LOJACK CORPORATION
TEST REPORT

SCOPE OF WORK
EMC TESTING – VLU10

REPORT NUMBER
103364832BOX-005b

ISSUE DATE **REVISED DATE**
03/08/2018 03/13/2018

PAGES
52

DOCUMENT CONTROL NUMBER
Non-Specific Radio Report Shell Rev. December 2017

EMC TEST REPORT

(FULL COMPLIANCE)

Report Number: 103364832BOX-005b
Project Number: G103364832

Report Issue Date: 03/08/2018

Model(s) Tested: VLU10
Model(s) Partially Tested: None
Model(s) Not Tested but declared equivalent by the client: None

Standards: FCC 47CFR Part 15 Subpart C (15.247): 01/2018
FCC 47CFR Part 15 Subpart B: 01/2018

Tested by:
Intertek Testing Services NA, Inc.
70 Codman Hill Road
Boxborough, MA 01719
USA

Client:
LoJack Corporation
40 Pequot Way
Canton, MA 02021
USA

Report prepared by Naga Suryadevara

Naga Suryadevara/Project Engineer, EMC

Report reviewed by Kouma Sinn

Kouma Sinn/Staff Engineer, EMC

Table of Contents

1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
3	Client Information	--
4	Description of Equipment Under Test and Variant Models	--
5	System Setup and Method	--
6	Output Power and Human RF Exposure (FCC Part 15 Subpart C (15.247)))	Pass
7	Power Spectral Density (FCC Part 15 Subpart C (15.247))	Pass
8	Occupied and 6dB bandwidth (FCC Part 15 Subpart C (15.247))	Pass
9	Transmitter Spurious Emissions and Band edge (FCC Part 15 Subpart C (15.247))	Pass
10	Receiver Spurious Emissions (FCC Part 15 Subpart C (15.247))	Pass
11	Revision History	--

3 Client Information

This EUT was tested at the request of:

Client: LoJack Corporation
40 Pequot Way
Canton, MA 02021
USA

Contact: Vincent Ricci
Telephone: (781) 302-4332
Fax: N/A
Email: vricci@lojack.com

4 Description of Equipment Under Test and Variant Models

Manufacturer: LoJack Corporation
40 Pequot Way
Canton, MA 02021
USA

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
Vehicle Locator transmit mode	LoJack Corporation	VLU10	CJ525017108 16
Vehicle locator in receive mode	LoJack Corporation	VLU10	CJ525017108 12

Receive Date:	01/09/2018
Received Condition:	Good
Type:	Production

Description of Equipment Under Test (provided by client)
The EUT is a vehicle locator.

Equipment Under Test Power Configuration			
Rated Voltage	Rated Current	Rated Frequency	Number of Phases
12 VDC	Not provided	N/A	N/A

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	Transmit mode (Low, Mid and High channels with duty cycle greater than 98%)
2	Receive mode

Software used by the EUT:

No.	Descriptions of EUT Exercising
1	Not provided

Radio/Receiver Characteristics	
Frequency Band(s)	2402-2480 MHz
Modulation Type(s)	GFSK
Maximum Output Power	0.0172 mW
Test Channels	Low Channel - 2402 MHz Mid Channel – 2441 MHz High Channel – 2480 MHz
Occupied Bandwidth	1.0811 MHz
Frequency Hopper: Number of Hopping Channels	N/A
Frequency Hopper: Channel Dwell Time	N/A
Frequency Hopper: Max interval between two instances of use of the same channel	N/A
MIMO Information (# of Transmit and Receive antenna ports)	N/A
Equipment Type	Standalone host
ETSI LBT/Adaptivity	N/A
ETSI Adaptivity Type	N/A
ETSI Temperature Category (I, II, III)	N/A
ETSI Receiver Category (1, 2, 3)	N/A
Antenna Type and Gain	Integral antenna, 5.3 dBi.

Variant Models:

The following variant models were not tested as part of this evaluation, but have been identified by the manufacturer as being electrically identical models, depopulated models, or with reasonable similarity to the model(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

None

5 System Setup and Method

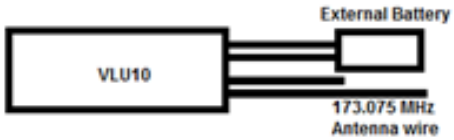
Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
1	DC wires (2)	0.5	None	None	12 V battery
2	Antenna wire	1	None	None	Unterminated

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
Laptop	Lenovo	T440P	None listed

5.1 Method:

Configuration as required by FCC 47CFR Part 15 Subpart C (15.247), FCC Part 15 Subpart B, ANSI C 63.4: 2014, and ANSI C 63.10: 2013.

5.2 EUT Block Diagram:



6 Output Power and Human RF Exposure

6.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C (15.247) and ANSI C 63.10.

TEST SITE: 10M ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample 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
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

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

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

UF = $10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
UF = $10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

6.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV002'	Weather Station	Davis Instruments	7400	PE80519A93	06/14/2017	06/14/2018
145128'	EMI Receiver (20 Hz - 40 Ghz)	Rohde & Schwarz	ESIB 40	839283/001	03/15/2017	03/15/2018
ETS001'	1-18GHz DRG Horn Antenna	ETS-Lindgren	3117	00143259	02/13/2017	02/13/2018
145-416'	Cables 145-420 145-423 145-425 145-408	Huber + Suhner	3m Track B cables	multiple	07/25/2017	07/25/2018

Software Utilized:

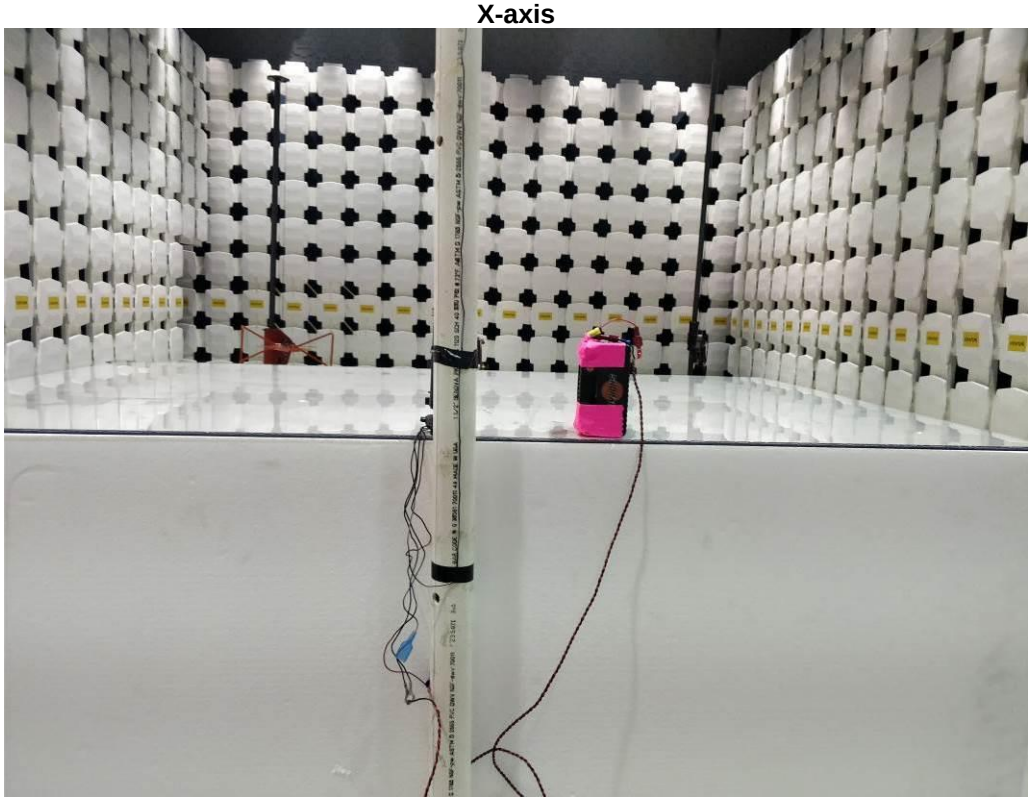
Name	Manufacturer	Version
EMI Tables Program	Intertek Boxborough	08/27/2010

6.3 Results:

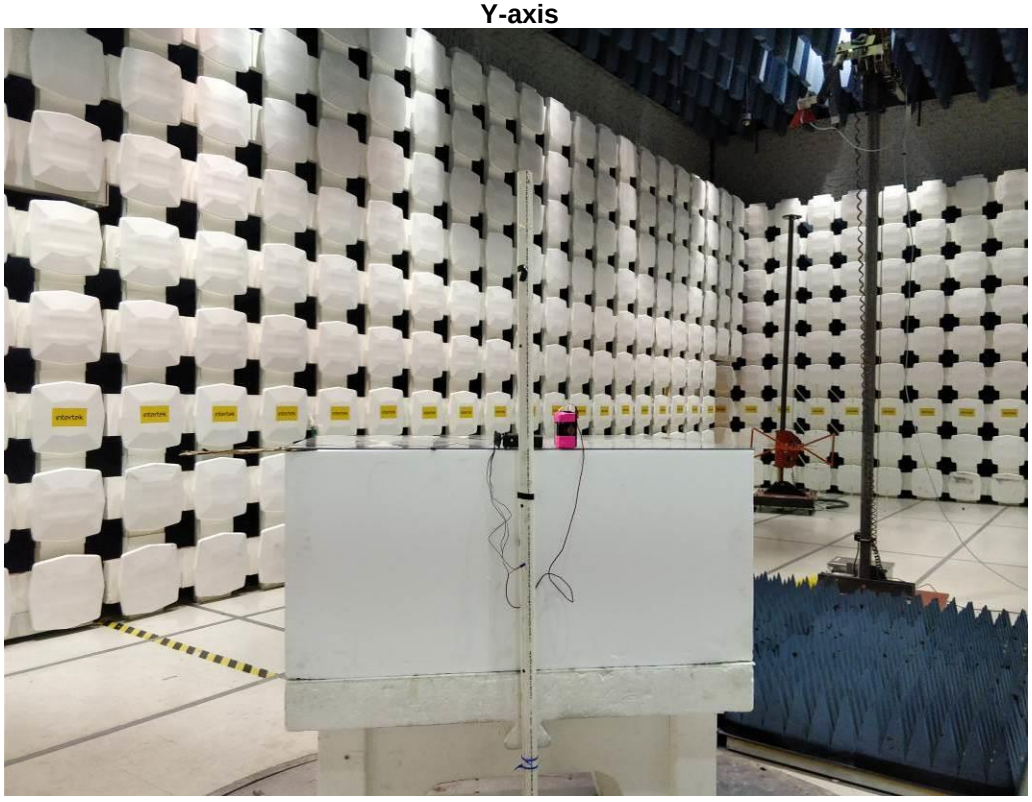
The sample tested was found to Comply. For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands the limit for output power is 1Watt/30dBm.

6.4 Setup Photographs:

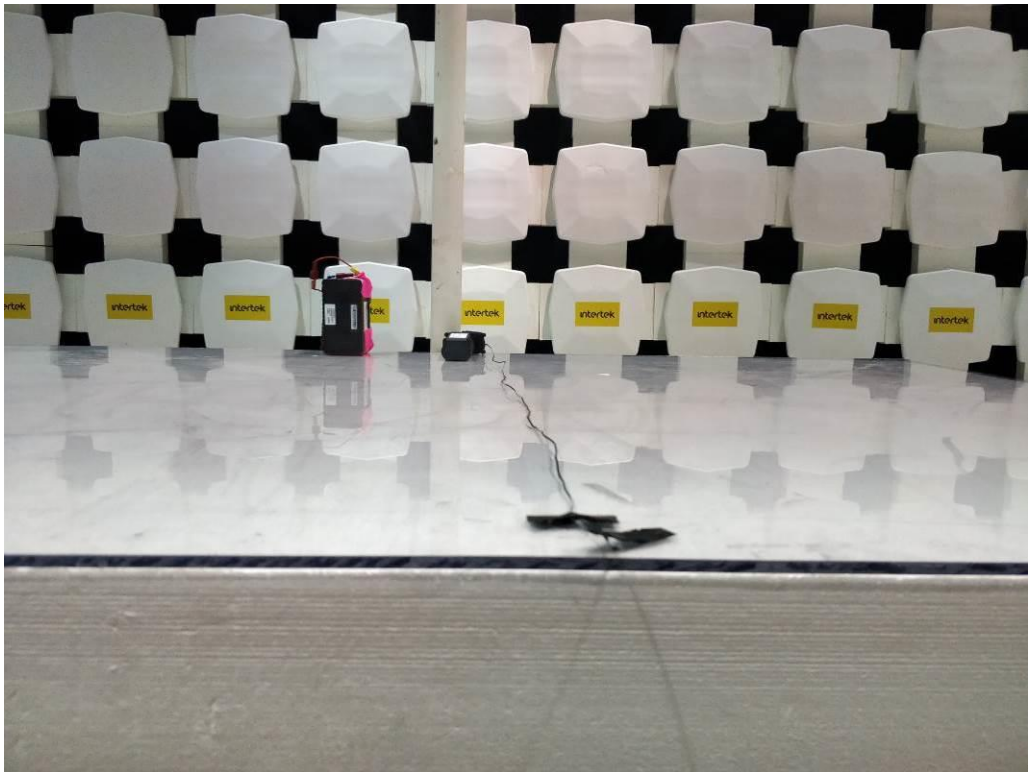
X-axis



Y-axis



Z-axis



6.5 Test Data:

Output Power											
Company:	LoJack						Antenna & Cables:	HF	Bands: N, LF, HF, SHF		
Model #:	As specified in section 4.0						Antenna:	ETS001_2-13-2018.txt	ETS001_2-13-2018.txt		
Serial #:	As specified in section 4.0						Cable(s):	145-416__7-25-17.txt	NONE.		
Engineers:	Naga Suryadevara			Location:	10M ALSE		Barometer:	DAV002		Filter:	NONE
Project #:	G103364832	Date(s):	01/10/18								
Standard:	FCC Part 15 Subpart C (15.247)						Temp/Humidity/Pressure:	21C	10%	1003mbars	
Receiver:	145-128		Limit Distance (m):	3							
PreAmp:	NONE.		Test Distance (m):	3							
PreAmp Used? (Y or N):		N	Voltage/Frequency:	12VDC			Frequency Range:		As specified below		
Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)											
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW											

Detector Type	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dBm	Limit dBm	Margin dB	Bandwidth
			Output Power Low, Mid and High Channels X-axis								
PK	V	2402.000	33.23	32.12	6.48	0.00	0.00	-23.36	36.00	-59.36	3/10 MHz
PK	V	2440.000	38.37	32.18	6.46	0.00	0.00	-18.19	36.00	-54.19	3/10 MHz
PK	V	2480.000	38.89	32.23	6.44	0.00	0.00	-17.64	36.00	-53.64	3/10 MHz
			Output Power Low, Mid and High Channels Y-axis								
PK	H	2402.000	34.63	32.12	6.48	0.00	0.00	-21.96	36.00	-57.96	3/10 MHz
PK	H	2440.000	31.11	32.18	6.46	0.00	0.00	-25.45	36.00	-61.45	3/10 MHz
PK	H	2480.000	33.63	32.23	6.44	0.00	0.00	-22.90	36.00	-58.90	3/10 MHz
			Output Power Low, Mid and High Channels Z-axis								
PK	H	2402.000	33.47	32.12	6.48	0.00	0.00	-23.12	36.00	-59.12	3/10 MHz
PK	H	2440.000	33.63	32.18	6.46	0.00	0.00	-22.93	36.00	-58.93	3/10 MHz
PK	H	2480.000	36.77	32.23	6.44	0.00	0.00	-19.76	36.00	-55.76	3/10 MHz

Note: Data is from worst case polarization. As the measurements are performed using radiated method, limit specified above includes the 6dBi antenna gain.

Human RF Exposure Calculation

§ 1.1310: The criteria listed in table 1 shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

Part 1.1310 Limits for Maximum Permissible Exposure (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*(900/f^2)	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*(180/f^2)	30
30–300	27.5	0.073	0.2	30
300–1500			f/1500	30
1500–100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.

NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

An MPE evaluation for was performed in order to show that the device was compliant with §2.1091. The maximum power density was calculated for each transmitter at a separation distance of 20cm.

For each transmitter the maximum RF exposure at a 20 cm distance using the formula:

$$ConductedPower_{mW} = 10^{ConductedPower\,(dBm)/10}$$

$$PowerDensity = \frac{ConductedPower_{mW} \times Ant.Gain}{4\pi \times (20_{cm})^2}$$

Maximum Conducted Output Power = 0.0172 mW

Maximum Antenna Gain = 5.3 dBi

Numeric antenna gain = 3.38

Power Density = (0.0172*3.3)/5025.6

Power Density = 0.000011294 mW/cm^2

Limit at 2.4GHz = 1mW/cm^2

The calculated maximum power density at 20cm distance is less that the limit specified. .

Test Personnel:	Naga Suryadevara N.S	Test Date:	01/10/2018
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15 Subpart C (15.247)	Limit Applied:	As specified in section 6.3
Input Voltage:	12VDC		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	21 ºC
		Relative Humidity:	10 %
		Atmospheric Pressure:	1003 mbars

Deviations, Additions, or Exclusions: None

7 Power Spectral Density

7.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C (15.247) and ANSI C 63.10.

TEST SITE: 10M ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample 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
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

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

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

UF = $10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
UF = $10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

7.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV002'	Weather Station	Davis Instruments	7400	PE80519A93	06/14/2017	06/14/2018
145128'	EMI Receiver (20 Hz - 40 Ghz)	Rohde & Schwarz	ESIB 40	839283/001	03/15/2017	03/15/2018
ETS001'	1-18GHz DRG Horn Antenna	ETS-Lindgren	3117	00143259	02/13/2017	02/13/2018
145-416'	Cables 145-420 145-423 145-425 145-408	Huber + Suhner	3m Track B cables	multiple	07/25/2017	07/25/2018

Software Utilized:

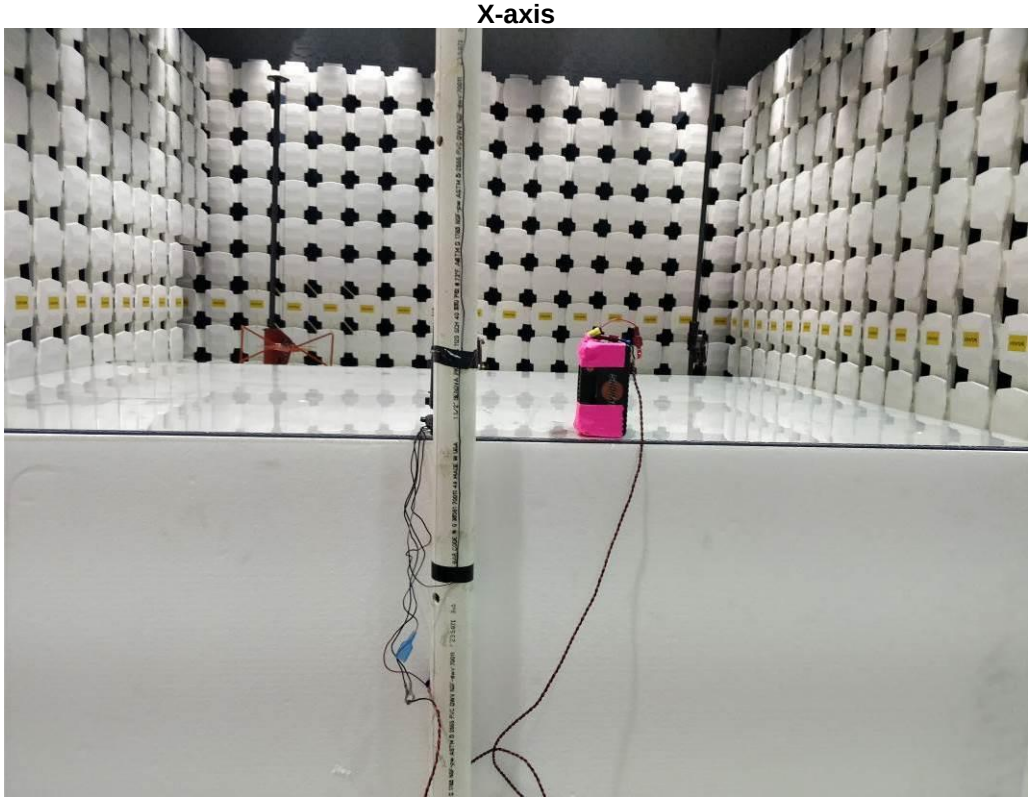
Name	Manufacturer	Version
EMI Tables Program	Intertek Boxborough	08/27/2010

7.3 Results:

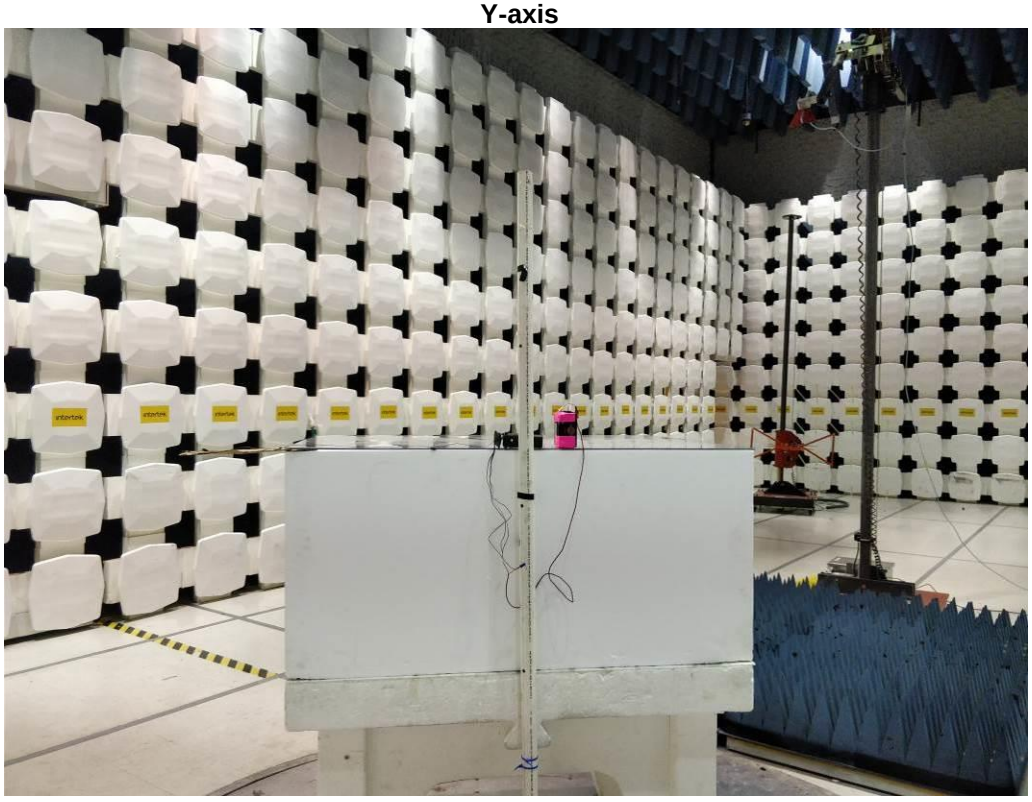
The sample tested was found to Comply. For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

7.4 Setup Photographs:

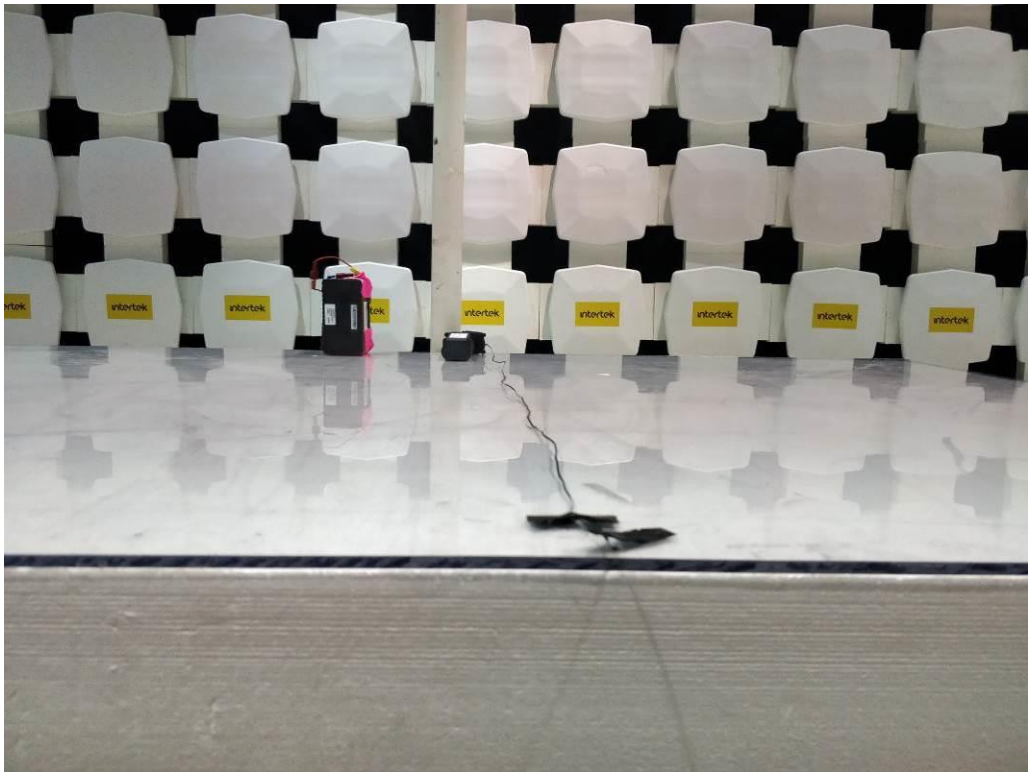
X-axis



Y-axis



Z-axis



7.5 Test Data:

Power Spectral Density											
Company:	LoJack						Antenna & Cables:	HF	Bands: N, LF, HF, SHF		
Model #:	As specified in section 4.0						Antenna:	ETS001_2-13-2018.txt	ETS001_2-13-2018.txt		
Serial #:	As specified in section 4.0						Cable(s):	145-416__7-25-17.txt	NONE.		
Engineers:	Naga Suryadevara			Location:	10M ALSE		Barometer:	DAV002		Filter:	NONE
Project #:	G103364832	Date(s):	01/10/18								
Standard:	FCC Part 15 Subpart C (15.247)						Temp/Humidity/Pressure:	22C	10%	1003mbars	
Receiver:	145-128		Limit Distance (m):	3							
PreAmp:	NONE.		Test Distance (m):	3							
	PreAmp Used? (Y or N):	N	Voltage/Frequency:	12VDC			Frequency Range:		As specified below		
Net = Reading (dBuV/m) + Antenna Factor (dB1/m) + Cable Loss (dB) - Preamp Factor (dB) - Distance Factor (dB)											
Peak: PK Quasi-Peak: QP Average: AVG RMS: RMS; NF = Noise Floor, RB = Restricted Band; Bandwidth denoted as RBW/VBW											

Detector Type	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dBm	Limit dBm	Margin dB	Bandwidth
			PSD Low, Mid and High Channels X-axis								
PK	V	2402.000	32.23	32.12	6.48	0.00	0.00	-24.36	14.00	-38.36	100/300 kHz
PK	V	2440.000	37.37	32.18	6.46	0.00	0.00	-19.19	14.00	-33.19	100/300 kHz
PK	V	2480.000	36.89	32.23	6.44	0.00	0.00	-19.64	14.00	-33.64	100/300 kHz
			PSD Low, Mid and High Channels Y-axis								
PK	H	2402.000	33.23	32.12	6.48	0.00	0.00	-23.36	14.00	-37.36	100/300 kHz
PK	H	2440.000	30.12	32.18	6.46	0.00	0.00	-26.44	14.00	-40.44	100/300 kHz
PK	H	2480.000	32.22	32.23	6.44	0.00	0.00	-24.31	14.00	-38.31	100/300 kHz
			PSD Low, Mid and High Channels Z-axis								
PK	H	2402.000	31.87	32.12	6.48	0.00	0.00	-24.72	14.00	-38.72	100/300 kHz
PK	H	2440.000	31.19	32.18	6.46	0.00	0.00	-25.37	14.00	-39.37	100/300 kHz
PK	H	2480.000	35.43	32.23	6.44	0.00	0.00	-21.10	14.00	-35.10	100/300 kHz

Note: Data is from worst case polarization. As the measurements are performed using radiated method, limit specified above includes the 6dBi antenna gain.

Test Personnel:	Naga Suryadevara N·S	Test Date:	01/10/2018
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15 Subpart C (15.247)	Limit Applied:	As specified in section 7.3
Input Voltage:	12 VDC		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	21 ºC
		Relative Humidity:	10 %
		Atmospheric Pressure:	1003 mbars

Deviations, Additions, or Exclusions: None

8 Occupied and 6dB Bandwidth

8.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C (15.247) and ANSI C 63.10.

TEST SITE: 10M ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample 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
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

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

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
$UF = 10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

8.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV002'	Weather Station	Davis Instruments	7400	PE80519A93	06/14/2017	06/14/2018
145128'	EMI Receiver (20 Hz - 40 Ghz)	Rohde & Schwarz	ESIB 40	839283/001	03/15/2017	03/15/2018
ETS001'	1-18GHz DRG Horn Antenna	ETS-Lindgren	3117	00143259	02/13/2017	02/13/2018
145-416'	Cables 145-420 145-423 145-425 145-408	Huber + Suhner	3m Track B cables	multiple	07/25/2017	07/25/2018

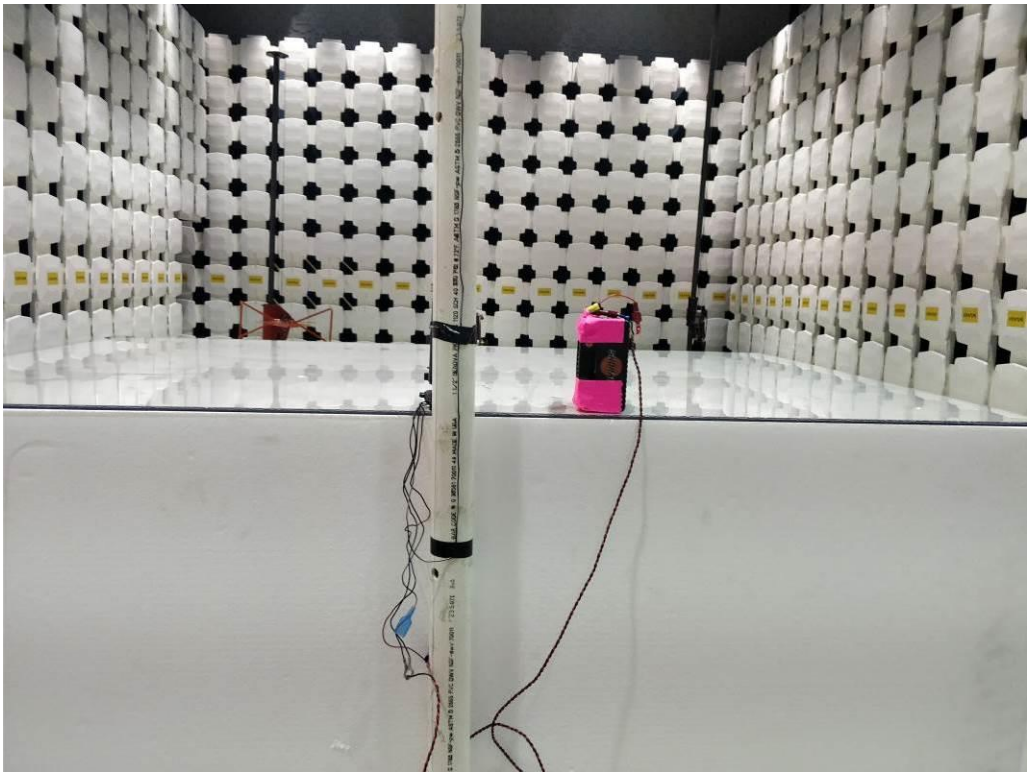
Software Utilized:

Name	Manufacturer	Version
None		

8.3 Results:

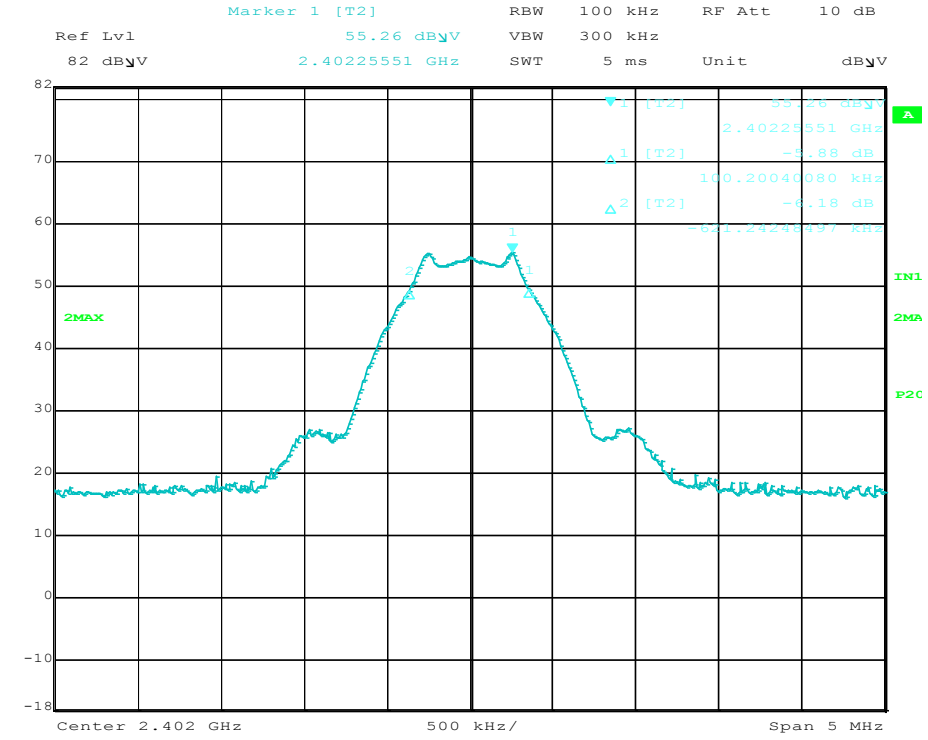
The sample tested was found to Comply. Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

8.4 Setup Photograph:



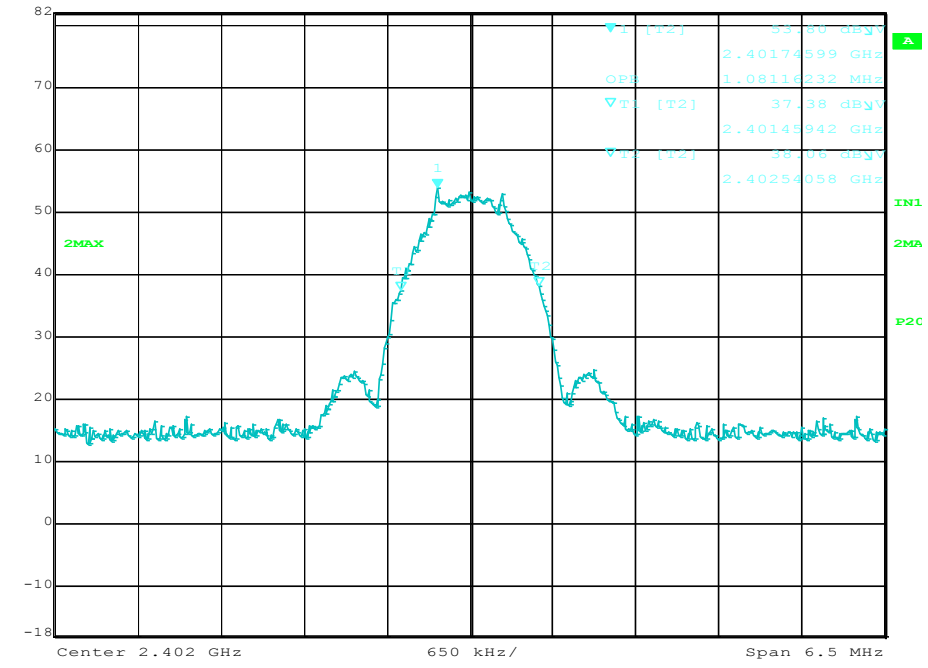
8.5 Plots/Data:

Low channel 6dB bandwidth 721.44 kHz



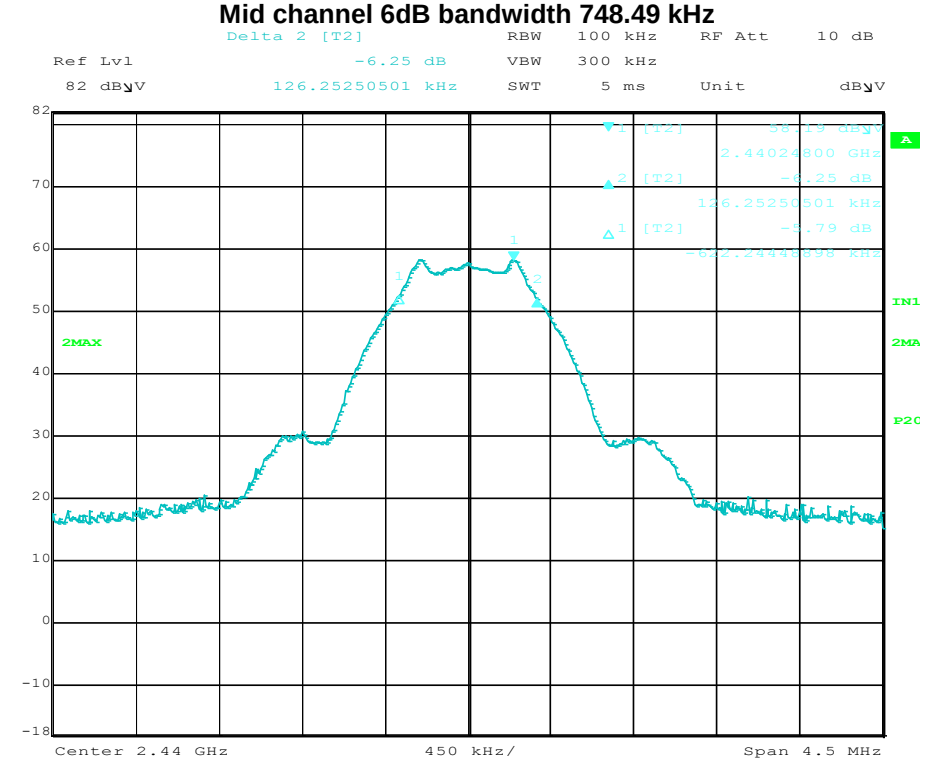
Date: 9.JAN.2018 16:40:29

Low channel occupied bandwidth 1.0811 MHz



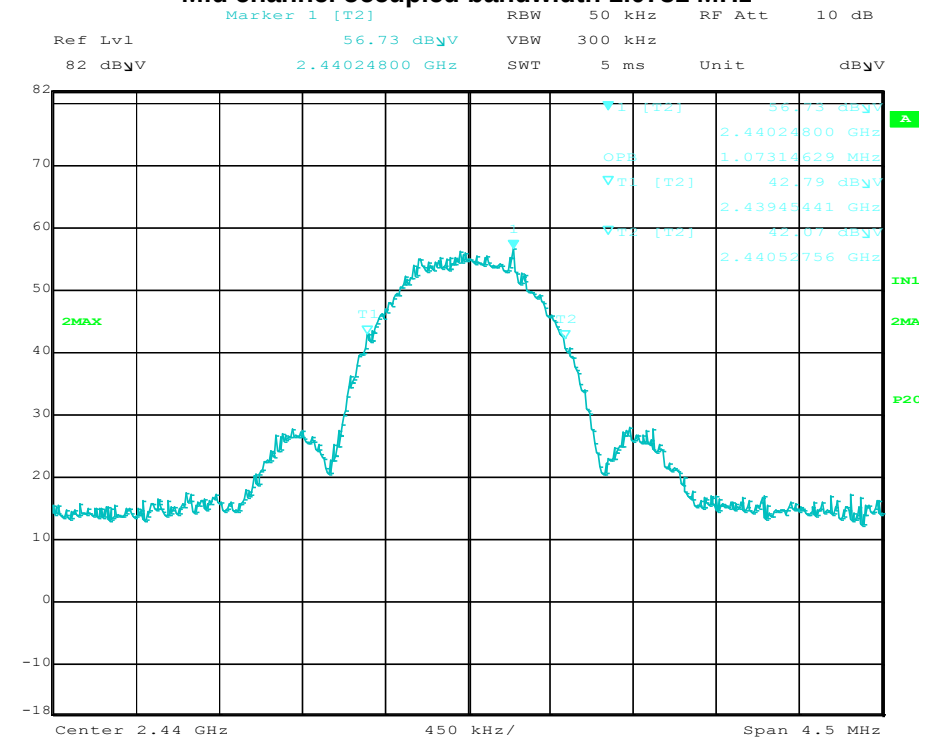
Date: 9.JAN.2018 16:43:26

Mid channel 6dB bandwidth 748.49 kHz



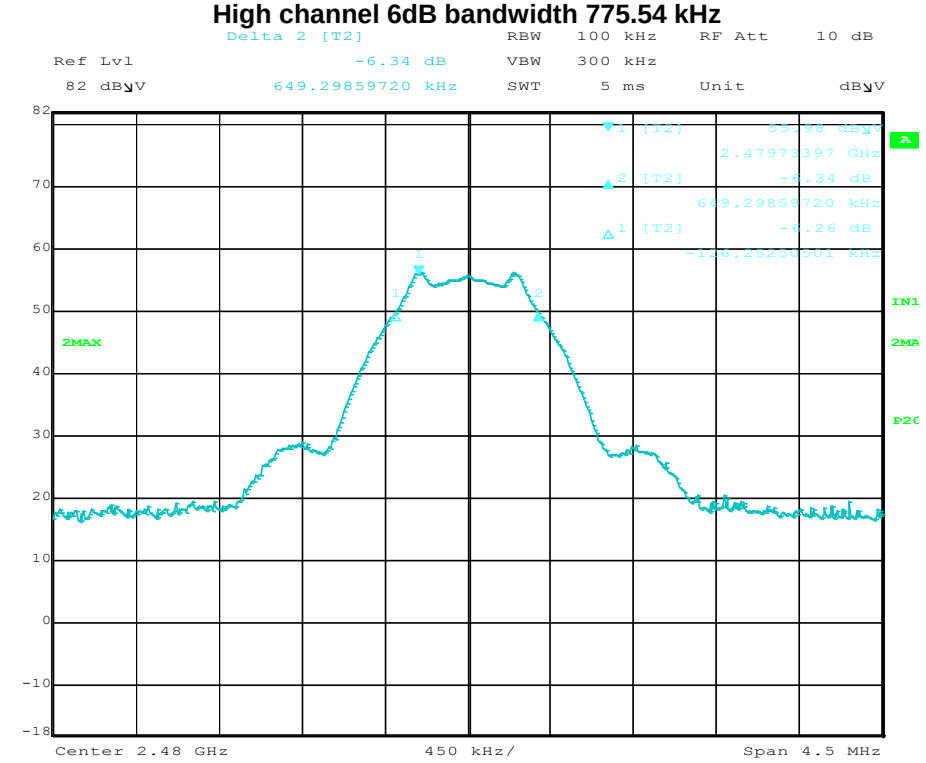
Date: 9.JAN.2018 16:52:51

Mid channel occupied bandwidth 1.0731 MHz



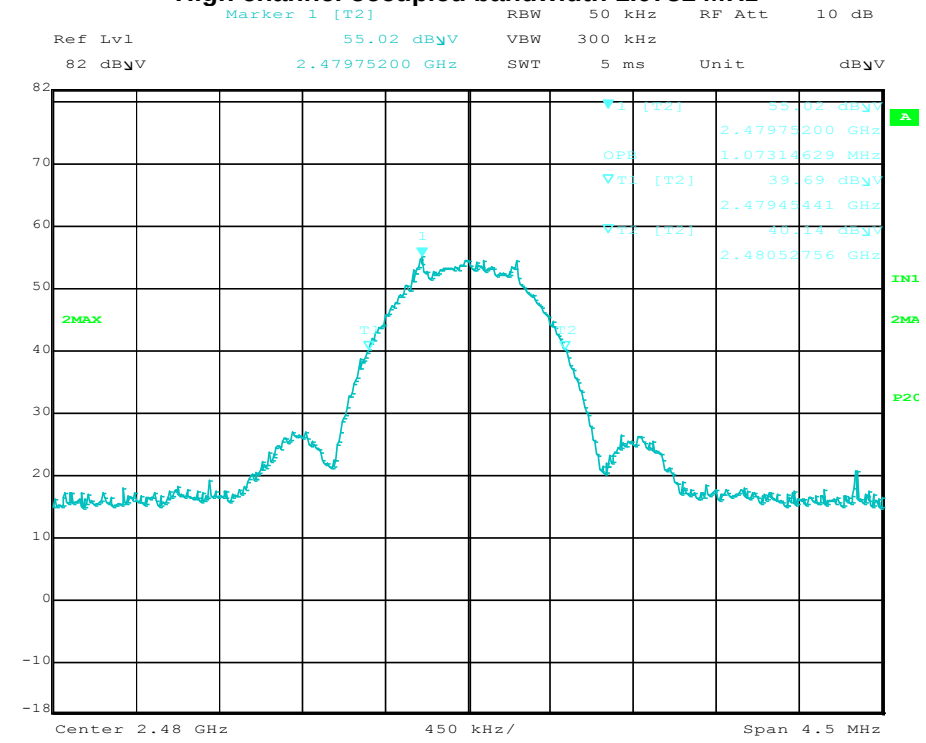
Date: 9.JAN.2018 16:53:52

High channel 6dB bandwidth 775.54 kHz



Date: 9.JAN.2018 17:03:22

High channel occupied bandwidth 1.0731 MHz



Date: 9.JAN.2018 17:02:16

Test Personnel:	Naga Suryadevara N.S	Test Date:	01/09/2018
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15 Subpart C (15.247)	Limit Applied:	As specified in section 8.3
Input Voltage:	12 VDC		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	22 ºC
		Relative Humidity:	18 %
		Atmospheric Pressure:	1006 mbars

Deviations, Additions, or Exclusions: None

9 Transmitter Radiated Spurious Emissions and Band Edge Emissions

9.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C (15.247) and ANSI C 63.10.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample 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
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

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

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

UF = $10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
UF = $10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the "Level" includes all losses and gains and is compared directly in the "Margin" column to the "Limit". The "Correction" includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the "Level" column.

9.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV002	Weather Station	Davis Instruments	7400	PE80519A93	06/14/2017	06/14/2018
145128'	EMI Receiver (20 Hz - 40 Ghz)	Rohde & Schwarz	ESIB 40	839283/001	03/15/2017	03/15/2018
145-410'	Cables 145-420 145-421 145-422 145-406	Huber + Suhner	10m Track A Cables	multiple	07/25/2017	07/25/2018
PRE11'	50dB gain pre-amp	Keith H	PRE11	PRE11	12/02/2017	12/02/2018
145145'	Broadband Hybrid Antenna 30 MHz - 3 GHz	Sunol Sciences Corp.	JB3	A122313	05/02/2017	05/02/2018
145014'	Preamplifier (1 GHz to 26.5 GHz)	Hewlett Packard	8449B	3008A00232	06/03/2017	06/03/2018
ETS001'	1-18GHz DRG Horn Antenna	ETS-Lindgren	3117	00143259	02/13/2017	02/13/2018
145-416'	Cables 145-420 145-423 145-425 145-408	Huber + Suhner	3m Track B cables	multiple	07/25/2017	07/25/2018
REA004'	3GHz High Pass Filter	Reactel, Inc	7HSX-3G/18G-S11	06-1	02/17/2017	02/17/2018
ETS003'	9kHz-30MHz Active Loop Antenna	ETS Lindgren	6502	00143396	05/23/2017	05/23/2018
PRE8'	PREAMPLFIER 1- 40 GHz	MITEQ	NSP4000-NF	507145	10/02/2017	10/02/2018

Software Utilized:

Name	Manufacturer	Version
EMI Tables Program	Intertek Boxborough	08/27/2010
BAT-EMC	Nexio	3.17.0.3

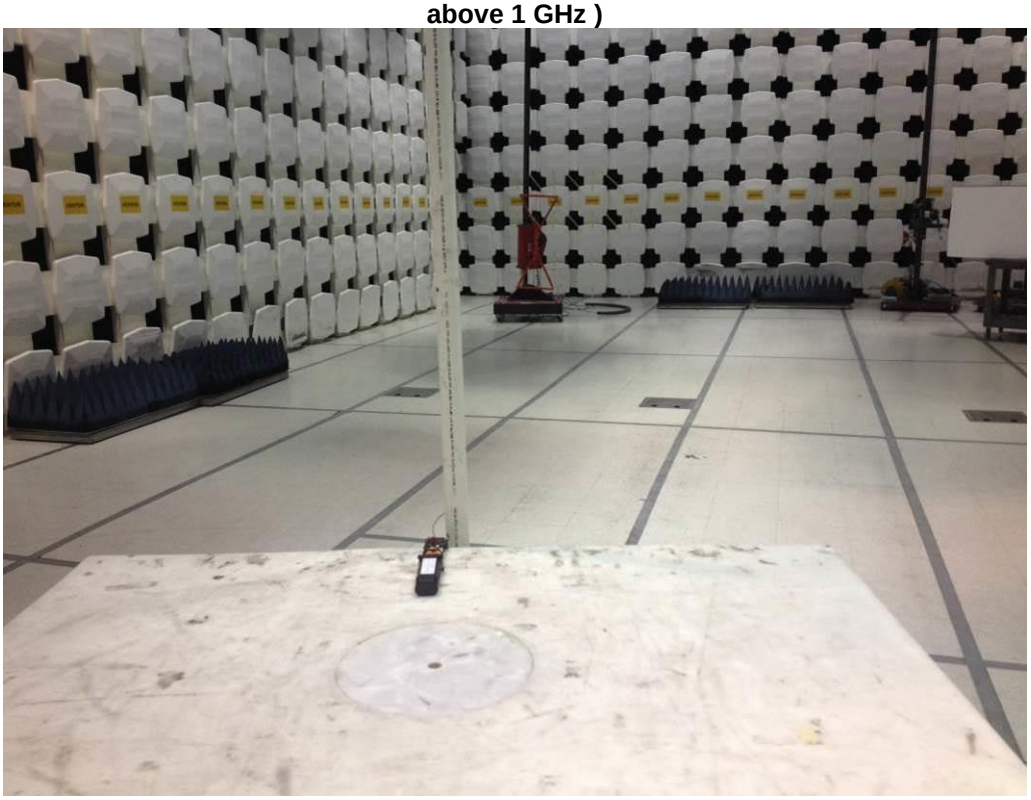
9.3 Results:

The sample tested was found to comply.

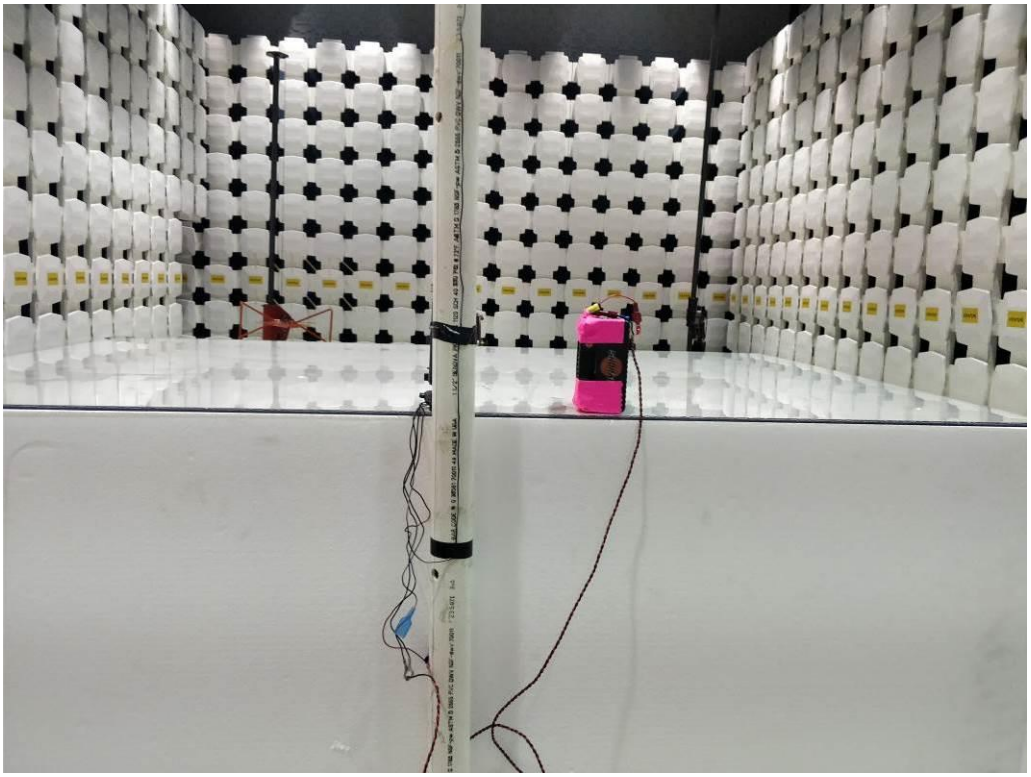
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, 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)).

9.4 Setup Photograph:

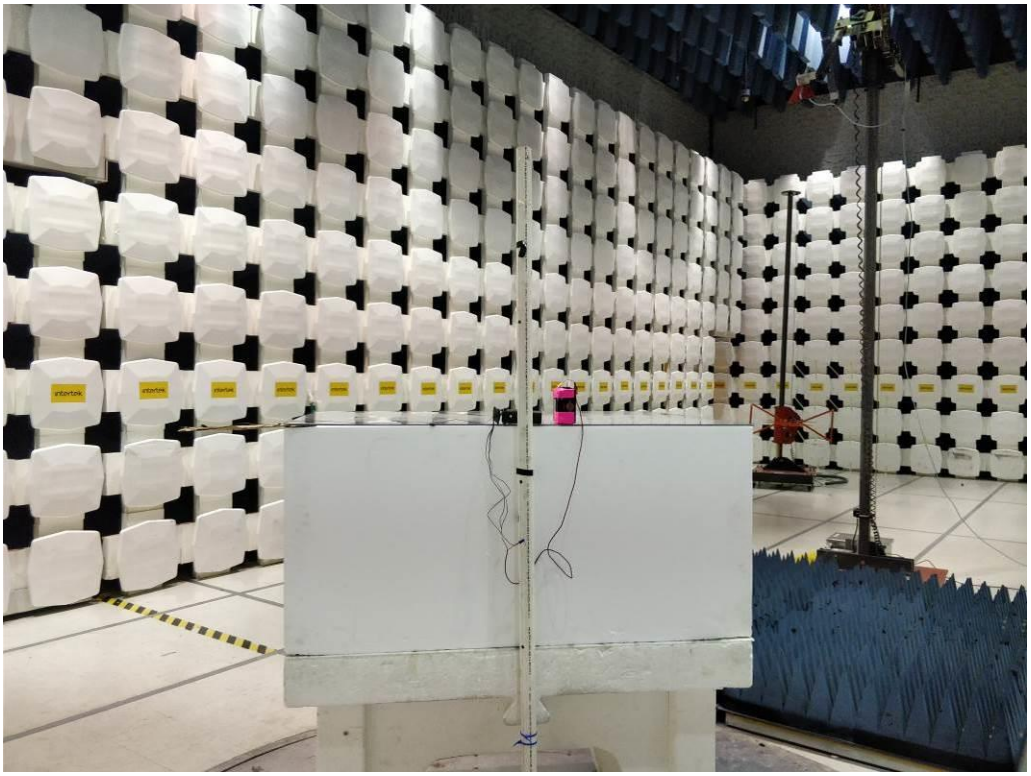
30-1000 MHz (Representative picture for setup, EUT axis was changed exactly similar to the setup above 1 GHz)



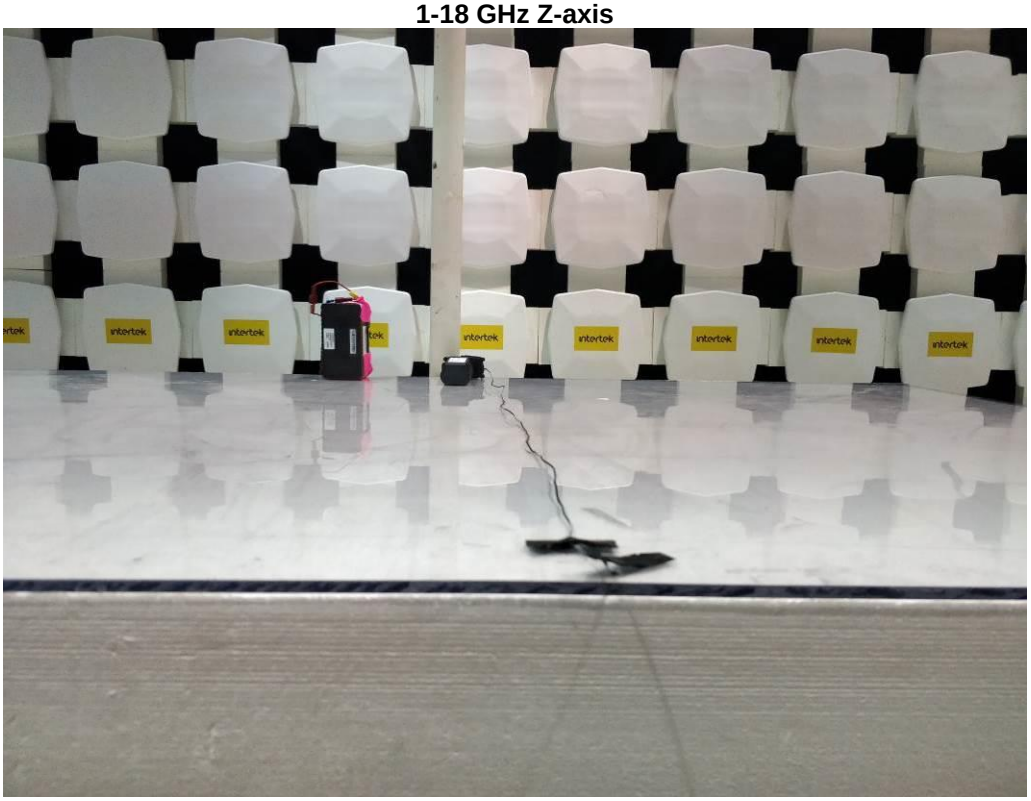
1-18 GHz X-axis



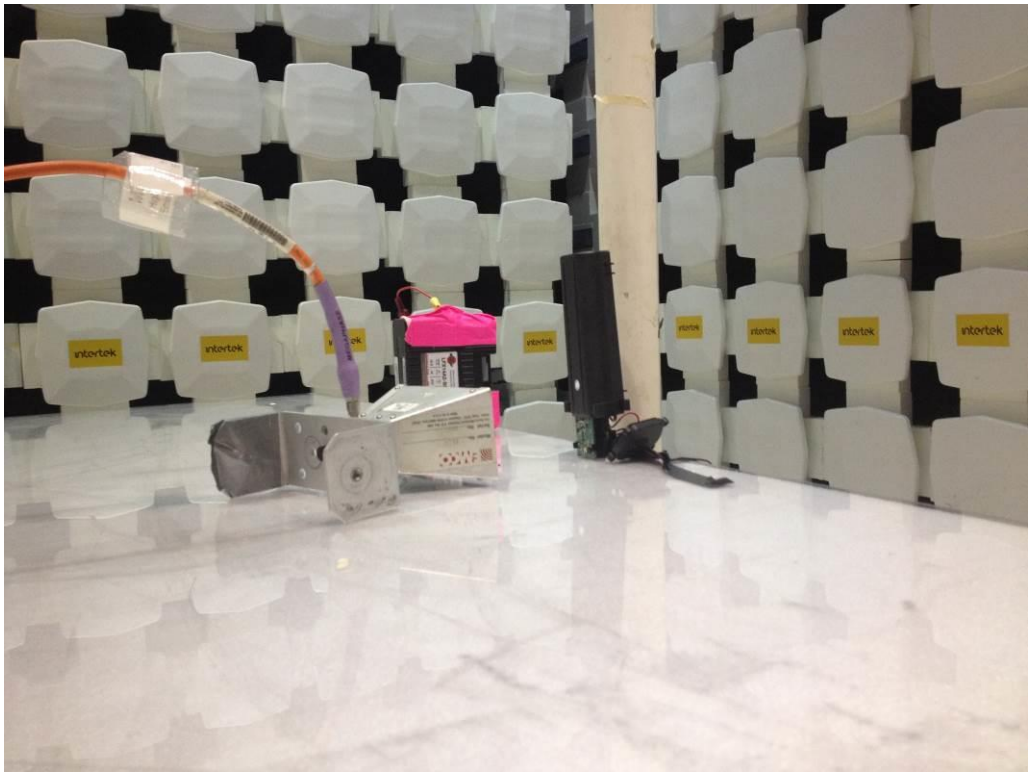
1-18 GHz Y-axis



1-18 GHz Z-axis



18-25 GHz



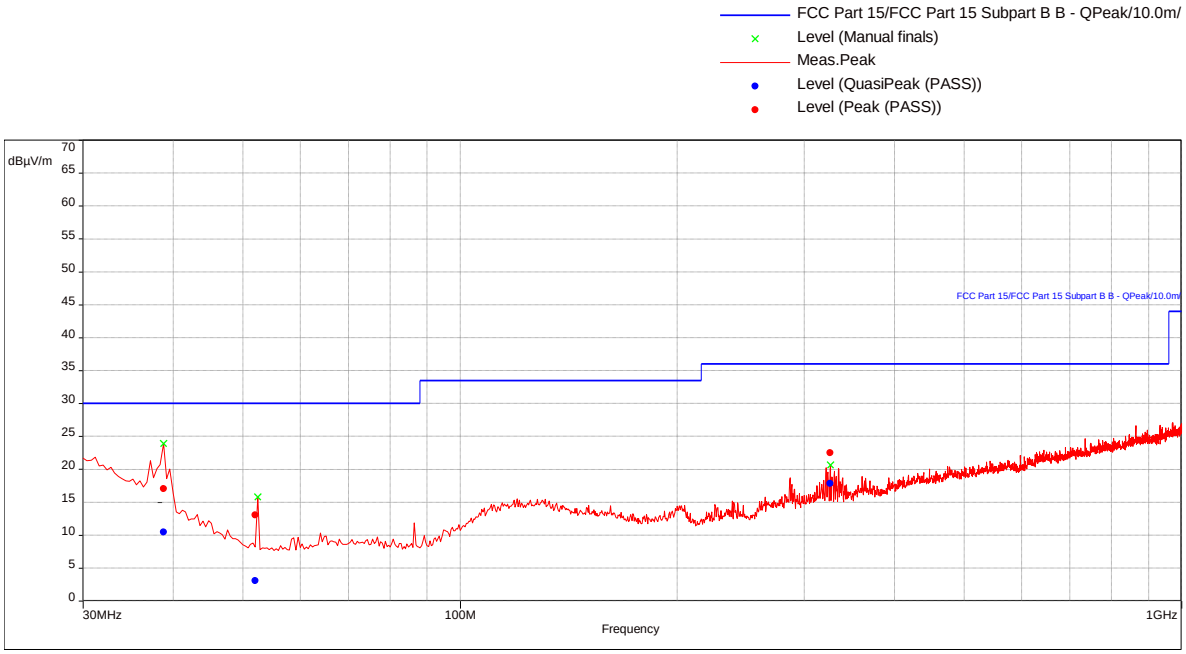
9.5 Plots/Data:

30-1000 MHz Tx mode (X-axis)

Test Information:

Date and Time	1/12/2018 5:00:55 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	21 deg C
Humidity	38%
Atmospheric Pressure	997 mB
Comments	RE 30-1000MHz_BLE_Tx mode_Lo Ch_X-axis

Graph:



Results:

QuasiPeak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
38.64210526	10.42	30.00	-19.58	1.00	2.49	Vertical	120000.00	-29.01
51.89473684	3.07	30.00	-26.93	193.00	2.04	Vertical	120000.00	-36.01
325.7473684	17.81	36.00	-18.19	271.00	3.19	Horizontal	120000.00	-27.68

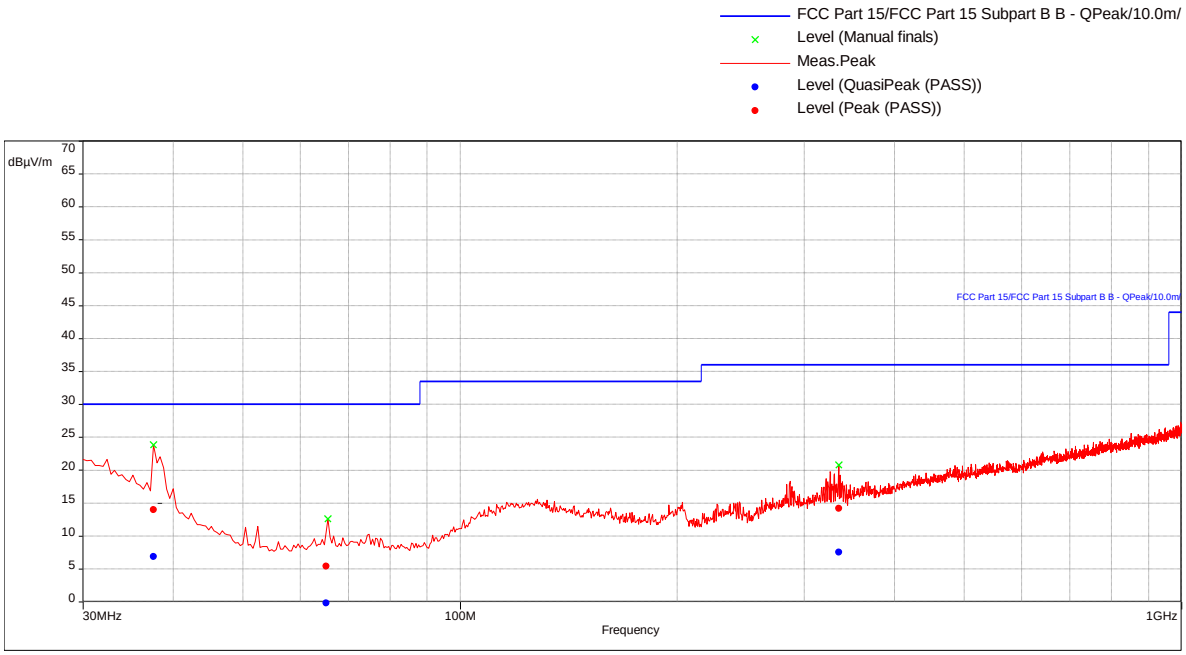
Note: Test was only performed on low channel from 30-1000 MHz; no change in emission was detected with channel changing.

30-1000 MHz Tx mode (Y-axis)

Test Information:

Date and Time	1/12/2018 5:52:38 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	21 deg C
Humidity	38%
Atmospheric Pressure	997' mB
Comments	RE 30-1000MHz_BLE_Tx mode_Lo Ch_Y-axis

Graph:



Results:

QuasiPeak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
37.66315789	6.88	30.00	-23.12	82.00	1.76	Vertical	120000.00	-28.23
65.15789474	-1.20	30.00	-31.20	186.00	3.30	Vertical	120000.00	-35.60
334.9578947	7.55	36.00	-28.45	217.00	1.76	Vertical	120000.00	-27.62

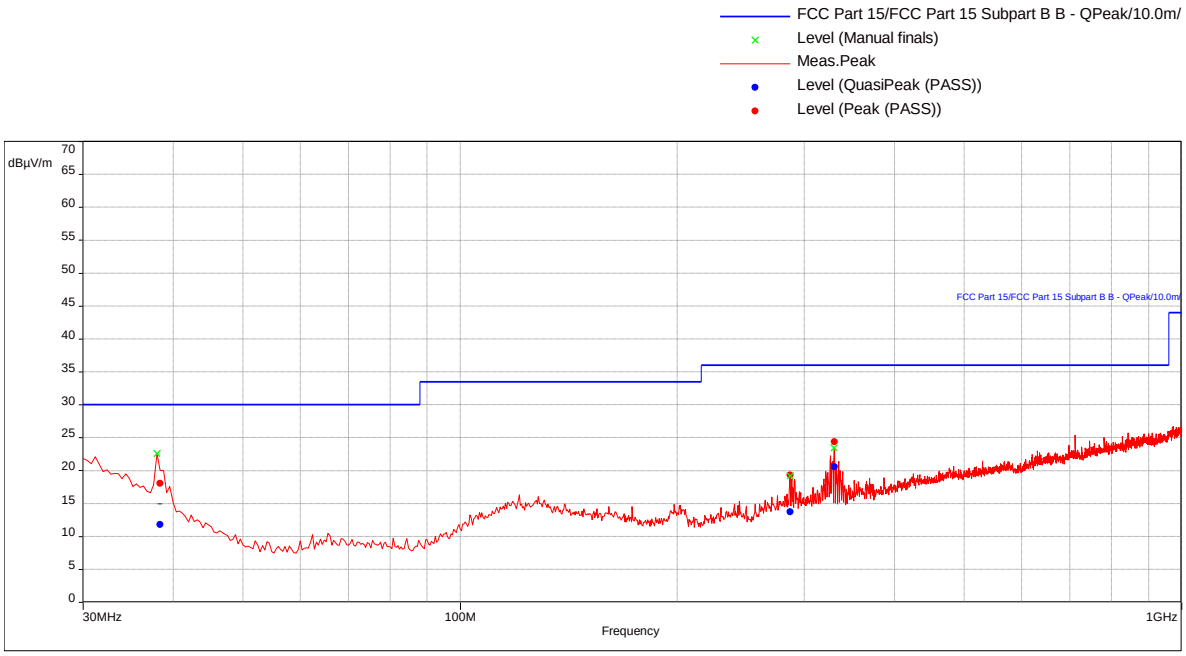
Note: Test was only performed on low channel from 30-1000 MHz; no change in emission was detected with channel changing.

30-1000 MHz Tx mode (Z-axis)

Test Information:

Date and Time	1/12/2018 6:33:43 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	21 deg C
Humidity	38%
Atmospheric Pressure	997' mB
Comments	RE 30-1000MHz_BLE_Tx mode_Lo Ch_Z-axis

Graph:



Results:

QuasiPeak (PASS) (3)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
38.47368421	11.81	30.00	-18.19	114.00	2.51	Vertical	120000.00	-28.87
286.6421053	13.68	36.00	-22.32	263.00	1.38	Vertical	120000.00	-28.73
330.3157895	20.56	36.00	-15.44	181.00	2.79	Vertical	120000.00	-27.64

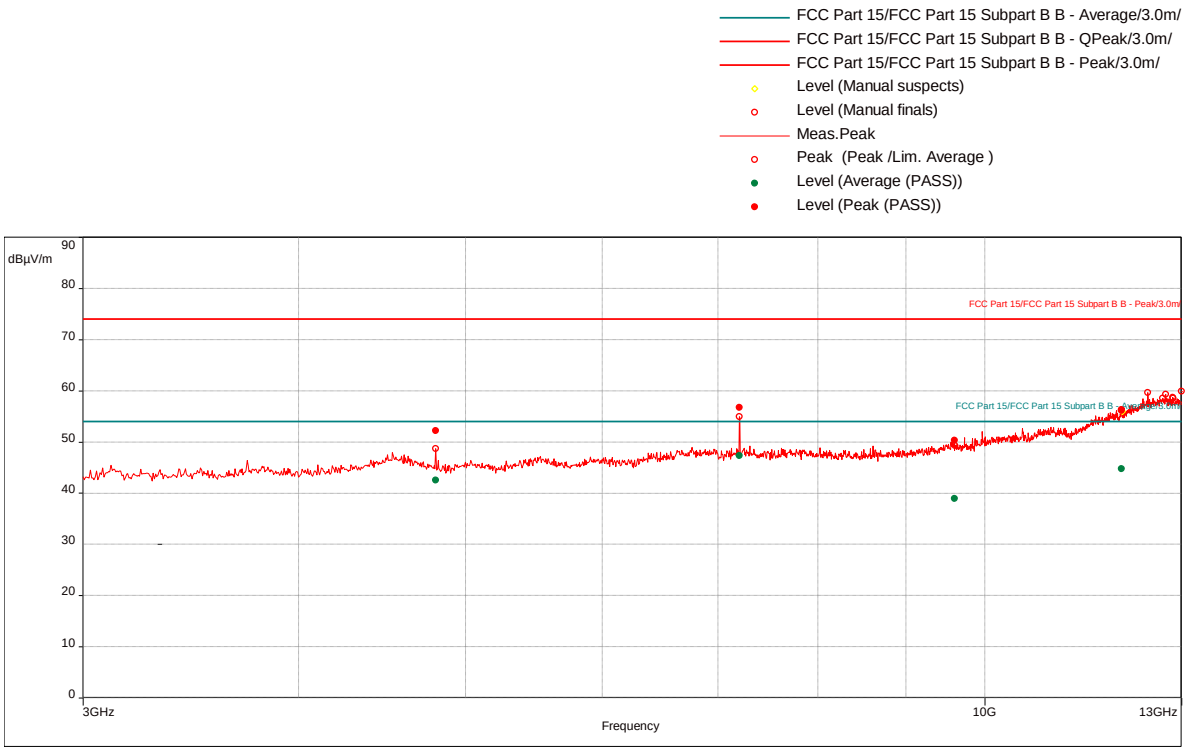
Note: Test was only performed on low channel from 30-1000 MHz; no change in emission was detected with channel changing.

1-25 GHz Tx mode Low channel (X-axis)

Test Information:

Date and Time	1/9/2018 7:22:33 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Lo Ch_Tx mode_-3dBm_X-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4804.473684	52.22	74.00	-21.78	332.00	1.30	Vertical	1000000.00	9.18
7205.263158	56.74	74.00	-17.26	236.00	1.22	Vertical	1000000.00	11.98
9606.578947	50.35	74.00	-23.65	141.00	2.58	Vertical	1000000.00	13.00
11997.63158	56.26	74.00	-17.74	348.00	1.38	Horizontal	1000000.00	21.22

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4804.473684	42.50	54.00	-11.50	332.00	1.30	Vertical	1000000.00	9.18
7205.263158	47.32	54.00	-6.68	236.00	1.22	Vertical	1000000.00	11.98
9606.578947	38.95	54.00	-15.05	141.00	2.58	Vertical	1000000.00	13.00
11997.63158	44.74	54.00	-9.26	348.00	1.38	Horizontal	1000000.00	21.22

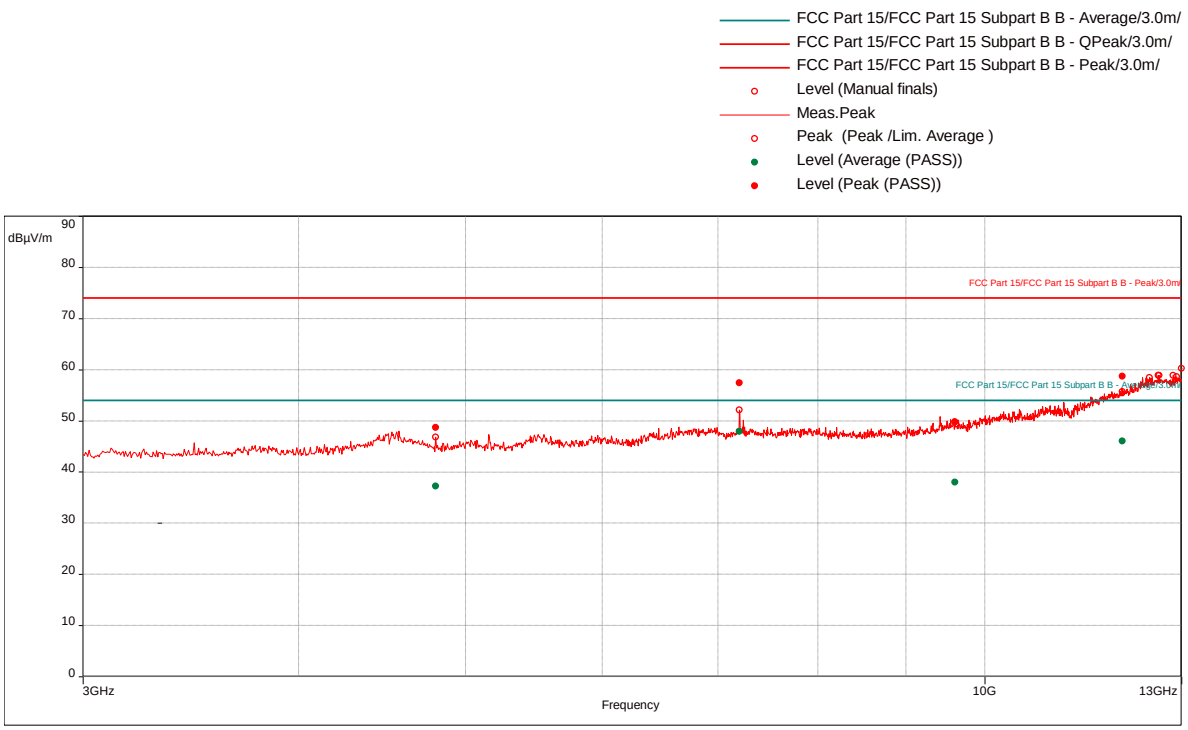
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode Low channel (Y-axis)

Test Information:

Date and Time	1/9/2018 7:50:06 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Lo Ch_Tx mode_-3dBm_Y-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4803.684211	48.70	74.00	-25.30	198.00	2.46	Horizontal	1000000.00	9.18
7205.263158	57.41	74.00	-16.59	185.00	3.35	Vertical	1000000.00	11.98
9611.578947	49.83	74.00	-24.17	88.00	1.80	Horizontal	1000000.00	13.01
12008.68421	58.73	74.00	-15.27	185.00	1.49	Horizontal	1000000.00	21.25

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4803.684211	37.19	54.00	-16.81	198.00	2.46	Horizontal	1000000.00	9.18
7205.263158	47.89	54.00	-6.11	185.00	3.35	Vertical	1000000.00	11.98
9611.578947	38.03	54.00	-15.97	88.00	1.80	Horizontal	1000000.00	13.01
12008.68421	46.03	54.00	-7.97	185.00	1.49	Horizontal	1000000.00	21.25

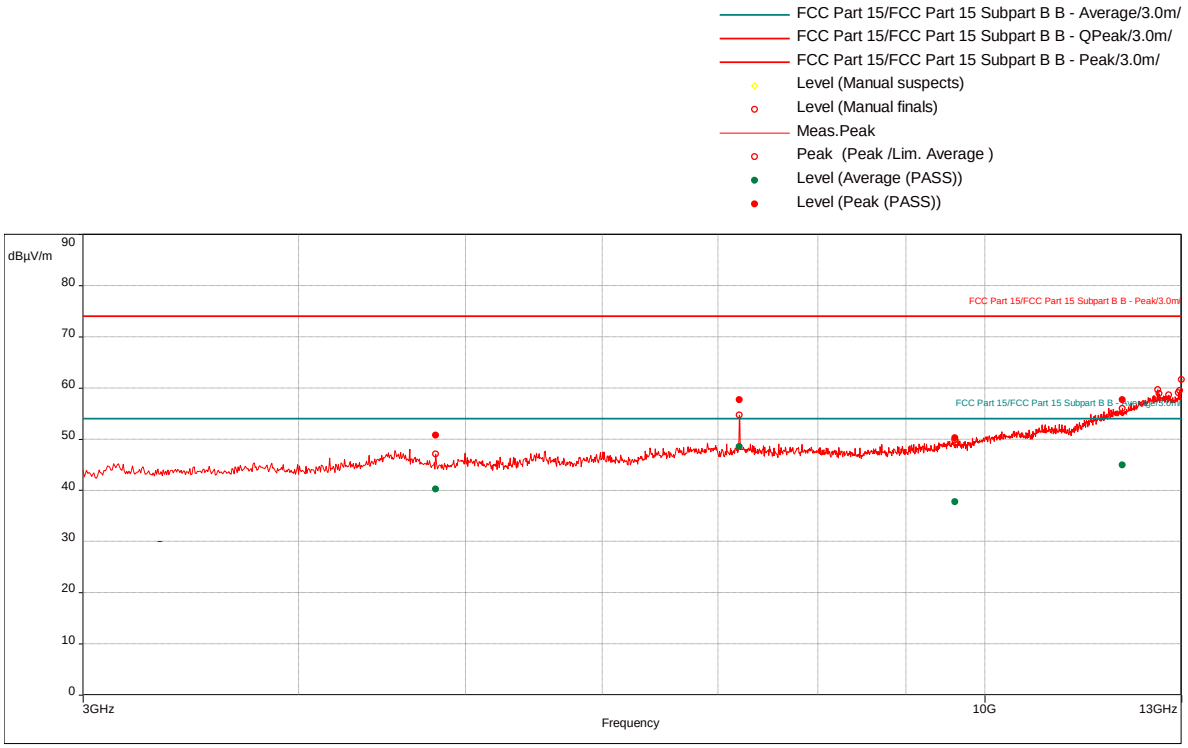
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode Low channel (Z-axis)

Test Information:

Date and Time	1/9/2018 8:15:41 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Lo Ch_Tx mode_-3dBm_Z-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4803.421053	50.77	74.00	-23.23	204.00	3.88	Vertical	1000000.00	9.18
7205.263158	57.66	74.00	-16.34	200.00	2.73	Horizontal	1000000.00	11.98
9608.684211	50.21	74.00	-23.79	204.00	1.33	Vertical	1000000.00	13.01
12008.42105	57.68	74.00	-16.32	184.00	1.00	Vertical	1000000.00	21.25

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4803.421053	40.22	54.00	-13.78	204.00	3.88	Vertical	1000000.00	9.18
7205.263158	48.54	54.00	-5.46	200.00	2.73	Horizontal	1000000.00	11.98
9608.684211	37.70	54.00	-16.30	204.00	1.33	Vertical	1000000.00	13.01
12008.42105	44.96	54.00	-9.04	184.00	1.00	Vertical	1000000.00	21.25

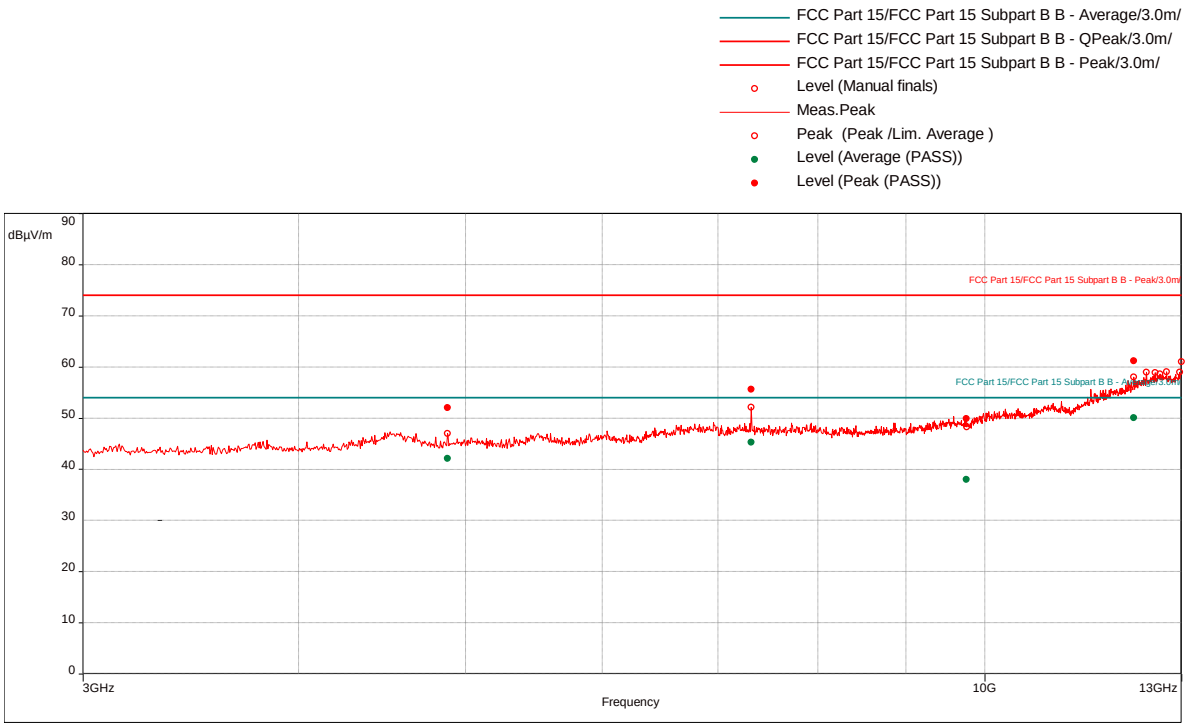
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode Mid channel (X-axis)

Test Information:

Date and Time	1/9/2018 9:32:12 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Mid Ch_Tx mode_-3dBm_X-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4879.473684	52.02	74.00	-21.98	36.00	1.22	Vertical	1000000.00	9.25
7320.789474	55.65	74.00	-18.35	328.00	1.42	Vertical	1000000.00	11.96
9755.526316	49.89	74.00	-24.11	328.00	2.34	Horizontal	1000000.00	13.33
12201.05263	61.22	74.00	-12.78	230.00	1.57	Vertical	1000000.00	21.56

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4879.473684	42.11	54.00	-11.89	36.00	1.22	Vertical	1000000.00	9.25
7320.789474	45.24	54.00	-8.76	328.00	1.42	Vertical	1000000.00	11.96
9755.526316	38.02	54.00	-15.98	328.00	2.34	Horizontal	1000000.00	13.33
12201.05263	50.02	54.00	-3.98	230.00	1.57	Vertical	1000000.00	21.56

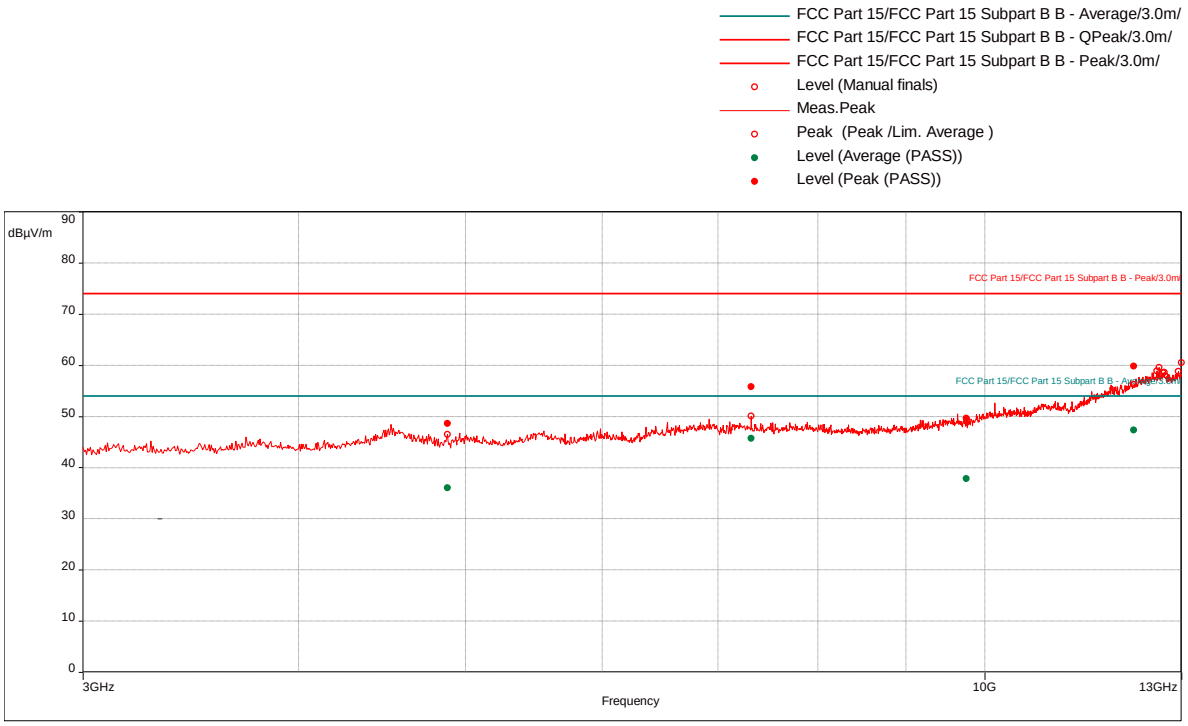
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode Mid channel (Y-axis)

Test Information:

Date and Time	1/9/2018 9:08:23 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Mid Ch_Tx mode_-3dBm_Y-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4879.473684	48.63	74.00	-25.37	42.00	3.12	Horizontal	1000000.00	9.25
7320.789474	55.78	74.00	-18.22	334.00	3.05	Vertical	1000000.00	11.96
9756.842105	49.63	74.00	-24.37	199.00	1.27	Horizontal	1000000.00	13.33
12198.68421	59.85	74.00	-14.15	114.00	3.02	Vertical	1000000.00	21.56

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4879.473684	36.03	54.00	-17.97	42.00	3.12	Horizontal	1000000.00	9.25
7320.789474	45.70	54.00	-8.30	334.00	3.05	Vertical	1000000.00	11.96
9756.842105	37.85	54.00	-16.15	199.00	1.27	Horizontal	1000000.00	13.33
12198.68421	47.35	54.00	-6.65	114.00	3.02	Vertical	1000000.00	21.56

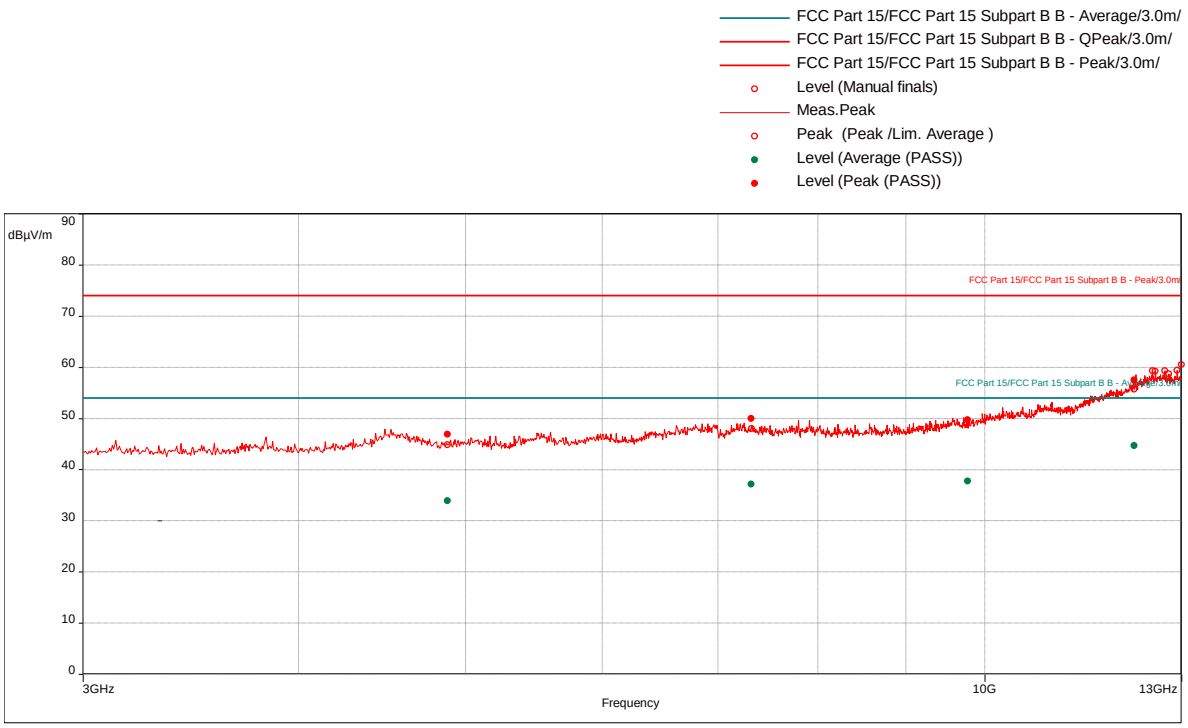
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode Mid channel (Z-axis)

Test Information:

Date and Time	1/9/2018 8:43:18 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Mid Ch_Tx mode_-3dBm_Z-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4880.526316	46.86	74.00	-27.14	146.00	2.03	Vertical	1000000.00	9.25
7320.789474	49.98	74.00	-24.02	94.00	3.23	Vertical	1000000.00	11.96
9768.947368	49.69	74.00	-24.31	358.00	1.00	Vertical	1000000.00	13.39
12204.47368	57.46	74.00	-16.54	308.00	1.49	Vertical	1000000.00	21.56

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4880.526316	33.85	54.00	-20.15	146.00	2.03	Vertical	1000000.00	9.25
7320.789474	37.14	54.00	-16.86	94.00	3.23	Vertical	1000000.00	11.96
9768.947368	37.73	54.00	-16.27	358.00	1.00	Vertical	1000000.00	13.39
12204.47368	44.69	54.00	-9.31	308.00	1.49	Vertical	1000000.00	21.56

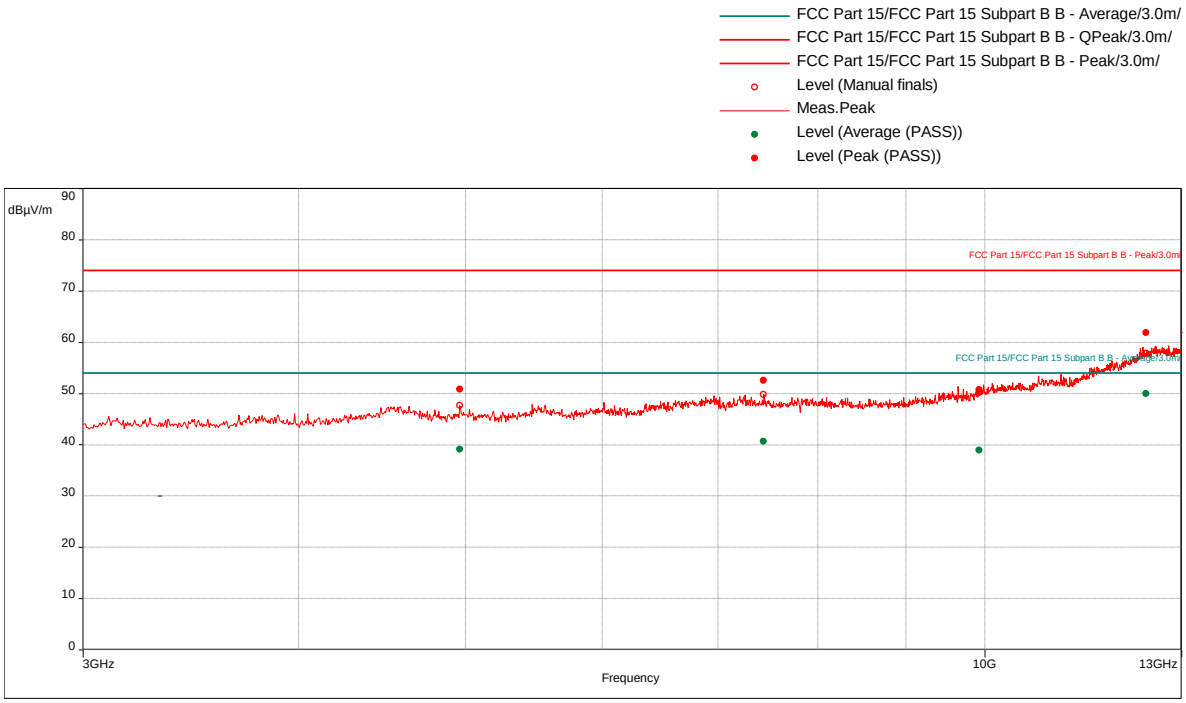
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode High channel (X-axis)

Test Information:

Date and Time	1/9/2018 5:56:51 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Hi Ch_Tx mode_-3dBm_X-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4959.473684	50.86	74.00	-23.14	145.00	1.92	Horizontal	1000000.00	9.39
7439.210526	52.50	74.00	-21.50	36.00	1.30	Vertical	1000000.00	11.84
9919.736842	50.78	74.00	-23.22	229.00	3.17	Horizontal	1000000.00	13.84
12401.05263	61.89	74.00	-12.11	165.00	2.66	Vertical	1000000.00	22.51

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4959.473684	39.12	54.00	-14.88	145.00	1.92	Horizontal	1000000.00	9.39
7439.210526	40.63	54.00	-13.37	36.00	1.30	Vertical	1000000.00	11.84
9919.736842	38.94	54.00	-15.06	229.00	3.17	Horizontal	1000000.00	13.84
12401.05263	49.93	54.00	-4.07	165.00	2.66	Vertical	1000000.00	22.51

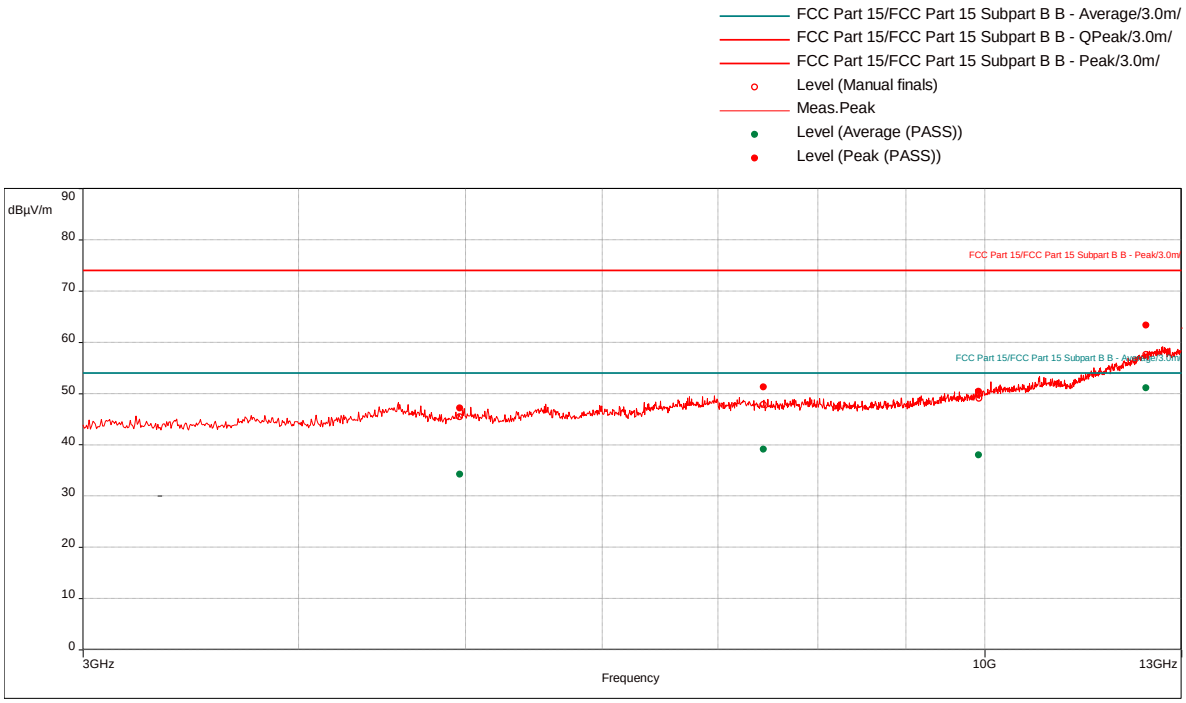
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode High channel (Y-axis)

Test Information:

Date and Time	1/9/2018 6:24:41 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Hi Ch_Tx mode_-3dBm_Y-axis

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4960.263158	47.14	74.00	-26.86	256.00	2.78	Horizontal	1000000.00	9.39
7439.210526	51.23	74.00	-22.77	55.00	3.72	Vertical	1000000.00	11.84
9916.315789	50.39	74.00	-23.61	158.00	3.58	Horizontal	1000000.00	13.83
12398.42105	63.29	74.00	-10.71	12.00	2.77	Horizontal	1000000.00	22.49

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4960.263158	34.25	54.00	-19.75	256.00	2.78	Horizontal	1000000.00	9.39
7439.210526	39.14	54.00	-14.86	55.00	3.72	Vertical	1000000.00	11.84
9916.315789	38.00	54.00	-16.00	158.00	3.58	Horizontal	1000000.00	13.83
12398.42105	51.12	54.00	-2.88	12.00	2.77	Horizontal	1000000.00	22.49

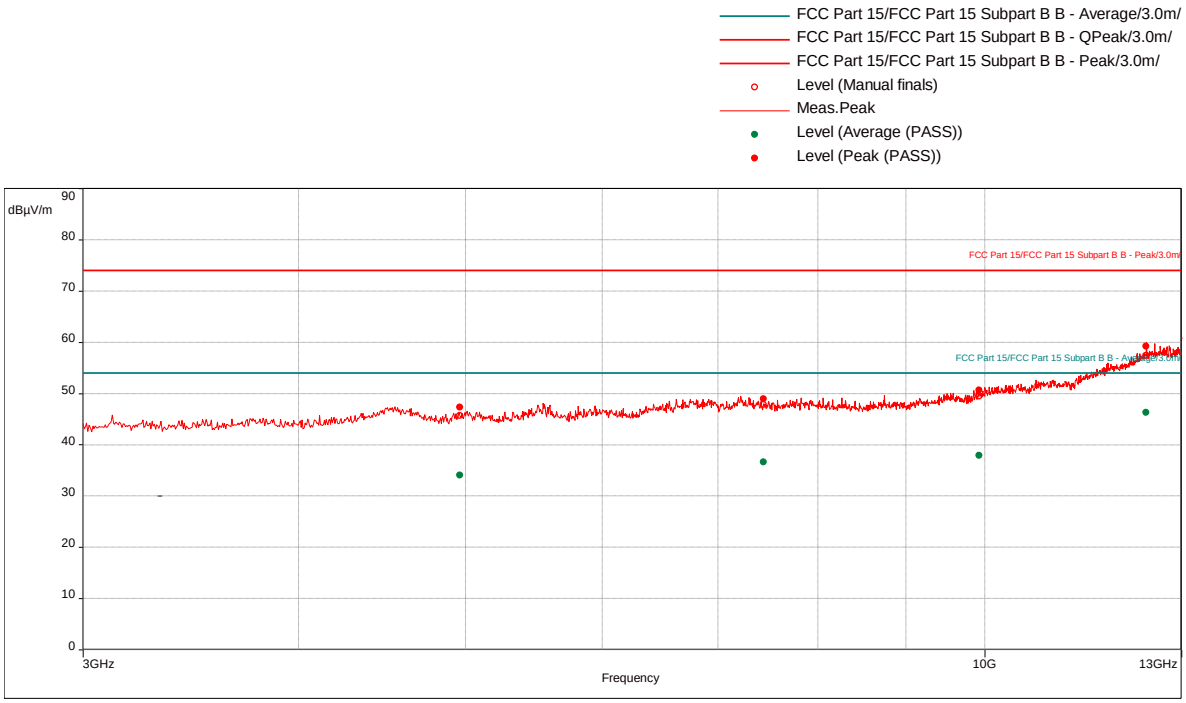
Note: 1-3 GHz and 13-25 GHz scans were performed manually, no emissions were detected.

1-25 GHz Tx mode High channel (Z-axis)

Test Information:

Date and Time	1/9/2018 6:54:37 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 3 to 13 GHz_12VDC_BLE_Hi Ch_Tx mode_-3dBm_Z-axis

Graph:



Results:

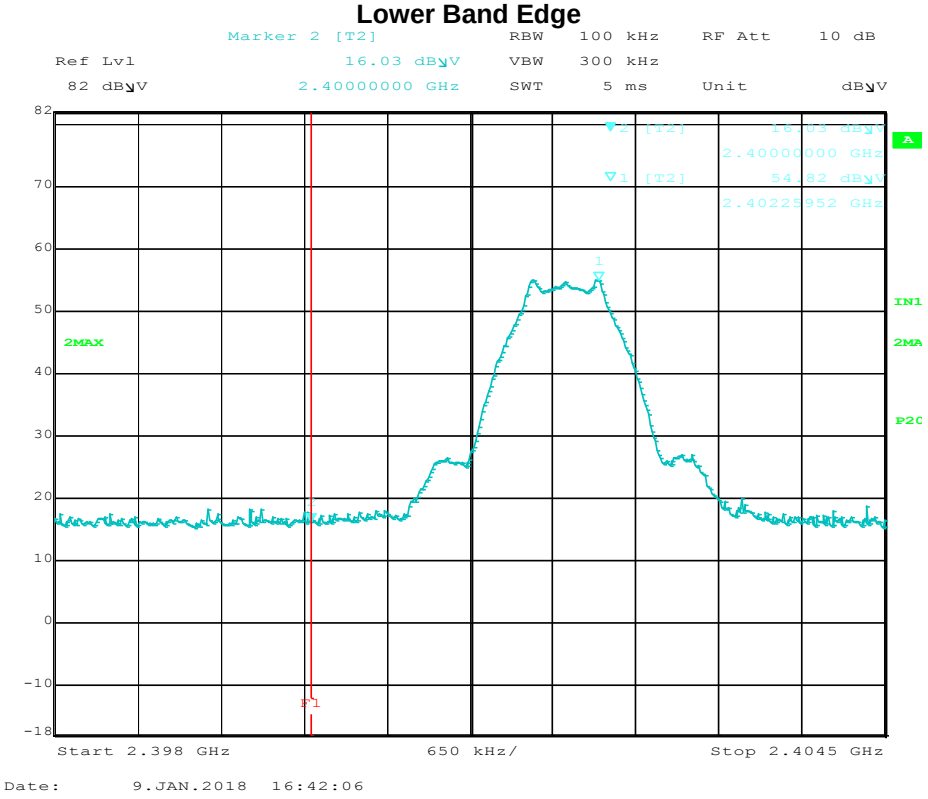
Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4960	47.29	74.00	-26.71	197.00	3.15	Vertical	1000000.00	9.39
7438.684211	48.93	74.00	-25.07	121.00	2.78	Horizontal	1000000.00	11.84
9922.368421	50.67	74.00	-23.33	82.00	1.65	Horizontal	1000000.00	13.85
12400.52632	59.20	74.00	-14.80	236.00	2.03	Vertical	1000000.00	22.51

Average (PASS) (4)

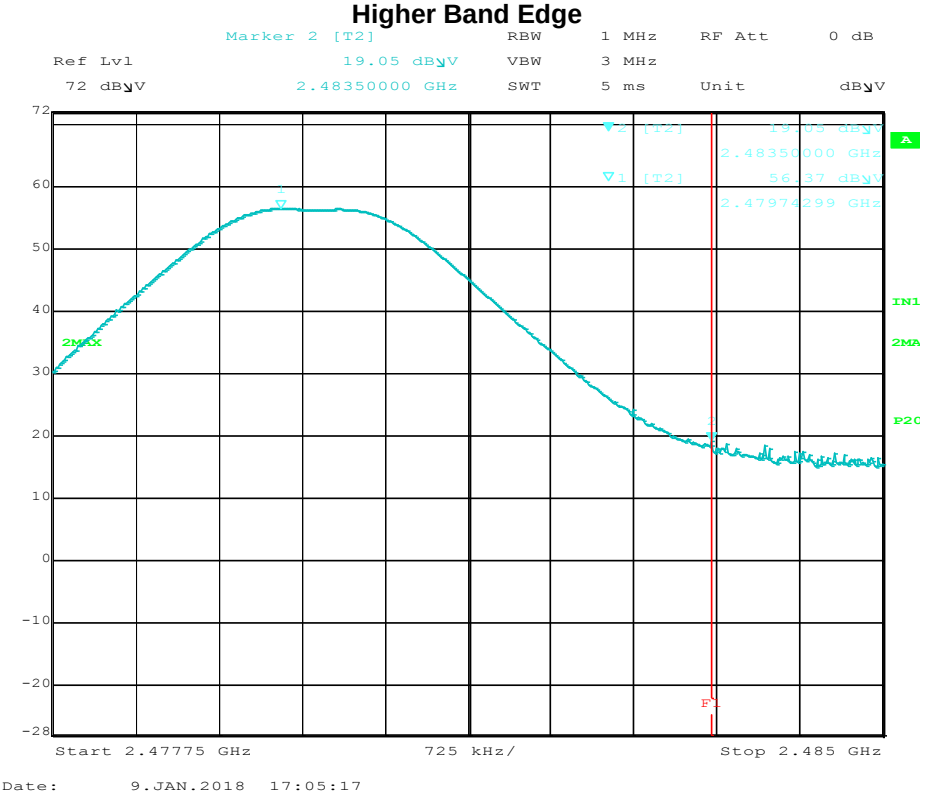
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
4960	34.08	54.00	-19.92	197.00	3.15	Vertical	1000000.00	9.39
7438.684211	36.62	54.00	-17.38	121.00	2.78	Horizontal	1000000.00	11.84
9922.368421	37.93	54.00	-16.07	82.00	1.65	Horizontal	1000000.00	13.85
12400.52632	46.31	54.00	-7.69	236.00	2.03	Vertical	1000000.00	22.51

Lower Band Edge



Notes: In a 100 kHz resolution bandwidth the emission at lower band edge is 20dB lower than the fundamental. No change in emission level was detected with change in orientation.

Higher Band Edge



Detector Type	Ant. Pol. (V/H)	Frequency MHz	Reading dB(uV)	Antenna Factor dB(1/m)	Cable Loss dB	Pre-amp Factor dB	Distance Factor dB	Net dBuV/m	Limit dBuV/m	Margin dB	Bandwidth
				Higher Bandedge							
PK	V	2480.000	19.05	32.23	6.44	0.00	3.52	54.20	74.00	-19.80	1/3 MHz
AVG	V	2480.000	13.32	32.23	6.44	0.00	3.52	48.47	54.00	-5.53	1/3 MHz

Note: Test was performed at 2m distance, data is from worst case polarization.

Test Personnel: Vathana Ven VJV
Test Date: 01/08/2018
01/09/2018

Supervising/Reviewing Engineer: (Where Applicable) N/A

Product Standard: FCC Part 15 Subpart C (15.247)
Limit Applied: As specified in section 9.3

Input Voltage: 12 VDC

Pretest Verification w/ Ambient Signals or BB Source: BB Source

Ambient Temperature: 22, 22 ºC

Relative Humidity: 16, 18 %

Atmospheric Pressure: 1011, 1006 mbars

Deviations, Additions, or Exclusions: None

10 Digital Device and Receiver Spurious Emissions

10.1 Method

Tests are performed in accordance with FCC Part 15 Subpart B and ANSI C 63.4.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	5.3 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.5 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.2 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	5.0 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	5.0 dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample 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
Where FS = Field Strength in dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB
AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

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

RA = 52.0 dBμV
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dBμV/m

To convert from dBμV to μV or mV the following was used:

UF = $10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

FS = RA + AF + CF – AG = 52.0 + 7.4 + 1.6 – 29.0 = 32.0
UF = $10^{(32\ dB\mu V / 20)}$ = 39.8 μV/m

Alternately, when BAT-EMC Emission Software is used, the "Level" includes all losses and gains and is compared directly in the "Margin" column to the "Limit". The "Correction" includes Antenna Factor, Preamp, and Cable Loss. These are already accounted for in the "Level" column.

10.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
DAV002	Weather Station	Davis Instruments	7400	PE80519A93	06/14/2017	06/14/2018
145128'	EMI Receiver (20 Hz - 40 Ghz)	Rohde & Schwarz	ESIB 40	839283/001	03/15/2017	03/15/2018
145-410'	Cables 145-420 145-421 145-422 145-406	Huber + Suhner	10m Track A Cables	multiple	07/25/2017	07/25/2018
PRE11'	50dB gain pre-amp	Keith H	PRE11	PRE11	12/02/2017	12/02/2018
145145'	Broadband Hybrid Antenna 30 MHz - 3 GHz	Sunol Sciences Corp.	JB3	A122313	05/02/2017	05/02/2018
145014'	Preamplifier (1 GHz to 26.5 GHz)	Hewlett Packard	8449B	3008A00232	06/03/2017	06/03/2018
ETS001'	1-18GHz DRG Horn Antenna	ETS-Lindgren	3117	00143259	02/13/2017	02/13/2018
145-416'	Cables 145-420 145-423 145-425 145-408	Huber + Suhner	3m Track B cables	multiple	07/25/2017	07/25/2018

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.17.0.3

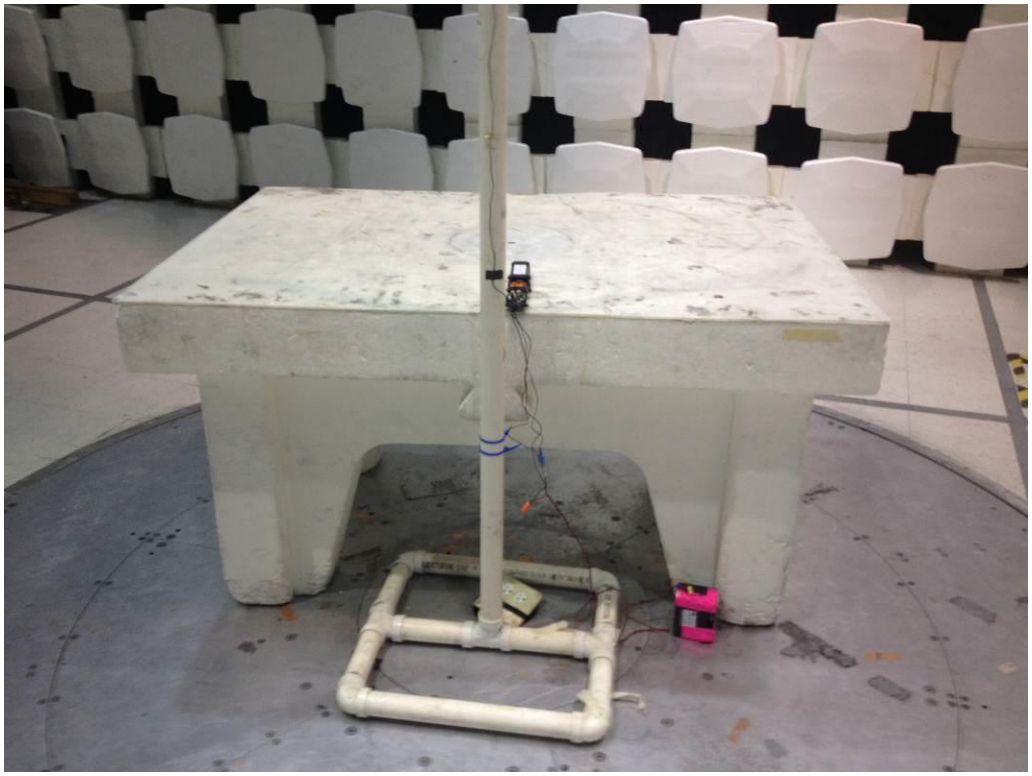
10.3 Results:

The sample tested was found to comply.

§15.109 (a) The field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency of emission (MHz)	Field strength (microvolts/meter)
30-88	100
88-216	150
216-960	200
Above 960	500

10.4 Setup Photograph:



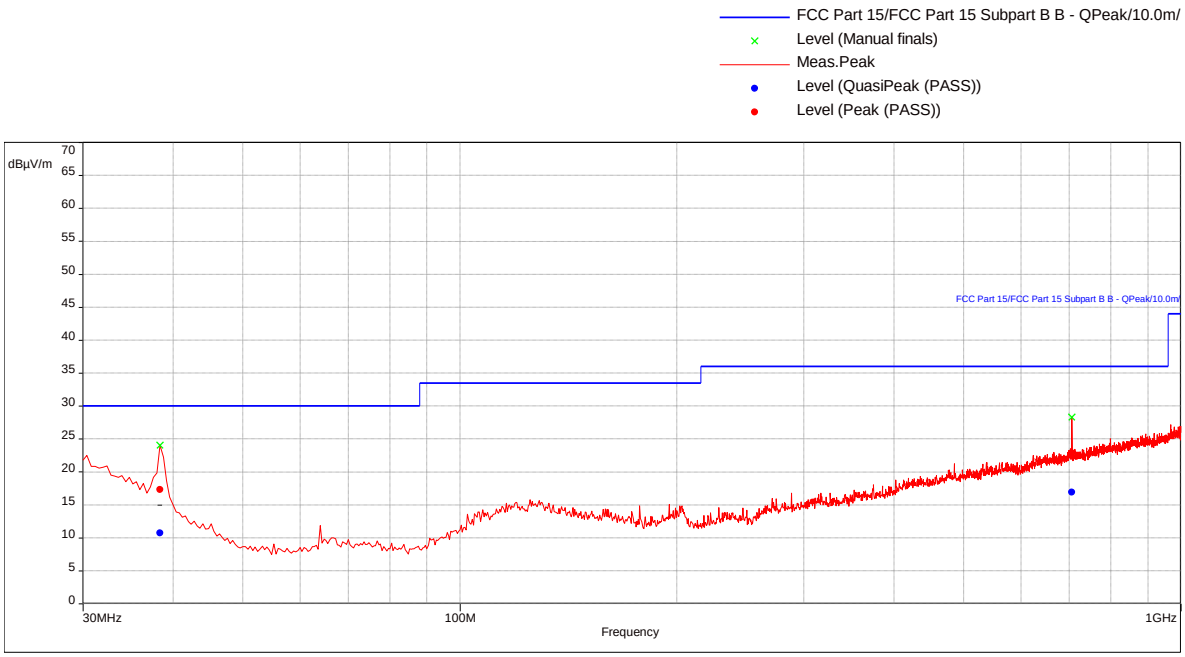
10.5 Plots/Data:

Rx mode 30-1000 MHz

Test Information:

Date and Time	1/12/2018 7:28:36 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	21 deg C
Humidity	38%
Atmospheric Pressure	997' mB
Comments	RE 30-1000MHz_Rx mode

Graph:



Results:

QuasiPeak (PASS) (2)

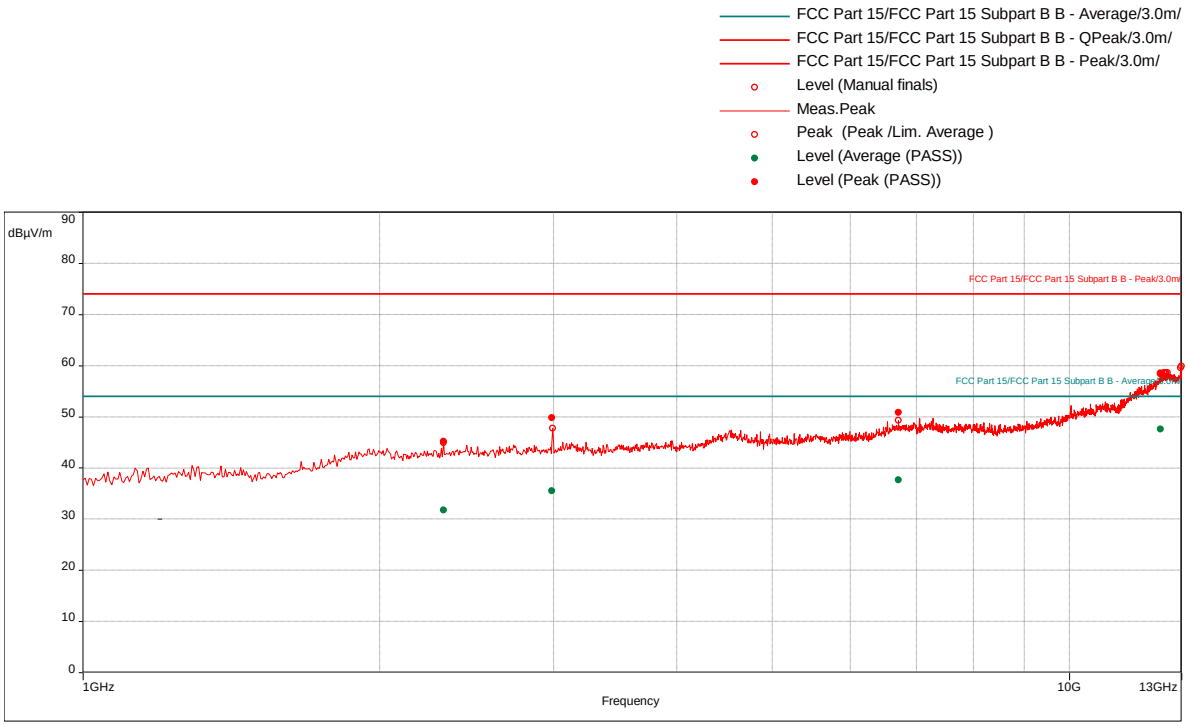
Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
38.30526316	10.73	30.00	-19.27	126.00	2.50	Vertical	120000.00	-28.74
706.4	16.89	36.00	-19.11	24.00	1.39	Vertical	120000.00	-19.35

Rx mode 1-13 GHz (Device also has Bluetooth and it was considered the highest operating receiver in the device, hence test was performed up to 13 GHz)

Test Information:

Date and Time	1/9/2018 10:04:04 PM
Client and Project Number	LoJack_G103364832
Engineer	Vathana Ven
Temperature	20 deg C
Humidity	16%
Atmospheric Pressure	1011 mB
Comments	RE 1 to 13 GHz_12VDC_Rx mode

Graph:



Results:

Peak (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
2319.736842	45.22	74.00	-28.78	197.00	3.01	Vertical	1000000.00	4.99
2992.368421	49.83	74.00	-24.17	120.00	1.92	Vertical	1000000.00	6.01
6714.210526	50.83	74.00	-23.17	147.00	3.34	Vertical	1000000.00	11.59
12372.89474	58.51	74.00	-15.49	63.00	1.99	Vertical	1000000.00	22.35

Average (PASS) (4)

Frequency (MHz)	Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	RBW	Correction (dB)
2319.736842	31.70	54.00	-22.30	197.00	3.01	Vertical	1000000.00	4.99
2992.368421	35.50	54.00	-18.50	120.00	1.92	Vertical	1000000.00	6.01
6714.210526	37.61	54.00	-16.39	147.00	3.34	Vertical	1000000.00	11.59
12372.89474	47.53	54.00	-6.47	63.00	1.99	Vertical	1000000.00	22.35

Test Personnel:	Vathana Ven VJV	Test Date:	01/09/2017 01/12/2018
Supervising/Reviewing Engineer: (Where Applicable)	N/A		
Product Standard:	FCC Part 15 Subpart B	Limit Applied:	As specified in section 10.3
Input Voltage:	12 VDC		
Pretest Verification w/ Ambient Signals or BB Source:	BB Source	Ambient Temperature:	20, 21 ºC
		Relative Humidity:	16, 38 %
		Atmospheric Pressure:	1011, 997 mbars

Deviations, Additions, or Exclusions: None

11 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	03/08/2018	103364832BOX-006	N.S	KPS KPS	Original Issue
1	03/13/2018	103364832BOX-006	N.S	KPS KPS	Revised output power and power spectral density limits.