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WLAN TEST REPORT

Report Number:	**102448906LEX-002**
Project Number:	**G102448906**
Report Issue Date:	**2/4/2016**
Product Name:	**On-Board Validator**
FCC Standards:	**Title 47 CFR Part 15 Subpart C**
Industry Canada Standards:	**RSS-210 Issue 8 & RSS-GEN Issue 4**

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Drive
Lexington, KY 40510

Client:
Trapeze Software Group, Inc
5265 Rockwell Dr NE
Cedar Rapids, IA 52402-2014

Report prepared by
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Report reviewed by
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TABLE OF CONTENTS

1 Introduction and Conclusion

The tests indicated in section 2 were performed on the product constructed as described in section 3. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test method, a list of the actual test equipment used, documentation photos, results and raw data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested complied with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested.

The INTERTEK-Lexington is located at 731 Enterprise Drive, Lexington Kentucky, 40510. The radiated emission test site is a 10-meter semi-anechoic chamber. The chamber meets the characteristics of CISPR 16-1 and ANSI C63.4. For measurements, a remotely controlled flush-mount metal-top turntable is used to rotate the EUT a full 360 degrees. A remote controlled non-conductive antenna mast is used to scan the antenna height from one to four meters. The test site is listed with the FCC under registration number 485103. The test site is listed with Industry Canada under site number IC 2042M-1.

2 Test Summary

Page	Test full name	FCC Reference	IC Reference	Result
6	Peak Conducted Power	§ 15.247(b)(3)(4)	RSS-210 (A8.4)	Pass
8	Occupied Bandwidth	§ 15.247(a)(2)	RSS-210 (A8.2), RSS-GEN (4.6.1)	Pass
15	Conducted Spurious Emissions	§ 15.247(d)	RSS-210 (A8.5)	Pass
19	Power Spectral Density	§ 15.247(e)	RSS-210 A8.2(B)	Pass
25	Radiated Spurious Emissions (Transmitter)	§ 15.247(d), § 15.209, and § 15.205	RSS-210 (2.2)	Pass
31	Radiated Spurious Emissions (Receiver)	§ 15.109	RSS-Gen (6.1)	Pass
33	AC Powerline Conducted Emissions	§ 15.107, § 15.207	RSS-Gen (7.2.4)	Pass
38	Antenna Requirement per FCC Part 15.203	§ 15.203	RSS-Gen (7.1.2)	Pass

3 Description of Equipment Under Test

Equipment Under Test	
Manufacturer	Trapeze Software Group, Inc
Model Number	50T0177
Serial Number	Sample 1
Receive Date	1/25/2016
Test Start Date	1/26/2016
Test End Date	2/3/2016
Device Received Condition	Good
Test Sample Type	Production
Frequency Band	2412MHz – 2462MHz
Mode(s) of Operation	802.11b,g,n
Modulation Type	BPSK, QPSK, CCK, OFDM
Duty Cycle	100%
Transmission Control	Test Commands
Maximum Output Power	23.56 dBm
Test Channels	1,6,11
Antenna Type (15.203)	PCB Antenna
Operating Voltage	120Vac 60Hz

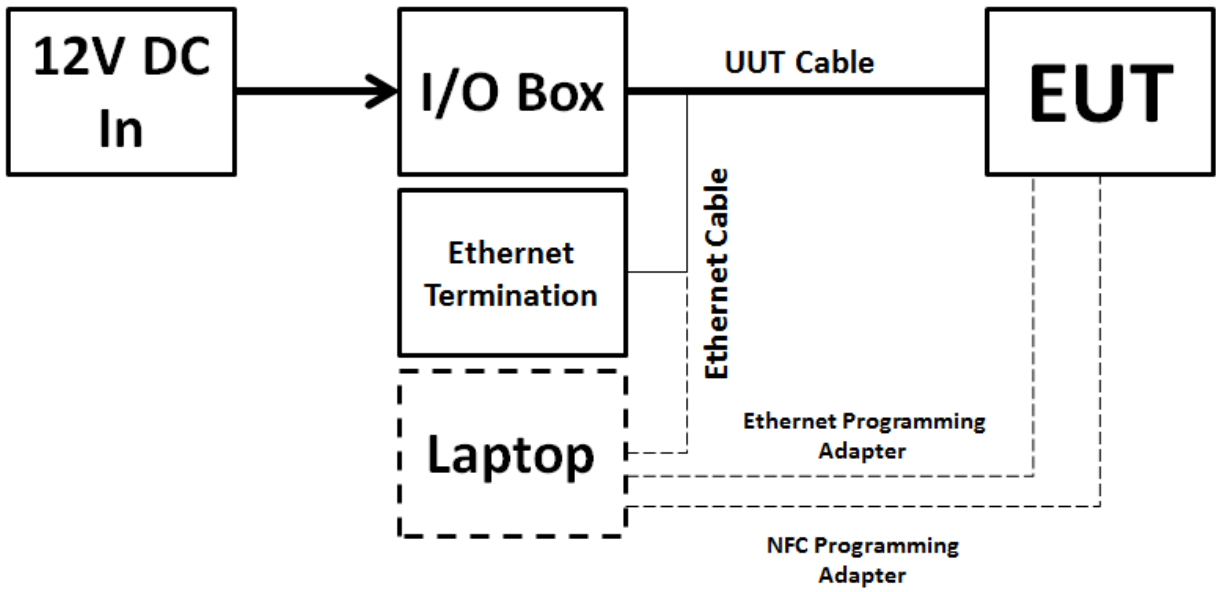
Description of Equipment Under Test
The On-Board Validator is used a mass transit vehicles to collect fares either by scanning 1-D or 2-D barcodes, or reading Smartcards.

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	Transmitting 802.11 b, g or n on low, mid or high channels
2	Receive mode / idle mode

3.1 System setup including cable interconnection details, support equipment and simplified block diagram

3.2 EUT Block Diagram:



3.3 Cables:

Cables					
Description	Length	Shielding	Ferrites	Connection	
				From	To
UUT Cable	4ft	No	No	EUT (UUT Cable Port)	I/O Box (Multiple)
Ethernet Programming Adapter	8ft	No	No	EUT (Exposed Header)	Laptop (USB)
Ethernet Cable	8ft	No	No	EUT (UUT Cable Port)	Laptop (Ethernet) / Ethernet Termination
NFC Programming Adapter	4ft	No	No	EUT (NFC Module)	Laptop (USB)

3.4 Support Equipment:

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
I/O Box	Trapeze Group	N/A	N/A
Ethernet Termination	Trapeze Group	N/A	N/A
Laptop	HP	EliteBook 8440p	CND046136B

4 Peak Conducted Power

4.1 Test Limits

§ 15.247(b)(3): For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the *maximum conducted output power* is the highest total transmit power occurring in any mode.

§ 15.247(b)(4): The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

4.2 Test Procedure

ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247). The peak output power was measured using a power meter.

4.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Wideband Power Sensor	4022	Rohde & Schwarz	NRP-Z81	9/20/2015	9/20/2016

4.4 Results:

802.11 b Mode

Mode	Frequency (MHz)	Channel Number	Type	Conducted Power (dBm) Data Rate (Mbps) 1	2	5.5	11
802.11b	2412	1	Peak	17.73	17.77	17.80	17.61
	2437	6	Peak	17.54	17.51	17.55	17.54
	2462	11	Peak	17.50	17.49	17.32	17.41

802.11g Mode

Mode	Frequency (MHz)	Channel Number	Type	Conducted Power (dBm) Data Rate (Mbps) 6	9	12	18	24	36	48	54
802.11g	2412	1	Peak	22.99	23.06	23.29	23.14	23.24	23.49	23.19	23.56
	2437	6	Peak	23.08	23.41	23.14	23.05	23.06	23.36	23.22	23.38
	2462	11	Peak	22.94	23.06	23.05	23.12	23.06	23.44	23.32	23.47

802.11n Mode

Mode	Frequency (MHz)	Channel Number	Type	Conducted Power (dBm) Data Rate (Mbps) 6.5	13	19.5	26	39	52	58.5	65
802.11n	2412	1	Peak	22.81	23.30	23.43	23.30	23.20	23.16	23.11	23.29
	2437	6	Peak	22.70	23.25	23.11	23.30	23.23	23.35	23.07	23.32
	2462	11	Peak	23.02	22.93	23.23	22.97	22.81	23.26	23.45	23.54

5 Occupied Bandwidth

5.1 Test Limits

§ 15.247(a)(2): For digital modulation systems, the minimum 6dB bandwidth shall be at least 500kHz.

5.2 Test Procedure

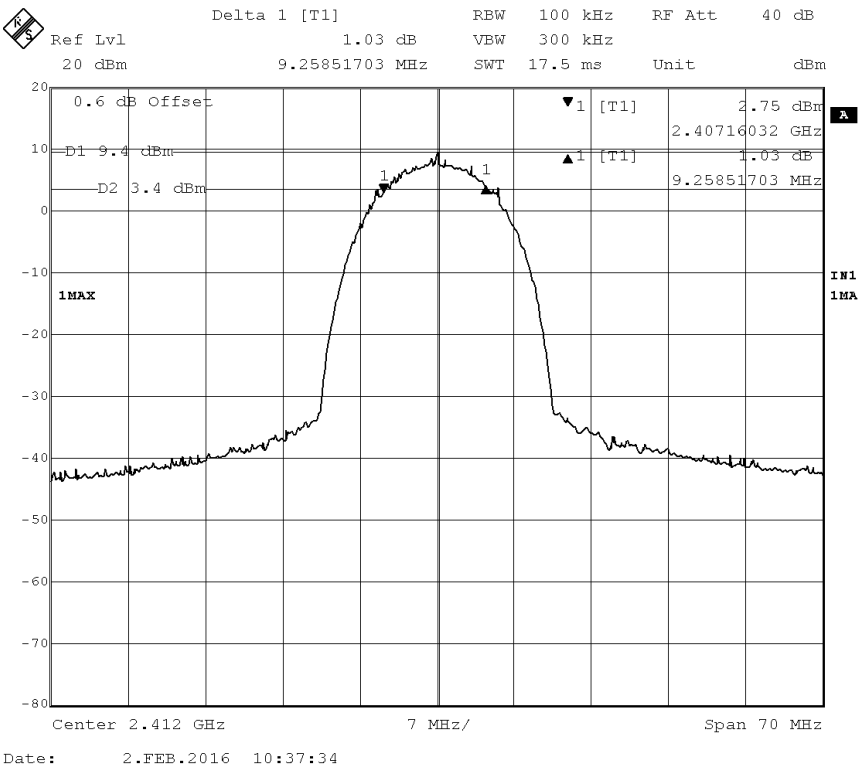
ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

5.3 Test Equipment Used:

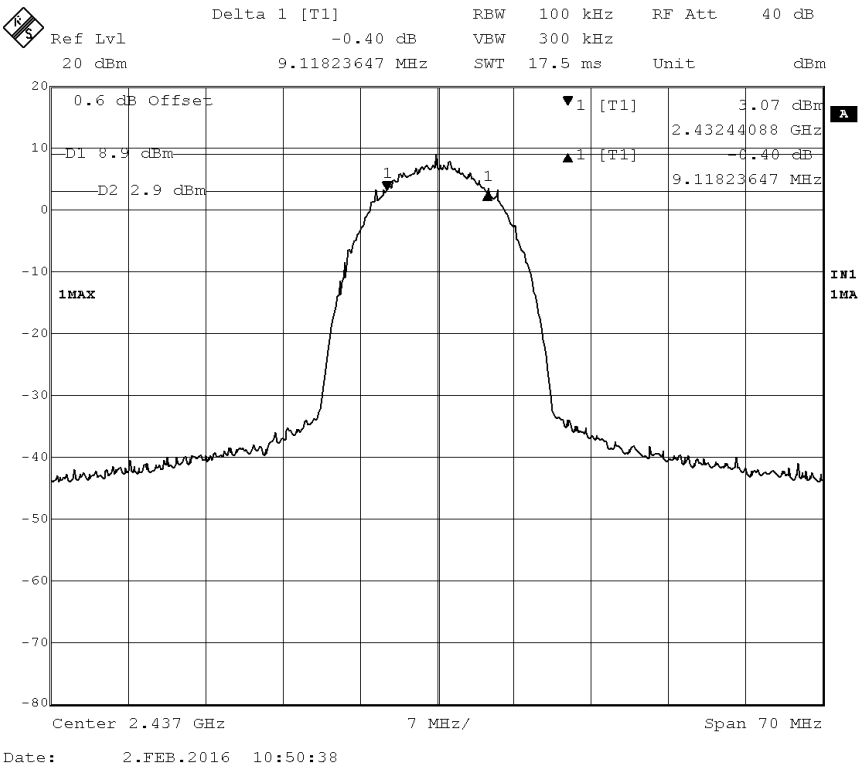
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESI26	9/20/2015	9/20/2016

5.4 Results:

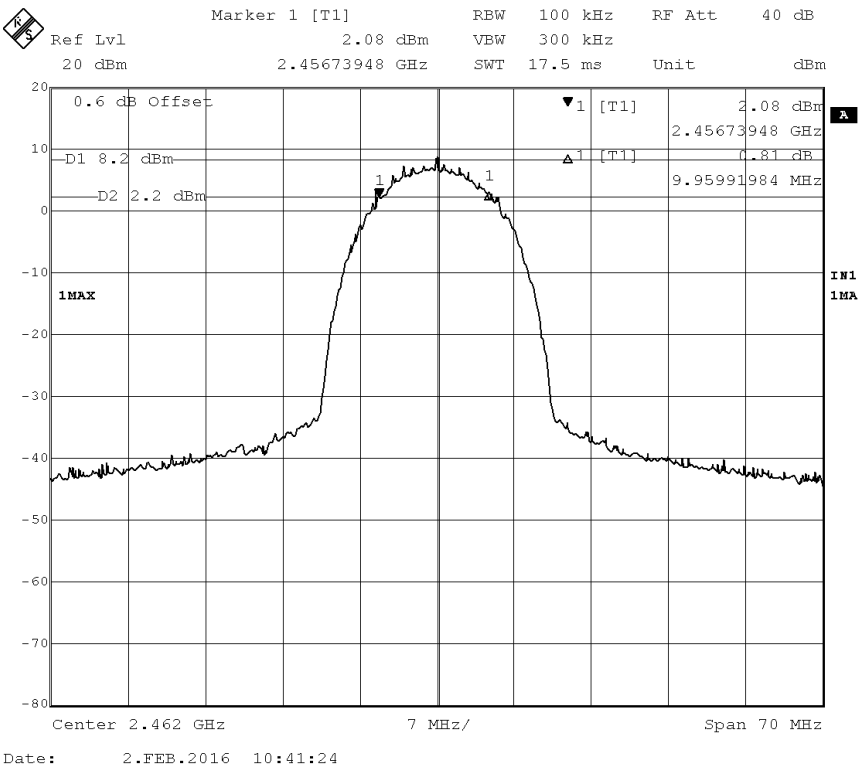
Mode	Channel Number	Frequency (MHz)	6dB Bandwidth	99% Power Bandwidth	Result
802.11b	1	2412	9.259MHz	---	Pass
802.11b	6	2437	9.118MHz	15.291MHz	Pass
802.11b	11	2462	9.960MHz	---	Pass
802.11g	1	2412	16.413MHz	---	Pass
802.11g	6	2437	16.413MHz	16.553MHz	Pass
802.11g	11	2462	16.413MHz	---	Pass
802.11n	1	2412	17.255MHz	---	Pass
802.11n	6	2437	17.535MHz	17.535MHz	Pass
802.11n	11	2462	17.395MHz	---	Pass



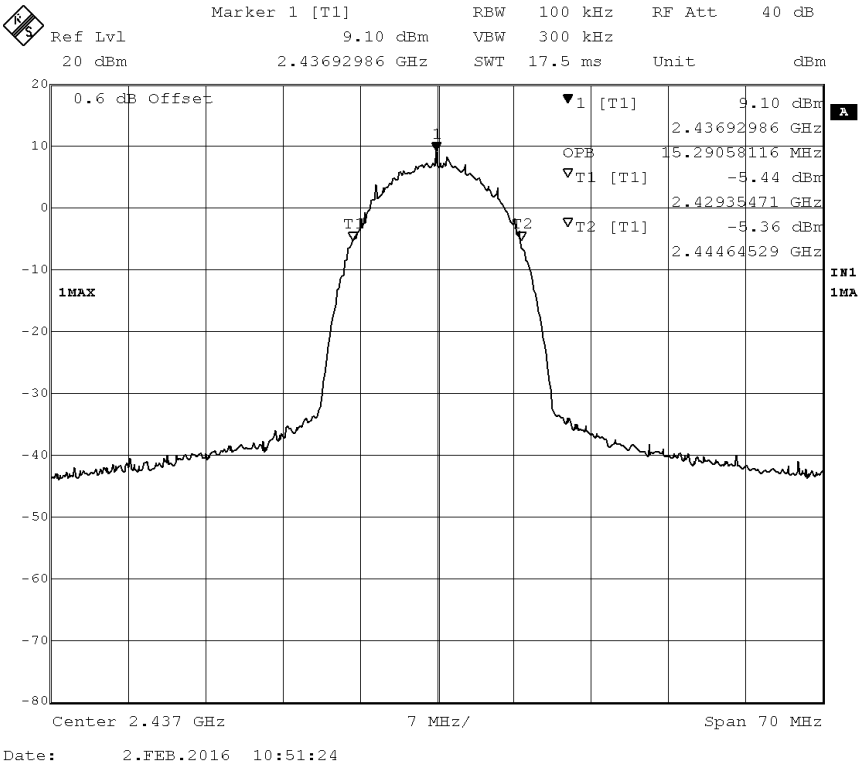
6dB Bandwidth Plot (Channel 1) – 802.11b mode



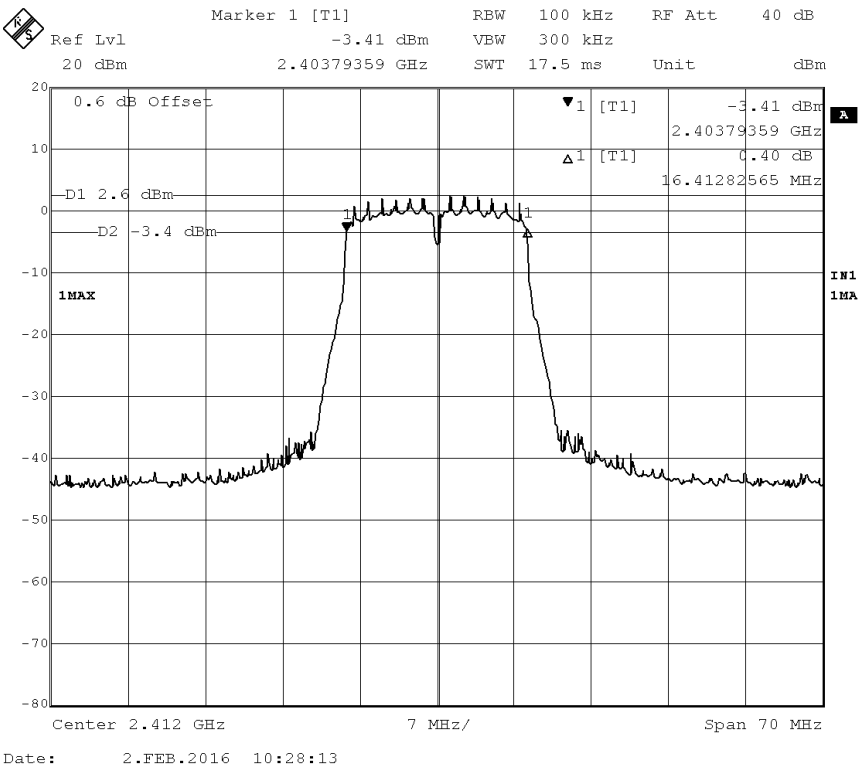
6dB Bandwidth Plot (Channel 6) – 802.11b mode



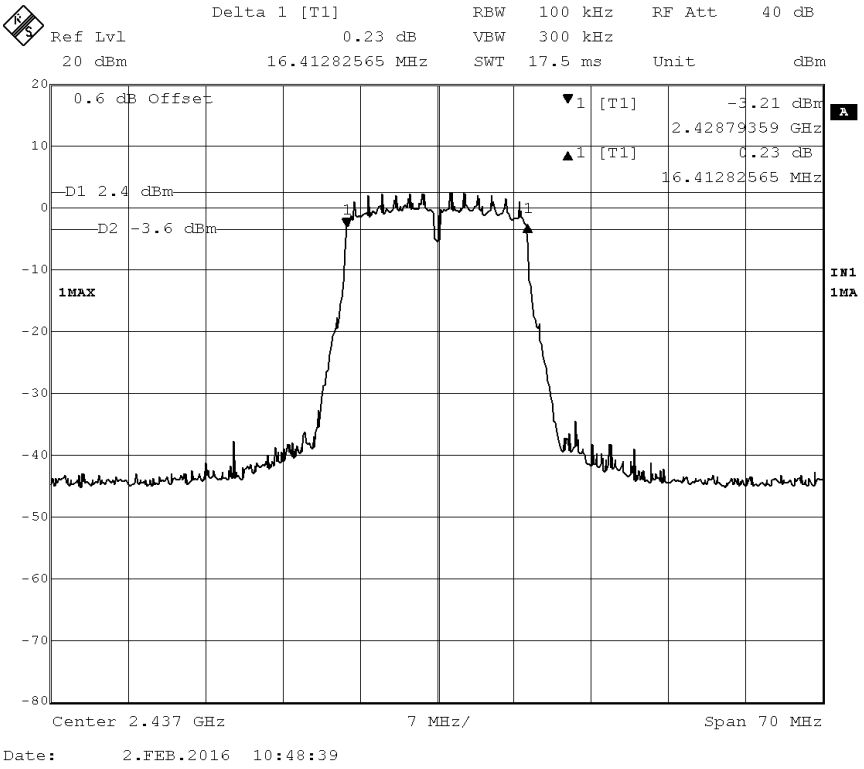
6dB Bandwidth Plot (Channel 11) – 802.11b mode



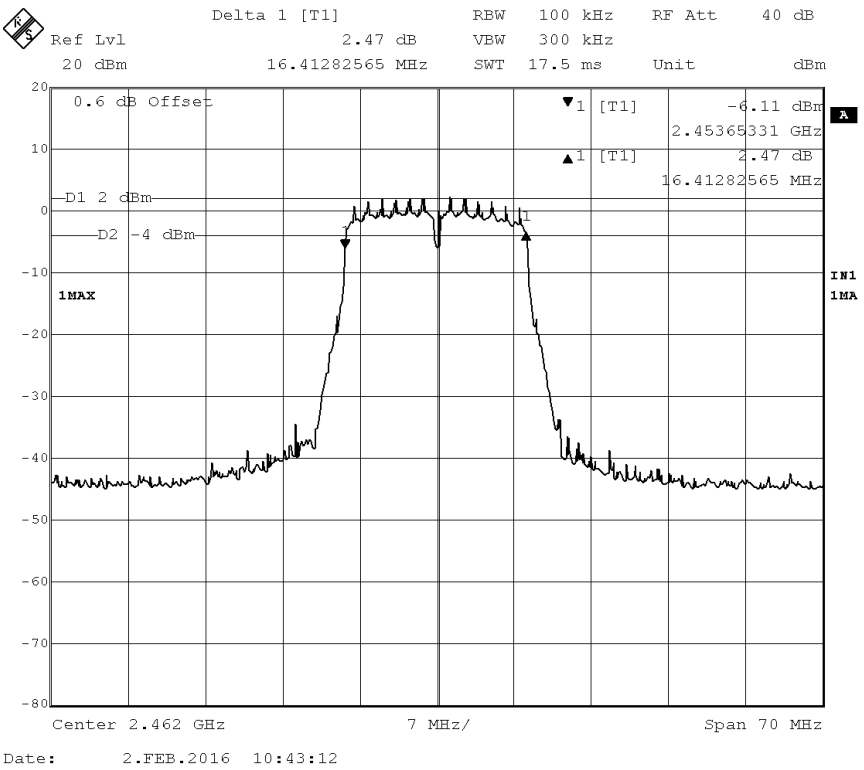
99% Power Bandwidth Plot (Channel 6) – 802.11b mode



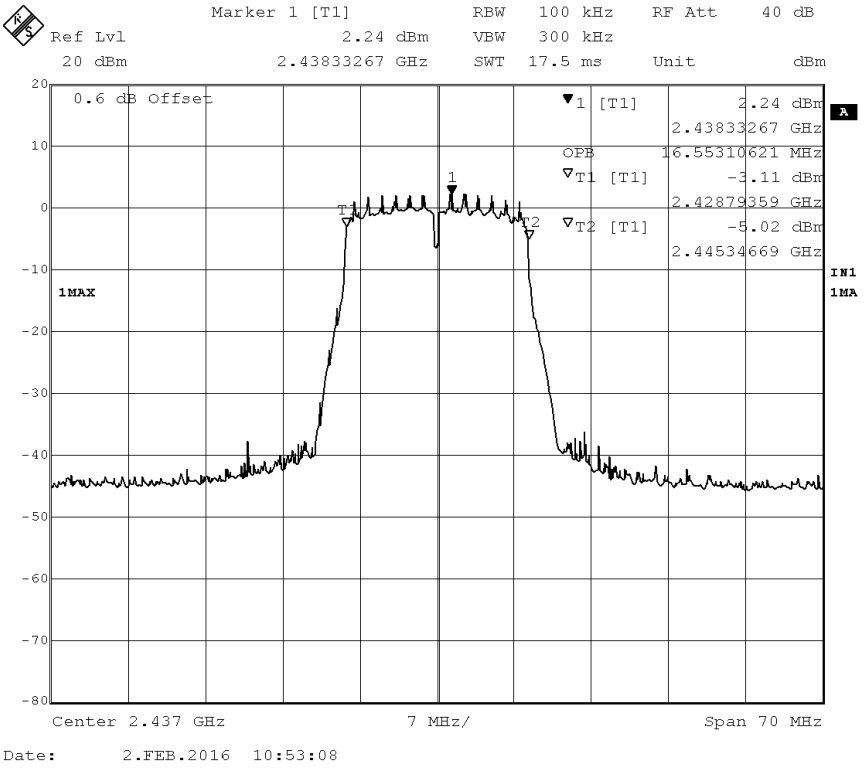
6dB Bandwidth Plot (Channel 1) – 802.11g mode



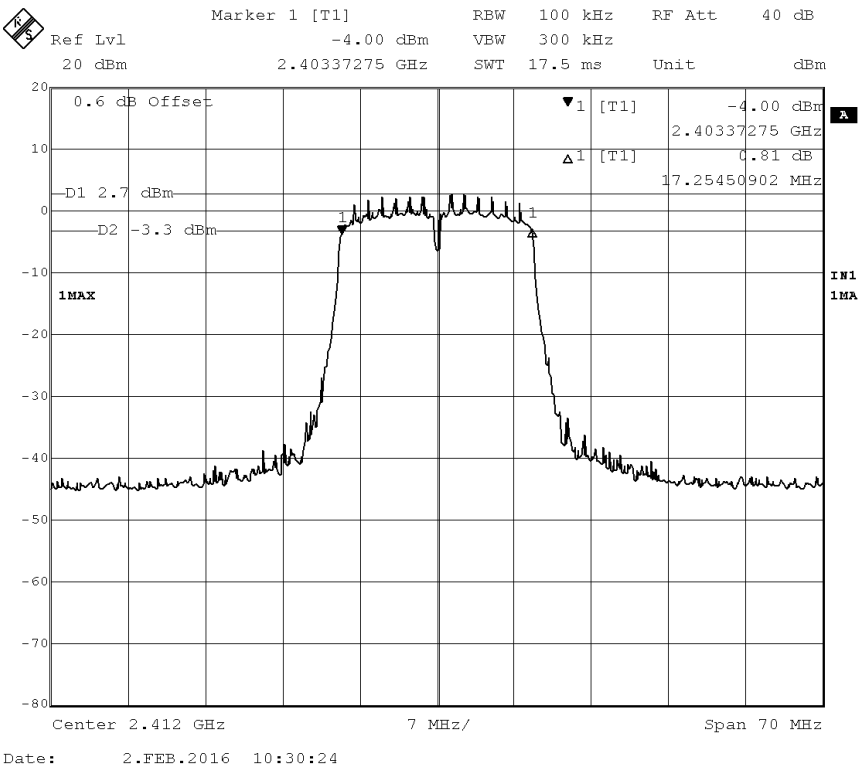
6dB Bandwidth Plot (Channel 6) – 802.11g mode



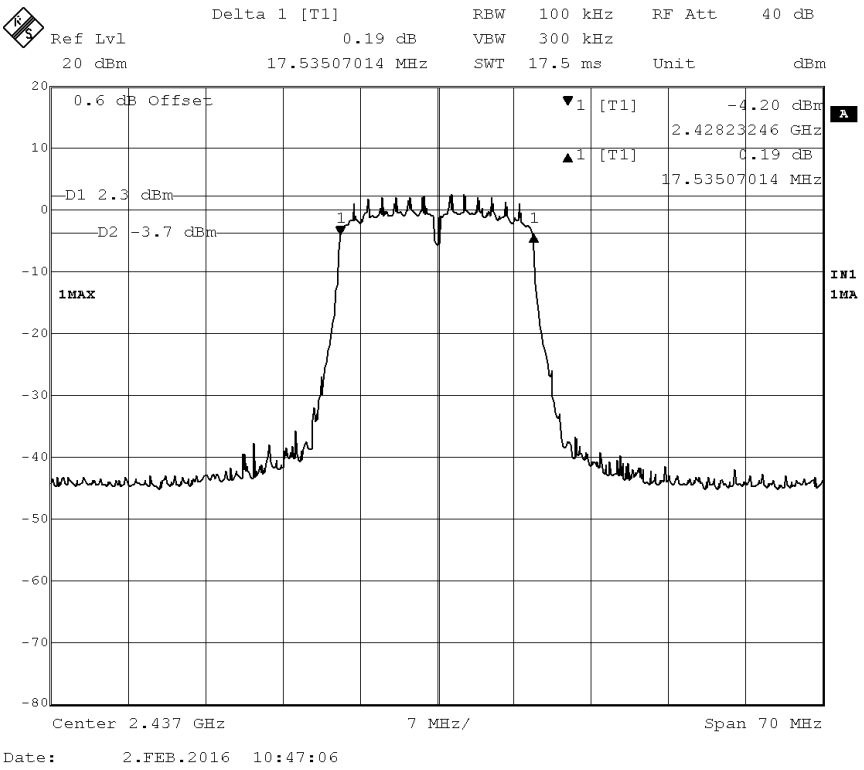
6dB Bandwidth Plot (Channel 11) – 802.11g mode



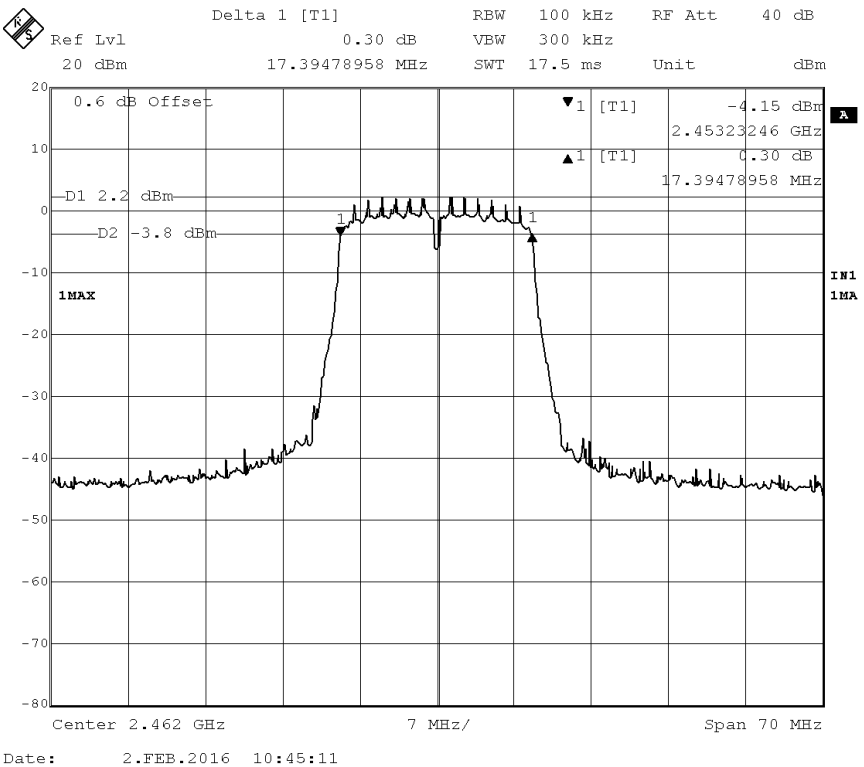
99% Power Bandwidth Plot (Channel 6) – 802.11g mode



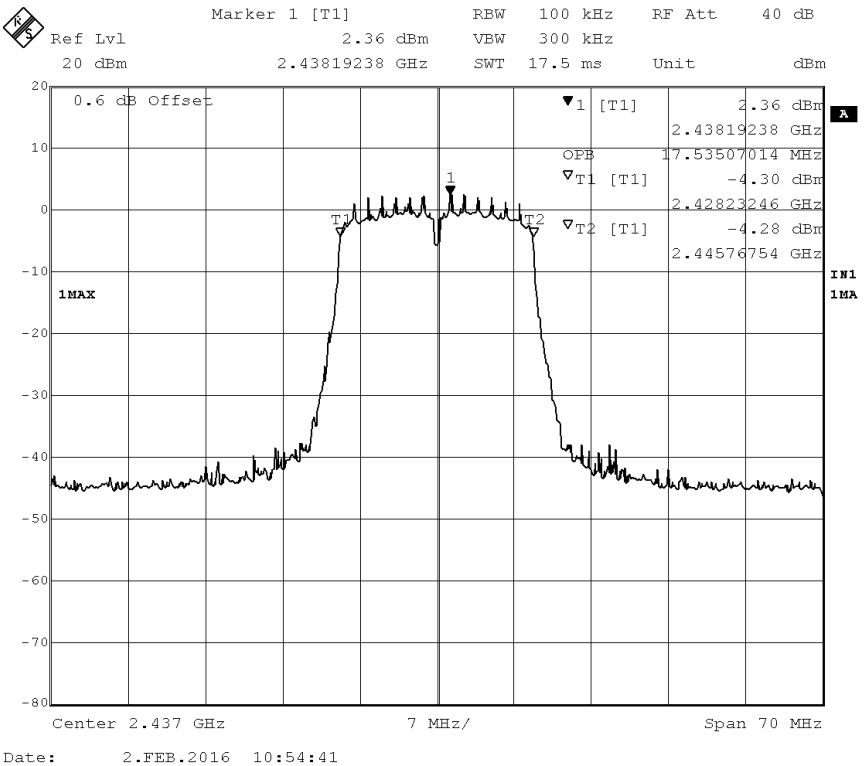
6dB Bandwidth Plot (Channel 1) – 802.11n mode



6dB Bandwidth Plot (Channel 6) – 802.11n mode



6dB Bandwidth Plot (Channel 11) – 802.11n mode



99% Power Bandwidth Plot (Channel 6) – 802.11n mode

6 Conducted Spurious Emissions

6.1 Test Limits

§ 15.247(d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

6.2 Test Procedure

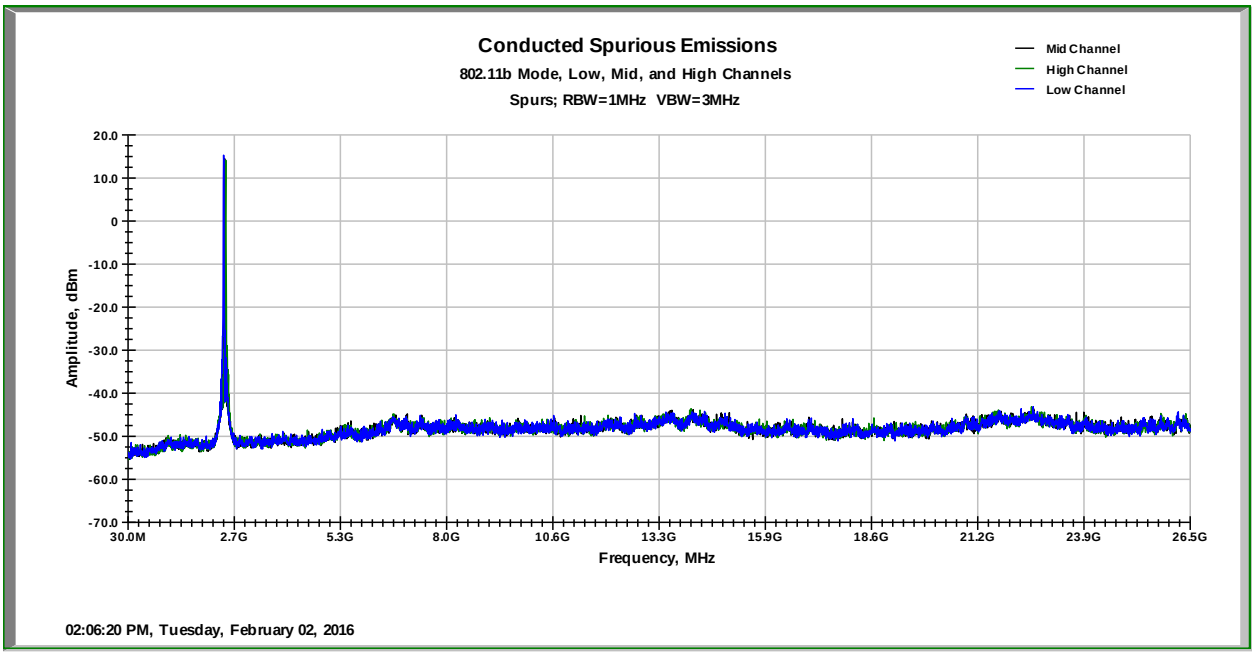
ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

6.3 Test Equipment Used:

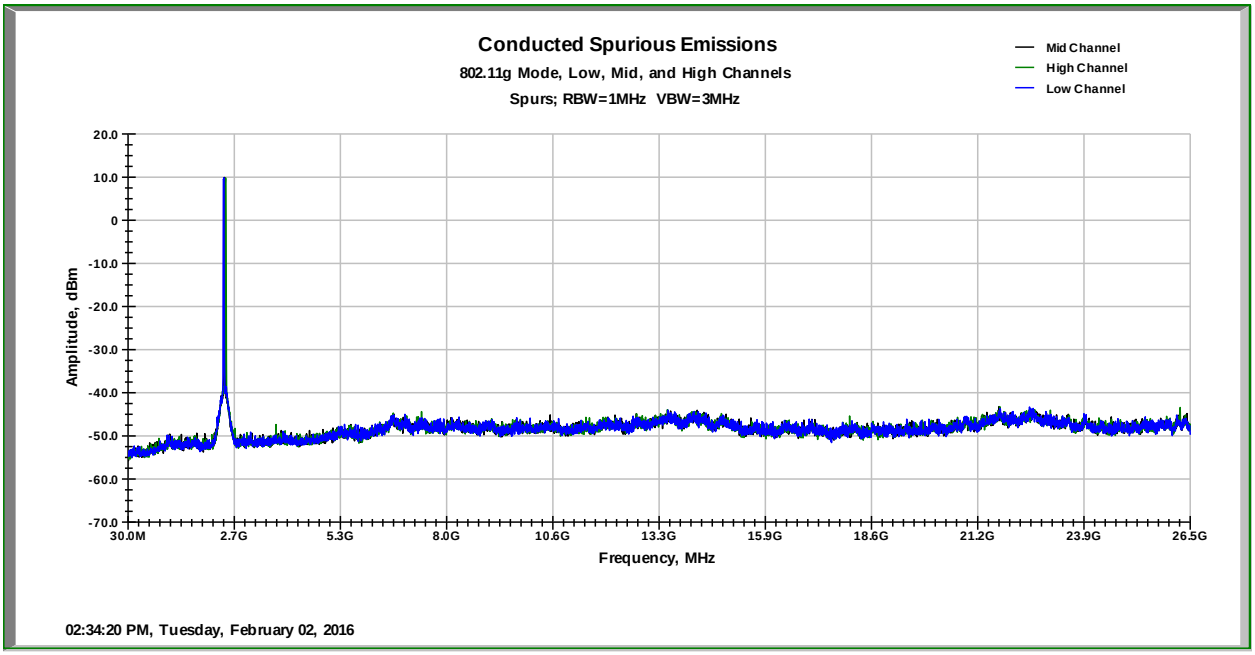
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	1088.3494	Rohde & Schwarz	FSEK 30	9/20/2015	9/20/2016

6.4 Results:

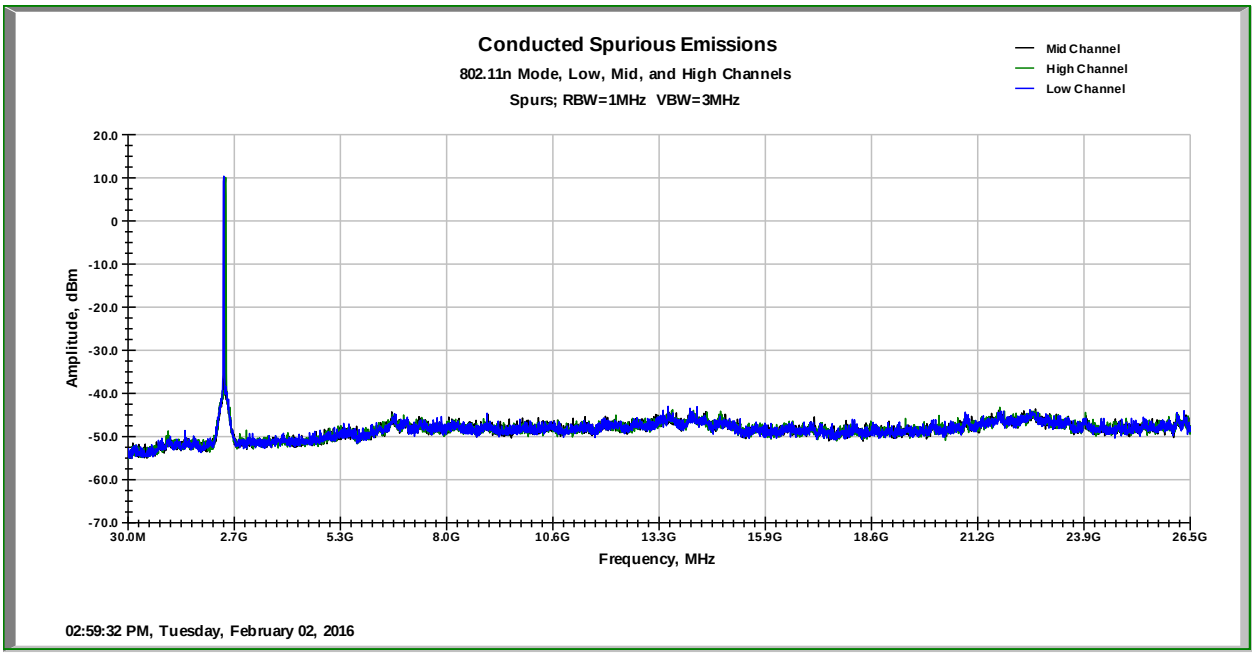
The following plots show that there are no conducted spurious emissions exceeding the 20dB down criteria.



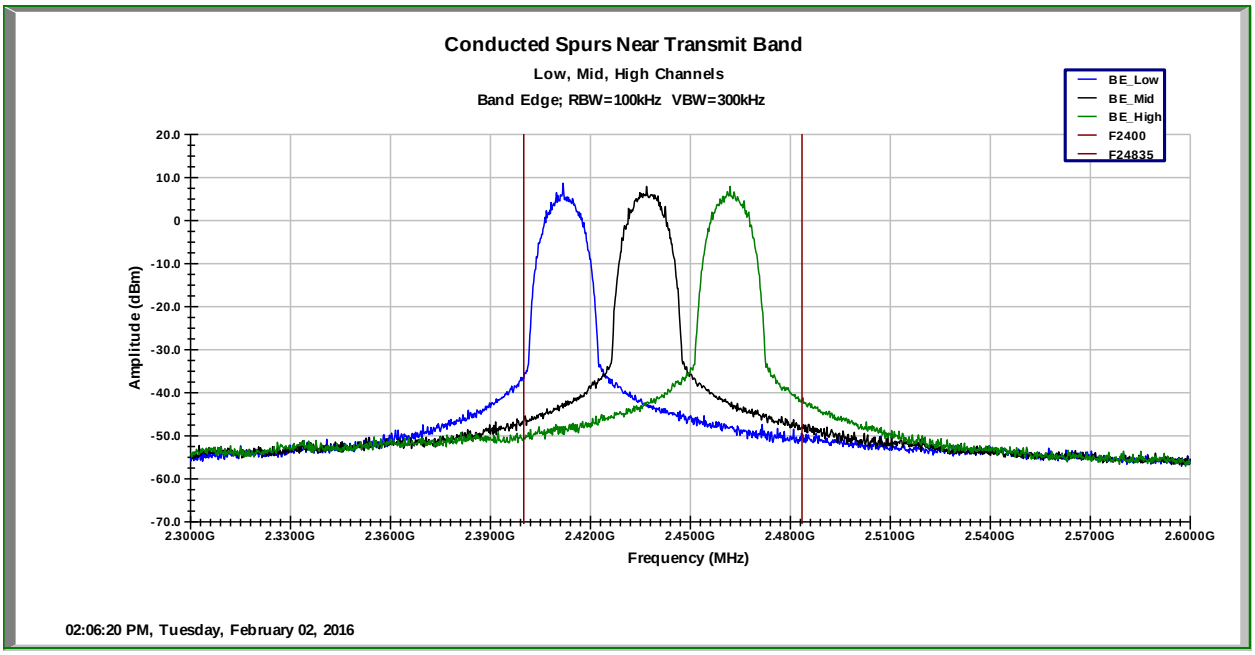
Conducted Spurious Emissions - 802.11b Mode



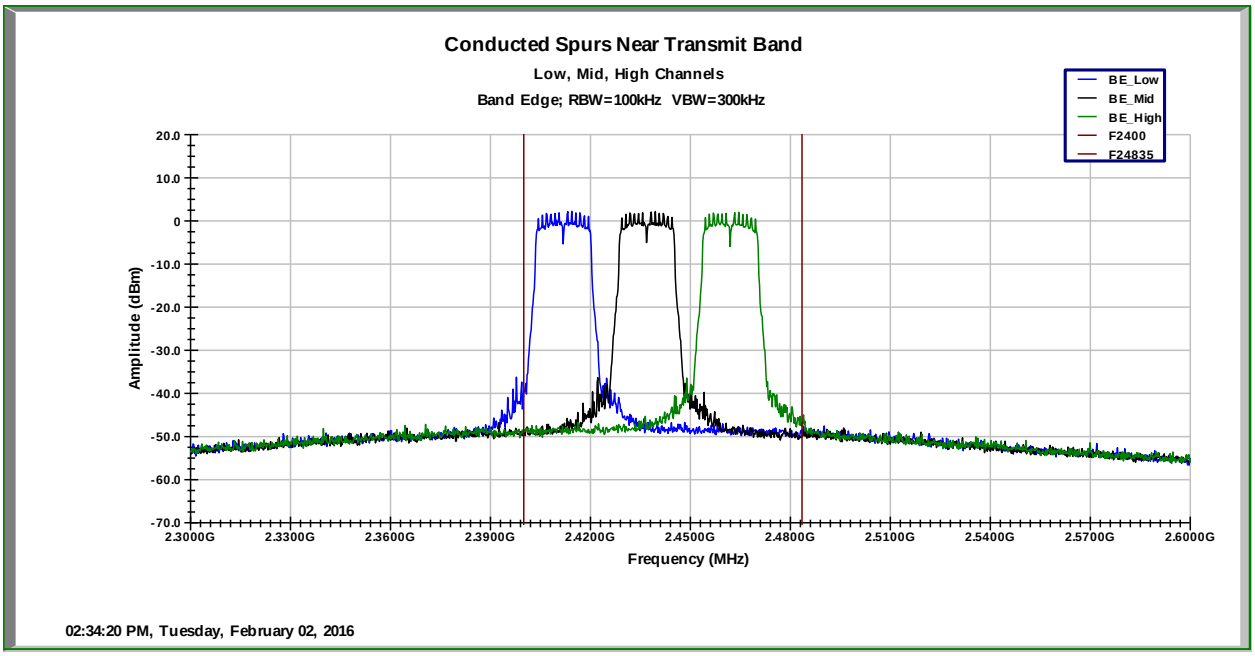
Conducted Spurious Emissions - 802.11g Mode



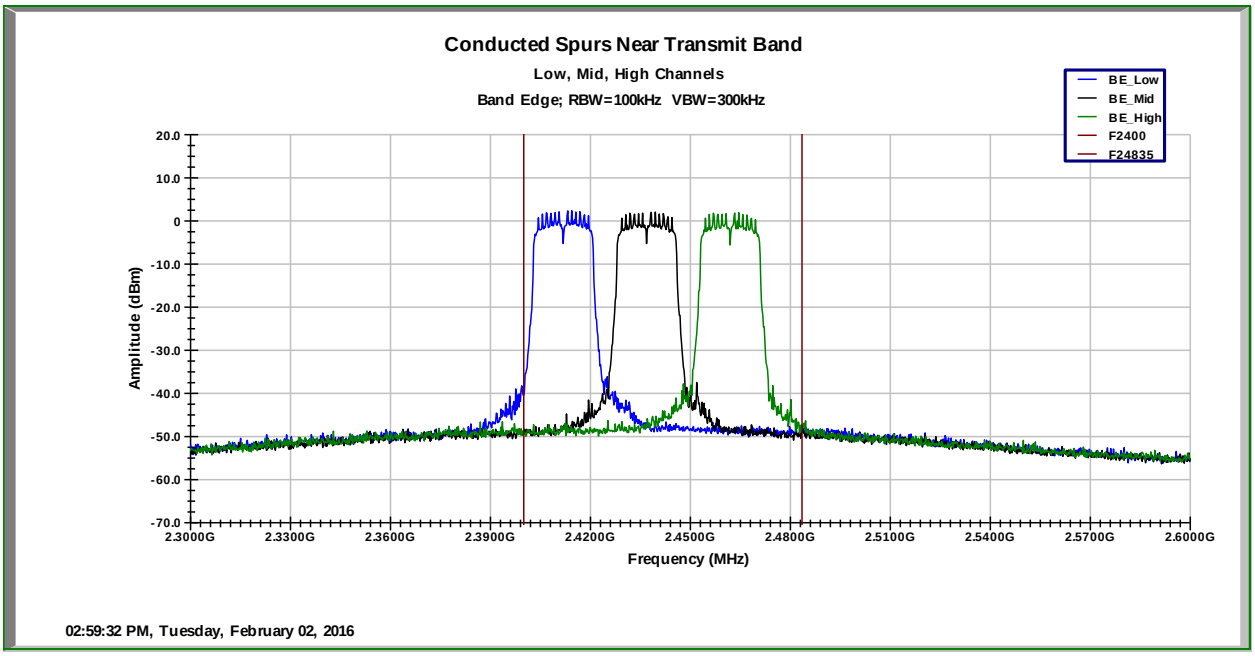
Conducted Spurious Emissions - 802.11n Mode



Emissions Close to Band Edge - 802.11b Mode



Emissions Close to Band Edge - 802.11g Mode



Emissions Close to Band Edge - 802.11n Mode

7 Power Spectral Density

7.1 Test Limits

§ 15.247(e): For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

7.2 Test Procedure

ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

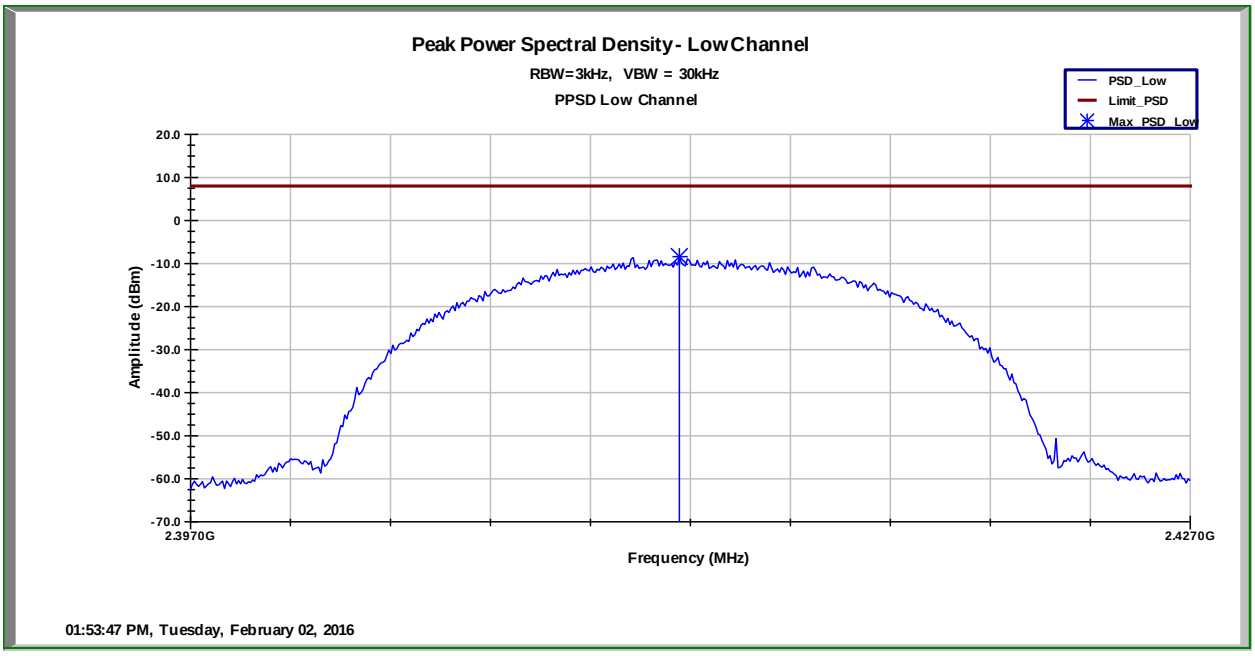
7.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	1088.3494	Rohde & Schwarz	FSEK 30	9/20/2015	9/20/2016

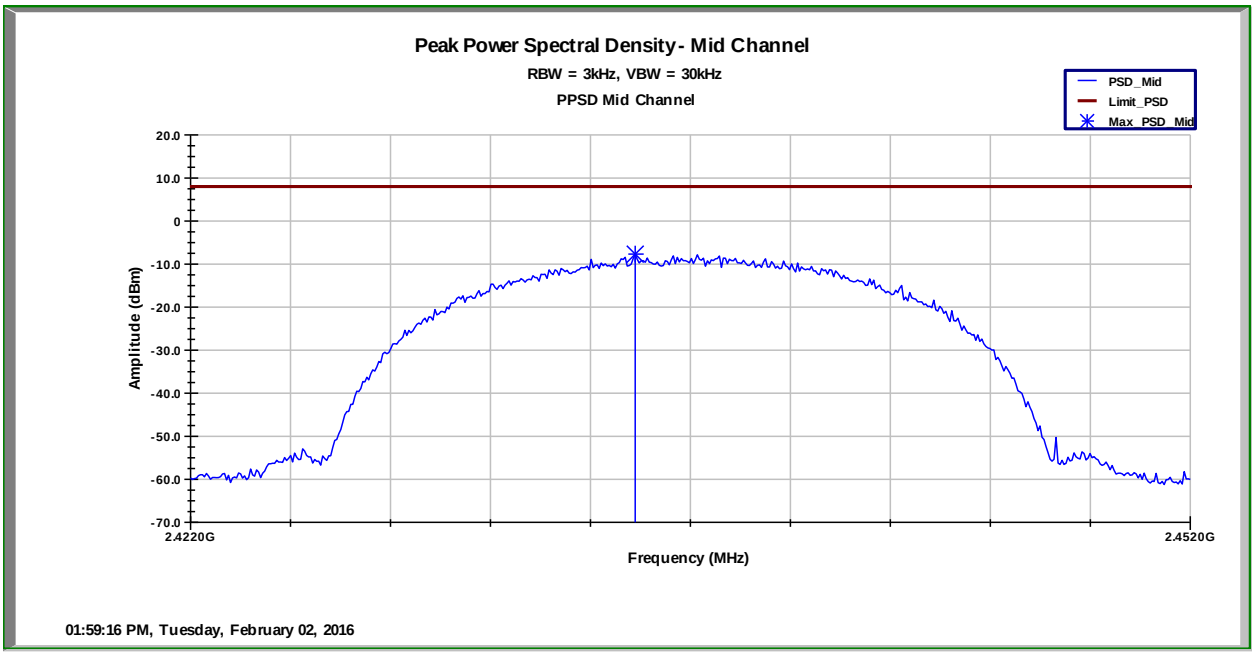
7.4 Results:

*PSD Option 1 Method

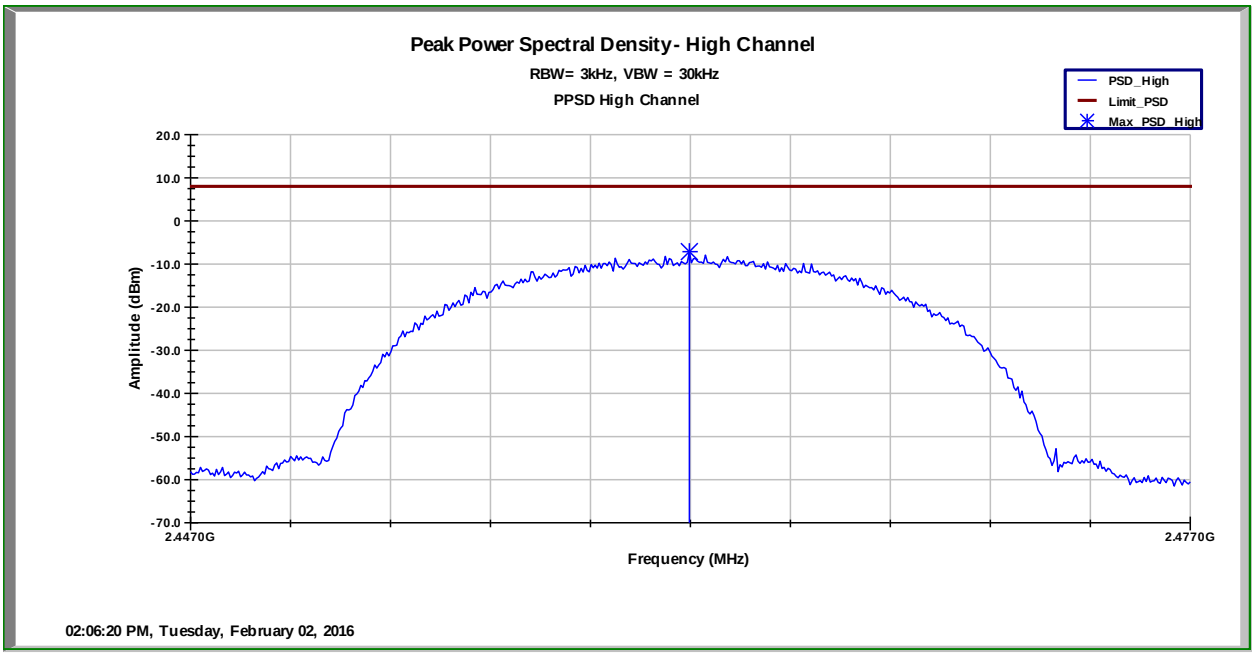
Mode	Channel Number	Frequency (MHz)	PSD in 3kHz BW (dBm)	Limit (dBm)	Margin (dBm)	Result
802.11b	1	2412	-8.401	8.0	16.401	Pass
802.11b	6	2437	-7.696	8.0	15.696	Pass
802.11b	11	2462	-7.138	8.0	15.138	Pass
802.11g	1	2412	-10.799	8.0	18.799	Pass
802.11g	6	2437	-9.520	8.0	17.520	Pass
802.11g	11	2462	-10.484	8.0	18.484	Pass
802.11n	1	2412	-10.618	8.0	18.618	Pass
802.11n	6	2437	-10.575	8.0	18.575	Pass
802.11n	11	2462	-11.903	8.0	19.903	Pass



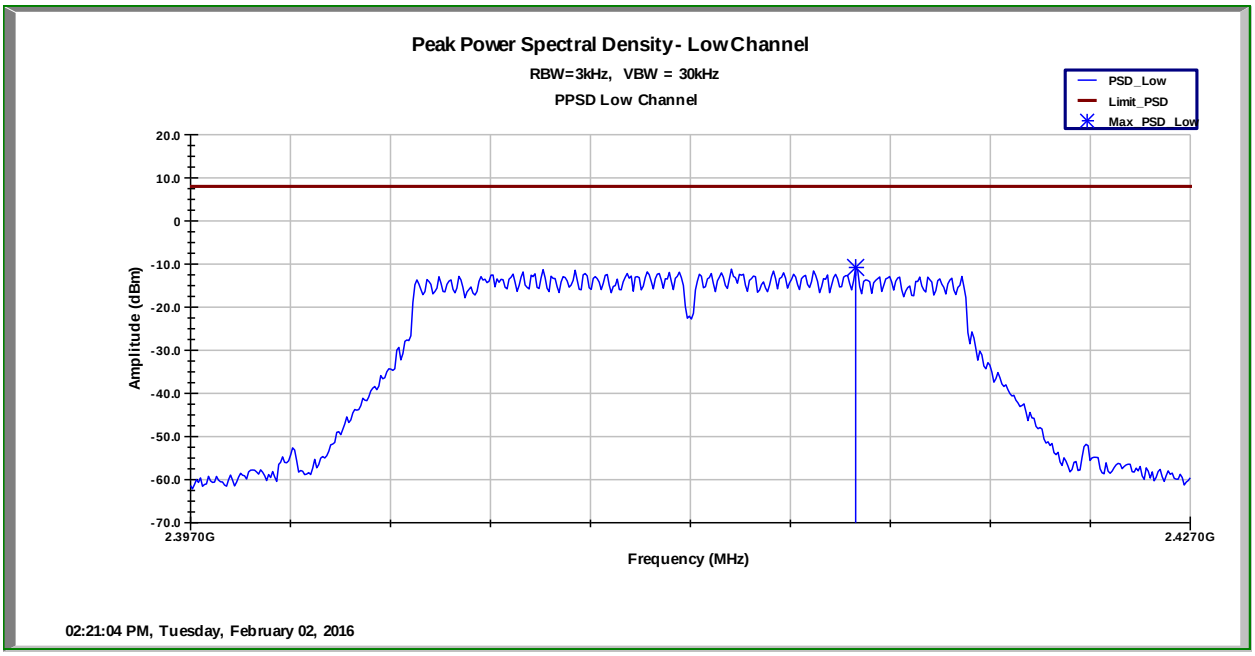
Power Spectral Density – Channel 1 802.11b mode



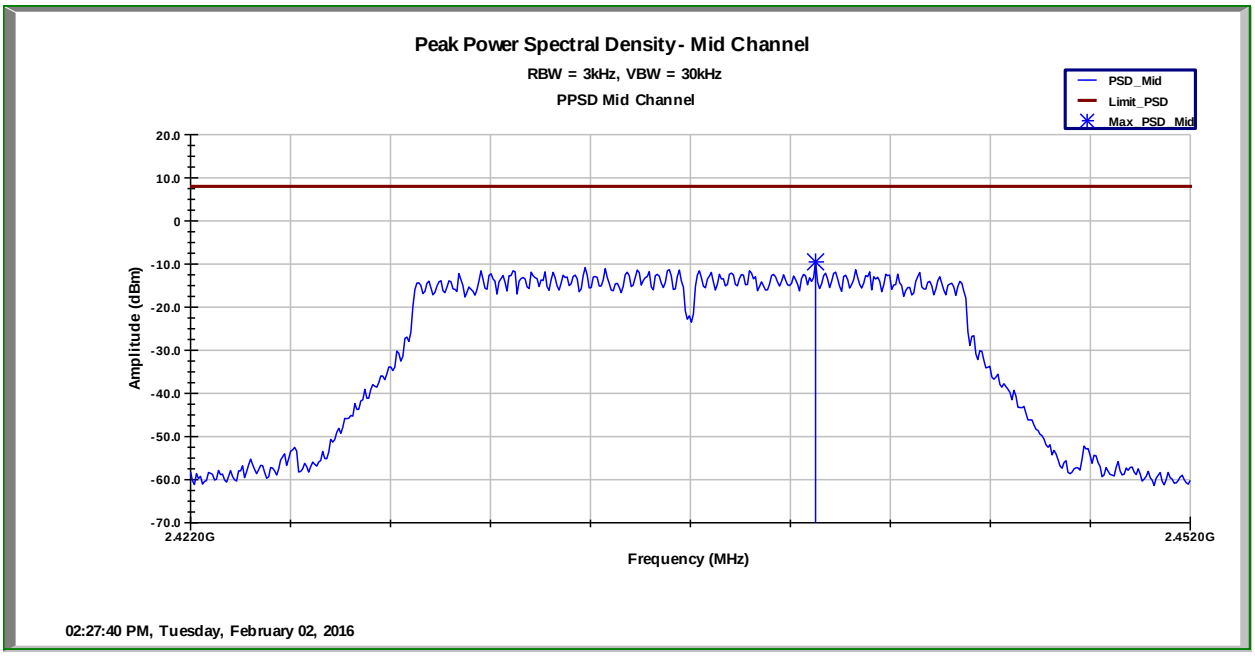
Power Spectral Density – Channel 6 802.11b mode



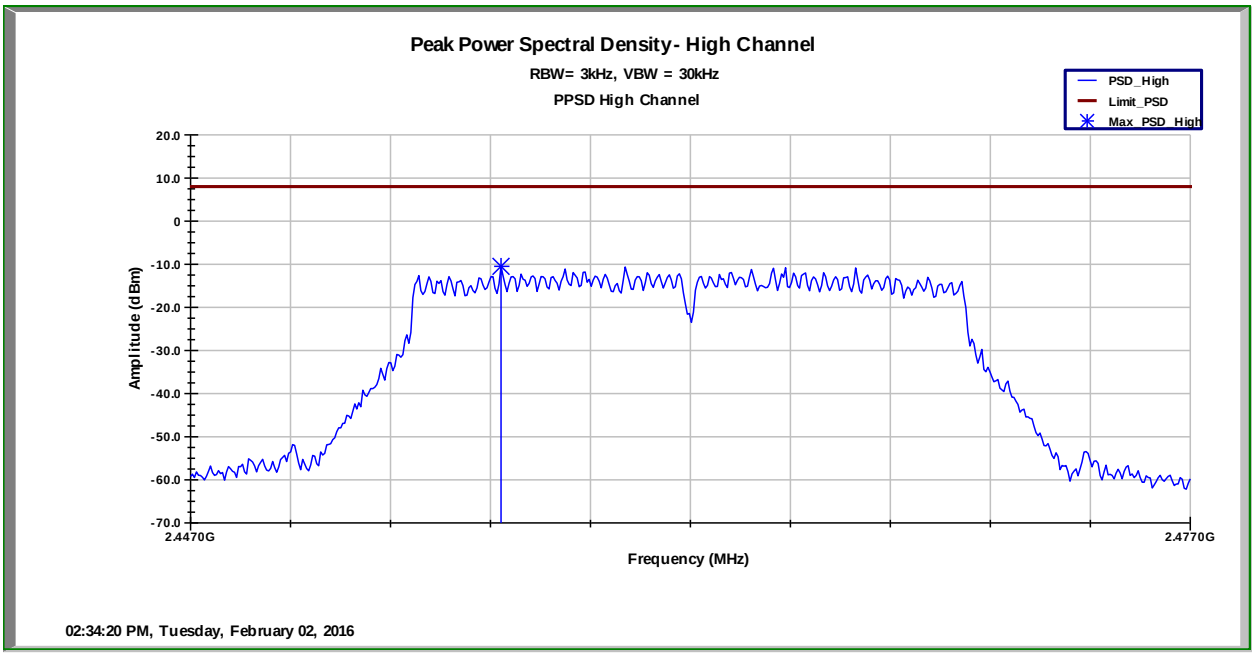
Power Spectral Density – Channel 11 802.11b mode



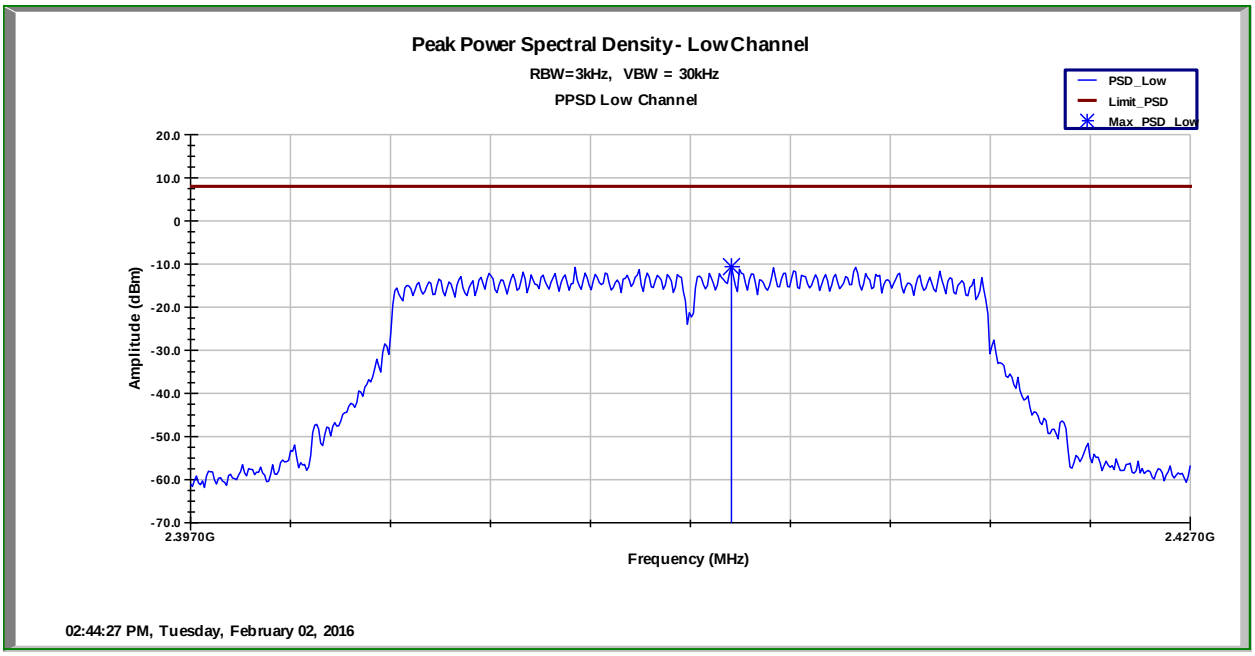
Power Spectral Density – Channel 1 802.11g mode



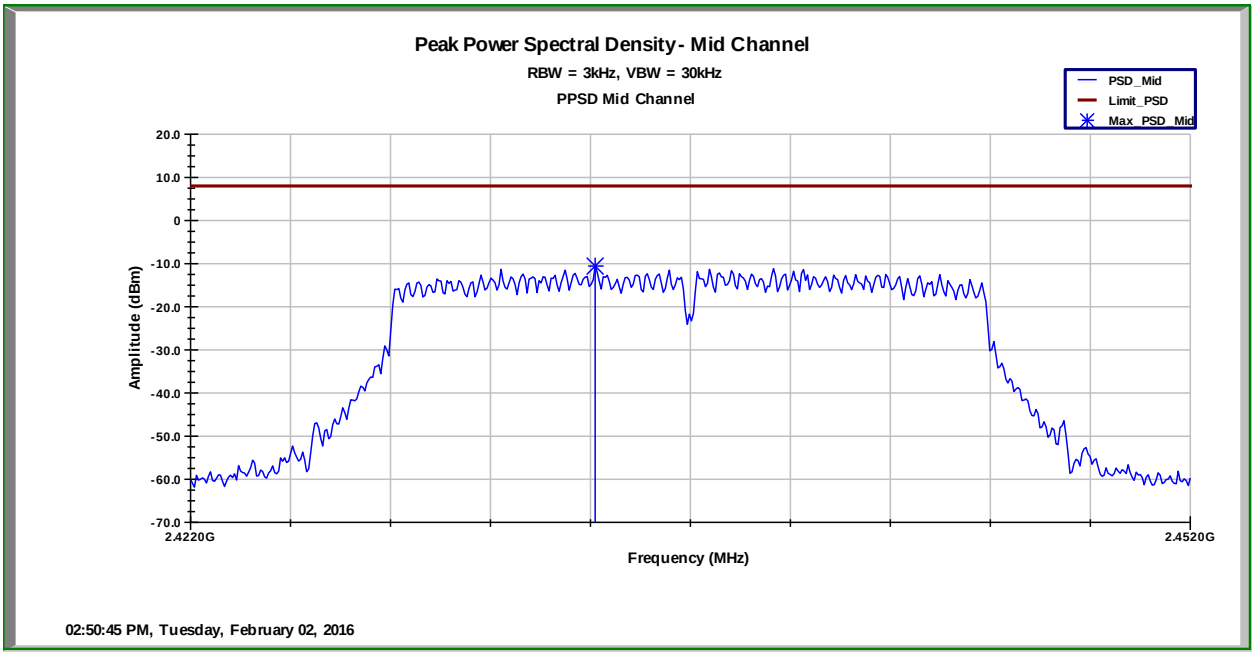
Power Spectral Density – Channel 6 802.11g mode



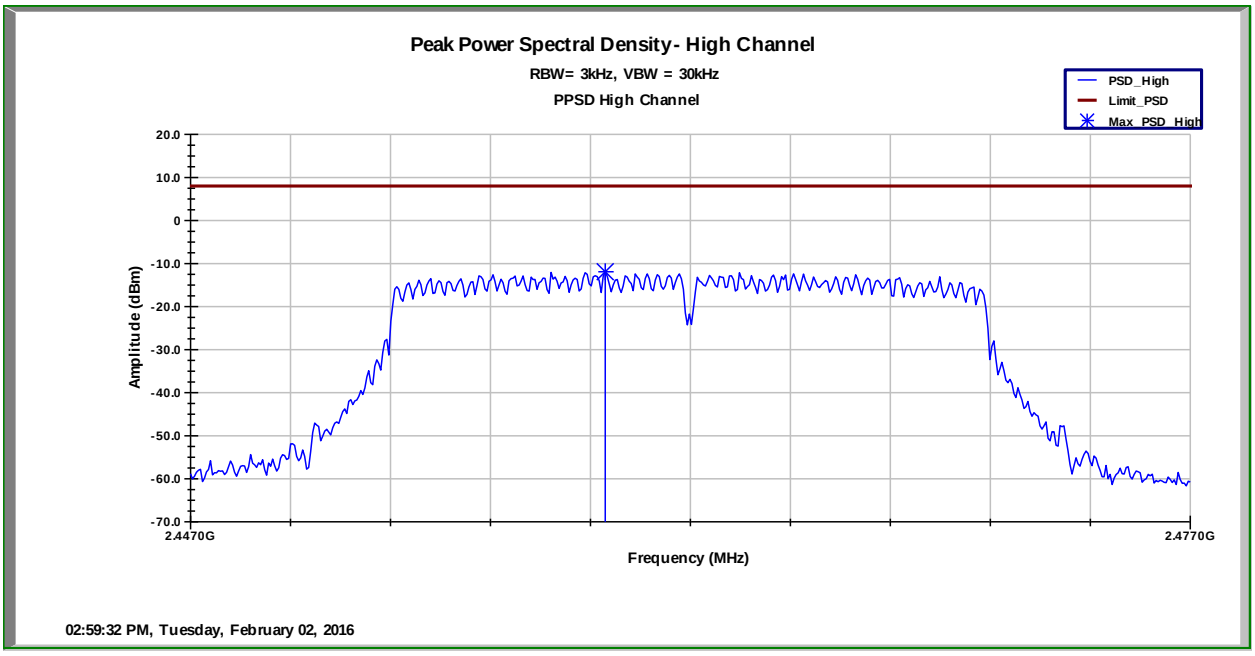
Power Spectral Density – Channel 11 802.11g mode



Power Spectral Density – Channel 1 802.11n mode



Power Spectral Density – Channel 6 802.11n mode



Power Spectral Density – Channel 11 802.11n mode

8 Radiated Spurious Emissions (Transmitter)

8.1 Test Limits

§ 15.247(d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Part 15.205(a): Restricted Bands of Operations

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	[2]
13.36–13.41.			

[1] Until February 1, 1999, this restricted band shall be 0.490–0.510 MHz.
[2] Above 38.6

Part 15.209(a): Field Strength Limits for Restricted Bands of Operation

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 - 0.490	2,400 / F (kHz)	300
0.490 - 1.705	24,000 / F (kHz)	30
1.705 - 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 – 960	200	3
Above 960	500	3

8.2 Test Procedure

ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

8.3 Example of Field Strength Calculation Method:

The measured field strength was calculated by summing the readings taken from the spectrum analyzer with the appropriate correction factors associated with the antenna losses and cable losses. The calculation formula and sample calculations are listed below:

Formula:
FS = RA + AF + CF

FS = Field Strength in dBμV/m
RA = Receiver Amplitude in dBμV
AF = Antenna Factor in dB
CF = Cable Attenuation Factor in dB (Including preamplifier and filter attenuation)

Example Calculation:

RA = 19.48 dBμV
AF = 18.52 dB
CF = 0.78 dB

FS = 19.48 + 18.52 + 0.78 = 38.78 dBμV/m
Level in μV/m = Common Antilogarithm [(38.78 dBμV/m)/20] = 86.89 μV/m

8.4 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	1302.6005.40	Rohde&Schwarz	ESU40	9/19/2015	9/19/2016
Preamplifier	122005	Rohde&Schwarz	TS-PR18	11/19/2015	11/19/2016
Horn Antenna (18 – 40GHz)	00117798	ETS	3116c	4/22/2015	4/22/2016
Horn Antenna	00156319	ETS	3117	5/15/2015	5/15/2016
Bilog Antenna	145	AH Systems	SAS-521-4	3/4/2015	3/4/2017
System Controller	3957	Sunol Sciences	SC110V	Time of Use	Time of Use
High Pass Filter	1	Wainwright	WHKX12-2533.85-2710-18000-40SS	Time of Use	Time of Use
EMC Software	Version 9.15.02	Rohde&Schwarz	EMC32	Time of Use	Time of Use

8.5 Results:

All spurious emissions were attenuated by at least 20dB below the level of the fundamental as required by Part 15.247(d). Additionally, all emissions falling within restricted bands of operation and at the band edges were found to be below the limit specified in Part 15.209(a). The spurious emissions listed in the following tables are the worst case emissions.

Worst Case Spurious Measurements (802.11b Mode)

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4823.800000	---	42.53	74.00	31.47	1000.000	410.0	H	143.0	7.5
4823.800000	30.75	---	54.00	23.25	1000.000	410.0	H	143.0	7.5
7236.600000	31.29	---	54.00	22.71	1000.000	410.0	V	0.0	10.4
7236.600000	---	43.69	74.00	30.31	1000.000	410.0	V	0.0	10.4
9647.800000	---	48.41	74.00	25.59	1000.000	220.0	H	342.0	13.6
9647.800000	35.62	---	54.00	18.38	1000.000	220.0	H	342.0	13.6
12060.600000	---	49.61	74.00	24.39	1000.000	282.0	V	241.0	17.4
12060.600000	36.84	---	54.00	17.16	1000.000	282.0	V	241.0	17.4
14471.800000	---	48.19	74.00	25.81	1000.000	374.0	V	140.0	17.2
14471.800000	35.95	---	54.00	18.05	1000.000	374.0	V	140.0	17.2
16885.000000	40.10	---	54.00	13.90	1000.000	326.0	H	260.0	21.7
16885.000000	---	52.45	74.00	21.55	1000.000	326.0	H	260.0	21.7

802.11b Channel 1 Radiated Spurs

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4873.800000	---	42.49	74.00	31.51	1000.000	410.0	H	142.0	7.4
4873.800000	29.71	---	54.00	24.29	1000.000	410.0	H	142.0	7.4
7311.600000	---	43.85	74.00	30.15	1000.000	367.0	V	130.0	10.5
7311.600000	31.23	---	54.00	22.77	1000.000	367.0	V	130.0	10.5
9747.800000	34.82	---	54.00	19.18	1000.000	264.0	V	144.0	13.7
9747.800000	---	46.97	74.00	27.03	1000.000	264.0	V	144.0	13.7
12184.000000	36.50	---	54.00	17.50	1000.000	257.0	H	144.0	17.2
12184.000000	---	49.87	74.00	24.13	1000.000	257.0	H	144.0	17.2
14621.800000	---	48.84	74.00	25.16	1000.000	286.0	H	150.0	17.3
14621.800000	36.11	---	54.00	17.89	1000.000	286.0	H	150.0	17.3
17058.000000	---	52.16	74.00	21.84	1000.000	249.0	H	200.0	21.4
17058.000000	39.99	---	54.00	14.01	1000.000	249.0	H	200.0	21.4

802.11b Channel 6 Radiated Spurs

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4923.800000	---	41.26	74.00	32.74	1000.000	410.0	H	142.0	7.3
4923.800000	28.96	---	54.00	25.04	1000.000	410.0	H	142.0	7.3
7385.000000	---	45.57	74.00	28.43	1000.000	339.0	H	328.0	10.7
7385.000000	33.77	---	54.00	20.23	1000.000	339.0	H	328.0	10.7
9847.800000	---	48.10	74.00	25.90	1000.000	208.0	H	344.0	14.0
9847.800000	36.94	---	54.00	17.06	1000.000	208.0	H	344.0	14.0
12309.000000	---	50.02	74.00	23.98	1000.000	257.0	H	151.0	17.1
12309.000000	36.60	---	54.00	17.40	1000.000	257.0	H	151.0	17.1
14773.000000	36.44	---	54.00	17.56	1000.000	315.0	V	184.0	17.7
14773.000000	---	49.44	74.00	24.56	1000.000	315.0	V	184.0	17.7
17233.000000	39.54	---	54.00	14.46	1000.000	410.0	H	146.0	21.0
17233.000000	---	51.50	74.00	22.50	1000.000	410.0	H	146.0	21.0

802.11b Channel 11 Radiated Spurs

*Emissions were investigated with the test sample positioned in 3 orthogonal axis and the worst case reported.

Worst Case Spurious Measurements (802.11g Mode)

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4823.400000	---	42.19	74.00	31.81	1000.000	253.0	H	142.0	7.5
4823.400000	29.71	---	54.00	24.29	1000.000	253.0	H	142.0	7.5
7236.600000	---	43.62	74.00	30.38	1000.000	410.0	V	0.0	10.4
7236.600000	30.98	---	54.00	23.02	1000.000	410.0	V	0.0	10.4
9647.800000	36.88	---	54.00	17.12	1000.000	204.0	H	308.0	13.6
9647.800000	---	48.15	74.00	25.85	1000.000	204.0	H	308.0	13.6
12059.000000	36.81	---	54.00	17.19	1000.000	244.0	H	143.0	17.4
12059.000000	---	49.55	74.00	24.45	1000.000	244.0	H	143.0	17.4
14471.000000	35.92	---	54.00	18.08	1000.000	271.0	H	228.0	17.2
14471.000000	---	48.42	74.00	25.58	1000.000	271.0	H	228.0	17.2
16884.600000	40.26	---	54.00	13.74	1000.000	211.0	H	257.0	21.7
16884.600000	---	54.08	74.00	19.92	1000.000	211.0	H	257.0	21.7

802.11g Channel 1 Radiated Spurs

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4873.800000	---	41.84	74.00	32.16	1000.000	251.0	H	144.0	7.4
4873.800000	29.35	---	54.00	24.65	1000.000	251.0	H	144.0	7.4
7311.200000	---	43.76	74.00	30.24	1000.000	368.0	V	131.0	10.5
7311.200000	31.08	---	54.00	22.92	1000.000	368.0	V	131.0	10.5
9747.800000	34.79	---	54.00	19.21	1000.000	245.0	H	310.0	13.7
9747.800000	---	47.00	74.00	27.00	1000.000	245.0	H	310.0	13.7
12186.000000	36.55	---	54.00	17.45	1000.000	255.0	H	147.0	17.2
12186.000000	---	49.85	74.00	24.15	1000.000	255.0	H	147.0	17.2
14622.200000	---	49.07	74.00	24.93	1000.000	295.0	V	138.0	17.3
14622.200000	35.96	---	54.00	18.04	1000.000	295.0	V	138.0	17.3
17058.400000	---	52.44	74.00	21.56	1000.000	337.0	V	132.0	21.4
17058.400000	39.97	---	54.00	14.03	1000.000	337.0	V	132.0	21.4

802.11g Channel 6 Radiated Spurs

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4923.800000	---	40.80	74.00	33.20	1000.000	238.0	H	147.0	7.3
4923.800000	28.46	---	54.00	25.54	1000.000	238.0	H	147.0	7.3
7386.200000	---	45.10	74.00	28.90	1000.000	337.0	H	332.0	10.7
7386.200000	31.63	---	54.00	22.37	1000.000	337.0	H	332.0	10.7
9847.800000	33.57	---	54.00	20.43	1000.000	257.0	V	142.0	14.0
9847.800000	---	46.30	74.00	27.70	1000.000	257.0	V	142.0	14.0
12309.800000	36.59	---	54.00	17.41	1000.000	262.0	H	152.0	17.1
12309.800000	---	49.23	74.00	24.77	1000.000	262.0	H	152.0	17.1
14773.000000	36.53	---	54.00	17.47	1000.000	410.0	H	232.0	17.7
14773.000000	---	48.83	74.00	25.17	1000.000	410.0	H	232.0	17.7
17233.000000	39.53	---	54.00	14.47	1000.000	287.0	H	332.0	21.0
17233.000000	---	52.18	74.00	21.82	1000.000	287.0	H	332.0	21.0

802.11g Channel 11 Radiated Spurs

*Emissions were investigated with the test sample positioned in 3 orthogonal axis and the worst case reported.

Worst Case Spurious Measurements (802.11n Mode)

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4823.000000	---	42.30	74.00	31.70	1000.000	344.0	V	208.0	7.5
4823.000000	29.67	---	54.00	24.33	1000.000	344.0	V	208.0	7.5
7236.600000	31.00	---	54.00	23.00	1000.000	288.0	V	116.0	10.4
7236.600000	---	43.95	74.00	30.05	1000.000	288.0	V	116.0	10.4
9647.800000	34.70	---	54.00	19.30	1000.000	233.0	H	310.0	13.6
9647.800000	---	47.70	74.00	26.30	1000.000	233.0	H	310.0	13.6
12059.000000	---	49.25	74.00	24.75	1000.000	344.0	V	246.0	17.4
12059.000000	36.79	---	54.00	17.21	1000.000	344.0	V	246.0	17.4
14471.000000	35.85	---	54.00	18.15	1000.000	248.0	H	207.0	17.2
14471.000000	---	48.73	74.00	25.27	1000.000	248.0	H	207.0	17.2
16885.000000	40.19	---	54.00	13.81	1000.000	343.0	H	336.0	21.7
16885.000000	---	53.29	74.00	20.71	1000.000	343.0	H	336.0	21.7

802.11n Channel 1 Radiated Spurs

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4873.400000	---	42.04	74.00	31.96	1000.000	410.0	H	149.0	7.4
4873.400000	29.40	---	54.00	24.60	1000.000	410.0	H	149.0	7.4
7311.200000	---	43.77	74.00	30.23	1000.000	275.0	V	0.0	10.5
7311.200000	31.17	---	54.00	22.83	1000.000	275.0	V	0.0	10.5
9747.800000	35.09	---	54.00	18.91	1000.000	252.0	H	310.0	13.7
9747.800000	---	47.09	74.00	26.91	1000.000	252.0	H	310.0	13.7
12186.000000	---	49.21	74.00	24.79	1000.000	250.0	H	150.0	17.2
12186.000000	36.62	---	54.00	17.38	1000.000	250.0	H	150.0	17.2
14621.800000	36.02	---	54.00	17.98	1000.000	338.0	V	136.0	17.3
14621.800000	---	49.29	74.00	24.71	1000.000	338.0	V	136.0	17.3
17058.400000	---	53.06	74.00	20.94	1000.000	341.0	H	189.0	21.4
17058.400000	39.99	---	54.00	14.01	1000.000	341.0	H	189.0	21.4

802.11n Channel 6 Radiated Spurs

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4923.000000	28.55	---	54.00	25.45	1000.000	229.0	V	143.0	7.3
4923.000000	---	41.03	74.00	32.97	1000.000	229.0	V	143.0	7.3
7385.800000	31.52	---	54.00	22.48	1000.000	347.0	H	336.0	10.7
7385.800000	---	44.99	74.00	29.01	1000.000	347.0	H	336.0	10.7
9847.800000	37.32	---	54.00	16.68	1000.000	316.0	H	312.0	14.0
9847.800000	---	48.13	74.00	25.87	1000.000	316.0	H	312.0	14.0
12309.800000	---	49.36	74.00	24.64	1000.000	250.0	H	151.0	17.1
12309.800000	36.61	---	54.00	17.39	1000.000	250.0	H	151.0	17.1
14773.000000	36.41	---	54.00	17.59	1000.000	275.0	V	344.0	17.7
14773.000000	---	48.83	74.00	25.17	1000.000	275.0	V	344.0	17.7
17233.000000	---	52.13	74.00	21.87	1000.000	229.0	H	149.0	21.0
17233.000000	39.55	---	54.00	14.45	1000.000	229.0	H	149.0	21.0

802.11n Channel 11 Radiated Spurs

*Emissions were investigated with the test sample positioned in 3 orthogonal axis and the worst case reported.

Low Channel Band Edge Emissions - 802.11b Mode

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	---	54.51	74.00	19.49	1000.000	370.0	V	0.0	37.7
2390.000000	43.83	---	54.00	10.17	1000.000	370.0	V	0.0	37.7

High Channel Band Edge - 802.11b Mode

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	61.04	74.00	12.96	1000.000	410.0	V	0.0	37.8
2483.500000	46.71	---	54.00	7.29	1000.000	410.0	V	0.0	37.8

Low Channel Band Edge Emissions - 802.11g Mode

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	---	58.14	74.00	15.86	1000.000	370.0	V	0.0	37.7
2390.000000	46.10	---	54.00	7.90	1000.000	370.0	V	0.0	37.7

High Channel Band Edge Emissions - 802.11g Mode

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	61.04	74.00	12.96	1000.000	410.0	V	0.0	37.8
2483.500000	46.71	---	54.00	7.29	1000.000	410.0	V	0.0	37.8

Low Channel Band Edge Emissions - 802.11n Mode

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	---	60.29	74.00	13.71	1000.000	371.0	V	0.0	37.7
2390.000000	46.70	---	54.00	7.30	1000.000	371.0	V	0.0	37.7

High Channel Band Edge Emissions - 802.11n Mode

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	58.36	74.00	15.64	1000.000	356.0	V	0.0	37.8
2483.500000	45.59	---	54.00	8.41	1000.000	356.0	V	0.0	37.8

9 Radiated Spurious Emissions (Receiver)

9.1 Test Limits

§ 15.109: Except for Class A digital devices, the field strength of radiated emissions from unintentional radiators at a distance of 3 meters shall not exceed the following values:

Frequency of emission (MHz)	Field strength (microvolts/meter)	Field strength (dBuV/m)
30–88	100	40
88–216	150	43.5
216–960	200	46
Above 960	500	54

These limits are identical to those in RSS-GEN

9.2 Test Procedure

ANSI C63.4: 2014

9.3 Example of Field Strength Calculation Method:

The measured field strength was calculated by summing the readings taken from the spectrum analyzer with the appropriate correction factors associated with the antenna losses and cable losses. The calculation formula and sample calculations are listed below:

Formula:
FS = RA + AF + CF

FS = Field Strength in dBμV/m
RA = Receiver Amplitude in dBμV
AF = Antenna Factor in dB
CF = Cable Attenuation Factor in dB (Including preamplifier and filter attenuation)

Example Calculation:

RA = 19.48 dBμV
AF = 18.52 dB
CF = 0.78 dB

FS = 19.48 + 18.52 + 0.78 = 38.78 dBμV/m
Level in μV/m = Common Antilogarithm [(38.78 dBμV/m)/20] = 86.89 μV/m

9.4 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	1302.6005.40	Rohde & Schwarz	ESU40	9/19/2015	9/19/2016
Preamplifier	122005	Rohde&Schwarz	TS-PR18	11/19/2015	11/19/2016
Bilog Antenna	145	AH Systems	SAS-521-4	3/4/2015	3/4/2017
Horn Antenna	00156319	ETS	3117	5/15/2015	5/15/2016
System Controller	3957	Sunol Sciences	SC110V	Time of Use	Time of Use
EMC Software	Version 9.15.02	Rohde & Schwarz	EMC32	Time of Use	Time of Use

9.5 Results:

All spurious emissions with the test sample in receive mode were below the limits specified in Part 15.109 for a class B digital device and RSS-GEN Section 6.1.

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.320000	33.35	40.00	6.65	120.000	105.0	V	146.0	19.2
51.819000	37.01	40.00	2.99	120.000	104.9	V	126.0	9.4
51.831000	37.45	40.00	2.55	120.000	104.8	V	118.0	9.4
51.842000	37.75	40.00	2.25	120.000	104.9	V	126.0	9.4
51.856000	36.75	40.00	3.25	120.000	213.1	V	294.0	9.4
64.162000	34.98	40.00	5.02	120.000	104.9	V	82.0	8.4
64.833000	32.47	40.00	7.53	120.000	202.2	V	273.0	8.4
101.920000	36.45	43.52	7.07	120.000	177.5	H	247.0	15.5
151.560000	33.57	43.52	9.95	120.000	166.7	H	258.0	20.0
947.460000	38.60	46.02	7.42	120.000	401.6	V	128.0	29.7

802.11rx

10 AC Powerline Conducted Emissions

10.1 Test Limits

§ 15.107(e): Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

*Decreases with the logarithm of the frequency.

10.2 Test Procedure

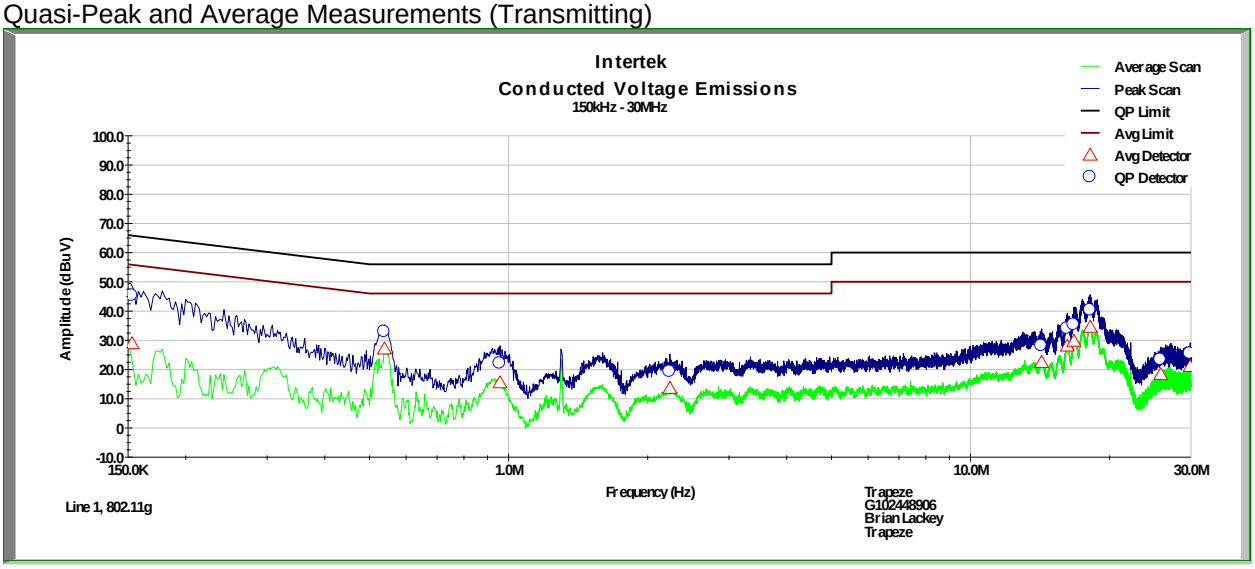
ANSI C63.4: 2014

10.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESI26	9/20/2015	9/20/2016
LISN	110WT50202	PMM	L3-100	12/18/2015	12/18/2016

10.4 Results:

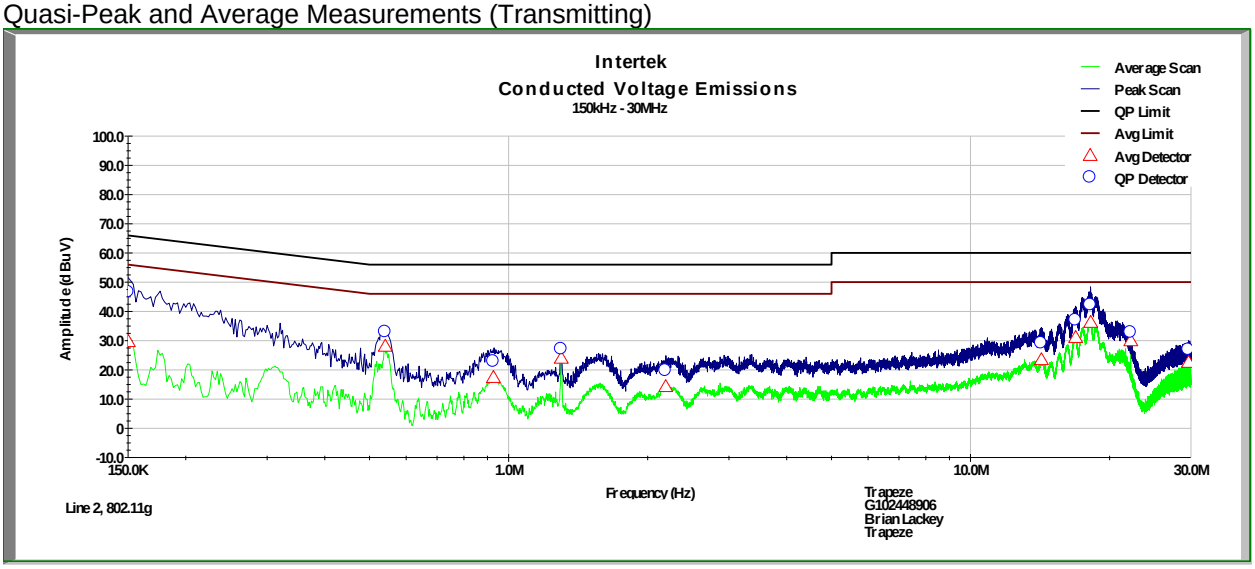
Quasi-Peak and Average Measurements (Transmitting)



Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
153.000 KHz	45.247	65.914	-20.667	28.858	55.914	-27.056
538.500 KHz	32.843	56.000	-23.157	27.043	46.000	-18.957
957.800 KHz	22.052	56.000	-33.948	15.467	46.000	-30.533
2.234 MHz	19.210	56.000	-36.790	13.540	46.000	-32.460
14.250 MHz	28.019	60.000	-31.981	22.403	50.000	-27.597
16.199 MHz	33.918	60.000	-26.082	28.031	50.000	-21.969
16.742 MHz	35.245	60.000	-24.755	29.672	50.000	-20.328
18.163 MHz	40.251	60.000	-19.749	34.466	50.000	-15.534
25.799 MHz	23.256	60.000	-36.744	18.259	50.000	-31.741
29.890 MHz	25.368	60.000	-34.632	21.032	50.000	-28.968

Line 1

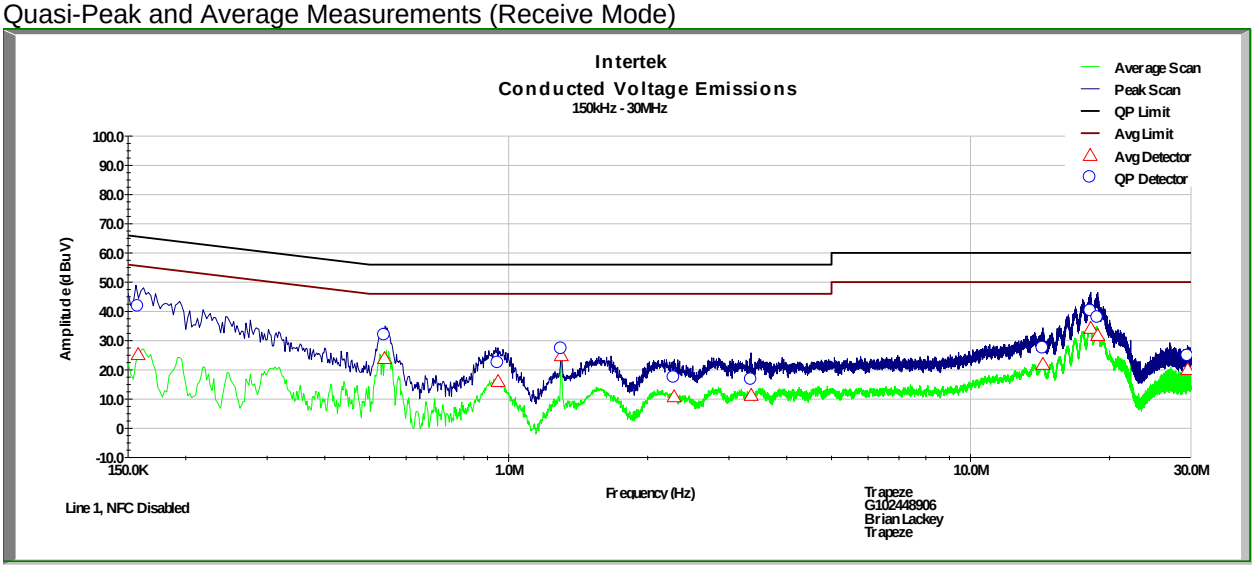
Quasi-Peak and Average Measurements (Transmitting)



Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
150.200 KHz	46.526	65.994	-19.469	29.649	55.994	-26.345
540.800 KHz	32.898	56.000	-23.102	28.093	46.000	-17.907
926.800 KHz	22.780	56.000	-33.220	17.394	46.000	-28.606
1.301 MHz	27.045	56.000	-28.955	23.989	46.000	-22.011
2.188 MHz	19.677	56.000	-36.323	14.264	46.000	-31.736
14.240 MHz	29.083	60.000	-30.917	23.478	50.000	-26.522
16.886 MHz	36.897	60.000	-23.103	31.068	50.000	-18.932
18.194 MHz	42.134	60.000	-17.866	36.229	50.000	-13.771
22.222 MHz	32.729	60.000	-27.271	29.962	50.000	-20.038
29.648 MHz	26.818	60.000	-33.182	22.562	50.000	-27.438

Line 2

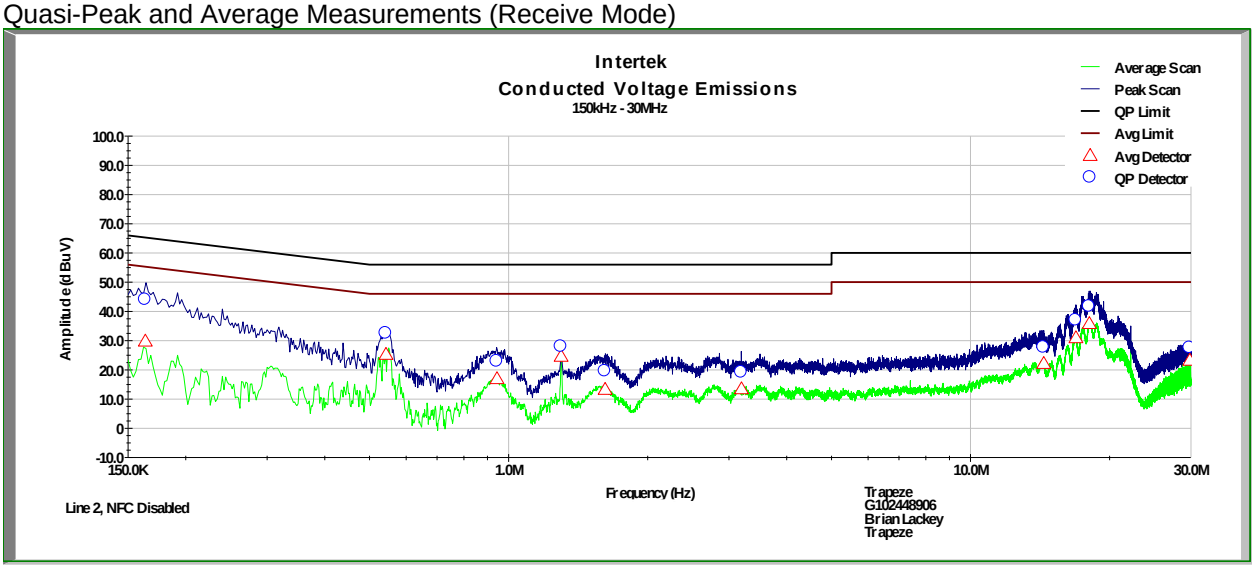
Quasi-Peak and Average Measurements (Receive Mode)



Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
157.700 KHz	41.671	65.780	-24.109	25.231	55.780	-30.549
538.700 KHz	31.798	56.000	-24.202	23.845	46.000	-22.155
948.500 KHz	22.340	56.000	-33.660	15.990	46.000	-30.010
1.300 MHz	27.135	56.000	-28.865	24.841	46.000	-21.159
2.281 MHz	17.336	56.000	-38.664	10.771	46.000	-35.229
3.351 MHz	16.570	56.000	-39.430	11.239	46.000	-34.761
14.349 MHz	27.371	60.000	-32.629	21.871	50.000	-28.129
18.204 MHz	40.070	60.000	-19.930	34.203	50.000	-15.797
18.849 MHz	37.827	60.000	-22.173	31.739	50.000	-18.261
29.525 MHz	24.732	60.000	-35.268	20.078	50.000	-29.922

Line 1

Quasi-Peak and Average Measurements (Receive Mode)



Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Margin (dB)	Average (dBuV)	Average Limit (dBuV)	Average Margin (dB)
163.500 KHz	43.935	65.614	-21.679	29.821	55.614	-25.793
542.500 KHz	32.417	56.000	-23.583	25.277	46.000	-20.723
943.600 KHz	22.870	56.000	-33.130	16.990	46.000	-29.010
1.299 MHz	27.872	56.000	-28.128	24.643	46.000	-21.357
1.617 MHz	19.519	56.000	-36.481	13.331	46.000	-32.669
3.192 MHz	19.089	56.000	-36.911	13.530	46.000	-32.470
14.402 MHz	27.588	60.000	-32.412	22.152	50.000	-27.848
16.911 MHz	36.912	60.000	-23.088	30.975	50.000	-19.025
18.073 MHz	41.615	60.000	-18.385	35.860	50.000	-14.140
29.830 MHz	27.455	60.000	-32.545	23.282	50.000	-26.718

Line 2

Antenna Requirement per FCC Part 15.203

10.5 Test Limits

§ 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. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

10.6 Results:

The sample tested met the antenna requirement. The antenna used was permanently attached and integral to the PCB.

11 Measurement Uncertainty

The measured value related to the corresponding limit will be used to decide whether the equipment meets the requirements.

The measurement uncertainty figures were calculated and correspond to a coverage factor of k = 2, providing a confidence level of respectively 95.45 % in the case where the distributions characterizing the actual measurement uncertainties are normal (Gaussian).

Measurement uncertainty Table

Parameter	Uncertainty	Notes
Radiated emissions, 30 to 1000 MHz	±3.9dB	
Radiated emissions, 1 to 18 GHz	±4.2dB	
Radiated emissions, 18 to 40 GHz	±4.3dB	
Power Port Conducted emissions, 150kHz to 30 MHz	±2.8dB	

12 Revision History

Revision Level	Date	Report Number	Notes
0	2/4/2016	102448906LEX-002	Original Issue