FCC TEST REPORT

For

Shenzhen Four Seas Global Link Network Technology Co., Ltd

11AC Dual Band Wireless Adapter

Test Model: CF-917AC

List Model No.: CF-913AC, CF-915AC, CF-916AC, CF-7500AC, CF-923AC, CF-926AC, CF-WU910A, CF-WU925A, CF-WU710N, CF-WU757F, CF-WU772AC, CF-918AC, CF-925AC, CF-927AC, CF-928AC, CF-930AC, CF-933AC, CF-935AC, CF-936AC

Prepared for	:	Shenzhen Four Seas Global Link Network Technology Co., Ltd
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Prepared by	:	Shenzhen LCS Compliance Testing Laboratory Ltd.
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Date of receipt of test sample	:	September 26, 2017
Number of tested samples	:	1
Serial number	:	Prototype
Date of Test	:	September 26, 2017~October 25, 2017
Date of Report	:	October 25, 2017

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FCC TEST REPORT
FCC CFR 47 PART 15 C(15.247): 2016

Report Reference No.	:	**LCS170925010AE1**
Date of Issue	:	October 25, 2017
Testing Laboratory Name.....	:	**Shenzhen LCS Compliance Testing Laboratory Ltd.**
Address	:	1/F., Xingyuan Industrial Park, Tongda Road, Bao'an Avenue, Bao'an District, Shenzhen, Guangdong, China
Testing Location/ Procedure	:	Full application of Harmonised standards ■ Partial application of Harmonised standards □ Other standard testing method □
Applicant's Name	:	**Shenzhen Four Seas Global Link Network Technology Co., Ltd**
Address	:	Room 607-610, Block B, TAOJINDI Electronic Business Incubation Base, Tenglong Road, Longhua District, Shenzhen, China
Test Specification		
Standard.....	:	FCC CFR 47 PART 15 C(15.247): 2016
Test Report Form No.	:	LCSEMC-1.0
TRF Originator.....	:	Shenzhen LCS Compliance Testing Laboratory Ltd.
Master TRF	:	Dated 2011-03

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EUT Description.	:	**11AC Dual Band Wireless Adapter**
Trade Mark.....	:	COMFAST
Test Model.....	:	CF-917AC
Ratings	:	DC 5V by USB Port of PC
Result	:	**Positive**

Compiled by:	**Supervised by:**	**Approved by:**
Leo Lee	Dick Su	Gavin Liang
Leo Lee/ File administrators	Dick Su/ Technique principal	Gavin Liang/ Manager

FCC -- TEST REPORT

Test Report No. : LCS170925010AE1	October 25, 2017 Date of issue

EUT.....	:	11AC Dual Band Wireless Adapter
Test Model.....	:	CF-917AC
Applicant.....	**:**	**Shenzhen Four Seas Global Link Network Technology Co., Ltd**
Address.....	:	Room 607-610, Block B, TAOJINDI Electronic Business Incubation Base, Tenglong Road, Longhua District, Shenzhen, China
Telephone.....	:	/
Fax.....	:	/
Manufacturer.....	**:**	**Shenzhen Four Seas Global Link Network Technology Co., Ltd**
Address.....	:	Room 607-610, Block B, TAOJINDI Electronic Business Incubation Base, Tenglong Road, Longhua District, Shenzhen, China
Telephone.....	:	/
Fax.....	:	/
Factory.....	**:**	**Shenzhen Four Seas Global Link Network Technology Co., Ltd**
Address.....	:	Room 607-610, Block B, TAOJINDI Electronic Business Incubation Base, Tenglong Road, Longhua District, Shenzhen, China
Telephone.....	:	/
Fax.....	:	/

Test Result	**Positive**

The test report merely corresponds to the test sample.

It is not permitted to copy extracts of these test result without the written permission of the test laboratory.

Revision History

Revision	Issue Date	Revisions	Revised By
00	October 25, 2017	Initial Issue	Gavin Liang

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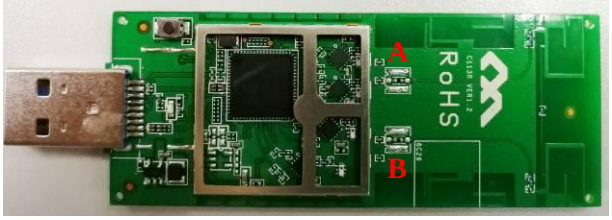
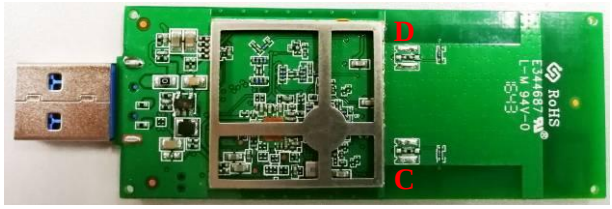
1. GENERAL INFORMATION

1.1. Description of Device (EUT)

EUT	:	11AC Dual Band Wireless Adapter
Model Number	:	CF-917AC, CF-913AC, CF-915AC, CF-916AC, CF-7500AC, CF-923AC, CF-926AC, CF-WU910A, CF-WU925A, CF-WU710N, CF-WU757F, CF-WU772AC, CF-918AC, CF-925AC, CF-927AC, CF-928AC, CF-930AC, CF-933AC, CF-935AC, CF-936AC
Model Declaration	:	PCB board, structure and internal of these model(s) are the same, Only models name is different for these models.
Test Model	:	CF-917AC
Power Supply	:	DC 5V by USB Port of PC
Hardware version	:	V1.3
Software version	:	1030.4
WLAN	:	Supported IEEE 802.11a/b/g/n/ac
WLAN FCC Operation Frequency	:	IEEE 802.11b:2412-2462MHz IEEE 802.11g:2412-2462MHz IEEE 802.11n HT20:2412-2462MHz / 5745-5825MHz IEEE 802.11n HT40:2422-2452MHz / 5755-5795MHz IEEE 802.11a: 5745-5825MHz IEEE 802.11ac VHT20: 5745-5825MHz IEEE 802.11ac VHT40: 5755-5795MHz IEEE 802.11ac VHT80: 5775MHz
WLAN Channel Number	:	11 Channels for 2412-2462MHz(IEEE 802.11b/g/n HT20) 7 Channels for 2422-2452MHz(IEEE 802.11n HT40) 5 Channels for 5745-5825MHz(IEEE 802.11a/ac VHT20/n HT20) 2 Channels for 5755-5795MHz(IEEE 802.11ac VHT40/n HT40) 1 Channels for 5775MHz(IEEE 802.11ac VHT80)
WLAN Modulation Technology	:	IEEE 802.11b: DSSS(CCK,DQPSK,DBPSK) IEEE 802.11g: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11n: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11a: OFDM (64QAM, 16QAM, QPSK, BPSK) IEEE 802.11ac: OFDM (256QAM, 64QAM, 16QAM, QPSK, BPSK)
Antenna Type And Gain	:	PCB Antenna A, 2.0dBi(Max.), for TX/RX (Antenna 0) PCB Antenna B, 2.0dBi(Max.), for TX/RX (Antenna 1) PCB Antenna C, 2.0dBi(Max.), for TX/RX (Antenna 2) PCB Antenna D, 2.0dBi(Max.), for RX Only This device is a 3T4R wireless product.
Directional Gain	:	2.0 + 10log(3) = 6.77 dBi





1.2. Host System Configuration List and Details

Manufacturer	Description	Model	Serial Number	Certificate

1.3. External I/O Cable

I/O Port Description	Quantity	Cable
USB Port	1	N/A

1.4. Description of Test Facility

CNAS Registration Number. is L4595.
FCC Registration Number. is 254912.
Industry Canada Registration Number. is 9642A-1.
ESMD Registration Number. is ARCB0108.
UL Registration Number. is 100571-492.
TUV SUD Registration Number. is SCN1081.
TUV RH Registration Number. is UA 50296516-001
NVLAP Registration Code is 600167-0

The 3m-Semi anechoic test site fulfils CISPR 16-1-4 according to ANSI C63.10 and CISPR 16-1-4:2010 SVSWR requirement for radiated emission above 1GHz.

1.5. Statement of the Measurement Uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. To CISPR 16 – 4 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements" and is documented in the LCS quality system acc. To DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

1.6. Measurement Uncertainty

Test Item		Frequency Range	Uncertainty	Note
Radiation Uncertainty	:	9KHz~30MHz	±3.10dB	(1)
		30MHz~200MHz	±2.96dB	(1)
		200MHz~1000MHz	±3.10dB	(1)
		1GHz~26.5GHz	±3.80dB	(1)
		26.5GHz~40GHz	±3.90dB	(1)
Conduction Uncertainty	:	150kHz~30MHz	±1.63dB	(1)
Power disturbance	:	30MHz~300MHz	±1.60dB	(1)

(1). This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

1.7. Description of Test Modes

The EUT has been tested under operating condition.

This test was performed with EUT in X, Y, Z position and the worse case was found when EUT in X position.

AC power line conducted emission pre-test at both at AC 120V/60Hz and AC 240V/50Hz modes, recorded worst case.
Worst-case mode and channel used for 150 KHz-30 MHz power line conducted emissions was the mode and channel with the highest output power, that was determined to be 802.11n HT40 mode(Low Channel, Chain 0+Chain 1+Chain 2).

Worst-case mode and channel used for 9 KHz-1000 MHz radiated emissions was the mode and channel with the highest output power, that was determined to be 802.11n HT40 mode(Low Channel, Chain 0+Chain 1+Chain 2).

Worst-Case data rates were utilized from preliminary testing of the Chipset, worst-case data rates used during the testing are as follows:

IEEE 802.11b Mode: 1 Mbps, DSSS.
IEEE 802.11g Mode: 6 Mbps, OFDM.
IEEE 802.11n Mode HT20: MCS0, OFDM.
IEEE 802.11n Mode HT40: MCS0, OFDM.

Antenna & Bandwidth

Antenna	Antenna 0		Antenna 1		Antenna 2		Simultaneously
Bandwidth Mode	20MHz	40MHz	20MHz	40MHz	20MHz	40MHz	/
IEEE 802.11b	☑	☐	☑	☐	☑	☐	☐
IEEE 802.11g	☑	☐	☑	☐	☑	☐	☐
IEEE 802.11n	☑	☑	☑	☑	☑	☑	☑

Note: The Antenna D is used for receiving only.

Channel List & Frequency

IEEE 802.11b/g/n HT20

Frequency Band	Channel No.	Frequency(MHz)	Channel No.	Frequency(MHz)
2412~2462MHz	1	2412	7	2442
	2	2417	8	2447
	3	2422	9	2452
	4	2427	10	2457
	5	2432	11	2462
	6	2437	--	--

IEEE 802.11n HT40

Frequency Band	Channel No.	Frequency(MHz)	Channel No.	Frequency(MHz)
2422~2452MHz	1	--	7	2442
	2	--	8	2447
	3	2422	9	2452
	4	2427	10	--
	5	2432	11	--
	6	2437	--	--

2. TEST METHODOLOGY

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

The radiated testing was performed at an antenna-to-EUT distance of 3 meters. All radiated and conducted emissions measurement was performed at Shenzhen LCS Compliance Testing Laboratory Ltd.

2.1. EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

2.2. EUT Exercise

The EUT was operated in the engineering mode to fix the TX frequency that was for the purpose of the measurements.

According to FCC's request, Test Procedure KDB 558074 D01 DTS Meas Guidance v04 and KDB 662911 D01 Multiple Transmitter Output v02r01 are required to be used for this kind of FCC 15.247 digital modulation device.

According to its specifications, the EUT must comply with the requirements of the Section 15.203, 15.205, 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C.

2.3. General Test Procedures

2.3.1 Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2.1 of ANSI C63.10-2013 Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using Quasi-peak and average detector modes.

2.3.2 Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna, which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the maximum emissions, exploratory radiated emission measurements were made according to the requirements in Section 6.3 of ANSI C63.10-2013

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3. SYSTEM TEST CONFIGURATION

3.1. Justification

The system was configured for testing in a continuous transmits condition.

3.2. EUT Exercise Software

The system was configured for testing in a continuous transmits condition and change test channels by software (MPTool) provided by application.

3.3. Special Accessories

No.	Equipment	Manufacturer	Model No.	Serial No.	Length	shielded/ unshielded	Notes
1	PC	Lenovo	Ideapad	A131101550	/	/	DOC
2	Power adapter	Lenovo	CPA-A090	36200414	1.00m	unshielded	DOC

3.4. Block Diagram/Schematics

Please refer to the related document

3.5. Equipment Modifications

Shenzhen LCS Compliance Testing Laboratory Ltd. has not done any modification on the EUT.

3.6. Test Setup

Please refer to the test setup photo.

4. SUMMARY OF TEST RESULTS

Applied Standard: FCC Part 15 Subpart C		
FCC Rules	Description of Test	Result
/	Duty Cycle	Compliant
§15.247(b)	Maximum Conducted Output Power	Compliant
§15.247(e)	Power Spectral Density	Compliant
§15.247(a)(2)	6dB Bandwidth	Compliant
§15.247(a)	Occupied Bandwidth	Compliant
§15.209, §15.247(d)	Radiated and Conducted Spurious Emissions	Compliant
§15.205	Emissions at Restricted Band	Compliant
§15.207(a)	Conducted Emissions	Compliant
§15.203	Antenna Requirements	Compliant
§15.247(i)§2.1093	RF Exposure	Compliant

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5. TEST RESULT

5.1. On Time and Duty Cycle

5.1.1. Standard Applicable

None; for reporting purpose only.

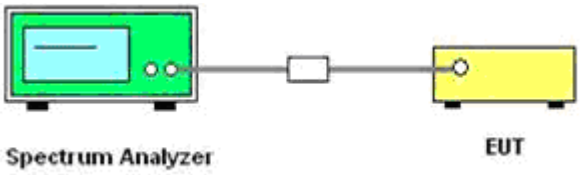
5.1.2. Measuring Instruments and Setting

Please refer to equipment's list in this report. The following table is the setting of the spectrum analyzer.

5.1.3. Test Procedures

1. Set the centre frequency of the spectrum analyzer to the transmitting frequency;
2. Set the span=0MHz, RBW=8MHz, VBW=50MHz, Sweep time=5ms;
3. Detector = peak;
4. Trace mode = Single hold.

5.1.4. Test Setup Layout



5.1.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

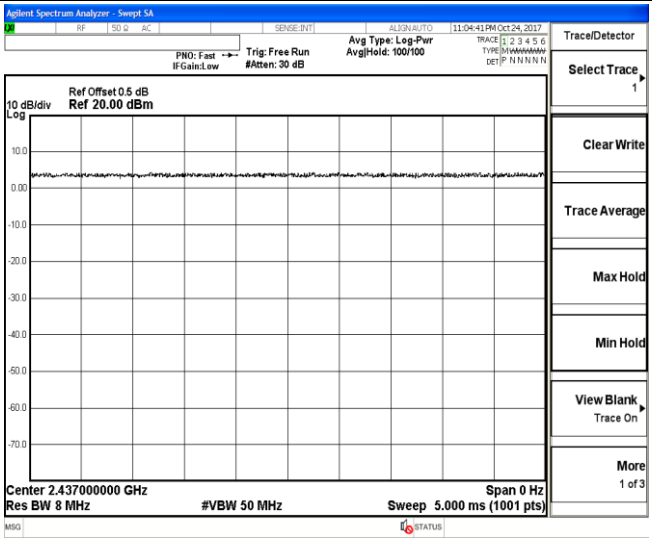
5.1.6. Test result

Mode	On Time B (ms)	Period (ms)	Duty Cycle x (Linear)	Duty Cycle (%)	Duty Cycle Correction Factor (dB)	1/B Minimum VBW(KHz)
IEEE 802.11b	5	5	1	100	0	0.010
IEEE 802.11g	5	5	1	100	0	0.010
IEEE 802.11n HT20	5	5	1	100	0	0.010
IEEE 802.11n HT40	5	5	1	100	0	0.010

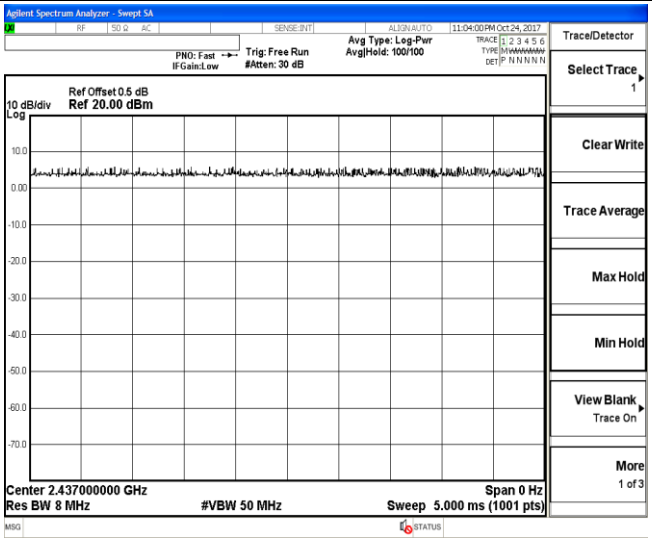
Remark:

1. Measured duty cycle for WLAN at antenna 0, antenna 1 and antenna 2 port, the two antenna ports results were same, just recorded results at antenna 0;

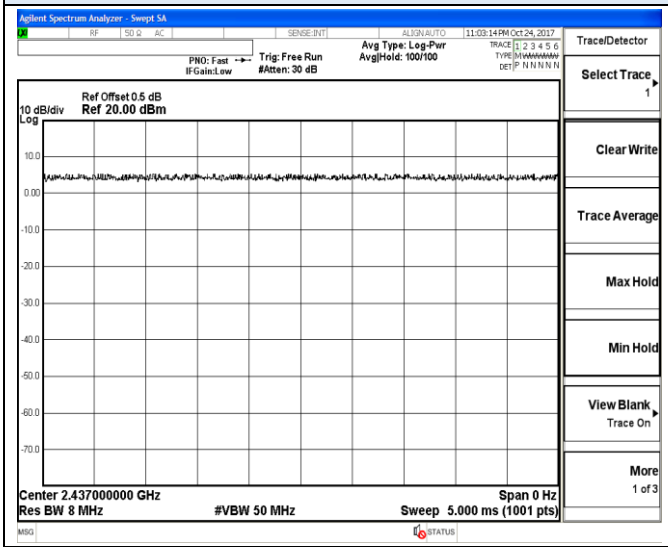
On Time and Duty Cycle



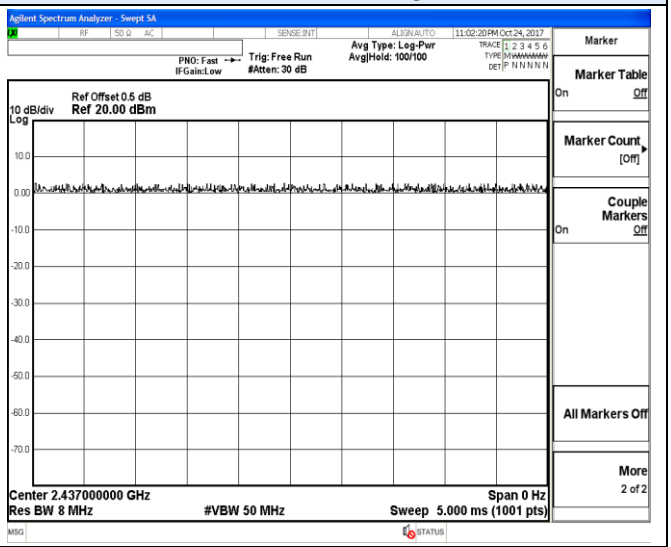
IEEE 802.11b



IEEE 802.11g



IEEE 802.11n HT20



IEEE 802.11n HT40

5.2. Maximum Conducted Output Power Measurement

5.2.1. Standard Applicable

According to §15.247(b): For systems using digital modulation in the 2400-2483.5 MHz and 5725-5850 MHz band, the limit for maximum peak conducted output power is 30dBm. The limited has to be reduced by the amount in dB that the gain of the antenna exceeds 6dBi. In case of point-to-point operation, the limit has to be reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

Systems operating in the 5725-5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi without any corresponding reduction in transmitter peak output power.

5.2.2. Measuring Instruments and Setting

Please refer to equipment list in this report. The following table is the setting of the power meter.

5.2.3. Test Procedures

According to KDB558074 D01 DTS Measurement Guidance Section 9.1 Maximum peak conducted output power, 9.1.2 the maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DTS bandwidth and shall utilize a fast-responding diode detector.

According to KDB558074 D01 DTS Measurement Guidance Section 9.2 Maximum average conducted output power, 9.2.3.1 Method AVGPM (Measurement using an RF average power meter)

(a) As an alternative to spectrum analyzer or EMI receiver measurements, measurements may be performed using a wideband RF power meter with a thermocouple detector or equivalent if all of the conditions listed below are satisfied.

1) The EUT is configured to transmit continuously, or to transmit with a constant duty factor.

2) At all times when the EUT is transmitting, it shall be transmitting at its maximum power control level.

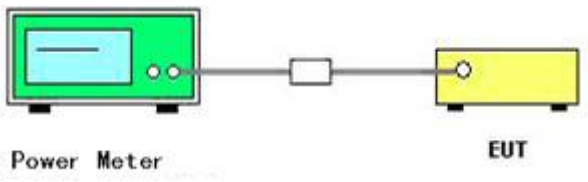
3) The integration period of the power meter exceeds the repetition period of the transmitted signal by at least a factor of five.

(b) If the transmitter does not transmit continuously, measure the duty cycle (x) of the transmitter output signal as described in Section 6.0.

(c) Measure the average power of the transmitter. This measurement is an average over both the on and off periods of the transmitter.

(d) Adjust the measurement in dBm by adding 10log (1/x), where x is the duty cycle to the measurement result.

5.2.4. Test Setup Layout



5.2.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.2.6. Test Result of Maximum Conducted Output Power

Temperature	25.1℃	Humidity	52.4%
Test Engineer	Jayden Zhuo	Configurations	IEEE 802.11b/g/n

Test Mode	Channel	Frequency (MHz)	Measured Peak Output Power (dBm)				Limits (dBm)	Verdict
			Antenna 0	Antenna 1	Antenna 2	Sum		
IEEE 802.11b	1	2412	10.56	10.87	10.69	-/-	30	PASS
	6	2437	10.64	11.16	10.43	-/-		
	11	2462	10.18	10.45	10.31	-/-		
IEEE 802.11g	1	2412	11.22	11.03	11.52	-/-	30	PASS
	6	2437	10.58	11.50	11.19	-/-		
	11	2462	11.65	11.57	10.88	-/-		
IEEE 802.11n HT20	1	2412	6.81	6.89	6.64	11.55	30	PASS
	6	2437	7.43	7.29	7.04	12.03		
	11	2462	6.24	7.01	7.37	11.67		
IEEE 802.11n HT40	3	2422	8.39	8.16	8.28	13.05	30	PASS
	6	2437	8.02	7.93	7.82	12.70		
	9	2452	7.55	7.21	7.43	12.17		

Test Mode	Channel	Frequency (MHz)	Measured Average Output Power (dBm)				Limits (dBm)	Verdict
			Antenna 0	Antenna 1	Antenna 2	Sum		
IEEE 802.11b	1	2412	8.77	8.95	8.79	-/-	30	PASS
	6	2437	8.81	9.03	8.71	-/-		
	11	2462	8.45	8.72	8.42	-/-		
IEEE 802.11g	1	2412	8.12	8.09	8.23	-/-	30	PASS
	6	2437	8.01	8.22	8.11	-/-		
	11	2462	8.29	8.25	8.05	-/-		
IEEE 802.11n HT20	1	2412	3.41	3.42	3.37	8.17	30	PASS
	6	2437	3.55	3.52	3.48	8.29		
	11	2462	3.28	3.33	3.29	8.07		
IEEE 802.11n HT40	3	2422	3.70	3.61	3.68	8.43	30	PASS
	6	2437	3.59	3.54	3.53	8.32		
	9	2452	3.37	3.28	3.32	8.09		

Remark:

1. *Measured output power at difference data rate for each mode and recorded worst case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11b; 6Mbps at IEEE 802.11g; 6.5Mbps at IEEE 802.11n HT20; 13.5Mbps at IEEE 802.11n HT40;*
4. *"-/-" means no need measured or sum as cannot work at MIMO mode;*
5. *Average power is for report only;*

5.3. Power Spectral Density Measurement

5.3.1. Standard Applicable

According to §15.247(e): For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

5.3.2. Measuring Instruments and Setting

Please refer to equipment's list in this report. The following table is the setting of Spectrum Analyzer.

5.3.3. Test Procedures

1. The transmitter was connected directly to a Spectrum Analyzer.

2. The power was monitored at the coupler port with a Spectrum Analyzer. The power level was set to the maximum level.

3. Set the RBW = 3 KHz~100 KHz.

4. Set the VBW ≥ 3*RBW

5. Set the span to 1.5 times the DTS channel bandwidth.

6. Detector = peak.

7. Sweep time = auto couple.

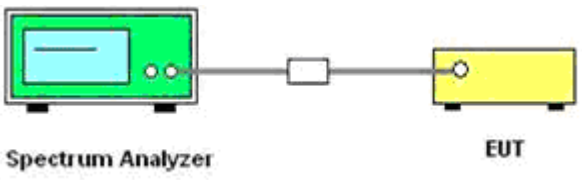
8. Trace mode = max hold.

9. Allow trace to fully stabilize.

10. Use the peak marker function to determine the maximum power level in any 3 kHz band segment within the fundamental EBW.

11. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

5.3.4. Test Setup Layout



5.3.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.3.6. Test Result of Power Spectral Density

Temperature	25.1℃	Humidity	52.4%
Test Engineer	Jayden Zhuo	Configurations	IEEE 802.11b/g/n

Test Mode	Channel	Frequency (MHz)	Measured Peak Power Spectral Density (dBm/100KHz)				Directional Gain	Limits (dBm/3KHz)	Verdict
			Antenna 0	Antenna 1	Antenna 2	Sum			
IEEE 802.11b	1	2412	-12.635	-12.112	-12.446	-/-	-/-	8.00	PASS
	6	2437	-12.488	-11.969	-12.958	-/-	-/-		
	11	2462	-12.977	-12.609	-12.798	-/-	-/-		
IEEE 802.11g	1	2412	-19.067	-19.385	-18.738	-/-	-/-	8.00	PASS
	6	2437	-19.160	-18.803	-19.034	-/-	-/-		
	11	2462	-18.468	-18.621	-19.531	-/-	-/-		
IEEE 802.11n HT20	1	2412	-18.606	-18.412	-18.841	-13.845	6.77	7.23	PASS
	6	2437	-18.640	-18.088	-18.894	-13.756	6.77		
	11	2462	-18.484	-18.813	-19.462	-14.130	6.77		
IEEE 802.11n HT40	3	2422	-21.937	-22.245	-23.025	-17.607	6.77	7.23	PASS
	6	2437	-21.986	-21.752	-23.213	-17.500	6.77		
	9	2452	-21.594	-21.530	-22.742	-17.150	6.77		

Remark:

1. *Measured peak power spectrum density at difference data rate for each mode and recorded worst case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11b; 6Mbps at IEEE 802.11g; 6.5Mbps at IEEE 802.11n HT20; 13.5Mbps at IEEE 802.11n HT40;*
4. *Please refer to following plots;*
5. *The PSD limits of IEEE 802.11n HT20 and IEEE 802.11n HT40 for MIMO with CDD technology should be reduce to 8.00-(2.0+10*log(3)-6.00)=7.23 dBm/3KHz according to KDB662911D01;*
6. *For MIMO with CCD technology device, The Directional Gain= Gain of individual transmit antennas (dBi) + Array gain;*
   Array gain = 10 log (N_{ant}), where N_{ant} is the number of transmit antennas.
7. *"-/-" means no need measured or sum as cannot work at MIMO mode;*

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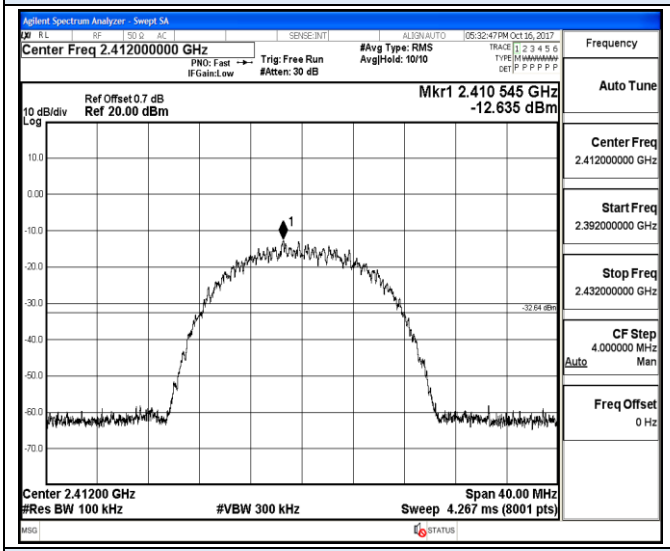
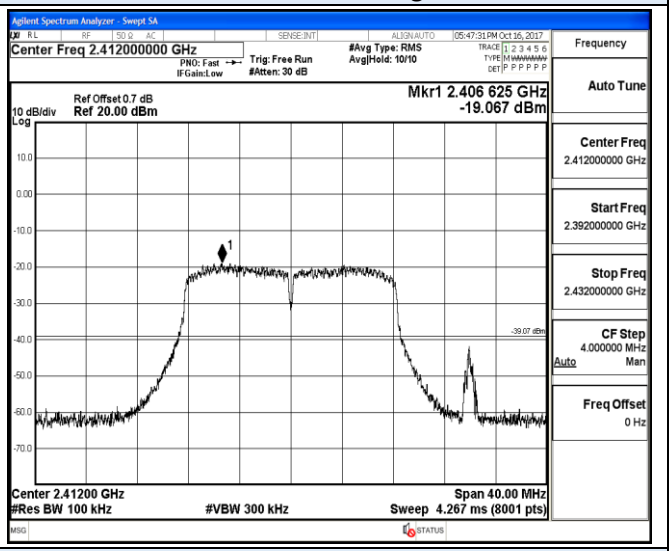
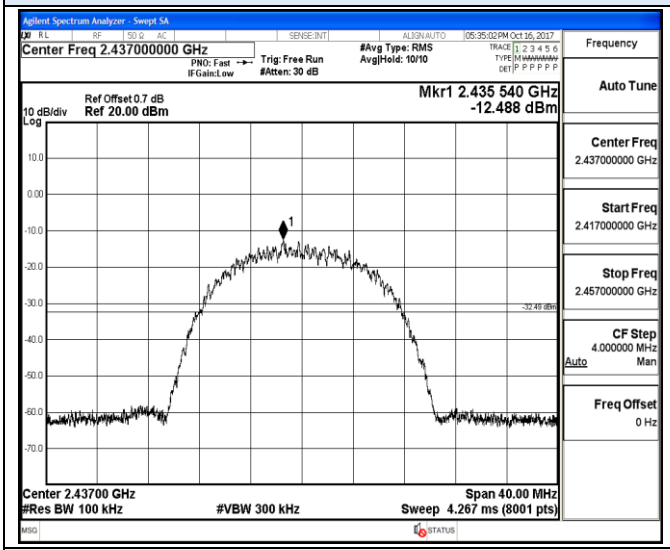
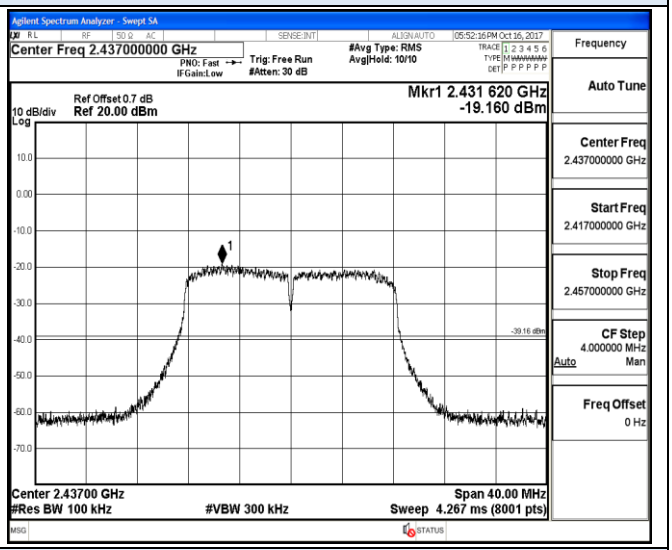
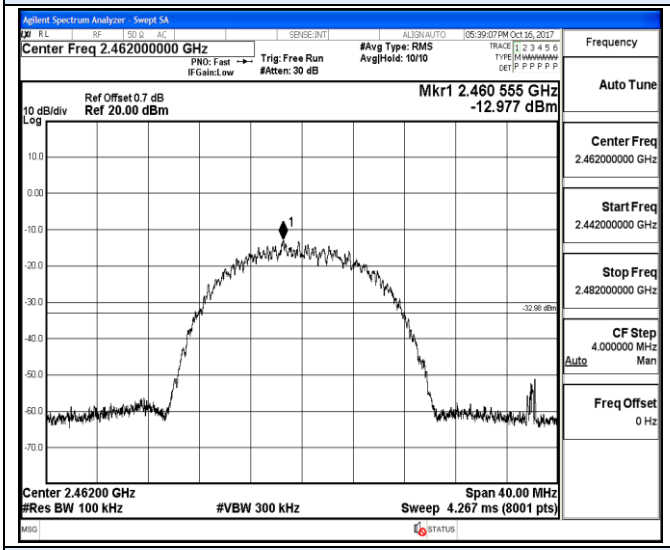
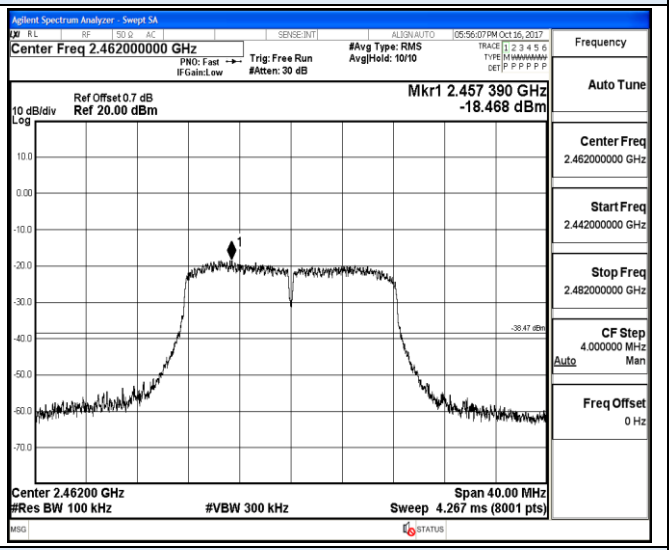
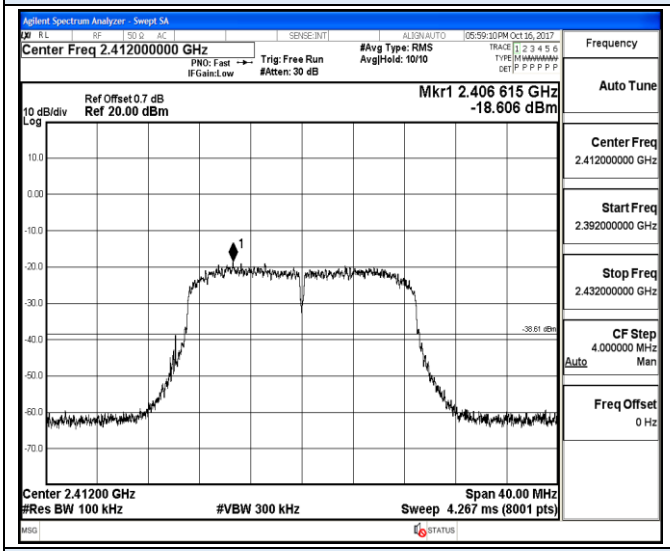
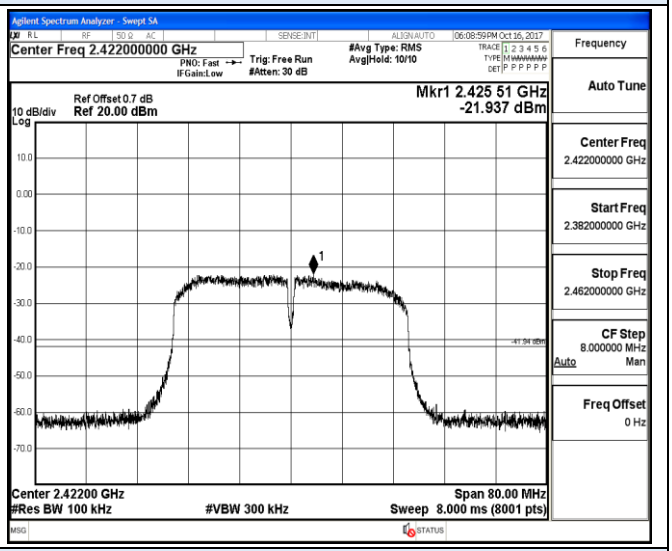
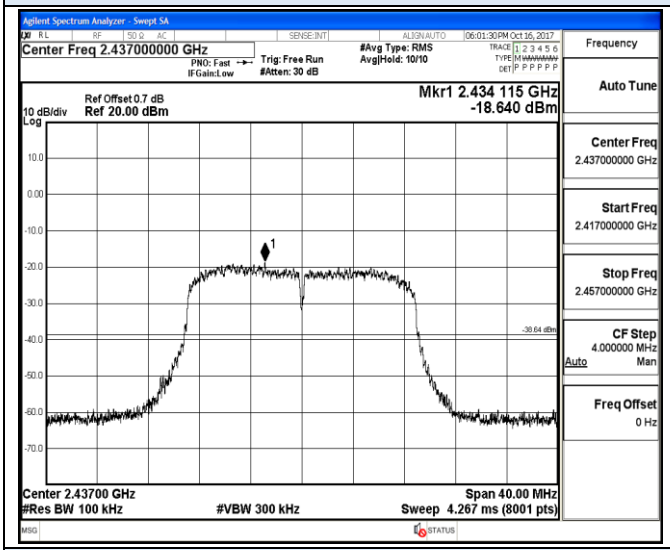
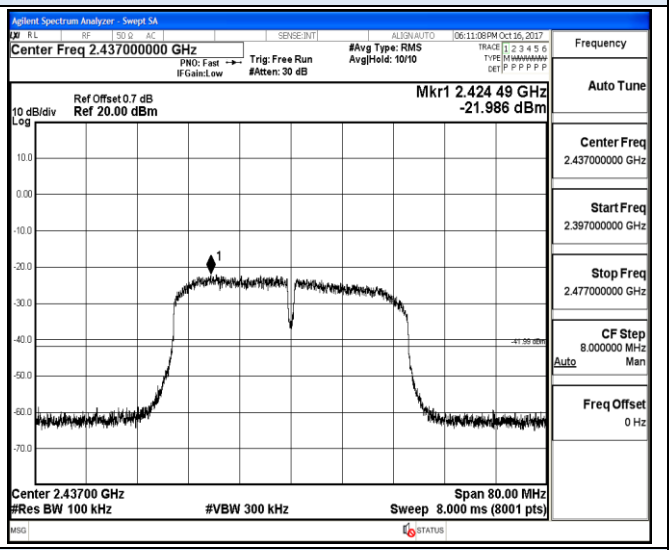
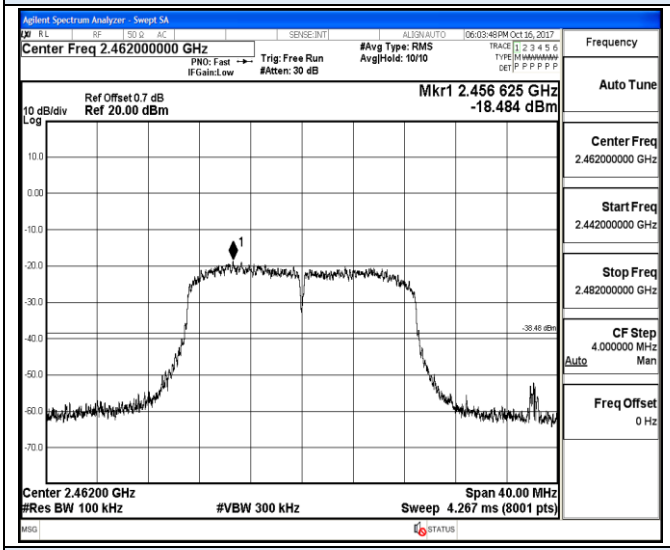
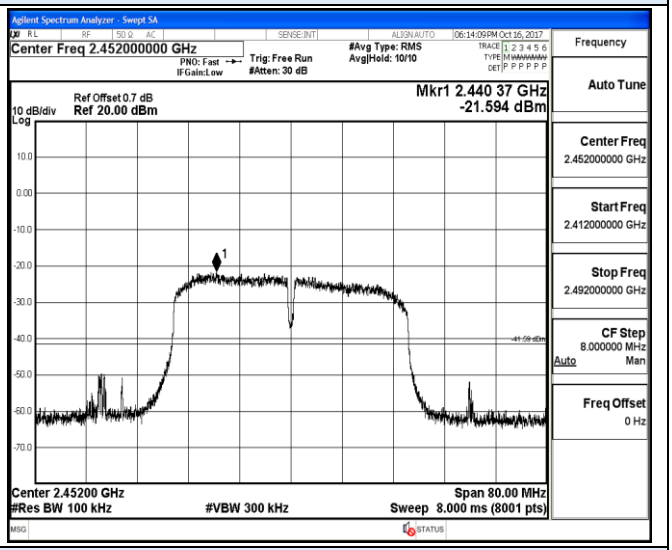
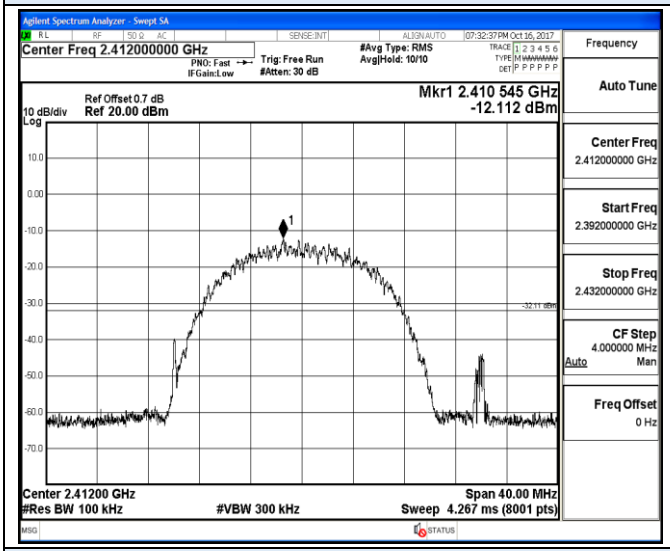
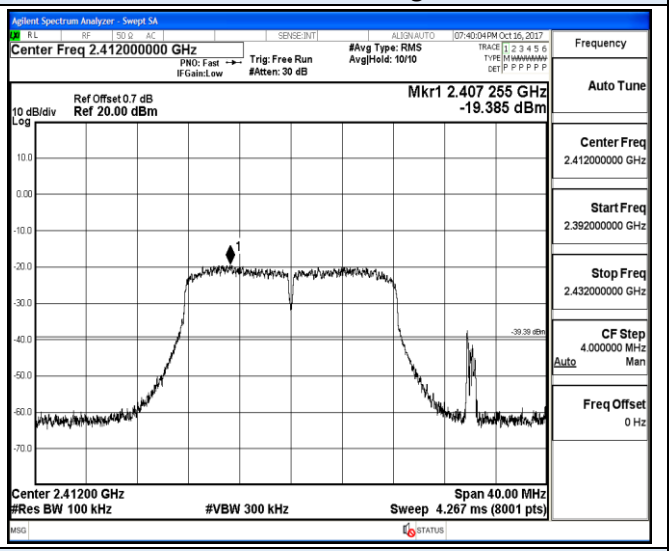
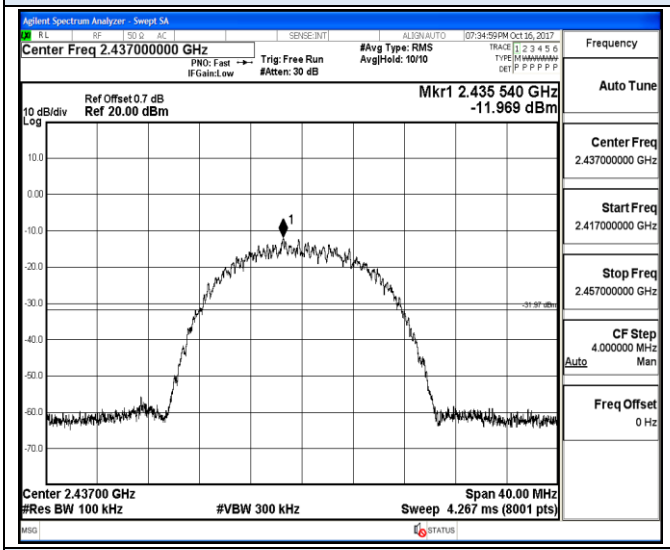
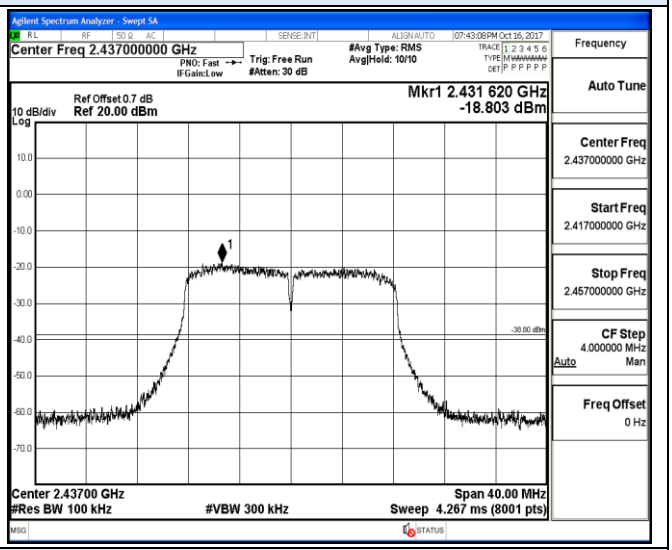
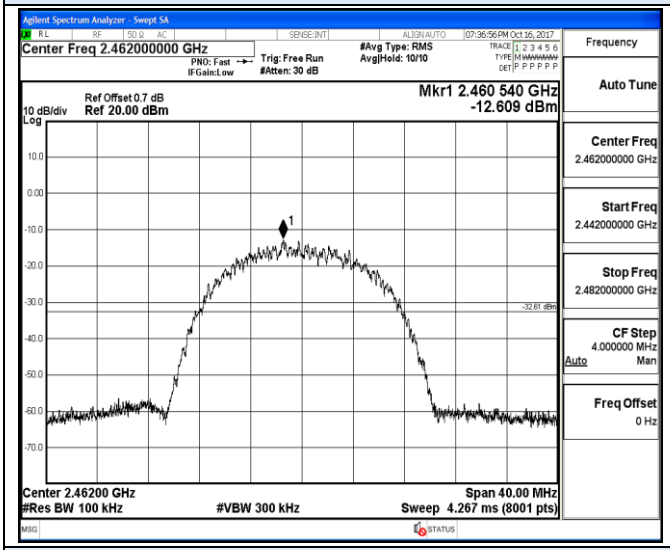
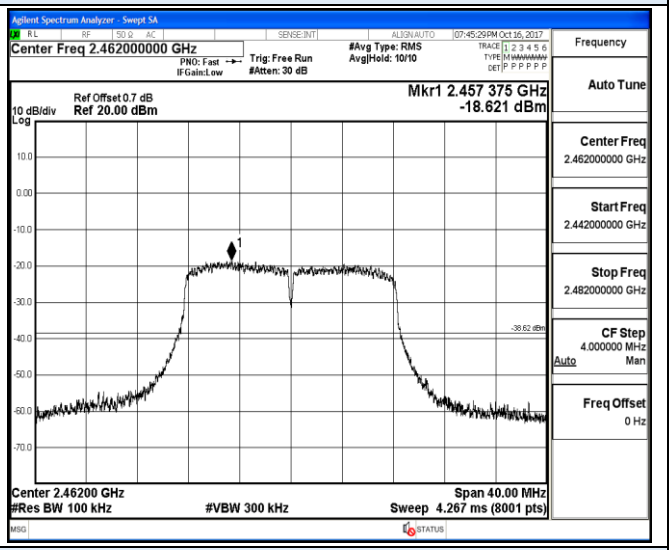
Power Spectral Density	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

Power Spectral Density	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz

Power Spectral Density	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

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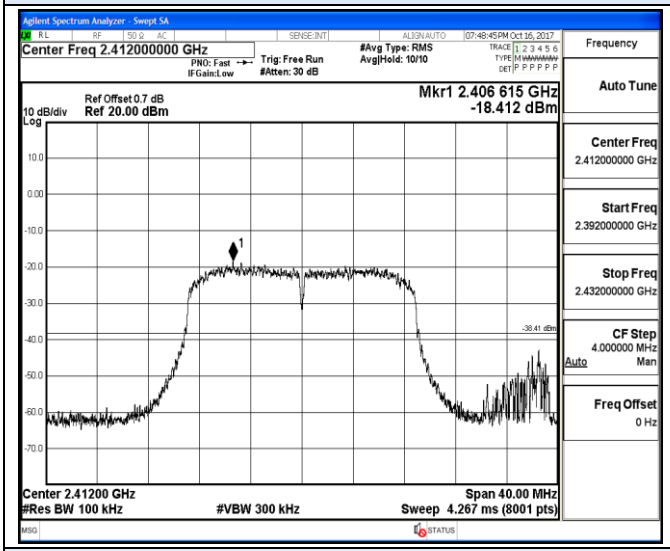
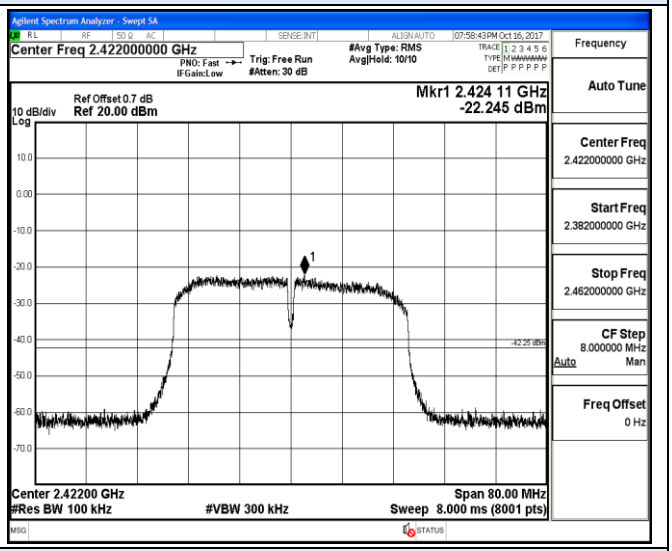
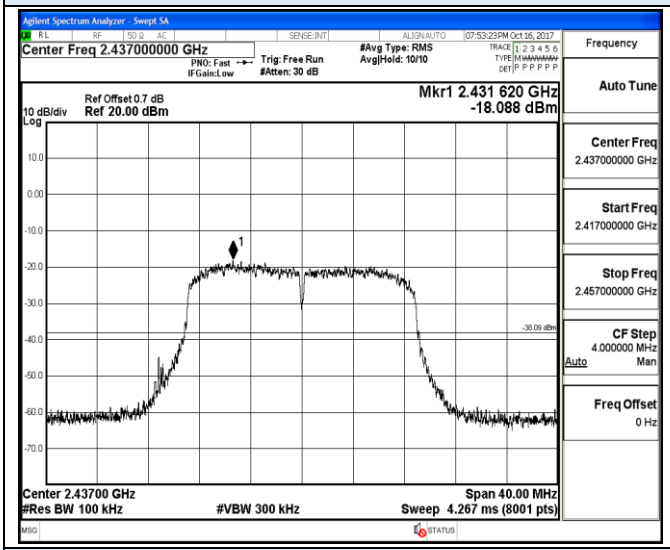
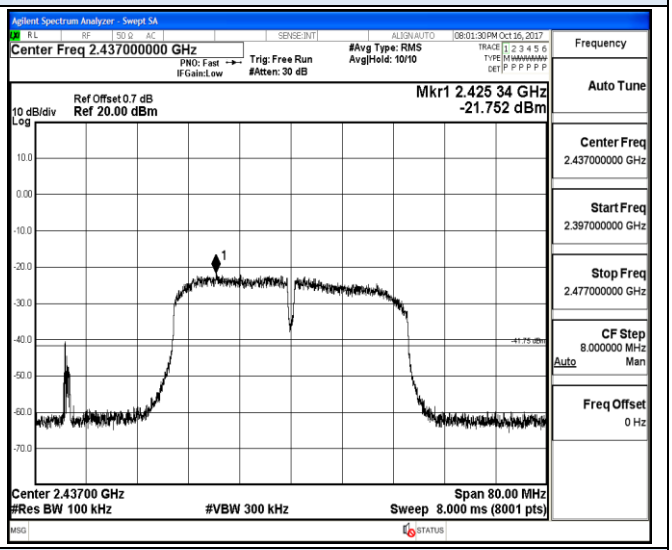
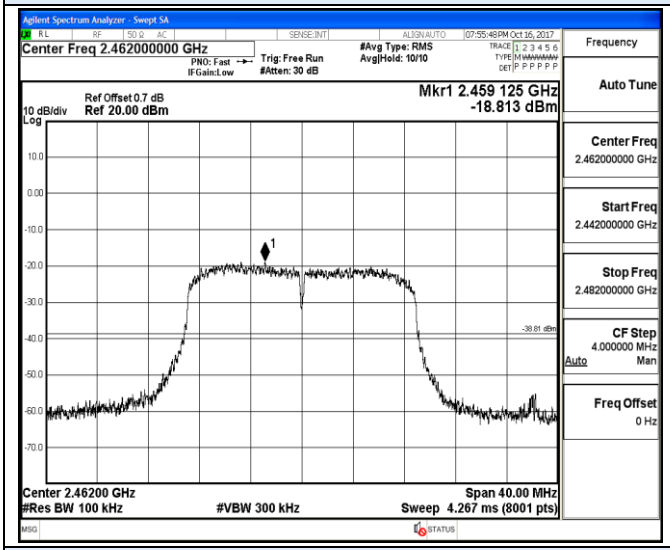
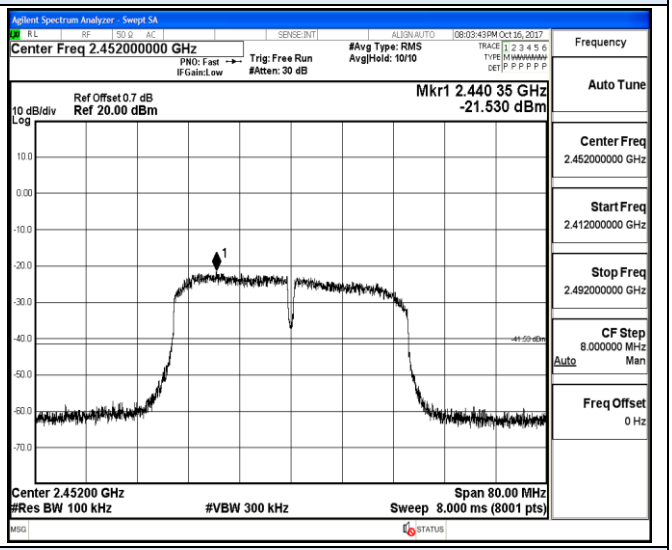
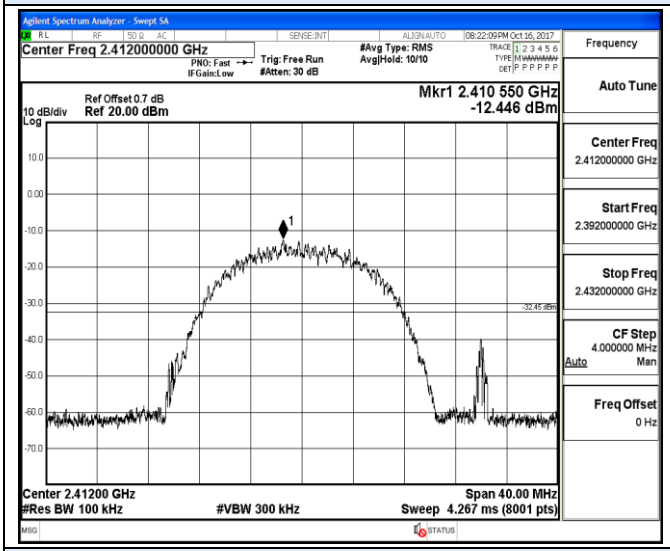
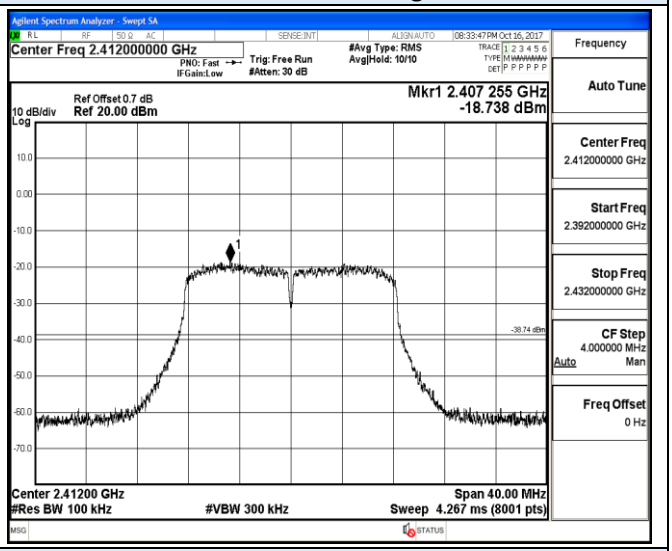
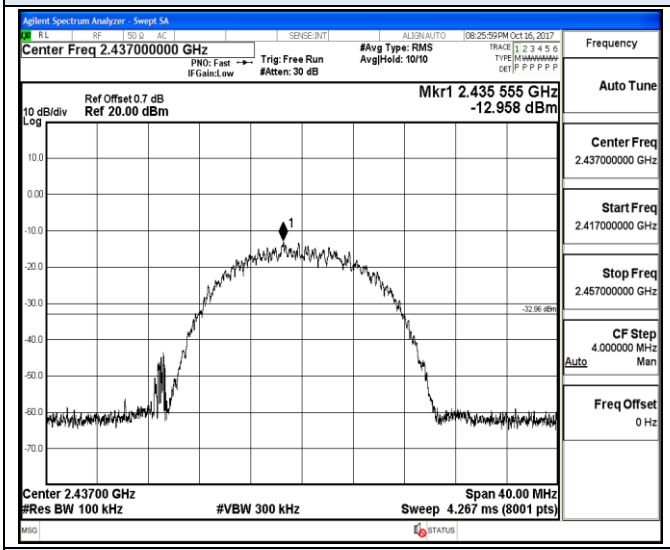
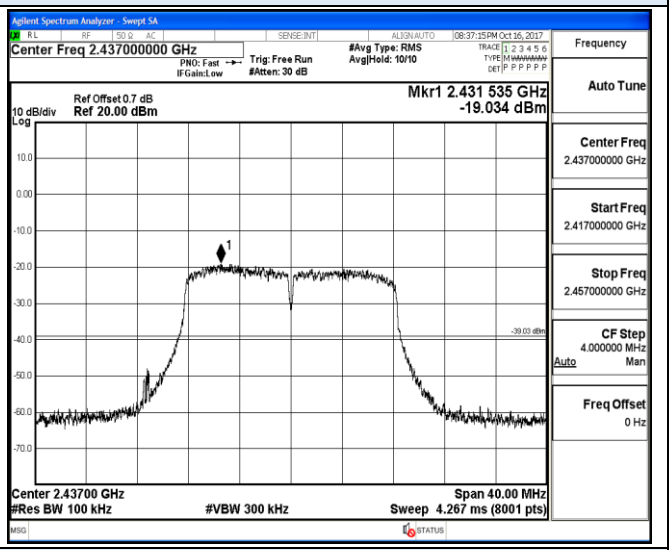
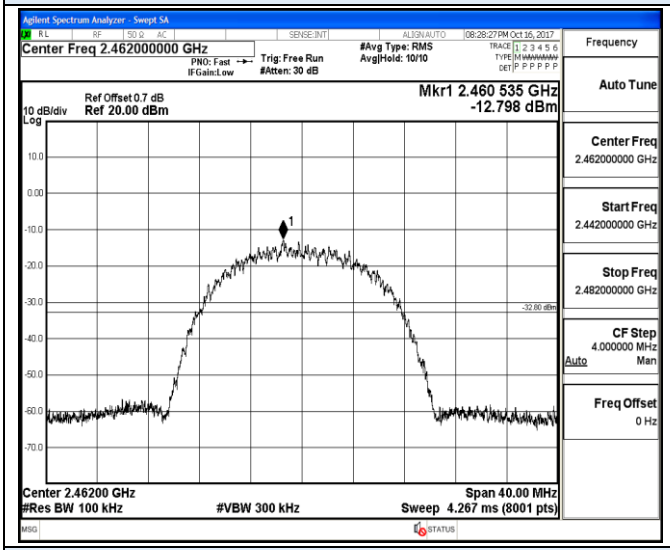
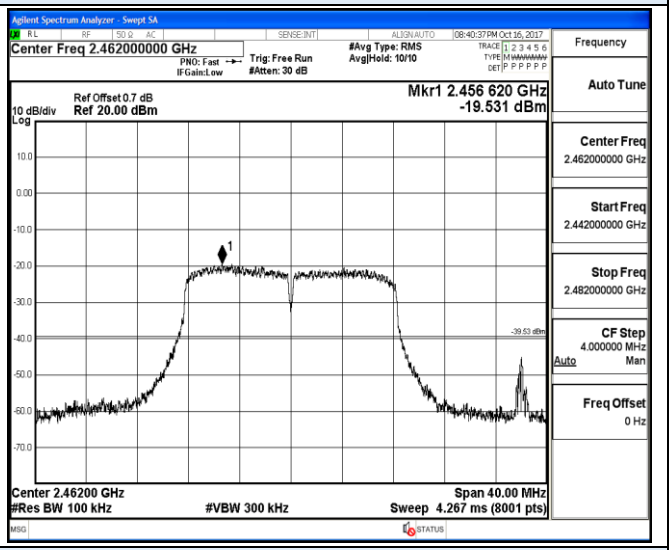
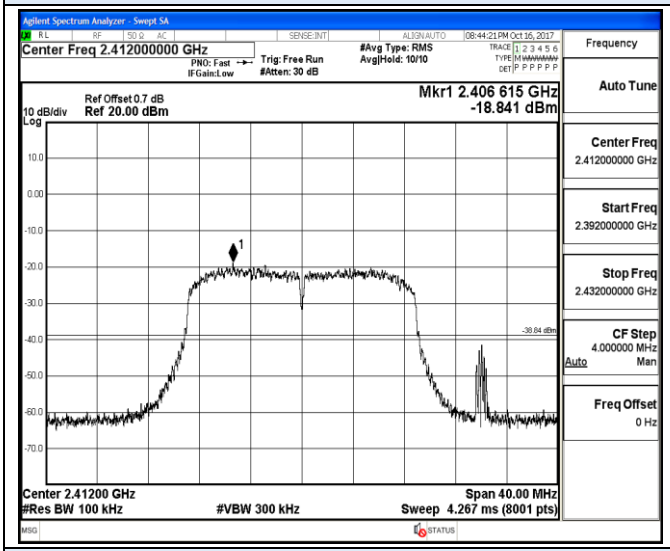
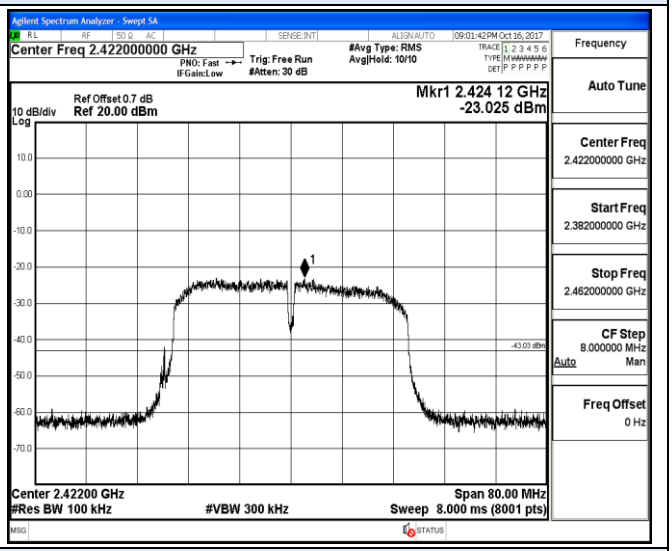
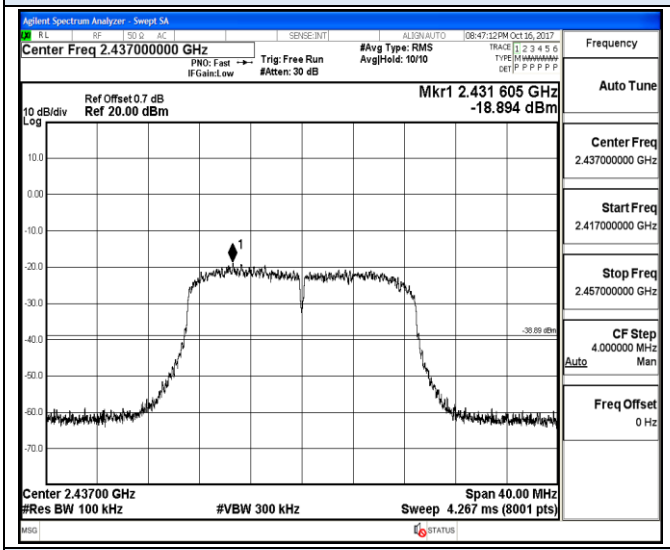
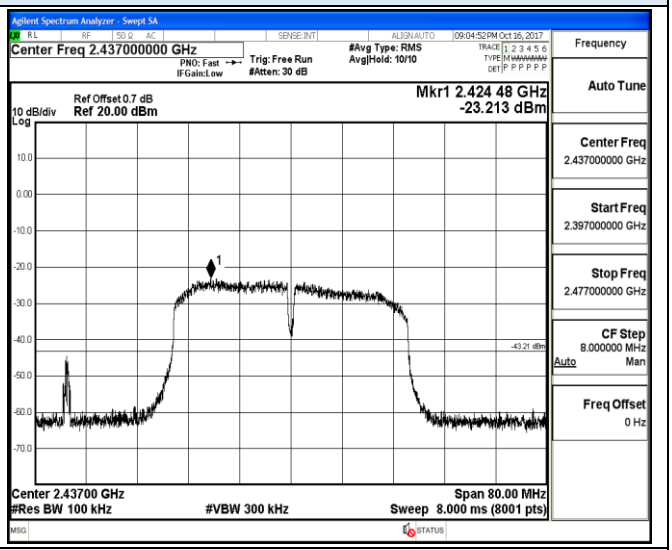
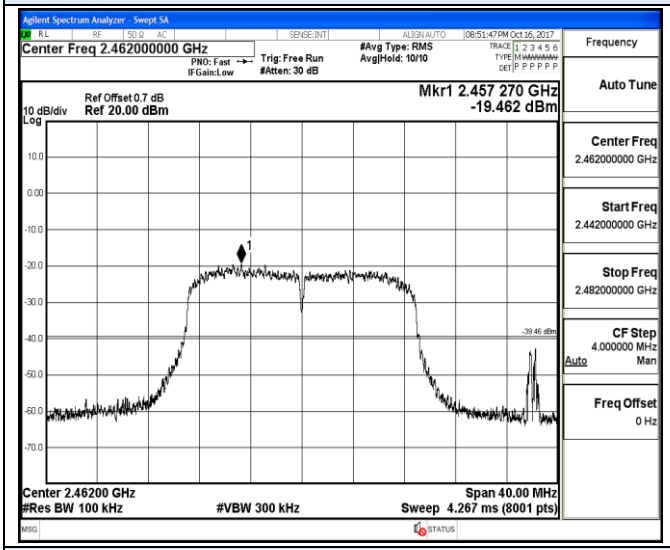
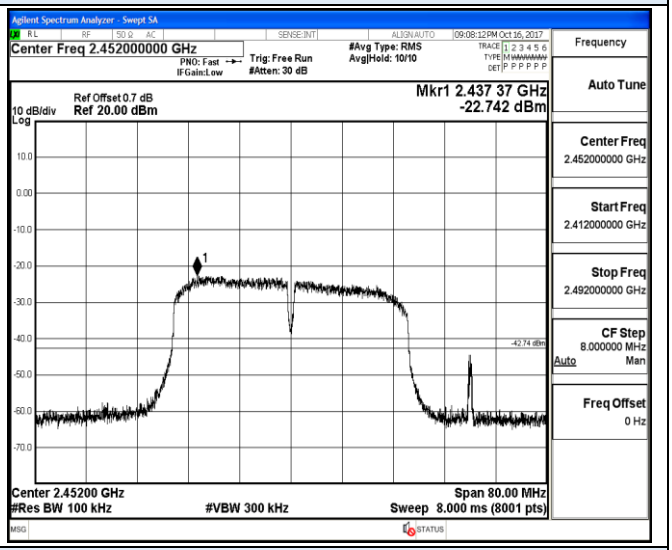
Power Spectral Density	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz

Power Spectral Density	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

Power Spectral Density	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz

5.4. 6 dB Spectrum Bandwidth Measurement

5.4.1. Standard Applicable

According to §15.247(a) (2): For digital modulation systems, the minimum 6 dB bandwidth shall be at least 500 kHz.

5.4.2. Measuring Instruments and Setting

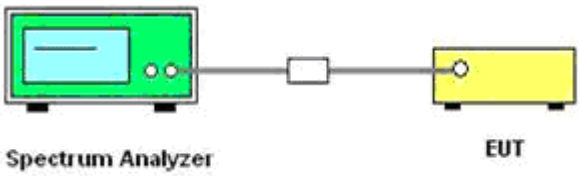
Please refer to equipments list in this report. The following table is the setting of the Spectrum Analyzer.

Spectrum Parameter	Setting
Attenuation	Auto
Span Frequency	> RBW
Detector	Peak
Trace	Max Hold
Sweep Time	100ms

5.4.3. Test Procedures

1. The transmitter output (antenna port) was connected to the spectrum analyzer in peak hold mode.
2. The resolution bandwidth and the video bandwidth were set according to KDB558074.
3. Measured the spectrum width with power higher than 6dB below carrier.

5.4.4. Test Setup Layout



5.4.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.4.6. Test Result of 6dB Spectrum Bandwidth

Temperature	25.1℃	Humidity	52.4%
Test Engineer	Jayden Zhuo	Configurations	IEEE 802.11b/g/n

Test Mode	Channel	Frequency (MHz)	6dB Bandwidth (MHz)			Limits (MHz)	Verdict
			Antenna 0	Antenna 1	Antenna 2		
IEEE 802.11b	1	2412	9.490	9.488	9.485	0.500	PASS
	6	2437	9.493	9.493	9.484		
	11	2462	9.494	9.483	9.487		
IEEE 802.11g	1	2412	16.380	16.380	16.380	0.500	PASS
	6	2437	16.360	16.160	16.170		
	11	2462	16.350	16.350	16.370		
IEEE 802.11n HT20	1	2412	16.940	16.940	16.940	0.500	PASS
	6	2437	16.930	16.950	16.680		
	11	2462	16.950	16.960	16.950		
IEEE 802.11n HT40	3	2422	34.550	34.440	34.430	0.500	PASS
	6	2437	33.810	33.930	34.220		
	9	2452	34.210	33.960	33.910		

Remark:

1. *Measured 6dB Bandwidth at difference data rate for each mode and recorded worst case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11b; 6Mbps at IEEE 802.11g; 6.5Mbps at IEEE 802.11n HT20; 13.5Mbps at IEEE 802.11n HT40;*
4. *Please refer to following plots;*

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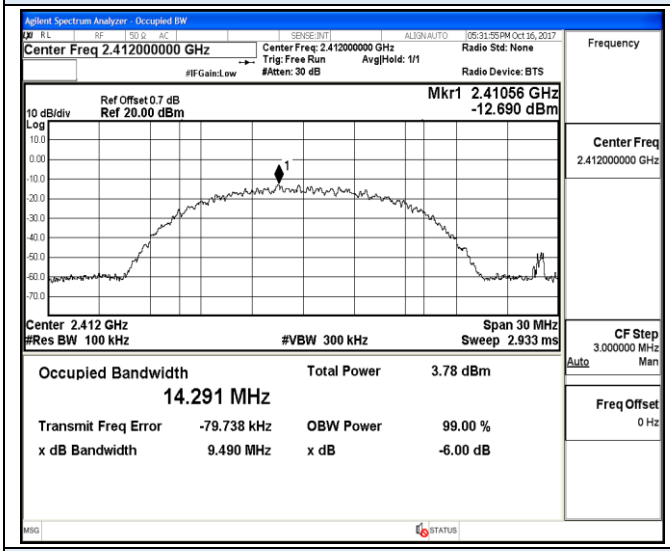
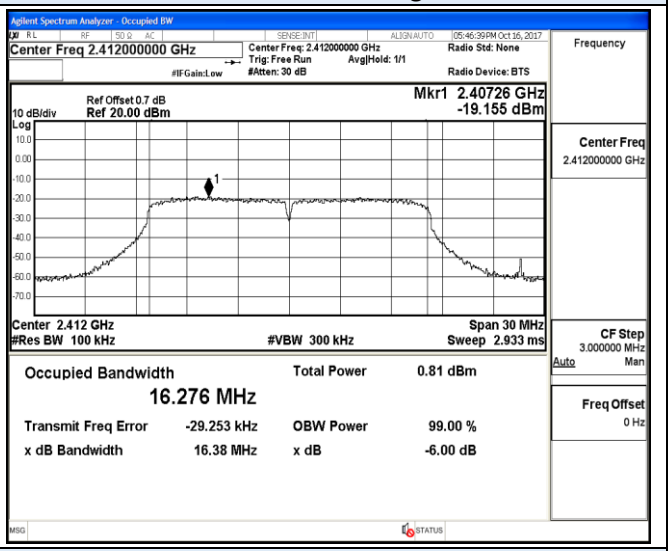
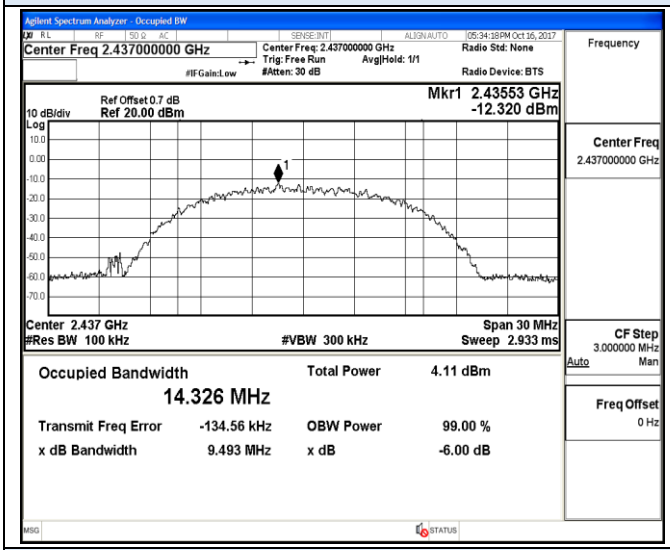
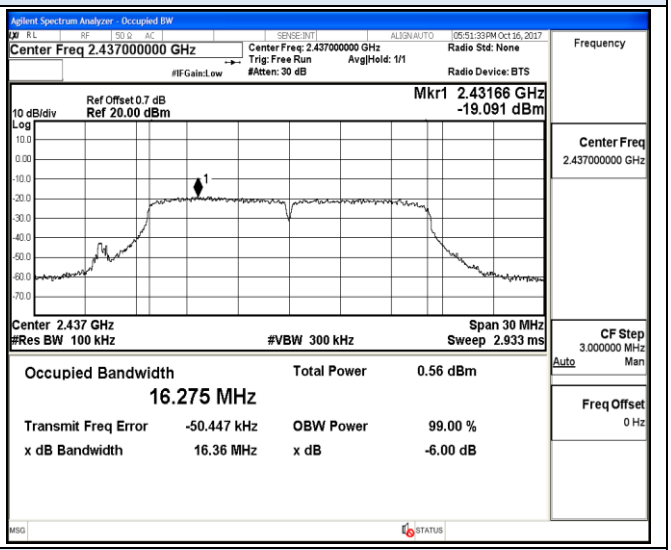
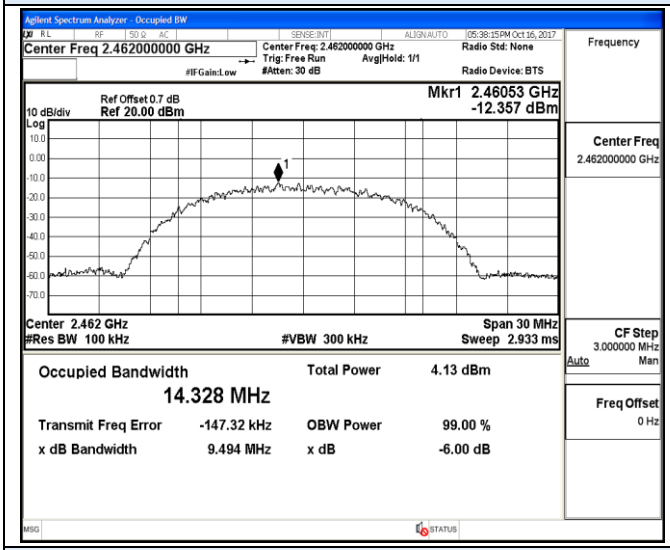
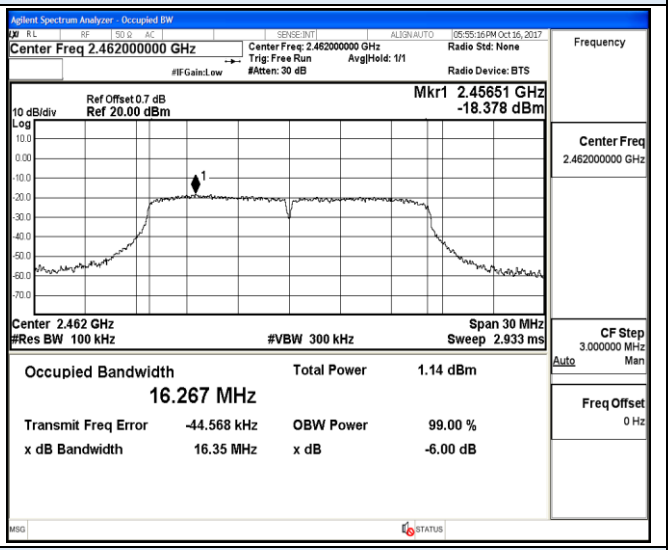
6 dB Bandwidth	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

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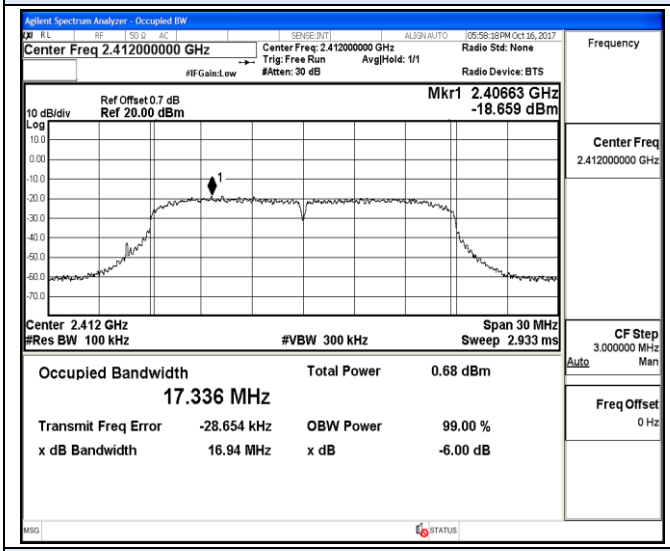
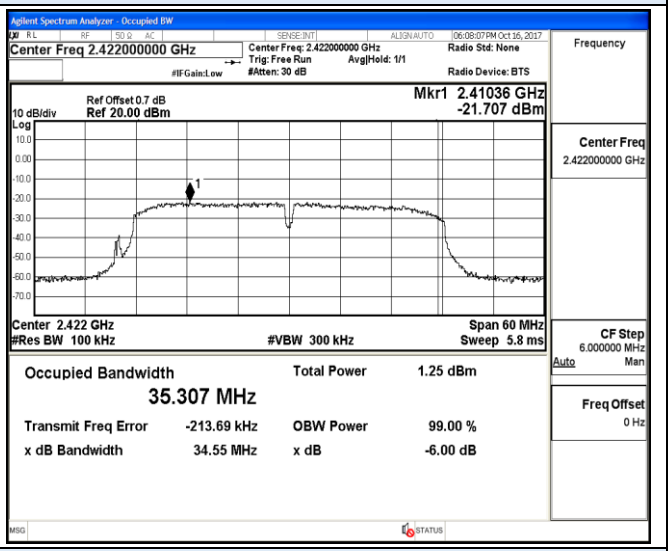
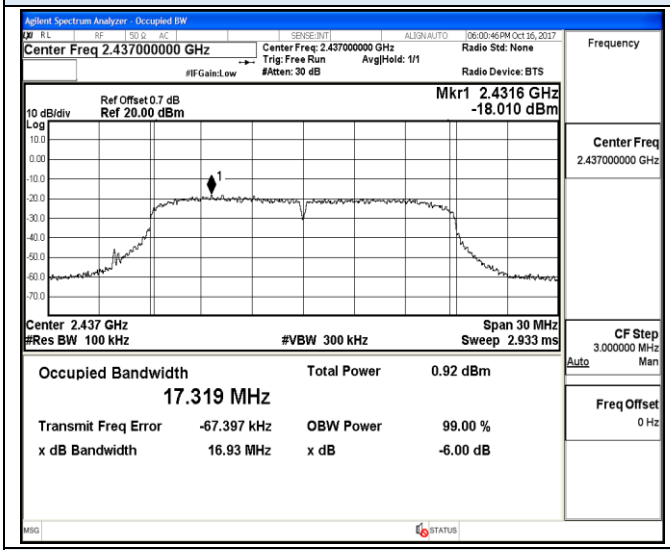
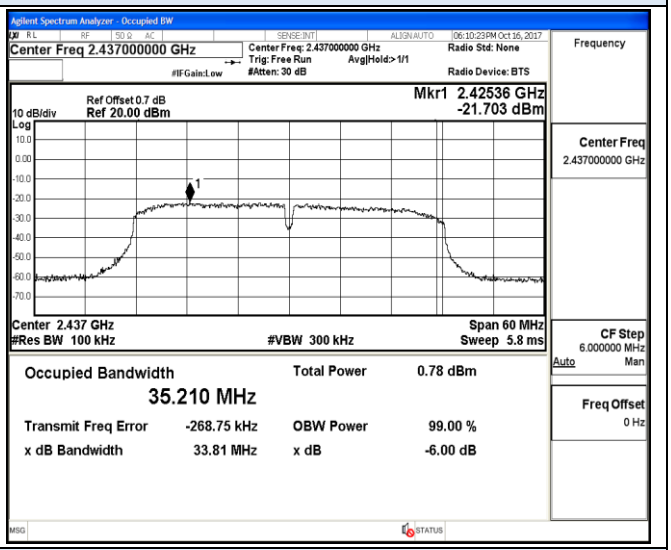
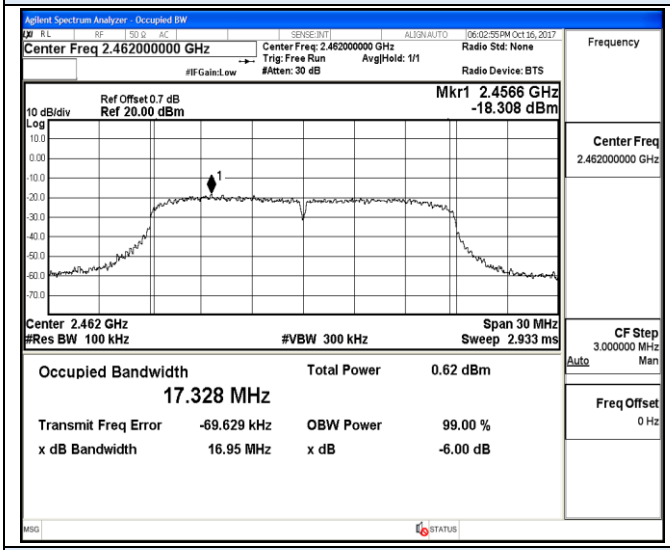
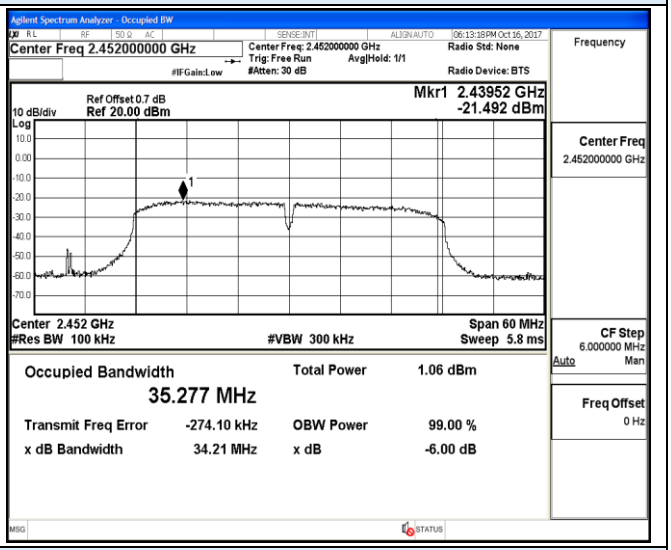
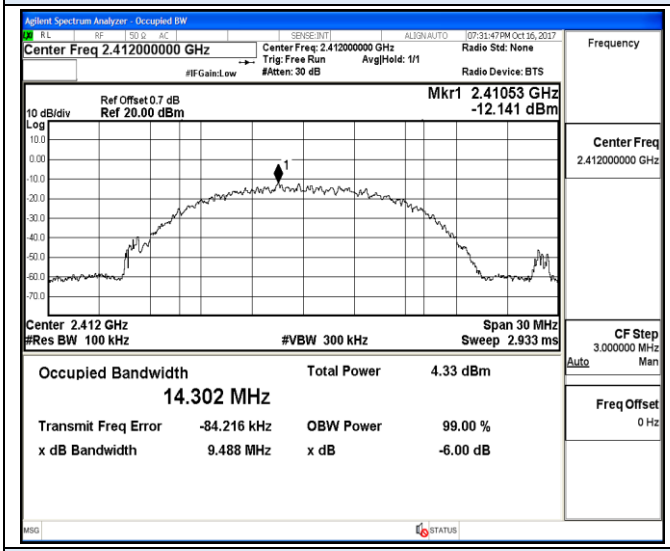
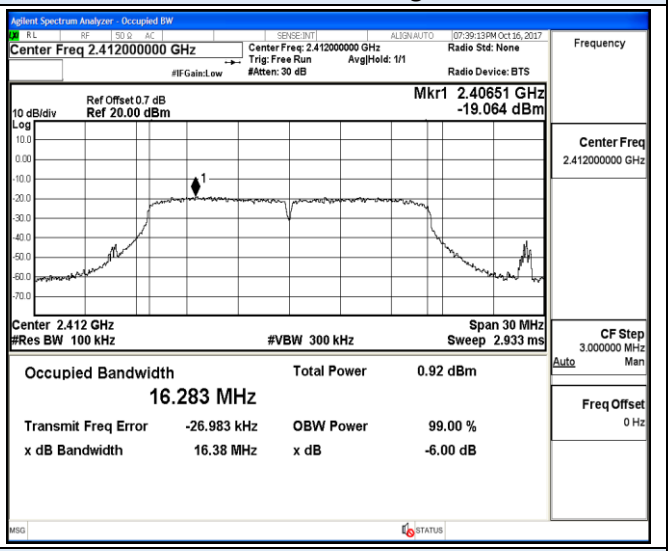
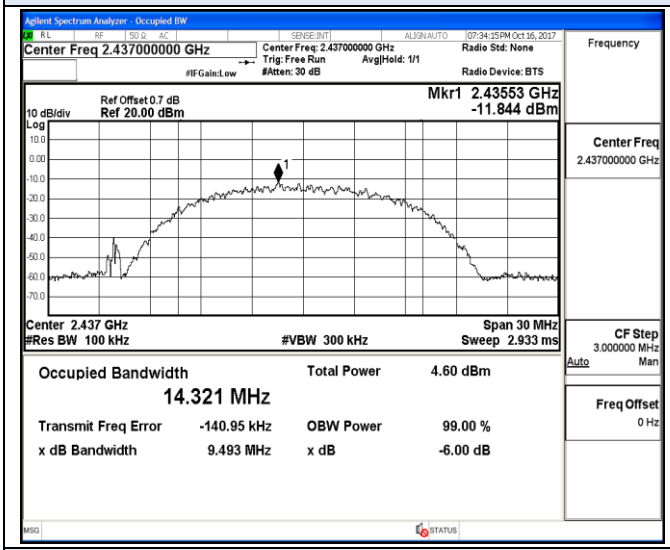
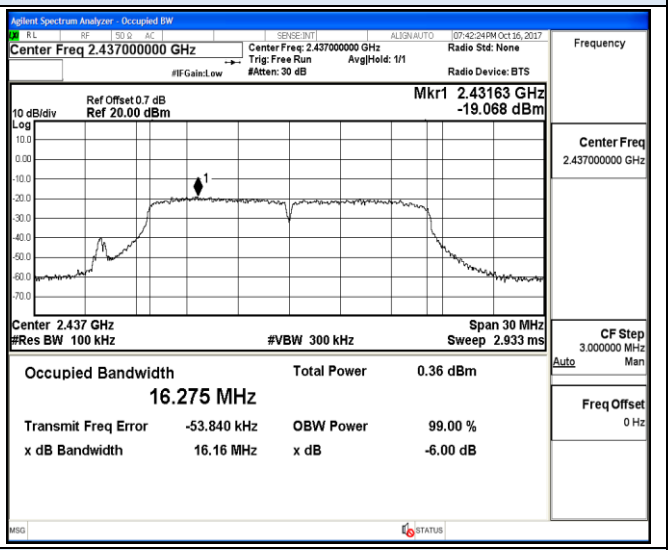
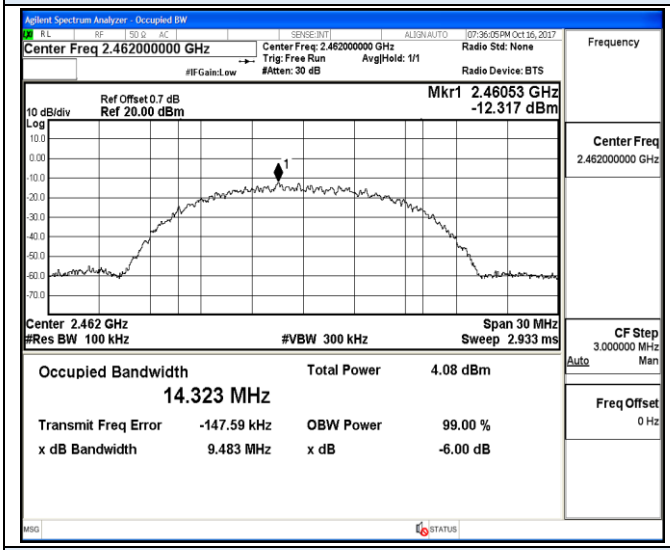
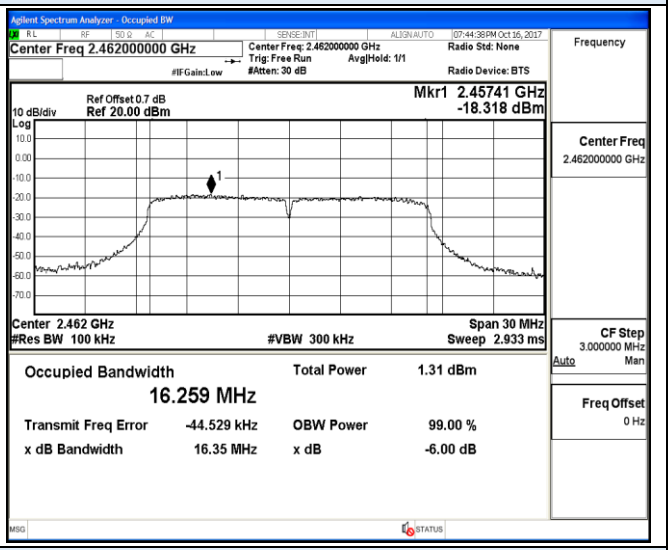
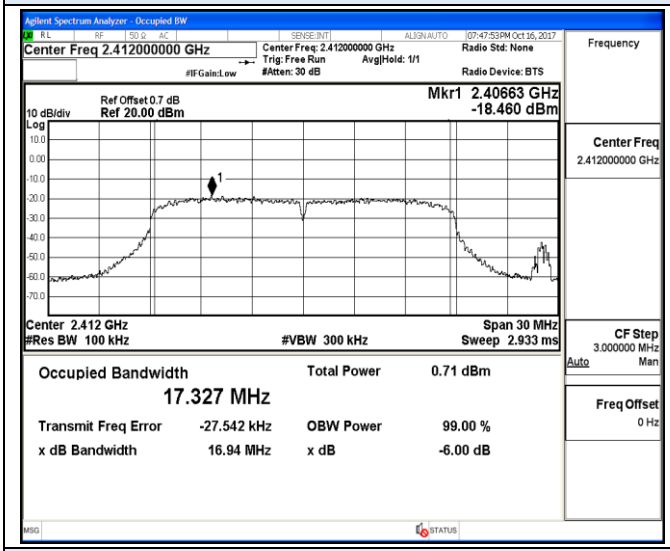
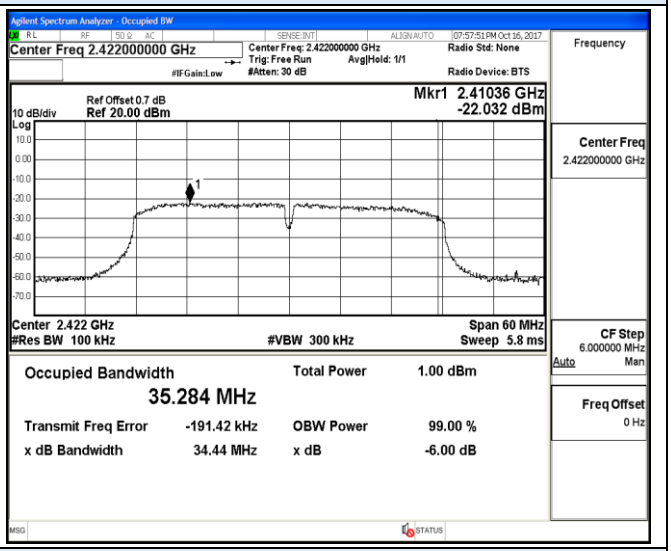
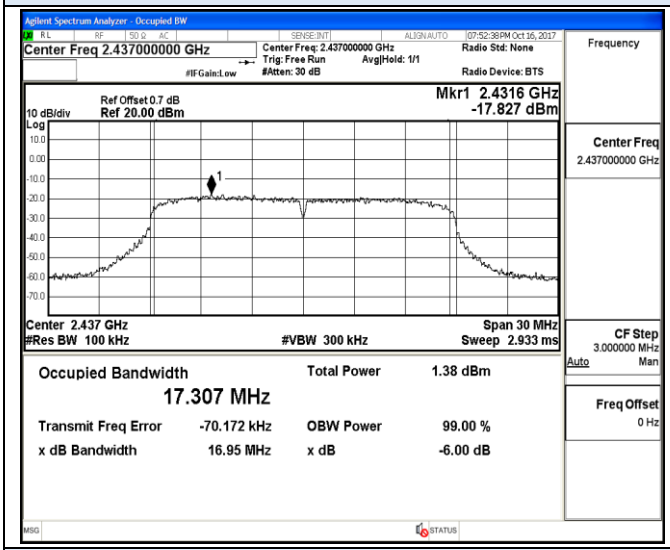
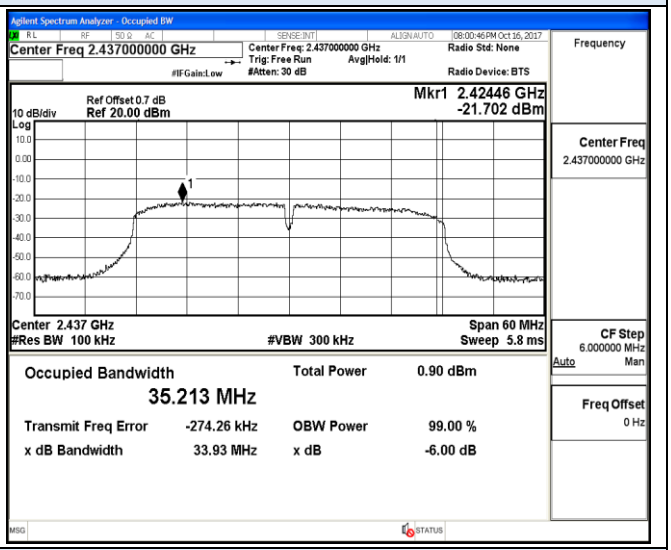
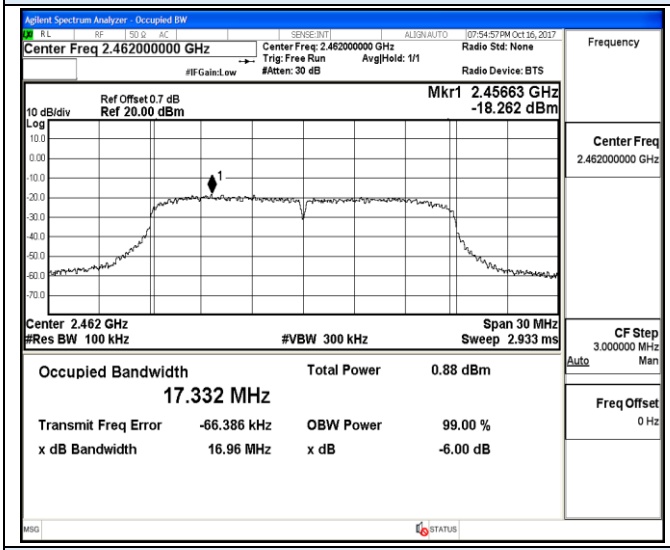
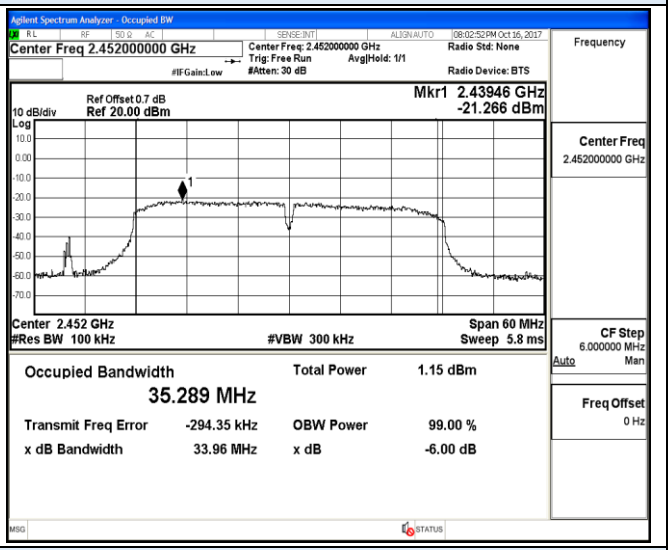
6 dB Bandwidth	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz

6 dB Bandwidth	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

6 dB Bandwidth	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz

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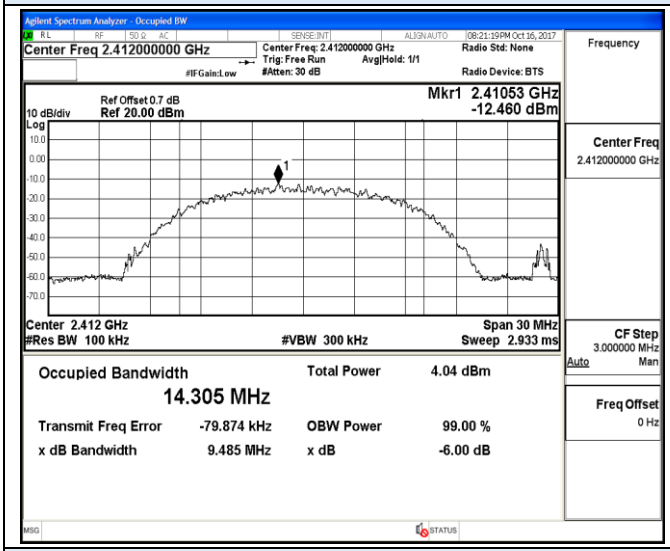
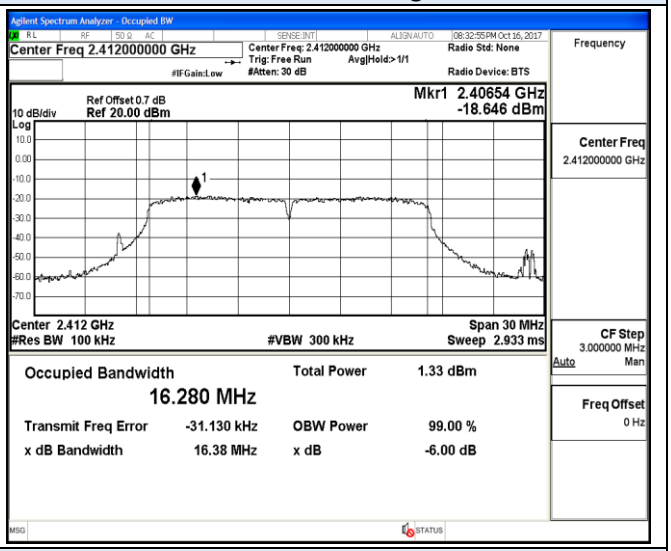
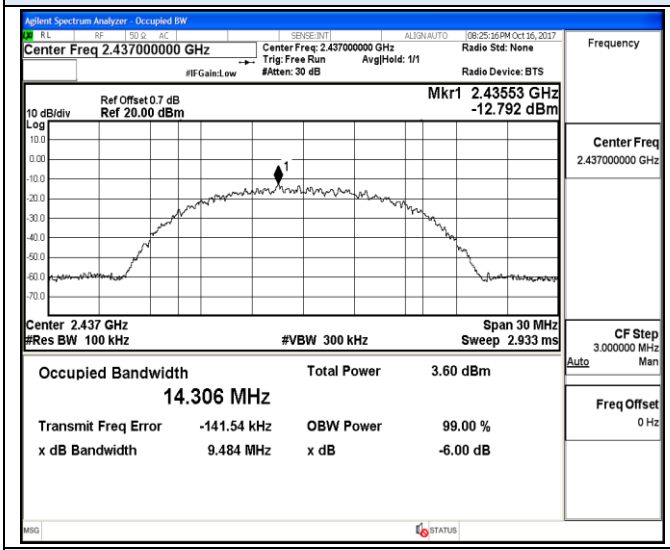
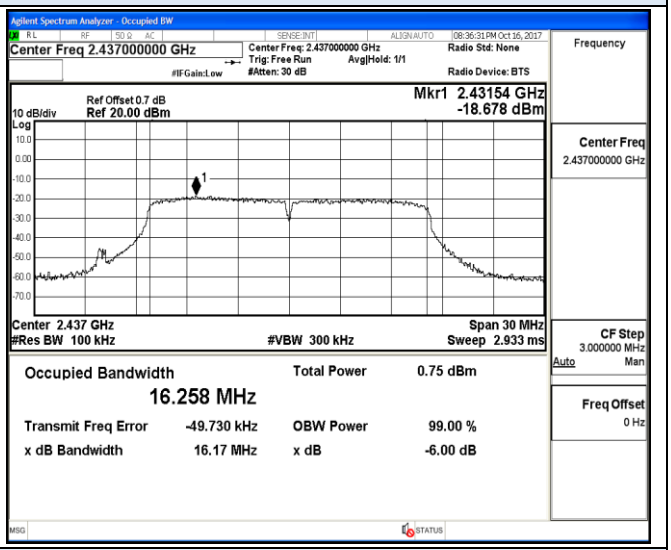
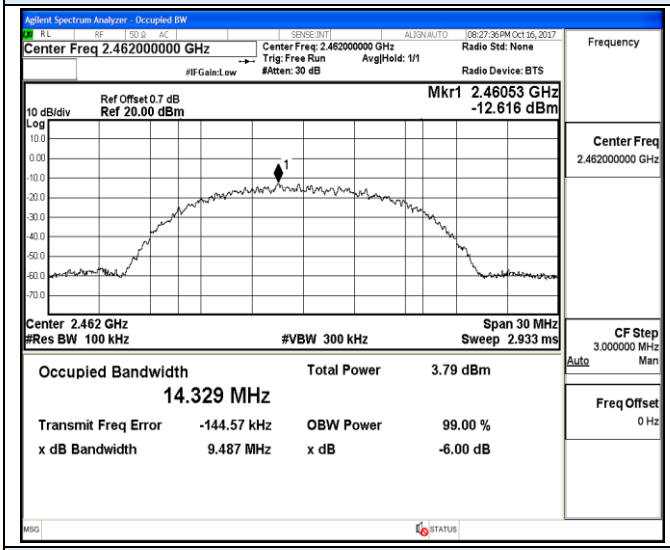
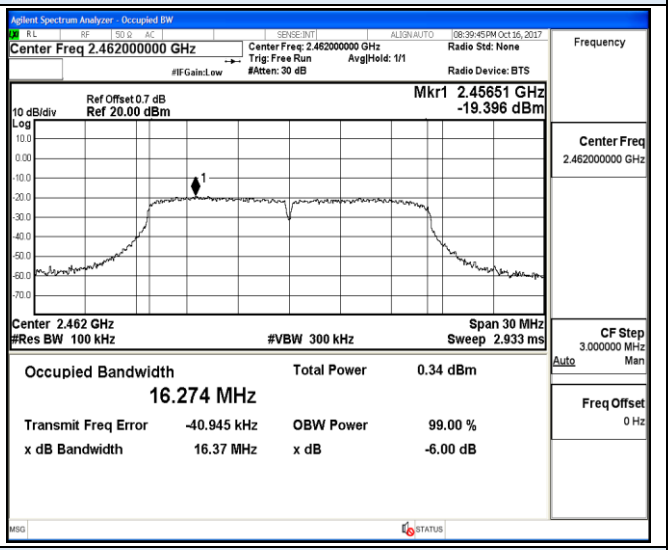
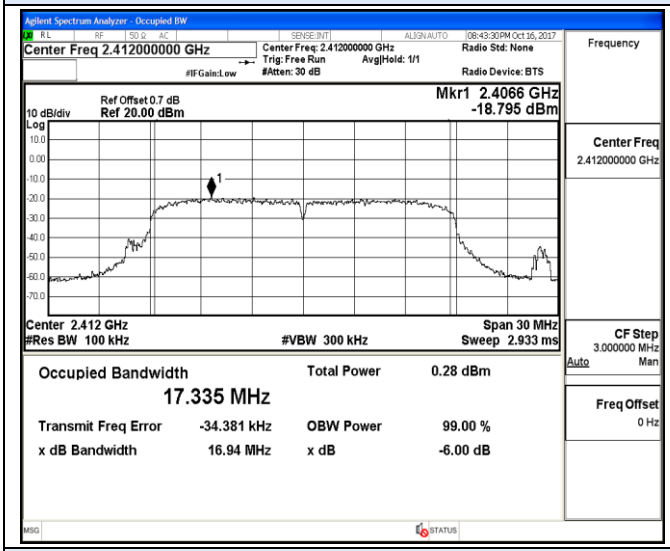
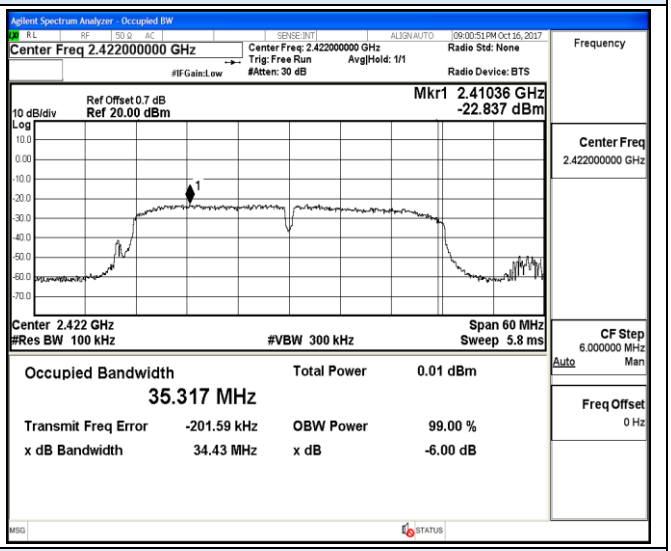
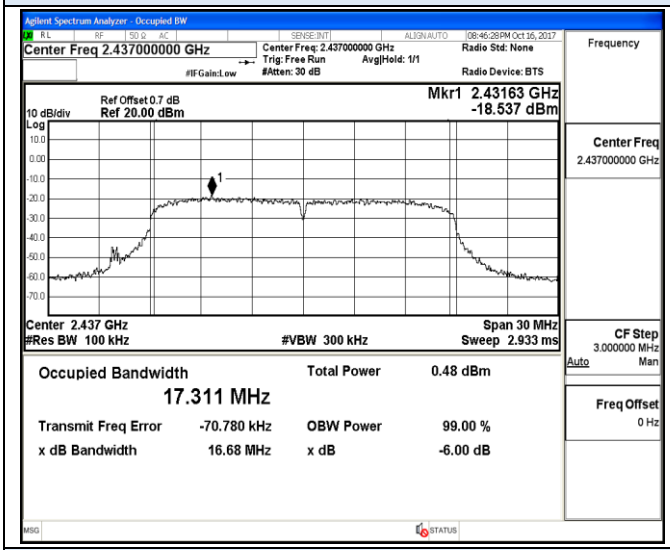
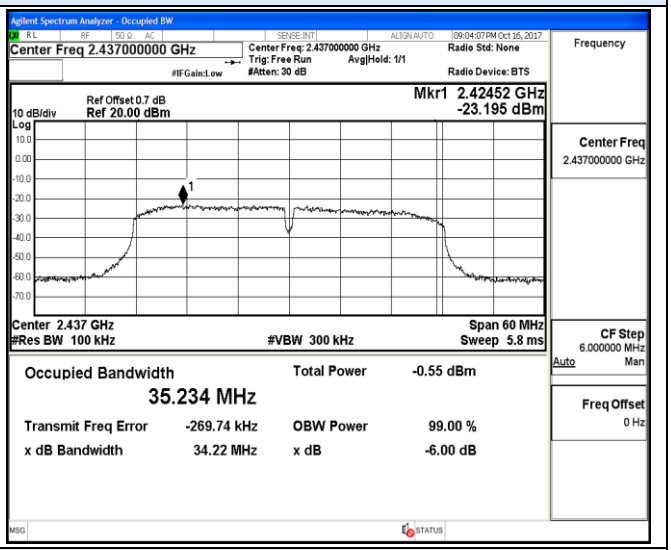
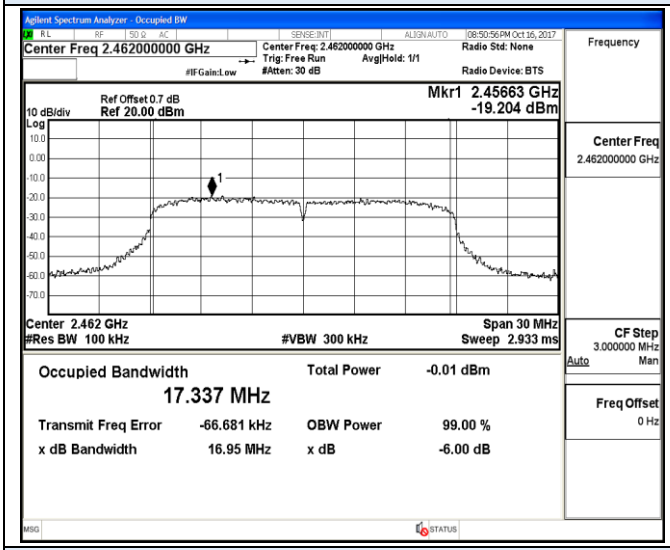
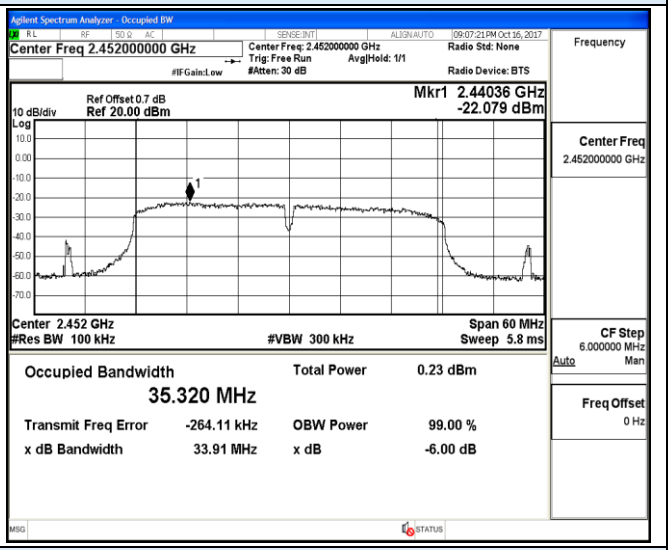
6 dB Bandwidth	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

6 dB Bandwidth	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz

5.5. Radiated Emissions Measurement

5.5.1. Standard Applicable

15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
\1\ 0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293.	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(\2\)
13.36-13.41			

\1\ Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

\2\ Above 38.6

According to §15.247 (d): 20dBc in any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the restricted band specified on 15.205(a), then the 15.209(a) limit in the table below has to be followed.

Frequencies (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/F(KHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

5.5.2. Measuring Instruments and Setting

Please refer to equipment list in this report. The following table is the setting of spectrum analyzer and receiver.

Spectrum Parameter	Setting
Attenuation	Auto
Start Frequency	1000 MHz
Stop Frequency	10th carrier harmonic
RB / VB (Emission in restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average
RB / VB (Emission in non-restricted band)	1MHz / 1MHz for Peak, 1 MHz / 1/B kHz for Average

Receiver Parameter	Setting
Attenuation	Auto
Start ~ Stop Frequency	9kHz~150kHz / RB/VB 200Hz/1KHz for QP/AVG
Start ~ Stop Frequency	150kHz~30MHz / RB/VB 9kHz/30KHz for QP/AVG
Start ~ Stop Frequency	30MHz~1000MHz / RB/VB 120kHz/1MHz for QP

5.5.3. Test Procedures

1) Sequence of testing 9 kHz to 30 MHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 0.8 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions.

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna height is 1.5 meter.

--- At each turntable position the analyzer sweeps with peak detection to find the maximum of all emissions

Final measurement:

--- Identified emissions during the premeasurement the software maximizes by rotating the turntable position (0° to 360°) and by rotating the elevation axes (0° to 360°).

--- The final measurement will be done in the position (turntable and elevation) causing the highest emissions with QPK detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

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2) Sequence of testing 30 MHz to 1 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a table with 0.8 m height is used, which is placed on the ground plane.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height changes from 1 to 3 meter.

--- At each turntable position, antenna polarization and height the analyzer sweeps three times in peak to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter.

--- The final measurement will be done with QP detector with an EMI receiver.

--- The final levels, frequency, measuring time, bandwidth, antenna height, antenna polarization, turntable angle, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

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3) Sequence of testing 1 GHz to 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 3 meter.

--- The EUT was set into operation.

Premeasurement:

--- The turntable rotates from 0° to 315° using 45° steps.

--- The antenna is polarized vertical and horizontal.

--- The antenna height scan range is 1 meter to 2.5 meter.

--- At each turntable position and antenna polarization the analyzer sweeps with peak detection to find the maximum of all emissions.

Final measurement:

--- The final measurement will be performed with minimum the six highest peaks.

--- According to the maximum antenna and turntable positions of premeasurement the software maximize the peaks by changing turntable position (± 45°) and antenna movement between 1 and 4 meter. This procedure is repeated for both antenna polarizations.

--- The final measurement will be done in the position (turntable, EUT-table and antenna polarization) causing the highest emissions with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, turntable position, EUT-table position, antenna polarization, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement with marked maximum final measurements and the limit will be stored.

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4) Sequence of testing above 18 GHz

Setup:

--- The equipment was set up to simulate a typical usage like described in the user manual or described by manufacturer.

--- If the EUT is a tabletop system, a rotatable table with 1.5 m height is used.

--- If the EUT is a floor standing device, it is placed on the ground plane with insulation between both.

--- Auxiliary equipment and cables were positioned to simulate normal operation conditions

--- The AC power port of the EUT (if available) is connected to a power outlet below the turntable.

--- The measurement distance is 1 meter.

--- The EUT was set into operation.

Premeasurement:

--- The antenna is moved spherical over the EUT in different polarizations of the antenna.

Final measurement:

--- The final measurement will be performed at the position and antenna orientation for all detected emissions that were found during the premeasurements with Peak and Average detector.

--- The final levels, frequency, measuring time, bandwidth, correction factor, margin to the limit and limit will be recorded. Also a plot with the graph of the premeasurement and the limit will be stored.

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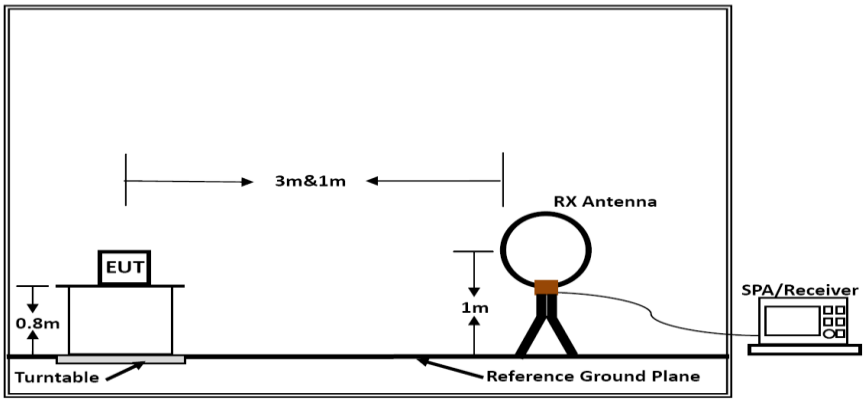
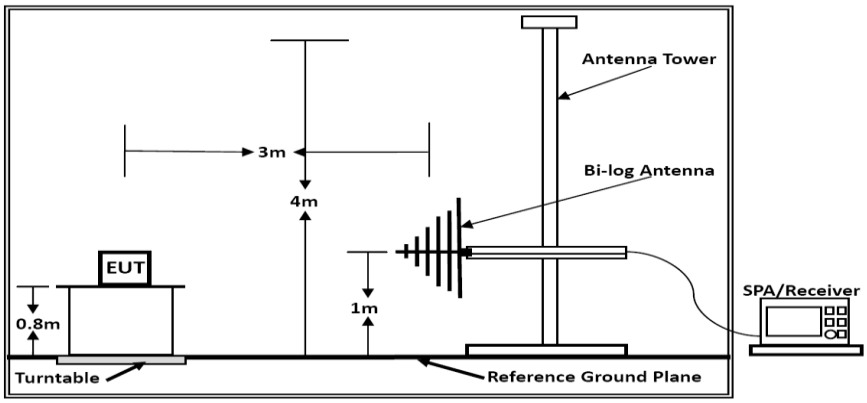
5.5.4. Test Setup Layout

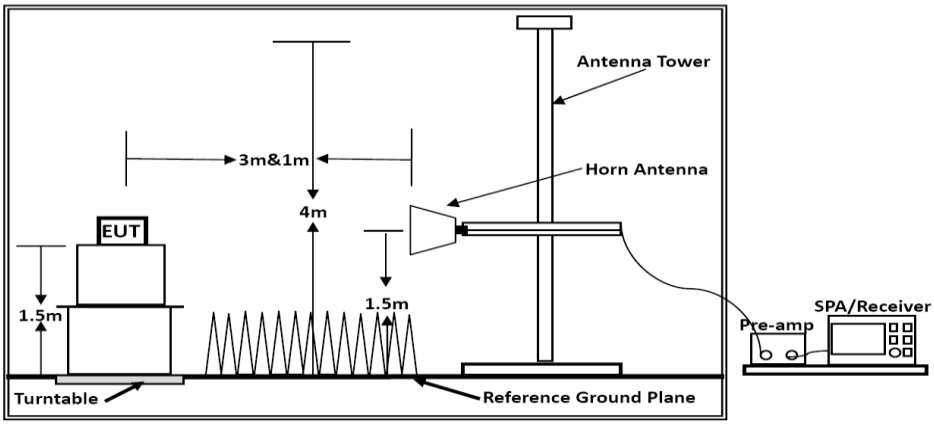
For radiated emissions below 30MHz



Below 30MHz



Below 1GHz



Above 1GHz

Above 18 GHz shall be extrapolated to the specified distance using an extrapolation factor of 20 dB/decade form 3m to 1m.

Distance extrapolation factor = 20 log (specific distanc [3m] / test distance [1m]) (dB);
Limit line = specific limits (dBuV) + distance extrapolation factor [6 dB].

5.5.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.5.6. Results of Radiated Emissions (9 KHz~30MHz)

Temperature	24.5℃	Humidity	56.2%
Test Engineer	Jayden Zhuo	Configurations	IEEE 802.11b/g/n
Test Date	September 27, 2017		

Freq. (MHz)	Level (dBuV)	Over Limit (dB)	Over Limit (dBuV)	Remark
-	-	-	-	See Note

Note:

The amplitude of spurious emissions which are attenuated by more than 20 dB below the permissible value has no need to be reported.

Distance extrapolation factor = 40 log (specific distance / test distance) (dB);

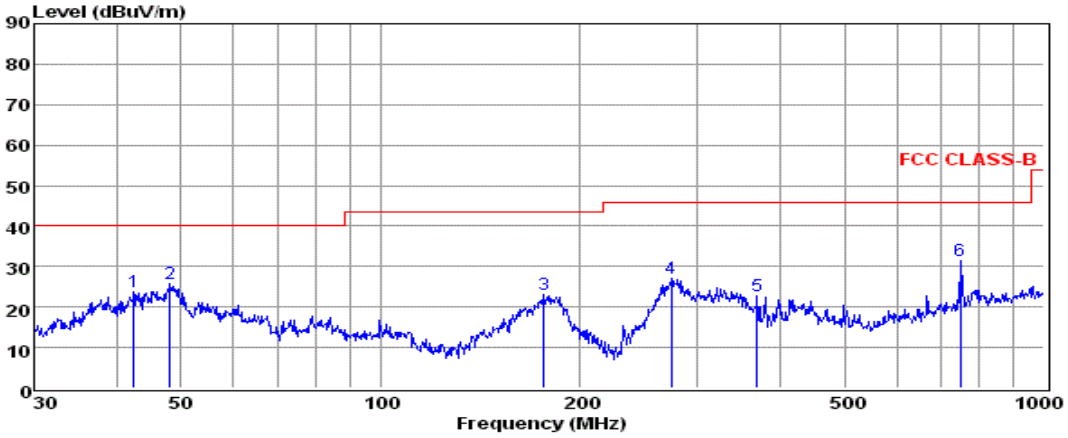
Limit line = specific limits (dBuV) + distance extrapolation factor.

5.5.7. Results of Radiated Emissions (30MHz~1GHz)

Temperature	24.5℃	Humidity	56.2%
Test Engineer	Jayden Zhuo	Configurations	802.11n HT40 Low Channel, Chain 0+Chain 1+Chain 2
Test Date	September 27, 2017		

The Worst Test result for 802.11n HT40 (Low Channel) @Chain 0+Chain 1+Chain 2

Horizontal

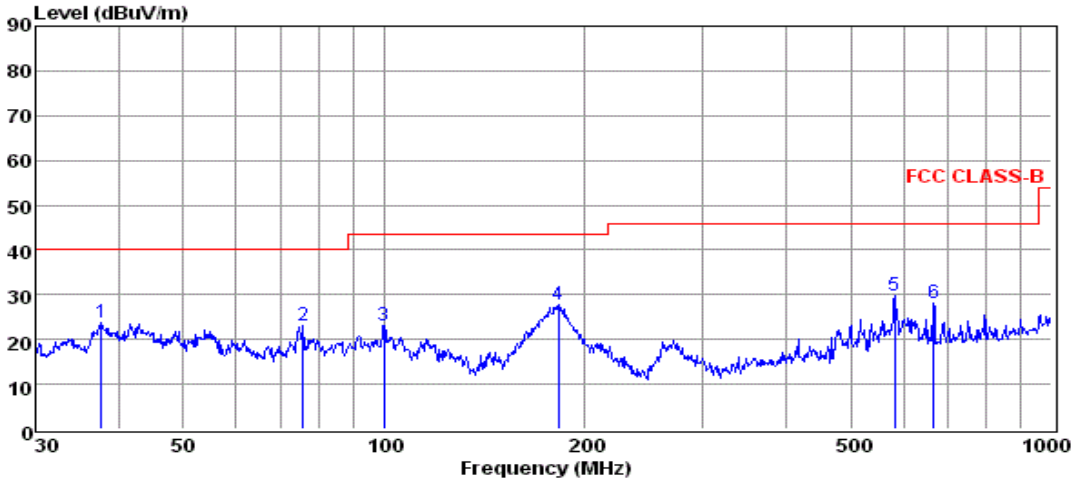


pol: HORIZONTAL

	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	42.45	9.54	0.50	13.57	23.61	40.00	-16.39	QP
2	48.16	12.13	0.35	13.36	25.84	40.00	-14.16	QP
3	176.27	12.88	0.73	9.42	23.03	43.50	-20.47	QP
4	274.19	13.42	1.04	12.49	26.95	46.00	-19.05	QP
5	369.40	6.95	1.22	14.51	22.68	46.00	-23.32	QP
6	747.48	10.28	1.65	19.40	31.33	46.00	-14.67	QP

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that ate 20db blow the offficial limit are not reported

Vertical



pol: VERTICAL

	Freq	Reading	CabLos	Antfac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB/m	dBuV/m	dBuV/m	dB	
1	37.68	10.24	0.38	12.99	23.61	40.00	-16.39	QP
2	75.45	14.66	0.54	7.87	23.07	40.00	-16.93	QP
3	99.88	9.29	0.60	13.15	23.04	43.50	-20.46	QP
4	182.56	17.03	0.89	9.91	27.83	43.50	-15.67	QP
5	582.74	10.09	1.54	18.13	29.76	46.00	-16.24	QP
6	665.80	7.74	1.55	18.69	27.98	46.00	-18.02	QP

Note: 1. All readings are Quasi-peak values.
2. Measured= Reading + Antenna Factor + Cable Loss
3. The emission that ate 20db blow the offficial limit are not reported

Note:
1). Pre-scan all modes and recorded the worst case results in this report (IEEE 802.11n HT40 (Low Channel) @ Chain 0+Chain 1+Chain 2.
2). Emission level (dBuV/m) = 20 log Emission level (uV/m).
3). Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level.

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5.5.8. Results for Radiated Emissions (Above 1GHz)

IEEEE 802.11b

Antenna 0

Channel 1 / 2412 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4824.00	56.48	33.06	35.04	3.94	58.44	74.00	-15.56	Peak	Horizontal
4824.00	41.69	33.06	35.04	3.94	43.65	54.00	-10.35	Average	Horizontal
4824.00	54.22	33.06	35.04	3.94	56.18	74.00	-17.82	Peak	Vertical
4824.00	41.44	33.06	35.04	3.94	43.40	54.00	-10.60	Average	Vertical

Channel 6 / 2437 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4874.00	59.42	33.16	35.15	3.96	61.39	74.00	-12.61	Peak	Horizontal
4874.00	40.45	33.16	35.15	3.96	42.42	54.00	-11.58	Average	Horizontal
4874.00	53.86	33.16	35.15	3.96	55.83	74.00	-18.17	Peak	Vertical
4874.00	41.91	33.16	35.15	3.96	43.88	54.00	-10.12	Average	Vertical

Channel 11 / 2462 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4924.00	57.72	33.26	35.14	3.98	59.82	74.00	-14.18	Peak	Horizontal
4924.00	44.20	33.26	35.14	3.98	46.30	54.00	-7.70	Average	Horizontal
4924.00	53.05	33.26	35.14	3.98	55.15	74.00	-18.85	Peak	Vertical
4924.00	39.99	33.26	35.14	3.98	42.09	54.00	-11.91	Average	Vertical

IEEEE 802.11g

Antenna 0

Channel 1 / 2412 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4824.00	54.93	33.06	35.04	3.94	56.89	74.00	-17.11	Peak	Horizontal
4824.00	40.84	33.06	35.04	3.94	42.80	54.00	-11.20	Average	Horizontal
4824.00	54.59	33.06	35.04	3.94	56.55	74.00	-17.45	Peak	Vertical
4824.00	41.50	33.06	35.04	3.94	43.46	54.00	-10.54	Average	Vertical

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Channel 6 / 2437 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4874.00	60.23	33.16	35.15	3.96	62.20	74.00	-11.80	Peak	Horizontal
4874.00	41.59	33.16	35.15	3.96	43.56	54.00	-10.44	Average	Horizontal
4874.00	53.20	33.16	35.15	3.96	55.17	74.00	-18.83	Peak	Vertical
4874.00	42.15	33.16	35.15	3.96	44.12	54.00	-9.88	Average	Vertical

Channel 11 / 2462 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4924.00	57.25	33.26	35.14	3.98	59.35	74.00	-14.65	Peak	Horizontal
4924.00	43.38	33.26	35.14	3.98	45.48	54.00	-8.52	Average	Horizontal
4924.00	54.09	33.26	35.14	3.98	56.19	74.00	-17.81	Peak	Vertical
4924.00	41.25	33.26	35.14	3.98	43.35	54.00	-10.65	Average	Vertical

IEEE 802.11n HT20

Combined Antenna 0, Antenna 1 and Antenna 2

Channel 1 / 2412 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4824.00	55.29	33.06	35.04	3.94	57.25	74.00	-16.75	Peak	Horizontal
4824.00	42.27	33.06	35.04	3.94	44.23	54.00	-9.77	Average	Horizontal
4824.00	54.49	33.06	35.04	3.94	56.45	74.00	-17.55	Peak	Vertical
4824.00	39.65	33.06	35.04	3.94	41.61	54.00	-12.39	Average	Vertical

Channel 6 / 2437 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4874.00	58.17	33.16	35.15	3.96	60.14	74.00	-13.86	Peak	Horizontal
4874.00	40.97	33.16	35.15	3.96	42.94	54.00	-11.06	Average	Horizontal
4874.00	54.42	33.16	35.15	3.96	56.39	74.00	-17.61	Peak	Vertical
4874.00	38.84	33.16	35.15	3.96	40.81	54.00	-13.19	Average	Vertical

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Channel 11 / 2462 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4924.00	59.14	33.26	35.14	3.98	61.24	74.00	-12.76	Peak	Horizontal
4924.00	43.02	33.26	35.14	3.98	45.12	54.00	-8.88	Average	Horizontal
4924.00	55.00	33.26	35.14	3.98	57.10	74.00	-16.90	Peak	Vertical
4924.00	38.80	33.26	35.14	3.98	40.90	54.00	-13.10	Average	Vertical

IEEE 802.11n HT40

Combined Antenna 0, Antenna 1 and Antenna 2

Channel 3 / 2422 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4844.00	54.45	33.06	35.04	3.94	56.41	74.00	-17.59	Peak	Horizontal
4844.00	41.56	33.06	35.04	3.94	43.52	54.00	-10.48	Average	Horizontal
4844.00	55.26	33.06	35.04	3.94	57.22	74.00	-16.78	Peak	Vertical
4844.00	39.78	33.06	35.04	3.94	41.74	54.00	-12.26	Average	Vertical

Channel 6 / 2437 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4874.00	58.48	33.16	35.15	3.96	60.45	74.00	-13.55	Peak	Horizontal
4874.00	41.66	33.16	35.15	3.96	43.63	54.00	-10.37	Average	Horizontal
4874.00	55.90	33.16	35.15	3.96	57.87	74.00	-16.13	Peak	Vertical
4874.00	38.52	33.16	35.15	3.96	40.49	54.00	-13.51	Average	Vertical

Channel 9 / 2452 MHz

Freq. MHz	Reading dBuV	Ant. Fac. dB/m	Pre. Fac. dB	Cab. Loss dB	Measured dBuV/m	Limit dBuV/m	Margin dB	Remark	Pol.
4904.00	58.56	33.26	35.14	3.98	60.66	74.00	-13.34	Peak	Horizontal
4904.00	42.82	33.26	35.14	3.98	44.92	54.00	-9.08	Average	Horizontal
4904.00	55.16	33.26	35.14	3.98	57.26	74.00	-16.74	Peak	Vertical
4904.00	39.25	33.26	35.14	3.98	41.35	54.00	-12.65	Average	Vertical

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Notes:

1. *Measuring frequencies from 9 KHz - 10th harmonic or 26.5GHz (which is less), No emission found between lowest internal used/generated frequency to 30MHz.*
2. *Radiated emissions measured in frequency range from 9 KHz ~10th harmonic or 26.5GHz (which is less) were made with an instrument using Peak detector mode.*
3. *Data of measurement within this frequency range shown "---" in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.*
4. *Worst case data at 1Mbps at IEEE 802.11b; 6Mbps at IEEE 802.11g; 6.5Mbps at IEEE 802.11n HT20; 13.5Mbps at IEEE 802.11n HT40;*
5. *Pre-scan at Antenna 0, Antenna 1 and Antenna 2 for IEEE 802.11b and IEEE 802.11g mode, pre-scan at Antenna 0, Antenna 1, Antenna 2 and Combined Antenna 0, Antenna 1 and Antenna 2 for IEEE 802.11n mode, recorded worst case;*

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5.6. Conducted Spurious Emissions and Band Edges Test

5.6.1. Standard Applicable

According to §15.247 (d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).

5.6.2. Measuring Instruments and Setting

Please refer to section 6 of equipment list in this report. The following table is the setting of the spectrum analyzer.

Spectrum Parameter	Setting
Detector	Peak
Attenuation	Auto
RB / VB (Emission in restricted band)	100KHz/300KHz
RB / VB (Emission in non-restricted band)	100KHz/300KHz

5.6.3. Test Procedures

The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100 kHz. The video bandwidth is set to 300 kHz

The spectrum from 9 KHz to 26.5GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

5.6.4. Test Setup Layout

This test setup layout is the same as that shown in section 5.4.4.

5.6.5. EUT Operation during Test

The EUT was programmed to be in continuously transmitting mode.

5.6.6. Test Results of Conducted Spurious Emissions

Temperature	24.5℃	Humidity	56.2%
Test Engineer	Jayden Zhuo	Configurations	IEEE 802.11b/g/n

Test Mode	Channel	Frequency (MHz)	Measured Frequency Range	Spurious RF Conducted Emission (dBc)			Limits (dBc)	Verdict
				Antenna 0	Antenna 1	Antenna 2		
IEEE 802.11b	1	2412	9 KHz – 26.5 GHz	<-20	<-20	<-20	-20	PASS
	6	2437	9 KHz – 26.5 GHz	<-20	<-20	<-20		
	11	2462	9 KHz – 26.5 GHz	<-20	<-20	<-20		
IEEE 802.11g	1	2412	9 KHz – 26.5 GHz	<-20	<-20	<-20	-20	PASS
	6	2437	9 KHz – 26.5 GHz	<-20	<-20	<-20		
	11	2462	9 KHz – 26.5 GHz	<-20	<-20	<-20		
IEEE 802.11n HT20	1	2412	9 KHz – 26.5 GHz	<-20	<-20	<-20	-20	PASS
	6	2437	9 KHz – 26.5 GHz	<-20	<-20	<-20		
	11	2462	9 KHz – 26.5 GHz	<-20	<-20	<-20		
IEEE 802.11n HT40	3	2422	9 KHz – 26.5 GHz	<-20	<-20	<-20	-20	PASS
	6	2437	9 KHz – 26.5 GHz	<-20	<-20	<-20		
	9	2452	9 KHz – 26.5 GHz	<-20	<-20	<-20		

Remark:

1. *Measured RF conducted spurious emission at difference data rate for each mode and recorded worst case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11b; 6Mbps at IEEE 802.11g; 6.5Mbps at IEEE 802.11n HT20; 13.5Mbps at IEEE 802.11n Ht40;*
4. *"---"means that the fundamental frequency not for 15.209 limits requirement.*
5. *Not recorded emission values from 9 KHz to 30 MHz as emission level at least 20 dBc lower than limit;*
6. *Please refer to following plots;*

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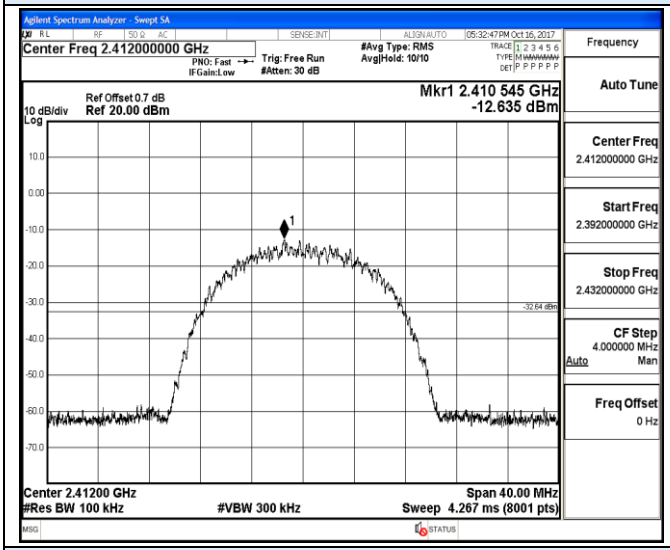
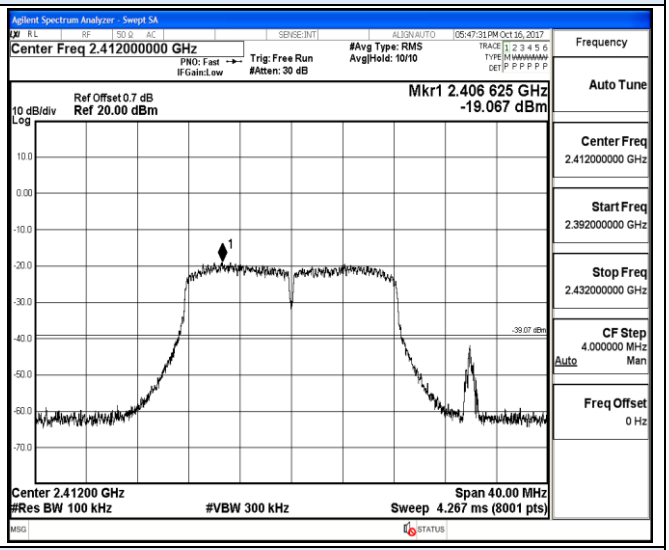
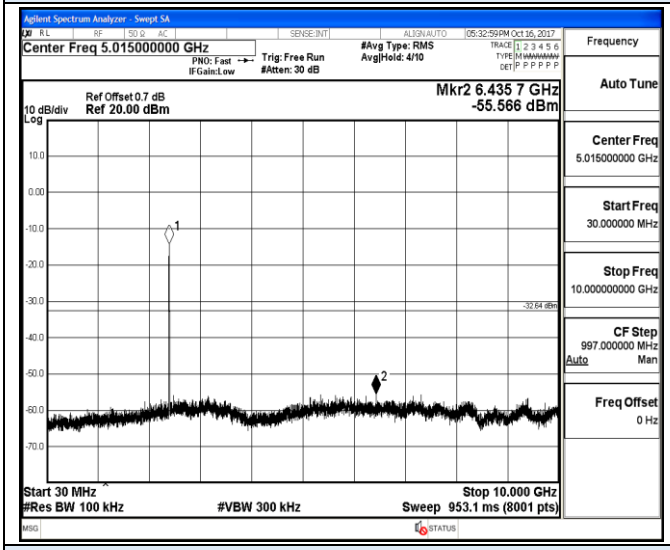
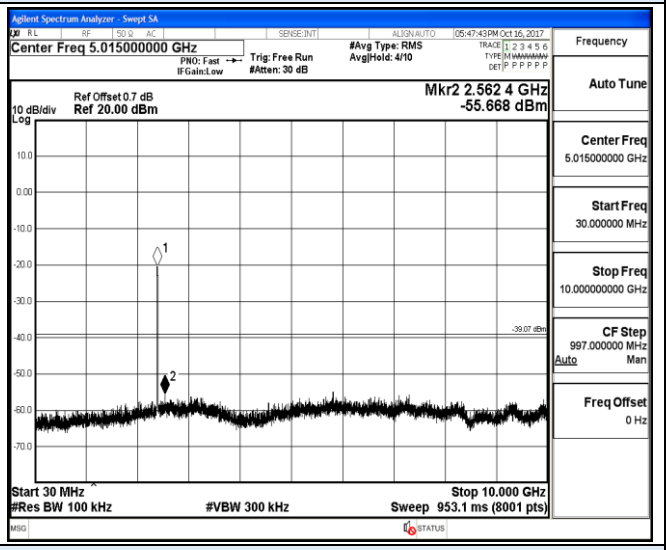
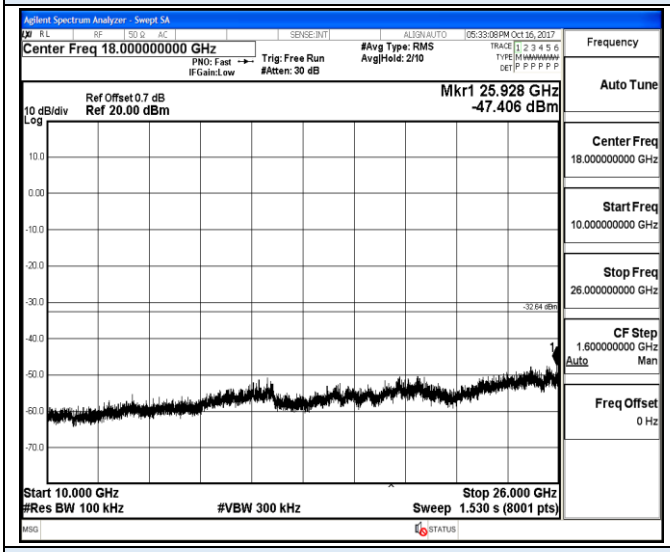
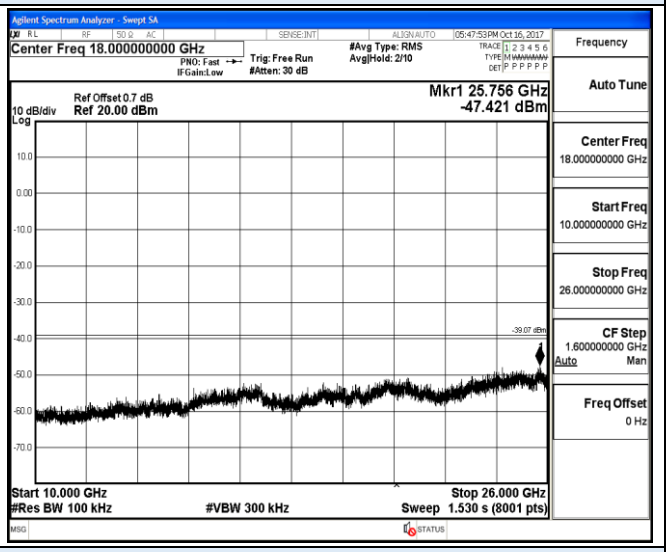
RF Conducted Spurious Emissions	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
2392 MHz – 2432 MHz	2392 MHz – 2432 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

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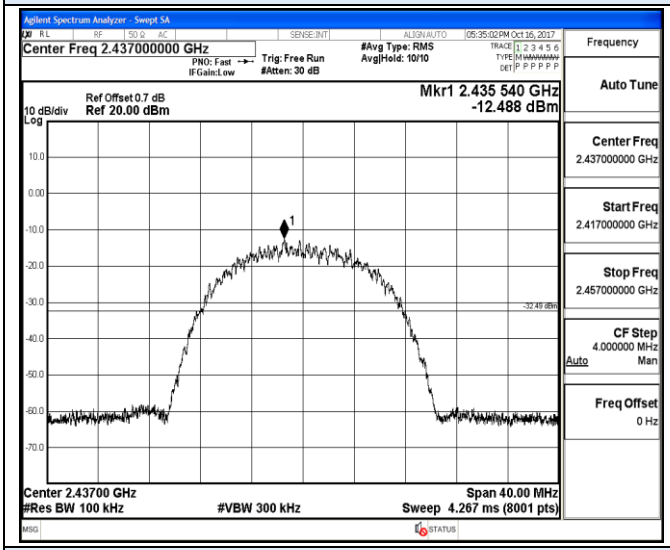
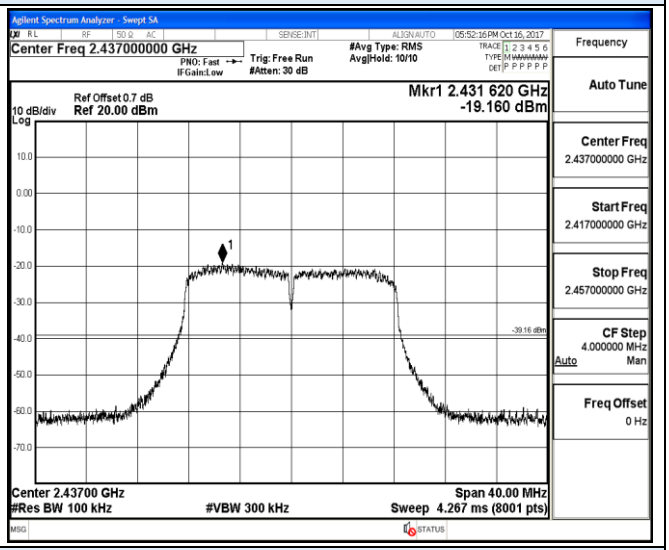
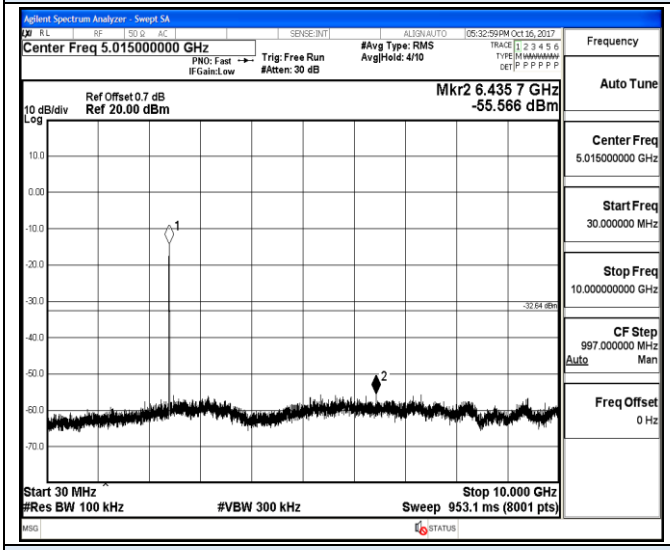
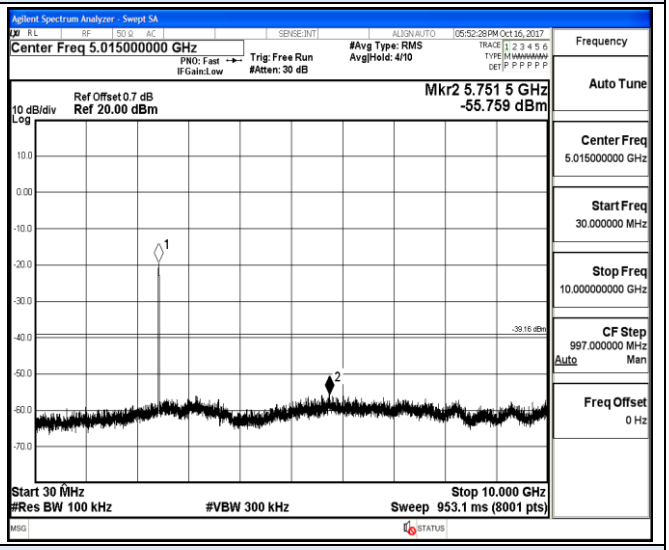
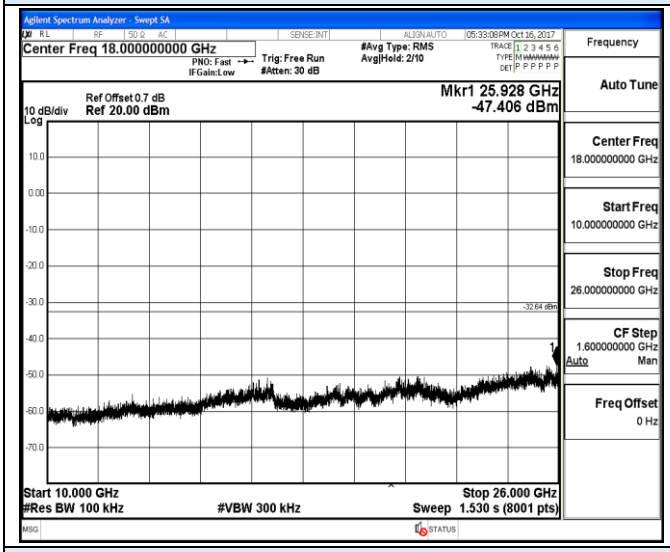
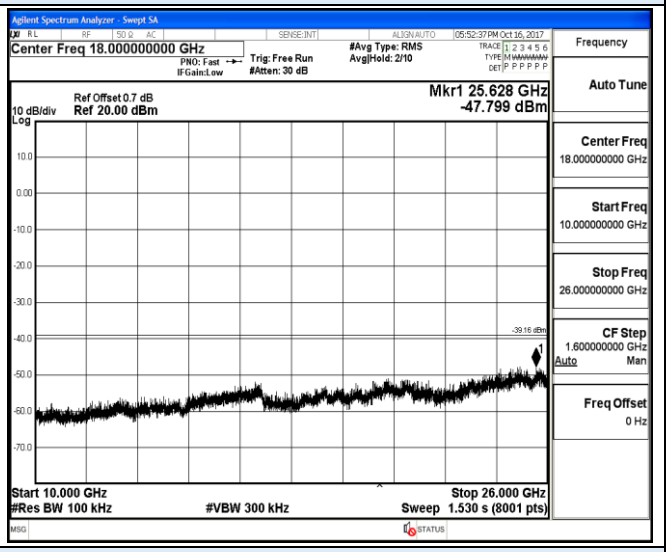
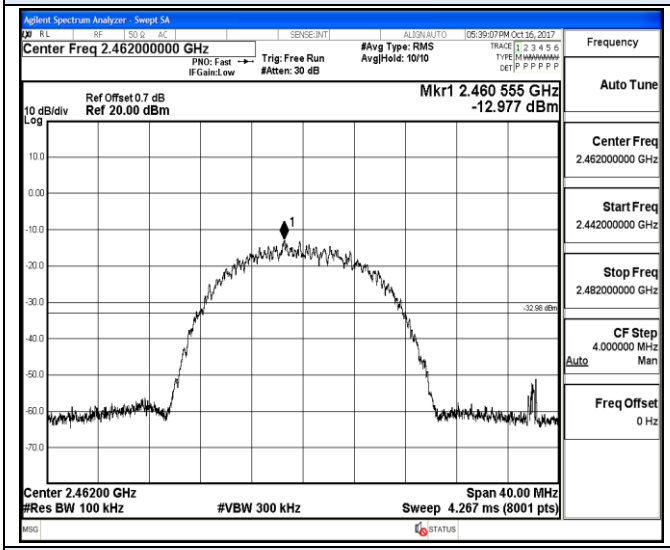
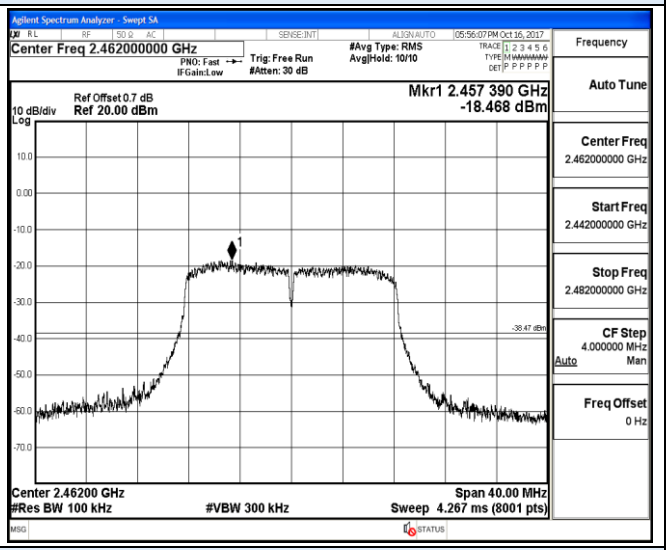
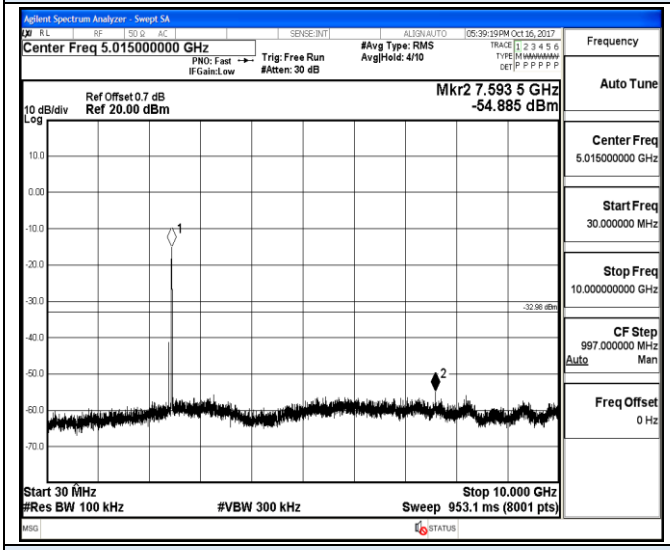
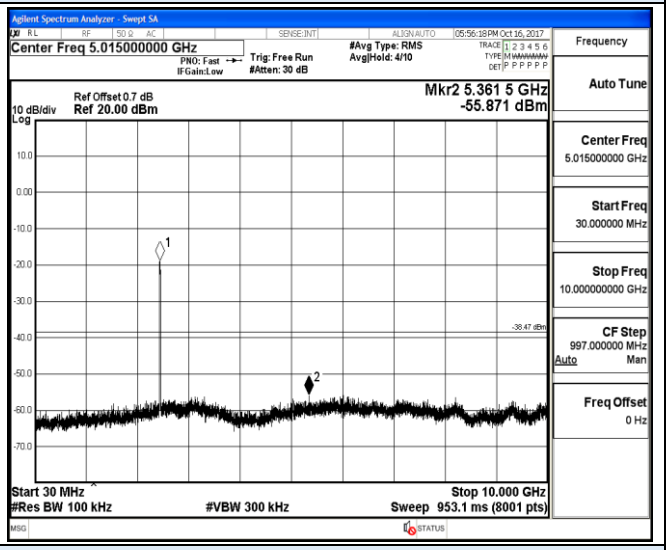
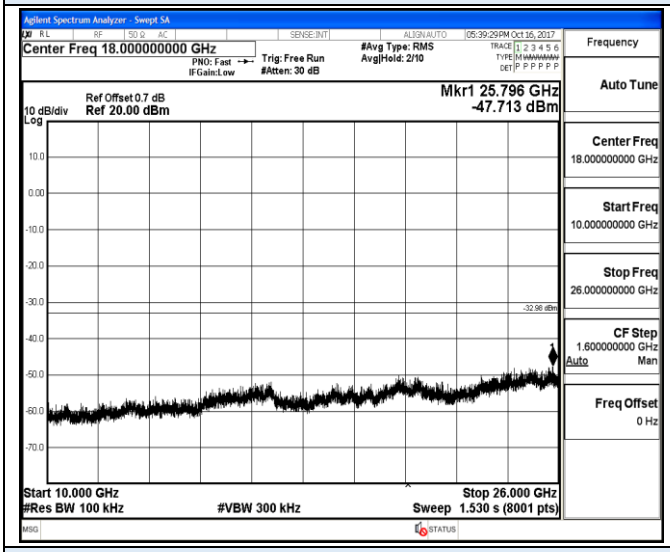
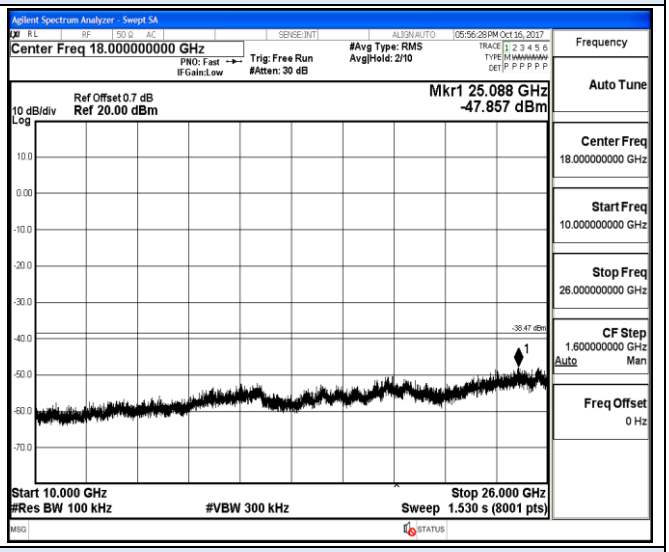
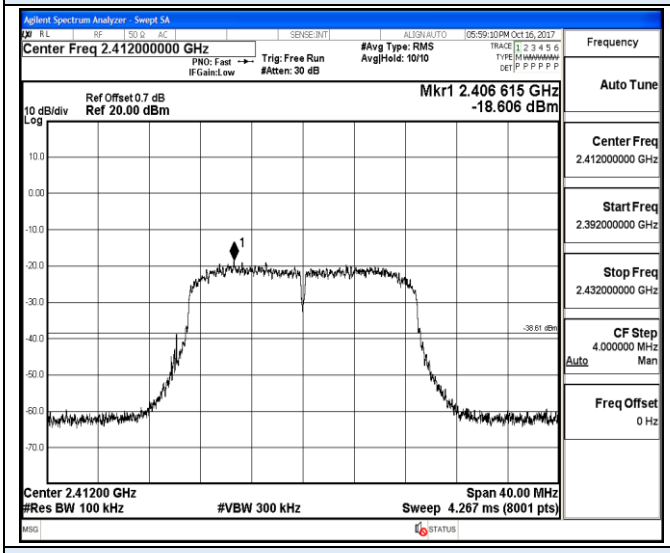
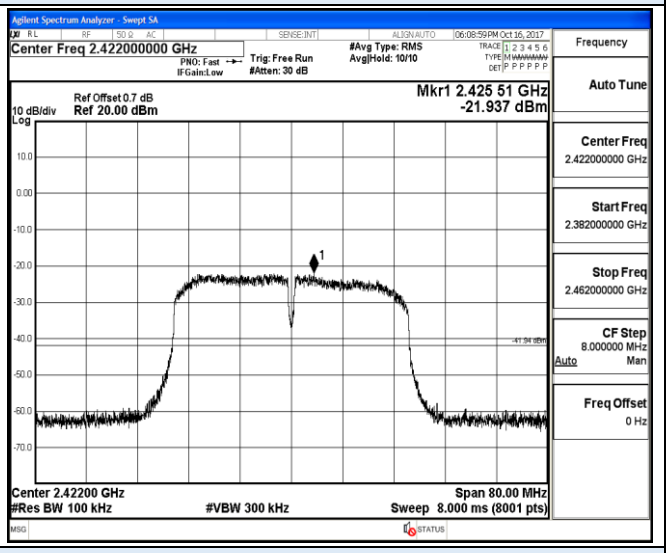
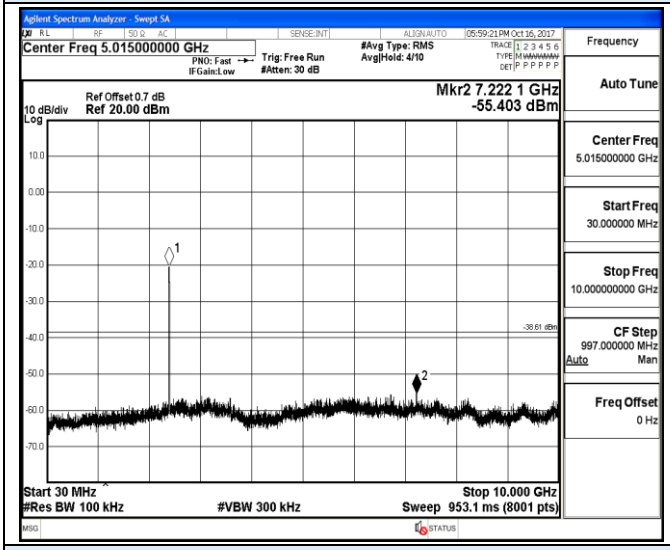
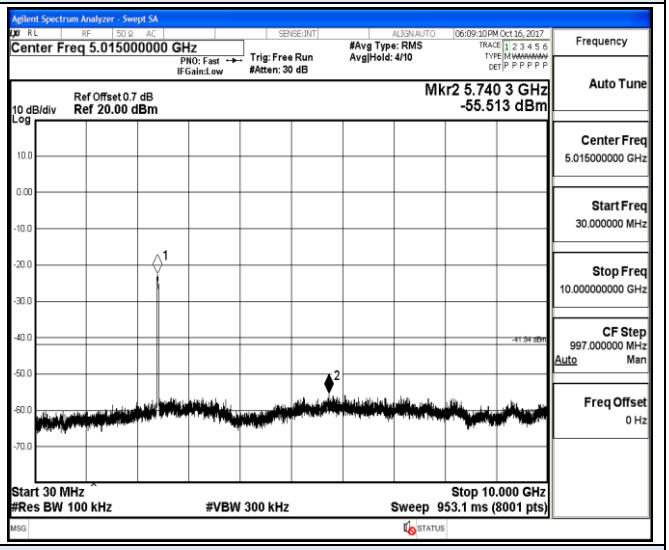
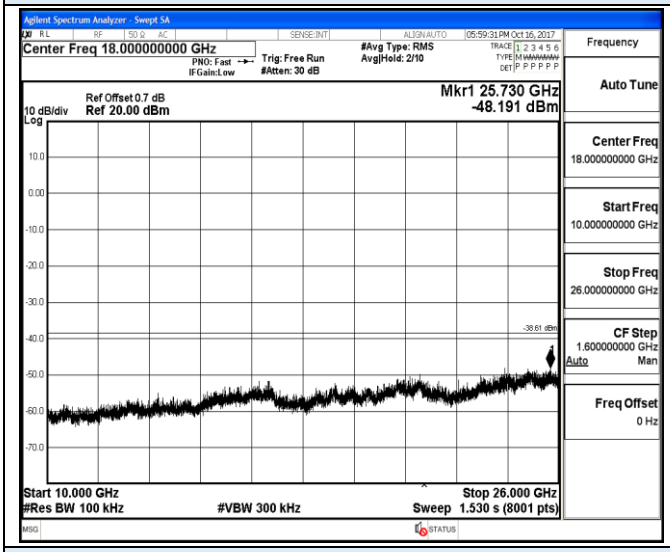
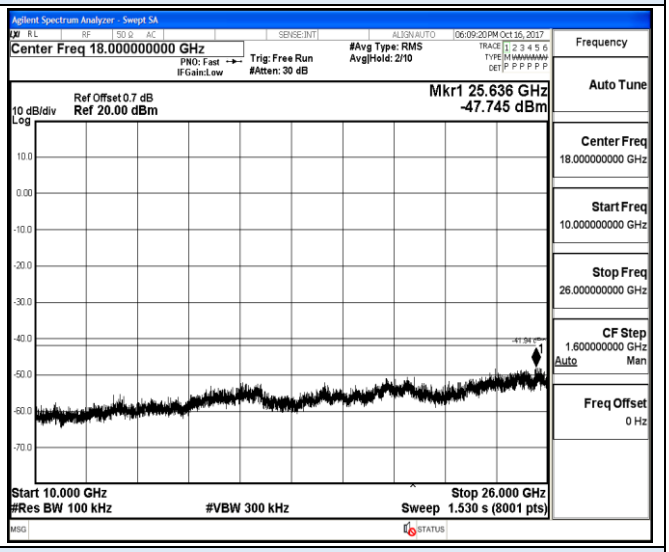
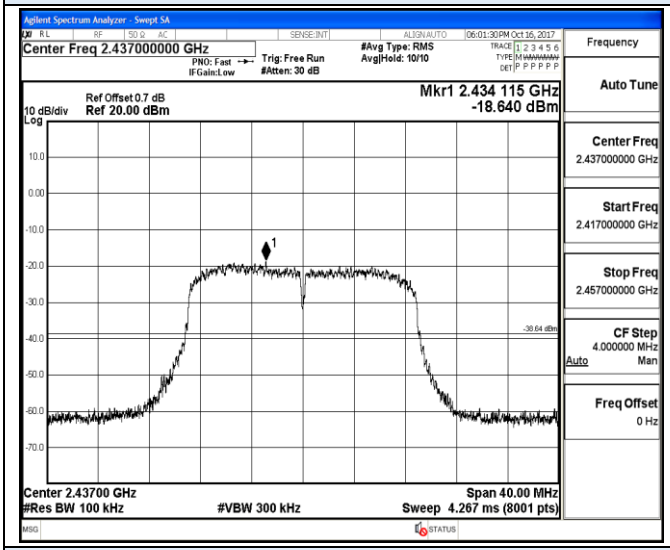
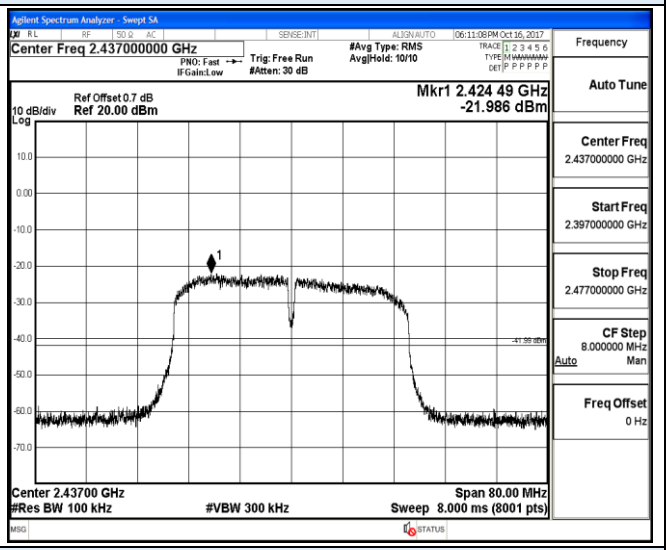
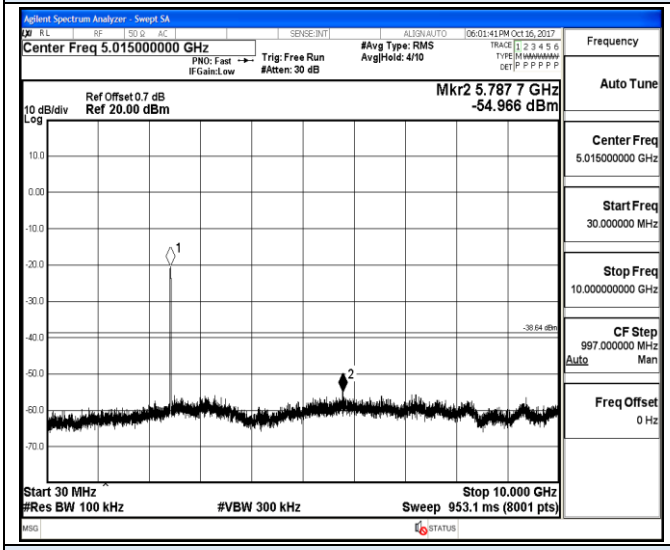
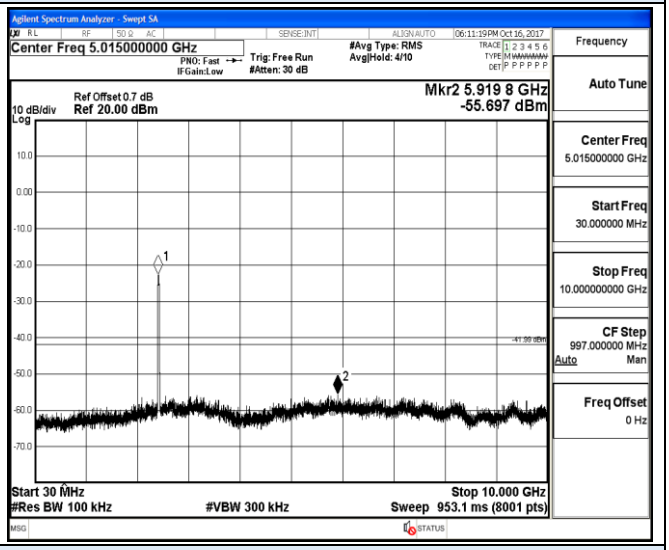
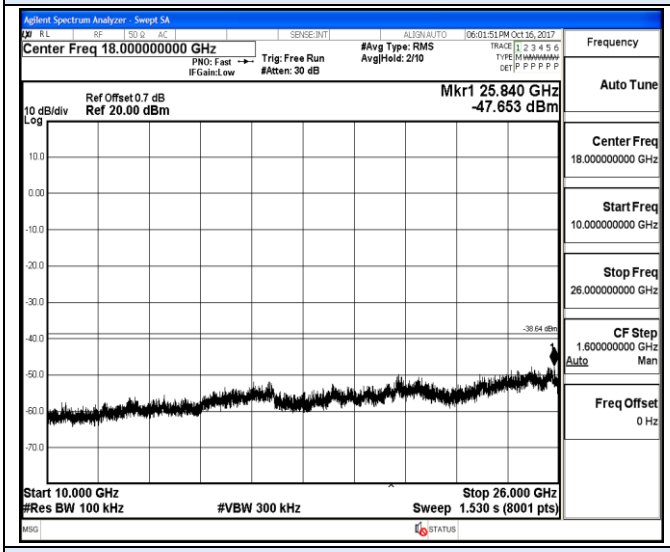
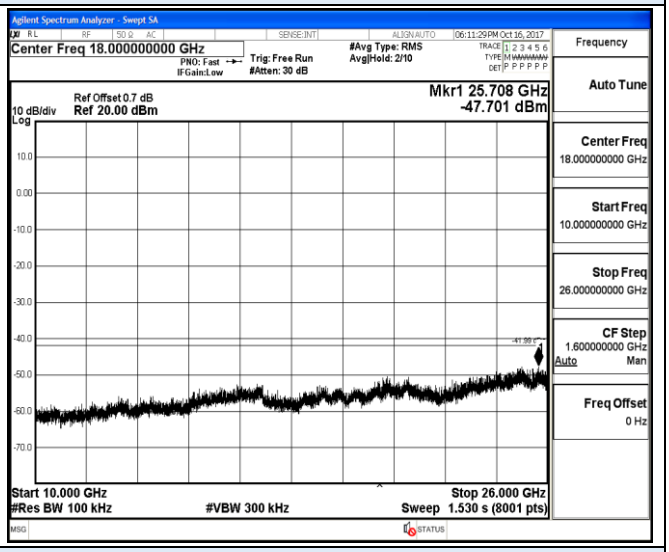
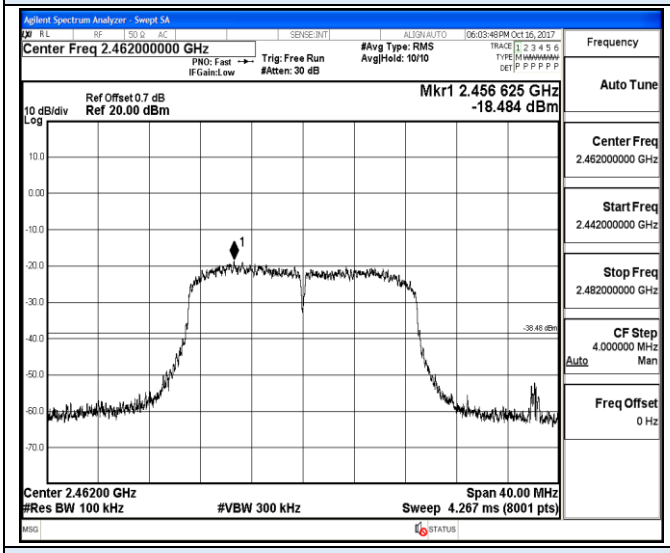
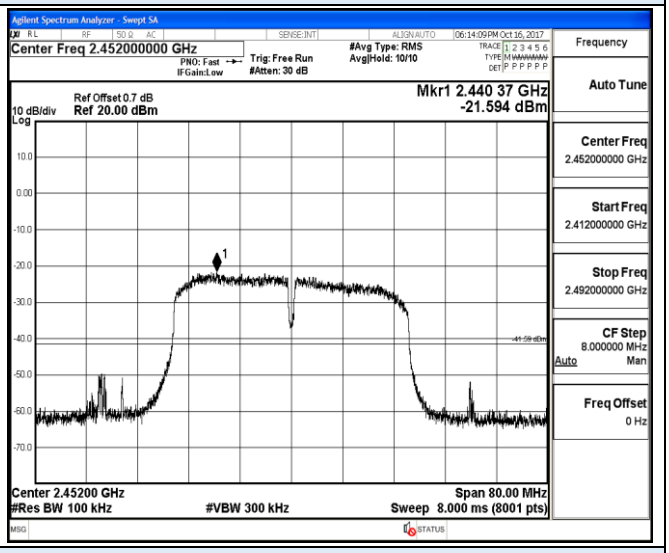
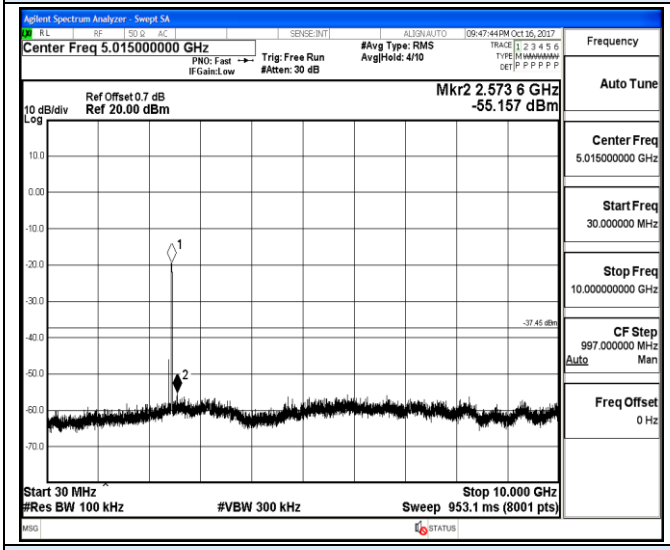
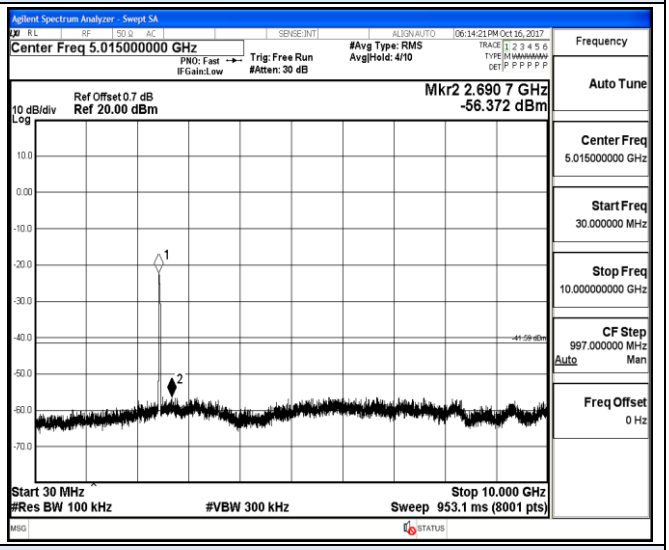
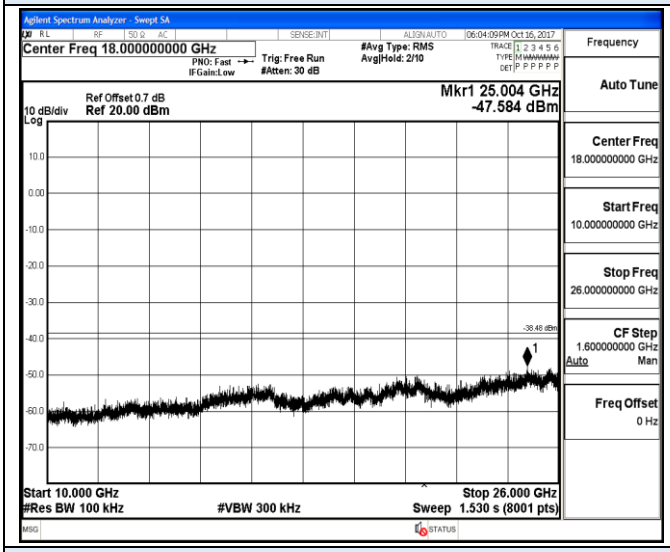
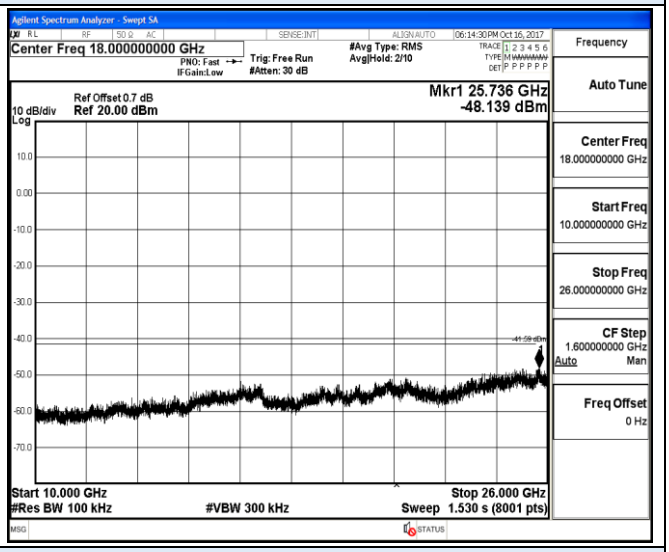
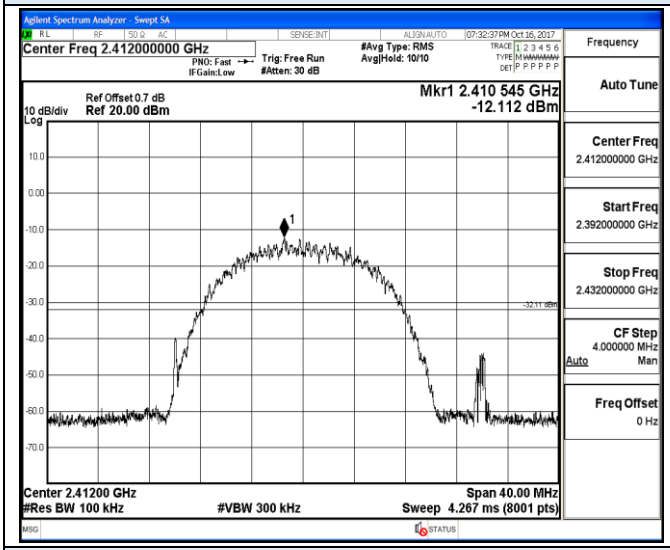
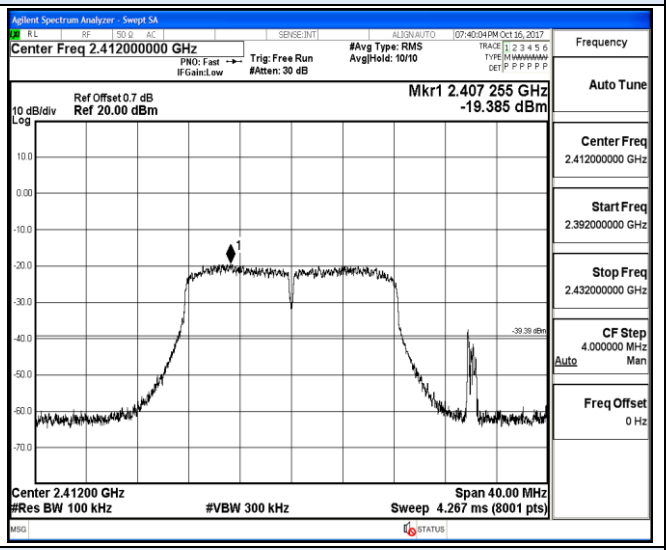
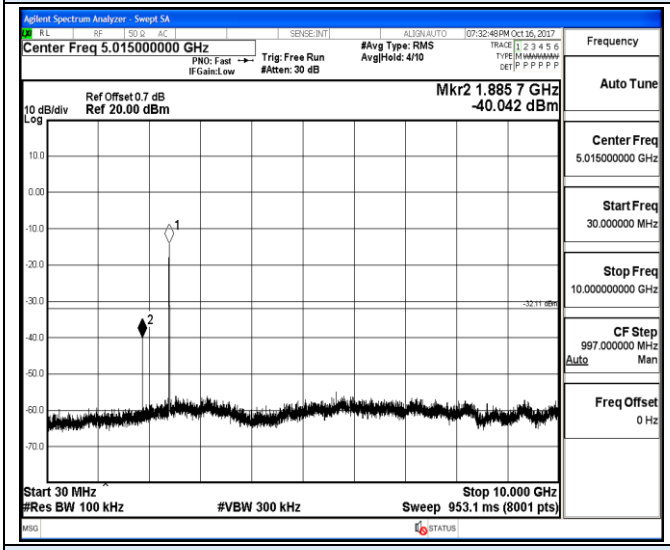
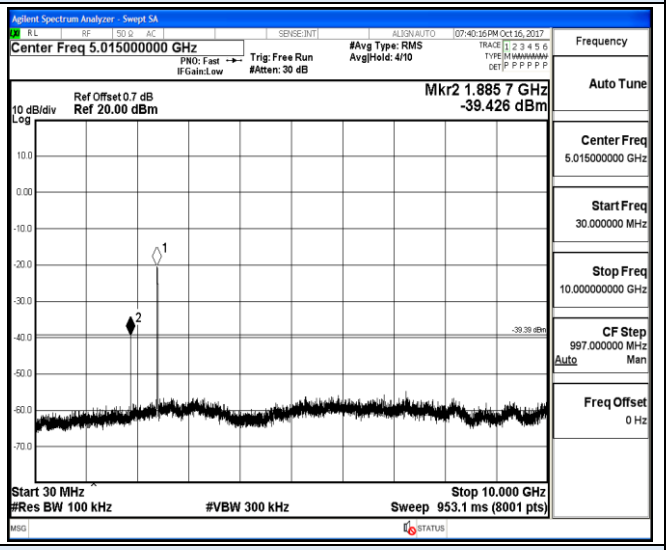
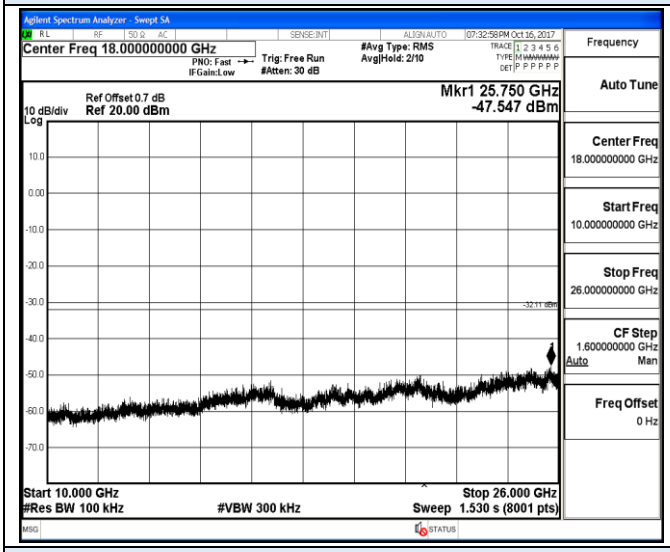
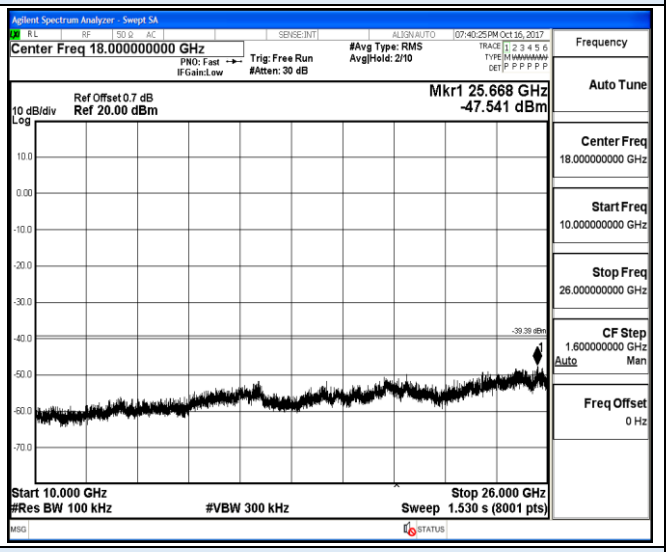
RF Conducted Spurious Emissions	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
2417 MHz – 2457 MHz	2417 MHz – 2457 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

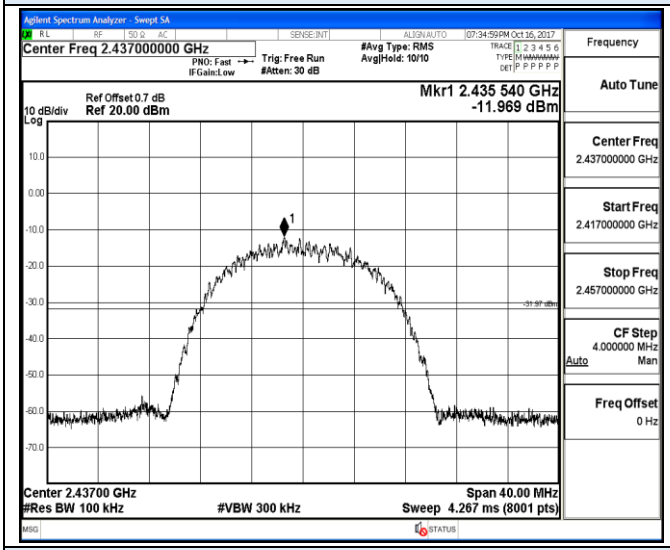
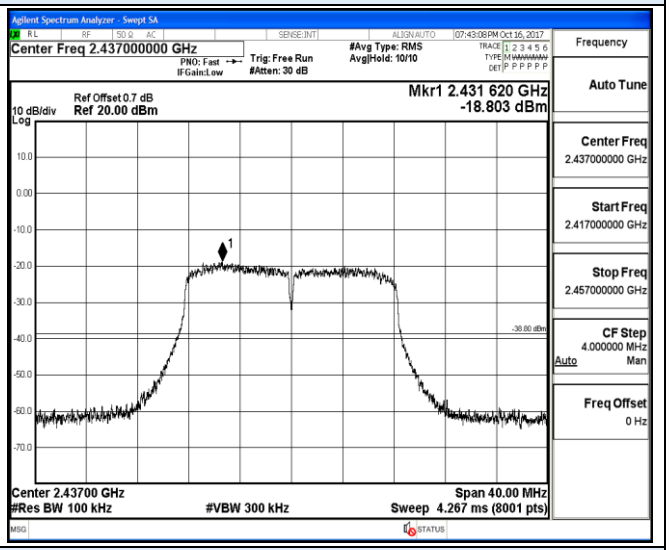
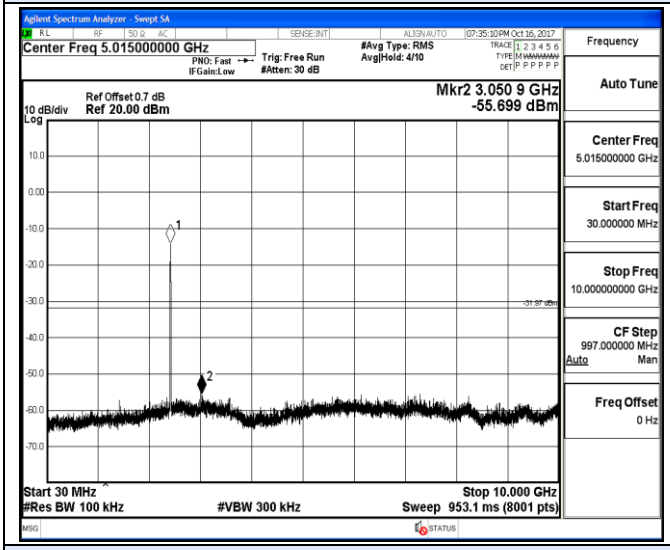
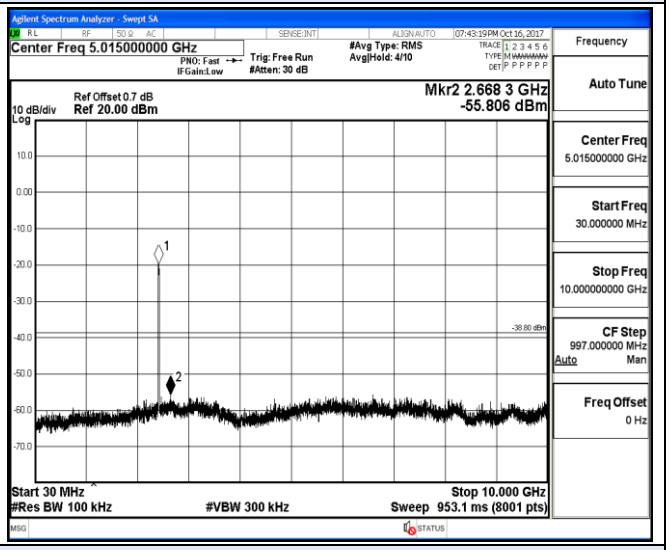
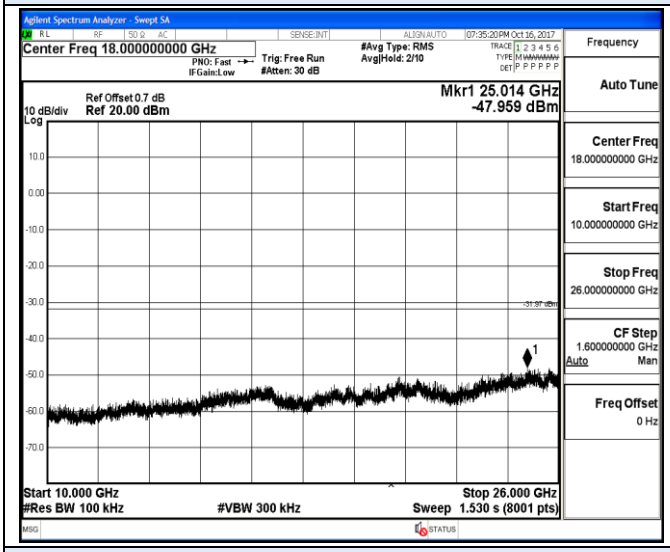
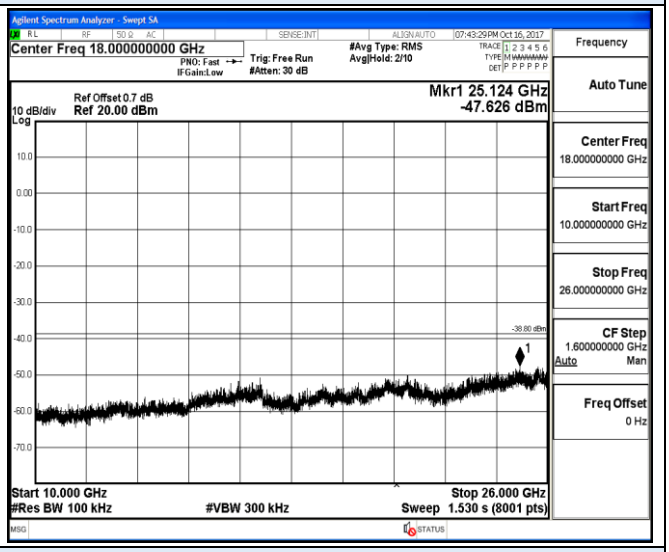
RF Conducted Spurious Emissions	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz
	
2442 MHz – 2482 MHz	2442 MHz – 2482 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
2392 MHz – 2432 MHz	2382 MHz – 2462 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
2417 MHz – 2457 MHz	2397 MHz – 2477 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz
	
2442 MHz – 2482 MHz	2412 MHz – 2492 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
2392 MHz – 2432 MHz	2392 MHz – 2432 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
2417 MHz – 2457 MHz	2417 MHz – 2457 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

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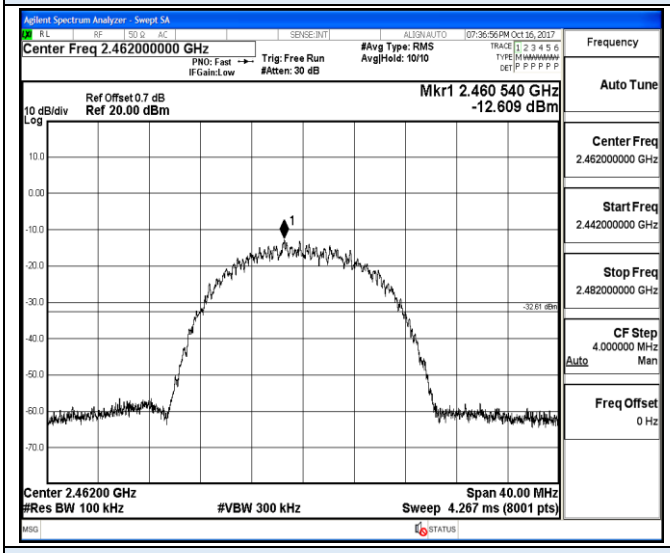
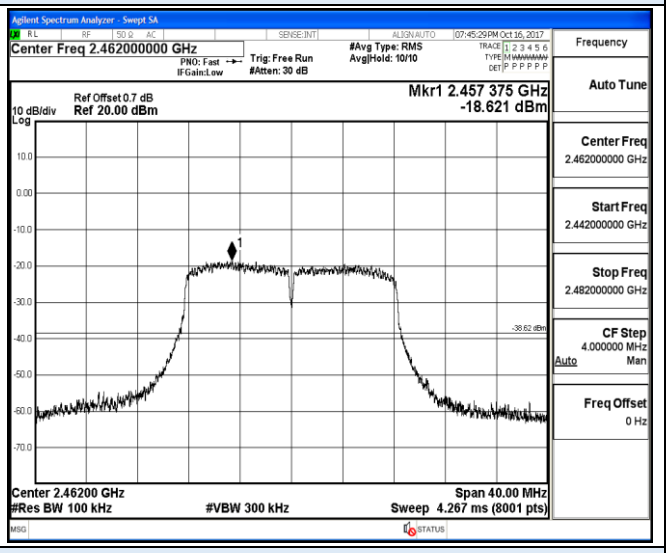
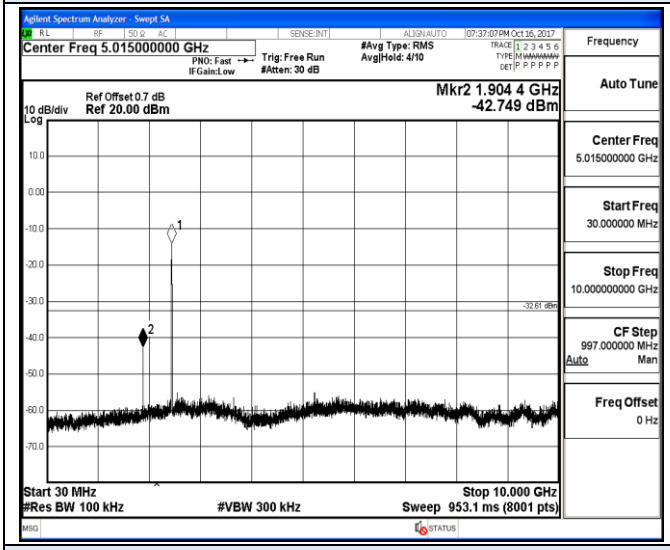
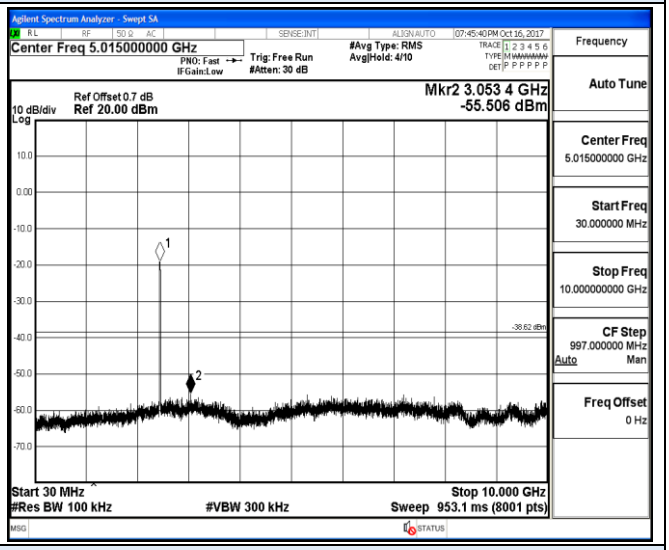
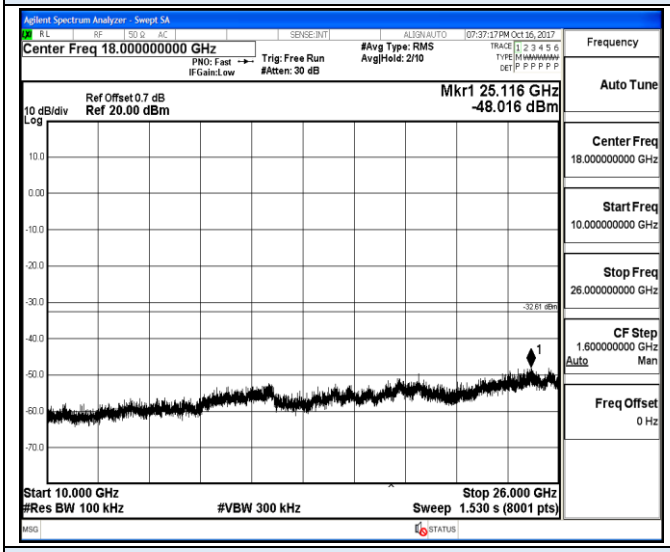
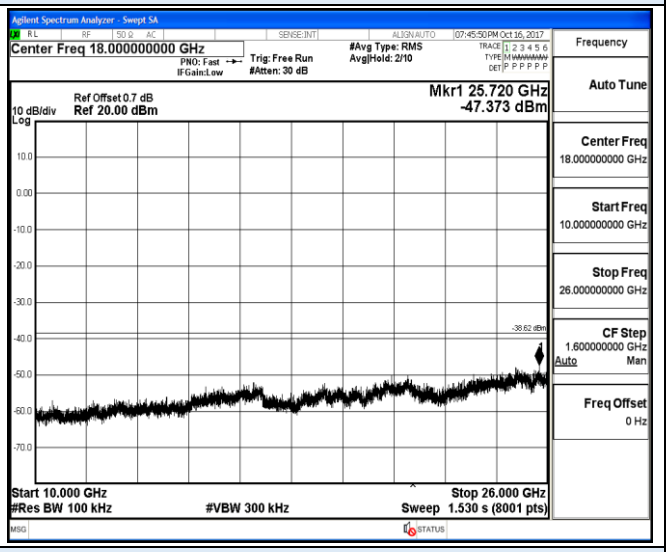
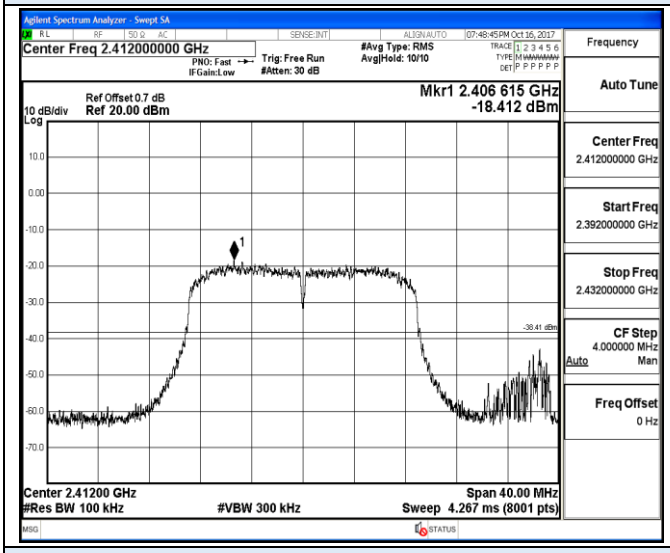
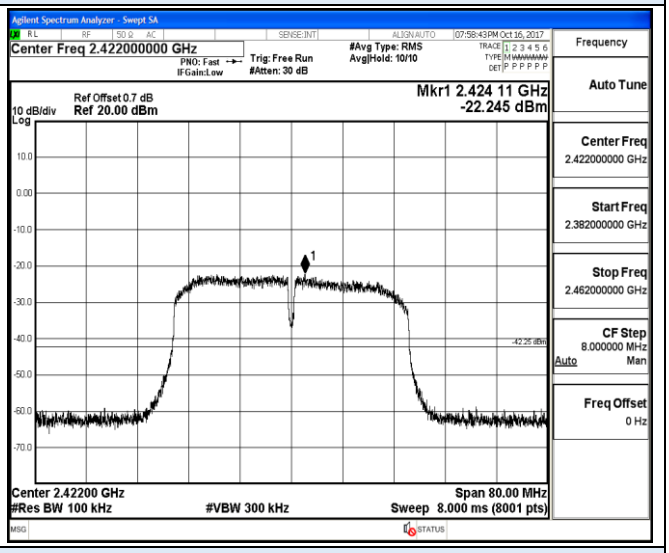
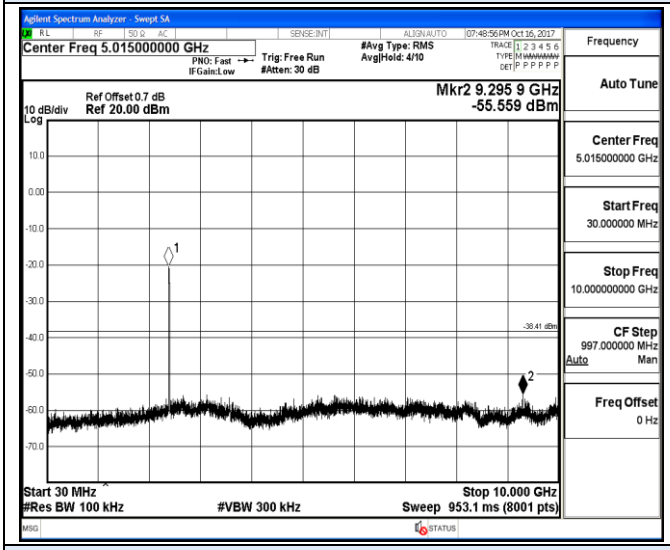
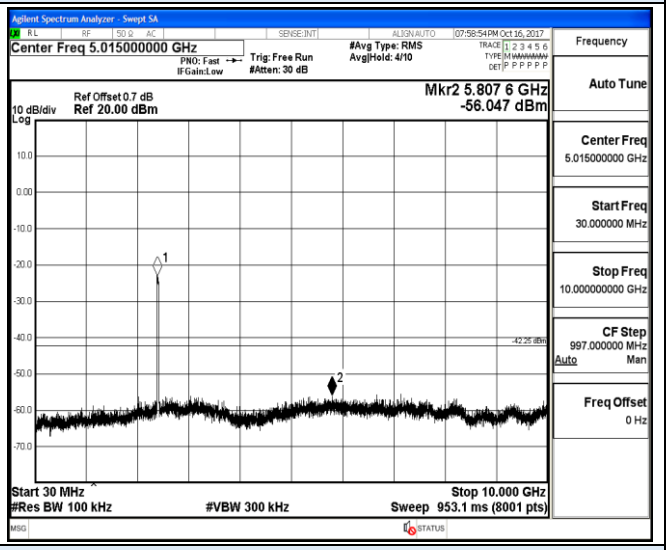
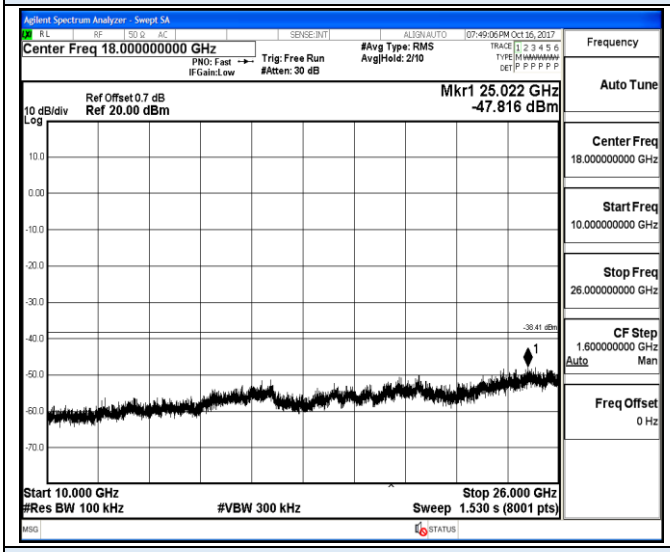
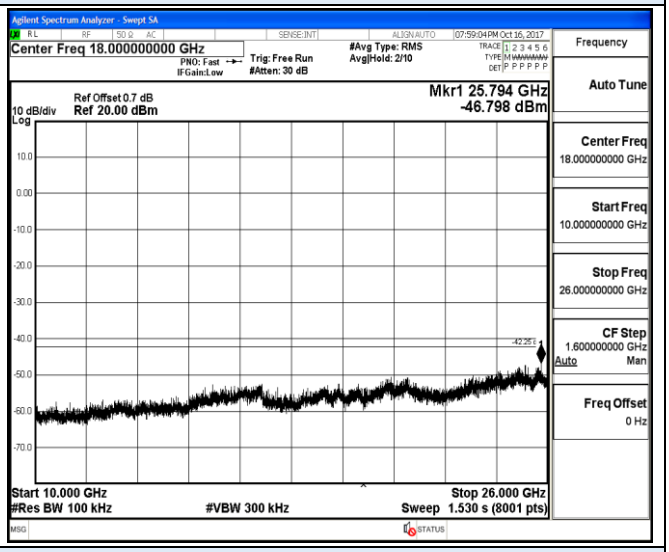
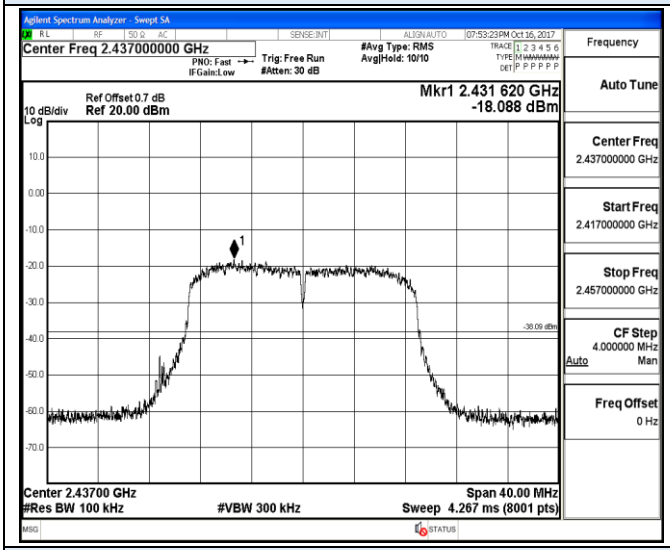
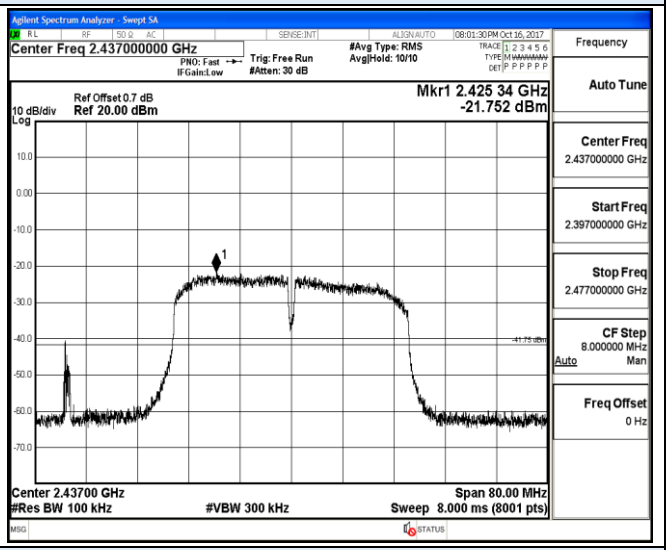
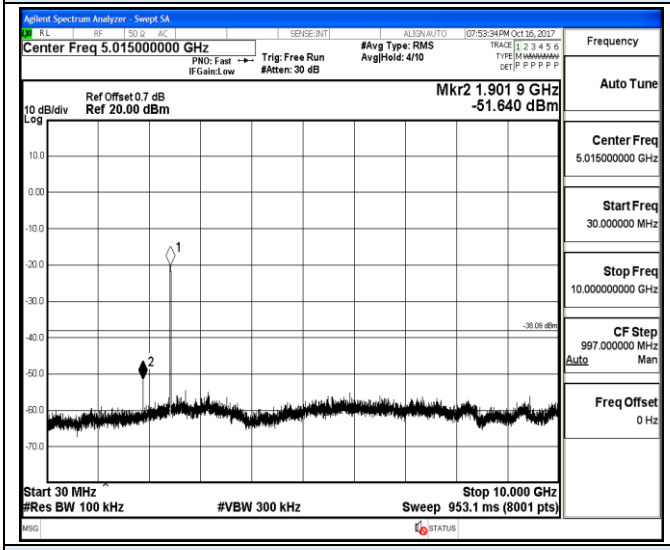
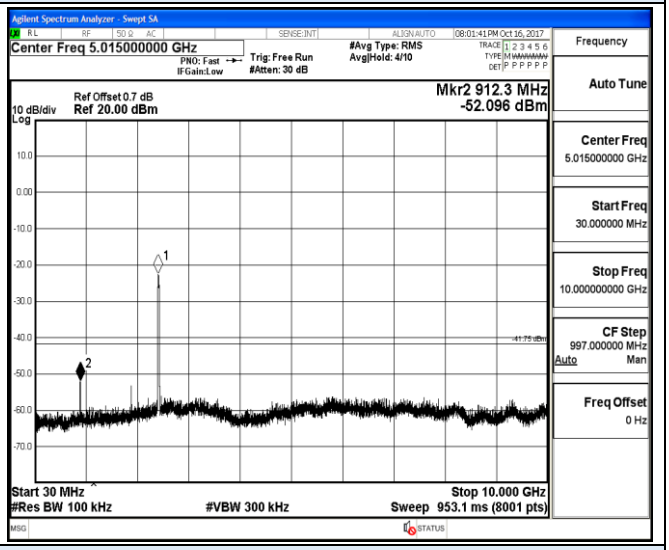
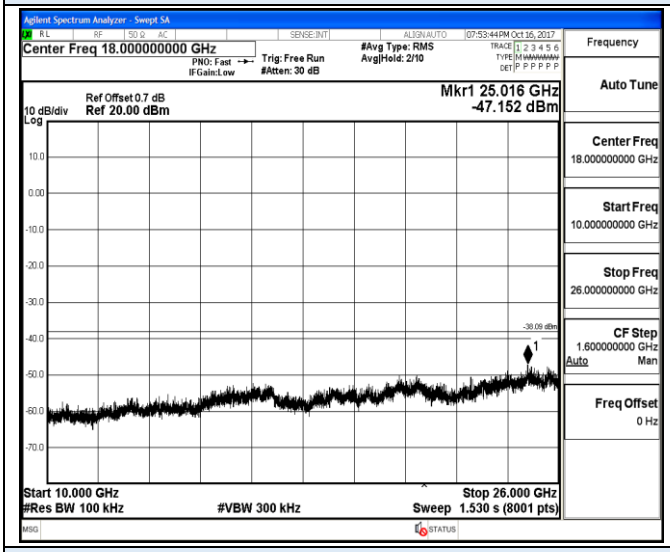
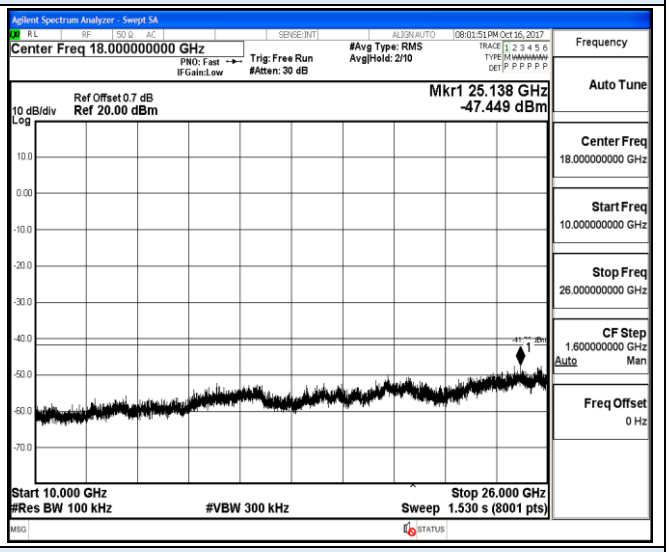
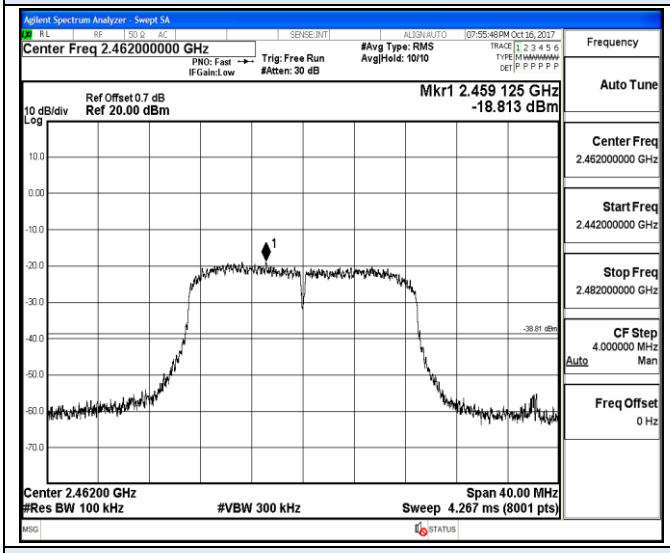
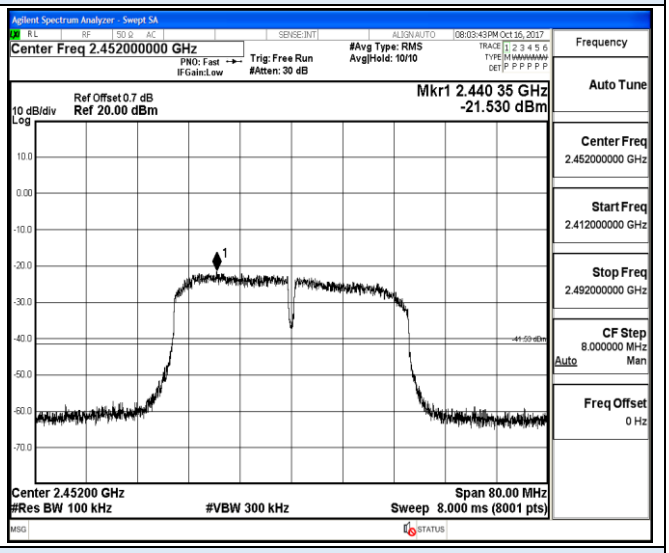
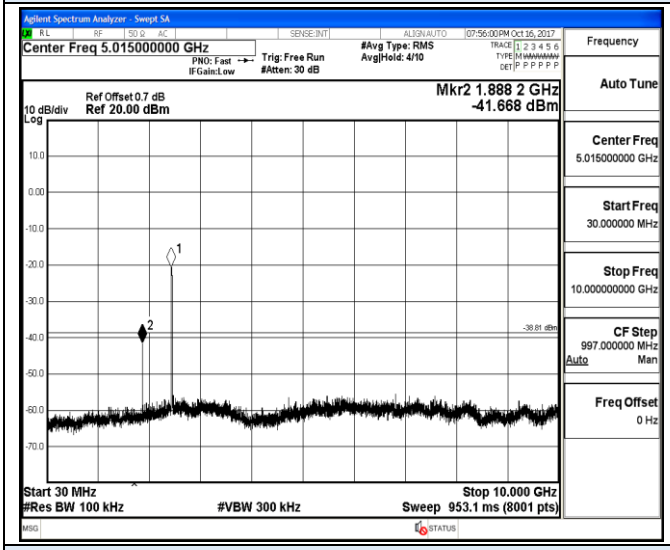
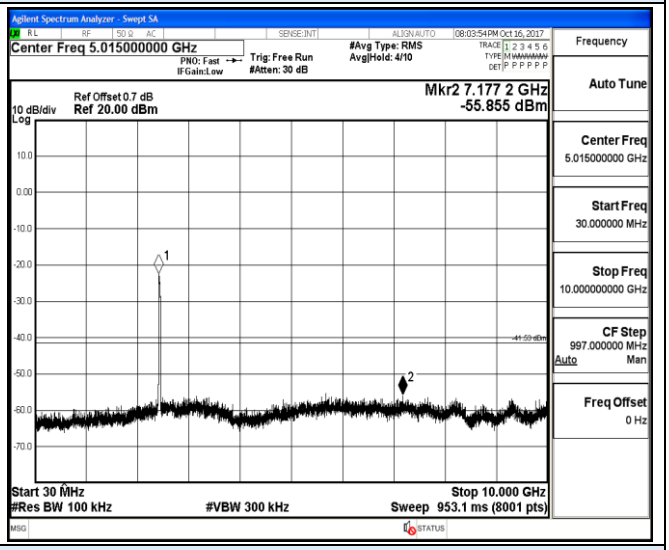
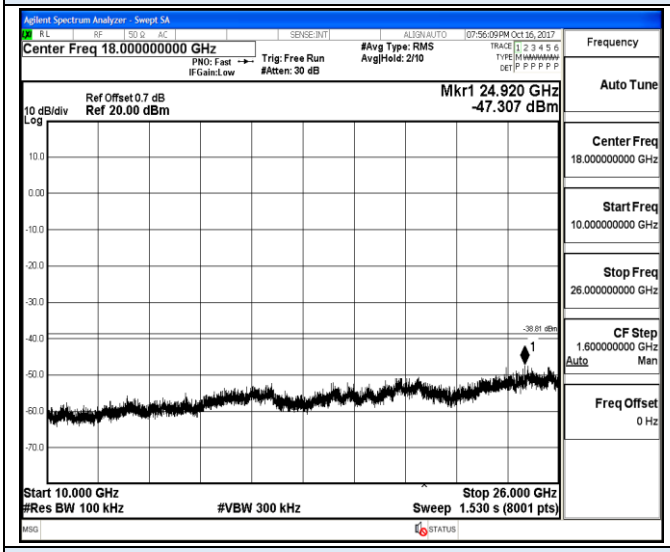
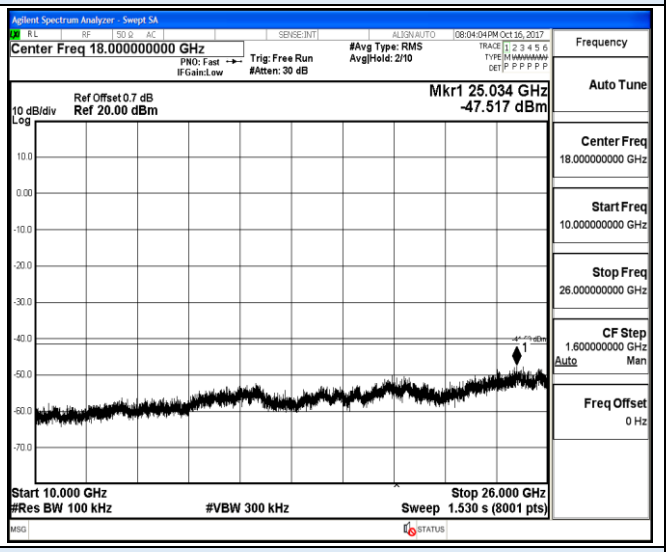
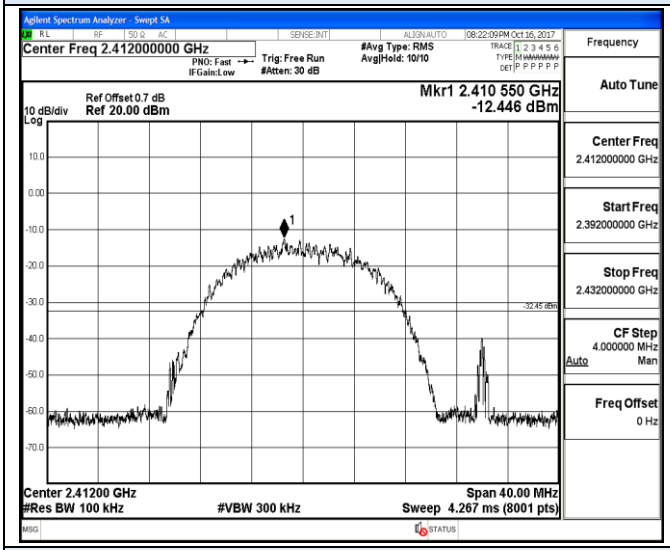
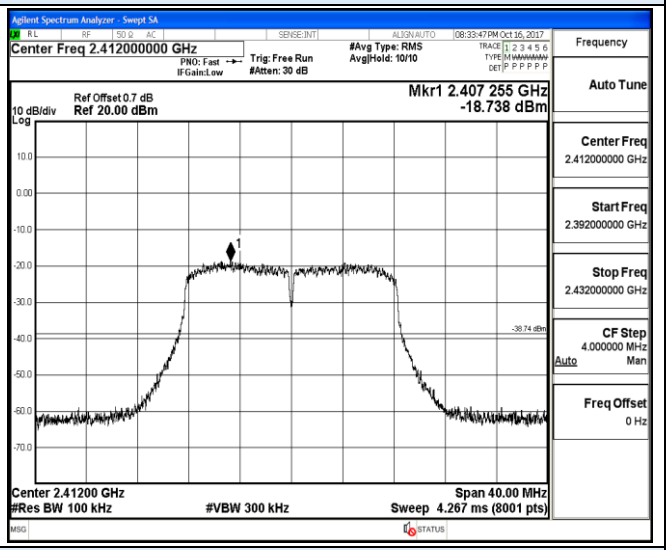
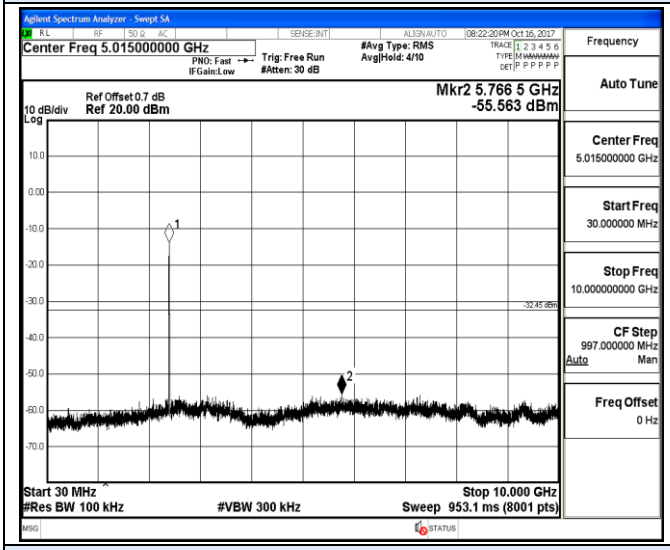
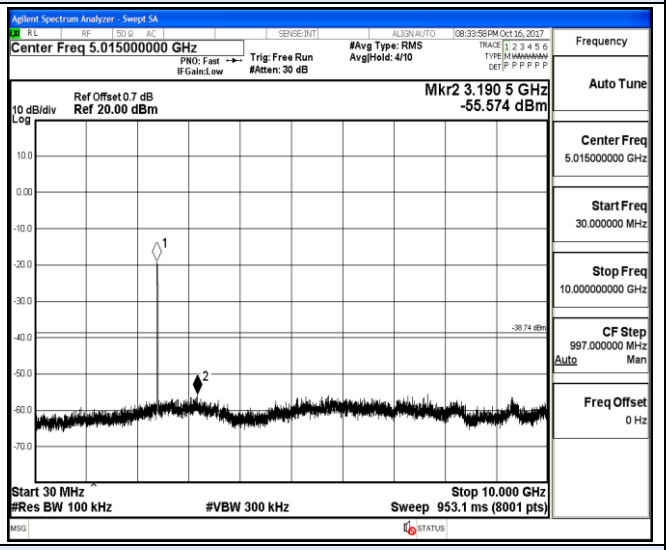
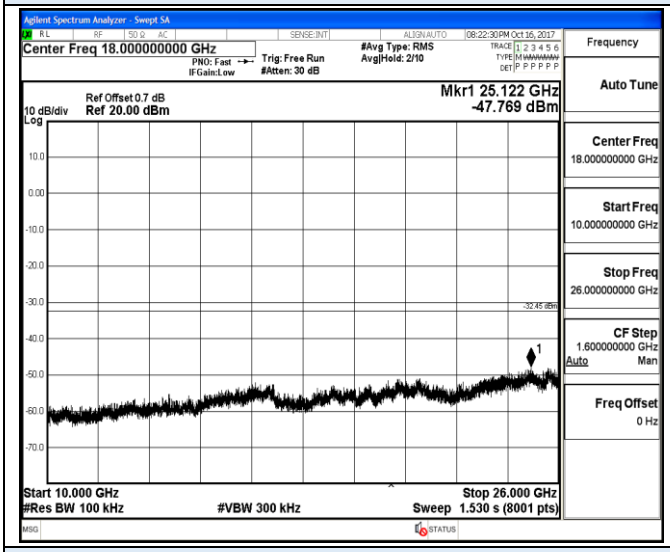
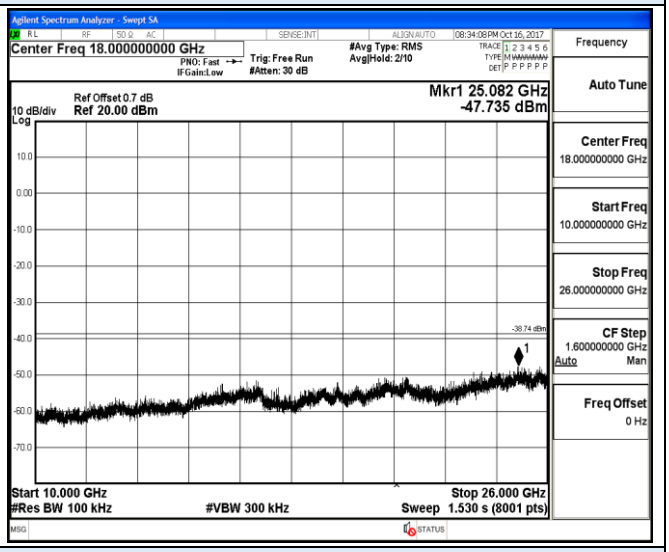
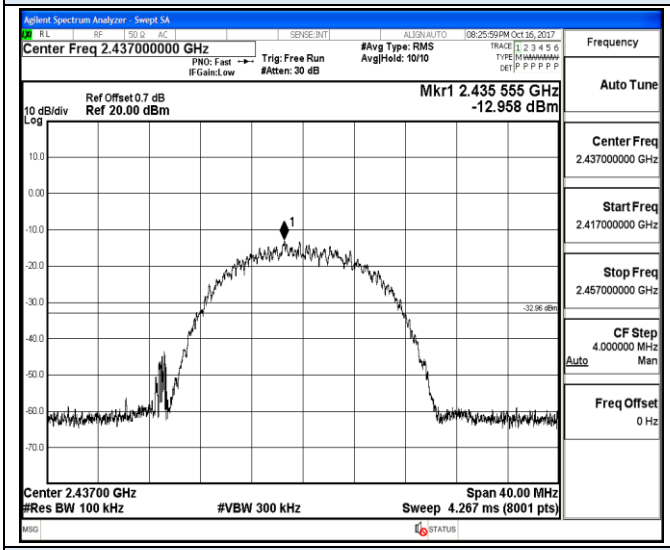
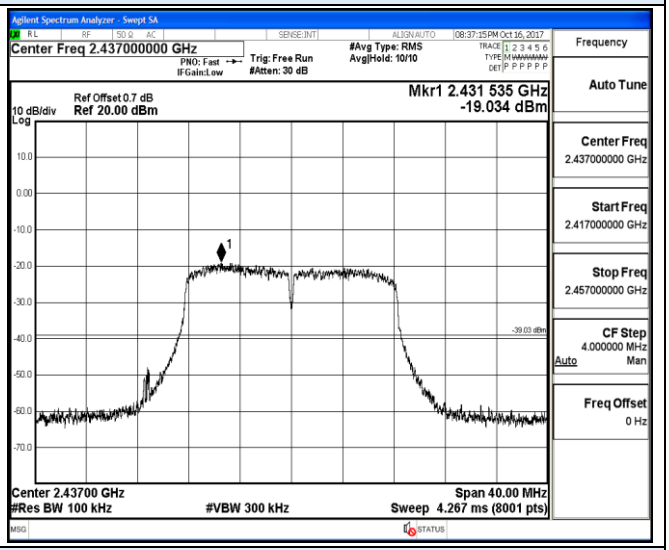
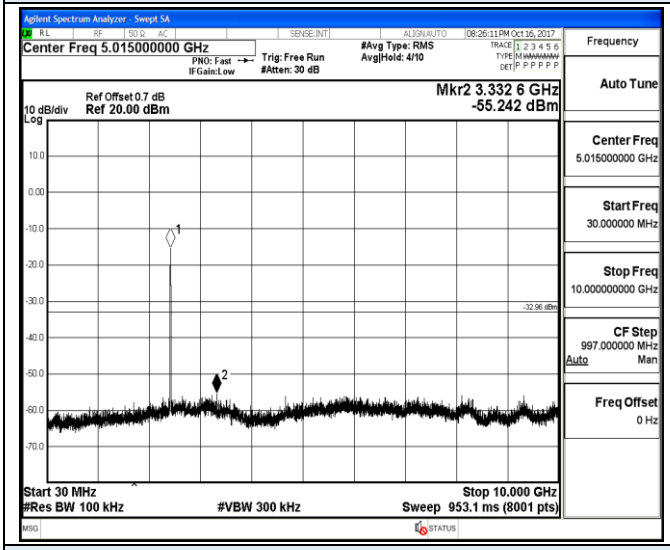
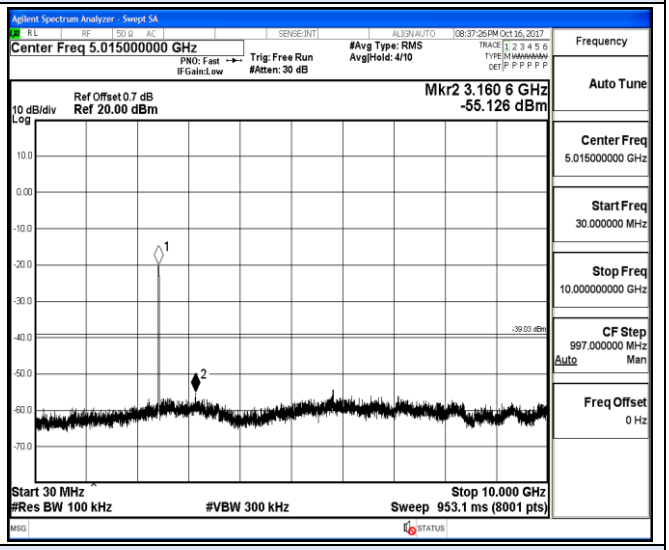
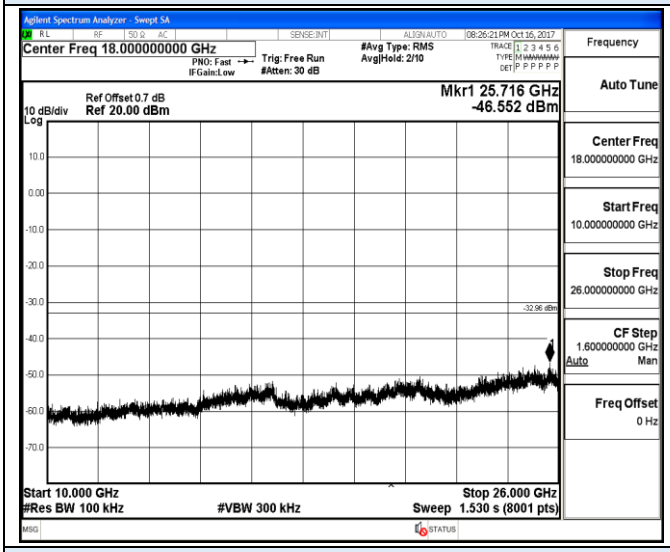
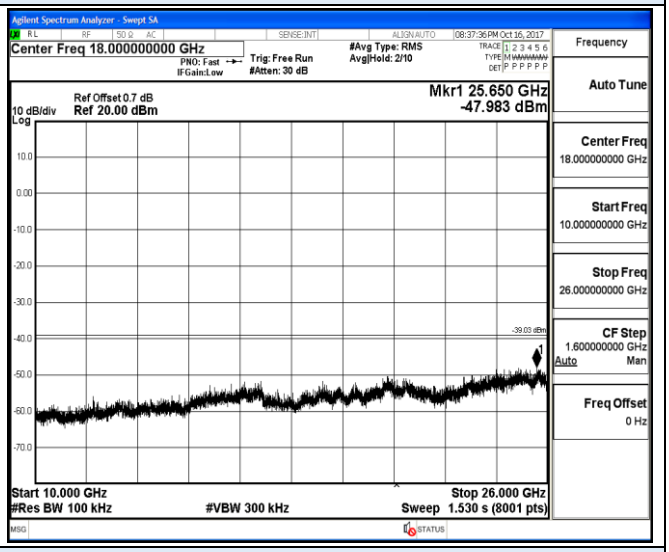
RF Conducted Spurious Emissions	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz
	
2442 MHz – 2482 MHz	2442 MHz – 2482 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

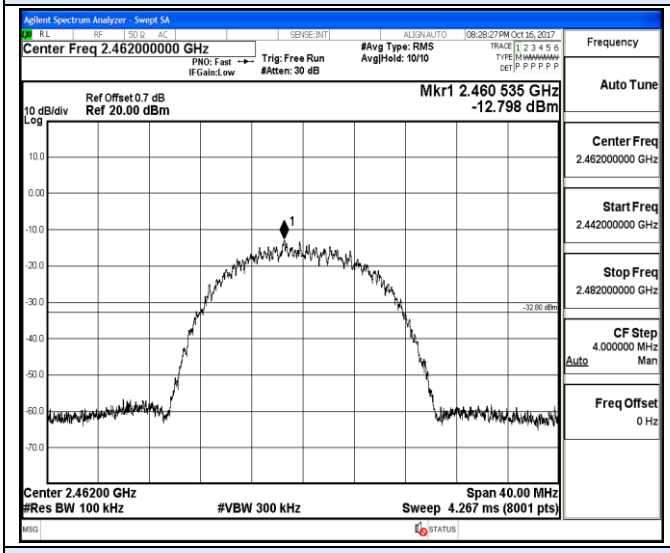
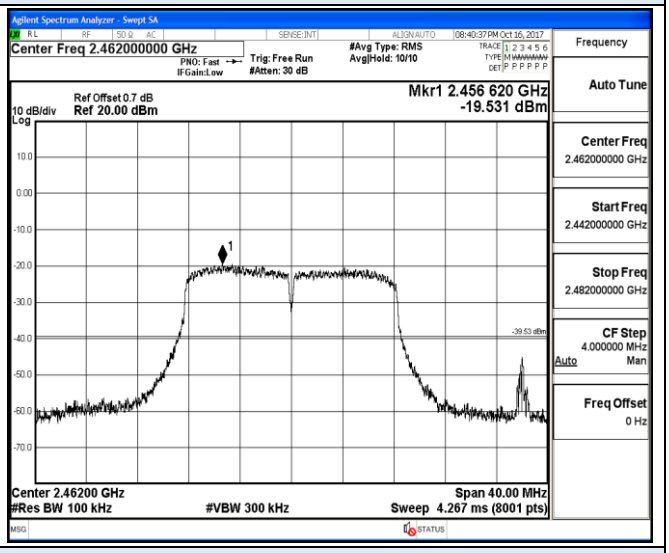
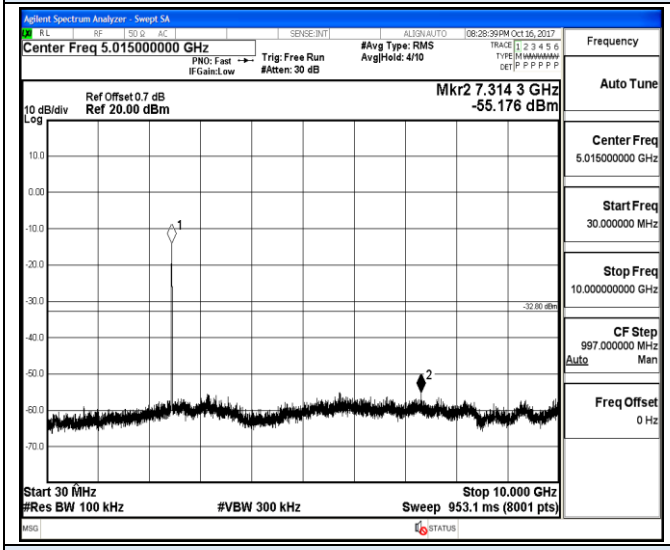
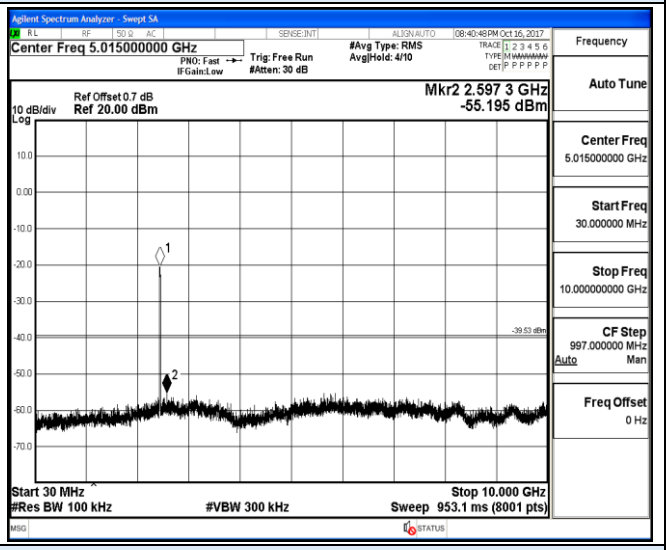
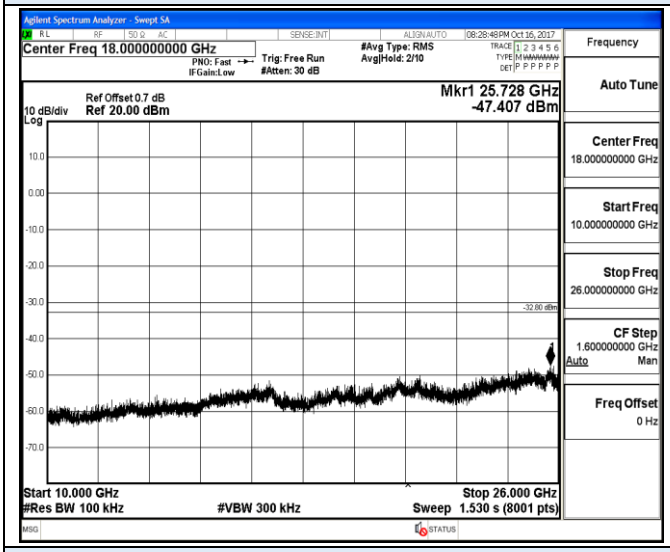
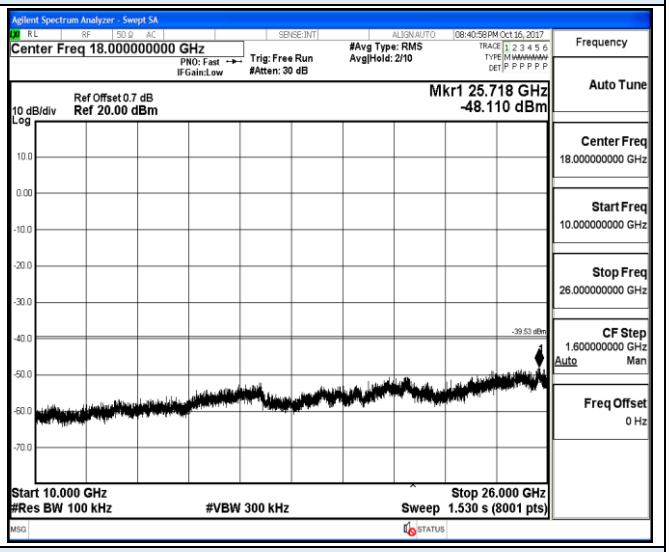
RF Conducted Spurious Emissions	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
2392 MHz – 2432 MHz	2382 MHz – 2462 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

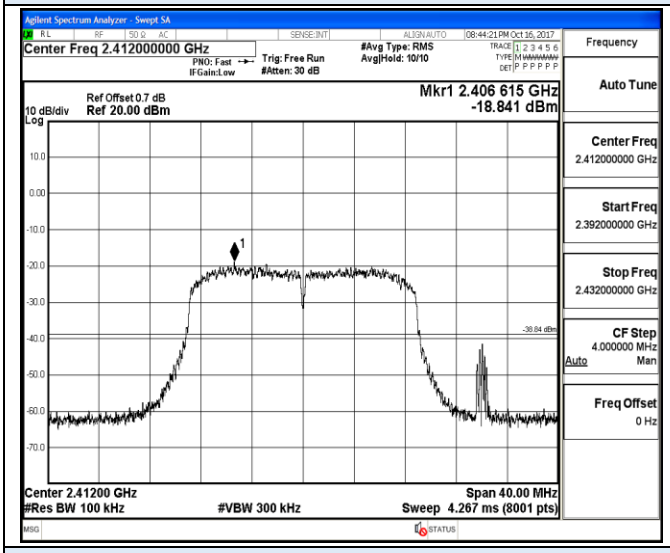
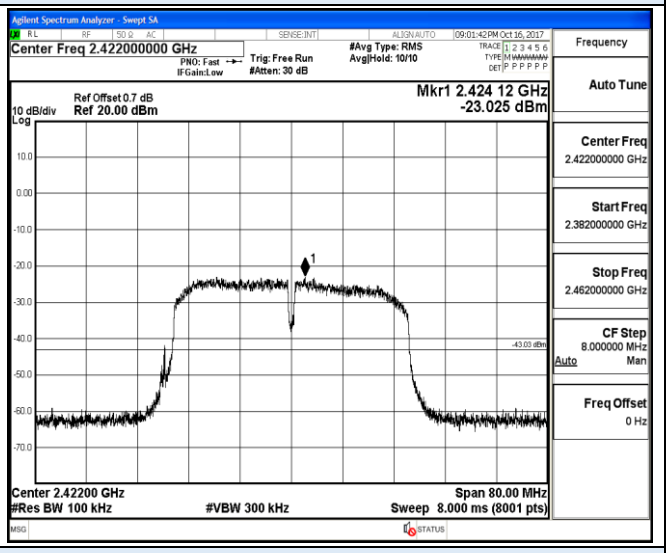
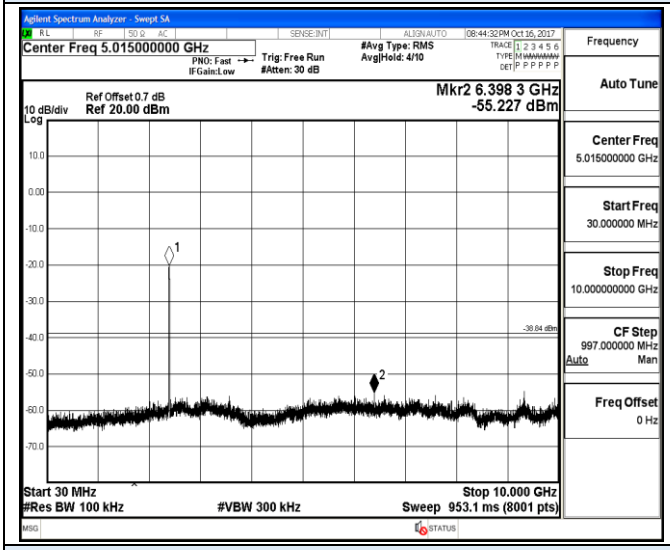
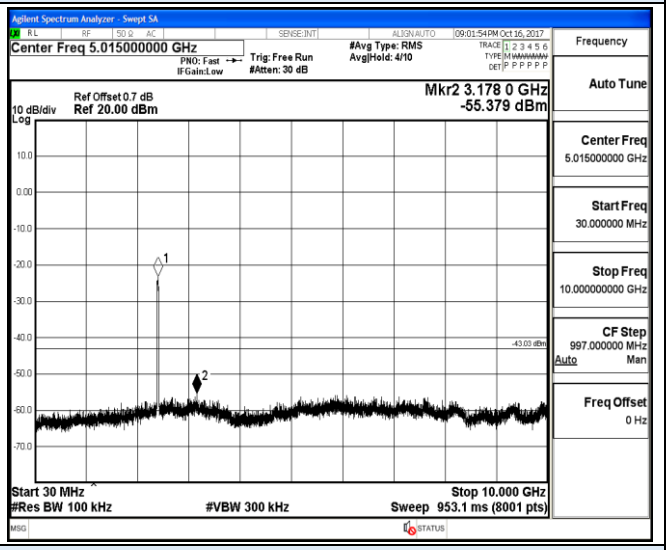
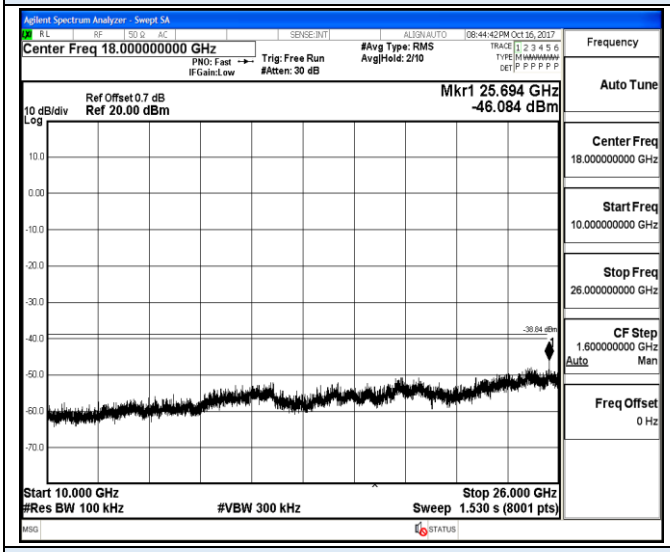
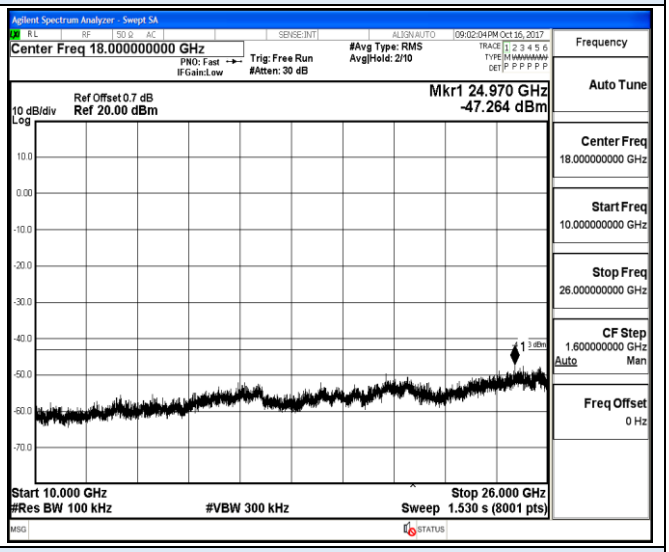
RF Conducted Spurious Emissions	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
2417 MHz – 2457 MHz	2397 MHz – 2477 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

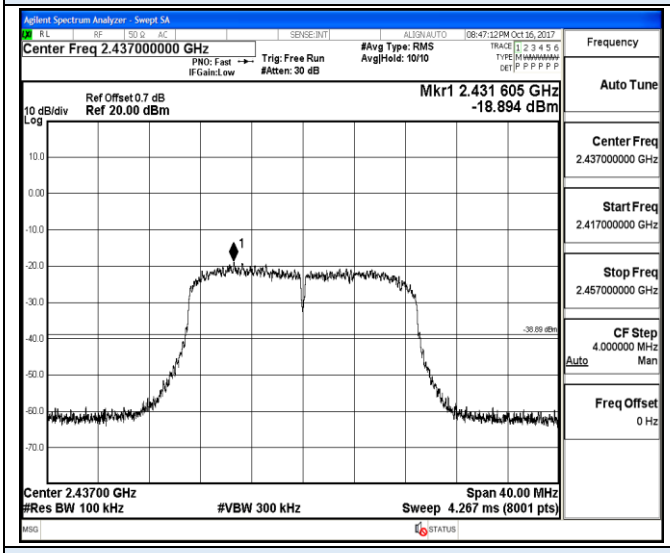
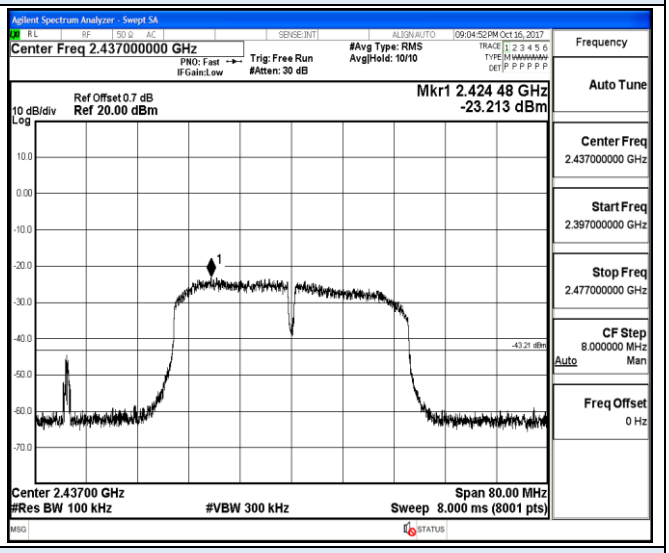
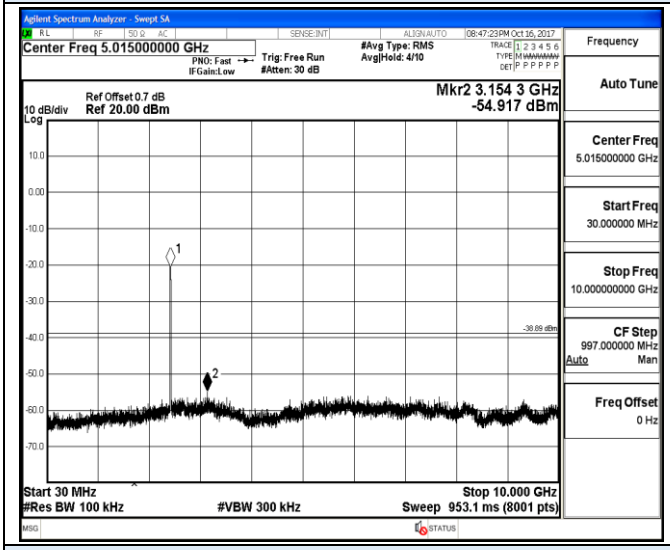
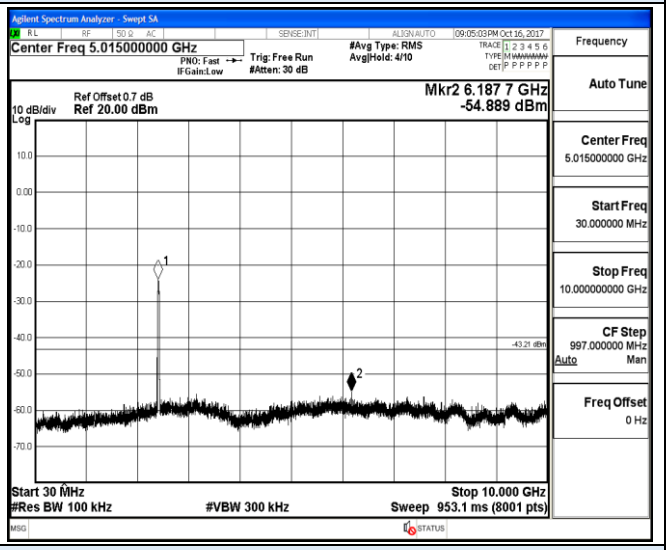
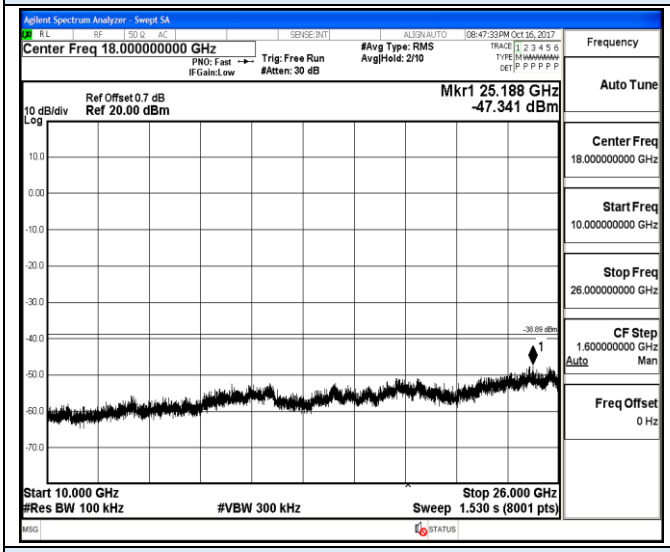
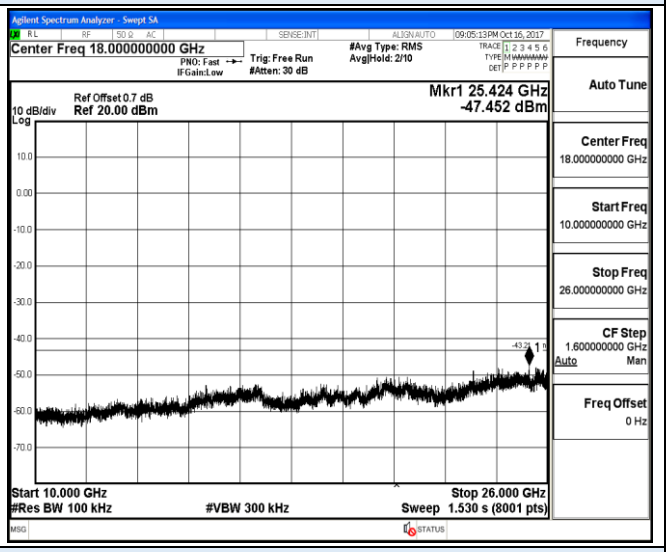
RF Conducted Spurious Emissions	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz
	
2442 MHz – 2482 MHz	2412 MHz – 2492 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

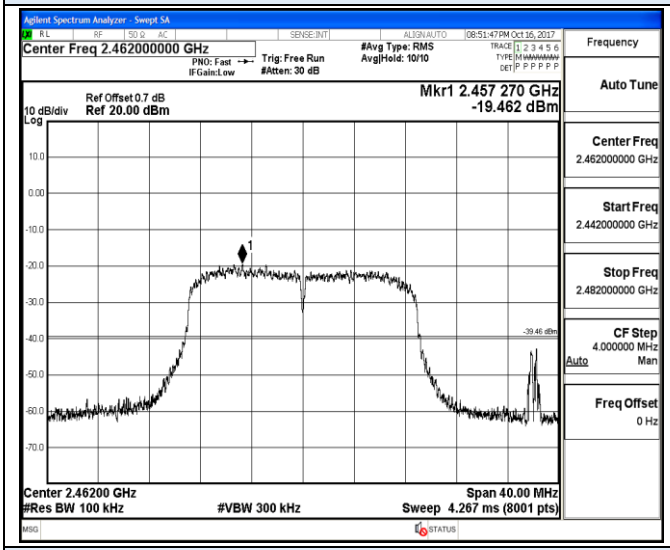
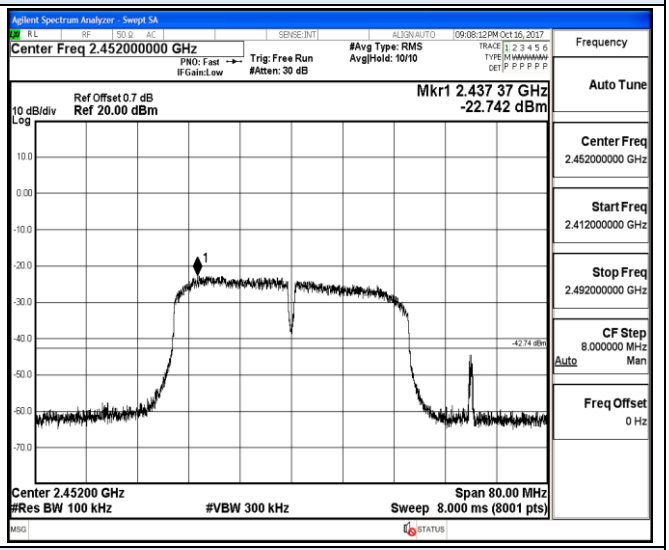
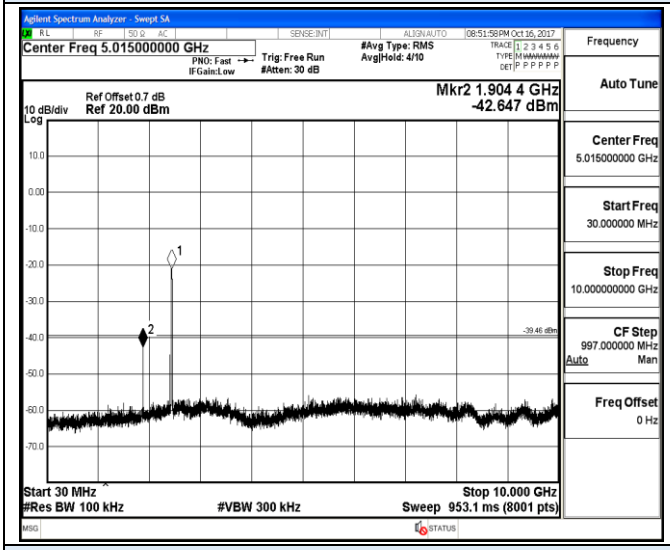
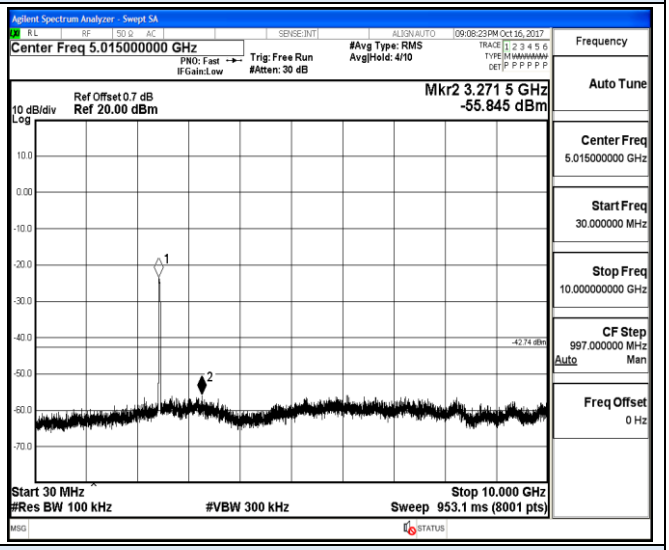
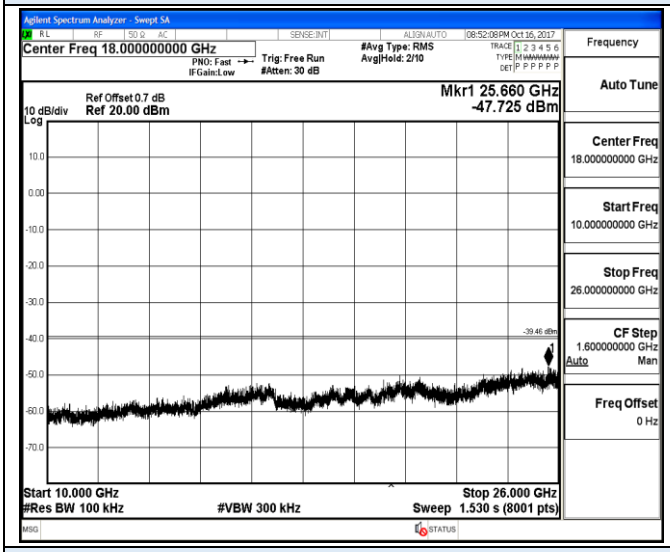
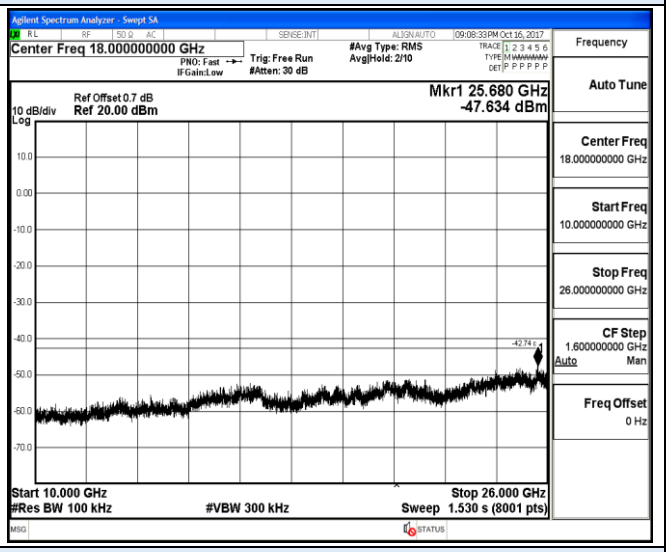
RF Conducted Spurious Emissions	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
2392 MHz – 2432 MHz	2392 MHz – 2432 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
2417 MHz – 2457 MHz	2417 MHz – 2457 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz
	
2442 MHz – 2482 MHz	2442 MHz – 2482 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz
	
2392 MHz – 2432 MHz	2382 MHz – 2462 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

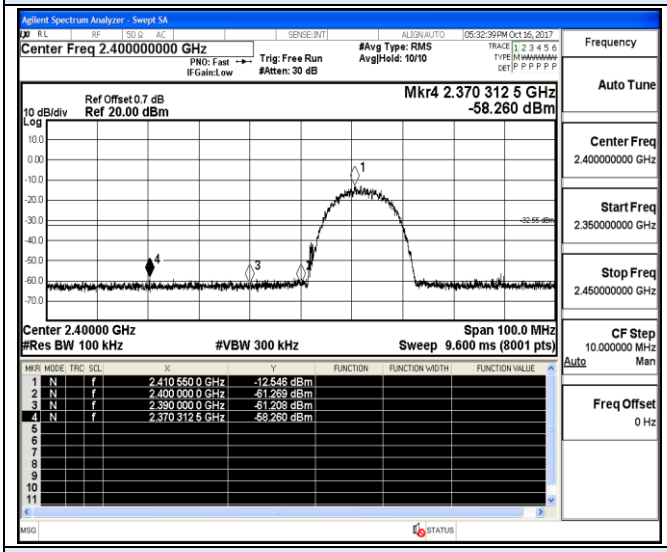
RF Conducted Spurious Emissions	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 6 / 2437 MHz	Channel 6 / 2437 MHz
	
2417 MHz – 2457 MHz	2397 MHz – 2477 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

RF Conducted Spurious Emissions	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
Channel 11 / 2462 MHz	Channel 9 / 2452 MHz
	
2442 MHz – 2482 MHz	2412 MHz – 2492 MHz
	
30 MHz – 10 GHz	30 MHz – 10 GHz
	
10 GHz – 26 GHz	10 GHz – 26 GHz

Band-edge Measurements for Conducted Emissions

Antenna 0

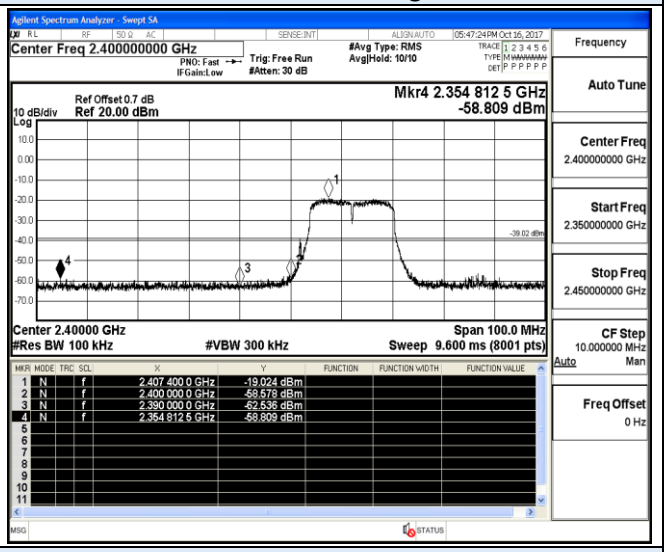
IEEE 802.11b



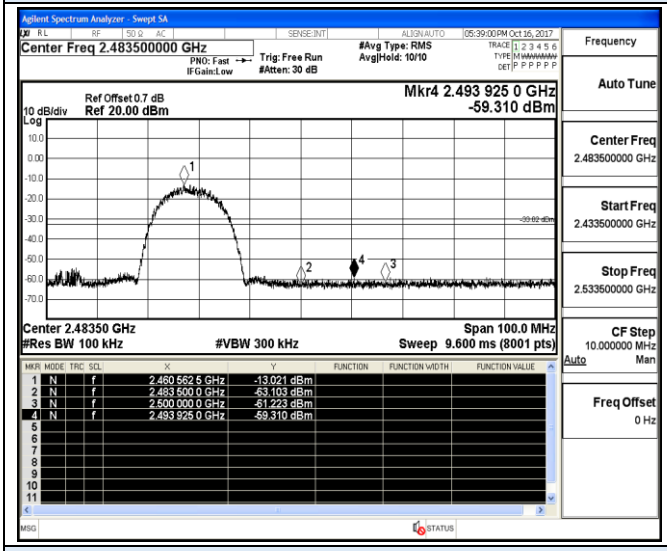
Channel 1 / 2412 MHz

Antenna 0

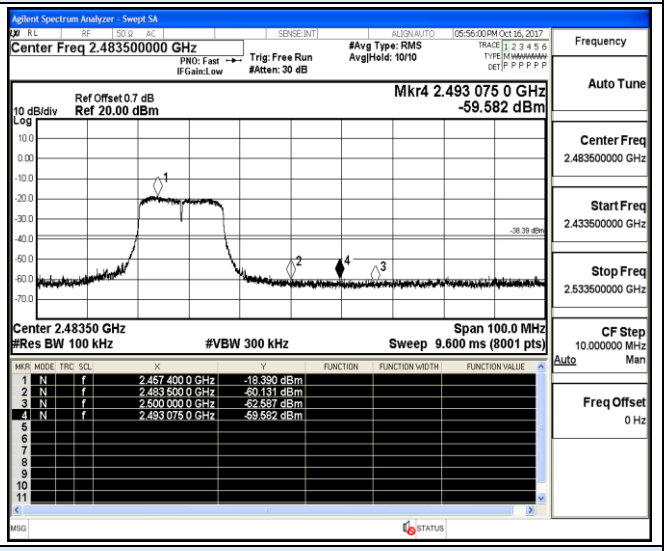
IEEE 802.11g



Channel 1 / 2412 MHz

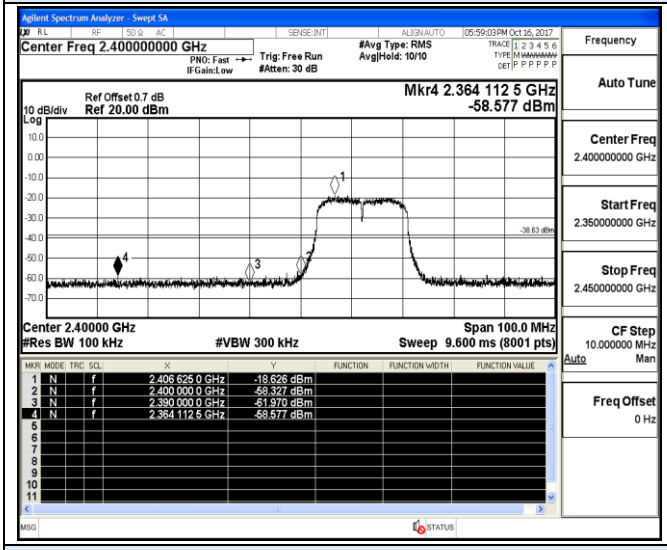


Channel 11 / 2462 MHz



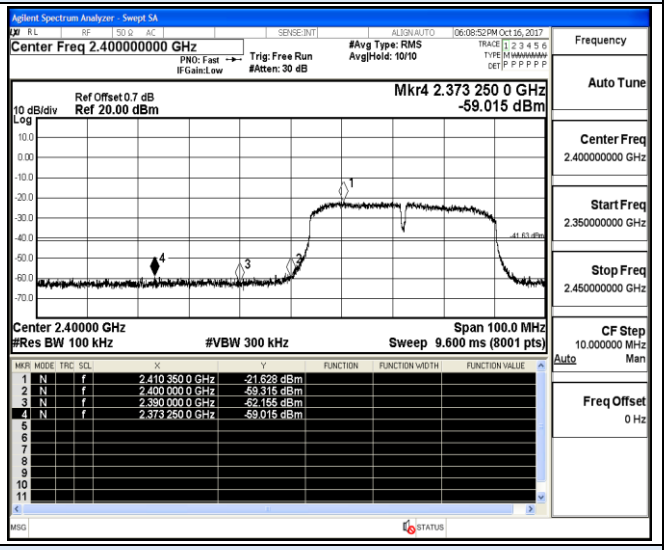
Channel 11 / 2462 MHz

IEEE 802.11n HT20

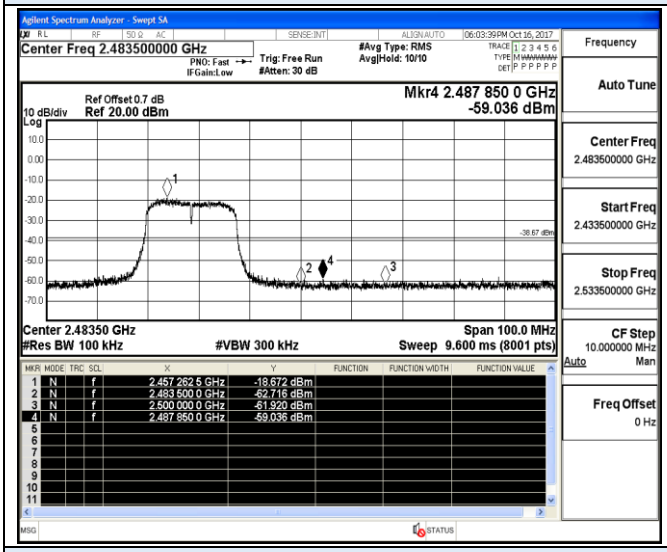
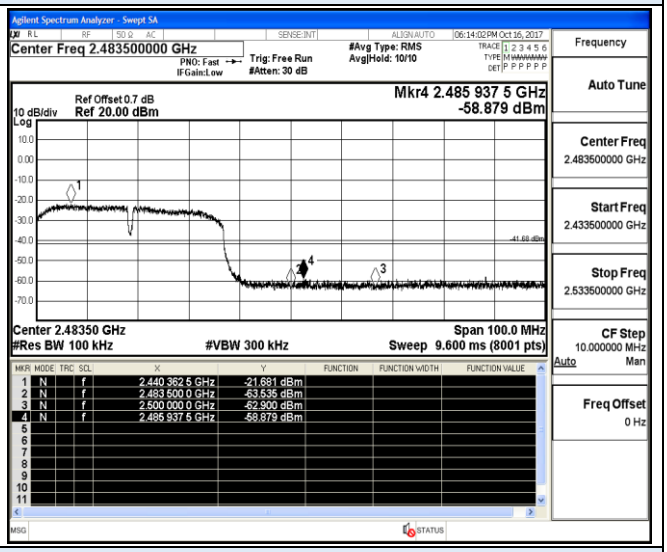


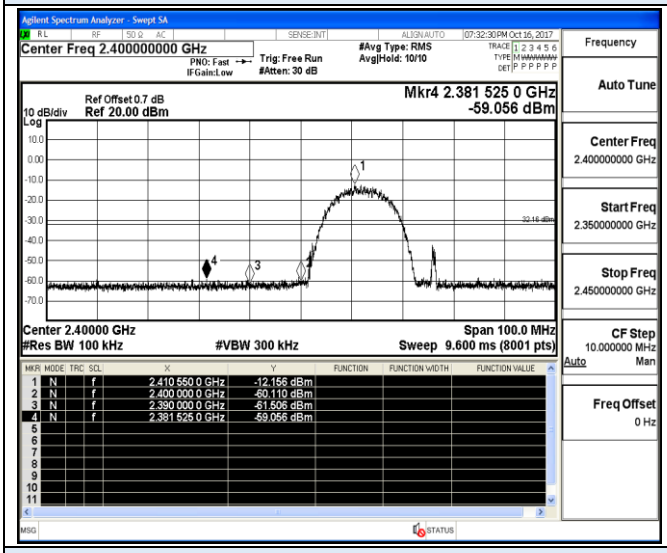
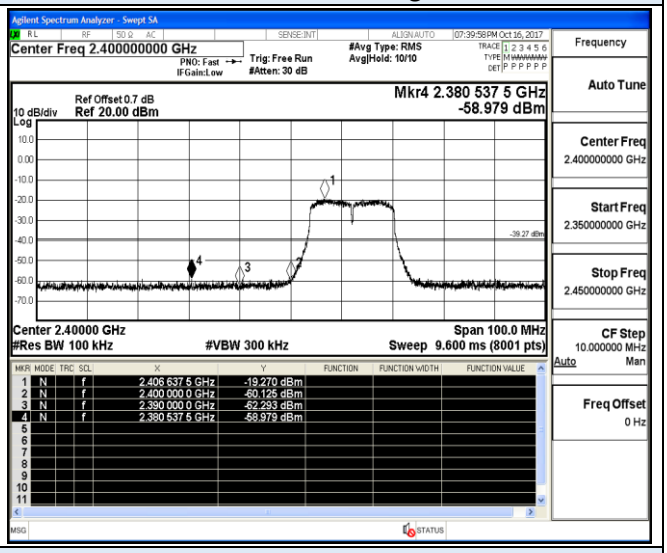
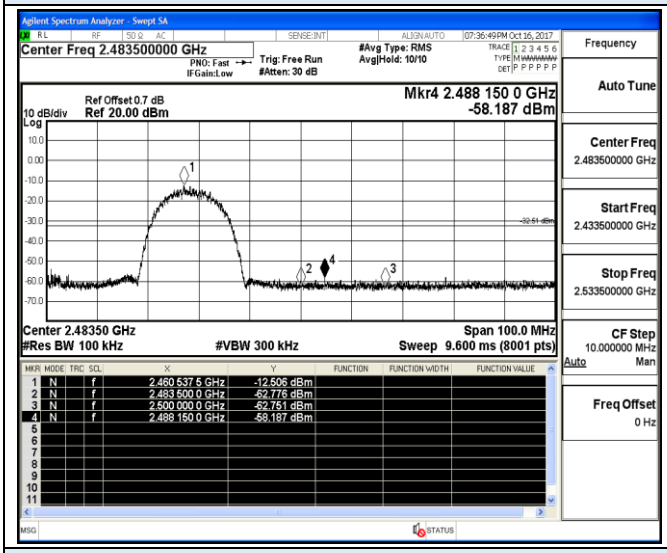
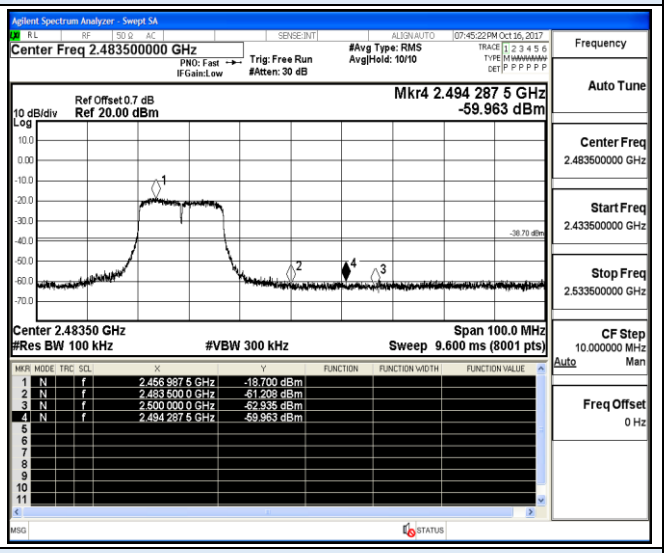
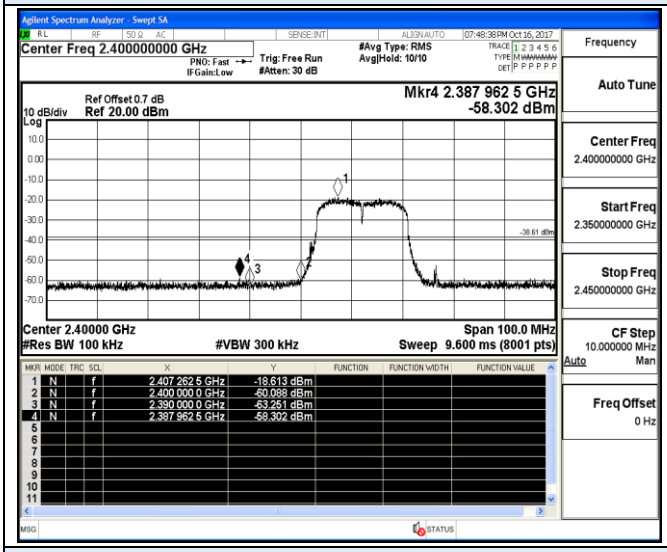
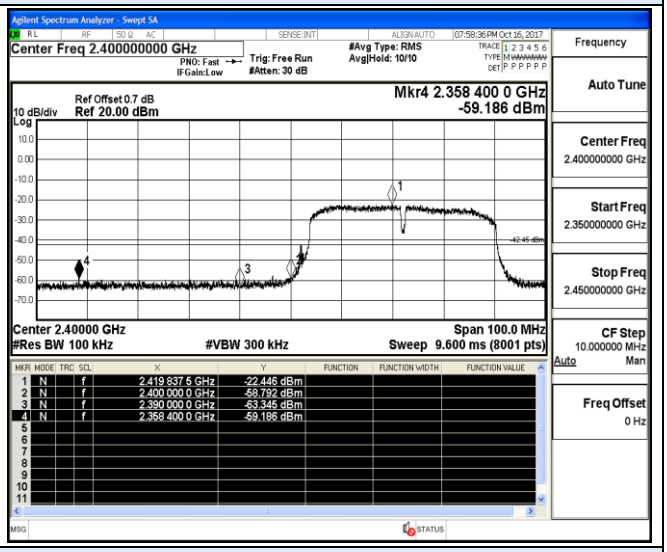
Channel 1 / 2412 MHz

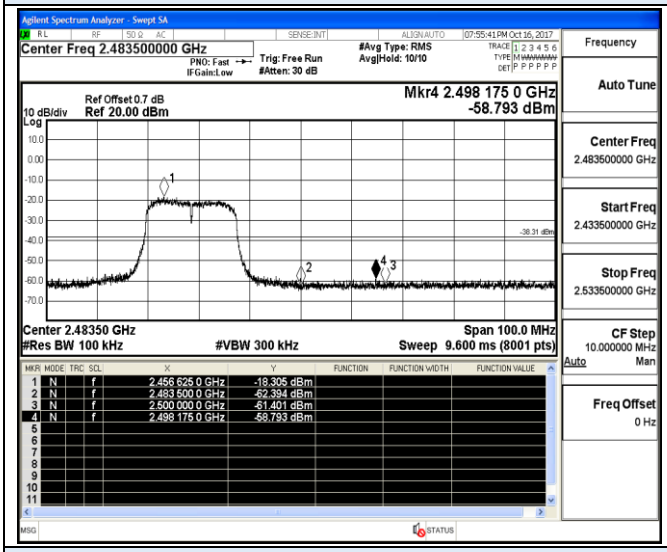
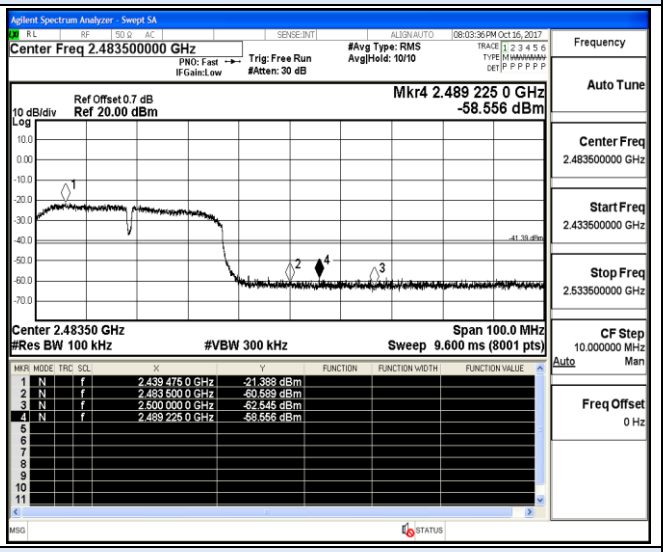
IEEE 802.11n HT40



Channel 3 / 2422 MHz

Band-edge Measurements for Conducted Emissions	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

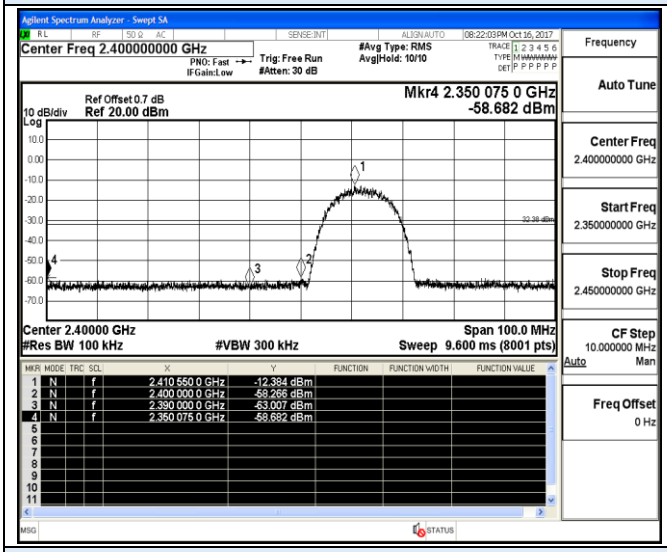
Band-edge Measurements for Conducted Emissions	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz	Channel 1 / 2412 MHz
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz	Channel 3 / 2422 MHz

Band-edge Measurements for Conducted Emissions	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

Band-edge Measurements for Conducted Emissions

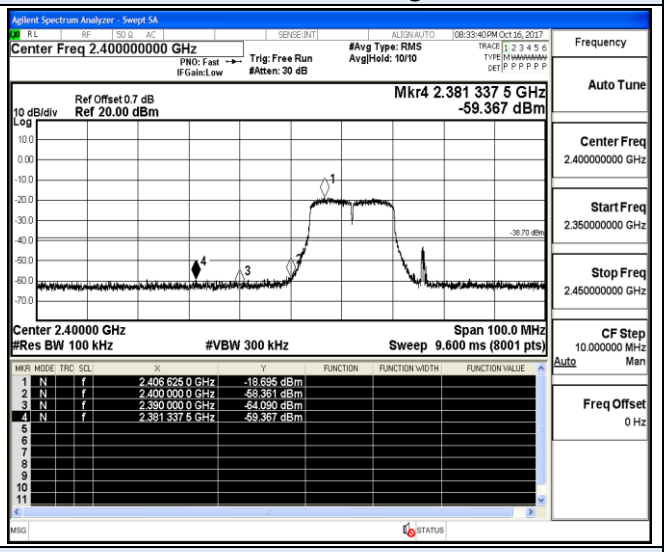
Antenna 2

IEEE 802.11b

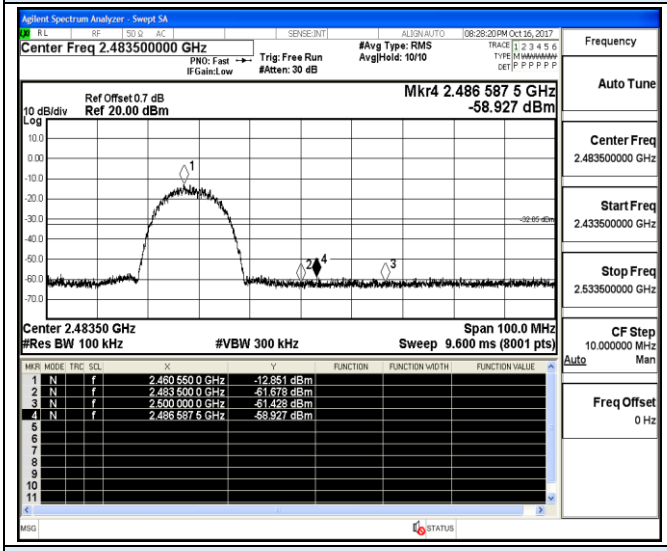


Channel 1 / 2412 MHz

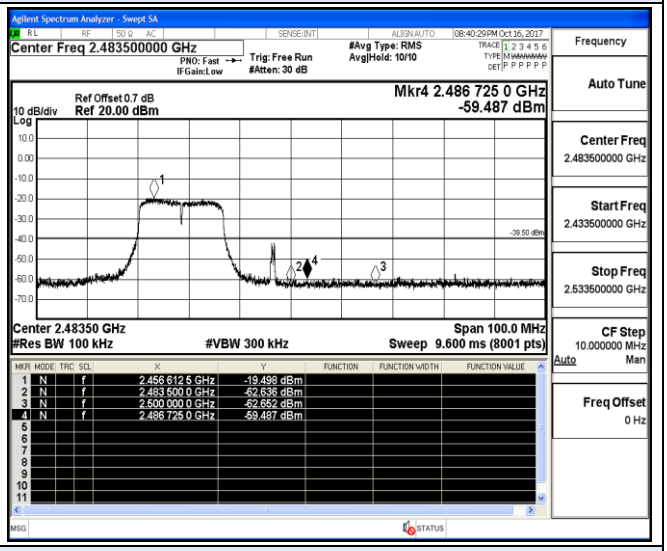
IEEE 802.11g



Channel 1 / 2412 MHz

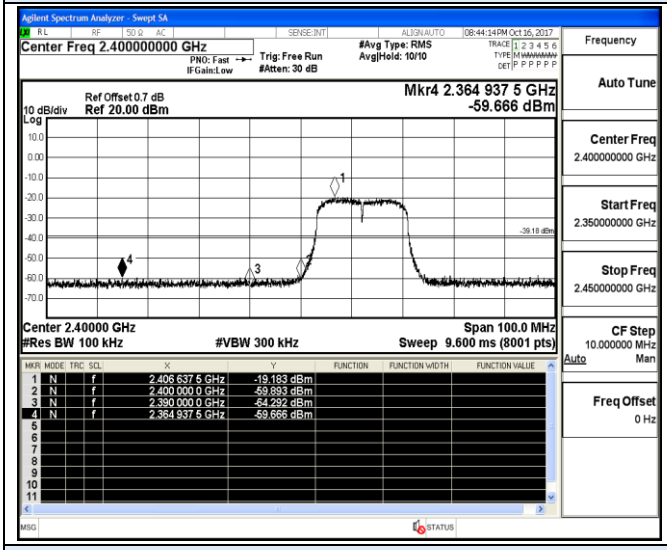


Channel 11 / 2462 MHz



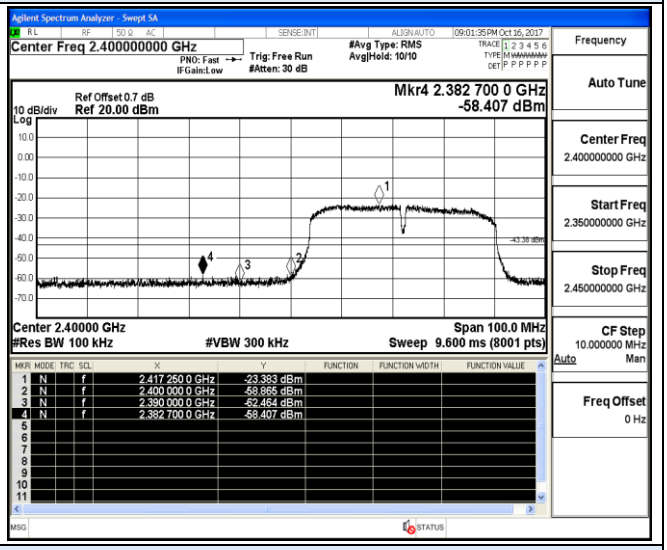
Channel 11 / 2462 MHz

IEEE 802.11n HT20

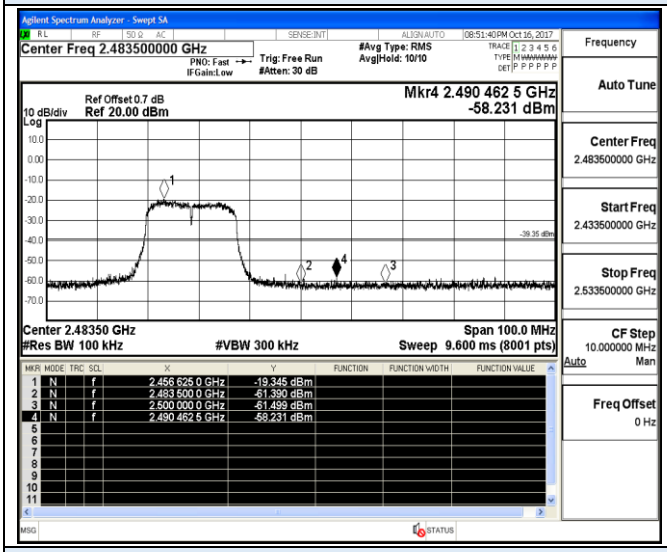
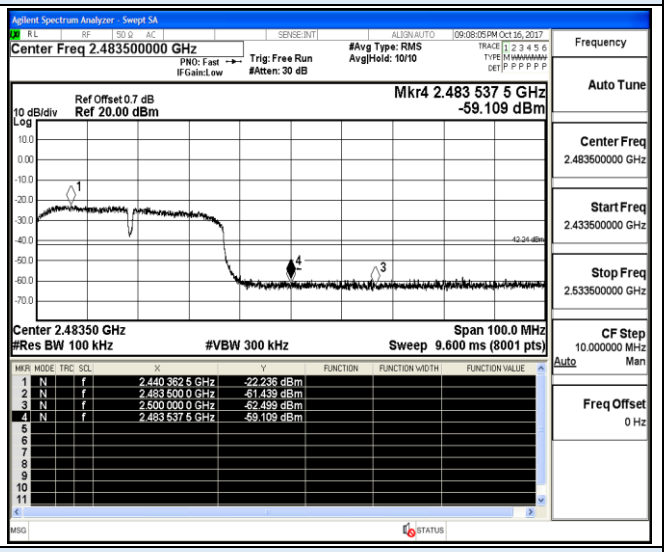


Channel 1 / 2412 MHz

IEEE 802.11n HT40



Channel 3 / 2422 MHz

Band-edge Measurements for Conducted Emissions	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 11 / 2462 MHz	Channel 11 / 2462 MHz

5.7. Power line conducted emissions

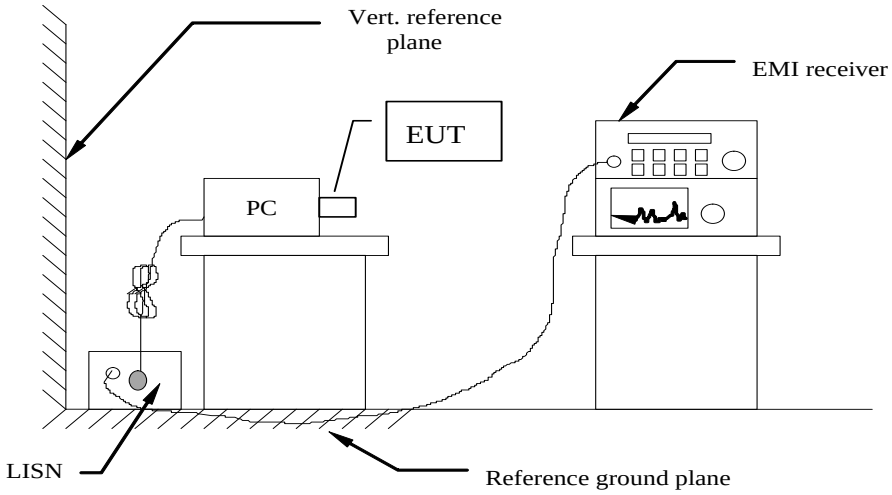
5.7.1 Standard Applicable

According to §15.207 (a): For an intentional radiator which is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed 250 microvolts (The limit decreases linearly with the logarithm of the frequency in the range 0.15 MHz to 0.50 MHz). The limits at specific frequency range are listed as follows:

Frequency Range (MHz)	Limits (dBμV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56	56 to 46
0.50 to 5	56	46
5 to 30	60	50

* Decreasing linearly with the logarithm of the frequency

5.7.2 Block Diagram of Test Setup



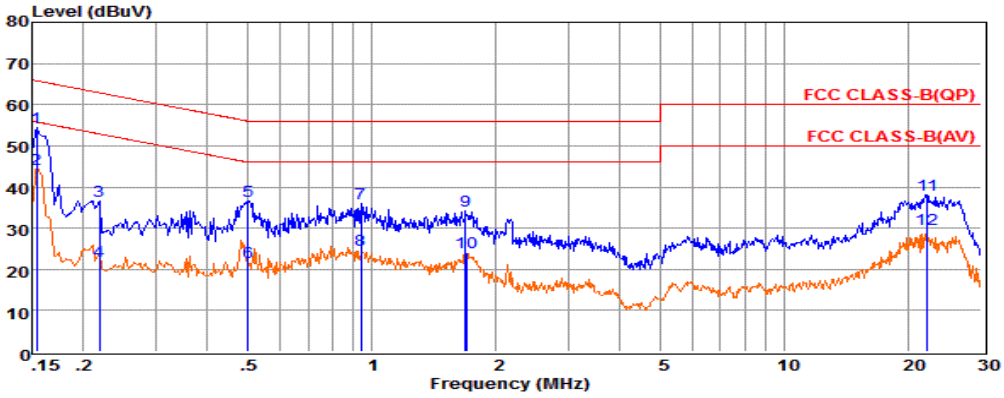
5.7.3 Test Results

PASS.

The test data please refer to following page.

AC Conducted Emission of power adapter @ AC 120V/60Hz @ IEEE 802.11n HT40 (worst case)

Line

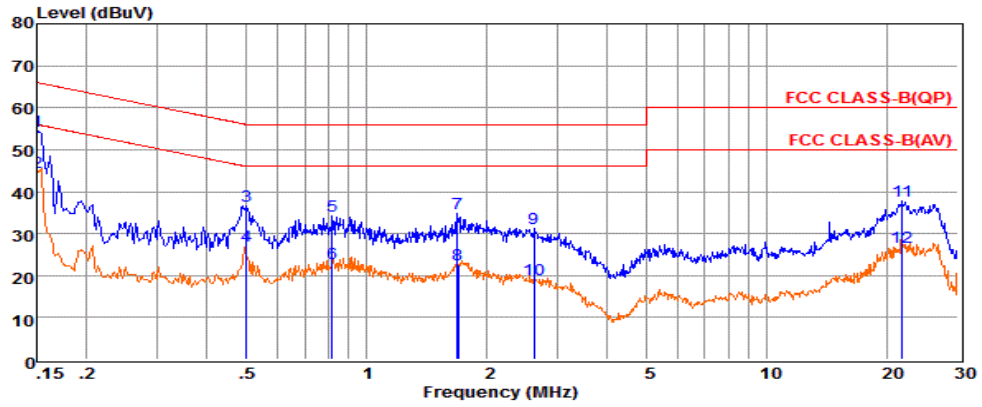


Pol: LINE

	Freq	Reading	LISNFac	CabLos	Aux2Fac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB	dB	dB	dBuV	dBuV	dB
1	0.15	34.84	9.58	0.02	10.00	54.44	65.78	-11.34	QP
2	0.15	24.60	9.58	0.02	10.00	44.20	55.77	-11.57	Average
3	0.22	16.78	9.63	0.03	10.00	36.44	62.88	-26.44	QP
4	0.22	2.30	9.63	0.03	10.00	21.96	52.87	-30.91	Average
5	0.50	16.94	9.62	0.04	10.00	36.60	56.00	-19.40	QP
6	0.50	2.16	9.62	0.04	10.00	21.82	46.00	-24.18	Average
7	0.94	16.38	9.63	0.05	10.00	36.06	56.00	-19.94	QP
8	0.94	5.05	9.63	0.05	10.00	24.73	46.00	-21.27	Average
9	1.69	14.43	9.64	0.05	10.00	34.12	56.00	-21.88	QP
10	1.69	4.37	9.64	0.05	10.00	24.06	46.00	-21.94	Average
11	22.18	18.31	9.71	0.12	10.00	38.14	60.00	-21.86	QP
12	22.18	9.90	9.71	0.12	10.00	29.73	50.00	-20.27	Average

Remarks: 1. Measured = Reading + LISNFac + Cable Loss + Aux2 Fac.
2. The emission levels that are 20dB below the official limit are not reported.

Neutral



Pol: NEUTRAL

	Freq	Reading	LISNFac	CabLos	Aux2Fac	Measured	Limit	Over	Remark
	MHz	dBuV	dB	dB	dB	dB	dBuV	dBuV	dB
1	0.15	34.78	9.70	0.02	10.00	54.50	66.00	-11.50	QP
2	0.15	25.00	9.70	0.02	10.00	44.72	55.99	-11.27	Average
3	0.50	16.88	9.62	0.04	10.00	36.54	56.00	-19.46	QP
4	0.50	7.27	9.62	0.04	10.00	26.93	46.00	-19.07	Average
5	0.82	14.41	9.63	0.04	10.00	34.08	56.00	-21.92	QP
6	0.82	3.28	9.63	0.04	10.00	22.95	46.00	-23.05	Average
7	1.69	15.20	9.63	0.05	10.00	34.88	56.00	-21.12	QP
8	1.69	2.82	9.63	0.05	10.00	22.50	46.00	-23.50	Average
9	2.62	11.67	9.64	0.05	10.00	31.36	56.00	-24.64	QP
10	2.62	-0.76	9.64	0.05	10.00	18.93	46.00	-27.07	Average
11	21.83	17.88	9.82	0.12	10.00	37.82	60.00	-22.18	QP
12	21.83	6.97	9.82	0.12	10.00	26.91	50.00	-23.09	Average

Remarks: 1. Measured = Reading + LISNFac + Cable Loss + Aux2 Fac.
2. The emission levels that are 20dB below the official limit are not reported.

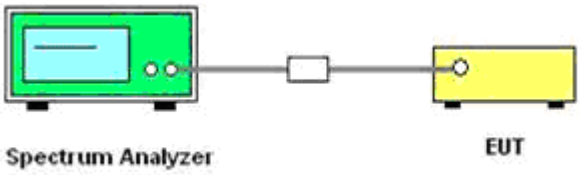
****Note: Pre-scan all modes and recorded the worst case results in this report (IEEE 802.11n HT40).*

5.8. Band-edge measurements for radiated emissions

5.8.1 Standard Applicable

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

5.8.2 Test Setup Layout



5.8.3. Measuring Instruments and Setting

Please refer to equipment list in this report. The following table is the setting of Spectrum Analyzer.

5.8.4. Test Procedures

According to KDB 558074 D01 for Antenna-port conducted measurement. Antenna-port conducted measurements may also be used as an alternative to radiated measurements for demonstrating compliance in the restricted frequency bands. If conducted measurements are performed, then proper impedance matching must be ensured and an additional radiated test for cabinet/case spurious emissions is required.

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to an EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set both RBW and VBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100kHz bandwidth from band edge, for Radiated emissions restricted band RBW=1MHz, VBW=3MHz for peak detector and RBW=1MHz, VBW=1/B for AV detector.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.
6. Measure the conducted output power (in dBm) using the detector specified by the appropriate regulatory agency (see 12.2.2, 12.2.3, and 12.2.4 for guidance regarding measurement procedures for determining quasi-peak, peak, and average conducted output power, respectively).
7. Add the maximum transmit antenna gain (in dBi) to the measured output power level to determine the EIRP level (see 12.2.5 for guidance on determining the applicable antenna gain)
8. Add the appropriate maximum ground reflection factor to the EIRP level (6 dB for frequencies ≤ 30 MHz, 4.7 dB for frequencies between 30 MHz and 1000 MHz, inclusive and 0 dB for frequencies > 1000 MHz).
9. For devices with multiple antenna-ports, measure the power of each individual chain and sum the EIRP of all chains in linear terms (e.g., Watts, mW).
10. Convert the resultant EIRP level to an equivalent electric field strength using the following relationship:

E = EIRP – 20log D + 104.77=EIRP+95.23

Where:
E = electric field strength in dBμV/m,
EIRP = equivalent isotropic radiated power in dBm

D = specified measurement distance in meters.

11. Since the out-of-band characteristics of the EUT transmit antenna will often be unknown, the use of a conservative antenna gain value is necessary. Thus, when determining the EIRP based on the measured conducted power, the upper bound on antenna gain for a device with a single RF output shall be selected as the maximum in-band gain of the antenna across all operating bands, or 2 dBi, whichever is greater. However, for devices that operate in multiple frequency bands while using the same transmit antenna, the highest gain of the antenna within the operating band nearest in frequency to the restricted band emission being measured may be used in lieu of the overall highest gain when the emission is at a frequency that is within 20 percent of the nearest band edge frequency, but in no case shall a value less than 2 dBi be used.
12. Per KDB662911 D01 section b) In cases where a combination of conducted measurements and cabinet radiated measurements are permitted to demonstrate compliance with absolute radiated out-of-band and spurious limits (e.g., KDB Publications 558074 for DTS and 789033 for U-NII), the conducted measurements must be combined with directional gain to compute the radiated levels of the out-of-band and spurious emissions as described in this section.
13. Compare the resultant electric field strength level to the applicable regulatory limit.
14. Perform radiated spurious emission test duress until all measured frequencies were complete.

5.8.5 Test Results

Antenna 0

IEEE 802.11b								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.575	2.000	0.000	45.683	Peak	74.00	-28.317	PASS
2310.000	-62.774	2.000	0.000	34.484	Average	54.00	-19.516	PASS
2390.000	-50.106	2.000	0.000	47.152	Peak	74.00	-26.848	PASS
2390.000	-62.247	2.000	0.000	35.011	Average	54.00	-18.989	PASS
2483.500	-51.634	2.000	0.000	45.624	Peak	74.00	-28.376	PASS
2483.500	-62.282	2.000	0.000	34.976	Average	54.00	-19.024	PASS
2500.000	-52.787	2.000	0.000	44.471	Peak	74.00	-29.529	PASS
2500.000	-62.379	2.000	0.000	34.879	Average	54.00	-19.121	PASS

IEEE 802.11g								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Limit (dBuV/m)	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-53.847	2.000	0.000	43.411	Peak	74.00	-30.589	PASS
2310.000	-62.760	2.000	0.000	34.498	Average	54.00	-19.502	PASS
2390.000	-51.976	2.000	0.000	45.282	Peak	74.00	-28.718	PASS
2390.000	-61.909	2.000	0.000	35.349	Average	54.00	-18.651	PASS
2483.500	-51.590	2.000	0.000	45.668	Peak	74.00	-28.332	PASS
2483.500	-61.887	2.000	0.000	35.371	Average	54.00	-18.629	PASS
2500.000	-51.636	2.000	0.000	45.622	Peak	74.00	-28.378	PASS
2500.000	-62.167	2.000	0.000	35.091	Average	54.00	-18.909	PASS

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IEEE 802.11n HT20								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-50.897	2.000	0.000	46.361	Peak	74.00	-27.639	PASS
2310.000	-62.766	2.000	0.000	34.492	Average	54.00	-19.508	PASS
2390.000	-51.704	2.000	0.000	45.554	Peak	74.00	-28.446	PASS
2390.000	-61.903	2.000	0.000	35.355	Average	54.00	-18.645	PASS
2483.500	-51.673	2.000	0.000	45.585	Peak	74.00	-28.415	PASS
2483.500	-61.989	2.000	0.000	35.269	Average	54.00	-18.731	PASS
2500.000	-51.609	2.000	0.000	45.649	Peak	74.00	-28.351	PASS
2500.000	-62.288	2.000	0.000	34.970	Average	54.00	-19.030	PASS

IEEE 802.11n HT40								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-52.809	2.0	0.000	44.449	Peak	74.00	-29.551	PASS
2310.000	-62.747	2.0	0.000	34.511	Average	54.00	-19.489	PASS
2390.000	-49.928	2.0	0.000	47.330	Peak	74.00	-26.670	PASS
2390.000	-61.996	2.0	0.000	35.262	Average	54.00	-18.738	PASS
2483.500	-51.859	2.0	0.000	45.399	Peak	74.00	-28.601	PASS
2483.500	-62.073	2.0	0.000	35.185	Average	54.00	-18.815	PASS
2500.000	-50.859	2.0	0.000	46.399	Peak	74.00	-27.601	PASS
2500.000	-62.254	2.0	0.000	35.004	Average	54.00	-18.996	PASS

Antenna 1

IEEE 802.11b								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.575	2.0	0.000	45.683	Peak	74.00	-28.317	PASS
2310.000	-62.794	2.0	0.000	34.464	Average	54.00	-19.536	PASS
2390.000	-49.604	2.0	0.000	47.654	Peak	74.00	-26.346	PASS
2390.000	-62.250	2.0	0.000	35.008	Average	54.00	-18.992	PASS
2483.500	-51.035	2.0	0.000	46.223	Peak	74.00	-27.777	PASS
2483.500	-62.261	2.0	0.000	34.997	Average	54.00	-19.003	PASS
2500.000	-50.647	2.0	0.000	46.611	Peak	74.00	-27.389	PASS
2500.000	-62.364	2.0	0.000	34.894	Average	54.00	-19.106	PASS

IEEE 802.11g								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.279	2.0	0.000	45.979	Peak	74.00	-28.021	PASS
2310.000	-62.740	2.0	0.000	34.518	Average	54.00	-19.482	PASS
2390.000	-50.528	2.0	0.000	46.730	Peak	74.00	-27.270	PASS
2390.000	-61.875	2.0	0.000	35.383	Average	54.00	-18.617	PASS
2483.500	-49.703	2.0	0.000	47.555	Peak	74.00	-26.445	PASS
2483.500	-61.937	2.0	0.000	35.321	Average	54.00	-18.679	PASS
2500.000	-50.347	2.0	0.000	46.911	Peak	74.00	-27.089	PASS
2500.000	-62.244	2.0	0.000	35.014	Average	54.00	-18.986	PASS

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IEEE 802.11n HT20								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-52.299	2.0	0.000	44.959	Peak	74.00	-29.041	PASS
2310.000	-62.740	2.0	0.000	34.518	Average	54.00	-19.482	PASS
2390.000	-51.347	2.0	0.000	45.911	Peak	74.00	-28.089	PASS
2390.000	-61.915	2.0	0.000	35.343	Average	54.00	-18.657	PASS
2483.500	-50.910	2.0	0.000	46.348	Peak	74.00	-27.652	PASS
2483.500	-61.954	2.0	0.000	35.304	Average	54.00	-18.696	PASS
2500.000	-51.456	2.0	0.000	45.802	Peak	74.00	-28.198	PASS
2500.000	-62.236	2.0	0.000	35.022	Average	54.00	-18.978	PASS

IEEE 802.11n HT40								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-49.332	2.0	0.000	47.926	Peak	74.00	-26.074	PASS
2310.000	-62.736	2.0	0.000	34.522	Average	54.00	-19.478	PASS
2390.000	-49.928	2.0	0.000	47.330	Peak	74.00	-26.670	PASS
2390.000	-61.981	2.0	0.000	35.277	Average	54.00	-18.723	PASS
2483.500	-50.778	2.0	0.000	46.480	Peak	74.00	-27.520	PASS
2483.500	-62.048	2.0	0.000	35.210	Average	54.00	-18.790	PASS
2500.000	-50.859	2.0	0.000	46.399	Peak	74.00	-27.601	PASS
2500.000	-62.254	2.0	0.000	35.004	Average	54.00	-18.996	PASS

Antenna 2

IEEE 802.11b								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.078	2.0	0.000	46.180	Peak	74.00	-27.820	PASS
2310.000	-62.773	2.0	0.000	34.485	Average	54.00	-19.515	PASS
2390.000	-50.705	2.0	0.000	46.553	Peak	74.00	-27.447	PASS
2390.000	-62.298	2.0	0.000	34.960	Average	54.00	-19.040	PASS
2483.500	-51.761	2.0	0.000	45.497	Peak	74.00	-28.503	PASS
2483.500	-62.270	2.0	0.000	34.988	Average	54.00	-19.012	PASS
2500.000	-52.307	2.0	0.000	44.951	Peak	74.00	-29.049	PASS
2500.000	-62.366	2.0	0.000	34.892	Average	54.00	-19.108	PASS

IEEE 802.11g								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.286	2.0	0.000	45.972	Peak	74.00	-28.028	PASS
2310.000	-62.772	2.0	0.000	34.486	Average	54.00	-19.514	PASS
2390.000	-51.103	2.0	0.000	46.155	Peak	74.00	-27.845	PASS
2390.000	-61.924	2.0	0.000	35.334	Average	54.00	-18.666	PASS
2483.500	-51.009	2.0	0.000	46.249	Peak	74.00	-27.751	PASS
2483.500	-61.906	2.0	0.000	35.352	Average	54.00	-18.648	PASS
2500.000	-50.588	2.0	0.000	46.670	Peak	74.00	-27.330	PASS
2500.000	-62.168	2.0	0.000	35.090	Average	54.00	-18.910	PASS

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IEEE 802.11n HT20								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.741	2.0	0.000	45.517	Peak	74.00	-28.483	PASS
2310.000	-62.760	2.0	0.000	34.498	Average	54.00	-19.502	PASS
2390.000	-51.362	2.0	0.000	45.896	Peak	74.00	-28.104	PASS
2390.000	-61.898	2.0	0.000	35.360	Average	54.00	-18.640	PASS
2483.500	-50.567	2.0	0.000	46.691	Peak	74.00	-27.309	PASS
2483.500	-61.956	2.0	0.000	35.302	Average	54.00	-18.698	PASS
2500.000	-52.471	2.0	0.000	44.787	Peak	74.00	-29.213	PASS
2500.000	-62.279	2.0	0.000	34.979	Average	54.00	-19.021	PASS

IEEE 802.11n HT40								
Frequency (MHz)	Conducted Power (dBm)	Antenna Gain (dBi)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
2310.000	-51.798	2.0	0.000	45.460	Peak	74.00	-28.540	PASS
2310.000	-62.748	2.0	0.000	34.510	Average	54.00	-19.490	PASS
2390.000	-50.707	2.0	0.000	46.551	Peak	74.00	-27.449	PASS
2390.000	-61.966	2.0	0.000	35.292	Average	54.00	-18.708	PASS
2483.500	-51.569	2.0	0.000	45.689	Peak	74.00	-28.311	PASS
2483.500	-62.042	2.0	0.000	35.216	Average	54.00	-18.784	PASS
2500.000	-52.416	2.0	0.000	44.842	Peak	74.00	-29.158	PASS
2500.000	-62.279	2.0	0.000	34.979	Average	54.00	-19.021	PASS

Combined Antenna 0, Antenna 1 and Antenna 2

IEEE 802.11n HT20											
Frequency (MHz)	Conducted Power (dBm)				Directional Gain (dB)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
	Antenna 0	Antenna 1	Antenna 2	Sum							
2310.000*	-50.897	-52.299	-51.741	-46.836	6.771*	0.000	55.193	Peak	74.00	-18.807	PASS
2310.000	-62.766	-62.740	-62.760	-57.984	6.771*	0.000	44.045	AV	54.00	-9.955	PASS
2390.000	-51.704	-51.347	-51.362	-46.697	6.771*	0.000	55.332	Peak	74.00	-18.668	PASS
2390.000	-61.903	-61.915	-61.898	-57.134	6.771*	0.000	44.895	AV	54.00	-9.105	PASS
2483.500*	-51.673	-50.910	-50.567	-46.255	6.771*	0.000	55.774	Peak	74.00	-18.226	PASS
2483.500	-61.989	-61.954	-61.956	-57.195	6.771*	0.000	44.834	AV	54.00	-9.166	PASS
2500.000	-51.609	-51.456	-52.471	-47.052	6.771*	0.000	54.977	Peak	74.00	-19.023	PASS
2500.000	-62.288	-62.236	-62.279	-57.496	6.771*	0.000	44.533	AV	54.00	-9.467	PASS

IEEE 802.11n HT40											
Frequency (MHz)	Conducted Power (dBm)				Directional Gain (dB)	Ground Reflection Factor (dB)	Covert Radiated E Level At 3m (dBuV/m)	Detector	Limit (dBuV/m)	Over limit dB	Verdict
	Antenna 0	Antenna 1	Antenna 2	Sum							
2310.000*	-52.809	-49.332	-51.798	-46.287	6.771*	0.000	55.742	Peak	74.00	-18.258	PASS
2310.000	-62.747	-62.736	-62.748	-57.972	6.771*	0.000	44.057	AV	54.00	-9.943	PASS
2390.000	-49.928	-49.928	-50.707	-45.401	6.771*	0.000	56.628	Peak	74.00	-17.372	PASS
2390.000	-61.996	-61.981	-61.966	-57.210	6.771*	0.000	44.819	AV	54.00	-9.181	PASS
2483.500*	-51.859	-50.778	-51.569	-46.606	6.771*	0.000	55.423	Peak	74.00	-18.577	PASS
2483.500	-62.073	-62.048	-62.042	-57.283	6.771*	0.000	44.746	AV	54.00	-9.254	PASS
2500.000	-50.859	-50.859	-52.416	-46.547	6.771*	0.000	55.482	Peak	74.00	-18.518	PASS
2500.000	-62.254	-62.254	-62.279	-57.491	6.771*	0.000	44.538	AV	54.00	-9.462	PASS

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Remark:

1. *Measured Band-edge measurements for radiated emissions at difference data rate for each mode and recorded worst case for each mode.*
2. *Test results including cable loss;*
3. *Worst case data at 1Mbps at IEEE 802.11b; 6Mbps at IEEE 802.11g; 6.5Mbps at IEEE 802.11n HT20; 13.5Mbps at IEEE 802.11n HT40;*
4. *"---"means that the fundamental frequency not for 15.209 limits requirement.*
5. *No need measure Average values if Peak values meets Average limits;*
6. ** means maximum values of frequency band 2310 – 2390 MHz, 2483.5 – 2500 MHz;*
7. *For MIMO with CCD technology device, The Directional Gain= Gain of individual transmit antennas (dBi) + Array gain;*
   Array gain = 10 log (N_{ant}), where N_{ant} is the number of transmit antennas.
8. *Directional Gain = 2.0 + 10*log(3) = 6.771**
9. *Covert Radiated E Level At 3m = Conducted average power + Directional Gain + 104.77-20*log(3);*
10. *Please refer to following plots;*

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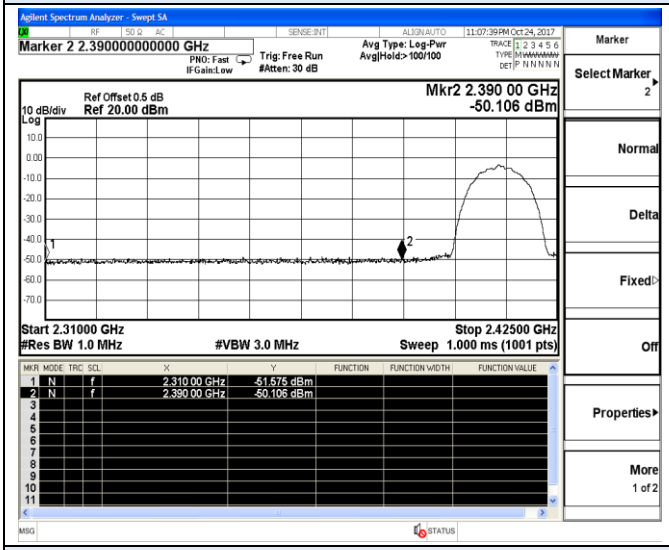
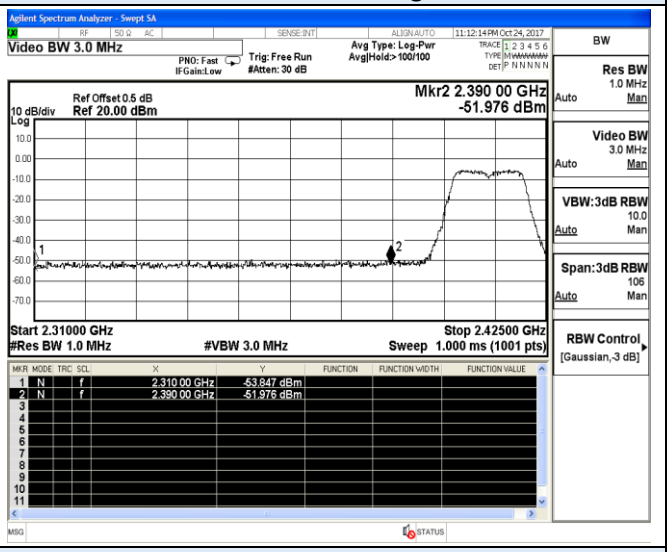
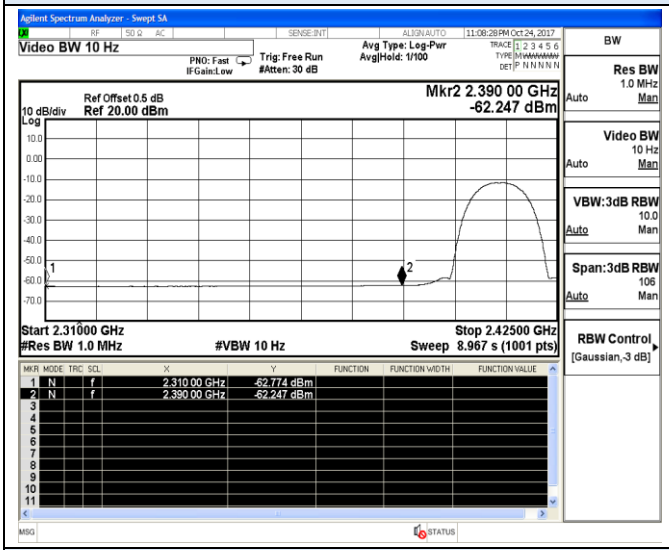
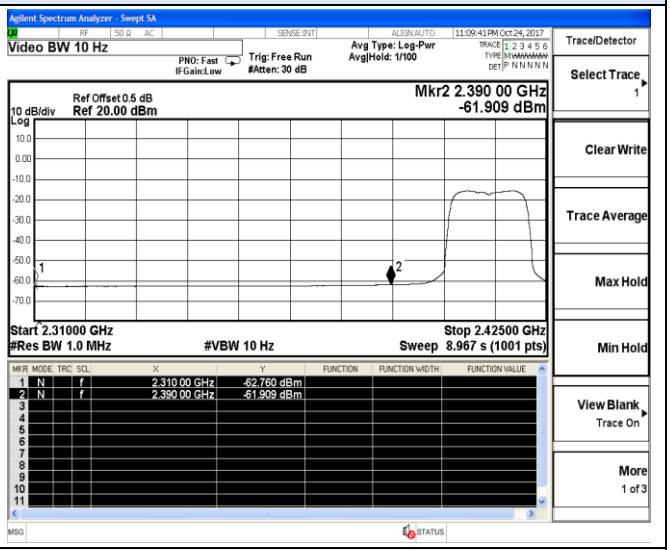
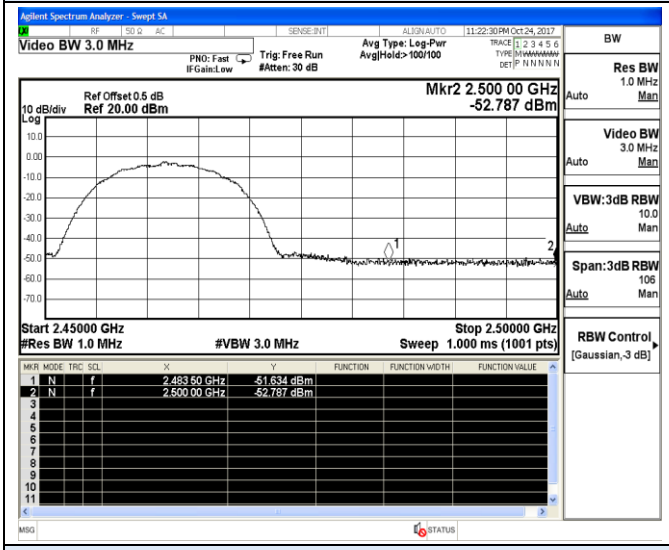
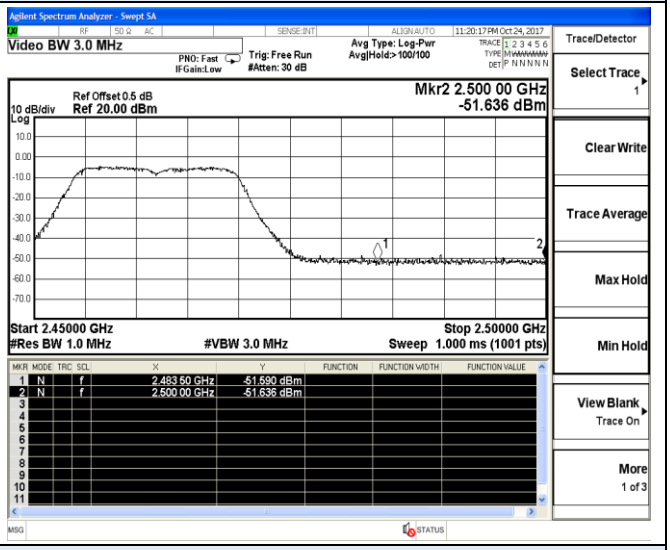
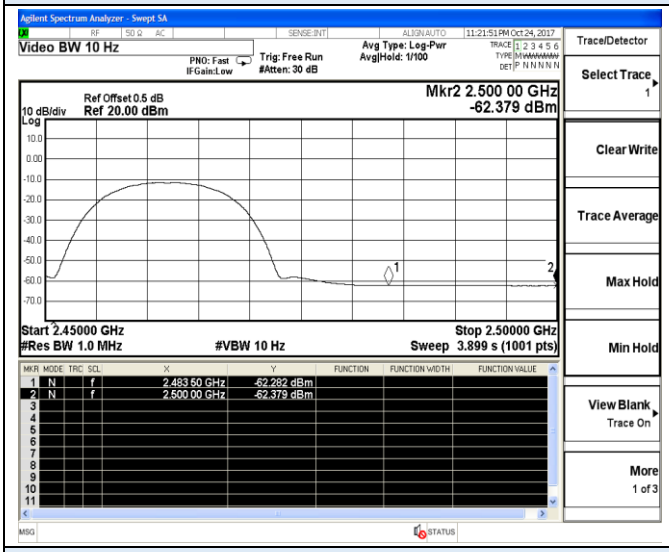
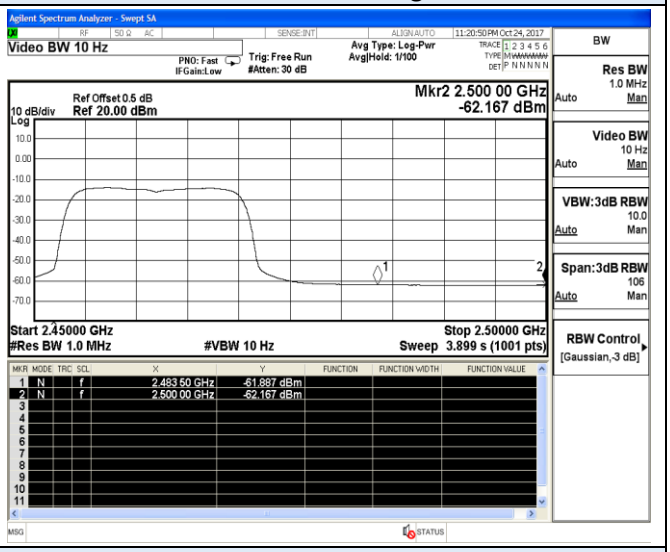
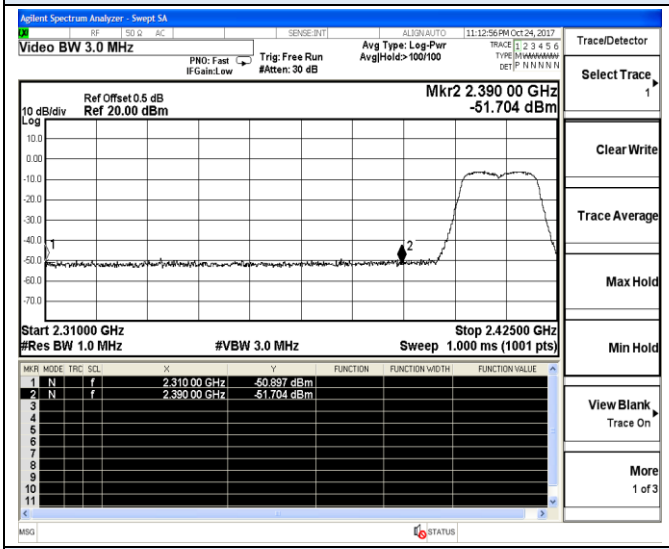
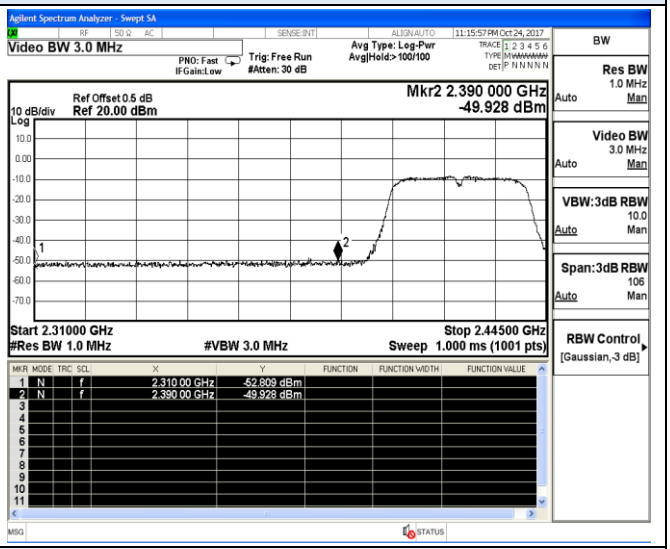
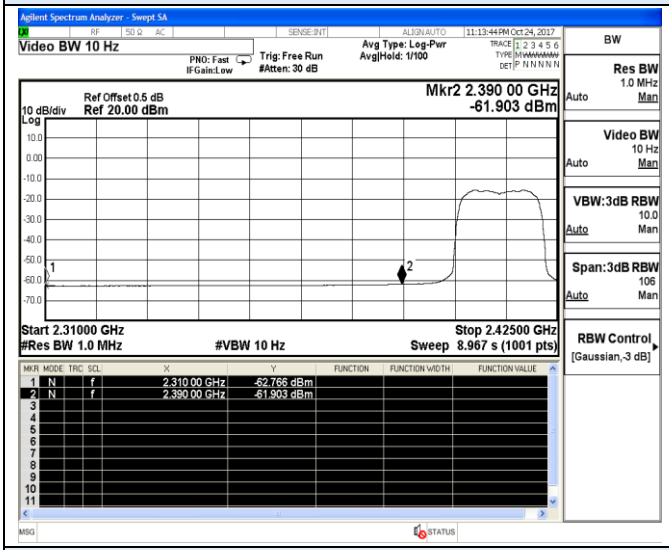
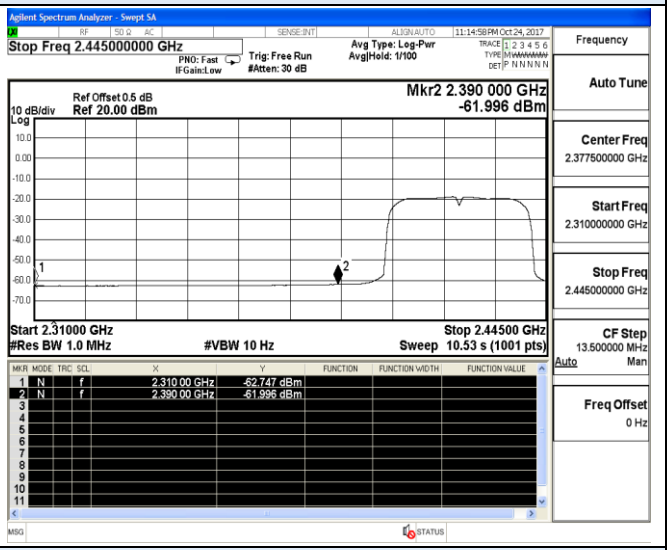
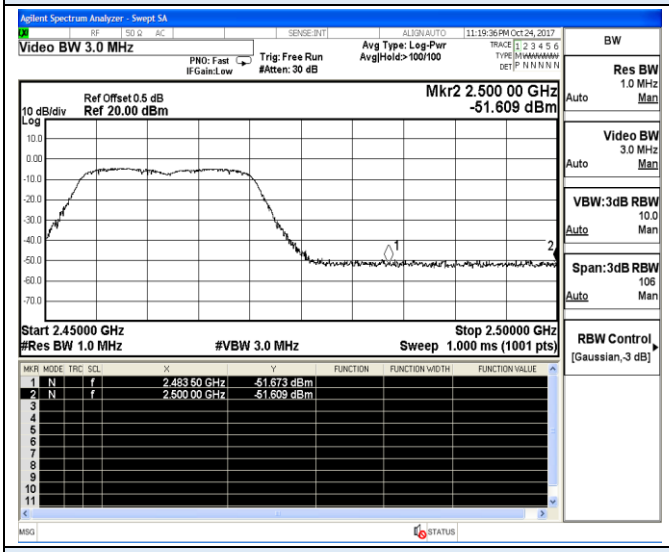
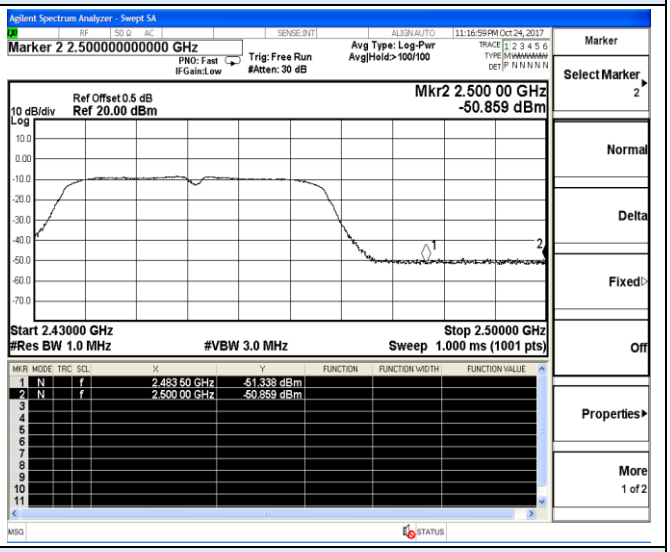
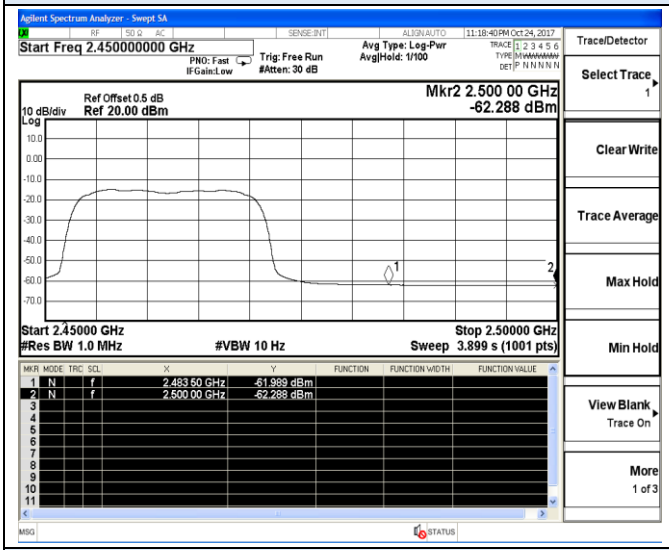
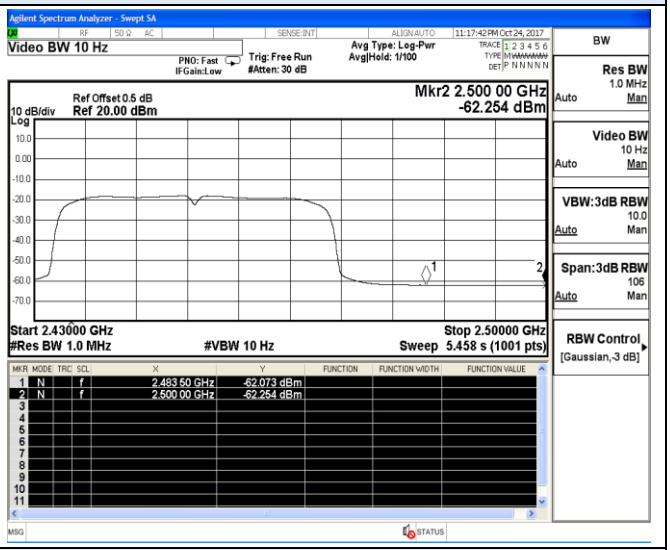
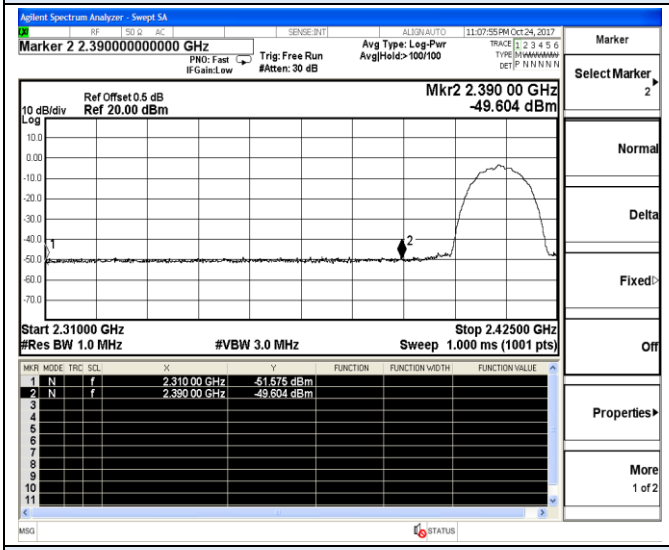
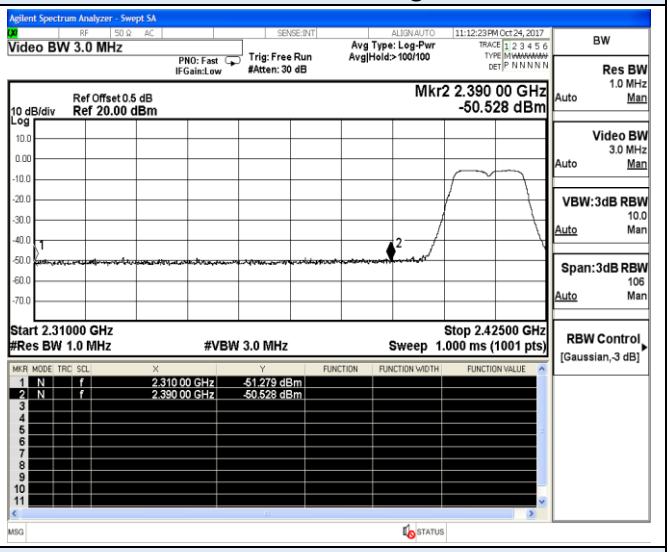
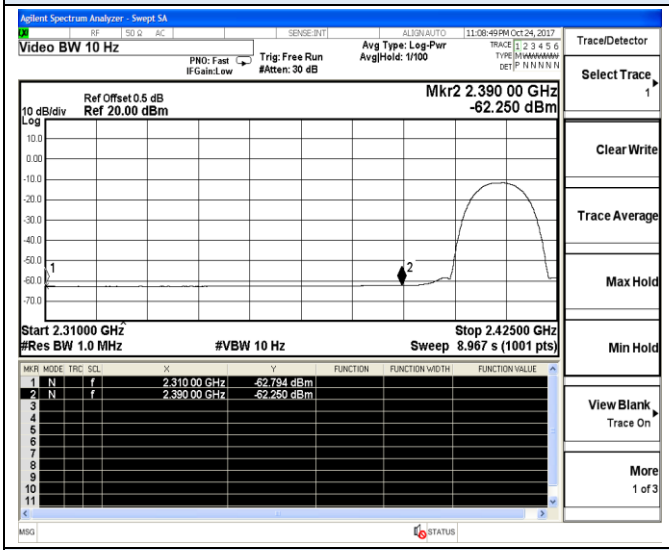
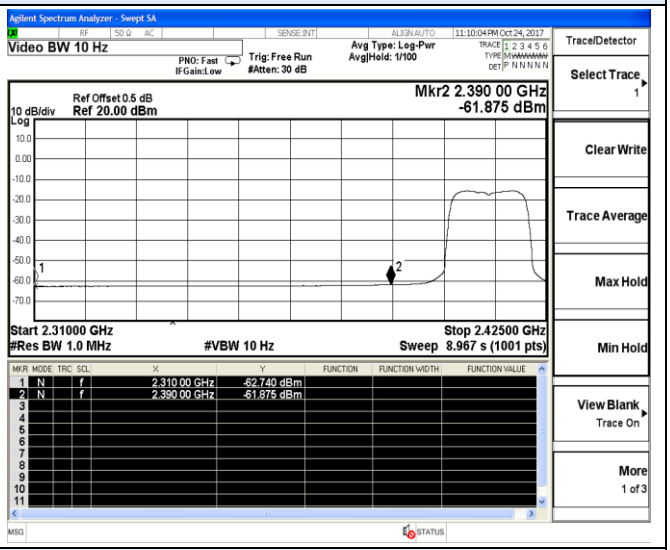
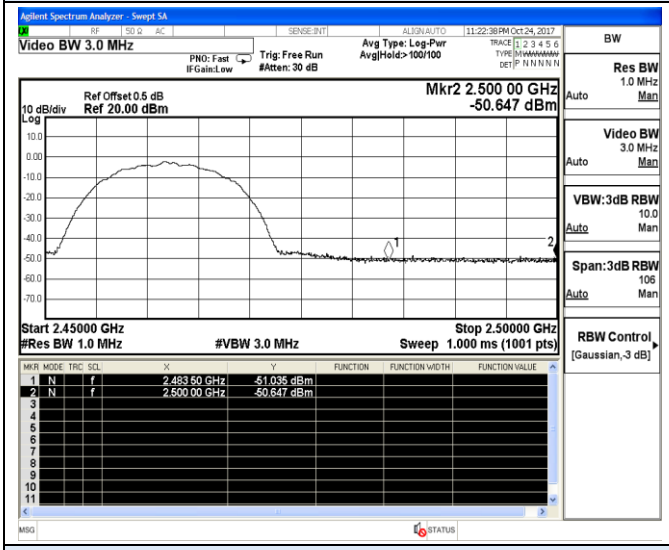
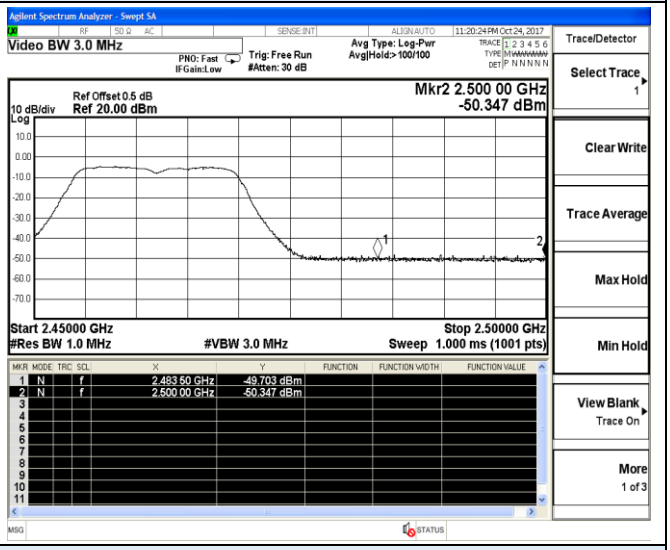
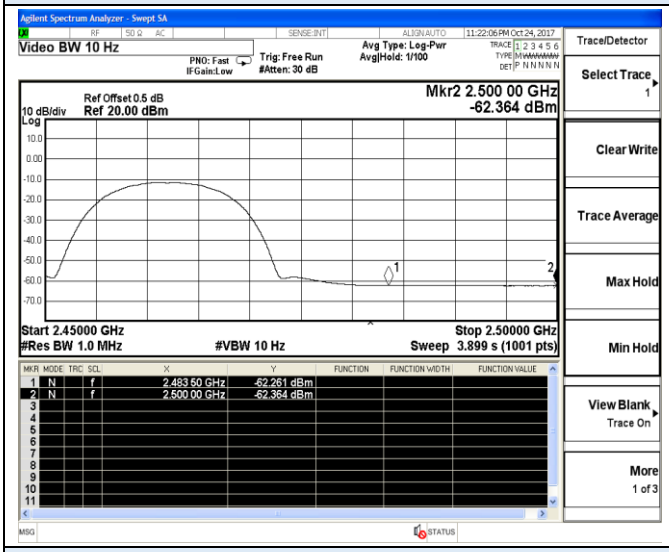
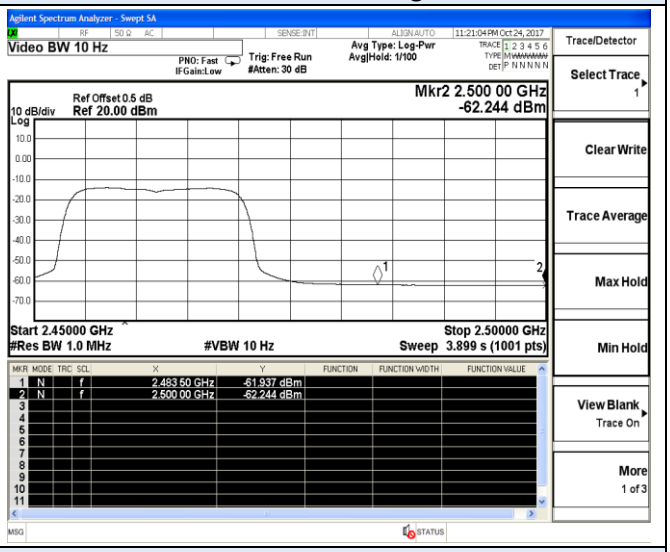
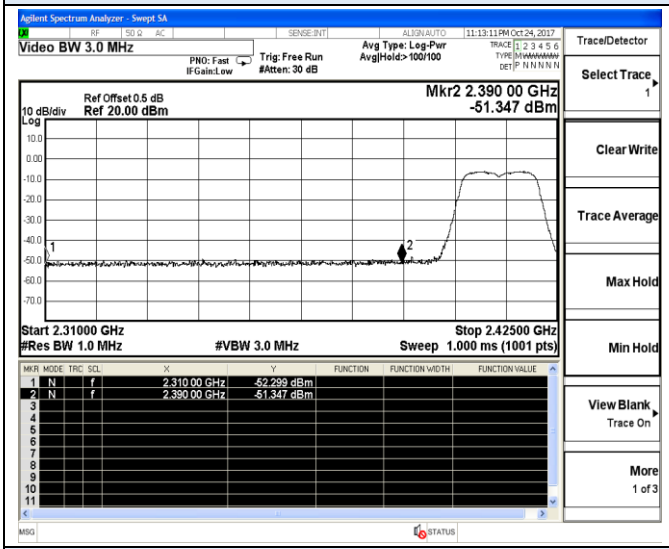
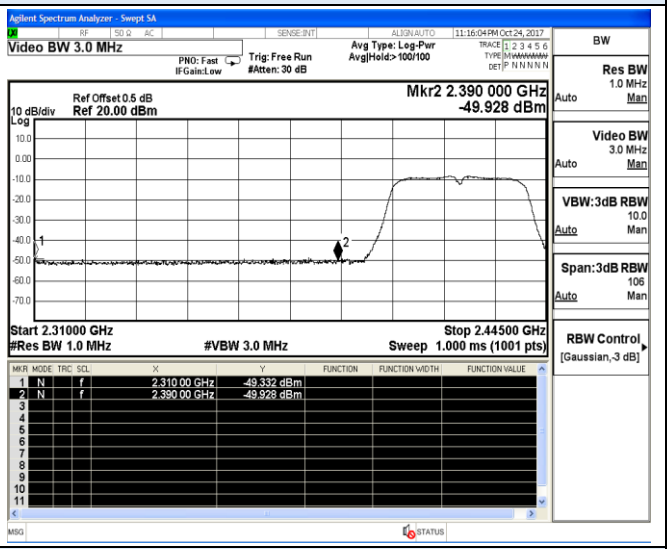
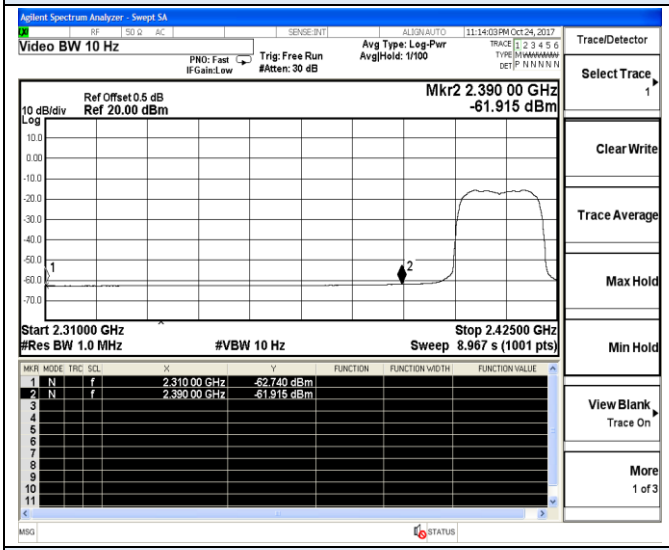
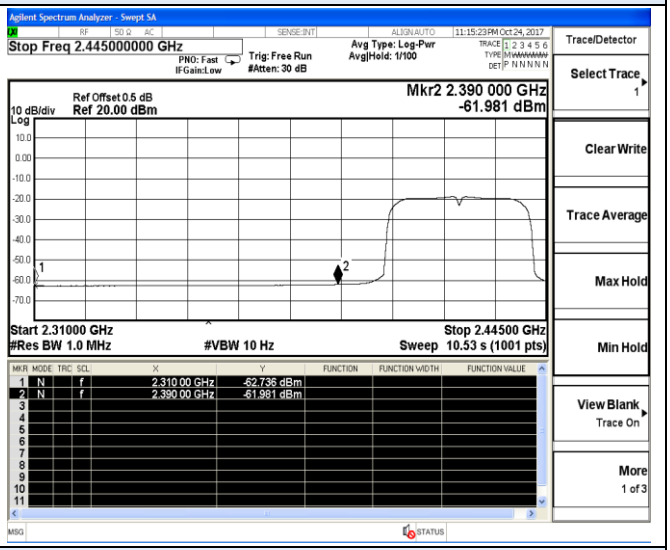
Band-edge measurements for radiated emissions	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz – Peak	Channel 1 / 2412 MHz – Peak
	
Channel 1 / 2412 MHz – Average	Channel 1 / 2412 MHz – Average
	
Channel 11 / 2462 MHz – Peak	

Band-edge measurements for radiated emissions	
Antenna 0	Antenna 0
IEEE 802.11b	IEEE 802.11g
	
Channel 11 / 2462 MHz – Average	Channel 11 / 2462 MHz – Average
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz – Peak	Channel 3 / 2422 MHz – Peak
	
Channel 1 / 2412 MHz – Average	Channel 3 / 2422 MHz – Average

Band-edge measurements for radiated emissions	
Antenna 0	Antenna 0
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 11 / 2462 MHz – Peak	Channel 9 / 2452 MHz – Peak
	
Channel 11 / 2462 MHz – Average	Channel 9 / 2452 MHz – Average

Band-edge measurements for radiated emissions	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz – Peak	Channel 1 / 2412 MHz – Peak
	
Channel 1 / 2412 MHz – Average	Channel 1 / 2412 MHz – Average
	
Channel 11 / 2462 MHz – Peak	

Band-edge measurements for radiated emissions	
Antenna 1	Antenna 1
IEEE 802.11b	IEEE 802.11g
	
Channel 11 / 2462 MHz – Average	Channel 11 / 2462 MHz – Average
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz – Peak	Channel 3 / 2422 MHz – Peak
	
Channel 1 / 2412 MHz – Average	Channel 3 / 2422 MHz – Average

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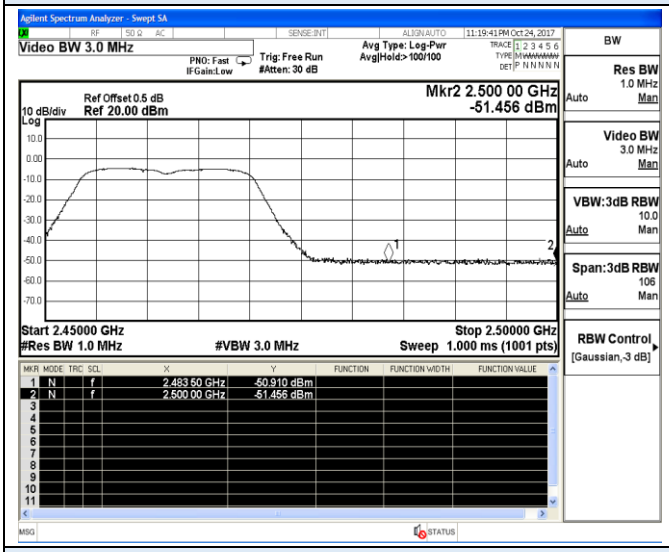
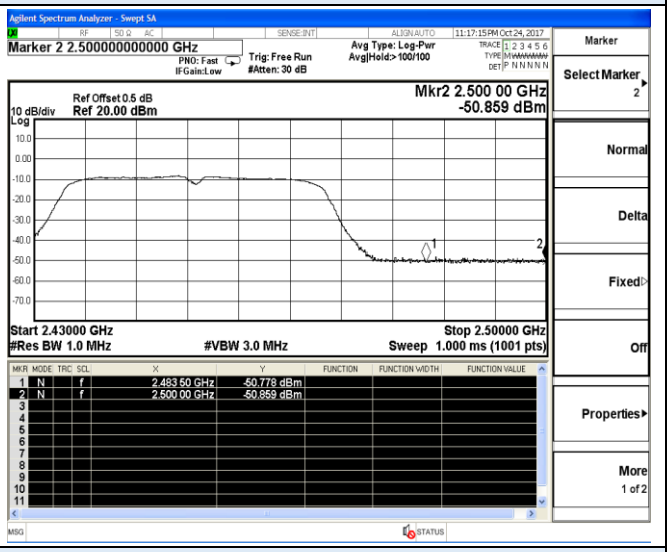
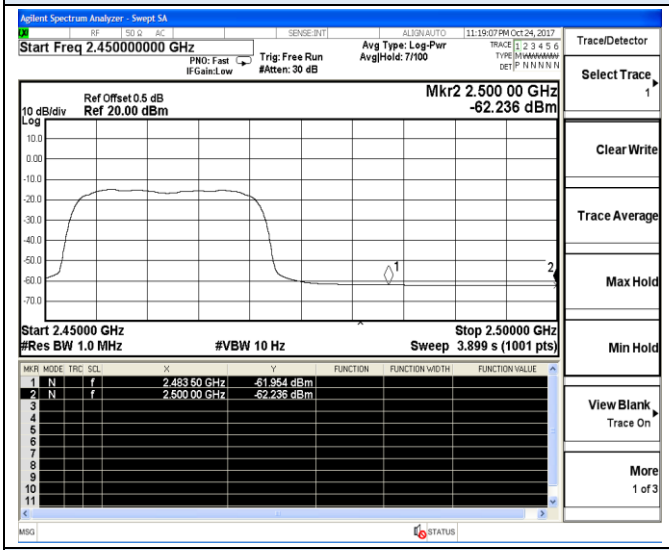
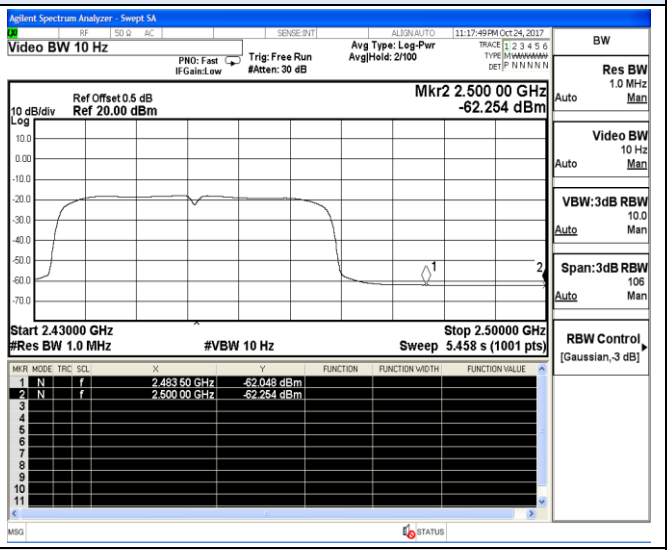
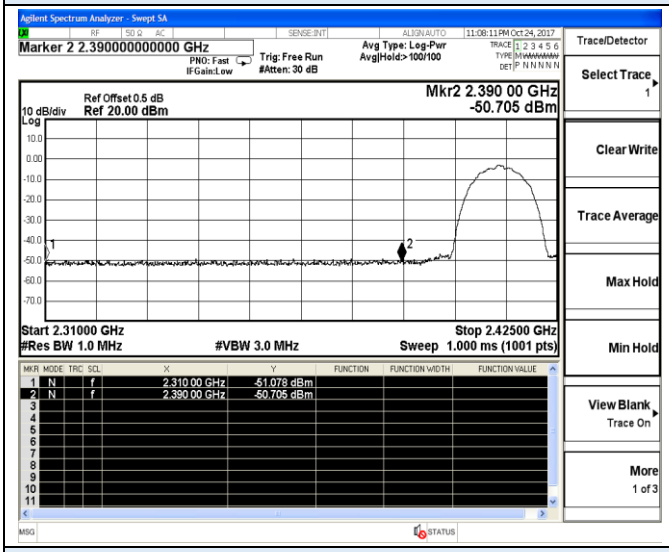
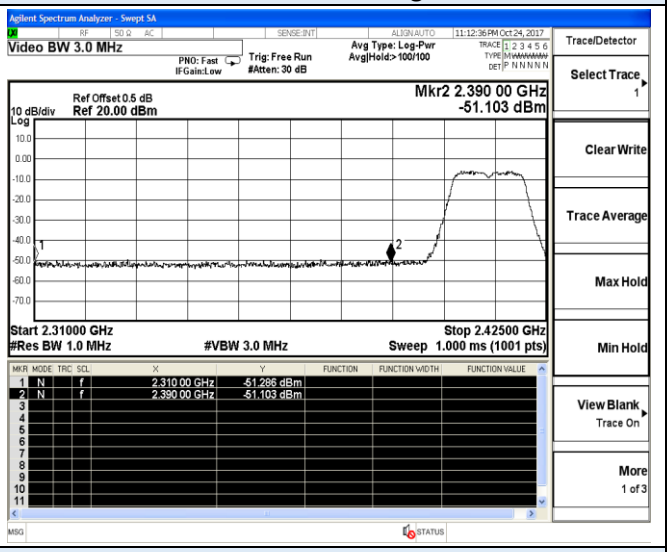
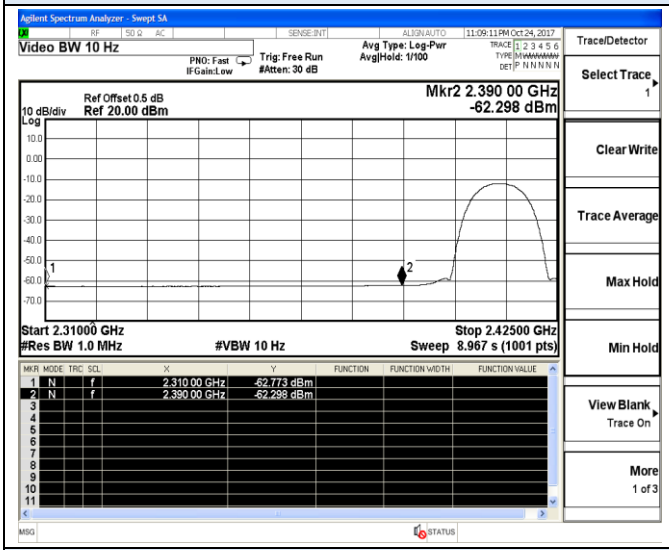
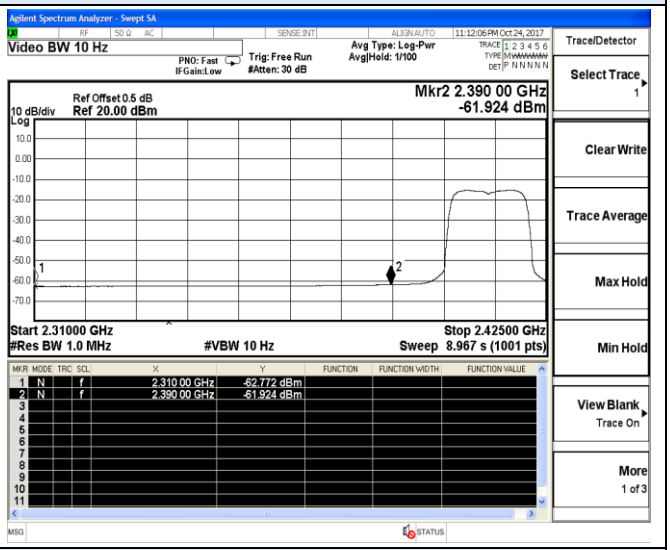
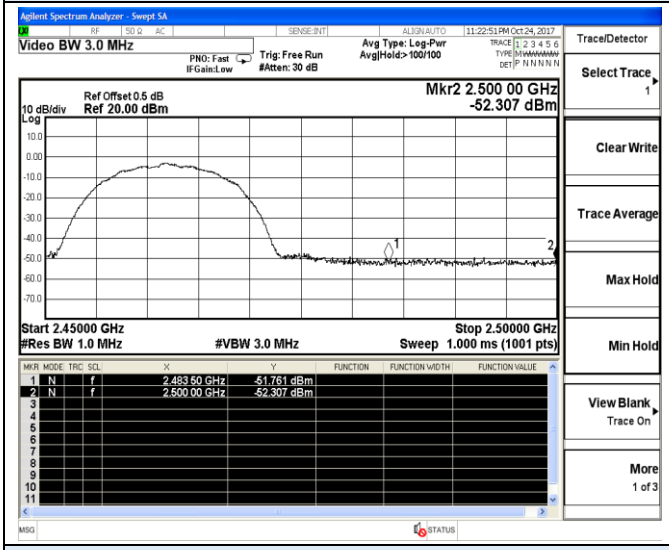
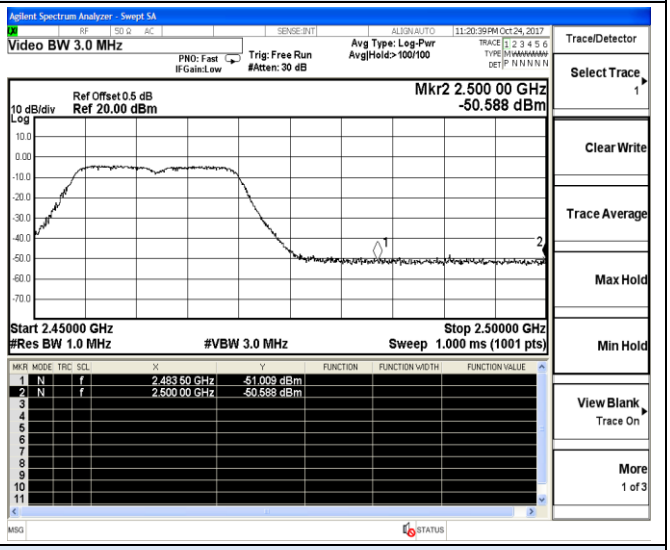
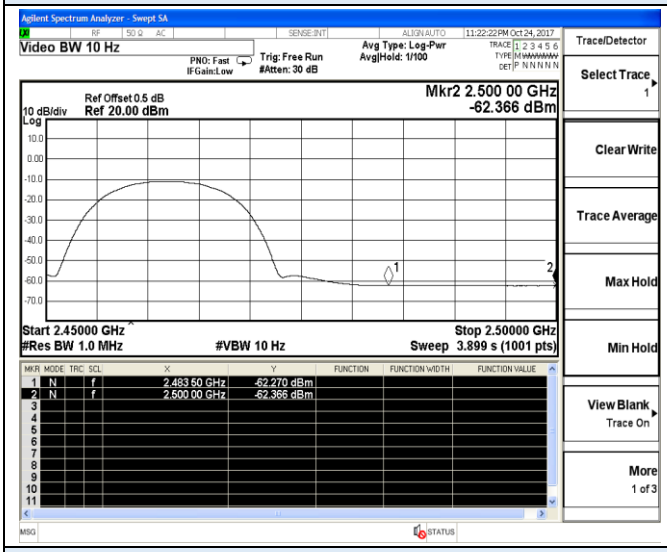
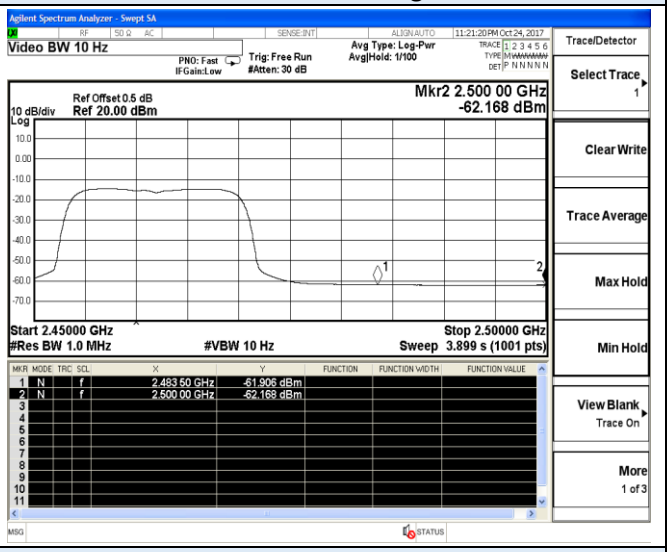
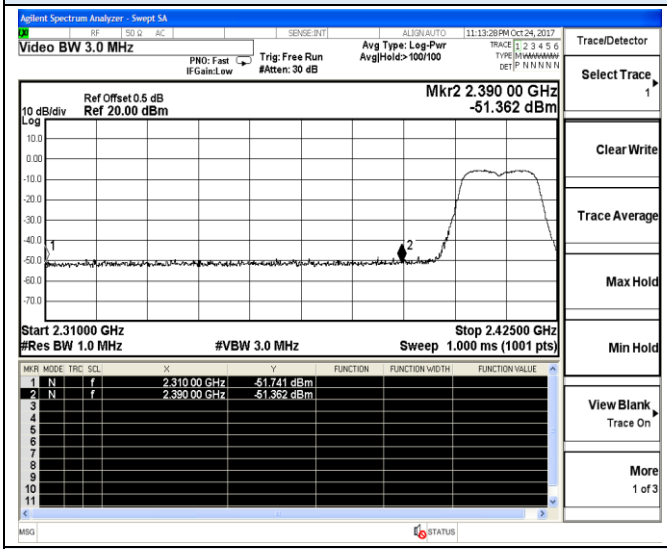
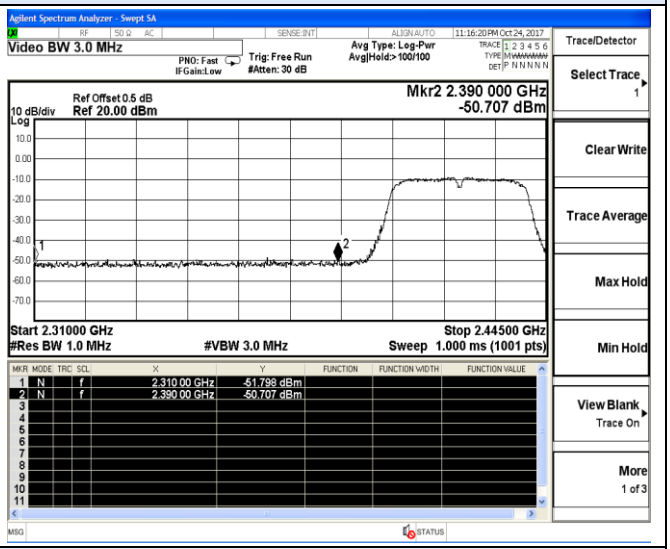
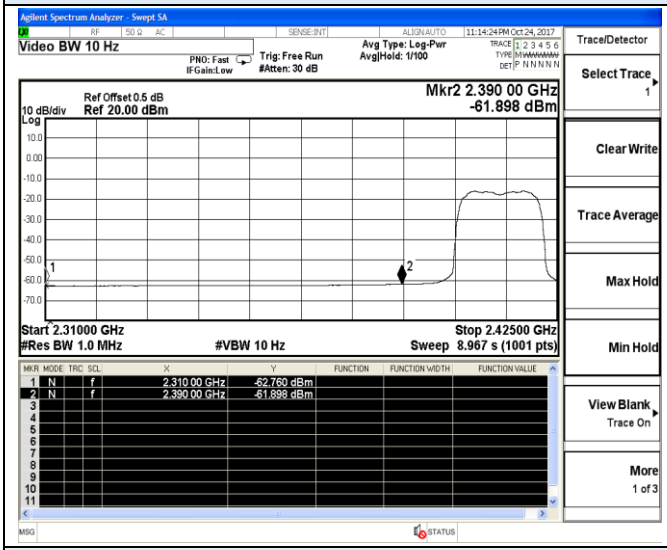
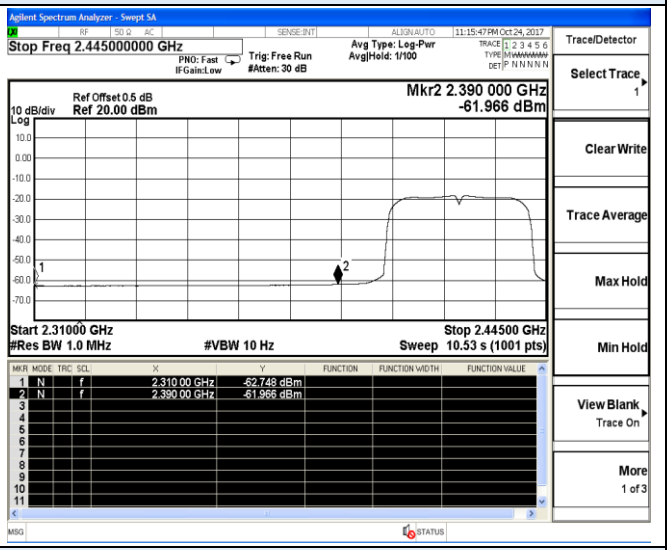
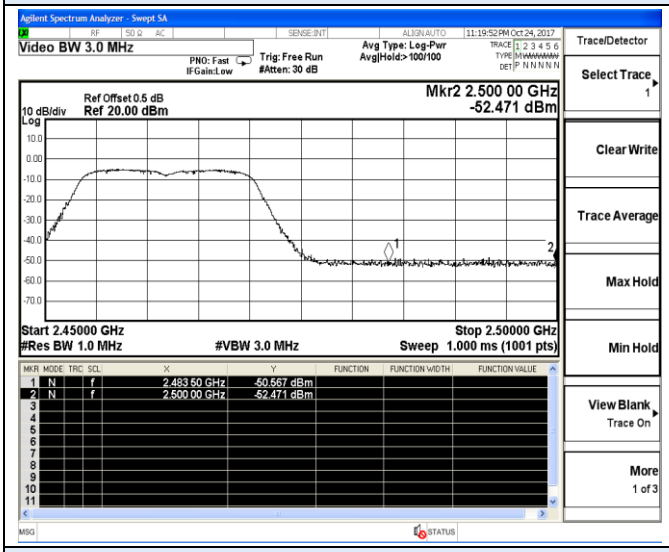
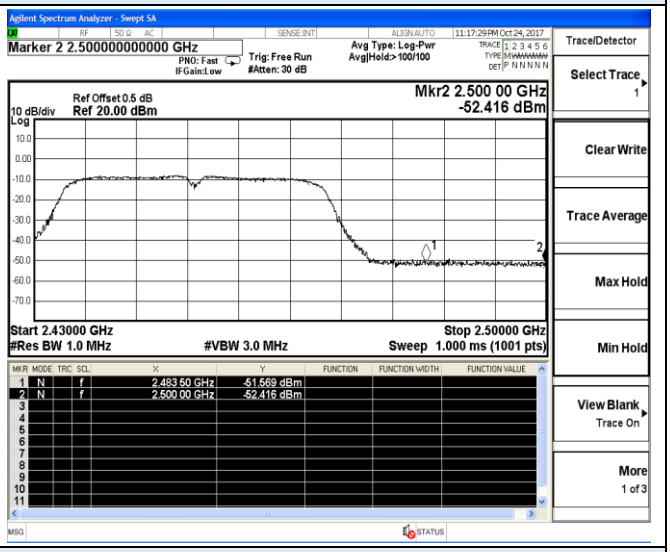
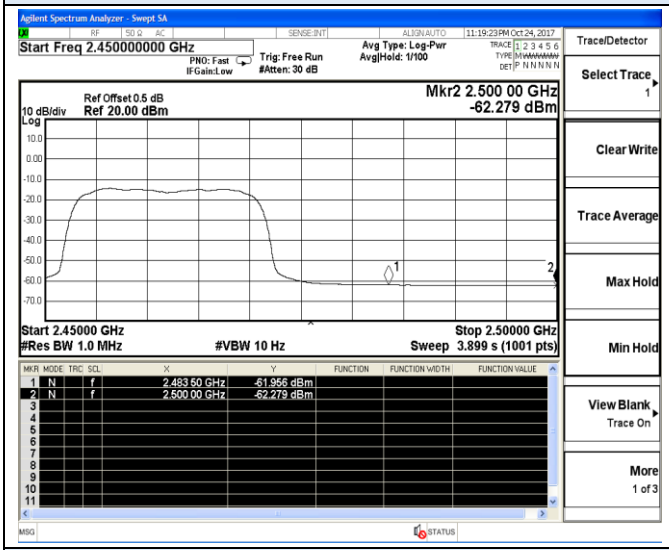
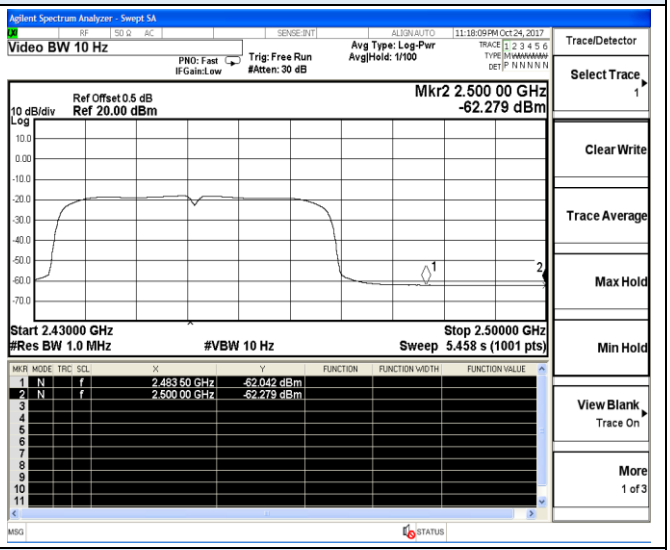
Band-edge measurements for radiated emissions	
Antenna 1	Antenna 1
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 11 / 2462 MHz – Peak	Channel 9 / 2452 MHz – Peak
	
Channel 11 / 2462 MHz – Average	Channel 9 / 2452 MHz – Average

Band-edge measurements for radiated emissions	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
	
Channel 1 / 2412 MHz – Peak	Channel 1 / 2412 MHz – Peak
	
Channel 1 / 2412 MHz – Average	Channel 1 / 2412 MHz – Average
	
Channel 11 / 2462 MHz – Peak	

Band-edge measurements for radiated emissions	
Antenna 2	Antenna 2
IEEE 802.11b	IEEE 802.11g
	
Channel 11 / 2462 MHz – Average	Channel 11 / 2462 MHz – Average
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 1 / 2412 MHz – Peak	Channel 3 / 2422 MHz – Peak
	
Channel 1 / 2412 MHz – Average	Channel 3 / 2422 MHz – Average

Band-edge measurements for radiated emissions	
Antenna 2	Antenna 2
IEEE 802.11n HT20	IEEE 802.11n HT40
	
Channel 11 / 2462 MHz – Peak	Channel 9 / 2452 MHz – Peak
	
Channel 11 / 2462 MHz – Average	Channel 9 / 2452 MHz – Average

5.9. Antenna Requirements

5.9.1. Standard Applicable

According to antenna requirement of §15.203.

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded.

And according to §15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

5.9.2. Antenna Connected Construction

5.9.2.1. Standard Applicable

According to § 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.

5.9.2.2. Antenna Connector Construction

The directional gains of antenna used for transmitting is 2.0dBi, and the antenna is a PCB antenna connect to PCB board and no consideration of replacement. Please see EUT photo for details.

5.9.2.3. Results: Compliance.

Measurement

The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module.

Conducted power refers ANSI C63.10:2013 Output power test procedure for DTS devices.

Radiated power refers to ANSI C63.10:2013 Radiated emissions tests.

Measurement parameters

Measurement parameter	
Detector:	Peak
Sweep Time:	Auto
Resolution bandwidth:	1MHz
Video bandwidth:	3MHz
Trace-Mode:	Max hold

Note: The antenna gain of the complete system is calculated by the difference of radiated power in EIRP and the conducted power of the module. For normal WLAN devices, the IEEE 802.11b mode is used.

Limits

FCC	ISED
Antenna Gain	
6 dBi	

Antenna 0

T_{nom}	V_{nom}	Lowest Channel 2412 MHz	Middle Channel 2437 MHz	Highest Channel 2462 MHz
Conducted power [dBm] Measured with DSSS modulation		-0.846	-1.044	-1.233
Radiated power [dBm] Measured with DSSS modulation		0.420	0.415	0.360
Gain [dBi] Calculated		1.266	1.459	1.593
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

Antenna 1

T_{nom}	V_{nom}	Lowest Channel 2412 MHz	Middle Channel 2437 MHz	Highest Channel 2462 MHz
Conducted power [dBm] Measured with DSSS modulation		-0.941	-0.997	-1.271
Radiated power [dBm] Measured with DSSS modulation		0.350	0.505	0.317
Gain [dBi] Calculated		1.291	1.502	1.588
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

Antenna 2

T_{nom}	V_{nom}	Lowest Channel 2412 MHz	Middle Channel 2437 MHz	Highest Channel 2462 MHz
Conducted power [dBm] Measured with DSSS modulation		-1.266	-1.028	-1.242
Radiated power [dBm] Measured with DSSS modulation		0.008	0.448	0.370
Gain [dBi] Calculated		1.274	1.476	1.612
Measurement uncertainty			± 1.6 dB (cond.) / ± 3.8 dB (rad.)	

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6. LIST OF MEASURING EQUIPMENTS

Item	Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Next Cal.
1	Power Meter	R&S	NRVS	100444	2017-06-17	2018-06-16
2	Power Sensor	R&S	NRV-Z81	100458	2017-06-17	2018-06-16
3	Power Sensor	R&S	NRV-Z32	10057	2017-06-17	2018-06-16
4	ESA-E SERIES SPECTRUM ANALYZER	Agilent	E4407B	MY41440754	2016-11-18	2017-11-17
5	MXA Signal Analyzer	Agilent	N9020A	MY49100040	2017-06-17	2018-06-16
6	SPECTRUM ANALYZER	R&S	FSP	100503	2017-06-17	2018-06-16
7	3m Semi Anechoic Chamber	SIDT FRANKONIA	SAC-3M	03CH03-HY	2017-06-17	2018-06-16
8	Positioning Controller	MF	MF-7082	/	2017-06-17	2018-06-16
9	EMI Test Software	AUDIX	E3	N/A	2017-06-17	2018-06-16
10	EMI Test Receiver	R&S	ESR 7	101181	2017-06-17	2018-06-16
11	AMPLIFIER	QuieTek	QTK-A2525G	CHM10809065	2016-11-18	2017-11-17
12	Active Loop Antenna	SCHWARZBECK	FMZB 1519B	00005	2017-06-23	2018-06-22
13	By-log Antenna	SCHWARZBECK	VULB9163	9163-470	2017-05-02	2018-05-01
14	Horn Antenna	EMCO	3115	6741	2017-06-23	2018-06-22
15	Broadband Horn Antenna	SCHWARZBECK	BBHA 9170	791	2017-09-21	2018-09-20
16	Broadband Preamplifier	SCHWARZBECK	BBV 9719	9719-025	2017-09-21	2018-09-20
17	RF Cable-R03m	Jye Bao	RG142	CB021	2017-06-17	2018-06-16
18	RF Cable-HIGH	SUHNER	SUCOFLEX 106	03CH03-HY	2017-06-17	2018-06-16
19	TEST RECEIVER	R&S	ESCI	101142	2017-06-17	2018-06-16
20	RF Cable-CON	UTIFLEX	3102-26886-4	CB049	2017-06-17	2018-06-16
21	10dB Attenuator	SCHWARZBECK	MTS-IMP136	261115-001-0032	2017-06-17	2018-06-16
22	Artificial Mains	R&S	ENV216	101288	2017-06-17	2018-06-16
Note: All equipment is calibrated through GUANGZHOU LISAI CALIBRATION AND TEST CO.,LTD.						

7. TEST SETUP PHOTOGRAPHS OF EUT

Please refer to separated files for Test Setup Photos of the EUT.

8. EXTERIOR PHOTOGRAPHS OF THE EUT

Please refer to separated files for External Photos of the EUT.

9. INTERIOR PHOTOGRAPHS OF THE EUT

Please refer to separated files for Internal Photos of the EUT.

----------THE END OF REPORT----------

1. TEST SETUP PHOTOGRAPHS

1.1. Photo of Radiated Emissions Measurement

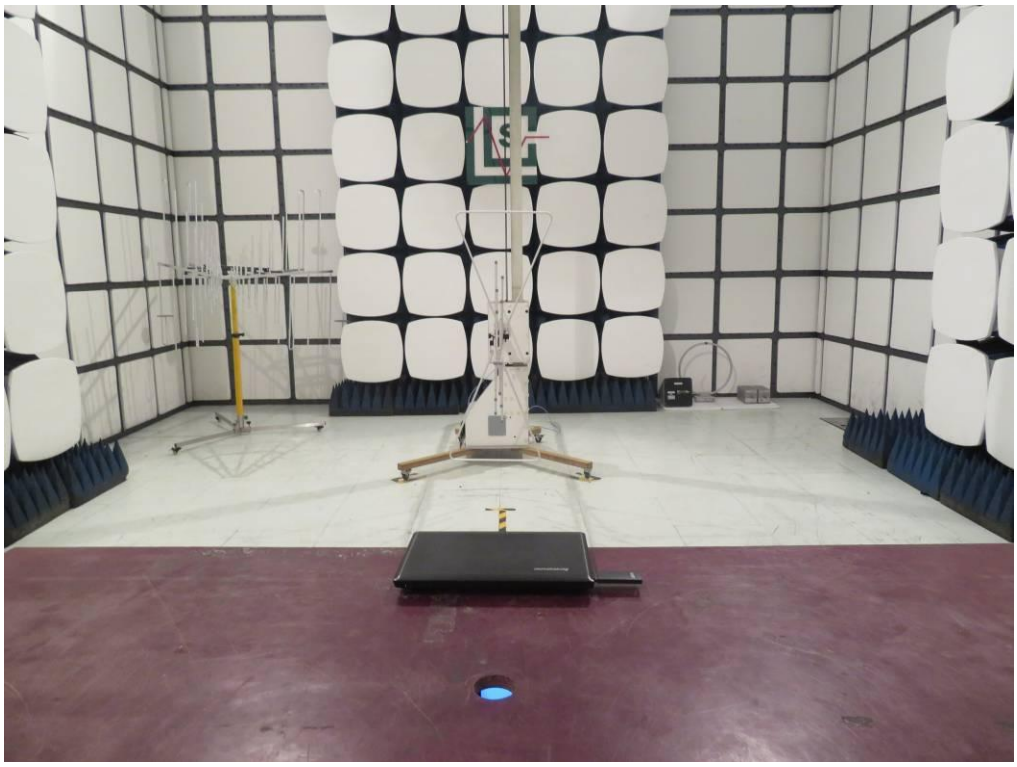

Fig.1

Fig.2

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1.2. Photo of Line Conducted Emissions Measurement

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1. EXTERIOR HOTOGRAPHS

Fig.1

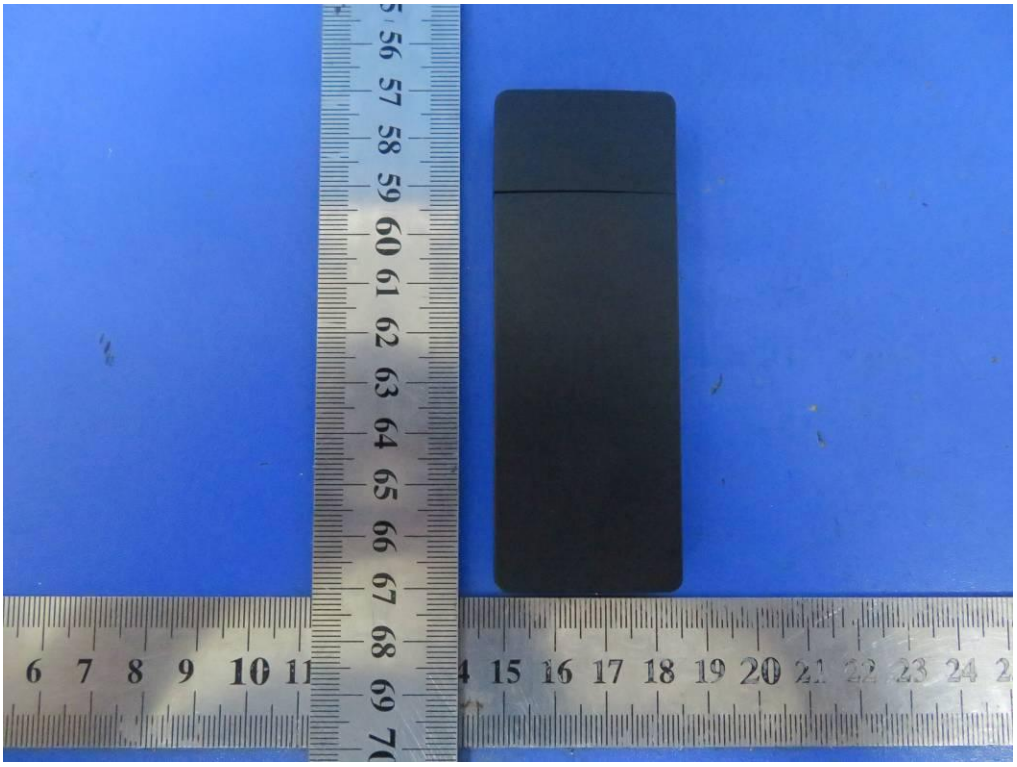

Fig.2

Fig.3

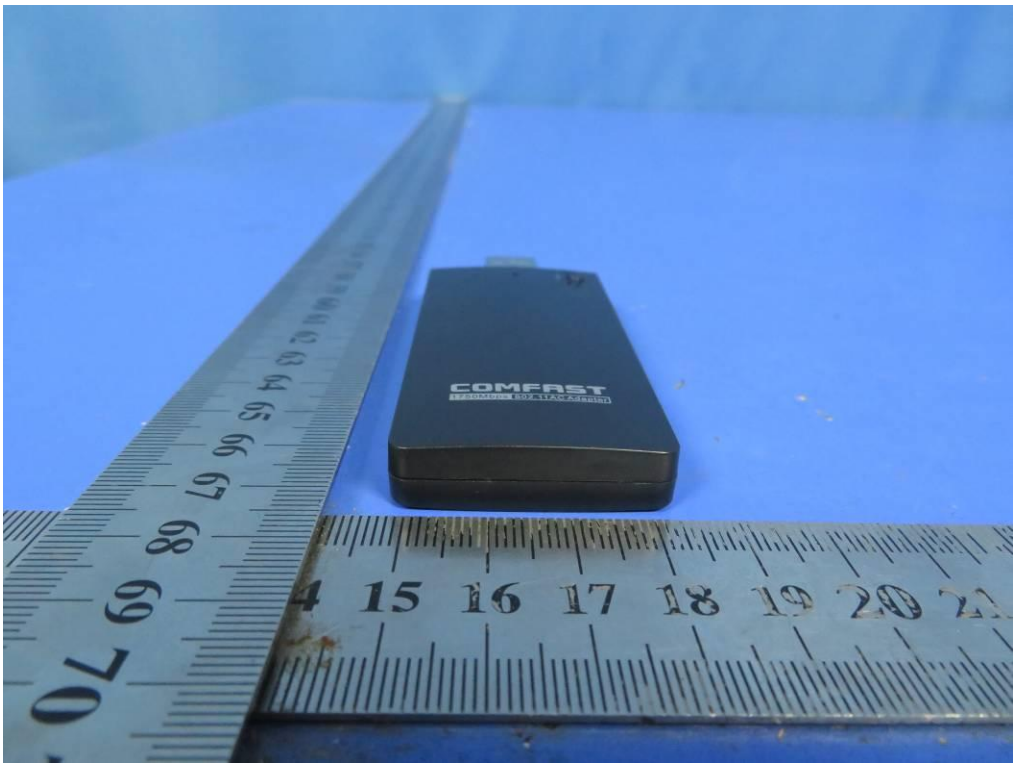

Fig.4

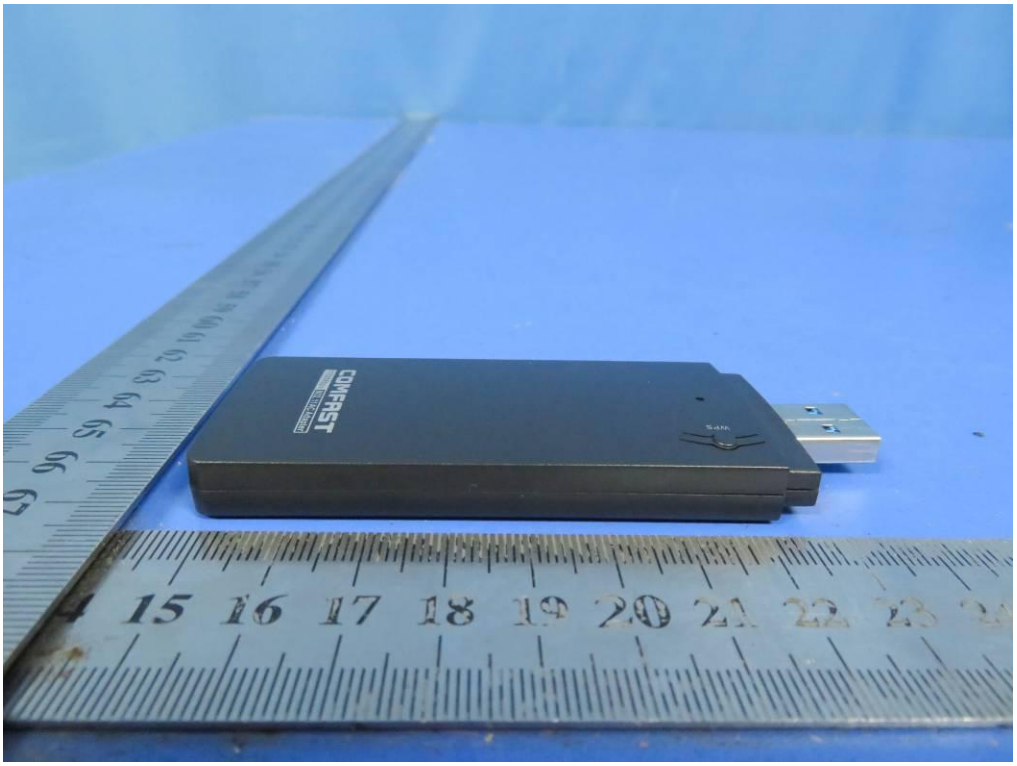

Fig.5

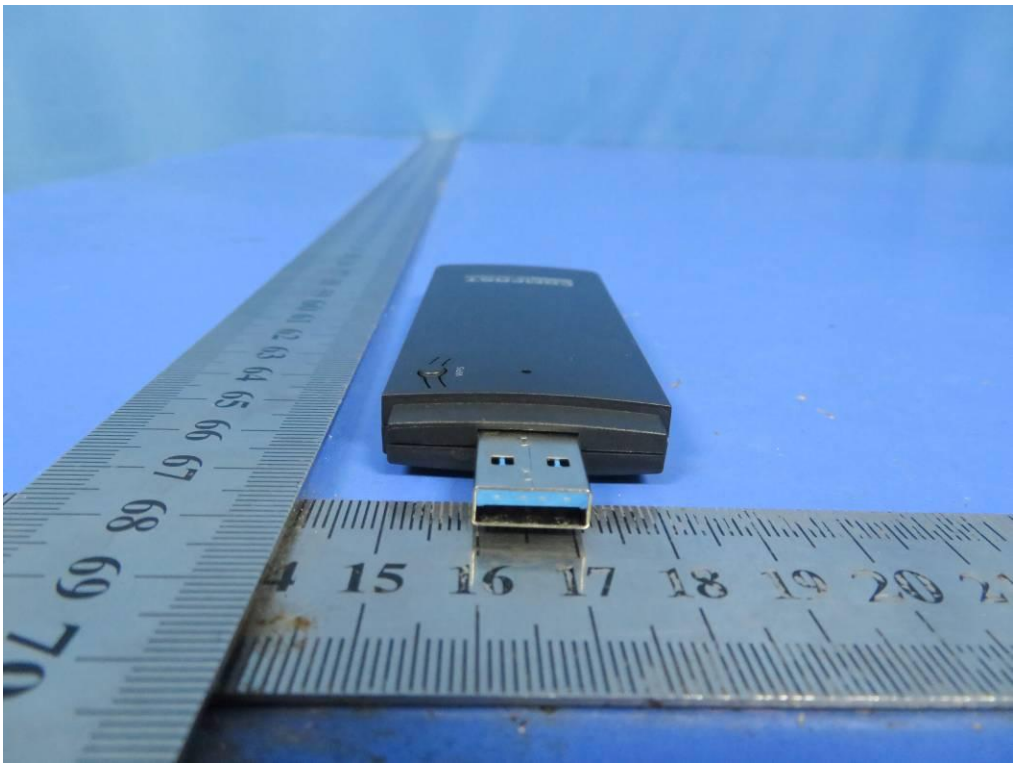

Fig.6

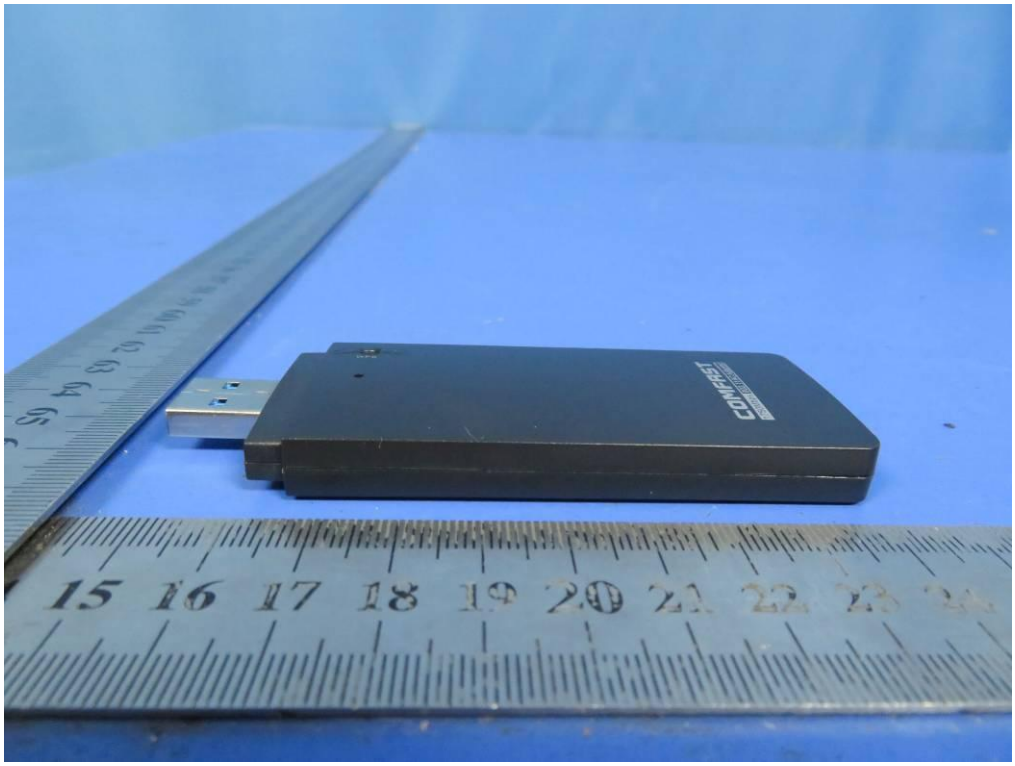

Fig.7

1. INTERIOR PHOTOGRAPHS

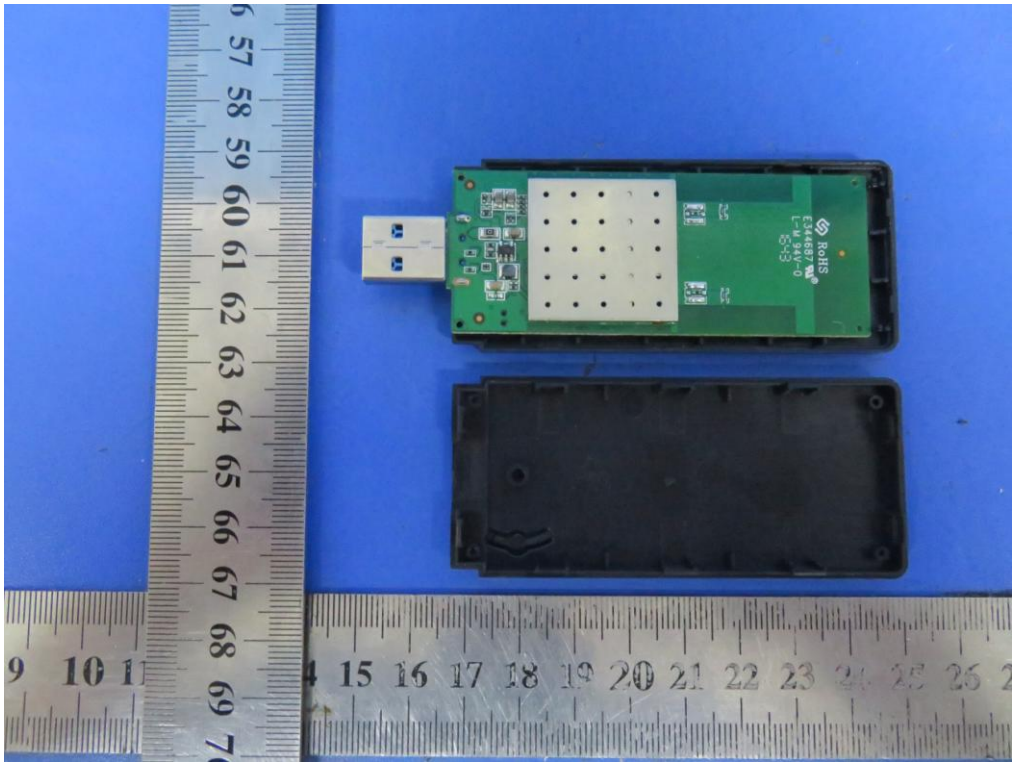

Fig.1

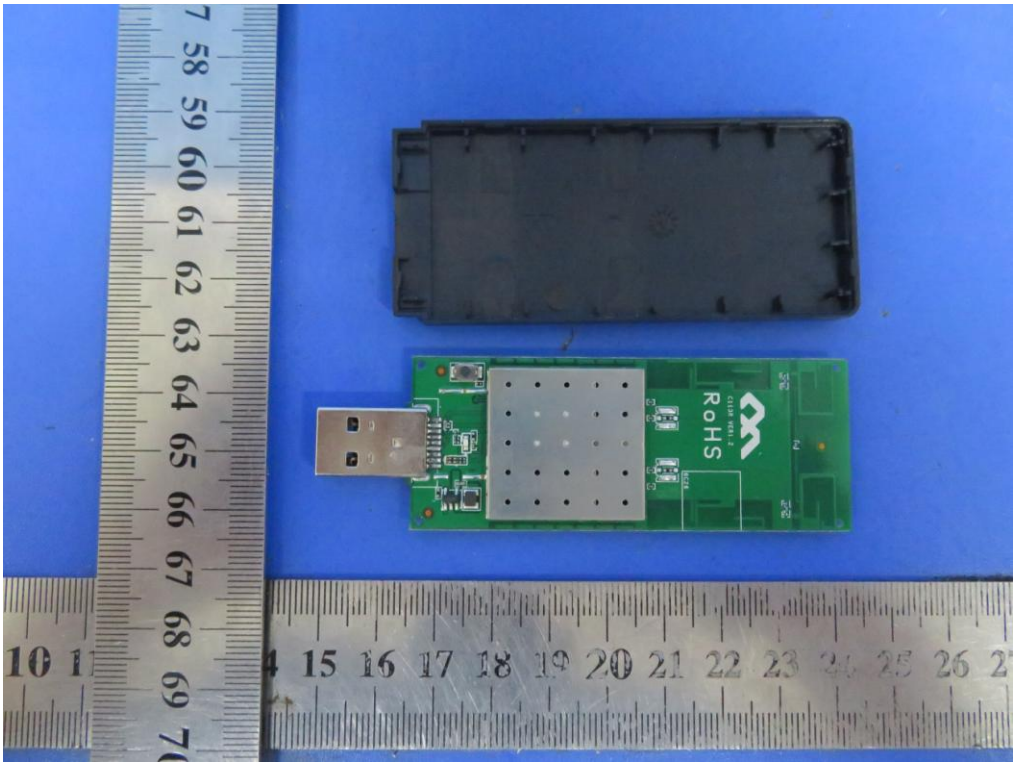

Fig.2

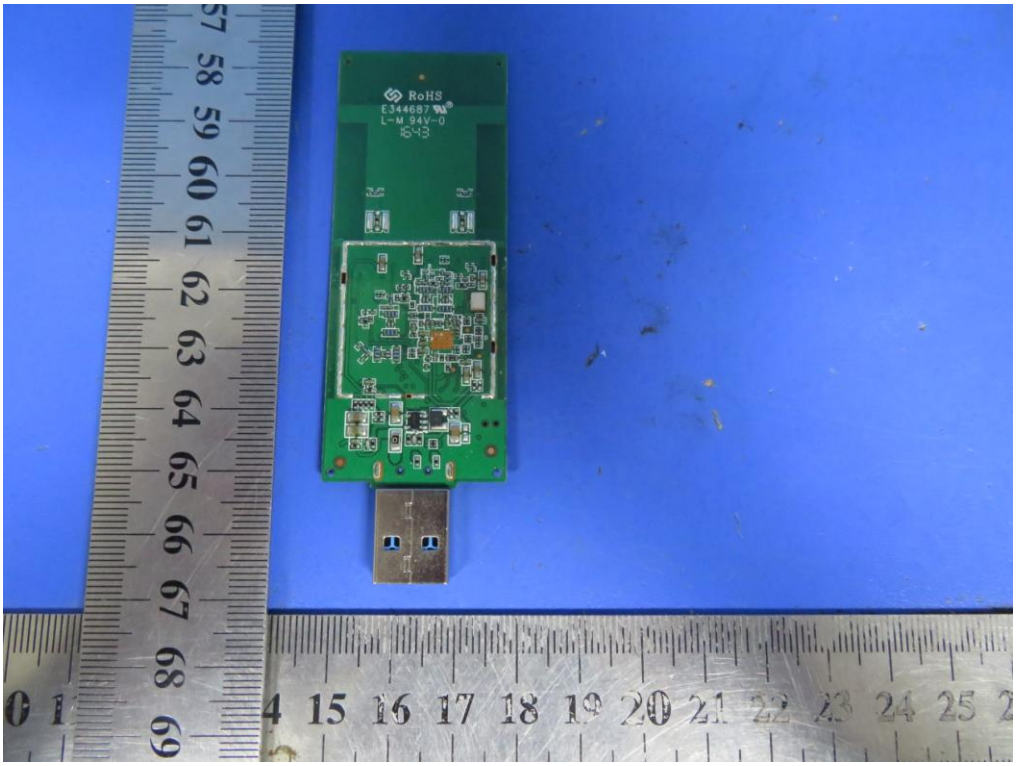

Fig.3

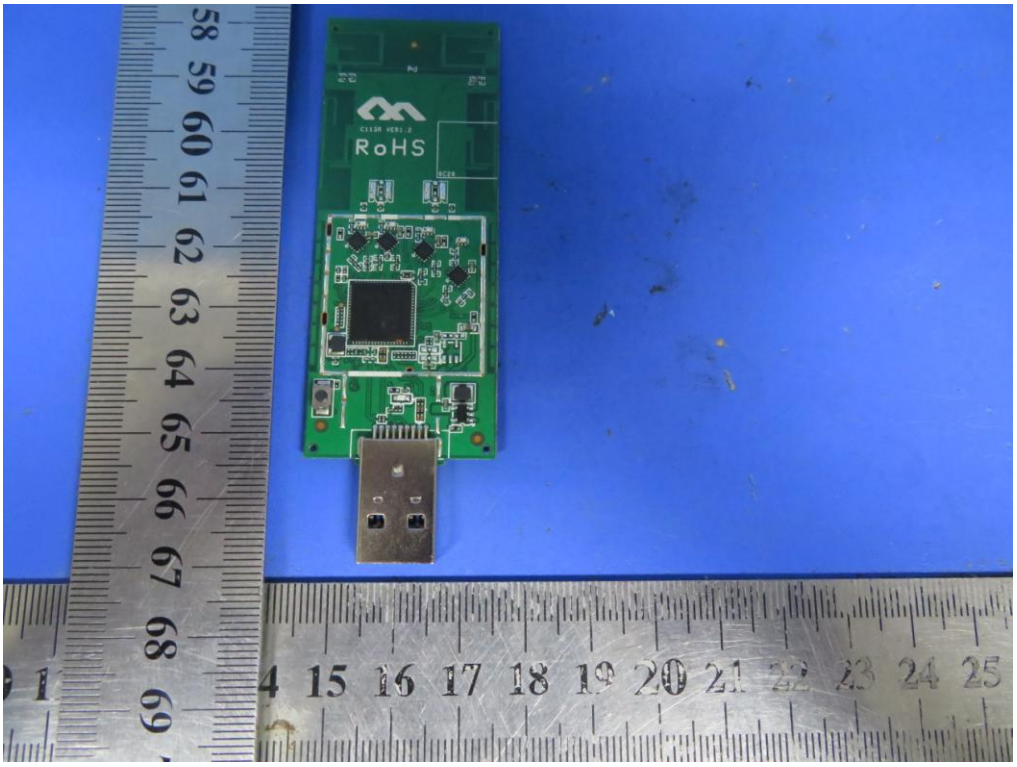

Fig.4

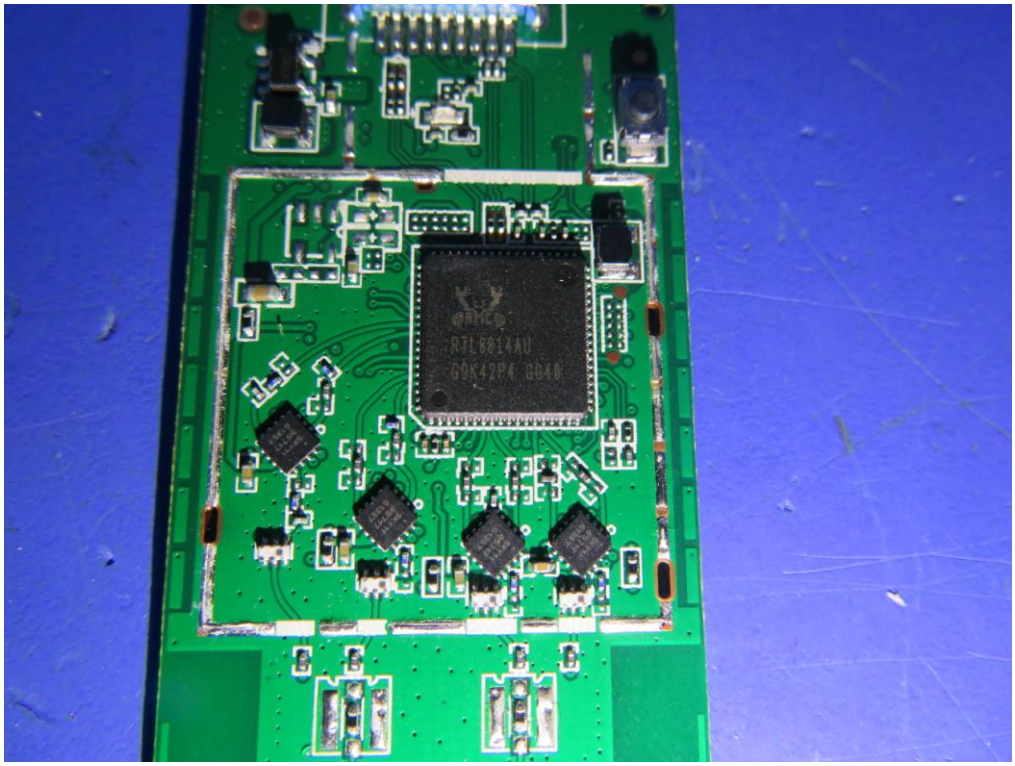

Fig.5

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