# THE ENDEVCO® HIGH-G SHOCK TRIAXIAL ACCELEROMETER: A SMALLER, MORE COST-EFFECTIVE SOLUTION TO MAKING TRIAXIAL MEASUREMENTS

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# Outline

- Background
- Introduction to the model 7274
- Performance characteristics, including:
  - Transverse sensitivity
  - Low-g and high-g shock survivability
  - Zero shift after shock
- Usage and handling
- Applications
- Summary
- Questions

# Background

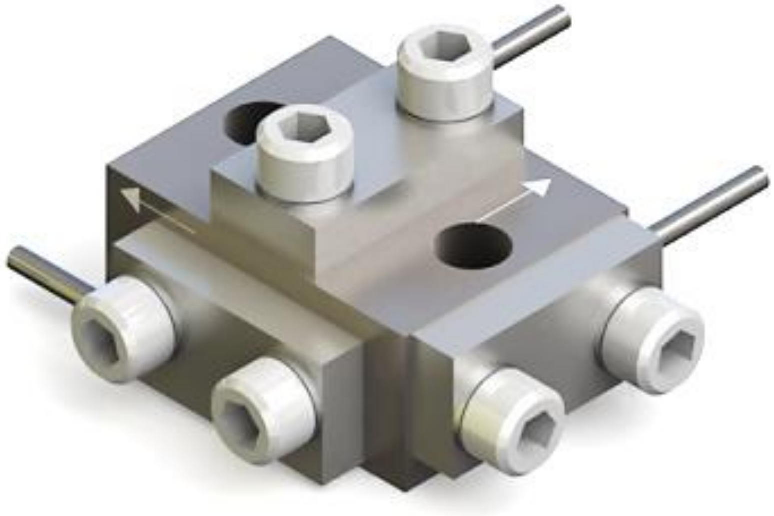
- Advanced penetrator weapons systems often require the triaxial measurement of mechanical shock
  - Fuzes
  - Fuzewell data recorders
- Current solution
  - Three single-axis accelerometers on a mounting block
- Size of the next generation designs are decreasing
  - Need for same measurement in a smaller envelope dimension
- Next solution
  - Endevco® model 7274 high-g shock triaxial accelerometer

# Introduction to the model 7274

» Triaxial version of the industry standard Endevco® model 7270A undamped, high-g shock accelerometer.


– Same sensing element with ~30 years of service
– Drop-in replacement in most application
  – Same footprint and bolt-pattern
  – Approximately twice the height
  – Compatible with existing tooling and test fixturing

# Introduction to the model 7274

- Ranges from 2,000 g to 60,000 g
- Rugged integral eight conductor cable
- Compare to three single-axis accelerometers on a mounting block
  - 13 percent the envelope volume
  - Roughly two-thirds the cost

# Performance characteristic
## Transverse sensitivity

- Transverse sensitivity
  - Also known as cross-axis sensitivity or crosstalk
  - The sensitivity of an accelerometer to a stimulus that is perpendicular to the sensing axis
- Specified as a percentage of the axial sensitivity
  - Commonly specified as 5 percent maximum for accelerometers
- Contributing factors:
  - Flatness and parallelism of the mating
  - Flatness of the mounting surface
  - MEMS sensing element
- Discussed in more detail in a technical paper [1]

# Performance characteristic

## Transverse sensitivity measurement techniques

- Vibratory test machines
  - Measure maximum output with a known vibration in the sensitive axis
  - Measure maximum output with the same vibration in an orthogonal axis
  - Effective for lower ranged unit-under-test (UUT) with higher sensitivity
  - 2,000 g version of the 7274 tested
    - less than 1.5 percent transverse sensitivity

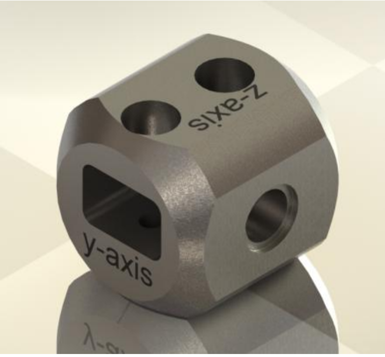
- Measurement during actual shock testing
  - Record output for all three channels simultaneously
  - Apply shock to one axis
  - Calculate transverse sensitivity for other axes
  - Results will be shown in the following sections

# Performance characteristic

## Low-g shock testing

- Endevco® model 2925 Comparison Shock Calibrator [2]
  - Part of the Automated Accelerometer Calibration System (AACS)
  - Used to calibrate high-g shock accelerometers
  - Shock amplitudes from 20 g to 10,000 g
  - Pulse durations from 3 ms to 100 µs

- Test fixtures required for testing in three axes
  - Commercially available; consult factory



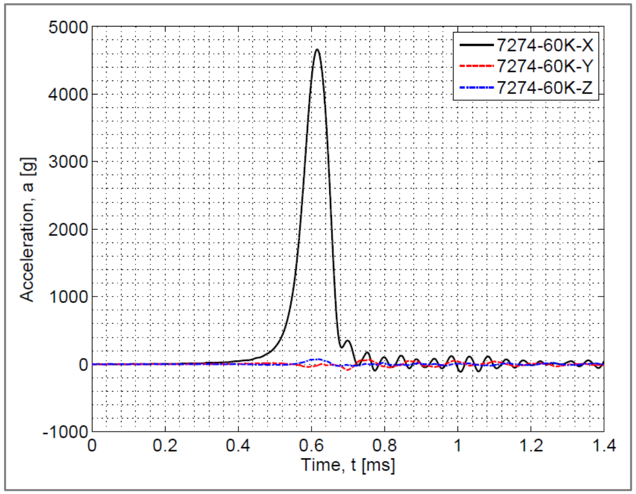




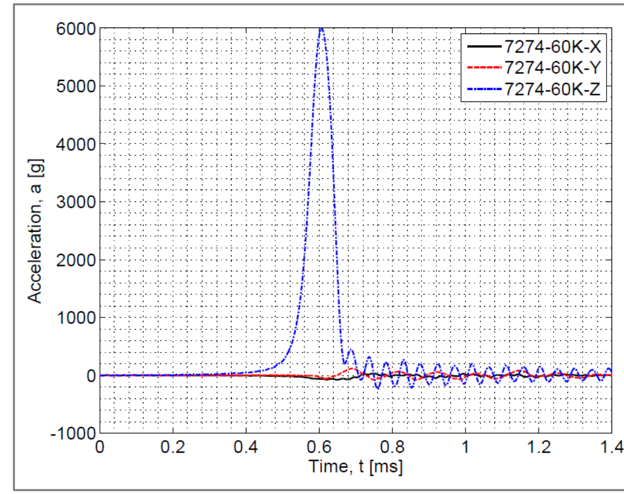
15 May 2012

# Performance characteristic

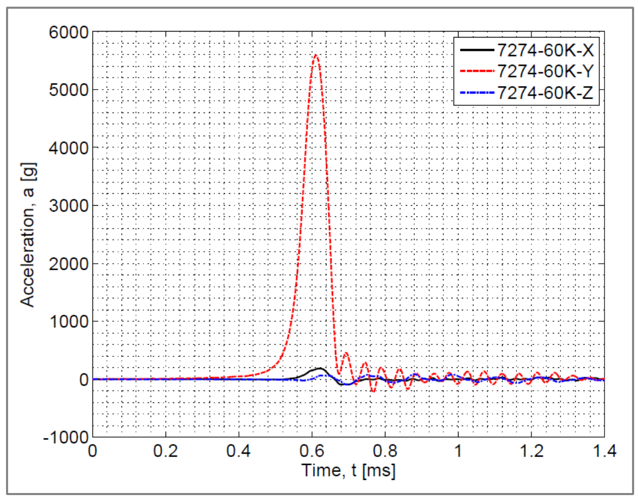
## Low-g shock testing




- 5,588 g POP in y-axis
- Transverse sensitivity:
  - x-axis = 3.3 percent
  - z-axis = 1.1 percent




- 5,987 g POP in z-axis
- Transverse sensitivity:
  - x-axis = 1.3 percent
  - y-axis = 1.0 percent




- 5,987 g POP in z-axis
- Transverse sensitivity:
  - x-axis = 1.3 percent
  - y-axis = 1.0 percent





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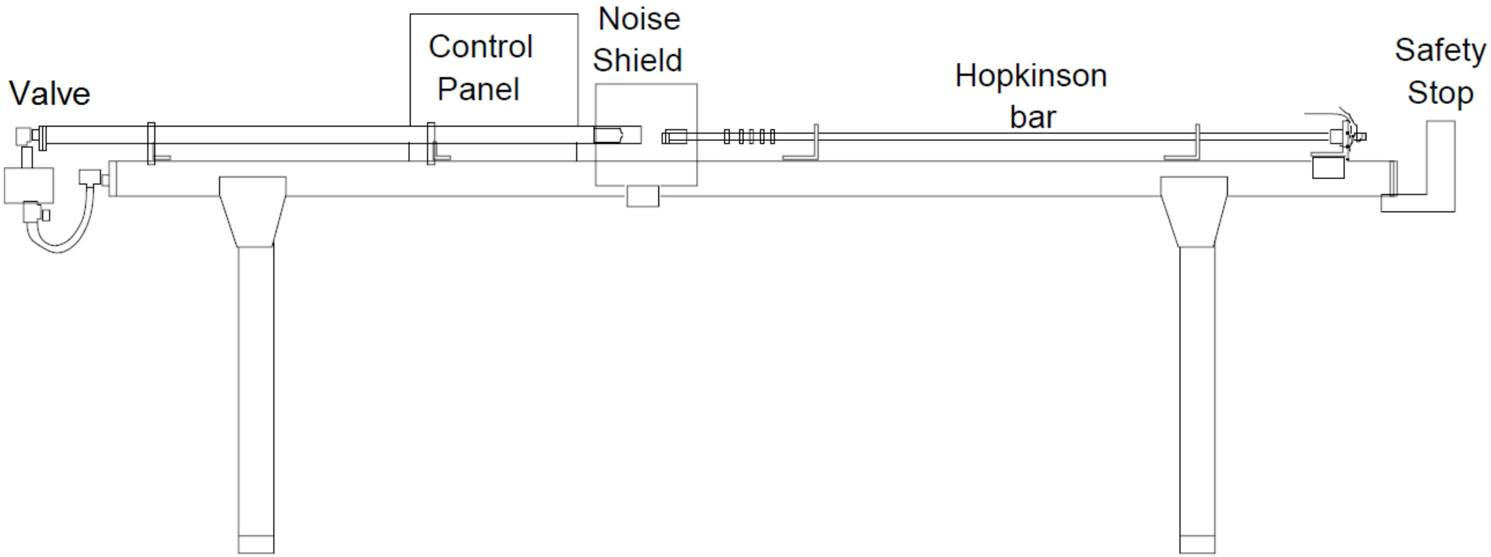
# Performance characteristic
## High-g shock testing

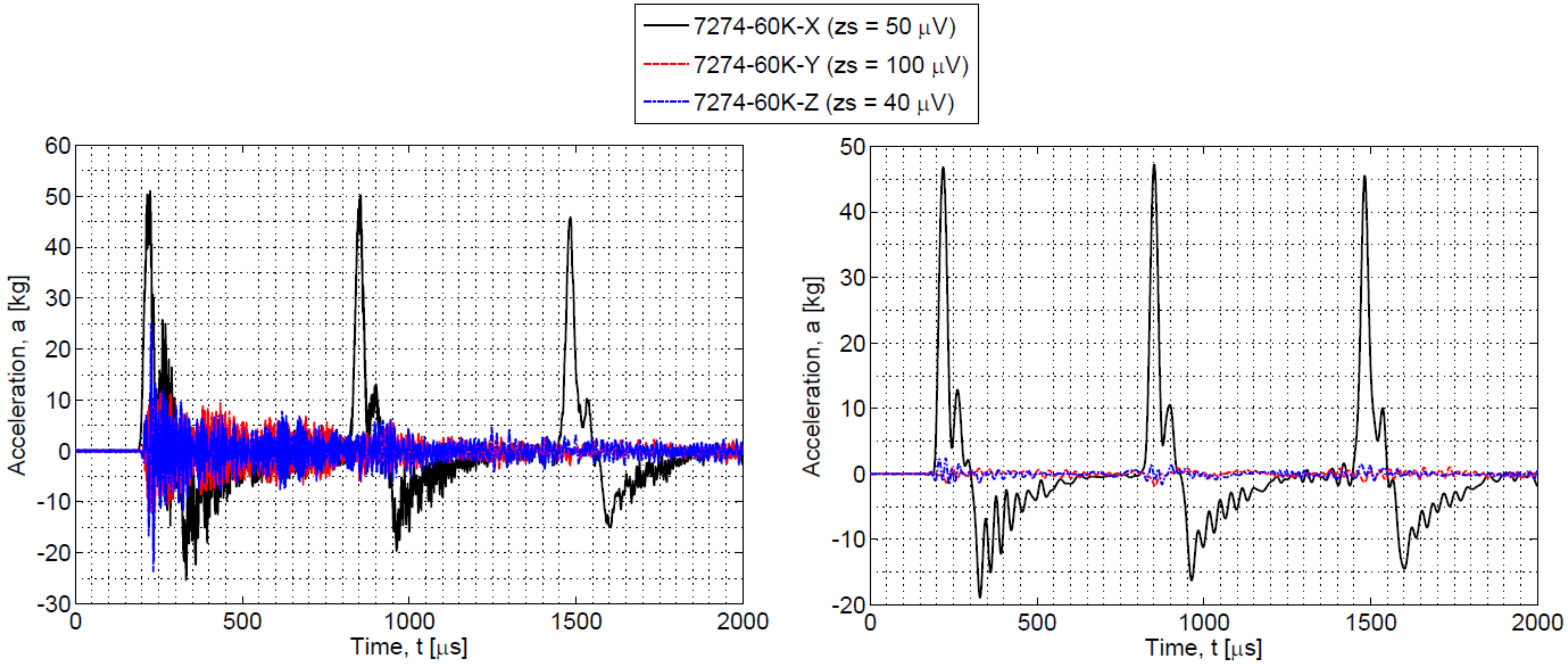
» Endevco® model 2973A Hopkinson bar
  - Optional on the Automated Accelerometer Calibration System (AACS)
  - Shock amplitudes from 10,000 g to >100,000 g
  - Pulse durations from 300 µs to <100 µs



# Performance characteristic

## High-g shock testing

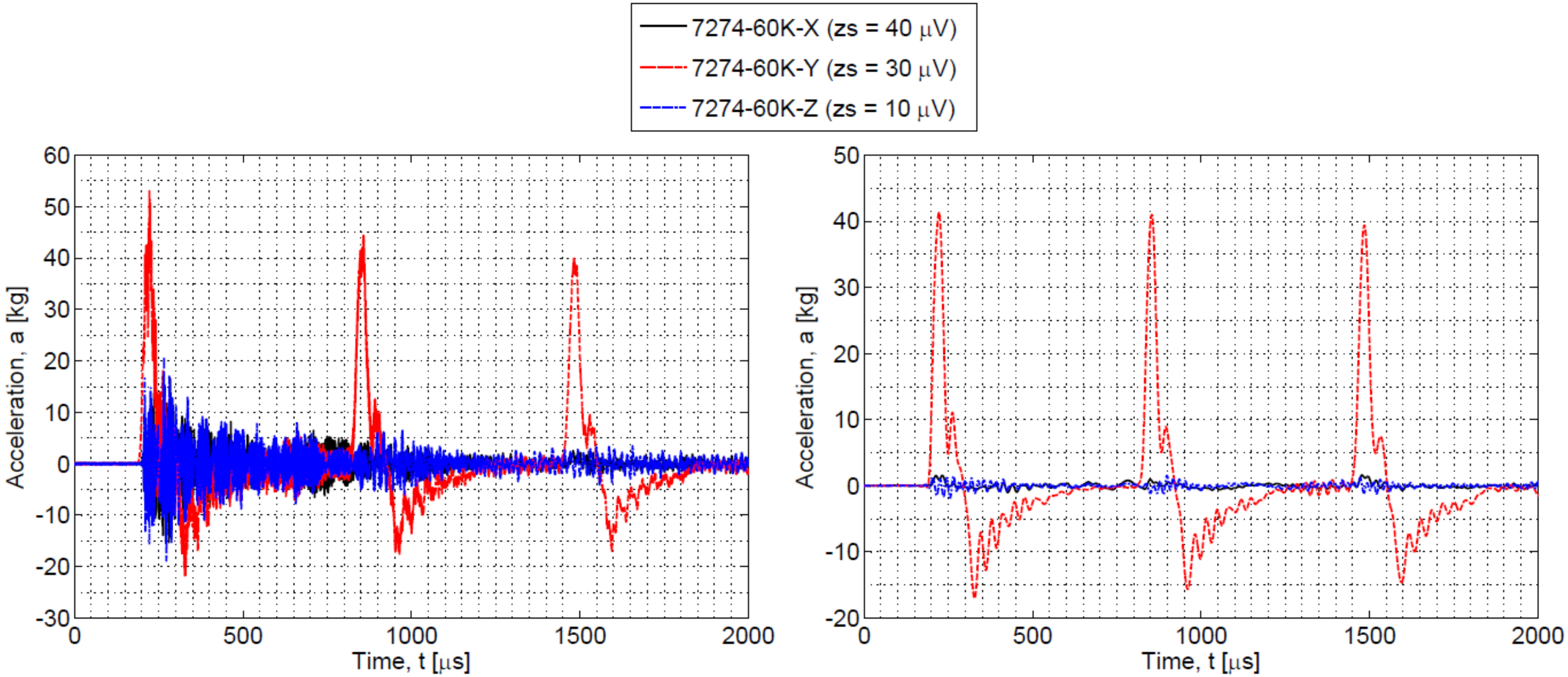
- Hopkinson bar test in x-axis near 50,000 g using calibration fixture
  - Unfiltered (left) and 50 kHz low-pass filtered (right)
  - Zero shift after shock less than 100 µV, or .06% full scale output



# Performance characteristic

## High-g shock testing

- Hopkinson bar test in y-axis near 40,000 g using calibration fixture
  - Unfiltered (left) and 50 kHz low-pass filtered (right)
  - Zero shift after shock less than 40 µV, or .024% full scale output







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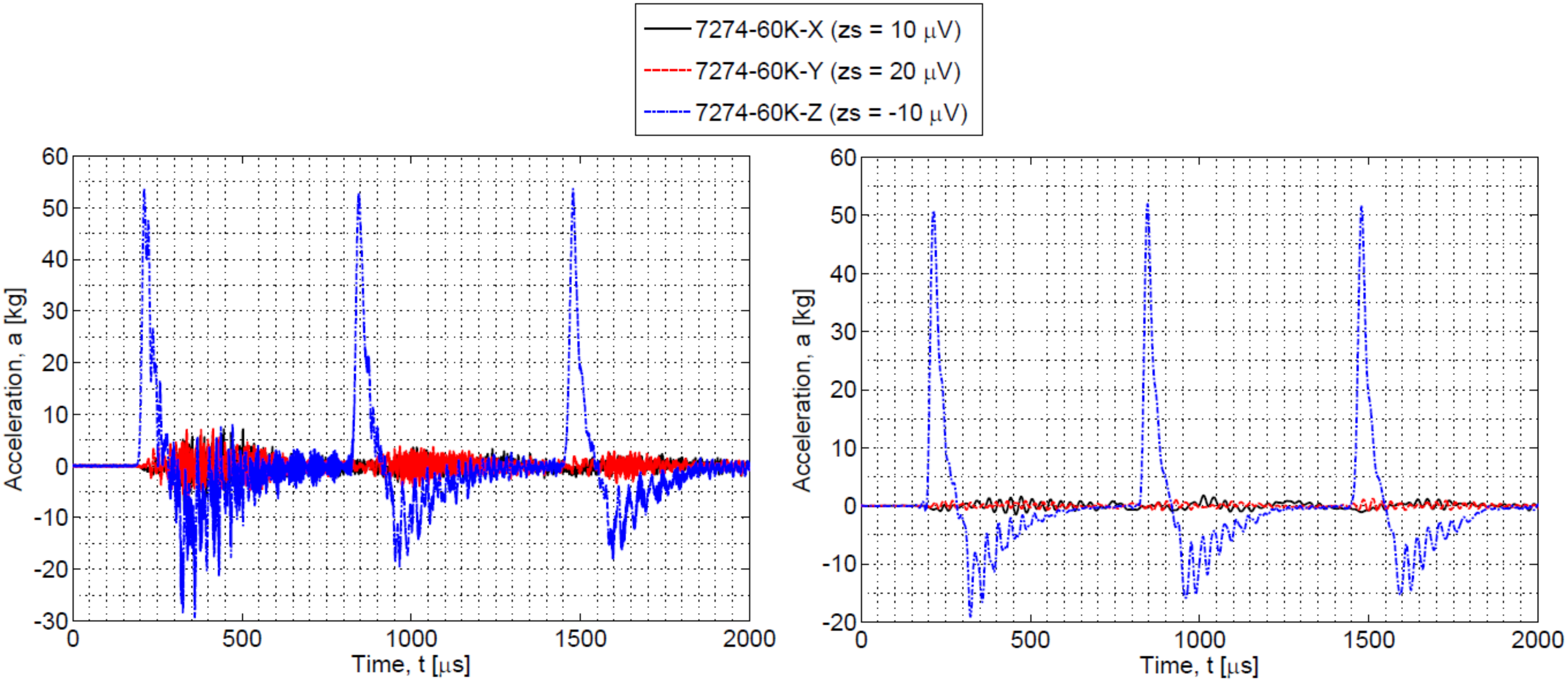
# Performance characteristic

## High-g shock testing

» Hopkinson bar test in z-axis near 50,000 g using calibration fixture
  - Unfiltered (left) and 50 kHz low-pass filtered (right)
  - Zero shift after shock less than 20 µV, or .01% full scale output



# Performance characteristic
## Survivability testing to greater than 3X range

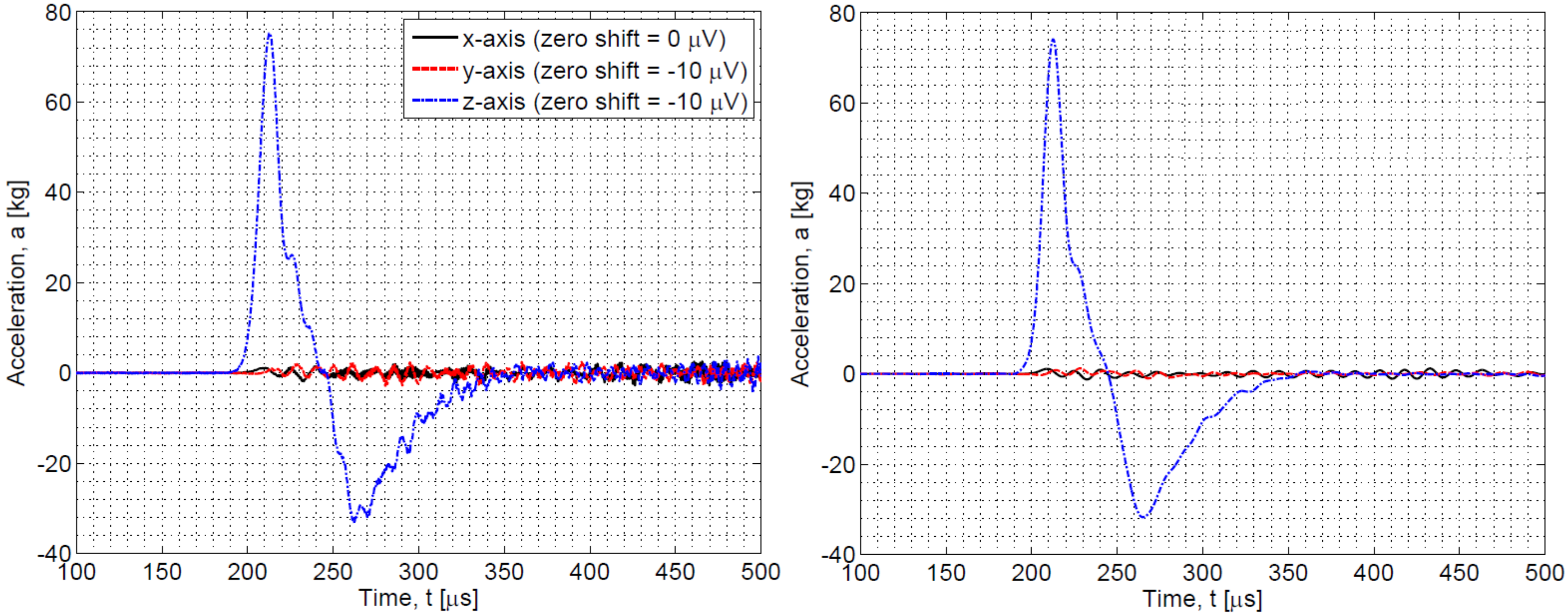
- UUT mounted directly to Hopkinson bar
  - Temporary adhesive between the mounting surface and the mounting screws (discussed in more detail later)

- Triaxial calibration fixture pushed to its limit in the previous testing
  - Designed to be a calibration fixture, not a high-g shock test fixture
  - Weight and size of fixture influences shock input
  - Weight at high acceleration levels becomes too much for the threaded stud to retain the test fixture on the Hopkinson bar

# Performance characteristic

## Survivability testing to greater than 3X range

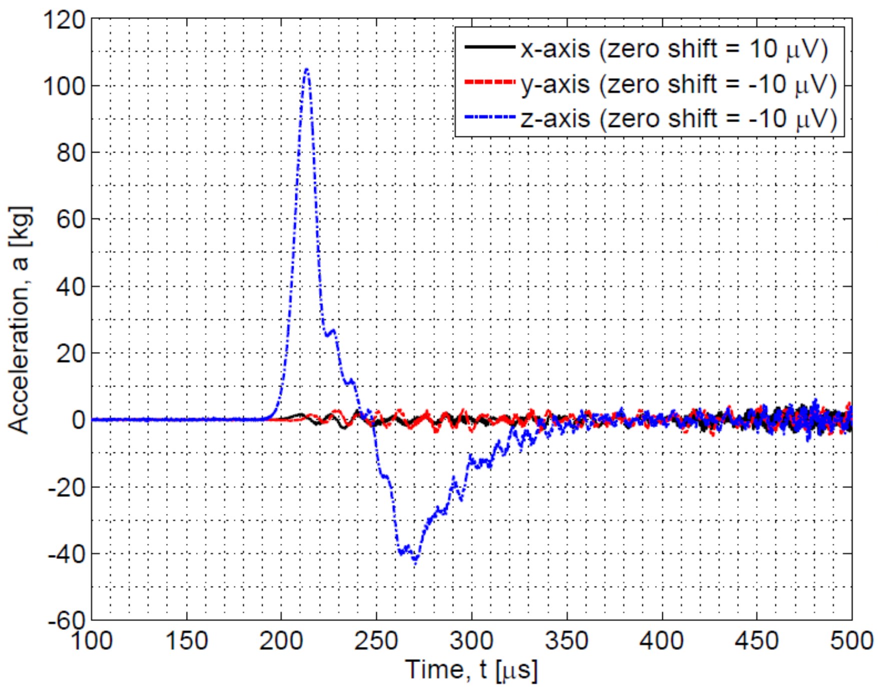
- Hopkinson bar test in the z-axis near 75,000 g
  - Unfiltered (left) and 80 kHz low-pass filtered (right)
  - Zero shift after shock less than 10 μV, or .01% full scale output
  - Transverse sensitivity measurements: x-axis = 1.6 percent, y-axis = 1.6 percent

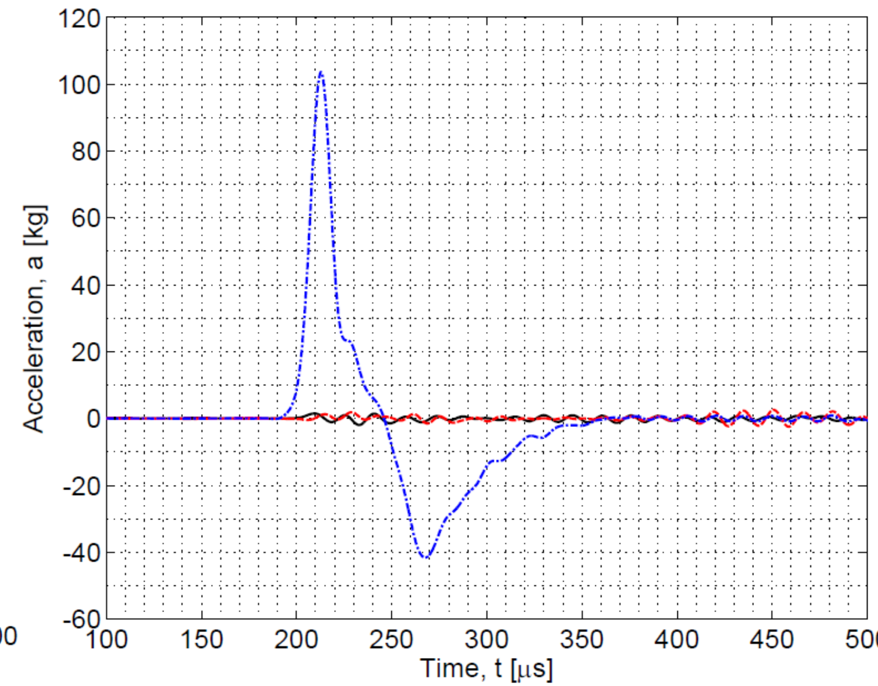


# Performance characteristic

## Survivability testing to greater than 3X range

- Hopkinson bar test in the z-axis near 104,000 g
  - Unfiltered (left) and 80 kHz low-pass filtered (right)
  - Zero shift after shock less than 10 µV, or .01% full scale output
  - Transverse sensitivity measurements: x-axis = 1.4 percent, y-axis = 1.7 percent







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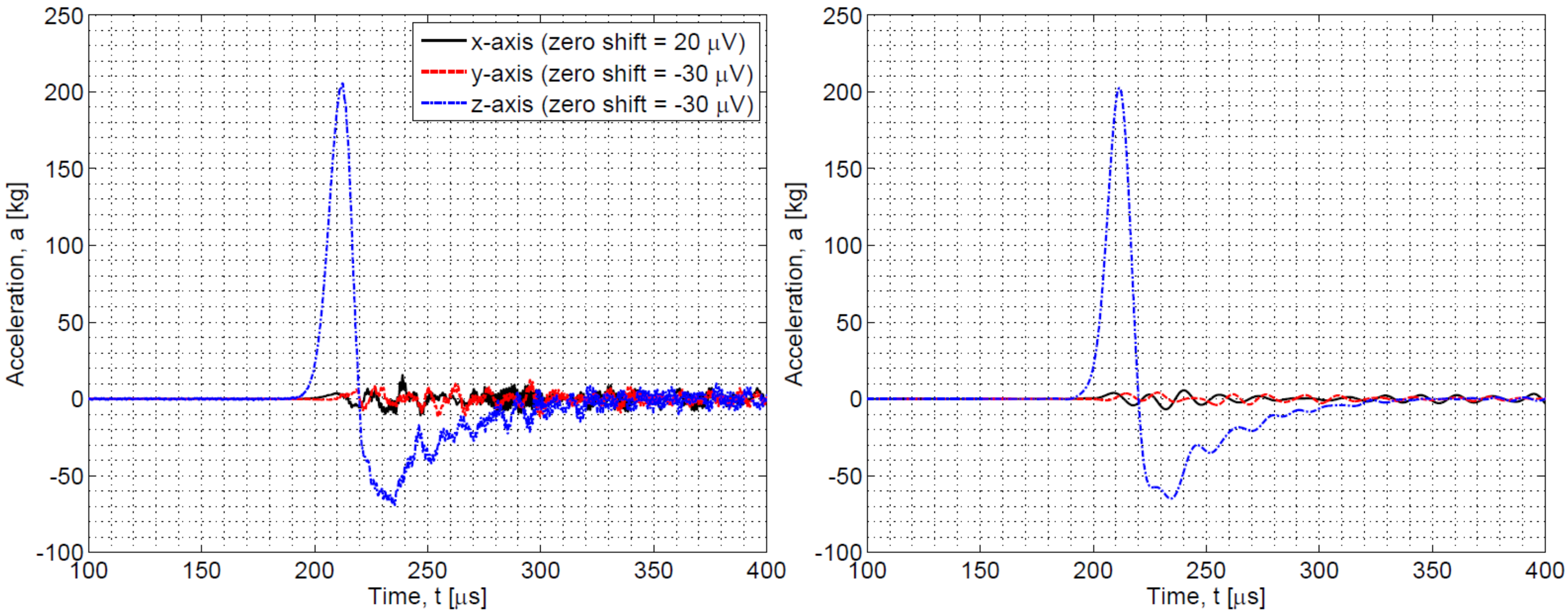
# Performance characteristic

## Survivability testing to greater than 3X range

» Hopkinson bar test in the z-axis near 200,000 g
  - Unfiltered (left) and 80 kHz low-pass filtered (right)
  - Zero shift after shock less than 30 µV, or .02% full scale output
  - Transverse sensitivity measurements: x-axis = 1.8 percent, y-axis = 1.6 percent



# Usage and handling of the 7274

- Handled the same as 7270A
  - Handle carefully to prevent unwanted resonant excitation
  - Unpack and install in ESD safe work areas

- Mounted the same as 7270A
  - Uneven mounting surfaces cause increased transverse sensitivity
  - Recommended use of an adhesive between the unit and the mounting surface
    - Enhance mounting strength of screws, especially in transverse loading conditions
    - Minimize effects of case dynamics on acceleration data
    - Optimize transmissibility of the shock input to the sensor

# Usage and handling of the 7274

- If no mounting adhesive is used an acoustic couplant is encouraged
  - Ensures that the accelerometer is in intimate contact with the mounting surface
  - Optimizes the transmissibility of the shock input to the sensor

- More specific usage and handling instructions found within the instruction manual [3]
  - If the instruction manual is not included in the shipment make sure to request one by contacting the factory

# Applications

- Compared to three single-axis accelerometers on a mounting block the 7274:
  - uses 13 percent the envelope volume
  - costs approximately two-thirds less

- Ideal applications
  - Any application where small size and lower cost is required
  - Applications where the individual axes are not required to be repairable
    - Hard potted modules
    - One-time use designs

# Coming soon

- Endevco® model 7284 damped, high-g shock triaxial accelerometer
  - Same sensing element discussed at past year's conferences [4] [5]
  - This year's conference presentation includes updated information [6]
- Includes light gas damping and mechanical over travel stops
  - More survivability in unpredictably harsh environments
  - Trade-offs (compared to the undamped version)
    - Reduced bandwidth resulting from a lower resonant frequency
    - Amplitude linearity to 1.5 times full scale range minimum
- With the realized space savings the 7274 and 7284 could be used together
  - 7274
    - high bandwidth data with extremely high linear overrange
  - 7284
    - improved survivability in unpredictably harsh environments
    - Reduces the risk of data loss if the undamped sensor is damaged

# Summary

- Endevco® 7274 high-g shock triaxial accelerometer
  - 13 percent the envelope volume and two-thirds the cost
  - Same undamped sensor as used on the 7270A (approx. 30 years of service)
  - Compatible footprint and bolt-pattern allowing it to be a drop-in replacement
  - Similar performance characteristics to 7270A
- Performance demonstration
  - Typically less than 3 percent transverse sensitivity
  - Shock survivability to greater than 3X range with minimal zero shift after shock
- Usage and handling
  - Handle the same as the 7270A
  - Recommended mounting uses an adhesive in combination with the screws
  - Recommended use of acoustic couplant if a mounting adhesive is not used
- Applications
  - Ideal for applications where small size and lower cost per axis are required
  - Space savings allow the 7274 and 7284 to be used together to optimize reliability

# References


[1] "Practical Understanding of Key Accelerometer Specifications," Technical Paper No. 328, Meggitt (San Juan Capistrano), Inc.

[2] "Model 2925 AACS Comparison Shock Calibrator (POP)", Datasheet No. 2925, Meggitt (San Juan Capistrano), Inc.

[3] "Model 7274 Triaxial Accelerometer", Instruction Manual No. IM7274 Revision A1, Meggitt (San Juan Capistrano), Inc., Revised January 2012.

[4] T. Kwa, G. Pender, J. Letterneau, K. Easler, R. Martin, "A New Generation of High-Shock Accelerometers with Extreme Survivability Performance," Proc. 53rd NDIA Fuze Conference, Lake Buena Vista, FL, May 21, 2009.

[5] R. Martin, G. Pender, J. Letterneau, T. Kwa, "Results from Preliminary Testing of a New Generation of High-Shock Accelerometers with Extreme Survivability Performance," Proc. 54th NDIA Fuze Conference, Kansas City, MO, May 13, 2010.

[6] R. Martin, J. Letterneau, "High Survivability Accelerometer for Fuze Applications," Proc. 56th NDIA Fuze Conference, Baltimore, MD, May 16, 2012.

# Questions?

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