

TEST REPORT

Report Number: 101812308MPK-002

Project Number: G101812308

December 09, 2014

Testing performed on the

Hammerhead One

Model: HH1

FCC ID: 2ADMXHH1NY

IC: 12534A-HH1NY

to

FCC Part 15.249

RSS-210, Annex 2.9

FCC Part 15, Subpart B

Industry Canada ICES-003

for

Hammerhead Navigation, Inc.


Test Performed by:

Intertek
1365 Adams Court
Menlo Park, CA 94025 USA

Test Authorized by:

Hammerhead Navigation, Inc.
353 West 39th Street, 3rd Floor
New York, NY 10018 USA

Prepared by:


Anderson Soungpanya

Date: December 09, 2014

Reviewed by:


Krishna K Vemuri

Date: December 09, 2014

This report is for the exclusive use of Intertek's Client and is provided pursuant to the agreement between Intertek and its Client. Intertek's responsibility and liability are limited to the terms and conditions of the agreement. Intertek assumes no liability to any party, other than to the Client in accordance with the agreement, for any loss, expense or damage occasioned by the use of this report. Only the Client is authorized to copy or distribute this report and then only in its entirety. Any use of the Intertek name or one of its marks for the sale or advertisement of the tested material, product or service must first be approved in writing by Intertek. The observations and test results in this report are relevant only to the sample tested. This report by itself does not imply that the material, product, or service is or has ever been under an Intertek certification program. This report must not be used to claim product endorsement by A2LA, NIST nor any other agency of the U.S. Government.

Report No. 101812308MPK-002

Equipment Under Test:	Hammerhead One
Trade Name:	Hammerhead Navigation, Inc.
Model Number:	HH1
Serial Number:	HH1_01NY-R0002
Applicant:	Hammerhead Navigation, Inc.
Contact:	Laurence Wattrus
Address:	Hammerhead Navigation, Inc. 353 West 39th Street, 3rd Floor New York, NY 10018
Country:	USA
Tel. Number:	(646) 926-7335
Email:	laurence@hammerhead.io
Applicable Regulation:	FCC Part 15.249 RSS-210, Annex 2.9 FCC Part 15, Subpart B Industry Canada ICES-003
Test Site Location:	ITS – Site 1 1365 Adams Drive Menlo Park, CA 94025
Date of Test:	November 4 to 24, 2014

We attest to the accuracy of this report:



Anderson Soungpanya
Project Engineer



Krishna K Vemuri
EMC Senior Staff Engineer

TABLE OF CONTENTS

1.0	Summary of Tests	4
2.0	General Description	5
2.1	Product Description	5
2.2	Related Submittal(s) Grants	6
2.3	Test Methodology	6
2.4	Test Facility	6
2.5	Measurement Uncertainty	6
3.0	System Test Configuration.....	7
3.1	Support Equipment and description.....	7
3.2	Block Diagram of Test Setup.....	7
3.3	Justification.....	8
3.4	Software Exercise Program.....	8
3.5	Mode of operation during test.....	8
3.6	Modifications required for Compliance.....	8
3.7	Additions, deviations and exclusions from standards.....	8
4.0	Measurement Results.....	9
4.1	Transmitter Radiated Emissions	9
4.2	Occupied Bandwidth.....	17
4.3	Radiated Emissions from Digital Parts	20
4.4	Line Conducted Emissions	24
5.0	List of Test Equipment	29
6.0	Document History	30

1.0 Summary of Tests

Equipment under Test (EUT) is the Hammerhead One, Model HH1. As described by the manufacturer, Hammerhead One is designed to be used on a bicycle. EUT consists of one Bluetooth 4.0, Low Energy radio and one ANT+ 2457MHz standard radio. The device never communicates over both protocols simultaneously. This report covers only ANT+ 2457MHz standard radio. A separate test report covers the Bluetooth 4.0 radio.

TEST	REFERENCE FCC Part 15C	REFERENCE IC RSS-210/ RSS-Gen	RESULT
Field Strength of Fundamental	15.249a	A2.9(1) RSS-210	Complies
Field Strength of Harmonics	15.249a	A2.9(1) RSS-210	Complies
Radiated Emissions outside the band	15.249c	A2.9(2) RSS-210	Complies
Occupied Bandwidth	15.215(c)	4.4.1 RSS-Gen	Complies
Line Conducted Emissions	15.207	7.2.2 RSS-Gen	Not Applicable ¹
Antenna requirement	15.203	7.1.4 RSS-Gen	Complies
Radiated and Conducted Emissions from Digital Part and receiver	FCC 47CFR 15B	ICES 003	Complies
Antenna Requirement	15.203	RSS-GEN	Complies (Internal Antenna)

¹ EUT is powered by a single-cell lithium-polymer battery and charged via a standard 5V micro USB connection. EUT does not transmit while charging.

2.0 General Description

2.1 Product Description

The Equipment Under Test (EUT) is the Hammerhead One, model number HH1. The Hammerhead One is designed to be used on a bicycle. It will be attached to the handle-bars of a bicycle and connect to a smartphone via Bluetooth 4.0, Low energy. The device indicates turn-by-turn instructions to the user. This allows them to stay focused on the road while navigating bike routes. The device will also pair with health and fitness sensors that are using the ANT+ 2457MHz standard. It intermittently switches between TX/RX on Bluetooth and TX/RX on ANT over the same internal antenna. The device never communicates over both protocols simultaneously.

The Hammerhead One is powered via a 3.70V Lithium-Polymer Battery.

Information about the Hammerhead One radio is presented below:

Applicant name & address	Hammerhead Navigation, Inc. 353 West 39th Street, 3rd Floor New York, NY 10018 USA
Manufacturer name & address	Hammerhead Navigation, Inc. 353 West 39th Street, 3rd Floor New York, NY 10018 USA
Model No.	HH1
FCC Identifier	2ADMXHH1NY
IC	12534A-HH1NY
Frequency Range	2457MHz
Rated RF Output	90.5 dB(μ V/m) at 3m
Number of Channel(s)	1
Type of Modulation	GFSK
Data Rate	1MB/s
Antenna(s) & Gain	Internal Antenna, PCB trace-antenna, Gain =1.6dBi

EUT receive date: November 4, 2014

EUT receive condition: The pre-production version of the EUT was received in good condition with no apparent damage. As declared by the Applicant, it is identical to the production units.

Test start date: November 4, 2014

Test completion date: November 24, 2014

The test results in this report pertain only to the item tested.

2.2 Related Submittal(s) Grants

None.

2.3 Test Methodology

Radiated emissions and AC mains conducted emissions measurements were performed according to the procedures in ANSI C63.10. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this report. All other measurements were made in accordance with the procedures in part 2 of CFR 47.

2.4 Test Facility

The test site used to collect the radiated data is site 1 (10-m semi-anechoic chamber). This test facility and site measurement data have been fully placed on file with the FCC, IC and A2LA accredited.

2.5 Measurement Uncertainty

Compliance with the limits was based on the results of the measurements and doesn't take into account the measurement uncertainty.

Estimated Measurement Uncertainty

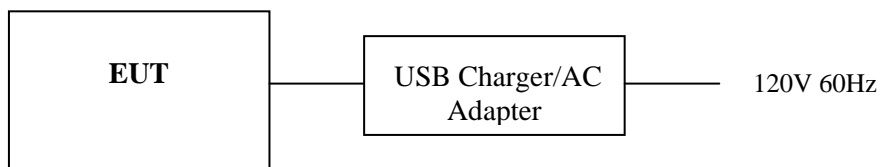
Measurement	Expanded Uncertainty (k=2)		
	0.15 MHz – 1 GHz	1 GHz – 2.5 GHz	> 2.5 GHz
RF Power and Power Density – antenna conducted	-	0.7 dB	-
Unwanted emissions - antenna conducted	1.1 dB	1.3 dB	1.9 dB
Bandwidth – antenna conducted	-	30 Hz	-
Radiated emissions	4.2 dB	3.4 dB	4.4 dB
AC mains conducted emissions	2.4 dB	-	-

3.0 System Test Configuration

3.1 Support Equipment and description

Item #	Description	Model No./ Part No.	Serial No.
1	Anker USB Charger	71AN3654WS-BA	Not Labeled

3.2 Block Diagram of Test Setup



S = Shielded	F = With Ferrite
U = Unshielded	M = Meter

3.3 Justification

For radiated emission measurements the EUT is placed on a non-conductive table. The EUT is attached to peripherals and they are connected and operational (as typical as possible). The EUT is programmed to transmit at full power. During testing, all cables are manipulated to produce worst-case emissions.

The EUT does not have any clock/frequency/oscillator operating above 108MHz; therefore Digital Emissions testing under FCC 15.109 shall only be investigated up to 1GHz.

3.4 Software Exercise Program

The EUT exercise program used during radiated and conducted testing was designed to exercise the various system components in a manner similar to a typical use.

3.5 Mode of operation during test

During the test the EUT was set to transmit the modulated signal with $\geq 98\%$ duty cycle.

3.6 Modifications required for Compliance

No modifications were installed by Intertek during compliance testing in order to bring the product into compliance.

3.7 Additions, deviations and exclusions from standards

No additions, deviations or exclusion have been made from standard.

4.0 Measurement Results

4.1 Transmitter Radiated Emissions

FCC Rules: 15.249, 15.209; IC Rules: RSS-210 (A2.9), RSS-Gen

Requirements

The Field Strength of emissions at a distance of 3 meters shall not exceed the following levels:

94 dB(μ V/m) for fundamental frequency,

54 dB(μ V/m) for harmonics.

Emissions radiated outside of the specified frequency band, except for harmonics, shall be attenuated by at least 50 dB below the level of fundamental or to the general radiated emission limits in 15.209, whichever is the lesser attenuation.

Procedure

Radiated emission measurements were performed from 30 MHz to 10 GHz according to the procedure described in ANSI C64.10. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz for frequencies above 1000 MHz. Above 1000 MHz Peak measurements were performed.

Radiated emissions are taken at 10 meters for frequencies below 1 GHz and at 3 meters for frequencies above 1 GHz

The EUT is placed on a plastic turntable that is 80 cm in height. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Test was performed with a fully charged battery, as per FCC Rule 15.31(e).

Data is included of the worst case configuration (the configuration which resulted in the highest emission levels). A sample calculation, configuration photographs and data tables of the emissions are included.



Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$FS = RA + AF + CF - AG$; if measurement is performed at a distance other than specified in the rule, a Distance Correction Factor (DCF) shall be added.

Where FS = Field Strength in dB(μ V/m)

RA = Receiver Amplitude (including preamplifier) in dB(μ V); AF = Antenna Factor in dB(1/m)

CF = Cable Attenuation Factor in dB; AG = Amplifier Gain in dB

Assume a receiver reading of 52.0 dB(μ V) is obtained. The antennas factor of 7.4 dB(1/m) and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving field strength of 32 dB(μ V/m). This value in dB(μ V/m) was converted to its corresponding level in μ V/m.

RA = 52.0 dB(μ V)

AF = 7.4 dB(1/m)

CF = 1.6 dB

AG = 29.0 dB

FS = $52.0 + 7.4 + 1.6 - 29.0 = 32$ dB(μ V/m).

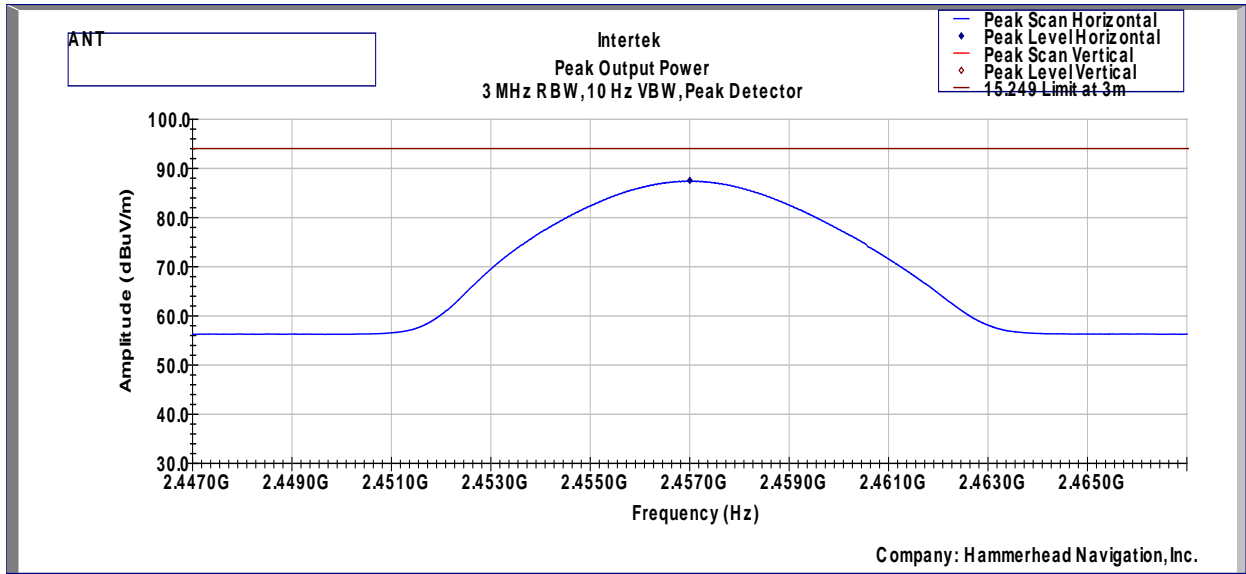
Level in μ V/m = Common Antilogarithm [$(32 \text{ dB}\mu\text{V/m})/20$] = 39.8 μ V/m.

Test Result

The data below shows the significant emission frequencies, the limit and the margin of compliance. Radiated emission measurements were performed up to 25GHz. No Emissions were identified when scanned from 18-25 GHz.

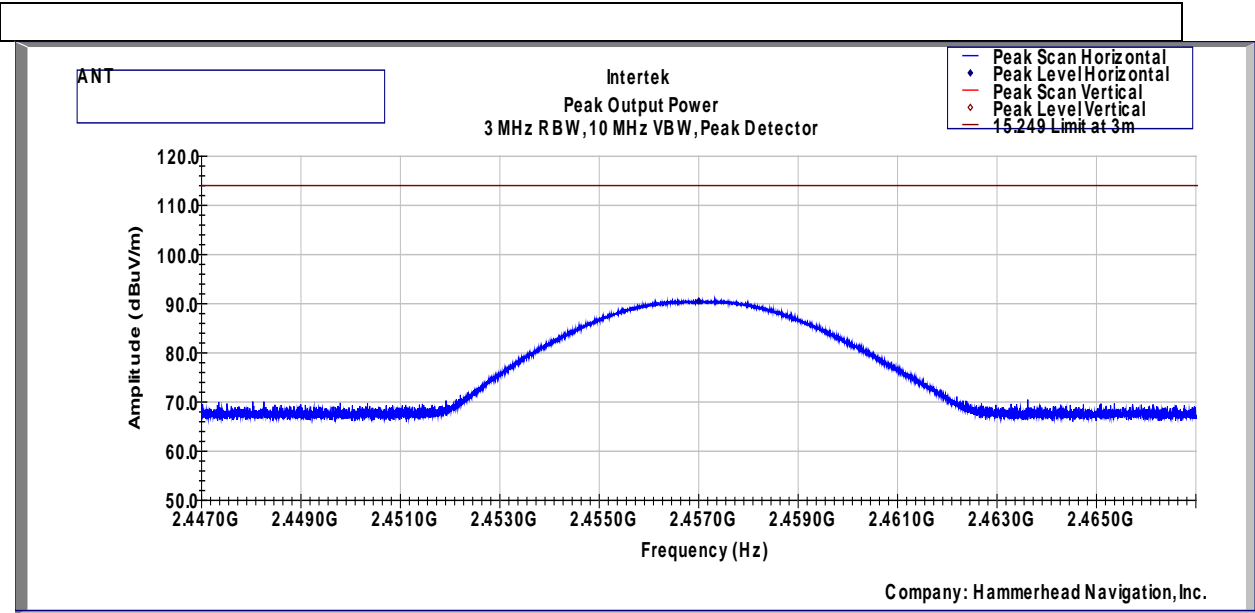
The EUT passed the test by 1.8dB.

Radiated emissions at fundamental frequency



Frequency	Ave Level	Limit@3m	Av Margin	Raw	Cable	Attenuator	AF
MHz	(dBuV/m)	(dBuV/m)	(dB)	(dBuV)	(dB)	(dB)	dB(1/m)
2457	87.5	94	-6.5	52.8	3.3	3	28.4

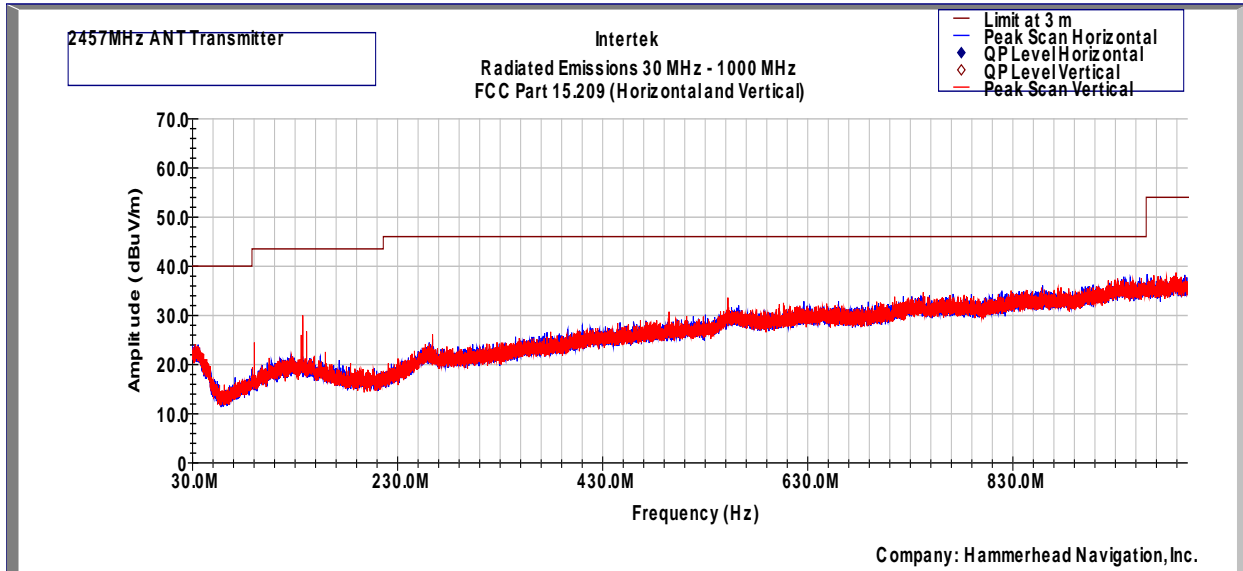
Results:	EUT Complies by 6.5 dB
-----------------	------------------------



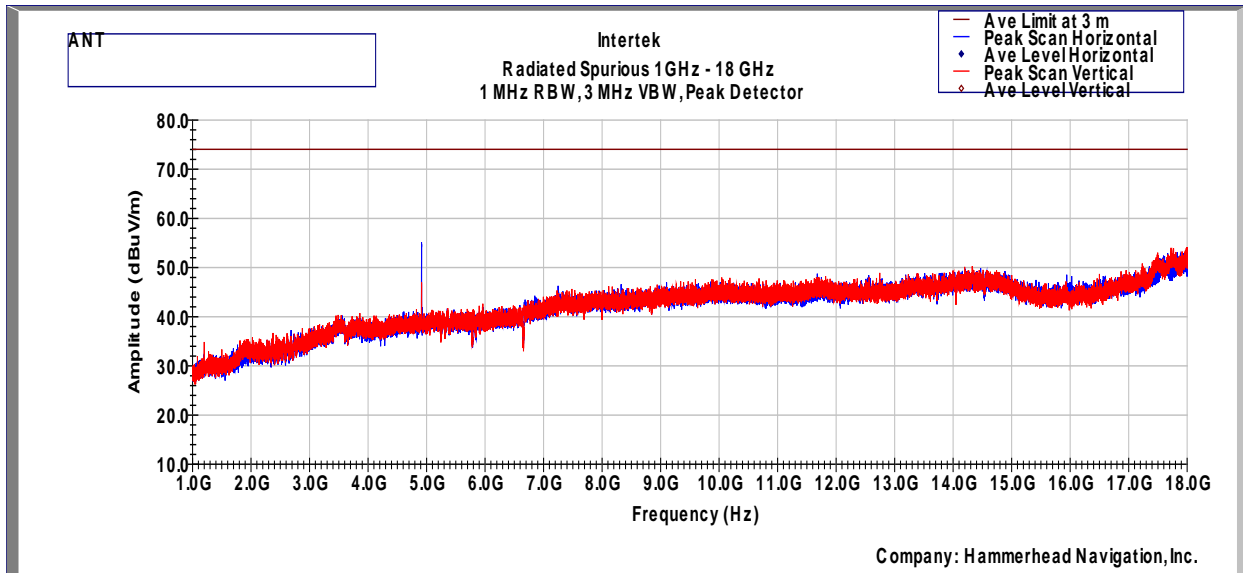
Frequency	Peak Level	Limit@3m	Peak Margin	Raw	Cable	Attenuator	AF
MHz	(dBuV/m)	(dBuV/m)	(dB)	(dBuV)	(dB)	(dB)	dB(1/m)
2457	90.5	114	-23.5	55.8	3.3	3	28.4

Results: EUT Complies by 23.5 dB

Transmitter Radiated Emissions

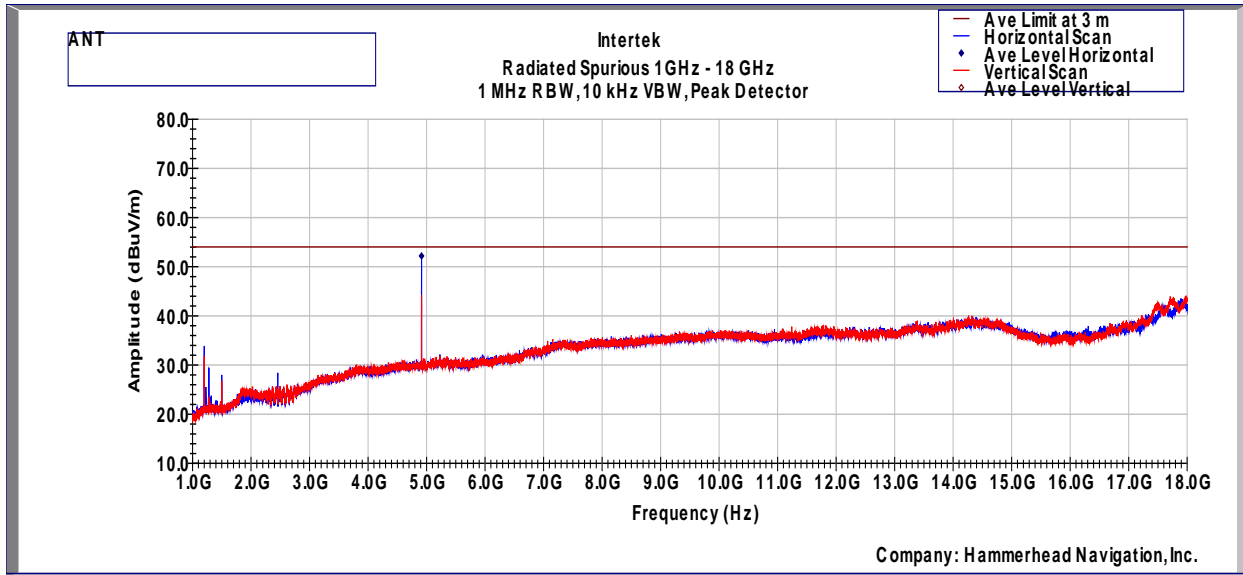


Plot 1: Spurious Emissions, 30MHz to 1000MHz, Peak



Plot 2: Spurious Emissions, 1000MHz to 18000MHz, Peak

Results:	Complies
-----------------	----------



Plot 3: Spurious Emissions, 1000MHz to 18000MHz, Average

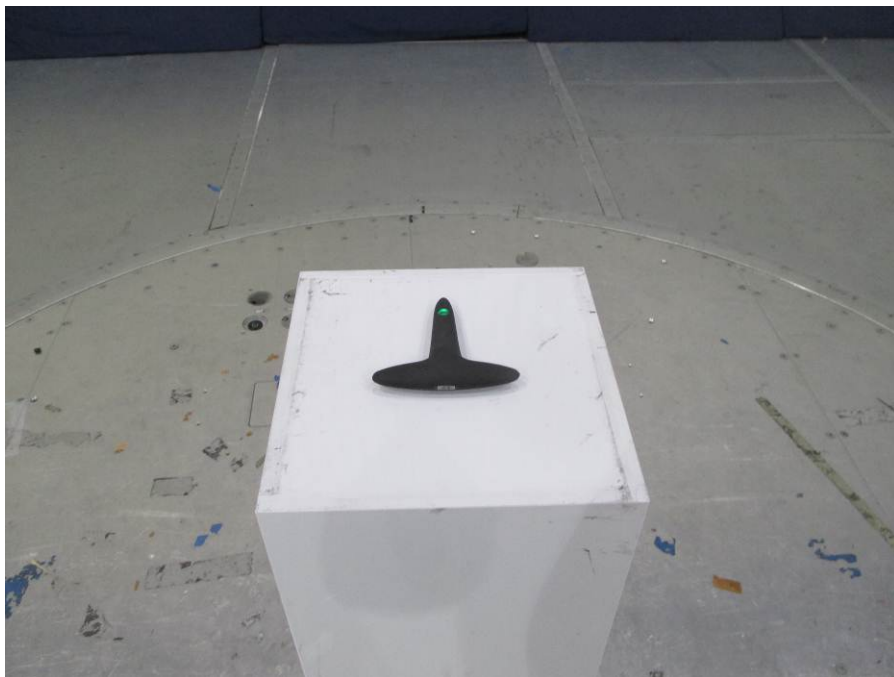
Frequency	Ave Level	Limit@3m	Av Margin	Raw	Cable	Preamp	AF
MHz	(dBuV/m)	(dBuV/m)	(dB)	(dBuV)	(dB)	(dB)	dB(1/m)
4914	52.2	54	-1.8	48.5	4.8	34.4	33.3

Results: Complies by 1.8 dB

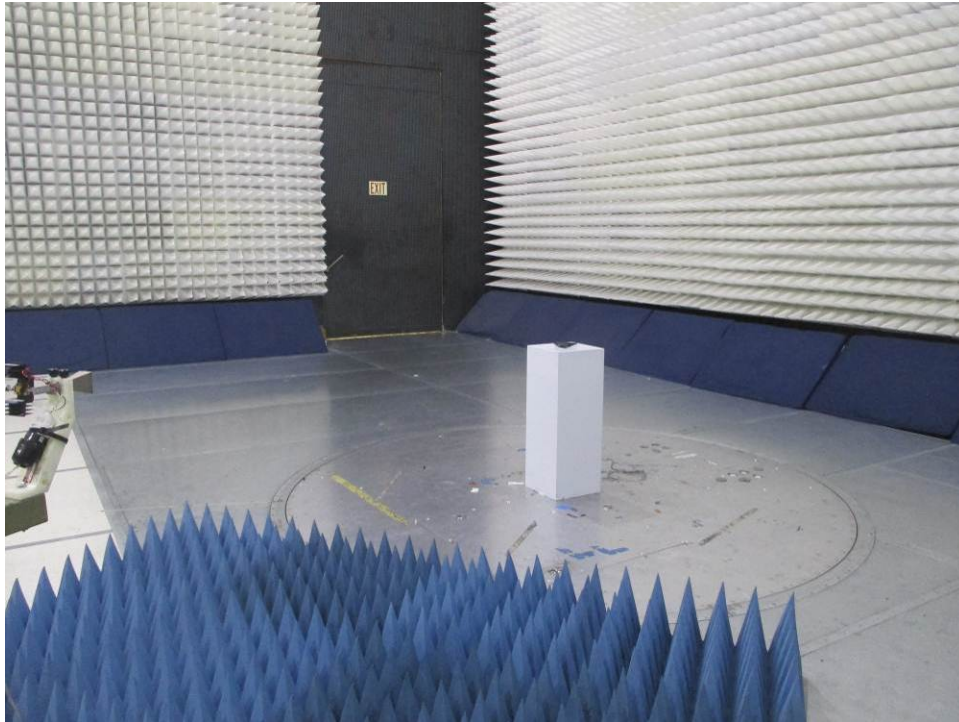
Note: All other emissions not reported are noise floor which is at least 10 dB below the limit.

Test setup photographs

The following photographs show the testing configurations used.



Test Configuration Photographs Continued



4.2 Occupied Bandwidth
FCC Rules: 15.215(c); IC Rules: RSS-Gen

Requirements

No limits for 20 dB Bandwidth and Occupied Bandwidths.

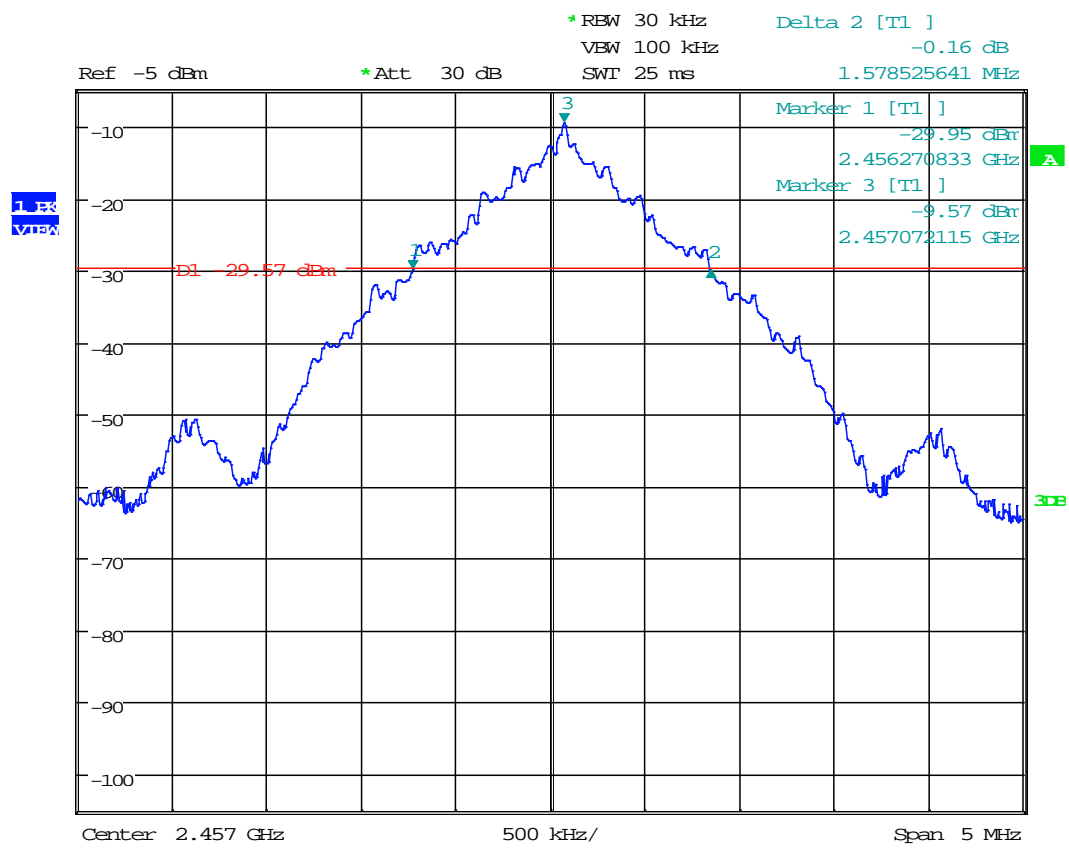
Procedure

The antenna port of the EUT was connected to the input of a spectrum analyzer (SA). For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. A PEAK output reading was taken, a DISPLAY line was drawn 20 dB lower than PEAK level. The 20 dB bandwidth was determined from where the channel output spectrum intersected the marker delta.

The occupied bandwidth was measured using the built-in spectrum analyzer function for 99% power bandwidth measurement.

Test Results

Frequency MHz	20-dB bandwidth MHz	99% Occupied bandwidth MHz
2457	1.58	1.66



Date: 24.NOV.2014 07:11:43

Plot 1: 20dB Bandwidth

4.3 Radiated Emissions from Digital Parts
FCC Ref: 15.109

Requirements

*Limits for Electromagnetic Radiated Emissions, FCC Section 15.109(b) and ICES 003 **

Frequency (MHz)	Class A at 10m dB(μV/m)	Class B at 3m dB(μV/m)
30-88	39	40.0
88-216	43.5	43.5
216-960	46.4	46.0
Above 960	49.5	54.0

* According to FCC Part 15.109(g) an alternative to the radiated emission limits shown above, digital devices may be shown to comply with the limit of CISPR Pub. 22

Procedure

Measurements are conducted with a quasi-peak detector instrument in the frequency range of 30 MHz to 1000 MHz and with the average detector instrument in the frequency range above 1000 MHz. The measuring receiver meets the requirements of Section One of CISPR 16 and the measuring antenna correlates to a balanced dipole.

Measurements of the radiated field are made with the antenna located at a distance of 10 meters from the EUT. If the field-strength measurements at 10m cannot be made because of high ambient noise level or for other reasons, measurements of Class B equipment may be made at a closer distance, for example 3m. An inverse proportionality factor of 20 dB per decade should be used to normalize the measured data to the specified distance for determining compliance.

The antenna is adjusted between 1m and 4m in height above the ground plane for maximum meter reading at each test frequency.

The antenna-to-EUT azimuth is varied during the measurement to find the maximum field-strength readings.

The antenna-to-EUT polarization (horizontal and vertical) is varied during the measurements to find the maximum field-strength readings.

The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for a larger EUT.

Floor standing EUTs are placed on a horizontal metal ground plane and isolated from the ground plane by 3 to 12 mm of insulating material.

Equipment setup for radiated disturbance tests followed the guidelines of ANSI C63.4.

Example Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor to from the measured reading, followed by subtracting the Amplifier Gain (if any) and Distance Correction Factor (if any). The basic equation with a sample calculation is as follows:

$$FS = RA + AF + CF - PA - DCF$$

Where

FS = Field Strength in dB ($\mu\text{V}/\text{m}$)

RA = Receiver Amplitude (including preamplifier) in dB (μV)

CF = Cable Attenuation Factor in dB

AF = Antenna Factor in dB (1/m)

AG = Amplifier Gain in dB

DCF=Distance Correction Factor in dB

(Formula: $DCF = 20\log_{10}(\text{measurement distance}/\text{specification distance})$)

Assume a receiver reading of 52.0 dB (μV) is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB and DCF of 10.5 dB (DCF in this example: $20\log_{10}(10/3)$) is subtracted, giving field strength of 21.5 dB ($\mu\text{V}/\text{m}$).

$$RA = 52.0 \text{ dB } (\mu\text{V})$$

$$AF = 7.4 \text{ dB } (1/\text{m})$$

$$CF = 1.6 \text{ dB}$$

$$AG = 29.0 \text{ dB}$$

$$DCF=10.5 \text{ dB}$$

$$FS = RF + AF + CF - AG - DCF$$

$$FS = 52.0 + 7.4 + 1.6 - 29.0 - 10.5$$

$$FS = 21.5 \text{ dB } (\mu\text{V}/\text{m})$$

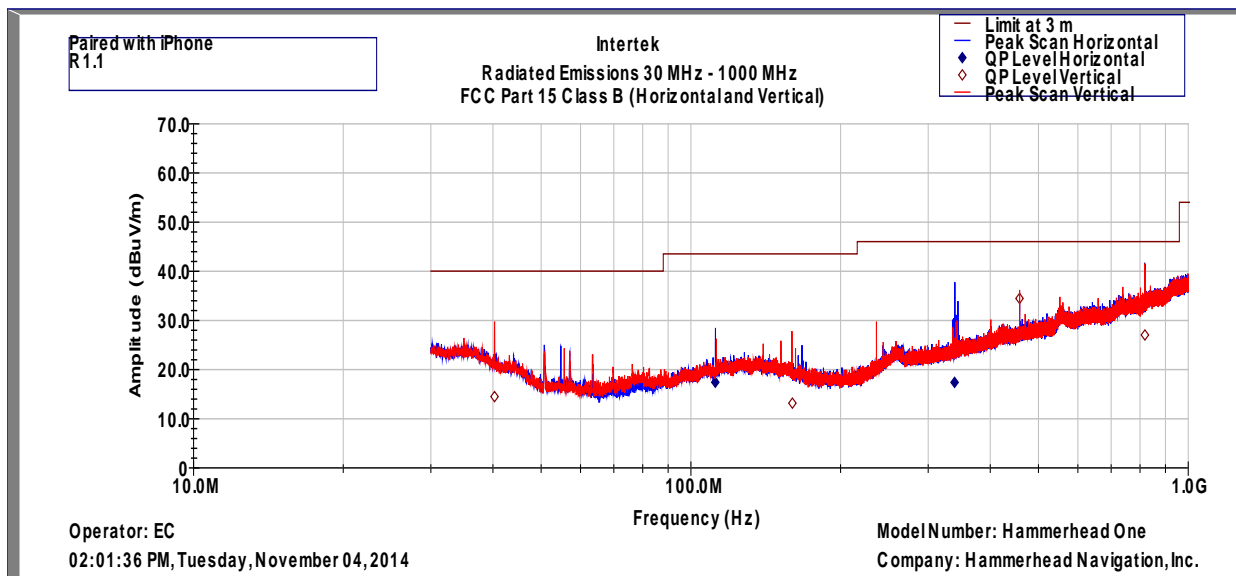
Test Results

Radiated emission measurements were performed from 30 MHz to 1000 MHz. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater below 1000 MHz and 1 MHz - above 1000 MHz.

The EUT passed 11.6dB for Class B.



FCC and ICES 003, Radiated Disturbance



Intertek Testing Services

Radiated Emissions 30 MHz - 1000 MHz

Company: Hammerhead Navigation, Inc.

Model Number: Hammerhead One

FCC Part 15 Class B (QP-Horizontal)

Frequency	Quasi Pk FS	Limit@3m	Margin	RA	CF	AG	DCF	AF	Azimuth	Height
MHz	dB(uV/m)	dB(uV/m)	dB	dB(uV)	dB	dB	dB	dB(1/m)	deg	cm
112.000	17.4	43.5	-26.1	26.7	1.2	32.1	10.5	11.1	0	100
339.000	17.4	46.0	-28.6	23.0	1.9	32	10.5	13.9	0	100

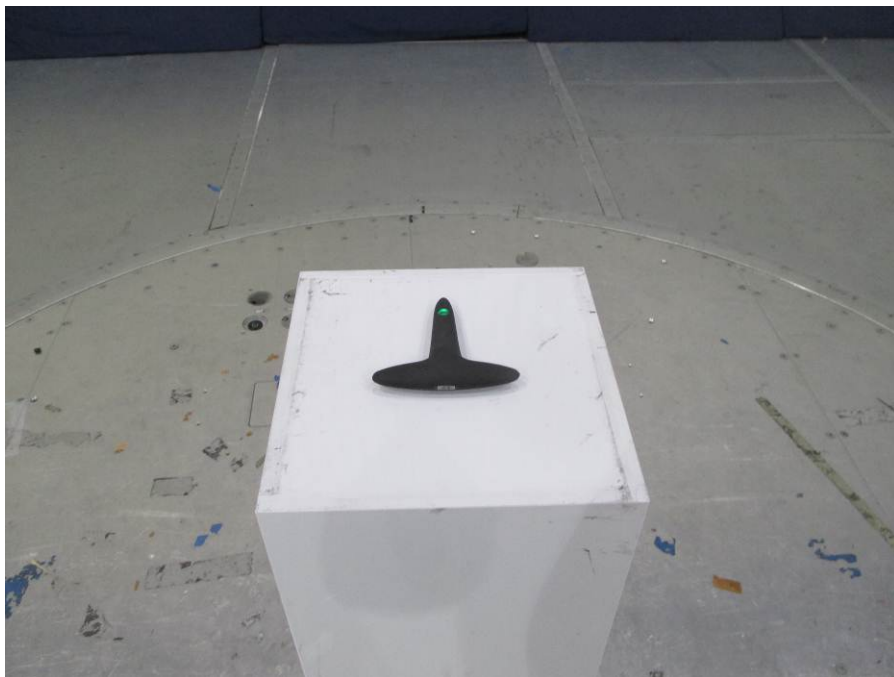
FCC Part 15 Class B (QP-Vertical)

Frequency	Quasi Pk FS	Limit@3m	Margin	RA	CF	AG	DCF	AF	Azimuth	Height
MHz	dB(uV/m)	dB(uV/m)	dB	dB(uV)	dB	dB	dB	dB(1/m)	deg	cm
40.300	14.5	40.0	-25.5	21.5	0.7	32.1	10.5	13.8	0	100
160.000	13.2	43.5	-30.3	230	1.2	32.0	10.5	10.4	0	100
458.000	34.4	46.0	-11.6	36.6	2.4	32.0	10.5	17.0	225	291
818.250	27.0	46.0	-19.0	23.1	3.3	32.1	10.5	22.2	0	400

Results: Complies by 11.6 dB

Test setup photographs

The following photographs show the testing configurations used.



4.4 Line Conducted Emissions
FCC Rules: 15.107; IC Rules: ICES 003

Requirements

Frequency Band MHz	Class B Limit dB(μV)	
	Quasi-Peak	Average
0.15-0.50	66 to 56 *	56 to 46 *
0.50-5.00	56	46
5.00-30.00	60	50

*Note: *Decreases linearly with the logarithm of the frequency
At the transition frequency the lower limit applies.*

Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide defined impedance at high frequencies across the power feed at the point of measurement of terminal voltage and also to provide isolation of the circuit under test from the ambient noise on the power lines. An AMN as defined in CISPR 16 shall be used.

The EUT is located so that the distance between the boundary of the EUT and the closest surface of the AMN is 0.8m.

Where a flexible mains cord is provided by the manufacturer, this shall be 1m long or if in excess of 1m, the excess cable is folded back and forth as far as possible so as to form a bundle not exceeding 0.4m in length.

The EUT is arranged and connected with cables terminated in accordance with the product specification.

Conducted disturbance is measured between the phase lead and the reference ground, and between the neutral lead and the reference ground. Both measured values are reported.

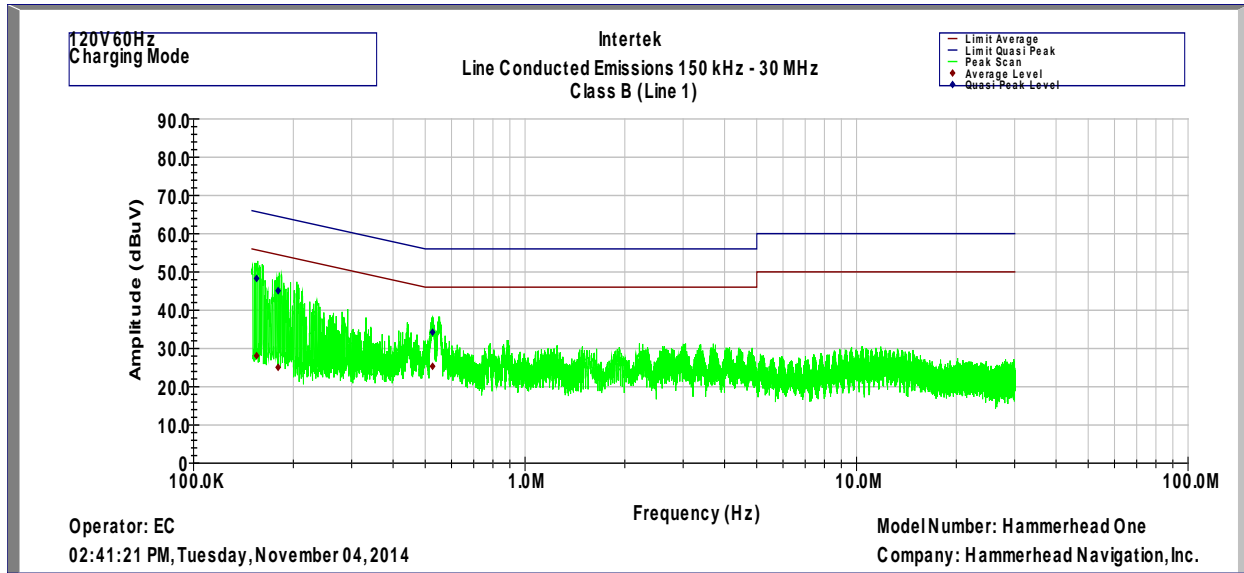
The EUT, where intended for tabletop use, is placed on a table whose top is 0.8m above the ground plane. A vertical, metal reference plane is placed 0.4m from the EUT. The vertical metal reference-plane is at least 2m by 2m. The EUT shall be kept at least 0.8m from any other metal surface or other ground plane not being part of the EUT. The table is constructed of non-conductive materials. Its dimensions are 1m by 1.5m, but may be extended for larger EUT.

Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

Equipment setup for conducted disturbance tests followed the guidelines of ANSI C63.4.

Test Result

AC Line Conducted Emission Data, EUT in transmitting mode



Intertek Testing Services

Radiated Emissions 30 MHz - 1000 MHz

Company: Hammerhead Navigation, Inc.

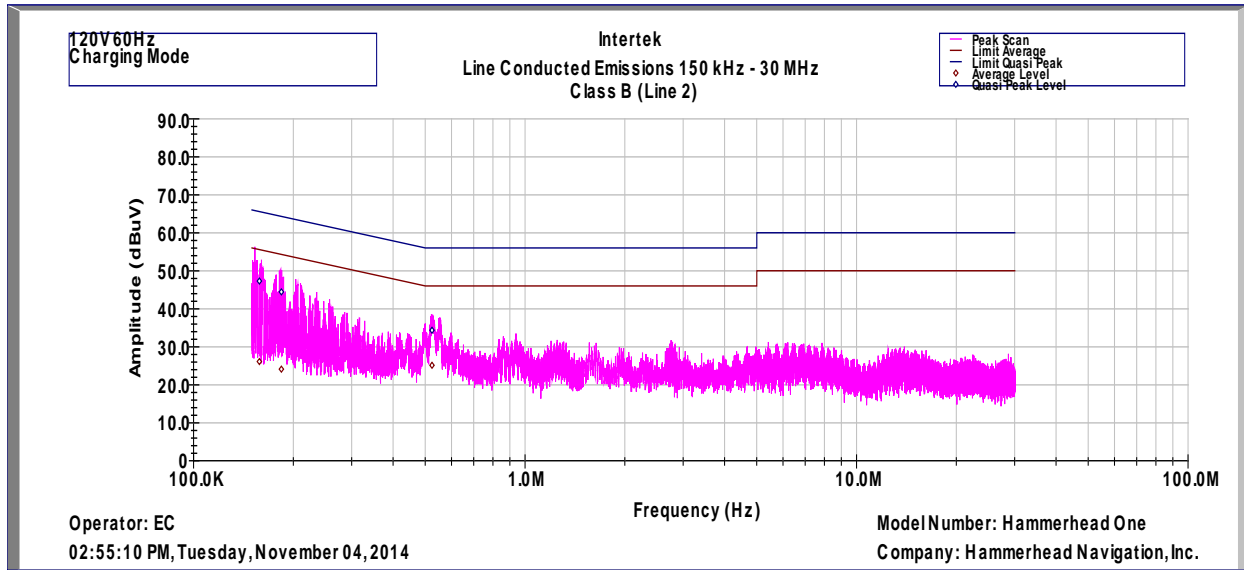
Model Number: Hammerhead One

QP and Ave Detector Class B (Line 1)

Frequency MHz	Av Level dBuV	QP Level dBuV	Av Limit dBuV	QP Limit dBuV	Av Margin dB	QP Margin dB
0.155	28.1	48.3	55.9	65.9	-27.8	-17.6
0.180	25.1	45.1	55.1	65.1	-30.1	-20.1
0.526	25.3	34.2	46.0	56.0	-20.7	-21.8

Test Mode: Charging Mode, 120V 60Hz

AC Line Conducted Emission Data, EUT in transmitting mode



Intertek Testing Services
Radiated Emissions 30 MHz - 1000 MHz
Company: Hammerhead Navigation, Inc.

Model Number: Hammerhead One

QP and Ave Detector Class B (Line 2)

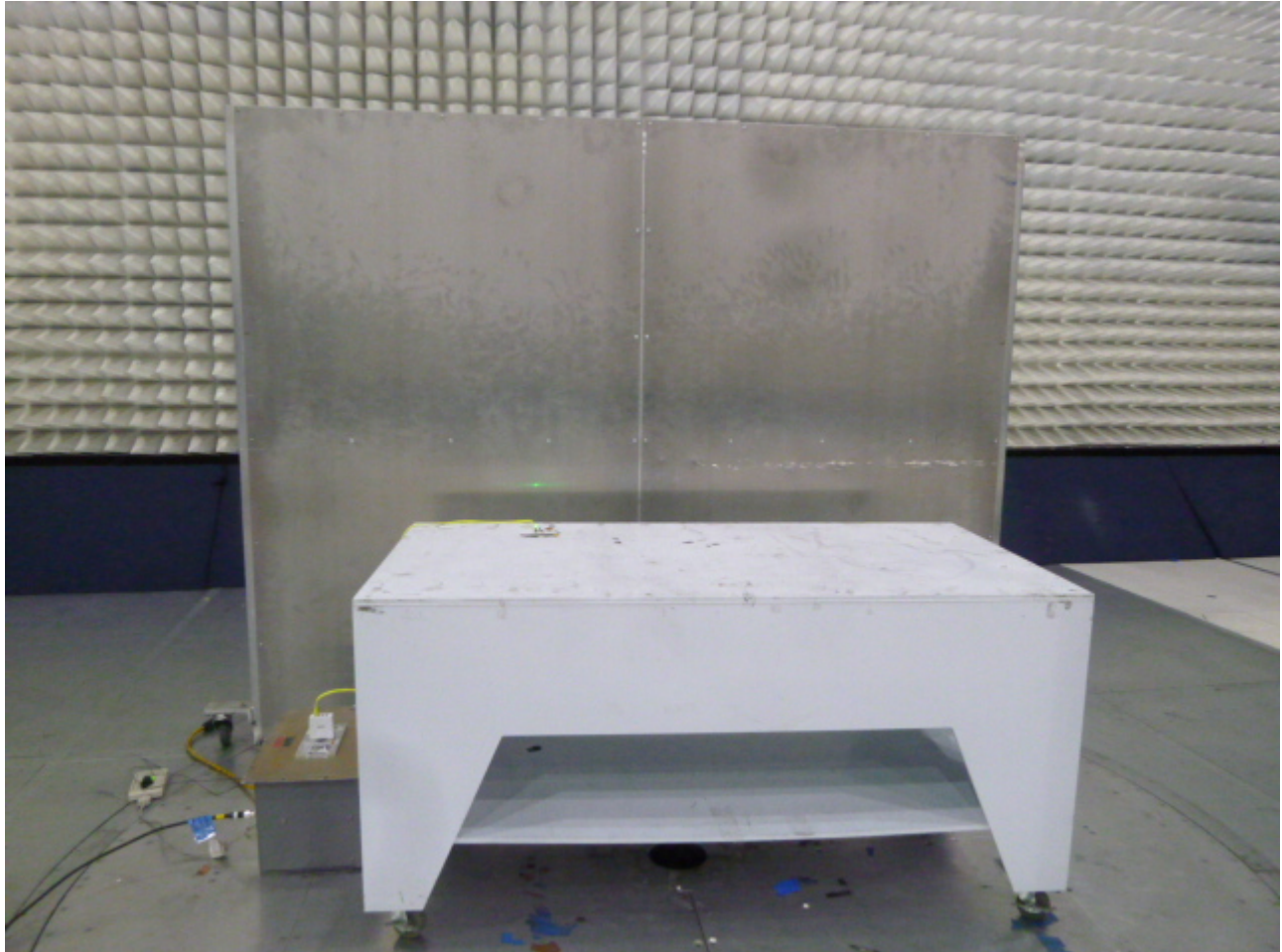
Frequency MHz	Av Level dBuV	QP Level dBuV	Av Limit dBuV	QP Limit dBuV	Av Margin dB	QP Margin dB
0.158	26.1	47.3	55.8	65.8	-29.7	-18.5
0.184	24.1	44.4	55.0	65.0	-30.9	-20.6
0.524	25.1	34.3	46.0	56.0	-20.9	-21.7

Test Mode: Charging Mode, 120V 60Hz

Results Complies by 17.6 dB

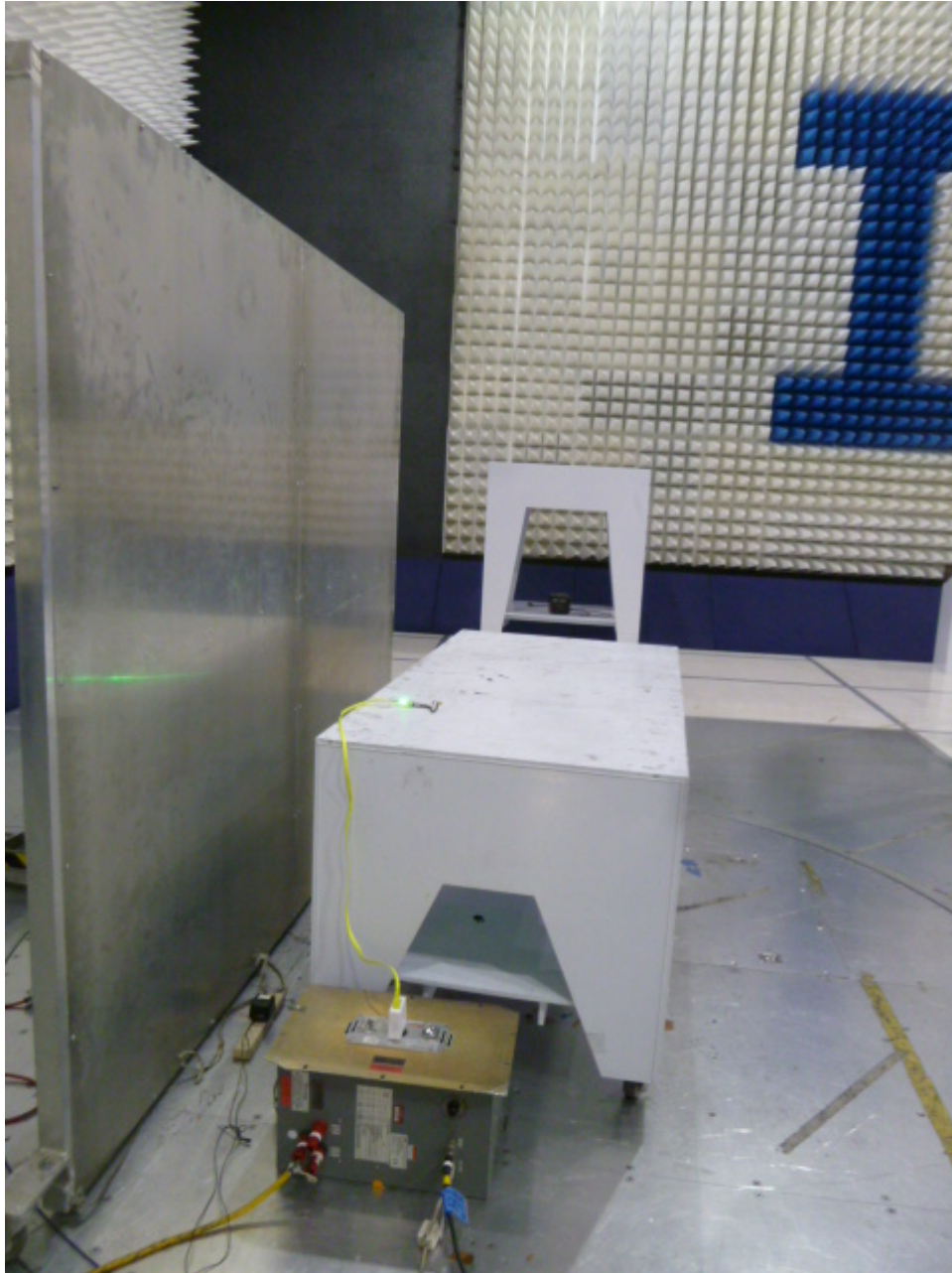
Test setup photographs

The following photographs show the testing configurations used.



Test setup photographs

The following photographs show the testing configurations used.



5.0 List of Test Equipment

Measurement equipment used for emission compliance testing utilized the equipment on the following list:

Equipment	Manufacturer	Model/Type	Serial No.	Calibration Interval	Cal Due
Bi-Log Antenna	ARA	LPB-2513/A	1154	12	08/21/15
Pre-Amplifier	Sonoma Instrument	310	185634	12	12/20/14
Bi-Log Antenna	Teseq	CBL 6111D	31222	12	11/21/15
Pre-Amplifier	Miteq	AMF-4D-001180-24-10P	799159	12	10/01/15
Digital Multi Meter	Fluke	87V	15720718	12	03/19/15
Spectrum Analyzer	Rohde & Schwarz	FSU	200482	12	12/11/14
EMI Receiver	Rohde & Schwarz	ESU	100172	12	11/10/15
Horn Antenna	ETS-Lindgren	3115	00126795	12	11/21/15
Signal Generator	Rohde & Schwarz	SMU200A	102499	12	06/30/15
Horn Antenna	EMCO	3115	9107-3712	12	12/17/14
Horn Antenna	EMCO	3160-09	00571	12	06/09/15
Pre-Amplifier	Miteq	JSD44-18004000-305P	1071636	12	06/09/15

6.0 Document History

Revision/ Job Number	Writer Initials	Reviewers Initials	Date	Change
1.0 / G101812308	AS	KK	December 09, 2014	Original document