



Electromagnetic Compatibility Test Report

Tests Performed on a Latchable, Inc.

Entry Security System, Model R2

Radiometrics Document RP-9194A



Product Detail:

FCC ID: 2AK5B-R2
 IC: 22134-R2
 Equipment type: Low power transmitter

Test Standards:

US CFR Title 47, Chapter I, FCC Part 15 Subpart C
 FCC Part 15 CFR Title 47: 2017
 Canada ISED; RSS-210, Issue 10: 2019 as required for Category I Equipment
 Canada ISED; RSS-247, Issue 2
 IC RSS-GEN Issue 5: 2018

This report concerns: Original Grant for Certification
 FCC Part 15.247, 15.209 & 15.249

Tests Performed For:

Latchable, Inc.
 450 West 33rd Street
 New York, NY 10001

Test Facility:

Radiometrics Midwest Corporation
 12 Devonwood Avenue
 Romeoville, IL 60446-1349
 (815) 293-0772

Test Date(s):

November 21, 2019 to January 10, 2020

Document RP-9194A Revisions:

Rev.	Issue Date	Revised By
0	February 5, 2020	
1	February 18, 2020	Joseph Strzelecki



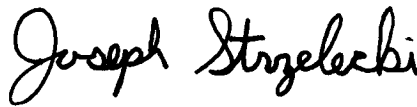
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1.0 ADMINISTRATIVE DATA

<i>Equipment Under Test:</i> A Latchable, Inc., Entry Security System Model: R2 This will be referred to as the EUT in this Report	
<i>Date EUT Received at Radiometrics:</i> November 21, 2019	<i>Test Date(s):</i> November 21, 2019 to January 10, 2020
<i>Test Report Written and Authorized By:</i> Joseph Strzelecki Senior EMC Engineer	<i>Test Witnessed By:</i> The tests were not witnessed by personnel from Latchable, Inc..
<i>Radiometrics' Personnel Responsible for Test:</i>  02/05/2020 Date Joseph Strzelecki Senior EMC Engineer NARTE EMC-000877-NE Chris D'Alessio EMC Technician Dave Jarvis EMC Technician Richard L. Tichgelaar EMC Technician	<i>EUT Checked By:</i> Joseph Strzelecki Richard Tichgelaar Dave Jarvis Radiometrics

2.0 TEST SUMMARY AND RESULTS

The EUT (Equipment Under Test) is an Entry Security System, Model R2, manufactured by Latchable, Inc.. The detailed test results are presented in a separate section. The following is a summary of the test results.

Wi-Fi Test Results

Environmental Phenomena	Frequency Range	FCC Section	RSS- Section	Test Result
RF AC Mains Conducted Emissions	0.15 - 30 MHz	15.207	RSS-GEN; 8.8	Pass
6 dB Bandwidth Test	2400 to 2483 MHz	15.247 a	RSS-247; 5.2a	Pass
Peak Output Power	2400 to 2483 MHz	15.247 b	RSS-247; 5.4	Pass
Band-edge Compliance of RF Conducted Emissions	2400 to 2483 MHz	15.247 d	RSS-247; 5.5	Pass
Spurious Radiated Emissions	30 MHz to 25 GHz	15.247 d	RSS-247; 5.5 & RSS-GEN	Pass
Power Spectral Density	2400 to 2483 MHz	15.247 e	RSS-247; 5.2	Pass



Bluetooth Results

Environmental Phenomena	Frequency Range	RSS Spec	RSS section	FCC Section	Test Result
All RF Radiated Emissions Fundamental and Spurious	30-25,000 MHz	RSS-210	B.10	15.249	Pass
Conducted Emissions, AC Mains	0.15 - 30 MHz	RSS-Gen	8.8	15.249	Pass
Occupied Bandwidth Test	Fundamental Freq.	RSS-Gen	6.6	15.249	Pass

Unintentional Emissions Tests Results

Environmental Phenomena	Frequency Range	Basic Standard	Test Result
RF Radiated Emissions	30-12,500 MHz	RSS-Gen & FCC Part 15	Pass
Conducted Emissions, AC Mains	0.15 - 30 MHz	RSS-Gen & FCC Part 15	Pass

13.56 MHz RFID results

Environmental Phenomena	Frequency Range	Test Result
RF Radiated Emissions	30-1000 MHz	Pass
RF Radiated Emissions H-Field	0.009 – 30 MHz	Pass
Occupied Bandwidth	13.56 MHz	Pass

The 13.56 MHz met the general limits of 15.209, so temperature stability tests were not performed. Both Bluetooth transmitters met the FCC 15.249 results.

IEC 17025 Decision Rule:

The declaration of pass or fail is based on the specifications listed above. The declaration of pass or fail did not consider measurement uncertainty.

3.0 EQUIPMENT UNDER TEST (EUT) DETAILS

3.1 EUT Description

The EUT is an Entry Security System, Model R2, manufactured by Latchable, Inc. The EUT was in good working condition during the tests, with no known defects.

3.1.1 FCC Section 15.203 & RSS-GEN Antenna Requirements

The antennas are permanently attached to the printed circuit board. The antenna is internal to the EUT and it is not readily available to be modified by the end user. Therefore, it meets the 15.203 Requirements.

Since the measurements at the antenna port are used to determine the RF output power, RSS-GEN section 6.8 requires that the effective gain of the products antenna be stated, based on a measurement or on data from the antenna’s manufacturer.



4.0 TESTED SYSTEM DETAILS

4.1 Tested System Configuration

The system was configured for testing in a typical fashion. The EUT was placed on an 80-cm or 150 cm high, nonconductive test stand. The testing was performed in conditions as close as possible to installed conditions. Wiring was consistent with manufacturer's recommendations. Since the EUT is wall or door mounted, it was placed in an upright configuration during the tests. The EUT was tested as a stand-alone device. Power was supplied at 120 VAC, 60 Hz single-phase to its external power supply.

The identification for all equipment, plus descriptions of all cables used in the tested system, are:

Tested System Configuration List

Item	Description	Type*	Manufacturer	Model Number	Serial Number
1	Entry Security System	E	Latchable, Inc.	R2	None
2	AC-DC Power Supply		SL Power Electronics	TE30A1203B01	None
3	Router	P	Dynex	DX-GB8PRT	10K22B16124

* Type: E = EUT, P = Peripheral, S = Support Equipment; H = Host Computer

List of System Cables

QTY	Length (m)	Cable Description	Shielded?
1	1.8	DC Cord from power supply to EUT (R2)	No
1	1.3	Ethernet cable to router	No
1	1.0	Output cable	No

4.2 EUT Operating Modes

WiFi Tests:

Environmental Phenomena	Channels Tested	Mode	Data Mbps	Notes
Bandwidth Test	1, 6, 11	802.11b	1.0	
Bandwidth Test	1, 6, 11	802.11g	6.0	
Bandwidth Test	1, 6, 11	802.11n	6.5	
Peak Output Power	1, 6, 11	802.11b	1.0	
Peak Output Power	1, 6, 11	802.11g	6.0	
Peak Output Power	1, 6, 11	802.11n	6.5	
Band-edge Conducted Emissions	1, 6, 11	802.11b	1.0	
Band-edge	1, 6, 11	802.11g	6.0	
Band-edge	1, 6, 11	802.11n	6.5	
RF Conducted Emissions	1, 6, 11	802.11b	1.0	
RF Conducted Emissions	1, 6, 11	802.11g	6.0	
RF Conducted Emissions	1, 6, 11	802.11n	6.5	
Radiated Emissions	1, 6, 11	802.11b	1.0	
Radiated Emissions	1, 6, 11	802.11g	6.0	
Radiated Emissions	1, 6, 11	802.11n	6.5	
Power Spectral Density	1, 6, 11	802.11b	1.0	
Power Spectral Density	1, 6, 11	802.11g	6.0	
Power Spectral Density	1, 6, 11	802.11n	6.5	
Conducted Emissions, AC Mains	6	802.11b	1.0	Note 1

Note 1: During preliminary testing, 802.11b mode, Channel 6 was found to be worst cast for this test.



The transmit mode for all transmitter tests was continuous. The continuous mode produces a Duty cycle of at least 98%.

Bluetooth testing:

The EUT was transmitting continuously with its maximum duty cycle.

13.56 MHz testing:

The EUT was transmitting continuously with its maximum duty cycle.

4.3 Special Accessories

No special accessories were used during the tests in order to achieve compliance.

4.4 Equipment Modifications

No modifications were made to the EUT at Radiometrics' test facility in order to comply with the standards listed in this report.

5.0 TEST SPECIFICATIONS

Document	Date	Title
FCC CFR Title 47	2018	Code of Federal Regulations Title 47, Chapter 1, Federal Communications Commission, Part 15 - Radio Frequency Devices
IC RSS-210 Issue 10	2019	Low Power Licence-Exempt Radiocommunication Devices (All Frequency Bands) Category I Equipment
IC RSS-247 Issue 2	2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
IC RSS-Gen Issue 5	2019	General Requirements and Information for the Certification of Radiocommunication Equipment (RSS-Gen)

6.0 TEST PROCEDURE DOCUMENTS

The tests were performed using the procedures from the following specifications:

Document	Date	Title
ANSI C63.4-2014	2014	Methods of Measurement of Radio Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10-2013	2013	American National Standard for Testing Unlicensed Wireless Devices
558074 D01 DTS Meas Guidance	2019	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247; v05r02



7.0 RADIOMETRICS' TEST FACILITIES

The results of these tests were obtained at Radiometrics Midwest Corp. in Romeoville, Illinois, USA. Radiometrics is accredited by A2LA (American Association for Laboratory Accreditation) to conform to ISO/IEC 17025: 2005 "General Requirements for the Competence of Calibration and Testing Laboratories". Radiometrics' Lab Code is 121191 and Certification Number is 1495.01. Radiometrics' scope of accreditation includes all of the test methods listed herein. A copy of the accreditation can be accessed on our web site (www.radiomet.com). Radiometrics accreditation status can be verified at A2LA's web site (www.a2la2.org).

The following is a list of shielded enclosures located in Romeoville, Illinois used during the tests:

Chamber E: Is a custom-made anechoic chamber that measures 52' L X 30' W X 18' H. The walls and ceiling are fully lined with RF absorber. Pro-shield of Collinsville, Oklahoma manufactured the chamber. The floor has a 9' x 9' section of microwave absorber for testing above 1 GHz.

Test Station F: Is an area that measures 10' D X 12' W X 10' H. The floor and back wall are metal shielded. This area is used for conducted emissions measurements.

A separate ten-foot long, brass plated, steel ground rod attached via a 6-inch copper braid grounds each of the above chambers. Each enclosure is also equipped with low-pass power line filters.

The FCC has accepted these sites as test site number US1065. The FCC test site Registration Number is 732175. Details of the site characteristics are on file with the Industry Canada as site number IC 3124A-1.

A complete list of the test equipment is provided herein. The calibration due dates are indicated on the equipment list. The equipment is calibrated in accordance to ANSI/NCSL Z540-1 with traceability to the National Institute of Standards and Technology (NIST).

8.0 DEVIATIONS AND EXCLUSIONS FROM THE TEST SPECIFICATIONS

There were no deviations or exclusions from the test specifications.

9.0 CERTIFICATION

Radiometrics Midwest Corporation certifies that the data contained herein was taken under conditions that meet or exceed the requirements of the test specification and the data contained herein was taken with calibrated test equipment. The results relate only to the EUT listed herein.

10.0 TEST EQUIPMENT TABLE

RMC ID	Manufacturer	Description	Model No.	Serial No.	Frequency Range	Cal Period	Cal Date
AMP-05	RMC/Celeritek	Pre-amplifier	MW110G	1001	1.0-12GHz	12 Mo.	01/10/19 01/14/20
AMP-20	Avantek	Pre-amplifier	SF8-0652	15221	8-18GHz	12 Mo	04/22/19
AMP-59	Amplitech	Pre-amplifier	APTMP44	AMP-59	18-26 GHz	12 Mo.	01/10/19 01/06/20
ANT-08	RMC	Log-Periodic Ant.	LP1000	1002	200-1000MHz	24 Mo.	11/19/18
ANT-13	EMCO	Horn Antenna	3115	2502	1.0-18GHz	24 Mo.	01/16/19
ANT-36	Ailtech (Eaton)	Horn Antenna	96001	2013	1.0-18GHz	24 Mo.	11/19/18
ANT-48	RMC	Std Gain Horn	HW2020	1001	18-26 GHz	36 Mo.	08/09/19
ANT-53	EMCO	Loop Antenna	6507	1453	1 kHz-30 MHz	24 Mo	12/28/17
ANT-66	ETS-Lindgren	Horn Antenna	3115	62580	1.0-18GHz	24 Mo.	03/05/19



RMC ID	Manufacturer	Description	Model No.	Serial No.	Frequency Range	Cal Period	Cal Date
ANT-80	AH Systems	Bicon Antenna	SAS-540	294	20-330MHz	24 Mo.	12/14/18
CAB-106A	Teledyne	Coaxial Cable	N/A	106A	DC-2 GHz	24 Mo.	05/07/18
CAB-1090	Teledyne	Coaxial Cable	N/A	1090	DC-18 GHz	24 Mo.	02/12/19
CAB-160B	Teledyne	Coaxial Cable	N/A	160B	DC-18 GHz	24 Mo.	05/09/18
CAB-090A	Teledyne	Coaxial Cable	N/A	090A	DC-26 GHz	24 Mo.	05/15/18
CAB-295A	Teledyne	Coaxial Cable	N/A	295A	DC-26 GHz	24 Mo.	05/09/18
HPF-01	Solar	High Pass Filter	7930-100	HPF-1	0.15-30MHz	24 Mo.	03/04/18
HPF-06	Mini-Circuits	High Pass Filter	VHF-3800+	31035	3-11 GHz	24 Mo.	04/04/18
LSN-17	EMCO	50 uH LISN	3810/2NM	9602-1356	0.15 - 30MHz	24 Mo.	03/04/19
LSN-03	Farnell	50 uH LISN	1EXLSN30B	000314	0.01-30MHz	24 Mo.	03/27/18
REC-11	HP / Agilent	Spectrum Analyzer	E7405A	US39110103	9Hz-26.5GHz	24 Mo	04/02/18
REC-20	HP / Agilent	Spectrum Analyzer	85460A/84562A	33330A00135 3410A00178	30Hz-6GHz	24 Mo.	08/14/19
REC-21	Agilent	Spectrum Analyzer	E7405A	MY45118341	9Hz-26.5 GHz	24 Mo.	01/06/18 01/14/20
REC-43	Adventest	Spectrum Analyzer	U3772	150800305	9Hz-43GHz	24 Mo.	06/24/19
RNT-17	Agilent	Spectrum Analyzer	E4440A	MY42510244	E4440A	36 Mo.	07/19/17
THM-03	Fluke	Temp/Humid Meter	971	95850465	N/A	12 Mo.	05/03/19

Note: All calibrated equipment is subject to periodic checks.
The test equipment was in calibration during the tests.

Software Company	Test Software Name	Version	Applicable Tests
Radiometrics	EN550XX0	07.16.19	RF Conducted Emissions (FCC Part 15 & EN 55032)
Radiometrics	RRECE11D	07.16.19	RF Radiated Emissions (FCC Part 15 & EN 55032)
Agilent	PSA/ESA-E/L/EMC	2.4.0.42	Bandwidth and screen shots

11.0 TEST SECTIONS

12.0 AC CONDUCTED EMISSIONS

The tests and limits are in accordance with FCC section 15.207 and RSS Gen section 8.8.

A computer-controlled analyzer was used to perform the conducted emissions measurements. The frequency range was divided into 500 subranges equally spaced on a logarithmic scale. The computer recorded the peak of each subrange. This data was then plotted on a semi-log graph generated by the computer. Adjusting the positions of the cables and orientation of the test system then maximizes the highest emissions.

Mains Conducted emission measurements were performed using a 50 Ohm/50 uH Line Impedance Stabilization Network (LISN) as the pick-up device. Measurements were repeated on both leads within the power cord. If the EUT power cord exceeded 80 cm in length, the excess length of the power cord was made into a 30 to 40 cm bundle near the center of the cord. The LISN was placed on the floor at the base of the test platform and electrically bonded to the ground plane.



FCC Limits of Conducted Emissions at the AC Mains Ports

Frequency Range (MHz)	Class B Limits (dBuV)	
	Quasi-Peak	Average
0.150 - 0.50*	66 - 56	56 - 46
0.5 – 5.0	56	46
5.0 - 30	60	50

* The limit decreases linearly with the logarithm of the frequency in this range.

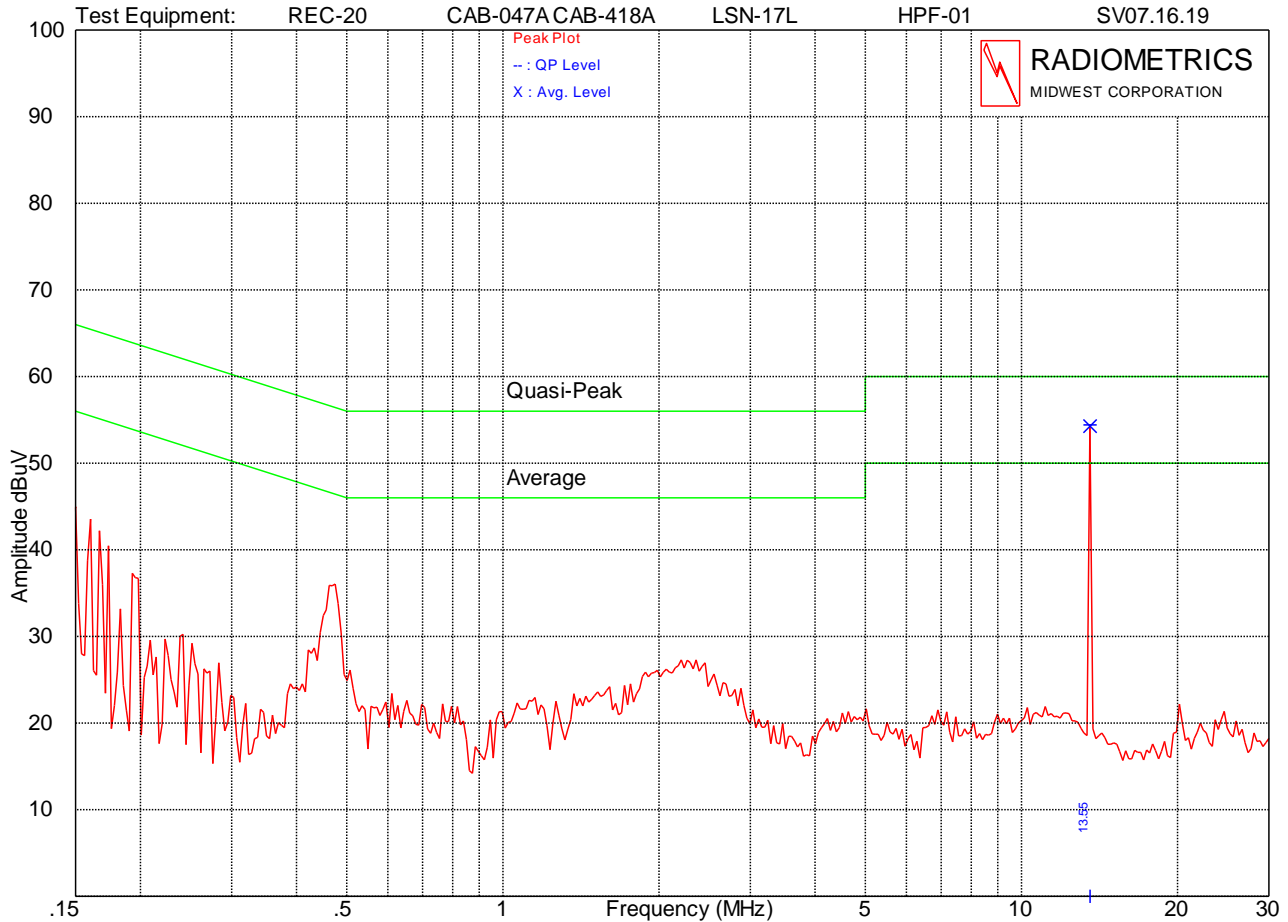
The initial step in collecting conducted data is a peak detector scan and the plotting of the measurement range. Significant peaks are then marked as shown on the following table, and these signals are then measured with the quasi-peak detector. The following represents the worst case emissions from the EUT power supply, after testing all modes of operation.

The transmitter was tested with a dummy load under the following conditions:

- 1) First, perform the AC line conducted tests with the antenna attached were performed to determine if the EUT complies with the 15.207 limits outside the transmitter's fundamental emission band.
- 2) The AC line conducted emissions were retested with a dummy load of to make sure the device complies with the 15.207 limits inside the transmitter's fundamental emission band. Only the fundamental TX emission band needs to be retested. The load was 100 Ohm. This is the characteristic impedance of the antenna.

Test Date : December 9, 2019

The Amplitude is the final corrected value with cable and LISN Loss.



Company: Latch Inc.

Lead Tested: AC Hot 120 VAC

Notes: 13.56 MHz & BT & WIFI TX ON.

FCC/ICES/EN; Class B Conducted Emissions; Mains Port

Model: R2

S/N : #5 New Firm 12/02/19

Date :12-09-2019

Time:09:35

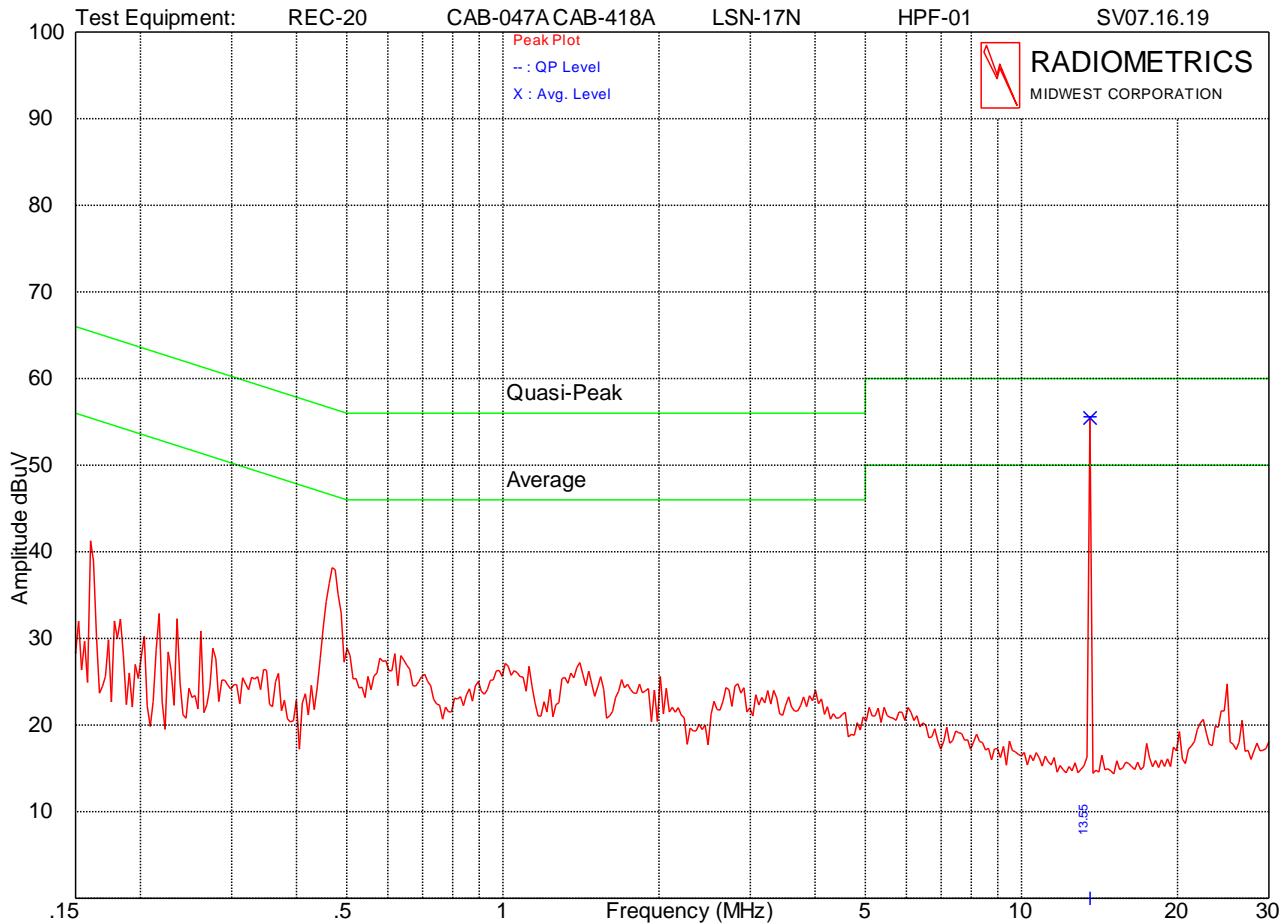
Tested By: RLT

RP-9194 | CE120HD

With Antenna installed

The emission at 13.56 MHz was re-measured with a resistive load in place of the antenna and was fully compliant.

Frequency (MHz)	QP Amplitude (dBuV)	QP Limit (dBuV)	Average Amplitude (dBuV)	Average Limit (dBuV)	Margin (dB)
13.560	54.4	60.0	54.3	50.0	-4.3

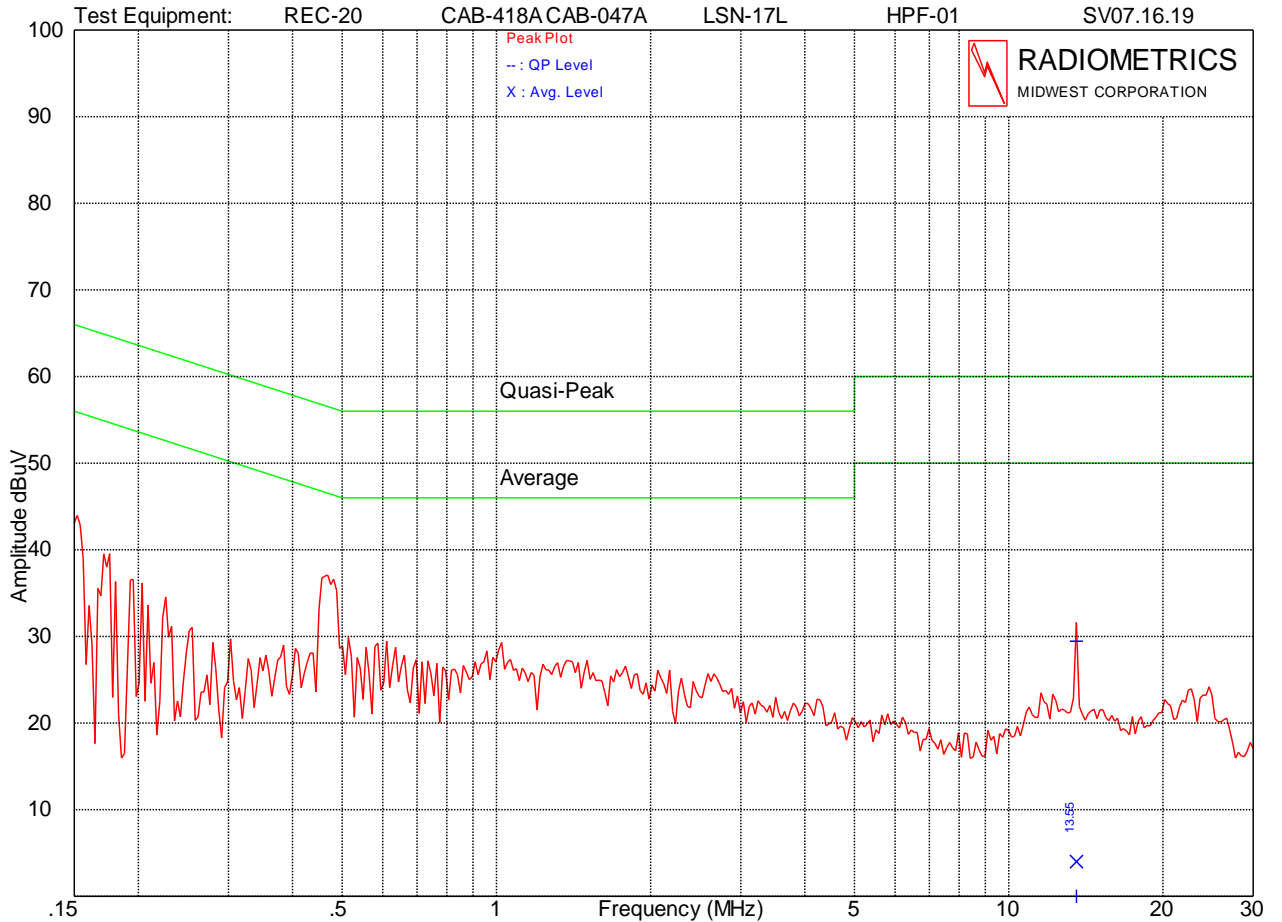


Company: Latch Inc. Model: R2 Date :12-09-2019
 Lead Tested: AC Neutral 120 VAC S/N : #5 New Firm 12/02/19 Time:09:38
 Notes: 13.56 MHz & BT & WIFI TX ON. Tested By: RLT
 FCC/ICES/EN; Class B Conducted Emissions; Mains Port RP-9194 | CE120ND

With Antenna installed

The emission at 13.56 MHz was re-measured with a resistive load in place of the antenna and was fully compliant.

Frequency (MHz)	QP Amplitude (dBuV)	QP Limit (dBuV)	Average Amplitude (dBuV)	Average Limit (dBuV)	Margin (dB)
13.560	55.6	60.0	55.5	50.0	-5.5

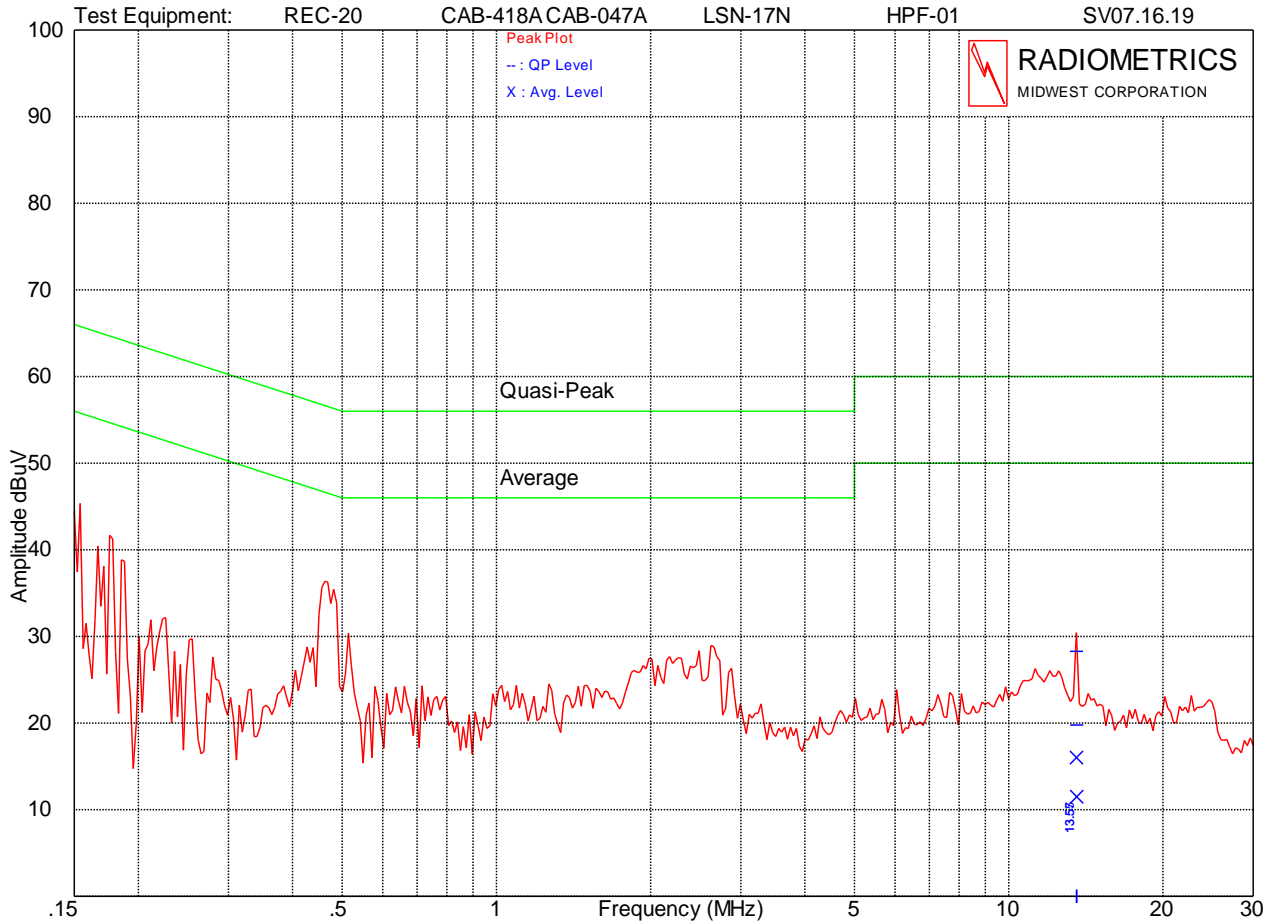


Company: Latch Model: R2 Date :12-13-2019
 Lead Tested: AC Hot 120 VAC S/N : RMC-8 NFC MOD Time:09:09
 Notes: Resistor in place of 13.56 MHz Antenna. Tested By: RLT
 FCC/ICES/EN; Class B Conducted Emissions; Mains Port RP-9194 | C120HMOD

With Load in place of Antenna

Frequency (MHz)	QP Amplitude (dBuV)	QP Limit (dBuV)	Average Amplitude (dBuV)	Average Limit (dBuV)	Margin (dB)
13.560	29.4	60.0	4.0	50.0	30.6

Pass by at least 10 dB at 13.56 MHz with Load in place of antenna



Company: Latch
 Lead Tested: AC Neutral 120 VAC
 Notes: Resistor in place of 13.56 MHz Antenna.
 FCC/ICES/EN; Class B Conducted Emissions; Mains Port

Model: R2
 S/N : RMC-8 NFC MOD

Date :12-13-2019
 Time:09:28
 Tested By: RLT
 RP-9194 | C120NMOD

With Load in place of Antenna

Frequency (MHz)	QP Amplitude (dBuV)	QP Limit (dBuV)	Average Amplitude (dBuV)	Average Limit (dBuV)	Margin (dB)
13.559	28.3	60.0	16.0	50.0	31.7

Pass by at least 10 dB at 13.56 MHz with Load in place of antenna

Judgment: Passed by 9 dB



13.0 WIFI TEST RESULTS

13.1 Occupied Bandwidth Data

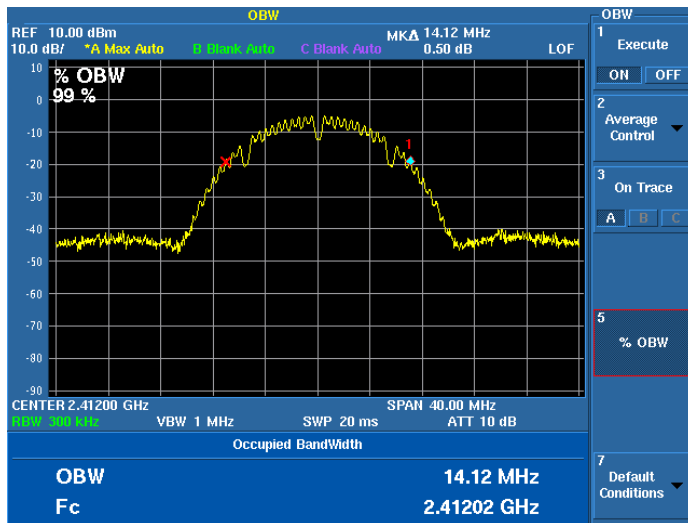
The test procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 8.1.

The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation. The EUT was transmitting at its maximum data rate. The trace was allowed to stabilize. The marker-to-peak function was set to the peak of the emission. Then the marker-delta function was used to measure 6 dB down one side of the emission. The marker-delta function was reset and then moved to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the bandwidth of the emission.

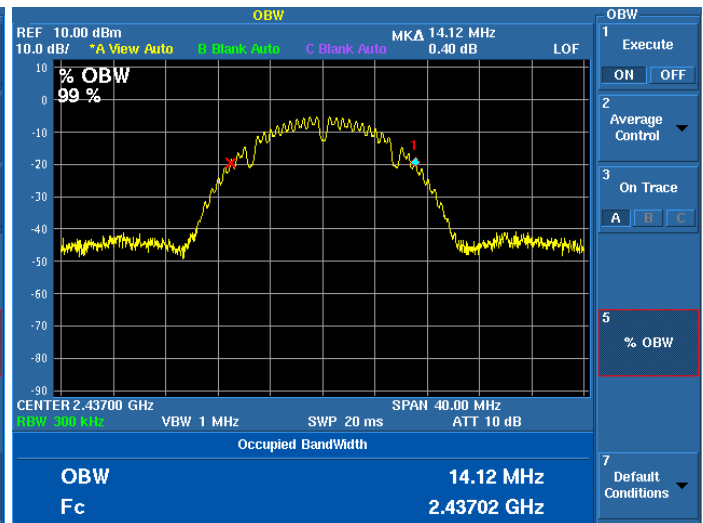
Mode	Freq. (MHz)	99% Bandwidth MHz	6 dB DTS EBW MHz
802.11b	2412	14.12	9.284
802.11b	2437	14.12	9.359
802.11b	2462	14.16	9.29
802.11g	2412	16.56	15.14
802.11g	2437	16.56	15.115
802.11g	2462	16.52	15.065
802.11N	2412	17.60	15.14
802.11N	2437	17.60	15.065
802.11N	2462	17.64	15.14

The 6 dB bandwidth is greater than 500 kHz
Judgement: Pass

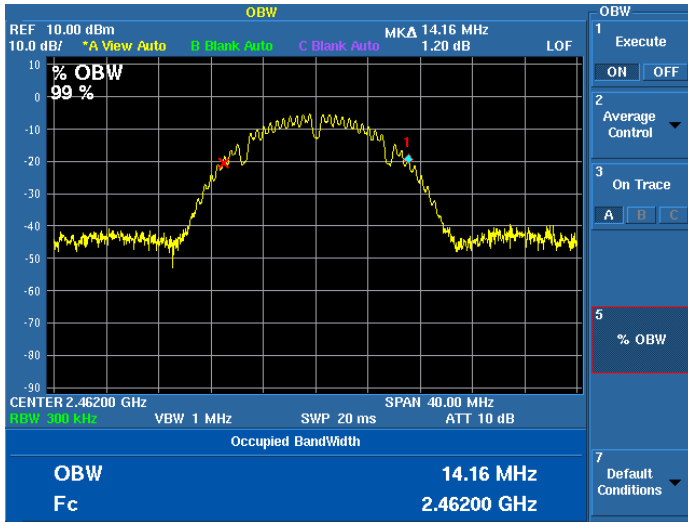
99%



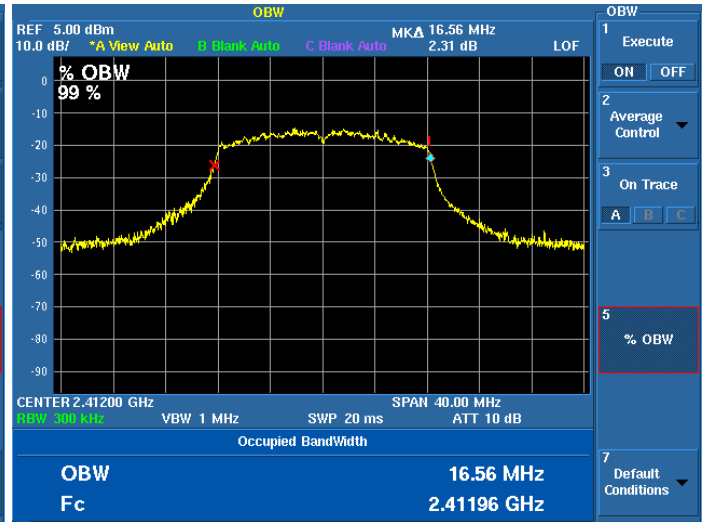
8011.b, Channel 1



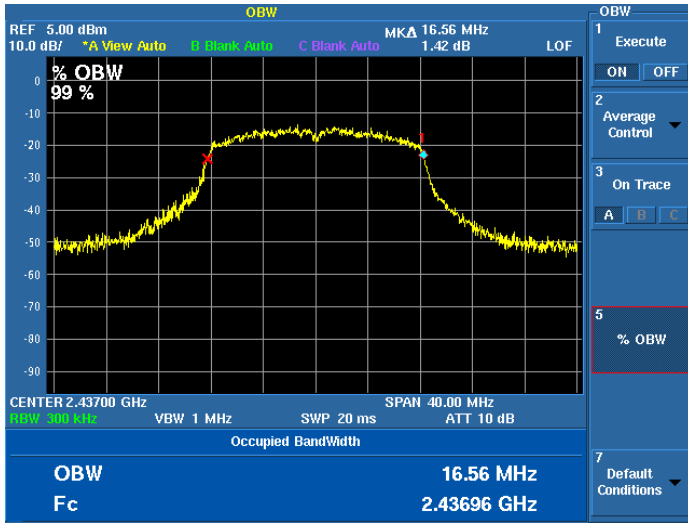
802.11b, Channel 6



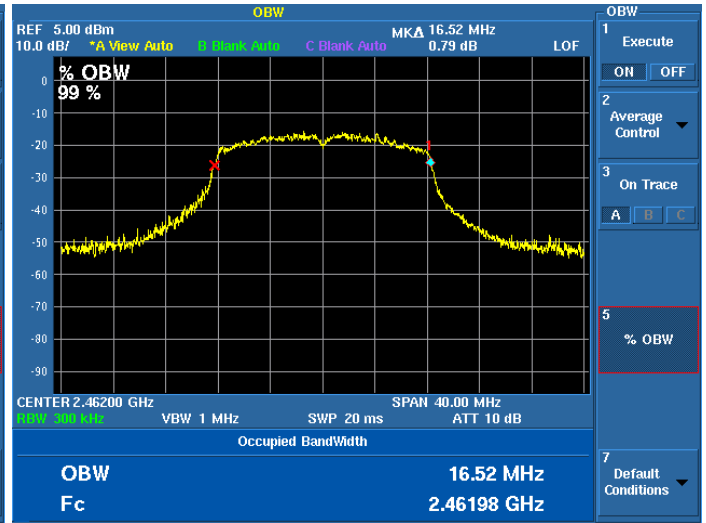
802.11b, Channel 6



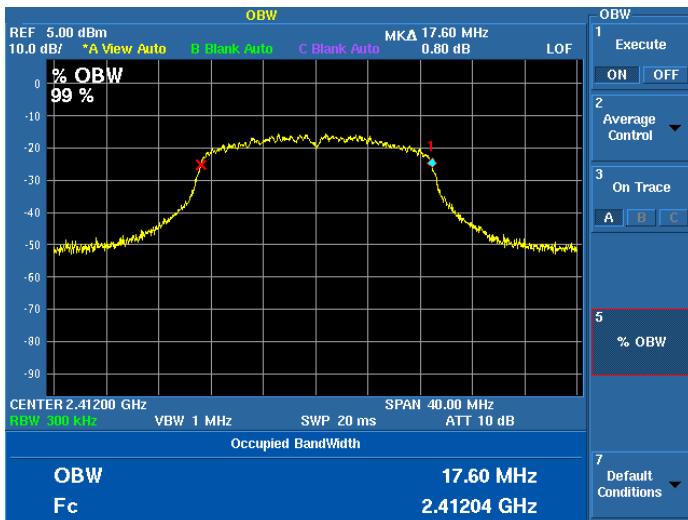
802.11g, Channel 1



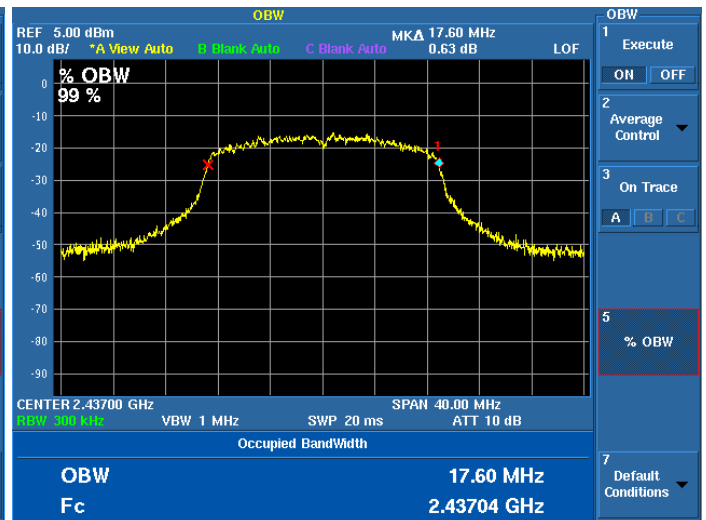
802.11g, Channel 6



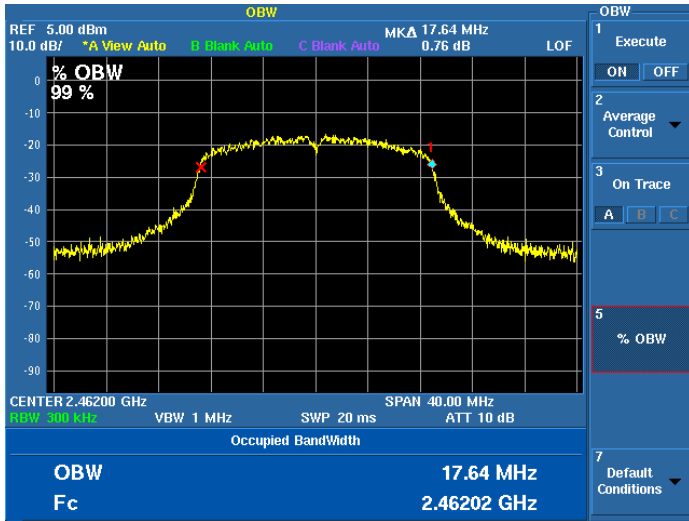
802.11g, Channel 11



802.11n, Channel 1

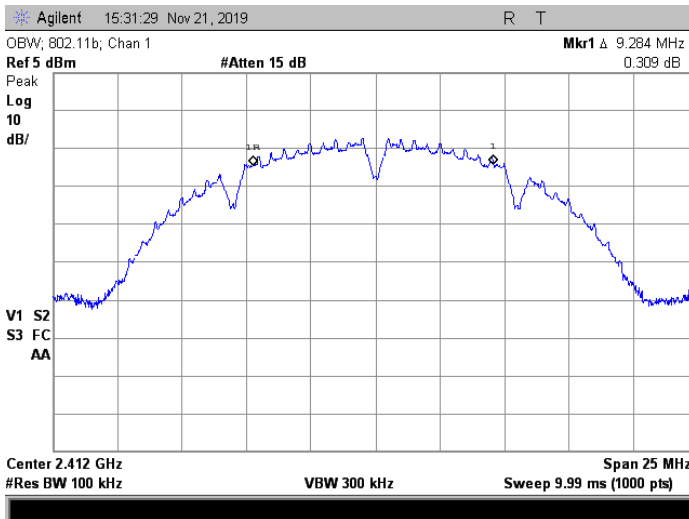


802.11n, Channel 6

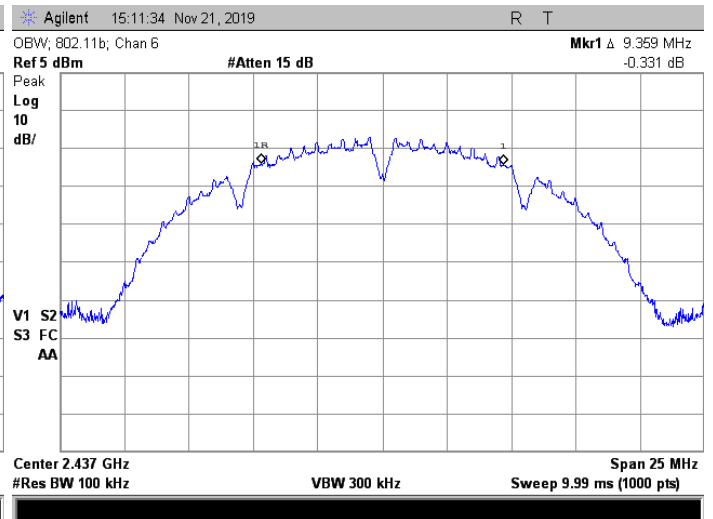


802.11n, Channel 11

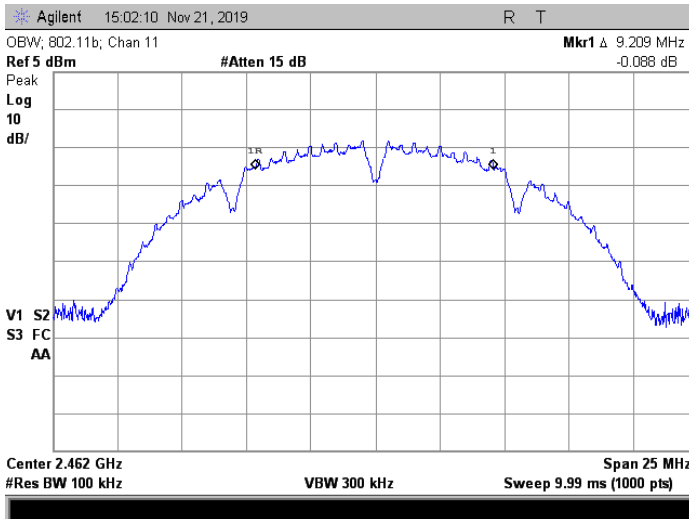
6 dB



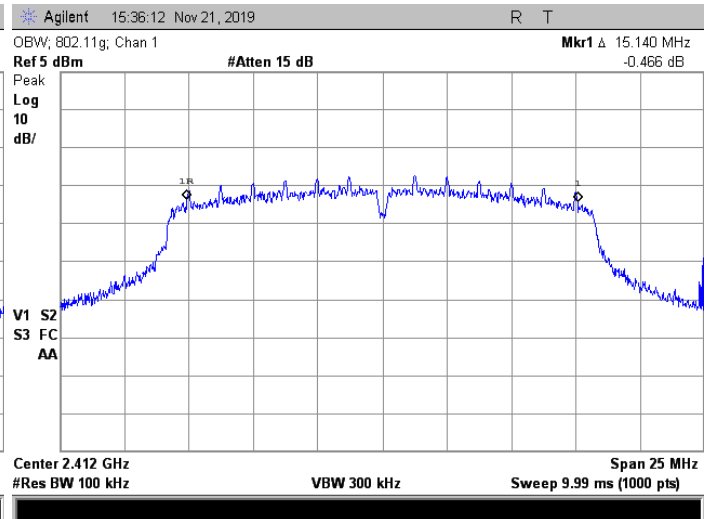
802.11b, Channel 1



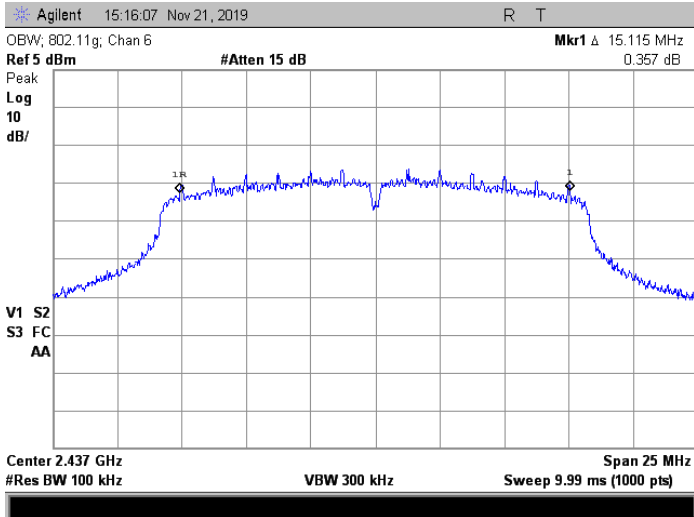
802.11b, Channel 6



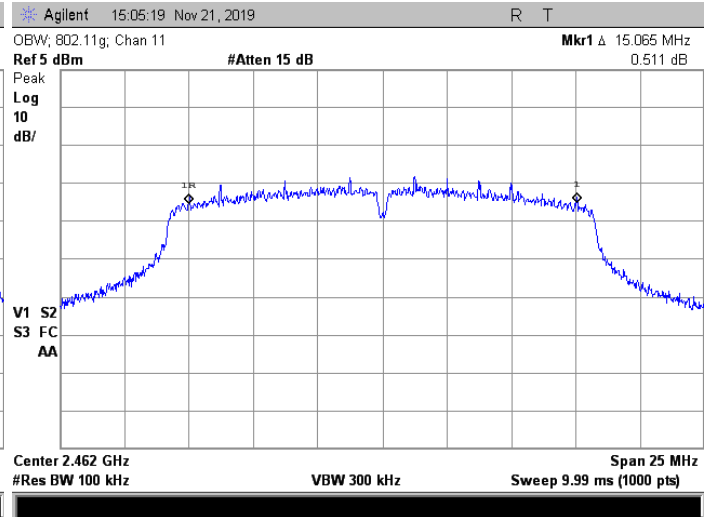
802.11b, Channel 11



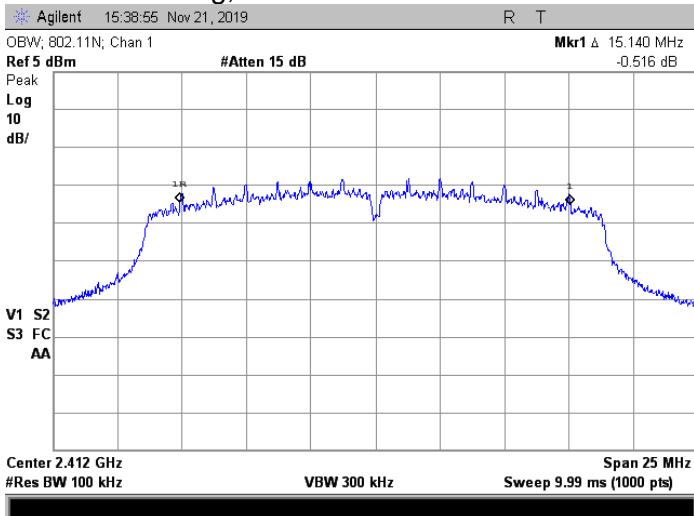
802.11g, Channel 1



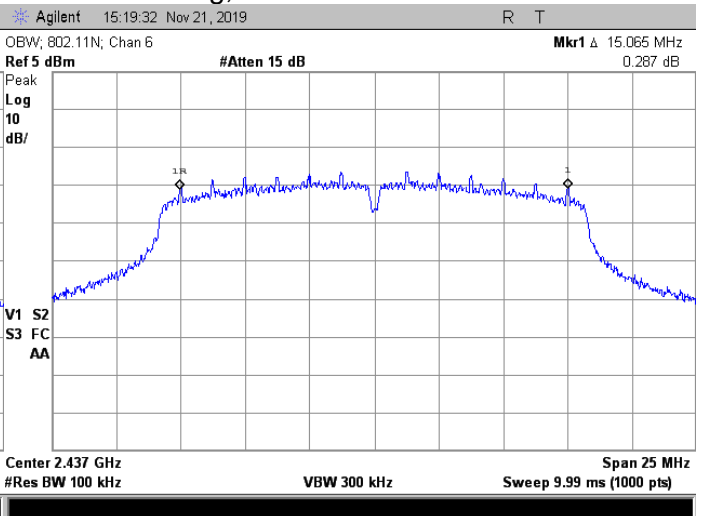
802.11g, Channel 6



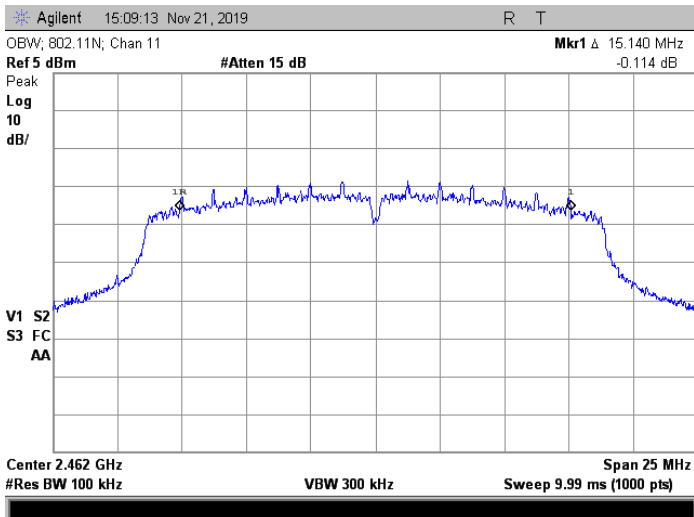
802.11g, Channel 11



802.11n, Channel 1



802.11n, Channel 6



802.11n, Channel 11



13.2 Peak Output Power

The test procedures were in accordance to FCC DTS Measurement Guideline 558074 D01 & ANSI C63.10-2013 section 11.9.1.2. The EUT antenna port was connected to the Spectrum analyzer Via a low loss coaxial cable. The trace was allowed to stabilize. The indicated level is the peak output power. Since the gain of the antenna is always less than 6 dB, the limit is not reduced.

The spectrum analyzer was set to peak channel power. The EUT antenna port was connected to the Spectrum analyzer Via a low loss coaxial cable.
Span = 30 MHz; RBW = 1 MHz; VBW = 3 MHz

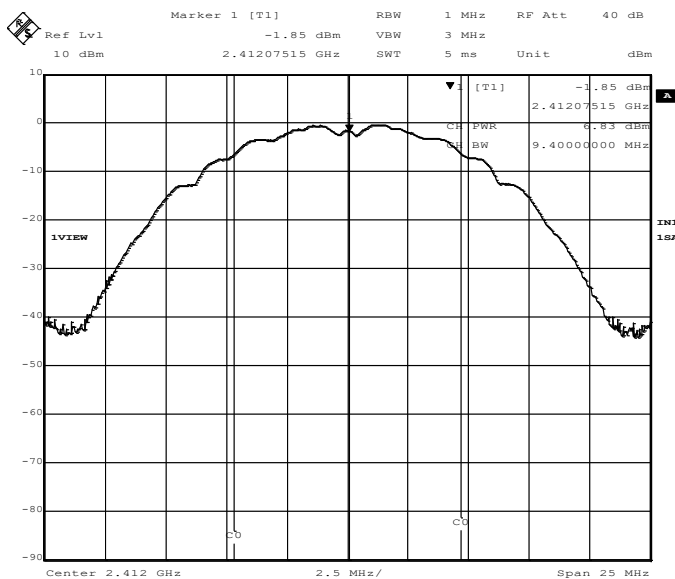
Tested by: Joseph Strzelecki/ Richard Tichgelaar
Test Date: 12/06/2019

Since the gain of the antenna is always less than 6 dB, the limit is not reduced. The antenna gain is 5 dBi.

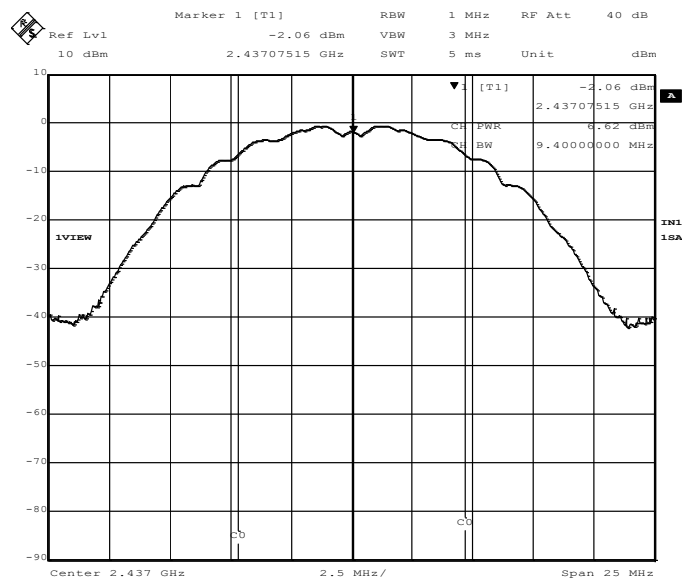
Mode	Freq. (MHz)	Reading (dBm)	Cable + Atten Loss (dB)	Total Power (dBm)		Limit (dBm)
				dBm	Watts	
802.11b	2412	6.8	10.0	16.8	0.0479	30
802.11b	2437	6.6	10.0	16.6	0.0457	30
802.11b	2462	6.9	10.0	16.9	0.0490	30
802.11g	2412	0.2	10.0	10.2	0.0105	30
802.11g	2437	2.4	10.0	12.4	0.0174	30
802.11g	2462	0.5	10.0	10.5	0.0112	30
802.11N	2412	0.3	10.0	10.3	0.0107	30
802.11N	2437	2.4	10.0	12.4	0.0174	30
802.11N	2462	0.6	10.0	10.6	0.0115	30

Overall Test result: Pass by 13.1 dB

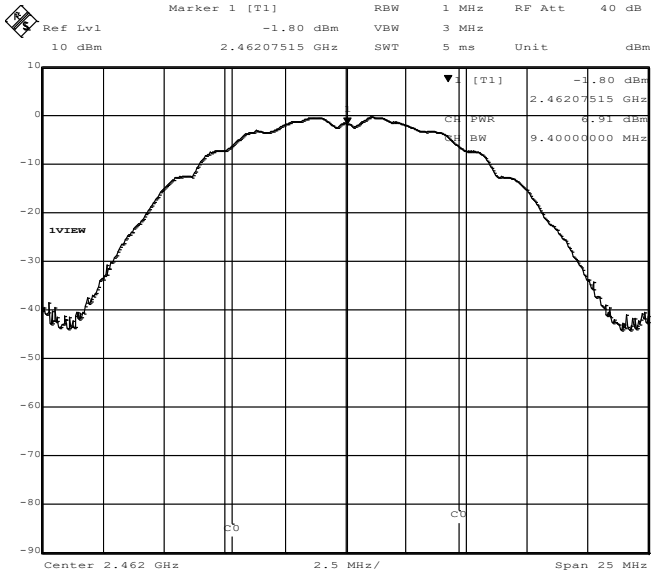
Peak Power Plots



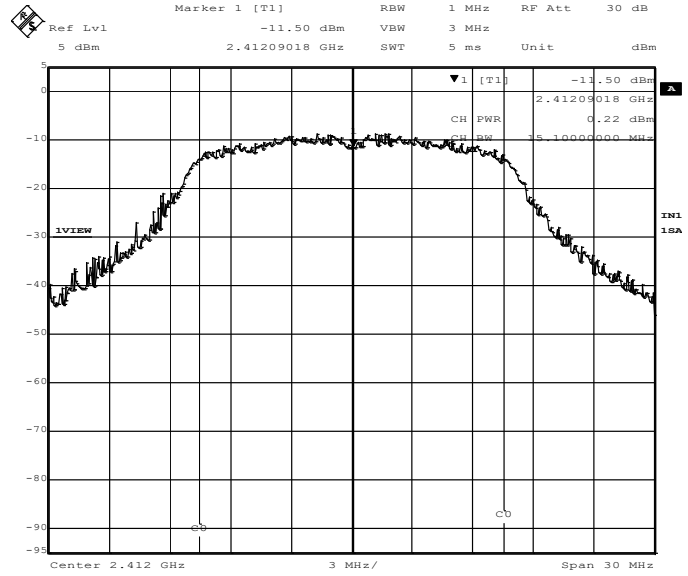
Comment A: 802.11b CH 1 ; Channel Power
Date: 6.DEC.2019 11:06:32



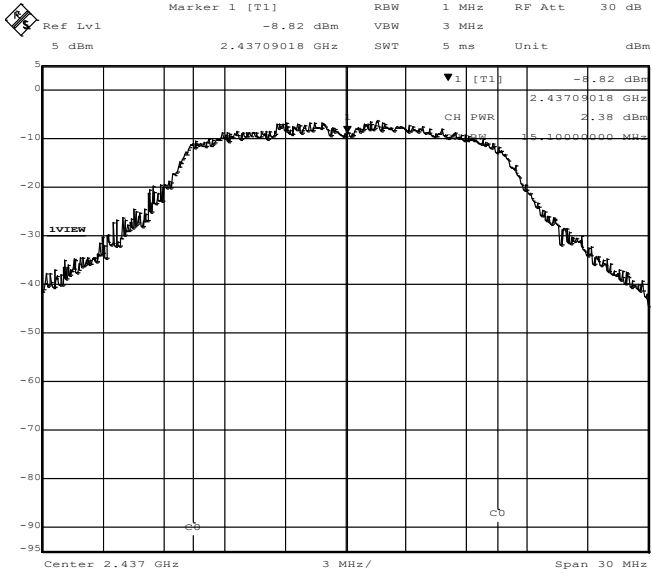
Comment A: 802.11b CH 6 ; Channel Power
Date: 6.DEC.2019 10:53:53



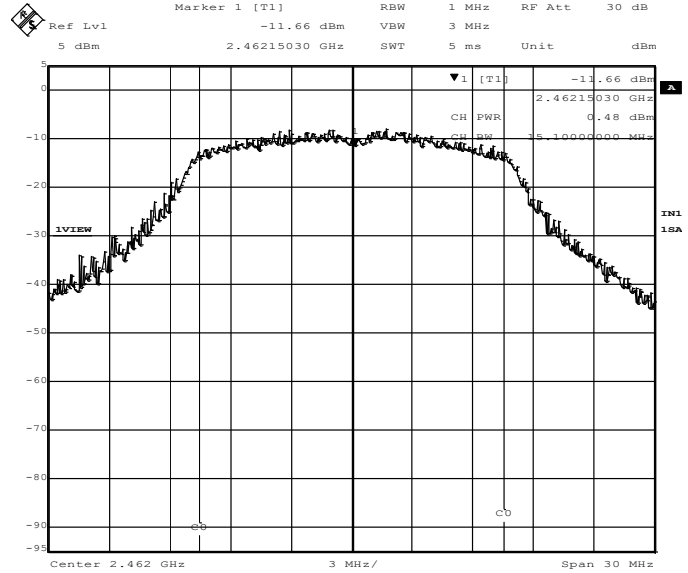
Comment A: 802.11b CH 11 ; Channel Power
Date: 6.DEC.2019 11:12:54



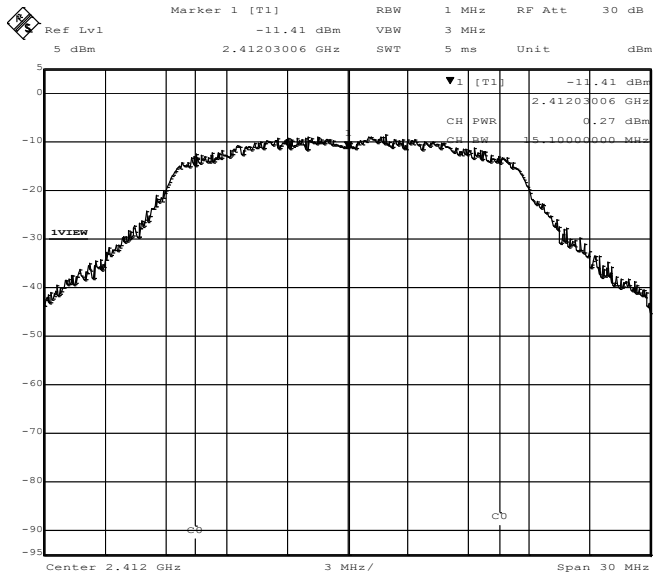
Comment A: 802.11g CH 1 ; Channel Power
Date: 6.DEC.2019 11:23:47



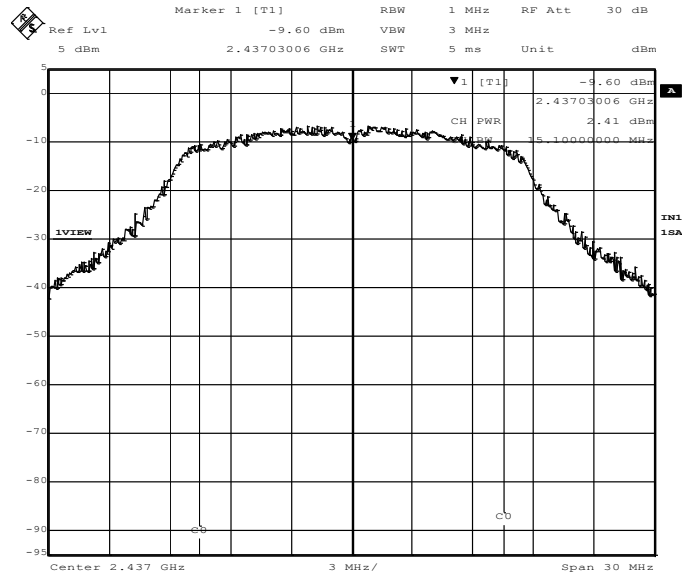
Comment A: 802.11g CH 6 ; Channel Power
Date: 6.DEC.2019 11:30:59



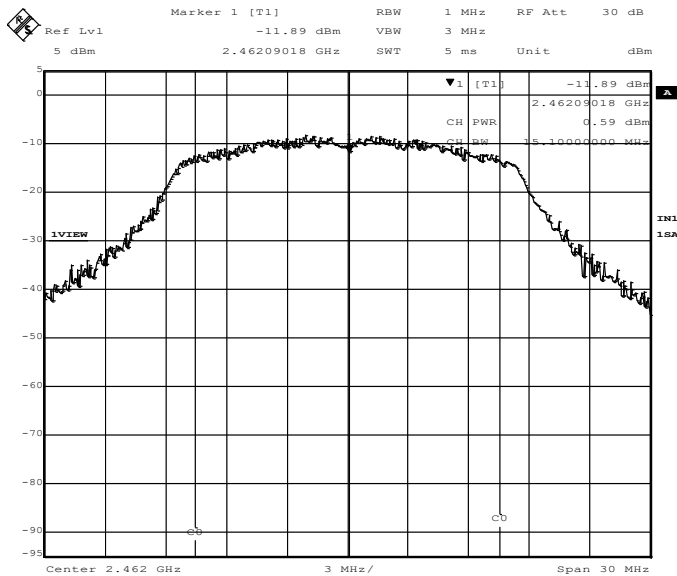
Comment A: 802.11g CH 11 ; Channel Power
Date: 6.DEC.2019 11:37:55



Comment A: 802.11N CH 1 ; Channel Power
Date: 6.DEC.2019 11:44:02



Comment A: 802.11N CH 6 ; Channel Power
Date: 6.DEC.2019 11:47:55



Comment A: 802.11N CH 11 ; Channel Power
Date: 6.DEC.2019 12:36:56

13.3 Power Spectral Density

The PSD test method from ANSI C63.10 section 11.10.2 and FCC DTS Measurement Guideline 558074 D01, Section 10.2. The spectrum analyzer was set to the following settings:

Span = 1.5x DTS Bandwidth; RBW = 10 kHz; VBW = 30 kHz
Tested by: Joseph Strzelecki/Richard Tichelaar

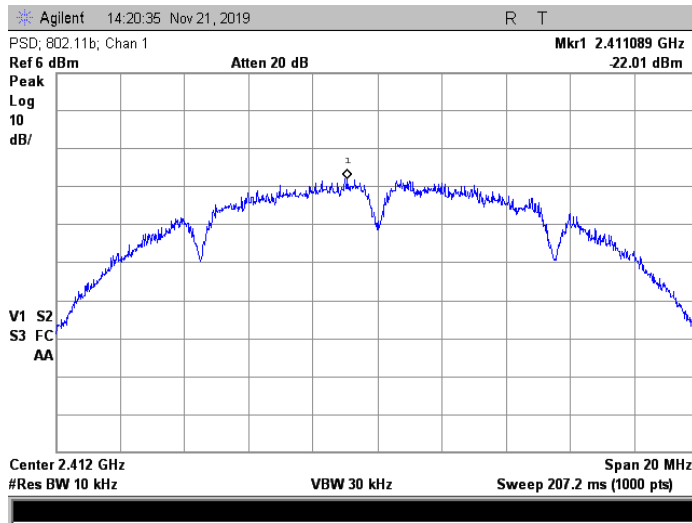
Test Date: 11/21/2019



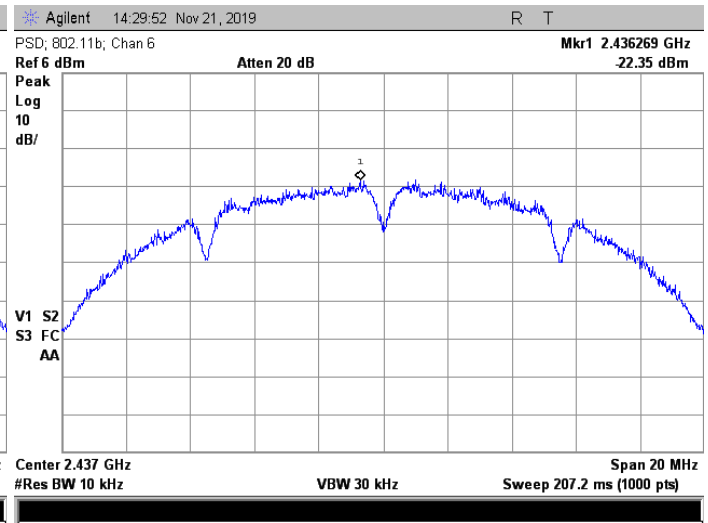
Mode	Frequency (MHz)	Reading dBm	Cable Loss (dB)	3 kHz Spectral Density (dBm)	Limit (dBm)	Margin (dB)
802.11b	2412	-22.01	12.0	-10.0	8.0	18.0
802.11b	2437	-22.35	12.0	-10.4	8.0	18.4
802.11b	2462	-23.12	12.0	-11.1	8.0	19.1
802.11g	2412	-31.76	12.0	-19.8	8.0	27.8
802.11g	2437	-31.19	12.0	-19.2	8.0	27.2
802.11g	2462	-34.65	12.0	-22.7	8.0	30.7
802.11N	2412	-30.35	12.0	-18.4	8.0	26.4
802.11N	2437	-31.41	12.0	-19.4	8.0	27.4
802.11N	2462	-32.85	12.0	-20.9	8.0	28.9

Judgment: Passed by 18.0 dB

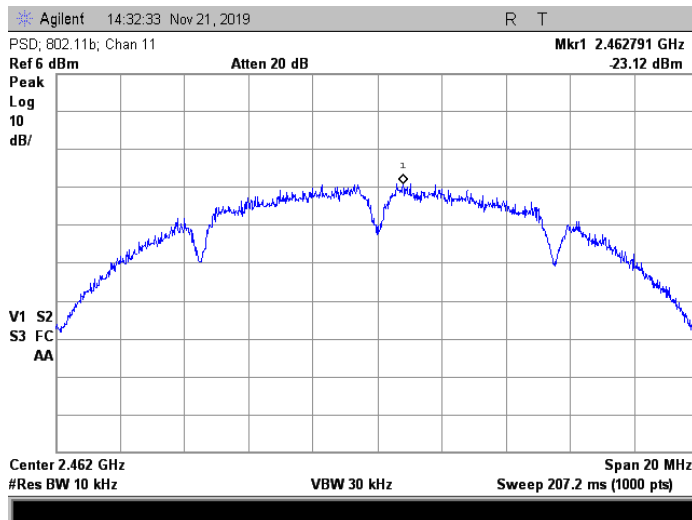
PSD Plots



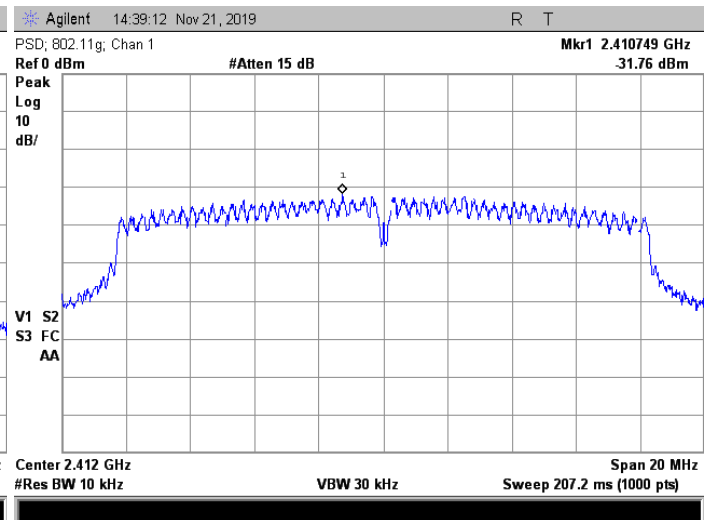
802.11b, Channel 1



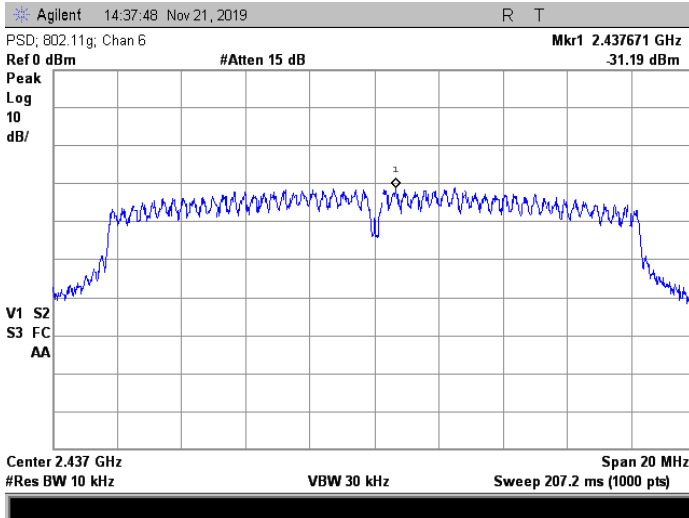
802.11b, Channel 6



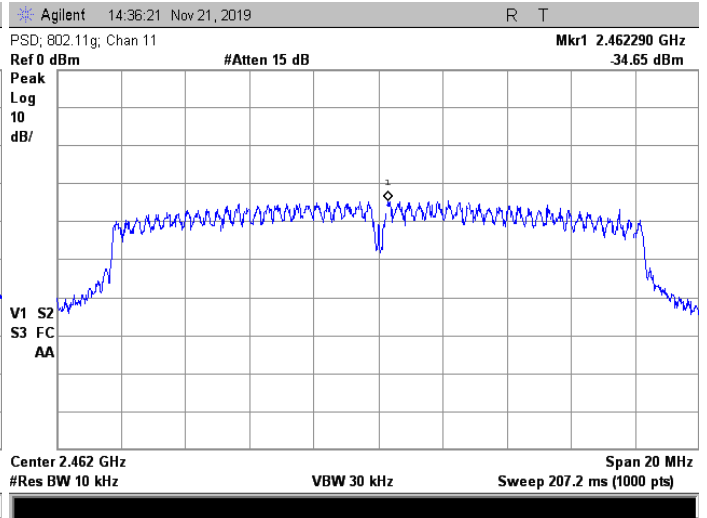
802.11b, Channel 11



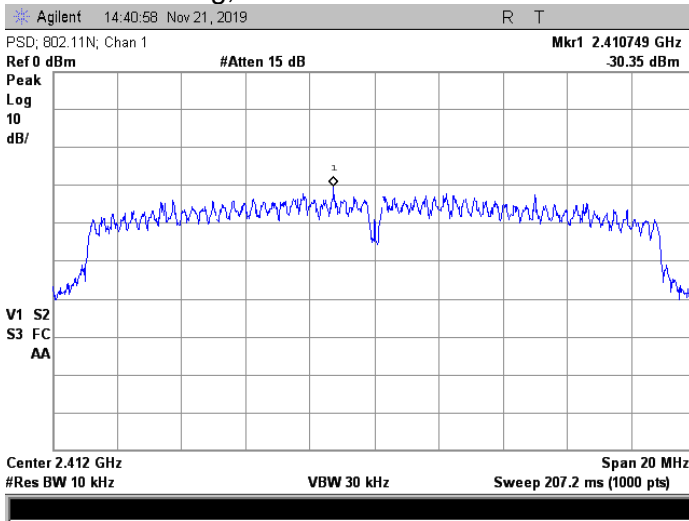
802.11g, Channel 1



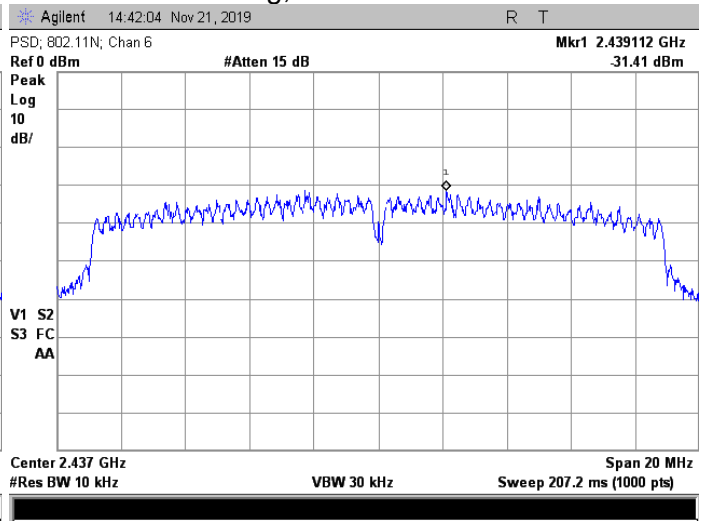
802.11g, Channel 6



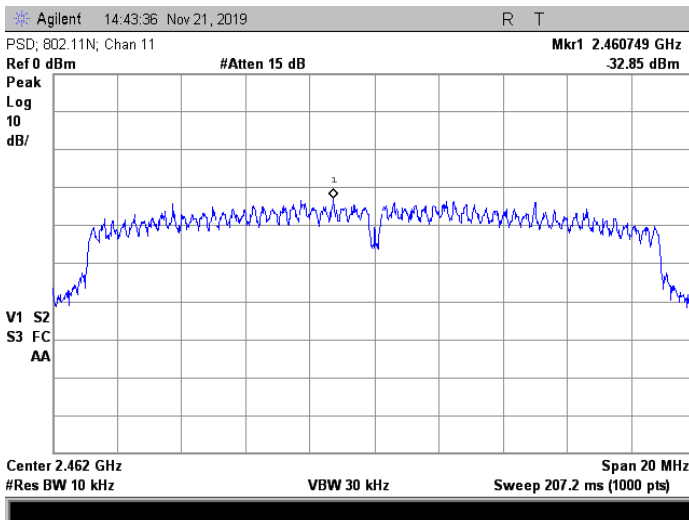
802.11g, Channel 11



802.11N, Channel 1



802.11N, Channel 6



802.11N, Channel 11



13.4 Band-edge Compliance of RF Conducted Emissions

The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation at the band-edge, with the EUT set to the lowest frequency. The trace was allowed to stabilize.

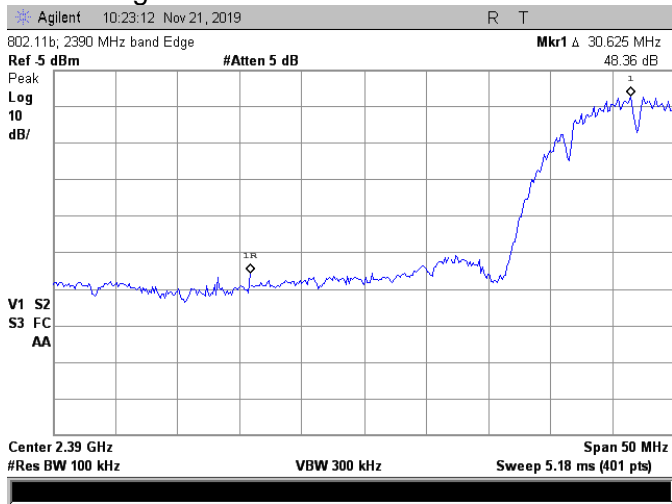
Tested by: Joseph Strzelecki/ Richard Tichelaar

Test Date: November 21, 2019

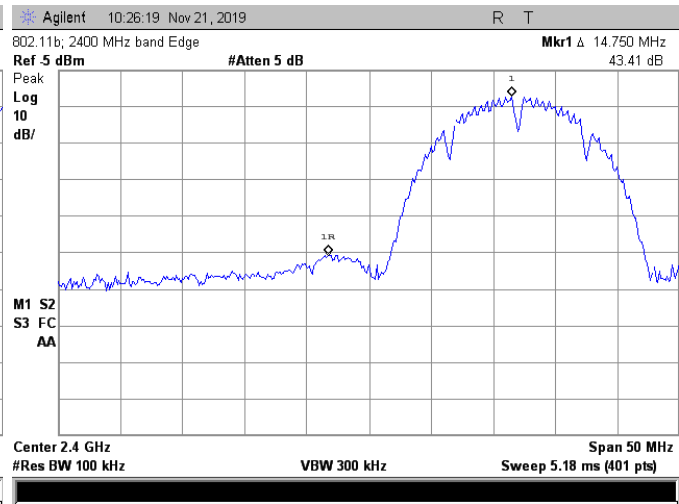
Channel	Band Edge Delta Readings in dB				Limit (dB)
	Freq (MHz)	802.11b (dB)	802.11g (dB)	802.11N (dB)	
2412 Lower Band edge	2400.0	43.41	33.37	32.8	20
2412 Lower Band edge	2390.0	48.36	44.2	42.3	20
2462 Upper Band edge	2483.5	47.2	40.0	40.0	20

Judgment: Passed by 12.8 dB

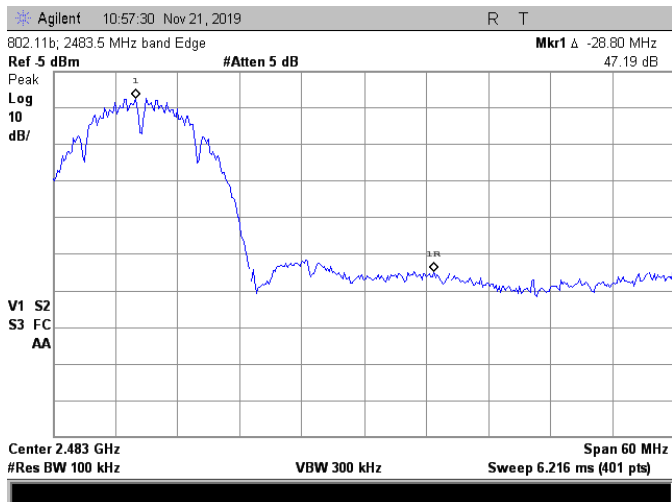
BAND Edge



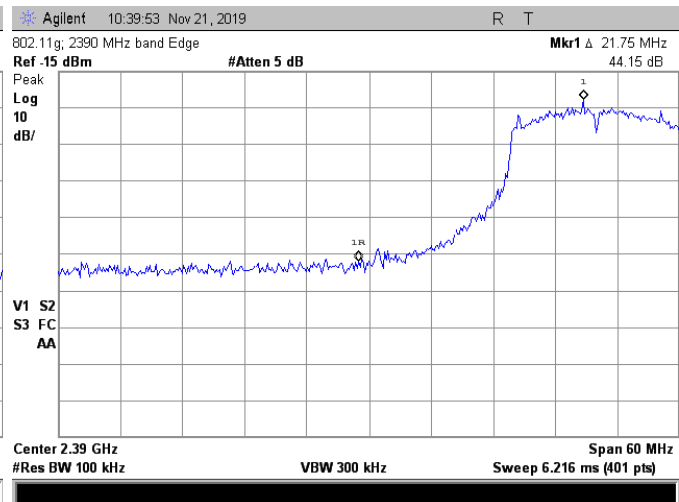
802.11b, Channel 1



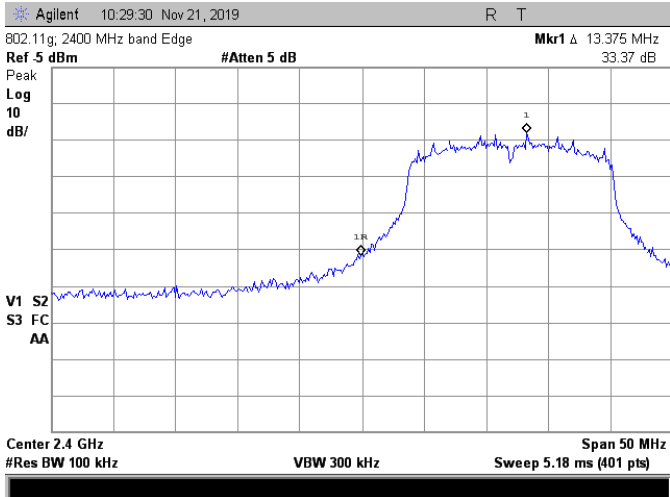
802.11b, Cannel 1



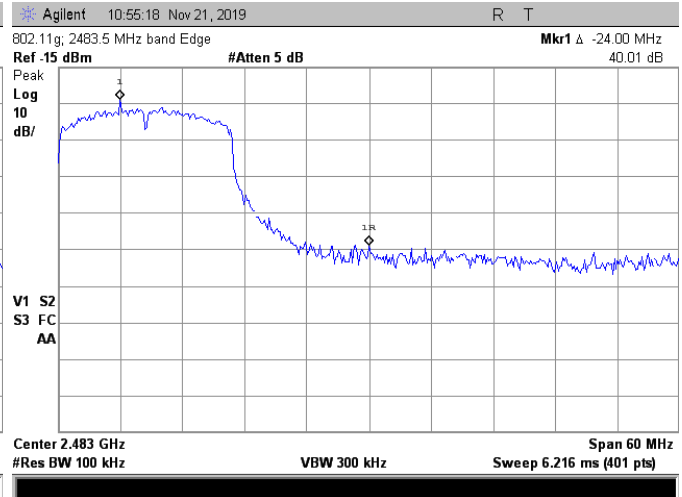
802.11b, Channel 11



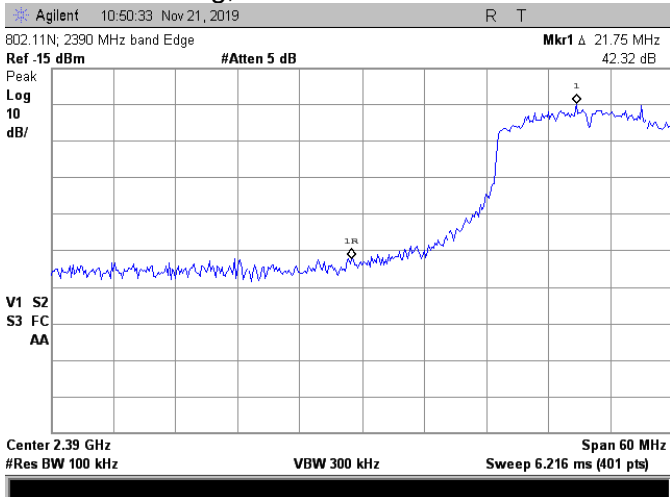
802.11g, Channel 1



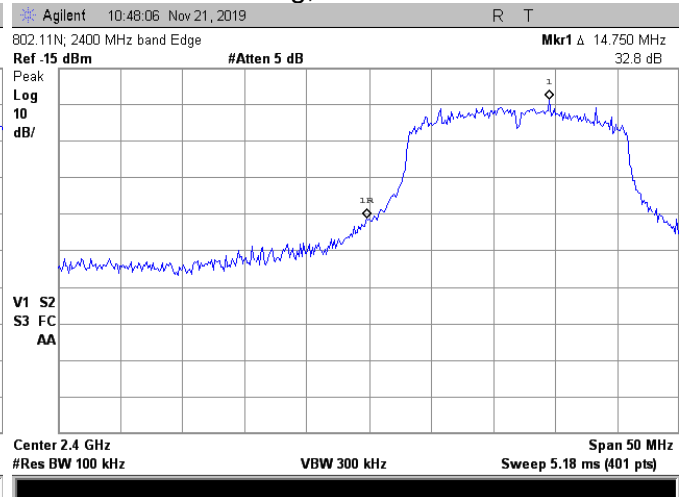
802.11g, Channel 1



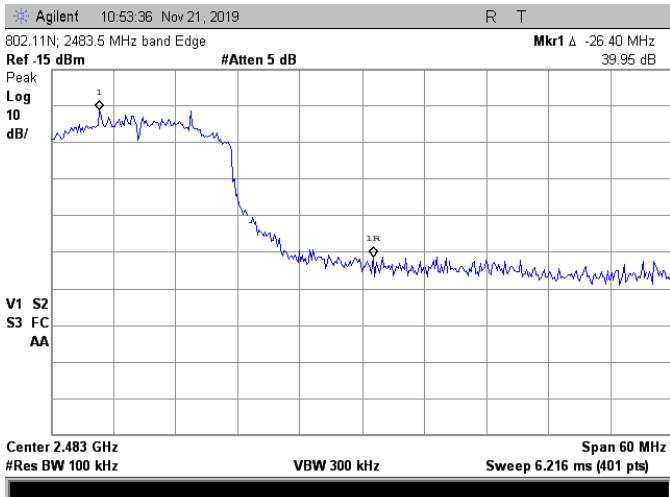
802.11g, Channel 11



802.11N, Channel 1



802.11N, Channel 1



802.11N, Channel 11



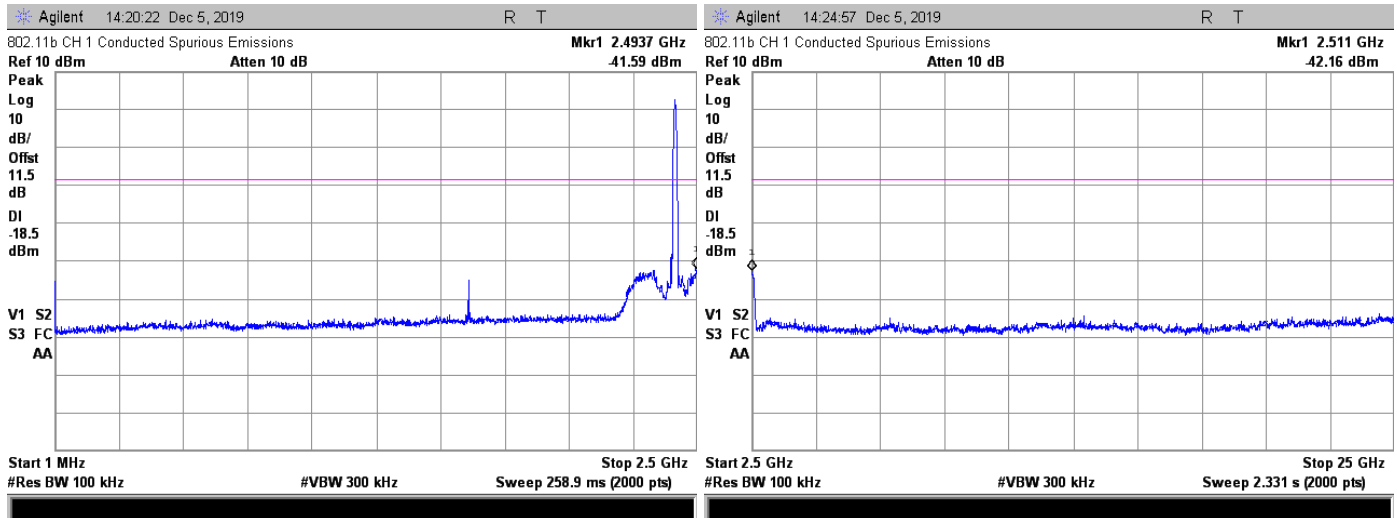
13.5 Spurious RF Conducted Emissions at Antenna Port

The spectrum analyzer was set to the MAX HOLD mode to record all spurious emissions from the lowest frequency generated in the EUT up through the 10th harmonic. The trace was allowed to stabilize. The first two plots were made while stepping through three frequencies (Low middle and high). Each frequency was on for at least 30 seconds.

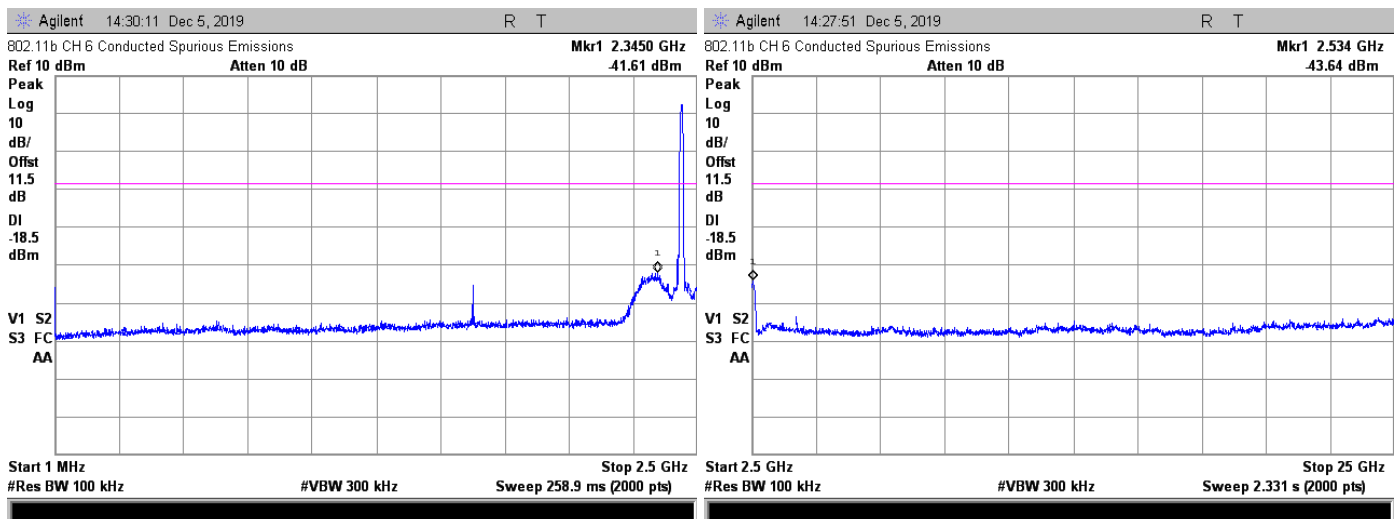
Tested by: Joseph Strzelecki/ Richard Tichgelaar
Test Date: December 6, 2019

Judgement: Pass by at least 15 dB

802.11b

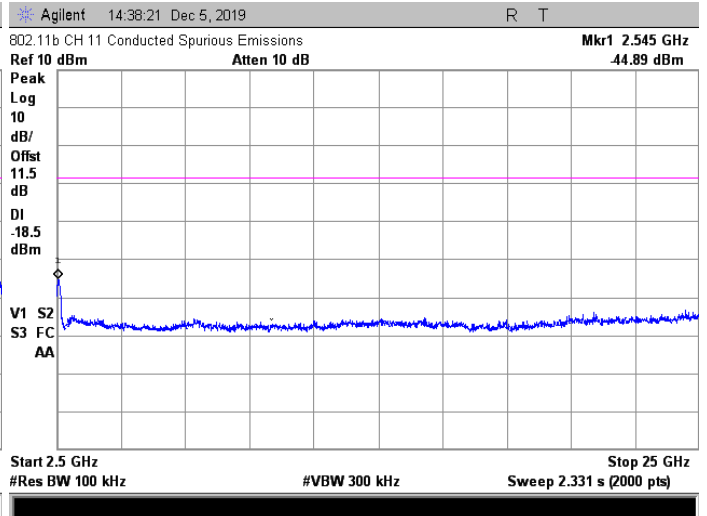
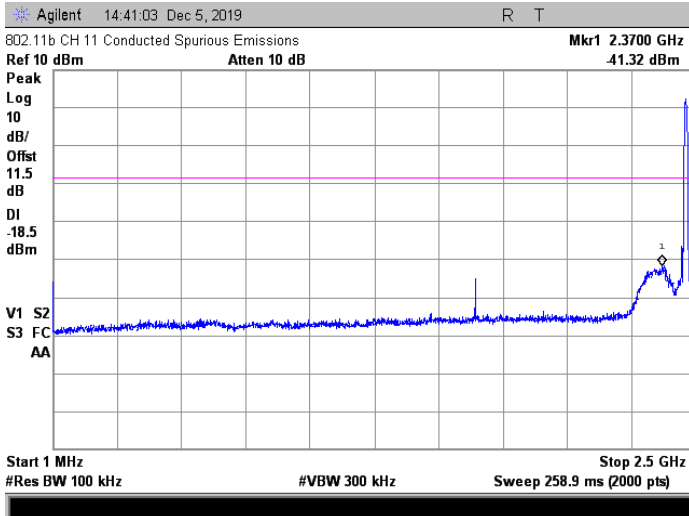


Channel 1



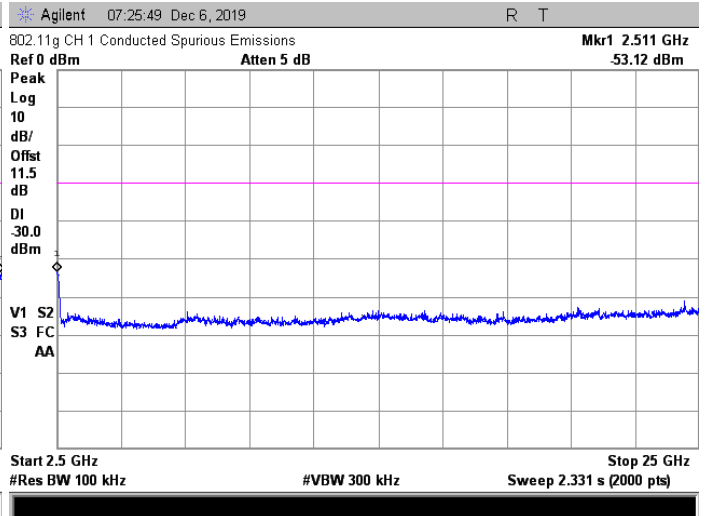
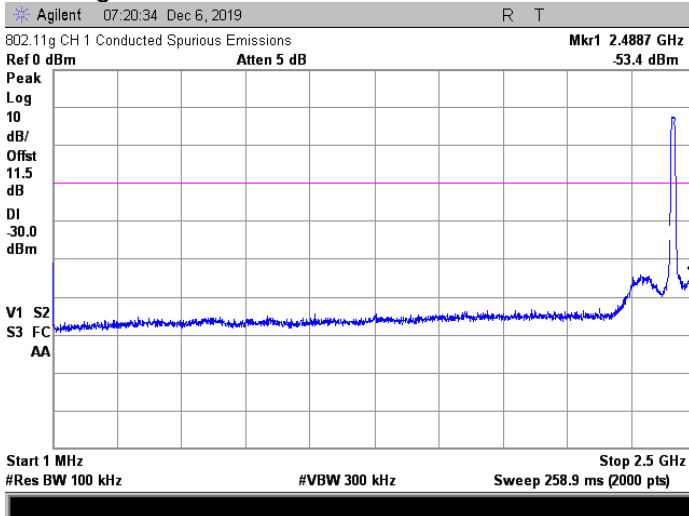
Channel 6

The Pink line is 20 dB below the fundamental.

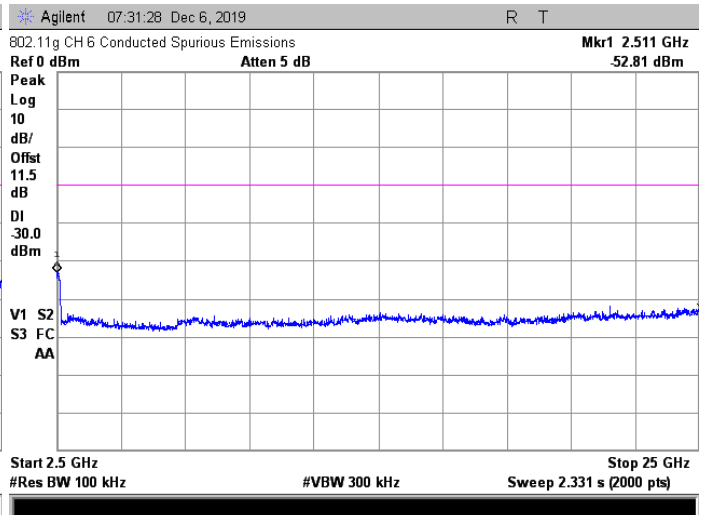
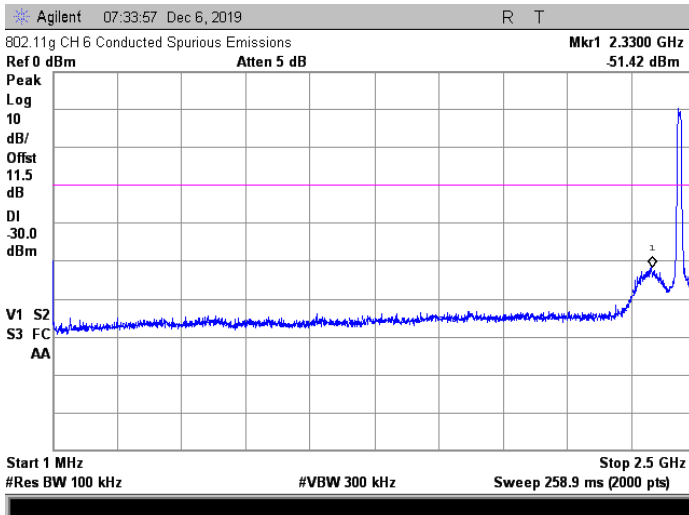


Channel 11

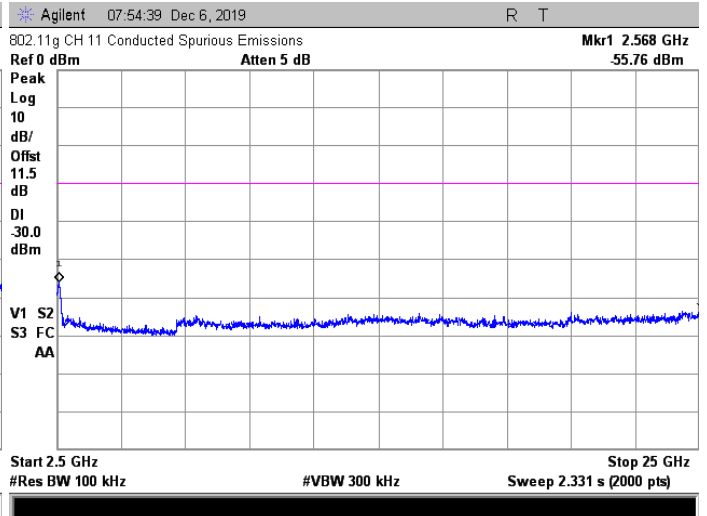
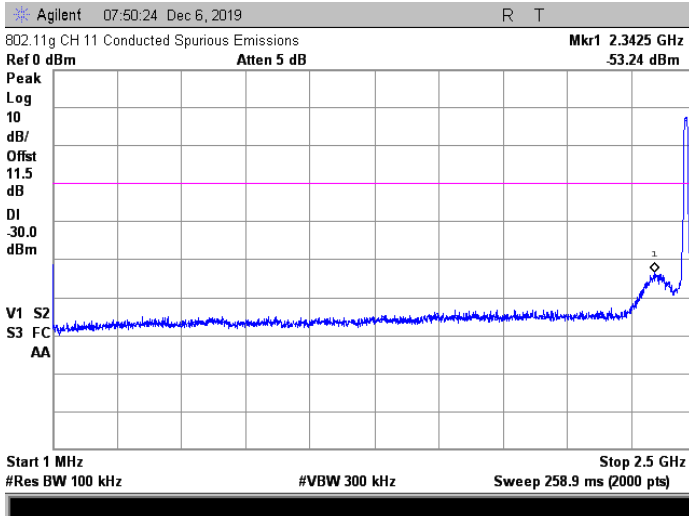
802.11g



Channel 1

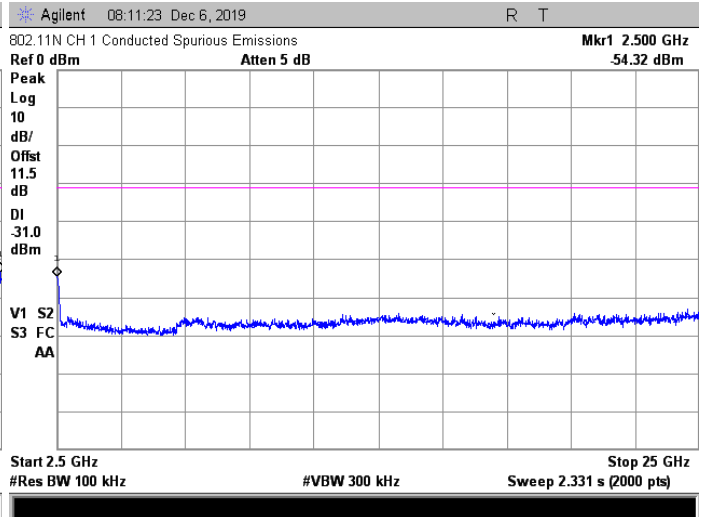
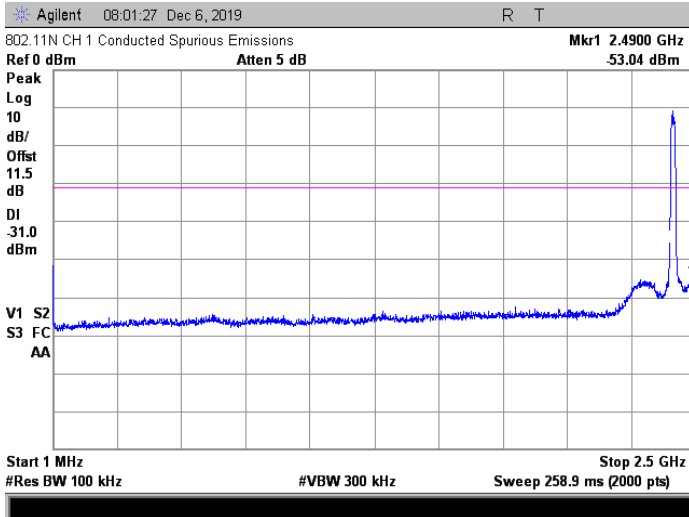


Channel 6

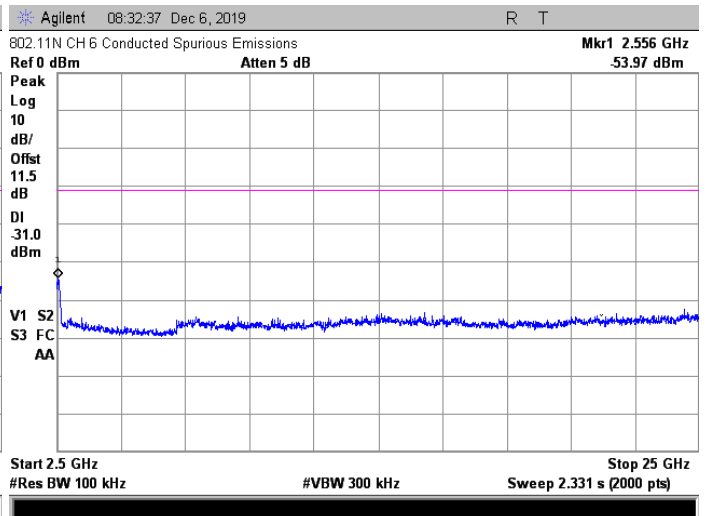
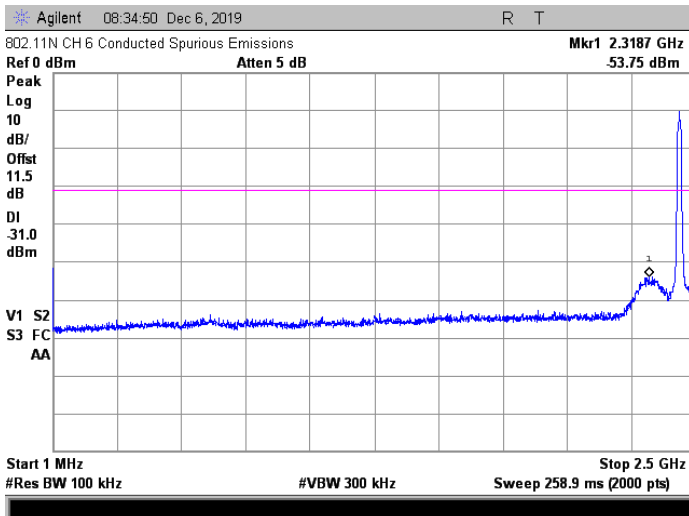


Channel 11

802.11n

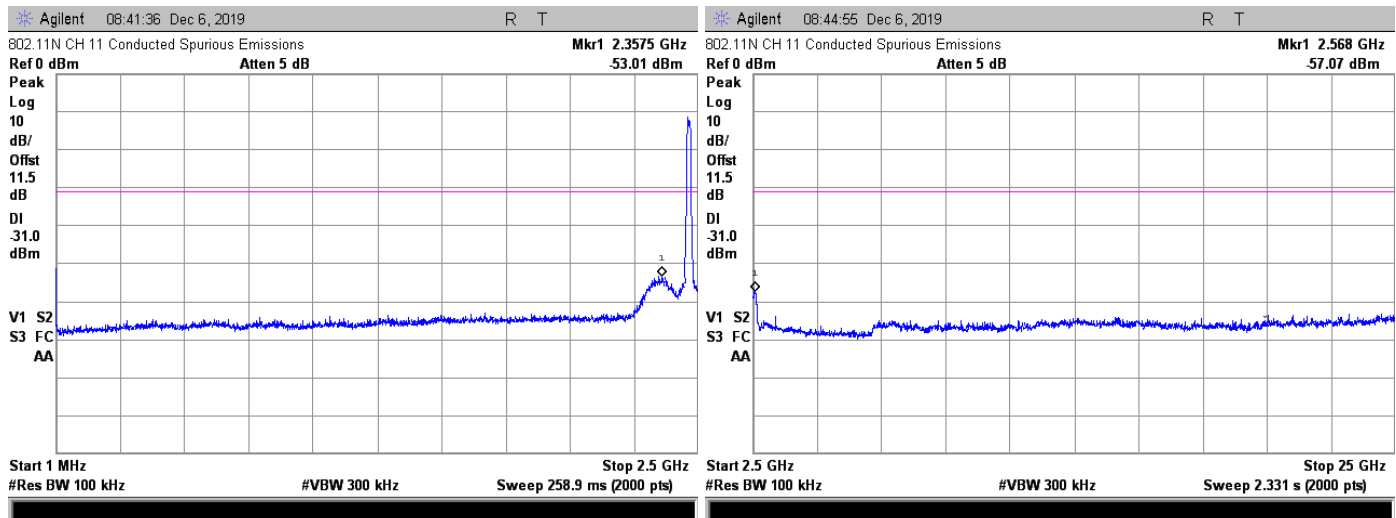


Channel 1



Channel 6

The Pink line is 20 dB below the fundamental.



Channel 11
The Pink line is 20 dB below the fundamental.

13.6 Spurious Radiated Emissions

The procedures were in accordance to FCC DTS Measurement Guideline 558074 D01, Section 12.1 and ANSI C63.10.

Radiated emission measurements were performed with linearly polarized broadband antennas. The results obtained with these antennas can be correlated with results obtained with a tuned dipole antenna. The radiated emission measurements were performed with a spectrum analyzer. The bandwidth used from 30 MHz to 1000 MHz is 120 kHz. Above 1 GHz, a 1 MHz bandwidth is used. A 10 dB linearity check is performed prior to start of testing in order to determine if an overload condition exists. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

For tests from 1 to 10 GHz, a high pass filter was used to reduce the fundamental emission. High pass filters were not needed above 10 GHz, since the preamplifiers attenuated the fundamental emission. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

Radiated emissions measurements were performed inside of an anechoic chamber at a test distance of 3 meters. The anechoic chamber is designated as Chamber E. This Chamber meets the Site Attenuation requirements of ANSI C63.4. Chamber E is located at 12 Devonwood Ave. Romeoville, Illinois EMI test lab.

The entire frequency range from 30 to 25,000 MHz was slowly scanned with particular attention paid to those frequency ranges which appeared high. Measurements were performed using two antenna polarizations, (vertical and horizontal). The worst-case emissions were recorded. All measurements may be performed using either the peak, average or quasi-peak detector functions. If the peak detector data exceeds or is marginally close to the limits, the measurements are repeated using a quasi-peak detector or average function as required by the specification for final determination of compliance.

The detected emission levels were maximized by rotating the EUT, adjusting the positions of all cables, and by scanning the measurement antenna from 1 to 4 meters above the ground.

13.6.1 Radiated Emissions Field Strength Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Loss, and by subtracting the Amplifier Gain from the measured reading. The antenna factor converts the voltage reading in dBuV to field strength in dBuV/meter. The basic equation is as follows:



FS = RA + AF + CF - AG

Where: FS = Field Strength in dBuV/m

RA = Receiver Amplitude dBuV

AF = Antenna Factor dB/m

CF = Cable Attenuation Factor dB

AG = Amplifier Gain dB

HPF = High pass Filter Loss dB

13.7 Radiated Emissions Test Results

Table with 2 columns: Test Parameter and Value. Rows include Test Date (11/21/2019 & 12/03/2019), Test Distance (3 Meters), Specification (FCC Part 15 Subpart C & RSS-GEN), Abbreviations (Pol = Antenna Polarization; V = Vertical; H = Horizontal; P = peak; Q = QP), and Configuration (The EUT is in the transmit mode with the receiver on).

This table includes all emissions except Fundamental, Band Edge, and Harmonics emissions.

Large table with 11 columns: Freq. MHz, Meter Reading dBuV, Decet., Ant. Pol., Ant Factor dB/m, Cbl/amp Factors, Dist Fact dB, EUT dBuV/m, Limit dBuV/m, Margin Under Limit dB, Note. Contains 34 rows of test data.



Freq. MHz	Meter Reading dBuV	Dect.	Ant. Pol.	Ant Factor dB/m	Cbl/amp Factors	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
5705.0	36.8	P	H	34.2	-27.3	0.0	43.7	74.0	30.3	1
5892.5	36.9	P	H	34.4	-27.3	0.0	44.0	74.0	30.0	1
6102.5	36.2	P	H	34.8	-26.9	0.0	44.1	74.0	29.9	1
6500.0	39.4	P	H	34.5	-26.4	0.0	47.5	74.0	26.5	1
40.5	21.9	P	V	11.1	0.6	0.0	33.7	40.0	6.3	
65.9	18.3	P	V	9.2	0.8	0.0	28.3	40.0	11.7	
89.1	15.9	P	V	9.7	1.0	0.0	26.6	43.5	16.9	
122.8	17.2	P	V	11.8	1.1	0.0	30.1	43.5	13.4	
149.3	16.3	P	V	12.8	1.2	0.0	30.4	43.5	13.1	
176.4	21.0	P	V	13.2	1.4	0.0	35.5	43.5	8.0	
194.6	6.2	Q	V	14.1	1.4	0.0	21.8	43.5	21.7	
207.4	16.2	P	V	14.6	1.5	0.0	32.2	43.5	11.3	
228.9	14.3	P	V	15.1	1.5	0.0	31.0	46.0	15.0	
243.3	13.8	P	V	15.2	1.6	0.0	30.6	46.0	15.4	
275.3	18.0	P	V	12.9	1.7	0.0	32.6	46.0	13.4	
284.8	20.3	P	V	13.5	1.8	0.0	35.5	46.0	10.5	
303.0	19.7	P	V	14.8	1.8	0.0	36.3	46.0	9.7	
432.2	16.5	P	V	16.3	2.2	0.0	35.0	46.0	11.0	
467.5	15.7	P	V	16.9	2.3	0.0	34.8	46.0	11.2	
608.8	14.5	P	V	18.7	2.6	0.0	35.8	46.0	10.2	
785.0	16.8	P	V	21.5	3.0	0.0	41.3	46.0	4.7	
805.0	12.9	P	V	20.1	3.1	0.0	36.1	46.0	9.9	
878.8	12.5	P	V	22.3	3.2	0.0	38.1	46.0	7.9	
987.5	9.1	P	V	22.9	3.4	0.0	35.4	54.0	18.6	
1000.0	39.9	P	V	24.3	-33.0	0.0	31.2	54.0	22.8	1
1067.5	42.8	P	V	24.9	-33.3	0.0	34.5	74.0	39.5	1
1215.0	47.7	P	V	25.5	-33.2	0.0	40.0	74.0	34.0	1
1400.0	48.6	P	V	25.5	-33.2	0.0	40.9	74.0	33.1	1
1930.0	47.8	P	V	27.8	-32.7	0.0	42.9	74.0	31.1	1
2247.5	48.1	P	V	27.7	-32.5	0.0	43.3	74.0	30.7	1
2326.0	53.6	A	V	28.0	-32.4	0.0	49.2	54.0	4.8	
2326.0	61.2	P	V	28.0	-32.4	0.0	56.9	74.0	17.1	
2522.1	56.9	P	V	28.7	-32.0	0.0	53.6	74.0	20.4	
2522.1	45.8	A	V	28.7	-32.0	0.0	42.5	54.0	11.5	
2590.0	52.4	P	V	28.9	-32.1	0.0	49.2	74.0	24.8	1
3377.5	39.7	P	V	31.2	-30.9	0.0	40.0	74.0	34.0	1
3740.0	38.6	P	V	32.2	-30.3	0.0	40.5	74.0	33.5	1
4060.7	48.0	P	V	32.9	-30.0	0.0	50.9	74.0	23.1	
4060.7	43.2	A	V	32.9	-30.0	0.0	46.1	54.0	7.9	
4290.0	37.2	P	V	32.7	-29.8	0.0	40.1	74.0	33.9	1
4517.5	36.6	P	V	33.4	-29.3	0.0	40.7	74.0	33.3	1
4875.0	45.9	P	V	33.5	-28.7	0.0	50.7	74.0	23.3	1
5087.5	35.4	P	V	33.8	-28.3	0.0	40.8	74.0	33.2	1
5460.0	35.9	P	V	34.3	-27.8	0.0	42.4	74.0	31.6	1
5830.0	37.3	P	V	34.2	-27.4	0.0	44.2	74.0	29.8	1
6255.0	36.7	P	V	34.8	-27.0	0.0	44.6	74.0	29.4	1
6460.0	36.4	P	V	34.5	-26.5	0.0	44.4	74.0	29.6	1
6635.0	36.6	P	V	34.9	-26.4	0.0	45.1	74.0	28.9	1
6872.5	36.3	P	V	35.3	-26.4	0.0	45.2	74.0	28.8	1

Note1 : Peak reading below Average limits, so average readings not performed for that frequency.

Judgment: Passed by 4.7 dB

No other emissions were detected in within 10 db of the limits.



Harmonic Emissions above 1 GHz; There is no radiated limit on the fundamental

#	Tx	Spectrum Analyzer Readings				EUT	Peak	Ave	Peak	Ave	Margin	Under	802.11 Mode					
		Vertical		Horizontal										Emission	Tot. FS		Limit	
		Peak	Ave	Peak	Ave										dB/m	Freq MHz	dBuV/m	
BE	2412	46.9	44.5	51.3	49.7	-3.0	2390.0	48.3	46.7	74	54	7.3	b					
2	2412	43.4	41.8	45.9	43.8	3.2	4824.0	49.1	47.0	74	54	7.0	b					
3	2412	40.7	38.7	40.9	39.0	8.1	7236.0	49.0	47.1	74	54	6.9	b					
2	2437	45.2	43.6	44.9	43.0	3.4	4874.0	48.6	47.0	74	54	7.0	b					
3	2437	43.1	41.0	43.8	41.3	8.6	7311.0	52.4	49.9	74	54	4.1	b					
BE	2462	47.0	44.7	46.6	44.3	-2.6	2483.5	44.4	42.1	74	54	11.9	b					
2	2462	41.0	38.8	39.5	37.3	3.4	4924.0	44.4	42.2	74	54	11.8	b					
3	2462	38.1	36.3	39.7	38.0	8.9	7386.0	48.6	46.9	74	54	7.1	b					
BE	2412	45.6	40.1	50.5	45.9	-3.0	2390.0	47.5	42.9	74	54	11.1	g					
2	2412	39.1	33.6	45.1	40.2	3.2	4824.0	48.3	43.4	74	54	10.6	g					
3	2412	37.4	31.9	38.2	33.6	8.1	7236.0	46.3	41.7	74	54	12.3	g					
2	2437	38.4	32.9	44.7	40.0	3.4	4874.0	48.1	43.4	74	54	10.6	g					
3	2437	39.2	33.7	38.6	33.5	8.6	7311.0	47.8	42.3	74	54	11.7	g					
BE	2462	45.2	39.7	53.4	48.1	-2.6	2483.5	50.8	45.5	74	54	8.5	g					
2	2462	38.3	32.8	45.0	40.2	3.4	4924.0	48.4	43.6	74	54	10.4	g					
3	2462	38.5	33.0	38.3	33.2	8.9	7386.0	47.4	42.1	74	54	11.9	g					
BE	2412	47.5	42.4	49.8	44.1	-3.0	2390.0	46.8	41.1	74	54	12.9	N					
2	2412	38.9	33.4	38.1	32.7	3.2	4824.0	42.1	36.6	74	54	17.4	N					
3	2412	38.9	33.5	37.3	32.2	8.1	7236.0	47.0	41.6	74	54	12.4	N					
2	2437	40.3	34.5	41.1	35.6	3.4	4874.0	44.5	39.0	74	54	15.0	N					
3	2437	38.7	32.8	37.7	32.0	8.6	7311.0	47.3	41.4	74	54	12.6	N					
BE	2462	48.7	43.5	52.9	47.5	-2.6	2483.5	50.3	44.9	74	54	9.1	N					
2	2462	38.1	32.5	38.3	32.3	3.4	4924.0	41.7	35.9	74	54	18.1	N					
3	2462	37.6	31.9	37.7	32.1	8.9	7386.0	46.6	41.0	74	54	13.0	N					
Column numbers (see below for explanations)																		
1	2	3	4	5	6	7	8	9	10	11	12	13	14					

Notes on Columns:

- Column #1. hrm = Harmonic; BE = Band Edge emissions
- Column #2. Frequency of Transmitter.
- Column #3. Peak reading readings from the spectrum analyzer (Vertical Pol)
- Column #4. Average reading readings from the spectrum analyzer (Vertical Pol)
- Column #5. Peak reading readings from the spectrum analyzer (Horizontal Pol)
- Column #6. Average reading readings from the spectrum analyzer (Horizontal Pol)
- Column #7. Corr. Factors = Cable Loss – Preamp Gain + Antenna Factor
- Column #8. Frequency of Tested Emission
- Column #9. Highest peak field strength at listed frequency.
- Column #10. Highest Average field strength at listed frequency.
- Column #11. Peak Limit using FCC 15.209
- Column #12. Average Limit using FCC 15.209.
- Column #13. The margin (last column) is the worst case margin under the peak or average limits for that row.
- Column #14. 802.11b, g or N mode tested

Judgment: Passed by 4.1 dB

All emissions outside of the band from 2390 to 2483.5 were below the limits of 15.209.

No other Emissions were detected from 30 to 25,000 MHz within 10 dB of the limits.

All emissions were measured including outside restricted bands.



14.0 BLUETOOTH RESULTS

14.1 Radiated Emissions Procedures

The procedures were in accordance to ANSI C63.10.

Radiated emission measurements were performed with linearly polarized broadband antennas. The results obtained with these antennas can be correlated with results obtained with a tuned dipole antenna. The radiated emission measurements were performed with a spectrum analyzer. The bandwidth used from 30 MHz to 1000 MHz is 120 kHz. Above 1 GHz, a 1 MHz bandwidth is used. A 10 dB linearity check is performed prior to start of testing in order to determine if an overload condition exists. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

For tests from 1 to 10 GHz, a high pass filter was used to reduce the fundamental emission. High pass filters were not needed above 10 GHz, since the preamplifiers attenuated the fundamental emission. Figure 4 herein lists the details of the test equipment used during radiated emissions tests.

Radiated emissions measurements were performed inside of an anechoic chamber at a test distance of 3 meters. The anechoic chamber is designated as Chamber E. This Chamber meets the Site Attenuation requirements of ANSI C63.4. Chamber E is located at 12 Devonwood Ave. Romeoville, Illinois EMI test lab.

The entire frequency range from 30 to 25,000 MHz was slowly scanned with particular attention paid to those frequency ranges which appeared high. Measurements were performed using two antenna polarizations, (vertical and horizontal). The worst-case emissions were recorded. All measurements may be performed using either the peak, average or quasi-peak detector functions. If the peak detector data exceeds or is marginally close to the limits, the measurements are repeated using a quasi-peak detector or average function as required by the specification for final determination of compliance.

The detected emission levels were maximized by rotating the EUT, adjusting the positions of all cables, and by scanning the measurement antenna from 1 to 4 meters above the ground.

14.2 Radiated Emissions Results

Test Date	12-06-2019
Test Distance	3 Meters
Specification	FCC Part 15 Subpart C & RSS-210 Section B.10
Abbreviations	Pol = Antenna Polarization; V = Vertical; H = Horizontal; P = peak; Q = QP
Configuration	Both bluetooth transmitters were on during the tests.

The EUT is in the transmit mode with the receiver on

This table includes all emissions except Fundamental, Band edge and harmonics emissions.

Freq. MHz	Meter Reading dBuV	Dect.	Ant. Pol.	Ant Factor dB/m	Cbl/amp Factors	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
40.5	11.3	P	H	11.1	0.6	0.0	23.0	40.0	17.0	
67.6	12.7	P	H	9.3	0.8	0.0	22.8	40.0	17.2	
172.0	14.7	P	H	13.1	1.3	0.0	29.1	43.5	14.4	
183.0	15.3	P	H	13.6	1.4	0.0	30.3	43.5	13.2	
200.2	15.1	P	H	14.3	1.4	0.0	30.8	43.5	12.7	
249.9	15.3	P	H	15.4	1.6	0.0	32.3	46.0	13.7	
580.0	12.9	P	H	18.2	2.5	0.0	33.7	46.0	12.3	
601.3	10.0	P	H	18.6	2.6	0.0	31.2	46.0	14.8	



Freq. MHz	Meter Reading dBuV	Decet.	Ant. Pol.	Ant Factor dB/m	Cbl/amp Factors	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
751.3	14.6	P	H	21.6	2.9	0.0	39.1	46.0	6.9	
876.3	11.9	P	H	22.2	3.2	0.0	37.3	46.0	8.7	
941.3	9.5	P	H	22.6	3.4	0.0	35.4	46.0	10.6	
1300.0	50.1	P	H	25.5	-33.2	0.0	42.4	74.0	31.6	1
1350.0	52.4	P	H	25.6	-33.2	0.0	44.7	74.0	29.3	1
1400.0	52.3	P	H	25.5	-33.2	0.0	44.6	74.0	29.4	1
1425.0	51.0	P	H	25.5	-33.2	0.0	43.3	74.0	30.7	1
1930.0	47.8	P	H	27.8	-32.7	0.0	42.9	74.0	31.1	1
2312.5	50.3	P	H	27.9	-32.4	0.0	45.7	74.0	28.3	1
2327.5	47.2	P	H	28.0	-32.4	0.0	42.9	74.0	31.1	1
2360.0	49.2	P	H	28.3	-32.3	0.0	45.2	74.0	28.8	1
2392.5	54.4	P	H	28.5	-32.3	0.0	50.6	74.0	23.4	1
2552.5	45.9	P	H	28.8	-31.9	0.0	42.8	74.0	31.2	1
4575.0	38.2	P	H	33.5	-29.2	0.0	42.5	74.0	31.5	1
4755.0	38.3	P	H	33.4	-28.9	0.0	42.8	74.0	31.2	1
5075.0	37.2	P	H	33.7	-28.4	0.0	42.5	74.0	31.5	1
5472.5	37.3	P	H	34.3	-27.8	0.0	43.8	74.0	30.2	1
42.2	9.8	Q	V	10.6	0.6	0.0	21.1	40.0	18.9	1
50.4	5.8	Q	V	9.4	0.7	0.0	15.9	40.0	24.1	1
74.8	19.2	P	V	9.3	0.9	0.0	29.4	40.0	10.6	
122.3	19.9	P	V	11.8	1.1	0.0	32.8	43.5	10.7	
130.6	18.9	P	V	12.2	1.2	0.0	32.3	43.5	11.2	
176.4	16.9	P	V	13.2	1.4	0.0	31.4	43.5	12.1	
200.2	17.0	P	V	14.3	1.4	0.0	32.8	43.5	10.7	
249.9	19.8	P	V	15.4	1.6	0.0	36.9	46.0	9.1	
250.1	22.6	P	V	11.9	1.6	0.0	36.2	46.0	9.8	
284.8	22.3	P	V	13.5	1.8	0.0	37.6	46.0	8.4	
325.1	13.0	P	V	14.0	1.9	0.0	28.9	46.0	17.1	
345.9	13.6	P	V	14.1	1.9	0.0	29.6	46.0	16.4	
423.4	11.1	P	V	16.2	2.2	0.0	29.5	46.0	16.5	
485.1	13.1	P	V	17.1	2.3	0.0	32.5	46.0	13.5	
571.3	18.7	P	V	18.4	2.5	0.0	39.7	46.0	6.3	
605.0	17.4	P	V	18.6	2.6	0.0	38.7	46.0	7.3	
612.5	13.5	P	V	18.7	2.6	0.0	34.8	46.0	11.2	
751.3	12.4	P	V	21.6	2.9	0.0	36.9	46.0	9.1	
902.5	11.7	P	V	21.5	3.3	0.0	36.5	46.0	9.5	
968.8	10.8	P	V	23.2	3.4	0.0	37.4	54.0	16.6	
1300.0	48.2	P	V	25.5	-33.2	0.0	40.5	74.0	33.5	1
1350.0	48.9	P	V	25.6	-33.2	0.0	41.2	74.0	32.8	1
1400.0	50.4	P	V	25.5	-33.2	0.0	42.7	74.0	31.3	1
1450.0	46.8	P	V	25.5	-33.2	0.0	39.2	74.0	34.8	1
2265.0	46.2	P	V	27.7	-32.5	0.0	41.4	74.0	32.6	1
2552.5	48.3	P	V	28.8	-31.9	0.0	45.2	74.0	28.8	1
2585.0	50.3	P	V	28.9	-32.1	0.0	47.1	74.0	26.9	1
2600.0	46.8	P	V	28.9	-32.0	0.0	43.8	74.0	30.2	1
3710.0	41.1	P	V	32.0	-30.4	0.0	42.6	74.0	31.4	1
3980.0	41.3	P	V	32.9	-30.2	0.0	44.0	74.0	30.0	1
4075.0	38.3	P	V	32.9	-29.9	0.0	41.3	74.0	32.7	1
4532.5	37.2	P	V	33.4	-29.3	0.0	41.3	74.0	32.7	1
5077.5	36.0	P	V	33.7	-28.4	0.0	41.3	74.0	32.7	1
5442.5	37.5	P	V	34.3	-27.9	0.0	43.9	74.0	30.1	1

Note1 : Peak reading below Average limits, so average readings not performed for that frequency.

Judgment: Passed by 6.3 dB



HS Bluetooth Fundamental, Band edge, and harmonics

		Spectrum Analyzer Readings				Corr.	EUT	Peak	Ave	Peak	Ave	Margin
hrm	Tx						Emission	Tot. FS		Limit		Under
#	Freq	Vertical		Horizontal		Fact. dB/m	Freq MHz	dBuV/m		dBuV/m		Limit
		Peak	Ave	Peak	Ave							
1	2402	103.8	85.9	100.9	83.8	-3.0	2402.0	100.8	82.9	114	94	11.1
BE	2402	63.8	46.0	60.9	42.8	-3.0	2400.0	60.8	43.0	74	54	11.0
2	2402	39.5	21.8	46.9	29.1	3.2	4804.0	50.1	32.3	74	54	21.7
3	2402	44.2	27.2	40.2	22.7	8.1	7206.0	52.3	35.3	74	54	18.7
1	2440	105.5	87.8	99.4	81.6	-2.8	2440.0	102.7	85.0	114	94	9.0
2	2440	39.4	21.6	47.6	29.7	3.4	4880.0	51.0	33.1	74	54	20.9
3	2440	44.4	26.2	40.3	22.9	8.6	7320.0	53.0	34.8	74	54	19.2
1	2480	103.6	86.6	94.0	76.4	-2.6	2480.0	101.0	84.0	114	94	10.0
BE	2480	63.0	45.2	53.4	35.1	-2.6	2483.5	60.4	42.6	74	54	11.4
2	2480	40.5	22.7	47.1	29.0	3.4	4960.0	50.5	32.4	74	54	21.6
3	2480	45.3	27.0	41.2	23.1	8.9	7440.0	54.2	35.9	74	54	18.1
Column numbers (see below for explanations)												
1	2	3	4	5	6	7	8	9	10	11	12	13

Notes on Columns:

- Column #1. hrm = Harmonic; BE = Band Edge emissions
- Column #2. Frequency of Transmitter.
- Column #3. Peak reading readings from the spectrum analyzer (Vertical Pol)
- Column #4. Average reading readings from the spectrum analyzer (Vertical Pol)
- Column #5. Peak reading readings from the spectrum analyzer (Horizontal Pol)
- Column #6. Average reading readings from the spectrum analyzer (Horizontal Pol)
- Column #7. Corr. Factors = Cable Loss – Preamp Gain + Antenna Factor
- Column #8. Frequency of Tested Emission
- Column #9. Highest peak field strength at listed frequency.
- Column #10. Highest Average field strength at listed frequency.
- Column #11. Peak Limit using FCC 15.209
- Column #12. Average Limit using FCC 15.209.
- Column #13. The margin (last column) is the worst case margin under the peak or average limits for that row.

Judgment: Passed by 9.0 dB

All emissions outside of the band from 2340 to 2483.5 were below the limits of 15.209. No other Emissions were detected from 30 to 25,000 MHz within 10 dB of the limits.



LENS Bluetooth Fundamental, Band edge and harmonics

		Spectrum Analyzer Readings				Corr.	EUT	Peak	Ave	Peak	Ave	Margin
hrm	Tx						Emission	Tot. FS		Limit		Under
#	Freq	Vertical		Horizontal		Fact. dB/m	Freq MHz	dBuV/m		dBuV/m		Limit
		Peak	Ave	Peak	Ave							
1	2402	96.4	77.8	88.1	68.3	-3.0	2402.0	93.4	74.8	114	94	19.2
BE	2402	62.6	43.4	54.3	35.9	-3.0	2400.0	59.6	40.4	74	54	13.6
2	2402	52.1	32.8	51.2	31.6	3.2	4804.0	55.3	36.0	74	54	18.0
3	2402	47.8	28.5	52.4	33.8	8.1	7206.0	60.5	41.9	74	54	12.1
4	2402	42.1	23.0	38.6	19.1	0.0	9608.0	42.1	23.0	74	54	31.0
1	2440	100.4	81.6	90.1	71.3	-2.8	2440.0	97.6	78.8	114	94	15.2
2	2440	51.4	32.9	50.0	30.6	3.4	4880.0	54.8	36.3	74	54	17.7
3	2440	46.0	27.4	51.6	33.3	8.6	7320.0	60.2	41.9	74	54	12.1
4	2440	42.1	23.0	41.8	22.3	0.0	9760.0	42.1	23.0	74	54	31.0
1	2480	97.3	78.4	91.6	73.2	-2.6	2480.0	94.7	75.8	114	94	18.2
BE	2480	60.8	41.4	55.1	36.1	-2.6	2483.5	58.2	38.8	74	54	15.2
2	2480	52.3	32.9	48.4	29.0	3.4	4960.0	55.7	36.3	74	54	17.7
3	2480	47.3	28.2	52.3	32.7	8.9	7440.0	61.2	41.6	74	54	12.4
4	2480	37.7	18.0	37.7	19.1	10.3	9920.0	48.0	29.4	74	54	24.6
Column numbers (see below for explanations)												
1	2	3	4	5	6	7	8	9	10	11	12	13

Notes on Columns:

- Column #1. hrm = Harmonic; BE = Band Edge emissions
- Column #2. Frequency of Transmitter.
- Column #3. Peak reading readings from the spectrum analyzer (Vertical Pol)
- Column #4. Average reading readings from the spectrum analyzer (Vertical Pol)
- Column #5. Peak reading readings from the spectrum analyzer (Horizontal Pol)
- Column #6. Average reading readings from the spectrum analyzer (Horizontal Pol)
- Column #7. Corr. Factors = Cable Loss – Preamp Gain + Antenna Factor
- Column #8. Frequency of Tested Emission
- Column #9. Highest peak field strength at listed frequency.
- Column #10. Highest Average field strength at listed frequency.
- Column #11. Peak Limit using FCC 15.209
- Column #12. Average Limit using FCC 15.209.
- Column #13. The margin (last column) is the worst case margin under the peak or average limits for that row.

Judgment: Passed by at least 10 dB

All emissions outside of the band from 2340 to 2483.5 were below the limits of 15.209. No other Emissions were detected from 30 to 25,000 MHz within 10 dB of the limits.

14.3 Occupied Bandwidth Data

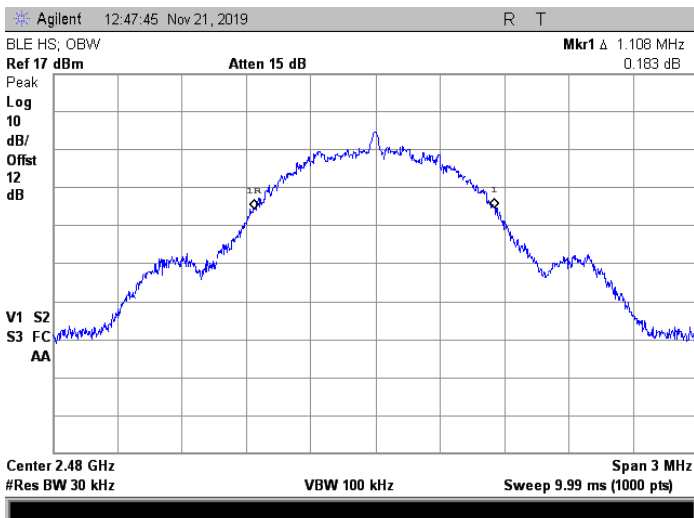
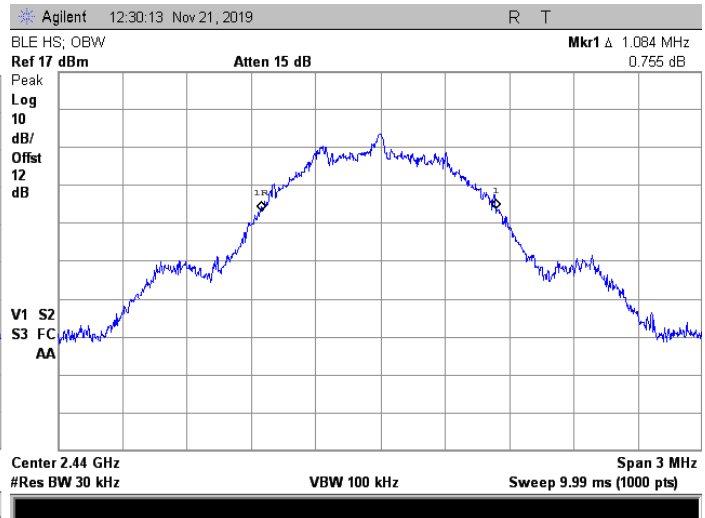
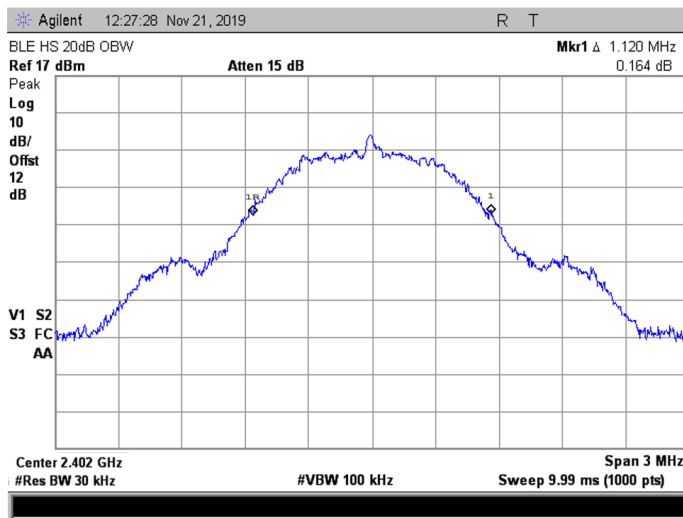
The occupied bandwidth of the RF output was measured using a spectrum analyzer. The bandwidth was measured using the peak detector function. The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation. The marker-to-peak function was set to the peak of the emission. Then the marker-delta function was used to measure 20 dB down one side of the emission. The marker-delta function was reset and then moved to the other side of the emission, until it is (as close as possible to) even with the reference marker level. The marker-delta reading at this point is the bandwidth of the emission. The plots of the occupied bandwidth for the EUT are supplied on the following pages.



The 20 dB OBW is within the allowed 2400 to 2483.5 MHz authorized band.

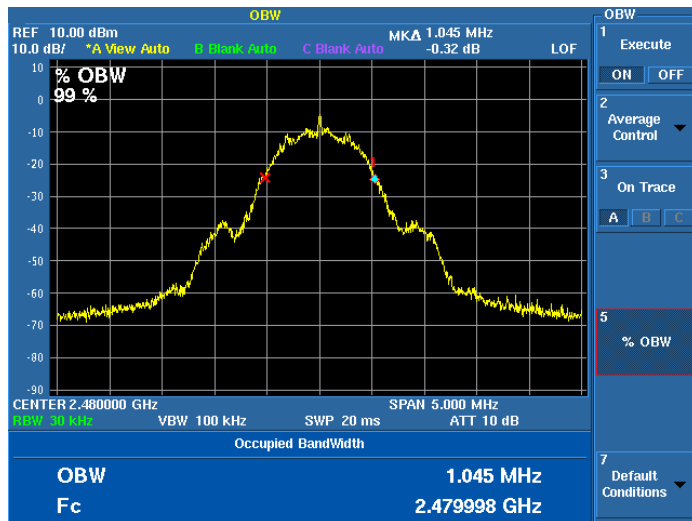
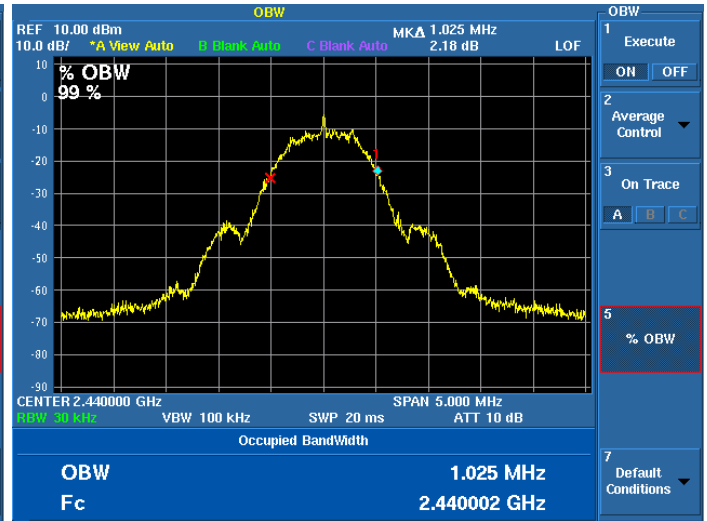
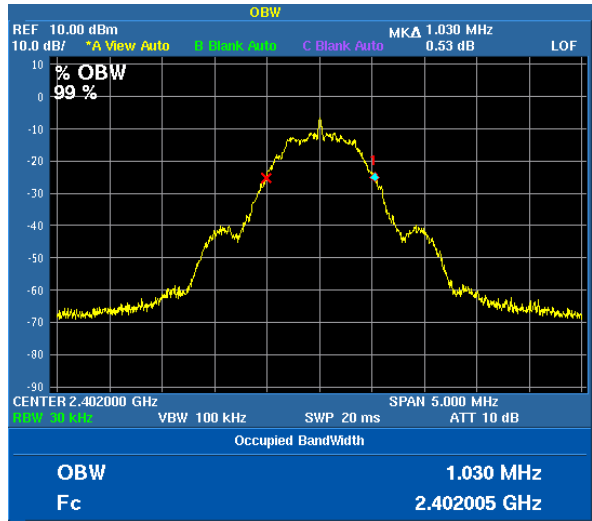
BLE EUT	Channel	20 dB OBW MHz	99% EBW MHz
HS	2402	1.120	1.030
HS	2440	1.084	1.025
HS	2480	1.108	1.045
LENS	2402	1.1806	1.090
LENS	2440	1.1946	1.085
LENS	2480	1.1926	1.080

HS 20 dB

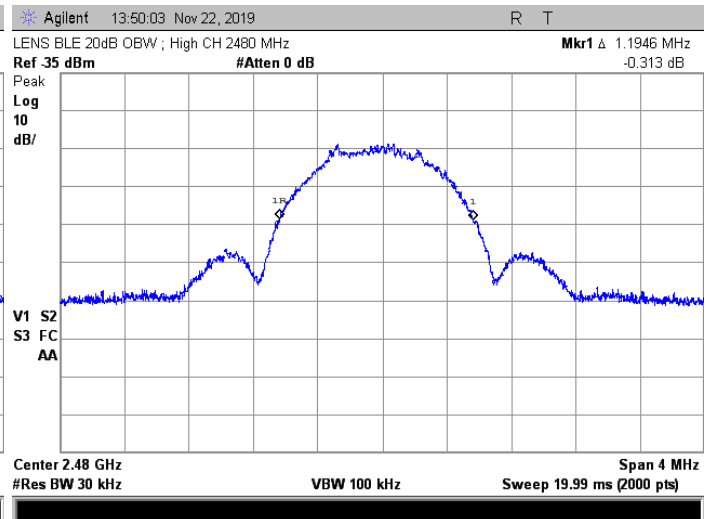
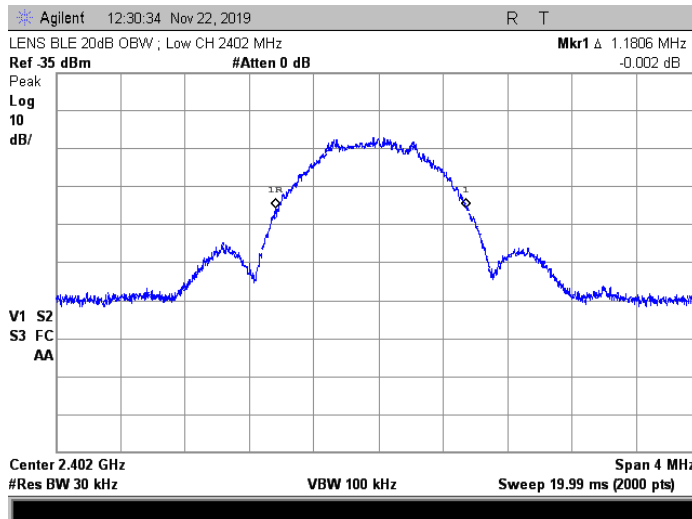


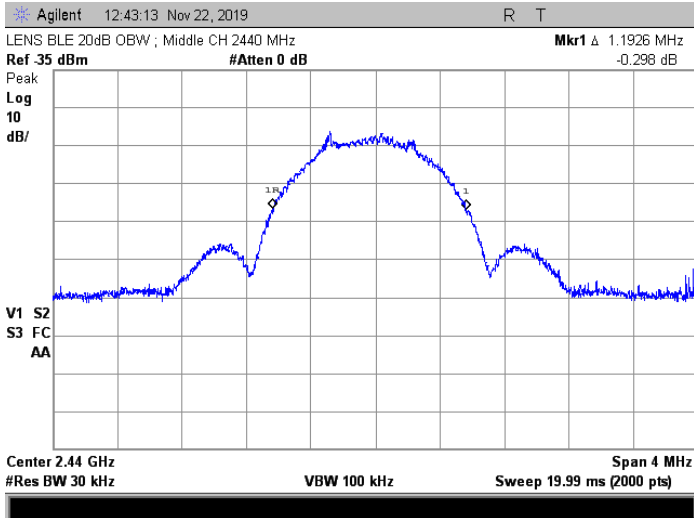


HS BLE 99%

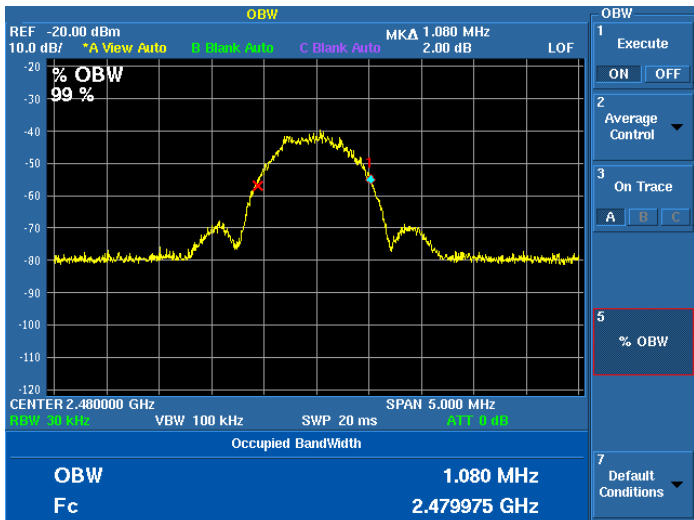
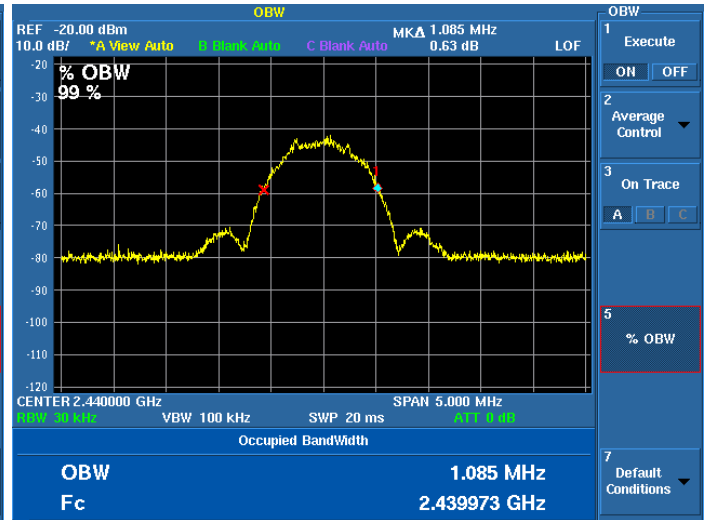
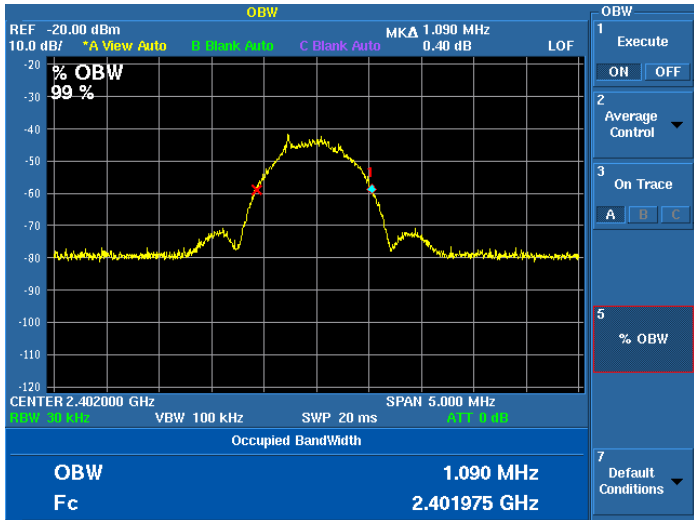


LENS 20 dB





LENS BLE 99%





15.0 FCC 15.209 TESTS RESULTS

15.1 Magnetic Field Measurements and Decay Factor Calculations

Radiated emission measurements are performed with an EMCO shielded loop antenna. The antenna was rotated in order to find the maximize readings.

The distance correction factor is calculated as follows:

The distance factor in (dB) = $DE \cdot 20 \cdot \log(TD/SD)$

Where: DE = Decay Exponent (2.0 is used for this)

TD = Test distance in meters. This is 3 meters

SD = Specification Distance in meters

From 9 kHz to 490 kHz, the Specification Distance is 300m therefore the distance factor is $2 \cdot 20 \cdot \log(300/3) = 80$ dB.

From 490 kHz to 30 MHz, the Specification Distance is 30m therefore the distance factor is $2 \cdot 20 \cdot \log(30/3) = 40$ dB.

15.1.1 Magnetic Field Radiated Emissions Results (0.009 to 30 MHz)

Test Date	12/20/2019
EUT	R2
Test Distance	3 Meters
Specification	FCC 15.209 & RSS-GEN table 5 limit for all frequencies
Tested by	Chris Dalessio; Joseph Strzelecki

Freq (kHz)	Peak reading dBuV	Loop Ant Factor dB/m	Test Dist. (m)	Decay exp	Cable Loss dB	FCC Distance factor dB	Field Strength dBuV/m	RSS & FCC Limit dBuV/m	Margin under limit	Notes
13560	46.7	16.8	3.0	2.0	0.4	-40.0	23.9	29.5	5.6	
27120	15.6	16.0	3.0	2.0	0.5	-40.0	-7.9	29.5	37.4	

All limits are general limits of FCC 15.209 or the RSS-Gen.

No other emissions were detected from 10 kHz to 30 MHz within 10 dB of the 15.209 or the RSS-GEN limits.

Judgement: Passed by 5.6 dB.

15.2 Occupied Bandwidth Data

The occupied bandwidth of the RF output was measured using a spectrum analyzer using a peak detector function and a narrow resolution bandwidth. A broadband antenna was used to receive the modulated signal. The spectrum analyzer was set to the MAX HOLD mode to record the worst case of the modulation. The spectrum analyzer display was digitized and plotted. The plots of the occupied bandwidth for the EUT are supplied on the following page.

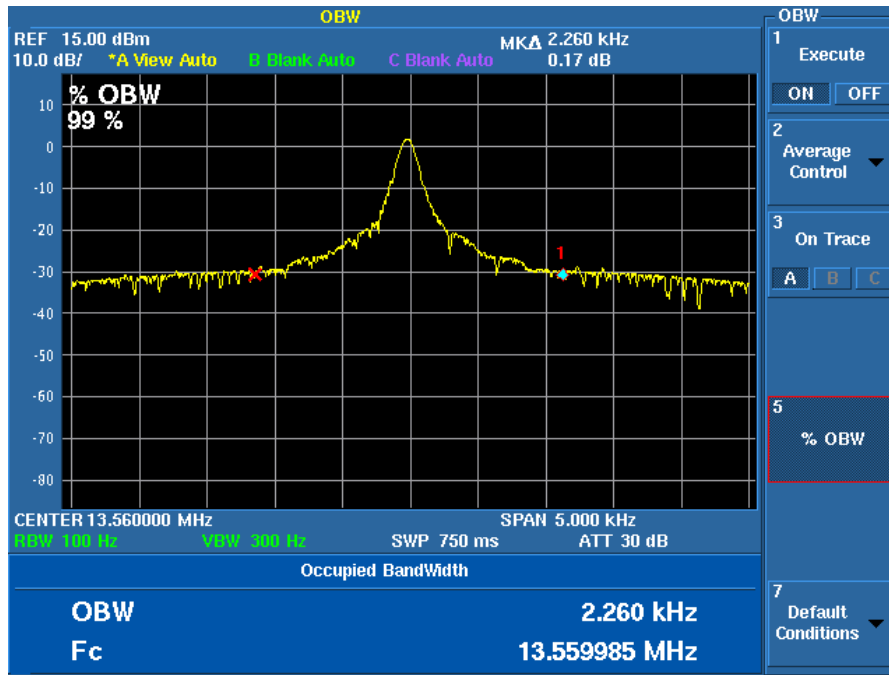
Model	R2	Specification	FCC Part 15.209 RSS-GEN
Test Personnel	Richard Tichgelaar	Test Date	12/20/2019

99% OBW = 2.26 kHz

Judgement: Pass



Figure 1. Occupied Bandwidth Plot



Worst case OBW

16.0 UNINTENTIONAL EMISSIONS (RECEIVE MODE)

Manufacturer	Latchable, Inc.	Specification	FCC Part 15.209 & RSS-GEN
Model	R2	Test Date	12/19/2019
Serial Number	RMC1	Test Distance	3 Meters
Abbreviations	Pol = Antenna Polarization; V = Vertical; H = Horizontal; P = peak; Q = QP		
Notes	Corr. Factors = Cable Loss – Preamp Gain		
Configuration	Receive mode		

Freq. MHz	Meter Reading dBuV	Dect.	Ant. Pol.	Ant Factor dB/m	Cbl/amp Factors dB	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
40.5	13.7	P	H	11.1	0.6	0.0	25.5	40.0	14.5	
67.6	14.0	P	H	9.3	0.8	0.0	24.2	40.0	15.8	
112.9	17.9	P	H	11.1	1.1	0.0	30.1	43.5	13.4	
176.4	15.6	P	H	13.2	1.4	0.0	30.1	43.5	13.4	
187.5	14.3	P	H	13.7	1.4	0.0	29.4	43.5	14.1	
200.2	14.8	P	H	14.3	1.4	0.0	30.5	43.5	13.0	
249.9	22.8	P	H	15.4	1.6	0.0	39.9	46.0	6.1	
275.3	15.6	P	H	12.9	1.7	0.0	30.3	46.0	15.7	
284.8	20.6	P	H	13.5	1.8	0.0	35.9	46.0	10.1	
311.9	16.3	P	H	14.9	1.8	0.0	33.0	46.0	13.0	
325.1	14.3	P	H	14.0	1.9	0.0	30.1	46.0	15.9	
366.7	15.1	P	H	14.4	2.0	0.0	31.5	46.0	14.5	
374.9	15.2	P	H	14.7	2.0	0.0	31.9	46.0	14.1	
390.0	14.2	P	H	14.8	2.0	0.0	31.0	46.0	15.0	
425.3	12.3	P	H	16.3	2.2	0.0	30.8	46.0	15.2	
500.2	14.7	P	H	17.5	2.4	0.0	34.6	46.0	11.4	
592.5	10.2	P	H	18.6	2.6	0.0	31.4	46.0	14.6	



Freq. MHz	Meter Reading dBuV	Decet.	Ant. Pol.	Ant Factor dB/m	Cbl/amp Factors dB	Dist Fact dB	EUT dBuV/m	Limit dBuV/m	Margin Under Limit dB	Note
726.3	13.1	P	H	20.1	2.9	0.0	36.0	46.0	10.0	
917.5	12.4	P	H	22.7	3.3	0.0	38.4	46.0	7.6	
1400.0	52.5	P	H	25.5	-33.2	0.0	44.8	74.0	29.2	1
1450.0	47.0	P	H	25.5	-33.2	0.0	39.3	74.0	34.7	1
1927.5	42.7	P	H	27.8	-32.7	0.0	37.8	74.0	36.2	1
2315.0	48.6	P	H	28.0	-32.4	0.0	44.2	74.0	29.8	1
2530.0	49.3	P	H	28.7	-31.9	0.0	46.1	74.0	27.9	1
2570.0	45.9	P	H	28.9	-32.0	0.0	42.8	74.0	31.2	1
3712.5	37.3	P	H	32.0	-30.4	0.0	38.9	74.0	35.1	1
4115.0	36.2	P	H	32.8	-29.9	0.0	39.2	74.0	34.8	1
4550.0	34.2	P	H	33.5	-29.2	0.0	38.4	74.0	35.6	1
4727.5	35.6	P	H	33.5	-29.0	0.0	40.1	74.0	33.9	1
4877.5	37.7	P	H	33.5	-28.7	0.0	42.5	74.0	31.5	1
5232.5	34.0	P	H	34.0	-28.1	0.0	39.9	74.0	34.1	1
5852.5	33.9	P	H	34.3	-27.3	0.0	40.9	74.0	33.1	1
32.2	17.7	P	V	13.1	0.6	0.0	31.3	40.0	8.7	
41.0	21.3	P	V	10.9	0.6	0.0	32.8	40.0	7.2	
70.3	20.5	Q	V	9.3	0.8	0.0	30.7	40.0	9.3	
133.9	16.7	P	V	12.3	1.2	0.0	30.2	43.5	13.3	
149.3	16.7	P	V	12.8	1.2	0.0	30.7	43.5	12.8	
176.4	19.7	P	V	13.2	1.4	0.0	34.2	43.5	9.3	
188.0	15.6	P	V	13.7	1.4	0.0	30.7	43.5	12.8	
200.2	15.9	P	V	14.3	1.4	0.0	31.6	43.5	11.9	
215.1	17.9	P	V	14.8	1.5	0.0	34.2	43.5	9.3	
225.0	15.3	P	V	15.1	1.5	0.0	31.9	46.0	14.1	
250.1	24.7	P	V	11.9	1.6	0.0	38.3	46.0	7.7	
267.1	18.0	P	V	12.3	1.7	0.0	32.0	46.0	14.0	
284.8	20.4	P	V	13.5	1.8	0.0	35.6	46.0	10.4	
315.6	16.7	P	V	14.6	1.8	0.0	33.2	46.0	12.8	
354.7	15.3	P	V	14.8	2.0	0.0	32.0	46.0	14.0	
374.9	14.7	P	V	14.7	2.0	0.0	31.4	46.0	14.6	
441.6	13.5	P	V	16.0	2.2	0.0	31.7	46.0	14.3	
473.8	15.0	P	V	16.8	2.3	0.0	34.1	46.0	11.9	
513.8	12.5	P	V	18.0	2.4	0.0	32.9	46.0	13.1	
527.5	13.0	P	V	17.6	2.4	0.0	33.1	46.0	12.9	
580.0	17.1	P	V	18.2	2.5	0.0	37.9	46.0	8.1	
750.0	10.0	P	V	21.6	2.9	0.0	34.5	46.0	11.5	
862.5	10.4	P	V	21.9	3.2	0.0	35.5	46.0	10.5	
946.3	11.6	P	V	22.8	3.4	0.0	37.7	46.0	8.3	
1350.0	46.1	P	V	25.6	-33.2	0.0	38.5	74.0	35.5	1
1400.0	47.4	P	V	25.5	-33.2	0.0	39.7	74.0	34.3	1
1927.5	47.3	P	V	27.8	-32.7	0.0	42.4	74.0	31.6	1
2512.5	49.5	P	V	28.7	-32.0	0.0	46.2	74.0	27.8	1
2552.5	46.8	P	V	28.8	-31.9	0.0	43.7	74.0	30.3	1
2587.5	43.2	P	V	28.9	-32.1	0.0	40.0	74.0	34.0	1
3250.0	39.3	P	V	31.1	-31.0	0.0	39.4	74.0	34.6	1
3945.0	37.6	P	V	32.9	-30.3	0.0	40.2	74.0	33.8	1
4717.5	34.8	P	V	33.5	-29.0	0.0	39.3	74.0	34.7	1
4967.5	33.0	P	V	33.5	-28.6	0.0	37.9	74.0	36.1	1
5030.0	35.9	P	V	33.6	-28.5	0.0	41.1	74.0	32.9	1
5817.5	34.4	P	V	34.2	-27.4	0.0	41.3	74.0	32.7	1

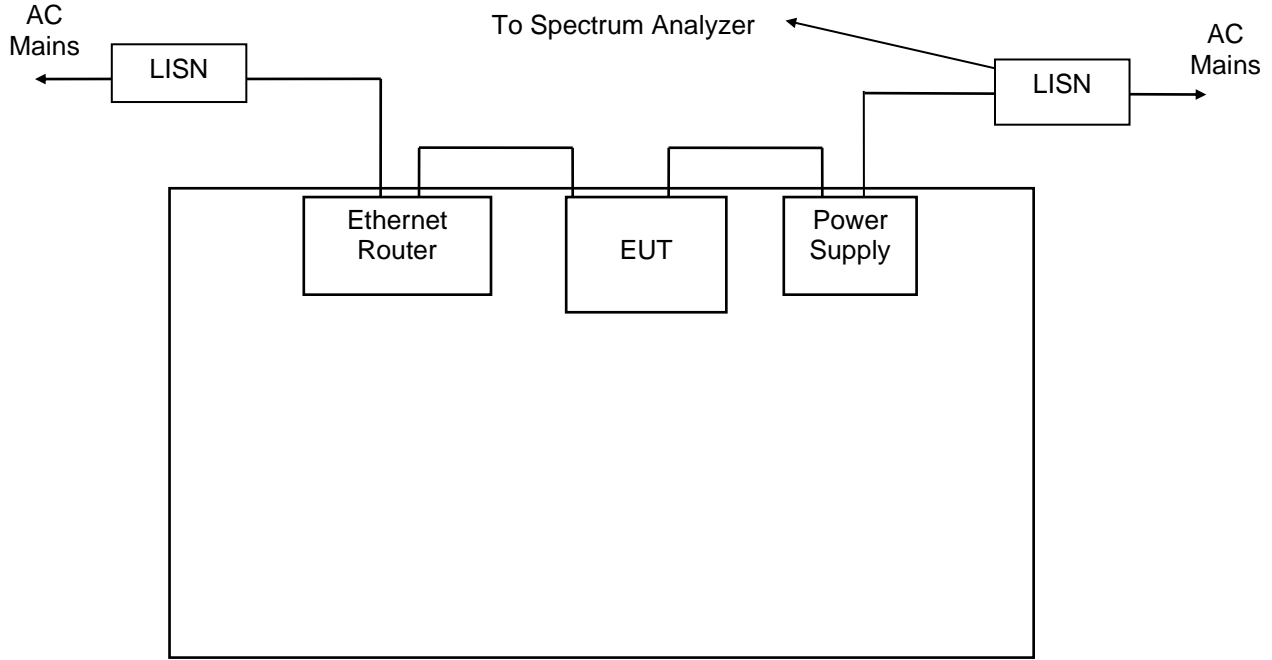
Note1 : Peak reading below Average limits, so average readings not performed for that frequency.

Judgment: Passed by 6.1 dB



17.0 GENERAL TEST SETUPS

Figure 2. Conducted Emissions Test Setup



1x1.5m surface

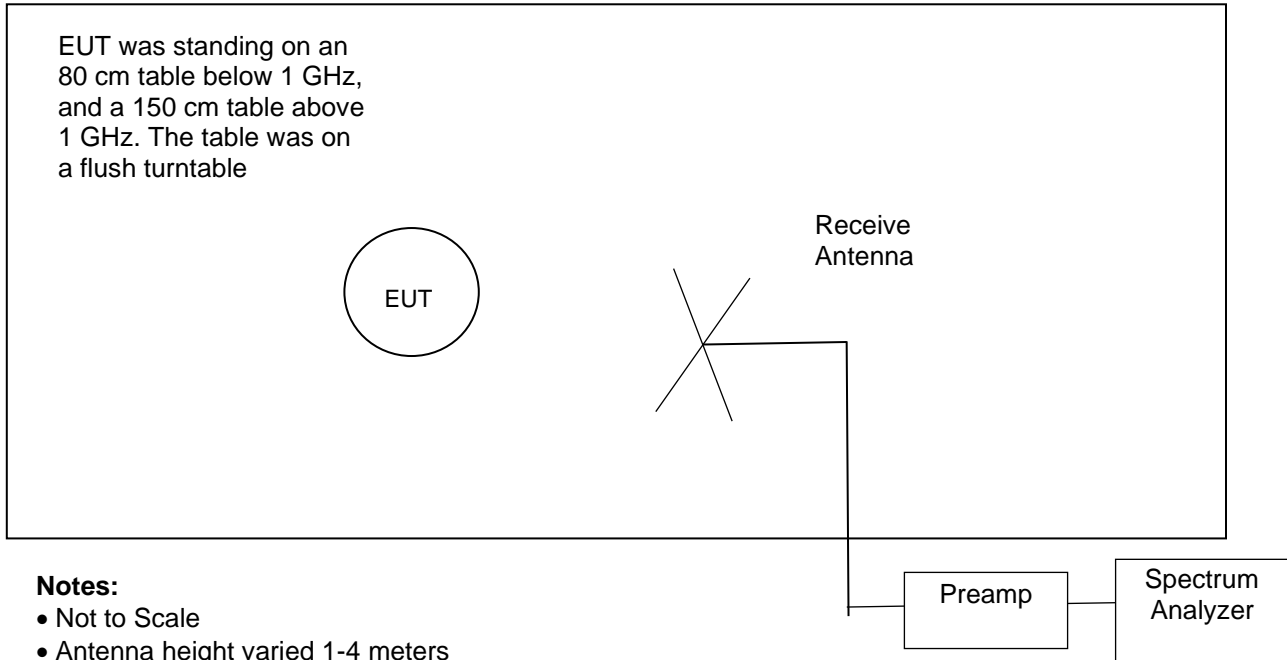
Notes:

- LISN's at least 80 cm from EUT chassis
- Vertical conductive plane 40 cm from rear of tabletop
- EUT power cord bundled



Figure 3. Drawing of Radiated Emissions Setup

Chamber E, anechoic



Notes:

- Not to Scale
- Antenna height varied 1-4 meters
- Distance from antenna to tested system is 3 meters
- AC cords not shown. They are connected to AC outlet with low-pass filter on turntable

Frequency Range	Receive Antenna	Pre-Amplifier	Spectrum Analyzer	High Pass Filter
0.01 to 30 MHz	ANT-53	None	REC-11	None
30 to 200 MHz	ANT-80	None	REC-11	None
200 to 1000 MHz	ANT-08	None	REC-11	None
1 to 10 GHz	ANT-66	AMP-05	REC-21 or RNT-17	HPF-06
10 to 18 GHz	ANT-66	AMP-20	REC-21 or RNT-17	None*
18 to 25 GHz	ANT-48	AMP-59	REC-21 or RNT-17	None*

* A high pass filter was not needed since the fundamental frequency was outside of the amplifiers pass band.

17.1 Radiated emissions Limits

Unintentional Radiated Emissions Field Strength Limits

Frequency Range (MHz)	Test Distance (meters)	Class B Limits	
		uV/m	dB(uV/m)
0.009-0.490	300	2400/F(kHz)	20*LOG(2400/kHz)
0.490-1.705	30	24000/F(kHz)	20*LOG(24000/kHz)
1.705-30.0	30	30	29.5
30 - 88	3	100	40.0
88 - 216	3	150	43.5
216 - 960	3	200	46.0
Above 960	3	500	54.0



18.0 MEASUREMENT INSTRUMENTATION UNCERTAINTY

Measurement	Uncertainty
Conducted Emissions, LISN method, 150 kHz to 30 MHz	2.2 dB
Radiated Emissions, H-field, 3 meters, 9 kHz to 30 MHz	2.7 dB
Radiated Emissions, E-field, 3 meters, 30 to 200 MHz	4.7 dB
Radiated Emissions, E-field, 3 meters, 200 to 1000 MHz	6.2 dB
Radiated Emissions, E-field, 3 meters, 1 to 6 GHz	5.0 dB
Radiated Emissions, E-field, 3 meters, 6 to 18 GHz	5.5 dB
Radiated Emissions, E-field, 3 meters, 18 to 26 GHz	5.9 dB
Bandwidth using marker delta method at a span of 20 MHz	8 kHz
99% Occupied Bandwidth using REC-43	1% of frequency span
Direct Amplitude measurement 1-26,000 MHz	1.5 dB
Temperature THM-02	0.6 Deg C

The uncertainties represent expanded uncertainties expressed at approximately the 95% confidence level using a coverage factor of k=2 in accordance with CISPR 16-4-2.

19.0 REVISION HISTORY

Document RP-9194 Revisions:			
Rev.	Affected Sections	Description	Rationale
1	6.0	The version of KDB 558074 was updated	This was an oversight. The previous version was used.
1	10.0	The calibration date for THM-03 was revised.	This was an oversight. An old calibration date was was used.