SAND2010-7699P

MEMS COMPONENT RELIABILITY TESTING

Fall Meeting
TECHNOLOGY COORDINATION GROUP XIV (TCG XIV)
Predictive Materials Aging and Reliability
Panama City, Florida

John R. Lopez, Thomas E. Buchheit, Abdul Kudiya, Judy Potter-Shields
James Clements, Rachelle Thompson, Christina Benavidez,
Fernando Bitsie, Evan Johnson, Matt Spletzer

Sandia National Labs
Albuquerque, NM

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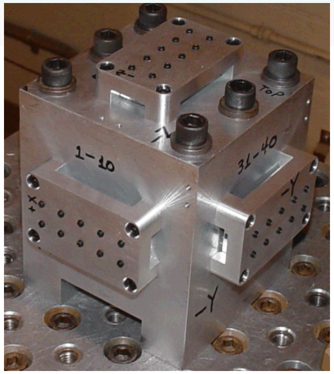
PROJECT OVERVIEW



Background:

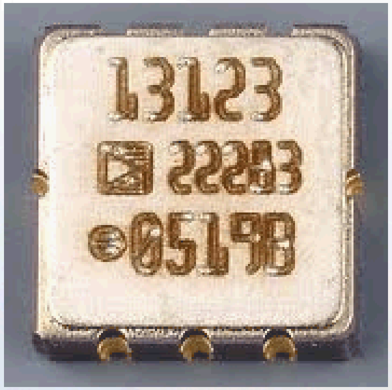
- SNL shall assist AMRDEC with ascertaining major causes of COTS-MEMS device failures that are of general interest to weapons design and development to both laboratories.

Objective:

- Conduct specific mechanical reliability tests and subsequent analysis on failed parts as part of a broad-based reliability study managed by AMRDEC/RDECOM.

Description:

- Reliability testing will be performed on a single axis, High-G MEMS accelerometer ADXL193 manufactured by Analog Devices Inc.



Analog Devices ADXL193
AD22283-B-R2

Milestones:

- 4th quarter of fiscal year FY10 Procurement of devices
- 1st quarter of FY11 Completed Variable Frequency Vibration Experiments
- 2nd quarter of FY11 Completed Mechanical Drop, Shock and Cycling Reliability Experiments
- 1st and 3rd quarter of FY11 Reported Results (Presentation)
- 3rd quarter of FY11 Completed Failure Analysis
- 4th quarter of FY11 Completed Final Report

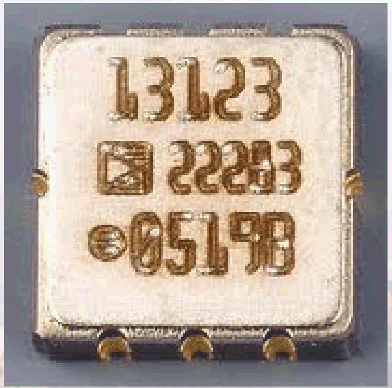
Deliverables:

- Progress reports
- Final report

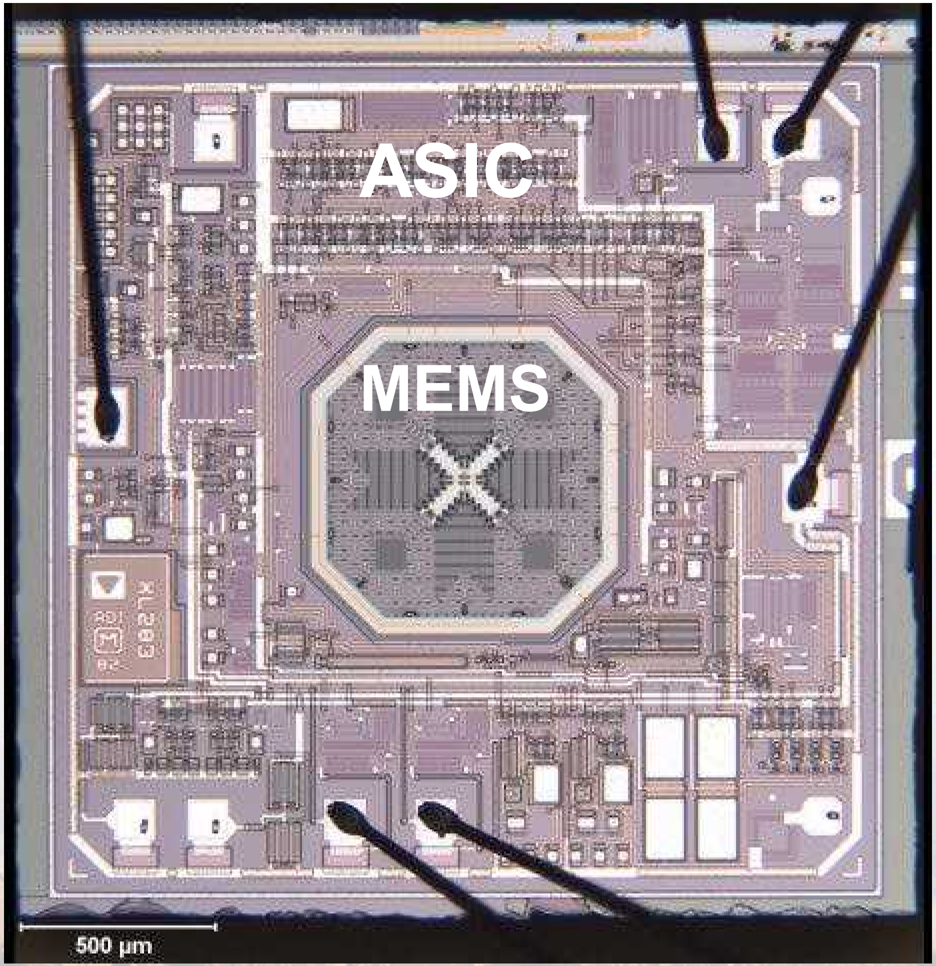
MEMS Accelerometer Device

ADXL193 AD22283-B-R2

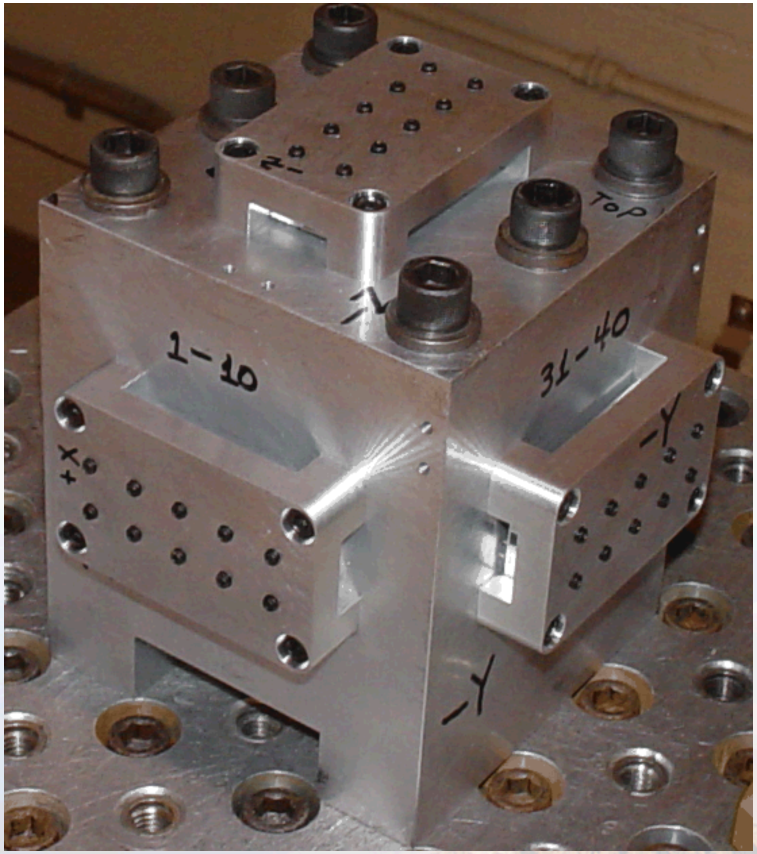
- Analog Devices
- ±250g full scale range
- 8.0±0.4mV/g sensitivity
- 8-terminal ceramic LCC package.
- Automotive grade
- MEMS and ASIC on a single monolithic IC
- Surface micro-machined
- -65ºC to +150ºC operating range
- 4000g maximum acceleration

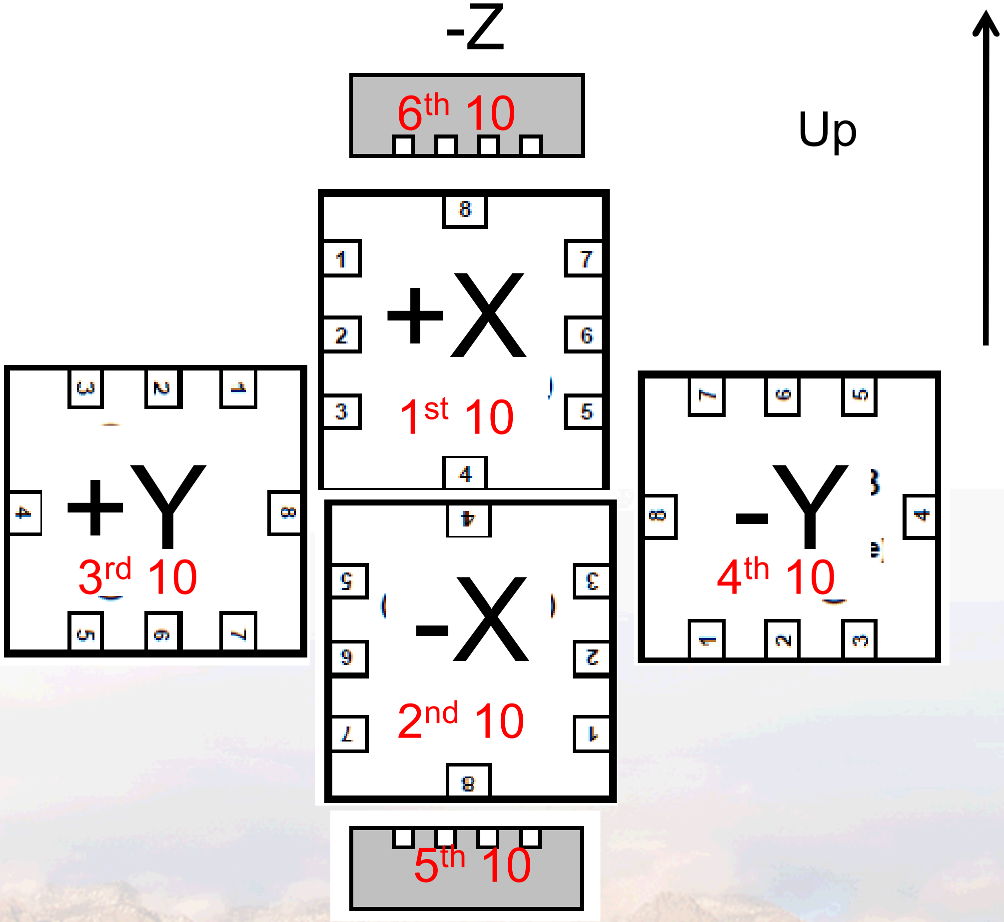


Similar De-lidded Device



Part Orientation





TOP

-Z

6th 10

+X

1st 10

+Y

3rd 10

-X

2nd 10

-Y

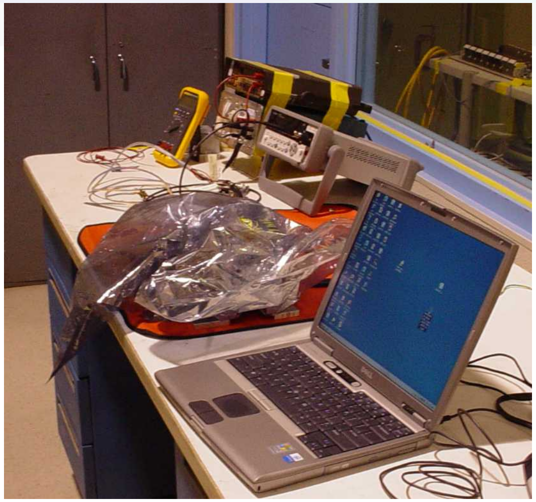
4th 10

5th 10

Up

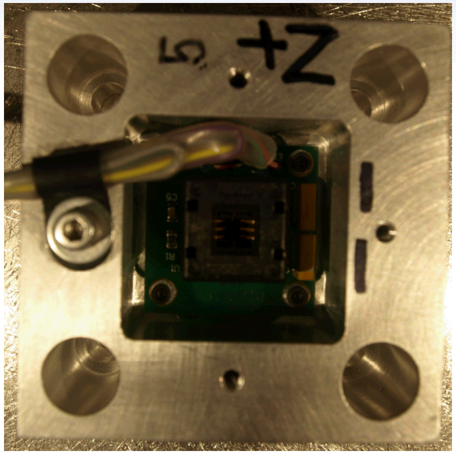
+Z

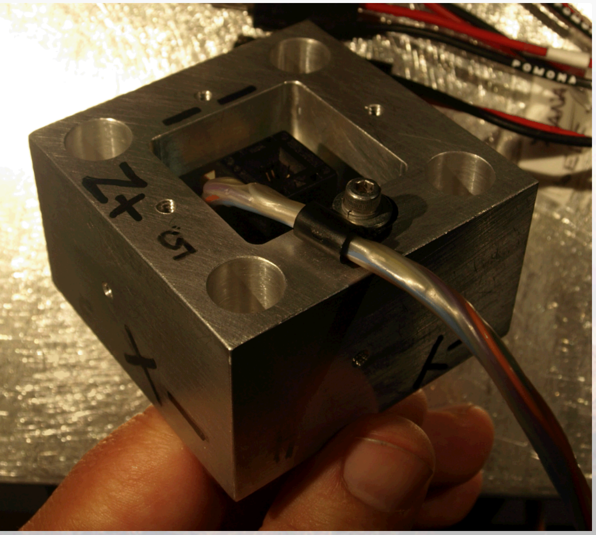
Electrical Testing

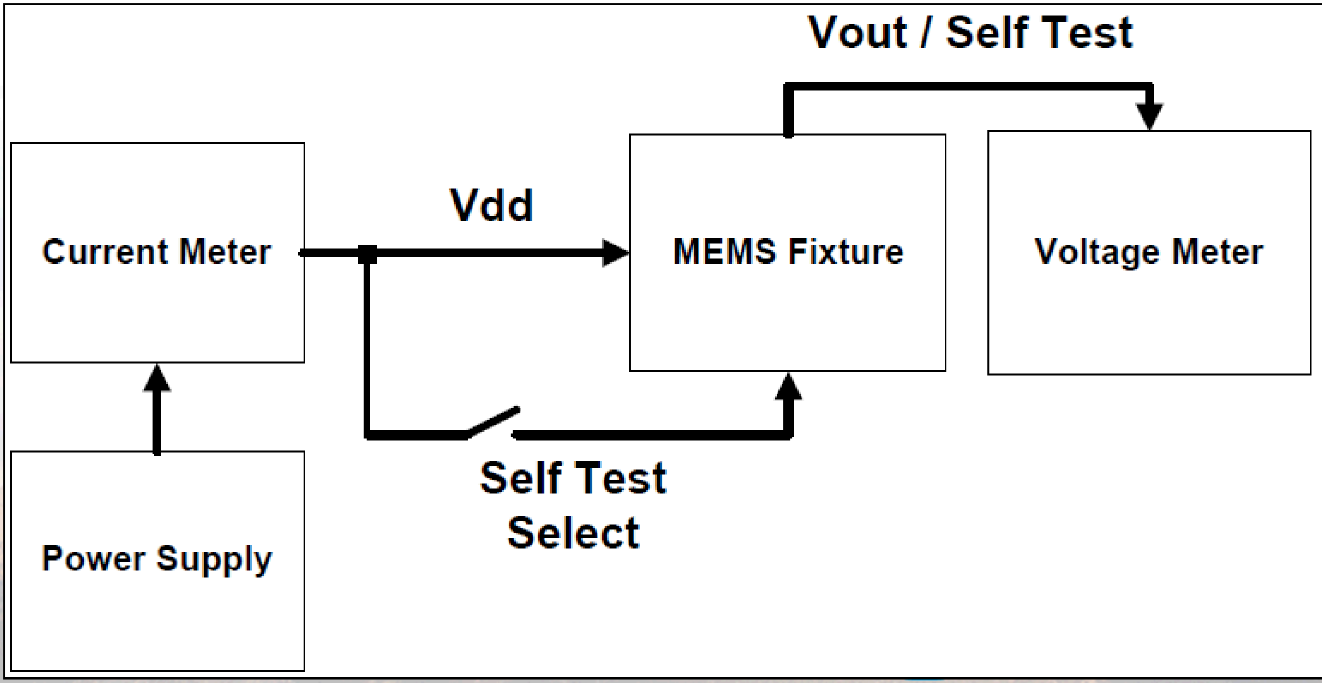


Tested Parameters:

- V_{out} for 6 orientations,
- Supply Current,
- V_{out} for activated self test.







Vout / Self Test

Current Meter

Vdd

MEMS Fixture

Voltage Meter

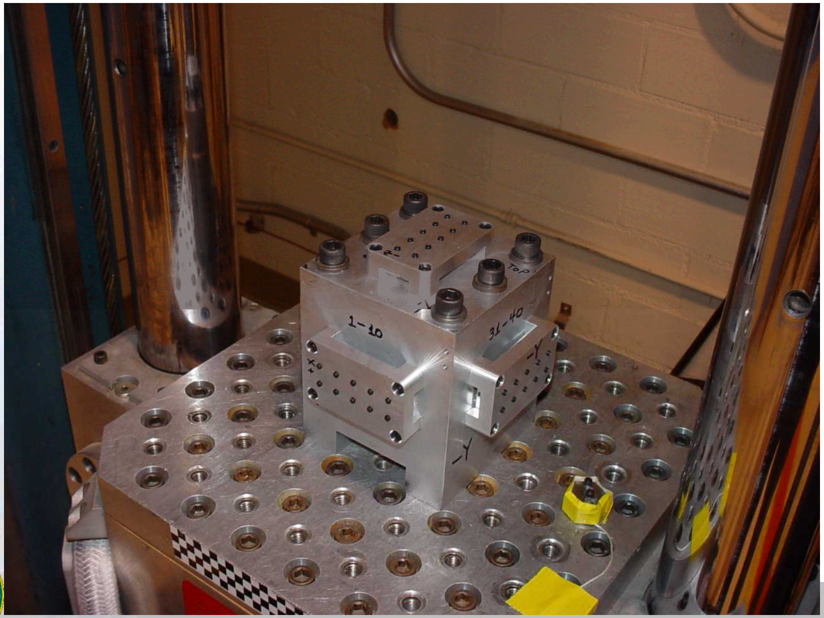
Power Supply

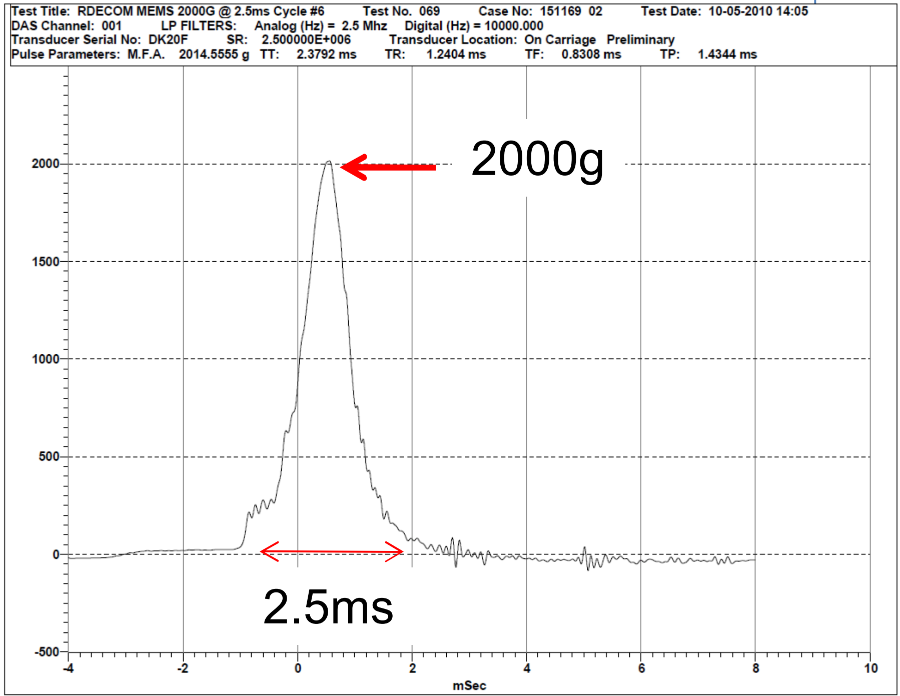
Self Test Select

Mechanical Drop Test

Per MIL STD 810 Method 516.5F

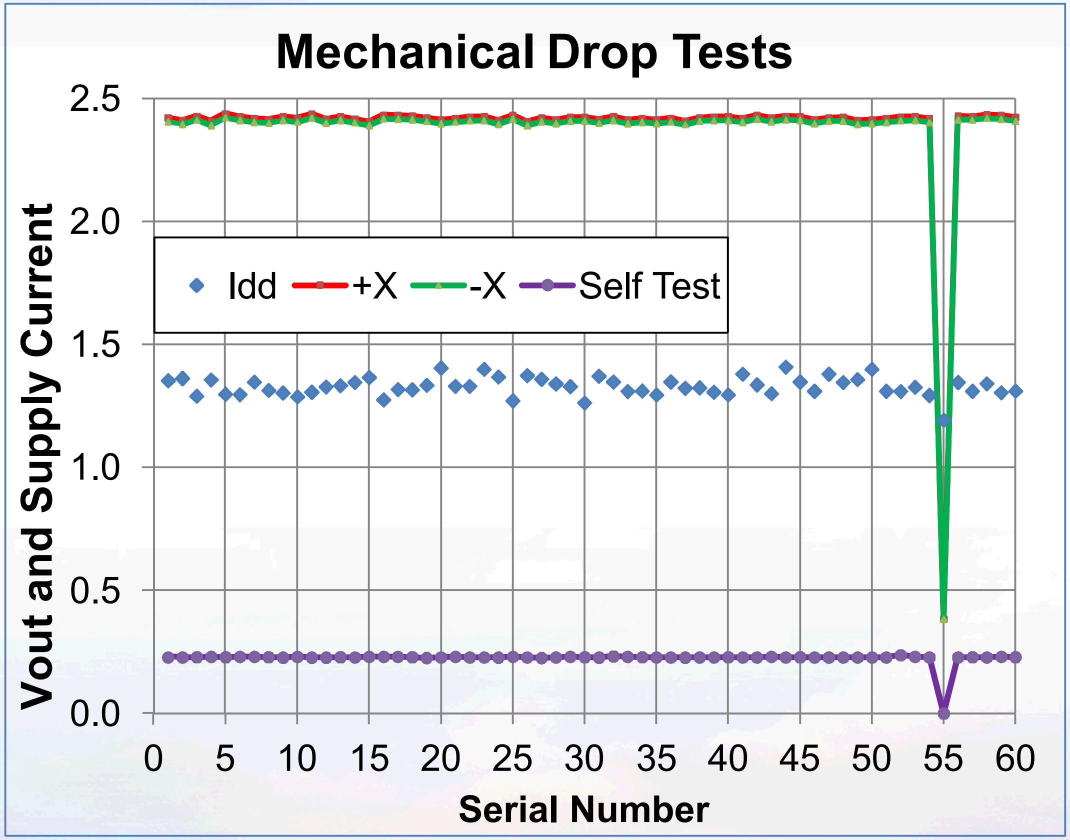
- Max acceleration of 2000g and a pulse duration of 2.5 mS.
- Performed test on 10 devices mounted in the +/-x, +/-y, and +/- z orientations.
  - 60 devices total
- Repeat experiment until failure or until 100 cycles are completed.
  - Perform electrical tests at 10 cycle increments.
    - Self-test,
    - +1g and-1g response tests





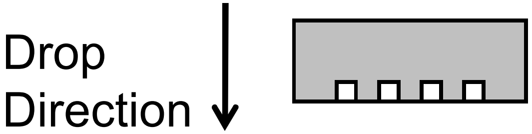
Test Title: RDECOM MEMS 2000G @ 2.5ms Cycle #6 Test No. 069 Case No: 151169 02 Test Date: 10-05-2010 14:05
DAS Channel: 001 LP FILTERS: Analog (Hz) = 2.5 Mhz Digital (Hz) = 10000.000
Transducer Serial No: DK20F SR: 2.500000E+006 Transducer Location: On Carriage Preliminary
Pulse Parameters: M.F.A. 2014.5555 g TT: 2.3792 ms TR: 1.2404 ms TF: 0.8308 ms TP: 1.4344 ms

Mechanical Drop Test Results



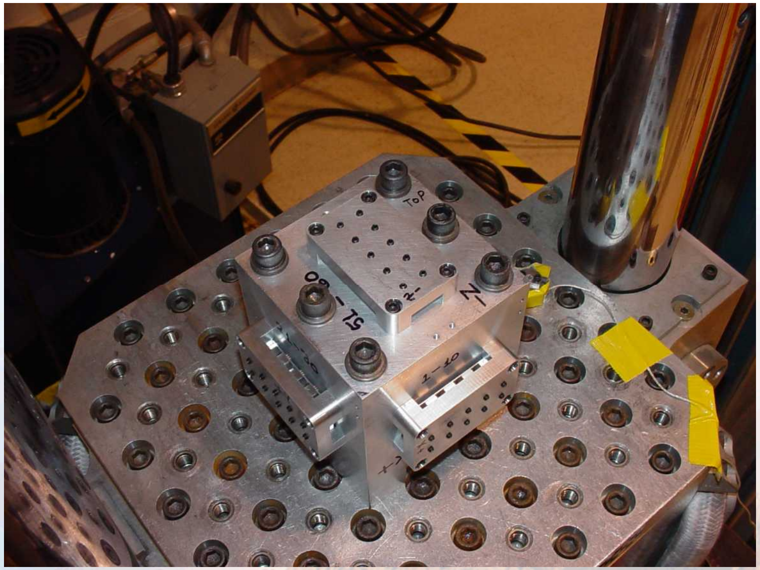
Failure occurred after 100 drops

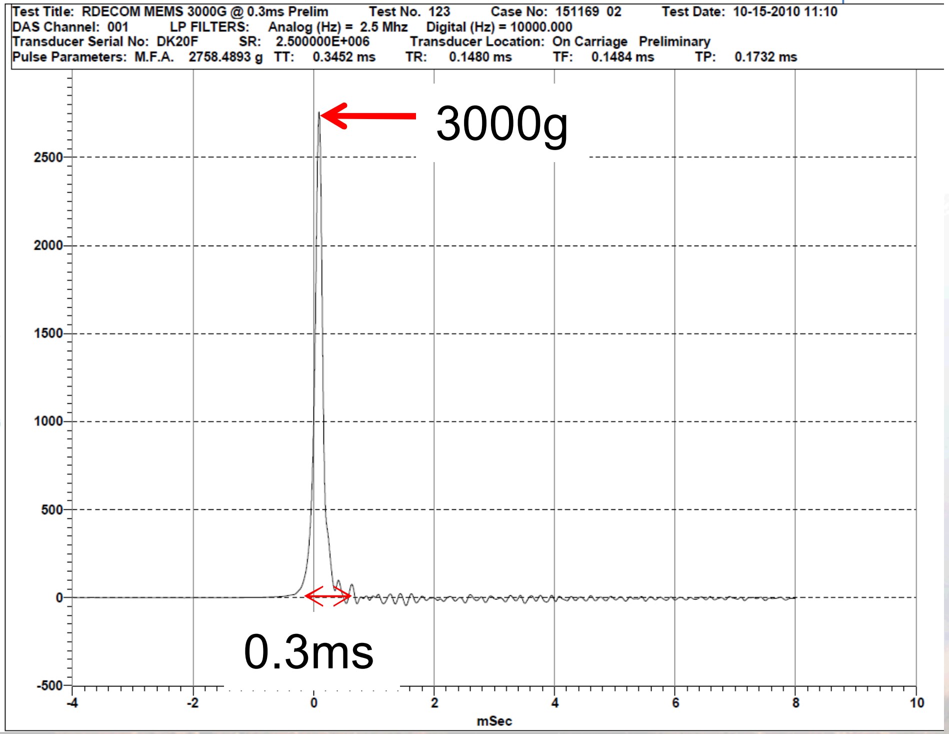
- V_{out} failed for all 6 axes
- Self test failed
- Measured drop in current draw
- Device was in –Z drop orientation



Mechanical Shock Test

- 3000g max. acceleration and approximately 0.3 ms pulse width.
- Performed test on 10 devices mounted in the +/-x, +/-y, and +/- z orientations.
  - 60 devices total
- Repeat experiment until failure or until 100 cycles are completed.
  - Perform electrical tests at 10 cycle increments.
    - Self-test,
    - +1g and-1g response tests



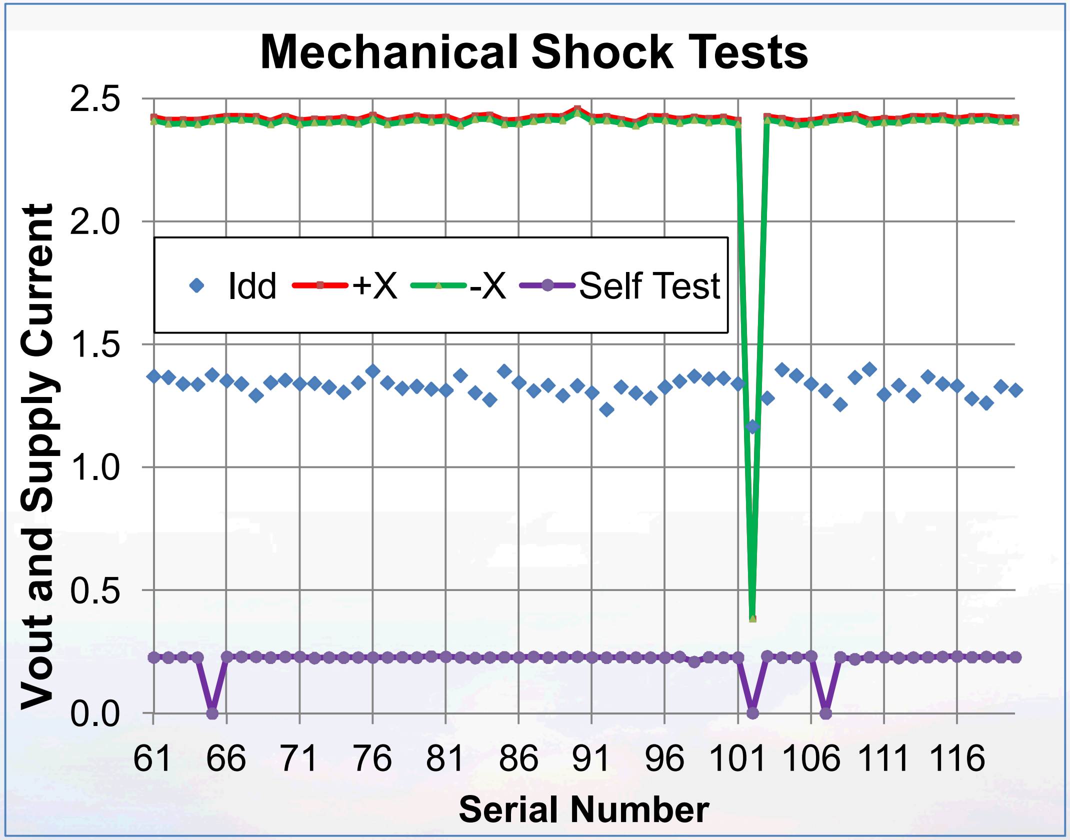


Test Title: RDECOM MEMS 3000G @ 0.3ms Prelim Test No. 123 Case No: 151169 02 Test Date: 10-15-2010 11:10
DAS Channel: 001 LP FILTERS: Analog (Hz) = 2.5 Mhz Digital (Hz) = 10000.000
Transducer Serial No: DK20F SR: 2.500000E+006 Transducer Location: On Carriage Preliminary
Pulse Parameters: M.F.A. 2758.4893 g TT: 0.3452 ms TR: 0.1480 ms TF: 0.1484 ms TP: 0.1732 ms

3000g

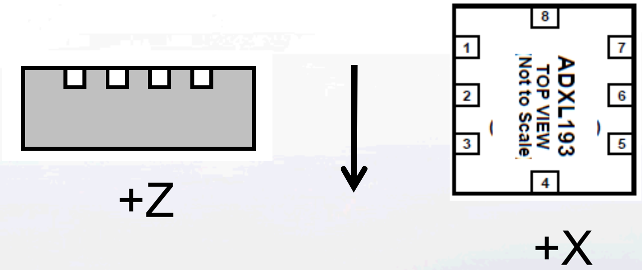
0.3ms

Mechanical Shock Test Results



Failures occurred after initial 3000g drop

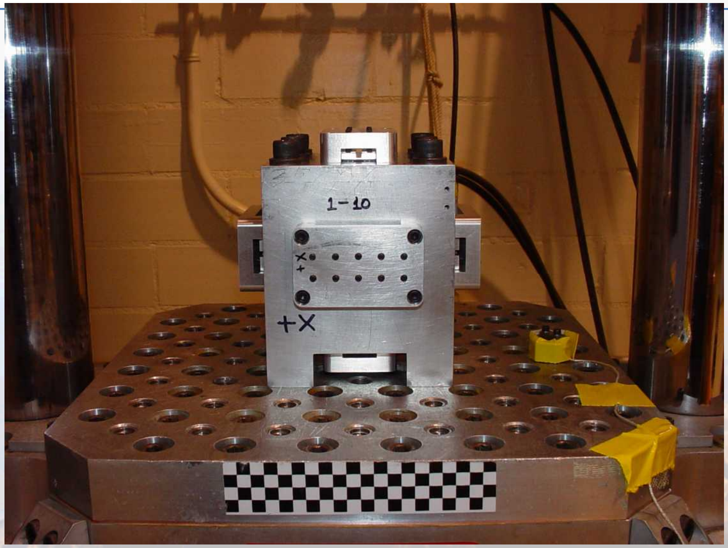
- One device failed V_{out} for all 6 axes and Self Test
  - Measured drop in current
  - +Z drop orientation
- Two devices failed Self test only
- +X and +Z drop orientations

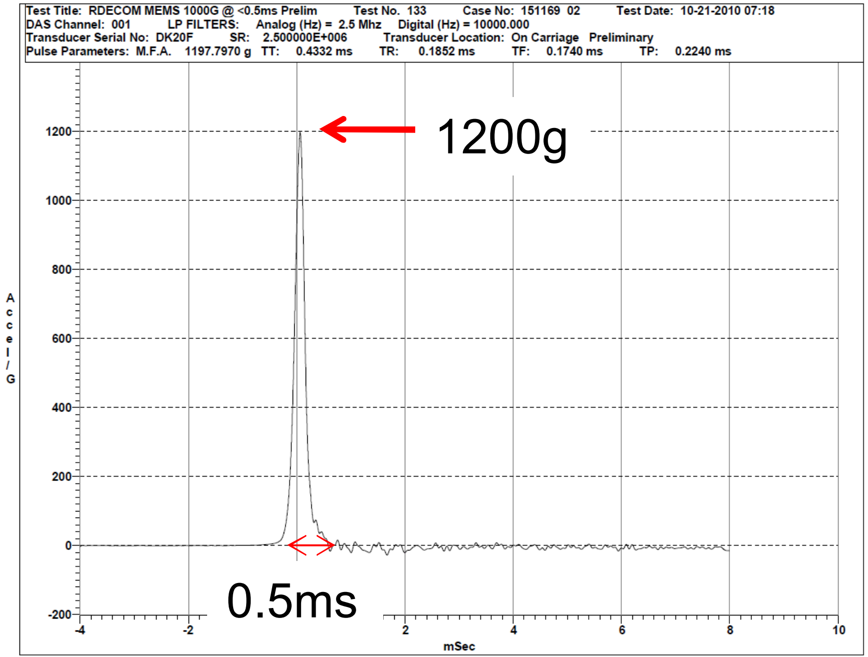


Mechanical Cycling Test

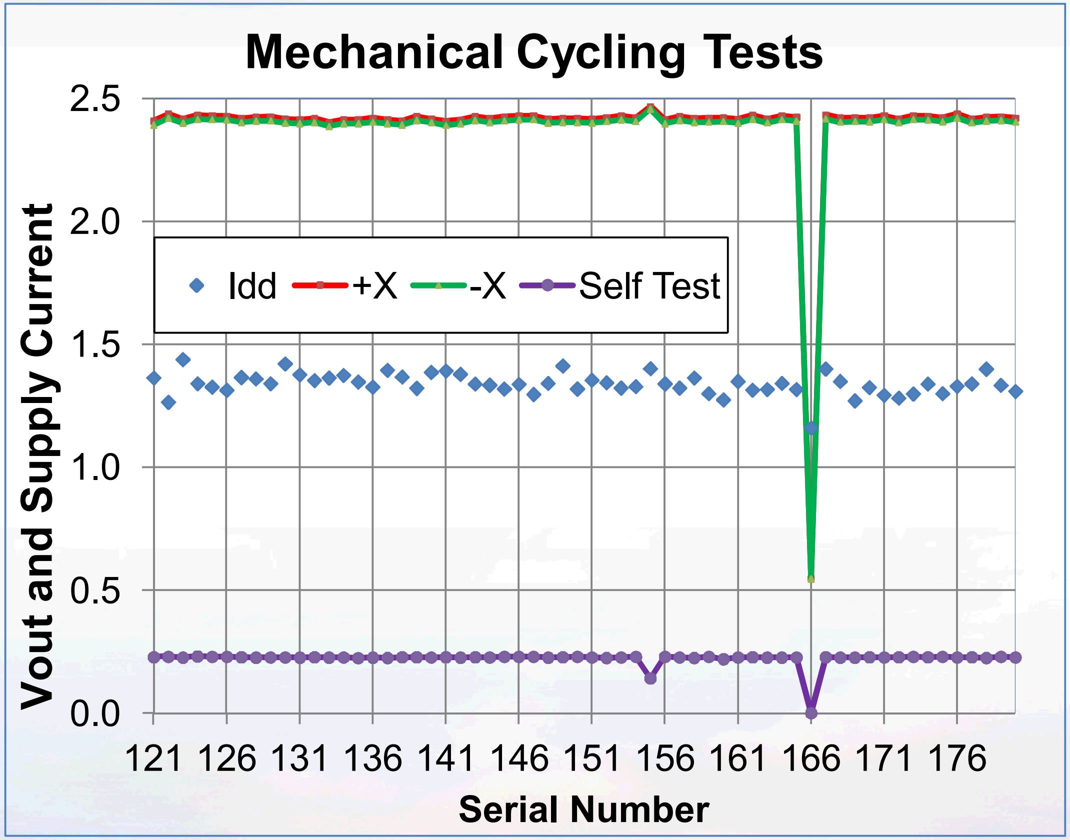
Per MIL STD 810 Method 516.5F

- Shock pulses with max. accelerations between 1000g and 10000g, at 1000g intervals with a pulse width not exceeding 0.5 ms.
- Performed test on 10 devices mounted in the +/-x, +/-y, and +/- z orientations.
    - 60 devices total
- Repeat experiment until failure or until 100 cycles are completed.
    - Perform electrical tests at 10 cycle increments.
        - Self-test,
        - +1g and-1g response tests



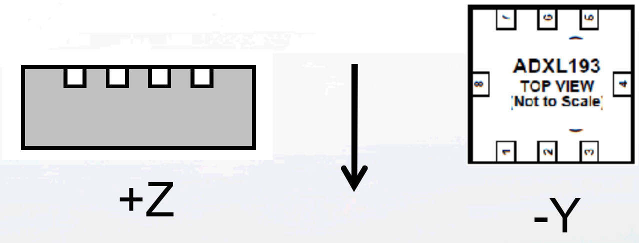

Test Title: RDECOM MEMS 1000G @ <0.5ms Prelim Test No. 133 Case No: 151169 02 Test Date: 10-21-2010 07:18
DAS Channel: 001 LP FILTERS: Analog (Hz) = 2.5 Mhz Digital (Hz) = 10000.000
Transducer Serial No: DK20F SR: 2.500000E+006 Transducer Location: On Carriage Preliminary
Pulse Parameters: M.F.A. 1197.7970 g TT: 0.4332 ms TR: 0.1852 ms TF: 0.1740 ms TP: 0.2240 ms

Mechanical Cycling Test Results



Failures occurred after initial 1000g drop

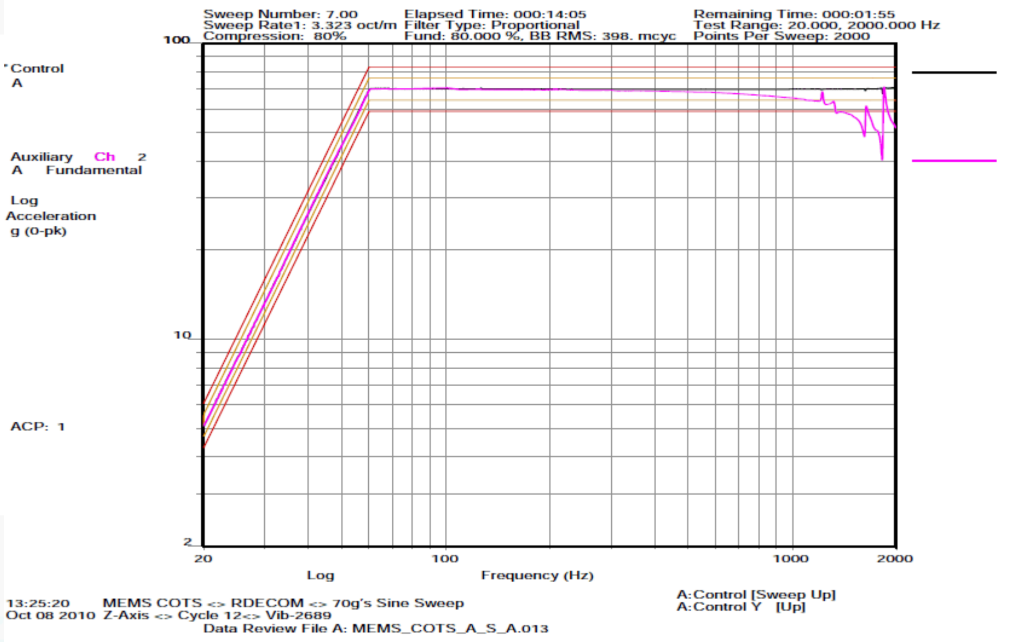
- One device failed V_{out} for all 6 axes and Self Test
  - Measured drop in current
  - +Z drop orientation
- One device failed Self test only
- -Y drop orientation



Variable Frequency Vibration Test

Per Mil-Std 883 2007.3

- Peak acceleration of 70g.
- Vary frequency range across 20-2000Hz range in approximately logarithmic intervals.
- Traverse frequency range 20-2000 Hz then return to 20 Hz in 4 minutes.
- Perform test on 10 devices mounted in the x, y, and z orientations.
    - 30 devices total
- Repeat experiment until failure or until 12 cycles are completed.
    - Perform electrical tests at 1 cycle increments.
        - Self-test,
        - +1g and-1g response tests

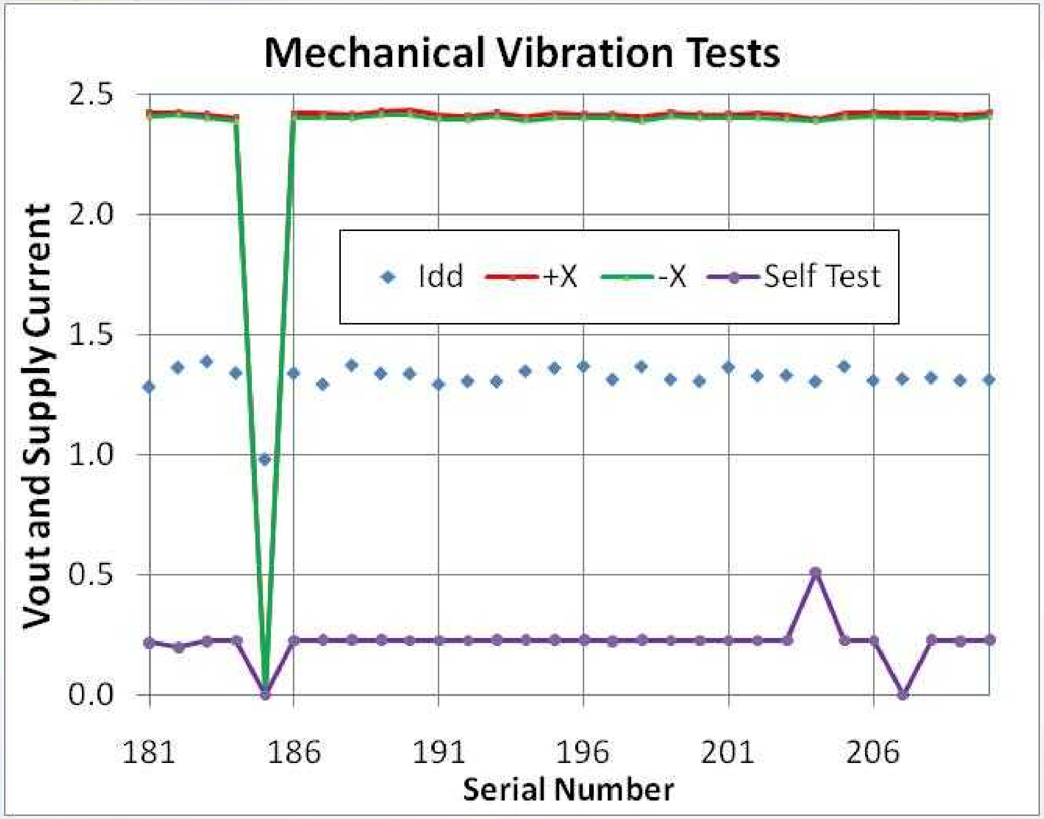


Sweep Number: 7.00
Sweep Rate1: 3.323 oct/m
Compression: 80%
Elapsed Time: 000:14:05
Filter Type: Proportional
Fund: 80.000 %, BB RMS: 398. mcyc
Remaining Time: 000:01:55
Test Range: 20.000, 2000.000 Hz
Points Per Sweep: 2000

13:25:20 MEMS COTS <> RDECOM <> 70g's Sine Sweep
Oct 08 2010 Z-Axis <> Cycle 12<> Vib-2689
Data Review File A: MEMS_COTS_A_S_A.013

A:Control [Sweep Up]
A:Control Y [Up]

Mechanical Vibration Test Results

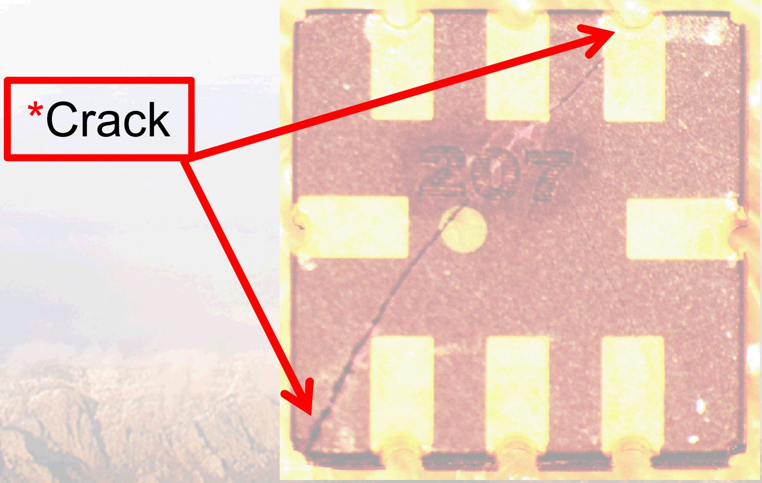


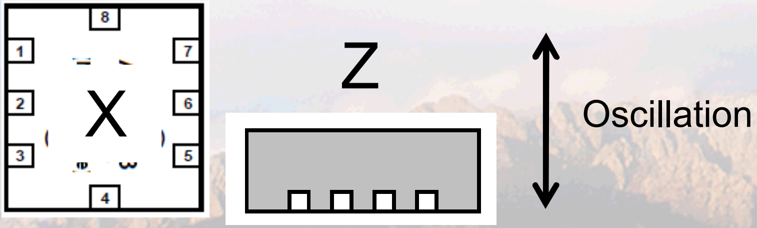
First Failure occurred after 9th Sweep

- Failed V_{out} for all 6 axes and Self Test
    - Measured decrease in current
    - X orientation

Three Additional Failures after 10th Sweep

- Failed Self test only
- X and Z* orientation


*Crack



Pending Activities

- Continue tests sequences past initial failures.
- Perform failure analysis on selected failed devices.
- Communicate with AMRDEC counterparts for feedback.
- Final Report.