



# ESD Considerations in High Shock Testing (U-020)

James Nelson  
Endevco  
Orange County, CA  
jnelson@endevco.com

Dr. Ted Diehl  
Magic Leap  
Plantation, FL  
tdiehl@magicleap.com

93<sup>rd</sup> Shock and Vibration  
Symposium  
September 24 – 28, 2023  
Atlanta, GA

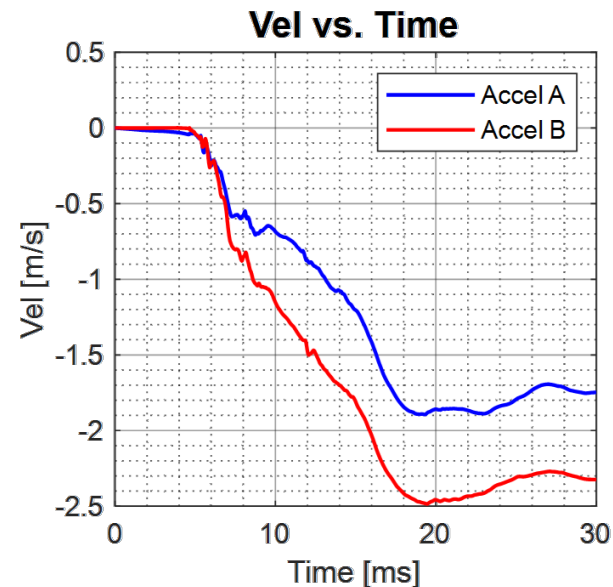
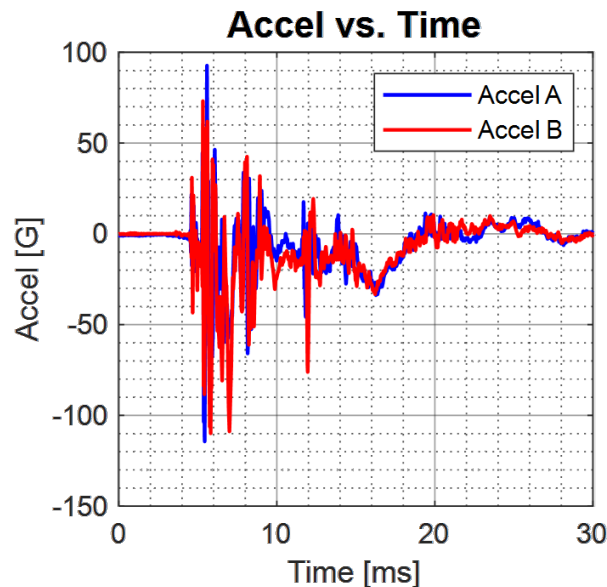
# Agenda

- Problem discovery in drop testing
- Root cause identified
- ESD Description
- Test Overview
- ESD Mitigation Solutions
- Identifying Suspicious Data
- Conclusions

# Package Drop Test

- 1\*m Drop Test
- 2 accels mounted near each other, horizontally on package contents
- Initial test data assessment seems plausible

$$V_{impact} = \sqrt{2Gh} = 4.43 \cdot \text{m/s}$$

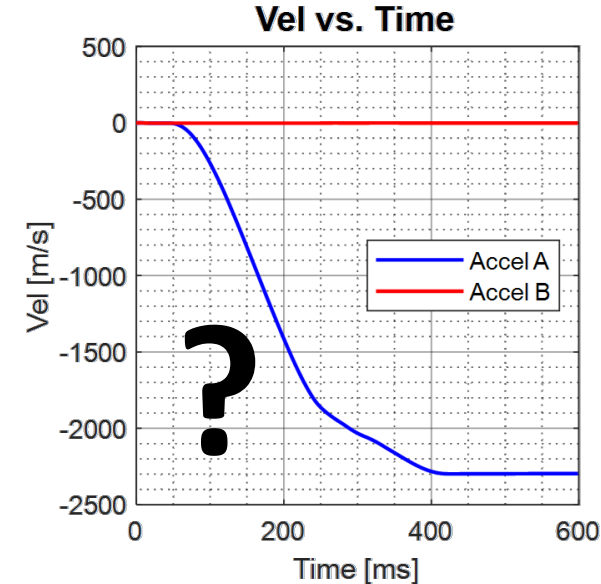
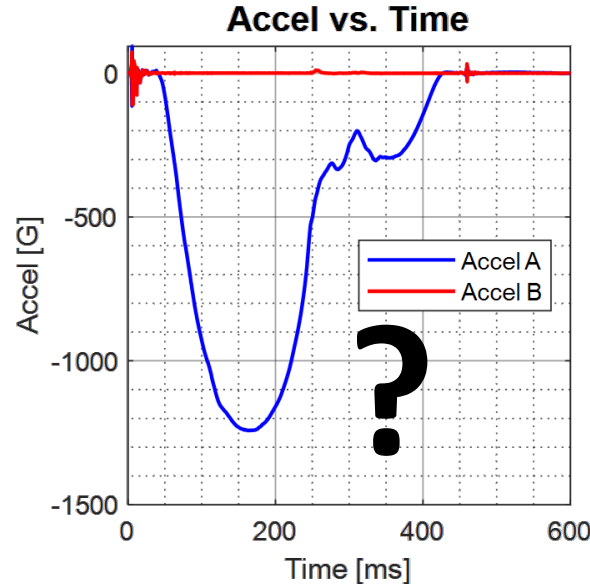


# Same Drop Test – Longer Duration

- Same data, just plotted for more time
- Abs Max acceleration on A increased > 10x
- $|\Delta v| = 2300 \cdot \text{m/s}$

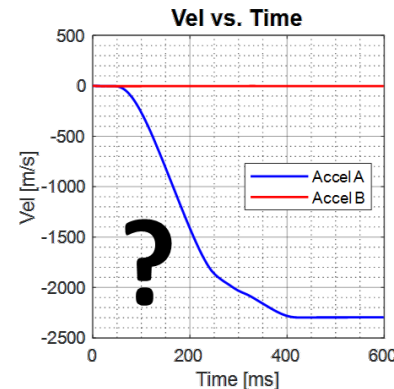
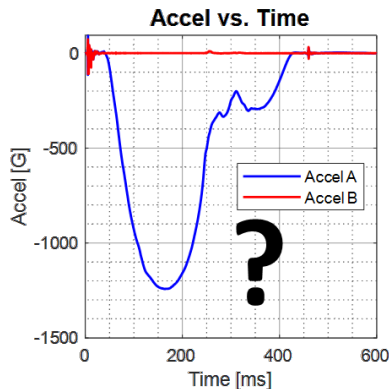
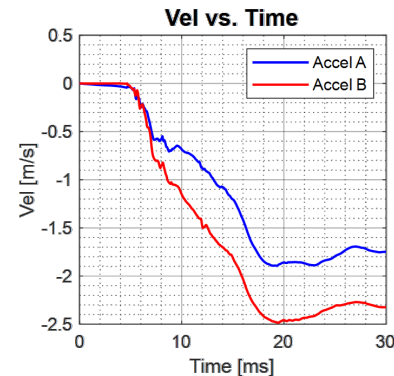
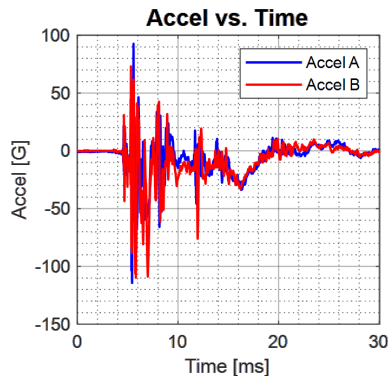
**That's Mach 6.7  
in our lab!**

$$V_{\text{impact}} = \sqrt{2Gh} = 4.43 \cdot \text{m/s}$$



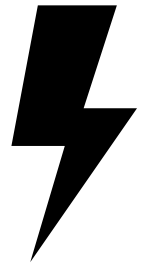
# Problem Found

- Within the same test event, both sensors were at first nearly the same (and plausible), but then later in time one sensor's response becomes completely implausible while the other remains OK.
  - What gives?



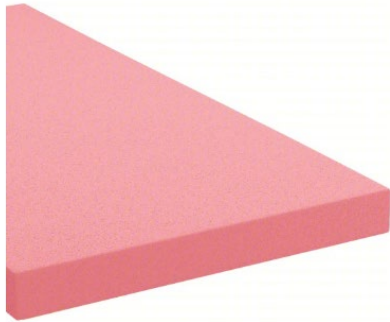
# Cause of Problem

- Large anomaly was consistent and repeatable across tests
- Not present in other contexts, like factory calibration
- Discovered a buildup of voltage on the test article, confirmed with an electrostatic field meter
- Anomaly eliminated when surface charge was brought to zero before test



# Root Cause

- Non-metallic surfaces can create ESD if they are not explicitly labeled “ESD safe”
- Pink bags, pink bubble wrap, silver bags dissipate charge
- In our test, certain materials allowed static charge buildup



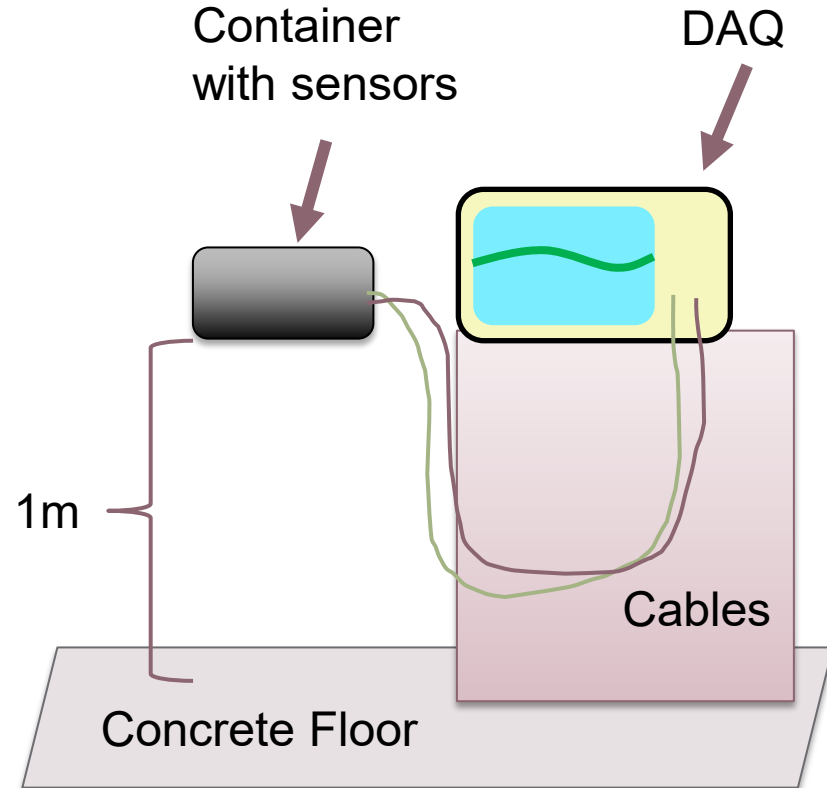
# Electrostatic Discharge Definition

- ESD is a sudden and unpredictable release of static charge buildup
- The discharge can be large and spectacular (lightning) or practically invisible
- Small and delicate electronics can be susceptible to unseen ESD events

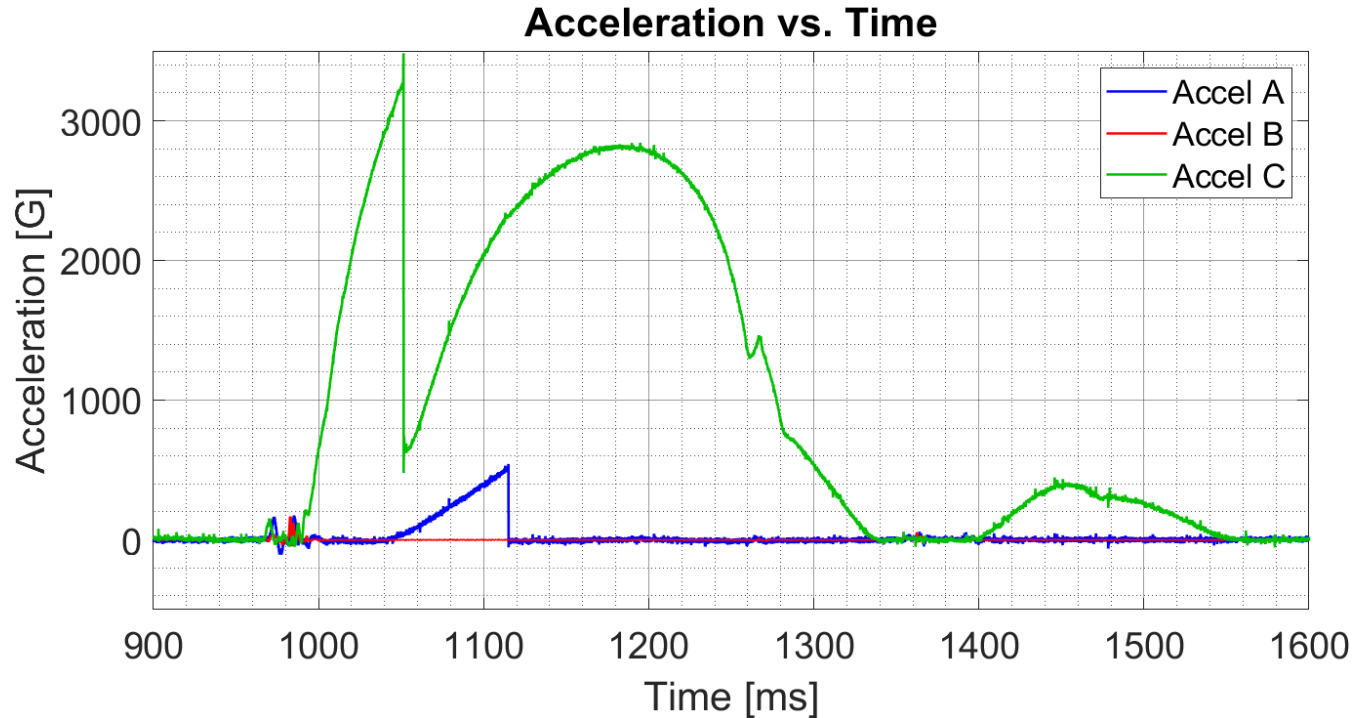


# Application: Drop Test

- Sensors are installed onto a test specimen that is placed inside of a foam-padded container
- Container drops onto a concrete floor from 1-meter height
- Sensors measure the shock impact

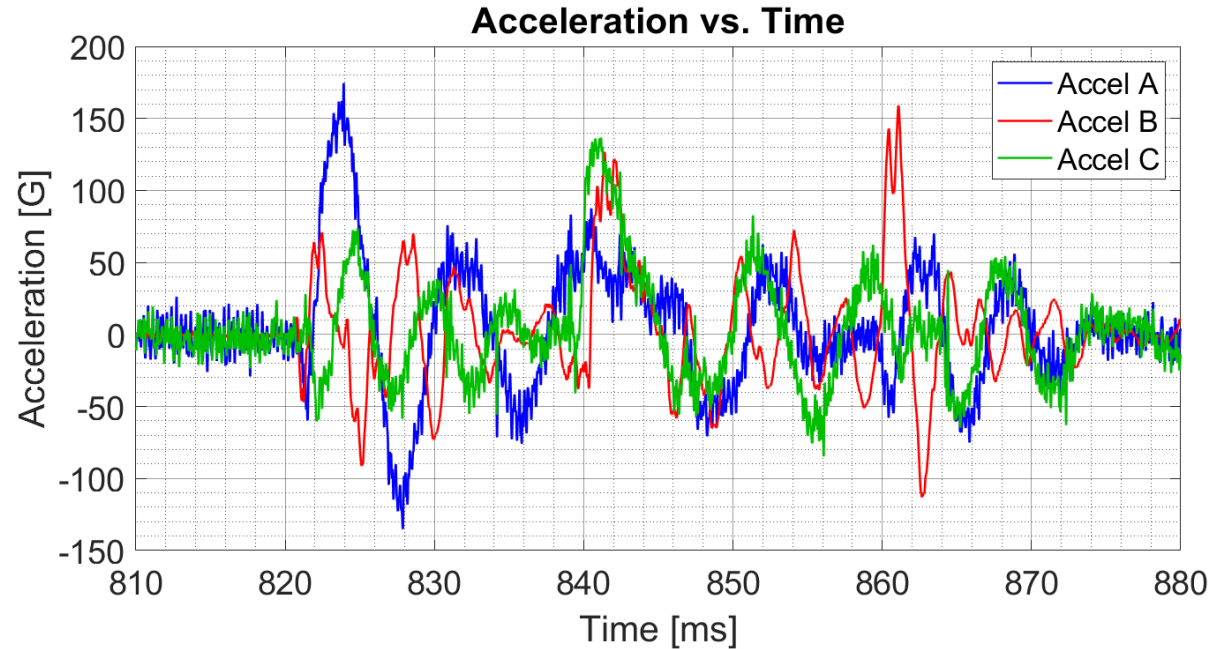


# Example Data



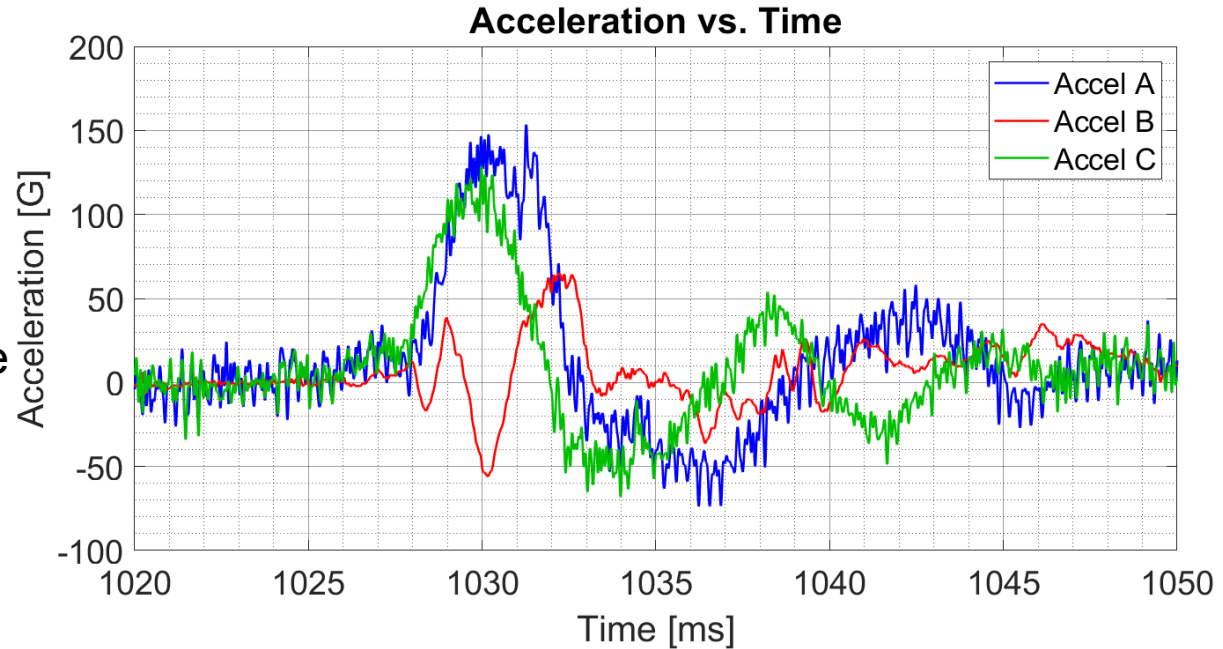
# Experiment #1 – Changing Foam Material

- Placed sensors inside a PCB Piezotronics box with ESD-dissipative plastic and foam inside
- The sensors had no anomaly when subjected to the drop test



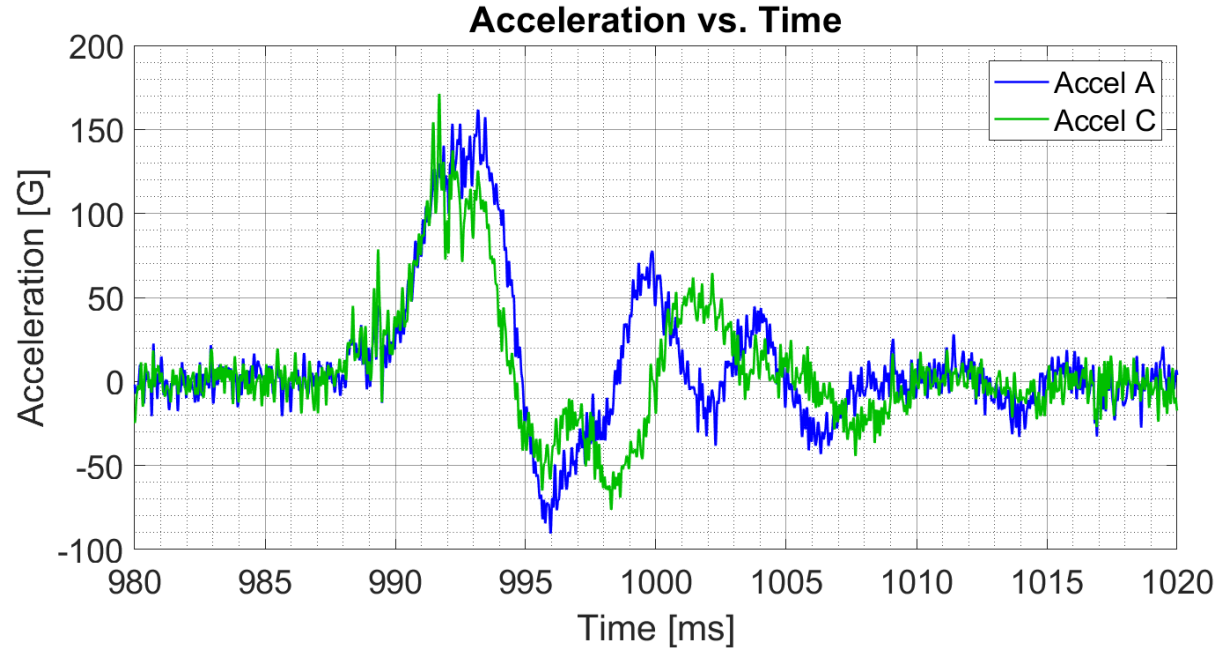
# Experiment #2 – De-ionized Air

- Placed sensors inside the original ESD-susceptible container
- Blew air from a de-ionizing fan across the inside and outside of the container
- No anomaly



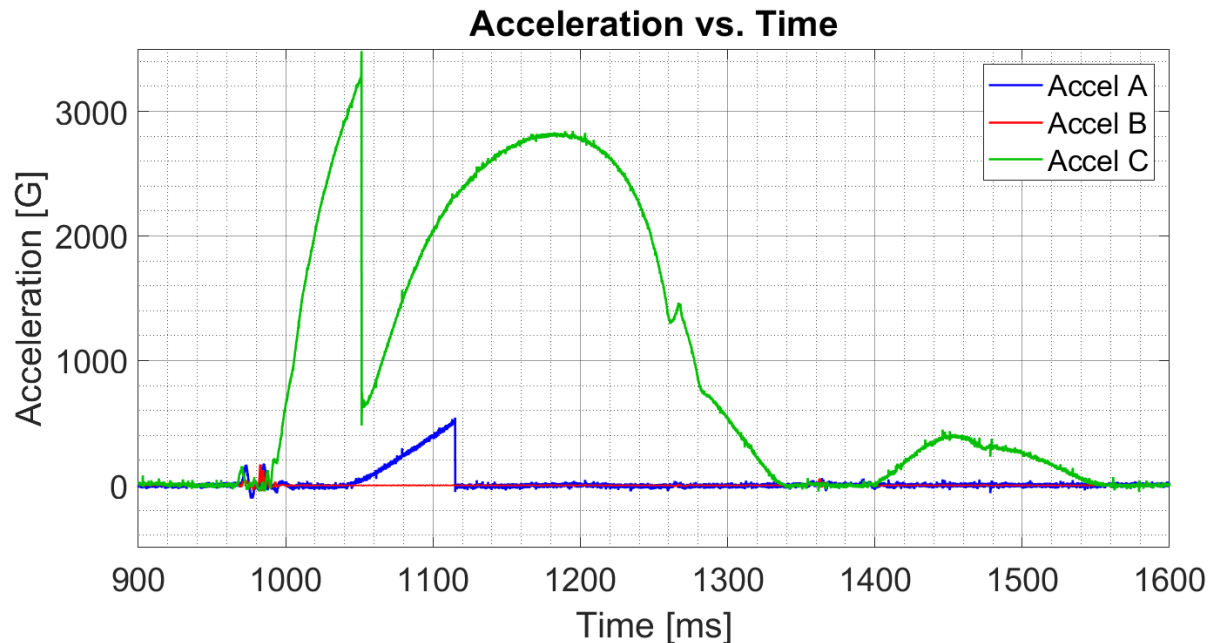
# Experiment #3 – Conductive Wrap

- Wrapped sensor housings with copper tape, soldered cable shield to tape
- The housing was now surrounded with a shield-grounded conductive layer
- No anomaly



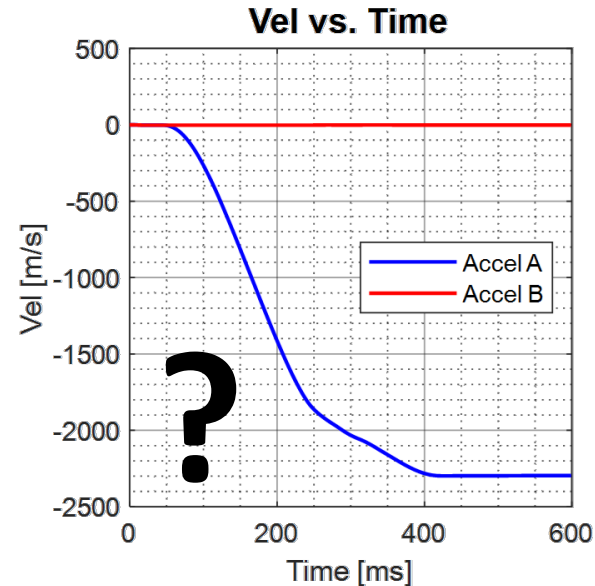
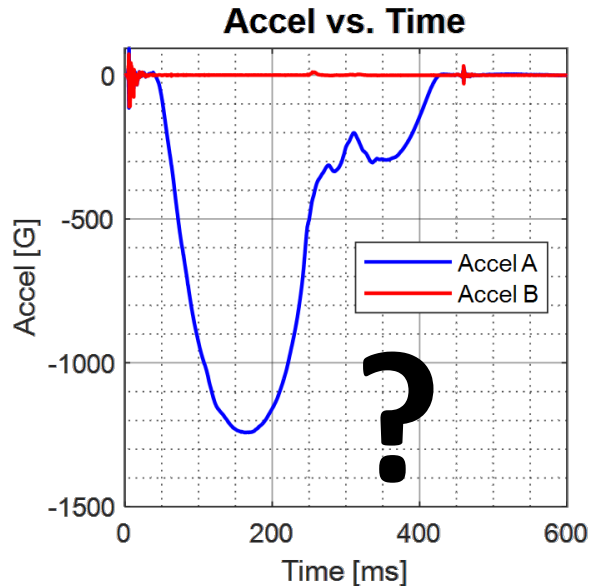
# Experiment #4 – Alternate Sensor

- Sensors A and C: Anodized aluminum housing, cable shield isolated
- Sensor B: Full metal housing surrounds sensor, cable shield grounded
- No anomaly in Sensor B data



# Identifying Suspicious Data

- Look at the test plots as soon as you can. Any unusual activity?



# Conclusions

- Check for ESD ratings in your sensors and DAQ equipment
- Consider the test environment – do you need ESD-suppressing foam, copper shielding wrap, or de-ionized air?
- Open line of communication between testers and analysts
- ESD can affect other bridge-type devices, not just accelerometers
- ESD needs to be physically negated – cannot be filtered

# Questions?

James Nelson

Endevco

Orange County, CA

[jnelson@endevco.com](mailto:jnelson@endevco.com)