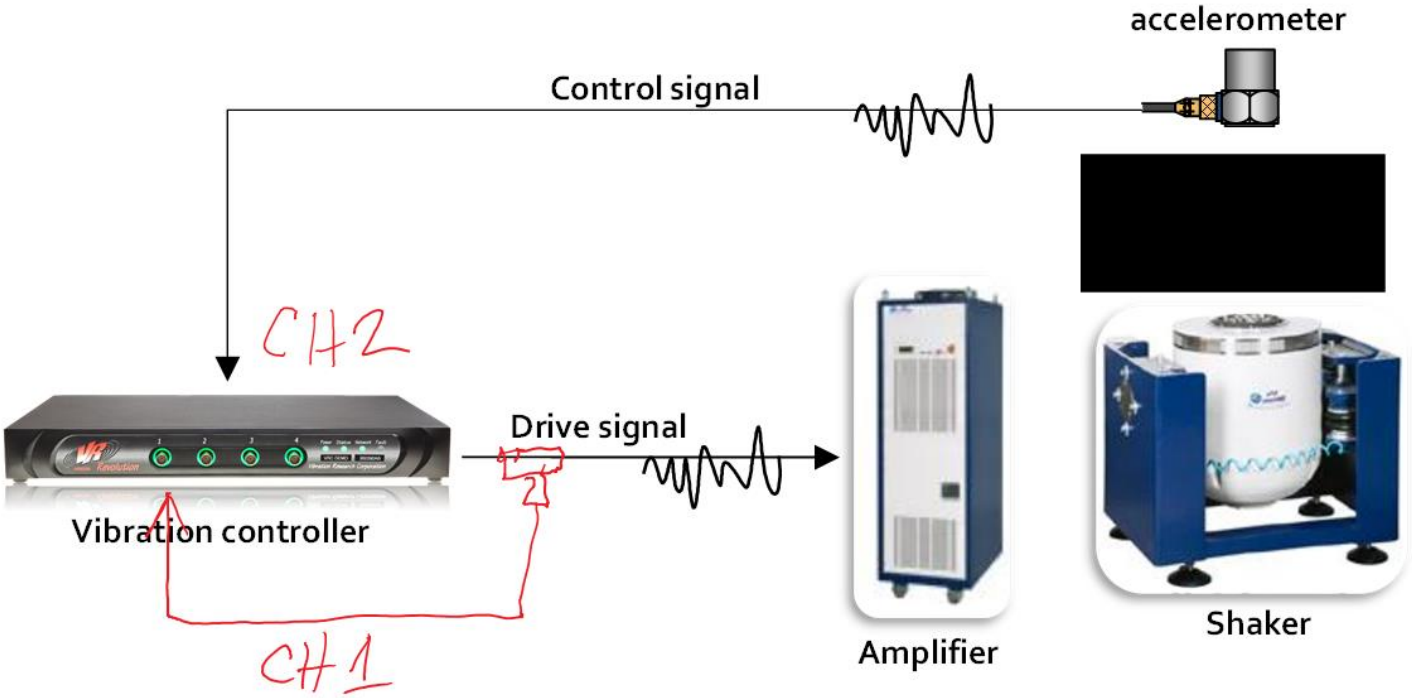

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Multiplication of Low-Level Data

- Most common method
- What it does
  - Averages PSD at low level
  - ***Scales*** the average to match level changes

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Multiplication of Low-Level Data

- Pros
  - Quickly displays a PSD within tolerance
- Cons
  - ***Can hide*** actual out-of-tolerance conditions

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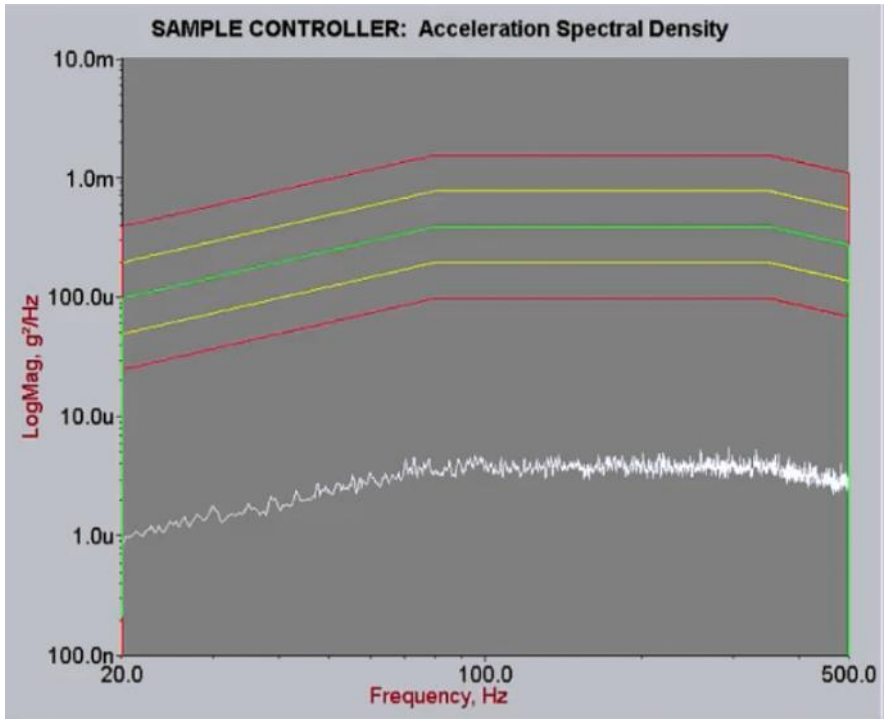
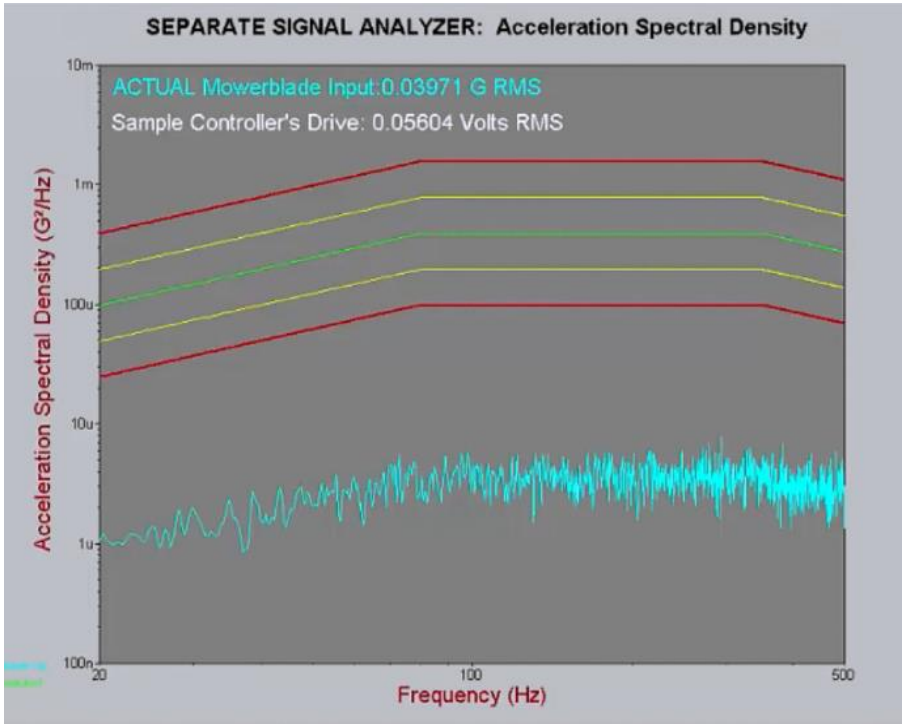
Level: -20 dB





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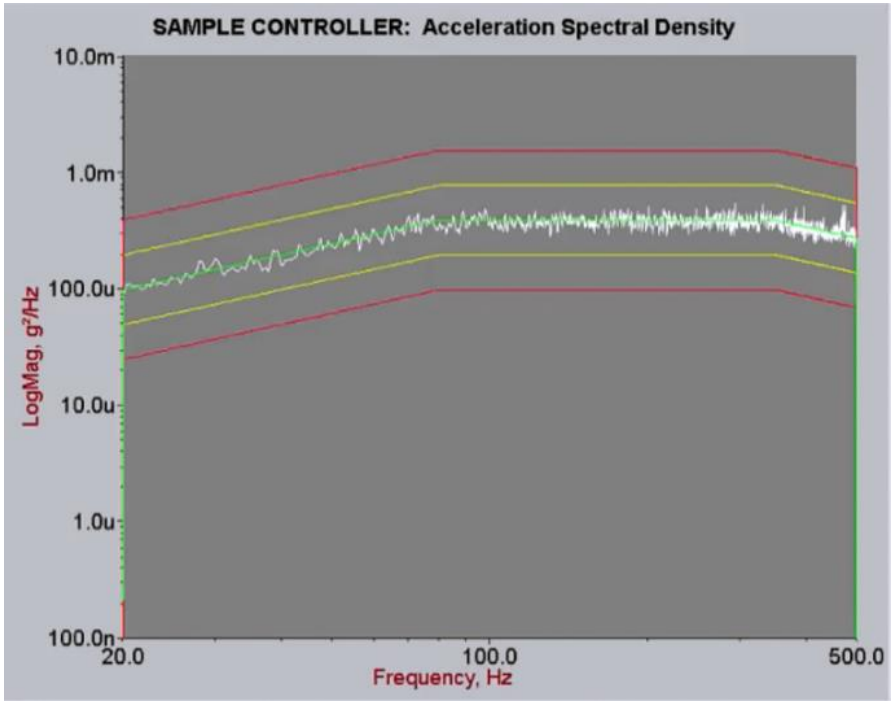
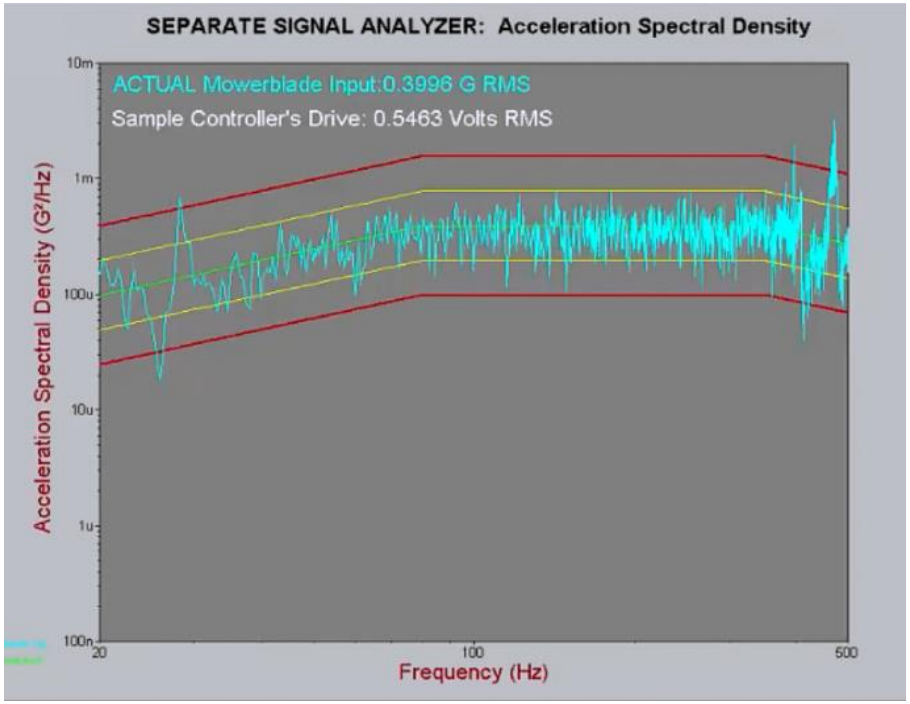
Level: Full Level





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Non-updating of the PSD

- What it does
  - ***Suppresses*** display until traces are sufficiently averaged

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Non-updating of the PSD

- Cons
  - ***Can't see*** what is happening on the shaker
  - ***Can hide*** actual out-of-tolerance conditions

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Reset Averaging

- What it does
  - ***Restarts*** averaging with every change in level

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Reset Averaging

- Pros
  - Quickly displays ***exactly*** what is occurring on the shaker
- Cons
  - ***Takes some time*** for the averaging to bring traces within tolerance lines

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With a resetting of averaging comes an increasing of variance.

Why?

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The Generation of the PSD Plot

Welch's Method

Gaussian data

partitioned into frames

transformed into the frequency domain

squared-magnitude taken

averaged

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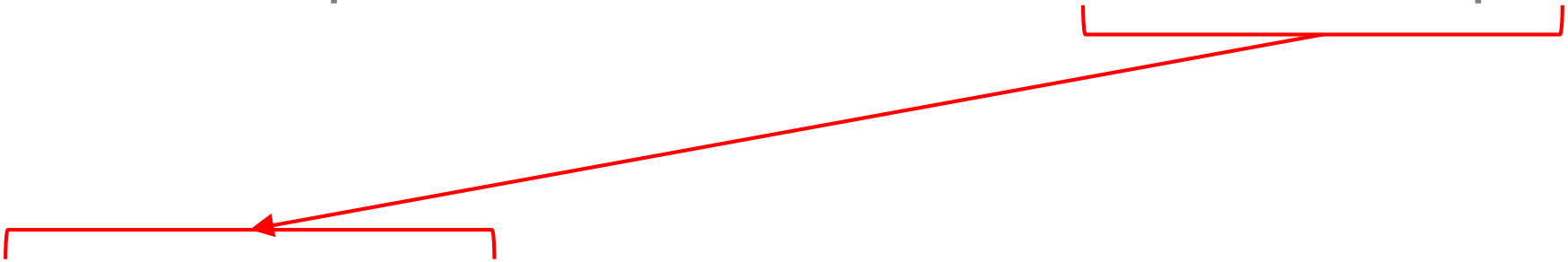
Chi, Chi, Chi

Welch's Method

Gaussian input + linear transform → Gaussian output



Gaussian output + squared-magnitude → Chi-square distribution

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Inherent Properties of PSD Estimation

Variance (Raggedness)

Inversely proportional to number of frames averaged

→High variance in the early test stage

→High variance when averaging is reset

Cause: ***Randomness***. Therefore, ***expected.***

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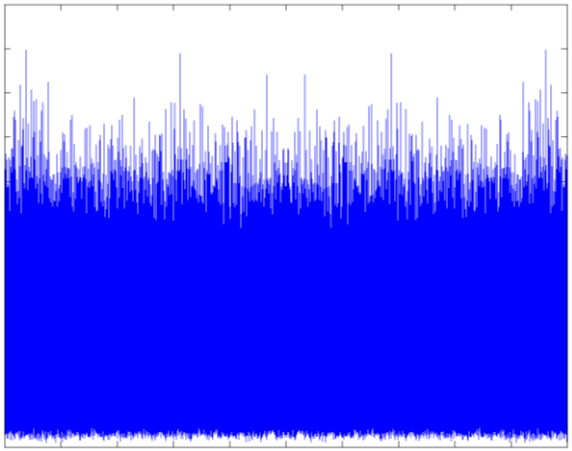
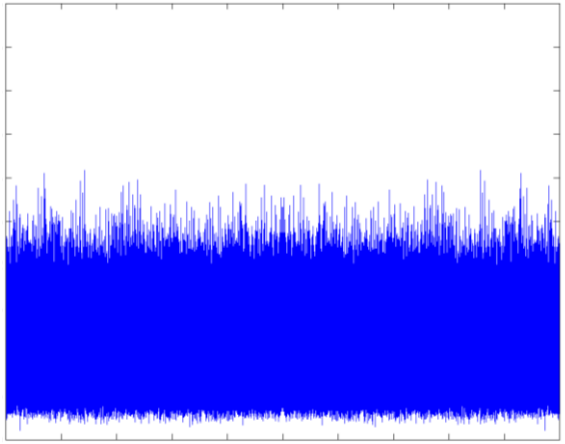
F = Frames

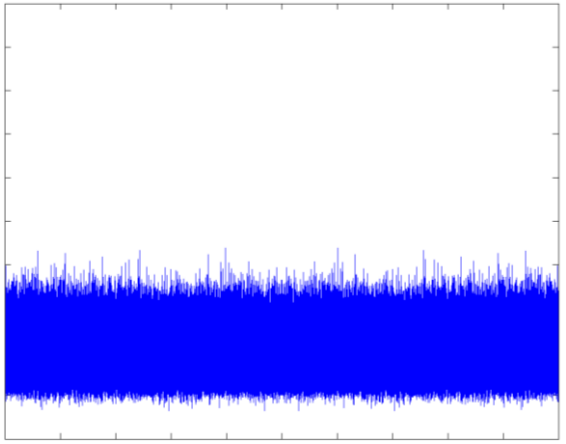
F = 5



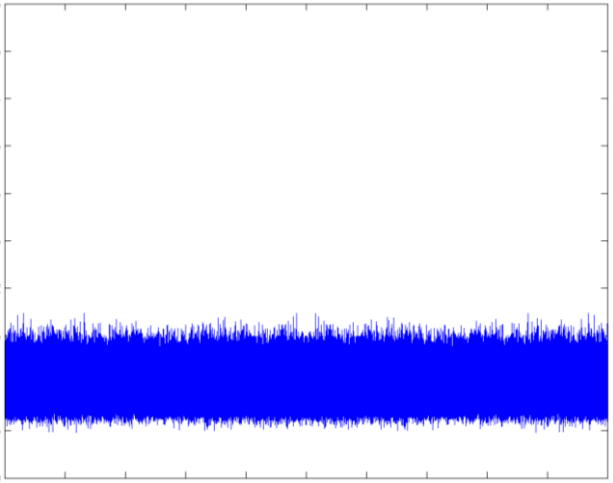
F = 10

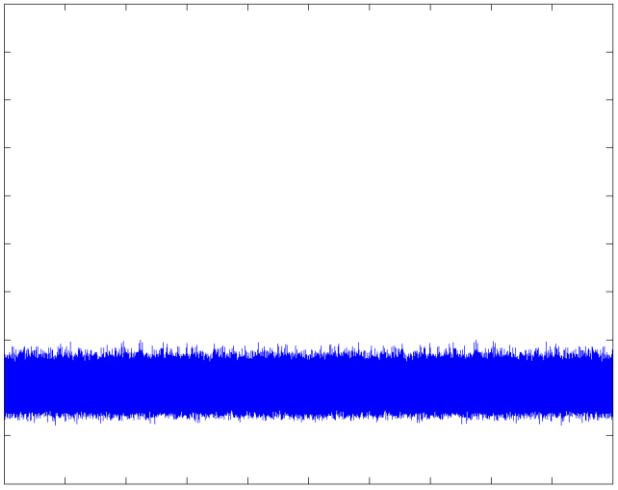


F = 25



F = 50





F = 100

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Inherent Properties of PSD Estimation

Occasional lines out of tolerance

Reigned in with averaging

Cause: ***Randomness***. Therefore, ***expected.***

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Probability of all 800 lines within tolerance for a given tolerance dB and averaging DOF

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%

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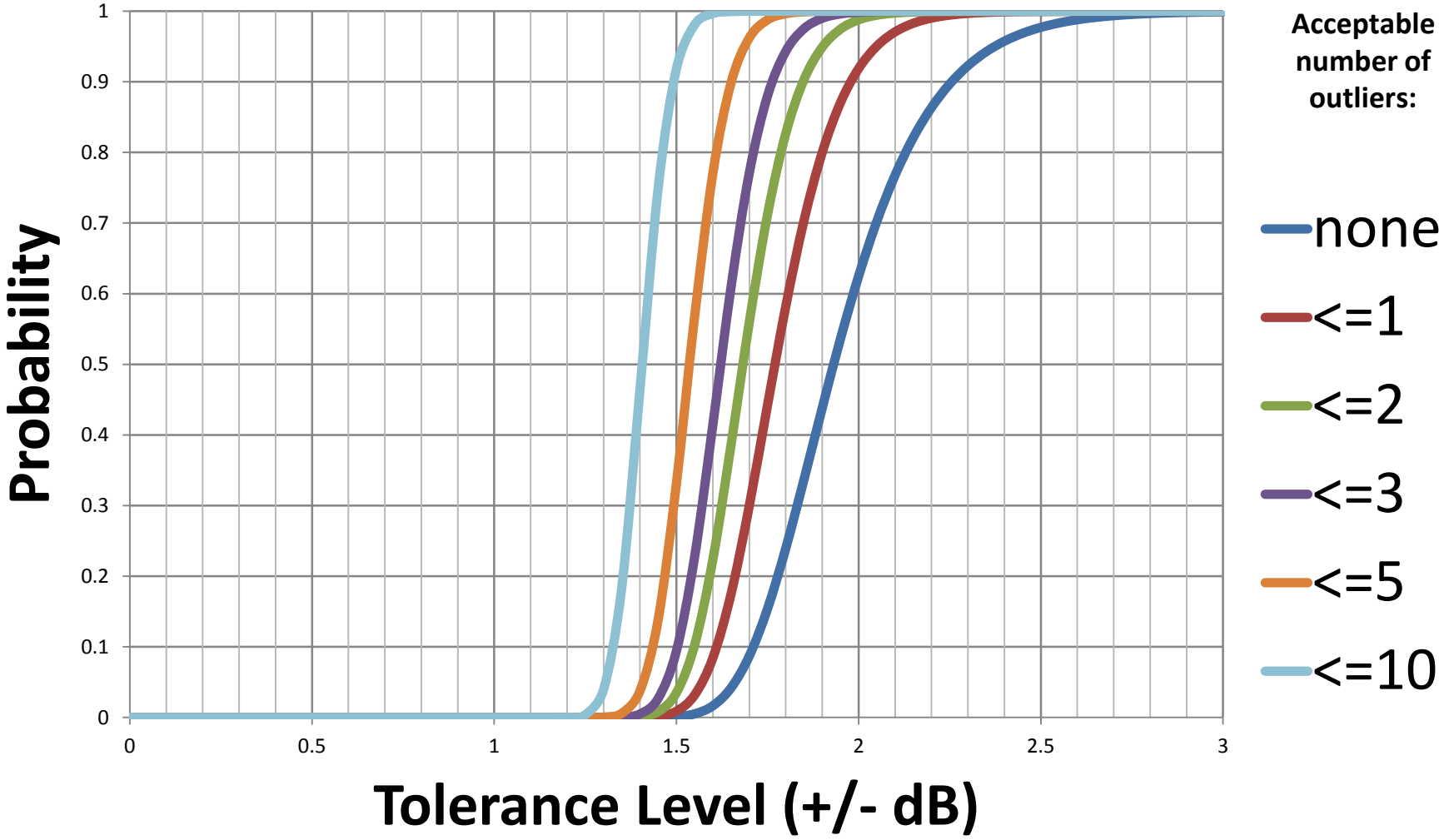
Probability of Satisfying Tolerance



DOF: 120; Lines: 800; Max Freq: 2 kHz;
Time required to achieve DOF: 24 s

Resetting the Averaging:
Does this meet tolerance?

Yes.

How? Look more closely at the test specs.

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In Conclusion

1. Multiplication of low-level-data method is ***misleading***.

2. Averaging should be ***reset*** at a change in level.

3. At times we ***expect*** high variance, or a line or lines out of tolerance, by virtue of ***randomness.***

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One More Thing…

- There is a way to *rapidly* but *accurately* display a *smooth, low-variance PSD plot.*

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Video

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iDOF™

- An innovative method of PSD estimation
  - ❖ Rapidly reduces estimation error
  - ❖ Accurately displays actual vibrations
  - ❖ Clearly informs the operator

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iDOF™ Methodology

- Two Sources of Error
  - Estimation Error
  - Control Error

- iDOF™ confidently removes estimation error, allowing the user to more clearly and quickly see control error.

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Result

- With iDOF™, the PSD plot
  - Accurately displays the actual vibrations at the current level
  - Converges to a smooth plot in a short amount of time
  - Manifests significantly lower variance (less raggedness)

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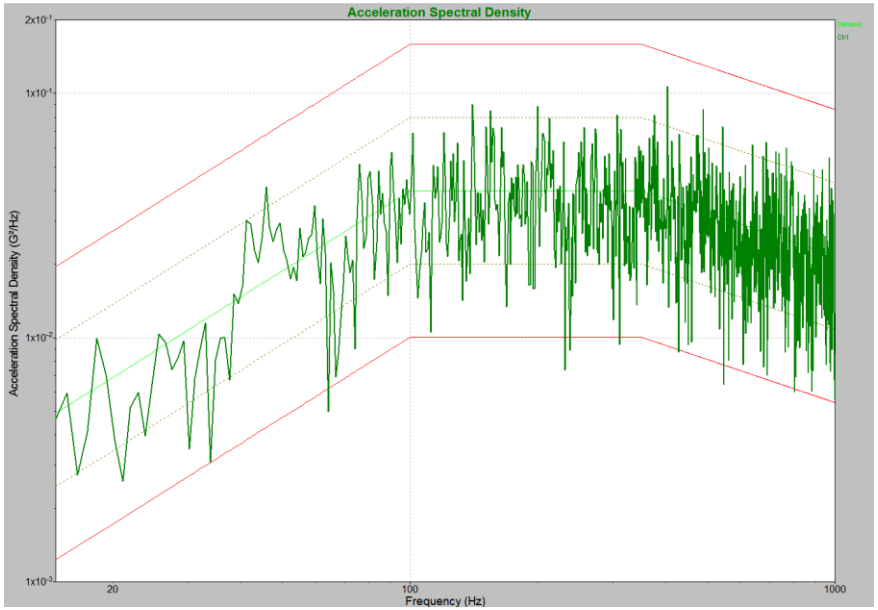
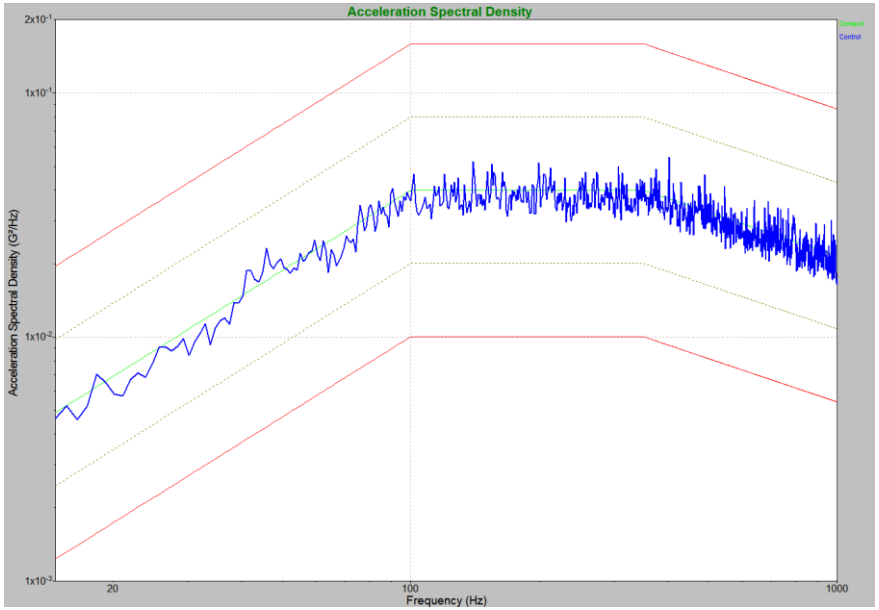
Example #1: Minimal Control Error



Traditional Averaging



With **iDOF™**

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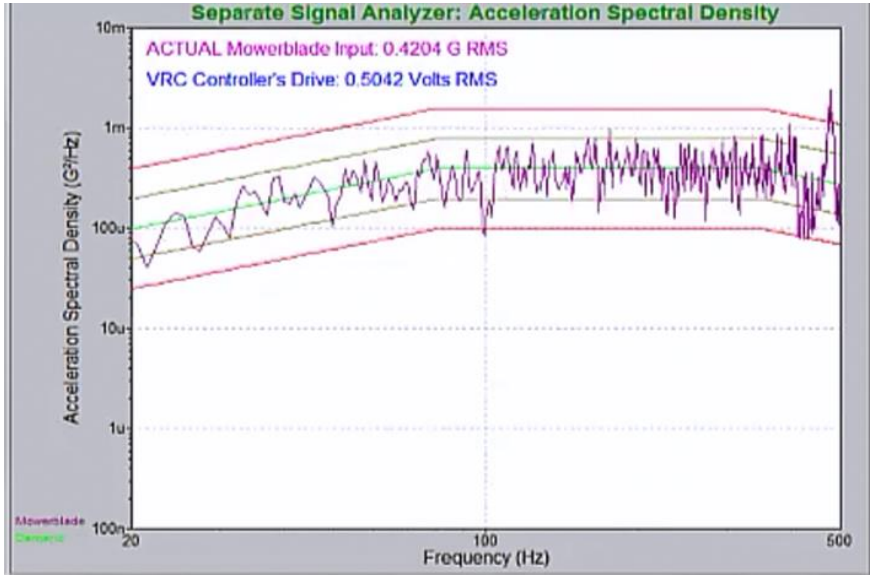
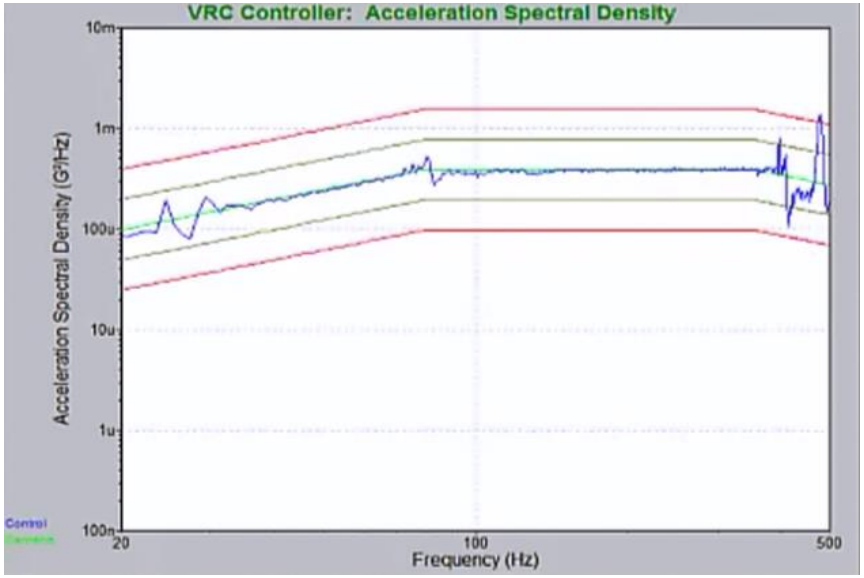
Example #2: Control Error Present



Traditional Averaging



With **iDOF™**

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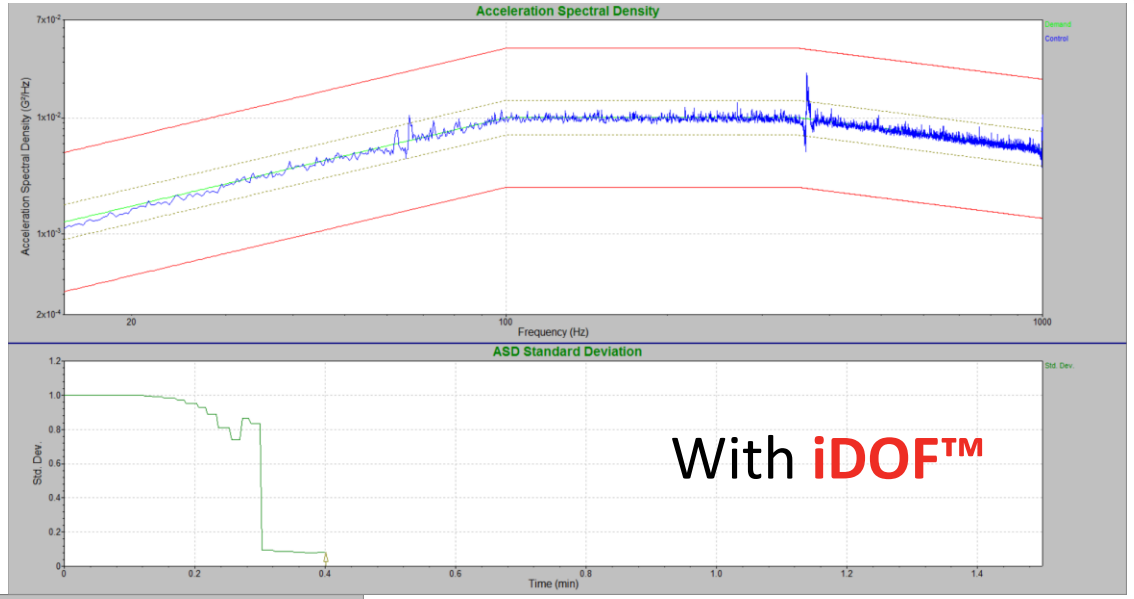
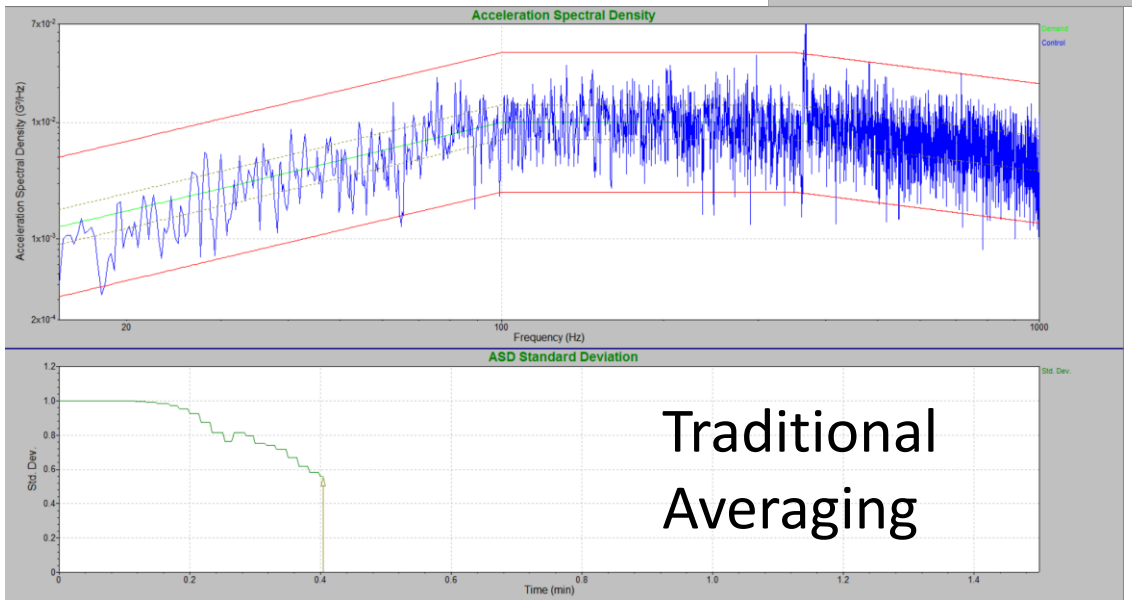
Variance Reduction



With iDOF™



Traditional Averaging

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iDOF™

INSTANT DEGREES OF FREEDOM

An innovative PSD estimation method that...

…Rapidly reduces estimation error and as a result…

Quickly smooths the PSD plot,

Clarifies the PSD plot,

Exposes actual vibrations, and

Clearly informs the operator.

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Demonstrate Live controller

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DoF Calculator

- Is it statistically possible to satisfy the tolerances of your random vibration test? How much time will it take to average enough data to meet your specifications?

- Click Here for Link

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Previous Questions

- Is IDOF a one time license? Is IDOF compatible with the VR8500?
- What is the method used by VR controllers for random control without iDOF?
- How do you integrate IDof into your current control system?
- In the absence of iDOF, how is data displayed in VibrationVIEW: scaling, display delay, rest averaging?

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For More Info

Schedule a personal conversation with our team following this presentation

Visit us at: www.vibrationresearch.com

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PowerPoint Presentation

If you want a copy of these slides please contact aaron@vibrationresearch.com

Thanks!

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References

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2. Van Baren, John, “Is Your Random Vibration Testing Fulfilling MIL-STD-1540D?”, Vibration Research Corporation Technical Paper, http://www.vibrationresearch.com/public_pdf/Fulfilling_MIL-STD-1540D-Tolerance_on_Vibration_Controllers.pdf.
3. Lang, George and Van Baren, Phil, “Does Your Random Controller Square With Chi?”, Vibration Research Corporation Technical Paper, http://www.vibrationresearch.com/public_pdf/SquaringWithChi.pdf.

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