PRODUCT ADVISORY NOTICE

KEEPING YOU INFORMED OF PRODUCT CHANGES

To: **All Customers, Sales Representatives and Distributors**

Date: June 3, 2022

Subject: SMT Optics conversion for 62A, 62V and 62D Series Optical Encoders

This Product Advisory Notice is to alert you that Grayhill is converting from wire-bonded optics to SMT Optics for 62A, 62V and 62D Series Optical Encoders. ***Please forward this notification to the appropriate person(s) in your organization.***

Description of Change

Grayhill currently uses die-and-wire bonded optics in the assembly of 62A (12 & 20 Resolutions), 62D, and 62V Optical Encoders. In order to improve production throughput, Grayhill will convert to surface mount technology optics for these series. This change includes the following:

- Replace wire bonded Three-Five Compounds TCD850 LED with SMT Kingbright APH1608-LM32 LED
- Replace wire bonded Opto Tech ST-0124 Phototransistor with SMT Three-Five Compounds TFE7-21/0124 Phototransistor
- Addition of Fairchild Semiconductor NC7WZ17P6X Dual Buffer with Schmitt Trigger
- Various resistor and capacitor changes in accordance with the changes above

This change will result in the output circuit being changed from an Open Collector type to a Push-Pull type. In most applications the new surface mount optics encoder will work as a drop in replacement for the old die and wire bond version. However, in applications where the pull-up resistors on the encoder outputs are connected to a voltage different than the voltage on the power pin, the new surface mount optics encoder will not operate correctly and should not be used. An example of where the new surface mount optics encoder will not operate correctly is as follows: encoder power pin tied to 3.3V and output pull-up resistors tied to 5.0V.

Reason for Change

Grayhill's current wire bonding manufacturing equipment is nearing the end of its service life and is being replaced with SMT technology to prevent any future supply interruptions to our customers.

Effective Date

Production Orders after July 1, 2022 will begin transitioning to SMT optics once the in-process inventory of wire bonded optics are consumed.

Actions Required

None

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Part Numbers Affected

The Grayhill part numbers are affected by this PAN:

62A03-01-035C	62D11-01-060S	62D15-02-060S	62D30-01-025C	62V11-02-040CH	62V22-01-040C
62A03-01-P	62D11-01-060SH	62D15-02-120C	62D30-01-P	62V11-02-040S	62V22-01-040CH
62A03-02-P	62D11-01-080S	62D15-02-140S	62D30-02-020C	62V11-02-040SH	62V22-01-040S
62A08-01-030S	62D11-01-080SH	62D15-02-175C	62D30-02-025CH	62V11-02-050C	62V22-01-050C
62A08-02-030S	62D11-01-120C	62D15-02-200S	62D30-02-030C	62V11-02-050S	62V22-01-060C
62A08-02-120S	62D11-01-120S	62D15-02-P	62D30-02-030S	62V11-02-055C	62V22-01-060CH
62A08-02-P	62D11-01-150S	62D18-01-020C	62D30-02-035S	62V11-02-060C	62V22-01-060S
62A18-01-020C	62D11-01-200CH	62D18-01-040C	62D30-02-040C	62V11-02-060CH	62V22-01-P
62A18-01-020S	62D11-01-250S	62D18-01-040S	62D30-02-040CH	62V11-02-060SH	62V22-02-020C
62A18-01-035C	62D11-01-P	62D18-02-020C	62D30-02-040S	62V11-02-070C	62V22-02-020CH
62A18-01-040CH	62D11-02-020C	62D18-02-020S	62D30-02-040SH	62V11-02-080CH	62V22-02-020S
62A18-01-040SH	62D11-02-020CH	62D18-02-040C	62D30-02-050C	62V11-02-100C	62V22-02-025CH
62A18-01-P	62D11-02-020S	62D18-02-040CH	62D30-02-060C	62V11-02-100CH	62V22-02-030C
62A18-02-020C	62D11-02-040C	62D18-02-040S	62D30-02-060CH	62V11-02-100SH	62V22-02-030CH
62A18-02-020S	62D11-02-040CH	62D18-02-090CH	62D30-02-120S	62V11-02-110C	62V22-02-030SH
62A18-02-030CH	62D11-02-040S	62D18-02-P	62D30-02-P	62V11-02-120C	62V22-02-040C
62A18-02-030S	62D11-02-050C	62D22-01-020C	62V01-01-020S	62V11-02-240SH	62V22-02-040CH
62A18-02-040C	62D11-02-050CH	62D22-01-020CH	62V01-01-025CH	62V11-02-P	62V22-02-050C
62A18-02-040CH	62D11-02-050S	62D22-01-020SH	62V01-01-050C	62V15-01-020C	62V22-02-050CH
62A18-02-040SH	62D11-02-060C	62D22-01-030C	62V01-01-080C	62V15-01-020S	62V22-02-050S
62A18-02-050S	62D11-02-060CH	62D22-01-040C	62V01-01-200SH	62V15-01-040CH	62V22-02-060C
62A18-02-060C	62D11-02-060S	62D22-01-040S	62V01-01-P	62V15-01-040S	62V22-02-060CH
62A18-02-060S	62D11-02-060SH	62D22-01-050CH	62V01-02-040C	62V15-01-060C	62V22-02-060S
62A18-02-120S	62D11-02-070C	62D22-01-060C	62V01-02-040CH	62V15-01-120C	62V22-02-160C
62A18-02-150S	62D11-02-070CH	62D22-01-060S	62V01-02-060C	62V15-01-P	62V22-02-P
62A18-02-P	62D11-02-070S	62D22-01-065C	62V01-02-060SH	62V15-02-020C	62V30-02-020C
62A22-02-060C	62D11-02-080CH	62D22-01-080S	62V01-02-P	62V15-02-020CH	62V30-02-020S
62A30-01-020C	62D11-02-080S	62D22-01-120C	62V02-01-P	62V15-02-020S	62V30-02-030C
62A30-01-070CH	62D11-02-090C	62D22-01-120S	62V02-02-P	62V15-02-020SH	62V30-02-030S
62A30-01-080S	62D11-02-100C	62D22-01-P	62V03-02-030S	62V15-02-030C	62V30-02-040C
62A30-01-120SH	62D11-02-100S	62D22-02-020C	62V05-01-020C	62V15-02-035C	62V30-02-080C
62A30-01-P	62D11-02-120S	62D22-02-020S	62V08-02-040C	62V15-02-035CH	62V30-02-P
62A30-02-020C	62D11-02-200C	62D22-02-025C	62V11-01-020C	62V15-02-040C	
62A30-02-020S	62D11-02-200S	62D22-02-030C	62V11-01-020S	62V15-02-040CH	
62A30-02-035CH	62D11-02-200SH	62D22-02-035C	62V11-01-020SH	62V15-02-040S	
62A30-02-040C	62D11-02-P	62D22-02-035S	62V11-01-030CH	62V15-02-060C	
62A30-02-040CH	62D15-01-020C	62D22-02-040C	62V11-01-040C	62V15-02-060S	
62A30-02-040S	62D15-01-020CH	62D22-02-040CH	62V11-01-050SH	62V15-02-080C	
62A30-02-040SH	62D15-01-040C	62D22-02-040S	62V11-01-060C	62V15-02-080CH	
62A30-02-050C	62D15-01-040SH	62D22-02-060C	62V11-01-060S	62V15-02-080S	
62A30-02-060C	62D15-01-060SH	62D22-02-060CH	62V11-01-080SH	62V15-02-180C	
62A30-02-P	62D15-01-100S	62D22-02-060S	62V11-01-100C	62V15-02-P	
62D11-01-020C	62D15-01-120CH	62D22-02-080C	62V11-01-110C	62V18-02-020C	
62D11-01-020SH	62D15-01-240C	62D22-02-080CH	62V11-01-P	62V18-02-040C	
62D11-01-030S	62D15-01-P	62D22-02-080S	62V11-02-020C	62V18-02-080CH	
62D11-01-035C	62D15-02-020C	62D22-02-080SH	62V11-02-020CH	62V18-02-100SH	
62D11-01-040CH	62D15-02-030CH	62D22-02-200S	62V11-02-020S	62V18-02-P	
62D11-01-040S	62D15-02-040C	62D22-02-P	62V11-02-025CH	62V22-01-020C	
62D11-01-040SH	62D15-02-040CH	62D30-01-020C	62V11-02-035C	62V22-01-020S	
62D11-01-060C	62D15-02-060C	62D30-01-020S	62V11-02-040C	62V22-01-030C	

Grayhill INC.
Intuitive Human Interface Solutions

Device Under Test:
62A22-02-020C

Environmental Test:
4 Corners, Operating High Temperature, Operating Low Temperature, Storage High Temperature, Storage Low Temperature, Thermal Shock,

Physical Test:
Mounting Torque, Push Out Force, Pull Out Force, Cable Strength, Transit Drop, Push Button Life, Dimensional, DI, IR, Vibration, Mechanical Shock, Rotational Life

Test Report Number:	**SP02-516**
Test Start Date:	**03/03/2014**
Test Completion Date:	**05/21/2014**
Test Facility:	**Grayhill Inc.**
Test Requested By:	**Jason Kifer**
Test Performed By:	**Greg Dombrowski** **Laboratory Technician**
Report Written By:	**Greg Dombrowski** **Laboratory Technician**
Report Approved By:	**Nicole Jachna** **Quality Lab Manager**

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1.0 REVISION HISTORY

Revision	Date	Written By	Description
A	11/05/2014	Greg Dombrowski	Original

2.0 MOUNTING TORQUE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Mounting Torque	LREQ-SP02-516	62A22-02-020C	Group 1 1-20	Grayhill Inc.	04/04/14 – 04/08/14

2.1. PURPOSE

The purpose for this test is to determine if the DUT housing can withstand the maximum torque directly applied to the screws after being subjected to specified environmental conditions. This test should be performed after Humidity Test.

2.2. TEST SETUP DETAILS

1) DUT shall be placed in the humidity chamber and soaked for 96 hrs at 90-95% humidity before submitting units for testing.
2) Mounting torque testing must be completed within 30 min. of removal from testing chamber.
3) The DUT shall be mounted onto a metal bracket.
4) A torque wrench shall be used to tighten the screws to the maximum allowable torque.
5) There shall be no visual damage or binding and there shall be no deformation or cracking of the DUT housing.

Table 1 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-1002	Humidity Chamber	SM-8C	Thermotron	02/2015
GT-400	Torque Driver	810587	Sturtevant/Rich	04/2015

Table 2 - Test Conditions

Test Condition	Units	Parameters
Quantity		20
Duration	Hours	96
Operational Mode		Unpowered
Temperature	℃	40
Humidity	%RH	95
Maximum Torque	in-lbs	5

2.3. TEST SETUP PHOTOS

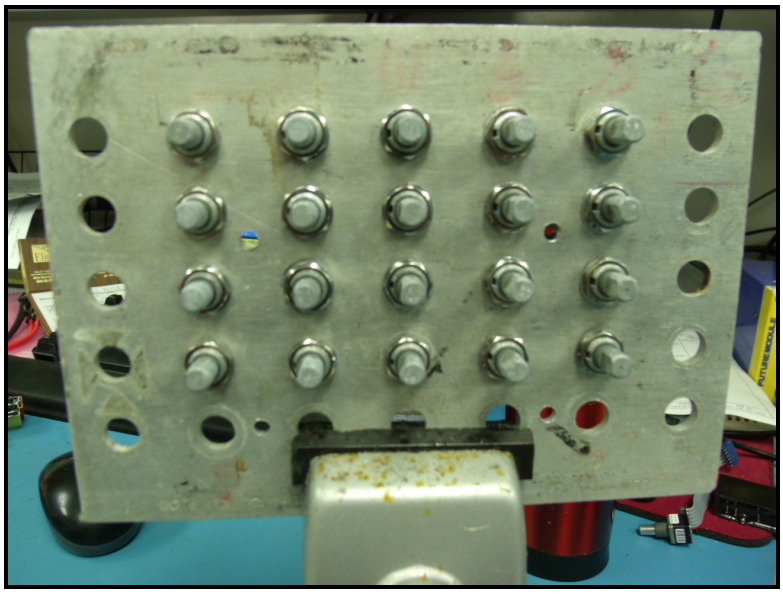


Figure 1– Torque Setup

2.4. ACCEPTANCE CRITERIA

DUT must have no damage or disassembled parts.

2.5. TEST RESULTS

DUT did not have any damage. All DUT passed.

Table 3 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 1 1-20	Mounting Torque	LREQ-SP02-516	PASS	Grayhill Inc.	04/04/14 – 04/08/14

3.0 PUSH OUT FORCE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Push Out Force	LREQ-SP02-516	62A22-02-020C	Group 1 4,5,10,15,20	Grayhill Inc.	04/21/2014

3.1. PURPOSE

The purpose of this test is to determine if the DUT can handle the specified compressive force applied in the direction of the axis of the shaft. The force applied shall be the minimum specified for the switch.

No damage or deformation shall be present after test.

3.2. TEST SETUP DETAILS

1. Mount DUT in a metal plate using the specified maximum mounting torque.
2. Apply a compressive force (45Lbs) in the direction of the axis of the shaft.
3. Perform functional check.
4. Re-mount DUT and push to failure.
5. Record the push to failure force.

Table 4 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-230	Force Tester Gage	UTSM	John Chatillin	N/A
GT-136	Force Gage	MG500	Mark-10	10/2014
GT-400	Torque Driver	810587	Sturtevant/Rich	04/2015

Table 5 - Test Conditions

Test Condition	Units	Parameters
Quantity		5
Compressive Force Limits	lbs	45 (20 Times)
Operational Mode		Non-Operating
Temperature	℃	Ambient
Mounting Torque	in-lbs	5

3.3. TEST SETUP PHOTOS

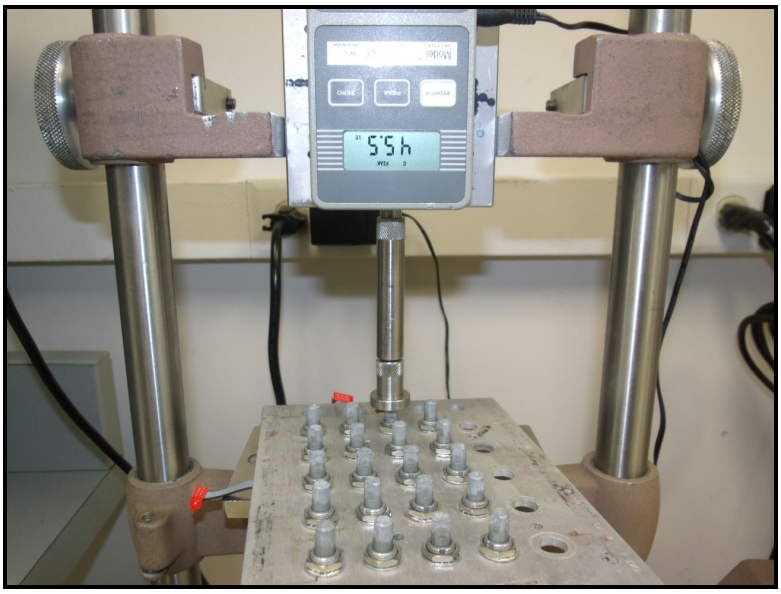


Figure 2– Push Out Force Setup

3.4. ACCEPTANCE CRITERIA

DUT must have no damage or disassembled parts when tested at a Compressive Force limits (45Lbs).

3.5. TEST RESULTS

Table 6 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 1 4	Push Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/21/2014
Group 1 5	Push Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/21/2014
Group 1 10	Push Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/21/2014
Group 1 15	Push Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/21/2014
Group 1 20	Push Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/21/2014

Table 7 – Testing to Failure results

DUT	Units	Failure Point Force
Group 1 4	lbs	312
Group 1 5	lbs	353
Group 1 10	lbs	322.5
Group 1 15	lbs	340
Group 1 20	lbs	372.5

4.0 PULL OUT FORCE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Pull Out Force	LREQ-SP02-516	62A22-02-020C	Group 1 1,2,3,6,7	Grayhill Inc.	04/22/2014

4.1. PURPOSE

To determine if the DUT can handle the specified tensile force applied in the direction of the axis of the shaft. The force applied shall be the minimum specified for the switch.

4.2. TEST SETUP DETAILS

1. Mount DUT in a metal plate using the specified maximum mounting torque.
2. Apply a tensile force (45Lbs) in the direction of the axis of the shaft.
3. Perform functional check.
4. Re-mount DUT and pull to failure.
5. Record the pull to failure force.

Table 8 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-230	Force Tester Gage	UTSM	John Chatillin	N/A
GT-136	Force Gage	MG500	Mark-10	10/2014
GT-400	Torque Driver	810587	Sturtevant/Rich	04/2015

Table 9 - Test Conditions

Test Condition	Units	Parameters
Quantity		5
Tensile Force Limits	lbs	45
Operational Mode		Non-Operating
Temperature	℃	Ambient
Mounting Torque	in-lbs	5

4.3. TEST SETUP PHOTOS

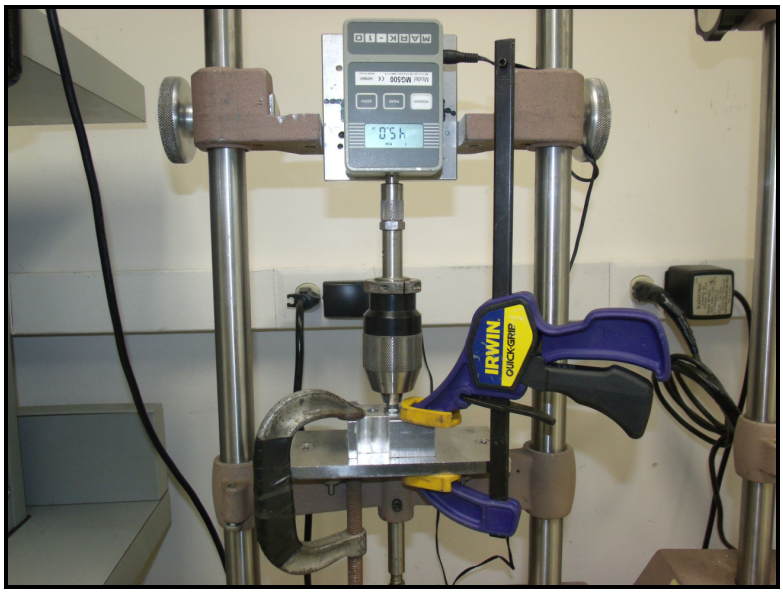


Figure 3– Pull Out Force Setup

4.4. ACCEPTANCE CRITERIA

DUT must have no damage or disassembled parts when tested at a Tensile Force limits (45Lbs)

4.5. TEST RESULTS

Table 10 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 1 1	Pull Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/22/2014
Group 1 2	Pull Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/22/2014
Group 1 3	Pull Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/22/2014
Group 1 6	Pull Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/22/2014
Group 1 7	Pull Out Force	LREQ-SP02-516	PASS	Grayhill Inc.	04/22/2014

Table 11 – Pull test until Failure

DUT	Units	Failure Point Force
Group 1 1	lbs	184.5
Group 1 2	lbs	118.5
Group 1 3	lbs	115.0
Group 1 6	lbs	84.0
Group 1 7	lbs	78.5

5.0 CABLE STRENGTH

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Cable Strength	Mil-Std-202 Method 211 A	62A22-02-020C	Group 1 8,9	Grayhill Inc.	04/22/2014

5.1. PURPOSE

The purpose of this test is to determine if the DUT can withstand the specified uniform tensile force applied to the Header of the DUT. The force applied shall be the minimum specified for the DUT.
No damage or deformation shall be present after test.

The potential product issue modes and effects detected in this test are:

- housing cracks
- product/component breakage
- electrical output changes

5.2. TEST SETUP DETAILS

1. Mount DUT in a metal plate using the specified maximum mounting torque.
2. Apply a tensile force (see table) in the direction of the axis of the header.
3. Perform functional check.
4. Re-mount DUT.
5. Apply a tensile force until header broken or separated from DUT.
6. Record the destruction force.

Table 12 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-230	Force Tester Gage	UTSM	John Chatillin	N/A
GT-136	Force Gage	MG500	Mark-10	10/2014
GT-400	Torque Driver	810587	Sturtevant/Rich	04/2015

Table 13 - Test Conditions

Test Condition	Units	Parameters
Quantity		2
Cable Pull Force Limit	lbs	15
Operational Mode		Unpowered
Temperature	° C	Ambient

5.3. TEST SETUP PHOTOS

Figure 4– Cable Strength Setup

5.4. ACCEPTANCE CRITERIA

DUT must have no damage or disassembled parts when tested at tensile force limits.

5.5. TEST RESULTS

Table 14 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 1 8	Cable Strength	Mil-Std-202 Method 211A	PASS	Grayhill Inc.	04/22/2014
Group 1 9	Cable Strength	Mil-Std-202 Method 211A	PASS	Grayhill Inc.	04/22/2014

Table 15 – Cable Strength to failure results

DUT	Units	Failure Point Force
Group 1 8	lbs	39
Group 1 9	lbs	36

6.0 FOUR CORNERS

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Four Corners	LREQ-SP02-516	62A22-02-020C	Group 2 1-10	Grayhill Inc.	03/14/2014 – 03/19/2014

6.1. PURPOSE

This test is performed to ensure that the DUT operates at temperature and voltage extremes called out in the table below.

6.2. TEST SETUP DETAILS

1. Place DUT in environmental chamber capable of high and low temperatures. The DUT will be exposed to 4 voltage/temperature extremes as follows:
2. Minimum voltage/minimum temperature, for the duration specified below.
3. Maximum voltage maximum temperature, for the duration specified below.
4. Minimum voltage maximum temperature, for the duration specified below.
5. Maximum voltage minimum temperature, for the duration specified below.
6. Perform the Functional Test after exposure.

Table 16 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-557	Power Supply	GPS-3030DD	GW Instek	Verified by GT-539
GT-539	Multimeter	Fluke 77	Fluke	07/2014
GT-97	Temperature / Humidity Chamber	T10RC-1.5	Tenney	07/2014

Table 17 - Test Conditions

Test Condition	Units	Parameters
Quantity		10
Duration	Hours	8 (per corner)
Operational Mode		Powered
Minimum Voltage	V	3.0
Maximum Voltage	V	3.6
Low Temperature	℃	-40
High Temperature	℃	85

6.3. TEST SETUP PHOTOS

Figure 5– Four Corner Setup

6.4. ACCEPTANCE CRITERIA

The DUT must be functionally tested and operate as intended during and after the test.

6.5. TEST RESULTS

DUT passed Four Corners and Functional Testing.

Table 18 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 2 1-10	Four Corners	LREQ-SP02-516	**PASS**	Grayhill Inc.	03/14/2014 – 03/19/2014

7.0 TRANSIT DROP

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Transit Drop	MIL-STD 810G, Method 516.6 / Procedure II	62A22-02-020C	Group 2 1-10	Grayhill Inc.	05/21/2014

7.1. PURPOSE

The package-shipping test is to provide a degree of confidence that material can physically and functionally withstand the relatively infrequent, non-repetitive shocks encountered in handling and transportation.

The potential product issue modes and effects detected in this test are:

- housing cracks
- product/component breakage
- Loose parts

7.2. TEST SETUP DETAILS

1. Visual Inspection of the DUT is to be performed before and after testing.
2. Document the results.
3. Place DUT in its shipping container.
4. Drop package by hand from a height of 48 inches onto a plywood surface.
5. Repeat until all DUT have completed their total drops
6. Perform the Functional Check after the test.

Table 19 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
N/A	Tape Measure	24ft	Hi-Line	N/A
N/A	Plywood Surface	N/A	N/A	N/A

Table 20 - Test Conditions

Test Condition	Units	Parameters
Quantity		10
Drop Height	Inches	48
Number of Drops		3 per orientation
Number of Orientations		8 Corners and 6 surfaces
Operational Mode		Unpowered
Temperature	℃	Ambient
Packing		Shipping Container

7.3. TEST SETUP PHOTOS

Figure 6 – Transit Drop Set Up

Figure 7 – Transit Drop

7.4. ACCEPTANCE CRITERIA

Upon completion of the Transit Drop test, the shipping container is allowed to show damage, but must still adequately protect the DUT. The DUT must be functionally tested and operate as intended. There shall not be any visible damage.

7.5. TEST RESULTS

All DUT passed the functional testing and met above acceptance criteria

Table 21 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 2 1-10	Transit Drop	MIL-STD 810G, Method 516.6 / Procedure II	**PASS**	Grayhill Inc.	05/21/2014

Figure 8 – DUT Packaging after Transit Drop

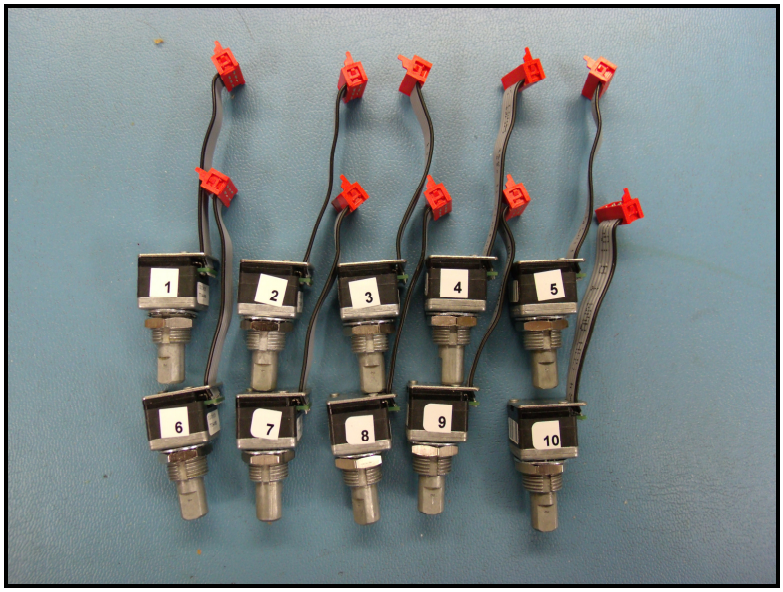


Figure 9 – DUT after Transit Drop

8.0 OPERATING HIGH TEMPERATURE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Operating High Temperature	LREQ-SP02-516	62A22-02-020C	Group 4 1-10	Grayhill Inc.	03/03/2014 – 03/07/2014

8.1. PURPOSE

This test simulates the exposure of the DUT to high temperatures with electrical operation, e.g. the use of the system/components at very high ambient temperature. Failure mode is electrical malfunction caused by high temperature.

8.2. TEST SETUP DETAILS

1. Visual Inspection of the DUT is to be performed before and after testing.
2. Place the DUT in the chamber.
3. Power up the chamber and let it stabilize at the specified temperatures.
4. Set DUT in normal operating mode.
5. Power up DUT by attaching its cable to test interface hardware.
6. Check DUT for operational function a minimum of once per day.
7. When the set duration is complete, return the DUT to ambient conditions.
8. Perform the Functional Test after exposure.

Table 22 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-1006	Temperature and Humidity Chamber	SM-8-8200	Thermotron	01/2015
GT-121	Multimeter	U1272A	Agilent	05/2015
GHSD-072	Power Supply	6038A	Hewlett Packard	Verified by use of GT-121

Table 23 - Test Conditions

Test Condition	Units	Parameters
Quantity		10
Duration	Hours	96
Operational Mode		Powered
Power	Volts	3.3
Maximum Temperature	℃	85

8.3. TEST SETUP PHOTOS

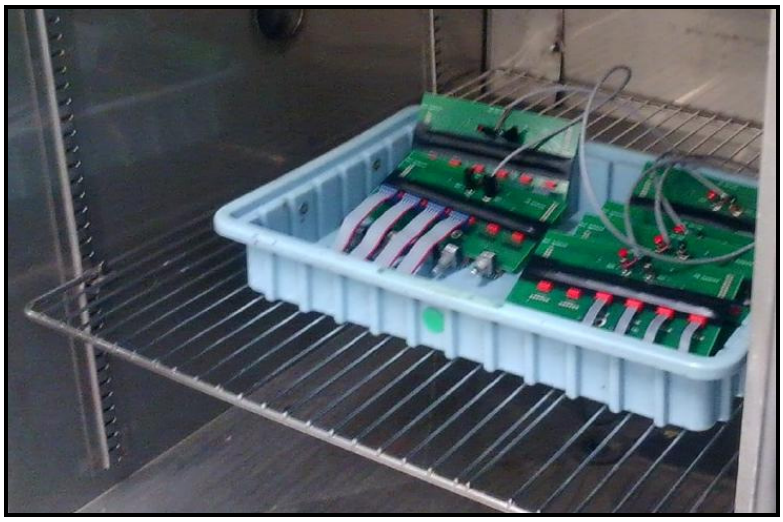


Figure 10 – Operating High Temperature Test Setup

8.4. ACCEPTANCE CRITERIA

The DUT must pass the Visual Check and Functional Check

8.5. TEST RESULTS

Functional status was verified by performing a functional test on the units after testing This functional test included electrical and mechanical validation of each test sample. All DUT passed the functional testing. Visually, the DUT did not show any signs of degradation

Table 24 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 4 1-10	Operating High Temperature	LREQ-SP02-516	**PASS**	Grayhill Inc.	03/03/2014 – 03/07/2014

9.0 OPERATING LOW TEMPERATURE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Operating Low Temperature	LREQ-SP02-516	62A22-02-020C	Group 4 1-10	Grayhill Inc.	03/07/2014 – 03/11/2014

9.1. PURPOSE

This test simulates the exposure of the DUT to low temperatures with electrical operation, e.g. the use of the system/components at very low ambient temperature. Failure mode is electrical malfunction caused by low temperature.

9.2. TEST SETUP DETAILS

1. Visual Inspection of the DUT is to be performed before and after testing.
2. Place the DUT in the chamber.
3. Power up the chamber and let it stabilize at the specified temperatures.
4. Set DUT in normal operating mode.
5. Power up DUT by attaching its cable to test interface hardware.
6. Check DUT for operational function a minimum of once per day.
7. When the set duration is complete, return the DUT to ambient conditions.
8. Perform the Functional Test after exposure.

Table 25 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-1006	Temperature and Humidity Chamber	SM-8-8200	Thermotron	01/2015
GT-121	Multimeter	U1272A	Agilent	05/2015
GHSD-072	Power Supply	6038A	Hewlett Packard	Verified by use of GT-121

Table 26 - Test Conditions

Test Condition	Units	Parameters
Quantity		10
Duration	Hours	96
Operational Mode		Powered
Power	Volts	3.3
Minimum Temperature	℃	-40

9.3. TEST SETUP PHOTOS

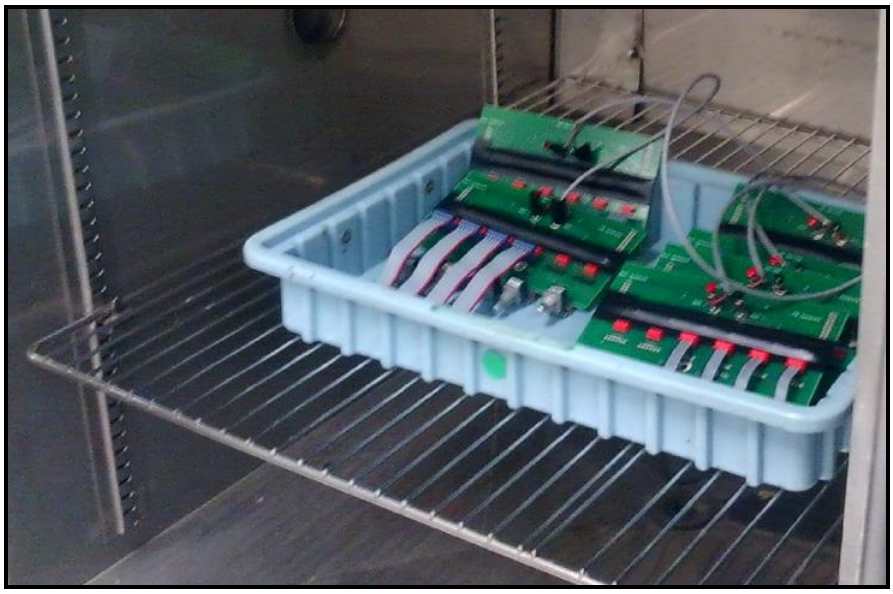


Figure 11 – Operating Low Temperature Test Setup

9.4. ACCEPTANCE CRITERIA

The DUT must pass the Visual Check and Functional Check.

9.5. TEST RESULTS

Functional status was verified by performing a functional test on the units after testing . This functional test included electrical and mechanical validation of each test sample. All DUT passed the functional testing. Visually, the DUT did not show any signs of degradation

Table 27 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 4 1-10	Operating Low Temperature	LREQ-SP02-516	**PASS**	Grayhill Inc.	03/07/2014 – 03/11/2014

10.0 STORAGE HIGH TEMPERATURE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Storage High Temperature	LREQ-SP02-516	62A22-02-020C	Group 4 1-10	Grayhill Inc.	03/28/2014 – 04/01/2014

10.1. PURPOSE

This test was conducted for the purpose of determining the resistance of DUT from constant extreme low or high temperature. Any changes to the physical properties or dimensions of the material can result in poor sealing, binding of moving components or the loss of heat sinking capabilities.

10.2. TEST SETUP DETAILS

1. Visual examination of the test item with special attention to stress areas such as corners of molded housing and document the results.
2. Take picture of the test item.
3. Set Temperature Chamber as specified in the test plan for storage.
4. Maintain the storage temperature for a period as specified in the test plan.
5. Adjust Temperature Chamber to standard ambient and maintain until the test item has achieved temperature stabilization.
6. Conduct a complete visual examination of the test item and document the results.
7. Compare these data with the initial visual examination.
8. Perform functional check on the test item.

Table 28 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-1006	Temperature and Humidity Chamber	SM-8-8200	Thermotron	08/2014

Table 29 - Test Conditions

Test Condition	Units	Parameters
Quantity		10
Duration	Hours	96
Operational Mode		Unpowered
Temperature	℃	100

10.3. TEST SETUP PHOTOS

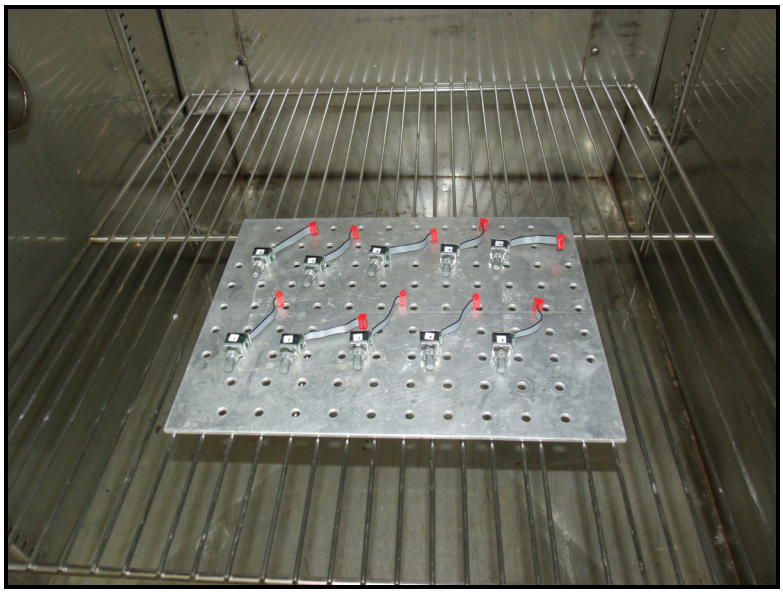


Figure 12 – High Storage Test Setup

10.4. ACCEPTANCE CRITERIA

Upon completion of the High Storage Temperature test, no degradation shall be observed with the DUT. There shall not be any visible damage.

10.5. TEST RESULTS

Functional status was verified by performing a functional test on the units after testing This functional test included electrical and mechanical validation of each test sample. All DUT passed the functional testing. Visually, the DUT did not show any signs of degradation.

Table 30 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 4 1-10	Storage High Temperature	LREQ-SP02-516	**PASS**	Grayhill	03/28/2014 – 04/01/2014

11.0 STORAGE LOW TEMPERATURE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Storage Low Temperature	Storage Low Temperature	LREQ-SP02-516	Group 4 1-10	Grayhill Inc.	04/01/2014 – 04/02/2014

11.1. PURPOSE

This test was conducted for the purpose of determining the resistance of DUT from constant extreme low or high temperature. Any changes to the physical properties or dimensions of the material can result in poor sealing, binding of moving components or the loss of heat sinking capabilities.

11.2. TEST SETUP DETAILS

1. Visual examination of the test item with special attention to stress areas such as corners of molded housing and document the results.
2. Take picture of the test item.
3. Set Temperature Chamber as specified in the test plan for storage.
4. Maintain the storage temperature for a period as specified in the test plan.
5. Adjust Temperature Chamber to standard ambient and maintain until the test item has achieved temperature stabilization.
6. Conduct a complete visual examination of the test item and document the results.
7. Compare these data with the initial visual examination.
8. Perform functional check on the test item.

Table 31 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-1006	Temperature and Humidity Chamber	SM-8-8200	Thermotron	08/2014

Table 32 - Test Conditions

Test Condition	Units	Parameters
Quantity		10
Duration	Hours	96
Operational Mode		Unpowered
Temperature	℃	-55

11.3. TEST SETUP PHOTOS

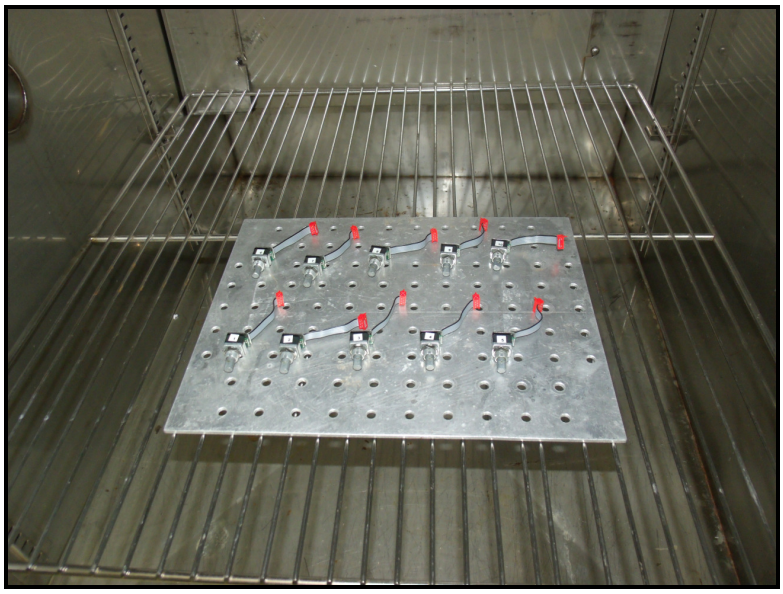


Figure 1 – Storage Low Temperature Test Setup

11.4. ACCEPTANCE CRITERIA

Upon completion of the High Storage Temperature test, no degradation shall be observed with the DUT. There shall not be any visible damage.

11.5. TEST RESULTS

Functional status was verified by performing a functional test on the units after testing This functional test included electrical and mechanical validation of each test sample. All DUT passed the functional testing. Visually, the DUT did not show any signs of degradation.

Table 33 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 4 1-10	Storage Low Temperature	LREQ-SP02-516	**PASS**	Grayhill	04/01/2014 – 04/05/2014

12.0 PUSH BUTTON LIFE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Push Button Life	PS62	62A22-02-020C	Group 5 1 - 30	Grayhill Inc.	03/12/2014 – 03/24/2014

12.1. PURPOSE

The purpose for this test is to determine the effects of subjecting the electrical and electronic parts, which are actuated with the finger sized tips that pressed against the Push Buttons to a number of operations approximating to the life of the DUT.

12.2. TEST SETUP DETAILS

1. Perform initial force and travel
2. Visual Inspection of DUT is to be performed before and after testing.
3. Mount DUT on test fixture.
4. Connect DUT to 5 VDC 10mA Load
5. Verify push button closure (continuity) by using a continuity meter.
6. Set push button tester speed to achieve 60 cycles per minute.
7. Perform functional test after 1 million cycles.

Table 34 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-606	Multimeter	175	Fluke	JAN-2015
GT-228	DC Power Supply	PS281	Tektronix	Verified by GT-606

Table 35 - Test Conditions

Test Condition	Units	Parameters
Quantity		30
Duration	Cycles	1,000,000
Operational Mode		Powered
Power	V	5
Power	mA	10

12.3. TEST SETUP PHOTOS

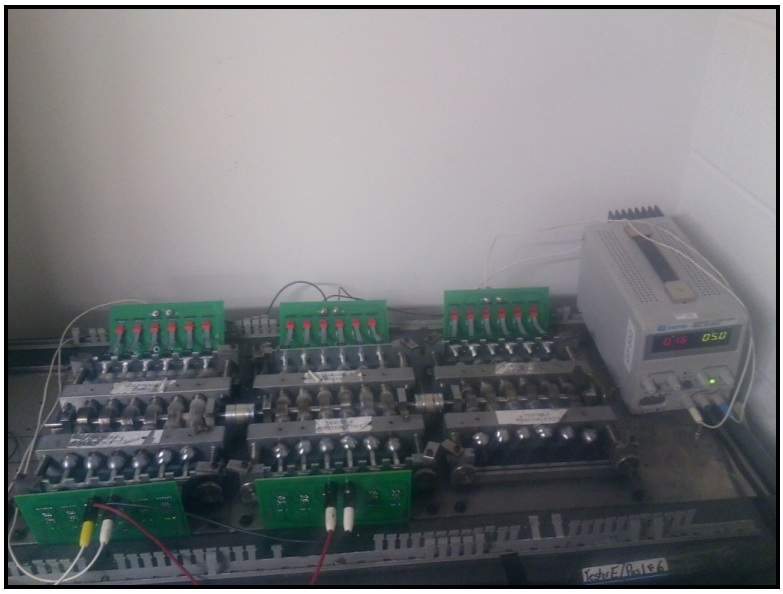


Figure 13 – Push Button Life Test Setup

12.4. ACCEPTANCE CRITERIA

Upon completion of the test DUT shall pass Functional Test .There shall not be any evidence of any visible damage.

12.5. TEST RESULTS

Table 36 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 5 1 - 30	Push Button Life	PS62	**PASS**	Grayhill Inc.	03/12/2014 – 03/24/2014

13.0 THERMAL SHOCK

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Thermal Shock	67B Qual Plan	62A22-02-020C	Group 6 1 - 10	Grayhill Inc.	03/04/2014 – 03/07/2014

13.1. PURPOSE

This test was performed to determine if DUT would maintain the structural integrity after being subjected to a rapid change in temperature multiple times.

13.2. TEST SETUP DETAILS

1. Visual examination of the test item with special attention to stress areas such as corners of molded housing and document the results.
2. Take picture of the test item.
3. Set Temperature Chamber as specified in the test plan for thermal shock.
4. Maintain the thermal shock temperature for a period as specified in the test plan.
5. Adjust Temperature Chamber to standard ambient and maintain until the test item has achieved temperature stabilization.
6. Conduct a complete visual examination of the test item and document the results.
7. Compare these data with the initial visual examination.

Table 37 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT- 1008	Thermal Shock	VTS-3-6-6-SC/WC	Cincinnati Sub Zero	10–2014
GT-542	Thermometer	EasyView 15	Extech	08– 2014

Table 38 - Test Conditions

Test Condition	Units	Parameters
Quantity	Assemblies	10
Test Duration	Cycles	25
Operational Mode		Unpowered
Dwell Duration	Hours	1
Minimum Temperature	°C	-55
Maximum Temperature	°C	100

13.3. TEST SETUP PHOTOS

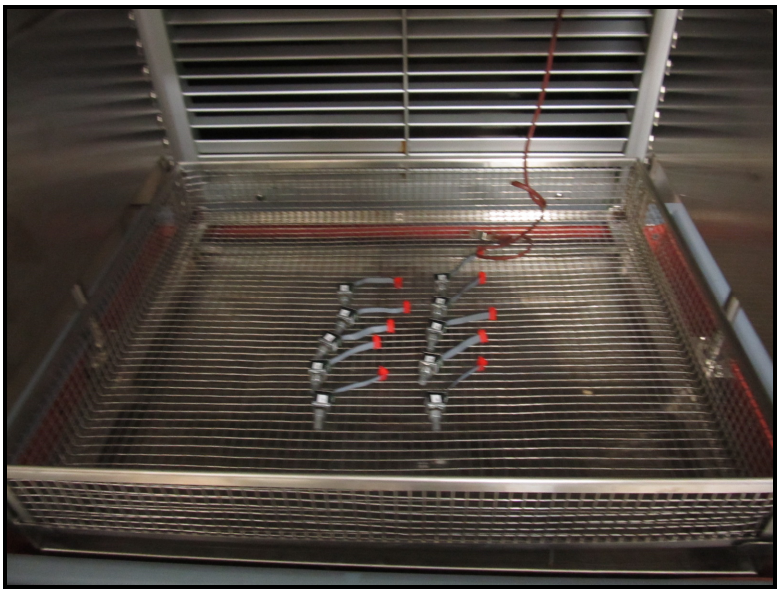


Figure 14 – Thermal Shock Test Setup

13.4. ACCEPTANCE CRITERIA

The DUT must have no epoxy cracking, no part breakage, and no disassembly of parts. The DUT must be functionally tested and operate as intended after test. All Critical Flag Dimensions shall be within specification

13.5. TEST RESULTS

All DUT passed thermal shock.

Table 39 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 6 1 - 10	Thermal Shock	LREQ-SP02-516	**PASS**	Grayhill	03/04/2014 – 03/07/2014

14.0 RANDOM VIBRATION

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Random Vibration	LREQ-SP02-516	62A22-02-020C	Group 6 1 - 10	Grayhill Inc.	03/10/2014 – 03/11/2014

14.1. PURPOSE

The purpose of this test is to evaluate the product design in terms of its ability to withstand random vibration. The potential product failure modes and effects detected in this test are:

- cracked housing/components
- broken product/components
- open solder joints
- dislodged parts
- Loose mounting interfaces

14.2. TEST SETUP DETAILS

1. Visual Inspection of the unit is to be performed before and after testing
2. Attach test product(s) in specified orientation.
3. Attach connector(s) and tie down wire harness(es) at appropriate lengths, if required.
4. Apply vibration, temperature and voltage per specified levels and verify operation, if required.
5. Test product(s) for specified duration.
8. Subject product to conditions in Test Checkpoint Table.
9. Repeat steps 5 – 10 until all modules have been tested for their total duration.
10. Perform the Functional Check after exposure.

Table 40 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-353	Shaker Table	DS-11000VH/1.7-50	Dynamic Solutions	Calibration Not Required
GT-354	Shaker Table Amplifier	SA-50	Dynamic Solutions	Calibration Not Required
GT-355	Shaker Table Controller	DVC-8	Vibration World	May 2015
GT-37	Shear Accelerometer	352C42	PCB Piezotronics	August 2015

Table 41 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	10
Duration	Hours	4
Operational Mode		Unpowered
Applicable Axes	3	Longitudinal, Transverse, and Vertical
Temperature	°C	Ambient
Acceleration Level(s)	Grms	3.78
Lower Limit Frequency	Hz	5
Upper Limit Frequency	Hz	500

14.3. TEST SETUP PHOTOS

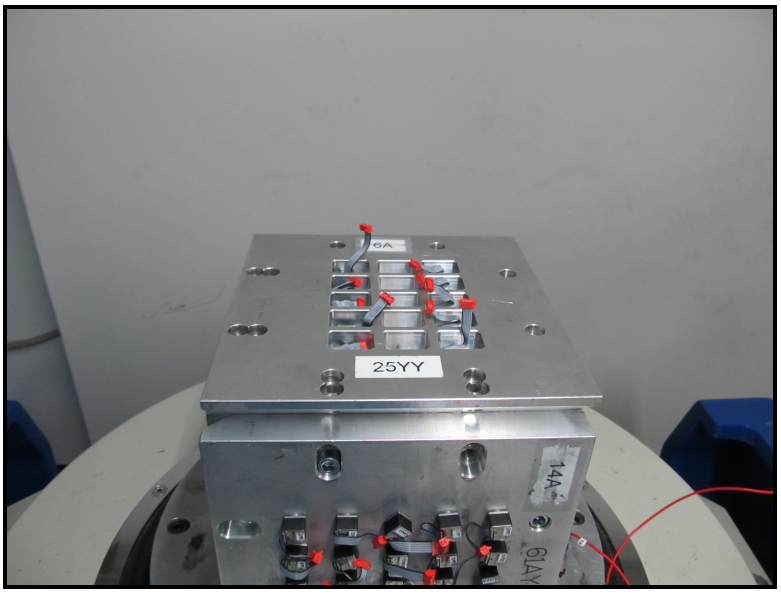


Figure 15 – Random Vibration Test Setup

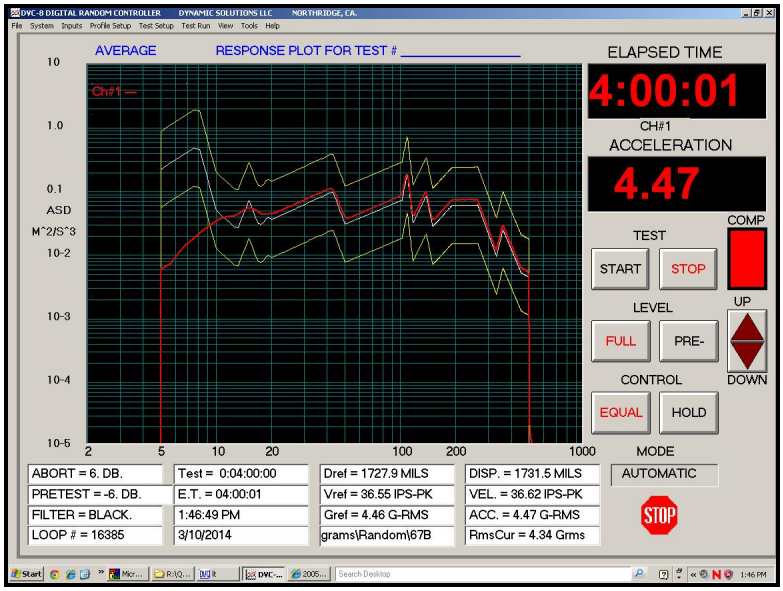


Figure 16 – Random Vibration Wave Form

14.4. ACCEPTANCE CRITERIA

Upon completion of the Random Vibration test, the DUT must be functionally tested and operate as intended. There shall not be any visible damage such as broken, loose, deformed or displaced parts. There shall be no change in the shaft position.

14.5.TEST RESULTS

All DUT passed the functional testing and showed no evidence of damage..

Table 42 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 6 1 - 10	Random Vibration	LREQ-SP02-516	**PASS**	Grayhill	03/10/2014 – 03/11/2014

15.0 MECHANICAL SHOCK

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Mechanical Shock	LREQ-SP02-516	62A22-02-020C	Group 6 1 - 10	Grayhill Inc.	04/28/2014

15.1. PURPOSE

The purpose of this test is to validate the manufacturing process in its ability to produce a product capable of withstanding the effects of shipping, handling, installation, and operational shock. The potential product issue modes and effects detected in this test are:

- Housing cracks
- Product/component breakage
- Inadvertent activation

15.2. TEST SETUP DETAILS

1. Visual Inspection of the DUT is to be performed before and after testing.
2. Verify specified test conditions table with test fixture on test table.
3. Place product in a holding fixture in specified orientation.
4. Attach connector(s) and tie down wire harness at appropriate lengths, if required.
5. Monitor DUT's outputs, if required.
6. Test product for specified shocks/axis.
7. Repeat until all DUT have completed their total shocks/unit.
8. Perform the Visual Examination and Functional Check after the test.

Table 43 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-353	Shaker Table	DS-11000VH/1.7-50	Dynamic Solutions	Calibration Not Required
GT-354	Shaker Table Amplifier	SA-50	Dynamic Solutions	Calibration Not Required
GT-355	Shaker Table Controller	DVC-8	Vibration World	May 2015
GT-532	Accelerometer	M-350A04	PCB Piezotronics	April 2014

Table 44 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	10
Operational Mode		Unpowered
Pulse Type		Half Sine
Acceleration	G	50
Pulse duration	'msec.	11
Direction		3 in each of +/-X, +/-Y, +/-Z (18 shocks total)

15.3. TEST SETUP PHOTOS

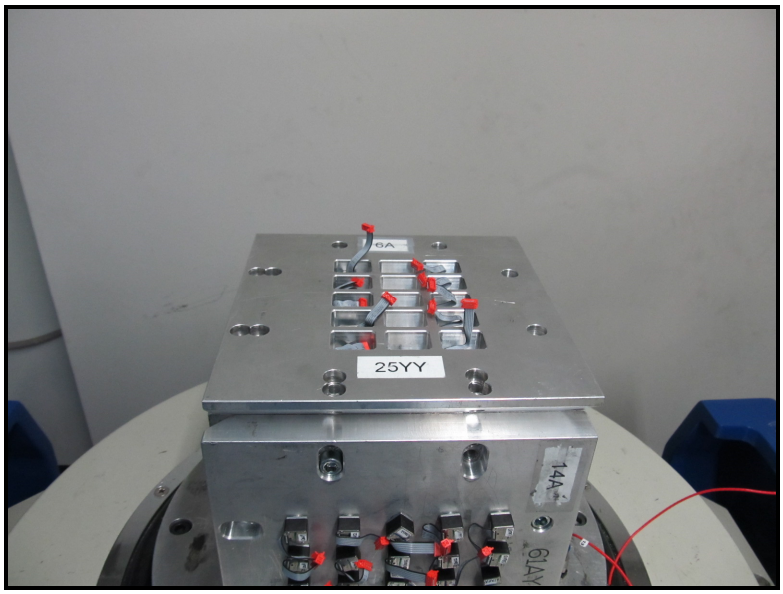


Figure 17 – Mechanical Shock Test Setup

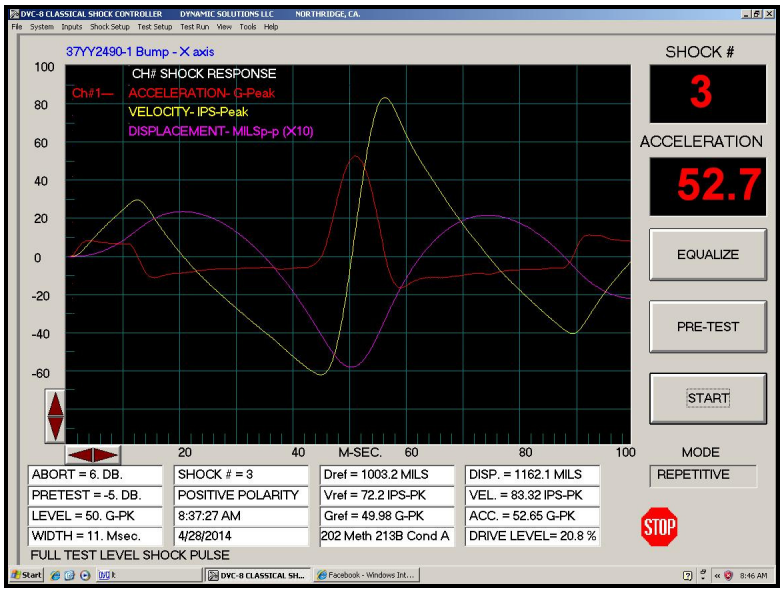


Figure 18 – Mechanical Shock Wave Form

15.4. ACCEPTANCE CRITERIA

Upon completion of the Mechanical Shock test, the DUT must be functionally tested and operate as intended. There shall not be any visible damage

15.5.TEST RESULTS

Functional status was verified by performing a functional test on the DUT after testing. This functional test included visual validation of the DUT as well as electrical and mechanical validation of each test sample. All DUT passed the functional testing.

Table 45 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 6 1 - 10	Mechanical Shock	LREQ-SP02-516	**PASS**	Grayhill	04/28/2014

16.0 ROTATIONAL LIFE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Rotational Life	LREQ-SP02-516	62A22-02-020C	Group 8 1 - 30	Grayhill Inc.	03/19/2014 – 04/26/2014

16.1. PURPOSE

The purpose for this test is to determine the effects of subjecting the electrical and electronic parts, which are rotated DUT shaft clockwise and counter clockwise type motion, to a number of operations approximating the life of the parts. Functional test measurements shall be made prior to and after test, which would show the effects of DUT shaft rotation.

16.2. TEST SETUP DETAILS

1. Visual Inspection of DUT is to be performed before and after testing.
2. Mount DUT on test fixture.
3. Set and adjust test fixture to Smart Motor Life Tester to assure that it rotated DUT correctly.
4. Set Life Tester to rotate clockwise 25 times and counter clockwise 25 time.
5. Power up DUT by attaching its cable to PC to I2C Adaptor that connected to the Laptop.
6. Monitor DUT during test by using Joystick Monitoring Software.
7. When the total number of cycles are complete, return the DUT to ambient conditions.
8. Perform the Functional Test.

Table 46 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
RLS-49	Rotational Life Tester	NA	Grayhill, Inc	Calibration Not Required
RLS-81	Rotational Life Tester	NA	Grayhill, Inc	Calibration Not Required
RLS-75	Rotational Life Tester	NA	Grayhill, Inc	Calibration Not Required

Table 47 - Test Conditions

Test Condition	Units	Parameters
Quantity		30
Duration	Cycles	1,000,000
Cycle Rate	CPM	10 (20 RPM)
Operational Mode		Operating Unpowered
Maximum Mounting Torque	In/lb	15
Temperature	℃	25.1
Humidity	RH%	17.8

16.3. TEST SETUP PHOTOS

Figure 19 – Rotational Life Test Setup

16.4. ACCEPTANCE CRITERIA

The DUT must be functionally tested and operate as intended during and after the test.
DUT must have no damage or disassembled parts.

16.5. TEST RESULTS

The (30) DUT that were subject to the rotational life test passed all functional testing, and had no physical damage.

Table 48 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
Group 8 1 - 30	Rotational Life Test	LREQ-SP02-516	**PASS**	Grayhill Inc.	03/19/2014 – 04/26/2014

Grayhill INC.
Intuitive Human Interface Solutions

Device Under Test:

62A22-02-020C

Environmental Test:
Radiated Immunity, Radiated Emission, Conducted Immunity, Conducted Emission, ESD, Magnetic Field

Physical Test:

Test Report Number:	**SP02-516 EMC**
Test Start Date:	**05/27/2014**
Test Completion Date:	**05/29/2014**
Test Facility:	**Grayhill QA Lab**
Test Requested By:	**Jason Kifer**
Test Performed By:	 **Rupinder Bains** **Lab Technician**
Report Written By:	 **Rupinder Bains** **Lab Technician**
Report Approved By:	 **Nicole Jachna** **Quality Lab Manager**

1.0 RADIATED IMMUNITY

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Radiated Immunity	IEC 61000-4-3	62A22-02-020C	1 -2	Grayhill Inc.	05/27/2014 to 05/28/2014

1.1. PURPOSE

The purpose of this test is to expose the DUT to radiated electromagnetic fields over the frequency range of 80 MHz to1000 MHz with modulation required by IEC 61000-4-3. The minimum applied field intensity is required to be 10 Volts per meter. The test shall be so repeated that each side of the DUT faces the antenna. For each orientation of the DUT, the radiating antenna shall be positioned so that the E-field polarization is horizontal and vertical.

1.2. OPERATING CONDITIONS OF DUT

DC Power Supply used to supply five volts to power the DUT. DUT was monitored by two Multimeters.

1.3. DUT MODIFICATIONS

No modifications were made to the DUT at Grayhill's test facility in order to comply with the standards listed in this report.

1.4. TEST FACILITIES AND INSTRUMENTATION

A complete list of the test equipment is provided in Equipment List Table. The equipment is calibrated at regular intervals with traceability to the National Institute of Standards and Technology (NIST).

1.5. IMMUNITY TEST REQUIREMENTS

The basic standard is IEC 61000-4-3. The DUT is exposed to radiated electromagnetic fields over the frequency range from 80 MHz to1000 MHz. The minimum applied field intensity is required to be 10 Volts per meter. The test signal is amplitude modulated to a depth of 80% with a 1 kHz sine wave. The test level in rms refers to the equivalent un-modulated open circuit amplitude of the test signal. Performance criteria A are required.

The test shall be so repeated that each side of the DUT faces the antenna. For each orientation of the DUT, the radiating antenna shall be positioned so that the E-field polarization is horizontal and vertical.

1.6. TEST SETUP DETAILS

The tests were performed using standard procedures of the IEC 61000-4-3: 2010 specification. The specific details of the test are described below for each frequency range.

The RF immunity test was repeated so that each side of the DUT was facing the transmitting antenna. For each orientation of the DUT, the radiating antenna was positioned so that the E-field polarization is horizontal and vertical. A computer controlled the signal generator, and spectrum analyzer. The computer maintained the amplitude of the applied signal at or slightly above the required amplitude as recorded during the calibration procedures. If the DUT responded to the applied signal, the amplitude of the signal was reduced and then slowly raised until the threshold of response was determined. The nature of the response was recorded in addition to the frequency and threshold amplitude of the applied signal. The DUT operation was constantly monitored during the tests.

Reference the Quality Standards Manual Test Lab Procedure (QSM-TLP), for details on setting up and running the Radiated Immunity test.

Table 1 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-143	Hygrometer	MDM25	Mitchell Instrument	06/2014
GT-325	Pre-Amp.	757LCB-CE	Kalmus	01/2016
GT-326	Bilog Antenna	CBL6140A	Schaffner	01/2016
GT-328	Spectrum Analyzer	8594EM	Hewlett Packard	01/2016
GT-329	Signal Generator	8648B	Hewlett Packard	12/2013
GT-336	Function Generator	DS335	Stanford Research	8/2014
Gt-340	Isotropic Field Probe	HI-4422	Holaday	01/2016
GT-120	Multimeter	U1272A	Agilent	05/2015
GT-227	Multimeter	True RMS	Fluke	07/2014
GT-557	DC Power Supply	GPS-3030DD	GwINSTEK	Verified with GT-227

Table 2 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	2
Operational Mode		Powered
Operational Voltage	DC Volts	5
Room Temperature	°C	23.4
Room Humidity	%Rh	17
Frequency	Hz	80 MHz to 1,000 MHz
Test Field Strength	V/m	10

1.7. TEST SETUP PHOTOS

Figure 1 - Radiated Immunity Test Setup

Figure 2 - Radiated Immunity Test Setup

1.8. DUT CONFIGURATION (GENERAL)

DC Power Supply used to supply five volts to power the DUT. DUT was monitored by an Oscilloscope.

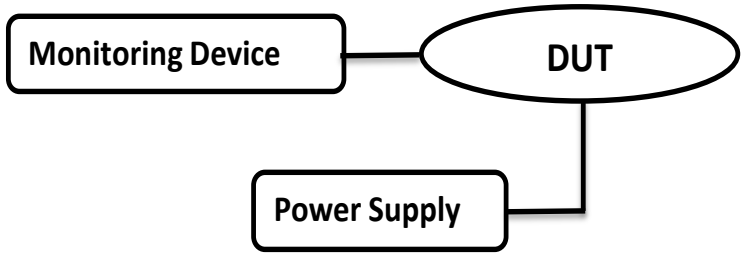


Figure 3 – DUT Configuration

1.9. ACCEPTANCE CRITERIA

The DUT shall continue to operate as intended. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the DUT is used as intended. In some cases, the performance level may be replaced by a permissible loss of performance. If the manufacturer does not specify the minimum performance level or the permissible performance loss, then either of these may be derived from the product description and documentation and what the user may reasonably expect from the apparatus if used as intended.

1.10. TEST RESULTS

The DUT passed Radiated Immunity with no loss of functionality during or after test.

Table 3 – Test Results of DUT with serial # 1

Frequency (MHz)	Antenna Polarization	DUT Position/Table Orientation	Applied Field (V / m)	Test Results
80 - 1000	Vertical	Cable facing East	10	PASS
80 - 1000	Horizontal	Cable facing East	10	PASS
80 - 1000	Vertical	Cable facing North	10	PASS
80 - 1000	Horizontal	Cable facing North	10	PASS
80 - 1000	Vertical	Cable facing West	10	PASS
80 - 1000	Horizontal	Cable facing West	10	PASS
80 - 1000	Vertical	Cable facing South	10	PASS
80 - 1000	Horizontal	Cable facing South	10	PASS
80 - 1000	Vertical	Shaft facing North	10	PASS
80 - 1000	Horizontal	Shaft facing South	10	PASS
80 - 1000	Vertical	Shaft facing North	10	PASS
80 - 1000	Horizontal	Shaft facing South	10	PASS

Table 4 – Test Results of DUT with serial # 2

Frequency (MHz)	Antenna Polarization	DUT Position/Table Orientation	Applied Field (V / m)	Test Results
80 - 1000	Vertical	Cable facing East	10	PASS
80 - 1000	Horizontal	Cable facing East	10	PASS
80 - 1000	Vertical	Cable facing North	10	PASS
80 - 1000	Horizontal	Cable facing North	10	PASS
80 - 1000	Vertical	Cable facing West	10	PASS
80 - 1000	Horizontal	Cable facing West	10	PASS
80 - 1000	Vertical	Cable facing South	10	PASS
80 - 1000	Horizontal	Cable facing South	10	PASS
80 - 1000	Vertical	Shaft facing North	10	PASS
80 - 1000	Horizontal	Shaft facing South	10	PASS
80 - 1000	Vertical	Shaft facing North	10	PASS
80 - 1000	Horizontal	Shaft facing South	10	PASS

2.0 RADIATED EMISSIONS

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Radiated Emissions	ANSI C63.4	62A22-02-020C	1 - 2	Grayhill Inc.	05/28/2014

2.1. PURPOSE

The purpose of this test is to measure the emissions characteristics of the DUT. This measurement will be performed over the frequency range of 30 MHz to1000 MHz at a distance specified in the setup portion of ANSI C63.4.

2.2. TEST SETUP DETAILS

1. Connect DUT with 3 Meters of shielded cable to the power supply.
2. Power DUT with 5 VDC Power Supply.
3. Place DUT 3 meters from antenna in chamber.
4. DUT is tested from 30 MHz to 1000 MHZ Vertical and Horizontal orientation.

Table 5 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-325	Pre-Amp.	757LCB-CE	Kalmus	01/2016
GT-326	Bilog Antenna	CBL6140A	Schaffner	01/2016
GT-328	Spectrum Analyzer	8594EM	Hewlett Packard	01/2016
GT-329	Signal Generator	8648B	Hewlett Packard	01/2016
GT-336	Function Generator	DS345	Stanford Research	8/2014
GT-557	Power Supply	GPS-3030DD	GW INSTEK	Verified with GT-227
GT-227	Multimeter	True RMS	Fluke	07/2014
GT-143	Hygrometer	MDM25	Mitchell Instrument	06/2014

Table 6 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	2
Duration	Hz	30M-1000MHz
Operational Mode		Powered
Operational Voltage	DC Volts	5
Room Temperature	°C	22.9
Room Humidity	%RH	16

2.3. TEST SETUP PHOTOS

Figure 4 – DUT under Radiated Emissions Test

2.4. ACCEPTANCE CRITERIA

The DUT shall not exceed radiated emissions per ANSI C63.4 microvolts/meter.

2.5. TEST RESULTS

The DUT passed Radiated Emissions test.

Table 7 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
1	Radiated Emissions	ANSI C63.4	**PASS**	Grayhill, Inc.	05/28/2014
2	Radiated Emissions	ANSI C63.4	**PASS**	Grayhill, Inc.	05/28/2014

2.6. TEST RESULTS PHOTOS

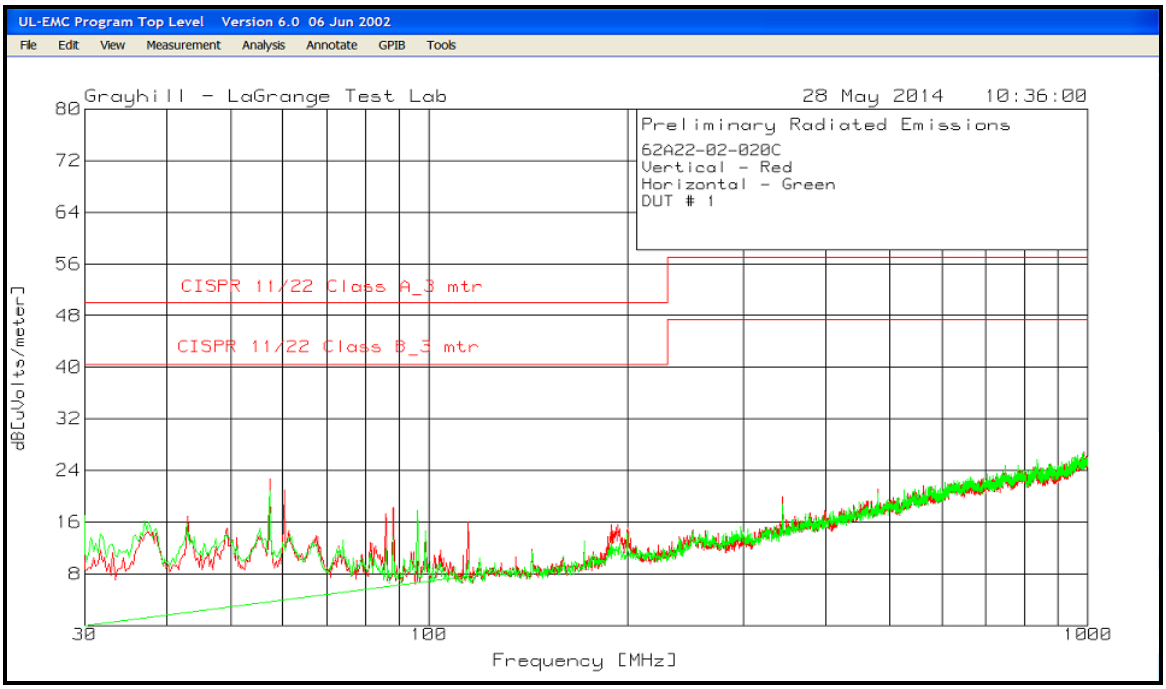


Figure 5 – Radiated Emissions Results (Red Vertical, Green Horizontal)

3.0 CONDUCTED IMMUNITY

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Conducted Immunity	IEC 61000-4-6	62A22-02-020C	1 - 2	Grayhill Inc.	05/27/2014

3.1. PURPOSE

The purpose of this test is to expose the DUT to RF noise applied to its DC power input leads and I/O leads. The required RF signal is applied over the frequency range of 150 kHz to 80 MHz and has amplitude of 10 Volts rms. The required signal is modulated to a depth of 80% with a 1 kHz sine wave.

3.2. TEST SETUP DETAILS

1. Perform Functional test on all DUT
2. Connect DUT with DC power supply
3. Power DUT with five 5 VDC
4. Place DUT ten (10) centimeters from ground plane
5. Test DUT from 150 k Hz to 80 MHZ at 10 V RMS
6. Monitor DUT with an Oscilloscope
7. Perform Functional test after the Conductive Immunity Test.

Table 8 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-325	Pre-Amp.	757LCB-CE	Kalmus	01/2016
GT-328	Spectrum Analyzer	8594EM	Hewlett Packard	01/2016
GT-329	Signal Generator	8648B	Hewlett Packard	01/2016
GT-336	Function Generator	DS345	Stanford Research	8/2014
GT-327	Coupling / Decoupling Network	9805-1 M2/M3	Solar	05/2014
GT-348	Attenuator	1N100W-6dB	Inmet Corp	05/2014
GT-557	Power Supply	GPS-3030DD	GW INSTEK	Verified with GT-227
GT-227	Multimeter	True RMS	Fluke	07/2014
GT-120	Multimeter	U1272A	Agilent	05/2015
GT-143	Hygrometer	MDM25	Mitchell Instrument	06/2014

Table 9 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	2
Duration	Hz	150kHz – 80MHz
Operational Mode		Powered
Operational Voltage	DC Volts	5
Power Level	V RMS	10
Room Temperature	°C	23.1
Room Humidity	%RH	17

3.3. TEST SETUP PHOTOS

Figure 6 – Conducted Immunity test setup

3.4. ACCEPTANCE CRITERIA

The DUT shall continue to operate as intended. No degradation of performance or loss of function is allowed.

3.5. TEST RESULTS

The DUT passed Conducted Immunity test with no interference of operation during and after test in all test conditions.

Table 10 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
1	Conductive Immunity	IEC 61000-4-6	PASS	Grayhill, Inc.	05/27/2014
2	Conductive Immunity	IEC 61000-4-6	PASS	Grayhill, Inc.	05/27/2014

4.0 CONDUCTED EMISSIONS

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Conducted Emissions	EN 55022 ANSI C63.4	62A22-02-020C	1 - 2	Grayhill Inc.	05/27/2014

4.1. PURPOSE

The purpose of this test is to measure the conducted emissions characteristics of the DUT from the AC/DC input of the DUT. This measurement will be performed over the frequency range of 150 kHz to 30 MHz. Measurements shall be repeated on both leads within the power cord.

4.2. TEST SUMMARY

The DUT (Device under Test) is the 62AY series manufactured by Grayhill, Inc. The DUT was tested to the emissions requirements of CENELEC document EN 55022 (2010), for class "B" equipment. Test methods chosen are appropriate for intended use. Conducted Emissions test scans were performed and the DUT was found to be compliant with the Conducted Emissions limits. Testing was based upon the following specs: EN 55022, clauses 5 (Limits for conducted disturbance at main terminals and telecommunication ports). The following is a summary of the test results on table 1.

Table 11 – Limits for conducted disturbance at the main ports of class B ITE

Frequency range MHz	Limits dB(micro V)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50
Note 1 The lower limit shall apply at the transition frequency	Note 2 The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz.	

4.3. TEST SETUP DETAILS

A computer-controlled analyzer was used to perform the conducted emissions measurements. Frequencies ranged from 150 kHz to 30 MHz. The computer recorded the peak of each sub-range. The data was then printed from the computer.

Measurements were repeated on both leads within the input power wires. If the DUT input power wires exceeded 80 cm in length, the excess length of the input wires was made into a 30 to 40 cm bundle near the center of the wires. The LISN was placed on the floor at the base of the test platform and electrically bonded to the ground plane.

Reference the Quality Standards Manual Test Lab Procedure (QSM-TLP), for details on setting up and running the Conducted Emissions tests.

Table 12 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-143	Hygrometer	MDM25	Mitchell Instrument	06/2014
GT-328	Spectrum Analyzer	8594EM	Hewlett Packard	01/2016
GT-329	Signal Generator	8648B	Hewlett Packard	01/2016
GT-338	Transient Limiter	EM-7600	Electro-Metrics	12/2015
GT-330	LISN	9252-50-R-24-BNC	Solar Electronics	12/2015

Table 13 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	2
Operational Mode		Powered
Operational Voltage	DC Volts	5
Temperature	°C	24.3
Humidity	%Rh	31
Frequency	Hz	150 kHz to 30 MHz
Mating Connector Attached	Y/N	Yes

4.4. TEST SETUP PHOTOS

Figure 7 - Conducted Emissions Test Setup

4.5. DUT CONFIGURATION (GENERAL)

DC Power Supply was used to power the DUT via LISN network.

4.6. ACCEPTANCE CRITERIA

Conduct emissions levels must be below levels listed in the class B table of CISP 11, Group I, Class B (See table below).

Table 14 – Class B Test Levels

Frequency (MHz)	Limits dB(µV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
.50 to 5	56	46
5 to 30	60	50

4.7. TEST RESULTS

DUT's conducted emissions levels were below Class B levels.

4.8. CONDUCTED EMISSIONS GRAPHS

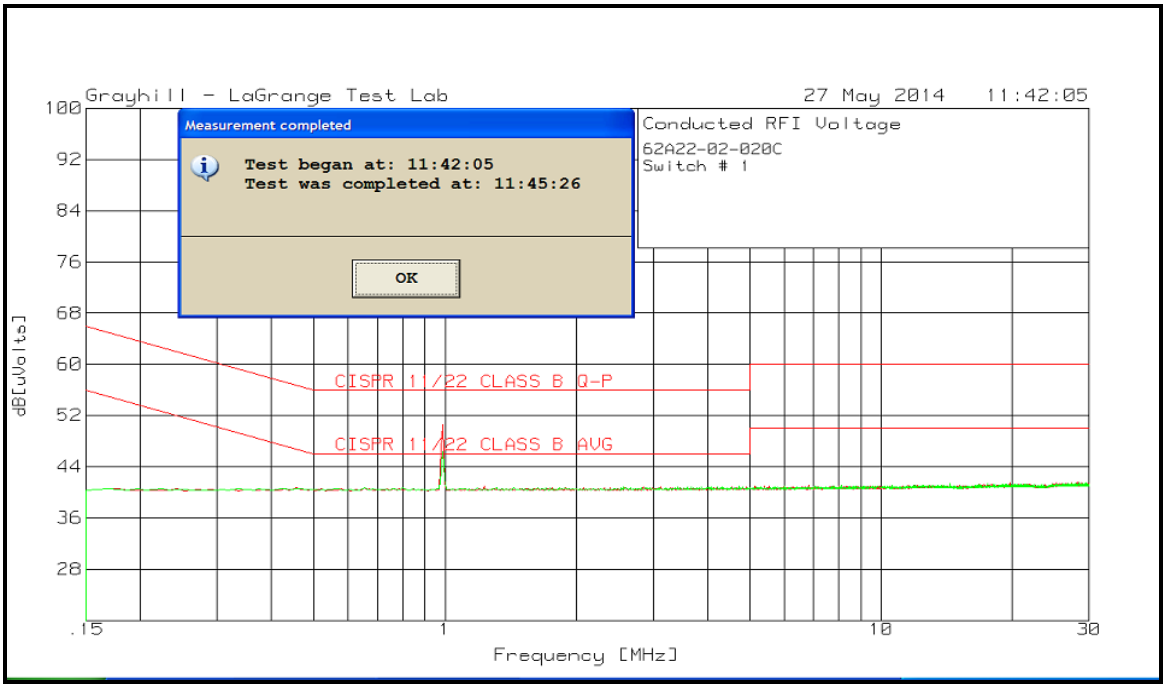


Figure 8 – Conducted Emissions Results

Table 15 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
1	Conductive Emissions	EN 55022 ANSI C63.4	**PASS**	Grayhill, Inc.	05/27/2014
2	Conductive Emissions	EN 55022 ANSI C63.4	**PASS**	Grayhill, Inc.	05/27/2014

4.9. CERTIFICATION

Grayhill, Inc. certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results relate only to the DUT listed herein. Any modifications made to the DUT subsequent to the indicated test dates will invalidate the data and void this certification.

5.0 ELECTROSTATIC DISCHARGE

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Electrostatic Discharge	IEC 61000-4-2	62A22-02-020C	1 - 2	Grayhill Inc.	05/29/2014

5.1. PURPOSE

Electrostatic discharge may occur from the human body or from nearby objects which has been electrically charged due to friction, airflow or material flow across their surface. The purpose of this test is to expose the DUT to Electrostatic Discharges at 8kV or higher using the air discharge method and to Electrostatic Discharges at 8kV or higher using the indirect discharge method. Testing also shall be satisfied at the lower levels. The potential product issue modes and effects detected in this test are:

- Anomalies in performance
- Intermittent operation
- Failure of electrical components

5.2. OPERATING CONDITIONS OF DUT

DC Power Supply used to supply five volts to power the DUT. DUT was monitored by an Oscilloscope during the test.

5.3. DUT MODIFICATIONS

No modifications were made to the DUT at Grayhill's test facility in order to comply with the standards listed in this report.

5.4. TEST FACILITIES AND INSTRUMENTATION

A complete list of the test equipment is provided in Equipment List Table. The equipment is calibrated at regular intervals with traceability to the National Institute of Standards and Technology (NIST).

5.5. IMMUNITY TEST REQUIREMENTS

The basic standard is EN61000-4-2.The DUT is exposed to Electrostatic Discharges at 8k volts using the air discharge method, contact discharge method, and discharge method. A performance criterion B is required.

5.6. TEST SETUP DETAILS

The tests were performed using standard procedures of the IEC 61000-4-2: 2008 specification. The specific details of the test are described below.

1. Visual check.
2. Mount the DUT in the Mounting Orientation specified in the Test Conditions Table if applicable.
3. Load the discharge network specified in the Test Conditions Table.
4. Apply the pulse to the DUT in the sequence specified in the Test Conditions Table.
5. Perform functional check after each voltage level
6. Perform the Visual Check after exposure.

Reference the Quality Standards Manual Test Lab Procedure (QSM-TLP), for details on setting up and running the Electrostatic discharge.

Table 16 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-143	Hygrometer	MDM25	Mitchell Instrument	06/2014
GT-361	ESD Generator	NSG 438	Teseq	12/2014
GT-361	Discharge Network 150pF / 330Ω	403-550	Teseq	12/2014
GT-557	Power Supply	GPS-3030DD	GW INSTEK	Verified with GT-227
GT-227	Multimeter	True RMS	Fluke	07/2014
GT-120	Multimeter	U1272A	Agilent	05/2015

Table 17 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	2
Operational Mode		Powered and Unpowered
Room Temperature	°C	22.1
Room Humidity	%Rh	17
Discharge Network	PF - Ohms	150pF / 330 Ohms
Discharge Location	NA	Shaft, Bushing, Housing, Cable, and Back Plate
Contact Discharge Voltage	k Volts	+/-2, +/-4, +/-8
Indirect Discharge VCP	k Volts	+/-2, +/-4, +/-8
Indirect Discharge HCP	k Volts	+/-2, +/-4, +/-8
Air Discharge Voltage	k Volts	+/-4, +/-8
Test Sequence		See Table # 3

5.7. TEST SETUP PHOTOS

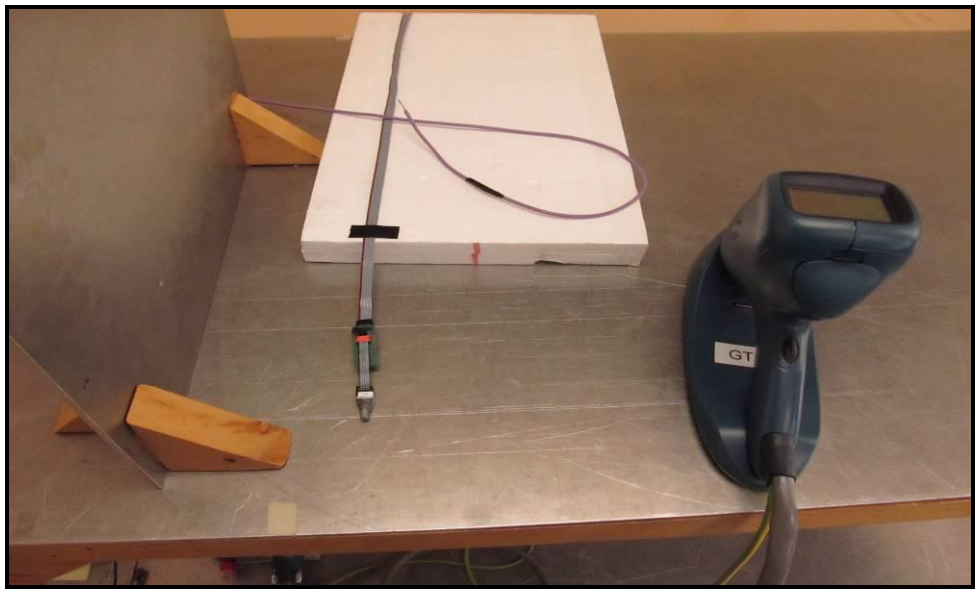


Figure 9 – Electrostatic Discharge Test Setup (Powered)

Figure 10 – Electrostatic Discharge Test Setup (Un-Powered)

5.8. DUT CONFIGURATION (GENERAL)

DUT was connected to a DC power source for Operational mode test. Functional test was performed before and after Powered and Unpowered tests.

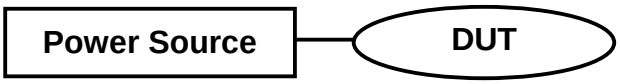


Figure 11 – DUT Configuration

5.9. ACCEPTANCE CRITERIA

The DUT shall continue to operate as intended. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer when the DUT is used as intended. In some cases, the performance level may be replaced by a permissible loss of performance. If the manufacturer does not specify the minimum performance level or the permissible performance loss, then either of these may be derived from the product description and documentation and what the user may reasonably expect from the DUT if used as intended.

5.10. TEST RESULTS

The DUT Passed functional test before and after the Electrostatic Discharge tests.

Table 18 – DUT # 1 ESD test results

Discharge Location	Applied Levels	Type	Number of Tries / Failures	Performance Criteria	Test Results	Test Date
Housing	+/-2, +/-4, +/-8	Air	10 / 0	B	Pass	05/29/2014
Cable	+/-2, +/-4, +/-8	Air	10 / 0	B	Pass	05/29/2014
Shaft	+/-2, +/-4, +/-8	Contact	10 / 0	B	Pass	05/29/2014
Bushing	+/-2, +/-4, +/-8	Contact	10 / 0	B	Pass	05/29/2014
Back Plate	+/-2, +/-4, +/-8	Contact	10 / 0	B	Pass	05/29/2014

Table 19 – DUT # 2 ESD test results

Discharge Location	Applied Levels	Type	Number of Tries / Failures	Performance Criteria	Test Results	Test Date
Housing	+/-2, +/-4, +/-8	Air	10 / 0	B	Pass	05/29/2014
Cable	+/-2, +/-4, +/-8	Air	10 / 0	B	Pass	05/29/2014
Shaft	+/-2, +/-4, +/-8	Contact	10 / 0	B	Pass	05/29/2014
Bushing	+/-2, +/-4, +/-8	Contact	10 / 0	B	Pass	05/29/2014
Back Plate	+/-2, +/-4, +/-8	Contact	10 / 0	B	Pass	05/29/2014

5.11. CERTIFICATION

Grayhill, Inc. certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specifications. The results relate only to the DUT listed herein. Any modifications made to the DUT subsequent to the indicated test dates will invalidate the data and void this certification.

6.0 MAGNETIC FIELD

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Magnetic Field	IEC61000-4-8	62A22-02-020C	1 - 2	Grayhill Inc.	05/29/2014

6.1. PURPOSE

The purpose of this test is to expose the DUT to a magnetic field using an induction coil of standard dimensions (1m x 1m). The coil shall be placed at a distance of 0.1m from the DUT. The induction coil will be rotated by 90 degrees in order to expose the DUT to the test field with different orientations.

6.2. TEST SETUP DETAILS

1. Verify condition of environment and test items prior to start of test, per lab manual.
2. Plug field coil into the 5-volt AC gray box.
3. Plug the variac into 115-volt AC wall outlet.
4. Plug the ELF magnetic field sensor into the ELF magnetic field meter.
5. Place the field coil on an 80-cm high table.
6. Place the ELF magnetic field sensor in the center of the field coil.
7. On the ELF magnetic field meter turn knob to select the 2G setting (2 Gauss).
8. Adjust the magnetic field to 30 A/m.
9. After adjusting the magnetic field, testing can begin.
10. Remove the field sensor and place the DUT in the center of the coil. Monitor the DUT for any disturbances. Raise the field coil 1-meter from DUT while keeping the DUT centered in field. Again, monitor the DUT for any disturbances.

Table 20 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-557	Power Supply	GPS-3030DD	GW INSTEK	Verified with GT-227
GT-227	Multimeter	True RMS	Fluke	07/2014
GT-344	Power Sensor	E4412A(ECP-E18A	Hewlett Packard	12/2014
GT-109	Oscilloscope	Infinium 500 MHz	Hewlett Packard	06/2014
GT-143	Hygrometer	MDM25	Mitchell Instrument	06/2014

Table 21 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	2
Operational Mode		Powered
Operational Voltage	DC Volts	5
Room Temperature	°C	22.9
Room Humidity	%RH	18
Immunity	A/m	3

6.3. TEST SETUP PHOTOS

Figure 12 – Magnetic Field Test Setup

6.4. ACCEPTANCE CRITERIA

The DUT shall be operative during and after Magnetic Field Test.

6.5. TEST RESULTS

The DUT passed Magnetic field with no interference of operation.

Table 22 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
1	Magnetic Field	IEC61000-4-8	PASS	Grayhill, Inc.	05/29/2014
2	Magnetic Field	IEC61000-4-8	PASS	Grayhill, Inc.	05/29/2014

Intuitive Human Interface Solutions

Device Under Test:
62D SMT - 16, 24, and 32 Position

Physical Test:
Rotational Life

Test Report Number:	LREQ-SP02-2539
Test Start Date:	8/09/2018
Test Completion Date:	8/18/2018
Test Facility:	Grayhill, Inc.
Test Requested By:	Jason Kifer
Test Performed By:	Jake Tilton Laboratory Technician II
Report Written By:	Jake Tilton Laboratory Technician II
Report Approved By:	Nick Walls Quality Lab Manager

1.0 Rotational Life (PS62.)

Test	Specification	DUT Part Number	DUT Serial Number	Test Location	Test Date
Rotational Life	PS62	62D SMT - 16, 24, and 32 Position	1 - 75	Grayhill Inc.	8/09/2018 - 8/18/2018
				Results :	PASS

1.1. PURPOSE

The purpose of this effort is to Rotational life testing of SMT versions of the 16, 24, and 32 position 62D encoder. for the 62D SMT - 16, 24, and 32 Position per PS62, Rotate at 200RPM to 1 million cycles. Check torque at initial and every 250K cycles. Check initial and final code output..

1.2. TEST SETUP DETAILS

1. Perform initial Functional Test.
2. Visual Inspection of DUT is to be performed before and after testing.
3. Mount DUT on test fixture.
4. Set and adjust test fixture to Smart Motor to assure that it rotated DUT correctly.
5. Program Smart Motor at 200 RPM and rotate 360 degree clockwise and back counter clockwise to complete 1 cycle. Run for 250K cycles.
6. After cycles are complete, check torque of all DUT.
7. Repeat steps 5-6 until 1 million total cycles are completed.
8. When the total numbers of cycles are completed, perform the Functional Test.
9. Examined and test DUT then compared with pretest data.

Table 1 – Equipment List

Equipment ID	Equipment Type	Model Number	Manufacturer	Calibration Due Date
GT-400	Torque Wrench	CAL-36/4 Roto Torq	Sturtevant Richmont	4/2019
PAL-7	Torque Sensor	BGI	Mark-10	10/2018
RLS-82 w/fix #55	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-89 w/fix #74	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-92 w/fix #65	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-90 w/fix #63	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-105 w/fix #102	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-72 w/fix #52	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-80 w/fix #54	Rotational Life Cycle Assy.	N/A	Grayhill	N/A
RLS-88 w/fix #62	Rotational Life Cycle Assy.	N/A	Grayhill	N/A

Table 2 - Test Conditions

Test Condition	Units	Parameters
Quantity	DUT	75
Operational Mode		Unpowered
Cycles		750K cycles in CW/CCW
Rotational Speed	CPM	100
Temperature	°C	23

1.3. TEST SETUP PHOTOS

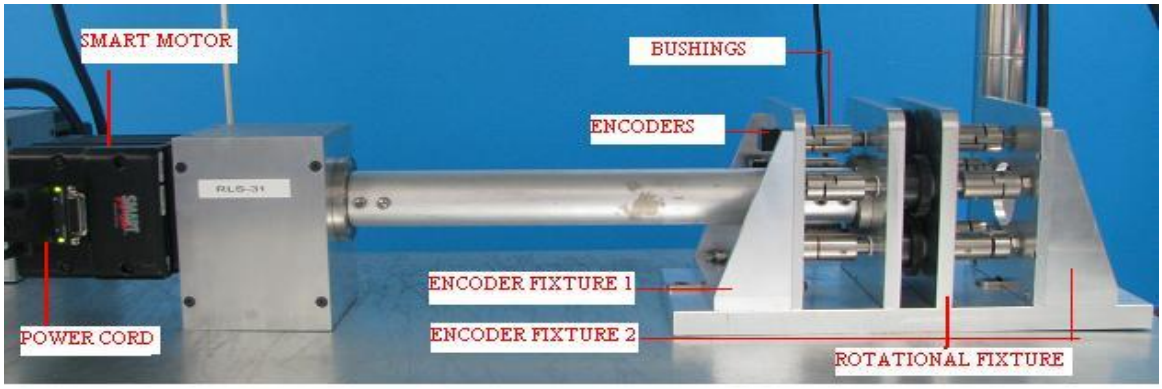


Figure 1 – Rotational Life Setup

1.4. ACCEPTANCE CRITERIA

All 62D SMT - 16, 24, and 32 Position must be functionally tested and operate as intended after the Rotational Life test. There shall not be any evidence of damage or disassembled parts.

PS62, Rotate at 200RPM to 1 million cycles. Check torque at initial and every 250K cycles. Check initial and final code output.

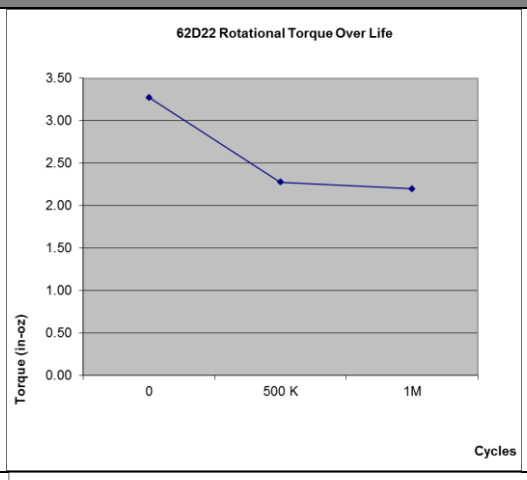
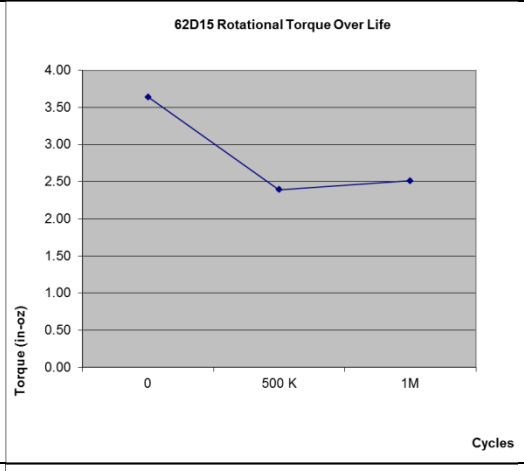
1.5. TEST RESULTS

All 62D SMT - 16, 24, and 32 Position had no failures with torque.
Seven DUT had damaged cables and was unable to check Code output. Damaged cables were determined by engineering to be caused by handling issues and not as a result of the testing. All other DUT passed code output

Table 3 – Test Results

DUT	Test	Specification	Pass	Test Location	Test Date
62D22	Rotational Life	PS62.	PASS	Grayhill, Inc.	8/09/2018 - 8/18/2018
62D15	Rotational Life	PS62.	PASS	Grayhill, Inc.	8/09/2018 - 8/18/2018
62D11	Rotational Life	PS62.	PASS	Grayhill, Inc.	8/09/2018 - 8/18/2018

Table 4 – Test Data

DUT	Data
62D22	
62D15	
62D11