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TEST REPORT

Report Number:	**100891782LEX-002**
Project Number:	**G100891782**
Report Issue Date:	**11/4/2012**
Product Name:	**Gateway**
Model Number Tested:	**QEW**
FCCID:	**WEF-QEW**
ICID:	**7713A-QEW**
FCC Standards:	**Title 47 CFR Part 15 Subpart B and C**
Industry Canada Standards:	**RSS-210 Issue 8 & RSS-GEN Issue 3**

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

Client:
Stanley Security Solutions, Inc.
14670 Cumberland Road
Noblesville, IN 46060

Report prepared by
Bryan Taylor, Team Leader

Report reviewed by
James Sudduth, Assistant Chief Engineer

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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.

All testing was performed at the Intertek office 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)	RSS210 A8.4 (4)	Pass
7	Occupied Bandwidth	§ 15.247(a)(2)	RSS210 A8.2(A)	Pass
12	Conducted Spurious Emissions	§ 15.247(d)	RSS210 (A8.5)	Pass
18	Power Spectral Density	§ 15.247(e)	RSS210 A8.2(B)	Pass
22	Radiated Spurious Emissions (Transmitter)	§ 15.247(d), § 15.209, and § 15.205	RSS-210 (2.2)	Pass
35	AC Powerline Conducted Emissions	§ 15.207	RSS-Gen (7.2.2)	Pass
38	Antenna Requirement per FCC Part 15.203	§ 15.203	RSS-Gen (7.1.4)	Pass

3 Description of Equipment Under Test

Equipment Under Test	
Manufacturer	Stanley Security Solutions, Inc.
Model Number	QEW
Serial Number	Test Sample 1
FCC Identifier	WEF-QEW
Industry Canada Identifier	7713A-QEW
Receive Date	10/15/2012
Test Start Date	10/15/2012
Test End Date	10/30/2012
Device Received Condition	Good
Test Sample Type	Production
Frequency Band	2405MHz – 2480MHz
Mode(s) of Operation	Zigbee
Modulation Type	QPSK
Transmission Control	Test Commands
Maximum Output Power	19.37dBm (conducted output)
Test Channels	11, 18, 24, 25, and 26 (reduced power at band edge on channels 25 and 26)
Antenna Type (15.203)	Rubber Duck Antenna (L-Com HG2402RD-RSF, 2.2dBi Gain) Remote Mount Antenna (Maxrad Model MC2400PT, 2.5dBi Gain)
Operating Voltage	24VDC

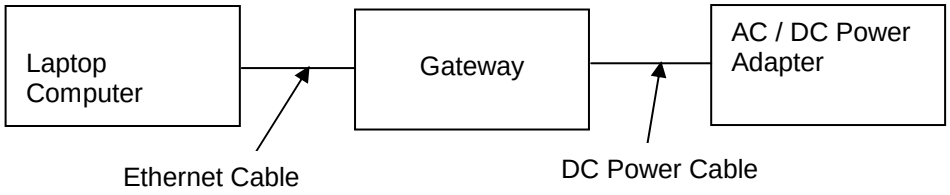
Description of Equipment Under Test
The QEW (Gateway) is zigbee gateway which communicates with a zigbee enabled door lock.

Operating modes of the EUT:

No.	**Descriptions of EUT Exercising**
1	Transmitting on channels 11, 18, 24, 25, and 26 (reduced power at band edge on channels 25 and 26).
2	Receive / idle mode

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

3.2 EUT Block Diagram:



3.3 Cables Connected to Test Sample:

Cables					
Description	Length	Shielding	Ferrites	Connection	
				From	To
Ethernet Cable	50 ft	None	None	Test Sample	Laptop Computer or POE Injector
DC Power Cable	6 ft	None	None	Test Sample	AC / DC Power Adapter

3.4 Support Equipment:

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
Laptop Computer	Gateway	ZE6	11906695725
AC / DC Power Adapter	Triad	WSU240-1000	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: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

4.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/12/2012	9/12/2013

4.4 Results:

Channel Number	Frequency (MHz)	Peak Conducted Power (dBm)	Peak Conducted Power Limit (dBm)	Margin (dB)	Result
11	2405	18.35	30	-11.65	Pass
18	2440	18.73	30	-11.27	Pass
24	2470	19.37	30	-10.63	Pass

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: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

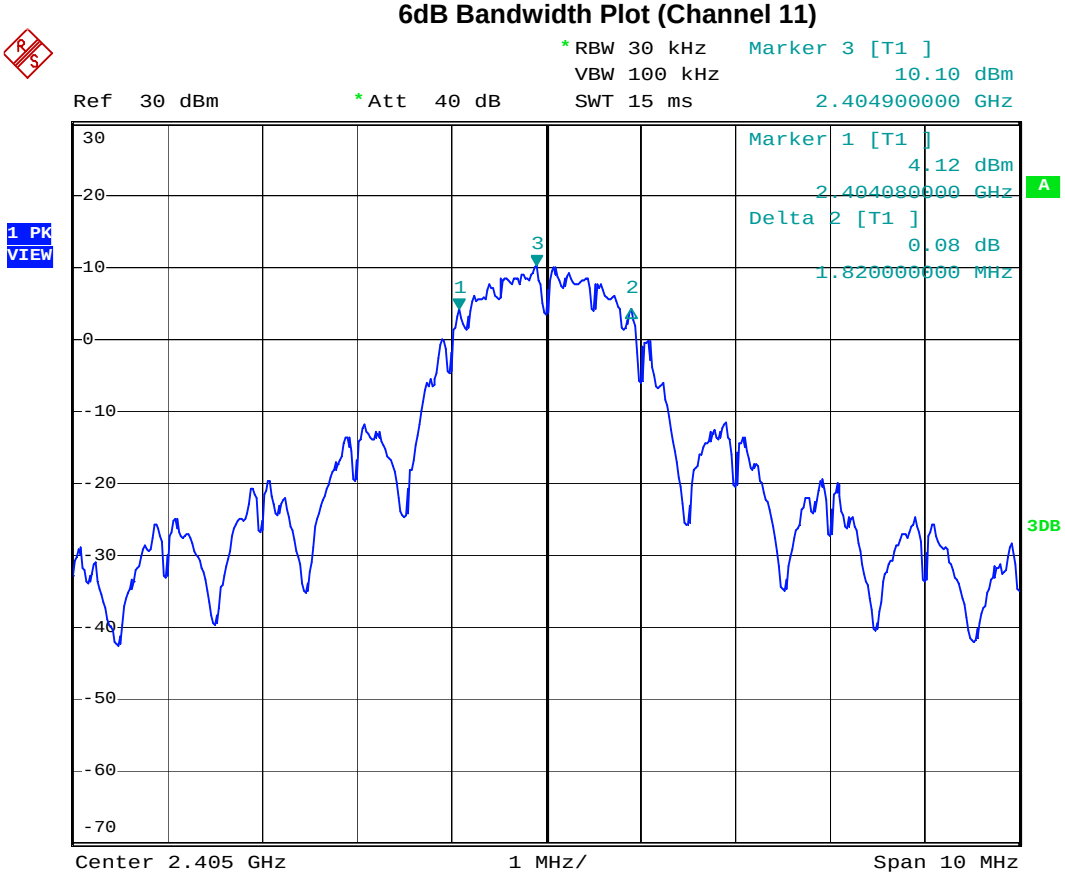
5.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/12/2012	9/12/2013

5.4 Results:

Channel Number	Frequency (MHz)	6dB Bandwidth	99% Power Bandwidth	Result
11	2405	1.82MHz	---	Pass
18	2440	1.82MHz	2.44MHz	Pass
24	2470	1.84MHz	---	Pass

6dB Bandwidth Plot (Channel 11)



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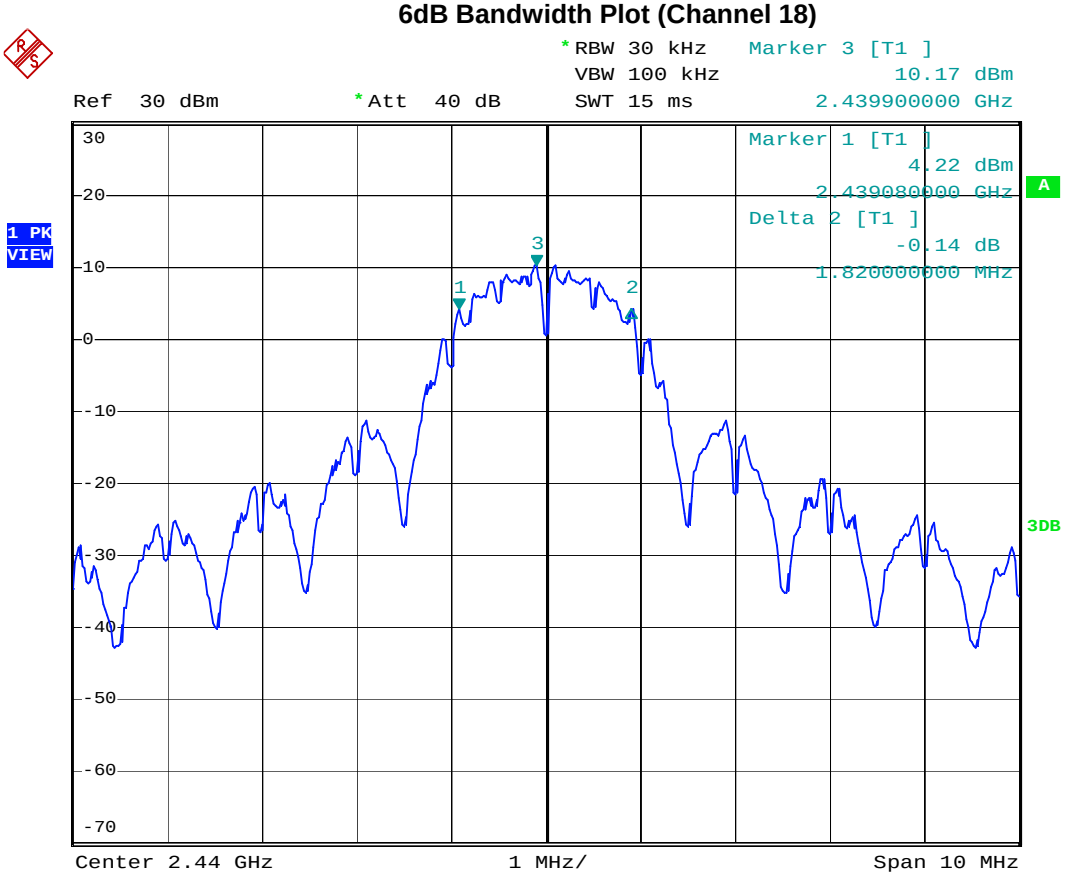
6dB Bandwidth Plot (Channel 18)



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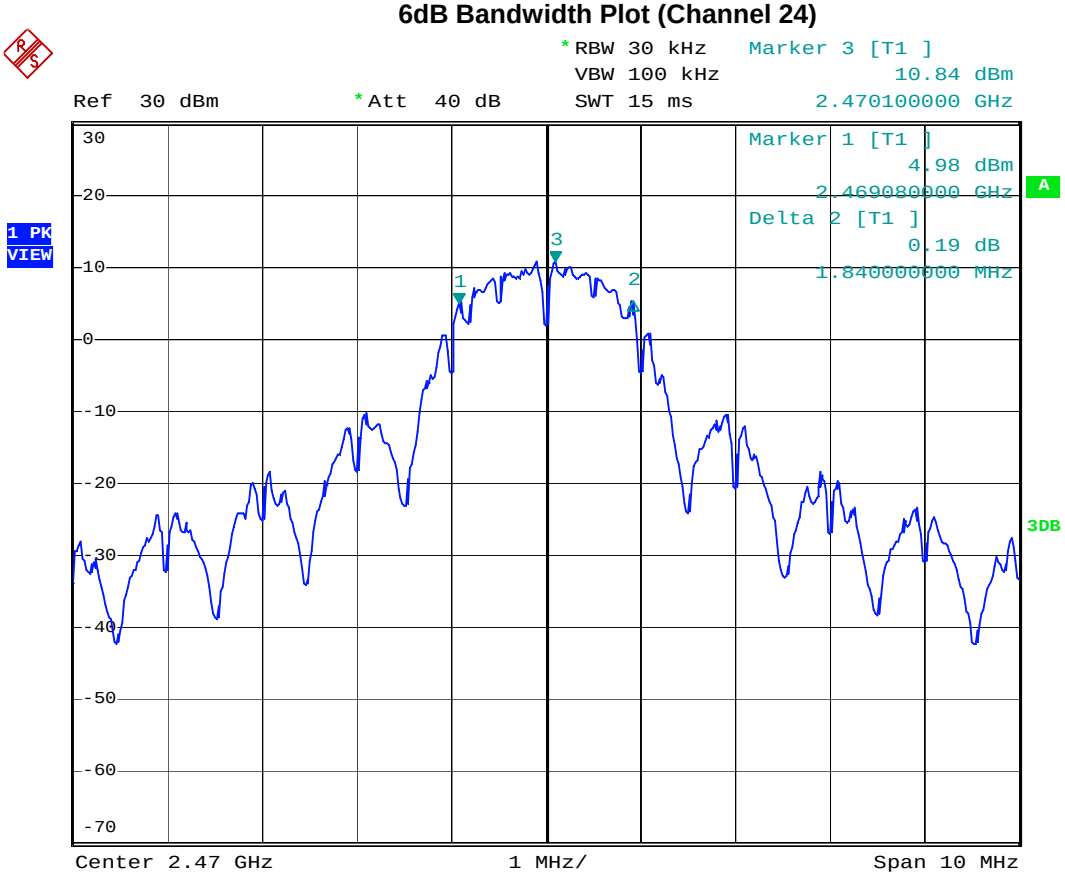
6dB Bandwidth Plot (Channel 24)



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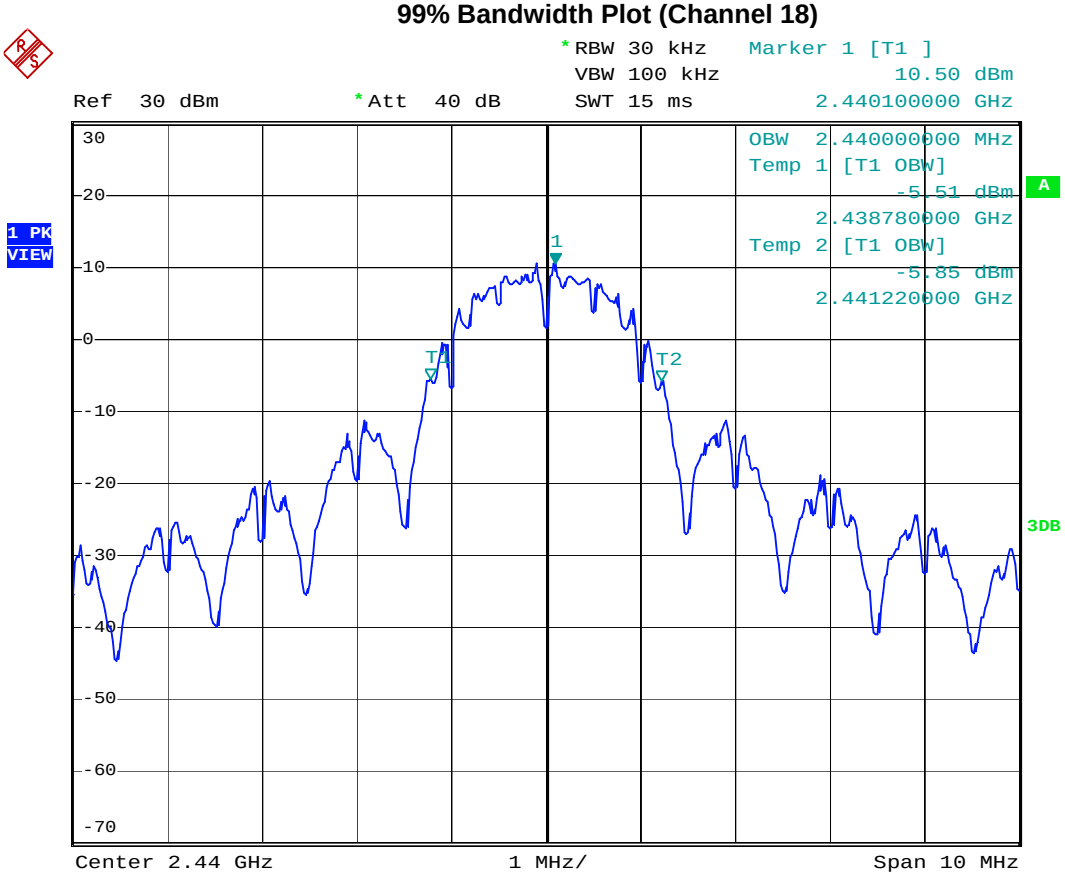
99% Bandwidth Plot (Channel 18)



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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: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247)

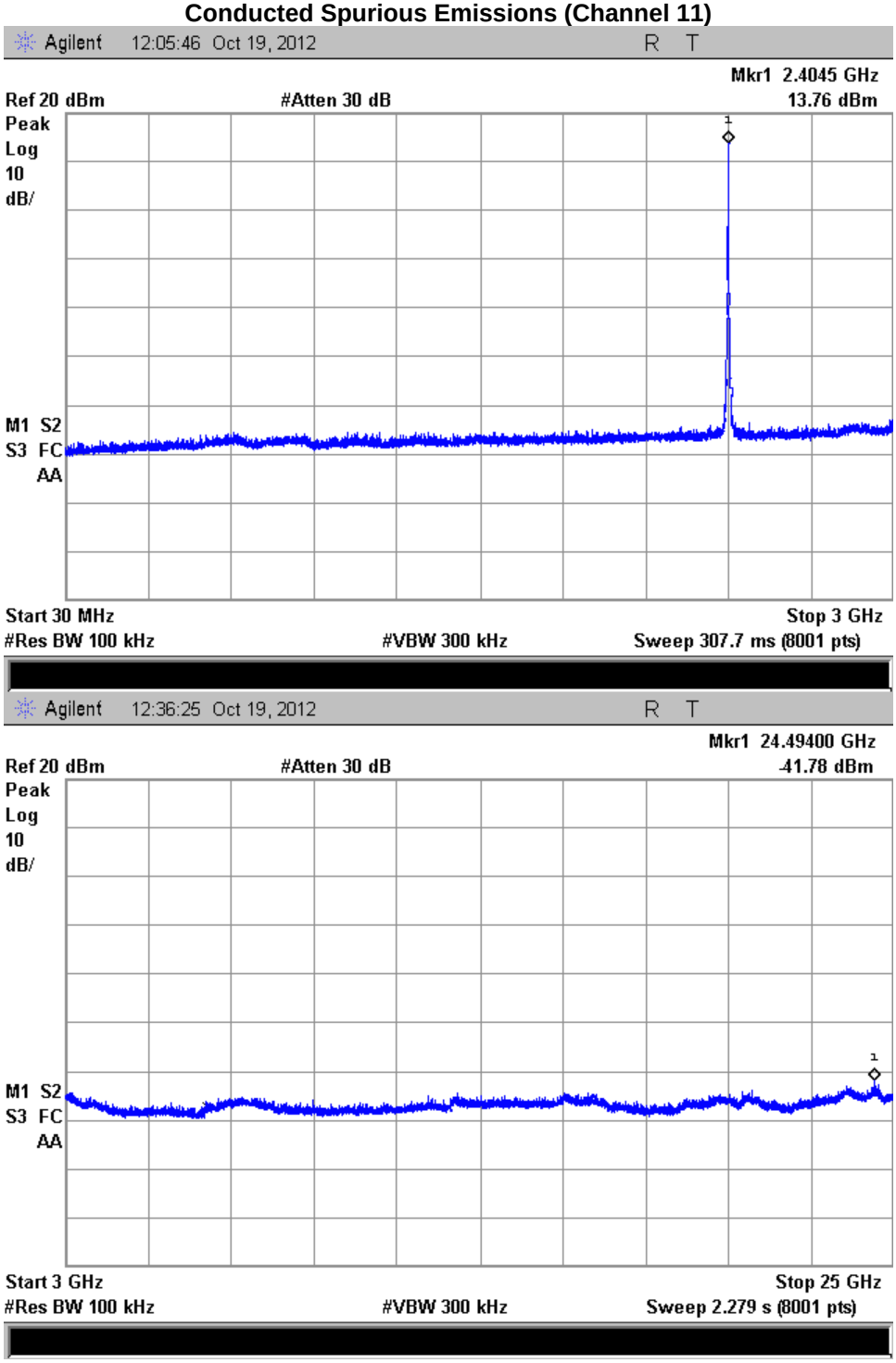
6.3 Test Equipment Used:

Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMC Analyzer	2142	HP	E7405	3/20/2012	3/20/2013
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/12/2012	9/12/2013

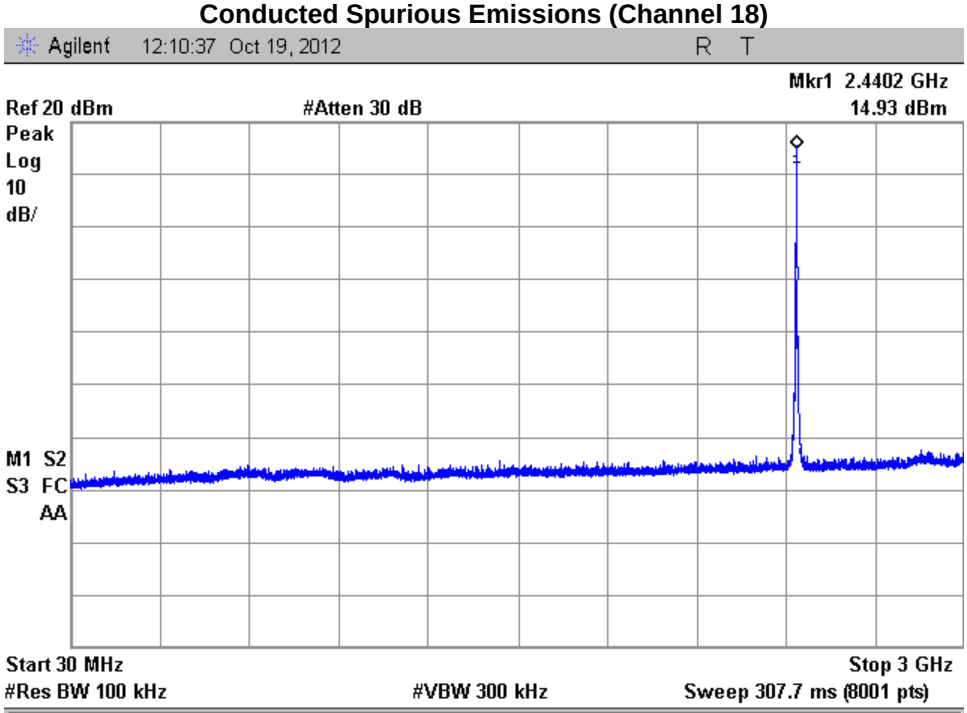
6.4 Results:

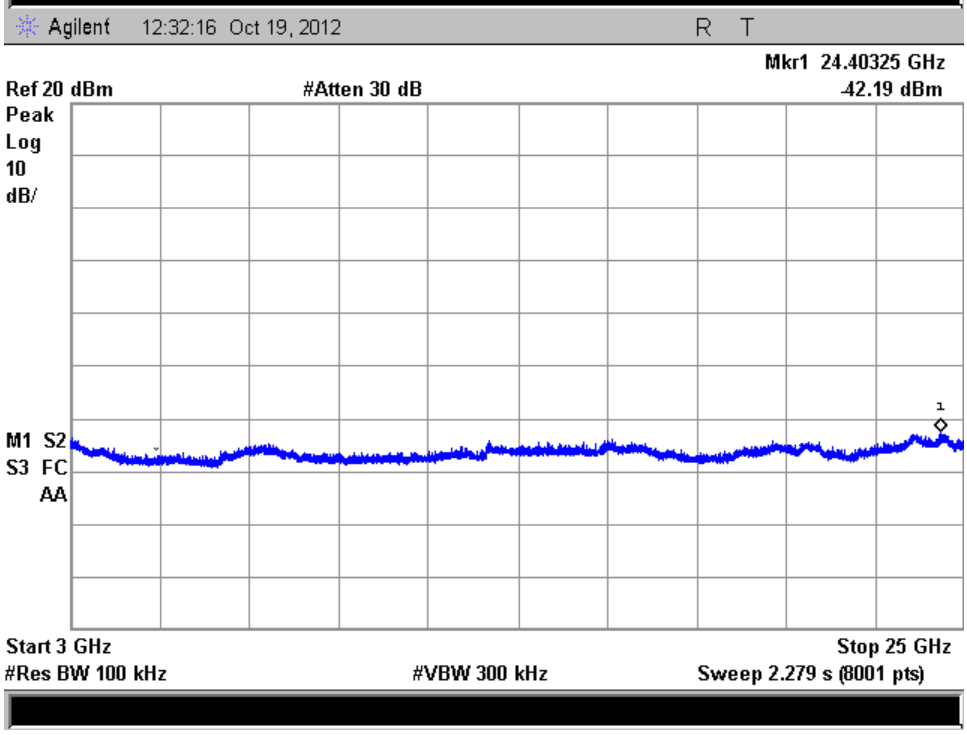
The following plots show that there are no conducted spurious emissions exceeding the 20dB down criteria.

Conducted Spurious Emissions (Channel 11)

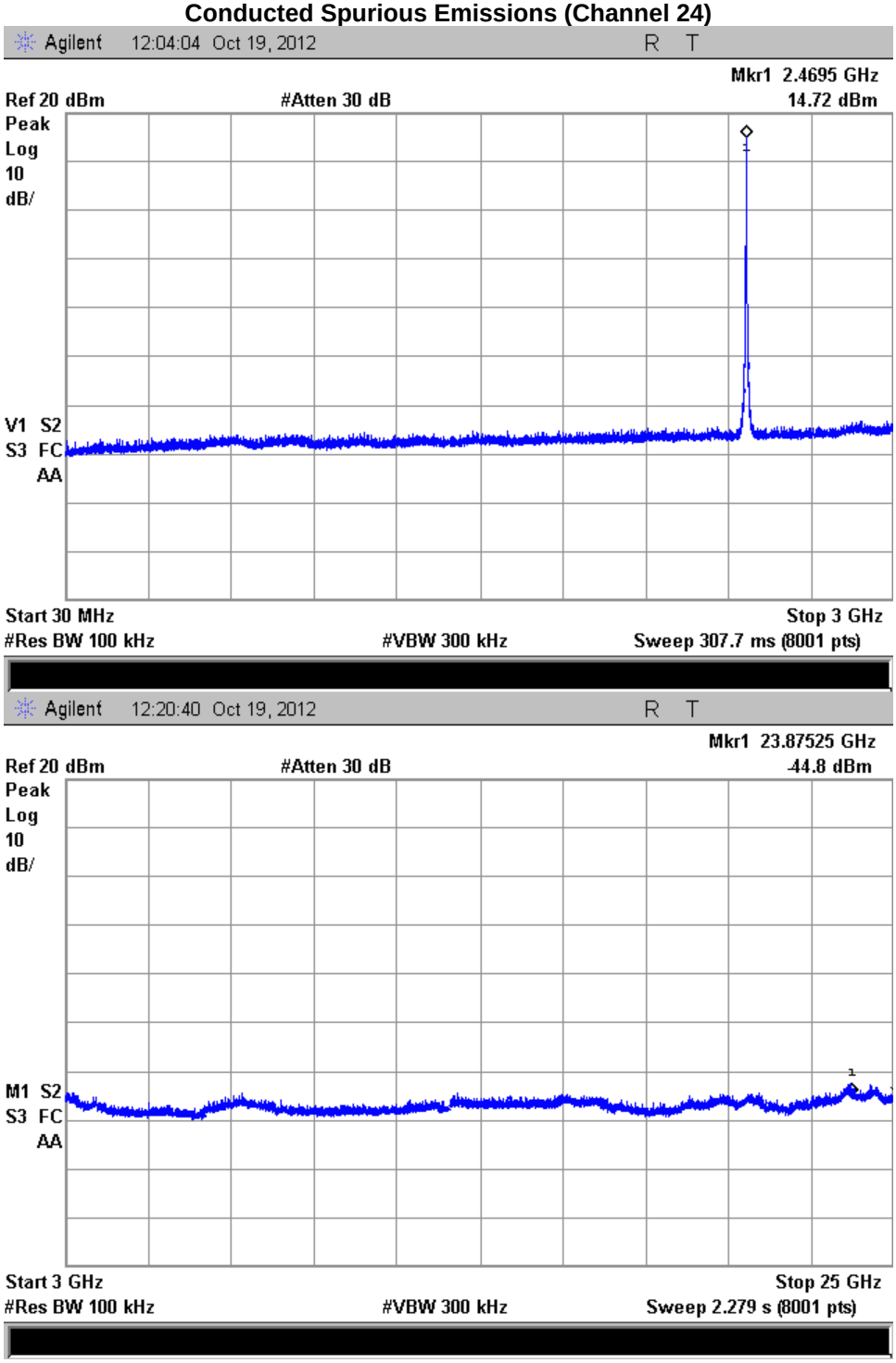


Conducted Spurious Emissions (Channel 18)





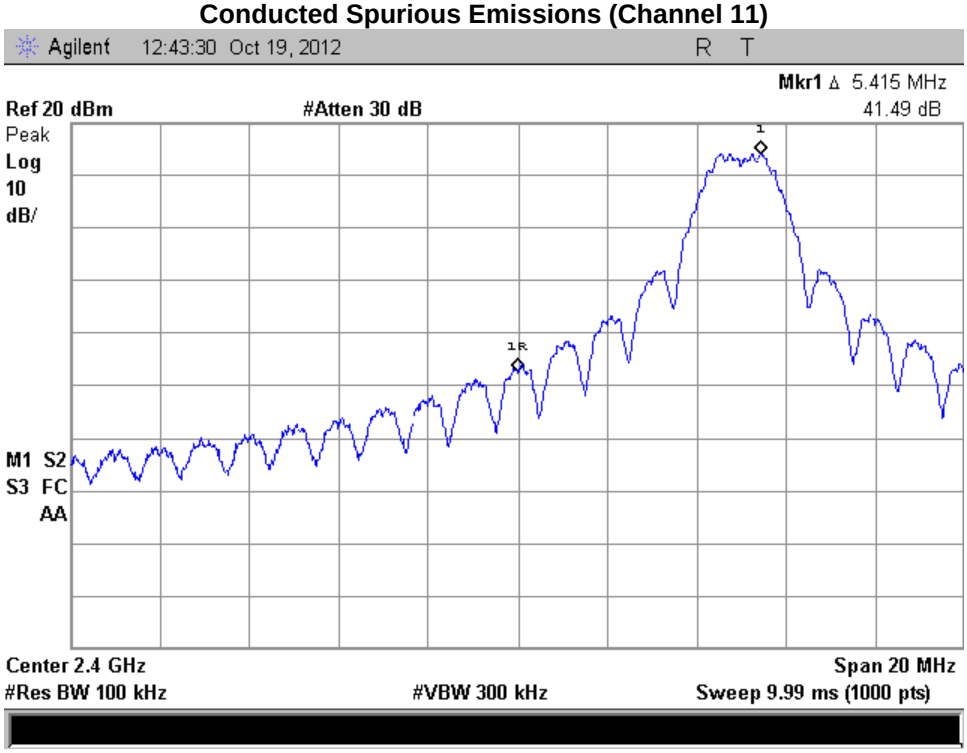
Conducted Spurious Emissions (Channel 24)



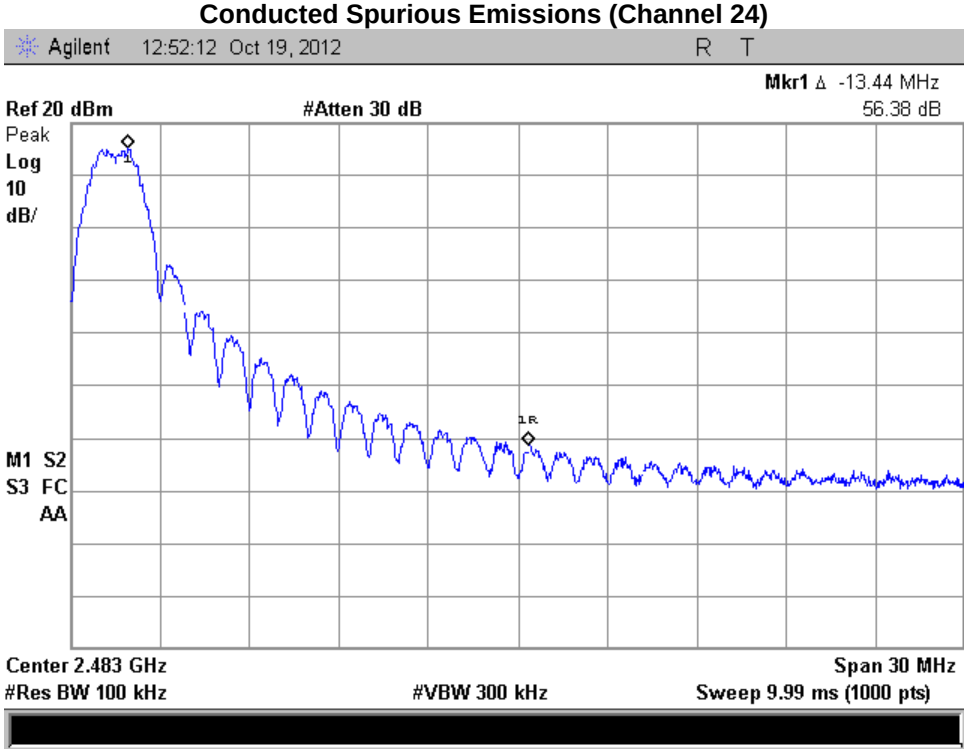
Conducted Spurious Emissions Close to the Band Edge:

The following plots show that the conducted spurious emissions close to the fundamental signal but outside of the transmit band are at least 20dB down.

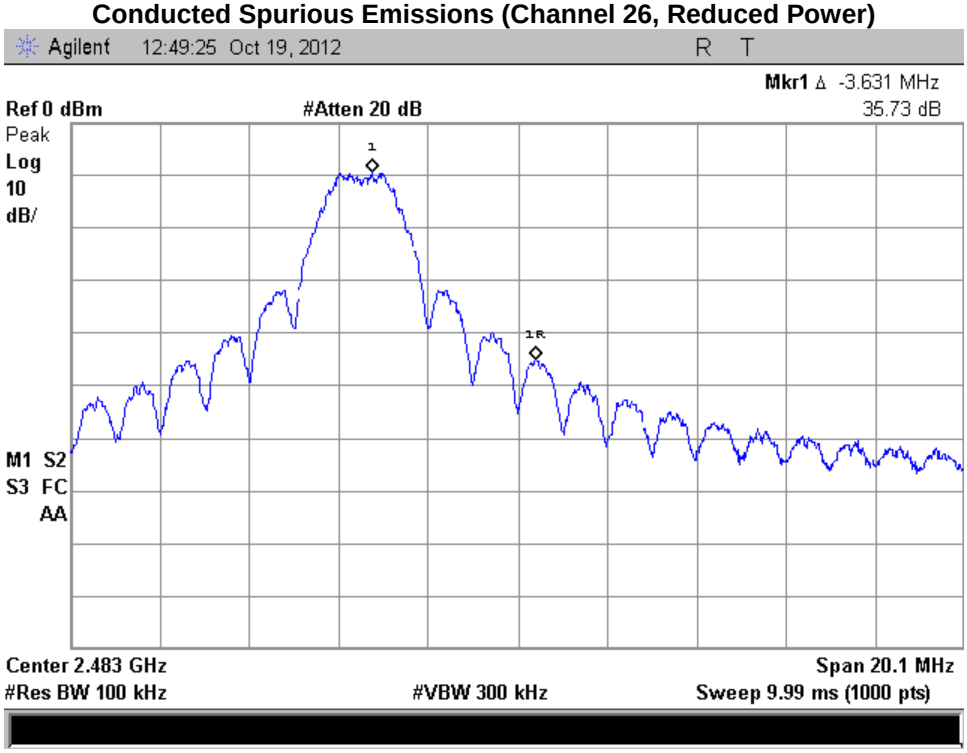
Conducted Spurious Emissions (Channel 11)



Conducted Spurious Emissions (Channel 24)



Conducted Spurious Emissions (Channel 26, Reduced Power)



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: 2009 and KDB Publication No. 558074: Guidance on Measurements for Digital Transmission Systems (47 CFR 15.247) PSD Option 1 Method

7.3 Test Equipment Used:

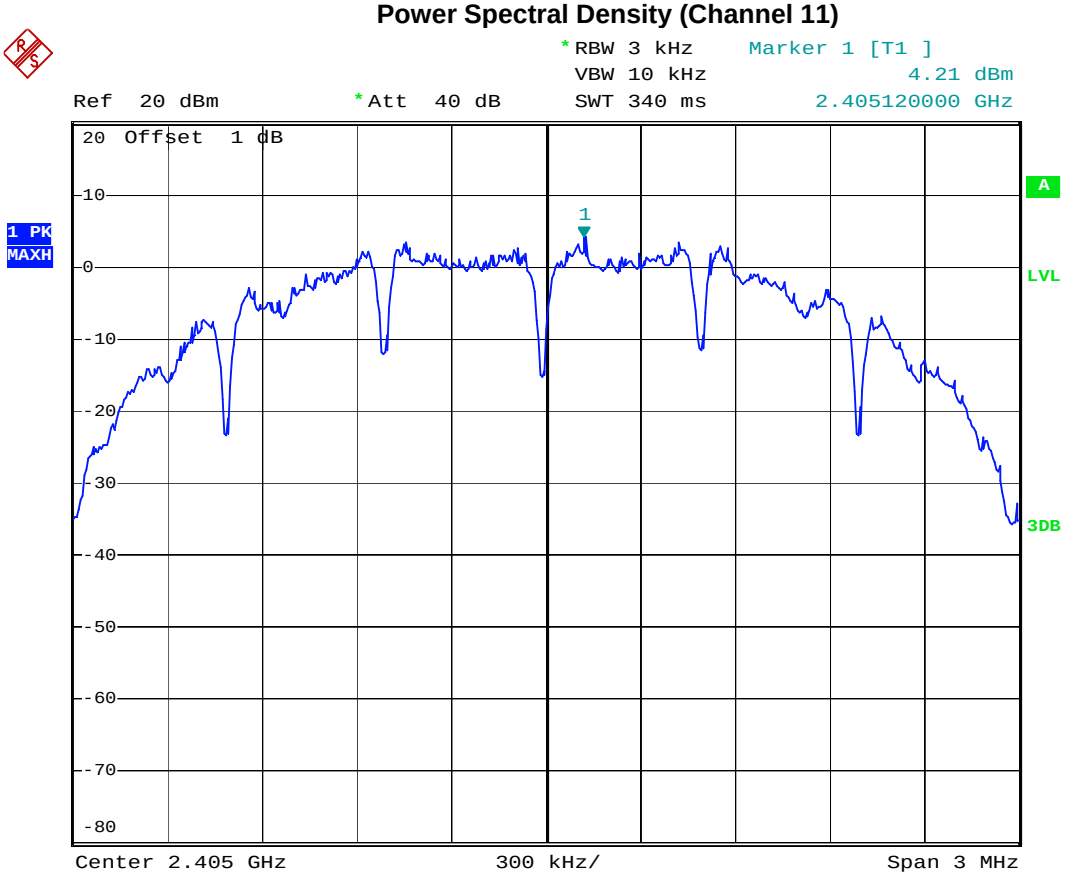
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
Spectrum Analyzer	3099	Rohde & Schwarz	FSP7	9/12/2012	9/12/2013

7.4 Results:

***PSD Option 1 Method**

Channel Number	PSD in 3kHz BW (dBm)	Limit (dBm)	Margin (dB)	Result
11	4.21dBm	8	3.79dB	Pass
18	3.90dBm	8	4.1dB	Pass
24	4.41dBm	8	3.59dB	Pass

Power Spectral Density (Channel 11)



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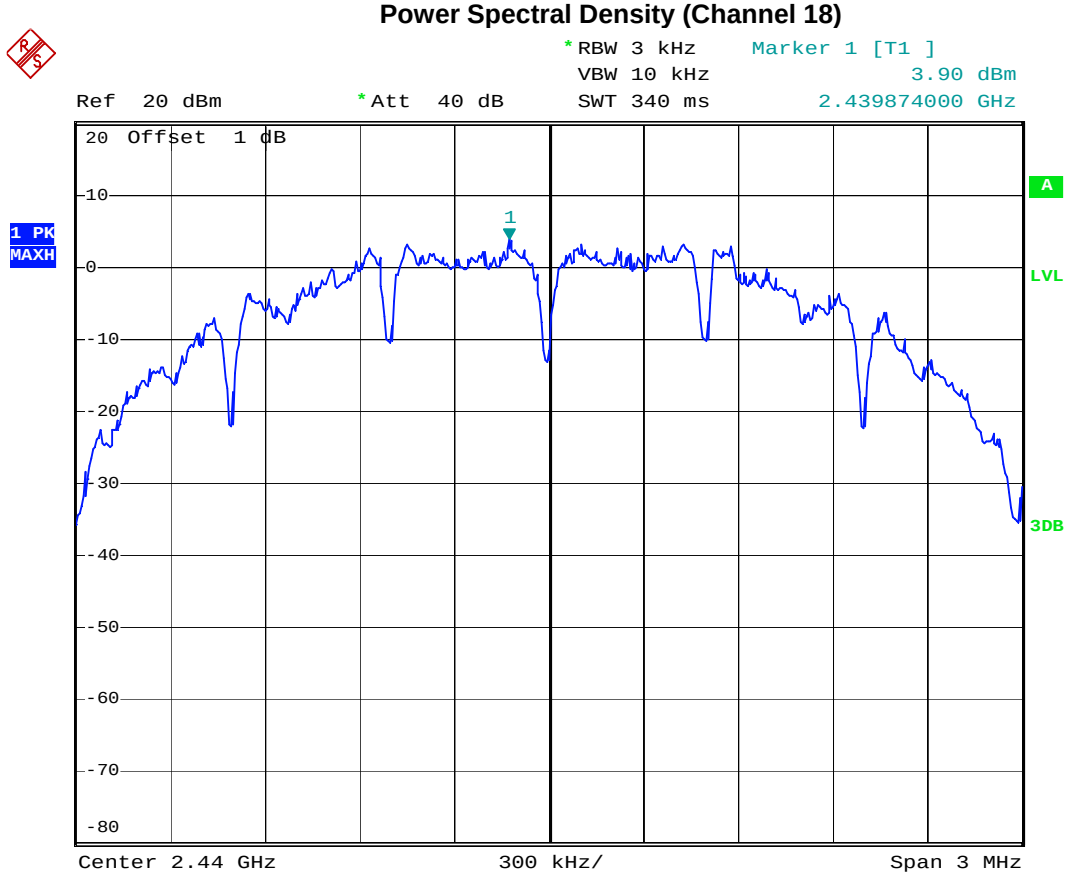
Power Spectral Density (Channel 18)



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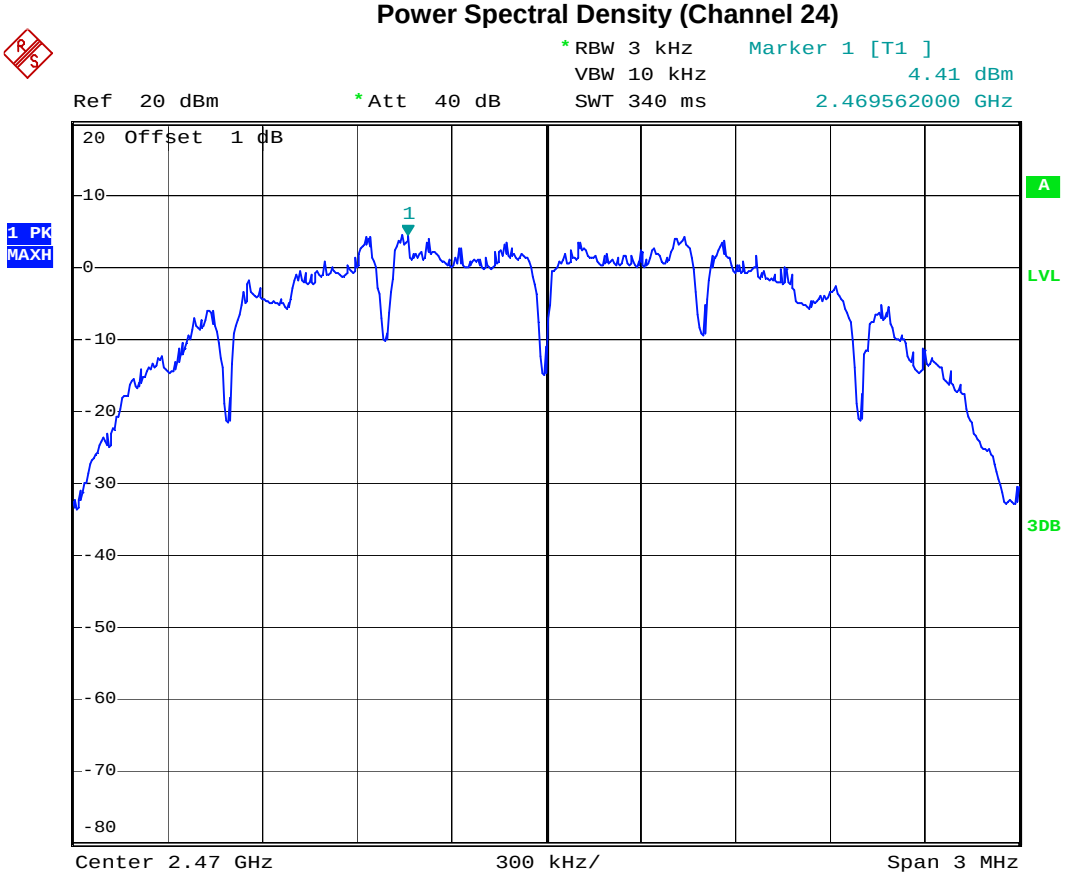
Power Spectral Density (Channel 24)



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: 2009 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	10887490.26	Rohde & Schwarz	ESI26	9/15/2012	9/14/2013
Preamplifier	987410	Miteq	AFS44-00102000-30-10P-44	9/4/2012	9/4/2013
Preamplifier	SF456200904	Mini-Circuits	ZX60-3018G-S+	9/4/2012	9/4/2013
Biconnilog Antenna	00051864	ETS	3142C	12/20/2011	12/20/2012
Horn Antenna	6556	ETS	3115	8/7/2012	8/7/2013
Horn Antenna	1096	Antenna Research	DRG-118/A	9/13/2012	9/13/2013
System Controller	121701-1	Sunol Sciences	SC99V	Not Required	Not Required
High Pass Filter	3986-01 DC0408	Microwave Circuits, Inc.	H3G020G2	Verify At Time of Use	Verify At Time of Use

8.5 Results:

For each channel it was verified that no change in radiated signal level occurred with the input power varied from 85% to 115% of nominal voltage. 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. The emissions were measured to 10 times the fundamental with the test sample in three orthogonal positions. The worst case data is reported below.

Worst Case Spurious Measurements (Channel 11)
Rubber Duck Antenna

TX Channel	Spurious Frequency	Polarity	Corr. Peak Reading. (dBuV/m)	Avg Reading. (dBuV/m)	Peak Limit (dBuV/m)	Avg. Limit (dBuV/m)	Results	Comments
Ch 11	4.8111 GHz	H	48.929	40.729	74	54	Compliant	Rubber Duck Antenna
Ch 11	7.2165 GHz	H	47.677	38.777	74	54	Compliant	Rubber Duck Antenna
Ch 11	9.622 GHz	H	46.196	35.946	74	54	Compliant	Rubber Duck Antenna
Ch 11	4.8109 GHz	V	49.818	41.388	74	54	Compliant	Rubber Duck Antenna
Ch 11	7.2168 GHz	V	50.978	41.668	74	54	Compliant	Rubber Duck Antenna
Ch 11	9.6221 GHz	V	47.856	38.766	74	54	Compliant	Rubber Duck Antenna

Worst Case Spurious Measurements (Channel 11)
Remote Mount Antenna

TX Channel	Spurious Frequency	Polarity	Corr. Peak Reading. (dBuV/m)	Avg Reading. (dBuV/m)	Peak Limit (dBuV/m)	Avg. Limit (dBuV/m)	Results	Comments
Ch 11	4.811 GHz	H	50.168	42.138	74	54	Compliant	Remote Mount Antenna
Ch 11	7.2165 GHz	H	55.426	46.196	74	54	Compliant	Remote Mount Antenna
Ch 11	9.622 GHz	H	51.986	40.286	74	54	Compliant	Remote Mount Antenna
Ch 11	4.811 GHz	V	51.148	43.838	74	54	Compliant	Remote Mount Antenna
Ch 11	7.2164 GHz	V	52.526	42.616	74	54	Compliant	Remote Mount Antenna
Ch 11	9.6223 GHz	V	51.727	39.787	74	54	Compliant	Remote Mount Antenna

Worst Case Spurious Measurements (Channel 18)
Rubber Duck Antenna

TX Channel	Spurious Frequency	Polarity	Corr. Peak Reading. (dBuV/m)	Avg Reading. (dBuV/m)	Peak Limit (dBuV/m)	Avg. Limit (dBuV/m)	Results	Comments
18	4.8792 GHz	H	46.68	36.51	74	54	Compliant	Rubber Duck Antenna
18	7.3186 GHz	H	53.46	44.11	74	54	Compliant	Rubber Duck Antenna
18	9.7581 GHz	H	51.272	39.022	74	54	Compliant	Rubber Duck Antenna
18	4.881 GHz	V	53.636	46.286	74	54	Compliant	Rubber Duck Antenna
18	7.3186 GHz	V	55.28	45.93	74	54	Compliant	Rubber Duck Antenna
18	9.7582 GHz	V	52.453	41.483	74	54	Compliant	Rubber Duck Antenna

Worst Case Spurious Measurements (Channel 18)
Remote Mount Antenna

TX Channel	Spurious Frequency	Polarity	Corr. Peak Reading. (dBuV/m)	Avg Reading. (dBuV/m)	Peak Limit (dBuV/m)	Avg. Limit (dBuV/m)	Results	Comments
18	4.881 GHz	H	47.406	37.826	74	54	Compliant	Remote Mount Antenna
18	7.3214 GHz	H	49.979	39.509	74	54	Compliant	Remote Mount Antenna
18	9.7619 GHz	H	52.589	41.509	74	54	Compliant	Remote Mount Antenna
18	4.8808 GHz	V	54.416	43.286	74	54	Compliant	Remote Mount Antenna
18	7.3215 GHz	V	54.089	43.159	74	54	Compliant	Remote Mount Antenna
18	9.7579 GHz	V	50.342	40.382	74	54	Compliant	Remote Mount Antenna

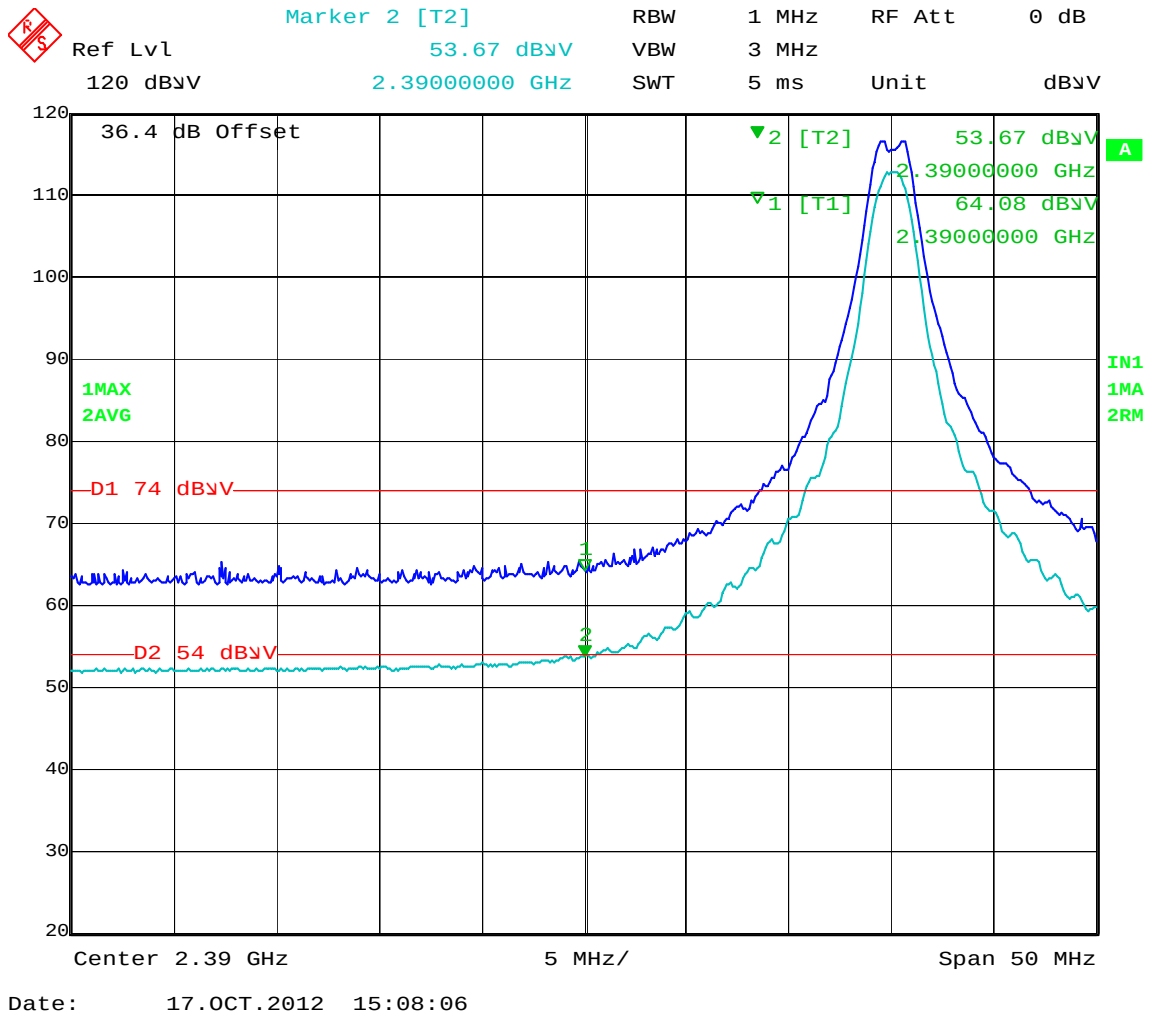
Worst Case Spurious Measurements (Channel 24)
Rubber Duck Antenna

TX Channel	Spurious Frequency	Polarity	Corr. Peak Reading. (dBuV/m)	Avg Reading. (dBuV/m)	Peak Limit (dBuV/m)	Avg. Limit (dBuV/m)	Results	Comments
Ch 24	4.941 GHz	H	46.087	36.987	74	54	Compliant	Rubber Duck Antenna
Ch 24	7.4115 GHz	H	52.064	41.914	74	54	Compliant	Rubber Duck Antenna
Ch 24	9.8811 GHz	H	49.601	36.421	74	54	Compliant	Rubber Duck Antenna
Ch 24	4.9409 GHz	V	55.367	45.787	74	54	Compliant	Rubber Duck Antenna
Ch 24	7.4116 GHz	V	54.614	45.704	74	54	Compliant	Rubber Duck Antenna
Ch 24	9.8819 GHz	V	52.411	41.151	74	54	Compliant	Rubber Duck Antenna

Worst Case Spurious Measurements (Channel 24)
Remote Mount Antenna

TX Channel	Spurious Frequency	Polarity	Corr. Peak Reading. (dBuV/m)	Avg Reading. (dBuV/m)	Peak Limit (dBuV/m)	Avg. Limit (dBuV/m)	Results	Comments
Ch 24	4.9411 GHz	H	51.198	43.408	74	54	Compliant	Remote Mount Antenna
Ch 24	7.4115 GHz	H	54.484	41.794	74	54	Compliant	Remote Mount Antenna
Ch 24	9.8821 GHz	H	50.561	38.901	74	54	Compliant	Remote Mount Antenna
Ch 24	4.9411 GHz	V	56.388	49.168	74	54	Compliant	Remote Mount Antenna
Ch 24	7.4115 GHz	V	54.734	43.494	74	54	Compliant	Remote Mount Antenna
Ch 24	9.8821 GHz	V	55.011	45.081	74	54	Compliant	Remote Mount Antenna

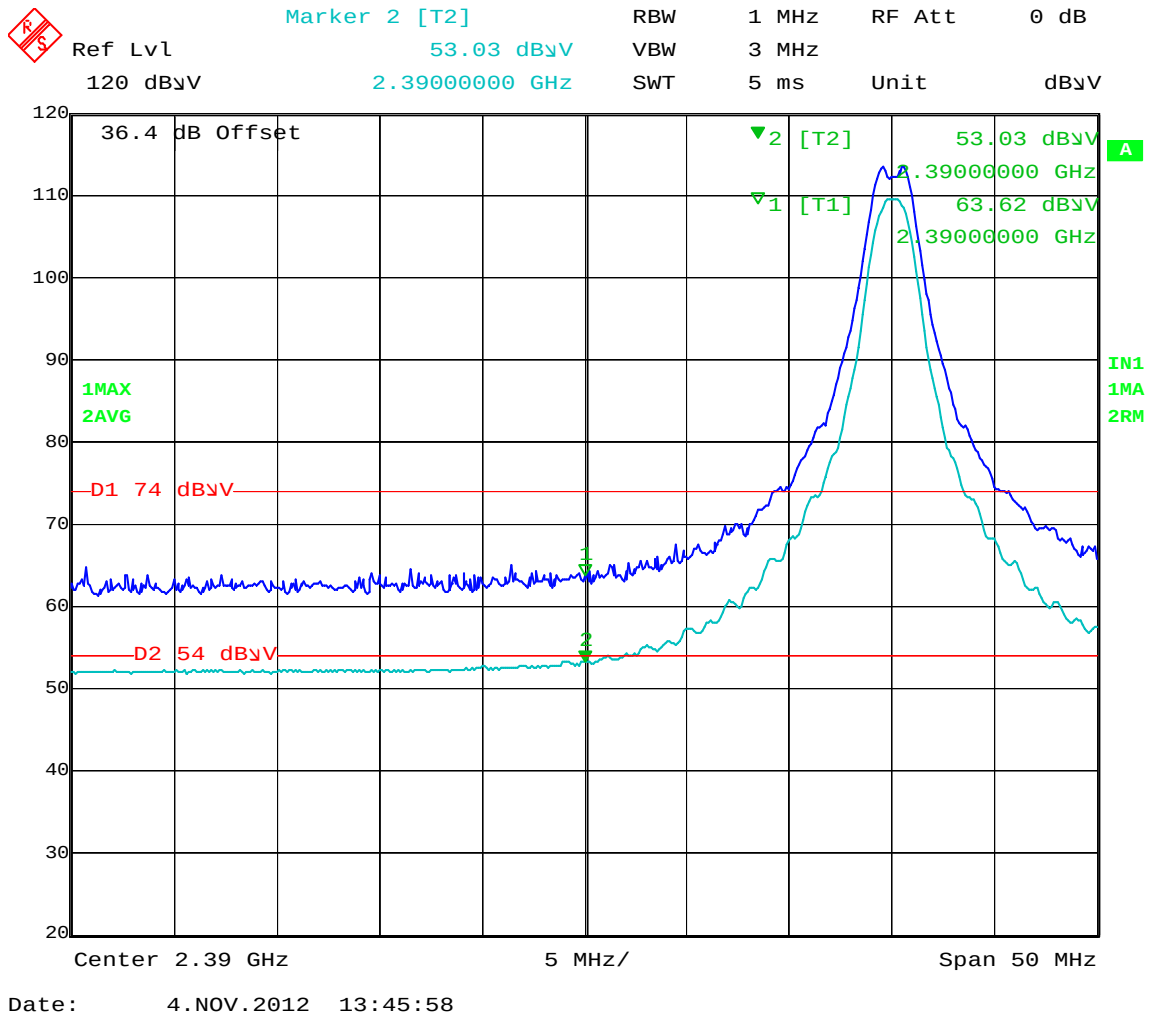
Radiated Band Edge Measurement: Channel 11
Average Measurements Using Option 1
Rubber Duck Antenna



Software Settings:
Channel: 11
setTxPowMode 0 1
setTxPower -0x02
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

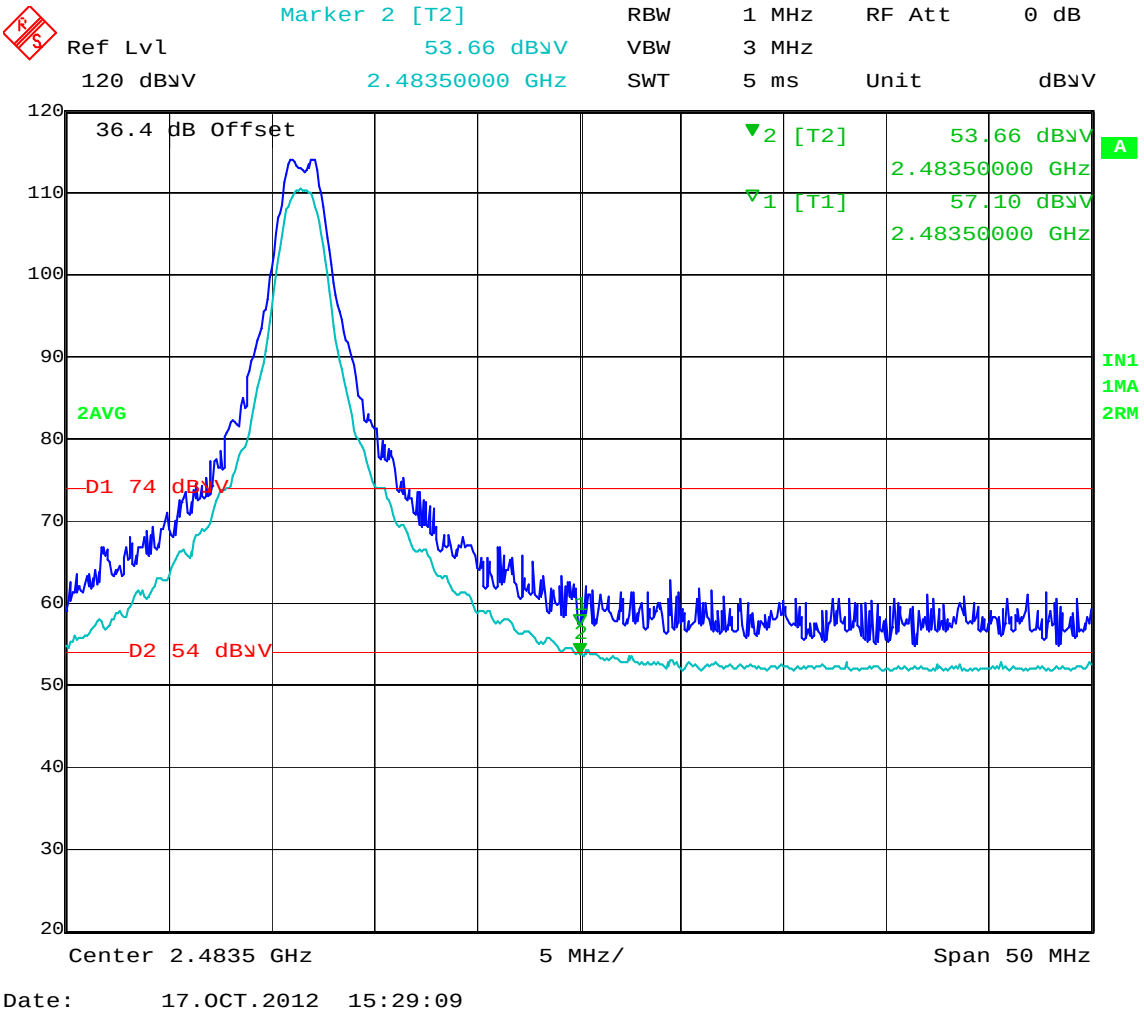
Radiated Restricted Band Edge Measurement: Low Channel
Average Measurements Using Option 1
Remote Mount Antenna



Software Settings:
Channel: 11
setTxPowMode 0 1
setTxPower -0x02
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

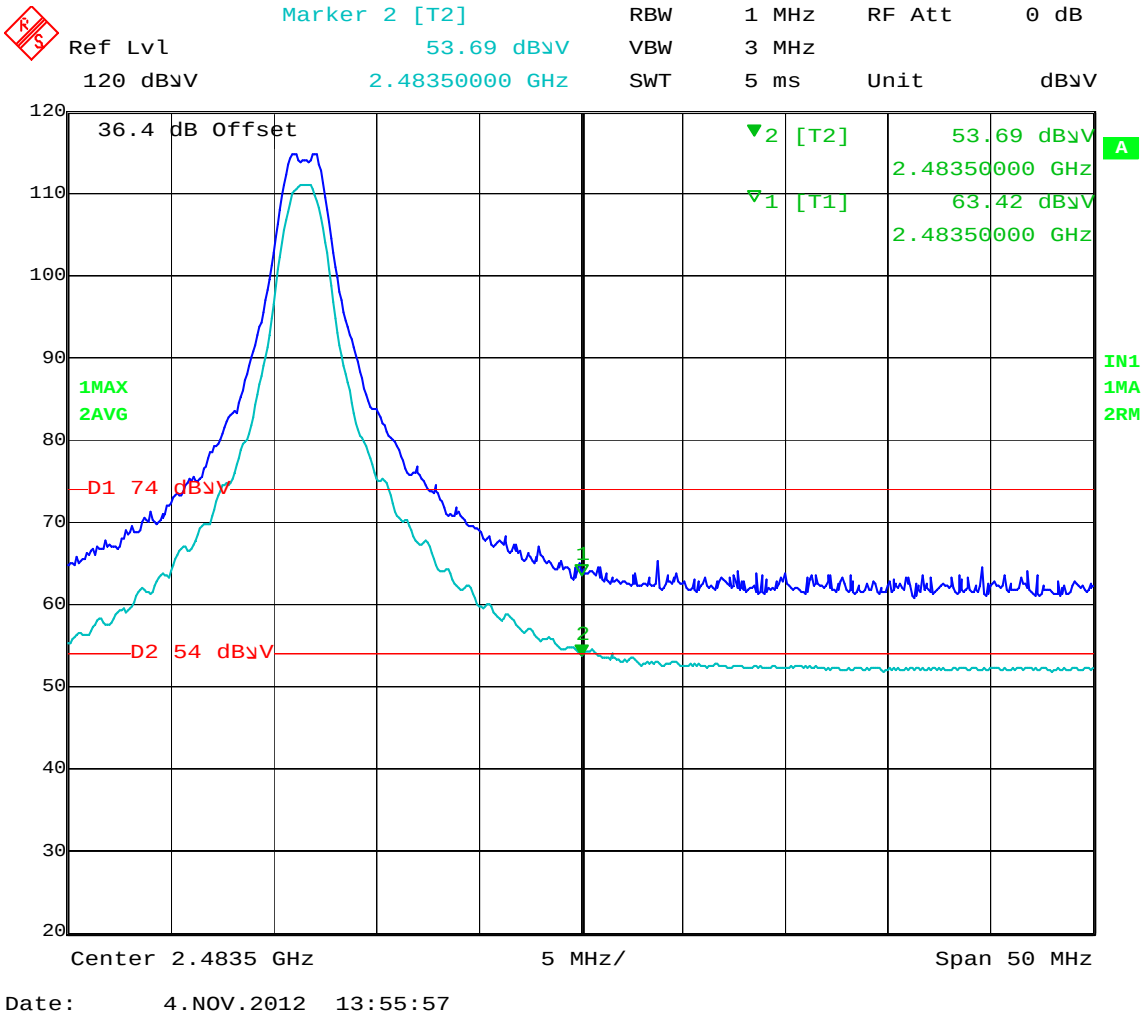
Radiated Restricted Band Edge Measurement: High Channel
Average Measurements Using Option 1
Rubber Duck Antenna



Software Settings:
Channel: 24
setTxPowMode 0 1
setTxPower -0x02
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

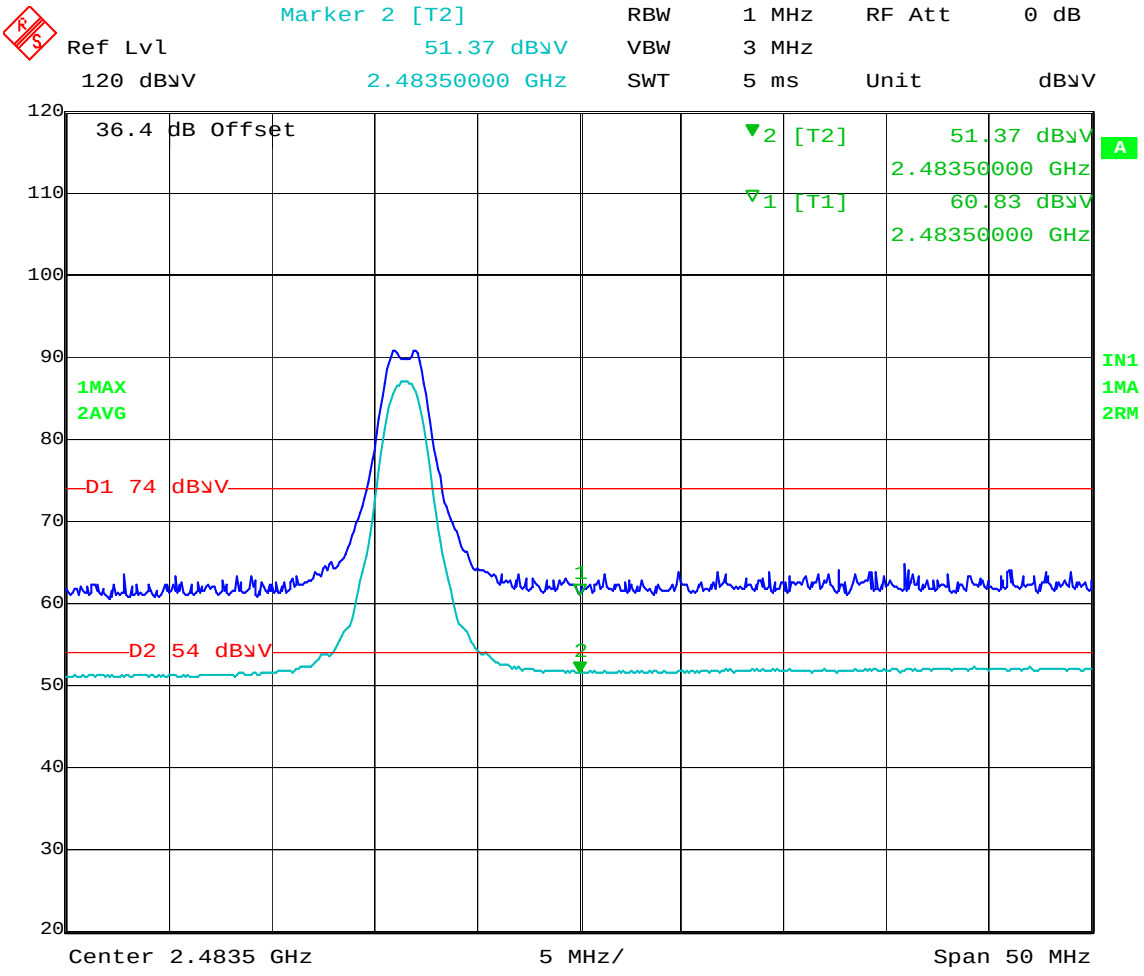
Radiated Restricted Band Edge Measurement: High Channel
Average Measurements Using Option 1
Remote Mount Antenna



Software Settings:
Channel: 24
setTxPowMode 0 1
setTxPower -0x02
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

Radiated Restricted Band Edge Measurement: High Channel (Reduced Power[1])
Average Measurements Using Option 1
Rubber Duck Antenna

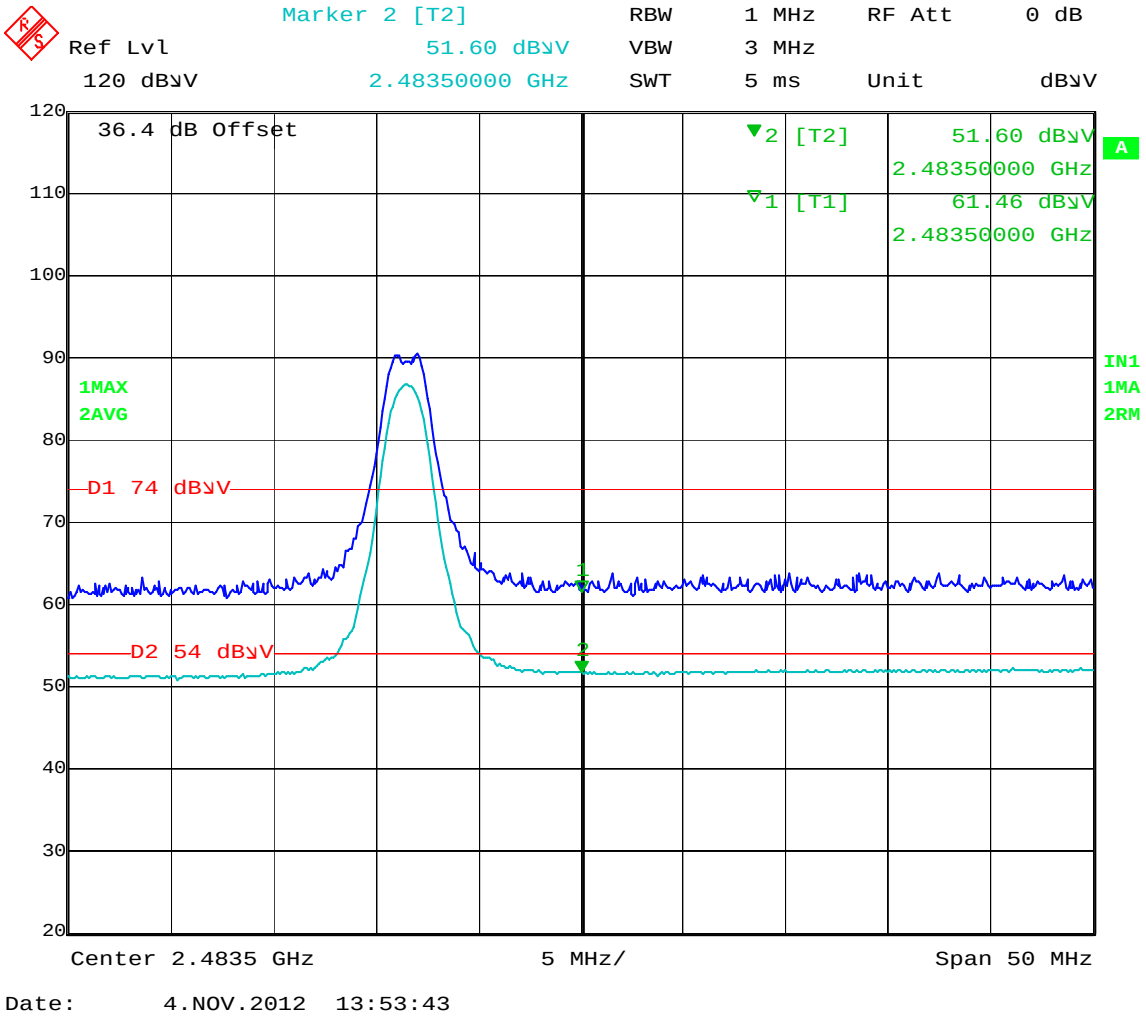


Software Settings:
Channel: 25
setTxPowMode 0 1
setTxPower -0x1A
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

1 In order to comply with the general radiated emission limit at the restricted band beginning at 2483.5MHz, the transmitter output power was reduced on this channel as shown in the software settings.

Radiated Restricted Band Edge Measurement: High Channel (Reduced Power[2])
Average Measurements Using Option 1
Remote Mount Antenna

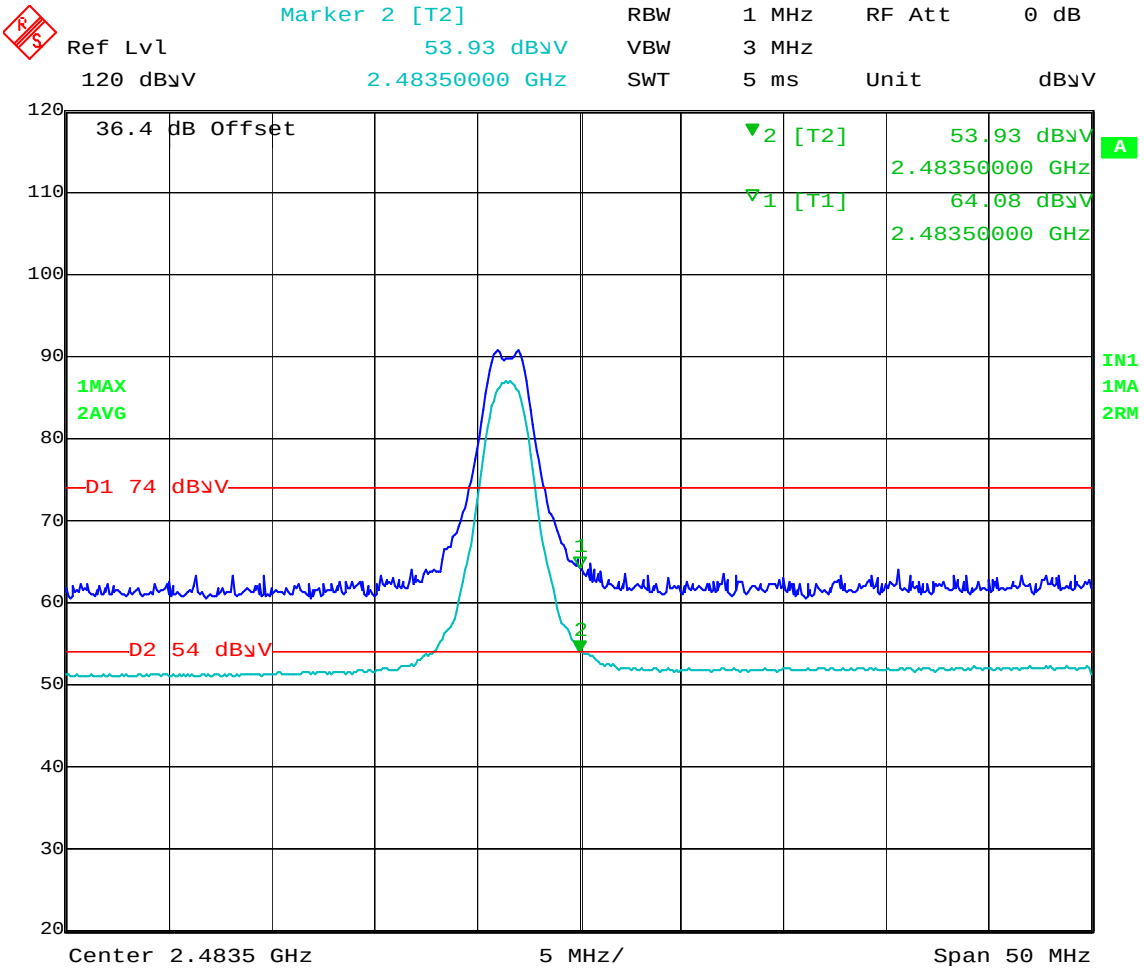


Software Settings:
Channel: 25
setTxPowMode 0 1
setTxPower -0x1A
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

2 In order to comply with the general radiated emission limit at the restricted band beginning at 2483.5MHz, the transmitter output power was reduced on this channel as shown in the software settings.

Radiated Restricted Band Edge Measurement: High Channel (Reduced Power[3])
Average Measurements Using Option 1
Rubber Duck Antenna

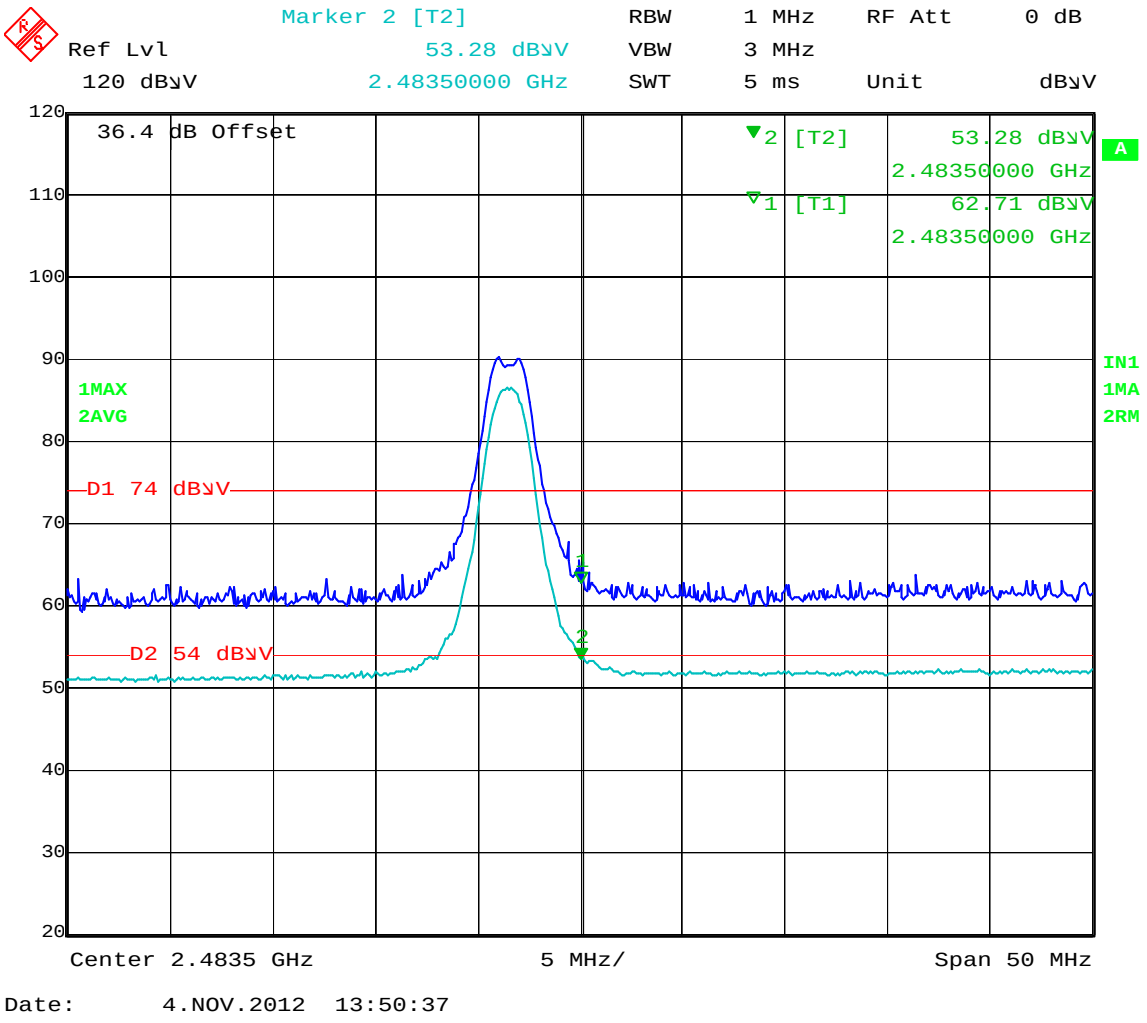


Software Settings:
Channel: 26
setTxPowMode 0 1
setTxPower -0x1A
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

3 In order to comply with the general radiated emission limit at the restricted band beginning at 2483.5MHz, the transmitter output power was reduced on this channel as shown in the software settings.

Radiated Restricted Band Edge Measurement: High Channel (Reduced Power[4])
Average Measurements Using Option 1
Remote Mount Antenna



Software Settings:
Channel: 26
setTxPowMode 0 1
setTxPower -0x1A
txStream

Duty Cycle Correction for Average Measurement:
The average measurement shown in the plot above can be reduced by 3.6dB in order to account for the worst case duty cycle from the Ember Zigbee stack (66%). By doing so the average measurement clearly passes.

4 In order to comply with the general radiated emission limit at the restricted band beginning at 2483.5MHz, the transmitter output power was reduced on this channel as shown in the software settings.

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: 2009

9.3 Test Equipment Used:

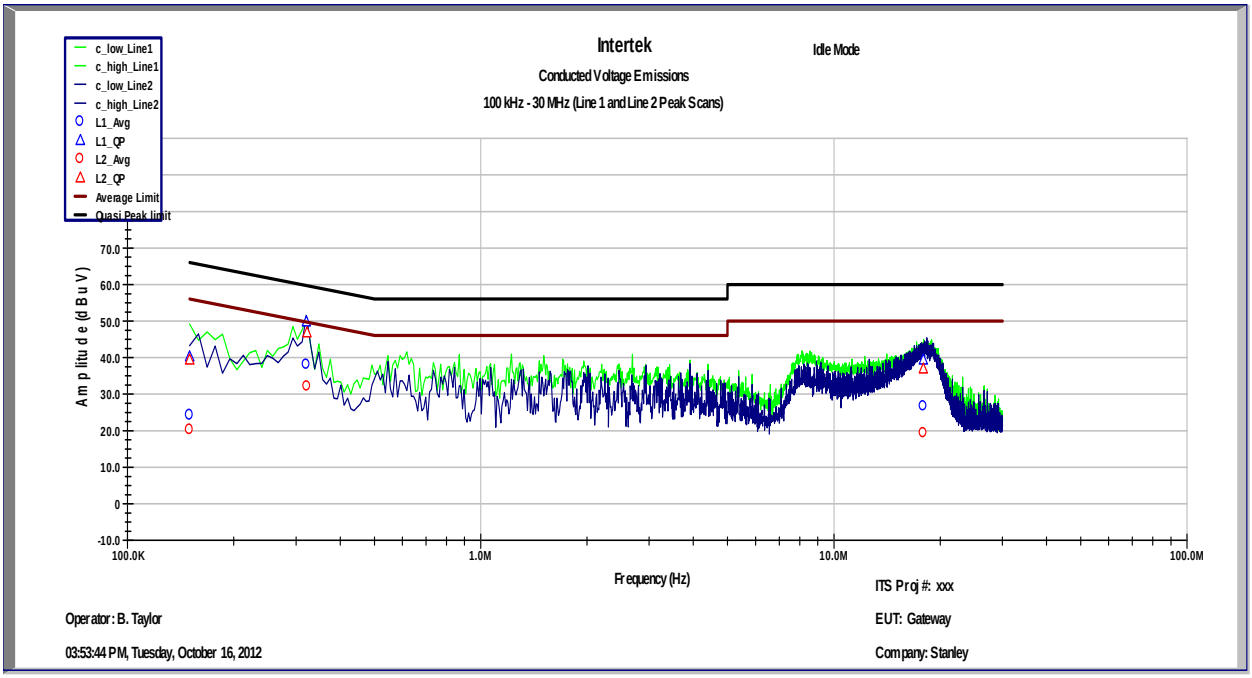
Description	Serial Number	Manufacturer	Model	Cal. Date	Cal. Due
EMI Test Receiver	10887490.26	Rohde & Schwarz	ESI26	9/15/2012	9/14/2013
LISN	3333	Teseq	NNB52	3/8/2012	3/8/2013

9.4 Results:

Conducted Voltage Emissions on Power Lines								
Test Engineer:	Bryan Taylor	**Start Date:**	10/16/2012	**End Date:**	10/16/2012			
Temperature:	25.1C	**Humidity:**	43.50%	**Pressure:**	988.8			
Specification:	FCC Part 15	**Test Limit:**	Class B	**RBW:**	9kHz			
Notes:	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	150.0 KHz	40.28	66	-25.72	24.17	56	-31.83	**Compliant**
Line 1	321.0 KHz	49.81	59.68	-9.87	37.99	49.68	-11.69	**Compliant**
Line 1	17.9 MHz	39.35	60	-20.65	26.62	50	-23.38	**Compliant**
Line 2	150.0 KHz	39.41	66	-26.59	20.18	56	-35.82	**Compliant**
Line 2	322.4 KHz	46.81	59.64	-12.83	32.03	49.64	-17.61	**Compliant**
Line 2	17.9 MHz	36.94	60	-23.06	19.3	50	-30.7	**Compliant**

Idle Mode
Quasi-Peak and Average Measurements

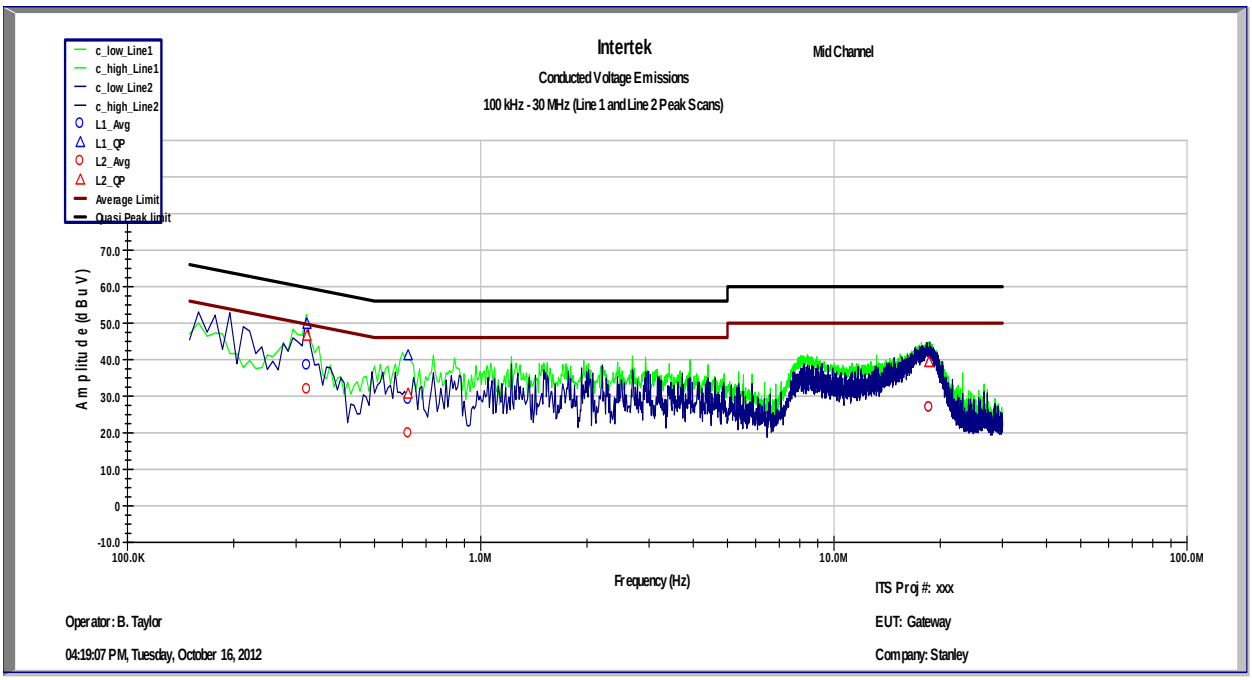


Idle Mode
Peak Scan (Line 1 and 2)

Conducted Voltage Emissions on Power Lines					
Test Engineer:	Bryan Taylor	**Start Date:**	10/16/2012	**End Date:**	10/16/2012
Temperature:	25.1C	**Humidity:**	43.50%	**Pressure:**	988.8
Specification:	FCC Part 15	**Test Limit:**	Class B	**RBW:**	9kHz
Notes:	Transmitting on Middle channel				

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	322.2 KHz	49.74	59.65	-9.91	38.43	49.65	-11.22	**Compliant**
Line 1	623.2 KHz	41.17	56	-14.83	29.01	46	-16.99	**Compliant**
Line 1	18.6 MHz	39.28	60	-20.72	26.88	50	-23.12	**Compliant**
Line 2	322.2 KHz	46.48	59.65	-13.17	31.83	49.65	-17.82	**Compliant**
Line 2	623.2 KHz	30.65	56	-25.35	19.81	46	-26.19	**Compliant**
Line 2	18.6 MHz	39.28	60	-20.72	26.88	50	-23.12	**Compliant**

Transmitting on Middle Channel
Quasi-Peak and Average Measurements



Transmitting on Middle Channel
Peak Scan (Line 1 and 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. The test sample utilized a reverse polarity SMA connector which is non-standard and meets the requirements of Part 15.203.

11 Duty Cycle Correction Factor Determination

The worst case duty cycle over a 100ms windows was calculated by the manufacture to determine the duty cycle factor.

Goal: Calculate the worse case time a ZigBee Node will be in TX Mode in any 100ms Time Window.
Correction Factor is: 20*Log10(Duty Cycle)

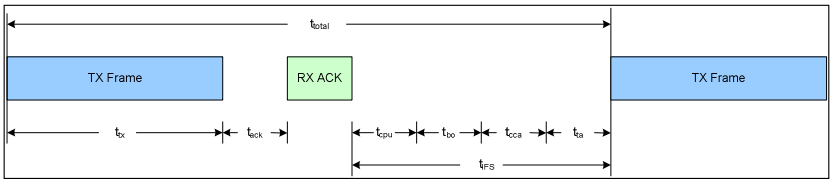
Procedure: In order to calculate the worse case TX on time, Ember started by reviewing the IEEE 802.15.4 MAC and PHY constants. In addition, Ember used the slotted ACK LIFS and SIFS scenarios. Each scenario is described below.

Worst Case Scenario: The worst case scenario utilizes LIFS, and a TX, RX ACK, TX, RX ACK… from a single node. It has been proven through calculation, this scenario keeps the node in TX Mode for the longest

Summary: ***If you are using EmberZNet Stack SW, the TX duty cycle: 66%***

IEEE 802.15.4-2003 2.4 GHz PHY Constants

Data Rate	250000	bits / sec	
	31250	bytes / sec	
Symbols/byte	2	sym / bytes	
Symbol Timing	62500	sym / sec	
	0.000016	sec / sym	
Byte Timing	0.000032	sec / byte	
PHY PSDU	6	bytes	4 Pramble, SPD, Length
Max Length	127	bytes	
Total Packet Length	133	bytes	
Maximum Time TX PKT	0.004256	sec	



Long Frame Scenario:
1) TX Frame — Assume Frame is Data Frame
2) Wait for ACK
3) RX ACK
4) CPU Processing of ACK
5) Wait for Backoff
6) Repeat 1)

MAC-Level Calculation (LIFS)

Long InterFrame Spacing (Slotted w/ ACK)			
Long Frame	127	bytes	
Data Frame Payload	102	bytes	
ACK Frame	5	bytes	
tack	12	sym	
LIFS	40	sym	
Backoff Period	20	sym	
Maximum Backoff	7		Random between 0 and 7
Backoff Required	2		
Backoff Time	70	sym	Average at 3.5

Transmit Time	
TX Time (Packet)	0.004256
Total TX Time (sec)	0.004256

NOT Transmit time (RX or Idle)		
Wait for ACK (tack)	0.000192	
RX Time (ACK)	0.000352	
Backoff Time (tbo)	0.00112	(Backoff Time * Backoff Period)
CPU Processing (tcpu)	0.0002	(0.2ms average on EM2xx running EmberZNet)
CCA Assessment (tcca)	0.000128	(averaged over 8 symbols in RX Mode)
Turn Around Time (RX to TX)	0.000192	(After CCA, Radio turns over to TX in 12 symbols)
Total Off Time (sec)	0.002184	

Total Time (ttotal)	0.00644
Number of RX / TX cycles in 100ms	15.5279503

Worse Case (100ms window)

TX Frame 10 times	0.04256
RX or IDLE 10 Times	0.02184
Sum	0.0644

MAC TX Duty Cycle (On /total)	66.09%		Represents theoretical ZigBee / MAC performance
	3.59768496	dB	

12 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	

13 Revision History

Revision Level	Date	Report Number	Notes
0	11/4/2012	100891782LEX-002	Original Issue