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TEST REPORT

Report Number: 102216394LEX-001
Project Number: G102216394

Report Issue Date: 9/2/2015

Product Name: 2.4GHz Spread Spectrum Transceiver

Standards: Title 47 CFR Part 15.247
RSS-247 Issue 1

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

Client:
Opex Corporation
305 Commerce Drive
Moorestown, NJ 08057-4215

Report prepared by

Bryan Taylor, Team Leader

Report reviewed by

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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-247 (5.4)(4)	Pass
9	Occupied Bandwidth	§ 15.247(a)(2)	RSS-247 (5.2)(1) RSS-GEN (4.6.1)	Pass
14	Conducted Spurious Emissions	§ 15.247(d)	RSS-247 (5.5)	Pass
16	Power Spectral Density	§ 15.247(e)	RSS-247 (5.2)(2)	Pass
19	Radiated Spurious Emissions (Transmitter)	§ 15.247(d), § 15.209, and § 15.205	RSS-247 (5.5)	Pass
29	AC Powerline Conducted Emissions	§ 15.107, § 15.207	RSS-Gen (7.2.4)	Pass
34	Antenna Requirement per FCC Part 15.203	§ 15.203	RSS-Gen (7.1.2)	Pass

3 Description of Equipment Under Test

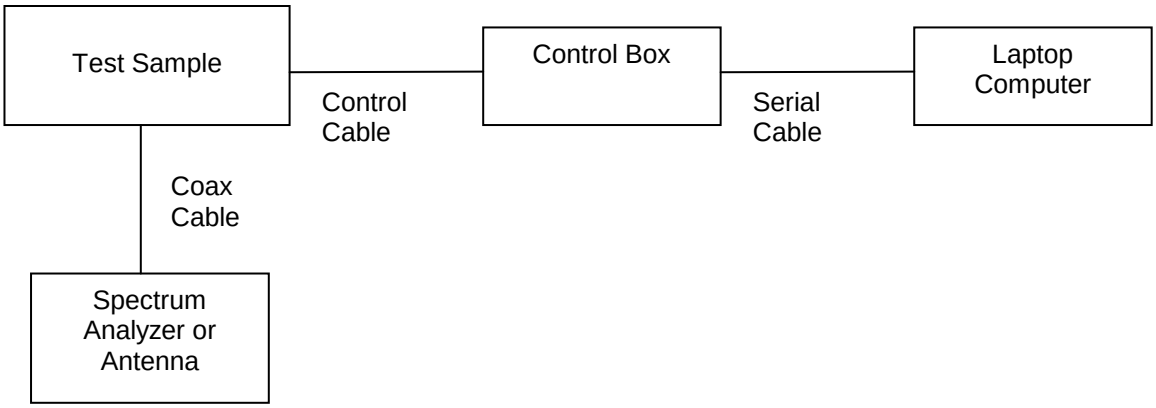
Equipment Under Test	
Manufacturer	Opex Corporation
Model Number	2054710
Serial Number	Test Sample 1
Receive Date	8/1/2015
Test Start Date	8/1/2015
Test End Date	8/12/2015
Device Received Condition	Good
Test Sample Type	Production
Frequency Band	2405MHz – 2480MHz
Mode(s) of Operation	Zigbee
Modulation Type	OFDM
Duty Cycle	100%
Transmission Control	Test commands were provided by the manufacturer and used to set the transmit channel and output power.
Test Channels	11, 18, 26
Antenna Type (15.203)	Four antenna types were considered during the radiated testing as follows: Linx: ANT-2.4-WRT-UFL: 3.5dBi MaxStream: A24-HASM-450: 2.41dBi Molex: 47950-1011: 3.0dBi Opex Corporation: PCB Inverted F: 2.2dBi
Operating Voltage	Powered by 24VDC via a 120VAC/60Hz AC power adapter (CUI Model EPSA240100U)

Description of Equipment Under Test
The equipment under test was a Zigbee 2.4GHz wireless transceiver module.

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	Transmitting a modulated test signal on low, mid or high channels.
2	Receive mode/ Idle mode.

3.1 EUT Block Diagram:



3.2 Cables:

Cables					
Description	Length	Shielding	Ferrites	Connection	
				From	To
Control Cable	30cm	None	None	Test Sample	Control Box

3.3 Support Equipment:

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
Laptop Computer	HP	EliteBook 8470p	Not Labeled

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

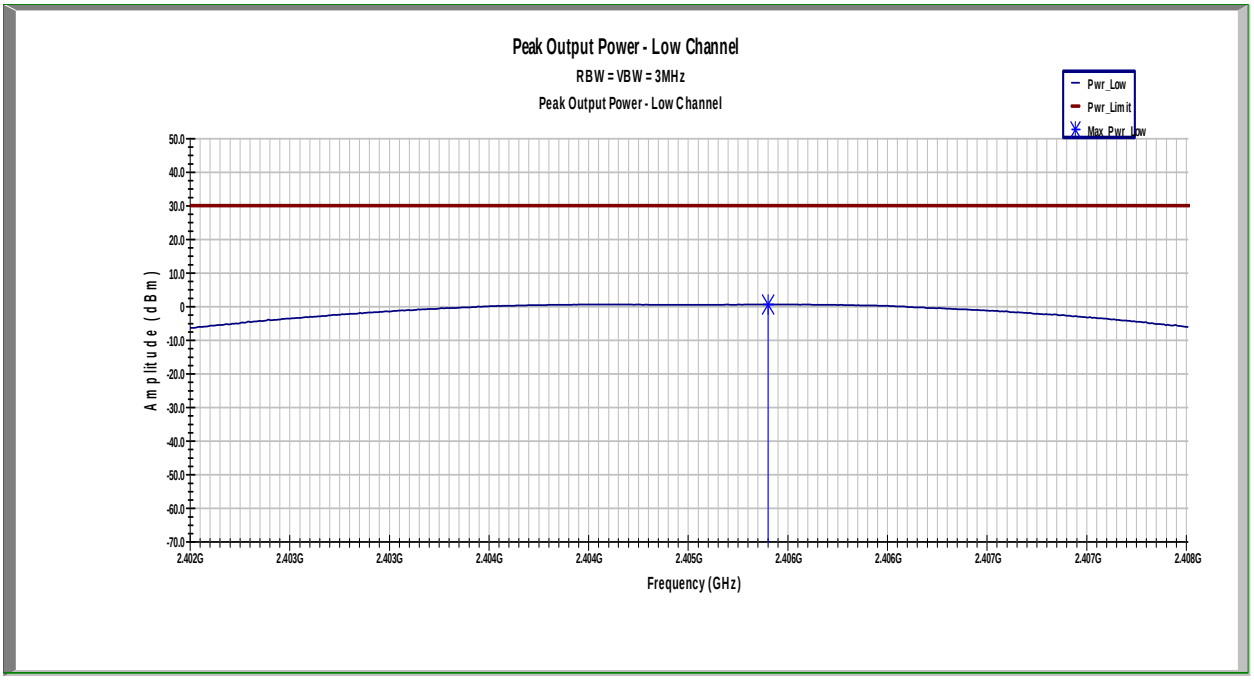
ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247). The peak output power was measured a spectrum analyzer with a RBW setting higher then the DTS bandwidth of the transmitted signal.

4.3 Test Equipment Used:

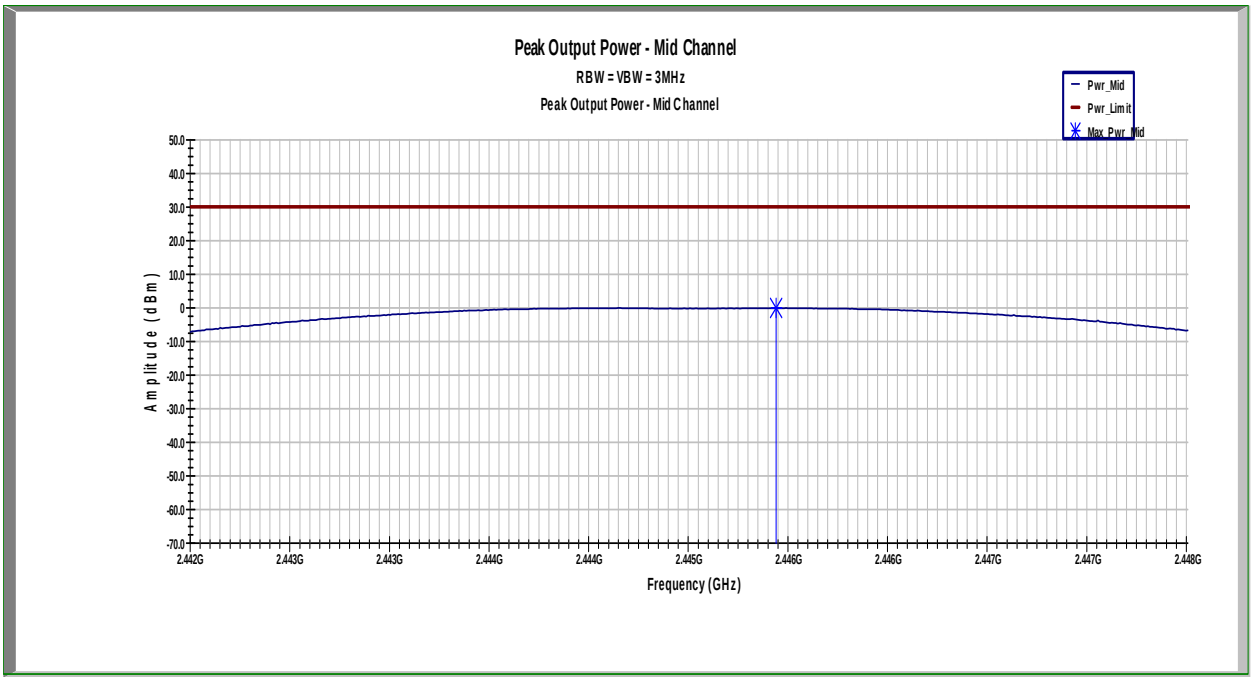
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	9/15/2014	9/15/2015

4.4 Results:

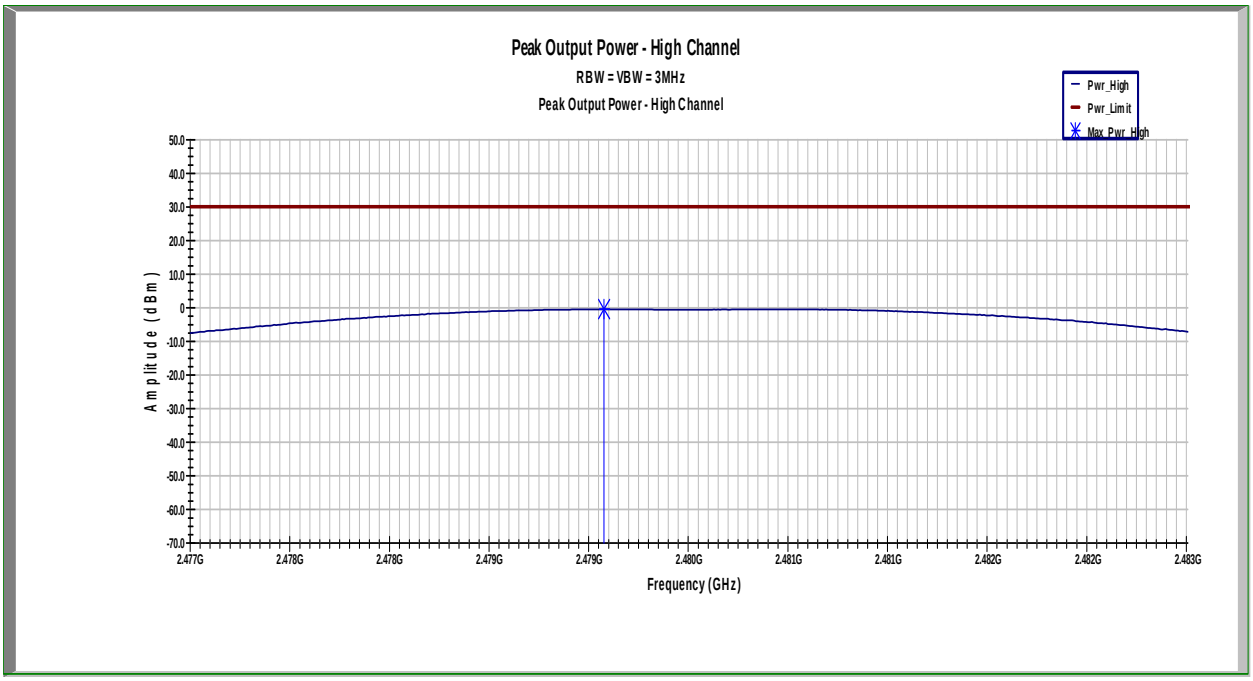
Mode	Channel Number	Frequency (MHz)	Peak Output Power (dBm)	Limit (dBm)	Result
Zigbee	11	2405	0.623	30	Pass
Zigbee	18	2445	-0.054	30	Pass
Zigbee	26	2480	-0.442	30	Pass



Peak Output Power – Channel 11



Peak Output Power – Channel 18



Peak Output Power – Channel 26

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

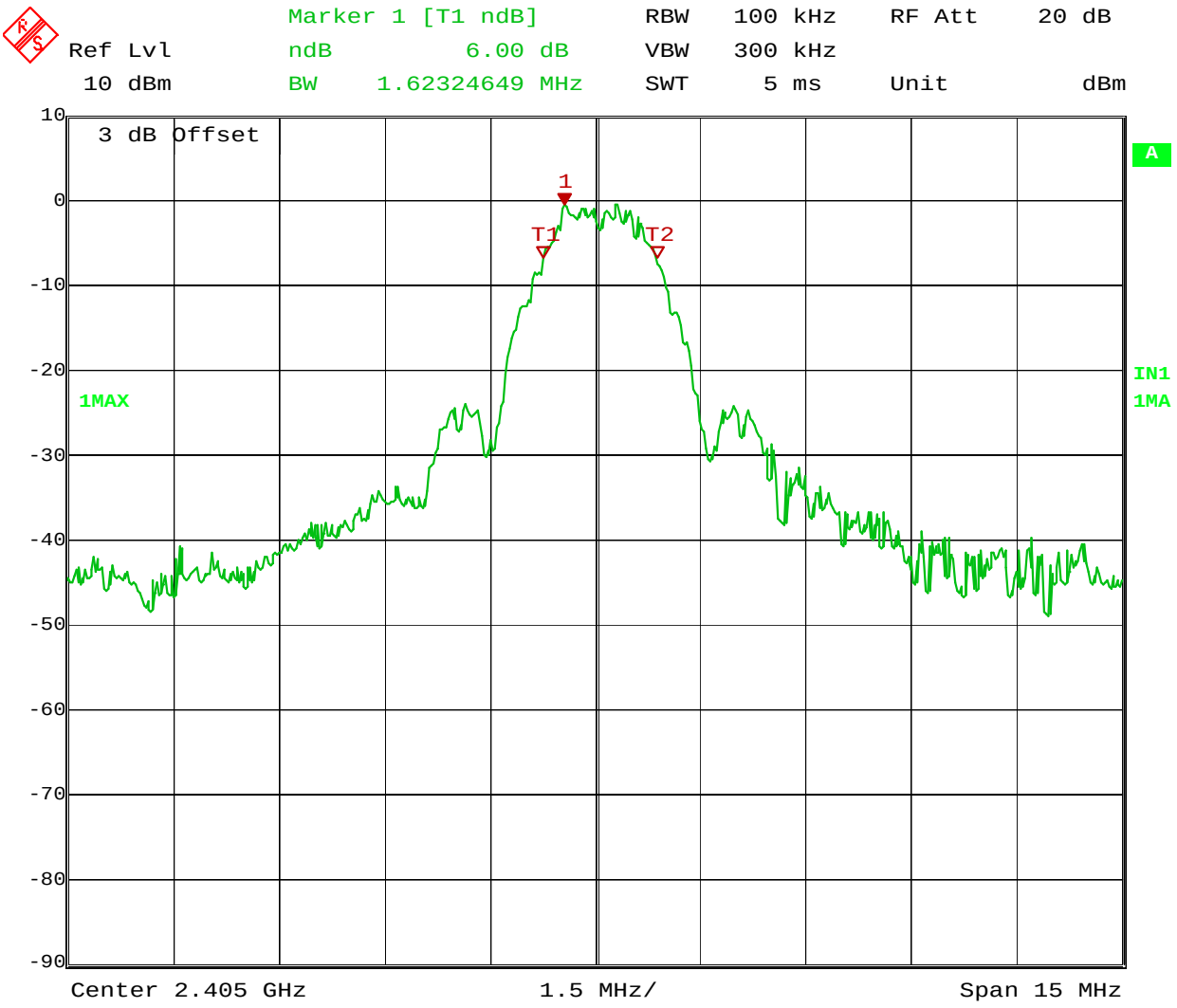
ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

5.3 Test Equipment Used:

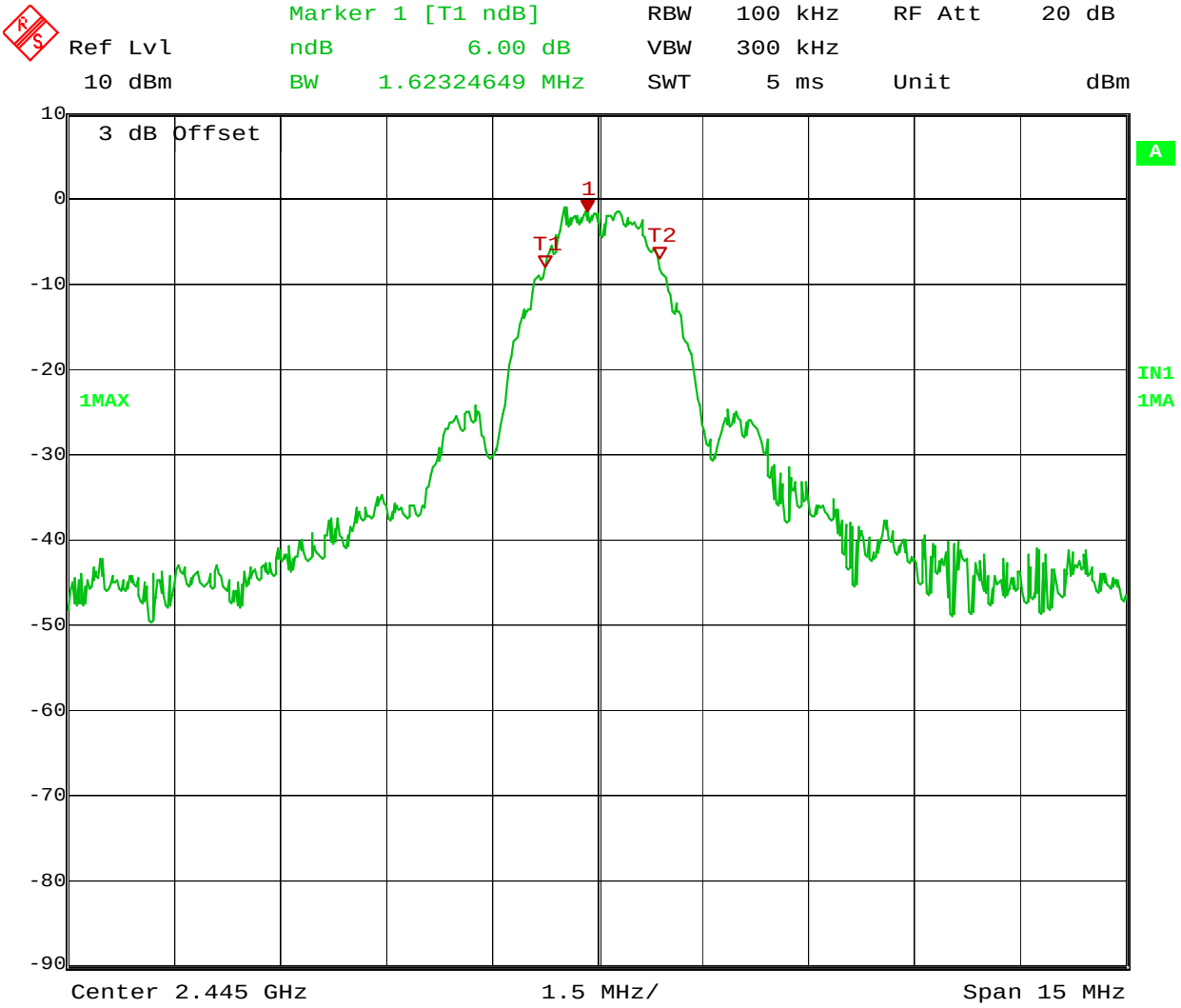
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	9/15/2014	9/15/2015

5.4 Results:

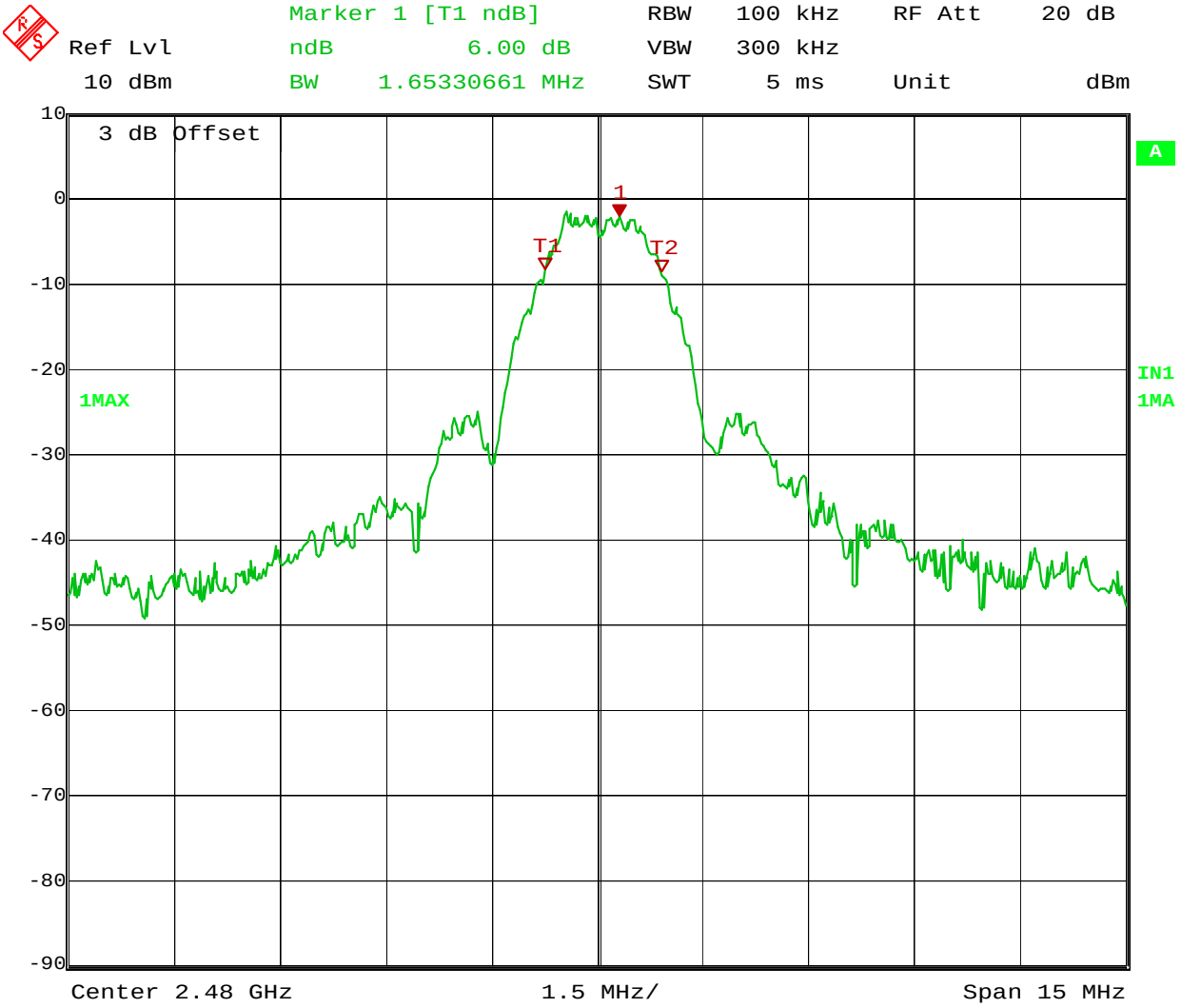
Mode	Channel Number	Frequency (MHz)	6dB Bandwidth	99% Power Bandwidth	Result
Zigbee	11	2405	1.62MHz	---	Pass
Zigbee	18	2445	1.62MHz	2.49MHz	Pass
Zigbee	26	2480	1.65MHz	---	Pass



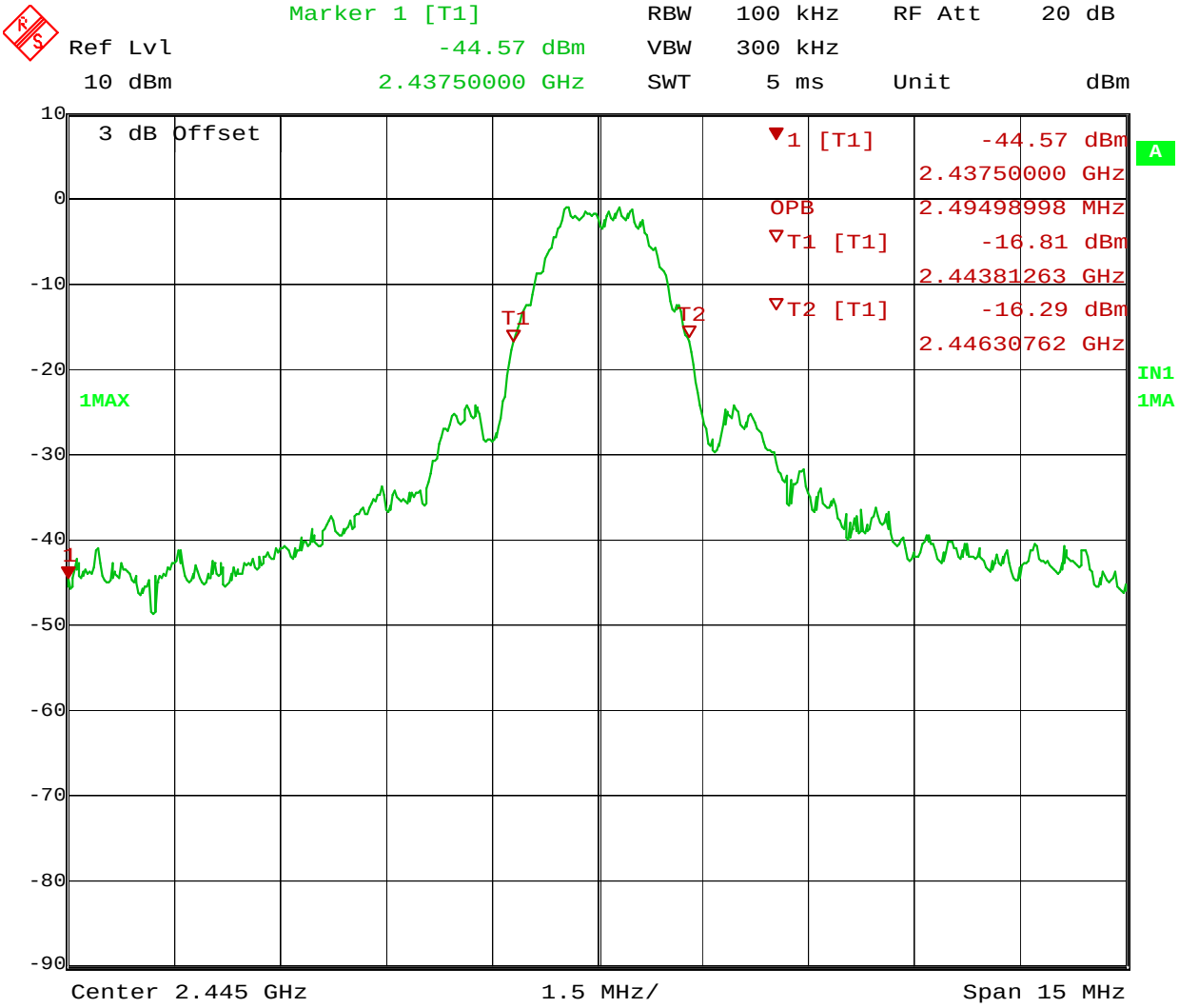
6dB Bandwidth Plot (Channel 11)



6dB Bandwidth Plot (Channel 18)



6dB Bandwidth Plot (Channel 26)



99% Power Bandwidth Plot (Channel 18)

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

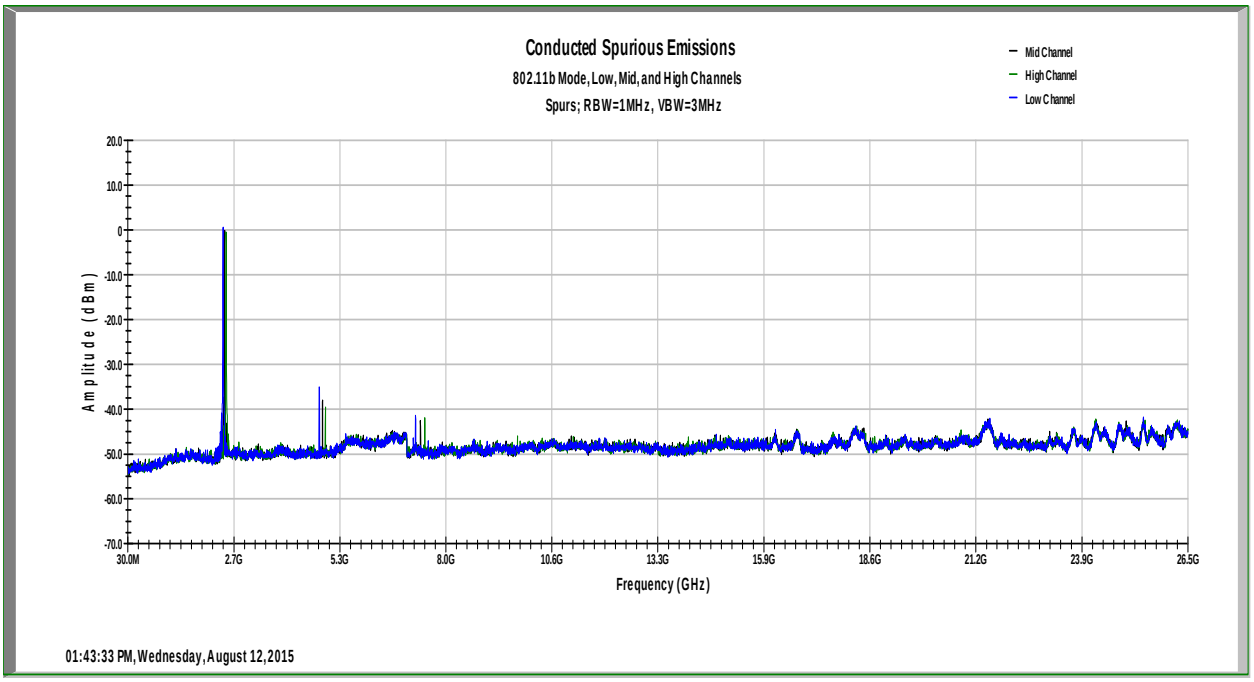
ANSI C63.10: 2013 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

6.3 Test Equipment Used:

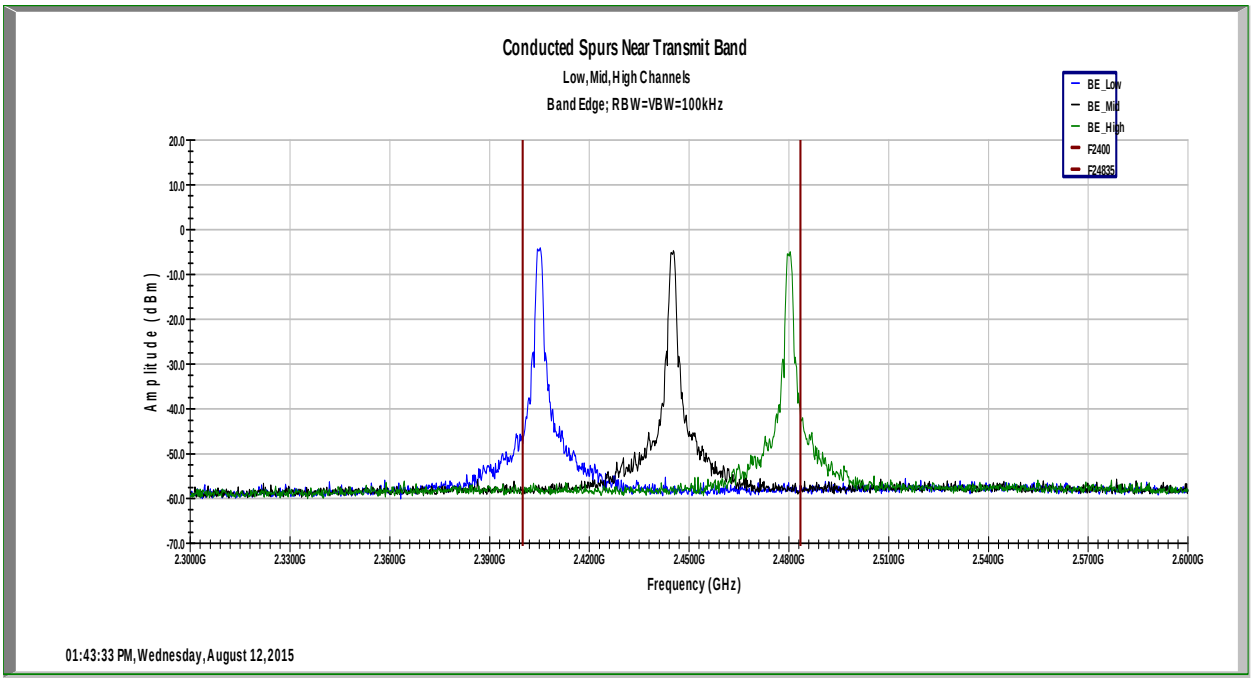
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	9/15/2014	9/15/2015

6.4 Results:

The following plots show that there are no conducted spurious emissions exceeding the 20dB down criteria. The device was tested at maximum power on channels the low, mid and high channels.



Conducted Spurious Emissions - Low, Mid, High Channels



Conducted Emissions Close to Band Edge - Low, Mid, High Channels

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)

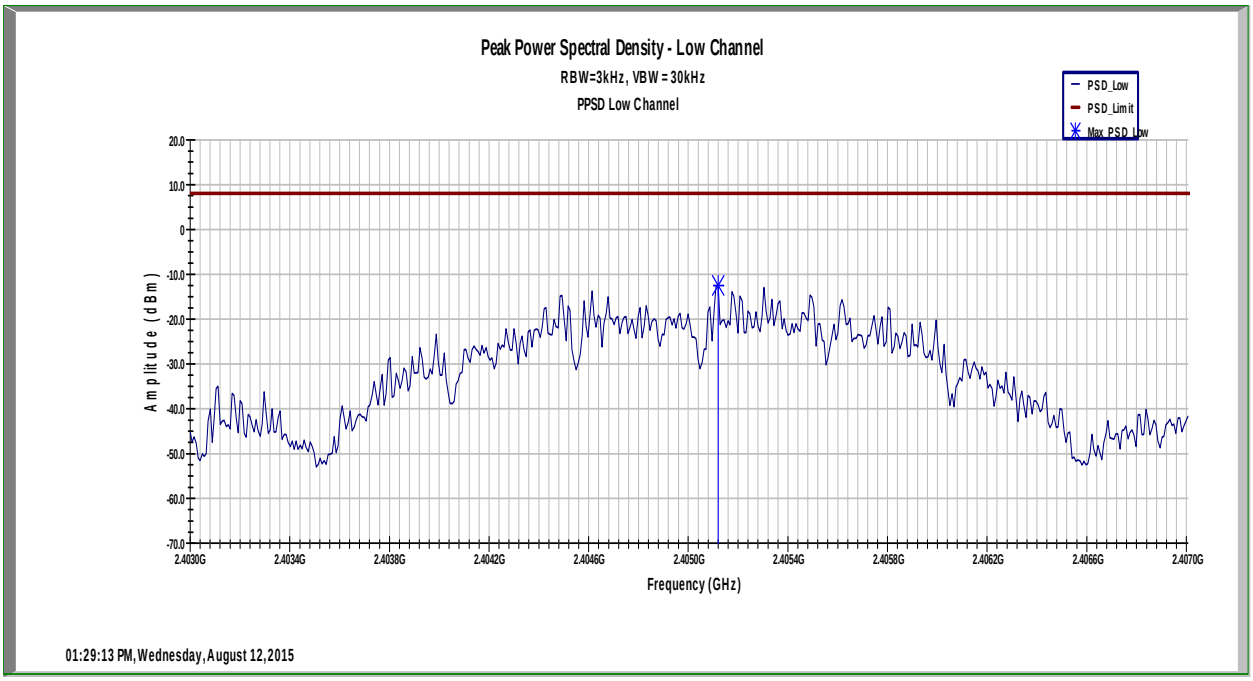
7.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	9/15/2014	9/15/2015

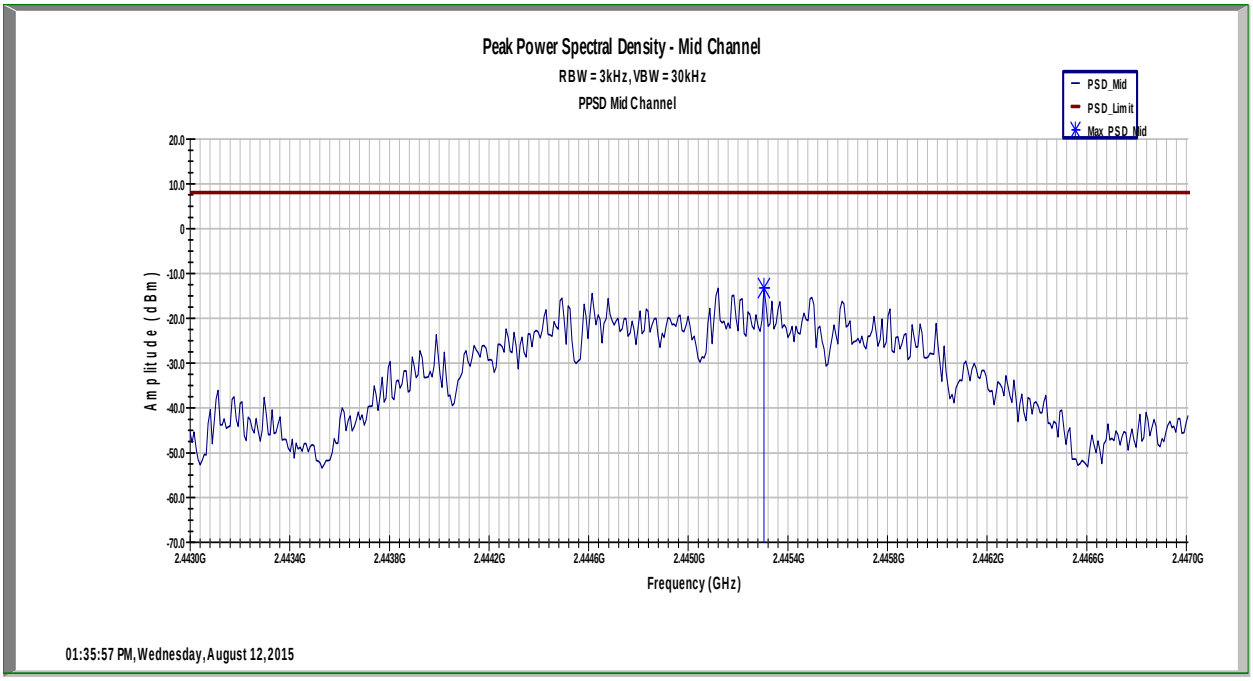
7.4 Results:

*PSD Option 1 Method

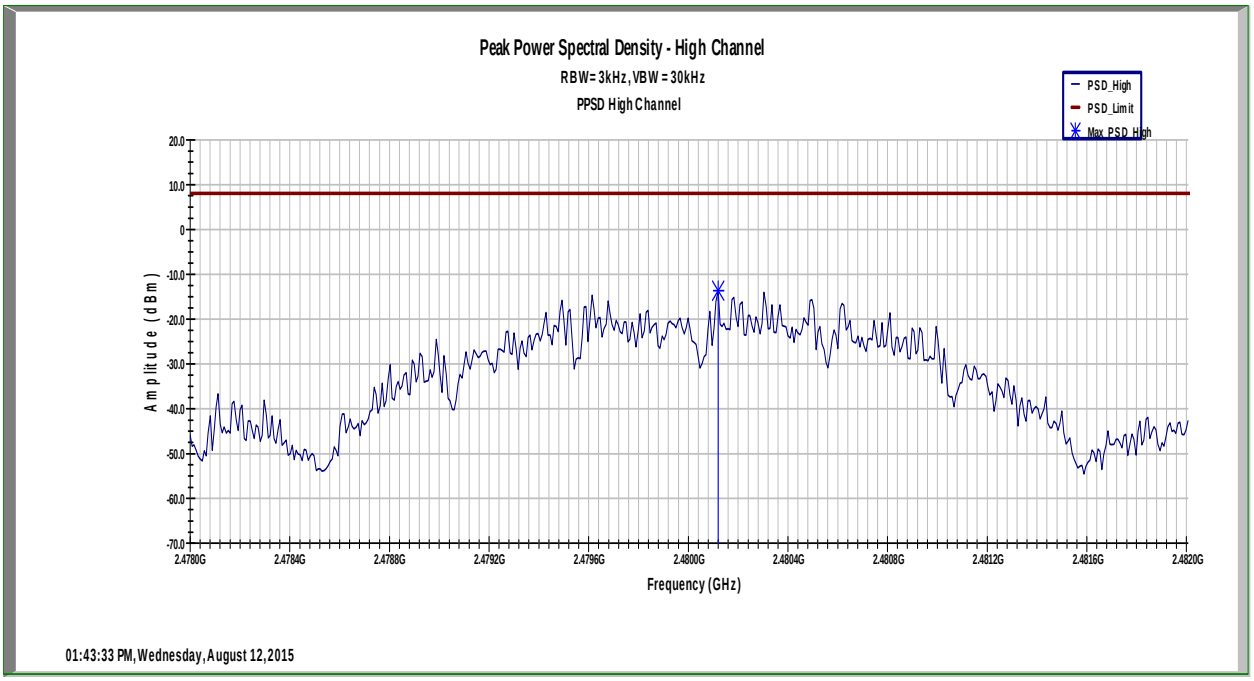
Mode	Channel Number	Frequency (MHz)	PSD in 3kHz BW (dBm)	Limit (dBm)	Margin (dBm)	Result
Zigbee	11	2405	-12.545	8.0	-20.545	Pass
Zigbee	18	2445	-13.275	8.0	-21.275	Pass
Zigbee	26	2480	-13.674	8.0	-21.674	Pass



Power Spectral Density – Channel 11



Power Spectral Density – Channel 18



Power Spectral Density – Channel 26

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	9/17/2014	9/17/2015
Preamplifier	122005	Rohde&Schwarz	TS-PR18	11/26/2014	11/26/2015
Preamplifier	100050	Rohde&Schwarz	TS-PR26	11/26/2014	11/26/2015
Bilog Antenna	00051864	ETS	3142C	1/20/2015	1/20/2016
Horn Antenna	00156319	ETS	3117	5/15/2015	5/15/2016
Horn Antenna (18 – 40GHz)	00117798	ETS	3116c	4/22/2015	4/22/2016
Band Reject Filter	155	Microtronics	BRM50702	Time of Use	Time of Use
System Controller	121701-1	Sunol Sciences	SC99V	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. Radiated emissions was investigated up to the tenth harmonic of the transmit frequency and with the sample positioned in three orthogonal axis. Band edge data is also presented for the low and high channels for each antenna.

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4809.400000	---	42.31	74.00	31.69	1000.000	233.0	H	233.0	7.5
4809.400000	29.55	---	54.00	24.45	1000.000	233.0	H	233.0	7.5
7216.000000	---	43.85	74.00	30.15	1000.000	380.0	V	225.0	10.4
7216.000000	31.34	---	54.00	22.66	1000.000	380.0	V	225.0	10.4
9620.200000	---	46.34	74.00	27.66	1000.000	410.0	H	175.0	13.6
9620.200000	33.45	---	54.00	20.55	1000.000	410.0	H	175.0	13.6
12025.200000	---	49.72	74.00	24.28	1000.000	359.0	V	212.0	17.4
12025.200000	37.04	---	54.00	16.96	1000.000	359.0	V	212.0	17.4
14429.400000	---	47.73	74.00	26.27	1000.000	242.0	H	272.0	16.9
14429.400000	35.65	---	54.00	18.35	1000.000	242.0	H	272.0	16.9
16835.600000	---	53.69	74.00	20.31	1000.000	242.0	H	166.0	21.6
16835.600000	40.76	---	54.00	13.24	1000.000	242.0	H	166.0	21.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	42.61	---	54.00	11.39	1000.000	389.0	V	0.0	37.7
2390.000000	---	57.40	74.00	16.60	1000.000	389.0	V	0.0	37.7
2399.470000	42.57	---	54.00	11.43	1000.000	383.0	H	146.0	37.8
2399.470000	---	63.02	74.00	10.98	1000.000	383.0	H	146.0	37.8

Inverted F Antenna; Low channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4889.000000	---	42.25	74.00	31.75	1000.000	203.0	H	223.0	7.4
4889.000000	29.37	---	54.00	24.63	1000.000	203.0	H	223.0	7.4
7334.000000	---	44.11	74.00	29.89	1000.000	371.0	V	225.0	10.5
7334.000000	31.31	---	54.00	22.69	1000.000	371.0	V	225.0	10.5
9779.000000	---	46.73	74.00	27.27	1000.000	390.0	V	128.0	13.8
9779.000000	33.84	---	54.00	20.16	1000.000	390.0	V	128.0	13.8
12225.200000	---	49.83	74.00	24.17	1000.000	297.0	V	221.0	17.2
12225.200000	37.02	---	54.00	16.98	1000.000	297.0	V	221.0	17.2
14669.000000	36.34	---	54.00	17.66	1000.000	235.0	H	195.0	17.4
14669.000000	---	49.38	74.00	24.62	1000.000	235.0	H	195.0	17.4
17115.200000	39.65	---	54.00	14.35	1000.000	338.0	H	164.0	21.2
17115.200000	---	52.40	74.00	21.60	1000.000	338.0	H	164.0	21.2

Inverted F Antenna; Middle Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4959.800000	---	40.64	74.00	33.36	1000.000	284.0	H	228.0	7.2
4959.800000	28.39	---	54.00	25.61	1000.000	284.0	H	228.0	7.2
7440.600000	---	44.34	74.00	29.66	1000.000	310.0	V	314.0	10.9
7440.600000	31.67	---	54.00	22.33	1000.000	310.0	V	314.0	10.9
9919.000000	33.79	---	54.00	20.21	1000.000	221.0	V	160.0	14.0
9919.000000	---	46.63	74.00	27.37	1000.000	221.0	V	160.0	14.0
12399.000000	36.05	---	54.00	17.95	1000.000	385.0	H	148.0	16.9
12399.000000	---	48.91	74.00	25.09	1000.000	385.0	H	148.0	16.9
14879.400000	---	49.99	74.00	24.01	1000.000	208.0	H	140.0	18.2
14879.400000	37.15	---	54.00	16.85	1000.000	208.0	H	140.0	18.2
17359.400000	---	51.51	74.00	22.49	1000.000	207.0	H	125.0	20.6
17359.400000	38.96	---	54.00	15.04	1000.000	207.0	H	125.0	20.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	70.90	74.00	3.10	1000.000	410.0	V	0.0	37.8
2483.500000	43.29	---	54.00	10.71	1000.000	410.0	V	0.0	37.8

Inverted F Antenna; High Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4811.000000	---	46.76	74.00	27.24	1000.000	410.0	H	197.0	7.5
4811.000000	31.07	---	54.00	22.93	1000.000	410.0	H	197.0	7.5
7214.000000	---	45.99	74.00	28.01	1000.000	410.0	V	153.0	10.4
7214.000000	31.89	---	54.00	22.11	1000.000	410.0	V	153.0	10.4
9619.000000	33.47	---	54.00	20.53	1000.000	392.0	V	231.0	13.6
9619.000000	---	46.45	74.00	27.55	1000.000	392.0	V	231.0	13.6
12025.200000	37.03	---	54.00	16.97	1000.000	385.0	H	208.0	17.4
12025.200000	---	49.86	74.00	24.14	1000.000	385.0	H	208.0	17.4
14429.400000	---	48.20	74.00	25.80	1000.000	410.0	H	258.0	16.9
14429.400000	35.60	---	54.00	18.40	1000.000	410.0	H	258.0	16.9
16835.600000	---	54.27	74.00	19.73	1000.000	410.0	H	122.0	21.6
16835.600000	40.76	---	54.00	13.24	1000.000	410.0	H	122.0	21.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2389.667000	---	53.29	74.00	20.71	1000.000	410.0	V	144.0	37.7
2389.667000	42.24	---	54.00	11.76	1000.000	410.0	V	144.0	37.7
2390.000000	---	55.59	74.00	18.41	1000.000	410.0	V	334.0	37.7
2390.000000	41.98	---	54.00	12.02	1000.000	410.0	V	334.0	37.7

ANT-2.4-WRT-UFL Antenna; Low Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4891.000000	---	45.42	74.00	28.58	1000.000	314.0	H	211.0	7.4
4891.000000	30.59	---	54.00	23.41	1000.000	314.0	H	211.0	7.4
7334.000000	---	49.23	74.00	24.77	1000.000	410.0	V	0.0	10.5
7334.000000	33.63	---	54.00	20.37	1000.000	410.0	V	0.0	10.5
9779.000000	---	47.10	74.00	26.90	1000.000	381.0	V	347.0	13.8
9779.000000	33.90	---	54.00	20.10	1000.000	381.0	V	347.0	13.8
12225.200000	---	49.44	74.00	24.56	1000.000	346.0	V	327.0	17.2
12225.200000	36.91	---	54.00	17.09	1000.000	346.0	V	327.0	17.2
14669.000000	36.39	---	54.00	17.61	1000.000	376.0	H	218.0	17.4
14669.000000	---	49.11	74.00	24.89	1000.000	376.0	H	218.0	17.4
17115.600000	39.70	---	54.00	14.30	1000.000	304.0	H	171.0	21.2
17115.600000	---	52.21	74.00	21.79	1000.000	304.0	H	171.0	21.2

ANT-2.4-WRT-UFL Antenna; Middle Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4961.000000	---	45.96	74.00	28.04	1000.000	410.0	H	214.0	7.2
4961.000000	30.72	---	54.00	23.28	1000.000	410.0	H	214.0	7.2
7439.000000	---	52.36	74.00	21.64	1000.000	202.0	V	322.0	10.9
7439.000000	35.51	---	54.00	18.49	1000.000	202.0	V	322.0	10.9
9919.000000	33.83	---	54.00	20.17	1000.000	410.0	H	301.0	14.0
9919.000000	---	47.00	74.00	27.00	1000.000	410.0	H	301.0	14.0
12399.800000	36.04	---	54.00	17.96	1000.000	313.0	H	269.0	16.9
12399.800000	---	49.21	74.00	24.79	1000.000	313.0	H	269.0	16.9
14879.400000	37.29	---	54.00	16.71	1000.000	410.0	H	165.0	18.2
14879.400000	---	49.64	74.00	24.36	1000.000	410.0	H	165.0	18.2
17359.400000	39.10	---	54.00	14.90	1000.000	204.0	H	180.0	20.6
17359.400000	---	51.89	74.00	22.11	1000.000	204.0	H	180.0	20.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	44.34	---	54.00	9.66	1000.000	410.0	H	294.0	37.8
2483.500000	---	61.53	74.00	12.47	1000.000	410.0	H	294.0	37.8

ANT-2.4-WRT-UFL Antenna; High Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4811.000000	43.61	---	54.00	10.39	1000.000	302.0	V	172.0	7.5
4811.000000	---	62.33	74.00	11.67	1000.000	302.0	V	172.0	7.5
7214.000000	35.23	---	54.00	18.77	1000.000	230.0	V	327.0	10.4
7214.000000	---	52.36	74.00	21.64	1000.000	230.0	V	327.0	10.4
9620.200000	---	46.28	74.00	27.72	1000.000	392.0	V	341.0	13.6
9620.200000	33.57	---	54.00	20.43	1000.000	392.0	V	341.0	13.6
12024.000000	37.09	---	54.00	16.91	1000.000	410.0	V	204.0	17.4
12024.000000	---	49.79	74.00	24.21	1000.000	410.0	V	204.0	17.4
14429.000000	35.63	---	54.00	18.37	1000.000	373.0	H	275.0	16.9
14429.000000	---	48.73	74.00	25.27	1000.000	373.0	H	275.0	16.9
16836.000000	40.76	---	54.00	13.24	1000.000	227.0	H	229.0	21.6
16836.000000	---	54.48	74.00	19.52	1000.000	227.0	H	229.0	21.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	---	54.84	74.00	19.16	1000.000	231.0	V	150.0	37.7
2390.000000	42.31	---	54.00	11.69	1000.000	231.0	V	150.0	37.7
2398.070000	---	61.78	74.00	12.22	1000.000	233.0	V	147.0	37.8
2398.070000	43.79	---	54.00	10.21	1000.000	233.0	V	147.0	37.8

A24-HASM-450 Antenna; Low Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4891.000000	32.92	---	54.00	21.08	1000.000	202.0	H	196.0	7.4
4891.000000	---	48.88	74.00	25.12	1000.000	202.0	H	196.0	7.4
7334.000000	34.09	---	54.00	19.91	1000.000	209.0	H	1.0	10.5
7334.000000	---	50.18	74.00	23.82	1000.000	209.0	H	1.0	10.5
9779.400000	33.69	---	54.00	20.31	1000.000	389.0	V	128.0	13.8
9779.400000	---	46.11	74.00	27.89	1000.000	389.0	V	128.0	13.8
12225.200000	36.87	---	54.00	17.13	1000.000	316.0	H	126.0	17.2
12225.200000	---	49.34	74.00	24.66	1000.000	316.0	H	126.0	17.2
14669.000000	36.38	---	54.00	17.62	1000.000	383.0	V	247.0	17.4
14669.000000	---	48.96	74.00	25.04	1000.000	383.0	V	247.0	17.4
17115.200000	39.70	---	54.00	14.30	1000.000	317.0	H	173.0	21.2
17115.200000	---	52.90	74.00	21.10	1000.000	317.0	H	173.0	21.2

A24-HASM-450 Antenna; Middle Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4961.000000	---	47.37	74.00	26.63	1000.000	281.0	V	174.0	7.2
4961.000000	31.26	---	54.00	22.74	1000.000	281.0	V	174.0	7.2
7439.000000	34.82	---	54.00	19.18	1000.000	203.0	H	2.0	10.9
7439.000000	---	51.10	74.00	22.90	1000.000	203.0	H	2.0	10.9
9919.000000	33.82	---	54.00	20.18	1000.000	385.0	V	265.0	14.0
9919.000000	---	46.77	74.00	27.23	1000.000	385.0	V	265.0	14.0
12399.800000	36.04	---	54.00	17.96	1000.000	311.0	H	329.0	16.9
12399.800000	---	49.65	74.00	24.35	1000.000	311.0	H	329.0	16.9
14879.800000	---	50.52	74.00	23.48	1000.000	213.0	V	224.0	18.2
14879.800000	37.29	---	54.00	16.71	1000.000	213.0	V	224.0	18.2
17360.200000	39.11	---	54.00	14.89	1000.000	375.0	H	169.0	20.6
17360.200000	---	51.60	74.00	22.40	1000.000	375.0	H	169.0	20.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	71.67	74.00	2.33	1000.000	388.0	V	215.0	37.8
2483.500000	51.23	---	54.00	2.77	1000.000	388.0	V	215.0	37.8

A24-HASM-450 Antenna; High Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4811.000000	---	56.97	74.00	17.03	1000.000	246.0	H	317.0	7.5
4811.000000	38.98	---	54.00	15.02	1000.000	246.0	H	317.0	7.5
7214.000000	---	51.76	74.00	22.24	1000.000	233.0	H	306.0	10.4
7214.000000	35.16	---	54.00	18.84	1000.000	233.0	H	306.0	10.4
9619.800000	---	46.40	74.00	27.60	1000.000	410.0	H	188.0	13.6
9619.800000	33.50	---	54.00	20.50	1000.000	410.0	H	188.0	13.6
12025.600000	---	50.32	74.00	23.68	1000.000	410.0	H	140.0	17.4
12025.600000	37.06	---	54.00	16.94	1000.000	410.0	H	140.0	17.4
14429.400000	---	48.29	74.00	25.71	1000.000	248.0	H	116.0	16.9
14429.400000	35.53	---	54.00	18.47	1000.000	248.0	H	116.0	16.9
16835.600000	---	53.35	74.00	20.65	1000.000	306.0	V	188.0	21.6
16835.600000	40.71	---	54.00	13.29	1000.000	306.0	V	188.0	21.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	---	52.68	74.00	21.32	1000.000	354.0	H	227.0	37.7
2390.000000	41.74	---	54.00	12.26	1000.000	354.0	H	227.0	37.7
2398.020000	---	53.54	74.00	20.46	1000.000	354.0	H	230.0	37.8
2398.020000	42.81	---	54.00	11.19	1000.000	354.0	H	230.0	37.8

47950-1011 Antenna; Low Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4891.000000	---	56.77	74.00	17.23	1000.000	295.0	H	322.0	7.4
4891.000000	38.56	---	54.00	15.44	1000.000	295.0	H	322.0	7.4
7334.000000	---	50.91	74.00	23.09	1000.000	253.0	H	302.0	10.5
7334.000000	34.53	---	54.00	19.47	1000.000	253.0	H	302.0	10.5
9779.400000	---	46.84	74.00	27.16	1000.000	410.0	H	302.0	13.8
9779.400000	33.81	---	54.00	20.19	1000.000	410.0	H	302.0	13.8
12225.200000	---	49.68	74.00	24.32	1000.000	410.0	H	304.0	17.2
12225.200000	36.98	---	54.00	17.02	1000.000	410.0	H	304.0	17.2
14670.600000	---	49.53	74.00	24.47	1000.000	384.0	V	242.0	17.4
14670.600000	36.40	---	54.00	17.60	1000.000	384.0	V	242.0	17.4
17115.600000	---	52.28	74.00	21.72	1000.000	396.0	V	200.0	21.2
17115.600000	39.68	---	54.00	14.32	1000.000	396.0	V	200.0	21.2

47950-1011 Antenna; Middle Channel

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4961.000000	37.41	---	54.00	16.59	1000.000	410.0	V	133.0	7.2
4961.000000	---	55.38	74.00	18.62	1000.000	410.0	V	133.0	7.2
7439.000000	33.46	---	54.00	20.54	1000.000	410.0	H	304.0	10.9
7439.000000	---	48.18	74.00	25.82	1000.000	410.0	H	304.0	10.9
9919.000000	---	47.46	74.00	26.54	1000.000	204.0	H	300.0	14.0
9919.000000	33.93	---	54.00	20.07	1000.000	204.0	H	300.0	14.0
12399.400000	---	49.08	74.00	24.92	1000.000	410.0	V	220.0	16.9
12399.400000	36.05	---	54.00	17.95	1000.000	410.0	V	220.0	16.9
14880.600000	---	50.15	74.00	23.85	1000.000	285.0	H	191.0	18.2
14880.600000	37.29	---	54.00	16.71	1000.000	285.0	H	191.0	18.2
17359.400000	---	51.86	74.00	22.14	1000.000	277.0	H	128.0	20.6
17359.400000	39.12	---	54.00	14.88	1000.000	277.0	H	128.0	20.6

Frequency (MHz)	Average (dBµV/m)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.500000	---	71.23	74.00	2.77	1000.000	392.0	H	237.0	37.8
2483.500000	49.42	---	54.00	4.58	1000.000	392.0	H	237.0	37.8

47950-1011 Antenna; High Channel

9 AC Powerline Conducted Emissions

9.1 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.

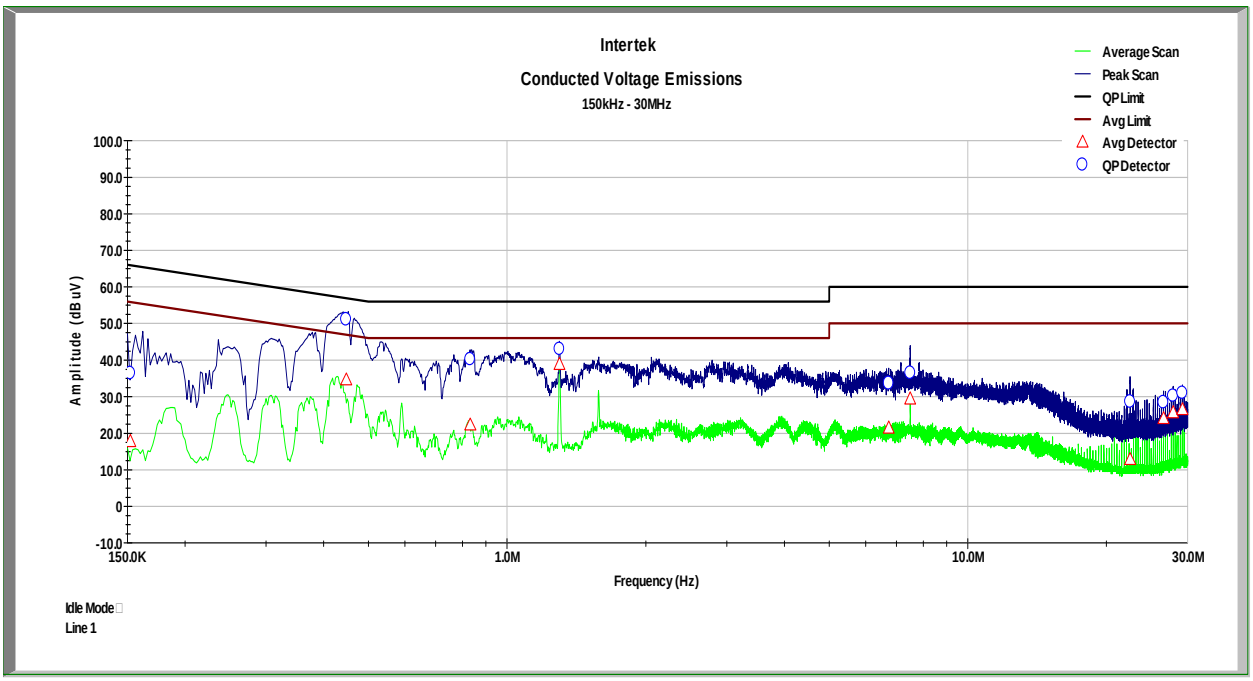
9.2 Test Procedure

ANSI C63.4: 2014

9.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESI26	8/22/2014	8/22/2015
LISN	3333	Teseq	NNB52	5/21/2015	5/21/2016
TILE Software	V7.0.6.545	ETS Lindgren	TILE	Time of Use	Time of Use

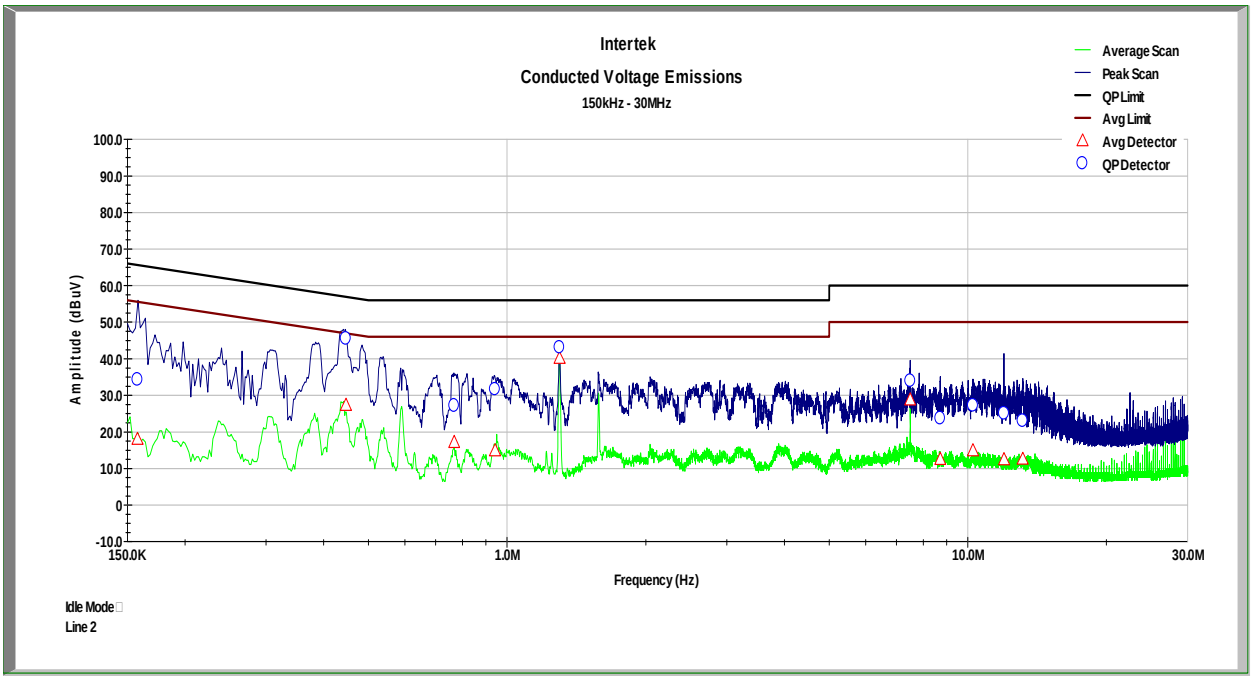
9.4 Results:



Conducted Voltage Emissions on Power Lines								
Test Engineer:	Bryan Taylor		**Start Date:**	8/7/2015		**End Date:**	Bar	
Temperature:	23.4C		**Humidity:**	52.40%		**Pressure:**	988.9m	
Specification:	FCC Part 15		**Test Limit:**	Class B		**RBW:**	9kHz	
Notes:	RX / Idle Mode							

Line	Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Delta (dB)	Average (dBuV)	Average Limit (dBuV)	Average Delta (dB)	Results
Line 1	152.100 KHz	36.375	65.94	-29.565	17.75	55.94	-38.19	**Compliant**
Line 1	447.400 KHz	51.106	57.503	-6.397	34.583	47.503	-12.92	**Compliant**
Line 1	831.900 KHz	40.193	56	-15.807	22.225	46	-23.775	**Compliant**
Line 1	1.299 MHz	42.984	56	-13.016	38.79	46	-7.21	**Compliant**
Line 1	6.734 MHz	33.611	60	-26.389	21.404	50	-28.596	**Compliant**
Line 1	7.499 MHz	36.447	60	-23.553	29.39	50	-20.61	**Compliant**
Line 1	22.501 MHz	28.621	60	-31.379	12.809	50	-37.191	**Compliant**
Line 1	26.588 MHz	28.383	60	-31.617	24.011	50	-25.989	**Compliant**
Line 1	27.906 MHz	30.187	60	-29.813	25.617	50	-24.383	**Compliant**
Line 1	29.221 MHz	31.003	60	-28.997	26.431	50	-23.569	**Compliant**

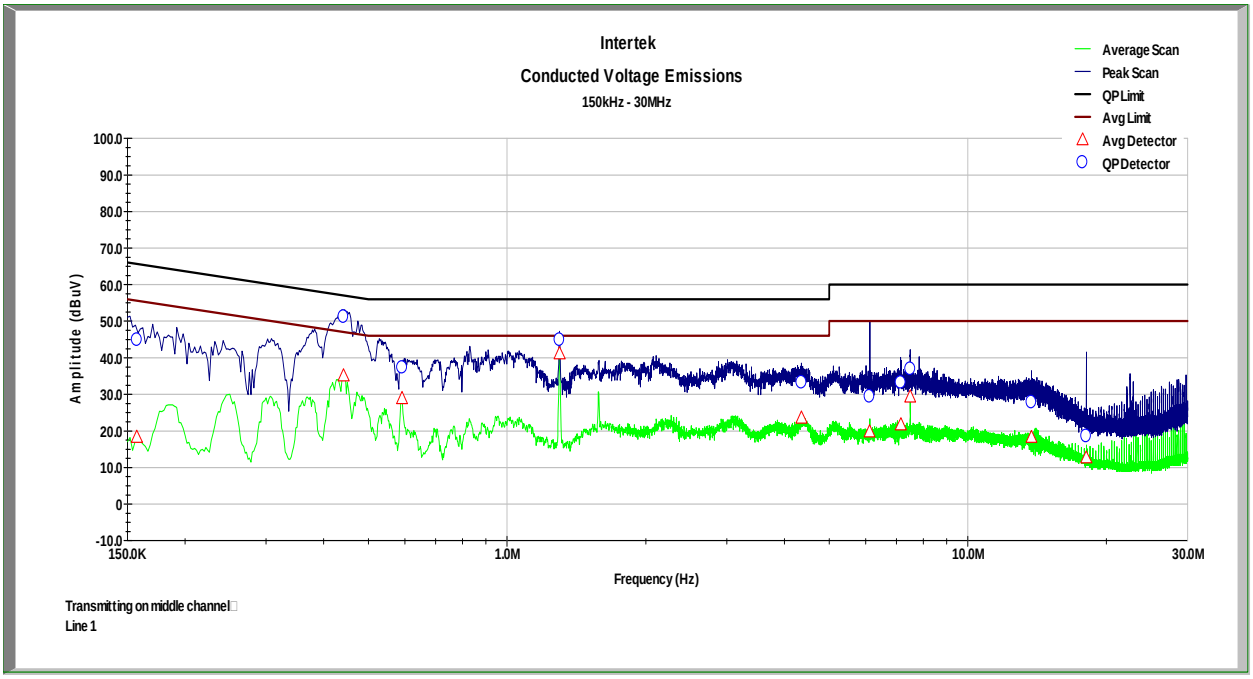
Idle / RX Mode; Line 1



Conducted Voltage Emissions on Power Lines								
Test Engineer:	Bryan Taylor		**Start Date:**	8/7/2015		**End Date:**	Bar	
Temperature:	23.4C		**Humidity:**	52.40%		**Pressure:**	988.9m	
Specification:	FCC Part 15		**Test Limit:**	Class B		**RBW:**	9kHz	
Notes:	RX / Idle Mode							

Line	Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Delta (dB)	Average (dBuV)	Average Limit (dBuV)	Average Delta (dB)	Results
Line 2	157.700 KHz	34.237	65.78	-31.543	17.968	55.78	-37.812	**Compliant**
Line 2	446.900 KHz	45.512	57.517	-12.006	27.271	47.517	-20.246	**Compliant**
Line 2	767.700 KHz	27.119	56	-28.881	17.131	46	-28.869	**Compliant**
Line 2	941.200 KHz	31.632	56	-24.368	14.829	46	-31.171	**Compliant**
Line 2	1.300 MHz	43.081	56	-12.919	40.097	46	-5.903	**Compliant**
Line 2	7.500 MHz	33.897	60	-26.103	28.739	50	-21.261	**Compliant**
Line 2	8.715 MHz	23.689	60	-36.311	12.506	50	-37.494	**Compliant**
Line 2	10.266 MHz	27.176	60	-32.824	14.848	50	-35.152	**Compliant**
Line 2	11.988 MHz	25.024	60	-34.976	12.398	50	-37.602	**Compliant**
Line 2	13.158 MHz	22.974	60	-37.026	12.524	50	-37.476	**Compliant**

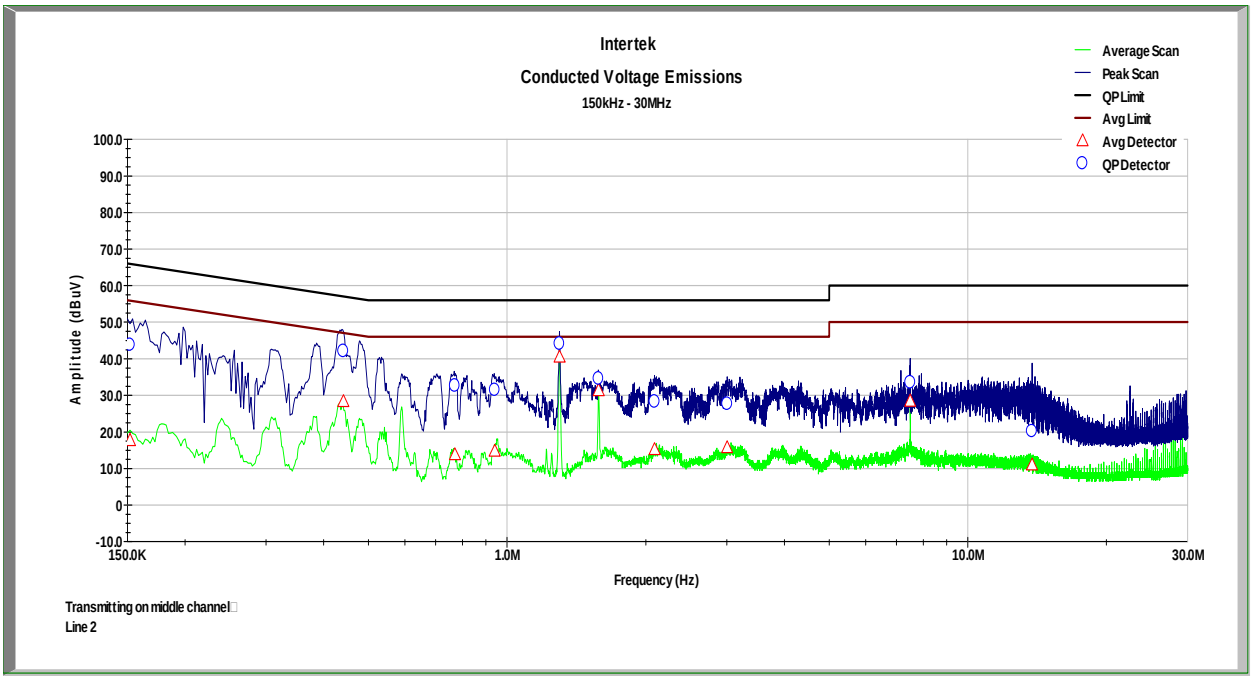
Idle / RX Mode; Line 2



Conducted Voltage Emissions on Power Lines								
Test Engineer:	Bryan Taylor		**Start Date:**	8/7/2015		**End Date:**	Bar	
Temperature:	23.4C		**Humidity:**	52.40%		**Pressure:**	988.9m	
Specification:	FCC Part 15		**Test Limit:**	Class B		**RBW:**	9kHz	
Notes:	Transmitting							

Line	Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Delta (dB)	Average (dBuV)	Average Limit (dBuV)	Average Delta (dB)	Results
Line 1	157.200 KHz	44.87	65.794	-20.925	18.264	55.794	-37.53	**Compliant**
Line 1	441.500 KHz	51.161	57.671	-6.51	35.047	47.671	-12.624	**Compliant**
Line 1	591.400 KHz	37.277	56	-18.723	28.887	46	-17.113	**Compliant**
Line 1	1.300 MHz	44.901	56	-11.099	41.114	46	-4.886	**Compliant**
Line 1	4.355 MHz	33.205	56	-22.795	23.527	46	-22.473	**Compliant**
Line 1	6.119 MHz	29.367	60	-30.633	19.781	50	-30.219	**Compliant**
Line 1	7.154 MHz	33.143	60	-26.857	21.669	50	-28.331	**Compliant**
Line 1	7.500 MHz	36.922	60	-23.078	29.259	50	-20.741	**Compliant**
Line 1	13.745 MHz	27.796	60	-32.204	18.216	50	-31.784	**Compliant**
Line 1	18.079 MHz	18.541	60	-41.459	12.629	50	-37.371	**Compliant**

Transmitting; Line 1



Conducted Voltage Emissions on Power Lines								
Test Engineer:	Bryan Taylor		**Start Date:**	8/7/2015		**End Date:**	Bar	
Temperature:	23.4C		**Humidity:**	52.40%		**Pressure:**	988.9m	
Specification:	FCC Part 15		**Test Limit:**	Class B		**RBW:**	9kHz	
Notes:	Transmitting							

Line	Frequency (MHz)	Quasi-Peak (dBuV)	Quasi-Peak Limit (dBuV)	Quasi-Peak Delta (dB)	Average (dBuV)	Average Limit (dBuV)	Average Delta (dB)	Results
Line 2	151.900 KHz	43.776	65.946	-22.17	17.668	55.946	-38.278	**Compliant**
Line 2	441.000 KHz	42.046	57.686	-15.64	28.271	47.686	-19.415	**Compliant**
Line 2	770.200 KHz	32.588	56	-23.412	13.758	46	-32.242	**Compliant**
Line 2	939.800 KHz	31.43	56	-24.57	14.737	46	-31.263	**Compliant**
Line 2	1.300 MHz	44.072	56	-11.928	40.463	46	-5.537	**Compliant**
Line 2	1.580 MHz	34.529	56	-21.471	31.308	46	-14.692	**Compliant**
Line 2	2.090 MHz	28.241	56	-27.759	15.176	46	-30.824	**Compliant**
Line 2	3.004 MHz	27.64	56	-28.36	15.687	46	-30.313	**Compliant**
Line 2	7.499 MHz	33.509	60	-26.491	28.405	50	-21.595	**Compliant**
Line 2	13.783 MHz	20.164	60	-39.836	10.969	50	-39.031	**Compliant**

Transmitting; Line 2

10 Antenna Requirement per FCC Part 15.203

10.1 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.

10.2 Results:

The sample tested met the antenna requirement. There were four separate antennas used with this product, three of which used a U.FL connection to the transmitter and a fourth that was integrated into the circuitry as a trace antenna.

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	9/2/2015	102216394LEX-001	Original Issue