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August 21, 2013

AZIMA | DLI

A New Method for Detecting Bearing Wear in Slow Speed Machines

Warning – Technical Content *

Window Factor

Anti – Aliasing

$$\#FFT\ Lines = \frac{\#\ Samples}{2.56}$$

Nyquist Criterion

$$DAT = \frac{\#\ FFT\ Lines}{Fmax}$$

DownSampling

*** If These Expressions Are Not Familiar To You Then The Following Content My Not Be Suitable**

Slow Speed Machines

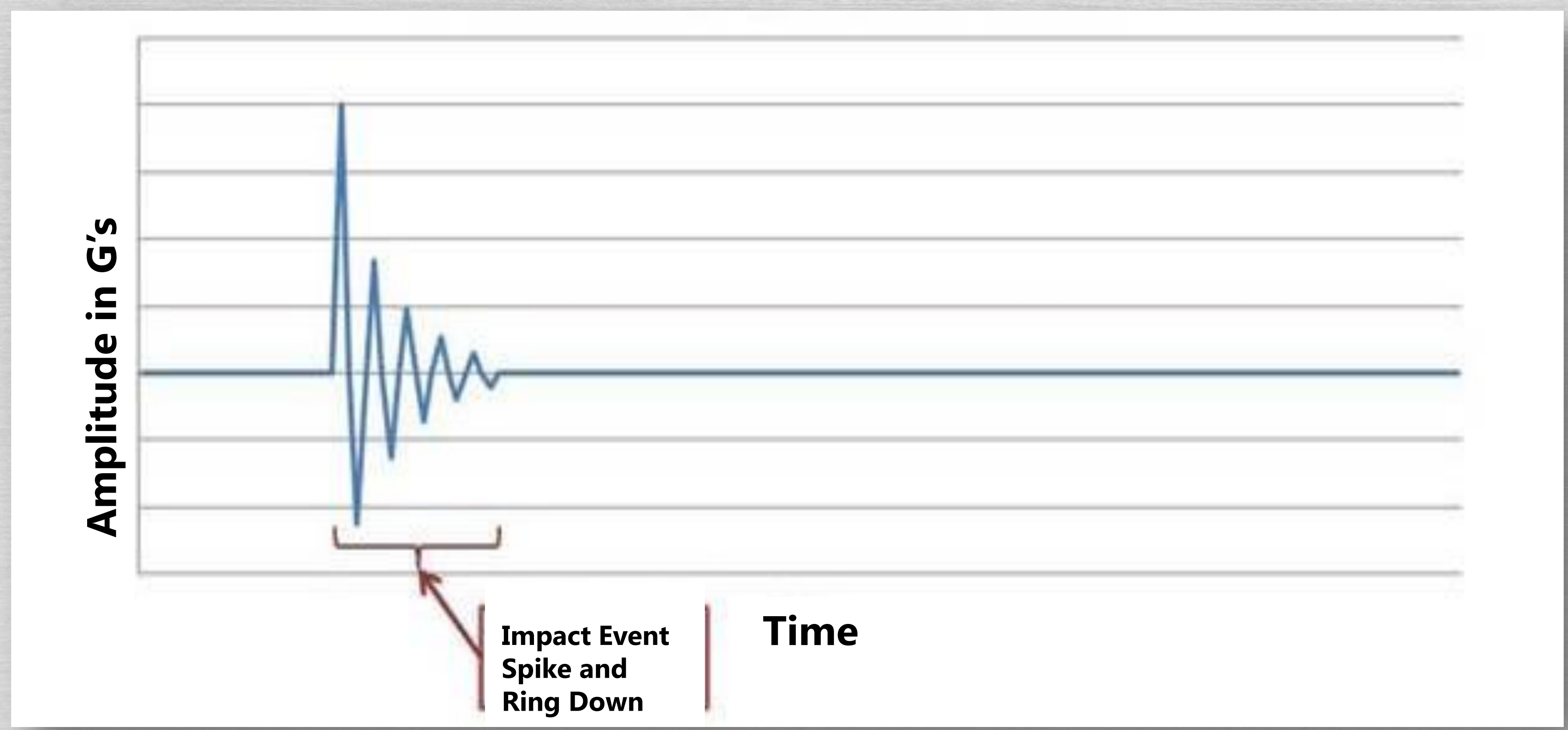
Impact Demod

- **Impact signals** in machinery
- **Impact detection difficulties** in slow speed machines
- **Legacy Demodulation** ineffectiveness
- **Impact Demod functionality**
- Impact Demod **setup and analysis tips**
- Impact Demod **in action**

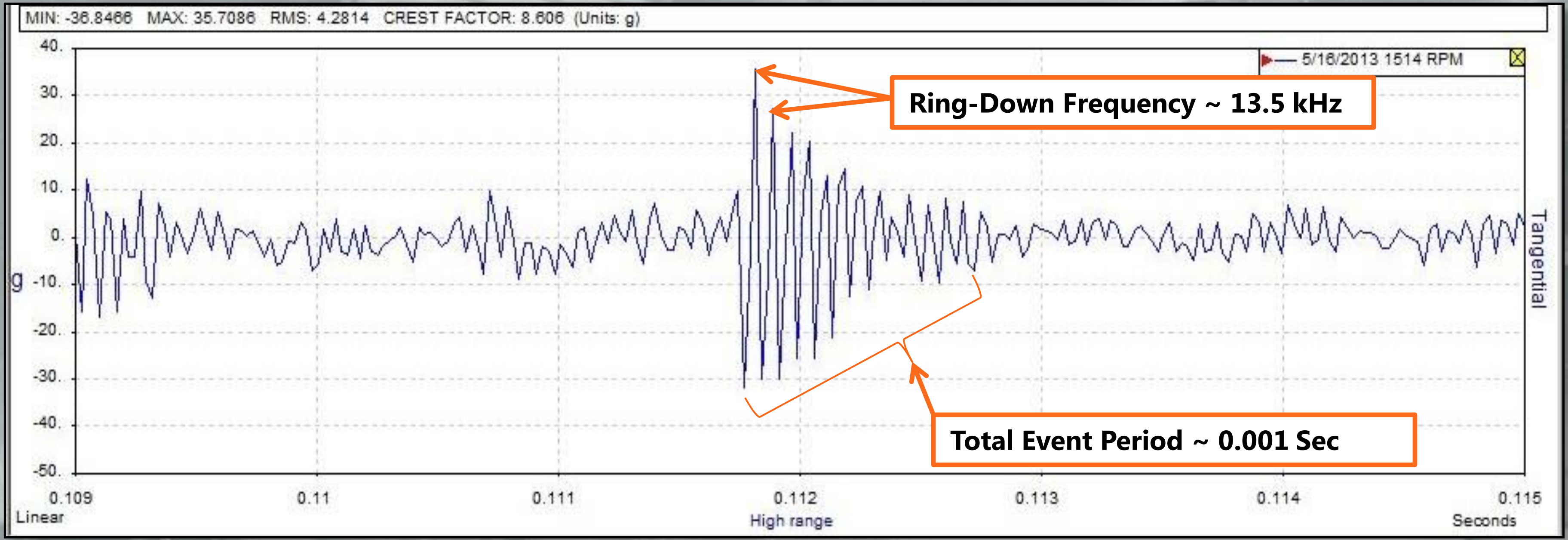
Impact
Demod

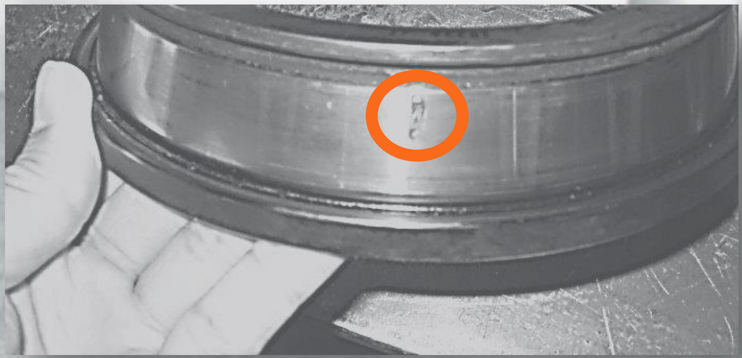
Distinguishing an Impact

Single Impact Illustration in Time Waveform



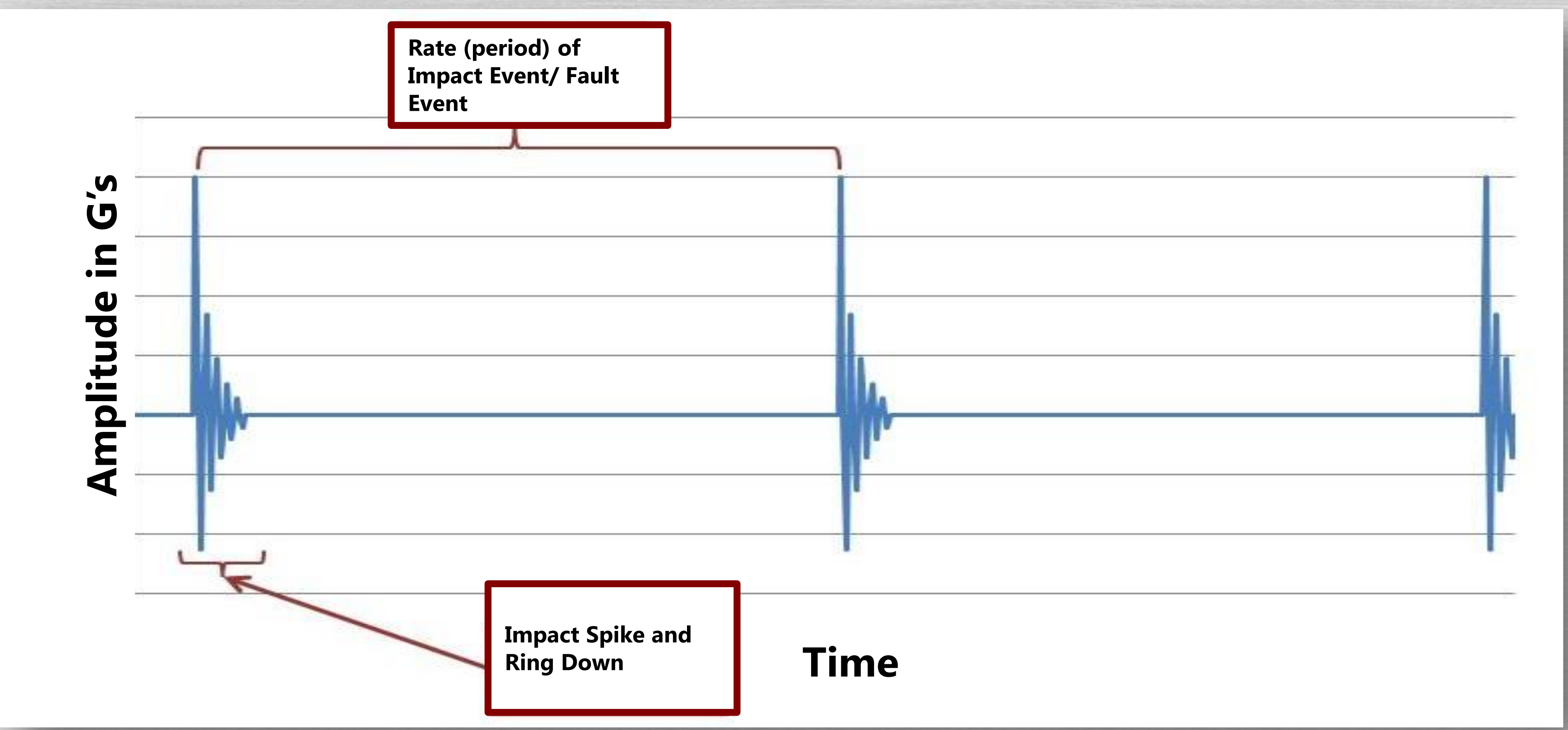
Example: Single Impact Event



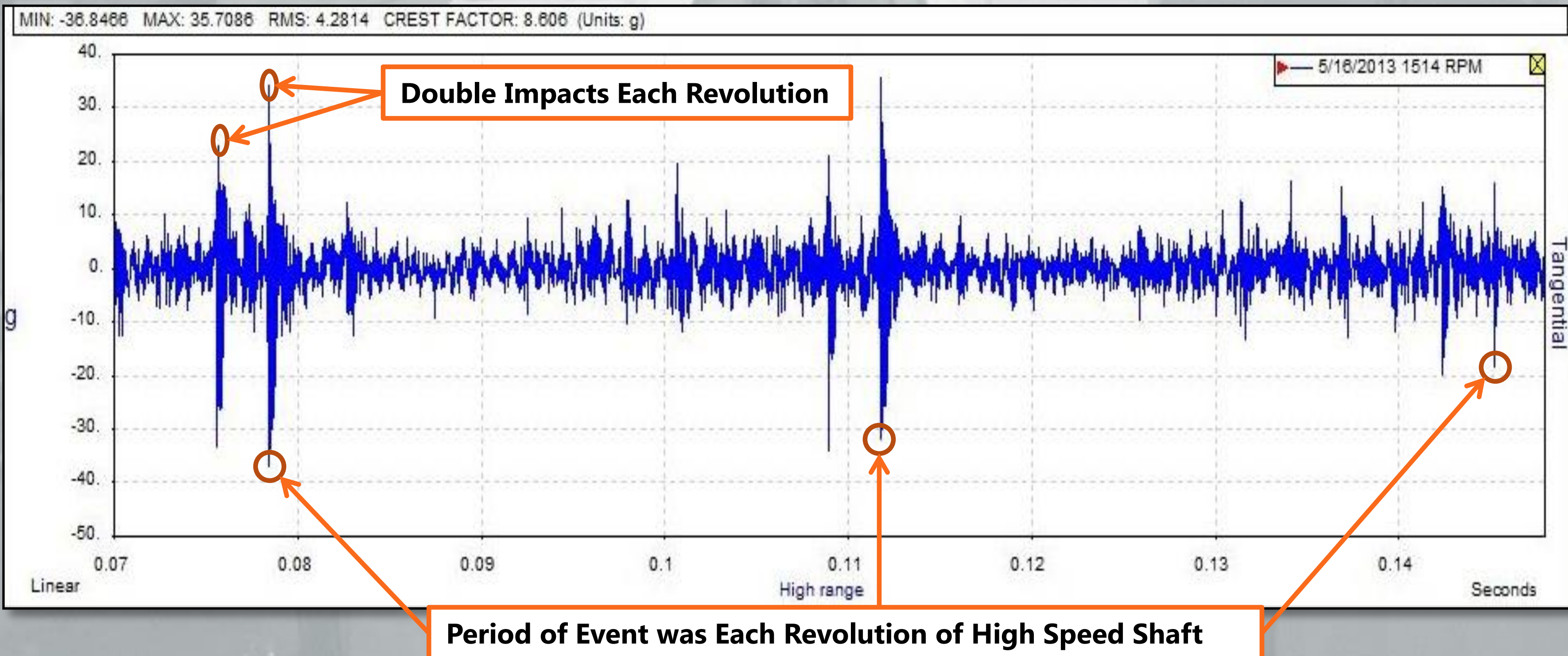


Periodic Impact Spikes

Impact Illustration in Time Waveform



Example: Periodic Impact Events



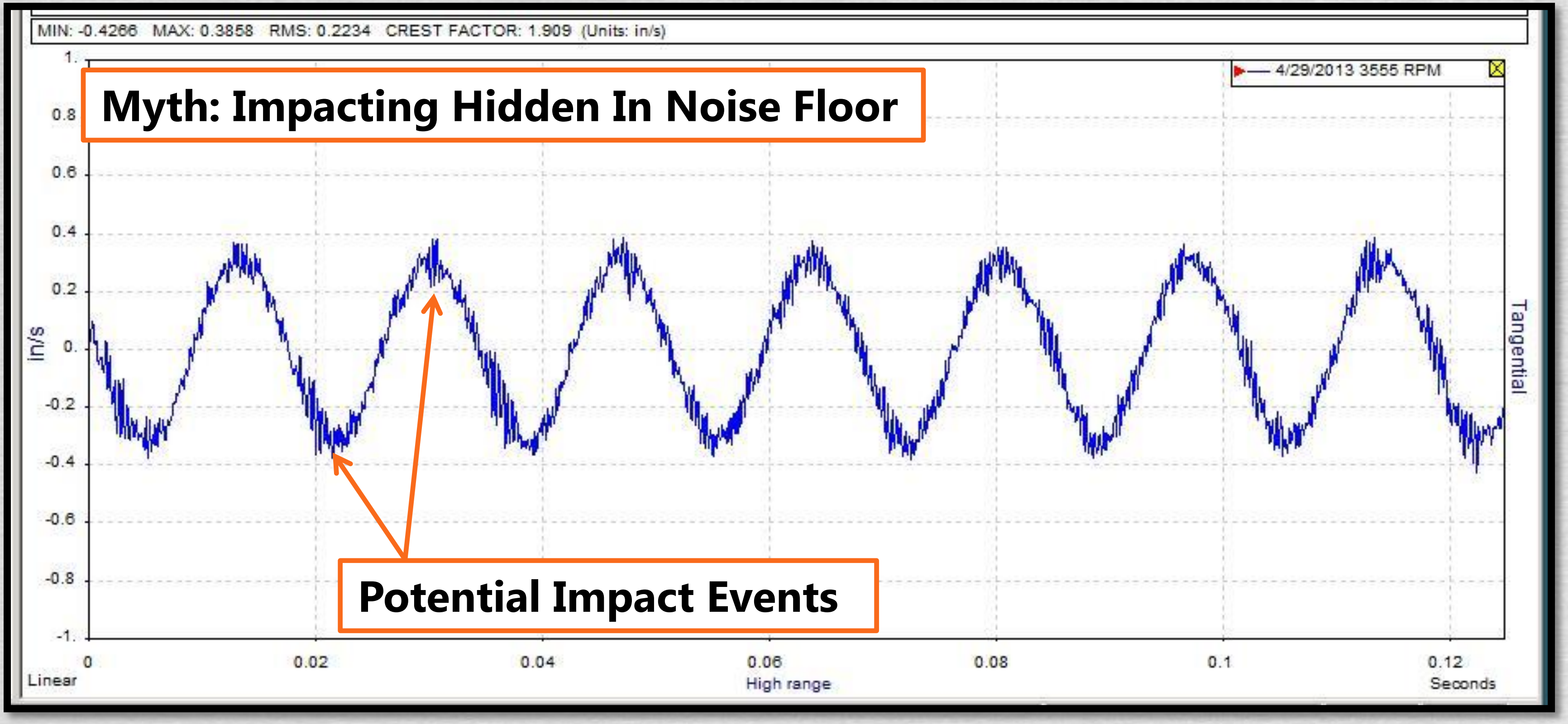
Bearing Impact Faults are Difficult to Detect Because They Produce "Tiny" Signals That Are Hidden in the Noise Floor.

Not True!

What We've Been Told

Impacting Amplitude Example - Low Impacting

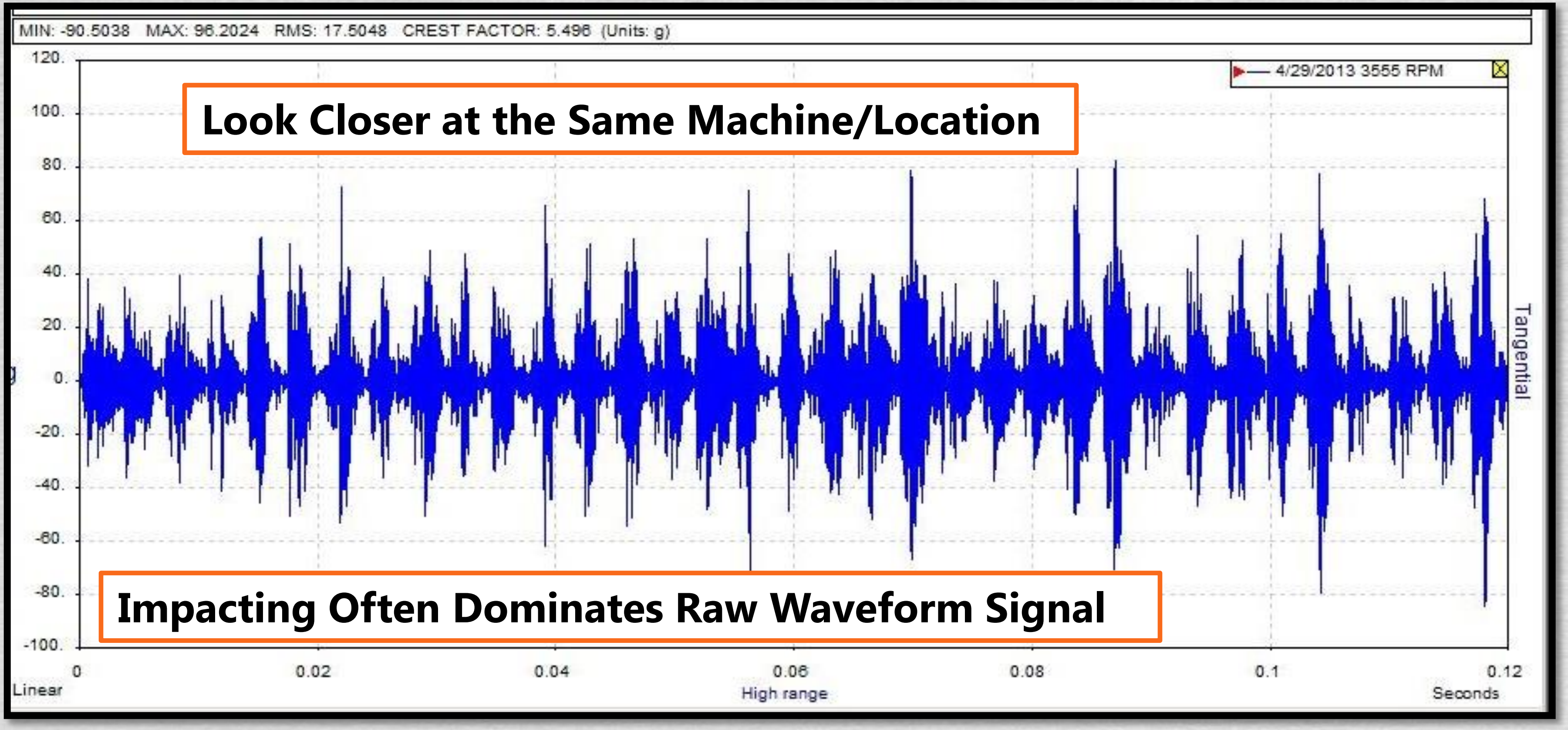
- Fmax at 6000Hz and Integrated



The Reality

Impacting Amplitude Example >180 g

- Fmax at 16,000Hz non-integrated



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Why is it Difficult to Detect?

- Requires Very High Sampling Rate
  - Fmax 16,000hz Or Greater
- Requires Long Sampling Times To Provide Adequate Low Frequency Resolution
  - A Sample Time Long Enough To Capture 15 Shaft Revolutions Is Suggested
- Results In Extremely Large Data Set

Why is it Difficult to Detect?

Slow Speed Machine Example

Machine Requiring Lowest Resolvable Frequency of 60 CPM

Typical:

- Fmax – 250Hz
  #Lines - 800
- Resulting Minimum Resolvable Frequency = 0.94 Hz

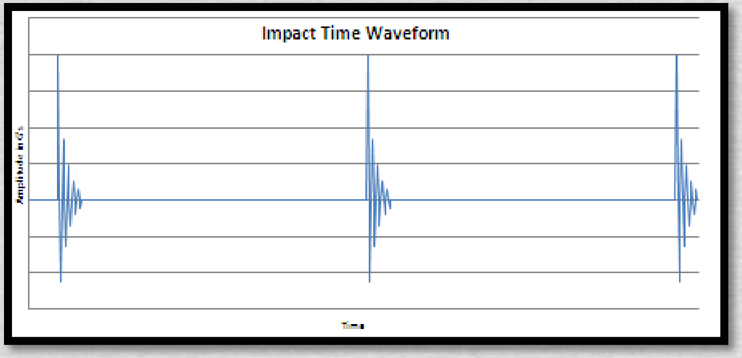
To Match Resolution at Required High Sample Rate

Capture Impacts:

- Fmax - 16,000Hz
  #Lines – 51,200
- Resulting Minimum Resolvable Frequency = 0.94 Hz

Legacy Demodulation

- Impact Signals Have Similar Characteristics To Amplitude Modulated Radio Signals
- Amplitude Demodulation Techniques Were Adapted As Bearing Detection Method



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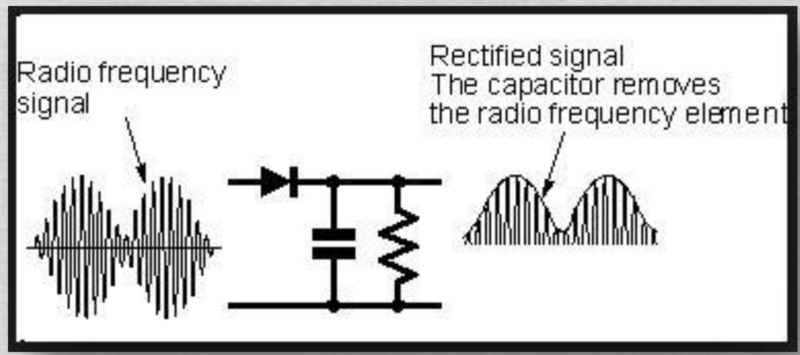
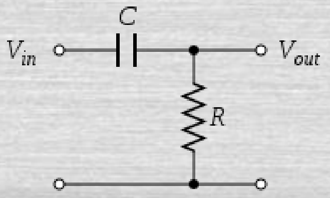
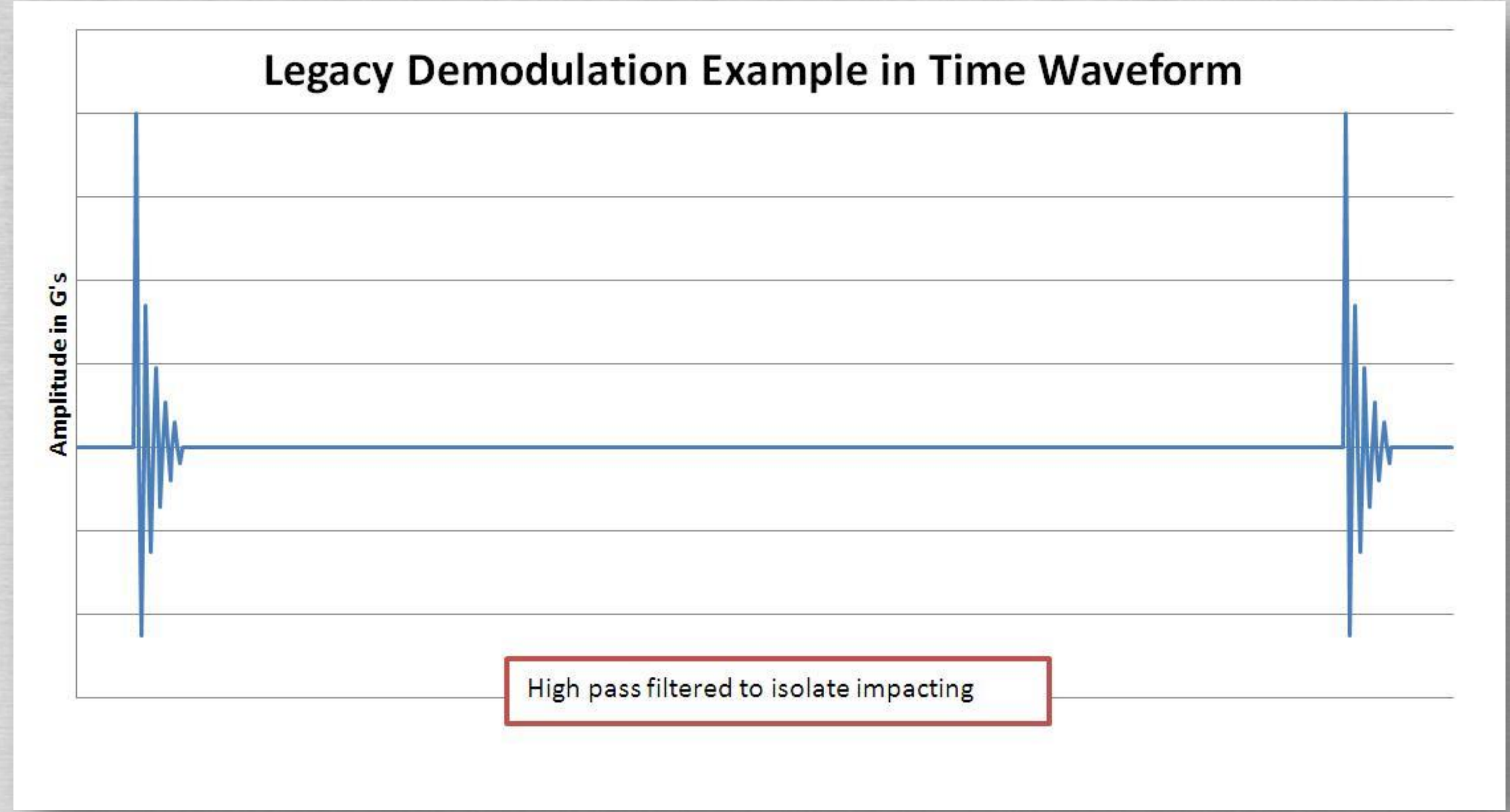


Legacy Demodulation – 1

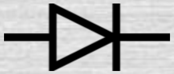
Signal High Pass Filtered

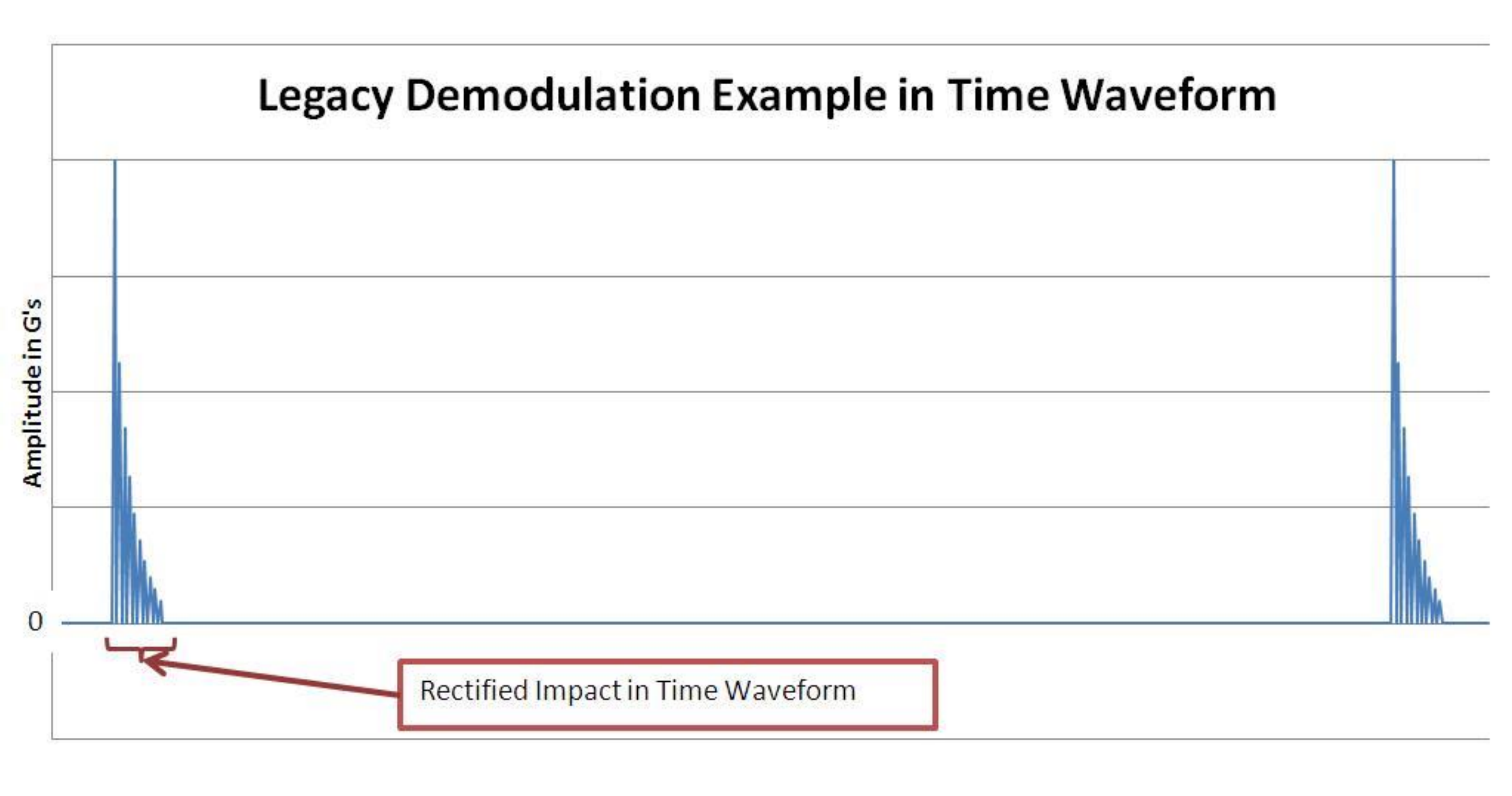




Legacy Demodulation – 2

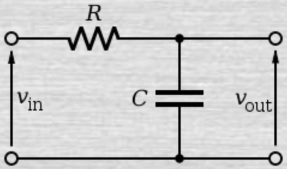
Force All Peaks to be Positive

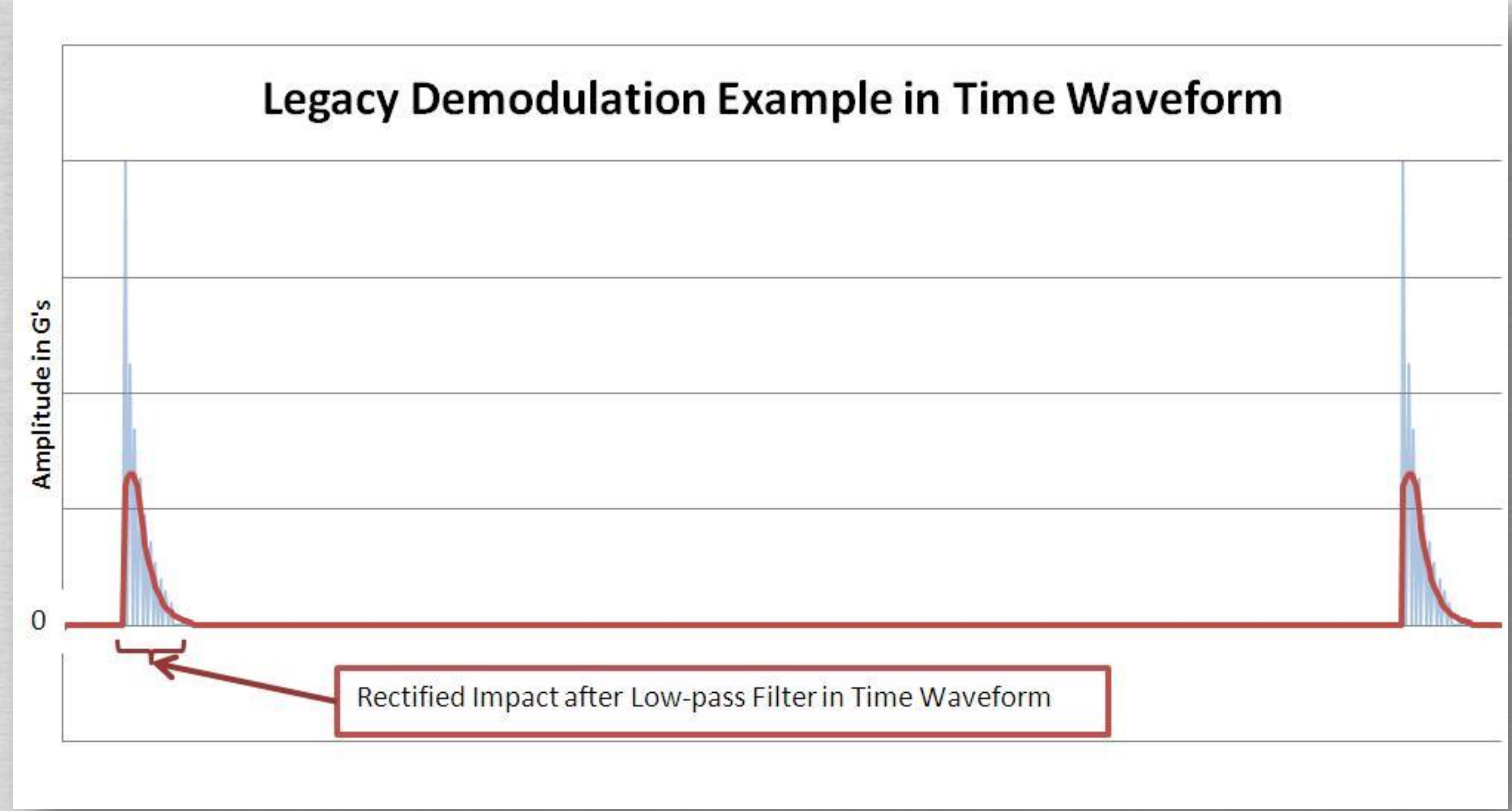




Legacy Demodulation – 3

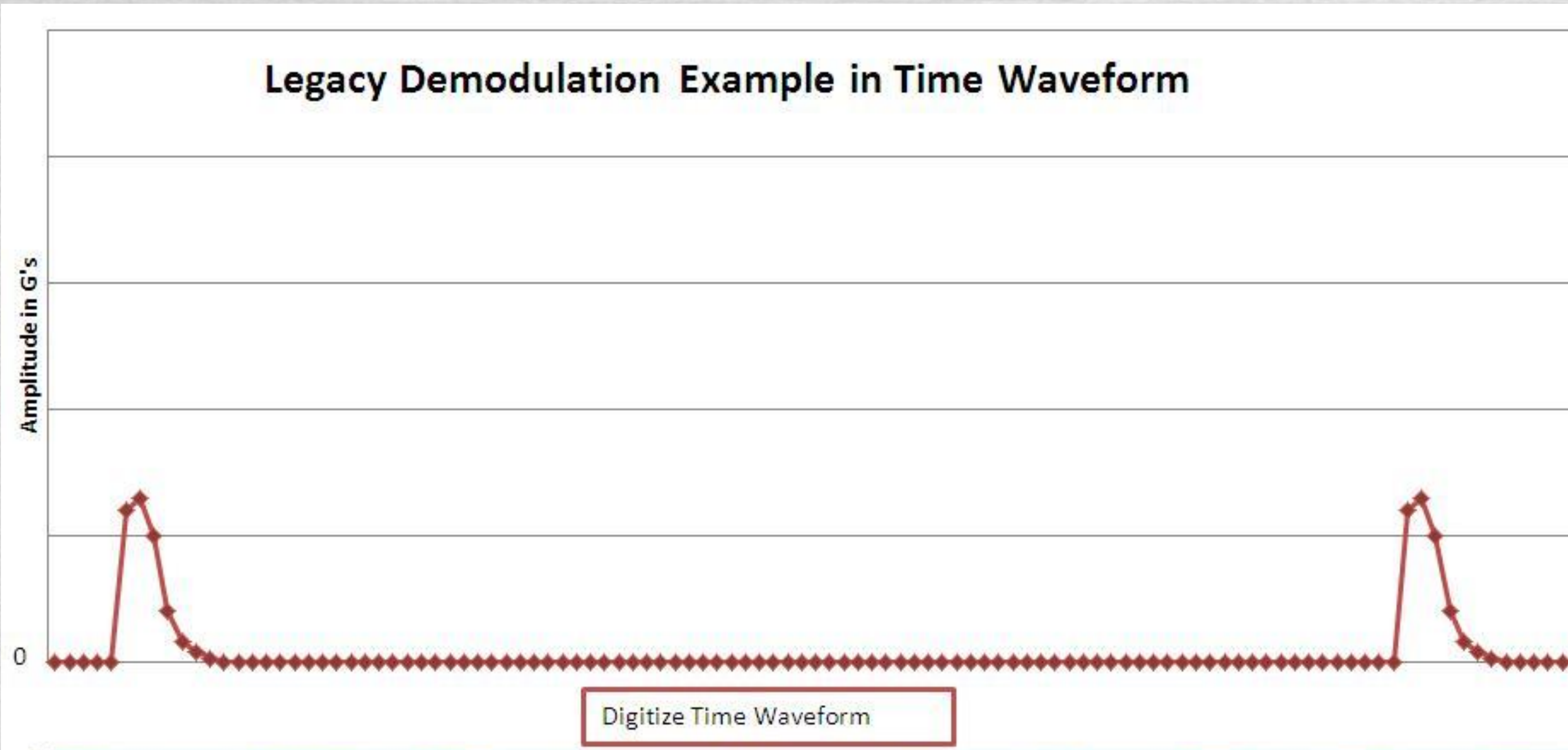
Signal Low Pass Filtered (Enveloped)





Legacy Demodulation – 4

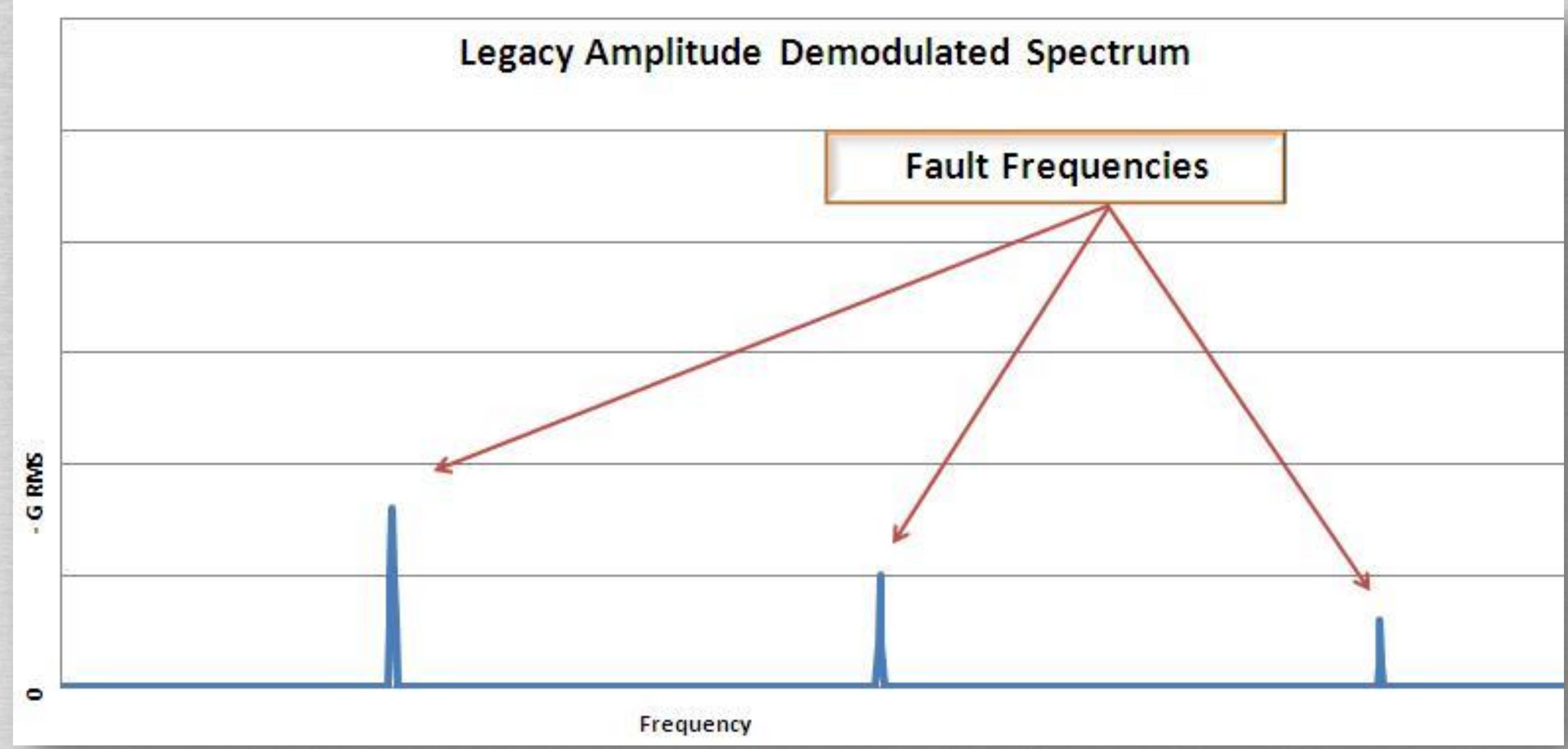
Pass Waveform Though A/D Converter



Time	0.001	0.002	.003	.004	.005	.006	.007	.008	.009
Amplitude	0	0.	0	0	.085	0.552	.612	.685	.662

Legacy Demodulation – 5

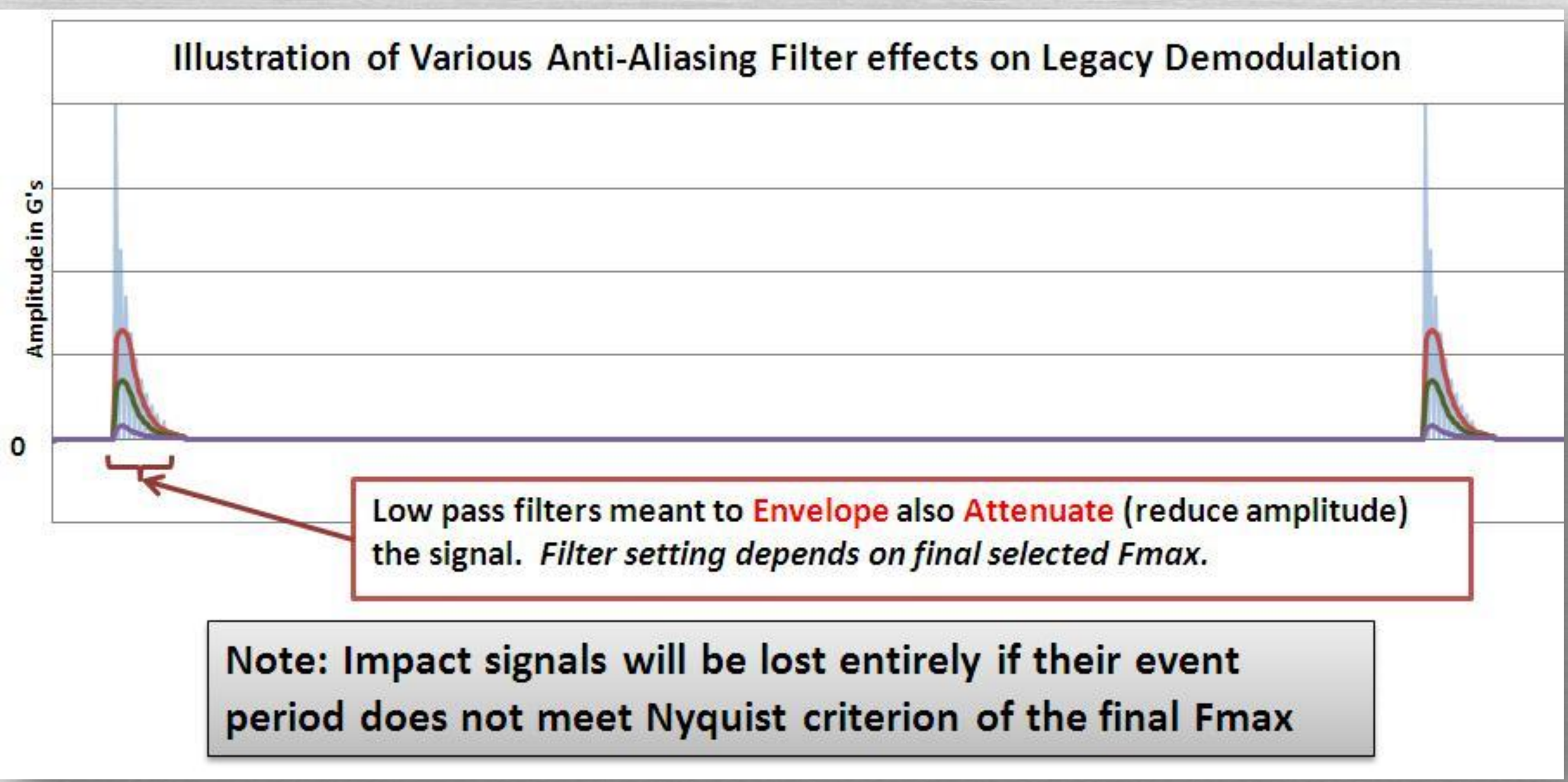
FFT Process – Generate Spectrum



Legacy Demodulation and Slow Speed Machines

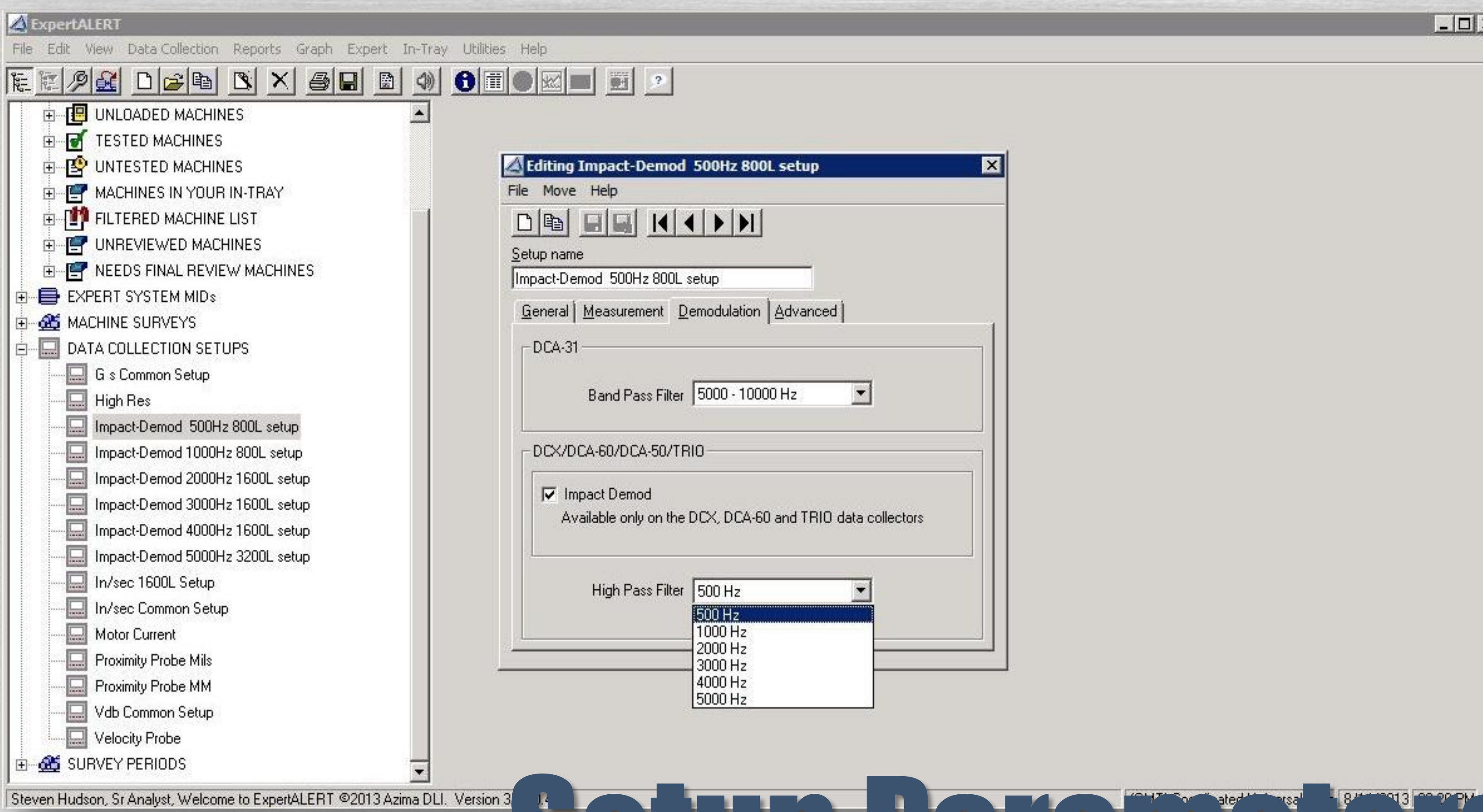
Enveloping Flaw

Low Pass Filter is Actually Instrument Anti-Aliasing Filters



Solution: Impact Demod

Impact Demod



Setup Parameters

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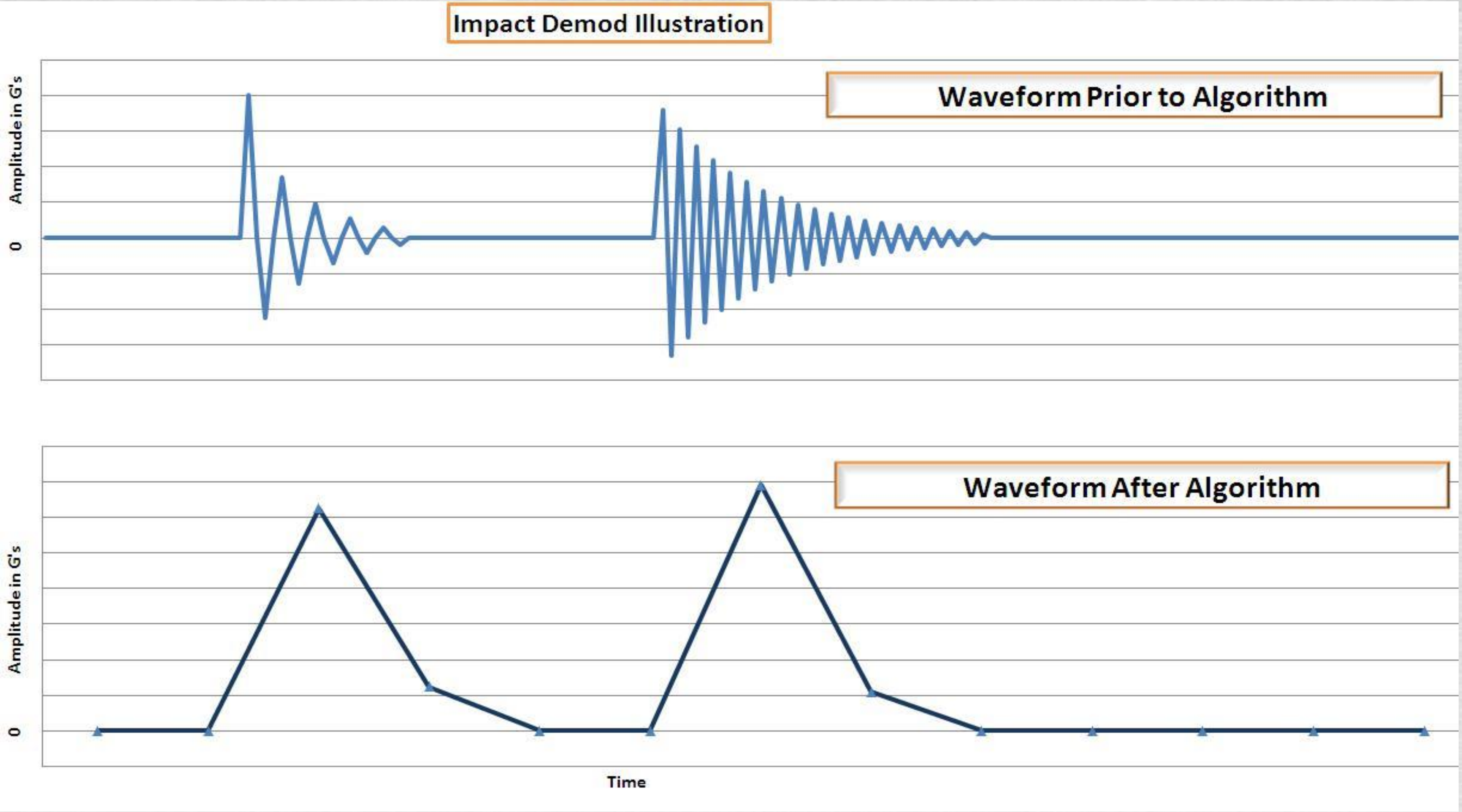
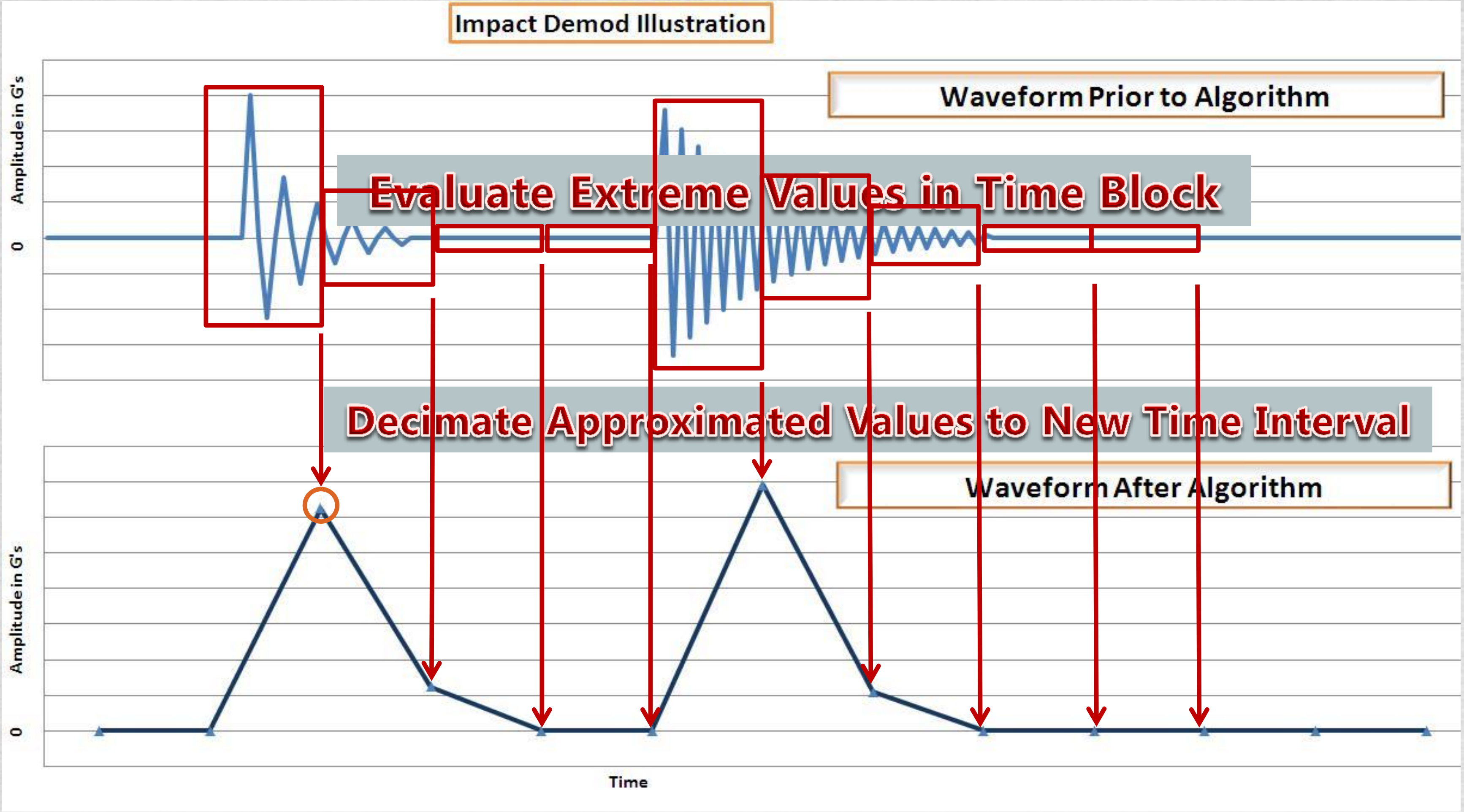
Impact Demod



Impact Demod



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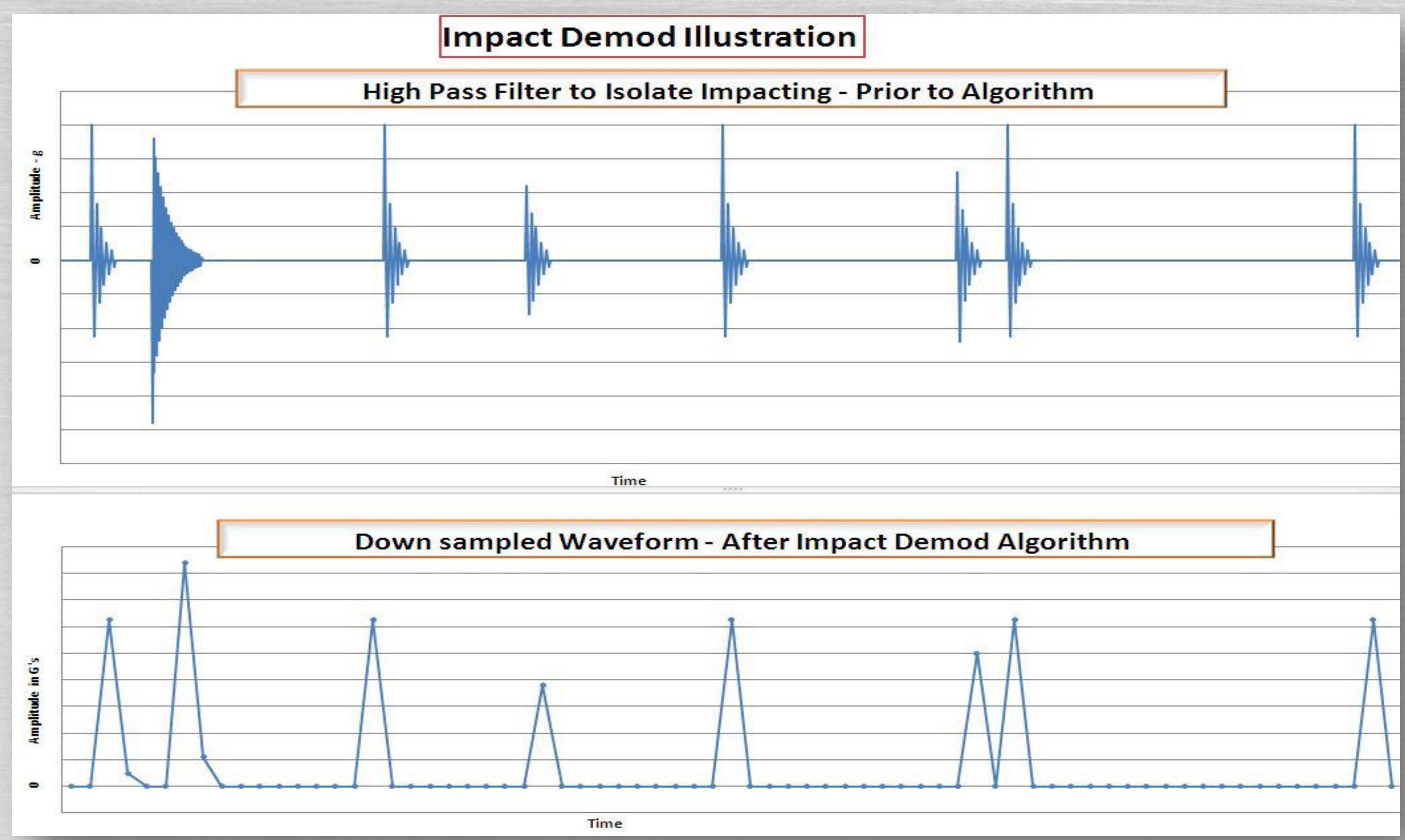
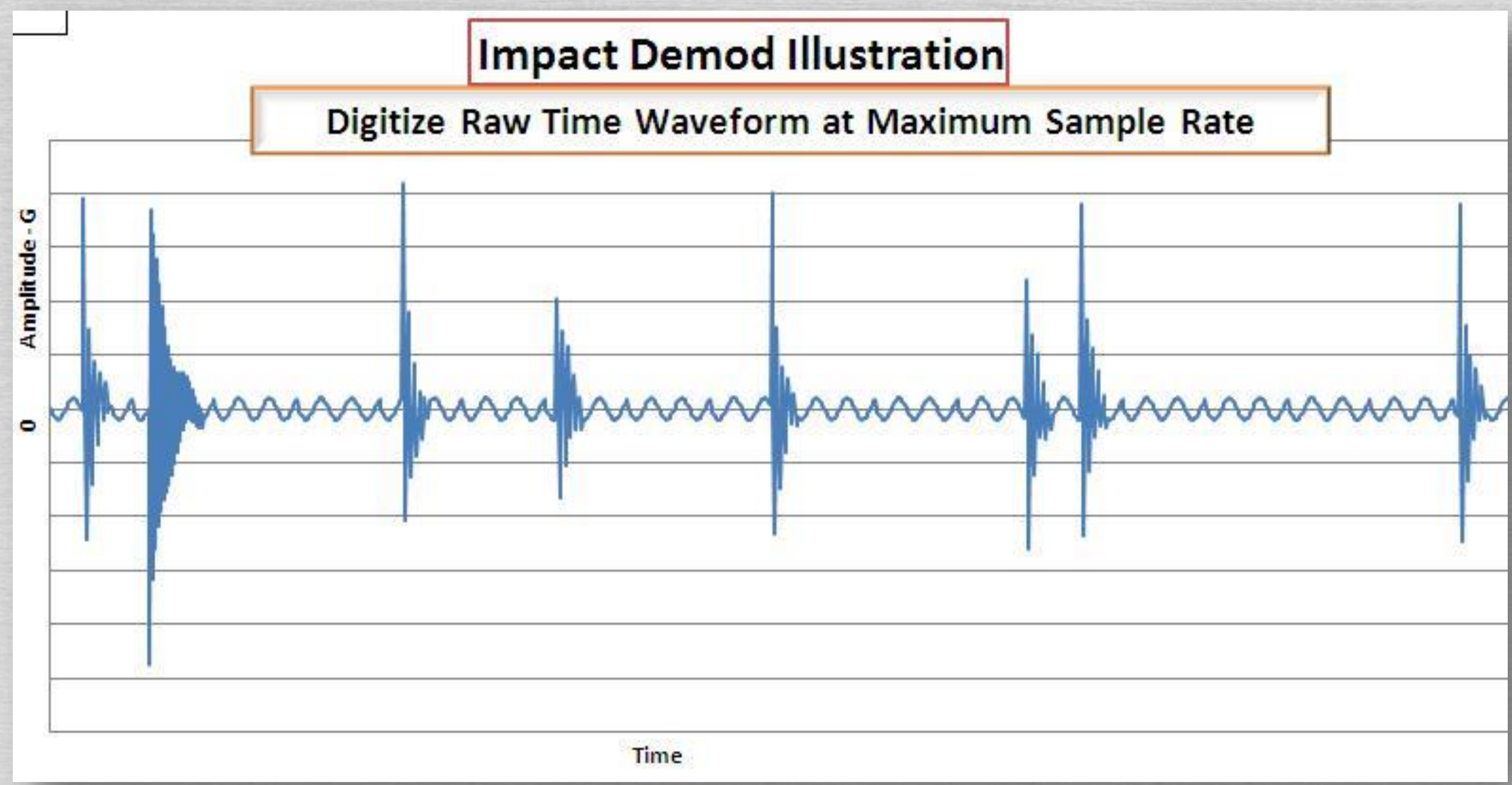
Impact Demod



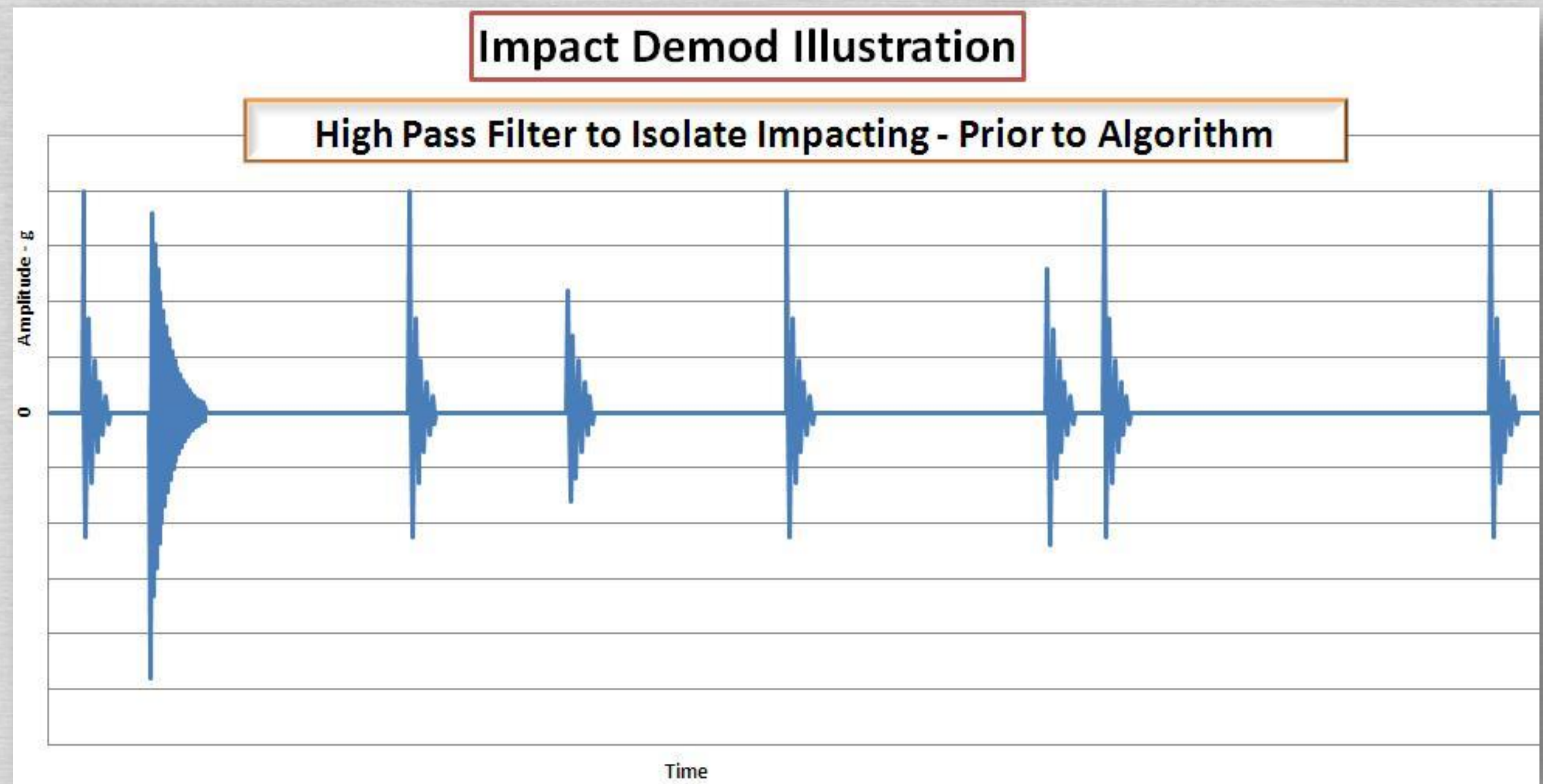
Impact Demod - Step 1

Digitize Acceleration Data



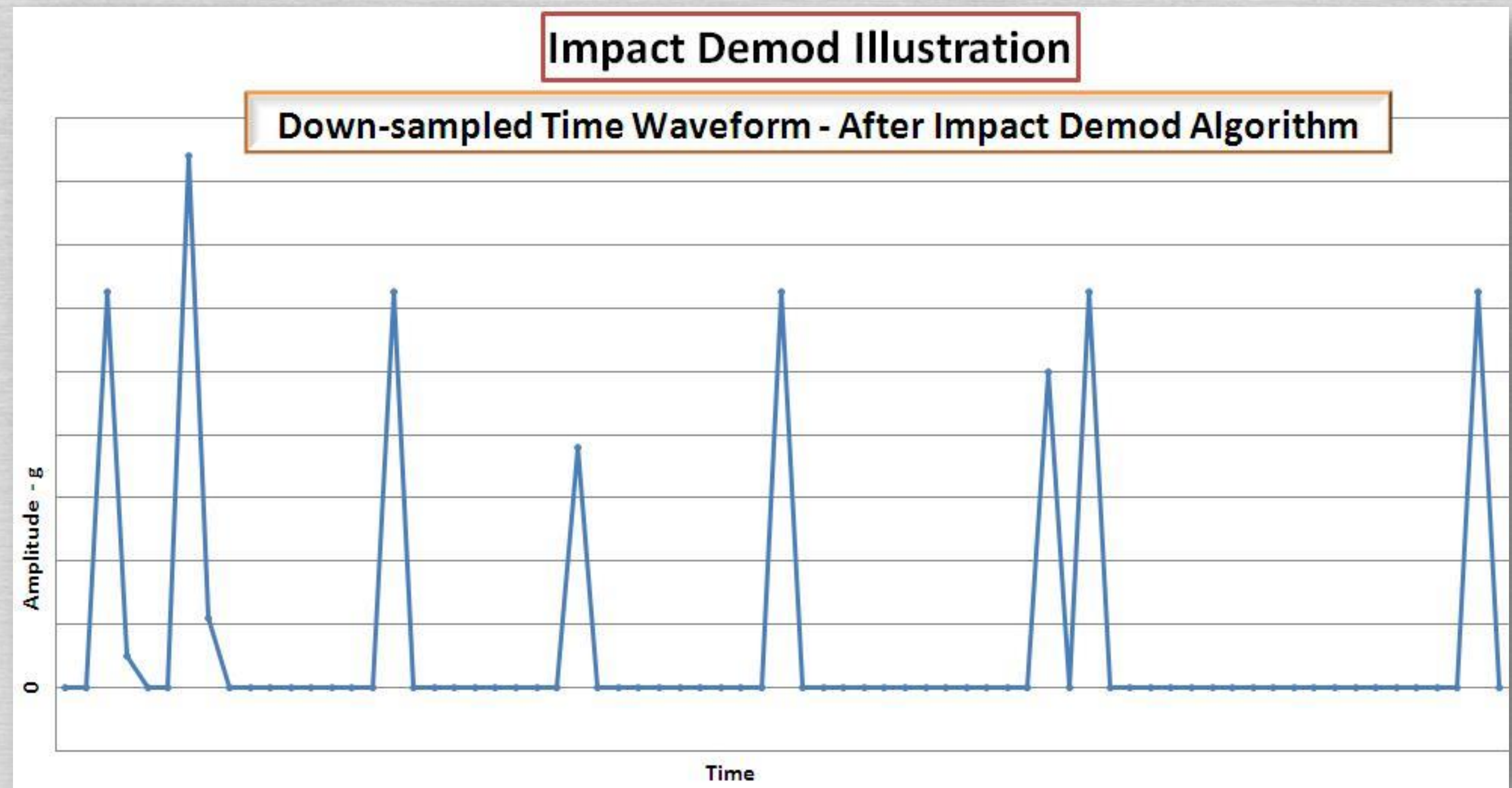
Impact Demod - Step 2

High Pass Filtering



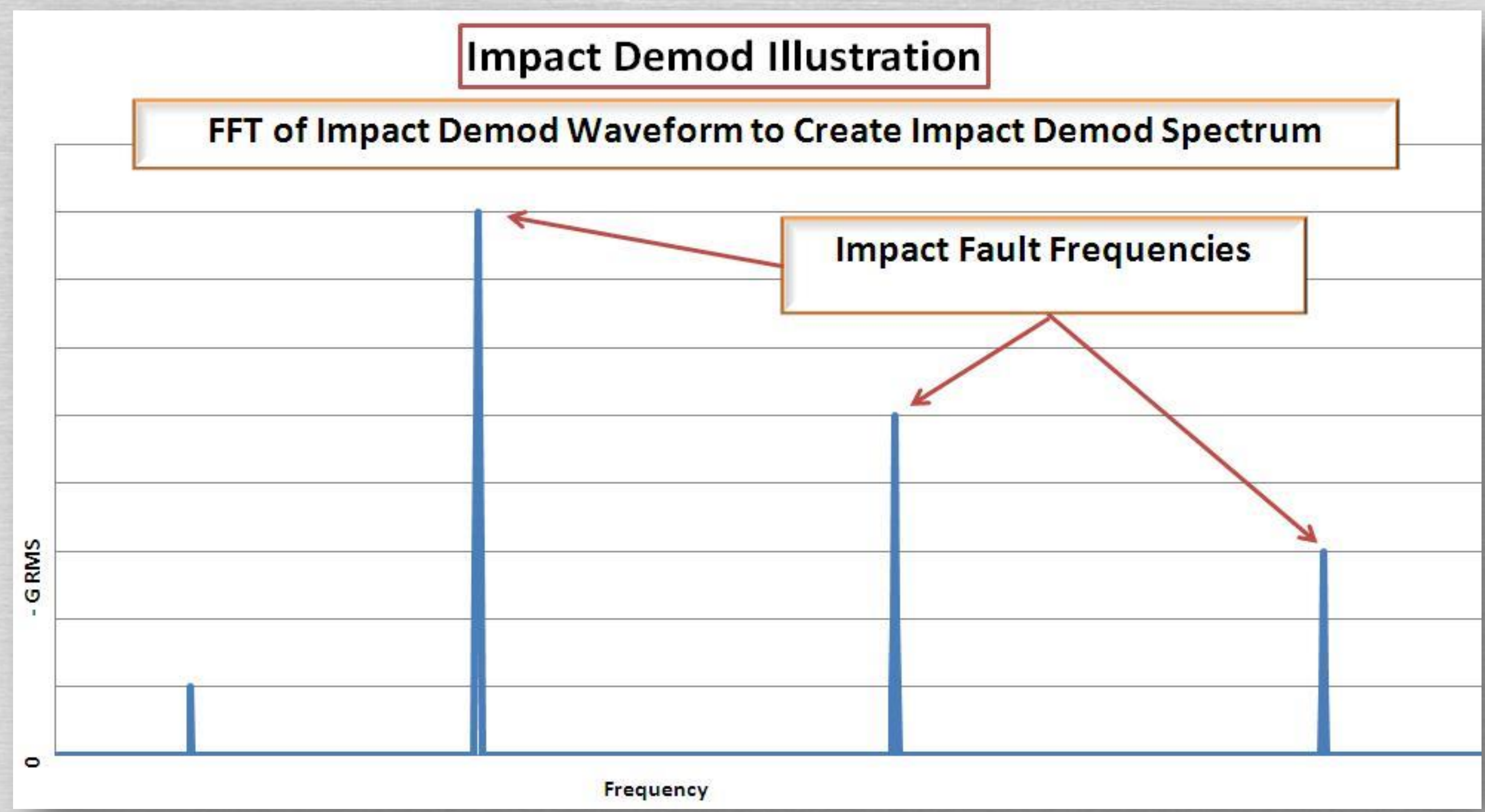
Impact Demod - Step 3

Run Impact Demod Alogrithm



Impact Demod - Step 4

FFT Process – Generate Impact Demod Spectrum



Impact Demod

- Advantages
  - No Low-pass filter attenuation
  - Retains maximum waveform amplitude Regardless of final Fmax chosen
  - Simplified filter selection
  - Does not rely on knowing resonance peak

Impact Demod

Setup Tips

- Use units of acceleration
- Attempt to capture at least 15 shaft revolutions in time waveform
- Only one average is recommended
- Use lowest available filter that does not overlap desired Fmax
- Use in-line axis if triaxial sensor

Impact Demod

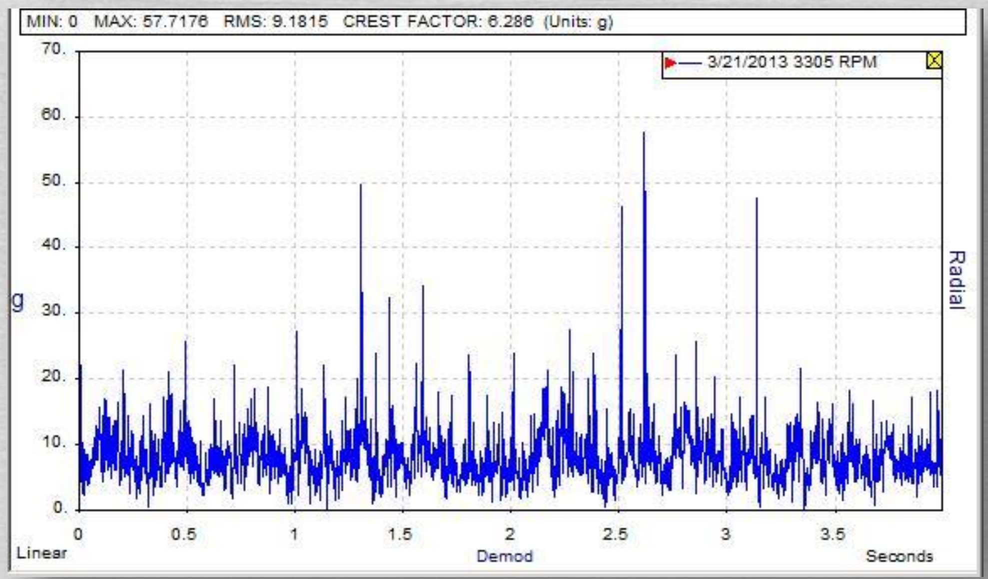
Analysis Tips

- Review the time waveform first
- Maximum values determine severity
- Compare to other like machines
- Determine if waveform content appears Random or periodic (Repetitive Pattern)
- Identify any harmonic sets in spectrum

Impact Demod
Analysis Tips (continued)

- Random impacting indicates
  - Metal to metal friction
  - Pump cavitation

Impact Demod Time Waveform

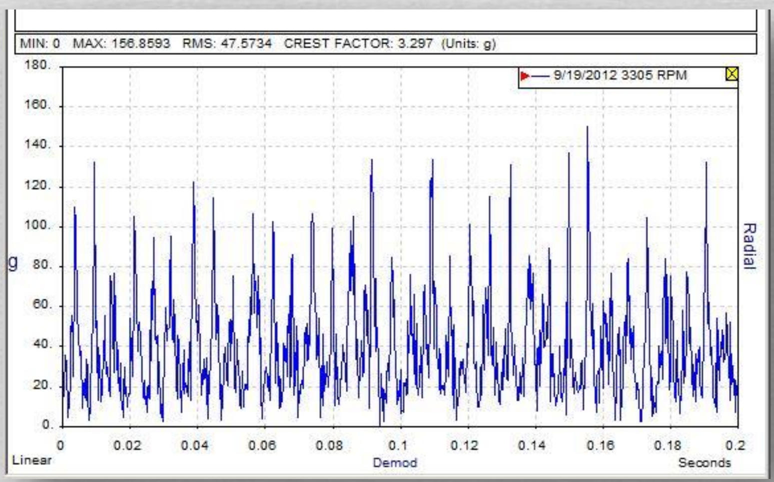


Impact Demod

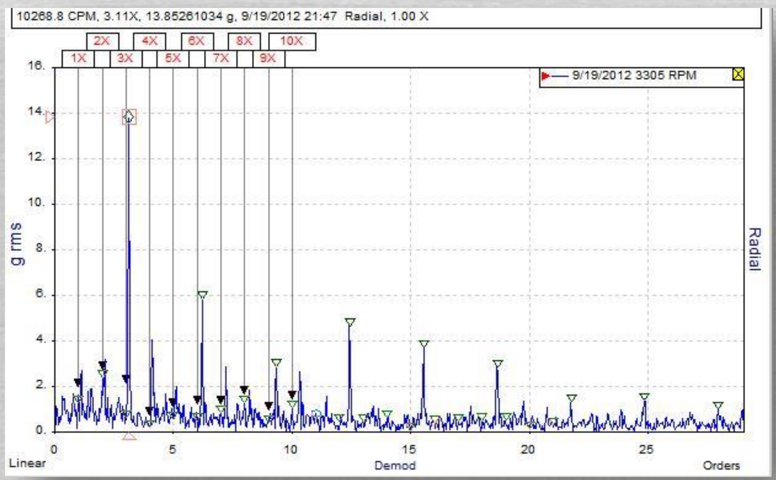
Analysis Tips (continued)

- Periodic Impacting
  - Impact rate indicates faulty component
  - Review spectrum to determine fault frequency

Impact Demod Time Waveform



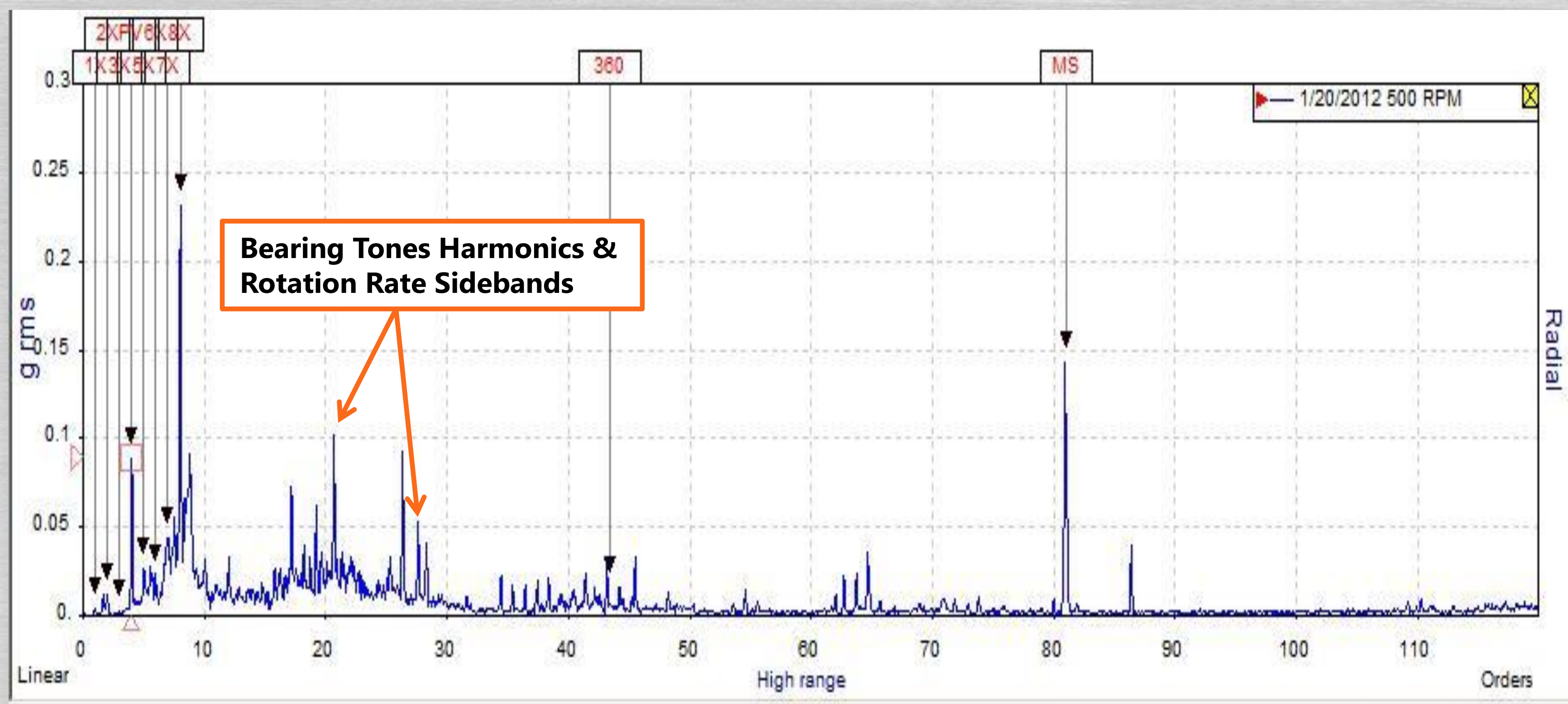
Impact Demod Spectrum



Impact Demod: *In Practice*

Slow Speed - Motor Coupled End

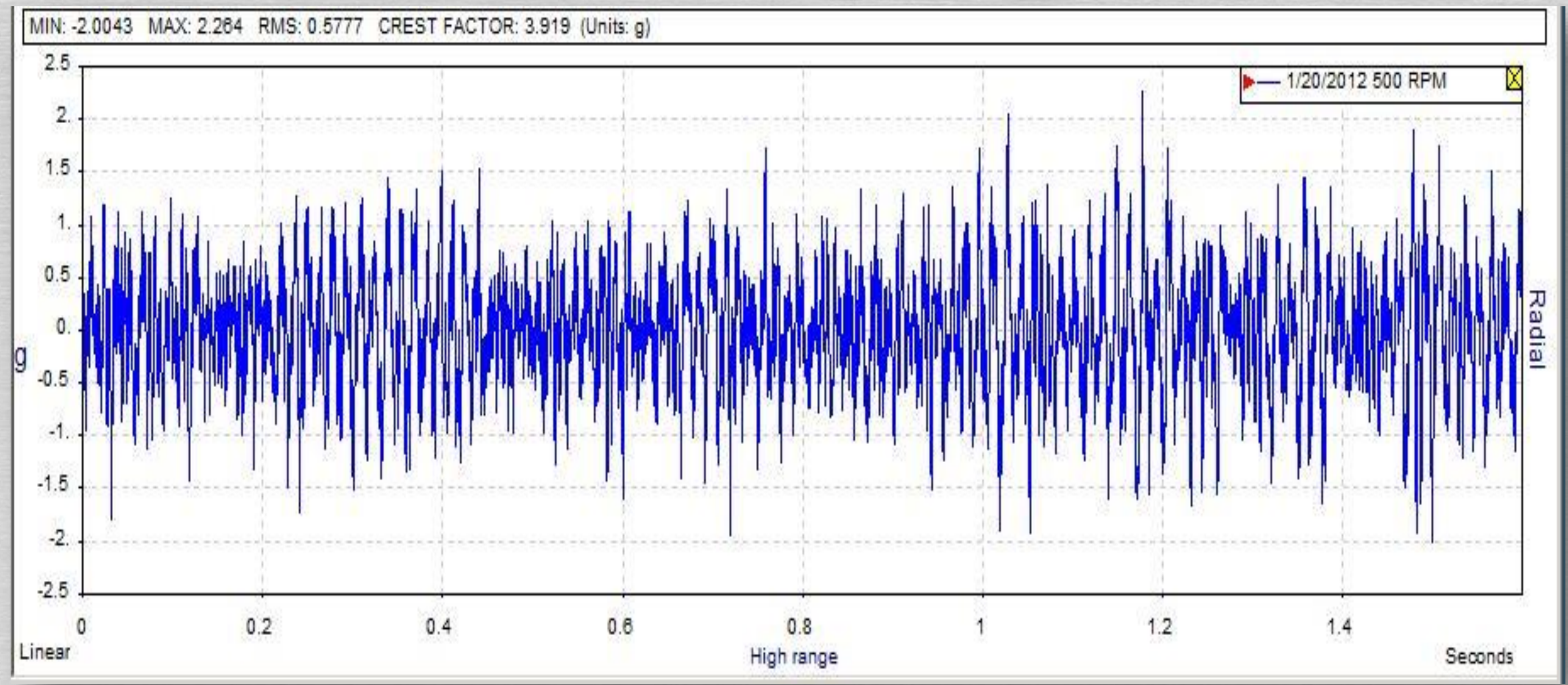
Standard High Range Spectrum



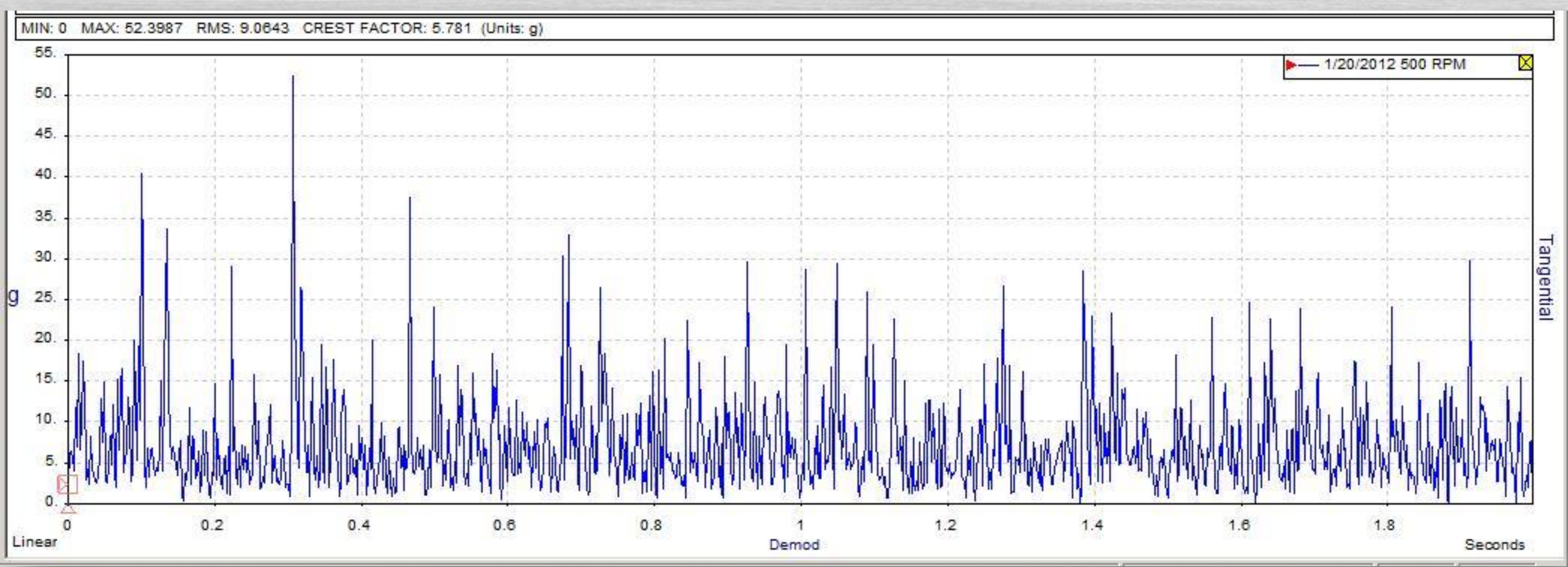
Indication of some HF bearing noise

Slow Speed - Motor Coupled End

High Range Time Waveform



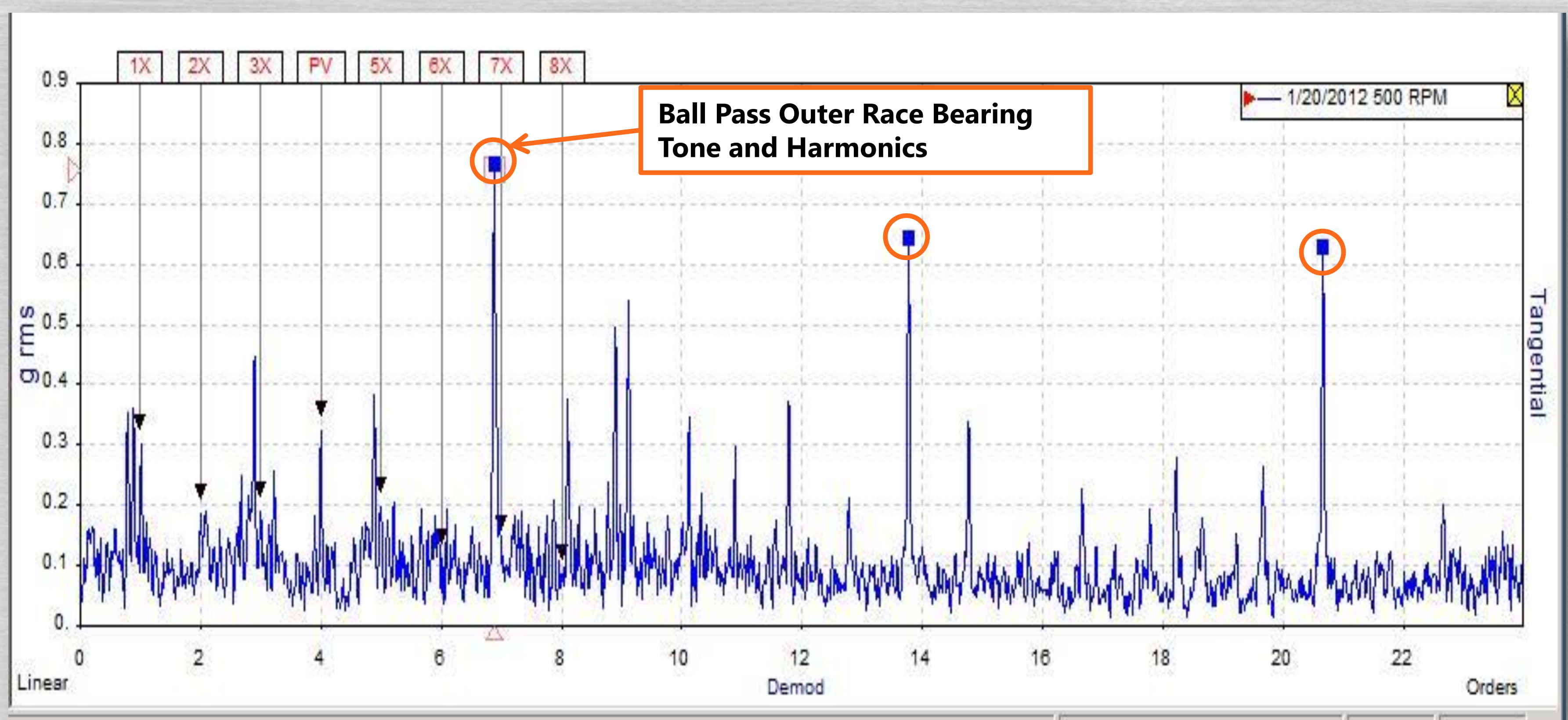
Slow Speed - Motor Coupled End
Impact Demod Waveform



Indication of serious impacting – 52g

Slow Speed - Motor Coupled End

Impact Demod Spectra



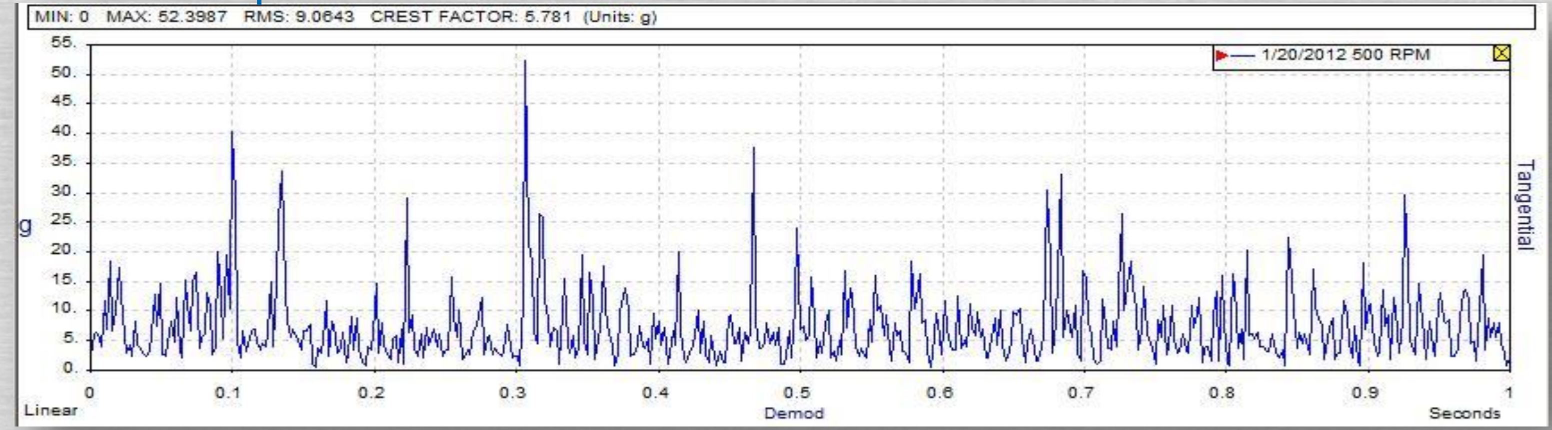
Indication of periodic content at 6.9xM

What Was Found

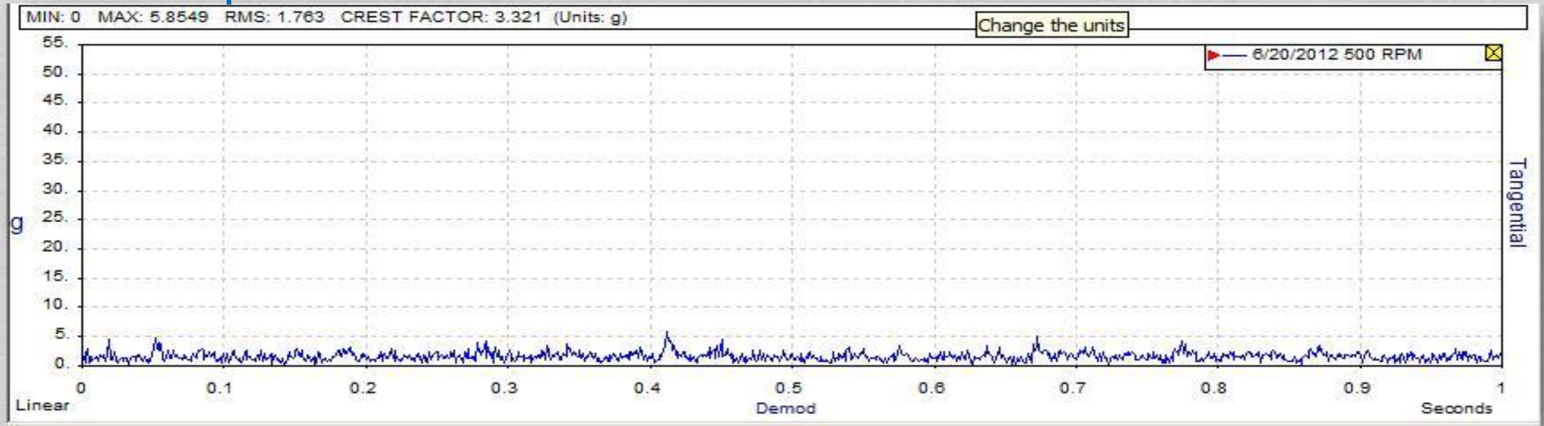
Motor Coupled End

Impact Demod Time Waveform - Comparison

Before Repair



After Repair



Impact Demod

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THANK YOU!


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