

# *What's up with Bump Testing ?*

By: Jack D. Peters

Connection Technology Center, Inc

590 Fishers Station Drive

Victor, New York 14564

(585) 924-5900 x834

[www.ctconline.com](http://www.ctconline.com)



VIBRATION ANALYSIS HARDWARE

# What is a bump test ?

- A bump test is the measured response of an impact to an object.
- The force of the impact is not controlled or measured.
- The response of the object is not controlled, **BUT IS MEASURED.**
- A single channel response measurement.

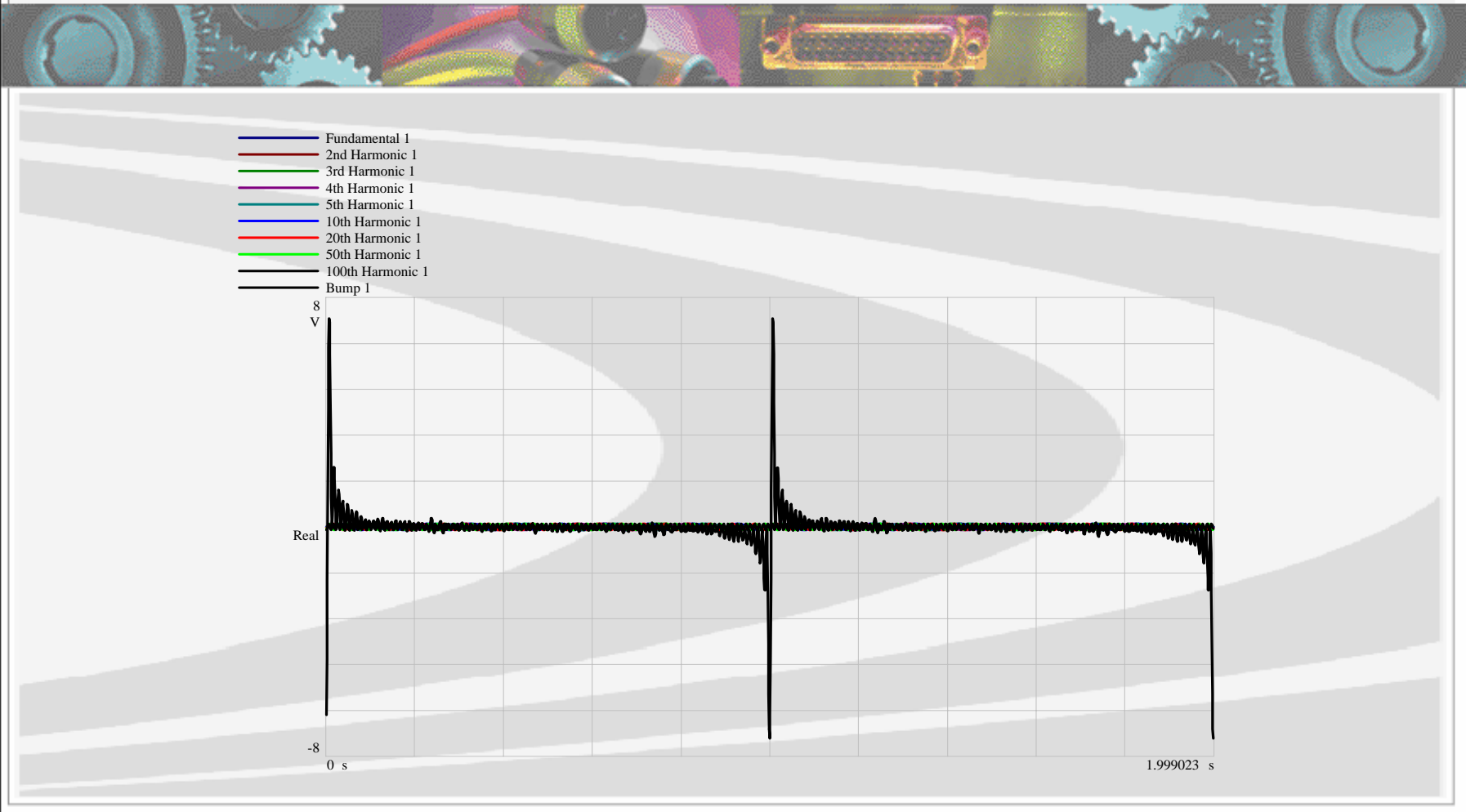
# Why do a bump test ?

- To excite and measure the natural frequency(s) of an object.
  - ✓ To identify a resonance
  - ✓ To understand a change in mass
  - ✓ To understand a change in stiffness
  - ✓ To understand a change in damping



## Bump Testing

# How does it work ?



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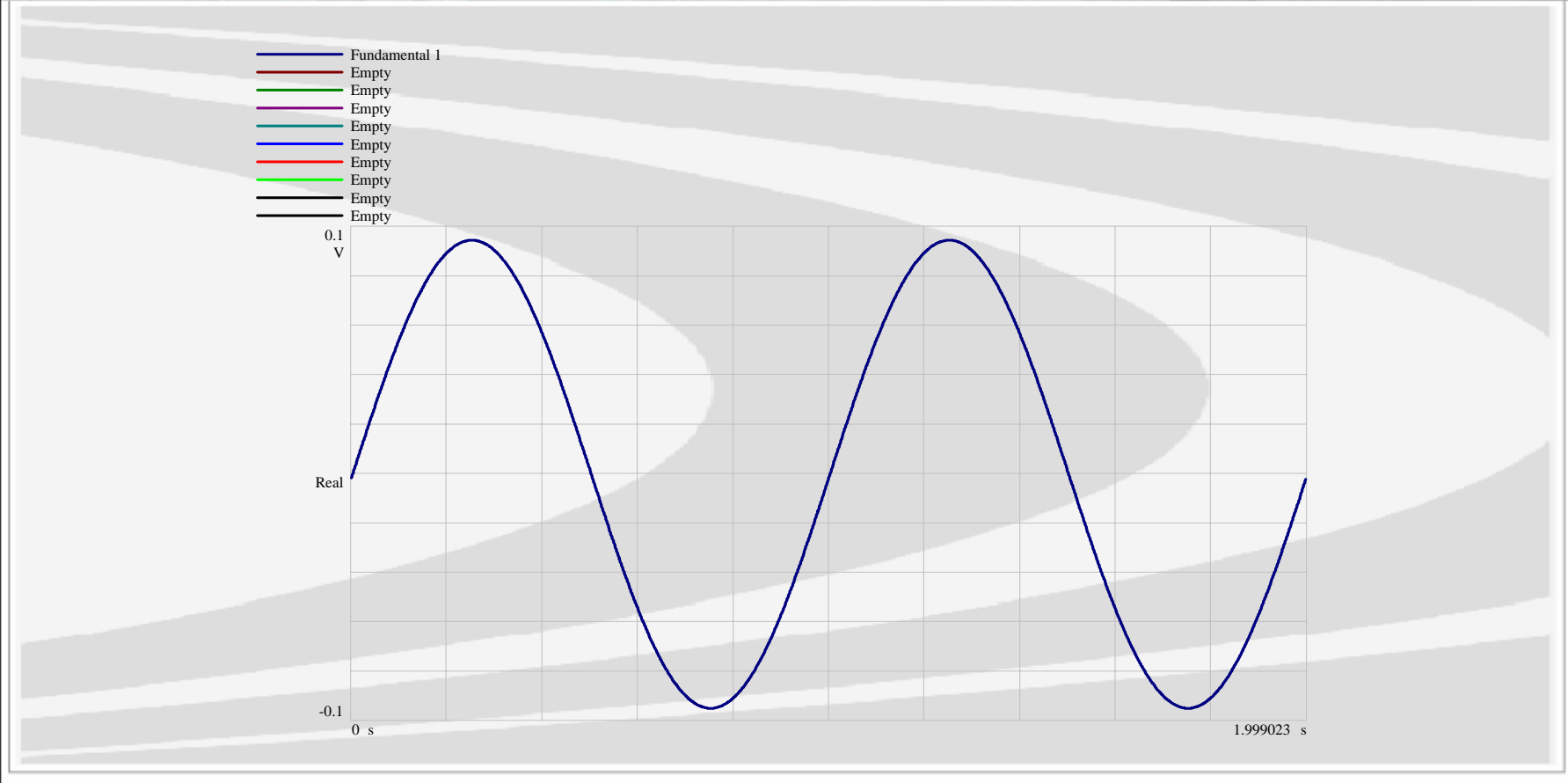
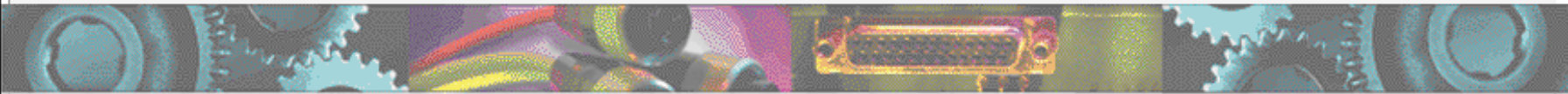
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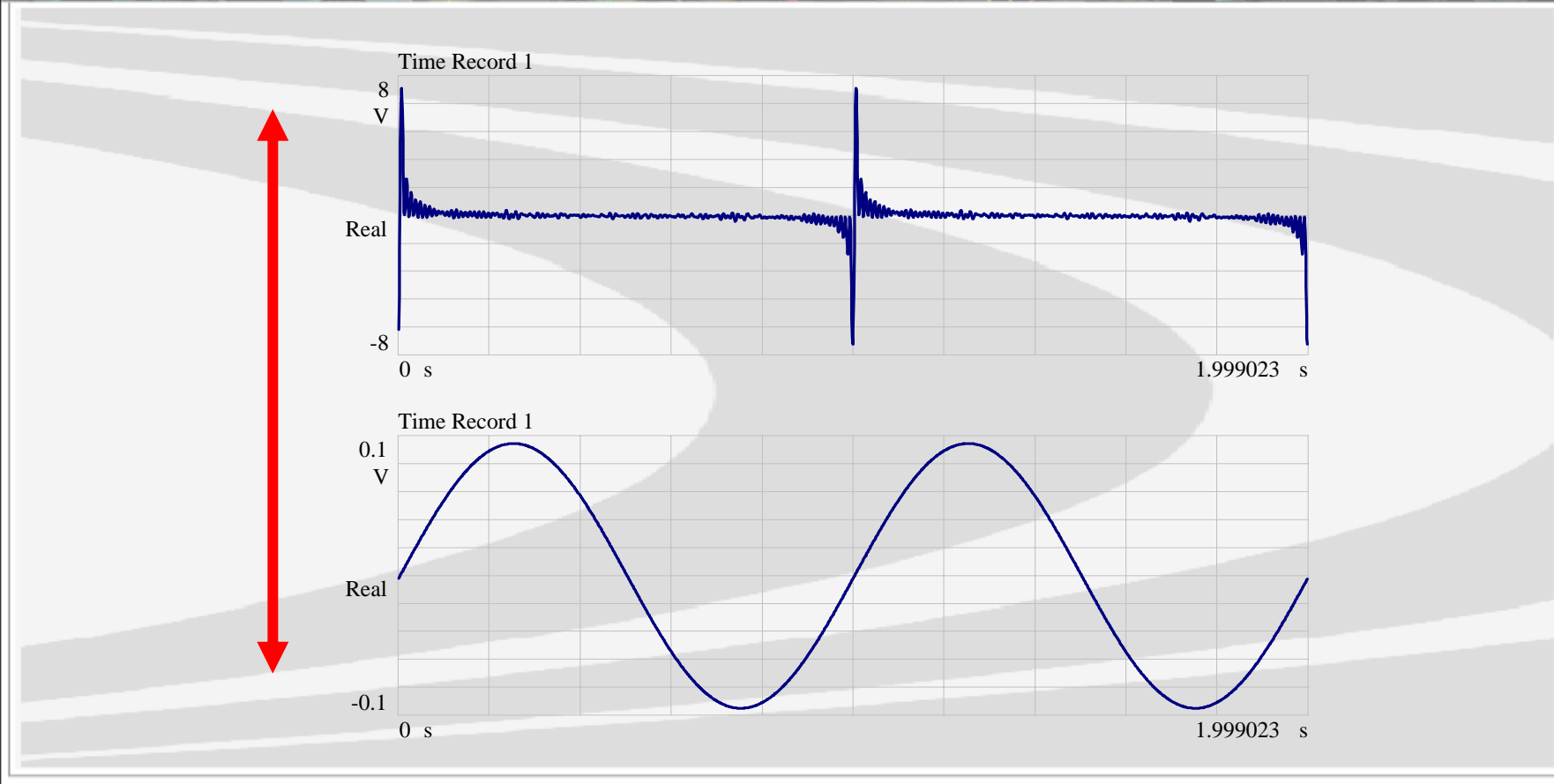
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# Sine Waves ?



## Bump Testing

# Bumps from Sine Waves ?



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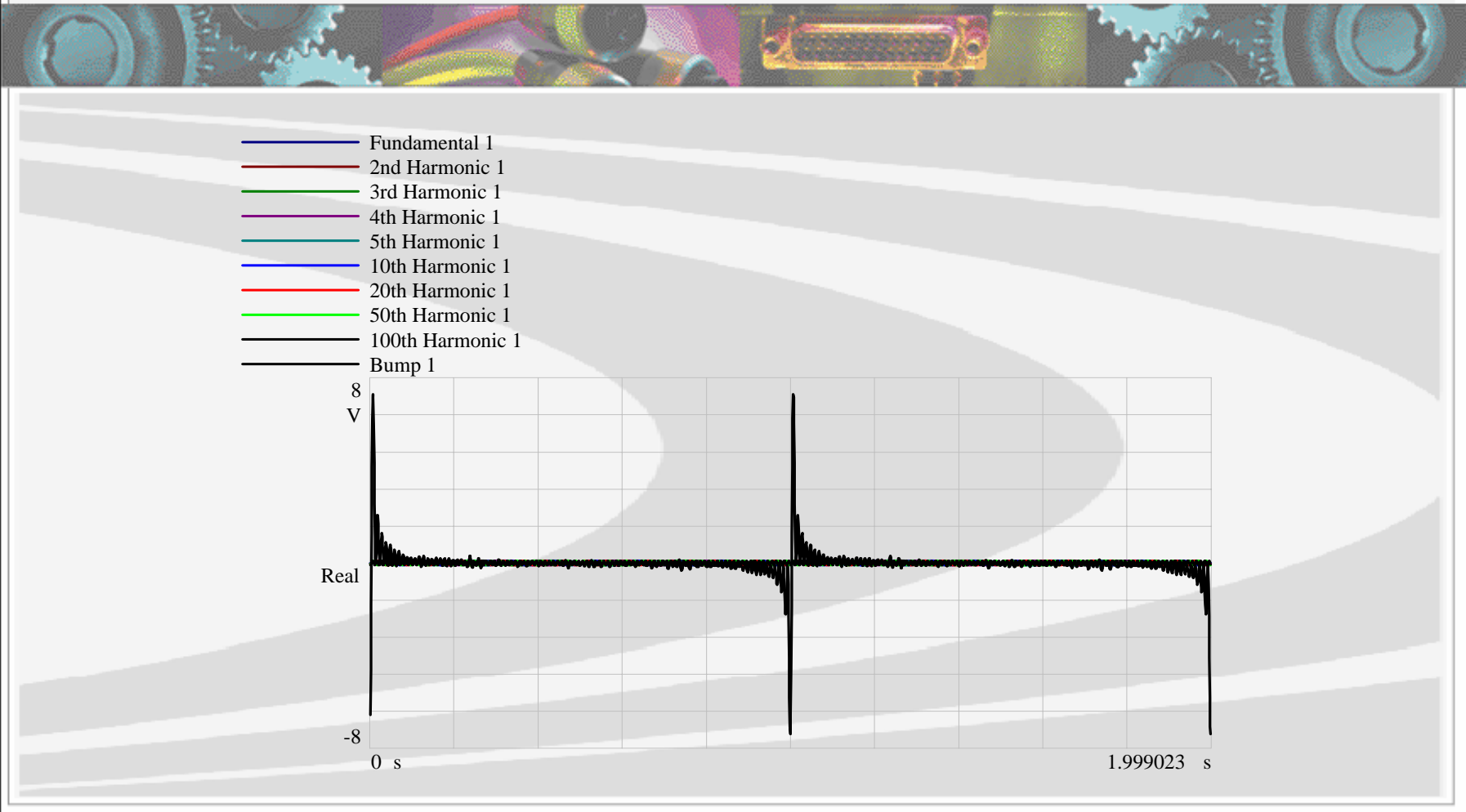
6



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## Bump Testing

# 100<sup>th</sup> Harmonic



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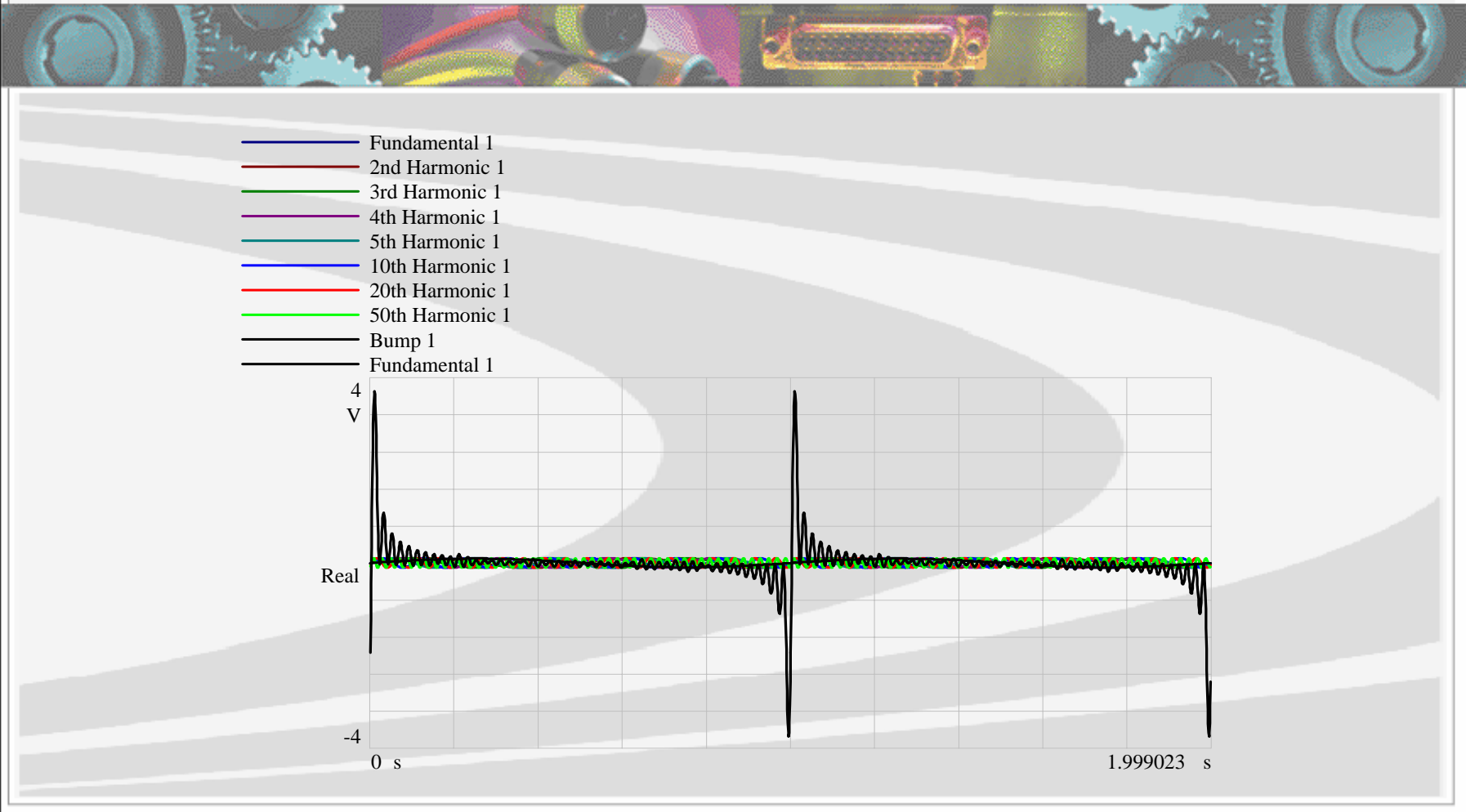


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## Bump Testing

# 50<sup>th</sup> Harmonic



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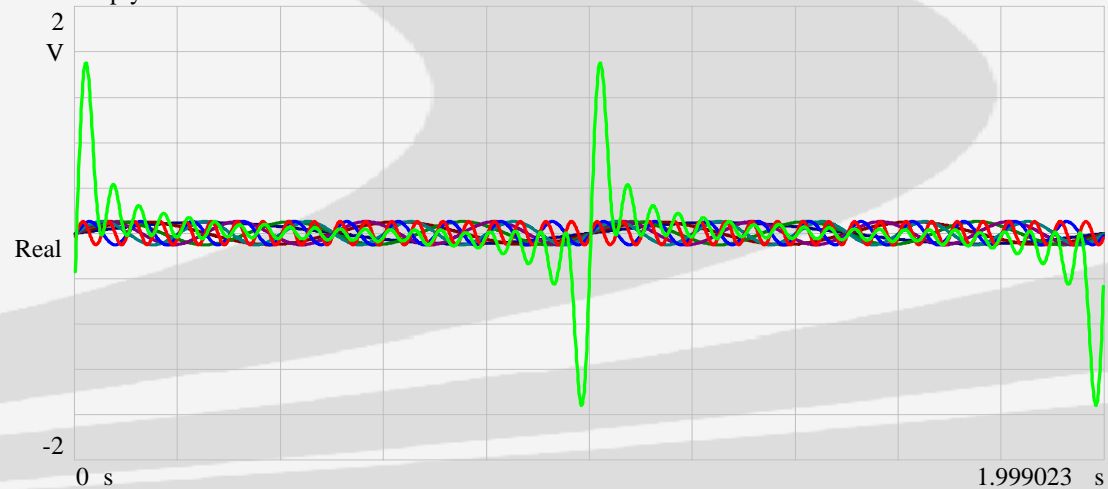
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## Bump Testing

# 20<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- 10th Harmonic 1
- 20th Harmonic 1
- Bump 1
- Empty
- Empty



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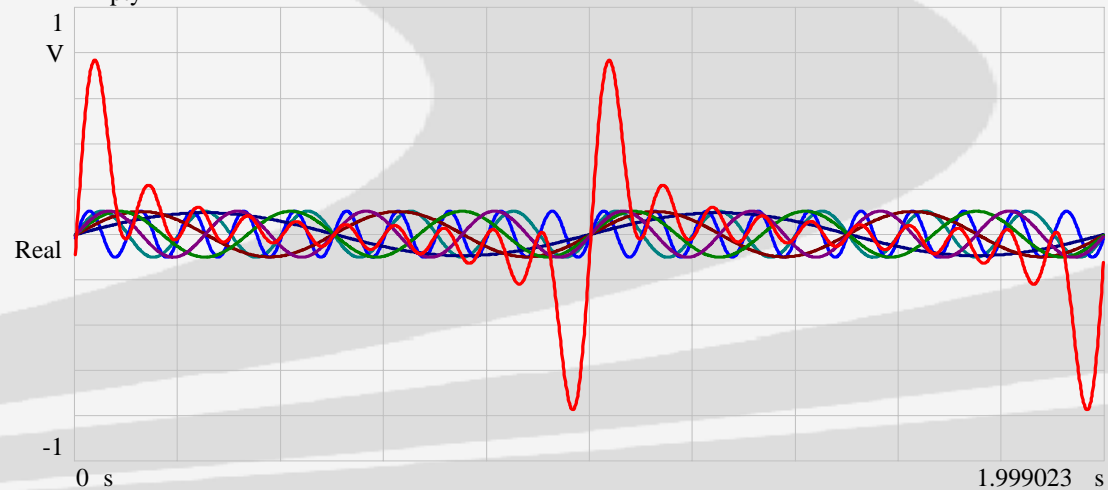


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## Bump Testing

# 10<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- 10th Harmonic 1
- Bump 1
- Empty
- Empty
- Empty



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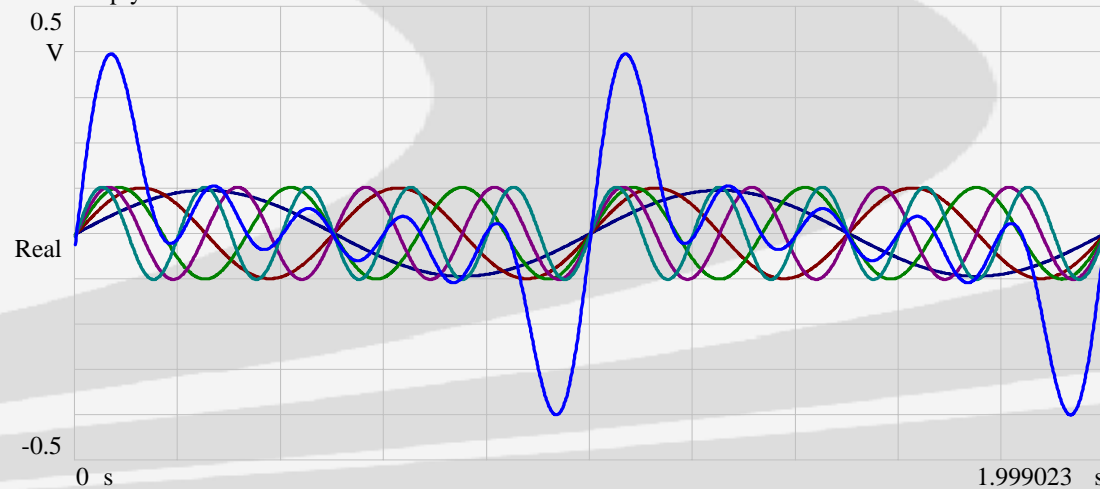


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## Bump Testing

# 5<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- Bump 1
- Empty
- Empty
- Empty
- Empty



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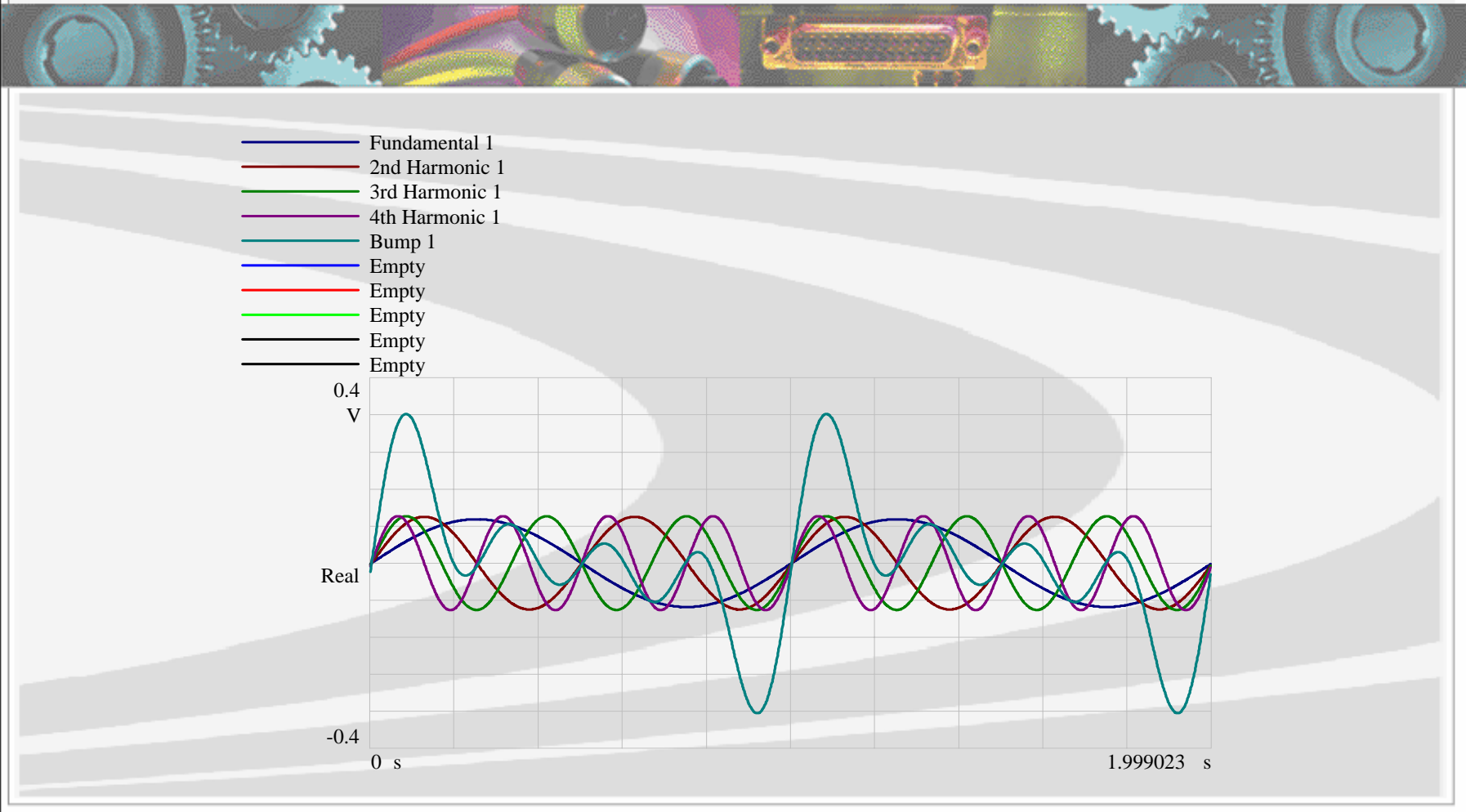
11



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## Bump Testing

# 4<sup>th</sup> Harmonic



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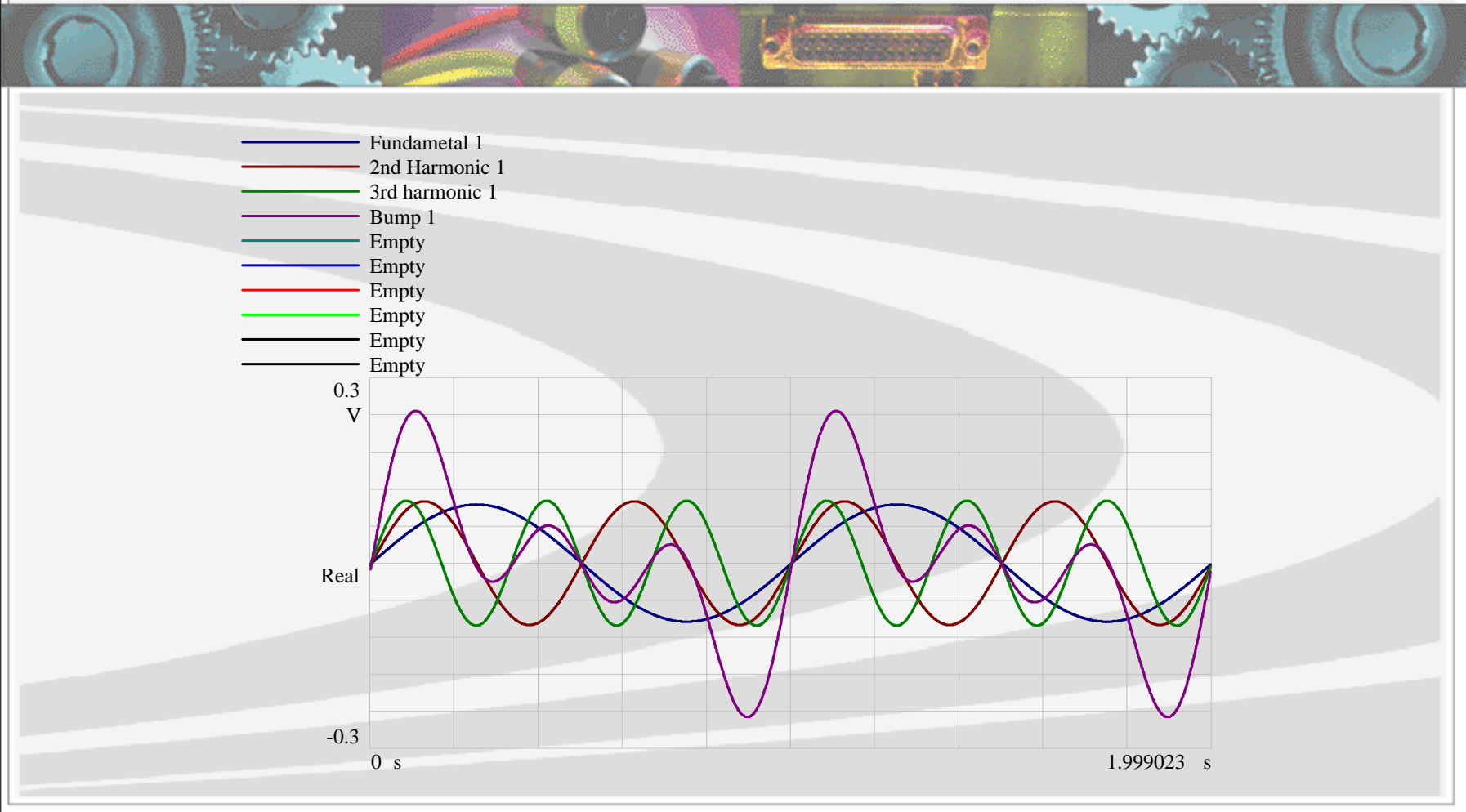
12



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## Bump Testing

# 3<sup>rd</sup> Harmonic



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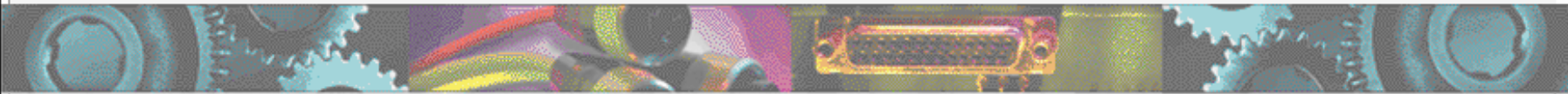
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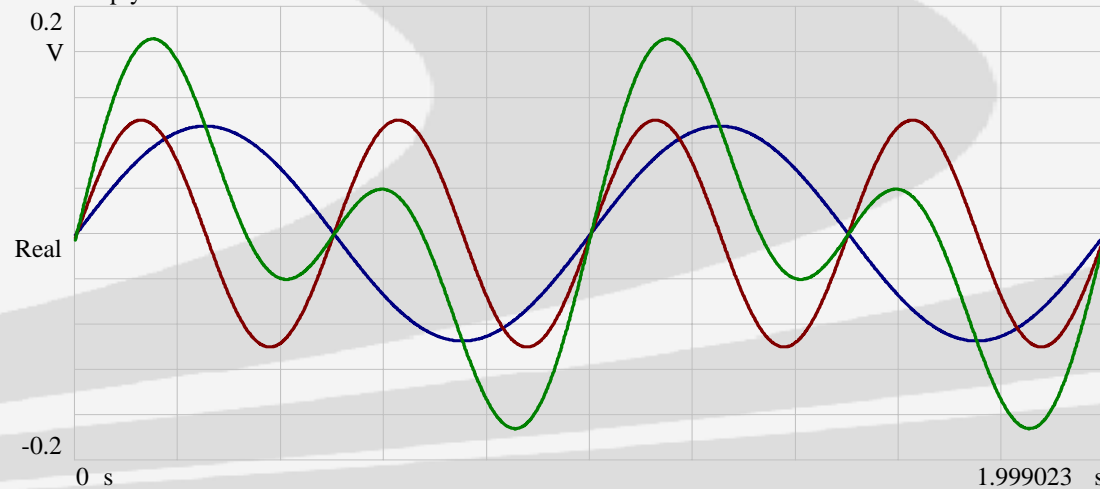
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## Bump Testing

# 2<sup>nd</sup> Harmonic



- Fundamental 1
- 2nd Harmonic 1
- Bump 1
- Empty
- Empty
- Empty
- Empty
- Empty
- Empty
- Empty
- Empty



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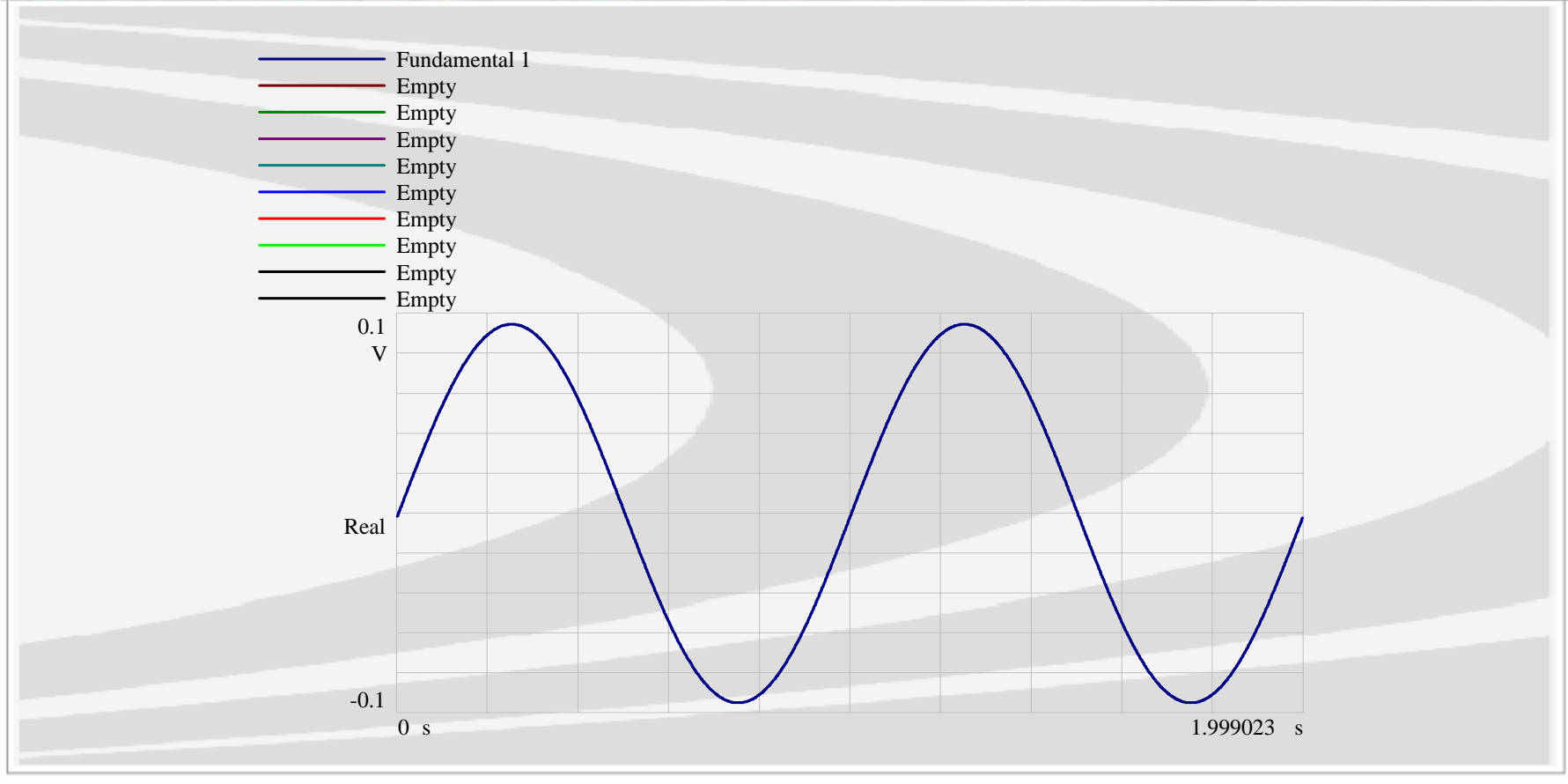
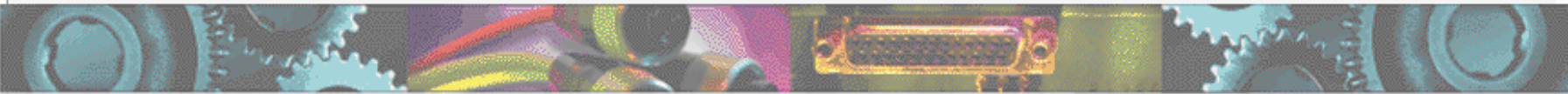
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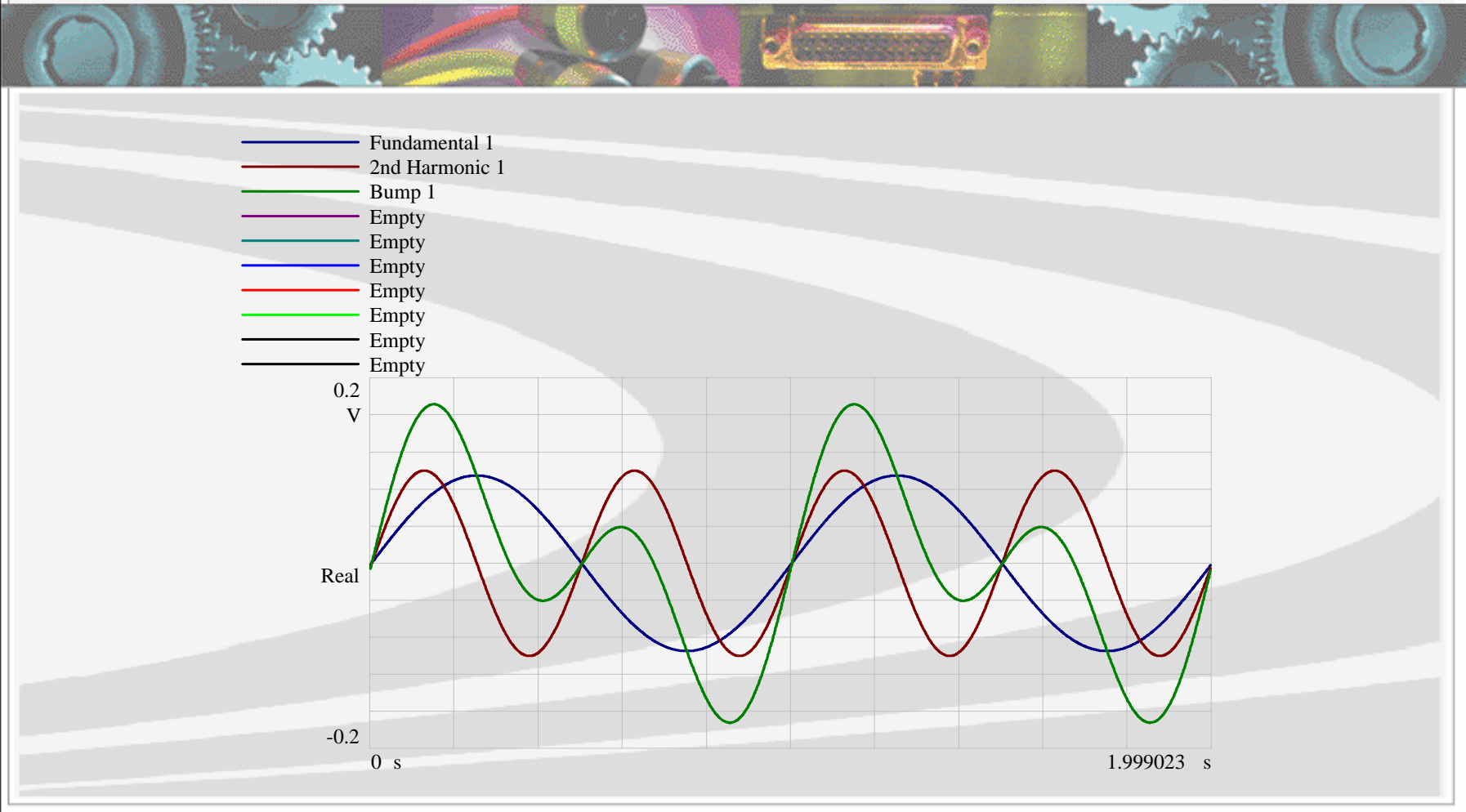
# Fundamental





## Bump Testing

# 2<sup>nd</sup> Harmonic



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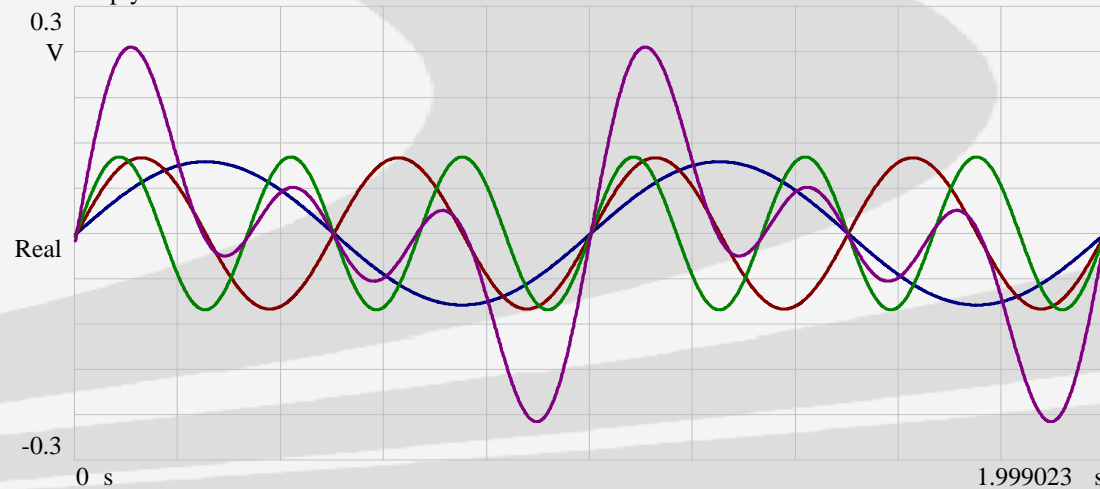
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## Bump Testing

# 3<sup>rd</sup> Harmonic



- Fundametal 1
- 2nd Harmonic 1
- 3rd harmonic 1
- Bump 1
- Empty
- Empty
- Empty
- Empty
- Empty
- Empty
- Empty



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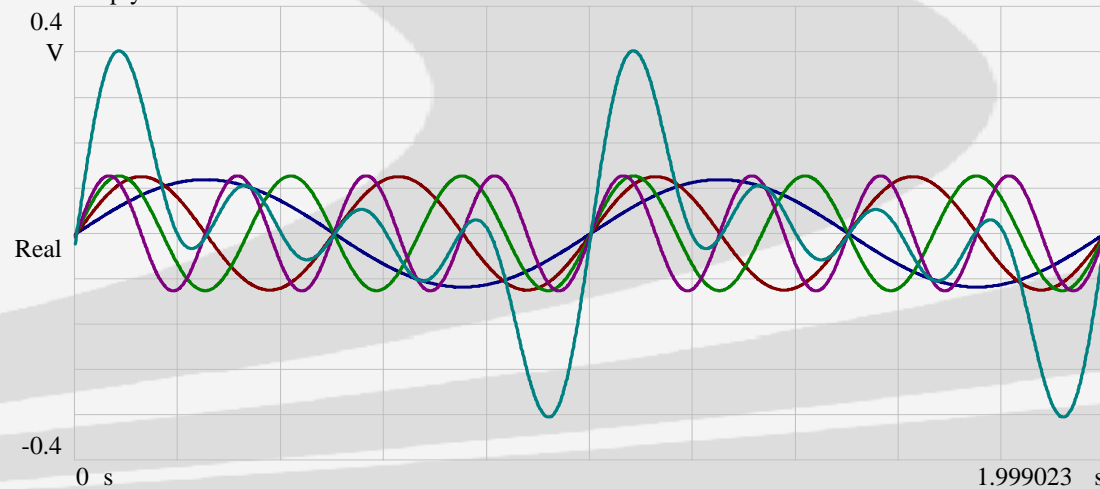


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## Bump Testing

# 4<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- Bump 1
- Empty
- Empty
- Empty
- Empty
- Empty



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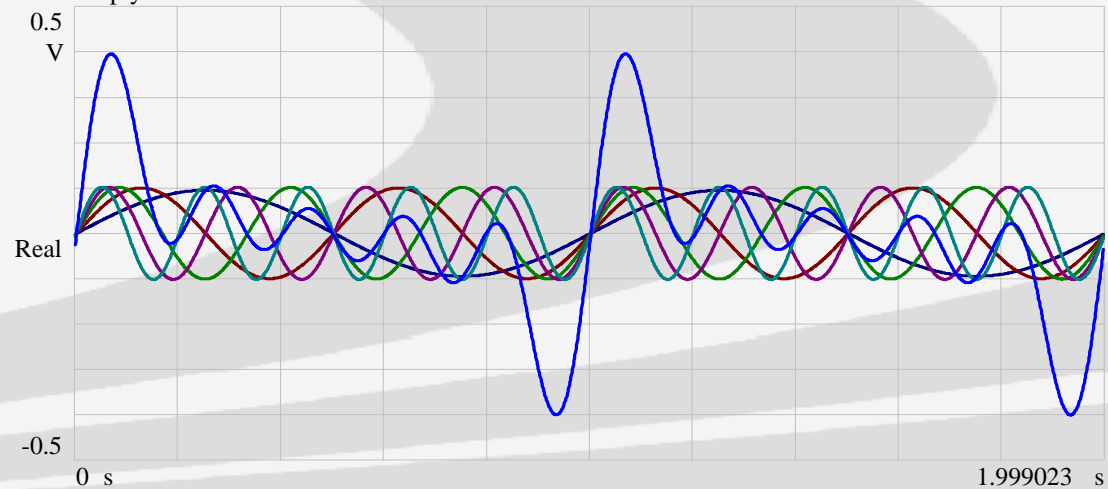


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## Bump Testing

# 5<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- Bump 1
- Empty
- Empty
- Empty
- Empty



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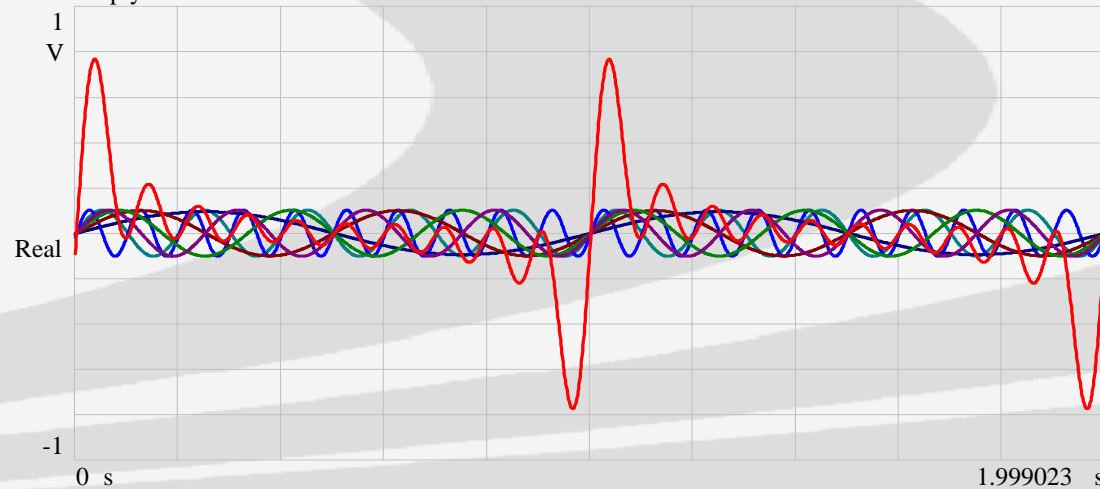


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## Bump Testing

# 10<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- 10th Harmonic 1
- Bump 1
- Empty
- Empty
- Empty



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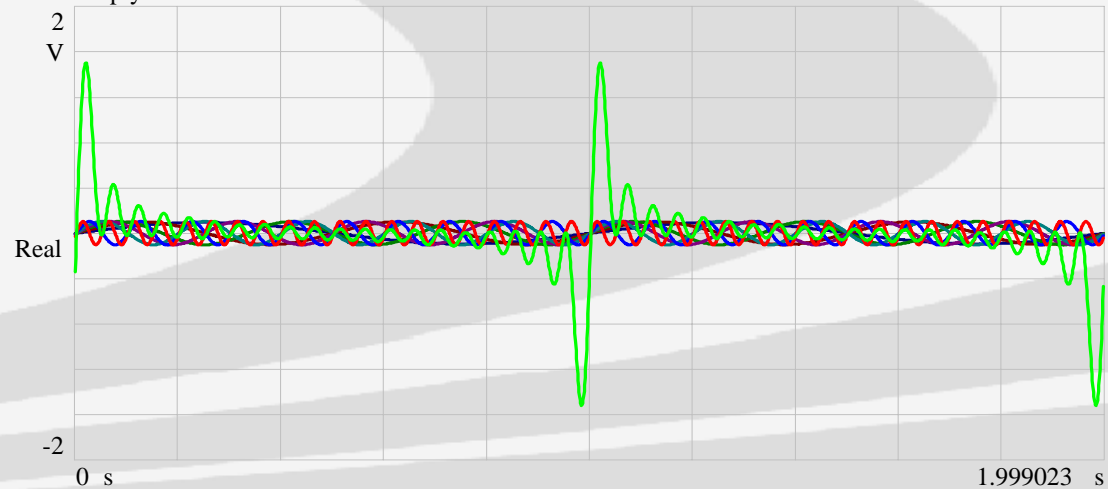


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## Bump Testing

# 20<sup>th</sup> Harmonic

- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- 10th Harmonic 1
- 20th Harmonic 1
- Bump 1
- Empty
- Empty



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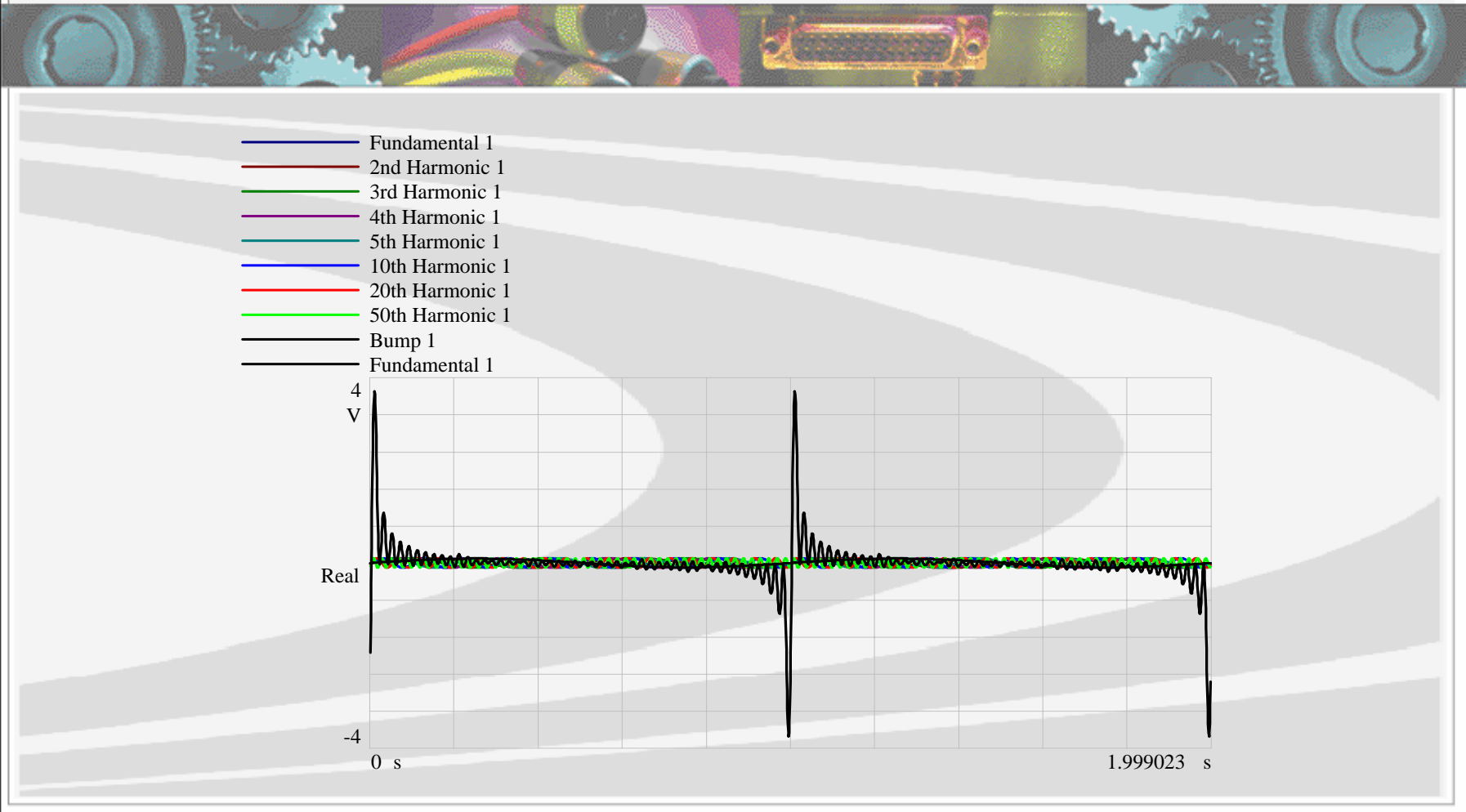
21



VIBRATION ANALYSIS HARDWARE

## Bump Testing

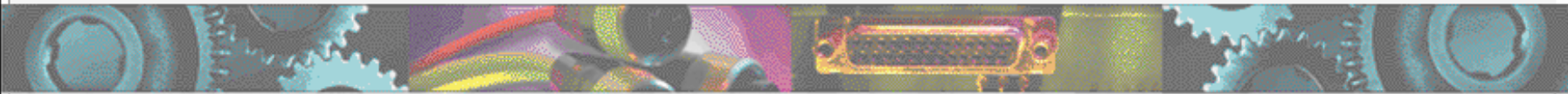
# 50<sup>th</sup> Harmonic



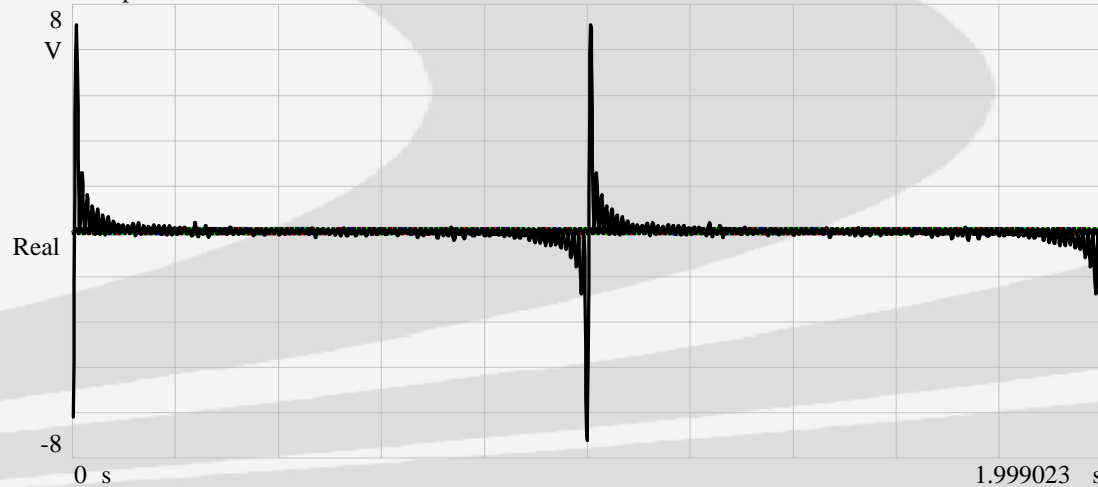


## Bump Testing

# 100<sup>th</sup> Harmonic



- Fundamental 1
- 2nd Harmonic 1
- 3rd Harmonic 1
- 4th Harmonic 1
- 5th Harmonic 1
- 10th Harmonic 1
- 20th Harmonic 1
- 50th Harmonic 1
- 100th Harmonic 1
- Bump 1



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# How does it work ?

- Bump testing or impact testing works because the bump or impact contains all of the individual frequencies or sign waves.
- When you bump or impact the object under test, you will excite all of the natural frequencies of that object.



# What do you impact with ?

## ➤ Pin Drops !

- ✓ High frequency content
- ✓ Low energy value



## ➤ Cow Plops !

- ✓ Low frequency content
- ✓ High energy value



# Energy Value vs. Frequency

- The item used to deliver the impact to the object under test will determine the energy that is delivered to the object.
  - ✓ Large objects with considerable mass should be impacted with rubber or wood. This will generate high energy low frequency responses. (cow plops)
  - ✓ Small objects with considerable stiffness should be impacted with metal or hard plastics. This will generate low energy high frequency responses. (pin drops)

# Set-up

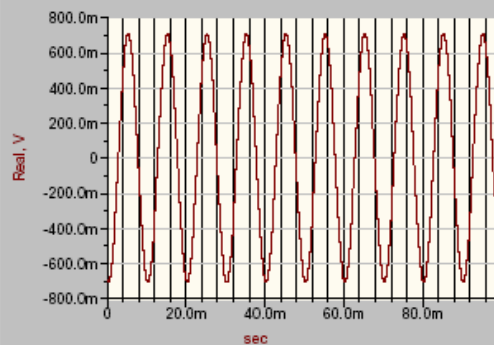
## ➤ UNIFORM WINDOW

- Take your time – Bump around
- Do not over range or clip the input signal
- 800 – 1600 lines of resolution
- Try some different frequency spans
- Only 1 bump for each time record
- About 4 averages (depends on noise)

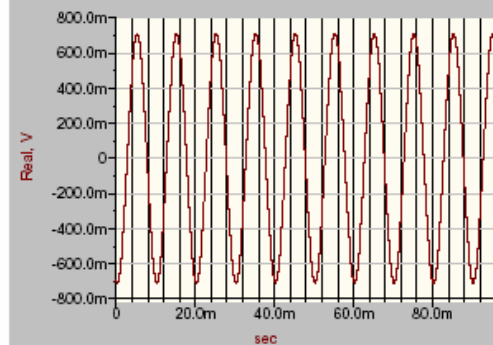
## Bump Testing

# Why the Uniform Window ?

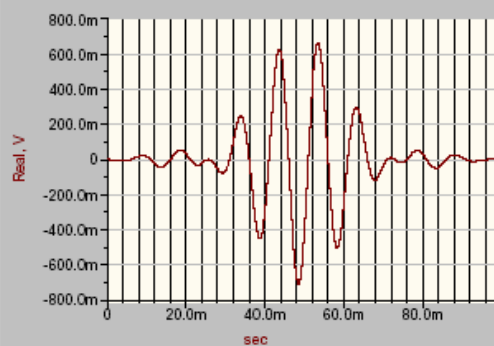
Run00008 Real Time



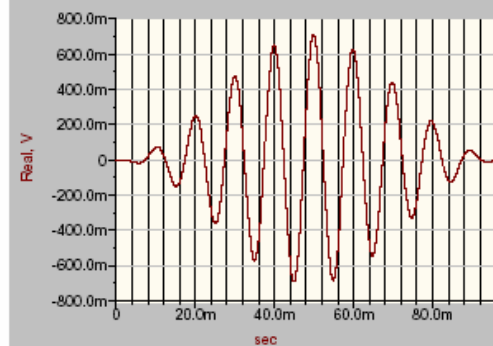
Run00008 Uniform



Run00010 Flat Top



Run00009 Hanning



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# What to Bump ?

- 1" diameter steel round stock
- 36" length
- Clamped in "V" blocks at each end
- CTC AC140 accelerometer stud mounted on center (100 mV/g)

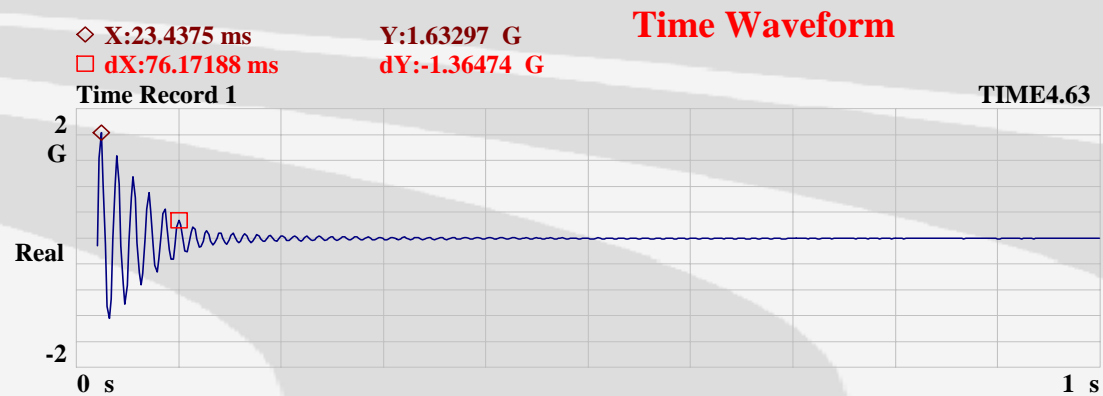




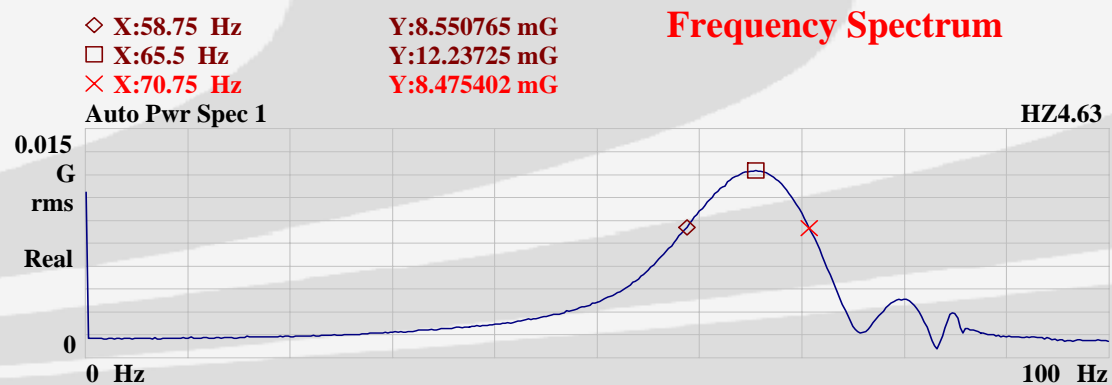
# Bump It ! Two Responses !



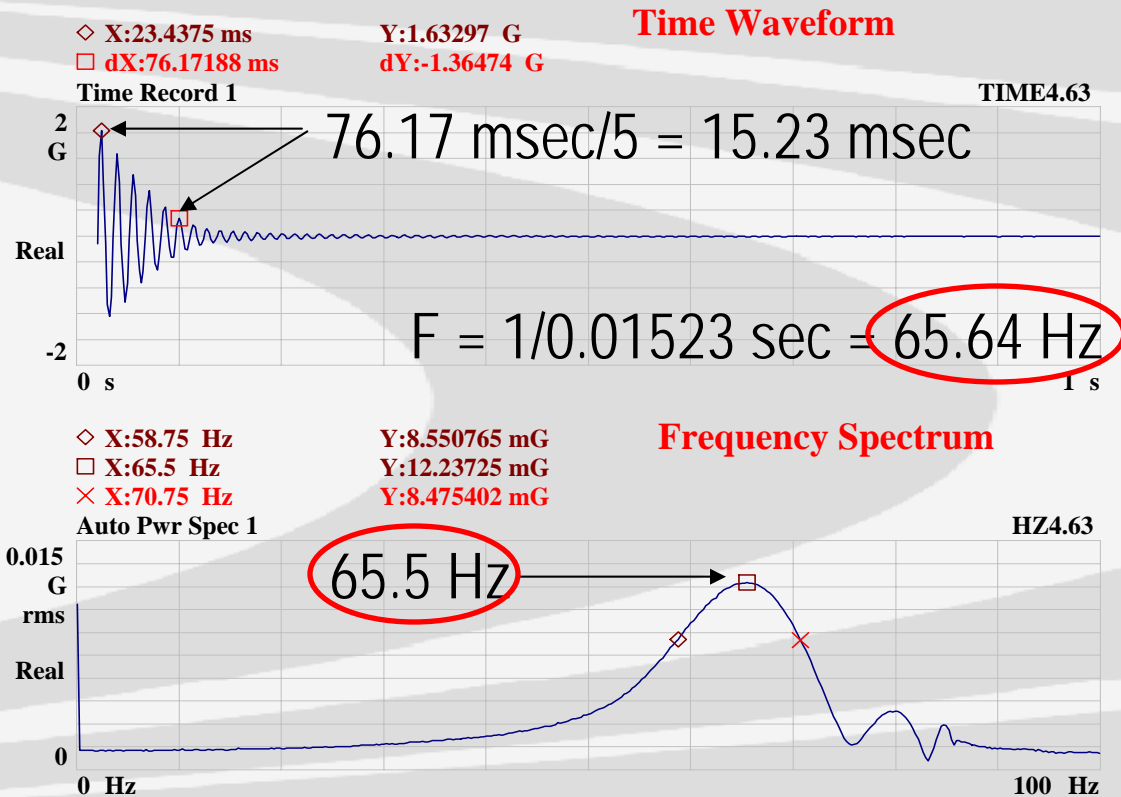
**TIME**



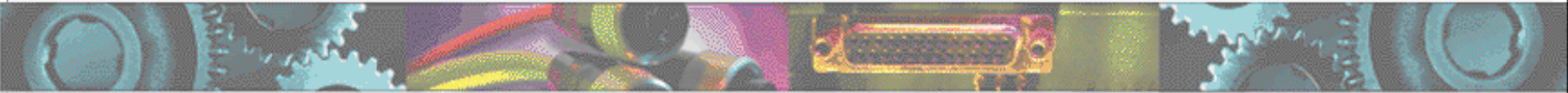
**FREQUENCY**



# Mental Health Check !



# CASE HISTORY

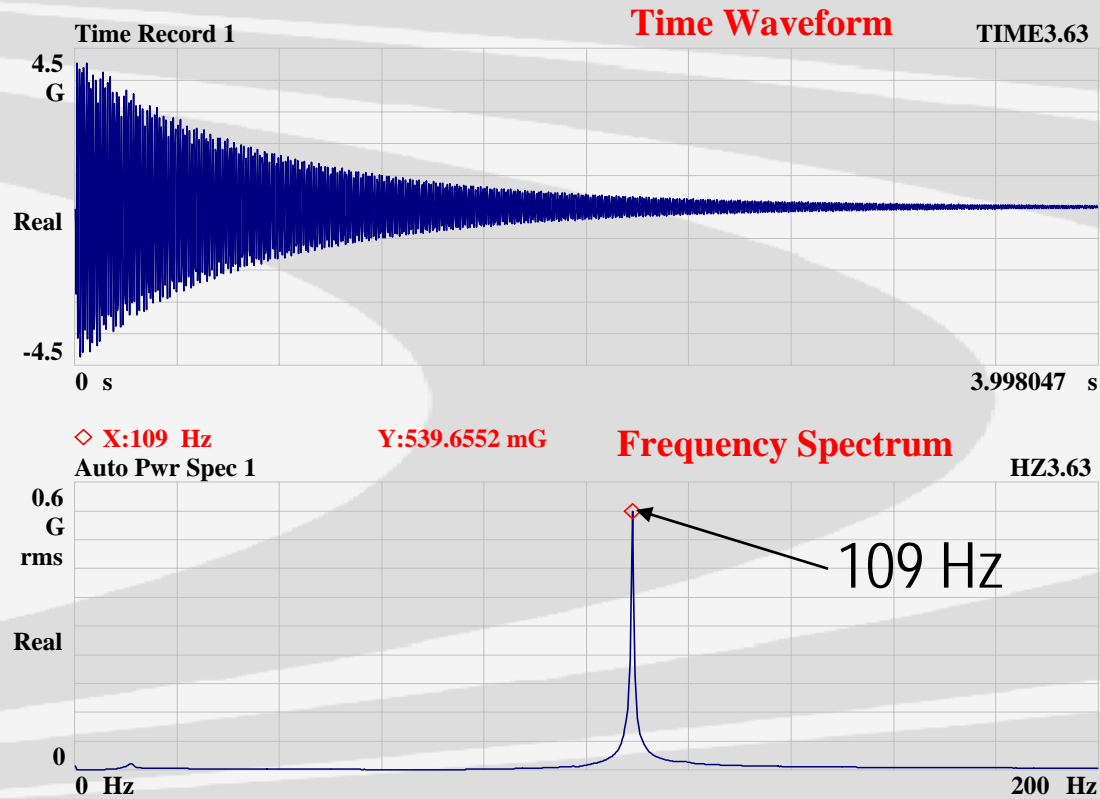
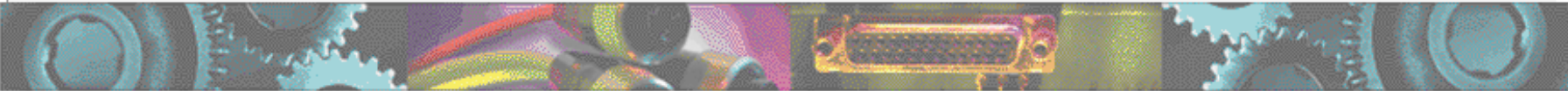


Bumps in the Road !

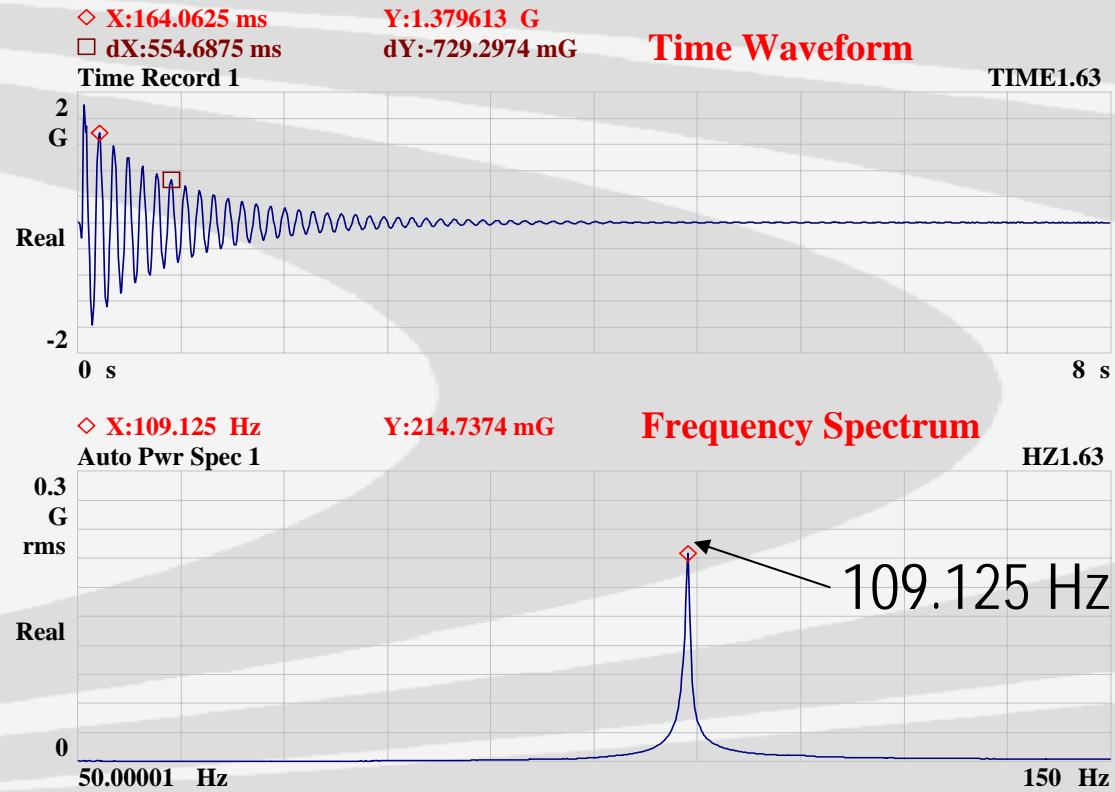
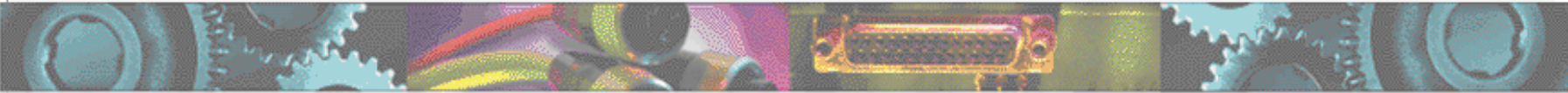


Case History

# So Easy !!!!!

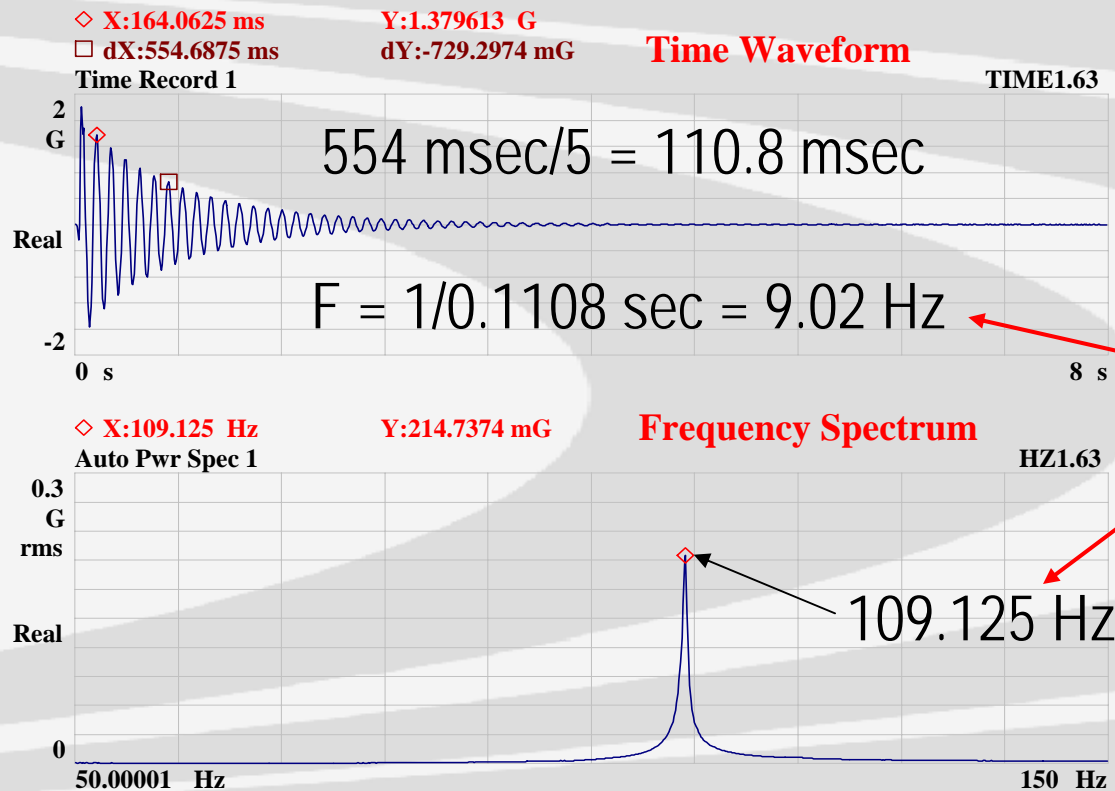


# Zoom



## Case History

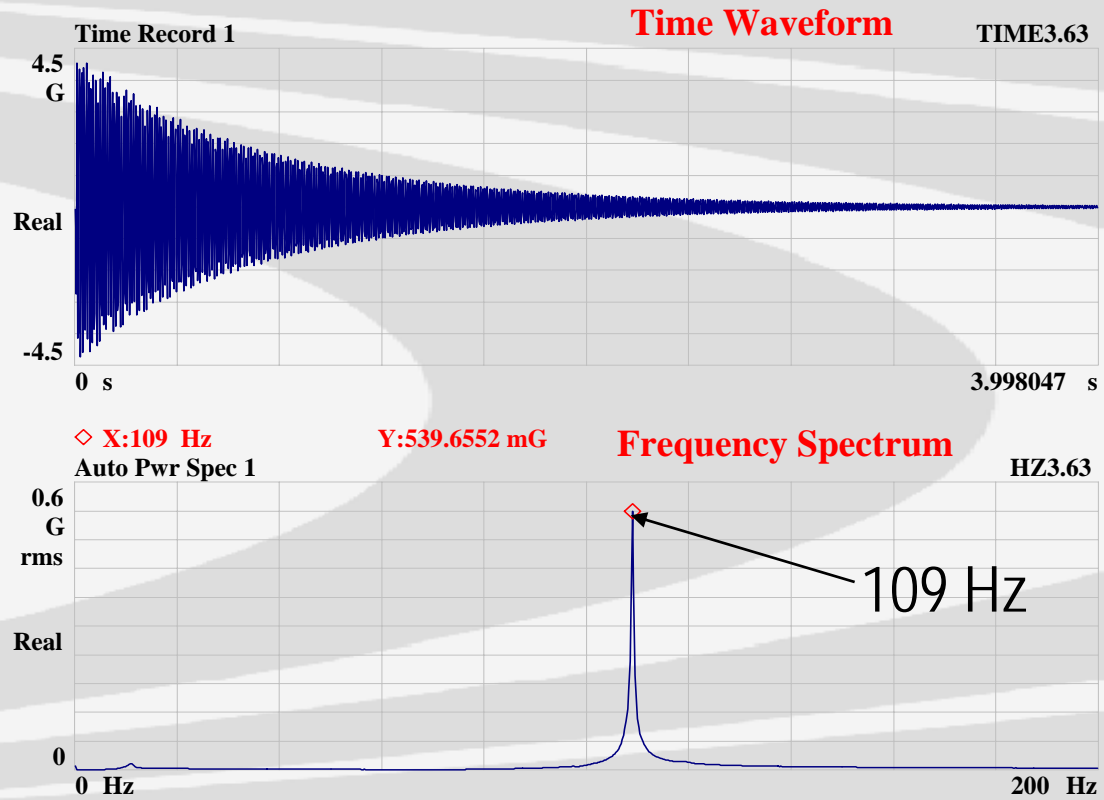
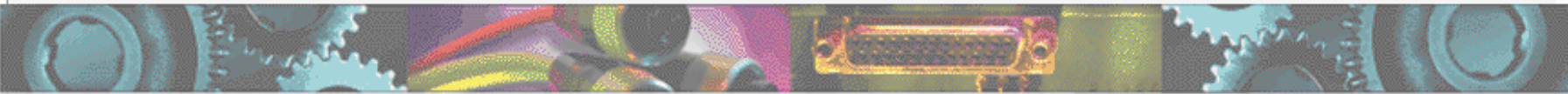
# Zoom & Mental Health Check



What  
the  
He\_\_!

Case History

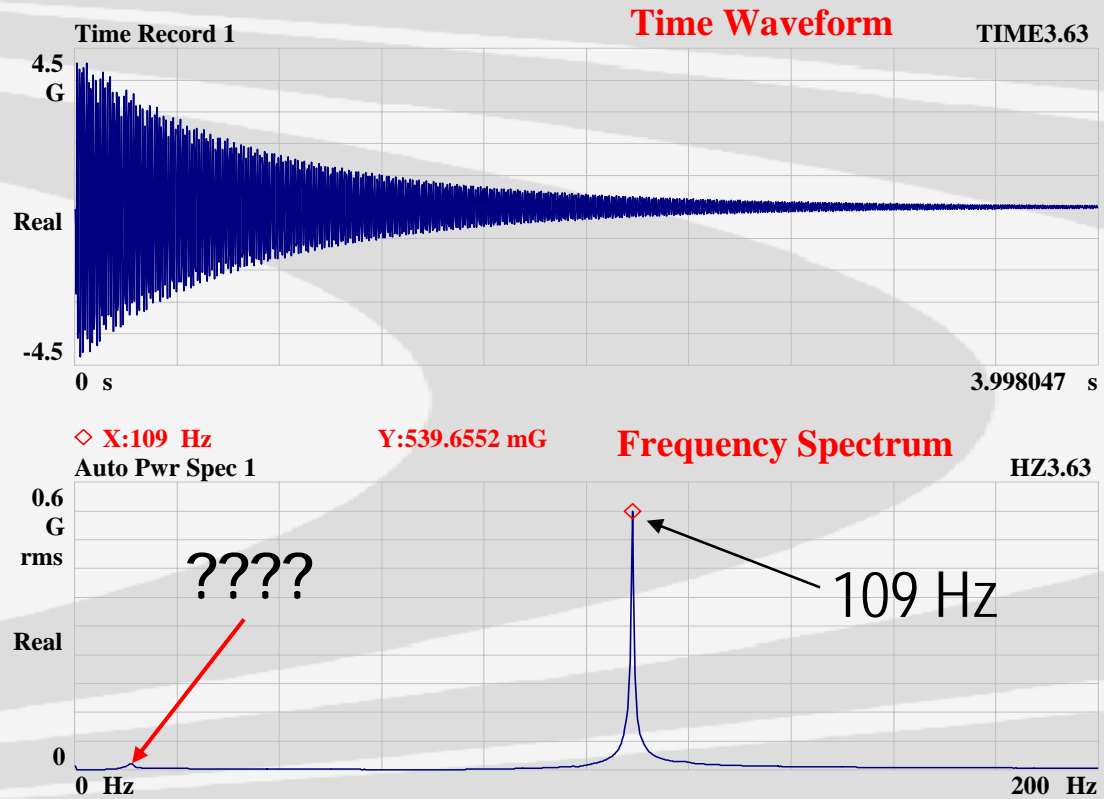
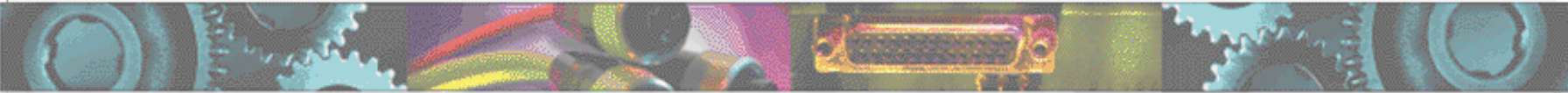
# So Easy ???????





Case History

# What's This ?



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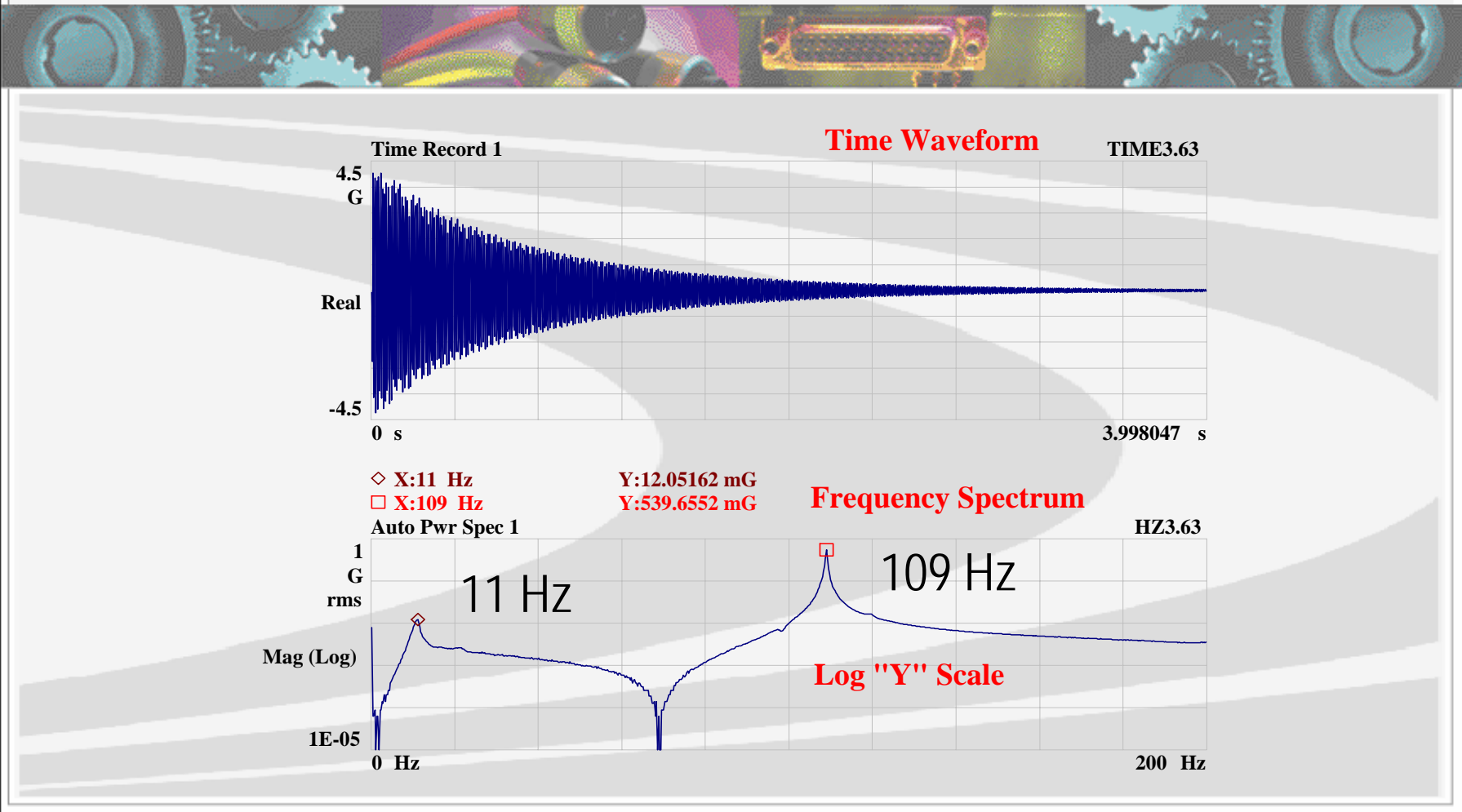
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## Case History

# Log – Can't Live With It, Can't Live Without It !



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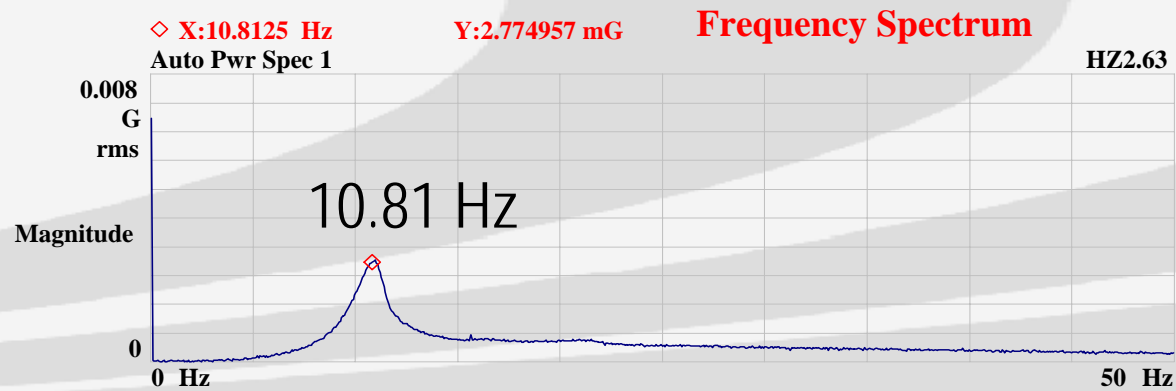
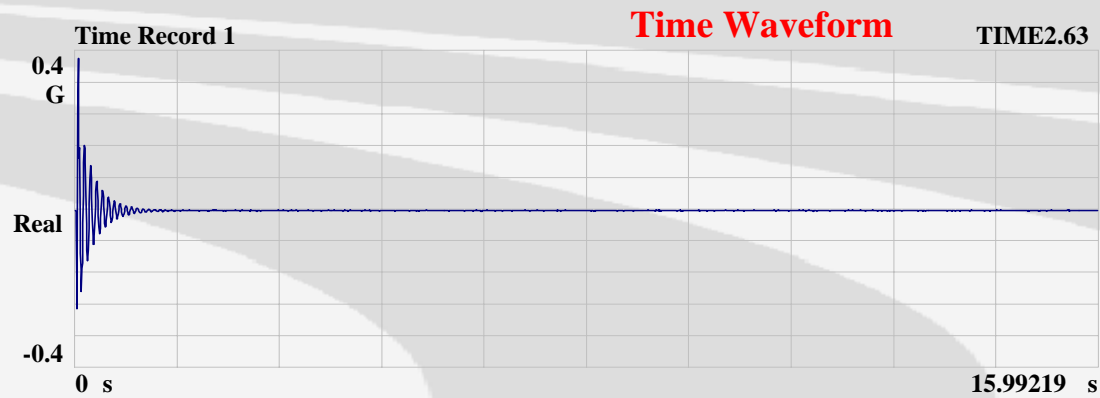
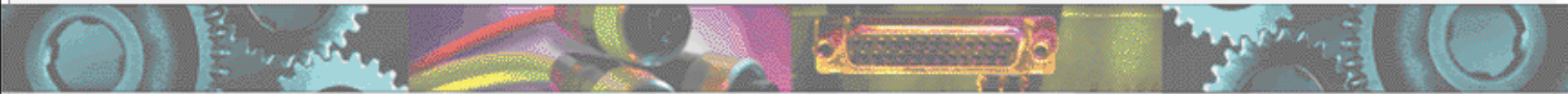
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## Case History

# 0 – 50 Hz Span



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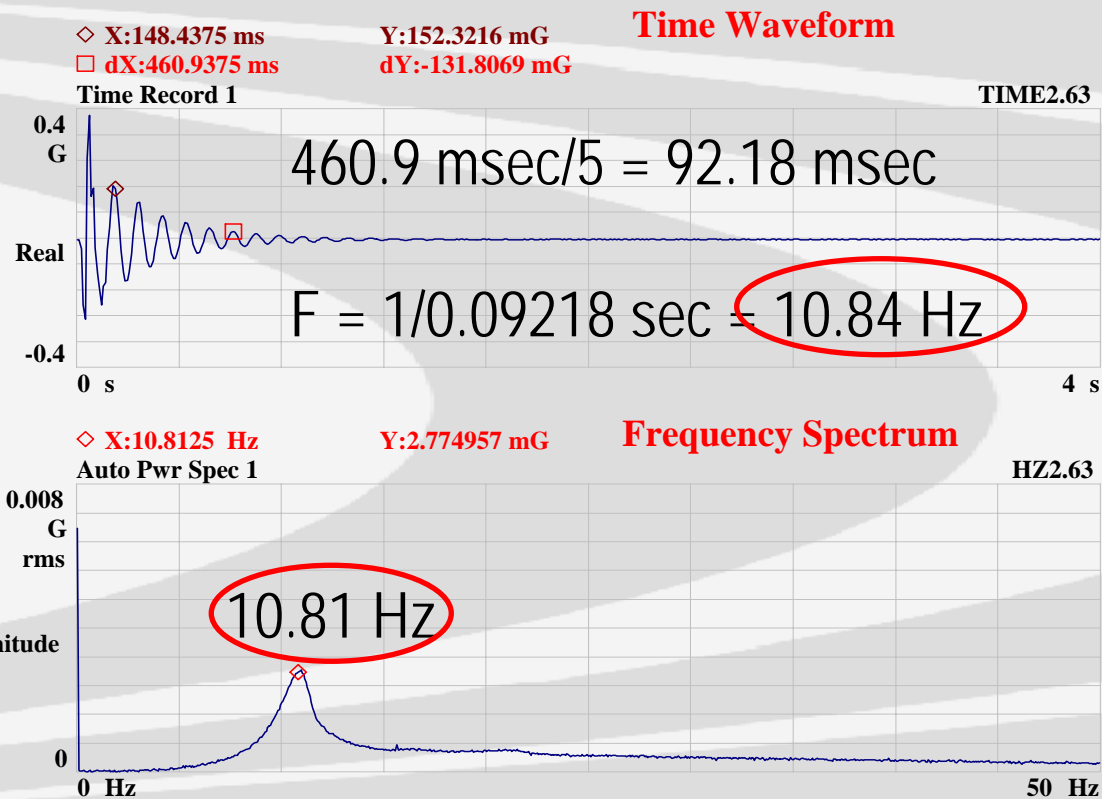
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## Case History

# 0 - 50 Hz (expanded "x" scale)



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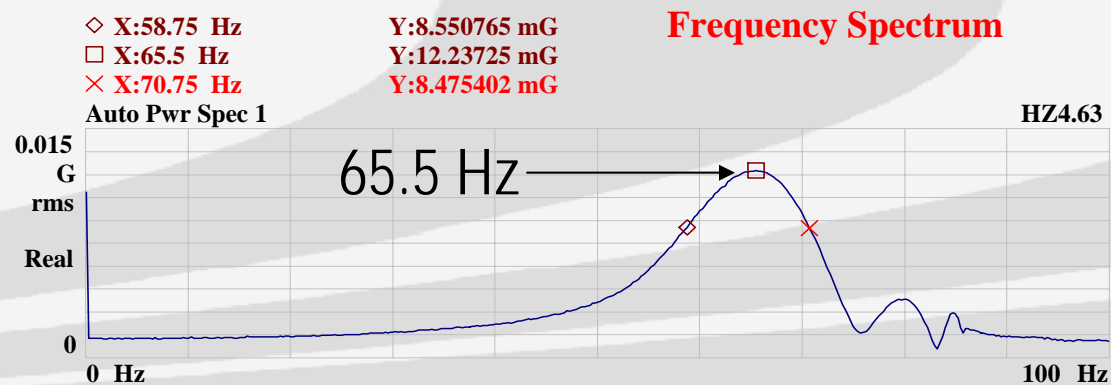
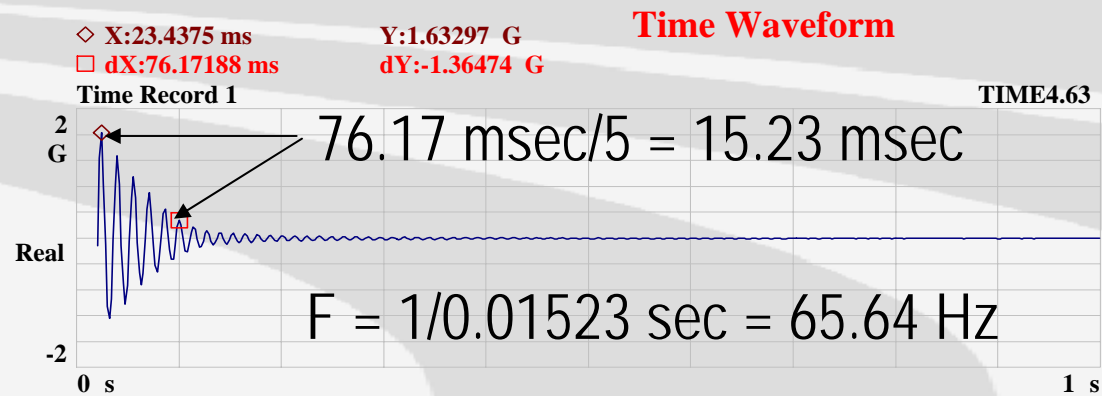
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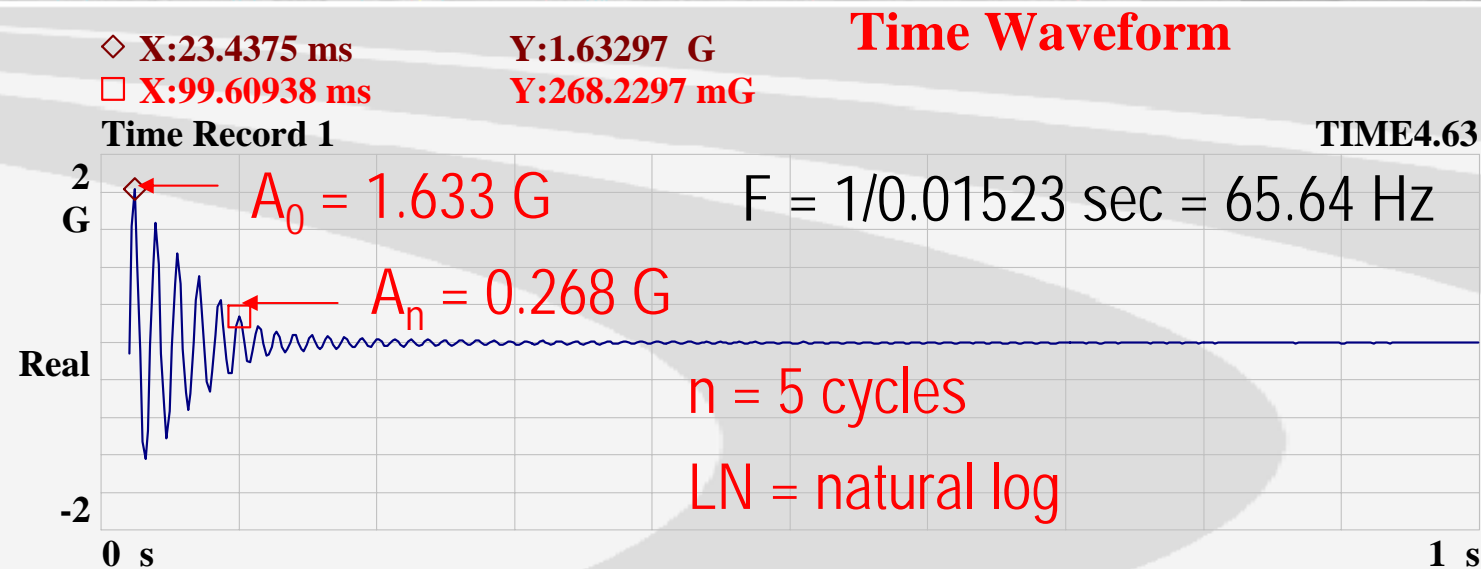


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# Back to Bump Testing



# Using the Time Waveform



$$\text{Log decrement} = [1/n[\text{LN}(A_0/A_n)]] = [1/5[\text{LN}(1.633/0.268)]] = 0.36$$

$$\text{Damping ratio} = \text{Log dec}/2\text{Pi} = 0.36/2\text{Pi} = 0.36/6.28 = 0.057$$

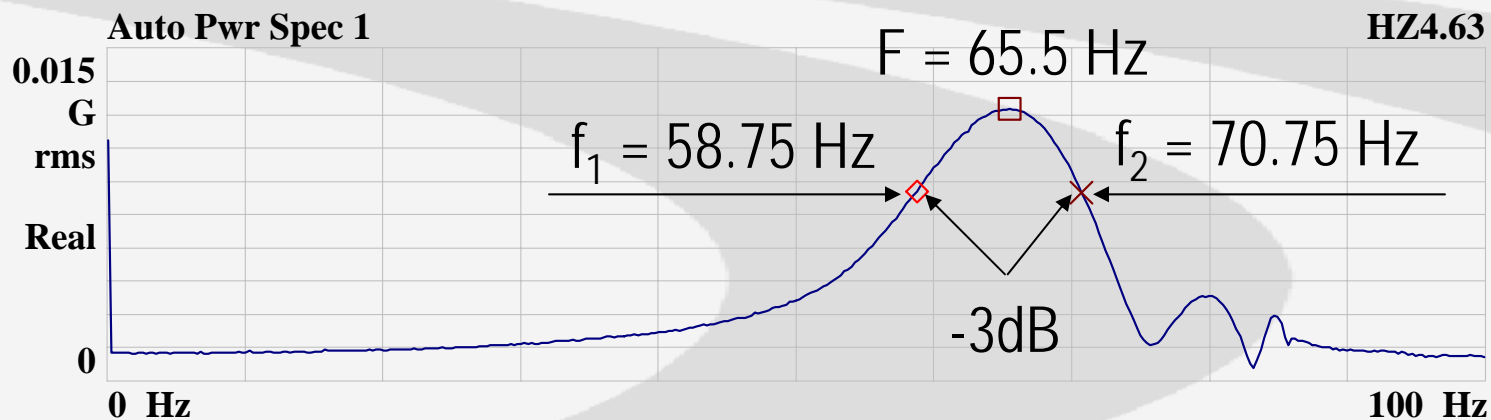
$$\text{Amplification factor} = 1/(2*\text{Damping}) = 1/(2*0.057) = 8.68$$



# Using the Spectrum

◇ X:58.75 Hz      Y:8.550765 mG  
 □ X:65.5 Hz      Y:12.23725 mG  
 × X:70.75 Hz      Y:8.475402 mG

## Frequency Spectrum



Find the -3dB points =  $A_F * .707 = 12.24 \text{ mG} * .707 = 8.65 \text{ mG}$

Find the frequencies at the -3dB points ( $f_1$  and  $f_2$ )

Amplification factor =  $F / (f_2 - f_1) = 65.5 / (70.75 - 58.75) = 5.46$



## Mass & Stiffness

$$F_n = 1/2\pi\sqrt{k/m}$$

▲ INCREASE the stiffness ( k )

▲ INCREASE the frequency ( F )

▲ INCREASE the mass ( m )

▼ DECREASE the frequency ( F )



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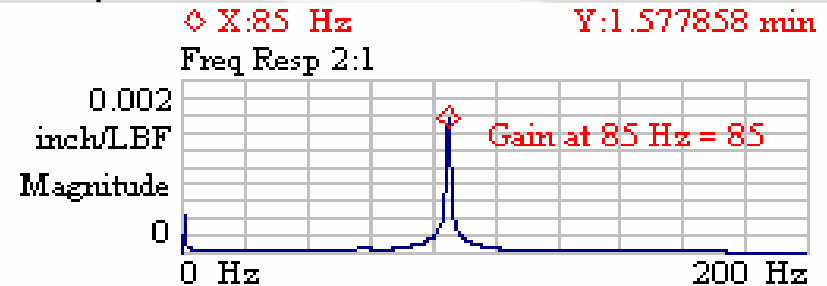
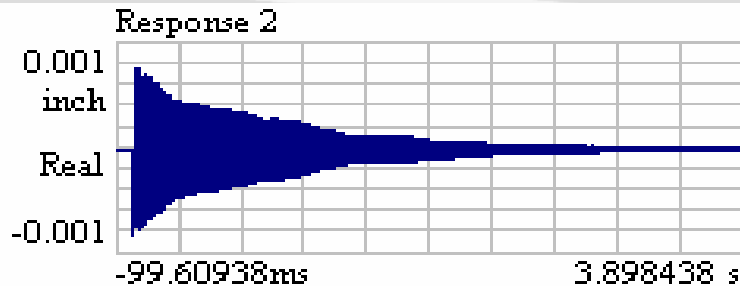


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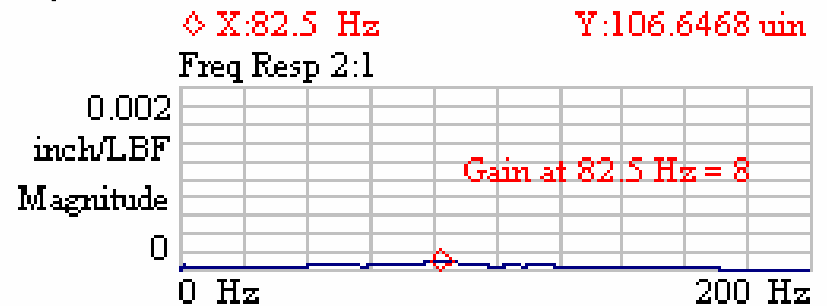
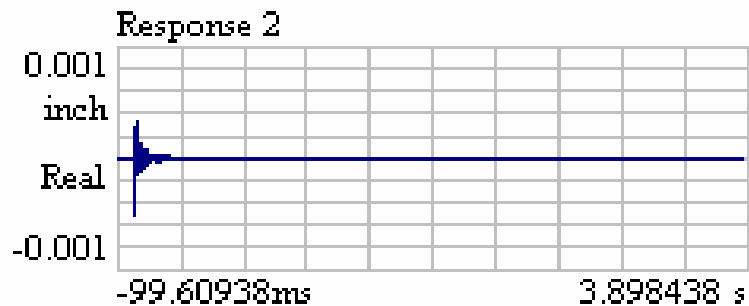
## Damping

# Control the Response

### Un-Damped



### Damped



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# Summary

- Take your time
- Choose your weapon
- Bump around
- Uniform Window
- Look at the time waveform
- Look at the frequency spectrum
- Do a mental health check
- Calculate the amplification factor
- Change the mass
- Change the stiffness
- Add damping
- Bump around

Thank You !

# Thank You !

You can find technical papers on  
this and other subjects at  
[www.ctconline.com](http://www.ctconline.com)  
in the “*Technical  
Resources*” section



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