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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:**

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

**DATE:** 16 June 2020

**Total Pages:** 88



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TESTING LABORATORY
CERTIFICATE NO. 1953.01

## REVISION PAGE

| Rev. No. | Date | Description |
|---|---|---|
| 0 | 28 February 2020 | Original – NJohnson<br>Prepared by CFarrington |
| A | 8 June 2020 | Updated average power measurements.<br>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. |

## CONTENTS

## 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<br>RSS Gen, Issue 4, Section 6.10 | Duty Cycle | Pass |
| FCC Part 15.247(a)(1)<br>RSS-247 Issue 2 Section 5.2 | Peak output power | Pass |
| FCC Part 15.247(a)(1)<br>RSS-247 Issue 2 Section 5.2 | Bandwidth | Pass |
| FCC Part 15.209<br>RSS-Gen Issue 4, Section 7.1 | Receiver Radiated Emissions | Pass |
| FCC Part 15.209 (restricted bands), 15.247 (unrestricted)<br>RSS-247 Issue 2 Section 5.5, RSS-Gen Issue 4, Section 8.9 | Transmitter Radiated Emissions | Pass |
| FCC Part 15.247(a)(1)<br>RSS-247 Issue 2 Section 5.2 | Power Spectral Density | Pass |
| FCC Part 15.209, 15.247(d)<br>RSS-247 Issue 2 Section 11.13 | Band Edge Measurement | Pass |
| FCC Part 15.207<br>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);<br>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<br>(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:**

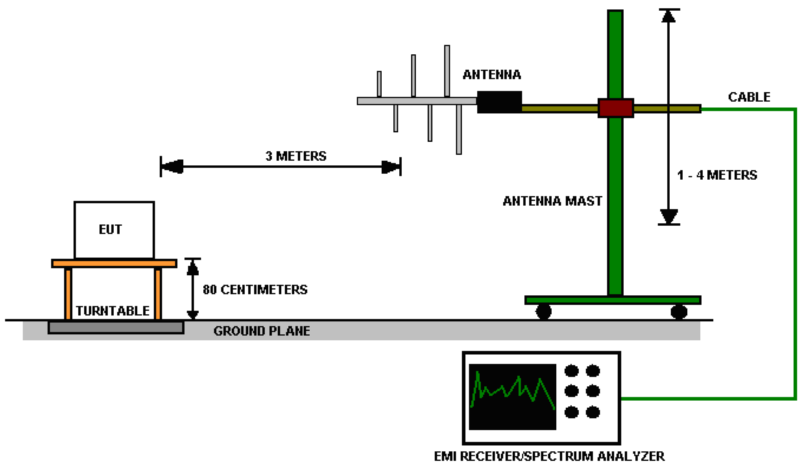



Figure 1 - Radiated Emissions Test Setup

**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:**

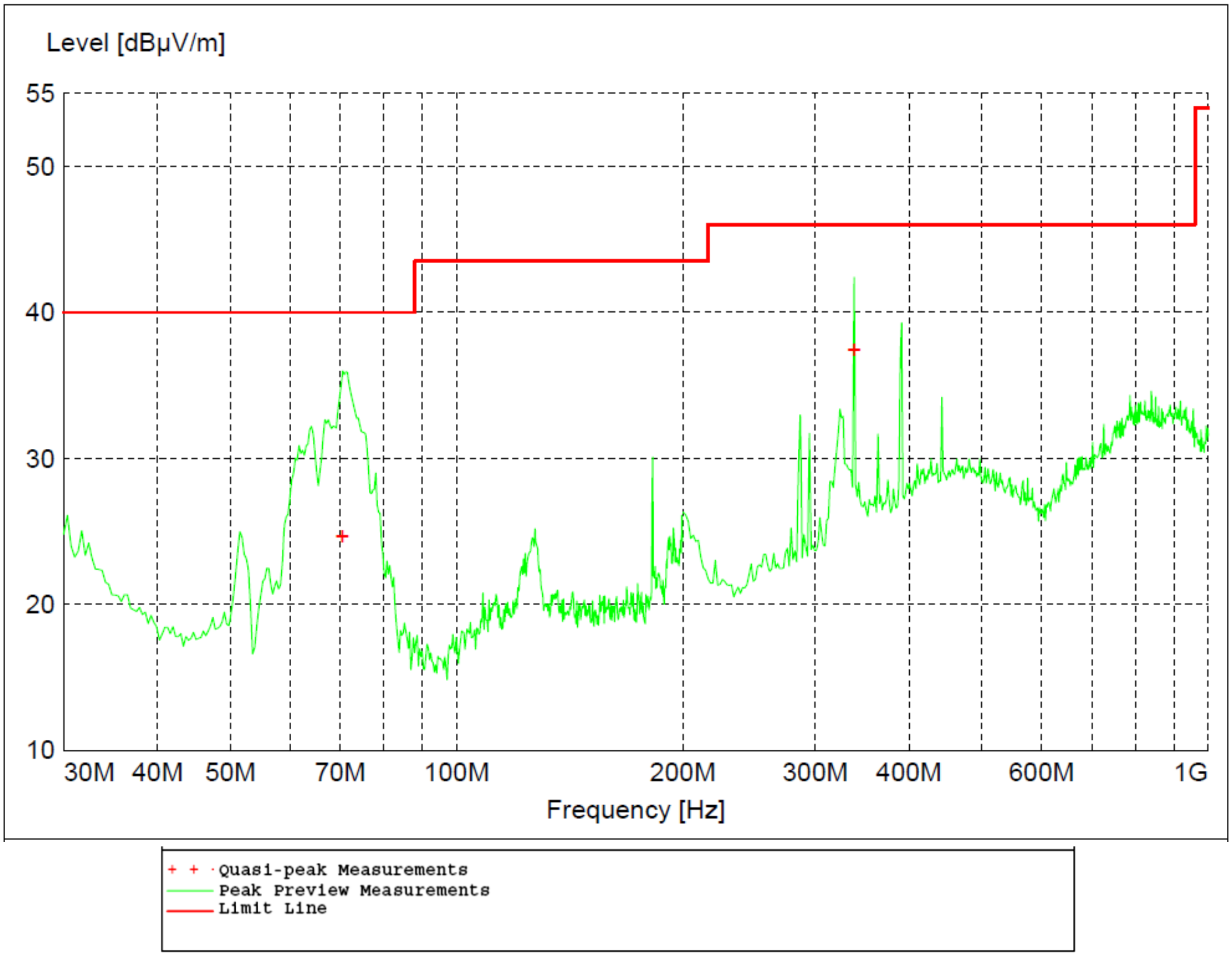



Figure 2 - Radiated Emissions Plot, Receive

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 |

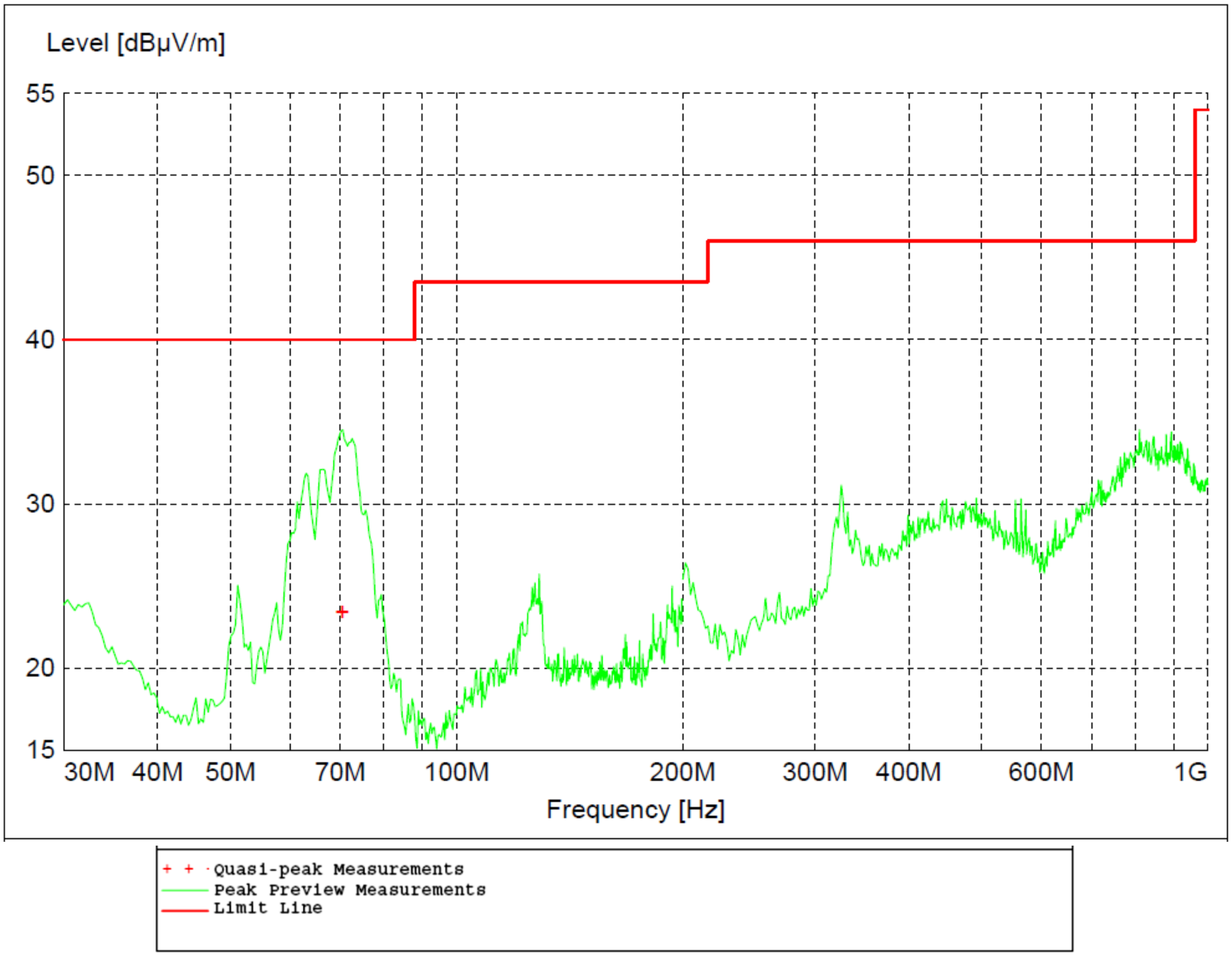



Figure 3 - Radiated Emissions Plot, 802.11b

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.

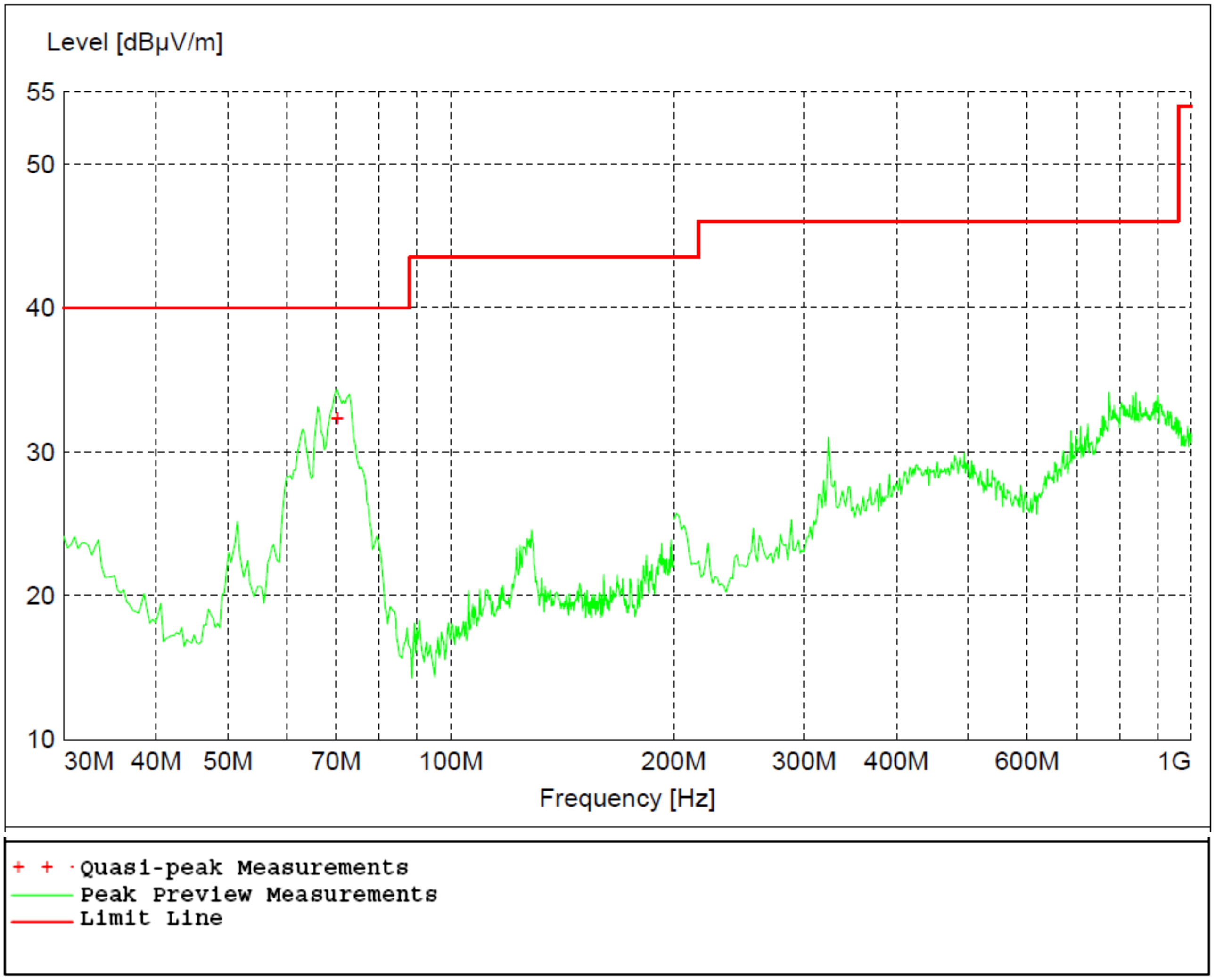



Figure 4 - Radiated Emissions Plot, 802.11g

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.

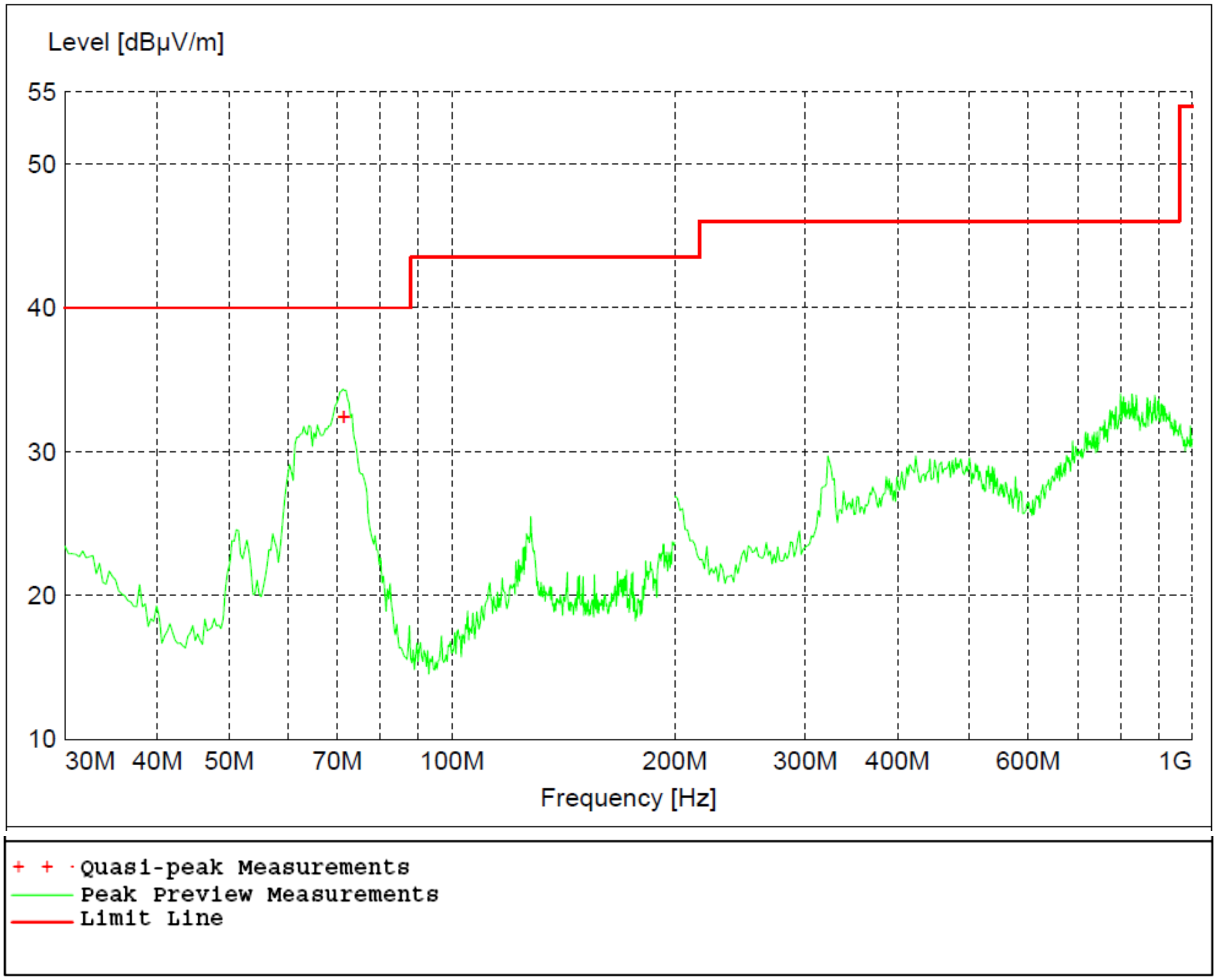



Figure 5 - Radiated Emissions Plot, 802.11n

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:**

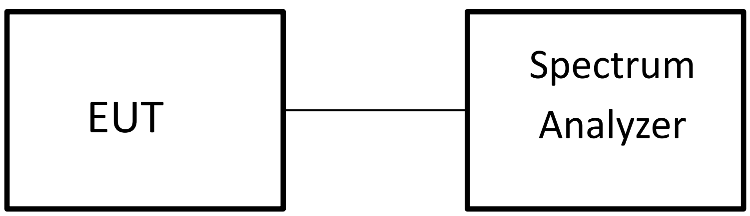



Figure 6 – Peak Output Power Measurements Test Setup

**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 |

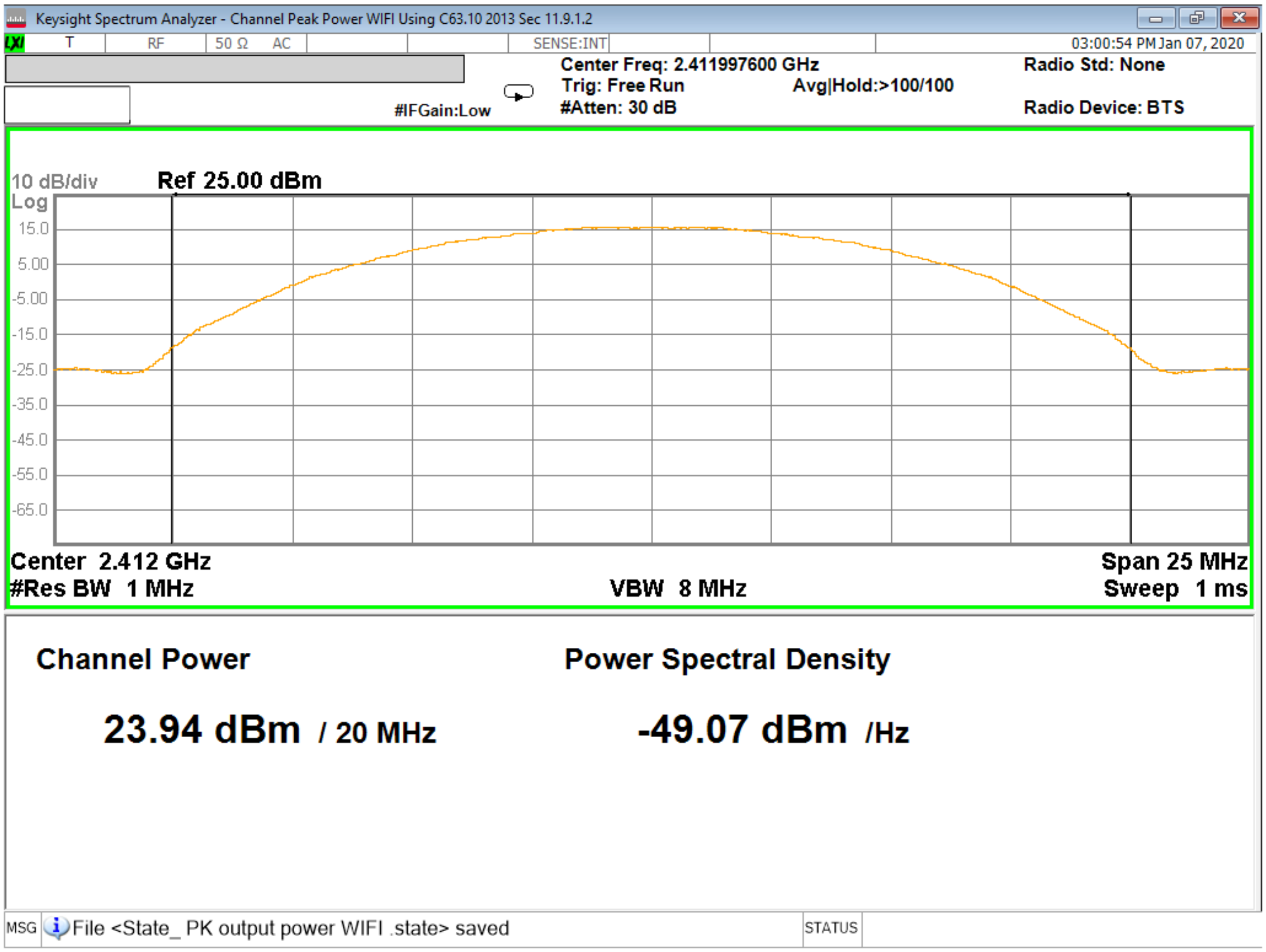



Figure 7 – Peak Output Power, Low Channel, 802.11b

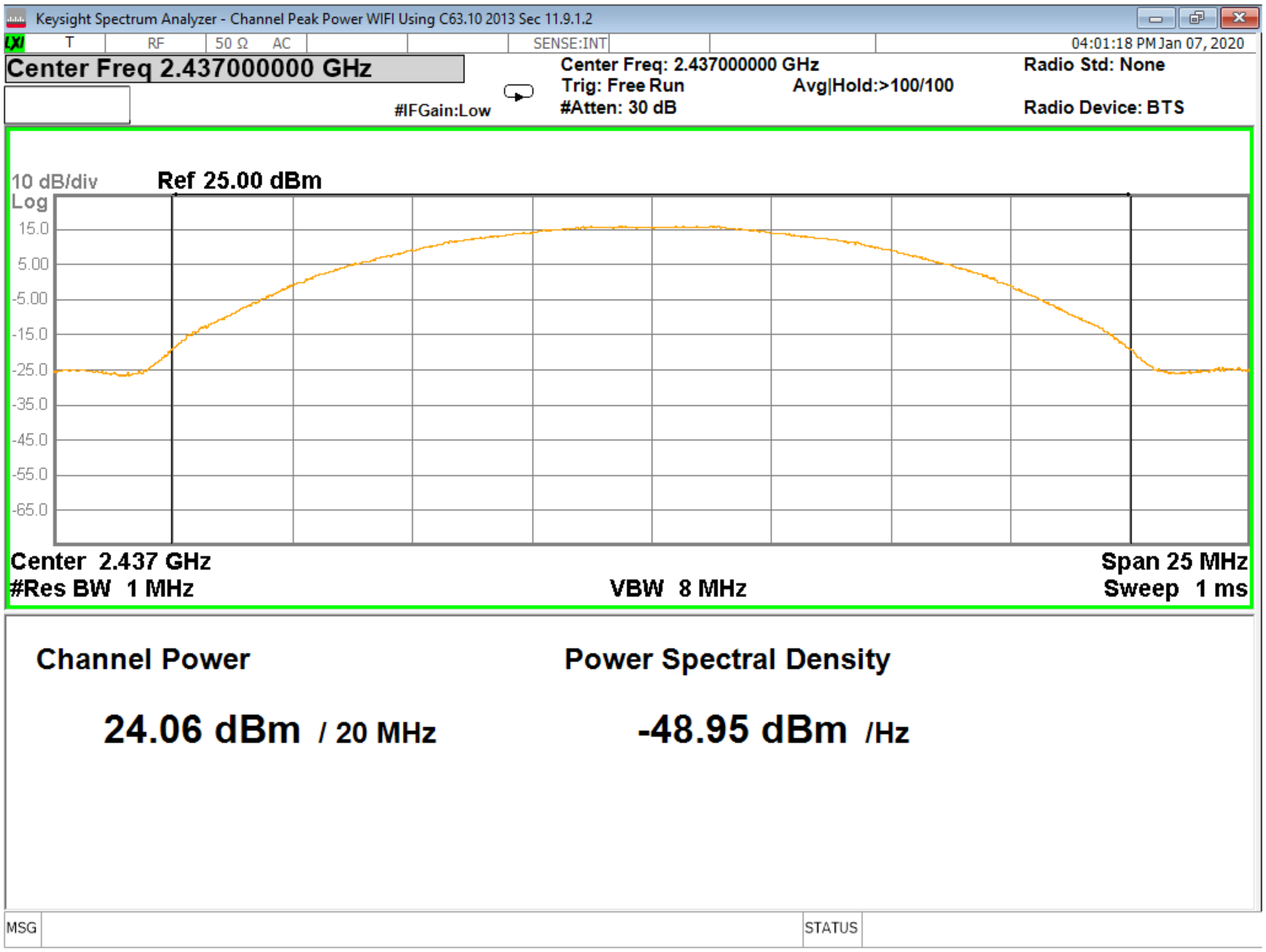



**Figure 8 – Peak Output Power, Mid Channel, 802.11b**

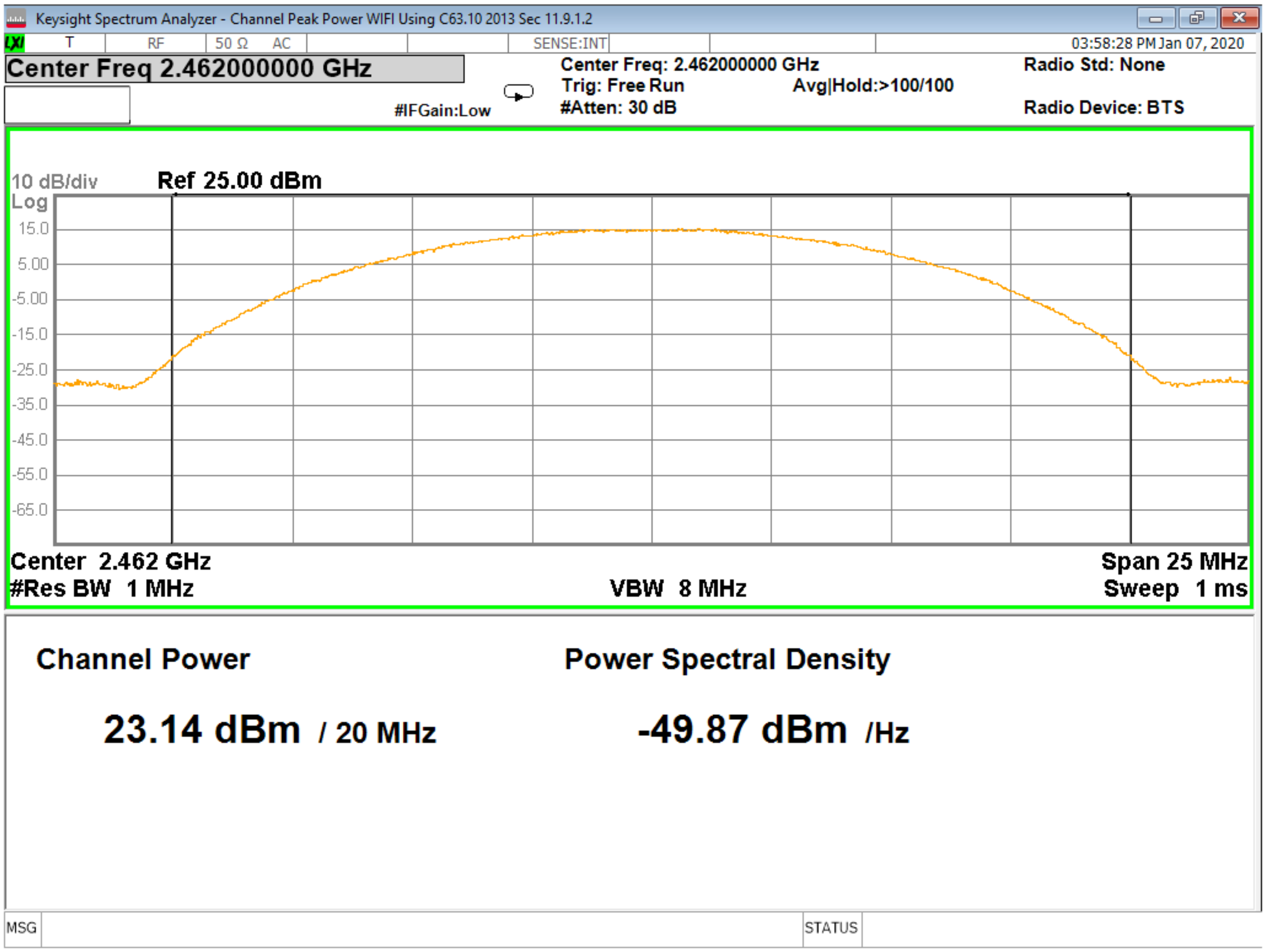



**Figure 9 – Peak Output Power, High Channel, 802.11b**

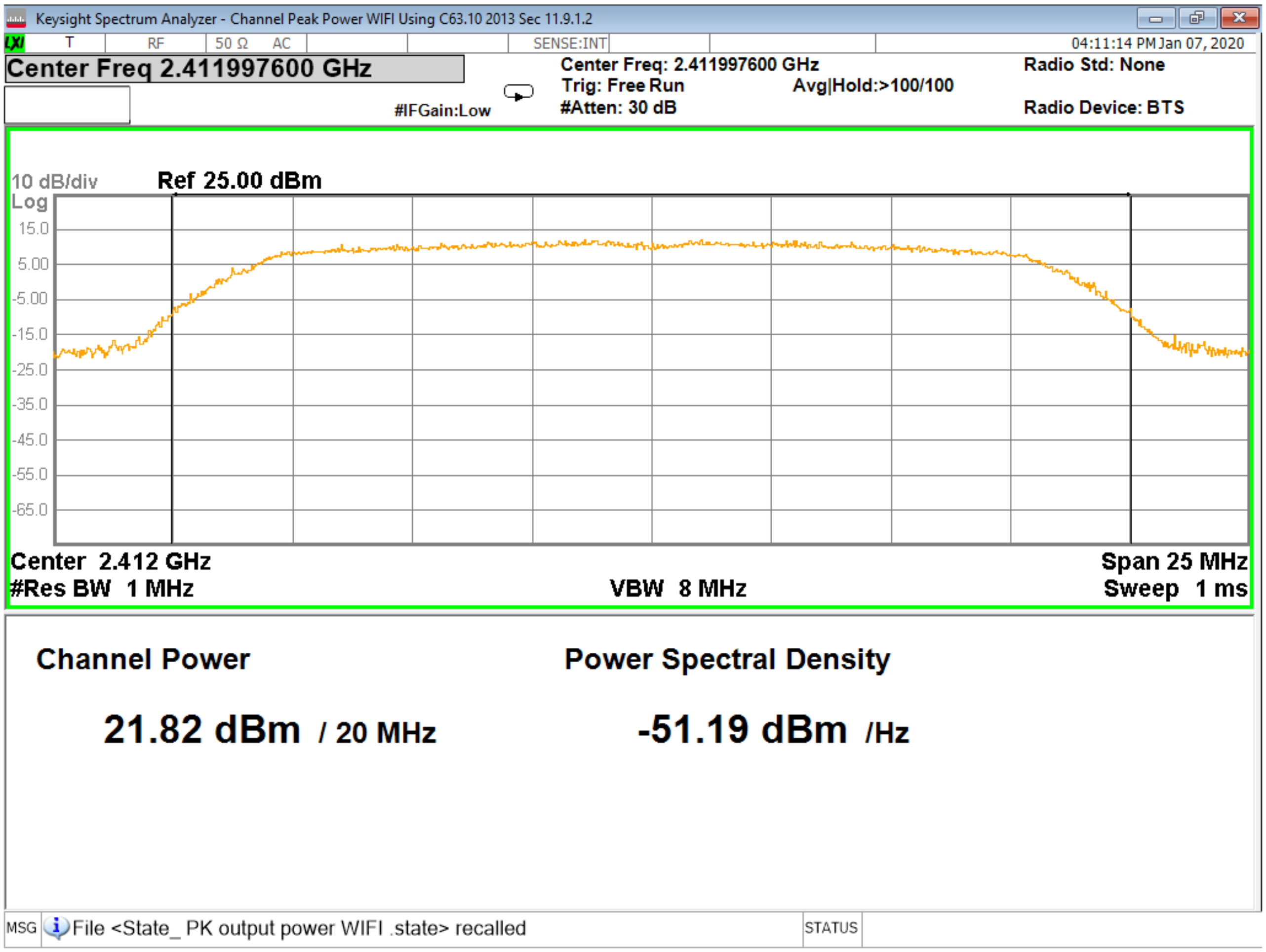



Figure 10 – Peak Output Power, Low Channel, 802.11g

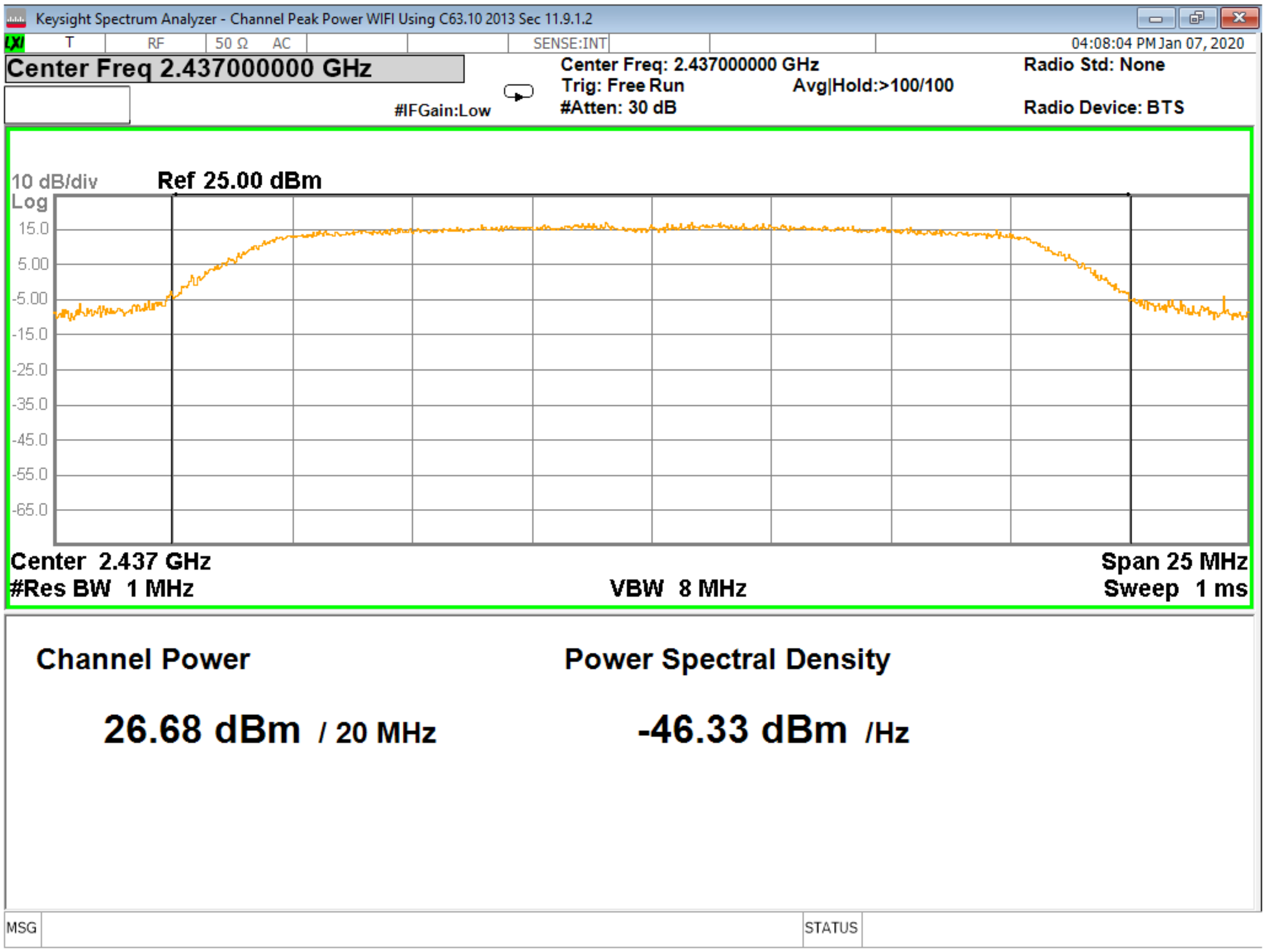



**Figure 11 – Peak Output Power, Mid Channel, 802.11g**

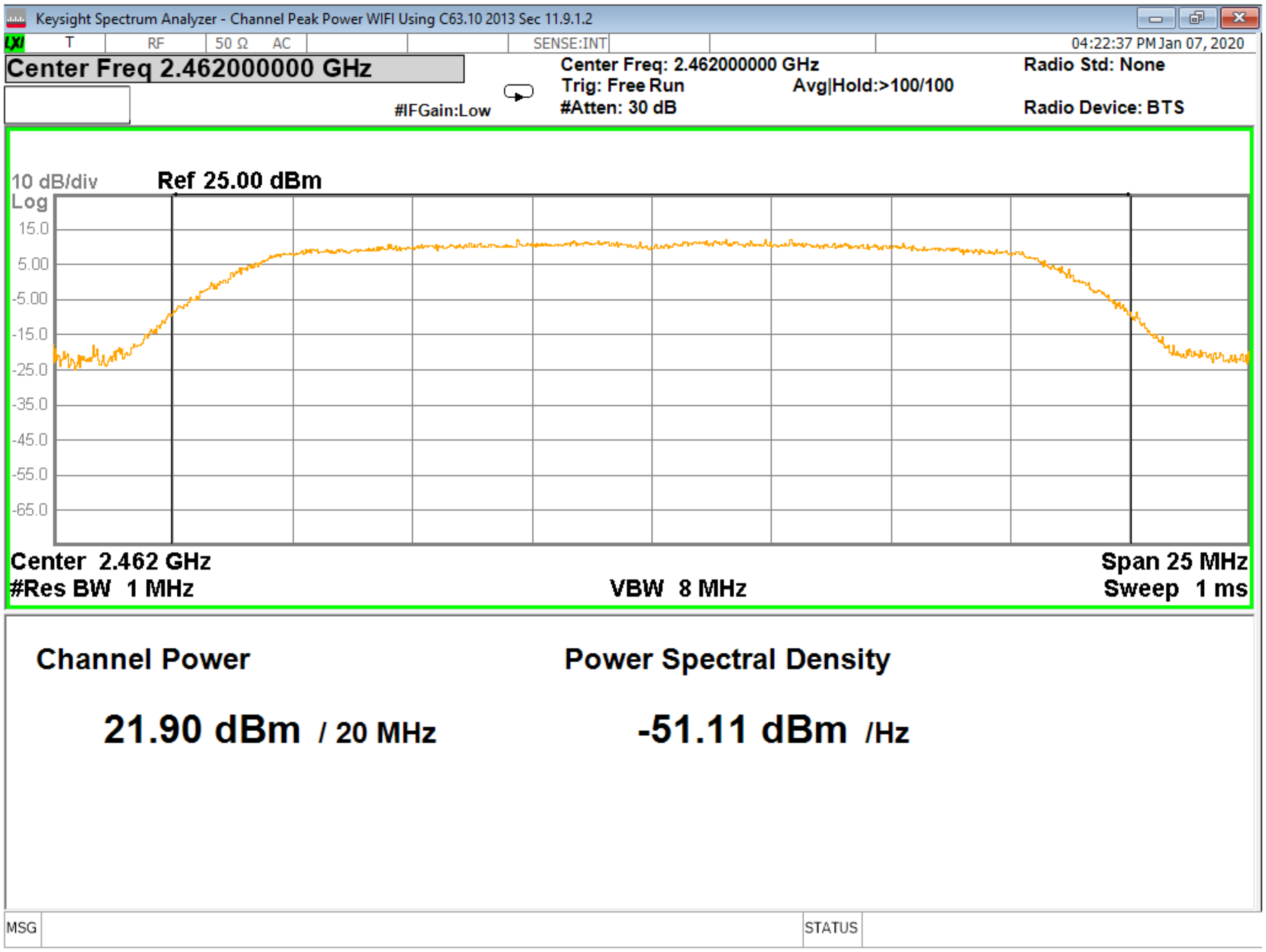



**Figure 12 – Peak Output Power, High Channel, 802.11g**

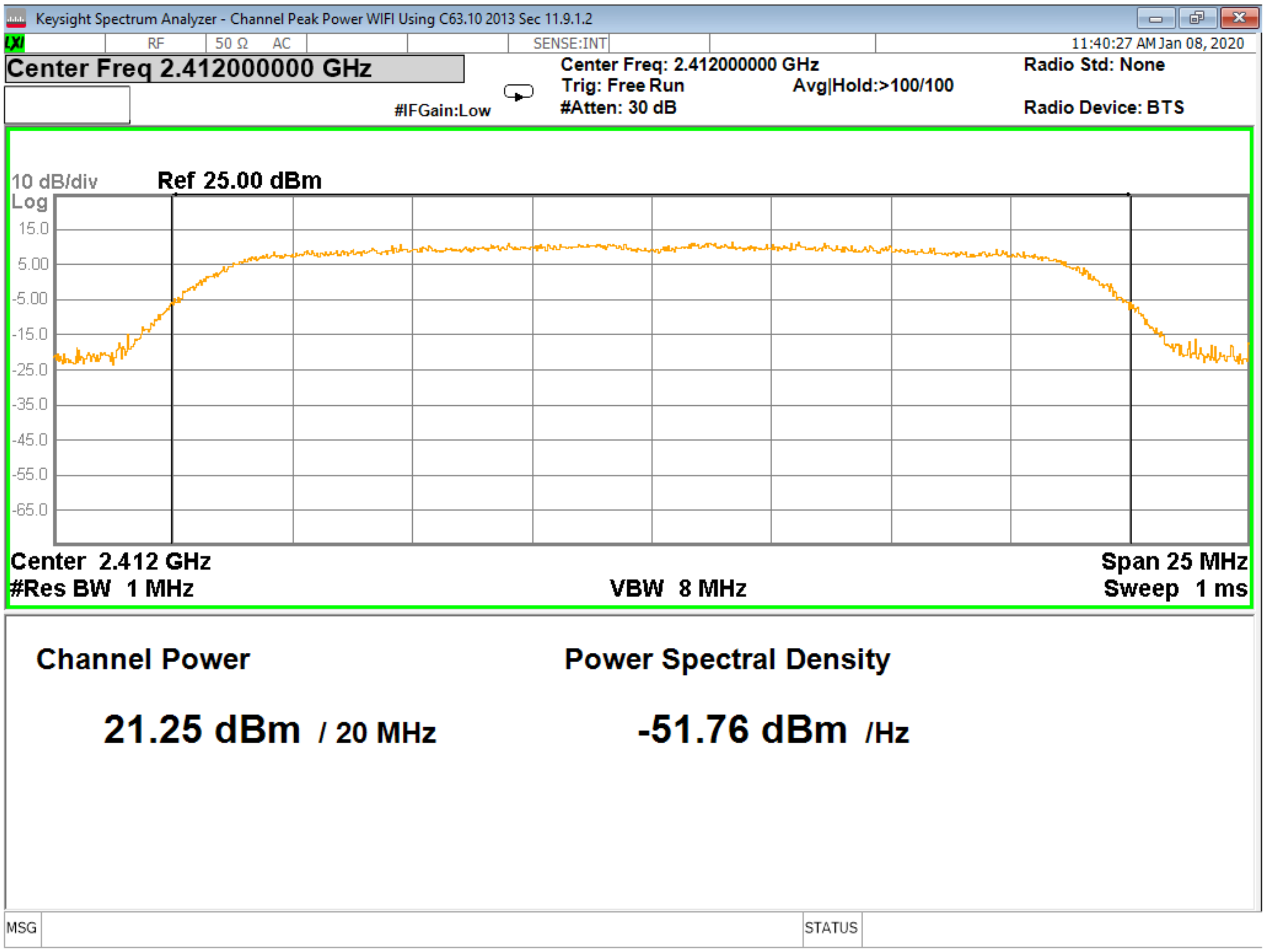



Figure 13 – Peak Output Power, Low Channel, 802.11n

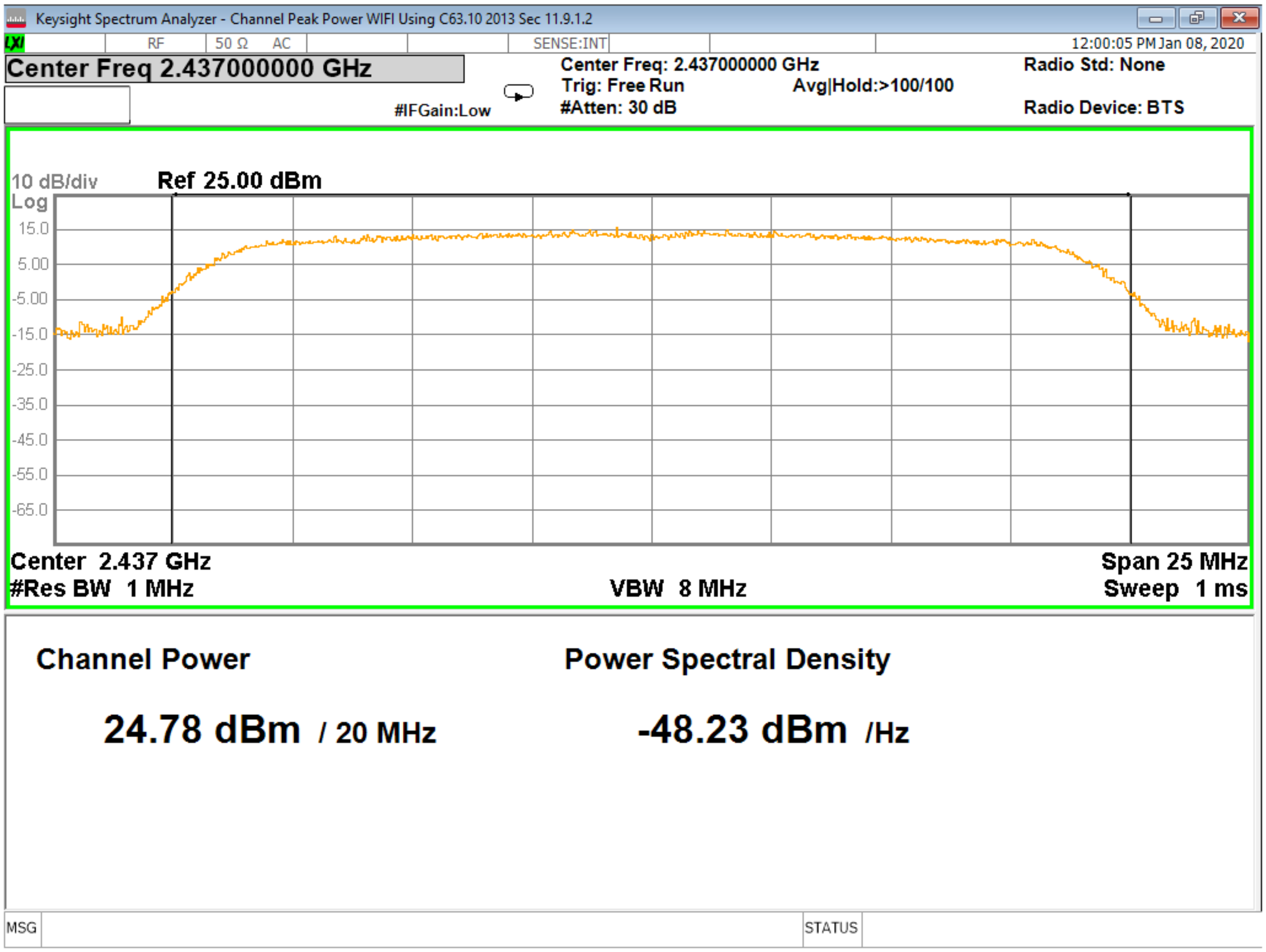



Figure 14 – Peak Output Power, Mid Channel, 802.11n

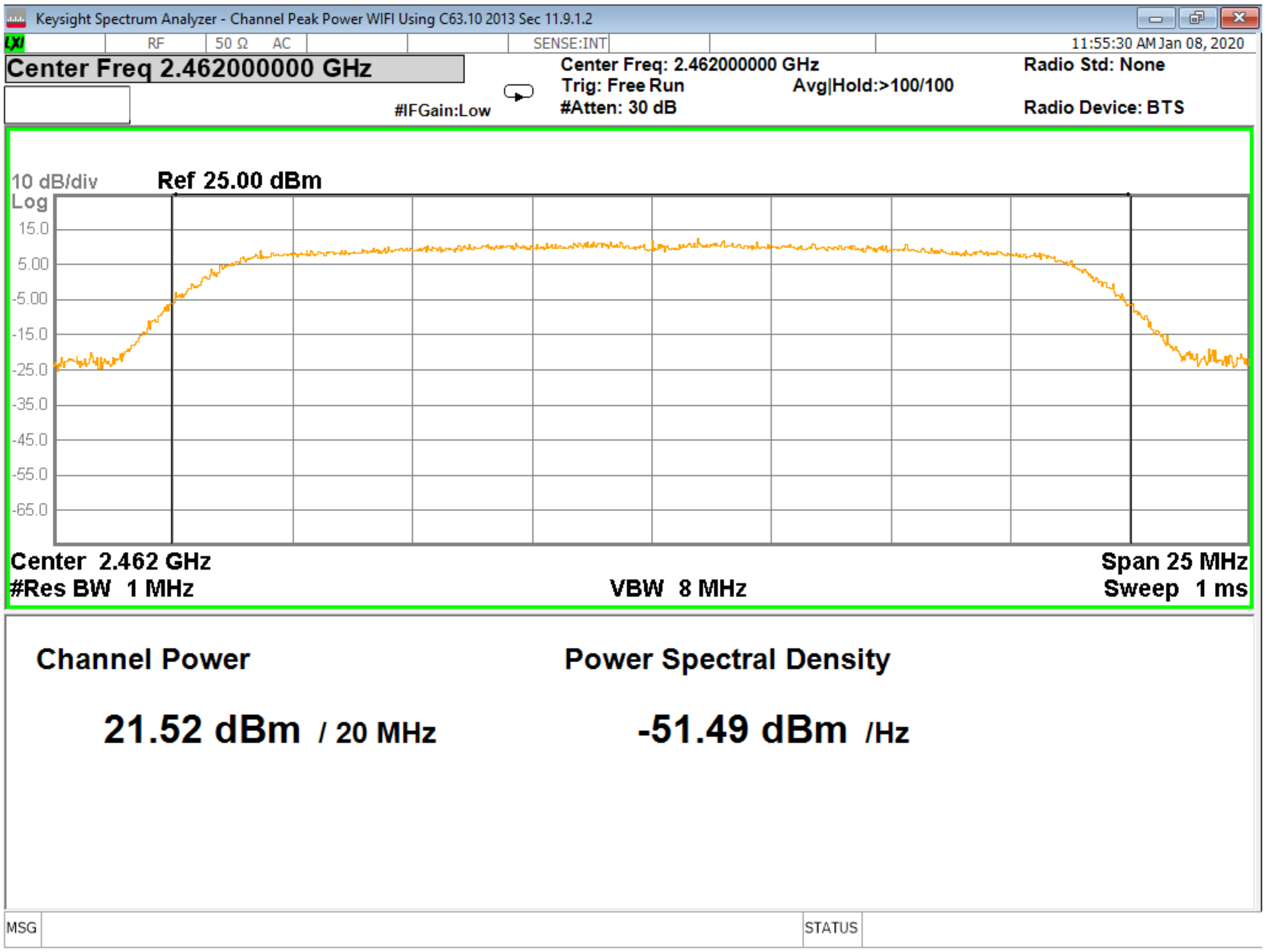



**Figure 15 – Peak Output Power, High Channel, 802.11n**

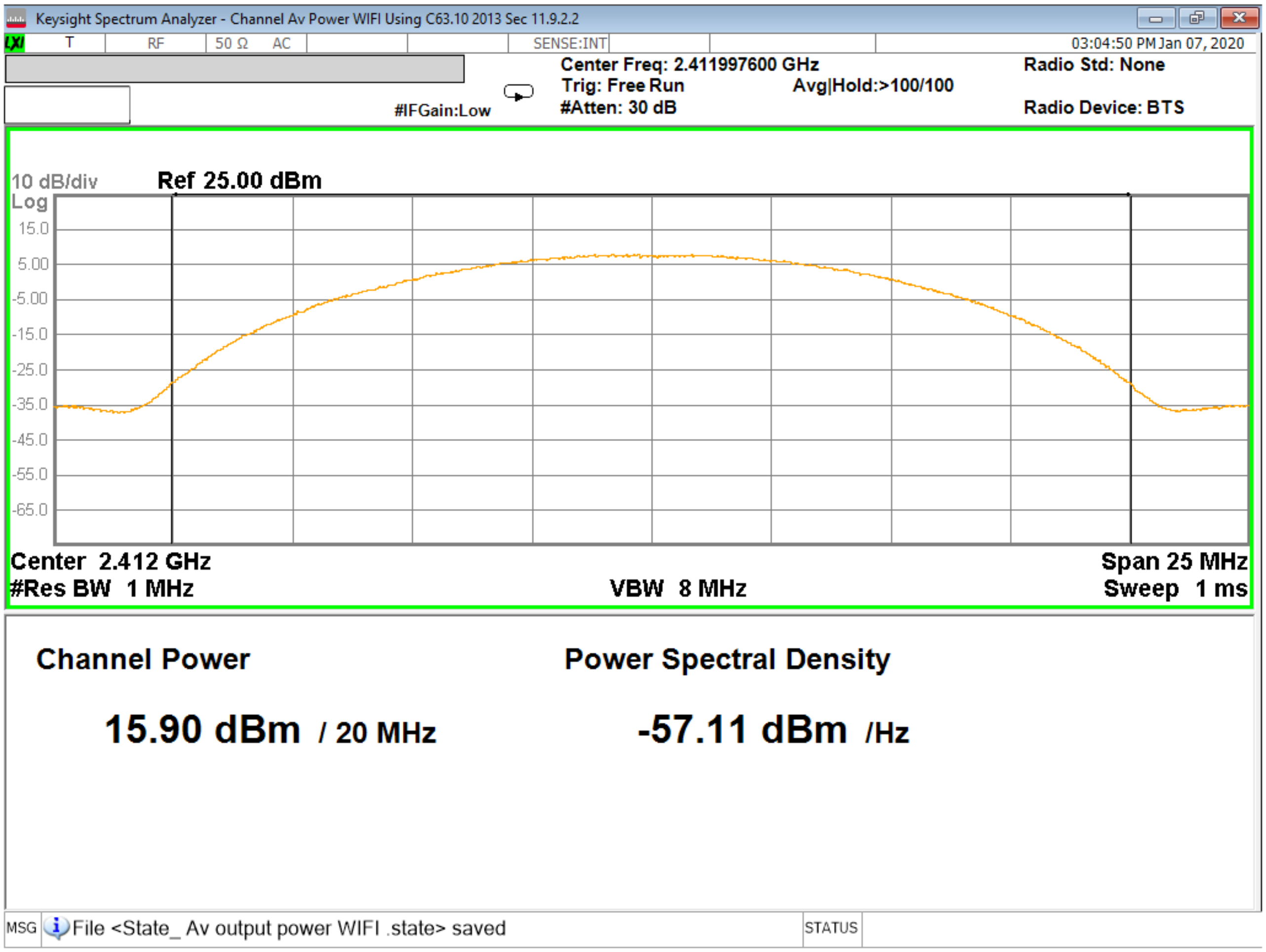



**Figure 16 – Average Output Power, Low Channel, 802.11b**

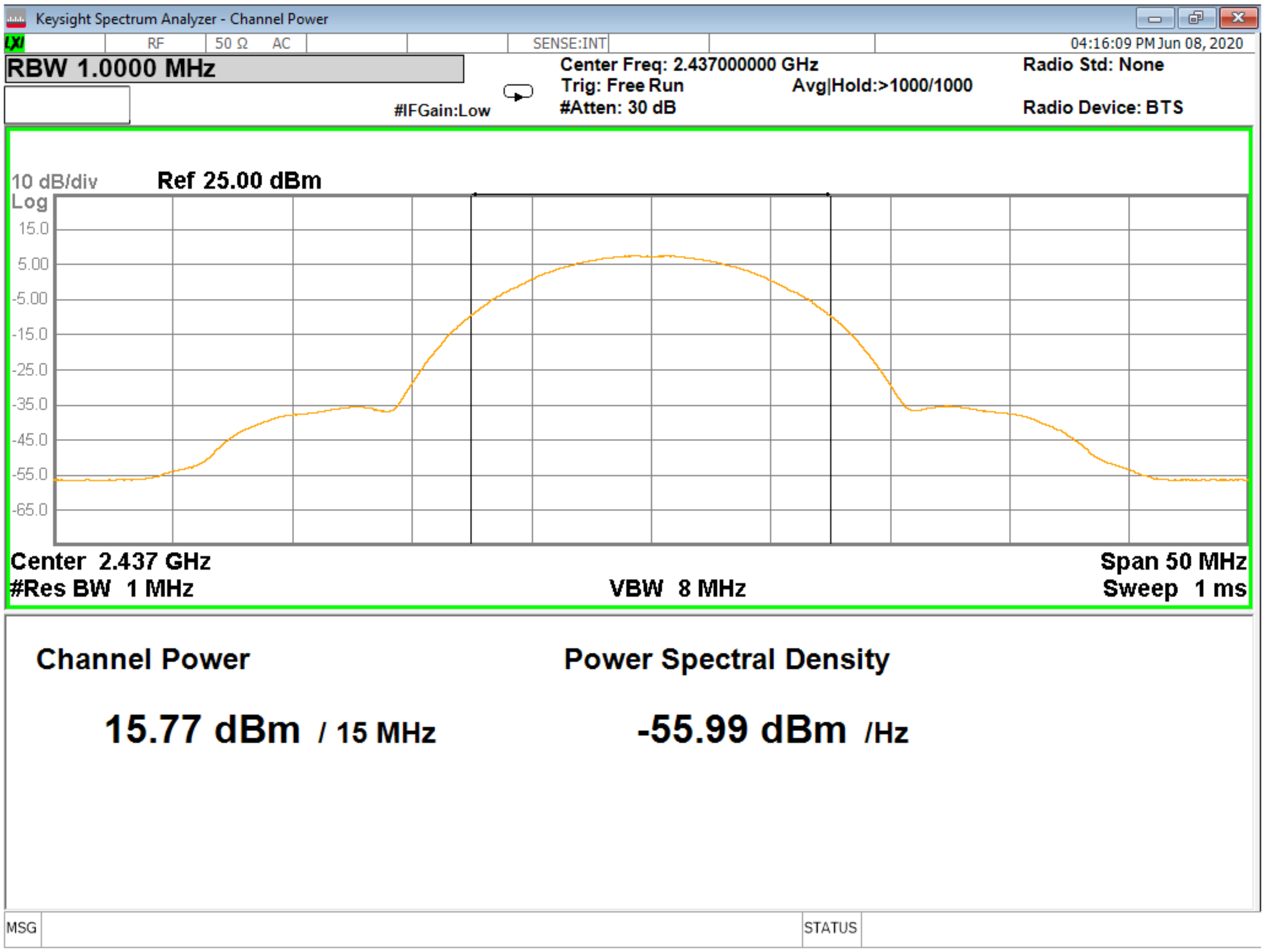



Figure 17 – Average Output Power, Mid Channel, 802.11b

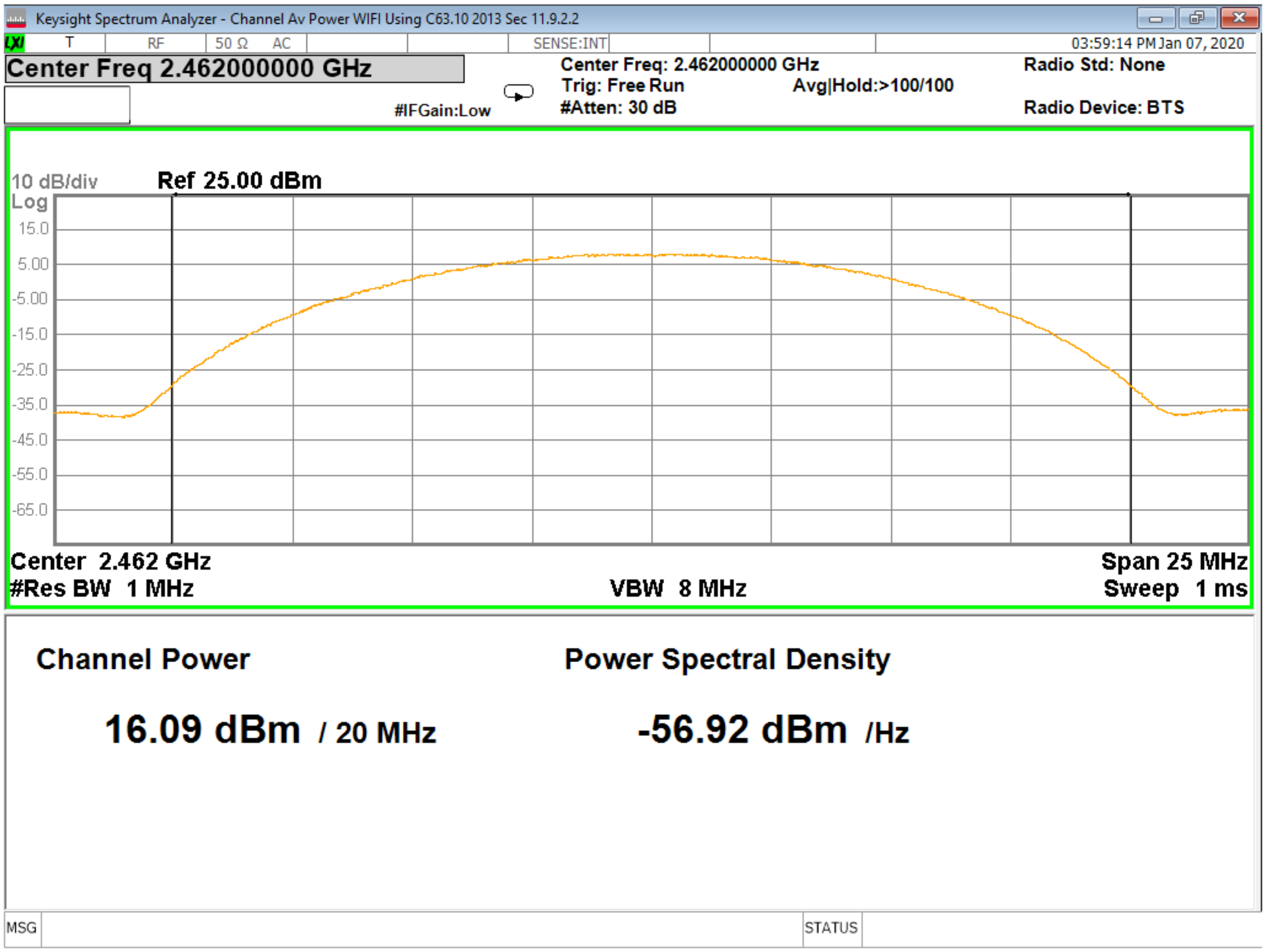



Figure 18 – Average Output Power, High Channel, 802.11b

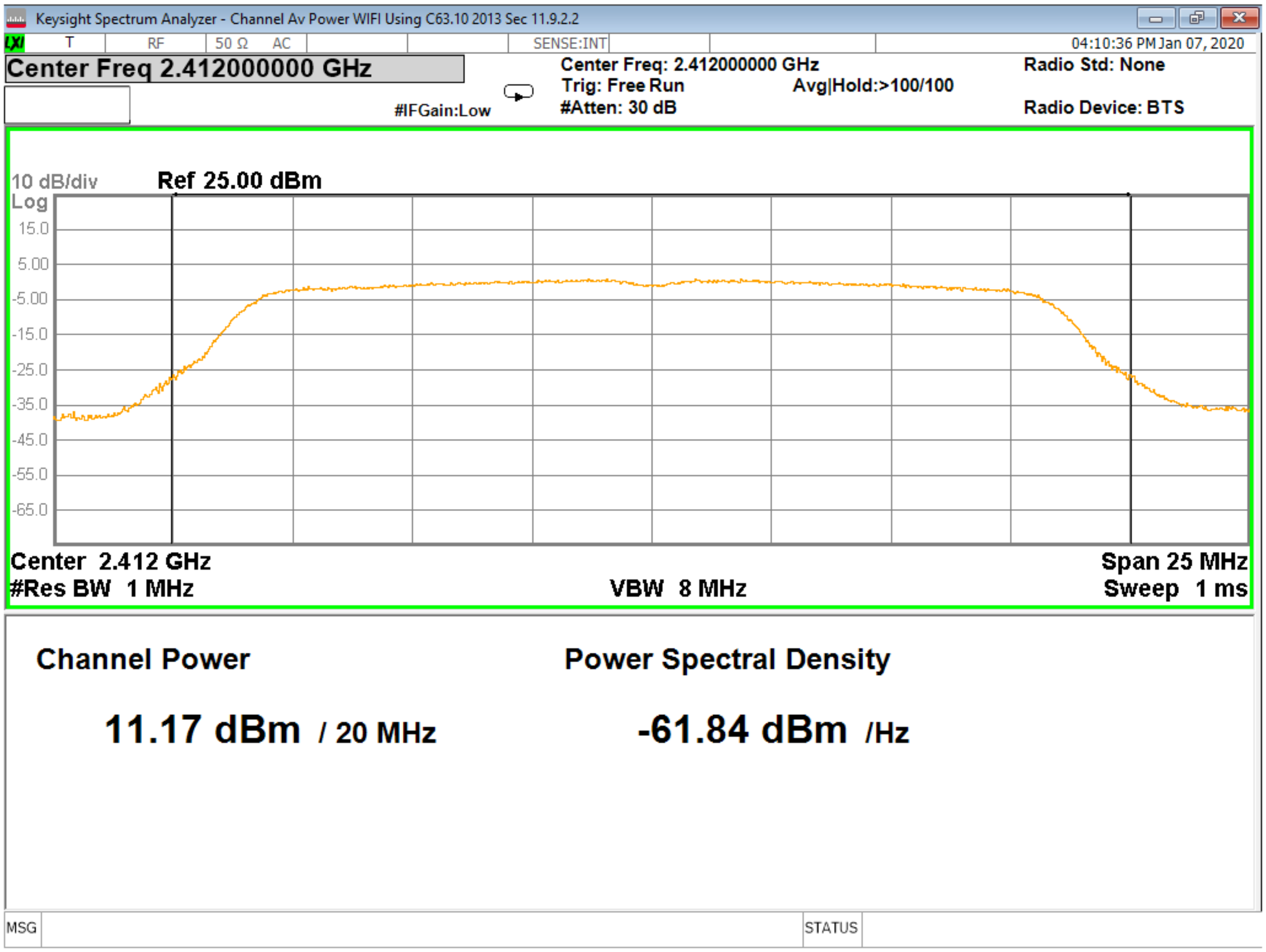



Figure 19 – Average Output Power, Low Channel, 802.11g

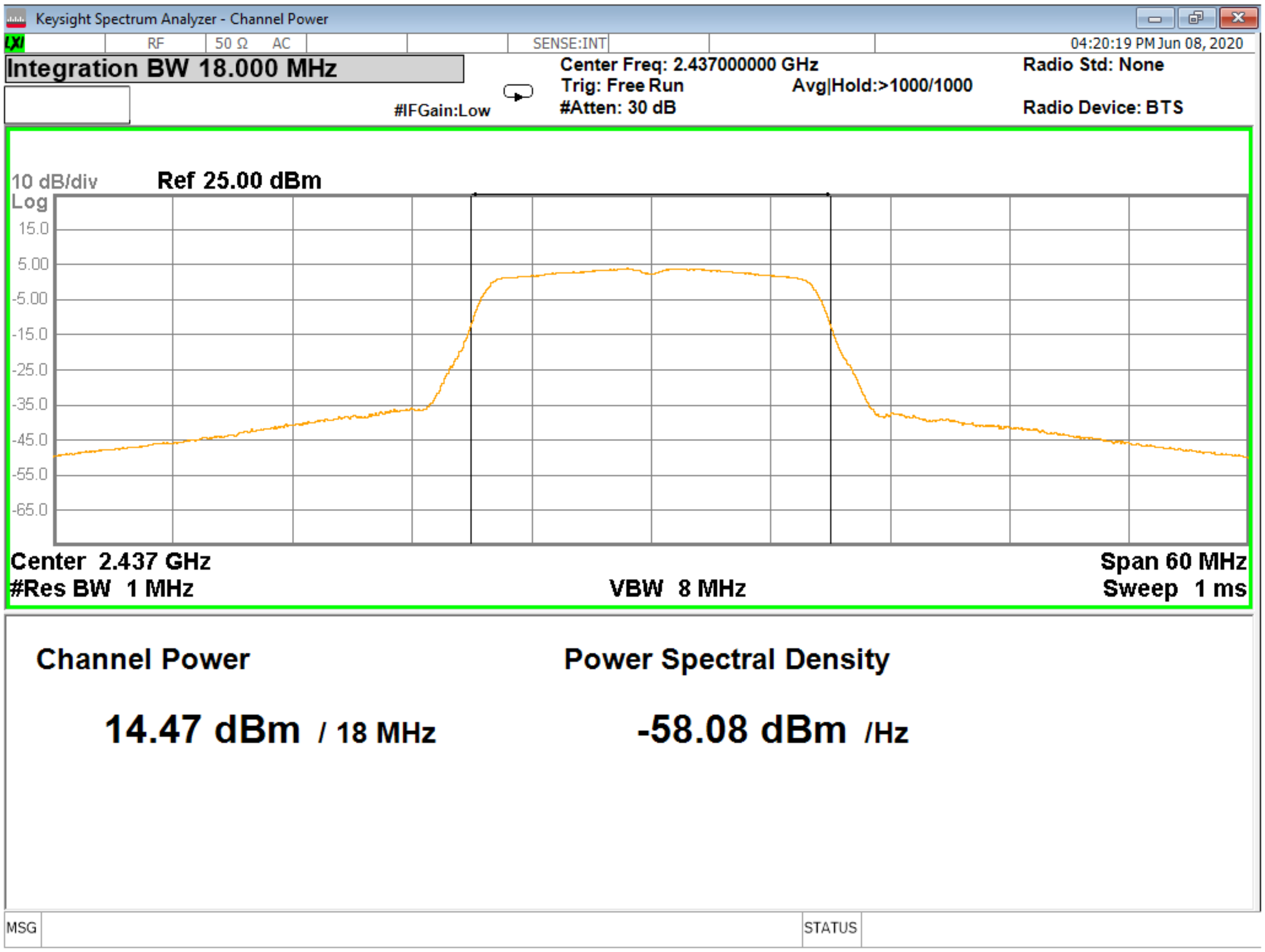



Figure 20 – Average Output Power, Mid Channel, 802.11g

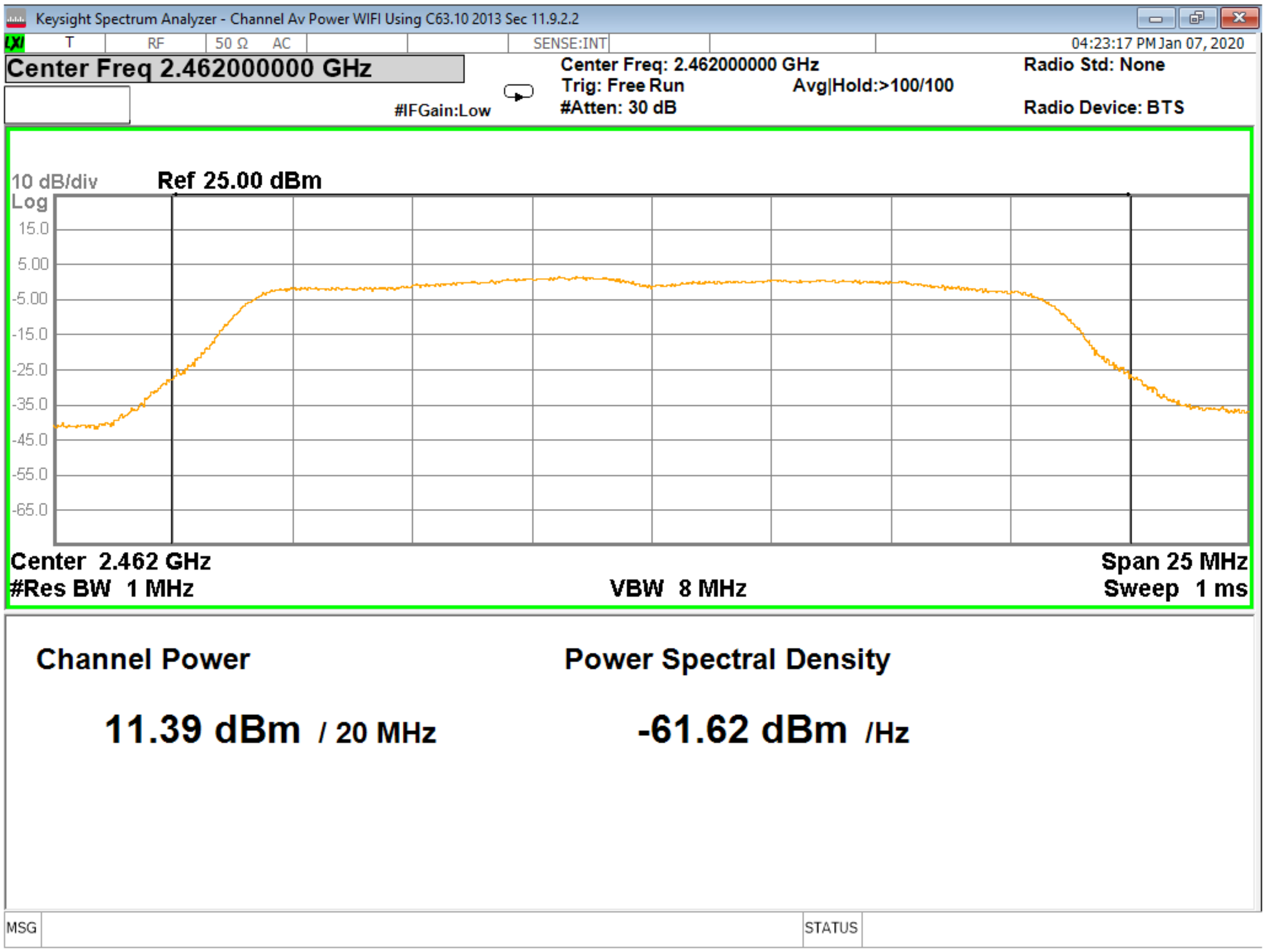



**Figure 21 – Average Output Power, High Channel, 802.11g**

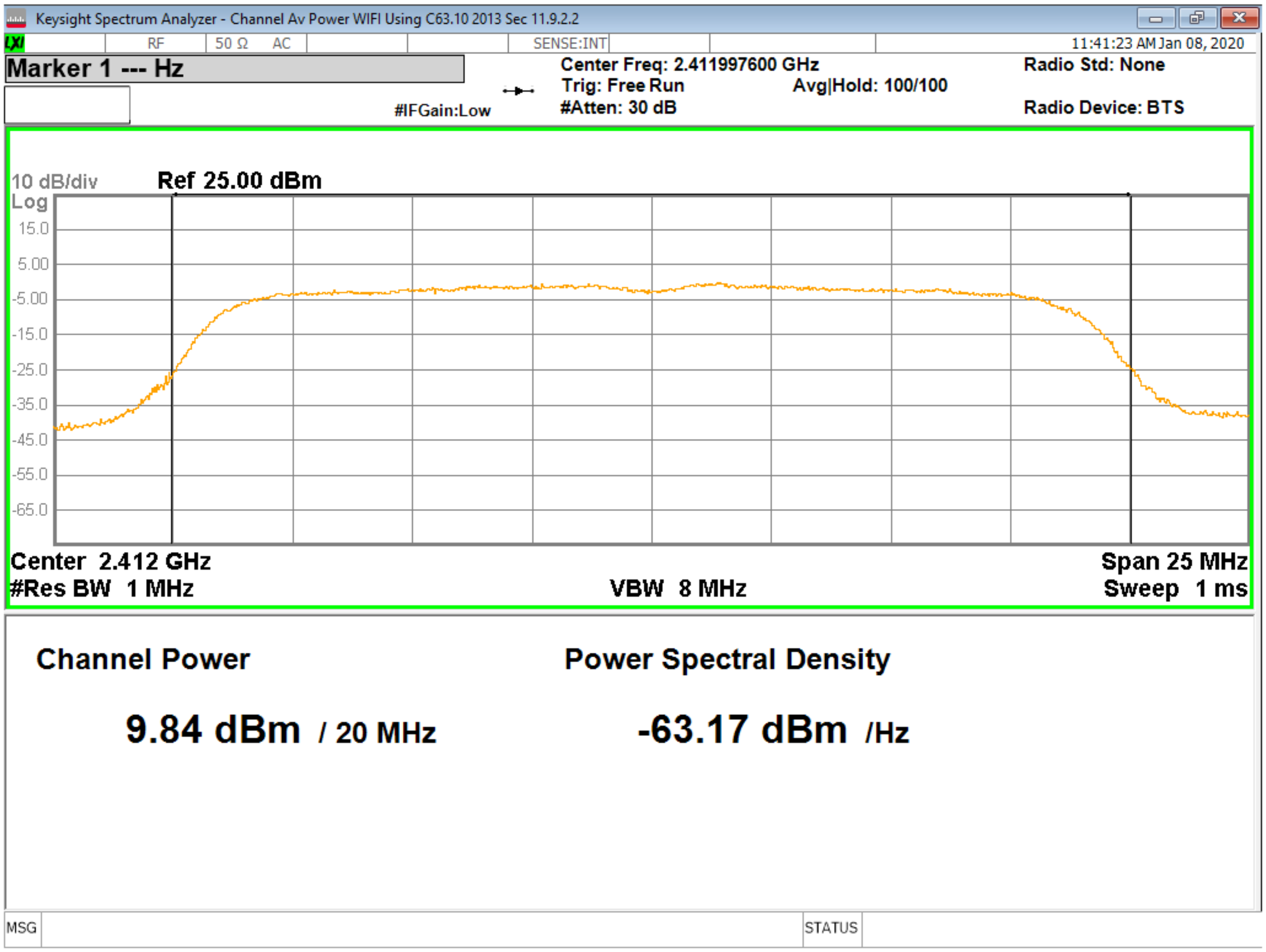



Figure 22 – Average Output Power, Low Channel, 802.11n

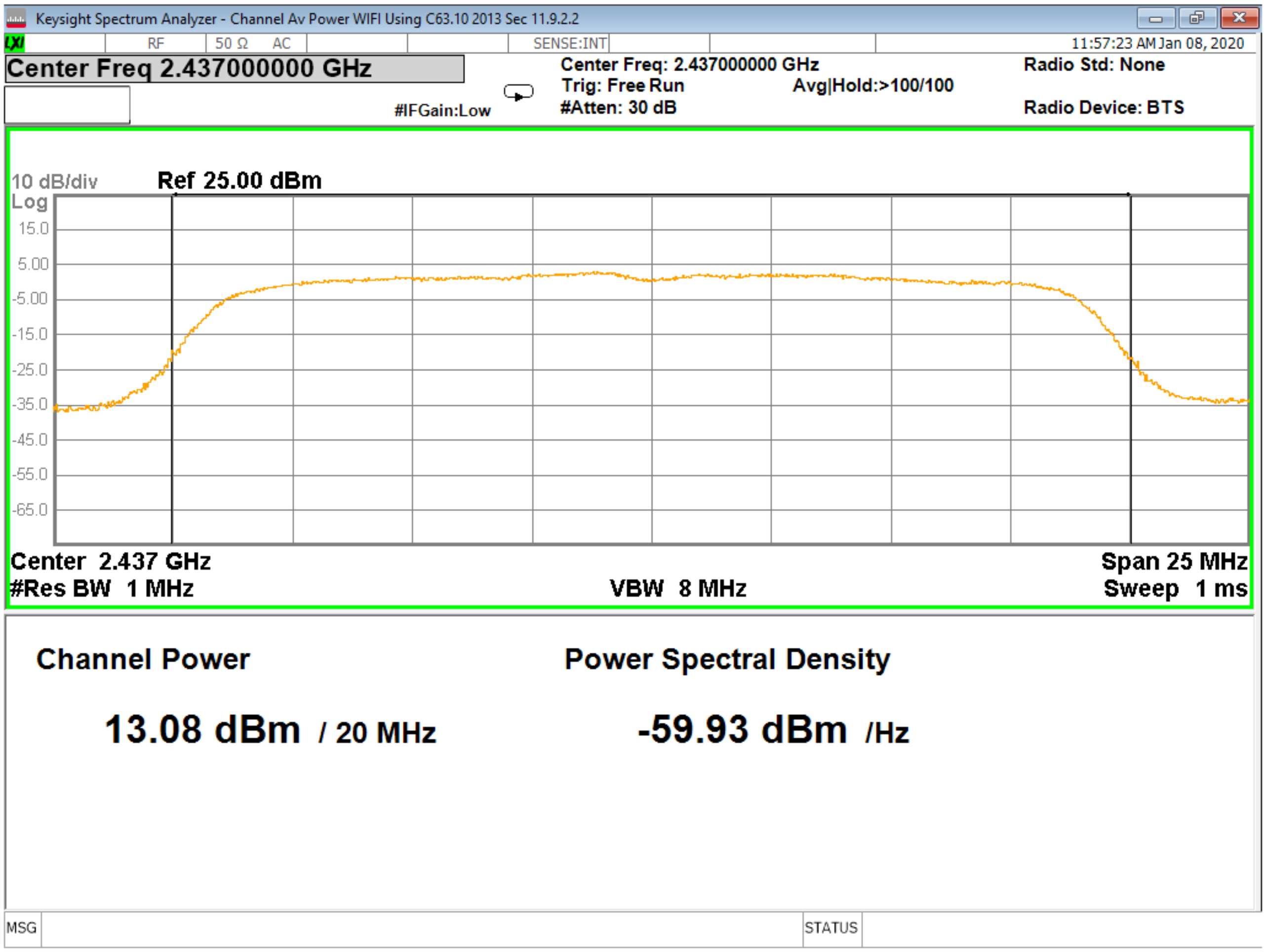



Figure 23 – Average Output Power, Mid Channel, 802.11n

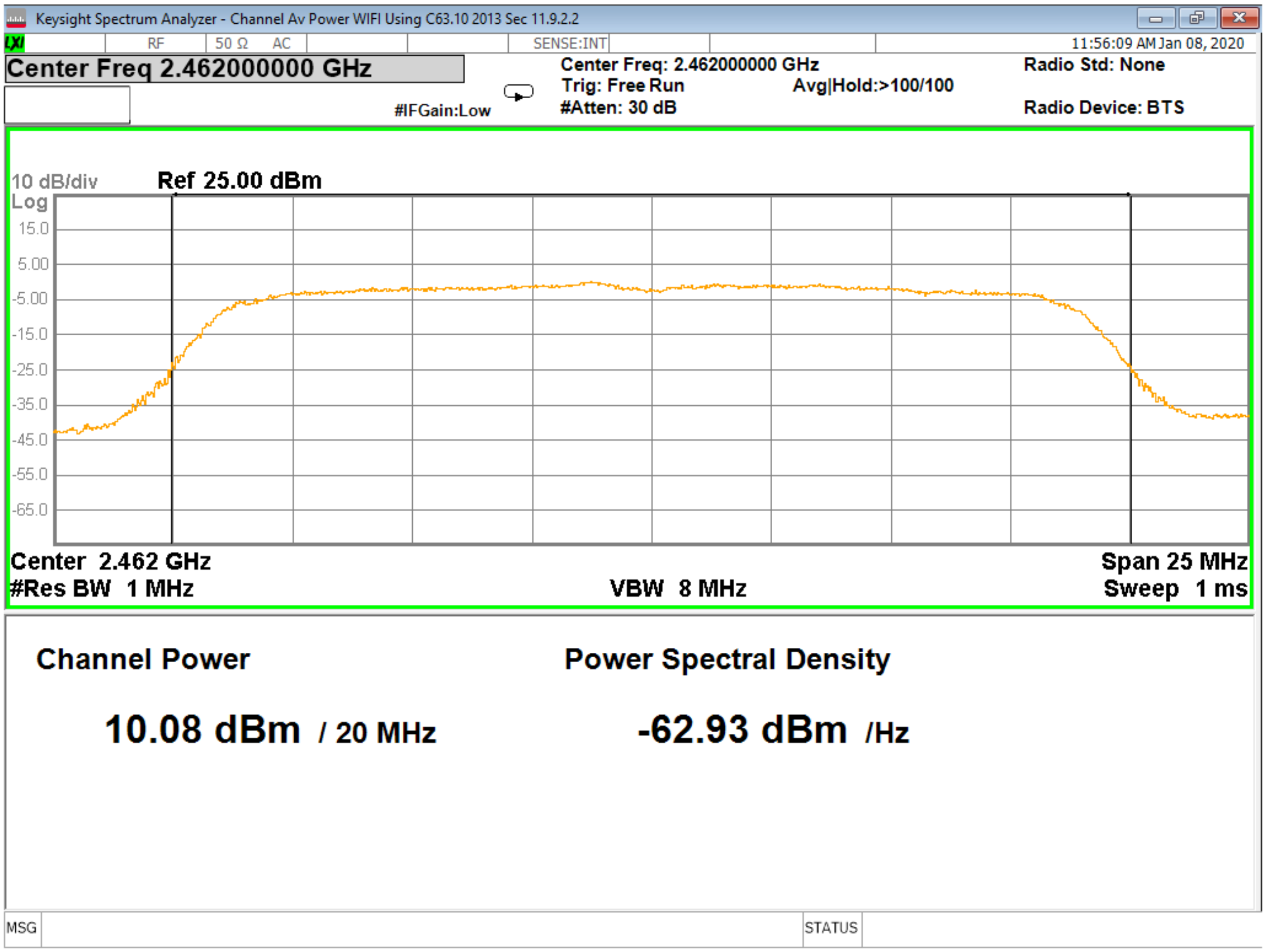



Figure 24 – Average Output Power, High Channel, 802.11n

## 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:**

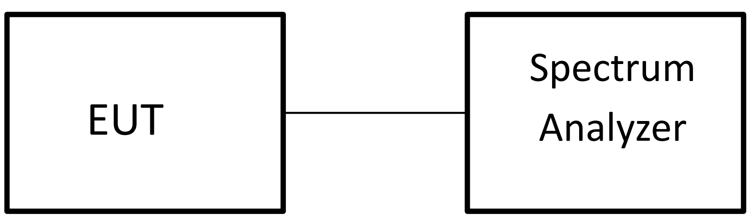



Figure 25 – Peak Output Power Measurements Test Setup

**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 |

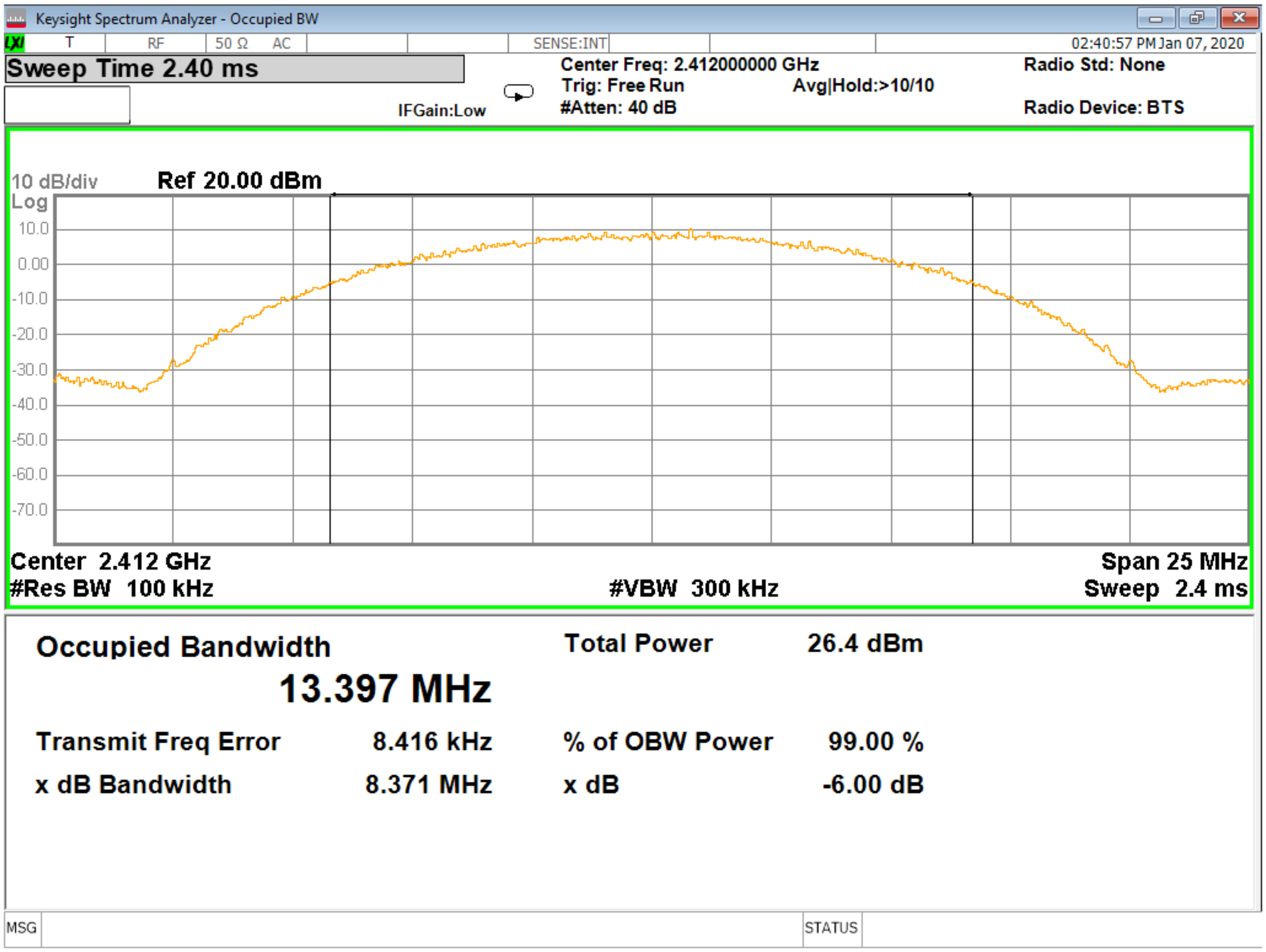



Figure 26 - Bandwidth, Low Channel, 802.11b

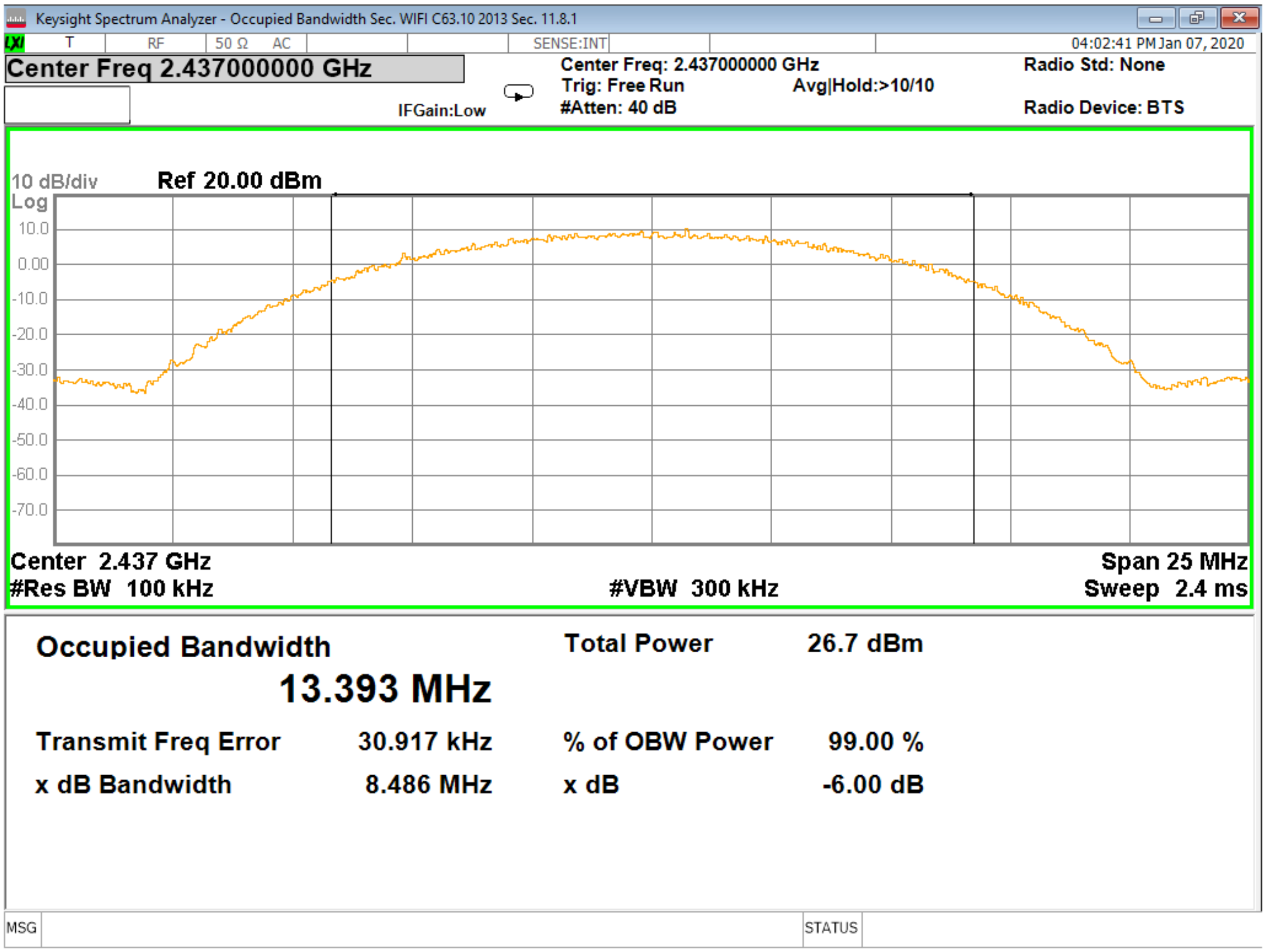



Figure 27 - Bandwidth, Mid Channel, 802.11b

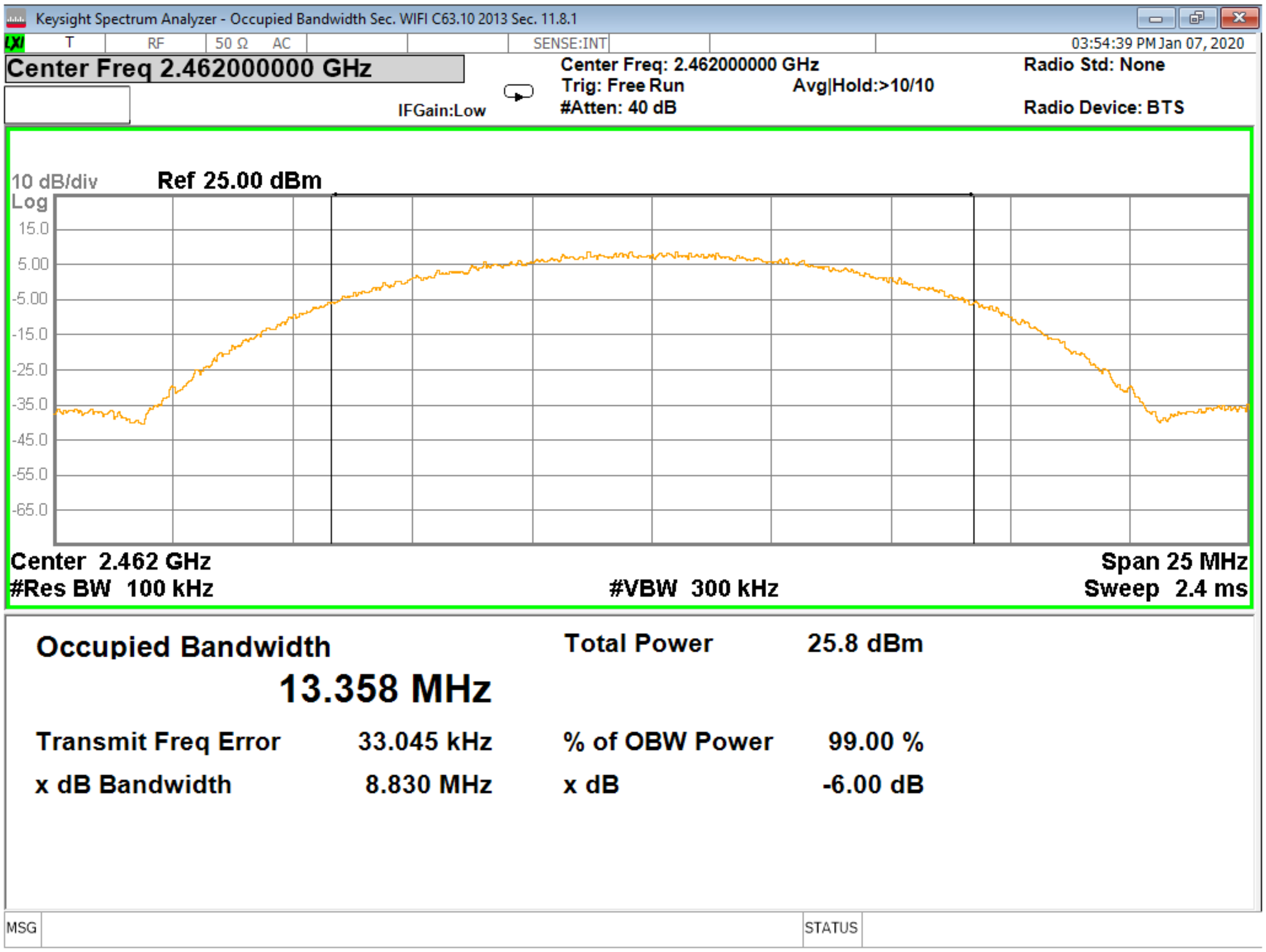



Figure 28 - Bandwidth, High Channel, 802.11b

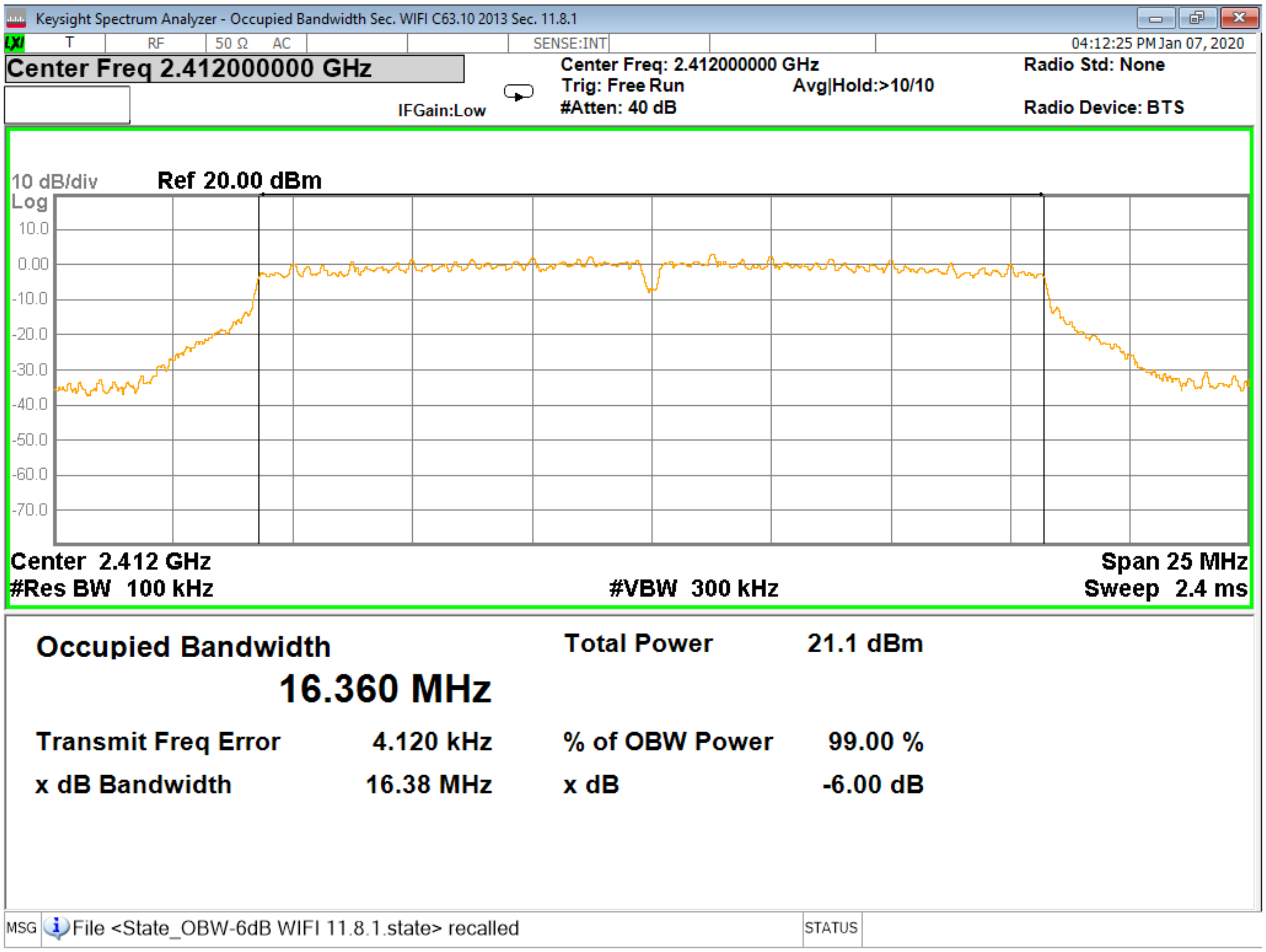



Figure 29 - Bandwidth, Low Channel, 802.11g

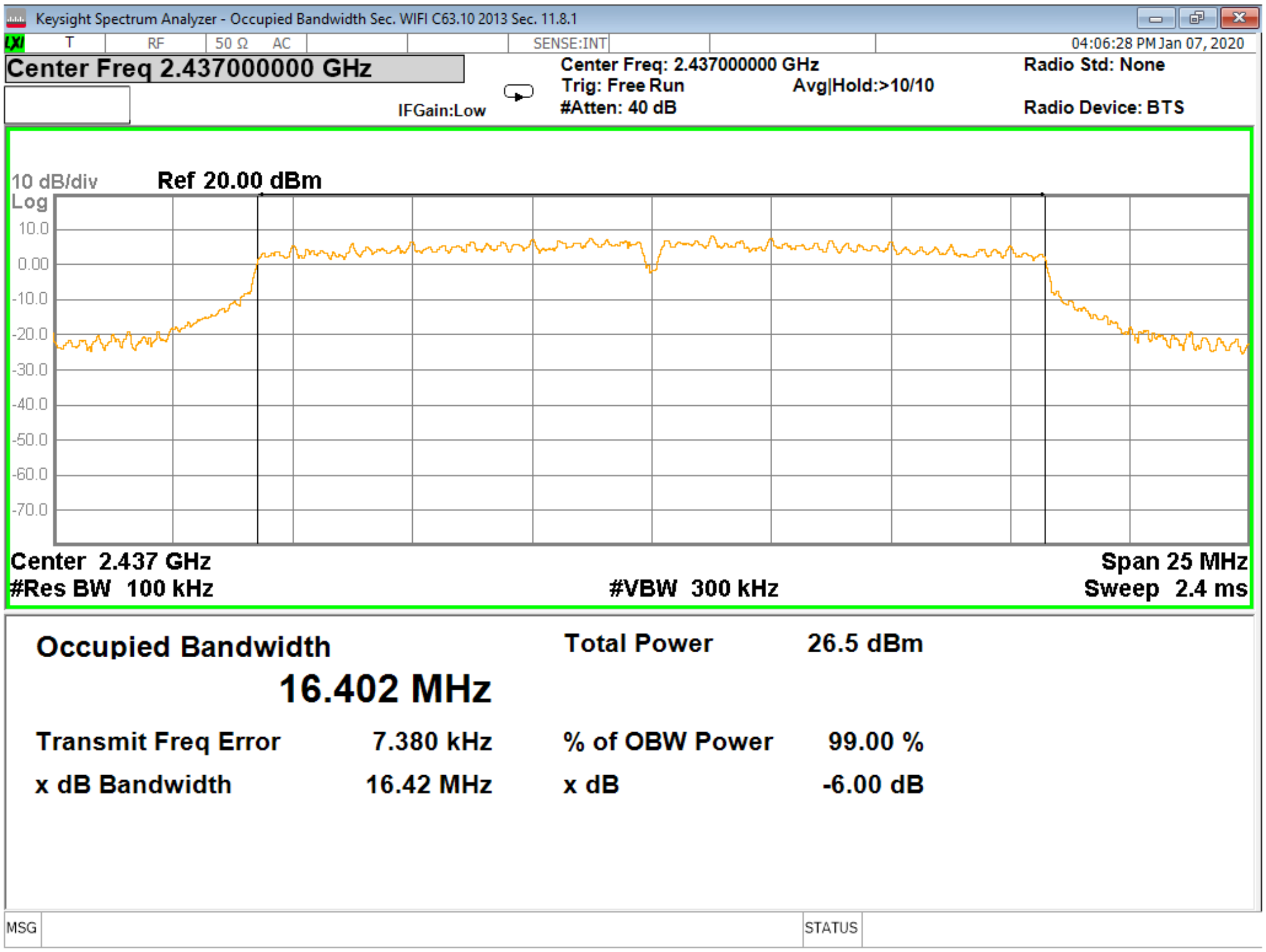



**Figure 30 - Bandwidth, Mid Channel, 802.11g**

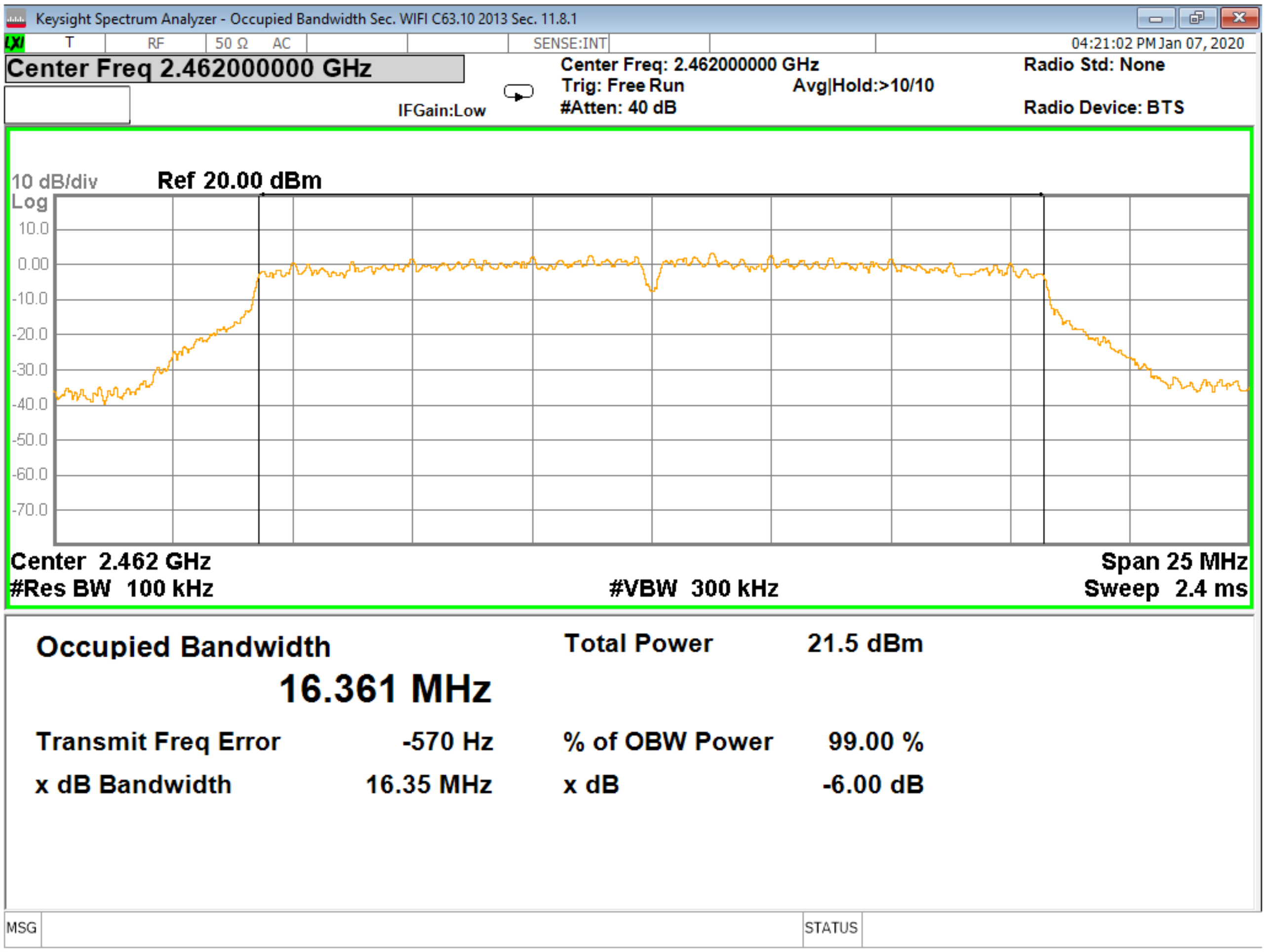



Figure 31 - Bandwidth, High Channel, 802.11g

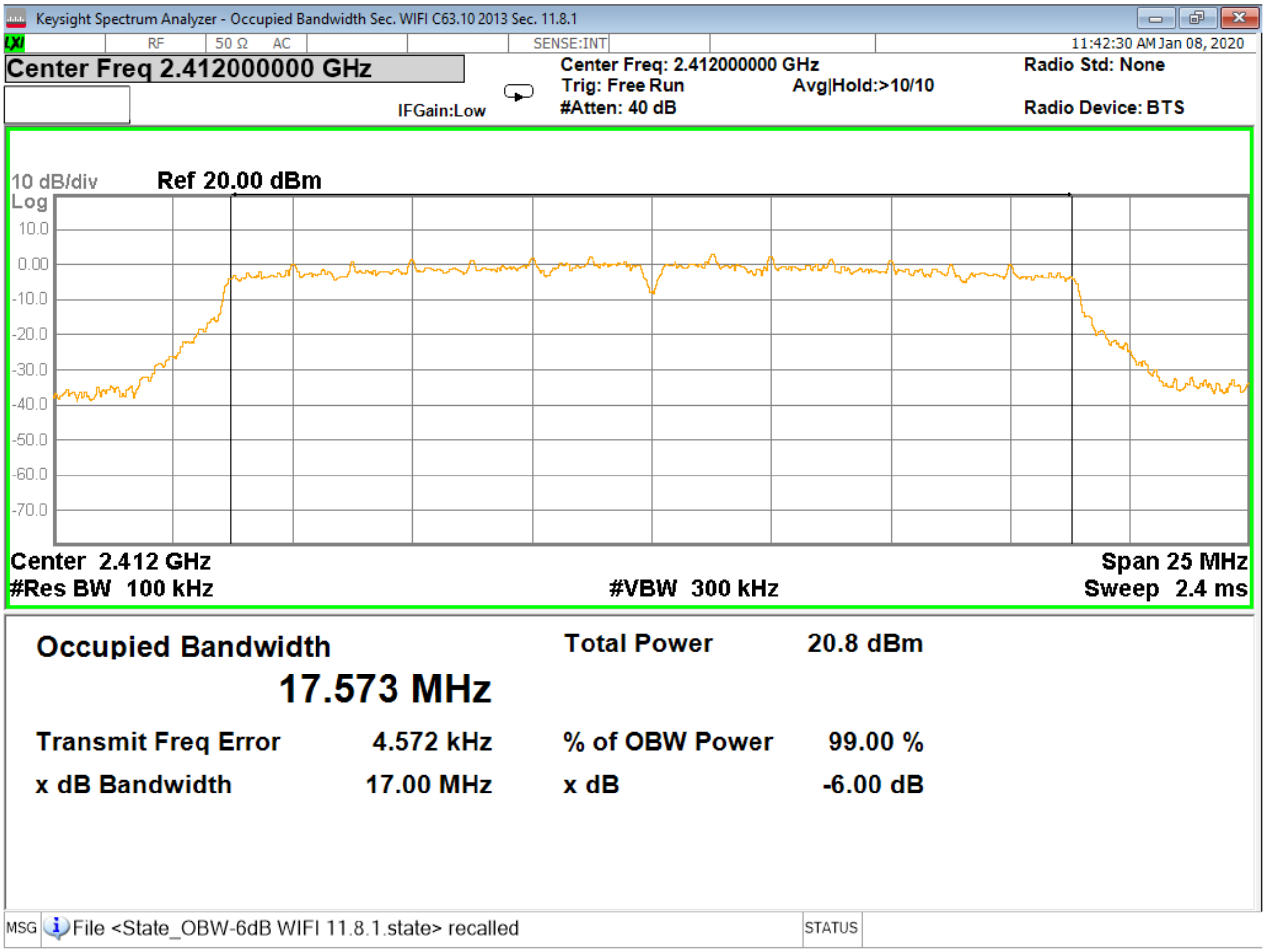



Figure 32 - Bandwidth, Low Channel, 802.11n

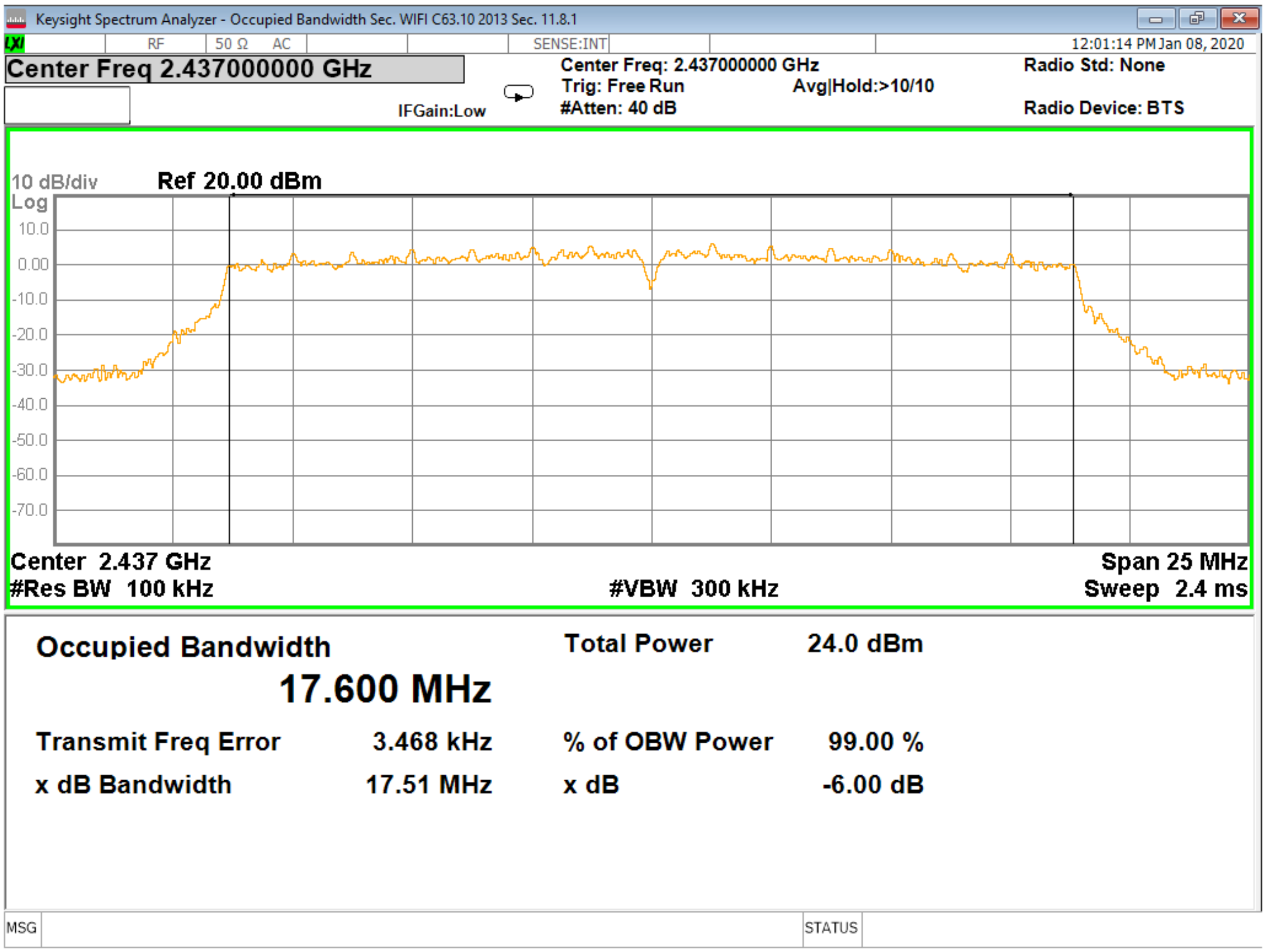



Figure 33 - Bandwidth, Mid Channel, 802.11n

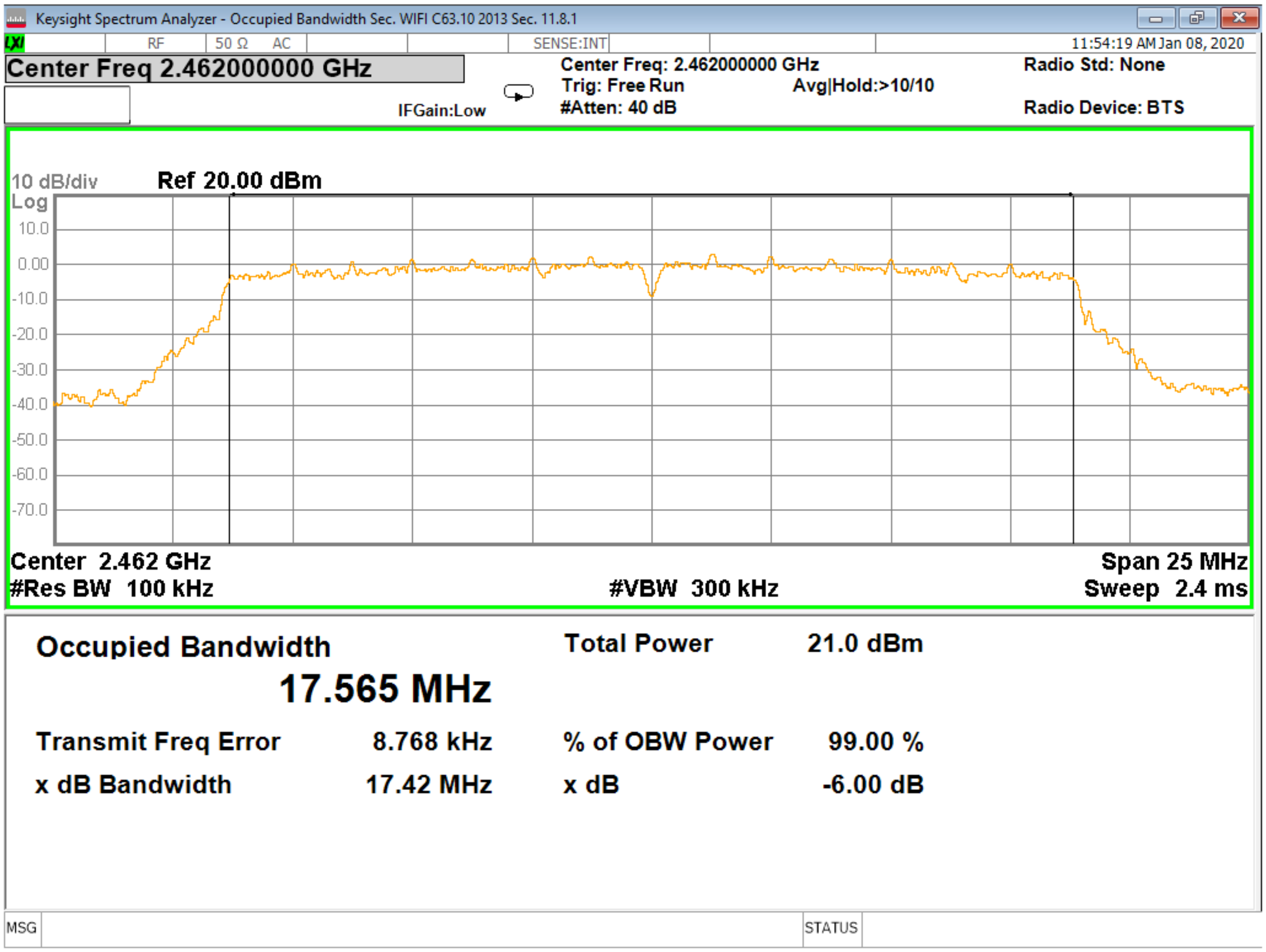



Figure 34 - Bandwidth, High Channel, 802.11n

## 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.

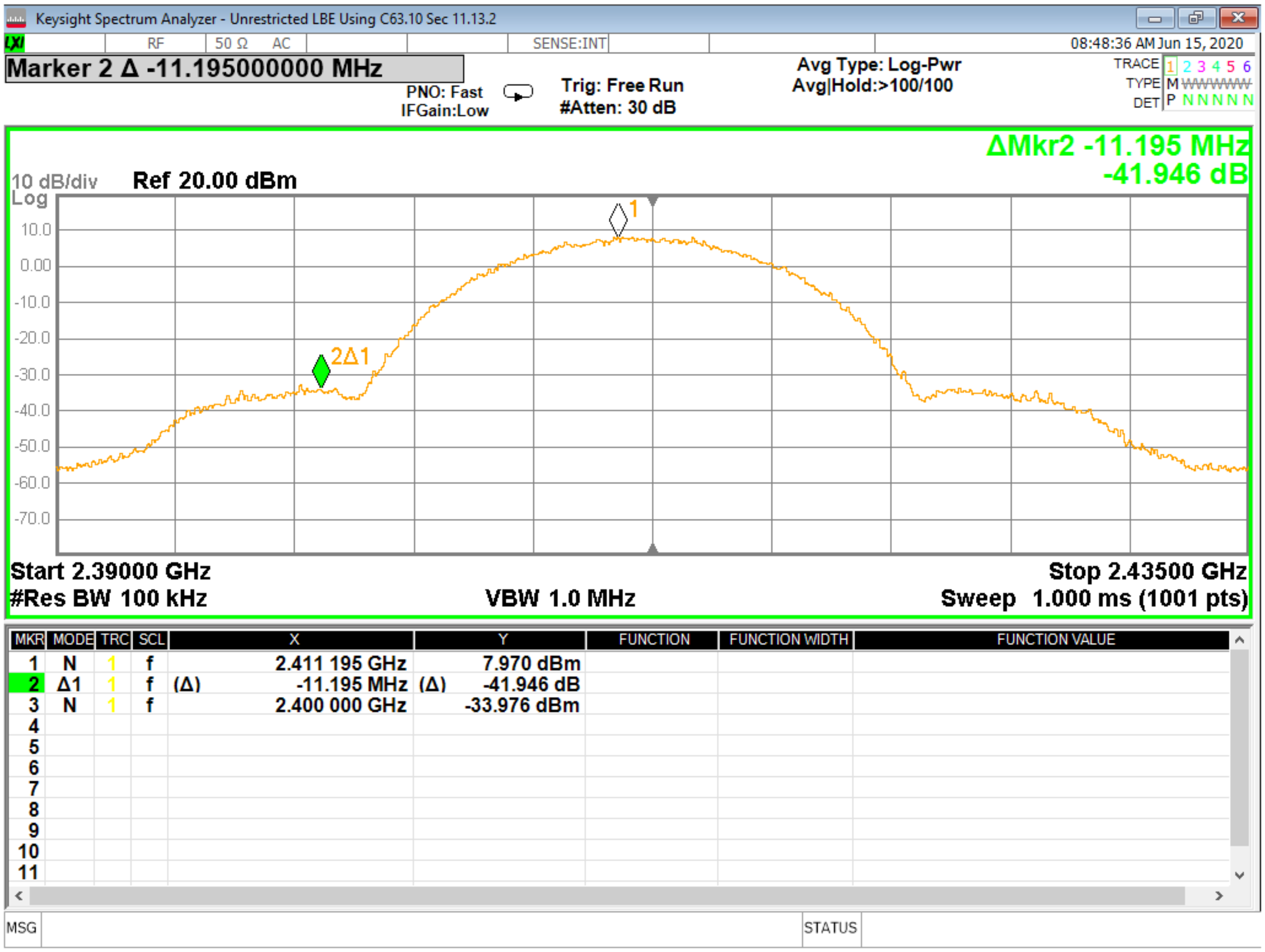



Figure 35 - Band-edge Measurement, Low Channel, Fundamental, Peak

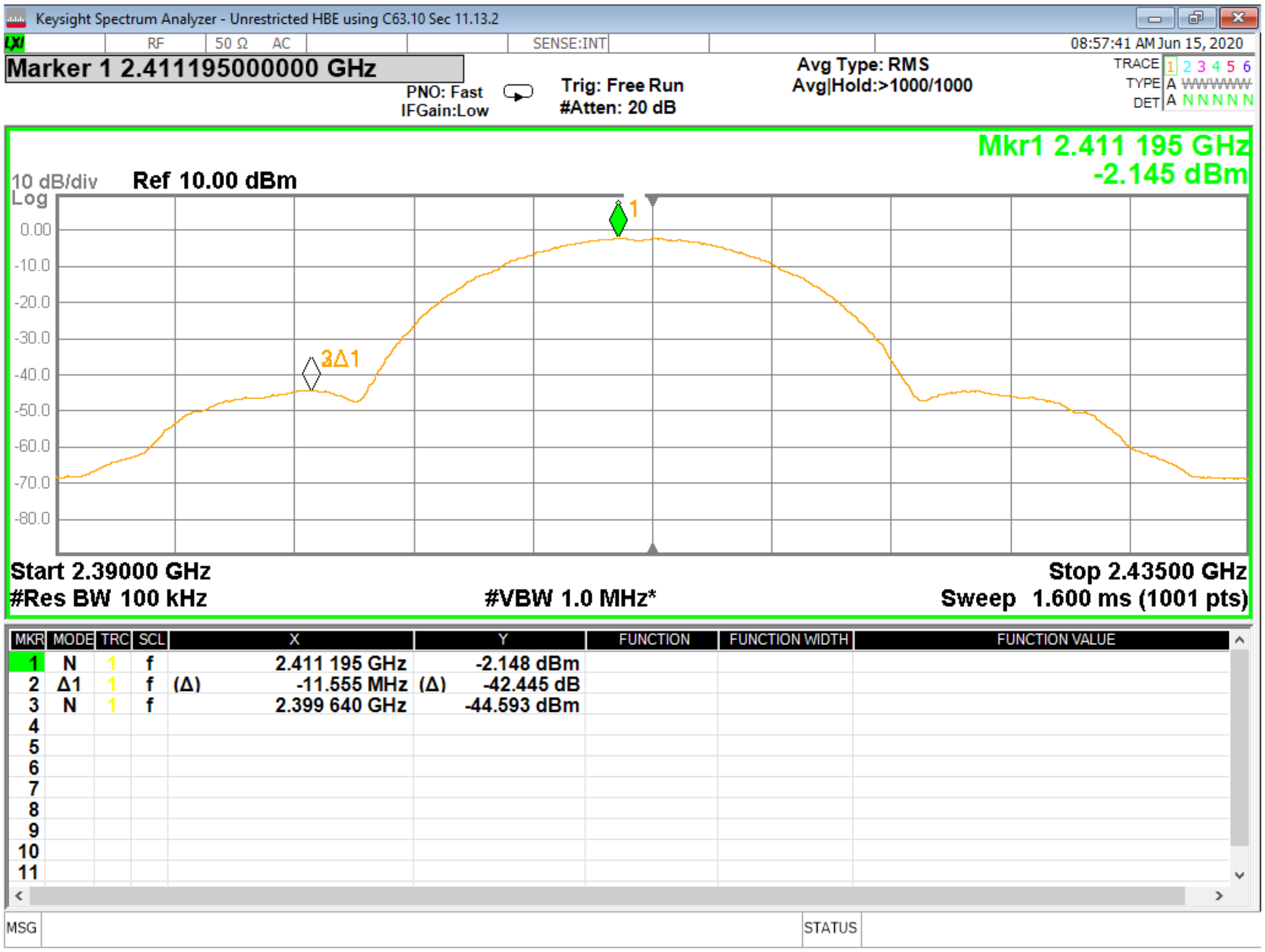
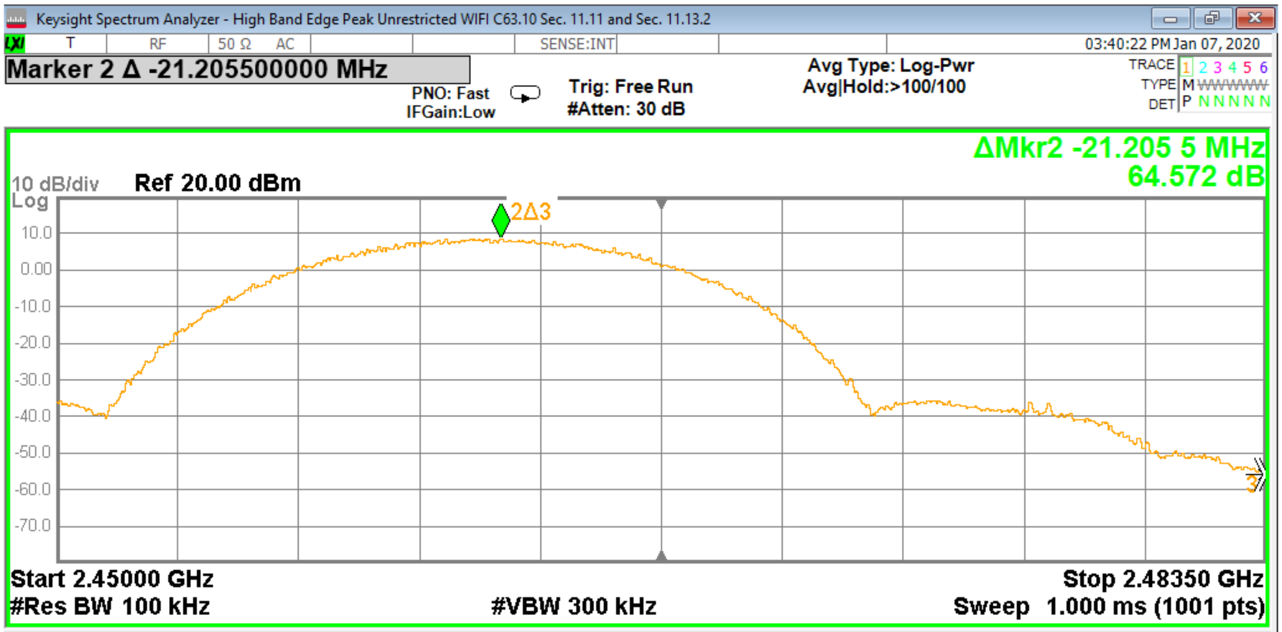



Figure 36 - Band-edge Measurement, Low Channel, Fundamental, Average




| MKR | MODE | TRC | SCL | X | Y | FUNCTION | FUNCTION WIDTH | FUNCTION VALUE |
|---|---|---|---|---|---|---|---|---|
| 1 | N | 1 | f | 2.462 294 5 GHz | 8.482 dBm | | | |
| 2 | Δ3 | 1 | f (Δ) | -21.205 5 MHz | (Δ) 64.572 dB | | | |
| 3 | F | 1 | f | 2.483 500 0 GHz | -56.091 dBm | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

MSG STATUS

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

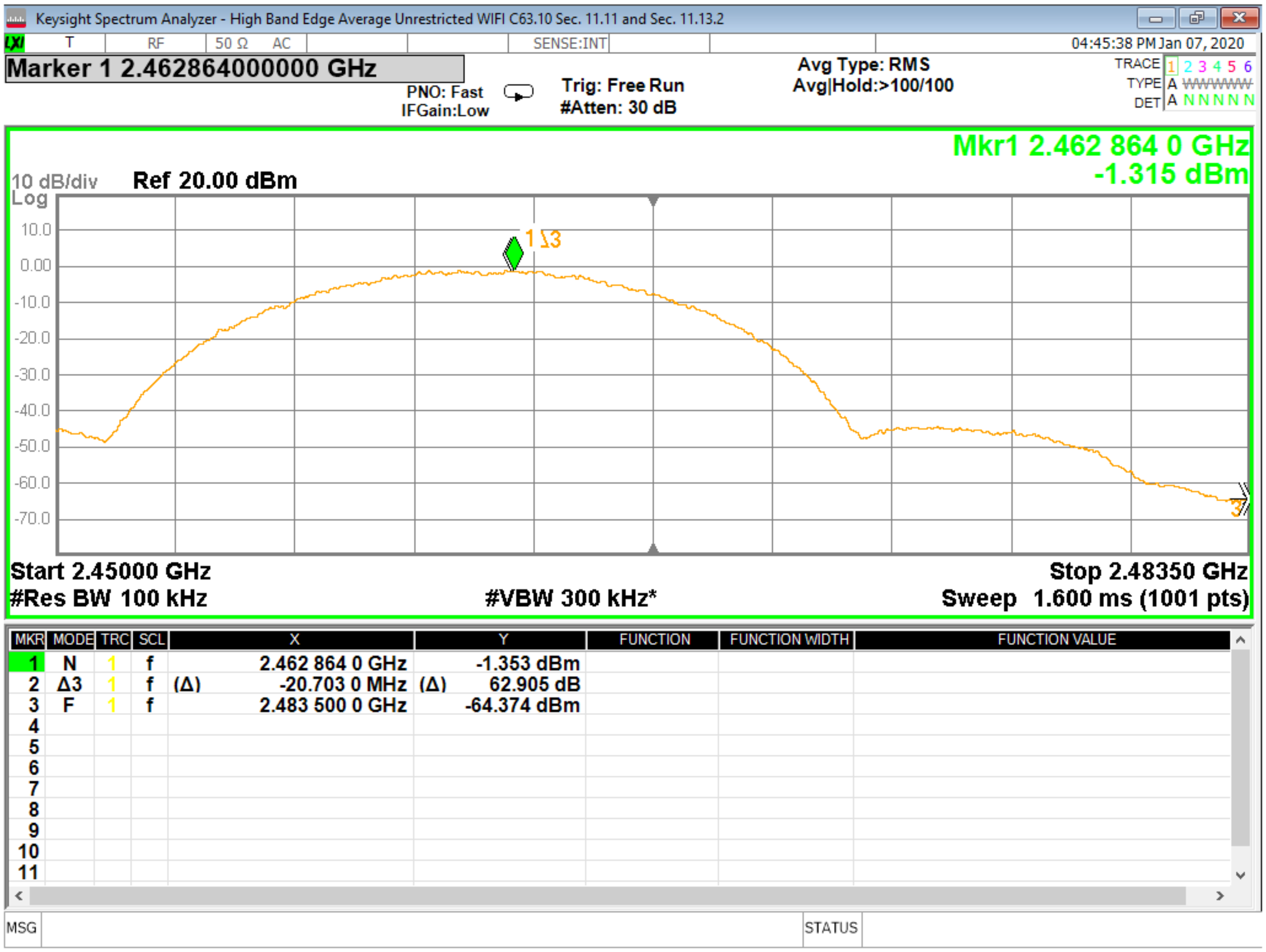



**Figure 38 - Band-edge Measurement, High Channel, Fundamental, Average**

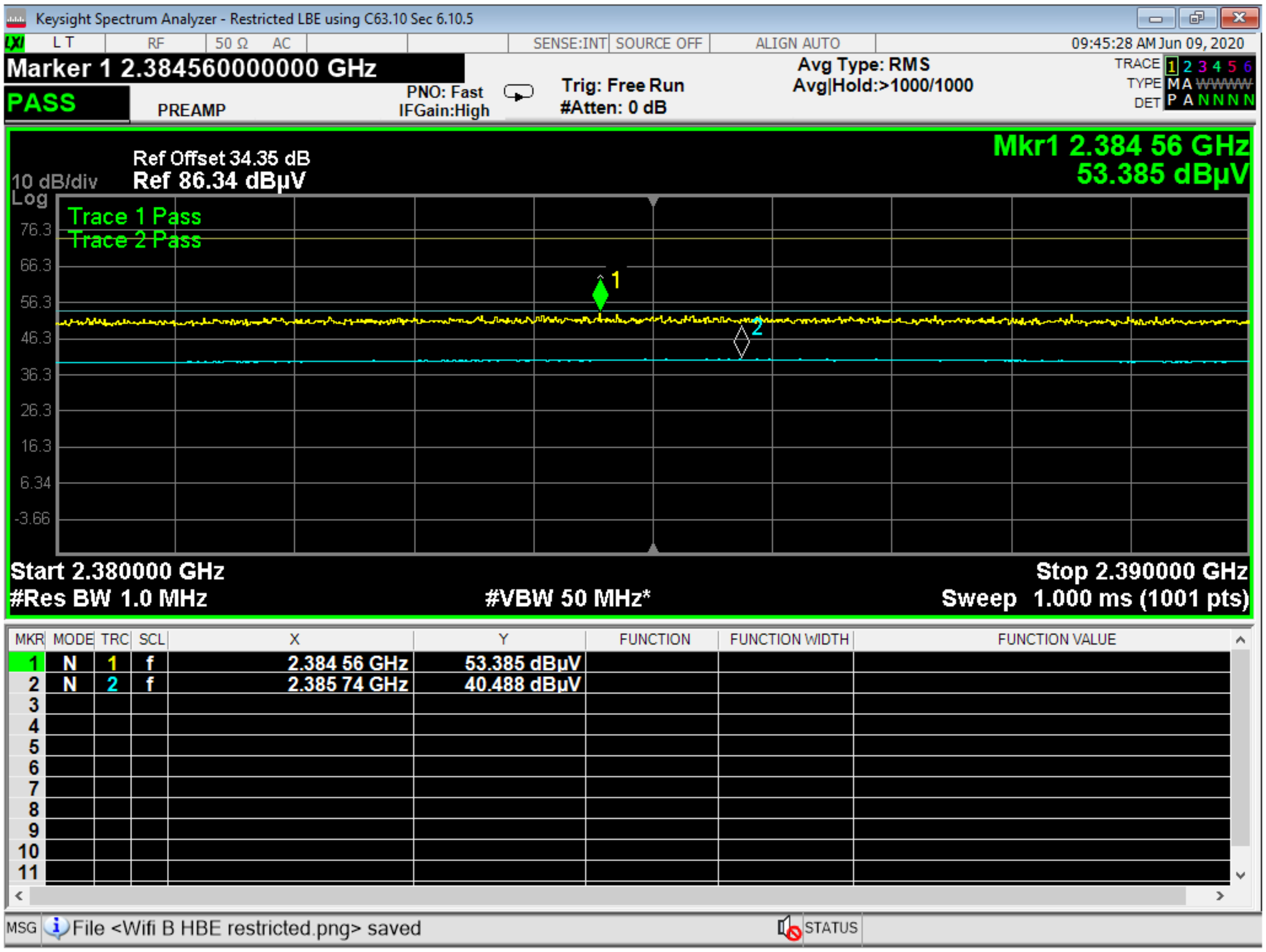



**Figure 39 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak and Average**

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.

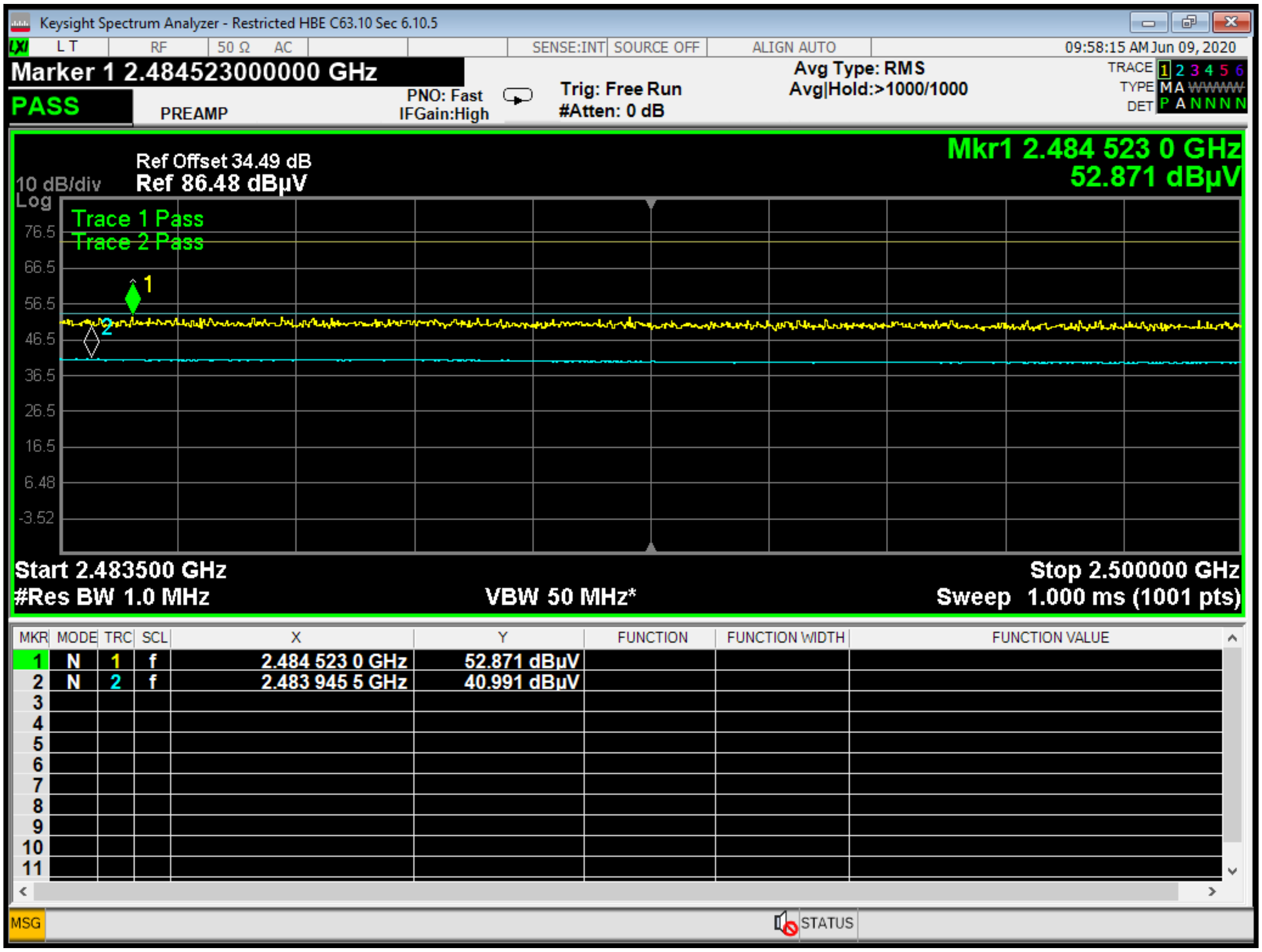



Figure 40 - Band-edge Measurement, High Channel, Restricted Frequency, Peak and Average

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.

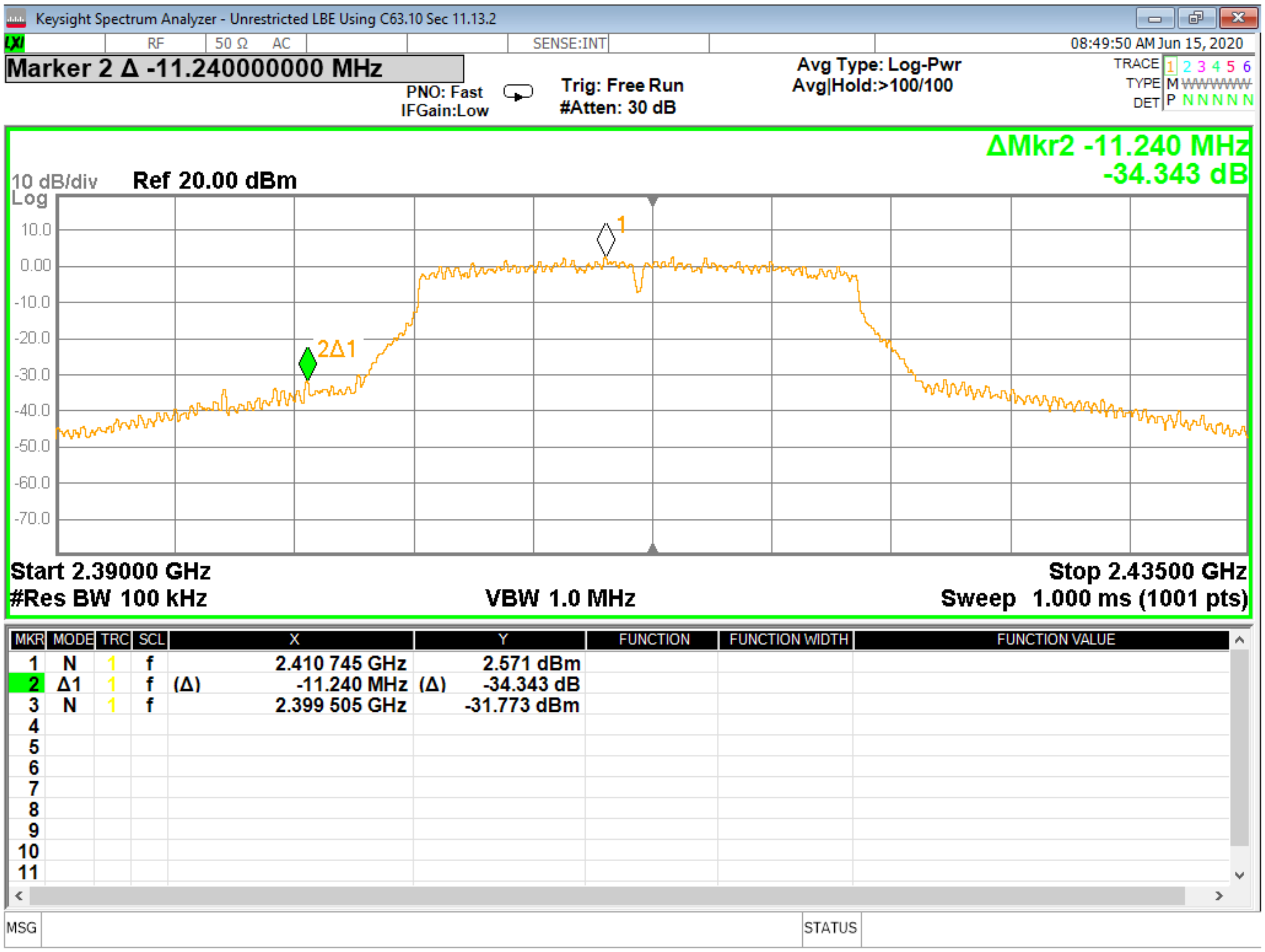



Figure 41 - Band-edge Measurement, Low Channel, Fundamental, Peak

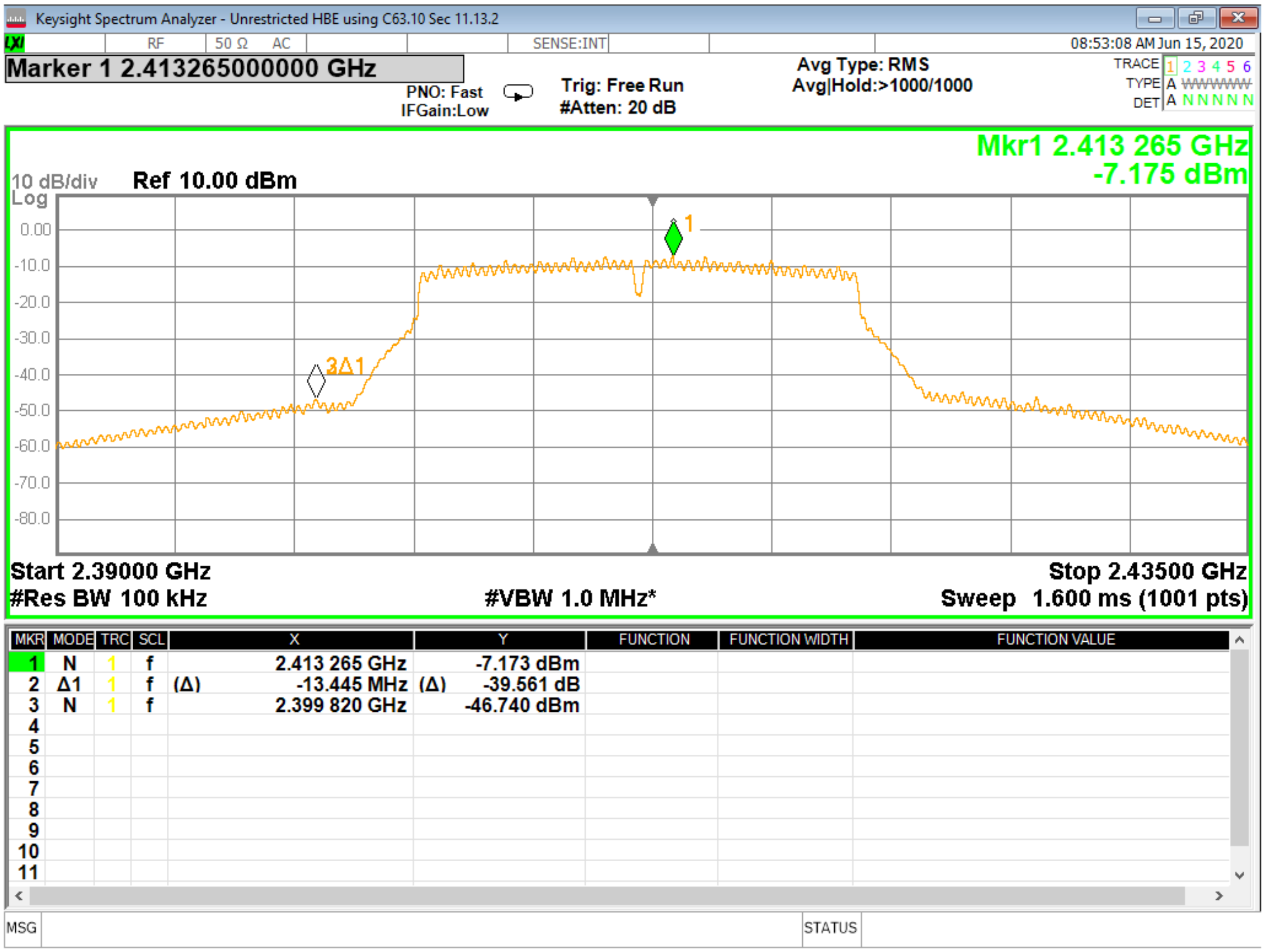



Figure 42 - Band-edge Measurement, Low Channel, Fundamental, Average

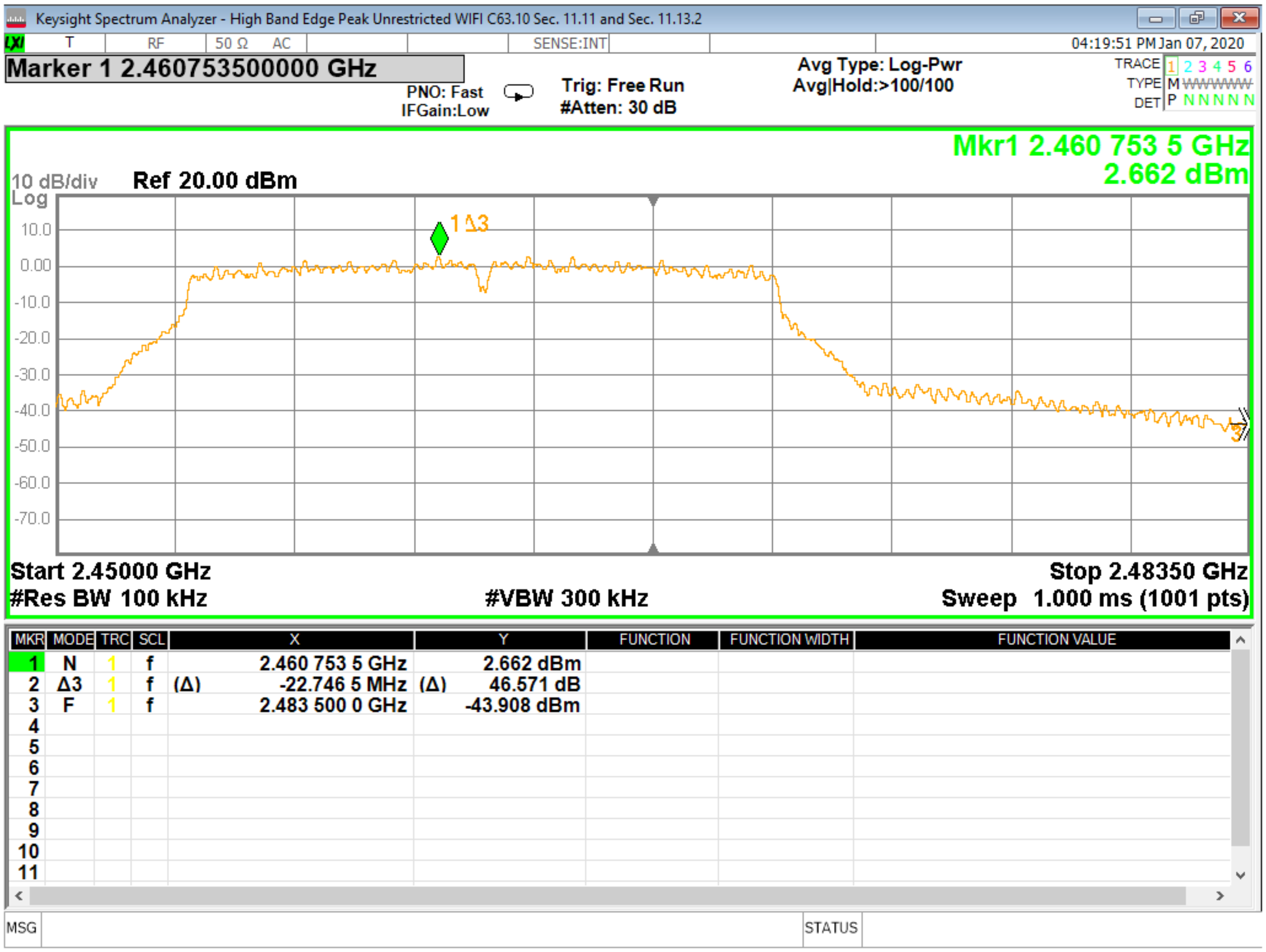
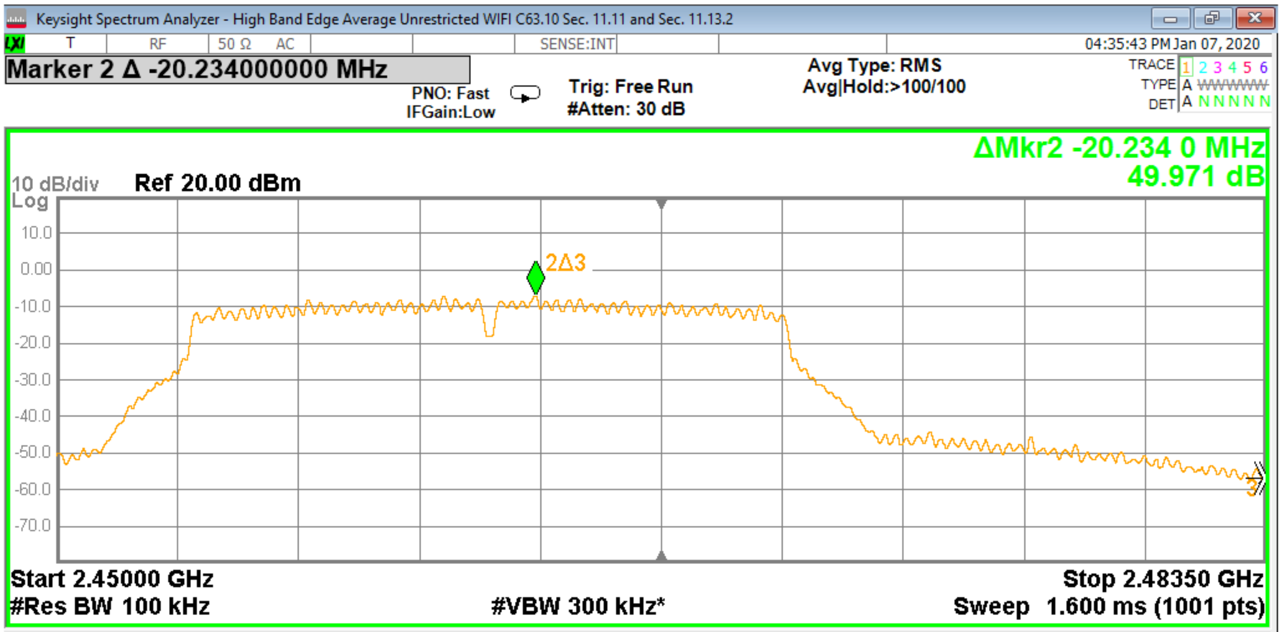



Figure 43 - Band-edge Measurement, High Channel, Fundamental, Peak




| MKR | MODE | TRC | SCL | X | Y | FUNCTION | FUNCTION WIDTH | FUNCTION VALUE |
|---|---|---|---|---|---|---|---|---|
| 1 | N | 1 | f | 2.463 266 0 GHz | -7.051 dBm | | | |
| 2 | Δ3 | 1 | f (Δ) | -20.234 0 MHz | (Δ) 49.971 dB | | | |
| 3 | F | 1 | f | 2.483 500 0 GHz | -57.031 dBm | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
| 7 | | | | | | | | |
| 8 | | | | | | | | |
| 9 | | | | | | | | |
| 10 | | | | | | | | |
| 11 | | | | | | | | |

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

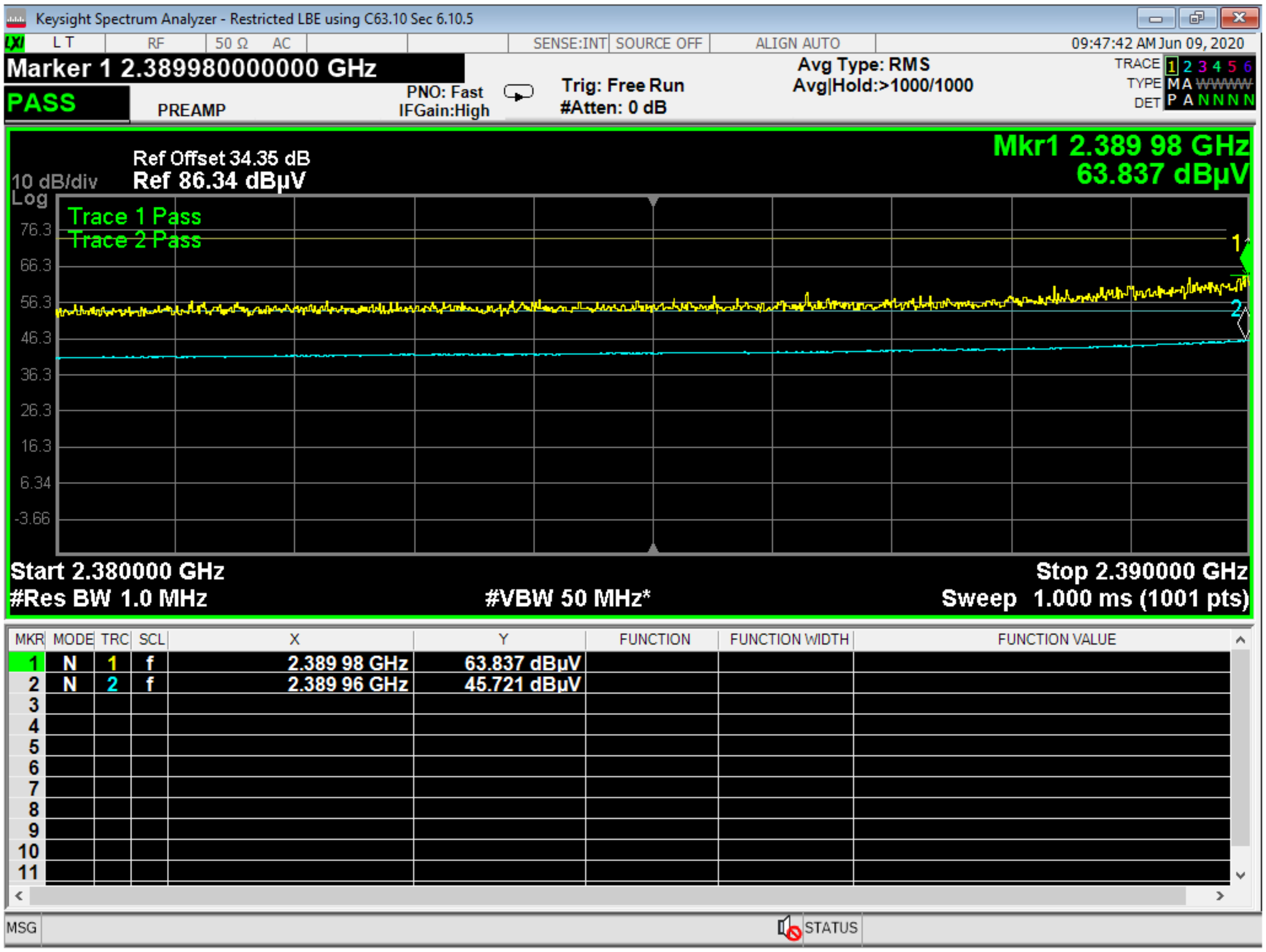



Figure 45 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak and Average

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.

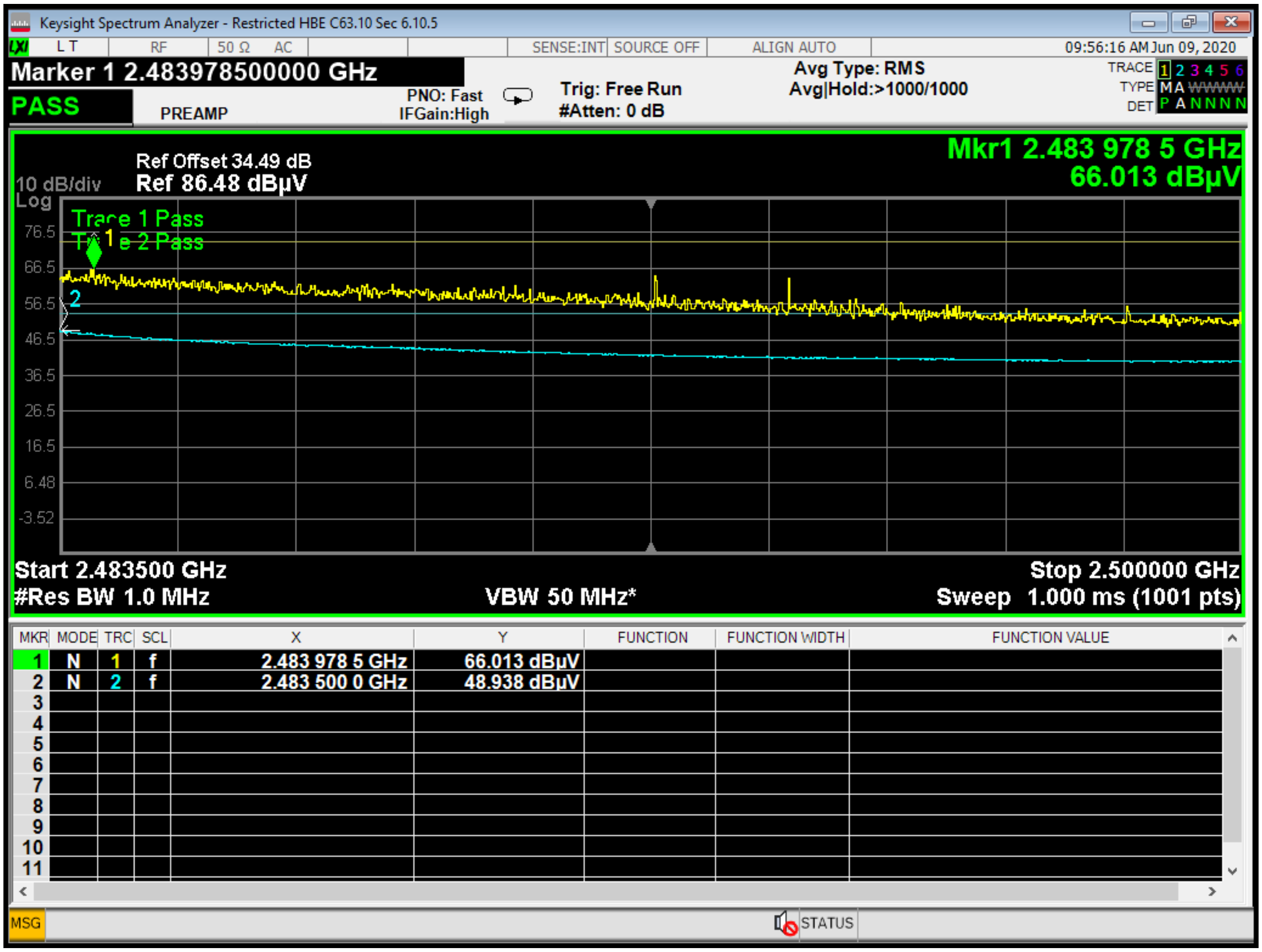



**Figure 46 - Band-edge Measurement, High Channel, Restricted Frequency, Peak and Average**

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.

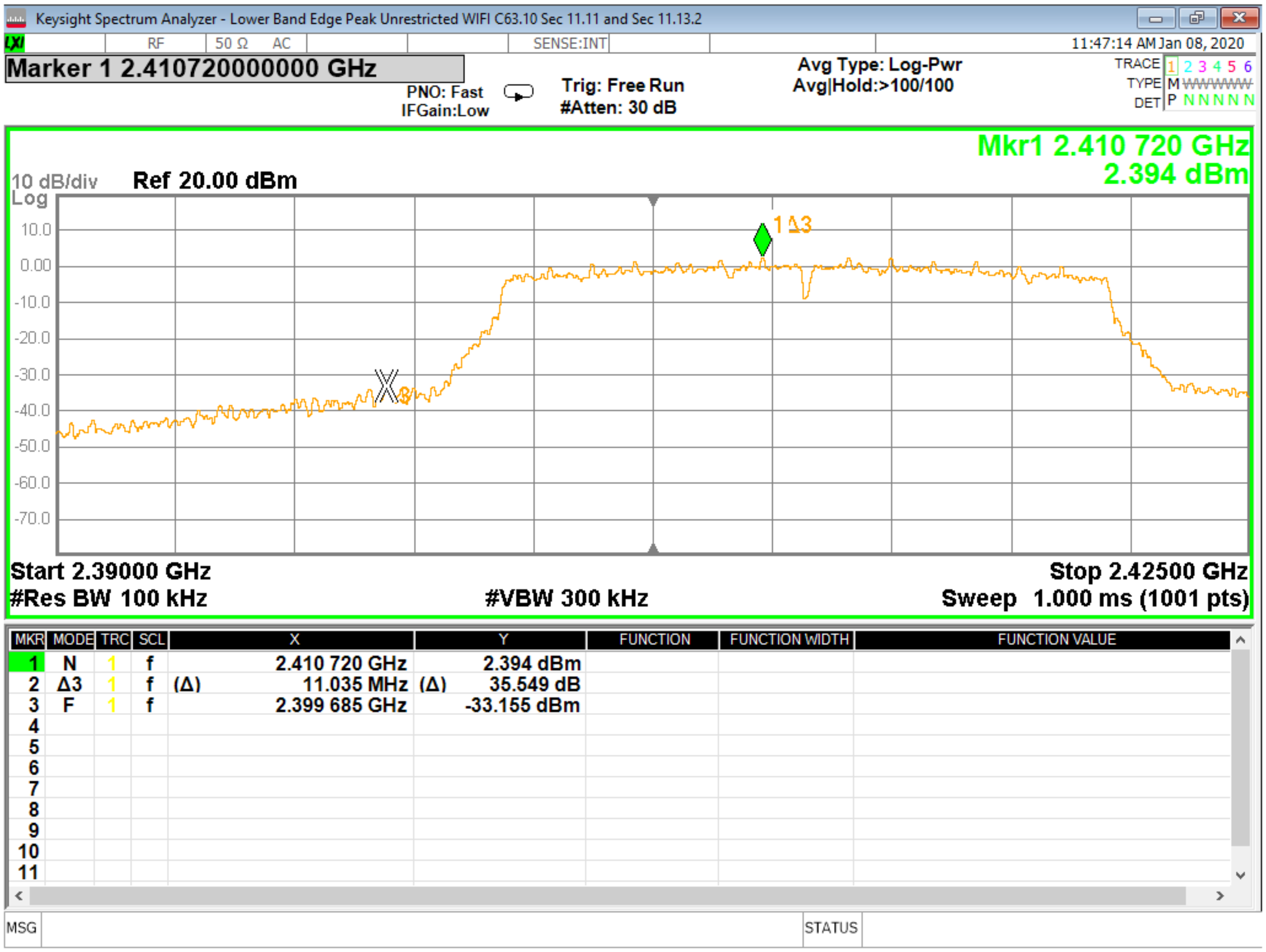



Figure 47 - Band-edge Measurement, Low Channel, Fundamental, Peak

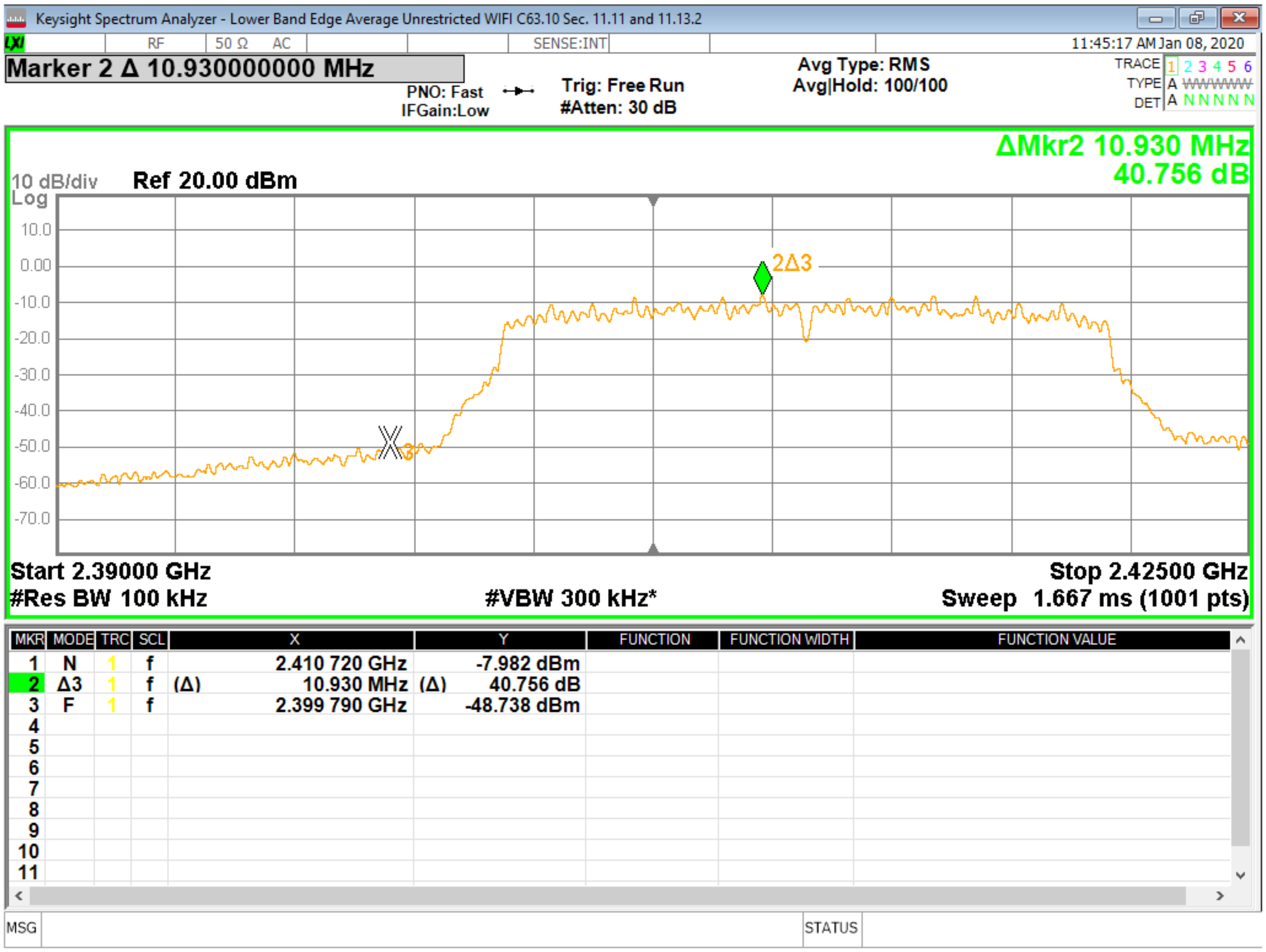



Figure 48 - Band-edge Measurement, Low Channel, Fundamental, Average

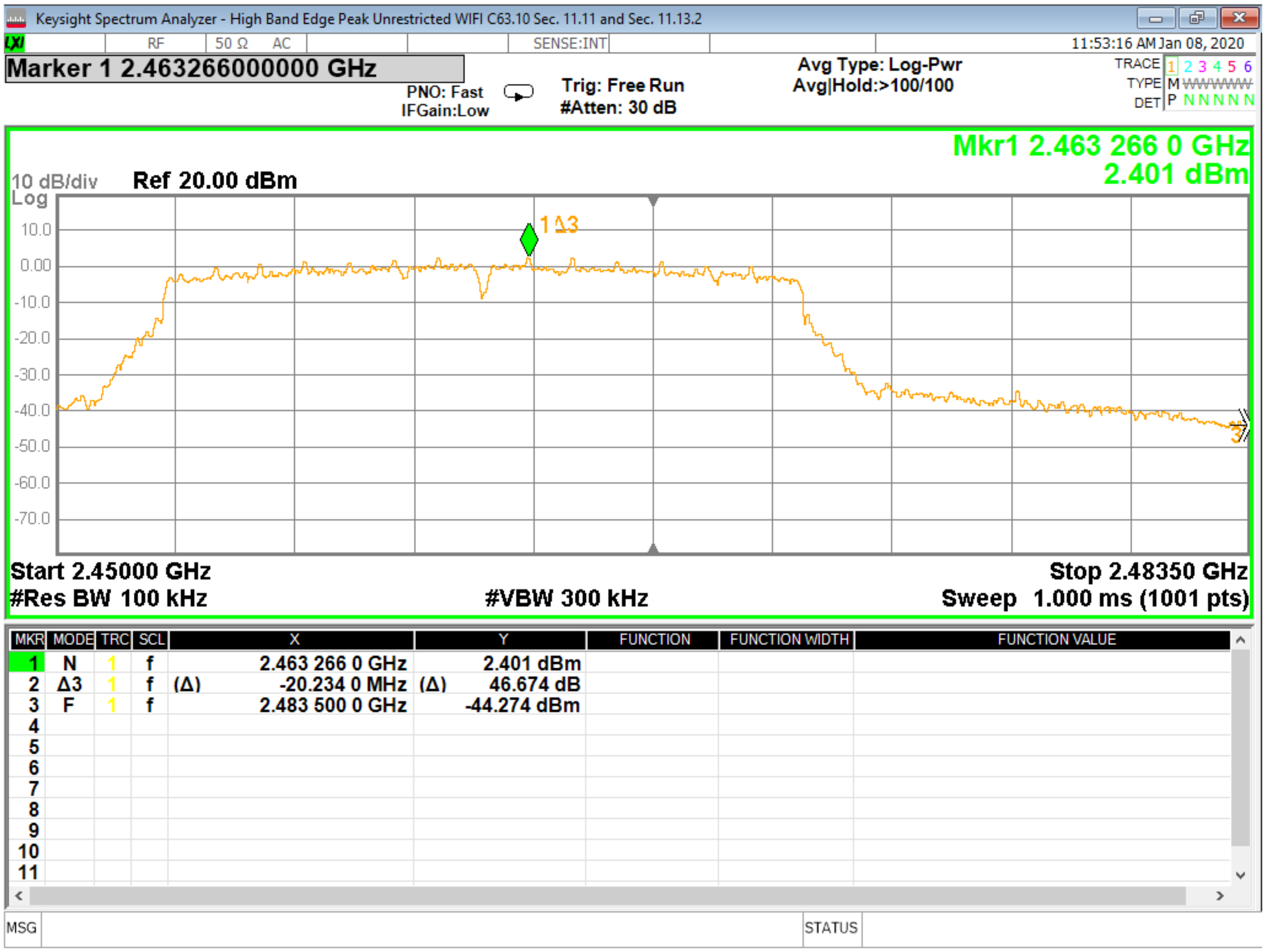
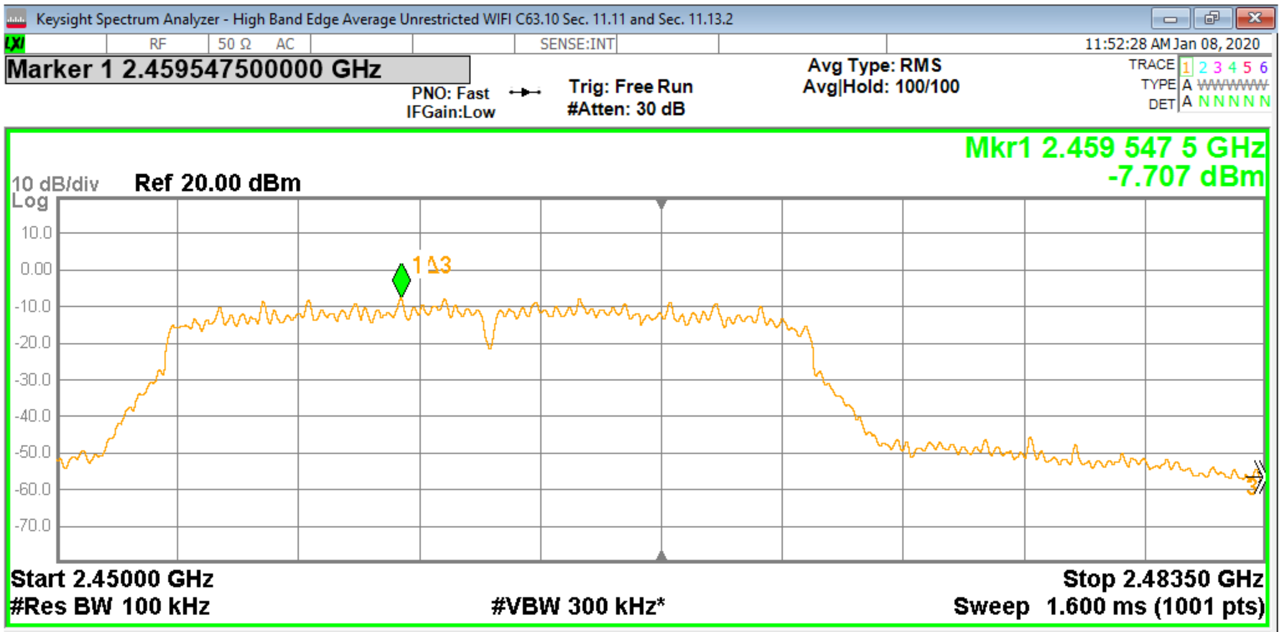



Figure 49 - Band-edge Measurement, High Channel, Fundamental, Peak




| MKR | MODE | TRC | SCL | | X | | Y | FUNCTION | FUNCTION WIDTH | FUNCTION VALUE |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | N | 1 | f | | 2.459 547 5 GHz | | -7.707 dBm | | | |
| 2 | Δ3 | 1 | f | (Δ) | -23.952 5 MHz | (Δ) | 49.076 dB | | | |
| 3 | F | 1 | f | | 2.483 500 0 GHz | | -56.782 dBm | | | |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |
| 11 | | | | | | | | | | |

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

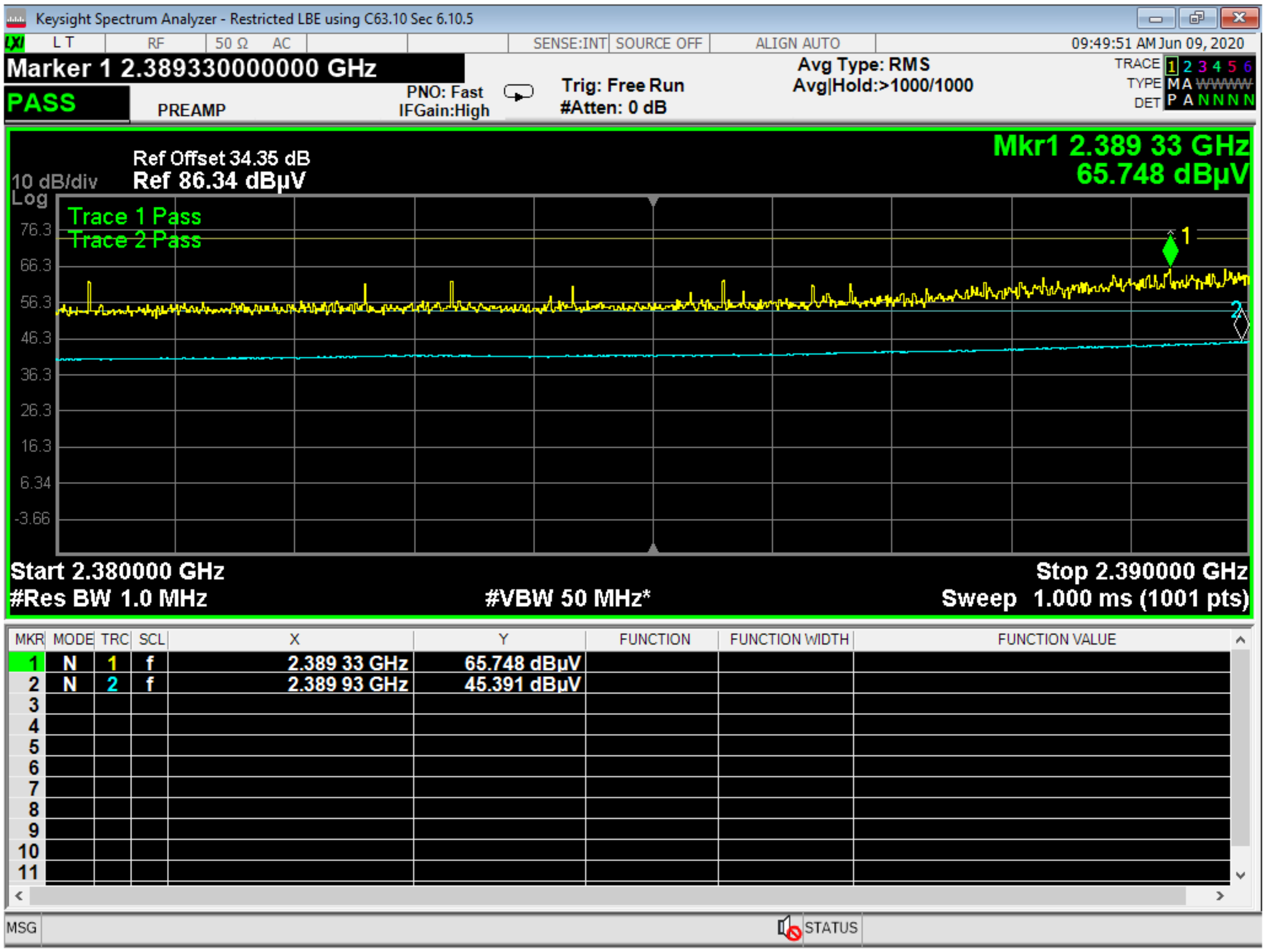



Figure 51 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak and Average

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.

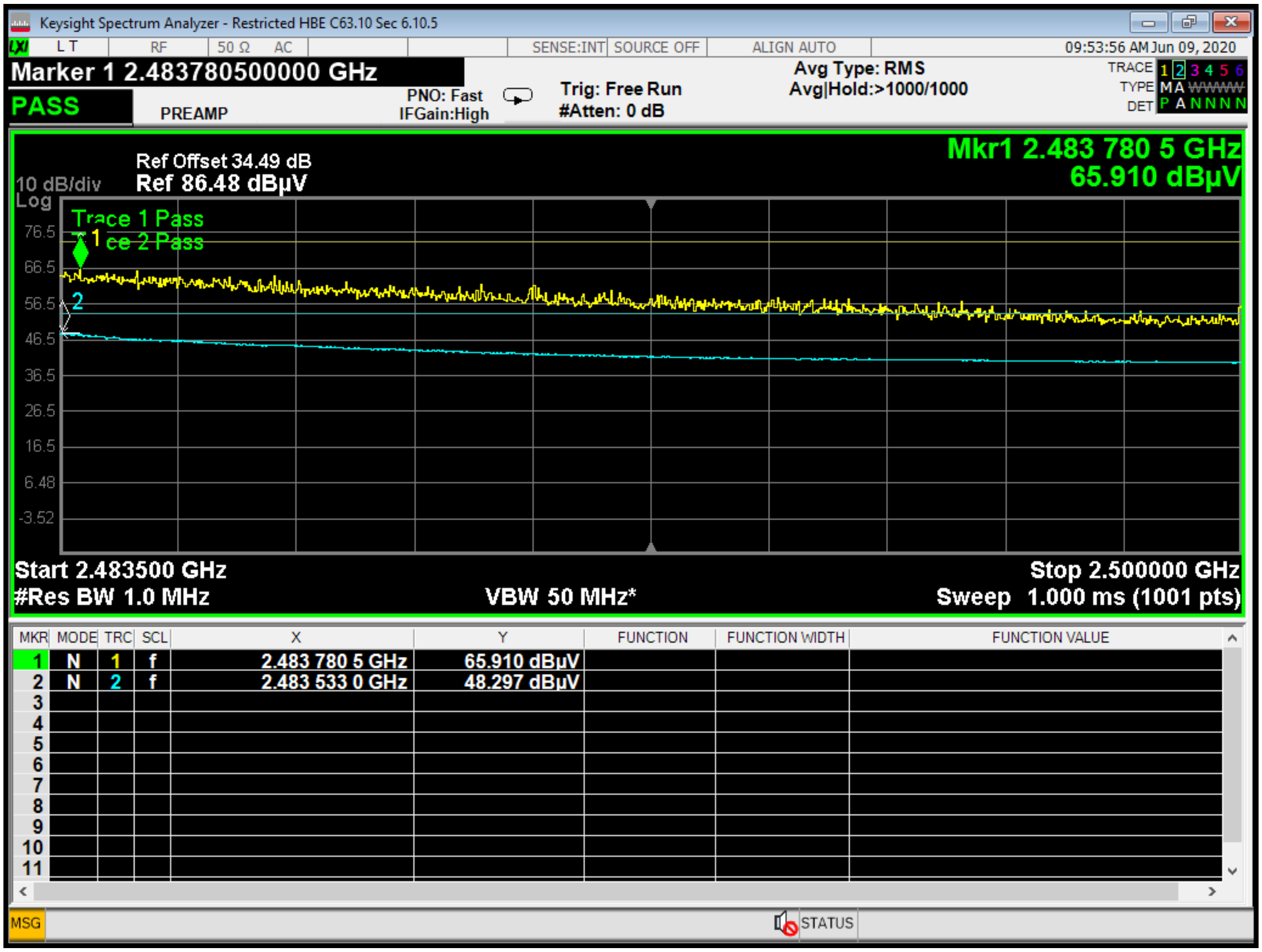



Figure 52 - Band-edge Measurement, High Channel, Restricted Frequency, Peak and Average

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 |

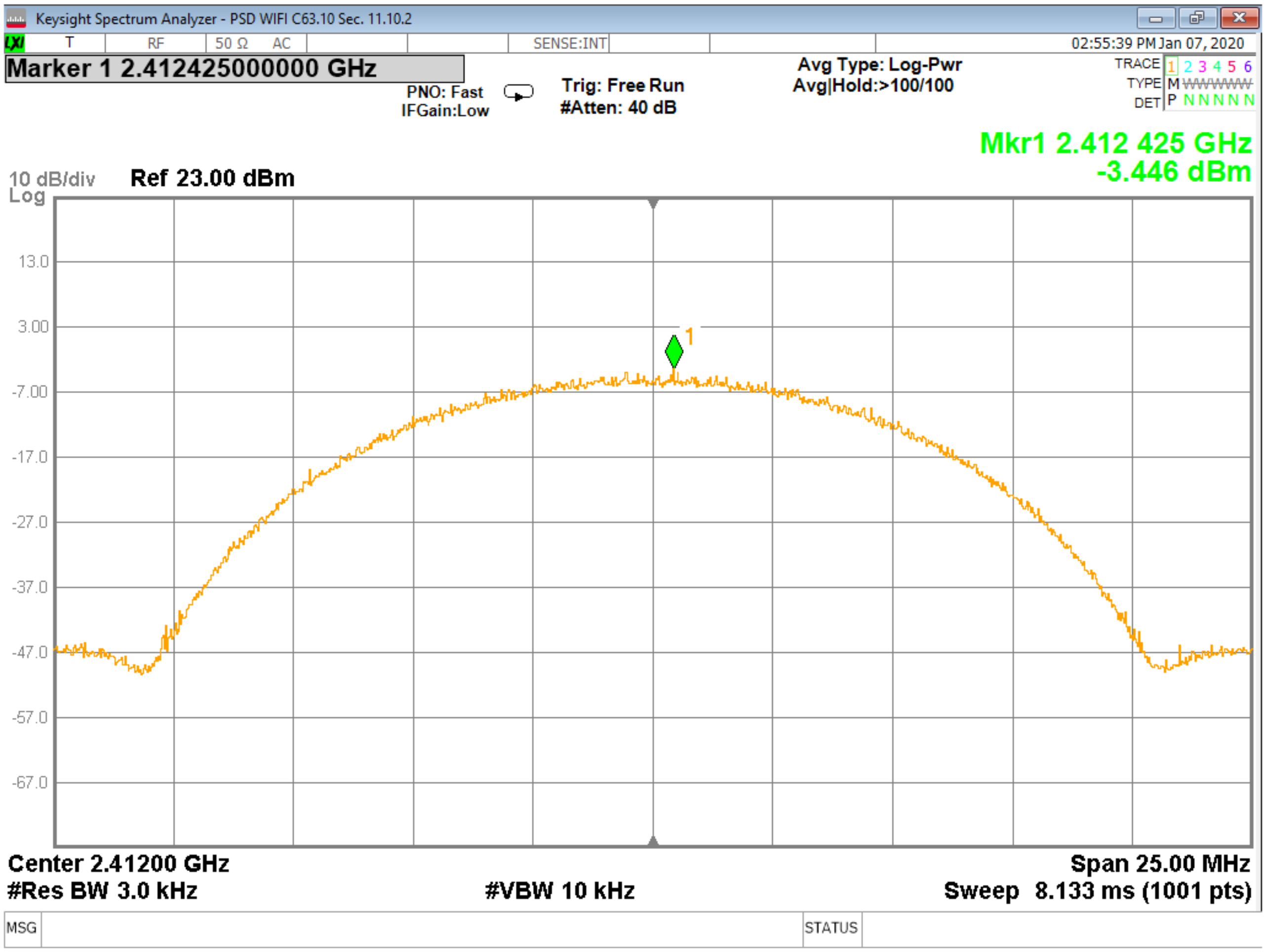



Figure 53 - Power Spectral Density, Low Channel, 802.11b

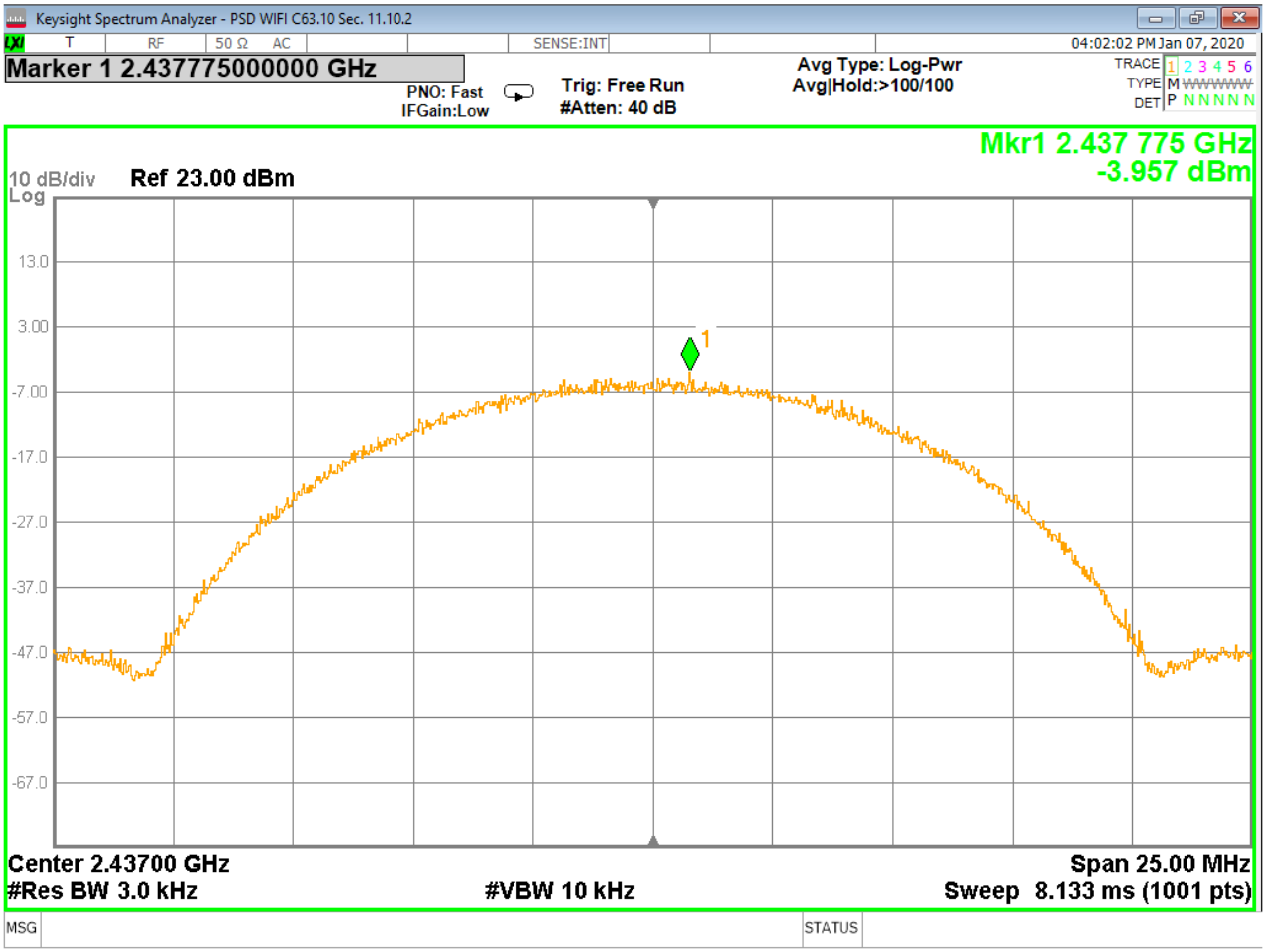



Figure 54 - Power Spectral Density, Mid Channel, 802.11b

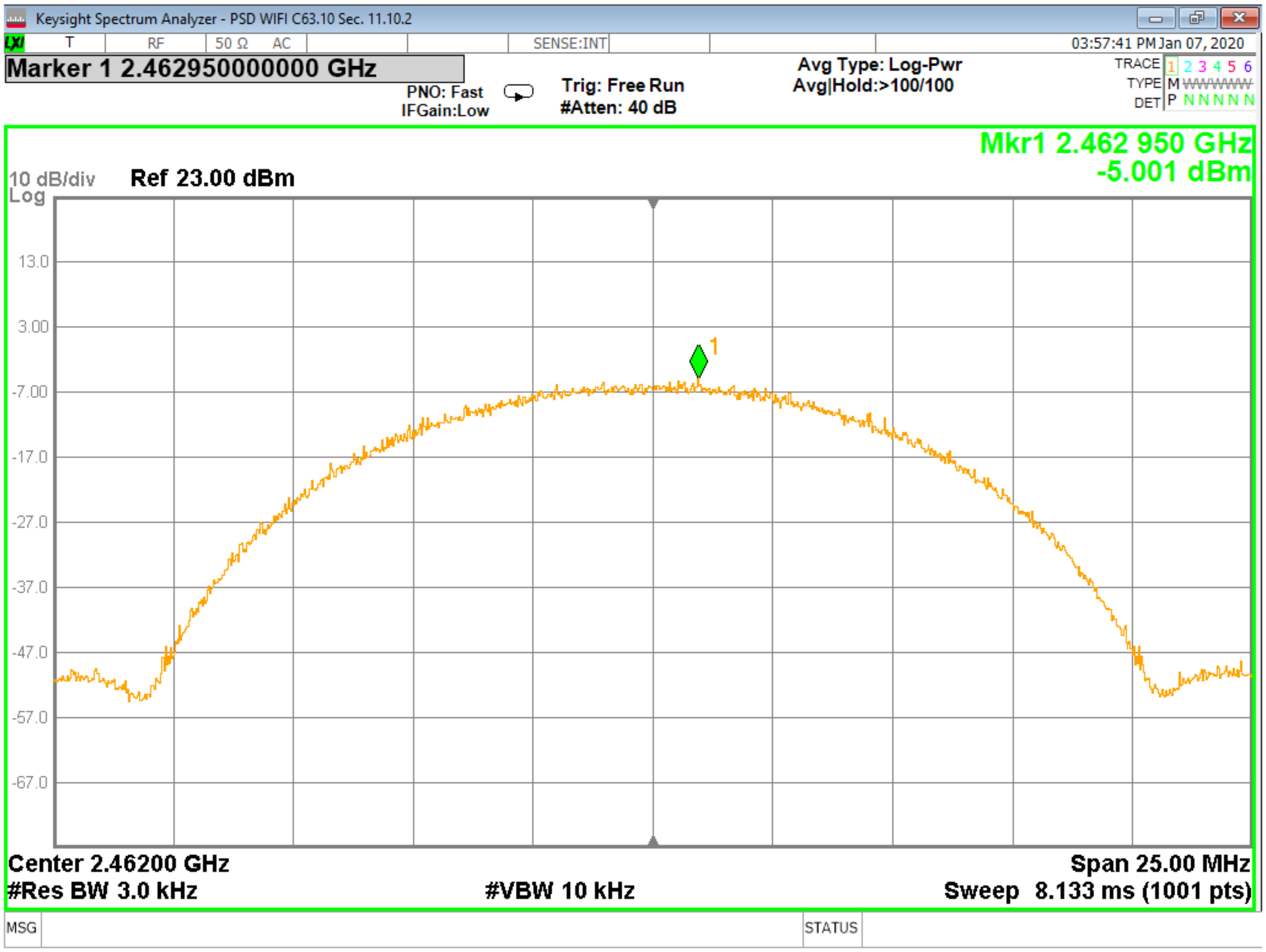



Figure 55 - Power Spectral Density, High Channel, 802.11b

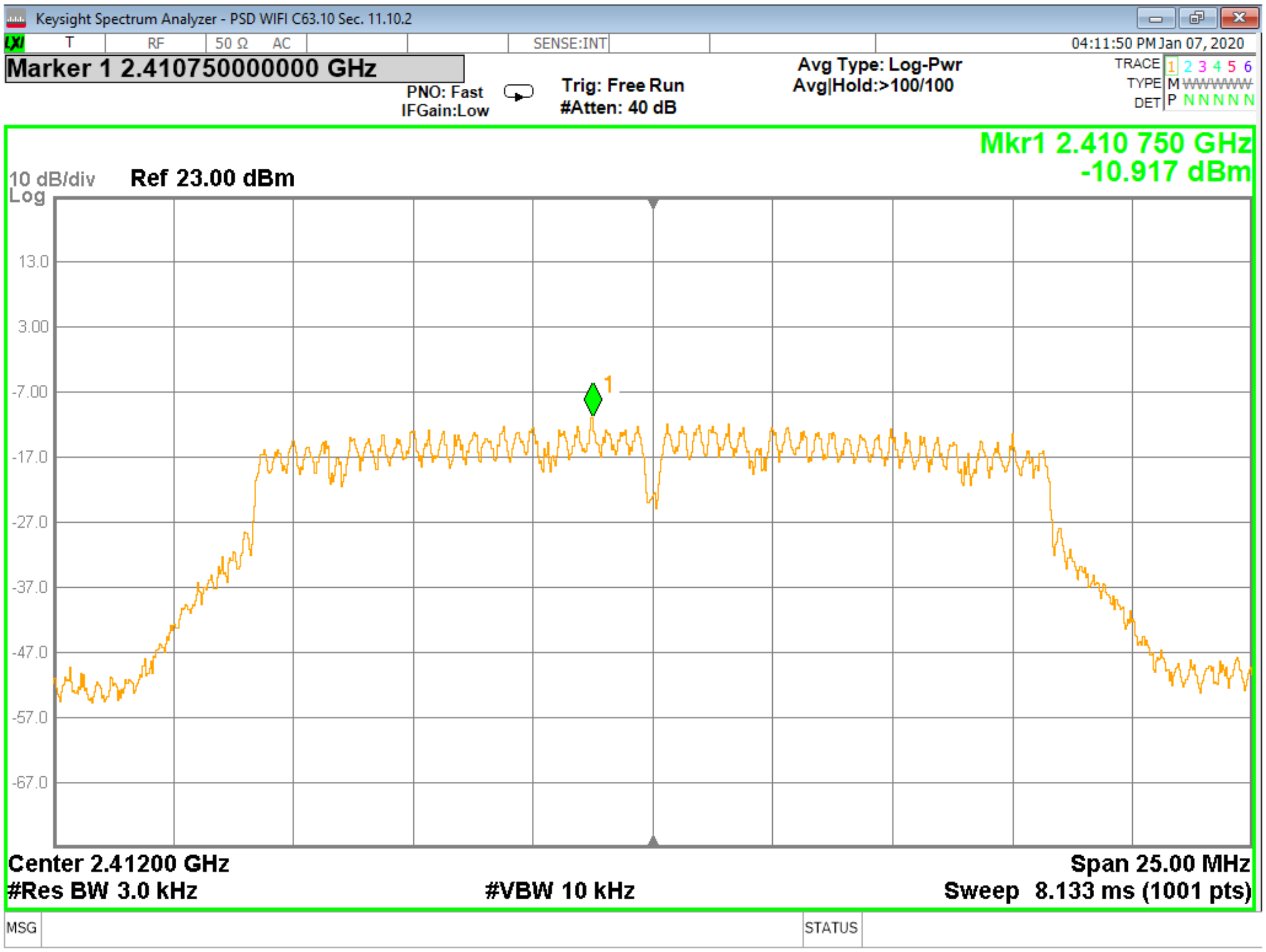



Figure 56 - Power Spectral Density, Low Channel, 802.11g

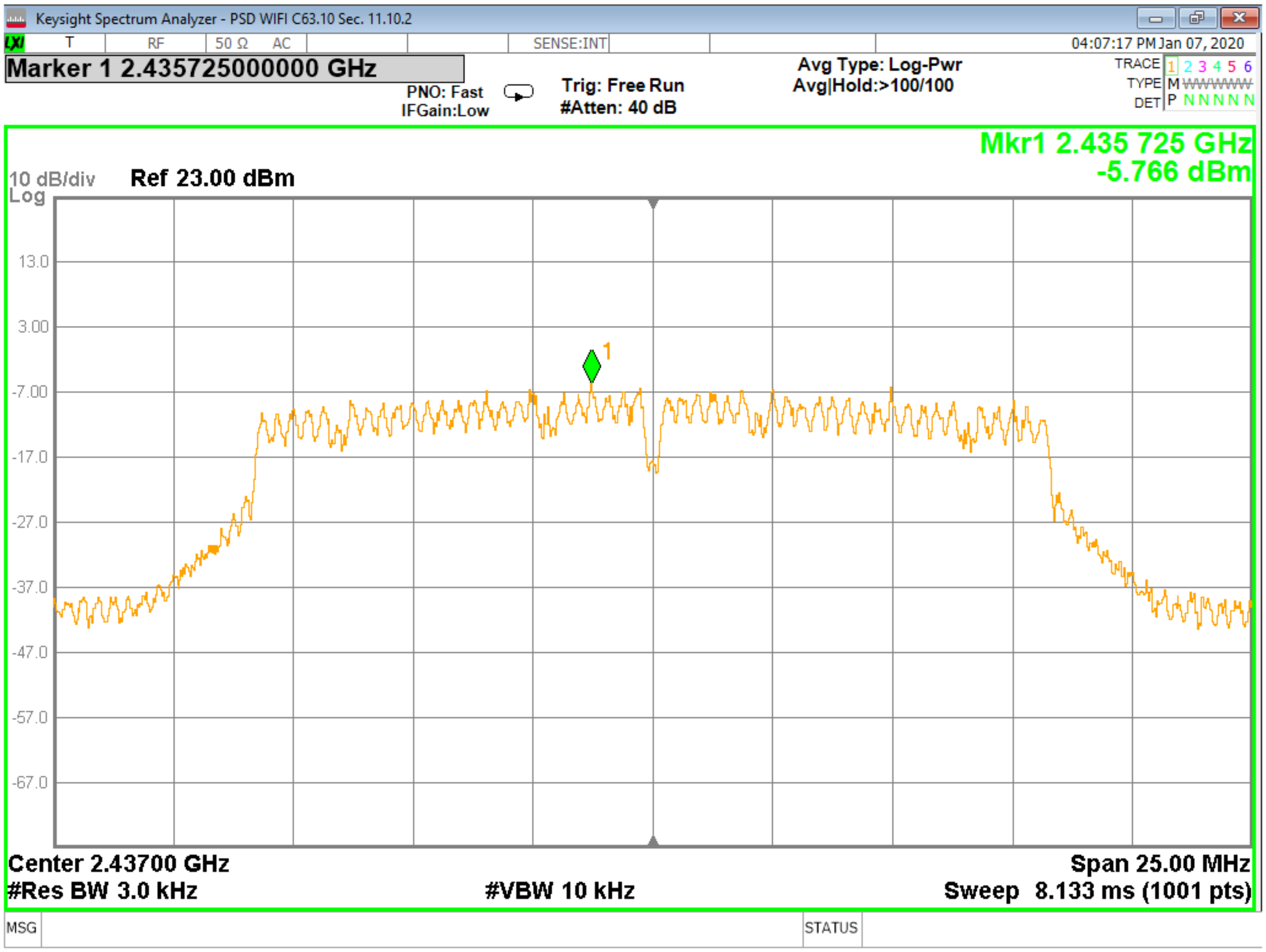



Figure 57 - Power Spectral Density, Mid Channel, 802.11g

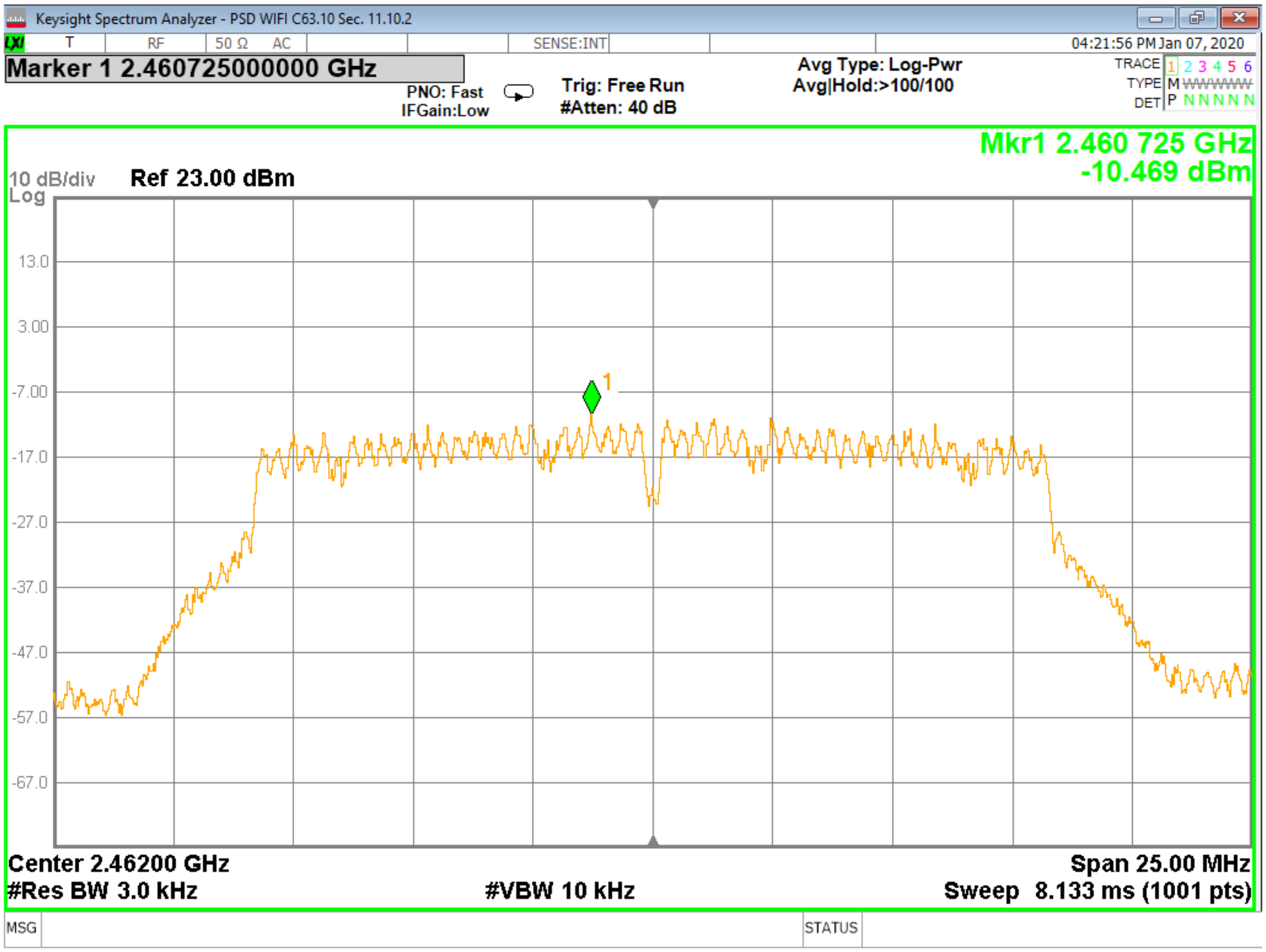



Figure 58 - Power Spectral Density, High Channel, 802.11g

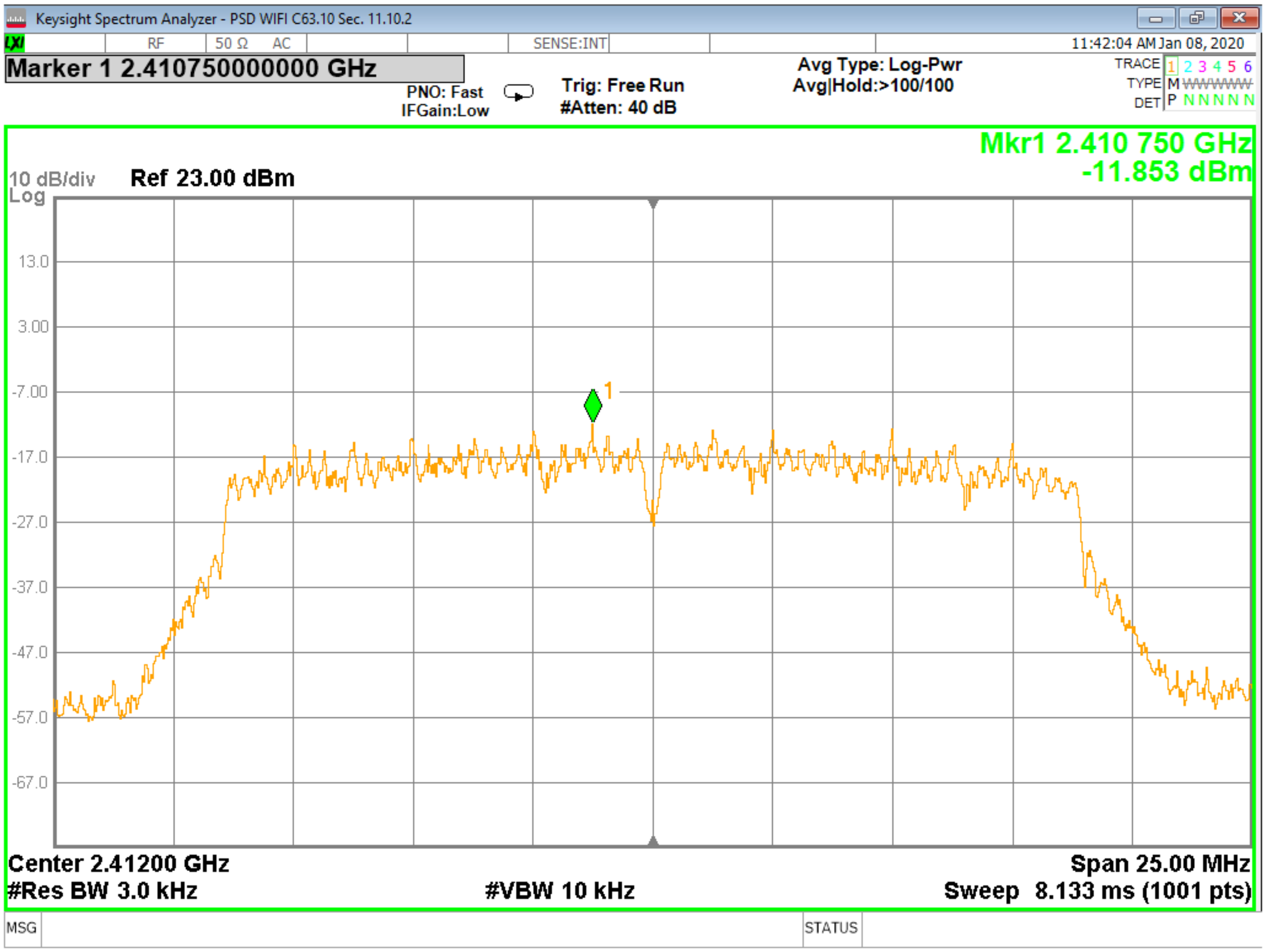



Figure 59 - Power Spectral Density, Low Channel, 802.11n

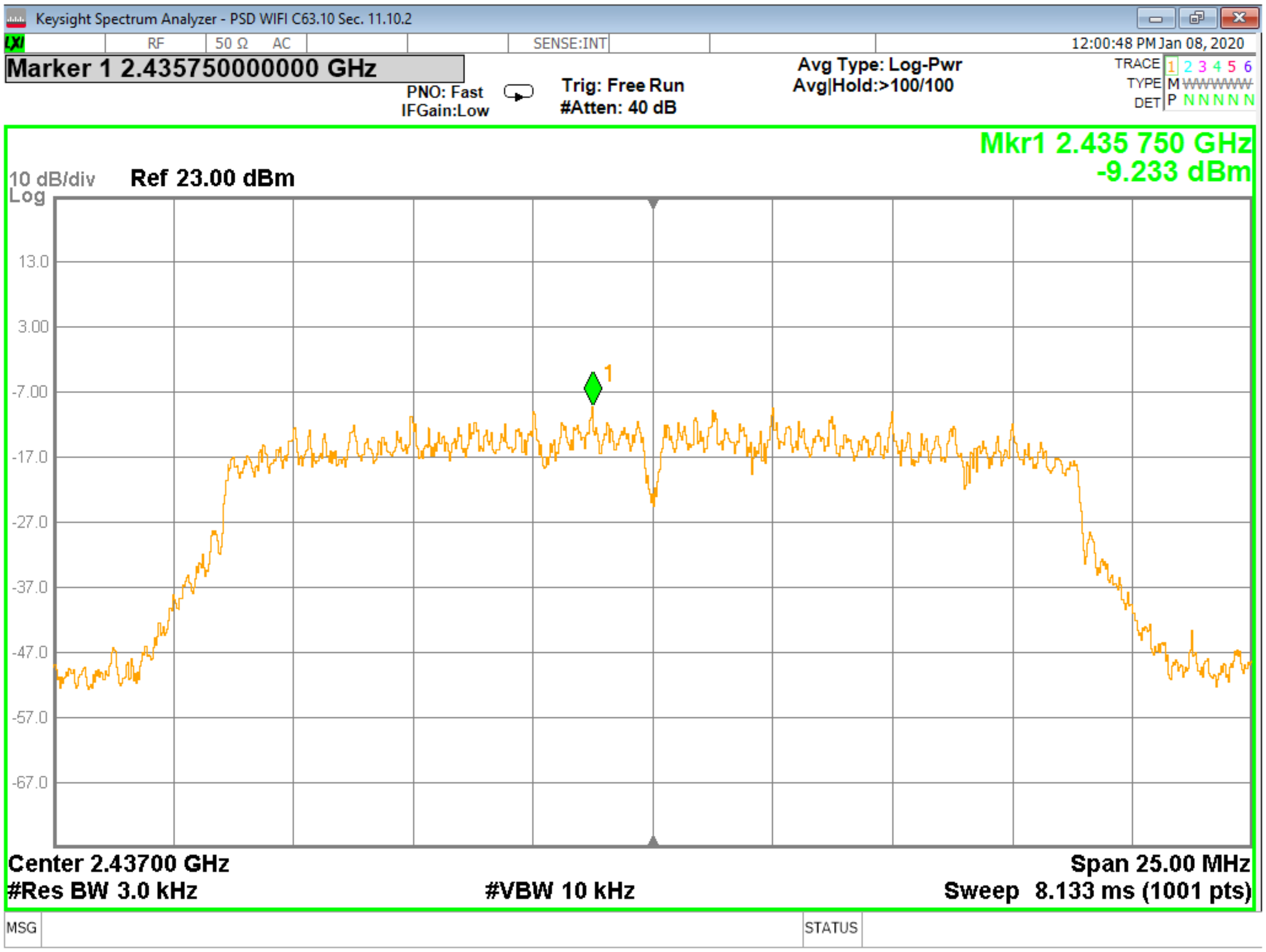



Figure 60 - Power Spectral Density, Mid Channel, 802.11n

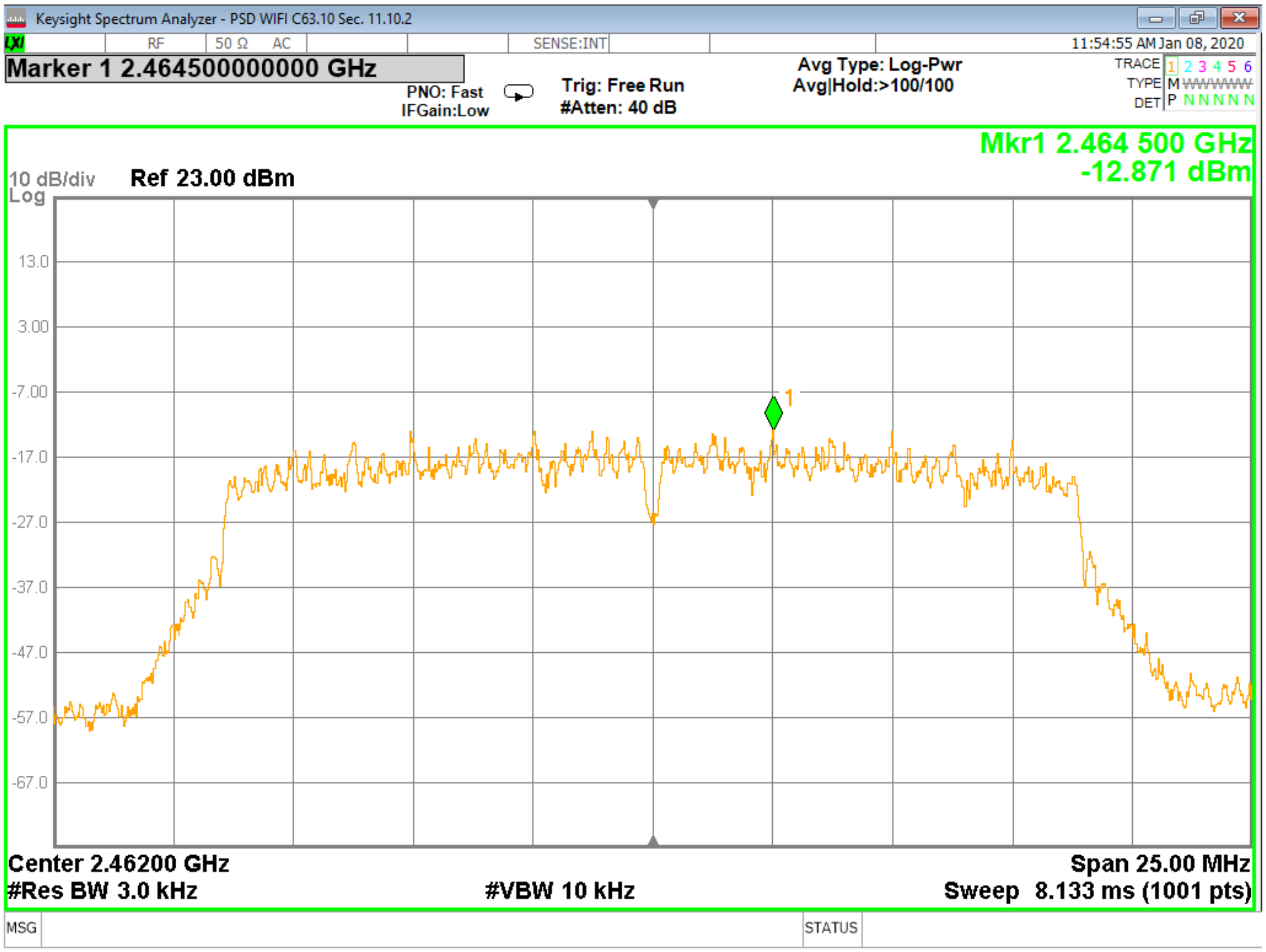



Figure 61 - Power Spectral Density, High Channel, 802.11n

## 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.

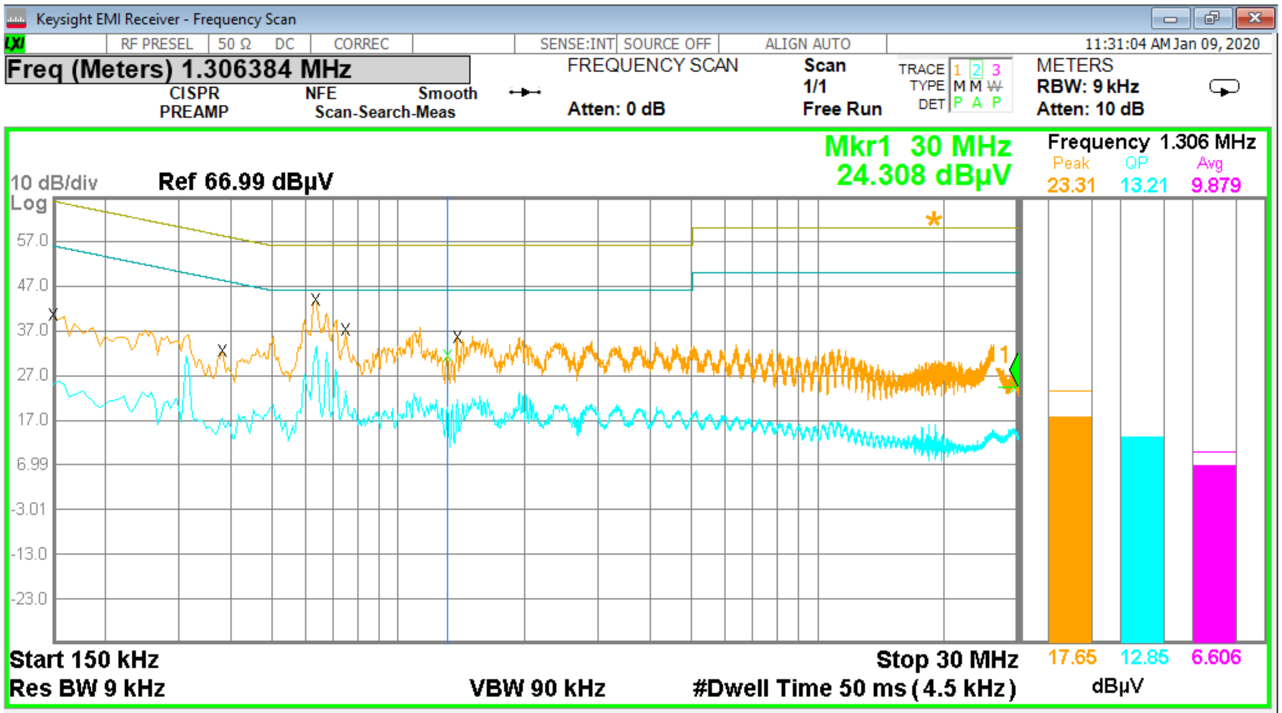
**Test Procedures:**

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.

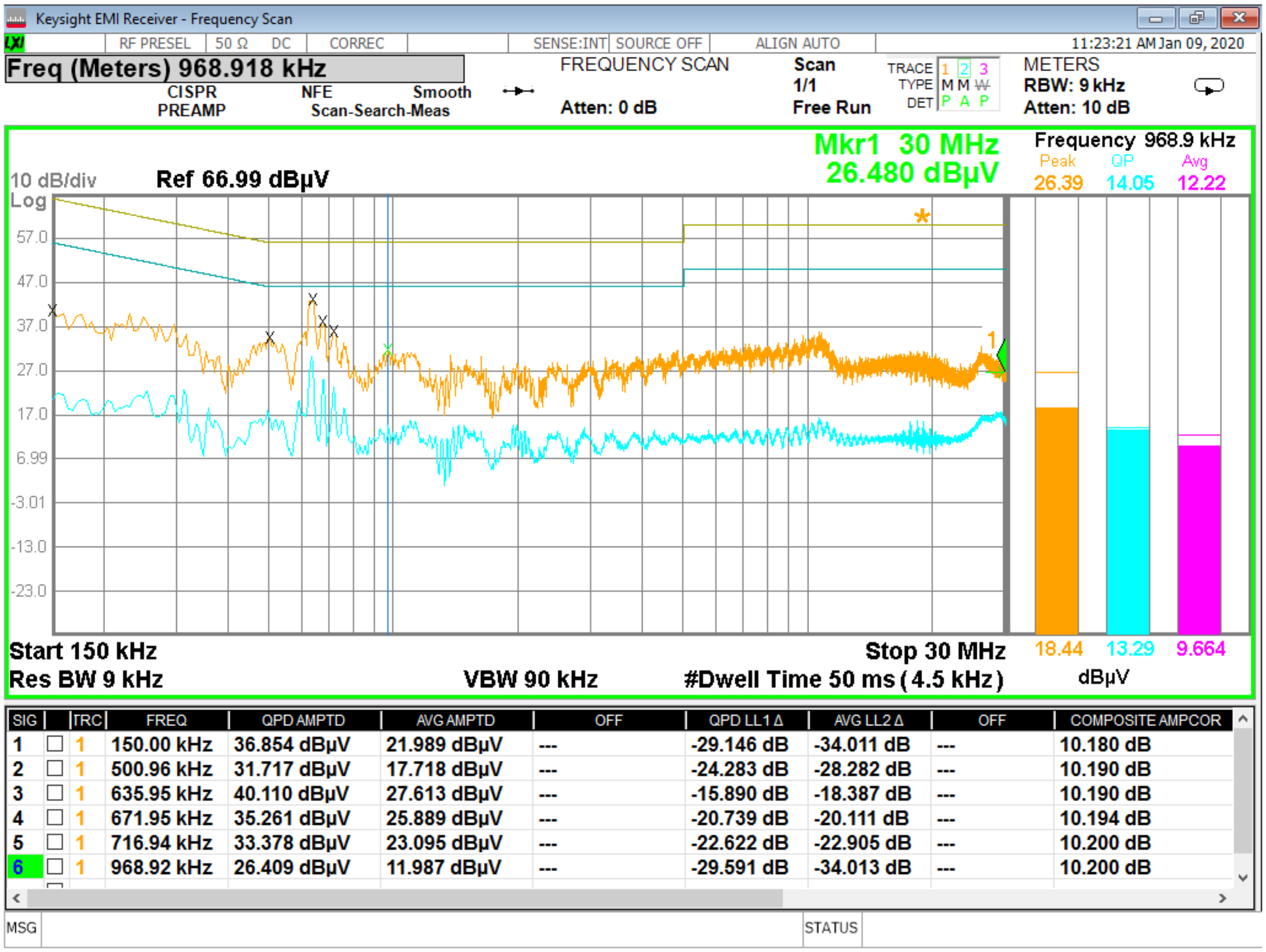
**Test Results:**




| 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 |

MSG STATUS

**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