



Testing Tomorrow's Technology

Application

For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart B, paragraph 15.109, Subpart C, paragraphs 15.207, 15.209 and 15.249

And

IC Radio Standards Specification: RSS-210 Issue 9, Annex A 2.9

For the

**BoxLock, Inc.
Model: BOXLOCK001**

**FCC ID: 2APA3-BOXLOCK001
IC: 23723-BOXLOCK001**

**UST Project: 18-0042
Issue Date: May 4, 2018**

Total Pages in This Report: 35

**3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com**



I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: George Yang

Name: 

Title: Laboratory Manager

Date May 4, 2018



TESTING

NVLAP LAB CODE 200162-0

This report shall not be reproduced except in full. This report may be copied in part only with the prior written approval of US Tech. The results contained in this report are subject to the adequacy and representative character of the sample provided. This report must not be used to claim product certification, approval, or endorsement by NVLAP, NIST or any agency of the Federal Government.

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

MEASUREMENT TECHNICAL REPORT

COMPANY NAME: BoxLock, Inc.
MODEL: BOXLOCK001
FCC ID: 2APA3-BOXLOCK001
IC ID: 23723-BOXLOCK001
DATE: May 4, 2018

This report concerns (check one): Original grant ☒
Class II change

Equipment type: 2400 – 2483.5 MHz Transmitter Module

Deferred grant requested per 47 CFR 0.457(d)(1)(ii)? Yes _____ No X

If yes, defer until: N/A
date

agrees to notify the Commission by N/A
date

of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

US Tech
3505 Francis Circle
Alpharetta, GA 30004
Phone Number: (770) 740-0717
Fax Number: (770) 740-1508

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

Table of Contents

<u>Paragraph</u>	<u>Title</u>	<u>Page</u>
1	General Information.....	7
1.1	Purpose of this Report	7
1.2	Characterization of Test Sample.....	7
1.3	Product Description	7
1.4	Configuration of Tested System.....	8
1.5	Test Facility.....	8
1.6	Related Submittals.....	8
2	Tests and Measurements	10
2.1	Test Equipment.....	10
2.2	Modifications to EUT Hardware	11
2.3	Number of Measurements for Intentional Radiators (15.31(m)).....	11
2.4	Frequency Range of Radiated Measurements (Part 15.33).....	11
2.4.1	Intentional Radiator	11
2.4.2	Unintentional Radiator	12
2.5	Measurement Detector Function and Bandwidth (CFR 15.35)	12
2.5.1	Detector Function and Associated Bandwidth.....	12
2.5.2	Corresponding Peak and Average Requirements	12
2.5.3	Pulsed Transmitter Averaging	12
2.6	EUT Antenna Requirements (CFR 15.203)	13
2.7	Restricted Bands of Operation (Part 15.205).....	14
2.8	Pulsed Operation, Average value (CFR 15.35 (c))	14
2.9	Intentional Radiator, Power Line Conducted Emissions (CFR 15.207).....	16
2.10	Intentional Radiator, Radiated Emissions (CFR 15.209, 15.249(a),(c)) (IC RSS 210, A2.9 (a))	17
2.11	Band Edge Measurements – (CFR 15.249 (d))	22
2.12	99% Occupied Bandwidth (Part 2.1049).....	31
2.13	Measurement Uncertainty	35
2.13.1	Conducted Emissions Measurement Uncertainty	35
2.13.2	Radiated Emissions Measurement Uncertainty	35
3	Conclusions	35

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

List of Figures

<u>Figures</u>	<u>Title</u>	<u>Page</u>
Figure 1.	Block Diagram of Test Configuration	13
Figure 2.	Pulse Width.....	14
Figure 3.	TX Off time.....	15
Figure 4.	Band Edge Compliance, Low Channel Delta - Peak.....	23
Figure 5.	Radiated Restricted Band 2310 MHz to 2390 MHz, Peak	24
Figure 6.	Band Edge Compliance, Low Channel Delta - Average.....	25
Figure 7.	Radiated Restricted Band 2310 MHz to 2390 MHz Plot, Average	26
Figure 8.	Band Edge Compliance, High Channel Delta – Peak	27
Figure 9.	Radiated Restricted Band 2483.5 MHz to 2500 MHz, Peak	28
Figure 10.	Band Edge Compliance, High Channel Delta – Average	29
Figure 11.	Radiated Restricted Band 2483.5 MHz to 2500 MHz, Average	30
Figure 12.	99% Occupied Bandwidth – Low Channel	32
Figure 13.	99% Occupied Bandwidth – Mid Channel.....	33
Figure 14.	99% Occupied Bandwidth – High Channel	34

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

List of Tables

<u>Table</u>	<u>Title</u>	<u>Page</u>
Table 1.	EUT and Peripherals.....	9
Table 2.	Test Instruments	10
Table 3.	Number of Test Frequencies for Intentional Radiators.....	11
Table 4.	Allowed Antenna(s).....	13
Table 5.	Transmitter Power Line Conducted Emissions Test Data, Part 15.207	16
Table 6.	Spurious Radiated Emissions Below 30 MHz	18
Table 7.	Spurious Radiated Emissions 30MHz to 25 GHz (other than Fundamental & Harmonics)	19
Table 8.	Fundamental Emissions (Peak & AVG)	20
Table 9.	Harmonics Emissions (Peak & AVG)	21
Table 10.	Radiated Restricted Band 2310 MHz to 2390 MHz, Peak.....	24
Table 11.	Radiated Restricted Band 2310 MHz to 2390 MHz, Average	26
Table 12.	Radiated Restricted Band 2483.5 MHz to 2500 MHz, Peak.....	28
Table 13.	Radiated Restricted Band 2483.5 MHz to 2500 MHz, Average	30
Table 14.	20 dB Bandwidth and 99% Occupied Bandwidth	31

List of Attachments

Agency Agreement
Application Forms
Letter of Confidentiality
Equipment Label(s)
Block Diagram(s)
Schematic(s)
Test Configuration Photographs
Internal Photographs
External Photographs
Theory of Operation
User's Manual

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to the FCC Rules and Regulations Part 15, Section 249 and IC Radio Standards Specification RSS-210 Issue, 8.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on April 16, 2018 in good operating condition.

1.3 Product Description

The Equipment Under Test (EUT) is the BoxLock, Inc. 2.4 GHz Model: BOXLOCK001. The EUT is a Bluetooth low energy device operating in the same spectrum range (2400 - 2483.5 MHz, ISM band) as classical Bluetooth technology (a system using digital modulation techniques), but uses a different set of channels.

Radio: Bluetooth
Spec. (Low Energy, Single mode)
Range: 2400-2483.5 MHz ISM Band
Modulation: GFSK
RF Output Power (EIRP): +10 dBm
Data Rate: Mbps (Max): 1 Mbps
Channels: 40

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)*, and *ANSI C63.10.2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices*.

A list of EUT and Peripherals is found in Table 1 below. A block diagram of the tested system is shown in Figure 1. Test configuration photographs are provided in separate Appendices

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC under designation number US5301. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittals

The EUT is subject to the following FCC authorizations:

- a) Certification under section 15.249 as a transmitter.
- b) Verification under 15.101 as a digital device and receiver.

The Verification requirement shares many common report elements with the Certification report. Therefore, though this report is mostly intended to provide data for the Certification process, the Verification authorization report (part 15.107 and 15.109) for the EUT is included herein.

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

Table 1. EUT and Peripherals

EUT	MODEL NUMBER	SERIAL NUMBER	Pending FCC/IC ID	CABLES P/D
BOXLOCK001 (EUT) /BoxLock, Inc.	Engineering sample	Engineering Sample	FCC ID: 2APA3-BOXLOCK001 IC ID: 23723-BOXLOCK001	UD
PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
Computer/ GateWay	LT21	LUWH20D00 60131CAD21 601	FCC ID: HLZ-AR5B95/ IC:1754F-AR5B95	N/A
AC/DC Adapter/ Delta Electronics	ADP-40TH A	AP04001002 00904F57P1 01	N/A	P
Interface/ Total Phase	TP240141	2238-490510	N/A	D
Battery/ Tenenergy Li-ion	N/A	N/A	N/A	P

U= Unshielded
 S= Shielded
 P= Power
 D= Data

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers and their calibration status are indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	CALIBRATION DUE DATE
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	6/22/2018
SPECTRUM ANALYZER	DSA815	RIGOL	DSA8A18030 0138	10/11/2018
BICONICAL ANTENNA	3110B	EMCO	9307-1431	10/23/2019 2 yr
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	9/21/2018 2 yr
HORN ANTENNA	3115	EMCO	9107-3723	9/22/2018 2 yr
PRE-AMPLIFIER	8449B	HEWLETT-PACKARD	3008A00480	12/1/2018
PRE-AMPLIFIER	8477D	HEWLETT-PACKARD	1937A02980	3/7/2019

Note: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2.2 Modifications to EUT Hardware

No physical modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in Table 3 below.

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range over which the device operates	Number of Frequencies	Location in the Range of Operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

Because the EUT operates at 2402 MHz to 2480 MHz, 3 test frequencies were used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

The spectrum was investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10th harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range tested was 30 MHz to 1000 MHz, or to 5 times the highest internal clock frequency.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the parameters listed below.

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified there is also a corresponding Peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

2.5.3 Pulsed Transmitter Averaging

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG), the duty cycle factor calculated will be applied.

2.6 EUT Antenna Requirements (CFR 15.203)

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. Only the antenna(s) listed in Table 4 will be used with this device.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dBi	TYPE OF CONNECTOR
Antenna	Johanson	BLE	2450AT18A100	-0.5	soldered

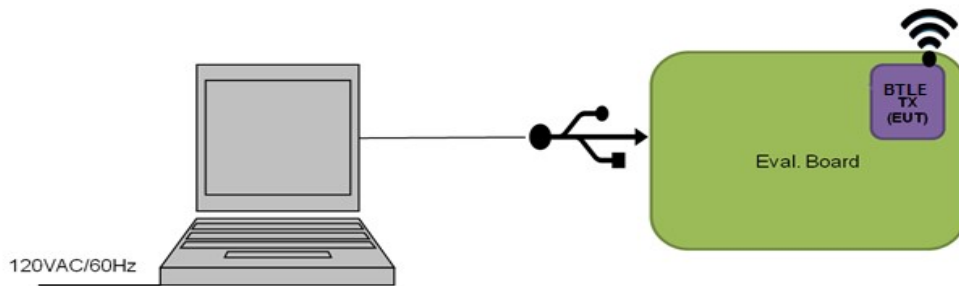


Figure 1. Block Diagram of Test Configuration

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious emissions cannot exceed the limits of 15.209. Radiated harmonics and other spurious emissions are examined for this requirement see paragraph 2.1

2.8 Pulsed Operation, Average value (CFR 15.35 (c))

The pulse train of the EUT did not exceed 0.1 seconds. Duty cycle plots are collected below to calculate the Duty Cycle factor to be employed in cases where the EUT was programmed to transmit at >98% Duty Cycle rate for testing purpose.

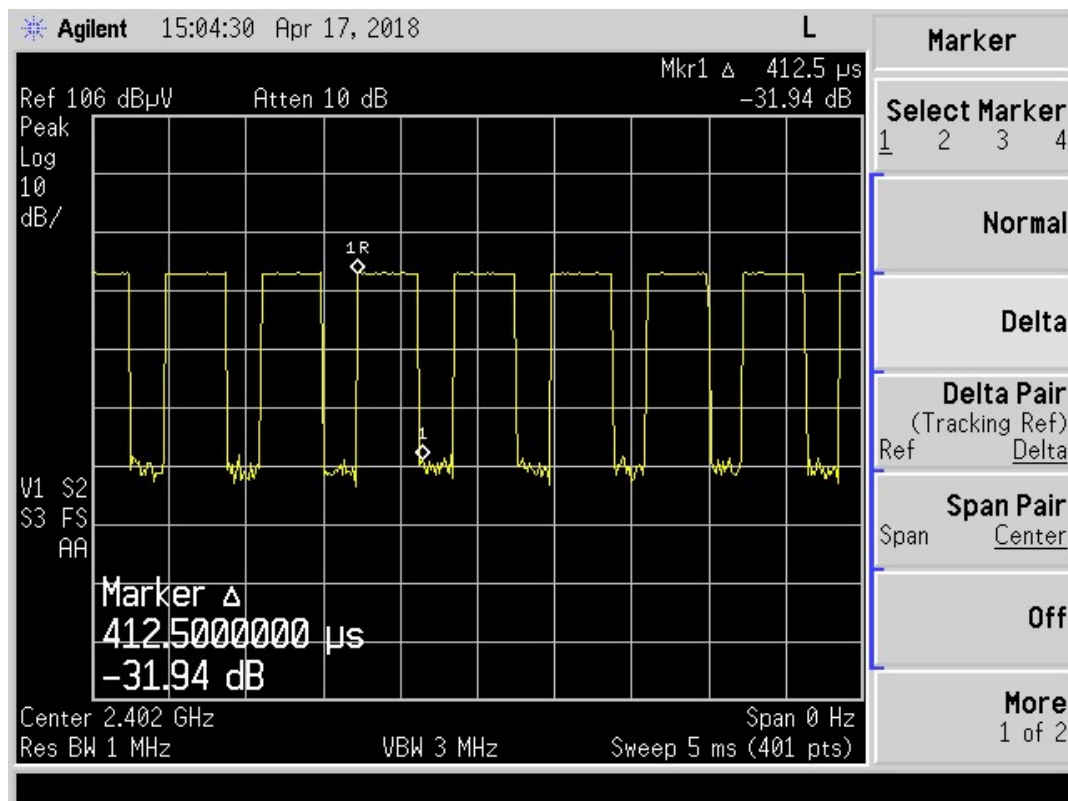


Figure 2. Pulse Width

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

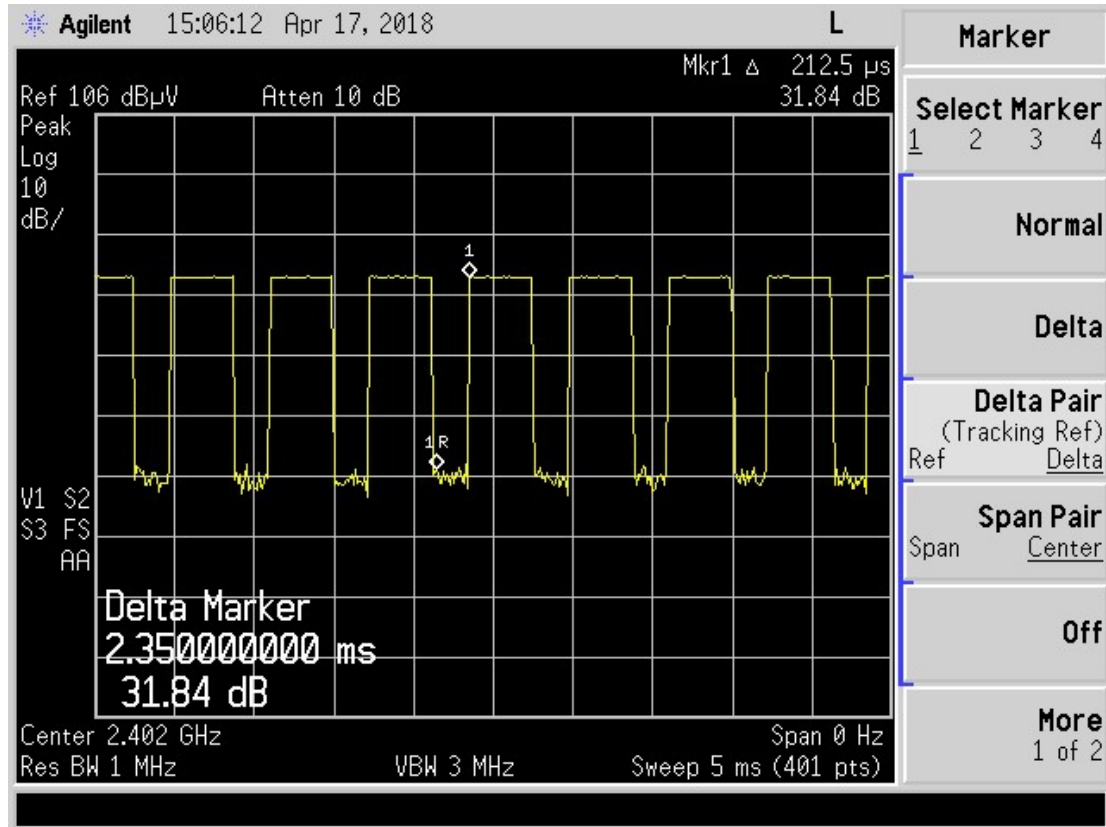


Figure 3. TX Off time

The Duty Cycle is $20\log(PW/(PW + TX \text{ off-time})) =$
 $20\log(412.5\mu s/[412.5+212.5]\mu s) = 20\log(412.5\mu s/625\mu s) = 20\log(.66) = \boxed{-3.61 \text{ dB}}$

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

2.9 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

The EUT was evaluated for compliance to 15.207, Power line conducted emissions.

Table 5. Transmitter Power Line Conducted Emissions Test Data, Part 15.207

150KHz to 30 MHz						
Test: Power Line Conducted Emissions				Client: BoxLock, Inc.		
Project: 18-0042				Model: BOXLOCK001		
Frequency (MHz)	Test Data (dBuV)	LISN+CL-PA (dB)	Results (dBuV)	AVG Limits (dBuV)	Margin (dB)	Detector PK, QP, or AVG
Phase						
0.1512	48.99	0.50	49.49	55.9	6.5	QP
0.6100	39.93	0.14	40.07	46.0	5.9	PK
1.2933	35.07	0.14	35.21	46.0	10.8	QP
9.7250	37.02	0.39	37.41	50.0	12.6	PK
11.9833	37.09	0.48	37.57	50.0	12.4	PK
20.2000	26.36	0.64	27.00	50.0	23.0	PK
Neutral						
0.1693	49.51	0.45	49.96	55.0	5.0	QP
0.6400	37.03	0.27	37.30	46.0	8.7	QP
1.8666	36.35	0.31	36.66	46.0	9.3	PK
8.8500	37.99	0.50	38.49	50.0	11.5	PK
15.4160	37.05	0.76	37.81	50.0	12.2	PK
23.6660	25.52	0.86	26.38	50.0	23.6	PK

Sample Calculation at: 0.1512 MHz

Magnitude of Measured Frequency	48.99	dBuV
+Antenna Factor + Cable Loss	0.50	dB
Corrected Result	49.49	dBuV/m

Test Date: April 25, 2018

Tested By

Signature: 

Name: John Freeman

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.249(a),(c)) (IC RSS 210, A2.9 (a))

Radiated Spurious measurements: the EUT was placed into a continuous transmit mode of operation transmitting at >98% duty cycle and tested per ANSI C63.10:2013. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the device. To obtain worse case results the EUT was tested in X, Y and Z axes or in the orientation of normal operation if the device is designed to operation in a fixed position.

Radiated measurements were then conducted between the frequency range of 9 KHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no greater than 40 GHz). In the band below 30 MHz a resolution bandwidth (RBW) of 9 kHz was used; emissions below 1 GHz were tested with a RBW of 120 KHz and emissions above 1 GHz were tested with a RBW of 1 MHz. All video bandwidth settings were at least three times the RBW value.

The EUT was investigated to CFR 15.209, General requirements for unwanted spurious emissions.

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

Table 6. Spurious Radiated Emissions Below 30 MHz

150 kHz to 30 MHz, 15.209 limits							
Test: Radiated Emissions				Client: BoxLock, Inc.			
Project: 18-0042				Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	QP Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK, or AVG
X Position							
0.16	47.39	11.94	59.33	87.4	m./meters.	28.1	PK
0.55	36.29	11.82	48.11	85.5	m./meters.	37.4	PK
1.85	24.32	11.77	36.09	49.5	m./meters.	13.5	PK
Y Position							
0.16	45.79	11.94	57.73	86.7	m./meters.	28.9	PK
0.49	35.16	11.54	46.70	87.6	m./meters.	40.9	PK
1.99	24.61	11.77	36.38	49.5	m./meters.	13.1	PK
Z Position							
0.16	44.70	11.94	56.64	86.8	m./meters.	30.2	PK
0.55	35.19	11.82	47.01	85.5	m./meters.	38.5	PK
1.78	24.89	11.77	36.66	49.5	m./meters.	12.8	PK

Sample Calculation at: 0.16 MHz

Magnitude of Measured Frequency	47.39	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	11.94	dB/m
Duty Cycle Correction Factor	0.00	dB
Corrected Result	59.33	dBuV/m

Test Date: April 18, 2018

Tested By

Signature: 

Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

Table 7. Spurious Radiated Emissions 30MHz to 25 GHz (other than Fundamental & Harmonics)

Test: FCC Part 15, Paragraph 15.209, 15.249(a)					Client: BoxLock, Inc.			
Project: 18-0042					Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
33.33	37.56	-	-13.40	24.16	40.0	3m./HORZ	15.8	PK
83.07	39.72	-	-17.47	22.25	40.0	3m./VERT	17.8	PK
159.68	37.24	-	-12.62	24.62	43.5	3m./VERT	18.9	PK
178.72	38.53	-	-12.85	25.68	43.5	3m./HORZ	17.8	PK
205.12	38.12	-	-13.69	24.43	43.5	3m./HORZ	19.1	PK
210.76	37.54	-	-14.52	23.02	43.5	3m./VERT	20.5	PK
500.58	38.72	-	-6.22	32.50	46.0	3m./VERT	13.5	PK
686.58	38.13	-	-3.25	34.88	46.0	3m./HORZ	11.1	PK
994.00	37.86	-	-2.19	35.67	54.0	3m./VERT	18.3	PK
999.10	37.86	-	-1.59	36.27	54.0	3m./HORZ	17.7	PK
3103.75	33.50	-	3.95	37.45	54.0	3.0m./HORZ	16.6	AVG
3278.75	33.32	-	4.23	37.55	54.0	3.0m./VERT	16.5	AVG

Notes:

1. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with the duty cycle programmed for >98% ON time in continuous transmit mode.
2. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

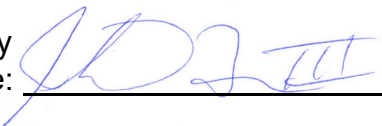
Sample Calculation at: 33.33 MHz

Magnitude of Measured Frequency	37.56	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-13.40	dB/m
Duty Cycle Correction Factor	0.00	dB
Corrected Result	24.16	dBuV/m

Test Date: April 17 & April 23, 2018

Tested By

Signature:



Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

Table 8. Fundamental Emissions (Peak & AVG)

Test: FCC Part 15, Paragraph 15.209, 15.249(a)					Client: BoxLock, Inc.			
Project: 18-0042					Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low - Channel								
2401.79	59.49	-	35.00	94.49	114.0	3.0m./VERT	19.5	PK
2401.79	44.89	-3.61	35.00	76.28	94.0	3.0m./VERT	17.7	AVG
Mid - Channel								
2442.17	60.87	-	34.95	95.82	114.0	3.0m./VERT	18.2	PK
2442.17	46.01	-3.61	34.95	77.35	94.0	3.0m./VERT	16.6	AVG
High - Channel								
2479.76	59.79	-	35.08	94.87	114.0	3.0m./VERT	19.1	PK
2479.76	45.73	-3.61	35.08	77.20	94.0	3.0m./VERT	16.8	AVG

Notes:

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
2. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with the duty cycle programmed for >98% ON time in continuous transmit mode.
3. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at: 2401.79

Magnitude of Measured Frequency	59.49	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	35.00	dB/m
Corrected Result	94.49	dBuV/m

Test Date: April 17, 2018

Tested By

Signature:  Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

Table 9. Harmonics Emissions (Peak & AVG)

Test: FCC Part 15, Paragraph 15.209, 15.249(a)					Client: BoxLock, Inc.			
Project: 18-0042					Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	Factor (dB)	AF+CA -AMP (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector Mode
Low - Channel								
4803.58	45.33	-	9.71	55.04	74.0	3.0m./VERT	19.0	PK
4803.58	45.33	-3.61	9.71	51.43	54.0	3.0m./VERT	2.6	AVG
Mid - Channel								
4884.35	47.79	-	9.32	57.11	74.0	3.0m./VERT	16.9	PK
4884.35	47.79	-3.61	9.32	53.50	54.0	3.0m./VERT	.5	AVG
High - Channel								
4959.46	45.57	-	10.99	56.56	74.0	3.0m./VERT	17.4	PK
4959.46	45.57	-3.61	10.99	52.95	54.0	3.0m./VERT	1.0	AVG

Notes:

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
2. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with the duty cycle programmed for >98% ON time in continuous transmit mode.
3. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at: 4803.58 MHz

Magnitude of Measured Frequency	48.33	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	4.11	dB/m
Duty Cycle Correction Factor	0.00	dB
Corrected Result	50.90	dBuV/m

Test Date: April 17, 2018

Tested By

Signature:

Name: John Freeman

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2.11 Band Edge Measurements – (CFR 15.249 (d))

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Radiated measurements are performed to demonstrate compliance with the requirement of 15.249(d) that all emissions outside of the band edges be attenuated by at least 50 dB or 15.209 limits, when compared to its highest in-band value (contained in a 100 kHz band).

To capture the band edge, set the Spectrum Analyzer frequency span to 2 MHz to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. See figure and calculations following for more detail.

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

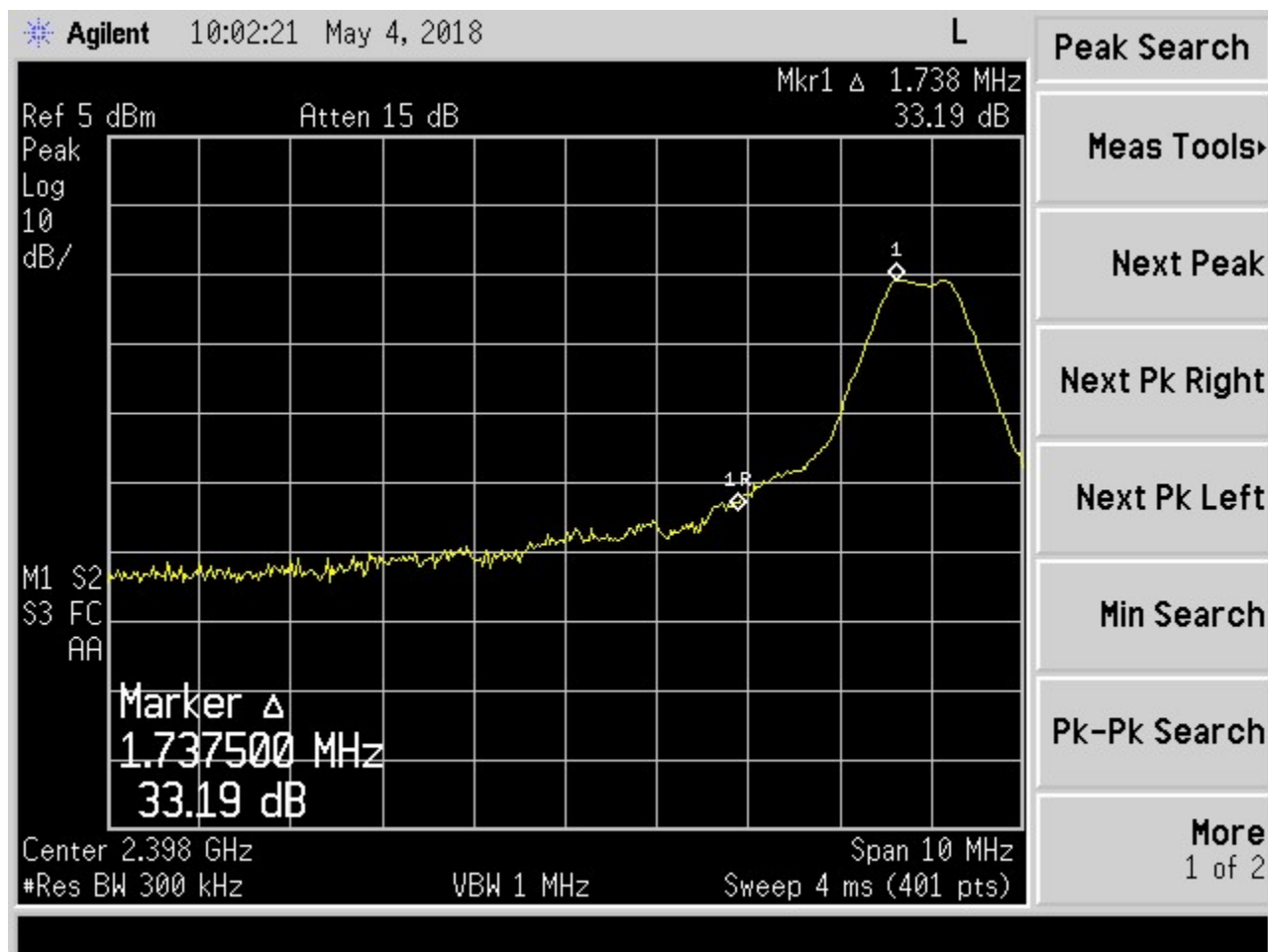


Figure 4. Band Edge Compliance, Low Channel Delta - Peak

Low Channel Corrected Measured Value from Table 8	94.49	dBuV
Low Channel Band Edge Delta from Figure 4	-33.19	dB
Calculated Result	61.30	dBuV/m
Band Edge Limit	74.00	dBuV/m
Calculated Result	61.30	dBuV/m
Band Edge Margin	12.70	dBuV/m

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

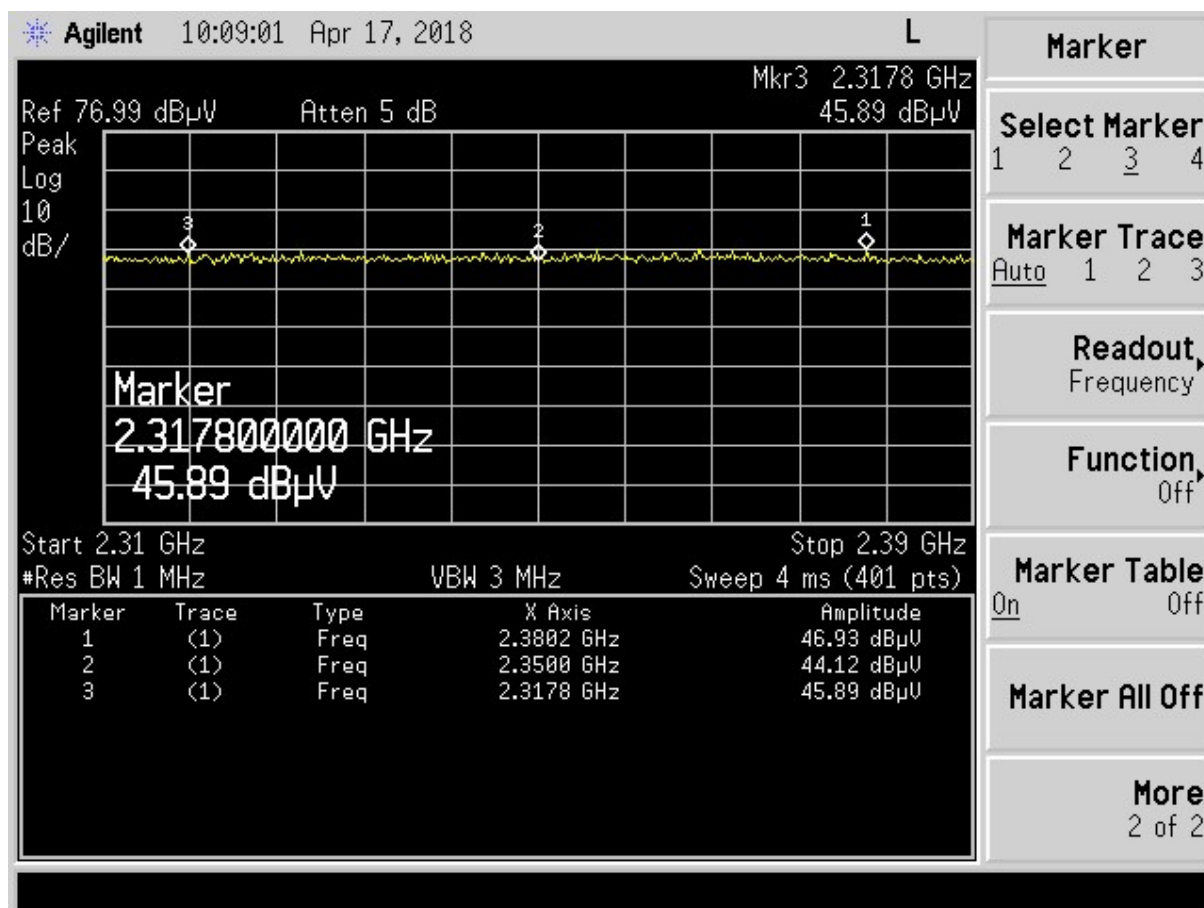


Figure 5. Radiated Restricted Band 2310 MHz to 2390 MHz, Peak

Table 10. Radiated Restricted Band 2310 MHz to 2390 MHz, Peak

2310 MHz to 2390 MHz Restricted Band Peak Measurements							
Test: Radiated Emissions				Client: BoxLock, Inc.			
Project: 18-0042				Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	PK Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK, or AVG
2317.80	45.89	-0.39	45.50	74.00	3.0m./VERT	28.5	PK
2350.00	44.12	-0.38	43.74	74.00	3.0m./VERT	30.3	PK
2380.20	46.93	-1.28	45.65	74.00	3.0m./VERT	28.3	PK

Test Date: April 17, 2018

Tested By

Signature:

Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

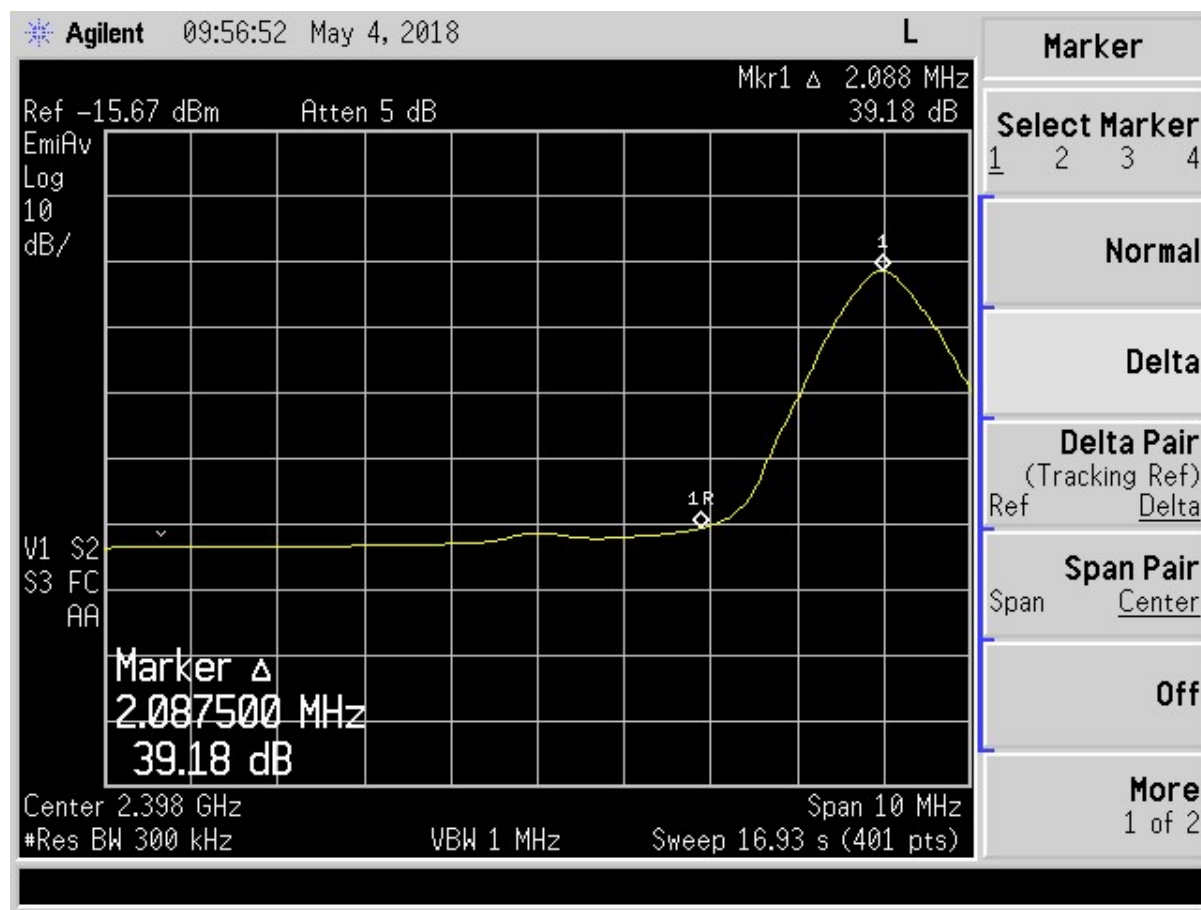


Figure 6. Band Edge Compliance, Low Channel Delta - Average

Low Channel Corrected Measured Value from Table 8	76.28	dBuV
Low Channel Band Edge Delta from Figure 4	-39.18	dB
Calculated Result	37.10	dBuV/m
Band Edge Limit	54.00	dBuV/m
Calculated Result	-37.10	dBuV/m
Band Edge Margin	16.90	dBuV/m

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

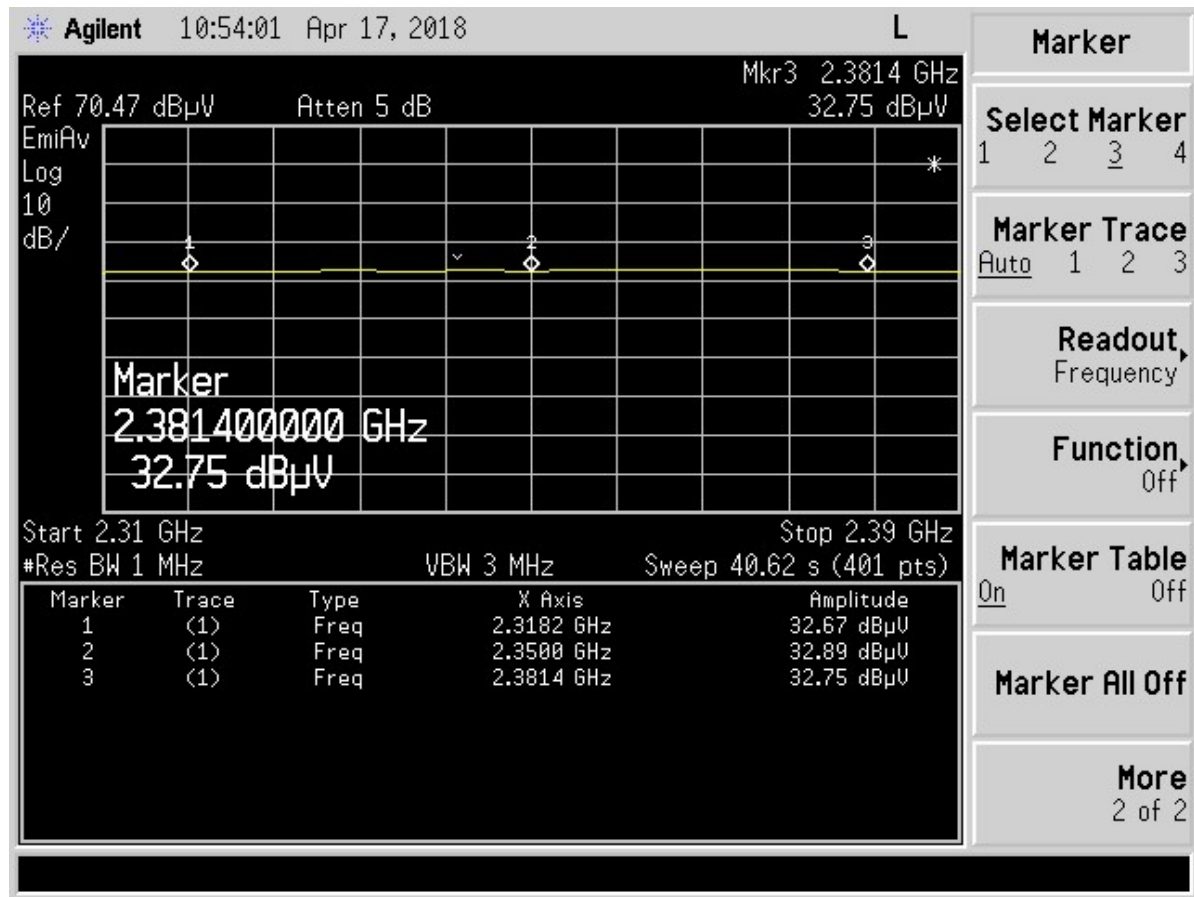


Figure 7. Radiated Restricted Band 2310 MHz to 2390 MHz Plot, Average

Table 11. Radiated Restricted Band 2310 MHz to 2390 MHz, Average

2310 MHz to 2390 MHz Restricted Band Peak Measurements								
Test: Radiated Emissions					Client: BoxLock, Inc.			
Project: 18-0042					Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuv)	Additional Factor (dB)	AF+CA-AMP+Duty Cycle (dB/m)	Results (dBuV/m)	AVG Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK, or AVG
2318.20	32.67	-	-0.39	32.28	54.0	3.0m./VERT	21.7	AVG
2350.00	32.89	-	-0.38	32.51	54.0	3.0m./VERT	21.5	AVG
2381.40	32.75	-	-1.28	31.47	54.0	3.0m./VERT	22.5	AVG

Note: the EUT was programmed to transmit at >98% duty cycle, therefore the PK values were adjusted using the duty cycle factor of -20 dB.

Test Date: April 17, 2018

Tested By

Signature: John Freeman Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

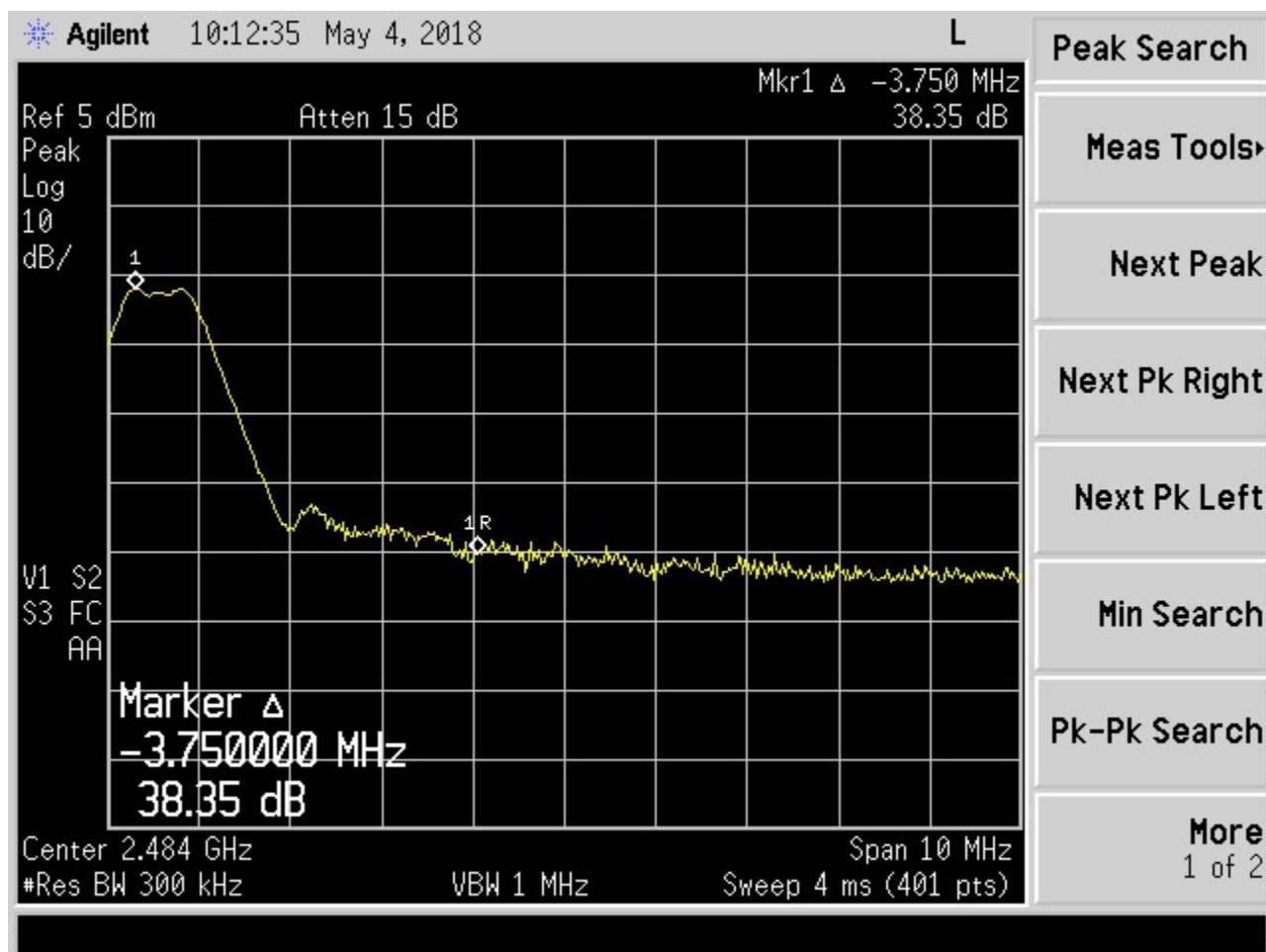


Figure 8. Band Edge Compliance, High Channel Delta – Peak

High Channel Corrected Measured Value from Table 8	94.87	dBuV
High Channel Band Edge Delta from Figure 6	-38.35	dB
Calculated Result	56.52	dBuV/m
Band Edge Limit	74.00	dBuV/m
Calculated Result	56.52	dBuV/m
Band Edge Margin	17.48	dBuV/m

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

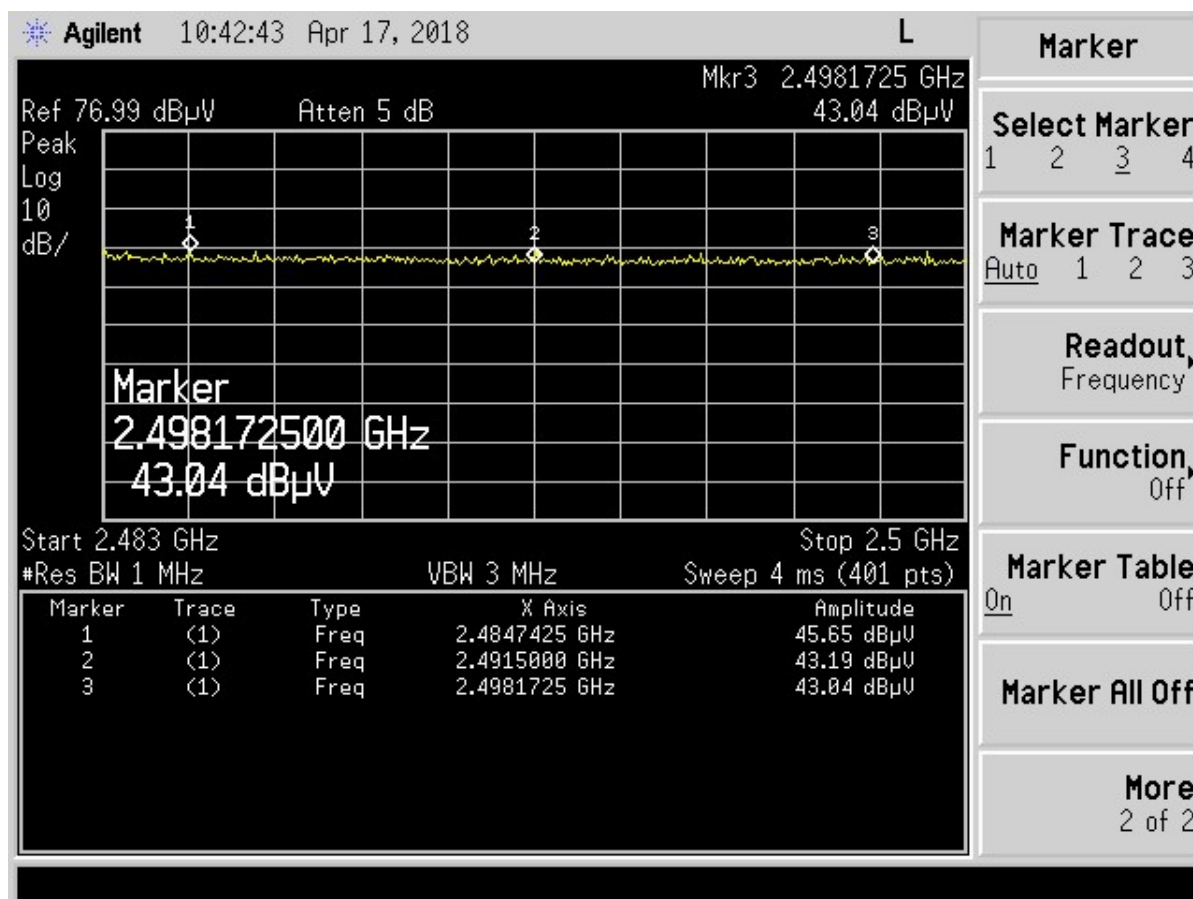


Figure 9. Radiated Restricted Band 2483.5 MHz to 2500 MHz, Peak

Table 12. Radiated Restricted Band 2483.5 MHz to 2500 MHz, Peak

2483.5 MHz to 2500 MHz Restricted Band Peak Measurements							
Test: Radiated Emissions				Client: BoxLock, Inc.			
Project: 18-0042				Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP (dB/m)	Results (dBuV/m)	PK Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK, or AVG
2484.75	45.65	0.48	46.13	74.00	3.0m./VERT	27.9	PK
2491.50	43.19	0.48	43.67	74.00	3.0m./VERT	30.3	PK
2498.17	43.04	0.48	43.52	74.00	3.0m./VERT	30.5	PK

Test Date: April 17, 2018

Tested By

Signature: John Freeman Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

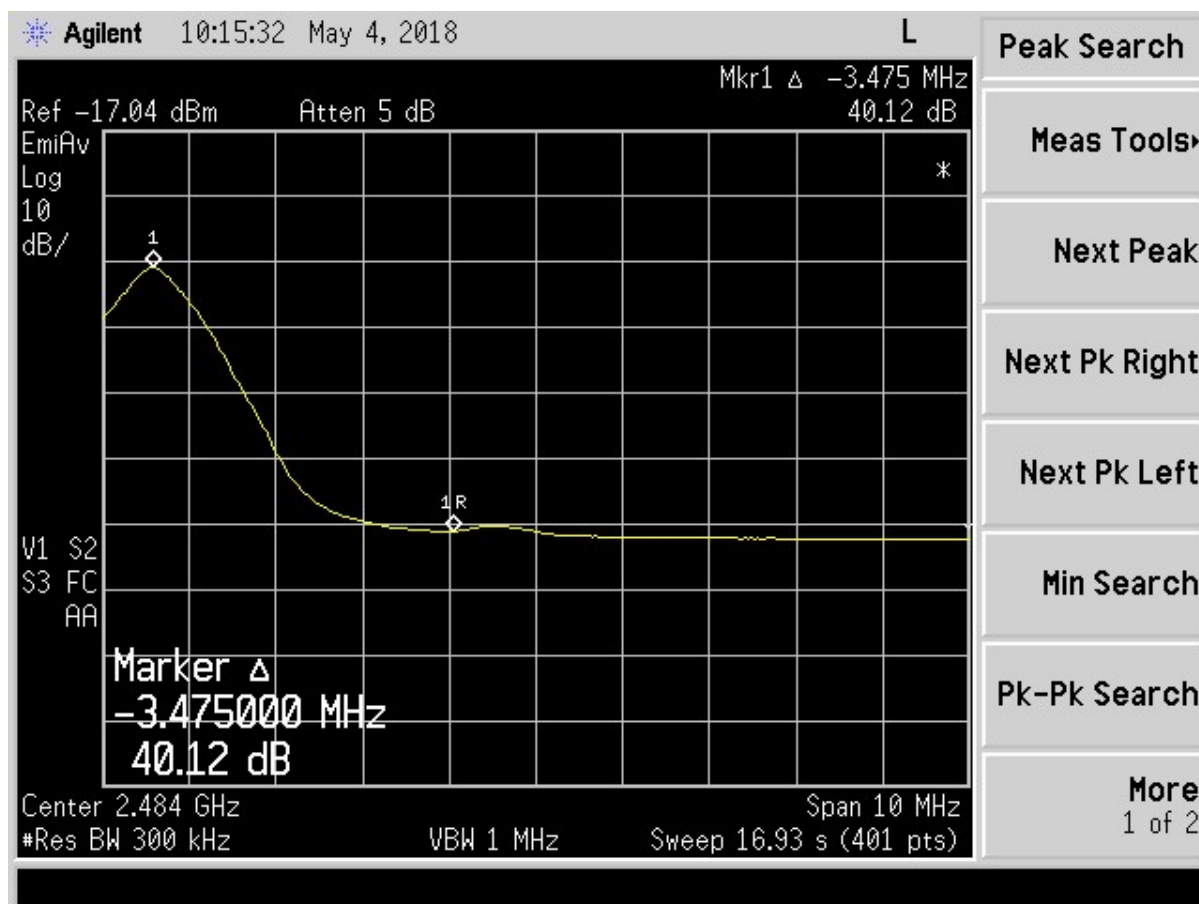


Figure 10. Band Edge Compliance, High Channel Delta – Average

High Channel Corrected Measured Value from Table 8	77.20	dBuV
High Channel Band Edge Delta from Figure 6	-40.12	dB
Calculated Result	37.08	dBuV/m
Band Edge Limit	54.00	dBuV/m
Calculated Result	-37.08	dBuV/m
Band Edge Margin	16.92	dBuV/m

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

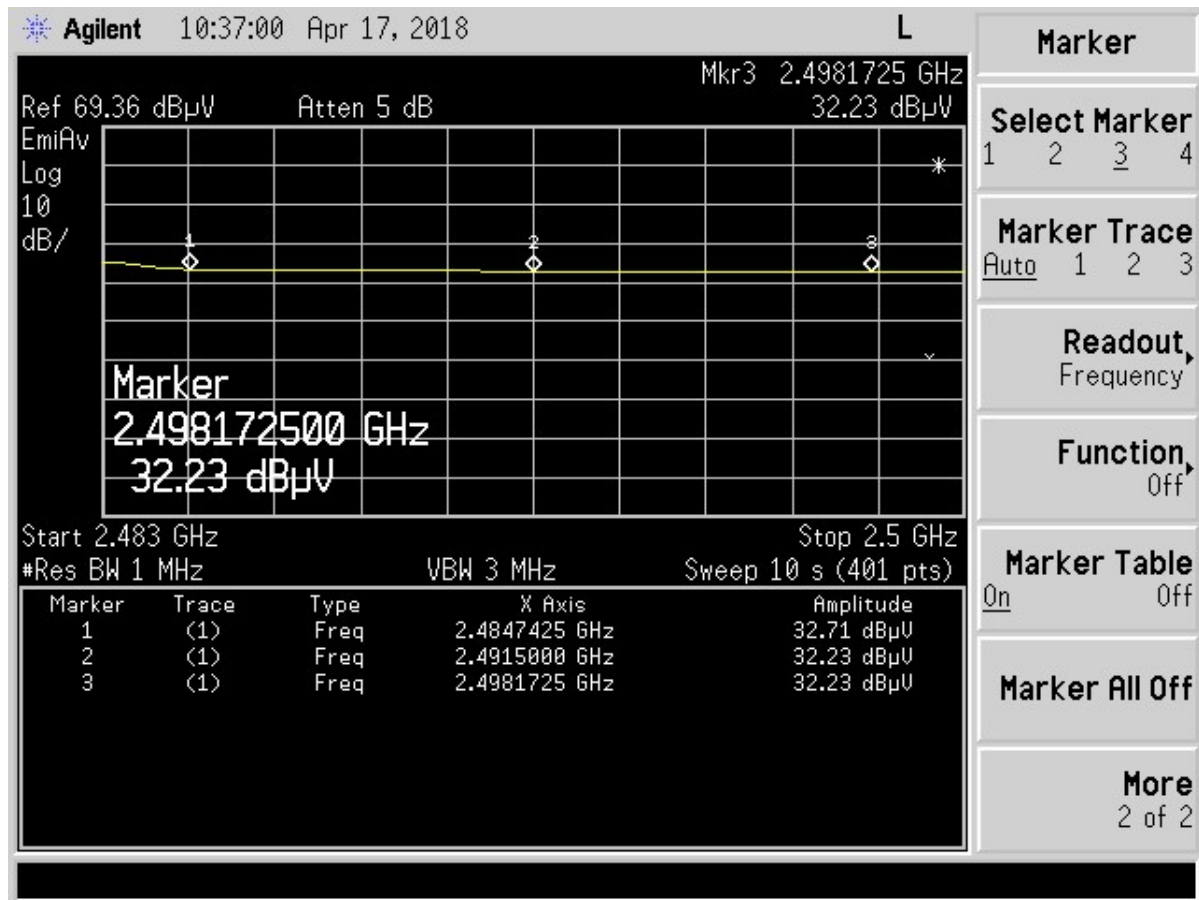


Figure 11. Radiated Restricted Band 2483.5 MHz to 2500 MHz, Average

Table 13. Radiated Restricted Band 2483.5 MHz to 2500 MHz, Average

2483.5 MHz to 2500 MHz Restricted Band Average Measurements								
Test: Radiated Emissions					Client: BoxLock, Inc.			
Project: 18-0042					Model: BOXLOCK001			
Frequency (MHz)	Test Data (dBuV)	Additional Factor (dB)	AF+CA-AMP+Duty Cycle (dB/m)	Results (dBuV/m)	AVG Limits (dBuV/m)	Antenna Distance/ Polarization	Margin (dB)	Detector PK, or AVG
2484.74	32.71	-	0.48	33.19	54.0	3.0m./VERT	20.8	AVG
2491.50	32.23	-	0.48	32.71	54.0	3.0m./VERT	21.3	AVG
2498.17	32.23	-	0.48	32.71	54.0	3.0m./VERT	21.3	AVG

Note: the EUT was programmed to transmit at >98% duty cycle, therefore the PK values were adjusted using the duty cycle factor of -20 dB.

Test Date: April 17, 2018

Tested By

Signature: John Freeman Name: John Freeman

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2.12 99% Occupied Bandwidth (Part 2.1049)

These measurements were performed while the EUT was in a constant transmit mode. A method similar to the marker delta method was used to capture the points. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW \geq RBW. The results of this test are given in Table 12 and Figures 10-12.

Table 14. 20 dB Bandwidth and 99% Occupied Bandwidth

Frequency (MHz)	20 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
2402	1.247	1.088
2442	1.272	1.101
2480	1.268	1.106

Test Date: April 17, 2018

Tested By

Signature: 

Name: John Freeman

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

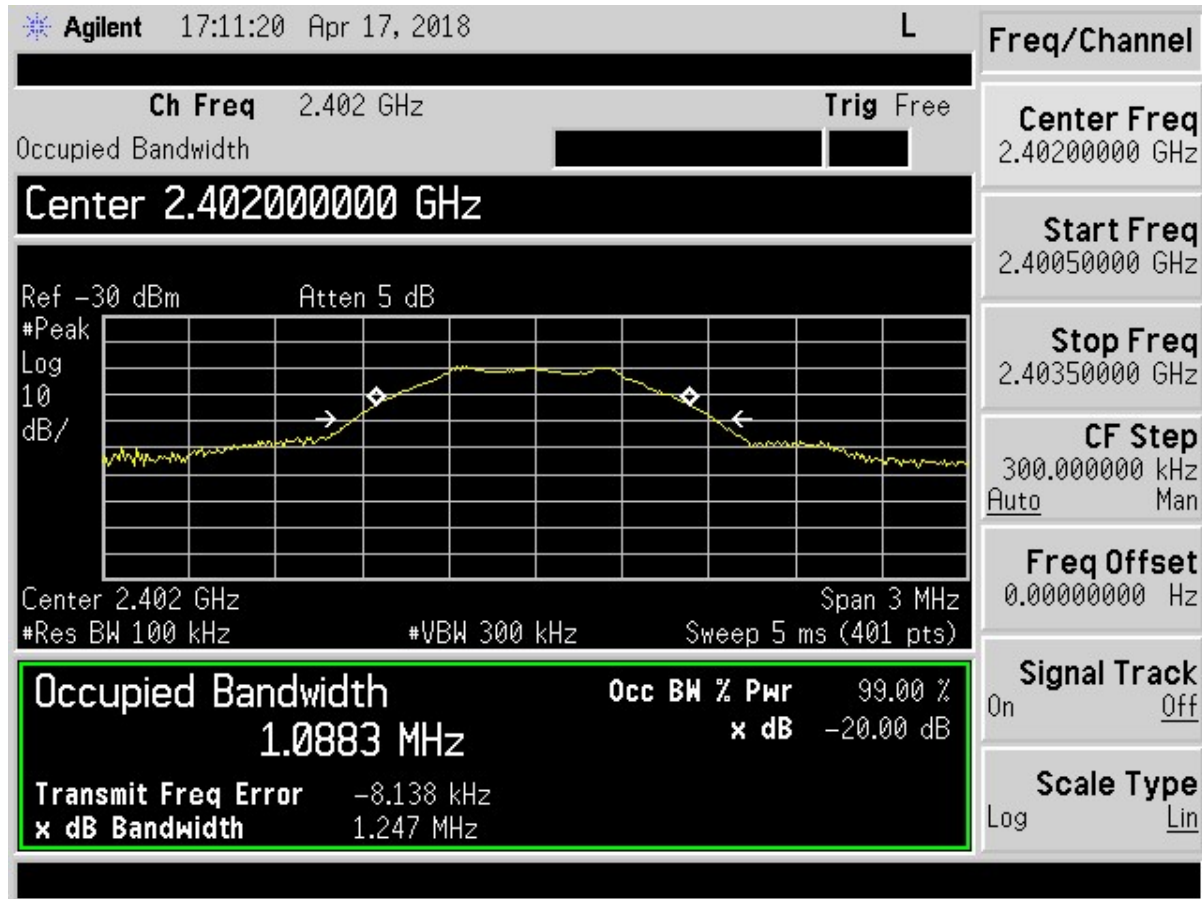


Figure 12. 99% Occupied Bandwidth – Low Channel

US Tech Test Report:
 FCC ID:
 IC:
 Test Report Number:
 Issue Date:
 Customer:
 Model:

FCC Part 15 Certification/ RSS 210
 2APA3-BOXLOCK001
 23723-BOXLOCK001
 18-0042
 February 15, 2018
 BoxLock, Inc.
 BOXLOCK001

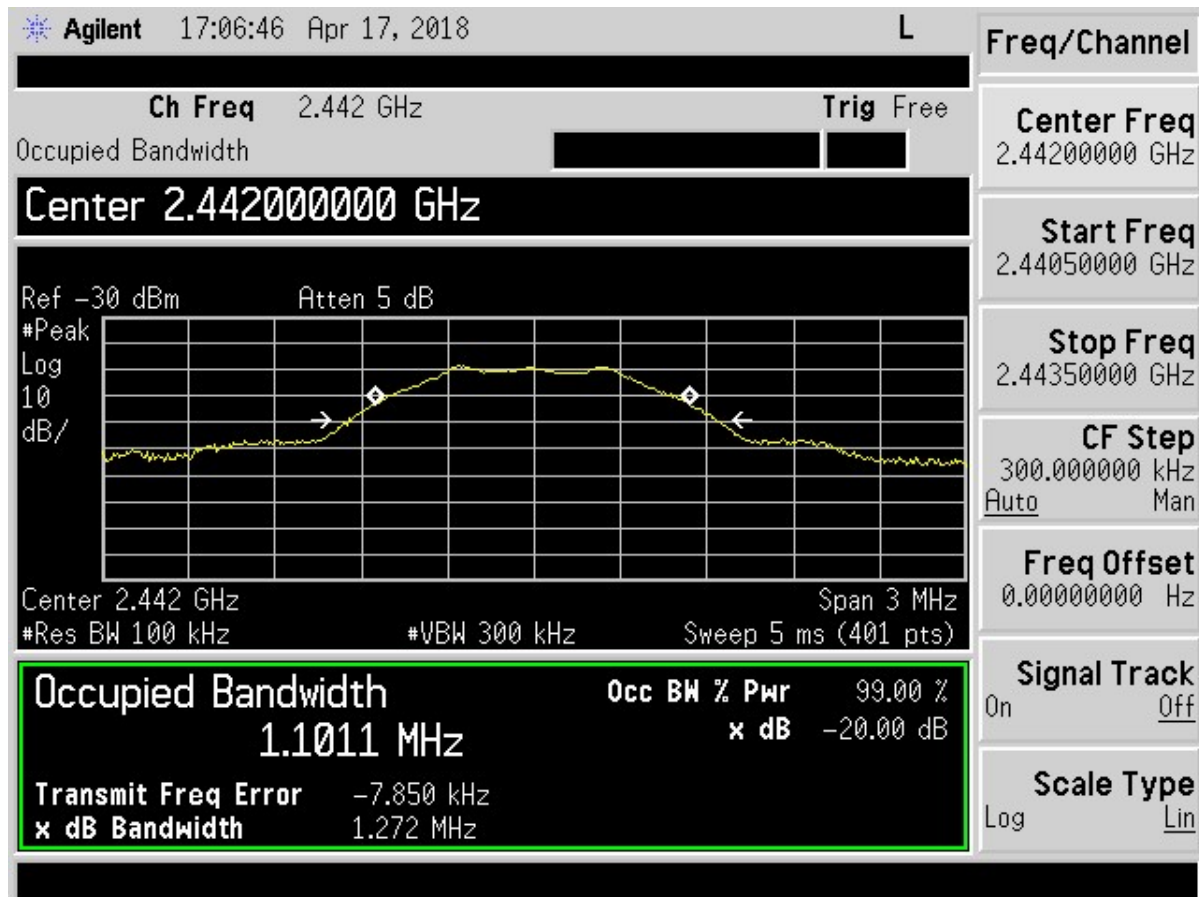


Figure 13. 99% Occupied Bandwidth – Mid Channel

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

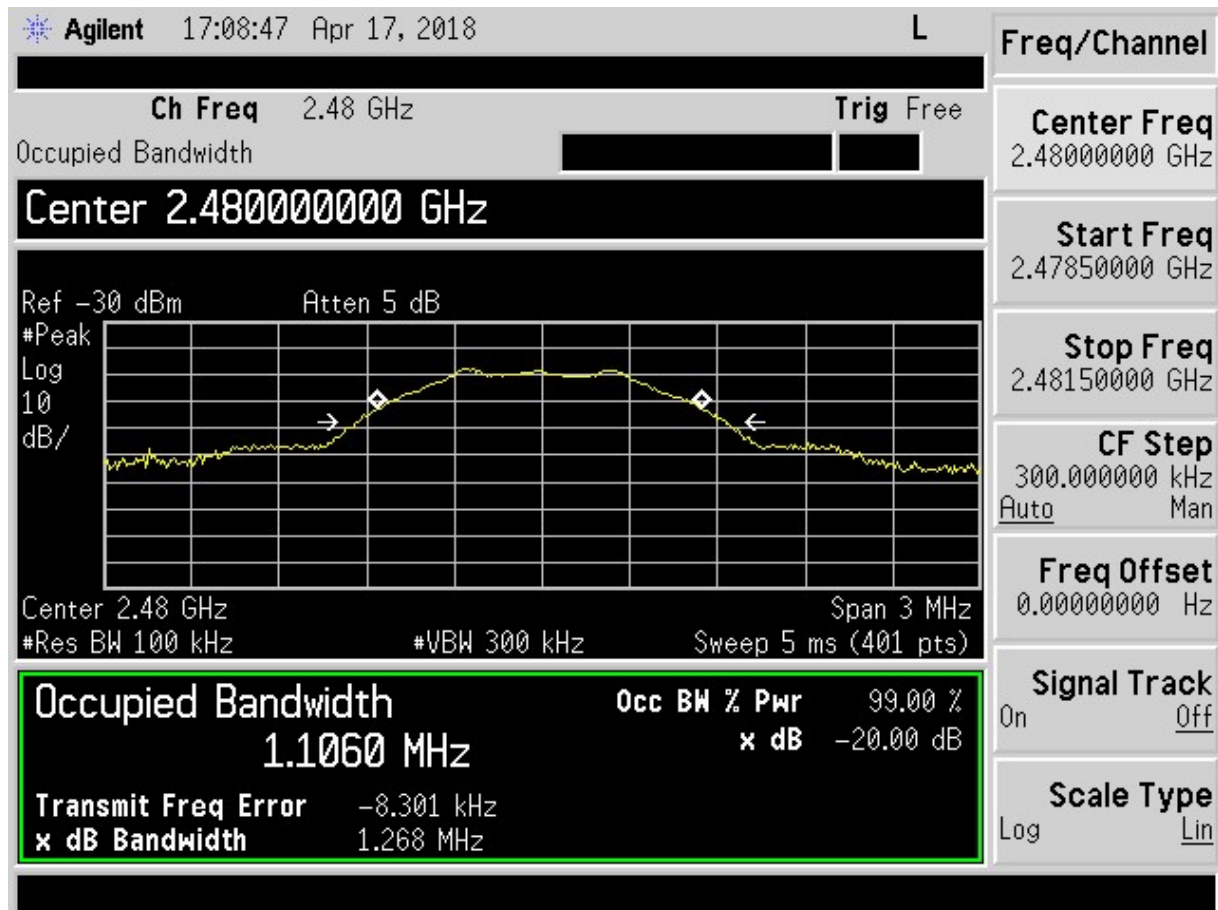


Figure 14. 99% Occupied Bandwidth – High Channel

US Tech Test Report:
FCC ID:
IC:
Test Report Number:
Issue Date:
Customer:
Model:

FCC Part 15 Certification/ RSS 210
2APA3-BOXLOCK001
23723-BOXLOCK001
18-0042
February 15, 2018
BoxLock, Inc.
BOXLOCK001

2.13 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2:2011. A coverage factor of $k=2$ was used to give a level of confidence of approximately 95%.

2.13.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ± 2.78 dB.

2.13.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ± 5.39 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21 dB.

3 Conclusions

The EUT is deemed to meet the requirements of the test standards cited herein when tested in the configuration detailed in this test report.