For Scope of Accreditation Under Certificate Number: AT-2021

EMC Technical Report

Prepared For: Johnson Outdoors Marine Electronics, Inc.

Model Covered: PiranhaMAX4 DI
Model Variants: PiranhaMAX4

In Accordance with the:
Electromagnetic Compatibility Directive – 2004/108/EC

Immunity Product Standard: EN 60945:2002
Emissions Product Standard(s):
EN 60945:2002

ACS Report: 15-0530.C08.1A
Report Revision: A
Report Issue Date: February 23, 2016

Project Manager:

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Advanced Compliance Solutions, Inc.

Reviewed by:

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Advanced Compliance Solutions, Inc.

This report must not be used by the client to claim product certification, approval, or endorsement by ANAB, NIST, or any agency of the Federal Government.

This report contains 44 pages

REVISION HISTORY
Report Number: 15-0530.C08.1A
Manufacturer: Johnson Outdoors Marine Electronics, Inc.
Model: PiranhaMAX4 DI

DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
February 23, 2016	---	A	Initial Release	All	Forrest Duncan

Project Information Sheet

ACS Project: 15-0530.C08.1A

Applicant Details

Manufacturer: Johnson Outdoors Marine Electronics, Inc.
Street Address: 678 Humminbird Lane
City, State/Province and Postal Code: Eufaula, AL 36027
Country: USA
Contact: Seth Bergman

Phone: (334) 687-6613
Fax:
Email: sbergman@johnsonoutdoors.com

Sample Information

Model: PiranhaMAX4 DI
Model Variant(s): PiranhaMAX4
Environment of Use: Commercial
Sample Receive Date: January 4, 2016
Sample Receive Condition: Good
Test Mode Description: Monitoring the transducer
Failure Mode (Provided by Mfg.): The Depth reading should stay with +/- 1ft. The manufacturer also declares an exclusion band in the range 195kHz to 205kHz range since the device is tuned to and designed to operate at 200kHz during normal operation.
Highest Data Rate: 120MHz
Source: Microcontroller

Product Description

The Humminbird PiranhaMAX4 DI is a Sonar/Fishfinder product with Down Imaging sonar capability to be used in the marine environment. The variant PiranhaMAX4 is the same as the PiranhaMAX4 SI except depopulated sonar section.

Test Information

Test Start Date: January 4, 2016
Test End Date: January 7, 2016
Emissions Pre-scan Site: SAC
Final Emissions Site: SAC
EMI Freq. Band: 150kHz - 2GHz
RFI Site: FAC
Radiated Emissions Equipment Class: Class B
Harmonic Current EMI Class: N/A

Test Methods Applied

(Check all that apply)

- ☒ CISPR 16-2-1 Ed. 1.1 2005
- ☒ CISPR 16-2-3 1st Ed. 2003
- ☒ IEC 61000-4-2 Ed. 2.0
- ☒ IEC 61000-4-3 Ed. 3.2
- ☒ IEC 61000-4-4 Ed. 3.0
- ☐ IEC 61000-4-5 2nd Ed.
- ☒ IEC 61000-4-6 3rd Ed.
- ☐ IEC 61000-4-8 2nd Ed.
- ☐ IEC 61000-4-11 2nd Ed.

Table of Contents

SECTION A: GENERAL INFORMATION

1.0 Introduction

1.1 Scope

This report documents conformance with the requirements set forth in EN 60945:2002 and details the results of testing performed on January 4, 2016 through January 7, 2016 on the model PiranhaMAX4 DI manufactured by Johnson Outdoors Marine Electronics, Inc..

1.2 Purpose

Testing was performed to evaluate the EUT with regard to EMC regulatory requirements in accordance with the European Unions CE Marking arrangements.

1.3 Results Summary

Product Standard or Test Method Applied	Description	Result
	Product Standards	
EN 60945:2002	Maritime navigation and radiocommunication equipment and systems – General requirements – Methods of testing and required test results	Pass
EN 61000-3-2:2006 w/A1:2009 and A2:2009	Electromagnetic compatibility (EMC) -- Part 3-2: Limits - Limits for harmonic current emissions (equipment input current <= 16 A per phase)	N/A
EN 61000-3-3:2008	Electromagnetic compatibility (EMC) - Part 3-3: Limits - Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current <= 16 A per phase and not subject to conditional connection	N/A
	Basic Immunity Standards per EN 60945:2002	
IEC 61000-4-2 Ed. 2.0	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	Pass
IEC 61000-4-3 Ed. 3.2	Electromagnetic compatibility (EMC) - Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	Pass
IEC 61000-4-4 Ed. 3.0	Electromagnetic compatibility (EMC) - Part 4-4: Testing and measurement techniques - Electrical fast transient/burst immunity test	Pass
IEC 61000-4-5 2nd Ed.	Electromagnetic compatibility (EMC) - Part 4-5: Testing and measurement techniques - Surge immunity test	N/A
IEC 61000-4-6 3rd Ed.	Electromagnetic compatibility (EMC) - Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields	Pass
IEC 61000-4-8 2nd Ed.	Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test	N/A
IEC 61000-4-11 2nd Ed.	Electromagnetic compatibility (EMC) - Part 4-11: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations immunity tests	N/A

N/A = Test Not Applicable to this EUT **N/P = Not Performed. See Test Justification for Details**

1.4 Performance Criteria

1.4.1 Emissions Performance Criteria

For model PiranhaMAX4 DI the limits which apply are EN 60945:2002 Class B. These limits are found in Table 1.4.1-1 below:

Table 1.4.1-1 Emissions Limits EN 60945:2002 Class B

Emission Type	Frequency Range	Quasi-Peak/Peak[4] Limits
Conducted Class B (Mains Port) (dBµV)	10kHz to 150kHz	96 to 50 dBuV
	150kHz to 350kHz	60 to 50 dBuV
	350kHz to 30 MHz	50 dBuV
Radiated Class B at 3 Meters (dBµV/m)	150kHz to 300kHz	80 to 52 dBuV/m
	300kHz to 30MHz	52 to 34 dBuV/m
	30MHz to 2GHz	54 dBuV/m
	156MHz to 165MHz	24 quasi-peak 30 peak dBuV/m

1.4.2 Immunity Performance Criteria

Each immunity test requires 1 of 3 performance criteria to be met. Below are descriptions of each.

Performance Criterion A: The EUT shall continue to operate as intended during and after the test. No degradation of performance or loss of function is allowed, as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

Performance Criterion B: The EUT shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed, as defined in the relevant equipment standard and in the technical specification published by the manufacturer. During the test, degradation or loss of function or performance which is self-recoverable is however, allowed, but no change of actual operating state or stored data is allowed.

Performance Criterion C: Temporary degradation or loss of function or performance is allowed during the test, provided the function is self-recoverable, or can be restored at the end of the test by the operation of the controls, as defined in the relevant equipment standard and in the technical specification published by the manufacturer.

2.0 Test Facilities & Environment

2.1 Test Facilities
All testing was performed at the following address:

Advanced Compliance Solutions, Inc.
5015 B.U. Bowman Drive
Buford GA 30518
Phone: (770) 831-8048
Fax: (770) 831-8598
www.acstestlab.com

The laboratory is fully equipped to carry out the tests outlined in section 1.0

2.2 Laboratory Accreditations/Recognitions/Certifications
ACS is accredited to ISO/IEC 17025 by the ANSI-ASQ National Accreditation Board/ANAB accreditation program, and has been issued certificate number AT-2021 in recognition of this accreditation. Unless otherwise specified, all tests methods described within this report are covered under the ISO/IEC 17025 scope of accreditation.

2.3 Test Environment
Unless otherwise specified by the generic or product standard, the EUT was evaluated within the climate conditions of the EUT as specified by the manufacturer.

Where the manufacturer does not specify climate parameters for the EUT, all test are performed within the climate parameters given below:

- Ambient temperature 15° to 35° C
- Relative Humidity 30% to 60%
- Atmospheric Pressure 860mbar to 1060mbar

2.4 Test Equipment Calibration Statement
Test equipment used for each test is specified in the relevant sections of this test report. Unless expressly given, all test equipment is calibrated on an annual basis, where applicable. All test equipment is operated within the climate specifications as defined by the manufacturer.

3.0 Equipment Under Test (EUT)

3.1 Manufacturer
Johnson Outdoors Marine Electronics, Inc.
678 Humminbird Lane
Eufaula, AL 36027
Seth Bergman
(334) 687-6613
sbergman@johnsonoutdoors.com

3.2 Modifications

Table 3.2-1 below describes any modification required to bring the EUT into compliance with the test standard. Photographs of the modifications, if any, are contained in appendix a.

Table 3.2-1: EUT Modifications

☒ **Modifications were not required to bring the EUT into compliance with the requirements.** ☐ **Modifications were required to bring the EUT into compliance with the requirements.**

3.3 System Block Diagram and Support Equipment

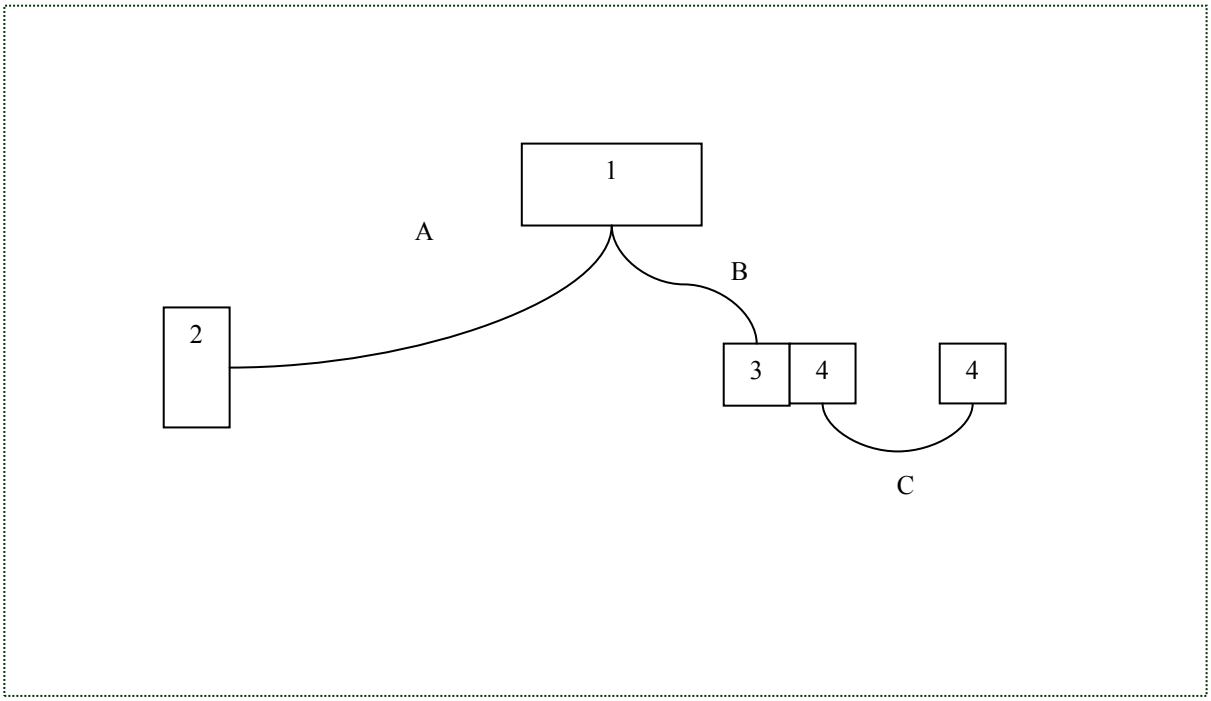


Figure 3.3-1: System Block Diagram

Table 3.3-1: EUT and Support Equipment Description

Item #	Type Device	Manufacturer	Model/Part #	Serial #
1	EUT	Johnson Outdoors Marine Electronics, Inc.	PiranhaMAX 4 DI	N/A
2	Battery	Autocraft	12VDC	N/A
3	Transducer	Johnson Outdoors Marine Electronics, Inc.	N/A	N/A
4	Depth simulator	Johnson Outdoors Marine Electronics, Inc.	N/A	N/A

Table 3.3-2: Cable Description

Cable #	Cable Type	Length	Shield	Termination
A	Power	180cm	No	1 – 2
B	Transducer	6 meter	No	1 – 3
C	Simulator interconnect	40cm	No	4 – 4

3.4 Observations

Any general observations regarding any part of the evaluation are given in table 3.4-1.

Table 3.4-1: Observations

Observation No.	Description

SECTION B: EMISSIONS – TEST INFORMATION AND RESULTS

4.0 Radiated and Conducted Emissions

4.1 Radiated Emissions

4.1.1 Test Site Description

4.1.1.1 Open Area Test Site

The open area test site consists of a 40' x 66' concrete pad covered with a perforated electro-plated galvanized sheet metal. The perforations in the sheet metal are 1/8" holes that are staggered every 3/16". The individual sheets are placed to overlap each other by 1/4" and are riveted together to provide a continuous seam. Rivets are spaced every 3" in a 3 x 20 meter perimeter around the antenna mast and EUT area. Rivets in the remaining area are spaced as necessary to properly secure the ground plane and maintain the electrical continuity.

The entire ground plane extends 12' beyond the turntable edge and 16' beyond the antenna mast when set to a 10 meter measurement distance. The ground plane is grounded via 4 - 8' copper ground rods, each installed at a corner of the ground plane and bound to the ground plane using 3/4" stainless steel braided cable.

The turntable is an all aluminum 10' flush mounted table installed in an all aluminum frame. The table is remotely operated from inside the control room located 40' from the range. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Adjacent to the turntable is a 7' x 7' square and 4' deep concrete pit used for support equipment if necessary. The pit is equipped with 5 - 4" PVC chases from the pit to the control room that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit. The pit is covered with 2 sheets of 1/4" diamond style re-enforced steel sheets. The sheets are painted to match the perforated steel ground plane; however the underside edges have been masked off to maintain the electrical continuity of the ground plane. All reflecting objects are located outside of the ellipse defined in ANSI C63.4.

A diagram of the Open Area Test Site is shown in Figure 4.1.1.1-1 below:

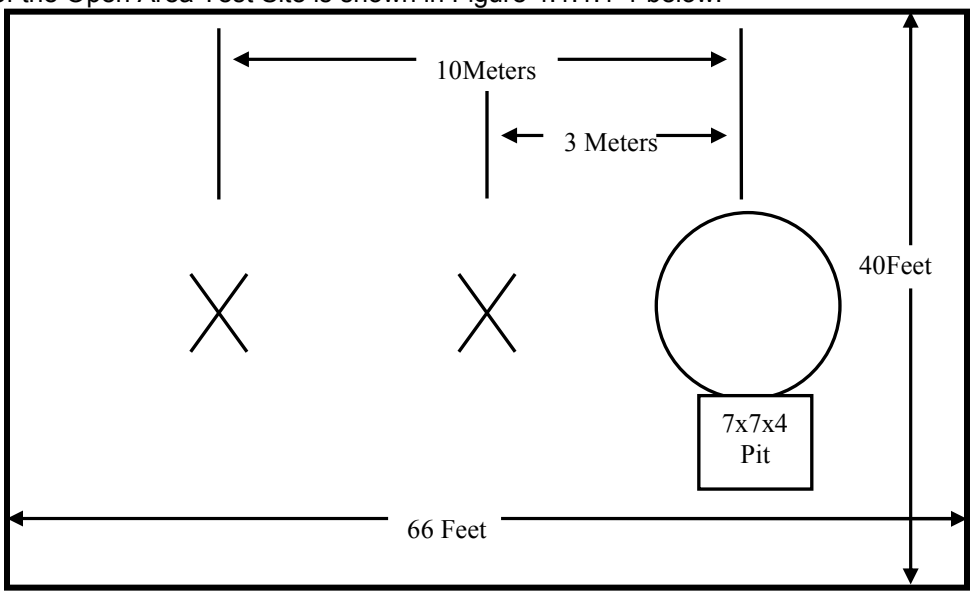


Figure 4.1.1.1-1: Open Area Test Site

4.1.1.2 Semi-Anechoic Chamber

The Semi-Anechoic Chamber Test Site consists of a 20' x 30' x 18' shielded enclosure. The chamber is lined with Toyo Ferrite Grid Absorber, model number FFG-1000. The ferrite tile grid is 4" x 4" x ¾" thick and weighs approximately 1.4lbs. These tiles are mounted on steel panels and installed directly on the inner walls of the chamber.

The turntable is 150cm in diameter and is located 160cm from the back wall of the chamber. The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the ground plane using 3/4" stainless steel braided cable. The turntable is all steel, flush mounted table installed in an all steel frame. The table is remotely operated from inside the control room located 25' from the turntable. The turntable is electrically bonded to the surrounding ground plane via steel fingers installed on the edge of the turn table. The steel fingers make constant contact with the ground plane during operation.

Behind the turntable is a 3' x 6' x 4' deep shielded pit used for support equipment if necessary. The pit is equipped with 1 - 4" PVC chase from the turntable to the pit that allow for cabling to the EUT if necessary. The underside of the turntable can be accessed from the pit so cables can be supplied to the EUT from the pit.

To comply with the requirements of the test methods given on page 3, RF absorbing foam was placed inside the chamber in a configuration that provided the best results. First, an 8 ft. patch of 12" tall absorber was placed on the floor between the turntable and the receiving antenna. This absorber meets the absorption requirements specified in ANSI C63.4:2009. Next, three vertical structures (Fences) were created and covered with 8" pyramidal RF absorbing foam, two 4 ft. x 4 ft. and one 6 ft. x 4 ft. These fences were placed at locations to prevent high energy signals from reaching the back chamber wall and reflecting back to the receive antenna.

A diagram of the Semi-Anechoic Chamber Test Site is shown in Figure 4.1.1.2-1 below:

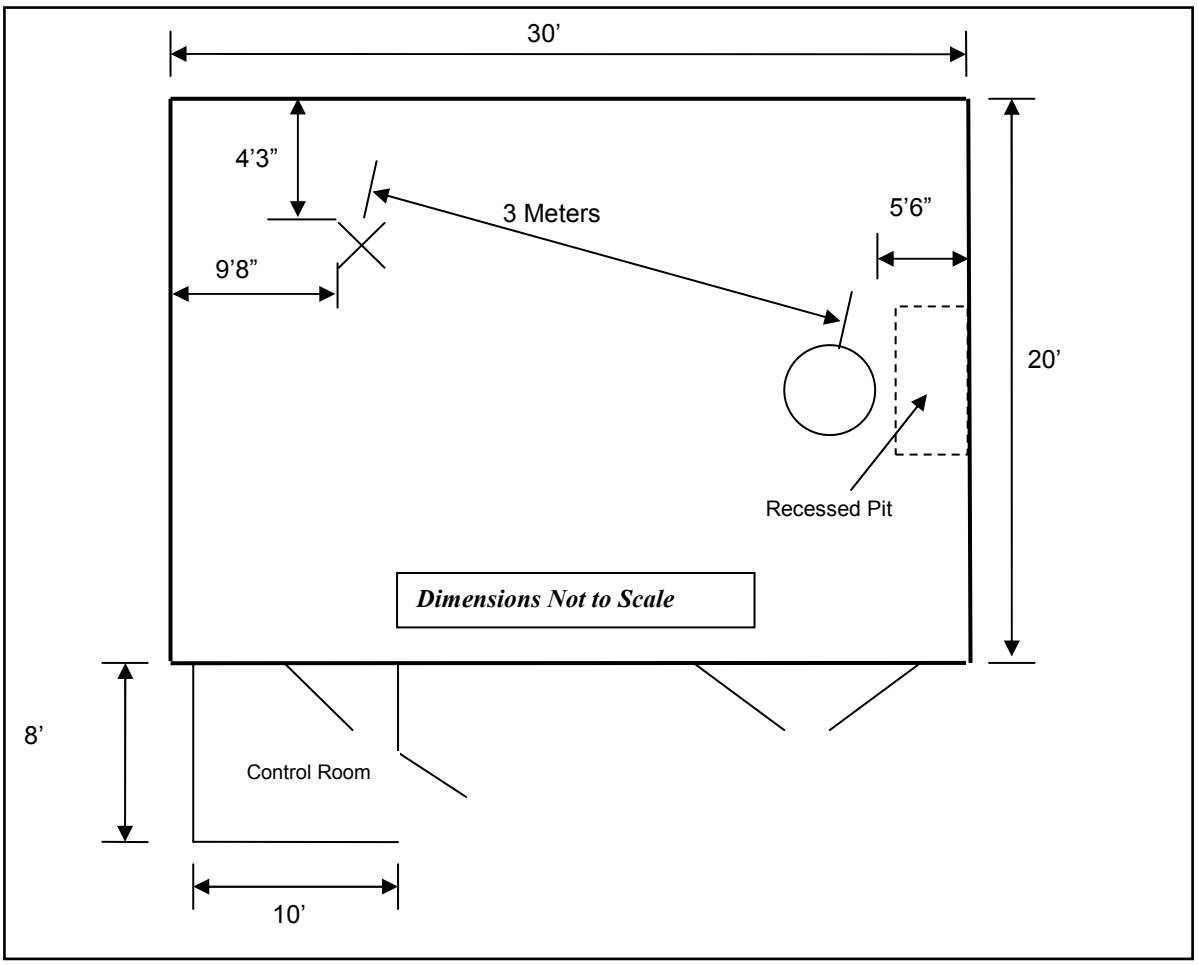


Figure 4.1.1.2-1: Semi-Anechoic Chamber Test Site

4.1.1.3 Fully Anechoic Chamber

The 3m fully anechoic chamber is used for pre-screening the EUT for emissions only. Final screening is performed on the OATS or in case of Class B EUT's, in the 3m semi-anechoic chamber. The Fully Anechoic Chamber has been characterized for field uniformity in accordance with IEC 61000-4-3 and can be used for final radiated fields immunity testing.

The Fully-Anechoic Chamber Test Site consists of a 24'L x 16'W x 12'H shielded enclosure. The chamber is fully lined with RF absorbing foam. The foam ranges in type from 8-24" conventional pyramidal cones, 8-12" conventional wedges and 6" and 16" Hybrid Foam over ferrite tile. The Hybrid material is placed in the 6 specular regions of the chamber for better low-frequency performance. The specular regions are 1) directly behind the receiving antenna, 2) on the floor between the receiving antenna and the EUT table, 3) the wall directly behind the EUT, 4&5) the side walls between the receiving antenna and the EUT table and 6) the ceiling between the receiving antenna and the EUT. The specular regions are 6' x 4' in size.

The chamber is grounded via 1 - 8' copper ground rod, installed at the center of the back wall, it is bound to the shield using 3/4" stainless steel braided cable.

The turntable is a remotely controlled EMCO Model 1060 and is 150cm in diameter and is located 1m from the absorber on the back wall of the chamber.

A diagram of the Fully Anechoic Chamber Test Site is shown in Figure 4.1.1.3-1 below:

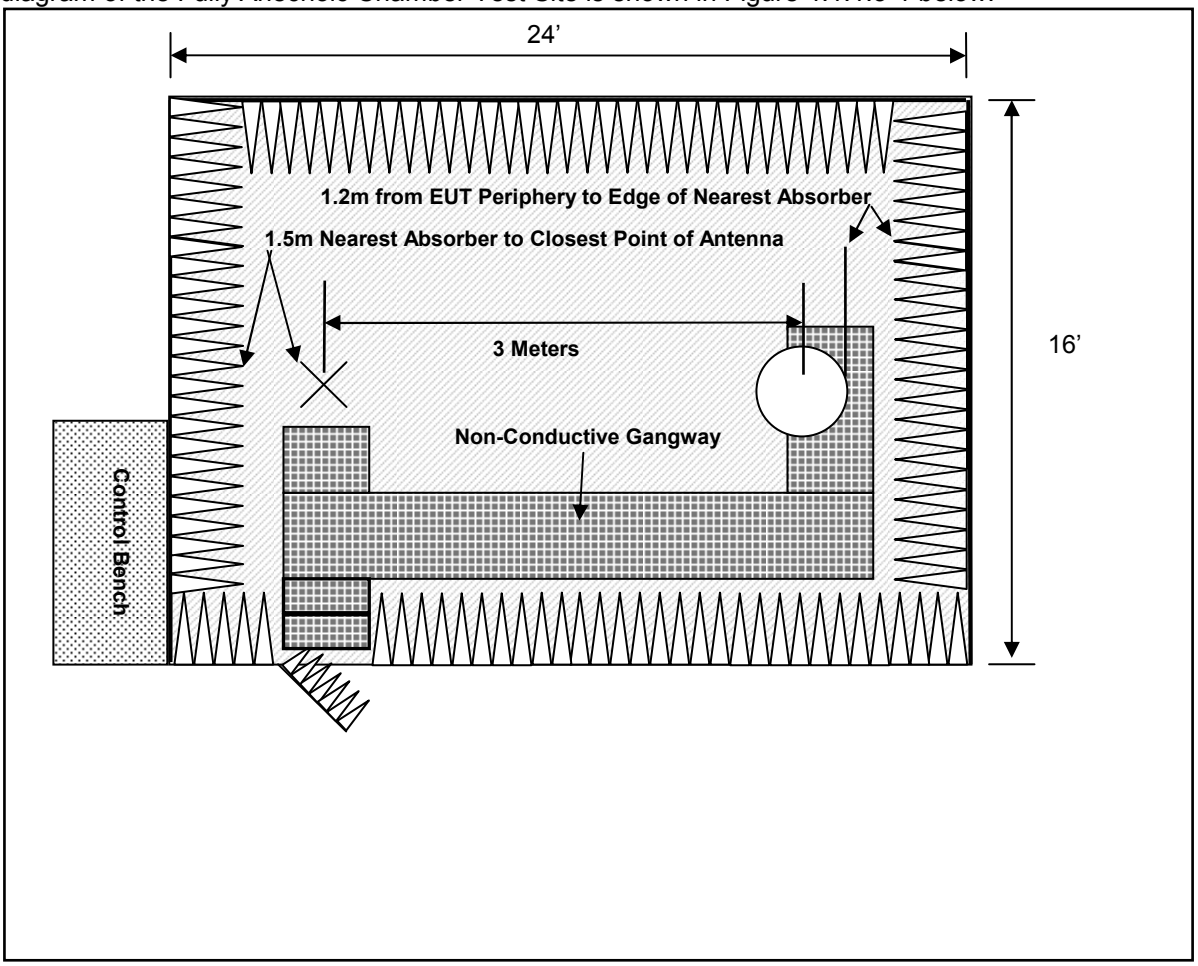


Figure 4.1.1.3-1: Fully Anechoic Chamber Test Site

4.1.2 Test Equipment

Table 4.1.2-1 identifies all equipment used for radiated emissions respectively.

Table 4.1.2-1 Test Equipment – Radiated Emissions

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
1	Rohde & Schwarz	ESMI - Display	Spectrum Analyzers	833771/007	7/14/2015	7/14/2016
2	Rohde & Schwarz	ESMI-Receiver	Spectrum Analyzers	839587/003	7/14/2015	7/14/2016
73	Agilent	8447D	Amplifiers	2727A05624	7/15/2015	7/15/2016
338	Hewlett Packard	8449B	Amplifiers	3008A01111	8/21/2015	8/21/2017
167	ACS	Chamber EMI Cable Set	Cable Set	167	10/20/2015	10/20/2016
422	Florida RF	SMS-200AW-72.0-SMR	Cables	805	10/30/2015	10/30/2016
40	EMCO	3104	Antennas	3211	2/10/2015	2/10/2017
412	Electro Metrics	LPA-25	Antennas	1241	7/24/2014	7/24/2016
30	Spectrum Technologies	DRH-0118	Antennas	970102	4/30/2015	4/30/2017
628	EMCO	6502	Antennas	9407-2877	2/7/2014	2/7/2016

NCR = No Calibration Required

4.1.3 Test Methodology

4.1.3.1 Pre-Scans

Radiated pre-scans are performed on all EUT's in either the 3m Semi-Anechoic or the 3m Fully-Anechoic Chamber. Final emission testing for Class A equipment is performed on the 3/10m Open Area Test Site (OATS) as described in section 4.1.1.1. Final emission testing on Class B equipment can be performed either in the 3m Semi-Anechoic chamber described in section 4.1.1.2 or on the OATS.

Pre-scans are a method by which the 10 highest emissions can be identified for final evaluation. This is achieved by taking automated emission snapshots of the EUT at various azimuths and antenna heights. The software is programmed to perform a peak sweep of the band using the maxhold function. This sweep is performed every 90º in both horizontal and vertical polarities and at antenna heights of 100cm and 300cm. Although not a fully maximized scan, the pre-scan gives a good indication of pass or fail.

4.1.3.2 Final Scans

Radiated emissions measurements were made over the frequency range of 150kHz – 2GHz. Quasi-Peak measurements are taken with the Spectrum Analyzer's resolution bandwidth was set to 120KHz and video bandwidth set to 300 kHz for measurements below 1000MHz. Average measurements above 1000MHz are taken using measurement instruments average detector. The calculation for the radiated emissions field strength is as follows:

Corrected Reading = Analyzer Reading + Cable Loss + Antenna Factor
Margin(dB) = Applicable Limit - Corrected Reading

4.1.3.3 Test Criteria

The EUT must meet the Class B Limits as given in section 1.4.1.

4.1.3.4 Test Justification

☒ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☐ **The test method, standard, and/or test plan was deviated from for the following reason:**

4.1.4 Test Setup Photographs

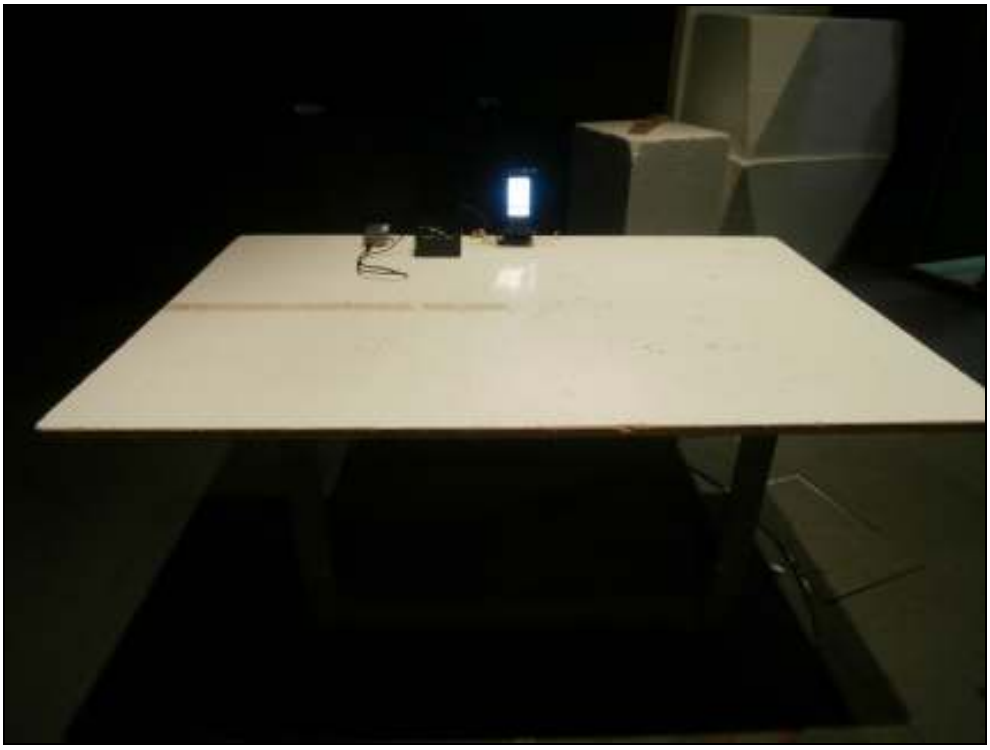


Figure 4.1.4-1: Radiated Emissions - Front View

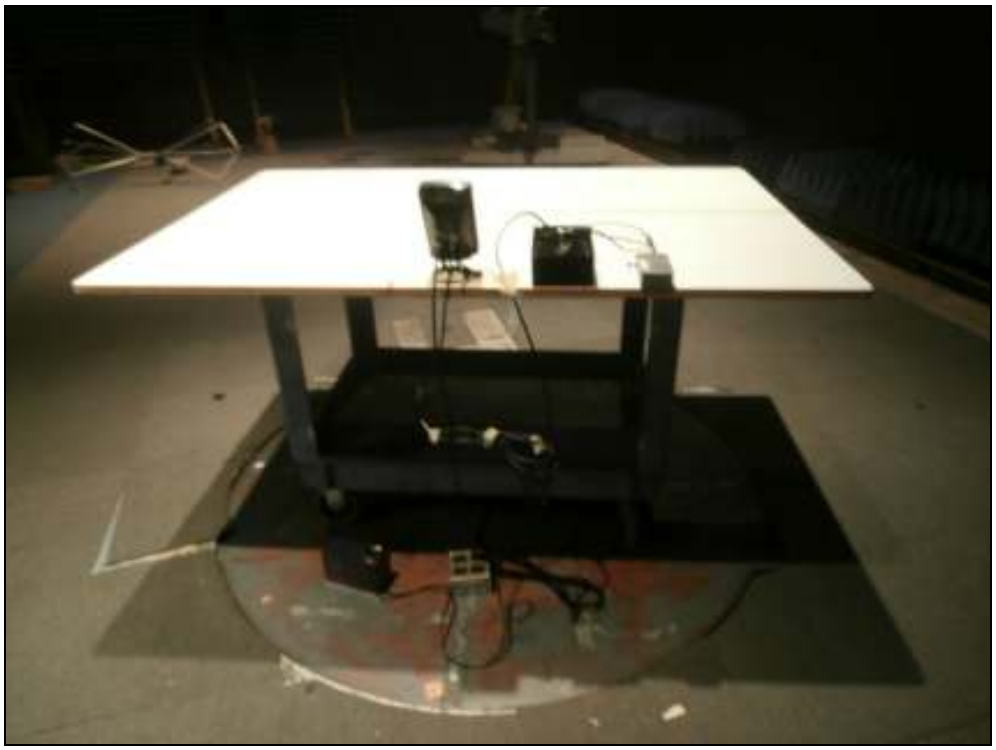


Figure 4.1.4-2: Radiated Emissions - Rear View

4.1.5 Test Data

Final tabulated radiated emissions data are reported in the Test Data Table below:

Test Parameters:

Test Date:	**January 4, 2016**	**Temperature (ºC)**	**22**
Technician:	**Art Sumner**	**Humidity (%)**	**36**
Equipment Class:	**Class B**	**Barometric Pressure (mBar)**	**1020**
Tested Modes:	**Powered ON; running sonar screen; transducer active**		
AC Input Power:	**N/A**		
DC Input Power:	**12Vdc**		

Test Data Table:

Measurement Distance:

☐ FAC ☒ SAC ☐ OATS
☐ 1 Meter ☒ 3 Meter ☐ 10 Meter

Frequency (MHz)	Measured Level (dBuV)		Antenna Polarity (H/V)	Antenna Height (cm)	Turntable Position (o)	Correction Factors (dB)	Corrected Level (dBuV/m)		Limit (dBuV/m)		Margin (dB)	
	Pk	Qpk/Av					Pk	Qpk/Av	Pk	Qpk/Av	Pk	Qpk/Av
30.75	39.12	37.10	V	100	5	-12.30	---------	24.81	--------	40.5	---------	15.7
38.68	41.89	38.40	V	100	2	-13.62	---------	24.78	--------	40.5	---------	15.7
69.47	26.83	21.43	V	100	0	-15.96	---------	5.47	--------	40.5	---------	35.0
70.23	37.62	24.18	V	100	0	-16.16	---------	8.02	--------	40.5	---------	32.4
120.47	35.89	33.24	V	100	0	-10.32	---------	22.92	--------	40.5	---------	17.5
200	35.13	33.90	V	182	355	-7.80	---------	26.10	--------	40.5	---------	14.4
162.41	12.23	5.92	v	100	0	-8.51	---------	-2.59	--------	24.0	---------	26.6
163.73	12.51	6.30	V	100	0	-8.30	---------	-2.00	--------	24.0	---------	26.0
164.86	10.75	6.23	H	100	0	-8.12	---------	-1.89	--------	24.0	---------	25.9
25.48	16.67	4.35	H	100	0	-16.28	---------	-11.93	--------	34.7	---------	46.6

Qpk = Quasi-Peak Measurement or Limit (< 1GHz)
AV = Average Measurement or Limit (>1GHz)

Notes:
There were no significant emissions found above 1GHz.

4.2 Conducted Emissions

4.2.1 Conducted Emissions Test Site

The AC mains conducted EMI site is located in the main EMC lab. It consists of an 12' x 8' solid aluminum horizontal ground reference plane (GRP) bonded every 3" to an 12' X 8' vertical ground plane.

A diagram of the room is shown below in figure 4.2.1-1:

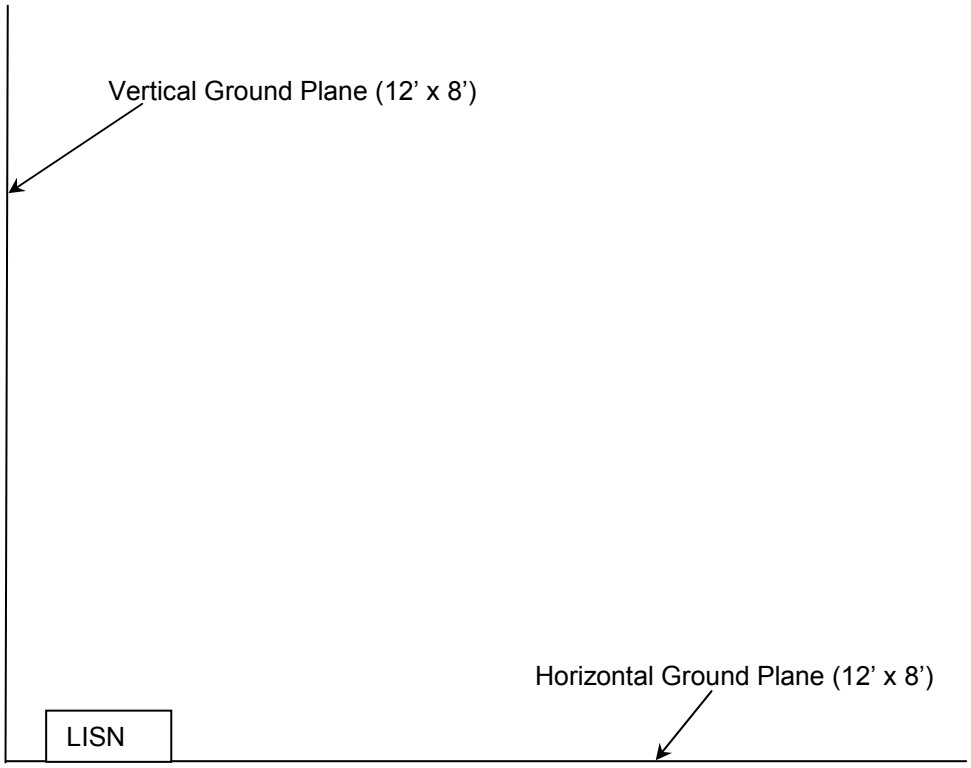


Figure 4.2.1-1: AC Mains Conducted EMI Site

4.2.2 Test Equipment

Table 4.2.2-1 Test Equipment – Conducted Emissions

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
RE112	Rohde & Schwarz	ESIB26	Receiver	836119/012	7/16/2015	7/16/2016
324	ACS	Belden	Cables	8214	5/5/2015	5/5/2016
3010	Rohde & Schwarz	ENV216	LISN	3010	7/10/2015	7/10/2016

NCR=No Calibration Required

4.2.3 Test Methodology

Conducted emissions were performed from 150kHz to 30MHz with the spectrum analyzer's resolution bandwidth set to 9kHz and the video bandwidth set to 30kHz. The calculation for the conducted emissions is as follows:

Corrected Reading = Analyzer Reading + LISN Loss + Cable Loss
Margin = Applicable Limit - Corrected Reading

4.2.3.1 Test Criteria

The EUT must meet the Class B Limits as given in section 1.4.1.

4.2.3.2 Test Justification

☒ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☐ **The test method, standard, and/or test plan was deviated from for the following reason:**

4.2.4 Test Setup Photographs

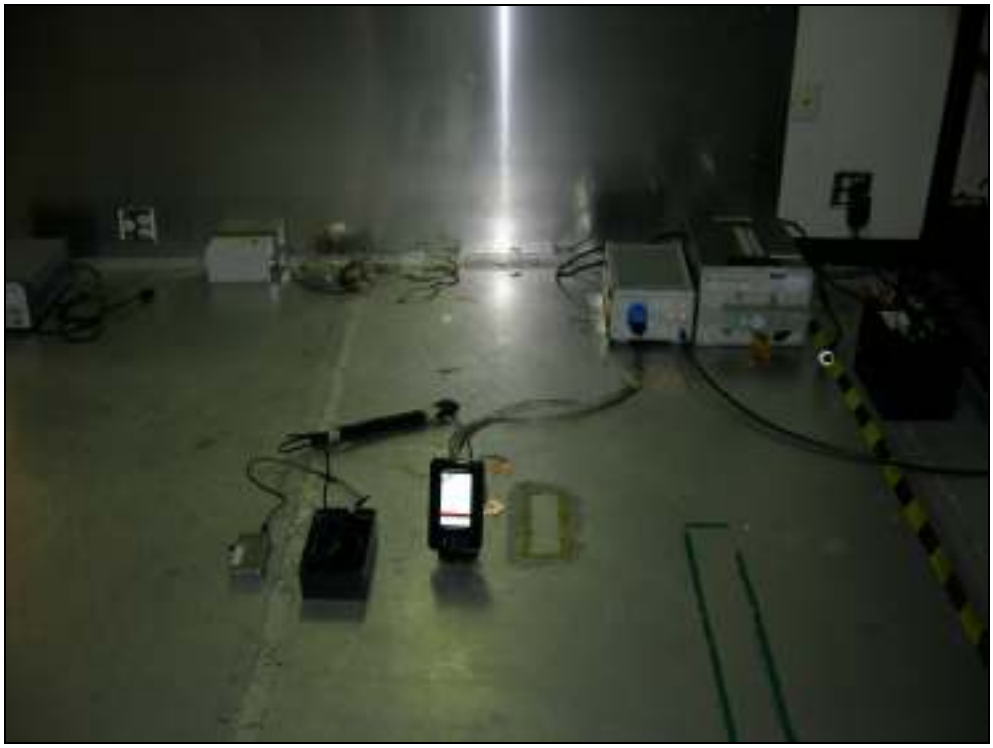


Figure 4.2.4-1: Conducted Emissions Test Setup – Front View

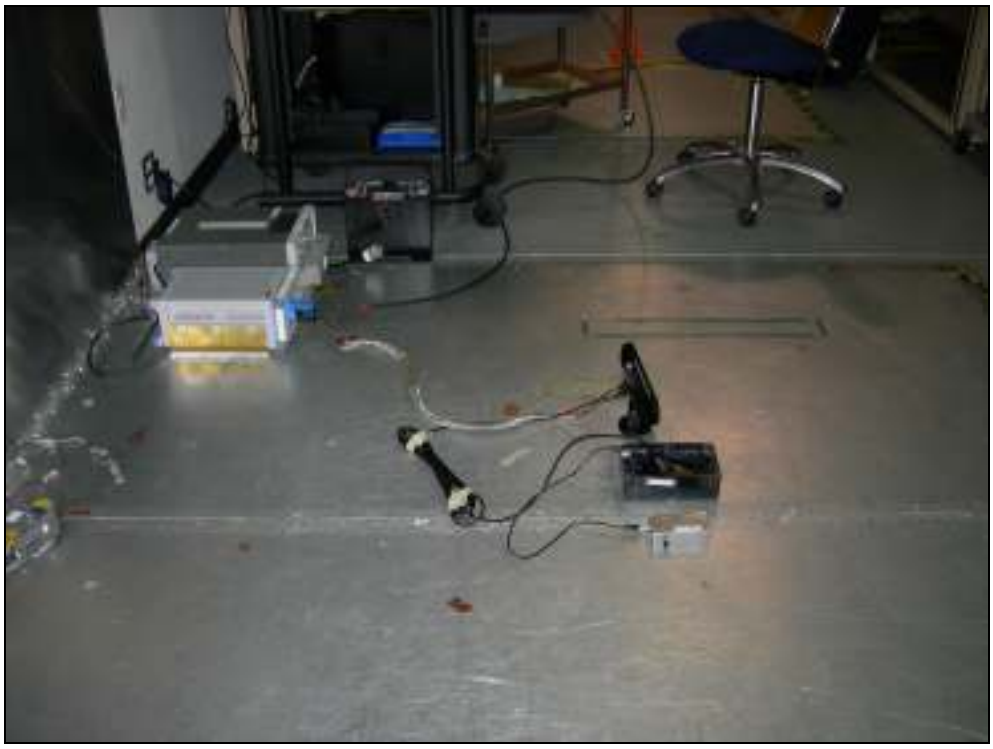


Figure 4.2.4-2: Conducted Emissions Test Setup – Side View

4.2.5 Test Data

Tabulated data is given in the Test Data Tables below.

Test Parameters:

Test Date:	**January 5, 2016**	**Temperature (ºC)**	**21**
Technician:	**Tommy Payton**	**Humidity (%)**	**31**
Equipment Class:	**Class B**	**Barometric Pressure (mBar)**	**1032**
Tested Modes:	**Transducer active is sonar mode**		
AC Input Power:	**N/A**		
DC Input Power:	**12Vdc**		

Tested Leads:

☐ **AC Mains – Number of Lines:**
☒ **DC Mains – Number of Lines: 2**
☐ **Telecom Port – Quantity:**

Test Data Tables:

Check All That Apply to This Data
☒ **Line 1** ☐ **Line 2** ☐ **Line 3**
☐ **Line 4**
☐ **To Ground** ☒ **Floating**
☐ **Telecom Port _____**
☒ **dBµV** ☐ **dBµA**

Power Supply Description: 12Vdc

Frequency (MHz)	Uncorrected Reading		Total Correction Factor (dB)	Corrected Level		Limit		Margin (dB)	
	Quasi-Peak	Average		Quasi-Peak	Average	Quasi-Peak	Average	Quasi-Peak	Average
0.0107214	40.23		15.16	55.39	15.16	94.81686387	66.00	39.4	
0.0213627	42.23		12.02	54.25	12.02	83.1071483	66.00	28.9	
0.038497	49.6		11.18	60.78	11.18	73.10395445	66.00	12.3	
0.20821	41.06		10.31	51.37	10.31	56.12928736	66.00	4.8	
0.39478	28.95		10.19	39.14	10.19	50	66.00	10.9	
0.60821	25.46		10.19	35.65	10.19	50	60.00	14.4	
1.048	16.69		10.19	26.88	10.19	50	60.00	23.1	
4.8236	19.37		10.33	29.70	10.33	50	60.00	20.3	
5.4108	17.94		10.37	28.31	10.37	50	60.00	21.7	
22.194	11.21		10.87	22.08	10.87	50	60.00	27.9	
29.759	16.32		11.22	27.54	11.22	50	60.00	22.5	

Notes:

Check All That Apply to This Data
☐ Line 1 ☒ Line 2 ☐ Line 3
☐ Line 4
☐ To Ground ☐ Floating
☐ Telecom Port _____
☒ dBµV ☐ dBµA

Power Supply Description: 12Vdc

Frequency (MHz)	Uncorrected Reading		Total Correction Factor (dB)	Corrected Level		Limit		Margin (dB)	
	Quasi-Peak	Average		Quasi-Peak	Average	Quasi-Peak	Average	Quasi-Peak	Average
0.02136	41.93		12.02	53.95	12.02	83.10929518	66.00	29.2	
0.038316	28.77		11.18	39.95	11.18	73.18400176	66.00	33.2	
0.124649	29.64		10.38	40.02	10.38	53.14761108	66.00	13.1	
0.17505	33.49		10.36	43.85	10.36	58.17701413	66.00	14.3	
0.20651	40.4		10.31	50.71	10.31	56.22606168	66.00	5.5	
0.27004	22.87		10.31	33.18	10.31	53.05994468	66.00	19.9	
0.4043	28.77		10.19	38.96	10.19	50	66.00	11.0	
0.61072	25.09		10.19	35.28	10.19	50	60.00	14.7	
4.418	18.35		10.33	28.68	10.33	50	60.00	21.3	
4.803	21.23		10.33	31.56	10.33	50	60.00	18.4	
16.883	13.56		10.80	24.36	10.80	50	60.00	25.6	
23.126	16.21		10.82	27.03	10.82	50	60.00	23.0	

Notes:

5.0 Harmonic Current Emissions

5.1 Test Justification

☐ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☒ **The test method, standard, and/or test plan was deviated from for the following reason:**

The EUT is DC powered; therefore, this test is not applicable because the EUT is not connected to the public utility AC power lines during operation.

6.0 Voltage Fluctuations & Flicker

6.1 Test Justification

☐ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☒ **The test method, standard, and/or test plan was deviated from for the following reason:**

The EUT is DC powered; therefore, this test is not applicable because the EUT is not connected to the public utility AC power lines during operation.

SECTION C: IMMUNITY – TEST INFORMATION AND RESULTS

7.0 Electrostatic Discharge Immunity

7.1 Test Site Description

The EUT was configured and connected to satisfy its functional requirements.

For a table top configuration, the EUT was placed on an insulating support of 0.5mm in the center of the Horizontal Coupling Plane (HCP). The HCP laid flat on a non-conductive table measuring 1.6 meters x 0.8 meters x 0.8 meters. The non-conductive table was placed on a 16 feet x 8 feet Ground Reference Plane (GRP). The Vertical Coupling Plane was placed 10cm from the EUT and insulated from the HCP.

For a floor standing configuration the EUT was placed on a 10cm insulated support. The non-conductive spacer was placed on a 16 feet x 8 feet Ground Reference Plane (GRP). The Vertical Coupling Plane was placed 10cm from the EUT.

Both the HCP and the VCP were connected to the GRP via cables with 470kΩ resistors located at each end. The ground lead of the ESD generator was also connected to the GRP.

7.2 Test Equipment

Table 7.2-1: Test Equipment List

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
582	Kikusui	KES4021A	ESD Gun	SA003046	4/28/2015	4/28/2016
595	ETS Lindgren	595	General Lab Equipment	595	NCR	NCR
re80	Tektronix	TDS 784C	Oscilloscope	7846	7/16/2015	7/16/2017

NCR = No Calibration Required

7.3 Test Methodology

IEC 61000-4-2 - Electromagnetic compatibility (EMC) - Part 4. Testing and measurement techniques - Section 4.2 Electrostatic discharge immunity test - Basic EMC Publication, was the guiding document for this test. The purpose of this test is to verify the immunity of single devices or systems against electrostatic discharges (ESD) generated by an operator or object touching the equipment, or by objects or persons coming into contact in the vicinity of the equipment.

Only areas of the EUT that are accessible to the user are considered for the evaluation.

Direct Contact Discharge

Devices with accessible conductive surfaces are subject to direct contact discharges. Each test point identified was subjected to 10 discharges of both positive and negatives impulses.

Indirect Contact Discharge

The EUT was subjected to indirect contact discharges to a horizontal coupling plane (HCP). At least 10 single discharges in both polarities were applied to the EUT via the HCP on all sides and at a separation distance of 10cm. In addition the EUT was subjected indirect discharges to a vertical coupling plane (VCP). At least 10 single discharges in both polarities were applied to the EUT via the VCP on all sides and at a separation distance of 10cm.

Air Discharge

Insulated surfaces of the EUT that are accessible were subjected to air discharges. Each test point is subjected to 10 discharges of each polarity.

7.3.1 Test Criteria

EN 60945:2002 requires performance criterion B to be met as described in section 1.4.2.

7.3.2 Test Justification

☒ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☐ **The test method, standard, and/or test plan was deviated from for the following reason:**

7.4 Test Setup Photograph

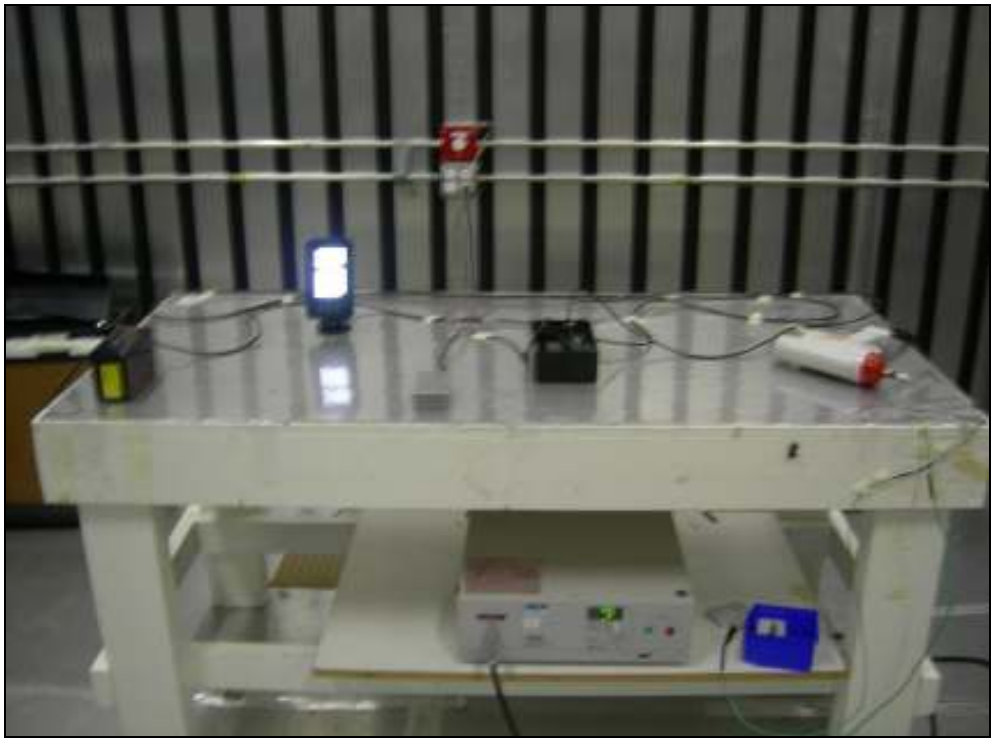


Figure 7.4-1: Test Setup Photograph

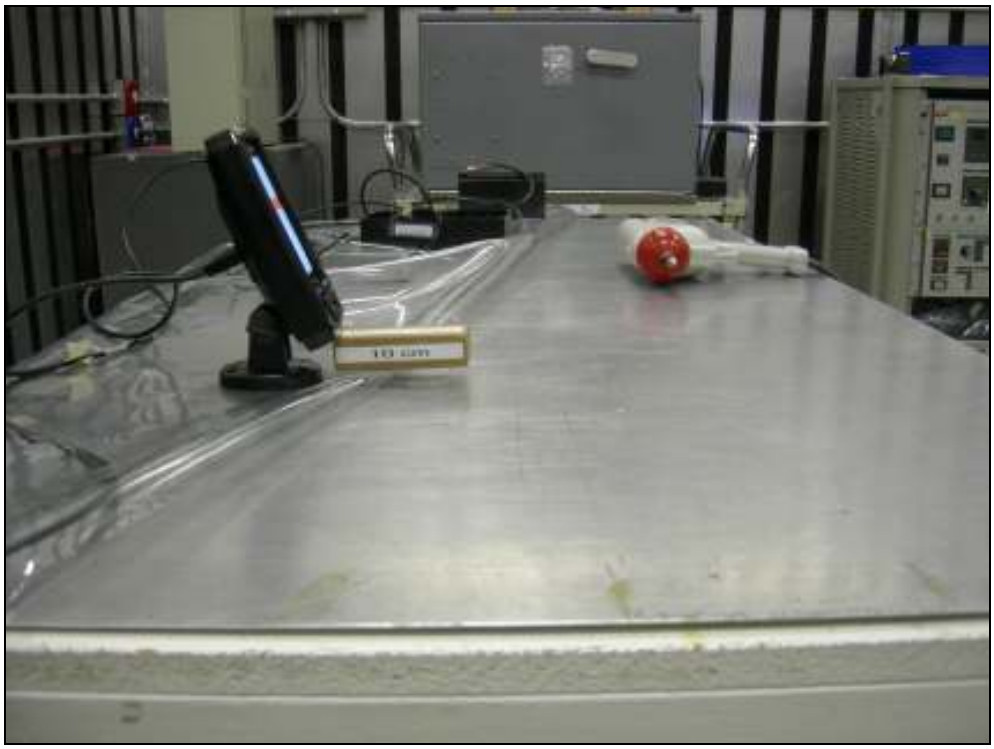


Figure 7.4-2: Test Setup Photograph

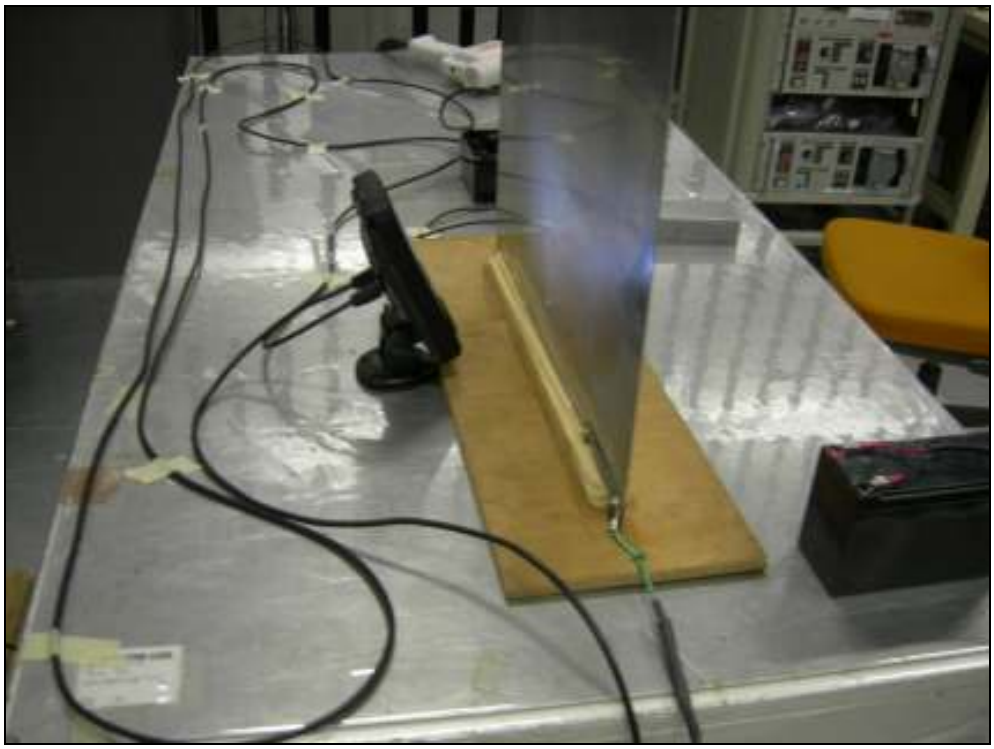
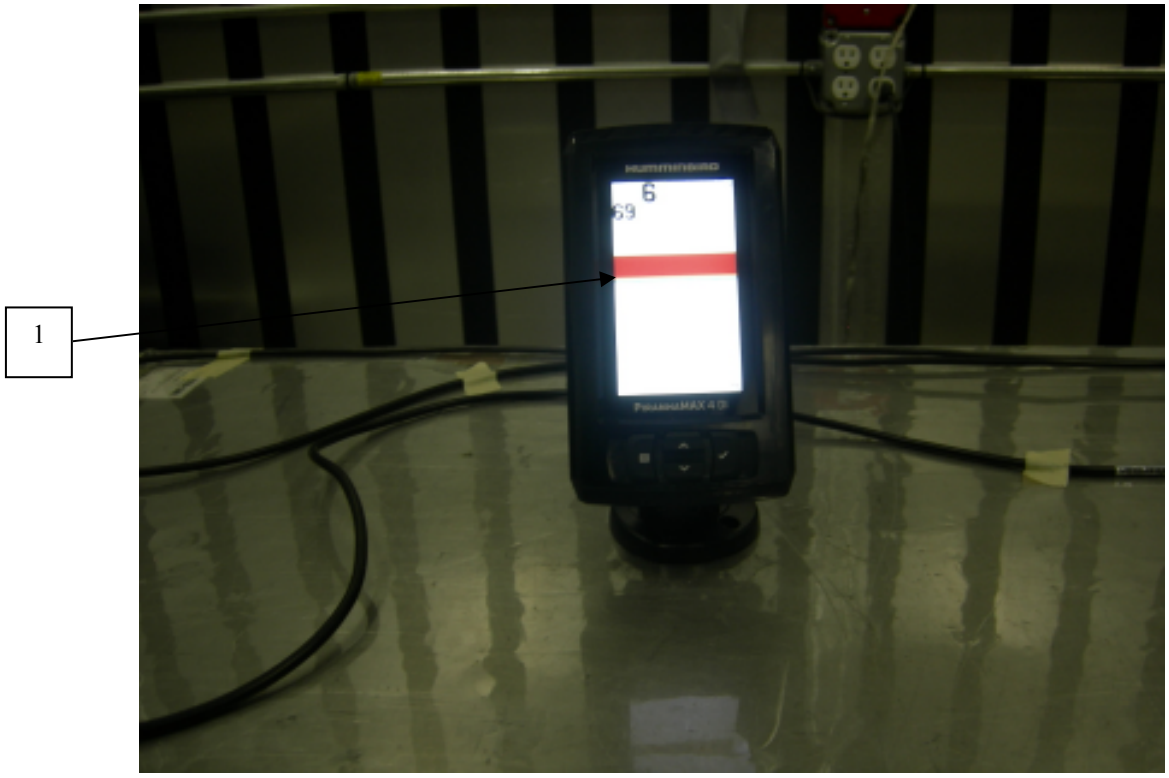


Figure 7.4-3: Test Setup Photograph

7.5 ESD Data Sheet

Test Point Photograph:



Test Point Selection:

TEST POINT#	DESCRIPTION	TYPE (C/A)
1	Display screen	**Air**
2	Rear center plug	**Air**
3	Rear screw placements	**C/A**

7.6 Test Data

Test Parameters:

Test Date:	**January 7, 2016**	**Temperature (ºC)**	**23**
Technician:	**Chris O'Steen**	**Humidity (%)**	**35**
Equipment Class:	**N/A**	**Barometric Pressure (mBar)**	**1021**
		☒ **Pre-test Verification Complete**	
Tested Modes:	**EUT powered 12V, sonar mode, 6 ft simulator.**		
AC Input Power:	**N/A**	**VCP Resistor Value Check:**	**960k Ohms**
DC Input Power:	**12V**	**HCP Resistor Value Check:**	**946k Ohms**

Indirect Contact Discharge:

Check All That Apply to This Data

Plane:	Polarity:	Tested Levels:	
☐ Vertical Coupling Plane	☐ Positive	☒ 2kV	☐ 8kV
☐ Horizontal Coupling Plane	☐ Negative	☒ 4kV	☐ 15kV
☒ Both	☒ Both	☒ 6kV	☐ Enter Other Level Here

Side	Result	Observation (Describe any detectable event)
Front	Pass	
Rear	Pass	
Left	Pass	
Right	Pass	
Bottom	Pass	

Notes:
Per 60945, which references the 1995 version of IEC 6100-4-2; while testing the EUT via the HCP, instead of directly discharging to the side of the HCP, the EUT was placed so that the side of the EUT under test was 50 cm away from the HCP side it faced. Furthermore, the generator discharges 10 cm away from the face under test perpendicular to the HCP rather than parallel. For each side of the EUT, these parameters were maintained through-out. In order to maintain the 50 cm separation from the edge of the HCP, while testing using the VCP, the mobile VCP was placed 10 cm away from the EUT @ 50 cm away from the edge of the HCP. The photographs illustrating the test method are Figure 7.4-3 and 7.4-3.

Air and Direct Contact Discharge:

Check All That Apply to This Data

Polarity:	Tested Levels:	
☐ Positive	☒ 2kV	☒ 8kV
☐ Negative	☒ 4kV	☐ 15kV
☒ Both	☒ 6kV	☐ Enter Other Level Here

Test Point	Discharge Type	Result	Observation (Describe any detectable event)
1	Air	Pass	Display
2	Air	Pass	Center plug, Air discharge when very close. 4 & 8kV
3	Air-Contact	Pass	Screw placement, Air and contact discharge.

Notes:

8.0 Radio-Frequency Electromagnetic Fields

8.1 Test Site Description

The radiated fields test was performed in the semi or fully-anechoic chamber described in section 4.1.1.2 or 4.1.1.3 respectively.

8.2 Test Equipment

Table 8.2-1: Test Equipment List

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
re89	Amplifier Research	25S1G4A	Amplifiers	324609	NCR	NCR
527	Chase	CIS9942	Software	V4.32	8/24/2015	2/24/2016
370	IFI	CMX5002	Amplifier	L364-0407	NCR	NCR
642	Fairview Microwave	FMC0101951-200CM	Cables	N/A	NCR	NCR
326	ACS	EMI Cable Set-FAC	Cables	326	7/20/2015	7/20/2016
445	Panasonic	WV-CS404	General Lab Equipment	7ZB20070	NCR	NCR
329	A.H.Systems	SAS-571	Antennas	721	7/22/2015	7/22/2017
1112	Wandel & Goltermann	BN2244/21	Probes	H0006	12/3/2015	12/3/2016

NCR = No Calibration Required

8.3 Test Methodology

IEC 61000-4-3 Ed. 3.- Electromagnetic compatibility (EMC) - Part 4. Testing and measurement techniques - Section 3: Radiated, radio-frequency, electromagnetic field immunity test, was the guiding document for this test. The purpose of this test is to verify the immunity of single devices or systems when subjected to radio-frequency electromagnetic field.

The EUT was configured and connected to satisfy its functional requirements. One representative sample was placed on the table and rotated 90° to expose all side of the EUT to the radiofrequency electromagnetic field. The table is non-conductive measuring 1.5 meters x 1.0 meters x 0.8 meters. The non-conductive table was placed 3 meters from the radiating antenna.

The frequency ranges to be considered are swept with the signal 80% amplitude modulated with a 1kHz AM sine wave, pausing to adjust the RF signal level or to switch oscillators and antennas as necessary. Where the frequency range is swept incrementally, the step size shall not exceed 1% of fundamental with linear interpolation between calibrated points.

The test shall normally be performed with the generating antenna facing each of the four sides of the EUT, however if the equipment can be used in different orientations, the test shall be performed on all sides, 6 total.

The polarization of the field generated by each antenna necessitates testing each side twice, once with the antenna positioned vertically and again with the antenna positioned horizontally.

8.3.1 Test Criteria

EN 60945:2002 requires criterion A to be met as described in section 1.4.2.

8.3.2 Test Justification

☒ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☐ **The test method, standard, and/or test plan was deviated from for the following reason:**

8.4 Test Setup Photographs

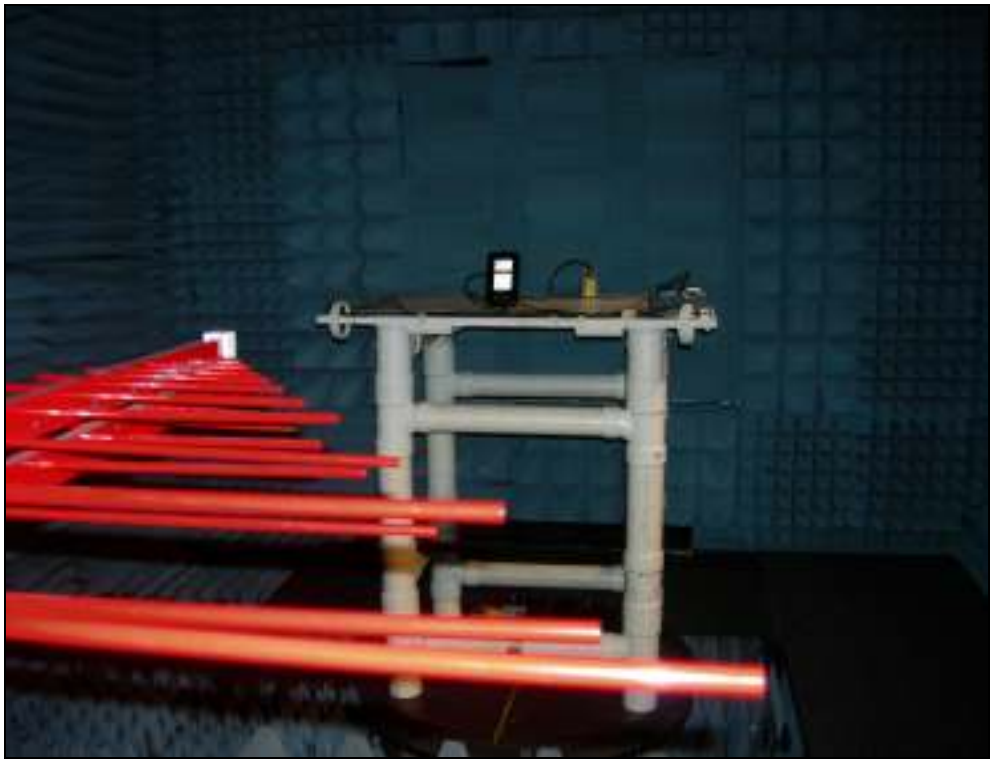


Figure 8.4-1: Test Setup Photograph

8.5 Test Results

Test Parameters:

Test Date:	**January 6, 2016**	**Temperature (ºC)**	**23.1**
Technician:	**Chris O'Steen**	**Humidity (%)**	**26.4**
Equipment Class:	**N/A**	**Barometric Pressure (mBar)**	**1025.2**
Tested Modes:	**EUT powered via battery, depth sensor 6 ft. Sonar active. 400Hz modulation**		
AC Input Power:	**N/A**	☒ **Pre-test Verification Complete**	
DC Input Power:	**12V**		

Test Data:

Check All That Apply to This Data

Polarity	Field Strength:	Freq. Band:	Dwell Time
☐ Horizontal	☐ 3V/m	☐ 80-1000MHz	☐ 1 Second
☐ Vertical	☒ 10V/m	☐ 80-2700MHz	☐ 3 Seconds
☒ Both	☐ 8V/m	☒ 80MHz-2GHz	☒ 3 secs to 1 GHz, 9 secs from 1GHz to 2GHz
	☐ Enter Other Level Here		

Azimuth	Result	Observation (Describe any detectable event)
0	Pass	
90	Pass	
180	Pass	
270	Pass	

Notes:
The 6 ft depth simulator was implemented instead of the 12 ft to achieve passing results.

9.0 Electrical Fast Transient/Bursts

9.1 Test Site Description

The EUT was configured and connected to satisfy its functional requirements. The EUT was placed in the center of a non-conductive support measuring 125cm x 96cm x 10 cm. The non-conductive support is placed on a 8 feet x 8 feet Ground Reference Plane (GRP). A minimum distance of 50 cm between the EUT and all other conductive structures was maintained. A minimum distance of 50 cm between the coupling clamp and all other conductive structures, except the GRP, was maintained. A 10 cm insulated support was placed between the capacitive coupling clamp and the GRP. The GRP was bonded to the EFT/B generator.

The input power port of the EUT was tested using the coupling/decoupling network. The +/-1kV bursts were applied to all lines individually as well as simultaneously.

The bursts were applied to the signal/control line ports, if present, using the capacitive coupling clamp.

9.2 Test Equipment

Table 9.2-1: Test Equipment List

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
474	Keytek	EMC PRO	General Lab Equipment	9808246	10/7/2015	10/7/2016
62	Haefely Trench	EFT Clamp	Immunity Equipment	None	NCR	NCR

NCR = No Calibration Required

9.3 Test Methodology

IEC 61000-4-4 - Electromagnetic compatibility (EMC) - Part 4. Testing and measurement techniques - Section 4: Electrical fast transient/burst immunity test - Basic EMC Publication., was the guiding document for this test. The purpose of this test is to verify the immunity of single devices or systems when subjected to types of transient disturbances such as those originating from switching transients such as interruption of inductive loads or relay contact bounce.

9.3.1 Test Criteria

EN 60945:2002 requires criterion B to be met as described in section 1.4.2.

9.3.2 Test Justification

☒ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☐ **The test method, standard, and/or test plan was deviated from for the following reason:**

9.4 Test Setup Photographs

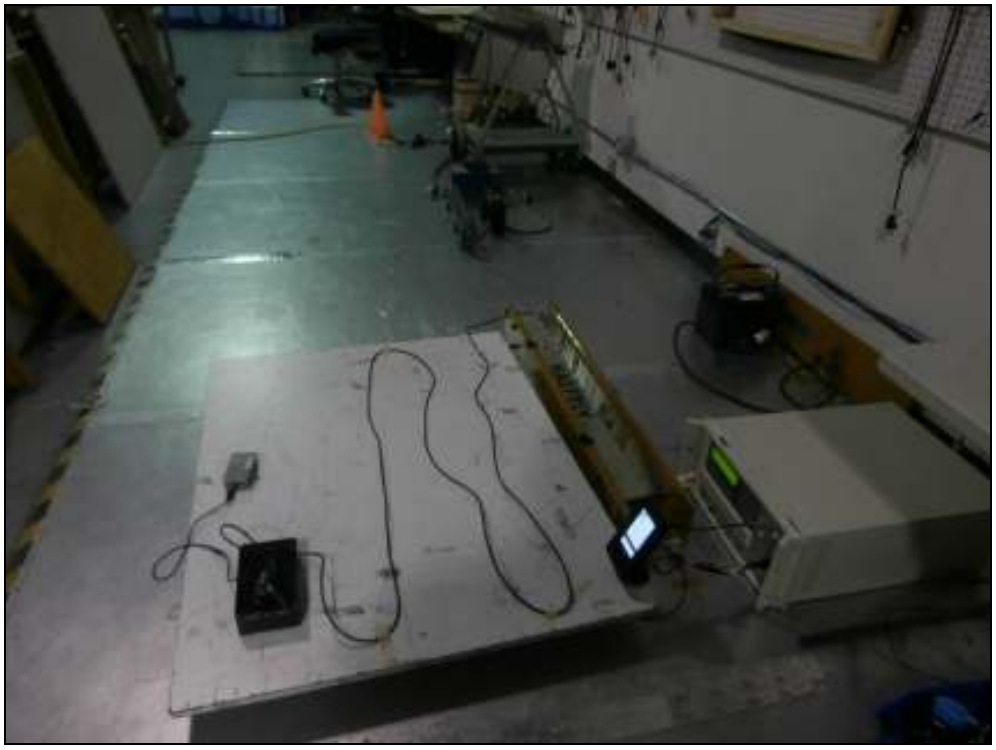


Figure 9.4-1: Test Setup Photograph

9.5 Test Results

Test Parameters:

Test Date:	**January 5, 2016**	**Temperature (ºC)**	**22**
Technician:	**Wayne Orwig**	**Humidity (%)**	**39**
Equipment Class:	**N/A**	**Barometric Pressure (mBar)**	**1032**
Tested Modes:	**Displaying depth**		
AC Input Power:	**N/A**	☒ **Pre-test Verification Complete**	
DC Input Power:	**12VDC**		

Mains Test Data:

Check All That Apply to This Data

Polarity:	Tested Levels:	Interface Type:
☐ Positive	☒ .5kV	☒ Input
☐ Negative	☒ 1kV	☐ Output
☒ Both	☐ 2kV	☐ Both
	☐	

Coupling Mode	Result	Observation (Describe any detectable event)
L1	Pass	See Notes
L2	Pass	See Notes
L1-L2	Pass	See Notes

Notes:
At all levels there was some noise on the graphics display. Occasionally the depth number would jump, usually to a lower number. But it would always return after the EFT was removed.

Signal Line Test Data:

Check All That Apply to This Data

Polarity:	Tested Levels:
☐ Positive	☒ .25kV
☐ Negative	☒ .5kV
☒ Both	☒ 1kV
	☐ 2kV
	☐ Enter Other Level Here

Signal Line	Result	Observation (Describe any detectable event)
Depth transducer	Pass	See Notes

Notes:
At all levels there was some noise on the graphics display. Occasionally the depth number would jump, usually to a lower number. But it would always return after the EFT was removed.

10.0 Surge Immunity

10.1 Test Justification

☐ No justification - The EUT was tested per the appropriate test methods and test plan.
☒ The test method, standard, and/or test plan was deviated from for the following reason:

The EUT is DC powered; therefore, this test is not applicable because the EUT is not connected to the public utility AC power lines during operation.

11.0 Radio-Frequency Common-Mode Immunity

11.1 Test Site Description

The EUT was configured and connected to satisfy its functional requirements. The EUT was placed on an insulating support of 0.1m height above a ground reference plane. All relevant cables were provided with the appropriate coupling and decoupling devices at a distance between 0.1m and 0.3m from the projected geometry of the EUT on the Ground Reference Plane (GRP).

11.2 Test Equipment

Table 11.2-1: Test Equipment List

AssetID	Manufacturer	Model #	Equipment Type	Serial #	Last Calibration Date	Calibration Due Date
5	Chase	CSP-8441	Probes	19	5/15/2015	5/15/2016
93	Chase	8101	Clamp	65	4/21/2015	4/21/2016
364	Amplfier Research	DC2600A	Coupler	322466	NCR	NCR
370	IFI	CMX5002	Amplifier	L364-0407	NCR	NCR
425	ACS	EMC Cable Set	Cable Set	425	NCR	NCR
457	Com Power	CDN-M2-25	Coupler	511023	7/15/2015	7/15/2016
471	Bird Technologies Group	150-A-FFN-06	Attenuators	914	NCR	NCR
494	Omega	iBTHX-W	Climate Monitoring Equipment	9460211	8/12/2014	8/12/2016
624	Avantest	R3261C	Analyzer	31720426	NCR	NCR
642	Fairview Microwave	FMC0101951-200CM	Cables	N/A	NCR	NCR
684	R&S	SML03	SIGGEN	3425	11/4/2015	11/4/2016

NCR = No Calibration Required

11.3 Test Methodology

IEC 61000-4-6 3rd Ed. - Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 6: Immunity to conducted disturbances, induced by radio- frequency fields, was the guiding document for this test. The purpose of this test is to verify the immunity of single devices or systems when subjected to radio-frequency electromagnetic field.

The EUT was caused to operate as intended and monitored for changes in performance. The frequency range is swept from 150 kHz to 80MHz, using the signal levels established during the setting process, and with the disturbance signal 80% amplitude modulated with a 1kHz AM sine wave, pausing to adjust the RF signal level or to switch coupling devices as necessary. The rate of sweep shall not exceed 1.5 x 10^{-3} decades. Where the frequency is swept incrementally, the step size shall not exceed 1% of the start and thereafter 1% of the preceding frequency value.

11.3.1 Test Criteria

EN 60945:2002 requires criterion A to be met as described in section 1.4.2.

11.3.2 Test Justification

☒ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☐ **The test method, standard, and/or test plan was deviated from for the following reason:**

11.4 Test Setup Photographs

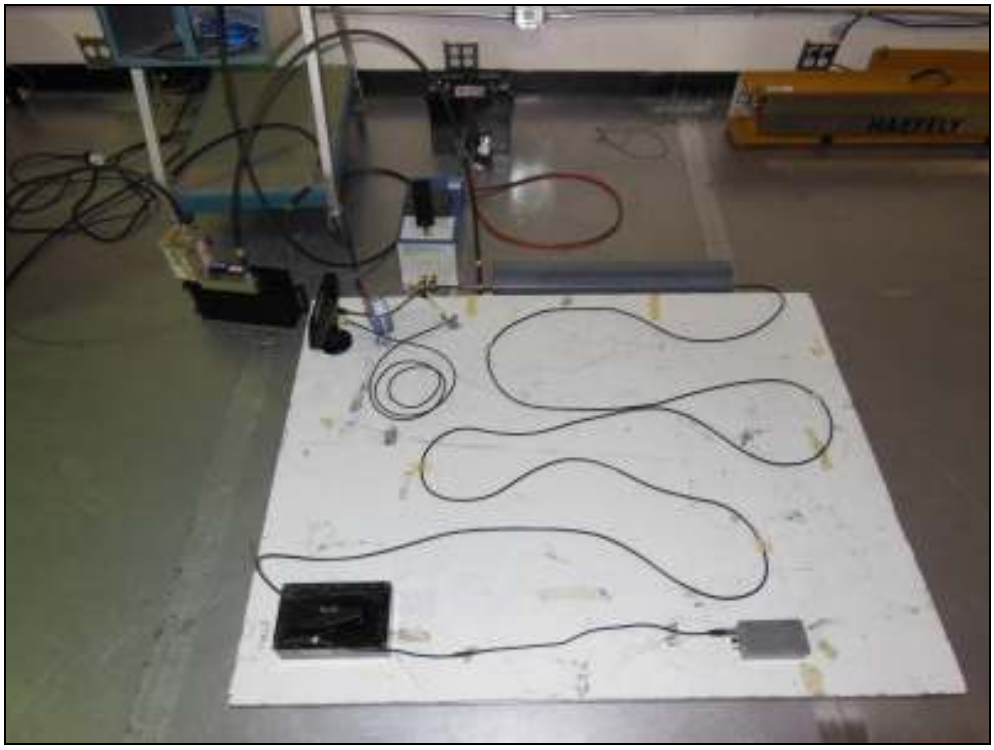


Figure 11.4-1: Test Setup Photograph

11.5 Test Results

Test Parameters:

Test Date:	**January 6, 2016**	**Temperature (ºC)**	**22.2**
Technician:	**Sean Vick**	**Humidity (%)**	**25.6**
Equipment Class:	**N/A**	**Barometric Pressure (mBar)**	**1025.5**
Tested Modes:	**EUT on; Monitoring depth & overall functionality**		
AC Input Power:	**N/A**	☒ **Pre-Test Verification**	
DC Input Power:	**12Vdc**		

Mains Test Data:

Check All That Apply to This Data

Test Level:
☒ 3Vrms
☐ 10Vrms
☐ 15Vrms
☐ Enter Other Level Here

Freq. Band:
☒ .150-80MHz
☐ Enter Other Band Here

Coupling Mode	Result	Observation (Describe any detectable event)
CDN	Pass	

Notes:

Signal Line Test Data:

Check All That Apply to This Data

Test Level:
☒ 3Vrms
☒ 10Vrms
☐ 15Vrms
☐ Enter Other Level Here

Freq. Band:
☒ .150-80MHz
☐ Enter Other Band Here

Signal Line	Result	Observation (Describe any detectable event)
Transducer cable	Pass	

Notes:
Spot frequencies 2MHz, 3MHz, 4MHz, 6.2MHz, 8.2MHz, 12.6MHz, 18.8MHz, 22MHz, 25MHz tested at 10Vrms per EN60945 with passing results.

12.0 Power Frequency Magnetic Fields Immunity

12.1 Test Justification

☐ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☒ **The test method, standard, and/or test plan was deviated from for the following reason:**

This test was not included in the scope of this project; therefore, it was not performed.

13.0 Voltage Dips and Interruptions

13.1 Test Justification

☐ **No justification - The EUT was tested per the appropriate test methods and test plan.**
☒ **The test method, standard, and/or test plan was deviated from for the following reason:**

The EUT is DC powered; therefore, this test is not applicable because the EUT is not connected to the public utility AC power lines during operation.

SECTION D: MEASUREMENT UNCERTAINTY

General
Measurement Uncertainty is based on the following publications:

- CISPR 16-4-2: Uncertainties, statistics and limit modeling – Uncertainty in EMC measurements
- The Guide to the Expression of Uncertainty in Measurement(GUM): 1995
- ANSI / NCSL Z540.2-1997 (R2002) U.S. Guide to Expression of Uncertainty in Measurement

Calculations for measurement uncertainty are available upon request.

Emissions:

Test Method	U_{Lab}	U_{CISPR}	Uncertainty Units
Radiated Emissions 30MHz-1000MHz	3.68	5.2	dB
Radiated Emissions 30MHz to 200MHz	3.79	5.2	dB
Radiated Emissions 200 to 1000MHz	3.62	5.2	dB
Radiated Emissions 1-18GHz	3.65	---	dB
Conducted Emissions .150k-30MHz	1.52	3.6	dB
Radiated Disturbances 5MHz to 30MHz	2.81	4.5	dB
Radiated Disturbances 30MHz to 950MHz	2.21	4.5	dB
Harmonic Current Emissions	1.7	---	%
Voltage Fluctuations & Flicker	1.7	---	%
Insertion Loss/Internal Calibrations	.65	---	dB
Radiated Immunity 80-1000MHz	1.21	---	dB
Conducted Immunity .150-80MHz	1.64	---	dB
Frequency Interpolations	.81 (ave)	---	dB

NOTE U_{cispr} resembles a value of measurement uncertainty for a specific test, which was determined by considering uncertainties associated with the quantities listed in CISPR 16-4-2:2003 Section 4.2. Where no value is given for U_{cispr} the procedure below does not apply.

Compliance or non-compliance with a disturbance limit shall be determined in the following manner.

If U_{Lab} is less than or equal to U_{cispr} in Table 5.0-1, then:
- compliance is deemed to occur if no measured disturbance exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

If U_{Lab} is greater than U_{cispr}, then:
- compliance is deemed to occur if no measured disturbance, increased by ($U_{Lab} – U_{cispr}$), exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance, increased by ($U_{Lab} – U_{cispr}$), exceeds the disturbance limit.

The ACS calculated MU is much less than the internationally accepted MU, therefore an adjustment to the measured result as mentioned above is not necessary.

Immunity
The EUT was subjected to the appropriate test levels required by the standard with a confidence level of 95%(k=2).

SECTION E: CONCLUSION
The EUT is determined to meet the requirements as defined in the applicable regulations.