

FCC/ISED Test Report

Prepared for: Garmin International Inc.

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

Product: AA3556

Test Report No: R20190123-20-05A

Approved By:



Nic S. Johnson, NCE

Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: 13 August 2019


Total Pages: 82

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REVISION PAGE

| Rev. No. | Date | Description |
|----------|----------------|---|
| 0 | 28 June 2019 | Original – NJohnson Prepared by KVepuri/CFarrington |
| A | 13 August 2019 | Includes NCEE Labs report R20190123-20-05 and its amendment in full -NJ |

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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 | N/A |
| 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.

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2.0 EUT DESCRIPTION

2.1 EQUIPMENT UNDER TEST

The Equipment Under Test (EUT) was a portable battery powered transceiver from Garmin. It features 802.11b, 802.11g, 802.11n, GFSK and GMSK modules and has transmit and receives capabilities.

| | |
|----------------|--|
| EUT | Portable transceiver |
| Model | AA3556 |
| EUT Received | 10 June 2019 |
| EUT Tested | 11 June 2019- 26 June 2019 |
| Serial No. | 3994474026 (used for radiated tests); 3994474016 (used for conducted tests) |
| 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: PSAI10R-050Q |

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

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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 |

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

| | | | | |
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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 $35 \pm 4\%$
 Temperature of $22 \pm 3^{\circ}$ Celsius

3.2 TEST PERSONNEL


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

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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 EXA Signal Analyzer | N9010A | MY56070862 | 14 Dec 2018 | 14 Dec 2020 |
| EMCO Biconilog Antenna | 3142B | 1647 | 02 Aug 2017 | 02 Aug 2019 |
| EMCO Horn Antenna | 3115 | 6416 | 26 Jan 2018 | 26 Jan 2020 |
| EMCO Horn Antenna | 3116 | 2576 | 31 Jan 2018 | 31 Jan 2020 |
| Rohde & Schwarz Preamplifier | TS-PR18 | 3545700803 | 09 Mar 2018* | 09 Mar 2020* |
| Trilithic High Pass Filter | 6HC330 | 23042 | 09 Mar 2018* | 09 Mar 2020* |
| RF Cable (preamplifier to antenna) | MFR-57500 | 01-07-002 | 09 Mar 2018* | 09 Mar 2020* |
| RF Cable (antenna to 10m chamber bulkhead) | FSCM 64639 | 01E3872 | 09 Mar 2018* | 09 Mar 2020* |
| RF Cable (10m chamber bulkhead to control room bulkhead) | FSCM 64639 | 01E3874 | 09 Mar 2018* | 09 Mar 2020* |
| RF Cable (Control room bulkhead to RF switch) | FSCM 64639 | 01E3871 | 09 Mar 2018* | 09 Mar 2020* |
| RF Cable (RF switch to test receiver) | FSCM 64639 | 01F1206 | 09 Mar 2018* | 09 Mar 2020* |
| RF switch – Rohde and Schwarz | TS-RSP | 1113.5503.14 | 09 Mar 2018* | 09 Mar 2020* |
| N connector bulkhead (10m chamber) | PE9128 | NCEEBH1 | 09 Mar 2018* | 09 Mar 2020* |
| N connector bulkhead (control room) | PE9128 | NCEEBH2 | 09 Mar 2018* | 09 Mar 2020* |
| Rohde & Schwarz power meter | NRVD | 036029/012 | 07 Aug 2018 | 07 Aug 2019 |
| Rohde & Schwarz power sensor | URV5-Z2 | 836416/022 | 07 Aug 2018 | 07 Aug 2019 |


*Internal Characterization

| | | | | |
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4.0 DETAILED RESULTS

4.1 DUTY CYCLE

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

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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 non-restricted 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.

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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 from 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.

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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:

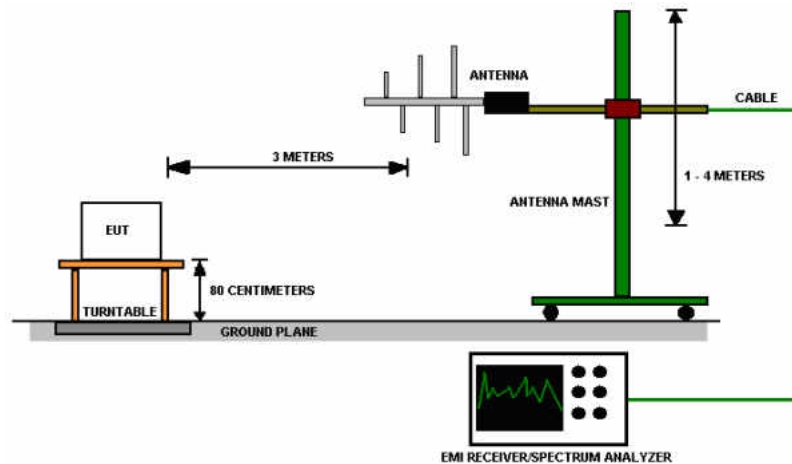



Figure 1 - Radiated Emissions Test Setup

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.

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Test results:

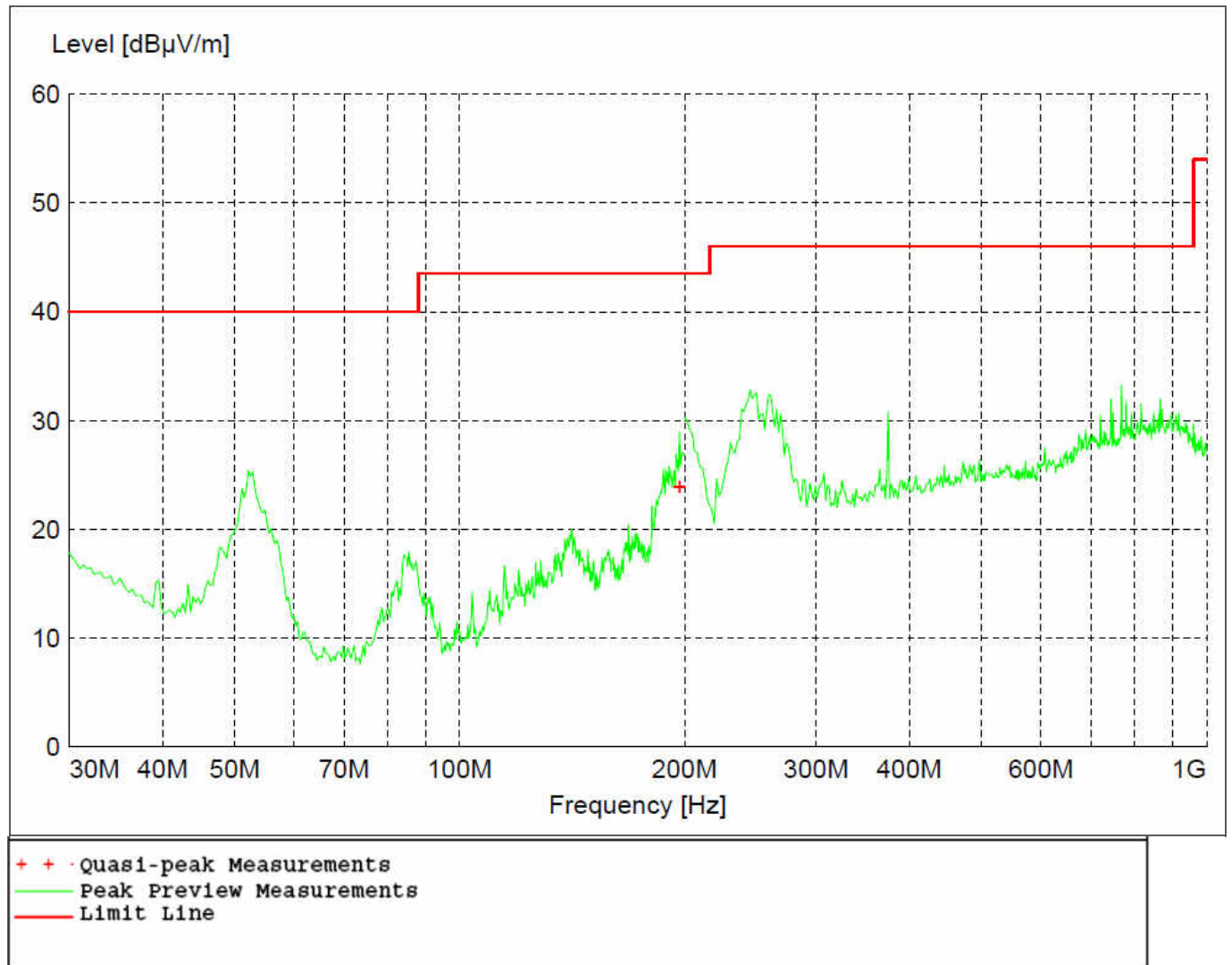



Figure 2 - Radiated Emissions Plot, Receive

Table 1 - Radiated Emissions Quasi-peak and Peak Measurements, Receive, 802.11b

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|------------|--------|--------|--------|--------|-------|------|
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | |
| 197.040000 | 23.97 | 43.50 | 19.50 | 143 | 358 | HORI |

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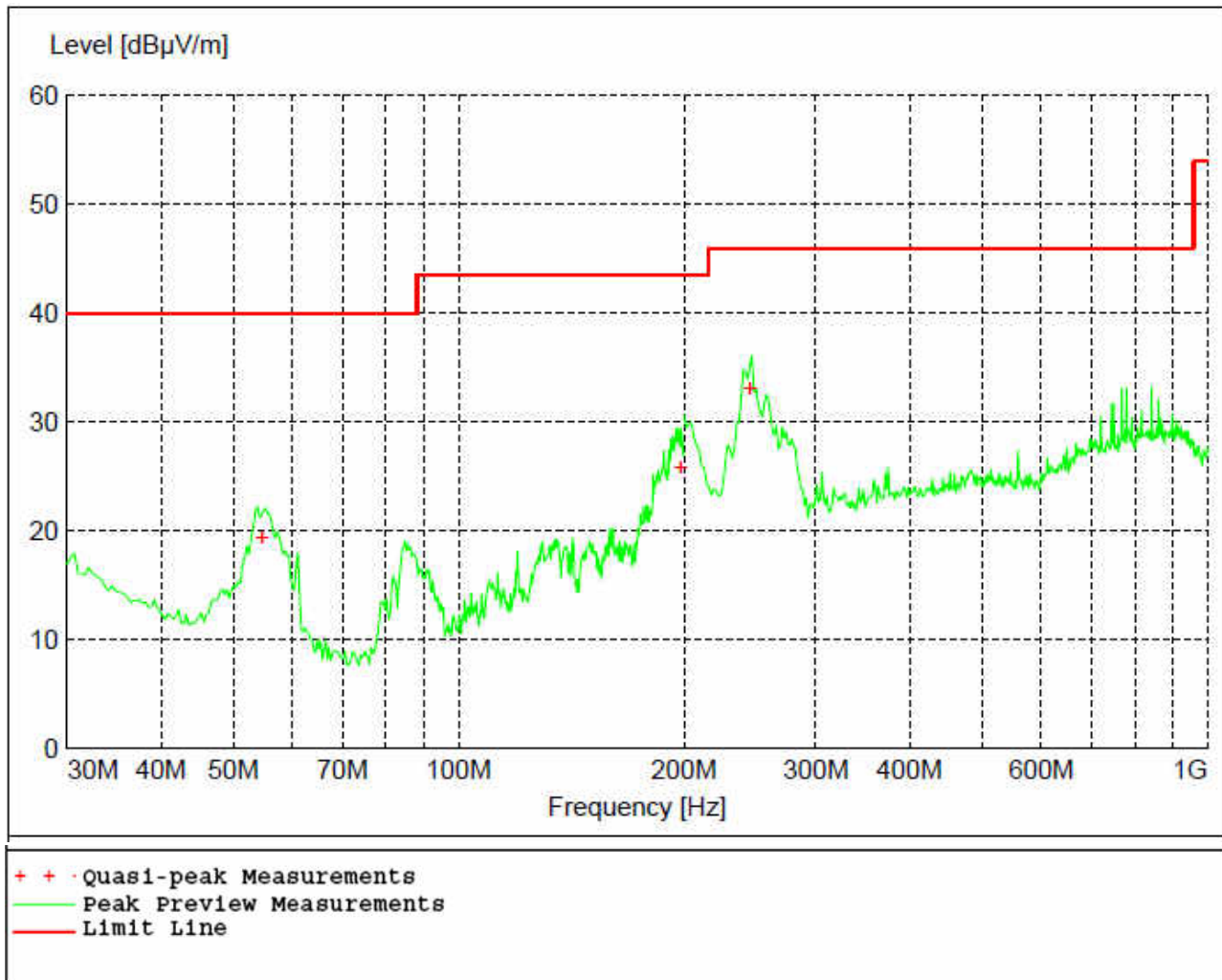



Figure 3 - Radiated Emissions Plot, 802.11b

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

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|------------|--------|--------|--------|--------|-------|------|
| MHz | dBμV/m | dBμV/m | dB | cm. | deg. | |
| 54.720000 | 19.27 | 40.00 | 20.70 | 98 | 244 | VERT |
| 198.000000 | 25.72 | 43.50 | 17.80 | 134 | 353 | HORI |
| 245.160000 | 33.06 | 46.00 | 12.90 | 143 | 231 | HORI |

All modulations were measured for receive mode and 802.11b was found to produce the highest emissions, although all odes were similar within 2 dB.

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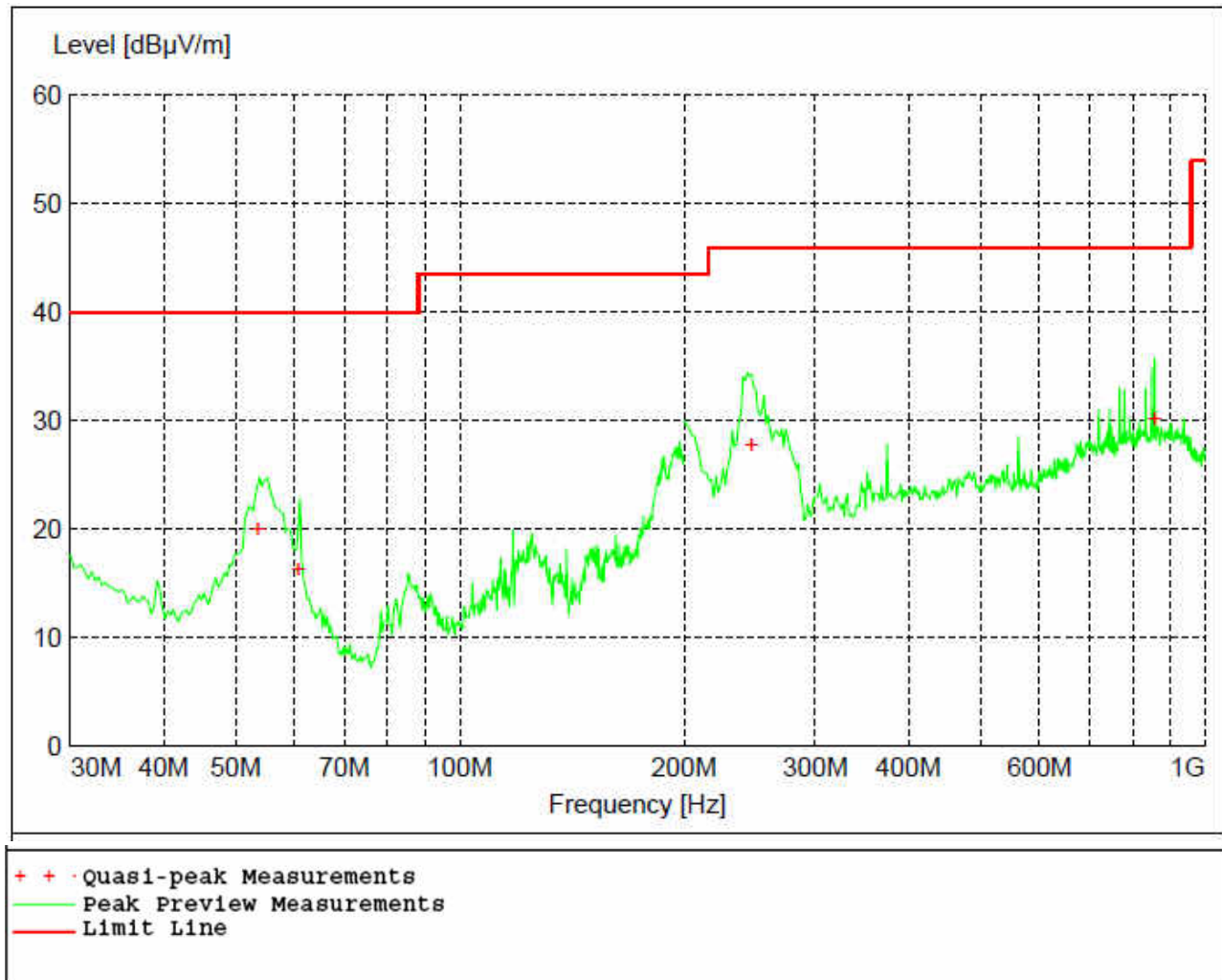



Figure 4 - Radiated Emissions Plot, 802.11g

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

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|------------|--------|--------|--------|--------|-------|------|
| MHz | dBμV/m | dBμV/m | dB | cm. | deg. | |
| 53.580000 | 19.96 | 40.00 | 20.00 | 99 | 285 | VERT |
| 60.720000 | 16.21 | 40.00 | 23.80 | 112 | 127 | VERT |
| 246.300000 | 27.69 | 46.00 | 18.30 | 137 | 70 | HORI |
| 857.160000 | 30.19 | 46.00 | 15.80 | 102 | 0 | HORI |

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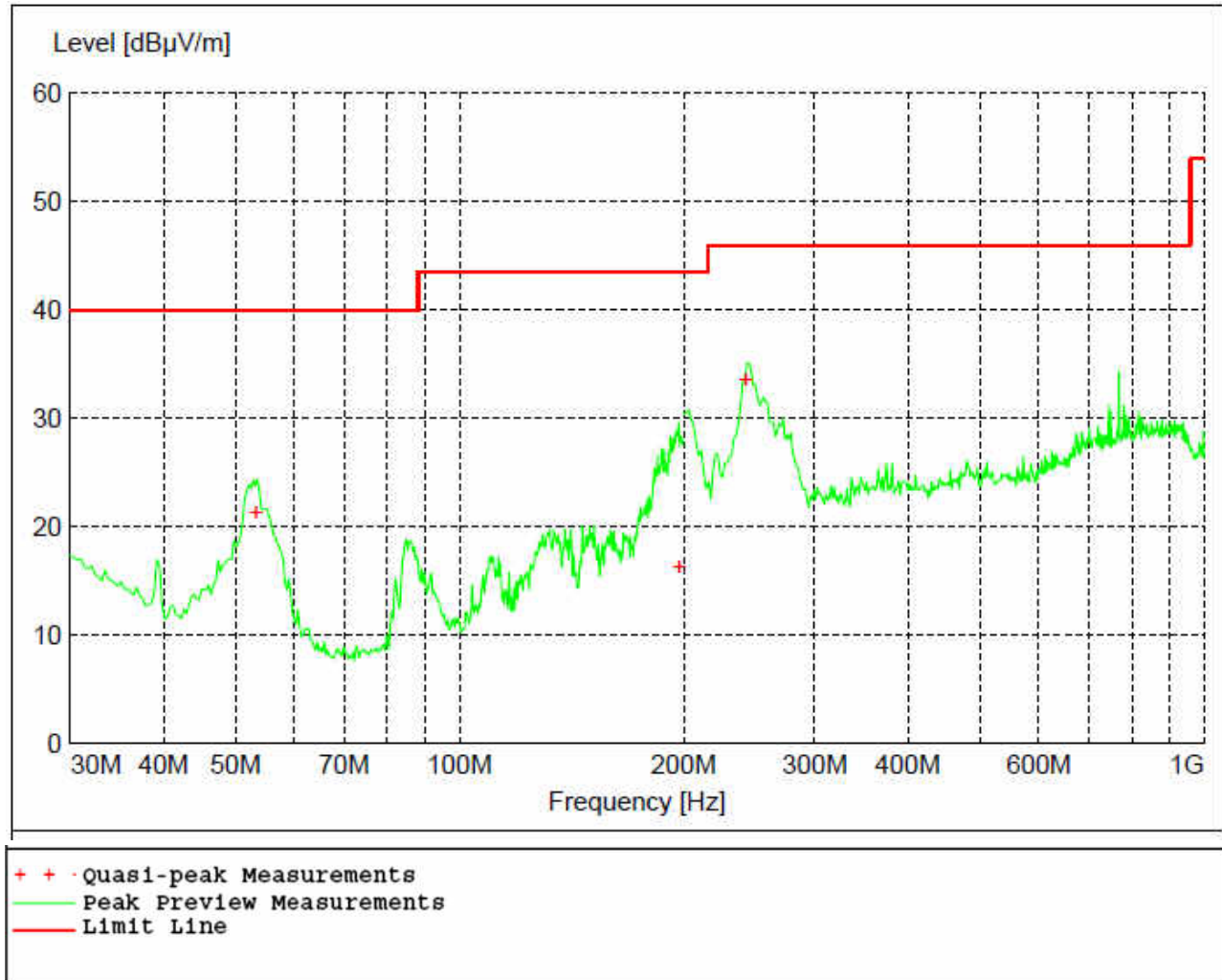


Figure 5 - Radiated Emissions Plot, 802.11n

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

| Frequency | Level | Limit | Margin | Height | Angle | Pol |
|------------|--------|--------|--------|--------|-------|------|
| MHz | dBμV/m | dBμV/m | dB | cm. | deg. | |
| 53.280000 | 21.21 | 40.00 | 18.80 | 100 | 235 | VERT |
| 197.280000 | 16.23 | 43.50 | 27.30 | 123 | 0 | HORI |
| 242.520000 | 33.48 | 46.00 | 12.50 | 129 | 222 | HORI |


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Table 5 - Radiated Emissions Average Measurements


| Frequency | Level | Limit | Margin | Height | Angle | Pol | Modulation |
|-------------|--------------|--------------|--------|--------|-------|------|------------|
| MHz | dB μ V/m | dB μ V/m | dB | cm. | deg. | | |
| 2412.000000 | 91.20 | NA | NA | 117 | 158 | HORI | 802.11 b |
| 2462.000000 | 90.16 | NA | NA | 170 | 314 | VERT | 802.11 b |
| 9648.000000 | 50.59 | 54.00 | 3.41 | 133 | 226 | HORI | 802.11 b |
| 2412.000000 | 84.40 | NA | NA | 119 | 165 | HORI | 802.11 g |
| 2462.000000 | 93.47 | NA | NA | 200 | 313 | VERT | 802.11 g |
| 2412.000000 | 80.69 | NA | NA | 201 | 63 | VERT | 802.11 n |
| 2437.000000 | 83.78 | NA | NA | 200 | 46 | HORI | 802.11 n |
| 2462.000000 | 80.83 | NA | NA | 99 | 166 | HORI | 802.11 n |

Table 6 - Radiated Emissions Peak Measurements

| Frequency | Level | Limit | Margin | Height | Angle | Pol | Modulation |
|-------------|--------------|--------------|--------|--------|-------|------|------------|
| MHz | dB μ V/m | dB μ V/m | dB | cm. | deg. | | |
| 2412.000000 | 100.68 | NA | NA | 117 | 158 | HORI | 802.11 b |
| 2462.000000 | 99.90 | NA | NA | 170 | 314 | VERT | 802.11 b |
| 9648.000000 | 54.35 | 74.00 | 19.65 | 133 | 226 | HORI | 802.11 b |
| 2412.000000 | 99.11 | NA | NA | 119 | 165 | HORI | 802.11 g |
| 2462.000000 | 97.76 | NA | NA | 200 | 313 | VERT | 802.11 g |
| 2412.000000 | 97.21 | NA | NA | 201 | 63 | VERT | 802.11 n |
| 2437.000000 | 100.03 | NA | NA | 200 | 46 | HORI | 802.11 n |
| 2462.000000 | 98.03 | NA | NA | 99 | 166 | HORI | 802.11 n |

REMARKS:

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

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4.3 OUTPUT POWER

Test Method: ANSI C63.10:
1. Section(s) 11.9.2.2.6

Limits of power measurements:
The maximum allowed peak 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. The intention was to verify that the measurement results were the same as the original filing for this device within the measurement uncertainty of the laboratory.

Deviations from test standard:
No deviation.

Test setup:

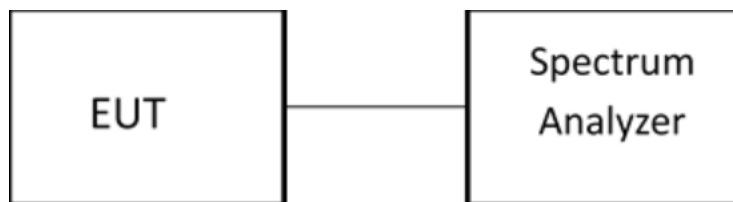



Figure 6 – Peak Output Power Measurements Test Setup

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

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Peak Output Power

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | PEAK OUTPUT POWER (dBm) MU = ± 1.1 dB | Method | RESULT |
|---------|-------------------------------|-----------|---|-----------|--------|
| Low | 2412 | 802.11b | 21.15 | Conducted | PASS |
| Middle | 2437 | 802.11b | 21.22 | Conducted | PASS |
| High | 2462 | 802.11b | 21.51 | Conducted | PASS |
| Low | 2412 | 802.11g | 17.79 | Conducted | PASS |
| Middle | 2437 | 802.11g | 19.91 | Conducted | PASS |
| High | 2462 | 802.11g | 18.45 | Conducted | PASS |
| Low | 2412 | 802.11n | 17.78 | Conducted | PASS |
| Middle | 2437 | 802.11n | 20.05 | Conducted | PASS |
| High | 2462 | 802.11n | 18.31 | Conducted | PASS |

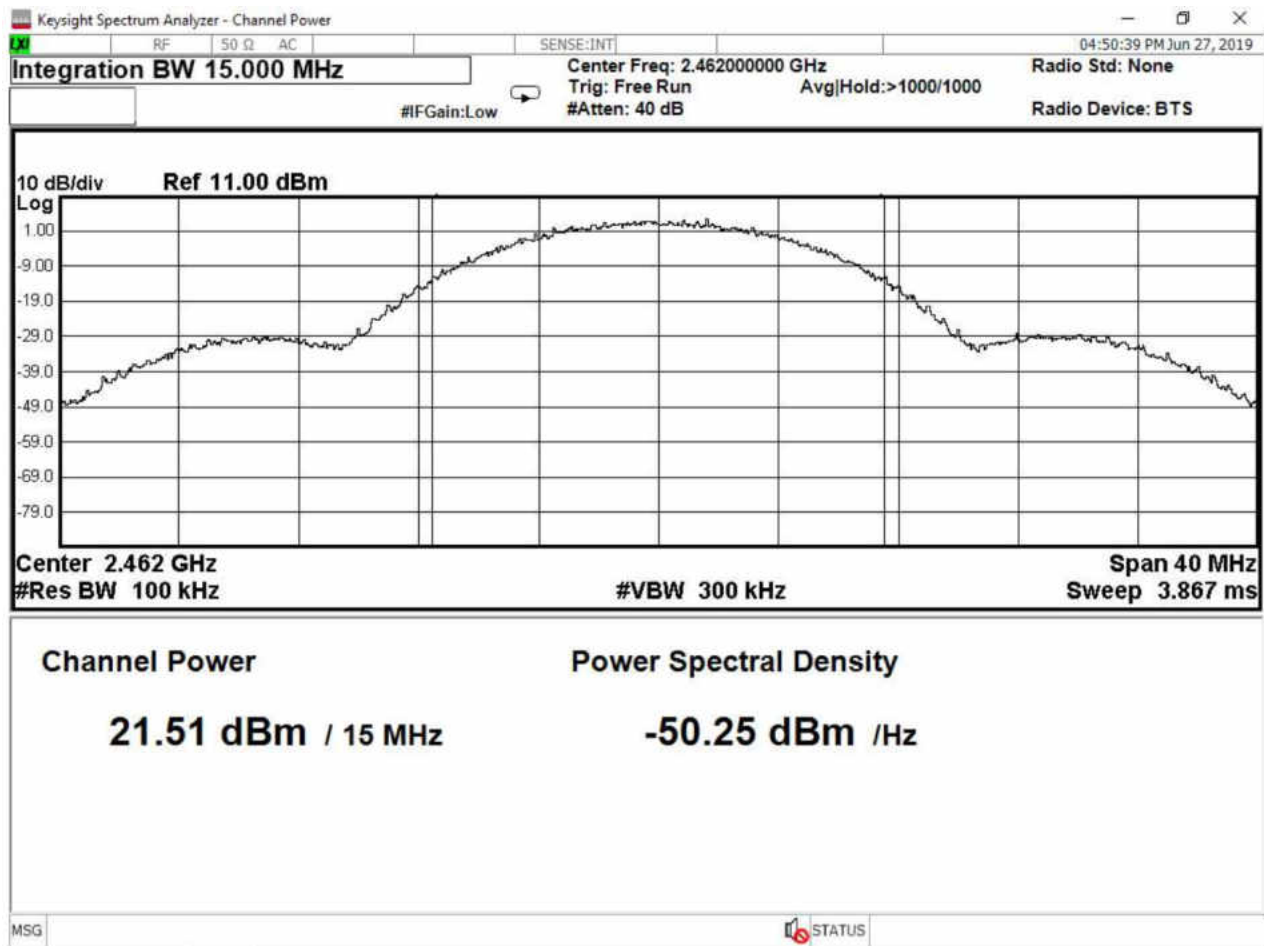
Average Output Power


| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | Average OUTPUT POWER (dBm) MU = ± 1.37 | Method | RESULT |
|---------|-------------------------------|-----------|---|-----------|--------|
| Low | 2412 | 802.11b | 19.62 | Conducted | PASS |
| Middle | 2437 | 802.11b | 19.39 | Conducted | PASS |
| High | 2462 | 802.11b | 19.58 | Conducted | PASS |
| Low | 2412 | 802.11g | 16.87 | Conducted | PASS |
| Middle | 2437 | 802.11g | 18.03 | Conducted | PASS |
| High | 2462 | 802.11g | 16.58 | Conducted | PASS |
| Low | 2412 | 802.11n | 15.64 | Conducted | PASS |
| Middle | 2437 | 802.11n | 18.07 | Conducted | PASS |
| High | 2462 | 802.11n | 16.28 | Conducted | PASS |

All measurements include 0.1 dB of cable loss.

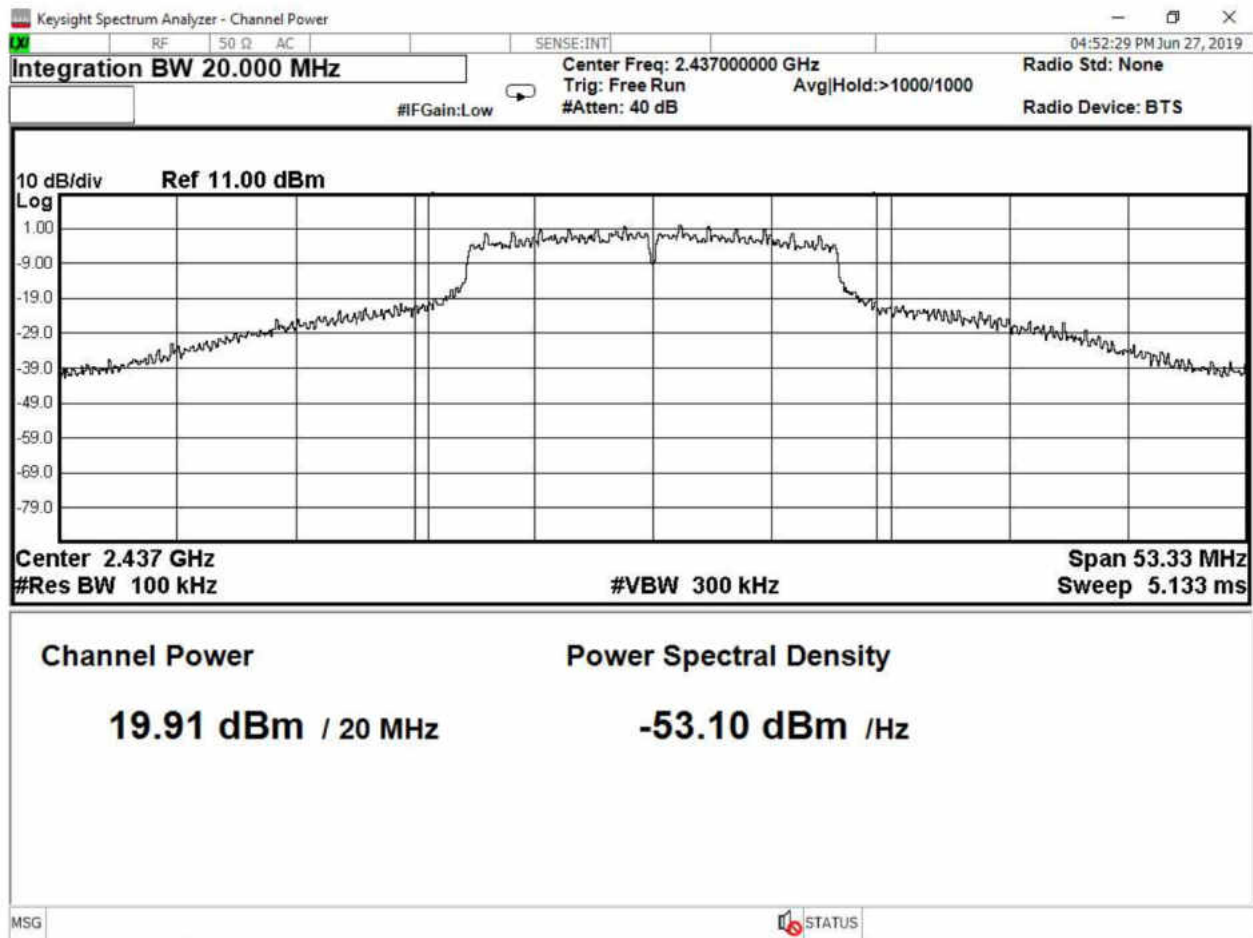
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Peak Output Power Plots, 802.11b, highest channel



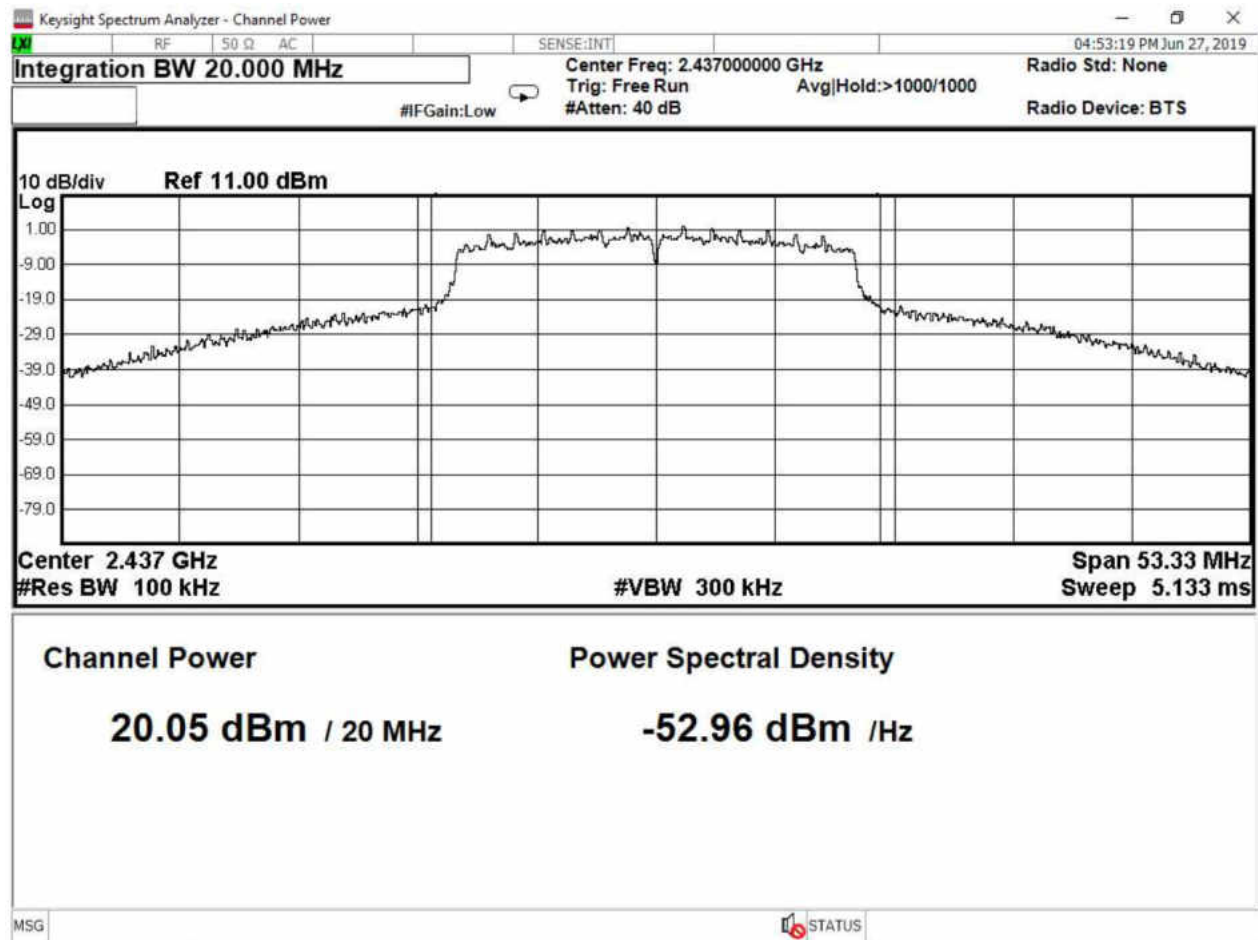
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Peak Output Power Plots, 802.11g, middle channel



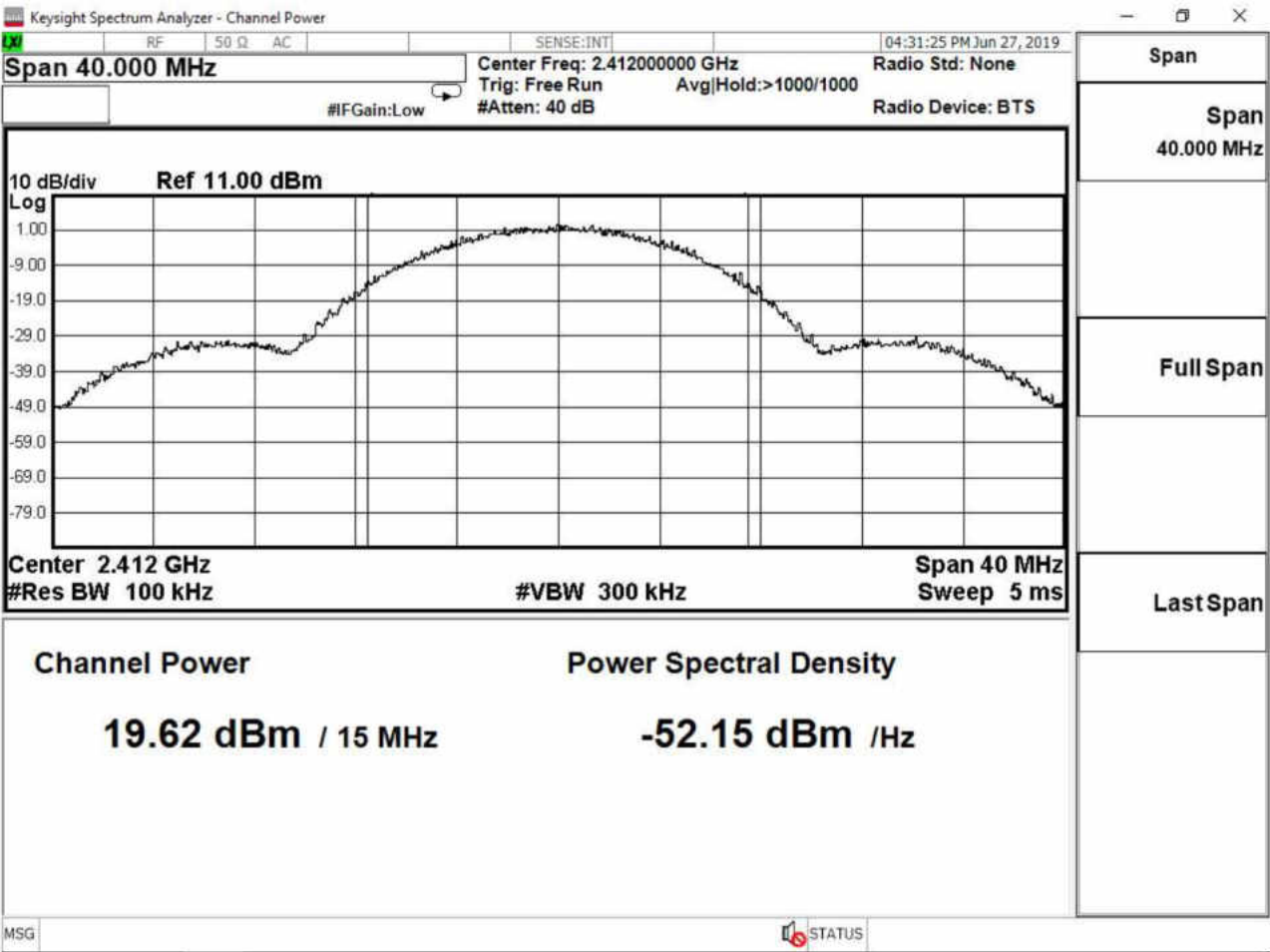
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Peak Output Power Plots, 802.11n, middle channel



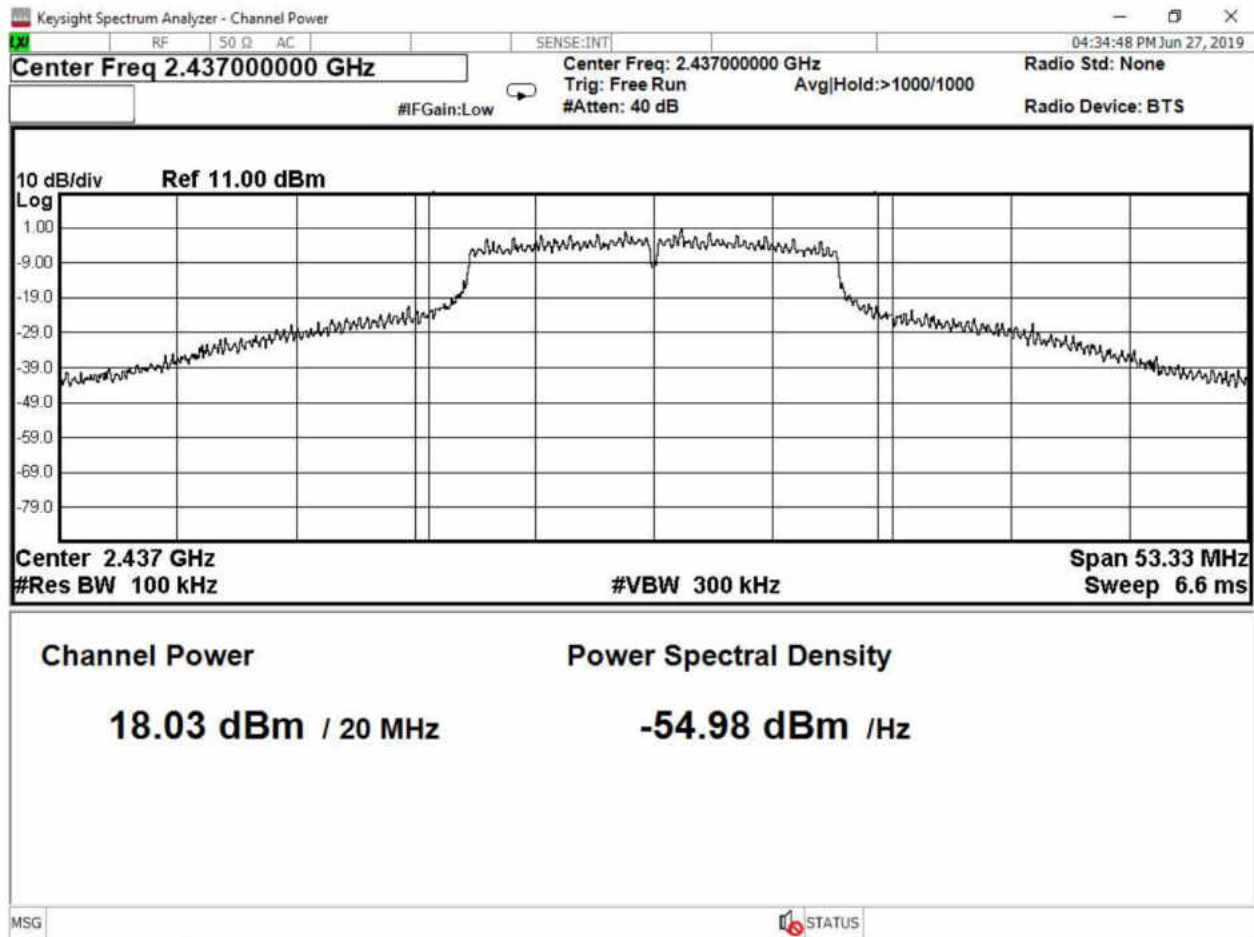
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Average Output Power Plots, 802.1b highest channel



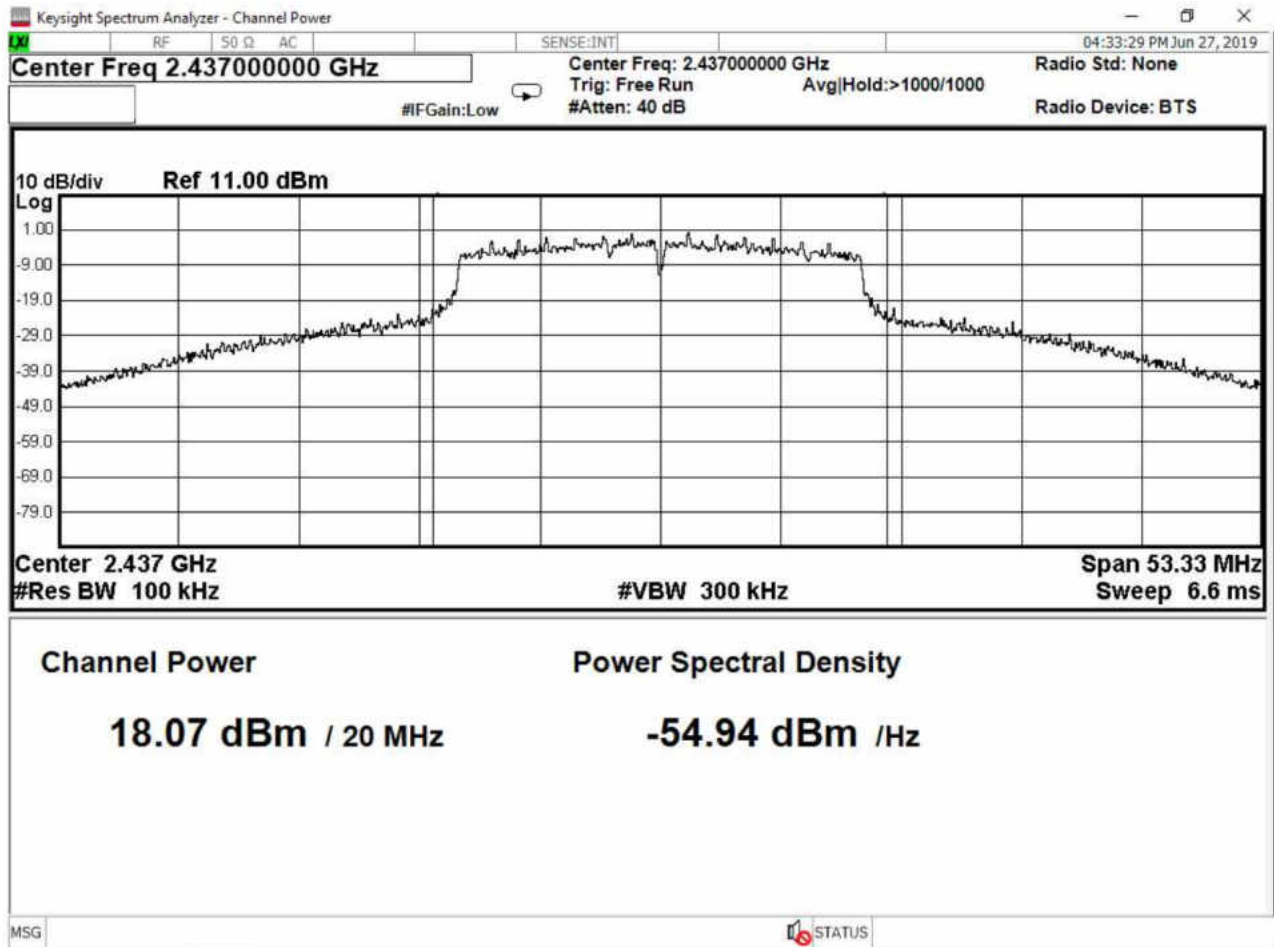
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Average Output Power Plots, 802.1g highest channel



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Average Output Power Plots, 802.1b highest channel



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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.

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

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

For peak output power measurements, the EUT was connected to the spectrum analyzer directly with a low-loss shielded coaxial cable with 3 MHz RBW and 10 MHz VBW.

Deviations from test standard:
No deviation

Test setup:

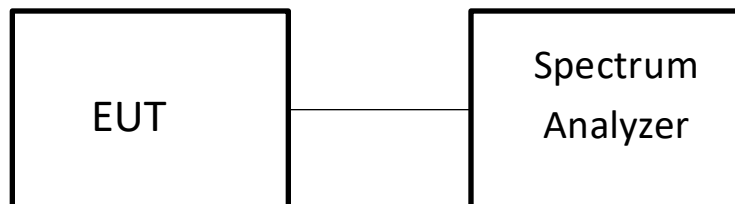



Figure 7 – Peak Output Power Measurements Test Setup

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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 | 13.981 |
| Middle | 2437 | 802.11b | 14.120 |
| High | 2462 | 802.11b | 14.002 |
| Low | 2412 | 802.11g | 16.491 |
| Middle | 2437 | 802.11g | 18.655 |
| High | 2462 | 802.11g | 16.536 |
| Low | 2412 | 802.11n | 17.673 |
| Middle | 2437 | 802.11n | 18.706 |
| High | 2462 | 802.11n | 17.684 |

6dB Bandwidth

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | 6 dB BW (MHz) |
|---------|-------------------------|-----------|---------------|
| Low | 2412 | 802.11b | 9.446 |
| Middle | 2437 | 802.11b | 8.664 |
| High | 2462 | 802.11b | 8.292 |
| Low | 2412 | 802.11g | 16.29 |
| Middle | 2437 | 802.11g | 16.37 |
| High | 2462 | 802.11g | 15.70 |
| Low | 2412 | 802.11n | 15.75 |
| Middle | 2437 | 802.11n | 16.29 |
| High | 2462 | 802.11n | 16.29 |

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

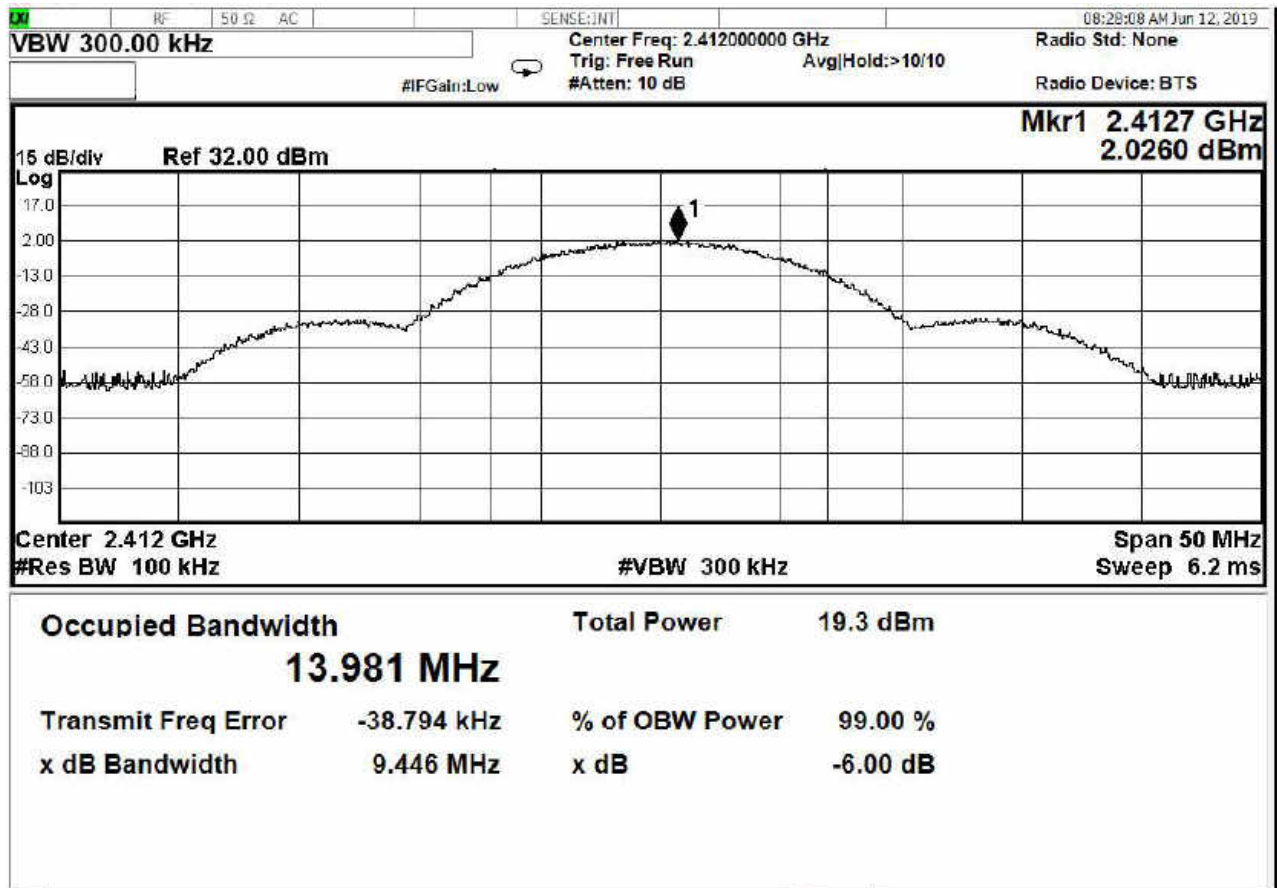



Figure 8 - Bandwidth, Low Channel, 802.11b

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

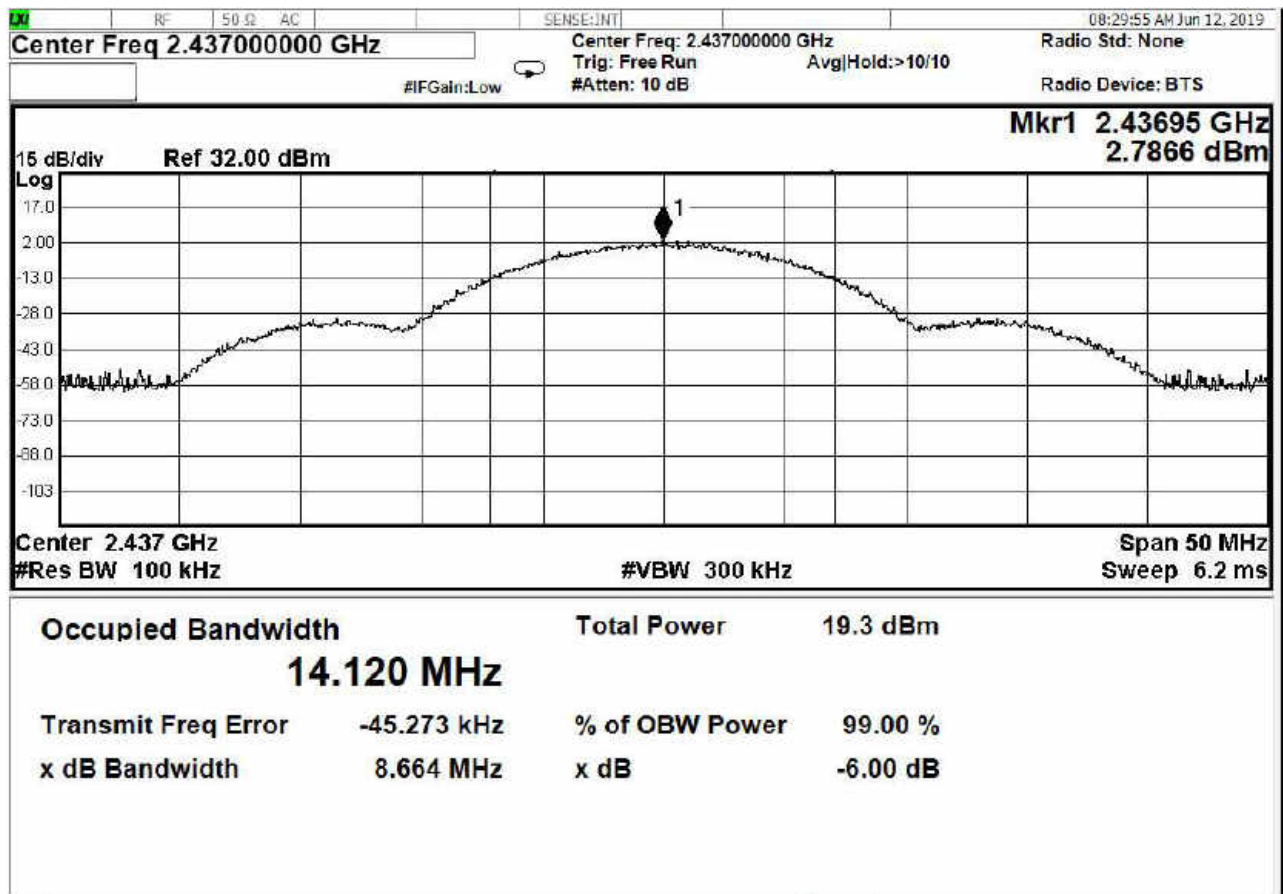



Figure 9 - Bandwidth, Mid Channel, 802.11b

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

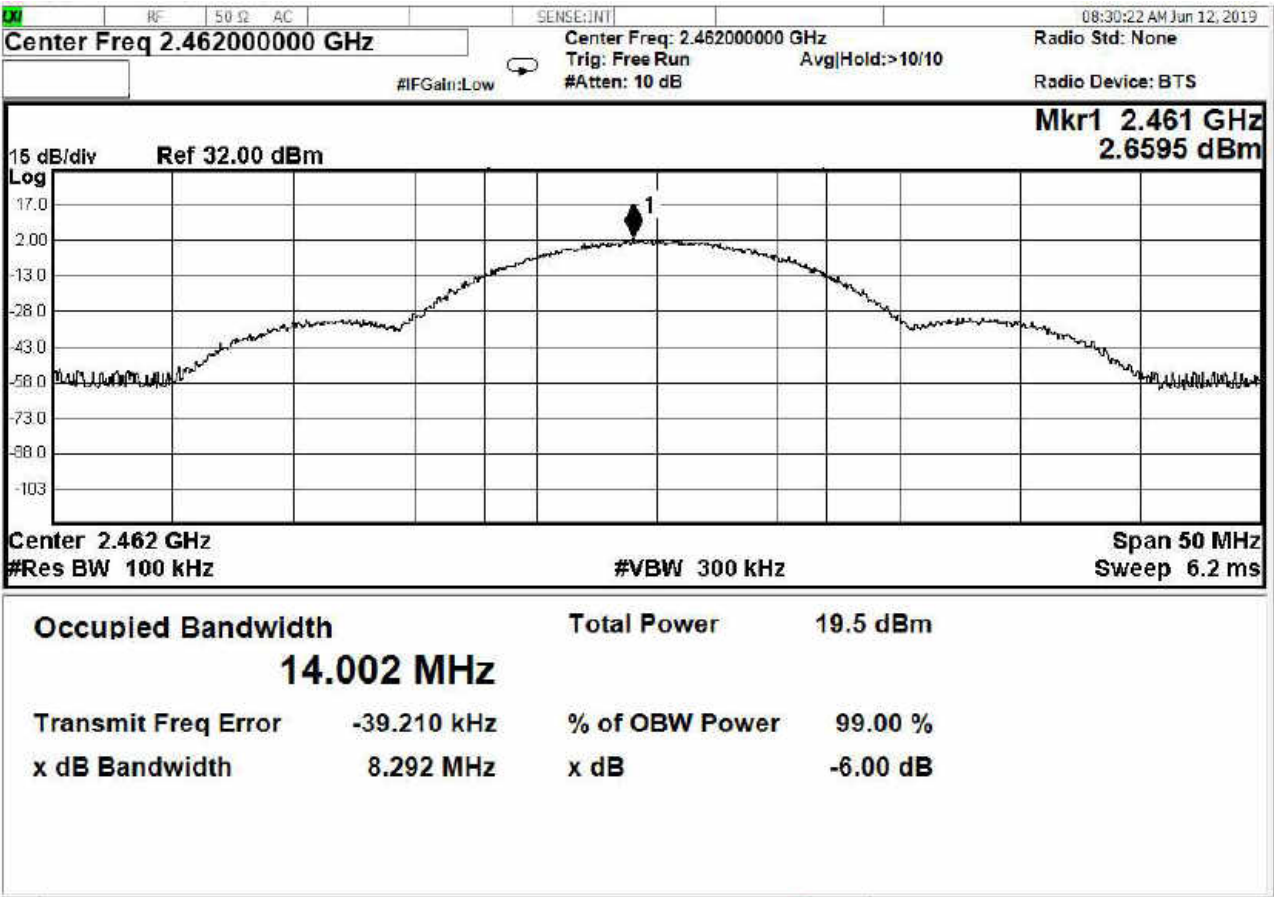



Figure 10 - Bandwidth, High Channel, 802.11b

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

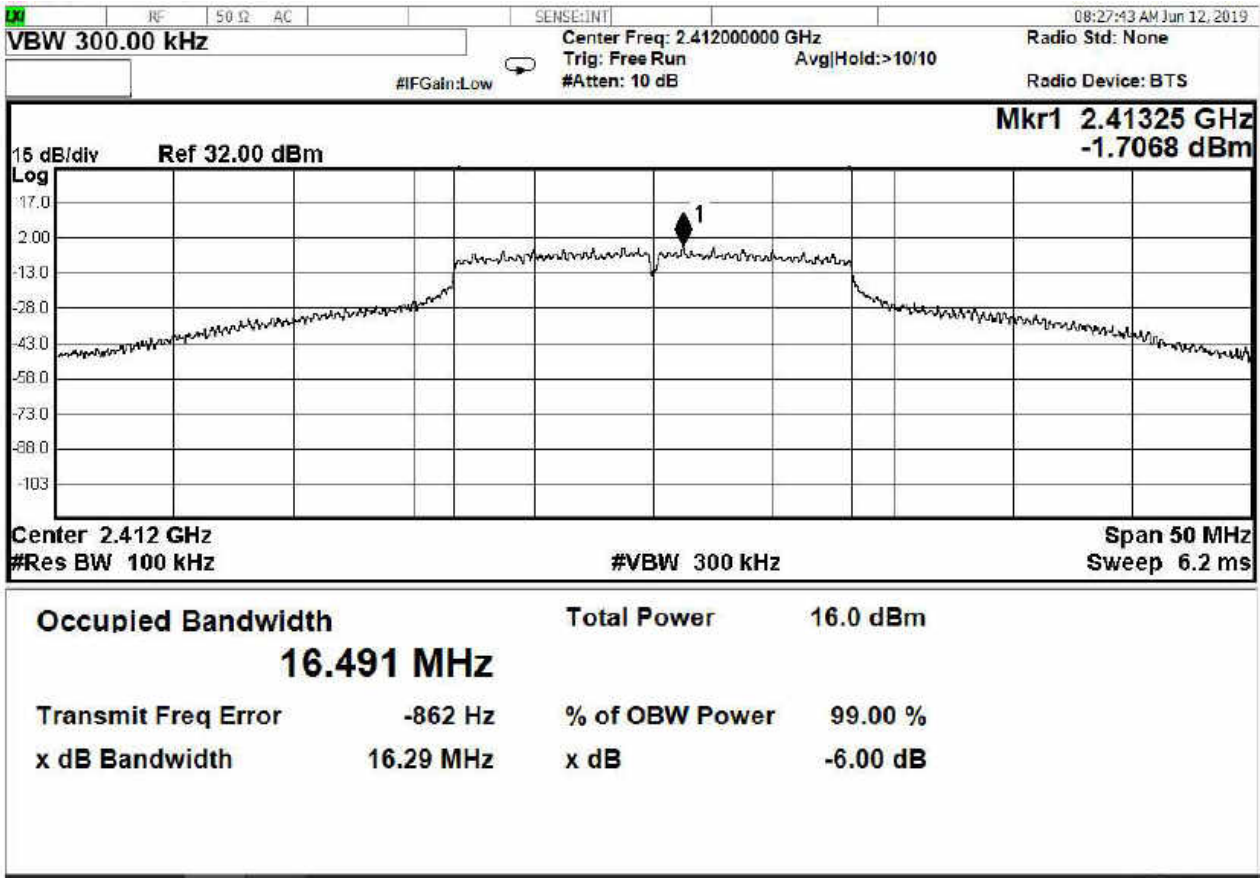



Figure 11 - Bandwidth, Low Channel, 802.11g

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

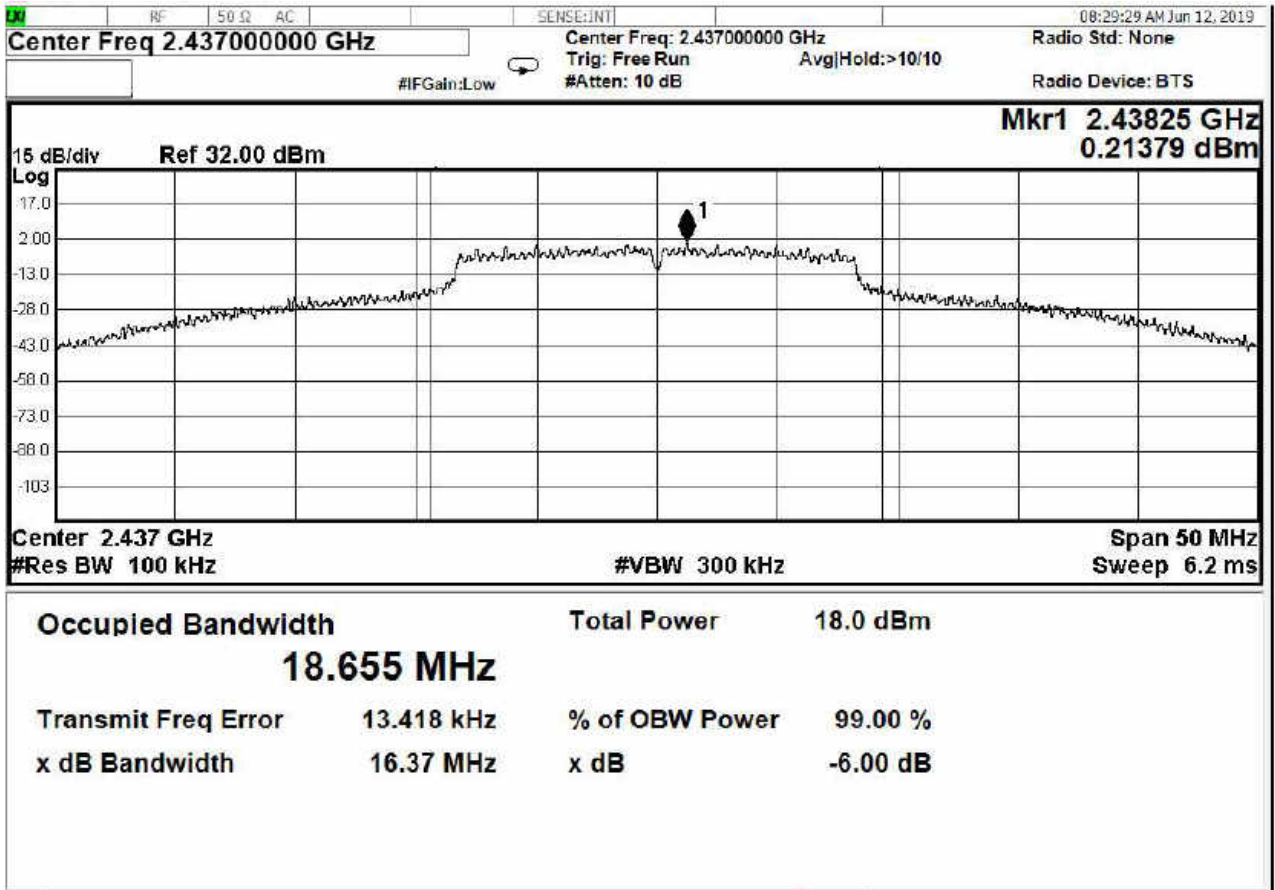



Figure 12 - Bandwidth, Mid Channel, 802.11g

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

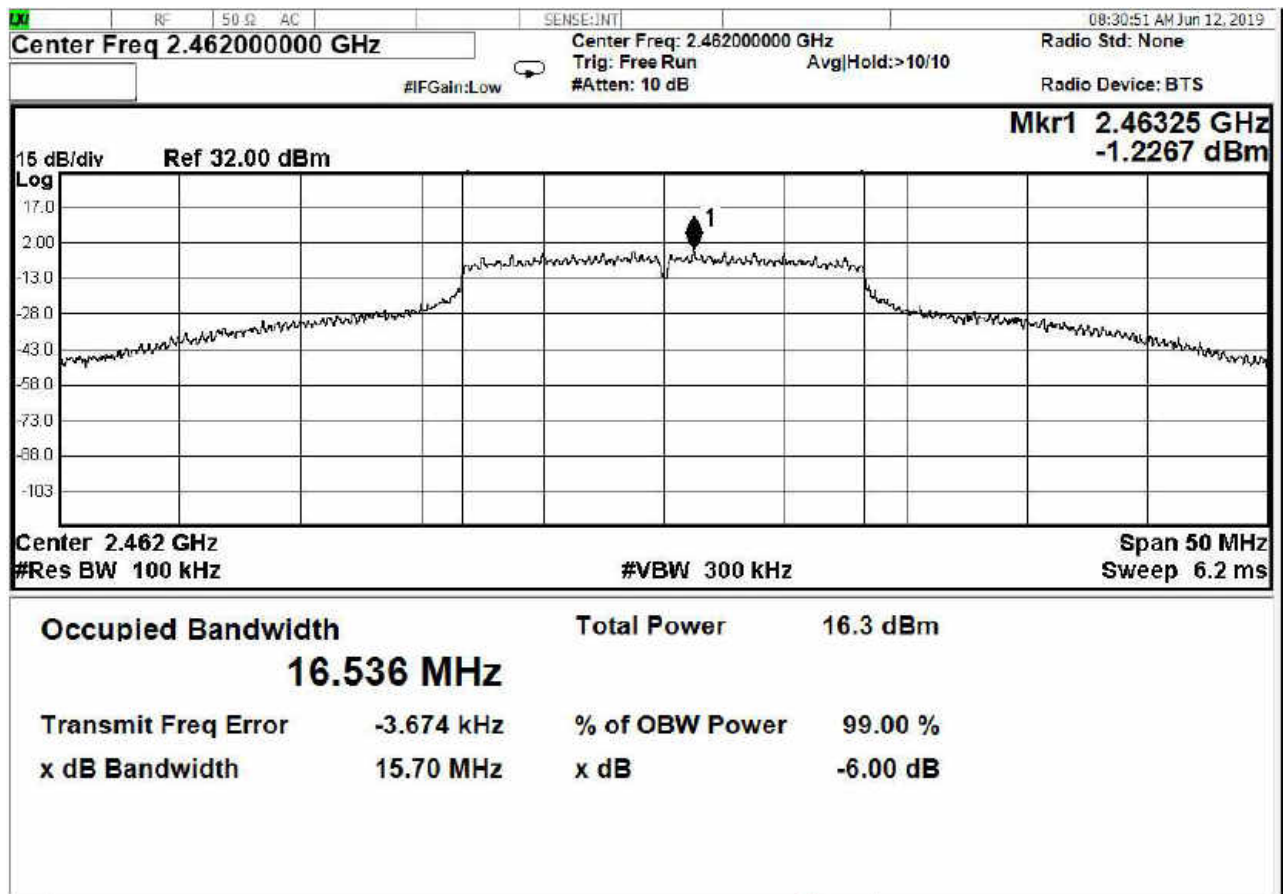



Figure 13 - Bandwidth, High Channel, 802.11g

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

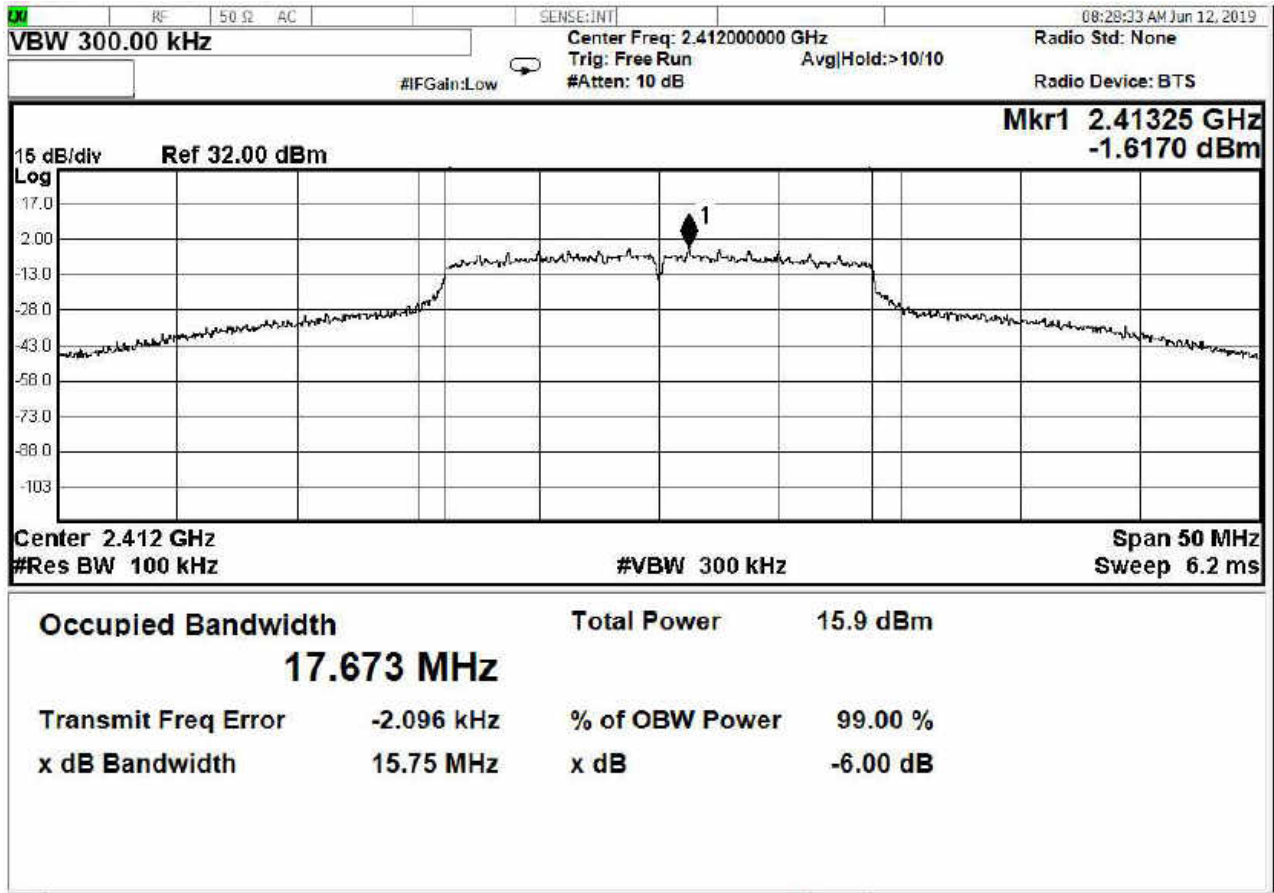



Figure 14 - Bandwidth, Low Channel, 802.11n

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

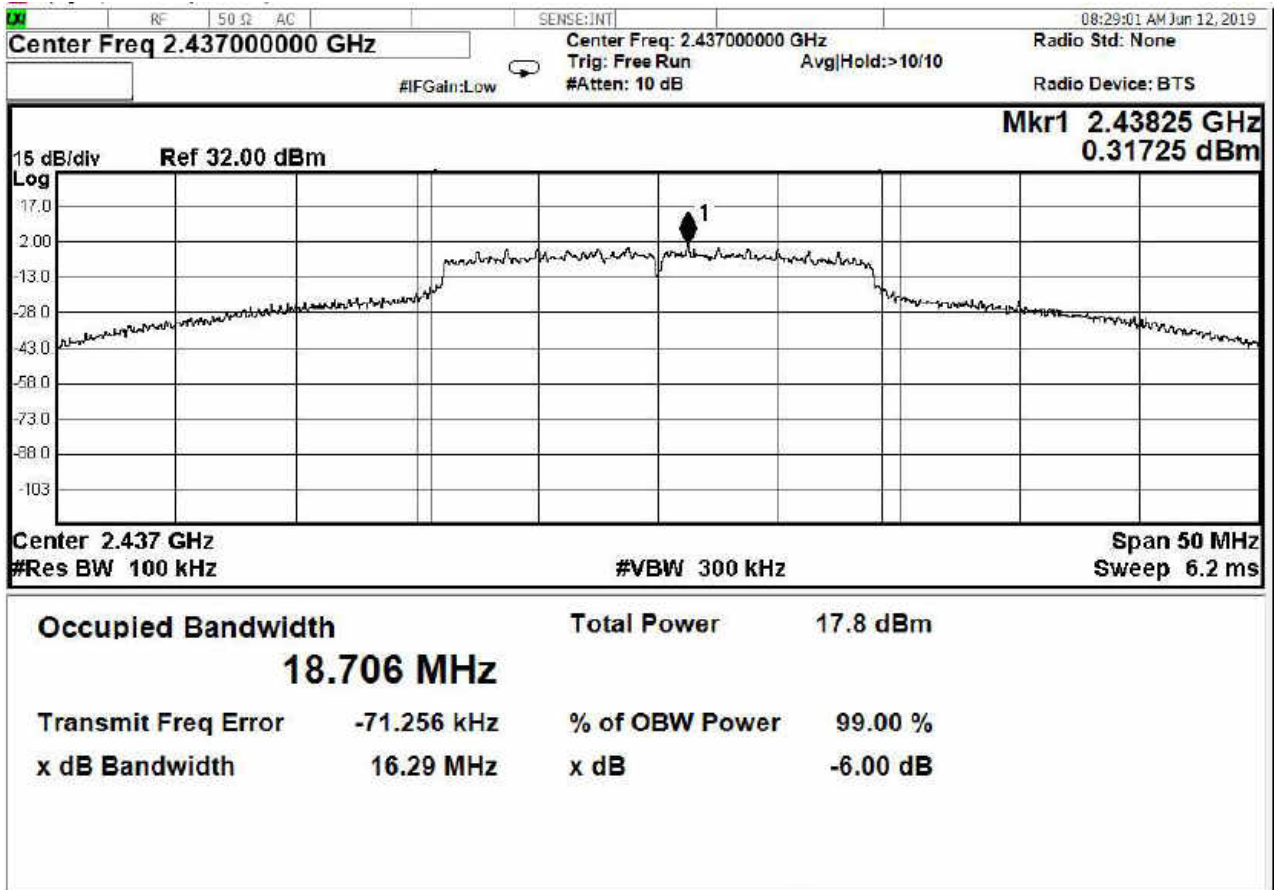



Figure 15 - Bandwidth, Mid Channel, 802.11n

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

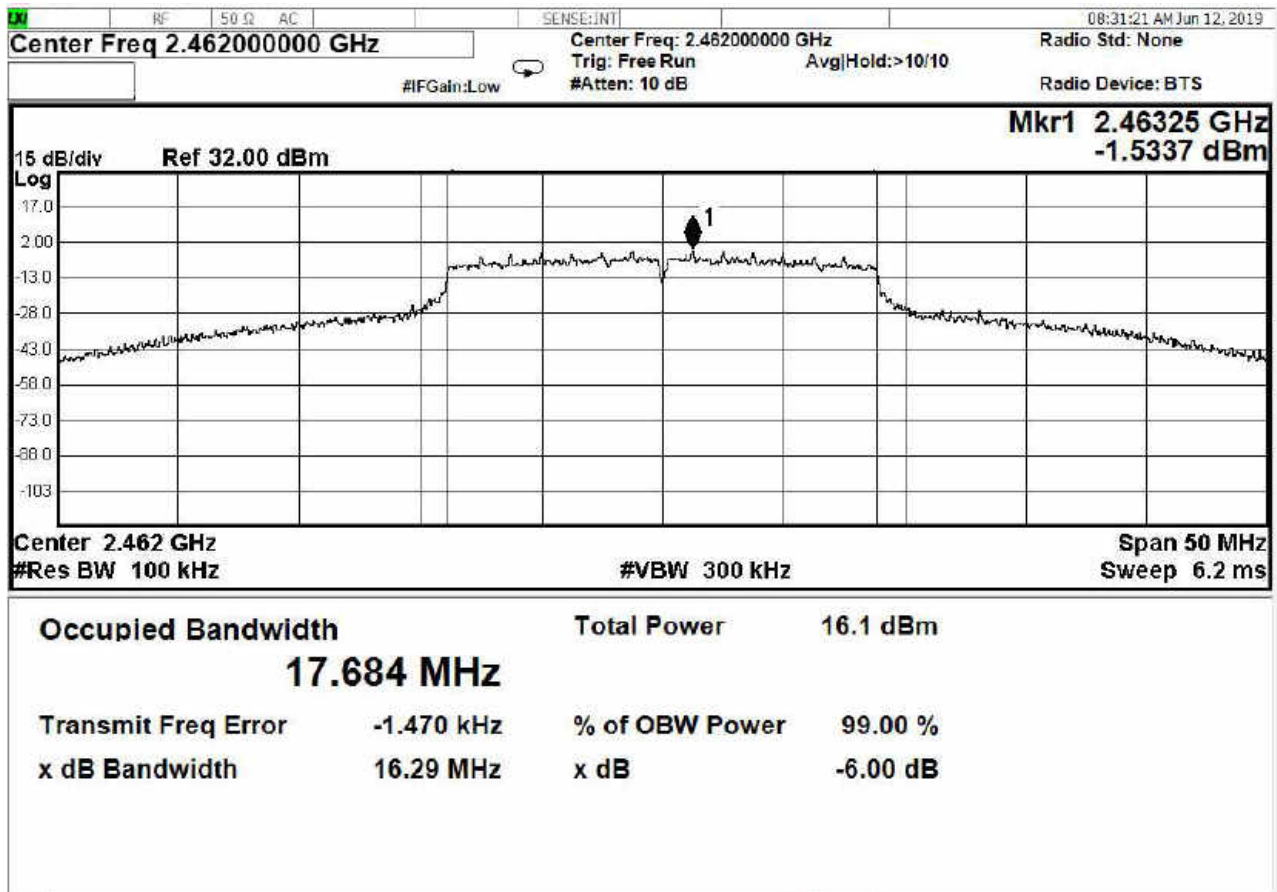



Figure 16 - Bandwidth, High Channel, 802.11n

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

4.5 BANDEDGES

Test Method: ANSI C63.10:

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

Limits of 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.

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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) | -28.543 | 3.7 | 32.243 | 20 | PASS |
| 1 | 2340.0 (Unrestricted, Average) | -26.931 | 2.963 | 29.894 | 20 | PASS |
| 11 | 2483.5 (Unrestricted, Peak) | -52.996 | 4.279 | 57.275 | 20 | PASS |
| 11 | 2483.5 (Unrestricted, Average) | -53.396 | 3.771 | 57.167 | 20 | PASS |

| CHANNEL | Band edge /Measurement Frequency (MHz) | Highest out of band level (dBm) | Corrected Emission Level (dBm) | Margin | Limit* (dBm) | Gain (dBi) | Result |
|---------|--|---------------------------------|--------------------------------|--------|--------------|------------|--------|
| 1 | 2390.0 (Restricted, Peak) | -49.846 | -49.846 | 28.616 | -21.23 | 0 | PASS |
| 1 | 2390.0 (Restricted, Average) | -50.693 | -50.693 | 9.463 | -41.23 | 0 | PASS |
| 11 | 2483.5 (Restricted, Peak) | -50.206 | -50.206 | 28.976 | -21.23 | 0 | PASS |
| 11 | 2483.5 (Restricted, Average) | -50.796 | -50.796 | 9.566 | -41.23 | 0 | PASS |

Corrected Emission level = Highest out of band level + Gain

Margin = Limit - Corrected Emission Level

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


Part 15.209 Peak Limit = 74.00 dBμV/m

Part 15.209 Average Limit = 54.00 dBμV/m

$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS_{3m}(dB\mu V/m) - 95.23$

Peak Limit (delta) = 74.00 dBμV/m – 95.23 = -21.23dBm

Average Limit (delta) = 54.00 dBμV/m – 95.23 = -41.23dBm

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

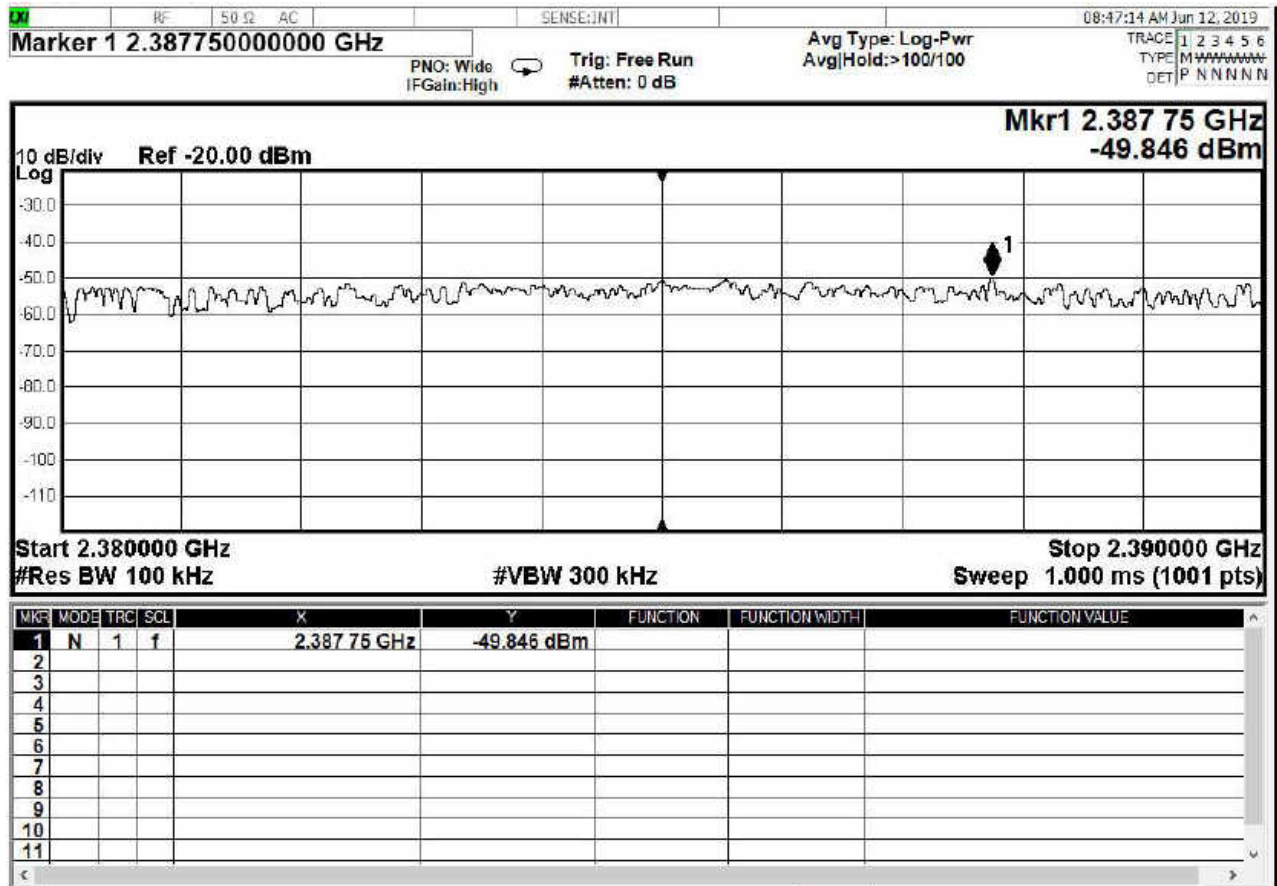



Figure 17 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

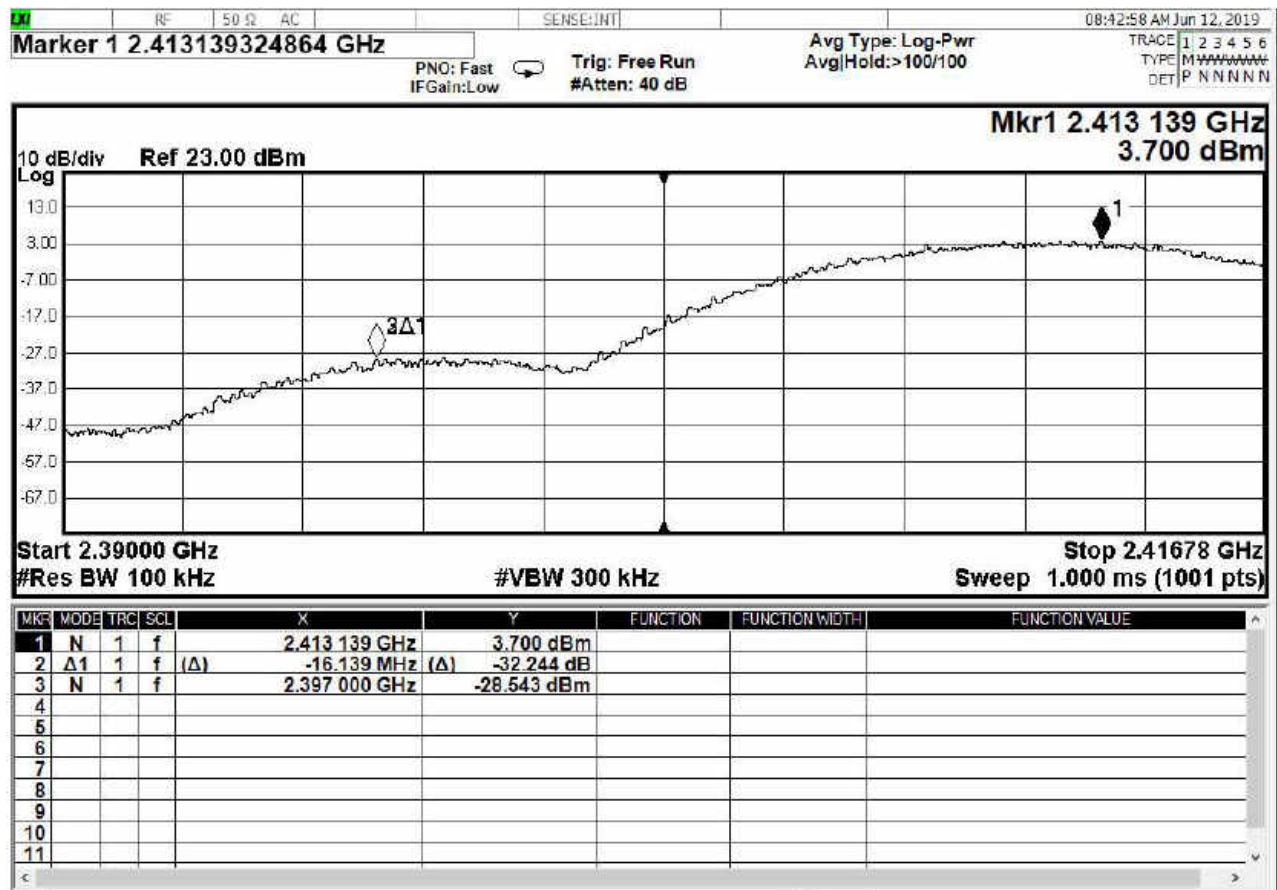



Figure 18 - Band-edge Measurement, Low Channel, Fundamental, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

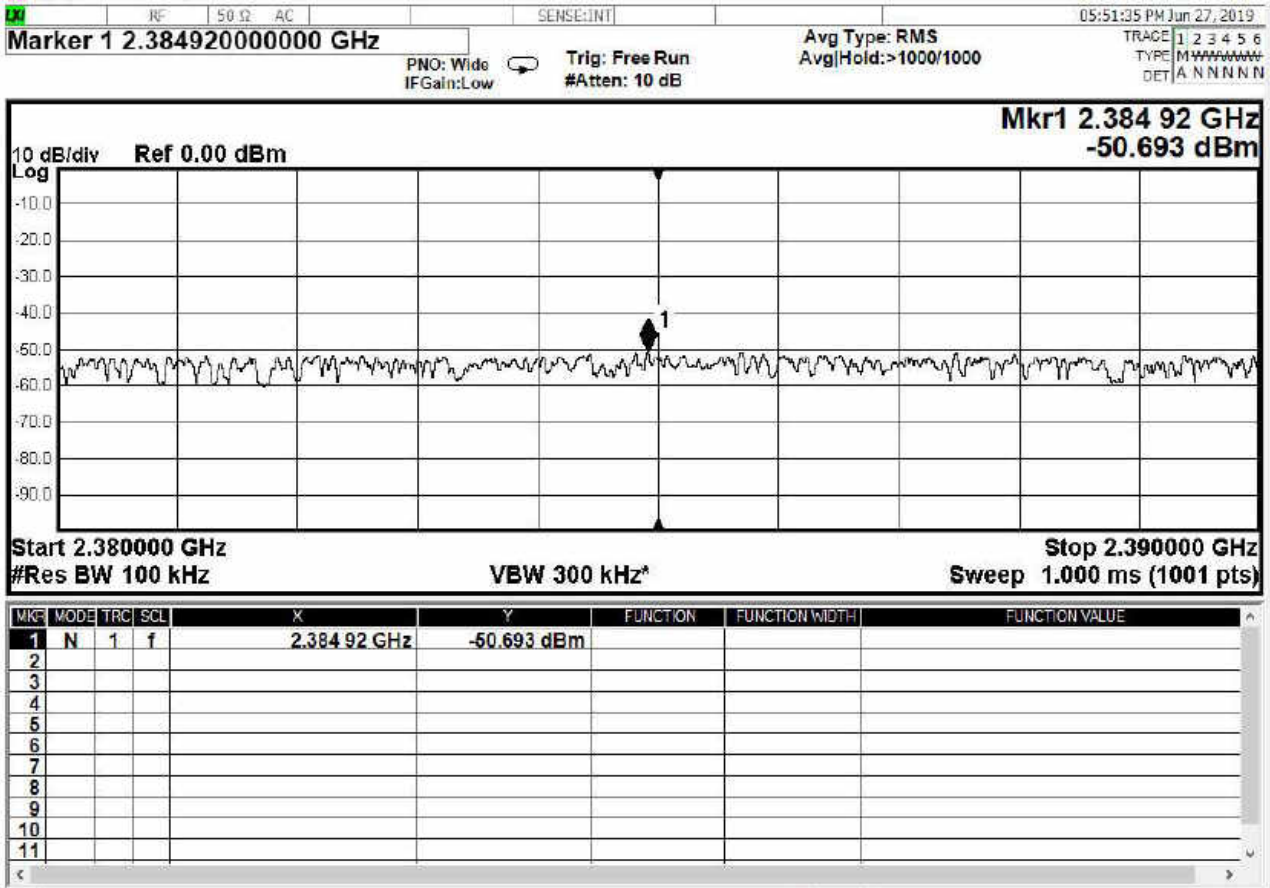



Figure 19 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

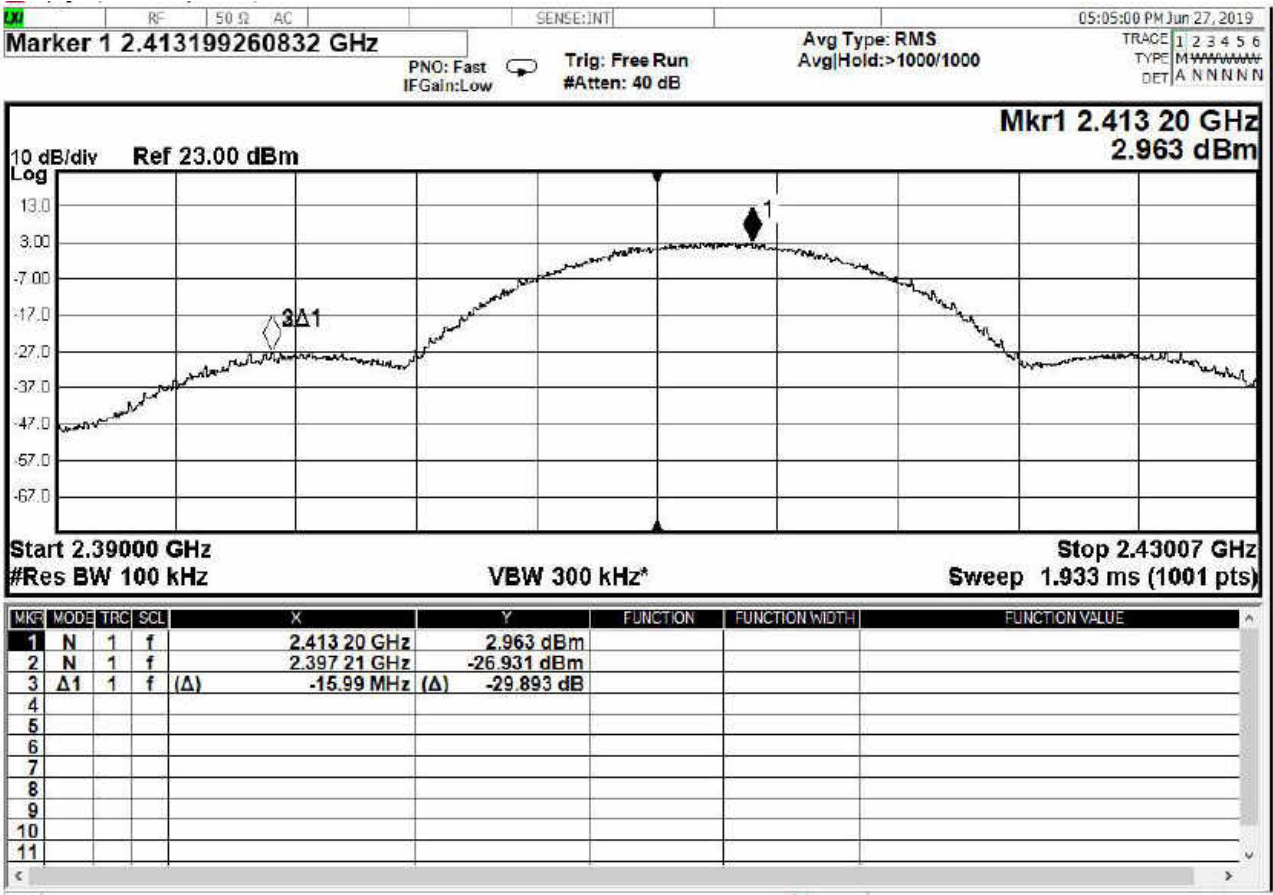



Figure 20 - Band-edge Measurement, Low Channel, Fundamental, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

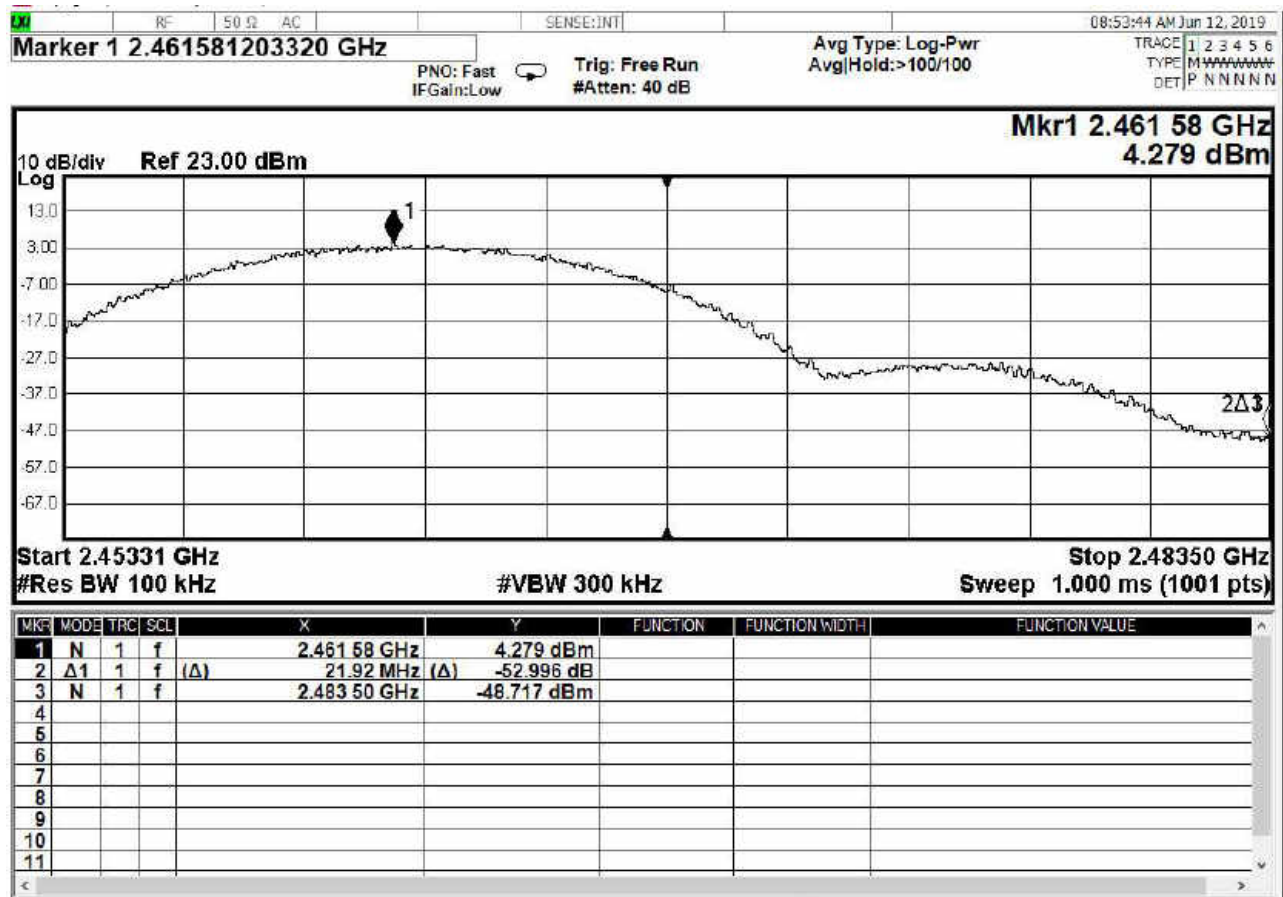



Figure 22 - Band-edge Measurement, High Channel, Fundamental, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

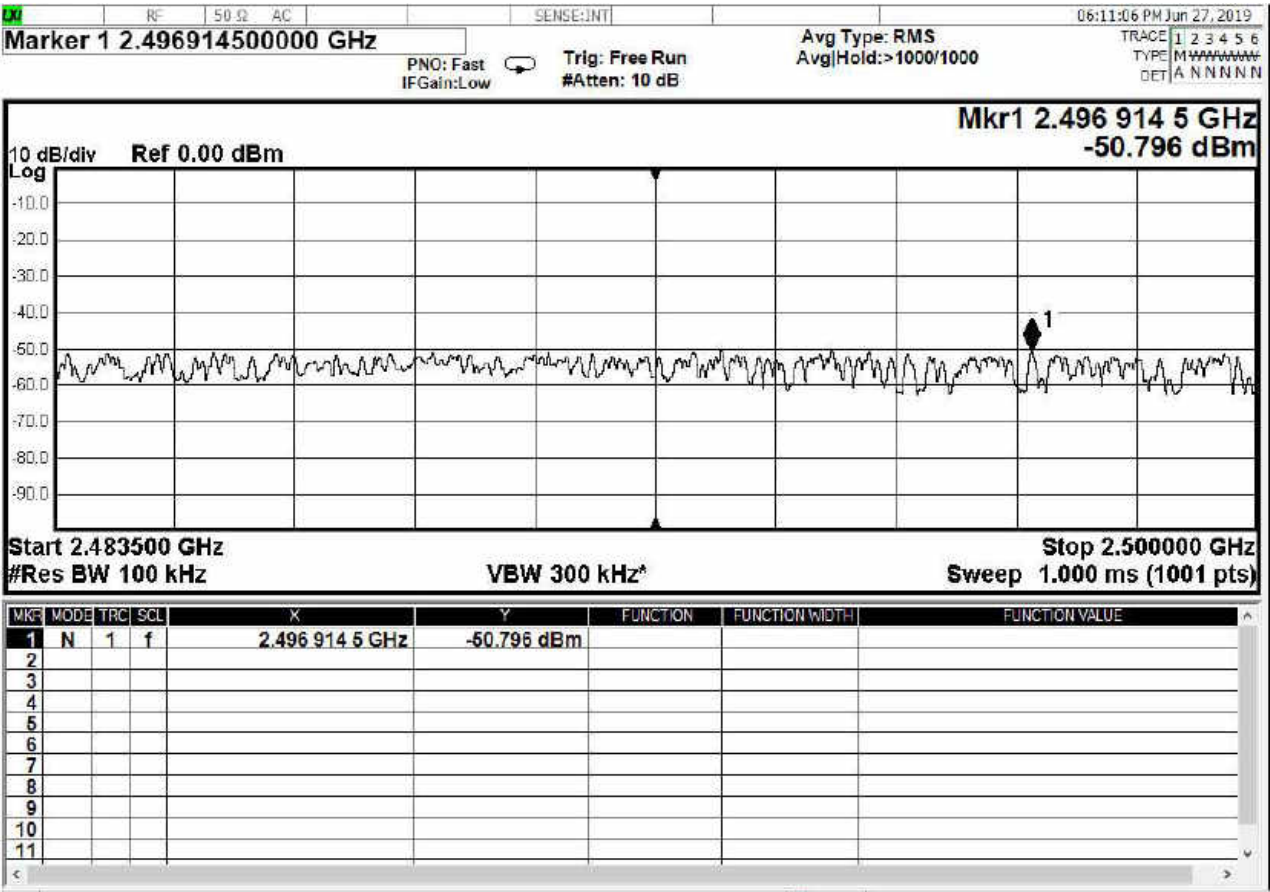



Figure 23 - Band-edge Measurement, High Channel, Restricted Frequency, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

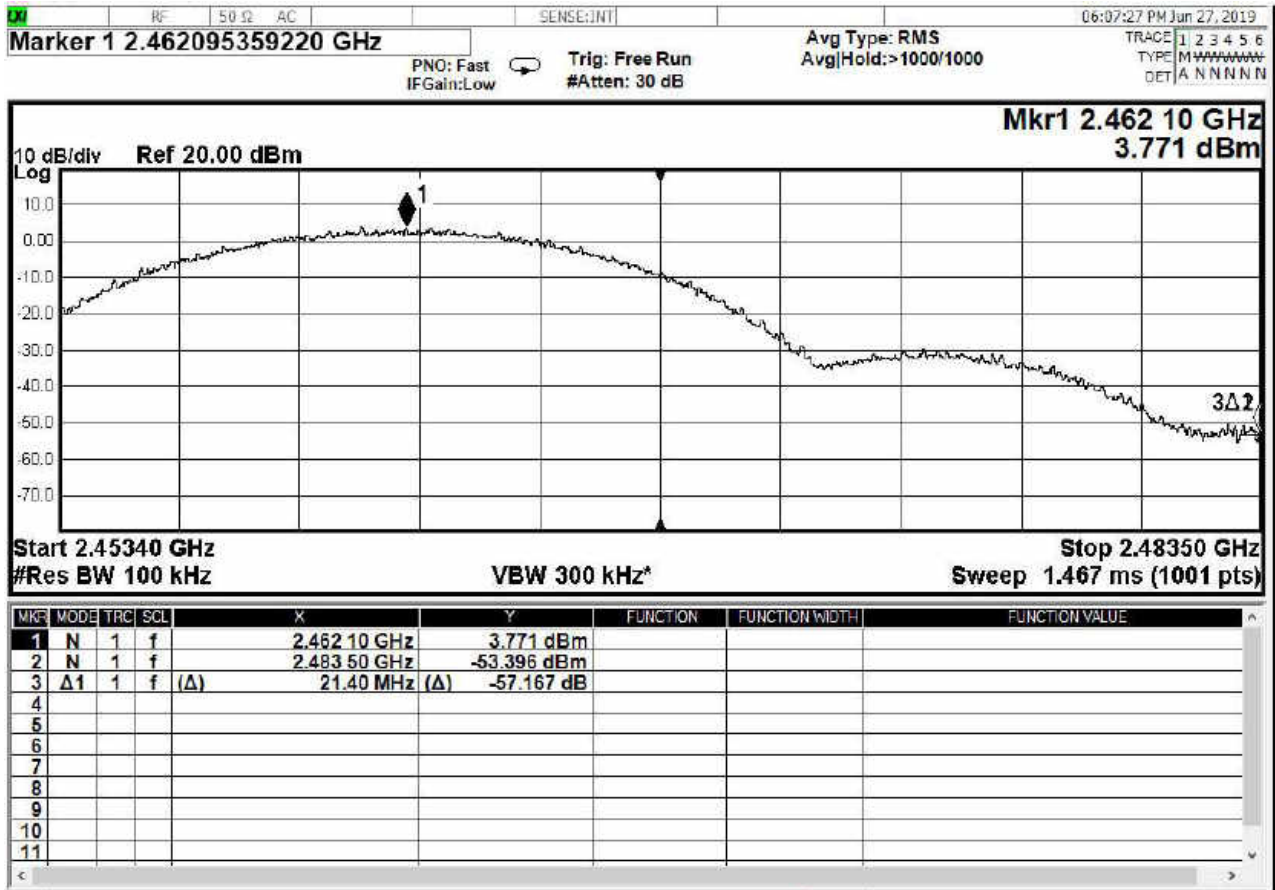



Figure 24 - Band-edge Measurement, High Channel, Fundamental, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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) | -25.909 | -0.677 | 25.232 | 20 | PASS |
| 1 | 2340.0 (Unrestricted, Average) | -23.935 | -1.009 | 22.926 | 20 | PASS |
| 11 | 2483.5 (Unrestricted, Peak) | -39.396 | -0.193 | 39.203 | 20 | PASS |
| 11 | 2483.5 (Unrestricted, Average) | -39.864 | -0.602 | 39.262 | 20 | PASS |

| CHANNEL | Band edge /Measurement Frequency (MHz) | Highest out of band level (dBm) | Corrected Emission Level (dBm) | Margin | Limit* (dBm) | Gain (dBi) | Result |
|---------|--|---------------------------------|--------------------------------|--------|--------------|------------|--------|
| 1 | 2390.0 (Restricted, Peak) | -40.141 | -40.141 | 18.911 | -21.23 | 0 | PASS |
| 1 | 2390.0 (Restricted, Average) | -54.587 | -54.587 | 13.357 | -41.23 | 0 | PASS |
| 11 | 2483.5 (Restricted, Peak) | -38.785 | -38.785 | 17.555 | -21.23 | 0 | PASS |
| 11 | 2483.5 (Restricted, Average) | -51.206 | -51.206 | 9.976 | -41.23 | 0 | PASS |

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

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


Part 15.209 Peak Limit = 74.00 dBμV/m

Part 15.209 Average Limit = 54.00 dBμV/m

$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS_{3m}(dB\mu V/m) - 95.23$

Peak Limit (delta) = 74.00 dBμV/m – 95.23 = -21.23dBm

Average Limit (delta) = 54.00 dBμV/m – 95.23 = -41.23dBm

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

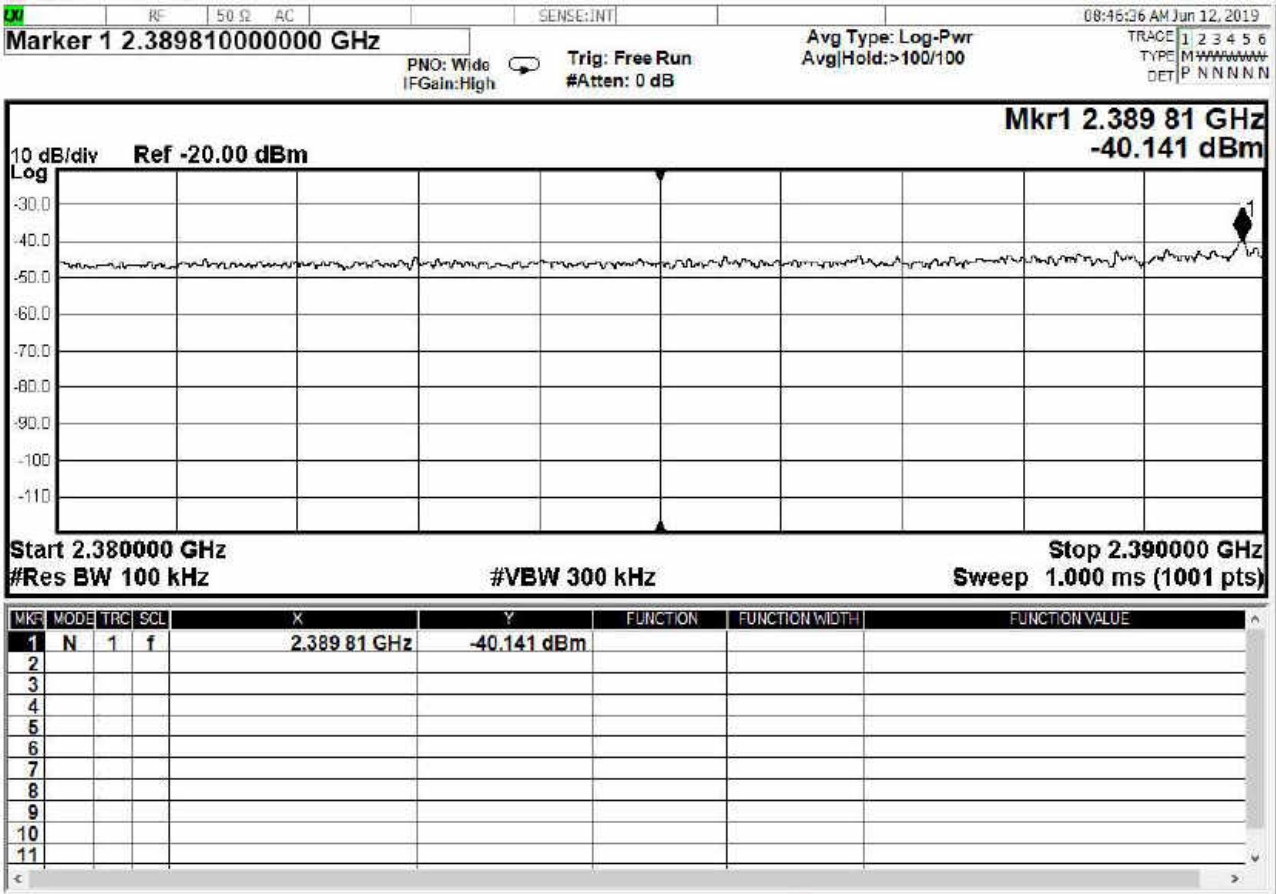



Figure 25 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

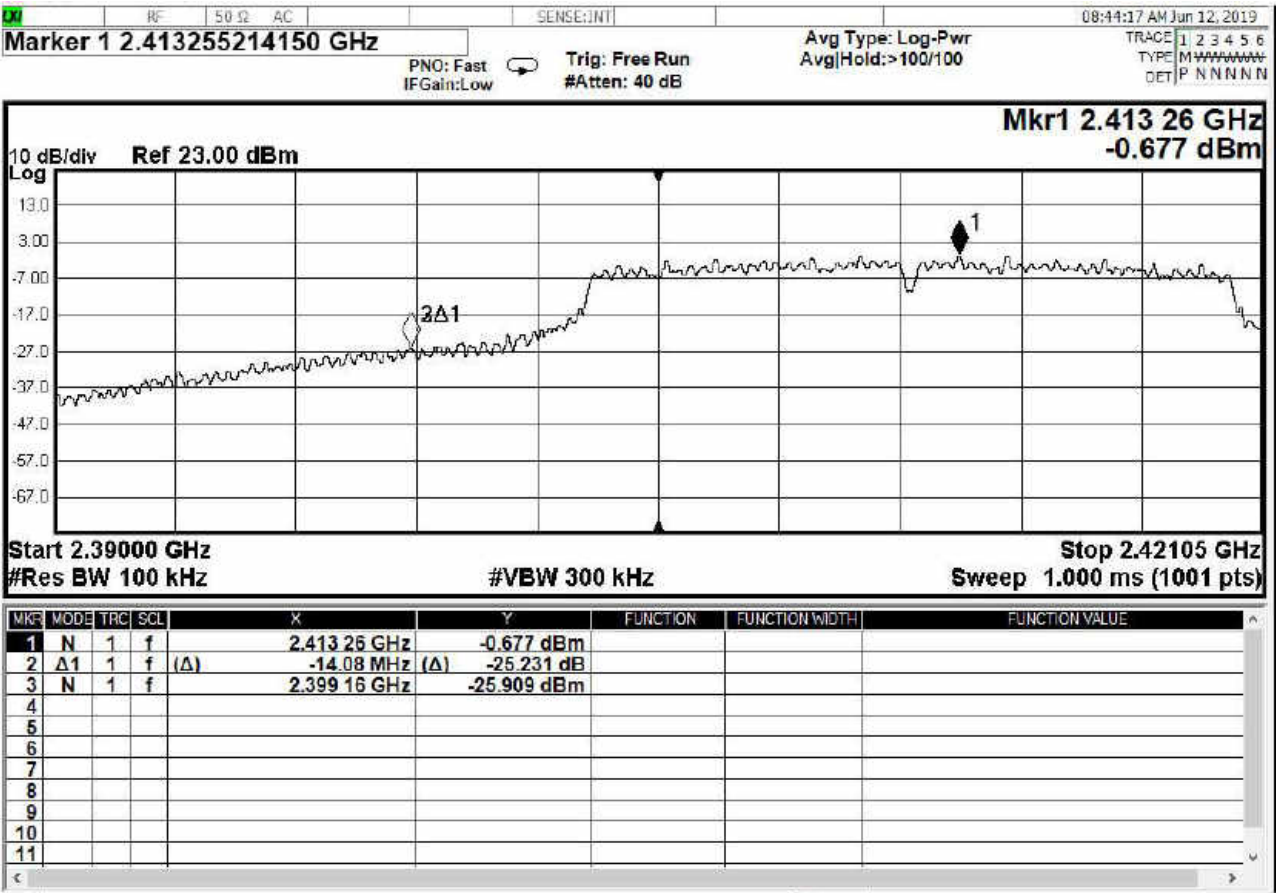



Figure 26 - Band-edge Measurement, Low Channel, Fundamental, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

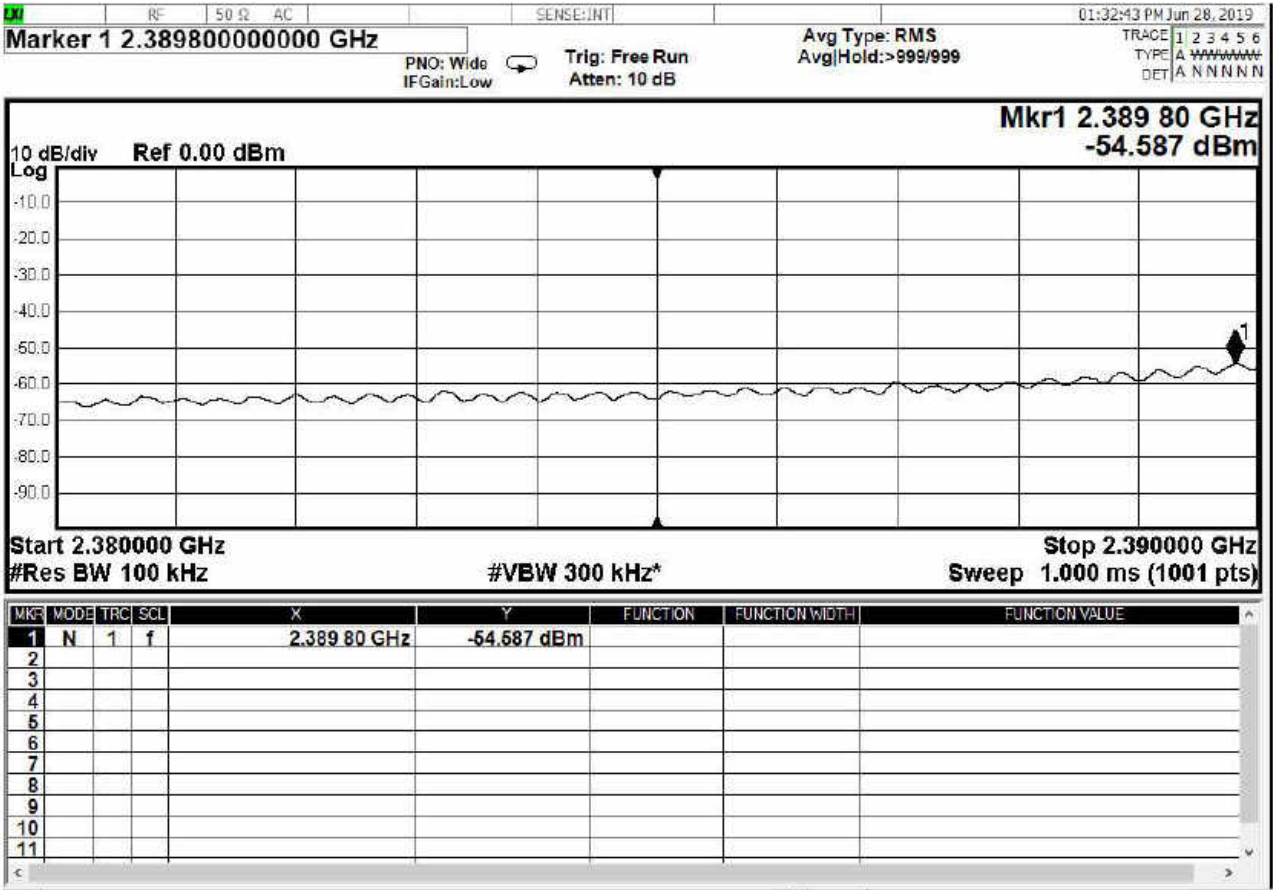



Figure 27 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

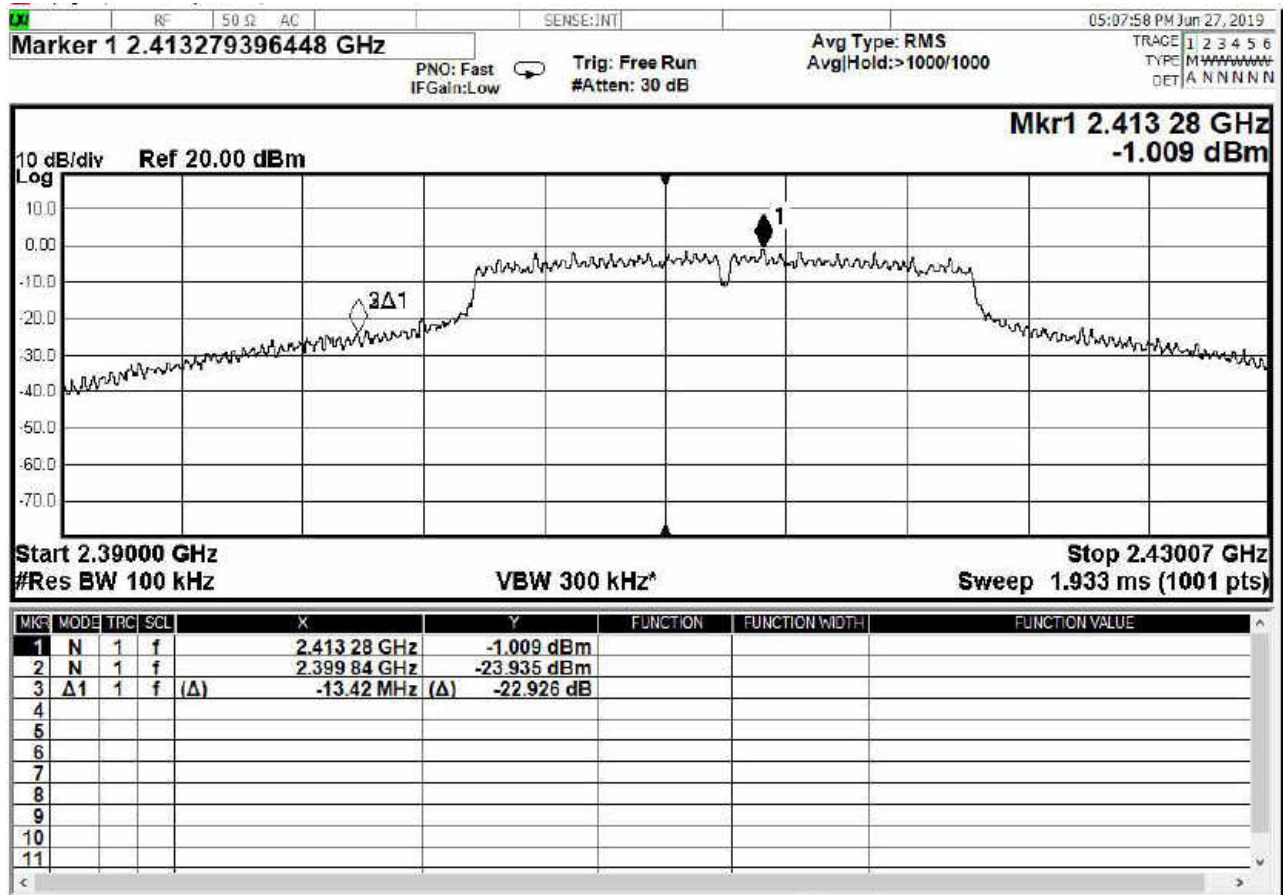



Figure 28 - Band-edge Measurement, Low Channel, Fundamental, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

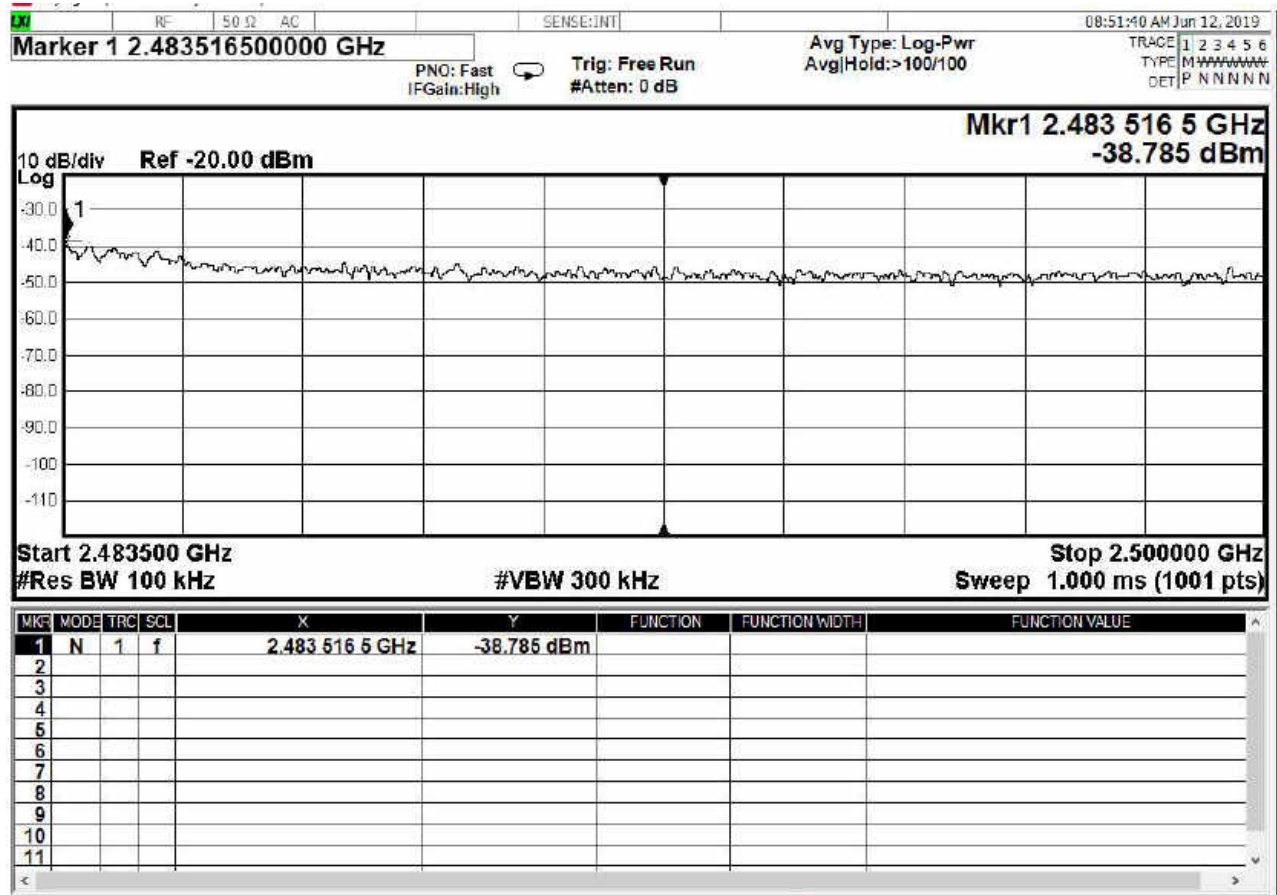



Figure 29 - Band-edge Measurement, High Channel, Restricted Frequency, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

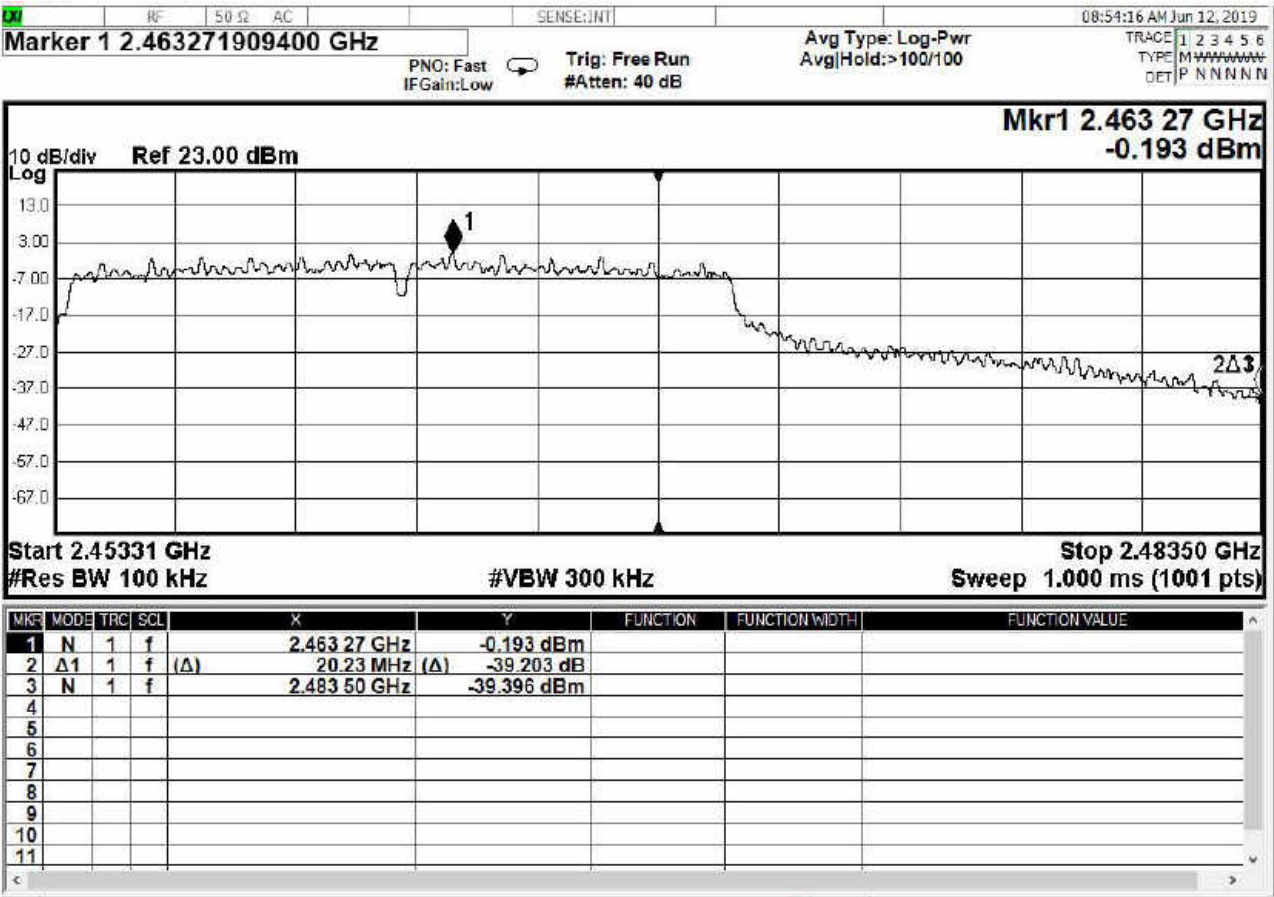



Figure 30 - Band-edge Measurement, High Channel, Fundamental, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

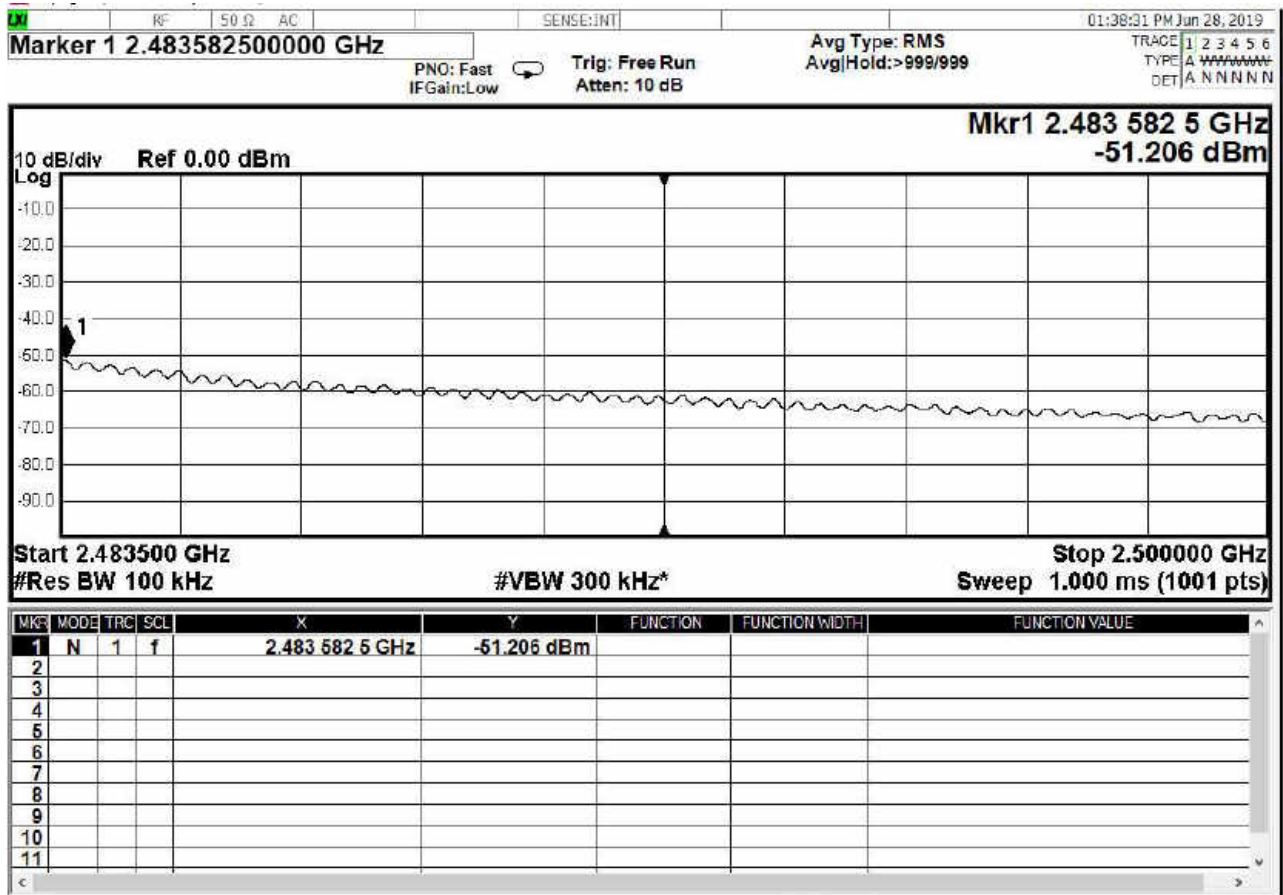



Figure 31 - Band-edge Measurement, High Channel, Restricted Frequency, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

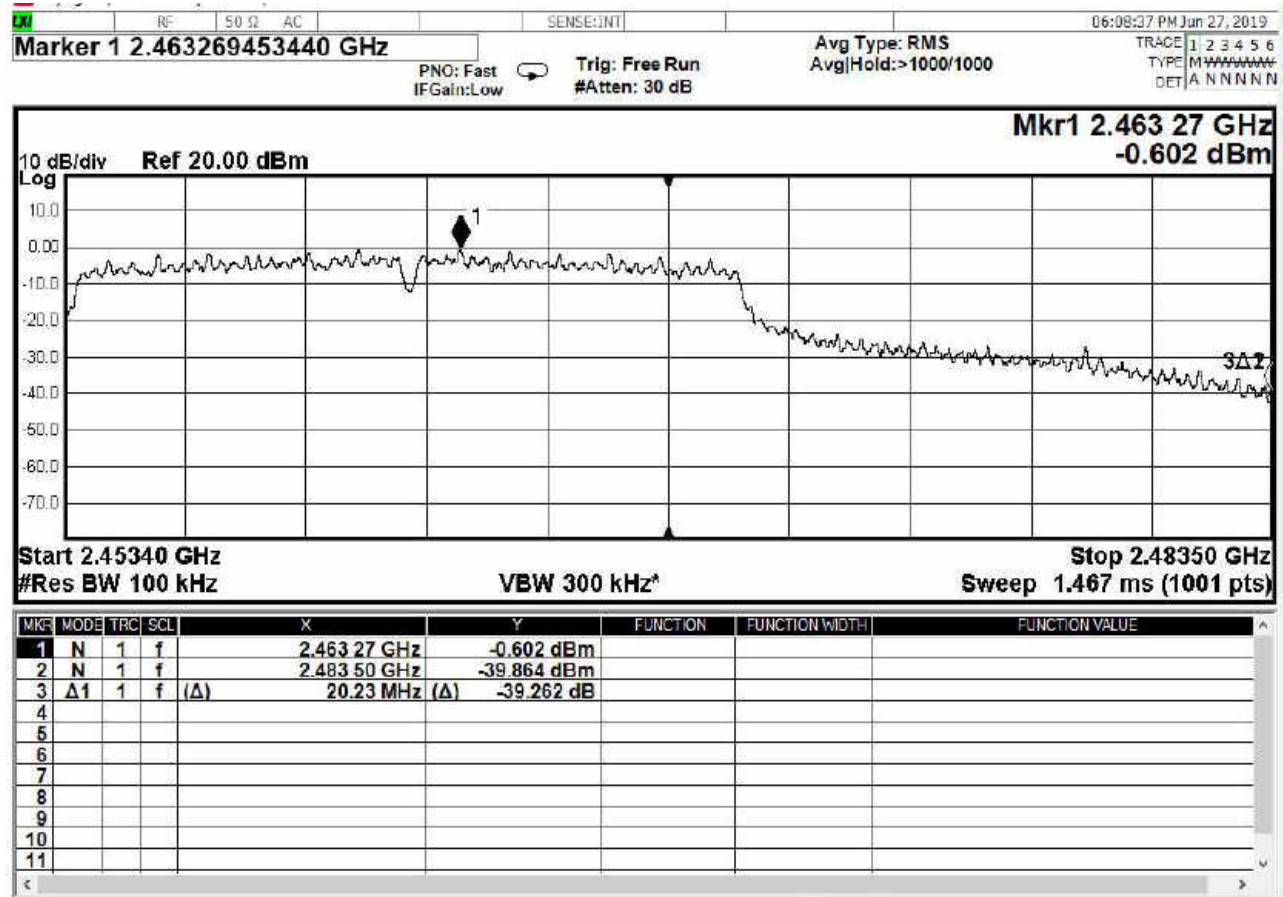



Figure 32 - Band-edge Measurement, High Channel, Fundamental, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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) | -26.064 | -0.706 | 25.358 | 20 | PASS |
| 1 | 2400.0 (Unrestricted, Average) | -24.083 | -1.036 | 23.047 | 20 | PASS |
| 11 | 2483.5 (Unrestricted, Peak) | -38.282 | -0.243 | 38.039 | 20 | PASS |
| 11 | 2483.5 (Unrestricted, Average) | -39.419 | -0.65 | 38.769 | 20 | PASS |

| CHANNEL | Band edge /Measurement Frequency (MHz) | Highest out of band level (dBm) | Corrected Emission Level (dBm) | Margin | Limit* (dBm) | Gain** (dBi) | Result |
|---------|--|---------------------------------|--------------------------------|--------|--------------|--------------|--------|
| 1 | 2390.0 (Restricted, Peak) | -39.596 | -39.596 | 18.366 | -21.23 | 0.00 | PASS |
| 1 | 2349.0 (Restricted, Average) | -54.005 | -54.005 | 12.775 | -41.23 | 0.00 | PASS |
| 11 | 2483.5 (Restricted, Peak) | -35.874 | -35.874 | 14.644 | -21.23 | 0.00 | PASS |
| 11 | 2483.5 (Restricted, Average) | -51.634 | -51.634 | 10.404 | -41.23 | 0.00 | PASS |

Corrected Emission level= Highest out of band level +Gain

Margin= Limit-Corrected Emission Level

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

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

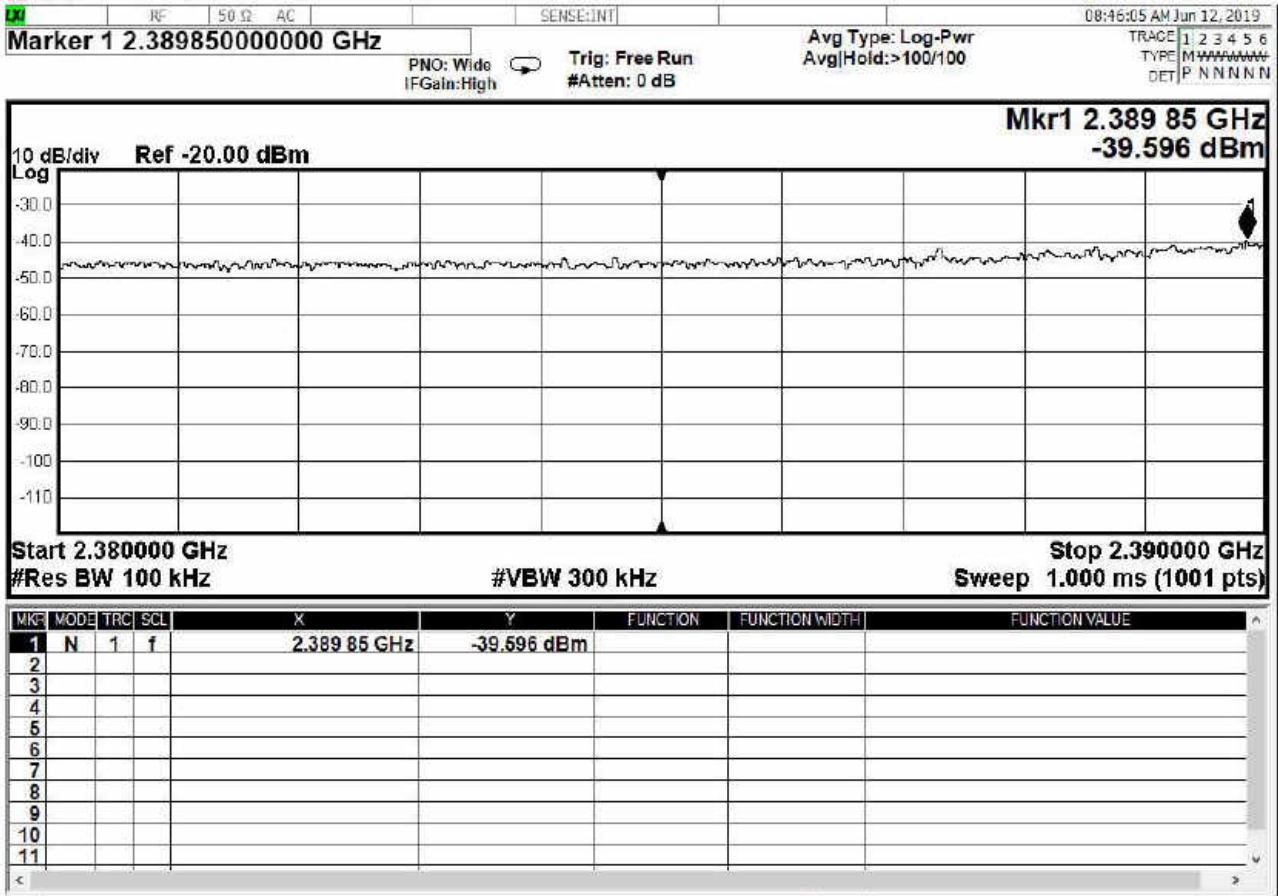



Figure 33 - Band-edge Measurement, Low Channel, Restricted Frequency, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

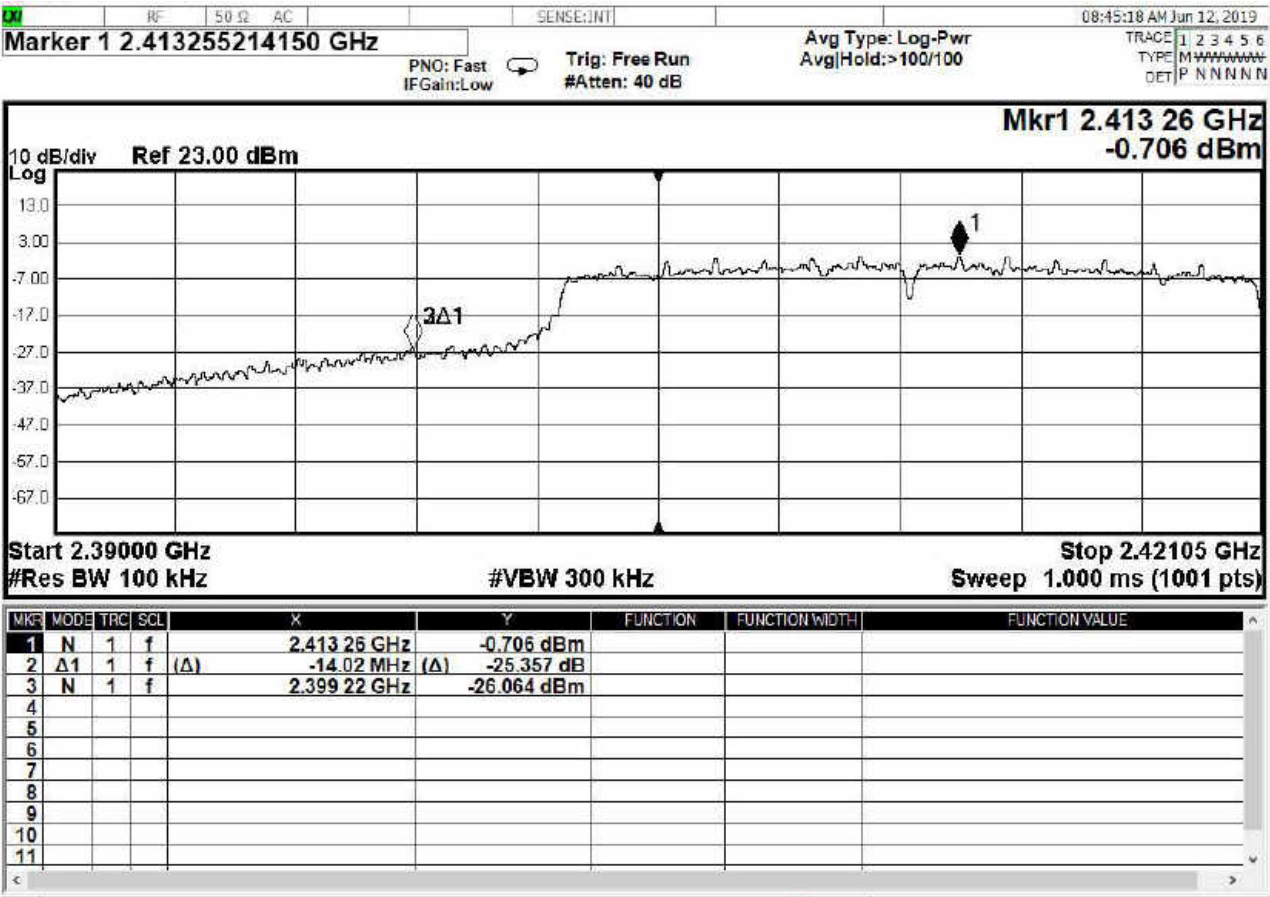



Figure 34 - Band-edge Measurement, Low Channel, Fundamental, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

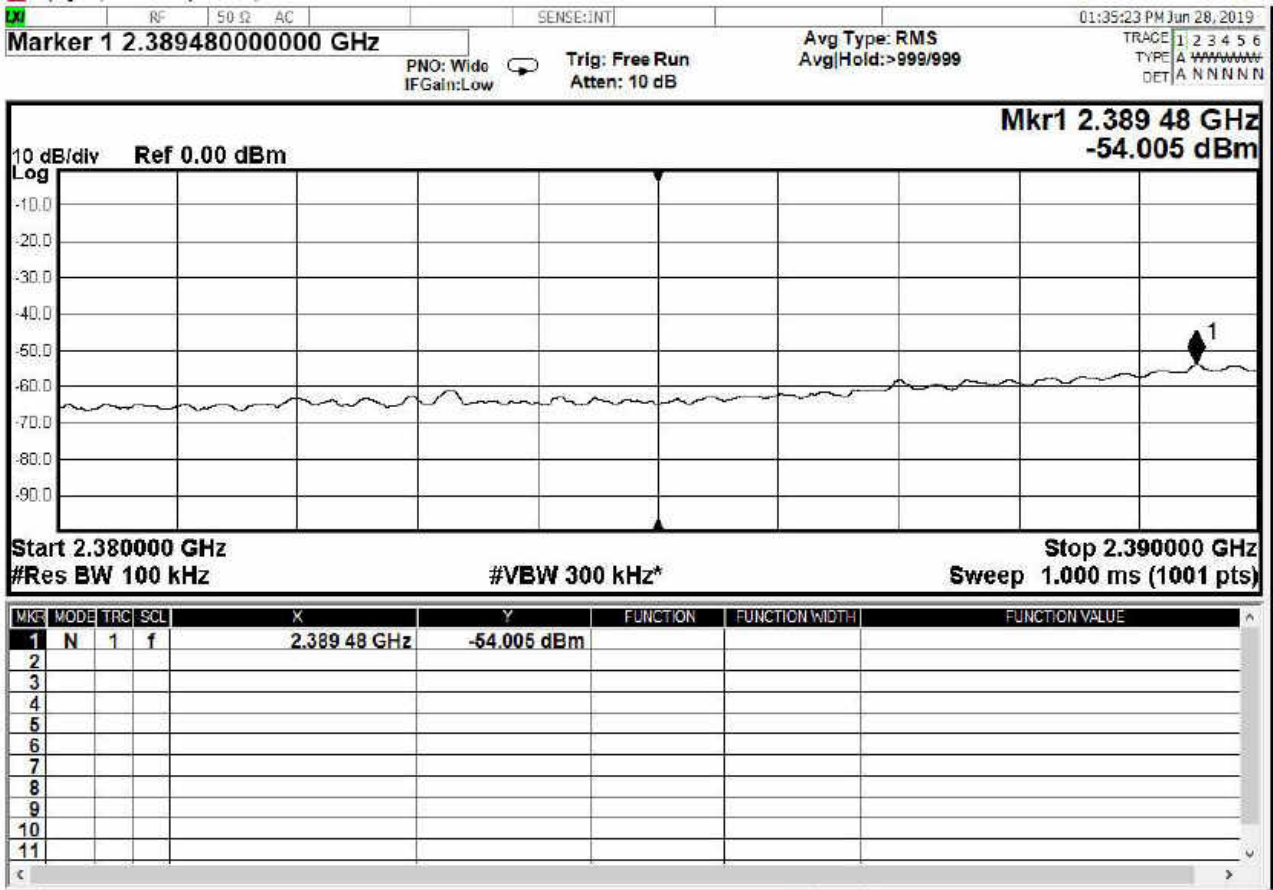



Figure 35 - Band-edge Measurement, Low Channel, Restricted Frequency, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

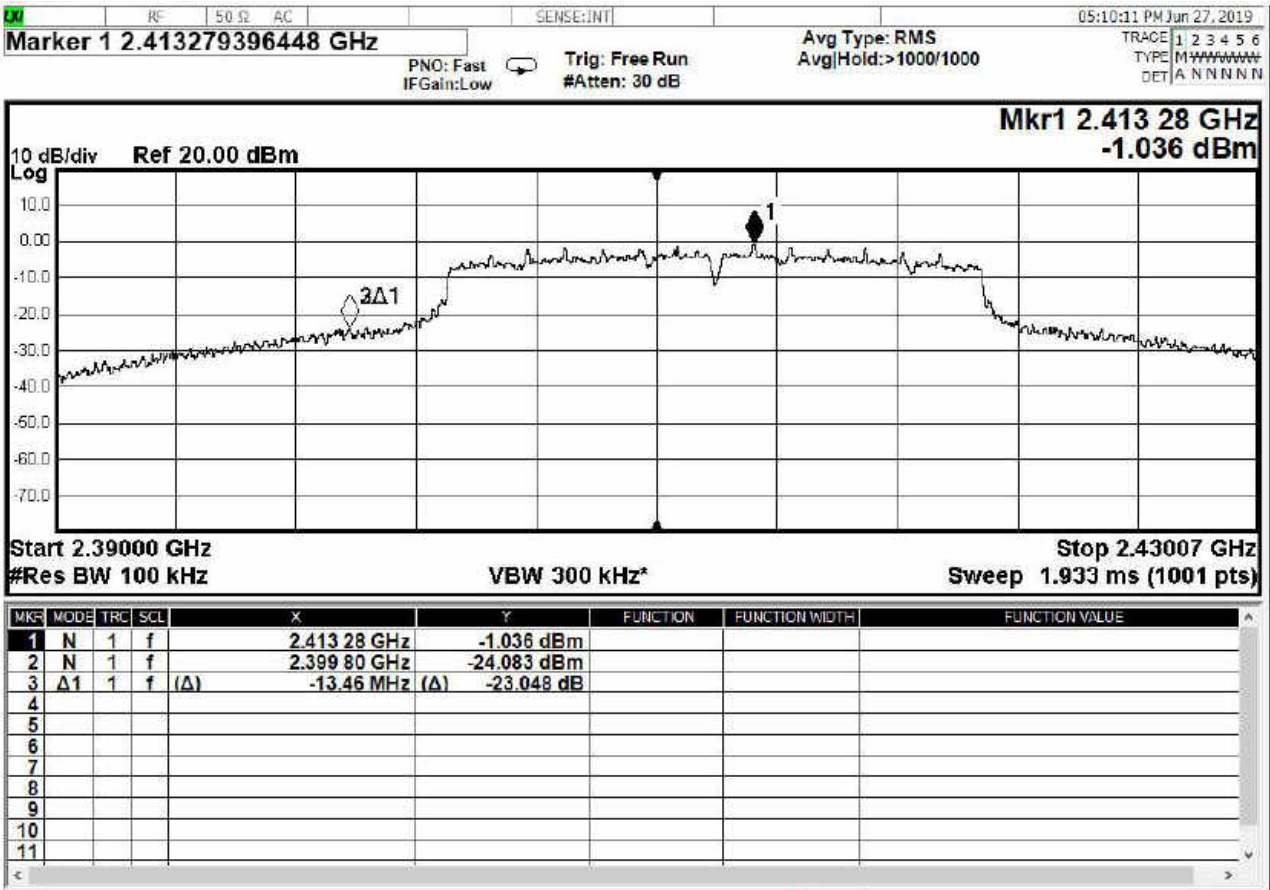



Figure 36 - Band-edge Measurement, Low Channel, Fundamental, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

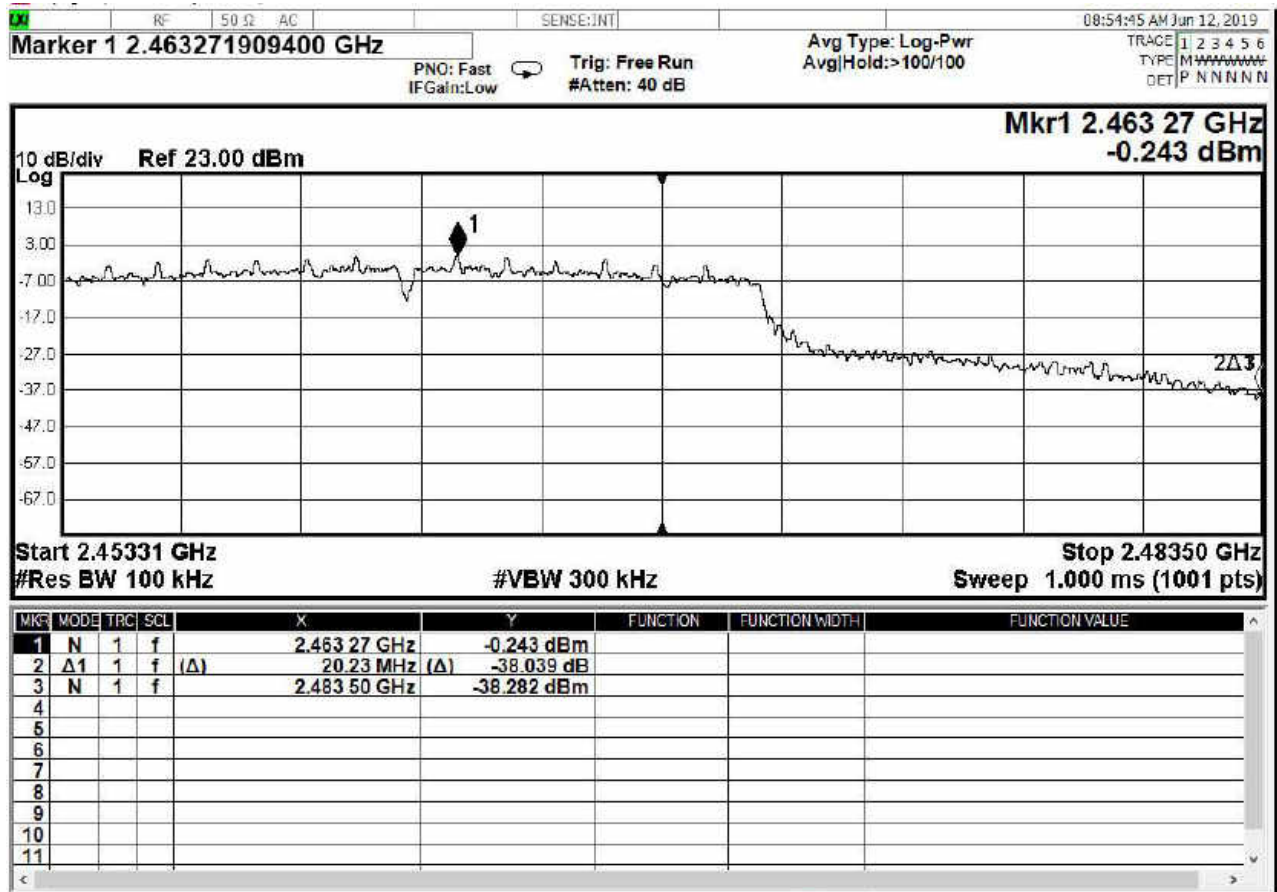



Figure 38 - Band-edge Measurement, High Channel, Fundamental, Peak

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

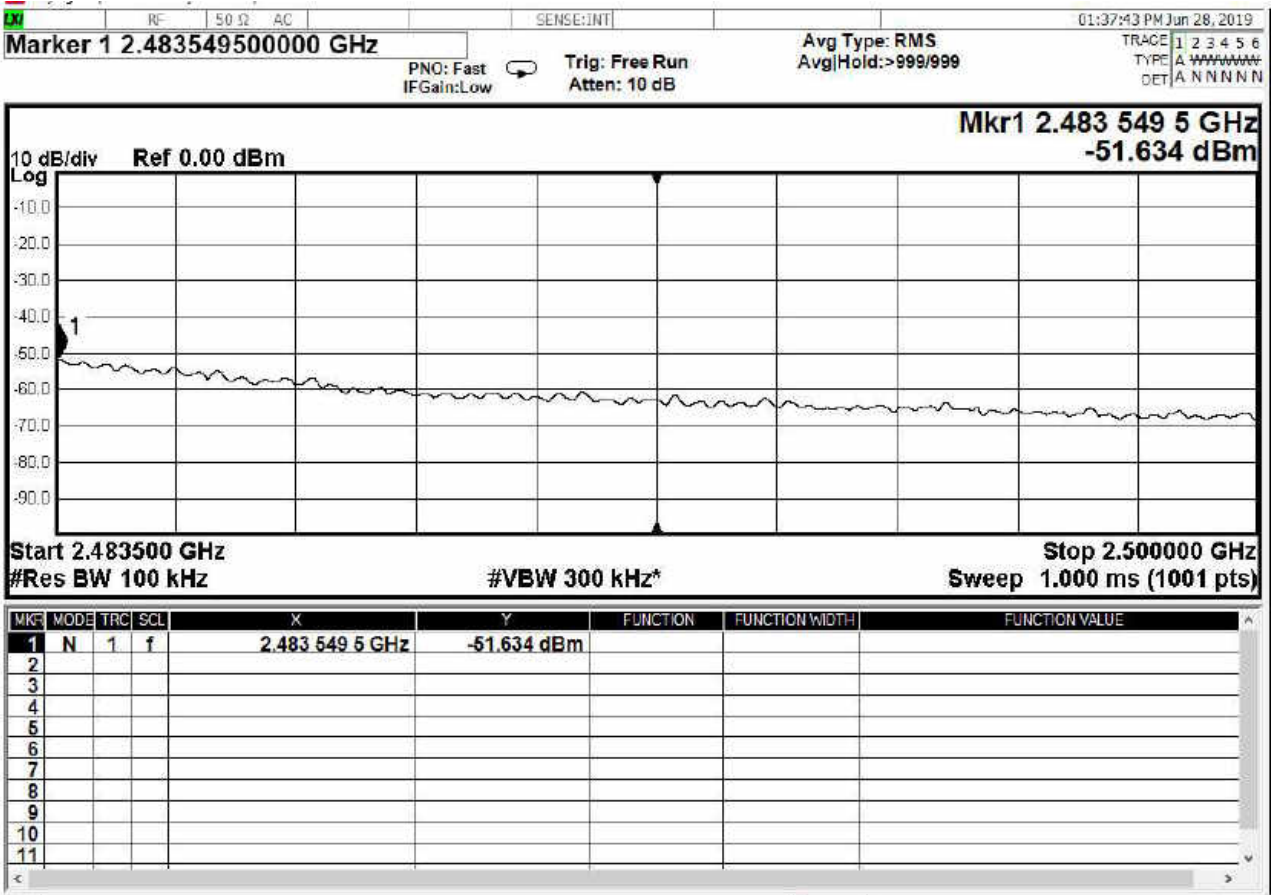



Figure 39 - Band-edge Measurement, High Channel, Restricted Frequency, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

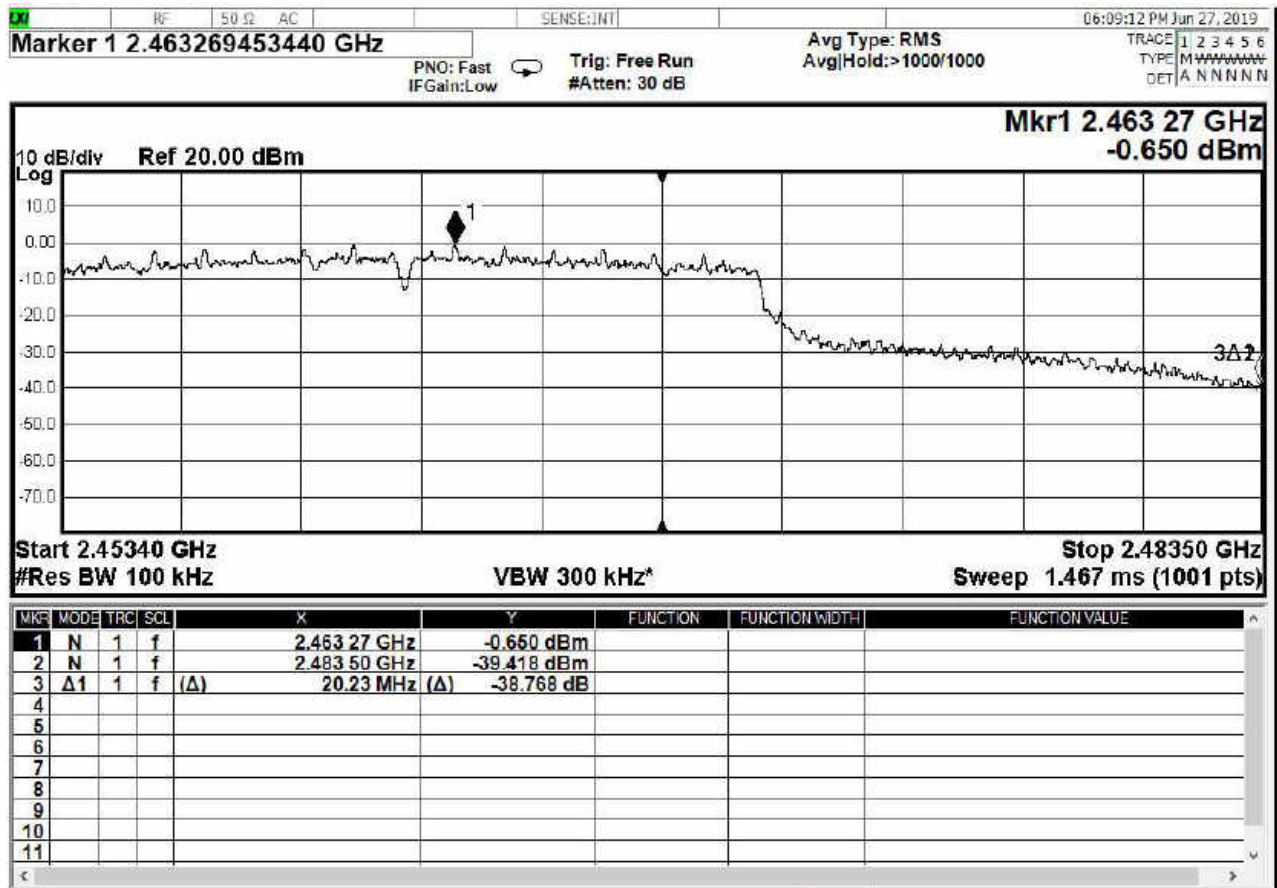



Figure 40 - Band-edge Measurement, High Channel, Fundamental, Average

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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:

| | | | | |
|--|----------------|-----------------|-----|---|
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| | Prepared for: | Garmin | | |

Power Spectral Density

| CHANNEL | CHANNEL FREQUENCY (MHz) | WIFI Type | PEAK PSD(dBm) | Method | Limit (dBm) | RESULT |
|---------|-------------------------------|--------------|------------------|-----------|----------------|--------|
| Low | 2412 | 802.11b | -9.301 | Conducted | 8.00 | PASS |
| Middle | 2437 | 802.11b | -9.638 | Conducted | 8.00 | PASS |
| High | 2462 | 802.11b | -9.756 | Conducted | 8.00 | PASS |
| Low | 2412 | 802.11g | -14.642 | Conducted | 8.00 | PASS |
| Middle | 2437 | 802.11g | -12.739 | Conducted | 8.00 | PASS |
| High | 2462 | 802.11g | -14.794 | Conducted | 8.00 | PASS |
| Low | 2412 | 802.11n | -15.480 | Conducted | 8.00 | PASS |
| Middle | 2437 | 802.11n | -13.085 | Conducted | 8.00 | PASS |
| High | 2462 | 802.11n | -15.250 | Conducted | 8.00 | PASS |

| | | | | |
|--|----------------|-----------------|-----|---|
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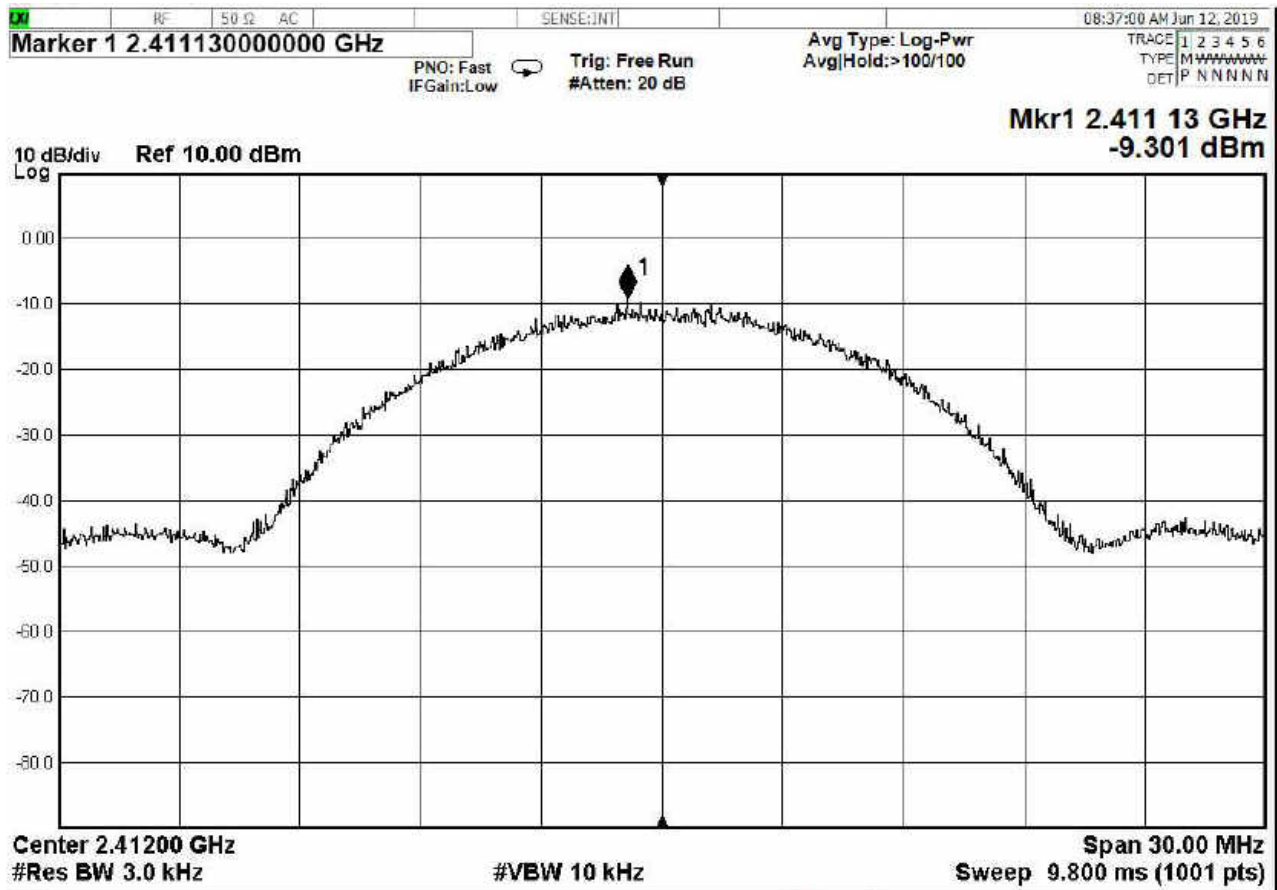


Figure 41 - Power Spectral Density, Low Channel, 802.11b



| | | | | |
|--|----------------|-----------------|-----|---|
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| | Prepared for: | Garmin | | |



Figure 42 - Power Spectral Density, Mid Channel, 802.11b

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

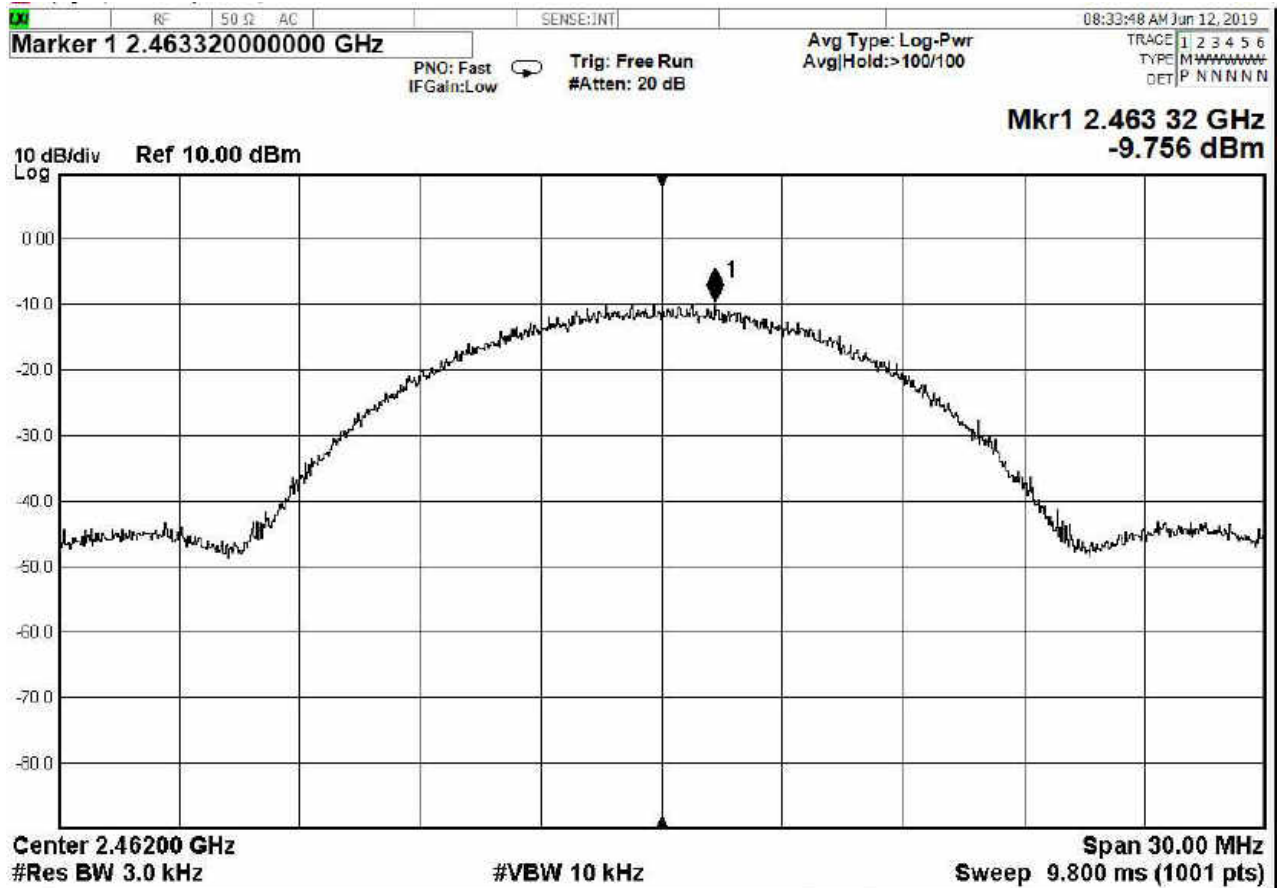



Figure 43 - Power Spectral Density, High Channel, 802.11b

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

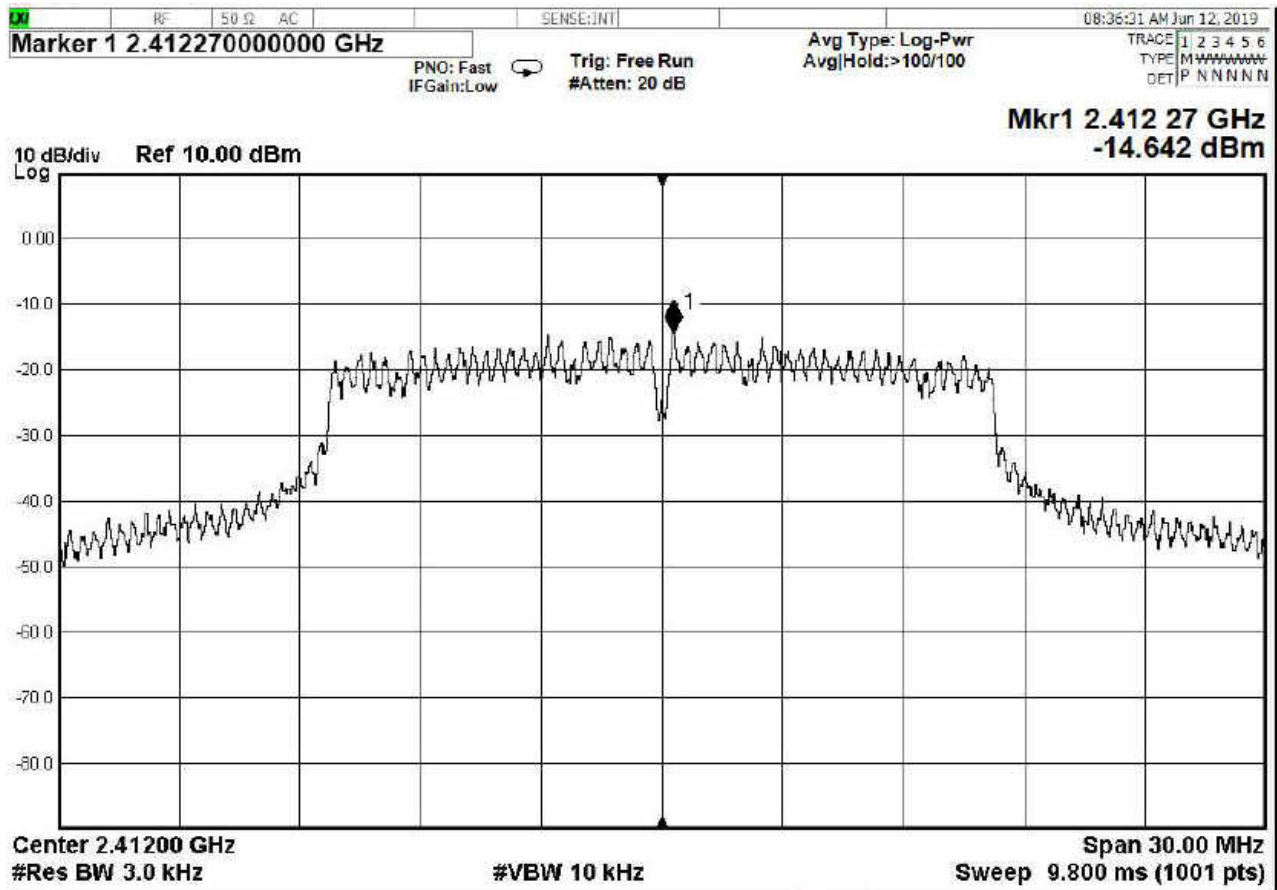



Figure 44 - Power Spectral Density, Low Channel, 802.11g

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

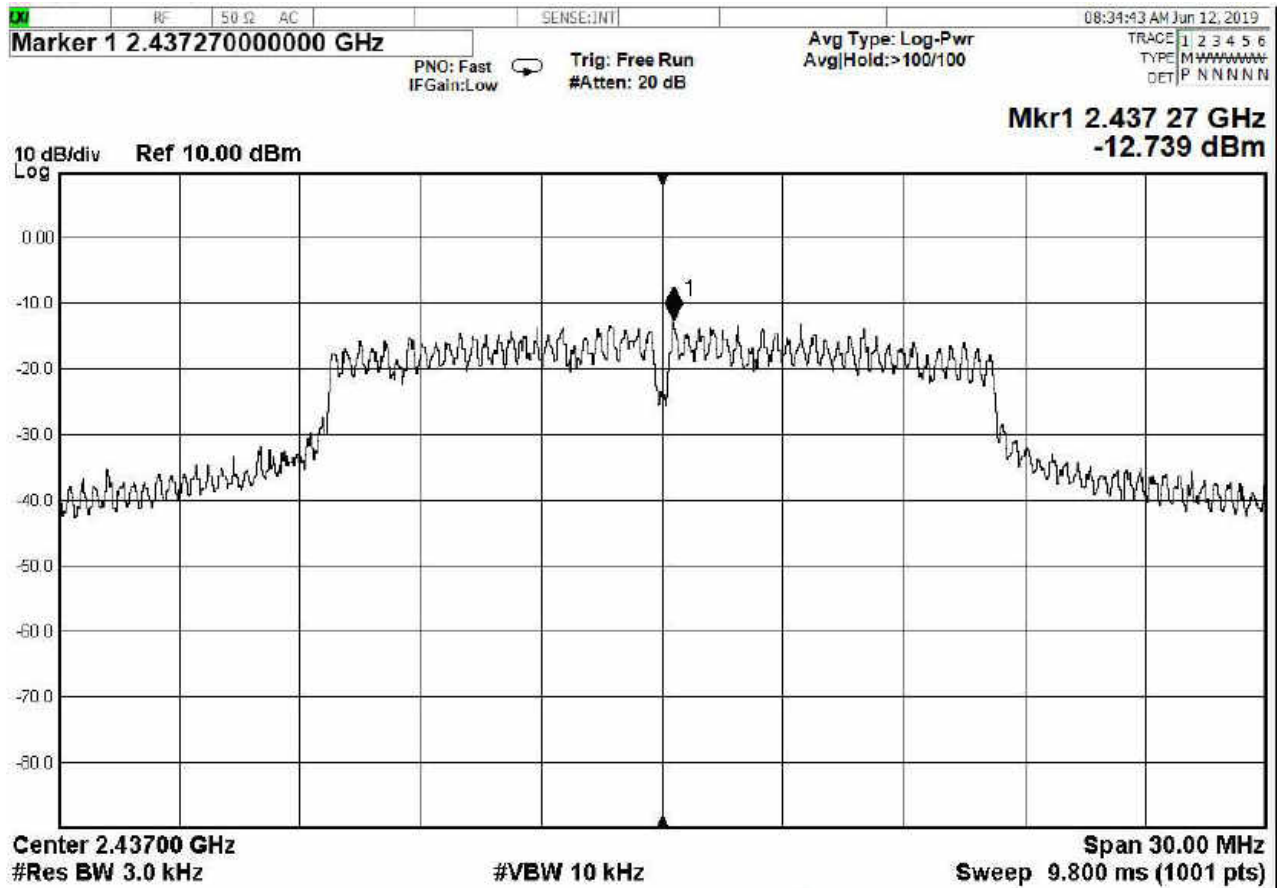



Figure 45 - Power Spectral Density, Mid Channel, 802.11g

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

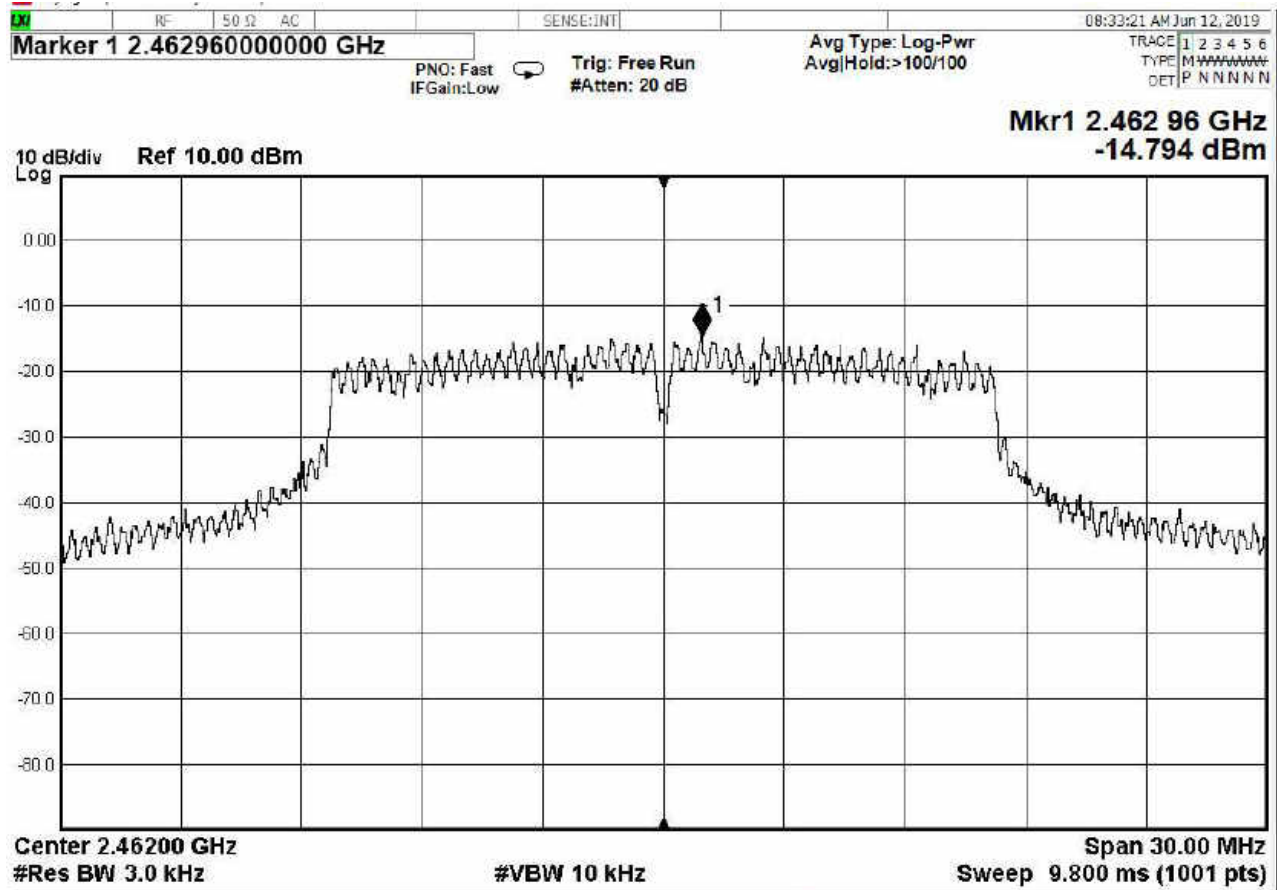



Figure 46 - Power Spectral Density, High Channel, 802.11g

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

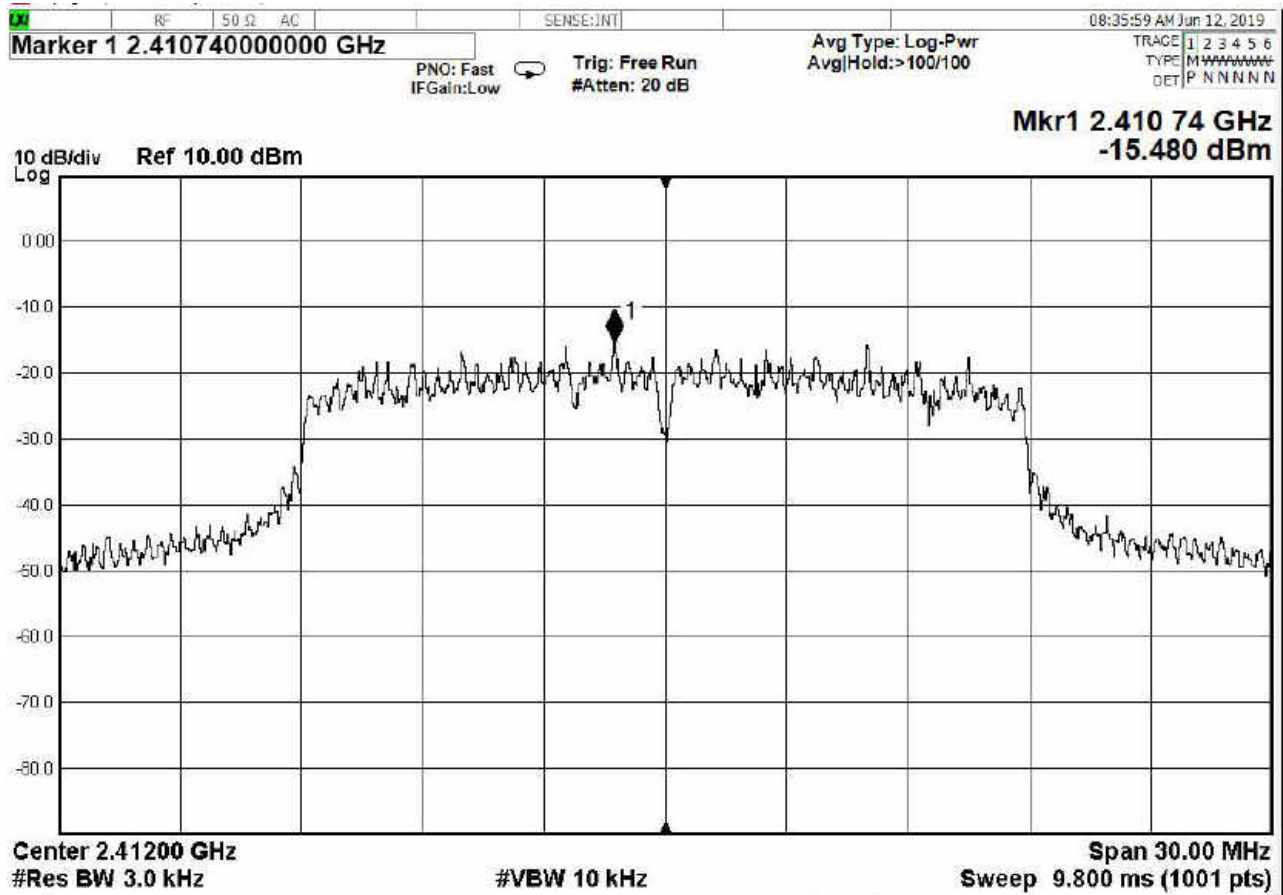



Figure 47 - Power Spectral Density, low Channel, 802.11n

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

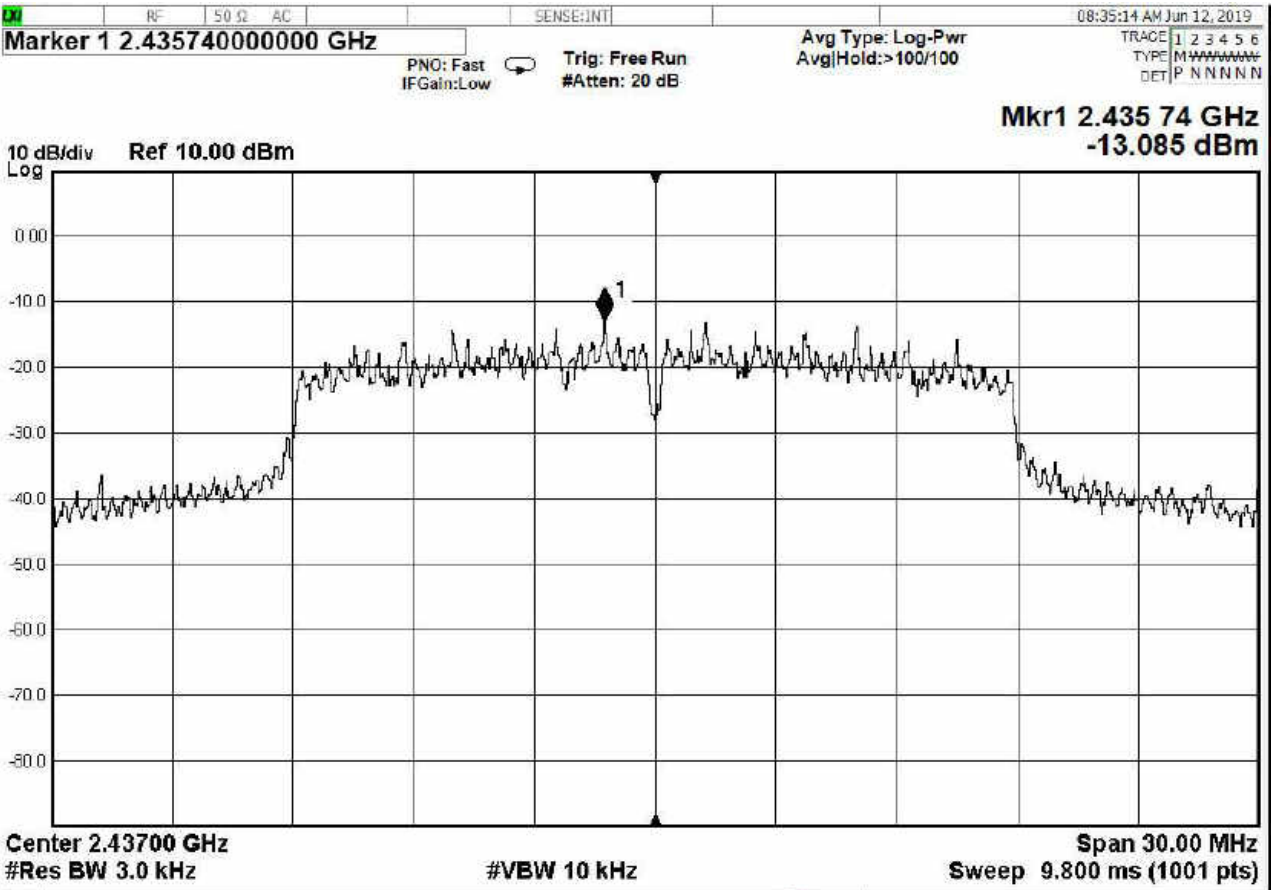



Figure 48 - Power Spectral Density, Mid Channel, 802.11n

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

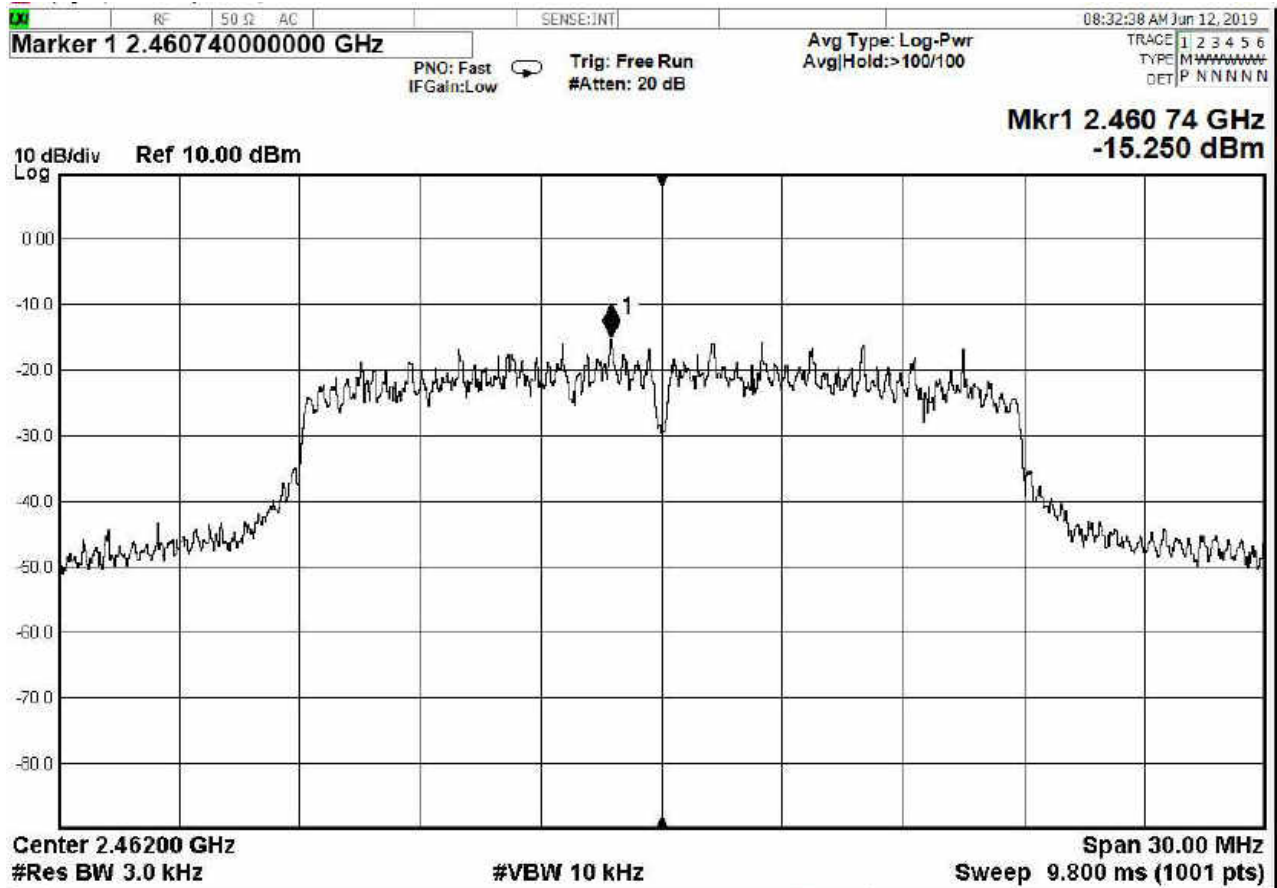



Figure 49 - Power Spectral Density, High Channel, 802.11n

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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 (dB μ V) | |
|--------------------------------|---------------------------------|----------|
| | 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.

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|--|----------------|-----------------|-----|---|
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Test Results:

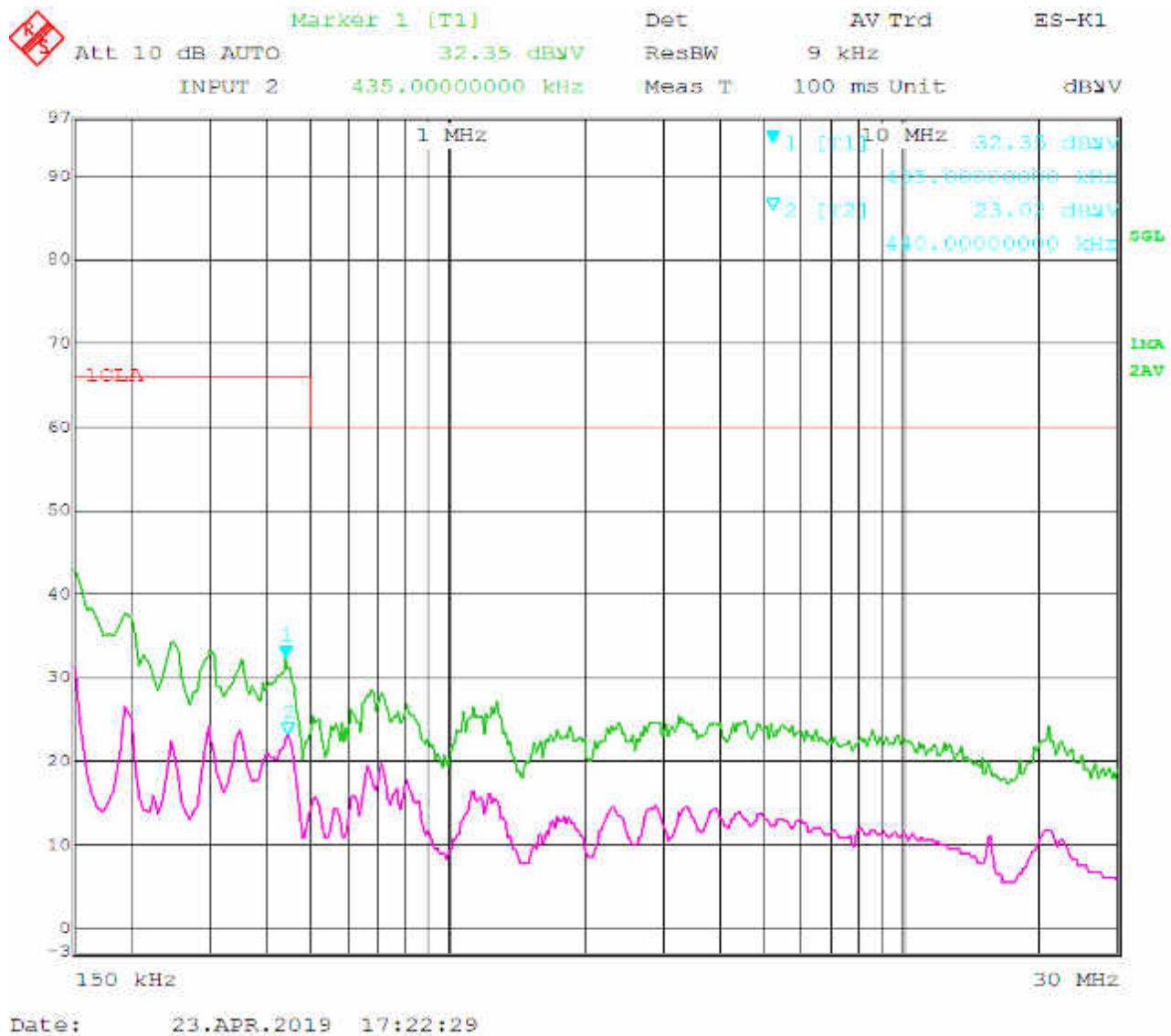



Figure 50 - Conducted Emissions Plot, L-F

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

| | | | |
|--|--------------------------------|-----|---|
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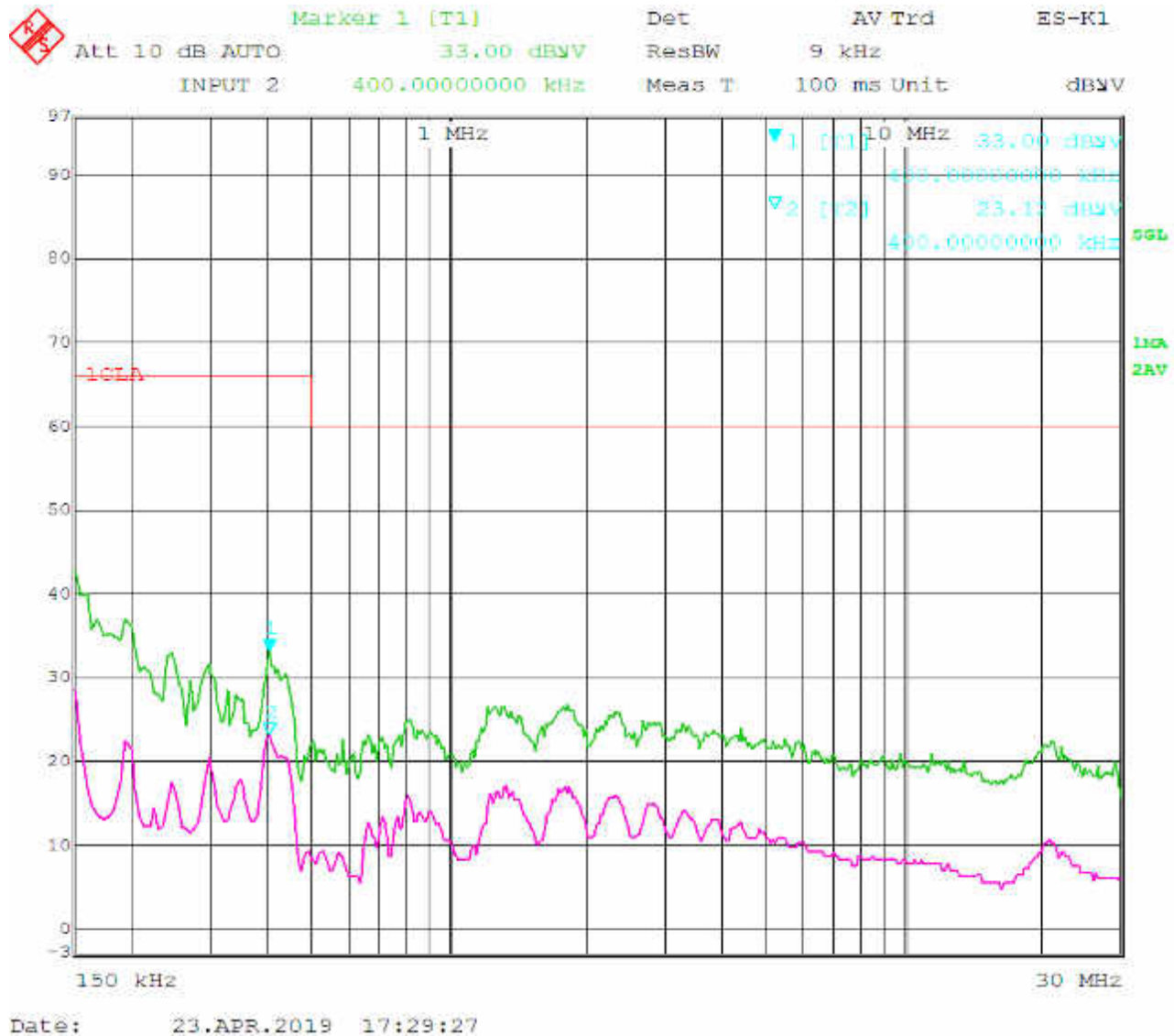



Figure 51 - Conducted Emissions Plot, L-G

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

| | | | | |
|--|----------------|-----------------|-----|---|
|  | Report Number: | R20181130-20-05 | Rev | A |
| | Prepared for: | Garmin | | |

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 dB μ V 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 dB μ V/m.

$$FS = 55 + 12 - (-1.1 + 20) + 0 = 48.1 \text{ dB}\mu\text{V/m}$$

The 48.1 dB μ V/m value can be mathematically converted to its corresponding level in μ V/m.

$$\text{Level in } \mu\text{V/m} = \text{Common Antilogarithm } [(48.1 \text{ dB}\mu\text{V/m})/20] = 254.1 \mu\text{V/m}$$

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

| | | | | |
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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;

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

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

$$Voltage (dB\mu V) = Power (dBm) + 107 \text{ (for } 50\Omega \text{ measurement systems)}$$

$$Field Strength (V/m) = 10^{[Field Strength (dB\mu V/m) / 20]} / 10^6$$


$$Gain = 1 \text{ (numeric gain for isotropic radiator)}$$

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

$$EIRP = [FS(V/m) \times d^2]/30 = FS [0.3] \quad \text{for } d = 3$$

$$EIRP(dBm) = FS(dB\mu V/m) - 10(\log 10^9) + 10\log[0.3] = FS(dB\mu V/m) - 95.23$$

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

| | | | | |
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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%.

| | | | | |
|--|----------------|-----------------|-----|---|
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| | Prepared for: | Garmin | | |

REPORT END