DUST NETWORKS/LINEAR TECHNOLOGY

OPERATIONAL PRODUCT VIBRATION

of the LTP5900, LTP5901, and LTP5902

Report No. 112-13-0085A Rev.1

Proposal No. 28647, Rev A.

Customer Information

Dust Networks/Linear Technology
Charles Gordon
30695 Huntwood Avenue
Hayward, CA 94544

Laboratory Information

Test engineers:	Rob Quarrato and Eric Lau; *Westpak, Inc.*
Test date:	January 18, 29, and 30, 2013
Westpak™ laboratory:	San Jose, California
Visitor:	Christophe Niglio; *Dust Networks/Linear Technology*

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ilac-MRA
A2LA ACCREDITED MECHANICAL TESTING CERT #'s # 2870.01 and # 2870.02
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WESTPAK, INC.
ISO 9001:2008
ISO 14001:2004
10001175 & 10004260
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Purpose of Testing

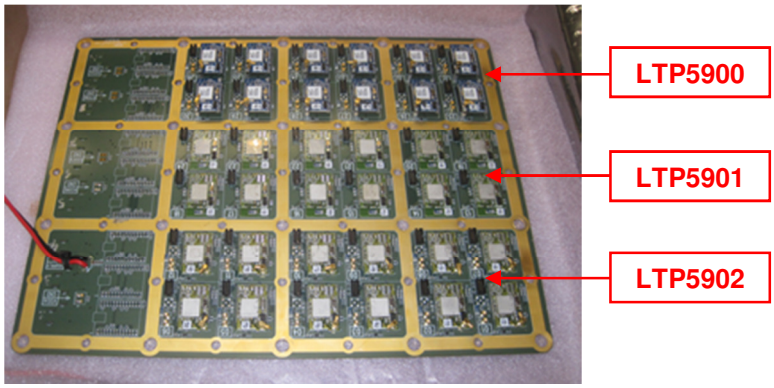
The purpose of this test was to determine resonant frequencies of each DUT and to determine what effect vibration hazards would have on the operational and mechanical performance of the Device Under Test (EUT): LTP5900, LTP5901, and LTP5902. One board containing the DUTs was subjected to the following test inputs:

Test Input	Standard Referenced
Sine Vibration	IEC 61298-3:2008

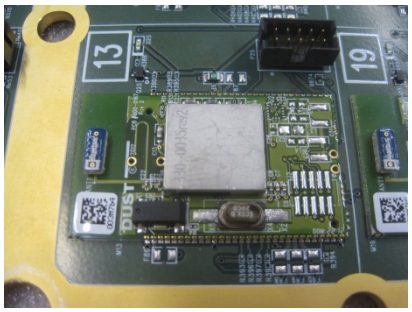
Acceptance criteria for the EUT are determined by Dust Networks/Linear Technology.

Product Information

Product:	LTP5900, LTP5901, and LTP5902
Quantity:	36 total units (12 of each DUT)
Notes:	Refer to following page for additional DUT details.




LTP5900


LTP5901


LTP5902

Product Information (*continued*)

Description	Model	Mac Address	Fixture #
DC9001A	Not a UUT	00-17-0D-00-00-3F-F5-16	n/a
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-8C	36
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-80	24
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-96	26
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-85	35
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-C3	4
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-B7	5
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-77	34
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-81	21
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-C2	3
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-C4	2
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-82	20
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-9B	33
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-7E	22
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-99	1
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-C5	6
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-B6	19
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-77	23
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-95	25
DC9001A	Not a UUT	00-17-0D-00-00-3F-FF-BD	n/a
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-B3	15
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-84	30
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-8F	8
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-AE	18
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-D1	9
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-8E	28
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-87	32
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-B5	16
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-B1	10
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-B4	13
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-7F	29
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-AF	14
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-C6	11
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-AB	31
LTP5900	Eterna 1	00-17-0D-00-00-3F-F8-AE	27
LTP5901	Eterna 2	00-17-0D-00-00-3F-F7-7D	17
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-95	7
LTP5902	Eterna 2	00-17-0D-00-00-3F-F6-C7	12

Test Equipment and Instrumentation

All testing was conducted in the package laboratory at ambient conditions.

Please refer to Appendix I for equipment and instrumentation information and calibration dates.

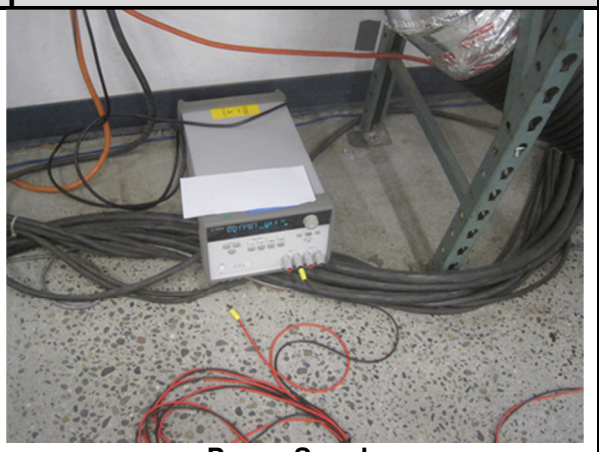
Test Descriptions

Test Setup

All DUTs remained in operational mode throughout all test inputs.

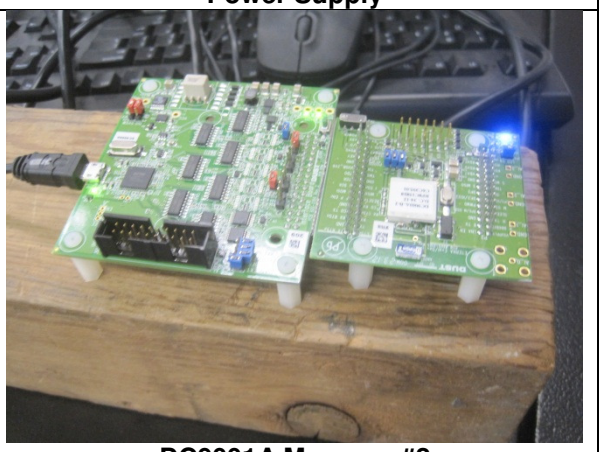
Operational Support Hardware

Laptop Running Script Logfiles



Power Supply

DC9001A Manager #1



DC9001A Manager #2

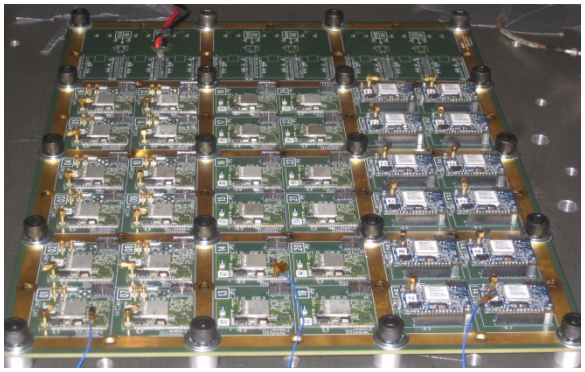
Test Descriptions *(continued)*

Operational Primary Resonance Search (Sine Sweep)

The test board was mounted onto an aluminum fixture plate and the vibration control accelerometer was secured to the fixture plate during this test input. Various studies were tested at the request of the client; refer to the table below for additional details.

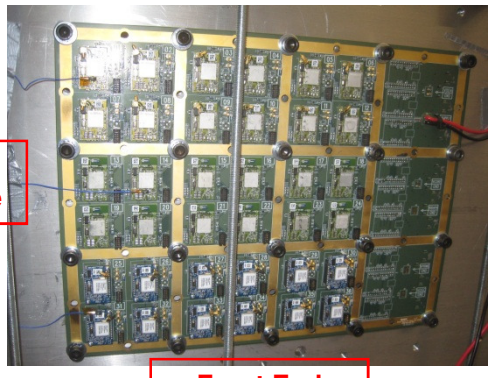
Frequency range: 10-1,000 Hz (58 Hz cross-over frequency)
Maximum displacement: 0.15 mm (0-peak)
Maximum acceleration: 2 G's (20 m/s^2)
Sweep Rate: 0.5 octave per minute

Number of Sweeps	Orientation	Run Notes
1	Base Down (Z-axis)	Response accelerometer on DUTs.
1	Base Down (Z-axis)	Response accelerometers on board in proximity to DUTs.
1	Front End Down (Y-axis)	Response accelerometer on DUTs.
1	Left Side Down (X-axis)	Response accelerometer on DUTs.



Accelerometers on DUTs

Accelerometers on Board in Proximity to DUTs



Base Down

Test Descriptions *(continued)*

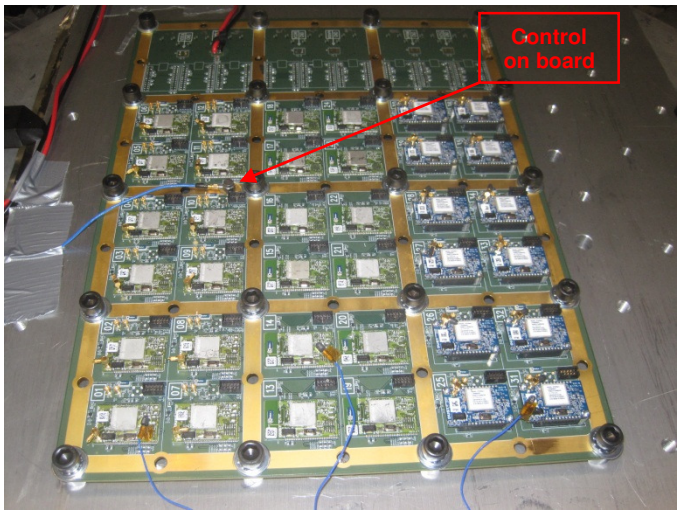
Operational Endurance Vibration

The first 9 cycles in the base down orientation was conducted using the aluminum fixture plate only, the control accelerometer was located directly on the DUT board during these initial 9 cycles. A new machined fixture was then provided for the remaining test inputs, the vibration control accelerometer was secured to this new fixture during testing.

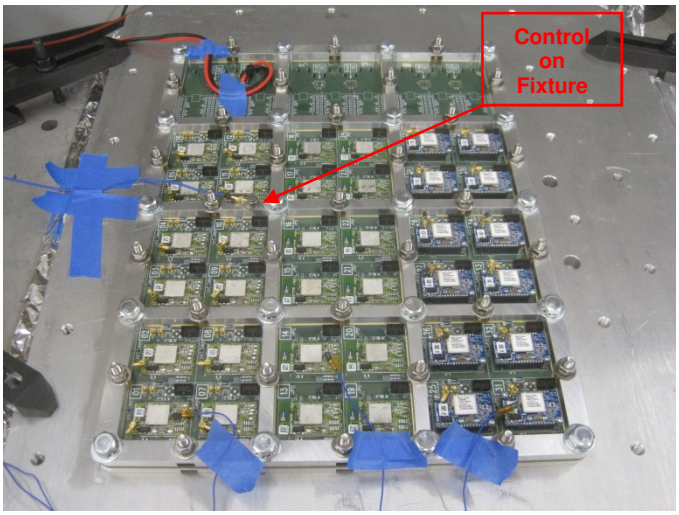
Frequency range: 10-1,000 Hz (58 Hz cross-over frequency)
Maximum displacement: 0.15 mm (0-peak)
Maximum acceleration: 2 G's (20 m/s^2)
Sweep Rate: 1.0 octave per minute

Number of Cycles	Orientation
20	Base Down (Z-axis)
20	Front End Down (Y-axis)
20	Left Side Down (X-axis)

Notes: A cycle consists of a sweep from low to high and back to low frequency.



Configuration for first 9 cycles in base down orientation.



New fixture for remaining testing.

Test Descriptions *(continued)*

Operational Final Resonance Search (Sine Sweep)

The control accelerometer was secured to the new fixture and response accelerometers on the DUTs throughout this test input.

Frequency range: 10-1,000 Hz (58 Hz cross-over frequency)
Maximum displacement: 0.15 mm (0-peak)
Maximum acceleration: 2 G's (20 m/s^2)
Sweep Rate: 0.5 octave per minute

Number of Sweeps	Orientation
1	Base Down (Z-axis)
1	Front End Down (Y-axis)
1	Left Side Down (X-axis)

Results and Observations

Test Input	Observations	Appendix
Initial Resonance Search	No unusual external physical damage was observed to the DUTs upon completion of this test input. All DUTs remained operational throughout this test input. With the control accelerometer located on the fixture plate and the response accelerometers on the DUTs: Resonant frequencies of the monitored DUTs ranged from 643 to 791 Hz with amplification levels up to 35 times the input at resonance. With the control accelerometer located on the fixture plate and the response accelerometers moved onto the main board in proximity of the DUTs: Resonant frequencies ranged from 637 to 756 Hz with amplification levels up to 79 times the input at resonance. Refer to Table 1 on the following page for all data collected during testing.	II
Endurance Vibration	No unusual external physical damage was observed to the DUTs upon completion of this test input. All DUTs remained operational throughout this test input. During the first 9 cycles of endurance vibration in the base down orientation (control accelerometer moved to main board and response accelerometers on DUTs): Resonant frequencies ranged from 637 to 756 Hz with amplification levels up to 49 times the input at resonance. A new machined fixture was provided (control accelerometer moved to new fixture and response accelerometers on DUTs): Resonant frequencies ranged from 339 to 679 Hz with amplification levels up to 5 times the input at resonance. Refer to Table 2 on the following pages for all data collected during testing.	III
Final Resonance Search	No unusual external physical damage was observed to the DUTs upon completion of this test input. All DUTs remained operational throughout this test input. Resonant frequencies ranged from 965 to 973 Hz with amplification levels up to 24 times the input at resonance.	IV

Results and Observations *(continued)*

Table 1
Initial Resonance Search Data
10 - 1,000 Hz at 0.5 octave per minute

Control Accelerometer on Fixture Plate Response Accelerometers on DUTs			
Test Orientation	**Monitored DUT**	**Resonant Frequency (Hz)**	**Amplification**
Base Down	LTP5900	643	35
	LTP5901	716	6
	LTP5902	710	18
Front End Down	LTP5900	649	9
	LTP5901	791	4
	LTP5902	791	4
Left Side Down	LTP5900	691	14
	LTP5901	691	12
	LTP5902	691	12
Control Accelerometer on Fixture Plate Response Accelerometers on Main Board in Proximity to DUTs			
Base Down	LTP5900	637	79
	LTP5901	756	51
	LTP5902	716	67

Results and Observations *(continued)*

Table 2
Endurance Vibration Data
10 - 1,000 Hz at 1.0 octave per minute

Test Orientation	Monitored DUT	Resonant Frequency (Hz)	Amp	Secondary Resonance (Hz)	Amp
Control Accelerometer on Board Response Accelerometers on DUTs					
Base Down	LTP5900	637	49	922	5
	LTP5901	743	21	n/a	n/a
	LTP5902	756	8	914	5
Control Accelerometer on New Fixture Response Accelerometers on DUTs					
Base Down	LTP5900	679	5	n/a	n/a
	LTP5901	673	3	n/a	n/a
	LTP5902	667	2	828	2
Front End Down	LTP5900	No resonances observed amplification levels below 2 times the input.			
	LTP5901	339	2	n/a	n/a
	LTP5902	339	2	n/a	n/a
Left Side Down	LTP5900	No resonances observed amplification levels below 2 times the input.			
	LTP5901				
	LTP5902				

Results and Observations *(continued)*

Table 3
Final Resonance Search Data
10 - 1,000 Hz at 0.5 octave per minute

Control Accelerometer on New Fixture Response Accelerometers on DUTs			
Test Orientation	**Monitored DUT**	**Resonant Frequency (Hz)**	**Amplification**
Base Down	LTP5900	970	24
	LTP5901	973	11
	LTP5902	965	8
Front End Down	LTP5900	No resonances observed; amplification levels below 2 times the input.	
	LTP5901		
	LTP5902		
Left Side Down	LTP5900		
	LTP5901		
	LTP5902		

Conclusions

A main test board containing the LTP5900, LTP5901, and LTP5902 DUTs was subjected to vibration testing as specified by Dust Networks/Linear Technology referencing IEC 61298-3:2008.

No unusual external physical damage was observed to the DUTs upon completion of this test input. All DUTs remained operational throughout testing.

Upon test completion, the test board was returned to **Dust Networks/Linear Technology** for further evaluation. The results of any such evaluations are unavailable to Westpak™ at this time.

There were no anomalies throughout the conduct of this test that would detract from the ability of **Dust Networks/Linear Technology** from making reasonable judgments concerning the testing as described herein.

WESTPAK™ is pleased to present this report to **Dust Networks/Linear Technology** covering the Operational Product Vibration of the LTP5900, LTP5901, and LTP5902. The equipment used to conduct this testing has been recently calibrated and is known to be in good operating condition. In addition the test operator uses good laboratory practice at all times. Therefore, the data is considered accurate and reliable. However, there is no warranty expressed or implied with the submission of this report, and **Dust Networks/Linear Technology** assumes all liability for use of the data contained herein.

Respectfully submitted,
WESTPAK, INCORPORATED

Eric Lau
Senior Test Engineer
February 4, 2013

Reviewed By

Kevin Fernandez
Senior Test Engineer
February 4, 2013

Revision History:
Rev 1 (March 11, 2013)

- Changed RF Card #1 and RF Card #2 to DC9001A Manager #1 and DC9001A Manager #2 in Test Setup pictures on page 5.

APPENDIX I

EQUIPMENT and INSTRUMENTATION

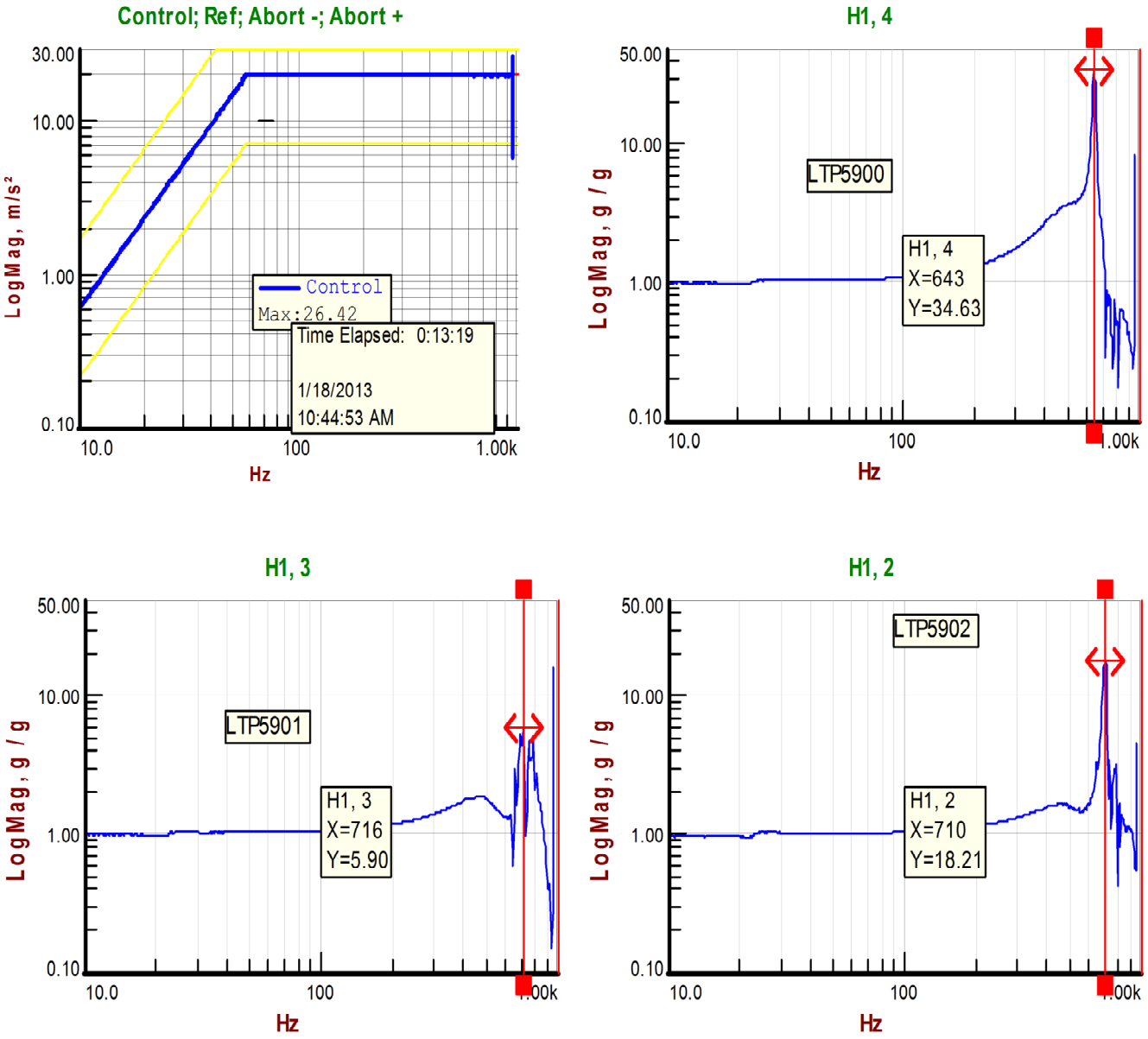
Instrumentation & Equipment	Westpak™ No.	Model No.	Last Calibration Date
PCB Accelerometer	5	353B15	2/9/2012
PCB Miniature Accelerometer	1090	352C23	9/7/2012
PCB Miniature Accelerometer	1092	352C23	9/7/2012
PCB Miniature Accelerometer	1091	352C23	9/7/2012
Unholtz-Dickie Electro-Dynamic Vibration Table	368	RTS-5	Not Required
Data Physics Vibration Controller	563	Abacus	12/3/2012
PCB Accelerometer	72	353B33	2/22/2012
Note: All calibration conducted annually on instrumentation only			

APPENDIX II

INITIAL RESONANCE SEARCH CONTROL DATA

Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Initial Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Base Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

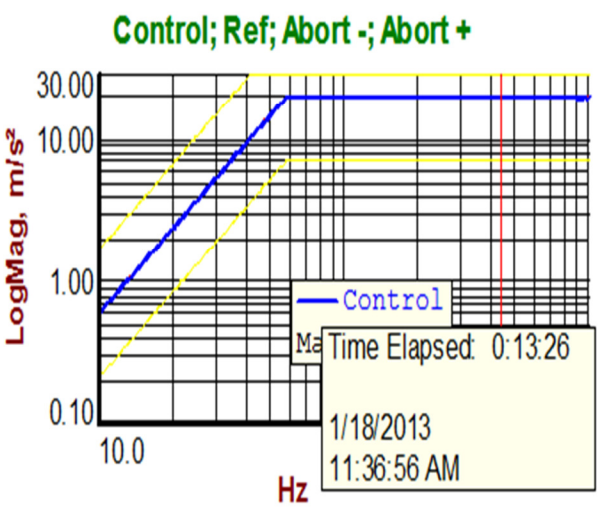
Note: (control accelerometer on fixture plate, resonance accelerometers on DUTs)

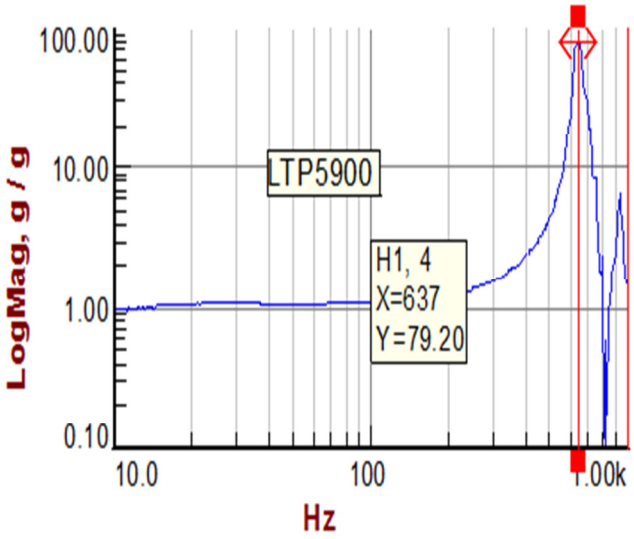


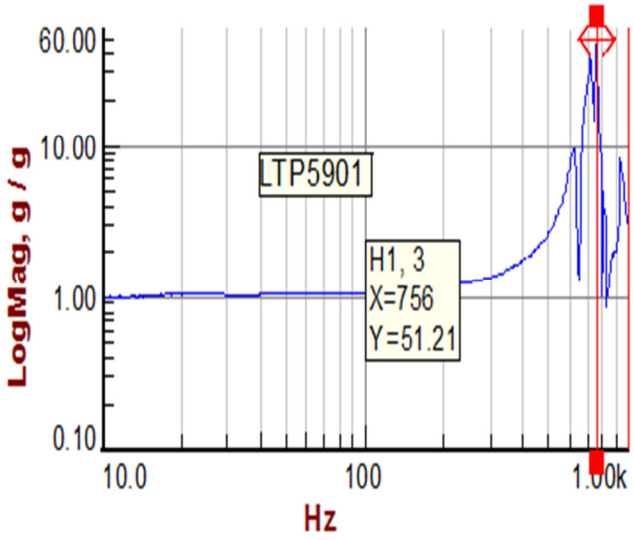
Note: Client is aware that this sweep aborted around 956 Hz due to fixture resonance on the table.

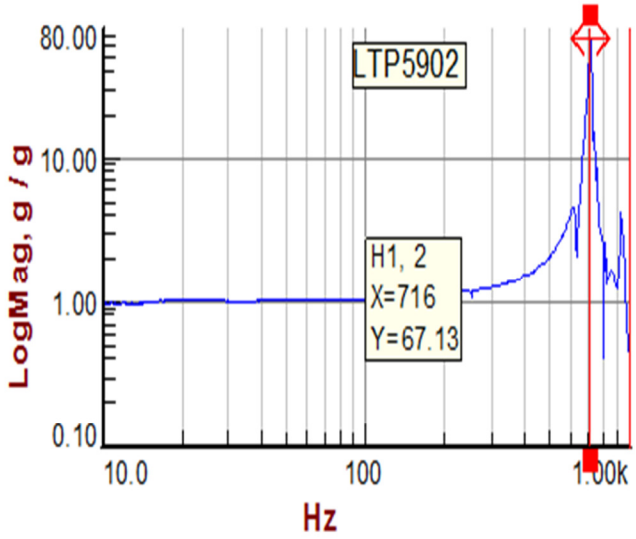
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Initial Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Base Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on fixture plate, resonance accelerometers on main board in proximity to DUTs)



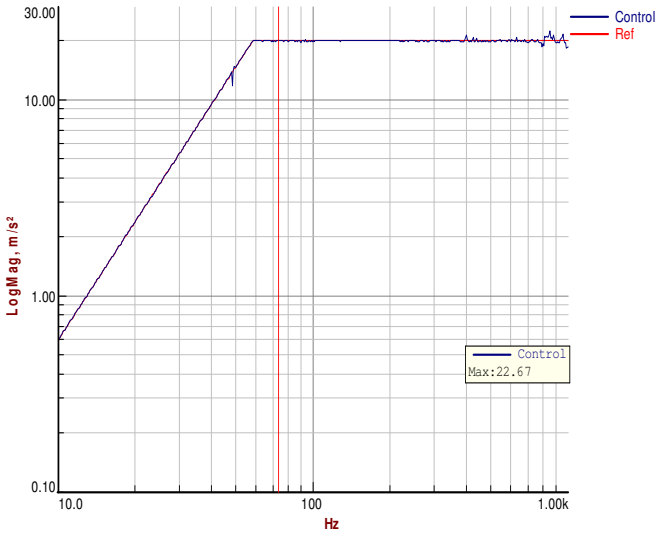


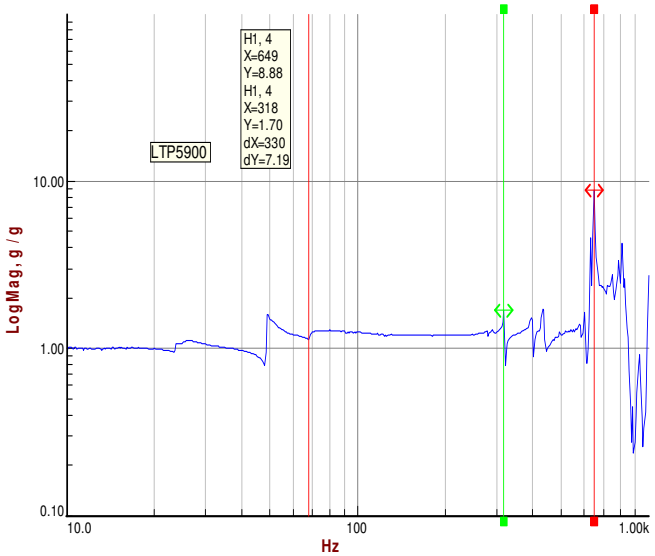


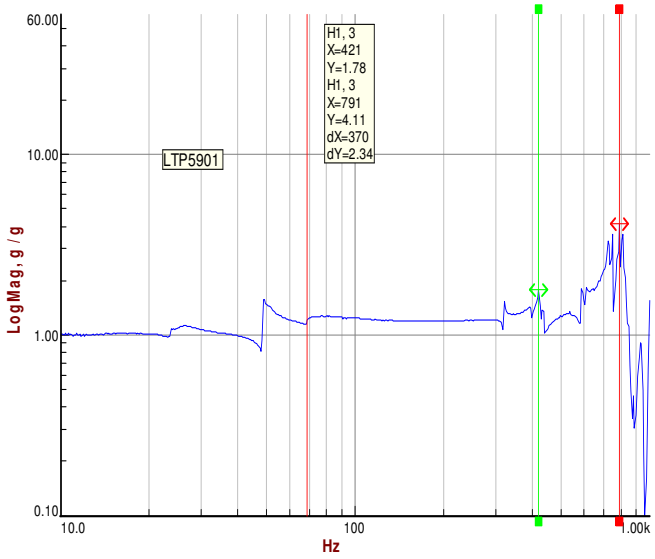


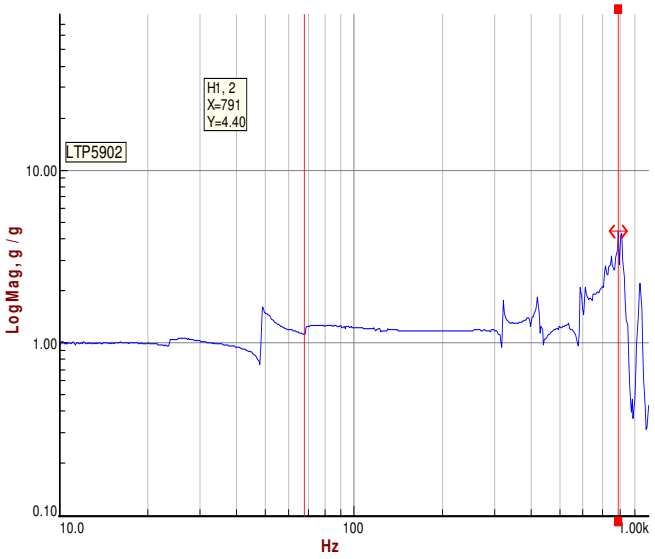
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Initial Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Front End Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on fixture plate, resonance accelerometers on DUTs)



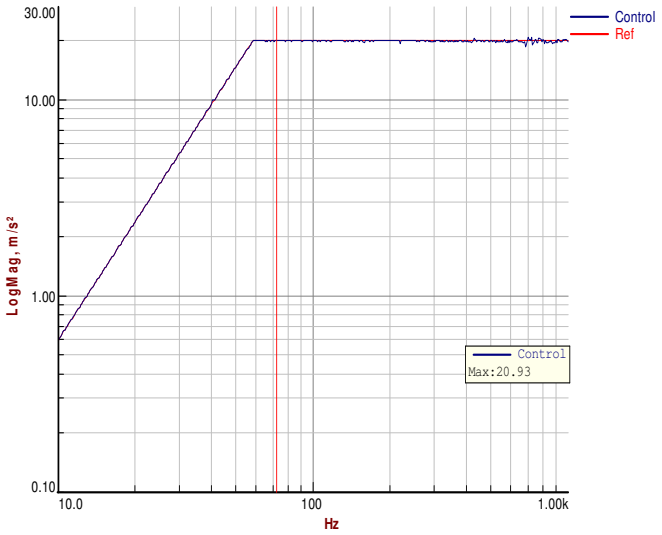


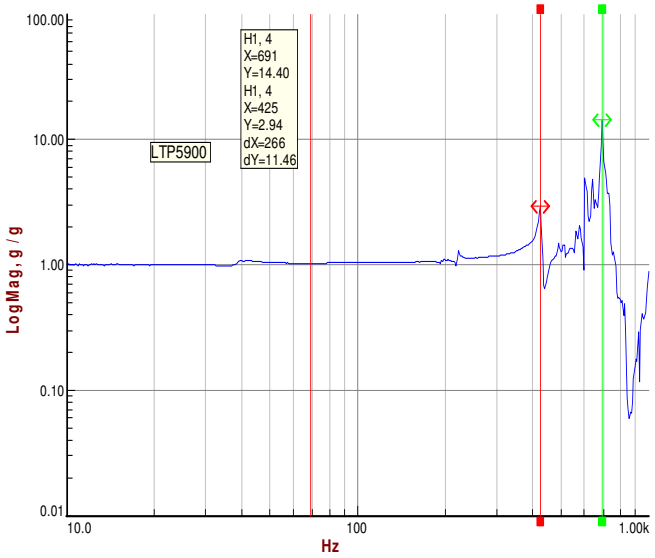


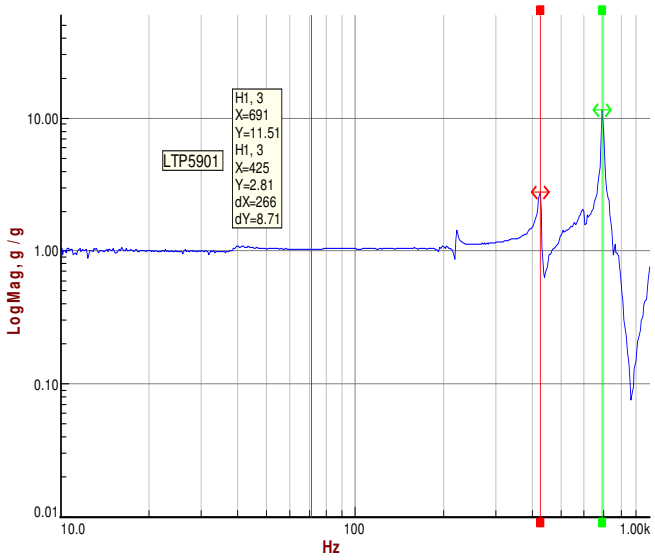


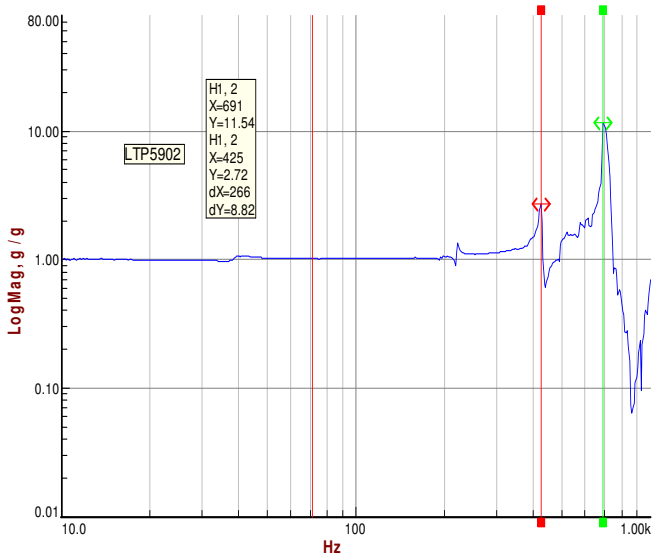
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Initial Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Left Side Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on fixture plate, resonance accelerometers on DUTs)







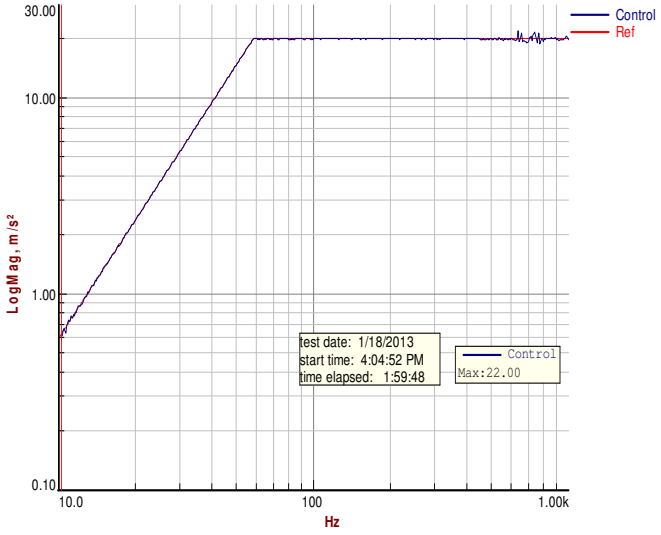


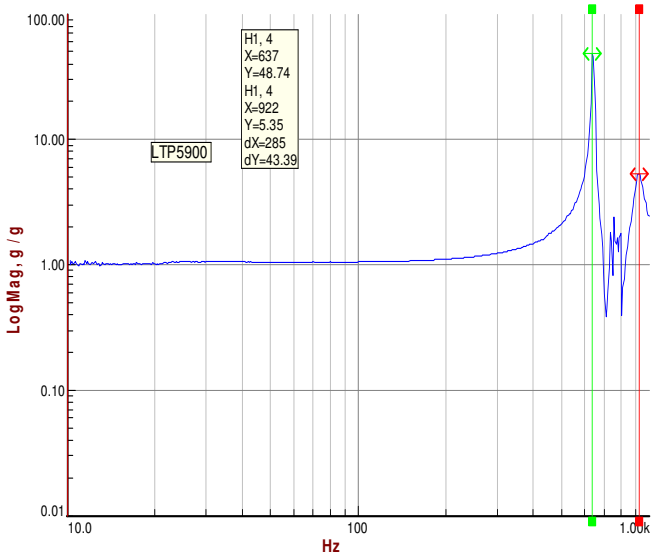
APPENDIX III

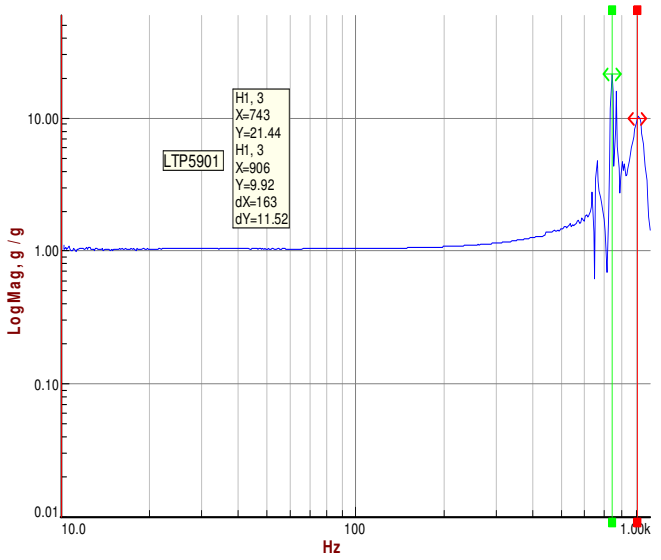
ENDURANCE SINE VIBRATION CONTROL DATA

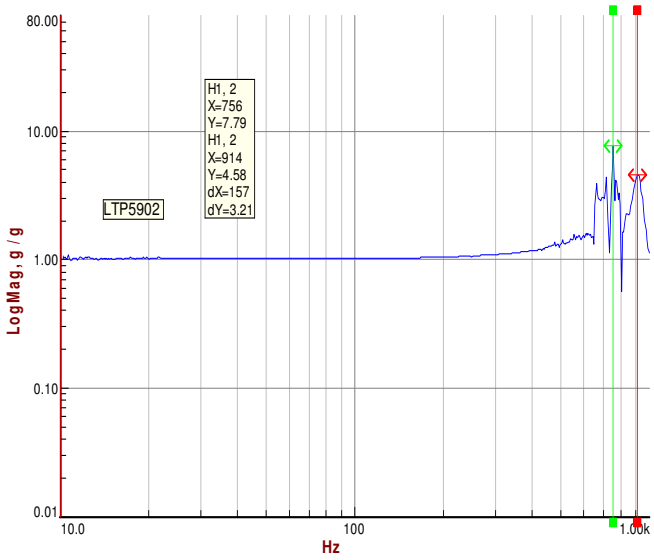
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Endurance Vibration, Sine Sweep from 10 – 1000 Hz at 1.0 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Base Down; 9 cycles
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on main board, resonance accelerometers on DUTs)



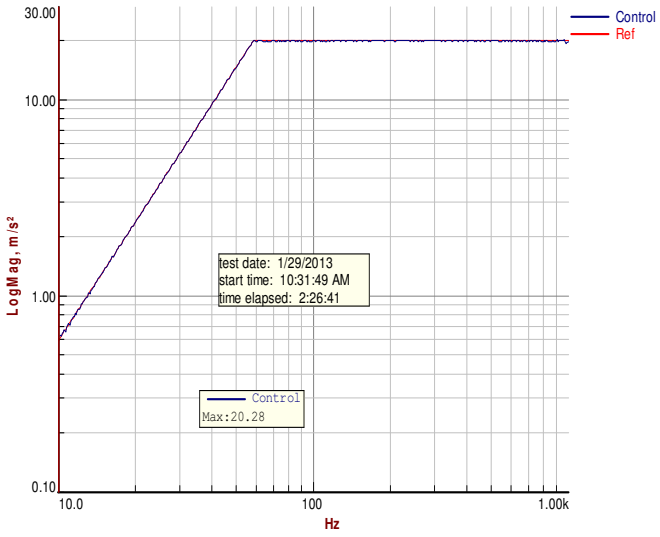


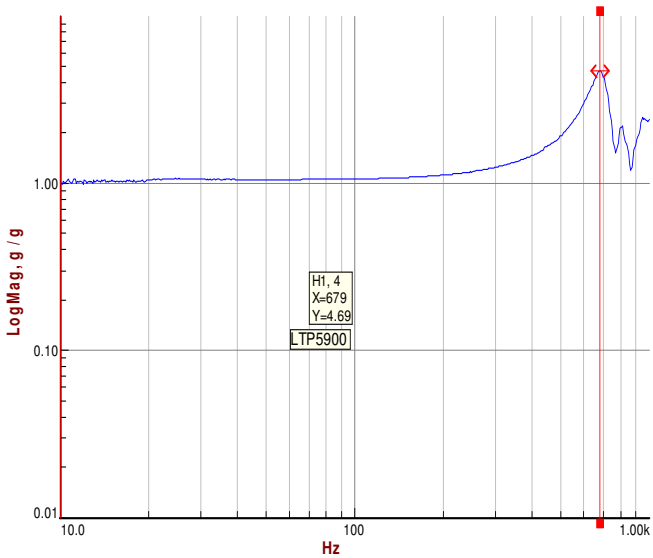


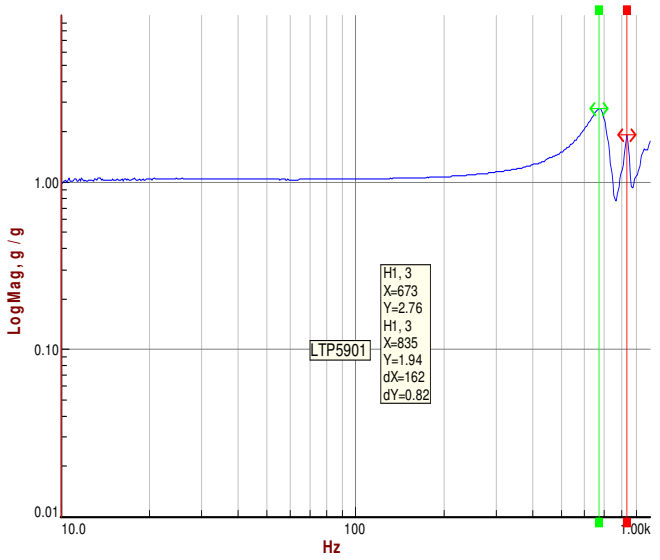


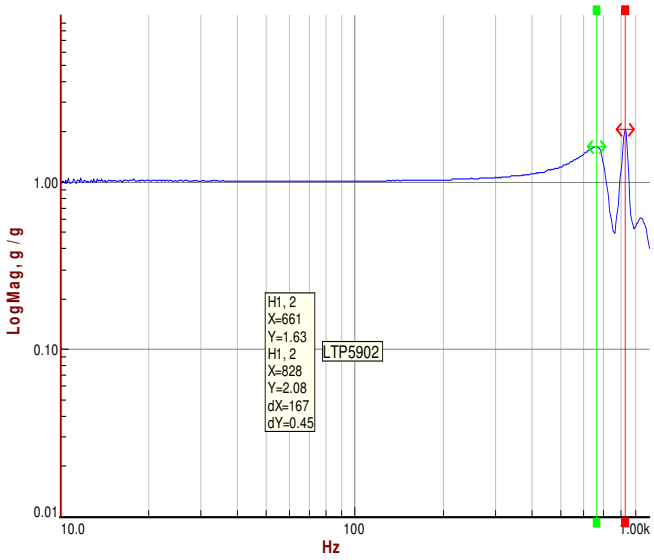
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Endurance Vibration, Sine Sweep from 10 – 1000 Hz at 1.0 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Base Down; 11 cycles
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on new fixture, resonance accelerometers on DUTs)



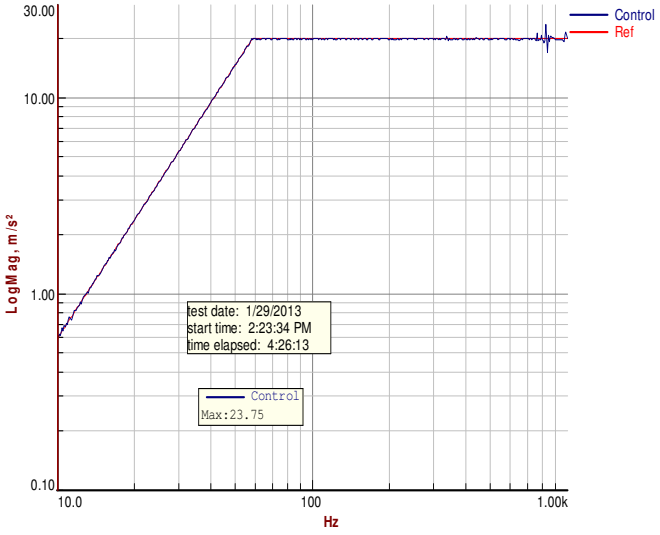


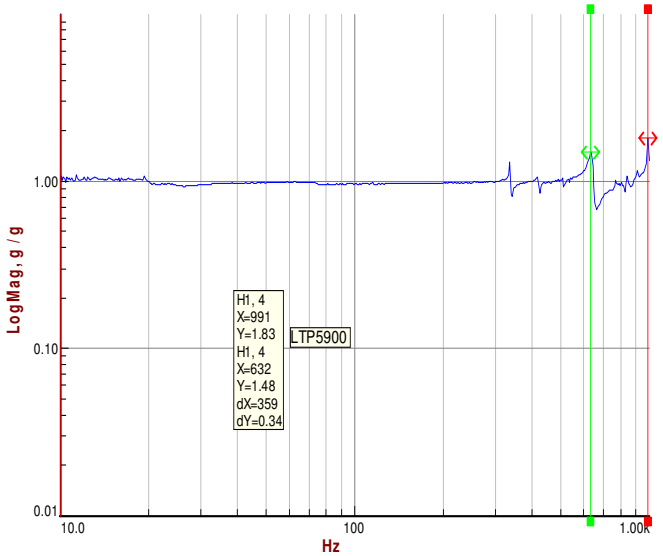


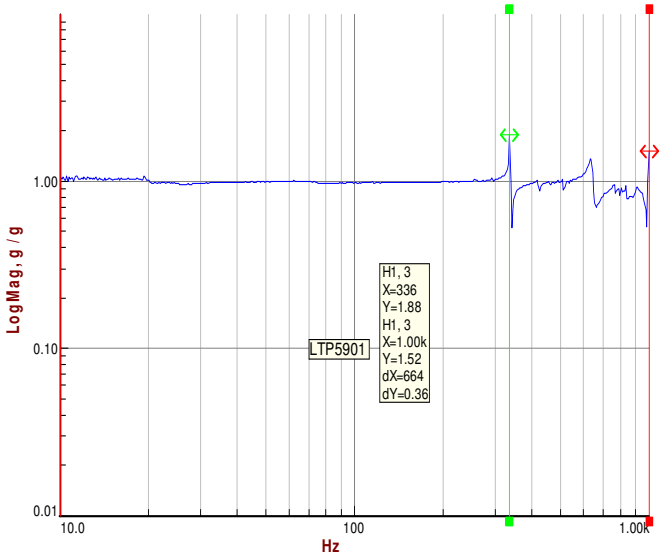


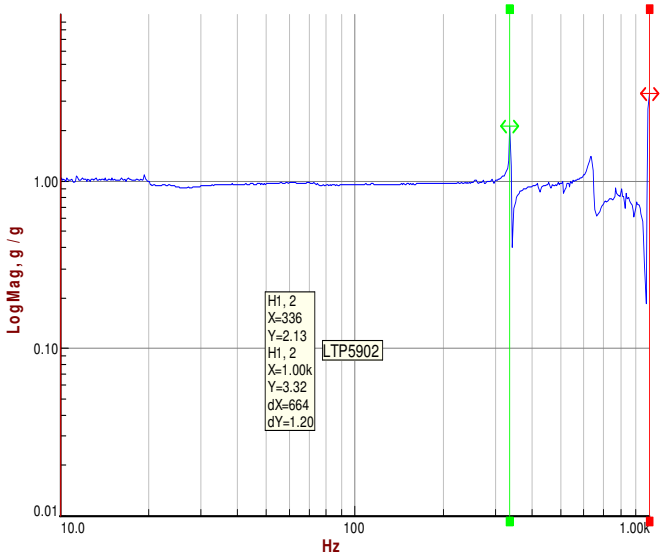
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Endurance Vibration, Sine Sweep from 10 – 1000 Hz at 1.0 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Front End Down; 20 cycles
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on new fixture, resonance accelerometers on DUTs)



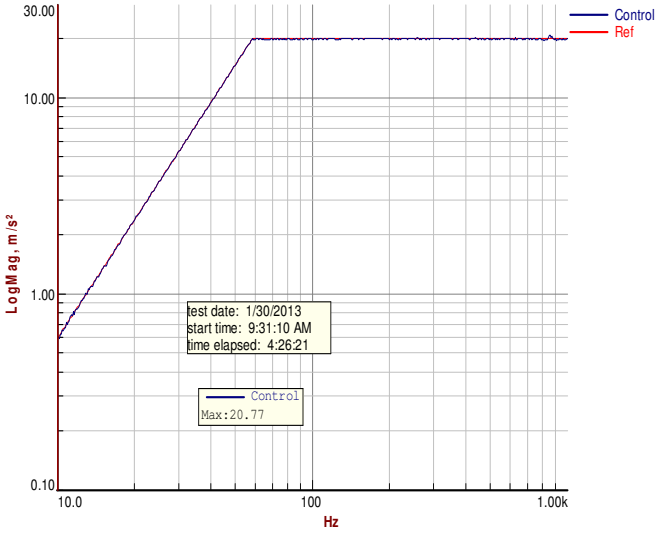


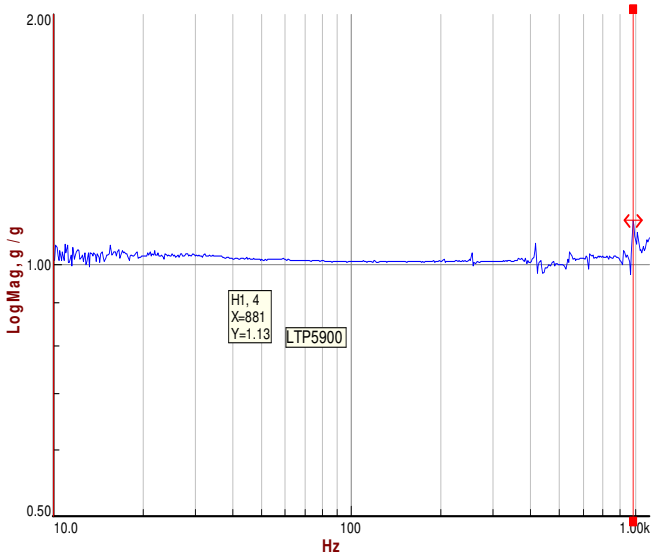


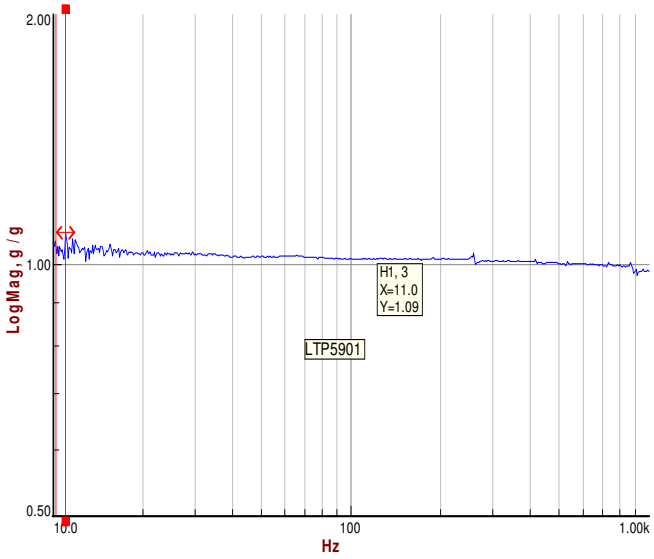


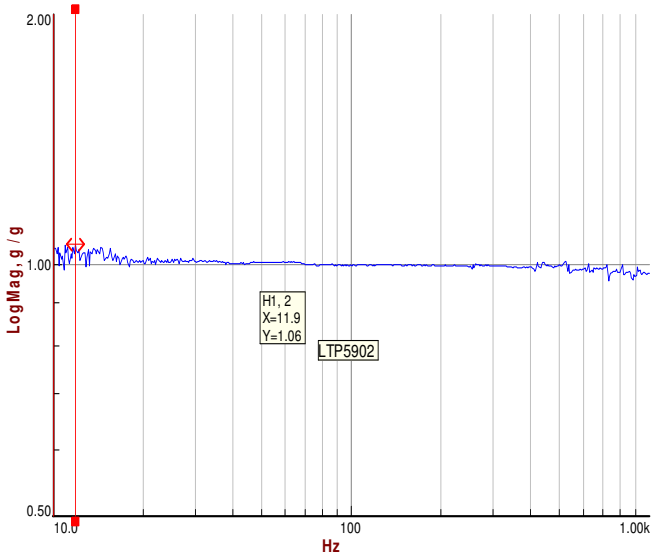
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Endurance Vibration, Sine Sweep from 10 – 1000 Hz at 1.0 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Left Side Down; 20 cycles
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on new fixture, resonance accelerometers on DUTs)







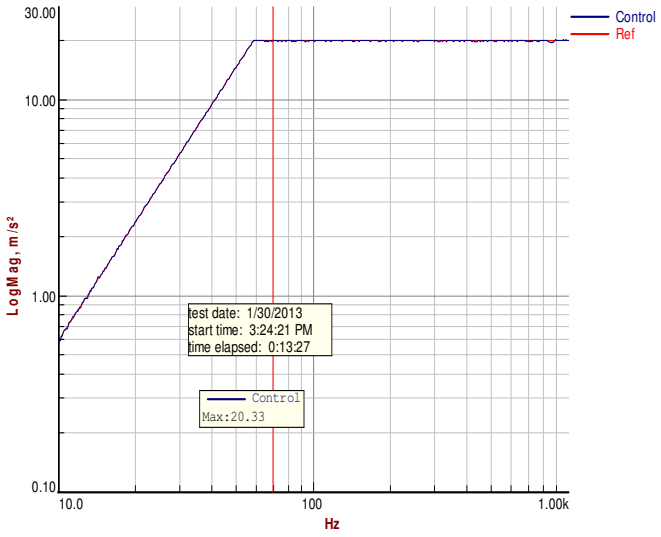


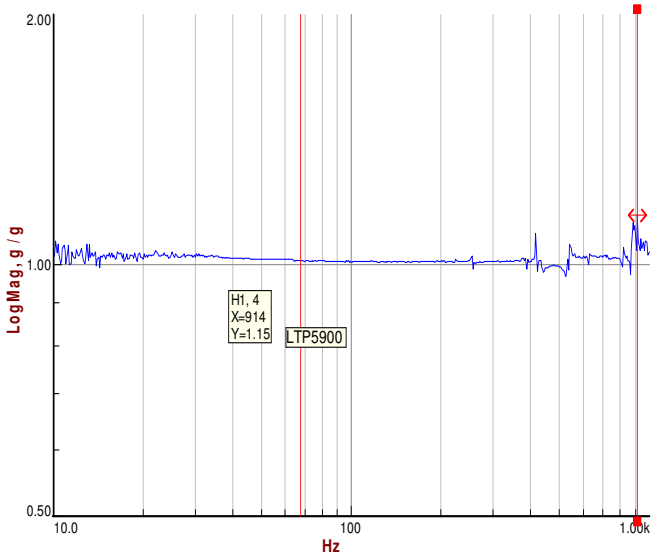
APPENDIX IV

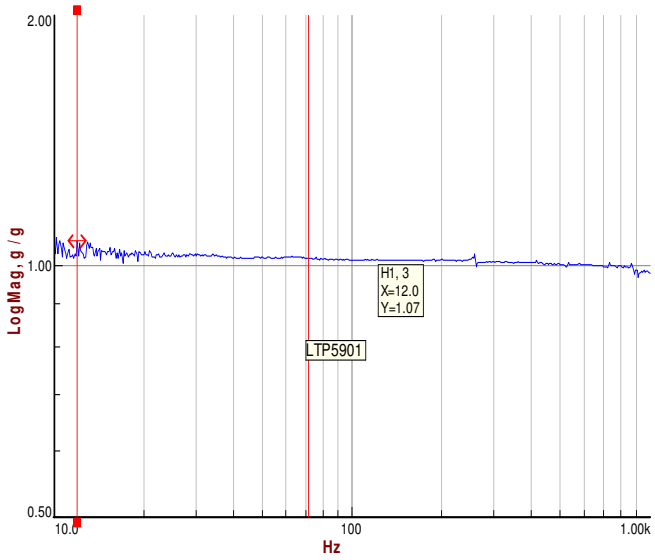
FINAL RESONANCE SEARCH CONTROL DATA

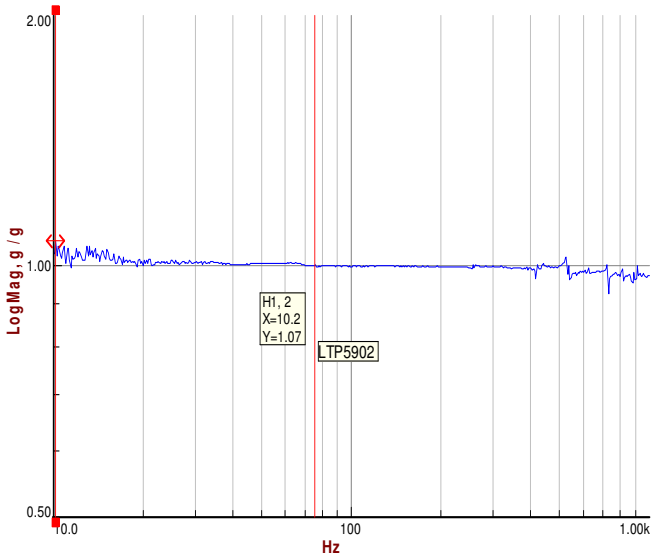
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Final Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Left Side Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on new fixture, resonance accelerometers on DUTs)



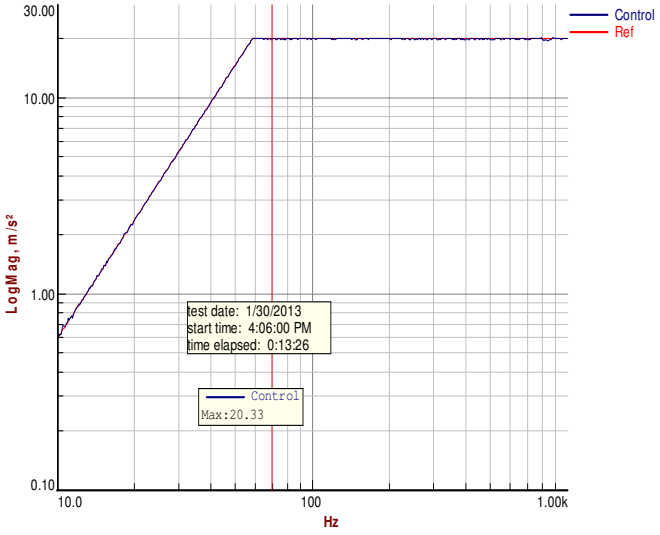


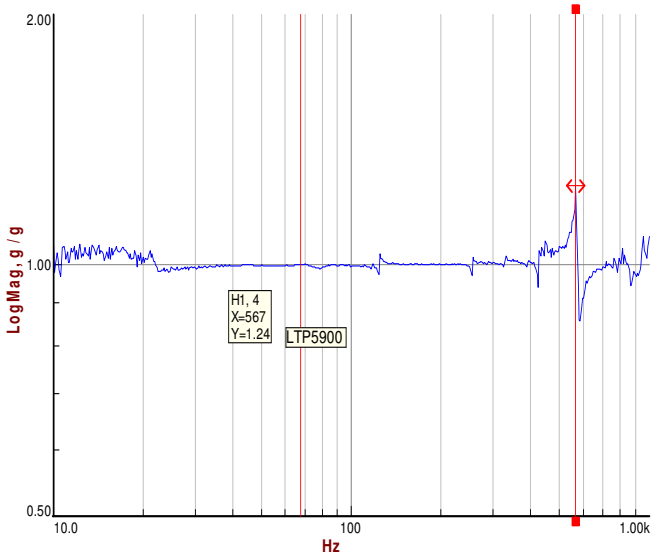


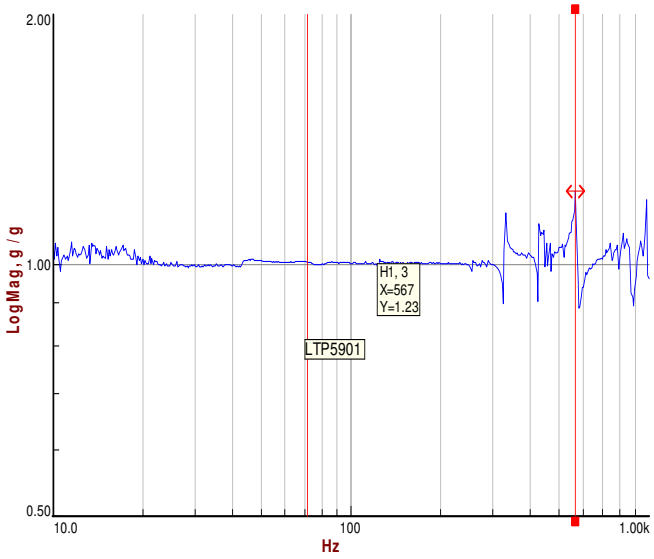


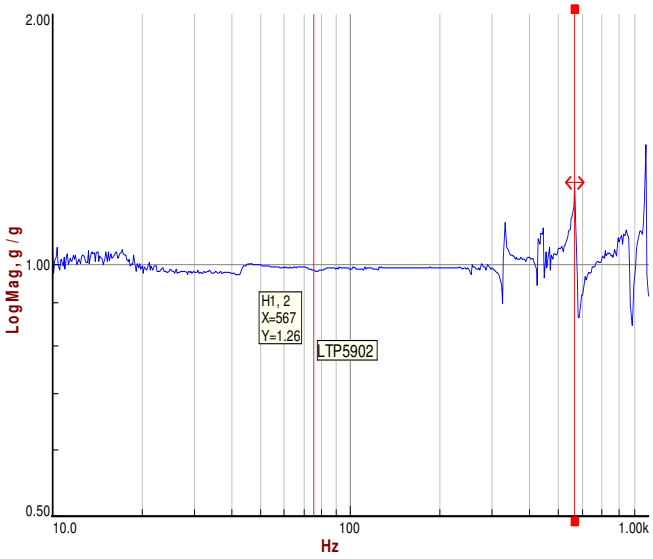
Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Final Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Front End Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on new fixture, resonance accelerometers on DUTs)









Dust Networks/Linear Technology: 1 main board containing LTP5900, LTP5901, and LT5902 DUTs
Final Resonance Search, Sine Sweep from 10 – 1000 Hz at 0.5 octave/minute, 0.15 mm (0-pk), 2G's max acceleration
Orientation: Base Down; 1 sweep up
Test Engineer: Eric Lau
Westpak Report No. 112-13-0085A

Note: (control accelerometer on new fixture, resonance accelerometers on DUTs)