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 C, paragraphs 15.207, 15.209 and 15.247

For the

WINK Inc.

Model: HUB
(WIFI Radio Evaluation)

FCC ID: 2ACAJ-WINK22

UST Project: 14-0071
Issue Date: May 15, 2014

Total Pages in this Report: 102

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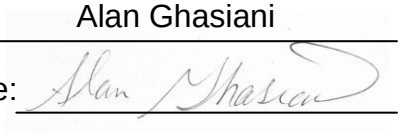
I certify that I am authorized to sign for the Test Agency and that all of the statements in this report and in the Exhibits attached hereto are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date May 15, 2014

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: WINK Inc.

MODEL: HUB

FCC ID: 2ACAJ-WINK22

DATE: May 15, 2014

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
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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 247.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on April 14, 2014 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the WINK Inc. home automation radio module, model HUB. The HUB has five transmitters, including: three 2.4 GHZ transmitters (Wifi, Bluetooth, and Zigbee), one 908 MHz transmitter (Zwave), and one 431 MHz transmitter (Lutron). The circuit board uses four trace 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 WiFi transmitter which includes 802.11b, 802.11g, and 802.11n. The test results for the other transmitters will be covered in separate reports.

Below are excerpts from a customer email describing the function of the transmitters.

The 802.11b testing:

1. The 802.11b test was run using a data rate of 11Mb/s using a 20MHz channel bandwidth (22MHz actual spacing)
2. The 802.11b test used DSSS (direct sequence spread spectrum) with CCK (complimentary code keying) spread spectrum with QPSK modulation for a total data rate of 11Mb/s

Looking at the two WiFi standards:

1. 802.11G and 802.11N both use OFDM with QAM64 modulation (at the higher data rates) providing 6 bits per symbol at high data rates 54Mb/s and 65Mb/s respectively
2. 802.11G uses a coding rate of ¾ while 802.11N uses 5/6 with less FEC which is more efficient, so N can push more data through, given the same bandwidth, with one spatial stream (no MIMO)
3. 802.11G uses 64 subcarriers (OFDM) while 802.11N uses 52
4. 802.11G symbol rate is slightly lower at 54Mb/s 187.5KHz vs. 250KHz for 802.11N
5. The occupied channel bandwidth (using 20MHz) channels would be almost identical

Based on these parameters, I would agree that G testing would not be necessary, assuming that N testing was completed. The spectral content would be almost identical.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.4:2003, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2003)* for FCC subpart B Digital equipment Verification requirements and per FCC KDB Publication number 558074 for Digital Transmission Systems Operating Under section 15.247. Also, FCC, KDB Publication No. 558074 was used as a test procedure guide.

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 2982A-1.

1.6 Related Submittal(s)/Grant(s)

The EUT will be used to wirelessly send/receive data. The transceiver presented in this report will be used with other like transceivers.

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification of the transmitter (with modular approval), see test data presented herein.

b) Verification as a class B digital device.

This device is a final product and is not a sub component; other radio testing was done and is compiled in other reports in this submittal.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER.	MODEL NUMBER	SERIAL NUMBER	FCC ID:	CABLES P/D
Home Gateway WINK Inc (EUT)	HUB	Engineering Sample	Pending: 2ACAJ-WINK22	1.5 m U Power cable
Antenna See antenna details	--	--	--	--

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	11/8/2013
SPECTRUM ANALYZER	8566B	HEWLETT-PACKARD	2410A00109	2/03/2014
RF PREAMP 100 kHz to 1.3 GHz	8447D	HEWLETT-PACKARD	2944A06291	2/06/2014
LOOP ANTENNA	SAS-200/562	A. H. Systems	142	9/12/2013 2 yr cycle
BICONICAL ANTENNA	3110B	EMCO	9306-1708	7/02/2012 2 yr cycle
LOG PERIODIC ANTENNA	3146	EMCO	3110-3236	6/05/12 2 yr cycle
HORN ANTENNA	SAS-571	A. H. Systems	605	7/23/2013 2 yr cycle
HORN ANTENNA	3116	EMCO	9505-2255	8/9/2012 2 yr cycle
PREAMP 1.0 GHz to 26.0 GHz	8449B	HEWLETT-PACKARD	3008A00480	2/06/14
LISN	8028-50-TS24-BNC	Solar Electronics	910495 & 910496	3/19/2014
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 physical modifications were made by US Tech in order to bring the EUT into compliance with FCC Part 15, Subpart C Intentional Radiator Limits for the transmitter portion of the EUT or the Subpart B Unintentional Radiator Limits (Receiver and Digital Device) Requirements.

During intentional radiation testing, the software setting for the output power was changed to bring the EUT into compliance with Part 15.247 limits.

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 were 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 10^{th} 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.

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 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 1	WINK INC	'F' Trace	NA	2.3	Printed PCB

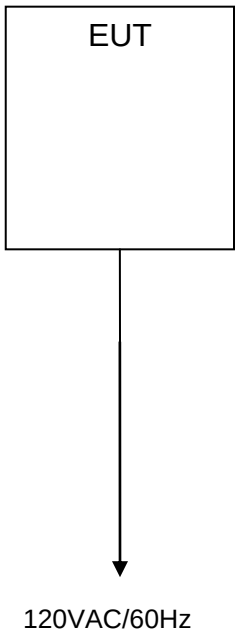


Figure 1. Test Configuration

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 (CFR 35 (c))

The transmitter is capable of sending three types of transmissions. They are listed below, along with their pulse-width duration:

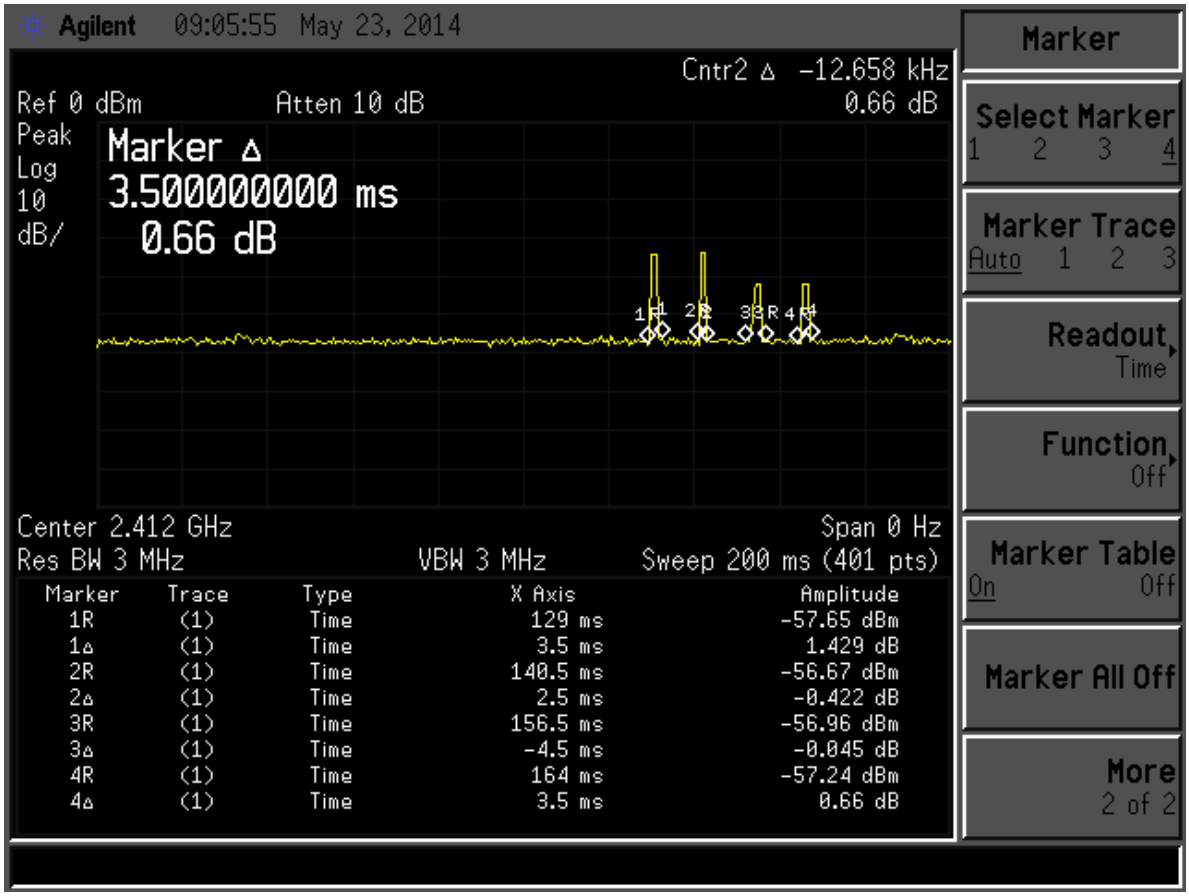


Figure 2. Duty Cycle 200ms Sweep

Total Time On from Figure 2 = 2.25mS

(14.0mS Total Time On)/(100mS FCC Standard) = 0.14 Numeric Duty Cycle
Duty Cycle = 20 Log (.14) = -17.0dB

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.

2.9 Intentional Radiator, Power Lines Conducted Emissions (CFR 15.207)

The power line conducted voltage emission measurements have been carried out in accordance with CFR 15.207, per ANSI C63.4:2003, Paragraph 7, with a spectrum analyzer connected to an LISN and the EUT placed into a continuous mode of transmission.

The worst-case results for conducted emissions were determined to be produced when the EUT was operating under continuous transmission. The worst case measurement occurred on the neutral line at 0.1646 MHz. The emission level was 6.3 dB from the applicable limit. All other emissions were at least 6.4 dB from the limit. Those results are given in the table following.

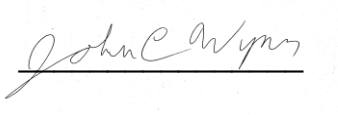
Table 5. Transmitter Power Line Conducted Emissions Test Data, Part 15.207

CONDUCTED EMISSIONS 150 kHz to 30 MHz						
Tested By: JCW	Specification Requirement: FCC Part 15.207 Class B		Project No.: 14-0071	Manufacturer: WINK Inc. Model: HUB		
Frequency (MHz)	**Test Data (dBuV)**	**LISN+CL (dB)**	**Corrected Results (dBuV)**	**Avg Limits (dBuV)**	**Margin (dB)**	**Detector**
120 VAC, 60 Hz, Phase Line						
0.1512	48.10	1.40	49.50	55.9	6.4	PK
0.5048	40.80	0.43	41.23	46.0	4.8	PK
1.4560	36.40	0.36	36.76	46.0	9.2	PK
5.1850	31.40	0.45	31.85	50.0	18.2	PK
15.0700	28.70	0.66	29.36	50.0	20.6	PK
28.1300	27.90	0.77	28.67	50.0	21.3	PK
120 VAC, 60 Hz, Neutral Line						
0.1646	47.70	1.24	48.94	55.2	6.3	PK
0.5083	31.60	0.42	32.02	46.0	14.0	PK
1.4320	34.30	0.35	34.65	46.0	11.3	PK
5.0450	32.10	0.44	32.54	50.0	17.5	PK
19.0200	29.60	0.61	30.21	50.0	19.8	PK
22.5400	27.90	0.65	28.55	50.0	21.4	PK

(*)= Quasi-Peak limit used

SAMPLE CALCULATION at 0.1512 MHz:

Magnitude of Measured Frequency	48.10	dBuV
+ Cable Loss+ LISN Loss	1.40	dB
Corrected Result	49.50	dBuV

Test Date: May 9, 2014
Tested By
Signature:  Name: John C. Wynn

2.10 Intentional Radiator, Radiated Emissions (Antenna Conducted) (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 for conducted out of band emissions emanating from the antenna port over the frequency range of 30 MHz to 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 4 through 30 below. The limit for antenna conducted power is 1 Watt (30 dBm) per 15.247 (b)(3).

For antenna conducted radiated measurements a short coax with a SMA connector was soldered to the board; also the trace antenna was disconnected. The EUT was set into a continuous transmission mode. The RBW of the measuring instrument was set equal to 100 kHz. The VBW was set to an equal or larger bandwidth, VBW >= RBW. Note if the device complies with the use of power option 2 the attenuation under this paragraph shall be 30 dB instead of 20 db.

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.

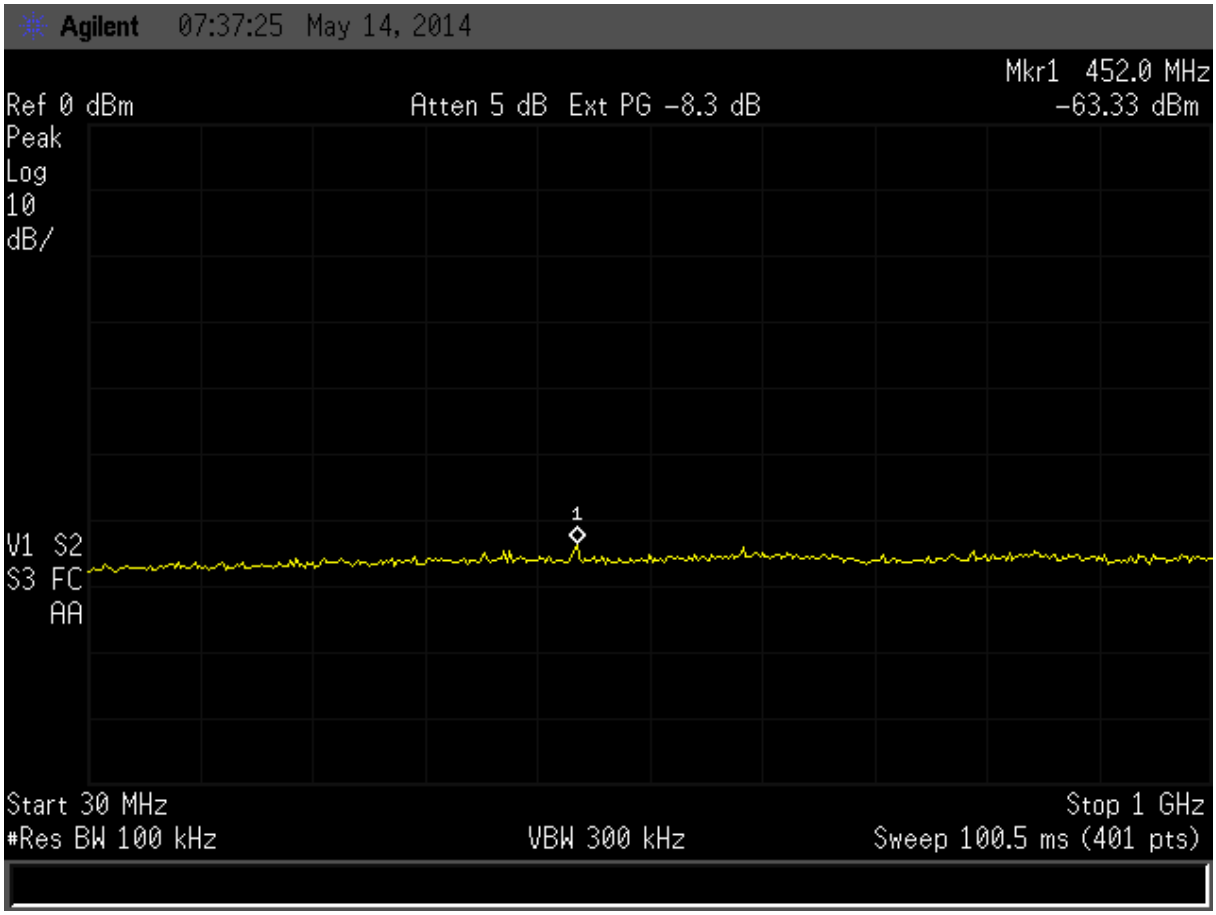


Figure 3. Antenna Conducted Emissions 802.11b Low, Part 1

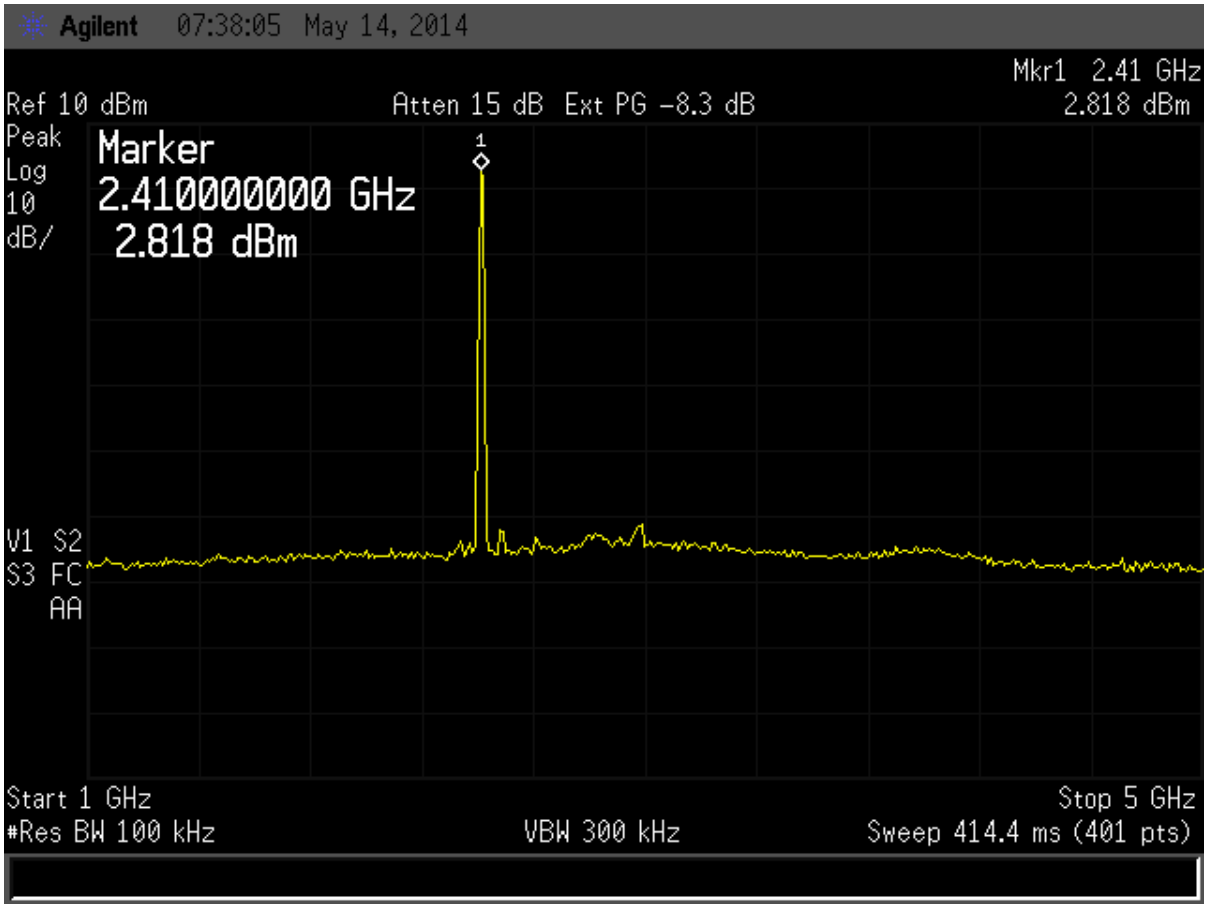


Figure 4. Antenna Conducted Emissions 802.11b Low, Part 2

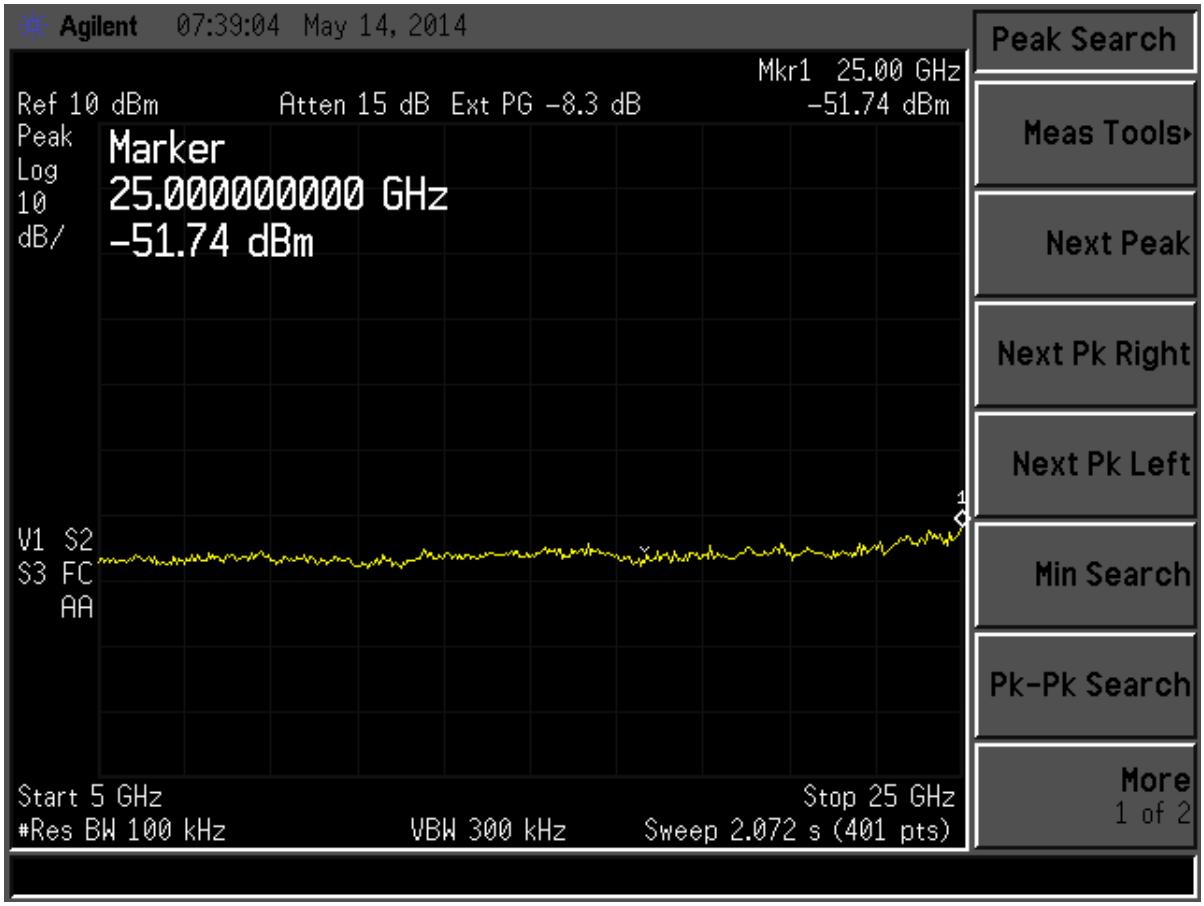


Figure 5. Antenna Conducted Emissions 802.11b Low, Part 3

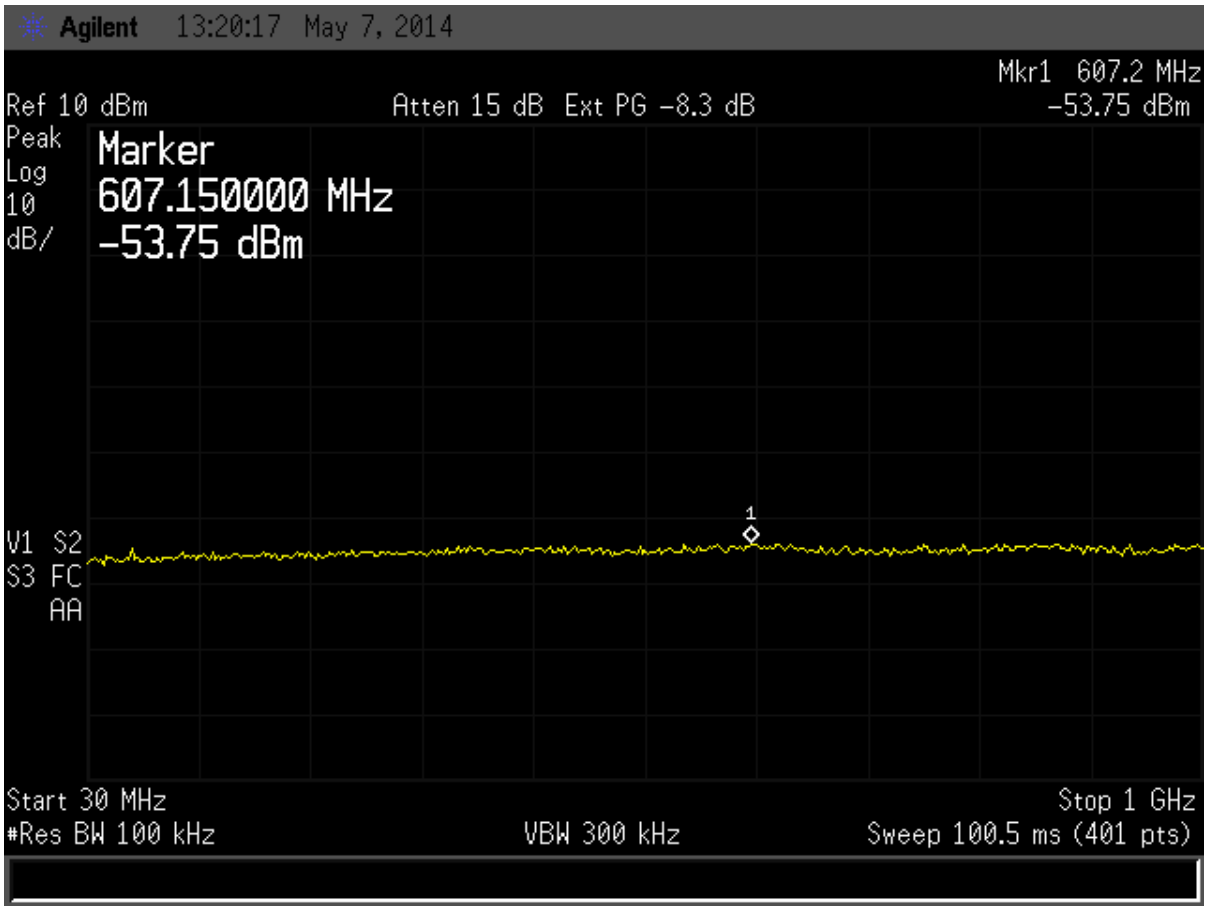


Figure 6. Antenna Conducted Emissions 802.11b Mid, Part 1

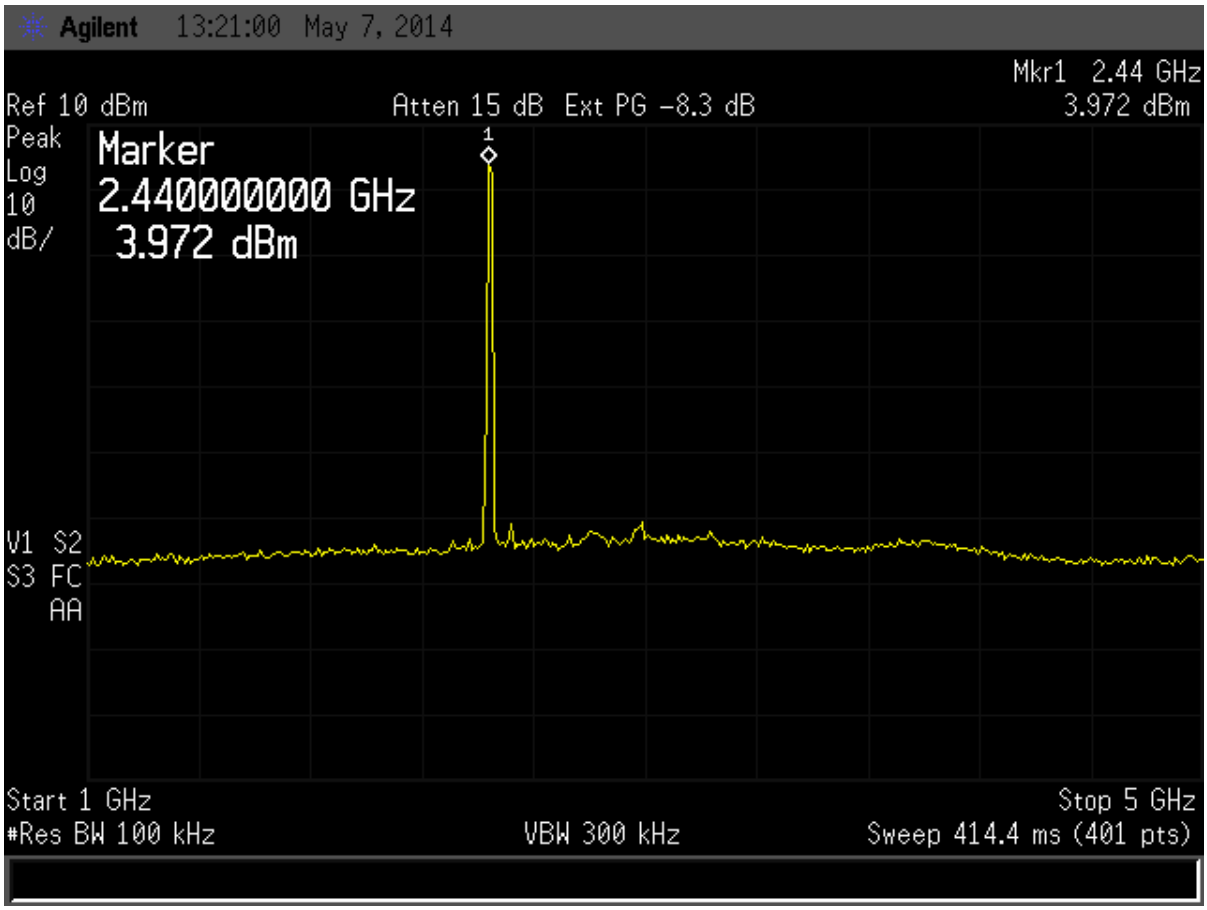


Figure 7. Antenna Conducted Emissions 802.11b Mid, Part 2

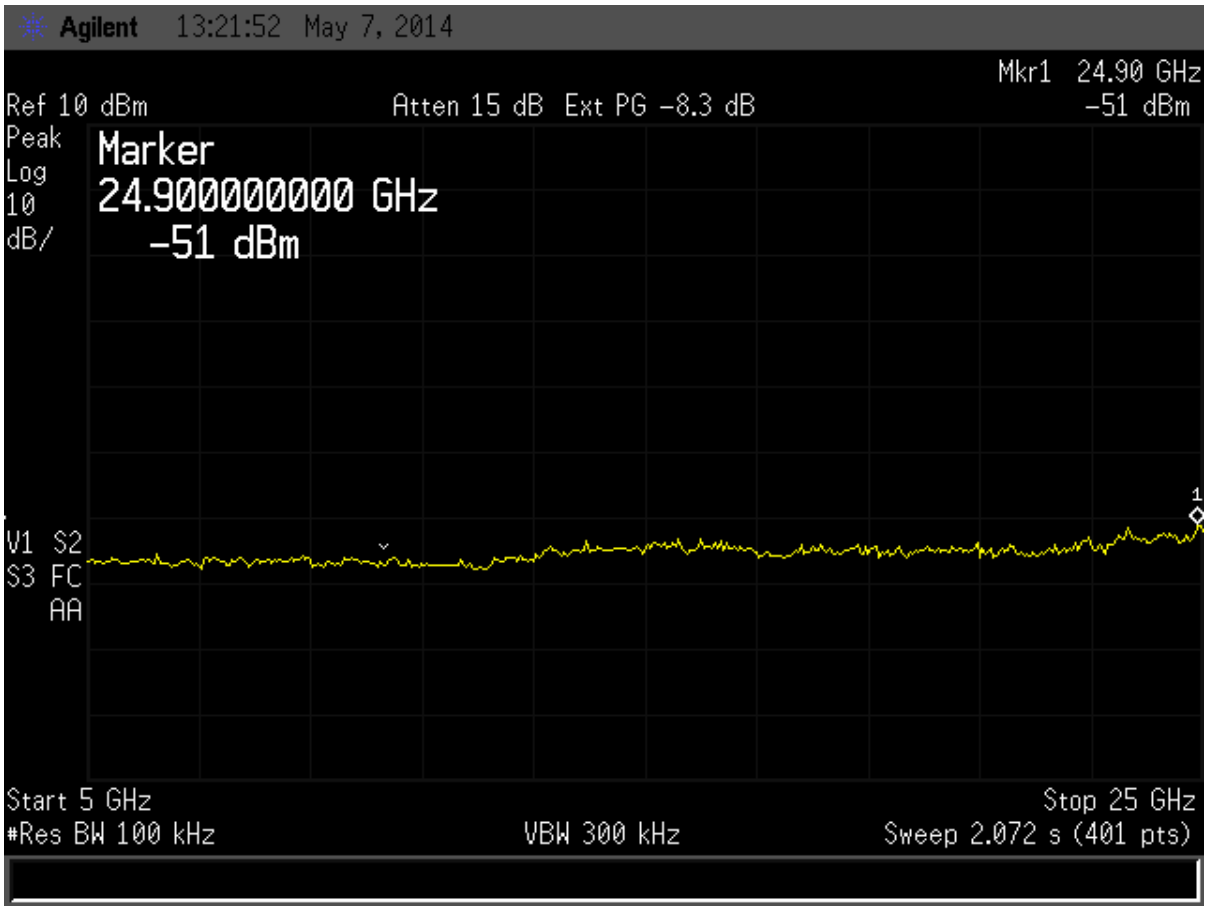


Figure 8. Antenna Conducted Emissions 802.11b Mid, Part 3

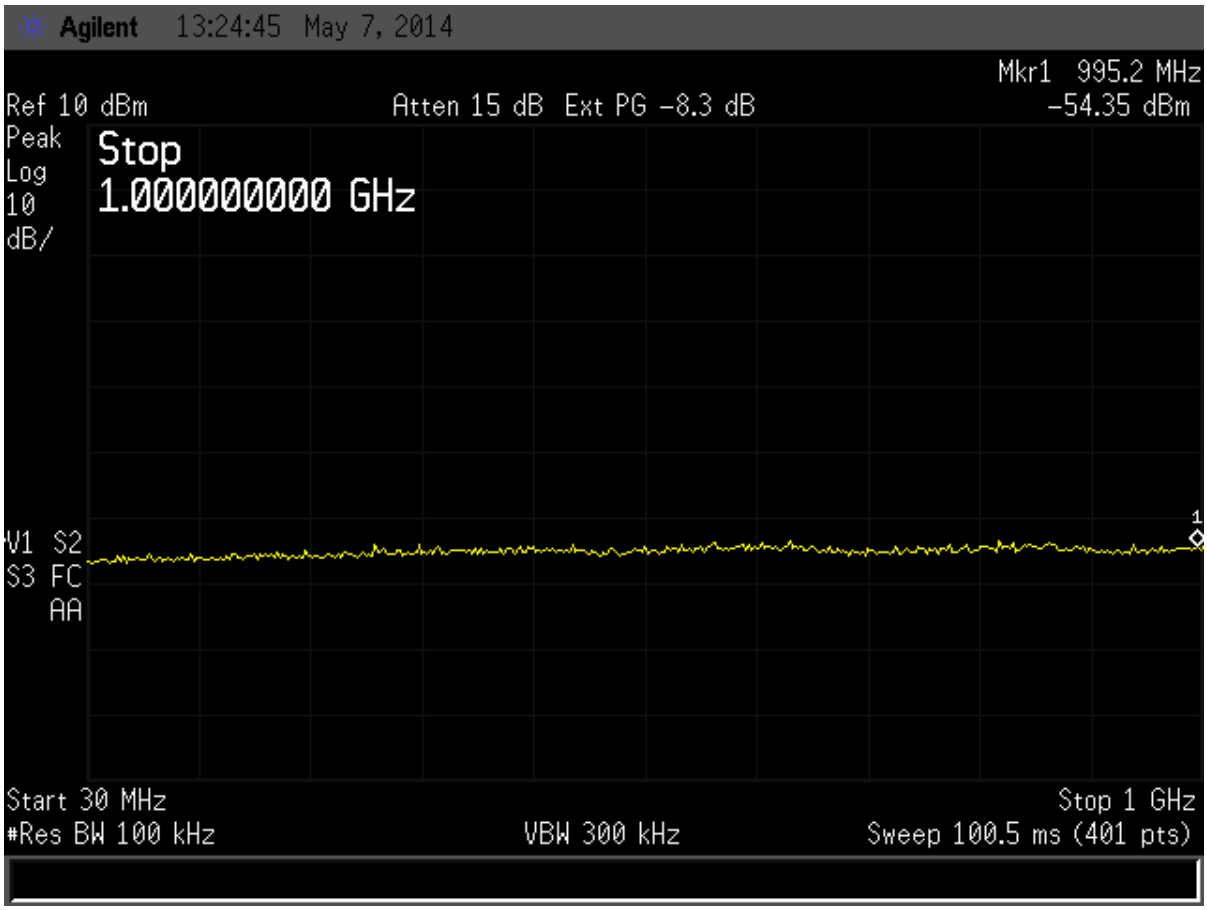


Figure 9. Antenna Conducted Emissions 802.11b High, Part 1

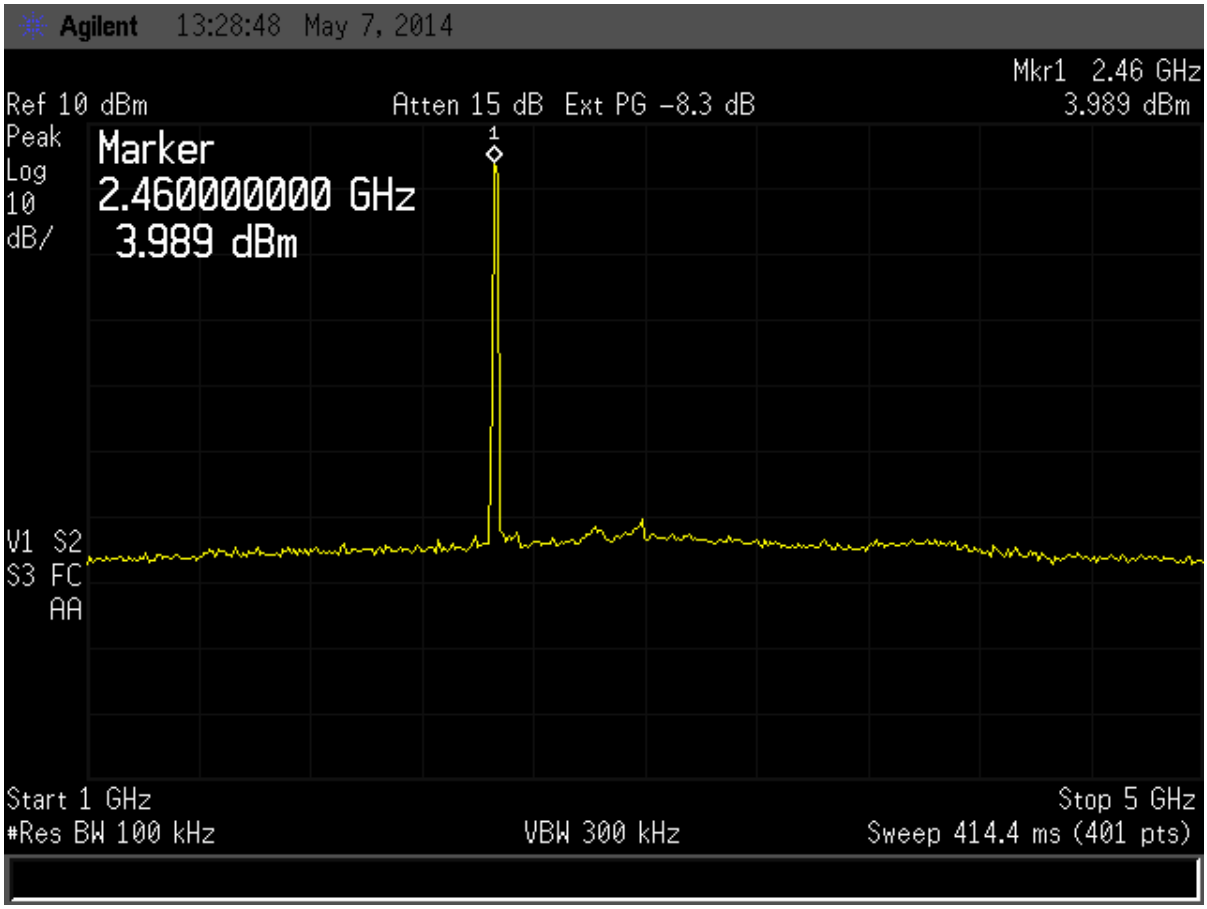


Figure 10. Antenna Conducted Emissions 802.11b High, Part 2

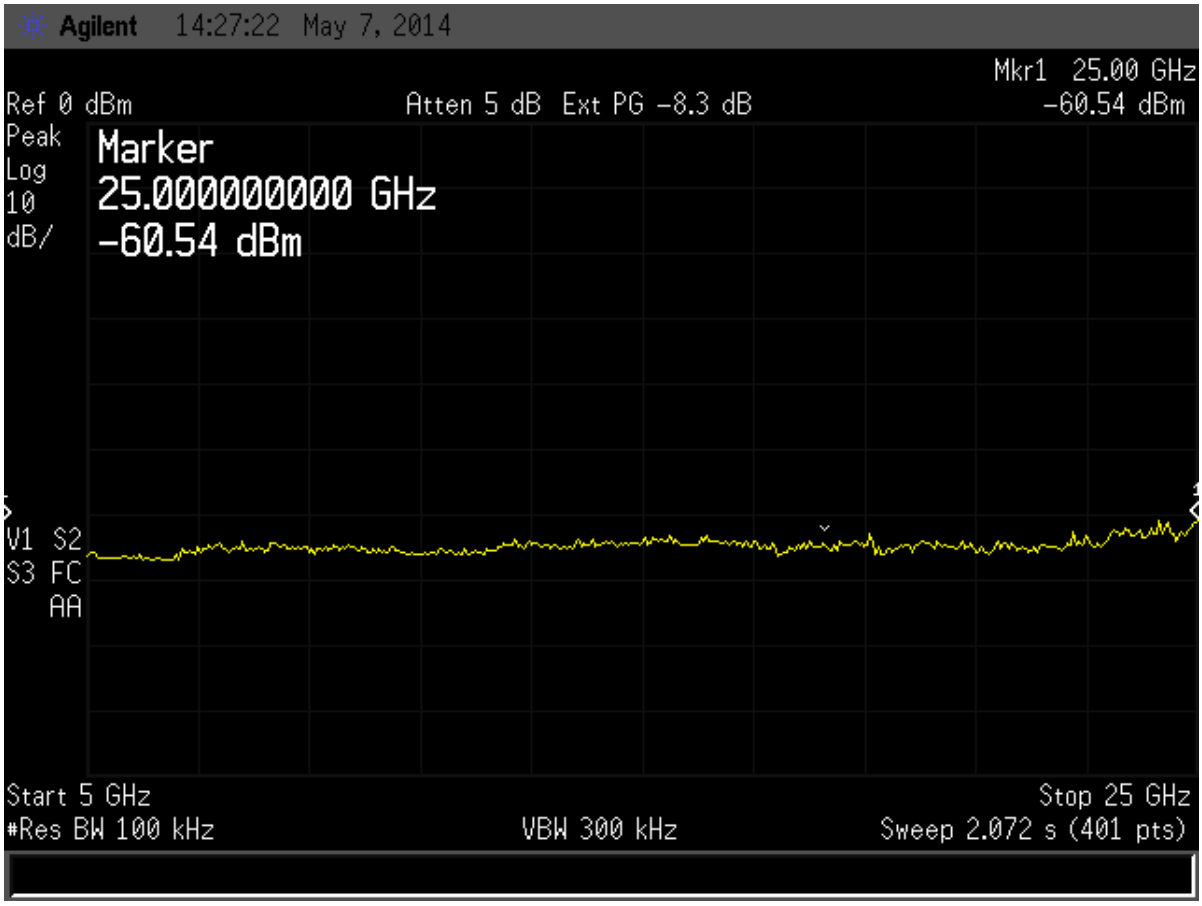


Figure 11. Antenna Conducted Emissions 802.11b High, Part 3

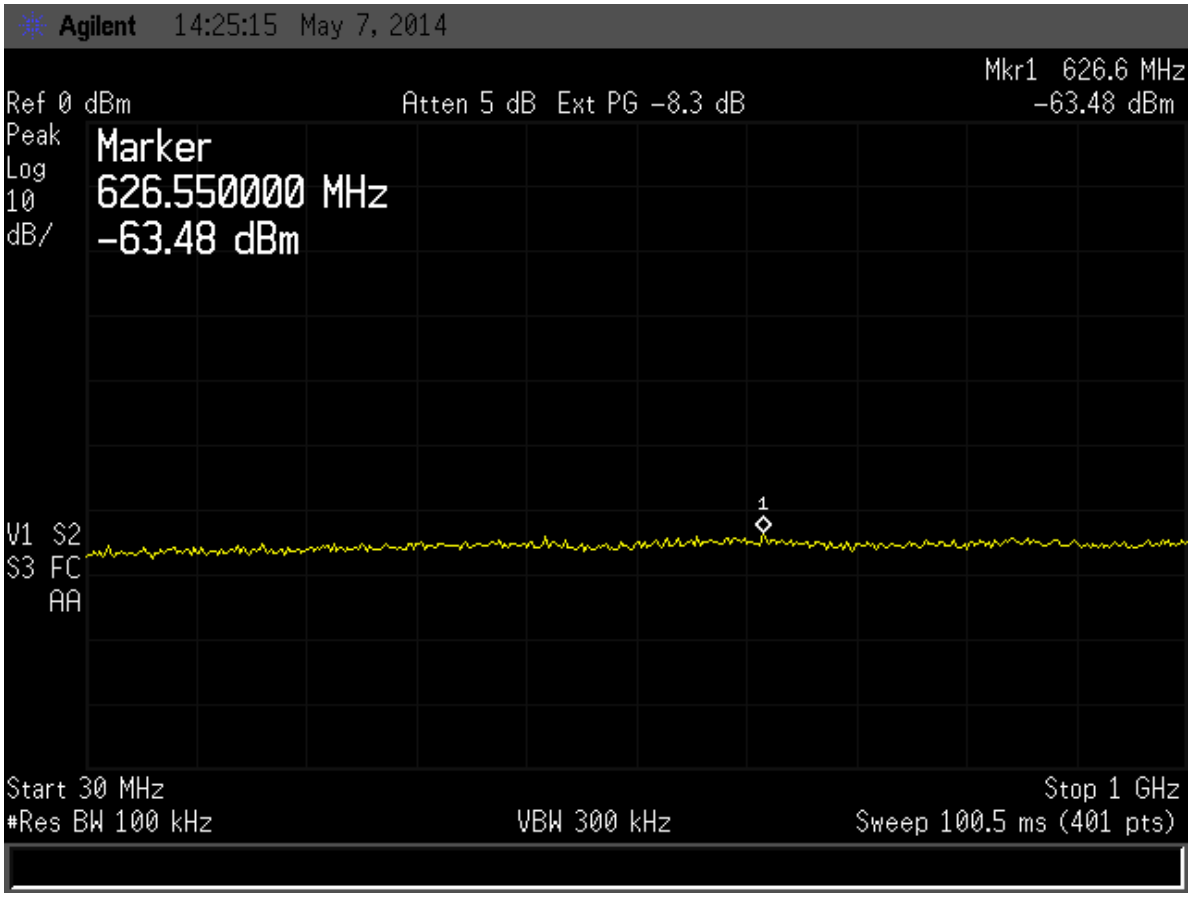


Figure 12. Antenna Conducted Emissions 802.11g Low, Part 1

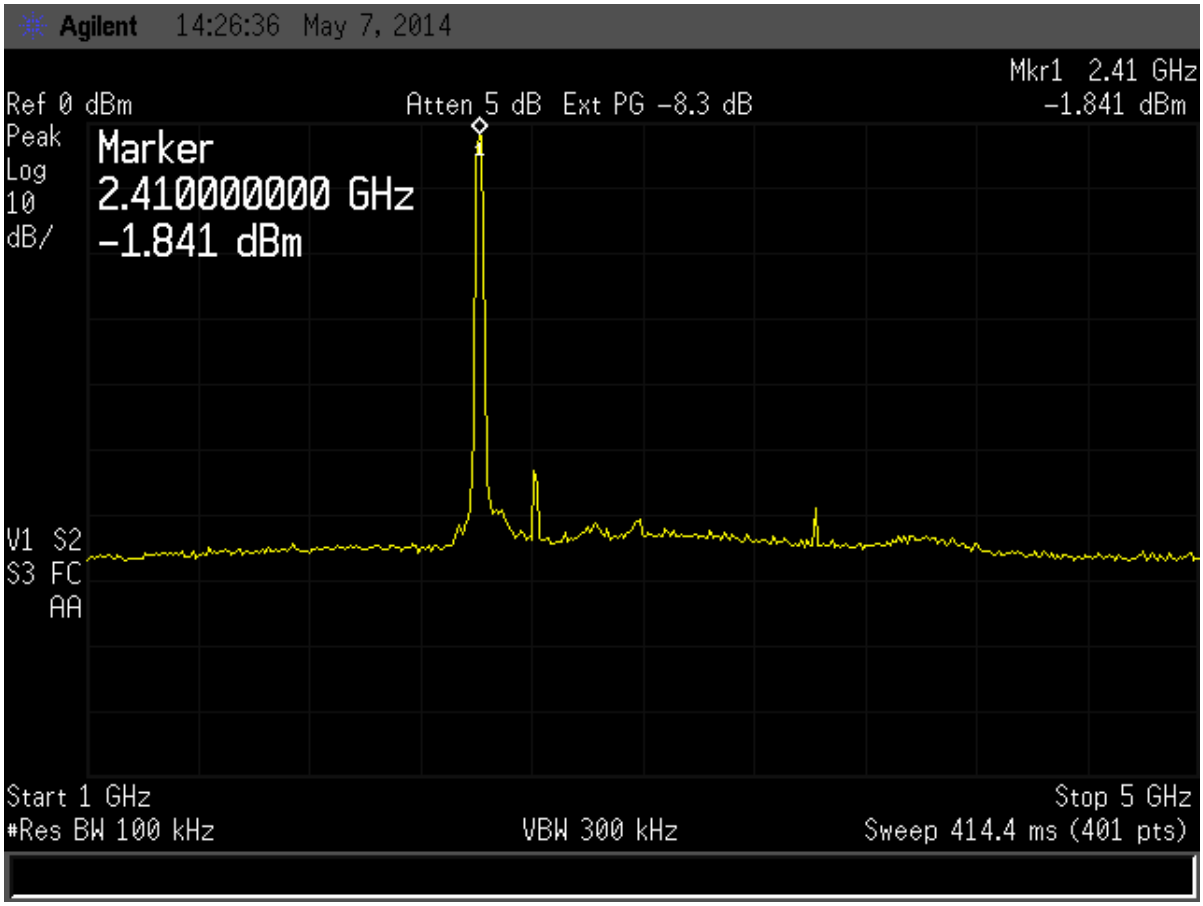


Figure 13. Antenna Conducted Emissions 802.11g Low, Part 2

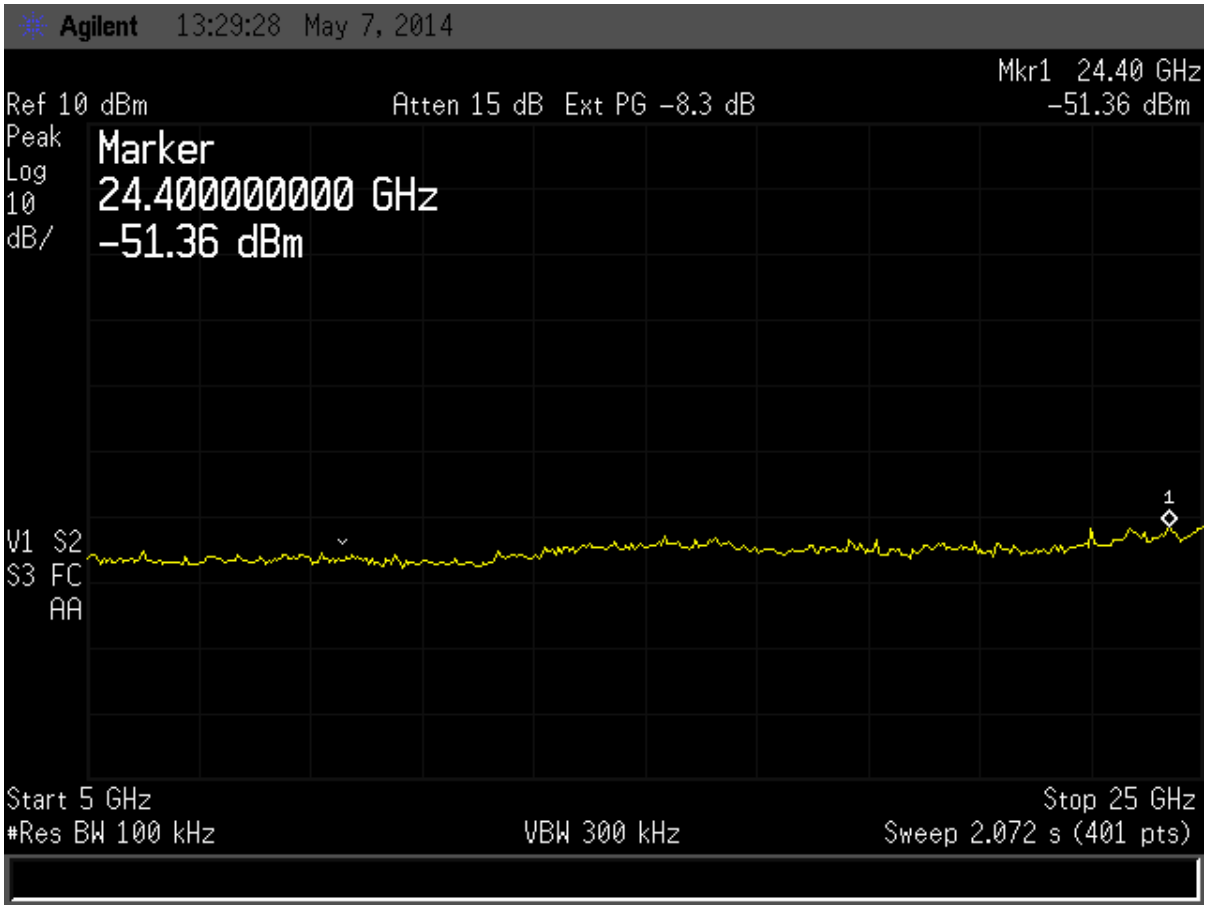


Figure 14. Antenna Conducted Emissions 802.11g Low, Part 3

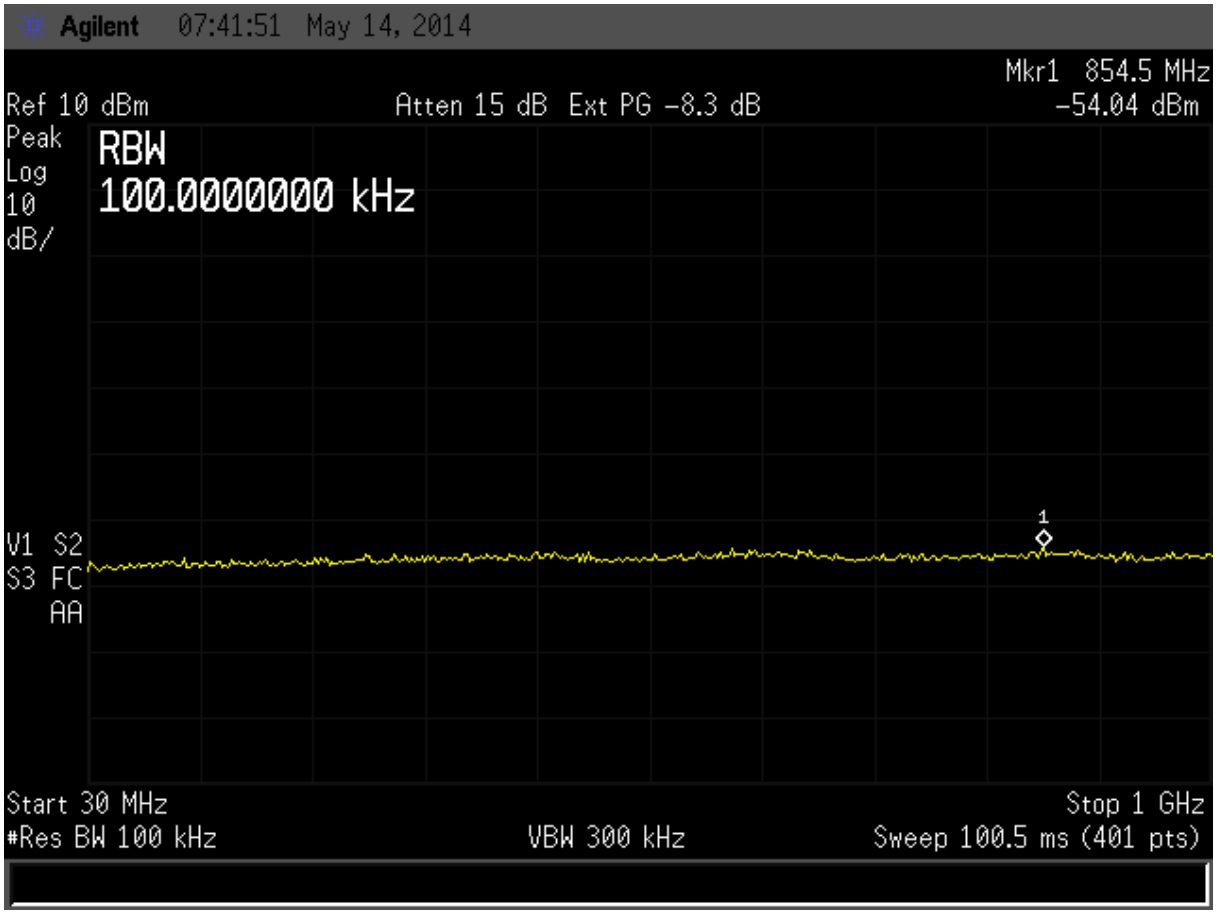


Figure 15. Antenna Conducted Emissions 802.11g Mid, Part 1

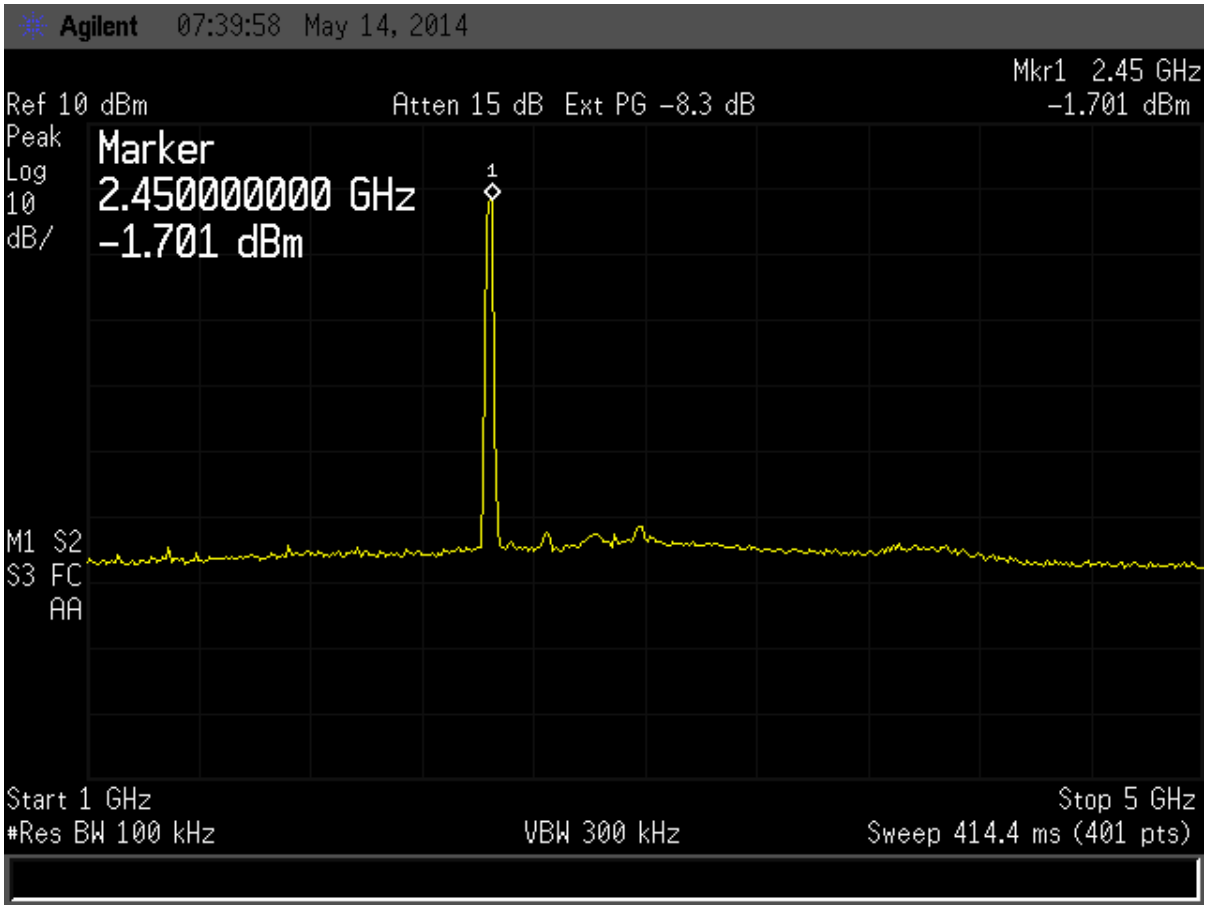


Figure 16. Antenna Conducted Emissions 802.11g Mid, Part 2

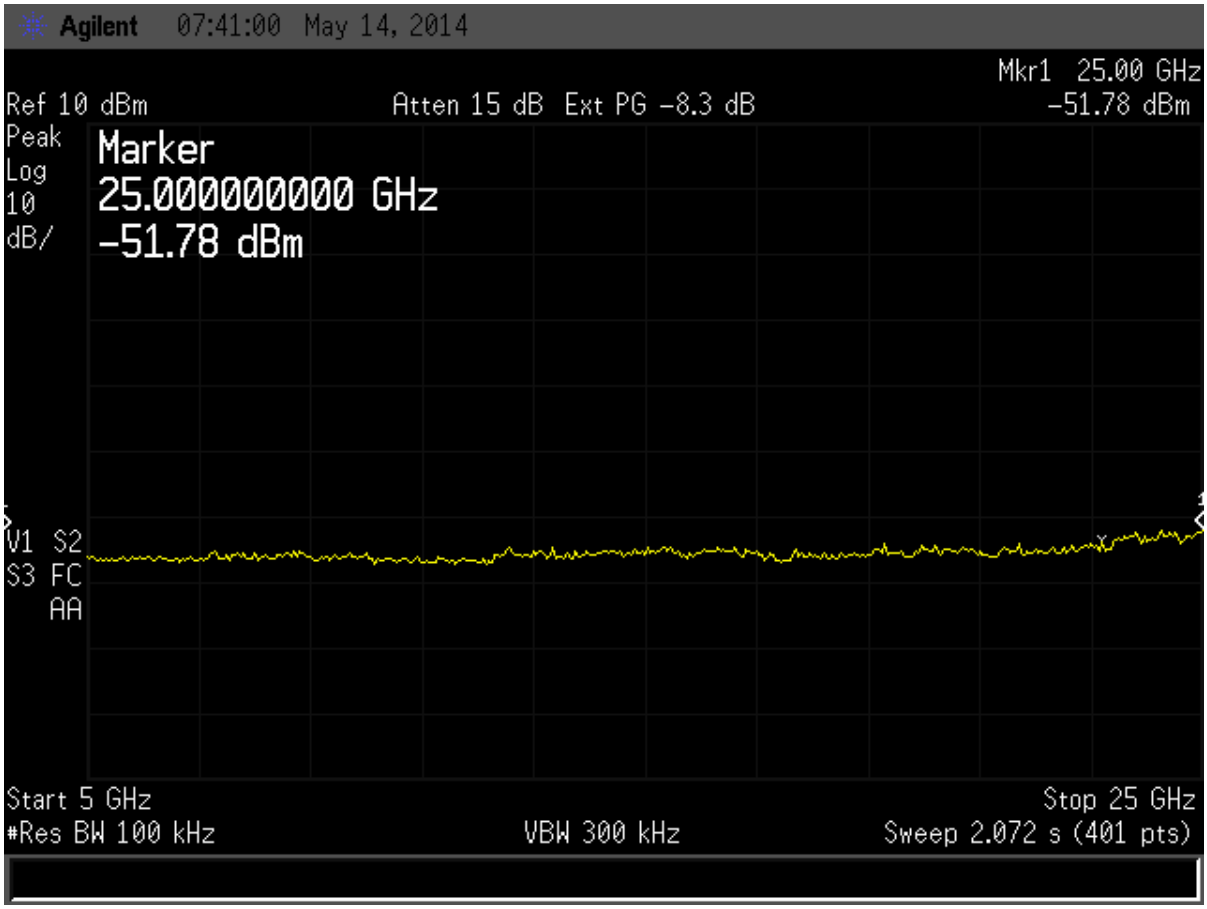


Figure 17. Antenna Conducted Emissions 802.11g Mid, Part 3

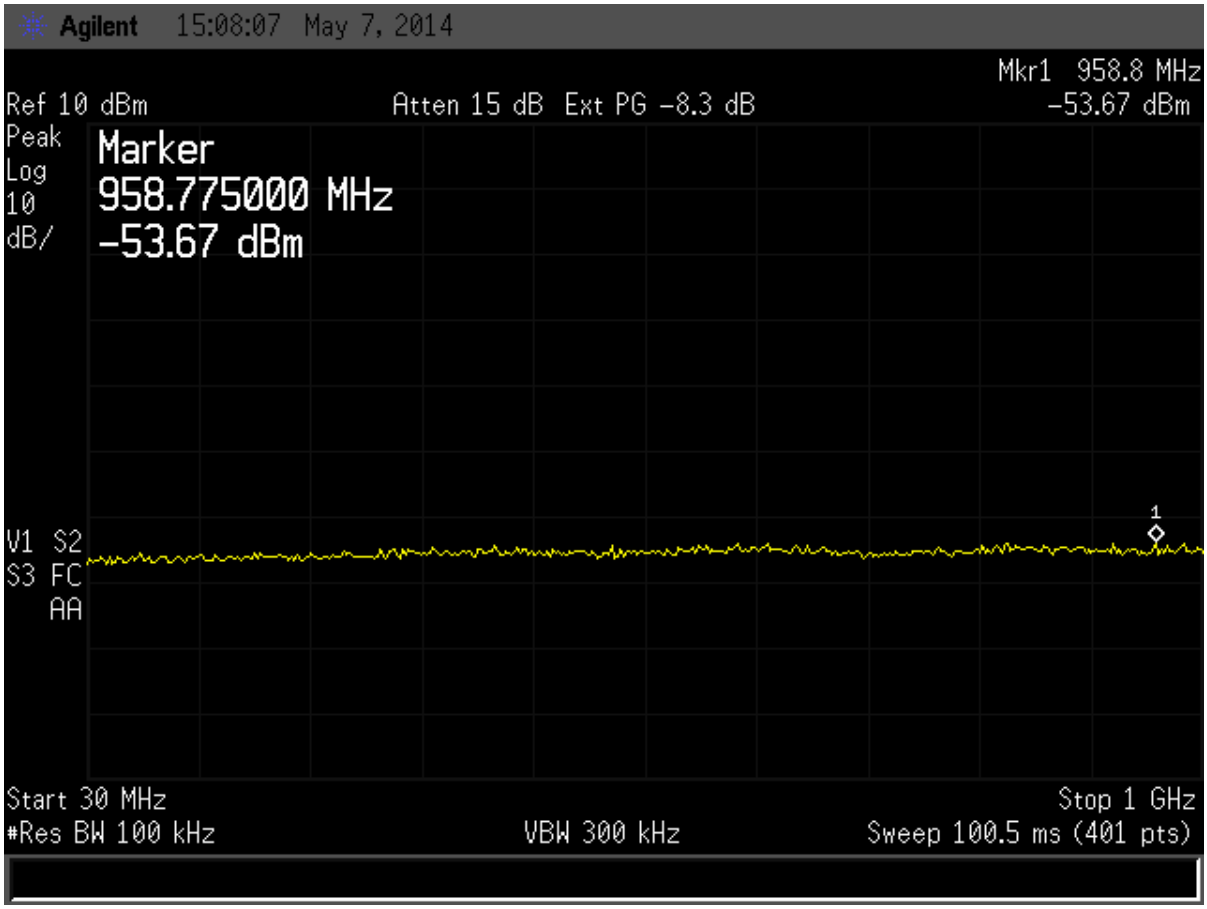


Figure 18. Antenna Conducted Emissions 802.11g High, Part 1

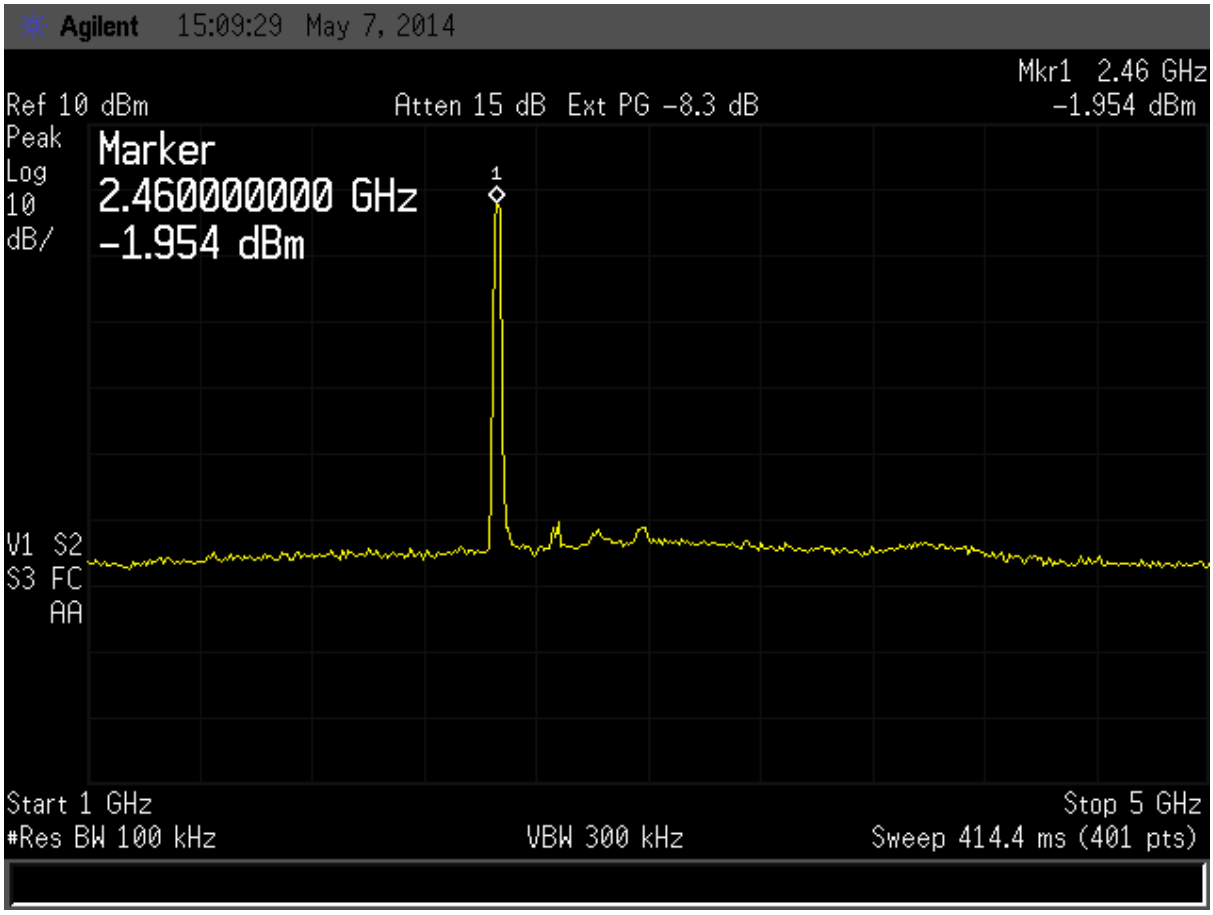


Figure 19. Antenna Conducted Emissions 802.11g High, Part 2

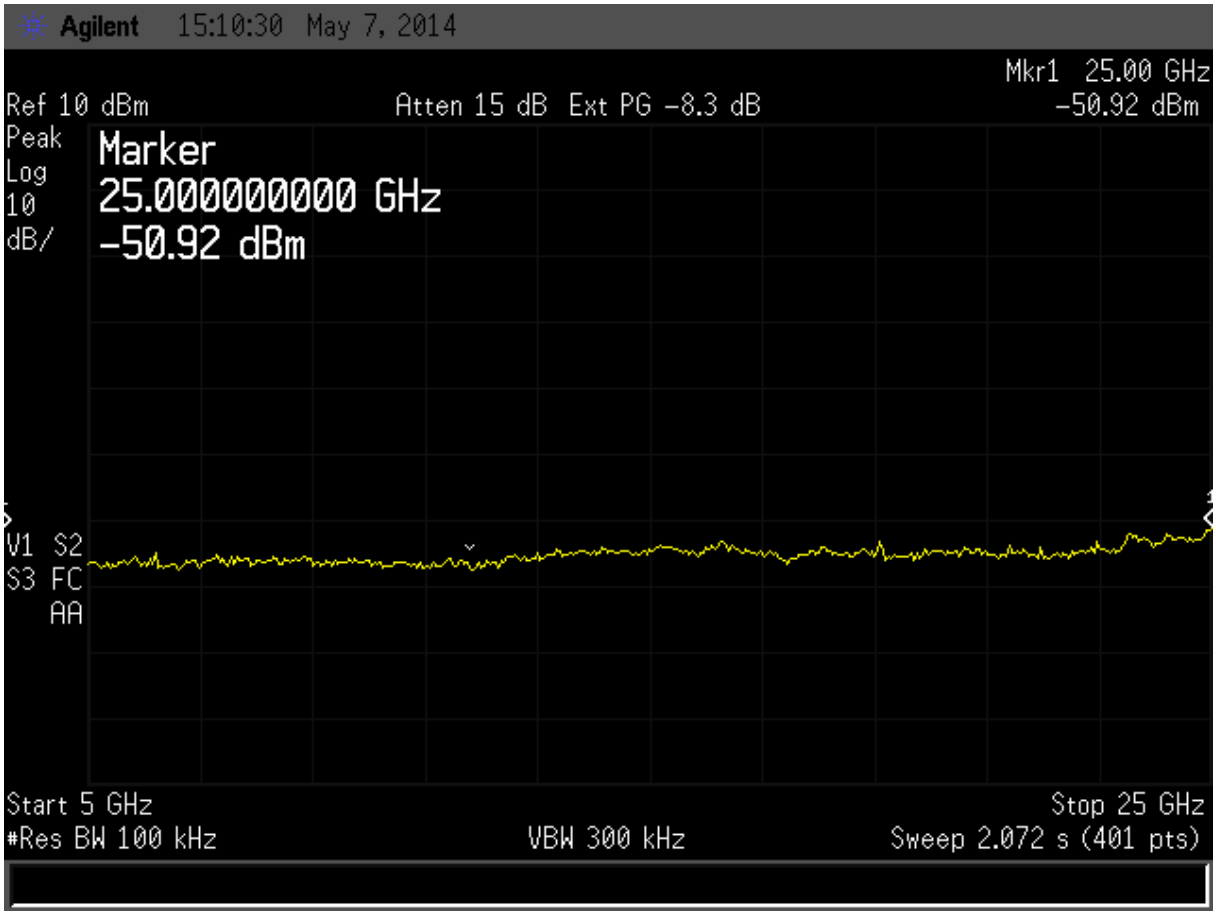


Figure 20. Antenna Conducted Emissions 802.11g High, Part 3

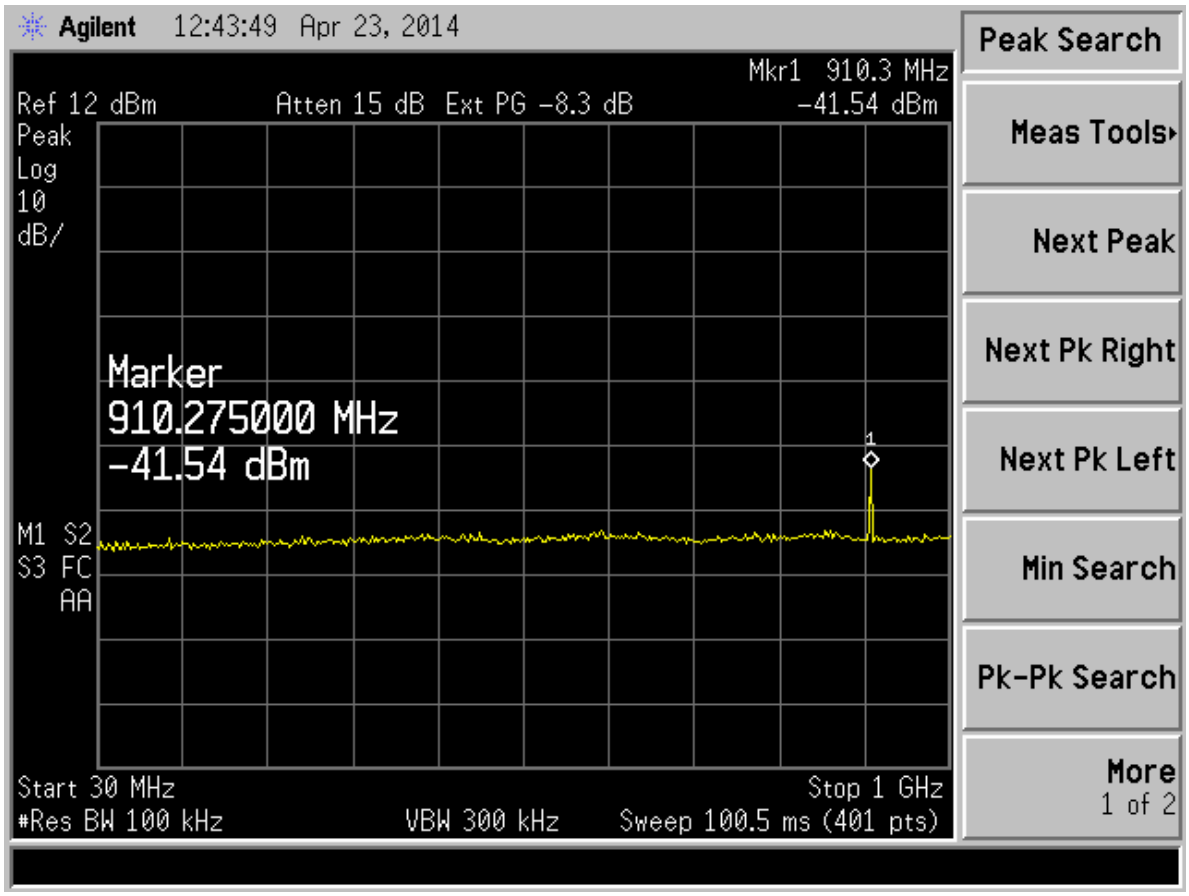


Figure 21. Antenna Conducted Emissions 802.11n Low, Part 1

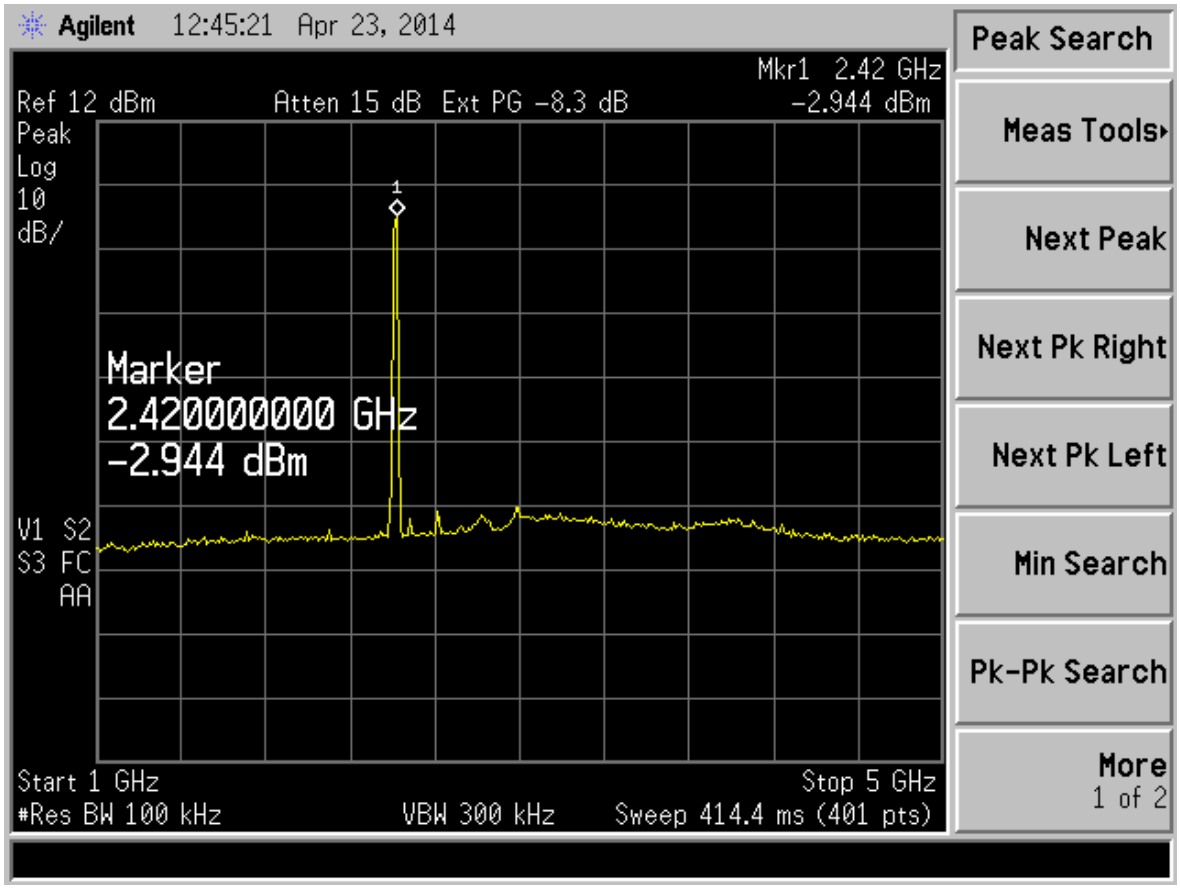


Figure 22. Antenna Conducted Emissions 802.11n Low, Part 2

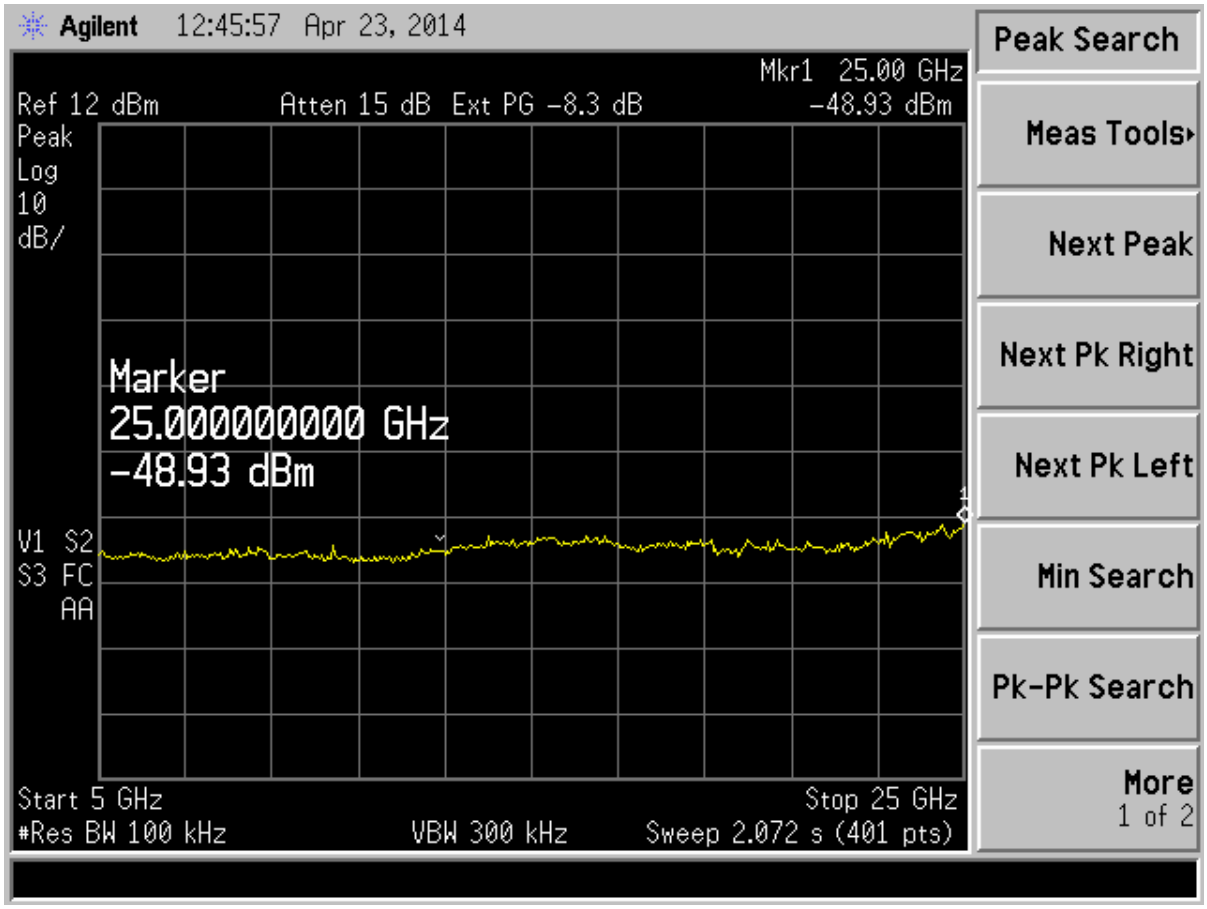


Figure 23. Antenna Conducted Emissions 802.11n Low, Part 3

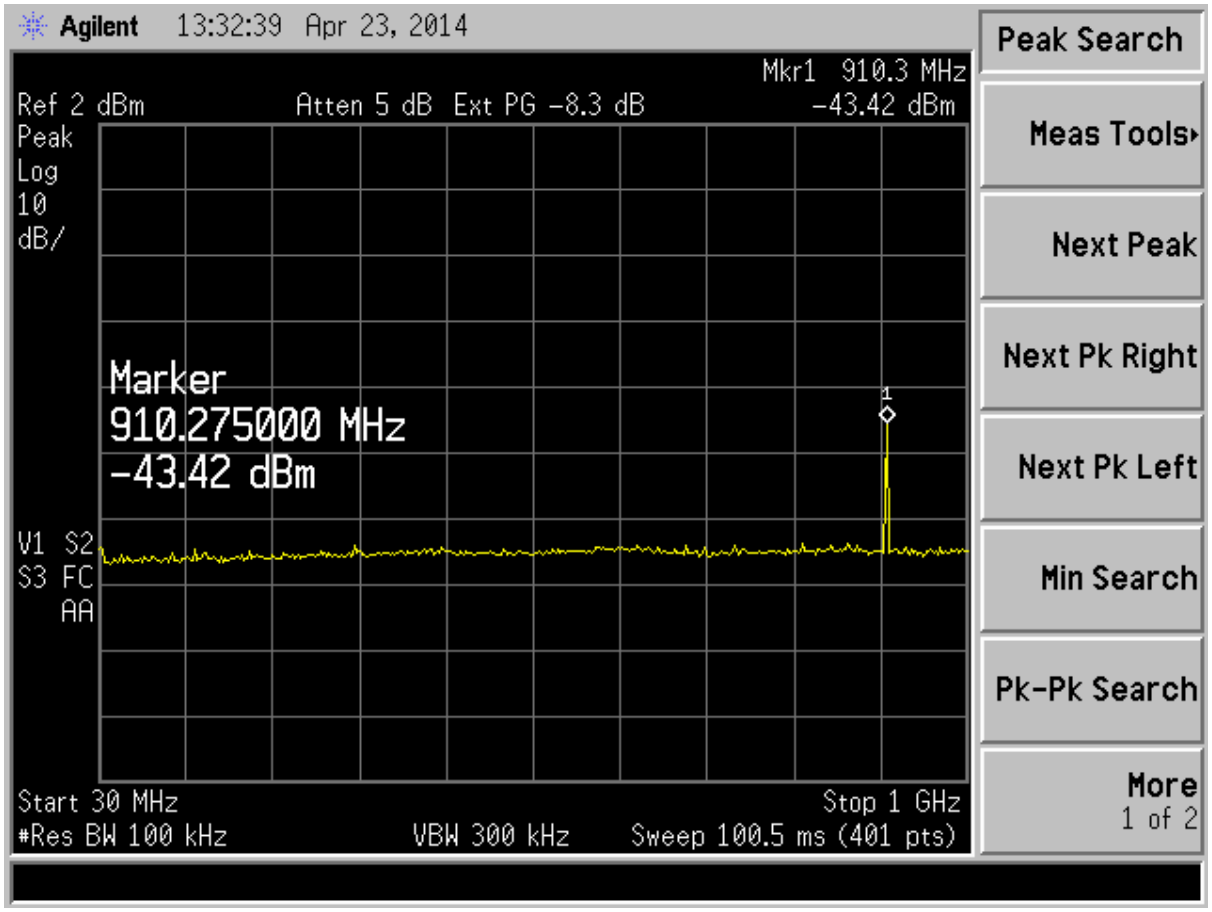


Figure 24. Antenna Conducted Emissions 802.11n Mid, Part 1

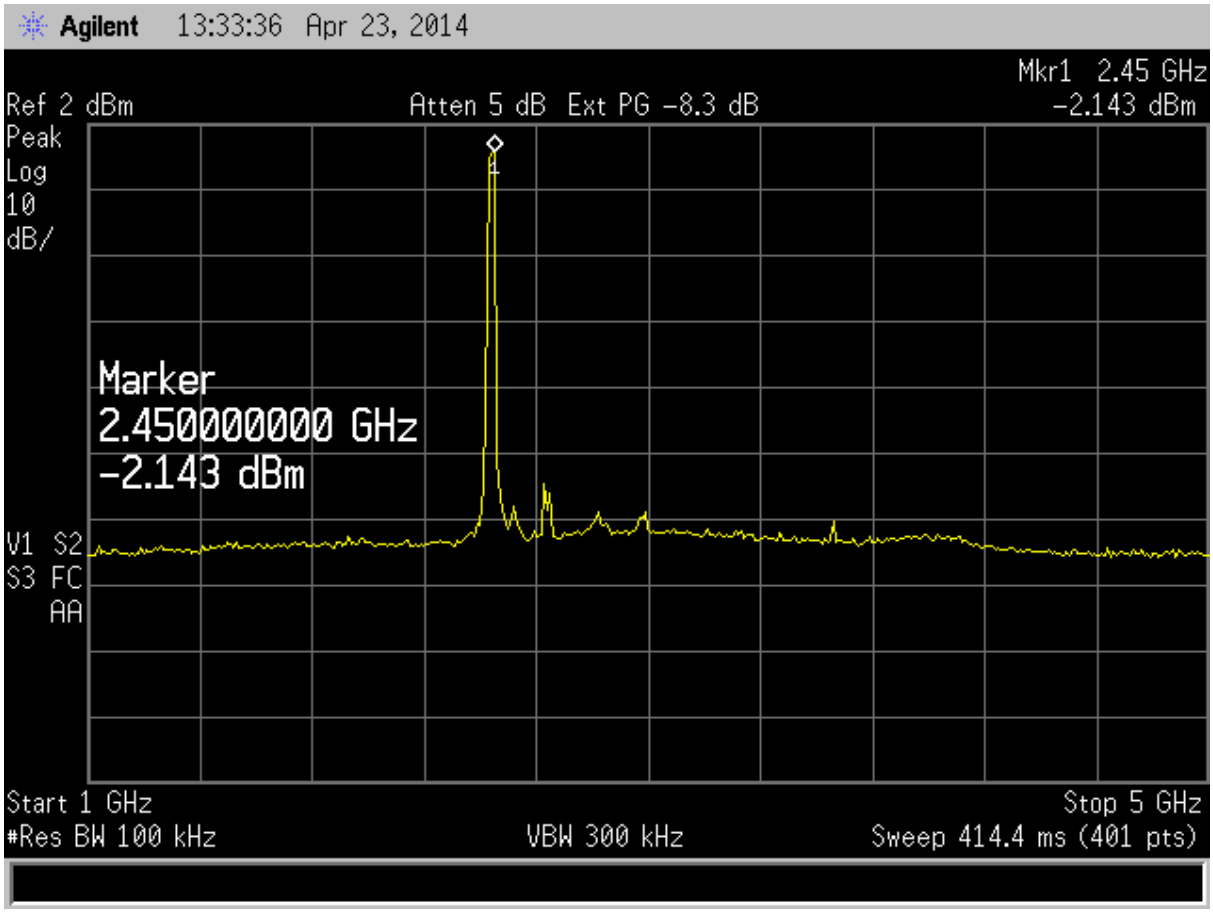


Figure 25. Antenna Conducted Emissions 802.11n Mid, Part 2

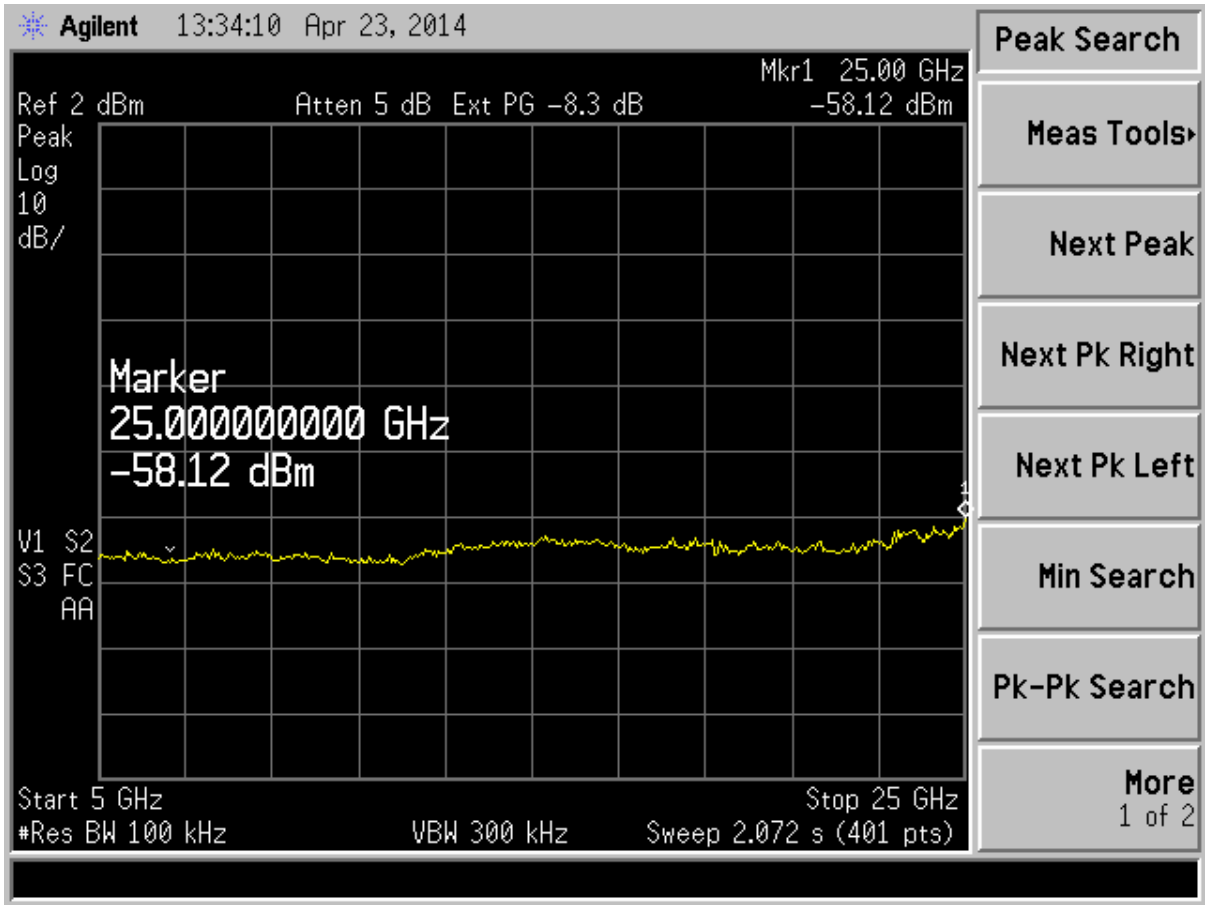


Figure 26. Antenna Conducted Emissions 802.11n Mid, Part 3

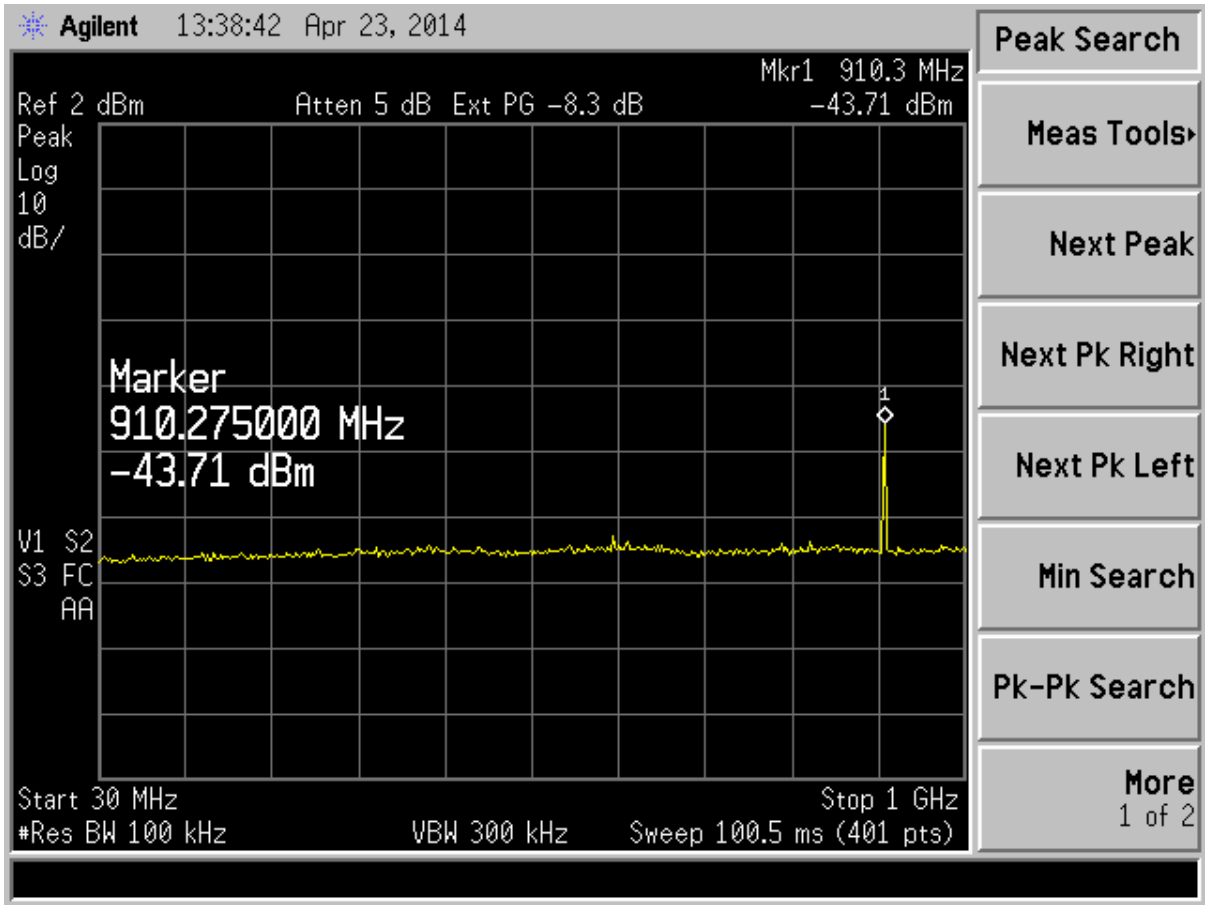


Figure 27. Antenna Conducted Emissions 802.11n High, Part 1

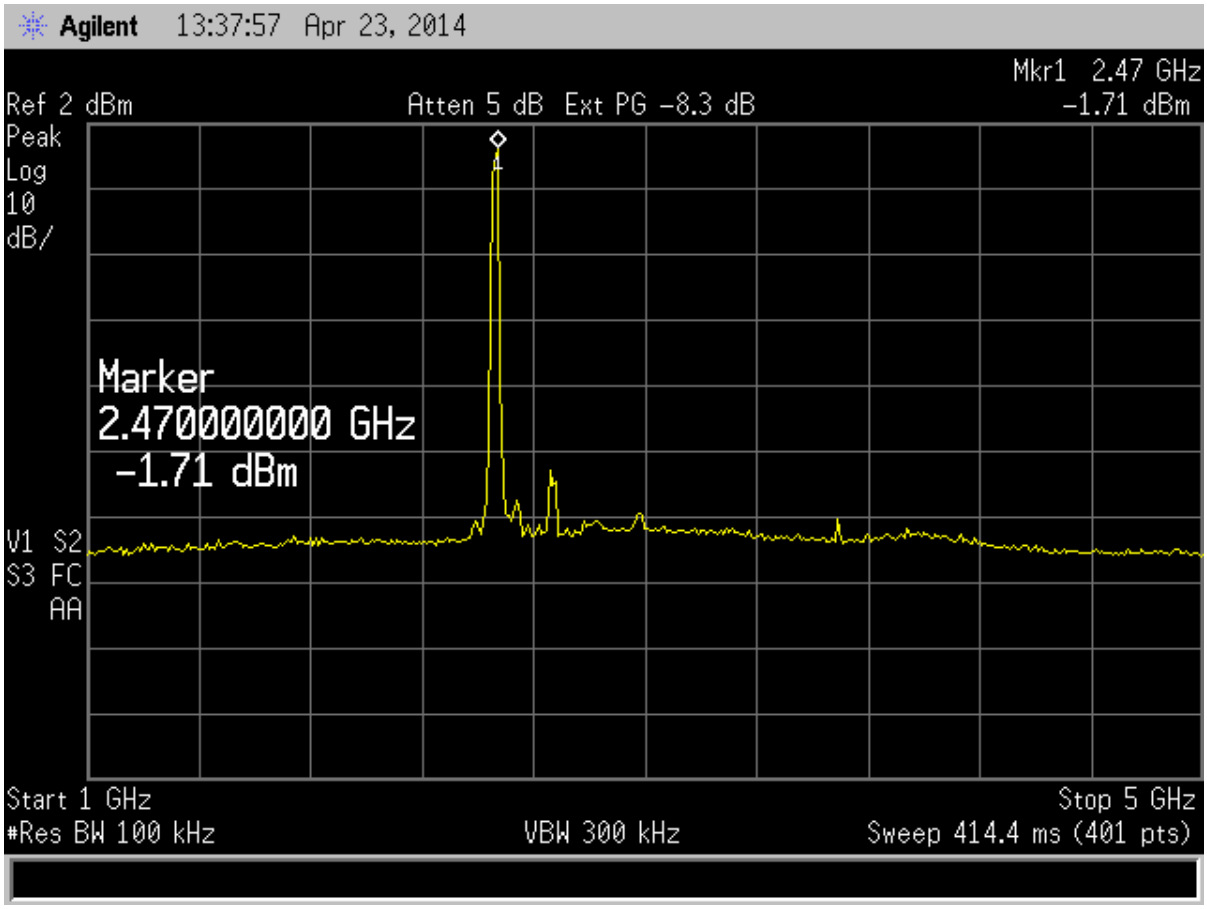


Figure 28. Antenna Conducted Emissions 802.11n High, Part 2

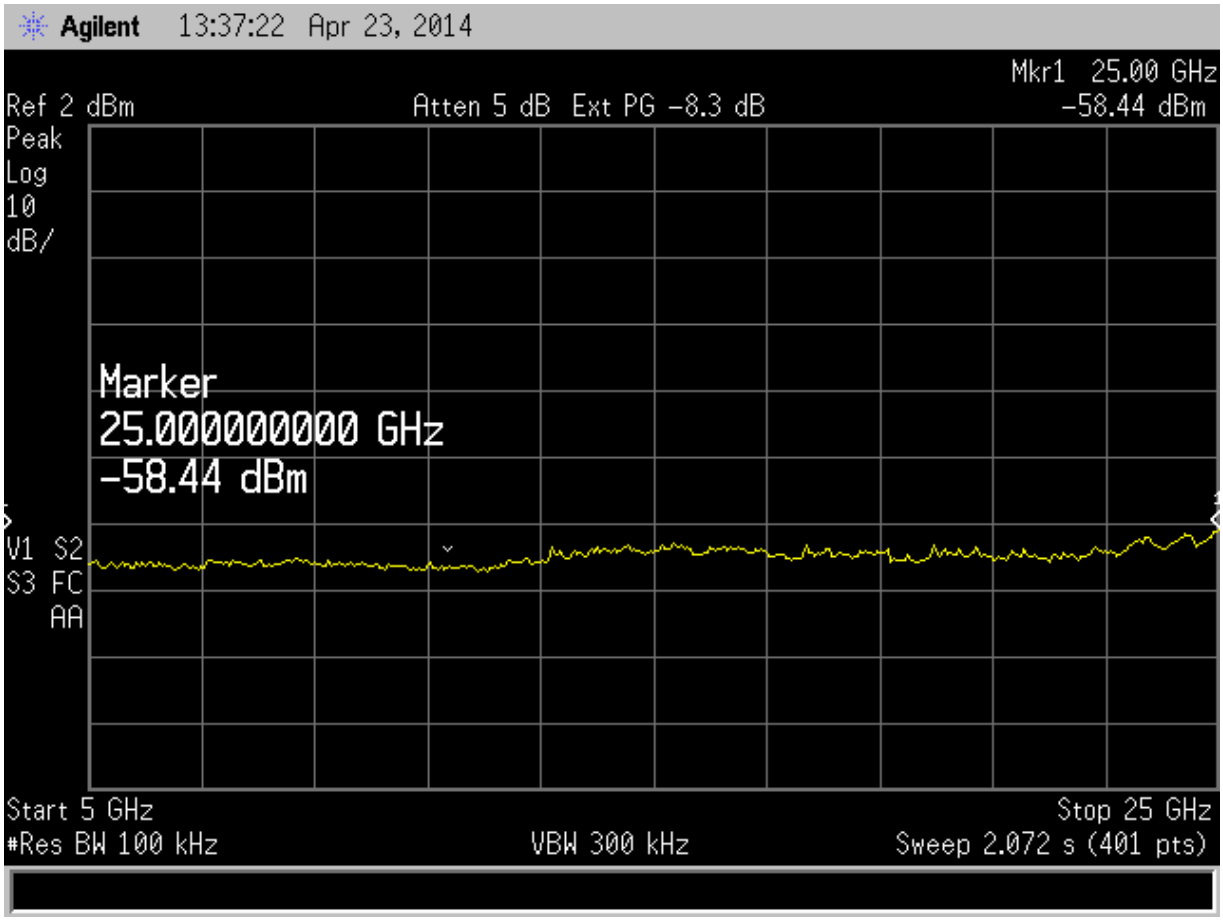


Figure 29. Antenna Conducted Emissions 802.11n High, Part 3

2.11 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d)) (IC RSS 210, A2.9 (a))

On the OATS, 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.

The test data is detailed below for this section. Several radiated emissions above 1 GHz were measured at a distance of 1 meter. The measured value at 1 meter was then extrapolated to the resultant at 3 meters using an inverse distance extrapolation factor of -20 dB/decade. There were no test failures.

Table 6. Peak Radiated Fundamental & Harmonic Emissions, 802.11b

Tested By: JW	Test: FCC Part 15, Para 15.247(d)			Client: WINK Inc.			
	Project: 14-0071			Model: HUB			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Mode**
Low Channel - PEAK							
2412.10	78.38	31.88	110.26		3M/Vert.		PK
7236.13	49.14	10.99	60.13	74.0	3M/Vert.	13.9	PK
Mid Channel - PEAK							
2442.10	75.79	31.98	107.77		3M/Vert.		PK
7326.38	49.17	12.09	61.26	74.0	3M/Vert.	12.7	PK
High Channel – PEAK							
2462.13	77.46	31.83	109.29		3M/Vert.		PK
7386.00	50.07	12.66	62.73	74.0	3M/Vert.	11.3	PK

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. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
3. (~)Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. 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 2412.00MHz:

Magnitude of Measured Frequency	78.38	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	31.88	dB/m
1 meter to 3 meter extrapolation	N/A	dB
Corrected Result	110.26	dBuV/m

Test Date: May 8, 2014
Tested By
Signature: _____ Name: John Wynn

Table 7. Average Radiated Fundamental & Harmonic Emissions, 802.11b

Tested By: JW	Test: FCC Part 15, Para 15.247(d)			Client: WINK Inc.			
	Project: 14-0071			Model: HUB			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA + DC (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Mode**
Low Channel – Average							
2412.10	77.80	14.88	92.68		3M/Vert.		AVG
7236.13	43.50	-6.01	37.49	54	3M/Vert.	16.5	AVG
Mid Channel – Average							
2442.10	74.98	14.98	89.96		3M/Vert.		AVG
4885.50	41.70	-4.91	36.79	54	3M/Vert.	17.2	AVG
High Channel – Average							
2462.13	76.78	14.83	91.61		3M/Vert.		AVG
7386.00	43.94	-4.34	39.60	54	3M/Vert.	14.4	AVG

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. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
3. (~)Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
4. All measurements are corrected with a -17dB duty. See section 2.8
5. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. 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 2412.00MHz:

Magnitude of Measured Frequency	77.80	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	14.88	dB/m
1 meter to 3 meter extrapolation	N/A	dB
Corrected Result	92.68	dBuV/m

Test Date: May 8, 2014
Tested By
Signature: John C Wynn Name: John Wynn

Table 8. Peak Radiated Fundamental & Harmonic Emissions, 802.11g

Tested By: JW	Test: FCC Part 15, Para 15.247(d)			Client: WINK Inc.			
	Project: 14-0071			Model: HUB			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Mode**
Low Channel – PEAK							
2412.00	70.33	31.78	102.11		3M/Vert.		PK
4824.00	45.47	4.30	49.77	74.0	3M/Vert.	24.2	PK
Mid Channel – PEAK							
2437.00	66.87	31.88	98.75		3M/Vert.		PK
4874.00	46.83	4.19	51.02	74.0	3M/Vert.	23.0	PK
High Channel – PEAK							
2462.00	70.97	31.73	102.70		3M/Vert.		PK
4924.00	45.05	4.30	49.35	74.0	3M/Vert.	24.6	PK

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. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
3. (~)Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emission were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 2407.83MHz:

Magnitude of Measured Frequency	70.33	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	31.73	dB/m
1 meter to 3 meter extrapolation	NA	dB
Corrected Result	102.70	dBuV/m

Test Date: April 28, 2014
Tested By
Signature: _____ Name: John Wynn

Table 9. Average Radiated Fundamental & Harmonic Emissions, 802.11g

Tested By: JW	Test: FCC Part 15, Para 15.247(d)			Client: WINK Inc.			
	Project: 14-0071			Model: HUB			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA - DC (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Mode**
Low Channel – Average							
2412.00	52.23	14.78	67.01		3M/Vert.		AVG
4824.00	44.99	-12.94	32.05	54.0	3M/Vert.	18.9	AVG
Mid Channel – Average							
2437.00	50.30	14.88	65.18		3M/Vert.		AVG
4874.00	45.19	-12.81	32.38	54.0	3M/Vert.	18.6	AVG
High Channel – Average							
2462.00	53.50	14.73	68.23		3M/Vert.		AVG
4924.00	45.05	-12.70	32.35	54.0	3M/Vert.	18.6	AVG

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. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
3. (~)Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
4. All measurements are corrected with a -17dB duty. See section 2.8
5. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emission were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 2407.83 MHz:

Magnitude of Measured Frequency	52.23	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	14.78	dB/m
1 meter to 3 meter extrapolation	N/A	dB
Corrected Result	67.01	dBuV/m

Test Date: April 28, 2014
Tested By
Signature: _____ Name: John Wynn

Table 10. Peak Radiated Fundamental & Harmonic Emissions, 802.11n

Tested By: JW	Test: FCC Part 15, Para 15.247(d)			Client: WINK Inc.			
	Project: 14-0071			Model: HUB			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Mode**
Low Channel – PEAK							
2412.00	70.80	31.78	102.58		3M/Vert.		PK
4824.00	45.23	4.21	49.44	74.0	3M/Vert.	24.6	PK
Mid Channel – PEAK							
2442.00	68.71	31.88	100.59		3M/Vert.		PK
4884.00	44.89	4.19	49.08	74.0	3M/Vert.	24.9	PK
High Channel – PEAK							
2462.00	71.94	31.73	103.67		3M/Vert.		PK
4924.00	44.68	4.30	48.98	74.0	3M/Vert.	25.0	PK

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. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
3. (~)Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
4. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emission were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 2411.13 MHz:

Magnitude of Measured Frequency	70.80	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	31.78	dB/m
1 meter to 3 meter extrapolation	NA	dB
Corrected Result	102.58	dBuV/m

Test Date: April 28, 2014
Tested By
Signature: _____ Name: John Wynn

Table 11. Average Radiated Fundamental & Harmonic Emissions, 802.11n

Tested By: JW	Test: FCC Part 15, Para 15.247(d)			Client: WINK Inc.			
	Project: 14-0071			Model: HUB			
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA -DC (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detection Mode**
Low Channel – Average							
2412.00	52.82	14.78	67.60		3M/Vert.		AVG
4824.00	44.99	-12.94	32.05	54.0	3M/Vert.	24.9	AVG
Mid Channel – Average							
2442.00	51.82	14.88	66.70		3M/Vert.		AVG
4884.00	45.19	-12.81	29.38	54.0	3M/Vert.	24.6	AVG
High Channel – Average							
2462.00	54.59	14.73	69.32		3M/Vert.		AVG
4924.00	44.80	-12.70	32.10	54.0	3M/Vert.	24.9	AVG

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. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic (25GHz using EMCO 3116 Horn Antenna)
3. (~)Measurements taken at 1 meter were extrapolated to 3 meter using a factor of (-9.5 dB).
4. All measurements are corrected with a -17dB duty. See section 2.8
5. The EUT was placed in three orthogonal positions and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emission were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was worst case.

Sample Calculation at 2411.13MHz:

Magnitude of Measured Frequency	52.82	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain – Duty Cycle	14.78	dB/m
1 meter to 3 meter extrapolation	NA	dB
Corrected Result	67.60	dBuV/m

Test Date: April 28, 2014
Tested By
Signature: _____ Name: John Wynn

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

Band Edge measurements are made following the guidelines in FCC KDB Publication No. 558074 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 figure and calculations below for more detail.

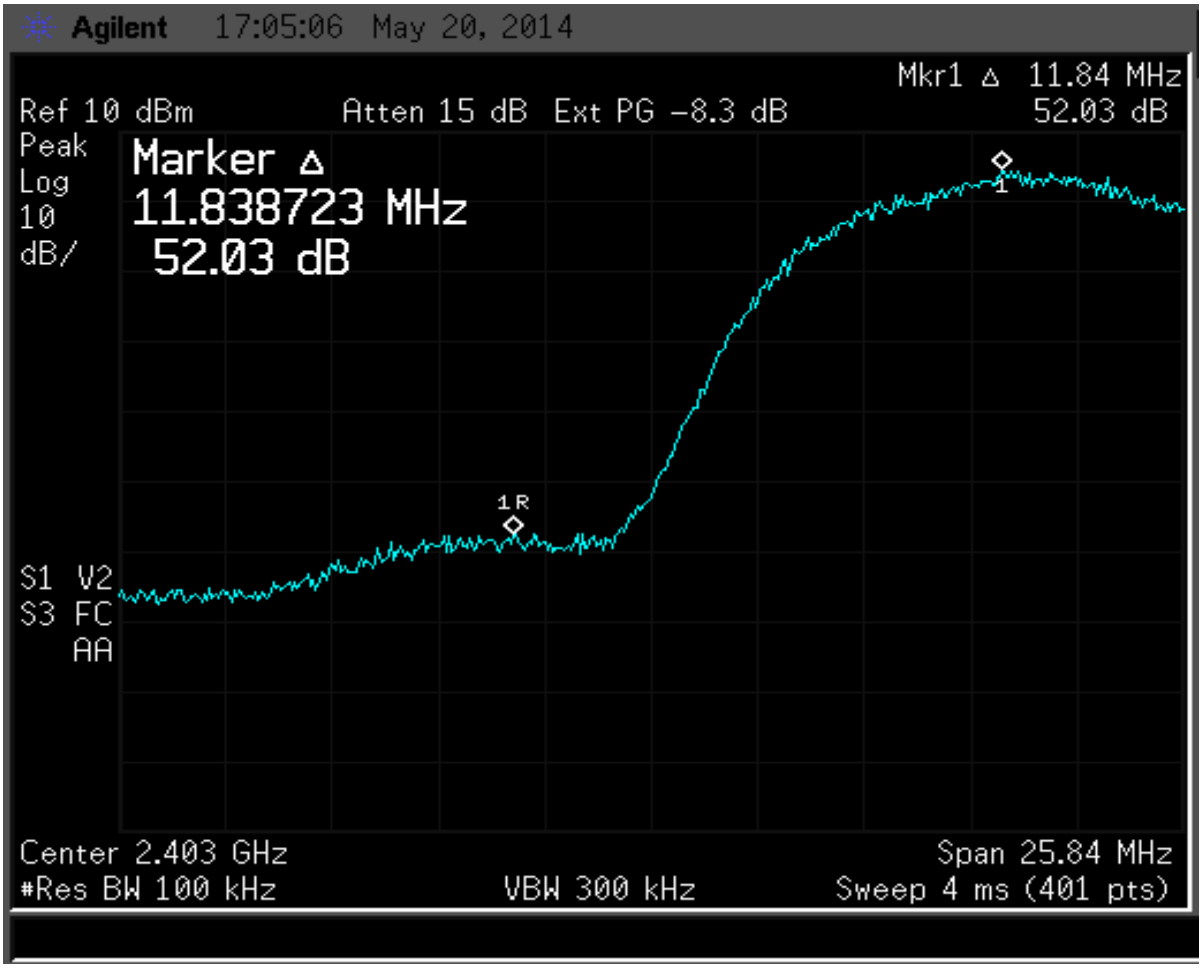


Figure 30. Band Edge Compliance – 802.11b – Low Channel Delta - Peak

(Lower band edge must be greater than 20 dB)

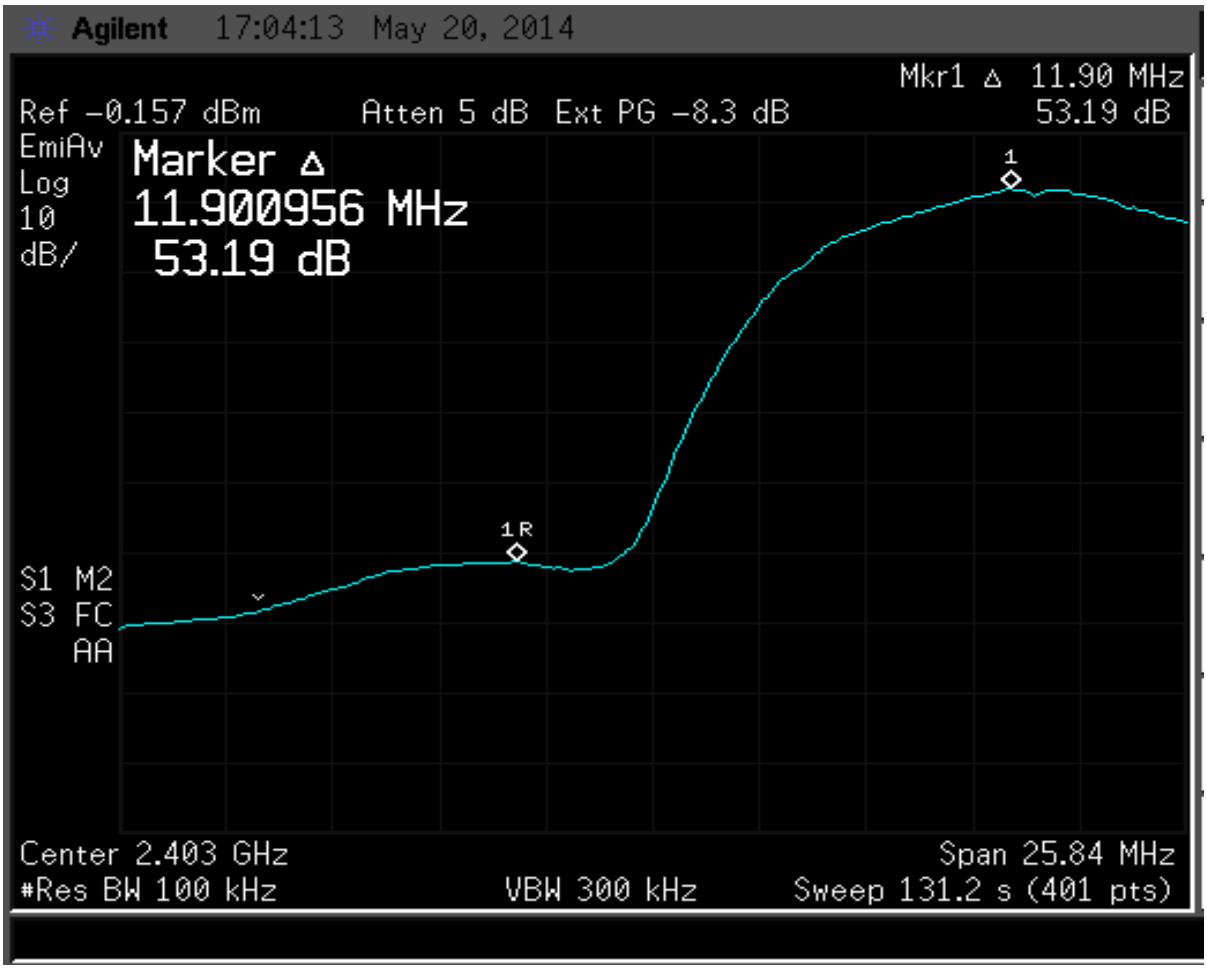


Figure 31. Band Edge Compliance – 802.11b – Low Channel Delta - Average

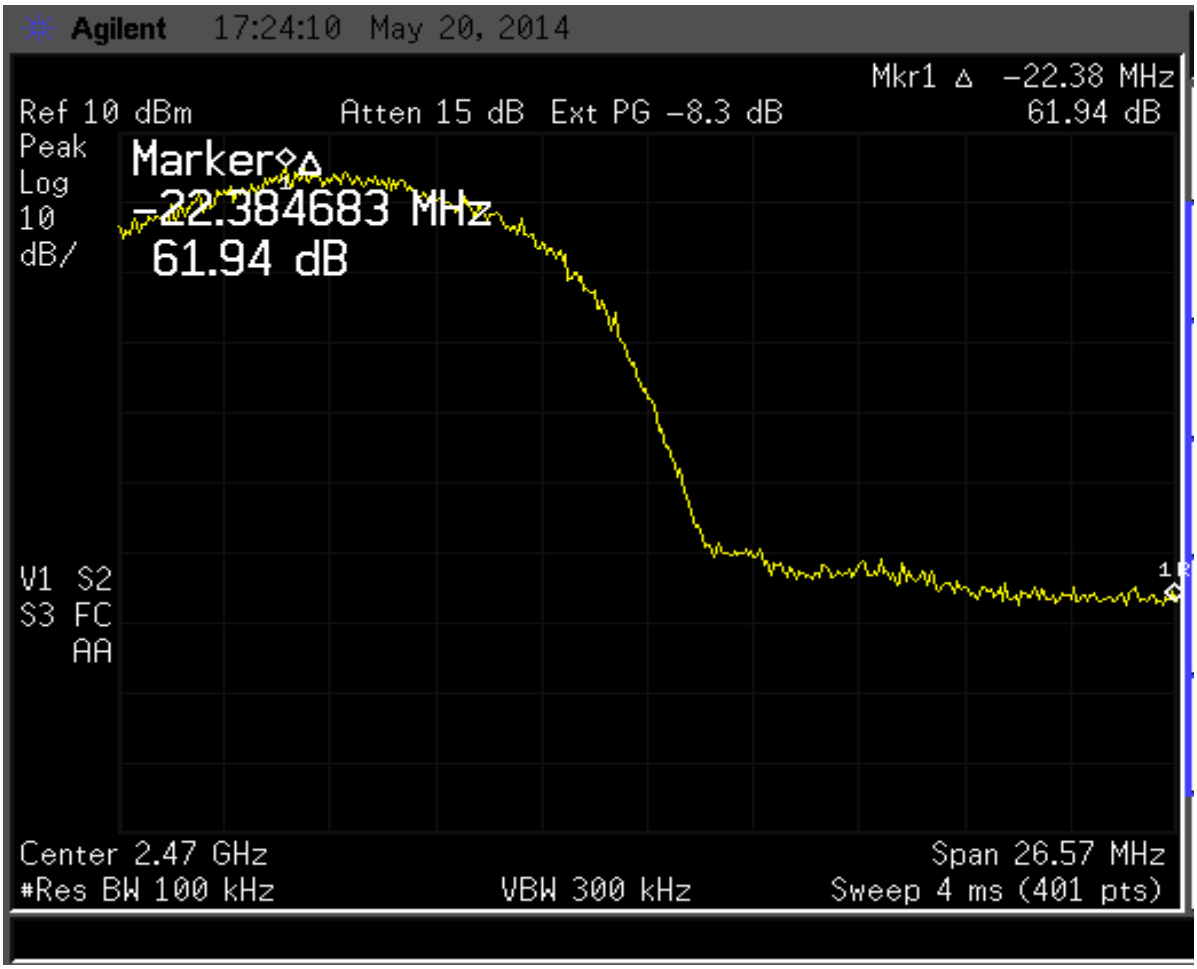


Figure 32. Band Edge Compliance – 802.11b – High Channel Delta – Peak

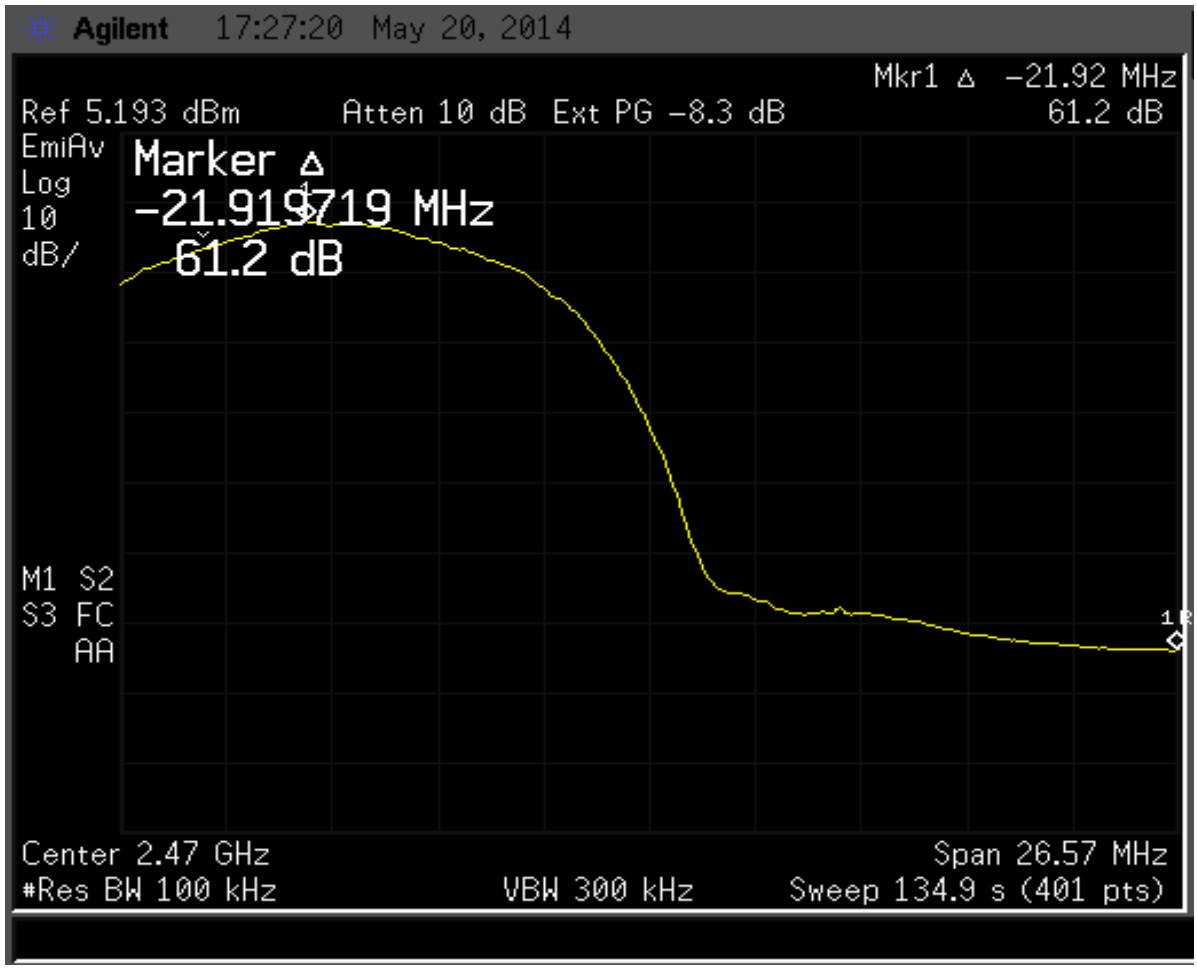


Figure 33. Band Edge Compliance – 802.11b – High Channel Delta – Average

The limit for the average value of radiated emissions in a Restricted Band is 54 dBuV/m. To compute the average values of the band edge emissions, the duty cycle correction factor of -17.0 dB is applied to the values in the Corrected Results column. After this correction the EUT is found to have met the restrictions placed on average radiated emissions in Restricted Bands. The worst-case measurement is computed below.

Calculation of worst case 802.11b PEAK upper band edge measurement:

High Channel Corrected Measured Value from Table 6	109.29	dBuV
High Channel Band Edge Delta from Figure 33	-61.94	dB
Calculated Result	47.35	dBuV/m
Average Limit + 20dB Relaxation for PEAK	74.00	dBuV/m
Calculated Result	-52.36	dBuV/m
Band Edge Margin	26.65	dBuV/m

Calculation of worst case 802.11b AVERAGE upper band edge measurement:

High Channel Corrected Measured Value from Table 7	88.61	dBuV
High Channel Band Edge Delta from Figure 34	-61.20	dB
Calculated Result	27.41	dBuV/m
Peak Limit	54.00	dBuV/m
Calculated Result	-26.52	dBuV/m
Band Edge Margin	26.59	dBuV/m

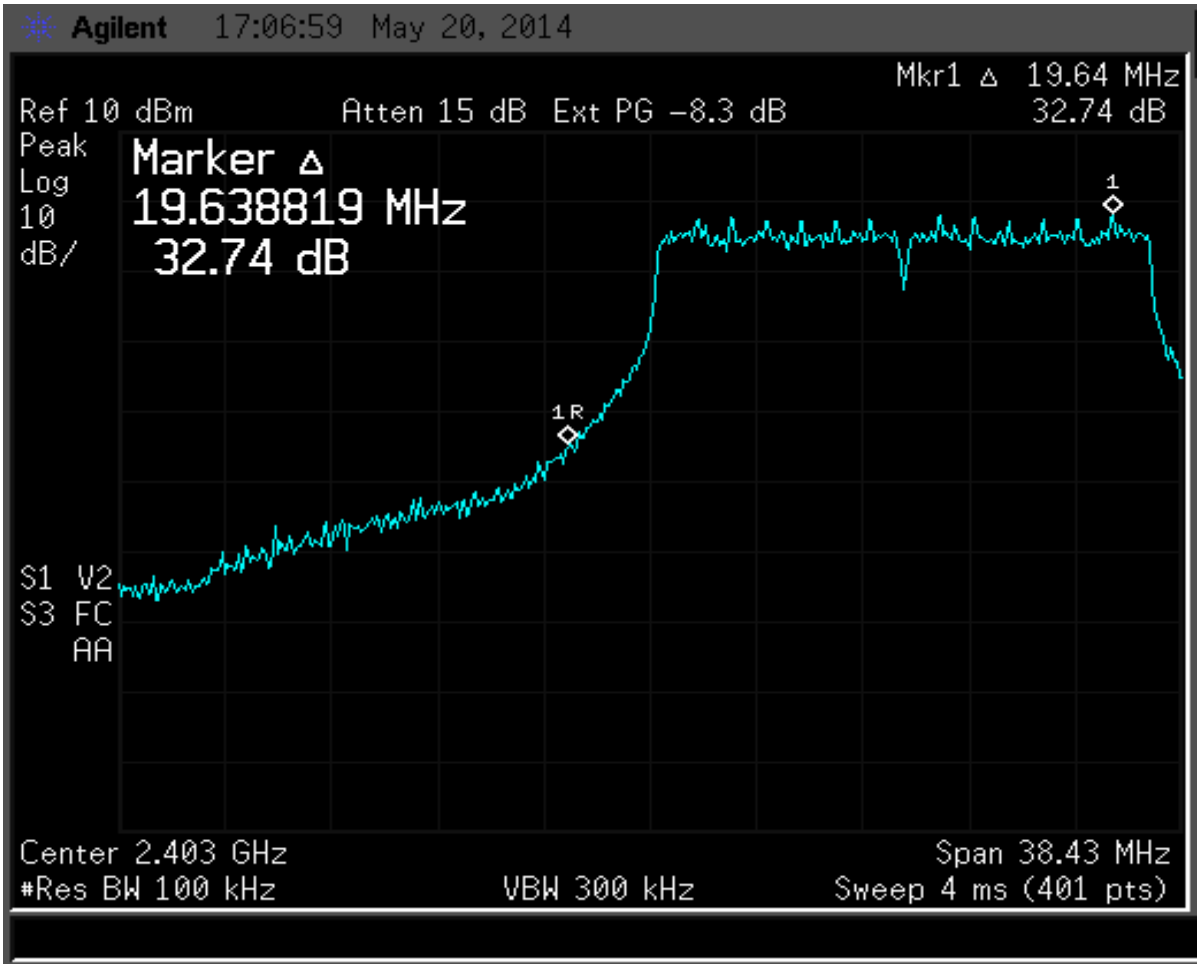


Figure 34. Band Edge Compliance – 802.11g – Low Channel Delta - Peak

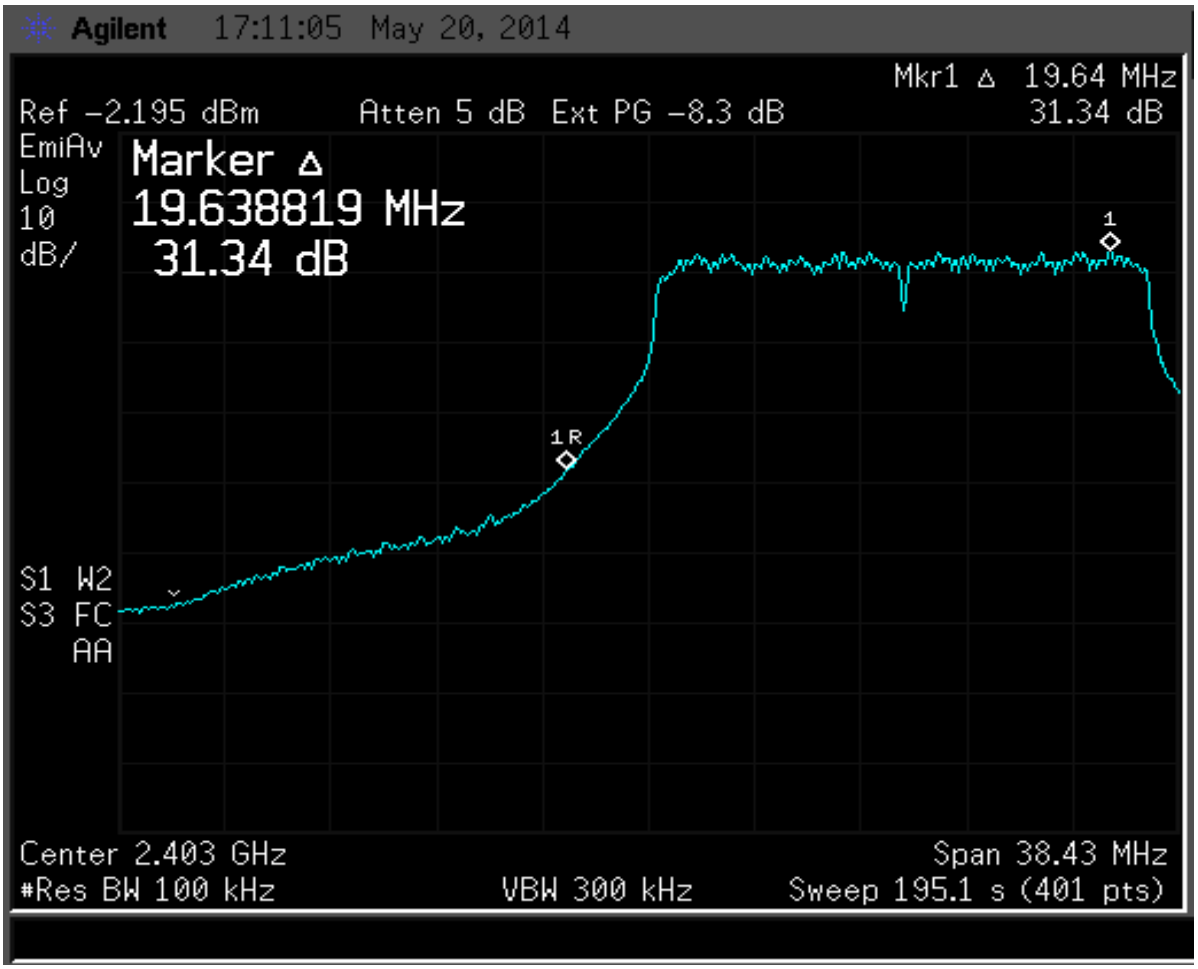


Figure 35. Band Edge Compliance – 802.11g – Low Channel Delta - Average

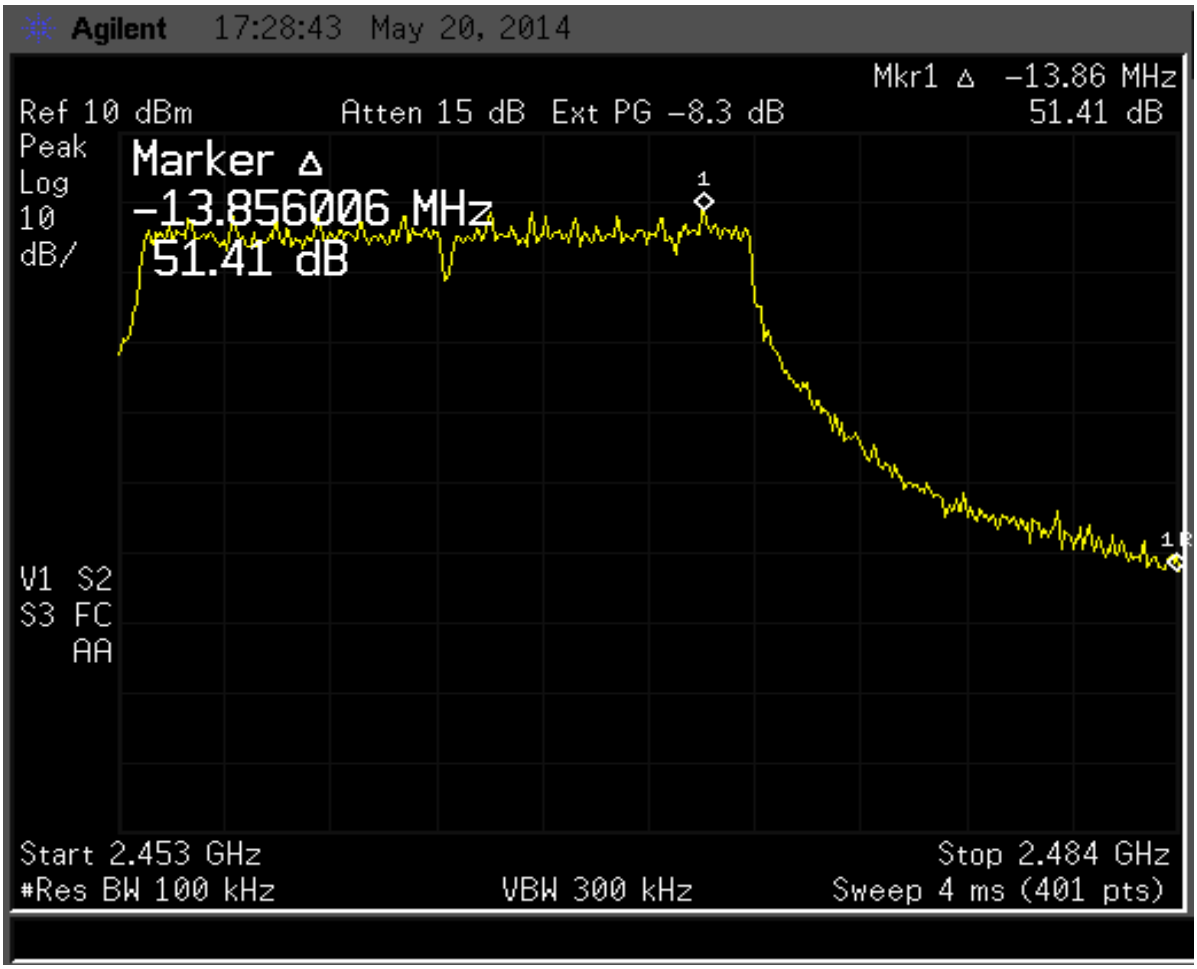


Figure 36. Band Edge Compliance – 802.11g – High Channel Delta – Peak

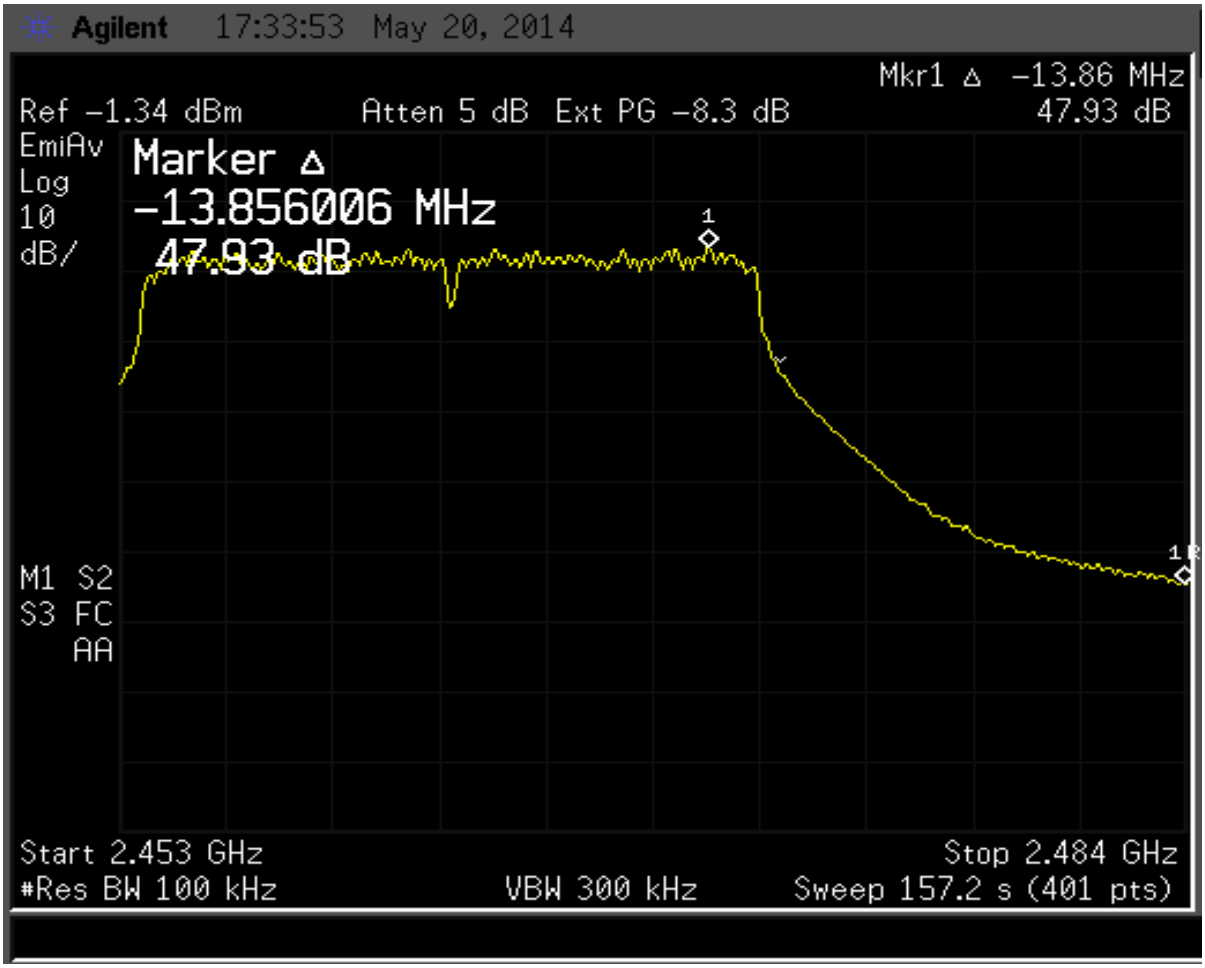


Figure 37. Band Edge Compliance – 802.11g – High Channel Delta – Average

Calculation of worst case 802.11g PEAK upper band edge measurement:

High Channel Corrected Measured Value from Table 8	102.70	dBuV
High Channel Band Edge Delta from Figure 37	-51.41	dB
Calculated Result	51.29	dBuV/m
Average Limit + 20dB Relaxation for PEAK	74.00	dBuV/m
Calculated Result	-51.29	dBuV/m
Band Edge Margin	23.71	dBuV/m

Calculation of worst case 802.11g AVERAGE upper band edge measurement:

High Channel Corrected Measured Value from Table 9	65.23	dBuV
High Channel Band Edge Delta from Figure 38	-47.93	dB
Calculated Result	17.30	dBuV/m
Peak Limit	54.00	dBuV/m
Calculated Result	-17.30	dBuV/m
Band Edge Margin	36.70	dBuV/m

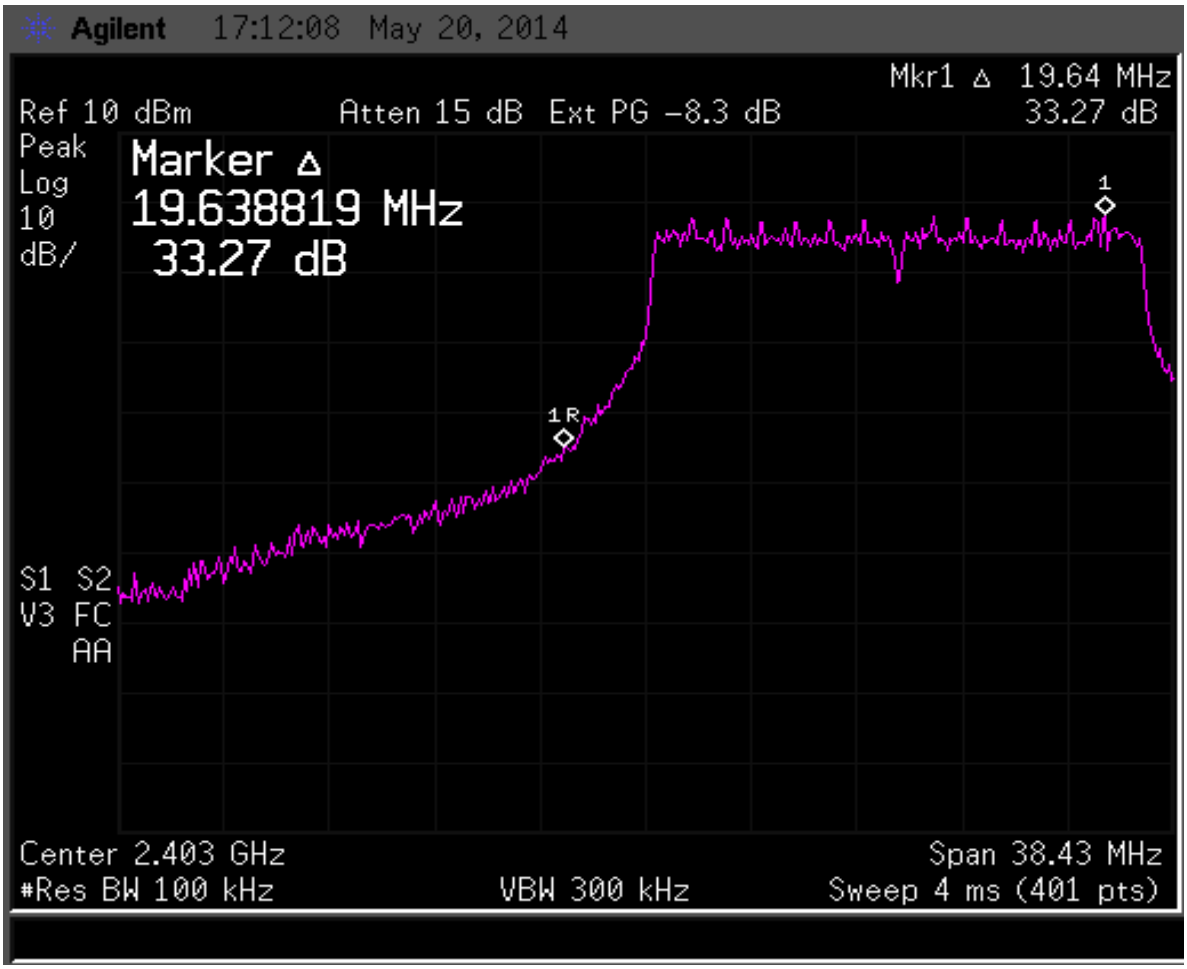


Figure 38. Band Edge Compliance – 802.11n – Low Channel Delta – Peak

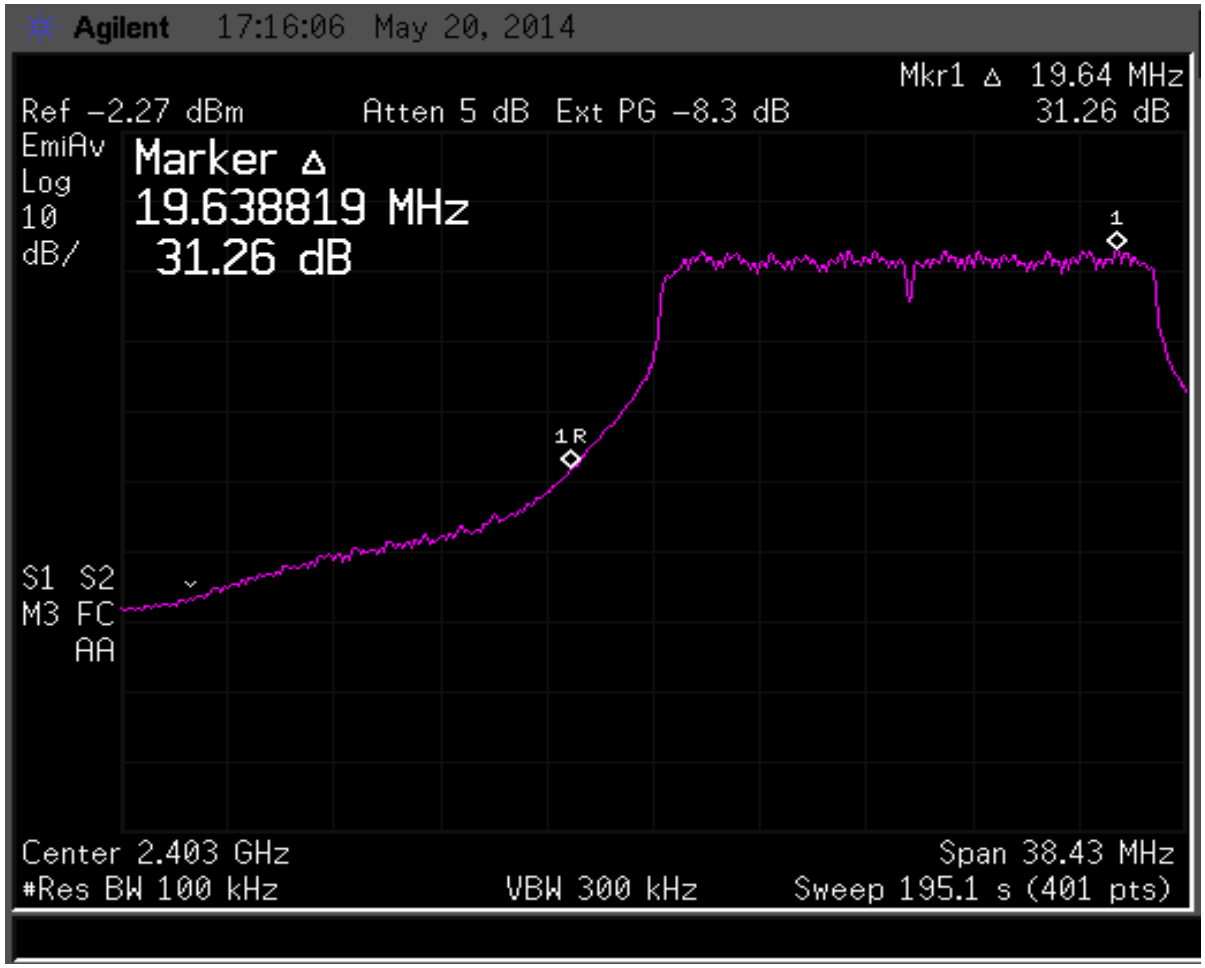


Figure 39. Band Edge Compliance – 802.11n – Low Channel Delta – Average

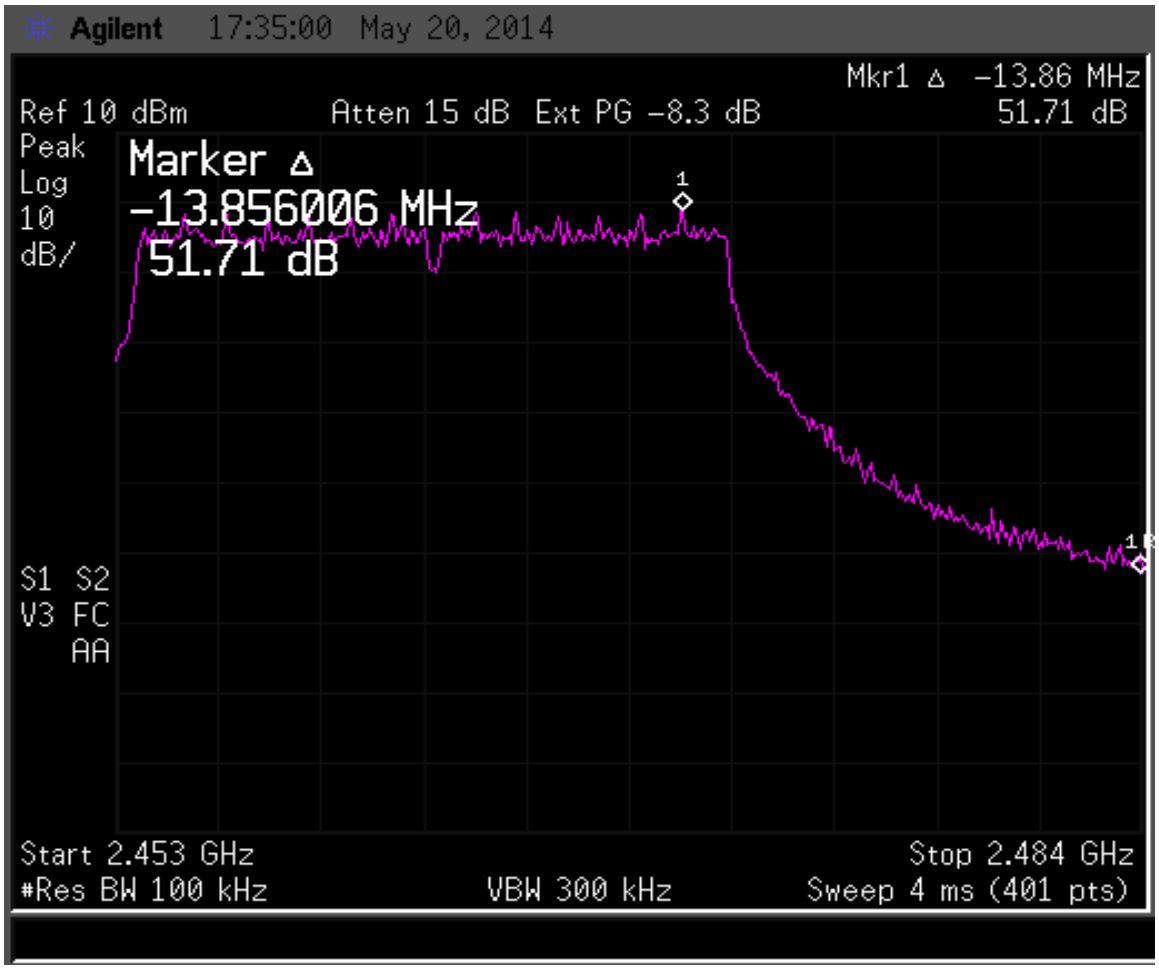


Figure 40. Band Edge Compliance – 802.11n – High Channel Delta – Peak

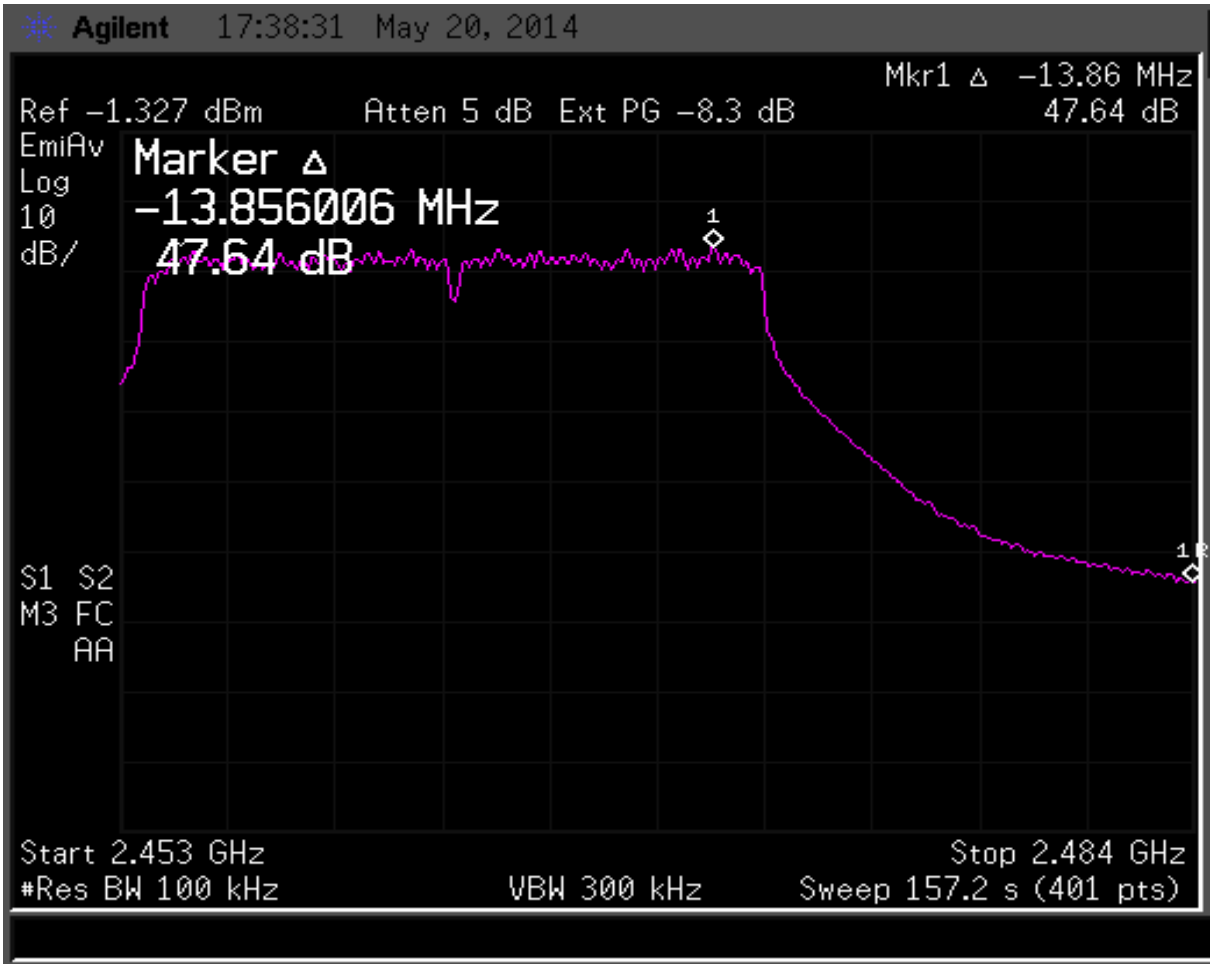


Figure 41. Band Edge Compliance – 802.11n – High Channel Delta – Average

Calculation of worst case 802.11n PEAK upper band edge measurement:

High Channel Corrected Measured Value from Table 10	103.67	dBuV
High Channel Band Edge Delta from Figure 41	-51.71	dB
Calculated Result	51.96	dBuV/m
Average Limit + 20dB Relaxation for PEAK	74.00	dBuV/m
Calculated Result	-51.71	dBuV/m
Band Edge Margin	22.04	dBuV/m

Calculation of worst case 802.11n AVERAGE upper band edge measurement:

High Channel Corrected Measured Value from Table 11	66.32	dBuV
High Channel Band Edge Delta from Figure 42	-47.64	dB
Calculated Result	19.00	dBuV/m
Peak Limit	54.00	dBuV/m
Calculated Result	-19.00	dBuV/m
Band Edge Margin	35.00	dBuV/m

2.13 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 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 12. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
802.11b		
2412	8.5	0.5
2442	8.4	0.5
2462	8.6	0.5
802.11g		
2412	18.4	0.5
2442	18.1	0.5
2462	18.3	0.5
802.11n		
2412	18.3	0.5
2442	18.1	0.5
2462	18.3	0.5

Test Date: May 7, 2014
Tested By
Signature: _____ Name: John Wynn

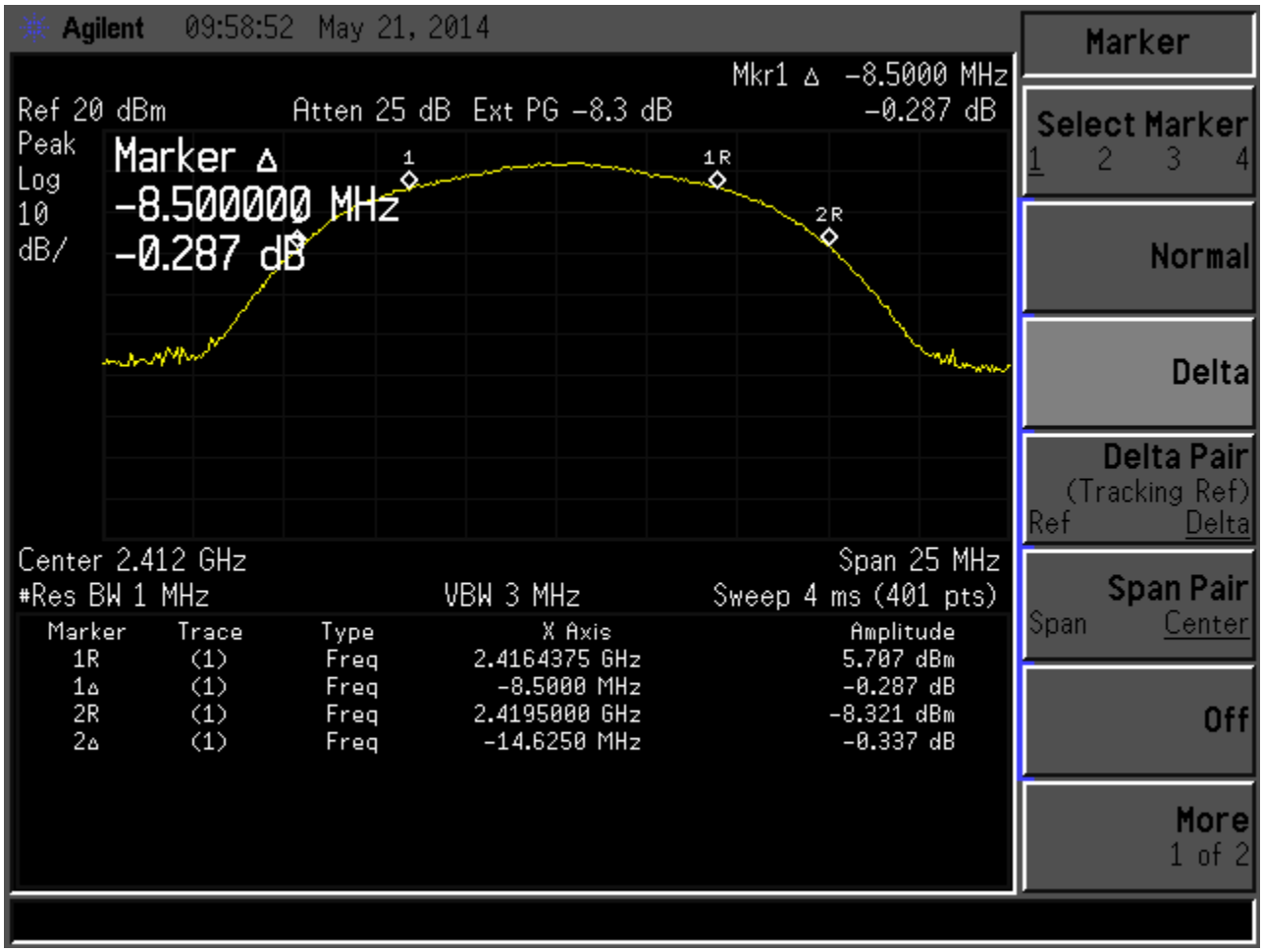


Figure 42. Six dB Bandwidth - 15.247 - Low Channel - 802.11b

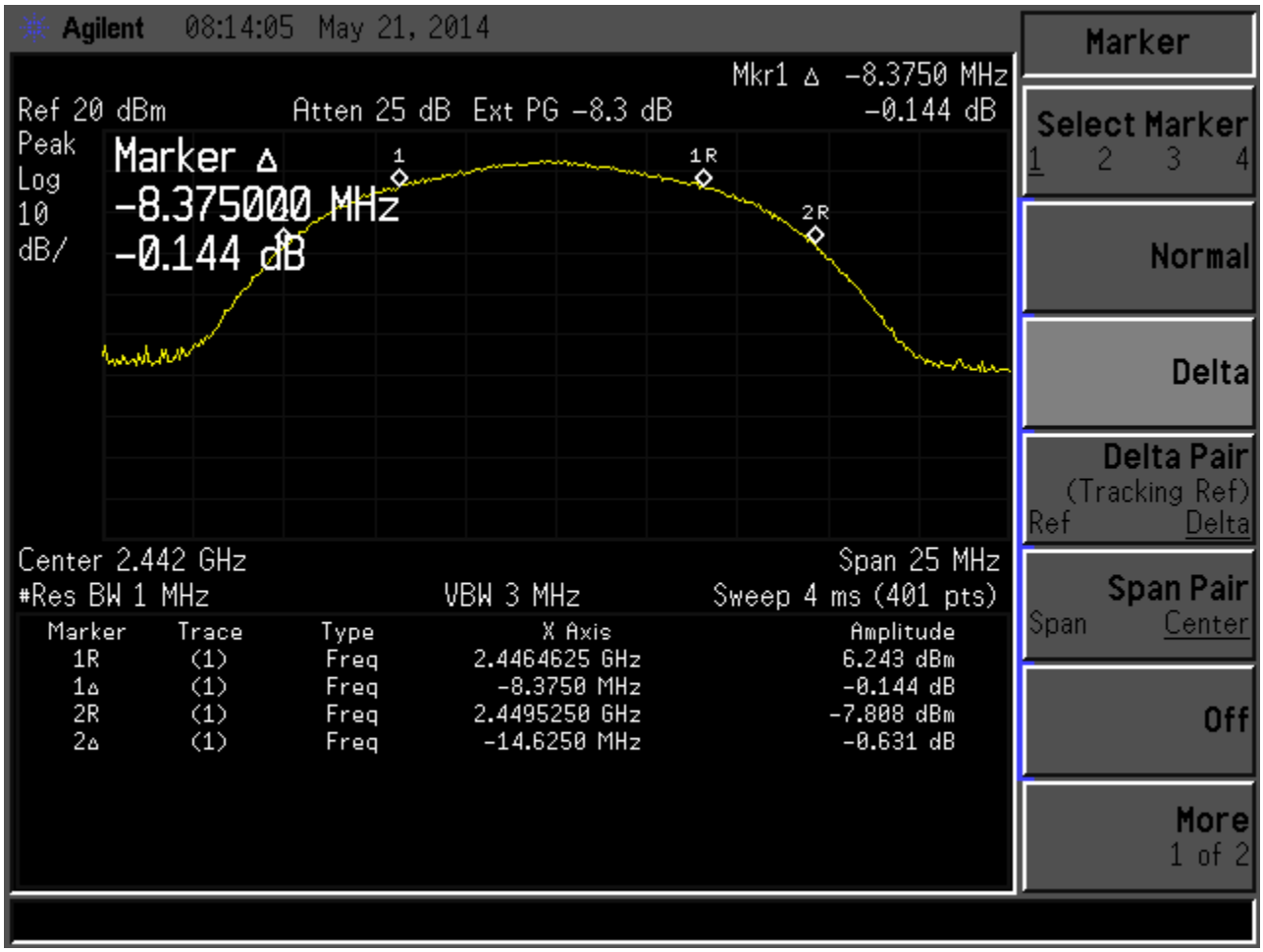


Figure 43. Six dB Bandwidth - 15.247 - Mid Channel - 802.11b

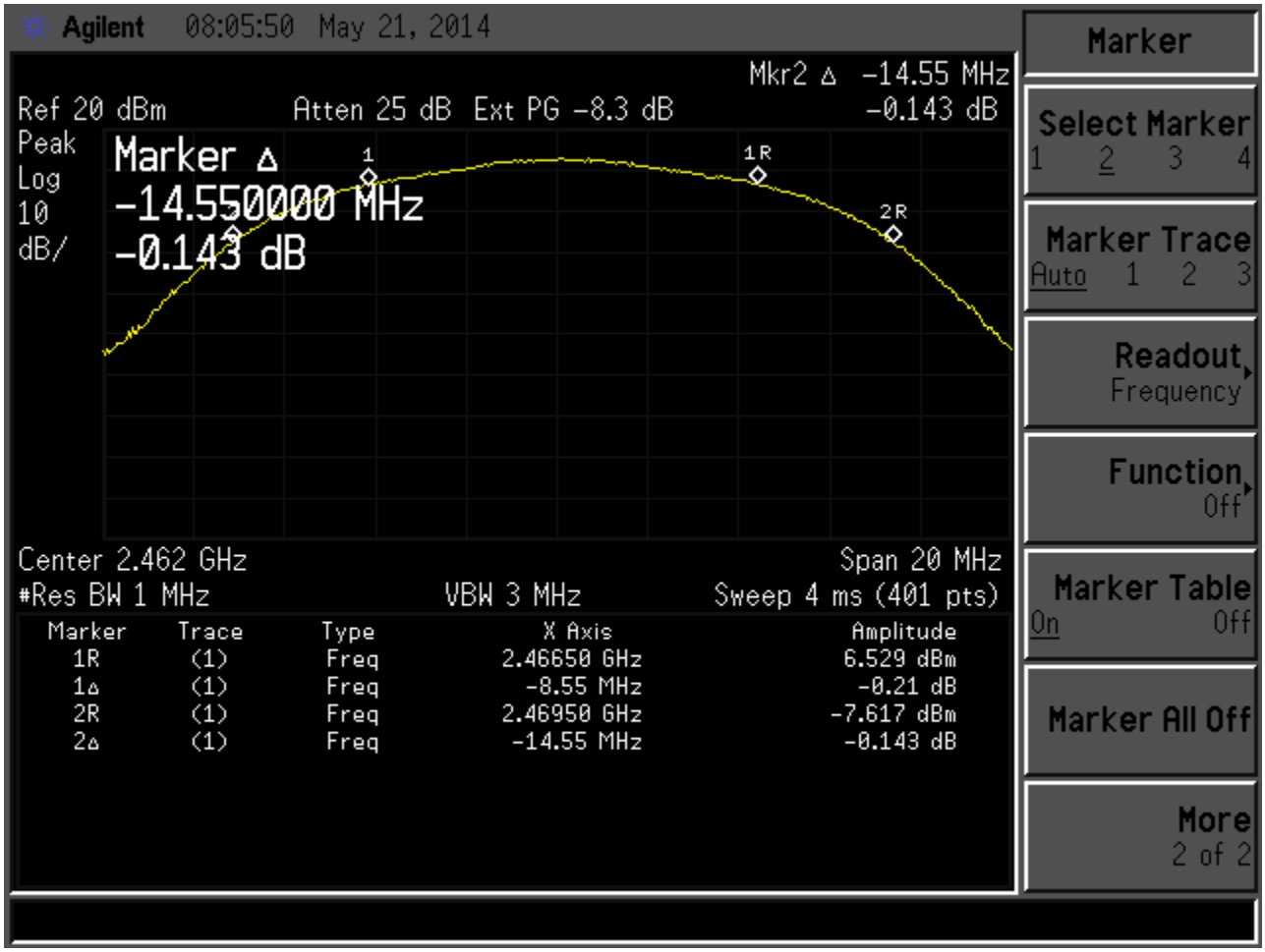


Figure 44. Six dB Bandwidth - 15.247 - High Channel - 802.11b

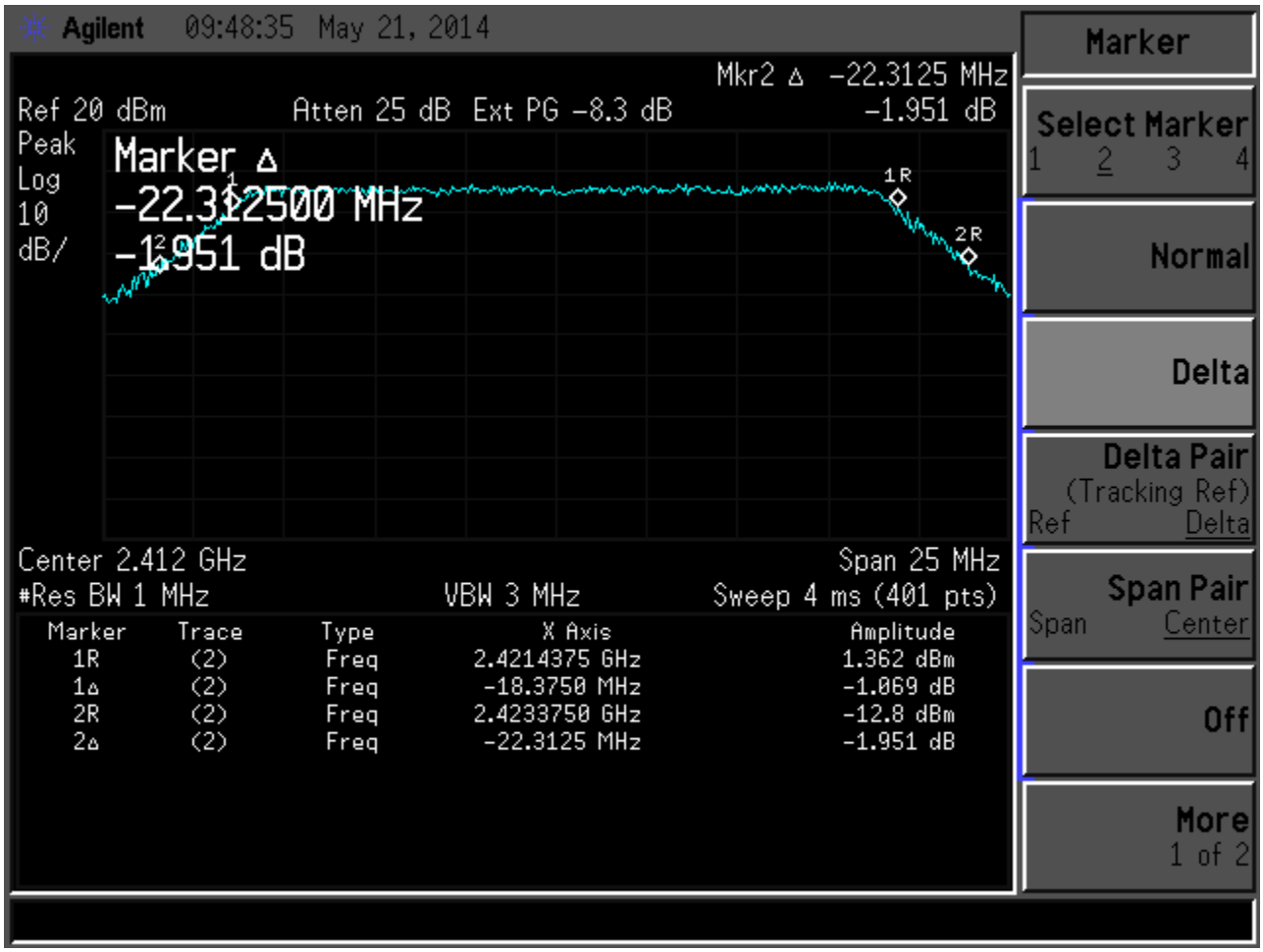


Figure 45. Six dB Bandwidth - 15.247 - Low Channel - 802.11g

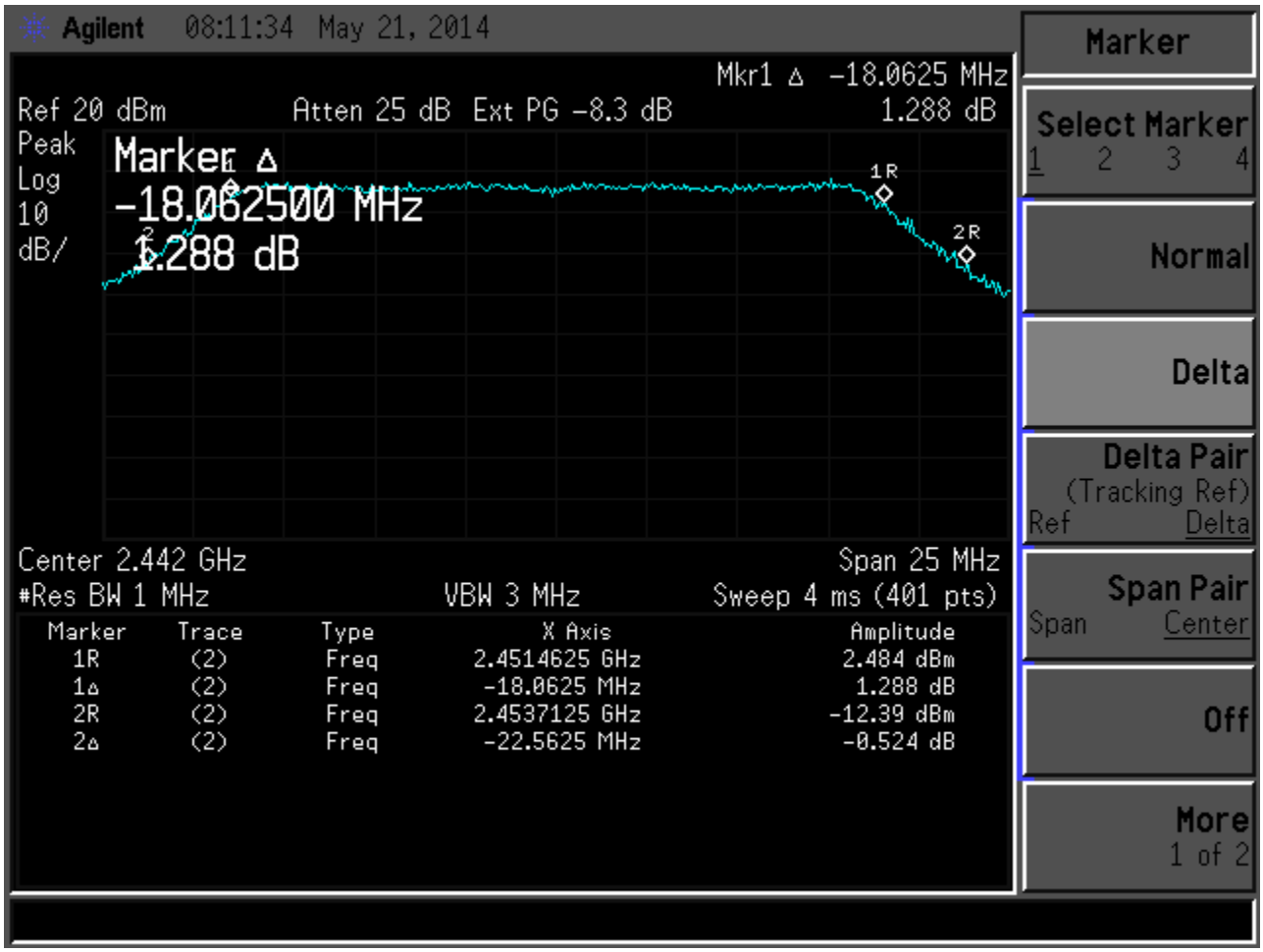


Figure 46. Six dB Bandwidth - 15.247 - Mid Channel - 802.11g

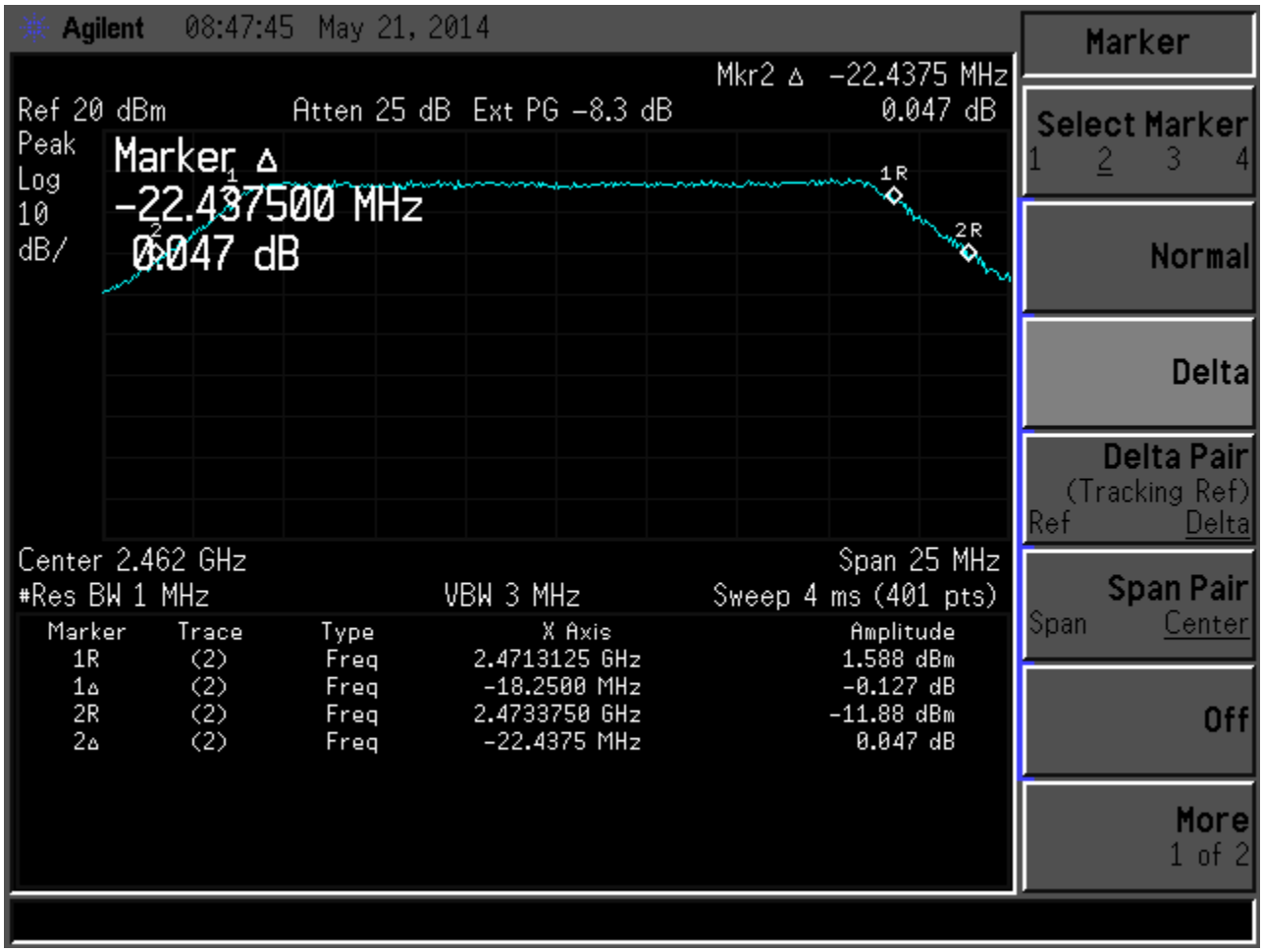


Figure 47. Six dB Bandwidth - 15.247 - High Channel - 802.11g

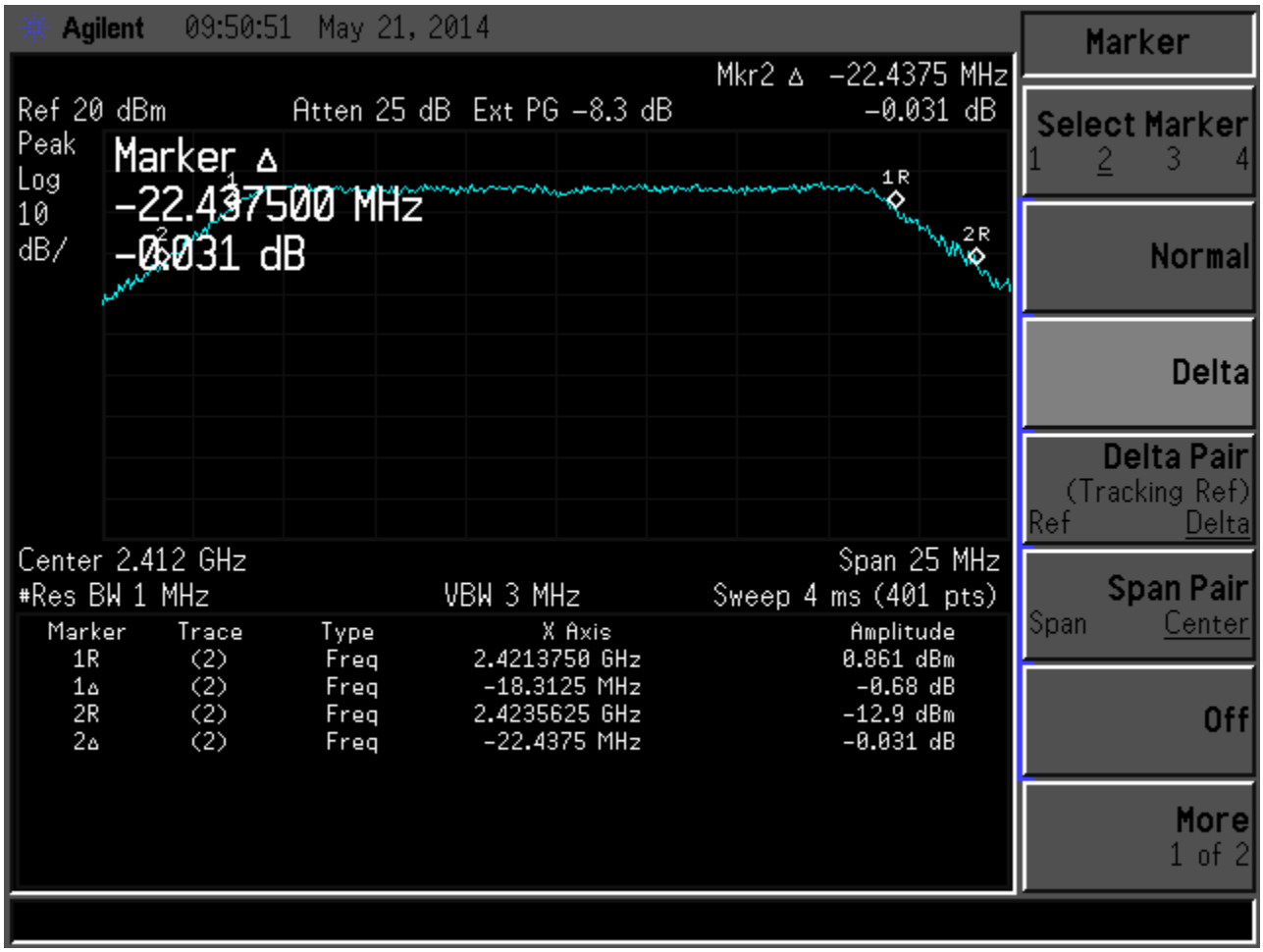


Figure 48. Six dB Bandwidth - 15.247 - Low Channel - 802.11n

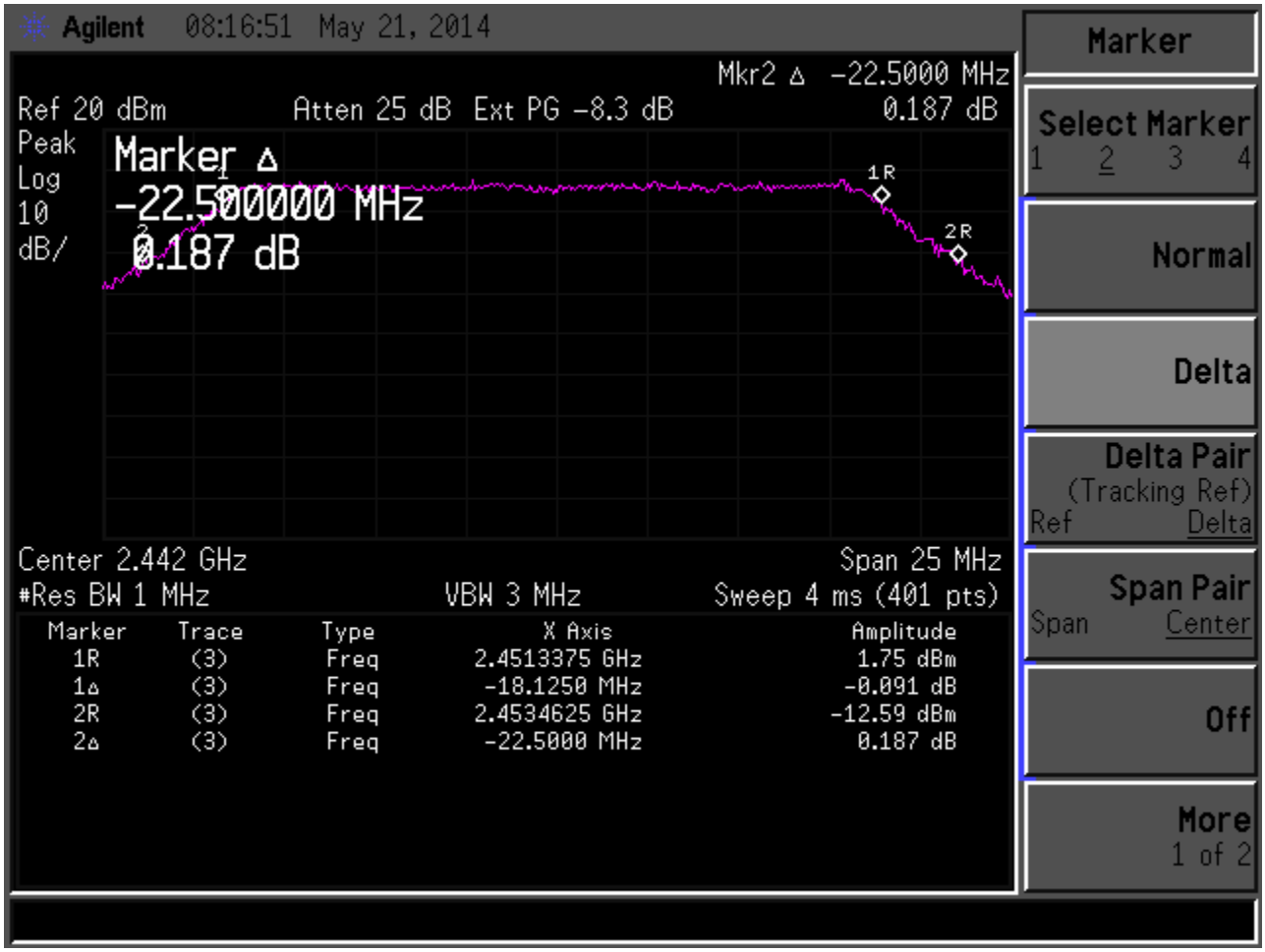


Figure 49. Six dB Bandwidth - 15.247 - Mid Channel - 802.11n

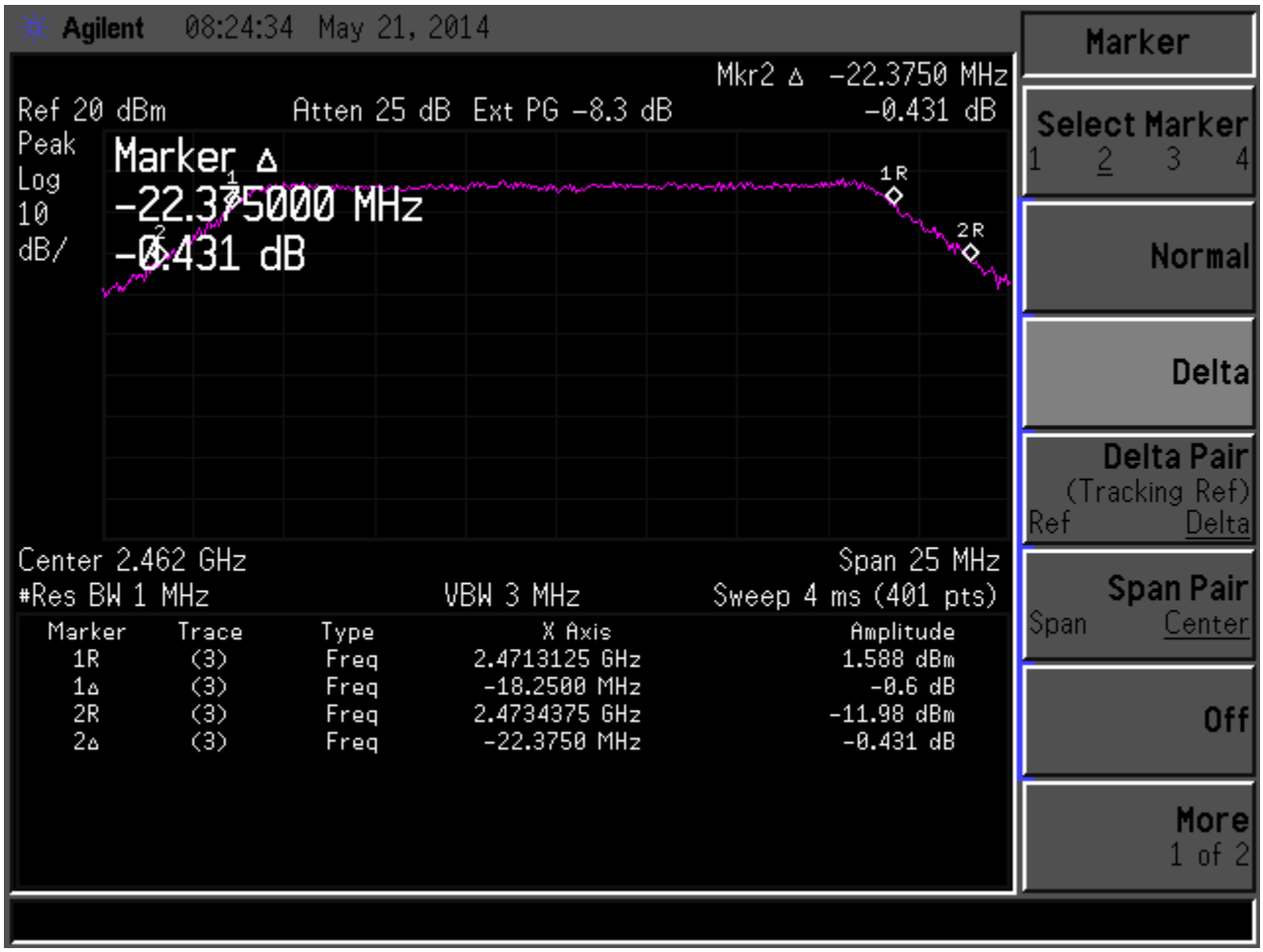


Figure 50. Six dB Bandwidth - 15.247 - High Channel - 802.11n

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

For the HUB module, the transmitter was programmed to operate at a maximum output power across the bandwidth.

Peak power within the band 2400 MHz to 2483.5 MHz was measured per FCC KDB Publication 558074 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. If the EUT bandwidth exceeds the RBW of the receiver, the procedures in KDB 558074 section 9.1.2 were followed. Peak antenna conducted output power is tabulated in the table below.

Table 13. 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)
802.11b			
2412.00	11.71	14.83	1000
2442.00	12.01	15.90	1000
2462.00	12.35	17.18	1000
802.11g			
2412.00	8.19	6.60	1000
2442.00	8.47	7.03	1000
2462.00	7.90	6.12	1000
802.11n			
2412.00	7.89	6.15	1000
2442.00	8.20	6.61	1000
2462.00	8.19	6.59	1000

Test Date: May 28, 2014
Tested By
Signature: _____ Name: John Wynn

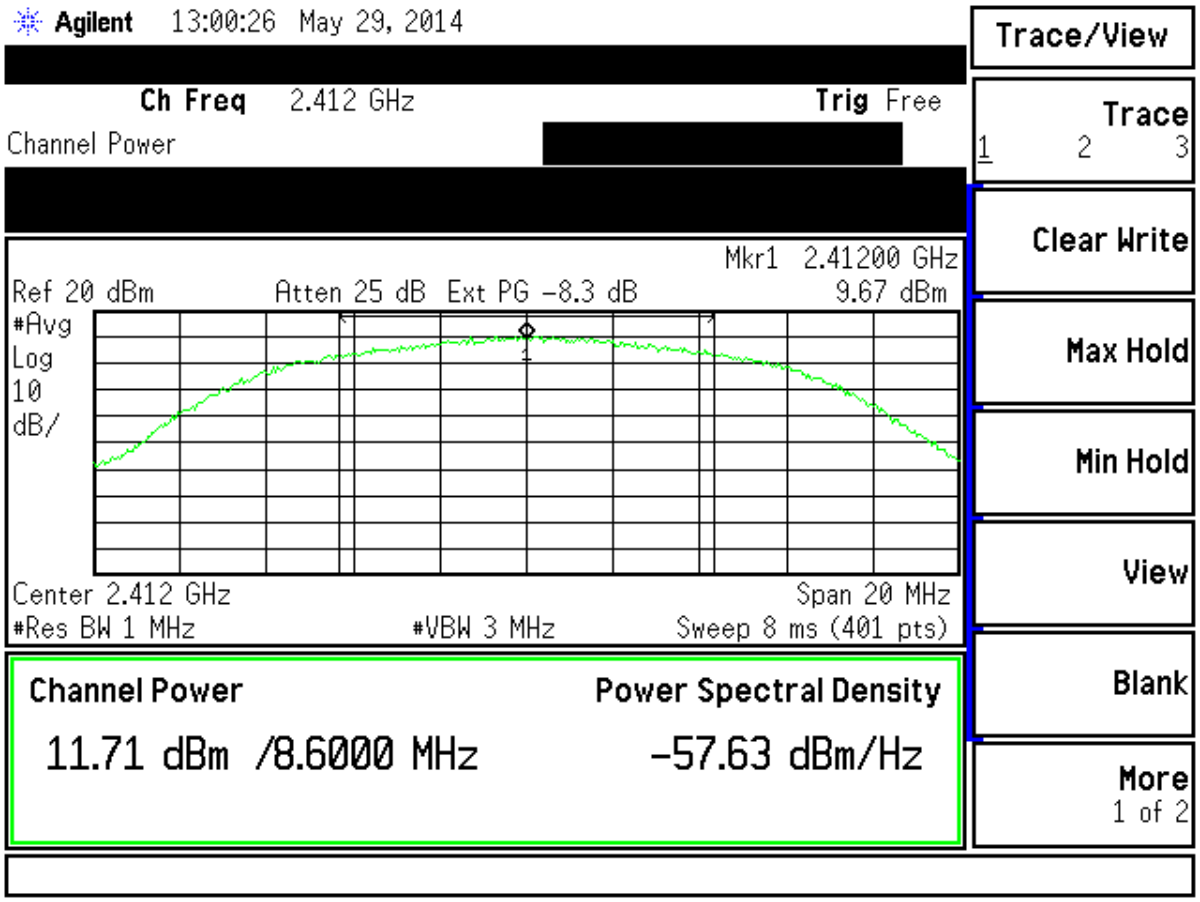


Figure 51. Peak Antenna Conducted Output Power, 802.11b Low Channel

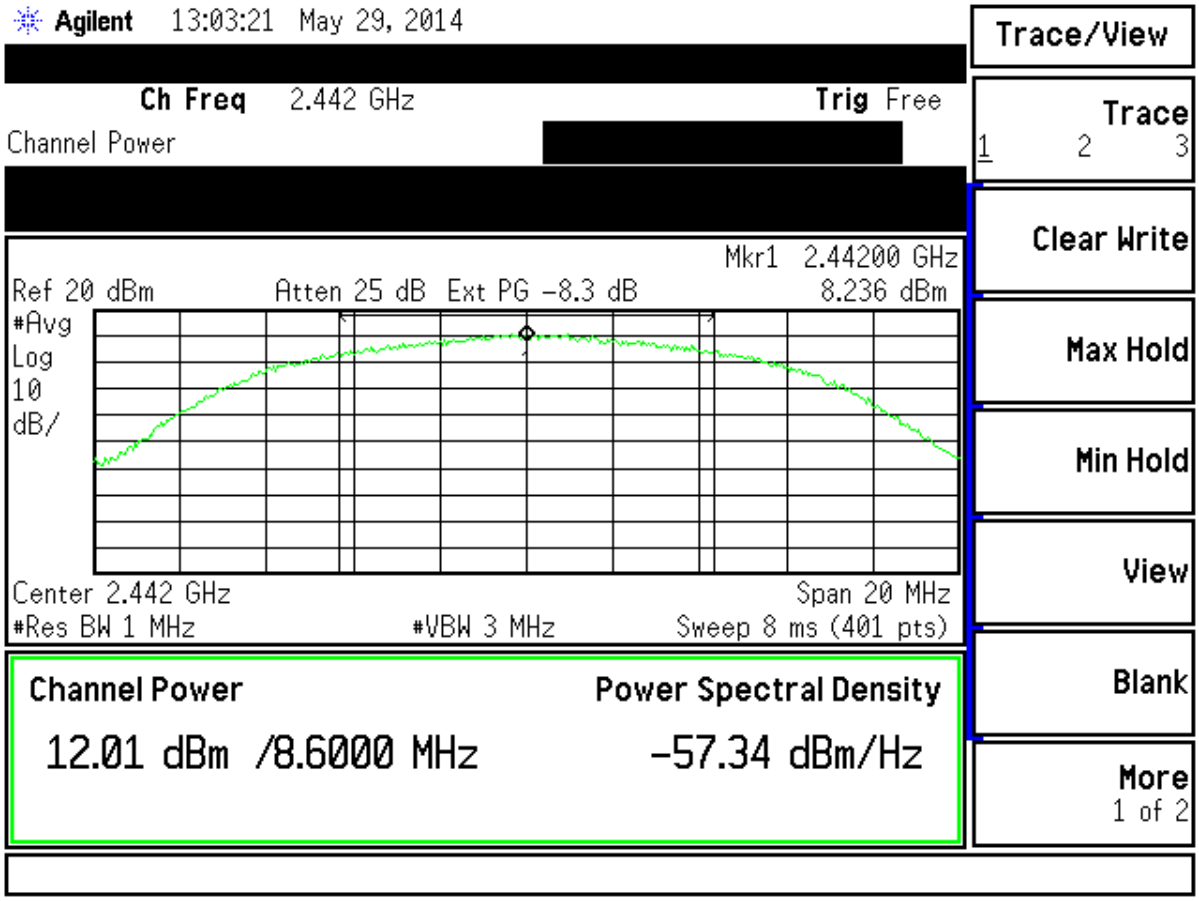


Figure 52. Peak Antenna Conducted Output Power, 802.11b Mid Channel

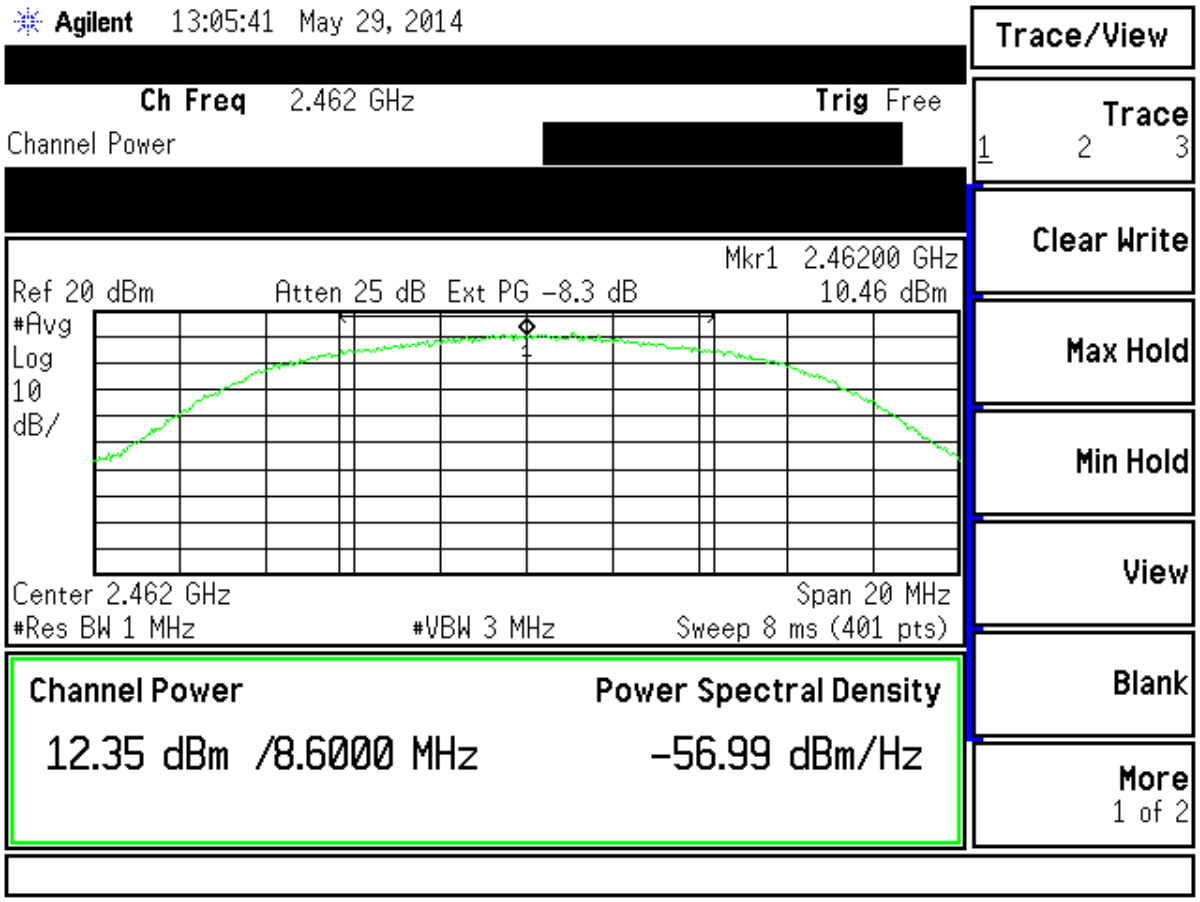


Figure 53. Peak Antenna Conducted Output Power, 802.11b High Channel

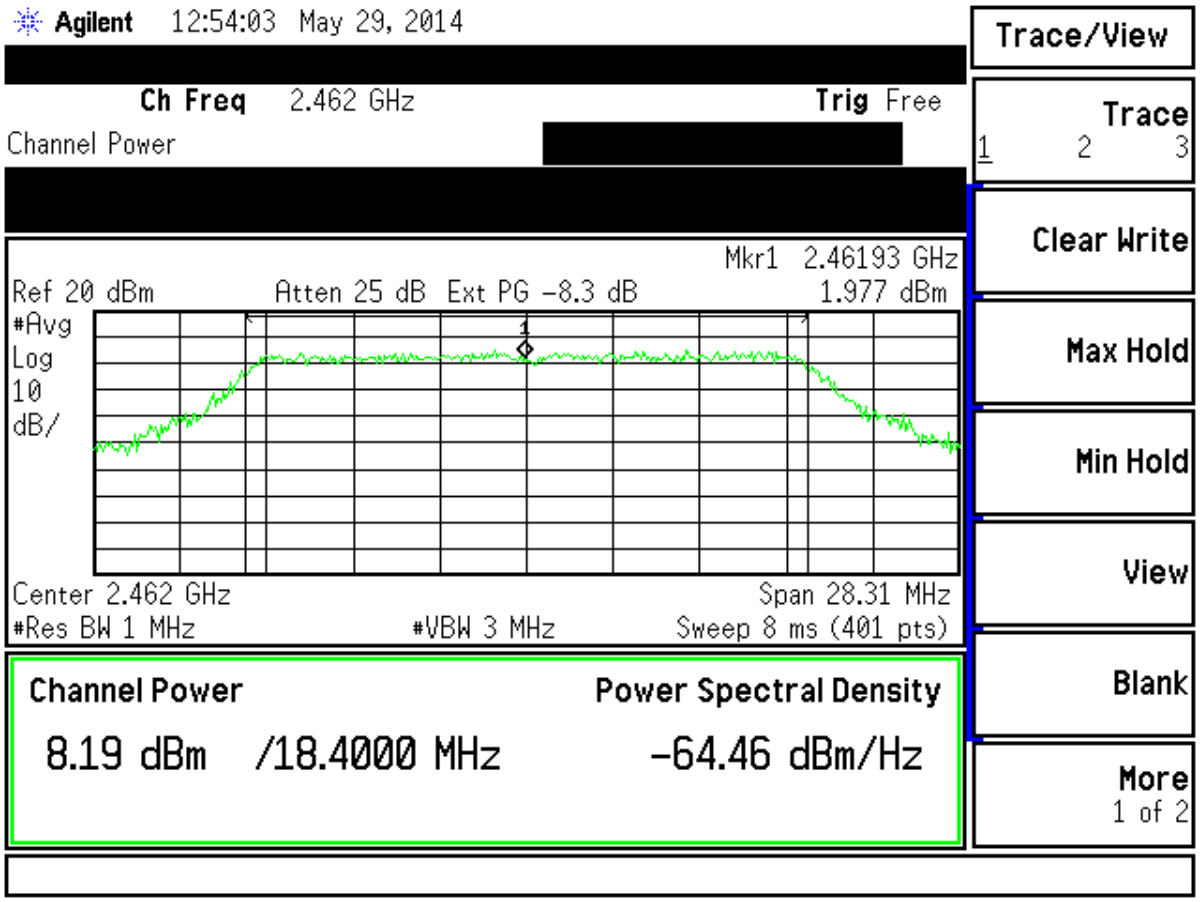


Figure 54. Peak Antenna Conducted Output Power, 802.11g Low Channel

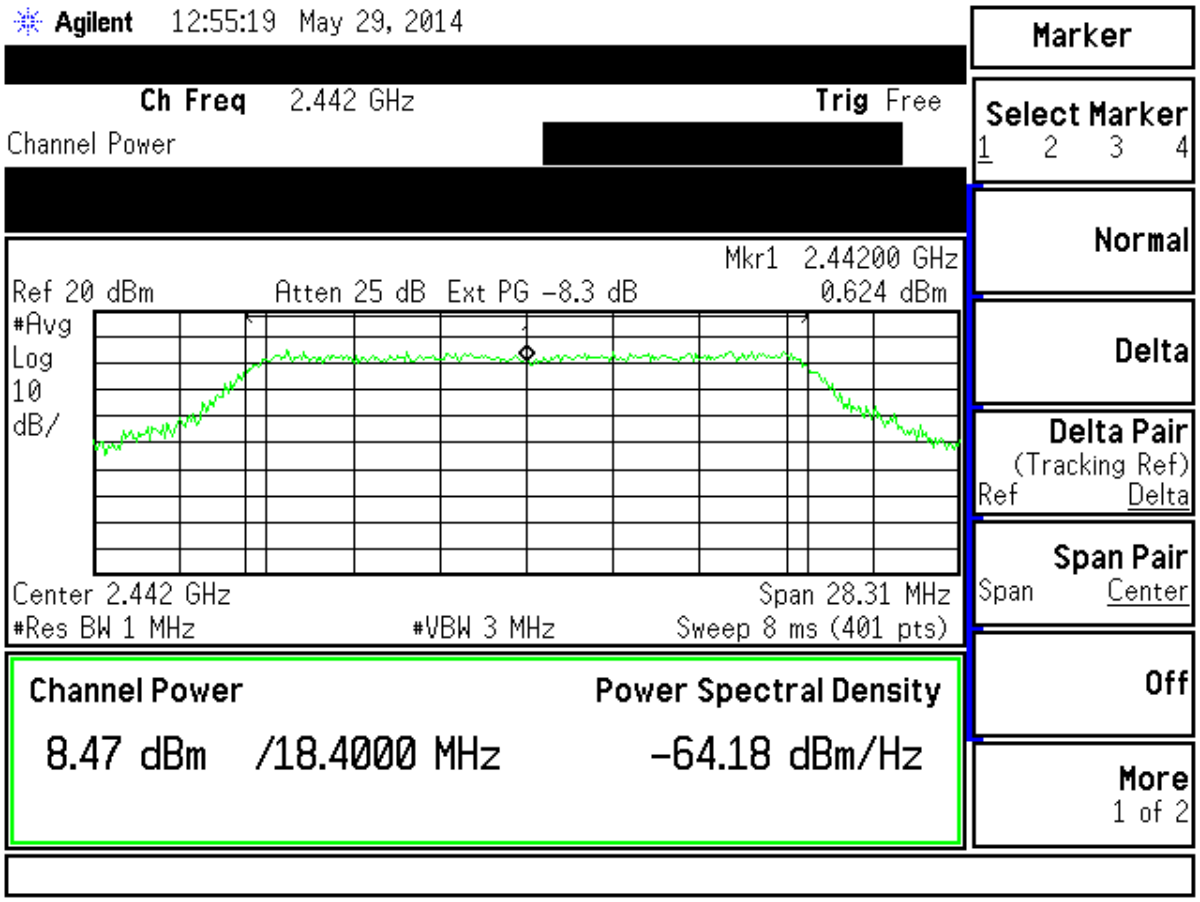


Figure 55. Peak Antenna Conducted Output Power, 802.11g Mid Channel

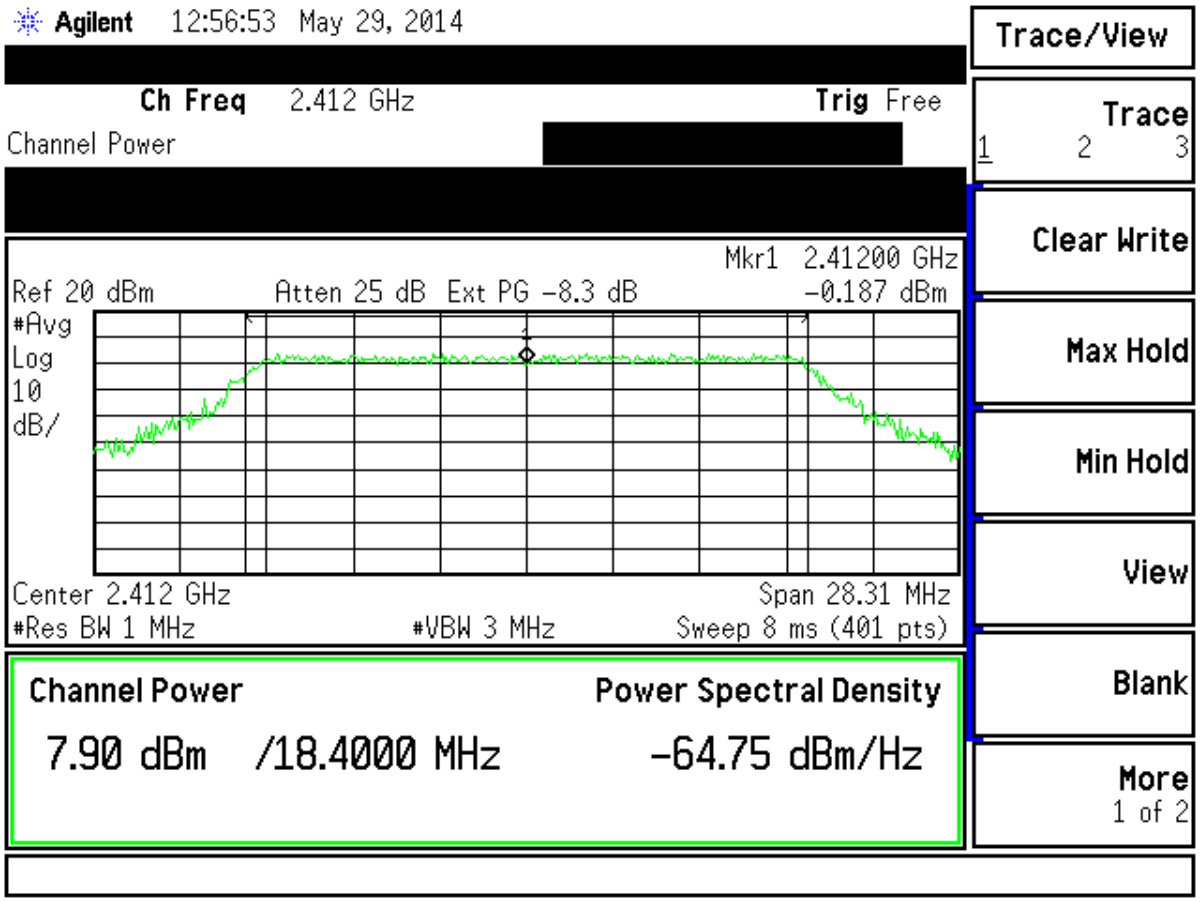


Figure 56. Peak Antenna Conducted Output Power, 802.11g High Channel

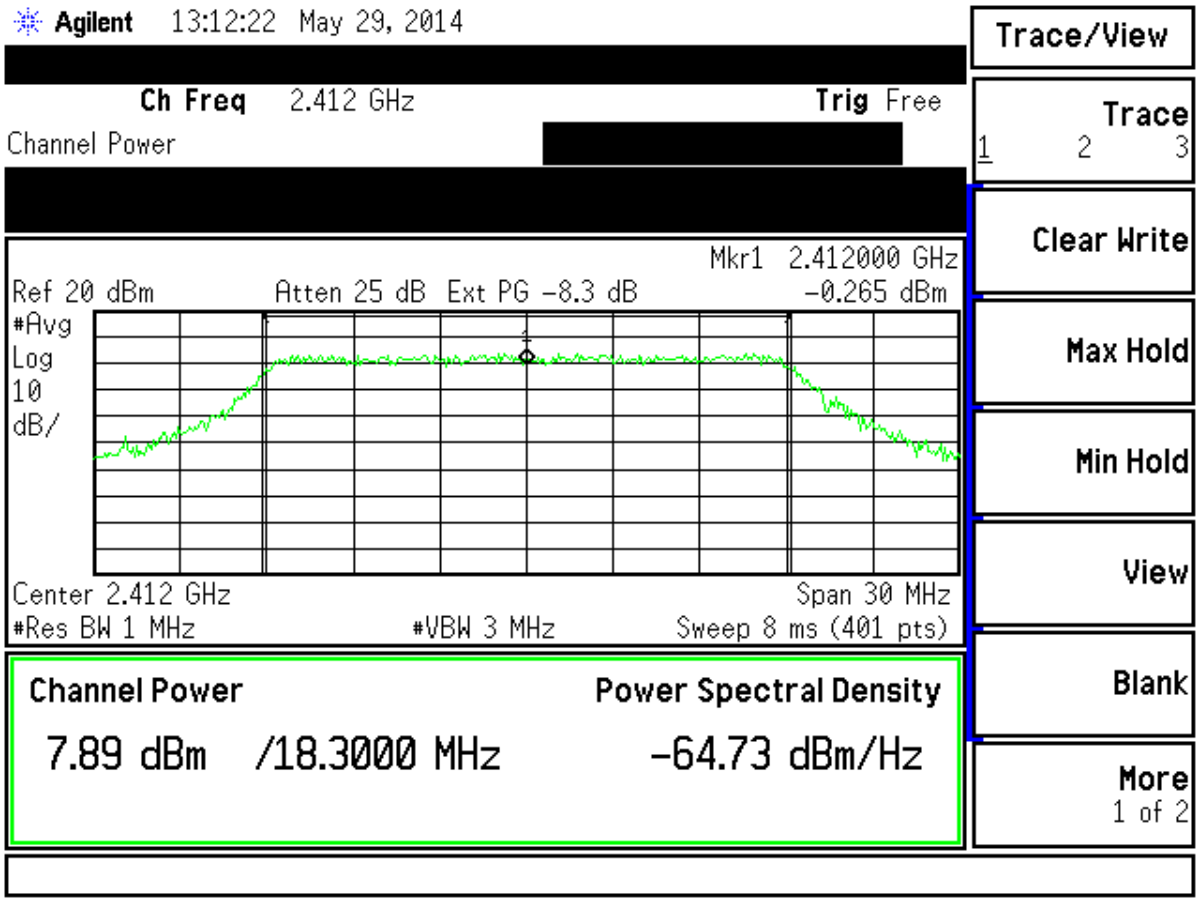


Figure 57. Peak Antenna Conducted Output Power, 802.11n Low Channel

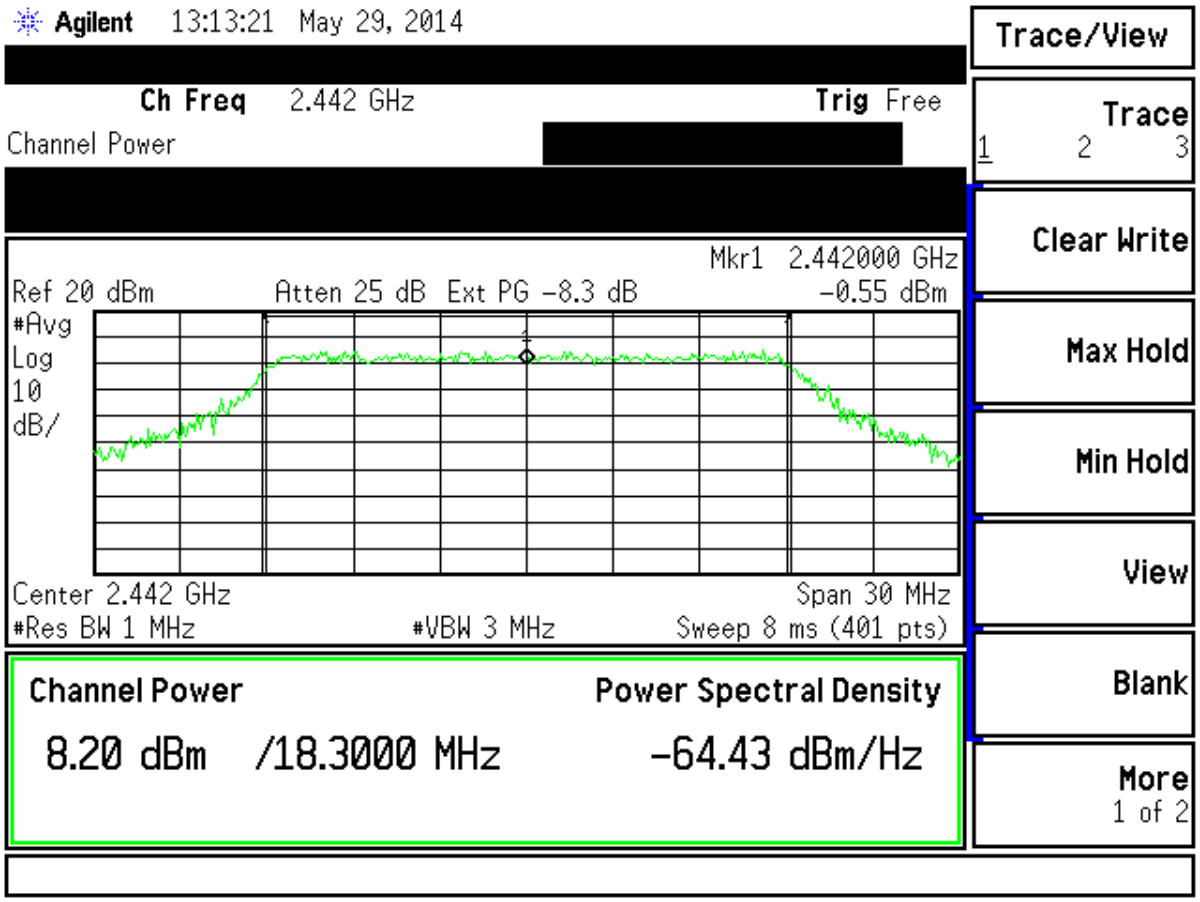


Figure 58. Peak Antenna Conducted Output Power, 802.11n Mid Channel

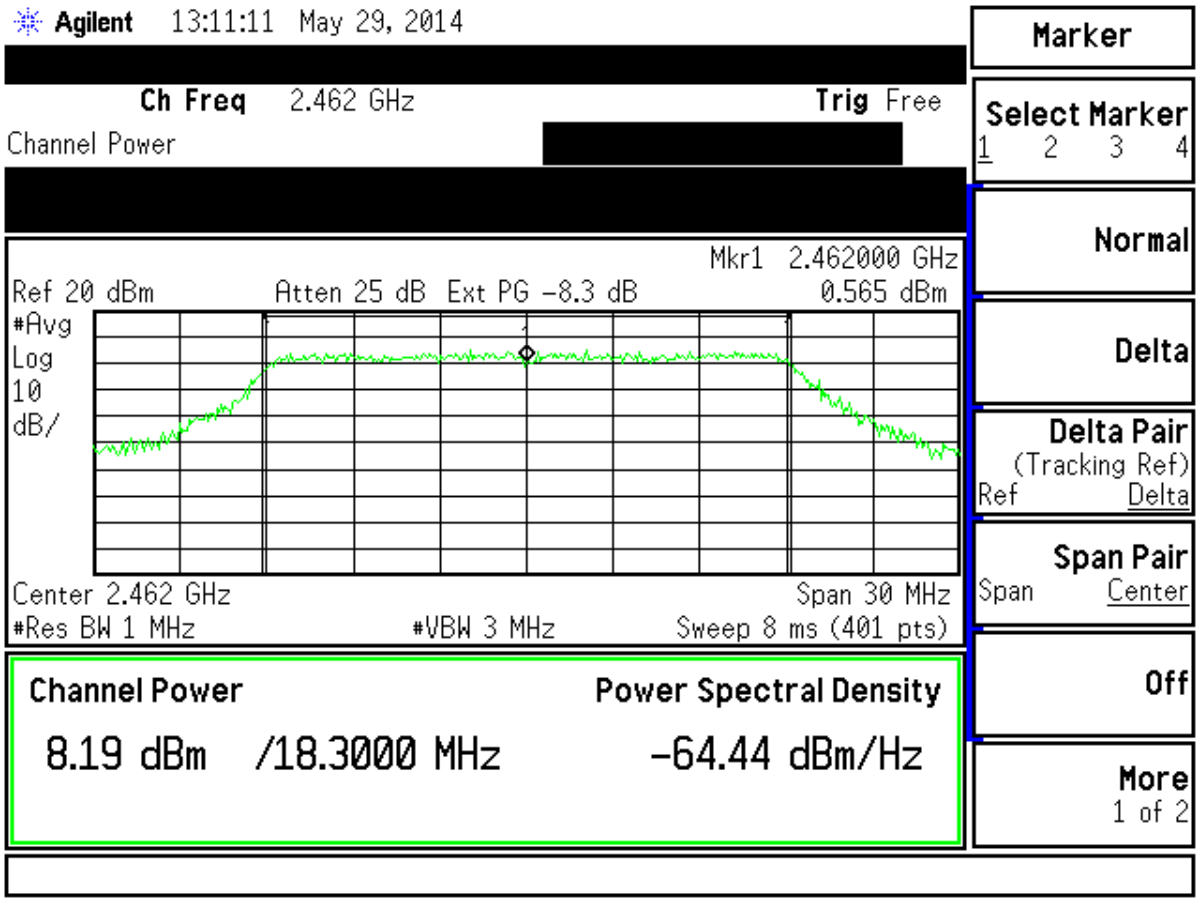


Figure 59. Peak Antenna Conducted Output Power, 802.11n High Channel

2.15 Power Spectral Density (CFR 15.247(e)) (IC RSS 210 A8.5)

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. 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.

The following results show that all are less than +8 dBm per 3 kHz band.

Table 14. Power Spectral Density for Low, Mid and High Bands

Frequency	Test Data	Results	FCC Limit

(MHz)	(dBm/3 KHz)	(dBm/3 kHz)	(dBm/3 kHz)
802.11b			
Low-2412	-7.975	-7.975	+8.0
Mid-2442	-7.999	-7.999	+8.0
High-2460	-8.369	-8.369	+8.0
802.11g			
Low-2412	-15.310	-15.310	+8.0
Mid-2442	-14.970	-14.970	+8.0
High-2460	-15.120	-15.120	+8.0
802.11n			
Low-2412	-16.540	-16.540	+8.0
Mid-2442	-16.000	-16.000	+8.0
High-2460	-15.370	-15.370	+8.0

Test Date: May 21, 2014
Tested By
Signature: _____ Name: John Wynn

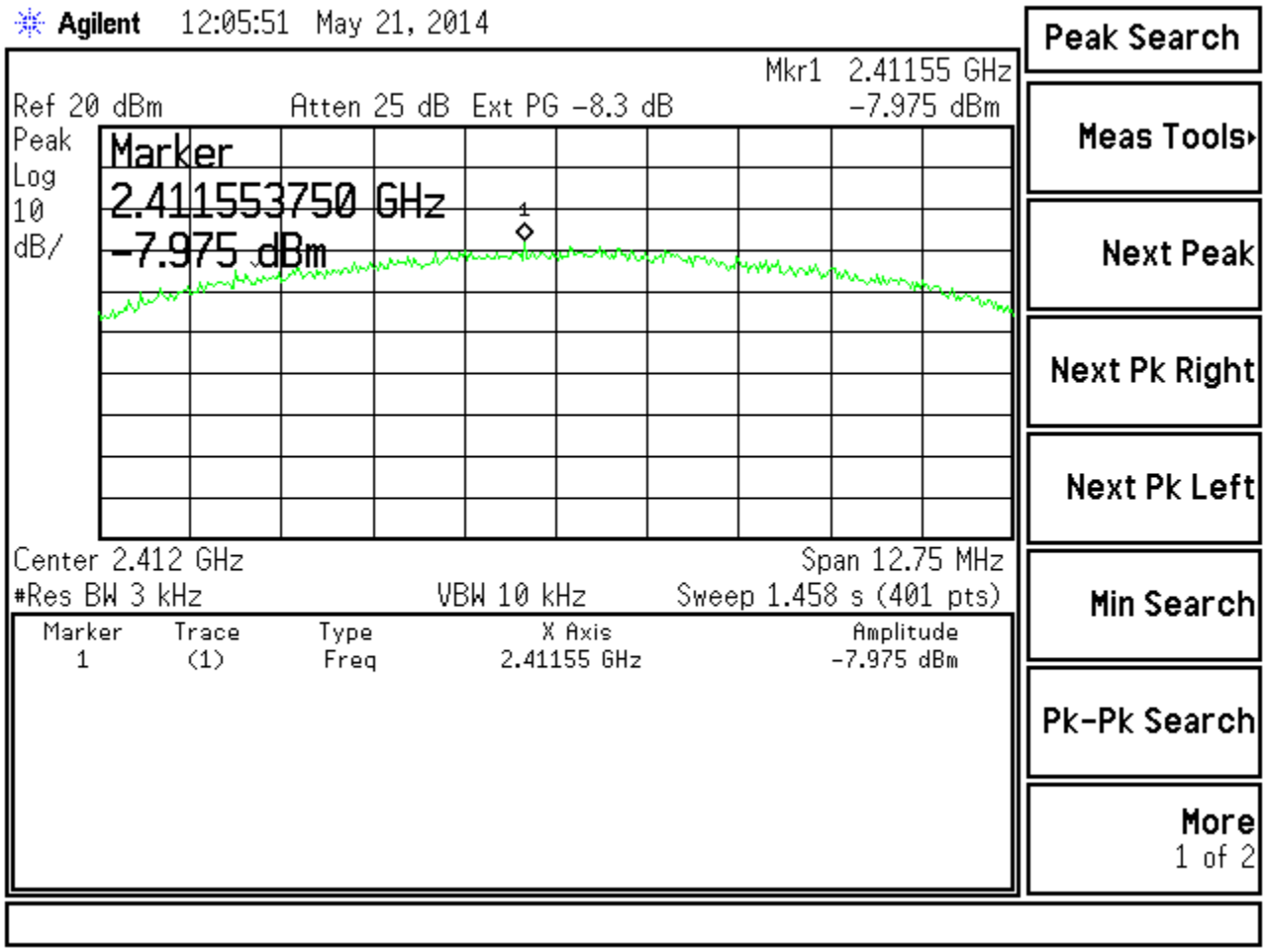


Figure 60. Peak Power Spectral Density - 802.11b - Low Channel

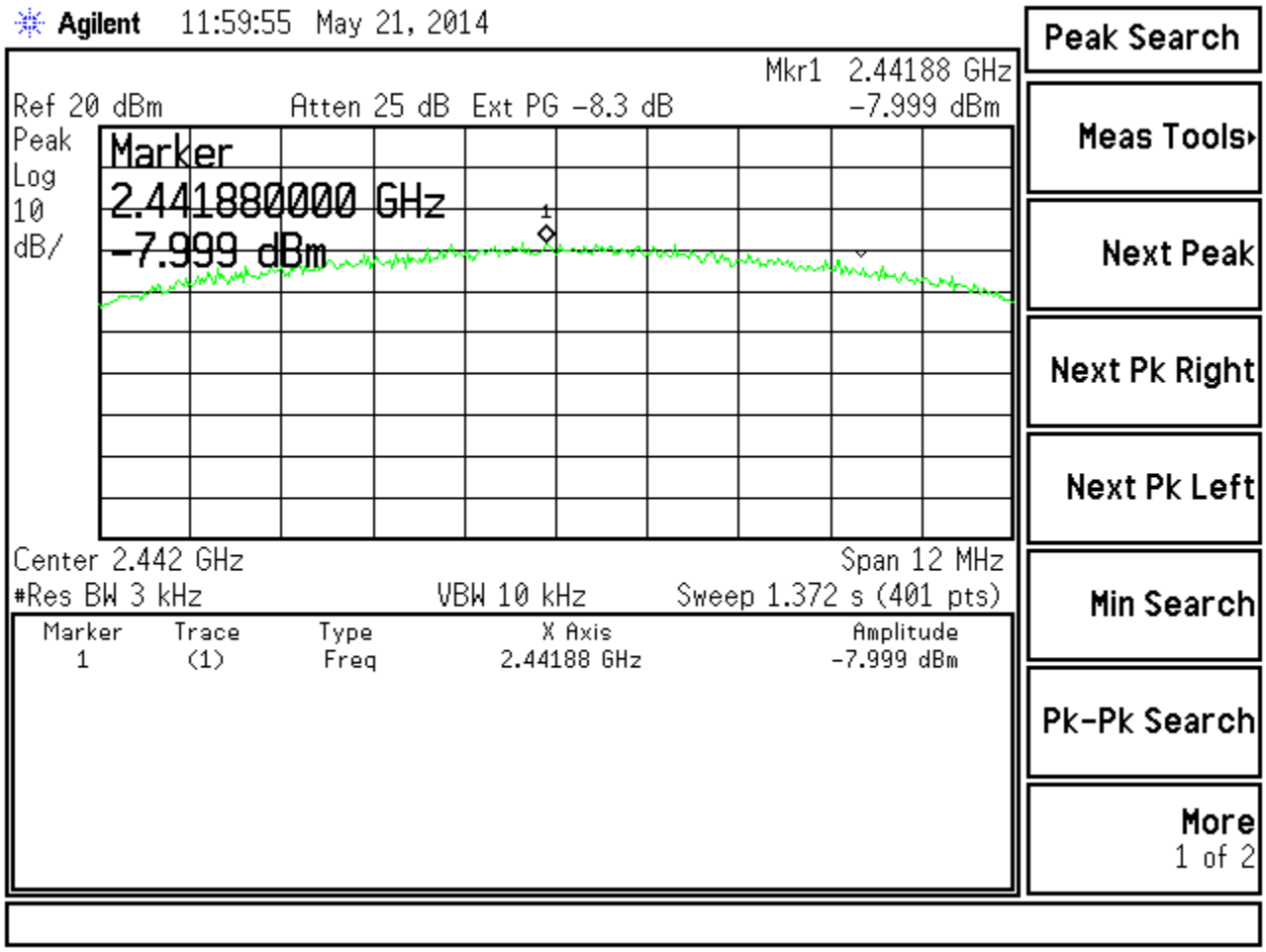


Figure 61. Peak Power Spectral Density - 802.11b - Mid Channel

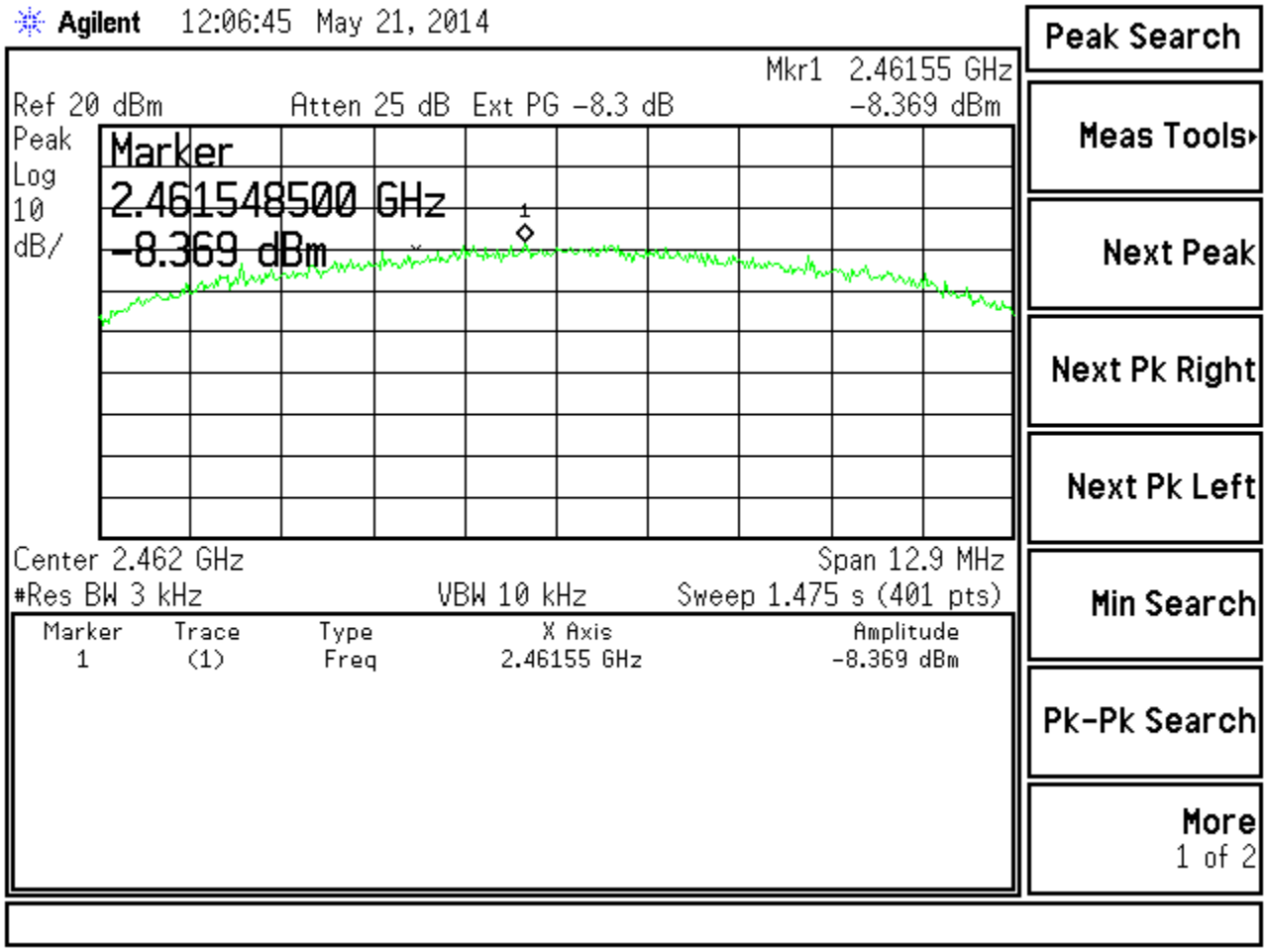


Figure 62. Peak Power Spectral Density - 802.11b - High Channel

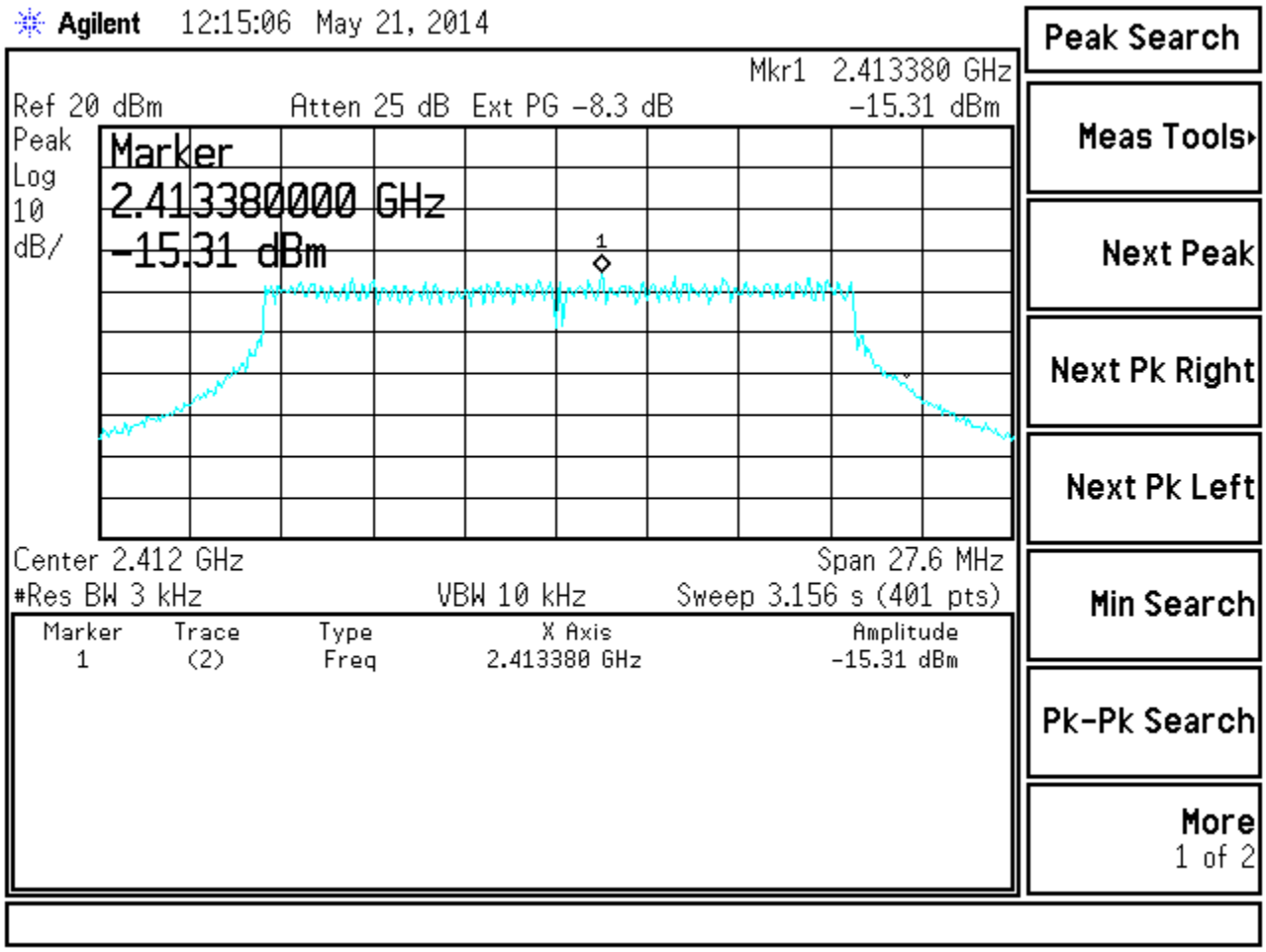


Figure 63. Peak Power Spectral Density - 802.11g - Low Channel

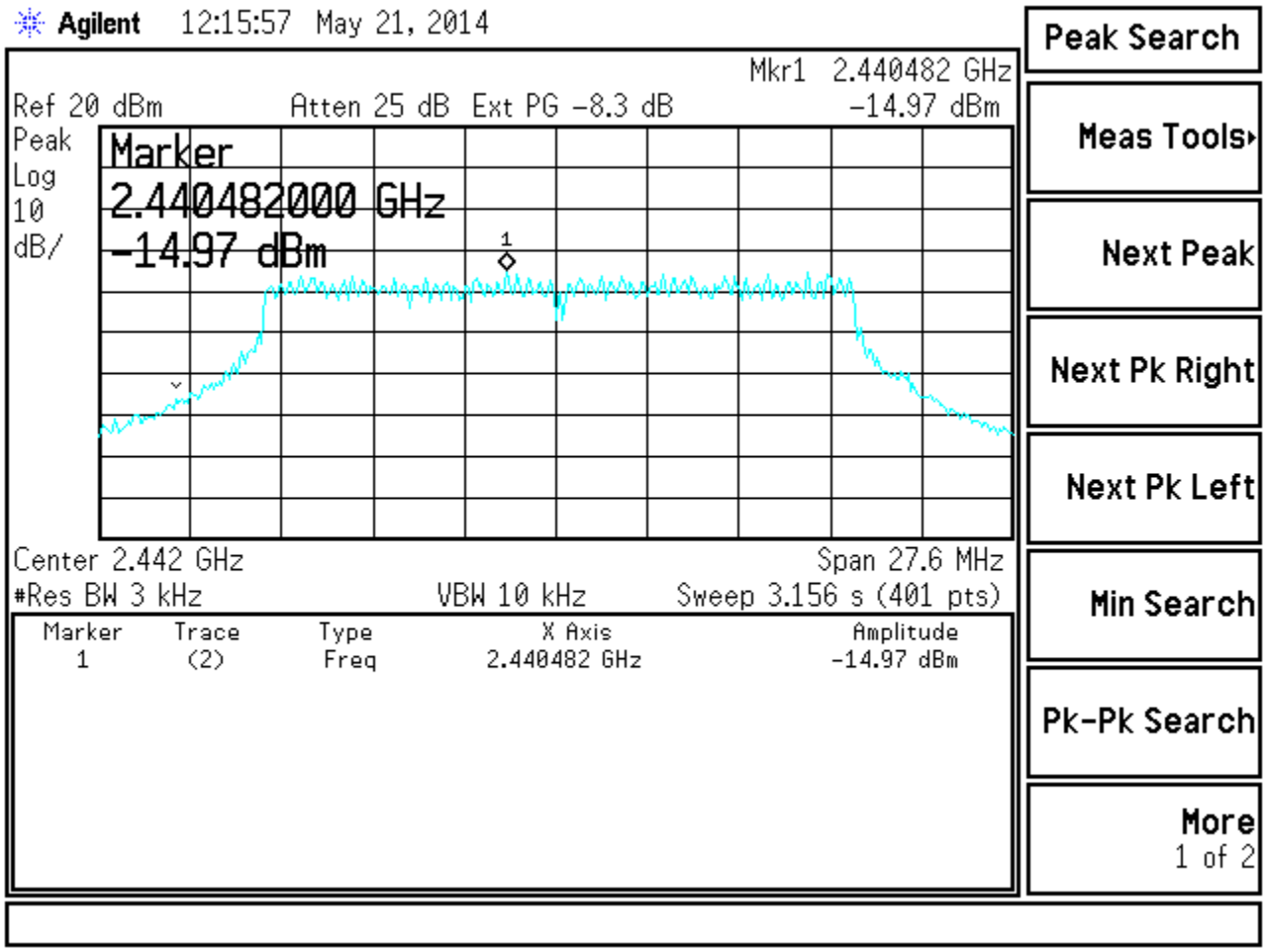


Figure 64. Peak Power Spectral Density - 802.11g - Mid Channel

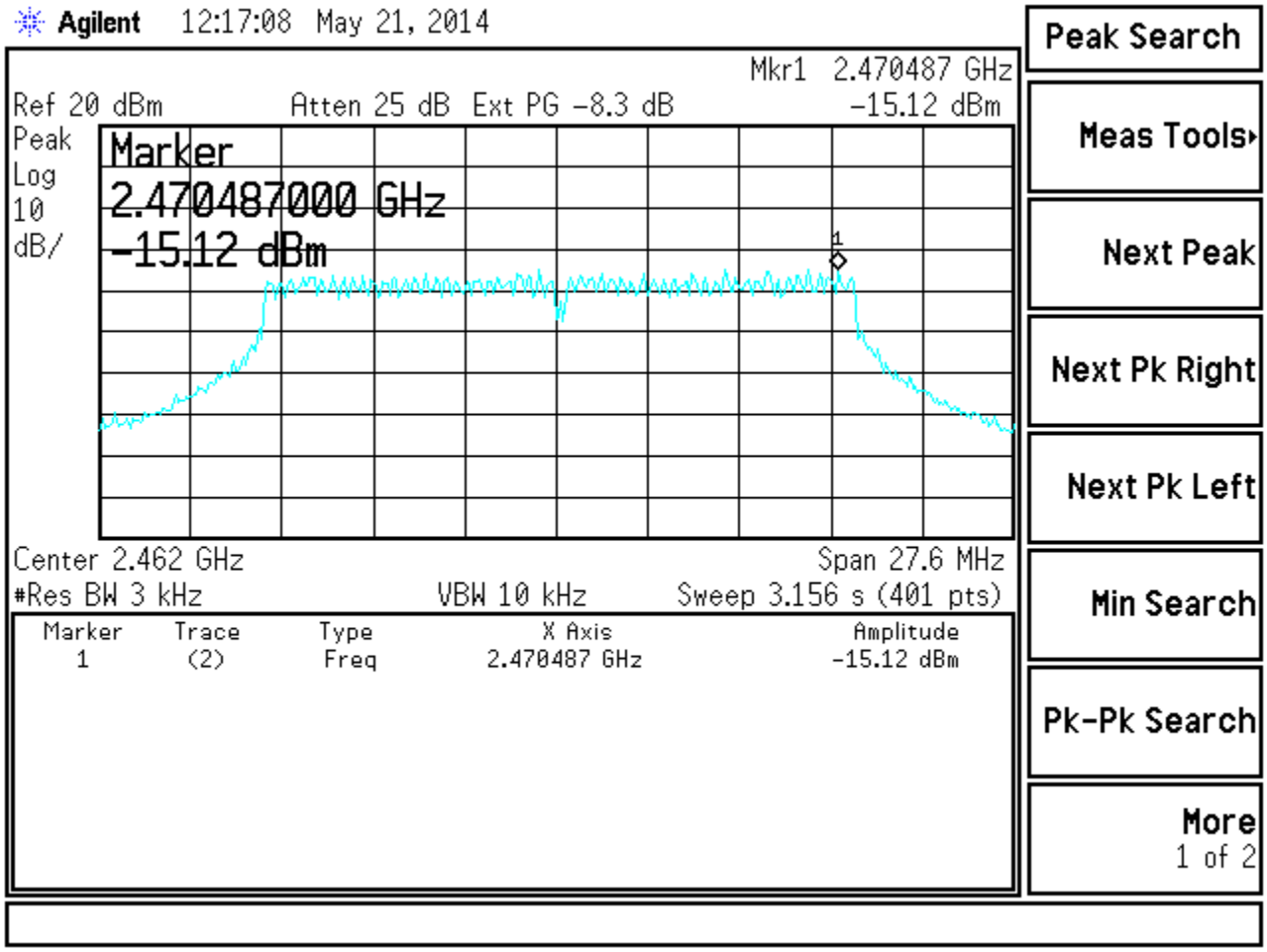


Figure 65. Peak Power Spectral Density - 802.11g - High Channel

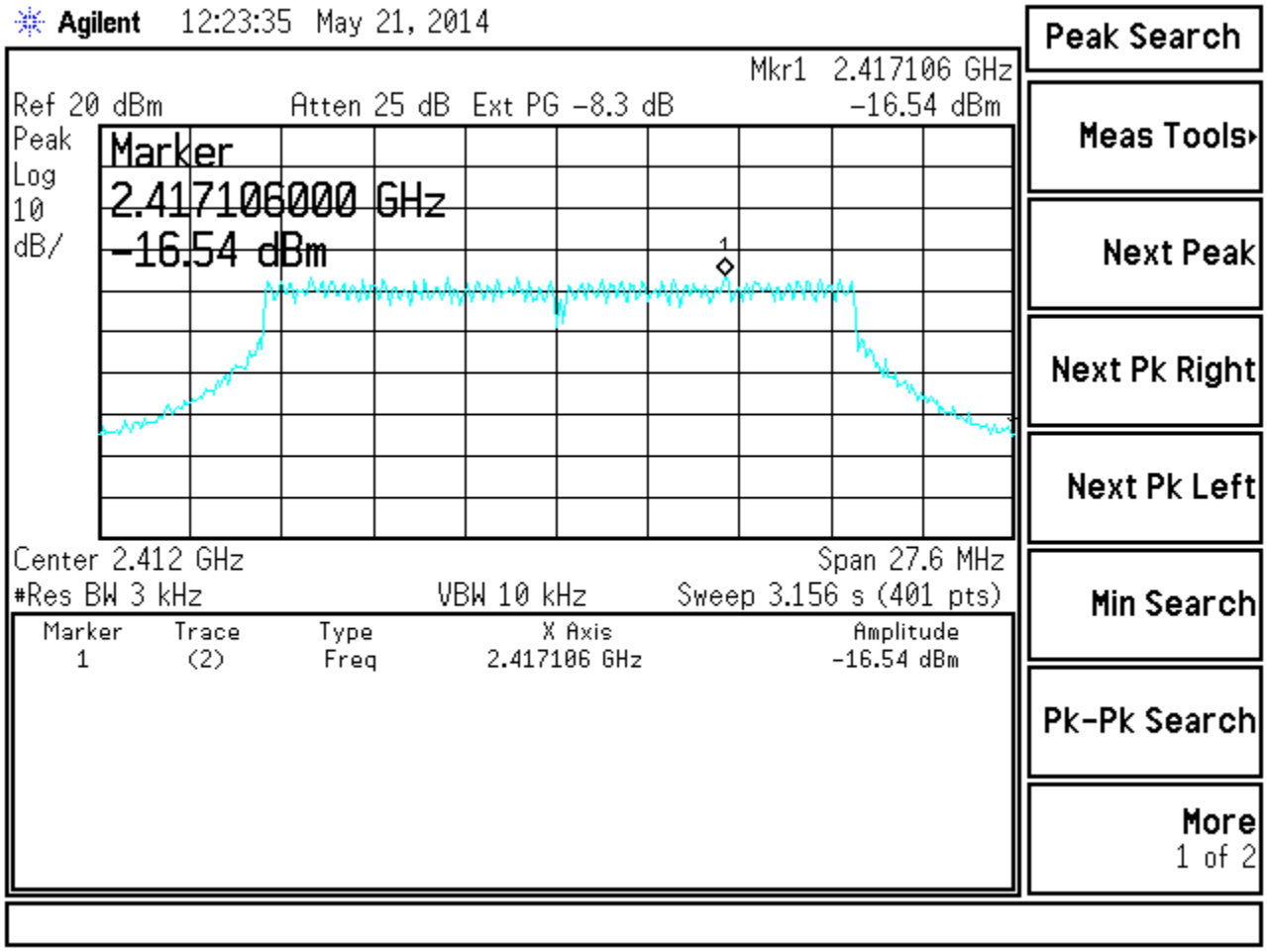


Figure 66. Peak Power Spectral Density - 802.11n - Low Channel

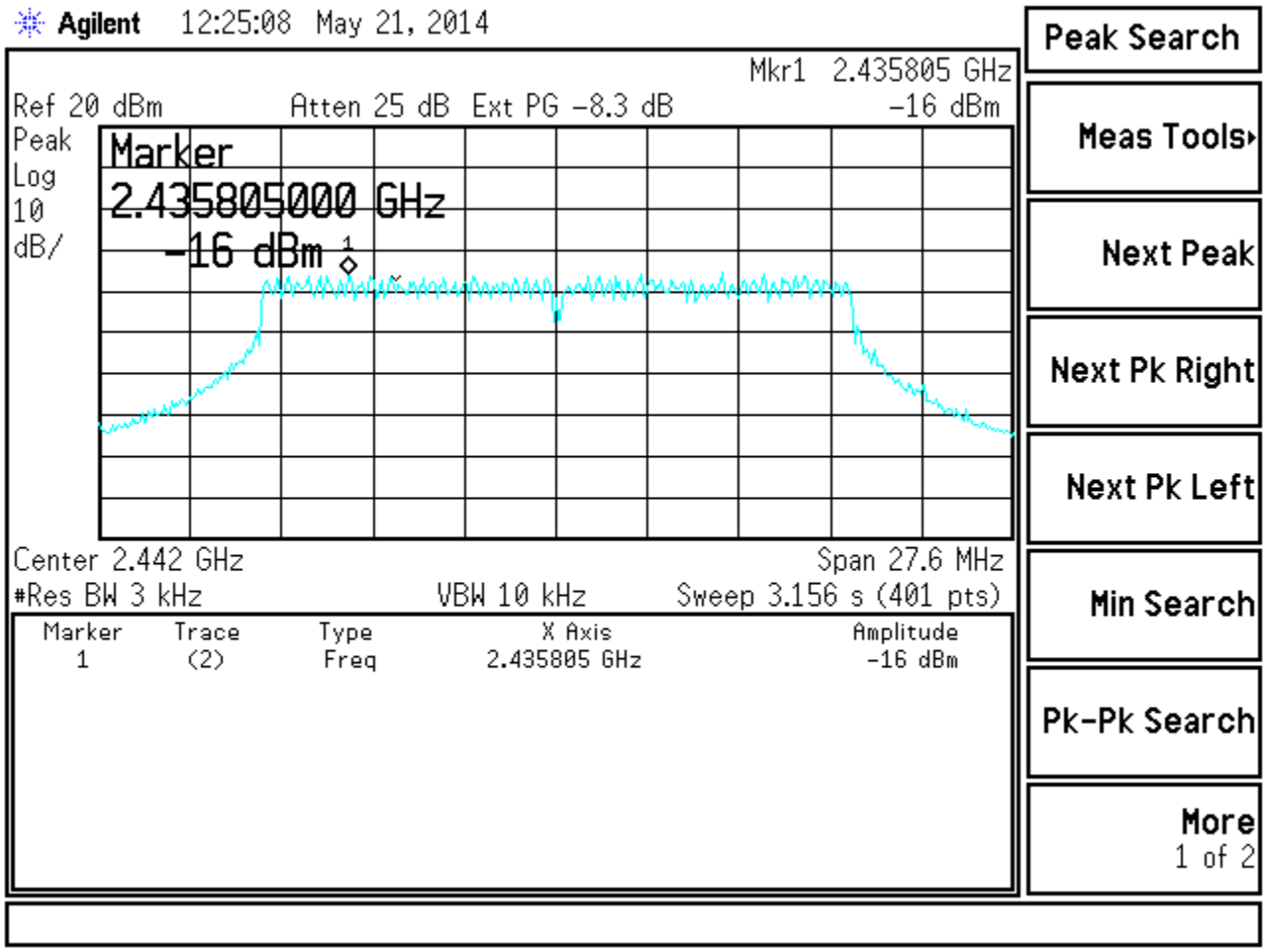


Figure 67. Peak Power Spectral Density - 802.11n - Mid Channel

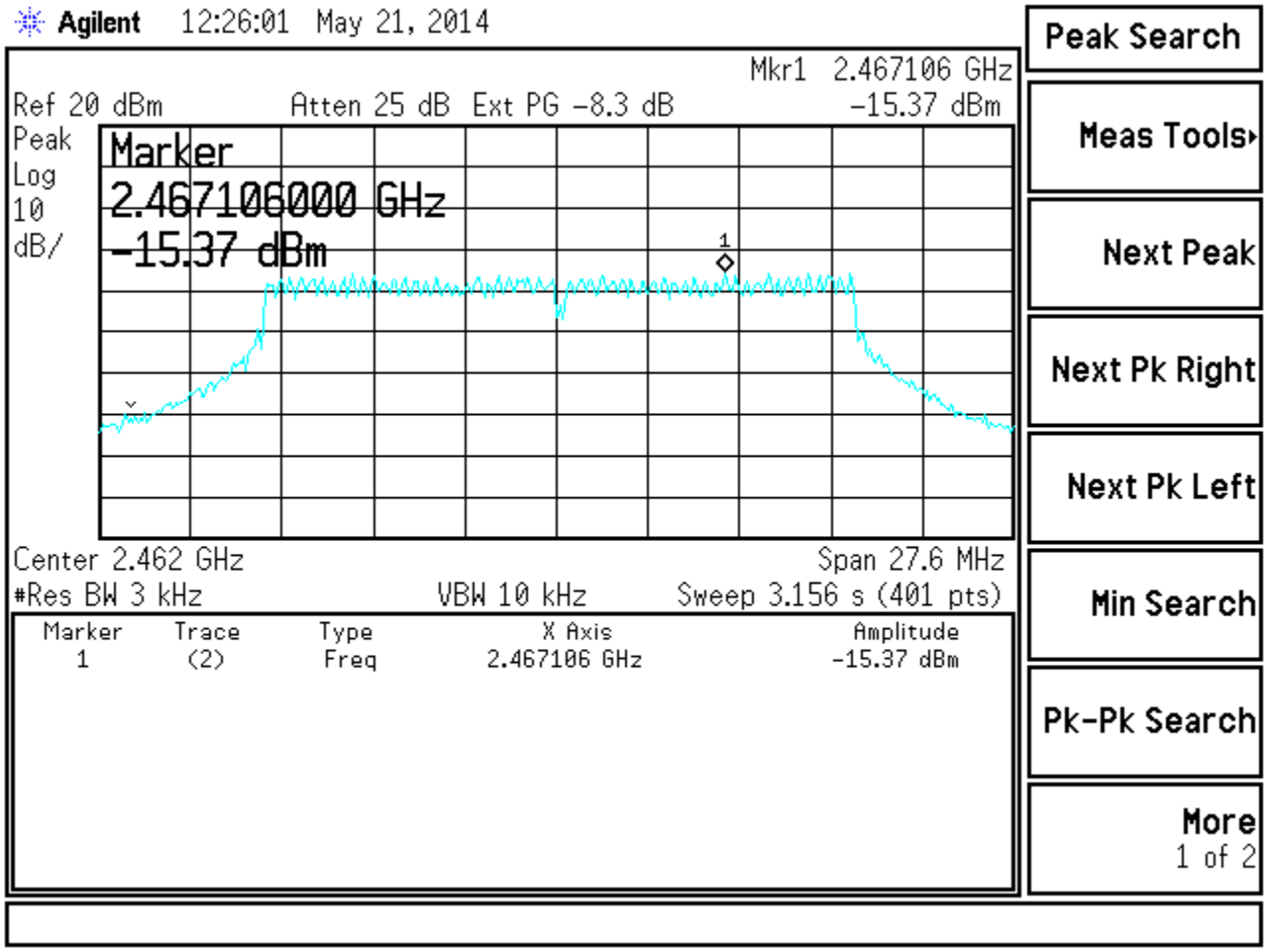


Figure 68. Peak Power Spectral Density - 802.11n - High Channel