

8.5 Radiated Spurious Emissions

Test Requirements and limit,

§15.247(d), §15.205, §15.209

In any 100 kHz bandwidth outside the operating frequency band. In case the emission fall within the restricted band specified on 15.205(a) and (b), then the 15.209(a) limit in the table below has to be followed

▪ **FCC Part 15.209(a) and (b)**

Frequency (MHz)	Limit (uV/m)	Measurement Distance (meter)
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

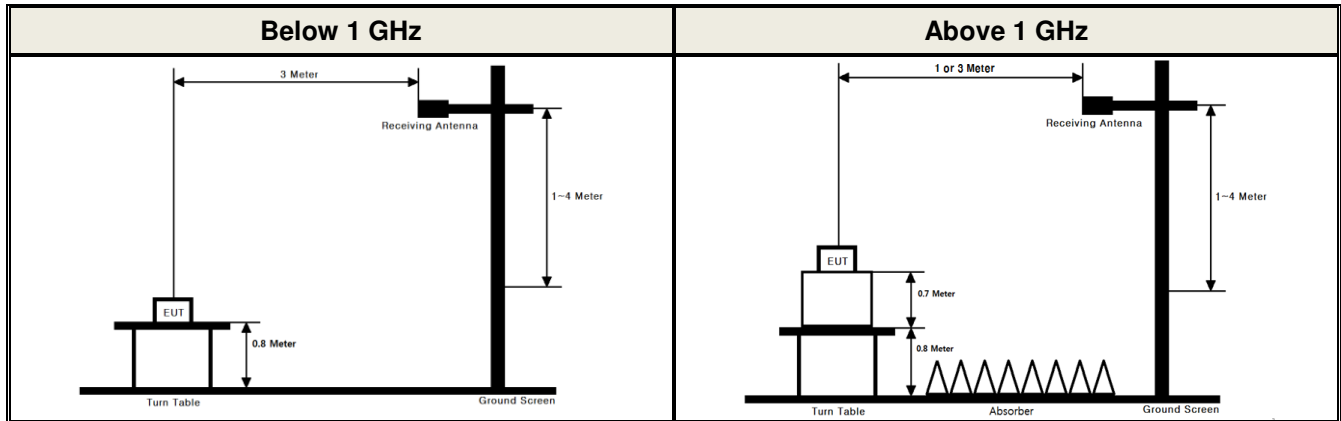
** Except as provided in 15.209(g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54 - 72 MHz, 76 - 88 MHz, 174 - 216 MHz or 470 - 806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g. 15.231 and 15.241.

▪ **FCC Part 15.205 (a):** Only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	MHz	GHz	GHz
0.009 ~ 0.110	8.41425 ~ 8.41475	108 ~ 121.94	1300 ~ 1427	4.5 ~ 5.15	14.47 ~ 14.5
0.495 ~ 0.505	12.29 ~ 12.293	123 ~ 138	1435 ~ 1626.5	5.35 ~ 5.46	15.35 ~ 16.2
2.1735 ~ 2.1905	12.51975 ~	149.9 ~ 150.05	1645.5 ~ 1646.5	7.25 ~ 7.75	17.7 ~ 21.4
4.125 ~ 4.128	12.52025	156.52475 ~	1660 ~ 1710	8.025 ~ 8.5	22.01 ~ 23.12
4.17725 ~ 4.17775	12.57675 ~	156.52525	1718.8 ~ 1722.2	9.0 ~ 9.2	23.6 ~ 24.0
4.20725 ~ 4.20775	12.57725	156.7 ~ 156.9	2200 ~ 2300	9.3 ~ 9.5	31.2 ~ 31.8
6.215 ~ 6.218	13.36 ~ 13.41	162.0125 ~ 167.17	2310 ~ 2390	10.6 ~ 12.7	36.43 ~ 36.5
6.26775 ~ 6.26825	16.42 ~ 16.423	167.72 ~ 173.2	2483.5 ~ 2500	13.25 ~ 13.4	Above 38.6
6.31175 ~ 6.31225	16.69475 ~	240 ~ 285	2655 ~ 2900		
8.291 ~ 8.294	16.69525	322 ~ 335.4	3260 ~ 3267		
8.362 ~ 8.366	16.80425 ~	399.90 ~ 410	3332 ~ 3339		
8.37625 ~ 8.38675	16.80475	608 ~ 614	3345.8 ~ 3358		
	25.5 ~ 25.67	960 ~ 1240	3600 ~ 4400		
	37.5 ~ 38.25				
	73 ~ 74.6				
	74.8 ~ 75.2				

▪ **FCC Part 15.205(b):** The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

Test Configuration



TEST PROCEDURE

1. The EUT is placed on a non-conductive table, emission measurements at below 1 GHz, the table height is 80 cm and above 1 GHz, the table height is 1.5 m.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. EUT is set 3 m away from the receiving antenna, which is varied from 1 m to 4 m to find out the highest emissions.
4. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
5. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
6. Repeat above procedures until the measurements for all frequencies are complete.

Measurement Instrument Setting for Radiated Emission Measurements.

The radiated emission was tested according to the section 6.3, 6.4, 6.5 and 6.6 of the ANSI C63.10-2013 with following settings.

Peak Measurement:

RBW = As specified in below table , VBW ≥ 3 x RBW, Sweep = Auto, Detector = Peak, Trace mode = Max Hold until the trace stabilizes.

Frequency	RBW
9 - 150 kHz	200 - 300 Hz
0.15 - 30 MHz	9 - 10 kHz
30 - 1000 MHz	100 - 120 kHz
> 1000 MHz	1 MHz

Average Measurement:

1. RBW = 1 MHz (unless otherwise specified).
2. VBW ≥ 3 x RBW.
3. Detector = RMS (Number of points ≥ 2 x Span / RBW)
4. Averaging type = power. (i.e., RMS)
5. Sweep time = auto.
6. Perform a trace average of at least 100 traces.
7. A correction factor shall be added to the measurement results prior to comparing to the emission limit in order to compute the emission level that would have been measured had the test been performed at 100 percent duty cycle. The correction factor is computed as follows:
 - 1) If power averaging (RMS) mode was used in step 4, then the applicable correction factor is $10 \log(1/x)$, where x is the duty cycle.
 - 2) If linear voltage averaging mode was used in step 4, then the applicable correction factor is $20 \log(1/x)$, where x is the duty cycle.
 - 3) If a specific emission is demonstrated to be continuous (≥ 98 percent duty cycle) rather than turning on and off with the transmit cycle, then no duty cycle correction is required for that emission.

Duty Cycle Corrections (Refer to appendix II for duty cycle measurement procedure and plots)

Band	Duty Cycle (%)	T _{on} (ms)	T _{on} + T _{off} (ms)	DCF = 10log(1 / Duty) (dB)
802.11b	100.00	-	-	-
802.11g	100.00	-	-	-
802.11n(HT20)	100.00	-	-	-
802.11n(HT40)	100.00	-	-	-

9 kHz~ 25 GHz Data (802.11b & 1 Mbps)

▪ 2412 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2384.83	V	Y	PK	46.98	0.78	N/A	N/A	47.76	74.00	26.24
2384.77	V	Y	AV	36.26	0.78	N/A	N/A	37.04	54.00	16.96
4823.96	H	Y	PK	49.10	7.60	N/A	N/A	56.70	74.00	17.30
4823.95	H	Y	AV	43.57	7.60	N/A	N/A	51.17	54.00	2.83

▪ 2437 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4873.69	H	Y	PK	48.58	7.54	N/A	N/A	56.12	74.00	17.88
4873.98	H	Y	AV	42.43	7.54	N/A	N/A	49.97	54.00	4.03

▪ 2462 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2485.50	V	Y	PK	46.10	1.10	N/A	N/A	47.20	74.00	26.80
2483.80	V	Y	AV	36.26	1.10	N/A	N/A	37.36	54.00	16.64
4923.72	H	Y	PK	49.11	7.40	N/A	N/A	56.51	74.00	17.49
4923.93	H	Y	AV	43.05	7.40	N/A	N/A	50.45	54.00	3.55

Note.

1. Measurement Distance = 3 m for below 10 GHz, Measurement Distance = 1 m for above 10 GHz.
So Distance Correction Factor : - 9.54 dB = 20*log(1 m / 3 m)
2. No other spurious and harmonic emissions were found greater than listed emissions on above table.
3. The band edge test has performed between 2310-2390 MHz and 2483.5-2500 MHz.
The worst results were reported in the table.
4. Sample Calculation.
Margin = Limit – Result / Result = Reading + T.F+ DCF + Distance Factor / T.F = AF + CL – AG
Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain,
DCF = Duty Cycle Correction Factor.

9 kHz~ 25 GHz Data (802.11g & 54 Mbps)

▪ 2412 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2381.50	V	Y	PK	47.17	0.78	N/A	N/A	47.95	74.00	26.05
2381.67	V	Y	AV	36.02	0.78	N/A	N/A	36.80	54.00	17.20
4824.51	H	Y	PK	45.29	7.60	N/A	N/A	52.89	74.00	21.11
4823.90	H	Y	AV	34.28	7.60	N/A	N/A	41.88	54.00	12.12

▪ 2437 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4874.09	H	Y	PK	44.55	7.54	N/A	N/A	52.09	74.00	21.91
4875.01	H	Y	AV	34.15	7.54	N/A	N/A	41.69	54.00	12.31

▪ 2462 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2485.10	V	Y	PK	46.31	1.10	N/A	N/A	47.41	74.00	26.59
2484.35	V	Y	AV	36.06	1.10	N/A	N/A	37.16	54.00	16.84
4923.69	H	Y	PK	44.79	7.40	N/A	N/A	52.19	74.00	21.81
4923.90	H	Y	AV	34.21	7.40	N/A	N/A	41.61	54.00	12.39

Note.

1. Measurement Distance = 3 m for below 10 GHz, Measurement Distance = 1 m for above 10 GHz.
So Distance Correction Factor : - 9.54 dB = 20*log(1 m / 3 m)
2. No other spurious and harmonic emissions were found greater than listed emissions on above table.
3. The band edge test has performed between 2310-2390 MHz and 2483.5-2500 MHz.
The worst results were reported in the table.
4. Sample Calculation.
Margin = Limit – Result / Result = Reading + T.F+ DCF + Distance Factor / T.F = AF + CL – AG
Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain,
DCF = Duty Cycle Correction Factor.

9 kHz~ 25 GHz Data (802.11n HT20 & MCS 0)

▪ 2412 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2383.47	V	Y	PK	46.01	0.78	N/A	N/A	46.79	74.00	27.21
2383.10	V	Y	AV	36.28	0.78	N/A	N/A	37.06	54.00	16.94
4824.07	H	Y	PK	45.11	7.60	N/A	N/A	52.71	74.00	21.29
4823.95	H	Y	AV	34.38	7.60	N/A	N/A	41.98	54.00	12.02

▪ 2437 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4873.88	H	Y	PK	44.20	7.54	N/A	N/A	51.74	74.00	22.26
4874.36	H	Y	AV	33.78	7.54	N/A	N/A	41.32	54.00	12.68

▪ 2462 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2484.42	V	Y	PK	45.94	1.10	N/A	N/A	47.04	74.00	26.96
2484.08	V	Y	AV	36.12	1.10	N/A	N/A	37.22	54.00	16.78
4923.55	H	Y	PK	44.44	7.40	N/A	N/A	51.84	74.00	22.16
4924.59	H	Y	AV	34.15	7.40	N/A	N/A	41.55	54.00	12.45

Note.

1. Measurement Distance = 3 m for below 10 GHz, Measurement Distance = 1 m for above 10 GHz.
So Distance Correction Factor : - 9.54 dB = 20*log(1 m / 3 m)
2. No other spurious and harmonic emissions were found greater than listed emissions on above table.
3. The band edge test has performed between 2310-2390 MHz and 2483.5-2500 MHz.
The worst results were reported in the table.
4. Sample Calculation.
Margin = Limit – Result / Result = Reading + T.F+ DCF + Distance Factor / T.F = AF + CL – AG
Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain,
DCF = Duty Cycle Correction Factor.

9 kHz~ 25 GHz Data (802.11n HT40 & MCS 0)

▪ 2422 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2382.73	V	Y	PK	46.10	0.78	N/A	N/A	46.88	74.00	27.12
2383.47	V	Y	AV	36.40	0.78	N/A	N/A	37.18	54.00	16.82
4843.73	H	Y	PK	45.45	7.58	N/A	N/A	53.03	74.00	20.97
4843.87	H	Y	AV	34.31	7.58	N/A	N/A	41.89	54.00	12.11

▪ 2437 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
4874.45	H	Y	PK	44.02	7.54	N/A	N/A	51.56	74.00	22.44
4873.92	H	Y	AV	33.90	7.54	N/A	N/A	41.44	54.00	12.56

▪ 2452 MHz

Frequency (MHz)	ANT Pol	EUT Position (Axis)	Detector Mode	Reading (dBuV)	T.F (dB/m)	DCF (dB)	Distance Factor(dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)
2483.92	V	Y	PK	45.52	1.10	N/A	N/A	46.62	74.00	27.38
2483.92	V	Y	AV	35.94	1.10	N/A	N/A	37.04	54.00	16.96
4904.08	H	Y	PK	44.08	7.35	N/A	N/A	51.43	74.00	22.57
4903.24	H	Y	AV	33.61	7.35	N/A	N/A	40.96	54.00	13.04

Note.

1. Measurement Distance = 3 m for below 10 GHz, Measurement Distance = 1 m for above 10 GHz.
So Distance Correction Factor : - 9.54 dB = 20*log(1 m / 3 m)
2. No other spurious and harmonic emissions were found greater than listed emissions on above table.
3. The band edge test has performed between 2310-2390 MHz and 2483.5-2500 MHz.
The worst results were reported in the table.
4. Sample Calculation.
Margin = Limit – Result / Result = Reading + T.F+ DCF + Distance Factor / T.F = AF + CL – AG
Where, T.F = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain,
DCF = Duty Cycle Correction Factor.

8.6 Power-line conducted emissions

Test Requirements and limit, §15.207

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 the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network(LISN).

Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

Frequency Range (MHz)	Conducted Limit (dBuV)	
	Quasi-Peak	Average
0.15 ~ 0.5	66 to 56 *	56 to 46 *
0.5 ~ 5	56	46
5 ~ 30	60	50

* Decreases with the logarithm of the frequency

■ TEST PROCEDURE

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to the test power supply.
3. The measurement results are obtained as described below:
4. Detectors – Quasi Peak and Average Detector.

■ Test Results: **NA**

8.7 Occupied Bandwidth

Test Requirements, RSS-Gen [6.6]

When an occupied bandwidth value is not specified in the applicable RSS, the transmitted signal bandwidth to be reported is to be its 99 % emission bandwidth, as calculated or measured.

■ TEST CONFIGURATION

Refer to the APPENDIX I.

■ TEST PROCEDURE

- The transmitter shall be operated at its maximum carrier power measured under normal test conditions.
- The span of the analyzer shall be set to capture all products of the modulation process, including the emission skirts.
- The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the occupied bandwidth (OBW) and video bandwidth (VBW) shall be approximately 3x RBW.

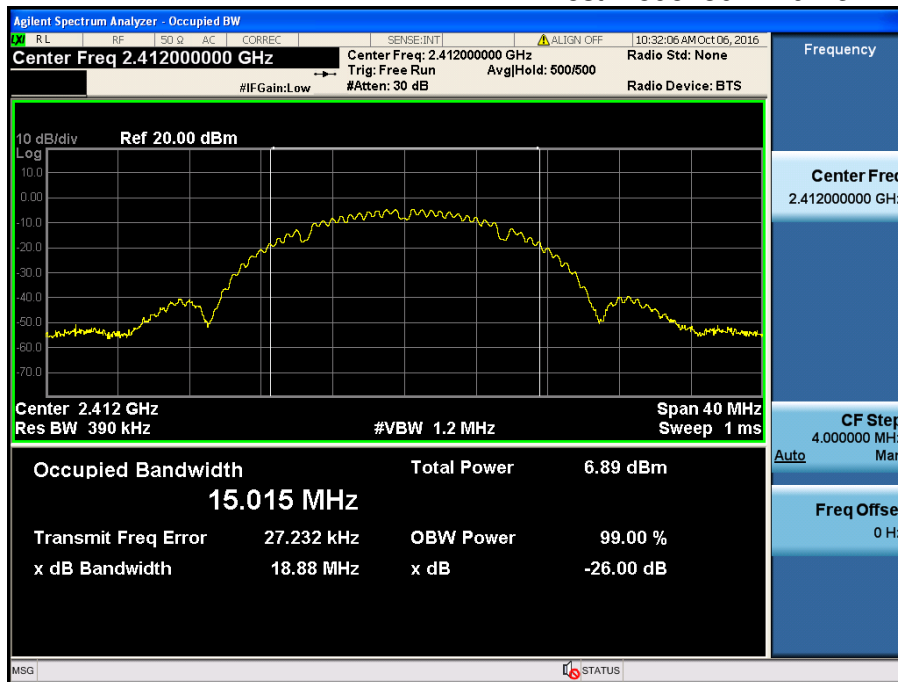
■ TEST RESULTS: **Comply**

Test Mode	Frequency	Test Results[MHz]
802.11b	Lowest	15.015
	Middle	15.023
	Highest	15.040
802.11g	Lowest	17.080
	Middle	17.161
	Highest	17.158
802.11n HT20	Lowest	18.359
	Middle	18.340
	Highest	18.371
802.11n HT40	Lowest	36.387
	Middle	36.528
	Highest	36.564

RESULT PLOTS

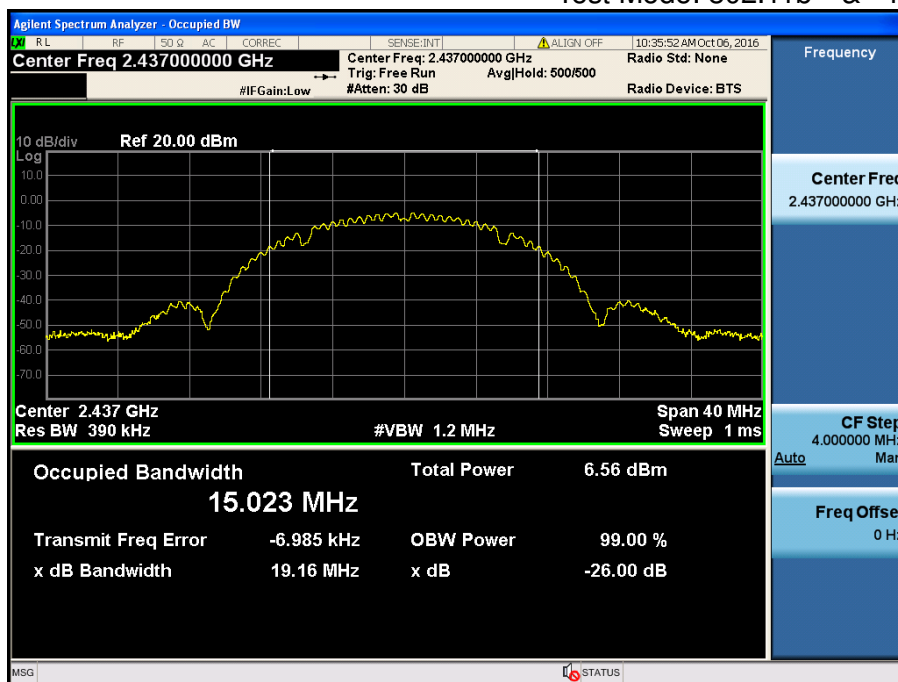
Occupied Bandwidth

Test Mode: 802.11b & Lowest



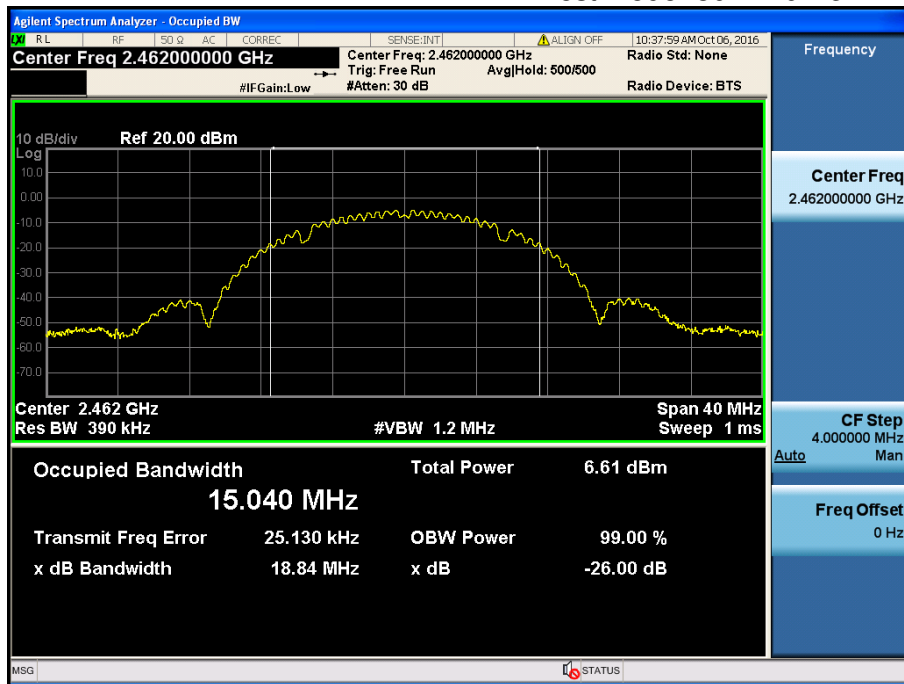
Occupied Bandwidth

Test Mode: 802.11b & Middle



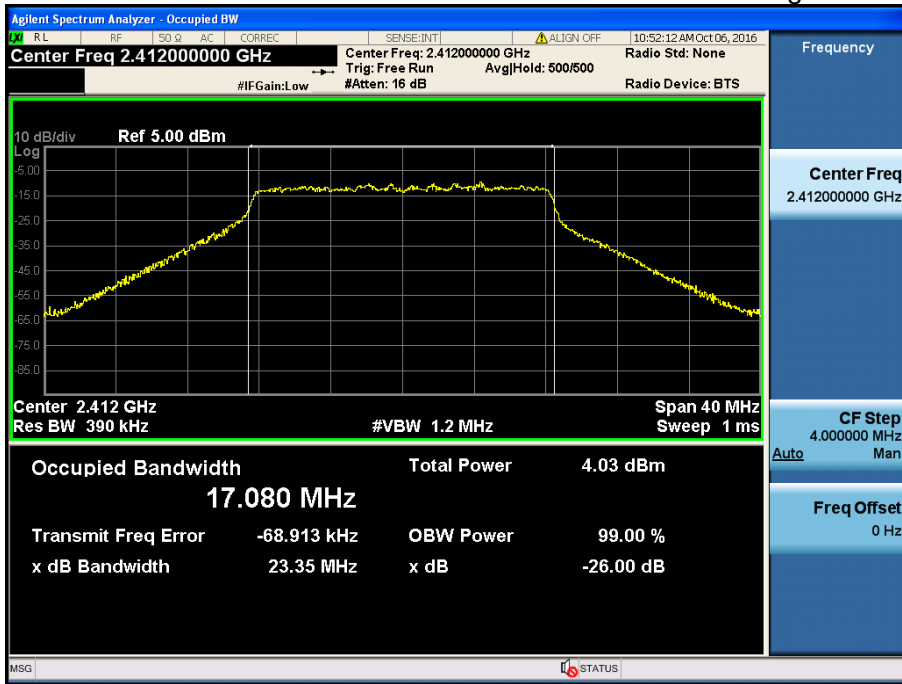
Occupied Bandwidth

Test Mode: 802.11b & Highest



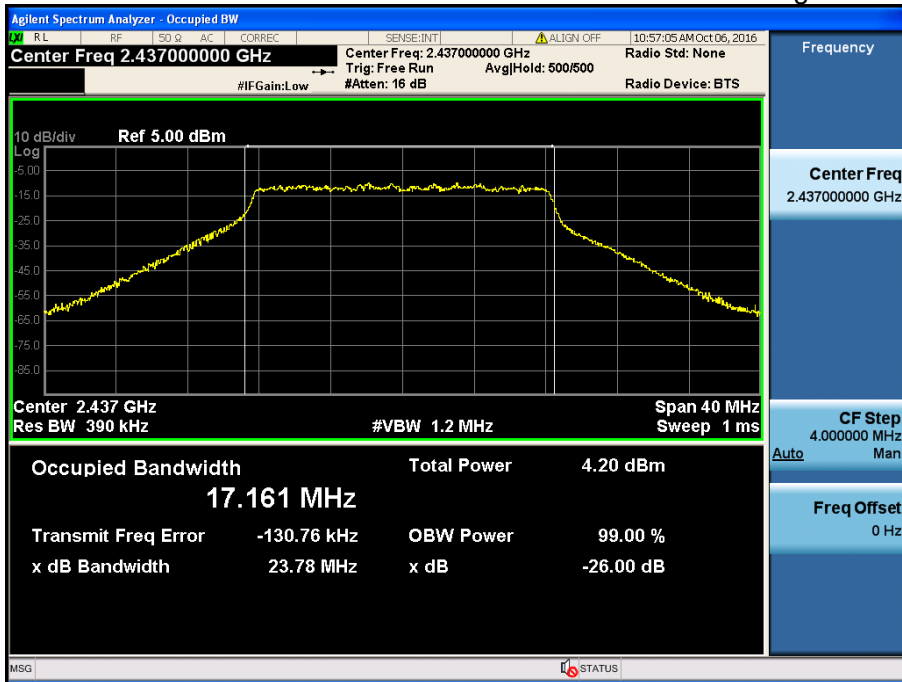
Occupied Bandwidth

Test Mode: 802.11g & Lowest



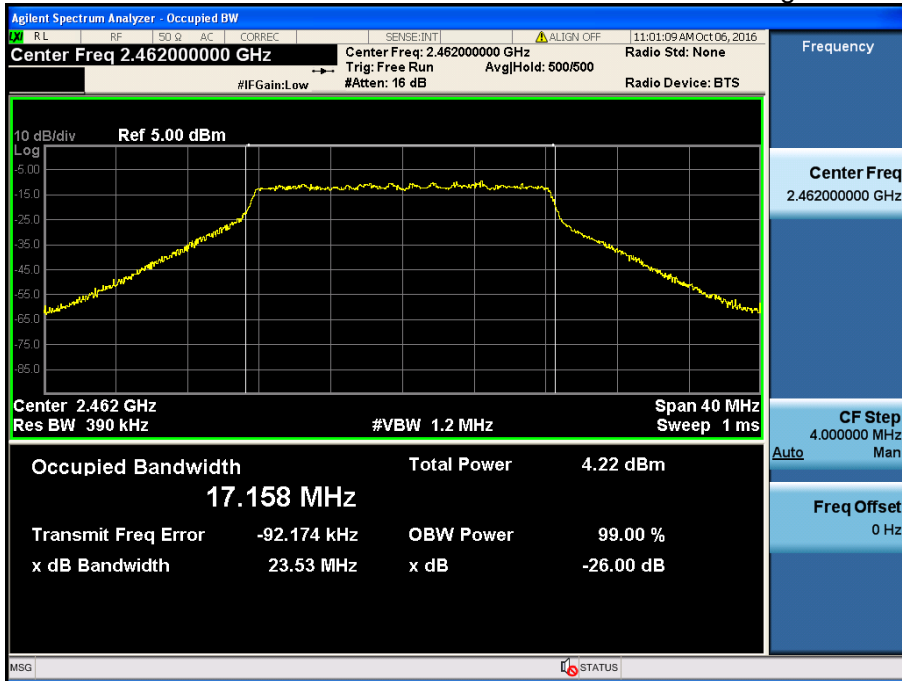
Occupied Bandwidth

Test Mode: 802.11g & Middle



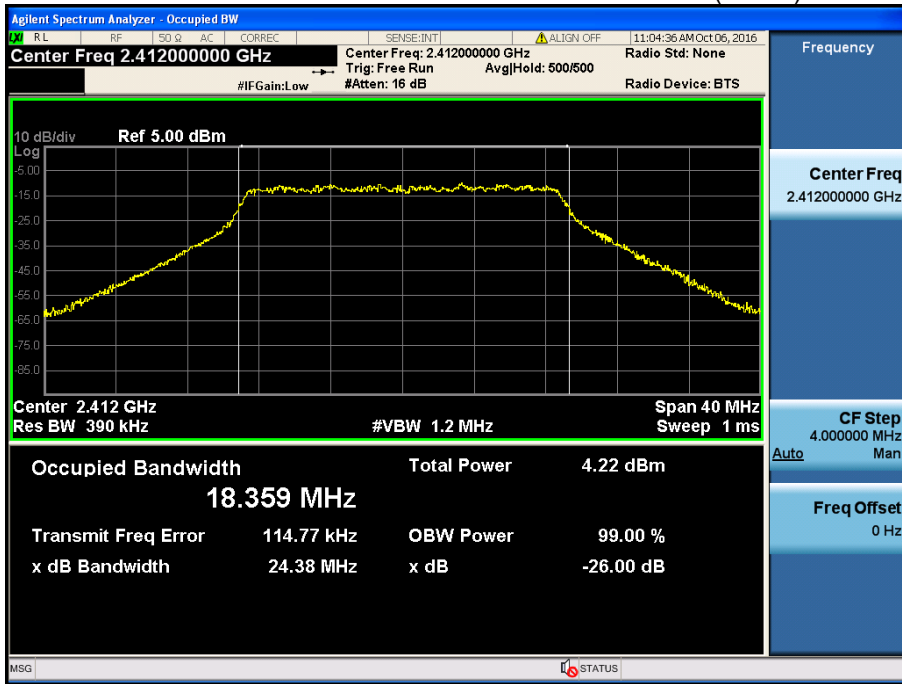
Occupied Bandwidth

Test Mode: 802.11g & Highest



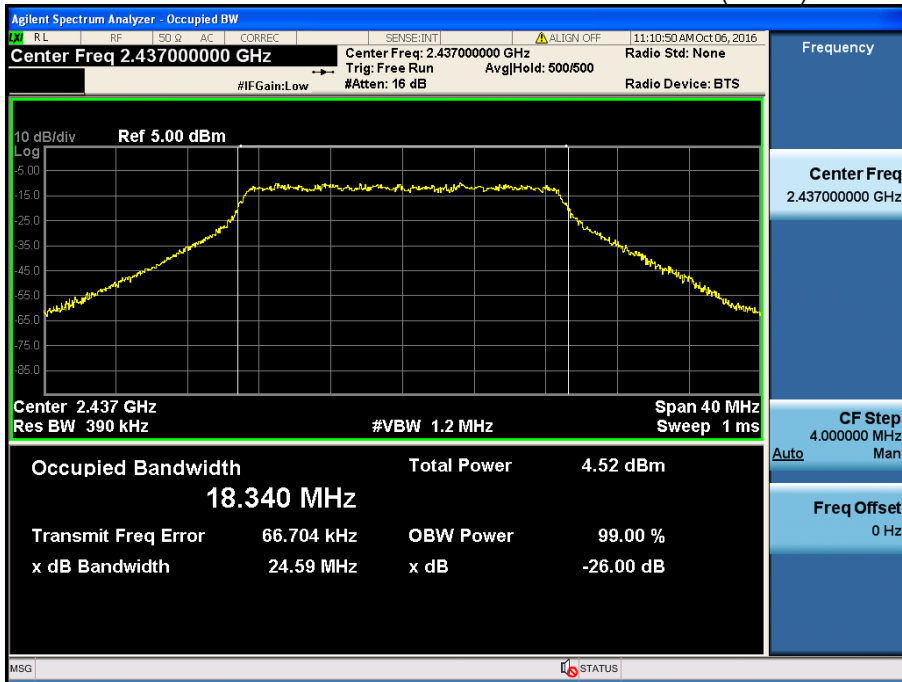
Occupied Bandwidth

Test Mode: 802.11n(HT20) & Lowest



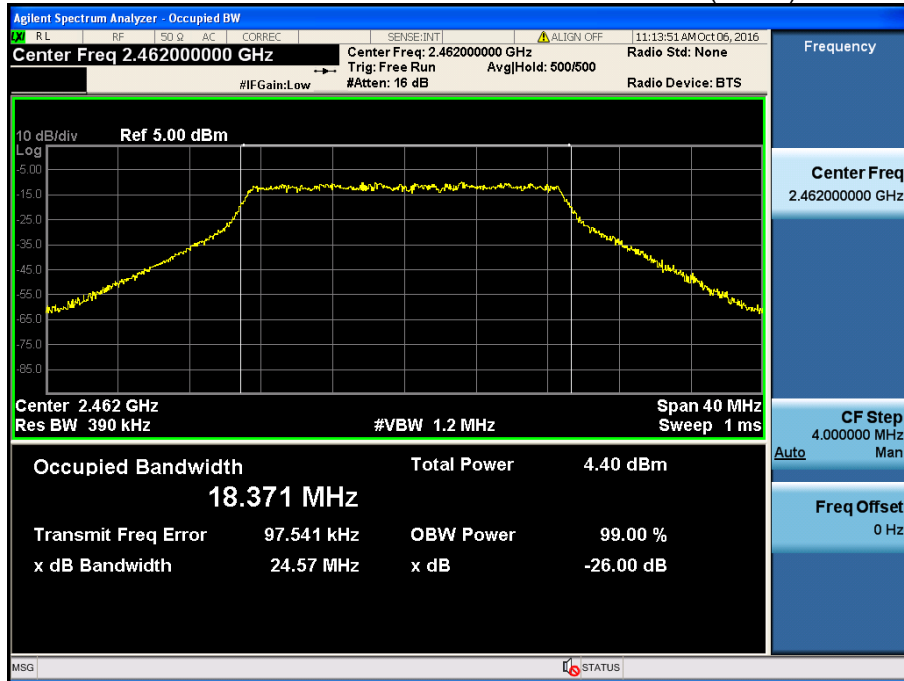
Occupied Bandwidth

Test Mode: 802.11n(HT20) & Middle



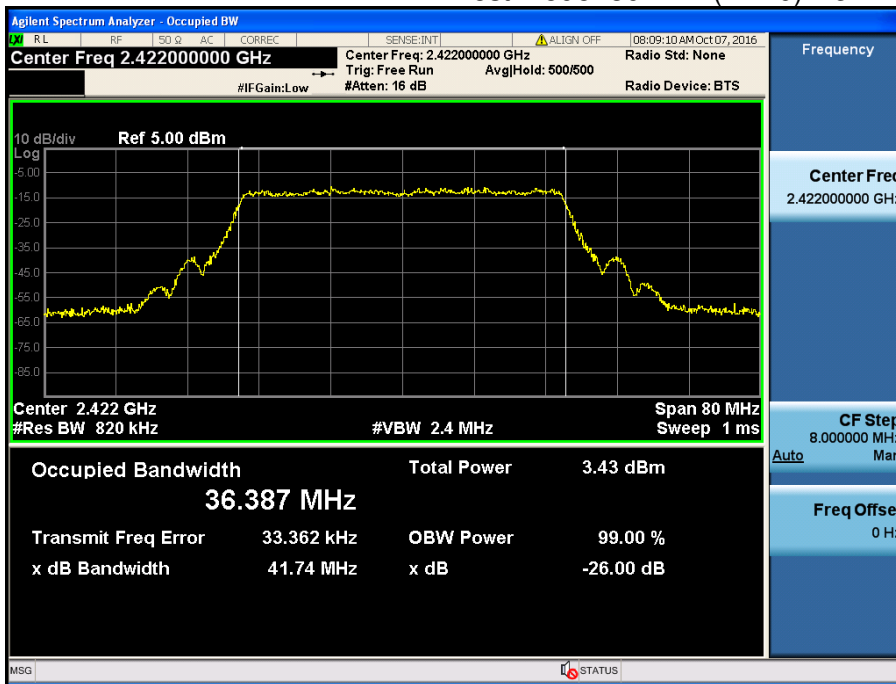
Occupied Bandwidth

Test Mode: 802.11n(HT20) & Highest



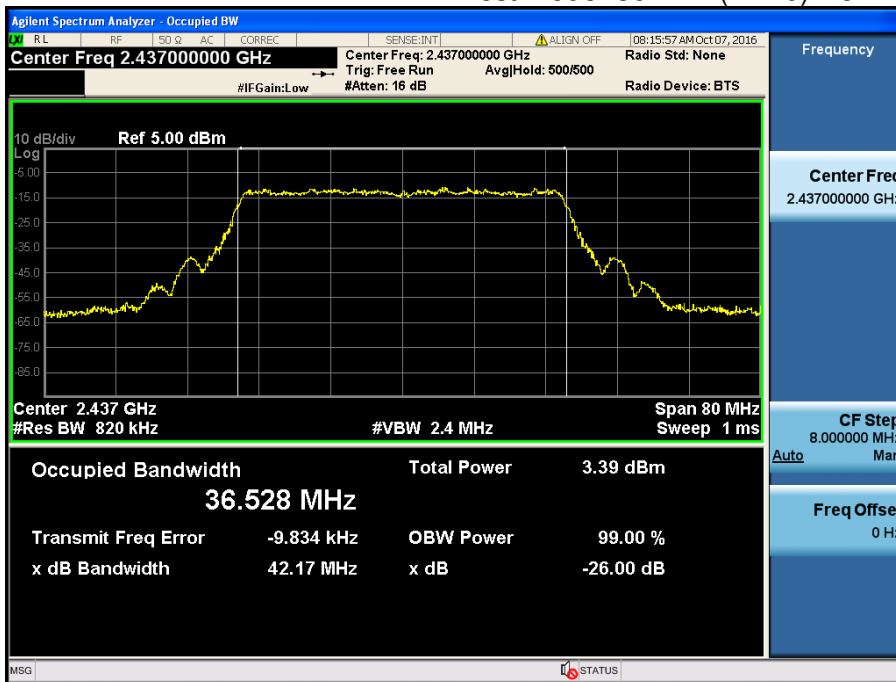
Occupied Bandwidth

Test Mode: 802.11n(HT40) & Lowest



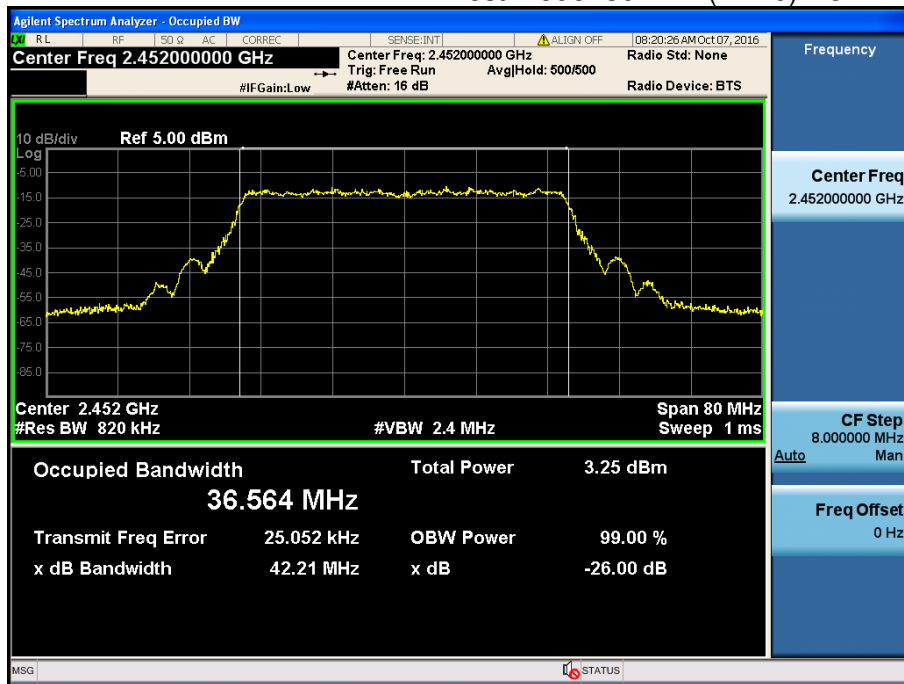
Occupied Bandwidth

Test Mode: 802.11n(HT40) & Middle



Occupied Bandwidth

Test Mode: 802.11n(HT40) & Highest



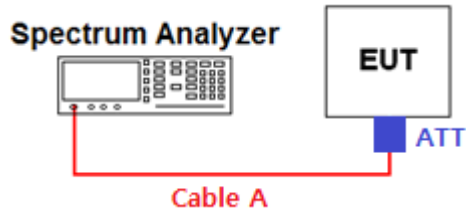
9. LIST OF TEST EQUIPMENT

Type	Manufacturer	Model	Cal.Date (yy/mm/dd)	Next.Cal.Date (yy/mm/dd)	S/N
MXA Signal Analyzer	Agilent Technologies	N9020A	16/09/09	17/09/09	MY46471248
Digital Multimeter	Agilent Technologies	34401A	16/01/05	17/01/05	US36099541
DC Power Supply	HP	66332A	16/01/05	17/01/05	US37471368
Vector Signal Generator	Rohde Schwarz	SMBV100A	16/01/05	17/01/05	255571
Signal Generator	Rohde Schwarz	SMF100A	16/06/23	17/06/23	102341
Thermohygrometer	BODYCOM	BJ5478	16/04/22	17/04/22	120612-2
Low Noise Pre Amplifier	tsj	MLA-010K01-B01-27	16/03/10	17/03/10	1844538
PreAmplifier	Agilent Technologies	8449B	16/02/24	17/02/24	3008A00370
Loop Antenna	Schwarzbeck	FMZB1513	16/04/22	18/04/22	1513-128
Double-Ridged Guide Antenna	ETS	3117	16/05/03	18/05/03	140394
Horn Antenna	A.H.Systems	SAS-574	15/04/30	17/04/30	154
BILOG ANTENNA(30MHz~2GHz)	SCHAFFNER	CBL6112B	16/05/23	18/05/23	2737
High-pass filter	Wainwright Instruments	WHKX3.0	16/01/06	17/01/06	12
EMI TEST RECEIVER	Rohde Schwarz	ESR7	15/10/19	16/10/19	101109
Power Meter & Wide Bandwidth Sensor	Anritsu	ML2496A/MA2411B	16/06/23	17/06/23	1338004/ 1306053

APPENDIX I

Conducted Test set up Diagram & Path loss Information

- Conducted Measurement



Path loss information

Frequency (GHz)	Path Loss (dB)	Frequency (GHz)	Path Loss (dB)
0.03	0.08	15	1.59
1	0.39	20	1.85
2412 & 2437 & 2462	0.58	25	2.02
5	0.75	-	-
10	1.37	-	-

Note. 1: The path loss from EUT to Spectrum analyzer was measured and used for test.

Path loss (S/A's correction factor) = Cable A (Attenuator, Applied only when it was used externally)

APPENDIX II

Duty cycle plots

TEST PROCEDURE

Duty Cycle measured using section 6.0 b) of KDB558074

The zero-span mode on a spectrum analyzer or EMI receiver if the response time and spacing between bins on the sweep are sufficient to permit accurate measurements of the on and off times of the transmitted signal.

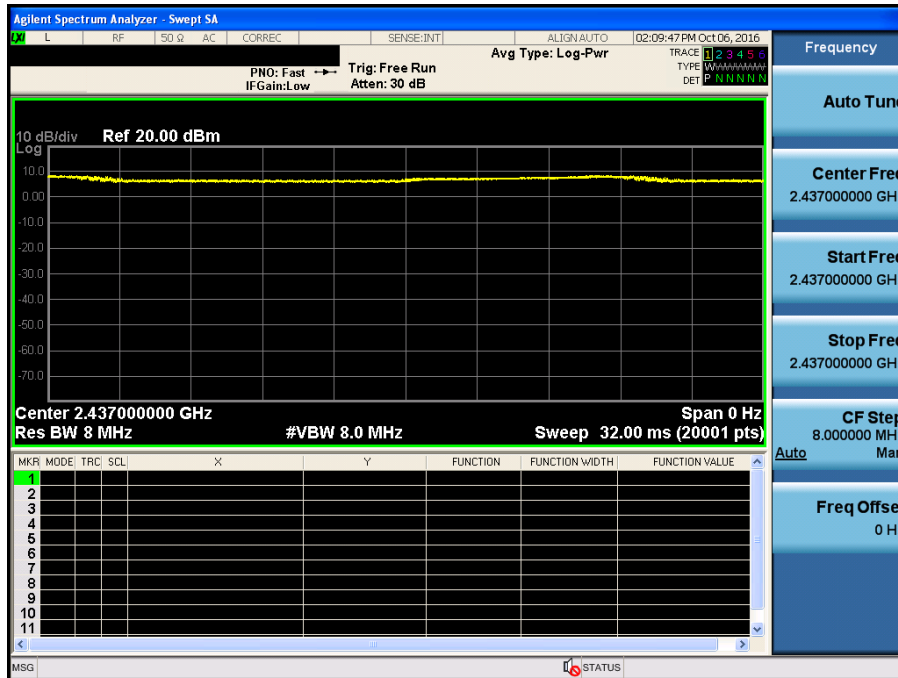
Set the center frequency of the instrument to the center frequency of the transmission. Set $RBW \geq OBW$ if possible; otherwise, set RBW to the largest available value. Set $VBW \geq RBW$. Set detector = peak or average.

The zero-span measurement method shall not be used unless both RBW and VBW are $> 50/T$ and the number of sweep points across duration T exceeds 100. (For example, if VBW and/or RBW are limited to 3 MHz, then the zero-span method of measuring duty cycle shall not be used if $T \leq 16.7$ microseconds.)

Test Plots :

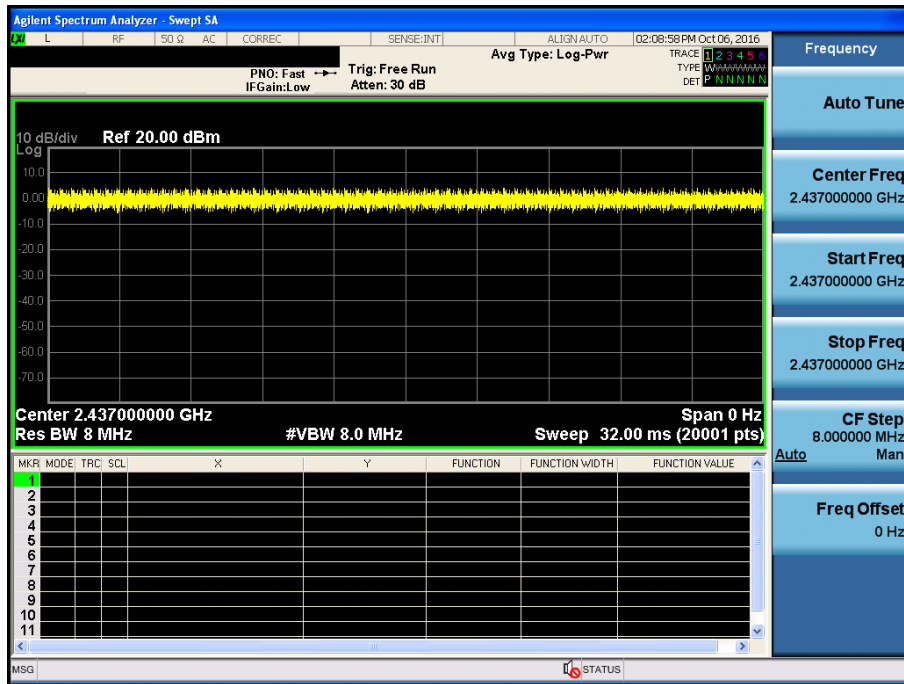
Duty Cycle

Test Mode: 802.11b & 1Mbps & 2437 MHz



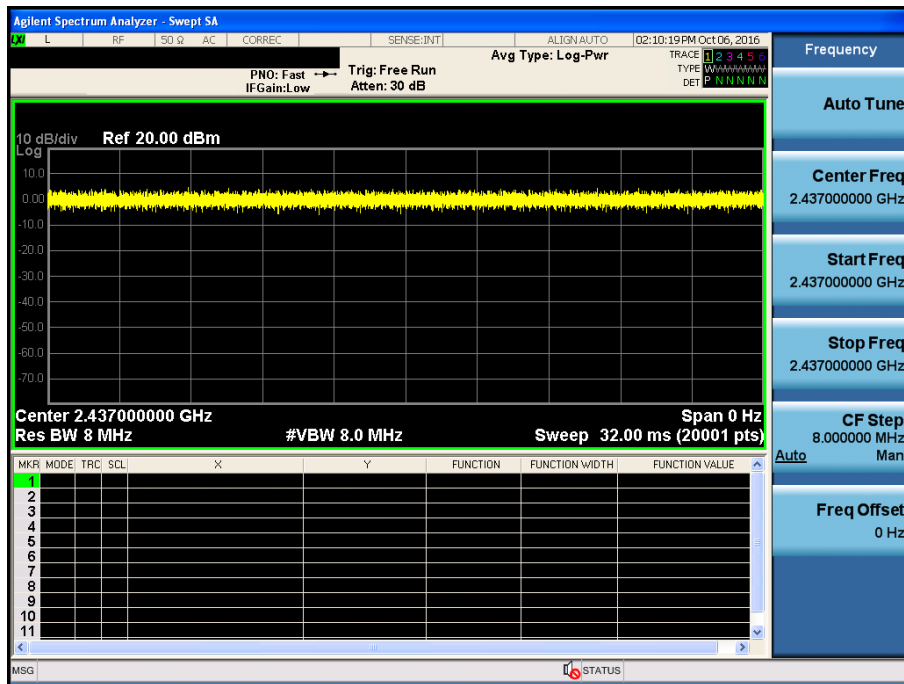
Duty Cycle

Test Mode: 802.11g & 54Mbps & 2437 MHz



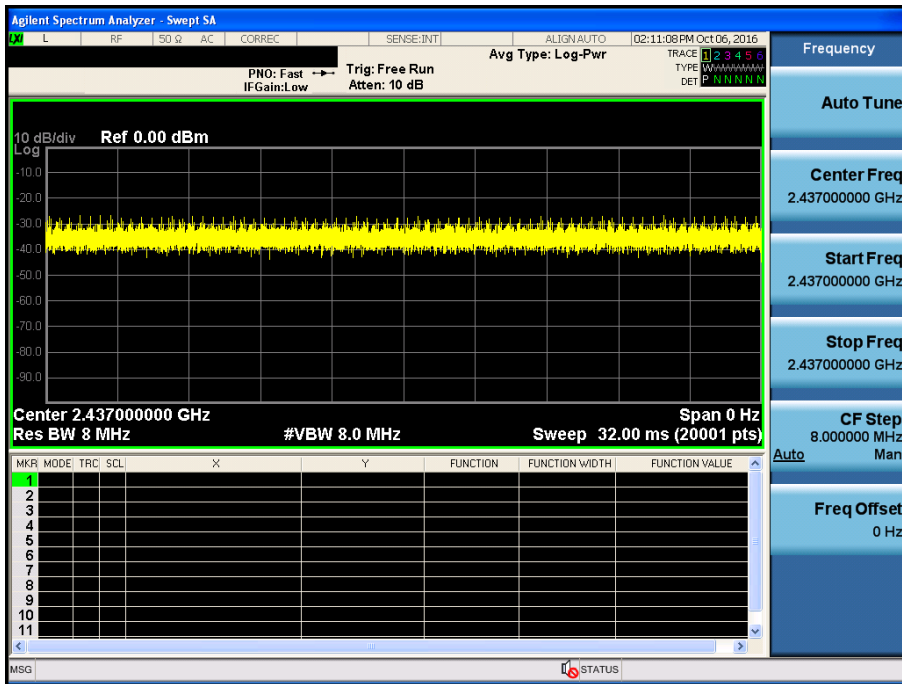
Duty Cycle

Test Mode: 802.11n HT20 & MCS 0 & 2437 MHz



Duty Cycle

Test Mode: 802.11n HT40 & MCS 0 & 2437 MHz

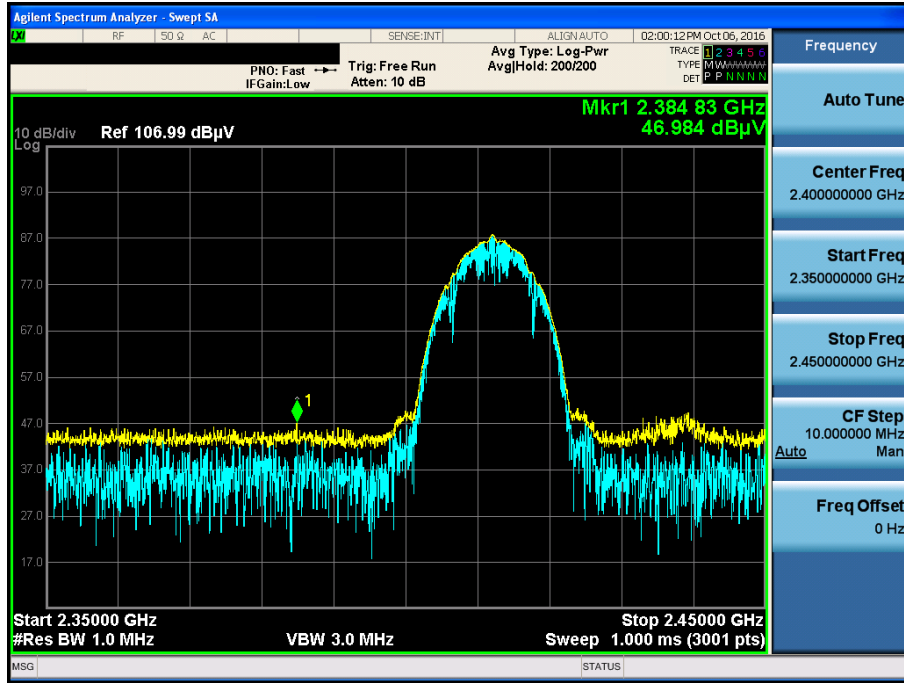


APPENDIX III

Unwanted Emissions (Radiated) Test Plot

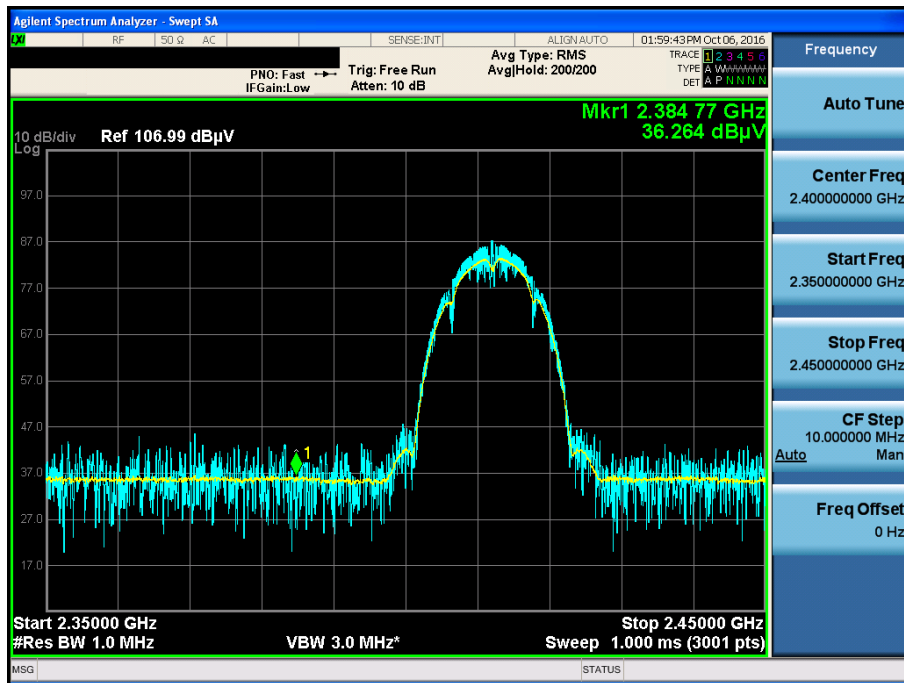
802.11b & Lowest & Y & Ver

Detector Mode : PK



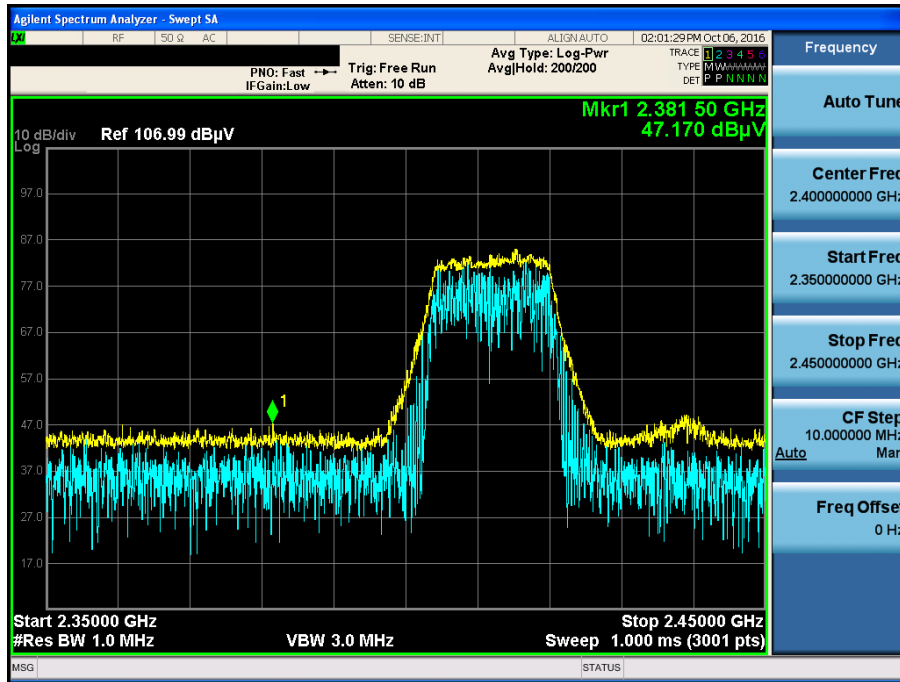
802.11b & Lowest & Y & Ver

Detector Mode : AV



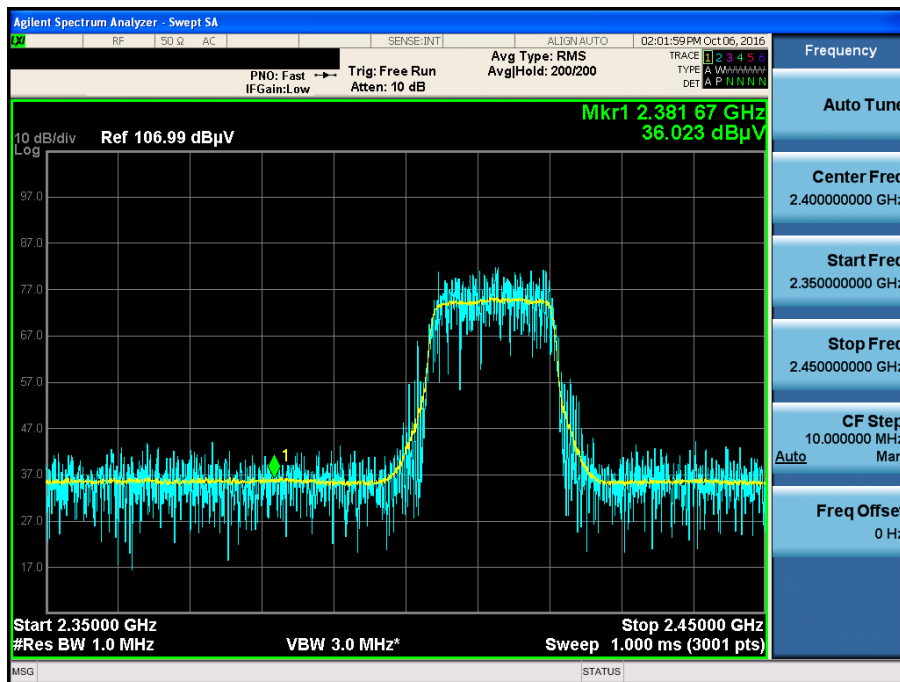
802.11g & Lowest & Y & Ver

Detector Mode : PK



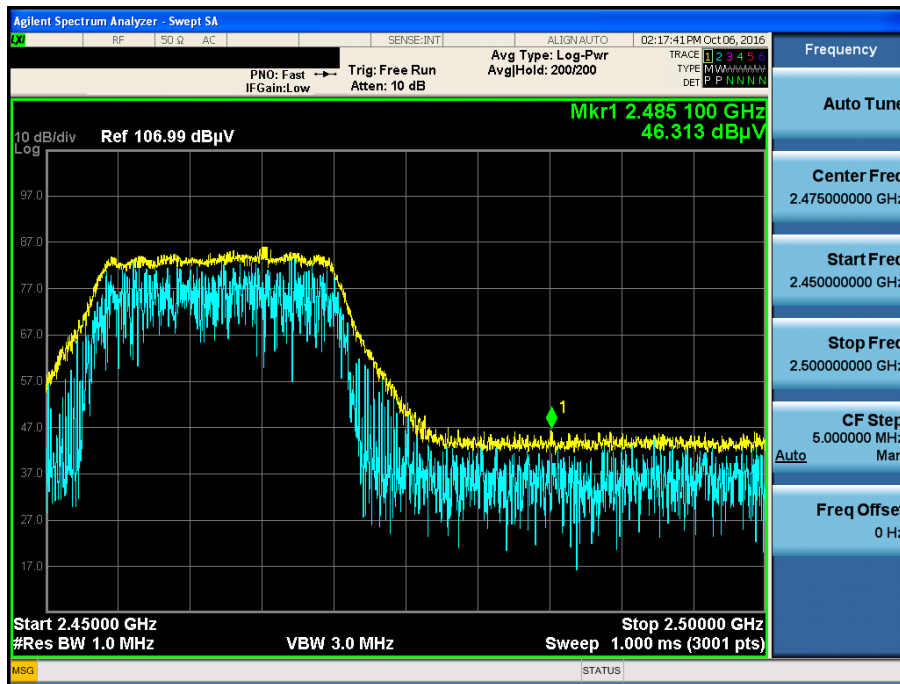
802.11g & Lowest & Y & Ver

Detector Mode : AV



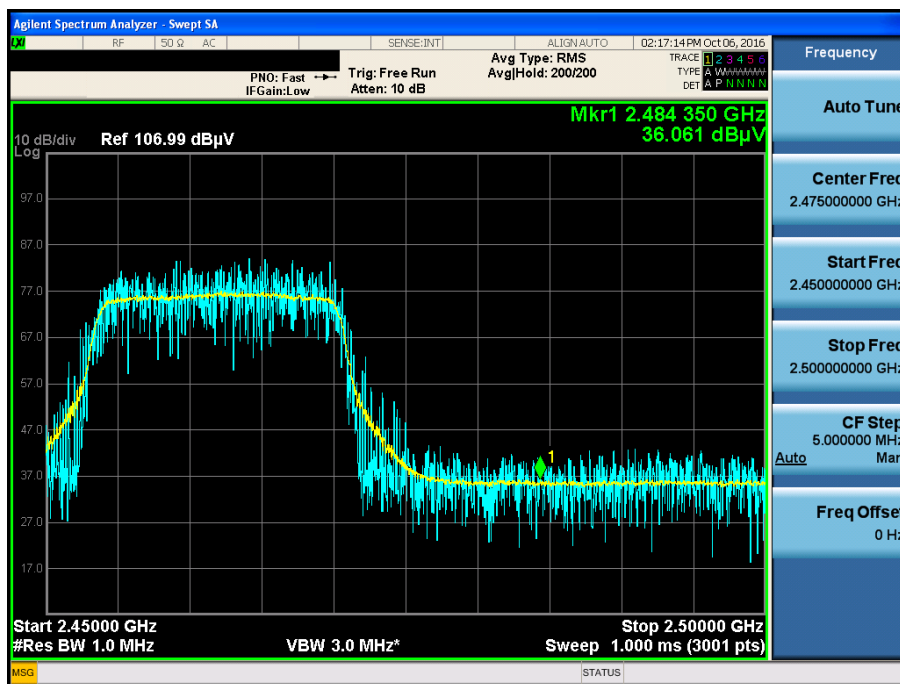
802.11g & Highest & Y & Ver

Detector Mode : PK



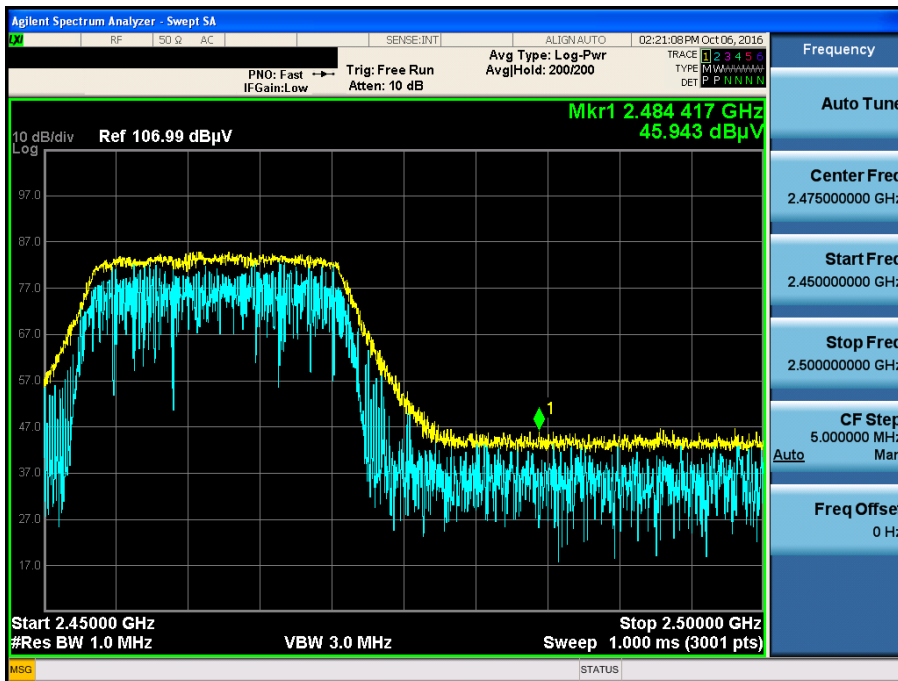
802.11g & Highest & Y & Ver

Detector Mode : AV



802.11n(HT20) & Highest & Y & Ver

Detector Mode : PK



802.11n(HT20) & Highest & Y & Ver

Detector Mode : AV

