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FCC/ISED DTS TEST REPORT

Prepared for: **Garmin International Inc.**

Address: **1200 E. 151st Street**
Olathe, Kansas, 66062, USA

Product: **A03690**

Test Report No: **R20191028-24-E2C**

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **16 June 2020**

Total Pages: **88**

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REVISION PAGE

Rev. No.	Date	Description
0	28 February 2020	Original – NJohnson Prepared by CFarrington
A	8 June 2020	Updated average power measurements. Repeated band edge measurements as radiated
B	15 June 2020	Updated band edge measurements and calibration table.
C	16 June 2020	Updated test dates and calibration table.

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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 4, 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	A03690
EUT Received	19 December 2019
EUT Tested	6 January 2020 – 9 June 2020
Serial No.	3319367796 (conducted antenna port measurements); 3319367789 (radiated measurements)
Operating Band	2400.0 - 2483.5 GHz
Device Type	802.11b, 802.11g, 802.11n
Antenna	Trace Antenna
Power Supply	Internal Battery/ Charger: Garmin (Phi Hong) MN: PSAF10R-050Q (Representative Power Supply)

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 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
Rohde & Schwarz Test Receiver	ES126	100037	30 Jan 2018	30 Jan 2020
Keysight MXE Signal Analyzer	N9038A	MY59050109	23 Apr 2019	23 Apr 2021
SunAR RF Motion Hybrid Antenna	JB1	A082918-1	15 Oct 2018	15 Oct 2020
EMCO Horn Antenna	3115	6416	26 Jan 2018	26 Jan 2021
EMCO Horn Antenna	3116	2576	31 Jan 2018	31 Jan 2021
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	09 Mar 2018*	09 Mar 2020*
Trilithic High Pass Filter	6HC330	23042	09 Mar 2018*	09 Mar 2020*
Rohde & Schwarz LISN	ESH3-Z5	836679/010	26 Jul 2019	26 Jul 2020
Rohde & Schwarz Test Software	ES-K1	12575	NA	NA
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

4.0 DETAILED RESULTS

4.1 DUTY CYCLE

Duty Cycle measurements were not conducted as the EUT is capable of continuous transmission.

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:

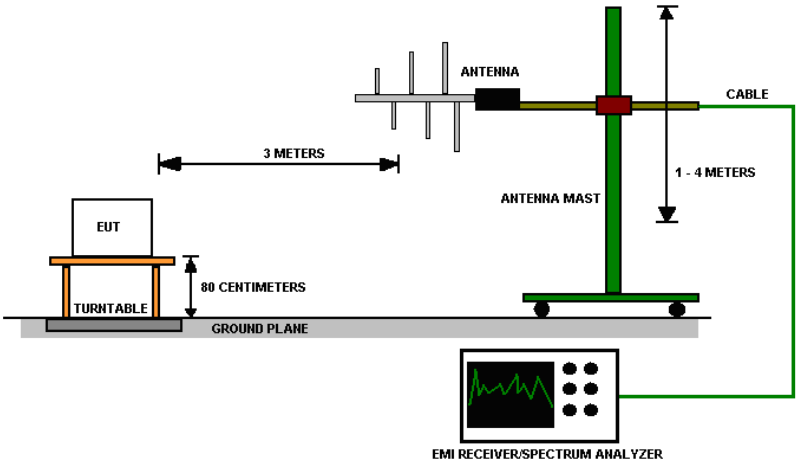


Figure 1 - Radiated Emissions Test Setup

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:

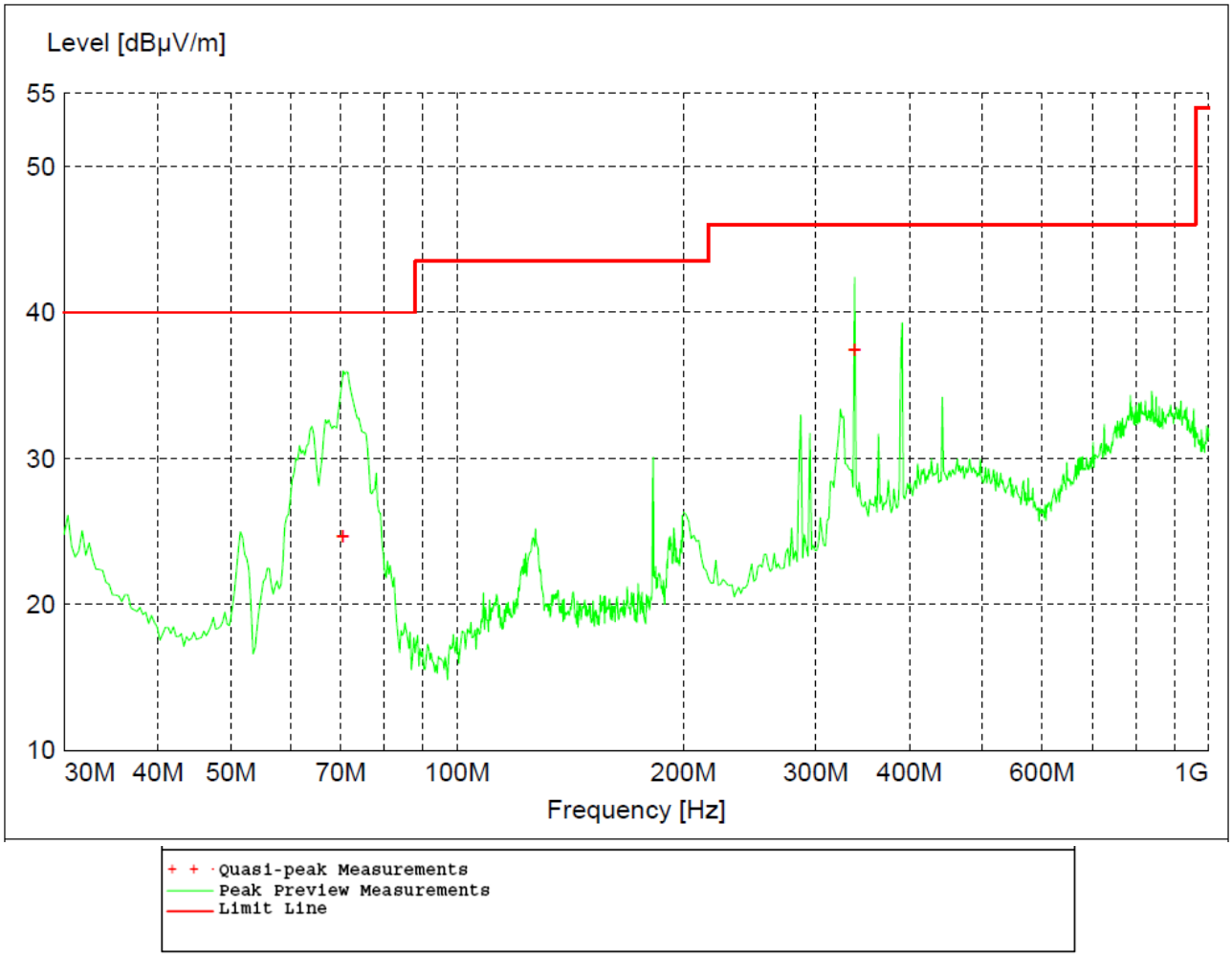


Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak and Peak Measurements, Receive

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
70.440000	24.70	40.00	15.30	100.00	295.00	VERT
338.040000	37.41	46.00	8.60	100.00	167.00	HORI

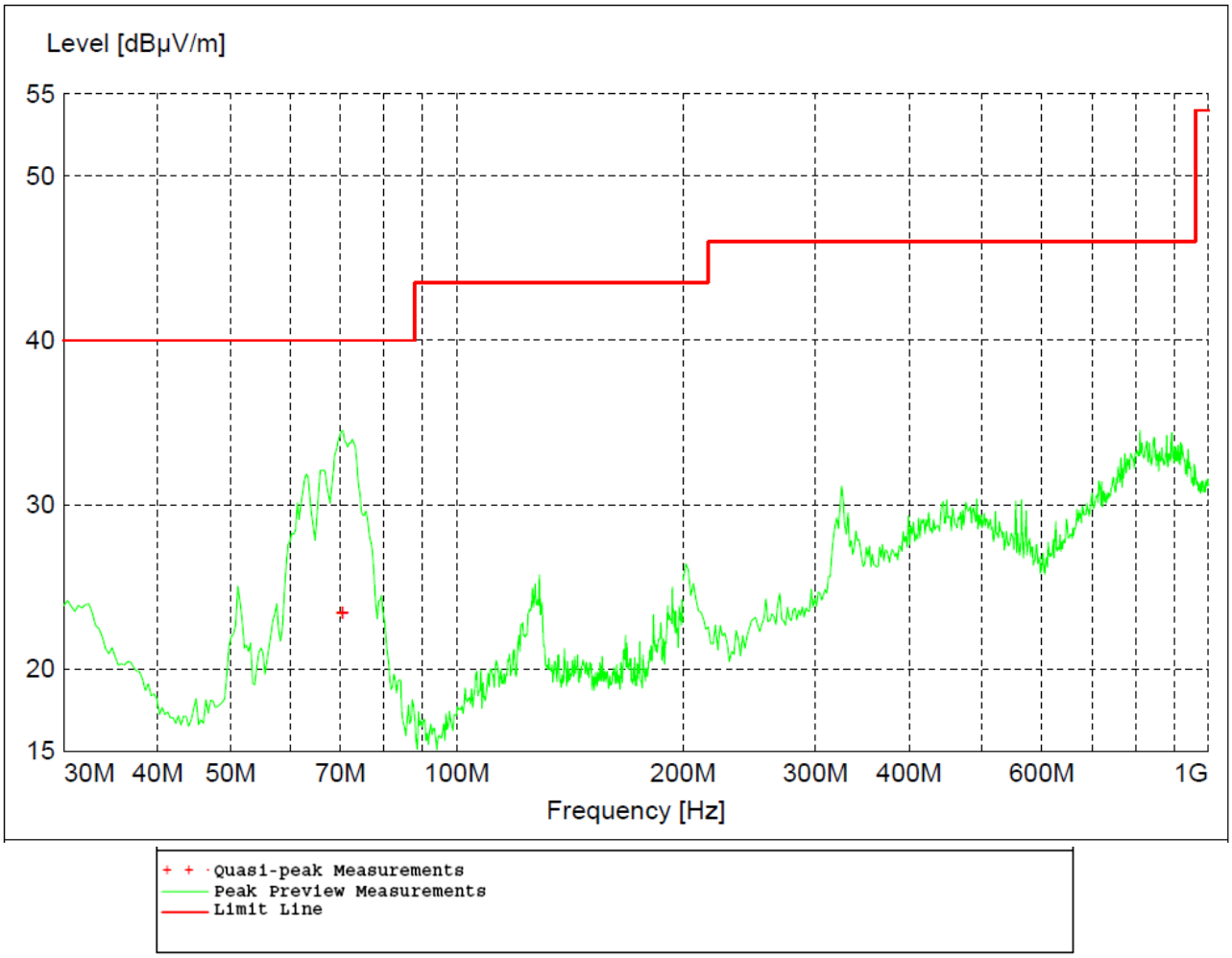


Figure 3 - Radiated Emissions Plot, 802.11b

Table 2 - Radiated Emissions Quasi-peak Measurements, 802.11b

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
70.440000	23.44	40.00	16.60	100	359	VERT

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

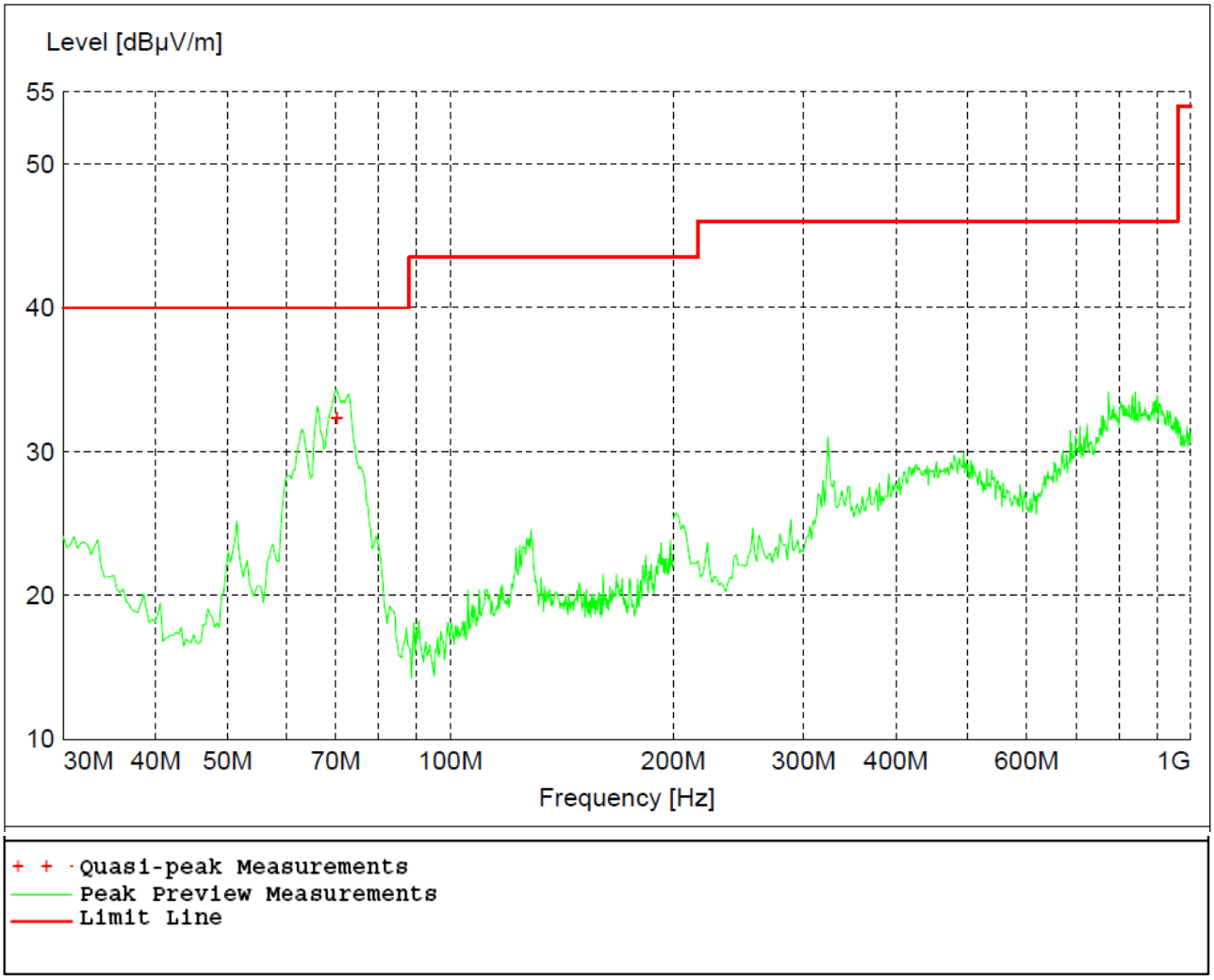


Figure 4 - Radiated Emissions Plot, 802.11g

Table 3 - Radiated Emissions Quasi-peak Measurements, 802.11g

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
70.320000	32.37	40.00	7.60	109	360	VERT

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

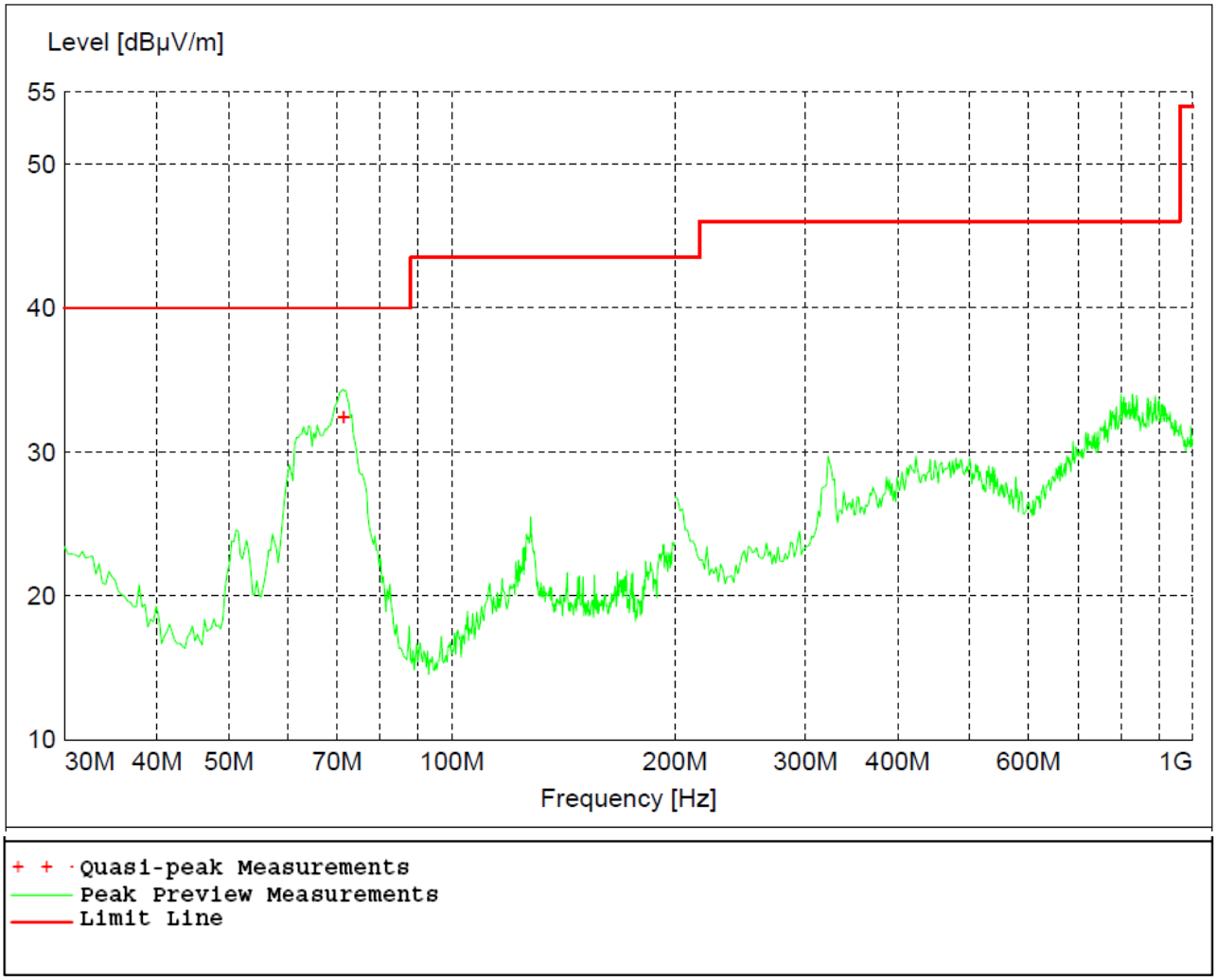


Figure 5 - Radiated Emissions Plot, 802.11n

Table 4 - Radiated Emissions Quasi-peak Measurements, 802.11n

Frequency	Level	Limit	Margin	Height	Angle	Pol
MHz	dBµV/m	dBµV/m	dB	cm.	deg.	
71.520000	32.45	40.00	7.60	100	261	VERT

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

Table 5 - Radiated Emissions Peak Measurements

Frequency	Level	Limit	Margin	Height	Angle	Pol	Radio	Channel
MHz	dBµV/m	dBµV/m	dB	cm.	deg.			
2412.000000	105.91	N/A	N/A	155	255	HORI	802.11b	Low
2437.000000	106.91	N/A	N/A	155	255	HORI	802.11b	Mid
2462.000000	108.52	N/A	N/A	155	255	HORI	802.11b	High
2412.000000	103.17	N/A	N/A	155	255	HORI	802.11g	Low
2437.000000	107.68	N/A	N/A	155	255	HORI	802.11g	Mid
2462.000000	106.76	N/A	N/A	155	255	HORI	802.11g	High
2412.000000	102.06	N/A	N/A	155	255	HORI	802.11n	Low
2437.000000	106.88	N/A	N/A	155	255	HORI	802.11n	Mid
2462.000000	105.99	N/A	N/A	155	255	HORI	802.11n	High

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

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 at least 6 dB below 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 “Integrated Band Power Method”

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

Test procedures:
The EUT was connected to a spectrum analyzer directly with a low-loss shielded coaxial cable with 100 MHz RBW and 300 MHz VBW. Power was determined using integrated power measurement.

Deviations from test standard:
No deviation.

Test setup:

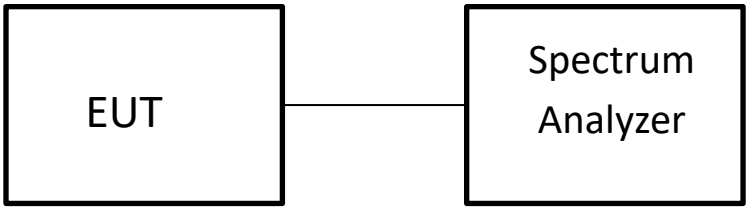


Figure 6 – Peak Output Power Measurements Test Setup

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:

The uncertainty for conducted peak power measurements is ±1.1 dB and average power is ±1.37 dB

Peak Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	PEAK OUTPUT POWER (dBm) MU = ±1.37	Method	RESULT
Low	2412	802.11b	23.94	Conducted	PASS
Middle	2437	802.11b	24.06	Conducted	PASS
High	2462	802.11b	23.14	Conducted	PASS
Low	2412	802.11g	21.82	Conducted	PASS
Middle	2437	802.11g	26.68	Conducted	PASS
High	2462	802.11g	21.90	Conducted	PASS
Low	2412	802.11n	21.25	Conducted	PASS
Middle	2437	802.11n	24.78	Conducted	PASS
High	2462	802.11n	21.52	Conducted	PASS

Average Output Power

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	Average OUTPUT POWER (dBm) MU = ±1.37	Method	RESULT
Low	2412	802.11b	15.90	Conducted	PASS
Middle	2437	802.11b	15.77	Conducted	PASS
High	2462	802.11b	16.09	Conducted	PASS
Low	2412	802.11g	11.17	Conducted	PASS
Middle	2437	802.11g	14.47	Conducted	PASS
High	2462	802.11g	11.39	Conducted	PASS
Low	2412	802.11n	9.84	Conducted	PASS
Middle	2437	802.11n	13.08	Conducted	PASS
High	2462	802.11n	10.08	Conducted	PASS

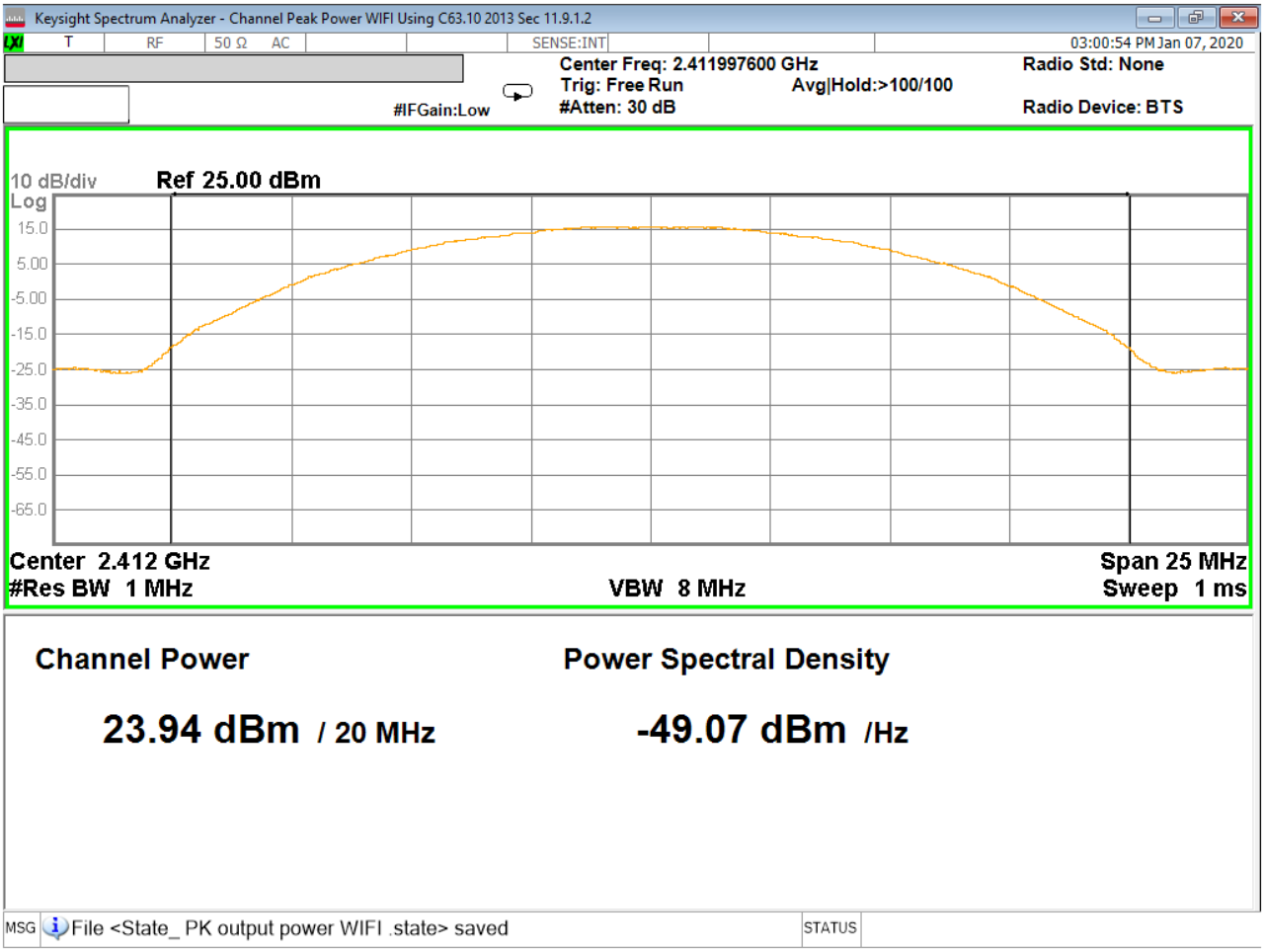


Figure 7 – Peak Output Power, Low Channel, 802.11b

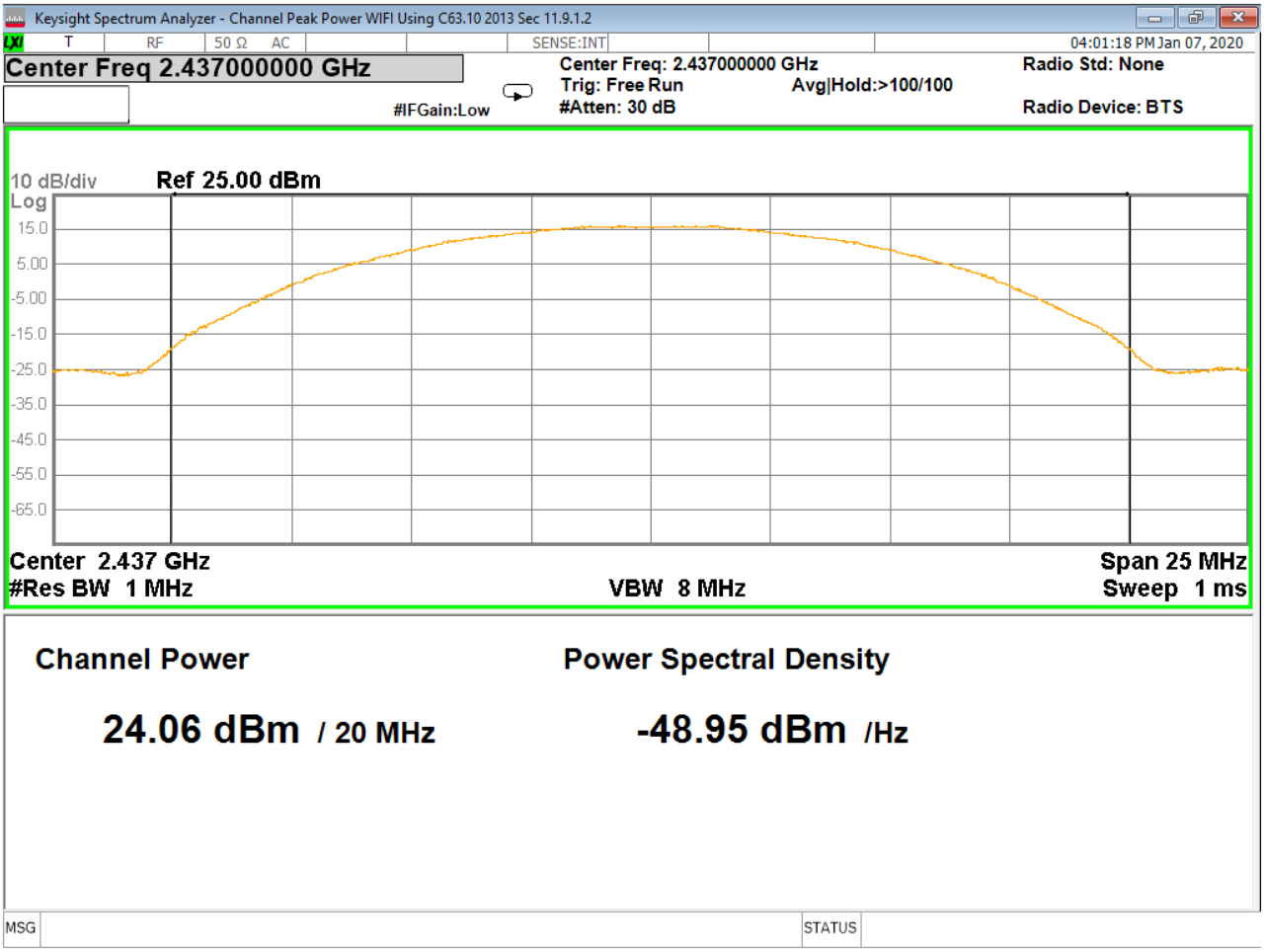


Figure 8 – Peak Output Power, Mid Channel, 802.11b

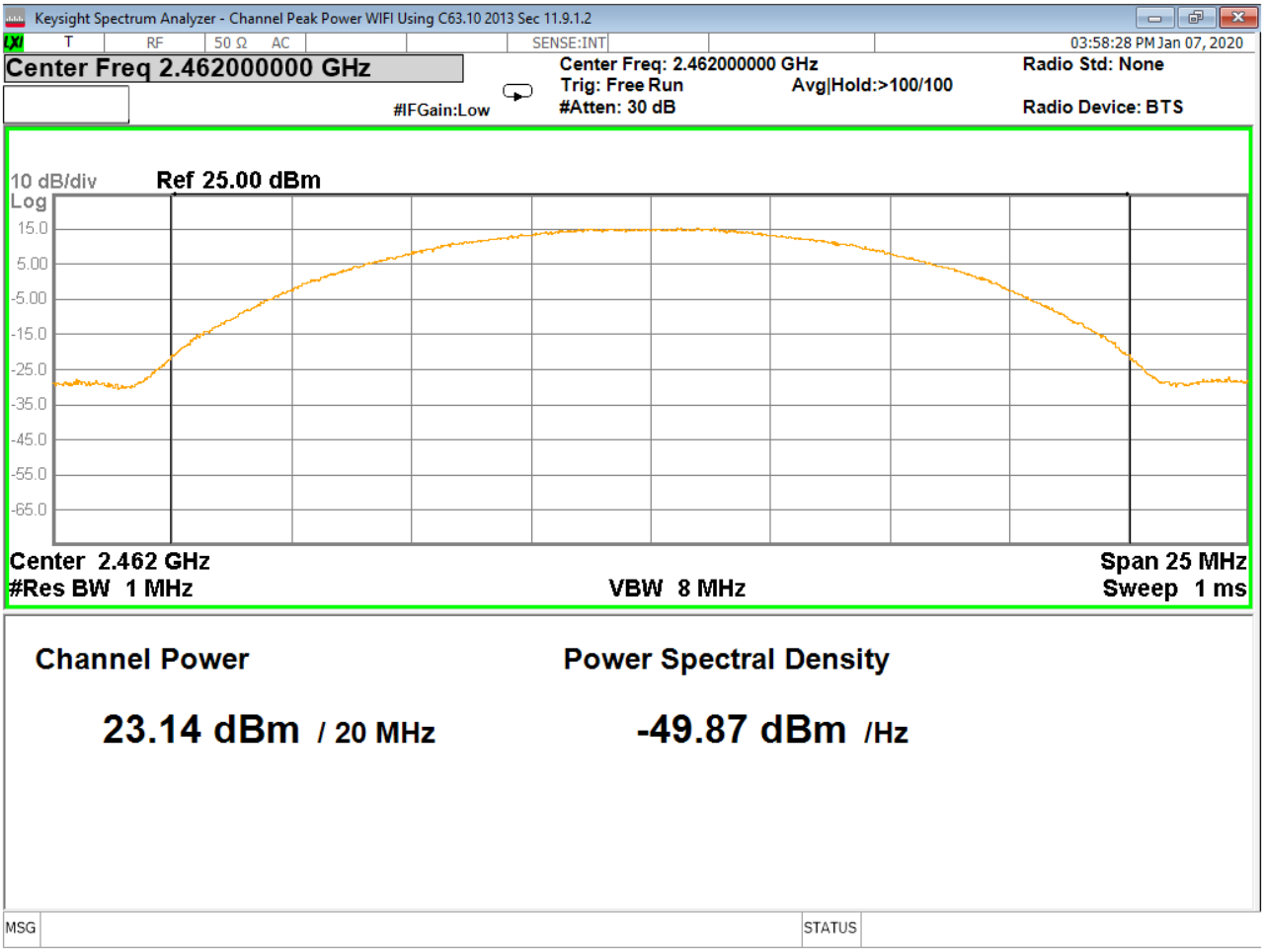


Figure 9 – Peak Output Power, High Channel, 802.11b

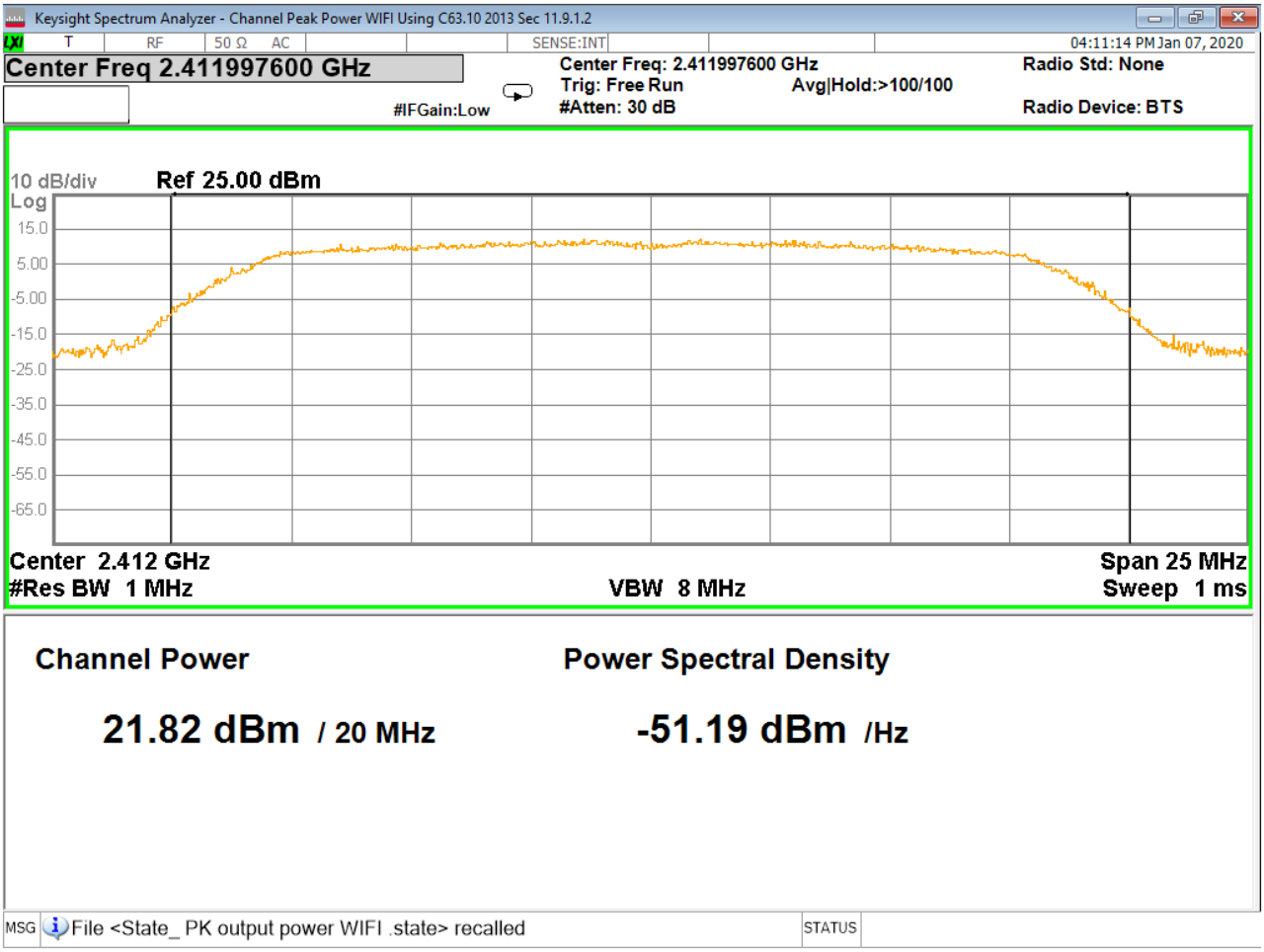


Figure 10 – Peak Output Power, Low Channel, 802.11g

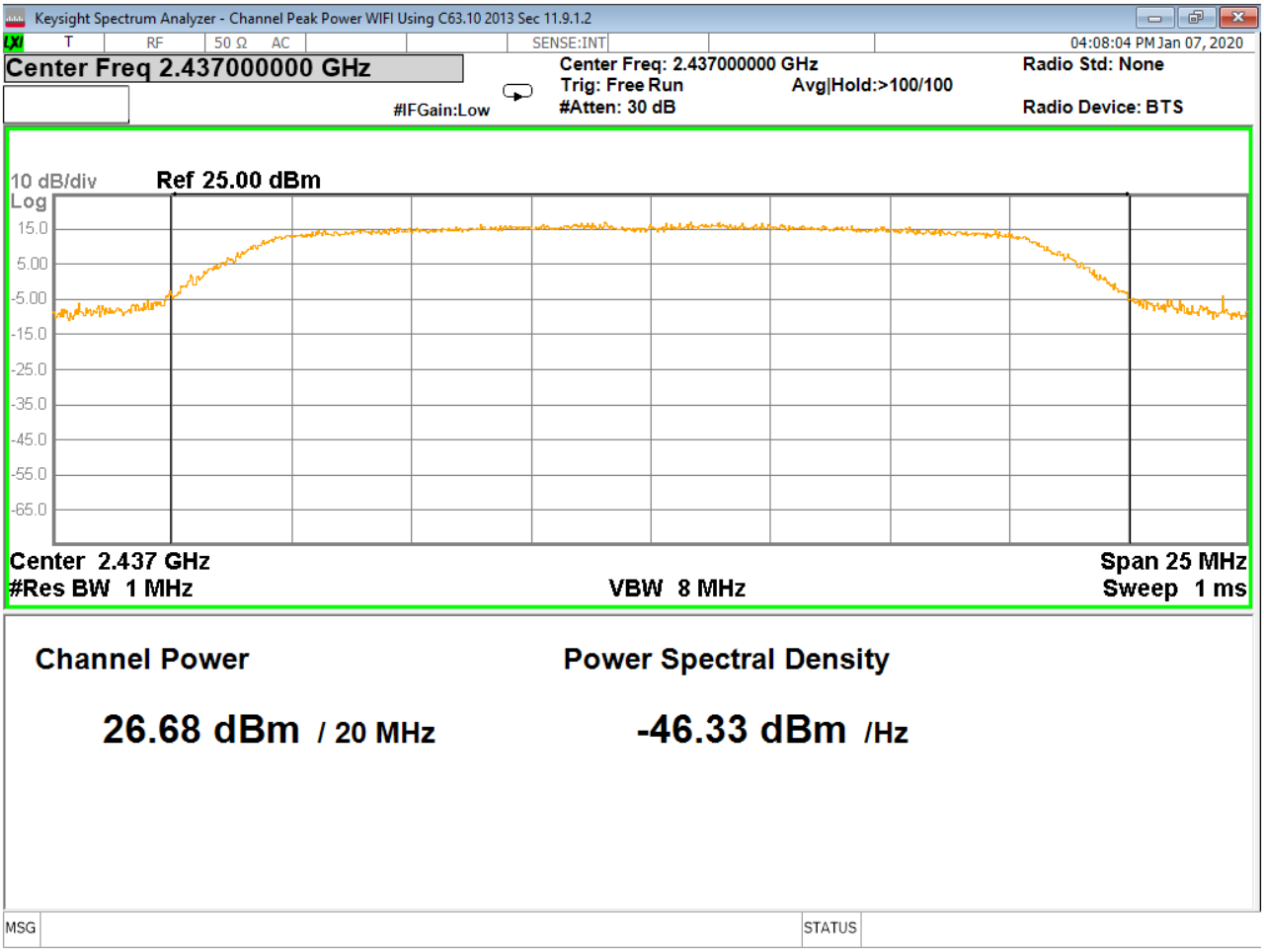


Figure 11 – Peak Output Power, Mid Channel, 802.11g

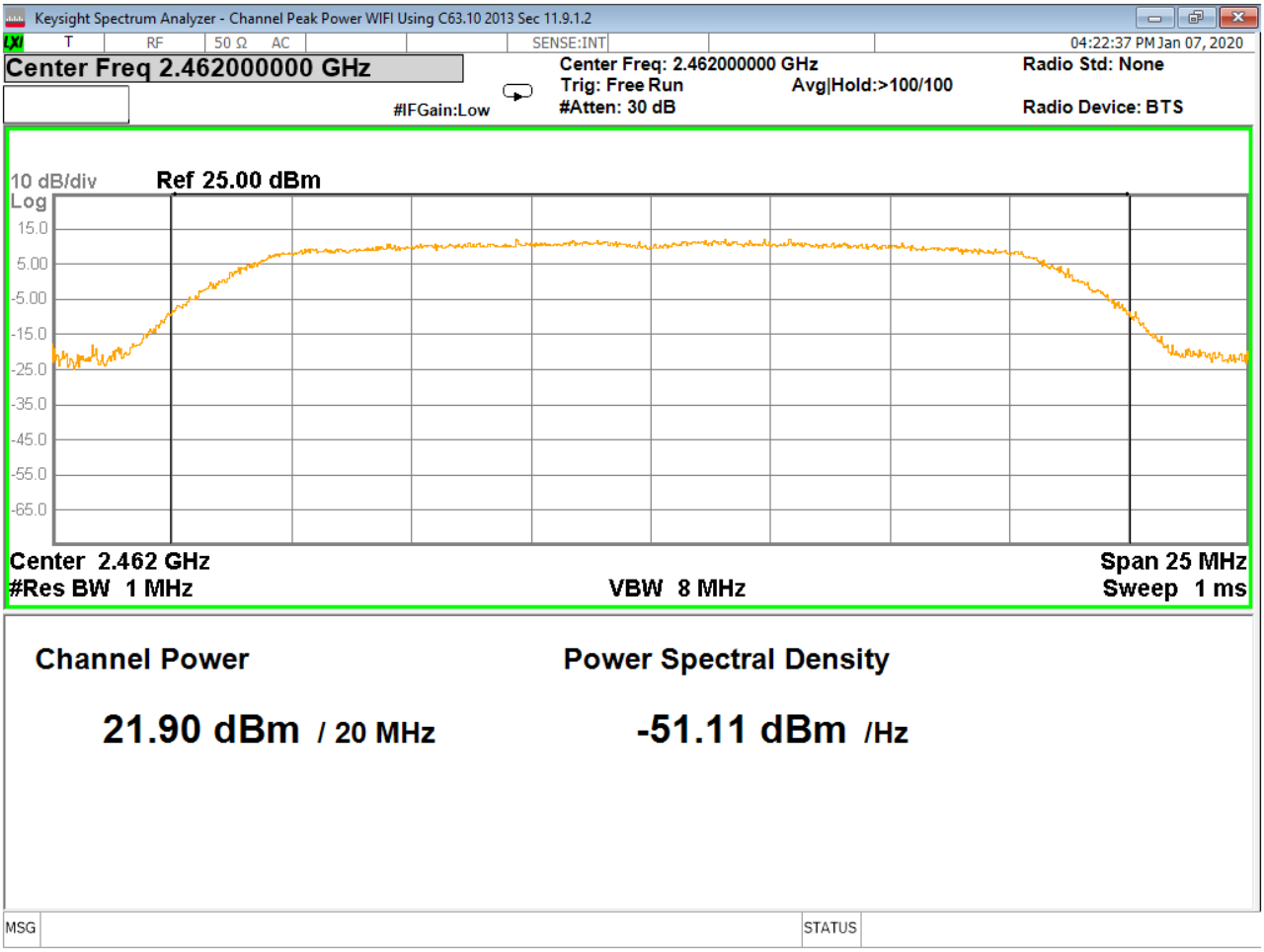


Figure 12 – Peak Output Power, High Channel, 802.11g

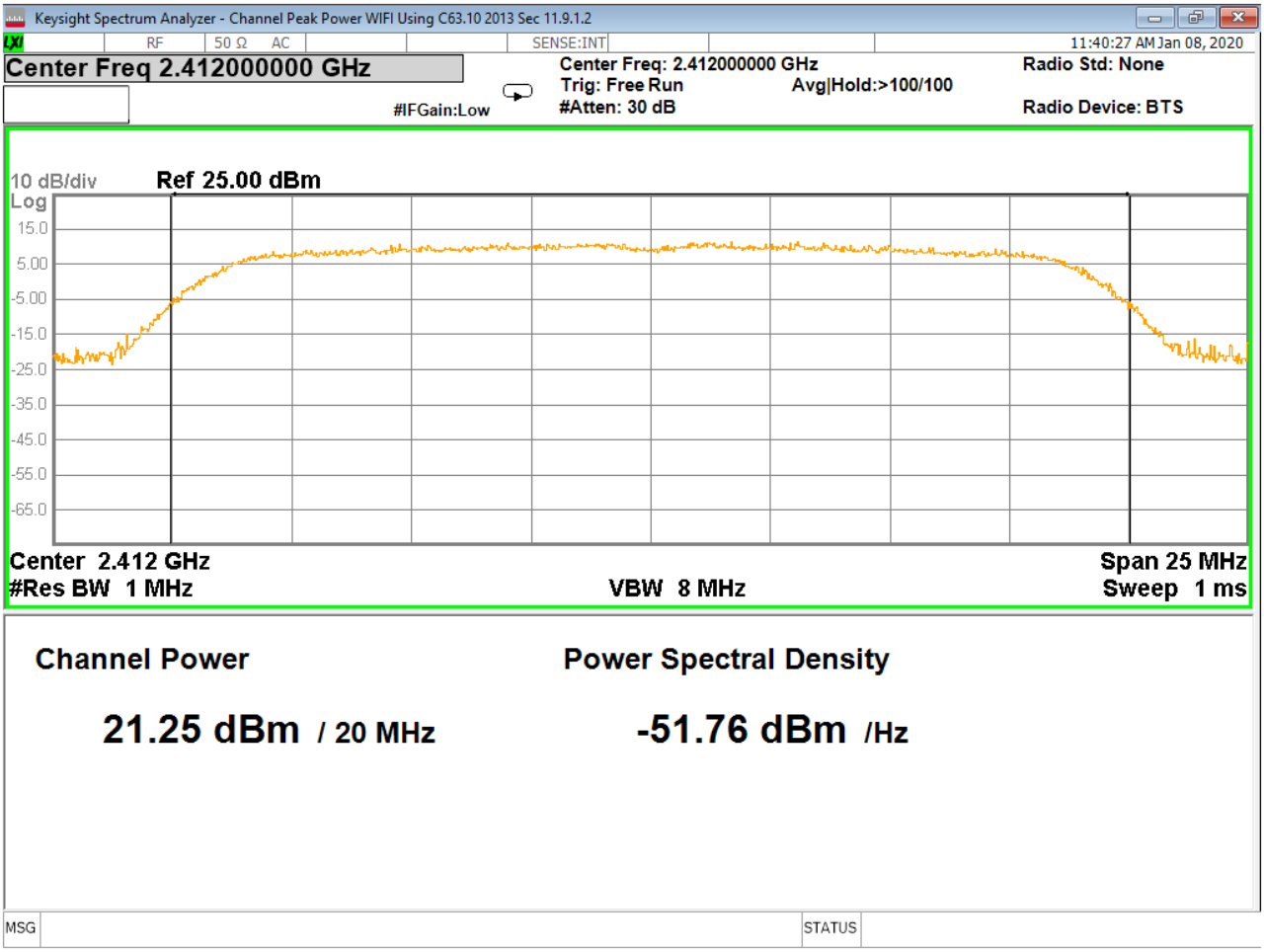


Figure 13 – Peak Output Power, Low Channel, 802.11n

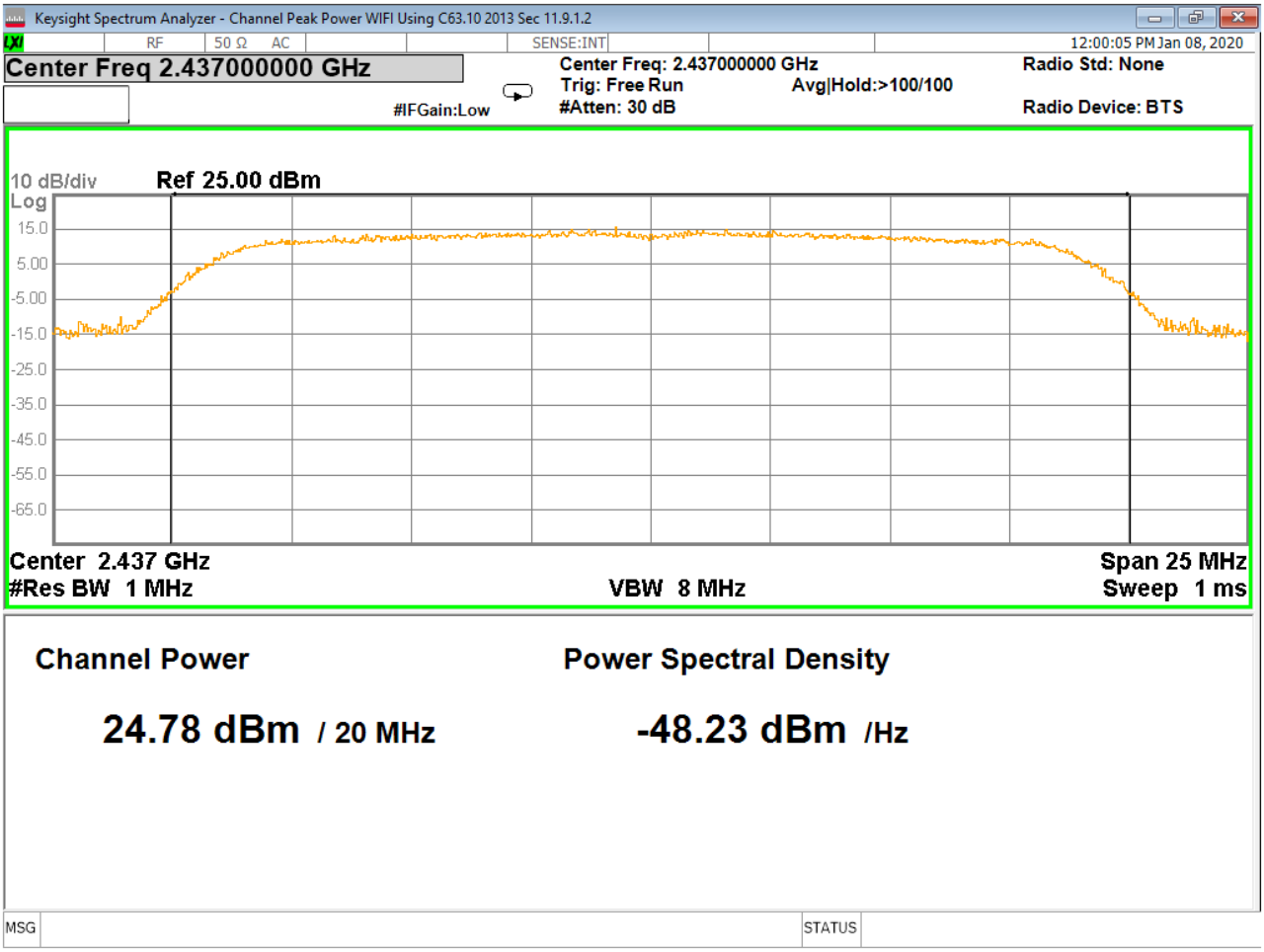


Figure 14 – Peak Output Power, Mid Channel, 802.11n

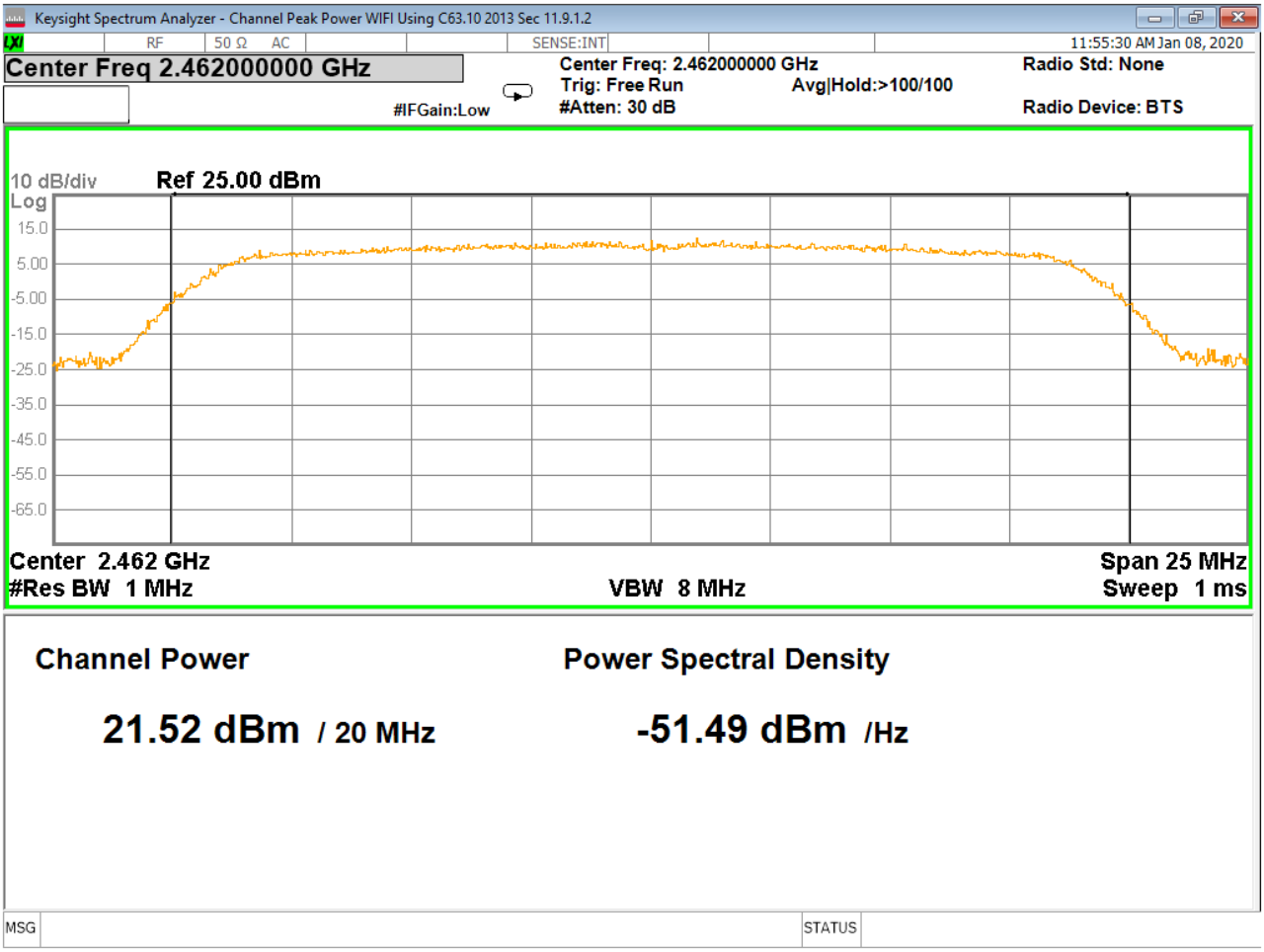


Figure 15 – Peak Output Power, High Channel, 802.11n

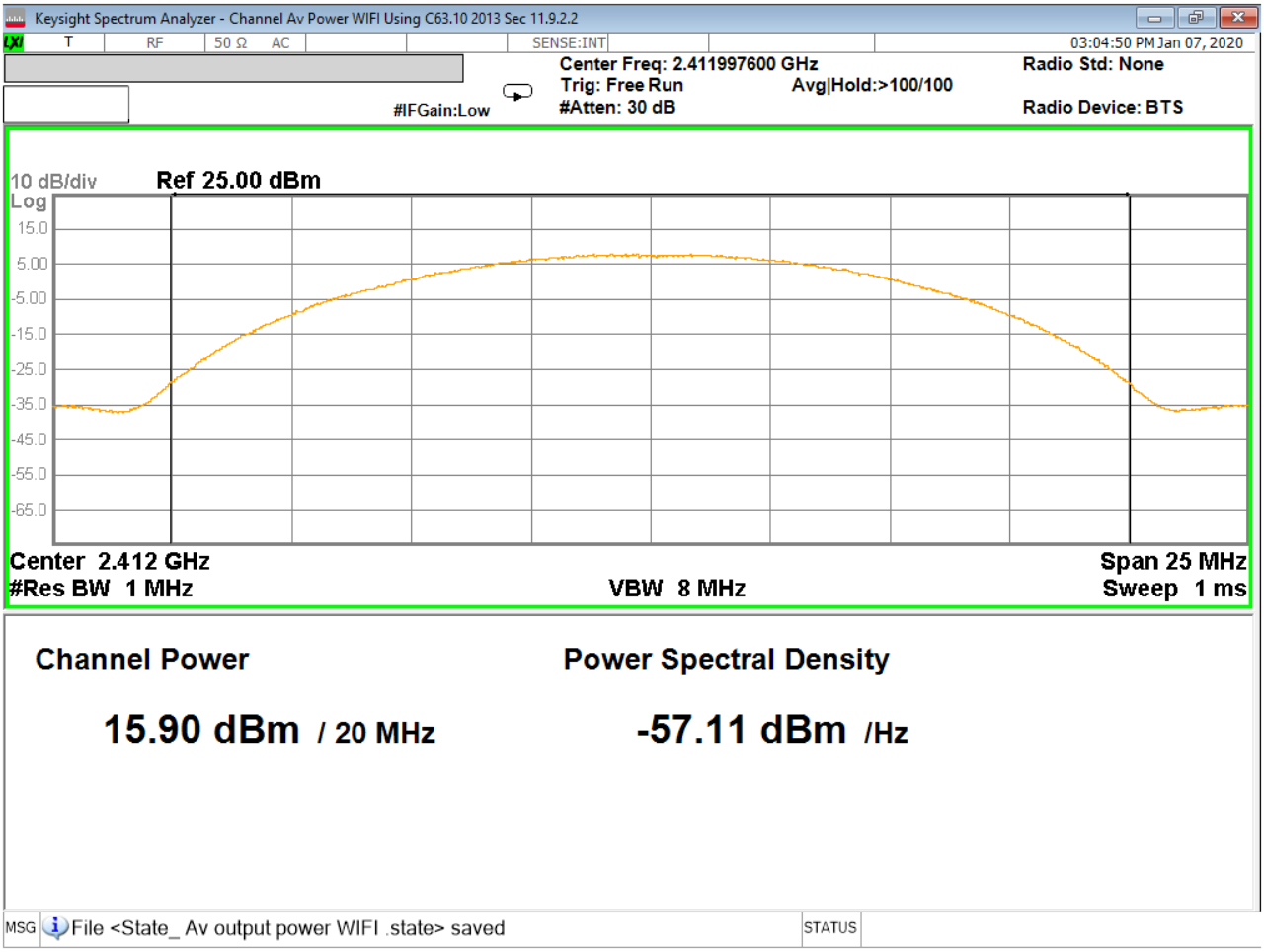


Figure 16 – Average Output Power, Low Channel, 802.11b

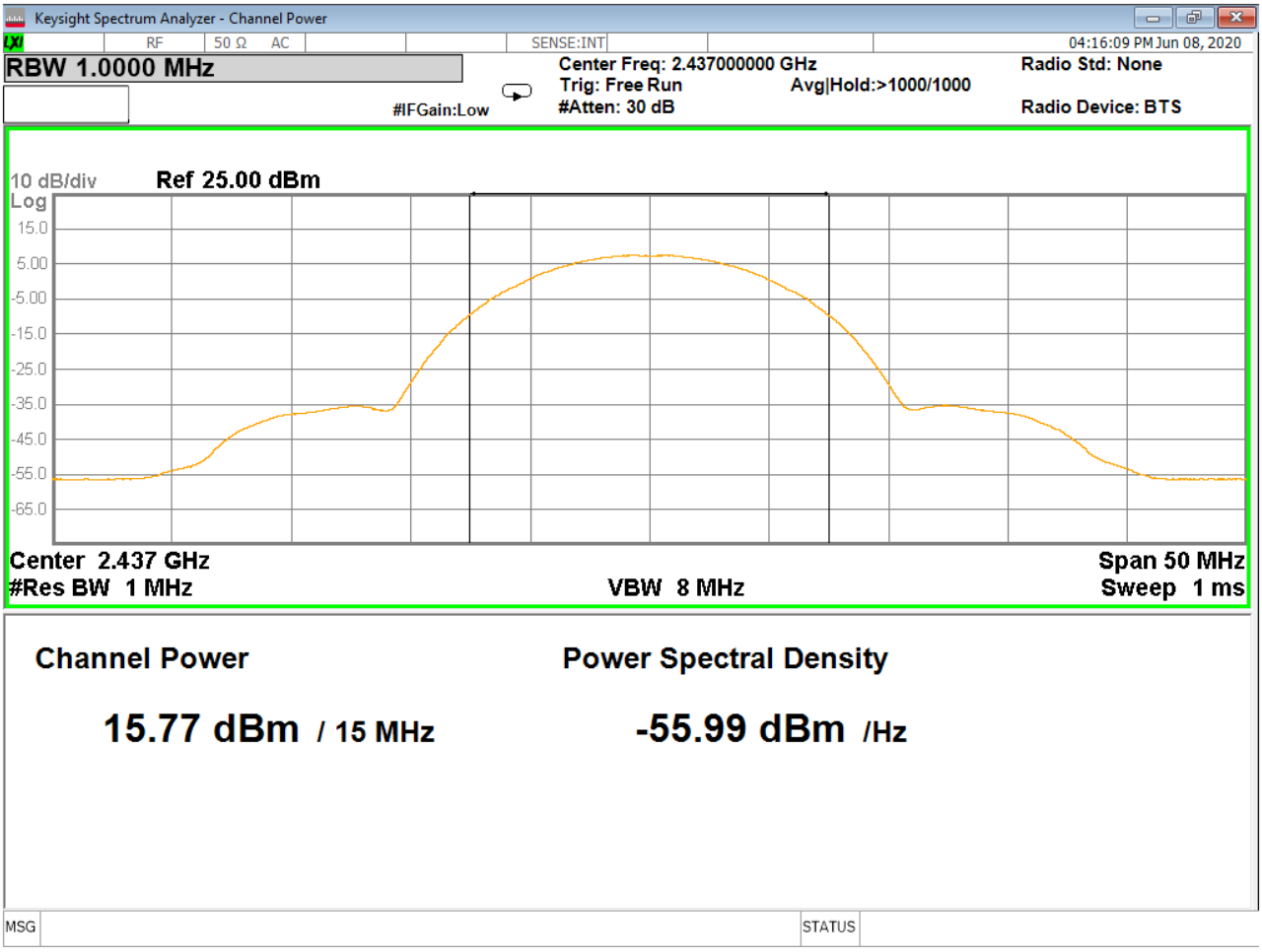


Figure 17 – Average Output Power, Mid Channel, 802.11b

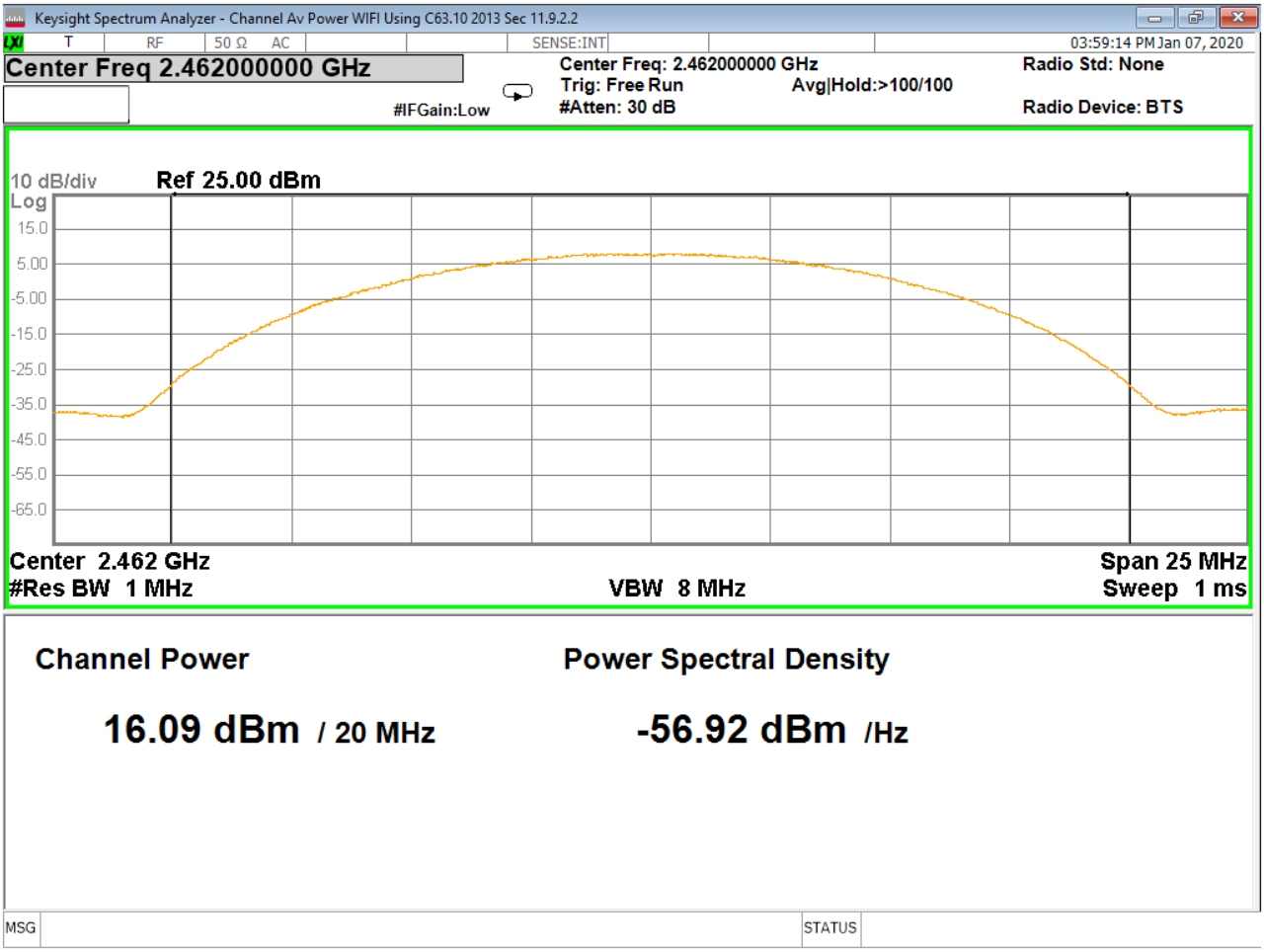


Figure 18 – Average Output Power, High Channel, 802.11b

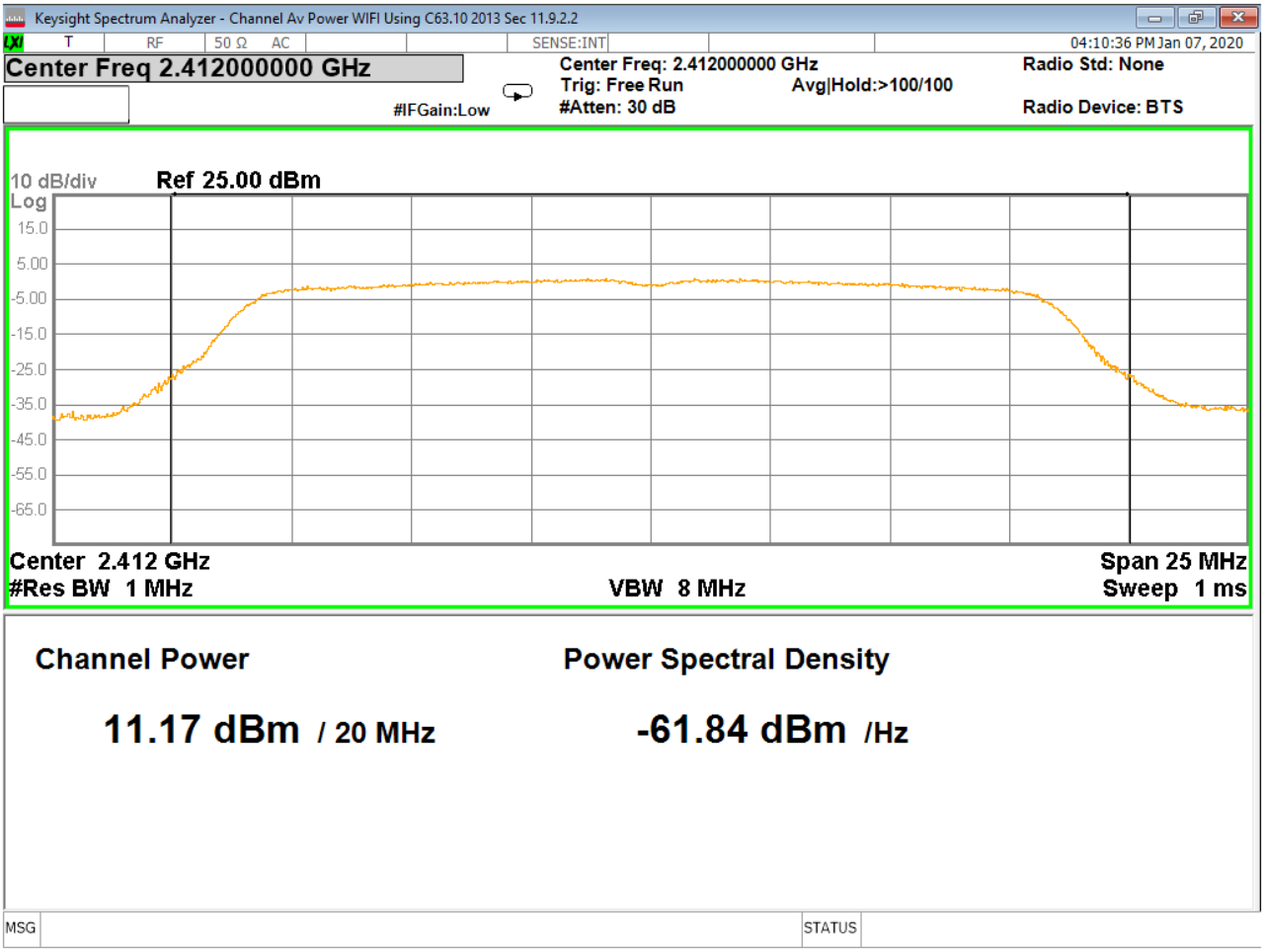


Figure 19 – Average Output Power, Low Channel, 802.11g

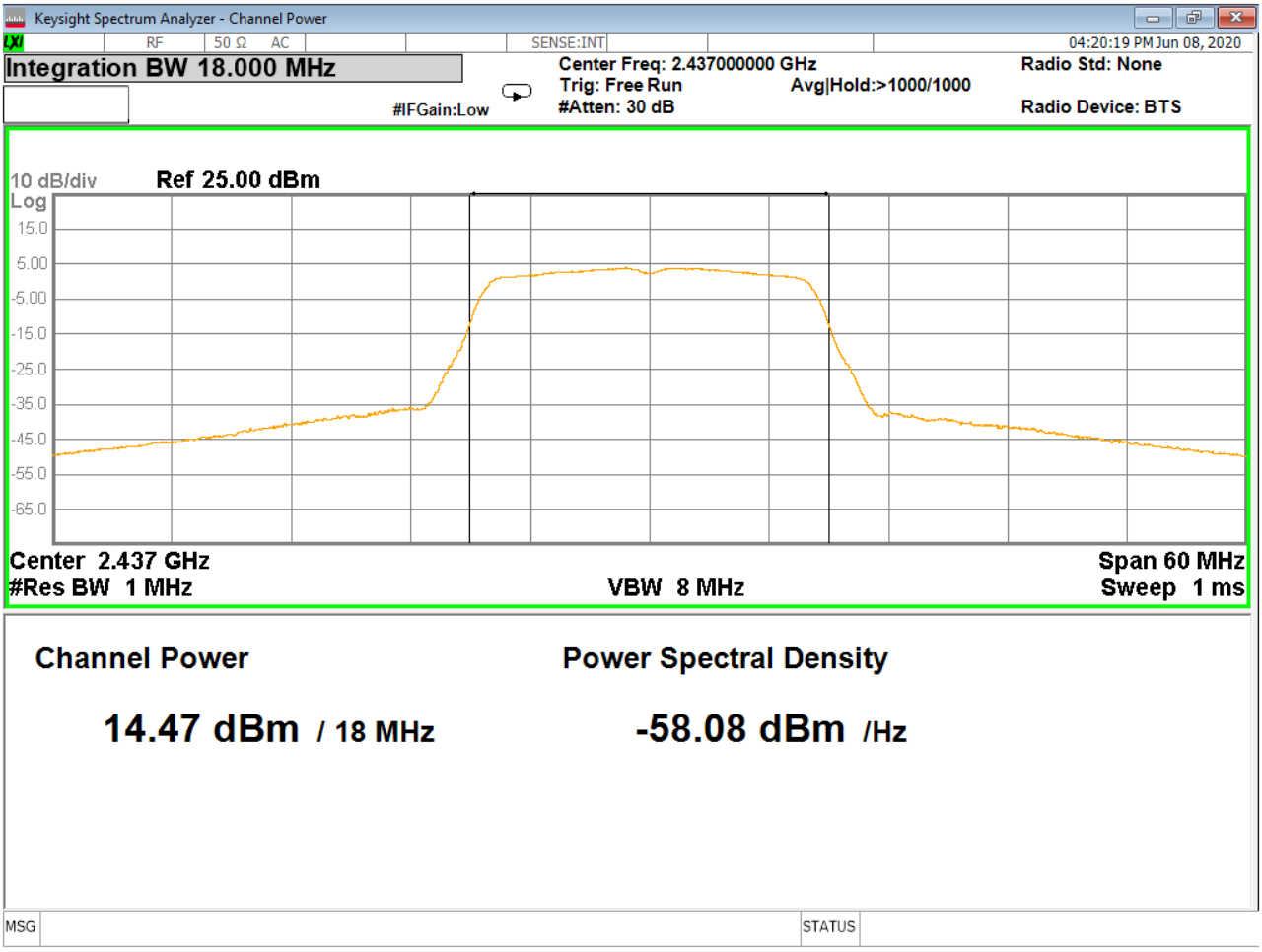


Figure 20 – Average Output Power, Mid Channel, 802.11g

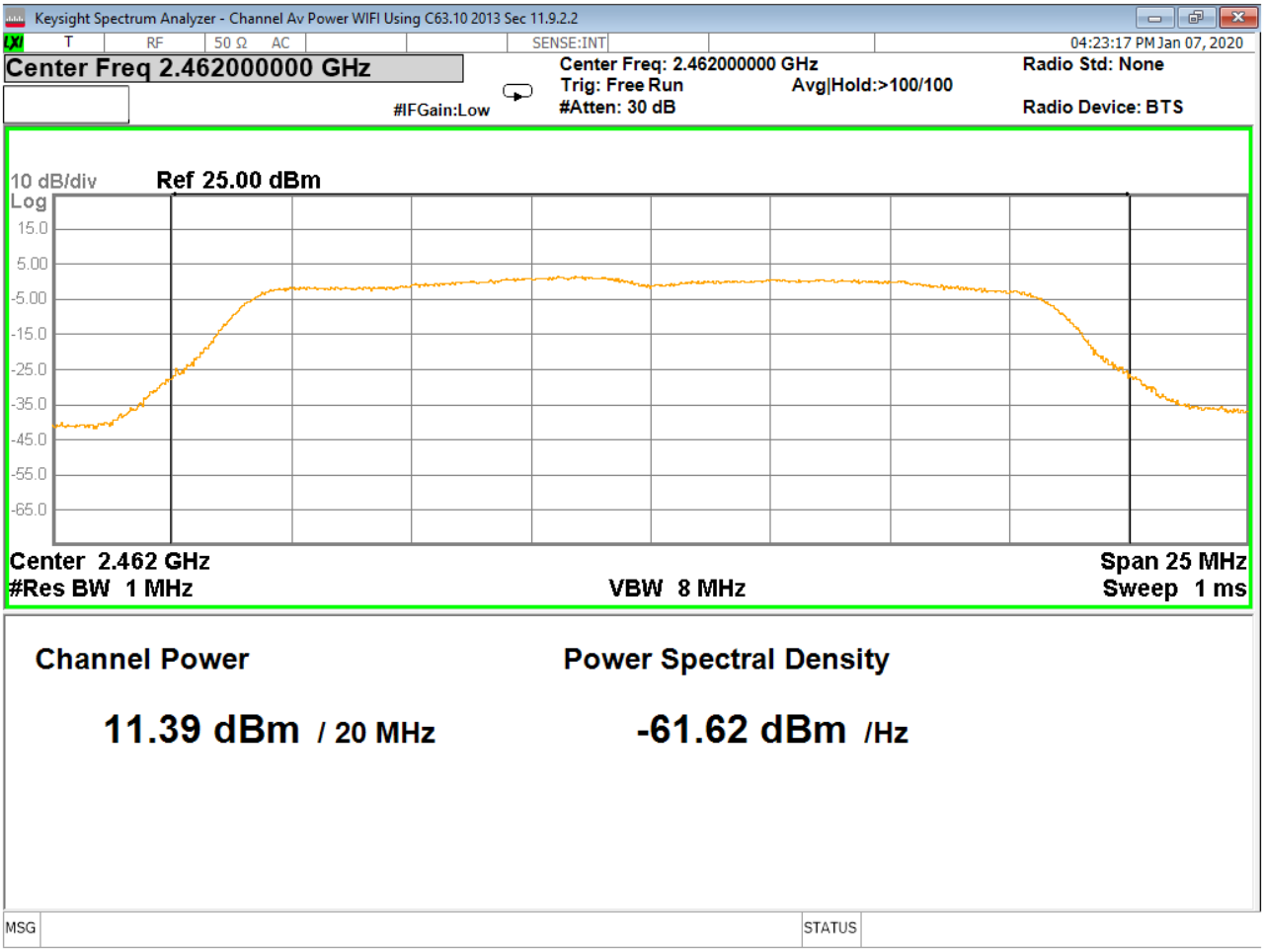


Figure 21 – Average Output Power, High Channel, 802.11g

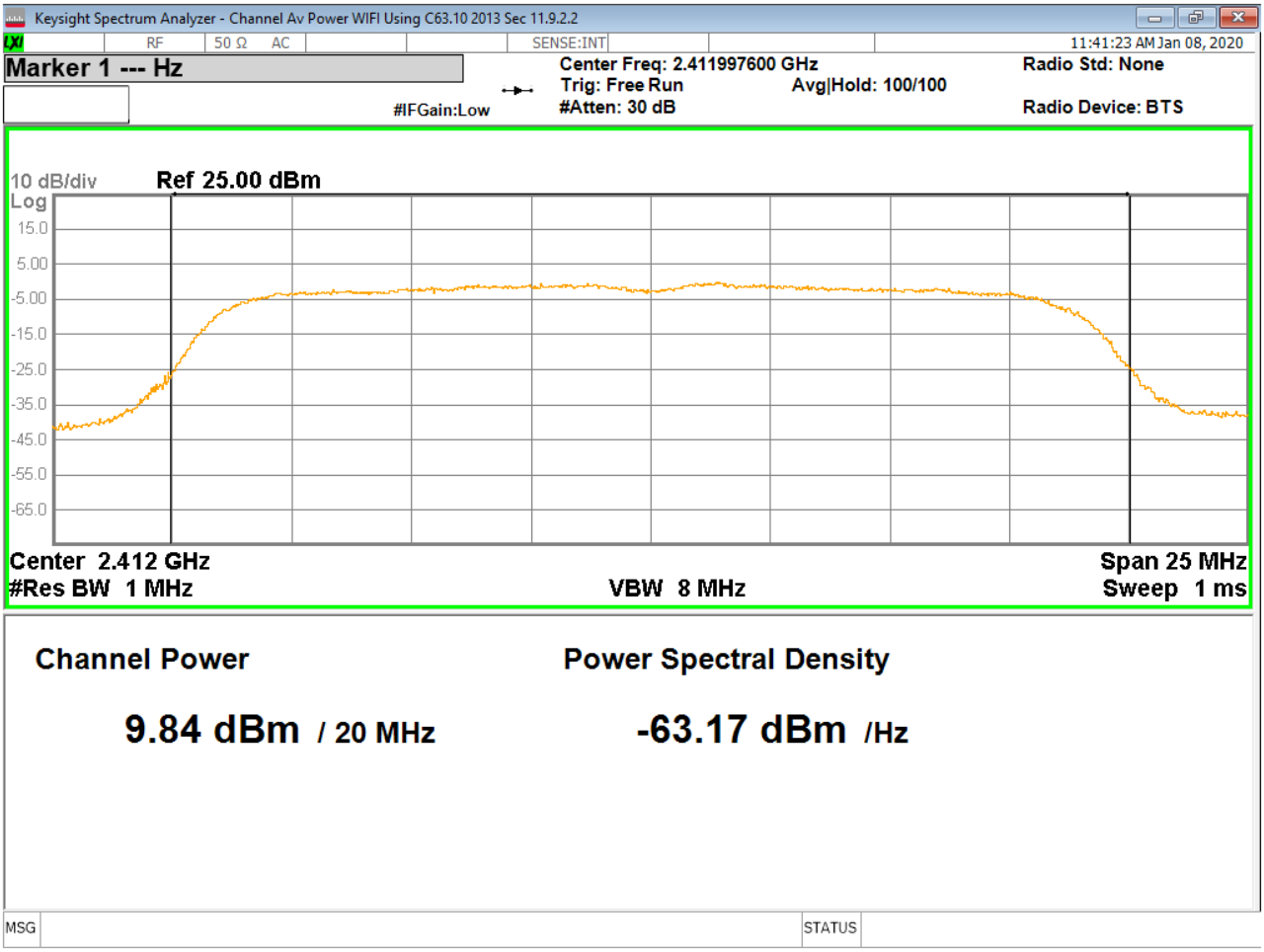


Figure 22 – Average Output Power, Low Channel, 802.11n

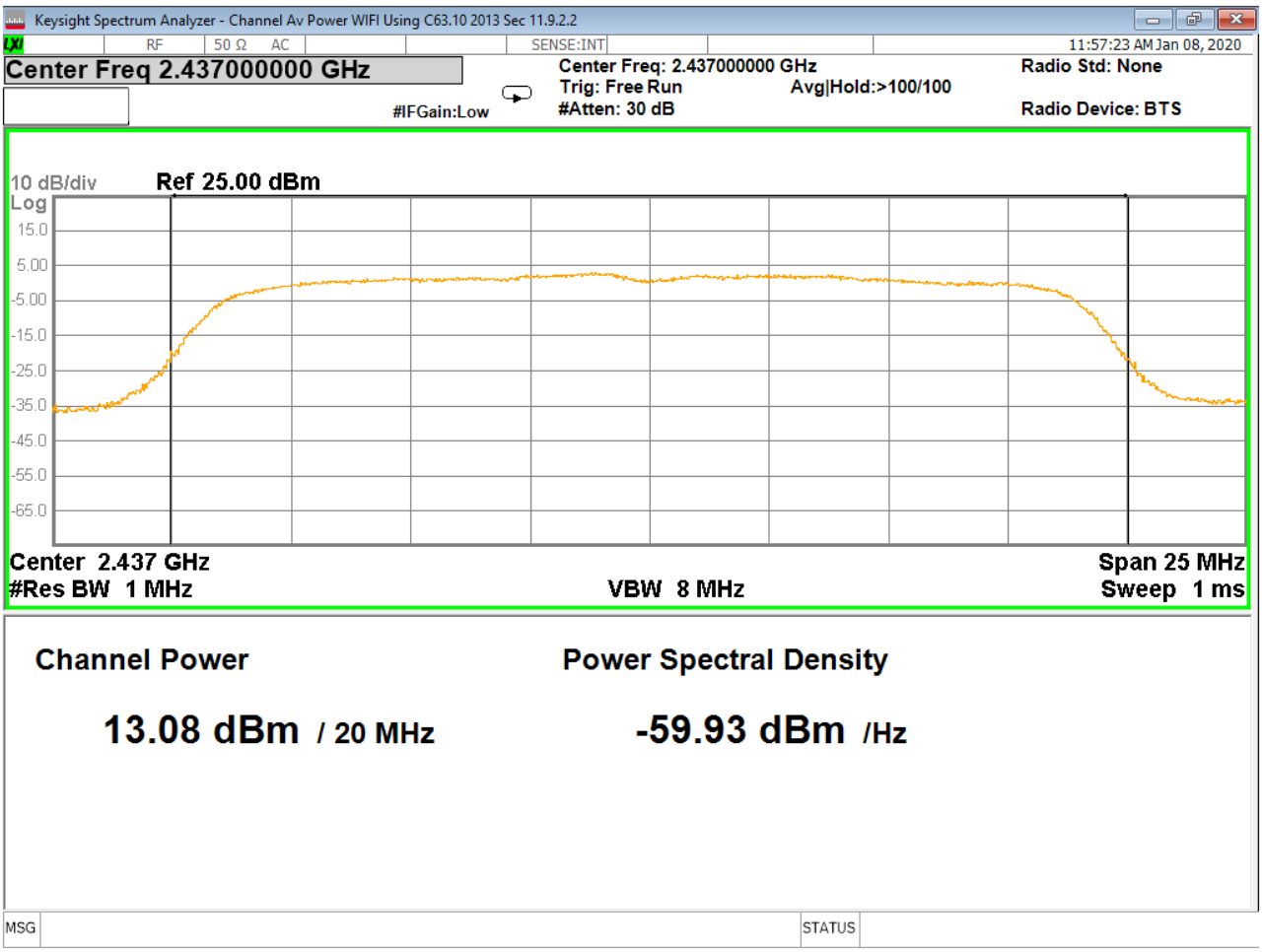


Figure 23 – Average Output Power, Mid Channel, 802.11n

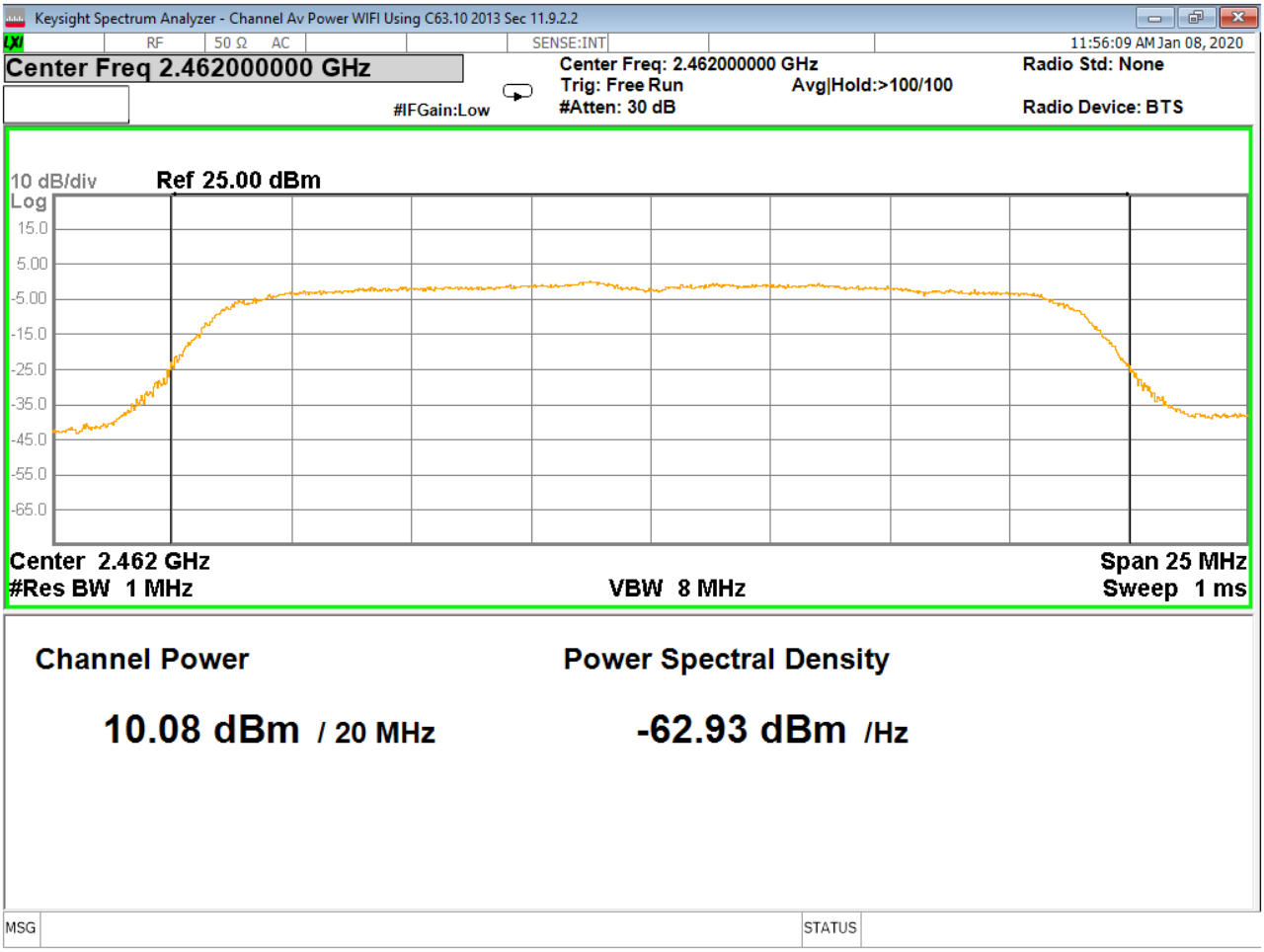


Figure 24 – Average Output Power, High Channel, 802.11n

4.4 BANDWIDTH

Test Method: ANSI C63.10,
1. Section(s) 11.8.1 “DTS Bandwidth, Option 1”

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 connected to the spectrum analyzer directly with a low-loss shielded coaxial cable. The bandwidth of the fundamental frequency was measured by spectrum analyzer with 100 kHz RBW and 300 kHz VBW. Bandwidth measuring functionality of the spectrum analyzer was used to make the measurement.

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:

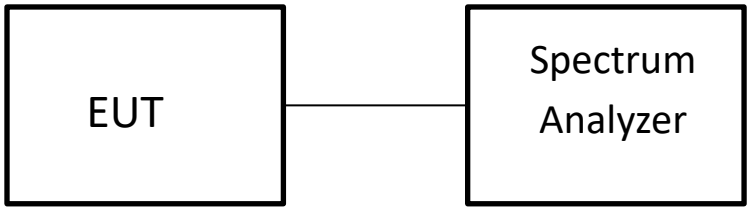


Figure 25 – Peak Output Power Measurements Test Setup

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:

99% Occupied Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	99% Occupied BW (MHz)
Low	2412	802.11b	13.397
Middle	2437	802.11b	13.393
High	2462	802.11b	13.358
Low	2412	802.11g	16.360
Middle	2437	802.11g	16.402
High	2462	802.11g	16.361
Low	2412	802.11n	17.573
Middle	2437	802.11n	17.600
High	2462	802.11n	17.565

6dB Bandwidth

CHANNEL	CHANNEL FREQUENCY (MHz)	WIFI Type	6 dB BW (MHz)
Low	2412	802.11b	8.371
Middle	2437	802.11b	8.486
High	2462	802.11b	8.830
Low	2412	802.11g	16.38
Middle	2437	802.11g	16.42
High	2462	802.11g	16.35
Low	2412	802.11n	17.00
Middle	2437	802.11n	17.51
High	2462	802.11n	17.42

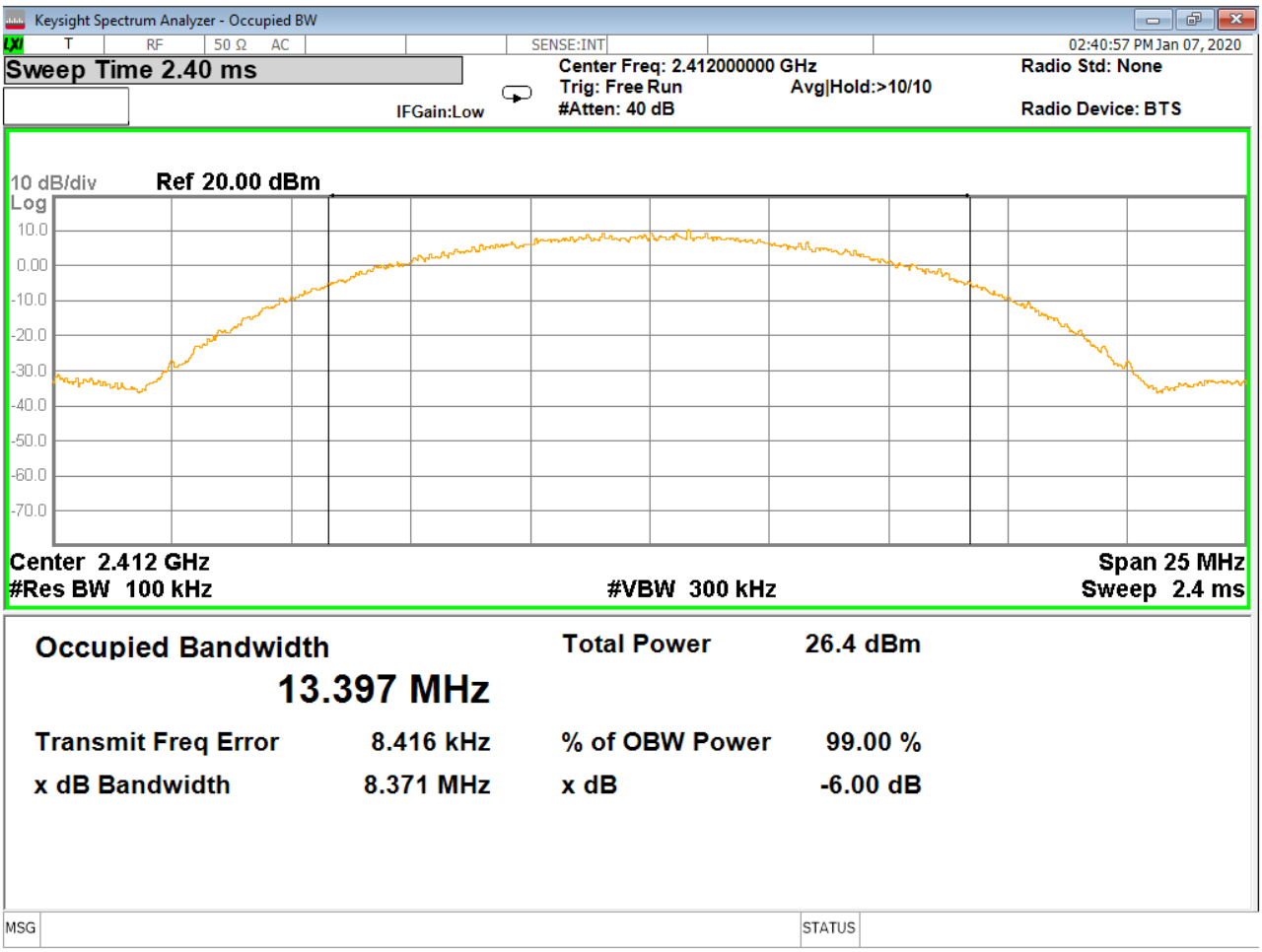


Figure 26 - Bandwidth, Low Channel, 802.11b

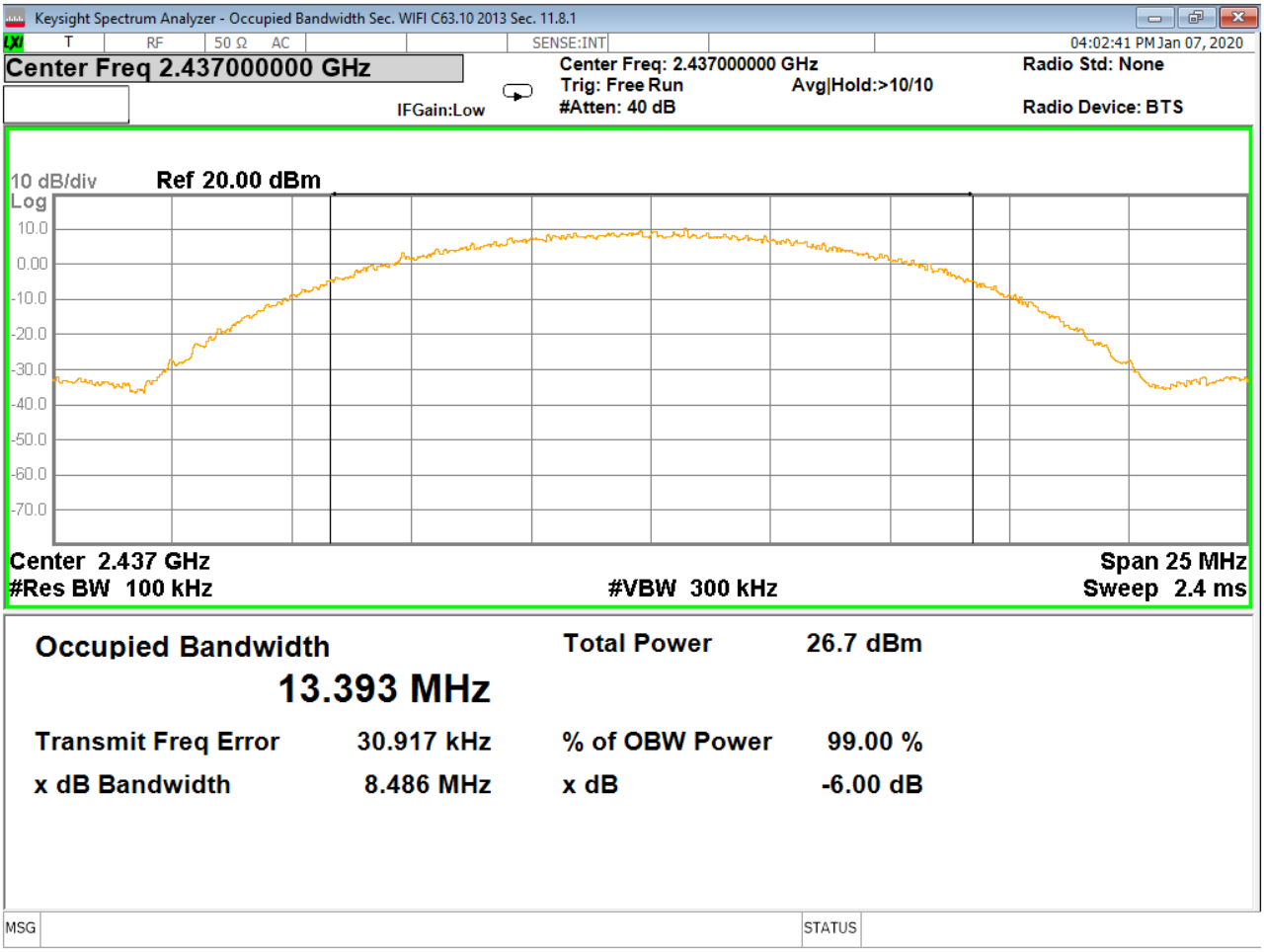


Figure 27 - Bandwidth, Mid Channel, 802.11b

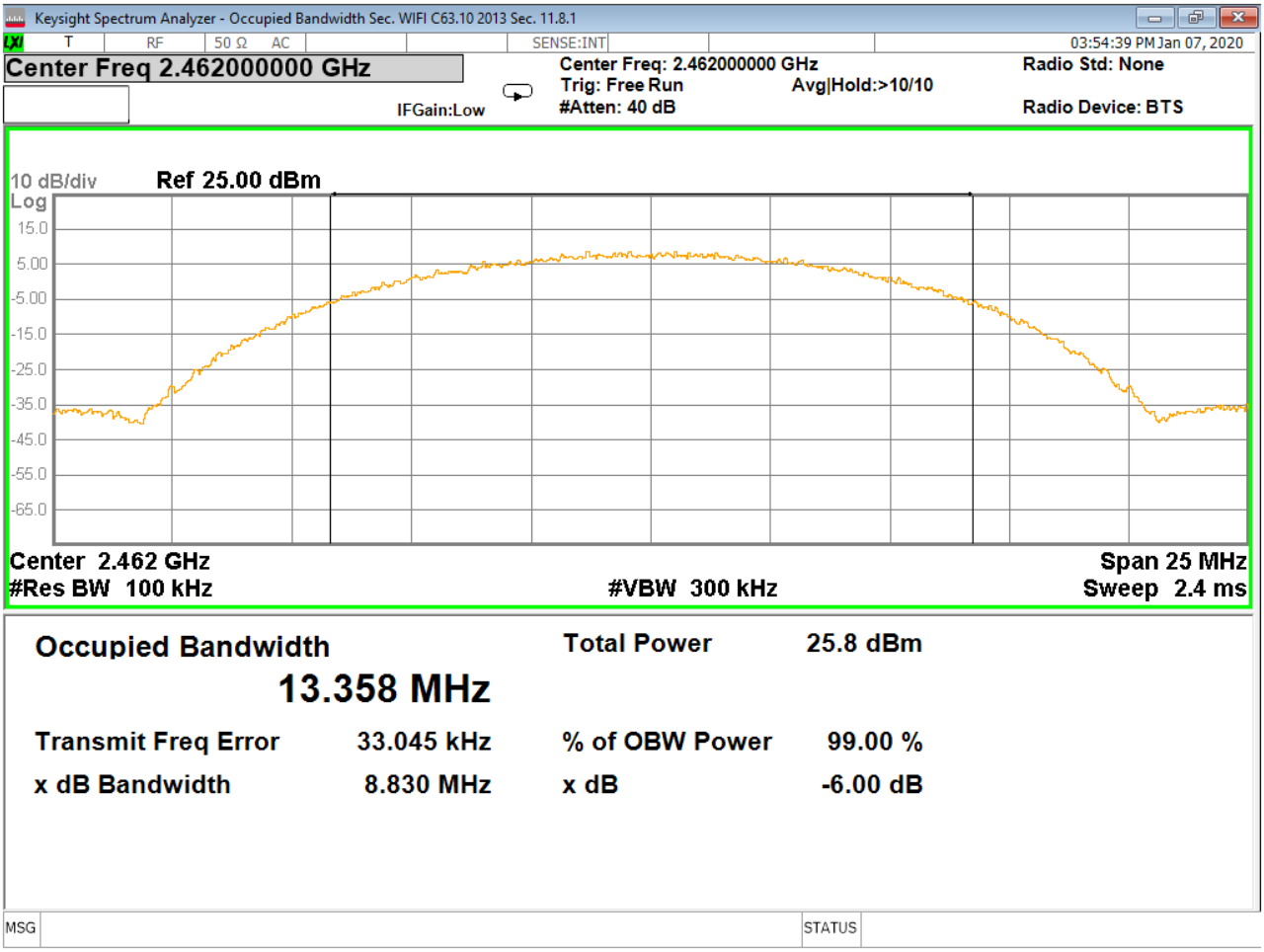


Figure 28 - Bandwidth, High Channel, 802.11b

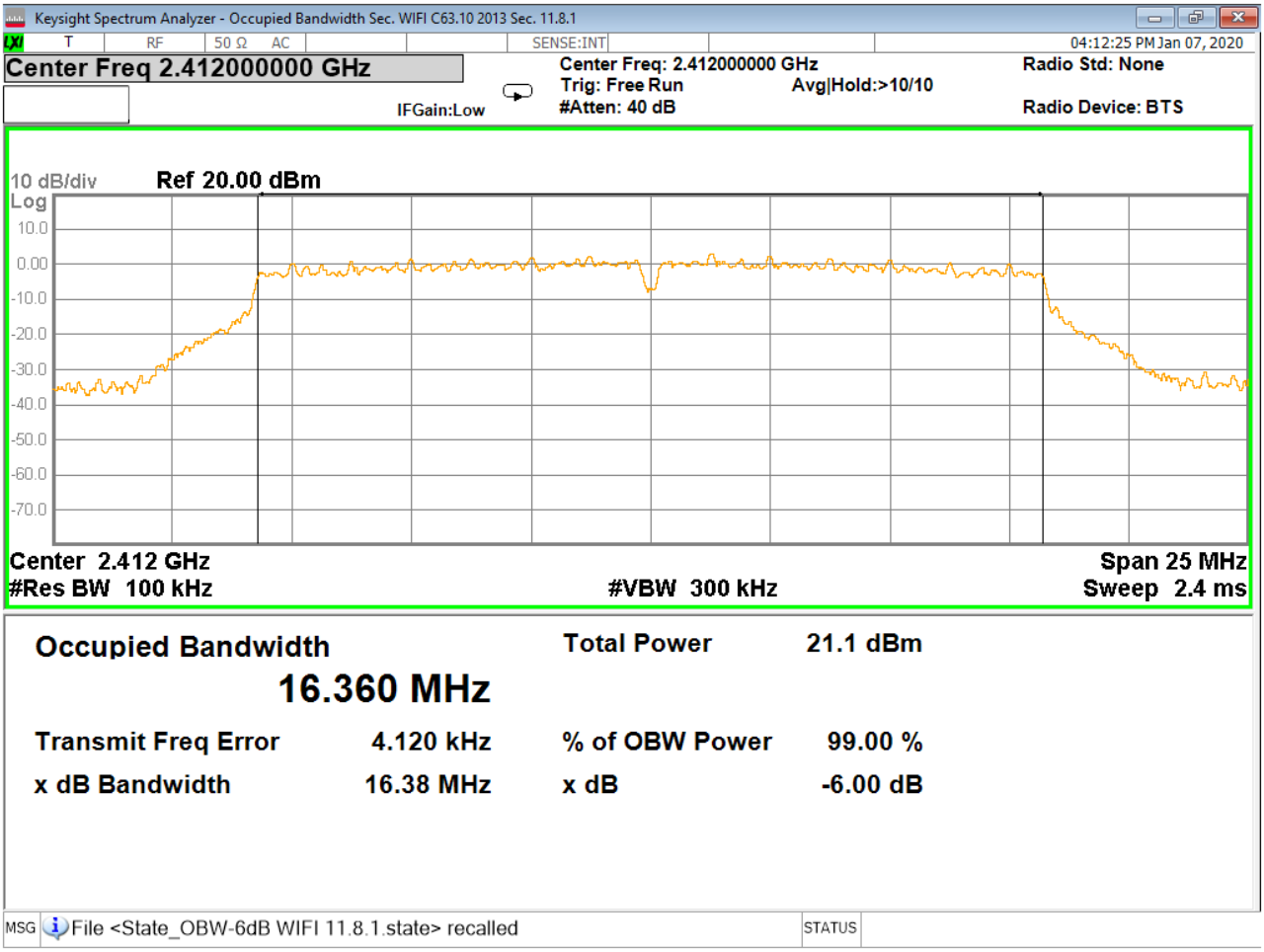


Figure 29 - Bandwidth, Low Channel, 802.11g

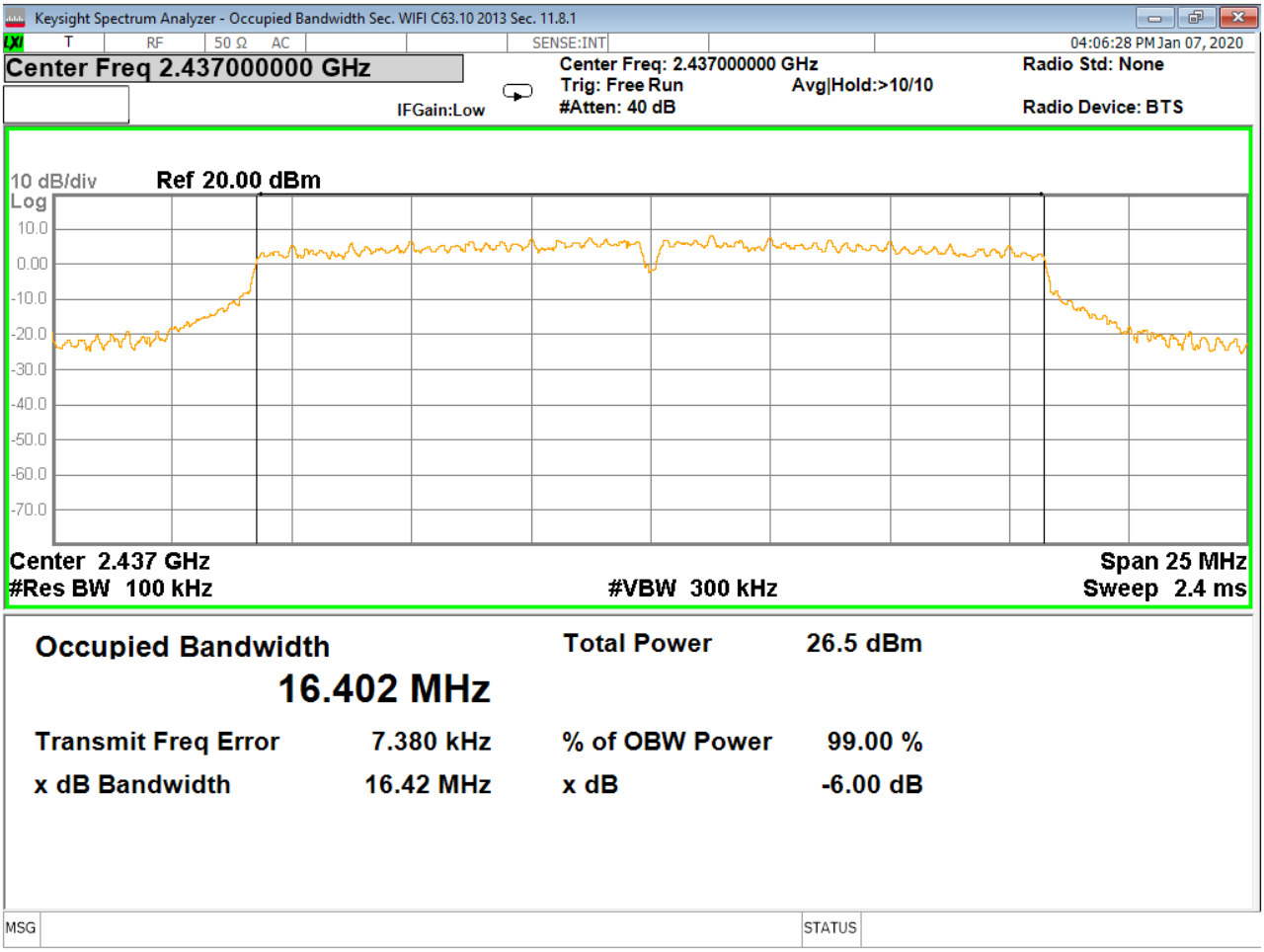


Figure 30 - Bandwidth, Mid Channel, 802.11g

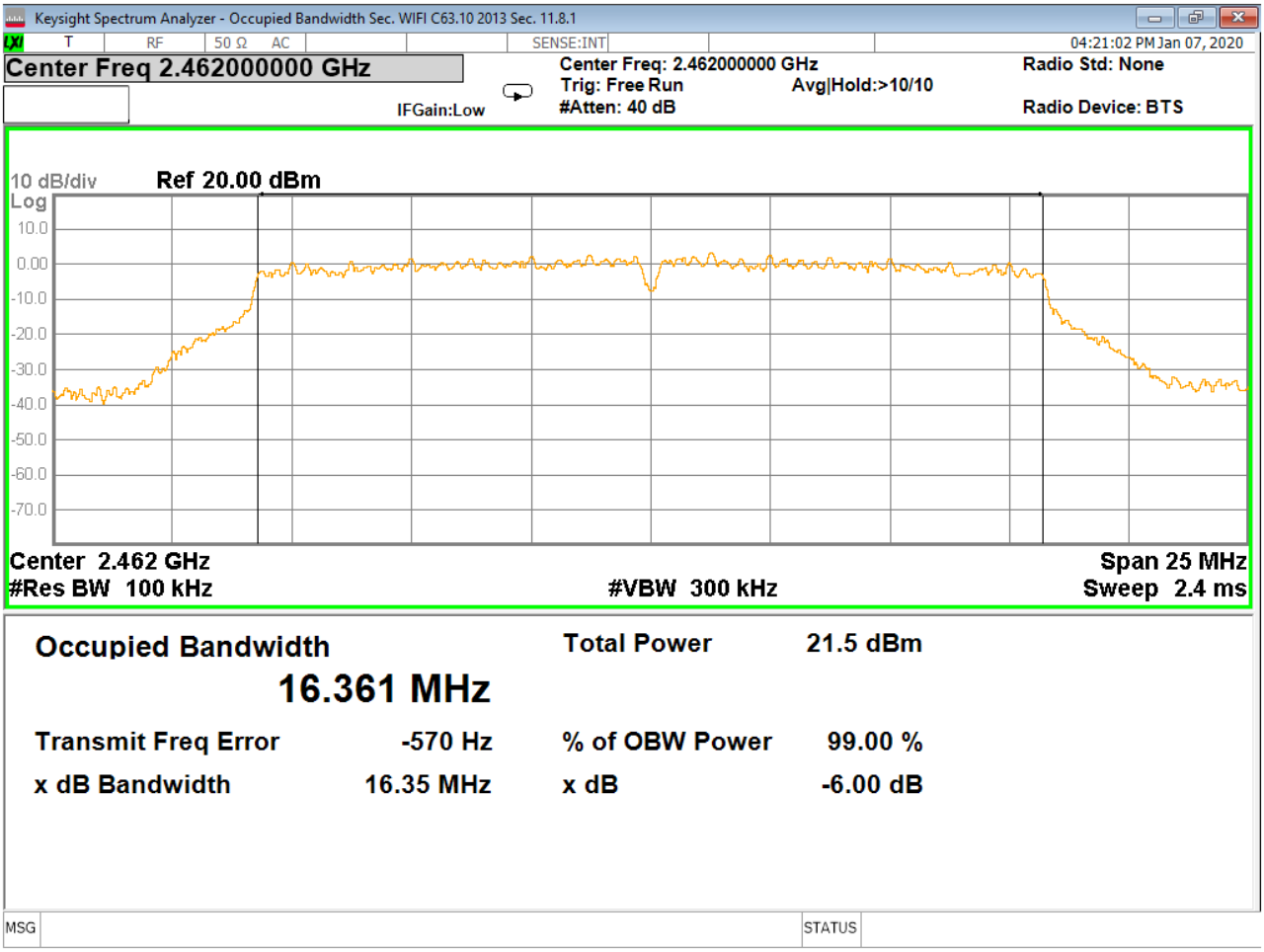


Figure 31 - Bandwidth, High Channel, 802.11g

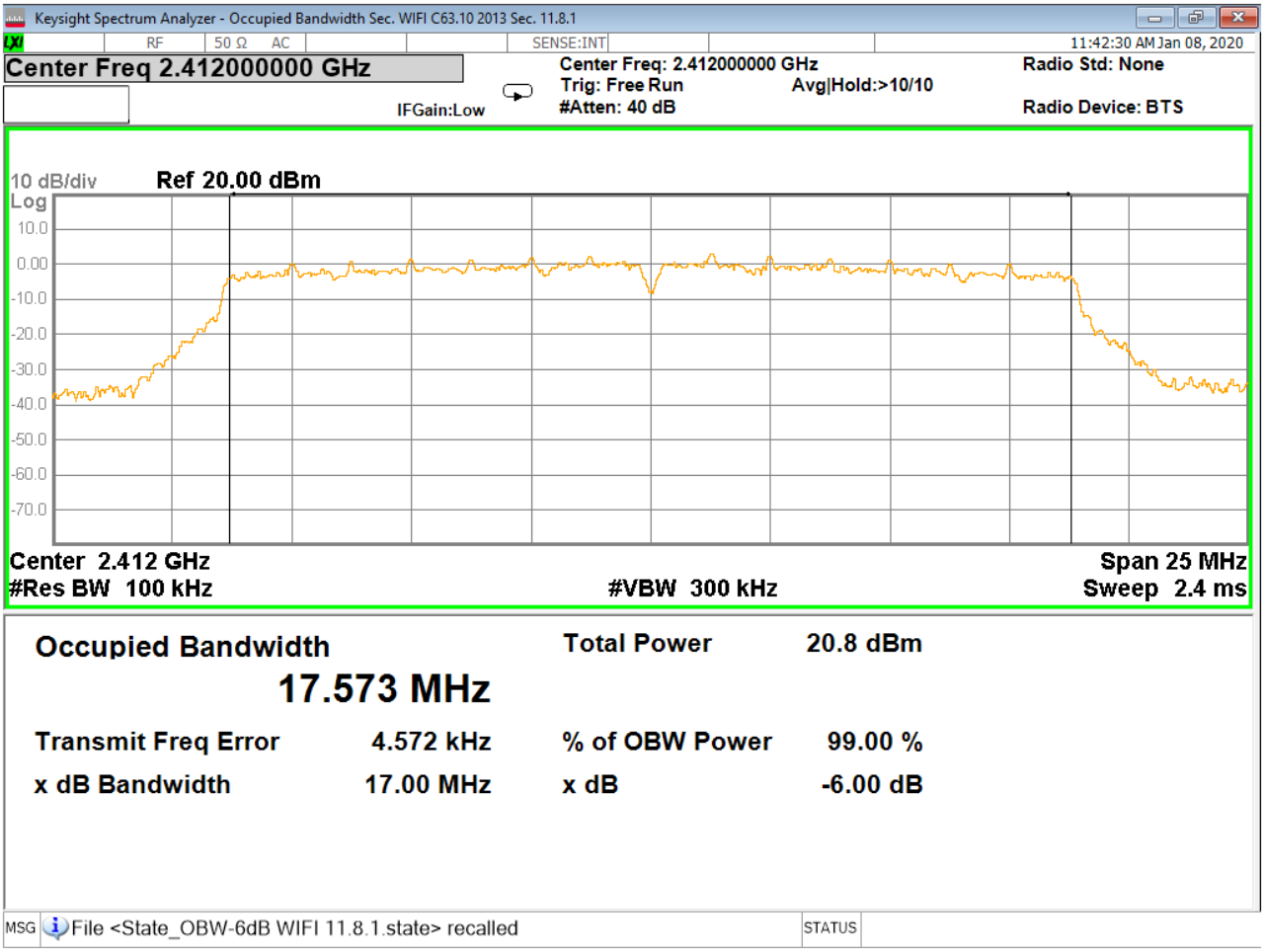


Figure 32 - Bandwidth, Low Channel, 802.11n

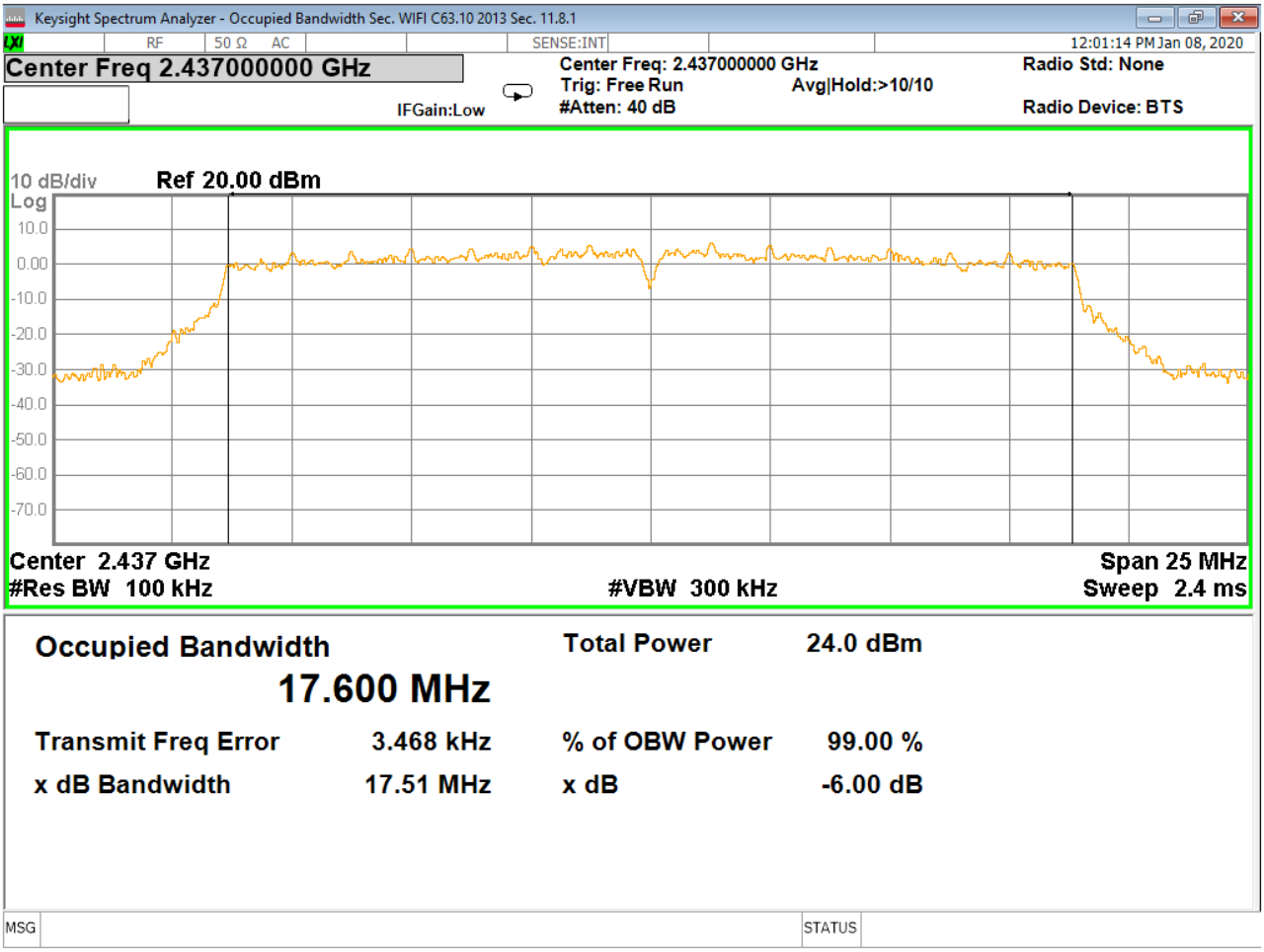


Figure 33 - Bandwidth, Mid Channel, 802.11n

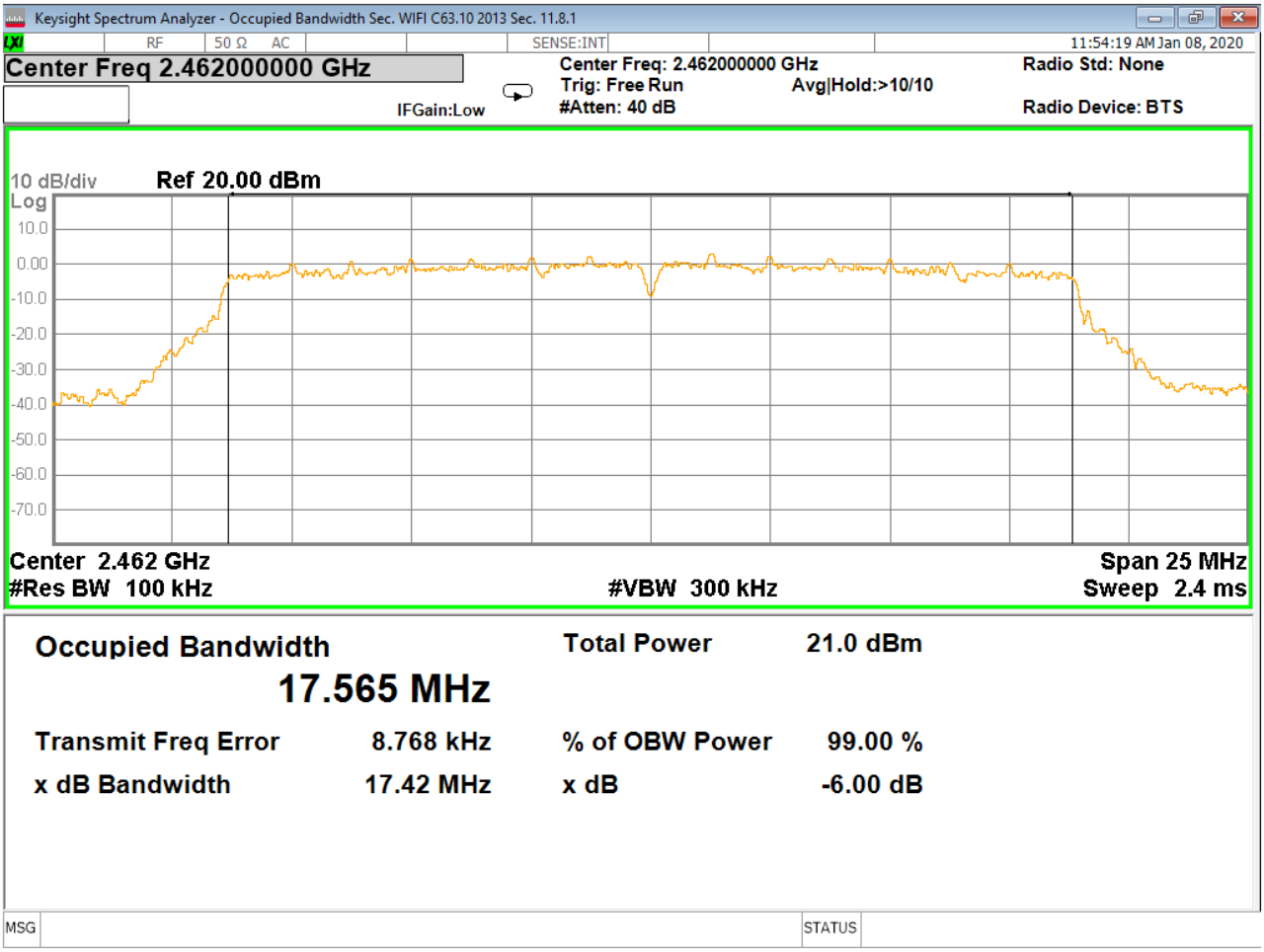


Figure 34 - Bandwidth, High Channel, 802.11n

4.5 BANDEDGES

Test Method: ANSI C63.10:

1. Section 6.10.5 (used for restricted bands)
2. Section 11.11, "Measurement in unrestricted frequency bands"

Limits of bandedge 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 bandedge to the fundamental frequency with a quasi-peak detector. The highest emissions level beyond the bandedge 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:
See Section 4.3

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	2400.0 (Unrestricted, Peak)	-33.976	7.970	41.946	20	PASS
1	2400.0 (Unrestricted, Average)	-44.593	-2.148	42.445	20	PASS
11	2483.5 (Unrestricted, Peak)	-56.091	8.482	64.572	20	PASS
11	2483.5 (Unrestricted, Average)	-64.374	-1.353	62.905	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m)	Limit* (dBm)	Margin	Result
1	2340.0 (Restricted, Peak)	53.385	74.00	20.615	PASS
1	2340.0 (Restricted, Average)	40.488	54.00	13.512	PASS
11	2483.5 (Restricted, Peak)	52.871	74.00	21.129	PASS
11	2483.5 (Restricted, Average)	40.991	54.00	13.009	PASS

Margin= Limit-Level
*Limits from Part 15.209

Unrestricted band measurements were performed conducted while restricted band measurements were performed radiated.

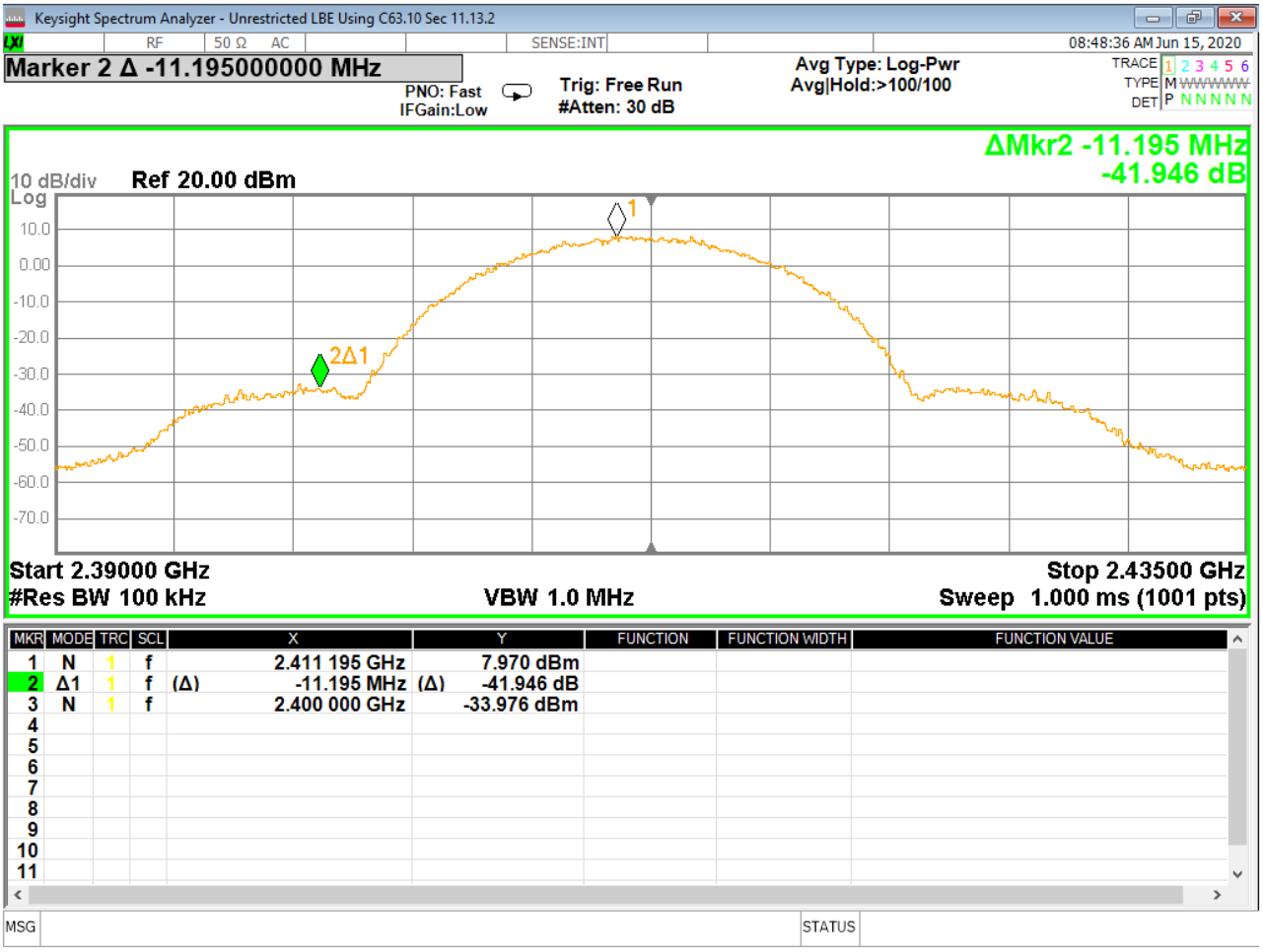


Figure 35 - Band-edge Measurement, Low Channel, Fundamental, Peak

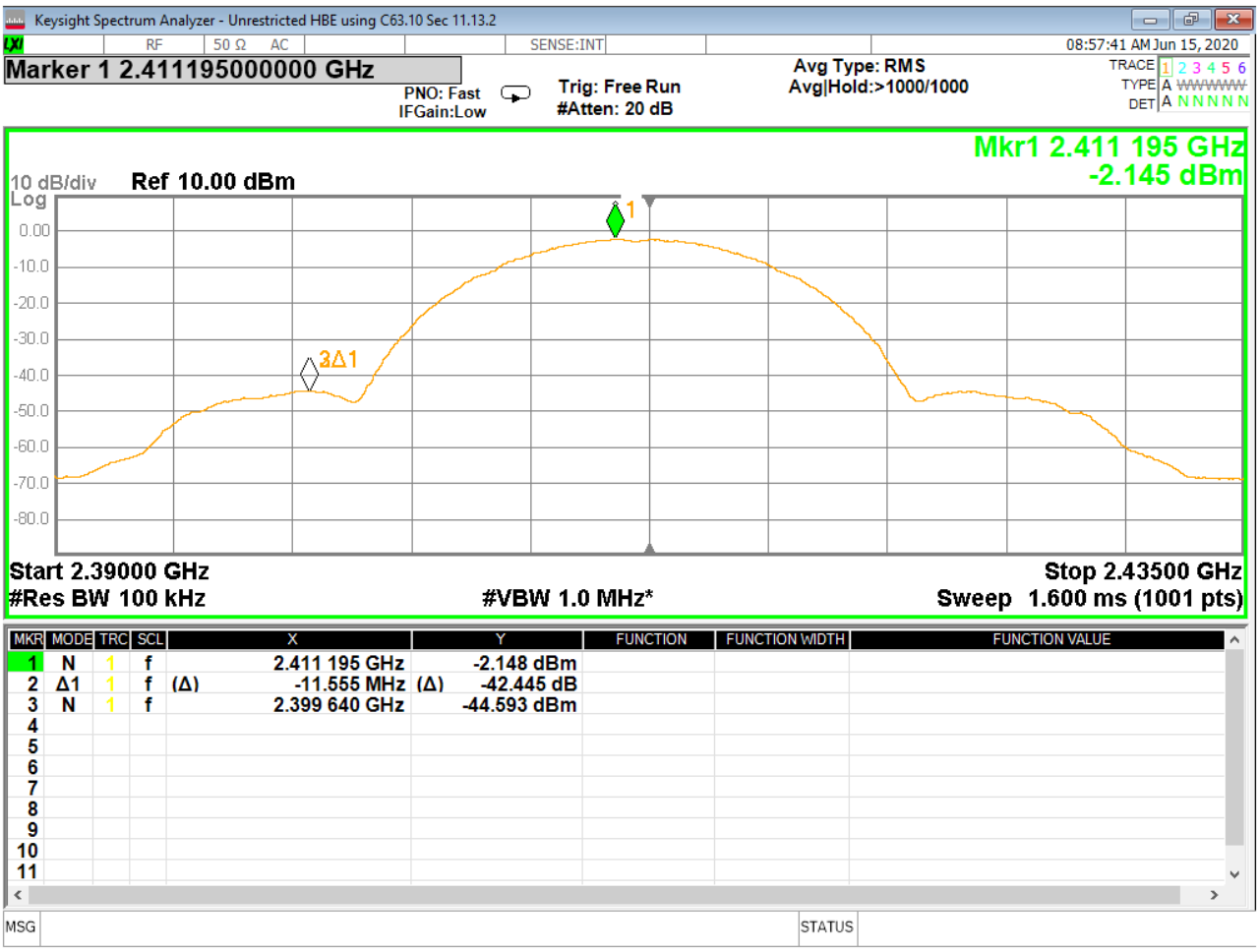


Figure 36 - Band-edge Measurement, Low Channel, Fundamental, Average

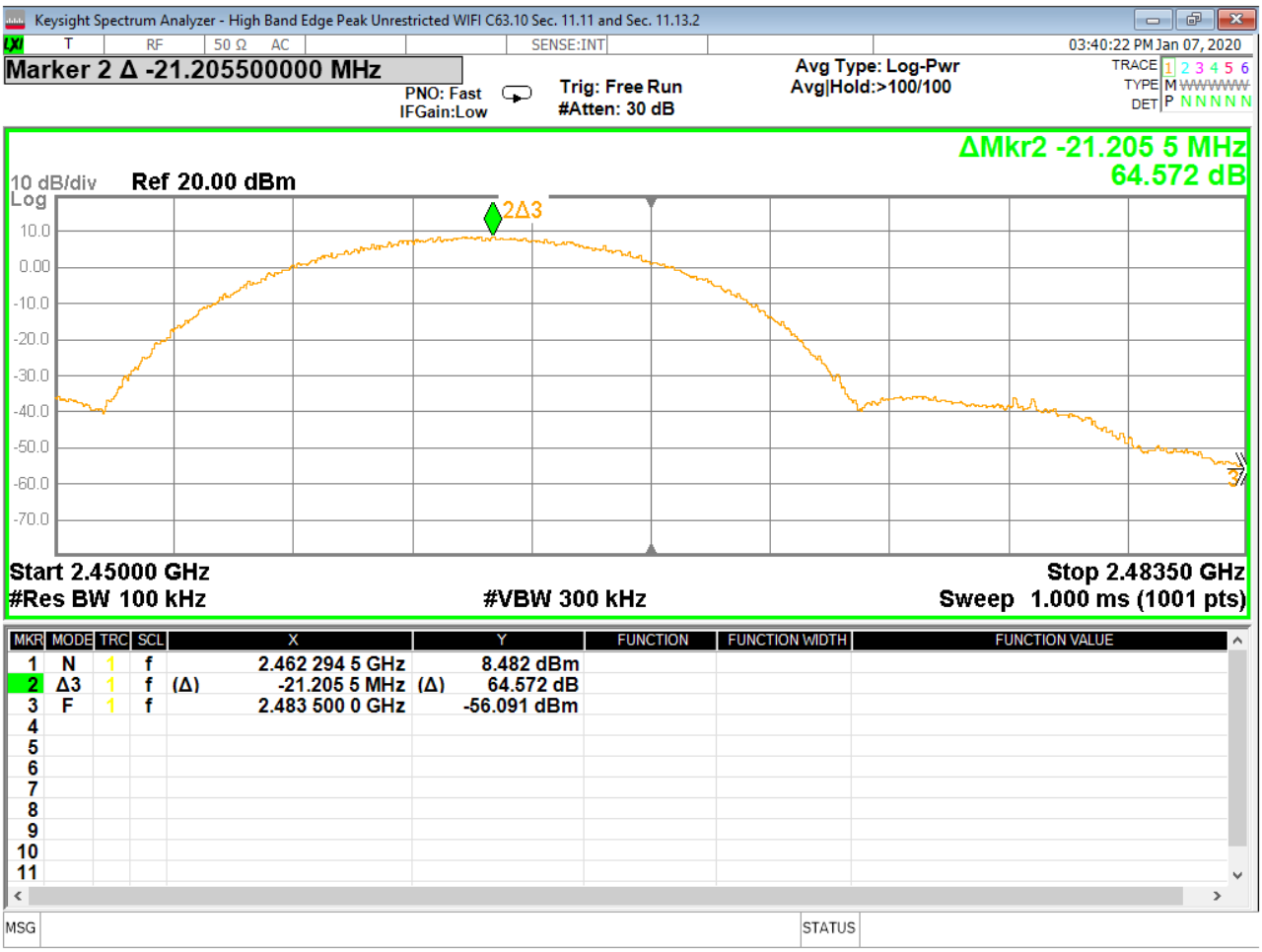


Figure 37 - Band-edge Measurement, High Channel, Fundamental, Peak

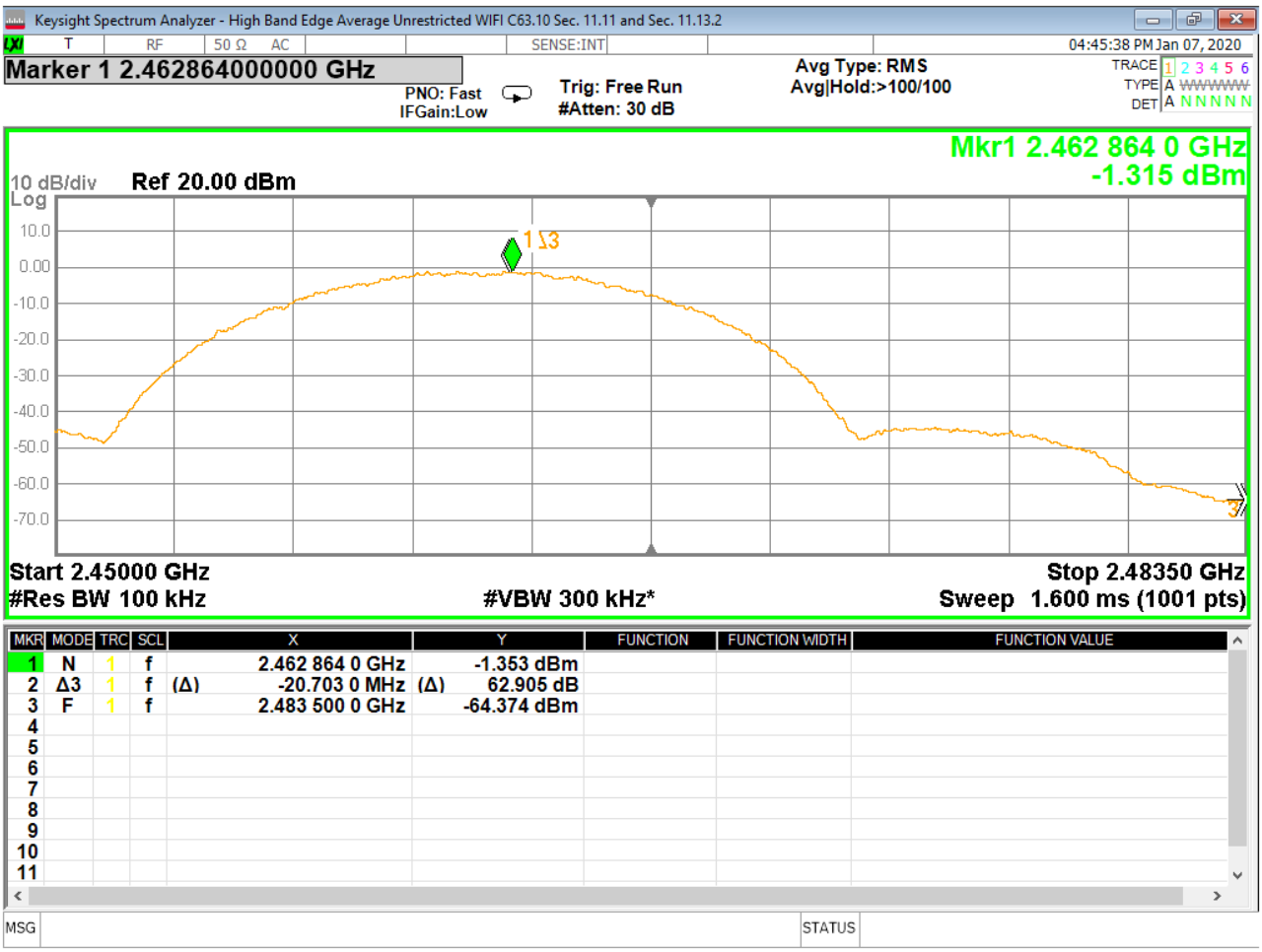


Figure 38 - Band-edge Measurement, High Channel, Fundamental, Average

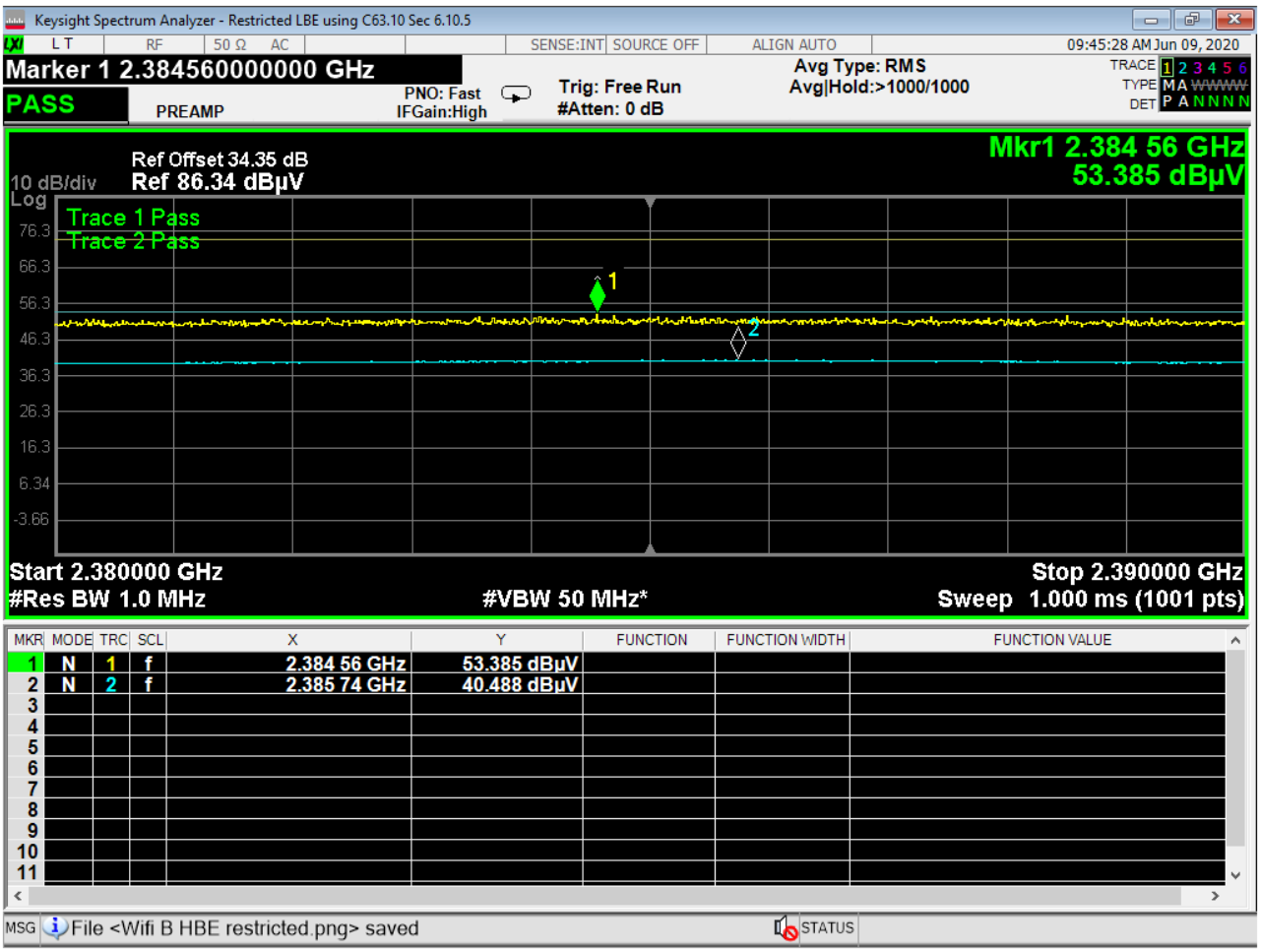


Figure 39 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak and Average

Peak and average trace are shown and compared to their respective limits. Reference offset has been added to account for transducer value of 28.389 dBuV/m @ 3m and cable loss of 5.96 dB.

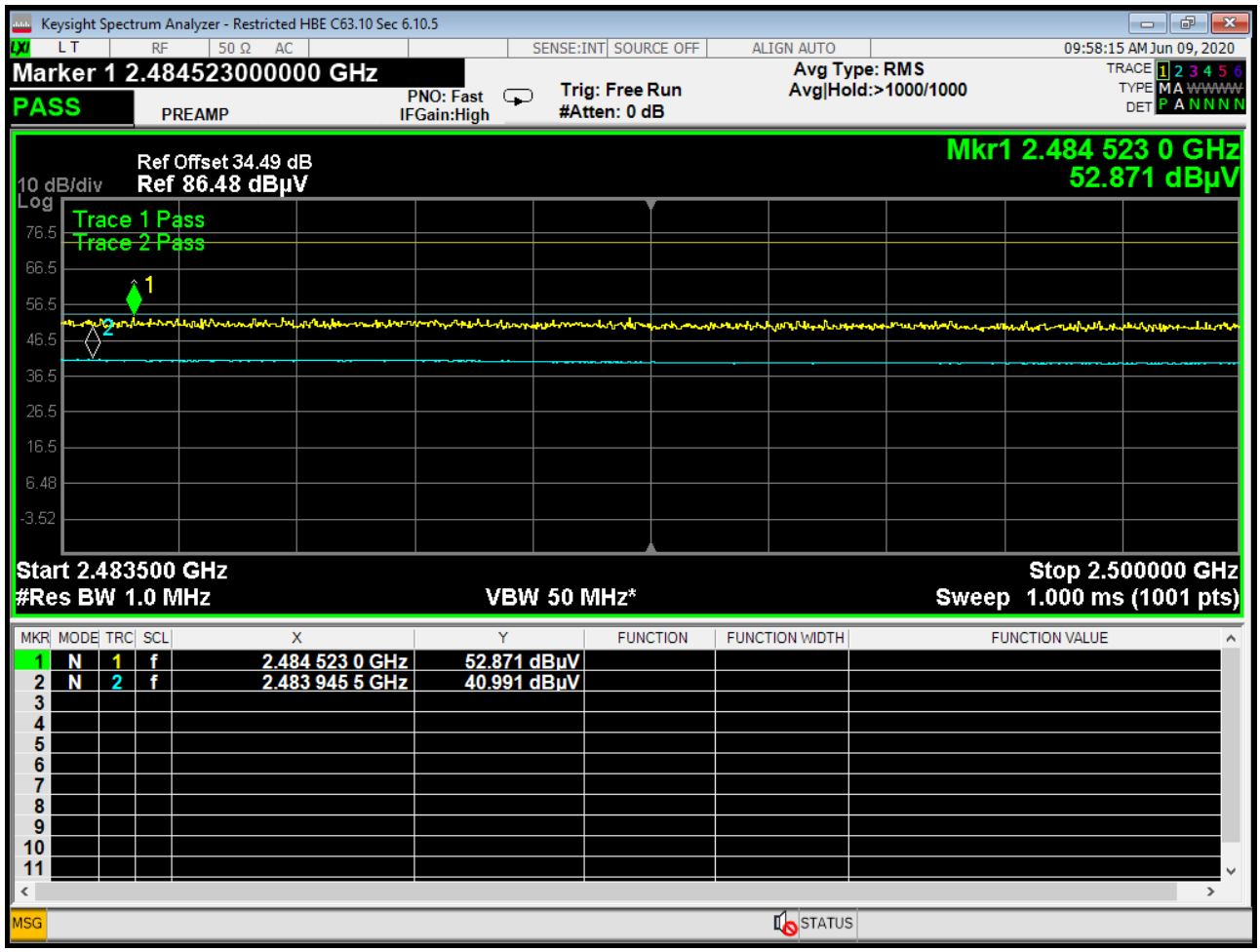


Figure 40 - Band-edge Measurement, High Channel, Restricted Frequency, Peak and Average

Peak and average trace are shown and compared to their respective limits. Reference offset has been added to account for transducer value of 28.45 dBuV/m @ 3m and cable loss of 6.04 dB.

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	2400.0 (Unrestricted, Peak)	-31.773	2.571	34.343	20	PASS
1	2400.0 (Unrestricted, Average)	-46.740	-7.173	39.561	20	PASS
11	2483.5 (Unrestricted, Peak)	-43.908	2.662	46.571	20	PASS
11	2483.5 (Unrestricted, Average)	-57.031	-7.051	49.971	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m)	Limit* (dBm)	Margin	Result
1	2340.0 (Restricted, Peak)	63.837	74.00	10.163	PASS
1	2340.0 (Restricted, Average)	45.721	54.00	8.279	PASS
11	2483.5 (Restricted, Peak)	66.013	74.00	7.987	PASS
11	2483.5 (Restricted, Average)	48.938	54.00	5.062	PASS

Margin= Limit-Level
*Limits from Part 15.209

Unrestricted band measurements were performed conducted while restricted band measurements were performed radiated.

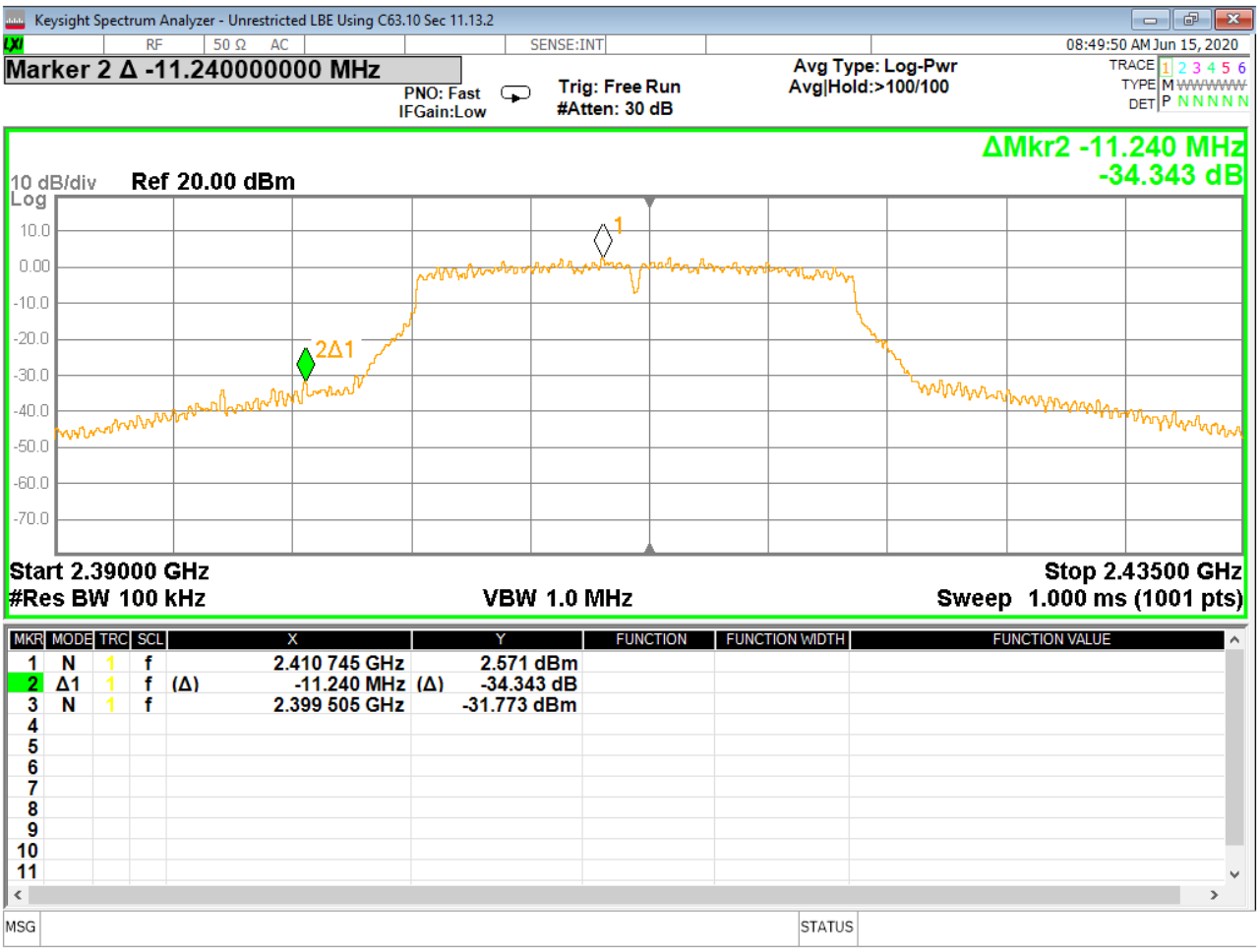


Figure 41 - Band-edge Measurement, Low Channel, Fundamental, Peak

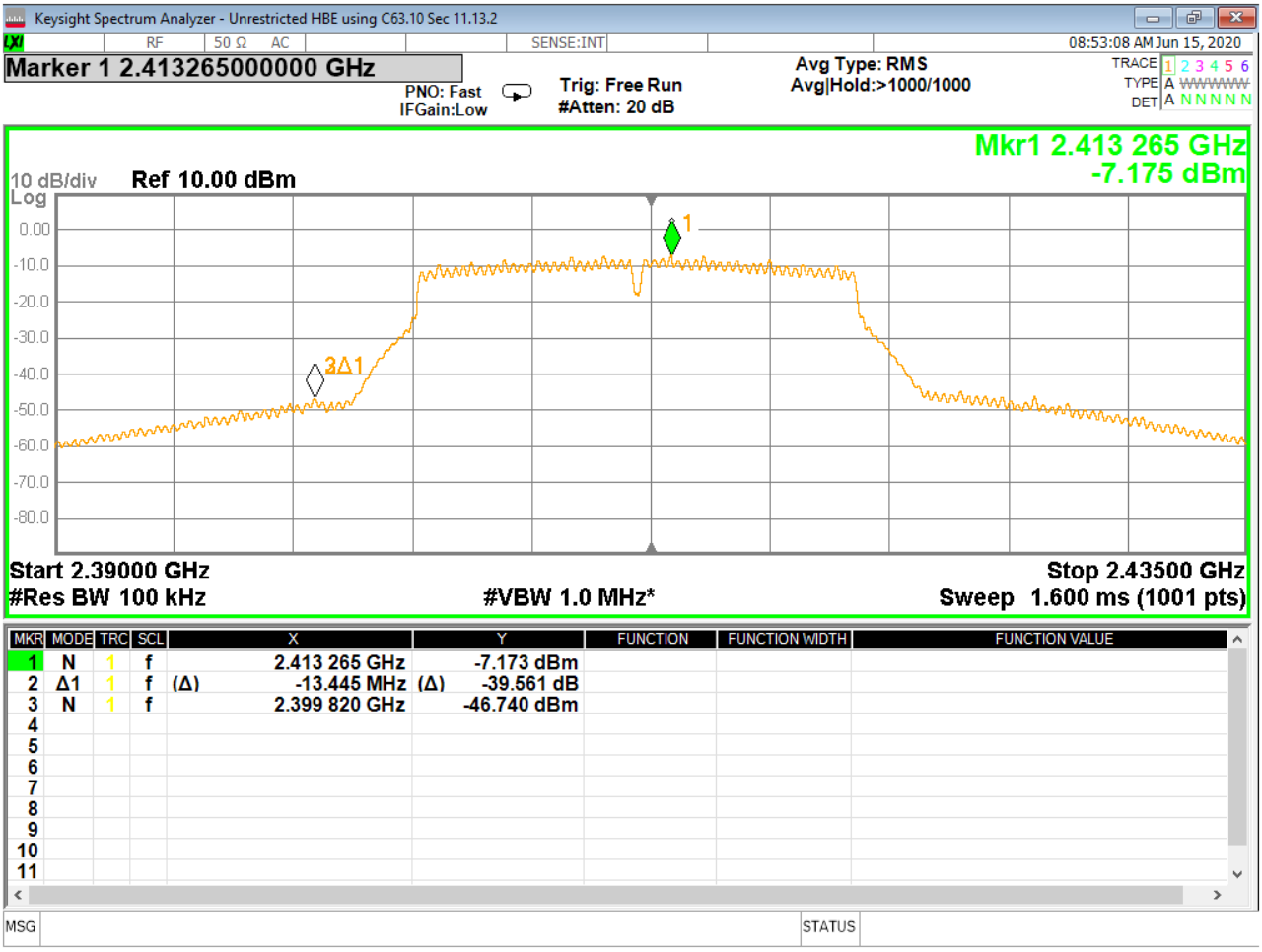


Figure 42 - Band-edge Measurement, Low Channel, Fundamental, Average

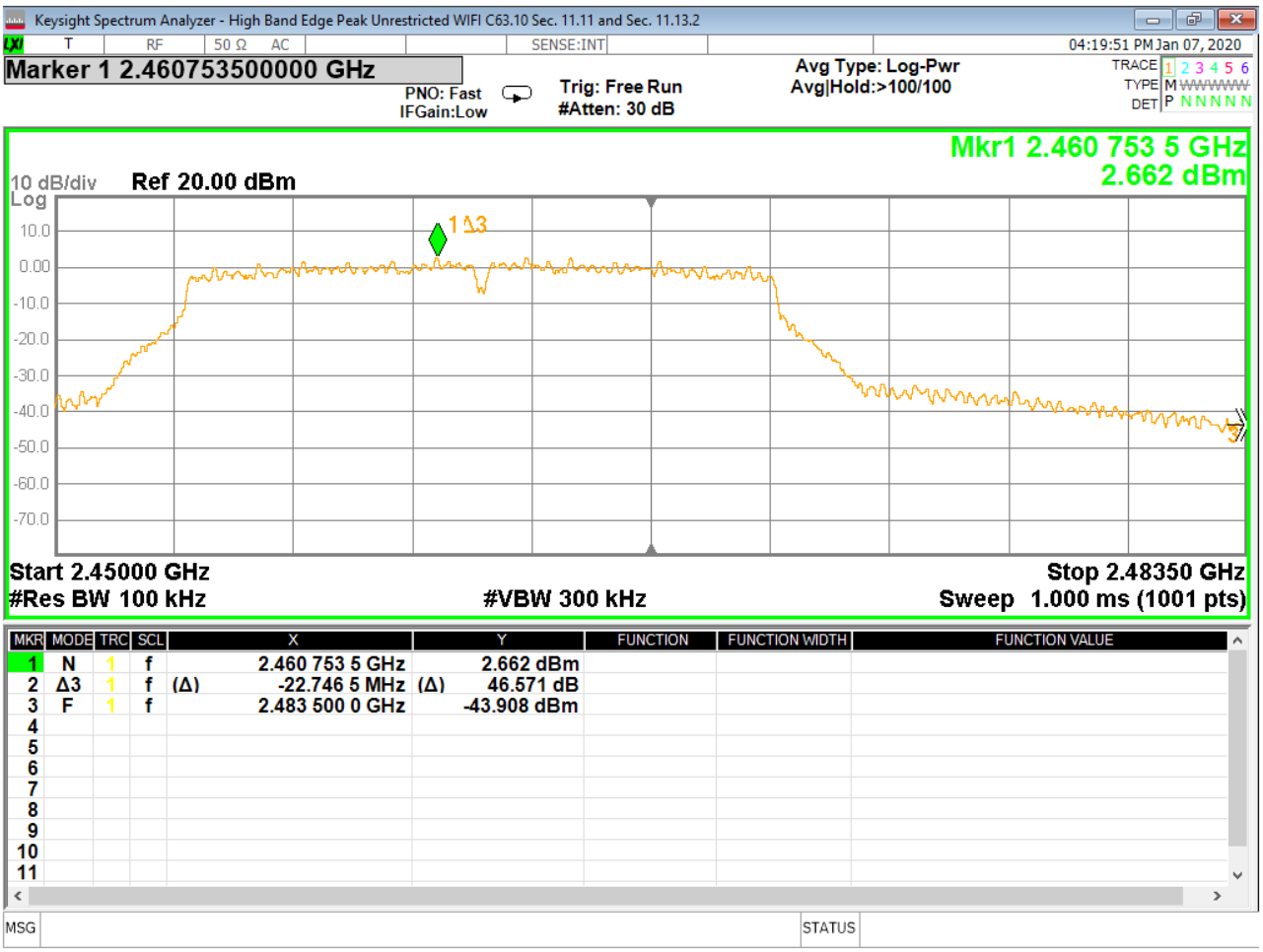


Figure 43 - Band-edge Measurement, High Channel, Fundamental, Peak

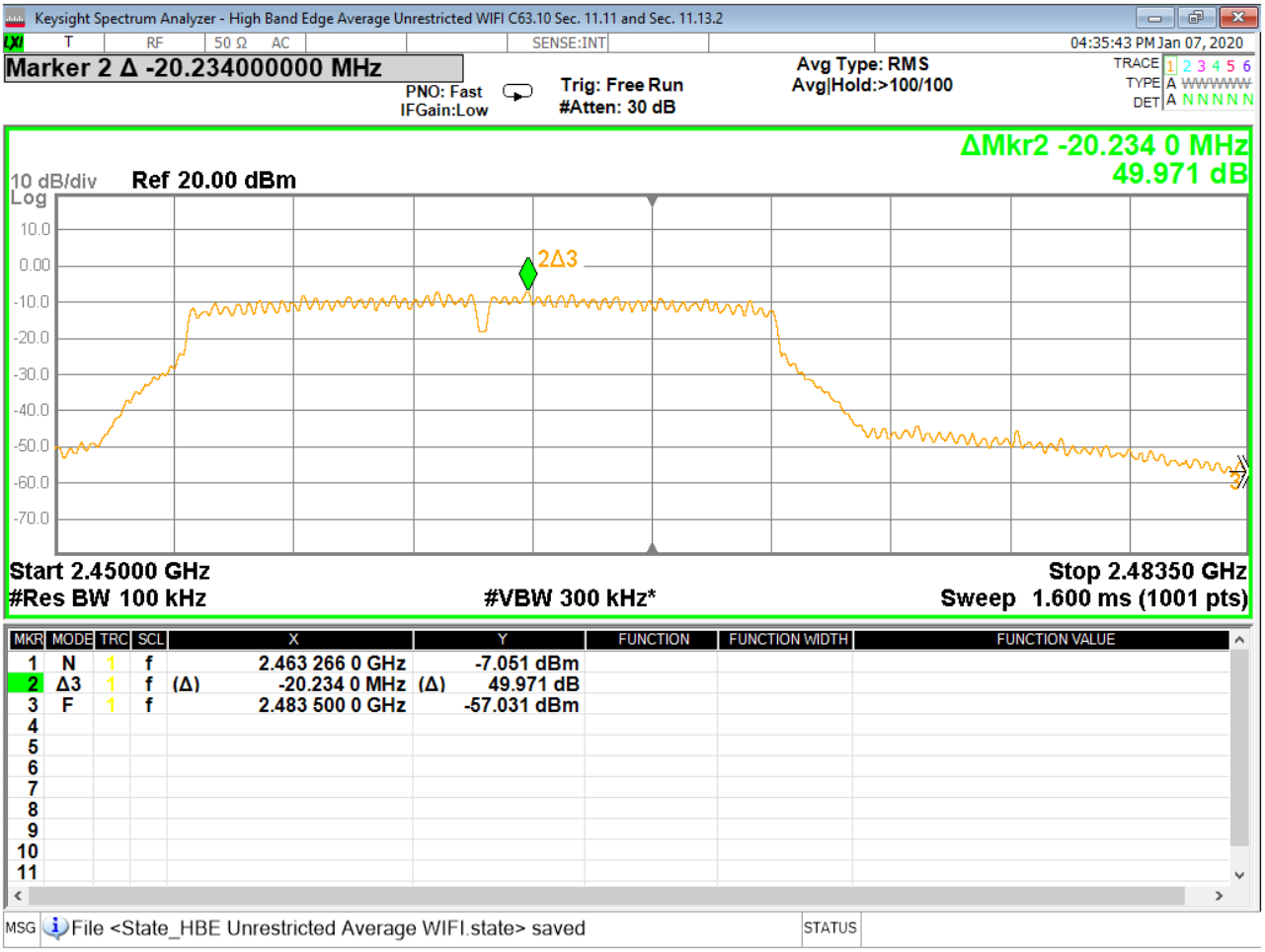


Figure 44 - Band-edge Measurement, High Channel, Fundamental, Average

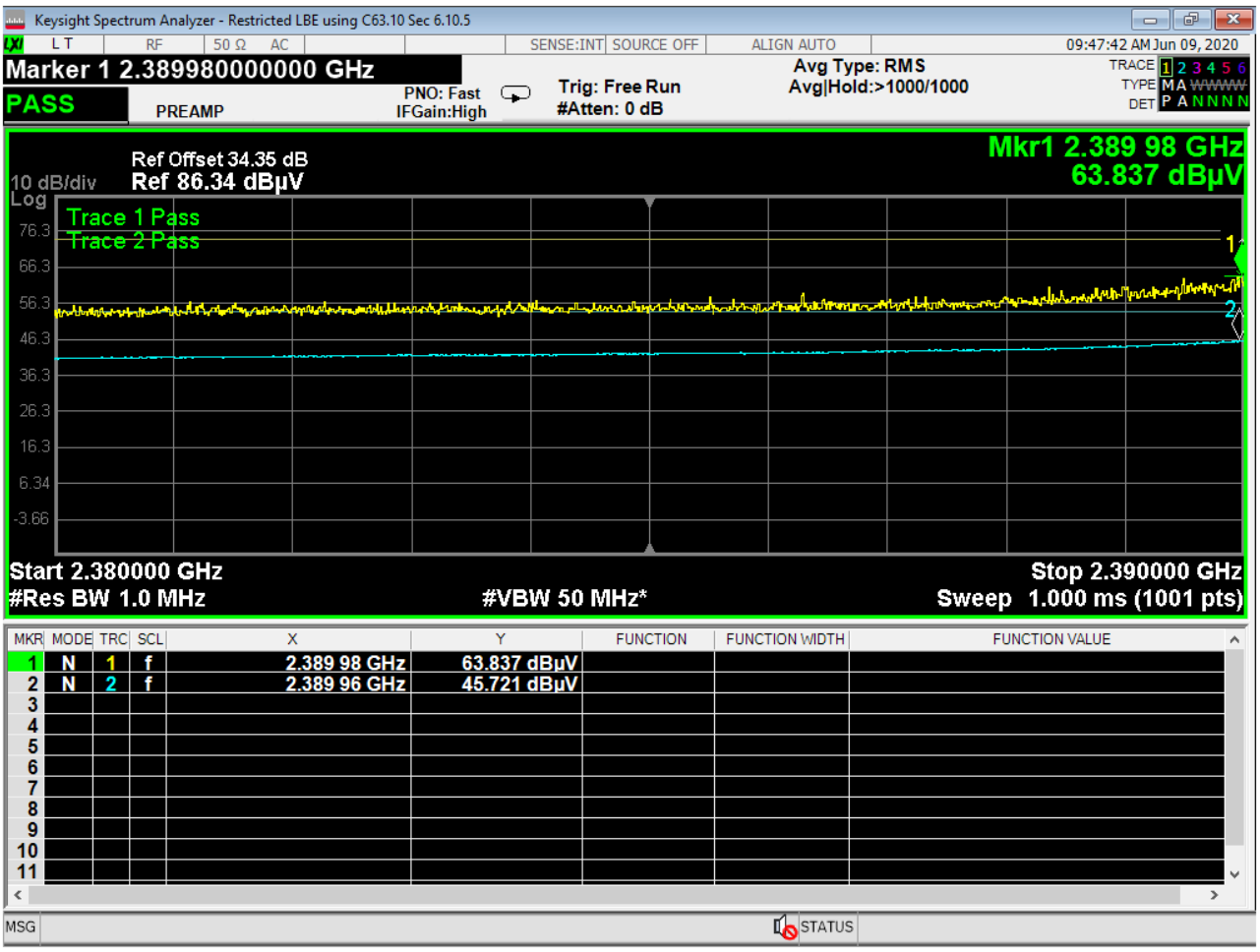


Figure 45 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak and Average

Peak and average trace are shown and compared to their respective limits. Reference offset has been added to account for transducer value of 28.389 dBuV/m @ 3m and cable loss of 5.96 dB.

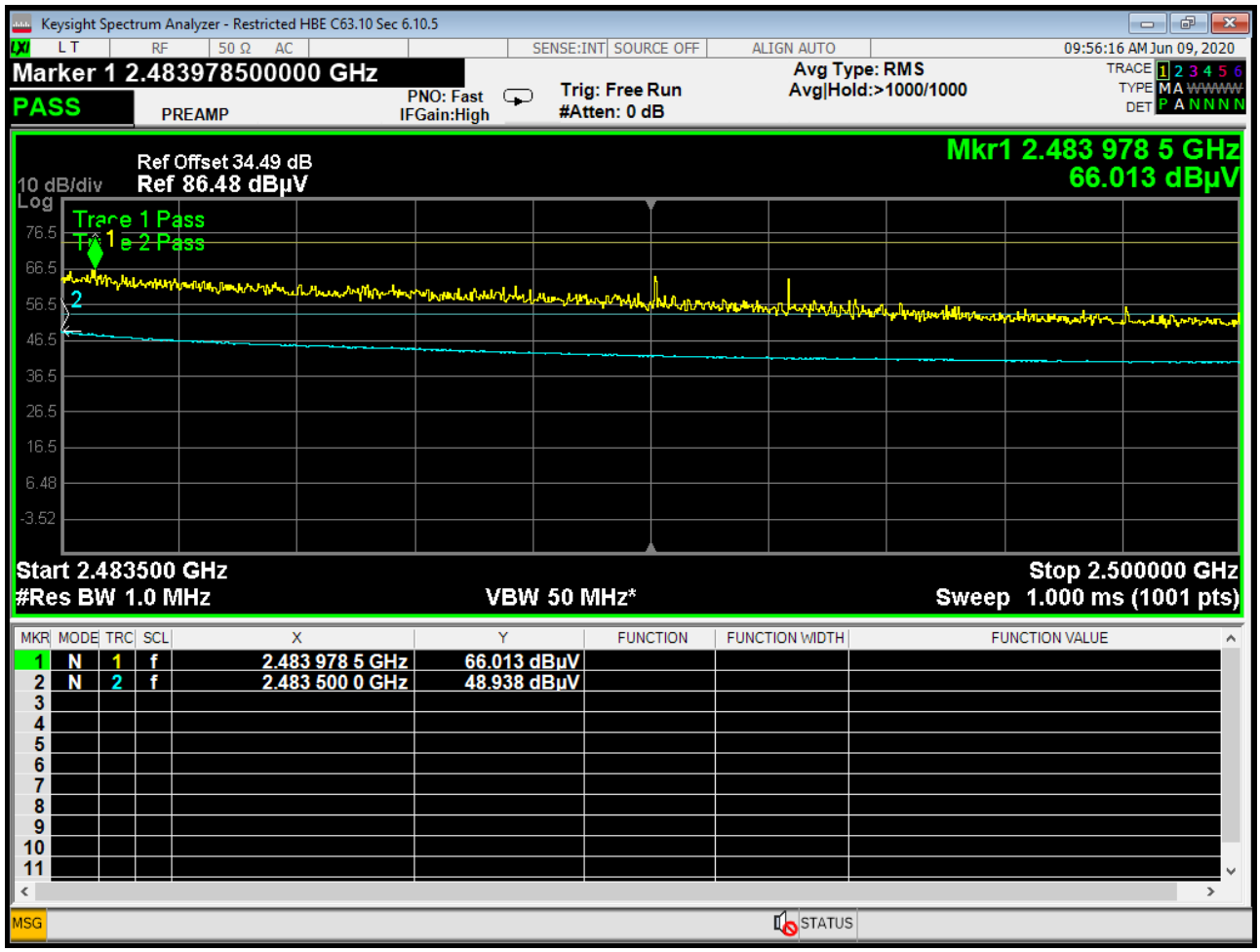


Figure 46 - Band-edge Measurement, High Channel, Restricted Frequency, Peak and Average

Peak and average trace are shown and compared to their respective limits. Reference offset has been added to account for transducer value of 28.45 dBuV/m @ 3m and cable loss of 6.04 dB.

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	2400.0 (Unrestricted, Peak)	-33.155	2.394	35.549	20	PASS
1	2400.0 (Unrestricted, Average)	-48.738	-7.982	40.756	20	PASS
11	2483.5 (Unrestricted, Peak)	-44.274	2.401	46.674	20	PASS
11	2483.5 (Unrestricted, Average)	-56.782	-7.707	49.076	20	PASS

CHANNEL	Band edge /Measurement Frequency (MHz)	Highest out of band level (dBuV/m)	Limit* (dBm)	Margin	Result
1	2340.0 (Restricted, Peak)	65.748	74.00	8.252	PASS
1	2340.0 (Restricted, Average)	45.391	54.00	8.609	PASS
11	2483.5 (Restricted, Peak)	65.910	74.00	8.090	PASS
11	2483.5 (Restricted, Average)	48.297	54.00	5.703	PASS

Margin= Limit-Level
*Limits from Part 15.209

Unrestricted band measurements were performed conducted while restricted band measurements were performed radiated.

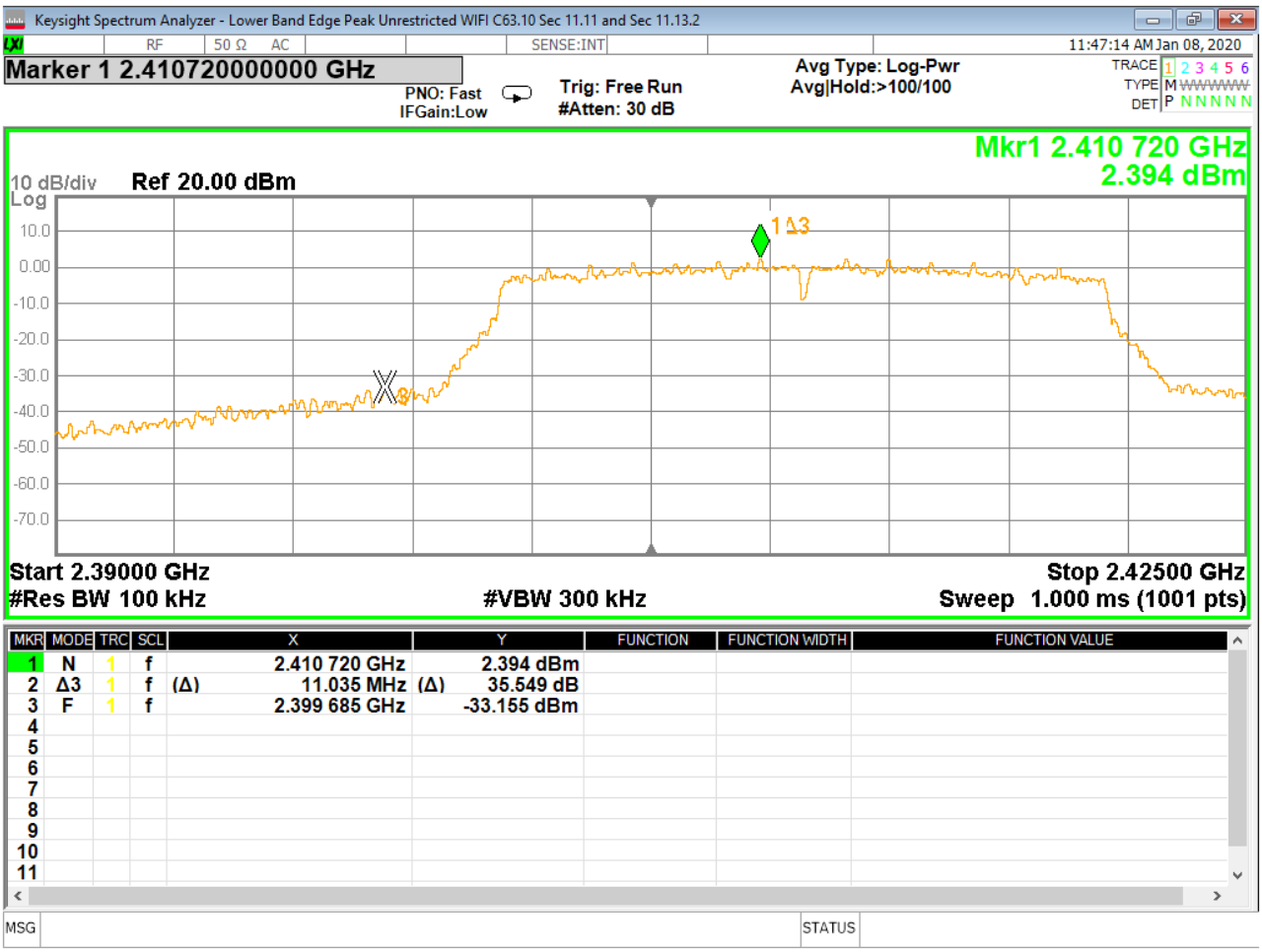


Figure 47 - Band-edge Measurement, Low Channel, Fundamental, Peak

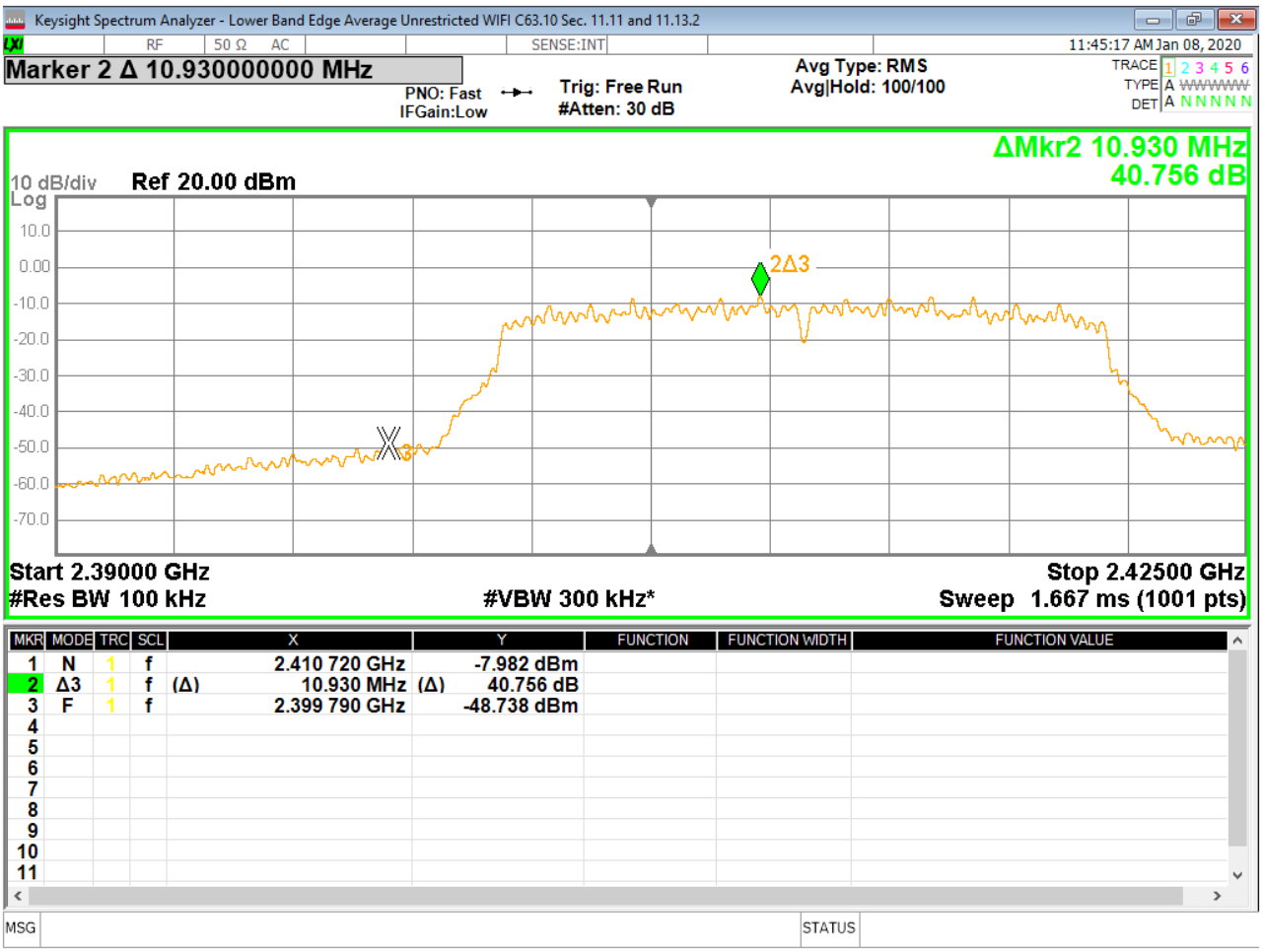


Figure 48 - Band-edge Measurement, Low Channel, Fundamental, Average

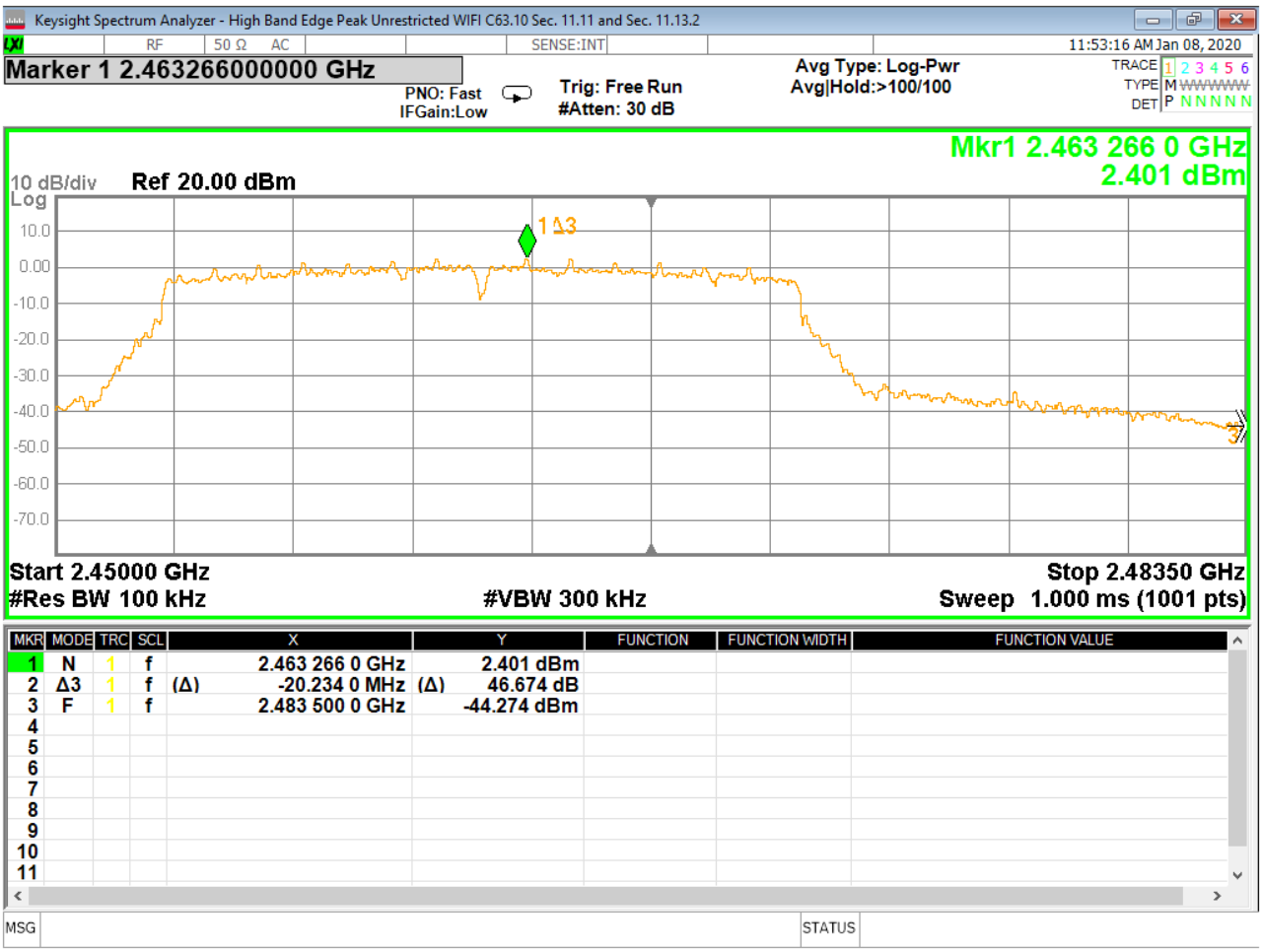


Figure 49 - Band-edge Measurement, High Channel, Fundamental, Peak

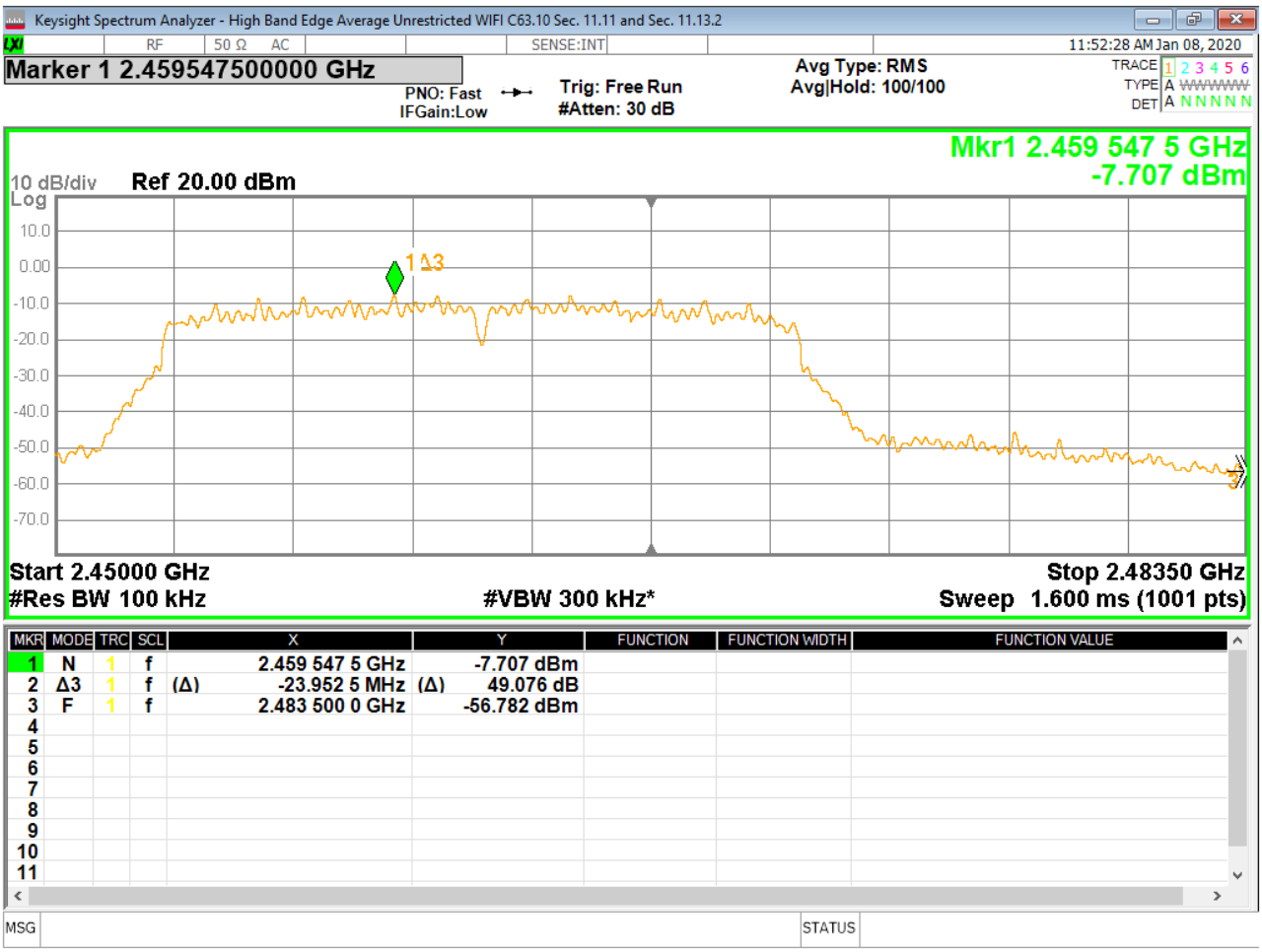


Figure 50 - Band-edge Measurement, High Channel, Fundamental, Average

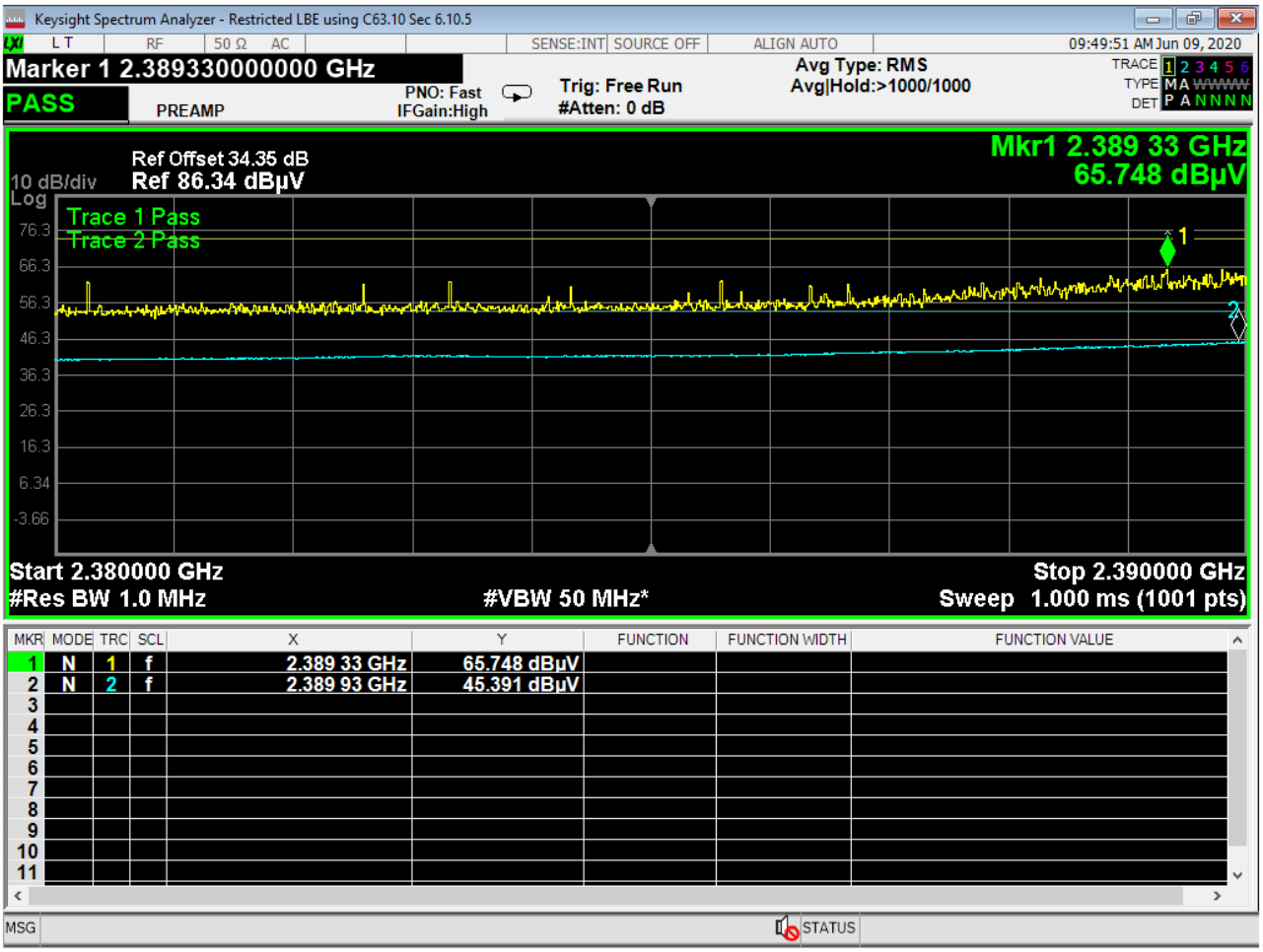


Figure 51 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak and Average

Peak and average trace are shown and compared to their respective limits. Reference offset has been added to account for transducer value of 28.389 dBuV/m @ 3m and cable loss of 5.96 dB.

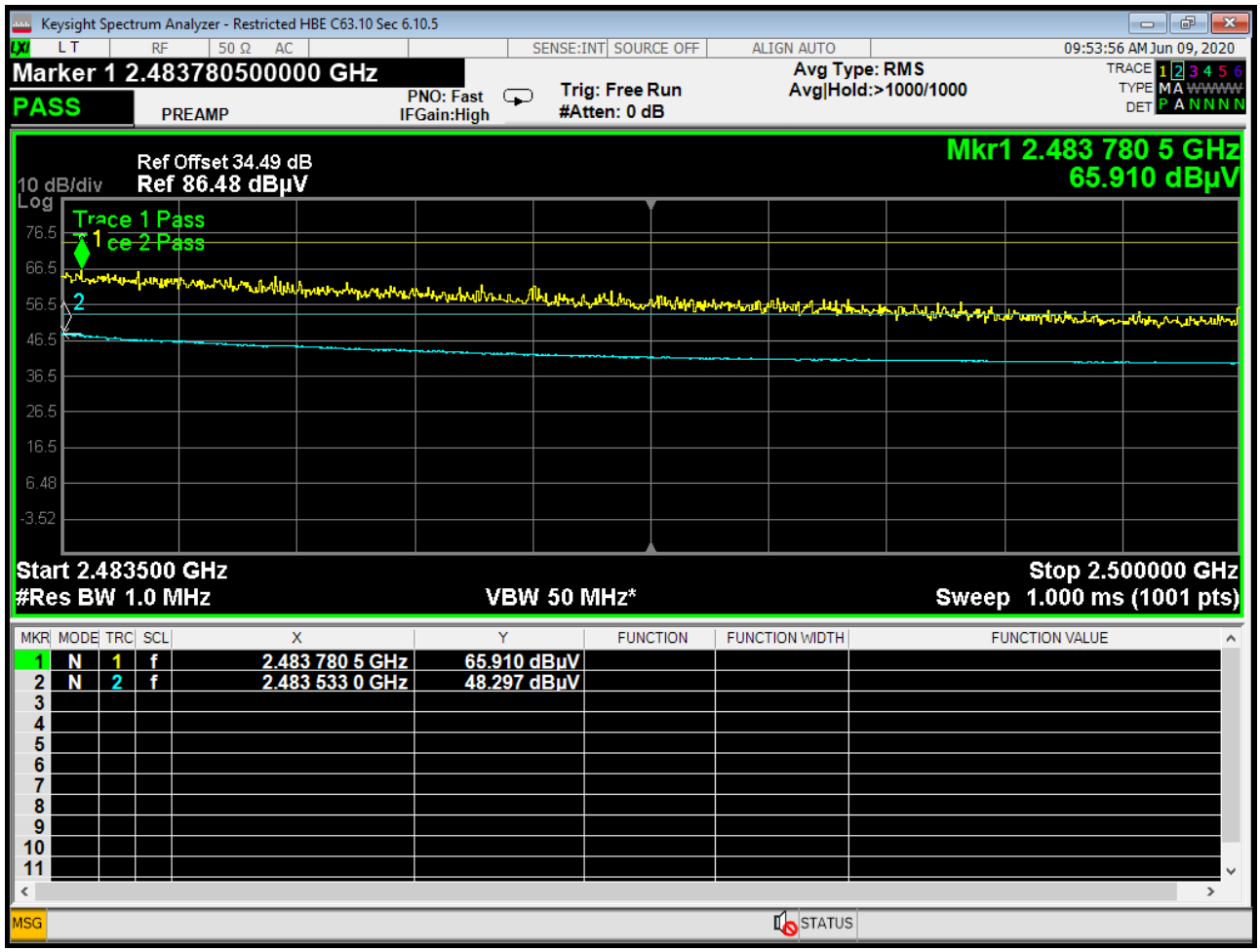


Figure 52 - Band-edge Measurement, High Channel, Restricted Frequency, Peak and Average

Peak and average trace are shown and compared to their respective limits. Reference offset has been added to account for transducer value of 28.45 dBuV/m @ 3m and cable loss of 6.04 dB.

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 connected to the spectrum analyzer directly with a low-loss shielded coaxial cable.

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:
The EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable on a bench top.

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 PSD(dBm)	Method	Limit (dBm)	RESULT
Low	2412	802.11b	-3.446	Conducted	8.00	PASS
Middle	2437	802.11b	-3.957	Conducted	8.00	PASS
High	2462	802.11b	-5.001	Conducted	8.00	PASS
Low	2412	802.11g	-10.917	Conducted	8.00	PASS
Middle	2437	802.11g	-5.766	Conducted	8.00	PASS
High	2462	802.11g	-10.469	Conducted	8.00	PASS
Low	2412	802.11n	-11.853	Conducted	8.00	PASS
Middle	2437	802.11n	-9.233	Conducted	8.00	PASS
High	2462	802.11n	-12.871	Conducted	8.00	PASS

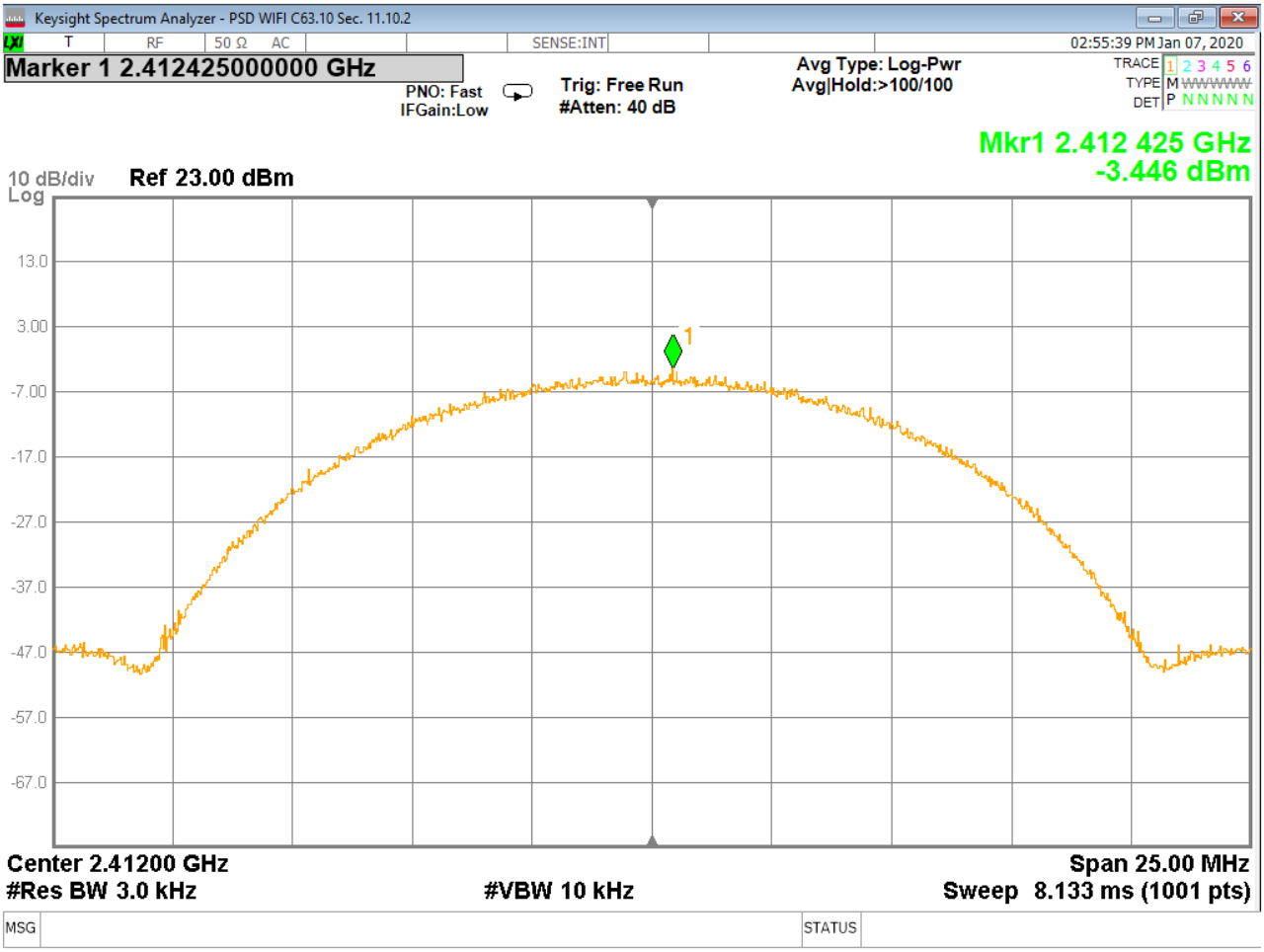


Figure 53 - Power Spectral Density, Low Channel, 802.11b

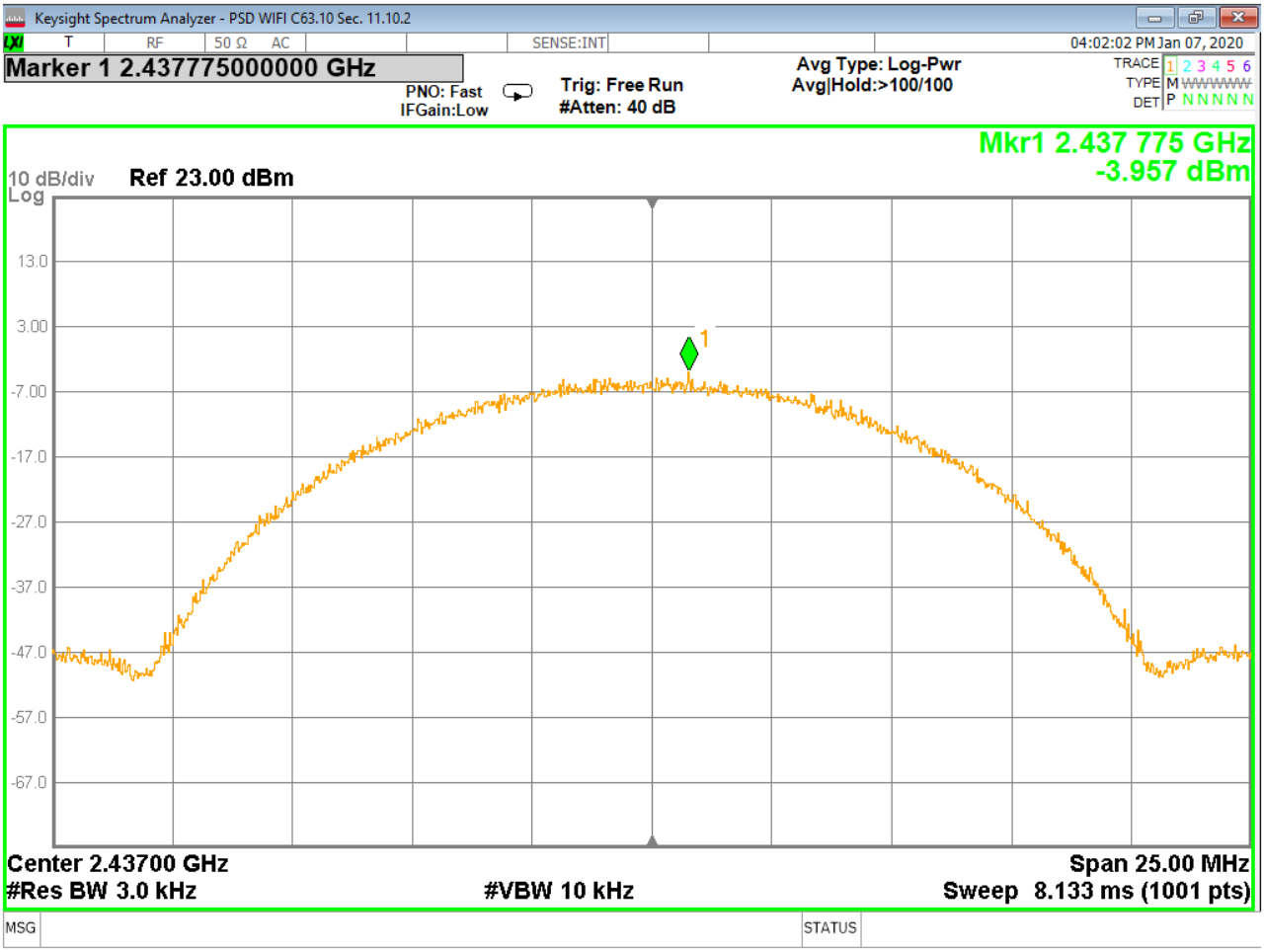


Figure 54 - Power Spectral Density, Mid Channel, 802.11b

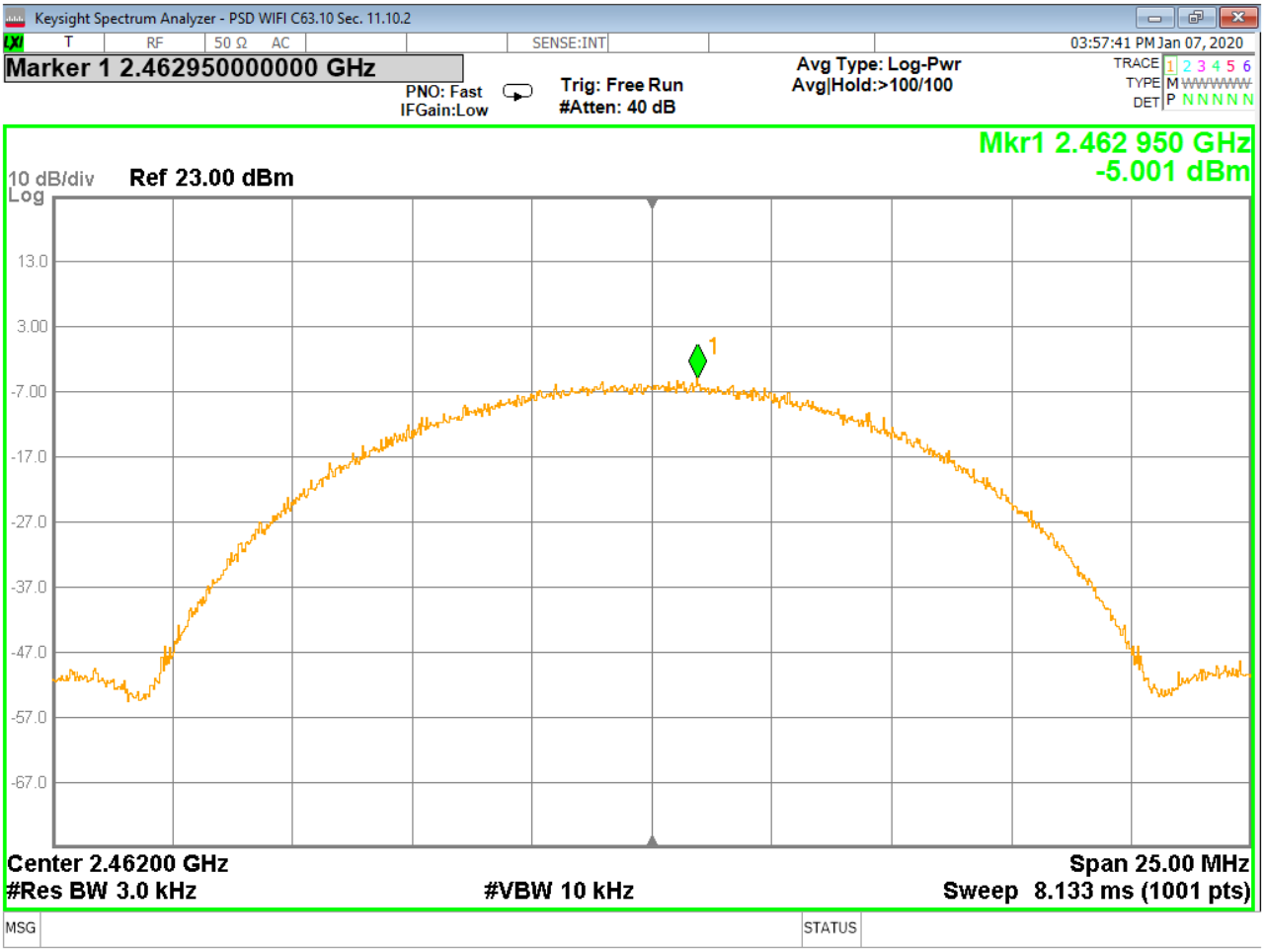


Figure 55 - Power Spectral Density, High Channel, 802.11b

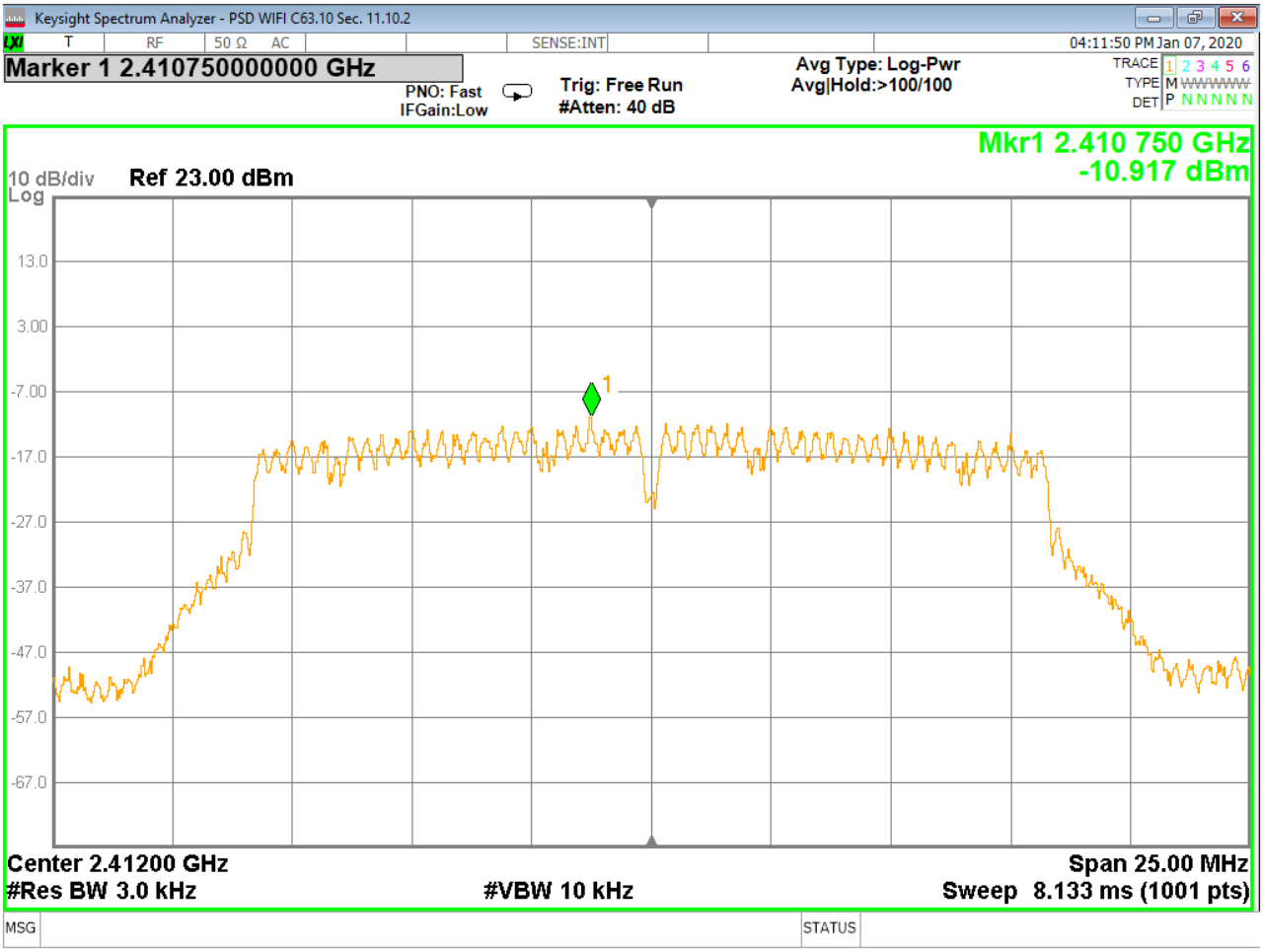


Figure 56 - Power Spectral Density, Low Channel, 802.11g

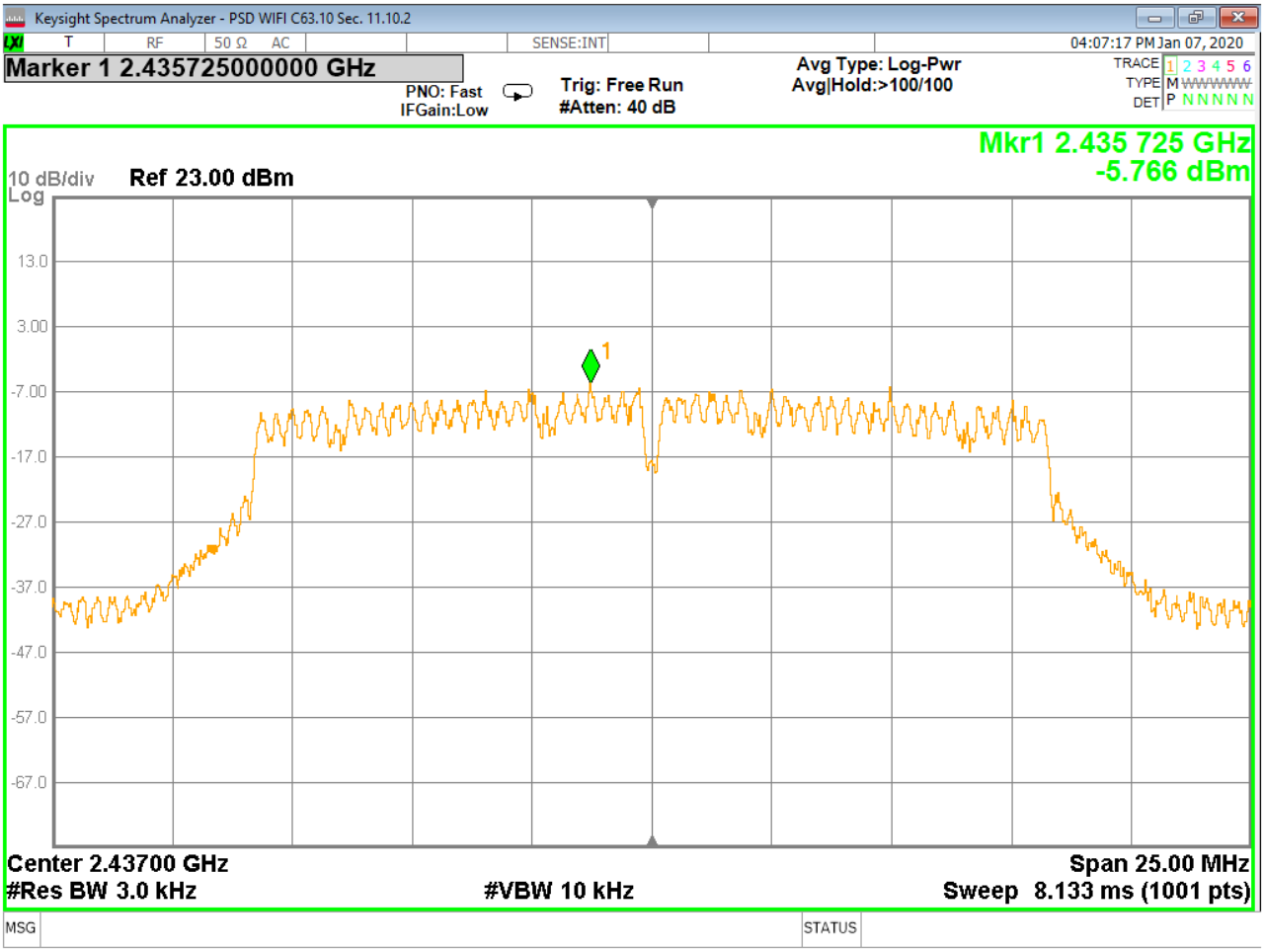


Figure 57 - Power Spectral Density, Mid Channel, 802.11g

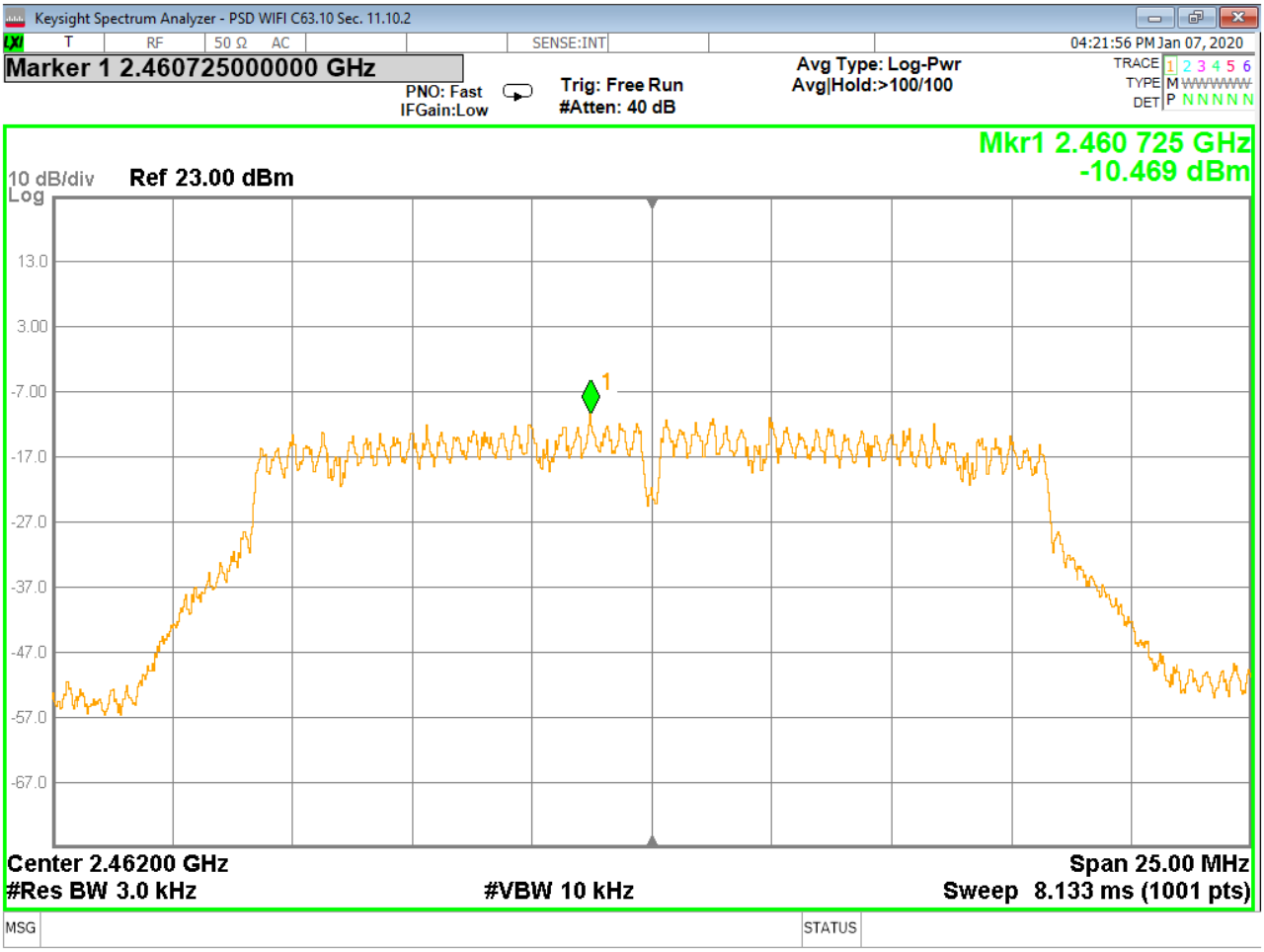


Figure 58 - Power Spectral Density, High Channel, 802.11g

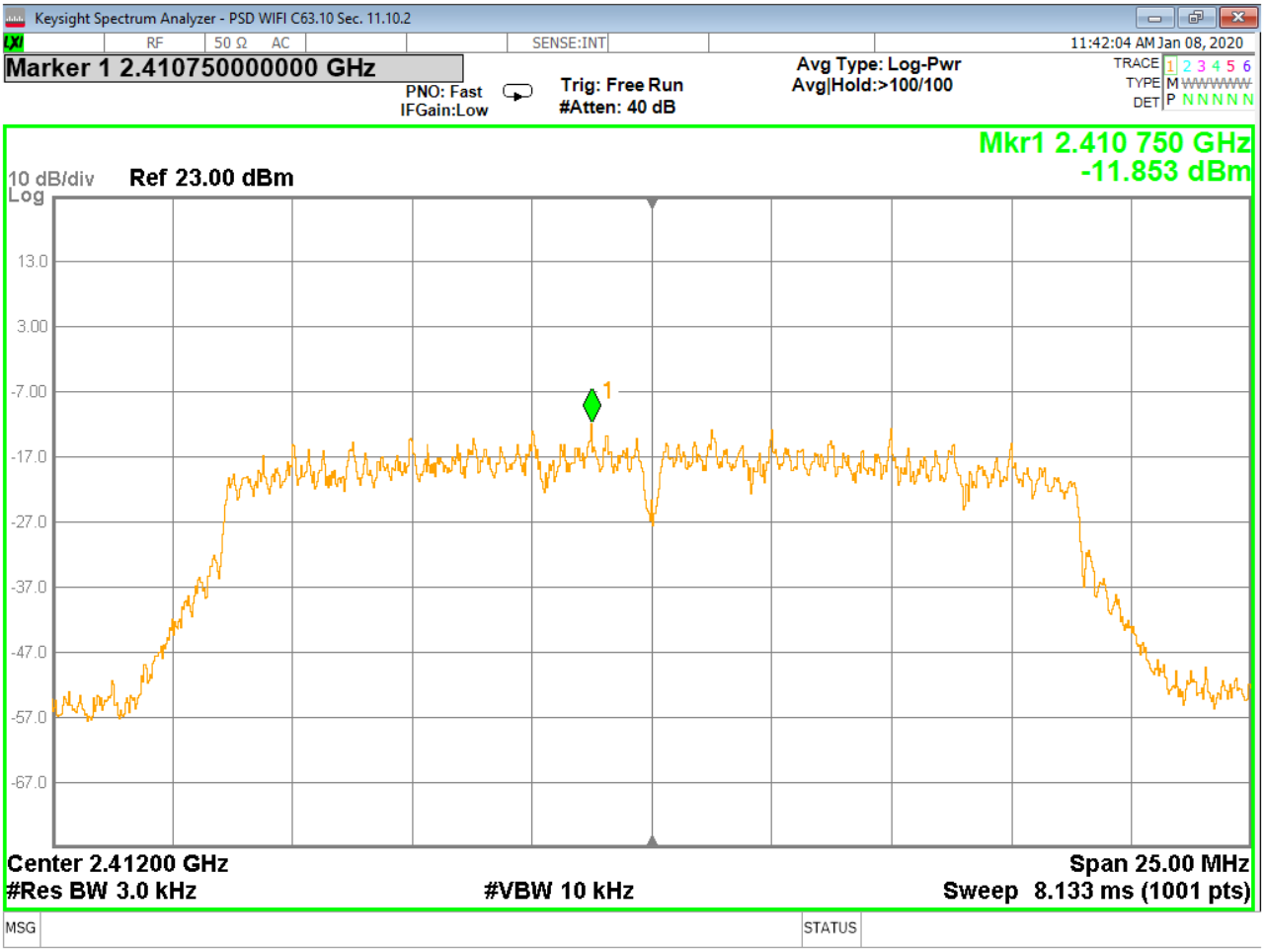


Figure 59 - Power Spectral Density, Low Channel, 802.11n

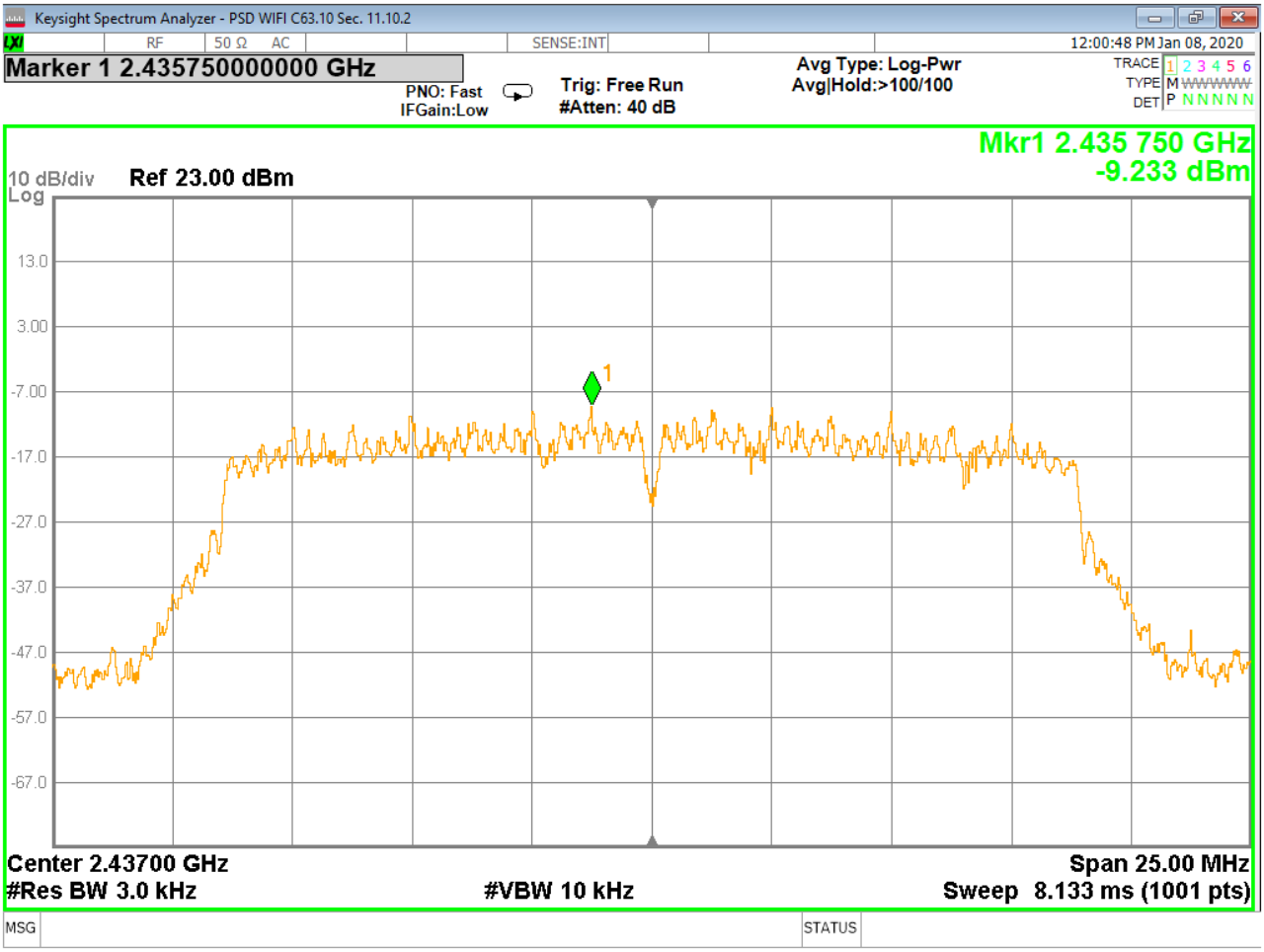


Figure 60 - Power Spectral Density, Mid Channel, 802.11n

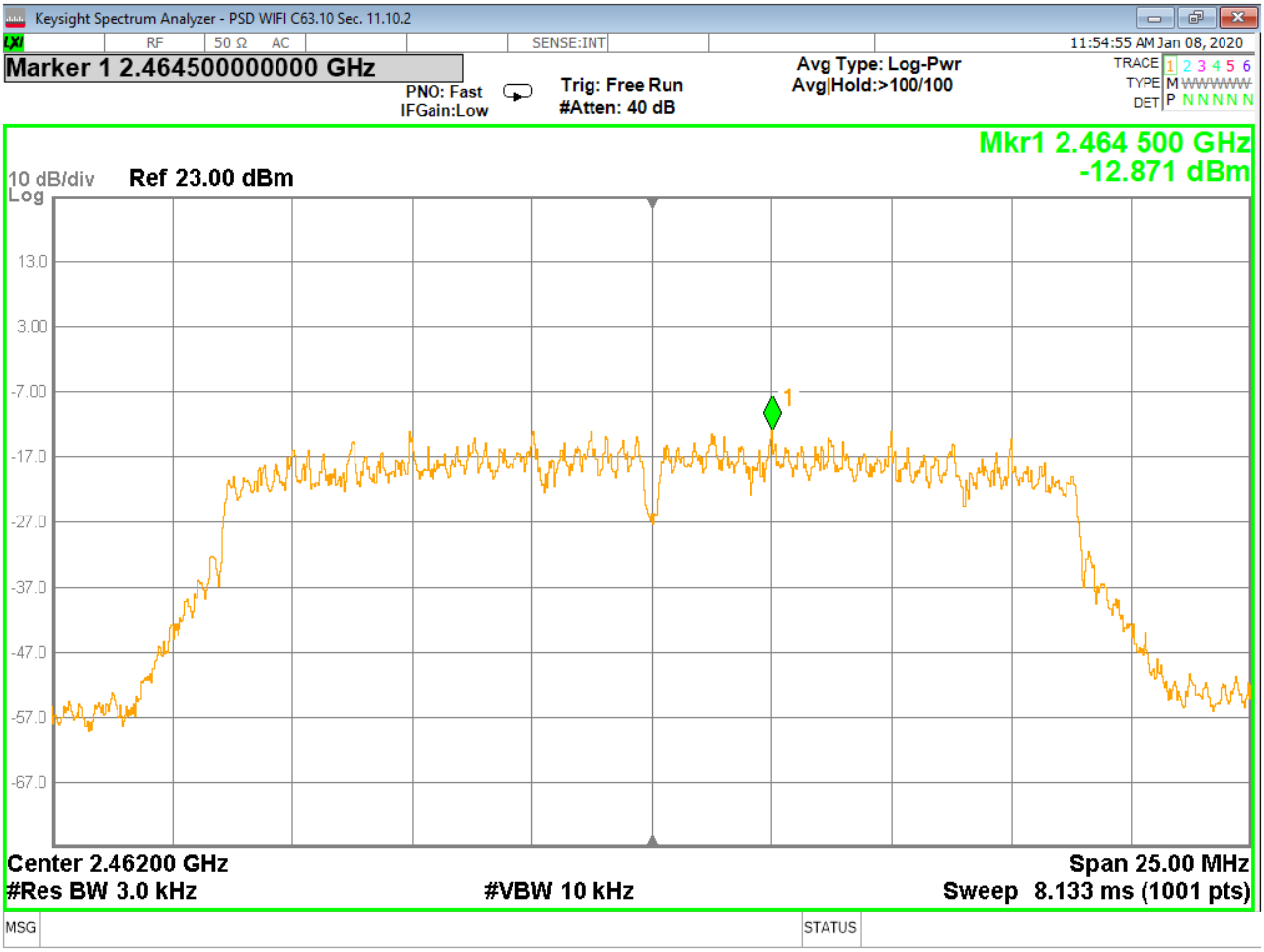


Figure 61 - Power Spectral Density, High Channel, 802.11n

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	66 to 56	56 to 46
0.5-5	56	46
5-30	60	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.

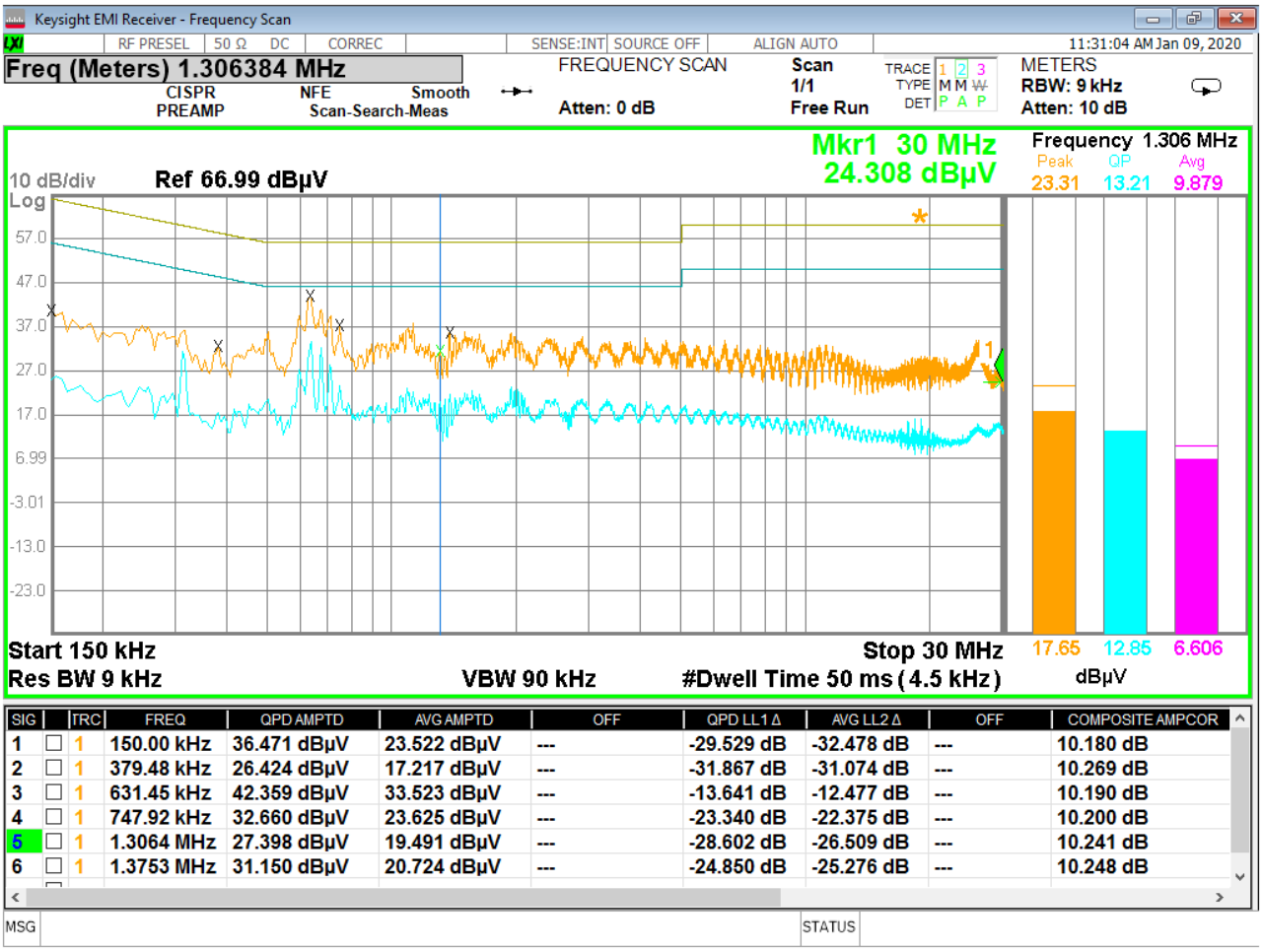
Test Procedures:

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

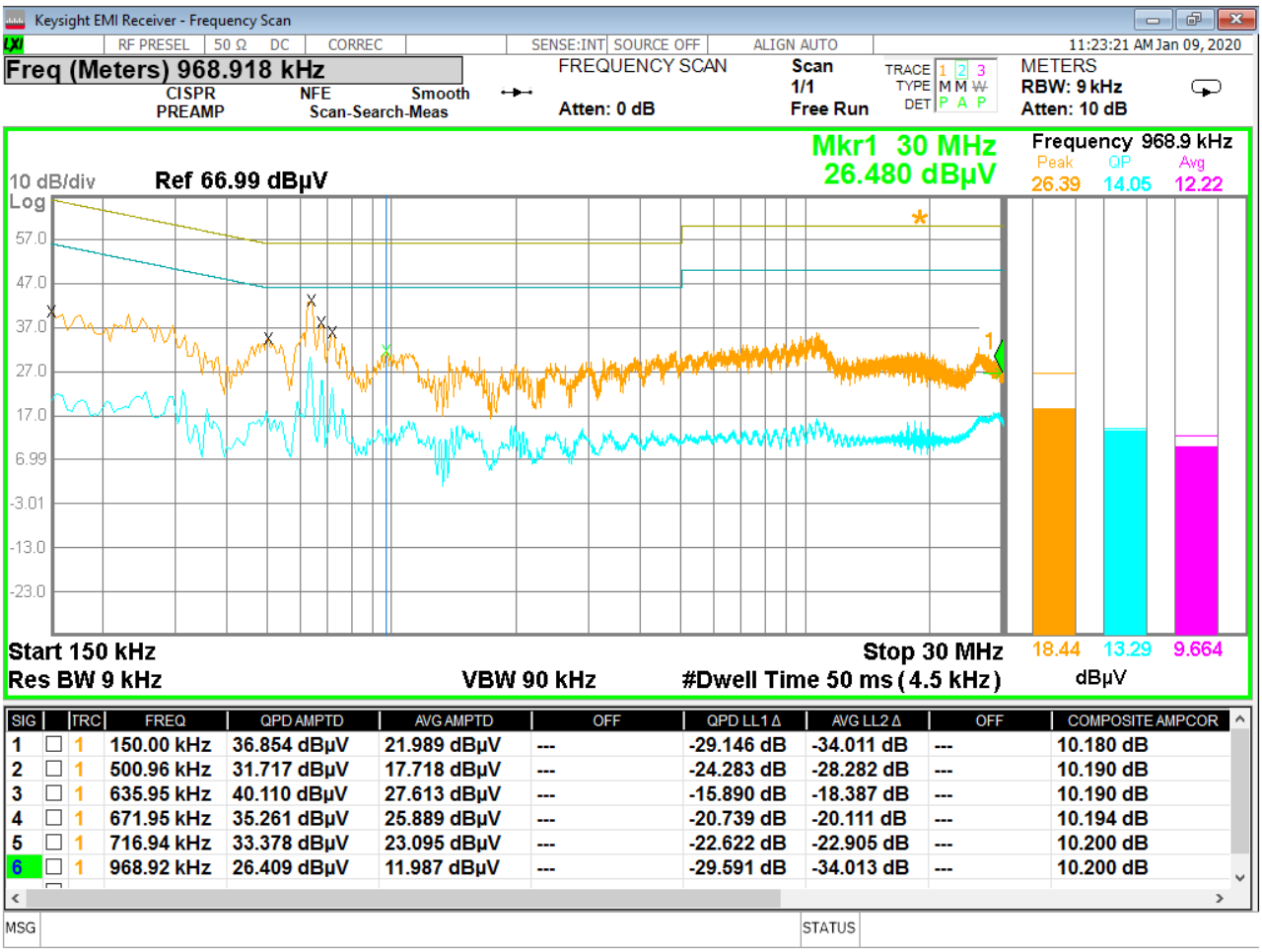
EUT operating conditions:
The EUT was powered by 5 VDC unless specified and set to transmit continuously on the middle channel.

Test Results:



SIG		TRC	FREQ	QPD AMPTD	AVG AMPTD	OFF	QPD LL1 Δ	AVG LL2 Δ	OFF	COMPOSITE AMPCOR
1	☐	1	150.00 kHz	36.471 dBµV	23.522 dBµV	---	-29.529 dB	-32.478 dB	---	10.180 dB
2	☐	1	379.48 kHz	26.424 dBµV	17.217 dBµV	---	-31.867 dB	-31.074 dB	---	10.269 dB
3	☐	1	631.45 kHz	42.359 dBµV	33.523 dBµV	---	-13.641 dB	-12.477 dB	---	10.190 dB
4	☐	1	747.92 kHz	32.660 dBµV	23.625 dBµV	---	-23.340 dB	-22.375 dB	---	10.200 dB
5	☐	1	1.3064 MHz	27.398 dBµV	19.491 dBµV	---	-28.602 dB	-26.509 dB	---	10.241 dB
6	☐	1	1.3753 MHz	31.150 dBµV	20.724 dBµV	---	-24.850 dB	-25.276 dB	---	10.248 dB

Figure 62 - Conducted Emissions Plot, Line



SIG		TRC	FREQ	QPD AMPTD	AVG AMPTD	OFF	QPD LL1 Δ	AVG LL2 Δ	OFF	COMPOSITE AMPCOR
1	☐	1	150.00 kHz	36.854 dBµV	21.989 dBµV	---	-29.146 dB	-34.011 dB	---	10.180 dB
2	☐	1	500.96 kHz	31.717 dBµV	17.718 dBµV	---	-24.283 dB	-28.282 dB	---	10.190 dB
3	☐	1	635.95 kHz	40.110 dBµV	27.613 dBµV	---	-15.890 dB	-18.387 dB	---	10.190 dB
4	☐	1	671.95 kHz	35.261 dBµV	25.889 dBµV	---	-20.739 dB	-20.111 dB	---	10.194 dB
5	☐	1	716.94 kHz	33.378 dBµV	23.095 dBµV	---	-22.622 dB	-22.905 dB	---	10.200 dB
6	☐	1	968.92 kHz	26.409 dBµV	11.987 dBµV	---	-29.591 dB	-34.013 dB	---	10.200 dB

. Figure 63 - Conducted Emissions Plot, Neutral

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