CONCURRENT TECHNOLOGIES

Product Information Pack for VP B12/m3d-RC Series (Rugged Conduction Cooled)

Pack 6 – Shock and Vibration Tests

Pack Order code VP B12/m3d-C6
Revision 01, October 2016
Engineering Part Number: 550-5050-06

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GLOSSARY

ANSI ..... American National Standards Institute
CCT ..... Concurrent Technologies
EUT..... Equipment Under Test
I/O ..... Input / Output
PCB ..... Printed Circuit Board
RC..... Rugged Conduction Cooled
SATA ..... Serial AT Attachment
SBC ..... Single Board Computer
SET..... Support Equipment for Test
SSD ..... Solid State Disk
USB ..... Universal Serial Bus
VGA ..... Video Graphics Array
VITA..... VMEbus International Trade Association
VME ..... Versa Module Europa
XMC..... Switched Mezzanine Card

PACK REVISION HISTORY

Revision	Revision History	ECO	Date
01	First full release	N/A	26 October 2016

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1 INTRODUCTION

1.1 Overview

This Product Information Pack covers the Mechanical Shock and the Vibration Qualification Testing of the VP B12/m3d-RC Series Rugged Conduction Cooled Single Board Computer (SBC).

The Mechanical Shock Qualification Testing is covered in Section 2 and the Vibration Qualification Testing is covered in Section 3. The test report to accompany both of these tests is in Section 6 and is identified as Report One.

Note that two products were tested in this procedure: VP B12/m3d-RC (identified as Board 1 in Report One) and VP B14/m3d-RC (identified as Board 2 in Report One). The boards are very similar in appearance and almost identical in function and accordingly the photographs of the test configurations show only Board 1. Board 2 was tested in the same configurations and fixture, and separate plots are included in Report One for the tests on both boards. The Mechanical Shock and Vibration tests for Board 2 are documented in a separate Product Information Pack and are not explicitly described herein.

Frequent reference is made in Report One to Concurrent Technologies document WIN3140, which describes the overall test plan. This document is proprietary to Concurrent Technologies but may be available under an appropriate Non-Disclosure Agreement.

The overall sequence of testing was as follows:

- Vibration testing, Y axis
- Mechanical Shock testing, Y axis
- Vibration testing, X axis
- Mechanical Shock testing, X axis
- Vibration testing, Z axis
- Mechanical Shock testing, Z axis

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2 MECHANICAL SHOCK TESTS

2.1 Introduction

This Section provides an overview of the Mechanical Shock Tests. It also provides supplementary information that is not present in the test report.

2.2 Equipment Used

The test equipment used was in calibration and is detailed on Page 3 of Report One.

The identity of the VP B12/m3d-RC SBC and supporting equipment is provided in Section 4 of this report.

The VP B12/m3d-RC was fitted into a 2-slot VME backplane, which was attached to a test fixture, bolted directly to the shaker head or to a slip table, depending on the axis of testing.

The VP B12/m3d-RC was fitted with the following support items:

- SwissBit 8 Gbytes Solid State Drive (SSD), which was used to exercise the first onboard SATA interface.
- XM 515/224-RC Quad Port 10/100/1000 Ethernet XMC adapter, which was used to exercise the onboard XMC site nearest the center of the VP B12/m3d-RC, including the rear I/O connections.
- SATA Flash Module AD 231/103 used to exercise the second onboard SATA interface.

The rear side of the 2-slot VME backplane provided connections from the VP B12/m3d-RC SBC to an external SATA hard disk drive, USB devices via a USB 4-port hub, and a DVI monitor.

The external SATA hard disk drive hosted the Operating System and functional verification test software as well as being used to exercise one of the SATA interfaces from the VP B12/m3d-RC.

The USB 4-port hub was used to connect an optical mouse and a keyboard via the P2 connector rear I/O USB port of the VP B12/m3d-RC SBC. A USB to serial port adapter was used to exercise the P0 connector USB port of the VP B12/m3d-RC SBC.

For the ±X and ±Y axis testing, the orientation of the test fixture and the VP B12/m3d-RC SBC is shown on Pages 6 and 7 of Report One. Figures 1 and 2 show the orientation for ±Y axis testing; for ±X axis testing the test fixture was rotated by 90 degrees and the control accelerometers were repositioned, see Figures 3 and 4.

Figures 5 and 6 on Page 8 of Report One show the orientation for ±Z axis testing, where the test fixture was attached directly to the shaker head.

2.3 Test Procedure

Mechanical Shock Testing was performed to MIL-STD-810G, Method 516.7, Procedure I. Test limits were as per BSEN 600068-2-27: 2009 (which has identical tolerances to MIL-STD 810G: 2014 with Change Notice 1). Compliance with the standards is stated in this way because the half sine shock pulse profile was selected, as allowed by the VITA 47 Class OS2 specification, but this profile is not defined by MIL-STD-810G: 2014 with Change Notice 1.

The test plan and the control strategy are described on Page 5 of Report One.

The EUTs were subjected to half sinusoidal Mechanical Shocks with the test fixture bolted directly to the shaker head or to a slip table, depending on the axis of testing. A total of 9 Mechanical Shocks were applied, 3 in each of three mutually orthogonal axes, labeled X, Y and Z. For each axis, 3 Mechanical Shocks were applied in one direction, followed by 3 Mechanical Shocks in the opposing direction. Figures 31 and 32, 54 and 55, and 68 and 69 in Report One illustrate one of the pulse and response plots for the ±Y, ±X and ±Z axes respectively.

The ±X axis was perpendicular to the plane of the PCB of the 2-slot VME backplane. The test fixture was bolted to the slip table.

The ±Y axis was parallel with the plane of the PCB of the 2-slot VME backplane. The test fixture

was bolted to the slip table.

The ±Z axis was perpendicular to the plane of the PCB of the VP B12/m3d-RC. The test fixture was bolted directly to the shaker head.

For the duration of the Mechanical Shock Tests and on completion, the EUTs were operated using the functional verification test software and monitored as described in Section 5.

The tests were conducted at a temperature of 25±10°C.

2.4 Test Results

The Mechanical Shock Test responses for ±Y, ±X and ±Z axes respectively are presented in Figures 31 and 32 on Page 23, Figures 54 and 55 on Page 35, and Figures 68 and 69 on Page 42 of Report One. Mechanical Shock Tests were performed, and passed, in all three axes in both positive and negative directions, (9 Mechanical Shock Tests in total).

In the figures listed above, the gray trace is the commanded acceleration. The black trace is the measurement accelerometer response and the red traces are the limits for the response.

The test levels were all within the tolerances allowed by MIL-STD-810G Change Notice 1.

2.5 Conclusions

The Mechanical Shock Tests were successful. No operating failures were observed during or on completion of the applied tests. The visual inspections of the EUTs did not raise any concerns.

3 VIBRATION TESTS

3.1 Introduction

This Section provides an overview of the Vibration Tests. It also provides supplementary information that is not present in the test report.

3.2 Equipment Used

The test equipment used was in calibration and is detailed on Page 3 of Report One.

The identity of the VP B12/m3d-RC SBC and supporting equipment is provided in Section 4 of this report.

The VP B12/m3d-RC was fitted into a 2-slot VME backplane, which was attached to a test fixture that bolted directly to the shaker head or to a slip table, depending on the axis of testing.

The VP B12/m3d-RC was fitted with the following support items:

- SwissBit 8 Gbytes Solid State Drive (SSD), which was used to exercise the first onboard SATA interface.
- XM 515/224-RC Quad Port 10/100/1000 Ethernet XMC adapter, which was used to exercise the onboard XMC site nearest the center of the VP B12/m3d-RC, including the rear I/O connections.
- SATA Flash Module AD 231/103-RC used to exercise the second onboard SATA interface.

The rear side of the 2-slot VME backplane provided connections from the VP B12/m3d-RC SBC to an external SATA hard disk drive, USB devices via a USB 4-port hub, and a DVI monitor.

The external SATA hard disk drive hosted the Operating System and functional verification test software as well as being used to exercise one of the SATA interfaces from the VP B12/m3d-RC.

The USB 4-port hub was used to connect an optical mouse and a keyboard via the P2 connector rear I/O USB port of the VP B12/m3d-RC SBC. A USB to serial port adapter was used to exercise the P0 connector USB port of the VP B12/m3d-RC SBC.

For the ±X and ±Y axis testing, the orientation of the test fixture and the VP B12/m3d-RC SBC is shown on Pages 6 and 7 of Report One. Figures 1 and 2 show the orientation for ±Y axis testing; for ±X axis testing the test fixture was rotated by 90 degrees and the control accelerometers were repositioned, see Figures 3 and 4.

Figures 5 and 6 on Page 8 of Report One show the orientation for ±Z axis testing, where the test fixture was attached directly to the shaker head.

3.3 Test Procedure

Vibration Testing was performed to MIL-STD-810G Change Notice 1, Method 514.7, Procedure I. Test limits were as per ANSI/VITA 47-2005 (R2007), Class V3.

The test plan and the control strategy are described on Page 3 of Report One.

This test was performed to levels as shown in Table 5 on Page 5 of Report One.

The ±X axis was perpendicular to the plane of the PCB of the 2-slot VME backplane. The test fixture was bolted to the slip table.

The ±Y axis was parallel with the plane of the PCB of the 2-slot VME backplane. The test fixture was bolted to the slip table.

The ±Z axis was perpendicular to the plane of the PCB of the VP B12/m3d-RC. The test fixture was bolted directly to the shaker head.

For the duration of the Vibration Tests and on completion, the EUTs were operated using the functional verification test software and monitored as described in Section 5.

The tests were conducted at a temperature of 25±10°C.

3.4 Test Results

The test fixture and board orientations on the slip table and shaker are shown on Pages 6, 7 and 8 of Report One. Figure 1 shows the orientation for Y-axis testing; Figure 3 shows the orientation for X-axis testing and Figure 5 for Z-axis testing.

The Vibration Test results are presented in Report One as Figures 11, 12, 16 and 20 for Y-axis, Figures 39, 43, 45 and 47 for X-axis, and Figures 59, 63, 65 and 67 for Z-axis.

Note that part way through the Y-axis testing of Board 1, a preamplifier channel failed and so accelerometer D0820 was no longer in use. Some plots include a caption for this transducer's trace but as a result of the above, the trace itself is not included.

Many additional plots are included as the results of the modal survey. In the Y-axis, Figures 7, 8, 9 from Report One show cross-axis responses in the X and Z axes which over most of the test frequency range do not exceed the 0.45 of excitation level indicated by MIL-STD-810G Change Notice 1. However, there are excursions beyond that level, most noticeably in the 1900-2000Hz range. Similarly for the X-axis (Figures 36 and 37) and Z-axis (Figures 59 and 60), with the X-axis results having the highest amplitudes. Following discussions with the test house personnel and with reference to their calibration data for the shaker system in use, Concurrent Technologies asserts that these levels of cross-axis acceleration are a characteristic of the shaker system, and that they do not adversely affect the effectiveness or validity of the vibration testing. Having regard to the stated test method, this characteristic is reported as a deviation in Report One, Section 3.5, Page 3.

In summary, the control strategy described on Page 3 of Report One was successful, with the qualification indicated in the paragraph above.

3.5 Conclusions

The Vibration Tests were successful. No operating failures were observed during or on completion of the applied tests. The visual inspections of the EUT did not raise any concerns.

4 QUALIFICATION PRE-TEST INFORMATION RECORD

The board level items were used in this test are listed in the table below.

EUT / SET	Manufacturer	Model	Description	Serial Number or Unique Item Identifier & Nomenclature	PCB Number	PCB Issue Level	Heat Frame Part Number	Heat Frame Issue Level
EUT 1	Concurrent Technologies	VP B12/msd-RC	VP B12/033-RC – 4th Generation Intel® Core™ i5 Processor Embedded Controller Rugged Conduction-Cooled	M28324/004	151-0050	D	011-9079	C0
SET 1a	Concurrent Technologies	XM 515/224-RC	Quad Port 10/100/1000 Ethernet XMC adapter - Rugged Conduction-Cooled	M28390/001	121-0337	B1		
SET 1b	Concurrent Technologies	AD 231/103-05RC	8 Gbyte - NAND Flash drive module - Rugged Conduction-Cooled	M26363/022	121-0332	B		
SET 1c	SwissBit	SFSA8192QBR4TO-I-DT-236-STD	8 Gbyte 2.5-inch Industrial SSD	00006009782100005385				
SET 1d	TDK Lambda	NV1-453TTH-N3-I	AC-DC Power Supply unit	8160540057				
SET 1e	Concurrent Technologies	EN BKP/004-00	2-slot VME bus test backplane	M29130/002	121-0344	A		

QUALIFICATION PRE-TEST INFORMATION RECORD

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5 FUNCTIONAL PARAMETERS MONITORED

The Functional Verification tests executed in this test are summarized in the table below.

Function to be Tested	Test Method	X Indicates Function On-board EUT	X Indicates Function Off-board EUT
RS232 Serial Port	Custom test program to transmit & receive data within the port and check for data errors.		X
2.5-inch SSD	Custom test program to write a test data pattern to the disk and then read it back and verify it against the original copy.	X	
SATA Flash module	Custom test program to write a test data pattern to the disk and then read it back and verify it against the original copy.	X	
USB Serial Adapter	Custom test program to write a test data pattern and then read it back and verify it against the original copy		X
PMC rear I/O	Third party program to exercise the Ethernet XMC fitted and check for data errors at the hardware level.		X

FUNCTIONAL PARAMETERS MONITORED

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6 REPORT ONE

TRW Conekt Test House,
Report Number 68806a

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0332

Test Report No. 68806A

Vibration and Shock Testing of Concurrent Technologies Boards

Summary:

VP B12/033 (Board 1) completed Vibration and Shock testing to Concurrent Technologies document reference: WIN3140 dated 25-Jun-15 with no apparent observed, or reported, failures.
VP B14/043 (Board 2) completed Vibration and Shock testing, in X and Y axis only, to Concurrent Technologies document reference: WIN3140 dated 25-Jun-15 with no apparent observed, or reported, failures.

The boards were returned to Concurrent Technologies on completion of testing.

Date: 25 October 2016

Author: ..... **P S Goymer, Vibration Consultant**

Authorised: ..... **G Morgan, Technical Specialist**

The results described in this report are applicable to the samples examined and should not necessarily be taken as representative of a larger sample distribution.

Opinions and interpretations expressed herein are outside the scope of UKAS Accreditation.

Tests performed by the Conekt Test Laboratory marked "Not UKAS Accredited" in this Report are not covered by the scope of this laboratory's UKAS Accreditation Schedule.

If this report has been received electronically there may be no signatures. If you wish to check its status please contact Conekt.

1. Introduction

1.1 Distribution: Essy Rabi-Laleh

1.2 Customer: Concurrent Technologies Plc

1.3 Address: 4 Gilberd Court
Newcomen Way
Colchester
CO4 9WN

1.4 Order Numbers: 1010118166

1.5 Objectives: To conduct testing to meet the robustness requirements of Concurrent Board sets to known international standards.

2. Samples/Test Items

Identification
Board 1 - VP B12/033 RC series s/n M28323/004. With support items: XM 515/224-RC XMC Adapter. AD 231/103-RC NAND flash module. 8 Gbyte SSD.
Board 2 - VP B14/034 RC series s/n M28366/001. With support items: XM 515/224-RC XMC Adapter. 16 Gbyte CFast Flash card. 30 Gbyte SSD.

Table 1: EUT Identification

2.1 Job Numbers: 68806

2.2 Date Received: 12th October, 2016.

3. Test Details

3.1 Quote Number: 68806-1

3.2 Deviation from Quote: Testing was conducted to (MIL-STD 810G:2014 w/Change 1 Method 514.7 and not to MIL-STD 810F:2000 Method 514.5 as quoted.

3.3 Preparation: The Boards were tested as received.

3.4 Specifications: Sine and Random Vibration Testing was carried out in general accordance with Concurrent Technologies document reference: WIN3140 dated 25-Jun-15 and MIL-STD 810G:2014 w/Change 1 Method 514.7 Procedure I
Shock testing was carried out in general accordance with Concurrent Technologies document reference: WIN3140 dated 25-Jun-15 and in accordance with BSEN 60068-2-27: 2009 (which has identical tolerances to MIL-STD 810G:2014 w/Change 1).

3.5 Agreed Deviations to Specification: The cross axis requirement measured on the vibration system and fixture combination would not meet the required cross-axis measurements i.e. a maximum acceleration equal to the referenced drive axis level over the entire frequency range (MIL-STD 810G:2014 w/Change 1 Method 514.7 Section 4.2.2.4).

3.6 Date of Test: 12th to 14th October, 2016.

3.7 Equipment:

Equipment	Manufacturer	Identification No	Calibration Due
Vibration System V870E	LDS	D0004	12 September 2017
Vibration Controller	Data Physics Vector 2	D0058	12 April 2017
Vibration Controller	Data Physics Vector 1	D0055	25 September 2017
Shock Controller	Data Physics	D0051	02 May 2017
Accelerometer	Brüel and Kjaer	D0974	07 April 2017
Accelerometer	Brüel and Kjaer	D0976	07 April 2017
Tri-axial Accelerometer	Brüel and Kjaer	D0952	30 May 2017
Tri-axial Accelerometer	Brüel and Kjaer	D0959	30 May 2017
Tri-axial Accelerometer	Brüel and Kjaer	D0961	21 March 2017
Miniature Accelerometer	PCB	D0820	08 June 2017
Miniature Accelerometer	PCB	D0824	04 August 2017
Miniature Accelerometer	PCB	D0826	14 August 2017
Charge Amplifier	LDS	D0025	14 September 2017
Torque Wrench	Norbar	D0701	CBU
Torque Wrench	Norbar	D0090	CBU
Torque Calibrator	Norbar	D0092	19 September 2017
Temp & Humidity Meter	Extech	D0437	14 September 2017
Equipment	**Manufacturer**	**Identification No**	**Calibration Due**
Vibration Plate	Concurrent	-	Not Required

Table 1: Vibration Test Equipment

3.8 Procedure:

A Concurrent fixture plate was attached to the shaker table using M8 socket cap-head bolts. All M8 bolts were tightened to a fixing torque of 30 Nm. An additional fixture block was also attached using M8 and M10 bolts. The M10 bolts were tightened to 40 Nm.

The test sequence was carried out as shown in Table 2.

Concurrent QTP Reference(s)	Test Description
2.8	Modal Survey of Test Fixture
2.9	Modal Survey of EUT
2.5	Random Vibration
2.5	Shock
Axis Order : Y-Axis Board 1, Y-Axis Board 2,	
- Change to next axis, X-Axis Board 1, X-Axis Board 2	
- Change to next axis, Z-Axis Board 1 only,	

Table 2: Sequence of Vibration Tests and Axis Order

3.8.1 Modal Survey of Test Fixture

MIL-STD 810G:2014 w/Change 1 Method 514.7 Procedure I section 4.2.2.4

The vibration profile used for the Modal Survey of the test fixture is shown in Section 3.8.1, Table 3. A modal survey of the fixture was performed in each axis prior to Random and Shock vibration.

For the initial test tin the Y-axis (Board 1 only) three groups of tri-axial accelerometers were attached to the fixture as shown in Figure 1 to establish the location of the control accelerometers. The two accelerometer groups D0952 and D0961 were chosen for control purposes.

For the remainder of the testing using a 4-channel vibration controller, multiple test sweeps were conducted. The two groups of accelerometers D0952 and D0961 were chosen for control purposes as shown in Figure 3 and Figure 5.

Sine Profile:	Frequency Range(Hz)	Amplitude
	5 - 2000	± 1.0 g_n Pk
Sweep Rate:	1 octave / minute	
Control Strategy:	Two-point	
EUT State:	Un-Powered	
Duration:	1 sweep	

Table 3: Modal Survey, Test Parameters

3.8.2 Modal Survey of EUT: WIN3140 Section 2.9

Prior to Random vibration testing each board in each axis a Modal Survey was performed. The vibration profile used is shown in Section 3.8.2, Table 4.
Initially three single axis accelerometers were attached to the board, by Concurrent Technologies, using hot melt, as shown in Figure 2, Figure 4 and Figure 6 for the three axes of test.
Following an equipment problem, the vibration controller was changed which then limited the number of measurement channels. Only measurement points D0824 and D0826 were then recorded.

Sine Profile:	**Frequency (Hz)**	**Amplitude**
	5 - 2000	± 1.0 gn Pk
Sweep Rate:	1 oct / min	
Control Strategy:	Two -point	
EUT State:	Powered and Monitored	
Duration:	1 sweep	

Table 4: Modal Survey of EUT

3.8.3 Random Vibration: WIN3140 Section 2.5

For Random Vibration Control the control points established from the Modal survey were used for random vibration control as detailed in Section 3.8.3, Table 5.

Random Profile:	**Frequency (Hz)**	**PSD / Slope**
	5 - 100	+3dB / oct
	100 - 1000	$0.1g_n^2$ / Hz
	1000 - 2000	-6dB / oct
Overall Level	20 g_n RMS	
Control Strategy:	Two - point	
EUT State:	Powered and Monitored	
Duration:	1 hour	

Table 5: Random Vibration Test Parameters

3.8.4 Shock: WIN3140 Section 2.5

For Shock Testing a single control point was used as shown in Figure 4 (horizontal planes) and Figure 6 (Vertical Plane) and as detailed in Section 3.8.4, Table 6.

	Amplitude
Shock Profile:	Half Sine
Control Strategy:	Single -point
EUT State:	Powered and Monitored
Number of Shocks:	3 Positive and 3 Negative

Table 6: Shock Test Parameters

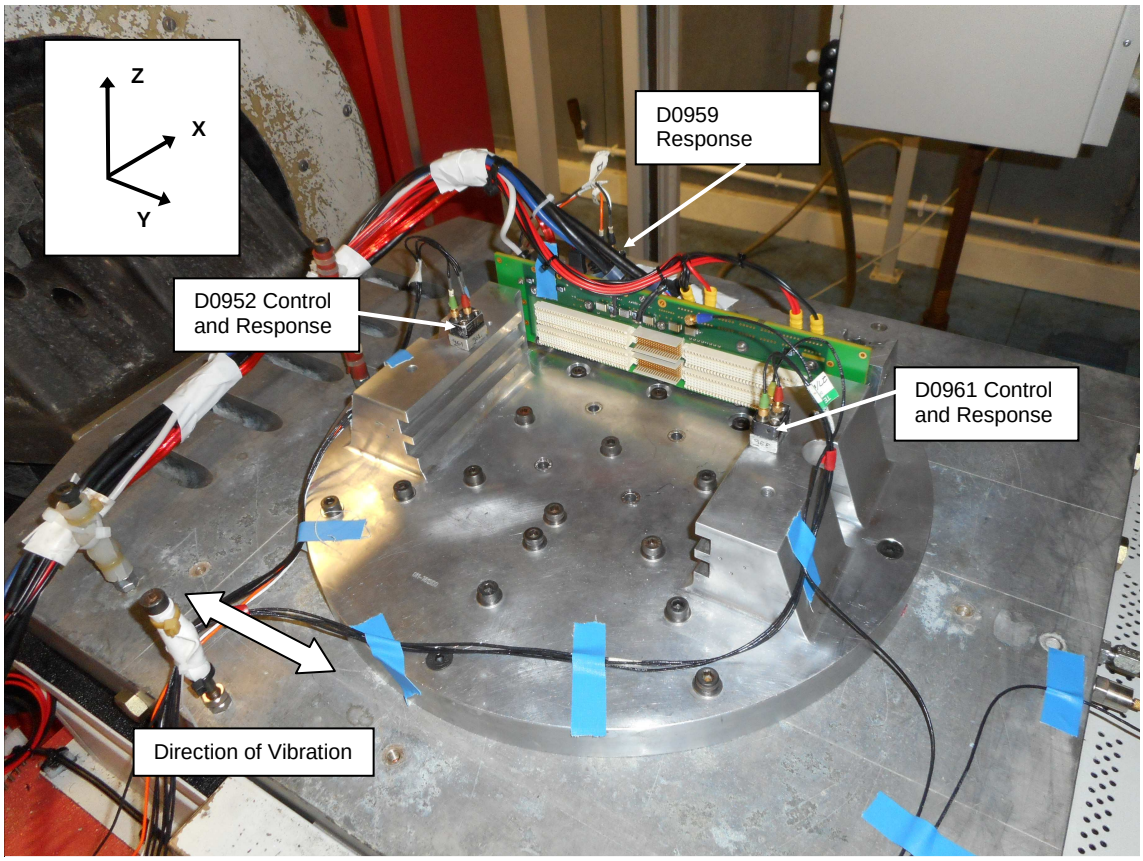

Figure 1: Fixture in Y-Axis for Fixture Cross-axis Measurements

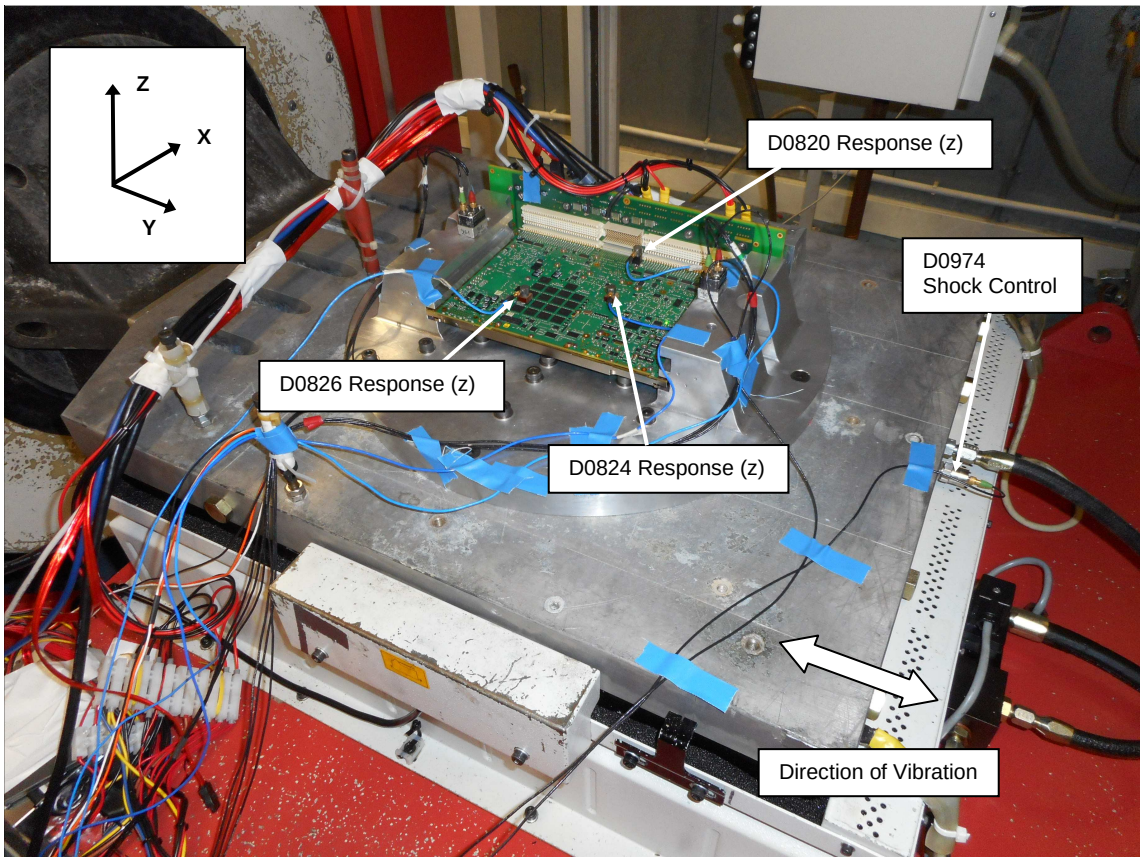

Figure 2: VP B12/033 (Board 1) in Y-axis

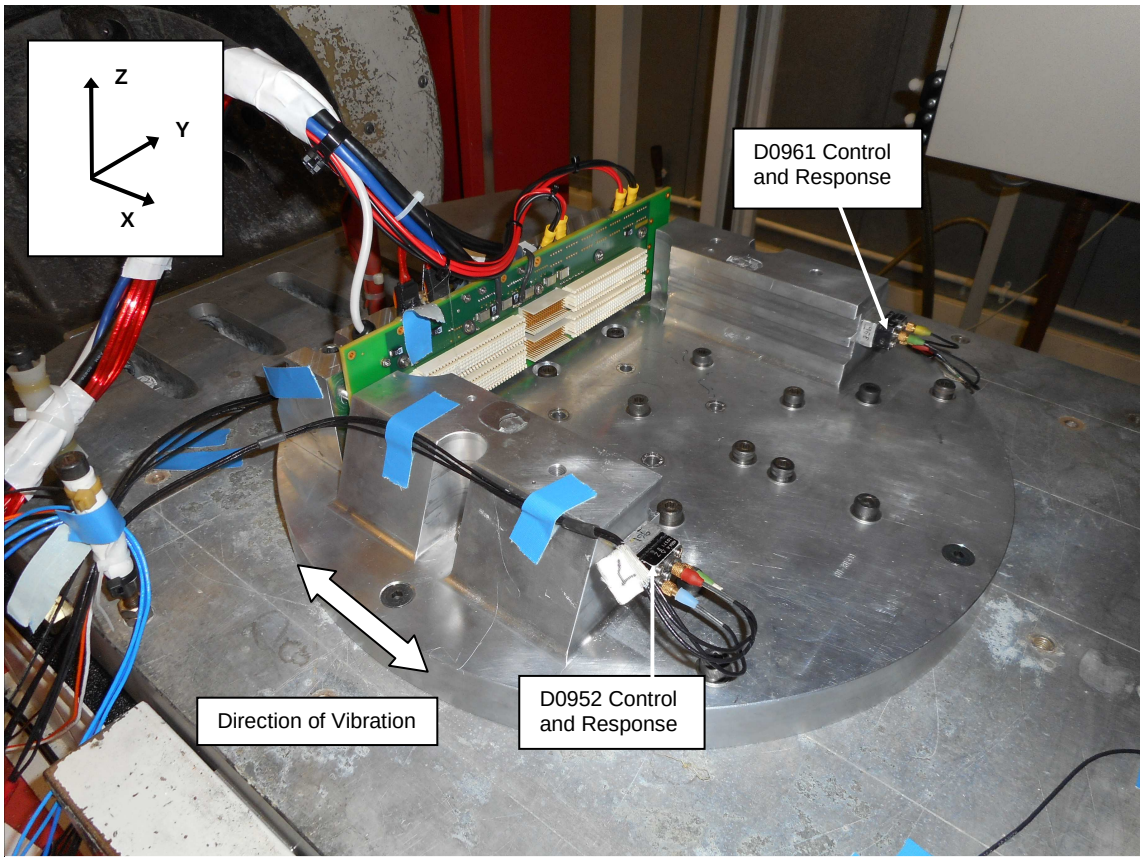

Figure 3: Fixture in X-Axis for Fixture Cross-axis Measurements

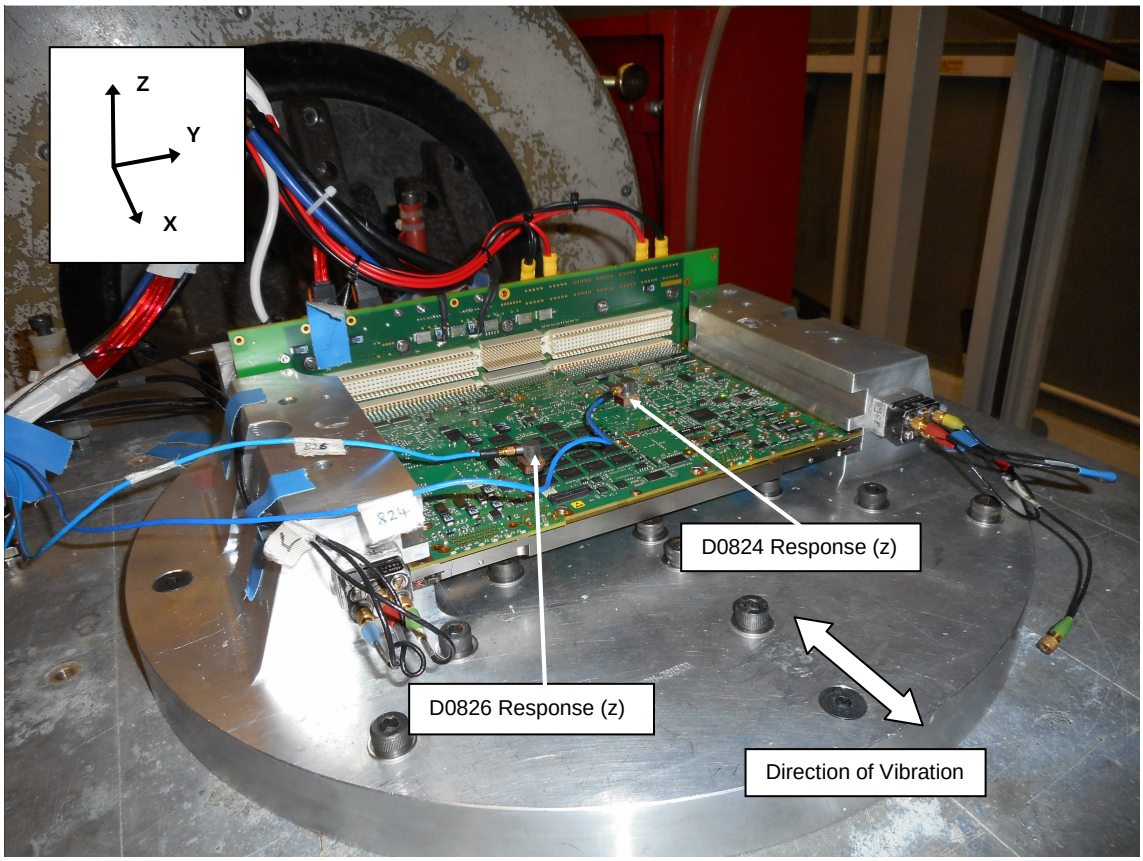

Figure 4: VP B12/033 (Board 1) in X-axis

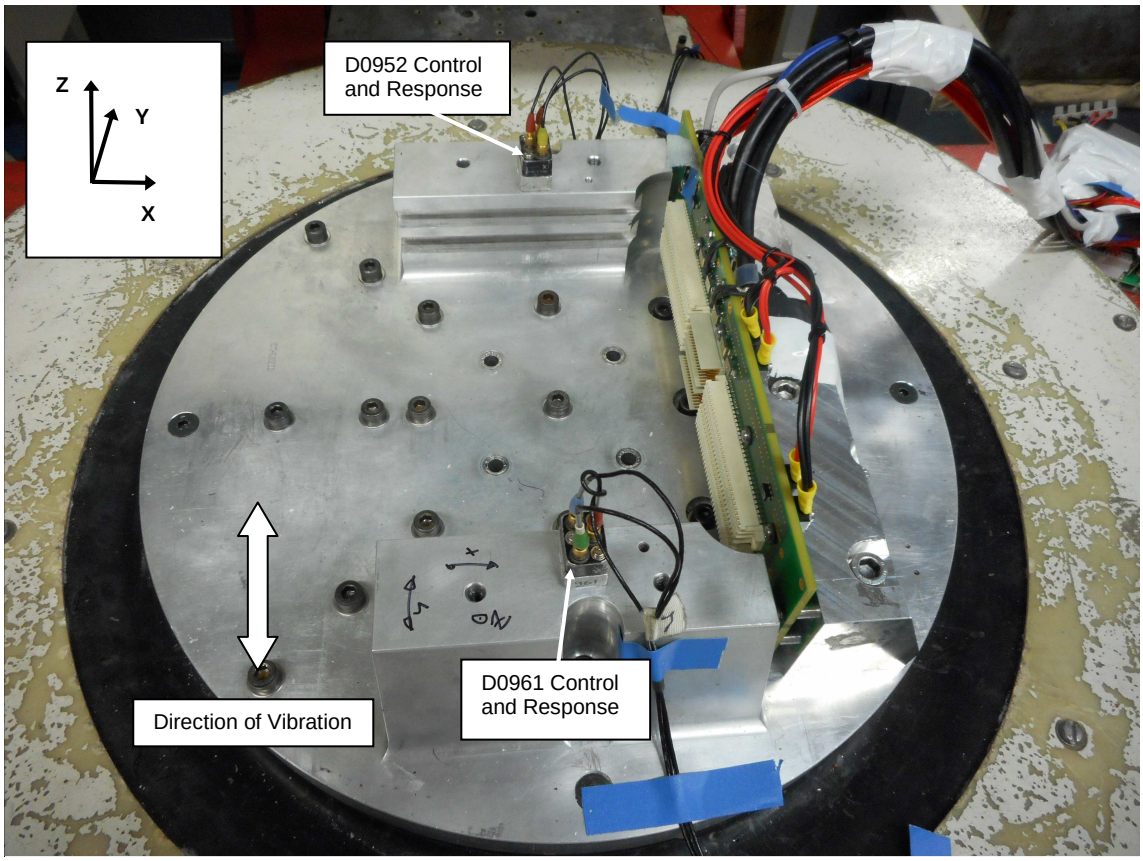

Figure 5: Fixture in Z-Axis for Fixture Cross-axis Measurements

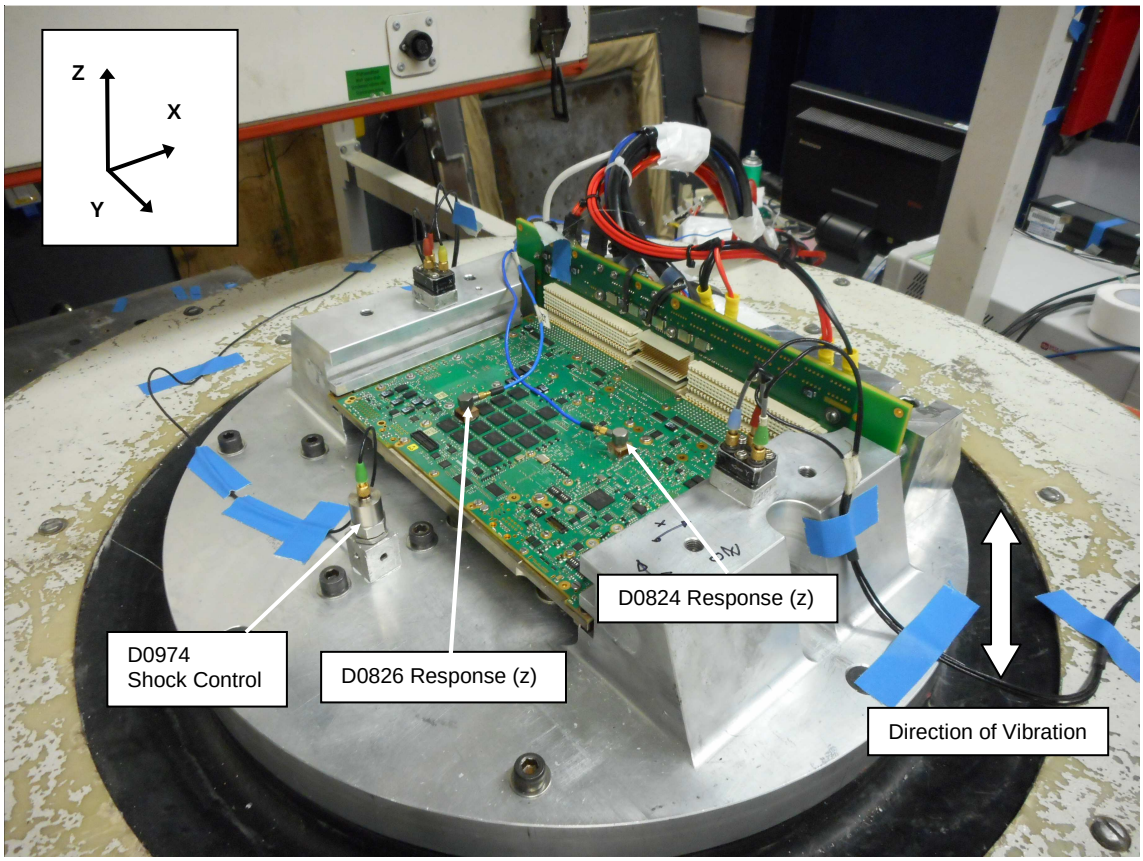

Figure 6: VP B12/033 (Board 1) in Z-axis

3.8.5 Measurement Uncertainty:

	Uncertainty of Measurement
Acceleration	± 4.0%
Frequency	± 1.3%
Time	± 1.0%

Table 7: Measurement Uncertainty

The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k=2, which provides a level of confidence of approximately 95%.
It has been assumed that the uncertainty is calculated at ambient temperature.

3.8.6 Deviations:

The plots presented for the 4-channel Vibration Controller (Figure 25 onwards) show the results only from 10 - 2000Hz. This was a presentation error only and all testing was conducted from 5 - 2000 Hz as per specification. In axis results were within the specified limits below 10 Hz and there were also no discernible cross-axis responses below 100 Hz.

4. Results

VP B12/033 (Board 1) completed Vibration and Shock testing to Concurrent Technologies document reference: WIN3140 dated 25-Jun-15 with no apparent observed, or reported, failures.

VP B14/043 (Board 2) completed Vibration and Shock testing, in X and Y axis only, to Concurrent Technologies document reference: WIN3140 dated 25-Jun-15 with no apparent observed, or reported, failures.

4.1.1 Recorded Test Conditions

The air conditioned test cell conditions were recorded, as detailed in Table 8.

Date	Test Axis and Sequence	Temp (^{o}C)	Humidity (%RH)	Pressure (mBar)
12-Oct	Y-Axis	19.6	49.5	1005.0
13-Oct	Y- Axis and X-Axis	19.1	45.8	994.4
14-Oct	Z-Axis	24.2	43.8	999.9

Table 8: Ambient Test Conditions

4.2 Vibration Test, Graphical Results

4.2.1 Legends and Conventions

Table 9 shows the legend key and axis convention that applies to the Vibration test plots.

Trace Colour	Plot Label (example)	Description
Black	**Control**	Averaged / Single point control
Grey	**Reference**	Reference level required
Blue	**Y Response e.g. D0952Y**	Measurements of response accelerometers in Y - plane
Green	**X Response e.g. D0952X**	Measurements of response accelerometers in X - plane
Red	**Z Response e.g. D0952Z**	Measurements of response accelerometers in Z - plane
Brown	**Z Response D0820**	Miniature accelerometer on Board (Connector)
Purple	**Z Response D0824**	Miniature accelerometer on Board (Hot Spot)
Magenta	**Z Response D0826**	Miniature accelerometer on Board (IC Position)
Note: Shades of blue, green and red are used to distinguish different accelerometers on the same plot and axis.		

Table 9: Definition of Signal Colours in Vibration Plots

Unless stated otherwise stated Abort limits for vibration plots are as shown in Table 10 and Table 11.

Reference	Test Type	Abort (%) [10 – 2000Hz]
MIL-STD-810G Ch/1	Sine Vibration	±15 %

Table 10: Abort Limits for Sine Vibration

Reference	Test Description	Abort (Red)
MIL-STD-810G Ch/1	Random Vibration (<500 Hz)	+3 dB, -3 dB
	Random Vibration (>= 500 Hz)	± 6 dB
Note: the abort lines shown on the Plots presented are shown as +3dB, -6dB		

Table 11: Abort Limits for Random Vibration

4.2.2 Vibration Test:

4.2.2.1 Y-Axis Fixture Cross-axis Measurements

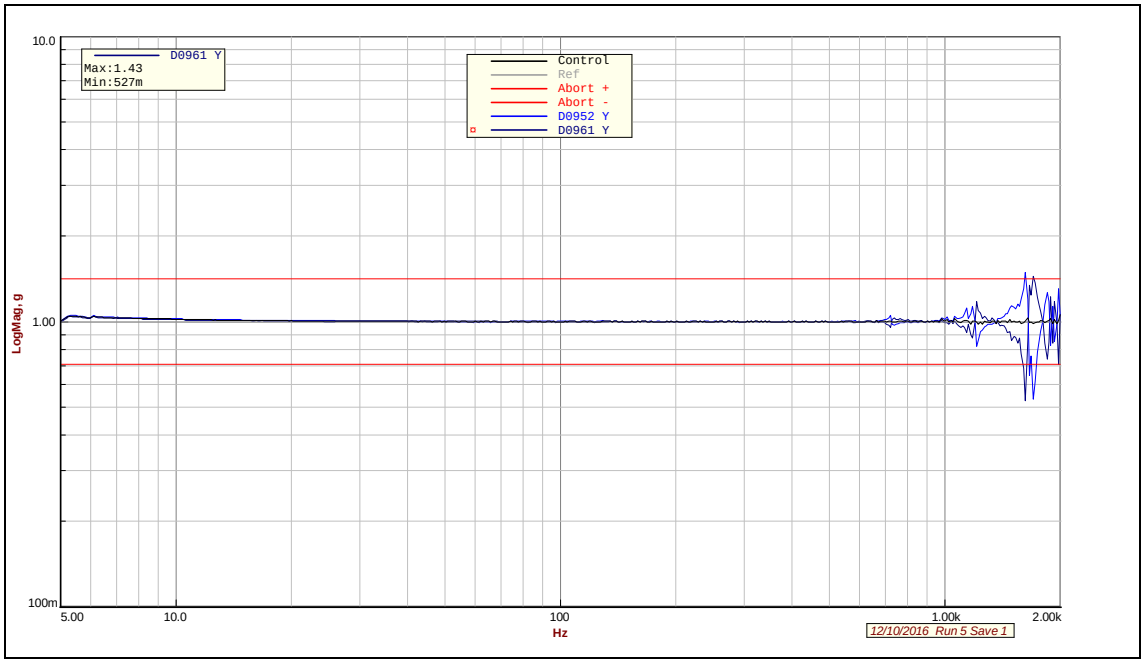

Figure 7: Control (Y-Axis)

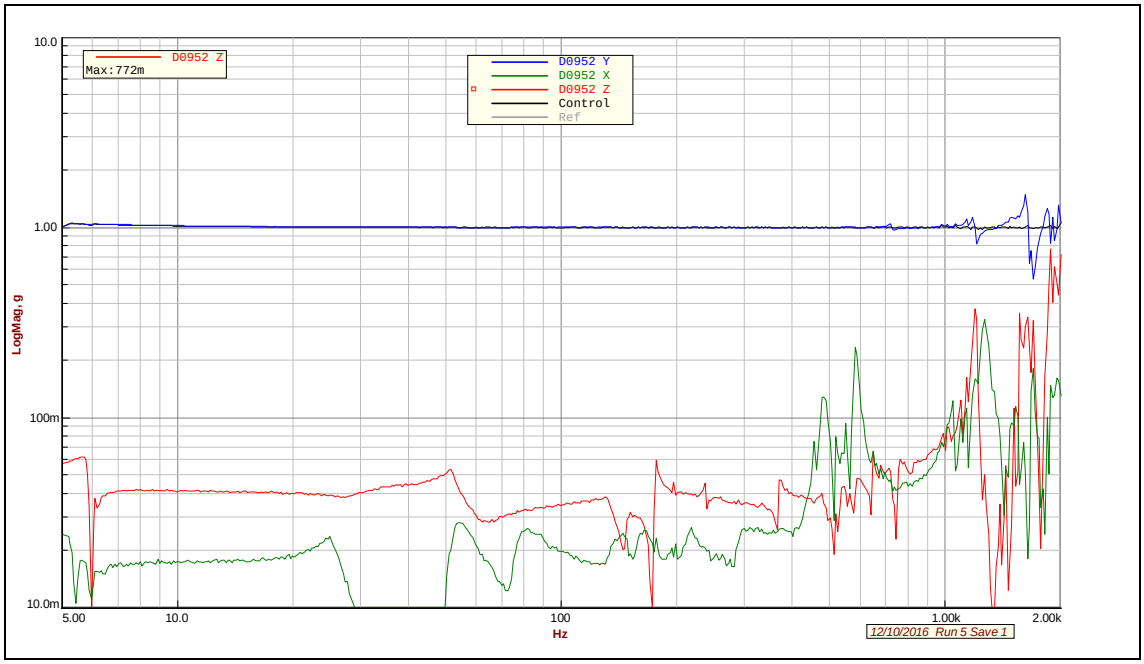

Figure 8: Cross-axis Response of D0952 (Y-Axis)

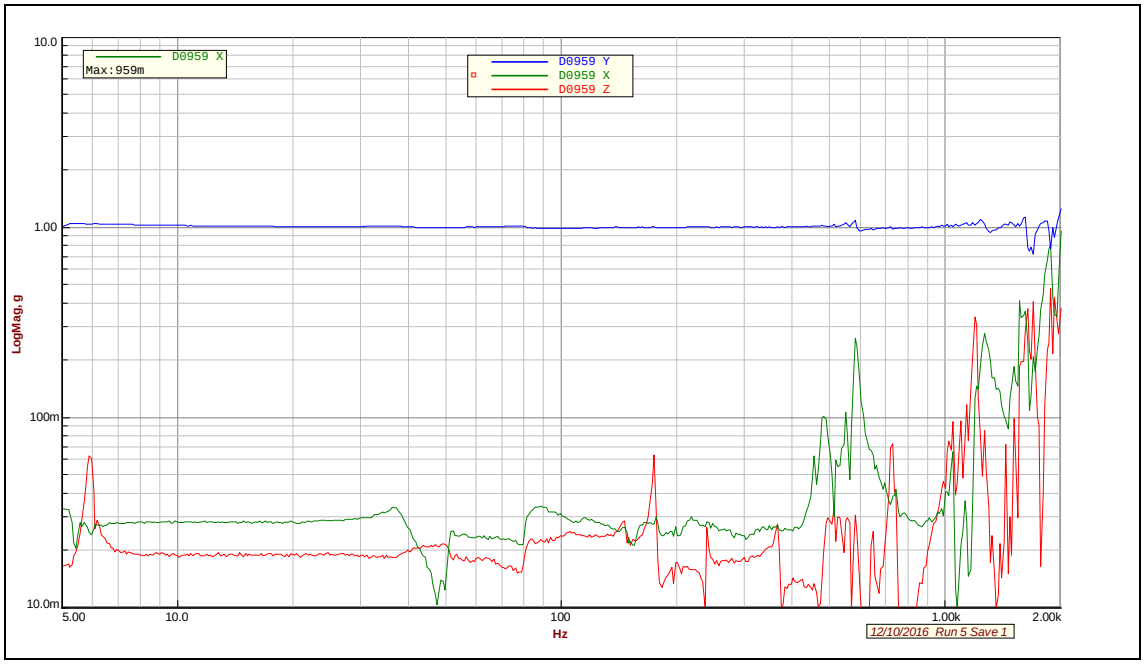

Figure 9: Cross-axis Response of D0959 (Y-Axis)

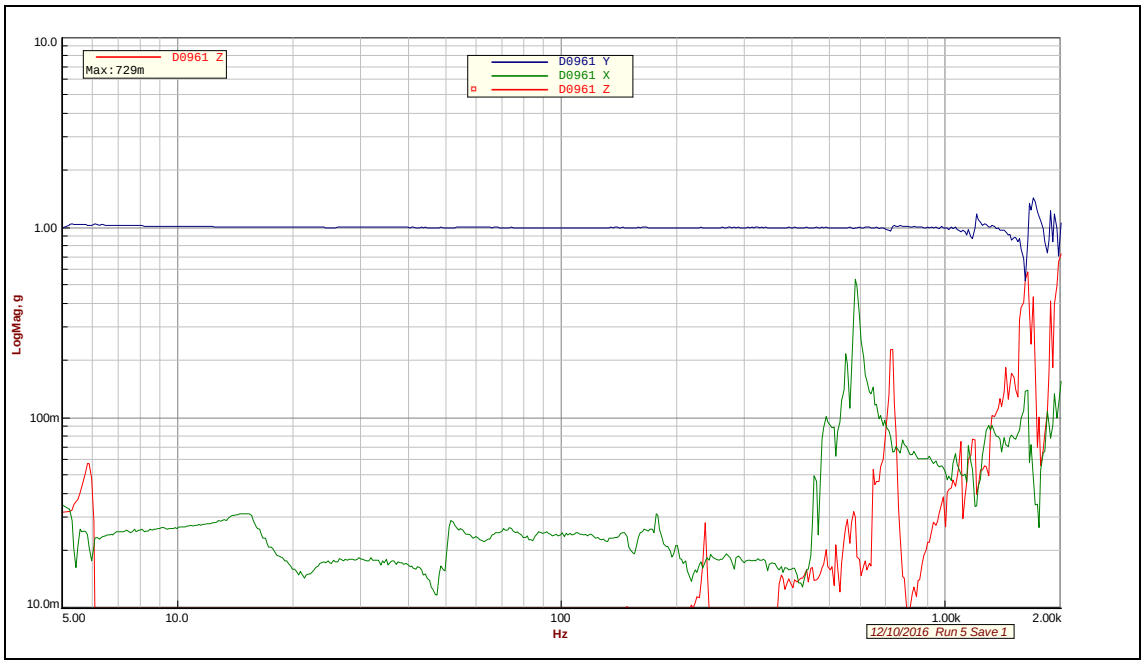

Figure 10: Cross-axis Response of D0961 (Y-Axis)

4.2.2.2 Board Response Measurements: Y-axis

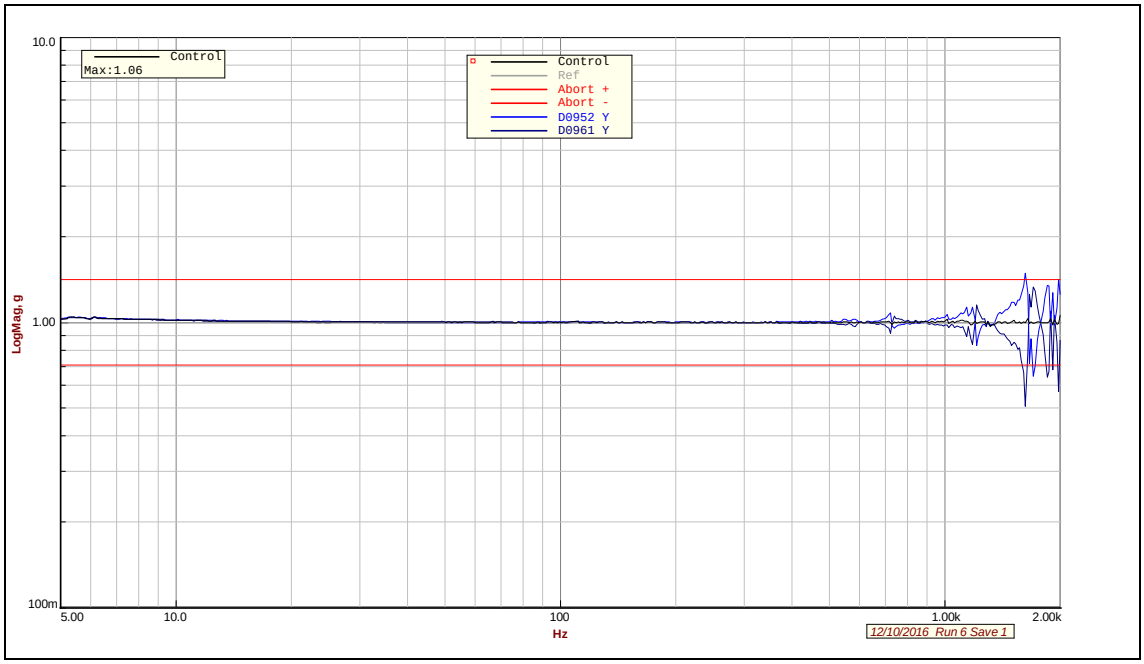

Figure 11: Control for Board Response Measurements (Y-Axis)

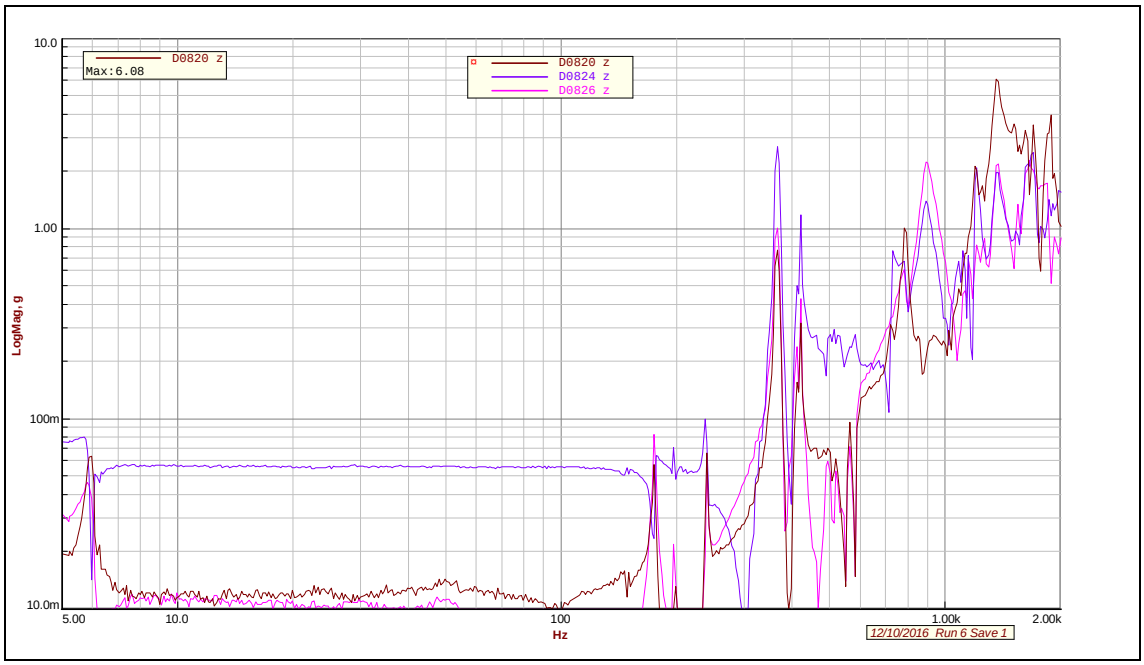

Figure 12: Response of Accelerometers D0820, D824 and D826 (Y-Axis)

4.2.2.3 Random Vibration: Y-axis

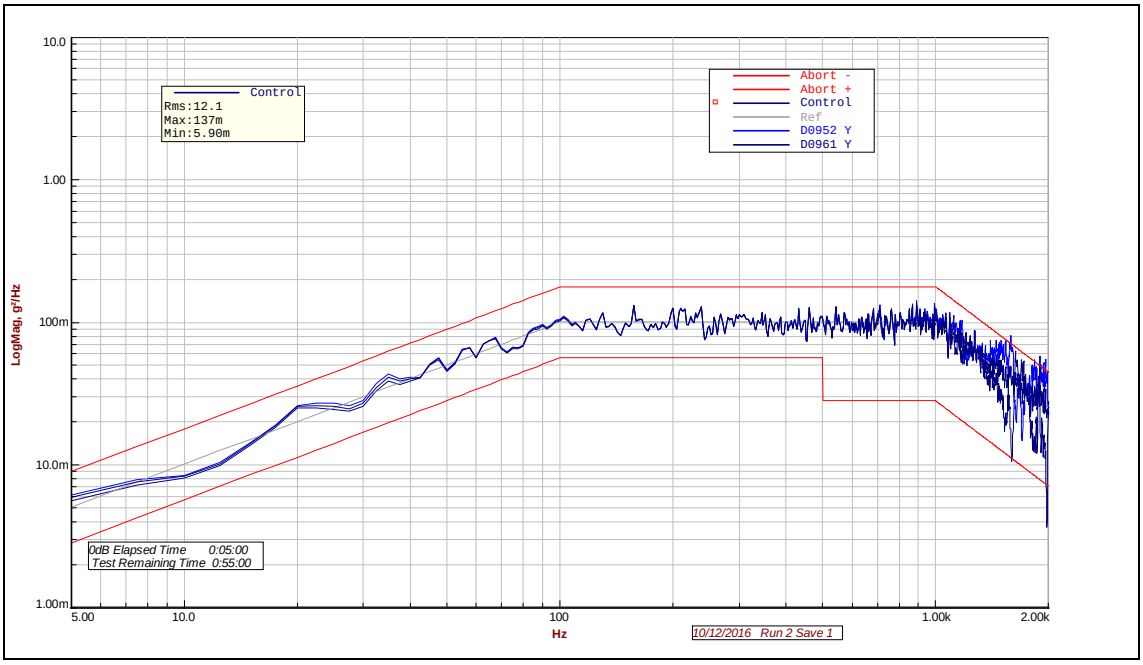

Figure 13: Random Control (Y-Axis) after 5 minutes [Board 1]

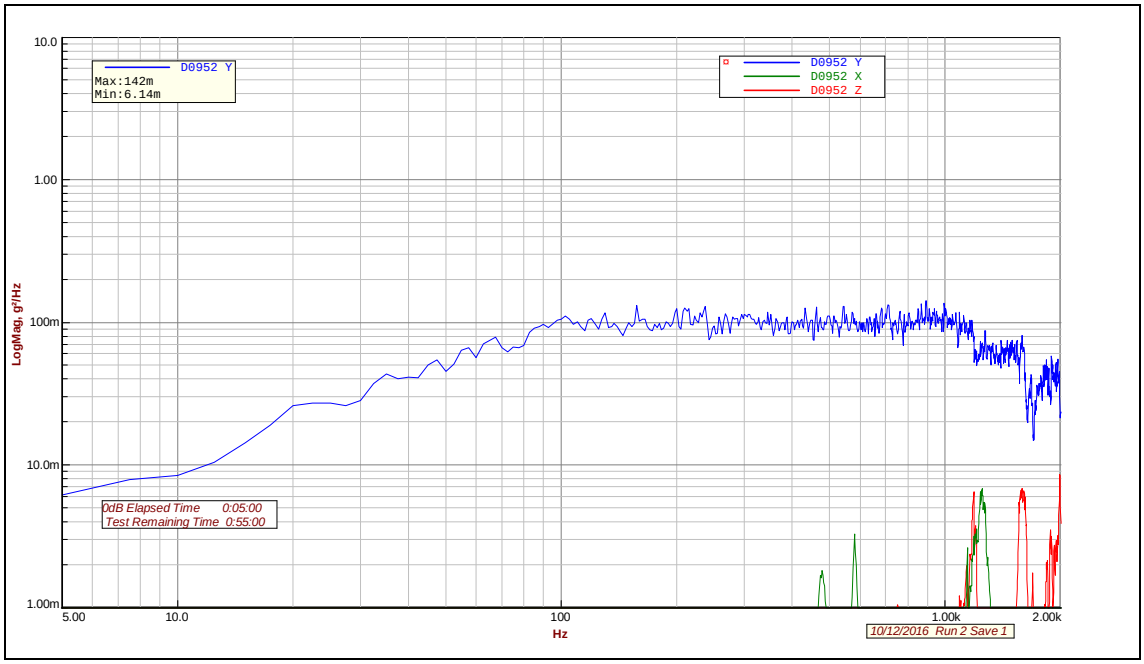

Figure 14: Cross-axis response of D0952 Control Point (Y-Axis) after 5 minutes [Board 1]

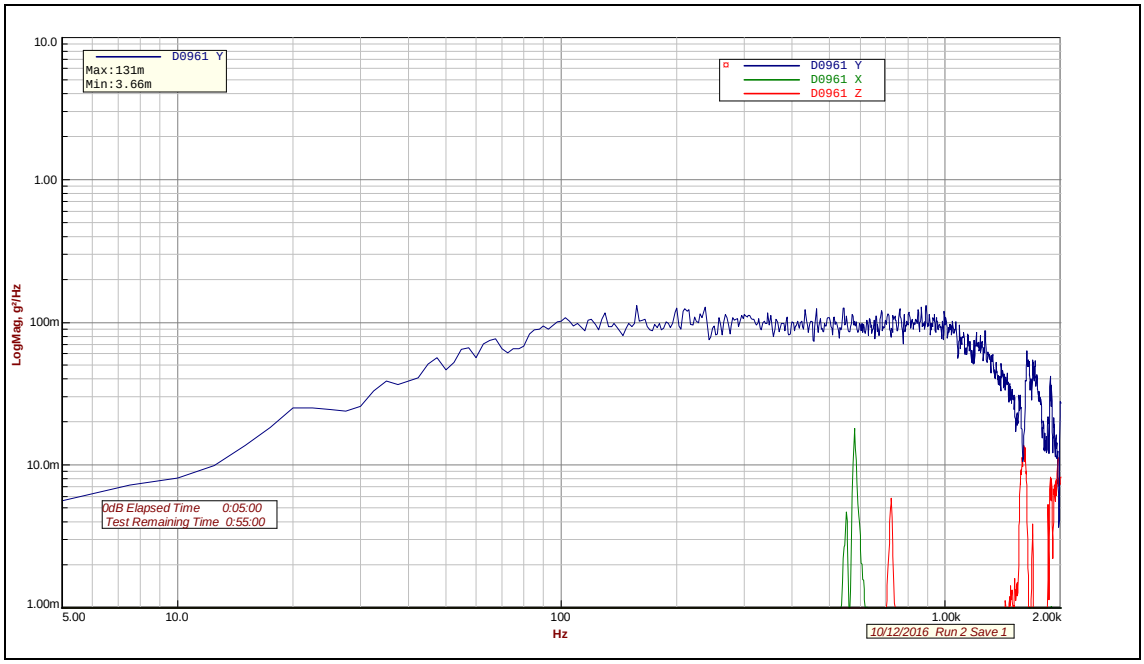

Figure 15: Cross-axis response of D0961 Control Point (Y-Axis) after 5 minutes [Board 1]

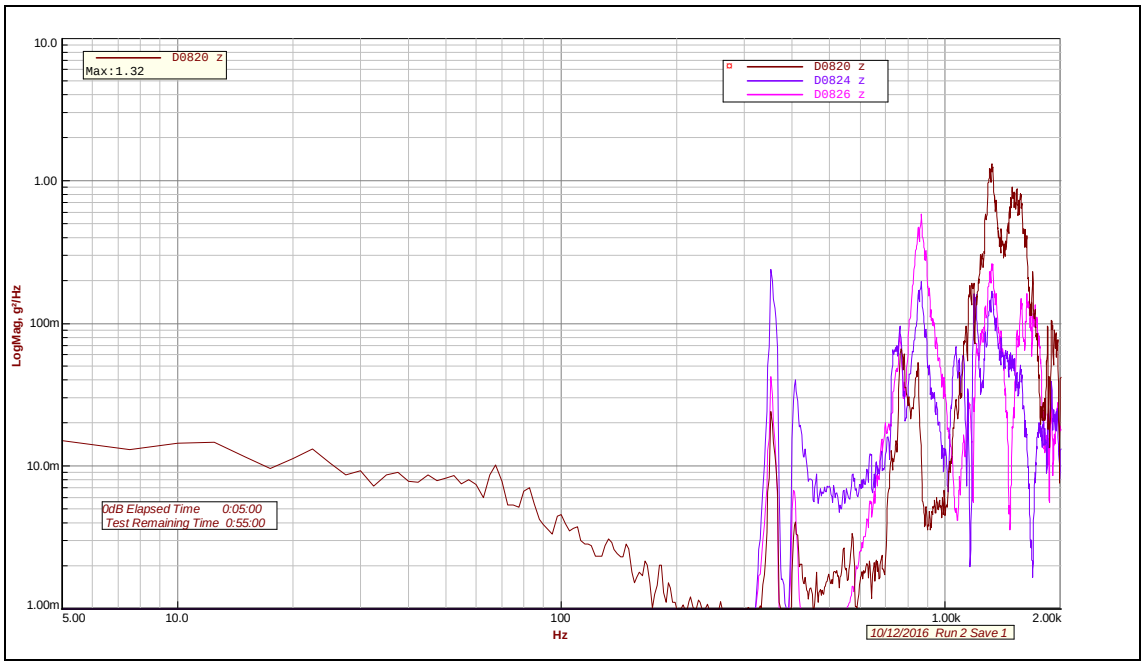

Figure 16: Response of Accelerometers D0820, D824 and D826 (Y-Axis) after 5 minutes [Board 1]

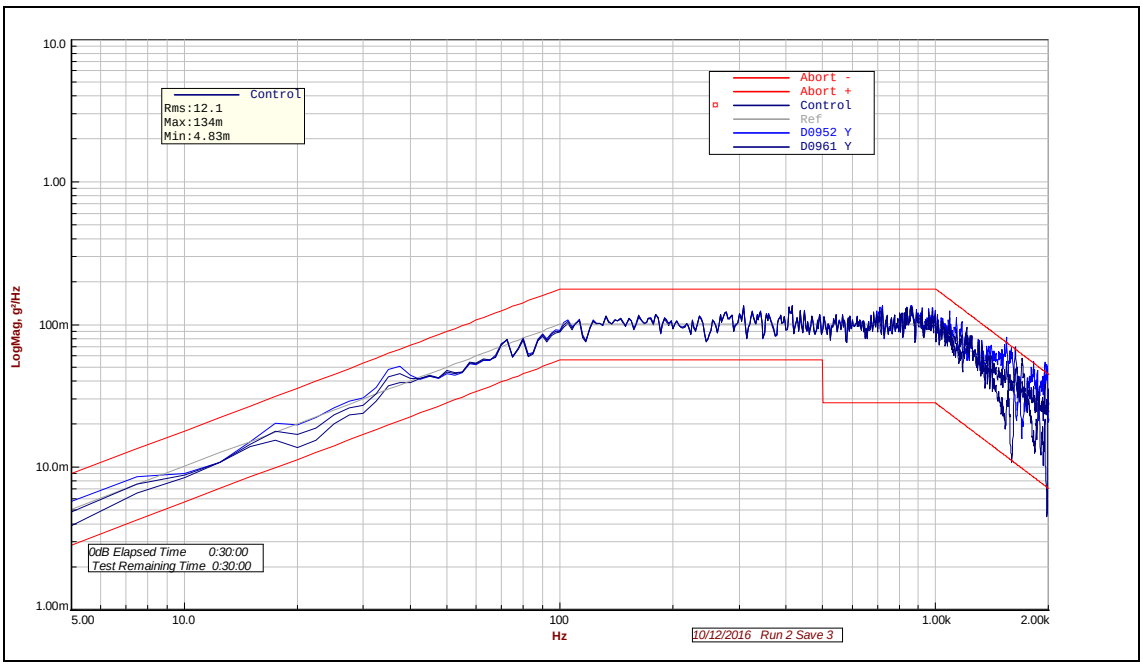

Figure 17: Random Control (Y-Axis) after 30 minutes [Board 1]

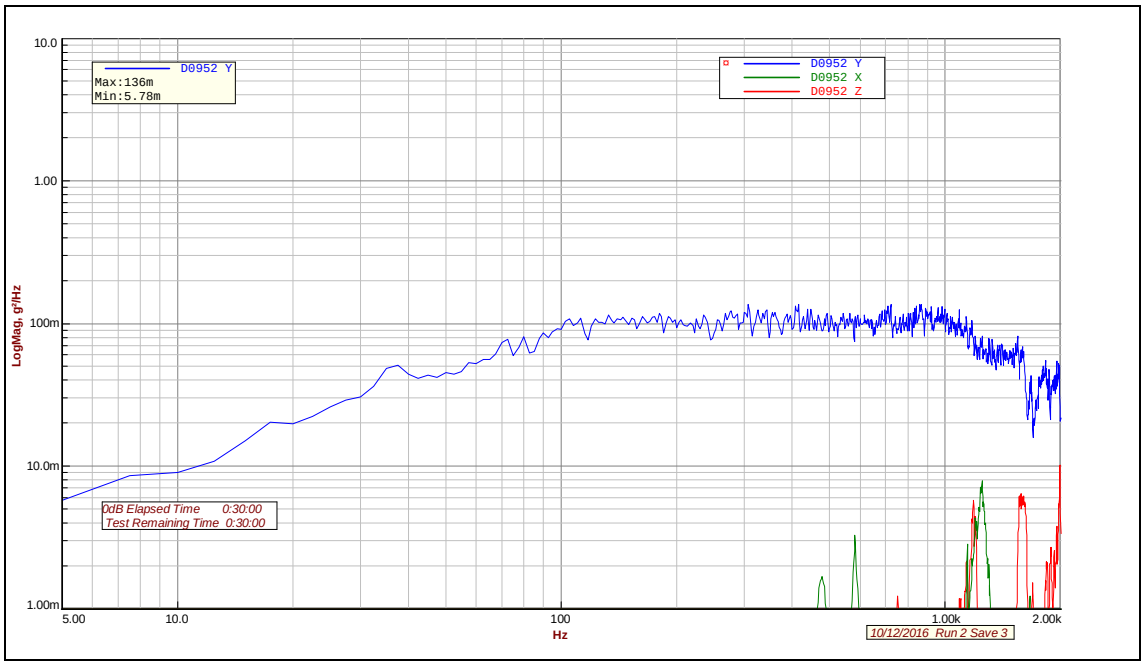

Figure 18: Cross-axis response of D0952 Control Point (Y-Axis) after 30 minutes [Board 1]

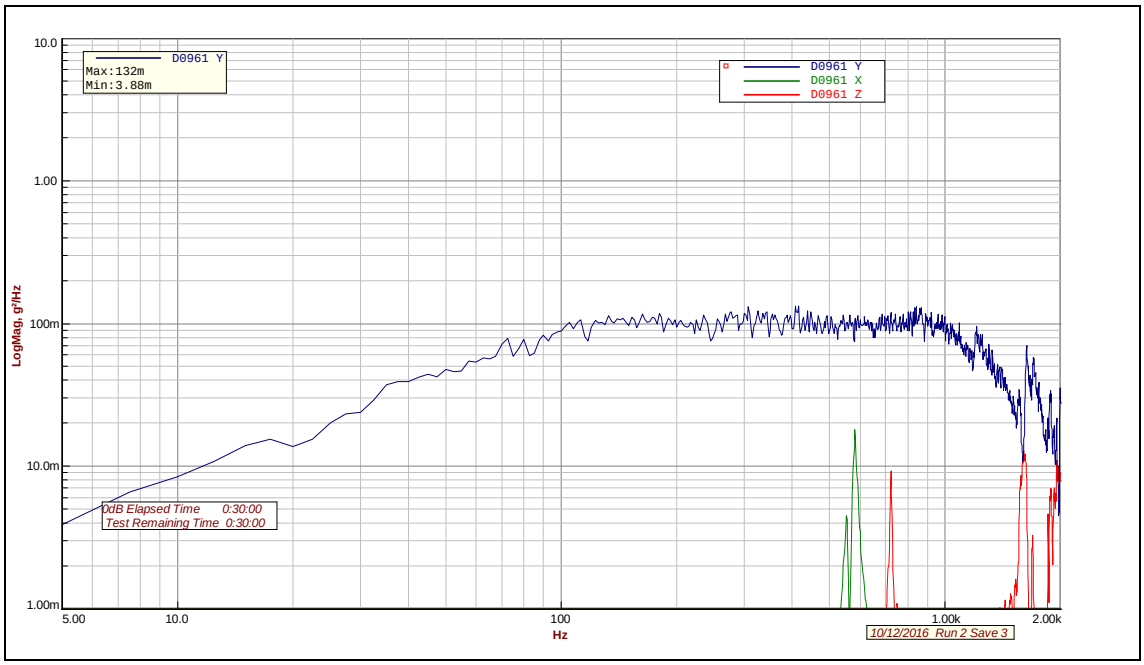

Figure 19: Cross-axis response of D0961 Control Point (Y-Axis) after 30 minutes [Board 1]

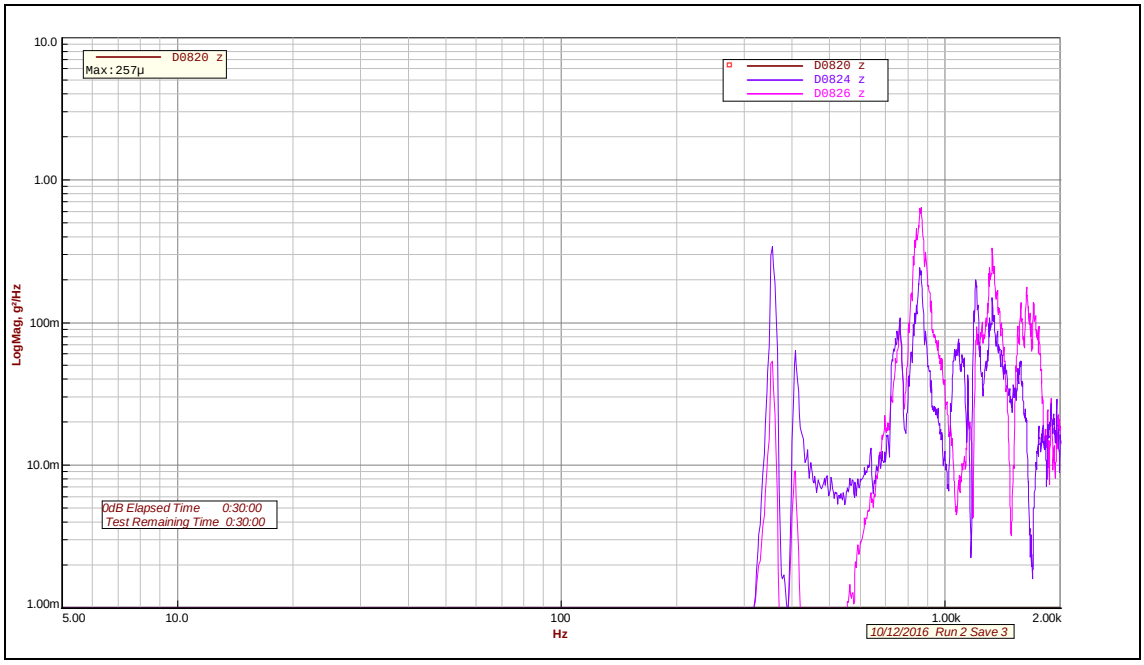

Figure 20: Response of Accelerometers D824 and D826 (Y-Axis) after 30 minutes [Board 1]

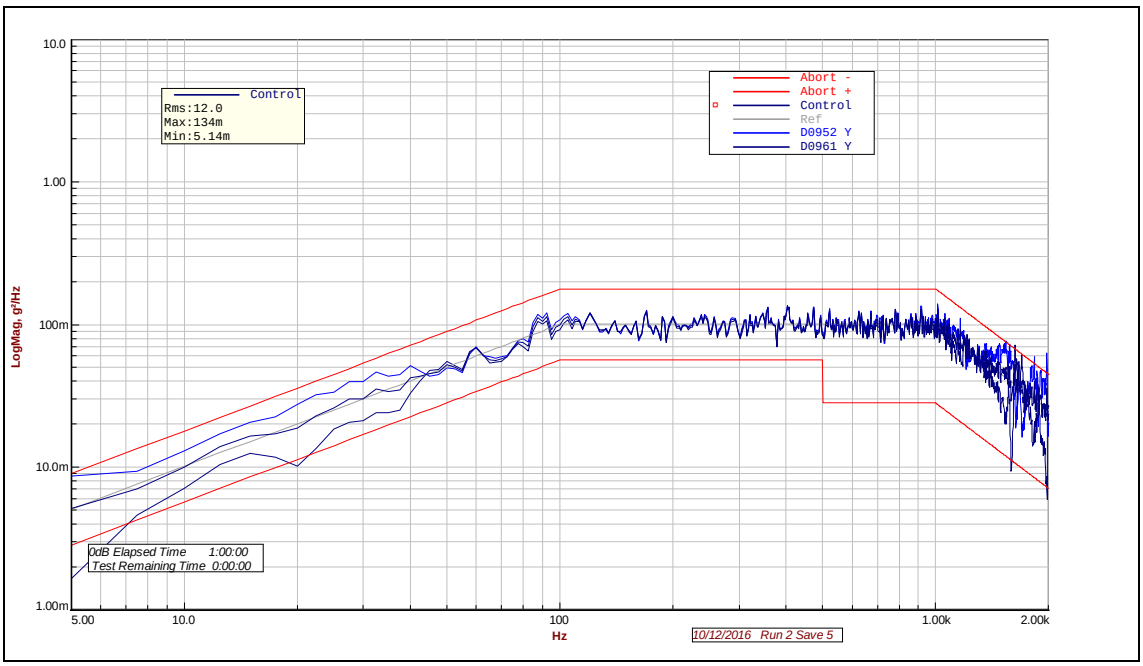

Figure 21: Random Control (Y-Axis) after 60 minutes [Board 1]

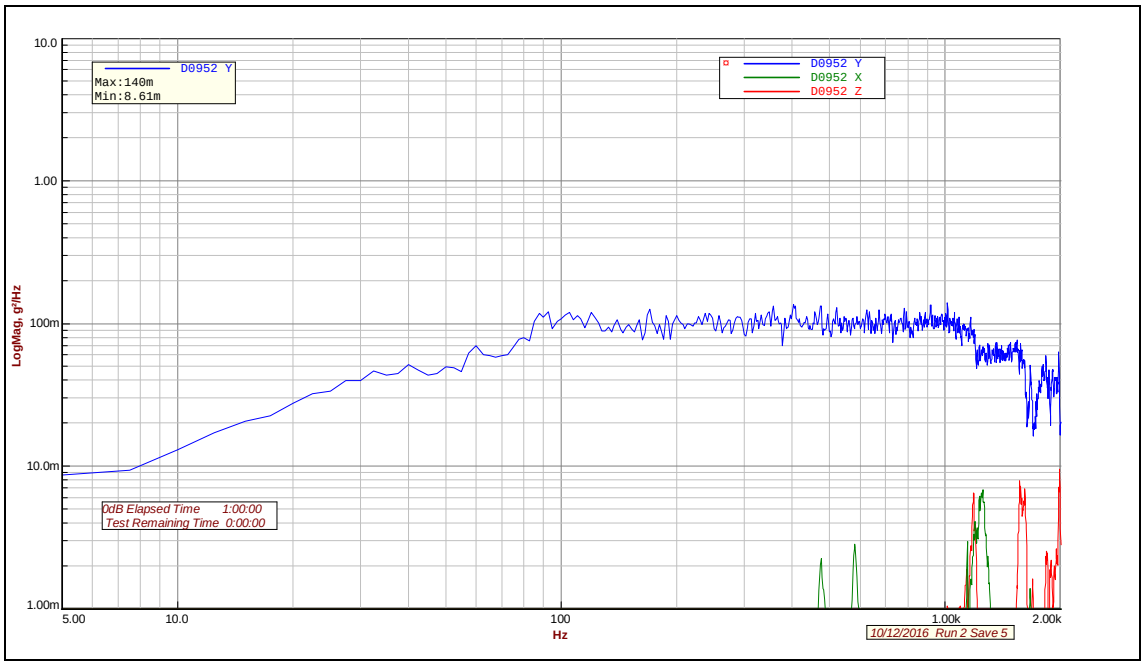

Figure 22: Cross-axis response of D0952 Control Point (Y-Axis) after 60 minutes [Board 1]

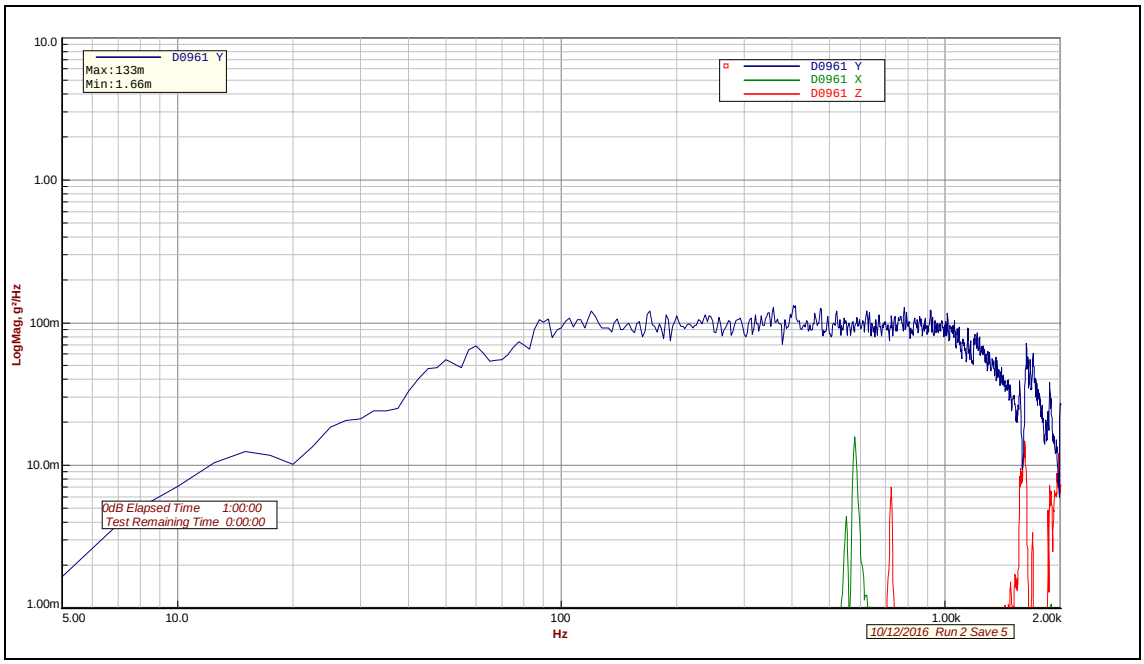

Figure 23: Cross-axis response of D0961 Control Point (Y-Axis) after 60 minutes [Board 1]

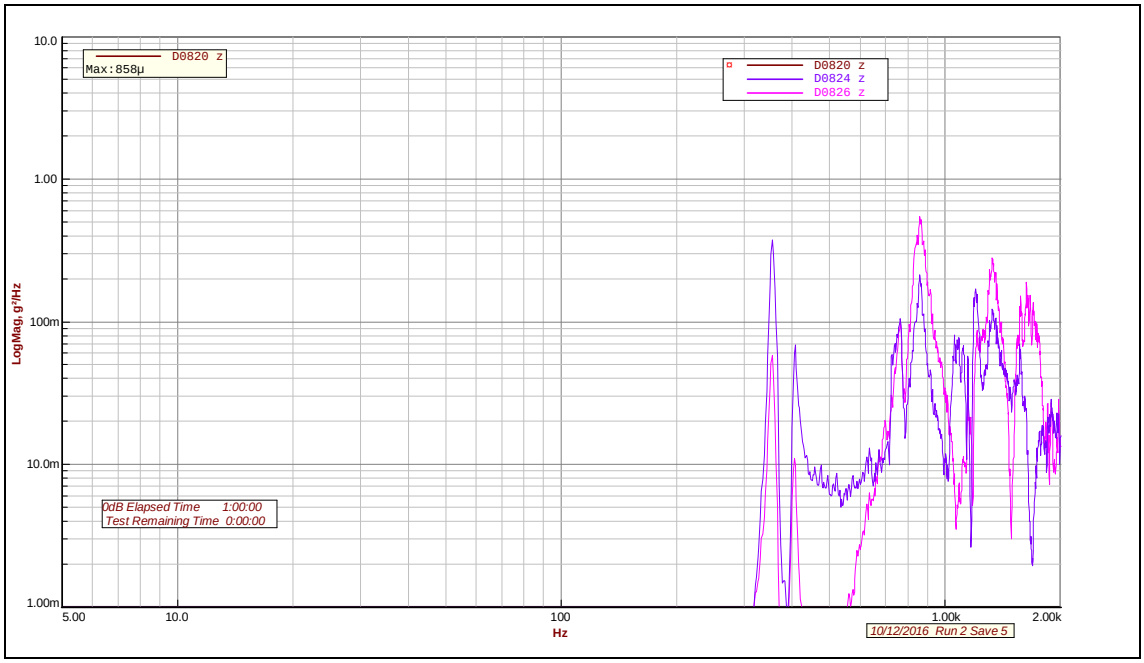

Figure 24: Response of Accelerometers D824 and D826 (Y-Axis) after 60 minutes [Board 1]

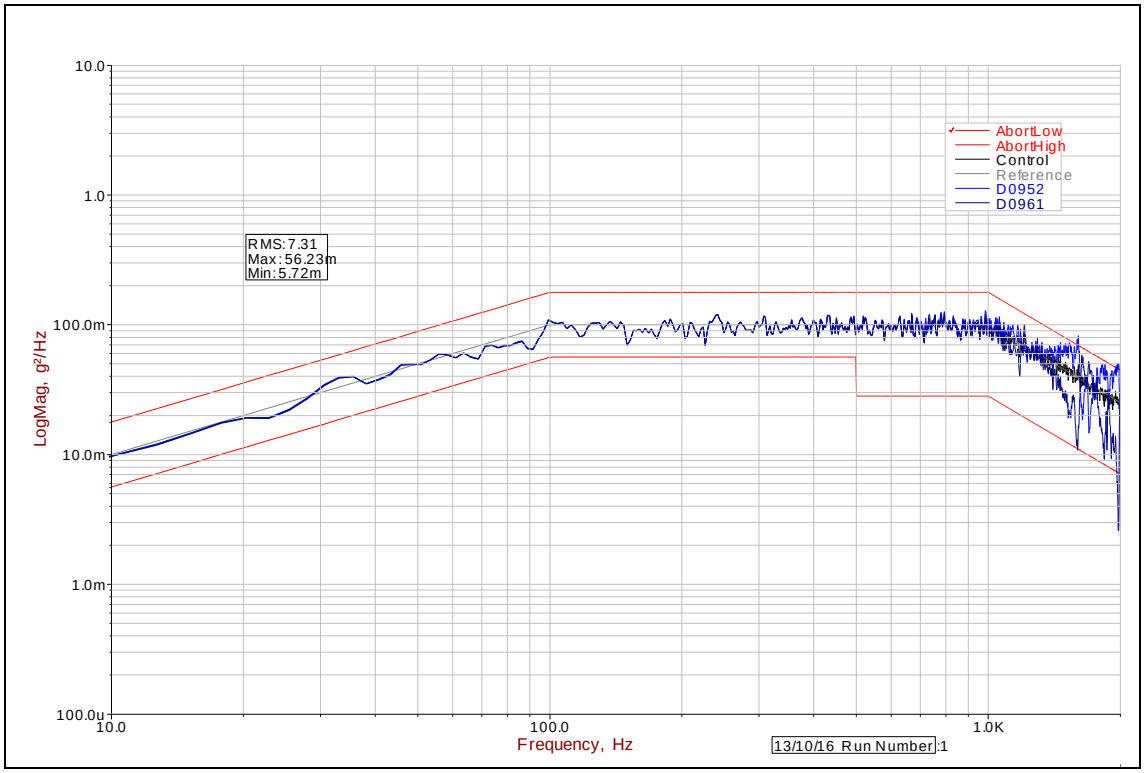

Figure 25: Random Control (Y-Axis) after 5 minutes [Board 2]

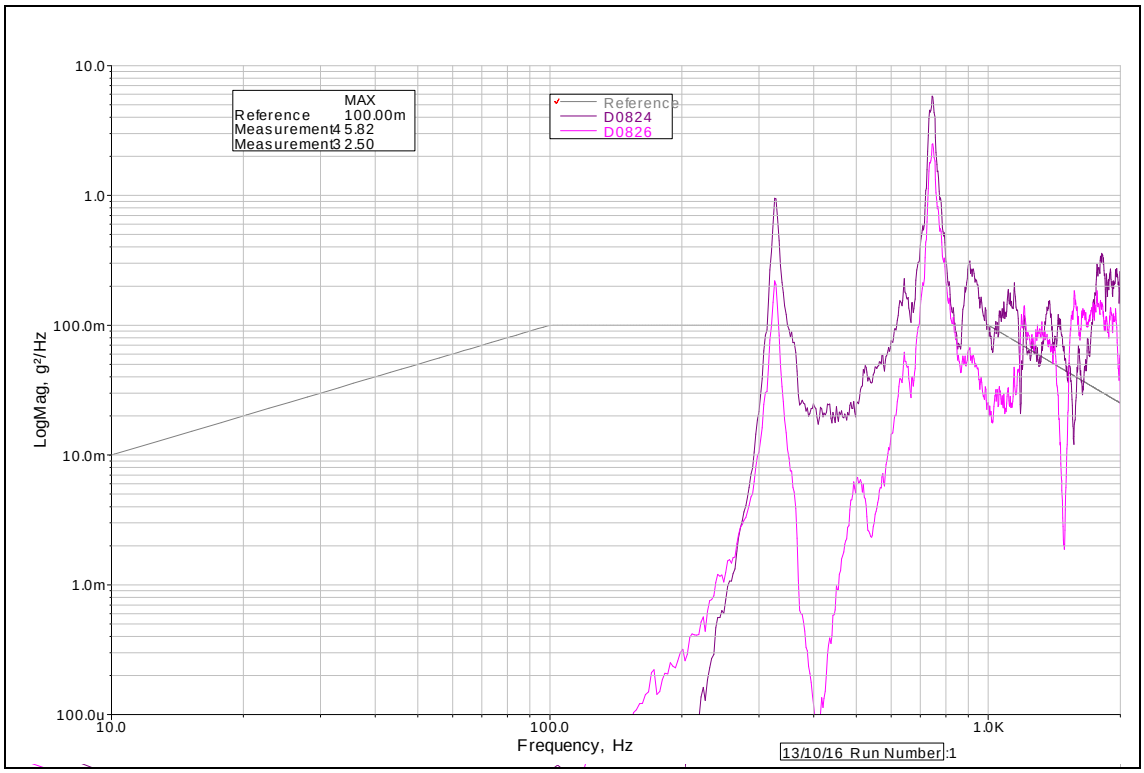

Figure 26: Response of Accelerometers D824 and D826 (Y-Axis) after 5 minutes [Board 2]

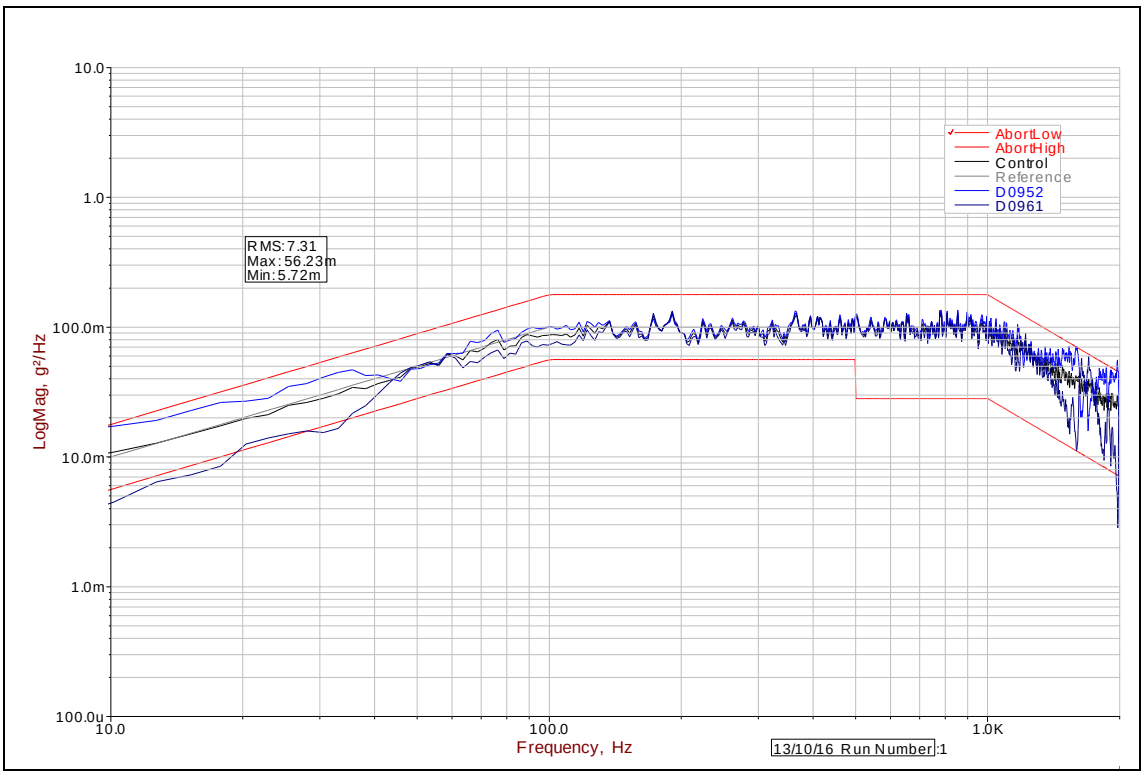

Figure 27: Random Control (Y-Axis) after 30 minutes [Board 2]

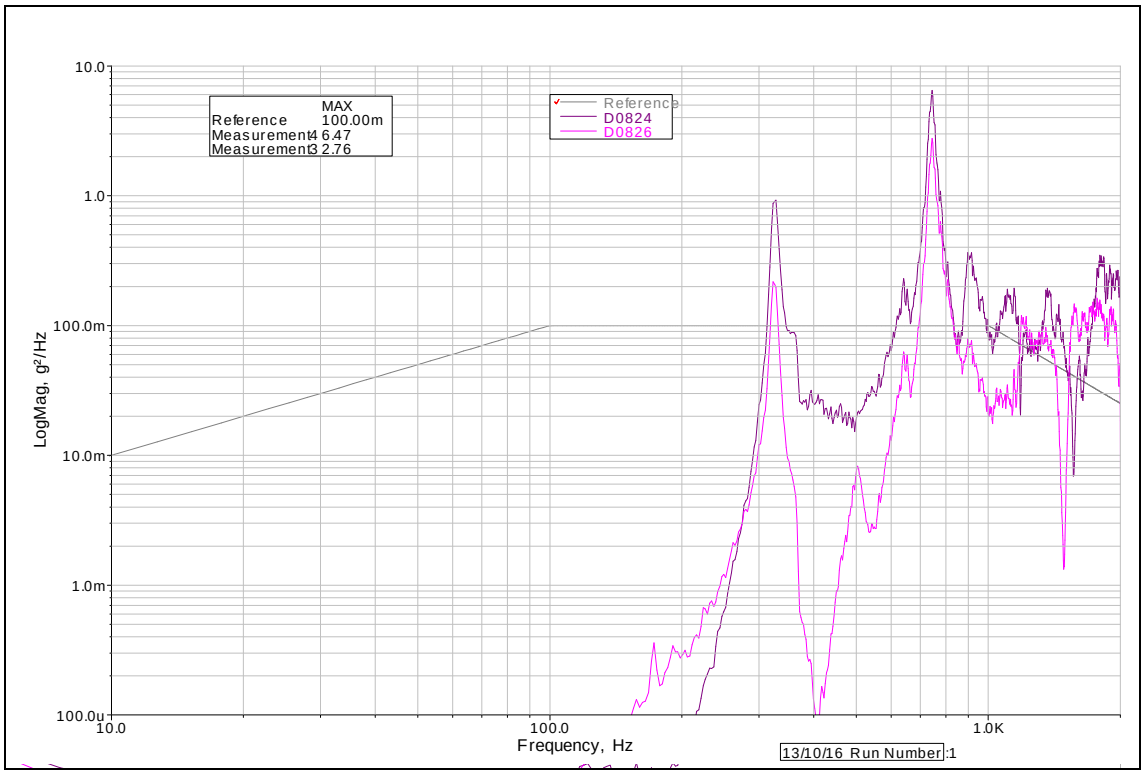

Figure 28: Response of Accelerometers D824 and D826 (Y-Axis) after 30 minutes [Board 2]

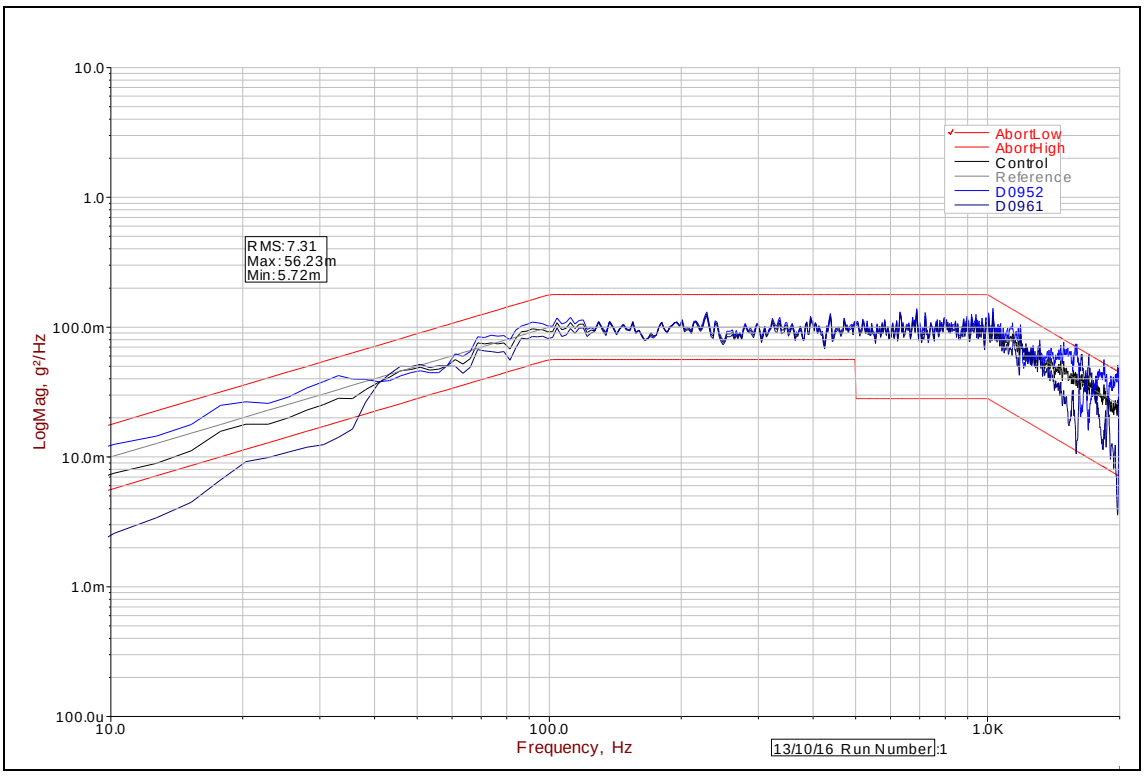

Figure 29: Random Control (Y-Axis) after 60 minutes [Board 2]

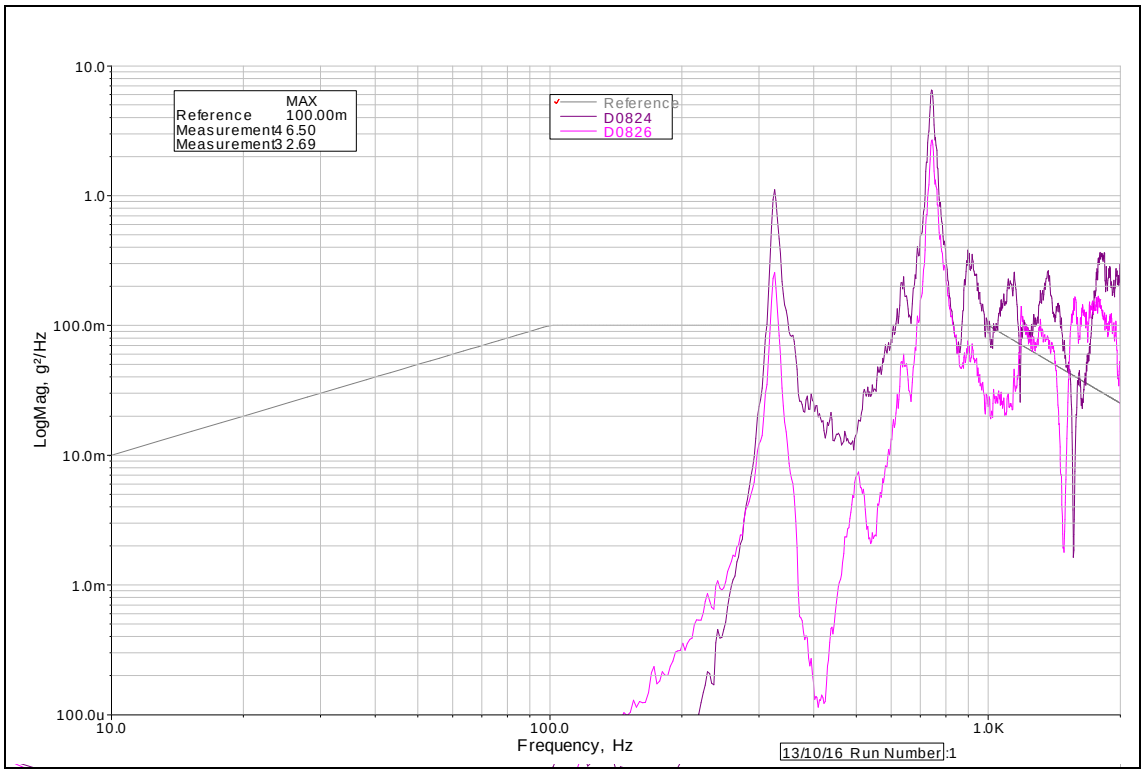

Figure 30: Response of Accelerometers D824 and D826 (Y-Axis) after 60 minutes [Board 2]

4.2.2.4 Shock: Y-axis

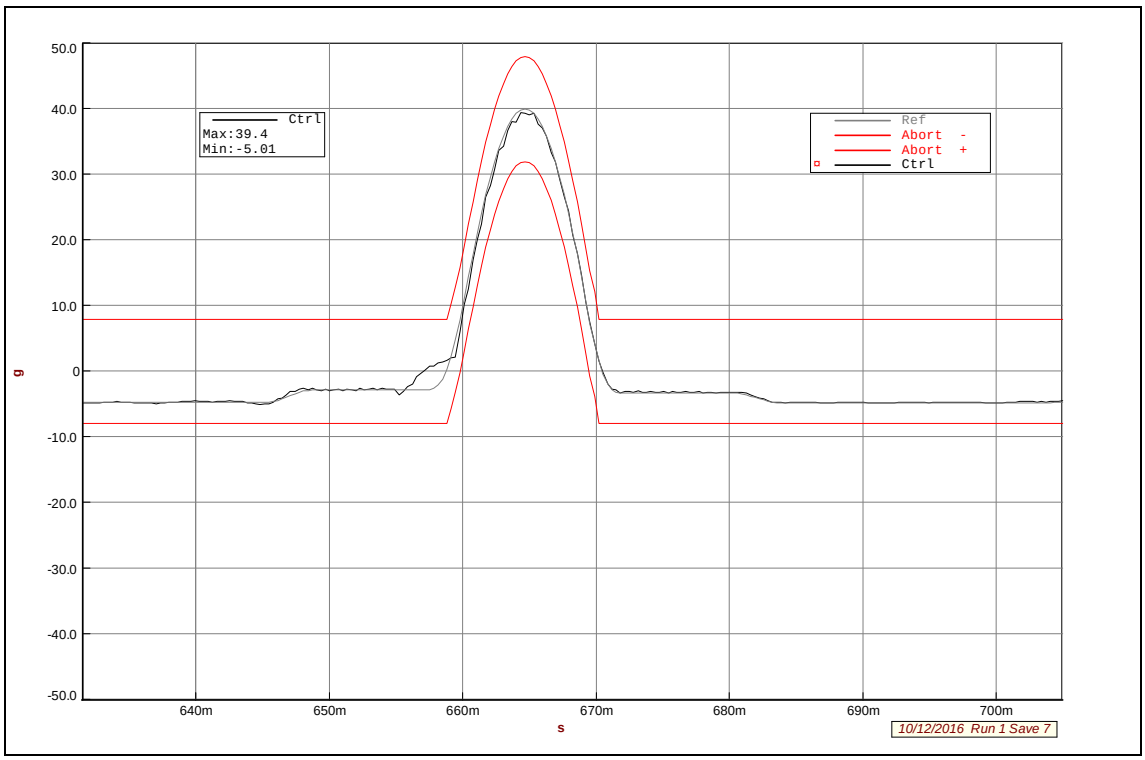

Figure 31: Typical Positive Shock Accelerometer D0974 (Y-Axis) [Board 1]

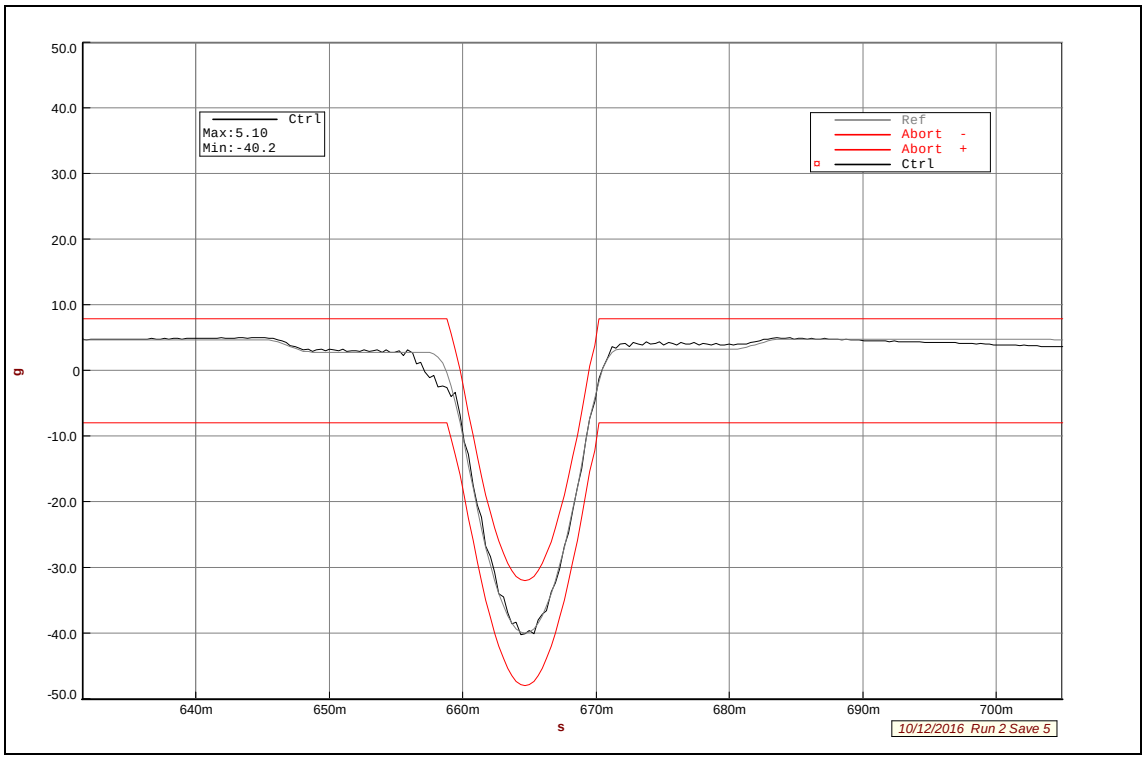

Figure 32: Typical Negative Shock Accelerometer D0974 (Y-Axis) [Board 1]

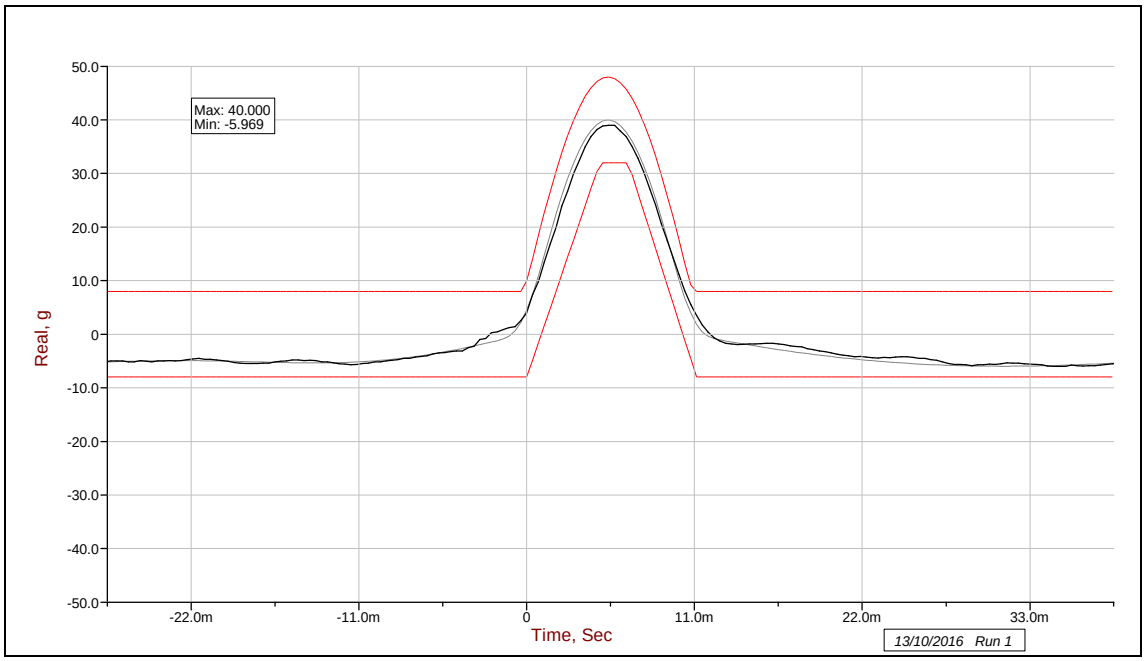

Figure 33: Typical Positive Shock Accelerometer D0974 (Y-Axis) [Board 2]

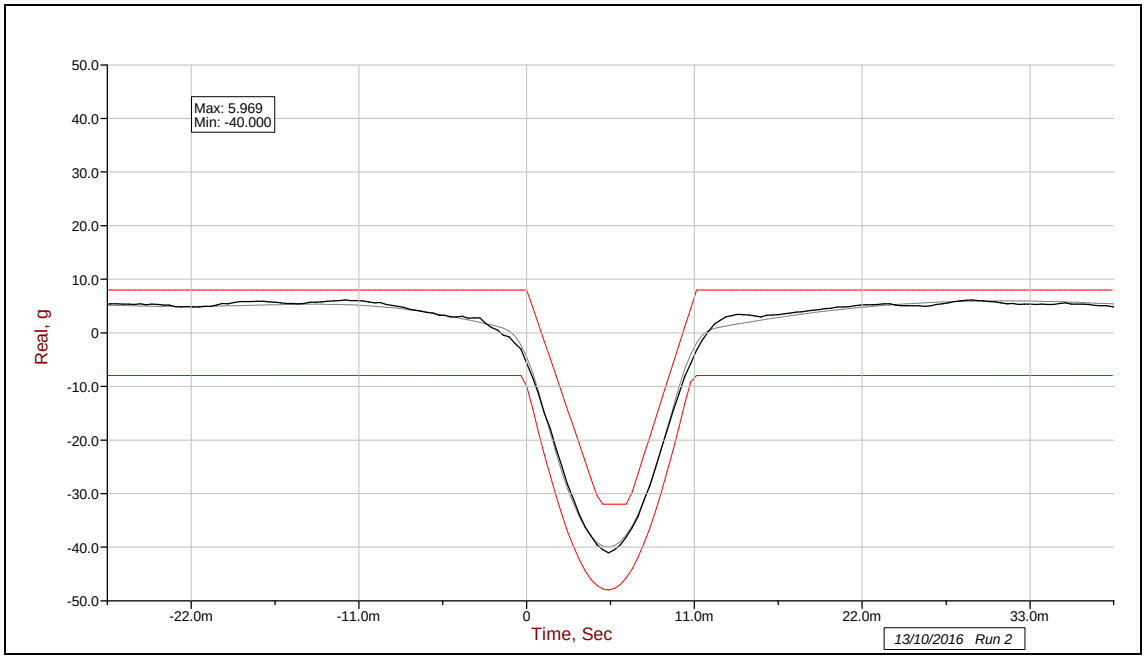

Figure 34: Typical Negative Shock Accelerometer D0974 (Y-Axis) [Board 2]

4.2.3 X-Axis

4.2.3.1 X-Axis Fixture Cross-axis Measurements

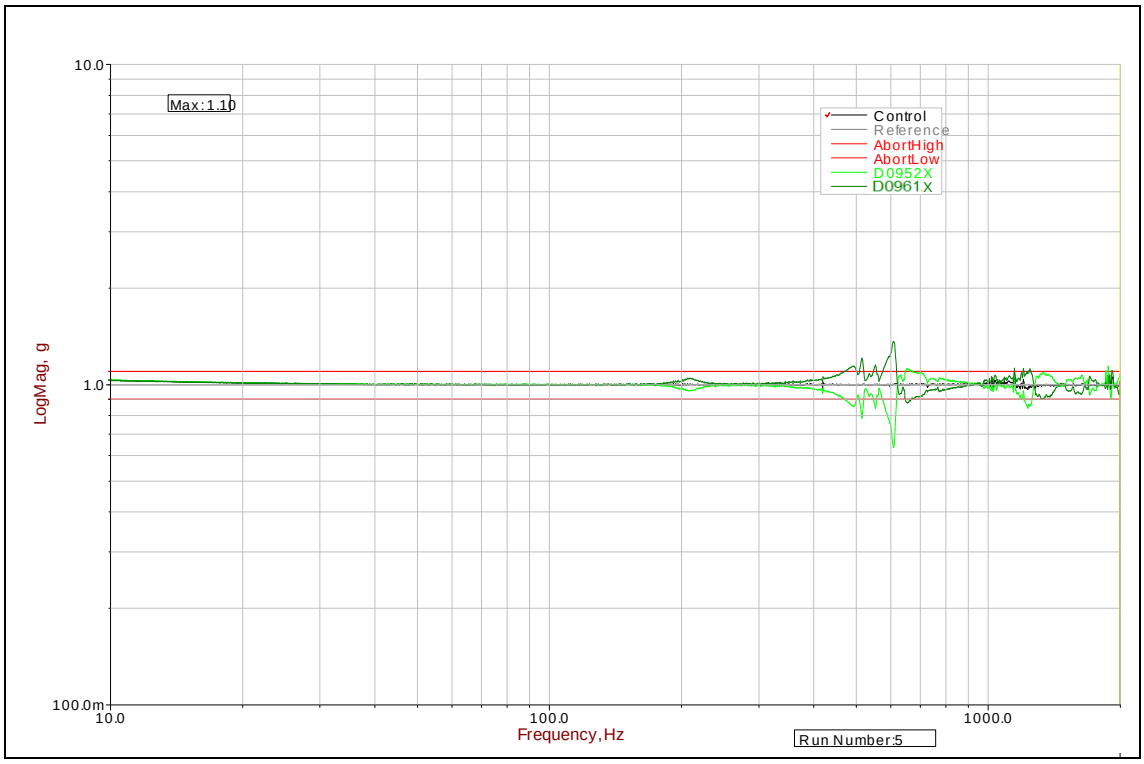

Figure 35: Control (X-Axis) {10% abort limits}

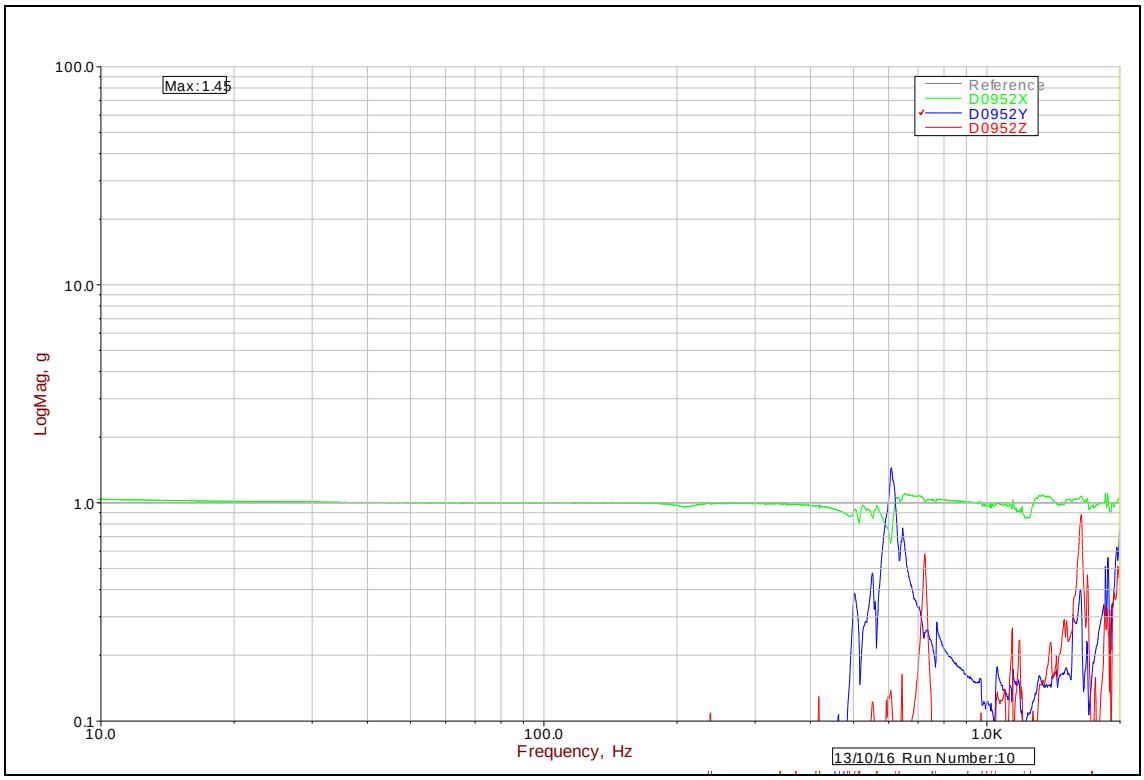

Figure 36: Cross-axis Response of D0952 (X-Axis)

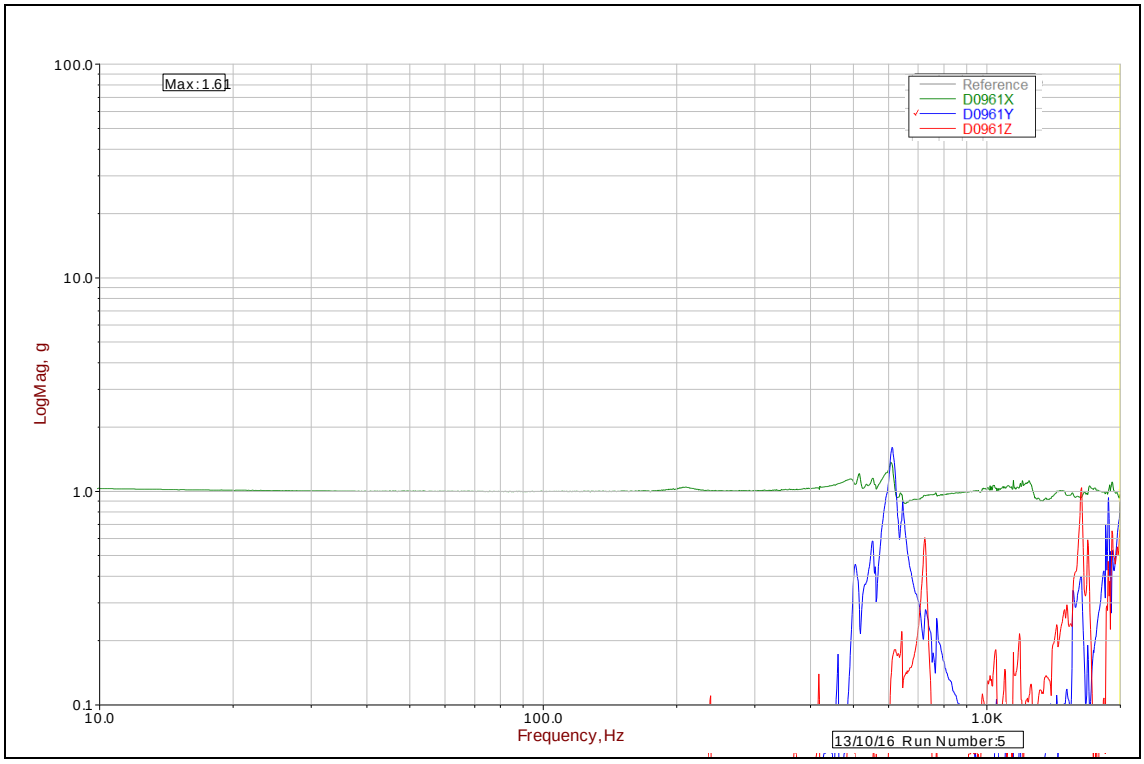

Figure 37: Cross-axis Response of D0961 (X-Axis)

4.2.3.2 EUT Response Measurements

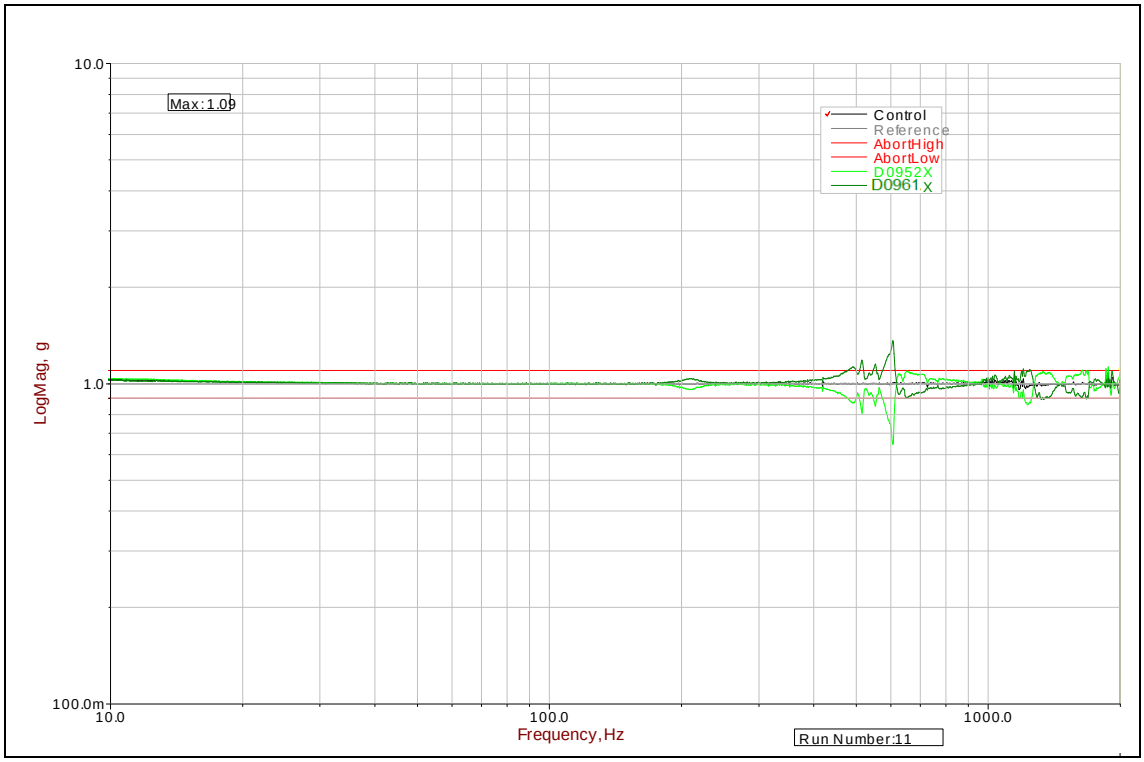

Figure 38: Control for Board Response measurements (X-Axis) [Board 1] {10% abort limits}

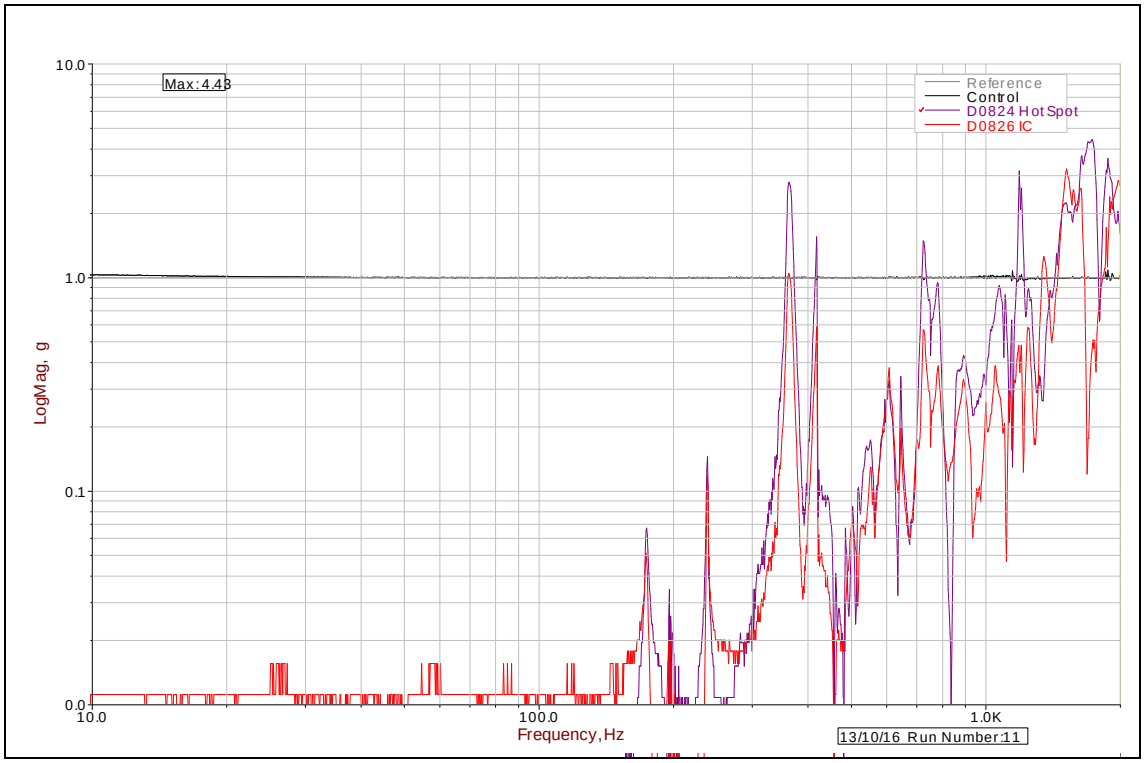

Figure 39: Response of Accelerometers D0824 and D826 (X-Axis) [Board1]

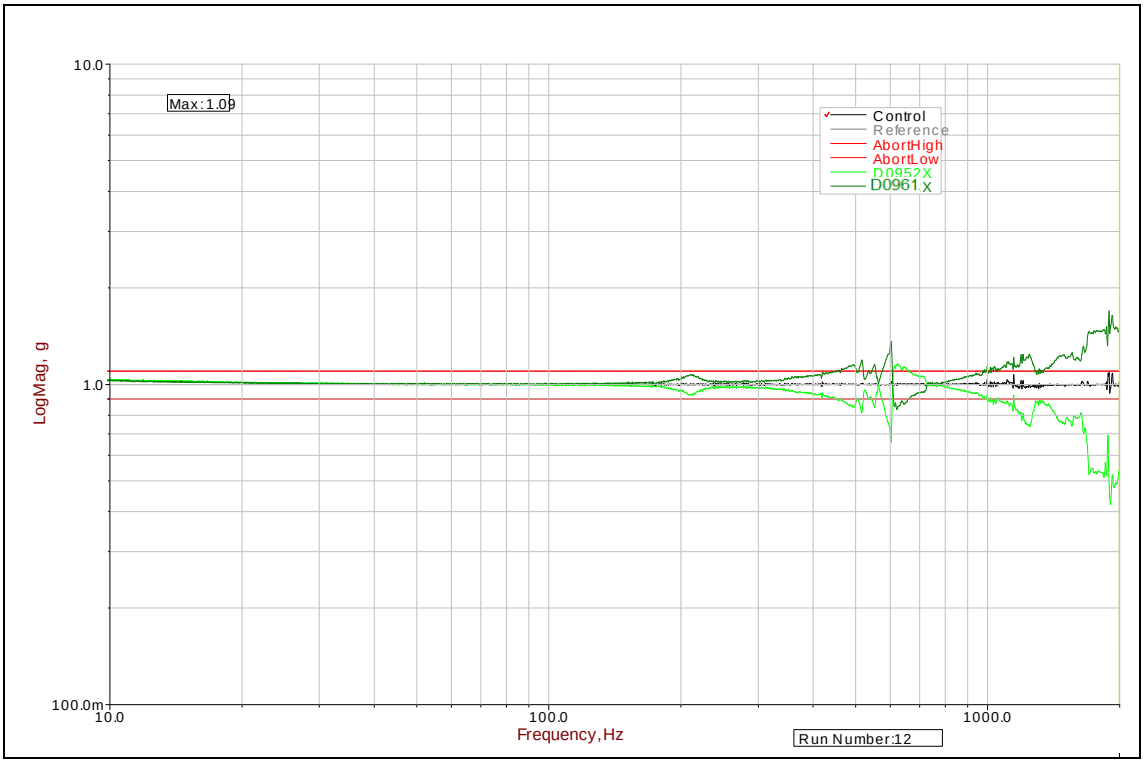

Figure 40: Control for Board Response Measurements (X-Axis) [Board 2] {10% abort limits}

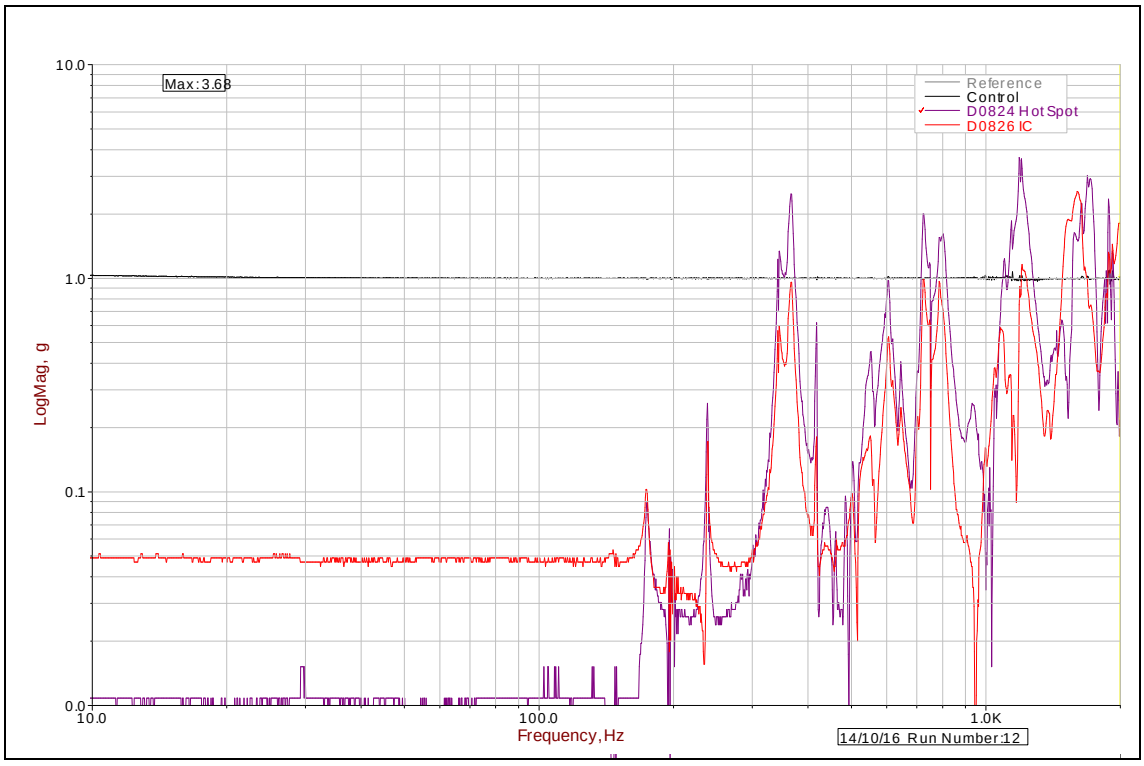

Figure 41: Response of Accelerometers D0824 and D826 (X-Axis) [Board 2]

4.2.3.3 Random Vibration

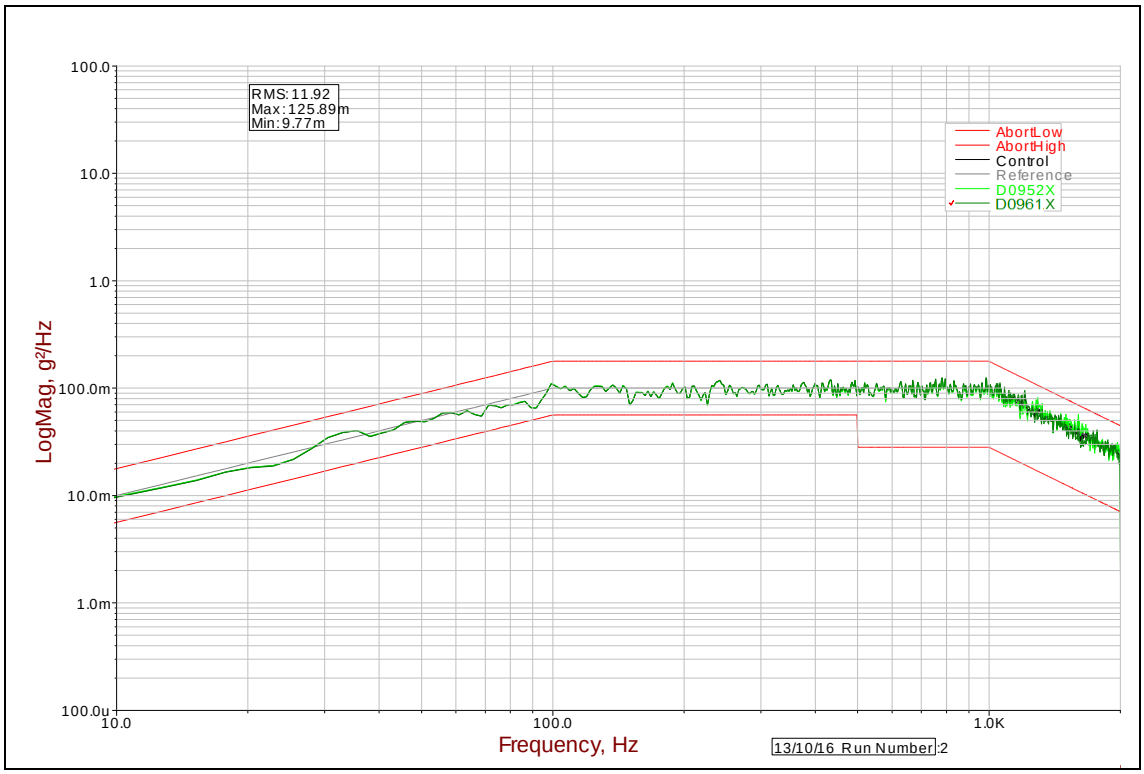

Figure 42: Random Control (X-Axis) after 5 mins [Board 1]

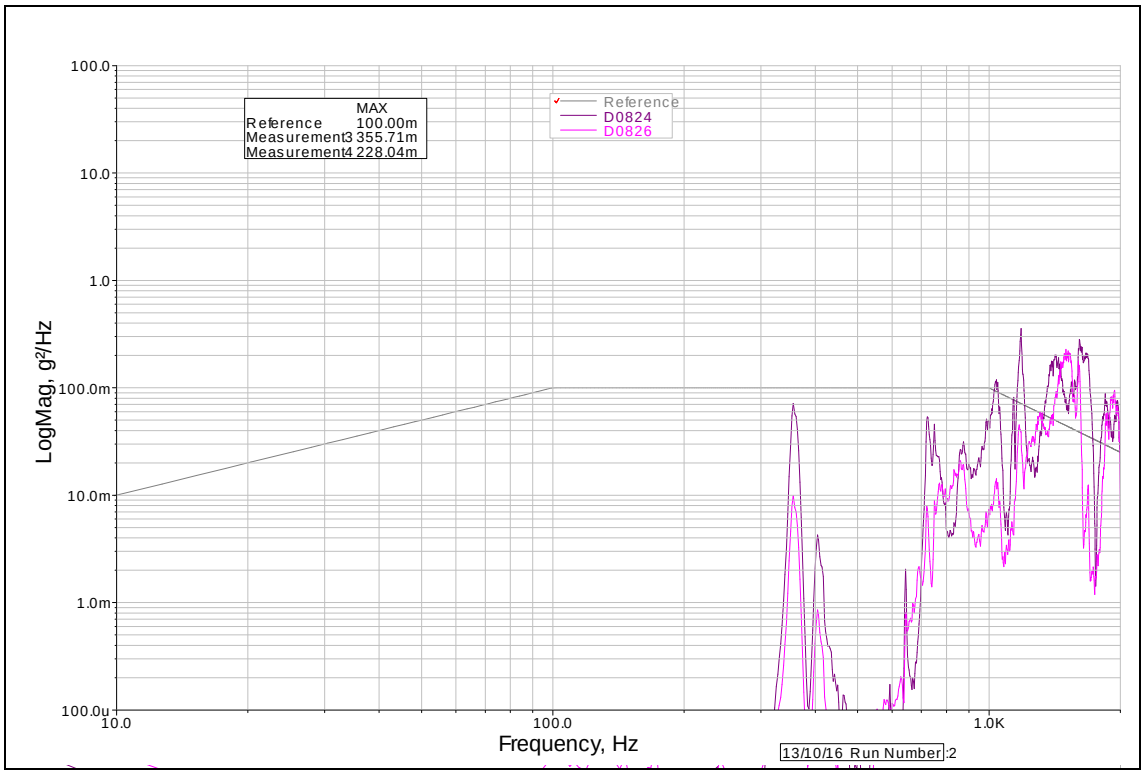

Figure 43: Response of Accelerometers D0824 and D0826 (X-Axis) after 5 mins [Board 1]

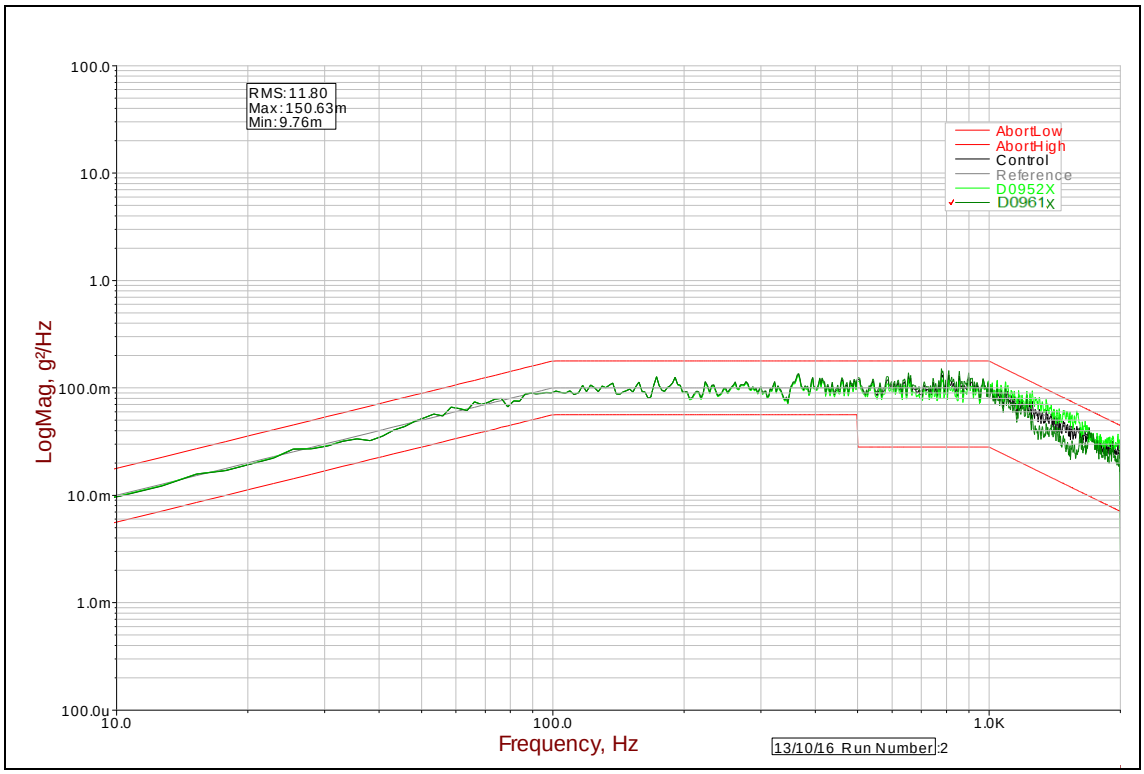

Figure 44: Random Control (X-Axis) after 30 mins [Board 1]

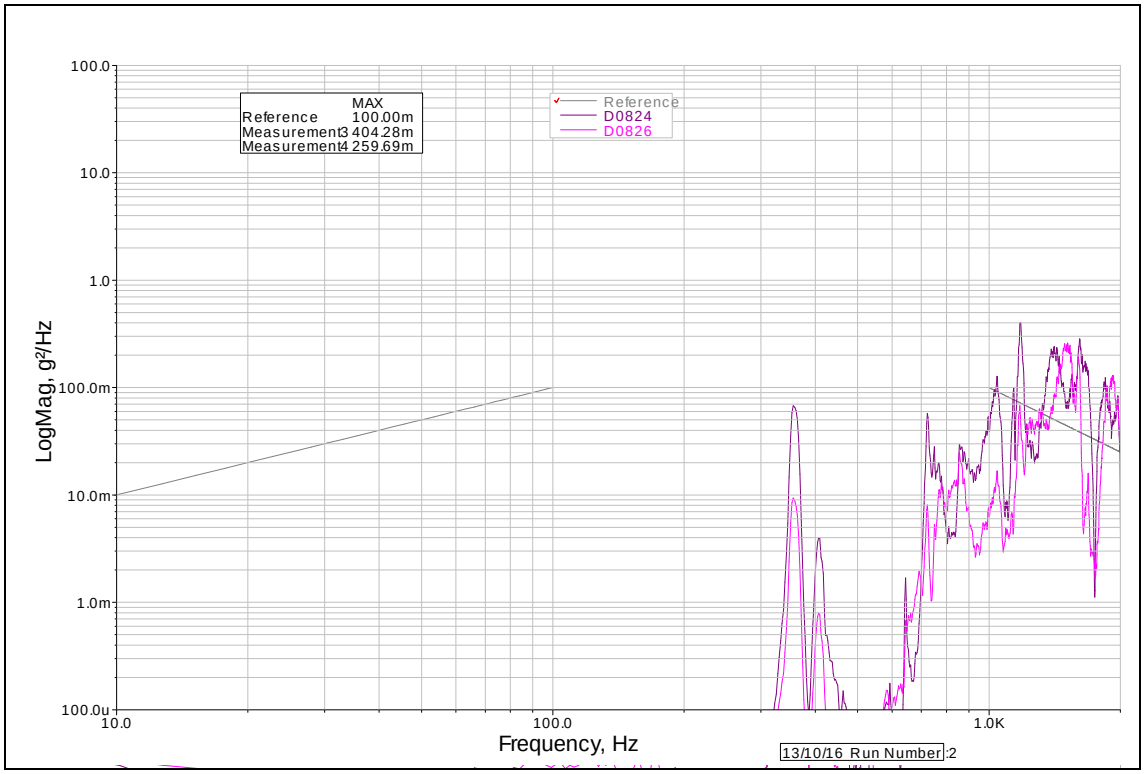

Figure 45: Response of Accelerometers D0824 and D0826 (X-Axis) after 30 mins [Board 1]

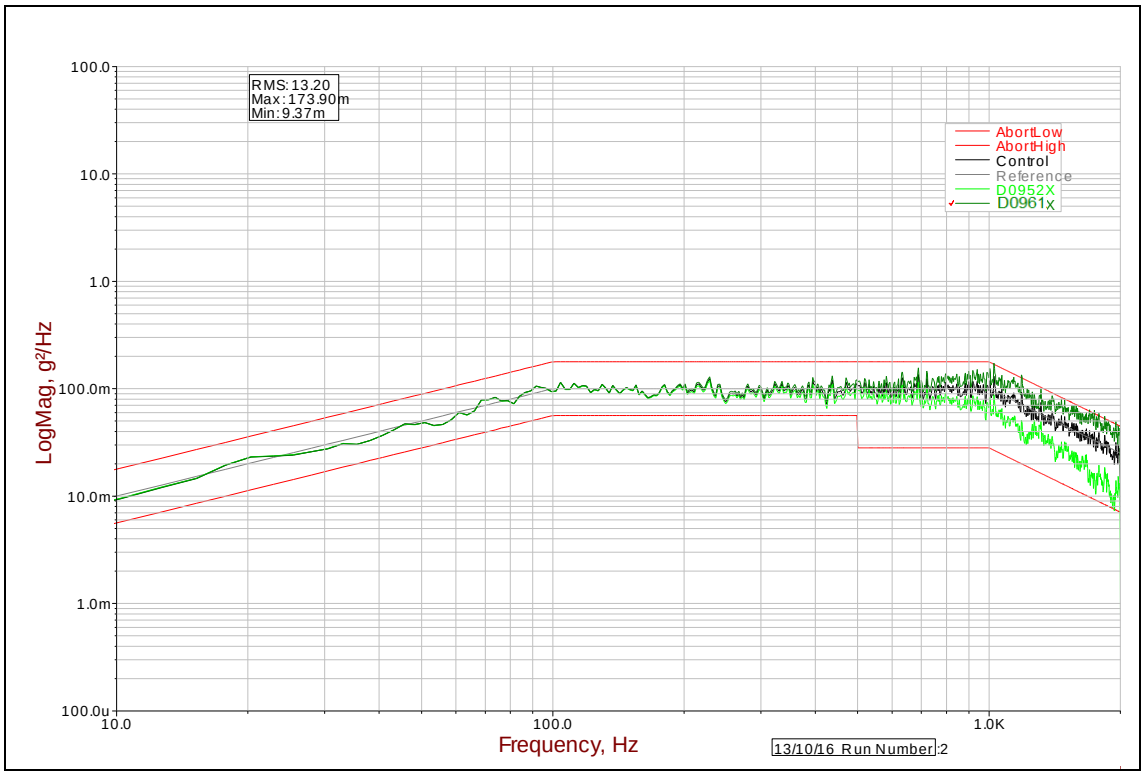

Figure 46: Random Control (X-Axis) after 60 mins [Board 1]

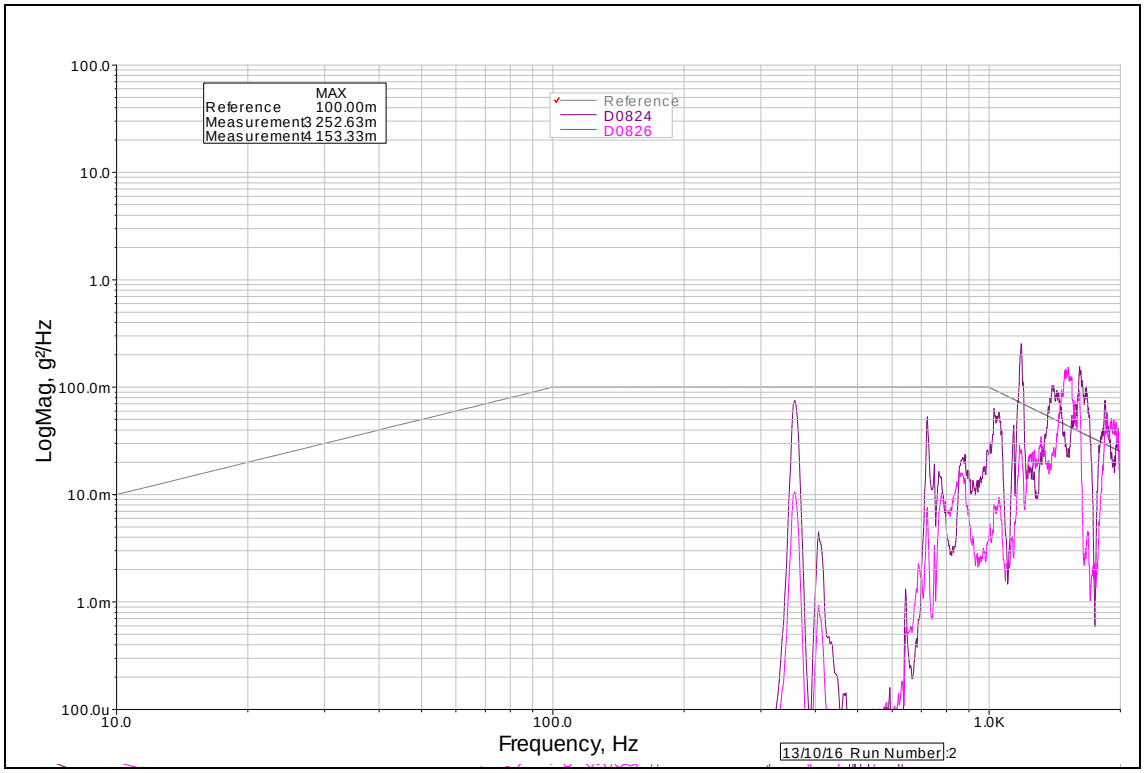

Figure 47: Random Control (X-Axis) after 60 mins [Board 1]

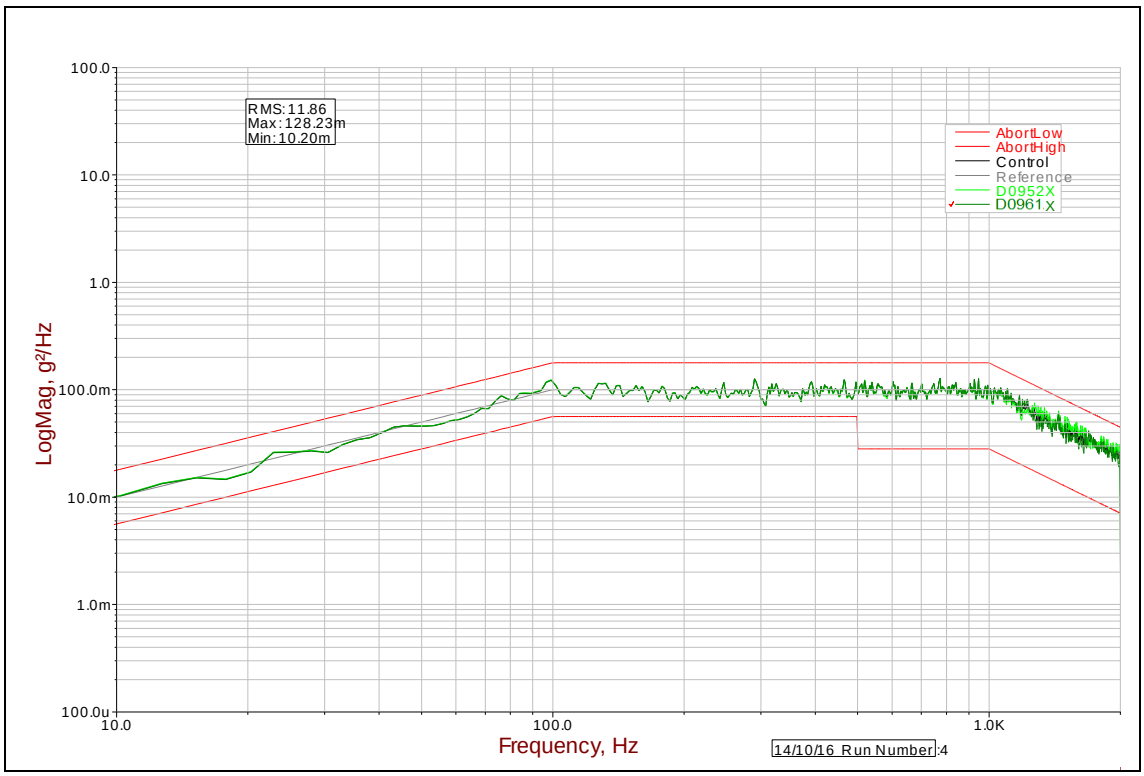

Figure 48: Random Control (X-Axis) after 3 mins 43secs [Board 2]

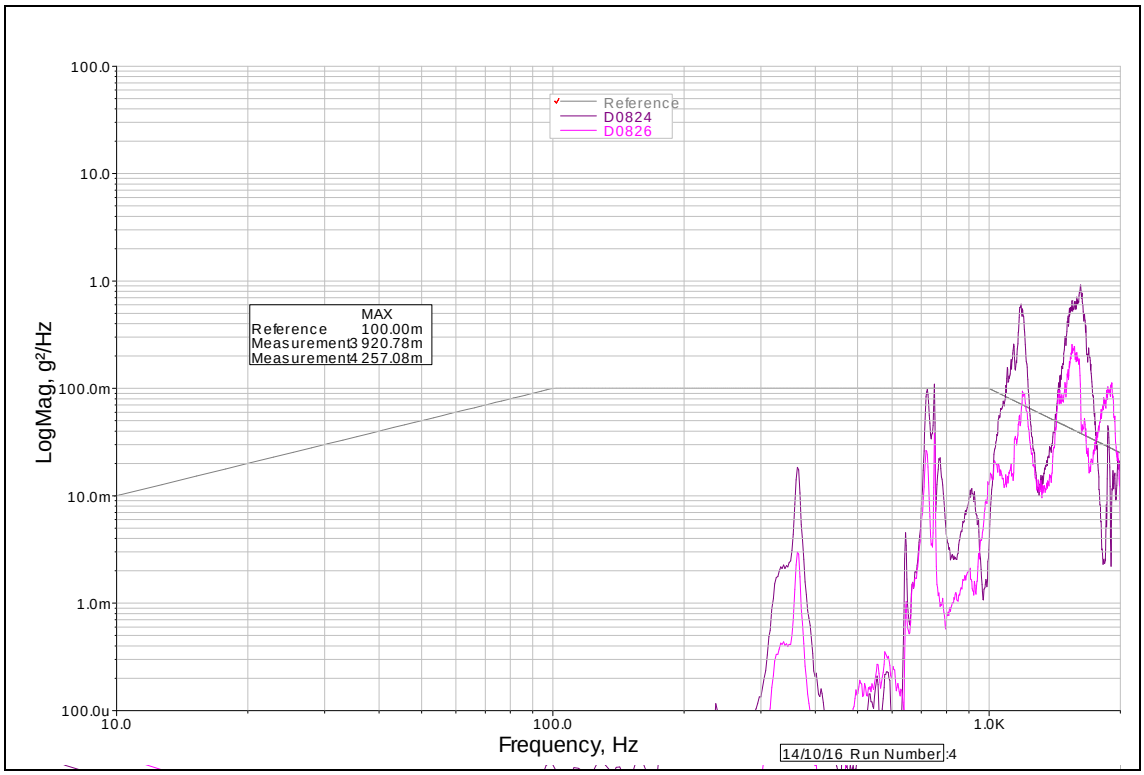

Figure 49: Response of Accelerometers D0824 and D0826 (X-Axis) after 3 mins 43secs [Board 2]

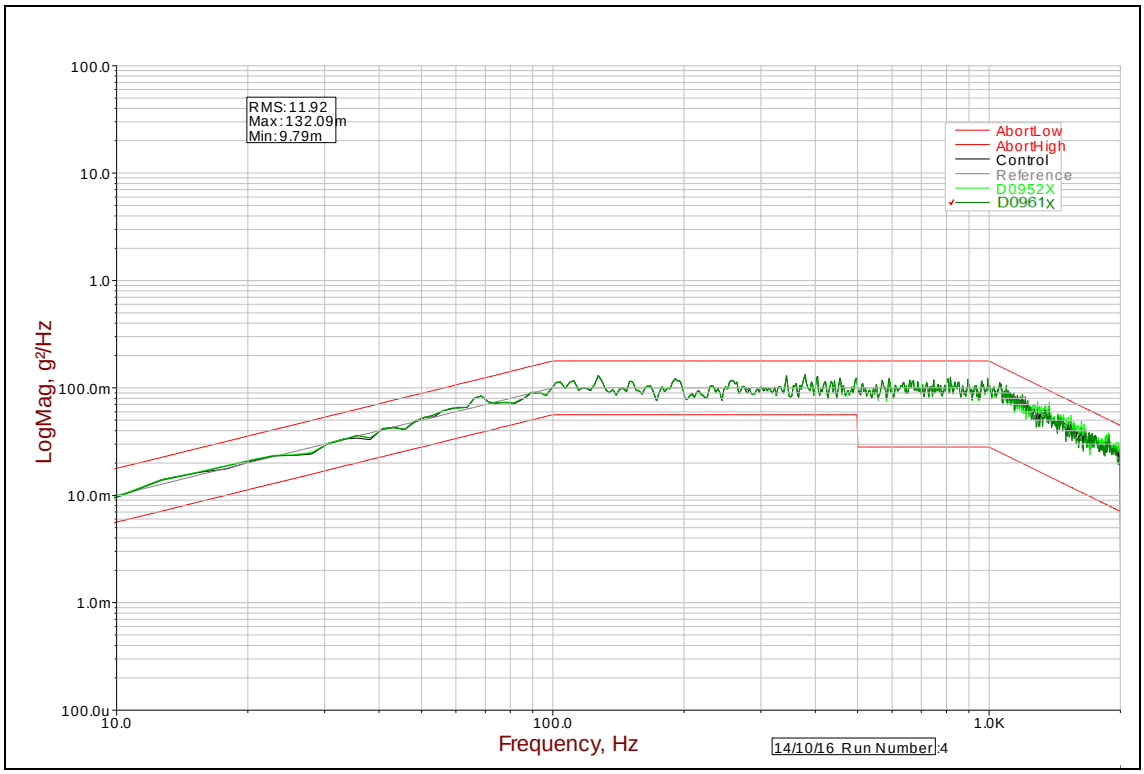

Figure 50: Random Control (X-Axis) after 30 mins [Board 2]

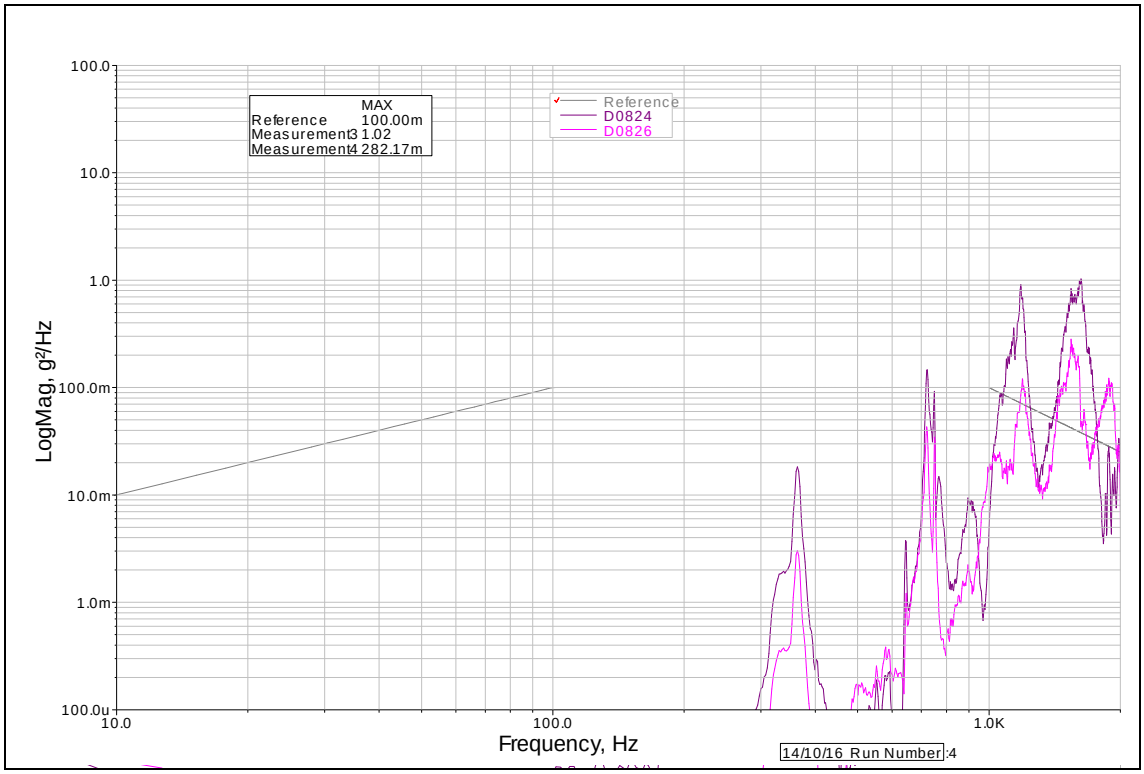

Figure 51: Response of Accelerometers D0824 and D0826 (X-Axis) after 30 mins [Board 2]

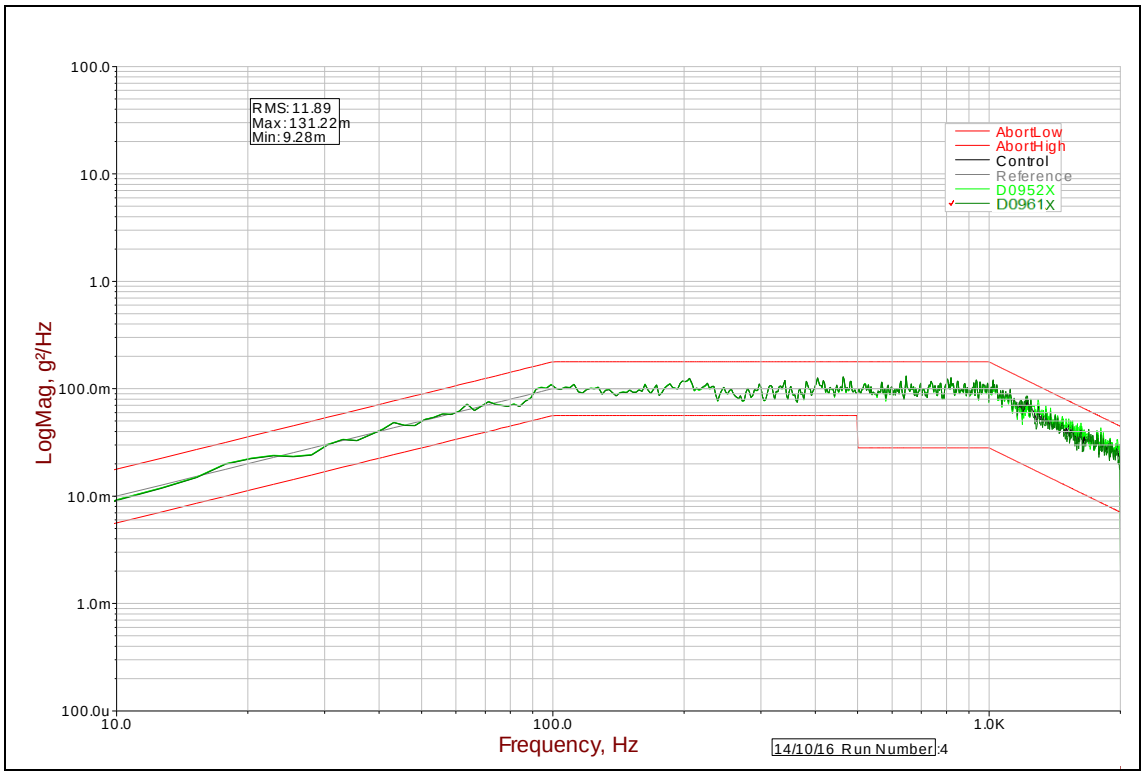

Figure 52: Random Control (X-Axis) after 60 mins [Board 2]

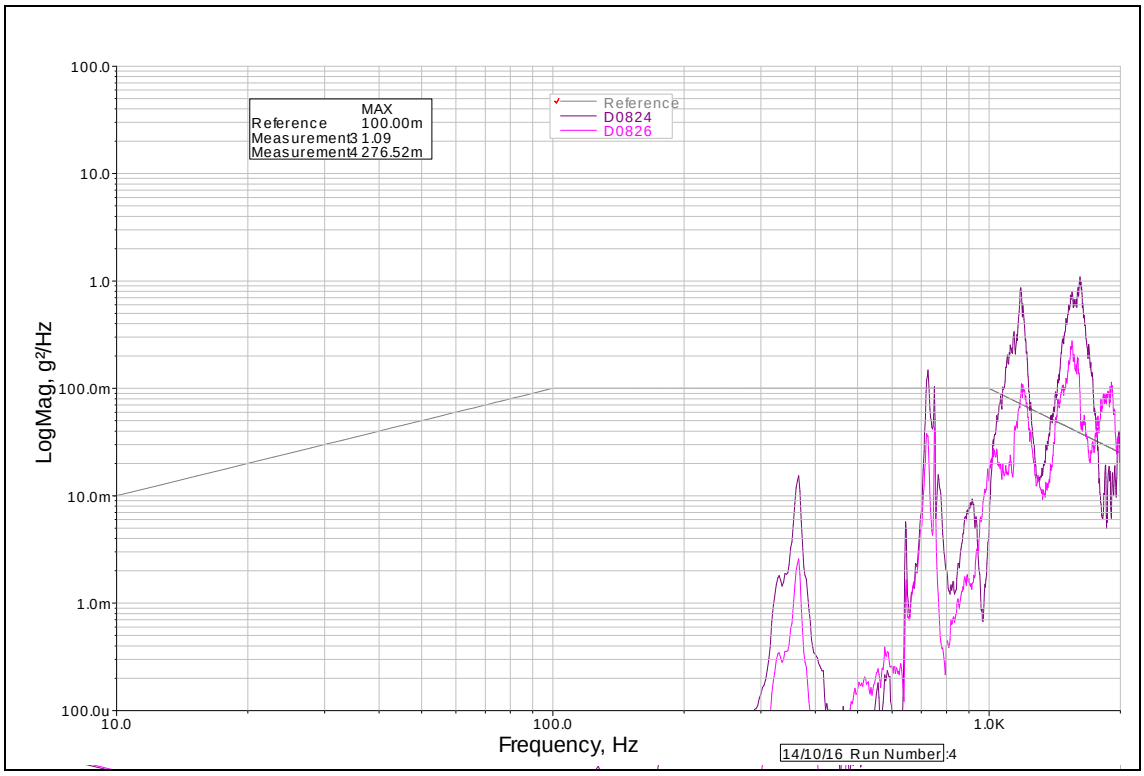

Figure 53: Response of Accelerometers D0824 and D0826 (X-Axis) after 60 mins [Board 2]

4.2.3.4 Shock

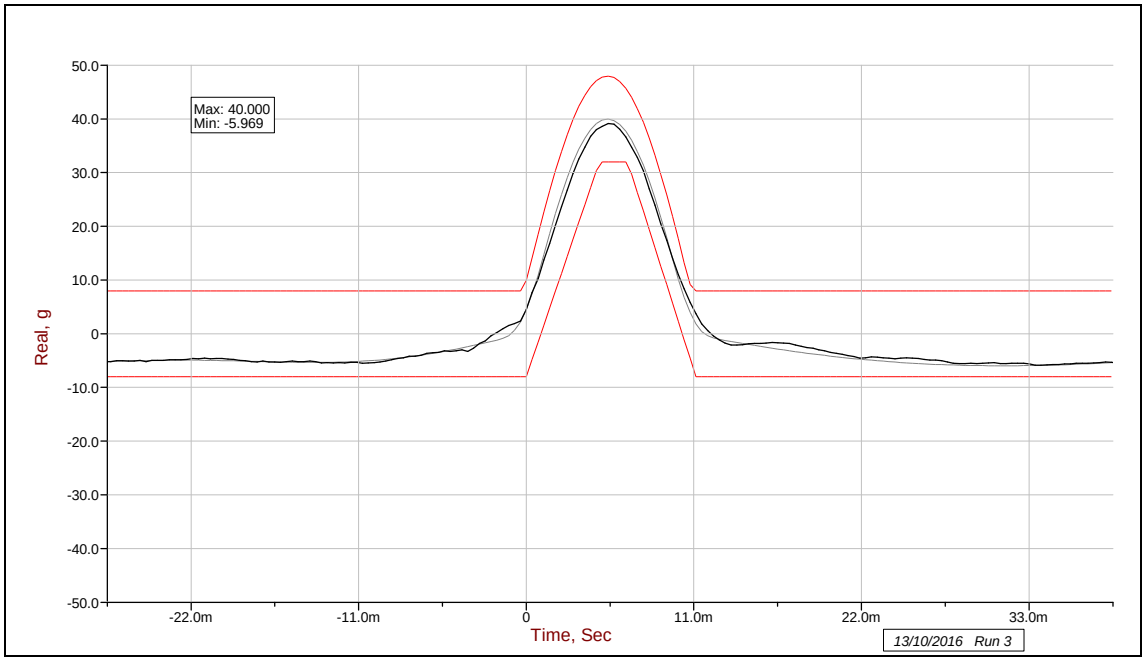

Figure 54: Typical Positive Shock Accelerometer D0974 (X- Axis) [Board 1]

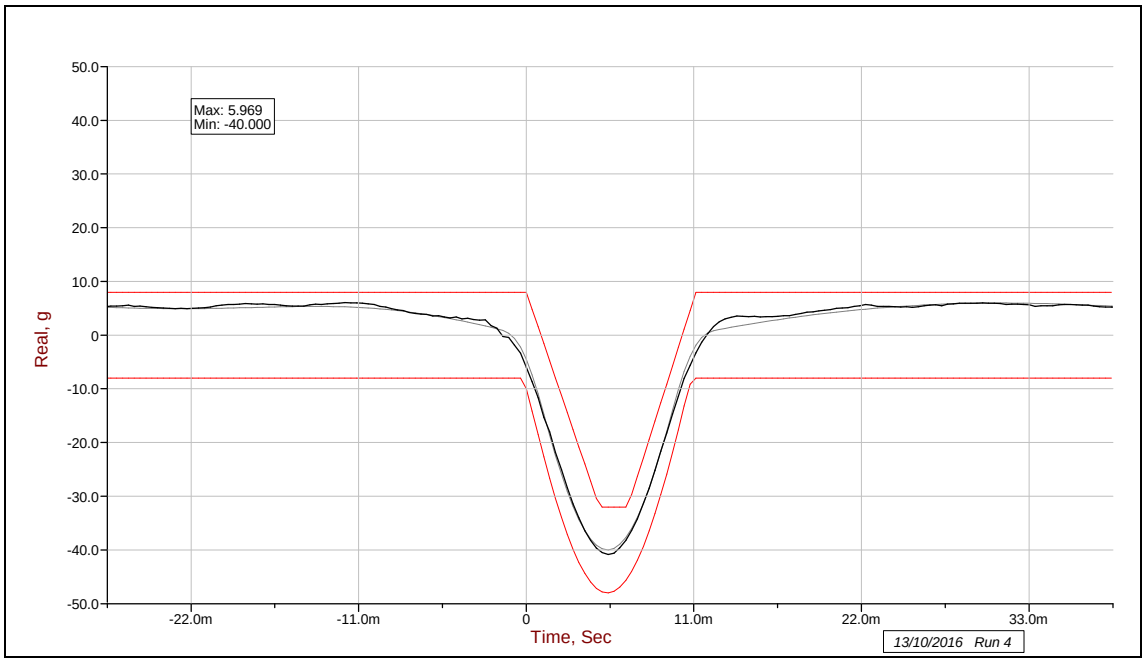

Figure 55: Typical Negative Shock Accelerometer D0974 (X-Axis) [Board 1]

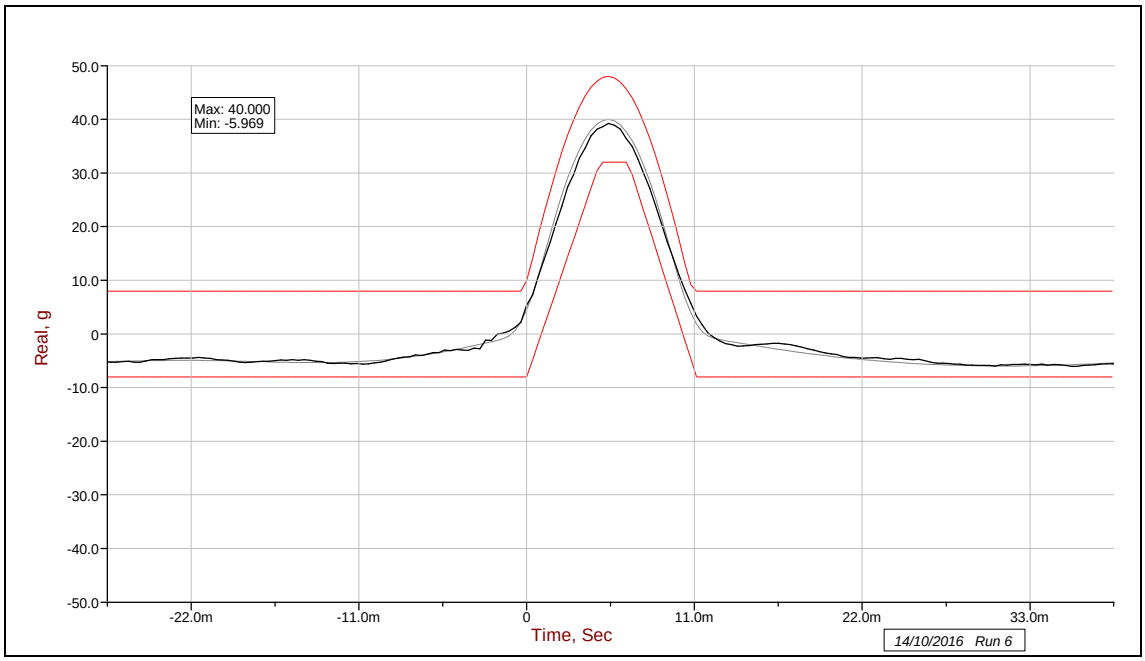

Figure 56: Typical Positive Shock Accelerometer D0974 (X-Axis) [Board 2]

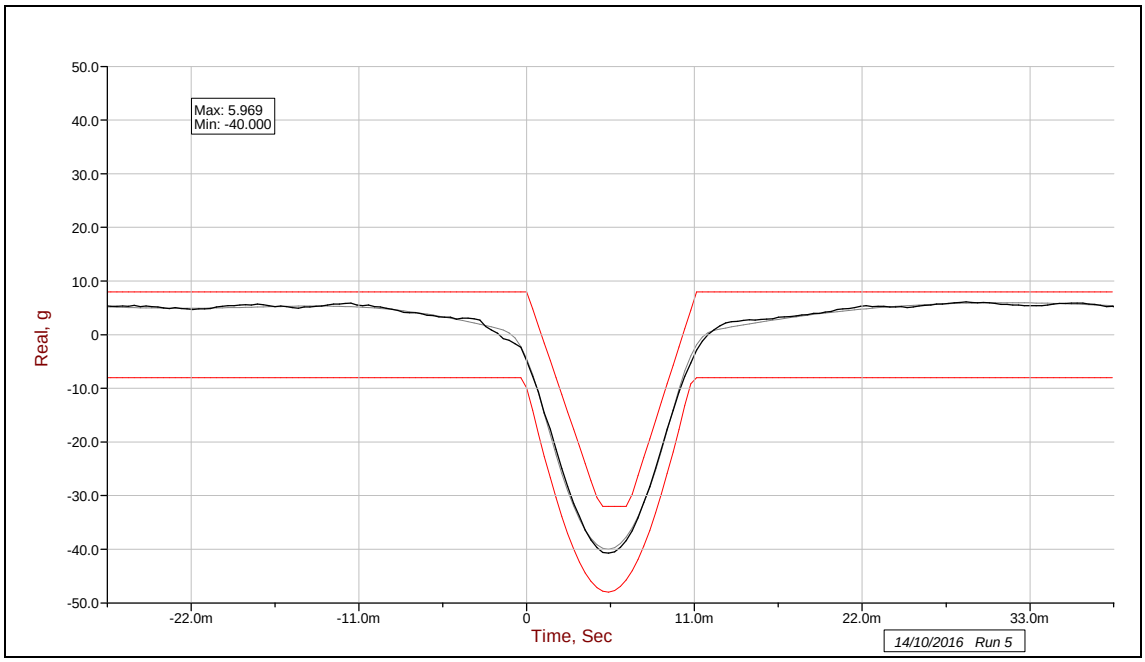

Figure 57: Typical Negative Shock Accelerometer D0974 (X-Axis) [Board 2]

4.2.4 Z-Axis

4.2.4.1 Z-Axis Fixture Cross-axis Measurements

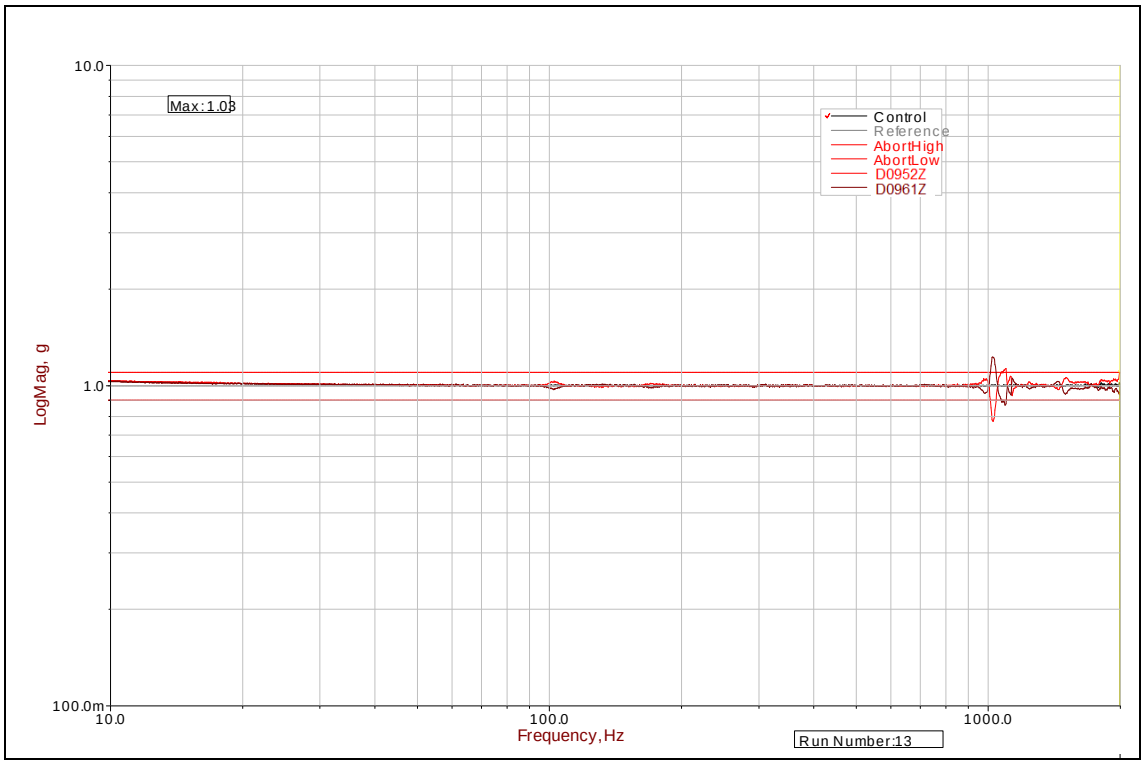

Figure 58: Control (Z-Axis) {10% abort limits}

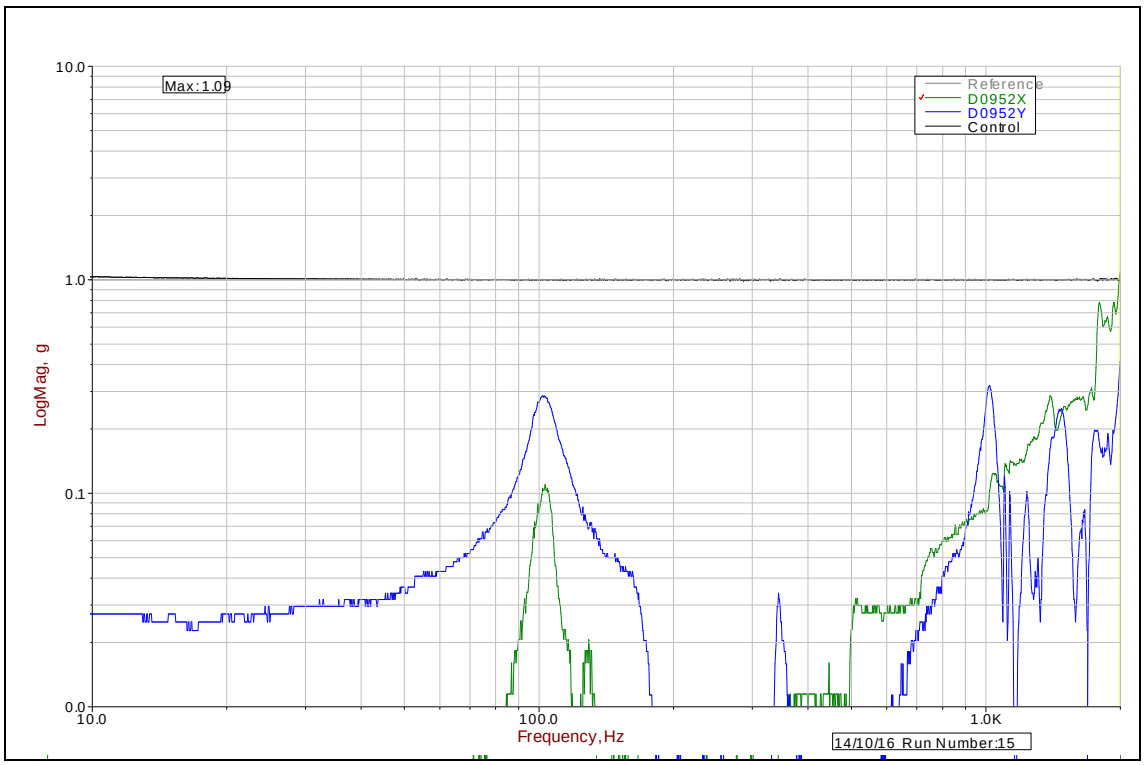

Figure 59: Cross Axis Response of D0952 (Z-Axis)

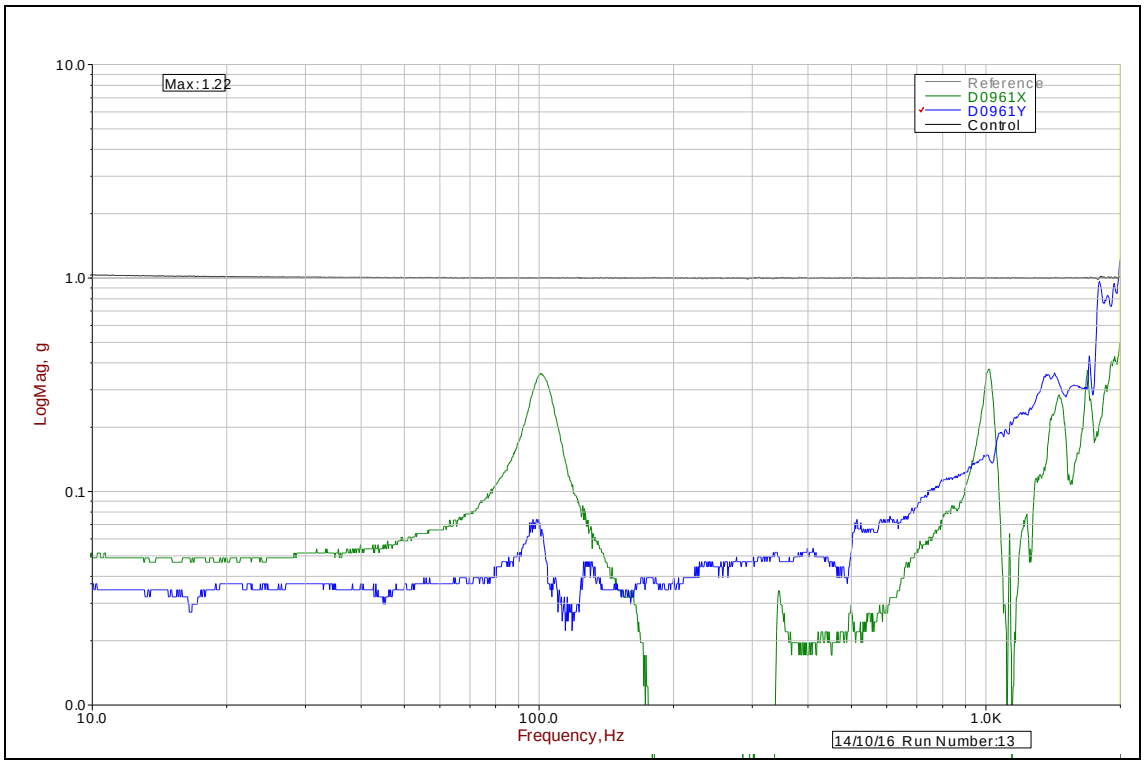

Figure 60: Cross Axis Response of D0961 (Z-Axis)

4.2.4.2 EUT Response Measurements

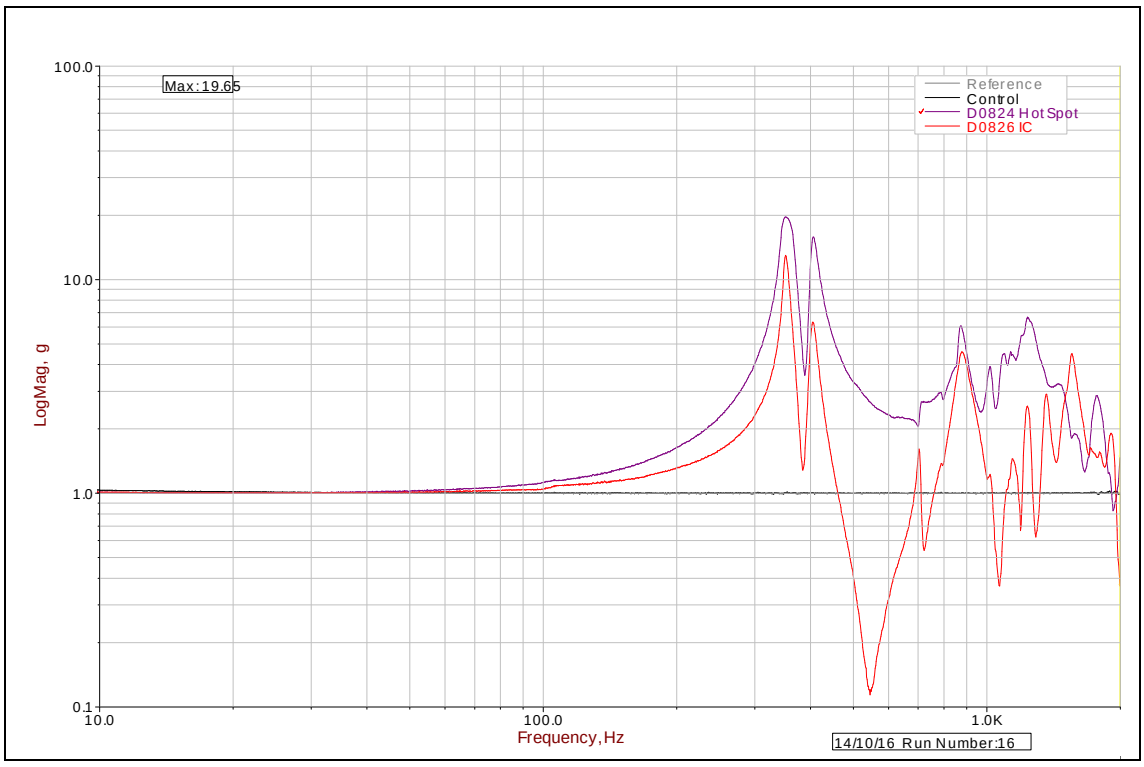

Figure 61: Response of Accelerometers D0824 and D0826 (Z-Axis)

4.2.4.3 Random Vibration

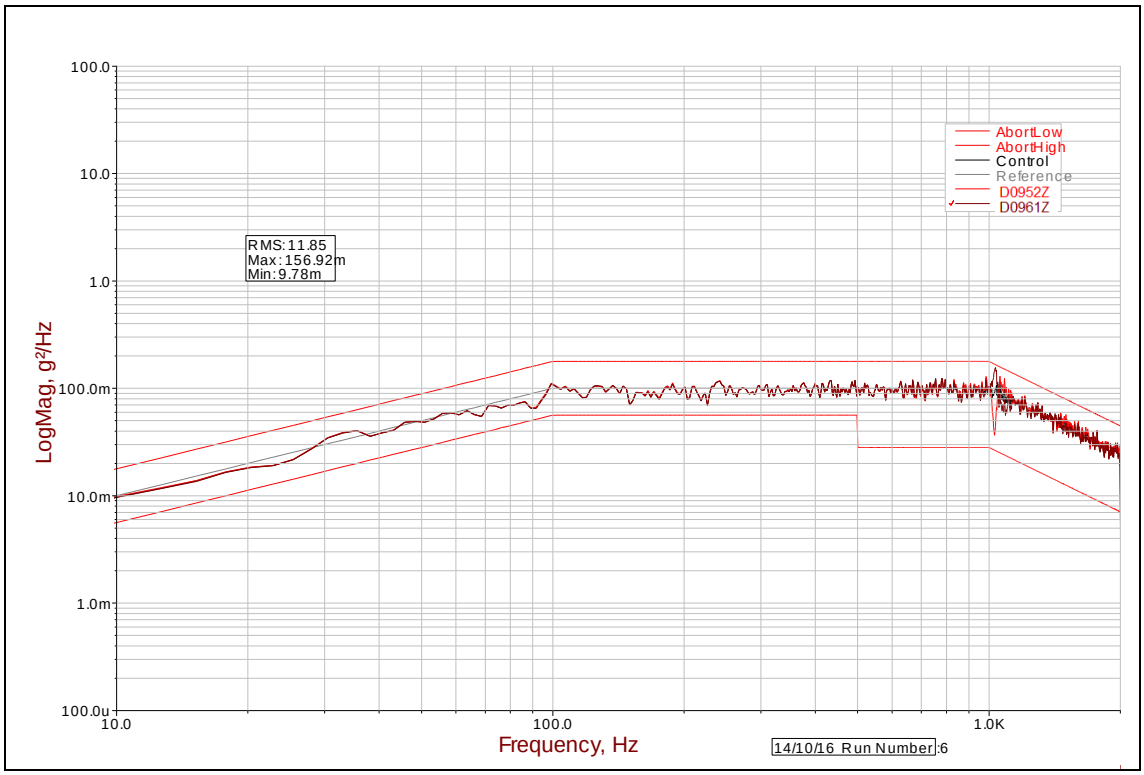

Figure 62: Random Control (Z-Axis) after 5 mins [Board 1]

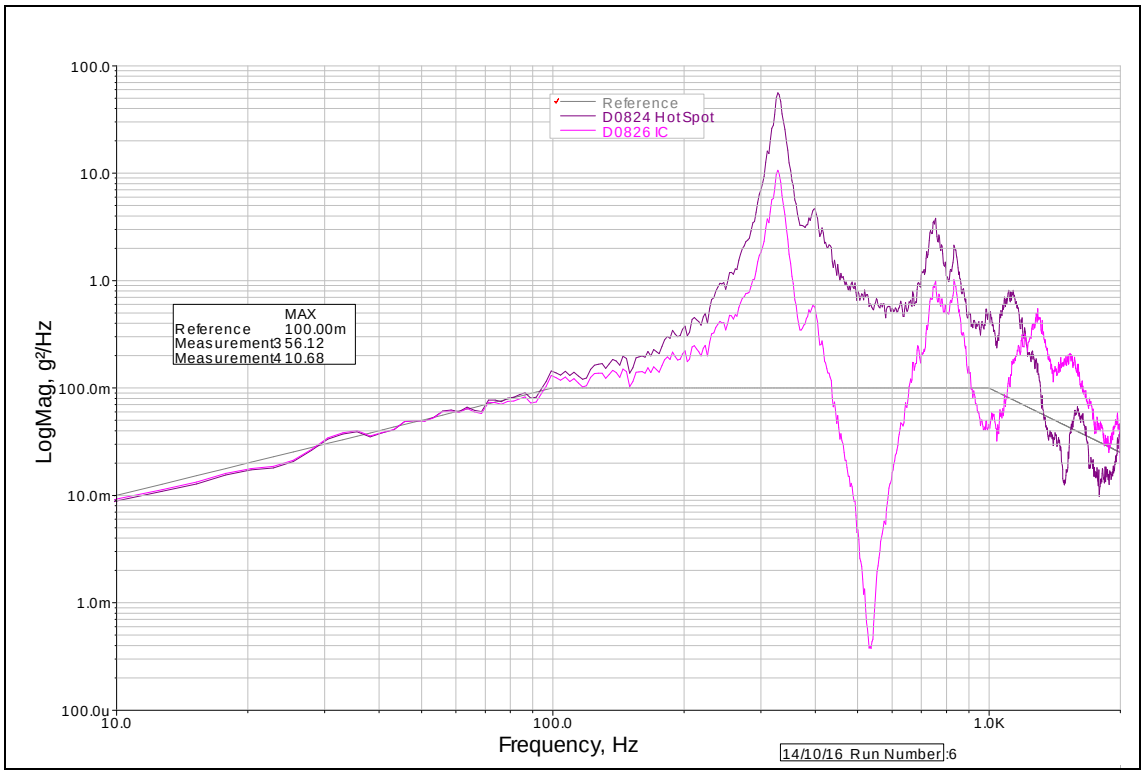

Figure 63: Response of Accelerometers D0824 and D0826 (Z-Axis) after 5 mins [Board 1]

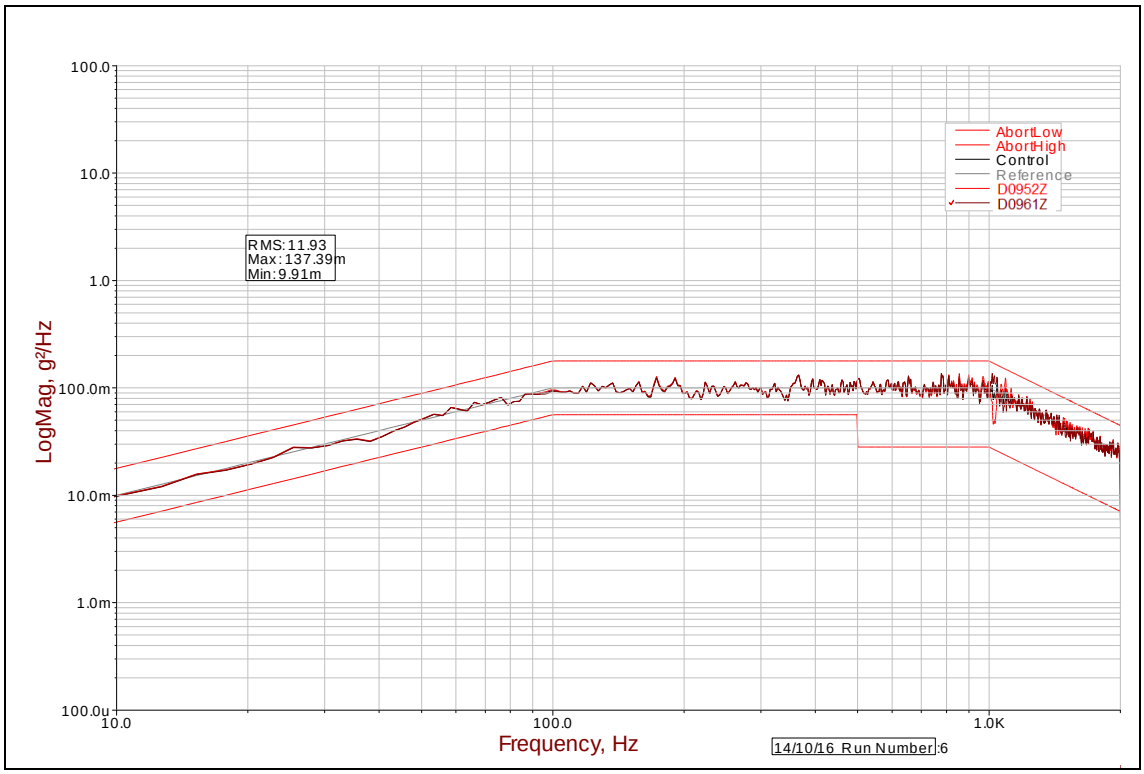

Figure 64: Random Control (Z-Axis) after 30 mins [Board 1]

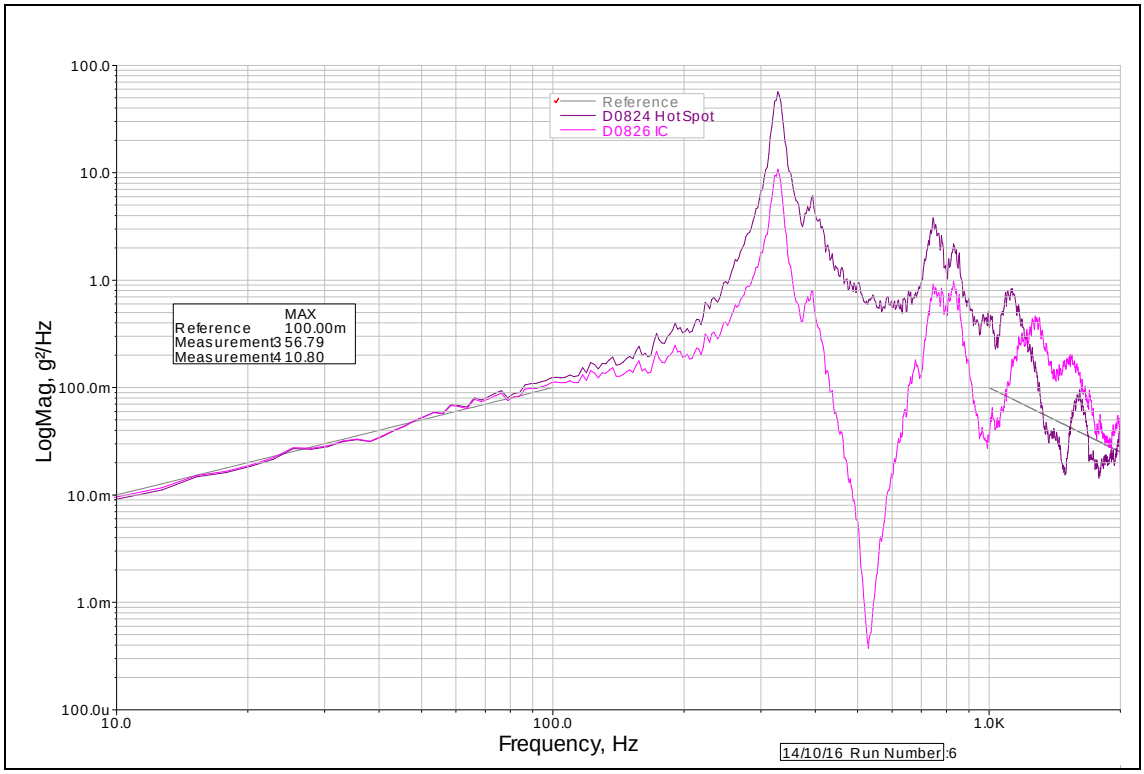

Figure 65: Response of Accelerometers D0824 and D0826 (Z-Axis) after 30 mins [Board 1]

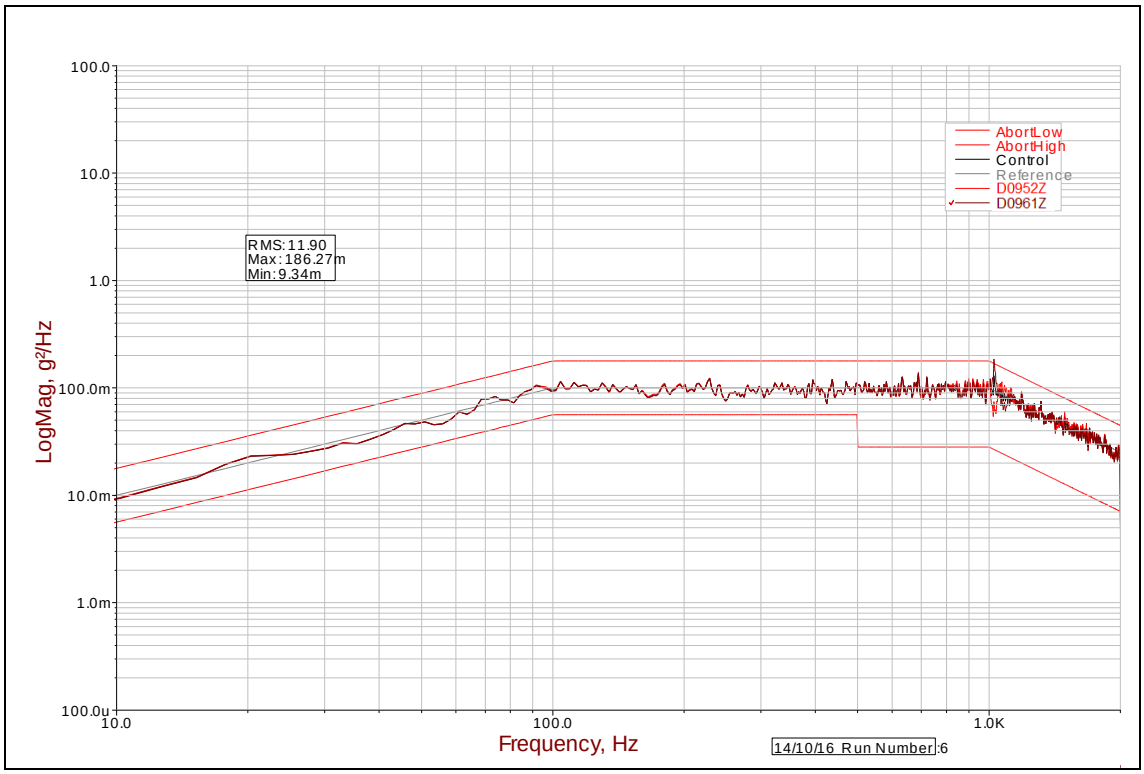

Figure 66: Random Control (Z-Axis) after 60 mins [Board 1]

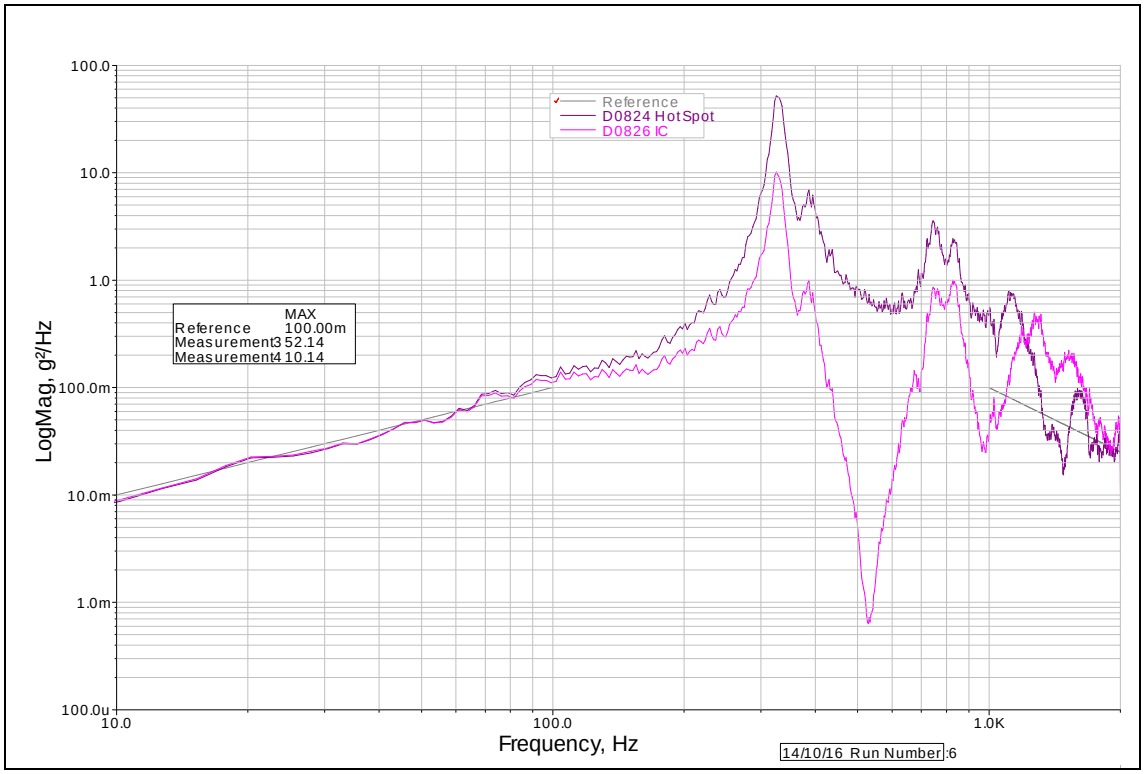

Figure 67: Response of Accelerometers D0824 and D0826 (Z-Axis) after 60 mins [Board 1]

4.2.4.4 Shock

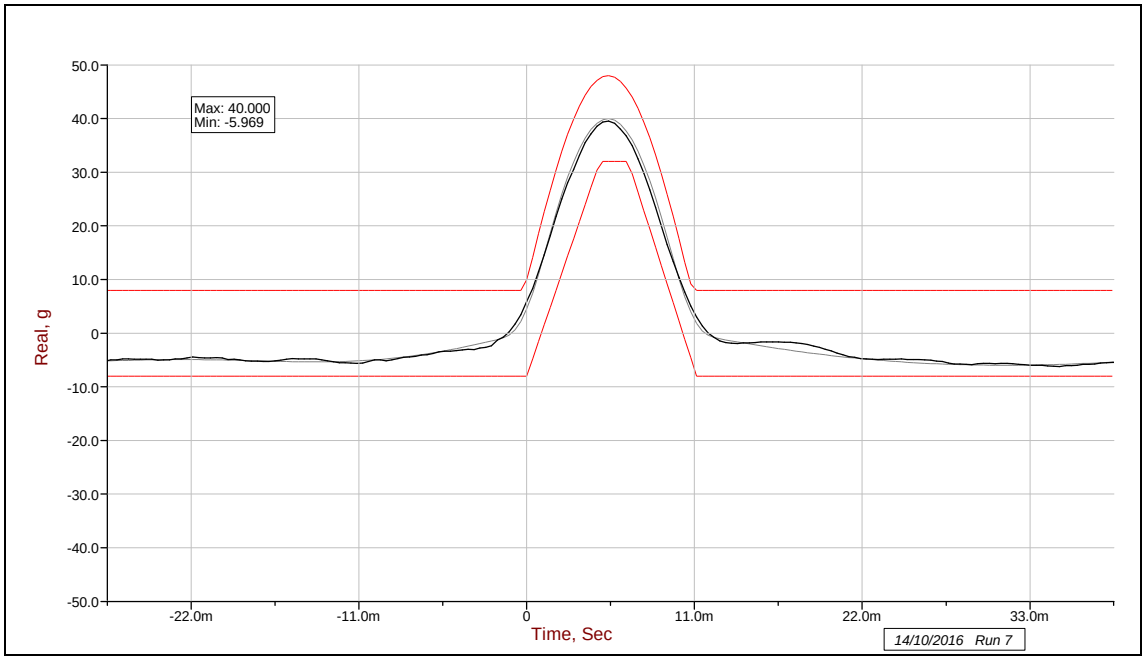

Figure 68: Typical Positive Shock Accelerometer D0974 (Z-Axis) [Board 1]

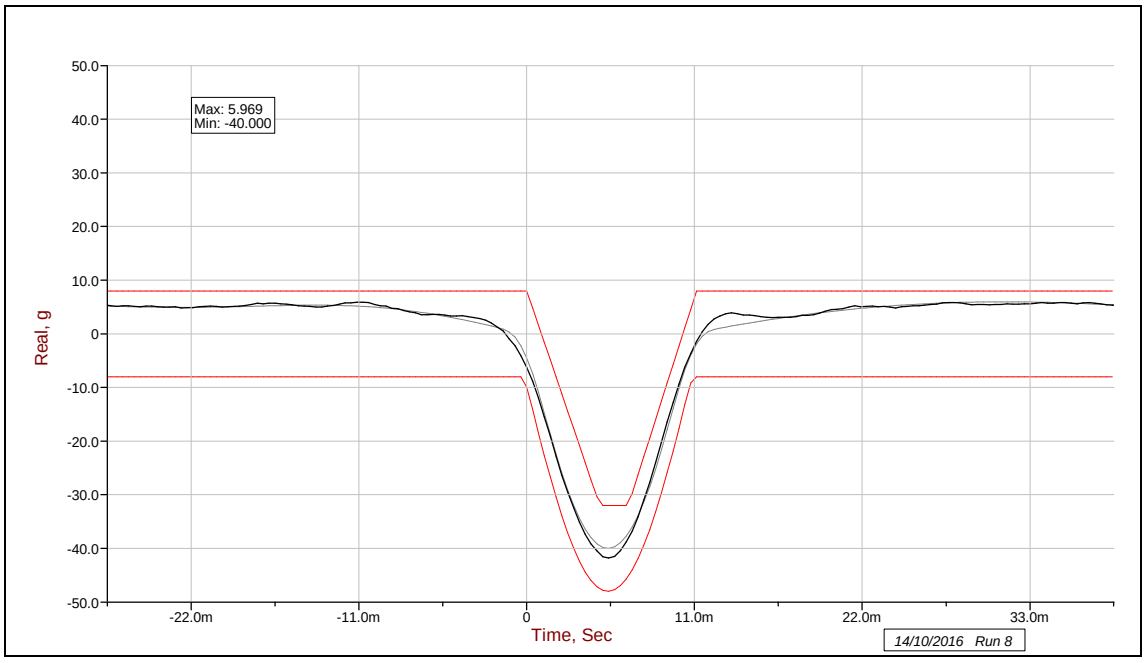

Figure 69: Typical Negative Shock Accelerometer D0974 (Z-Axis) [Board 1]

- End of Report -