High Rate In-situ Damage of Electronics Packages

Drop Tower shock tests of highly-instrumented electronics package

Alain Béliveau, Jonathan Hong
Applied Research Associates Inc.

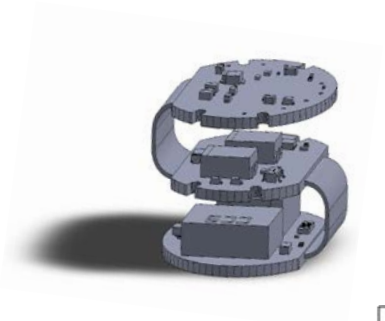
Jacob Dodson, Michael Davies
Air Force Research Laboratory

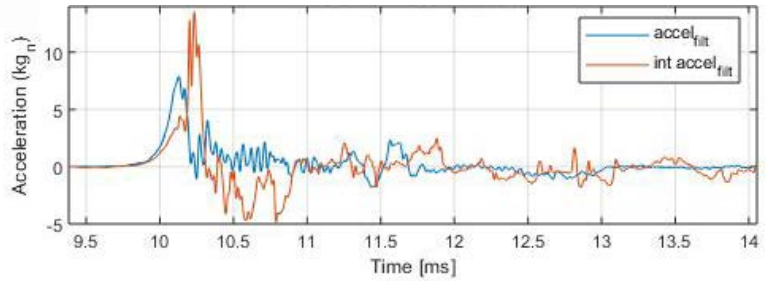
Objective

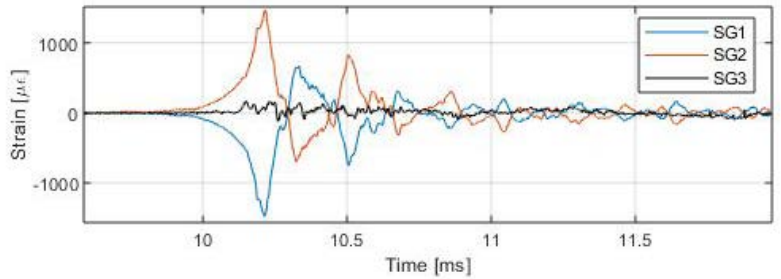
This data set will be shared with academic collaborators to provide relevant high-rate in-situ data on a highly instrumented electronic assembly under high level mechanical shock for development of real-time damage detection and remainable useful life (prognosis) algorithms on electronic systems.

Outline of Topics

- Electronics and Instrumentation
- Fixture
- Test Matrix
- Results







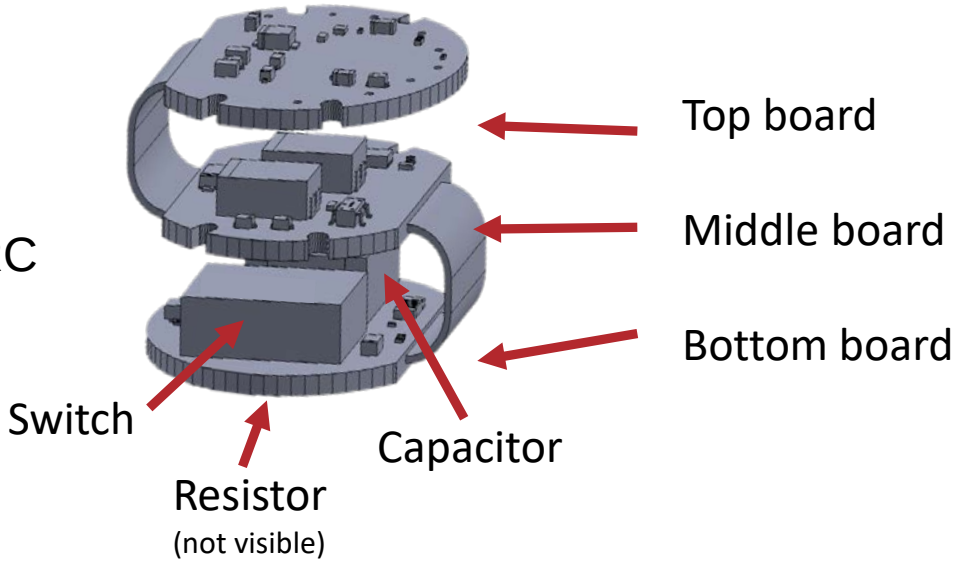
Summary:

In this test series, 1 unit (unpotted electronic assembly) was shock tested on a MTS drop tower at 5 shock levels (T04-T08). After the 5th test, the RC circuit was damaged no longer gave the appropriate charging signal.

Electronics and Instrumentation

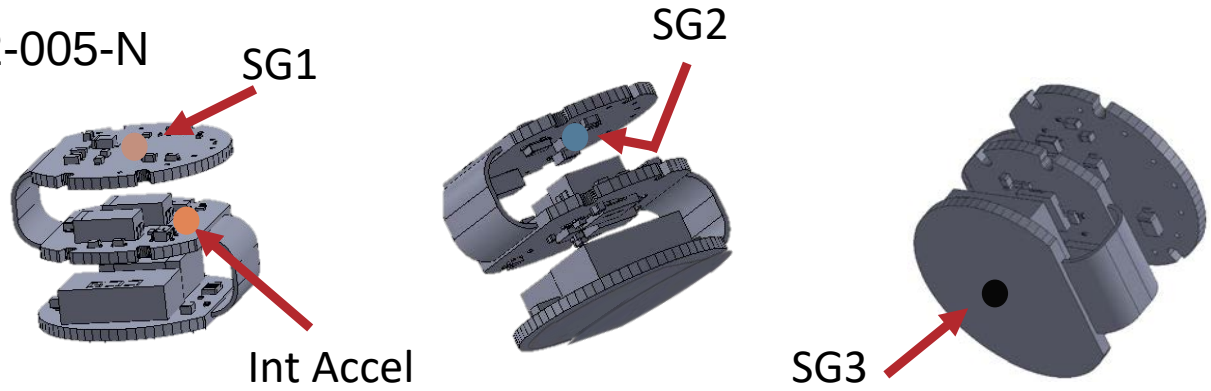
Electronic Assembly

The test article is a three board electronic assembly with a RC circuit with a switch on the bottom board. The goal is the successful discharge of the capacitor. The functionality of the RC circuit was tested after each test.



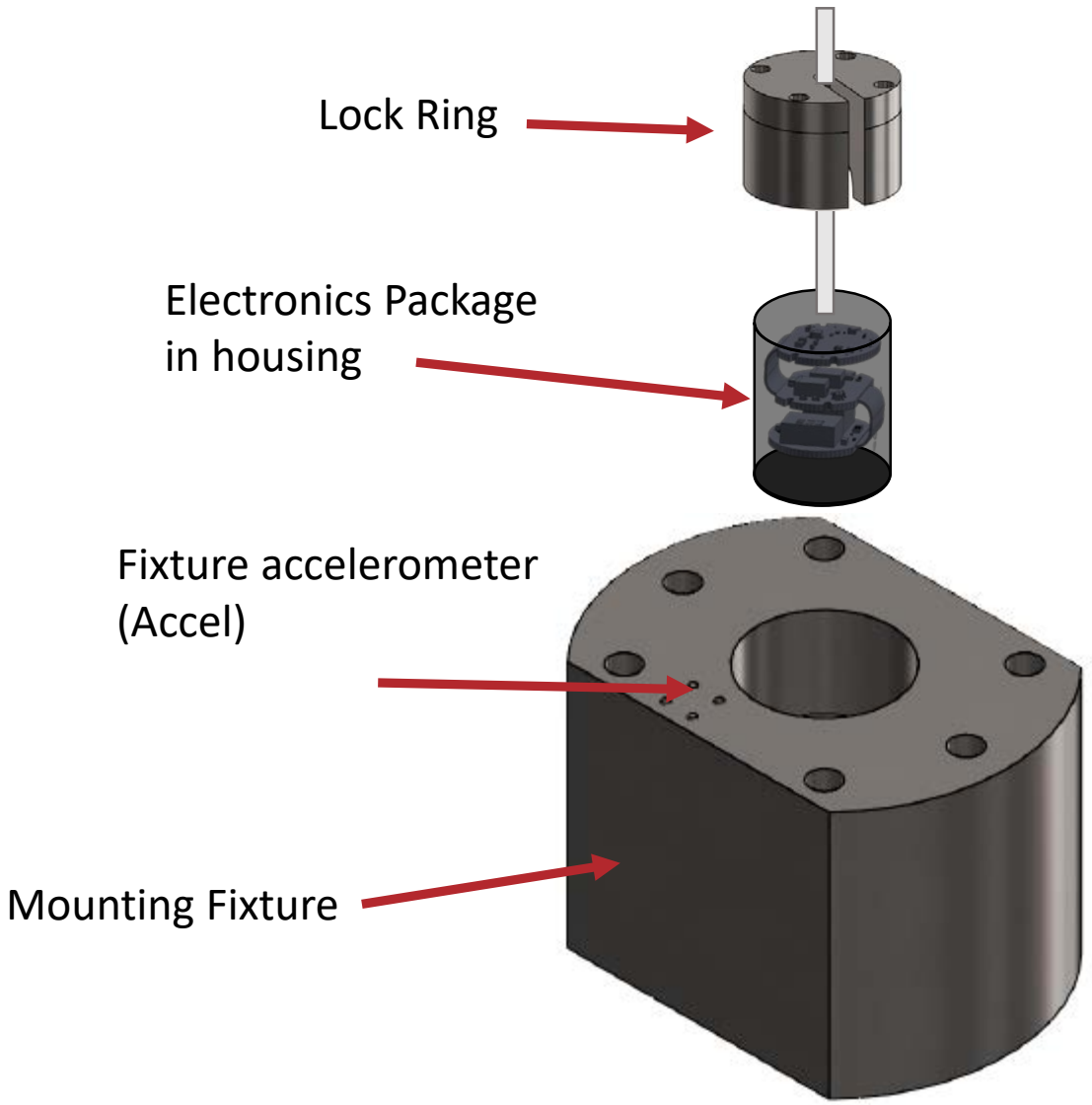
Instrumentation

- Accelerometer - Endevco Model 72-60k 
  - Int Accel (●) – glued to top face of middle board.
- Strain gages - HBM Model K-CLY4-0006-1-120-2-005-N
  - SG1 (●) – top face of top board
  - SG2 (●) – bottom face of top board
  - SG3 (●) – bottom face of bottom board



Fixture

- A Titanium fixture was used for testing the electronic package on the MTS-66 drop tower.
- Each unit was unpowered when subjected to a shock .
- The shock profile was measured by an accelerometer mounted on the fixture and an Endevco Model 72 accelerometer mounted on the middle board.



Test Matrix

- The unit was subjected to the test matrix below

Shock ID	Peak level	Duration
T04	6.5Kg	0.305msec
T04repeat	7.95Kg	0.29msec
T05	14Kg	0.22msec
T06	21Kg	0.155msec
T07	17.55Kg	0.13msec
T08	29.5Kg	0.095msec

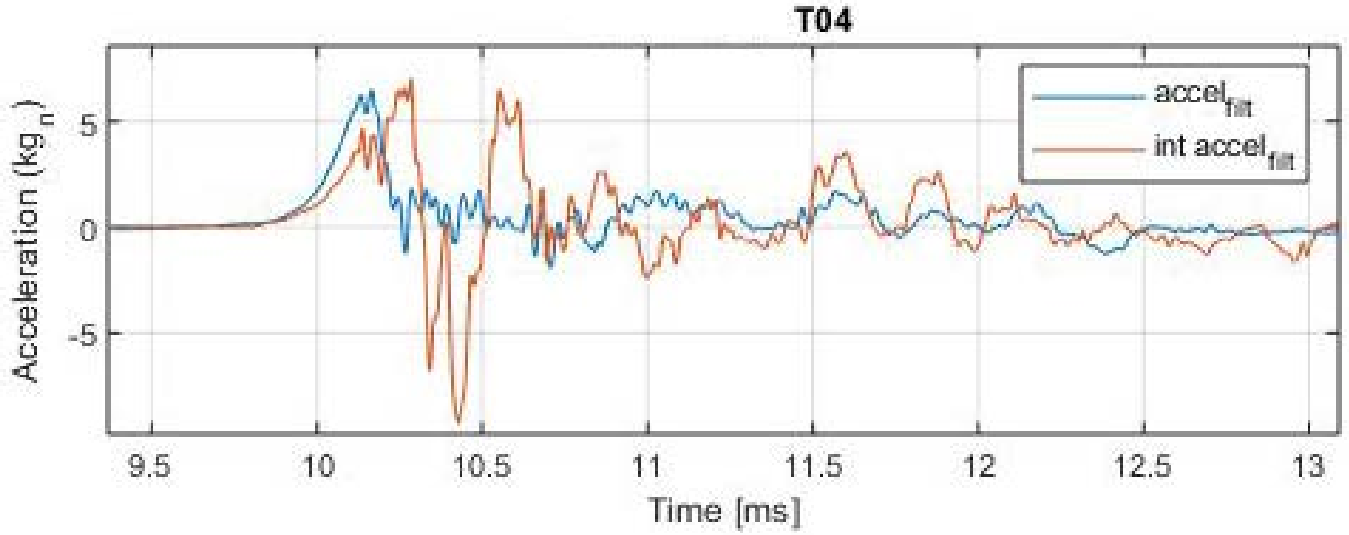
The table gives an approximate peak level (data filtered at 50kHz) and approximate duration (defined as the width of the pulse at 10% of the peak). These were extracted from the fixture accelerometer (not the internal accel.)

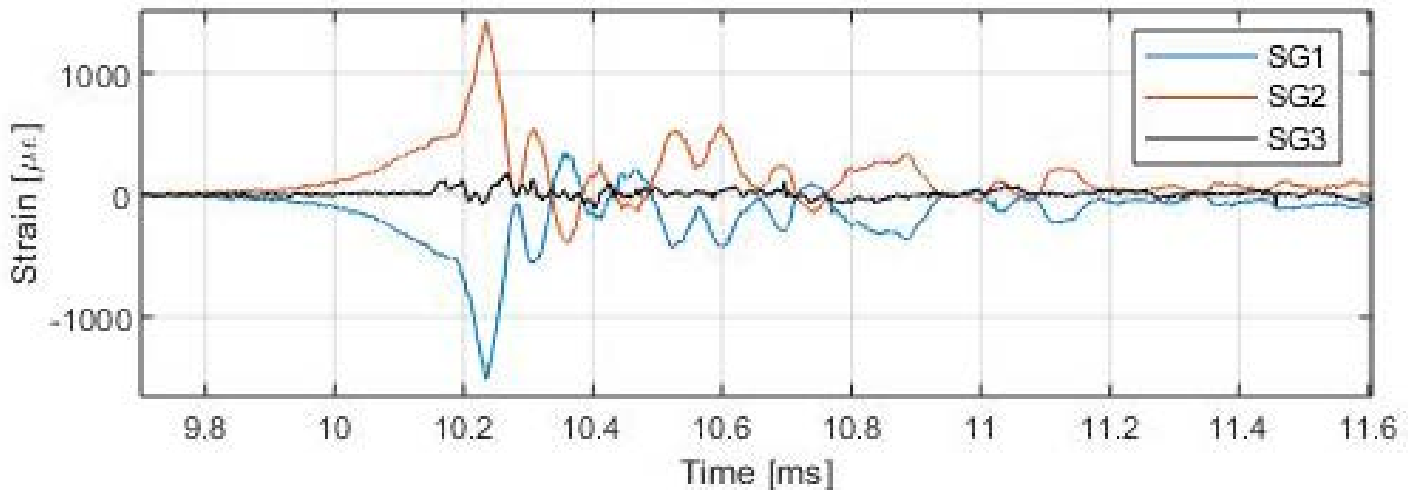
The residual strain and accelerometer offset were removed (balanced out) prior to shock.

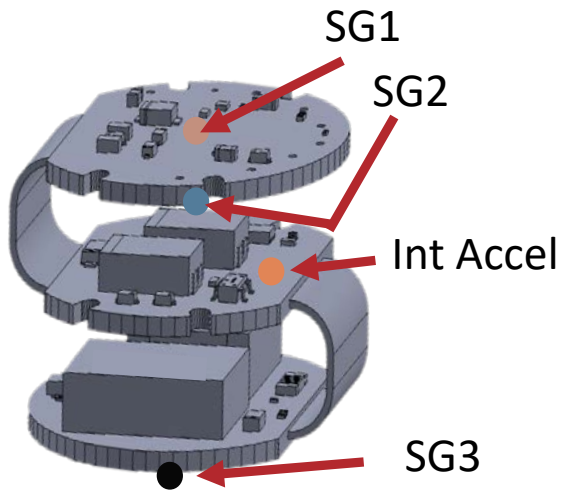
Before the test series and after each shock, the unit was powered, voltage applied, and the voltage was discharged. The discharge timing and profile were recorded. The units functioned properly until the final shock when voltage could not be applied correctly.

T04repeat test was done immediately after T04 with no changes made to the unit or the test set up.

Results – 1st shock (T04)





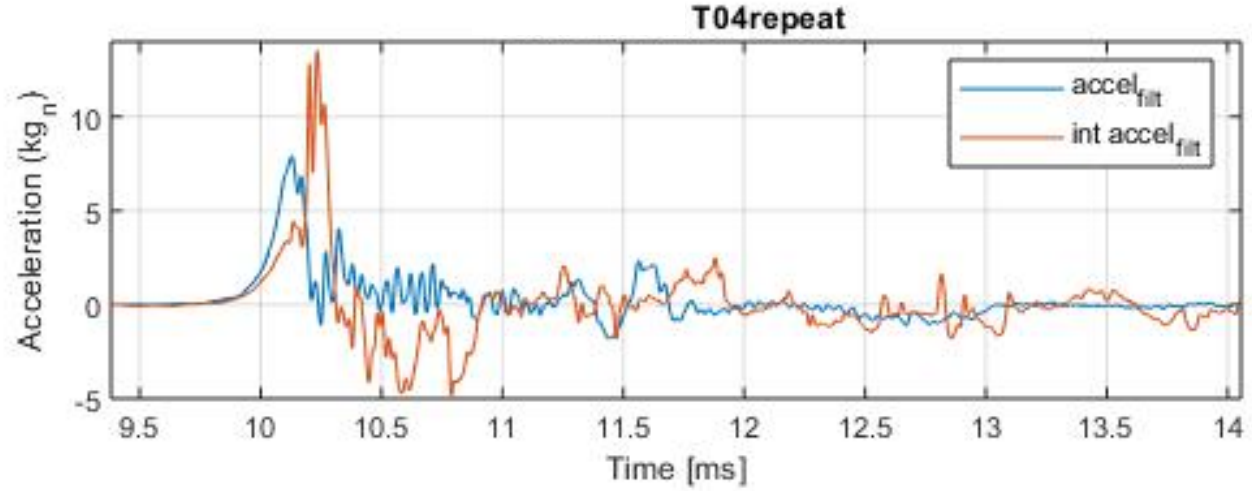


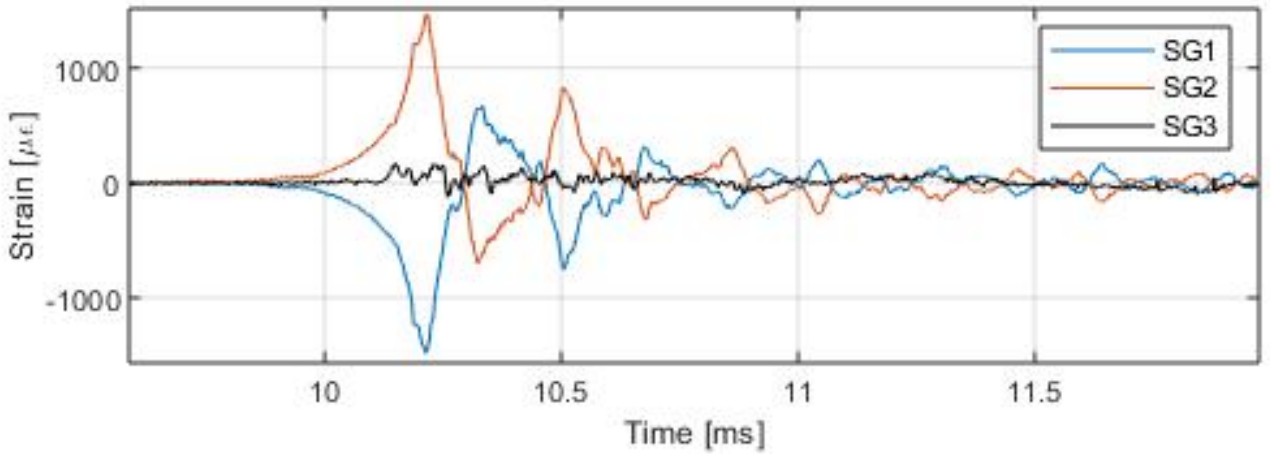
The internal accelerometer profile is different than the fixture accelerometer and might reflect the oscillation of the board to which it is mounted.

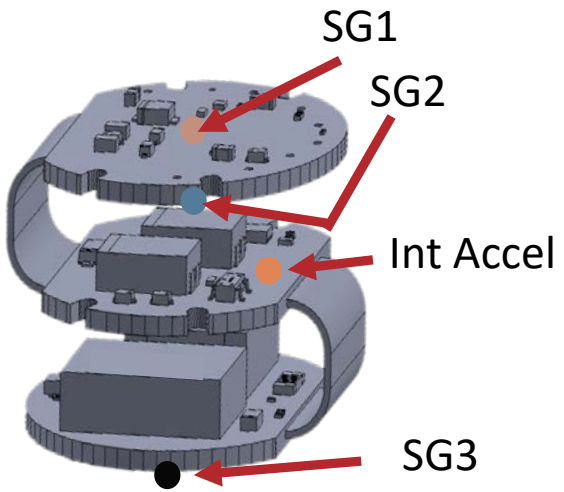
The strain measurements of the gauges mounted on each side of the top board (SG1 & SG2) are almost a perfect reflection of each other as expected.

The strain gauge mounted on the bottom board does not display a lot of signal, perhaps because the larger components make the board stiffer.

Results – 2nd shock (T04repeat)



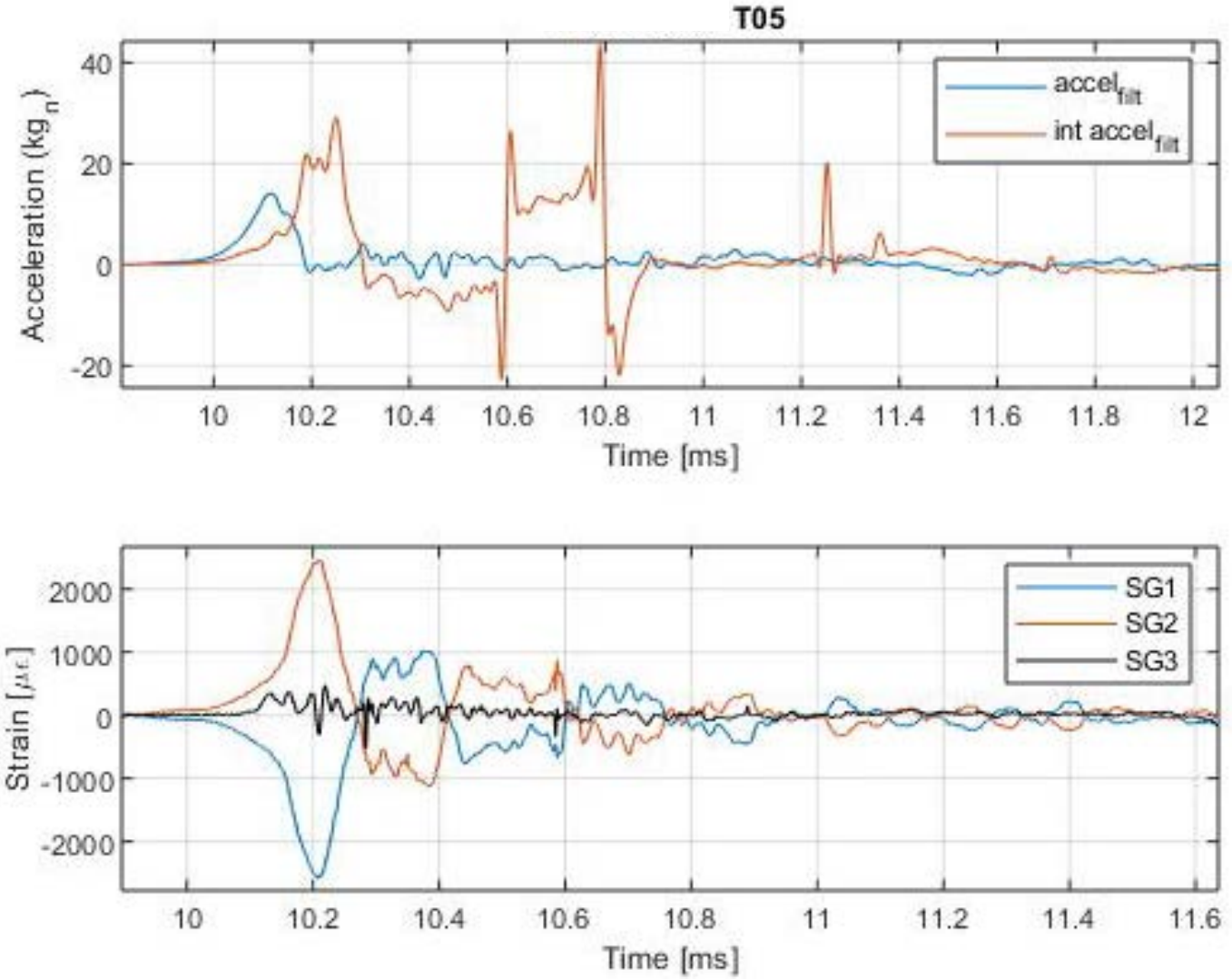


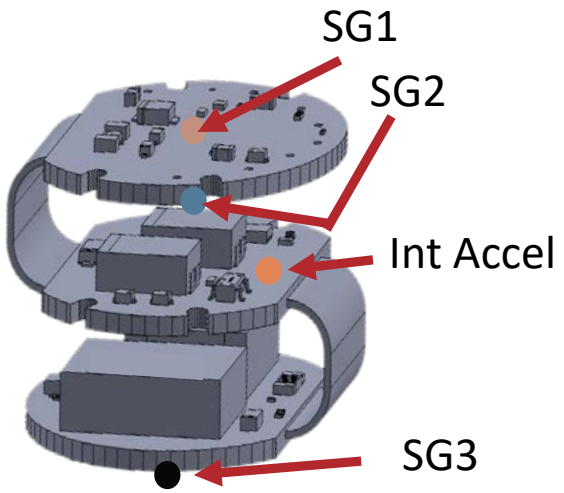


Note the small difference on the fixture accelerometer between T04 and T04repeat (from ~6.5kg to 7.95kg in peak value but with similar pulse shape) compared to the change on the internal accelerometer (very different shape!). Something changed!

The strain measurements are comparable in the two tests.

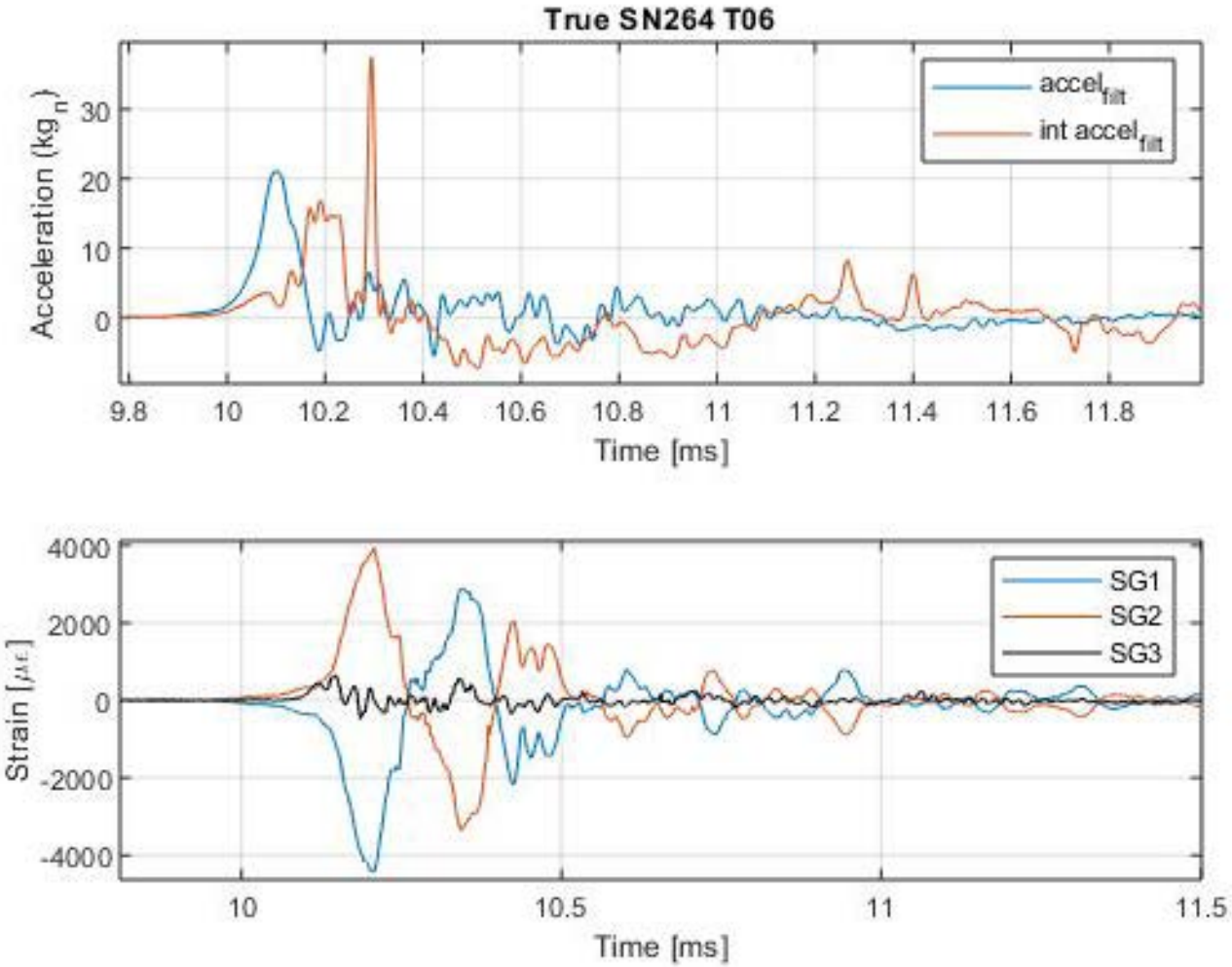
Results – 3rd shock (T05)

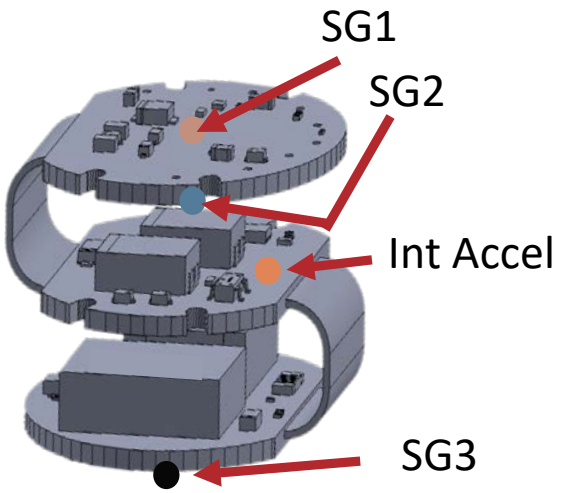




The fixture accelerometer response is much larger than the fixture accelerometer response. The abnormal behavior at 10.6 msec could be caused by the accelerometer de-bounding or the middle board changing boundary conditions.

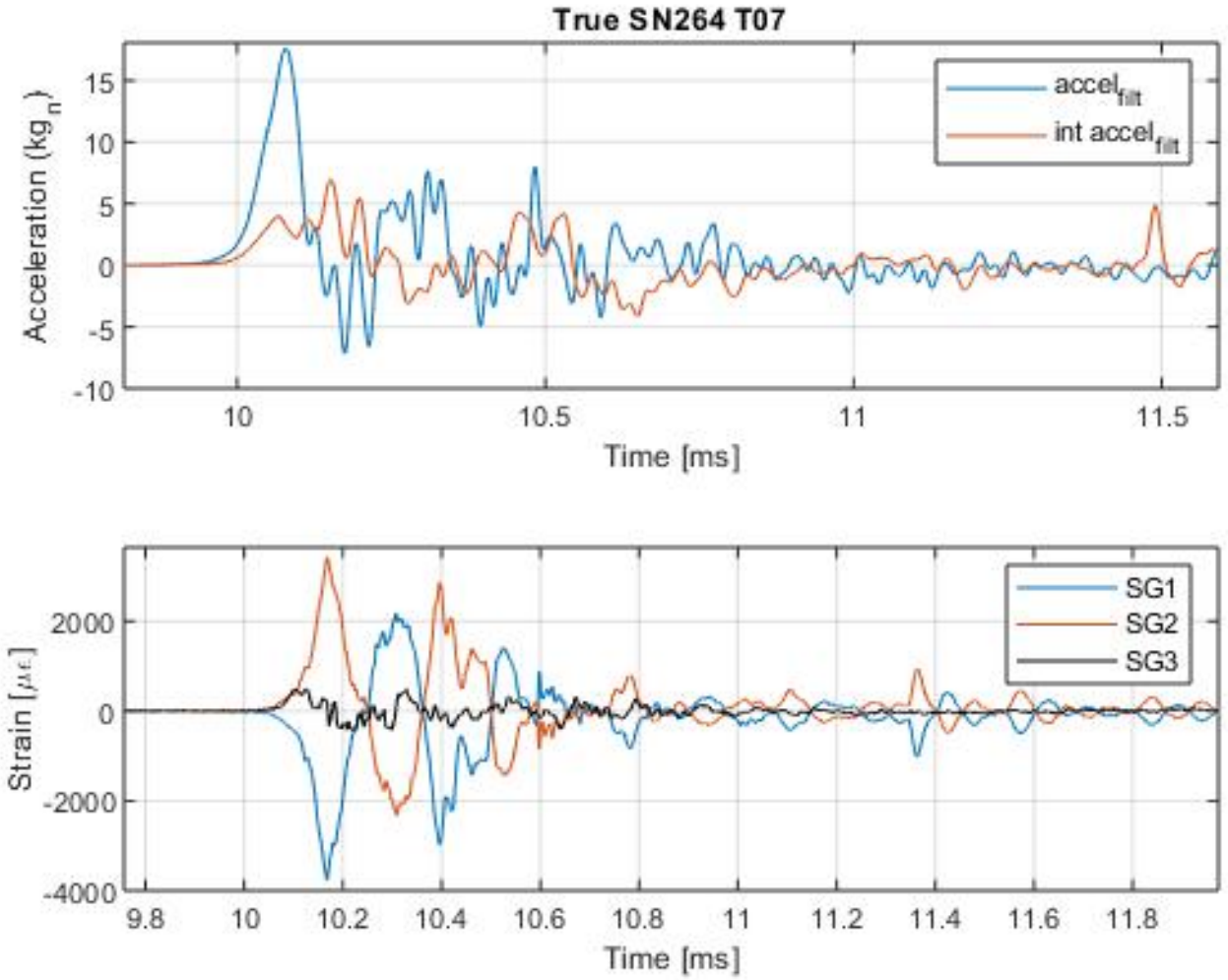
Results – 4th shock (T06)

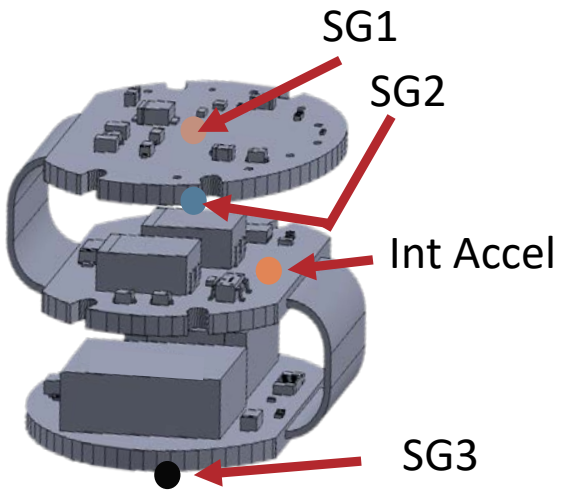




The fixture accelerometer response is now smaller than the fixture accelerometer response!

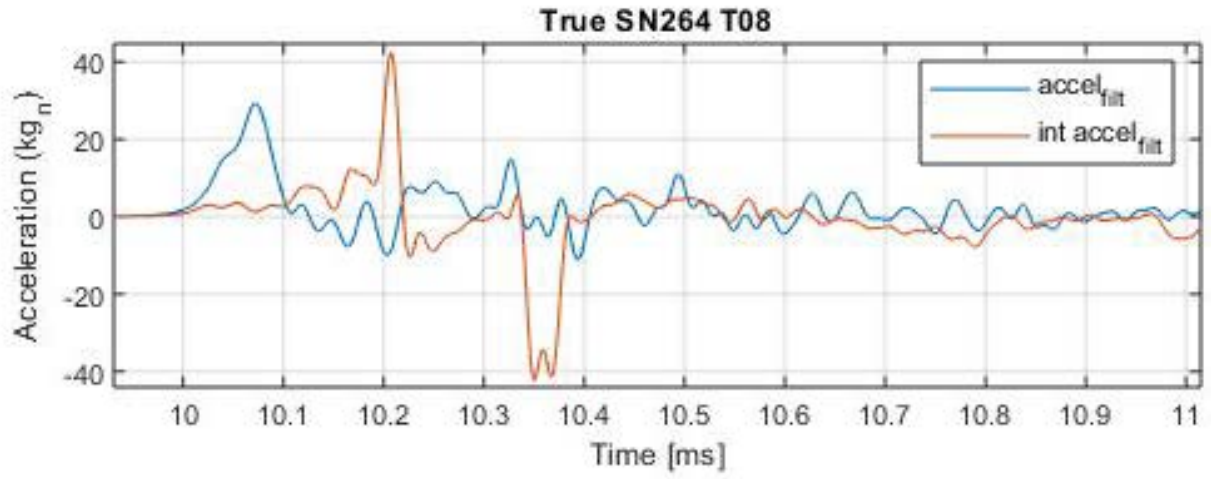
Results – 5th shock (T07)

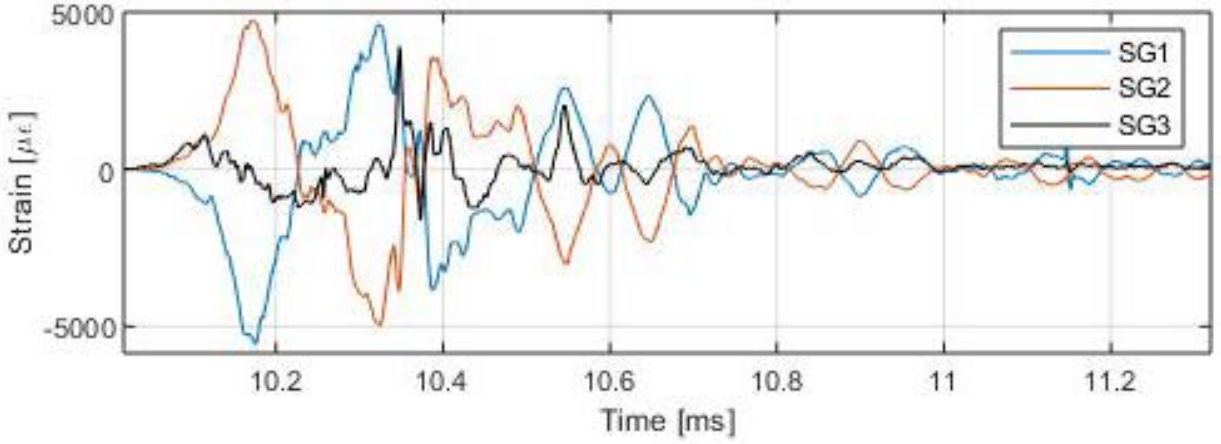


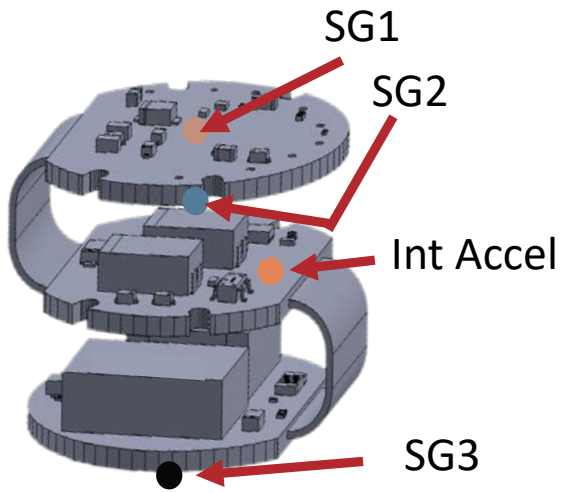


The fixture accelerometer response does not correlate well with the fixture accelerometer response. Perhaps something has failed.

Results – 6th shock (T08)





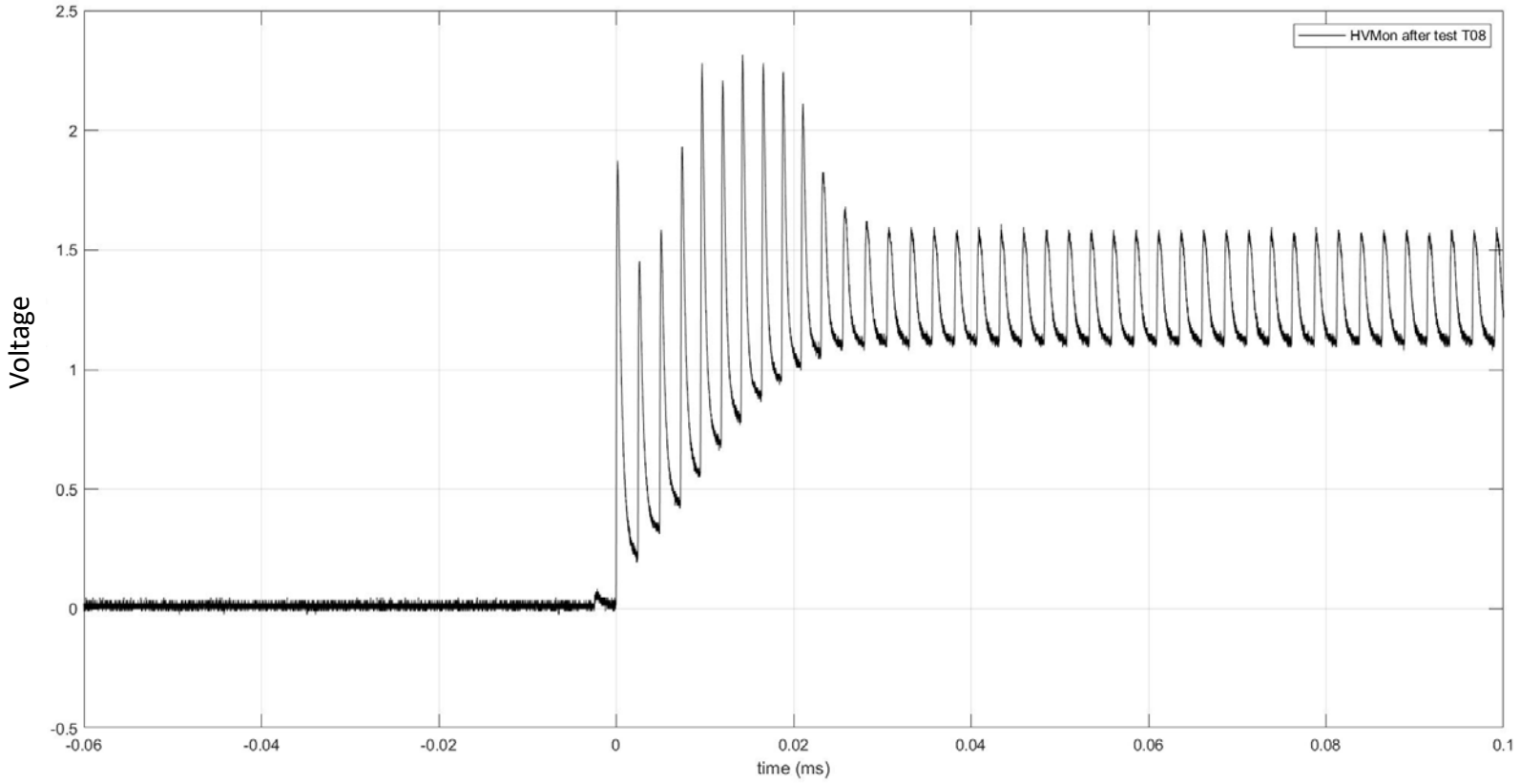


The fixture accelerometer response does not correlate well with the fixture accelerometer response. Perhaps something has changed.

Strain gauges SG1 and SG2 are still producing reliable data. Strain gauge SG3 on the bottom board is exhibiting more output than before.

The electrical checkout performed after the shock test T08 revealed a unique behavior that indicated an change in the function of the electric components of the unit (See next slide).

Results – Electrical Performance after T08 SN264 - Unpotted



After test T08, it was not possible to normally charge the capacitor. As seen in this figure, when Voltage is applied, the voltage displays a rise and a drop in the signal.

The behavior may relate to a malfunction in the switch or capacitor in the circuit located on the bottom board.