Testing Tomorrow's Technology

Application

For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart E, paragraphs 15.401, 15.403, 15.405 and 15.407

And

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

For the

Wink Labs, Inc.

Model: WINK HUB 2

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

UST Project: 16-0219
Issue Date: September 8, 2016

Total Pages in This Report: 71

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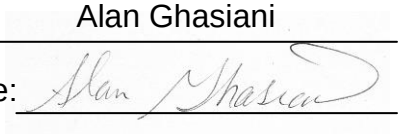
Testing Tomorrow's Technology

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 8, 2016

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Wink Labs, Inc.

MODEL: Wink Hub 2

FCC ID: 2ACAJ-WHUB2

IC: 11938A-WHUB2

DATE: September 8, 2016

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

Equipment type: 5.18-5.24 GHz and 5.745- 5.825 GHz Transmitter

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 the FCC Rules and Regulations Part 15, Section 407 and IC RSS 247 Issue 1.

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 908.42 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.

Measured maximum output: 16.0 dBm
Antenna Gain: -2.3 dBi
Modulation: 20 MHz bandwidth modulation at up to 54 Mbps

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* and *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for FCC subpart A Digital equipment Verification requirements and per FCC KDB Publication number 789033 D02 v01r03 for Digital Transmission Systems Operating Under section 15.407.

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 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 Submittals

The EUT is subject to the following FCC authorizations:

a) Certification under section 15.247 as a transmitter.
b) Verification under 15.101 as a digital device and receiver.
c) Certification under section 15.249 as a transmitter.
d) Certification under section 15.231 as a transmitter.
e) Certification under section 15.407 as a transmitter.

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	S012BEU1200100	None	None	1.5 m U P
Router	Various	Various	Various	1.5 m U P
Antenna See antenna details	--	--	--	--

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

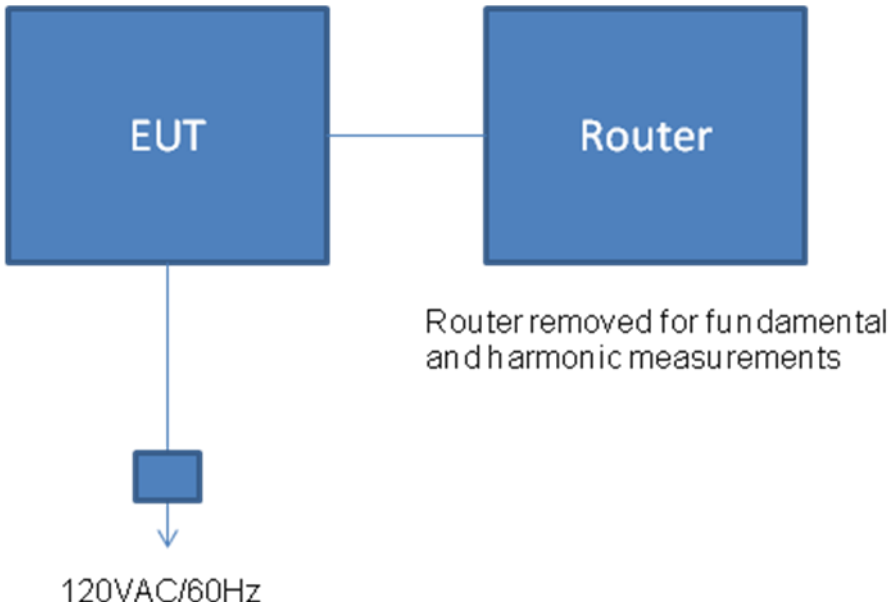


Figure 1. Block Diagram of Test Configuration

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 indicated.

Table 2. Test Instruments

TEST INSTRUMENT	MODEL NUMBER	MANUFACTURER	SERIAL NUMBER	DATE OF LAST CALIBRATION
SPECTRUM ANALYZER	8593E	HEWLETT-PACKARD	3325A00807	8/5/2016
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2747A05665	5/7/2015 Extended 120 days
SPECTRUM ANALYZER	E4407B	AGILENT	US41442935	2/11/2016
LOOP ANTENNA	SAS-200/562	A.H. Systems	142	9/28/2015 2 yr.
BICONICAL ANTENNA	3110B	EMCO	9306-1708	11/24/2014 2 yr.
BICONICAL ANTENNA	3110B	EMCO	9307-1431	8/25/2015 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9110-3236	11/19/2014 2 yr.
LOG PERIODIC ANTENNA	3146	EMCO	9305-3600	7/1/2014 2 yr. Extended 90 days
HORN ANTENNA	SAS-571	A.H. Systems	605	8/25/2015 2 yr.
HORN ANTENNA	3116	EMCO	9505-2255	1/27/2015 2 yr.
AMPLIFIER	11975A	HEWLETT-PACKARD	2517A00647	12/05/2014 2 yr.
HARMONIC MIXER	11970K	HEWLETT-PACKARD	2332A01241	Not Required
PRE-AMPLIFIER	8449B	HEWLETT-PACKARD	3008A00480	12/1/2015

PRE-AMPLIFIER	8447D	HEWLETT-PACKARD	1937A02980	12/2/2015
LISN x 2	8028-50-TS24-BNC	SOLAR ELECTRONICS	910494 & 910495	11/20/2015
Environmental Chamber	SM16/DR4 500A	Thermotron/ Honeywell	17095	8/6/2015 2 yr.

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 15.407 or IC RSS-247 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 below.

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

The EUT operates in UNII Band 1 and UNII Band 3. For each band two channels were evaluated. The channels evaluated are 36, 48, 149, and 165.

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 5 times the highest internal clock frequency.

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 be expressed logarithmically in dB.

NOTE: If the transmitter was programmed to transmit at >98% duty cycle, then, wherever applicable (where the detection mode was AVG) the duty cycle factor calculated will be applied.

2.6 Transmitter Duty Cycle (CFR 35 (c))

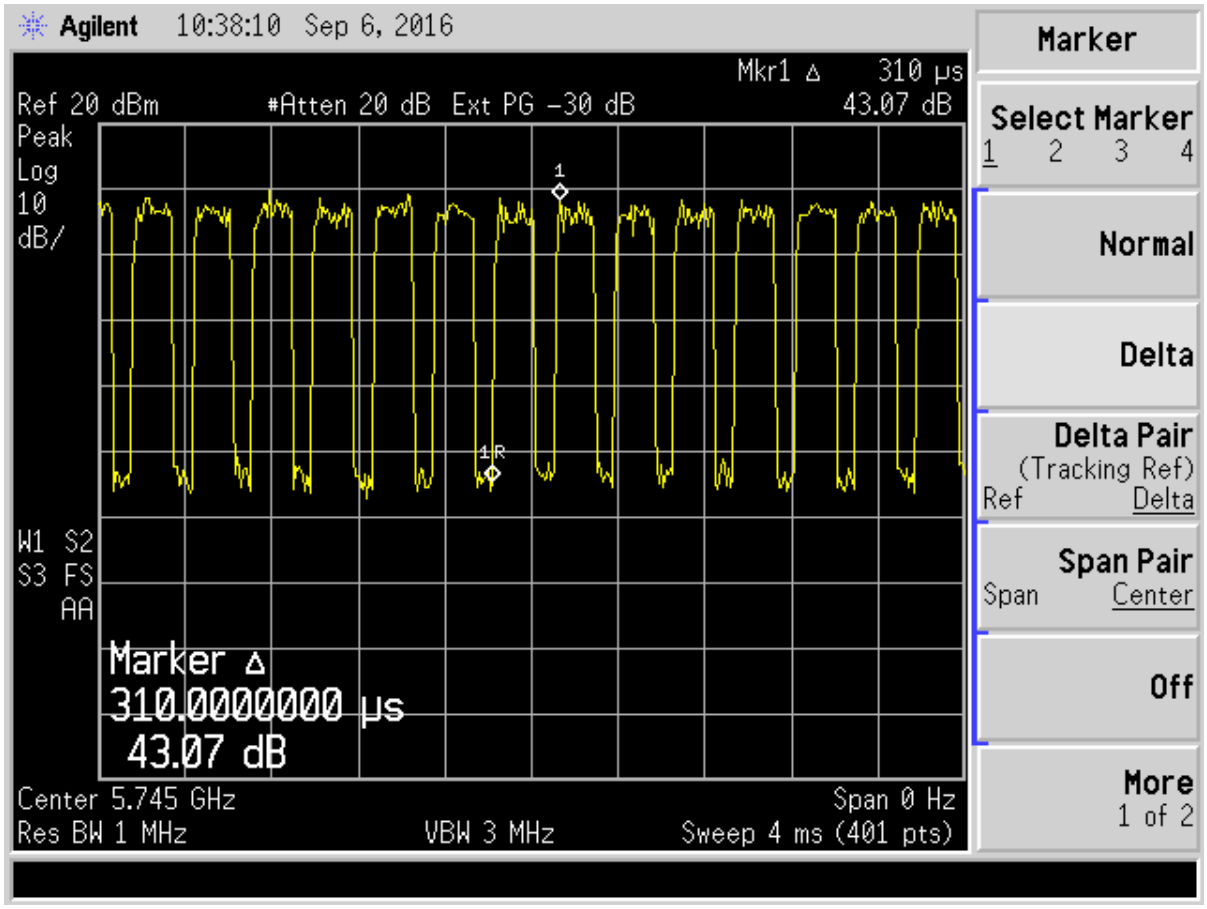


Figure 2. Total ON/OFF time

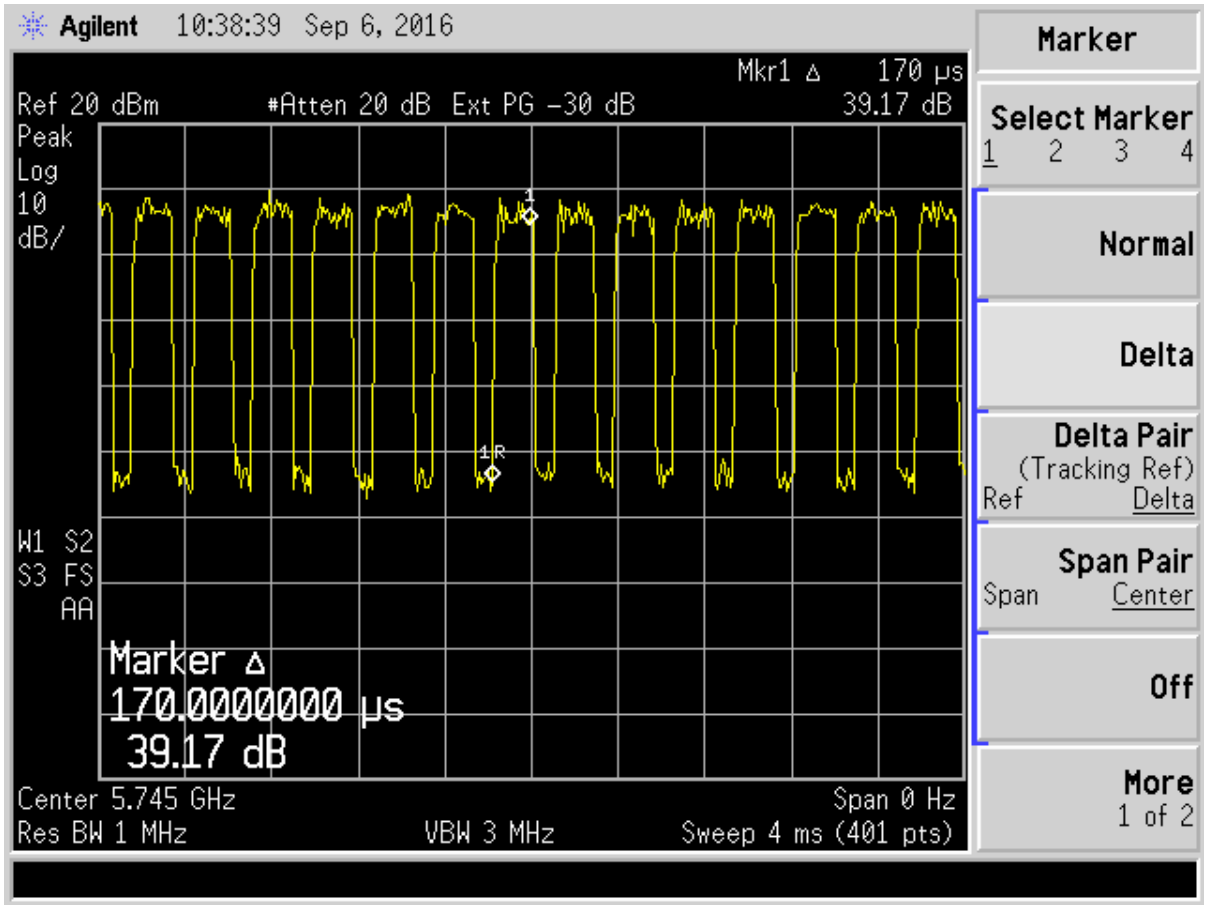


Figure 3. Total ON time

Total Time On from Figure 3 = 170.00 us (Transmitter Pulse Width)
Total Pulse Train from Figure 2 = 310.00 us (Pulse Train)

(170.0 us Total Time On)/(310.0 us Total Pulse Train) = 0.54 Numeric Duty Cycle
Duty Cycle = 20 Log (0.54) = -5.35 dB

NOTE: The transmitter was programmed to transmit at >98% duty cycle, therefore wherever applicable (where the detection mode was AVG) the duty cycle factor calculated above will be applied.

2.7 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
None	Johanson Technology	Chip	2450AD46A 5400	-2.5	Soldered SMT

2.8 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 2.1

2.9 Maximum Peak Conducted Output Power (CFR 15.407 (a)(1,2,3))

The transmitter was programmed to operate at a maximum output power across the bandwidth.

Peak power within the transmitting bands was measured per FCC KDB Publication 789033 D02 v01 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 to 1 MHz, the VBW ≥ 3*RBW, and span large enough to encompass the entire 99 % bandwidth and the channel power was integrated over the whole band. Peak antenna conducted output power is tabulated in the table below.

Table 5. Peak Antenna Conducted Output Power per 15.407 (a) (1,2,3) for 802.11n

Frequency of Fundamental (MHz)	Peak Test Data (dBm)	FCC Limit (dBm)	Margin (dB)
5180	15.86	23.98	8.12
5240	15.93	23.98	8.03
5745	15.68	30.00	14.32
5825	15.80	30.00	14.2

Note: EUT is considered client device, antenna gain does not exceed 6 dBi in any UNII band.

Test Date: September 6, 2016
Tested By
Tested By
Signature:  Name: Ashton Picas

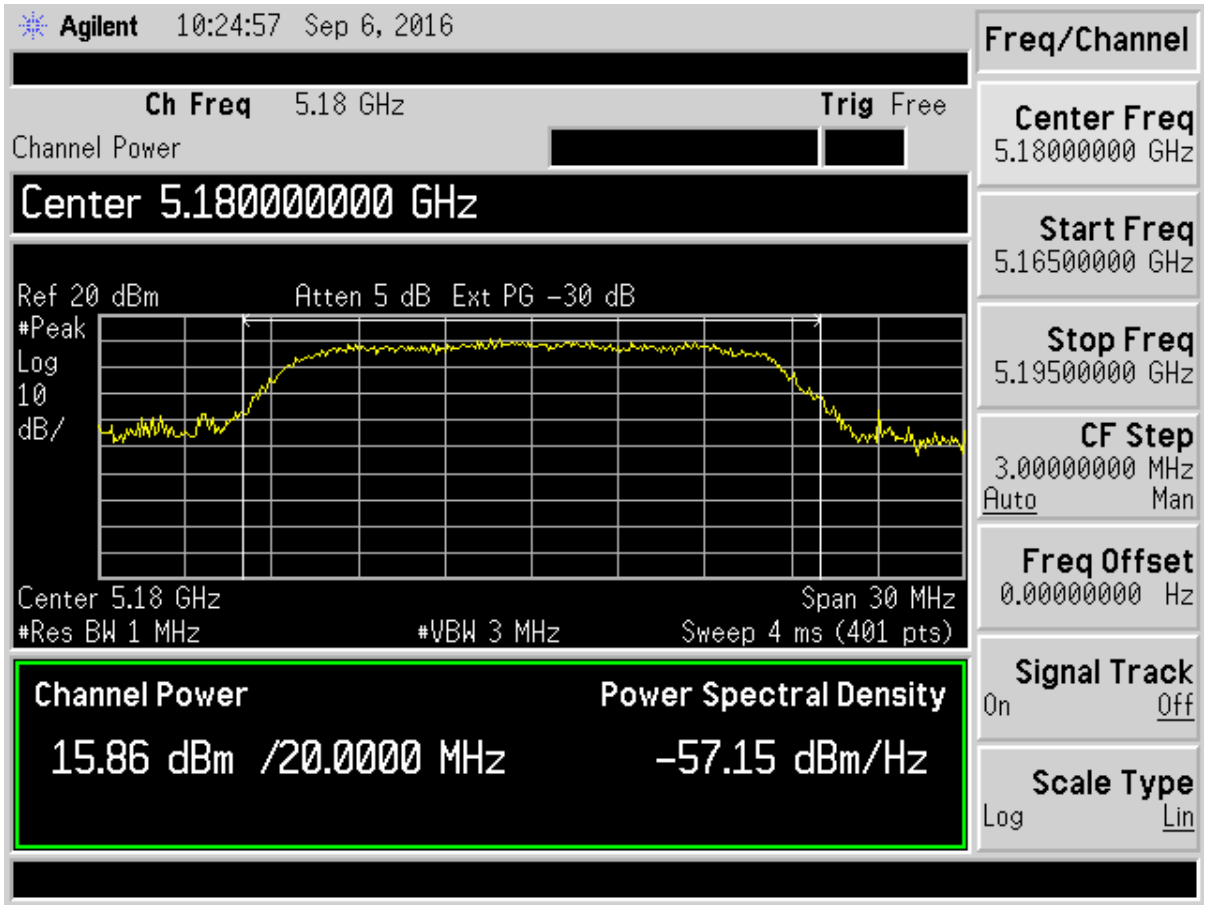


Figure 4. Peak Antenna Conducted Output Power, 802.11n Channel 36

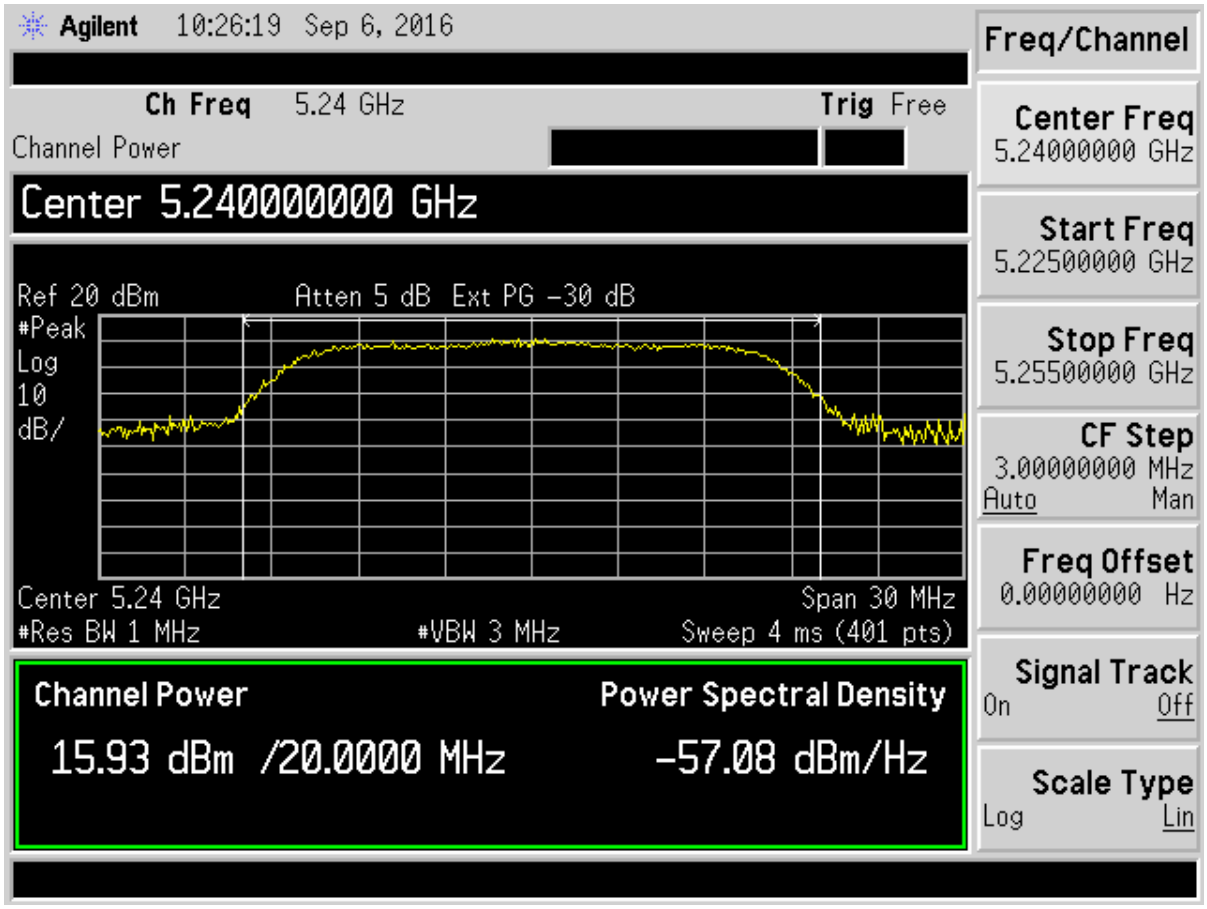


Figure 5. Peak Antenna Conducted Output Power, 802.11n Channel 48

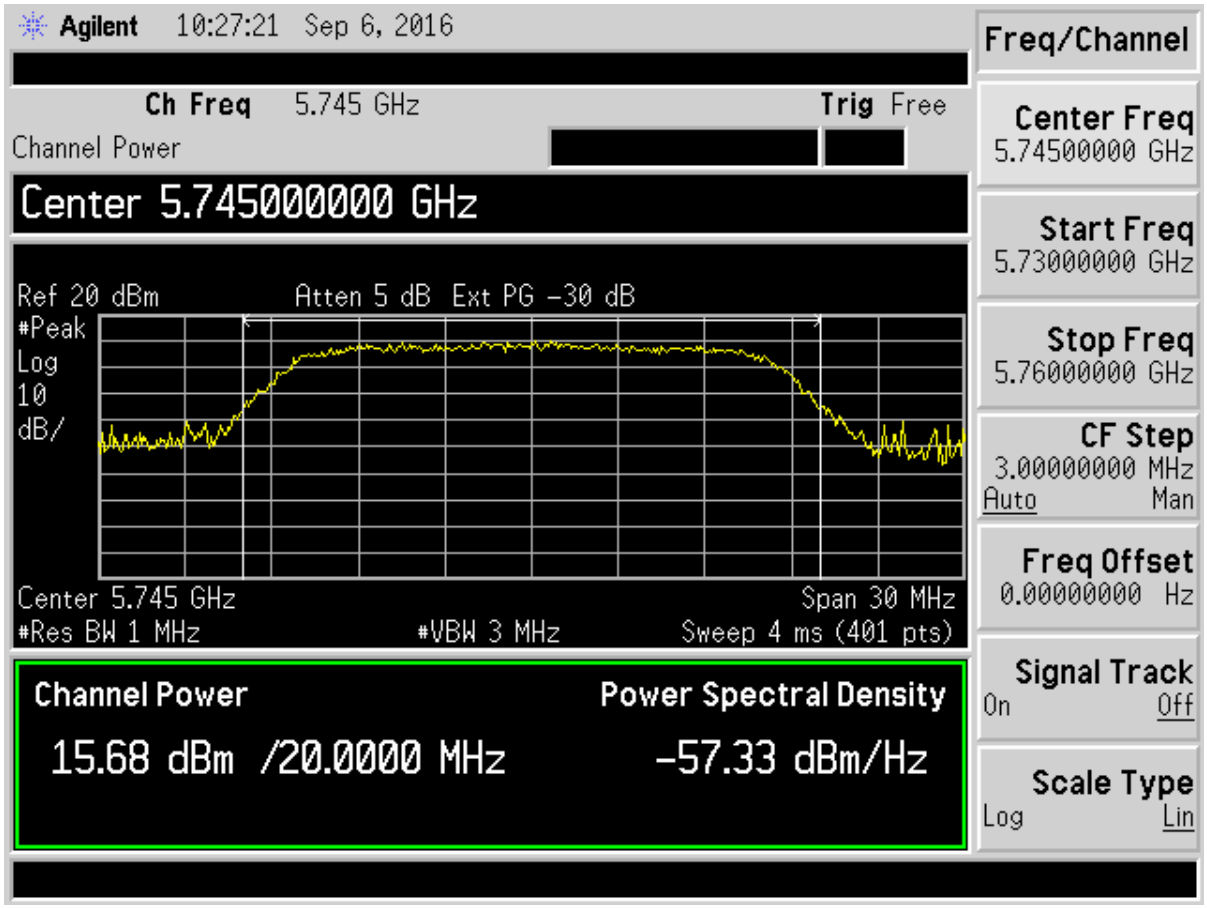


Figure 6. Peak Antenna Conducted Output Power, 802.11n Channel 149

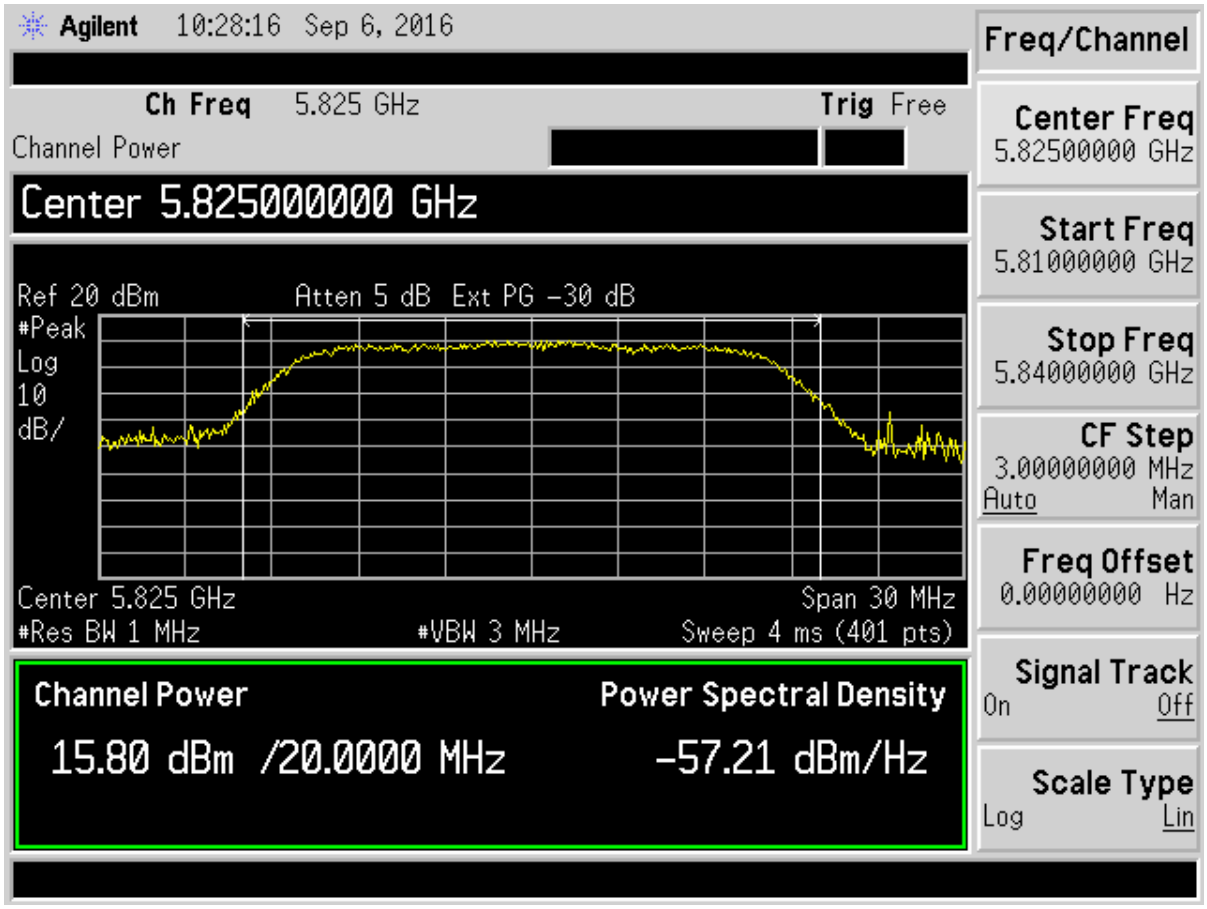


Figure 7. Peak Antenna Conducted Output Power, 802.11n Channel 165

2.10 Power Spectral Density (CFR 15.407(a)1(iv),3 & (5)) (IC RSS 247 5.1, 5.2)

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 789033 D02 v01. The RBW was set to 1 MHz and the Video Bandwidth was set to ≥ 3*RBW. The span was set to encompass the OBW. The averaging detector was used on the spectrum analyzer was used to determine the maximum PSD over the corresponding bandwidth

In the operating bands 5.15 – 5.25 GHz, 5.25 - 5.355 GHz, and 5.47 - 5.725 GHz, the maximum power spectral density shall not exceed 11 dBm in any 1 MHz band for client devices. The EUT is considered a client device. In the operating band 5.725 - 5.85 GHz the maximum conducted output power spectral density shall not exceed 30 dBm in any 500 kHz band. Since the spectrum analyzer used for testing is not have a 500 kHz RBW, the RBW was set to 1 MHz for a worst case testing configuration.

Table 6. Power Spectral Density for 902.11n in the Lower Frequency Bands

Frequency (MHz)	Test Data (dBm/1 MHz)	FCC Limit (dBm/1 MHz)	Margin (dB)
5180	10.39	11.00	0.61
5240	10.78	11.00	0.22

Test Date: September 6, 2016
Tested By
Tested By
Signature:  Name: Ashton Picas

Table 7. Power Spectral Density for 802.11n in the Upper Frequency Bands

Frequency (MHz)	Test Data (dBm/1 MHz)	FCC Limit (dBm/500 kHz)	Margin (dB)
5745	10.92	30	19.08
5825	10.75	30	19.25

Note: EUT meets the required using a 1 MHz resolution bandwidth. This is considered worst case.

Test Date: September 6, 2016
Tested By
Tested By
Signature: _____ Name: Ashton Picas

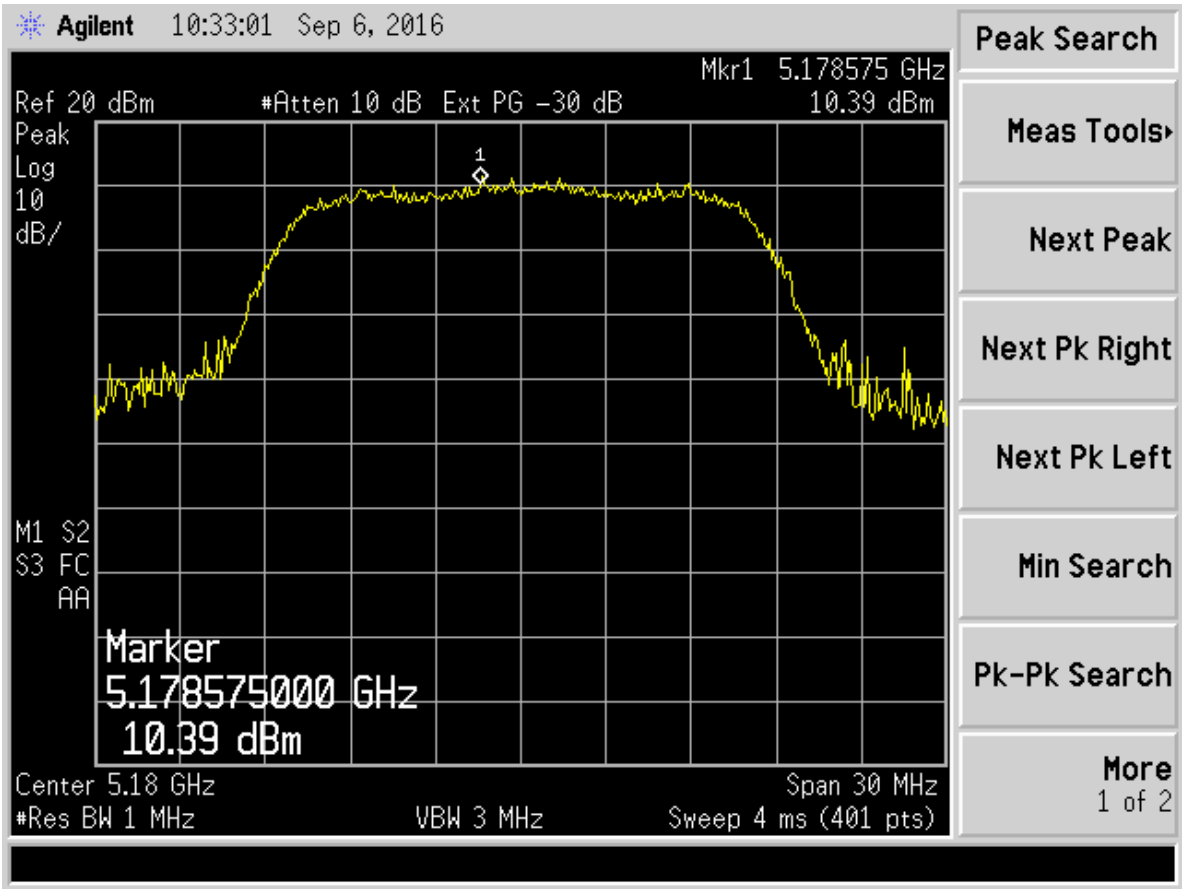


Figure 8. Power Spectral Density, Channel 36, 802.11n

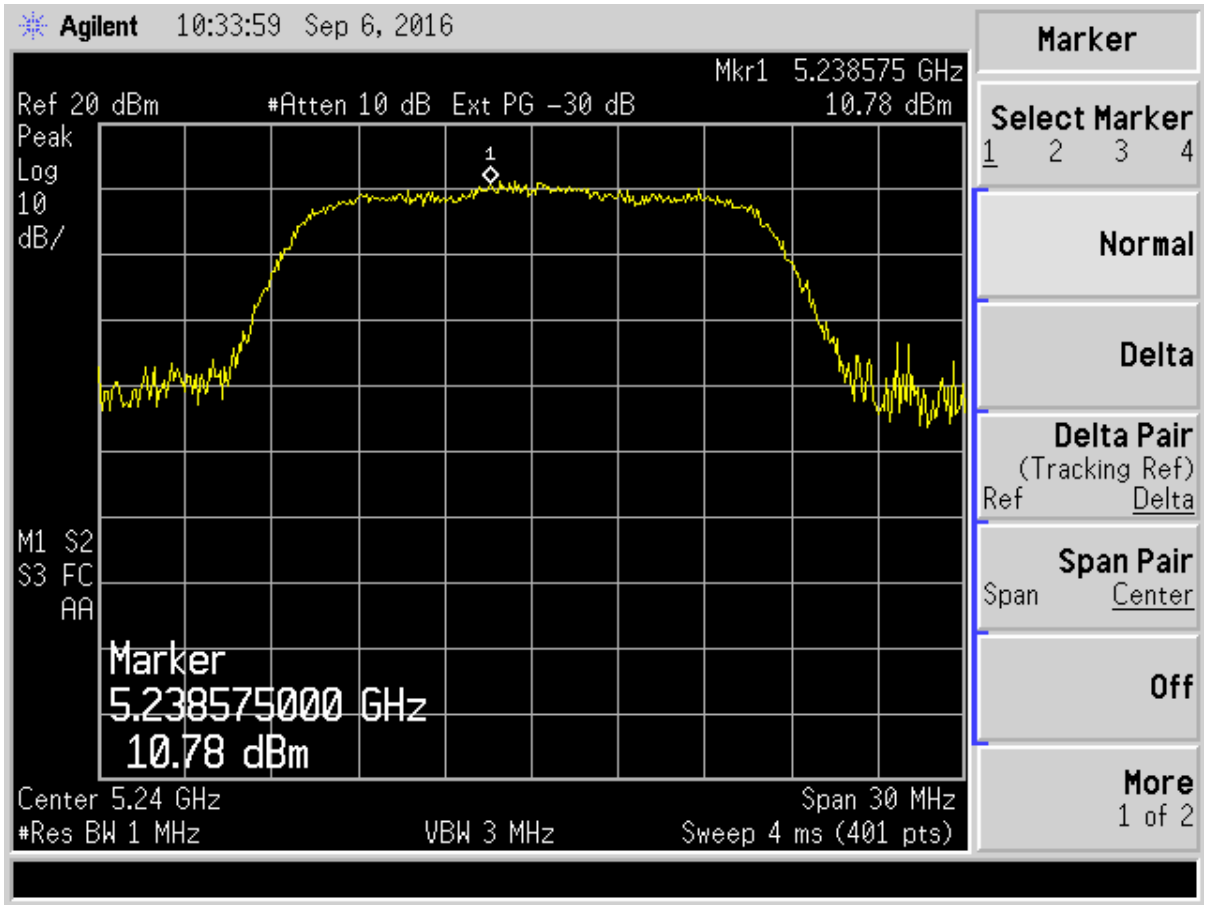


Figure 9. Power Spectral Density, Channel 48, 802.11n

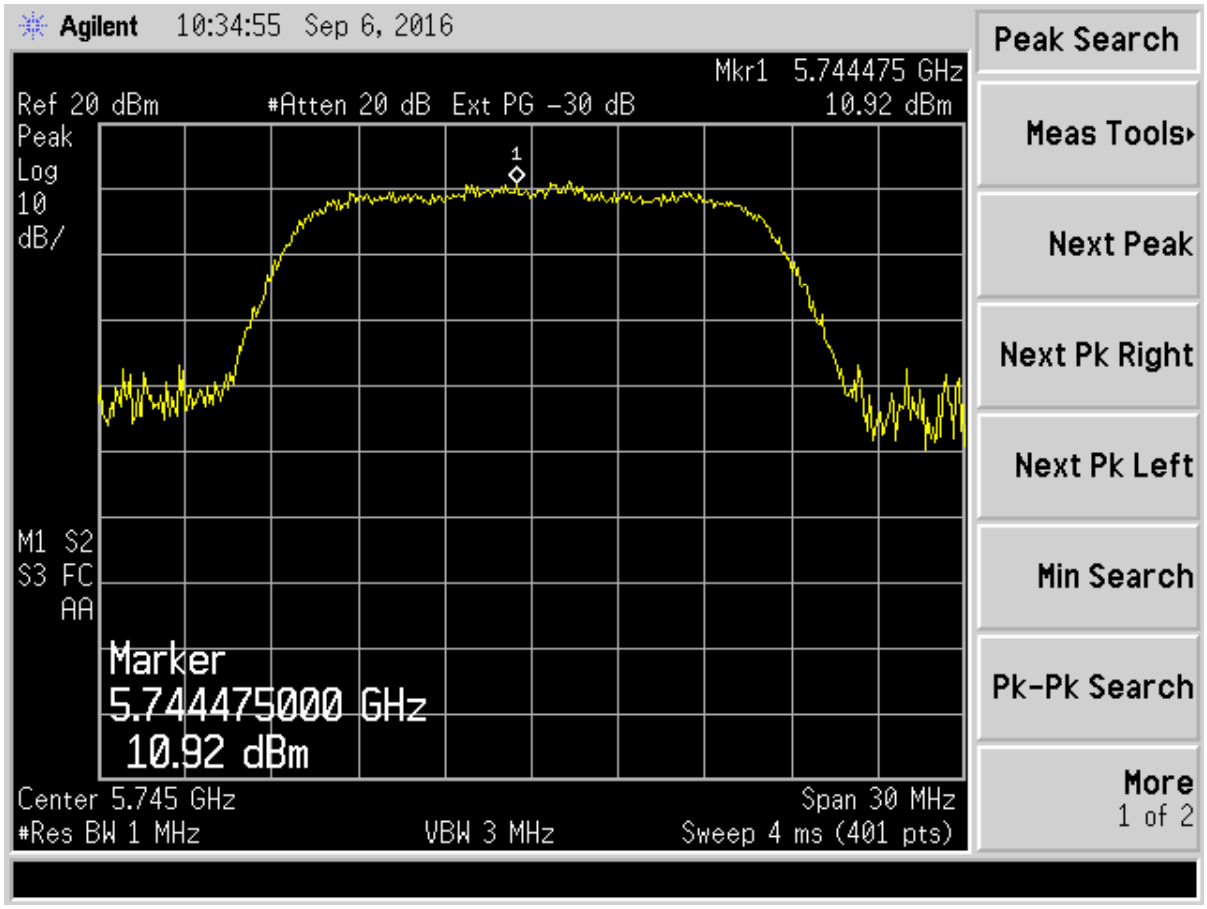


Figure 10. Power Spectral Density, Channel 149, 802.11n

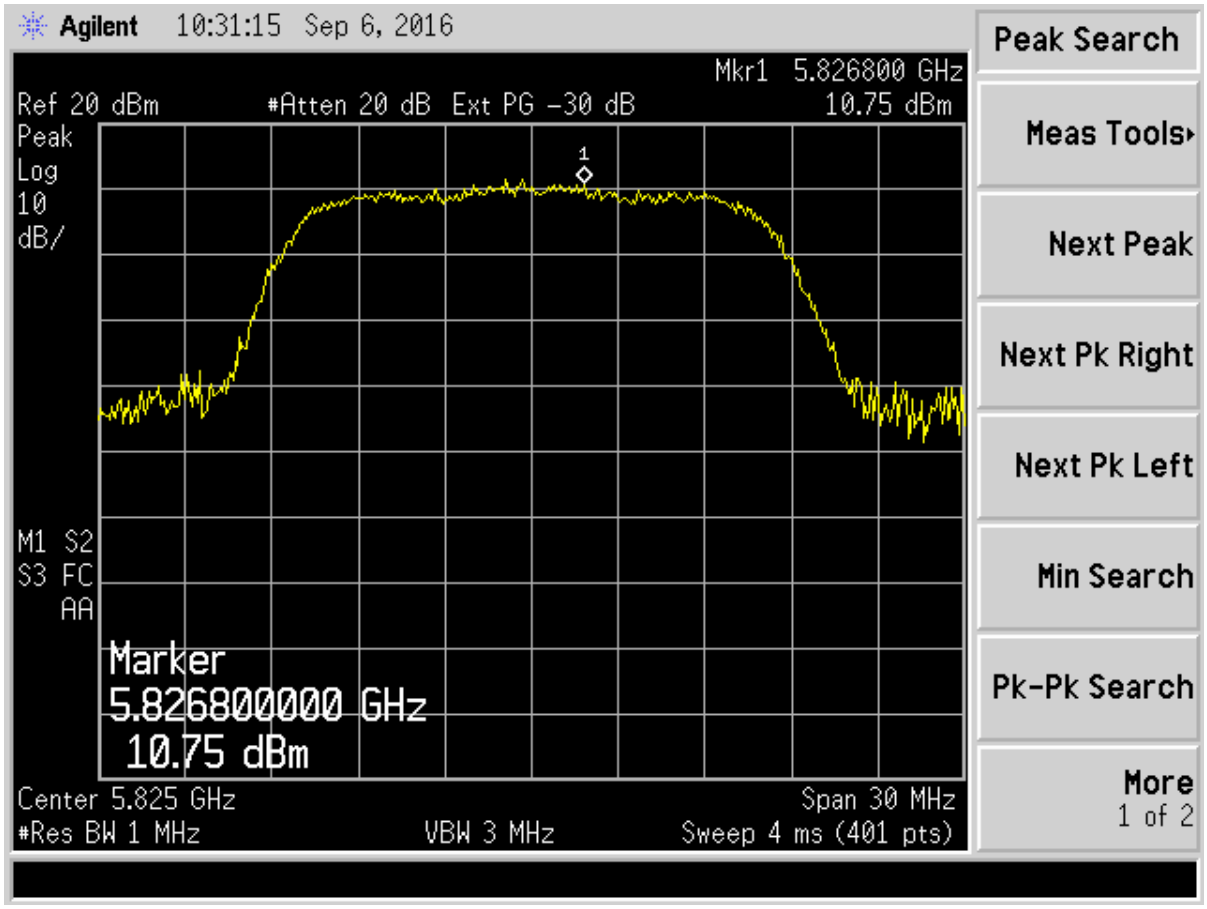


Figure 11. Power Spectral Density, Channel 165, 802.11n

2.11 Intentional Radiator, Power Line Conducted Emissions (CFR 15.207)

Power line conducted emissions testing was performed to ensure that with the EUT in operation (exercising all transmitter functions), the complete system will meet the applicable requirements for CFR 15.207. These measurements were completed and are displayed in the sections below.

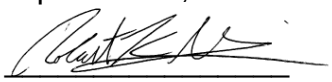
Table 8. Transmitter Power Line Conducted Emissions Test Data, Part 15.207/107

CONDUCTED EMISSIONS 150 kHz to 30 MHz						
Tested By: RKM	Specification Requirement: FCC Part 15.207 FCC Part 15.107 Class B		Project No.: 16-0219	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

2.12 Intentional Radiator, Spurious Emissions (CFR 15.209, 15.407(b6), IC RSS 247, 6.2)

2.12.1 Radiated Spurious Emissions (CFR 15.209, 15.407(b)6, IC RSS 247, 6.2)

Radiated Spurious measurements: the EUT was placed into a continuous transmit mode of operation (>98% duty cycle) and tested per FCC KDB Publication 789033 D02 v01 and ANSI C63.10:2013. A preliminary scan was performed on the EUT to find signal frequencies that were caused by the transmitter part of the device. To obtain worse case results the EUT was tested in X, Y, and Z axes or in the orientation of normal operation if the device is designed to operate in a fixed position.

Radiated measurements were then performed between the frequency range of 9KHz (or lowest frequency used/generated by the device) up to the tenth harmonic of the device (no greater than 40 GHz). In the band below 30 MHz a resolution bandwidth (RBW) of 9 kHz was used, emissions below 1 GHz were tested with a RBW of 120 KHz and emissions above 1 GHz were tested with a RBW of 1 MHz. All video bandwidth settings were at least three times the RBW value. This data is recorded in US Tech test report 16-0217 since that report covers the co-location testing aspects of the product.

The EUT was investigated to CFR 15.209, General requirements for unwanted spurious emissions. The conducted spurious method as described below was used to investigate all other emissions emanating from the antenna port.

Table 9. Peak Radiated Fundamental & Harmonic Emissions, 802.11n with Chip Antenna

Test: FCC Part 15, Para 15.209, 15.407(b)					**Client:** Wink Labs, Inc.			
Project: 16-0219					**Model:** WINK HUB 2			
Frequency (MHz)	**Test Data (dBuV)**	**Factor (dB)**	**AF+CA -AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Channel 36								
5179.00	61.93		38.45	100.38	--	3.0m./VERT	--	**PK**
No measureable harmonic emissions found.								
Channel 48								
5239.00	66.51		38.30	104.81	--	3.0m./VERT	--	**PK**
No measureable harmonic emissions found.								
Channel 149								
5744.00	64.88		38.19	103.07	--	3.0m./VERT	--	**PK**
No measureable harmonic emissions found.								
Channel 165								
5824.00	62.91		38.49	101.40	--	3.0m./VERT	--	**PK**
No measureable harmonic emissions found.								

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
2.The EUT was placed in the position of normal use (upright). The transmitter was programmed to transmit with a duty cycle of greater than 98%.
3.The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 5179.00 MHz:

Magnitude of Measured Frequency	61.93	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	38.45	dB/m
Corrected Result	100.38	dBuV/m

Test Date: August 29, 2016
Tested By
Signature: _____ Name: Ashton Picas

Table 10. Average Radiated Fundamental & Harmonic Emissions 802.11n with Chip Antenna

Test: FCC Part 15, Para 15.209, 15.407(b)					**Client:** Wink Labs, Inc.			
Project: 16-0219					**Model:** WINK HUB 2			
Frequency (MHz)	**Test Data (dBuV)**	**Factor (dB)**	**AF+CA -AMP (dB/m)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector Mode**
Channel 36								
5179.00	44.35		38.45	82.80	--	3.0m./VERT	--	**AVG**
No measureable harmonic emissions found.								
Channel 48								
5239.00	46.92		38.30	85.22	--	3.0m./VERT	--	**AVG**
No measureable harmonic emissions found.								
Channel 149								
5744.00	46.36		38.19	84.55	--	3.0m./VERT	--	**AVG**
No measureable harmonic emissions found.								
Channel 165								
5824.00	44.89		38.49	83.38	--	3.0m./VERT	--	**AVG**
No measureable harmonic emissions found.								

1. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
2.The EUT was placed in the position of normal use (upright). The transmitter was programmed to transmit with a duty cycle of greater than 98%.
3.The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.
4. Duty Cycle factor was not applied.

Sample Calculation at 5179.00MHz:

Magnitude of Measured Frequency	44.35	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	38.45	dB/m
-Duty Cycle	-0.0	dB
Corrected Result	82.80	dBuV/m

Test Date: August 29, 2016
Tested By
Signature: _____ Name: Ashton Picas

2.12.2 Conducted Spurious Emissions (15.209 & 15.407(b)1,5&6)

Conducted Spurious measurements: the EUT was put into a continuous-transmit mode of operation (>98% duty cycle) and tested per FCC KDB Publication 7789033 D02 v01 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to 10 times the fundamental frequency or 40 GHz. A conducted scan was performed on the EUT to identify and record spurious signals that were related to the transmitter.

The conducted output power (in dBm) was recorded. The maximum transmit antenna gain in dBi was added to determine the EIRP level. The appropriate maximum ground reflection factor to the EIRP level, 6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz – 1000 MHz, and 0 dB for frequencies > 1000 MHz, was also added to the EIRP calculation.

The results are displayed in the plots below. Radiated emissions per CFR 15.209 were performed to address the concerns of unwanted emissions that may radiate from the EUT cabinet, control circuits, or power leads. That data is recorded in US Tech test report 16-0217 since that report covers the co-location testing aspects of the product.

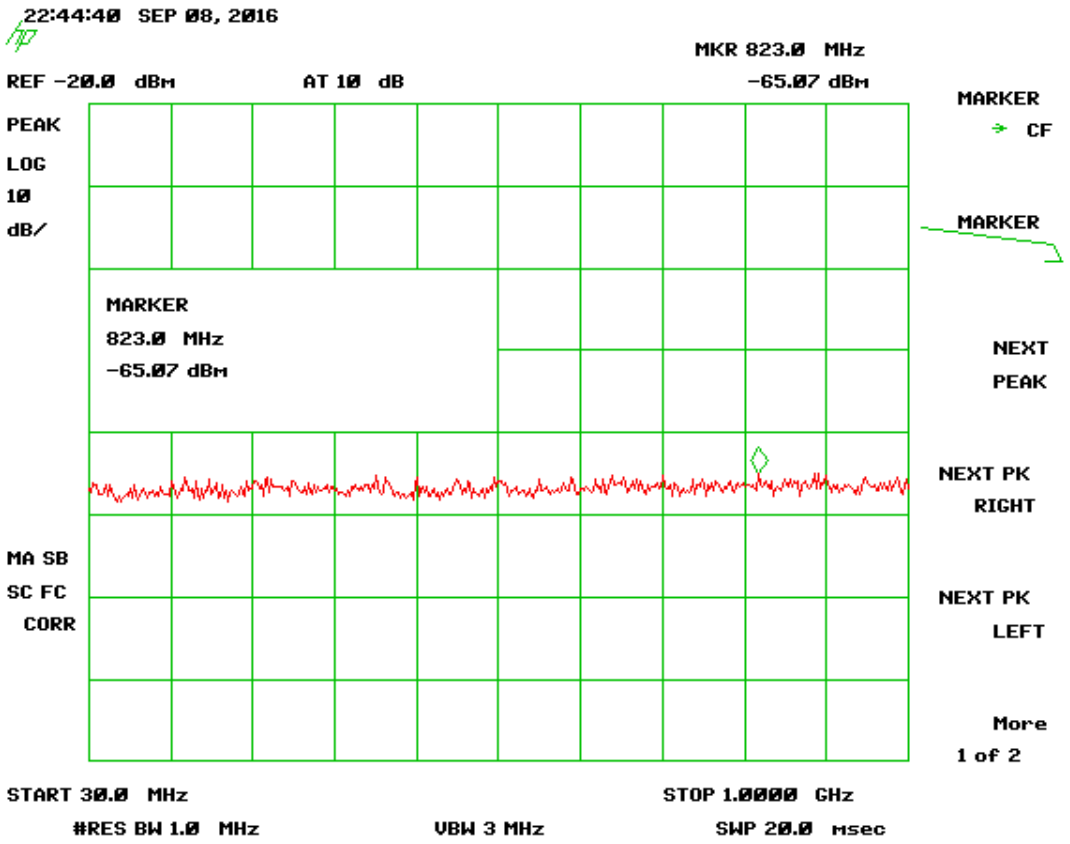


Figure 12. Antenna Conducted Emissions Channel 36 802.11n, Part 1

EIRP= -65.1 dBm + (-2.5) dBi (applied antenna gain) + 4.7 dB (ground reflection factor)= -62.9 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-62.9) dBm/MHz = 35.9 dB

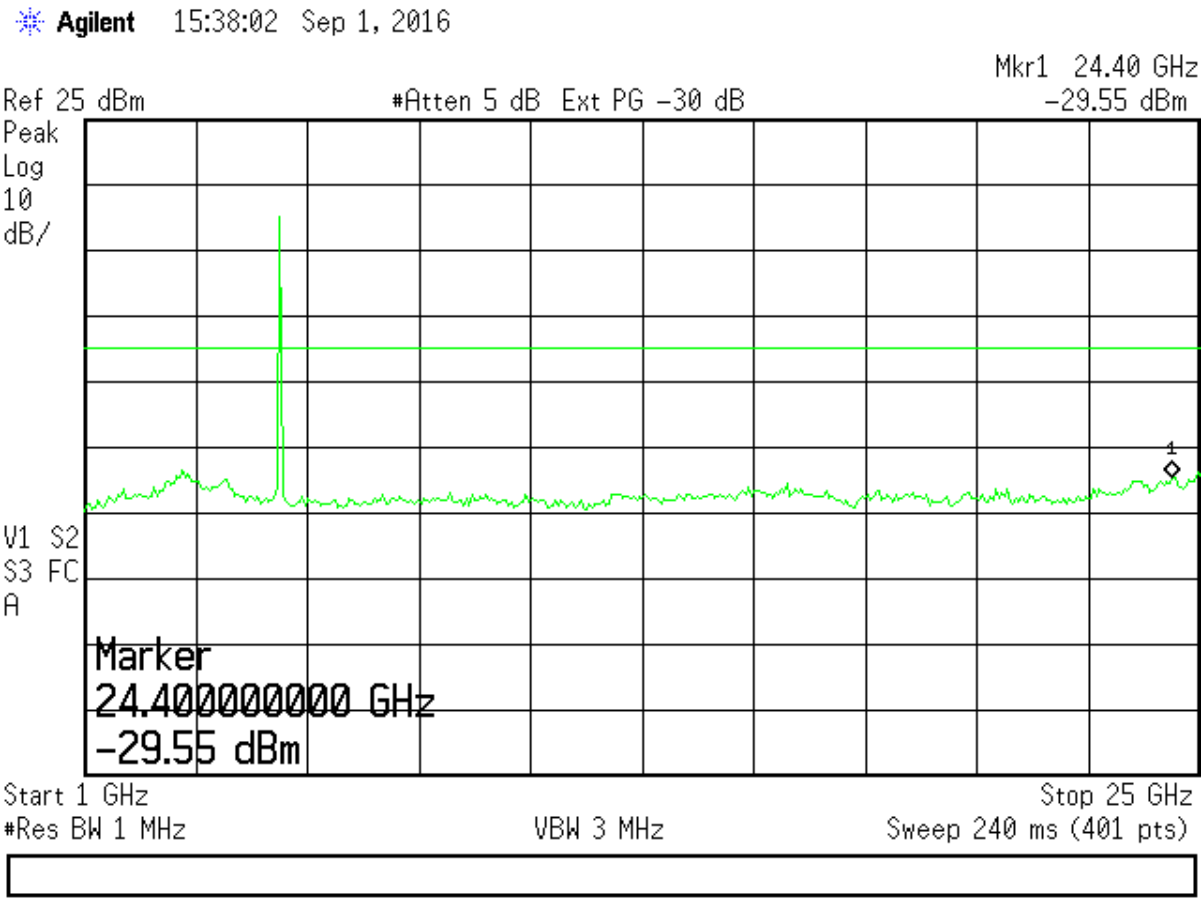


Figure 13. Antenna Conducted Emissions Channel 36 802.11n, Part 2

EIRP= -29.6 dBm + (-2.5) dBi (applied antenna gain) + 0 dB (ground reflection factor)= -32.1 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-32.1) dBm/MHz = 5.1 dB

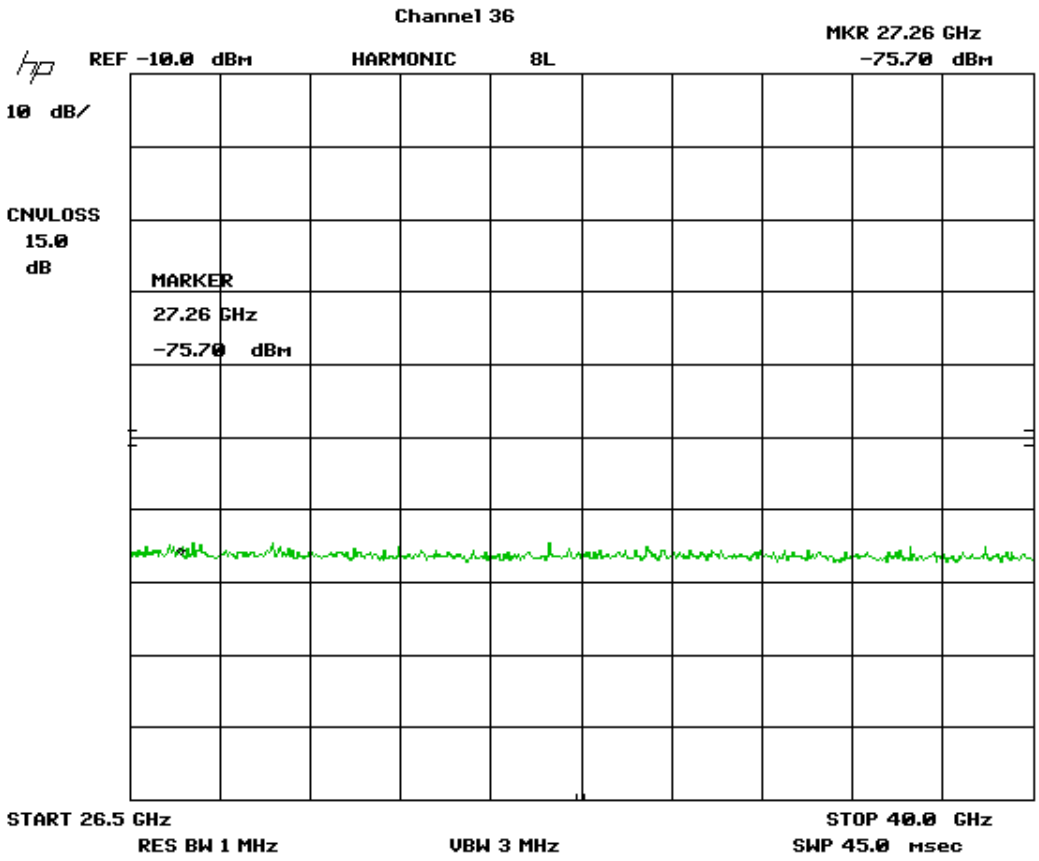


Figure 14. Antenna Conducted Emissions Channel 36 802.11n, Part 3

EIRP= -75.5 dBm + (-2.5) dBi (applied antenna gain) + 0 dB (ground reflection factor)= -78.0 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-78.0) dBm/MHz = 51.0 dB

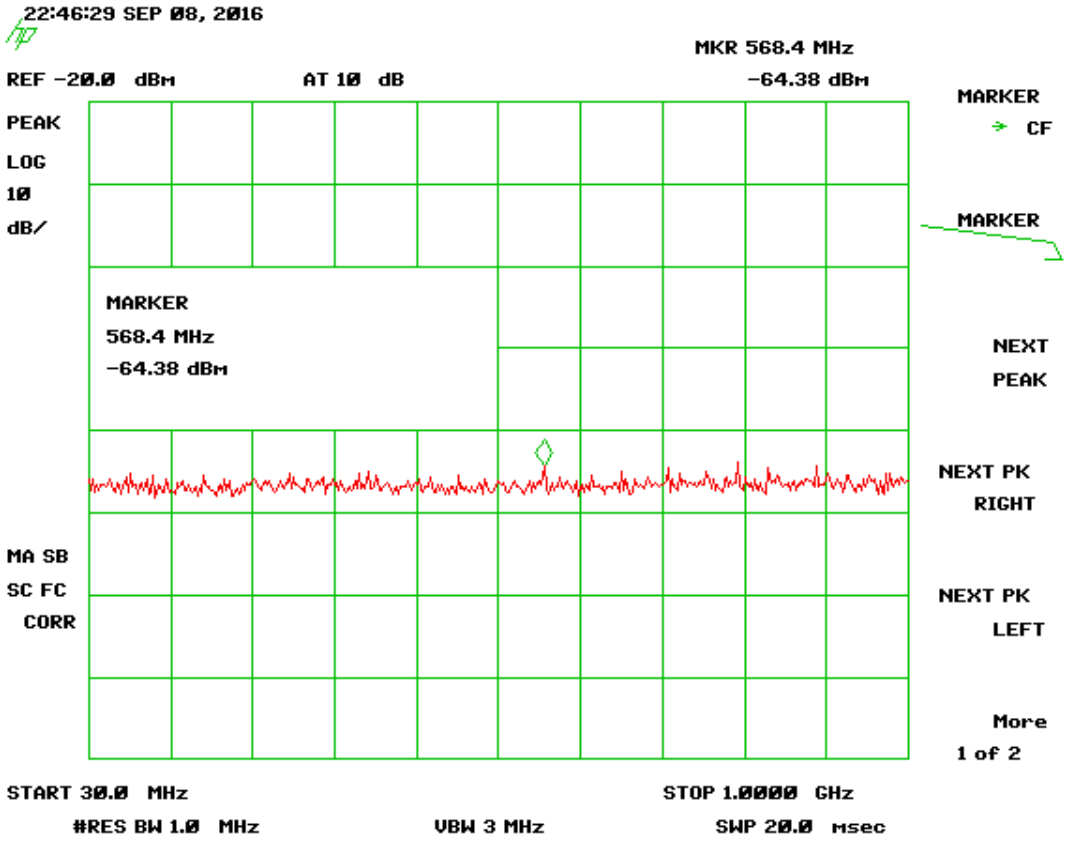


Figure 15. Antenna Conducted Emissions Channel 48 802.11n, Part 1

EIRP= -64.4 dBm + -2.5 dBi (applied antenna gain) + 4.7 dB (ground reflection factor)= -62.2 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-62.2) dBm/MHz = 35.2 dB

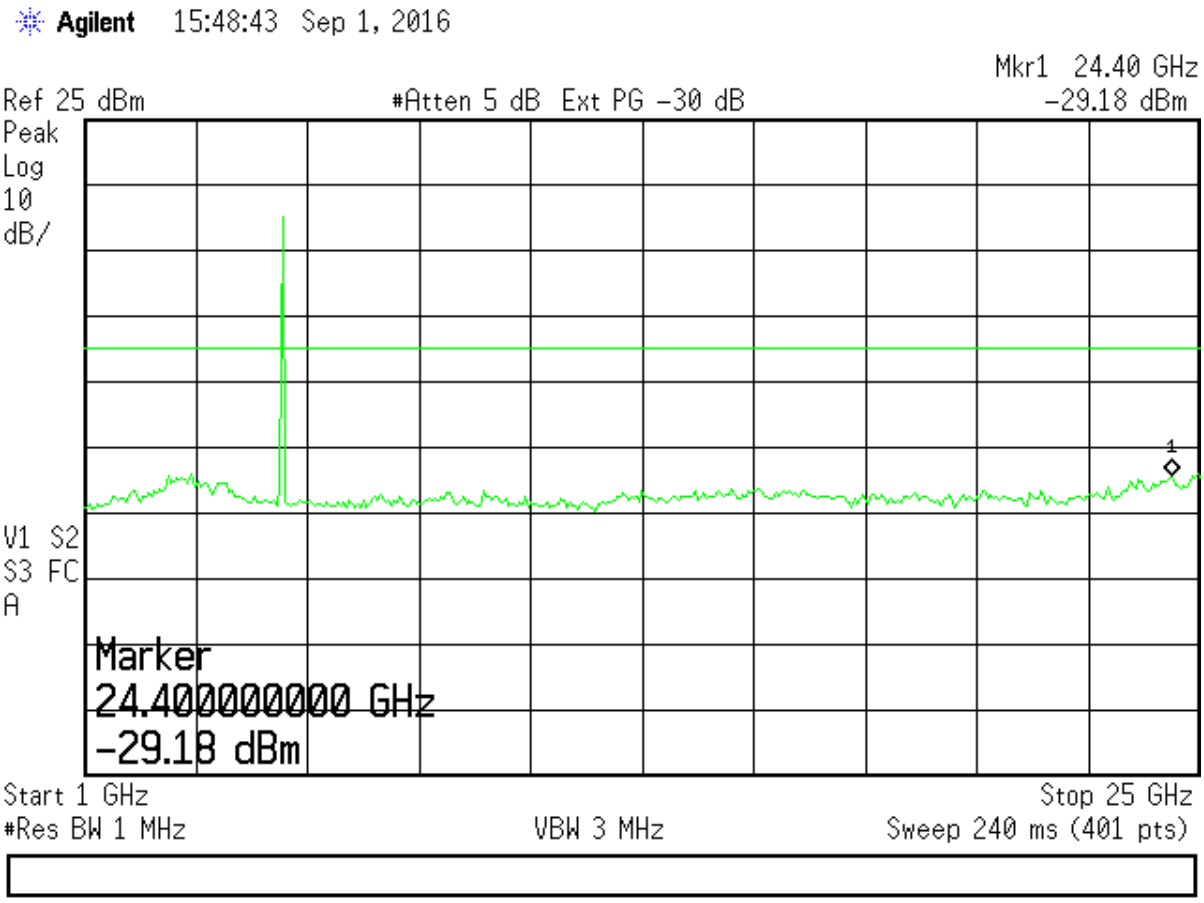


Figure 16. Antenna Conducted Emissions Channel 48 802.11n, Part 2

EIRP= -29.2 dBm + -2.5 dBi (applied antenna gain) + 0 dB (ground reflection factor)= -31.7 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-31.7) dBm/MHz = 4.7 dB

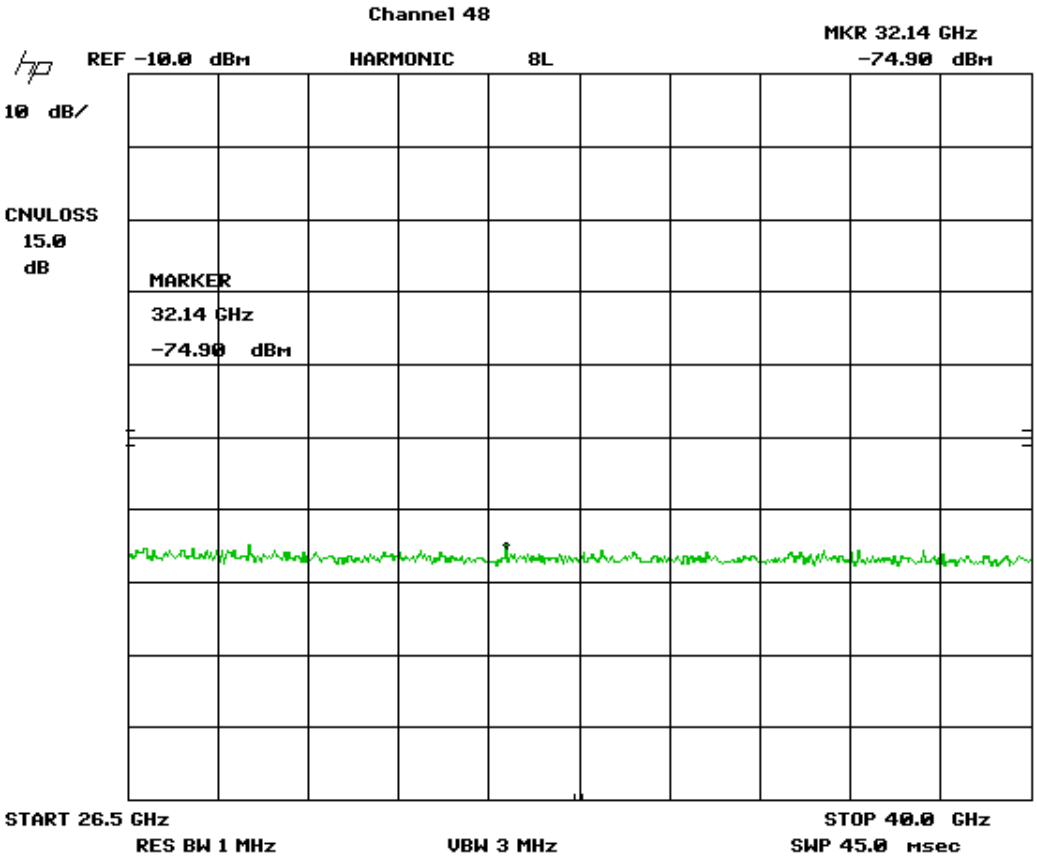


Figure 17. Antenna Conducted Emissions Channel 48 802.11n, Part 3

EIRP= -74.9 dBm + -2.5 dBi (applied antenna gain) + 0 dB (ground reflection factor)= -77.4 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-77.4) dBm/MHz = 50.4 dB

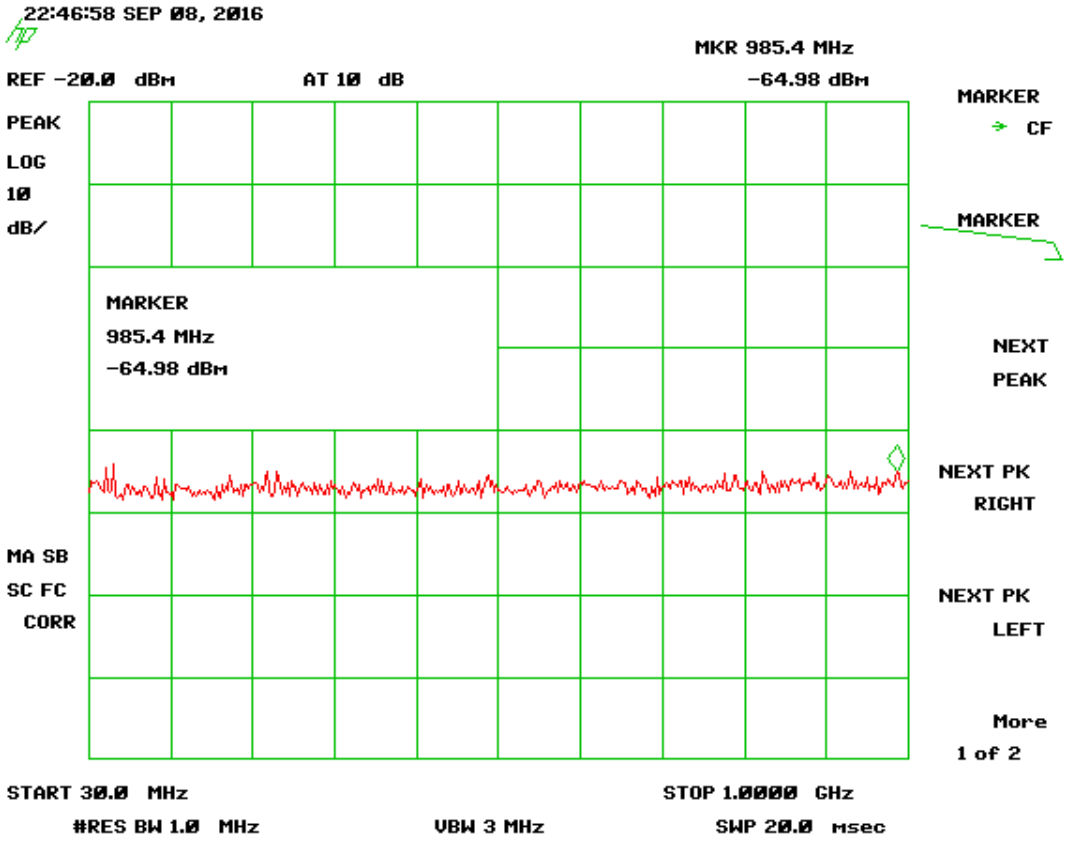


Figure 18. Antenna Conducted Emissions Channel 149 802.11n, Part 1

EIRP= -65.0 dBm+ -2.5 dBi (applied antenna gain) + 4.7 dB (ground reflection factor)= -62.8 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-62.8) dBm/MHz= 35.8 dB

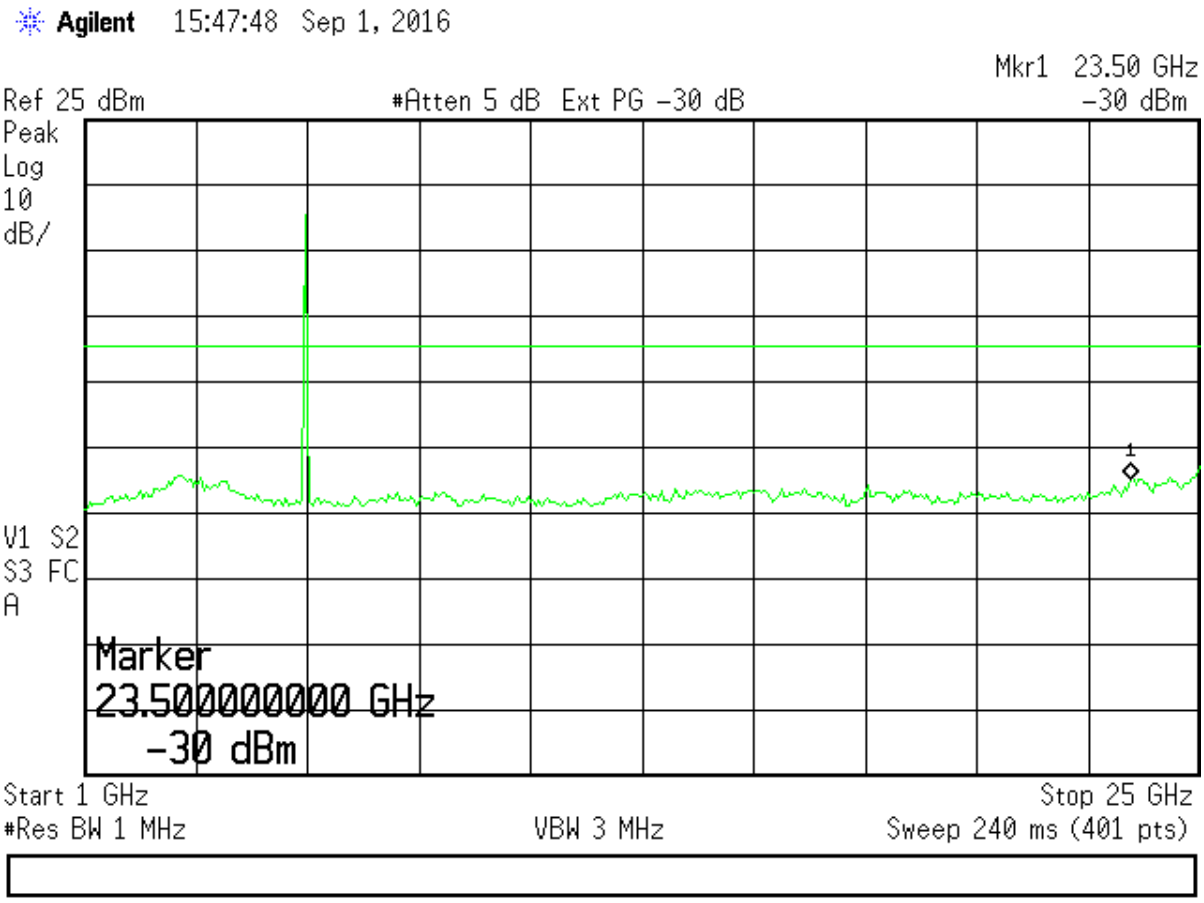


Figure 19. Antenna Conducted Emissions Channel 149 802.11n, Part 2

EIRP= -30.0 dBm + -2.5 dBi (applied antenna gain) + 0 dB (ground reflection factor)= -32.5 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-32.5) dBm/MHz = 5.5 dB

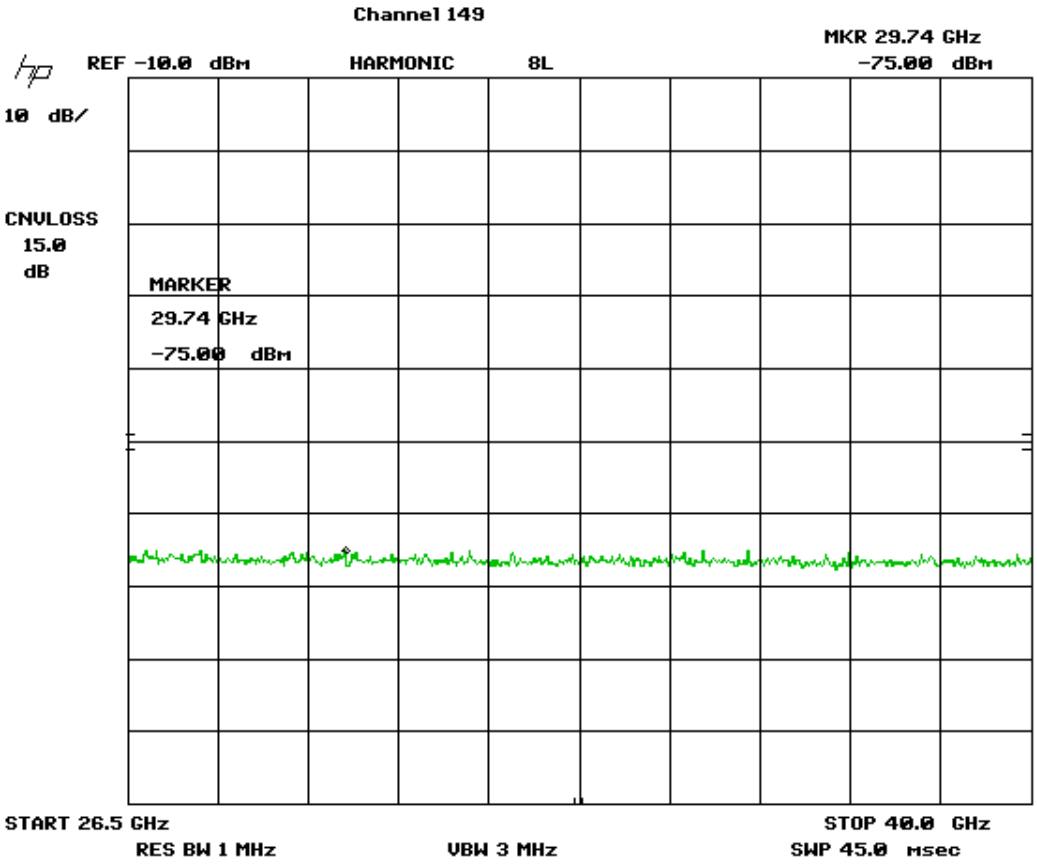


Figure 20. Antenna Conducted Emissions Channel 149 802.11n, Part 3

EIRP= -75.0 dBm + -2.5 dBi (applied antenna gain) + 0 dB (ground reflection factor)= -77.5 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-77.5) dBm/MHz = 50.5 dB

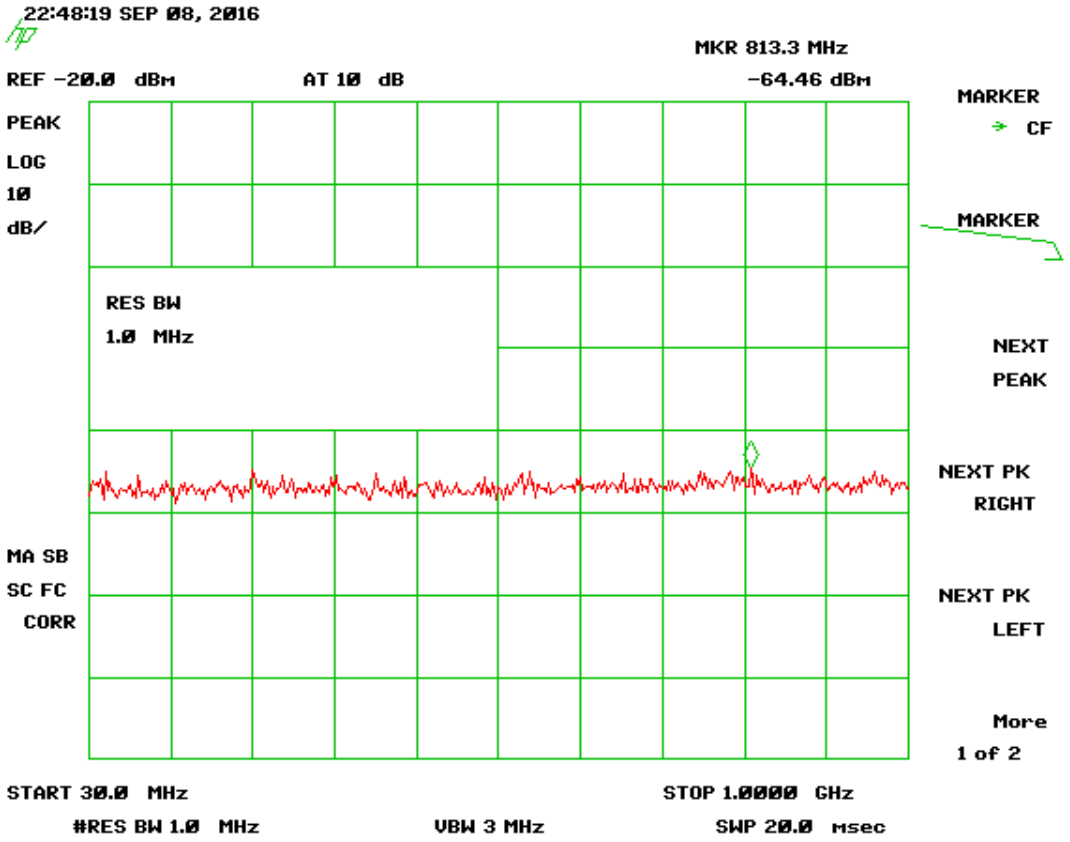


Figure 21. Antenna Conducted Emissions Channel 165 802.11n, Part 1

EIRP= -64.5 dBm + -2.5 dBi (applied antenna gain) + 4.7 dB (ground reflection factor)= -62.3 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz – (-62.3) dBm/MHz= 35.3 dB

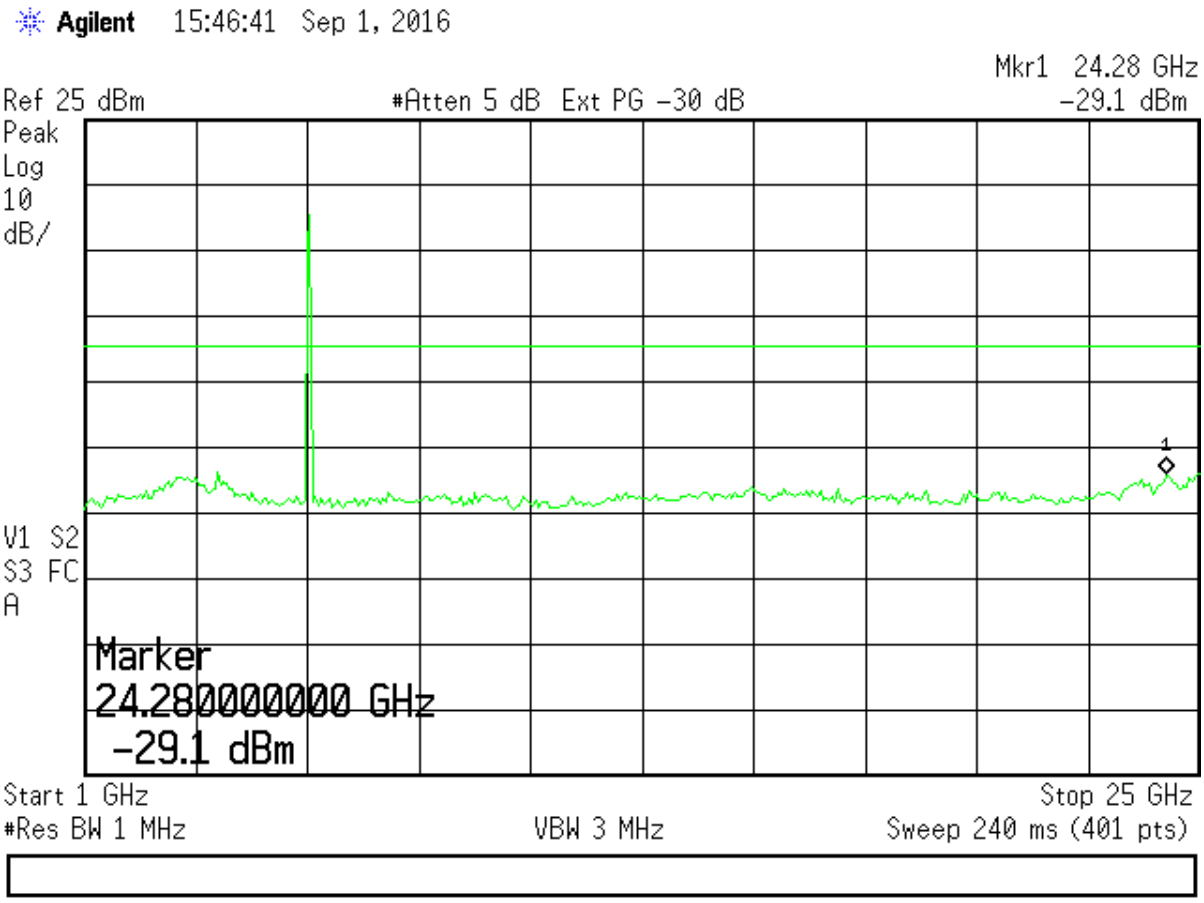


Figure 22. Antenna Conducted Emissions Channel 165 802.11n, Part 2

EIRP= -29.1 dBm + -2.5 dBi (applied antenna gain) + 0 dB (ground reflection factor)= -31.6 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz –(-31.6) dBm= 4.6 dB

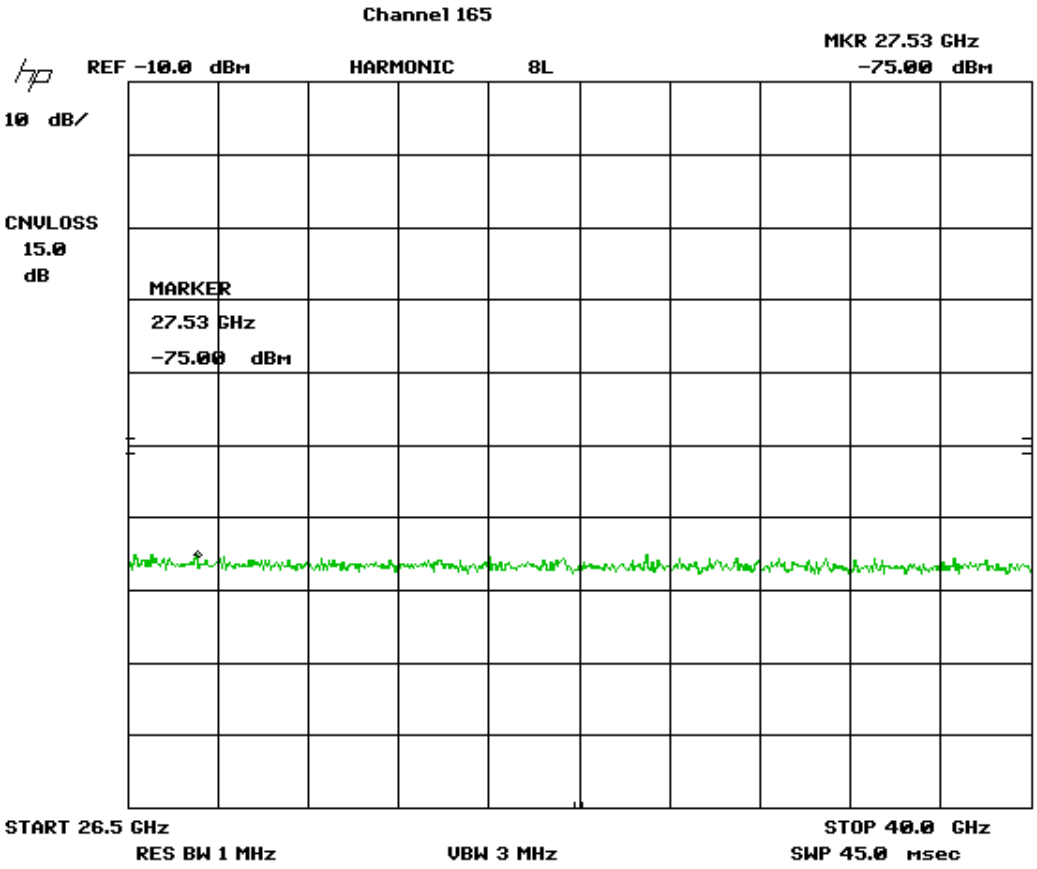


Figure 23. Antenna Conducted Emissions Channel 165 802.11n, Part 3

EIRP= -75.0 dBm + -2.5 dBi (applied antenna gain) + 0 dB (ground reflection factor)= -77.5 dBm

Limit= -27 dBm/MHz (15.407 (b))

Margin= -27 dBm/MHz –(-77.5) dBm= 50.5 dB

2.13 Undesirable Emissions at the Band Edge – (CFR 15.407 (b)(1)&(4i))

Undesirable emissions measurements are made following the guidelines in FCC KDB Publication No. 789033 D02 v01 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation for all modes of operation. Antenna port conducted measurements are performed to demonstrate compliance with the requirement of 15.407(b) that all emissions outside of the band edges do not exceed an e.i.r.p of -27 dBm/MHz.

The emission measurements shall be performed using a minimum resolution bandwidth of 1 MHz. A lower resolution bandwidth may be employed near the band edge, when necessary, provided the measured energy is integrated to show the total power over 1 MHz.

To capture the band edge the spectrum analyzer frequency span was set to >2.5 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 = 100 kHz. In all cases, the VBW is set ≥ 3*RBW. The integration function on the spectrum analyzer was used to calculate the Band edge measurement over 1 MHz. See figure and calculations below for more detail.

Measurements were made with the nominal carrier frequency adjusted as close to the upper and lower frequency band edges as possible.

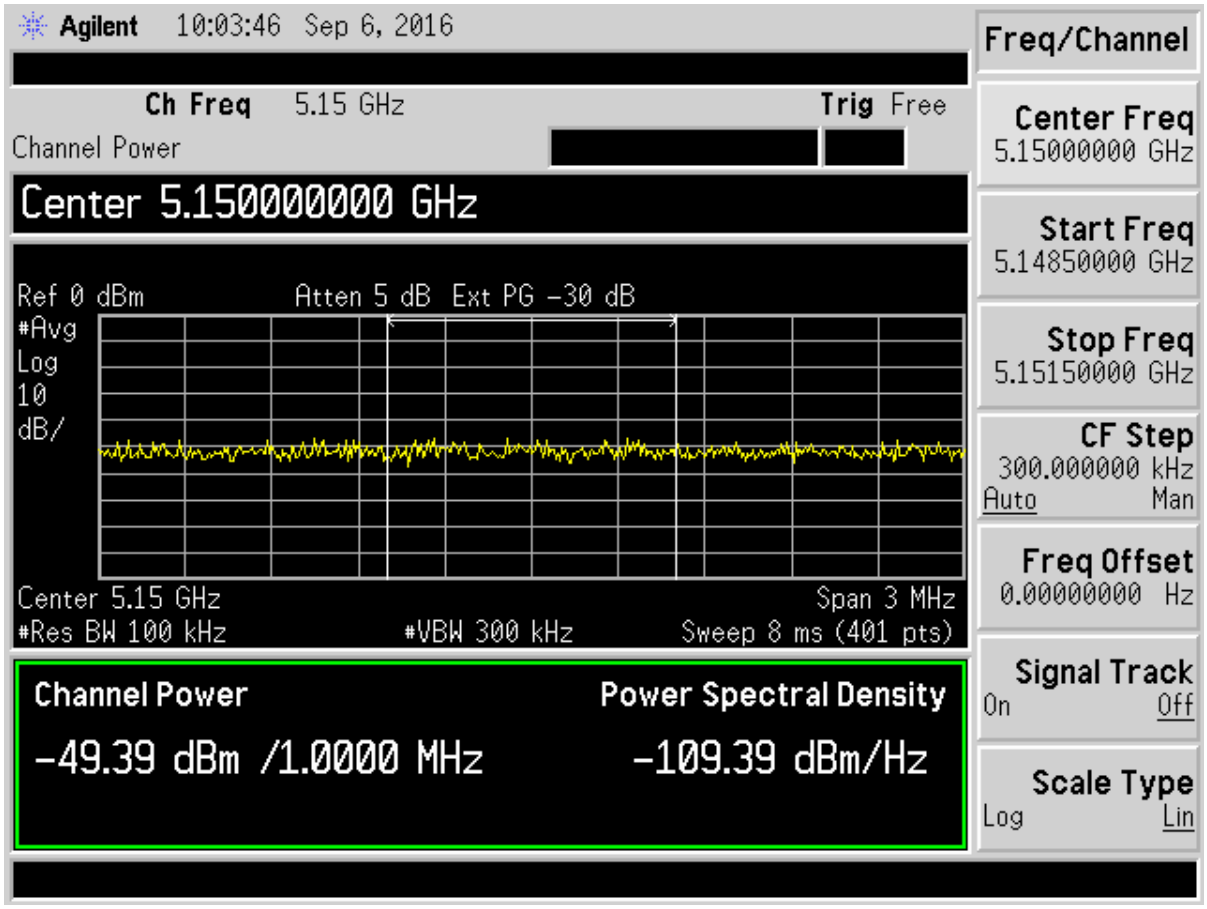


Figure 24. 5.15 GHz Band Edge Compliance, 802.11n

Calculation:

Band Edge Limit	-27.00	dBm/MHz
-Calculated Result	-49.39	dBm/MHz
Band Edge Margin	22.39	dB

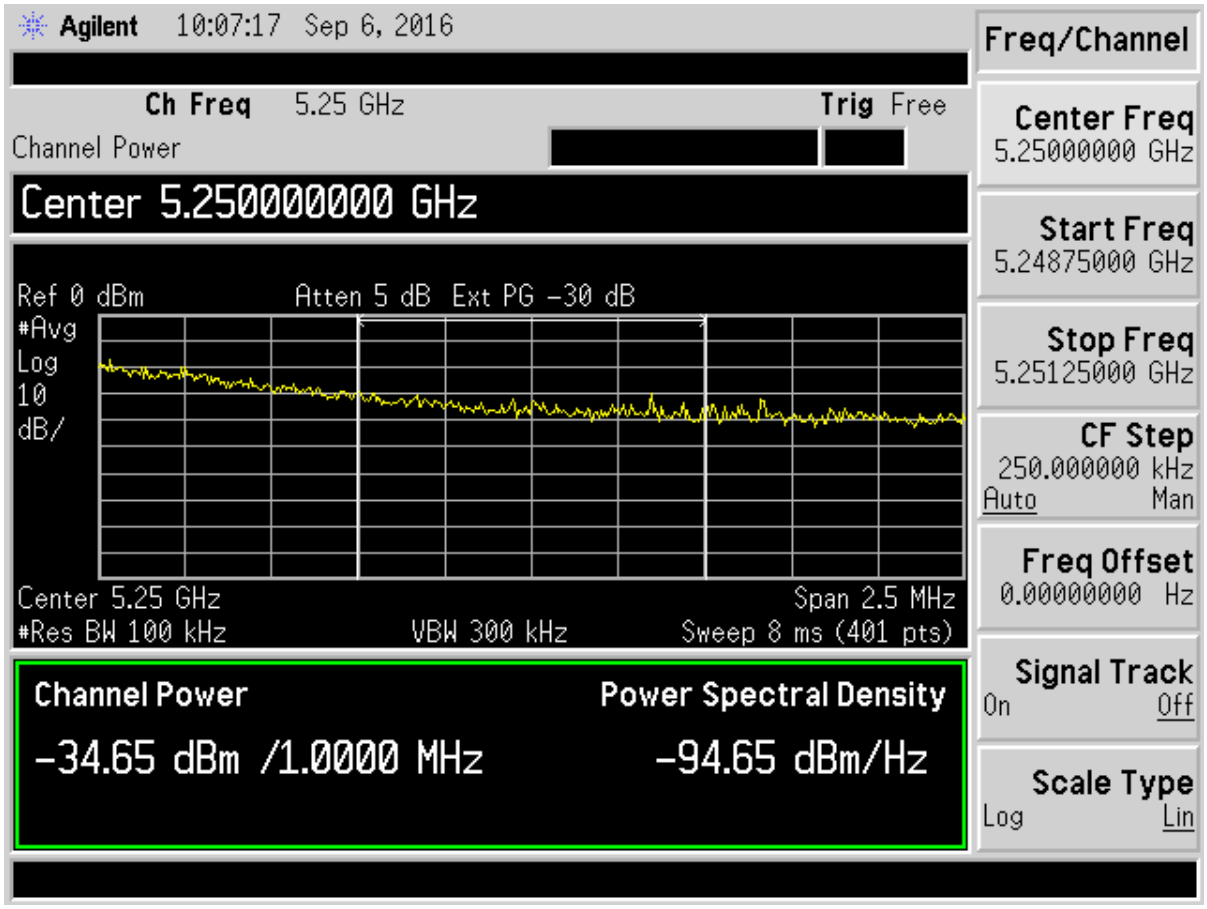


Figure 25. 5.25 GHZ Band Edge Compliance, 802.11n

Calculation:

Band Edge Limit	-27.00	dBm/MHz
-Calculated Result	-34.65	dBm/MHz
Band Edge Margin	7.65	dB

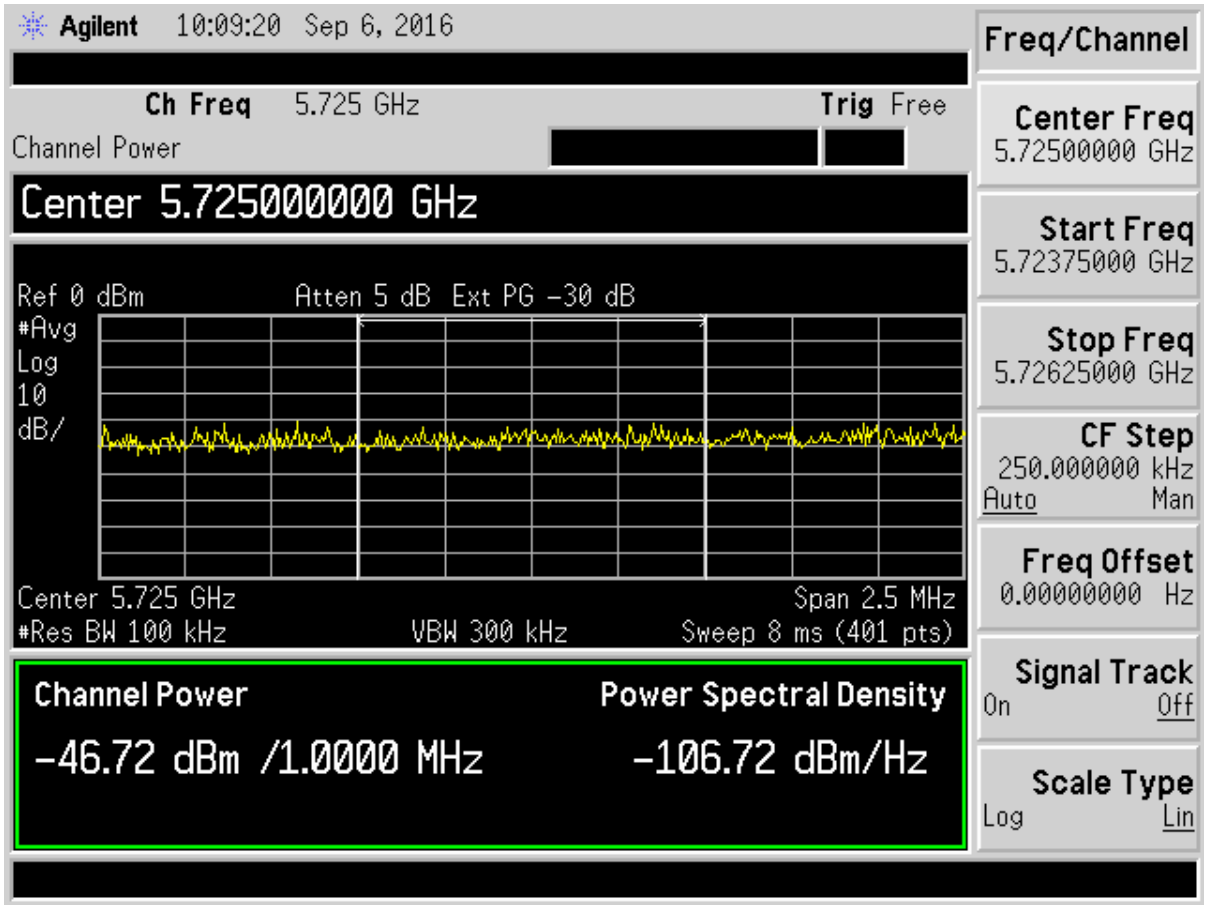


Figure 26. 5.725 GHZ Band Edge Compliance, 802.11n – Peak

Calculation:

Band Edge Limit	-27.00	dBm/MHz
-Calculated Result	-46.72	dBm/MHz
Band Edge Margin	19.72	dB

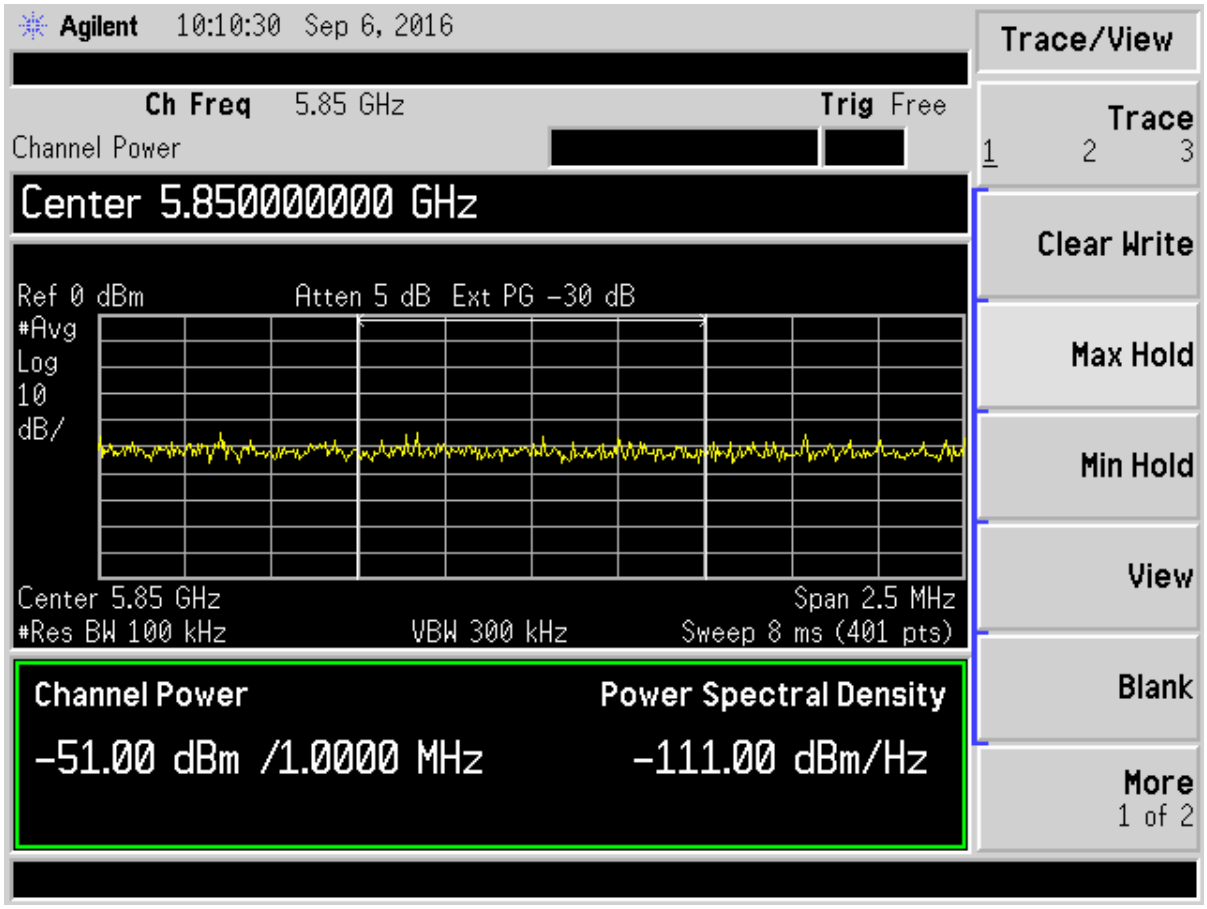


Figure 27. 5.825 GHZ Band Edge Compliance, 802.11n - Peak

Calculation:

Band Edge Limit	-27.00dBm/MHz	
-Calculated Result	-51.00dBm/MHz	
Band Edge Margin	24.00	dB

2.14 Unwanted Emissions in the Restricted Bands (CFR 15.205, 15.209)

Unwanted Emissions in the Restricted Bands were made following the guidelines in FCC KDB Publication No. 789033 D02 v01 with the EUT operating on the channels closest to the restricted bands of operation. These measurements were performed with the EUT transmitting at <98% duty Cycle.

To capture the unwanted emissions the Spectrum Analyzer frequency span set cover the full restricted band. Radiated measurements are performed with RBW = 1 MHz. In all cases, the VBW is set ≥ 3*RBW.

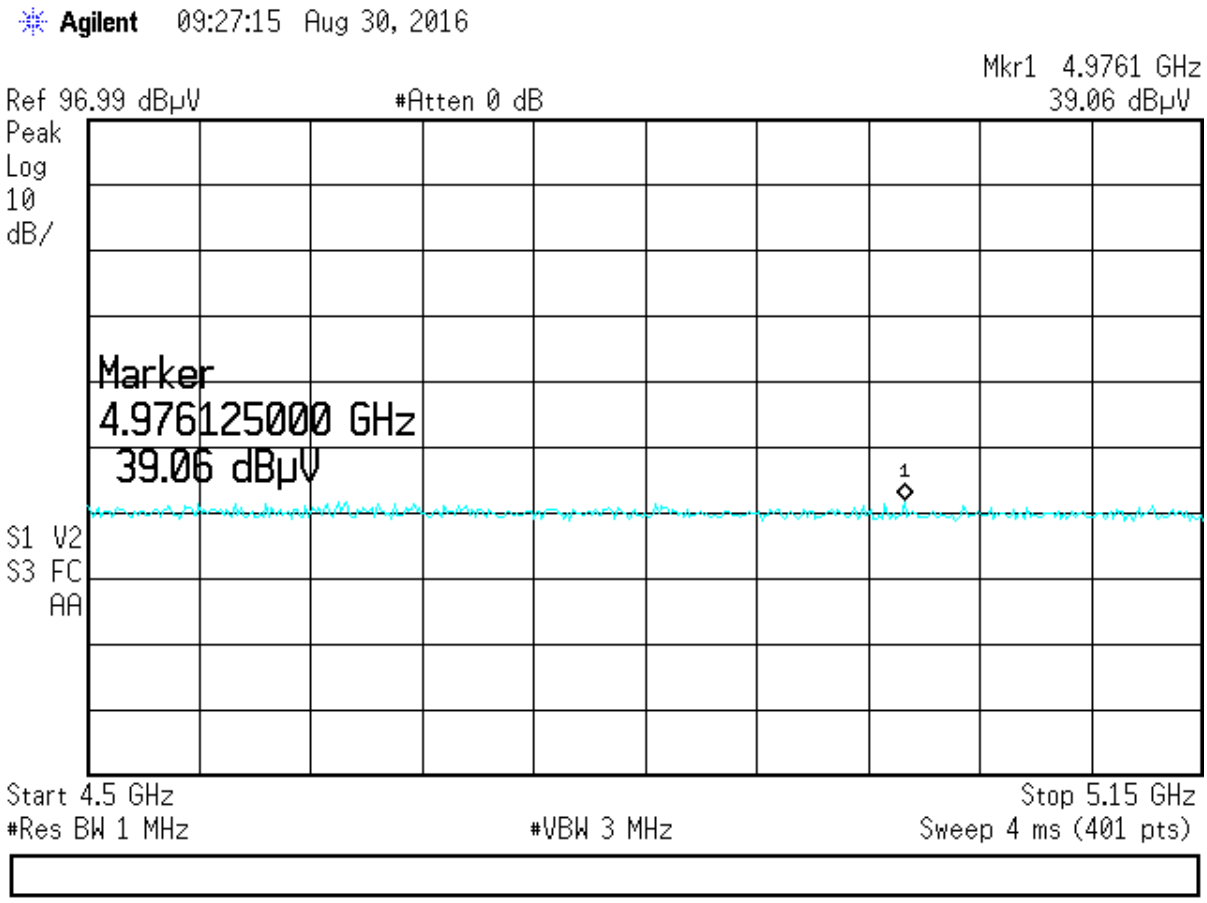


Figure 28. Restricted Band 4.5 - 5.15 GHz operating on Channel 36, 802.11n – Peak on Chip Antenna

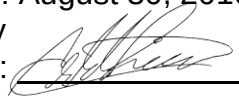
Table 11. Radiated Restricted Band 4.5 GHz to 5.15 GHz, 802.11n – Peak on Chip Antenna

4.5 GHz to 5.15 GHz Restricted Band Peak Measurements							
Test: Radiated Emissions				**Client:** Wink Labs, Inc.			
Project: 16-0219				**Model:** WINK HUB 2			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**PK Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
4976.13	39.06	32.72	71.78	74.0	3.0m./VERT	2.2	**PK**

Note: extrapolation factor of -9.5 dB applied to the results.

Sample calculation: at 4976.13 MHz, 39.06 dBuV + 32.72 (dB) = 71.78 dBuV/m

Margin= 74.0 dBuV/m – 71.78 dBuV/m = 2.22 dB

Test Date: August 30, 2016
Tested By
Signature:  Name: Ashton Picas

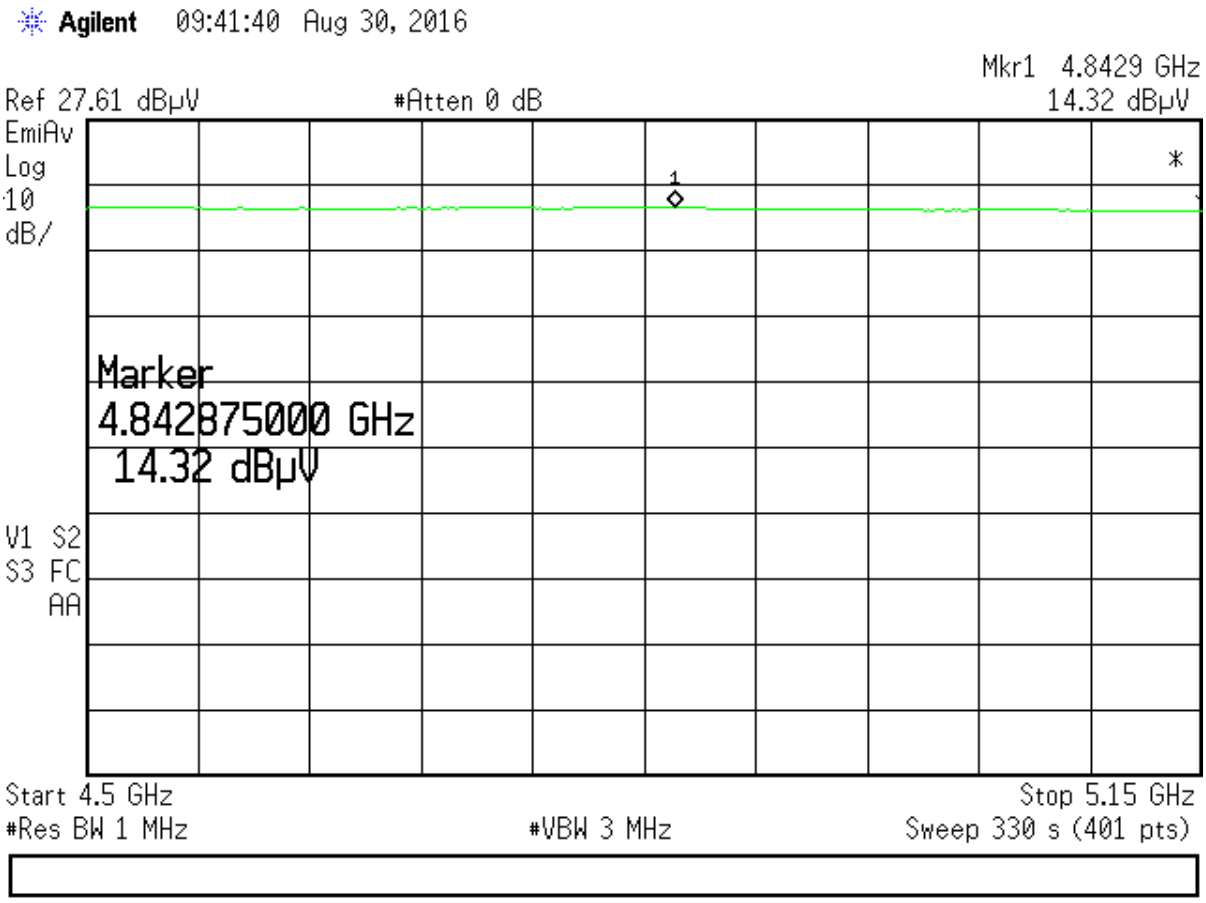


Figure 29. Restricted Band 4.5 - 5.15 GHz operating on Channel 36, 802.11n - Average on Chip Antenna

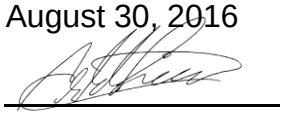
Table 12. Radiated Restricted Band 4.5 GHz to 5.15 GHz, 802.11n – Average on Chip Antenna

4.5 GHz to 5.15 GHz Restricted Band AVG Measurements							
Test: Radiated Emissions				**Client:** Wink Labs, Inc.			
Project: 16-0219				**Model:** WINK HUB 2			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
4842.87	14.13	32.72	47.04	54.0	3.0m./VERT	7.0	**AVG**

Note: extrapolation factor of -9.5 dB applied to the results.

Sample calculation: at 4842.87 MHz, 14.13 dBuV + 32.72 (dB) = 47.04 dBuV/m

Margin= 54 dBuV/m – 47.04 dBuV/m = 7.00 dB

Test Date: August 30, 2016
Tested By
Signature:  Name: Ashton Picas

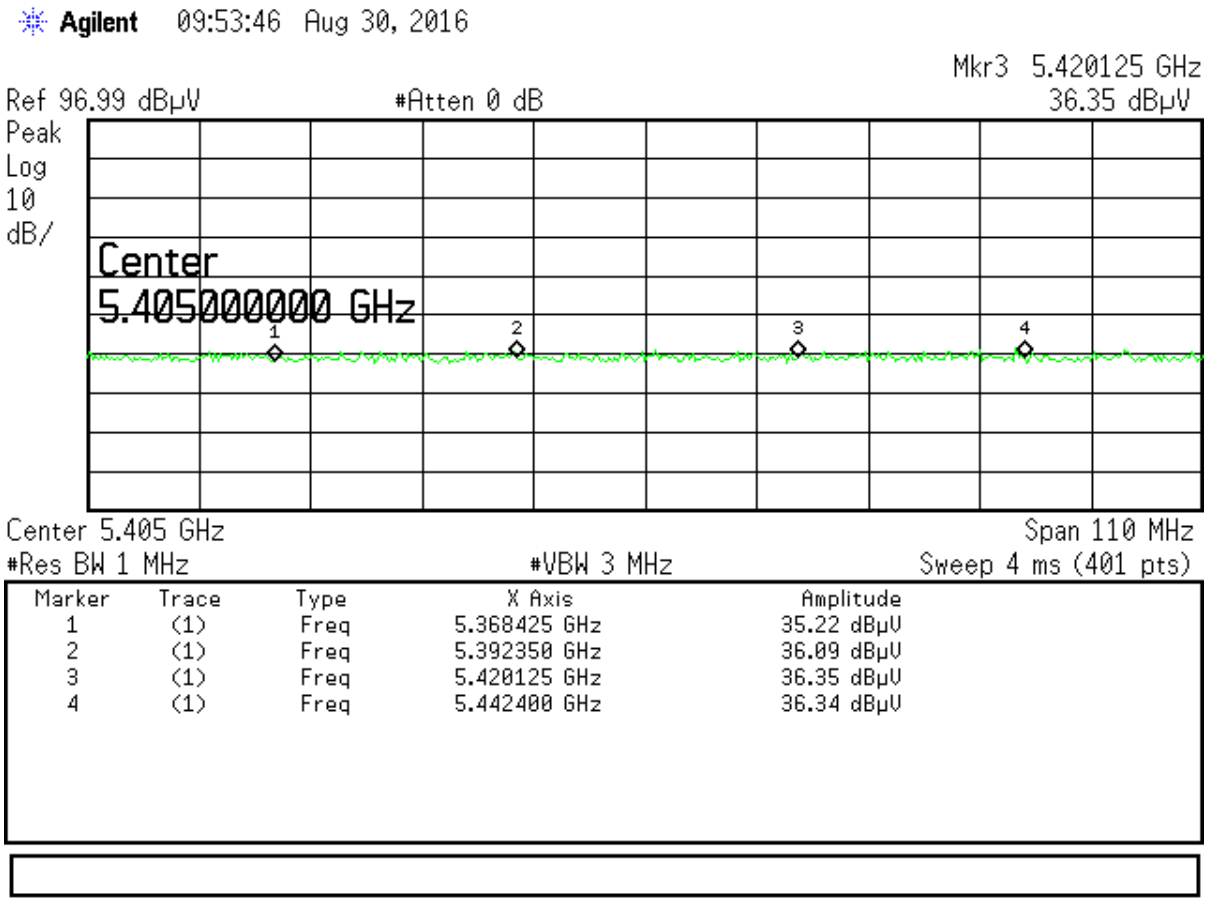


Figure 30. Restricted Band 4.5 - 5.15 GHz operating on Channel 36, 802.11a - Peak on Chip Antenna

Table 13. Radiated Restricted Band 4.5 GHz to 5.15 GHz, 802.11a – Peak on Chip Antenna

4.5 GHz to 5.15 GHz Restricted Band Peak Measurements							
Test: Radiated Emissions				**Client:** Wink Labs, Inc.			
Project: 16-0219				**Model:** WINK HUB 2			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**PK Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
5368.42	35.22	33.75	68.97	74.0	3.0m./VERT	5.0	**PK**
5392.35	36.09	33.75	69.84	74.0	3.0m./VERT	4.2	**PK**
5420.12	36.35	33.95	70.30	74.0	3.0m./VERT	3.7	**PK**
5442.40	36.34	33.95	70.29	74.0	3.0m./VERT	3.7	**PK**

Note: extrapolation factor of -9.5 dB applied to the results.

Sample calculation: at 5368.42 MHz, 35.22 dBuV = 68.97 dBuV/m

Margin= 74 dBuV/m – 68.97 dBuV/m= 5.00 dB

Test Date: August 30, 2016
Tested By
Signature: _____ Name: Ashton Picas

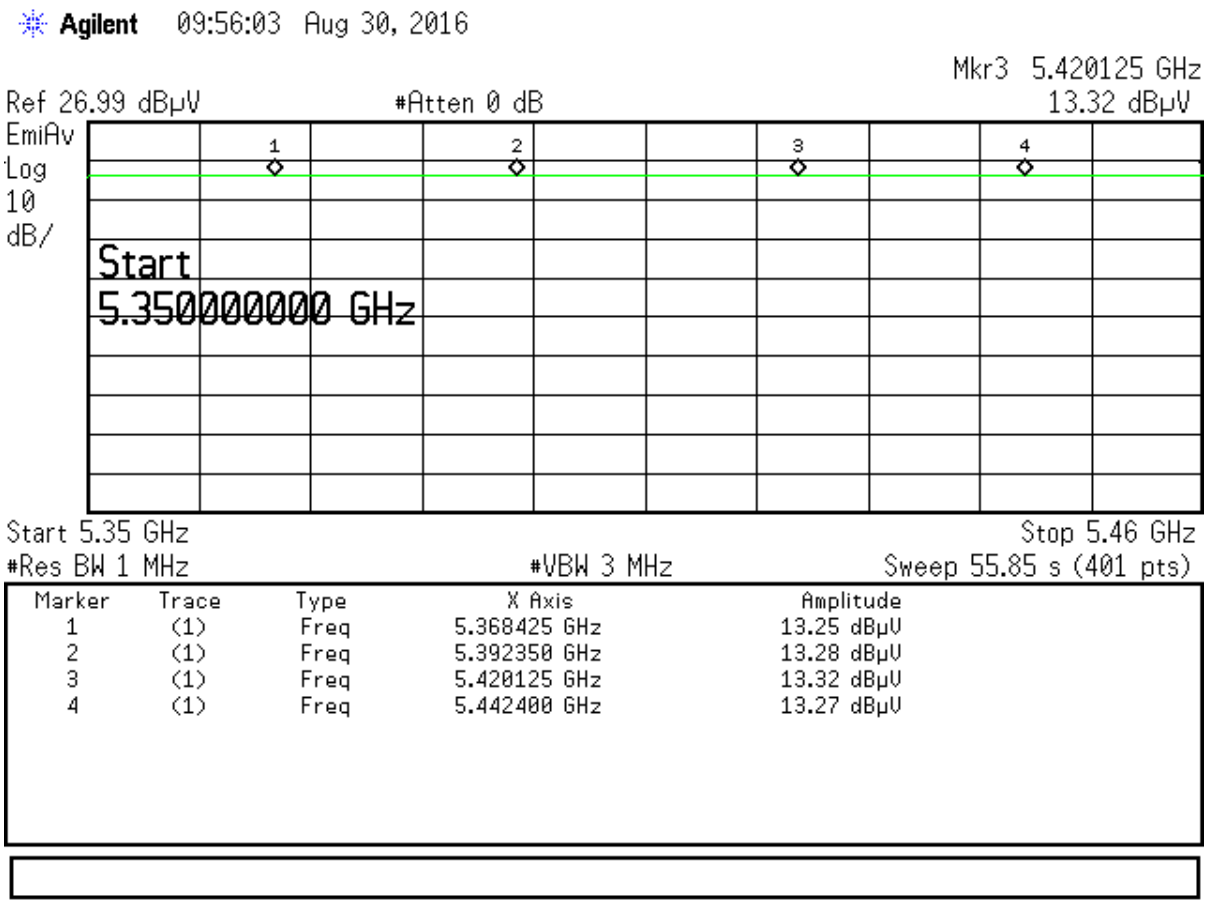


Figure 31. Restricted Band 4.5 - 5.15 GHz operating on Channel 36, 802.11a – Average on Chip Antenna

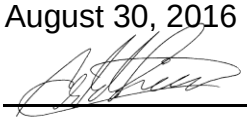
Table 14. Radiated Restricted Band 4.5 GHz to 5.15 GHz, 802.11a – Average on Chip Antenna

4.5 GHz to 5.15 GHz Restricted Band Average Measurements							
Test: Radiated Emissions				**Client:** Wink Labs, Inc.			
Project: 16-0219				**Model:** WINK HUB 2			
Frequency (MHz)	**Test Data (dBuv)**	**AF+CA-AMP (dB/m)**	**Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Antenna Distance/ Polarization**	**Margin (dB)**	**Detector PK, or AVG**
5368.42	13.25	38.51	47.00	54.0	3.0m./HORZ	7.0	**AVG**
5392.35	13.28	37.90	47.03	54.0	3.0m./HORZ	7.0	**AVG**
5420.12	13.32	39.26	47.27	54.0	3.0m./HORZ	6.7	**AVG**
5442.42	13.27	38.82	47.22	54.0	3.0m./HORZ	6.8	**AVG**

Note: extrapolation factor of -9.5 dB applied to the results.

Sample calculation: at 5368.42 MHz, 13.25 dBuV + 38.51 (dB) = 47.00 dBuV/m

Margin= 54 dBuV/m – 47.00 dBuV/m = 7.00 dB

Test Date: August 30, 2016
Tested By
Signature:  Name: Ashton Picas

2.15 Six (6) dB Bandwidth per CFR 15.407(e),

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω input impedance. The RBW was set to 1 MHz and with the VBW ≥ RBW. The results of this test are given in the table below and Figures below.

The minimum 6 dB bandwidth for EUT operation in the band 5.725-5.85 GHz shall be at least 500 kHz.

Table 15. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
802.11n		
5745	17.2324	0.500
5825	17.2571	0.500

Test Date: September 1, 2016
Tested By
Signature: _____ Name: Ashton Picas

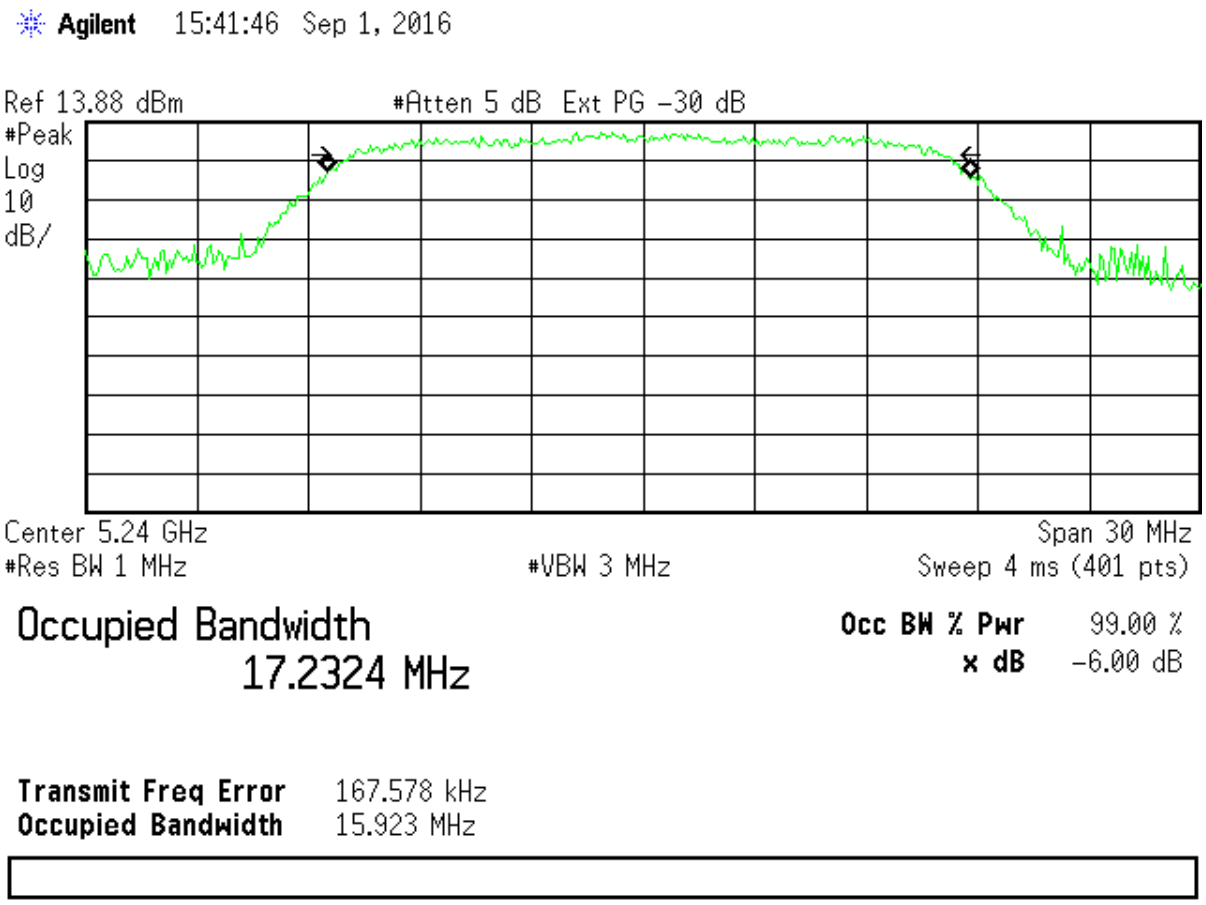


Figure 32. Six dB Bandwidth 802.11n - 15.407 - Low Channel

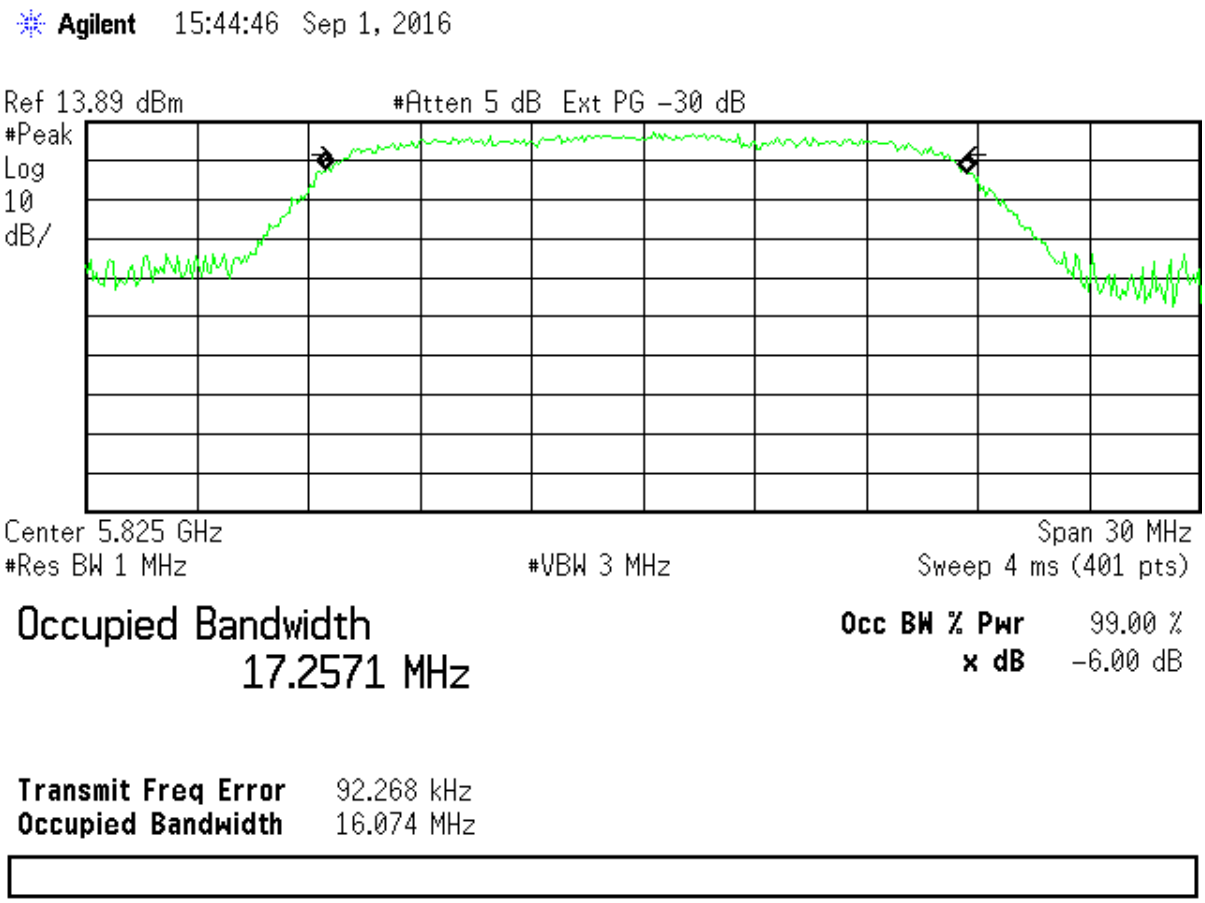


Figure 33. Six dB Bandwidth 802.11n - 15.407 - High Channel

2.16 Emission Bandwidth and 99% Occupied Bandwidth (15.407(a)(5), IC RSS 247, 6.4)

These measurements were performed while the EUT was in a constant transmit mode. The spectrum analyzers bandwidth measurement was used to determined the 26 dB bandwidth and the 99 % BW. The test procedures in the KDB document 789033 D02 v01 were followed. The RBW was set to approximately1 % to 5 % times the OBW with the VBW ≥ RBW and the span 1.5 to 5.0 times the OBW. The results of this test are given in Table 10 and 11 and Figures 86-99.

Table 23. 26 dB Bandwidth and 99% Occupied Bandwidth for 802.11n

Frequency (MHz)	26 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
5180	18.789	16.423
5240	18.687	16.528
5745	15.388	16.300
5825	15.168	16.726

Test Date: September 1, 2016
Tested By
Signature: _____ Name: Ashton Picas

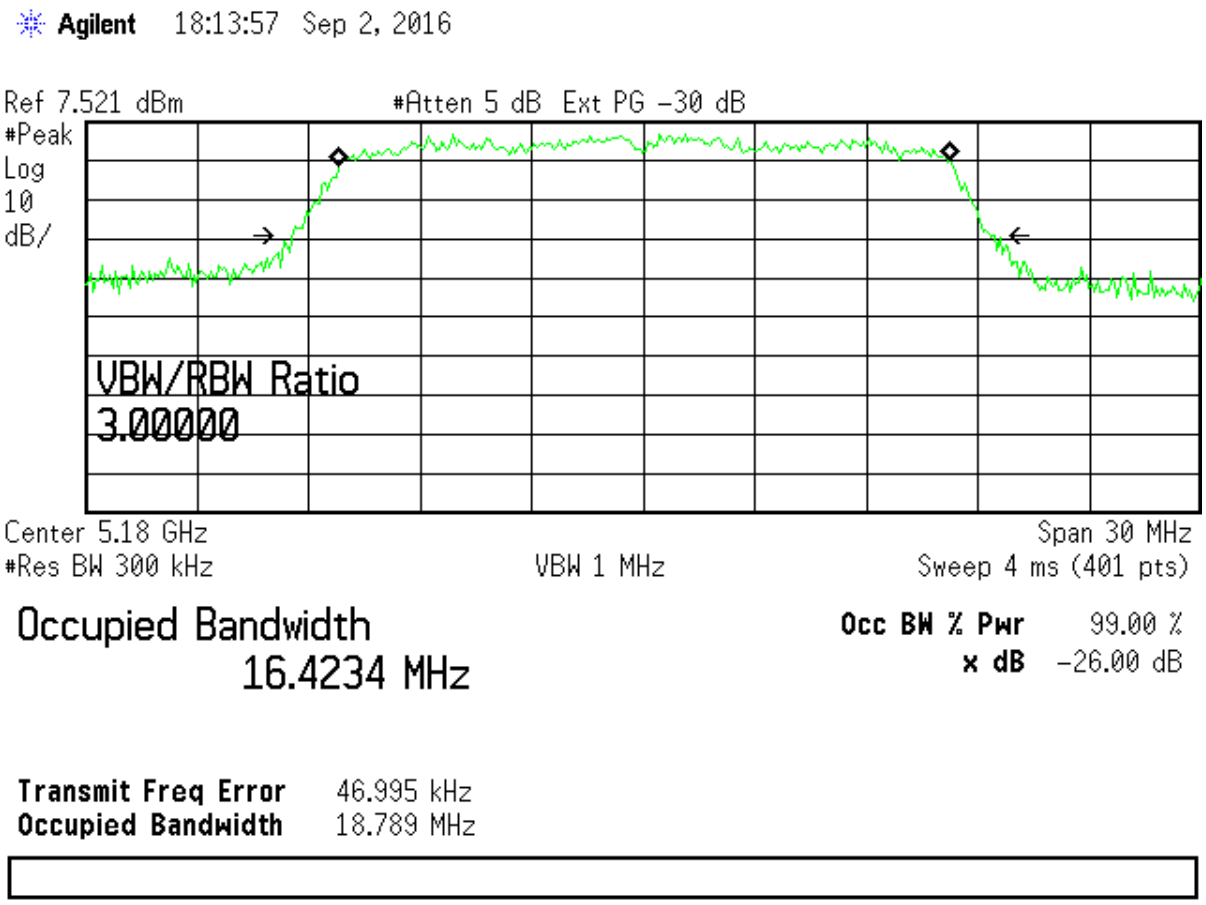


Figure 34. 26 dB BW and OBW -802.11n- Channel 36

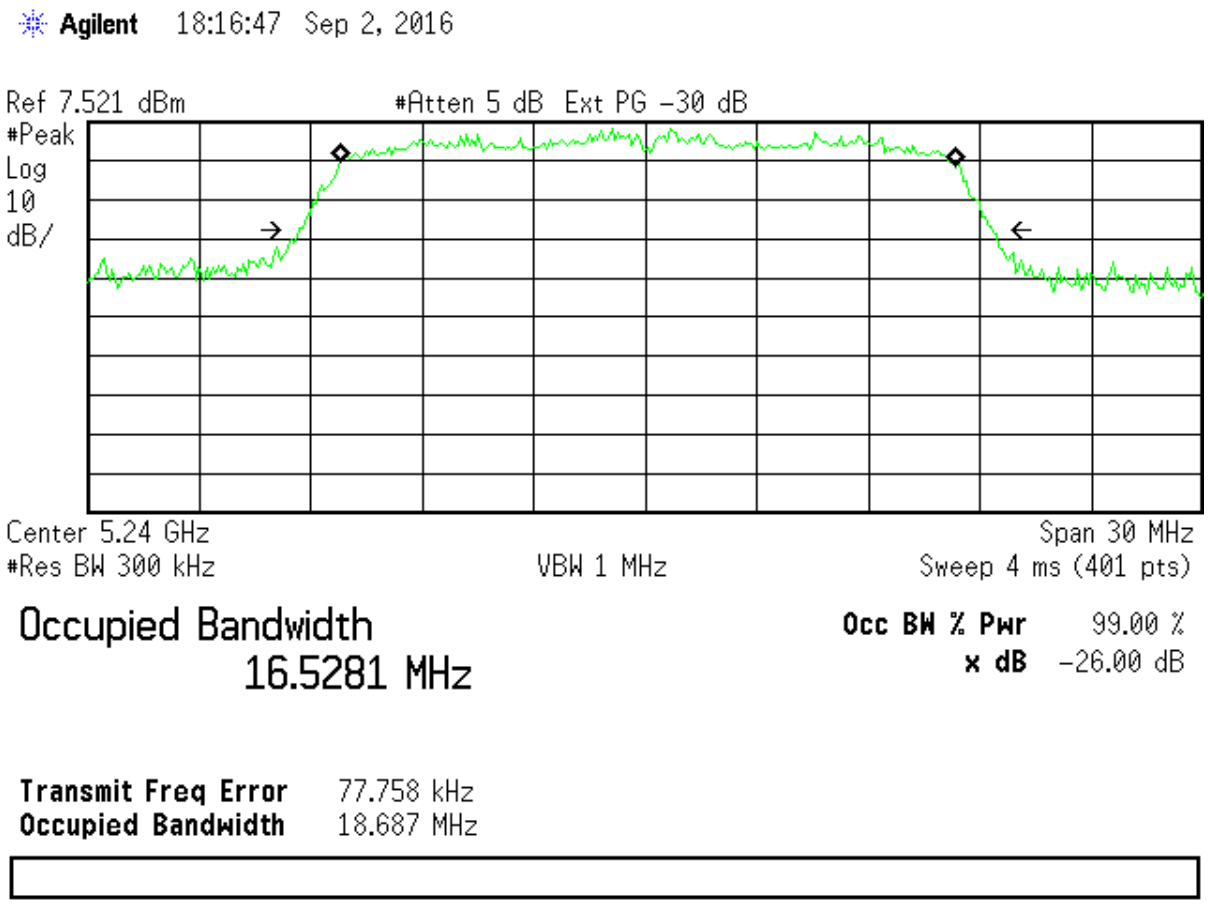


Figure 35. 26 dB BW and OBW -802.11n- Channel 48

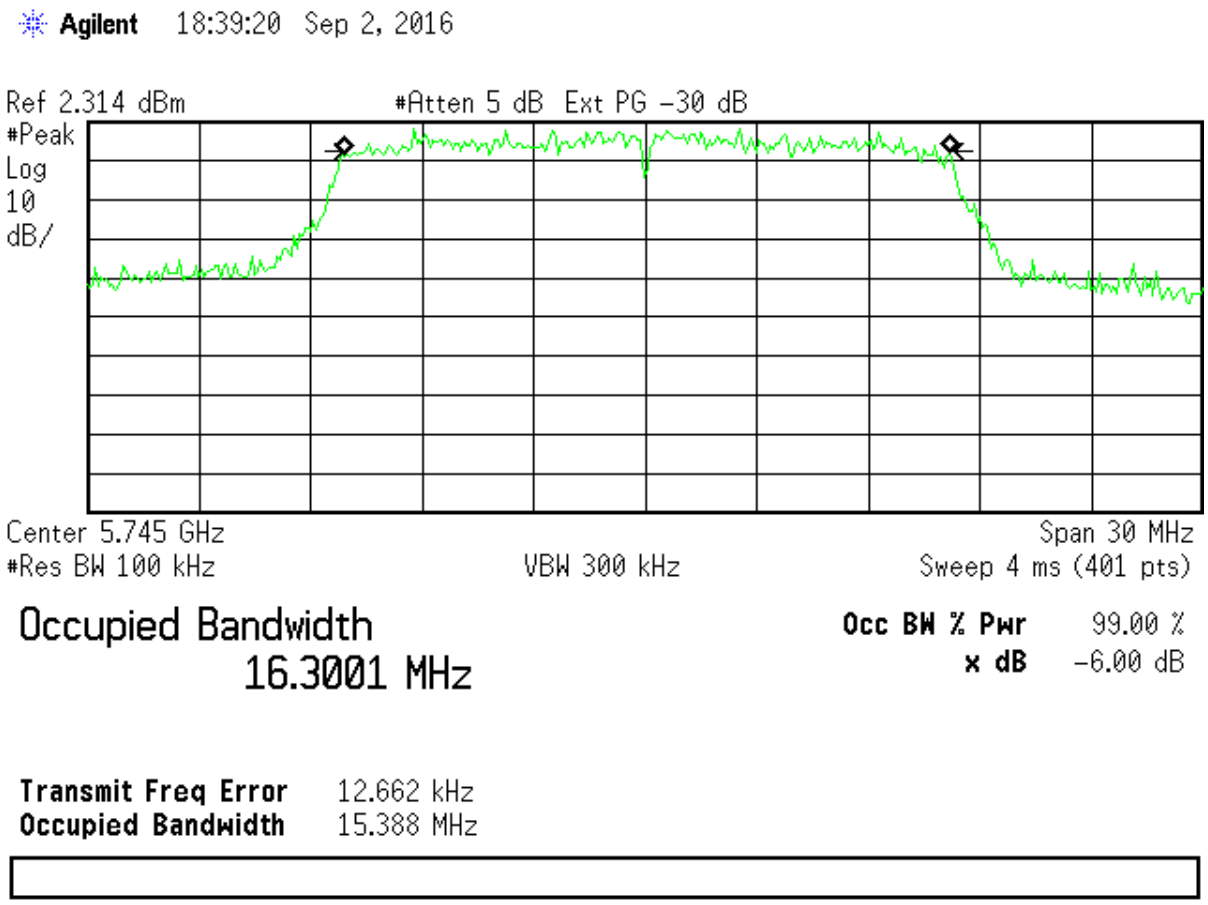


Figure 36. 26 dB BW and OBW -802.11n- Channel 149

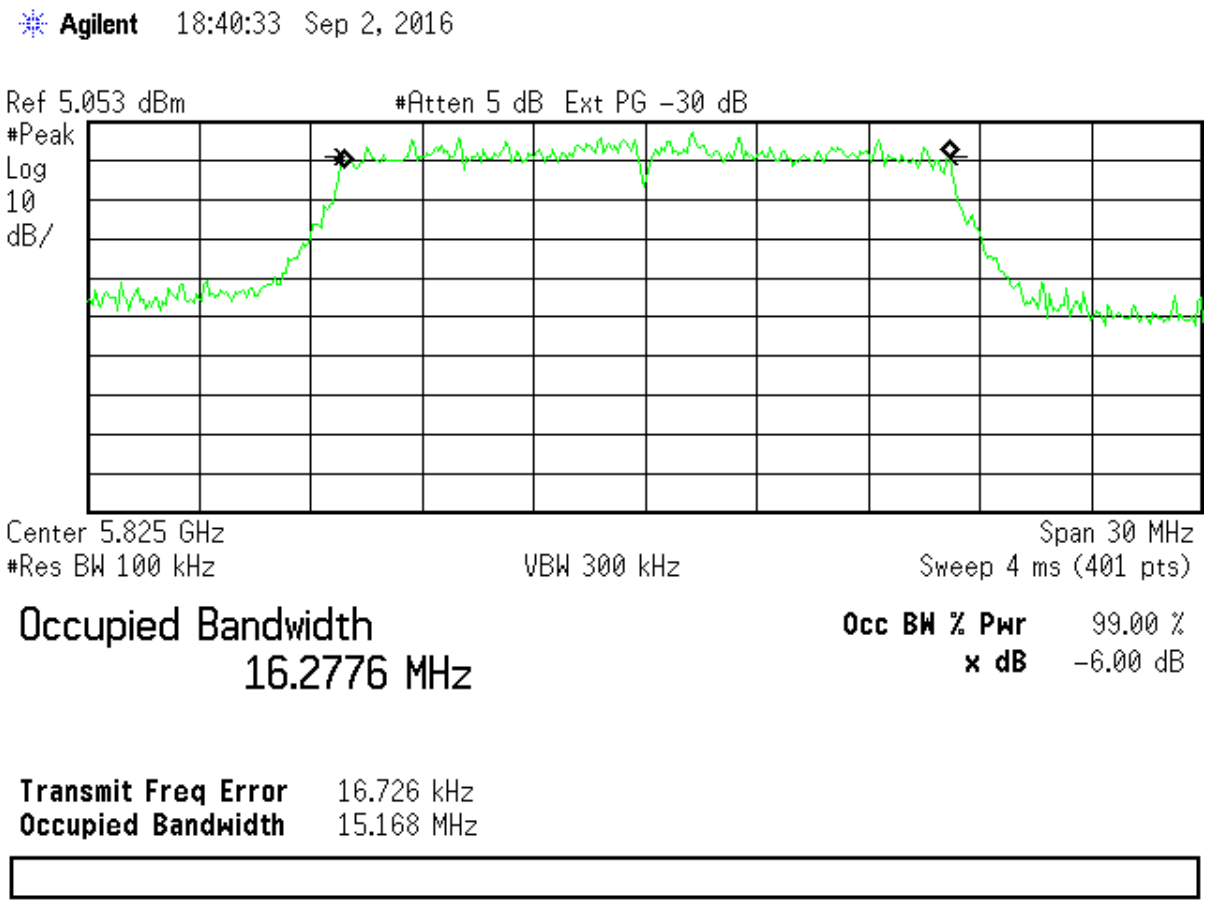


Figure 37. 26 dB BW and OBW -802.11n- Channel 165

2.17 Frequency Stability (CFR 15.407 (g))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The RBW was set to 1 MHz and the Video Bandwidth was set to ≥ 3*RBW. The span was adjusted during testing to ensure measurement accuracy. The carrier frequency was measured from 50˚C to -30˚C at 10 ˚C increments and at 85 % nominal voltage to 115 % Nominal voltage to ensure that it stayed within the band of operation.

Table 16. Frequency Stability 50˚C to -30˚C for 802.11n Channel 36

Temperature (˚C)	Measured Frequency (MHz)	Deviation (ppm)
-30	5180.0304	5.9
-20	5180.0385	7.4
-10	5180.0383	7.4
0	5180.0321	6.2
10	5180.0164	3.2
20	5180.0157	3.0
30	5180.0084	1.6
40	5180.0050	1.0
50	5180.0081	1.6

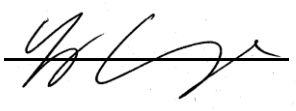
Test Date: September 6, 2016
Tested By
Signature:  Name: George Yang

Table 17. Frequency Stability 50˚C to -30˚C for 802.11n Channel 48

Temperature (˚C)	Measured Frequency (MHz)	Deviation (ppm)
-30	5240.0310	5.9
-20	5240.0390	7.4
-10	5240.0387	7.4
0	5240.0327	6.2
10	5240.0175	3.3
20	5240.0161	3.1
30	5240.0084	1.6
40	5240.0046	0.9
50	5240.0083	1.6

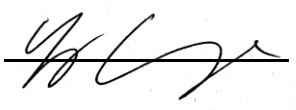
Test Date: September 6, 2016
Tested By
Signature:  Name: George Yang

Table 18. Frequency Stability 50˚C to -30˚C for 802.11n Channel 149

Temperature (˚C)	Measured Frequency (MHz)	Deviation (ppm)
-30	5745.0355	6.2
-20	5745.0432	7.5
-10	5745.0422	7.3
0	5745.0351	6.1
10	5745.0204	3.5
20	5745.0170	3.0
30	5745.0089	1.5
40	5745.0051	0.9
50	5745.0096	1.7

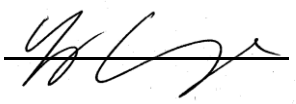
Test Date: September 6, 2016
Tested By
Signature:  Name: George Yang

Table 19. Frequency Stability 50˚C to -30˚C for 802.11n Channel 165

Temperature (˚C)	Measured Frequency (MHz)	Deviation (ppm)
-30	5825.0352	6.0
-20	5825.0437	7.5
-10	5825.0430	7.4
0	5825.0361	6.2
10	5825.0221	3.8
20	5825.0175	3.0
30	5825.0092	1.6
40	5825.0051	0.9
50	5825.0094	1.6

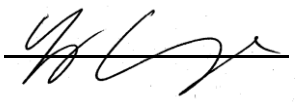
Test Date: September 6, 2016
Tested By
Signature:  Name: George Yang

Table 35. Frequency Stability 85% voltage to 115% voltage for 802.11n Channel 36

Voltage (%)	Measured Frequency (MHz)	Deviation (ppm)
85%	5180.0162	3.1
100%	5180.0157	3.0
115%	5180.0162	3.1

Table 36. Frequency Stability 85% voltage to 115% voltage for 802.11n Channel 48

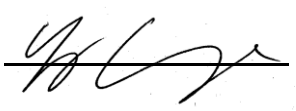
Voltage (%)	Measured Frequency (MHz)	Deviation (ppm)
85%	5240.0166	3.2
100%	5240.0161	3.1
115%	5240.0163	3.1

Table 37. Frequency Stability 85% voltage to 115% voltage for 802.11n Channel 149

Voltage (%)	Measured Frequency (MHz)	Deviation (ppm)
85%	5745.0175	3.1
100%	5745.0170	3.0
115%	5745.0173	3.0

Table 38. Frequency Stability 85% voltage to 115% voltage for 802.11n Channel 165

Voltage (%)	Measured Frequency (MHz)	Deviation (ppm)
85%	5825.0180	3.1
100%	5825.0175	3.0
115%	5825.0178	3.1

Test Date: September 6, 2016
Tested By
Signature:  Name: George Yang

2.18 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2. 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 ± 2.78 dB.

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 ± 5.39 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 ± 5.18 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ± 5.21dB.