Combined Thermal Shock G-Force HALT Test on HiQ Solar TS480-8k TrueString Inverter

Prepared for:

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Combined Thermal Shock G-Force HALT Test

Document Number 2755

Test Dates: 02/12/2015

TrueString 480V Inverter

Model Number: TS480-8K

Testing Performed for:

HiQ Solar, Inc.
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Testing Performed by:

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Reference Documents			
Document	**Revision**	**Number**	**Date Issued**
-	-	-	-

Table of Contents:

1. Objective

Combined Thermal Shock G-Force HALT Test is performed to uncover latent defects in product design, component selection, and/or manufacturing that would not otherwise be found through conventional qualification methods. The process subjects the test sample to a combination of temperature and vibration to precipitate inherent defects.

2. Scope

Run the Level 1 combined environment profile on a functional HiQ Solar TrueString 480V Inverter (HiQ Solar TS480-8k).

3. Acronyms and Definitions

- H.A.L.T. – Highly accelerated life test
- UUT – Unit under test
- Grms – Gravity Root Means Squared.

4. Executive Summary

- The HiQ Solar TS480-8k sample remained operational and passed during the Level 1 combined temperature and vibration profile.

5. Combined Environment Profile

Level 1 - Combined Thermal Shock G-Force HALT Profile:

- Lower Set Point: -40°C
- Upper Set Point: +65°C
- Ramp Rate: 10°C per minute
- Dwell Time at each extreme: 10 minutes
- Cycle Length – 41 minutes
- Total Cycles: 5
- Test Duration: 3.4 hours
- U.U.T.s – Functional
- Samples per Test: 1 unit

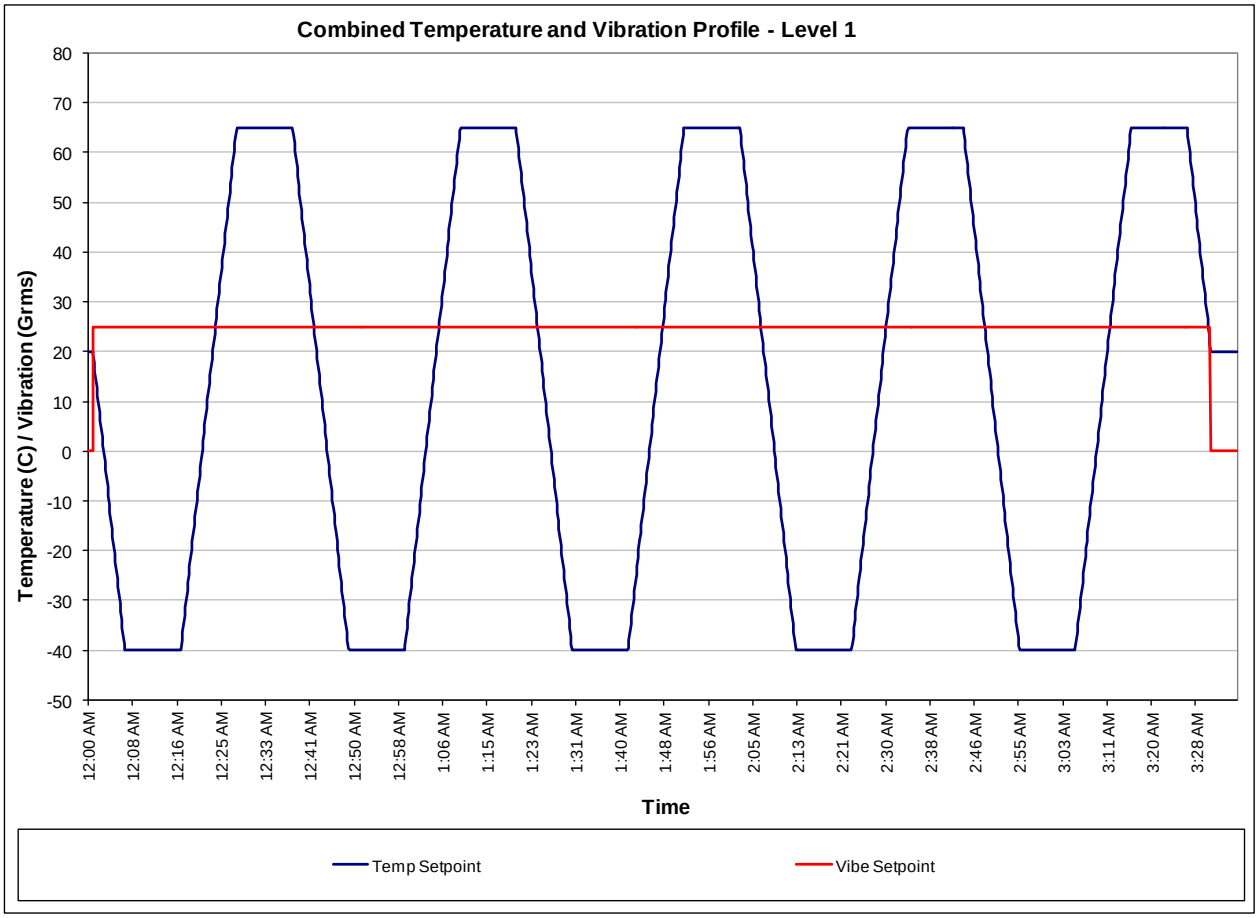


Figure 1 Combined Environment Test Profile - Level 1

6. Test Results - Level 1

The UUT was exposed to 5 rapid temperature cycles from -40°C to +65°C combined with vibration. The vibration level was set to a constant 25 Grms. The dwell time at each temperature extreme was 10 minutes and the thermal transition rate was set to 10°C per minute. The UUT was monitored for functionality throughout the combined environment process.

Table 1: Combined Environment Results

Cycle	Chamber Set point (°C)	Chamber Set point (Grms)	Pass/Fail	Comments
0	+20	0	Pass	Test Date: 02/12/2015 Test Sample: SN_2722
1	Transition	25	Pass	
1	-40	25	Pass	
1	Transition	25	Pass	
1	+65	25	Pass	
1/2	Transition	25	Pass	
2	-40	25	Pass	
2	Transition	25	Pass	
2	+65	25	Pass	
2/3	Transition	25	Pass	
3	-40	25	Pass	
3	Transition	25	Pass	
3	+65	25	Pass	
3/4	Transition	25	Pass	
4	-40	25	Pass	
4	Transition	25	Pass	
4	+65	25	Pass	
4/5	Transition	25	Pass	
5	-40	25	Pass	
5	Transition	25	Pass	
5	+65	25	Pass	
5	Transition	25	Pass	
	+20	0	Pass	

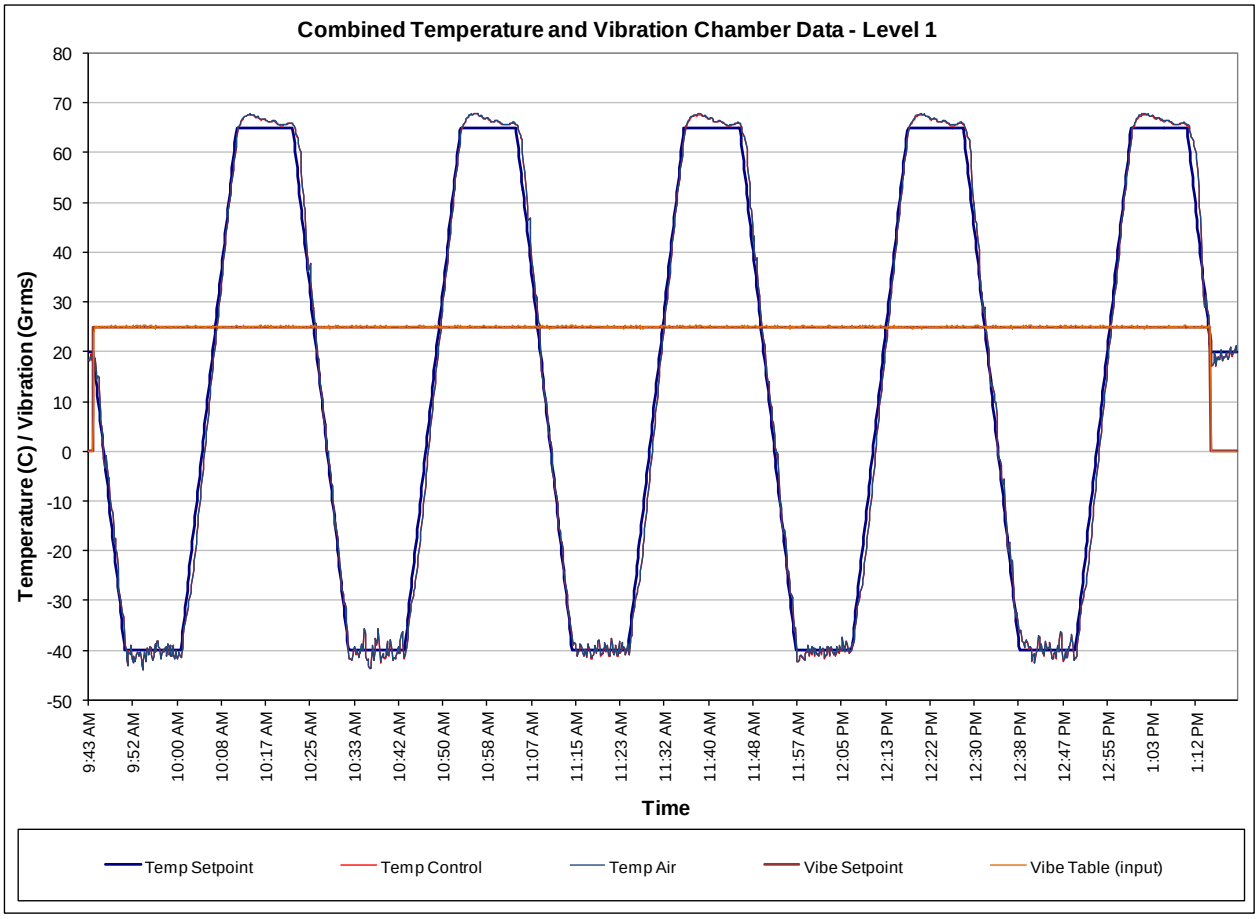


Figure 2 Combined Environment Chart

7. Products Tested

Table 2: Product Identification

Description	Model Number	Revision	Serial Number
HiQ Solar TrueString 480V String Inverter	HiQ TS480-8k	-	2722

8. Temperature Test Setup

Airflow from the chamber was directed onto the UUT using 4" aluminum ducting. This allowed for better temperature stabilization during the thermal cycling process. Pictures illustrating the temperature test setup are located in Appendix A.

9. Vibration Test Setup

The UUT was mounted to the vibration table using two 16"L x 2"W x 1"H sections of aluminum channel. The aluminum channel were bolted to the vibration table at four locations using 3/8" - 16 threaded steel rod. Pictures illustrating the fixture setup are located in Appendix A.

10. Test Equipment and Calibration Records

10.1. Customer Test Equipment

Functional test equipment provided by the customer and used to conduct the H.A.L.T. testing is detailed below. The model number and serial number have been documented to aid in the reproducibility and repeatability of test results.

Table 3: Customer Test Equipment

Description	Manufacturer	Model Number	Quantity
AC Transformer	Temco	TT1292	1
DC Power Supply	Main Wall	S-350-36	16
Gateway	HiQ Solar	GTWY1-Rev A	1

10.2. Reliant Labs Calibration Records

Equipment used to conduct the testing is detailed below. All test equipment that requires periodic calibration was in current calibration at time of test. The calibration certifications are traceable to the National Institute of Standards and Technology (NIST).

Table 4: Reliant Labs Calibration Records – Lab 5

Description	Manufacturer	Model Number	Serial Number	Calibration Due
HALT Chamber	Qualmark	Typhoon 3.0	30T11090903	08/06/2015
Thermocouples	Omega	TT-T-30-SLE ROHS	NA	NA
Accelerometer Control	PCB	300-0221	P14187	07/23/2015

11. Functional Test Description

During testing the UUT was continually monitored for functionality.

Test equipment used to monitor the UUT was set up on a bench outside the H.A.L.T. chamber. Cables, wires, and power cords were fed through the chamber access port. Before running the H.A.L.T., the following modifications were made to the UUT:

- Functional test cables were modified to reach outside the chamber.

During the test process, any abnormalities are considered possible failure modes until they can be determined otherwise. To establish clear failure characterization the list below details acceptable specifications and/or unit functionality.

- Monitored LED status and current draw throughout the test.
- The following was monitored on the communications Gateway:
  - System health.
  - Power output.

Appendix A – Photographs

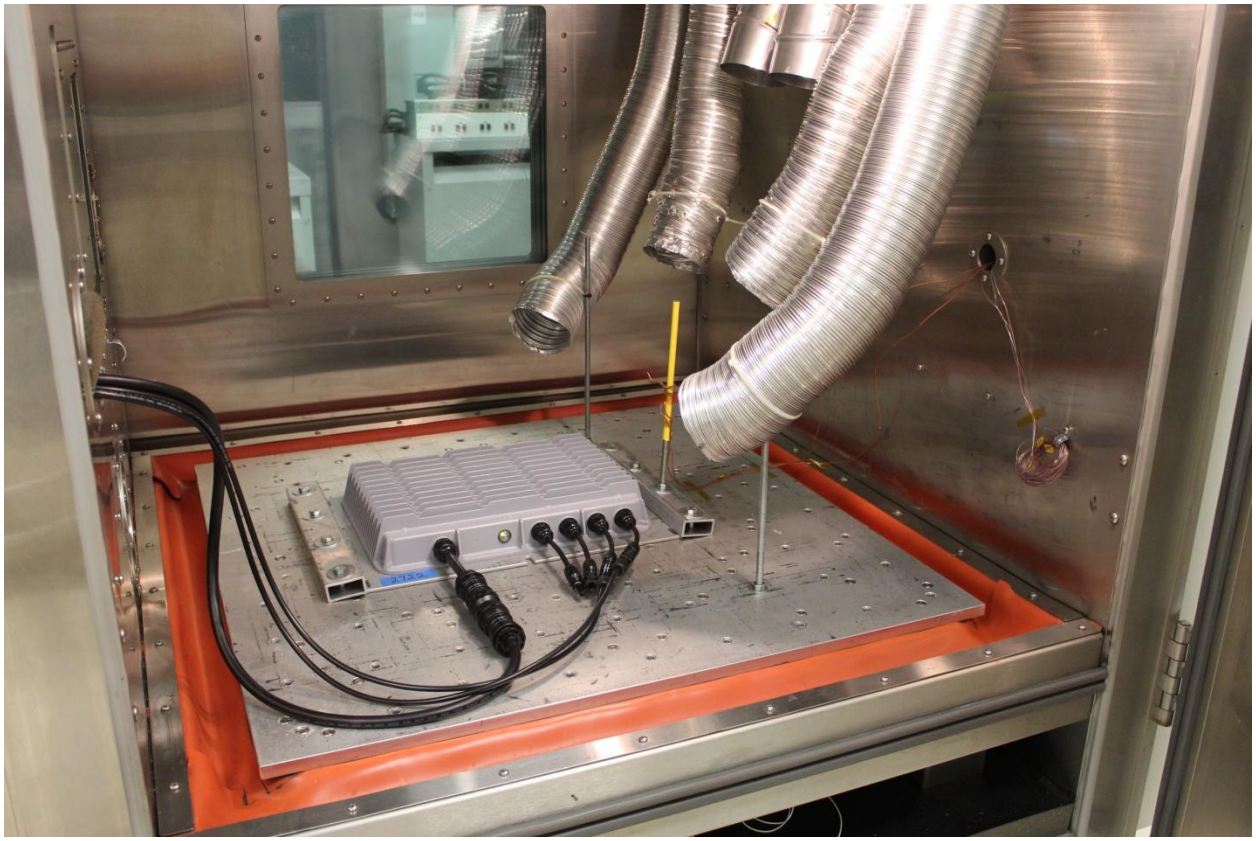


Figure A.1. Temperature & Vibration Test Setup

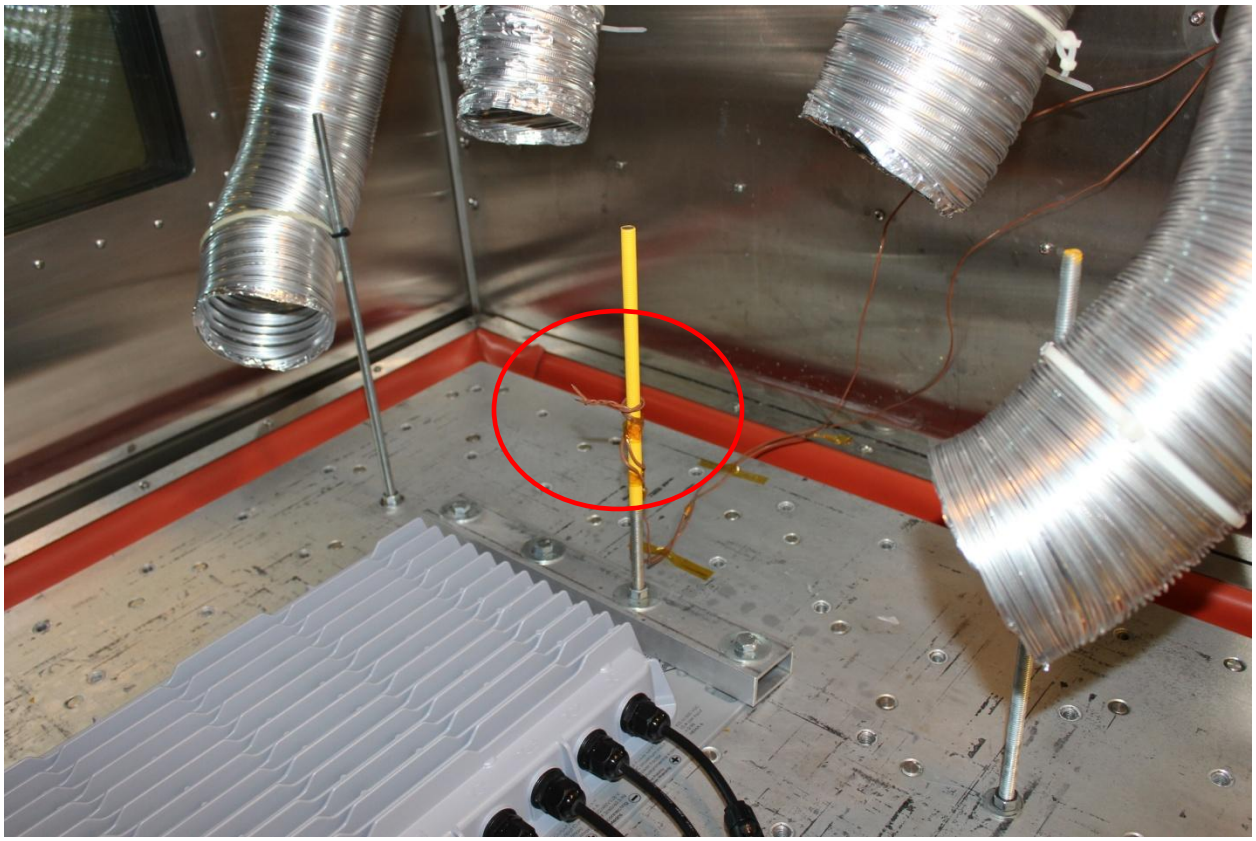


Figure A.2. Chamber Control Thermocouple Location

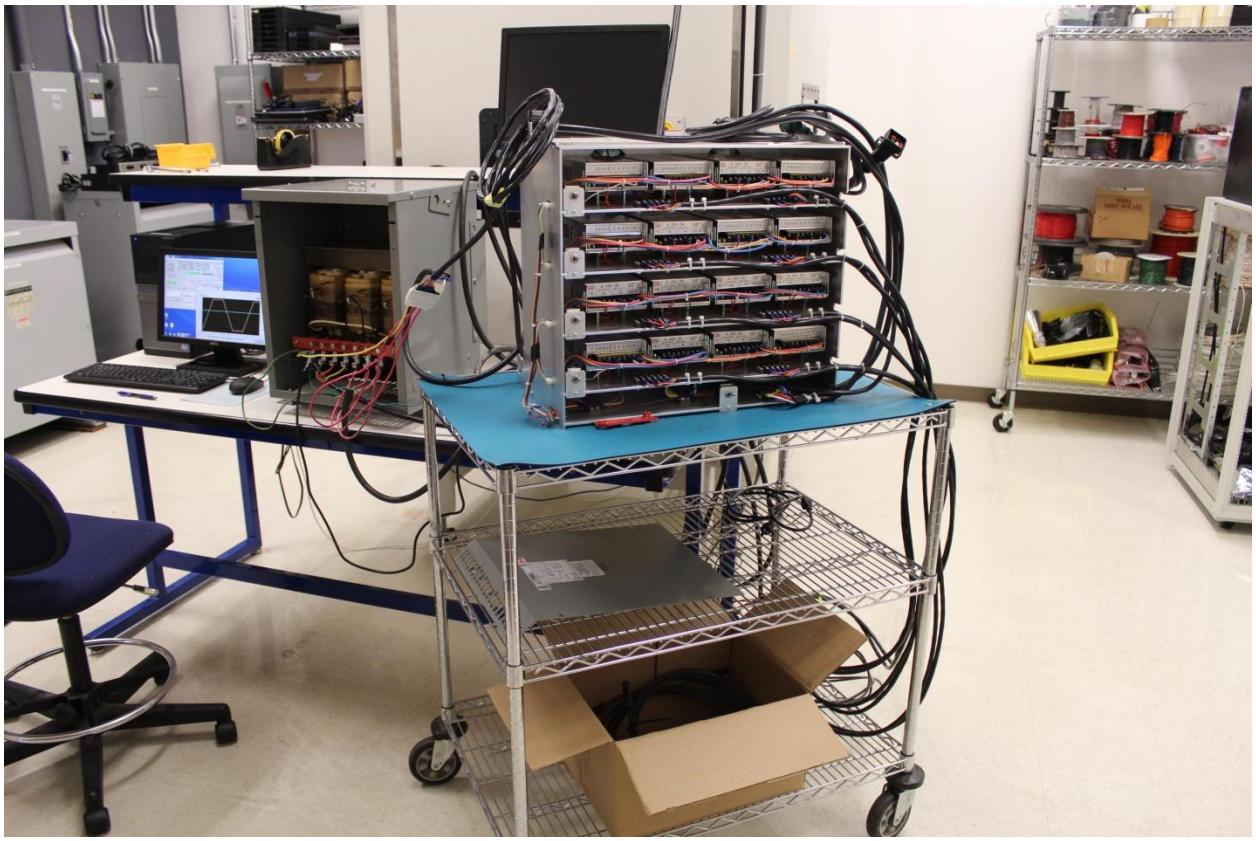


Figure A.3. Test Equipment Setup

Figure A.4. Chamber Lab Setup

Appendix B – HALT Six Degrees of Freedom Random Vibration

HALT vibration systems produce energy in all six axis simultaneously (x, y, z, pitch, roll and yaw). The frequency output is broadband from 2 Hz to 5 KHz.

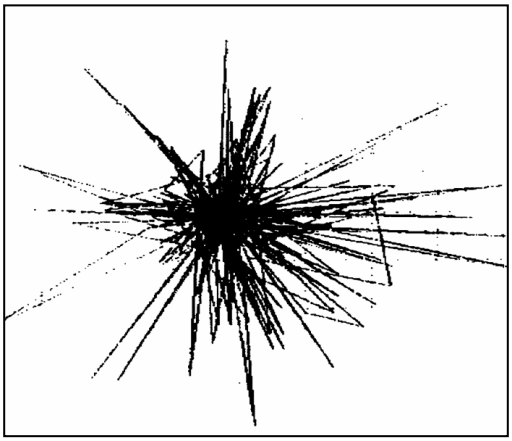


Figure 3 Tri Axial Accelerometer

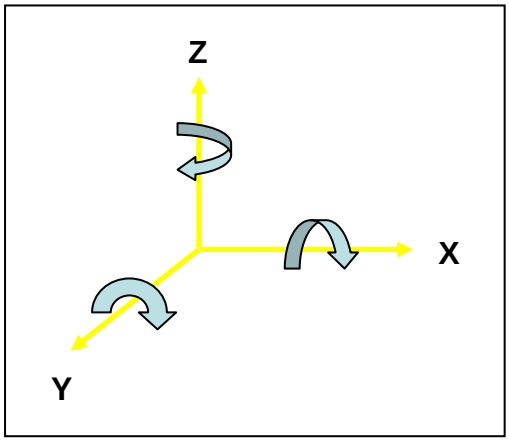


Figure 4 – X, Y, Z, Pitch, Roll & Yaw

Pneumatic or repetitive shock 6DOF vibration HALT chambers produce a continuously varying pseudo-random broad spectrum vibration. The vibration is controlled from a single accelerometer mounted at the center underneath the vibration table. The root mean square (RMS) value of this signal can be calculated by squaring the magnitude of the signal at every frequency, finding the average (mean) value of the squared magnitude, and then taking the square root of the average value. The resulting number is the Grms.

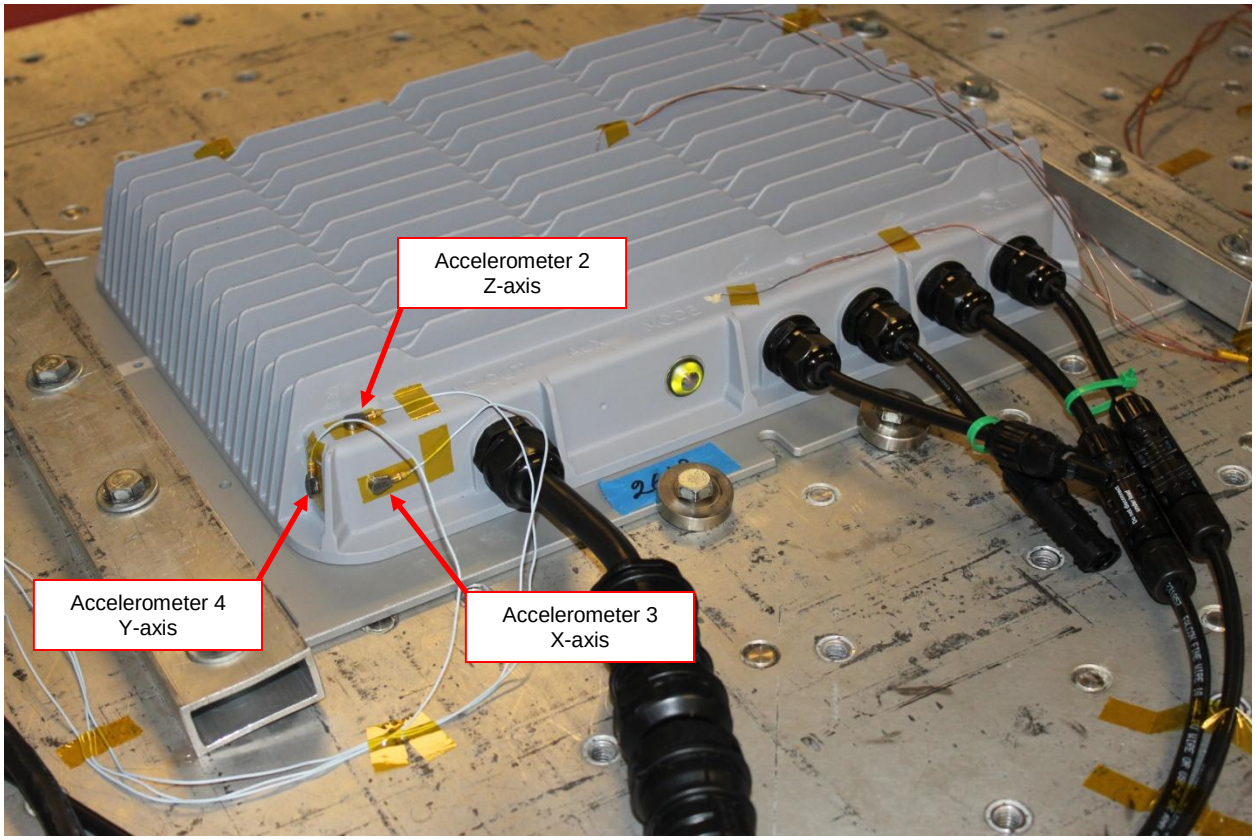


Figure B.1 Location of Accelerometers 2-4

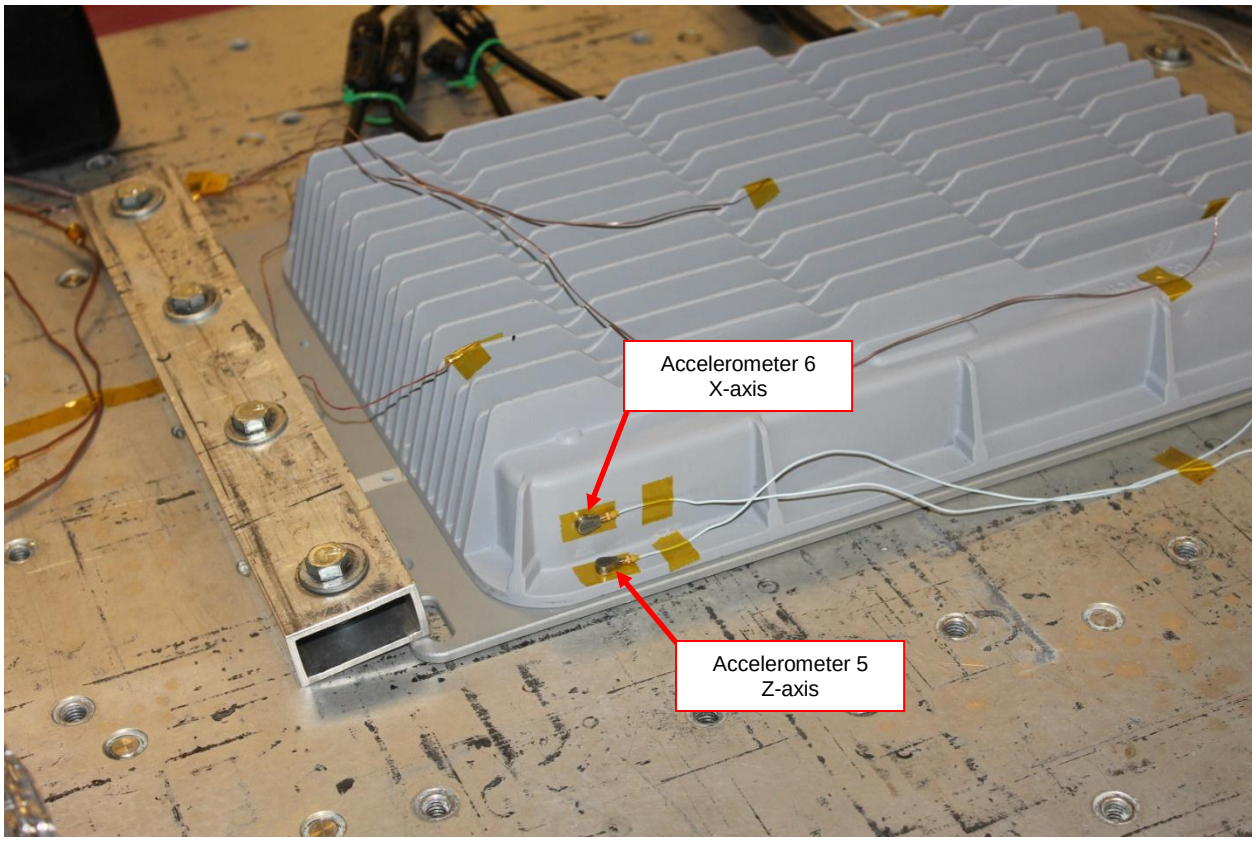
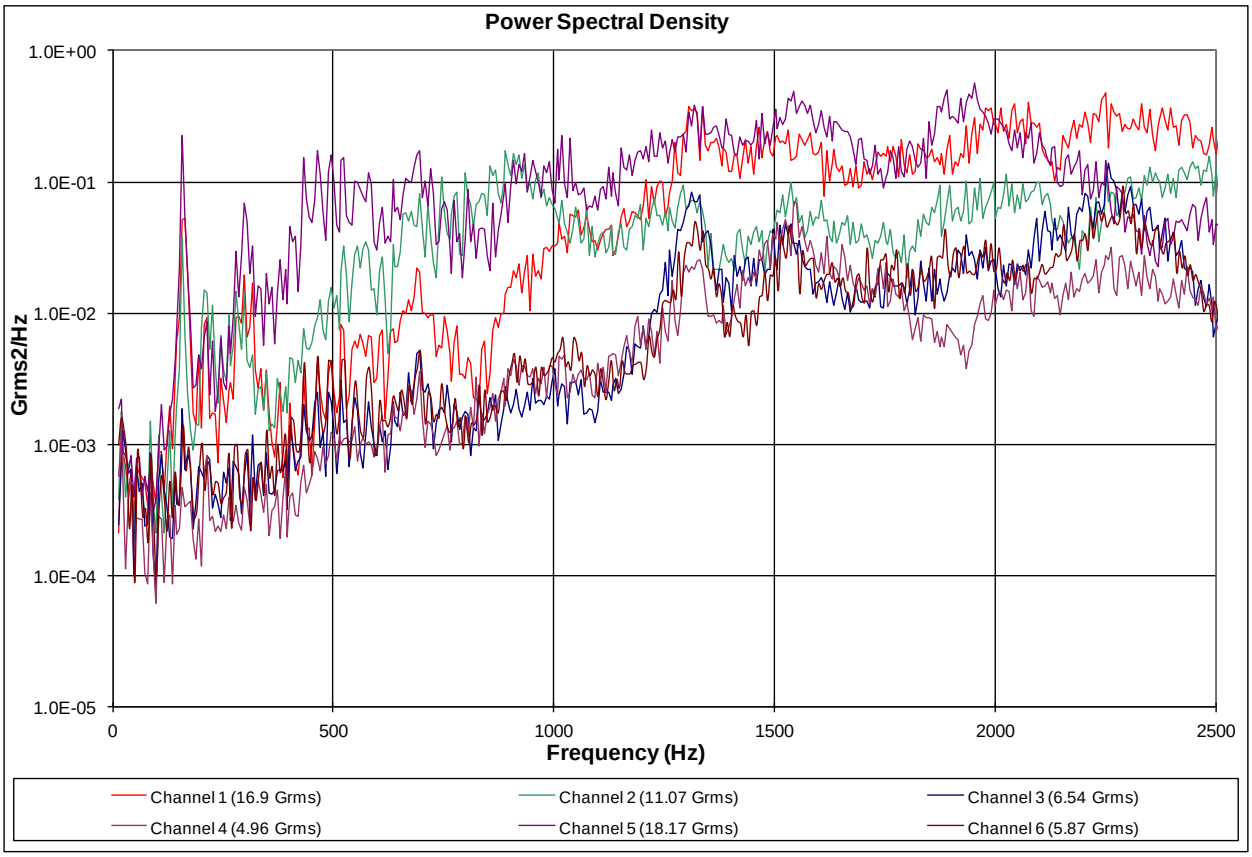


Figure B.2 Location of Accelerometer 5-6

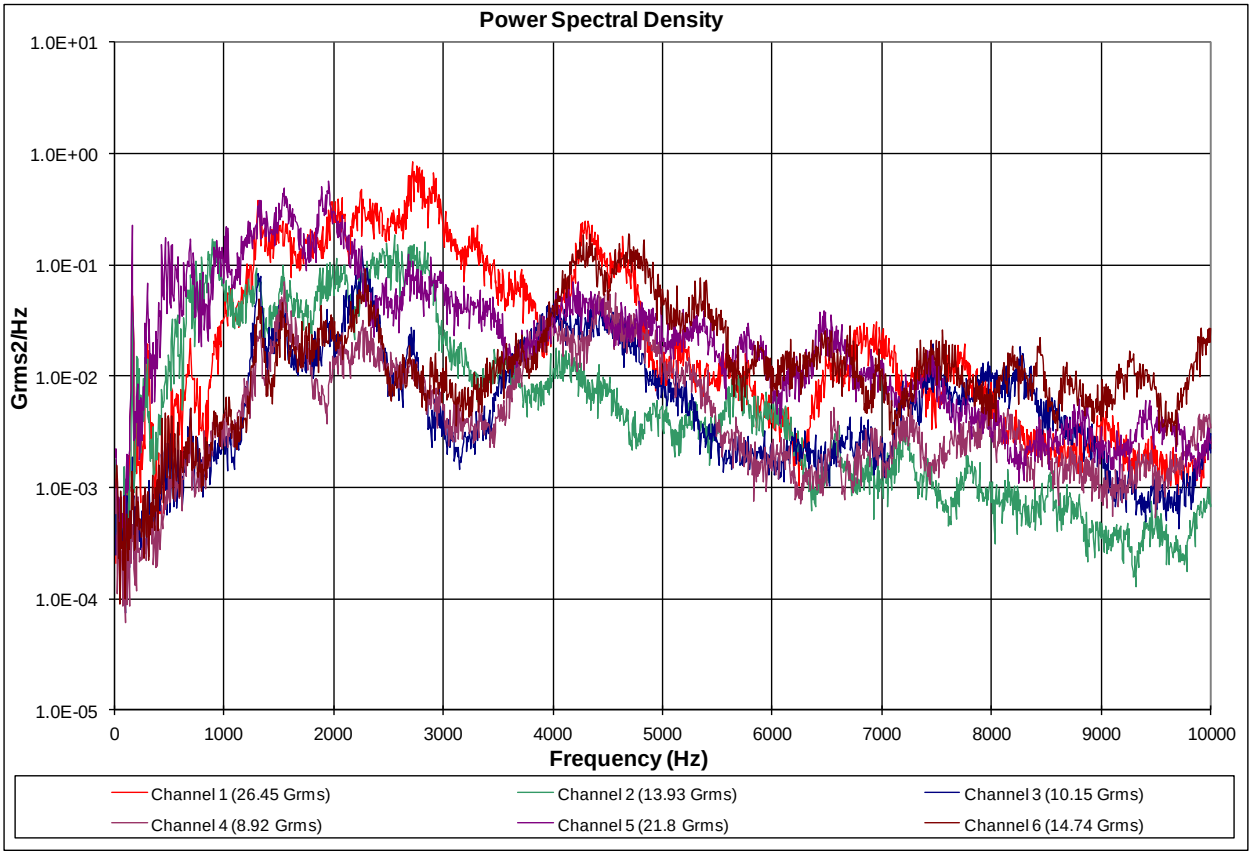
PSD Vibration Plot - 25 Grms 2 Hz – 2.5 kHz



Spectrum Analyzer Channel Assignment		
Channel	**Axis**	**Location or Description**
1	Z	Mounted underneath the vibration table at center.
2	Z	Front - Mounted on the Z axis
3	X	Front - Mounted on the X axis
4	Y	Front - Mounted on the Y axis
5	Z	Back - Mounted on the Z axis
6	Z	Back - Mounted on the X axis

Note: The X-axis runs through the chamber doors, the Y-axis runs from the access portal to air plenum, and the Z-axis is vertical to the vibration table.

PSD Vibration Plot - 25 Grms 2 Hz – 10 kHz



Spectrum Analyzer Channel Assignment		
Channel	**Axis**	**Location or Description**
1	Z	Mounted underneath the vibration table at center.
2	Z	Front - Mounted on the Z axis
3	X	Front - Mounted on the X axis
4	Y	Front - Mounted on the Y axis
5	Z	Back - Mounted on the Z axis
6	Z	Back - Mounted on the X axis

Note: The X-axis runs through the chamber doors, the Y-axis runs from the access portal to air plenum, and the Z-axis is vertical to the vibration table.