Testing Tomorrow's Technology

Application
For

Title 47 USC, Part 2, Subpart J, Paragraph 2.902, Equipment Authorization of Verification for an Unintentional Radiator per Part 15, Subpart B, Paragraphs 15.107 and 15.109

And

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247

And

Innovation, Science, and Economic Development Canada
Certification Per
IC RSS-Gen General Requirements for Radio Apparatus
And
RSS-247 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices

For the

Wink Labs, Inc.

Model Number: WINK HUB 2

FCC ID: 2ACAJ-WHUB2
IC: 11938A-WHUB2

UST Project: 16-0217
Issue Date: September 2, 2016

Total Pages: 61

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

Testing Tomorrow's Technology

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

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date September 2, 2016

NVLAP LAB CODE 200162-0

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

MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Wink Labs, Inc.
MODEL: Wink Hub 2
FCC ID: 2ACAJ-WHUB2
IC: 11938A-WHUB2
DATE: September 2, 2016

This report concerns (check one): Original grant [X]
Class II change

Equipment type: 2.4 GHz Transmitter Module

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

If yes, defer until: _____N/A_____
date
agrees to notify the Commission by N/A
date
of the intended date of announcement of the product so that the grant can be issued on that date.

Report prepared by:

US Tech
3505 Francis Circle
Alpharetta, GA 30004

Phone Number: (770) 740-0717
Fax Number: (770) 740-1508

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1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to IC RSS-247 and FCC Rules and Regulations Part 15, Section 247.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on August 26, 2016 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Wink Labs, Inc. home automation hub, model Wink Hub 2. The Wink Hub 2 has five transmitters, including three 2.4 GHZ transmitters: Wifi (2.4/5GHz), Bluetooth, and Zigbee; one 431 MHz transmitter (Lutron), and one 915 MHz transmitter (Zwave). The circuit board uses four on-board transmitter antennas. The Bluetooth and Wifi radios share one antenna and the other transmitters each have their own antennas.

This report will cover, in detail, the test results for the Zigbee transmitter, which is a 2.4 GHz radio. Test results for the other transmitters will be covered in different reports.

The ZigBee Transmitter is a fully ZigBee-compliant stack running on top of IEEE 802.15.4-compliant TI LPRF SoC/Transceiver and TIMAC.

This radio was loaded with production firmware by Flextronics which allowed the EUT to be placed into a test mode for testing purposes.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for the intentional radiator aspect of the device and *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* for the unintentional radiator aspect of the device as well as FCC subpart B and C of Part 15 and per FCC KDB Publication number 558074 v03r05 for Digital Transmission Systems Operating Under section 15.247.

Digital RF conducted and radiated emissions data below 1 GHz were taken with the measuring receiver (or spectrum analyzer's) resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements performed above 1.0 GHz were made with a RBW of 1 MHz. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was set to 3 times the RBW or as required per the standard throughout the evaluation process.

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

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is 186022. Additionally this site has also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

1.6 Related Submittal(s)/Grant(s)

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification of the transmitter incorporated within the EUT, see test data presented herein.

b) Verification as a class B digital device.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID:	CABLES P/D
Gateway Wink Labs, Inc. (EUT)	WINK HUB 2	Engineering Sample	Pending: FCC ID: 2ACAJ-WHUB2 IC:11938A-WHUB2	1.5 m U P 1.0 m U D
AC/DC Power Supply adapter Wink Labs, Inc	S012BEU1 200100	None	None	1.5 m U P
Router	Various	Various	Various	1.5 m U P
Antenna See antenna details	--	--	--	--

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

2 Tests and Measurements

2.1 Test Equipment

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

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	2/11/2016
RF PREAMP 100 kHz to 1.3 GHz	8447D	HEWLETT-PACKARD	1937A02980	12/2/2015
PREAMP 1.0 GHz to 26.0 GHz	8449B	HEWLETT-PACKARD	3008A00480	12/1/2015
RF PREAMP	RA106	US Tech	001	8/10/2016
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	9/28/2015 2 yr cycle
BICONICAL ANTENNA	3110B	EMCO	9307-1431	8/25/2015 2 yr cycle
BICONICAL ANTENNA	3110B	EMCO	9306-1708	11/24/2014 2 yr cycle
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr cycle
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	7/1/2014 2 yr cycle extended 90 days
HORN ANTENNA	3115	EMCO	9107-3723	7/8/2014 2 yr cycle extended 90 days
HORN ANTENNA	3116	EMCO	9505-2255	1/27/2015 2 yr cycle

CALCULATION PROGRAM	N/A	N/A	Ver. 6.0	N/A

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

2.2 Modifications to EUT Hardware

No modifications were made by US Tech to bring the EUT into compliance with FCC Part 15.247 or IC RSS-210 requirements.

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

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

Table 3. Number of Test Frequencies for Intentional Radiators

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

Because the EUT operates over 2.4 GHz to 2.4835 GHz, 3 test frequencies will be used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

2.4.1 Intentional Radiator

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

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to the range specified in 2.4.1 above, whichever is the higher range of investigation.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35)

The radiated and conducted emissions limits shown herein are based on the following:

2.5.1 Detector Function and Associated Bandwidth

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

2.5.2 Corresponding Peak and Average Requirements

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

2.5.3 Pulsed Transmitter Averaging

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

2.6 EUT Antenna Requirements (CFR 15.203)

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

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Antenna	Wink Labs	Inverted F	None	0.0	Trace Antenna

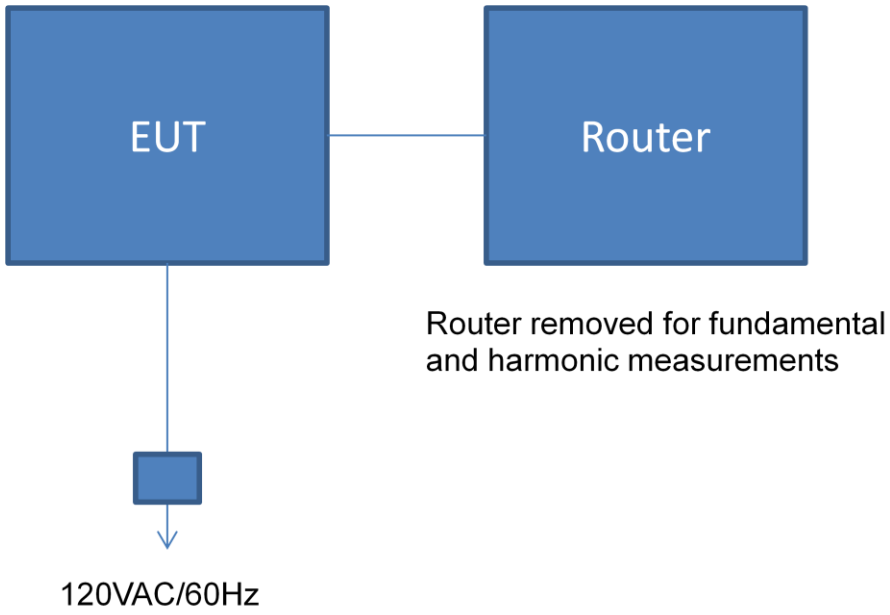


Figure 1. Block Diagram of Test Configuration

2.7 Restricted Bands of Operation (Part 15.205)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious cannot exceed the limits of 15.209. Radiated harmonics and other Spurious are examined for this requirement see paragraph 2.10.

2.8 Transmitter Duty Cycle (Part 15.35 (c))

Duty cycle measurements have been measured over one complete pulse train. The pulse train does not exceed 100 mSec.

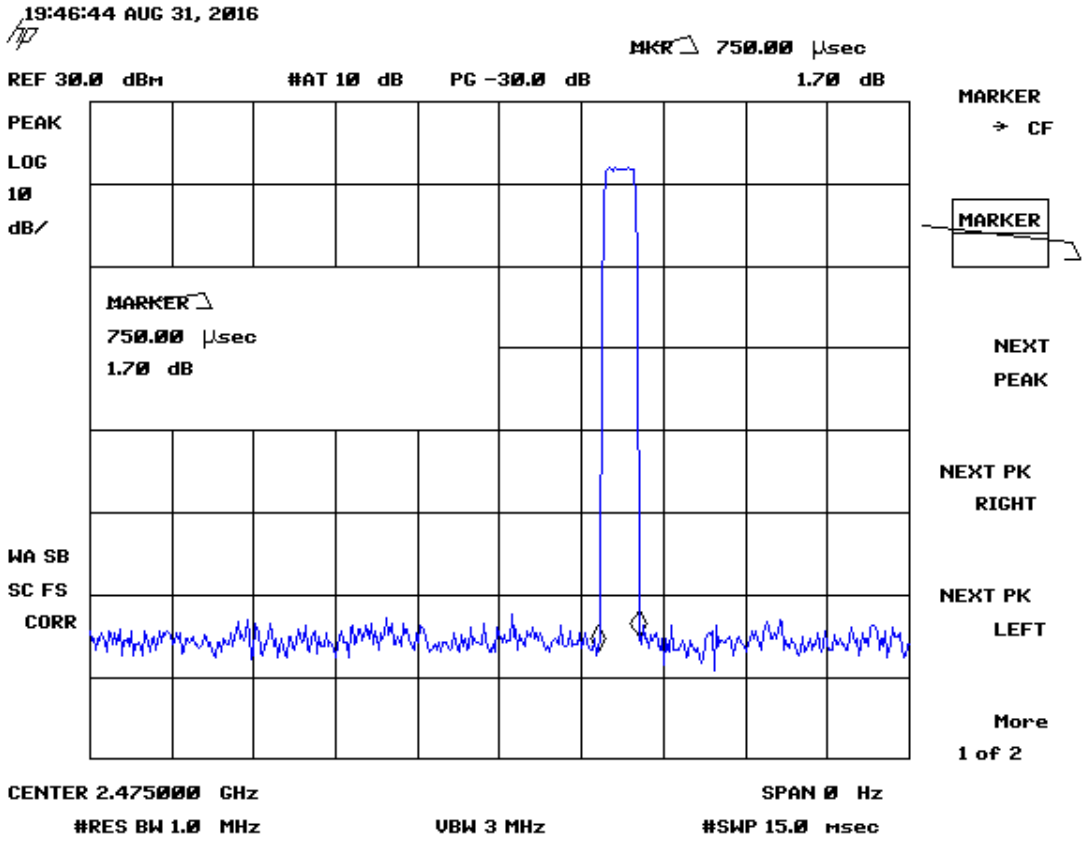


Figure 2. Pulse Width

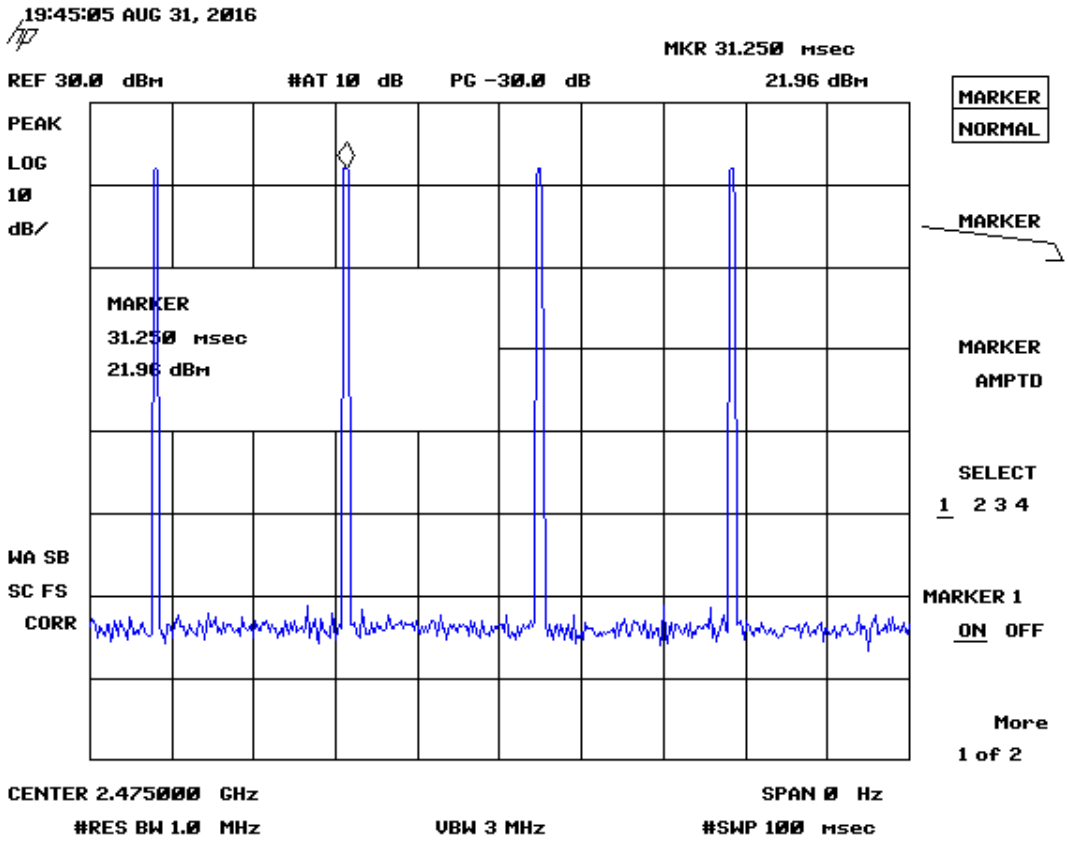


Figure 3. 100 mSecond Period

Total time ON= 750 uSec x 4 = 3.0 mSec
Duty Cycle = (Total time ON/100 mSec) = 3.0 mSec/100 mSec = 0.03
Duty Cycle Factor= 20 log (DC)= 20 log (0.03)= -30.45

For this test report the maximum duty cycle factor applied was -20 dB.

Note: The transmitter was programmed to transmit at >98% during all testing. Therefore where applicable (when using AVG detection) the duty cycle factor calculated above was applied.

2.9 Antenna Conducted Intentional and Spurious Emissions (CFR 15.209, 15.247(d)) (IC RSS 210, A2.9 (a))

The EUT was put into a continuous-transmit mode of operation and tested per FCC KDB Publication 558074 v03r05 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to ten times the highest clock frequency generate or used in this case, 25 GHz. A conducted scan was performed on the EUT to identify and record spurious signals that were related to the transmitter. Antenna Conducted Emissions of a significant magnitude that fell within restricted bands were then measured as radiated emissions on the OATS. The conducted emissions graphs are found in Figures 3 through 8 below. The limit for antenna conducted power is 1 Watt (30 dBm) per 15.247 (b)(3).

For Conducted RF antenna conducted tests, the RBW was set to 100 kHz, video bandwidth (VBW)> RBW, scan up through the 10^{th} harmonic of the fundamental frequency. All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band.

For radiated measurements, the EUT was set into a continuous transmission mode. Below 1 GHz, the RBW of the measuring instrument was set equal to 120 kHz. Peak measurements above 1 GHz were measured using a RBW = 1 MHz, with a VBW ≥ RBW. The results of peak radiated spurious emissions falling within restricted bands are given in Table 6 below.

For Average Voltage measurements above 1 GHz, the emissions were measured using RBW = 1 MHz and VBW = 10 Hz. For a pulse-modulated transmitter, the EUT's average emissions are further modified by adding to them the worst-case duty cycle, determined by adding the EUT's total pulse widths (on time) over a 100 ms period and dividing by 100 ms.

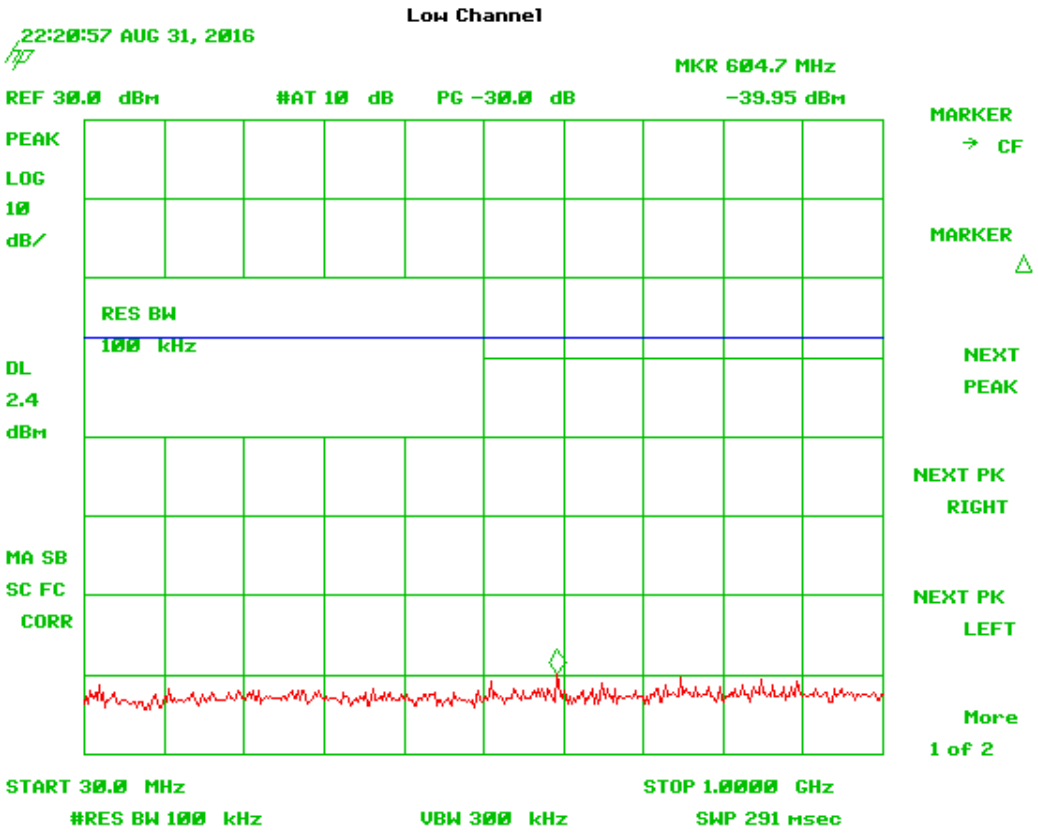


Figure 4. Antenna Conducted Spurious Emissions – Low Channel, Part 1

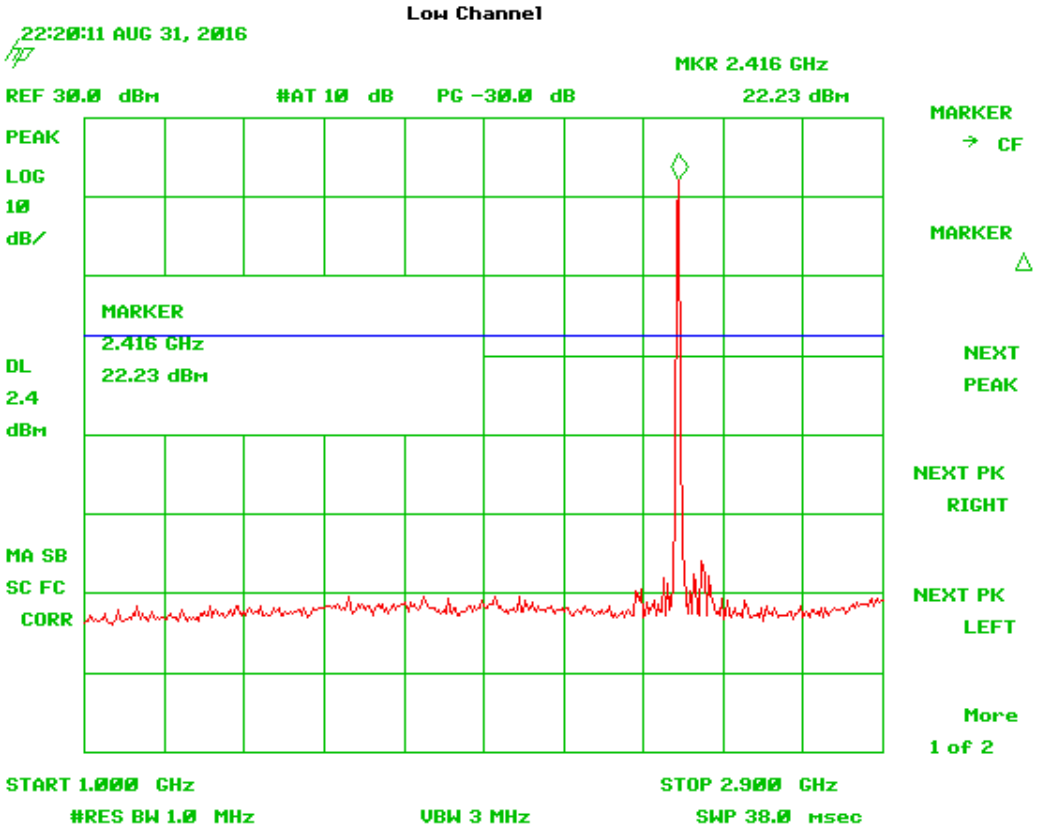


Figure 5. Antenna Conducted Spurious Emissions – Low Channel, Part 2

Note: Large Signal shown is Fundamental Frequency

Magnitude of Fundamental Frequency is less than 30 dBm.

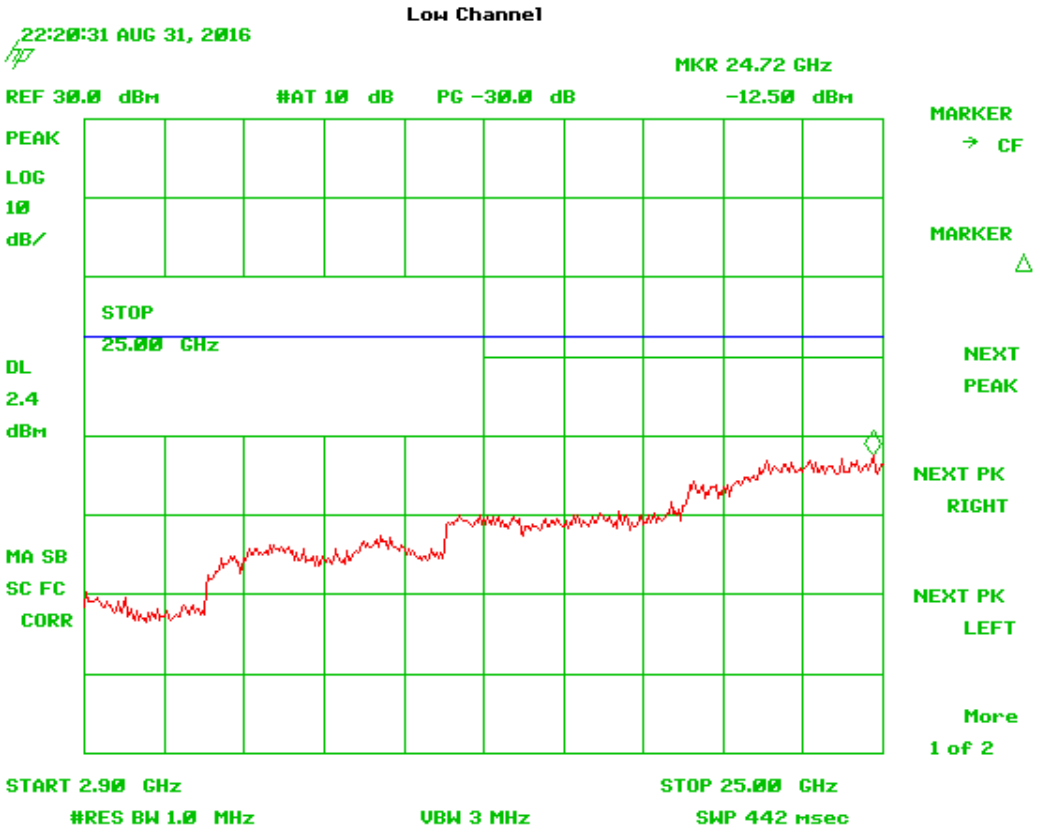


Figure 6. Antenna Conducted Spurious Emissions – Low Channel, Part 3

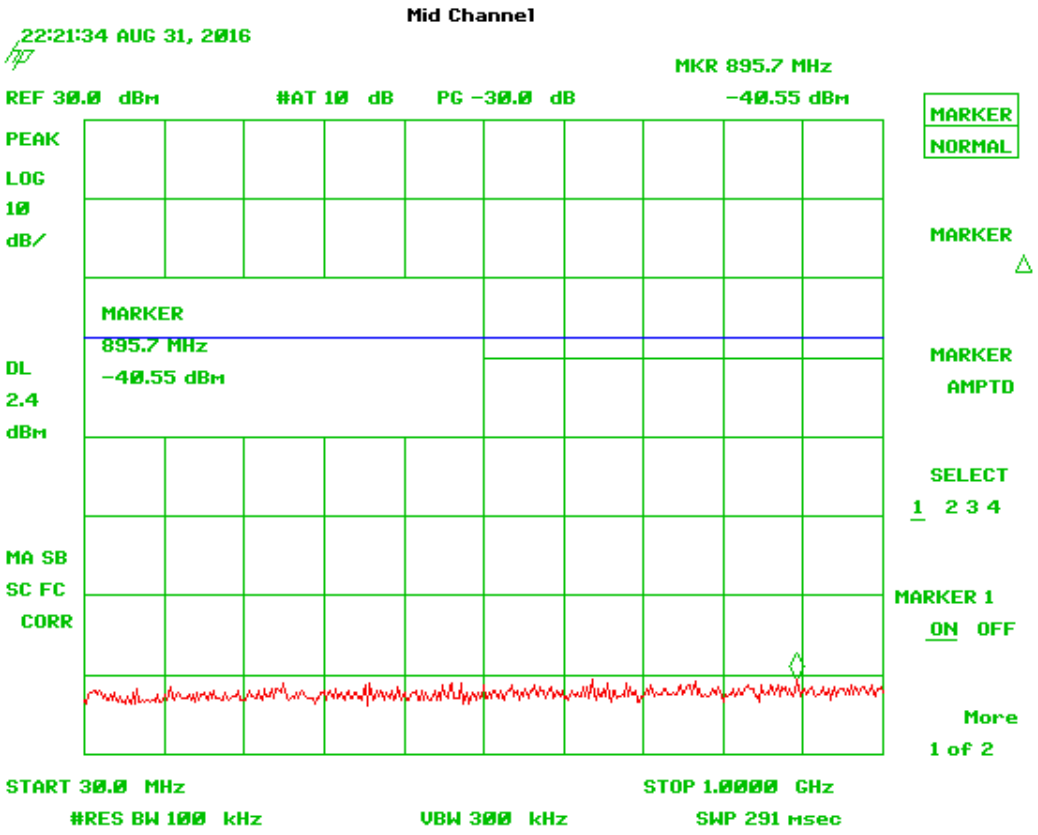


Figure 7. Antenna Conducted Spurious Emissions – Mid Channel, Part 1

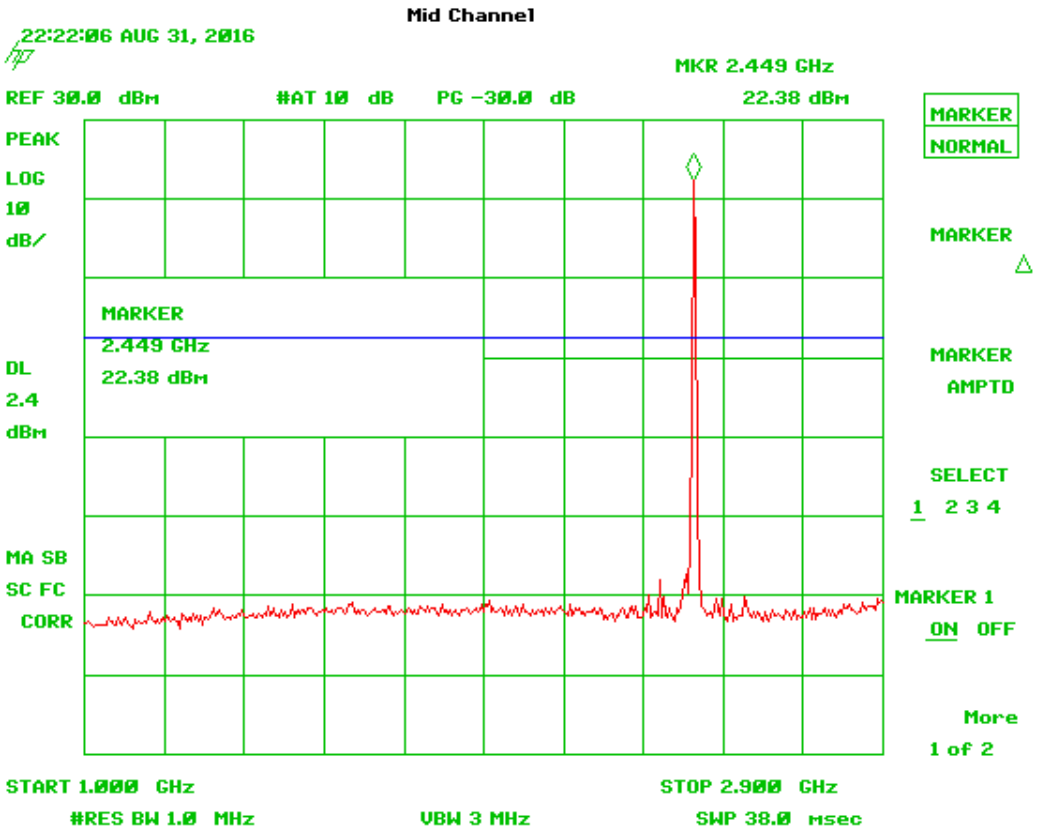


Figure 8. Antenna Conducted Spurious Emissions – Mid Channel, Part 2

Note: Large Signal shown is Fundamental Frequency

Magnitude of Fundamental Frequency is less than 30 dBm.

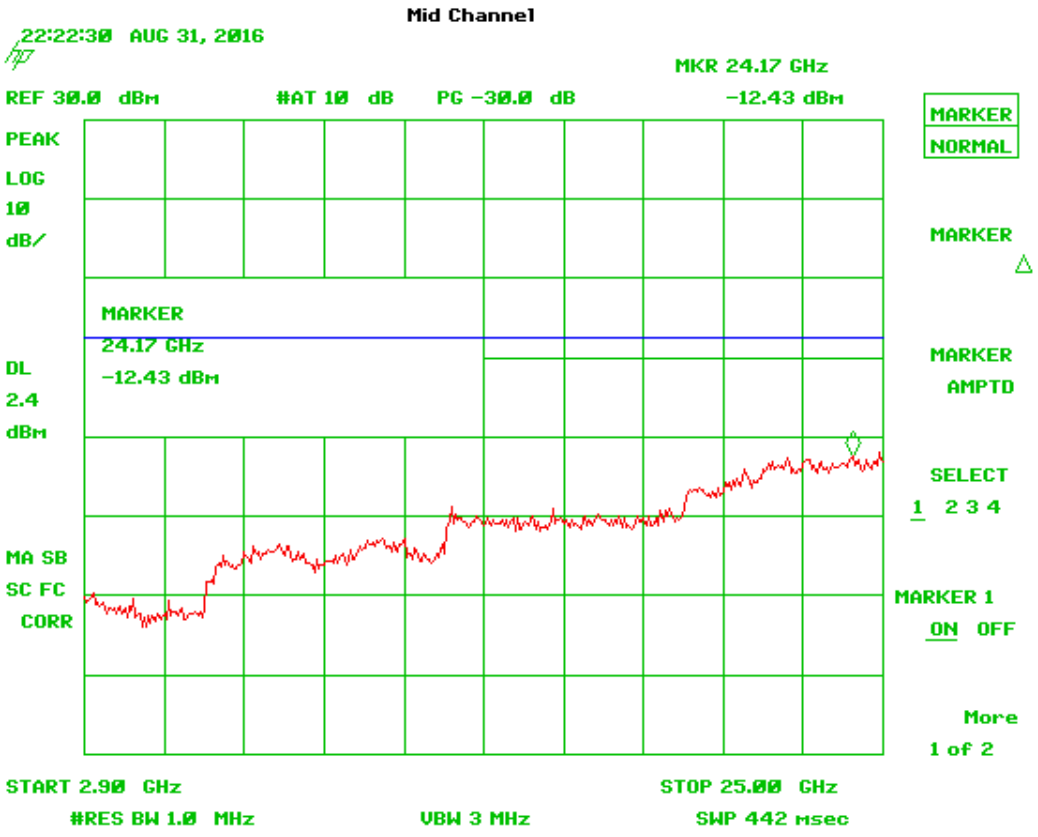


Figure 9. Antenna Conducted Spurious Emissions – Mid Channel, Part 3

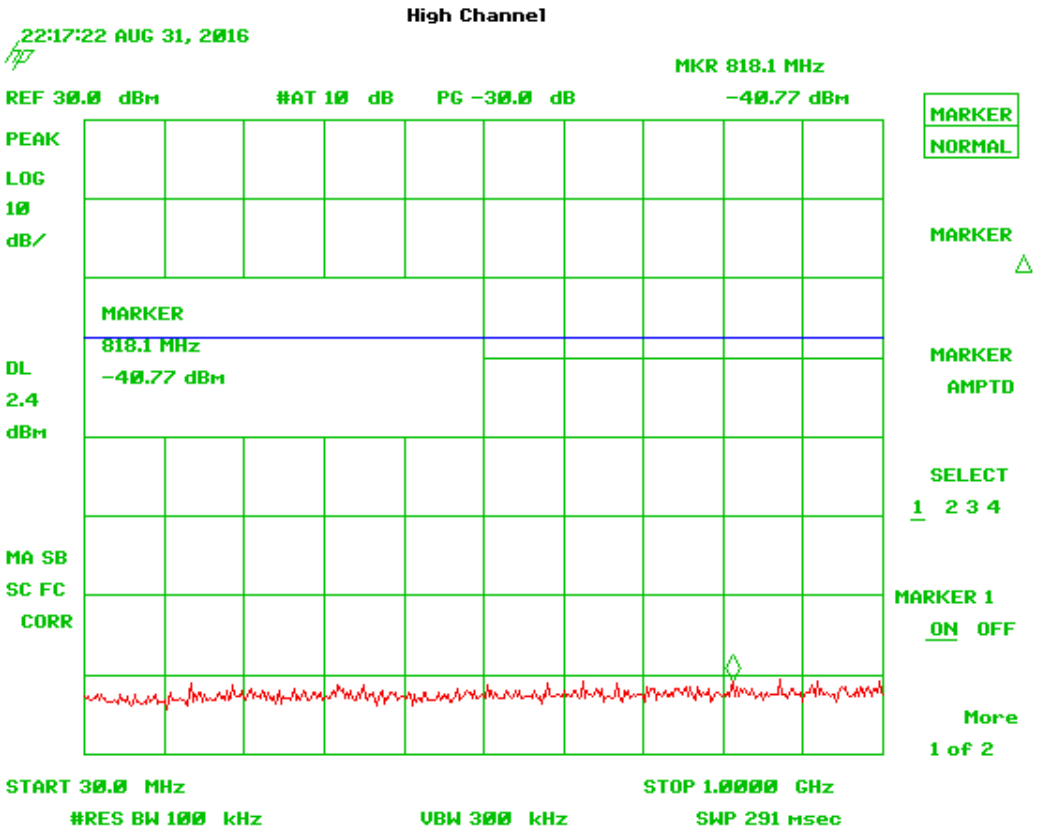


Figure 10. Antenna Conducted Spurious Emissions – High Channel, Part 1

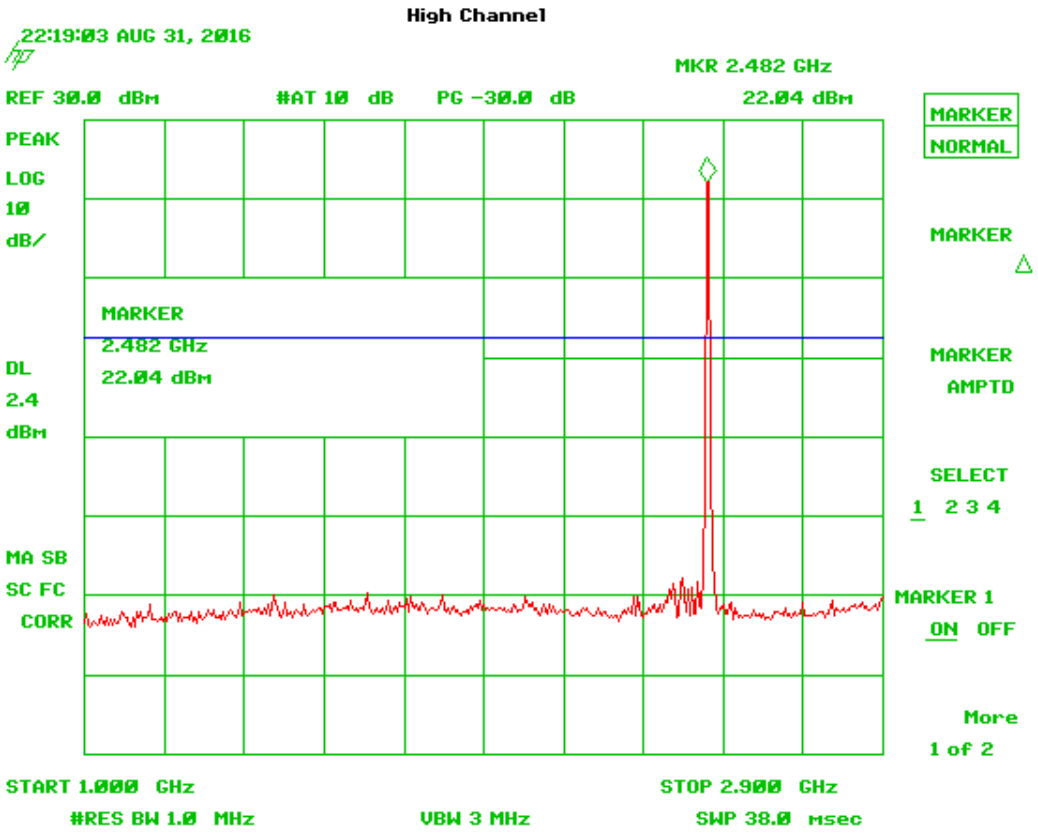


Figure 11. Antenna Conducted Spurious Emissions – High Channel, Part 2

Note: Large Signal shown is Fundamental Frequency

Magnitude of Fundamental Frequency is less than 30 dBm.

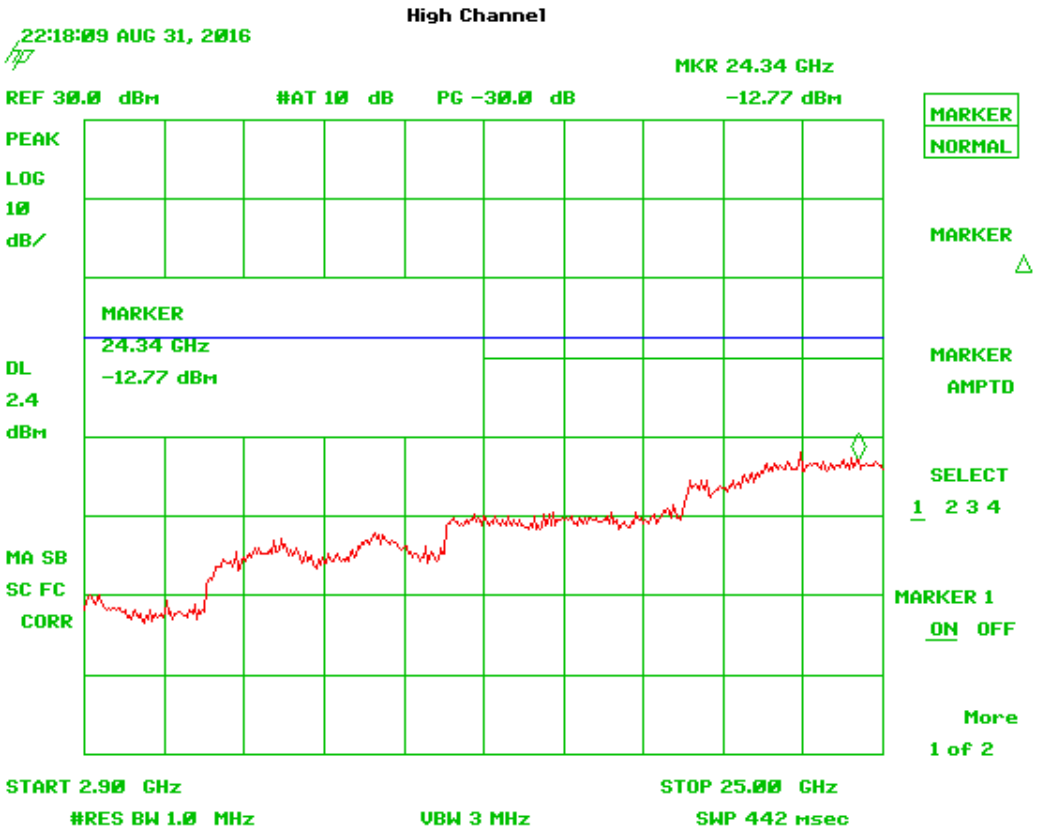


Figure 12. Antenna Conducted Spurious Emissions – High Channel, Part 3

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d))

On the test site, the EUT was mounted on top of a non-conductive table, 80 cm above the floor, by placing it in the X-Z plane along the Z axis with its bottom cover in parallel with the ground. The front of the EUT faced the measurement antenna located 3 meters away. Each signal measured was maximized by raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever changing spectrum analyzer display (with channel A in the Clear-Write mode and channel B in the Max-Hold mode) for the largest signal visible. That exact antenna height where the signal was maximized was recorded for reproducibility purposes. Also, the EUT was rotated about its Y-axis while monitoring the Spectrum Analyzer display for maximum. The EUT azimuth was recorded for reproducibility purposes. The EUT was measured when both maxima were simultaneously satisfied.

Table 5. Zigbee - Peak Radiated Fundamental & Harmonic Emissions

Tested By: RM		Test: FCC Part 15,247(d)			Client: Wink Labs, Inc.		
		Project: 16-0217			Model: Wink Hub 2		
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**
	Low Channel - PEAK						
2404.95	99.87		10.83	110.70		3M/Vert.	
4810.00	43.54	2.50	17.25	63.29*	74.0	3M/Vert.	10.7
7217.18	44.02	2.50	23.38	69.90	74.0	3M/Vert.	4.1
	Mid Channel - PEAK						
2439.95	103.10		10.80	113.90		3M/Vert.	
4880.60	42.96	2.50	17.25	62.71	74.0	3M/Vert.	11.3
7319.52	44.05	2.50	23.70	70.25*	74.0	3M/Vert.	3.8
	High Channel – PEAK						
2479.95	100.70		10.80	111.50		3M/Vert.	
4961.67	46.79	2.50	16.22	65.51	74.0	3M/Vert.	8.5
7437.47	44.51	2.50	22.97	69.98*	74.0	3M/Vert.	4.0

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 & 20 dB relaxation for peak measurements of CFR 15.35.
2. Additional factor of 2.5 dB added for using high pass filter.
3. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic

Sample Calculation at 4810.00:

Magnitude of Measured Frequency	43.54	dBuV
+Additional Factor	2.50	dB
+Antenna Factor + Cable Loss+ Amplifier Gain	17.25	dB/m
Corrected Result	63.29	dBuV/m

Test Date: August 29, 2016
Tested By
Signature: _____ Name: Robert K. Mills

Table 6. Zigbee - Average Radiated Fundamental & Harmonic Emissions

Tested By: RM		Test: FCC Part 15,247(d)			Client: Wink Labs, Inc.		
		Project: 16-0217			Model: WINK HUB 2		
Frequency (MHz)	**Test Data (dBuV)**	**Additional**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**
	Low Channel - Average						
2404.95	99.34	-20.00	10.83	90.17		3M/Vert.	
4801.00	20.29	-17.50	17.25	20.04*	54.0	3M/Vert.	34.0
7217.18	27.29	-17.50	23.38	33.37*	54.0	3M/Vert.	20.6
	Mid Channel – Average						
2439.95	102.70	-20.00	10.80	93.50		3M/Vert.	
4880.60	21.29	-17.50	16.29	20.08*	54.0	3M/Vert.	33.9
7319.52	27.57	-17.50	23.70	33.77*	54.0	3M/Vert.	20.2
	High Channel – Average						
2479.95	100.30	-20.00	10.80	91.10		3M/Vert.	
4961.67	23.48	-17.50	16.22	22.20*	54.0	3M/Vert.	31.8
7437.47	21.69	-17.50	22.97	27.16*	54.0	3M/Vert.	26.8

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209 CFR 15.35.
2. Additional factor of 2.5 dB (high pass filter) and -20.0 dB (Duty Cycle factor) applied.
3. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
4. All measurements are corrected with a -20 dB duty cycle.

Sample Calculation at 4801.00 MHz:

Magnitude of Measured Frequency	20.29	dBuV
+Additional Factor (filter + duty cycle)	-17.50	dB
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	17.25	dB/m
Corrected Result	20.04	dBuV/m

Test Date: August 29, 2016
Tested By
Signature: _____ Name: Robert K. Mills

Note: The transmitter was programmed to transmit at >98% during all testing. Therefore where applicable (when using AVG detection) the duty cycle factor calculated above was applied.

2.11 Band Edge Measurements – (CFR 15.247 (d))

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 v03r05 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Antenna port conducted measurements are performed to demonstrate compliance with the requirement of 15.247(d) that all emissions outside of the band edges be attenuated by at least 20 dB when compared to its highest in-band value (contained in a 100 kHz band). Because these frequencies occur above 1000 MHz they have both a peak and average requirement.

To capture the band edge set the Spectrum Analyzer frequency span large enough (usually around 10 MHz) to capture the peak level of the emission operating on the channel closest to the band edge as well as any modulation products falling outside of the authorized band of operation. Conducted measurements are performed with RBW ≥1% of the frequency span. In all cases, the VBW is set ≥ RBW. See figures and calculations below for more detail.

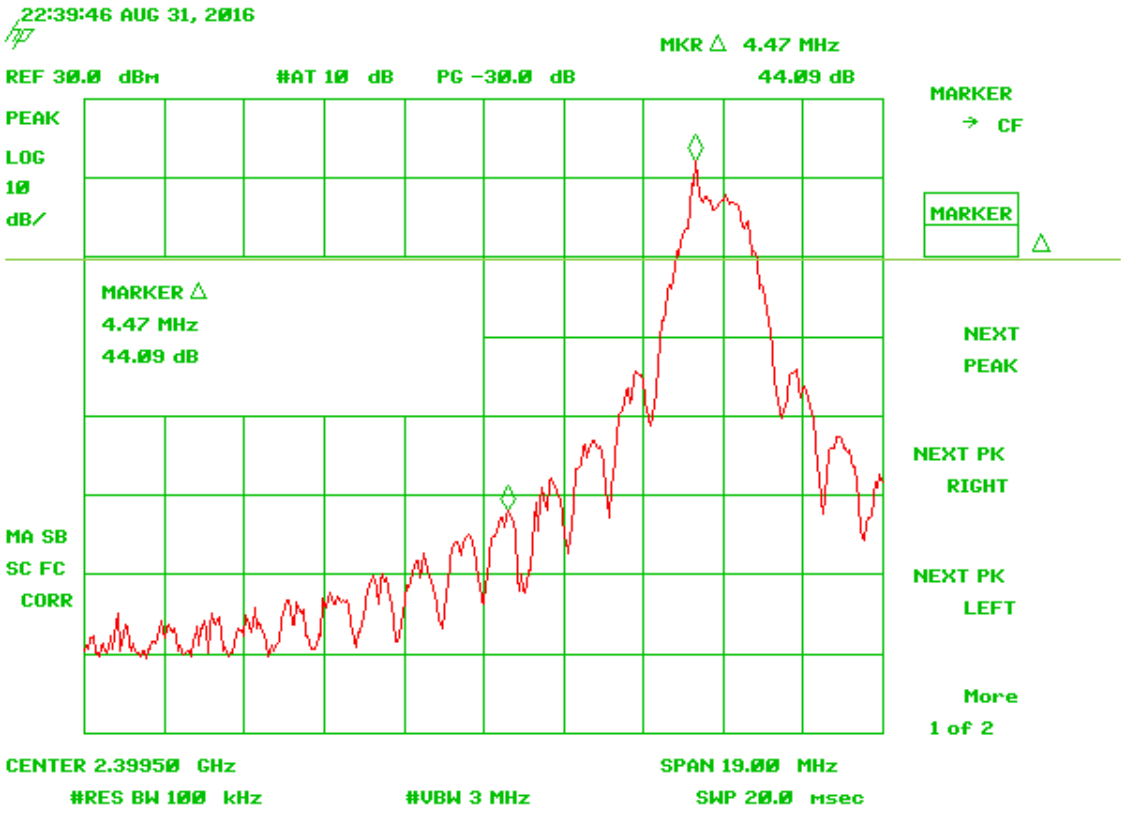


Figure 13. Band Edge Compliance – Low Channel Delta - Peak

Lower band edge must be 20 dB below the fundamental. This requirement is met.

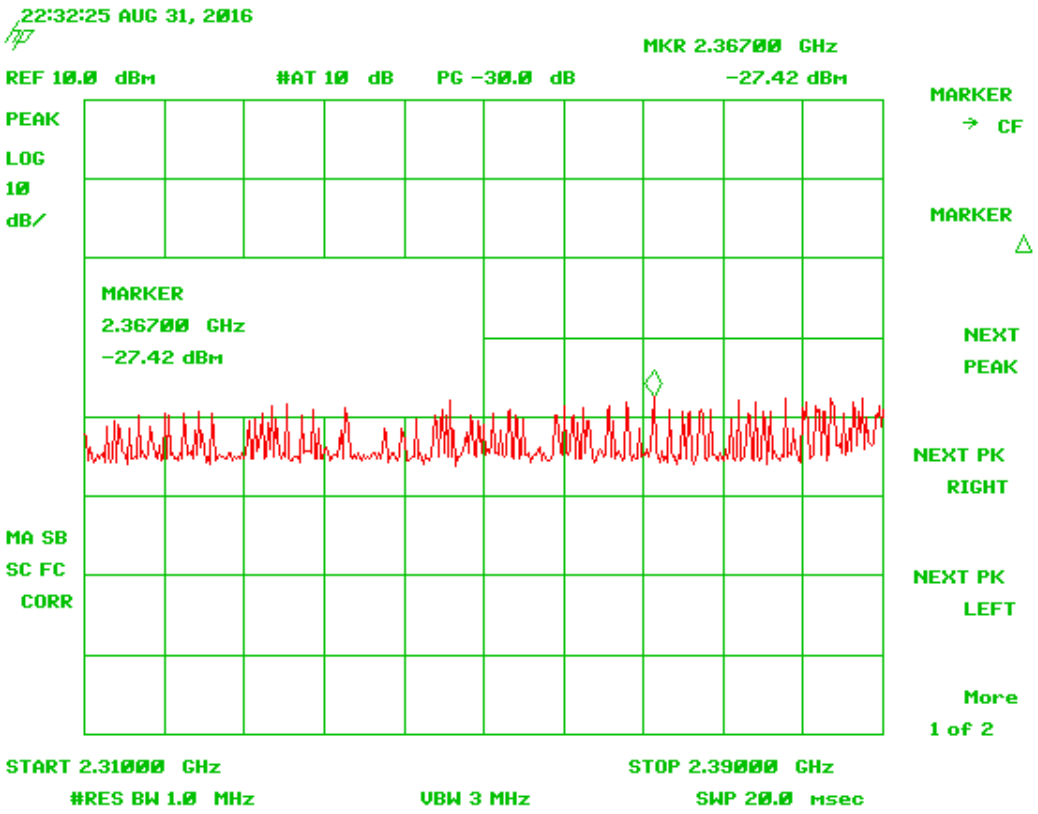


Figure 14. Low Channel Restricted Band PEAK

The restricted band plot above was performed using the conducted method per KDB 558074 v03r05, section 12.2.2.

Measured conducted output power	-27.47	dBm
Maximum transmit antenna gain	-0.00	dBi
Ground reflection factor	0.00	dB
Calculated EIRP Result	-27.47	dBm

Electric Field Conversion: E = EIRP – 20 Log D +104.8
Note: D= 3 meters
E= (-27.47) dBm – 20 Log (3) + 104.8 = -27.47 – (9.54) + 104.8 = 67.79 dBuV/m

PEAK limit	74.00	dBuV/m
Calculated Result	-67.79	dBuV/m
Margin	6.21	dB

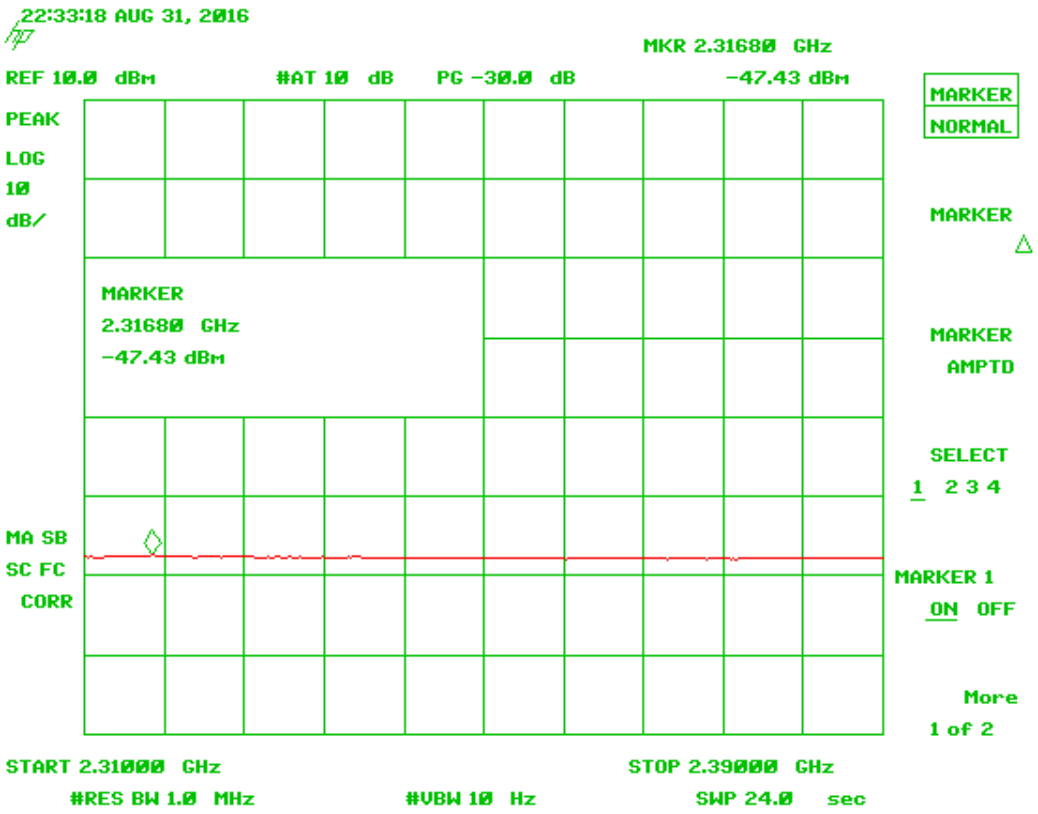


Figure 15. Low Channel Restricted Band AVG

The restricted band plot above was performed using the conducted method per KDB 558074 v03r05, section 12.2.2.

Measured conducted output power	-47.43	dBm
Maximum transmit antenna gain	-0.00	dBi
Ground reflection factor	0.00	dB
Calculated EIRP Result	-47.43	dBm

Electric Field Conversion: E = EIRP – 20 Log D +104.8
Note: D= 3 meters
E= (-47.43) dBm – 20 Log (3) + 104.8 = -47.43 – (9.54) + 104.8 = 47.83 dBuV/m

AVG limit	54.00	dBuV/m
Calculated Result	-47.83	dBuV/m
Margin	6.17	dB

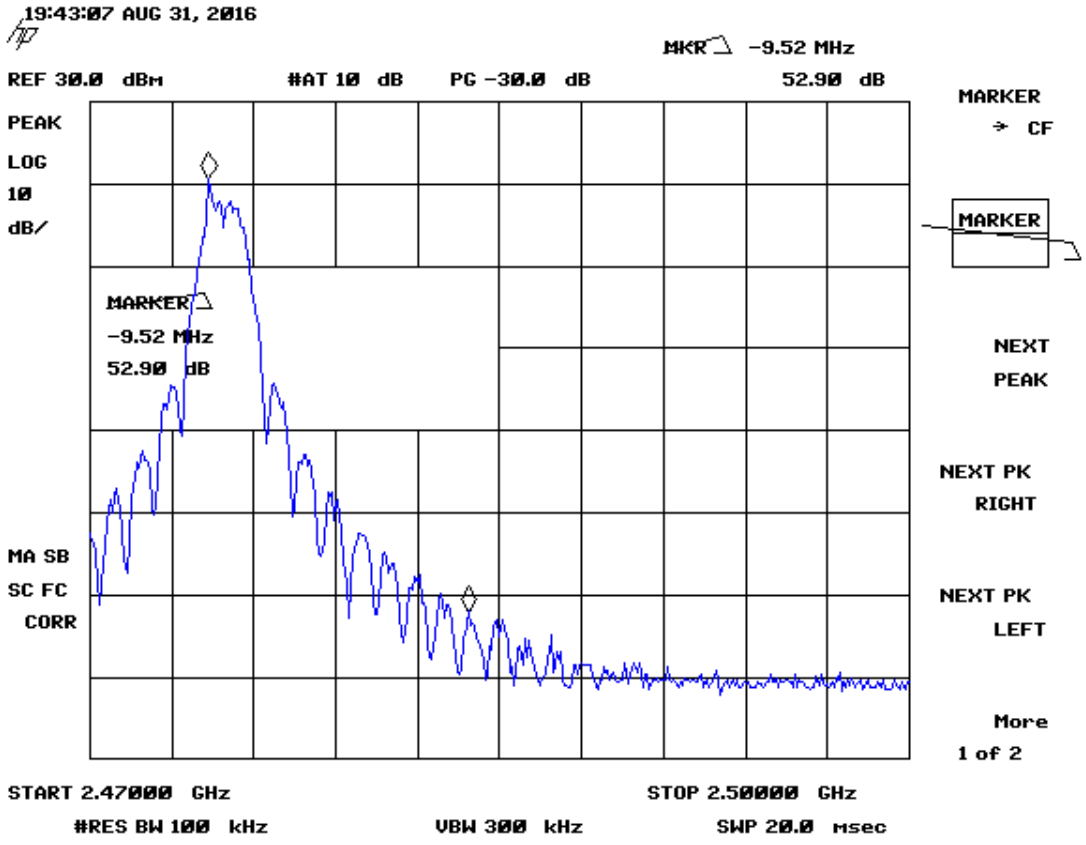


Figure 16. Band Edge Compliance – High Channel Delta - Peak

The spurious emissions for the high channel band edge fail within the restricted band. For this reason the delta method was use to show that the emissions are within the requirements. See the calculations below.

Calculation of worst case PEAK upper band edge measurement:

High Channel Corrected Measured Value from Table 5	111.50	dBuV
High Channel Band Edge Delta from Figure 16	-52.90	dB
Calculated Result	58.60	dBuV/m
PEAK limit	74.00	dBuV/m
Calculated Result	-58.60	dBuV/m
Band Edge Margin (PEAK)	15.40	dBuV/m

Calculation of worst case AVERAGE upper band edge measurement:

High Channel Corrected Measured Value from Table 6	91.10	dBuV
High Channel Band Edge Delta from Figure 16	-52.90	dB
Calculated Result	38.20	dBuV/m
AVERAGE Limit	54.00	dBuV/m
Calculated Result	-38.20	dBuV/m
Band Edge Margin (AVG)	15.80	dBuV/m

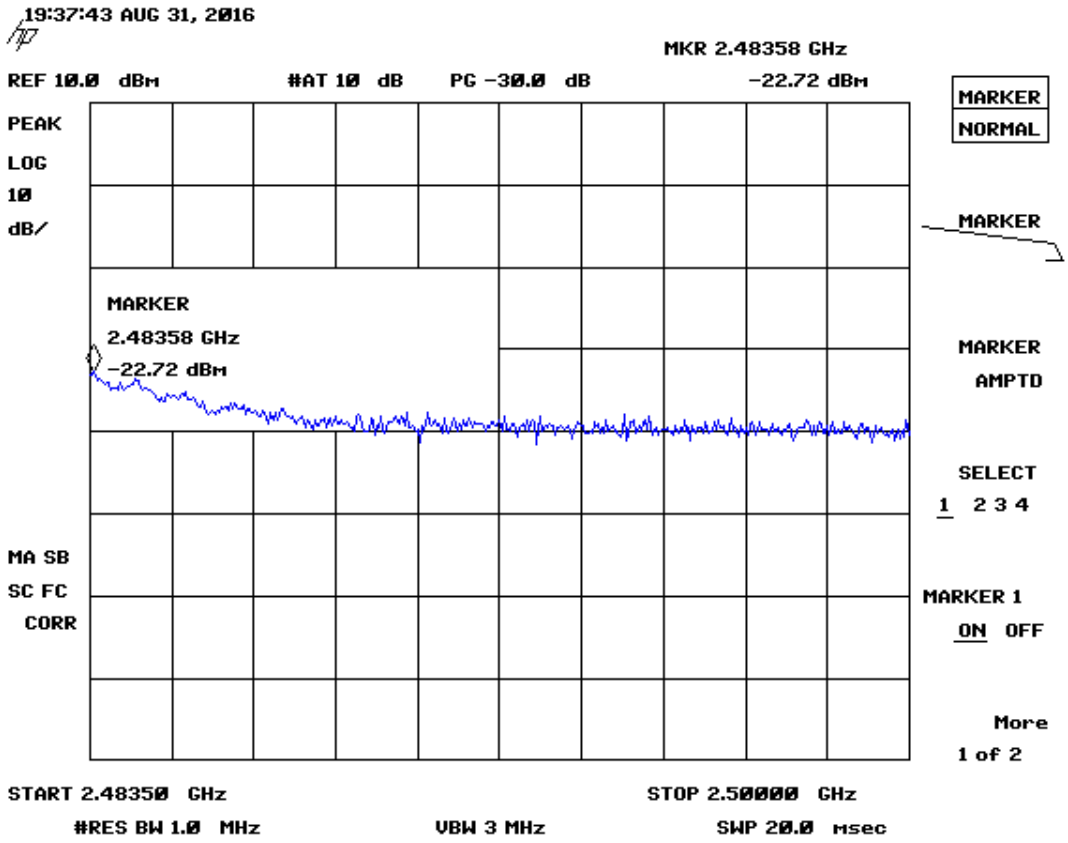


Figure 17. High Channel Restricted Band PEAK

The restricted band plot above was performed using the conducted method per KDB 558074 v03r05, section 12.2.2.

Measured conducted output power	-22.72	dBm
Maximum transmit antenna gain	-0.00	dBi
Ground reflection factor	0.00	dB
Calculated EIRP Result	-22.72	dBm

Electric Field Conversion: E = EIRP – 20 Log D +104.8
Note: D= 3 meters
E= (-22.72) dBm – 20 Log (3) + 104.8 = -22.72 – (9.54) + 104.8 = 72.54 dBuV/m

PEAK limit	74.00	dBuV/m
Calculated Result	-72.54	dBuV/m
Margin	1.46	dB

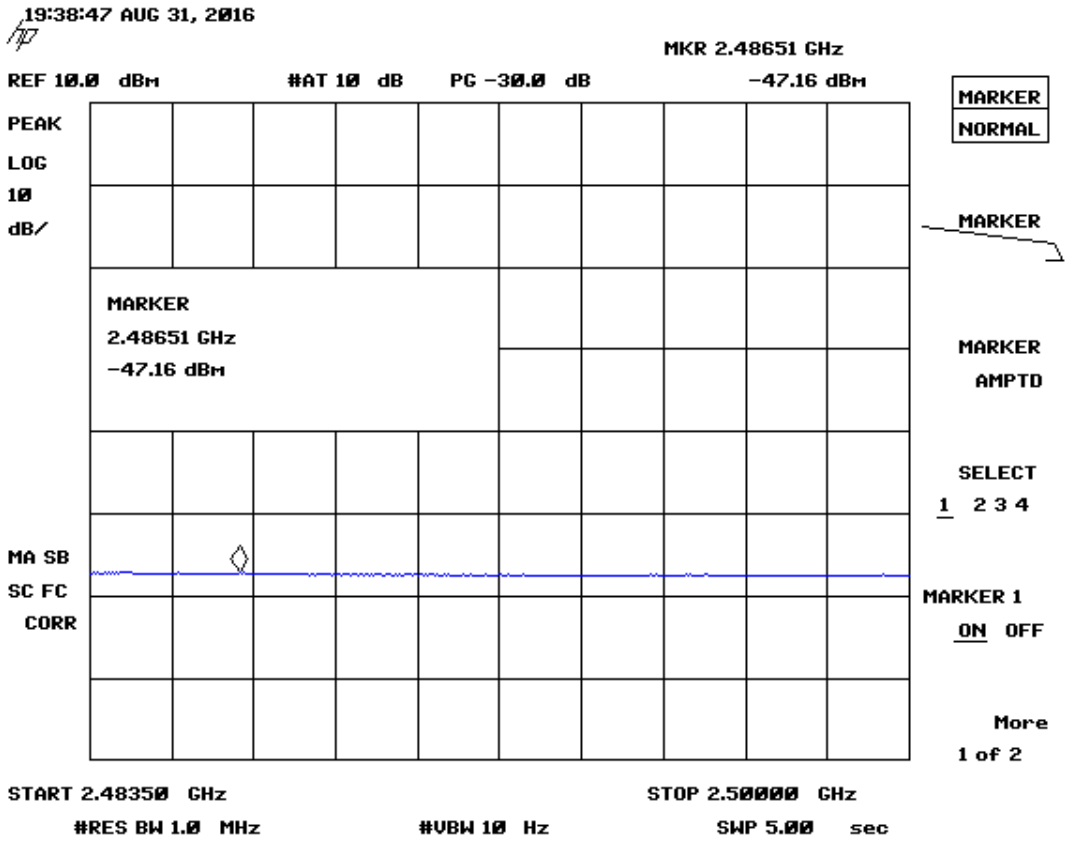


Figure 18. High Channel Restricted Band AVG

The restricted band plot above was performed using the conducted method per KDB 558074 v03r05, section 12.2.2.

Measured conducted output power	-47.16	dBm
Maximum transmit antenna gain	-0.00	dBi
Ground reflection factor	0.00	dB
Calculated EIRP Result	-47.16	dBm

Electric Field Conversion: E = EIRP – 20 Log D +104.8
Note: D= 3 meters
E= (-47.16) dBm – 20 Log (3) + 104.8 = -47.16 – (9.54) + 104.8 = 48.10 dBuV/m

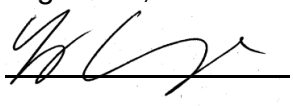
AVG limit	54.00	dBuV/m
Calculated Result	-48.10	dBuV/m
Margin	5.90	dB

2.12 Six (6) dB Bandwidth per CFR 15.247(a)(2)

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 v03r05 for a bandwidth of 6 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in the table below and figures below.

Table 7. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
2405	1.08	0.5
2440	1.10	0.5
2475	1.35	0.5

Test Date: August 30, 2016
Tested By
Signature:  Name: George Yang

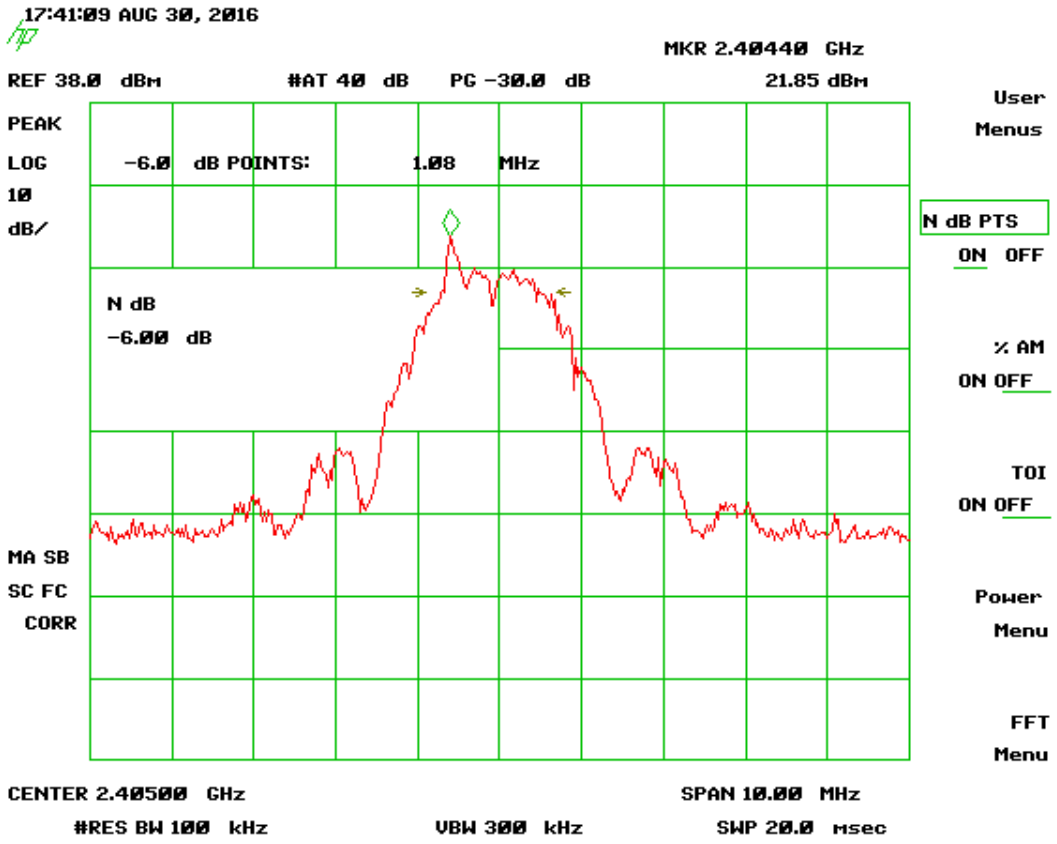


Figure 19. 6 dB Bandwidth Low Channel

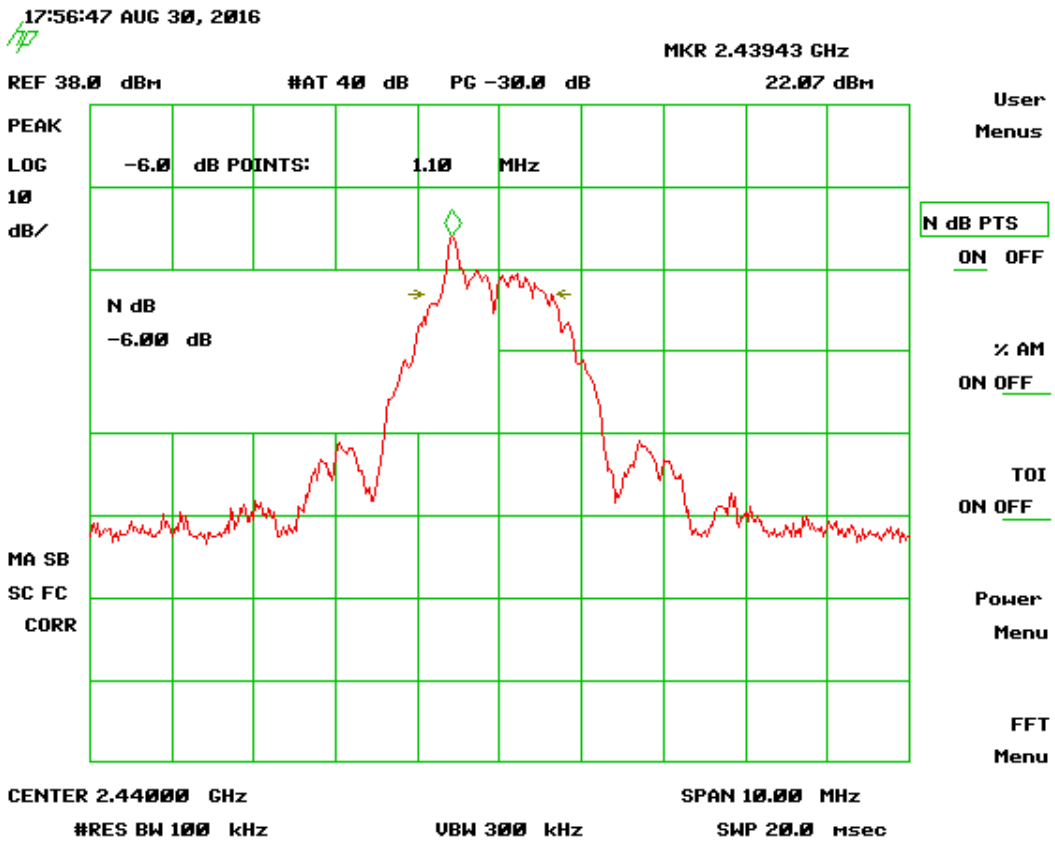


Figure 20. 6 dB Bandwidth Mid Channel

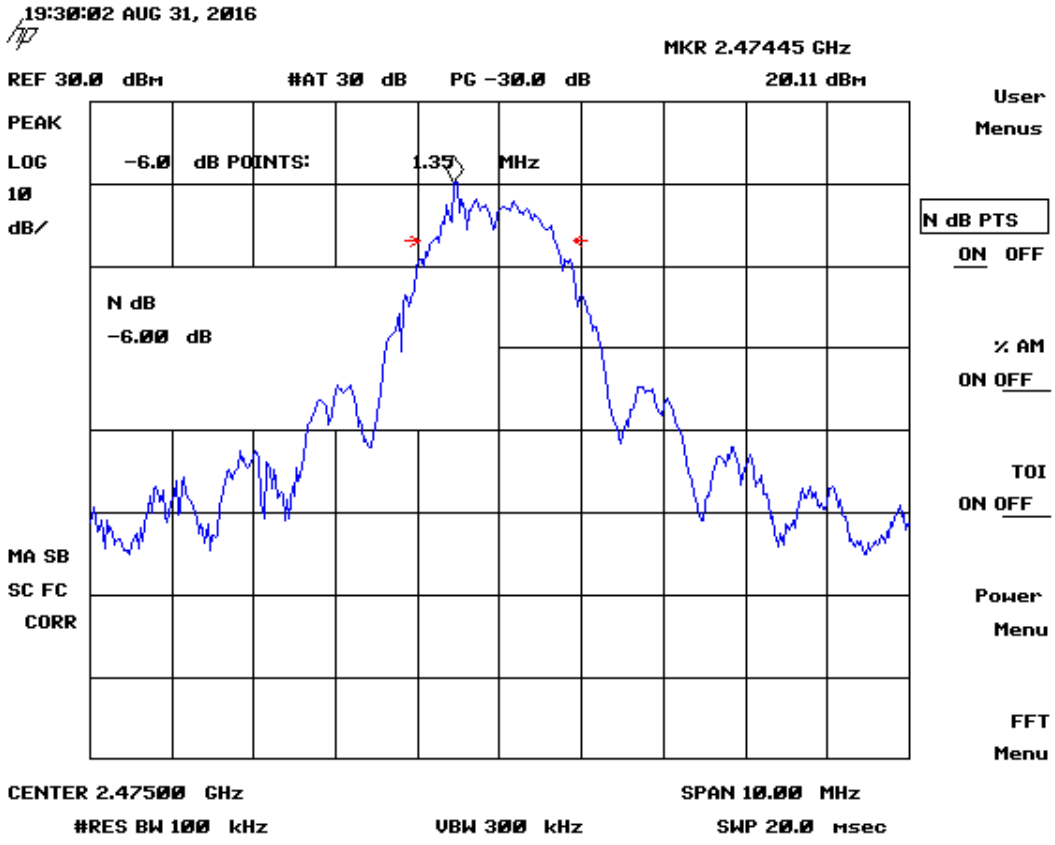


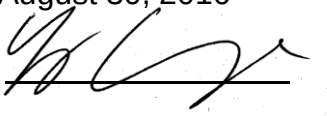
Figure 21. 6 dB Bandwidth High Channel

2.13 Occupied Bandwidth, 20 dB (99% bandwidth) (RSS-GEN (6.6))

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 v03r05 for a bandwidth of 20 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in Table 15 and Figures 29 through 31.

Table 8. 99% Occupied Bandwidth

Frequency (MHz)	20 dB (99%) Occupied Bandwidth (MHz)
2405.0	2.48
2450.0	2.53
2475.0	2.60

Test Date: August 30, 2016
Tested By
Signature:  Name: George Yang

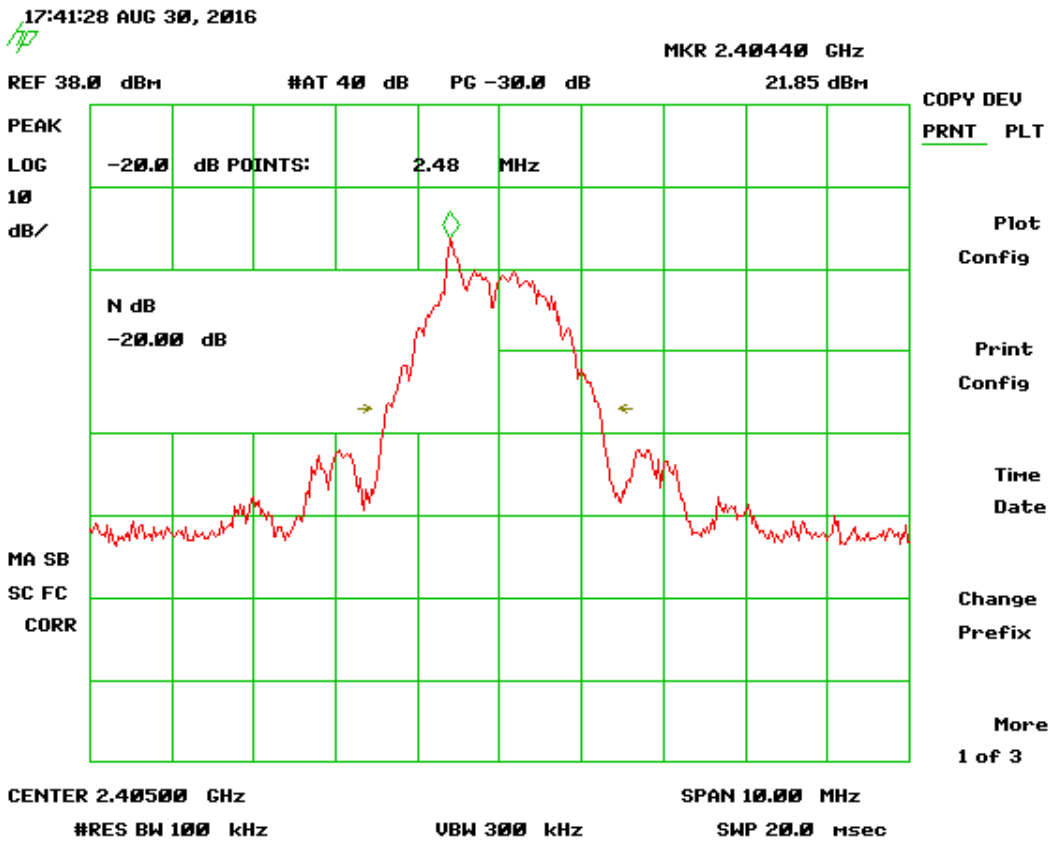


Figure 22. 20 dB Bandwidth - Low Channel

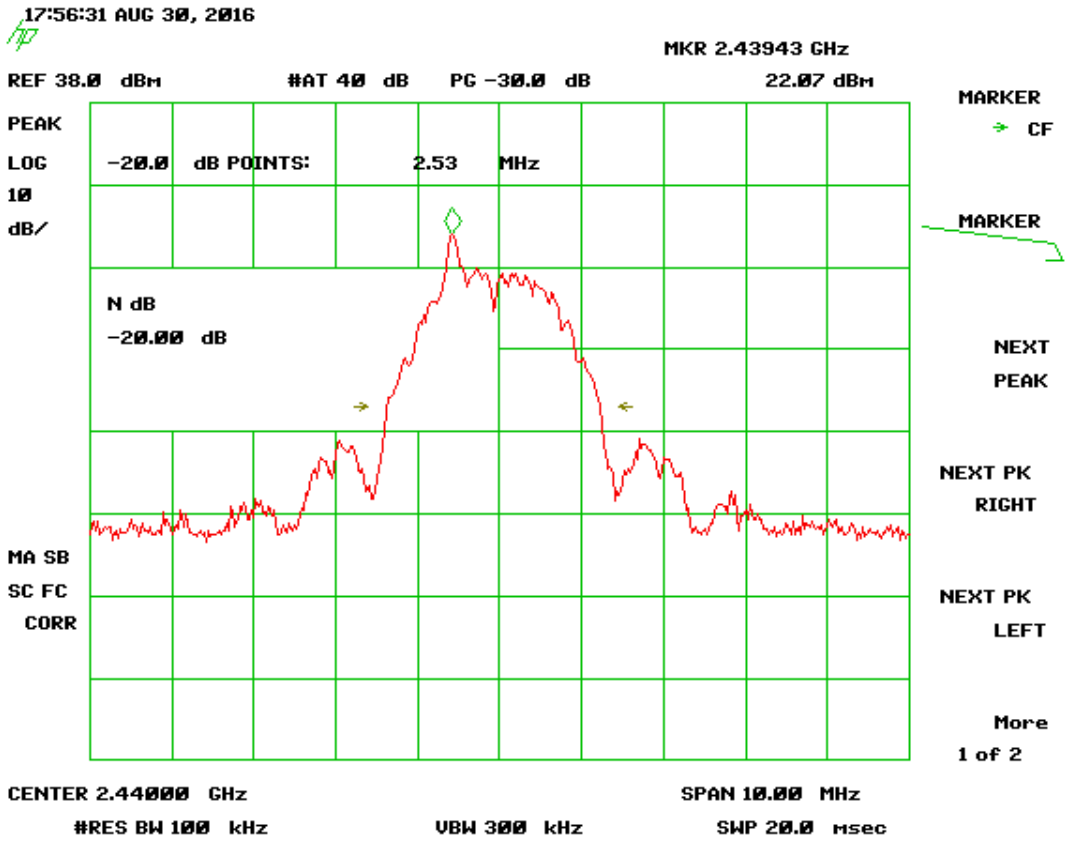


Figure 23. 20 dB Bandwidth - Mid Channel

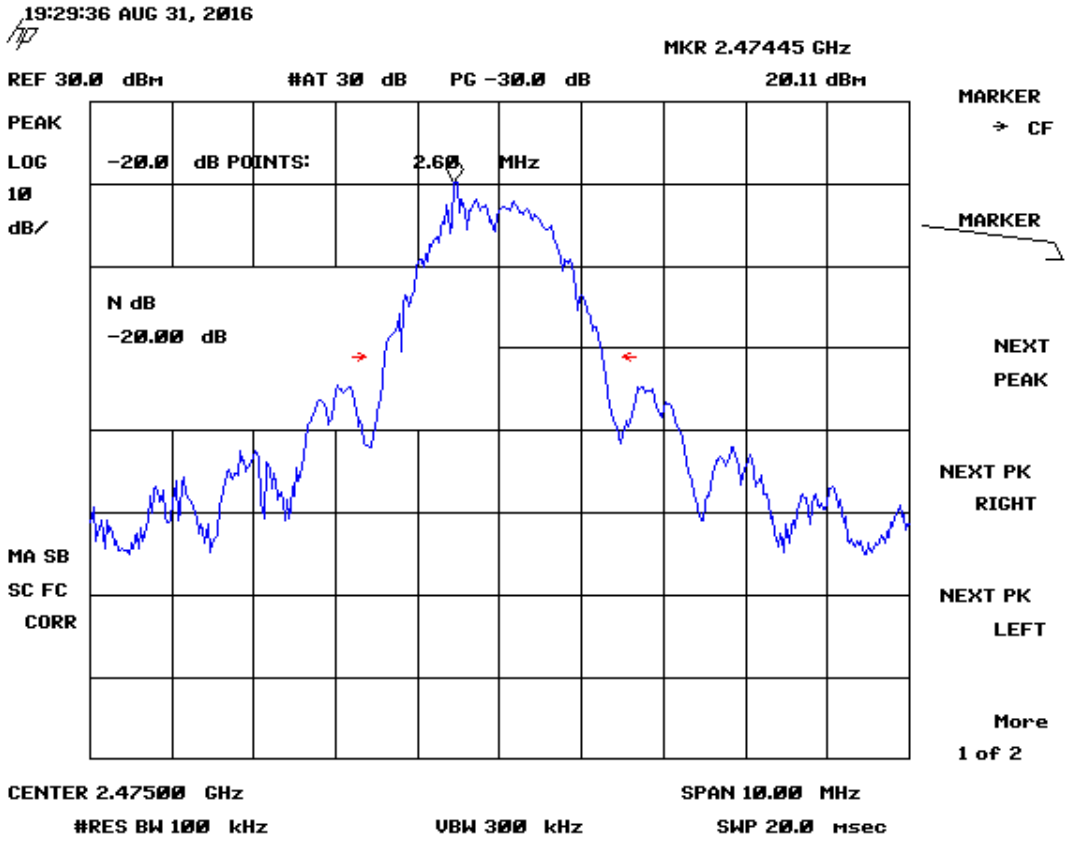


Figure 24. 20 dB Bandwidth - High Channel

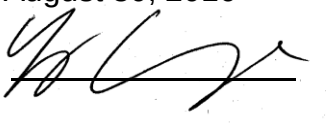
2.14 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

For the Wink Hub 2, the transmitter was programmed to operate at a maximum output power across the bandwidth. For this test the output power of the radio was set to the highest level, 0XFF.

Peak power within the band 2400 MHz to 2483.5 MHz was measured per FCC KDB Publication 558074 v03r05 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, and attenuators to the antenna output terminals on the EUT. The spectrum analyzer was set for an impedance of 50 Ω with the RBW set greater than the 6 dB bandwidth of the EUT, and the VBW ≥ RBW. Peak antenna conducted output power is tabulated in the table below.

Table 9. Peak Antenna Conducted Output Power per Part 15.247 (b)(3)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
2405	22.87	193.64	1000
2440	22.87	193.64	1000
2475	23.03	200.91	1000

Test Date: August 30, 2016
Tested By
Signature:  Name: George Yang

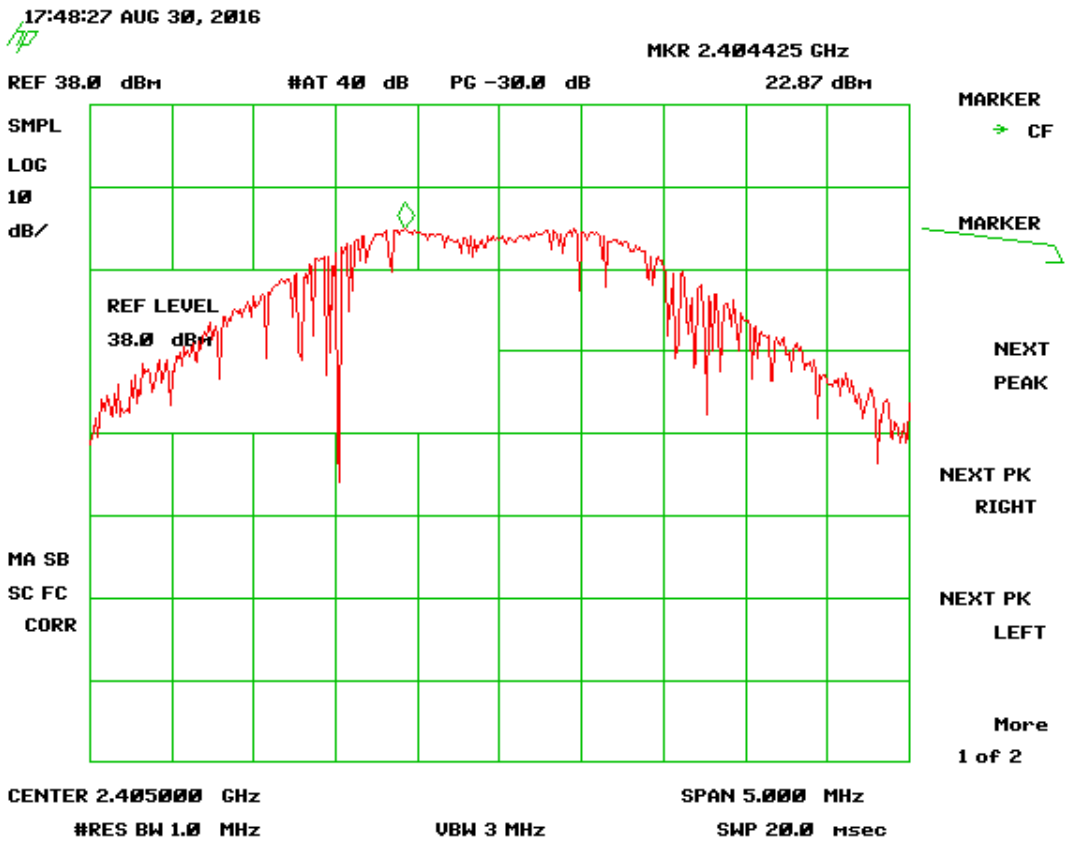


Figure 25. Peak Antenna Conducted Output Power, Low Channel

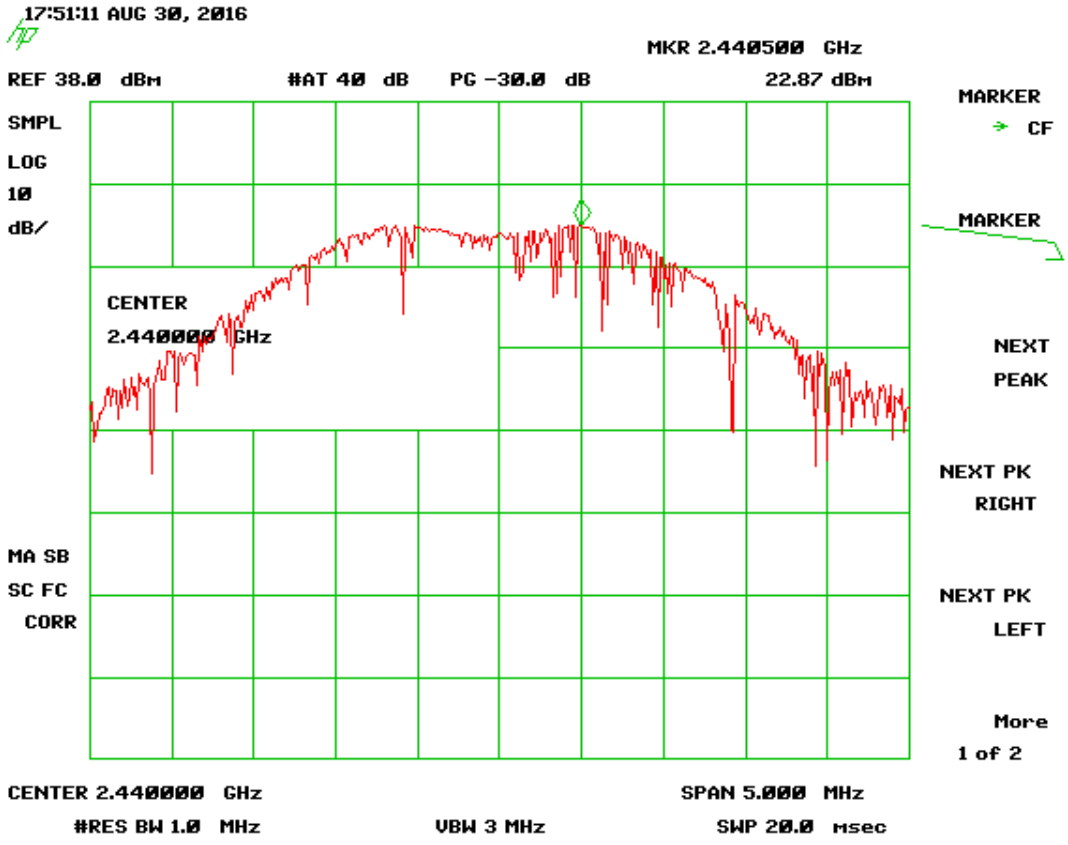


Figure 26. Peak Antenna Conducted Output Power, Mid Channel

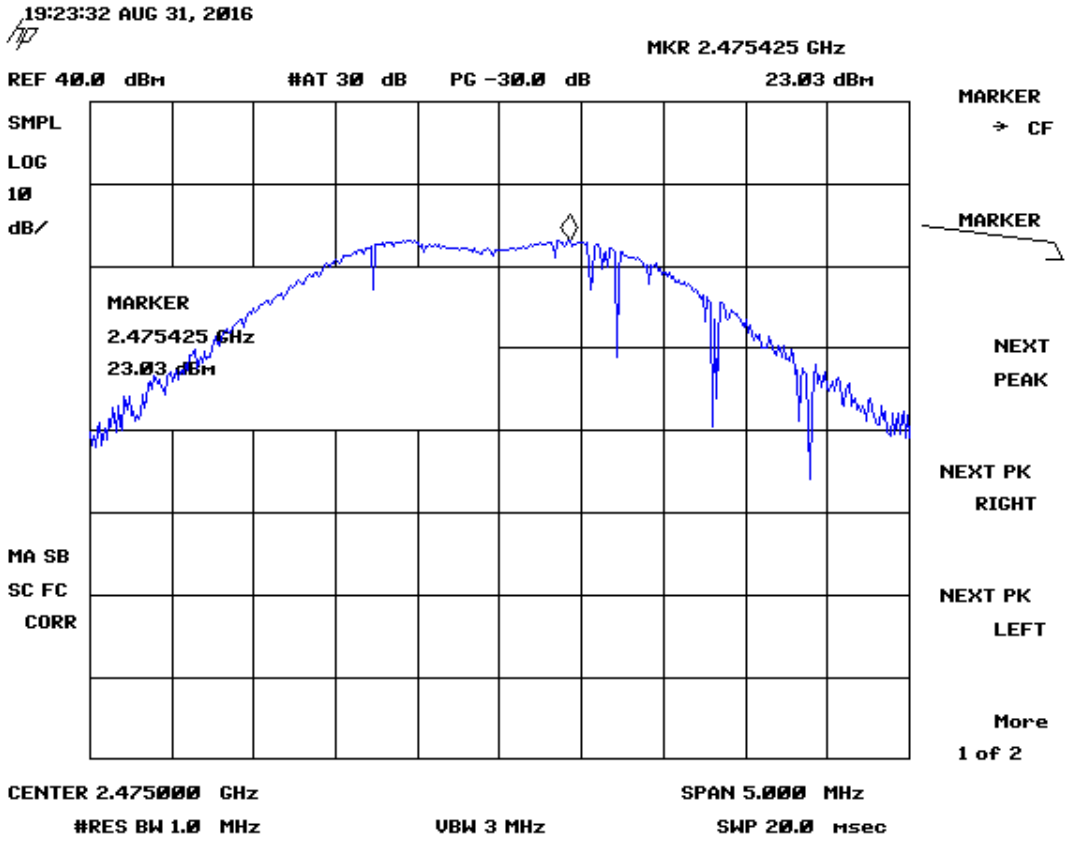


Figure 27. Peak Antenna Conducted Output Power, High Channel

2.15 Power Spectral Density (CFR 15.247(e))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of FCC KDB Procedure 558074 v03r05. The RBW was set to 3 kHz and the Video Bandwidth was set to ≥ RBW. The trace capture time was set to (Span/3 kHz).

In accordance with 15.247 (e), the power spectral density shall be no greater than +8 dBm per any 3 kHz band.

Results are shown in the table below and figures below. All are less than +8 dBm per 3 kHz band.

Table 10. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Results (dBm/3 kHz)	FCC Limit (dBm/3 kHz)
Low-2405	5.79	+8.0
Mid-2450	4.41	+8.0
High-2475	6.47	+8.0

Test Date: August 30, 2016
Tested By
Signature: Name: George Yang

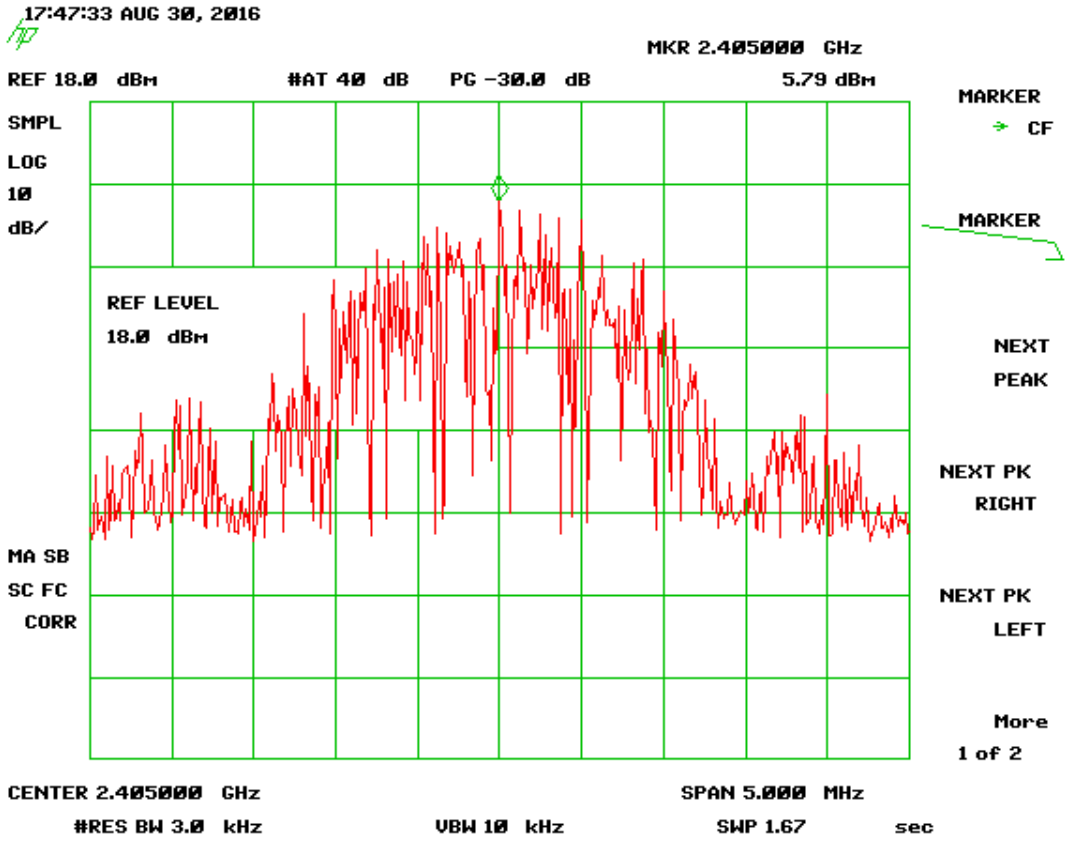


Figure 28. Peak Power Spectral Density - Part 15.247 (e) - Low Channel

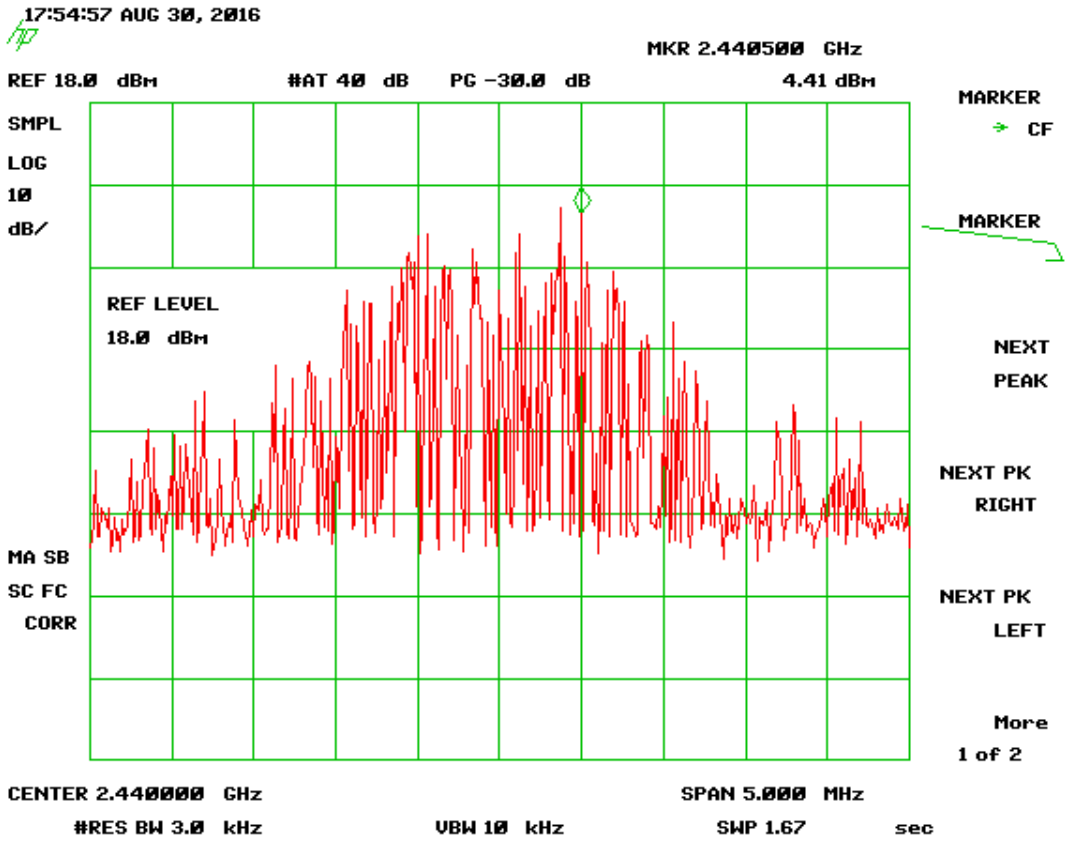


Figure 29. Power Spectral Density - Part 15.247 (e) - Mid Channel

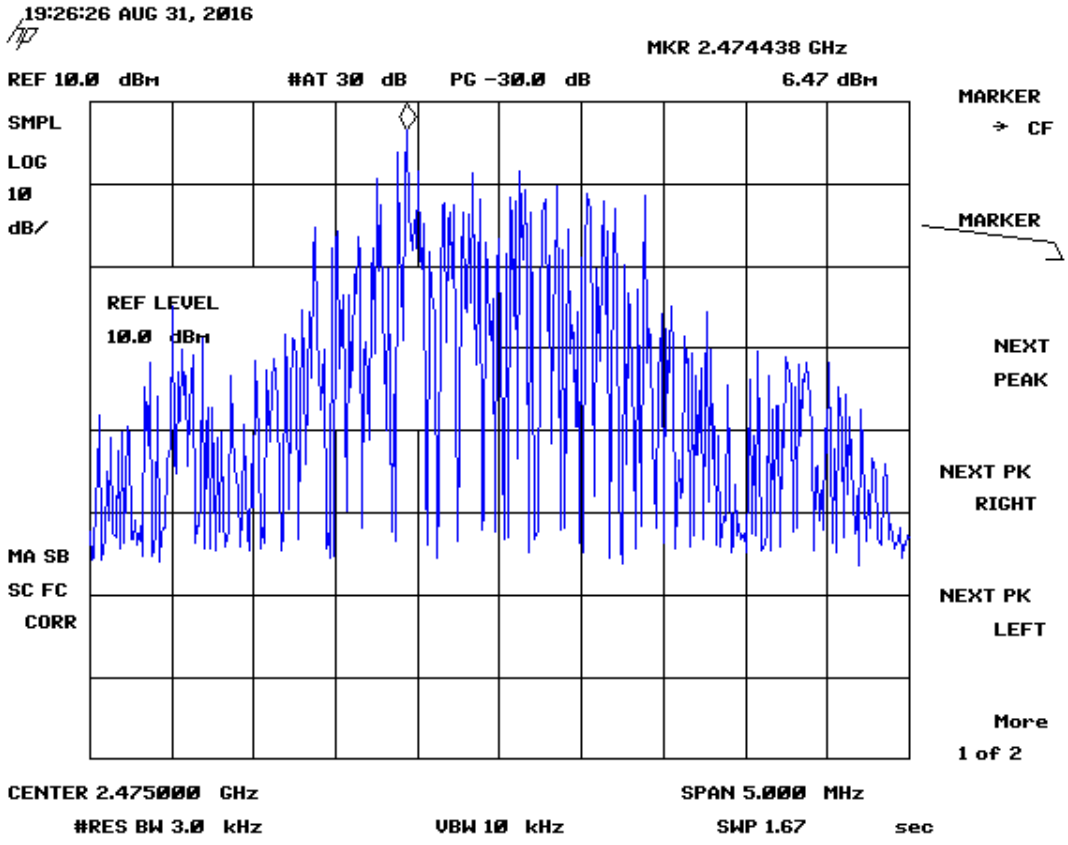


Figure 30. Peak Power Spectral Density - Part 15.247 (e) - High Channel

2.16 Unintentional Radiator and Intentional Radiator Power Lines Conducted Emissions (CFR 15.107, 15.207)

The test data provided in this section is to support the Verification requirement for the digital apparatus. The power line conducted voltage measurements for Receiver and Digital Devices have been carried out in accordance with CFR 15.107 and ANSI C63.4:2014, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into an idle condition or a continuous mode of receive (non-transmitting).

Additionally the power line conducted voltage emission measurements have been carried out in accordance with CFR 15.207, per ANSI C63.10:2013, Clause 6.2, with a spectrum analyzer connected to an LISN and the EUT placed into a continuous mode of transmission.

The transmitter evaluated in this report is considered a co-located radio because it is located less than 20 cm from all other radios on this product. The end product was therefore tested with all radios simultaneously transmitting as this was considered the worst case operation. The powerline emissions data is collected and presented below. This data is meant to show that this product has been evaluated as a product with co-located radios. Reports showing the evaluation of each of the other radios in this end product will be submitted separately.

The worst-case results for conducted emissions were determined to be produced when the EUT was operating under continuous transmission. The worst case measurement was 8.3 dB from the applicable limit. All other emissions were at least 6.4 dB from the limit. Those results are given in the table below.

NOTE: The test data provided in this section is to support the Verification and co-location requirement for the digital apparatus and the radios within.

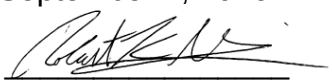
Table 11. Power Line Conducted Emissions Data, Class B (Co-location)

CONDUCTED EMISSIONS 150 kHz to 30 MHz						
Tested By: RKM	Specification Requirement: FCC Part 15.207 FCC Part 15.107 Class B		Project No.: 16-0217	Manufacturer: Wink Labs, Inc. Model: Wink Hub 2		
Frequency (MHz)	**Test Data (dBuV)**	**LISN+CL (dB)**	**Corrected Results (dBuV)**	**Avg Limits (dBuV)**	**Margin (dB)**	**Detector**
120 VAC, 60 Hz, Phase Line						
0.2999	46.80	0.35	47.15	60.2*	13.1	QP
0.2999	23.90	0.35	24.25	50.2	26.0	AVG
0.5008	37.37	0.32	37.69	46.0	8.3	PK
3.0603	26.56	0.36	26.92	46.0	19.1	PK
8.6666	27.23	0.51	27.74	50.0	22.3	PK
10.2833	25.80	0.54	26.34	50.0	23.7	PK
22.7000	21.06	0.85	21.91	50.0	28.1	PK
120 VAC, 60 Hz, Neutral Line						
0.3413	42.51	0.24	42.75	59.2*	16.4	QP
0.3413	15.20	0.24	15.44	49.2	33.7	AVG
0.5300	31.82	0.18	32.00	46.0	14.0	QP
1.0000	37.51	0.20	37.71	46.0	8.3	PK
9.7250	28.58	0.40	28.98	50.0	21.0	PK
10.2166	27.63	0.39	28.02	50.0	22.0	PK
27.1666	21.40	0.76	22.16	50.0	27.8	PK

(*)= Quasi-Peak limit used

SAMPLE CALCULATION AT 0.2999 MHz:

Magnitude of Measured Frequency	46.80	dBuV
+ Cable Loss+ LISN Loss	0.35	dB
Corrected Result	47.15	dBuV

Test Date: September 1, 2016
Tested By
Signature:  Name: Robert K. Mills

2.17 Unintentional Radiator and Intentional Radiator, Radiated Emissions (CFR 15.109 and 15.209)

The test data provided herein is to support the verification requirement for digital devices. Radiated emissions coming from the EUT in a non-transmit state per 15.109 were evaluated from 30 MHz to 12.5 GHz as well as radiated emissions coming for the EUT in a transmitting state per 15.209 and were investigated from 9 kHz or the lowest operating clock frequency to 25 GHz and tested as detailed in ANSI C63.10:2013, Clause 6.4-6.6. Data is presented in Table 12. The data presented is with the EUT and all transmitters ON and transmitting. This is intended to satisfy the requirements for co-location transmitter testing.

Radiated emissions within the band of 9 kHz to 30 MHz were investigated using a calibrated Loop Antenna and per the requirements of ANSI C63.10:2013.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure.

The transmitter evaluated in this report is considered a co-located radio because it is located less than 20 cm from all other radios on this product. The end product was therefore tested with all radios simultaneously transmitting as this was considered the worst case operation. The radiated emissions data is collected and presented below. This data is meant to show that this product has been evaluated as a product with co-located radios. Reports showing the evaluation of each of the other radios in this end product will be submitted separately.

The worst-case radiated emission was 6.9 dB below the specification limit at 625.10 Mhz. All other measured signals were at least 9.4 dB below the specification limit. The results are shown in the table below. These results are meant to show that this EUT's digital device portion has met the verification requirements for an unintentional radiator under CFR Part 15.109 as well as the intentional transmitter requirements of CFR Part 15.209.

NOTE: The test data provided in this section is to support the verification and co-location requirement for the digital apparatus and the radios within.

Table 12. Spurious Radiated Emissions (150 KHz-30MHz)

Test By: RKM	Test: FCC Part 15.109/15.209			Client: Wink Labs, Inc.			
	Project: 16-0217 Class B			Model: Wink Hub 2			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
All emissions were at least 20 dB from the applicable limit.							

No other emissions detected other than those presented in this table and the tables in section 2.10 above.
AF is antenna factor. CL is cable loss. PA is preamplifier gain.

SAMPLE CALCULATION: N/A

Test Date: September 1, 2016

Tested By Signature:  Name: Robert K. Mills

Table 13. Spurious Radiated Emissions (30 MHz – 1 GHz) (Co-location)

Test By: RKM		Test: FCC Part 15.109/15.209			Client: Wink Labs, Inc.			
		Project: 16-0217 Class B			Model: Wink Hub 2			
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factors**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
	Tested from 30 MHz to 1 GHz, Quasi Peak Limits							
77.87	39.15	0.0	-13.34	25.81	40.0	3m./HORZ	14.2	**PK**
92.30	41.34	0.0	-12.94	28.40	43.5	3m./HORZ	15.1	**PK**
189.25	41.89	0.0	-7.76	34.13	43.5	3m./HORZ	9.4	**PK**
49.38	38.78	0.0	-12.25	26.53	40.0	3m./VERT	13.5	**QP**
81.50	46.70	0.0	-13.41	33.29	40.0	3m./VERT	6.7	**PK**
108.75	42.40	0.0	-11.06	31.34	43.5	3m./VERT	12.2	**PK**
250.30	49.29	0.0	-12.84	36.45	46.0	3m./HORZ	9.5	**PK**
450.80	39.11	0.0	-7.22	31.89	46.0	3m./HORZ	14.1	**PK**
625.10	42.63	0.0	-3.48	39.15	46.0	3m./HORZ	6.9	**PK**
All other emissions were greater than 20 dB from the applicable limit.								

AF is antenna factor. CL is cable loss. PA is preamplifier gain.

SAMPLE CALCULATION AT 77.87 MHz:

Magnitude of Measured Frequency	39.15	dBuV
Additional Factor	0.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain	-13.34	dB
Corrected Result	25.81	dBuV/m

Test Date: September 1, 2016

Tested By Signature:  Name: Robert K. Mills

Table 14. Spurious Radiated Emissions (1 GHz – 25 GHz) (Co-location)

Test By: RKM		Test: FCC Part 15.109/15.209			Client: Wink Labs, Inc.			
		Project: 16-0217 Class B			Model: Wink Hub 2			
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factors**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
All emissions were at least 20 dB from the applicable limit.								

No other emissions detected other than those presented in this table and the tables in section 2.10 above.
AF is antenna factor. CL is cable loss. PA is preamplifier gain.

SAMPLE CALCULATION: N/A

Test Date: September 1, 2016

Tested By Signature:  Name: Robert K. Mills

2.18 Measurement Uncertainty

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

2.18.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ±2.8 dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty, therefore, the EUT unconditionally passes this requirement.

2.18.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ±5.3 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ±5.1 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ±5.1 dB.

The data listed in this test report does have sufficient margin to negate the effects of uncertainty, therefore, the EUT unconditionally passes this requirement.