Do all accelerometers behave the same ?

Meggitt-Endevco, Anthony Chu

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Agenda

- Accelerometer types
- Difference between DC and AC accelerometer
- Selection criteria

Accelerometer Classifications

There are two classes of accelerometer:

- DC-Response type (Static Response)

  Can measure static acceleration, such as gravity and centripetal acceleration, as well as dynamic acceleration. Most suitable for characterizing rigid body motion.

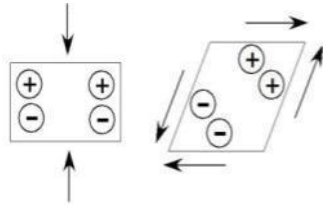
- AC-Response type (Dynamic Response)

  Can measure only dynamic acceleration. Most suitable for characterizing structural response.

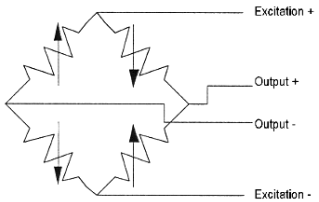
Accelerometer Types

Three sensing technologies are commonly used to design accelerometers:

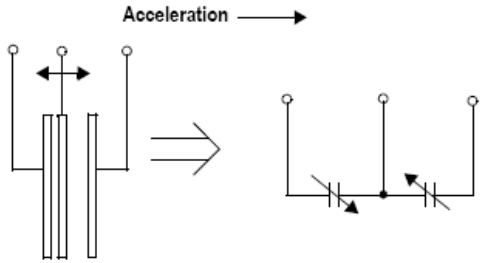
Piezoelectric



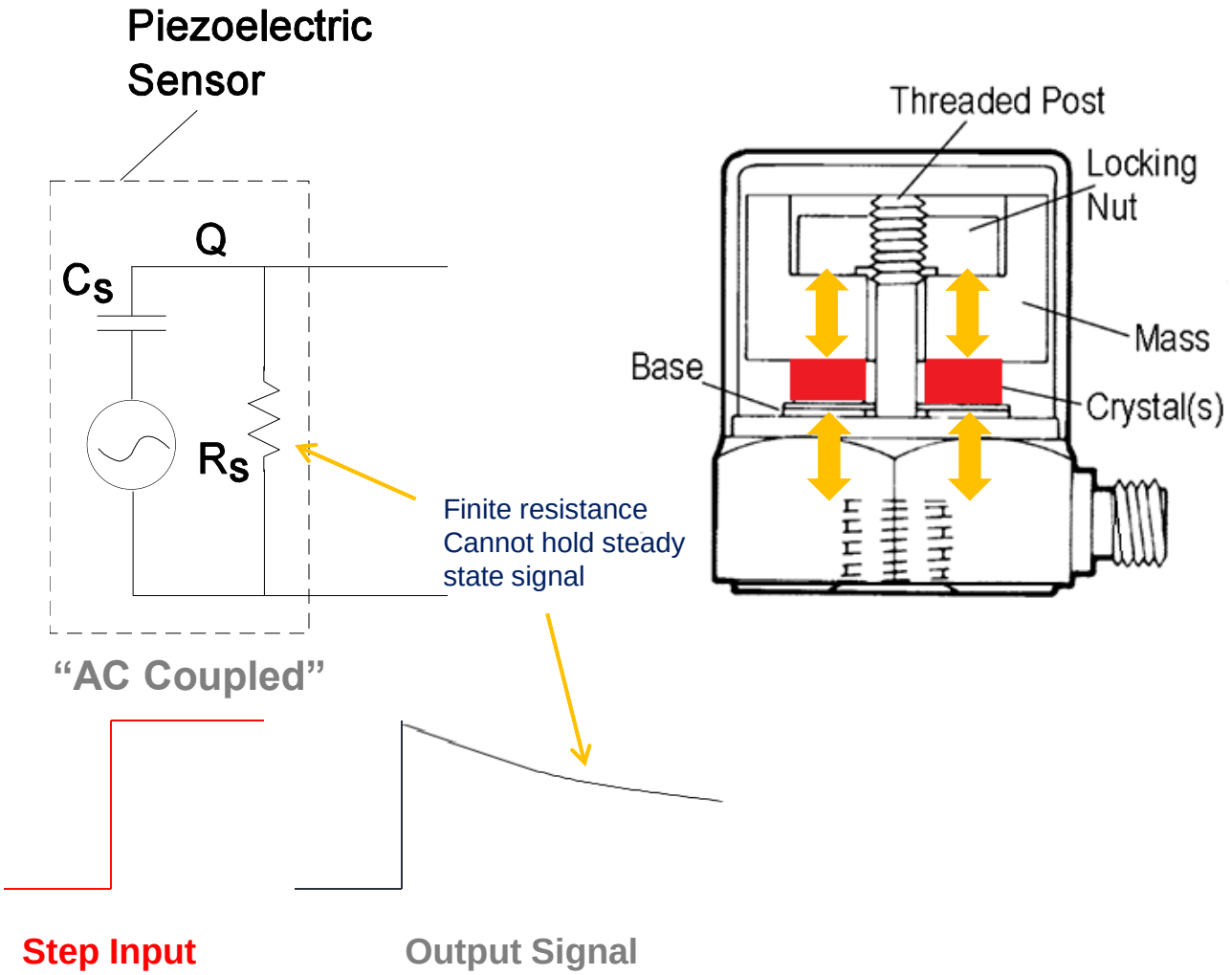
Piezoresistive



Capacitive

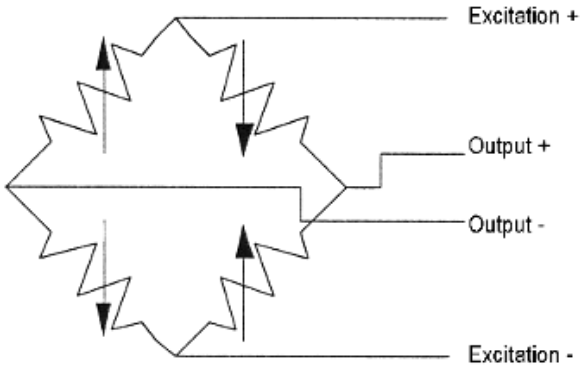


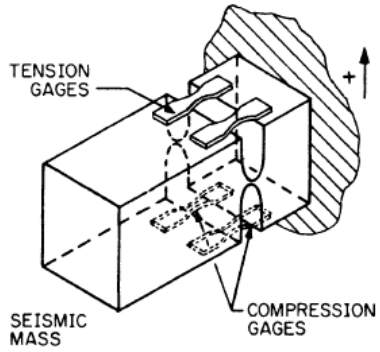
Piezoelectric Accelerometer



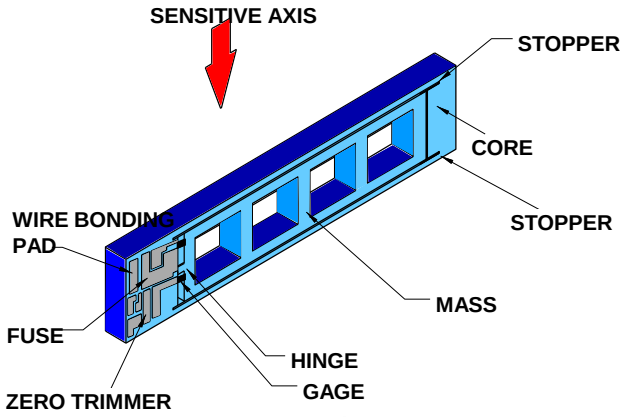
Not capable of measuring static (DC) acceleration

Piezoresistive Accelerometer

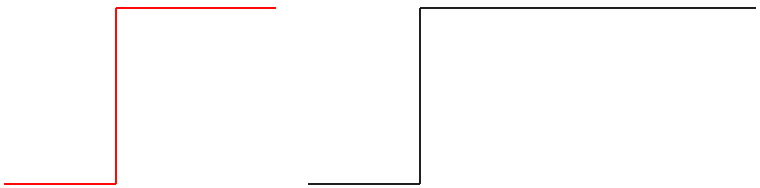




Piezoresistive Cantilever Beam Design



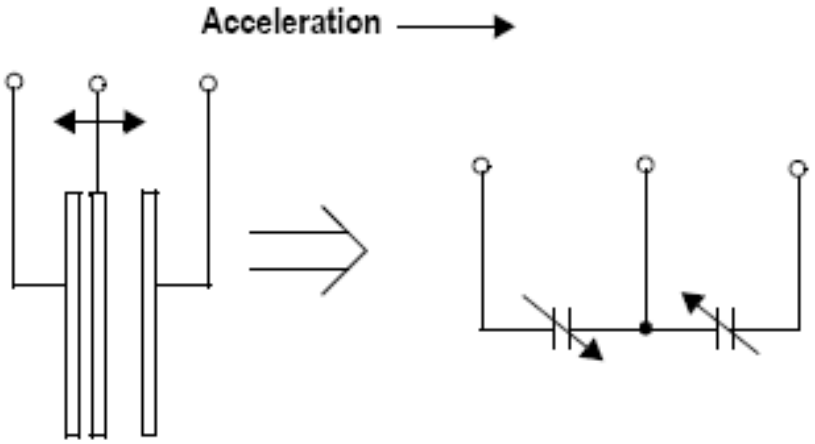
Piezoresistive MEMS



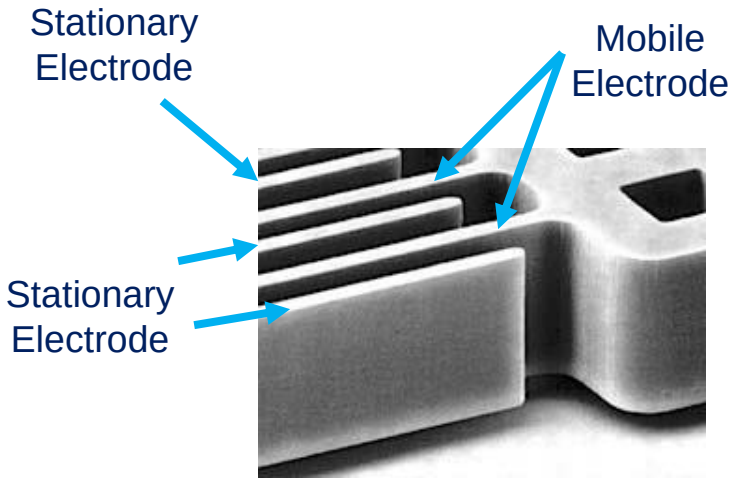
Step Input **Output Signal**

Capable of measuring static (DC) acceleration

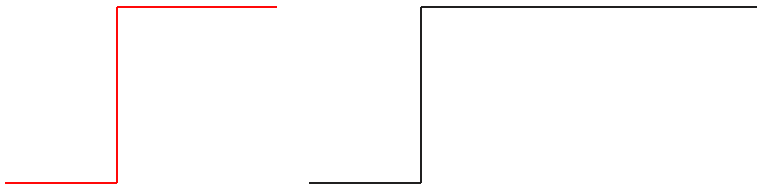
Capacitive Accelerometer



Differential Capacitors Arrangement



Typical Capacitive Silicon MEMS Element



Step Input **Output Signal**

Capable of measuring static (DC) acceleration

Accelerometer Selection

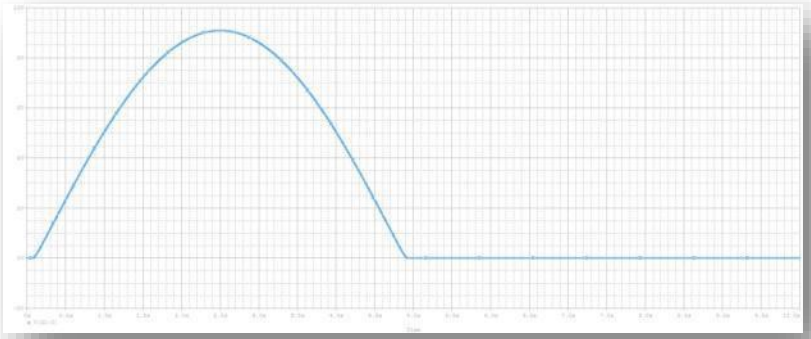
When to choose a DC-Response Accelerometer over an AC-Response Accelerometer?

- To measure static acceleration – that's obvious
- To measure very low frequency vibration – that's logical
- To get velocity and displacement by integrating and double-integrating acceleration signal (to characterize rigid body motion) – let's see why

DC vs. AC Accelerometer Responses

DC-Response Accelerometer

Input ——— Output ———



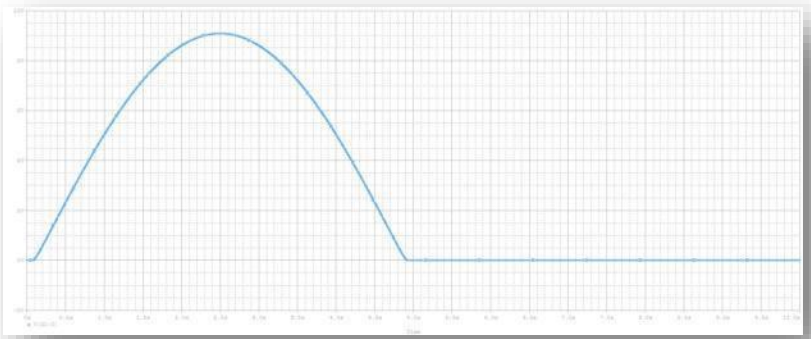
Input

Input + Output

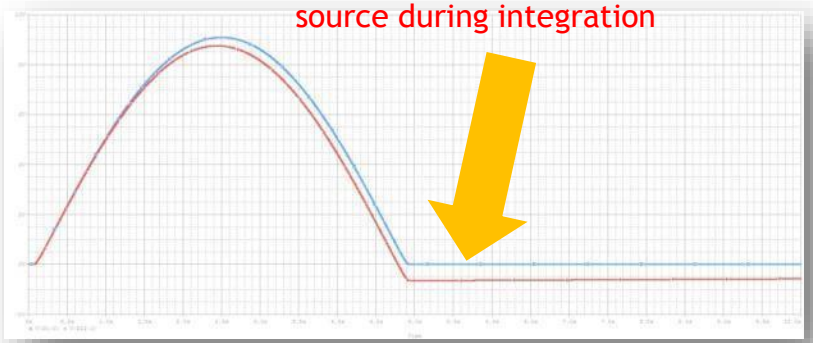
Very low frequency half-sine signal

AC-Response Accelerometer

Offset becomes a significant error source during integration



Input



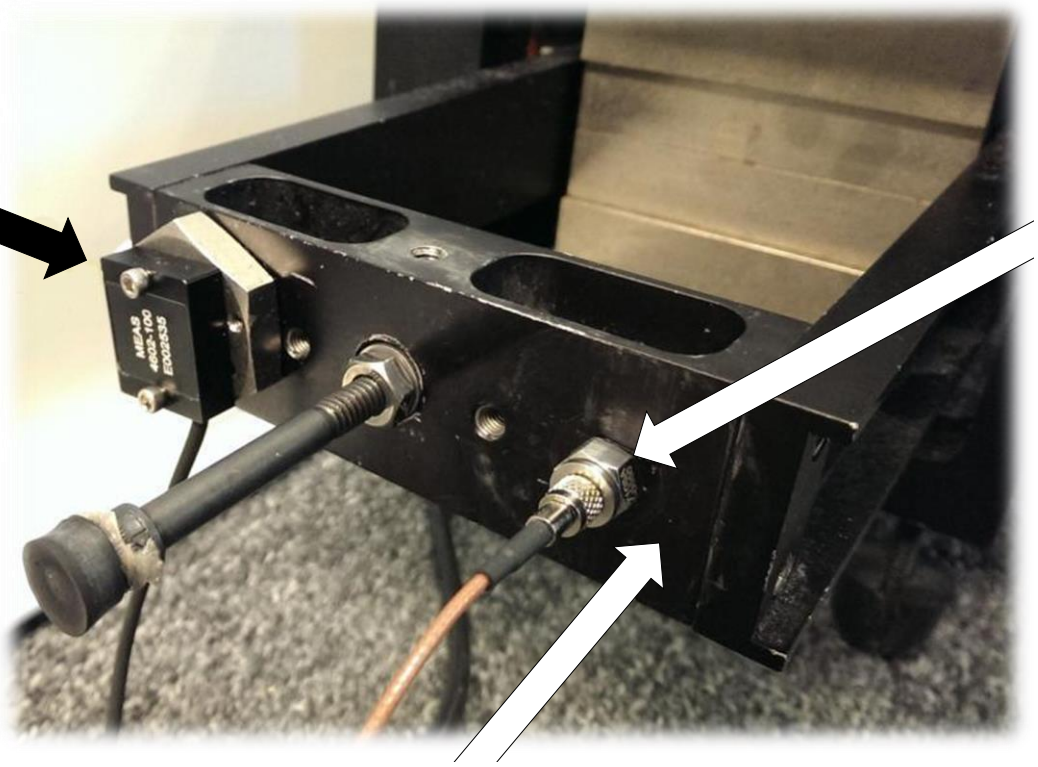
Input + Output

Very low frequency half-sine signal

An Experiment – for the Skeptics

Compare the output of two accelerometers under slow (4.5Hz) oscillatory motion (±2.5cm)

DC Accelerometer
30g full scale
(flat to 0Hz)



AC Accelerometer
50g full scale
(-1dB @ 1Hz)

Horizontal Carriage

An Experiment – for the Skeptics

Acceleration Time History – Free Release

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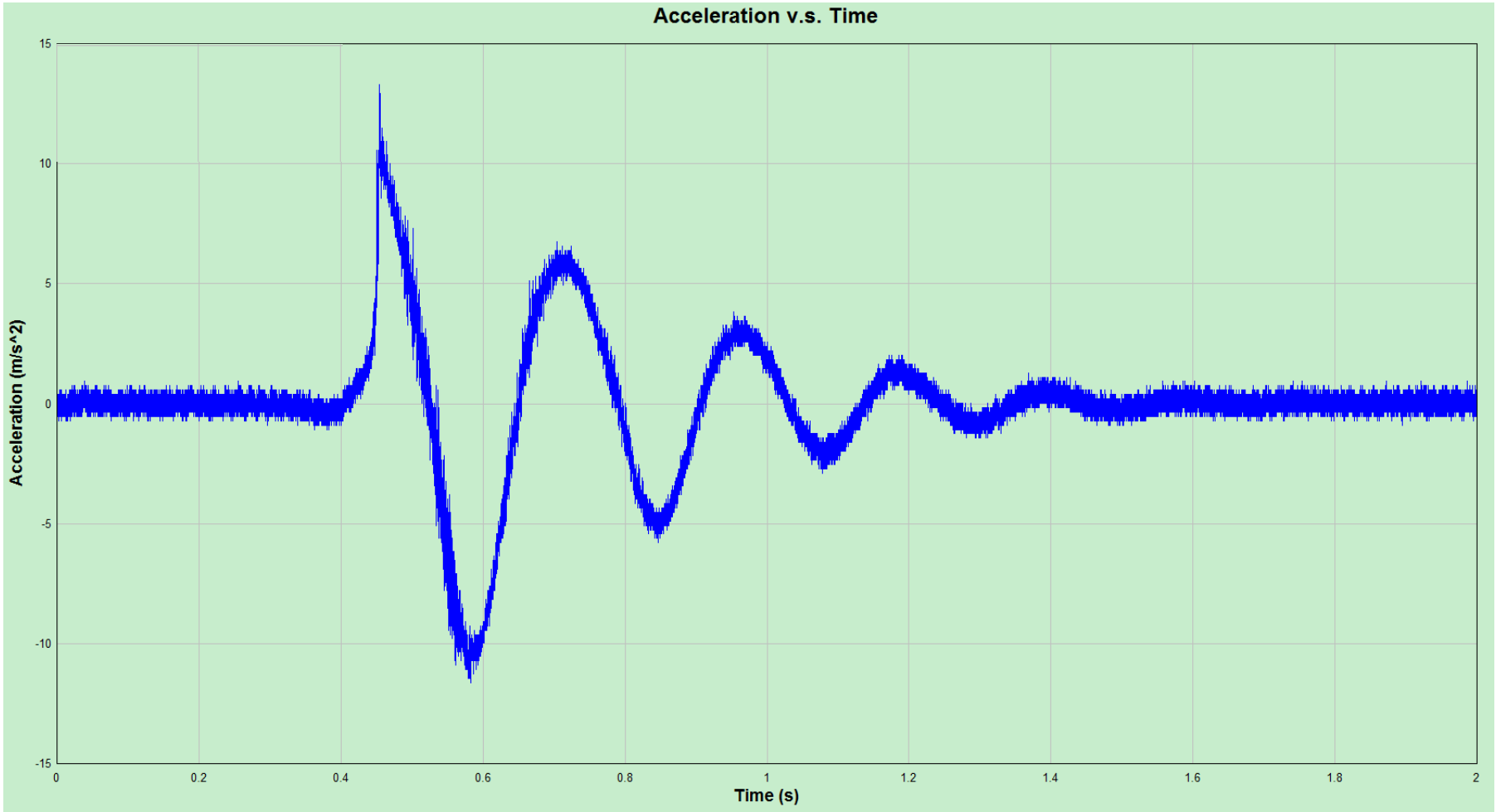
DC Accelerometer



Acceleration Time History – Free Release

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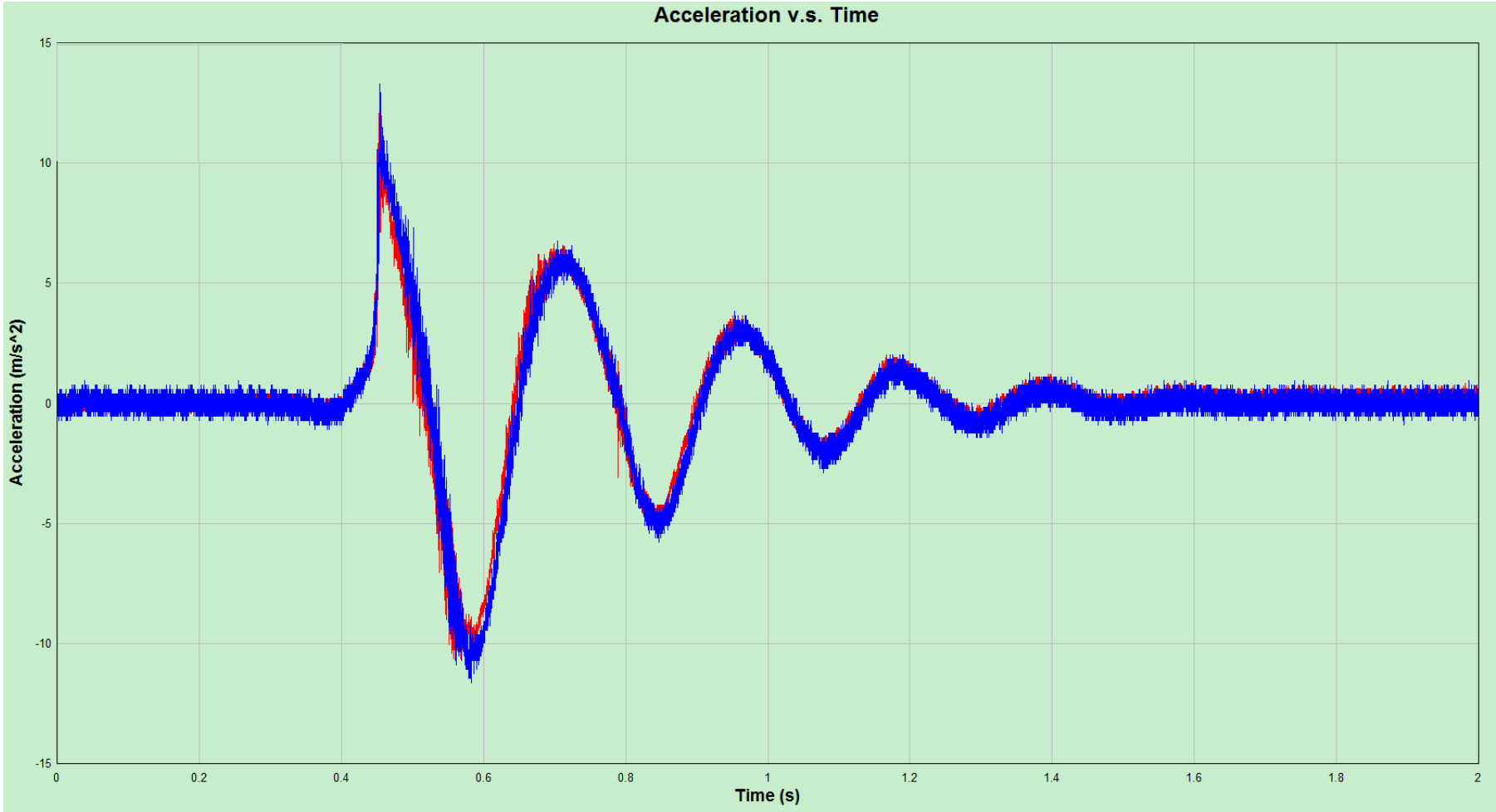
DC Accelerometer

AC Accelerometer



Velocity Time History – Free Release

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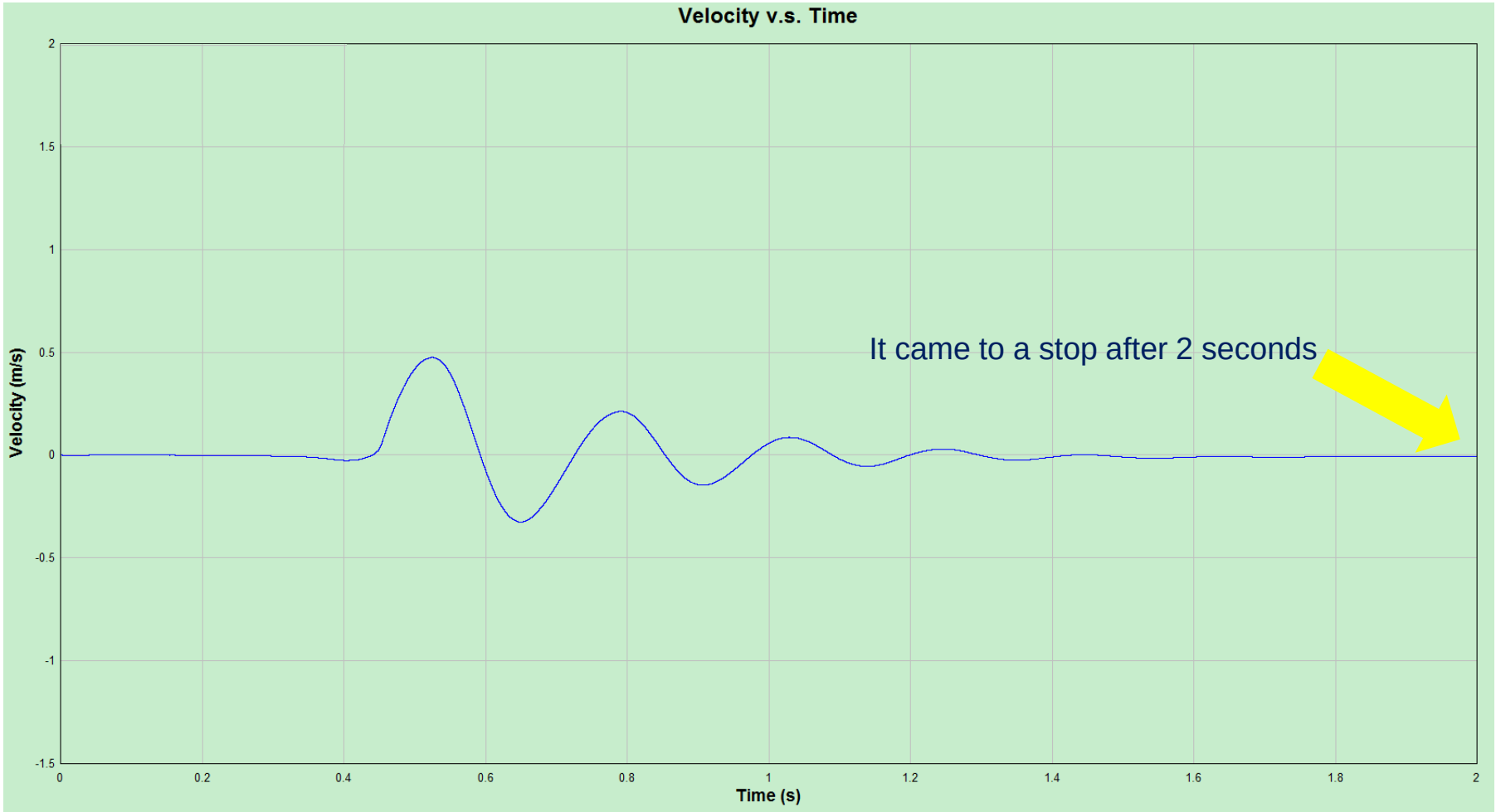
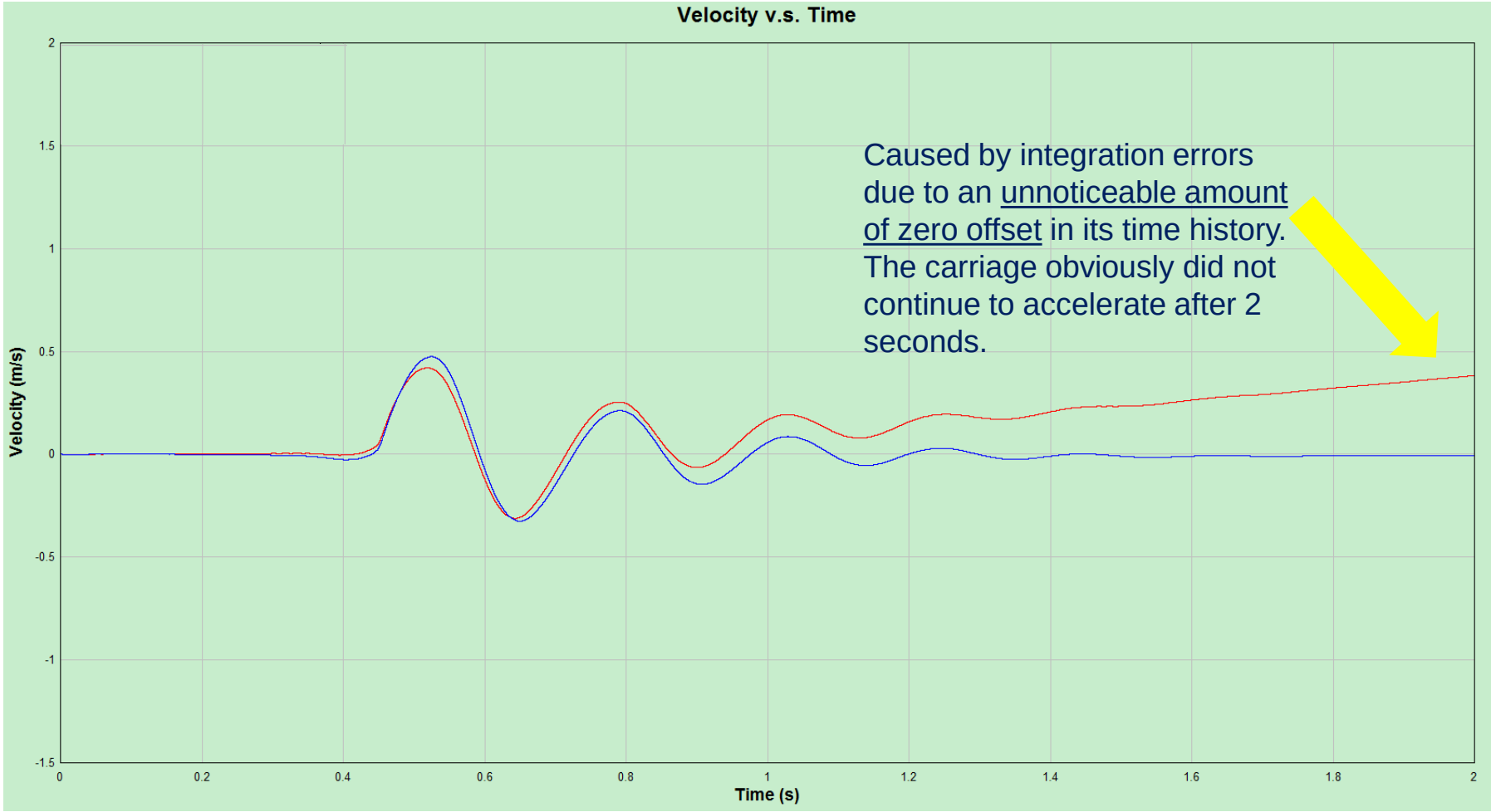
DC Accelerometer



Velocity Time History – Free Release

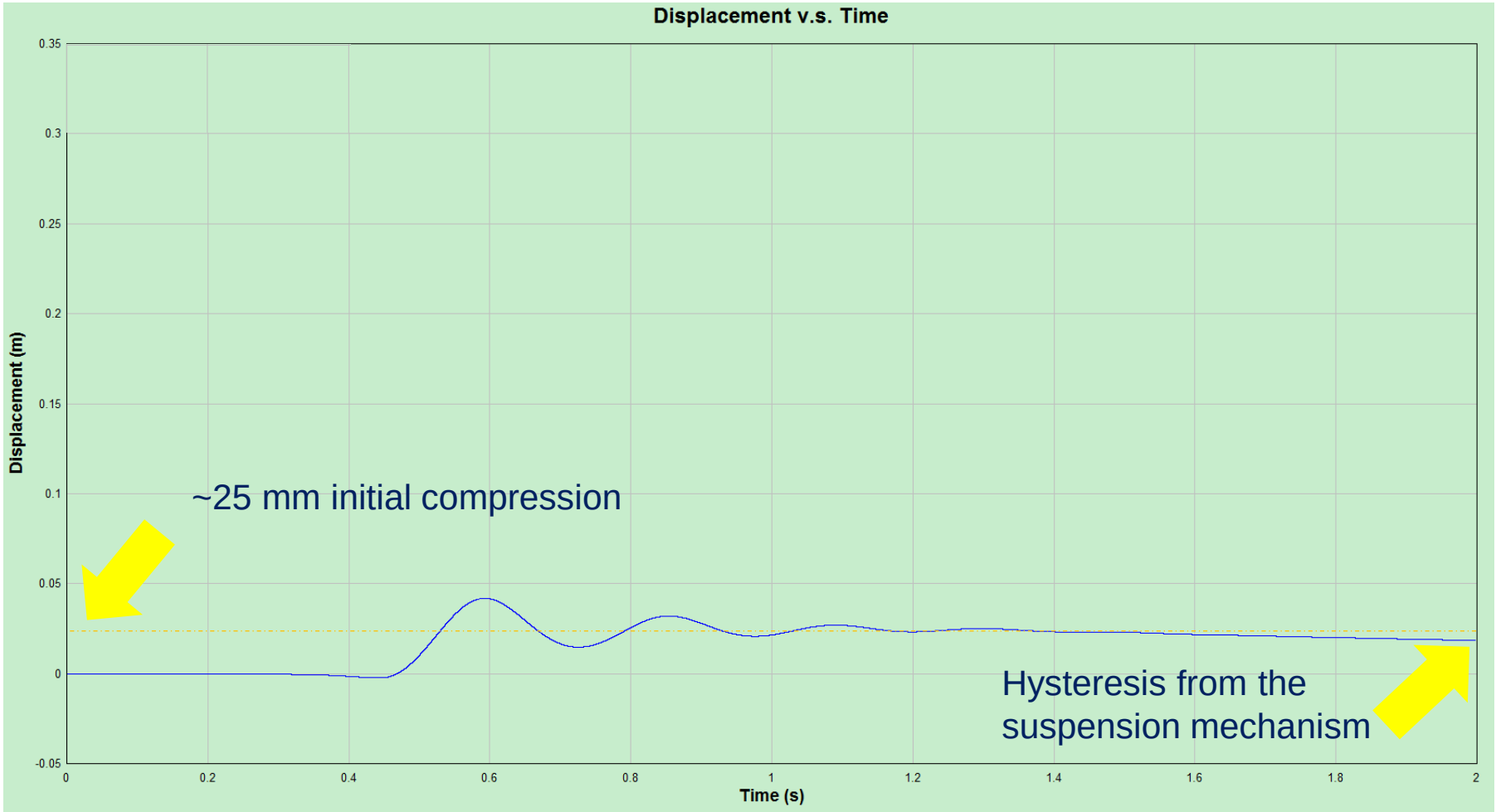
DC Accelerometer

AC Accelerometer



Displacement Time History – Free Release

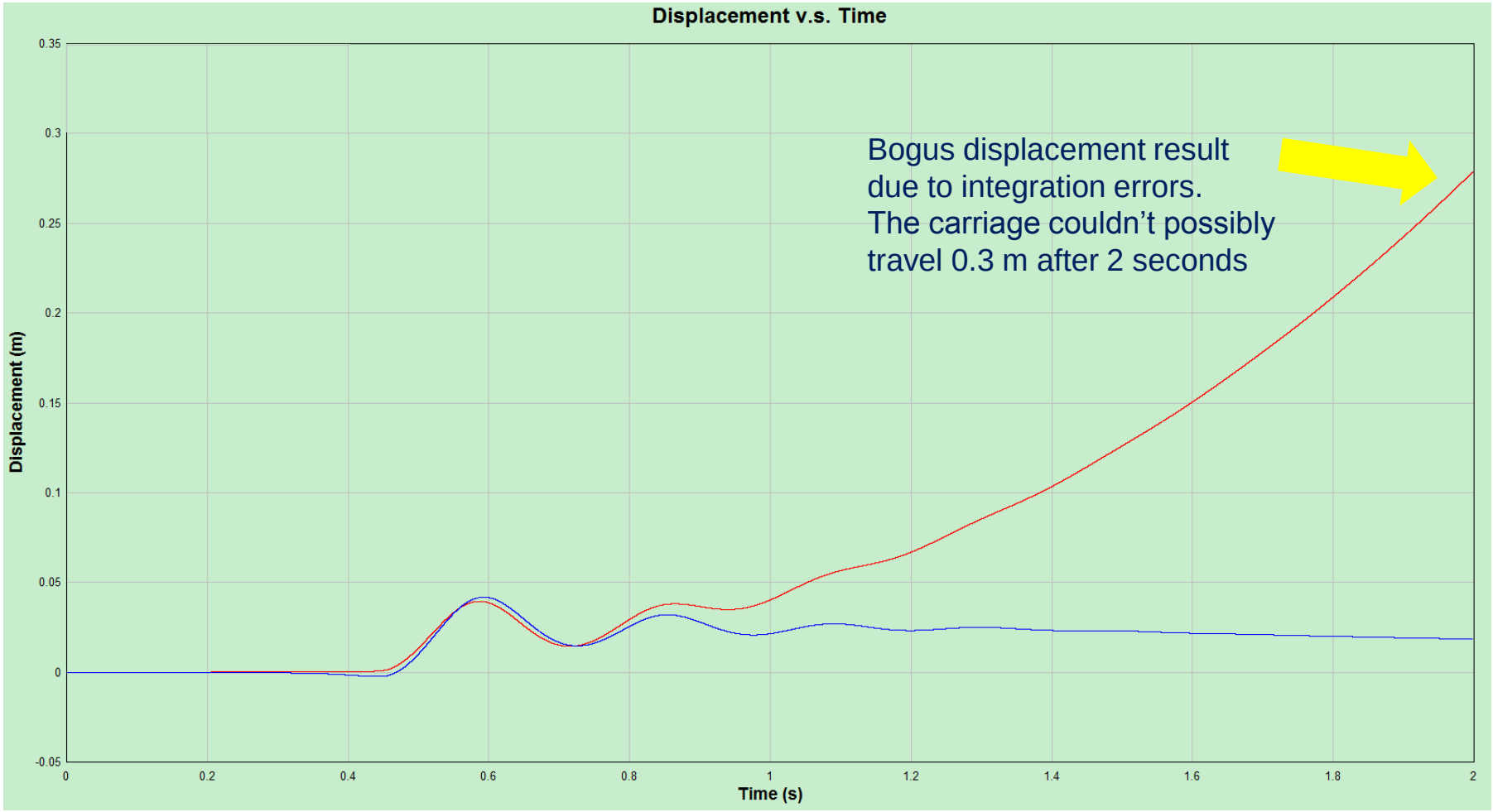
DC Accelerometer



Displacement Time History – Free Release

DC Accelerometer

AC Accelerometer



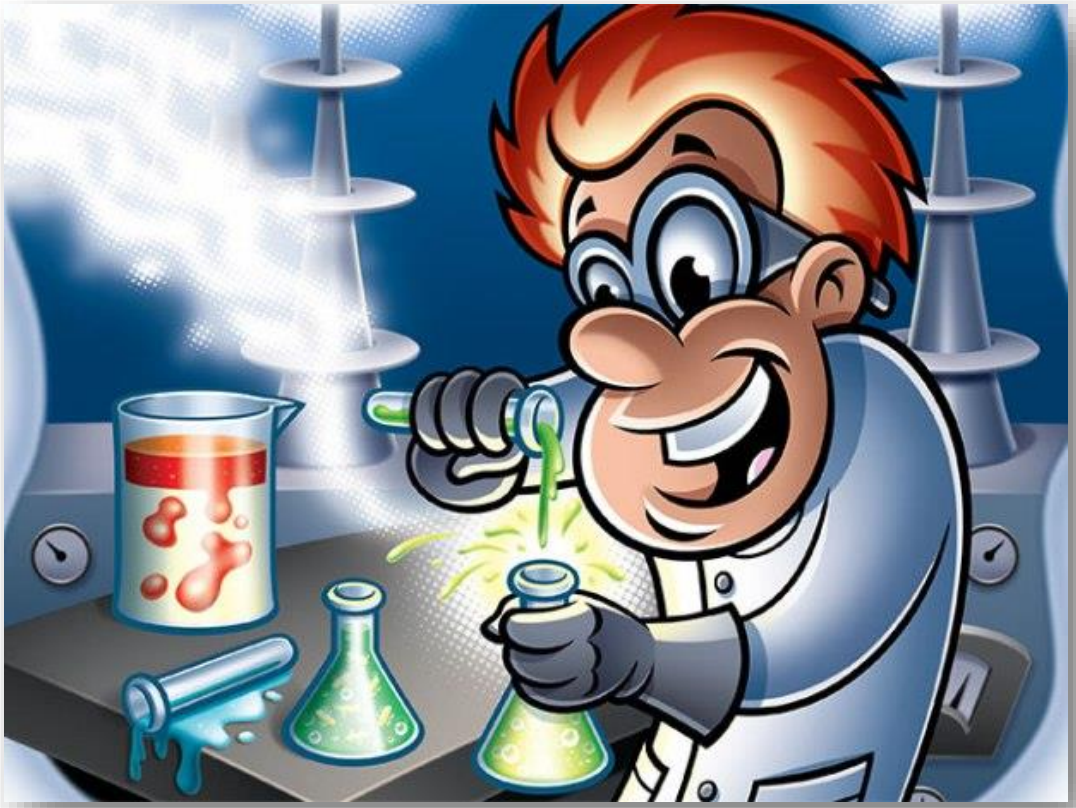
Accelerometer Selection

When to choose an DC-Response Accelerometer over an AC-Response Accelerometer?

- To measure static acceleration – that's obvious
- To measure very low frequency vibration – that's logical
- To get velocity and displacement by integrating and double-integrating acceleration signal (to characterize rigid body motion) – need to pay attention
- If the measurement involves more than just vibration

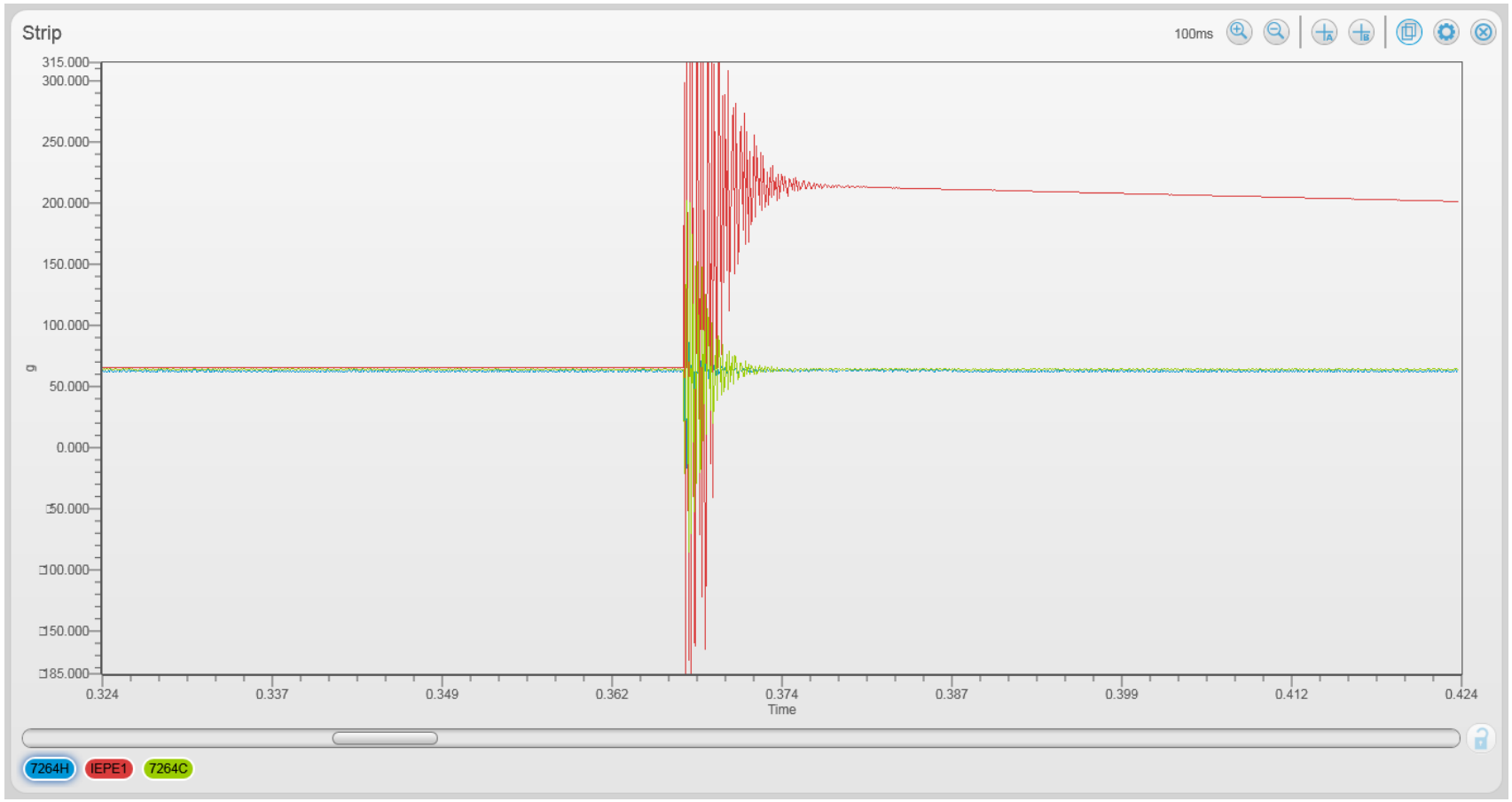
DC vs. AC Accelerometer Responses

An Experiment to simulate small Impact



DC vs. AC Accelerometer Responses

From a minor metal-to-metal impact



The AC accelerometer output suffered from zero shift under metal impact

DC vs. AC Accelerometer Responses

Test results suggested that:

- Under normal test condition within their specified range, both piezoelectric (AC) and piezoresistive (DC) accelerometers can be used to measure vibration responses
- Use in test condition involves even a low level of impact, piezoelectric accelerometer can be induced to produce zero shift error (a base line offset) due to an intrinsic characteristic common in piezoelectric materials, render the data unusable
- Piezoresisitve and capacitive (DC) accelerometers are much more tolerant to impact during vibration measurement

Accelerometer Selection

When to choose an AC-Response Accelerometer over an DC-Response Accelerometer?

- To only measure dynamic acceleration (to characterize structural response)
- Need higher temperature capability (>125°C)
- Don’t want to deal with a DC bias (zero-offset) in the output signal
- The need to measure over 10kHz

Recap

Two general classes of accelerometers

AC-coupled type (for dynamic measurements only)

- Charge mode piezoelectric
- Voltage mode piezoelectric

DC-coupled type (for dynamic & static measurements)

- Piezoresistive
- Capacitive

Choose the type carefully based on your applications' requirements

Accelerometer Selection Matrix

	Piezoelectric (PE)	Piezoelectric (IEPE, ICP)	Piezoresistive (Bridge)	Piezoresistive (Amplified)	Capacitive (Amplified)
Output Type	Charge output	Voltage output	Voltage output	Voltage output	Voltage output
Power Supply Req.	Charge Amplifier	Constant Current	Bridge Amplifier	DC Amplifier	DC Amplifier
Static Measurement?	No	No	Yes	Yes	Yes
Acceleration Data?	Yes	Yes	Yes	Yes	Yes
Velocity Data?	No	No	Yes	Yes	Yes
Displacement Data?	No	No	Yes	Yes	Yes
Measurement Bandwidth	Low to High Freq	Low to High Freq	DC to Mid Freq	DC to Mid Freq	DC to Low Freq
Temperature Range	To 400°C	To 150°C	To 125°C	To 125°C	To 125°C
Power Consumption	Self Generating	Low	High	High	Low
Intrinsic Noise	Low	Low	Low	Moderate	High
Shock Survivability	High	High	High	Moderate	Low

** Based on typical performance of each accelerometer type

Contacts

- Meggitt – Endevco
- 14600 Myford Rd., Irvine, CA 92606, USA
- +1 949 493 8181
- E-mail: endevco@meggitt.com

Thank you for your time!