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FCC/ISED Test Report

Prepared for:	**Garmin International Inc.**
Address:	**1200 E. 151st Street** **Olathe, Kansas, 66062, USA**
Product:	**A03626**
Test Report No:	**R20191022-26-03B**
Approved By:	**Nic S. Johnson, NCE** **Technical Manager** **iNARTE Certified EMC Engineer #EMC-003337-NE**
DATE:	**26 May 2020**
Total Pages:	**76**

ACCREDITED
TESTING LABORATORY
CERTIFICATE NO. 1953.01

REVISION PAGE

Rev. No.	Date	Description
0	27 March 2020	Original – NJohnson Prepared by CFarrington,FLane
A	26 May 2020	Updated calibration table Added duty cycle measurements Added antenna gain to EIRP values Includes NCEE Labs report R20191022-26-03 and its amendment in full. -NJ
A	26 May 2020	Updated calibration table Added antenna gain to EIRP power values Includes NCEE Labs report R20191022-26-03A and its amendment in full. -NJ

1.0 SUMMARY OF TEST RESULTS

The worst-case measurements were reported in this report. The EUT has been tested according to the following specifications:

APPLIED STANDARDS AND REGULATIONS		
Standard Section	**Test Type**	**Result**
FCC Part 15.35 RSS Gen, Issue 5, Section 6.10	Duty Cycle	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Peak output power	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Bandwidth	Pass
FCC Part 15.209 RSS-Gen Issue 4, Section 7.1	Receiver Radiated Emissions	Pass
FCC Part 15.209 (restricted bands), 15.247 (unrestricted) RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9	Transmitter Radiated Emissions	Pass
FCC Part 15.247(a)(1) RSS-247 Issue 2 Section 5.2	Power Spectral Density	Pass
FCC Part 15.209, 15.247(d) RSS-247 Issue 2 Section 11.13	Band Edge Measurement	Pass
FCC Part 15.207 RSS-Gen Issue 4, Section 7.1	Conducted Emissions	Pass

See Section 4 for details on the test methods used for each test.

2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

Model	A03626
EUT Received	25 November 2019
EUT Tested	25 November 2019 - 13 January 2020
Serial No.	3322745536
Operating Band	2400.0 - 2483.5 GHz
Device Type	802.11b, 802.11g, 802.11n
Antenna	Trace Antenna
Power Supply	Internal Battery/ Charger: Garmin MN: LAC046

NOTE: For more detailed features description, please refer to the manufacturer's specifications or user's manual.

2.2 DESCRIPTION OF TEST MODES

The EUT operates on, and was tested at the frequencies below:

Channel	Frequency
Low (Channel 1)	2412
Middle (Channel 6)	2437
High (Channel 11)	2462

As well as the following modes:

WIFI Mode
802.11b
802.11g
802.11n (HT20)

These are the only three representative channels tested in the frequency range according to FCC Part 15.31 and RSS-Gen Table A1. See the operational description for a list of all channel frequency and designations.

This EUT was set to transmit in a worse-case scenario with modulation on. The manufacturer modified the unit to transmit continuously on the lowest, highest and one channel in the middle.

2.3 DESCRIPTION OF SUPPORT UNITS

NA

3.0 LABORATORY DESCRIPTION

3.1 LABORATORY DESCRIPTION

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

Environmental conditions varied slightly throughout the tests:

Relative humidity of 35 ± 4%
Temperature of 22 ± 3° Celsius

3.2 TEST PERSONNEL

All testing was performed by Karthik Vepuri, Fox Lane, and Caleb Farrington of NCEE Labs. The results were reviewed by Nic Johnson.

3.3 TEST EQUIPMENT

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Keysight MXE Signal Analyzer	N9038A	MY59050109	23 Apr 2019	23 Apr 2021
Keysight EXA Signal Analyzer	N9010A	MY56070862	14 Dec 2018	14 Dec 2020
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2021
SunAR RF Motion	JB1	A082918-1	15 Oct 2018	15 Oct 2020
EMCO Horn Antenna	3115	6416	10 Mar 2020	10 Mar 2022
EMCO Horn Antenna	3116	2576	09 Mar 2020	09 Mar 2022
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2021
EMCO Horn Antenna	3116	2576	26 Jan 2018	26 Jan 2021
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2021*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2021*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2018	26 Jul 2019
TDK Emissions Lab Software	V11.25	700307	NA	NA
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Mar 2018*	09 Mar 2021*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Mar 2018*	09 Mar 2021*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Mar 2018*	09 Mar 2021*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Mar 2018*	09 Mar 2021*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Mar 2018*	09 Mar 2021*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Mar 2018*	09 Mar 2021*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Mar 2018*	09 Mar 2021*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Mar 2018*	09 Mar 2021*

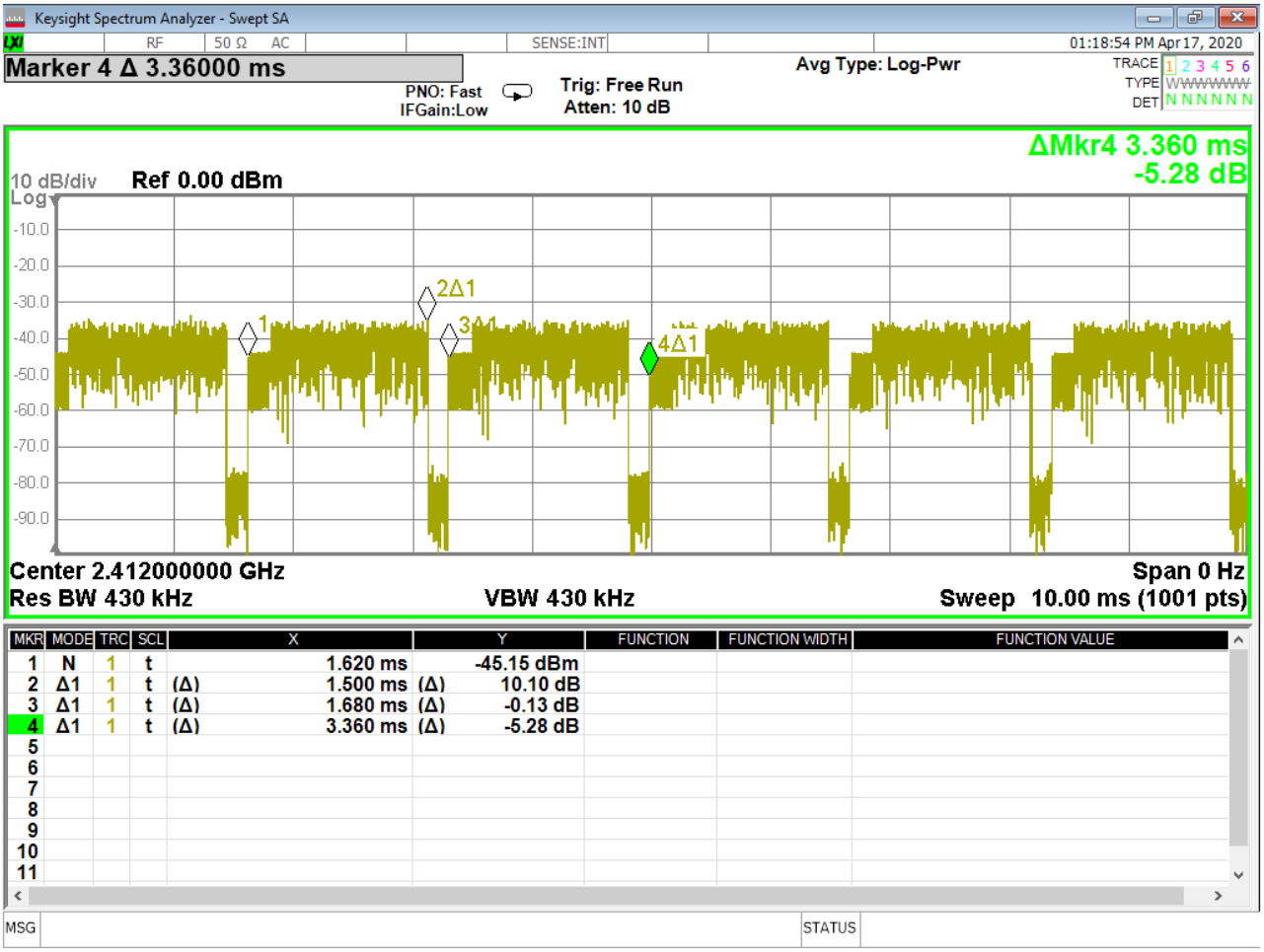
*Internal Characterization

Notes:

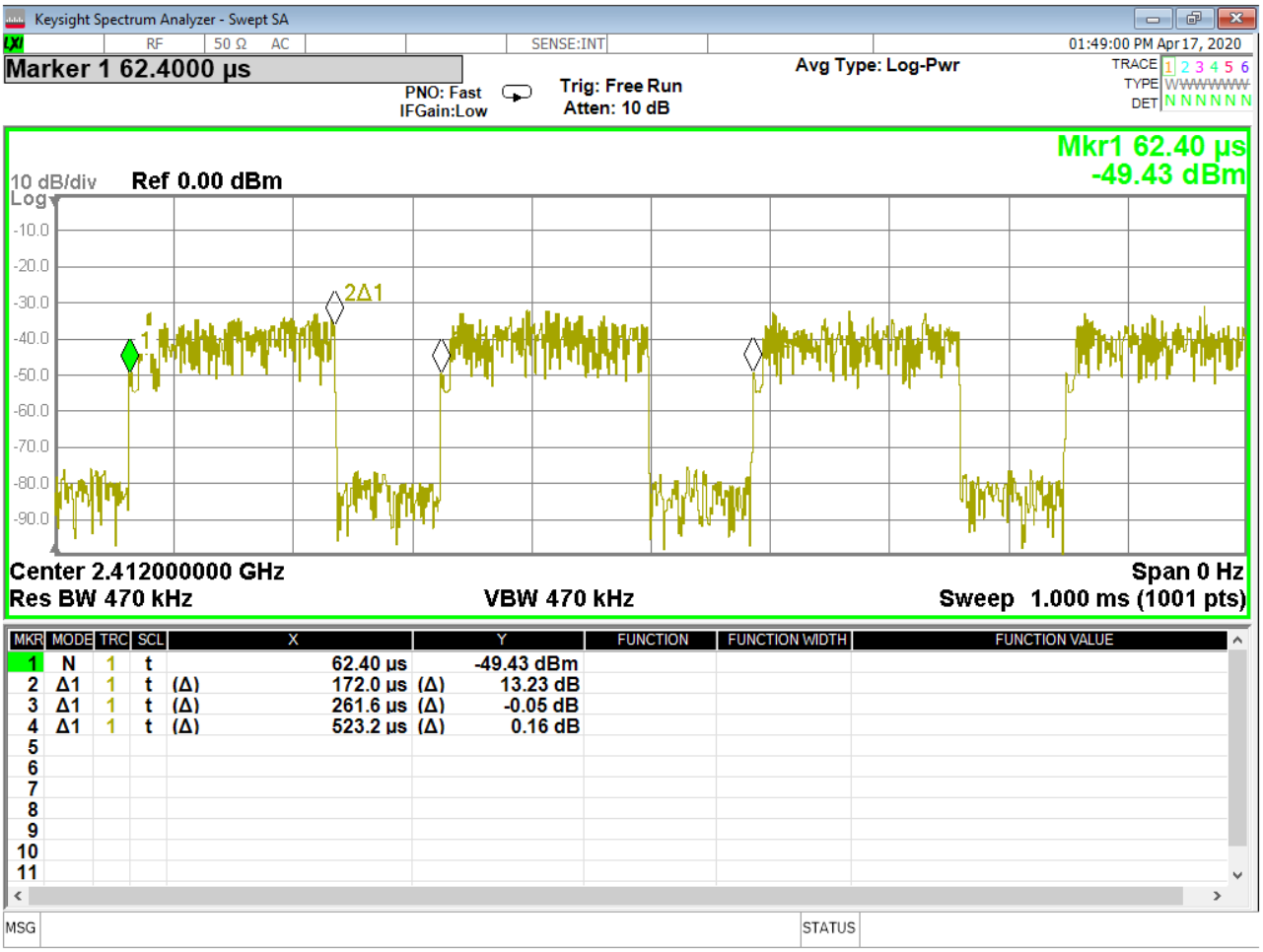
All equipment is owned by NCEE Labs and stored permanently at NCEE Labs facilities.

4.0 DETAILED RESULTS

4.1 DUTY CYCLE



802.11b, duty cycle = 1.5ms / 1.68ms = 89.3%



802.11g, duty cycle = 172 us / 261.6 us = 65.7%

802.11n, duty cycle = 87.4us / 186us = 30.9%

4.2 RADIATED EMISSIONS

Test Method: ANSI C63.10:2013:

1. Section 6.5, “Radiated emissions from unlicensed wireless devices in the frequency range of 30 MHz to 1000 MHz”
2. Section 6.6, “Radiated emissions from unlicensed wireless devices above 1 GHz”
3. Section 11.11, “Measurement in nonrestricted frequency bands”
4. Section 11.12, “Emissions in restricted bands”

Limits for radiated emissions measurements:

Emissions radiated outside of the specified bands shall be applied to the limits in 15.209 as followed:

FREQUENCIES (MHz)	FIELD STRENGTH (µV/m)	MEASUREMENT DISTANCE (m)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	3
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Note about requirement from FCC Part 15.247(d) and RSS-247, Section 5.5:
In addition to the limits shown above, all emissions were also required to be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power. All measurements were performed with a 1 MHz bandwidth, but the bandwidth conversion from 1 MHz to 100 kHz would be equally applied to the highest emission and the spurious emissions, so it would not affect the delta measurement.

Since the fundamental emissions was at least 20 dB over the spurious emissions limits from 15.209 and all spurious emissions were below the 15.209 limit, this requirement was met.

NOTE:
1. The lower limit shall apply at the transition frequencies.
2. Emission level (dBuV/m) = 20 * log * Emission level (µV/m).
3. As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits by more than 20dB under any condition of modulation.

Test procedures:

a. The EUT was placed on the top of a rotating table above the ground plane in a 10 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation. The table was 0.8m high for measurements form 30MHz-1Ghz and 1.5m for measurements from 1GHz and higher.

b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.

c. The antenna was a broadband antenna, and its height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are used to make the measurement.

d. For each suspected emission, the EUT was arranged to maximize its emissions and then the antenna height was varied from 1 meter to 4 meters and the rotating table was turned from 0 degrees to 360 degrees to find the maximum emission reading.

e. The test-receiver system was set to use a peak detector with a specified resolution bandwidth. For spectrum analyzer measurements, the composite maximum of several analyzer sweeps was used for final measurements.

f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

g. All 802.11 modes were examined (b, g, n, HT20) and it was found the 802.11n mode produced the highest emissions. All final measurements were performed with the EUT transmitting continuously in this mode.

NOTE:
1. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120kHz for Peak detection (PK) and Quasi-peak detection (QP) at frequencies below 1GHz.

2. The resolution bandwidth 1 MHz for all measurements and at frequencies above 1GHz, A peak detector was used for all measurements above 1GHz. Measurements were made with an EMI Receiver.

Deviations from test standard:

No deviation.

Test setup:

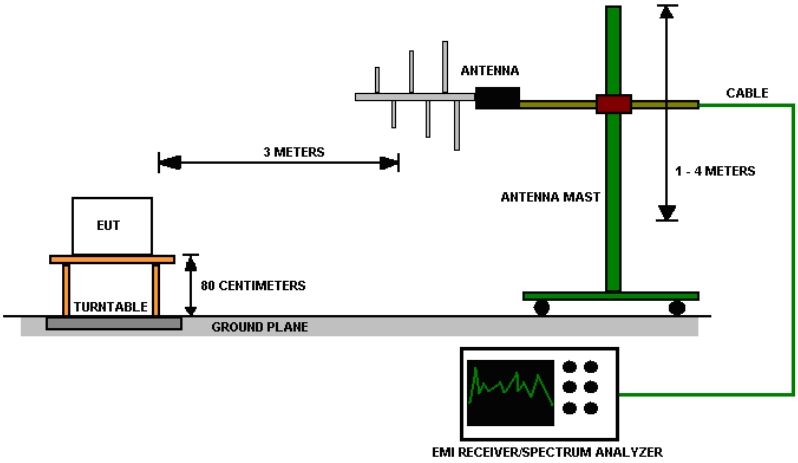


Figure 1 - Radiated Emissions Test Setup

EUT operating conditions
The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range. EUT was set to transmit in 80211b, 80211g and 80211n.

Test results:

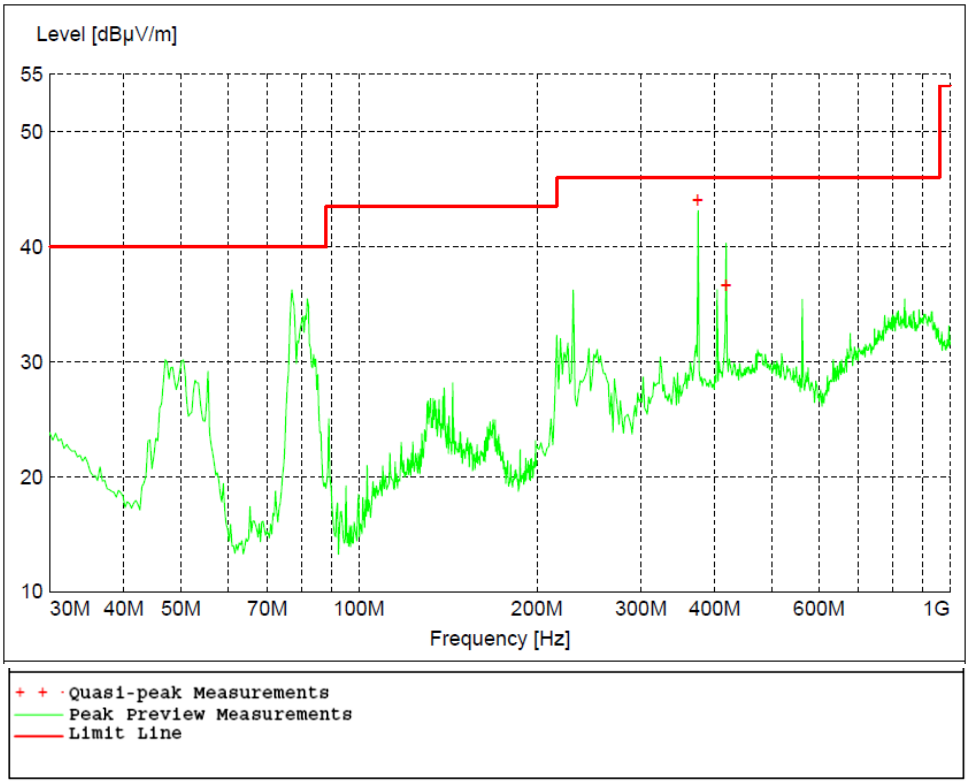


Figure 2 - Radiated Emissions Plot, Receive, 30-1G

Table 1 - Radiated Emissions Quasi-peak, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
374.400000	44.06	46.00	1.9	100	74	HORI
417.660000	36.69	46.00	9.3	100	51	HORI

Table 2 - Radiated Emissions Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
1714.800000	41.67	54.00	12.3	97	111	VERT

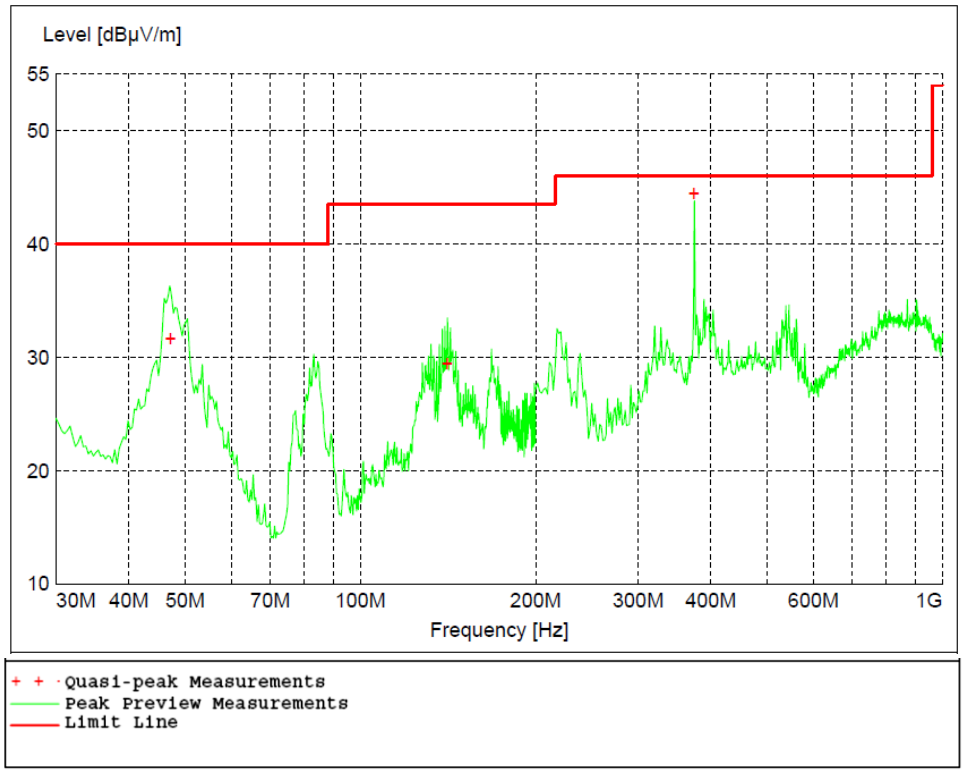


Figure 3 - Radiated Emissions Plot, 802.11b

Table 3 - Radiated Emissions Quasi-Peak Measurements, 802.11b

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.160000	31.69	40	8.3	101	195	VERT
141.060000	29.42	43.5	14.1	99	55	VERT
374.400000	44.51	46	1.5	100	118	HORI

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

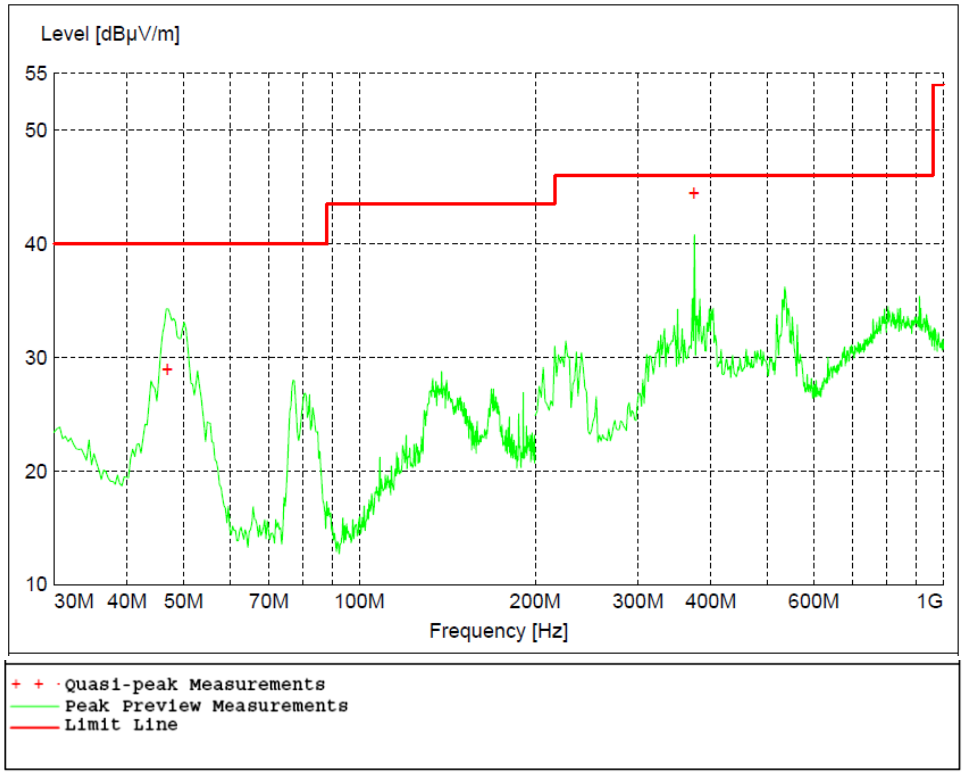


Figure 4 - Radiated Emissions Plot, 802.11g

Table 4 - Radiated Emissions Quasi-Peak Measurements, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
46.920000	29	40	11	106	216	VERT
374.400000	44.45	46	1.6	100	113	HORI

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

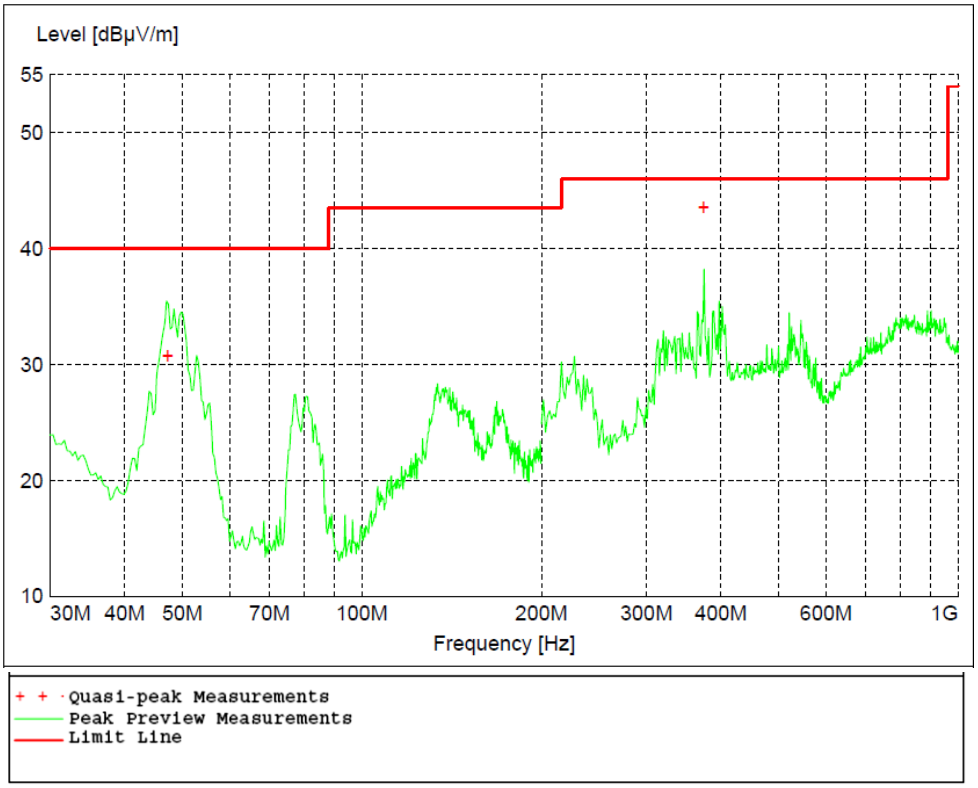


Figure 5 - Radiated Emissions Plot, 802.11n

Table 5 - Radiated Emissions Quasi-Peak Measurements, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
47.280000	30.8	40	9.2	100	84	VERT
374.400000	43.57	46	2.4	111	124	HORI

The EUT was maximized in all 3 orthogonal axis. The worst-case is shown in the plot and table above.

‘

Table 6 - Radiated Emissions Peak Detector Measurements, 802.11b, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	109.79	N/A	N/A	150	223	H	Low
2437.000000	109.63	N/A	N/A	150	223	H	Mid
2462.000000	110.79	N/A	N/A	150	223	H	High
4824.000000	54.90	74.00	19.10	195	191	H	Low
4874.000000	49.83	74.00	24.17	195	191	V	Mid
4924.000000	49.31	74.00	24.69	200	298	V	High
No signals detected above system sensitivity							

Table 7 - Radiated Emissions Average Detector Measurements, 802.11b, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	100.71	N/A	N/A	150	223	H	Low
2437.000000	100.61	N/A	N/A	150	223	H	Mid
2462.000000	101.86	N/A	N/A	150	223	H	High
4824.000000	43.13	54.00	10.87	195	191	H	Low
4874.000000	37.71	54.00	16.29	195	191	V	Mid
4924.000000	35.23	54.00	18.77	200	298	V	High
No signals detected above system sensitivity Average measurements performed within transmit on time.							

Table 8 - Radiated Emissions Peak Measurements, 802.11g, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	107.66	N/A	N/A	150	223	H	Low
2437.000000	108.59	N/A	N/A	150	223	H	Mid
2462.000000	107.45	N/A	N/A	150	223	H	High
4824.000000	49.74	74.00	24.26	212	299	H	Low
4874.000000	48.59	74.00	25.41	197	314	V	Mid
4924.000000	49.74	74.00	24.26	171	300	H	High

Table 9 - Radiated Emissions Average Measurements, 802.11g, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	91.97	N/A	N/A	150	223	H	Low
2437.000000	93.26	N/A	N/A	150	223	H	Mid
2462.000000	92.02	N/A	N/A	150	223	H	High
4824.000000	32.76	54.00	21.24	212	299	H	Low
4874.000000	31.88	54.00	22.12	197	314	V	Mid
4924.000000	33.77	54.00	20.23	171	300	H	High

Average measurements performed within transmit on time.

Table 10 - Radiated Emissions Peak Measurements, 802.11n, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	106.80	N/A	N/A	150	223	H	Low
2437.000000	108.69	N/A	N/A	150	223	H	Mid
2462.000000	106.91	N/A	N/A	150	223	H	High
4824.000000	48.85	74.00	25.15	185	236	H	Low
4874.000000	47.05	74.00	26.95	122	299	H	Mid
4924.000000	49.58	74.00	24.42	158	306	H	High
No signals detected above system sensitivity							

Table 11 - Radiated Emissions Average Measurements, 802.11n, 1-26 GHz

Frequency	Level	Limit	Margin	Height	Angle	Pol	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.		
2412.000000	89.26	N/A	N/A	150	223	H	Low
2437.000000	90.33	N/A	N/A	150	223	H	Mid
2462.000000	88.92	N/A	N/A	150	223	H	High
4824.000000	31.84	54.00	22.16	185	236	H	Low
4874.000000	30.92	54.00	23.08	122	299	H	Mid
4924.000000	33.18	54.00	20.82	158	306	H	High
No signals detected above system sensitivity Average measurements performed within transmit on time.							

REMARKS:

1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value.
5. All 3 possible 802.11 modes were tested. The highest of each is presented in the tables.

4.3 OUTPUT POWER

Test Method: ANSI C63.10:
1. Section(s) 11.9.2.2.2

Limits of power measurements:
The maximum allowed peak output power is 30 dBm.

Test procedures:
The EUT was measured at a distance of 3 meters with 330 kHz RBW and 3 MHz VBW. Power was determined using an integrated channel power measurement.

Deviations from test standard:
No deviation.

Test setup:

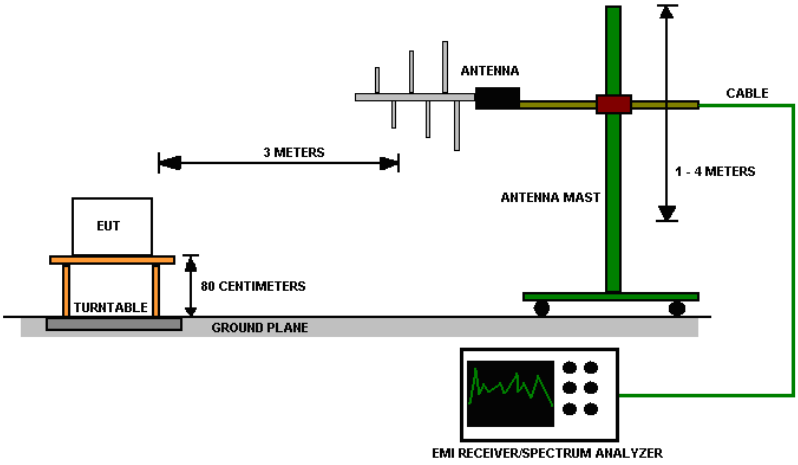


Figure 6 – Peak Output Power Measurements Test Setup

EUT operating conditions:
The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK OUTPUT POWER EIRP (dBm) MU = ±4.44 dB	PEAK OUTPUT POWER Conducted (dBm) MU = ±4.44 dB	RESULT
Low	2412	802.11b	23.060	20.560	PASS
Middle	2437	802.11b	22.660	20.160	PASS
High	2462	802.11b	22.090	19.590	PASS
Low	2412	802.11g	20.950	18.450	PASS
Middle	2437	802.11g	21.360	18.860	PASS
High	2462	802.11g	21.580	19.080	PASS
Low	2412	802.11n	20.590	18.090	PASS
Middle	2437	802.11n	20.290	17.790	PASS
High	2462	802.11n	20.890	18.390	PASS

Average Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	Average OUTPUT POWER EIRP (dBm) MU = ±4.44	Average OUTPUT POWER Conducted(dBm) MU = ±4.44	RESULT
Low	2412	802.11b	14.790	12.290	PASS
Middle	2437	802.11b	14.280	11.780	PASS
High	2462	802.11b	13.700	11.200	PASS
Low	2412	802.11g	11.180	8.680	PASS
Middle	2437	802.11g	11.030	8.530	PASS
High	2462	802.11g	11.640	9.140	PASS
Low	2412	802.11n	10.210	7.710	PASS
Middle	2437	802.11n	9.780	7.280	PASS
High	2462	802.11n	10.230	7.730	PASS

*Peak conducted power = Peak EIRP power – antenna gain. Antenna gain = 2.5 dBi

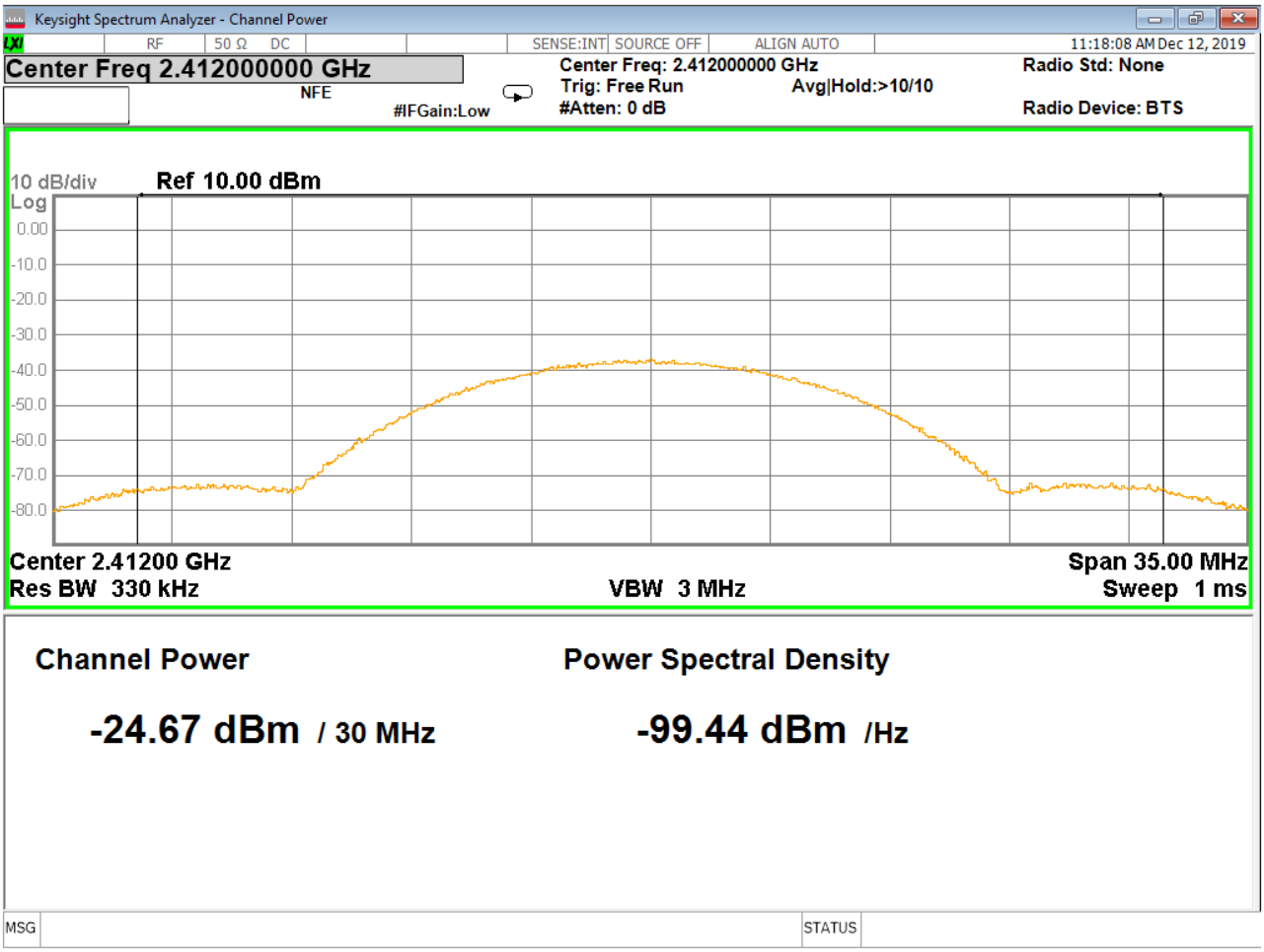


Figure 7 – Highest Peak Output Power, 802.11b

EIRP Peak Output Power = -24.67 + 107 – 95.23 + AF + CL = 23.06

Output power = -24.67 dBm

AF = Antenna Factor = 28.36

CL = Cable Loss = 7.6

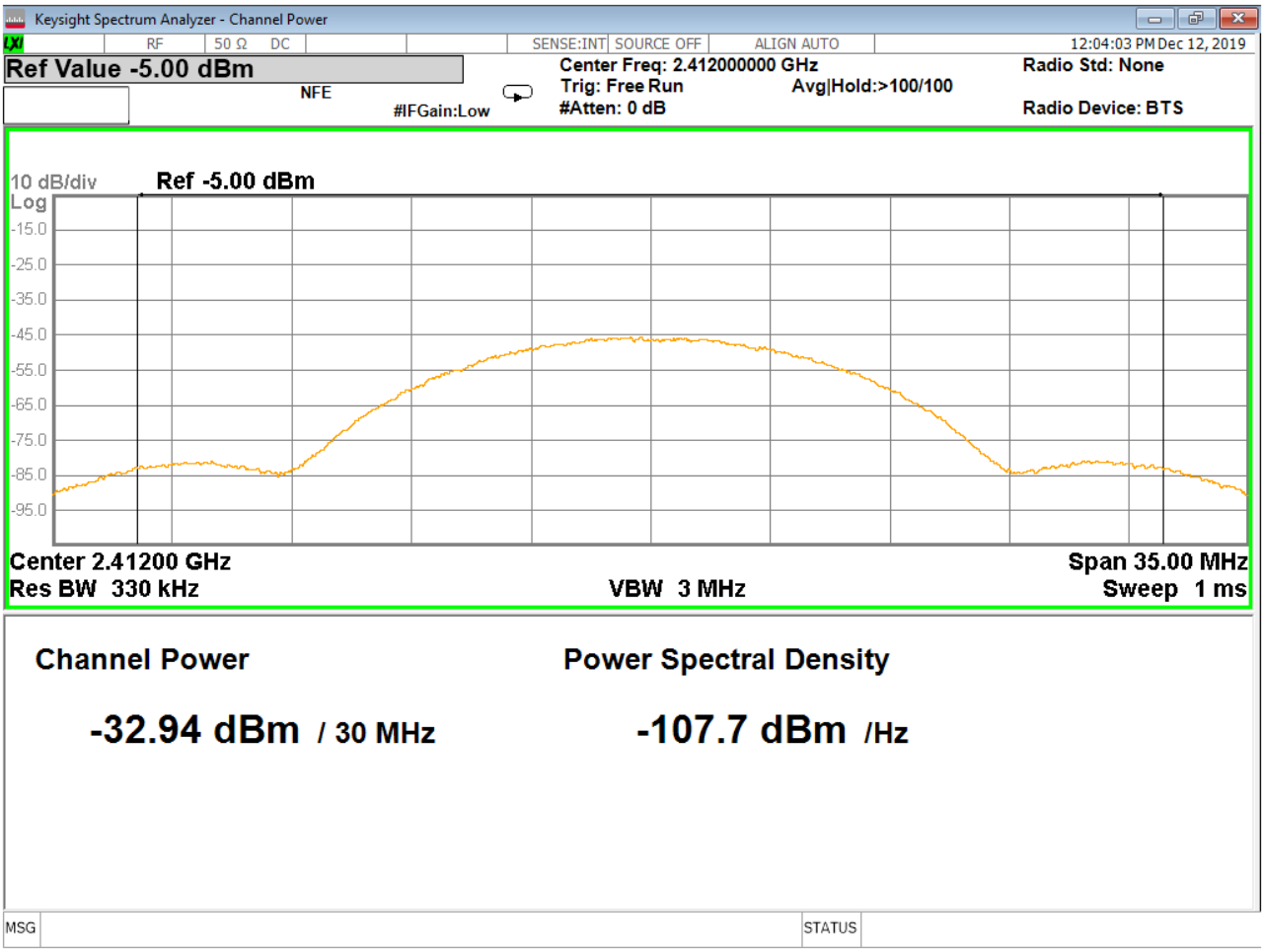


Figure 8 – Highest Average Output Power, 802.11b

EIRP Peak Output Power = -32.94 + 107 – 95.23 + AF + CL = 14.790

Output power = -32.94 dBm

AF = Antenna Factor = 28.36

CL = Cable Loss = 7.6

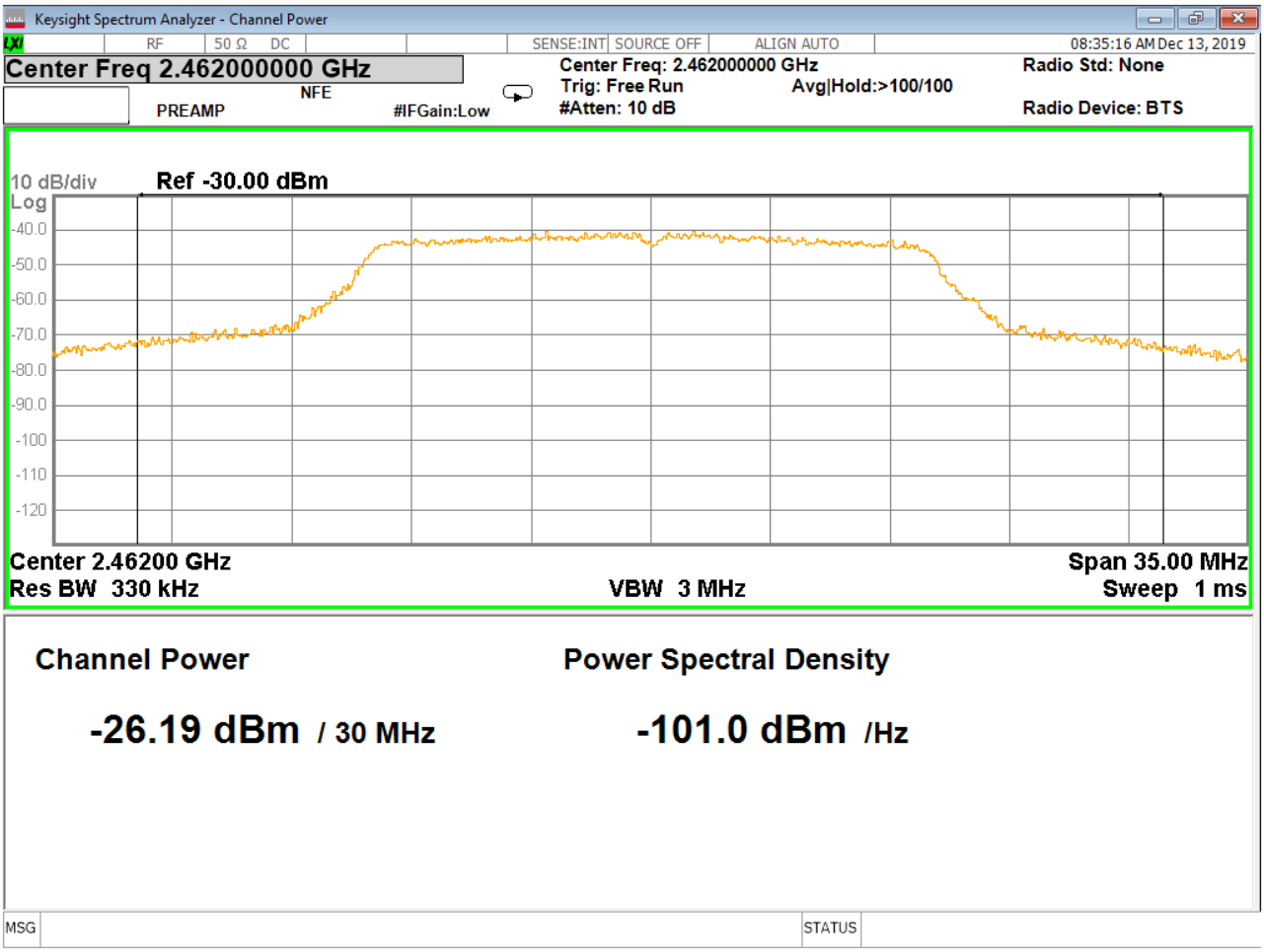


Figure 9 – Highest Peak Output Power, 802.11g

EIRP Peak Output Power = -26.19 + 107 – 95.23 + AF + CL = 21.580

Output power = -26.19 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

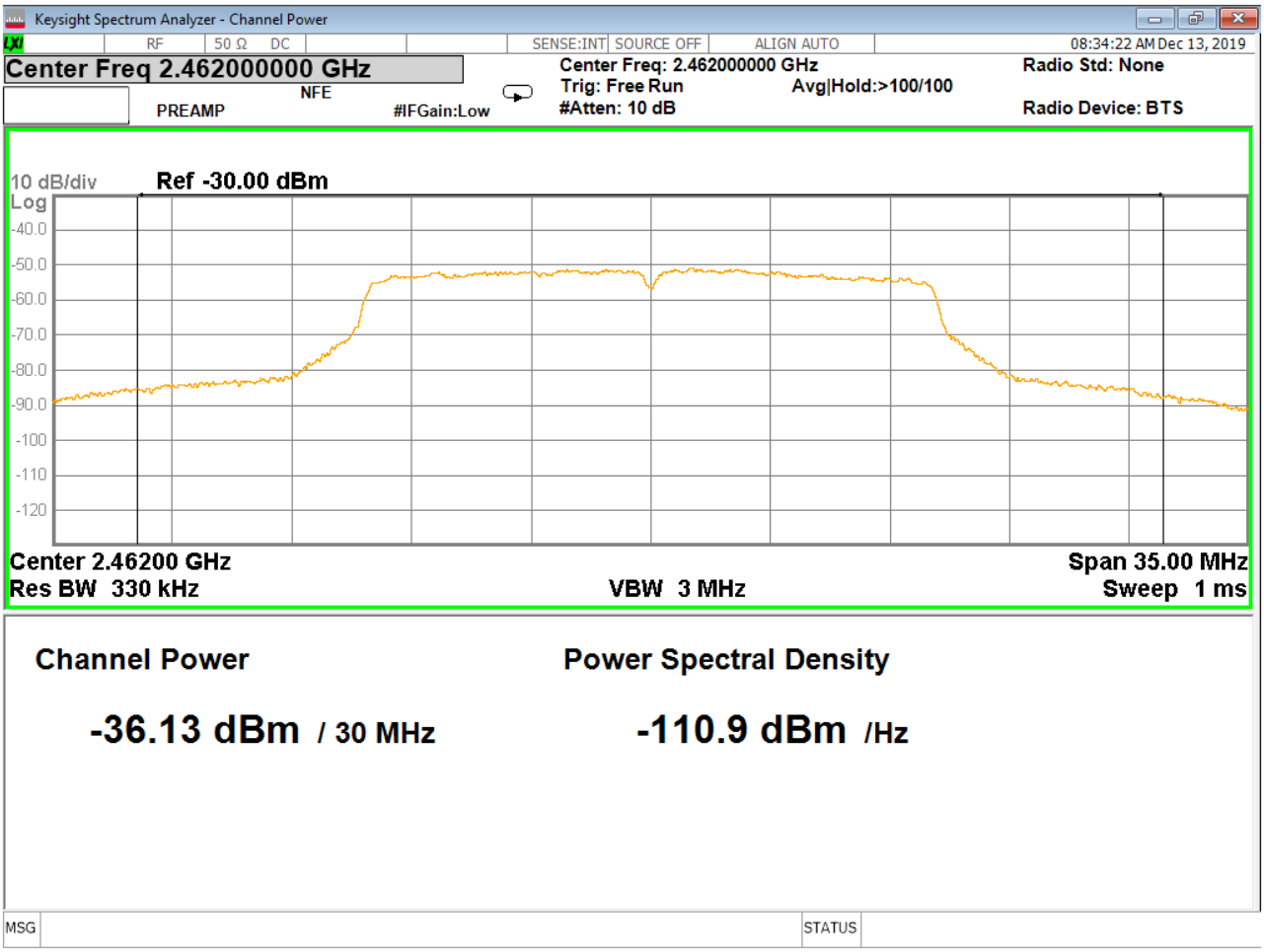


Figure 10 – Highest Average Output Power, 802.11g

EIRP Peak Output Power = -36.13 + 107 – 95.23 + AF + CL = 11.640

Output power = -36.13 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

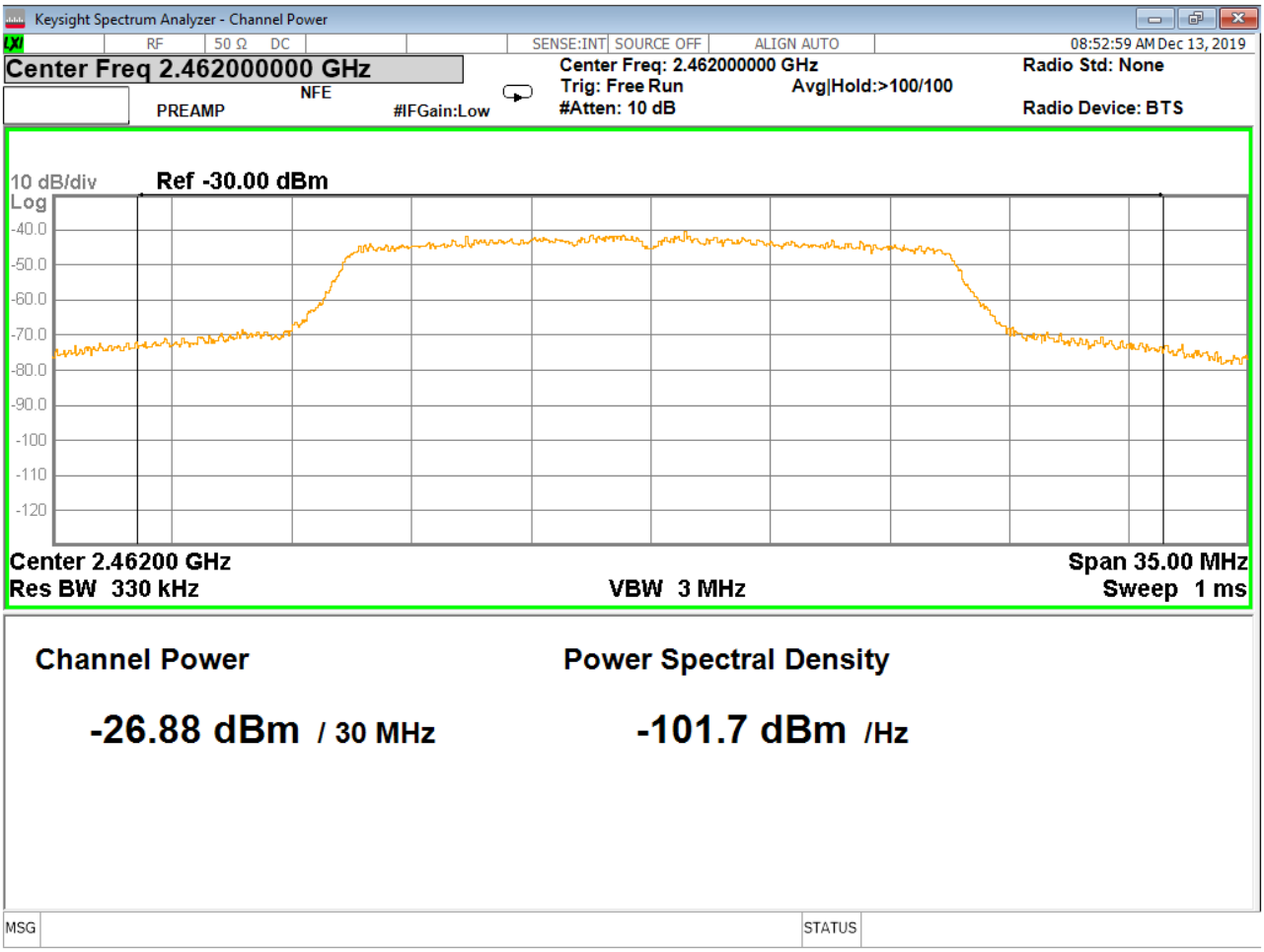


Figure 11 – Highest Peak Output Power, 802.11n

EIRP Peak Output Power = -26.88 + 107 – 95.23 + AF + CL = 20.890

Output power = -26.88 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

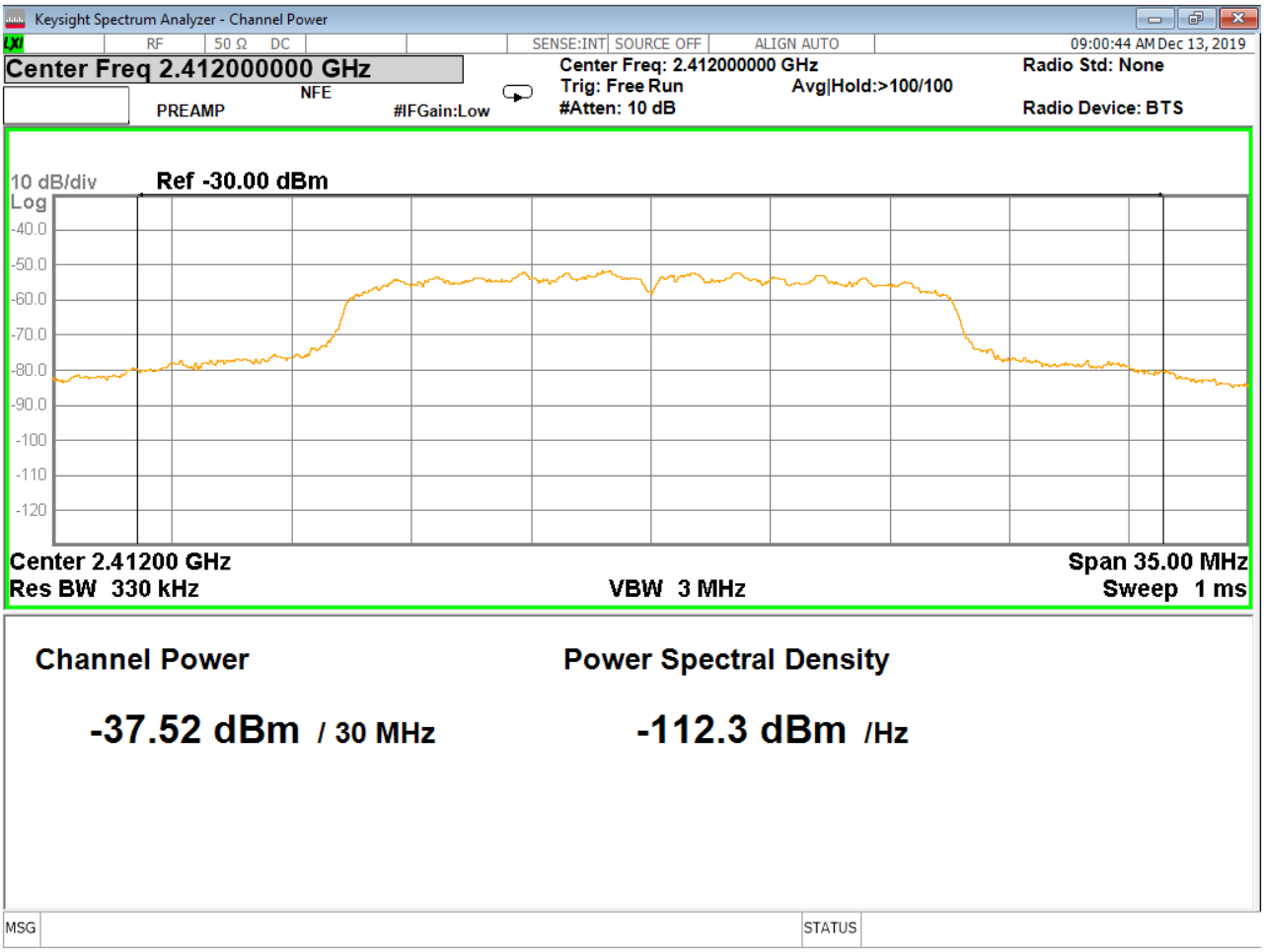


Figure 12 – Highest Average Output Power, 802.11n

EIRP Peak Output Power = --37.54 + 107 – 95.23 + AF + CL = 10.230

Output power = -37.54 dBm

AF = Antenna Factor = 28.36

CL = Cable Loss = 7.6

4.4 BANDWIDTH

Test Method: ANSI C63.10,
1. Section(s) 11.8.2 “DTS Bandwidth, Option 2”

Limits of bandwidth measurements:
The 99% occupied bandwidth is displayed.

The 6dB bandwidth of the signal must be greater than 500 kHz.

Test procedures:
The EUT was measured at a distance of 3 meters. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 330 kHz RBW and 3 MHz VBW.

The 99% occupied is defined as the bandwidth at which 99% of the signal power is found. This corresponds to 20dB down from the maximum power level. The maximum power was measured with the largest resolution bandwidth possible (10MHz) and this value was recorded. The signal was then captured with a 1 MHz resolution bandwidth and the frequencies where the measurements were 20dB below the maximum power were marked. The bandwidth between these frequencies was recorded as the 99% occupied bandwidth.

The 6 dB bandwidth is defined as the bandwidth of which is higher than peak power minus 6dB.

Deviations from test standard:
No deviation

Test setup:

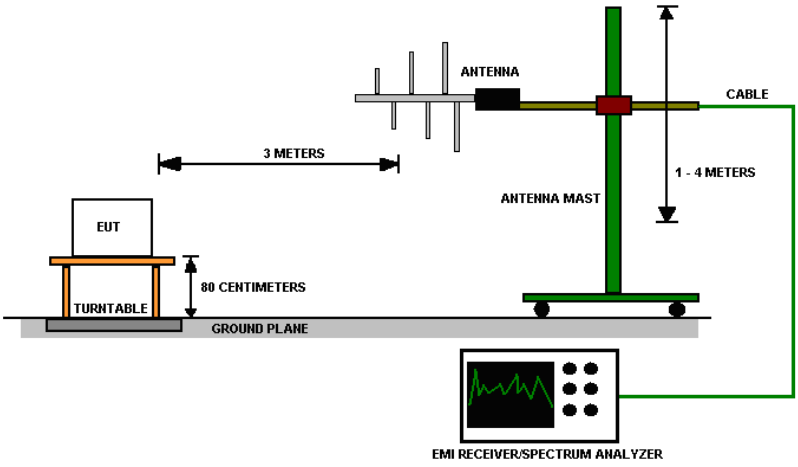


Figure 13 – Bandwidth Measurements Test Setup

EUT operating conditions:
The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	99% Occupied BW (MHz)
Low	2412	802.11b	13.677
Middle	2437	802.11b	13.421
High	2462	802.11b	13.439
Low	2412	802.11g	17.634
Middle	2437	802.11g	16.819
High	2462	802.11g	16.757
Low	2412	802.11n	18.351
Middle	2437	802.11n	17.887
High	2462	802.11n	17.820

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	9.085
Middle	2437	802.11b	8.803
High	2462	802.11b	8.907
Low	2412	802.11g	15.960
Middle	2437	802.11g	16.200
High	2462	802.11g	16.240
Low	2412	802.11n	17.500
Middle	2437	802.11n	17.320

High	2462	802.11n	17.590

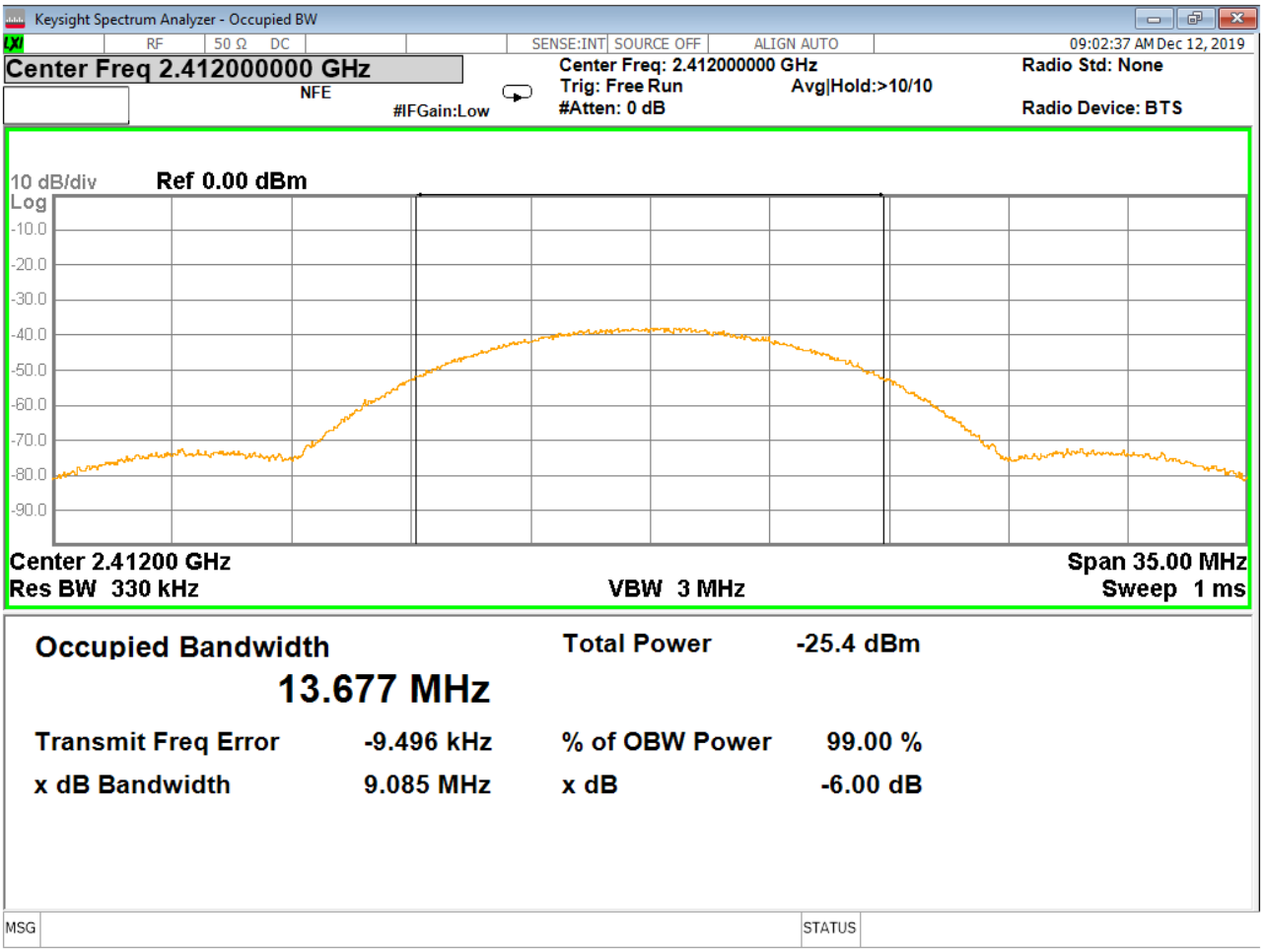


Figure 14 - 99% Occupied Bandwidth and 6dB Bandwidth, Low Channel, 802.11b

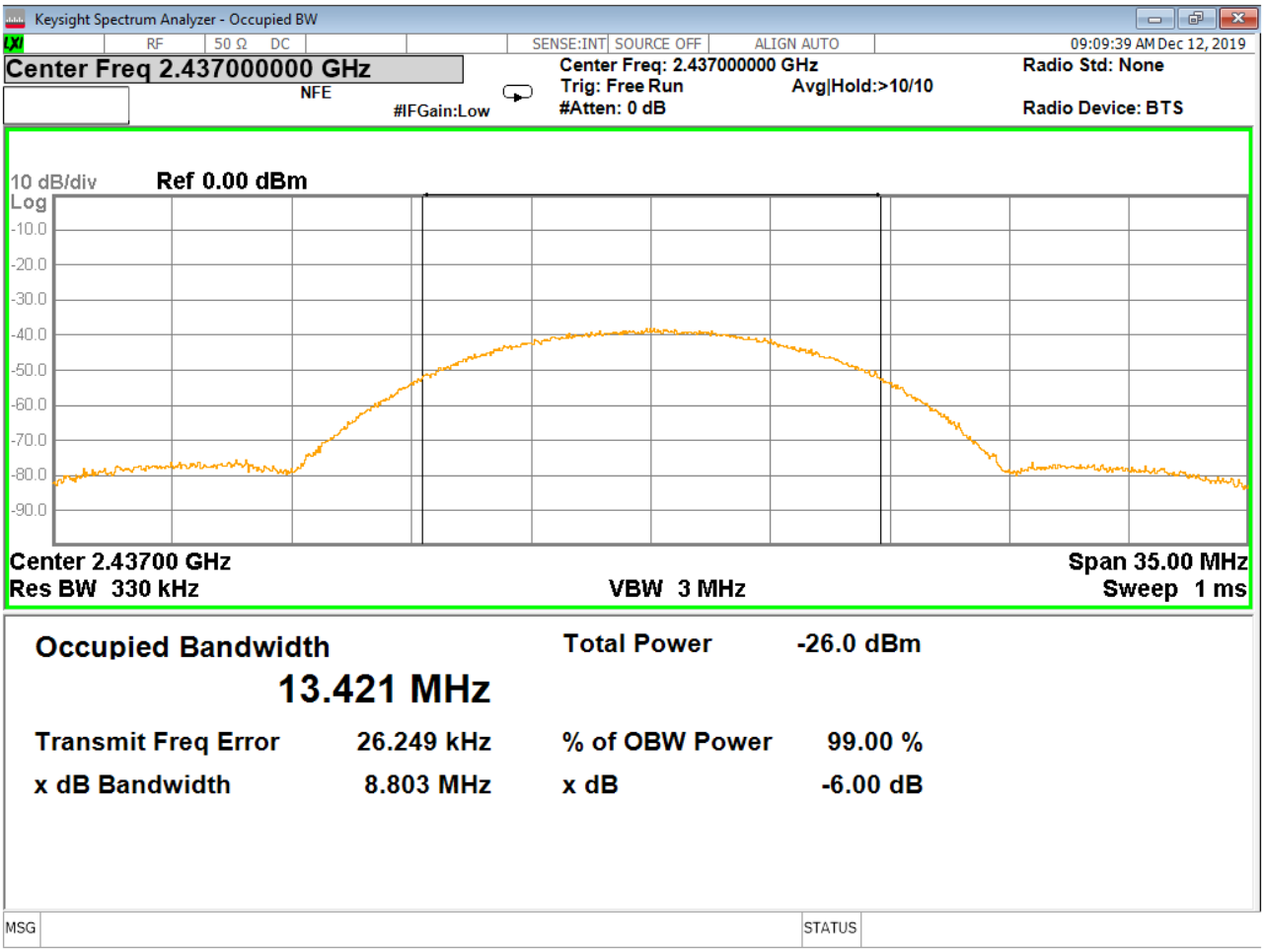


Figure 15 - 99% Occupied Bandwidth and 6dB Bandwidth, Mid Channel, 802.11b

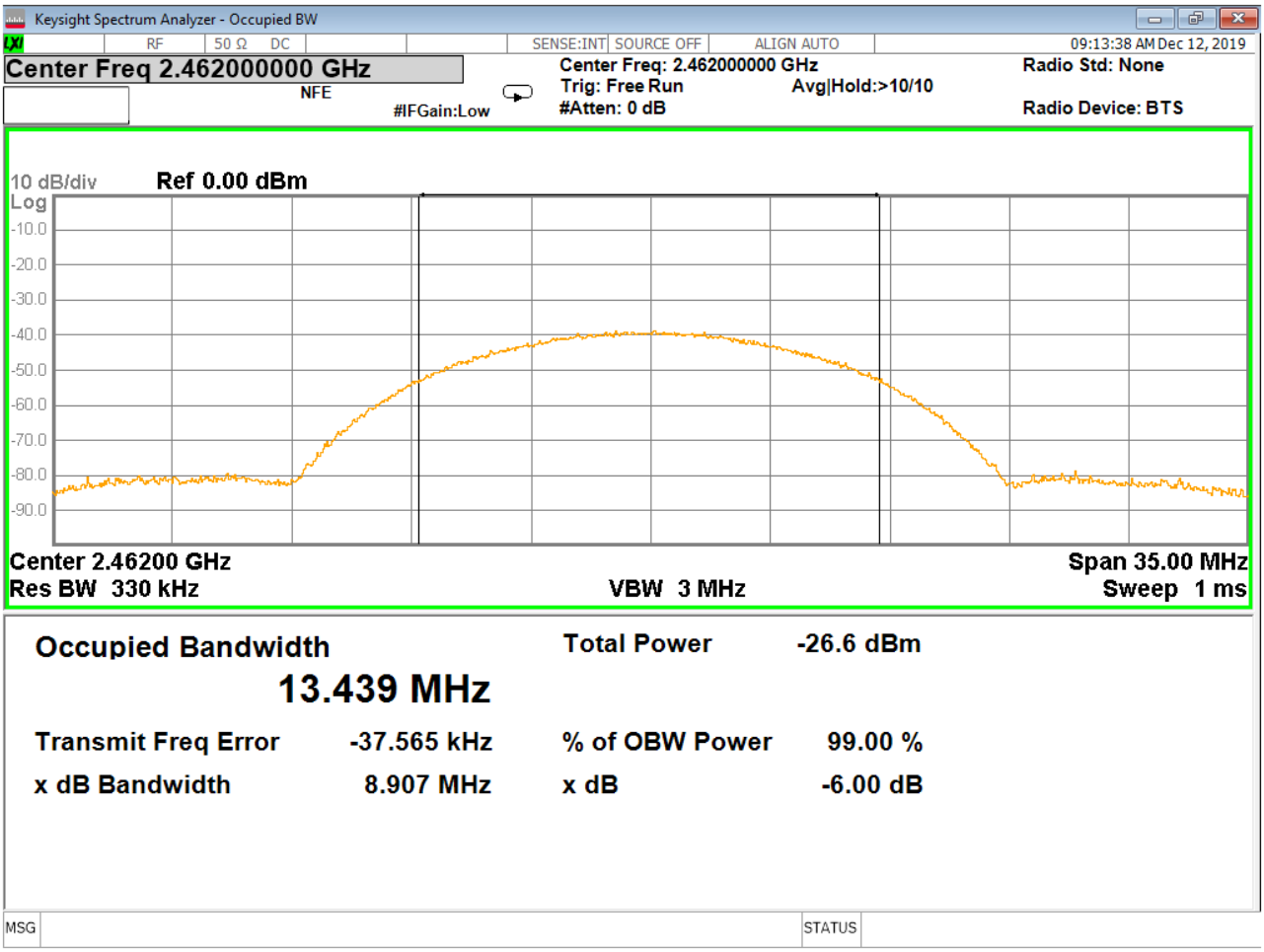


Figure 16 - 99% Occupied Bandwidth and 6dB Bandwidth, High Channel, 802.11b

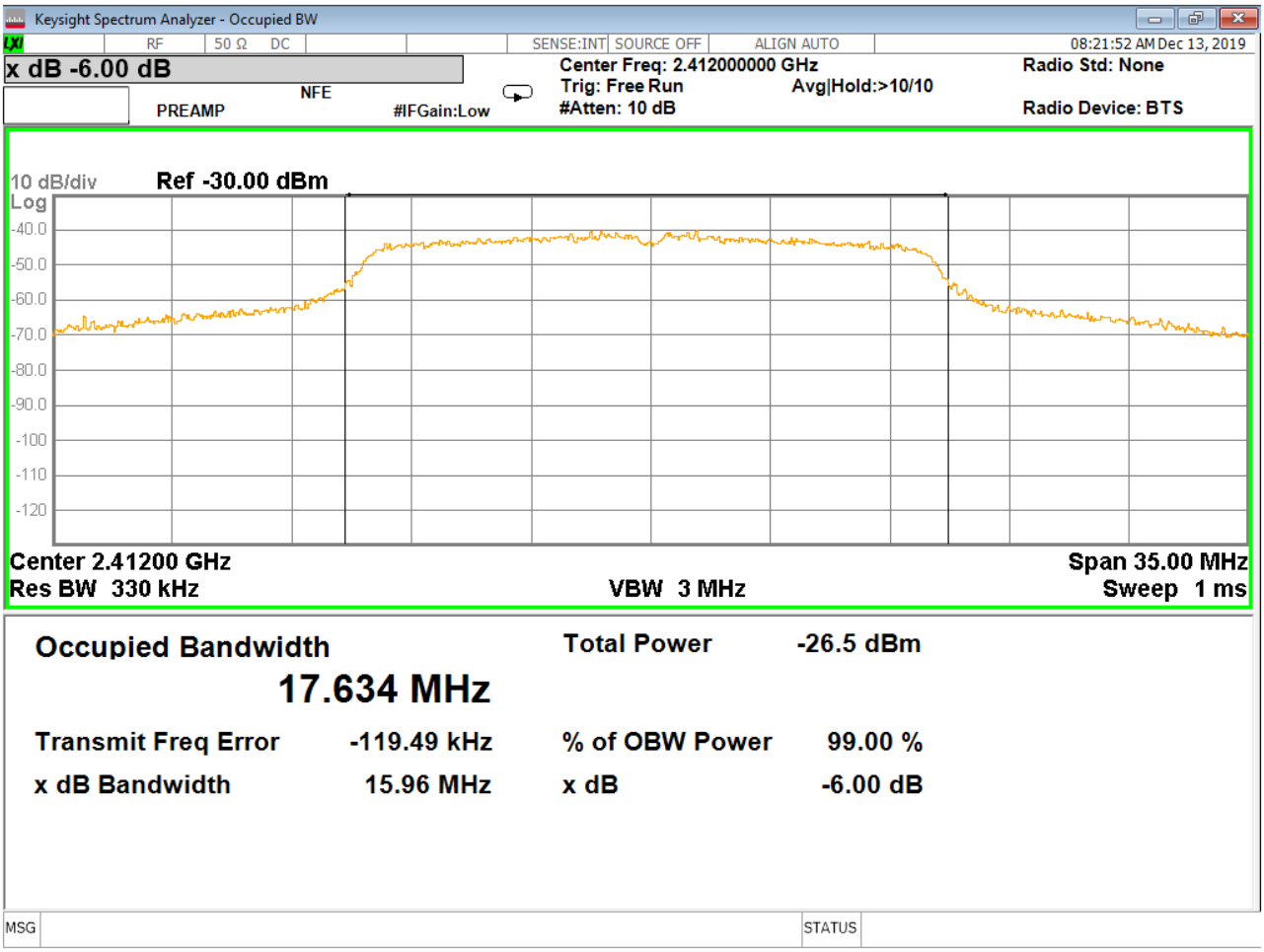


Figure 17 - 99% Occupied Bandwidth and 6dB Bandwidth, Low Channel, 802.11g

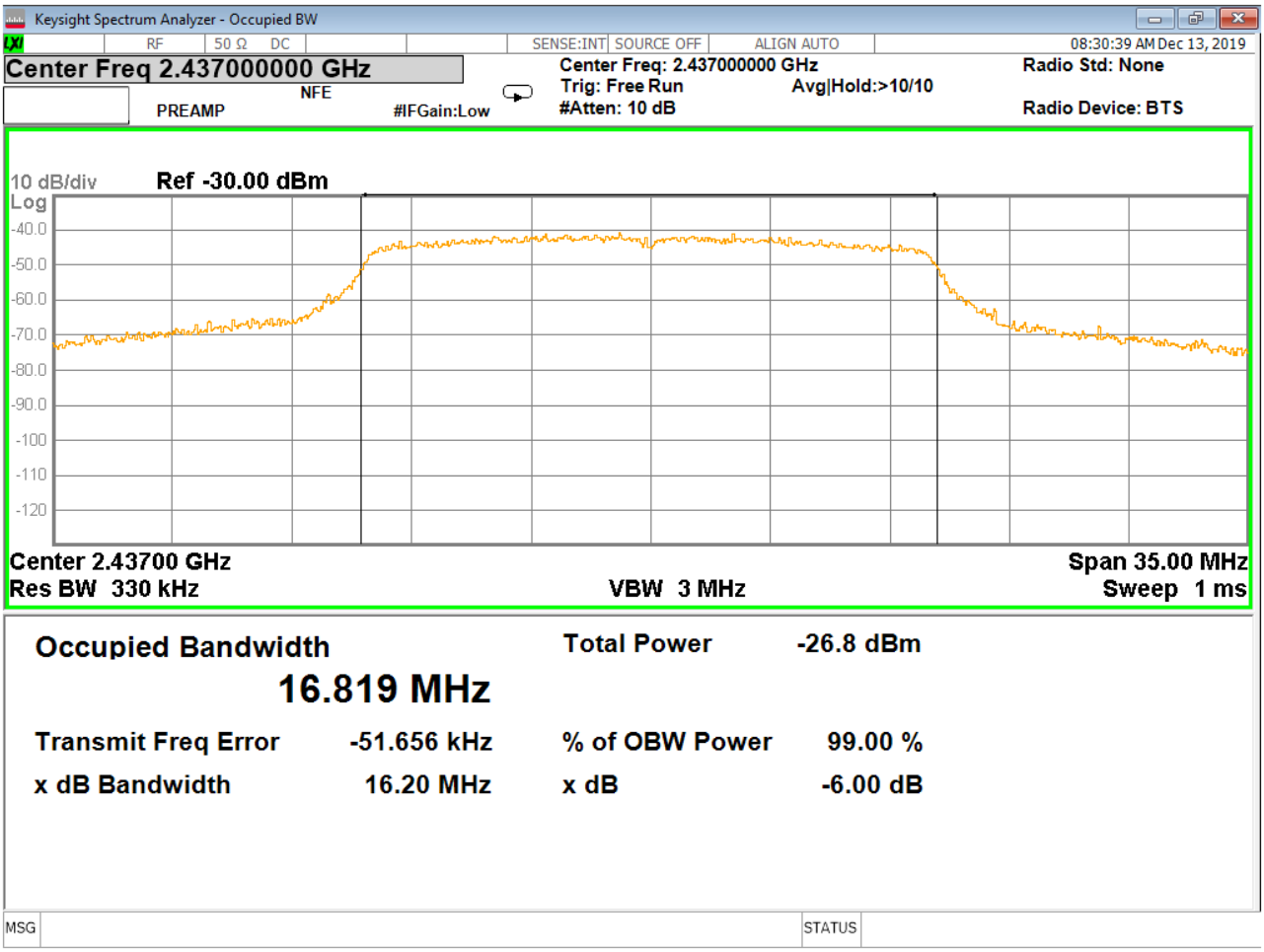


Figure 18 - 99% Occupied Bandwidth and 6dB Bandwidth, Mid Channel, 802.11g

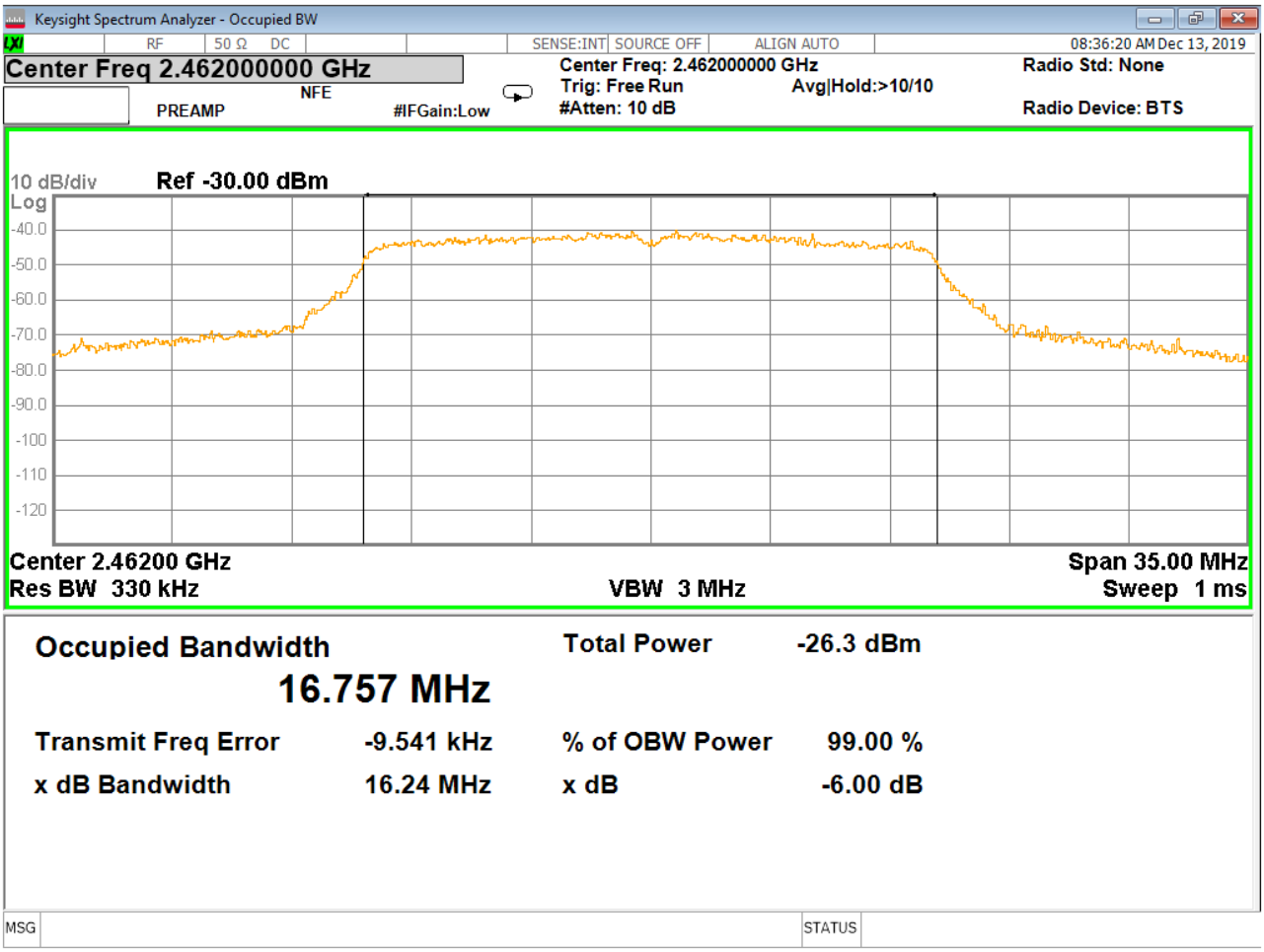


Figure 19 - 99% Occupied Bandwidth and 6dB Bandwidth, High Channel, 802.11g

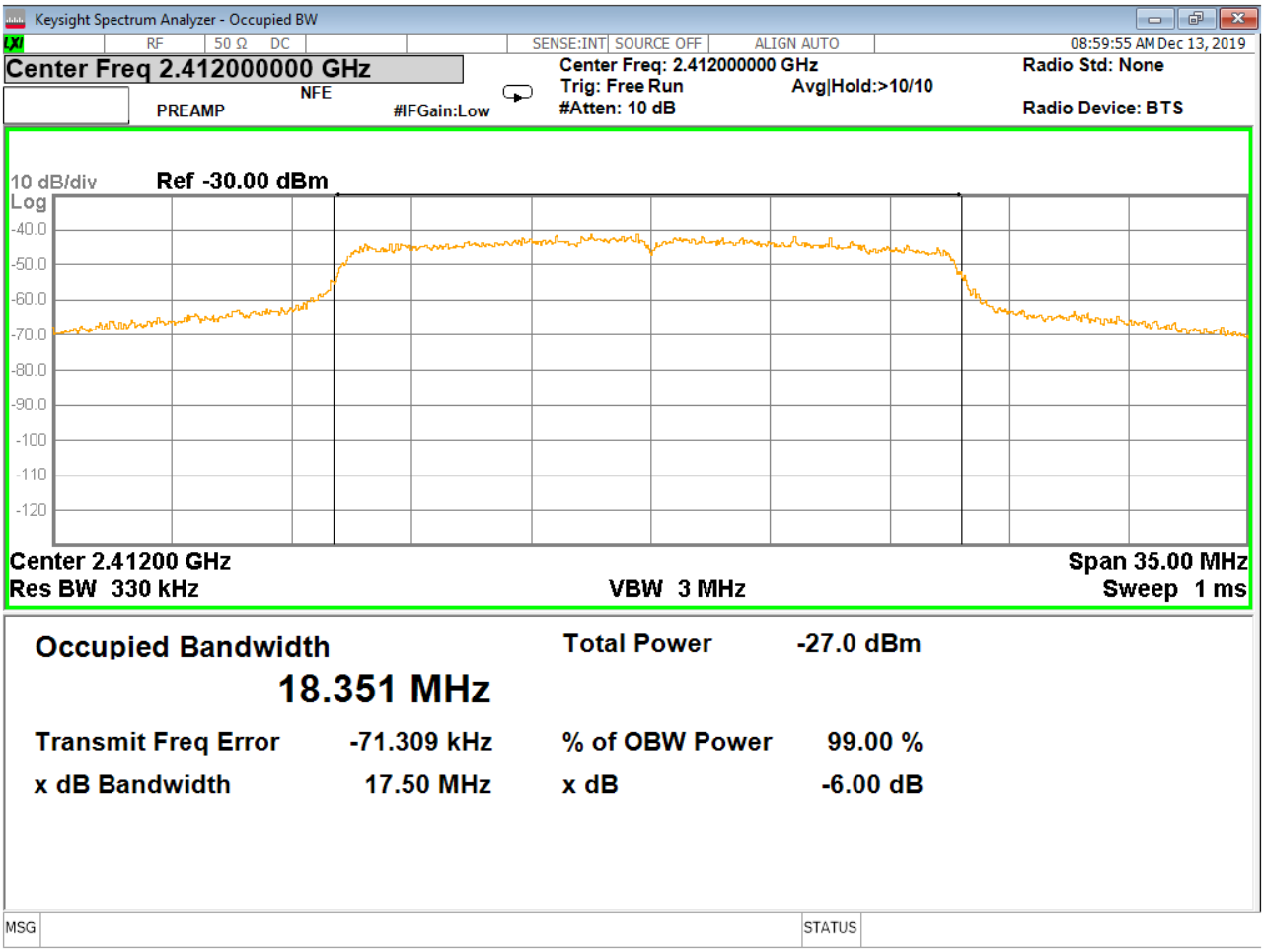


Figure 20 - 99% Occupied Bandwidth and 6dB Bandwidth, Low Channel, 802.11n

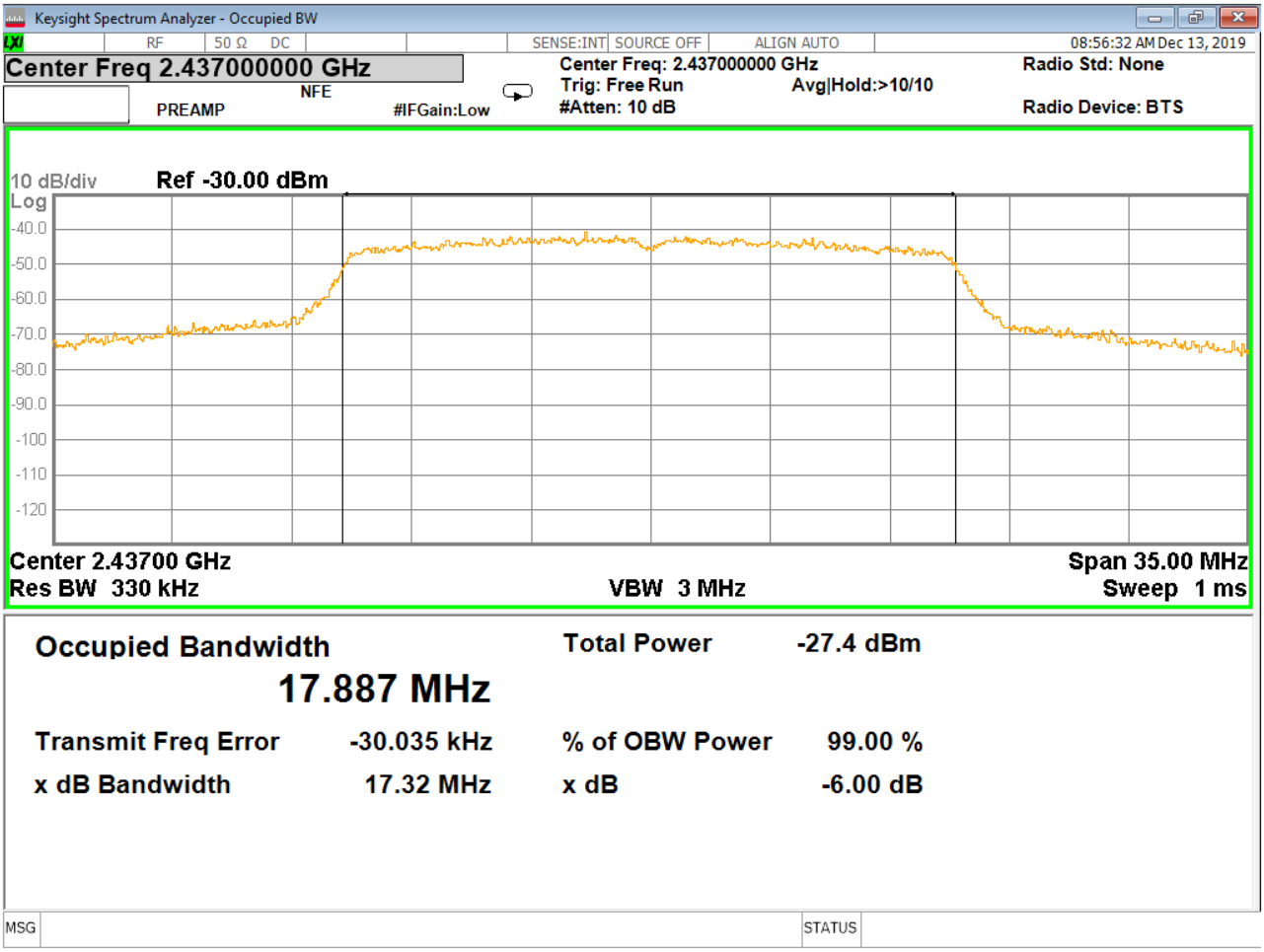


Figure 21 - 99% Occupied Bandwidth and 6dB Bandwidth, Mid Channel, 802.11n

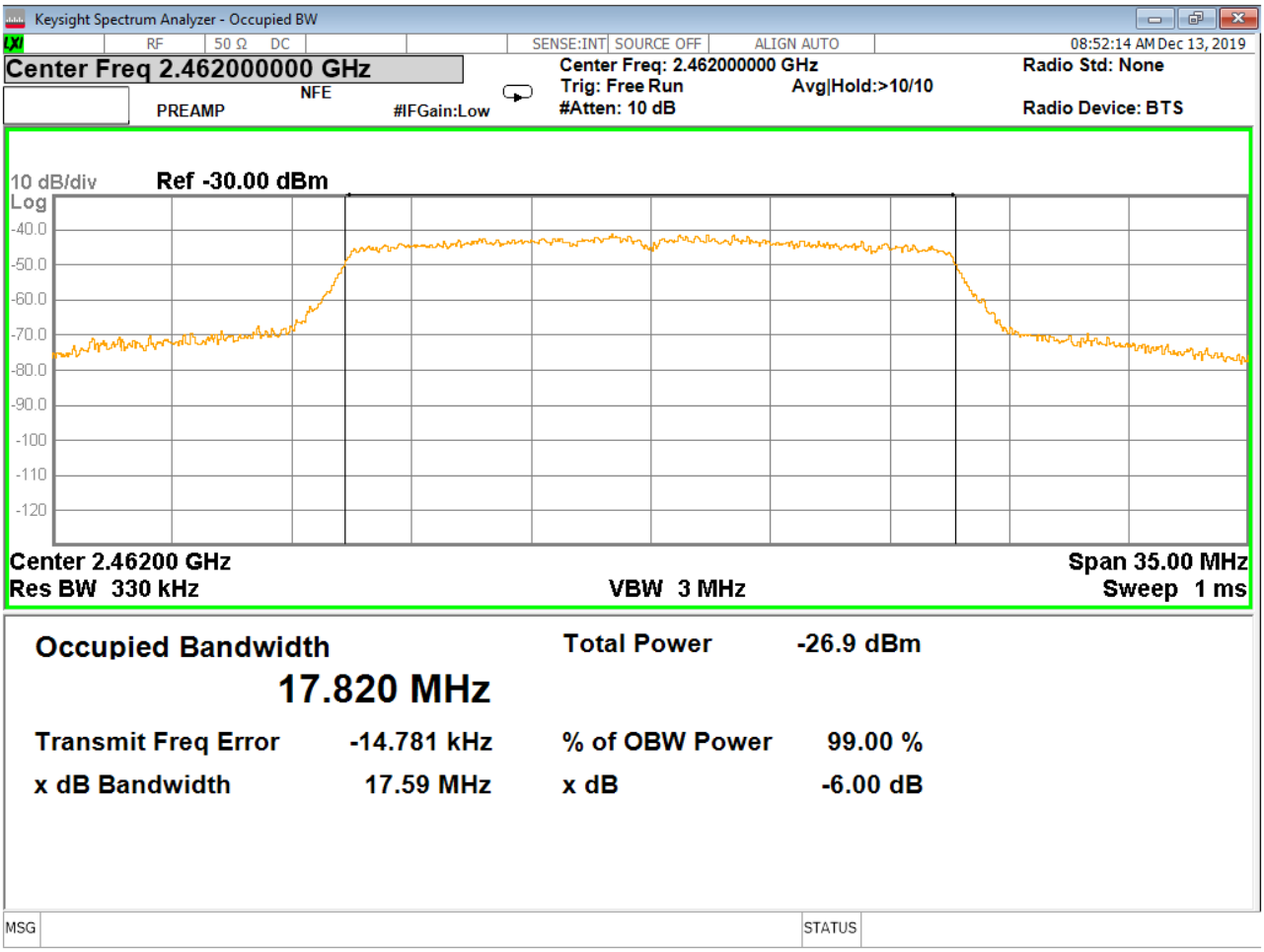


Figure 22 - 99% Occupied Bandwidth and 6dB Bandwidth, High Channel, 802.11n

4.5 BAND-EDGES

Test Method: ANSI C63.10:

1. Section 6.10.5 (used for restricted bands)
2. Section 11.13.2 “Marker-delta method” (for unrestricted bands)
3. Section 11.11, “Measurement in unrestricted frequency bands”

Limits of band-edge measurements:
For emissions outside of the allowed band of operation (2400.0MHz – 2480.0MHz), the emission level needs to be 20dB under the maximum fundamental field strength. However, if the emissions fall within one of the restricted bands from 15.205 the field strength levels need to be under that of the limits in 15.209.

Test procedures:
The EUT was tested in the same method as described in section *4.4 - Bandwidth*. The resolution bandwidth was set to 100kHz and video bandwidth to 300 kHz the EMI receiver was used to scan from the band-edge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209.

Deviations from test standard:
No deviation.

Test setup:

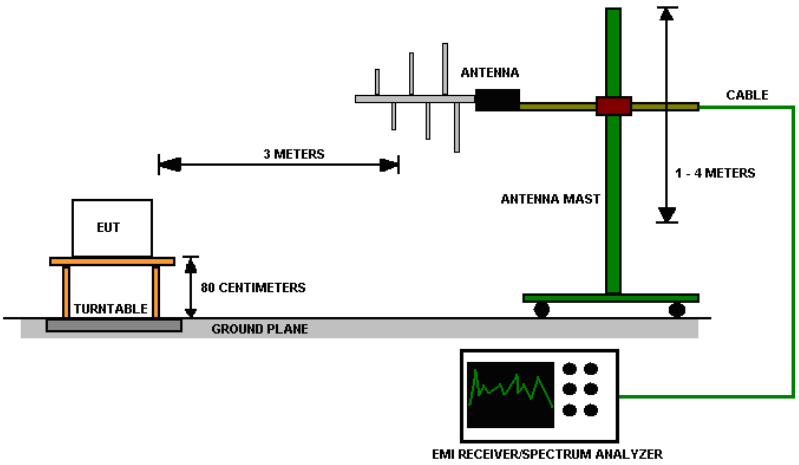


Figure 23 – Bandwidth Measurements Test Setup

EUT operating conditions:

The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Highest Out of Band Emissions, 802.11b

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2390.0 (Unrestricted, Peak)	-77.159	-42.297	34.862	20	PASS
1	2390.0 (Unrestricted, Average)	-87.825	-52.3	35.525	20	PASS
11	2483.5 (Unrestricted, Peak)	-93.729	-41.885	51.844	20	PASS
11	2483.5 (Unrestricted, Average)	-116.572	-52.672	63.9	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Gain (dBi)	Margin	Result
1	2340.0 (Restricted, Peak)	-98.178	-98.178	-21.23	0	76.95	PASS
1	2340.0 (Restricted, Average)	-113.458	-113.458	-41.23	0	72.23	PASS
11	2483.5 (Restricted, Peak)	-98.427	-98.427	-21.23	0	77.20	PASS
11	2483.5 (Restricted, Average)	-113.516	-113.516	-41.23	0	72.29	PASS

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

*Limits from Part 15.209 in dBm **Antenna gain declared by the manufacturer

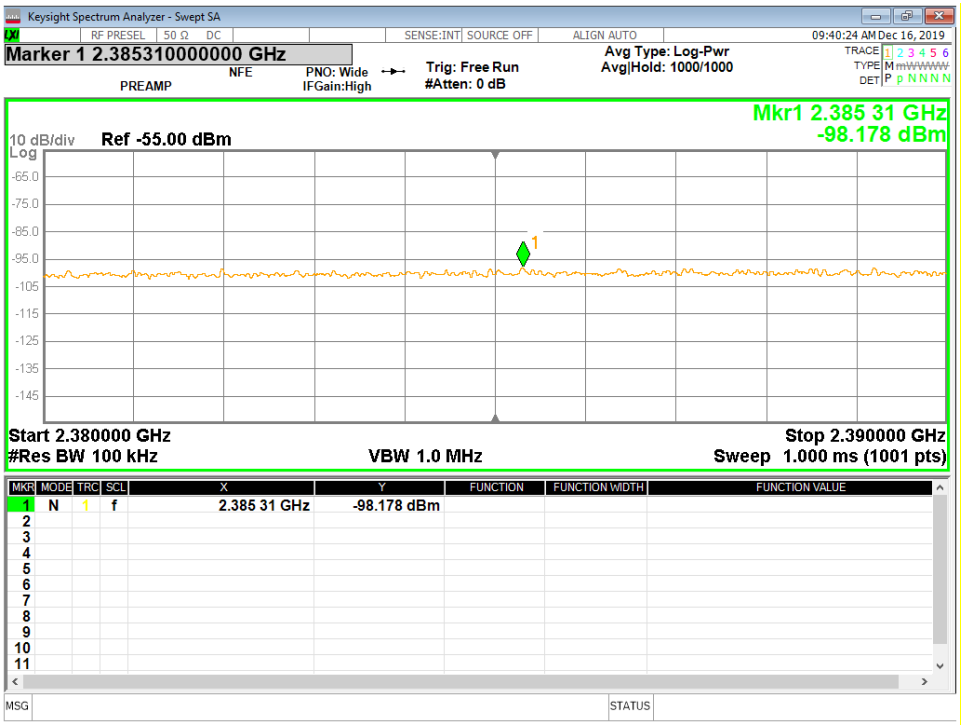


Figure 24 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

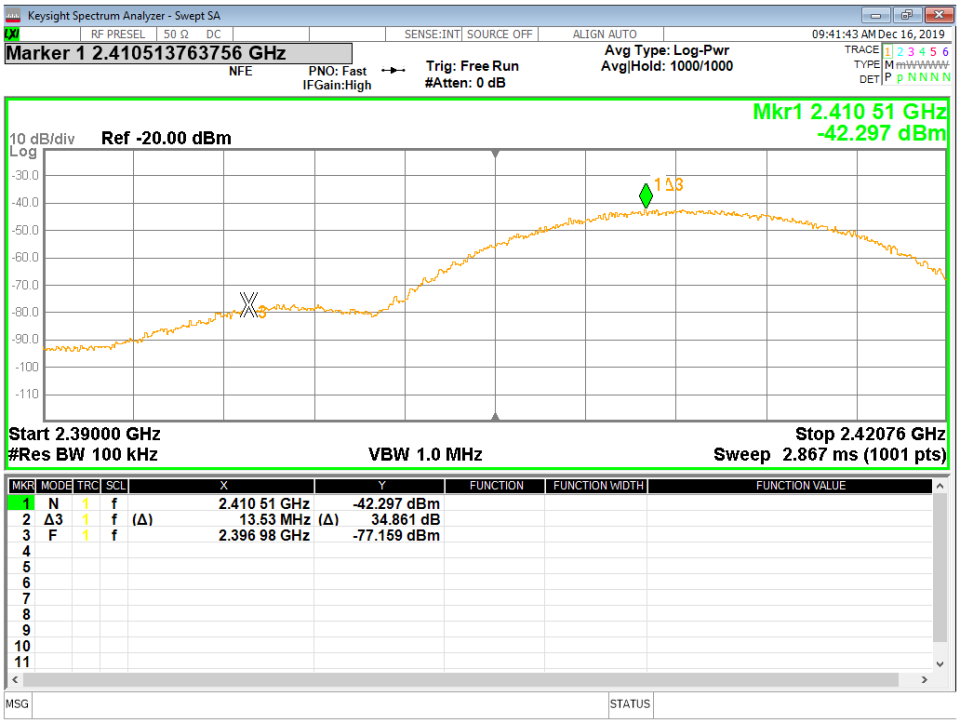


Figure 25 - Band-edge Measurement, Low Channel, Fundamental, Peak

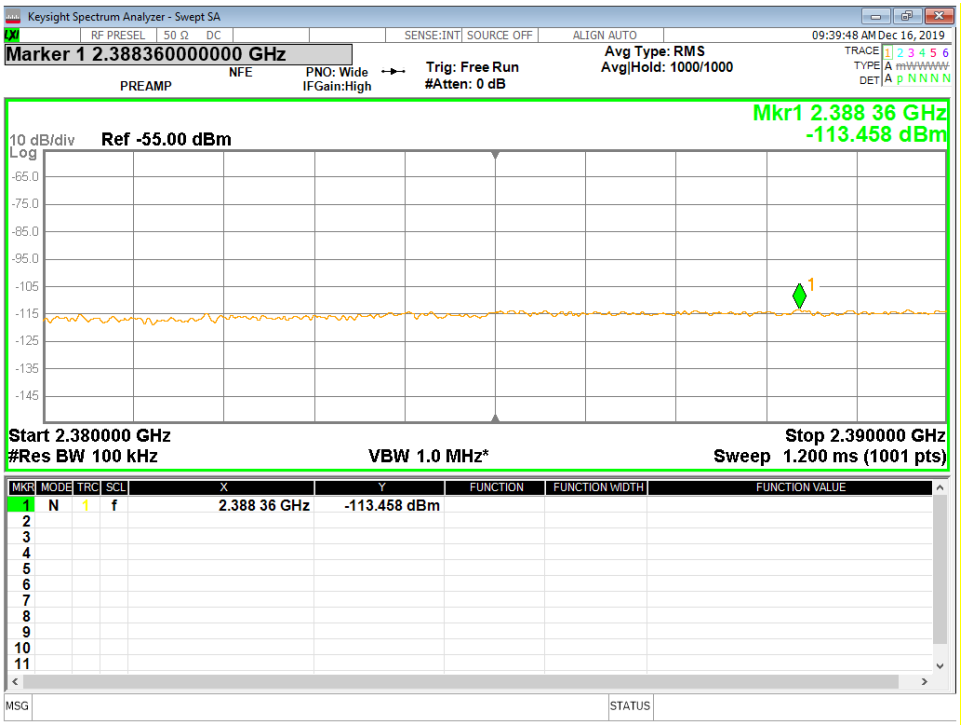


Figure 26 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

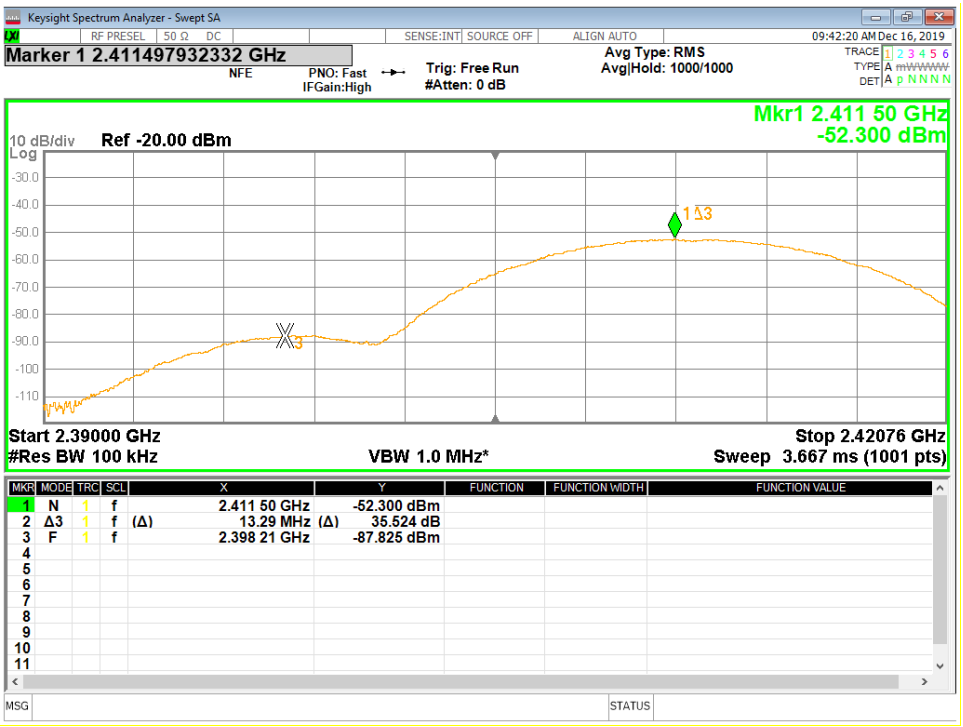


Figure 27 - Band-edge Measurement, Low Channel, Fundamental, Average

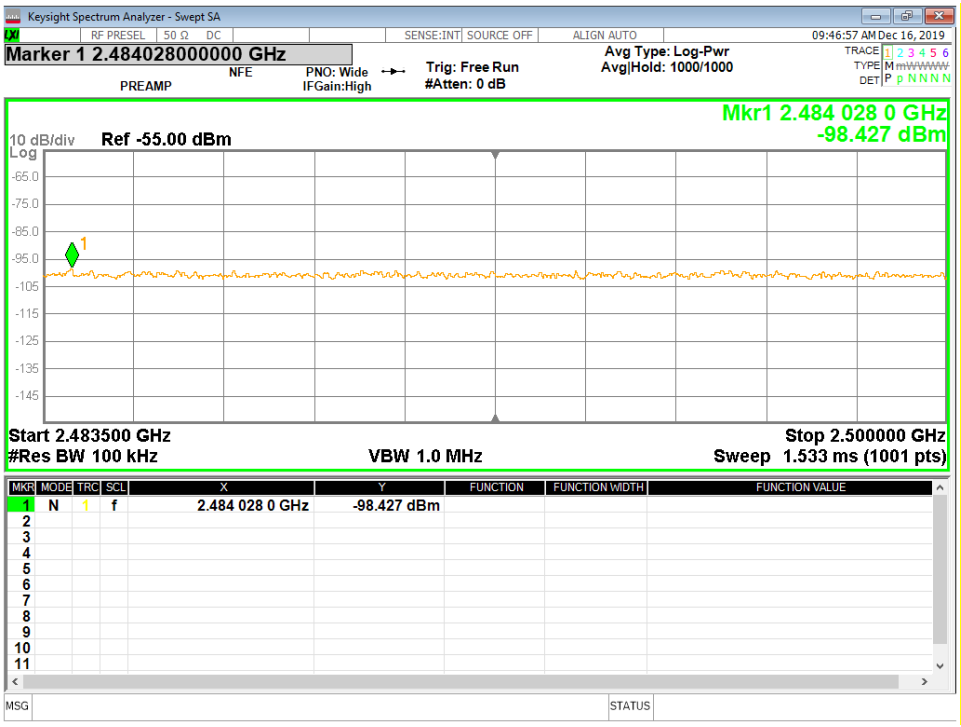


Figure 28 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

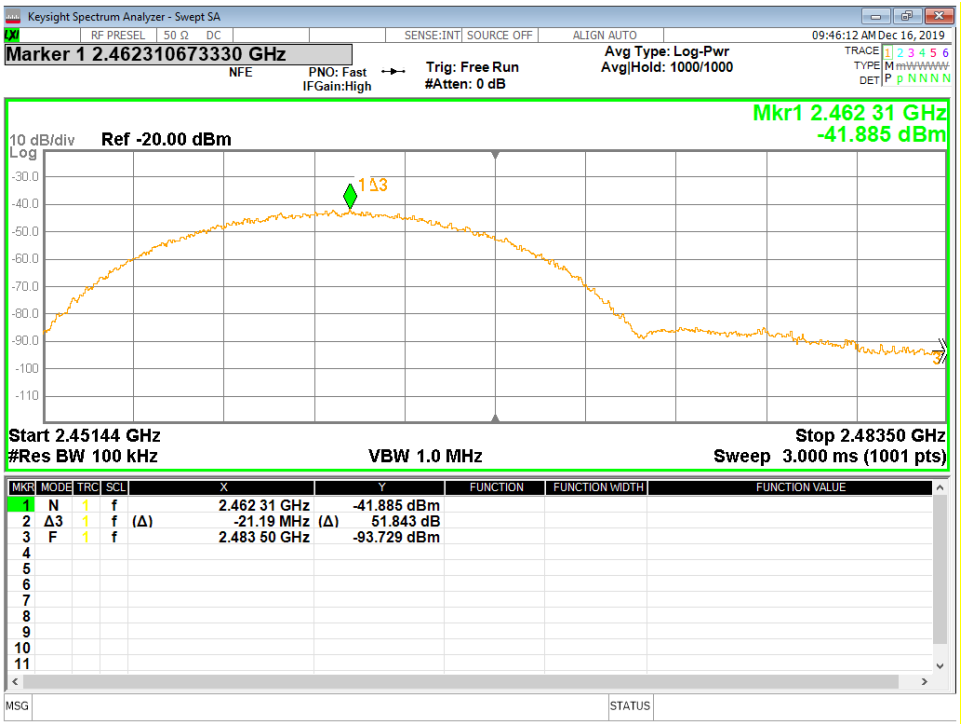


Figure 29 - Band-edge Measurement, High Channel, Fundamental, Peak

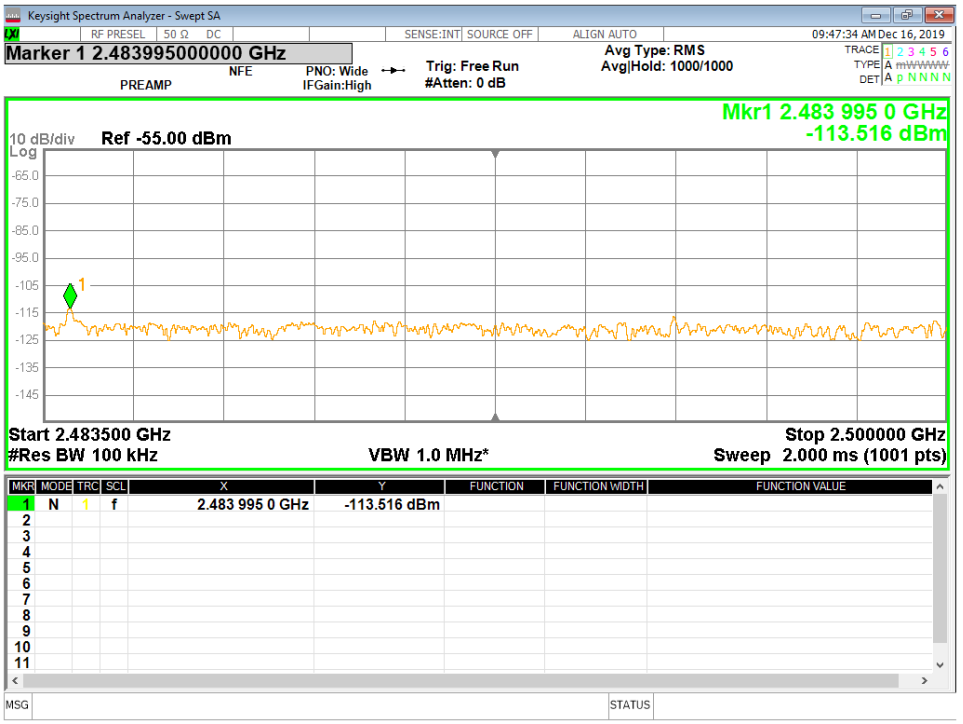


Figure 30 - Band-edge Measurement, High Channel, Restricted Frequency, Average

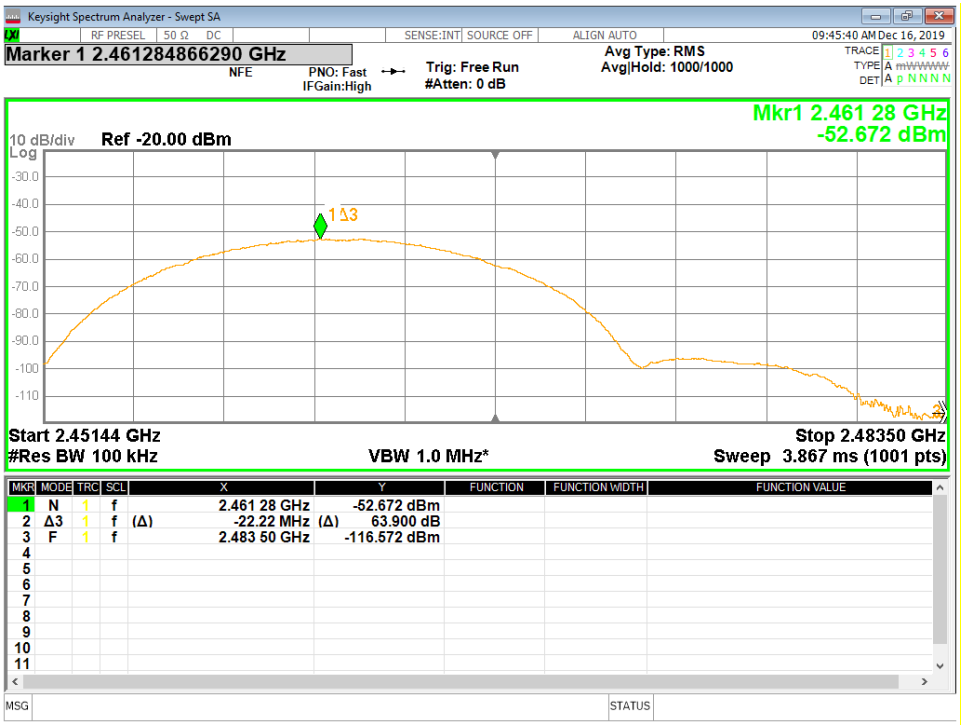


Figure 31 - Band-edge Measurement, High Channel, Fundamental, Average

Highest Out of Band Emissions, 802.11g

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2390.0 (Unrestricted, Peak)	-69.132	-45.249	23.883	20	PASS
1	2390.0 (Unrestricted, Average)	-81.428	-55.809	25.619	20	PASS
11	2483.5 (Unrestricted, Peak)	-90.689	-44.184	46.505	20	PASS
11	2483.5 (Unrestricted, Average)	-103.817	-55.208	48.609	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Gain (dBi)	Margin	Result
1	2340.0 (Restricted, Peak)	-83.52	-83.52	-21.23	0	62.29	PASS
1	2340.0 (Restricted, Average)	-95.751	-95.751	-41.23	0	54.52	PASS
11	2483.5 (Restricted, Peak)	-89.335	-89.335	-21.23	0	68.11	PASS
11	2483.5 (Restricted, Average)	-103.24	-103.24	-41.23	0	62.01	PASS

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

*Limits from Part 15.209 in dBm **Antenna gain declared by the manufacturer

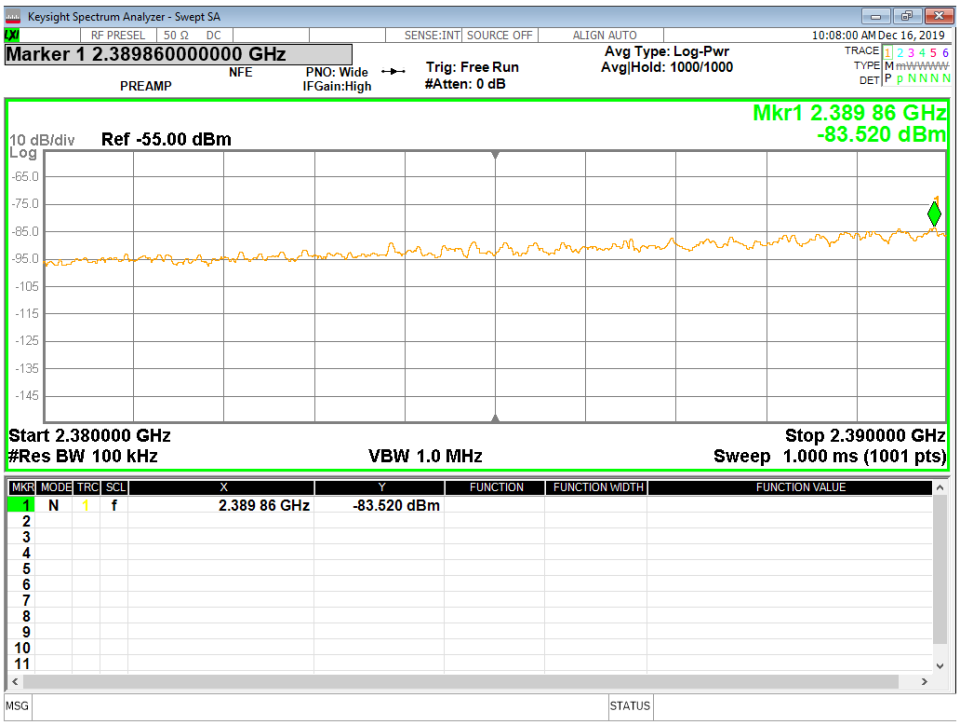


Figure 32 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

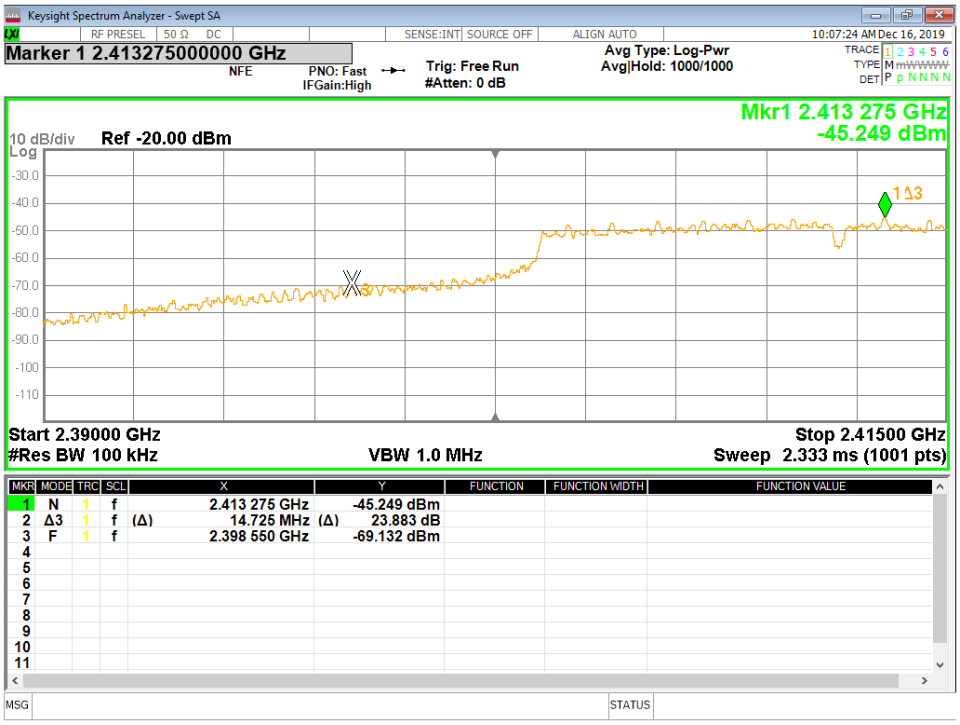


Figure 33 - Band-edge Measurement, Low Channel, Fundamental, Peak

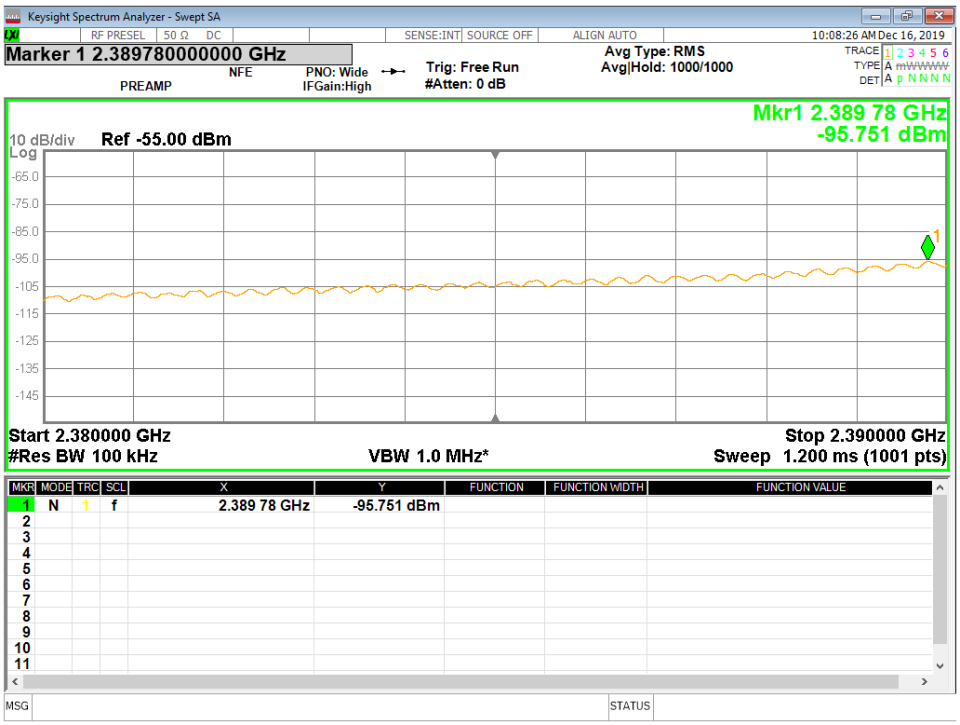


Figure 34 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

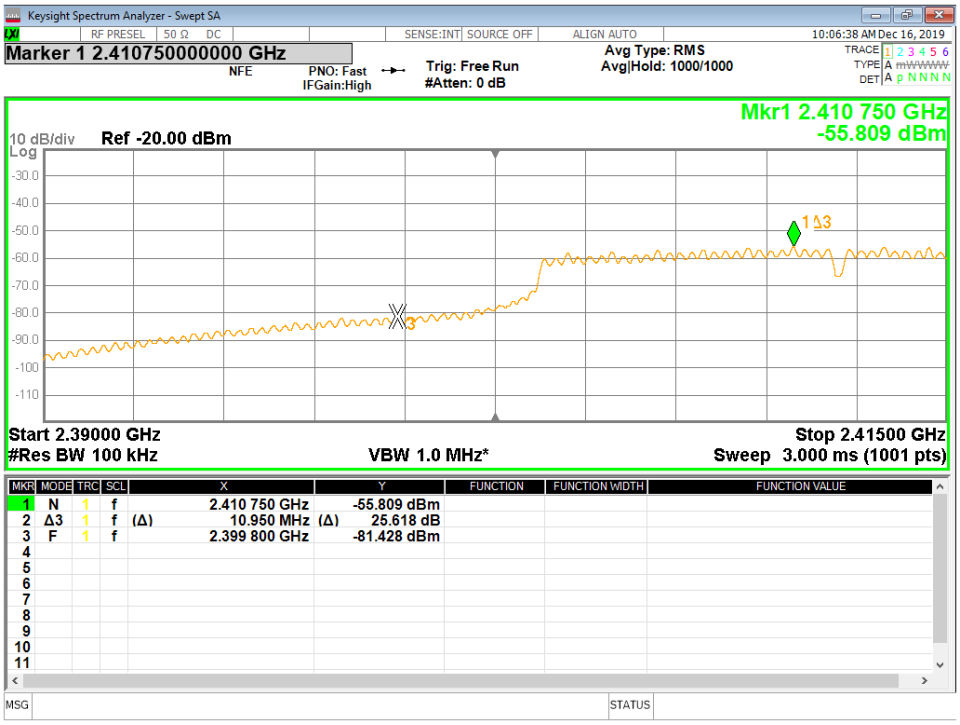


Figure 35 - Band-edge Measurement, Low Channel, Fundamental, Average

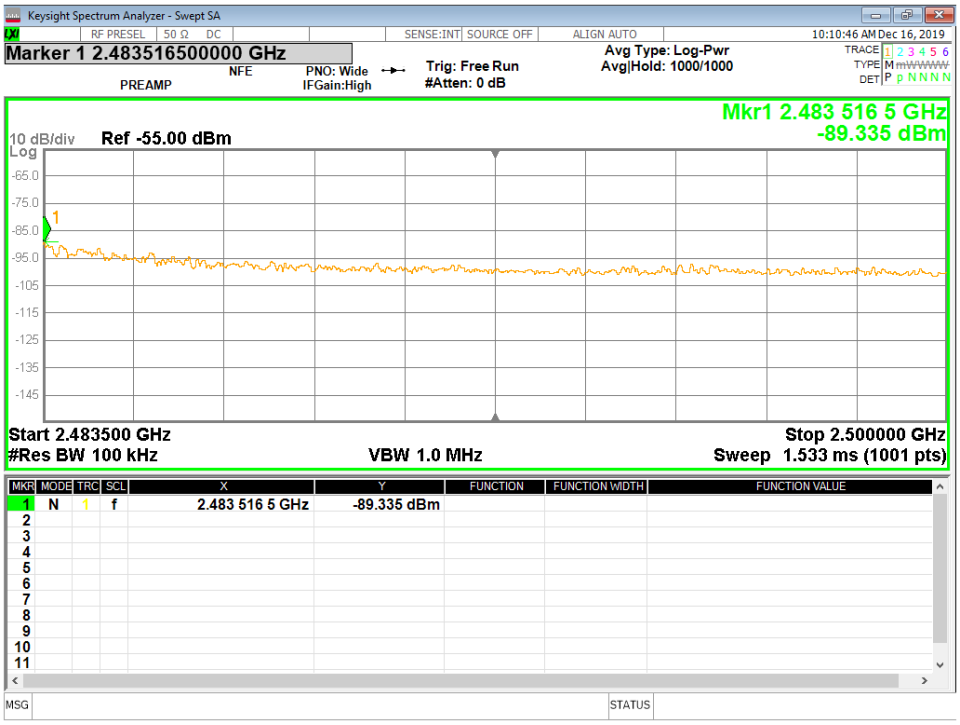


Figure 36 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

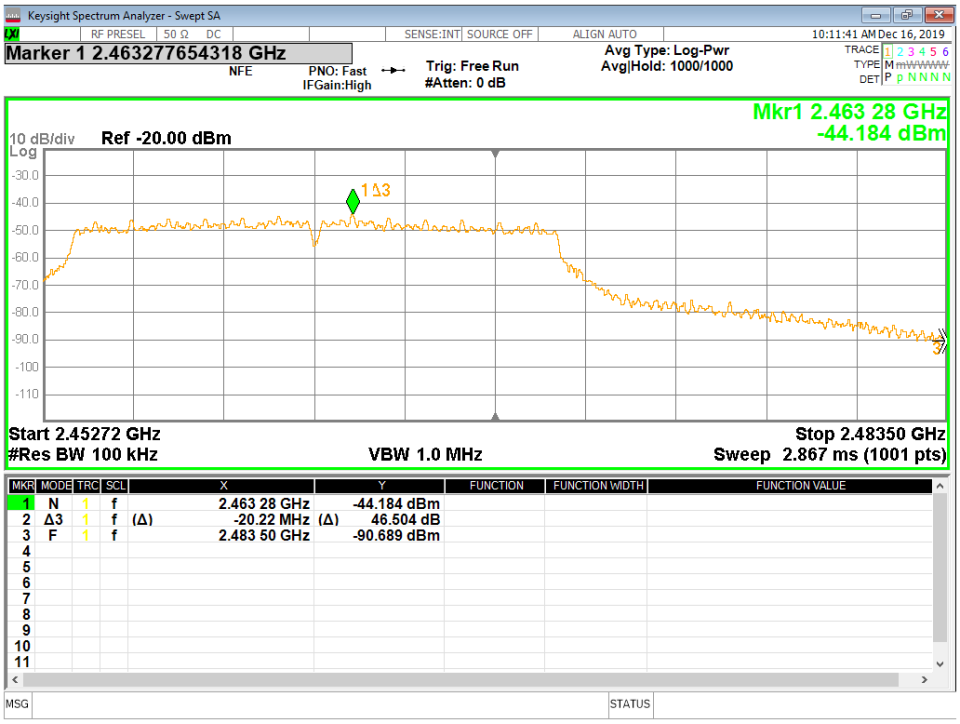


Figure 37 - Band-edge Measurement, High Channel, Fundamental, Peak

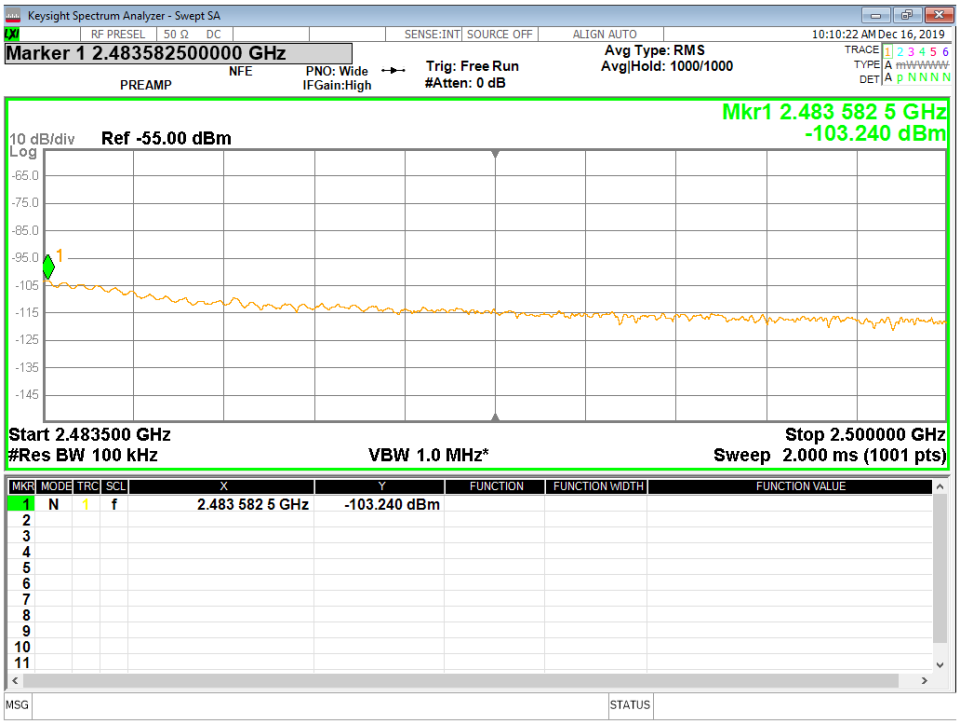


Figure 38 - Band-edge Measurement, High Channel, Restricted Frequency, Average

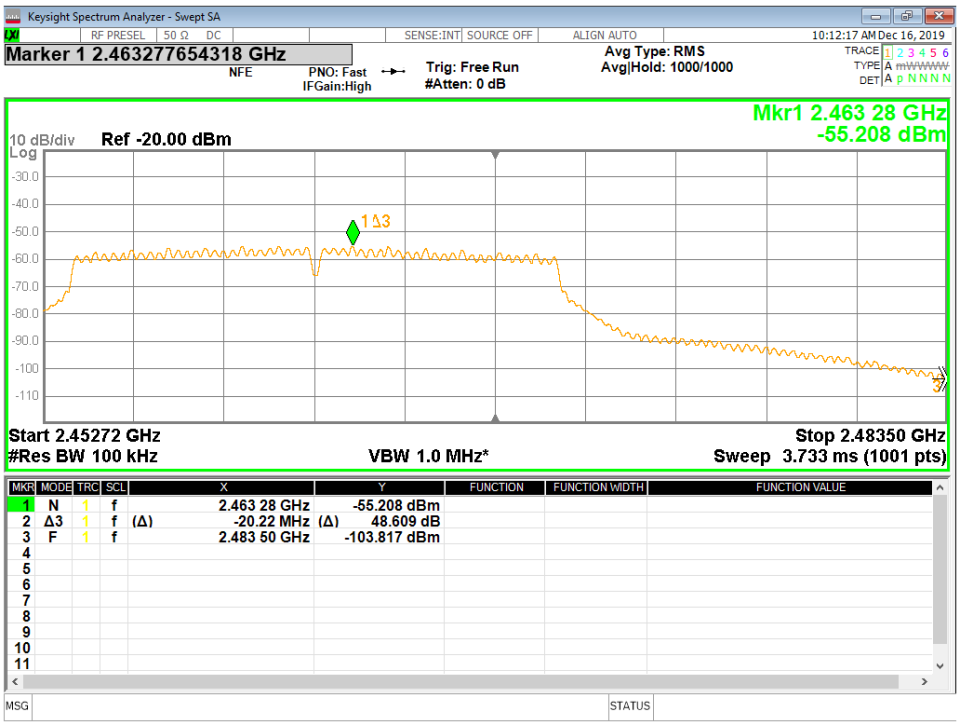


Figure 39 - Band-edge Measurement, High Channel, Fundamental, Average

Highest Out of Band Emissions, 802.11n

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level dBm	Fundamental Level (dBm)	Delta	Min (dBc)	Result
1	2390.0 (Unrestricted, Peak)	-70.42	-45.245	25.175	20	PASS
1	2390.0 (Unrestricted, Average)	-82.191	-55.457	26.734	20	PASS
11	2483.5 (Unrestricted, Peak)	-88.337	-44.25	44.087	20	PASS
11	2483.5 (Unrestricted, Average)	-103.931	-54.907	49.024	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBm)	Corrected Emission Level (dBm)	Limit* (dBm)	Gain** (dBi)	Margin	Result
1	2340.0 (Restricted, Peak)	-82.608	-82.608	-21.23	0	61.38	PASS
1	2340.0 (Restricted, Average)	-96.134	-96.134	-41.23	0	54.90	PASS
11	2483.5 (Restricted, Peak)	-88.459	-88.459	-21.23	0	67.23	PASS
11	2483.5 (Restricted, Average)	-103.087	-103.087	-41.23	0	61.86	PASS

Corrected Emission level= Highest out of band level +Gain
Margin= Limit-Corrected Emission Level
*Limits from Part 15.209 in dBm **Antenna gain declared by the manufacturer

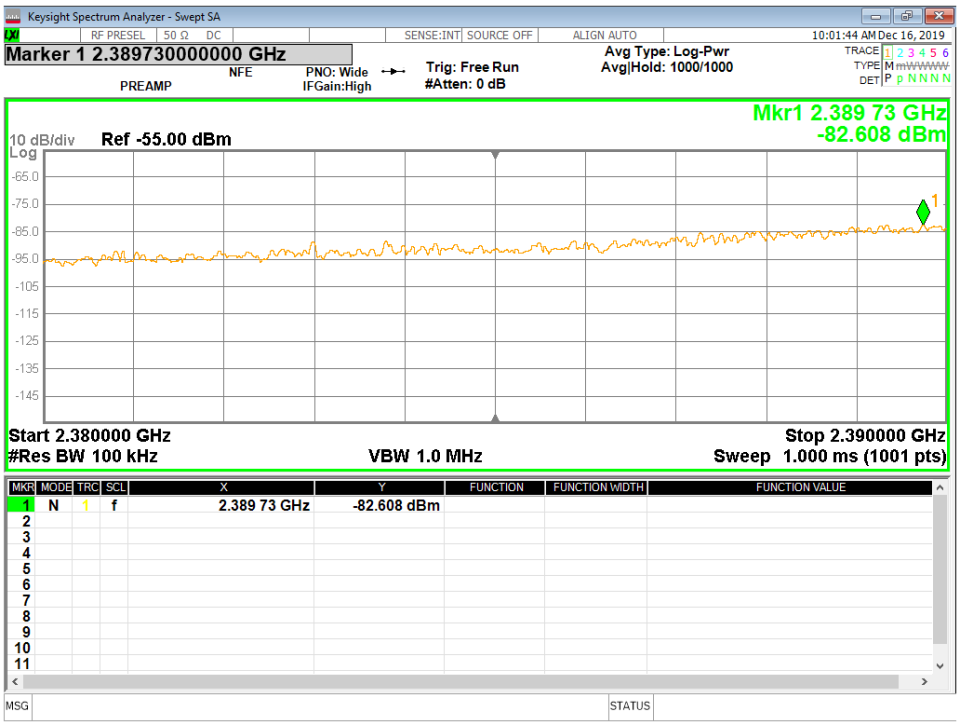


Figure 40 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

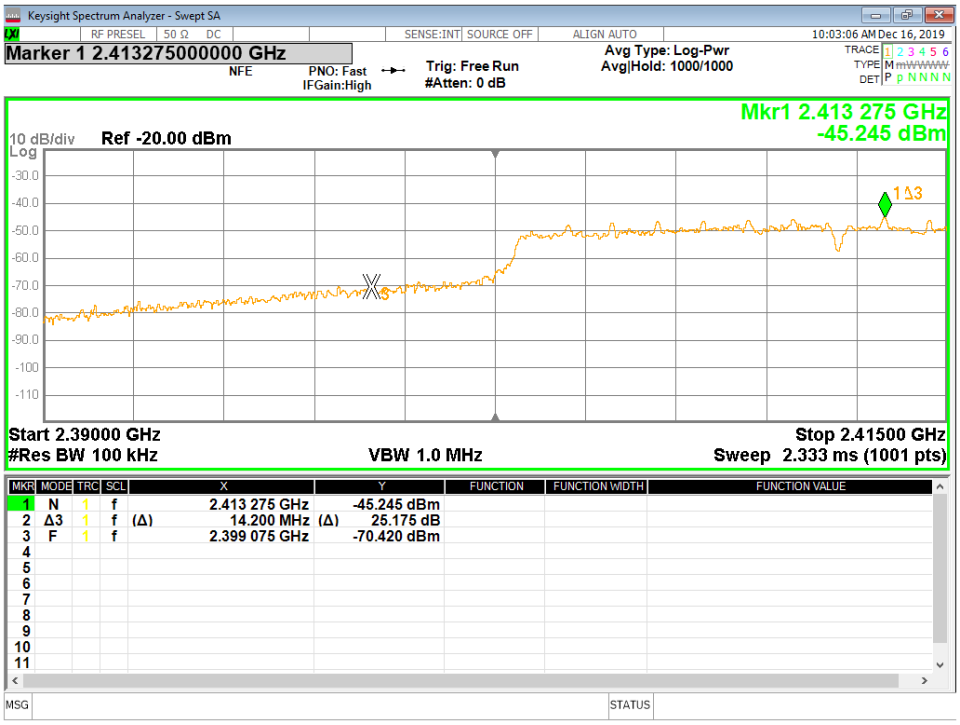


Figure 41 - Band-edge Measurement, Low Channel, Fundamental, Peak

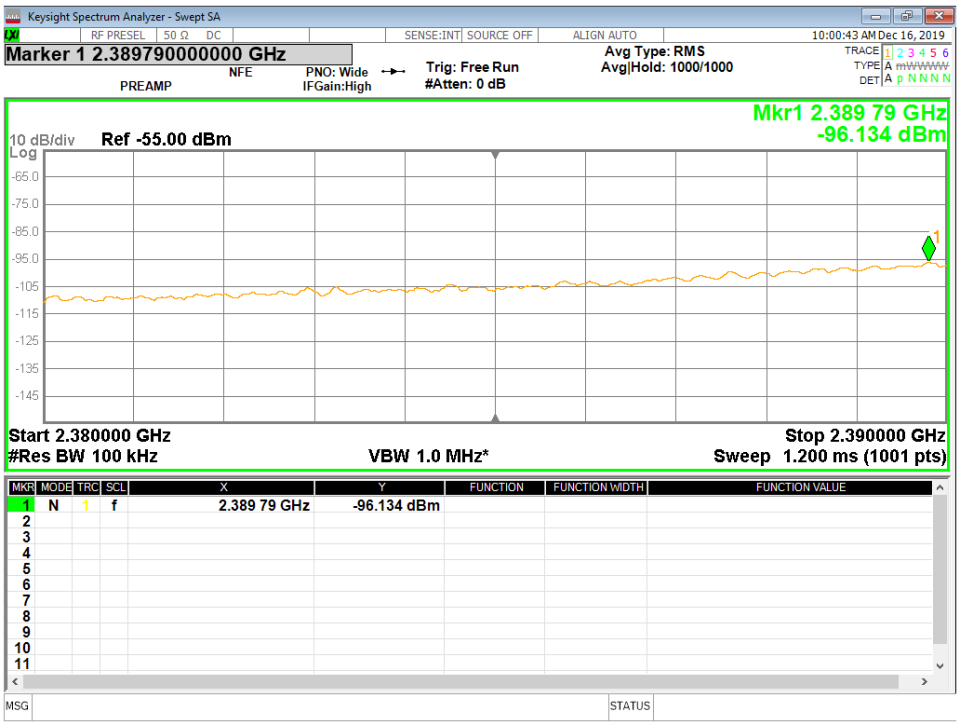


Figure 42 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

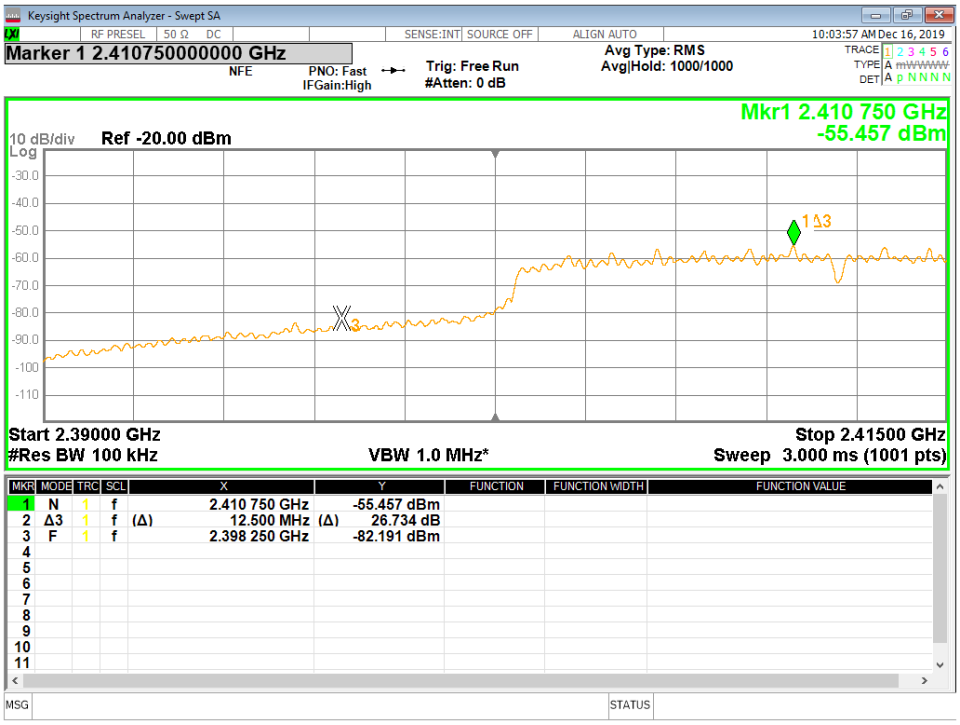


Figure 43 - Band-edge Measurement, Low Channel, Fundamental, Average

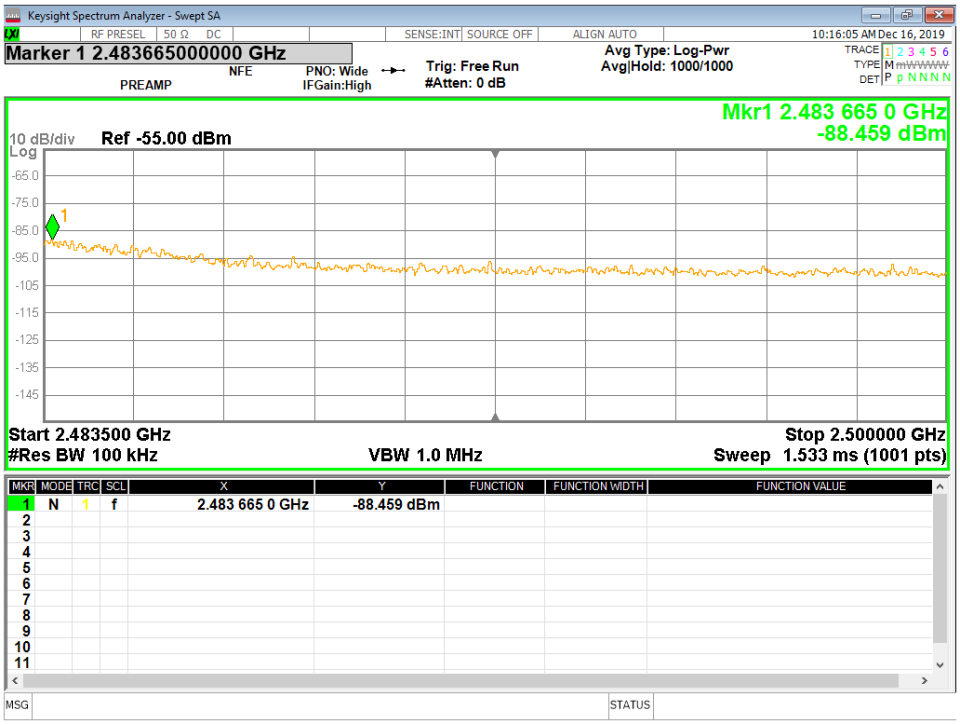


Figure 44 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

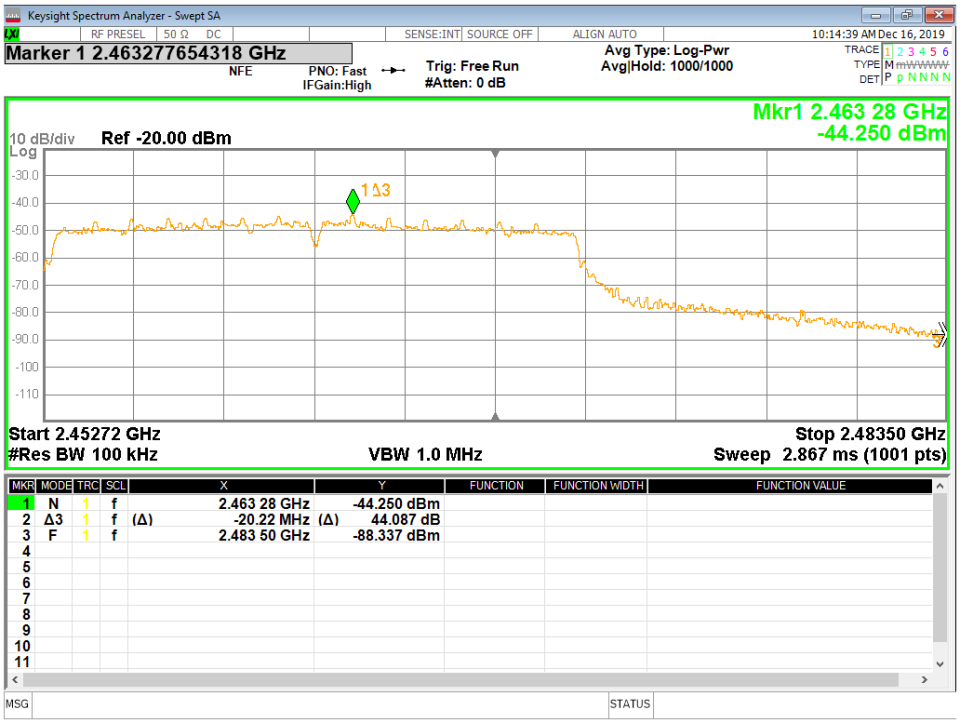


Figure 45 - Band-edge Measurement, High Channel, Fundamental, Peak

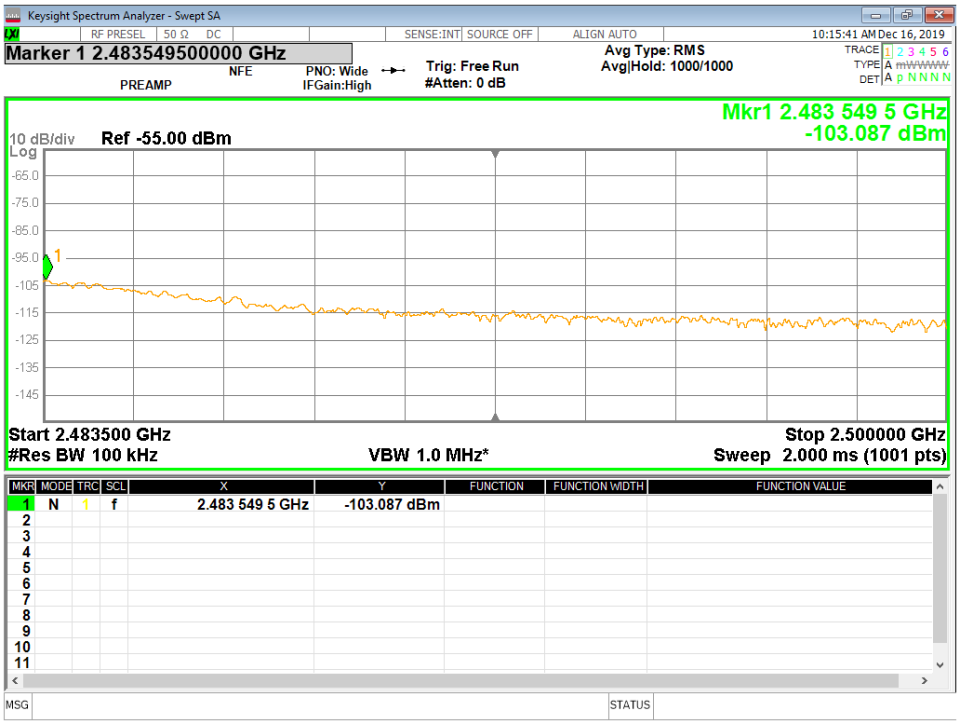


Figure 46 - Band-edge Measurement, High Channel, Restricted Frequency, Average

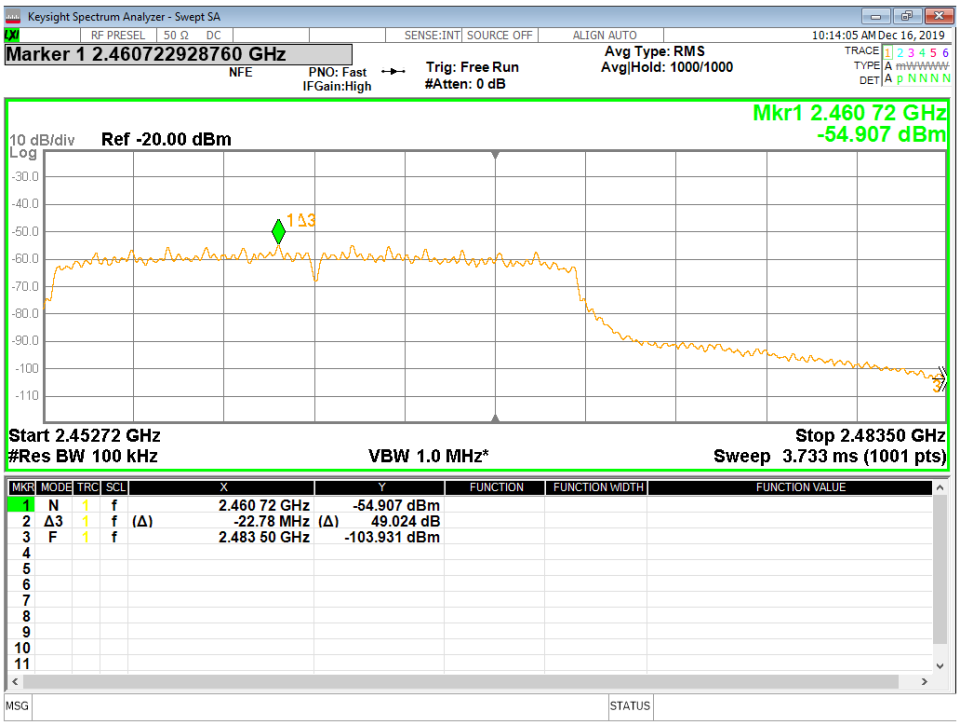


Figure 47 - Band-edge Measurement, High Channel, Fundamental, Average

4.6 POWER SPECTRAL DENSITY

Test Method: ANSI C63.10,
1. Section 11.10.2 “Method PKPSD (peak PSD)”

Limits of power measurements:
The maximum PSD allowed is 8 dBm.

Test procedures:
1. The EUT was at a distance of 3 meters.

2. The resolution bandwidth was set to 3 kHz and the video bandwidth was set to 10 kHz to capture the signal. The analyzer used a peak detector in max hold mode.

Test setup:

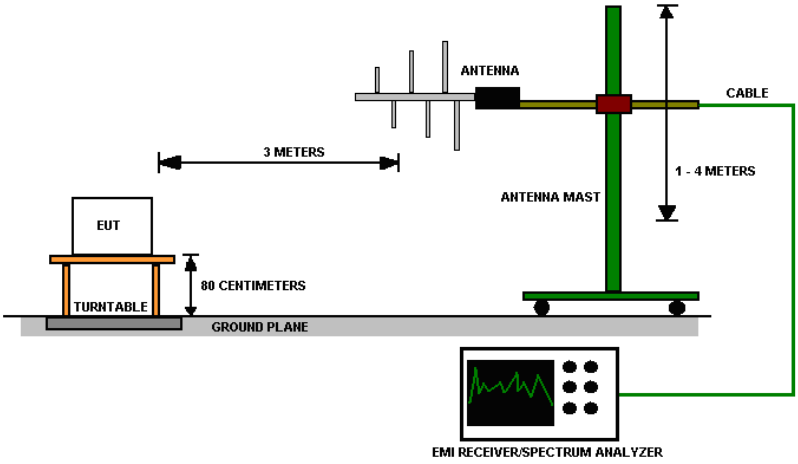


Figure 48 – Bandwidth Measurements Test Setup

EUT operating conditions:
The EUT was powered by internal battery power unless specified and set to transmit continuously on the lowest frequency channel, highest frequency channel and one in the middle of its operating range.

Test results:

Power Spectral Density

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK EIRP PSD(dBm)	PEAK CONDUCTED PSD (dBm)*	Limit (dBm)	RESULT
Low	2412	802.11b	-10.667	-13.167	8.00	PASS
Middle	2437	802.11b	-10.471	-12.971	8.00	PASS
High	2462	802.11b	-10.323	-12.823	8.00	PASS
Low	2412	802.11g	-14.879	-17.379	8.00	PASS
Middle	2437	802.11g	-14.527	-17.027	8.00	PASS
High	2462	802.11g	-14.207	-16.707	8.00	PASS
Low	2412	802.11n	-13.480	-15.980	8.00	PASS
Middle	2437	802.11n	-14.887	-17.387	8.00	PASS
High	2462	802.11n	-14.810	-17.310	8.00	PASS

*Peak conducted PSD = Peak EIRP PSD – antenna gain. Antenna gain = 2.5 dBi

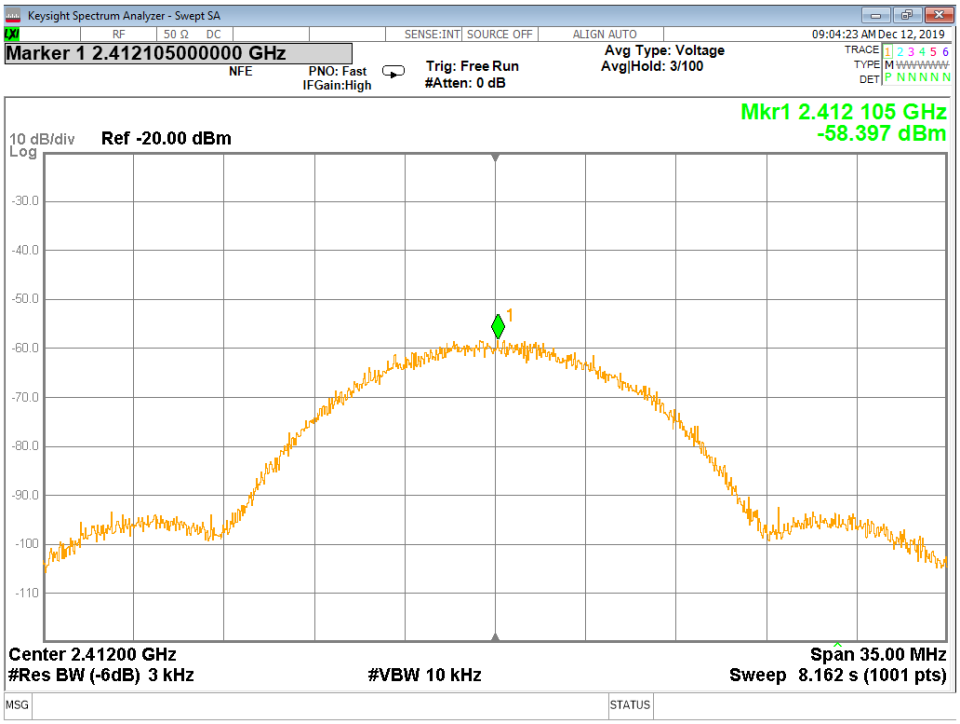


Figure 49 - Power Spectral Density, Low Channel, 802.11b

EIRP PSD = -58.397 + 107 – 95.23 + AF + CL = -10.667

Output PSD = -5.397 dBm

AF = Antenna Factor = 28.36

CL = Cable Loss = 7.6

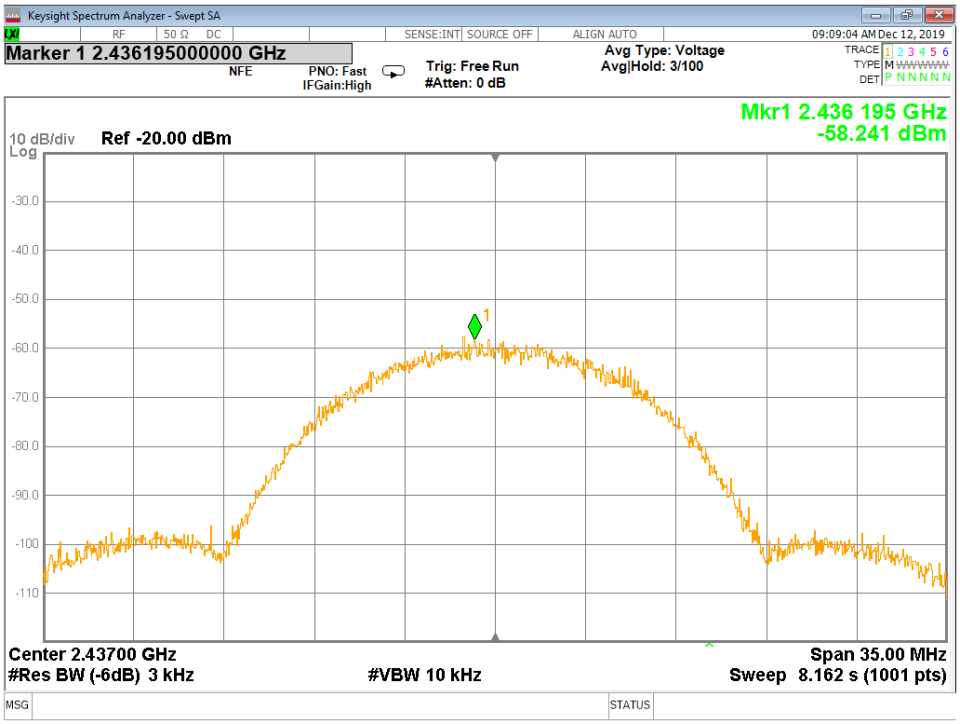


Figure 50 - Power Spectral Density, Mid Channel, 802.11b

EIRP Peak Output Power = -58.241 + 107 – 95.23 + AF + CL = -10.471

Output power = -58.241 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

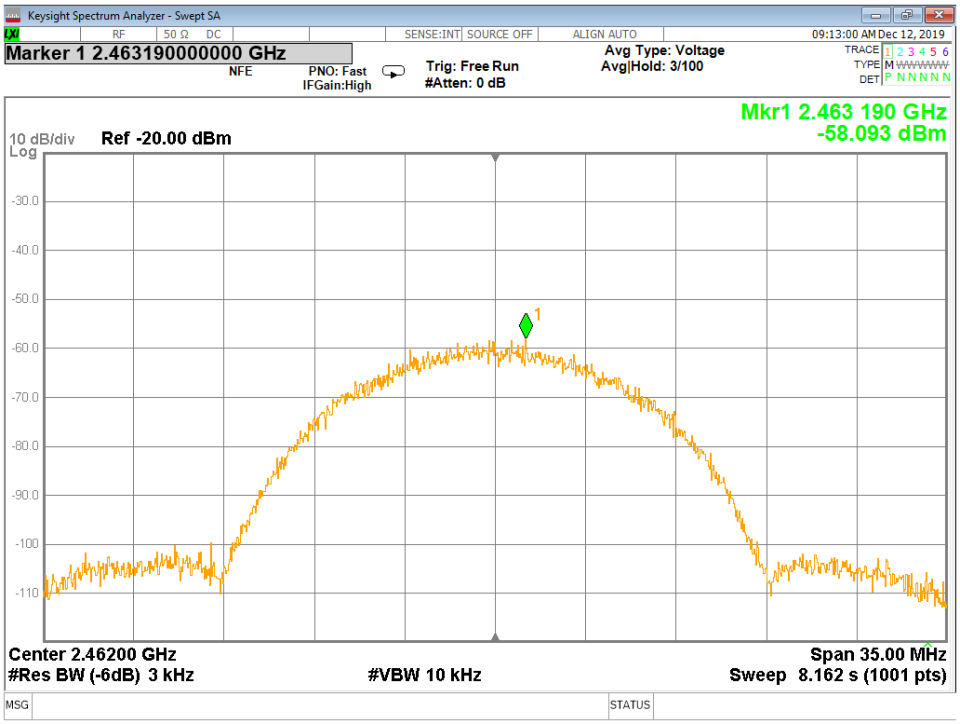


Figure 51 - Power Spectral Density, High Channel, 802.11b

EIRP Peak Output Power = -58.093 + 107 – 95.23 + AF + CL = -10.323

Output power = -58.093 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

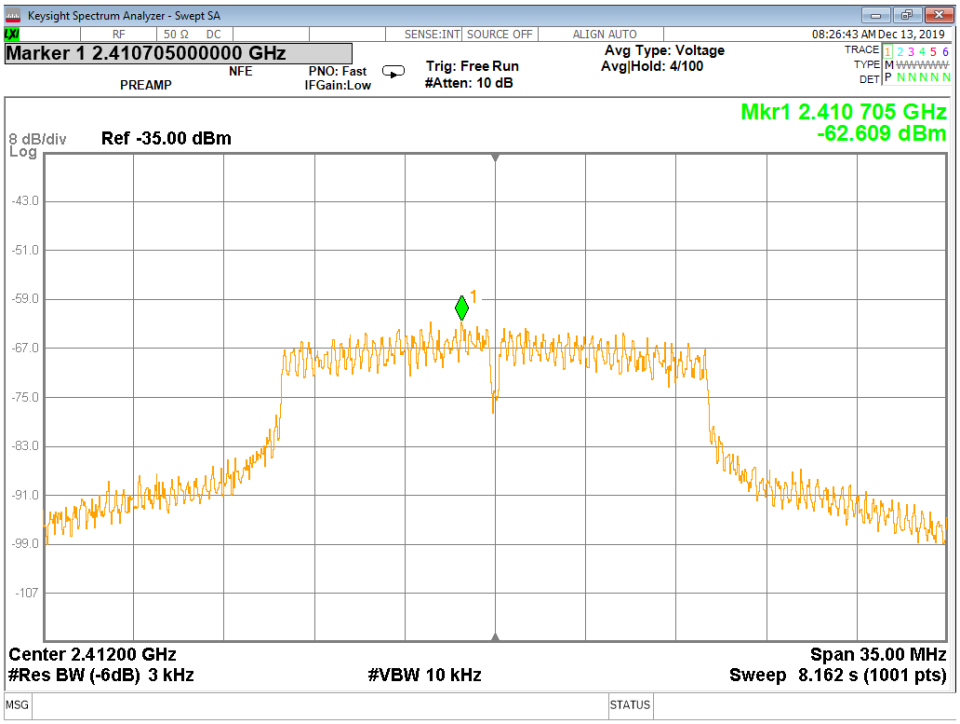


Figure 52 - Power Spectral Density, Low Channel, 802.11g

EIRP Peak Output Power = -62.609 + 107 – 95.23 + AF + CL = -14.879

Output power = -62.609 dBm

AF = Antenna Factor = 28.36

CL = Cable Loss = 7.6

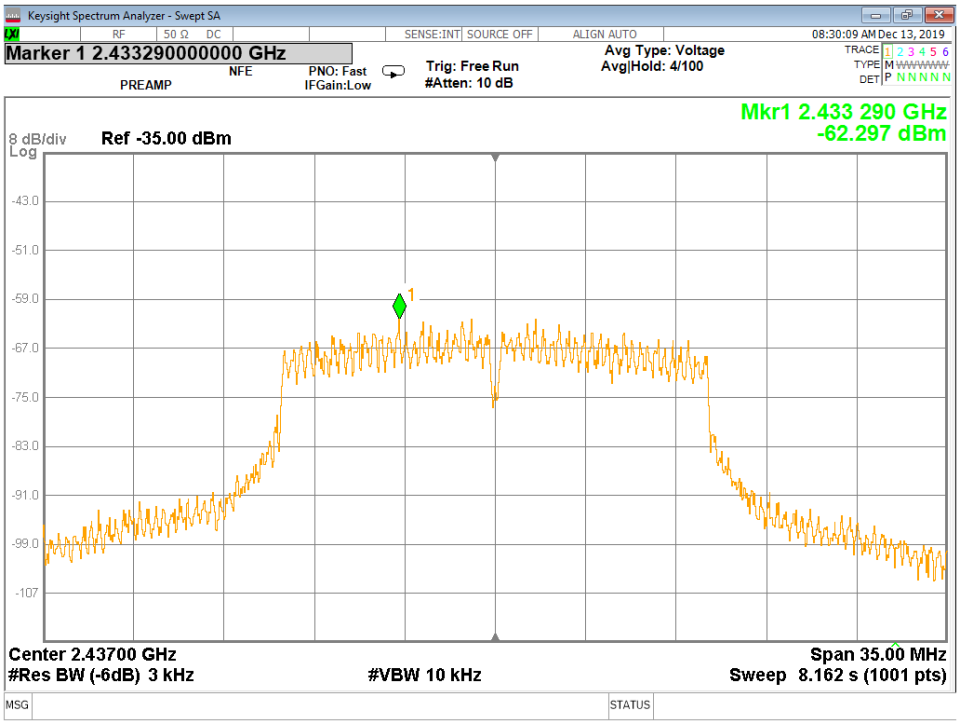


Figure 53 - Power Spectral Density, Mid Channel, 802.11g

EIRP Peak Output Power = -62.297 + 107 – 95.23 + AF + CL = -14.527

Output power = -62.297 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

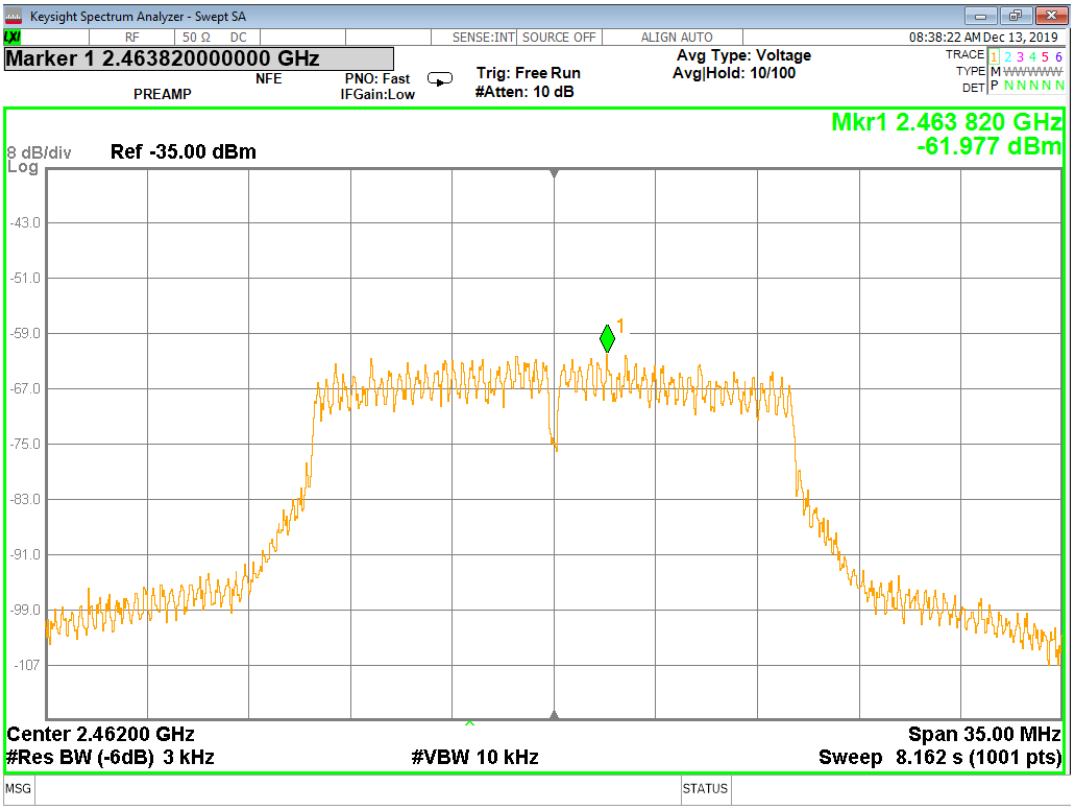


Figure 54 - Power Spectral Density, High Channel, 802.11g

EIRP Peak Output Power = -61.977 + 107 – 95.23 + AF + CL = -14.207

Output power = -61.977 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

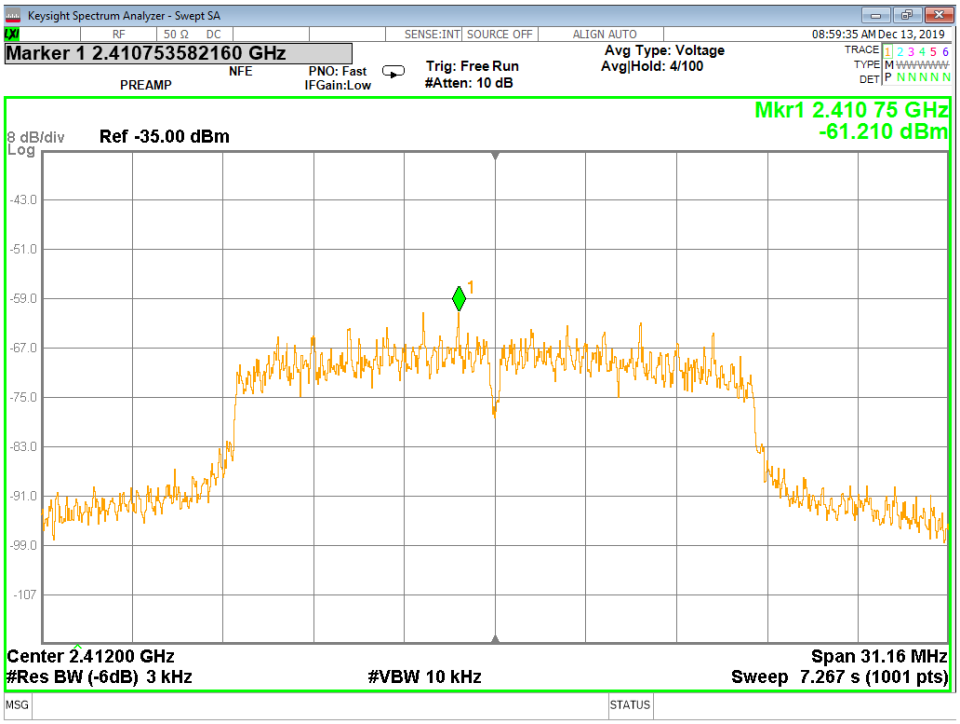


Figure 55 - Power Spectral Density, Low Channel, 802.11n

EIRP Peak Output Power = -61.210 + 107 – 95.23 + AF + CL = -13.48

Output power = -61.210 dBm

AF = Antenna Factor = 28.36

CL = Cable Loss = 7.6

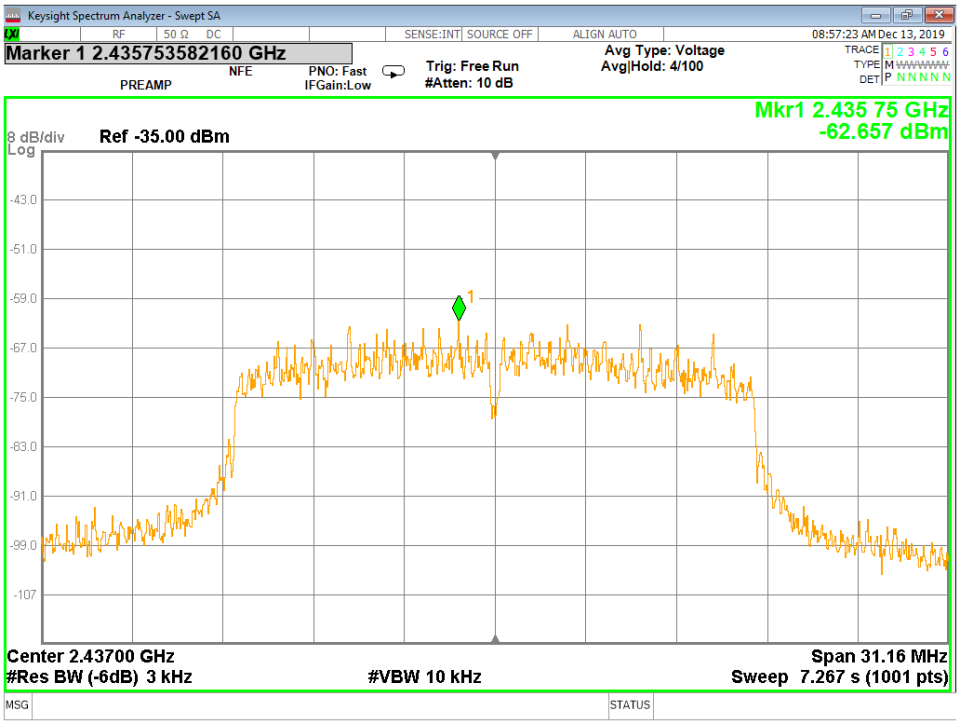


Figure 56 - Power Spectral Density, Mid Channel, 802.11n

EIRP Peak Output Power = -62.657 + 107 – 95.23 + AF + CL = -14.887

Output power = -62.657 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

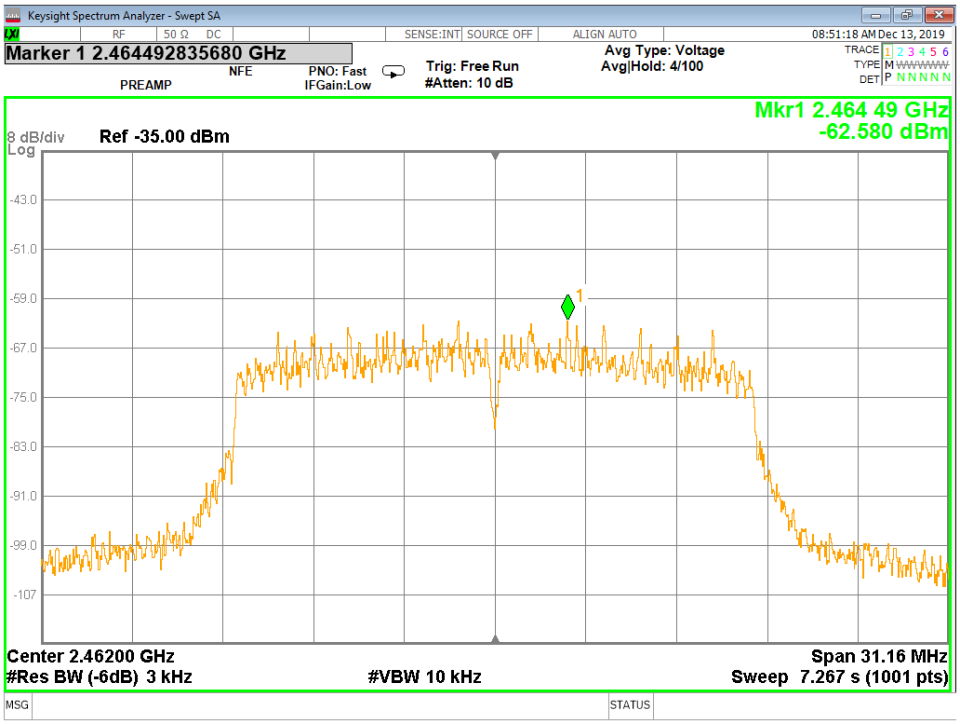


Figure 57 - Power Spectral Density, High Channel, 802.11n

EIRP Peak Output Power = -62.580 + 107 – 95.23 + AF + CL = -14.81

Output power = -62.580 dBm

AF = Antenna Factor = 28.3

CL = Cable Loss = 7.7

4.7 CONDUCTED AC MAINS EMISSIONS

Test Method: ANSI C63.10-2013, Section(s) 6.2

Limits for conducted emissions measurements:

FREQUENCY OF EMISSION (MHz)	CONDUCTED LIMIT (dBµV)	
	Quasi-peak	Average
0.15-0.5 0.5-5 5-30	66 to 56 56 60	56 to 46 46 50

Notes:
1. The lower limit shall apply at the transition frequencies.
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50 MHz
3. All emanations from a class A/B digital device or system, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strengths specified above.

Test Procedures:

a. The EUT was placed 0.8m above a ground reference plane and 0.4 meters from the conducting wall of a shielded room with EUT being connected to the power mains through a line impedance stabilization network (LISN). The LISN provides 50 ohm/ 50uH of coupling impedance for the measuring instrument.
b. Both lines of the power mains connected to the EUT were checked for maximum conducted interference as well as the ground.
c. The frequency range from 150 kHz to 30 MHz was searched. Emission levels over 10dB under the prescribed limits are not reported.
d. Results were compared to the 15.207 limits.

Deviation from the test standard:
No deviation

EUT operating conditions:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle channel.

Test Results:

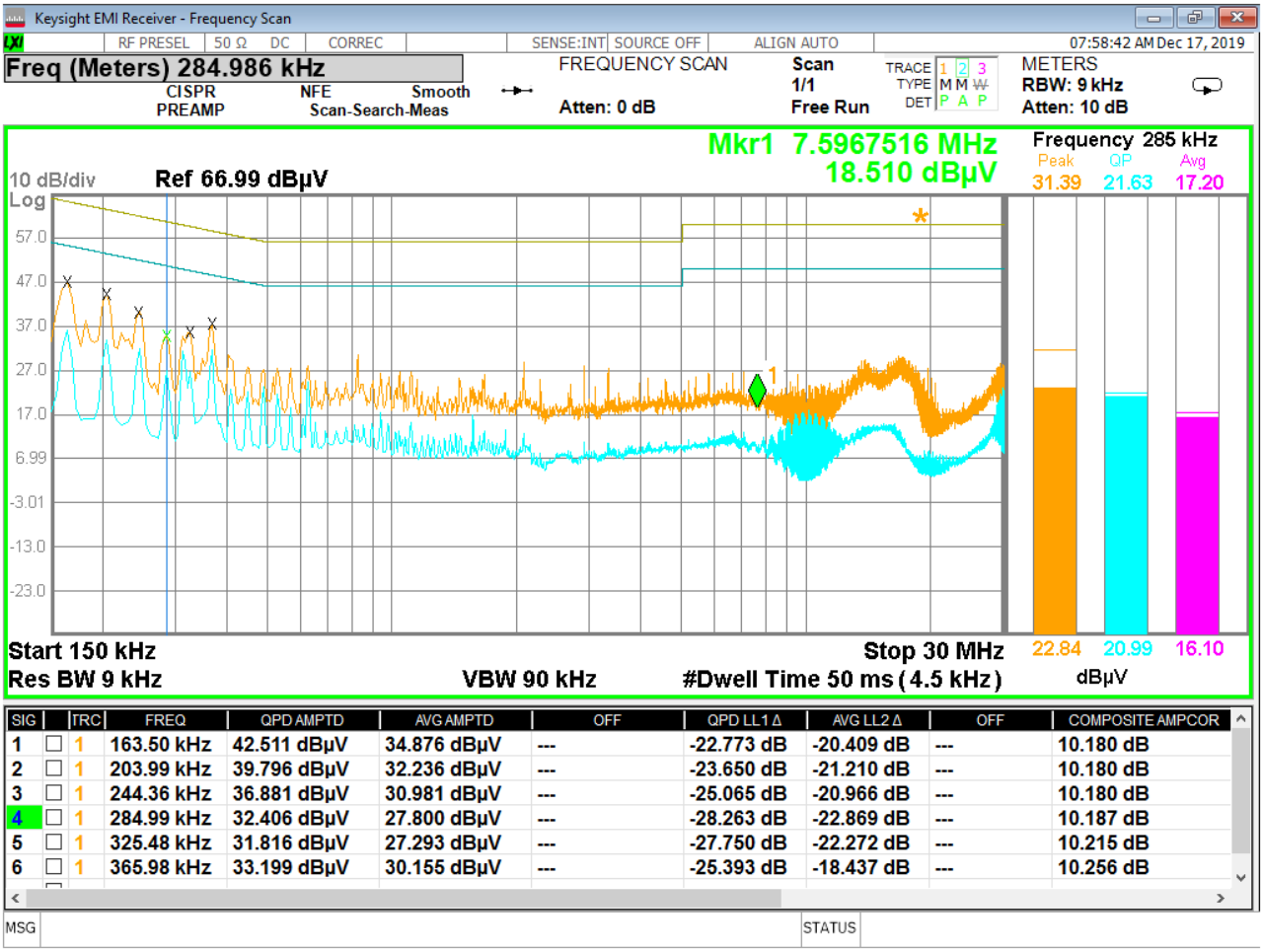
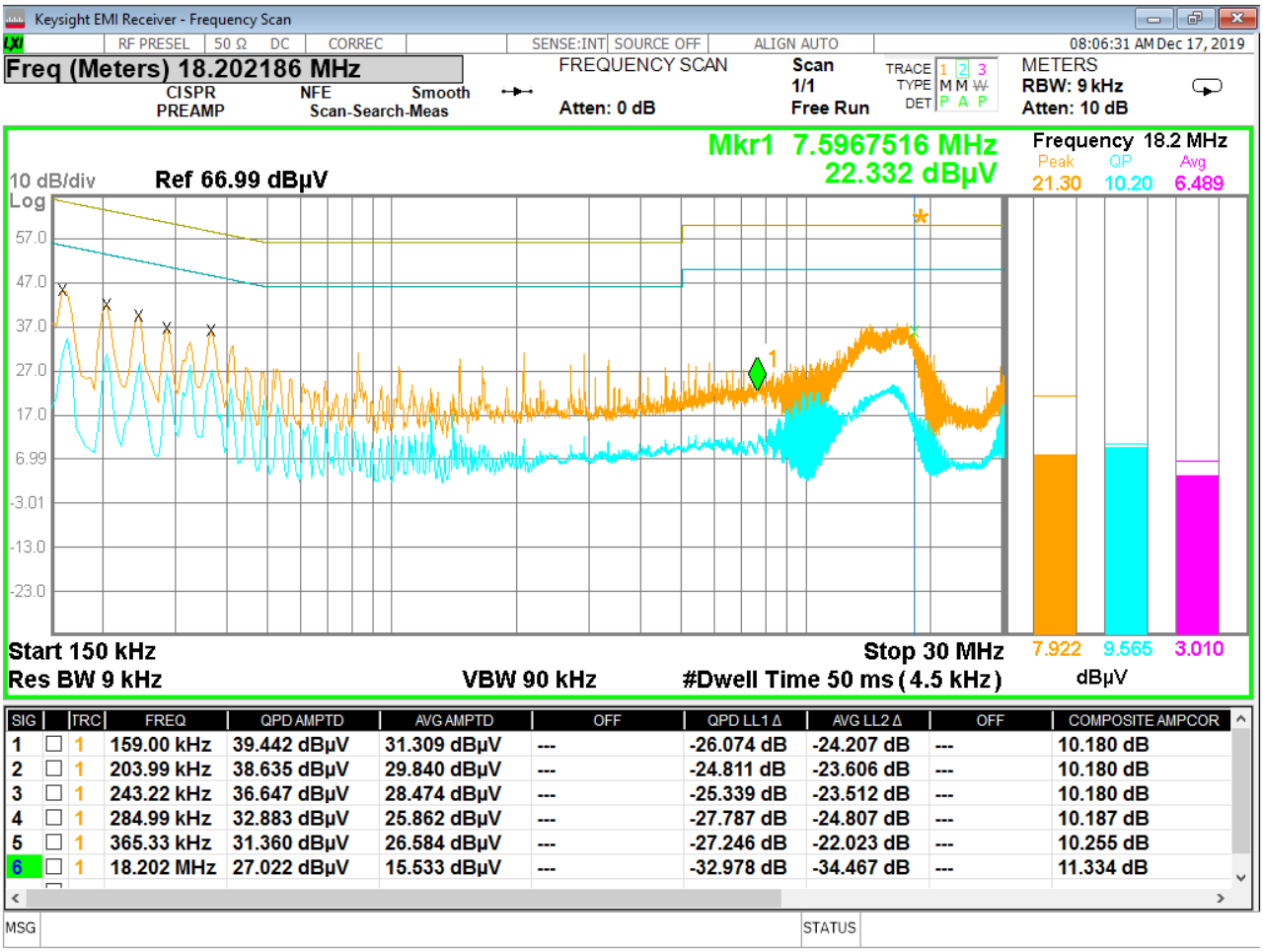


Figure 58 - Conducted Emissions Plot, Line, Single USB

All Measurements were found to be at least 10 dB below the limits.



. Figure 59 - Conducted Emissions Plot, Neutral, Single USB

All Measurements were found to be at least 10 dB below the limits.

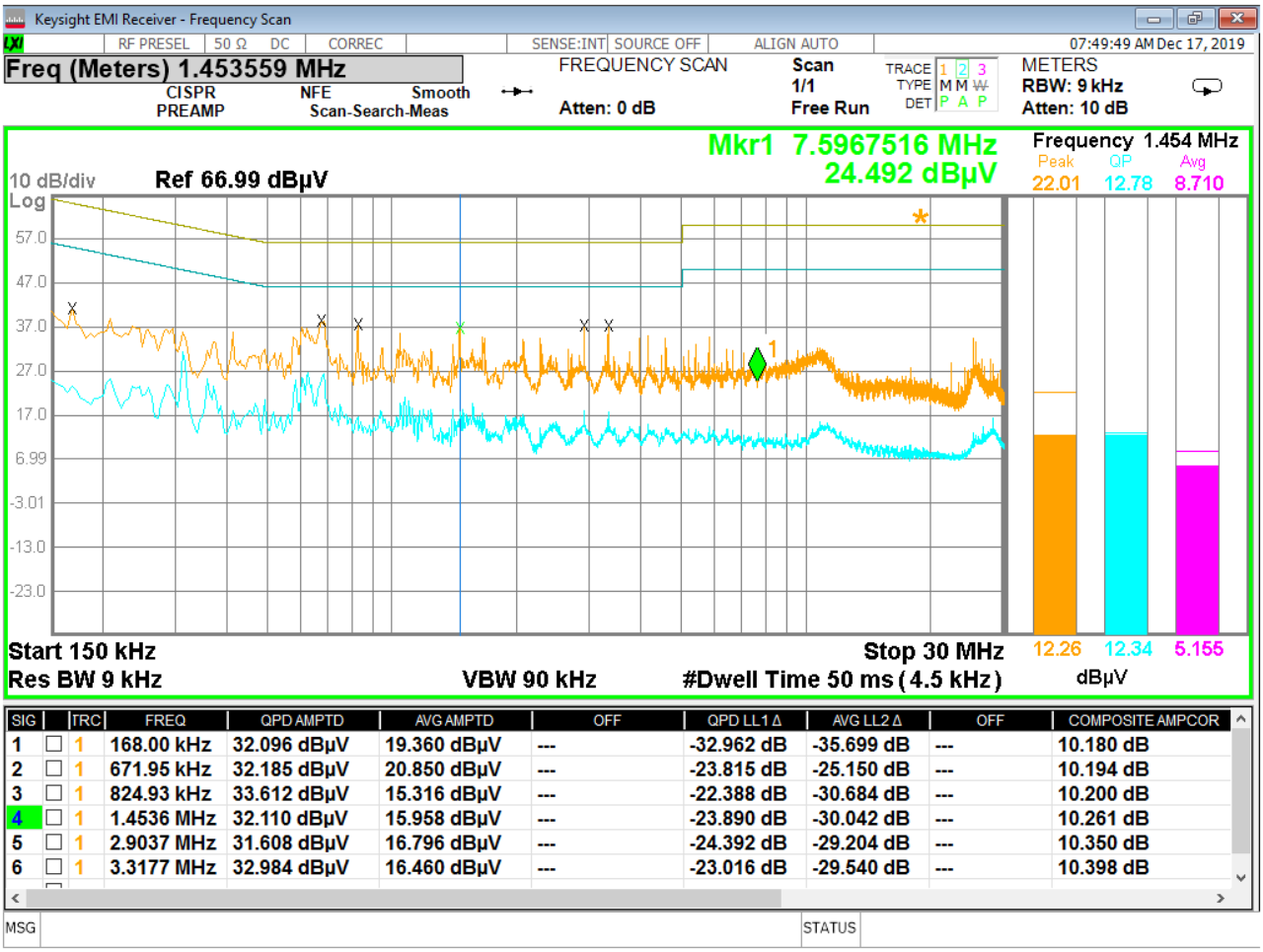
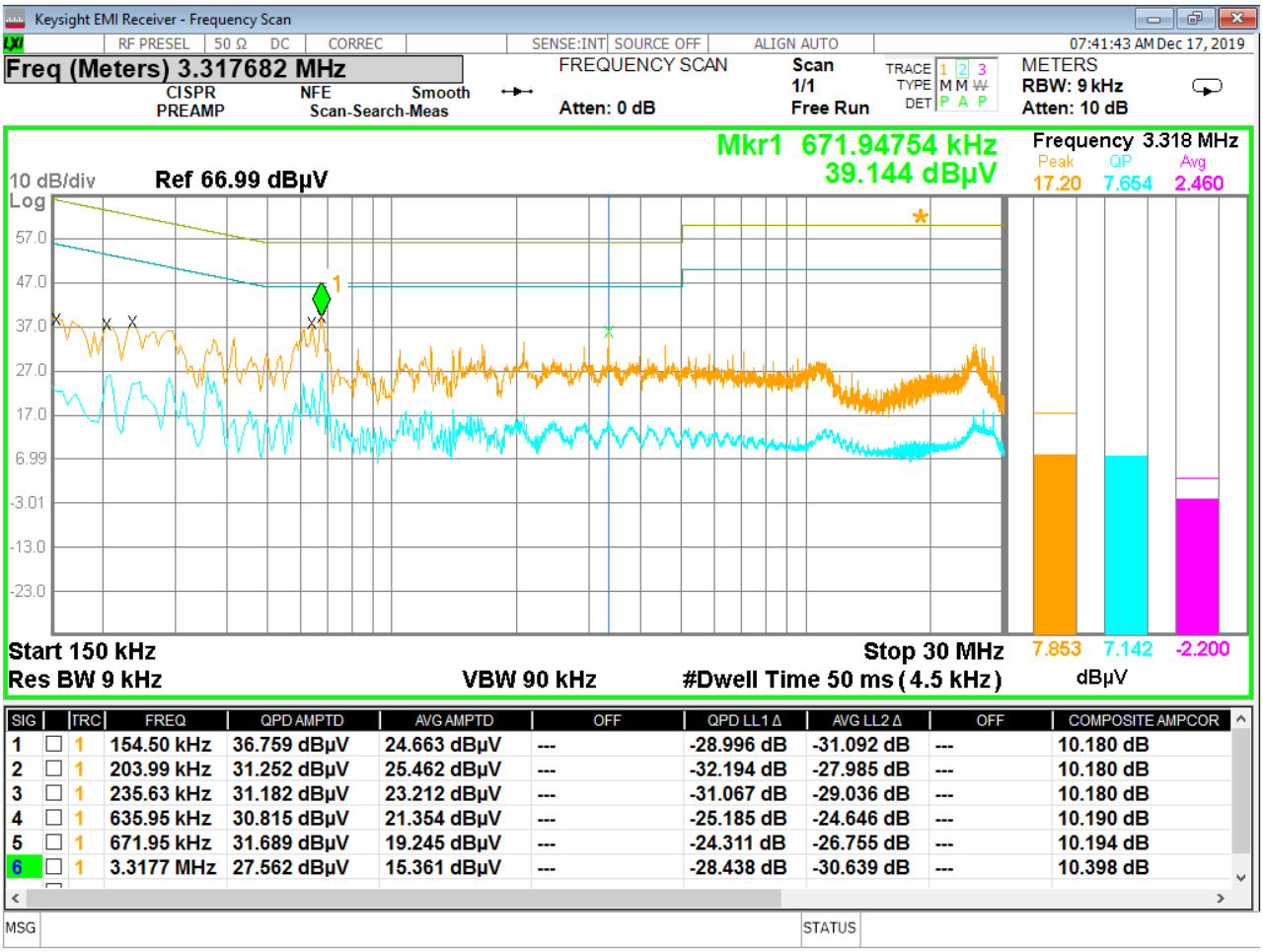


Figure 60 - Conducted Emissions Plot, Line, Dual USB

All Measurements were found to be at least 10 dB below the limits.



SIG		TRC	FREQ	QPD AMPTD	AVG AMPTD	OFF	QPD LL1 Δ	AVG LL2 Δ	OFF	COMPOSITE AMPCOR
1	☐	1	154.50 kHz	36.759 dBµV	24.663 dBµV	---	-28.996 dB	-31.092 dB	---	10.180 dB
2	☐	1	203.99 kHz	31.252 dBµV	25.462 dBµV	---	-32.194 dB	-27.985 dB	---	10.180 dB
3	☐	1	235.63 kHz	31.182 dBµV	23.212 dBµV	---	-31.067 dB	-29.036 dB	---	10.180 dB
4	☐	1	635.95 kHz	30.815 dBµV	21.354 dBµV	---	-25.185 dB	-24.646 dB	---	10.190 dB
5	☐	1	671.95 kHz	31.689 dBµV	19.245 dBµV	---	-24.311 dB	-26.755 dB	---	10.194 dB
6	☐	1	3.3177 MHz	27.562 dBµV	15.361 dBµV	---	-28.438 dB	-30.639 dB	---	10.398 dB

. Figure 61 - Conducted Emissions Plot, Neutral, Dual USB

All Measurements were found to be at least 10 dB below the limits.

APPENDIX A: SAMPLE CALCULATION

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:
FS = RA + AF – (-CF + AG) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

AV is calculated by the taking the 20*log(T_{on}/100) where T_{on} is the maximum transmission time in any 100ms window.

EIRP Calculations

In cases where direct antenna port measurement is not possible or would be inaccurate, output power is measured in EIRP. The maximum field strength is measured at a specified distance and the EIRP is calculated using the following equation;

EIRP (Watts) = [Field Strength (V/m) x antenna distance (m)]^2 / 30

Power (watts) = 10^[Power (dBm)/10] / 1000

Voltage (dBµV) = Power (dBm) + 107 (for 50Ω measurement systems)

Field Strength (V/m) = 10^[Field Strength (dBµV/m) / 20] / 10^6

Gain = 1 (numeric gain for isotropic radiator)

Conversion from 3m field strength to EIRP (d=3):

EIRP = [FS(V/m) x d^2]/30 = FS [0.3] for d = 3

EIRP(dBm) = FS(dBµV/m) – 10(log 10^9)+ 10log[0.3] = FS(dBµV/m) - 95.23

10log(10^9) is the conversion from micro to milli

APPENDIX B – MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	±3.82 dB
Radiated Emissions, 3m	1GHz - 18GHz	±4.44 dB
Emissions limits, conducted	30MHz – 18GHz	±3.30 dB
Antenna port conducted	9 kHz – 25 GHz	±0.50 dB

Values were calculated per CISPR 16-4-2:2011

Expanded uncertainty values are calculated to a confidence level of 95%.

REPORT END