TEST REPORT

Report Number: 101812308MPK-001
Project Number: G101812308
Report Date: December 09, 2014

Testing performed on the
Hammerhead One
Model Number: HH1
FCC ID: 2ADMX-HH1NY
IC: 12534A-HH1NY

to

FCC Part 15 Subpart C (15.247)
Industry Canada RSS-210 Issue 8, Annex 8
FCC Part 15, Subpart B
Industry Canada ICES-003

for

Hammerhead Navigation, Inc.

Test Performed by:	Test Authorized by:
Intertek	Hammerhead Navigation, Inc.
1365 Adams Court	353 West 39th Street, 3rd Floor
Menlo Park, CA 94025 USA	New York, NY 10018 USA

Prepared by: _____ **Date:** December 09, 2014
Anderson Soungpanya

Reviewed by: _____ **Date:** December 09, 2014
Krishna K Vemuri

Report No. 101812308MPK-001

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 Subpart C (15.247) Industry Canada RSS-210 Issue 8, Annex 8 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	Krishna K Vemuri
Project Engineer	EMC Senior Staff Engineer

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1.0 Introduction

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 Bluetooth 4.0 radio. A separate test report covers the ANT+ 2457MHz standard radio.

The Bluetooth 4.0 radio is a DTS (Digital Transmission System) transceiver operating in the 2.4GHz frequency band. This report is designed to show compliance of the 2.4 GHz transceiver with FCC Part 15.247 and RSS-210 requirements.

1.1 Summary of Tests

TEST	REFERENCE FCC 17.247	REFERENCE RSS-210	RESULTS
Output Power	15.247(b)(3)	A8.4(4)	Complies
6-dB Bandwidth	15.247(a)(2)	A8.2(a)	Complies
Power Spectral Density	15.247(e)	A8.2(b)	Complies
Out-of-Band Antenna Conducted Emission	15.247(d)	A8.5	The EUT has a permanently attached internal antenna. It does not contain an antenna port connector. Instead of Antenna Conducted measurements, Radiated measurements were performed.
Out-of-Band Radiated Emission (except emissions in Restricted Bands)	15.247(d)	A8.5	Complies
Radiated Emission in Restricted Bands	15.247(d), 15.205	2.2	Complies
RF exposure	15.247(i)	RSS-102	Complies
AC Conducted Emission	15.207	RSS-GEN	Not Applicable [1]
AC Conducted Emission from Digital Parts and Receiver	15.107	ICES-003	Complies
Radiated Emission from Digital Parts and Receiver	15.109	ICES-003 & RSS-GEN	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

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. 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.

For more information, refer to the following product specification, declared by the manufacturer.

Overview of the EUT

Applicant	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 Numbers	HH1
FCC Identifier	2ADMX-HH1NY
IC ID Number	12534A-HH1NY
Rated RF Output (EIRP)	-4.00 dBm, 0.398 mW
Frequency Range	2402 - 2480 MHz
Number of Channel(s)	40, Channels 0-39
Modulation Type	GFSK, Bluetooth 4.0 Low Energy (BLE)
Antenna Type and Gain	PCB trace-antenna, Gain =1.6dBi

Production versions of the samples were received on November 4, 2014 in fair condition. As declared by the Applicant, it is identical to production units.

Test start date November 4, 2014
Test end date: November 24, 2014

2.2 Related Submittal(s) Grants

None.

2.3 Test Methodology

Radiated and AC Line conducted emissions measurements were performed according to the procedures in ANSI C63.4. Radiated tests were performed at an antenna to EUT distance of 3 meters, unless stated otherwise in the "Data Sheet" of this Application. All other measurements were made in accordance with the procedures described in the FCC guidance document 558074 D01 DTS Meas Guidance v03r02, Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247.

2.4 Test Facility

The radiated emission test site and conducted measurement facility used to collect the data is 10m semi-anechoic chamber located in Menlo Park, California. This test facility and site measurement data have been fully placed on file with the FCC and Industry Canada (Site # 2042L-1).

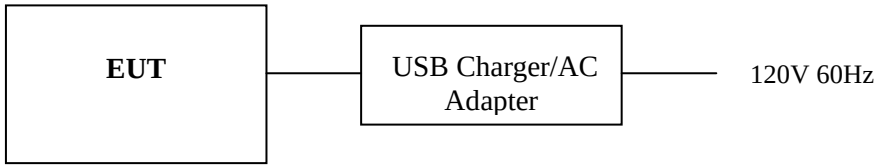
3.0 System Test Configuration

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

The diagram shown below details the interconnection of the EUT and support equipment. For specific layout, refer to the test configuration photograph in the relevant section of this report.



S = Shielded **U** = Unshielded	**F** = With Ferrite **m** = Length in Meters

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

None.

3.5 Mode of Operation During Test

The EUT was setup in the software controlled test mode to continuous transmit a modulated signal at the lowest (2402 MHz), middle (2440 MHz) and highest (2480 MHz) channels.

3.6 Modifications Required for Compliance

No modifications were installed by Intertek Testing Services during compliance testing to bring the product into compliance.

4.0 Measurement Results

4.1 Conducted Output Power at Antenna Terminals
FCC 15.247(b)(3)

4.1.1 Requirements

For systems operating in the 2400-2483.5 MHz band using digital modulation, the maximum peak output power is 1 watt (30 dBm), the conducted power limit is based on the use of antenna with directional gain that do not exceed 6dBi. If the transmitting antenna of directional gain greater than 6dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated value as in FCC 15.247(b)(4)(i).

4.1.2 Procedure

The procedure described in FCC Publication 558074 D01 DTS Meas Guidance v03r02 June 5, 2014 was used. Specifically, section 9.1.1 RBW ≥ DTS Bandwidth was utilized as the spectrum analyzer's resolution bandwidth was greater than the DTS bandwidth.

1. Set the RBW ≥ DTS Bandwidth
2. Set the VBW ≥ 3 x RBW
3. Set the span ≥ 3 x RBW
4. Detector = Peak
5. Sweep time = Auto couple
6. Trace mode = Max Hold
7. Allow trace to fully stabilize
8. Use peak marker function to determine the peak amplitude level.

The EUT has a permanently attached internal antenna. It does not contain an antenna port connector. Instead of Antenna Conducted measurements, Radiated measurements were performed.

The maximum field strength of the fundamental was measured 3 meters away from the EUT.

The transmitter's peak power was calculated using the following equation:

EIRP = E + 20log D - 104.8

where:

E = electric field strength in dBµV/m,

EIRP = equivalent isotropic radiated power in dBm

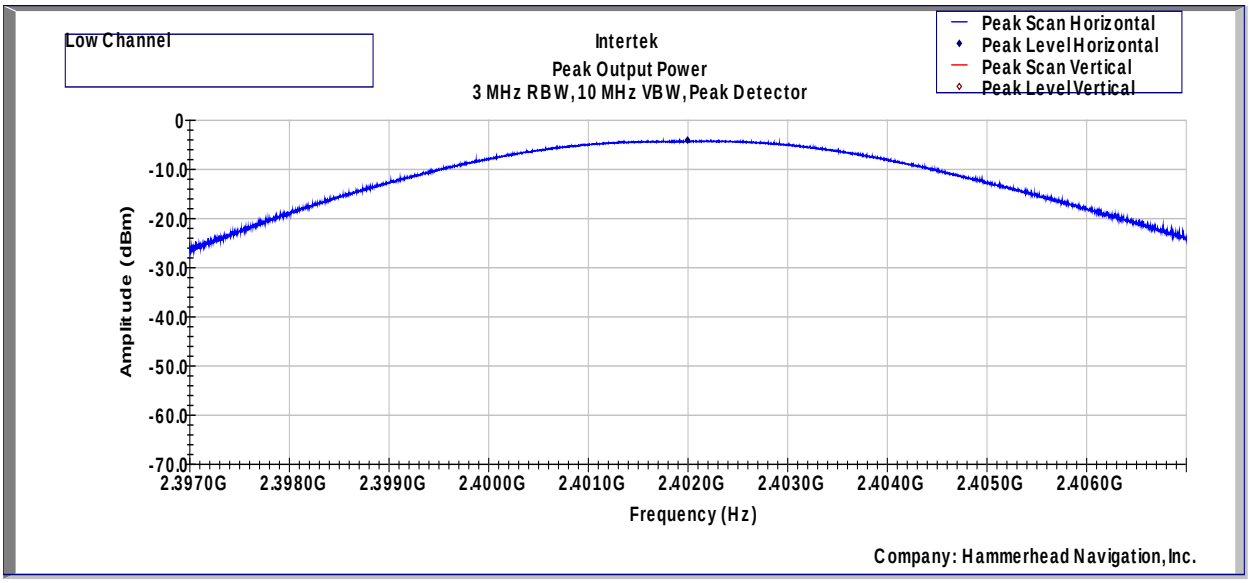
D = specified measurement distance in meters (3 meters)

4.1.3 Test Results

Frequency (MHz)	EIRP Output in dBm	EIRP Output in mW	Plot number
2402	-4.1	0.389	1.1
2440	-4.0	0.398	1.2
2480	-5.6	0.275	1.3

Note: The EUT's antenna is 1.6 dBi gain.

Plot 1.1



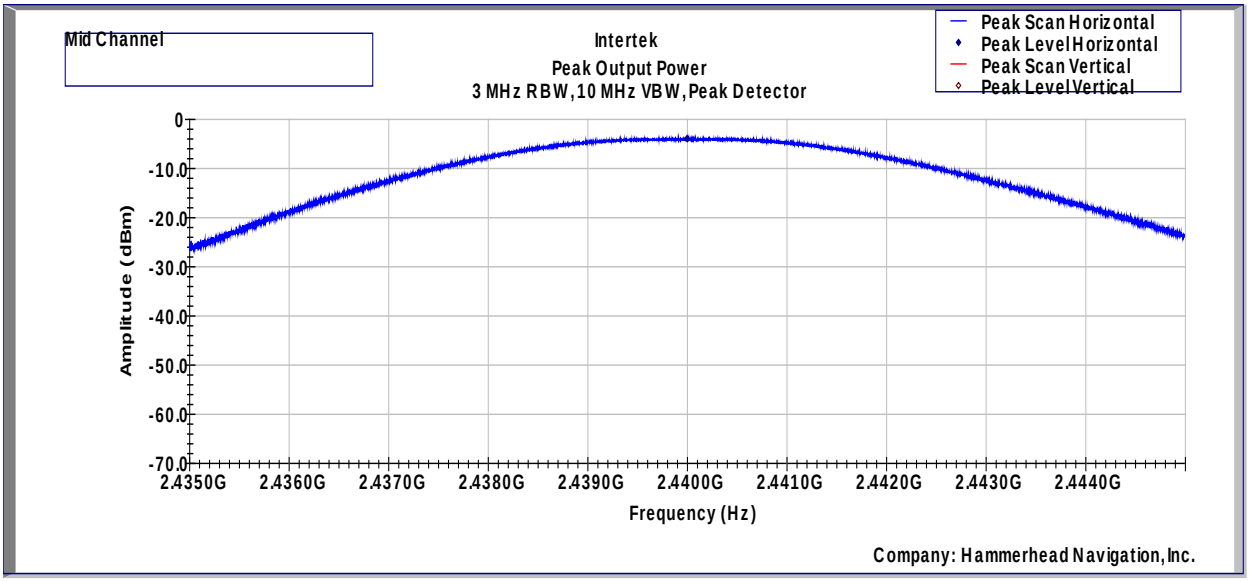
Final Corrected Reading

Frequency	RA	Attenuator	CF	AF	E	EIRP	EIRP
MHz	dB(uV)	dB	dB	dB(1/m)	dB(uV/m)	dBm	mW
2402.0	56.5	3.0	3.3	28.4	91.2	-4.1	0.389

RA = Raw Amplitude
CF = Cable Factor
AF = Antenna Factor
E = Final Field Strength

Results:	Complies

Plot 1.2



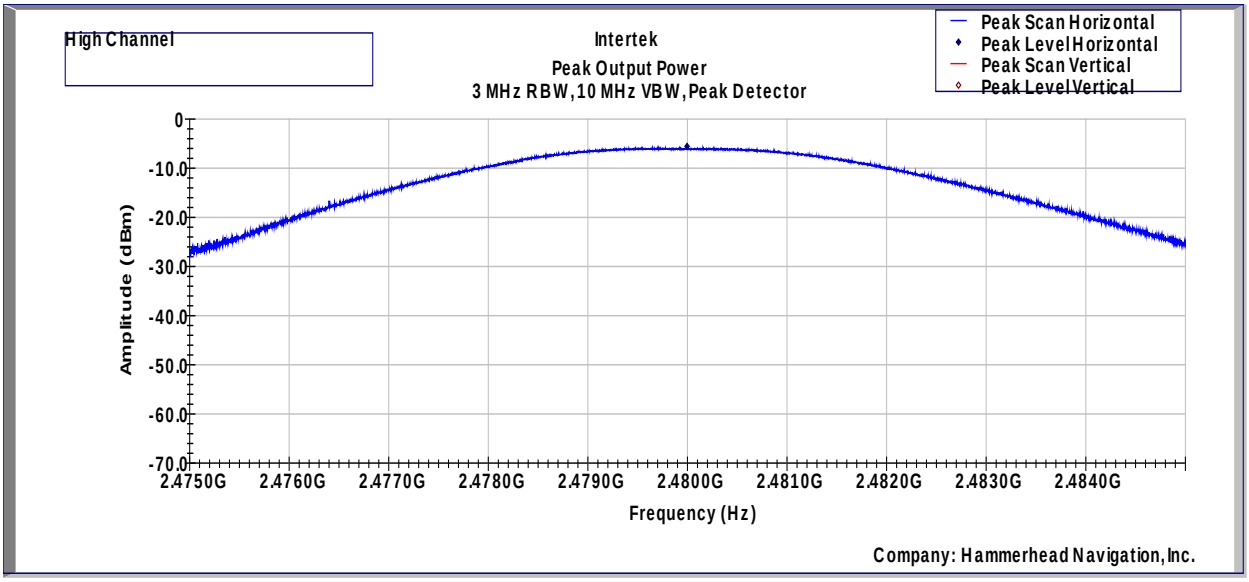
Final Corrected Reading

Frequency	RA	Attenuator	CF	AF	E	EIRP	EIRP
MHz	dB(uV)	dB	dB	dB(1/m)	dB(uV/m)	dBm	mW
2440.0	56.6	3.0	3.3	28.4	91.3	-4.0	0.398

RA = Raw Amplitude
CF = Cable Factor
AF = Antenna Factor
E = Final Field Strength

Results:	Complies

Plot 1.3



Final Corrected Reading

Frequency	RA	Attenuator	CF	AF	E	EIRP	EIRP
MHz	dB(uV)	dB	dB	dB(1/m)	dB(uV/m)	dBm	mW
2480.0	54.8	3.0	3.4	28.5	89.7	-5.6	0.275

RA = Raw Amplitude
CF = Cable Factor
AF = Antenna Factor
E = Final Field Strength

Results:	Complies

4.2 6-dB Bandwidth
FCC 15.247(a)(2)

4.2.1 Requirements
For systems operating in the 2400-2483.5 MHz band using digital modulation, the minimum 6-dB Bandwidth shall be at least 500kHz.

4.2.2 Procedure
A measuring antenna was placed in close proximity to the EUT.
For FCC 6dB Channel Bandwidth the Procedure described in the FCC Publication 558074 D01 DTS Meas Guidance v03r02 June 5, 2014 was used to determine the DTS occupied bandwidth. Section 8.1 Option 1 was used.

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW) ≥ 3 x RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

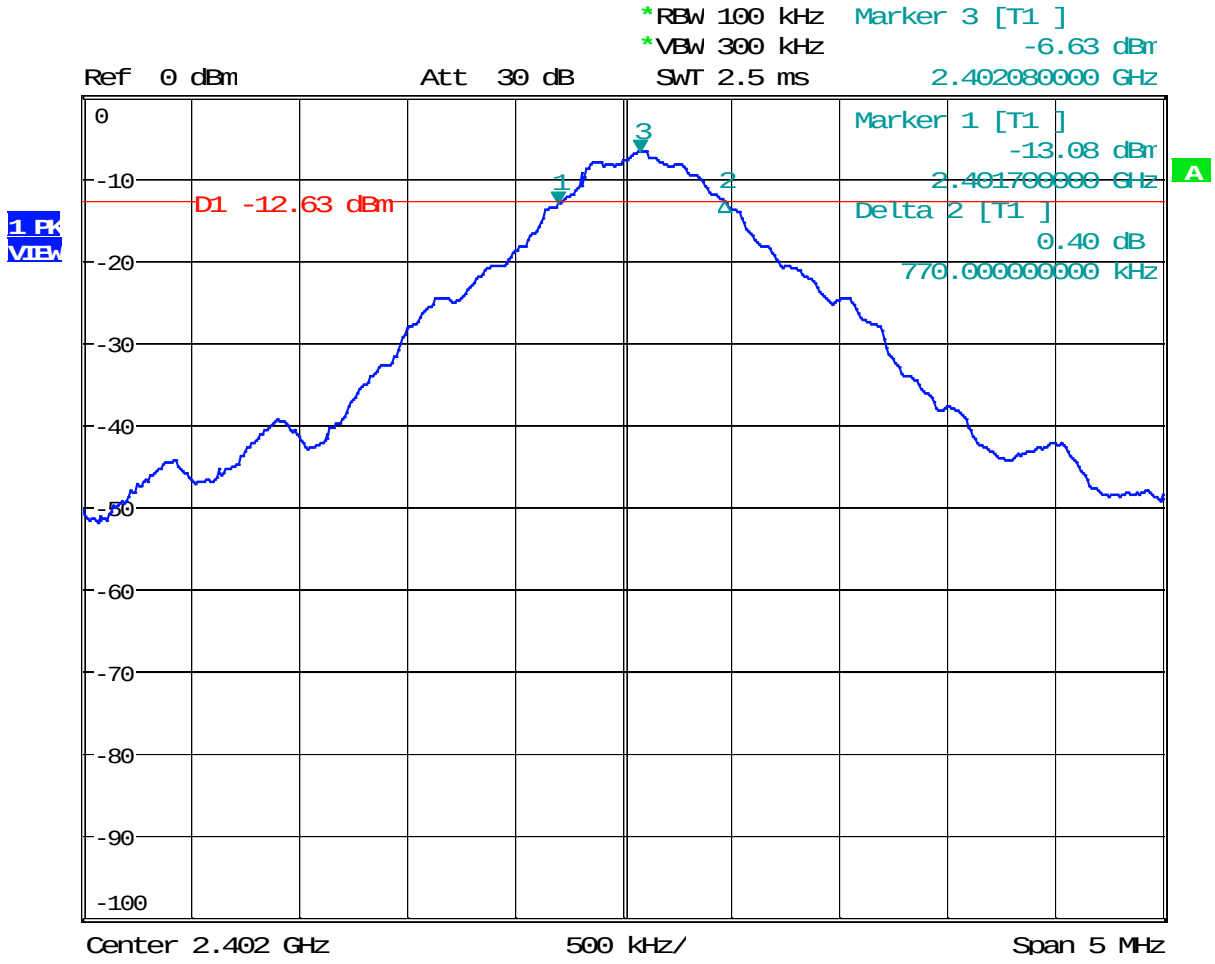
For 99% power bandwidth measurement, the bandwidth was determined by using the built-in 99% occupied bandwidth function of the spectrum analyzer. The resolution bandwidth is set to 1% of the selected span as is without being below 1%. The video bandwidth shall be set to 3 times the resolution bandwidth.

4.2.3 Test Results

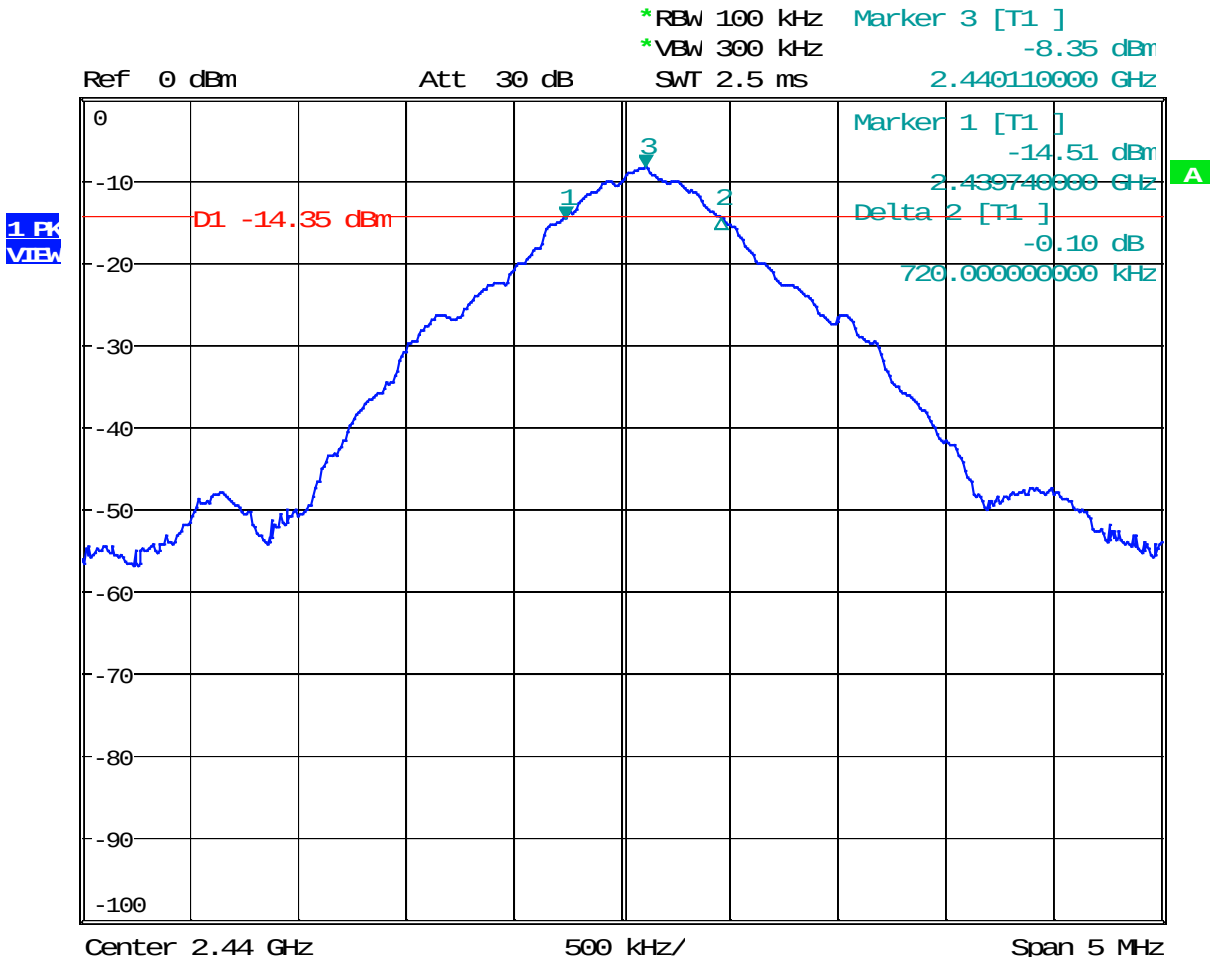
Frequency (MHz)	FCC, 6-dB Channel Bandwidth (kHz)	Plot
2402	770.0	2.1
2440	720.0	2.2
2480	740.0	2.3

Frequency (MHz)	99% Occupied Bandwidth (MHz)	Plot
2402	1.67	2.4
2440	1.67	2.5
2480	1.68	2.6

Plot 2. 1

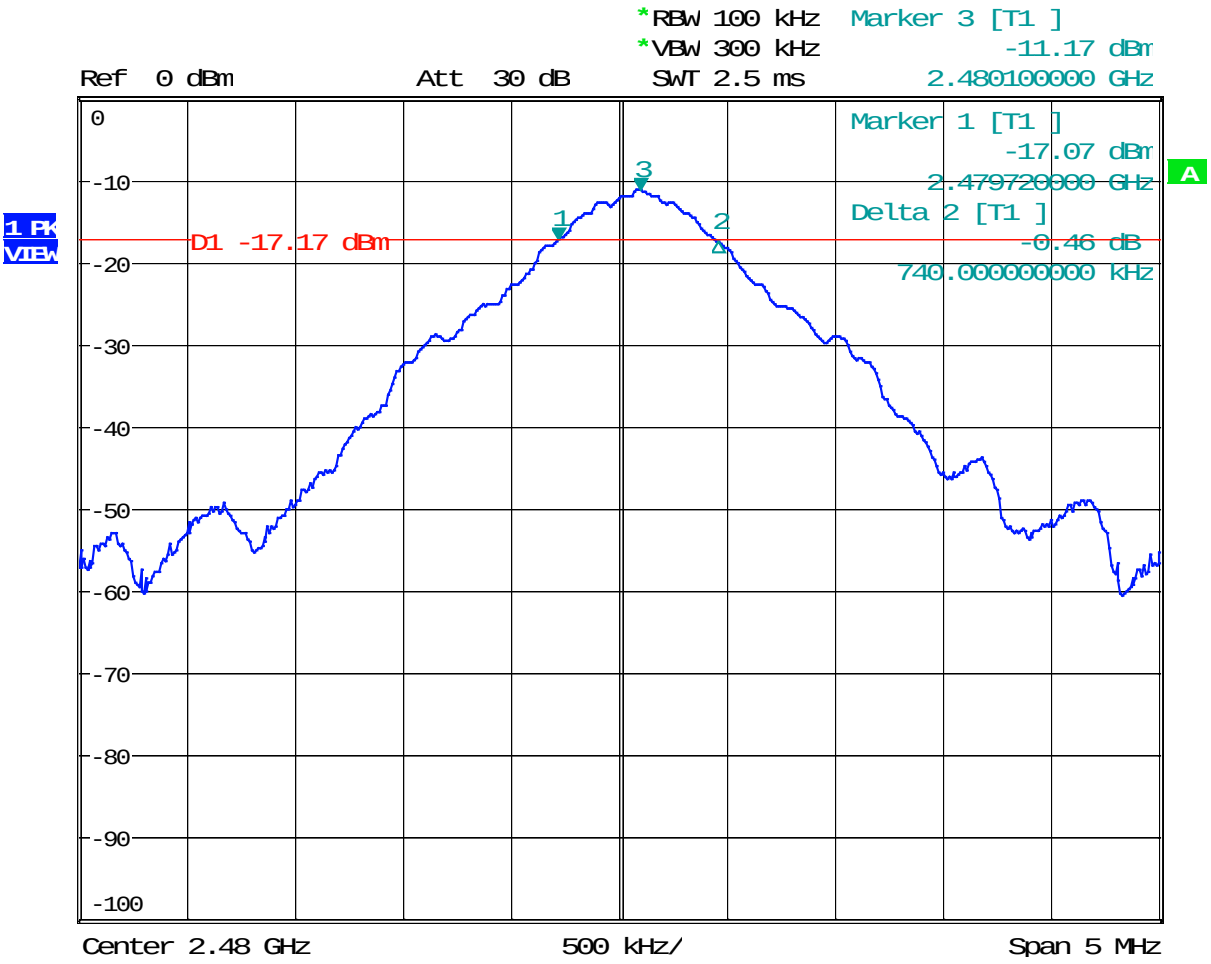

*RBW 100 kHz
*VBW 300 kHz
Ref 0 dBm
Att 30 dB
SWT 2.5 ms
Marker 3 [T1]
-6.63 dBm
2.402080000 GHz
Marker 1 [T1]
-13.08 dBm
2.401700000 GHz
Delta 2 [T1]
0.40 dB
770.000000000 kHz
D1 -12.63 dBm
1 PK
VIEW
A
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Center 2.402 GHz
500 kHz/
Span 5 MHz
Date: 11.NOV.2014 06:11:58

Plot 2. 2

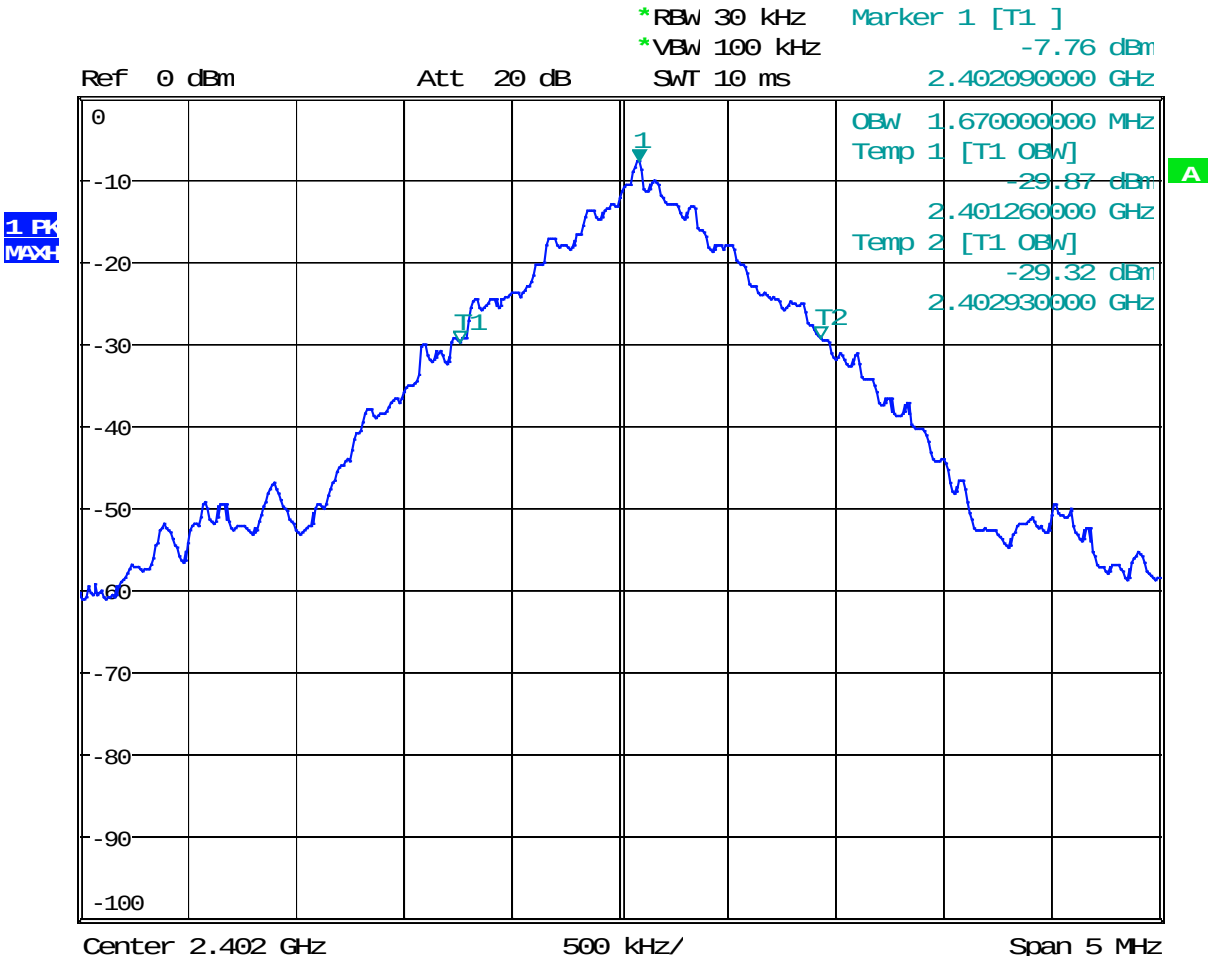


Date: 11.NOV.2014 06:25:33

Plot 2. 3

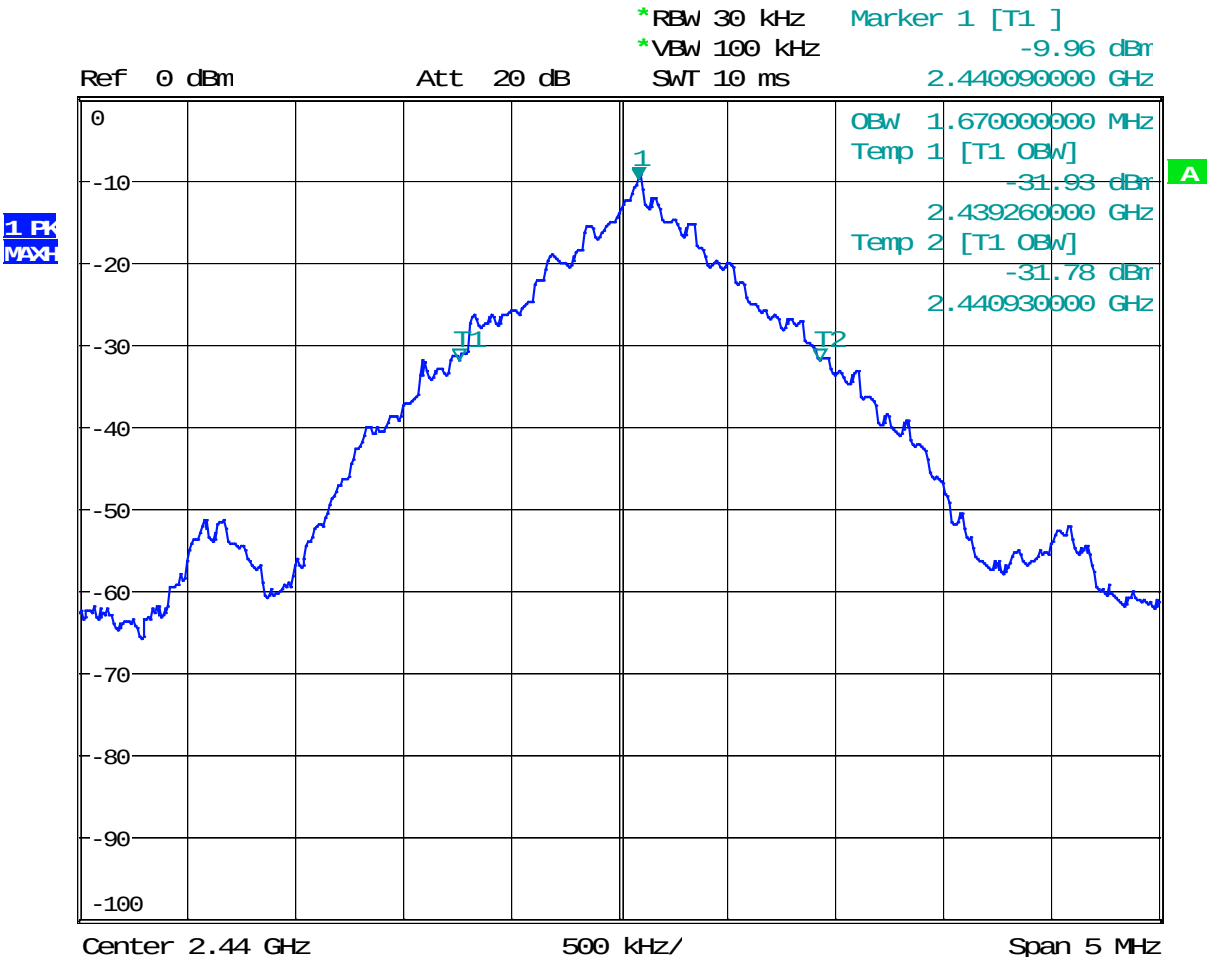

*RBW 100 kHz
*VBW 300 kHz
SWT 2.5 ms
Marker 3 [T1]
-11.17 dBm
2.480100000 GHz
Ref 0 dBm
Att 30 dB
Marker 1 [T1]
-17.07 dBm
2.479720000 GHz
Delta 2 [T1]
-0.46 dB
740.000000000 kHz
D1 -17.17 dBm
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Center 2.48 GHz
500 kHz/
Span 5 MHz
Date: 11.NOV.2014 06:30:07

Plot 2. 4

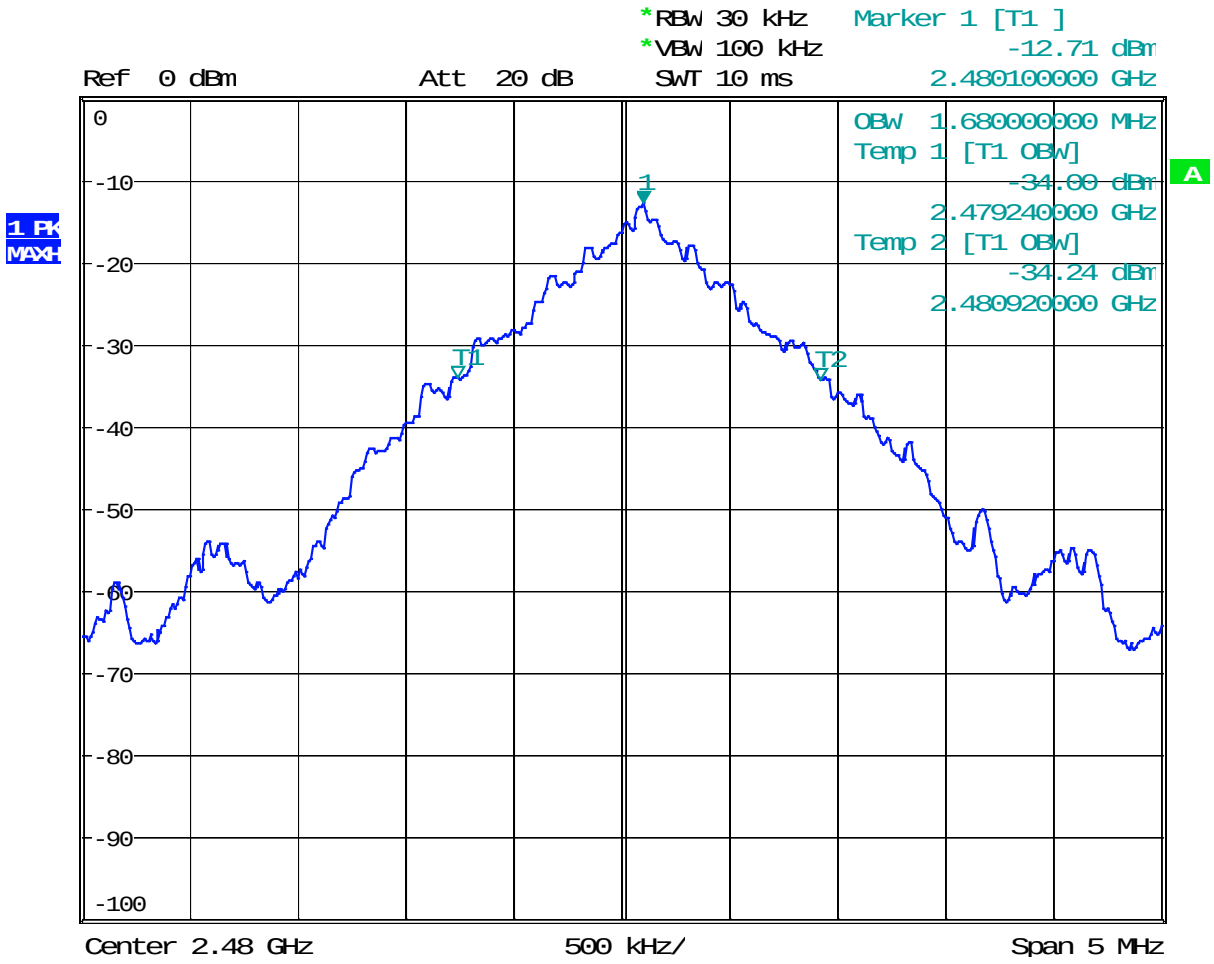


Date: 10.NOV.2014 09:41:26

Plot 2. 5


*RBW 30 kHz
*VBW 100 kHz
SWT 10 ms
Marker 1 [T1]
-9.96 dBm
2.440090000 GHz
Ref 0 dBm
Att 20 dB
OBW 1.670000000 MHz
Temp 1 [T1 OBW]
-31.93 dBm
2.439260000 GHz
Temp 2 [T1 OBW]
-31.78 dBm
2.440930000 GHz
1 PK
MAXH
A
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
Center 2.44 GHz
500 kHz/
Span 5 MHz
Date: 10.NOV.2014 10:19:34

Plot 2. 6



Date: 10.NOV.2014 11:10:14

4.3 Out-of-Band Conducted Emissions
FCC 15.247(d)

4.3.1 Requirement

In any 100 kHz bandwidth outside the EUT pass-band, the RF power shall be at least 20 dB below that of the maximum in-band 100 kHz emission.

4.3.2 Procedure

The EUT has a permanently attached internal antenna. It does not contain an antenna port connector. Instead of Antenna Conducted measurements, Radiated measurements were performed. The out-of-band emissions were measured from 30 MHz to 25 GHz.

4.3.3 Test Result

Refer to the radiated emissions test data located in report section 4.5.

The attenuation of emissions outside the EUT pass-band is more than 20 dB.

4.4 Power Spectral Density
FCC 15.247 (e)

4.4.1 Requirement

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna should not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

4.4.2 Procedure

The EUT has a permanently attached internal antenna. It does not contain an antenna port connector. Instead of Antenna Conducted measurements, Radiated measurements were performed 3 meters away.

The procedure described in FCC Publication 558074 D01 DTS Meas Guidance v03r02 June 5, 2014, specifically section 10.2 Method PKPSD (peak PSD).

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the *DTS bandwidth*.
3. Set the RBW to: 3 kHz ≤ RBW ≤ 100 kHz.
4. Set the VBW ≥ 3 x RBW.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

The transmitter's peak power was calculated using the following equation:

EIRP = E + 20log D - 104.8

where:

E = electric field strength in dBµV/m,

EIRP = equivalent isotropic radiated power in dBm

D = specified measurement distance in meters (3 meters)

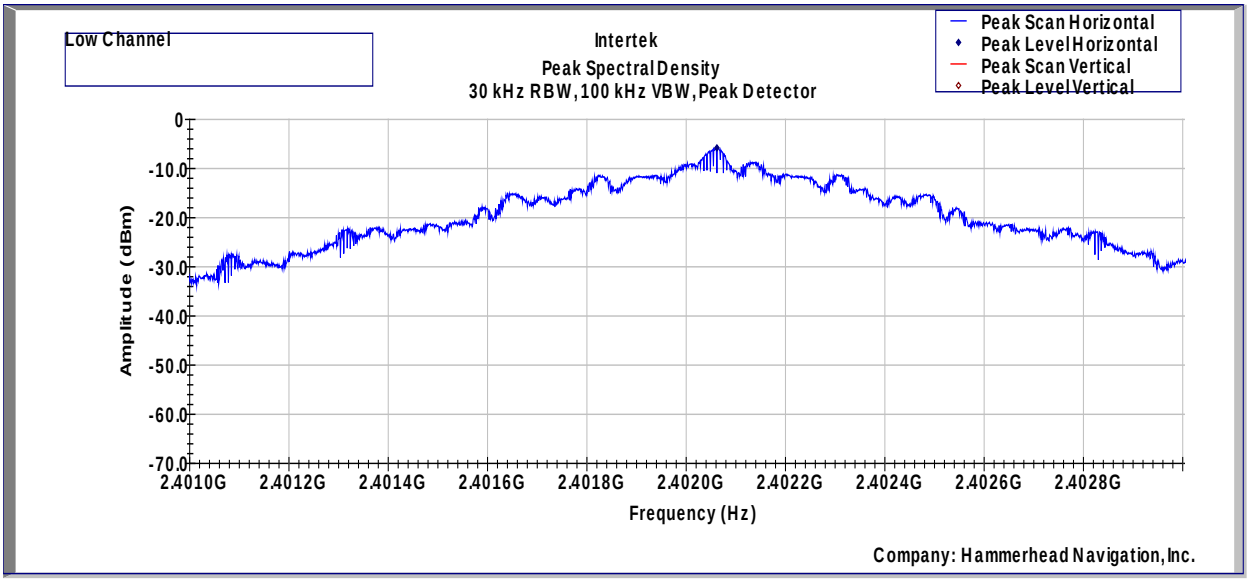
4.4.3 Test Result

Refer to the following plots for the test result:

Frequency (MHz)	EIRP Power Spectral Density (dBm)	Plot
2402	-5.9	4.1
2440	-5.7	4.2
2480	-7.7	4.3

Note: The EUT's antenna is 1.6 dBi gain

Plot 4. 1



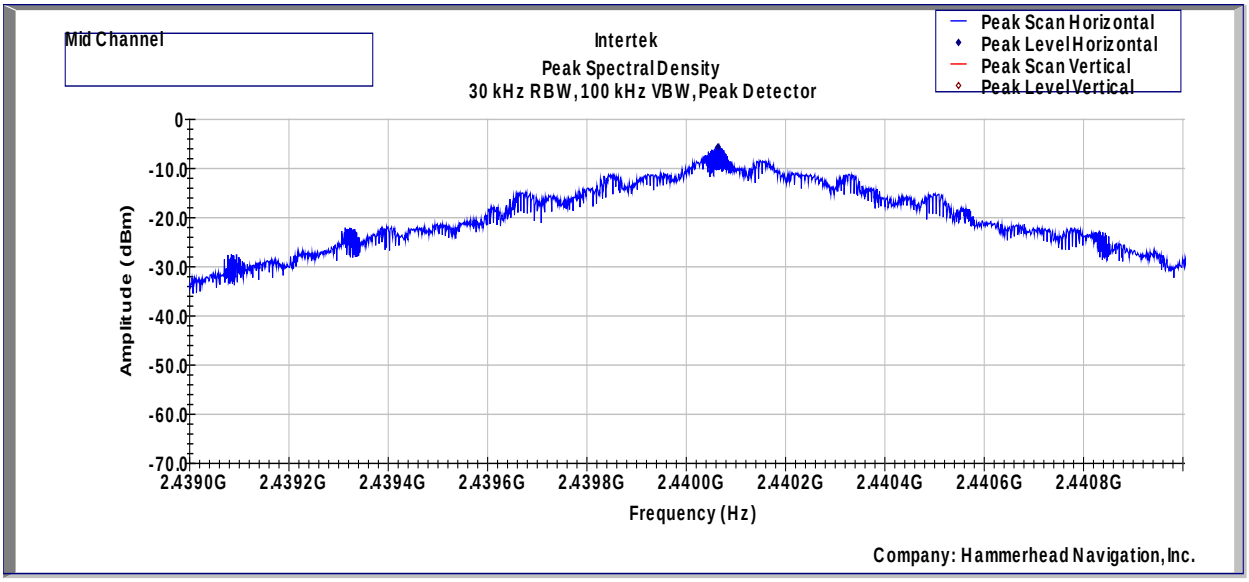
Final Corrected Reading

Frequency	RA	Attenuator	CF	AF	E	EIRP	EIRP
MHz	dB(uV)	dB	dB	dB(1/m)	dB(uV/m)	dBm	mW
2402.06	54.7	3.0	3.3	28.4	89.4	-5.9	0.257

RA = Raw Amplitude
CF = Cable Factor
AF = Antenna Factor
E = Final Field Strength

Results:	Complies

Plot 4. 2



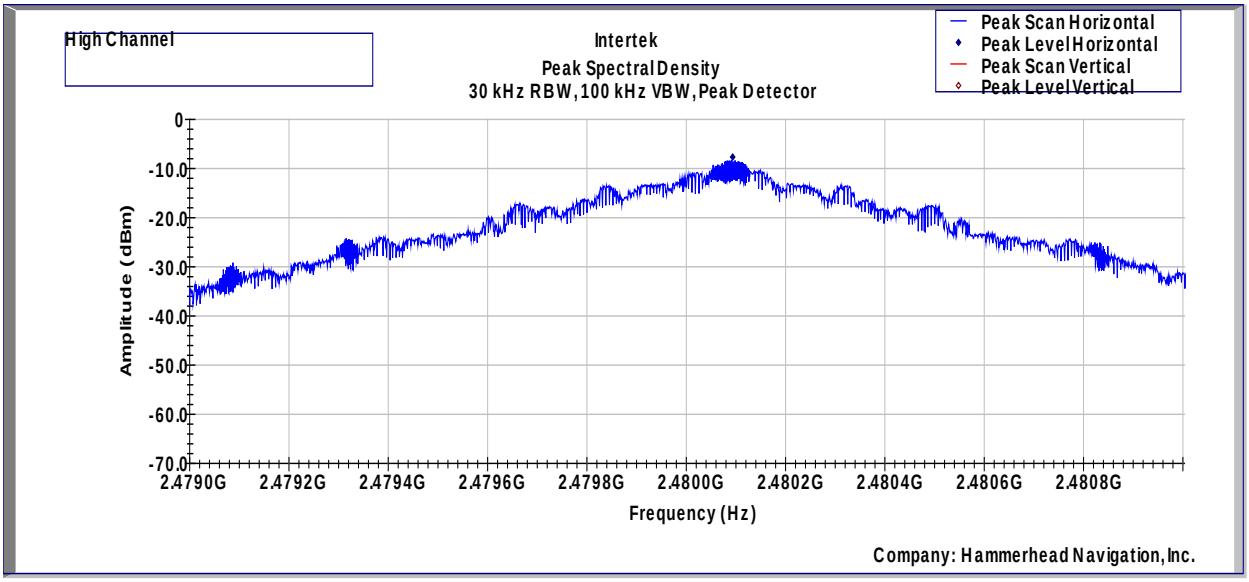
Final Corrected Reading

Frequency	RA	Attenuator	CF	AF	E	EIRP	EIRP
MHz	dB(uV)	dB	dB	dB(1/m)	dB(uV/m)	dBm	mW
2440.06	54.9	3.0	3.3	28.4	89.6	-5.7	0.269

RA = Raw Amplitude
CF = Cable Factor
AF = Antenna Factor
E = Final Field Strength

Results:	Complies

Plot 4. 3



Final Corrected Reading

Frequency	RA	Attenuator	CF	AF	E	EIRP	EIRP
MHz	dB(uV)	dB	dB	dB(1/m)	dB(uV/m)	dBm	mW
2480.09	52.7	3.0	3.4	28.5	87.6	-7.7	0.170

RA = Raw Amplitude
CF = Cable Factor
AF = Antenna Factor
E = Final Field Strength

Results:	Complies

4.5 Transmitter Radiated Emissions
FCC 15.247 (d), 15.205, 15.209

4.5.1 Requirement

Radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

For out of band radiated emissions (except for frequencies in restricted bands), in any 100 kHz bandwidths outside the EUT pass-band, the RF power shall be at least 20dB (peak) or 30 dB (average) below that of the maximum in-band 100 kHz emissions.

4.5.2 Procedure

Radiated emission measurements were performed from 30 MHz to 25,000 MHz. Spectrum Analyzer Resolution Bandwidth is 100 kHz or greater for frequencies 30 MHz to 1000 MHz, 1 MHz - for frequencies above 1000 MHz.

The EUT is placed on a non-conductive table. 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.

Radiated emissions are taken at three meters unless the signal level is too low for measurement at that distance. If necessary, a pre-amplifier is used and/or the test is conducted at a closer distance. All readings are extrapolated back to the equivalent three-meter reading using inverse scaling with distance.

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.

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

Measurements made from 1 GHz to 18GHz had a 2.4-2.5GHz notch filter in place. A preamp was used from 30MHz to 26GHz.

All measurements were made with a Peak Detector and compared to QP limits for 30MHz – 1GHz and Average limits for 1GHz – 25GHz.

Data is included of the worst-case configuration (the configuration which resulted in the highest emission levels).

Field Strength Calculation

For measurements made at 10 meters distance
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:

The field strength is calculated by adding the Antenna Factor and Cable Factor and the Distance Correction Factor; and subtracting the Amplifier Gain from the measured reading. The basic equation with a sample calculation is as follows:

FS = RA + AF + CF – AG + DCF

Where FS = Field Strength in dB(μV/m)
RA = Receiver Amplitude (including preamplifier) in dB(μV)
AF = Antenna Factor in dB(1/m)
CF = Cable Attenuation Factor in dB
AG = Amplifier Gain in dB
DCF = Distance Correction Factor in dB for measurements made at 10 meters distance

Assume a receiver reading of 52.5 dB(μV) 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 and Distance Correction Factor (for measurements made at 10 meters distance) of 10.5 dB is added, giving field strength of 43 dB(μV/m). This value in dB(μV/m) was converted to its corresponding level in μV/m.
RA = 52.5 dB(μV)
AF = 7.4 dB(1/m)
CF = 1.6 dB
AG = 29.0 dB
DCF = 10.5 dB
FS = 52.5+7.4+1.6-29.0+10.5 = 43 dB(μV/m).
Level in μV/m = Common Antilogarithm [(43 dBμV/m)/20] = 141.3 μV/m.

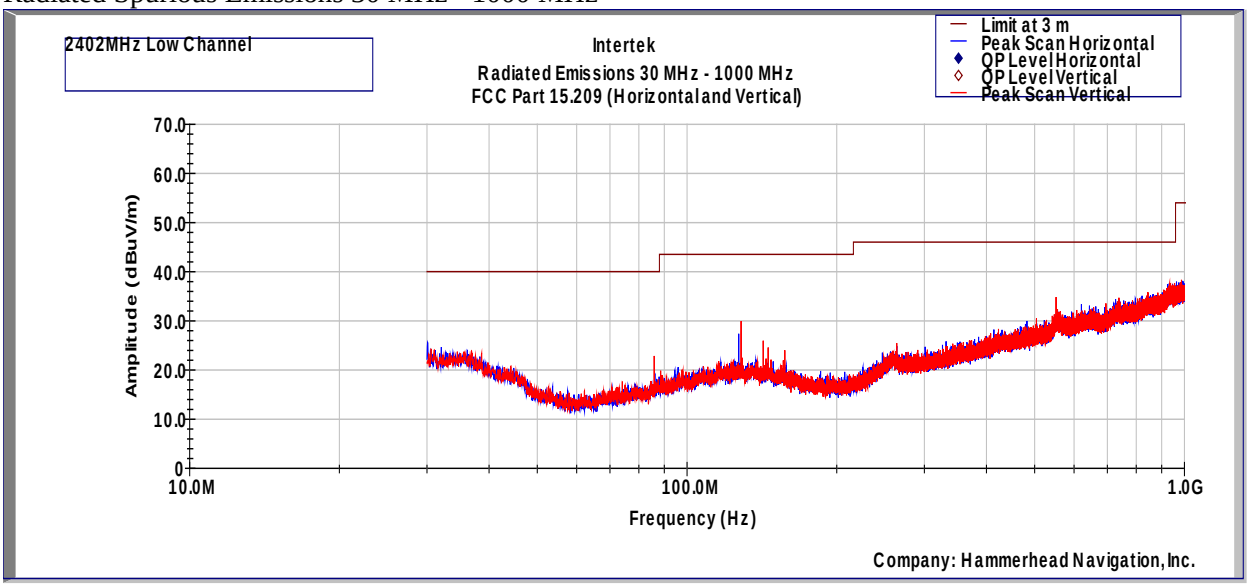
For measurements made at 3 meters distance
The field strength is calculated by following the example above *for measurements made at 10 meters distance* except the Distance Correction Factor in dB is not applied.

4.5.3 Result
The data on the following pages list 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 0.6dB.

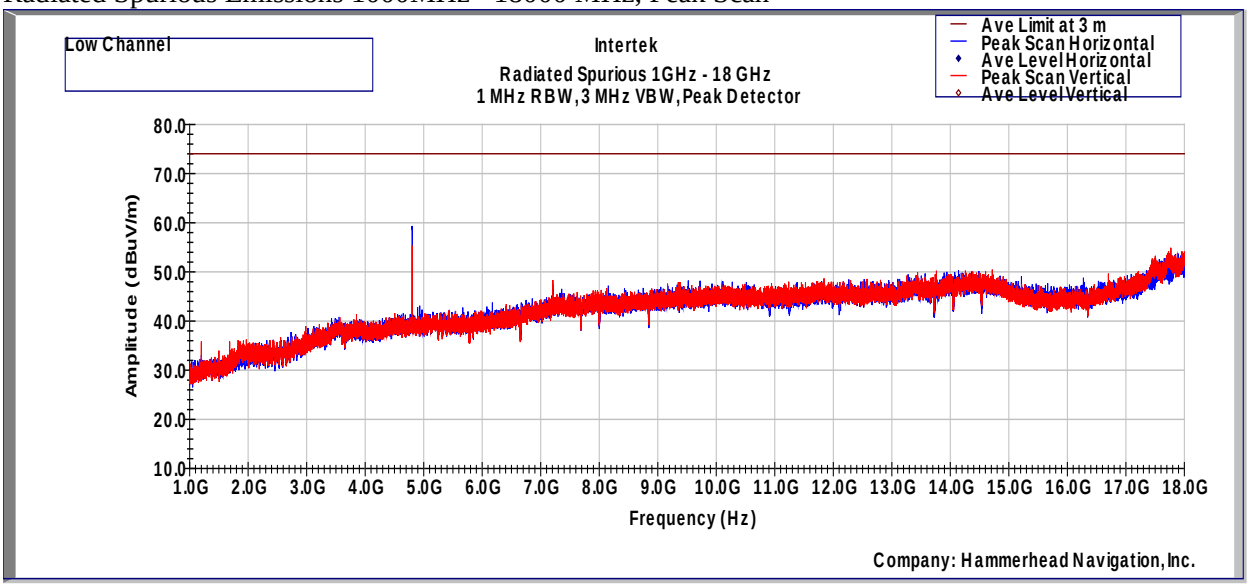
Test Results: 15.209, 2402MHz Low Channel

Radiated Spurious Emissions 30 MHz - 1000 MHz



Notes: Measurements made at 10 meters distance.

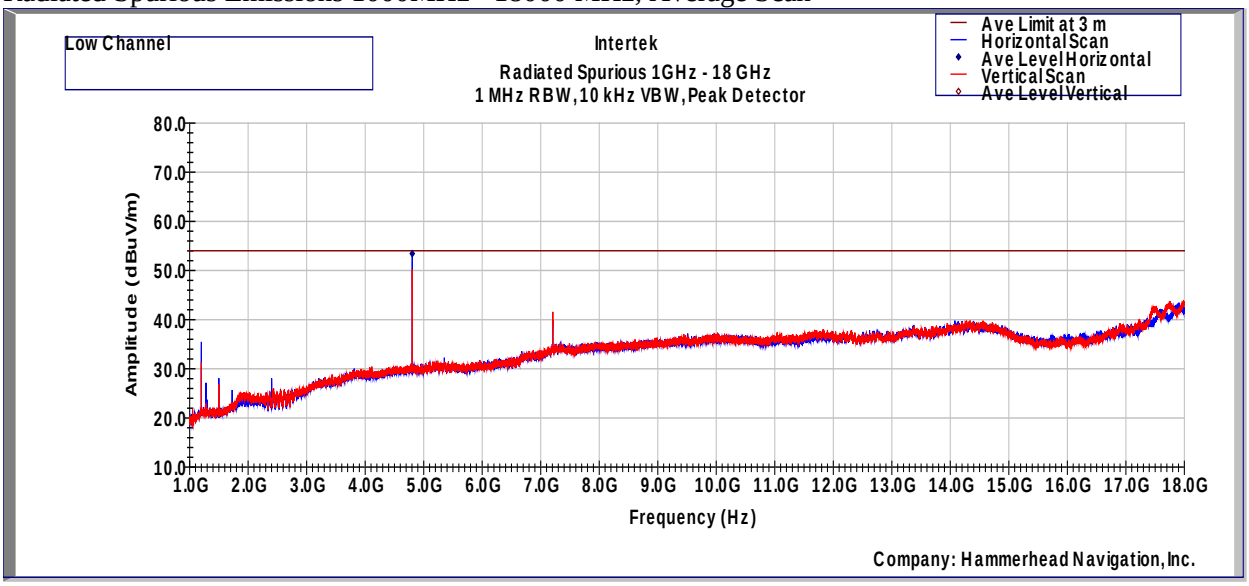
Radiated Spurious Emissions 1000MHz - 18000 MHz, Peak Scan



Notes: Measurements made at 3 meters distance.

Results:	Complies

Radiated Spurious Emissions 1000MHz - 18000 MHz, Average Scan



Radiated Emissions 1 GHz - 18 GHz

TX On, 2402 MHz

FCC 15.209 (Ave-Horizontal)

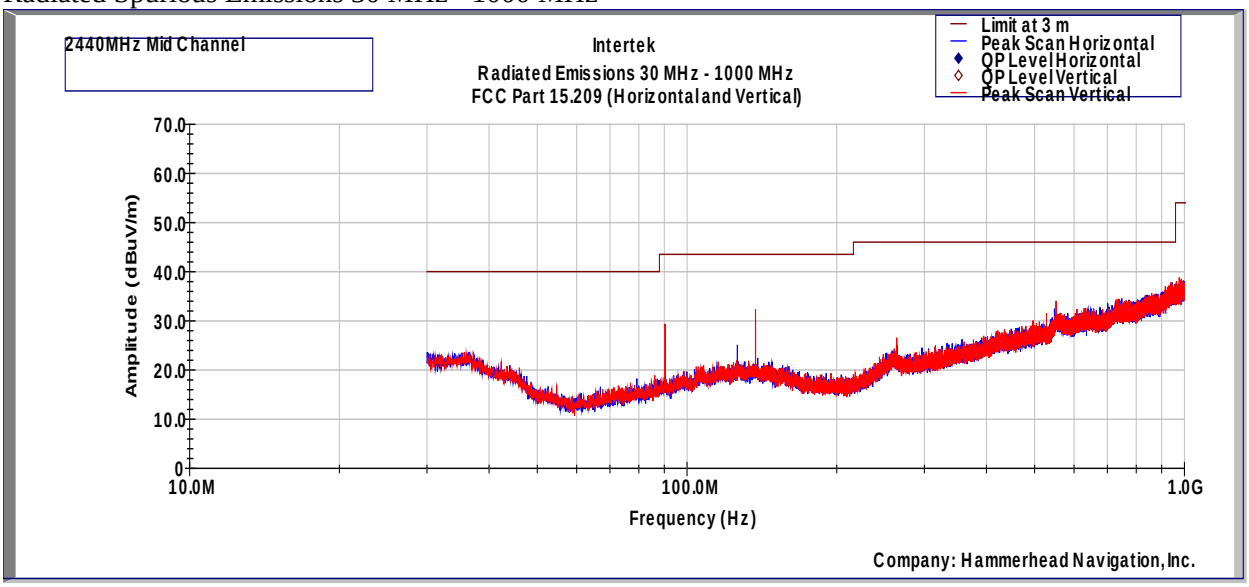
Frequency	Ave Level	Limit@3m	Av Margin	RA	CF	AG	AF
MHz	(dB)	(dBuV/m)	(dB)	(dBuV)	(dB)	(dB)	dB(1/m)
4804.0	53.4	54.0	-0.6	50.1	4.7	34.4	33.0

Notes: Measurements made at 3 meters distance.

Results:	Complies

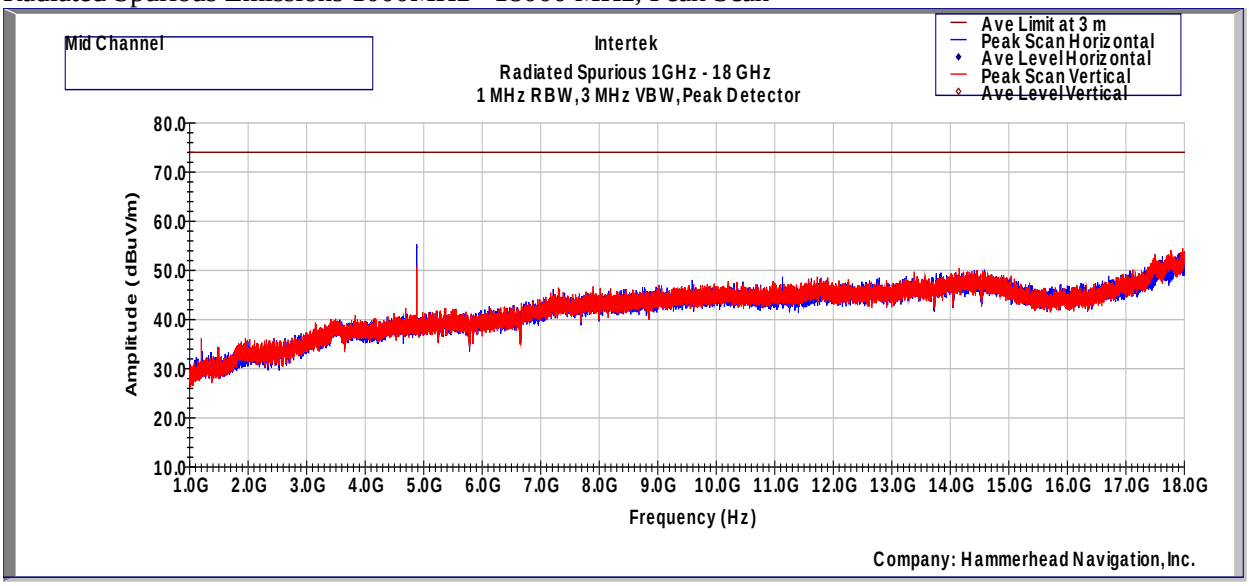
Test Results: 15.209, 2440MHz Middle Channel

Radiated Spurious Emissions 30 MHz - 1000 MHz



Notes: Measurements made at 10 meters distance.

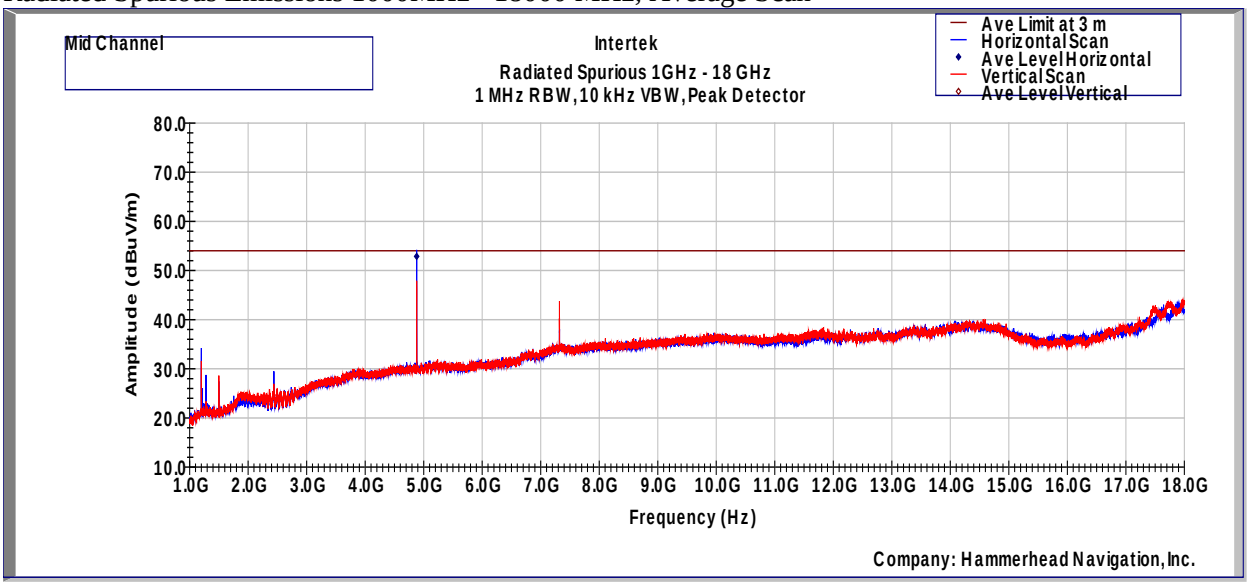
Radiated Spurious Emissions 1000MHz - 18000 MHz, Peak Scan



Notes: Measurements made at 3 meters distance.

Results:	Complies

Radiated Spurious Emissions 1000MHz - 18000 MHz, Average Scan



Radiated Emissions 1 GHz - 18 GHz

TX On, 2440 MHz

FCC 15.209 (Ave-Horizontal)

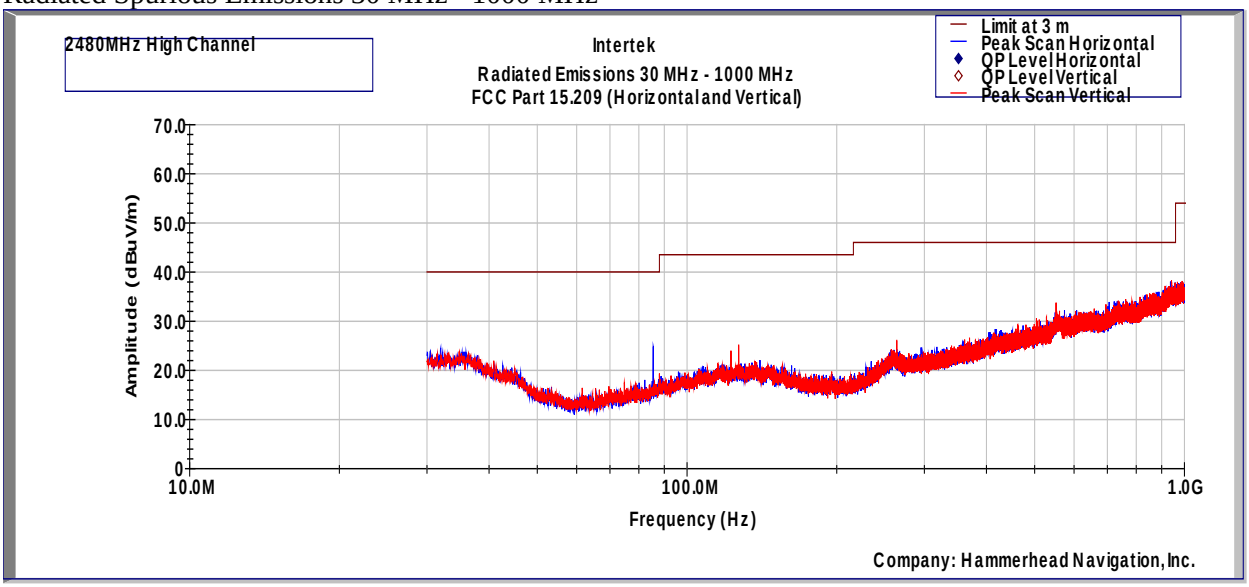
Frequency	Ave Level	Limit@3m	Av Margin	RA	CF	AG	AF
MHz	(dB)	(dBuV/m)	(dB)	(dBuV)	(dB)	(dB)	dB(1/m)
4880.0	52.9	54.0	-1.1	49.3	4.8	34.4	33.2

Notes: Measurements made at 3 meters distance.

Results:	Complies

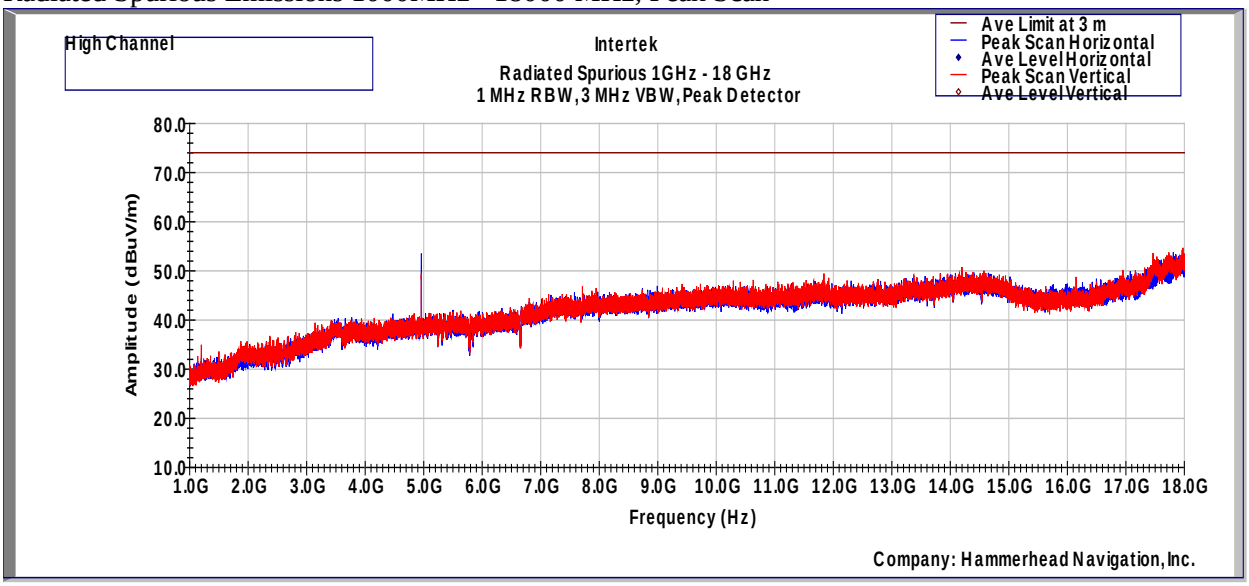
Test Results: 15.209, 2480MHz High Channel

Radiated Spurious Emissions 30 MHz - 1000 MHz



Notes: Measurements made at 10 meters distance.

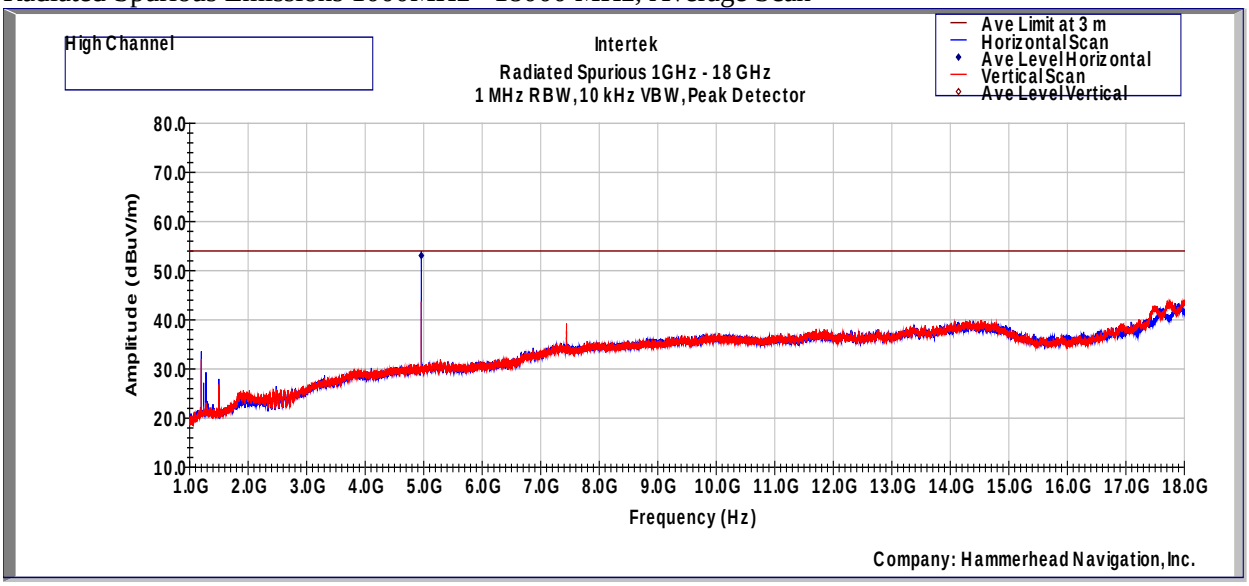
Radiated Spurious Emissions 1000MHz - 18000 MHz, Peak Scan



Notes: Measurements made at 3 meters distance.

Results:	Complies

Radiated Spurious Emissions 1000MHz - 18000 MHz, Average Scan



Radiated Emissions 1 GHz - 18 GHz

TX On, 2480 MHz

FCC 15.209 (Ave-Horizontal)

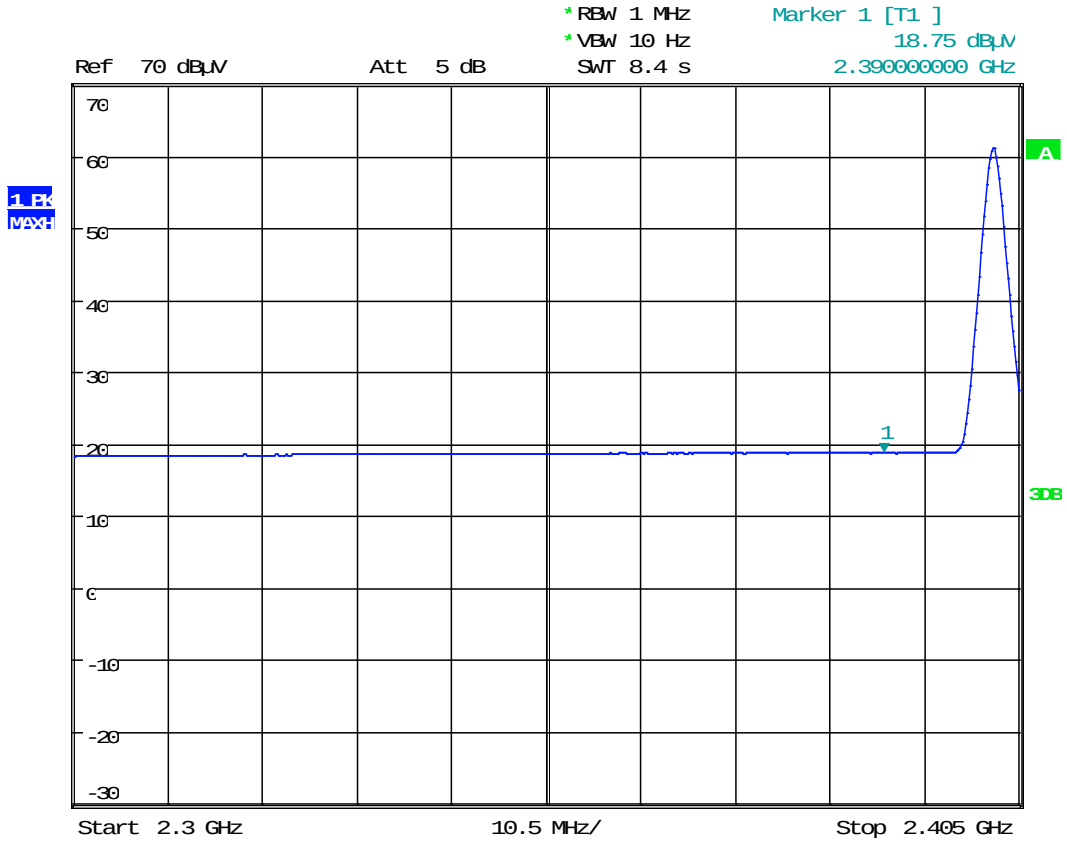
Frequency	Ave Level	Limit@3m	Av Margin	RA	CF	AG	AF
MHz	(dB)	(dBuV/m)	(dB)	(dBuV)	(dB)	(dB)	dB(1/m)
4960.0	53.1	54.0	-0.9	49.2	4.8	34.4	33.4

Notes: Measurements made at 3 meters distance.

Results:	Complies

Test Results: 15.209/15.205 Restricted Band Emissions

Average Out-of-Band Radiated spurious emissions at the Band-edge
2310–2390 MHz



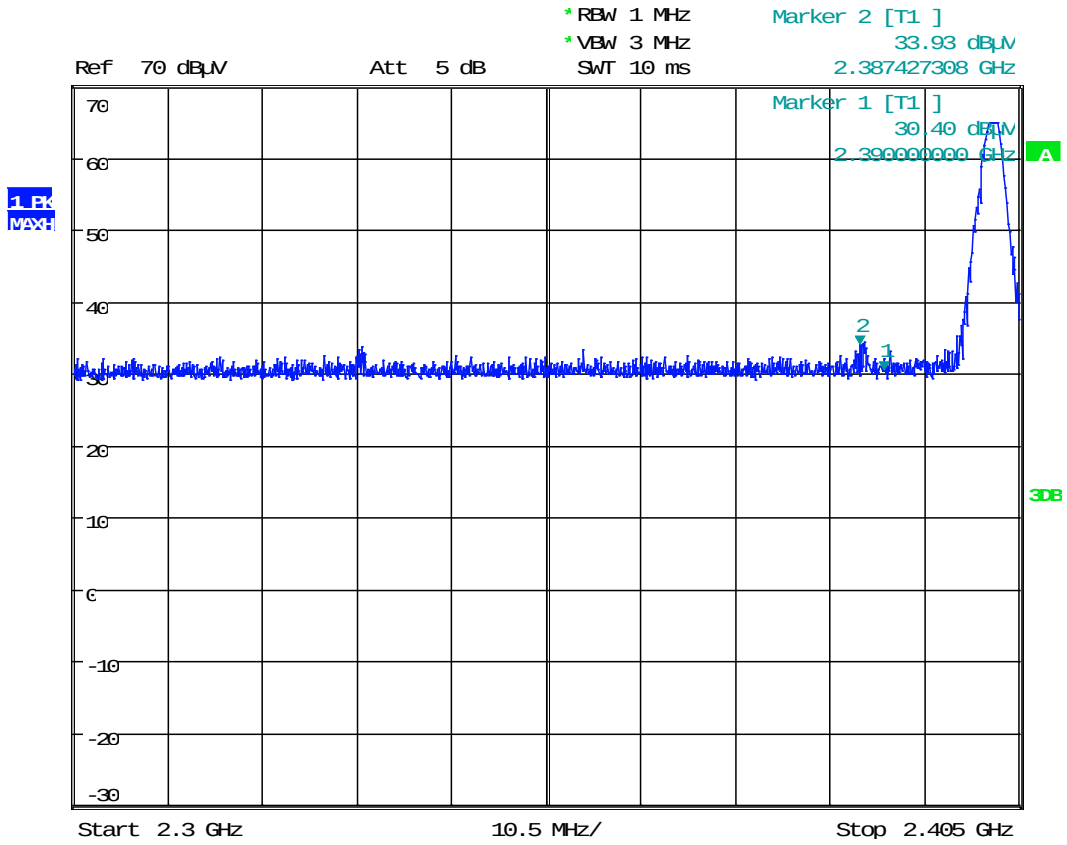
Date: 10.NOV.2014 06:05:36

Frequency MHz	Band Edge Freq.	Raw Amplitude @ 3 m	Antenna Corection Factor	Cable Loss	EUT Field Strength Final Amp.	Limit Detector	Limit @ 3 m	Margin
(GHz)	(GHz)	(dBuV/m)	(dB/m)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2.402	2.390	18.8	27.5	3.3	49.6	Average	54	-4.4

Band Edge Field Strength at 3m = Raw Amplitude+ Cable Loss+ Antenna Correction Factor

Results: Complies

Peak Out-of-Band Radiated spurious emissions at the Band-edge
2310–2390 MHz



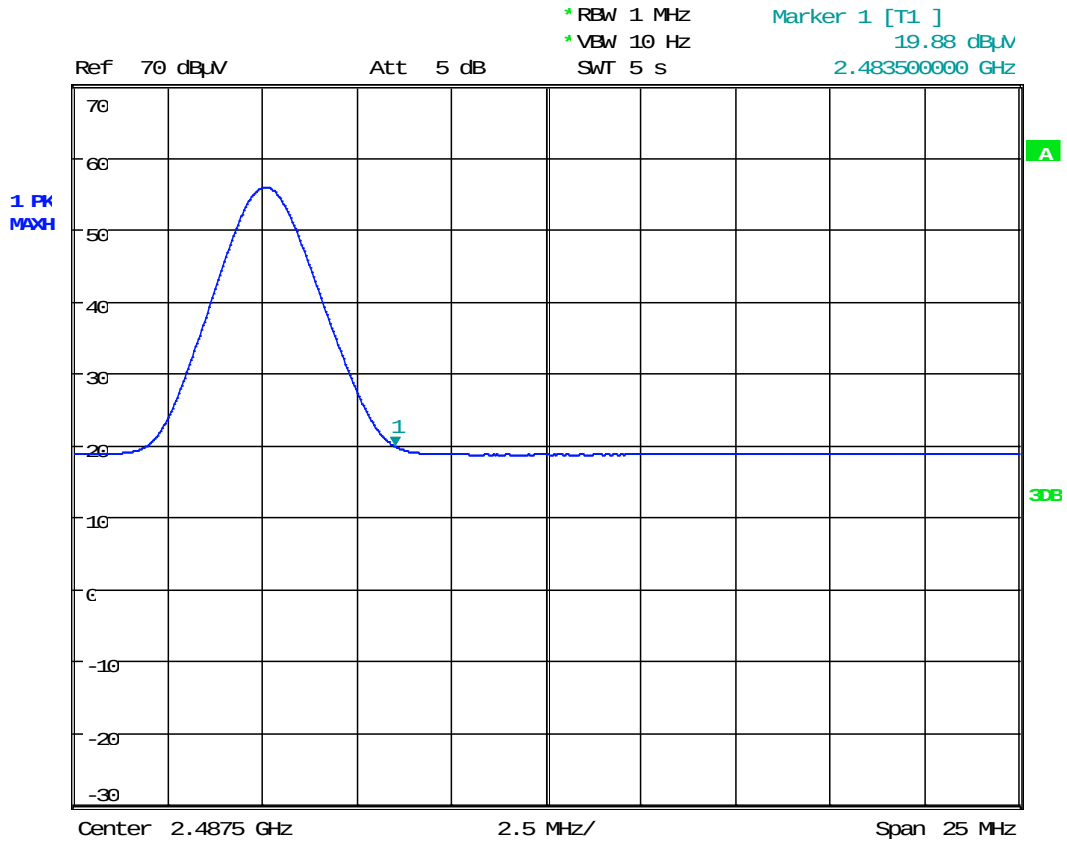
Date: 10.NOV.2014 06:09:59

Frequency MHz	Band Edge Freq.	Raw Amplitude @ 3 m	Antenna Corection Factor	Cable Loss	EUT Field Strength Final Amp.	Limit Detector	Limit @ 3 m	Margin
(GHz)	(GHz)	(dBuV/m)	(dB/m)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2.402	2.390	33.9	27.5	3.3	64.7	Peak	74	-9.3

Band Edge Field Strength at 3m = Raw Amplitude+ Cable Loss+ Antenna Correction Factor

Results:	Complies

Average Out-of-Band Radiated spurious emissions at the Band-edge
2483.5–2500 MHz



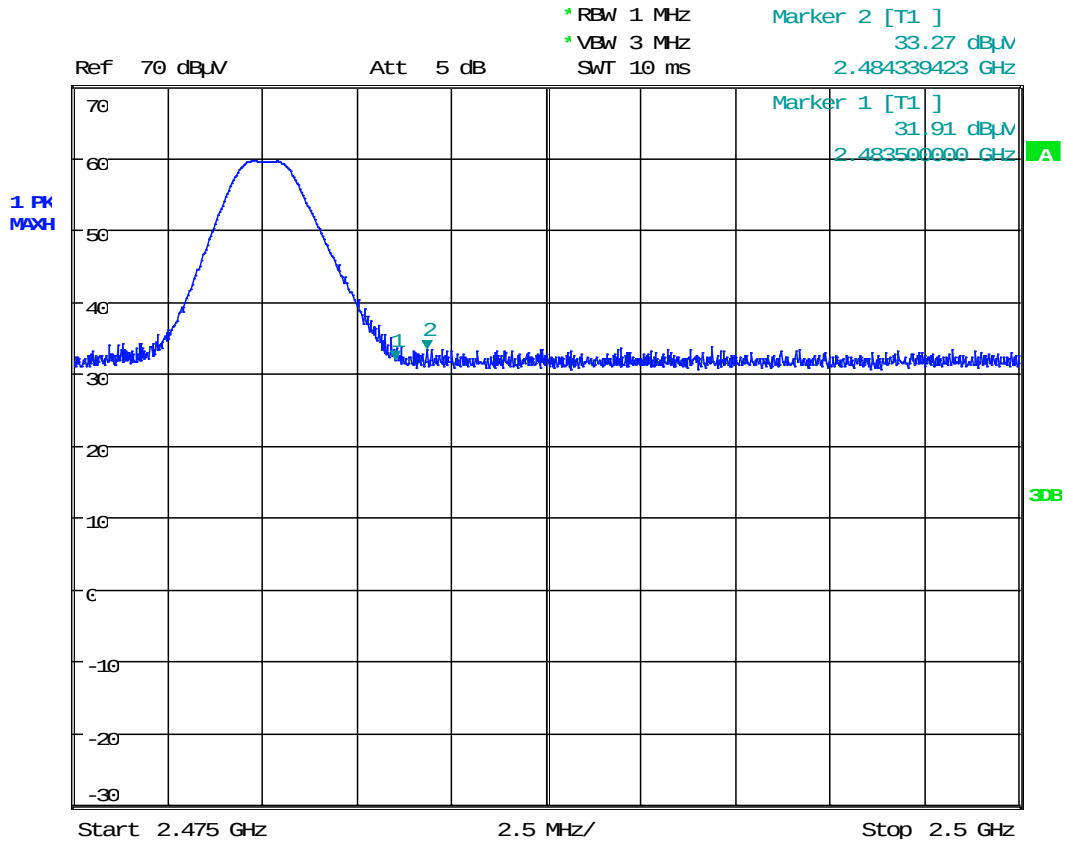
Date: 10.NOV.2014 06:35:31

Frequency MHz	Band Edge Freq.	Raw Amplitude @ 3 m	Antenna Corection Factor	Cable Loss	EUT Field Strength Final Amp.	Limit Detector	Limit @ 3 m	Margin
(GHz)	(GHz)	(dBuV/m)	(dB/m)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2.480	2.4835	19.9	27.9	3.6	51.4	Average	54	-2.6

Band Edge Field Strength at 3m = Raw Amplitude+ Cable Loss+ Antenna Correction Factor

Results:	Complies

Peak Out-of-Band Radiated spurious emissions at the Band-edge
2483.5–2500 MHz



Date: 10.NOV.2014 06:34:55

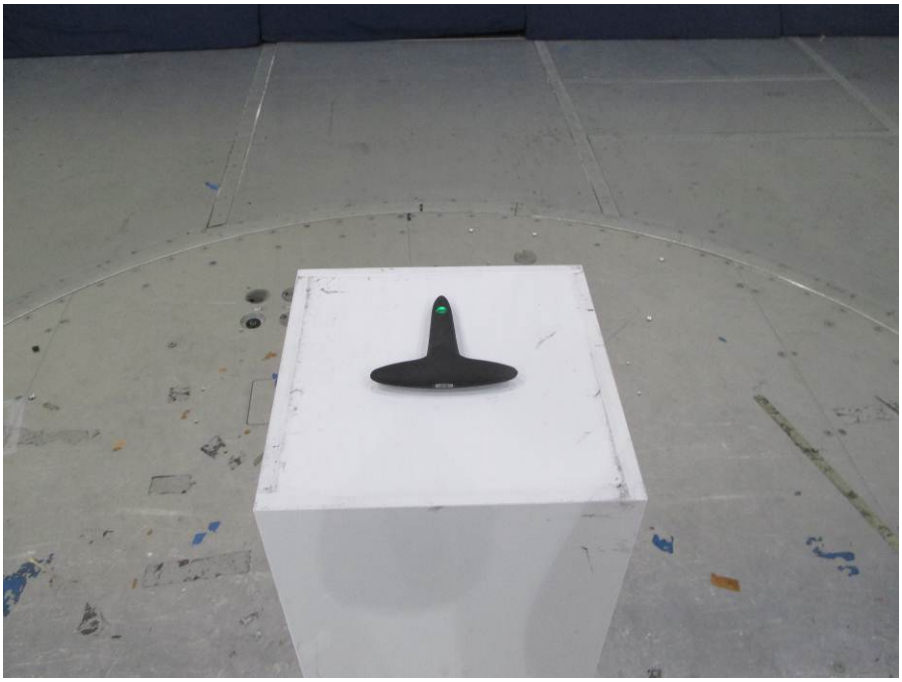
Frequency MHz	Band Edge Freq.	Raw Amplitude @ 3 m	Antenna Corection Factor	Cable Loss	EUT Field Strength Final Amp.	Limit Detector	Limit @ 3 m	Margin
(GHz)	(GHz)	(dBuV/m)	(dB/m)	(dB)	(dBuV/m)	(Peak) / (Average)	(dBuV/m)	(dB)
2.480	2.4835	33.3	27.9	3.6	64.8	Peak	74	-9.2

Band Edge Field Strength at 3m = Raw Amplitude+ Cable Loss+ Antenna Correction Factor

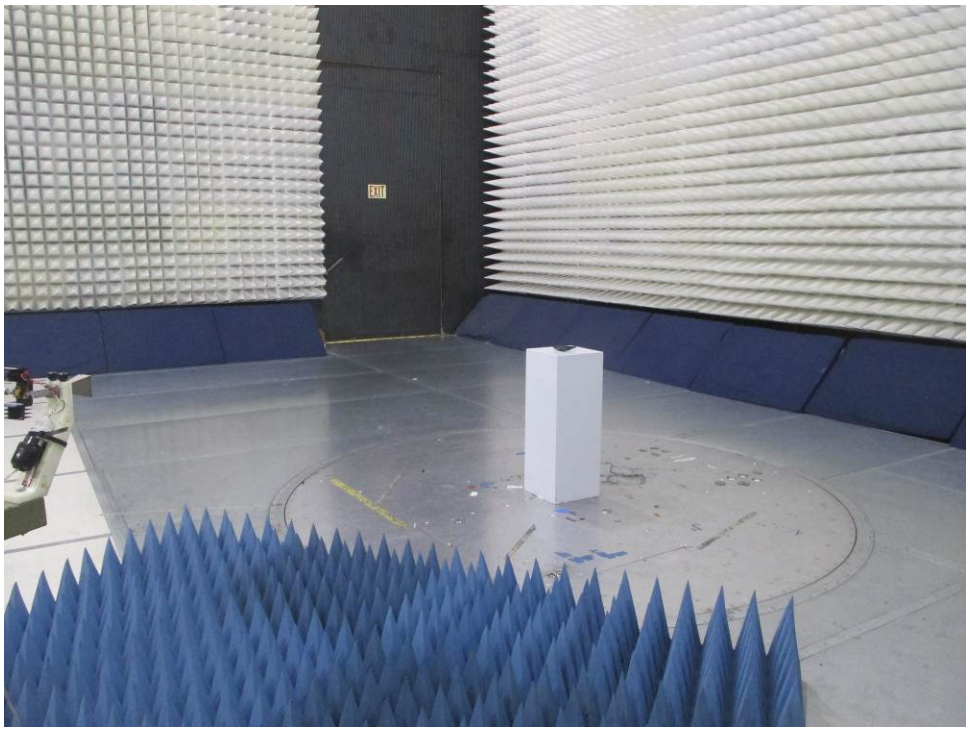
Results:	Complies

4.5.4 Test Configuration Photographs

The following photographs show the testing configurations used.



Test Configuration Photographs Continued



5.0 Emissions from Digital Parts and Receiver

5.1 Radiated Emissions
FCC Ref: 15.109, ICES 003

5.1.1 Test Limit

Limits for Electromagnetic Radiated Emissions FCC Section 15.109(b), 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

5.1.2 Procedures

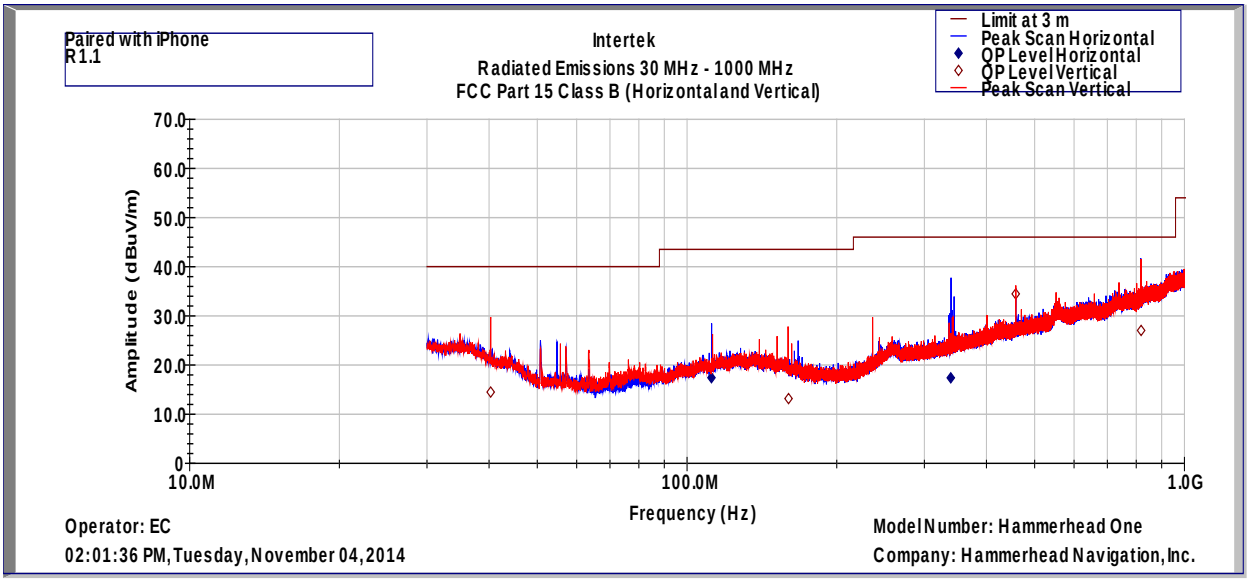
The EUT was set for receive mode only. Radiated measurements were taken. 120 kHz resolution bandwidth was used from 30 MHz - 1 GHz. 1 MHz resolution bandwidth was used for measurements done above 1 GHz. All plots are corrected for cable loss, antenna factor, and preamp.

5.1.3 Test Results

Radiated emission measurements were performed from 30 MHz to 18000 MHz. The data on the following pages list the significant emission frequencies, the limit and the margin of compliance.

Mode	Description
Receive Mode	Scan 30MHz – 1GHz
	Complies

Test Results: Receiver Spurious Emissions 30 MHz - 1000 MHz



Intertek
Radiated Emissions 30 MHz - 1000 MHz
Company: Hammerhead Navigation, Inc. Model Number: Hammerhead One

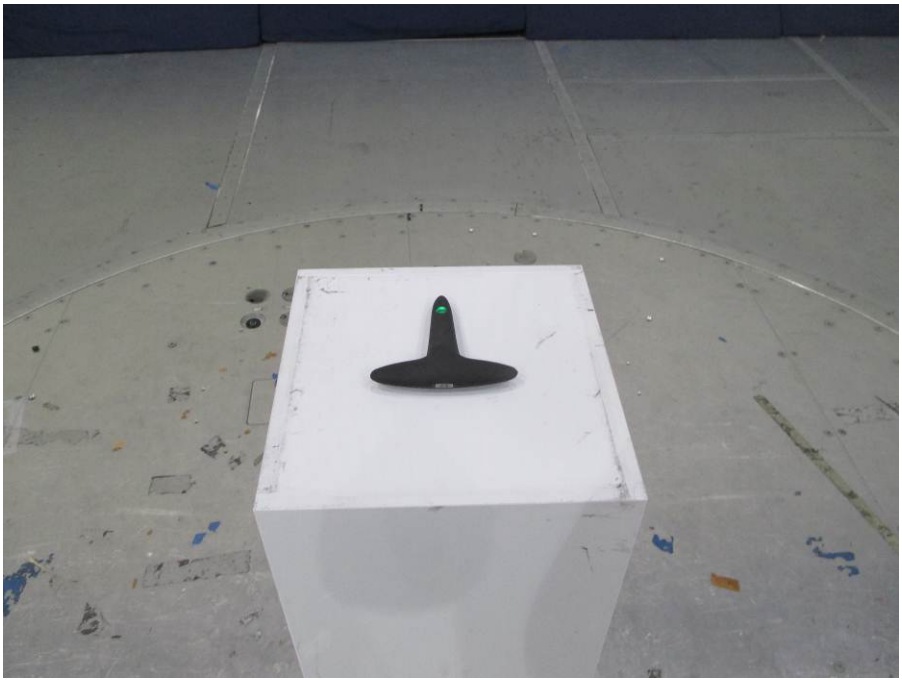
FCC Part 15 Class B (QP-Horizontal)									
Frequency	Quasi Pk FS	Limit@3m	Margin	RA	CF	AG	DCF	AF	Azimuth
MHz	dB(uV/m)	dB(uV/m)	dB	dB(uV)	dB	dB	dB	dB(1/m)	deg
112.0	17.4	43.5	-26.1	26.7	1.2	32.1	10.5	11.1	0
339.0	17.4	46.0	-28.6	23.0	1.9	32.0	10.5	13.9	0

FCC Part 15 Class B (QP-Vertical)									
Frequency	Quasi Pk FS	Limit@3m	Margin	RA	CF	AG	DCF	AF	Azimuth
MHz	dB(uV/m)	dB(uV/m)	dB	dB(uV)	dB	dB	dB	dB(1/m)	deg
40.3	14.5	40.0	-25.5	21.5	0.7	32.1	10.5	13.8	0
160.0	13.2	43.5	-30.3	23.0	1.2	32.0	10.5	10.4	0
458.0	34.4	46.0	-11.6	36.6	2.4	32.0	10.5	17.0	225
818.3	27.0	46.0	-19.0	23.1	3.3	32.1	10.5	22.2	0

Results: Complies

5.1.4 Test Configuration Photographs

The following photographs show the testing configurations used.



5.2 AC Line Conducted Emission
FCC 15.107

5.2.1 Requirement

Frequency Band MHz	Class B Limit dB (μV)	
	Quasi-Peak	**Average**
0.15-0.50	66 to 56 Decreases linearly with the logarithm of the frequency	56 to 46 Decreases linearly with the logarithm of the frequency
0.50-5.00	56	46
5.00-30.00	60	50

Note: At the transition frequency the lower limit applies.

5.2.2 Test Procedure

Measurements are carried out using quasi-peak and average detector receivers in accordance with CISPR 16. An AMN is required to provide a 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.

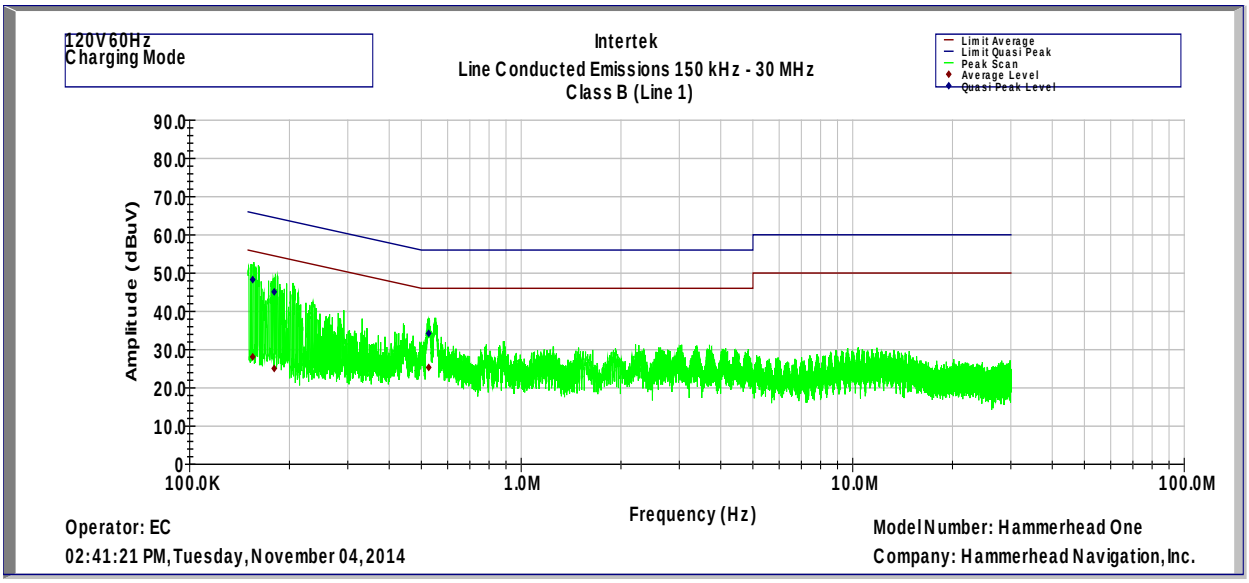
Floor standing EUT are placed on a horizontal metal ground plane and isolated from the ground plane by resting on an insulating material. The metal ground plane extends at least 0.5m beyond the boundaries of the EUT and has minimum dimensions of 2m by 2m.

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

5.2.3 Test Results

FCC 15B, ICES-003 Conducted Disturbance

Line 1, 120 VAC 60Hz



Intertek Testing Services
Line Conducted Emissions 150 kHz - 30 MHz
Company: Hammerhead Navigation, Inc. Model Number: Hammerhead One

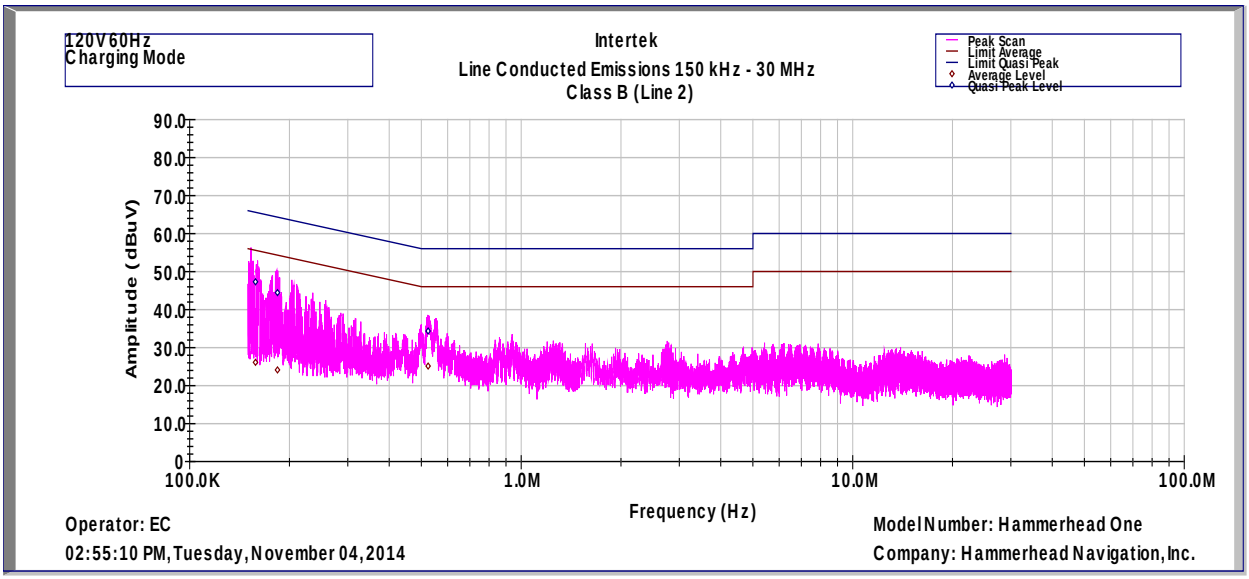
QP and Ave Detector Class B (Line 1)						
Frequency	Av Level	QP Level	Av Limit	QP Limit	Av Margin	QP Margin
MHz	dBuV	dBuV	dBuV	dBuV	dB	dB
0.155	28.1	48.3	55.9	65.9	-27.8	-17.6
0.180	25.1	45.1	55.1	65.1	-30.1	-20.1
0.526	25.3	34.2	46.0	56.0	-20.7	-21.8

120VAC 60Hz, Charging Mode

Results: Complies

FCC 15B, ICES-003 Conducted Disturbance

Line 2, 120 VAC 60Hz



Intertek Testing Services
Line Conducted Emissions 150 kHz - 30 MHz
Company: Hammerhead Navigation, Inc. Model Number: Hammerhead One

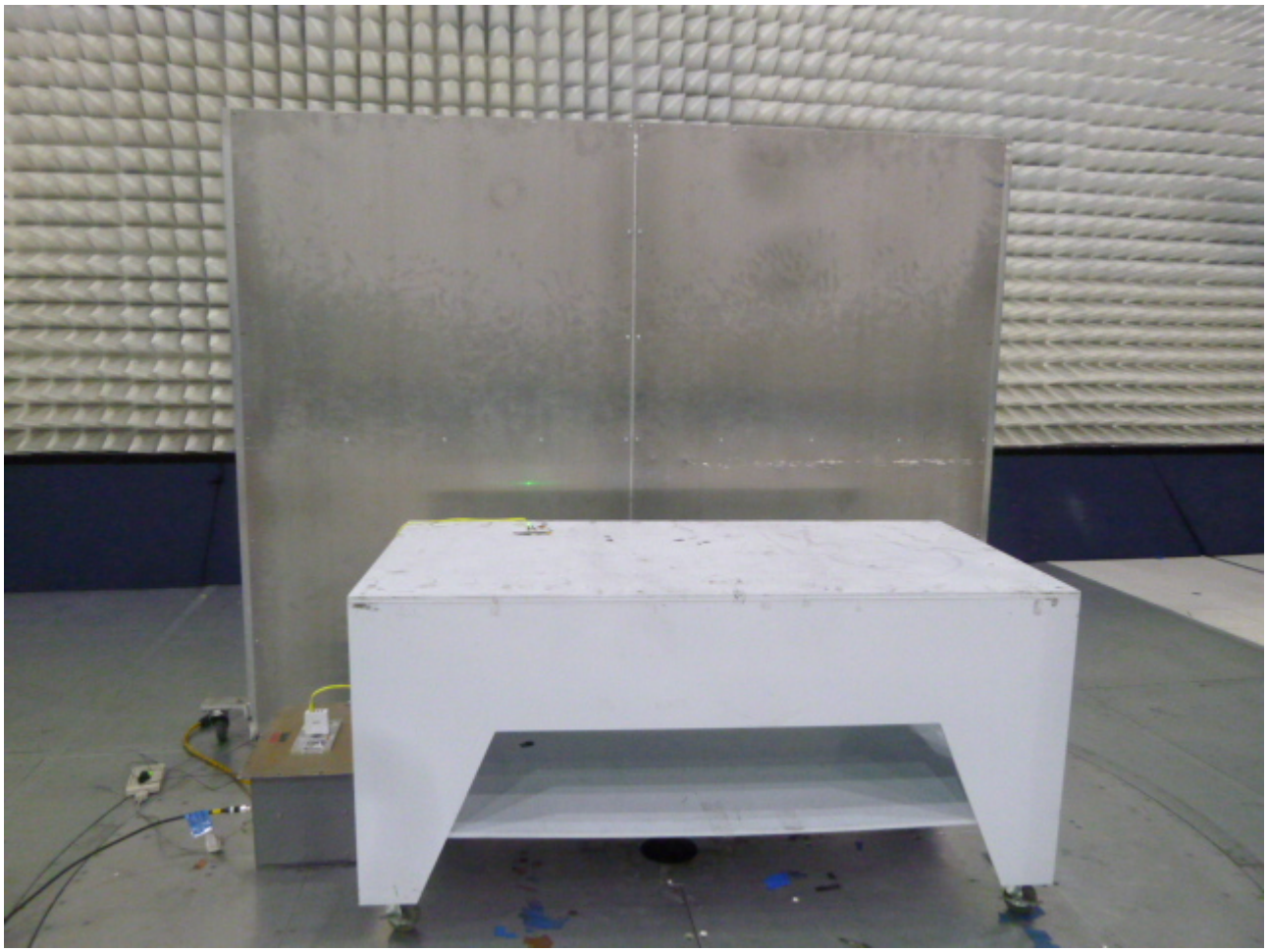
QP and Ave Detector Class B (Line 2)						
Frequency	Av Level	QP Level	Av Limit	QP Limit	Av Margin	QP Margin
MHz	dBuV	dBuV	dBuV	dBuV	dB	dB
0.158	26.1	47.3	55.8	65.8	-29.7	-18.5
0.184	24.1	44.4	55.0	65.0	-30.9	-20.6
0.524	25.1	34.3	46.0	56.0	-20.9	-21.7

120VAC 60Hz, Charging Mode

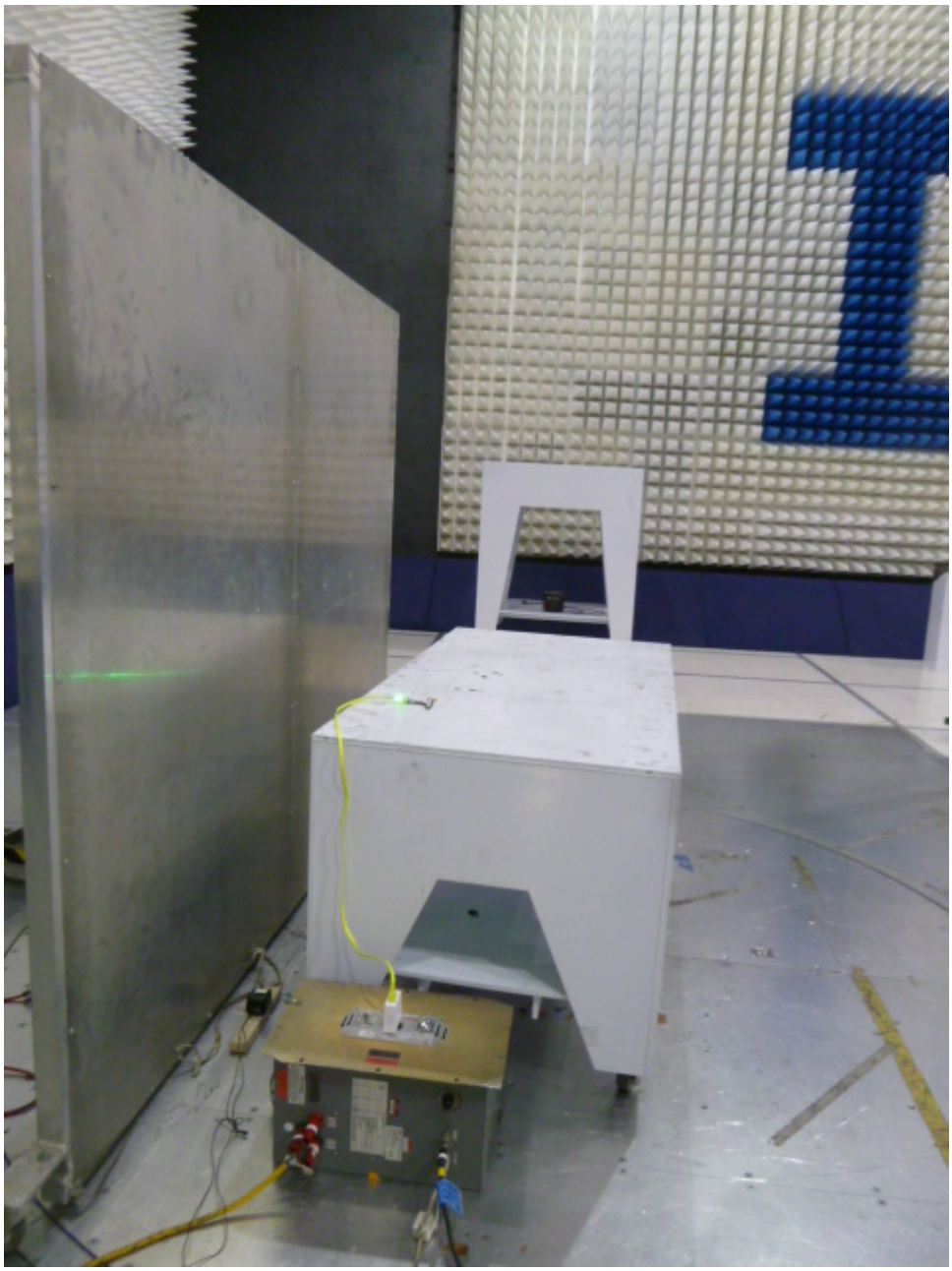
Results: Complies

5.2.4 Test Configuration Photographs

The following photographs show the testing configurations used.



5.2.4 Test Configuration Photographs



AC Mains Line-Conducted Disturbance Setup Photograph

6.0 RF Exposure Evaluation

MPE Evaluation

The EUT is a wireless device used in a mobile application, at least 20 cm from any body part of the user or nearby persons.

The maximum Peak EIRP calculated is -4.00 dBm or 0.398 mW; therefore, to comply with RF Exposure Requirement, the MPE is calculated.

The Power Density can be calculated using the formula

$$S = EIRP/ 4\pi D^2$$

Where: S is Power Density in W/m^2
D is the distance from the antenna.

It is considered that 20 cm is the minimum distance that user can go closest to the EUT.

At 20 cm, S =0.0000792 mW/cm^2, which is below the MPE Limit of 1 mW/cm^2 or $10W/m^2$

7.0 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

8.0 Document History

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