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Amended

# FCC/ISED Test Report

**Prepared for:** **Johnson Outdoors**

**Address:** **1521 Madison Ave**
**Mankato, MN 56002**

**Product:** **Raptor Shallow-water Anchor**

**Test Report No:** **R20191119-21-E1C**

**Approved by:**

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

**DATE:** **7 May 2020**

**Total Pages:** **54**

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## REVISION PAGE

| Rev. No. | Date | Description |
|---|---|---|
| 0 | 26 March 2020 | Original – NJohnson<br>Prepared by KVepuri/CFarrington |
| A | 29 April 2020 | Specified FCC Part 15.249/RSS-210<br><br>Includes NCEE Labs report R20191119-21-E1 and its amendment in full. -NJ |
| B | 5 May 2020 | Updated calibration table<br><br>Includes NCEE Labs report R20191119-21-E1A and its amendment in full. -NJ |
| C | 7 May 2020 | Removed PSD measurements<br><br>Includes NCEE Labs report R20191119-21-E1B 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. Summary of test results presented in this report correspond to the following section (Please see the checked box below for the rule part used):

### FCC Part 15.249 ☒

The EUT has been tested according to the following specifications:

(1) US Code of Federal Regulations, Title 47, Part 15
(2) ISED RSS-Gen, Issue 5
(3) ISED RSS-210, Issue 10

| SUMMARY | | | |
|---|---|---|---|
| **Requirement** | **Test Type and Limit** | **Result** | **Remark** |
| FCC 15.203 | Unique Antenna Requirement | Pass | PCB Antenna |
| FCC 15.35<br>RSS-Gen, 6.10 | Duty cycle of pulsed emissions | N/A | Not required |
| NA | Maximum Peak Output Power | N/A | Informational Purpose Only |
| NA | Minimum Bandwidth | N/A | Informational Purpose Only |
| FCC 15.209<br>RSS-Gen, 7.1 | Receiver Radiated Emissions | Pass | Meets the requirement of the limit. |
| FCC 15.209<br>RSS-Gen, 8.9<br>RSS-210 A1.2<br>FCC 15.249(a) | Transmitter Radiated Emissions | Pass | Meets the requirement of the limit. |
| FCC 15.209, 15.205, 15.249(d)<br>RSS-Gen, 8.9<br>RSS-210, 5.5 | Band Edge Measurement | Pass | Meets the requirement of the limit. |
| FCC 15.207<br>RSS-Gen. 8.8 | Conducted AC Emissions | Pass | Meets the requirement of the limit. |

# 2.0 EUT DESCRIPTION

## 2.1 EQUIPMENT UNDER TEST

**Summary and Operating Condition:**

| | |
|---|---|
| EUT | Raptor Shallow-water Anchor |
| EUT Received | 12 March 2020 |
| EUT Tested | 12 March 2020- 13 March 2020 |
| Serial No. | 00050 (Assigned by lab, used for conducted antenna port measurements);<br>00040 (Assigned by lab, used for radiated measurements); |
| Operating Band | 2400 – 2483.5 MHz |
| Device Type | ☒ BLE ☐ GFSK ☒ BT BR ☐ BT EDR 2MB ☐ BT EDR 3MB<br>☐ 802.11x |
| Power Supply / Voltage | 12 VDC Marine Battery |

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

## 2.2 DESCRIPTION OF TEST MODES

The operating range of the EUT is dependent on the device type found in section 2.1:

For Bluetooth Transmissions:

| Channel | Frequency |
|---|---|
| Low | 2402 MHz |
| Mid | 2440/2441 MHz |
| High | 2480 MHz |

These are the only 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.

## 2.3 DESCRIPTION OF SUPPORT UNITS

None

# 3.0 LABORATORY AND GENERAL TEST 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

| No. | PERSONNEL | TITLE | ROLE |
|---|---|---|---|
| 1 | Nic Johnson | Technical Manager | Review/editing |
| 2 | Karthik Vepuri | Test Engineer | Testing and report |
| 3 | Caleb Farrington | Test Engineer | Testing and report |
| 4 | April Inamura | Test Technician | Testing and report |

**Notes:**
All personnel are permanent staff members of NCEE Labs. No testing or review was sub-contracted or performed by sub-contracted personnel.

## 3.3 TEST EQUIPMENT

| DESCRIPTION AND MANUFACTURER | MODEL NO. | SERIAL NO. | LAST CALIBRATION DATE | CALIBRATION DUE DATE |
|---|---|---|---|---|
| Keysight MXE Signal Analyzer | N9038A | MY59050109 | 23 Apr 2019 | 23 Apr 2021 |
| Keysight EXA Signal Analyzer | N9010A | MY56070862 | 14 Dec 2018 | 14 Dec 2020 |
| SunAR RF Motion | JB1 | A082918-1 | 15 Oct 2018 | 15 Oct 2020 |
| EMCO Horn Antenna | 3115 | 6416 | 26 Jul 2018 | 26 Jul 2021 |
| EMCO Horn Antenna | 3116 | 2576 | 31 Jan 2018 | 31 Jan 2021 |
| Rohde & Schwarz Preamplifier | TS-PR18 | 3545700803 | 09 Mar 2018* | 09 Mar 2021* |
| Trilithic High Pass Filter | 6HC330 | 23042 | 09 Mar 2018* | 09 Mar 2021* |
| Rohde & Schwarz LISN | ESH3-Z5 | 836679/010 | 25 Jul 2019 | 25 Jul 2020 |
| TDK Emissions Lab Software | V11.25 | 700307 | NA | NA |
| RF Cable (preamplifier to antenna) | MFR-57500 | 01-07-002 | 09 Mar 2018* | 09 Mar 2021* |
| RF Cable (antenna to 10m chamber bulkhead) | FSCM 64639 | 01E3872 | 09 Mar 2018* | 09 Mar 2021* |
| RF Cable (10m chamber bulkhead to control room bulkhead) | FSCM 64639 | 01E3874 | 09 Mar 2018* | 09 Mar 2021* |
| RF Cable (Control room bulkhead to RF switch) | FSCM 64639 | 01E3871 | 09 Mar 2018* | 09 Mar 2021* |
| RF Cable (RF switch to test receiver) | FSCM 64639 | 01F1206 | 09 Mar 2018* | 09 Mar 2021* |
| RF switch – Rohde and Schwarz | TS-RSP | 1113.5503.14 | 09 Mar 2018* | 09 Mar 2021* |
| N connector bulkhead (10m chamber) | PE9128 | NCEEBH1 | 09 Mar 2018* | 09 Mar 2021* |
| N connector bulkhead (control room) | PE9128 | NCEEBH2 | 09 Mar 2018* | 09 Mar 2021* |

*Internal Characterization

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

## 3.4 GENERAL TEST PROCEDURE AND SETUP FOR RADIO MEASUREMNTS

Measurement type presented in this report (Please see the checked box below):

### Conducted ☒

The conducted measurements were performed by connecting the output of the transmitter directly into a spectrum analyzer using an impedance matched cable and connector soldered to the EUT in place of the antenna. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Figure 1 - Bandwidth Measurements Test Setup**

### Radiated ☐

All the radiated measurements were taken at a distance of 3m from the EUT. The information regarding resolution bandwidth, video bandwidth, span and the detector used can be found in the graphs provided in the Appendix C. All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

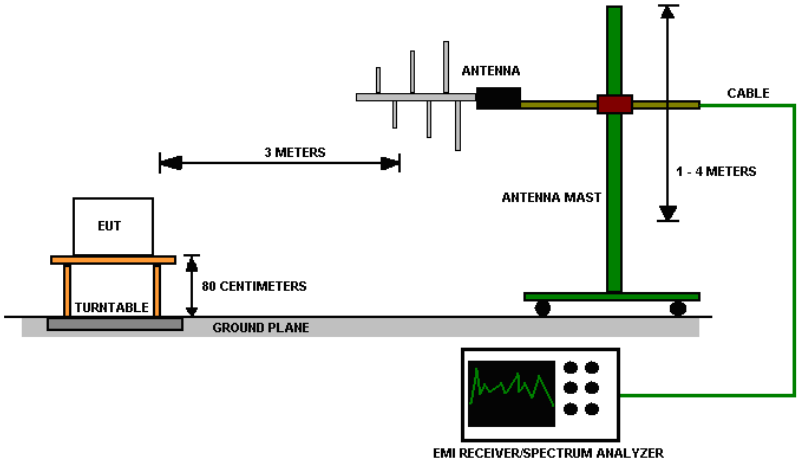



**Figure 2 - Radiated Emissions Test Setup**

# 4.0 RESULTS

## 4.1 OUTPUT POWER

**Test Method**: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of power measurements:**

**For FCC Part 15.249 Device:**
For Informational Purposes only

**For FCC Part 15.247 Device:**
The maximum allowed peak output power is 30 dBm.

**Test procedures:**
Details can be found in section 3.4 of this report.

**Deviations from test standard:**
No deviation.

**Test setup:**
Details can be found in section 3.4 of this report.

**EUT operating conditions:**
Details can be found in section 2.1 of this report.

**Test results: Pass**
Comments:
1. All the output power plots can be found in the Appendix C.
2. All the measurements were found to be compliant.
3. The measurements are listed in the table below.

## Peak Output Power

| CHANNEL | PEAK OUTPUT POWER (dBm) | PEAK OUTPUT POWER (mW) | RESULT | Transmitter |
|---|---|---|---|---|
| Low | 5.423 | 3.486 | PASS | BLE |
| Mid | 5.137 | 3.264 | PASS | BLE |
| High | 4.984 | 3.151 | PASS | BLE |
| Low | 5.894 | 3.885 | PASS | BT BR |
| Mid | 5.701 | 3.716 | PASS | BT BR |
| High | 5.608 | 3.637 | PASS | BT BR |

## 4.2 BANDWIDTH

**Test Method**: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of bandwidth measurements:**

**For FCC Part 15.249 Device:**
For Informational Purposes only

**For FCC Part 15.247 Device:**
The 99% occupied bandwidth is for informational purpose only. The 6dB bandwidth of the signal must be greater than 500 kHz.

**Test procedures:**
Details can be found in section 3.4 of this report.

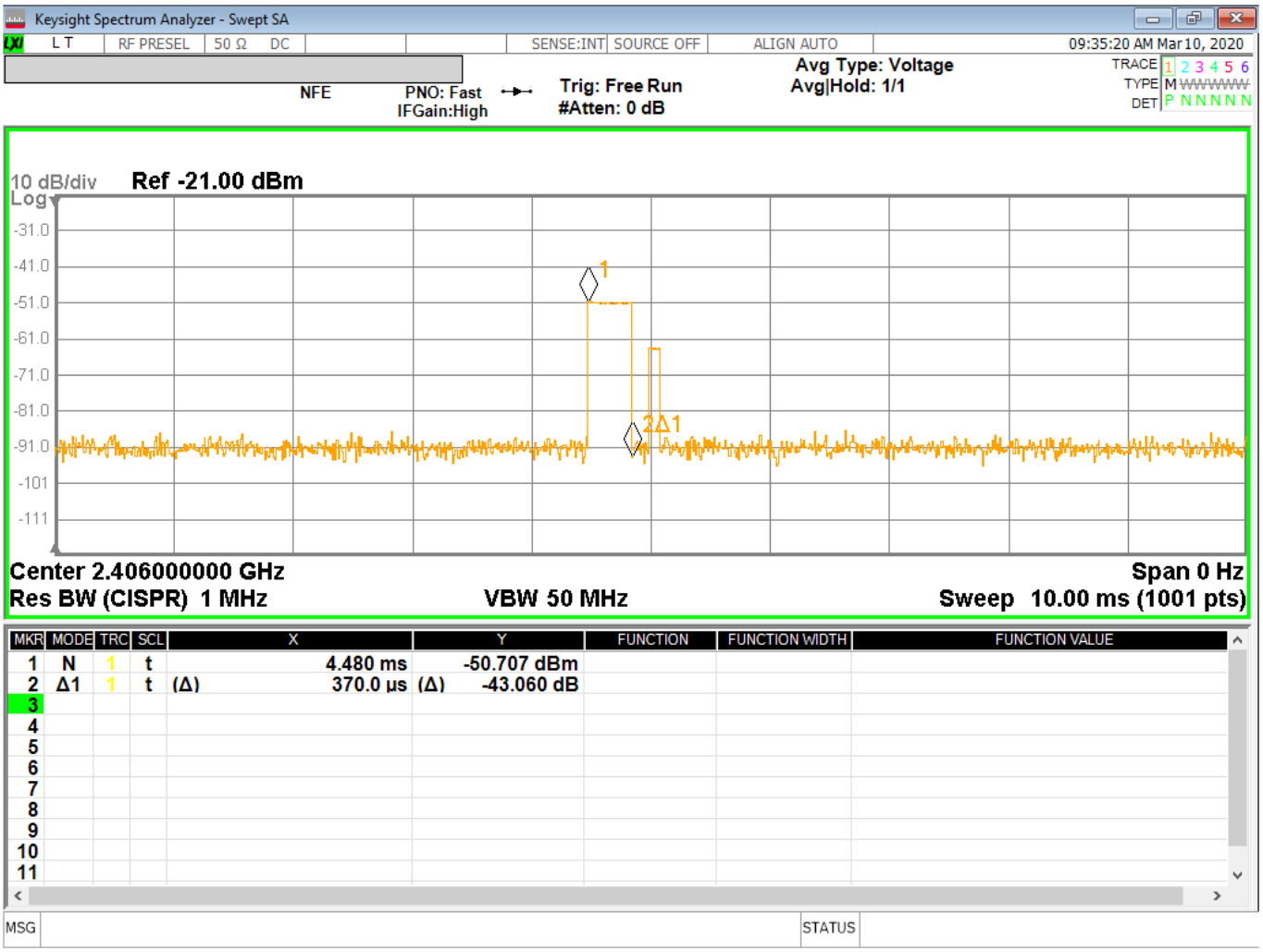
**Deviations from test standard:**
No deviation.

**Test setup:**
Test setup details can be found in section 3.4 of this report.

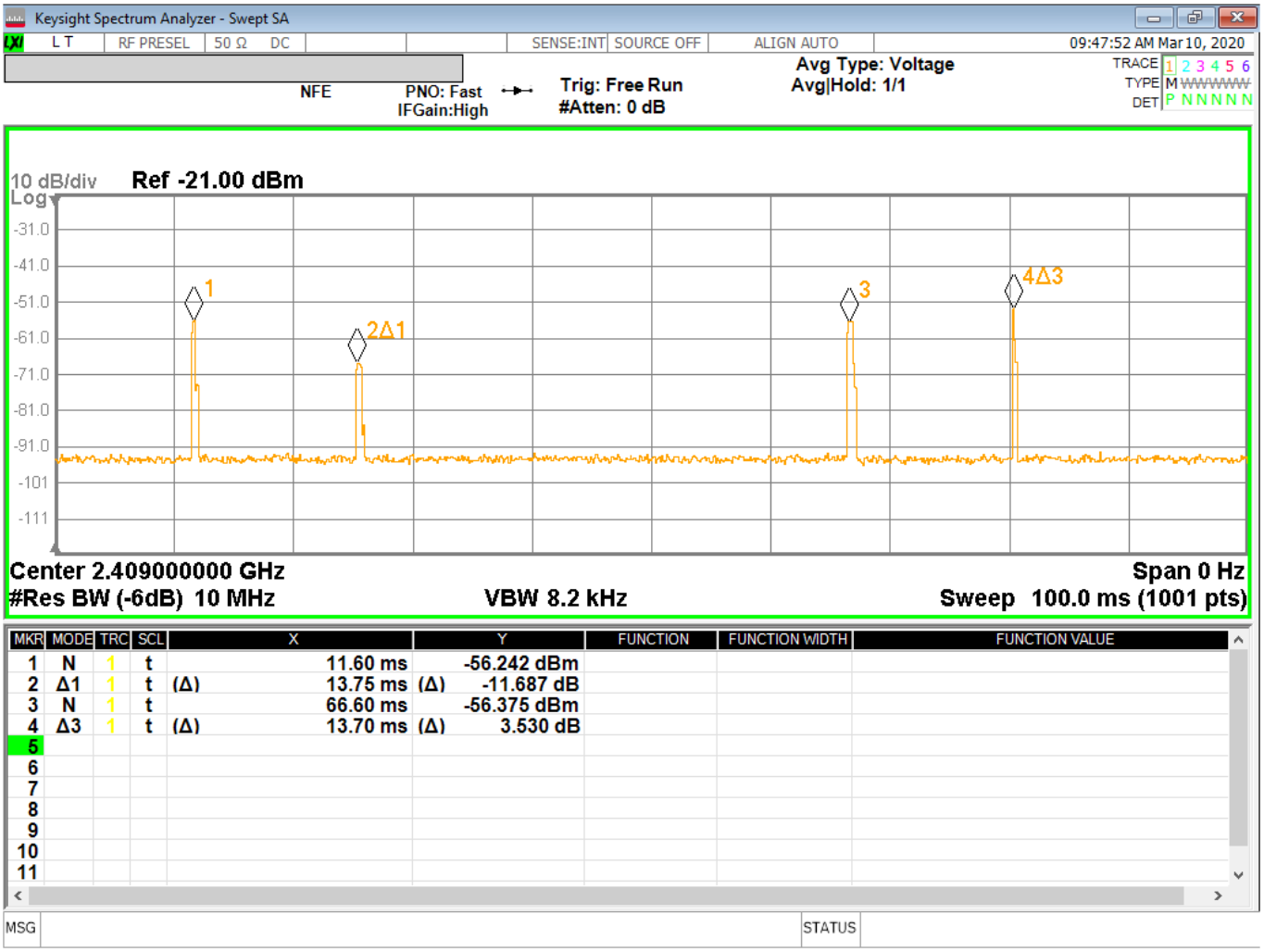
**EUT operating conditions:**
Details can be found in section 2.1 of this report.

**Test results:**
**Pass**
Comments:
1. All the bandwidth plots can be found in the Appendix C.
2. All the measurements were found to be compliant.

## 4.3 DUTY CYCLE




On Time Raptor Pump, BLE



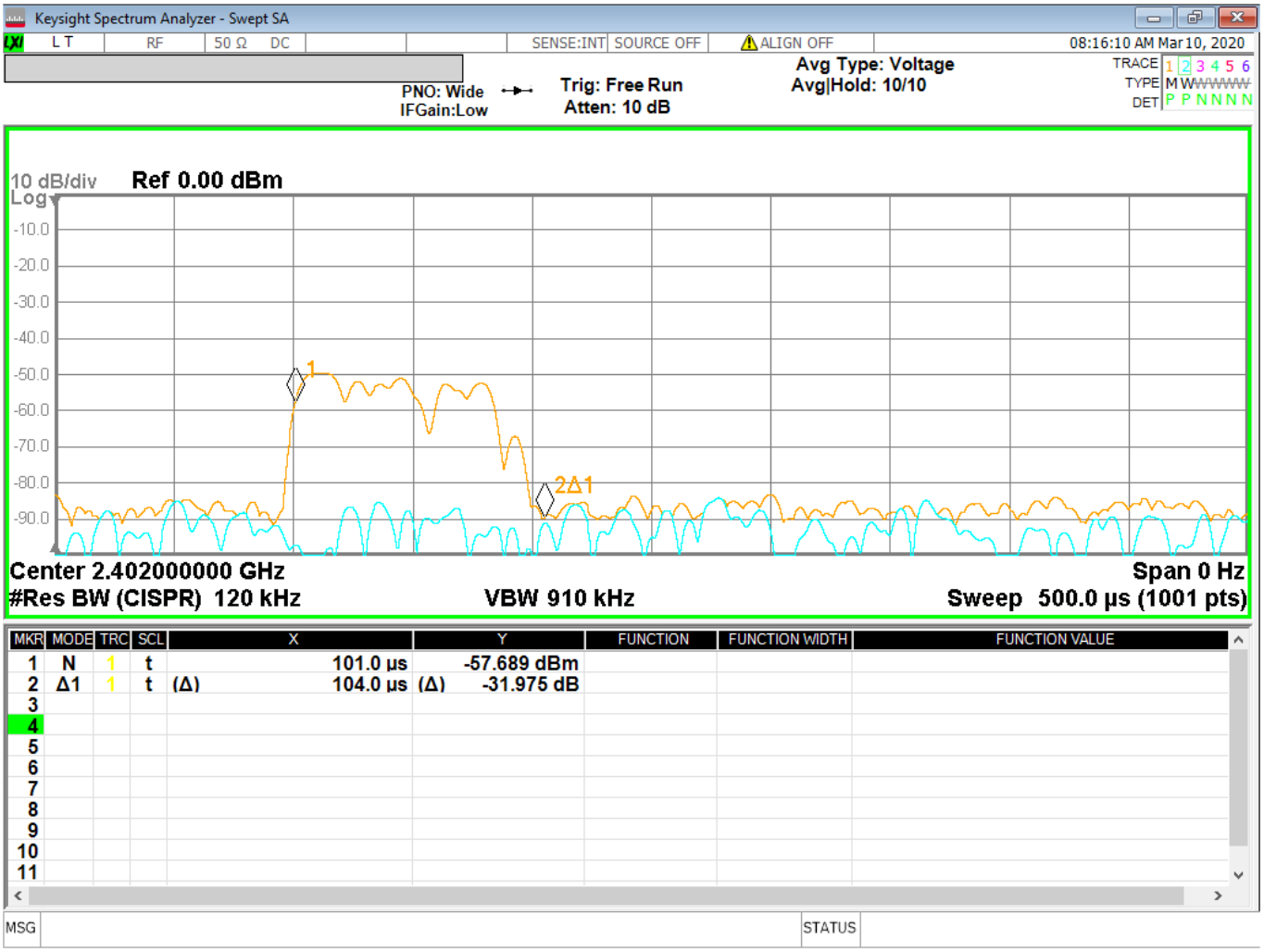

Period Raptor Pump, BLE

Duty cycle correction factor = 20*log((0.37 x 4)/100) = -36.59 dB

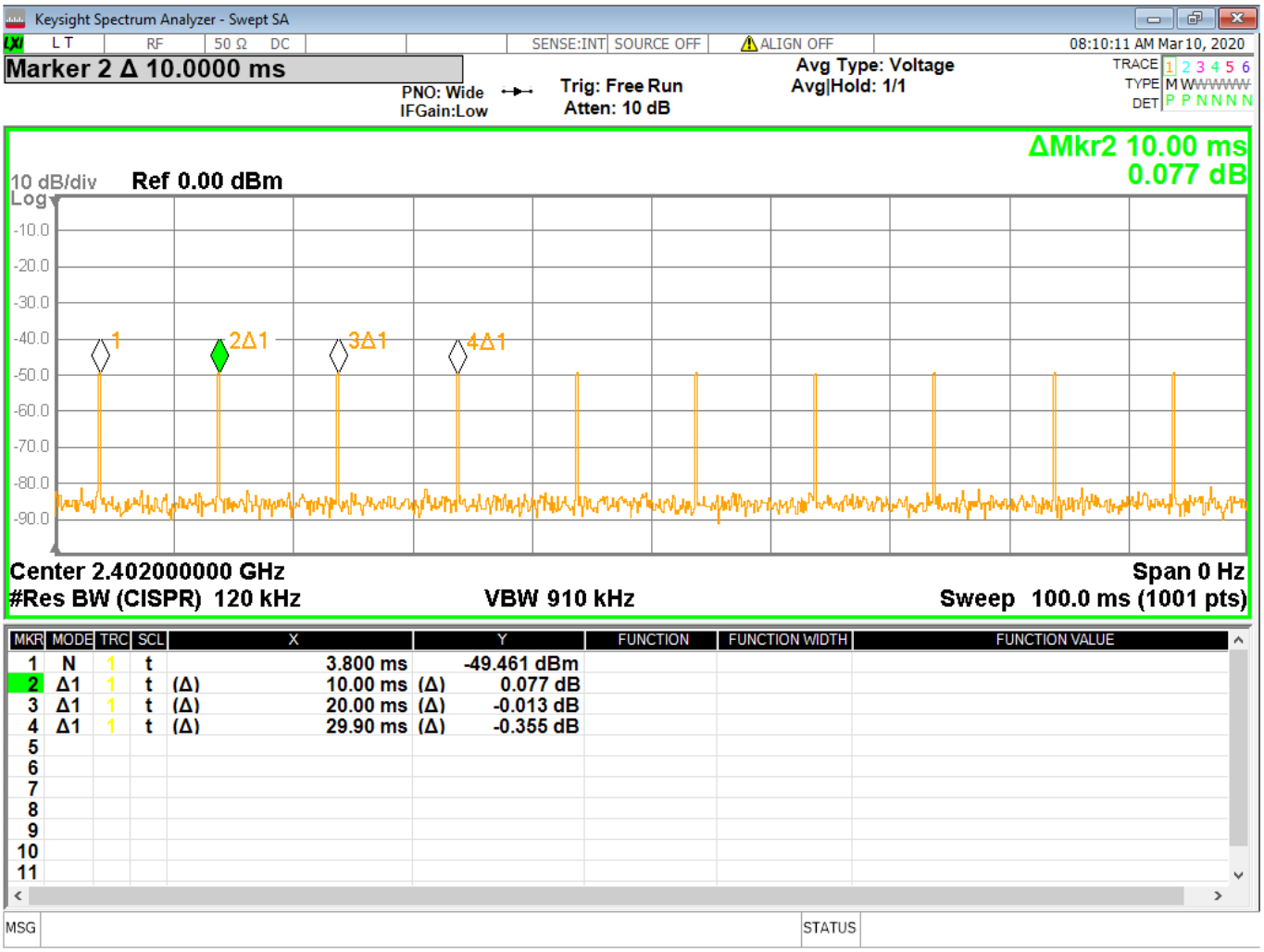
On time = 0.37

Period = 100 ms (worst case was used per FCC Part 15.35)

20dB is the maximum useable averaging factor. So, 20 dB of correction was applied to the peak measurements in section 4.4 to get average measurements.




On Time Raptor Pump, BT Classic




Period Raptor Pump, BT Classic

Duty cycle correction factor = 20*log((0.14x10)/100) = -37.07 dB

On time = 0.14

Period = 100 ms (worst case was used)

20dB is the maximum useable averaging factor. So, 20 dB of correction was applied to the peak measurements in section 4.4 to get average measurements.

## 4.4 RADIATED EMISSIONS

**Test Method**: ANSI C63.10-2013, Section 6.5, 6.6

**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:**
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.
4. The EUT was tested for spurious emissions while running off of battery power.

**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 the $10^{th}$ harmonic.

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. The EUT was maximized in all 3 orthogonal positions. The results are presented for the axis that had the highest emissions.

**Test setup:**

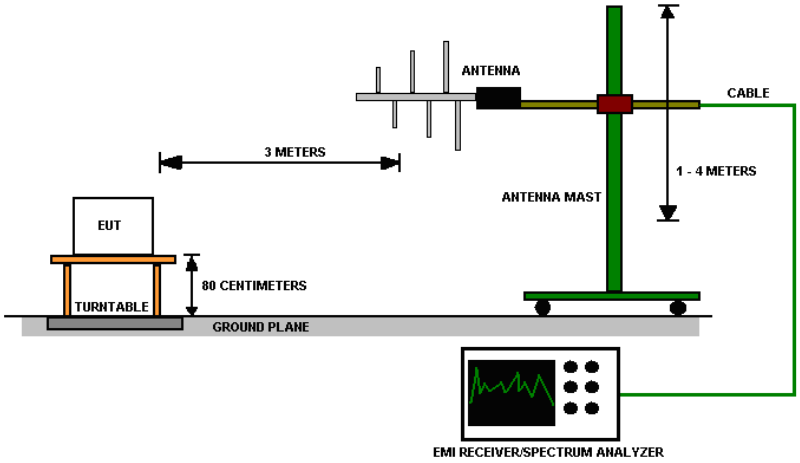



**Figure 3 - Radiated Emissions Test Setup**

**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.

**EUT operating conditions**
Details can be found in section 2.1 of this report.

## Test results:

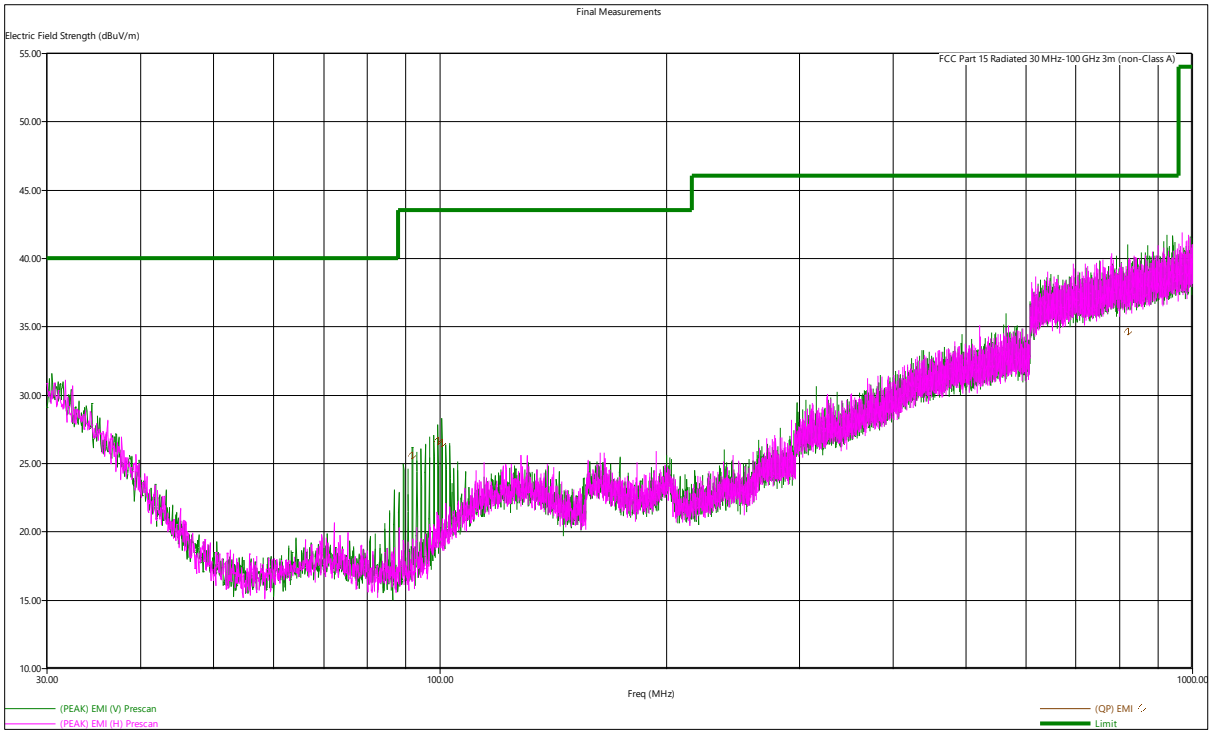



**Figure 4 - Radiated Emissions Plot, Receive, BLE & BTBR**

| Quasi-Peak Measurements, BLE & BTBR, RX Mode | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequency | Level | Limit | Margin | Height | Angle | Pol | Channel | Modulation |
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | | |
| 91.810000 | 25.50 | 43.52 | 18.02 | 114 | 264 | V | Low | GMSK |
| 99.260000 | 26.61 | 43.52 | 16.91 | 106 | 212 | V | Low | GMSK |
| 100.510000 | 26.46 | 43.52 | 17.06 | 103 | 353 | V | Low | GMSK |
| 820.380000 | 34.59 | 46.02 | 11.43 | 354 | 41 | V | Low | GMSK |

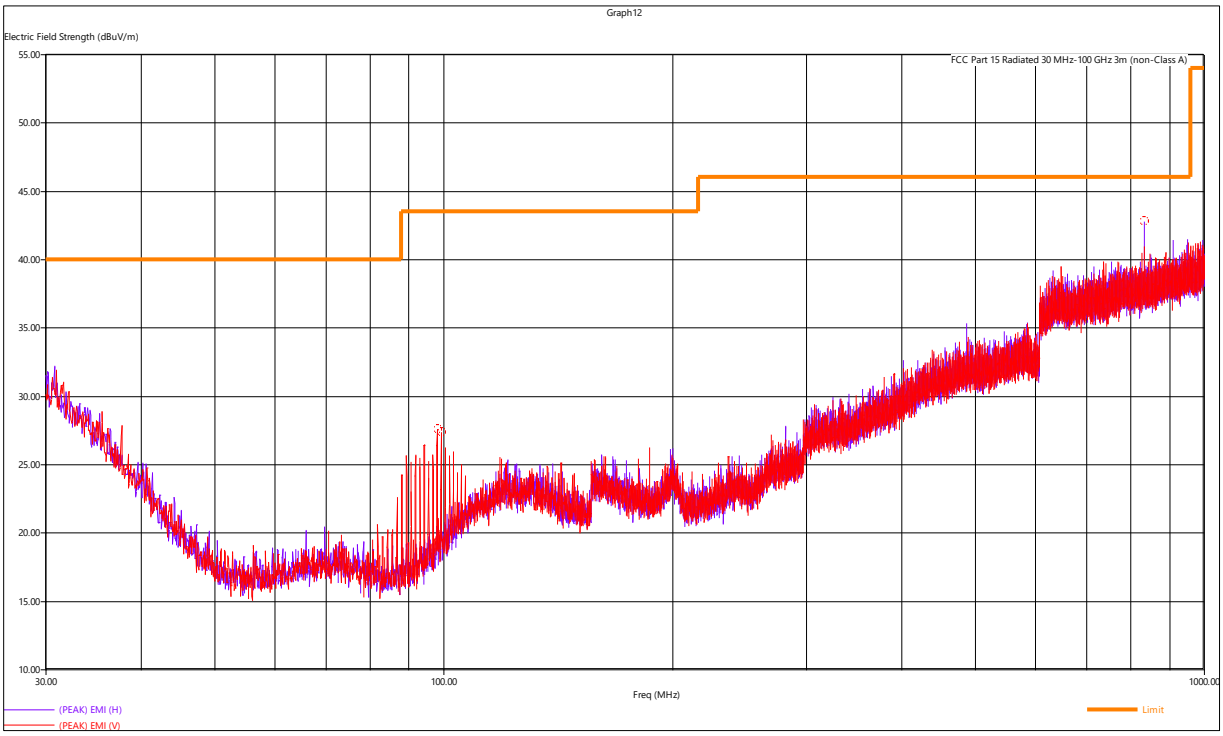



**Figure 5 - Radiated Emissions Plot, Low Channel, BLE**

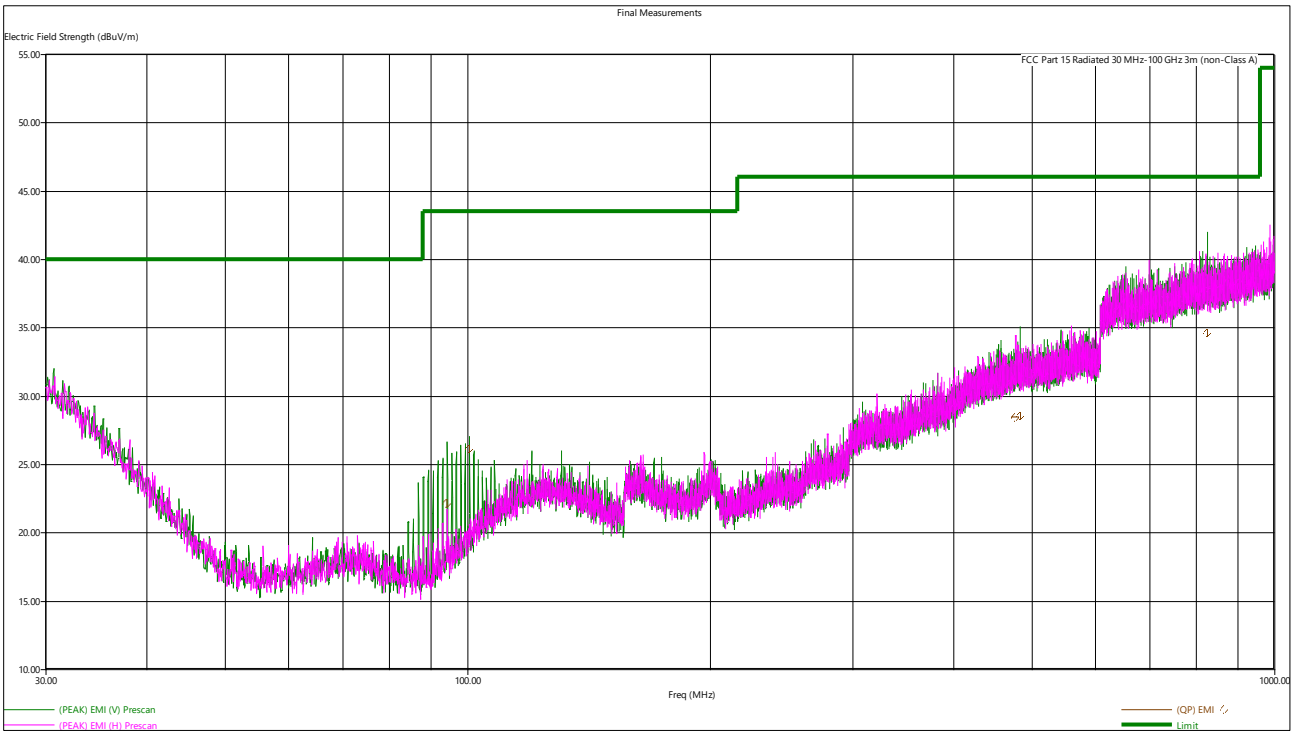



**Figure 6 - Radiated Emissions Plot, Mid Channel, BLE**

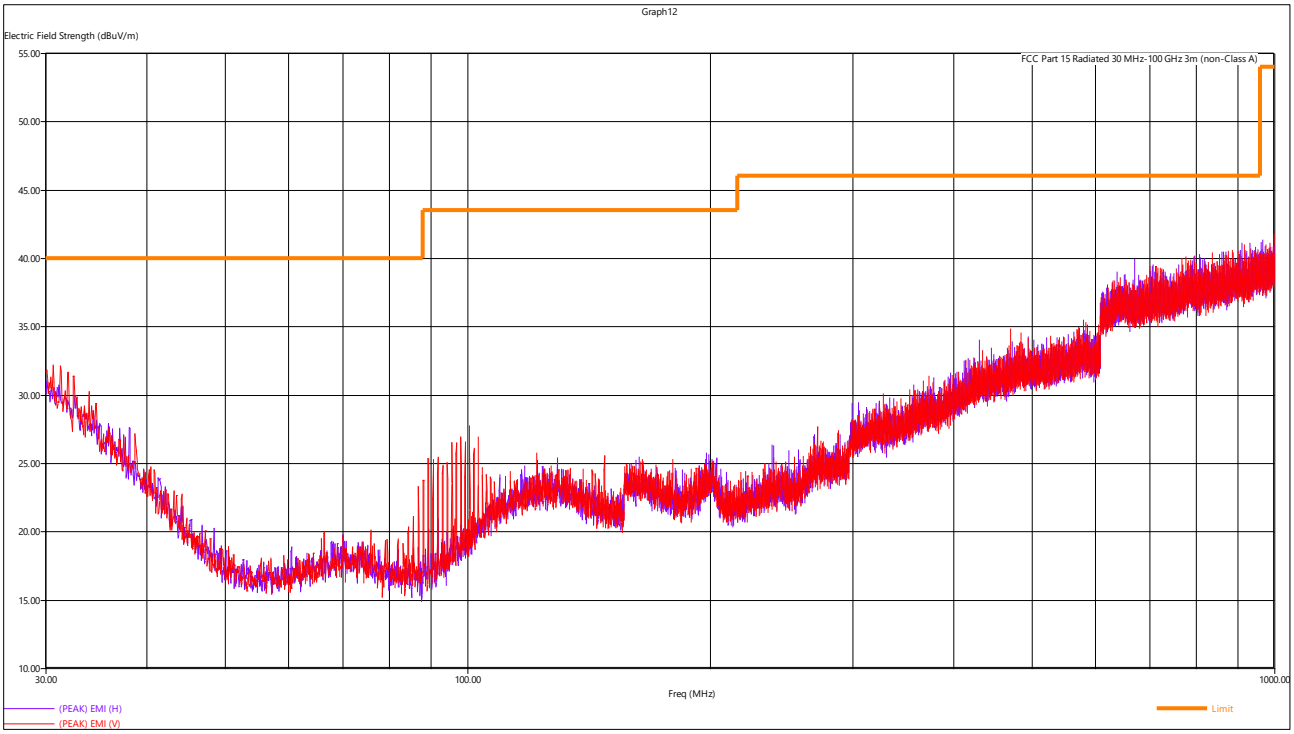



**Figure 7 - Radiated Emissions Plot, High Channel, BLE**

**REMARKS**:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

| Quasi-Peak Measurements, BLE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency** | **Level** | **Limit** | **Margin** | **Height** | **Angle** | **Pol** | **Channel** | **Modulation** |
| **MHz** | **dBµV/m** | **dBµV/m** | **dB** | **cm.** | **deg.** | | | |
| 833.580000 | 34.60 | 46.02 | 11.42 | 133 | 26 | H | Low | BLE |
| 98.040000 | 26.44 | 43.52 | 17.08 | 107 | 213 | V | Low | BLE |
| 99.240000 | 26.45 | 43.52 | 17.07 | 109 | 181 | V | Low | BLE |
| 477.540000 | 28.42 | 46.02 | 17.60 | 154 | 360 | H | Mid | BLE |
| 94.320000 | 22.14 | 43.52 | 21.38 | 106 | 263 | V | Mid | BLE |
| 100.500000 | 26.11 | 43.52 | 17.41 | 108 | 18 | V | Mid | BLE |
| 483.240000 | 28.53 | 46.02 | 17.49 | 366 | 63 | V | Mid | BLE |
| 825.840000 | 34.58 | 46.02 | 11.44 | 231 | 109 | V | Mid | BLE |

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

| Peak Measurements, BLE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequency | Level | Limit | Margin | Height | Angle | Pol | Channel | Modulation |
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | | |
| 2402.000000 | 104.23 | 113.98 | 9.75 | 203 | 206 | H | Low | BLE |
| 2404.000000 | 103.09 | 113.98 | 10.89 | 203 | 206 | H | Mid | BLE |
| 2480.000000 | 101.54 | 113.98 | 12.44 | 203 | 206 | H | High | BLE |
| 4803.500000 | 67.74 | 73.98 | 6.24 | 187 | 191 | H | Low | BLE |
| 7206.500000 | 58.24 | 73.98 | 15.74 | 232 | 146 | H | Low | BLE |
| 14412.500000 | 62.6 | 73.98 | 11.38 | 230 | 62 | H | Low | BLE |
| 9608.500000 | 58.18 | 73.98 | 15.8 | 201 | 130 | V | Low | BLE |
| 4879.500000 | 68.76 | 73.98 | 5.22 | 190 | 176 | H | Mid | BLE |
| 14640.500000 | 65.14 | 73.98 | 8.84 | 224 | 82 | H | Mid | BLE |
| 7319.500000 | 53.14 | 73.98 | 20.84 | 224 | 145 | V | Mid | BLE |
| 9759.500000 | 60.05 | 73.98 | 13.93 | 213 | 280 | V | Mid | BLE |
| 4959.500000 | 69.87 | 73.98 | 4.11 | 194 | 170 | H | High | BLE |
| 7440.000000 | 57.4 | 73.98 | 16.58 | 174 | 110 | H | High | BLE |
| 9919.500000 | 59.95 | 73.98 | 14.03 | 134 | 213 | H | High | BLE |
| 14881.000000 | 67.04 | 73.98 | 6.94 | 178 | 258 | H | High | BLE |
| 14880.500000 | 66.88 | 73.98 | 7.1 | 179 | 258 | V | High | BLE |

| Average Measurements, BLE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequency | Level | Limit | Margin | Height | Angle | Pol | Channel | Modulation |
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | | |
| 2402.000000 | 84.23 | 93.98 | 9.75 | 203 | 206 | H | Low | BLE |
| 2404.000000 | 83.09 | 93.98 | 10.89 | 203 | 206 | H | Mid | BLE |
| 2480.000000 | 81.54 | 93.98 | 12.44 | 203 | 206 | H | High | BLE |
| 4803.500000 | 47.74 | 53.98 | 6.24 | 187 | 191 | H | Low | BLE |
| 7206.500000 | 38.24 | 53.98 | 15.74 | 232 | 146 | H | Low | BLE |
| 14412.500000 | 42.6 | 53.98 | 11.38 | 230 | 62 | H | Low | BLE |
| 9608.500000 | 38.18 | 53.98 | 15.8 | 201 | 130 | V | Low | BLE |
| 4879.500000 | 48.76 | 53.98 | 5.22 | 190 | 176 | H | Mid | BLE |
| 14640.500000 | 45.14 | 53.98 | 8.84 | 224 | 82 | H | Mid | BLE |
| 7319.500000 | 33.14 | 53.98 | 20.84 | 224 | 145 | V | Mid | BLE |
| 9759.500000 | 40.05 | 53.98 | 13.93 | 213 | 280 | V | Mid | BLE |
| 4959.500000 | 49.87 | 53.98 | 4.11 | 194 | 170 | H | High | BLE |
| 7440.000000 | 37.4 | 53.98 | 16.58 | 174 | 110 | H | High | BLE |
| 9919.500000 | 39.95 | 53.98 | 14.03 | 134 | 213 | H | High | BLE |
| 14881.000000 | 47.04 | 53.98 | 6.94 | 178 | 258 | H | High | BLE |
| 14880.500000 | 46.88 | 53.98 | 7.1 | 179 | 258 | V | High | BLE |

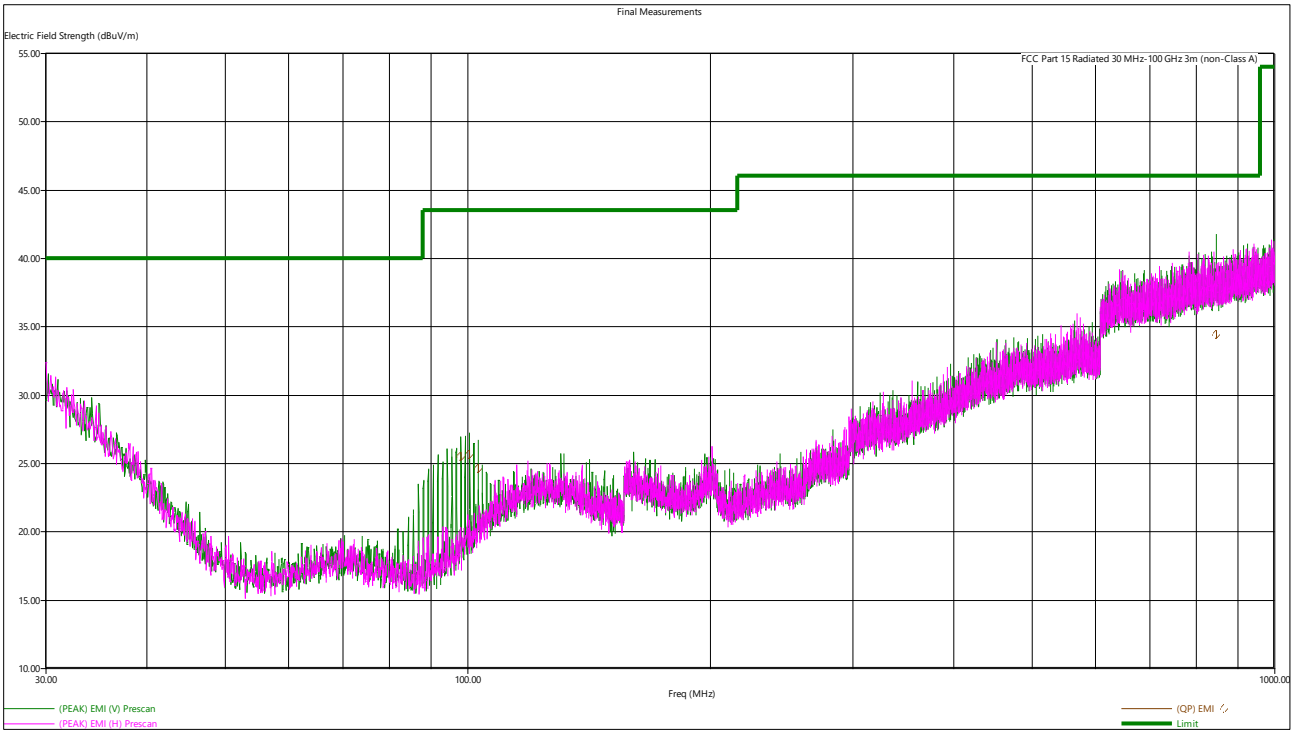



**Figure 8 - Radiated Emissions Plot, Low Channel, BT BR**

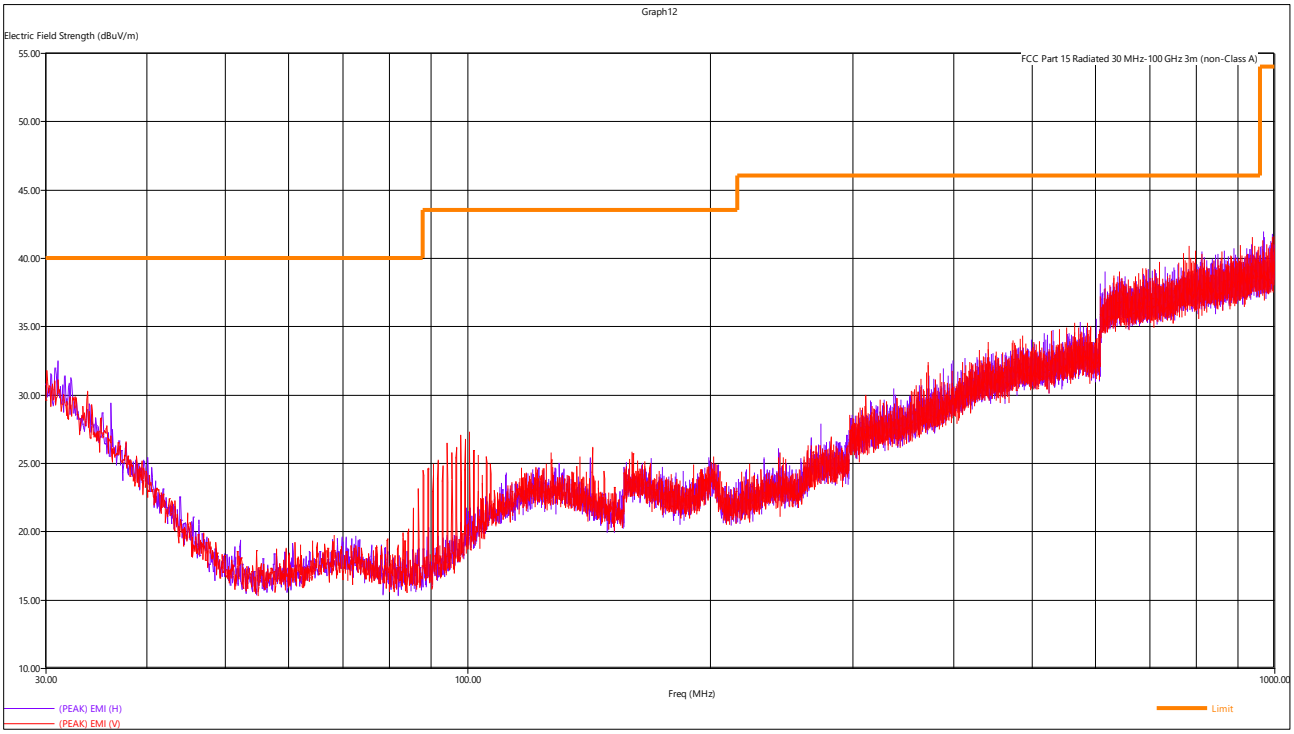



**Figure 9 - Radiated Emissions Plot, Mid Channel, BT BR**

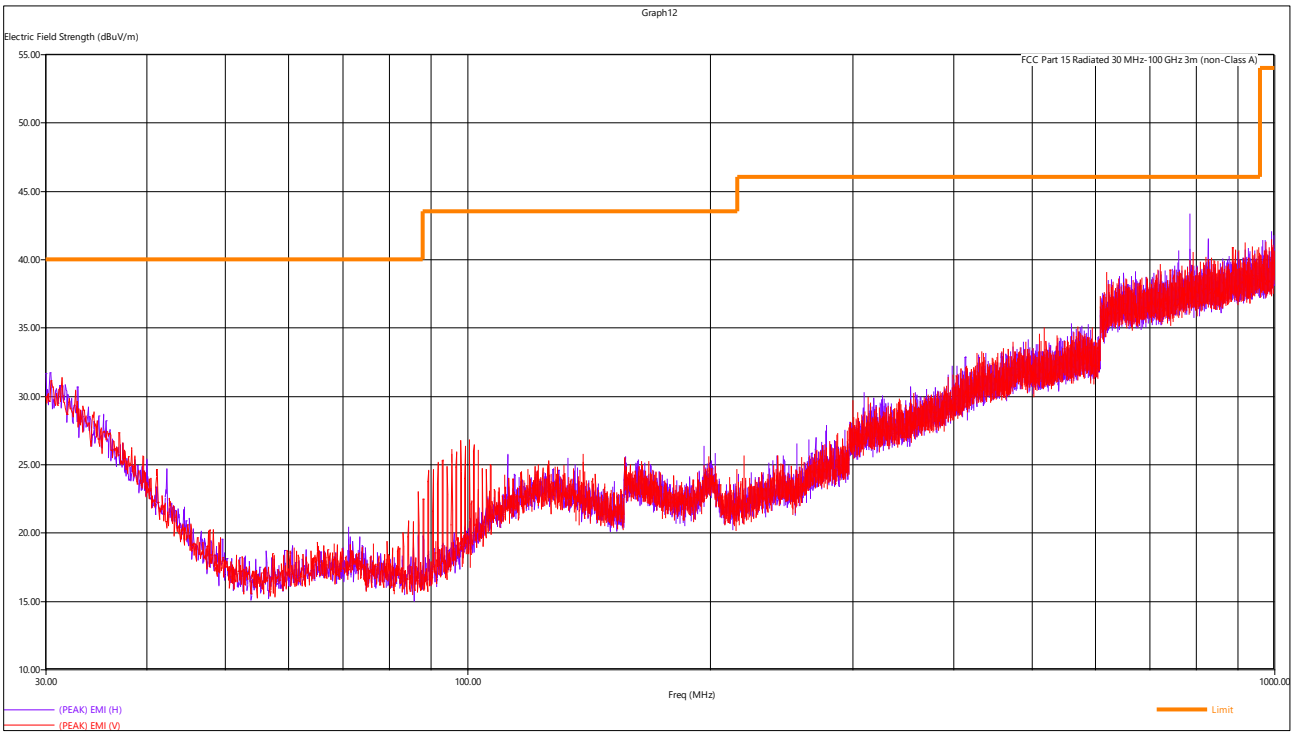



**Figure 10 - Radiated Emissions Plot, High Channel, BT BR**

**REMARKS**:
1. Emission level (dBuV/m) = Raw Value (dBuV) + Correction Factor (dB)
2. Correction Factor (dB/m) = Antenna Factor (dB/m) + Cable Factor (dB)
3. The other emission levels were very low against the limit.
4. Margin value = Emission level – Limit value

| Quasi-Peak Measurements, Bluetooth Classic, BTBR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Frequency** | **Level** | **Limit** | **Margin** | **Height** | **Angle** | **Pol** | **Channel** | **Modulation** |
| **MHz** | **dBµV/m** | **dBµV/m** | **dB** | **cm.** | **deg.** | | | |
| 98.040000 | 25.5 | 43.52 | 18.02 | 122 | 196 | V | Low | BT BR |
| 100.500000 | 25.63 | 43.52 | 17.89 | 130 | 297 | V | Low | BT BR |
| 103.020000 | 24.6 | 43.52 | 18.92 | 111 | 344 | V | Low | BT BR |
| 846.300000 | 34.44 | 46.02 | 11.58 | 276 | 279 | V | Low | BT BR |

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

| Peak Measurements, Bluetooth Classic, BTBR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequency | Level | Limit | Margin | Height | Angle | Pol | Channel | Modulation |
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | | |
| 2402.000000 | 103.62 | 73.98 | NA | 203 | 206 | H | Low | BT BR |
| 2441.000000 | 102.34 | 73.98 | NA | 203 | 206 | H | Mid | BT BR |
| 2480.000000 | 100.93 | 73.98 | NA | 203 | 206 | H | High | BT BR |
| 4804.000000 | 66.75 | 73.98 | 7.23 | 186 | 189 | H | Low | BT BR |
| 7206.000000 | 60.23 | 73.98 | 13.75 | 233 | 150 | H | Low | BT BR |
| 14412.500000 | 61.33 | 73.98 | 12.65 | 219 | 62 | H | Low | BT BR |
| 9608.000000 | 56.16 | 73.98 | 17.82 | 214 | 130 | V | Low | BT BR |
| 4882.000000 | 65.92 | 73.98 | 8.06 | 184 | 172 | H | Mid | BT BR |
| 7323.000000 | 50.91 | 73.98 | 23.07 | 214 | 260 | H | Mid | BT BR |
| 9764.000000 | 56.45 | 73.98 | 17.53 | 204 | 230 | V | Mid | BT BR |
| 14645.500000 | 63.17 | 73.98 | 10.81 | 199 | 79 | V | Mid | BT BR |
| 7440.000000 | 53.05 | 73.98 | 20.93 | 192 | 97 | H | High | BT BR |
| 14880.000000 | 63.78 | 73.98 | 10.2 | 222 | 255 | H | High | BT BR |
| 4960.000000 | 66.52 | 73.98 | 7.46 | 192 | 173 | V | High | BT BR |
| 9920.000000 | 58.9 | 73.98 | 15.08 | 133 | 212 | V | High | BT BR |

| Average Measurements, Bluetooth Classic, BTBR | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Frequency | Level | Limit | Margin | Height | Angle | Pol | Channel | Modulation |
| MHz | dBµV/m | dBµV/m | dB | cm. | deg. | | | |
| 2402.000000 | 83.62 | 53.98 | NA | 203 | 206 | H | Low | BT BR |
| 2441.000000 | 82.34 | 53.98 | NA | 203 | 206 | H | Mid | BT BR |
| 2480.000000 | 80.93 | 53.98 | NA | 203 | 206 | H | High | BT BR |
| 4804.000000 | 46.75 | 53.98 | 7.23 | 186 | 189 | H | Low | BT BR |
| 7206.000000 | 40.23 | 53.98 | 13.75 | 233 | 150 | H | Low | BT BR |
| 14412.500000 | 41.33 | 53.98 | 12.65 | 219 | 62 | H | Low | BT BR |
| 9608.000000 | 36.16 | 53.98 | 17.82 | 214 | 130 | V | Low | BT BR |
| 4882.000000 | 45.92 | 53.98 | 8.06 | 184 | 172 | H | Mid | BT BR |
| 7323.000000 | 30.91 | 53.98 | 23.07 | 214 | 260 | H | Mid | BT BR |
| 9764.000000 | 36.45 | 53.98 | 17.53 | 204 | 230 | V | Mid | BT BR |
| 14645.500000 | 43.17 | 53.98 | 10.81 | 199 | 79 | V | Mid | BT BR |
| 7440.000000 | 33.05 | 53.98 | 20.93 | 192 | 97 | H | High | BT BR |
| 14880.000000 | 43.78 | 53.98 | 10.2 | 222 | 255 | H | High | BT BR |
| 4960.000000 | 46.52 | 53.98 | 7.46 | 192 | 173 | V | High | BT BR |
| 9920.000000 | 38.9 | 53.98 | 15.08 | 133 | 212 | V | High | BT BR |

## 4.5 BAND EDGES

**Test Method**: All the radio measurements were performed using the sections from ANSI C63.10, details about the section used can be found in the spectrum analyzer titles on the graph.

**Limits of band-edge measurements:**
**For FCC Part 15.249 Device:**
For emissions outside of the allowed band of operation, the emission level needs to be 50dB 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.

**For FCC Part 15.247 Device:**
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 highest emissions level beyond the band-edge was measured and recorded. All band edge measurements were evaluated to the general limits in Part 15.209. More details can be found in section 3.4 of this report.

**Deviations from test standard:**
No deviation.

**Test setup:**
Test setup details can be found in section 3.4 of this report.

**EUT operating conditions:**
Details can be found in section 2.1 of this report.

**Test results: Pass**
Comments:
1. All the band edge plots can be found in the Appendix C.
2. If the device falls under FCC Part 15.247 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 20 dB between peak and the band edge.
3. If the device falls under FCC Part 15.249 (Details can be found in summary of test results), compliance is shown in the unrestricted band edges by showing minimum delta of 50 dB between peak and the band edge.
4. The restricted band edge compliance is shown by comparing to the general limit defined in Part 15.209. The limit shown in the graph accounts for the antenna gain of the device.

## 4.6 CONDUCTED AC MAINS EMISSIONS

N/A

## 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*

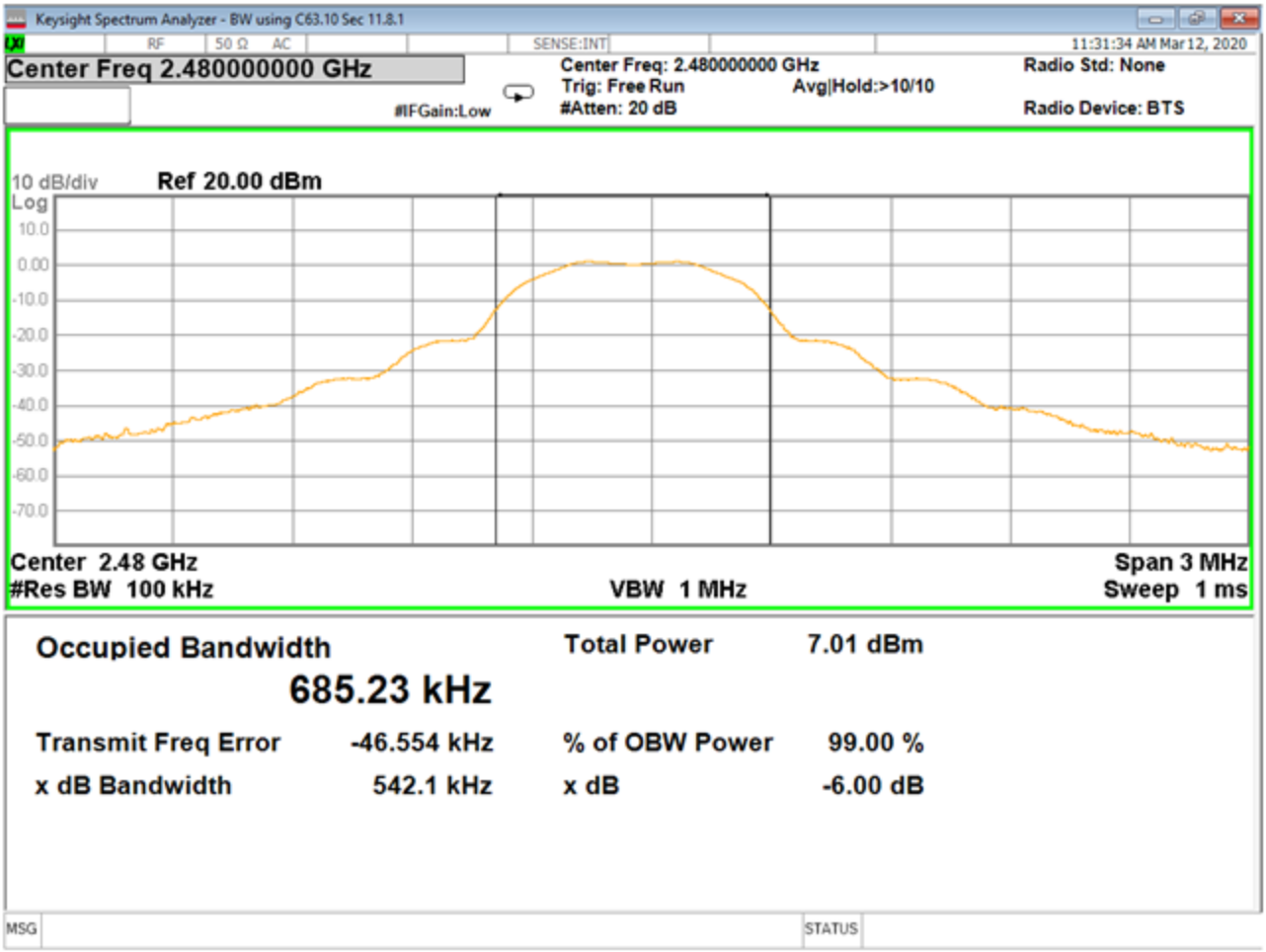
## APPENDIX B – MEASUREMENT UNCERTAINTY

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

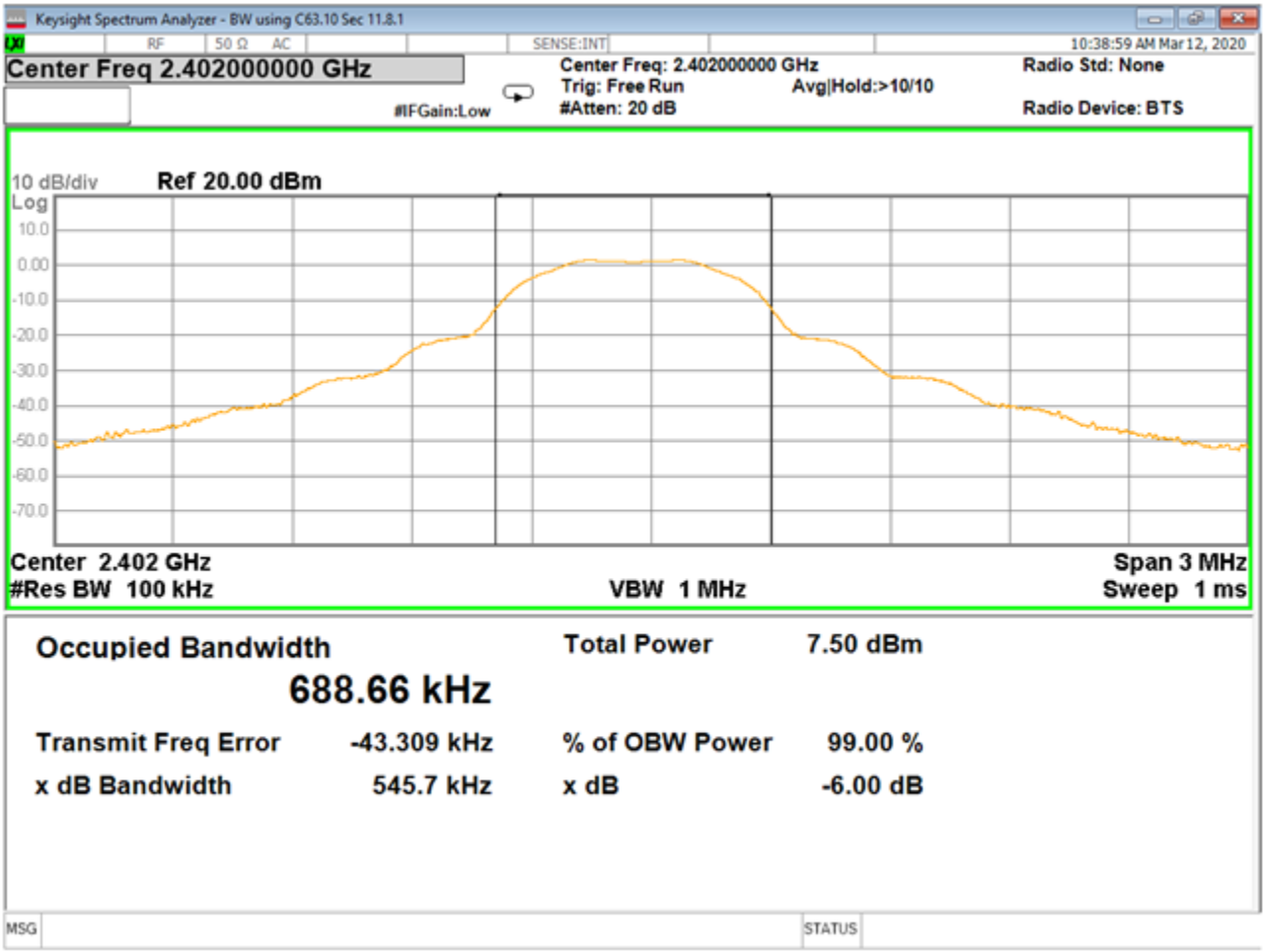
| Test | Frequency Range | Uncertainty Value (dB) |
|---|---|---|
| Radiated Emissions, 3m | 30MHz - 1GHz | 3.82 |
| Radiated Emissions, 3m | 1GHz - 18GHz | 4.44 |
| Emissions limits, conducted | 30MHz – 18GHz | ±3.30 dB |

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

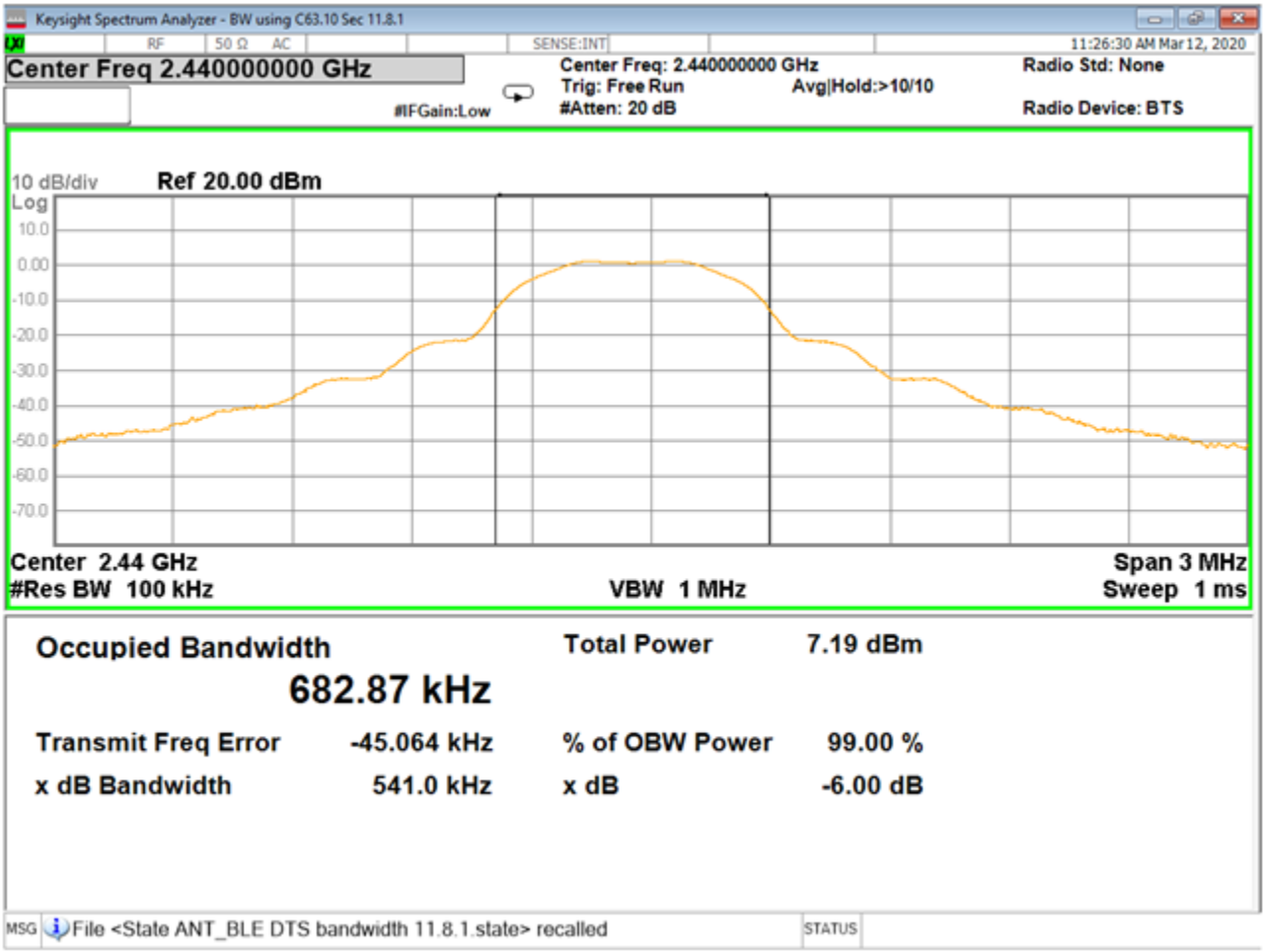
## APPENDIX C – GRAPHS AND TABLES



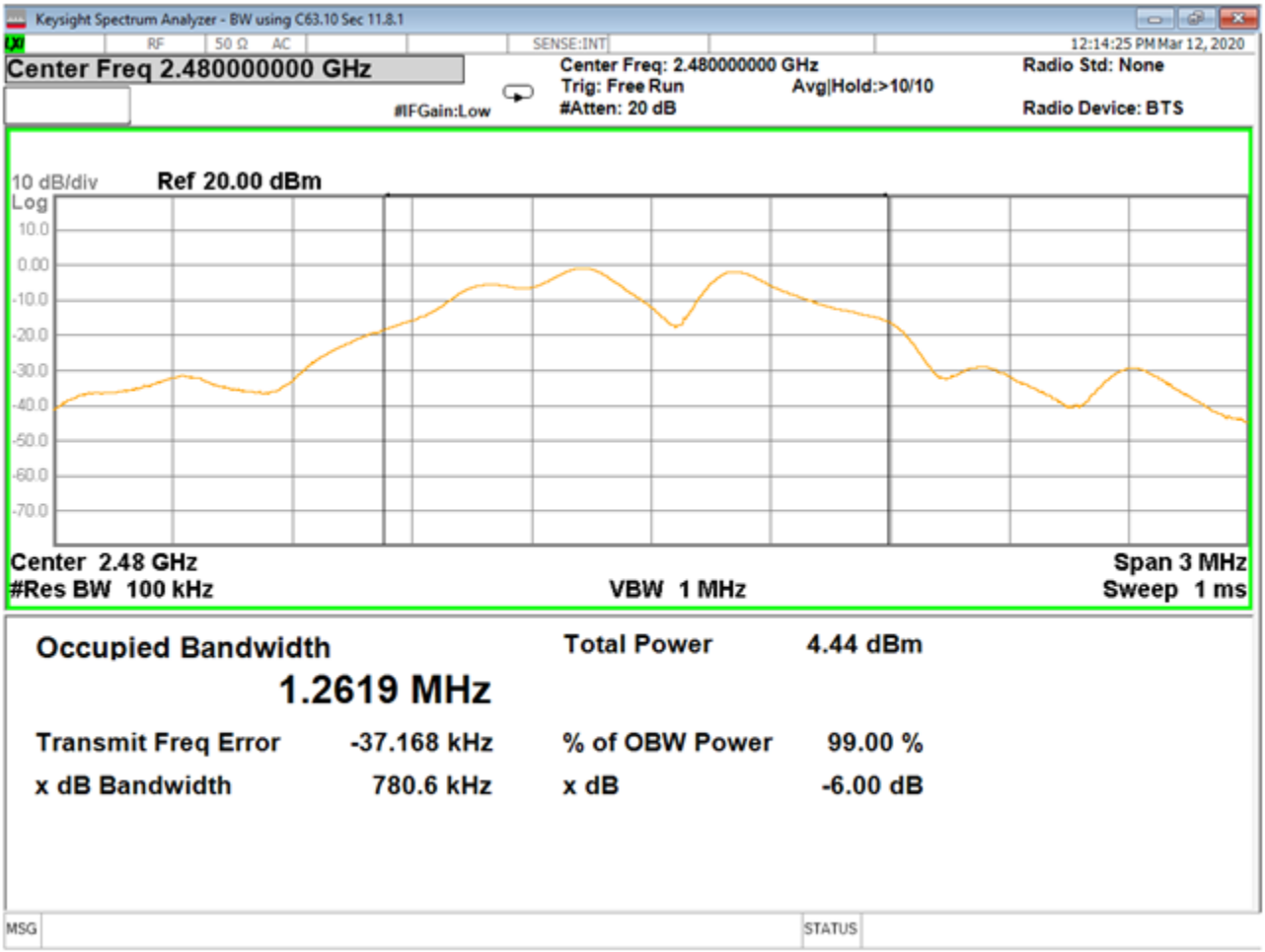

Bandwidth Plot, High Channel, BLE



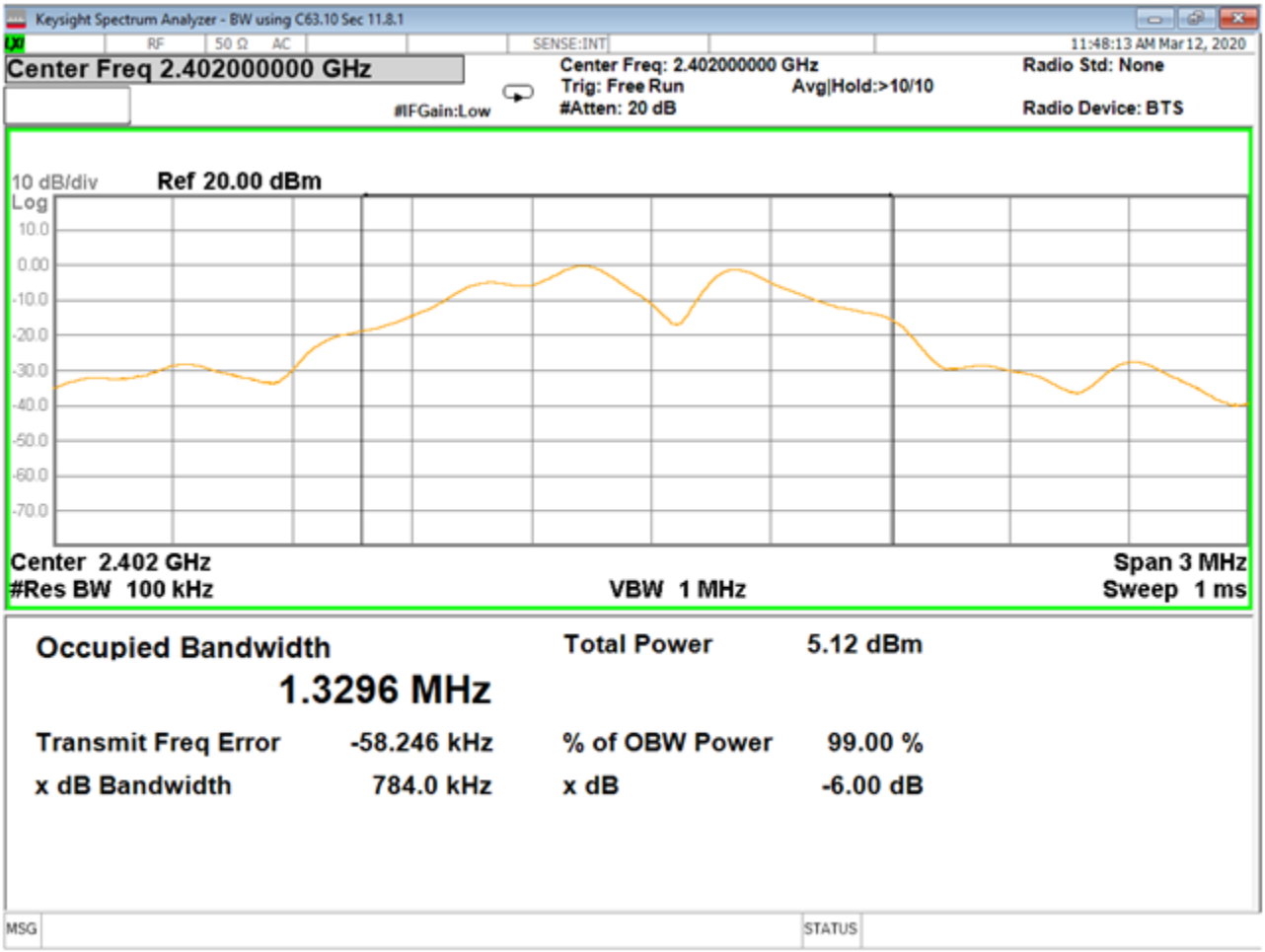

Bandwidth Plot, Low Channel, BLE



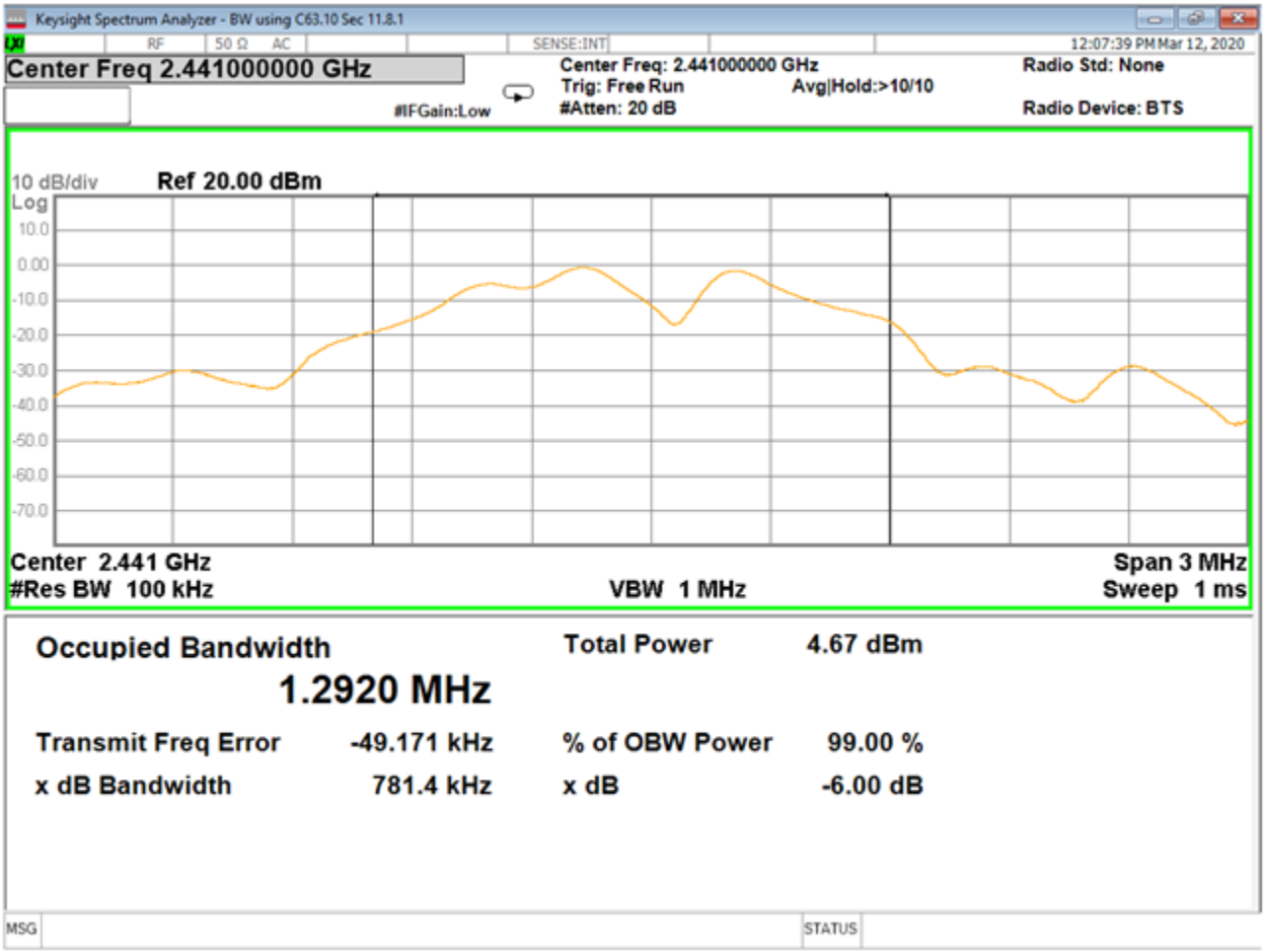

Bandwidth Plot, Mid Channel, BLE



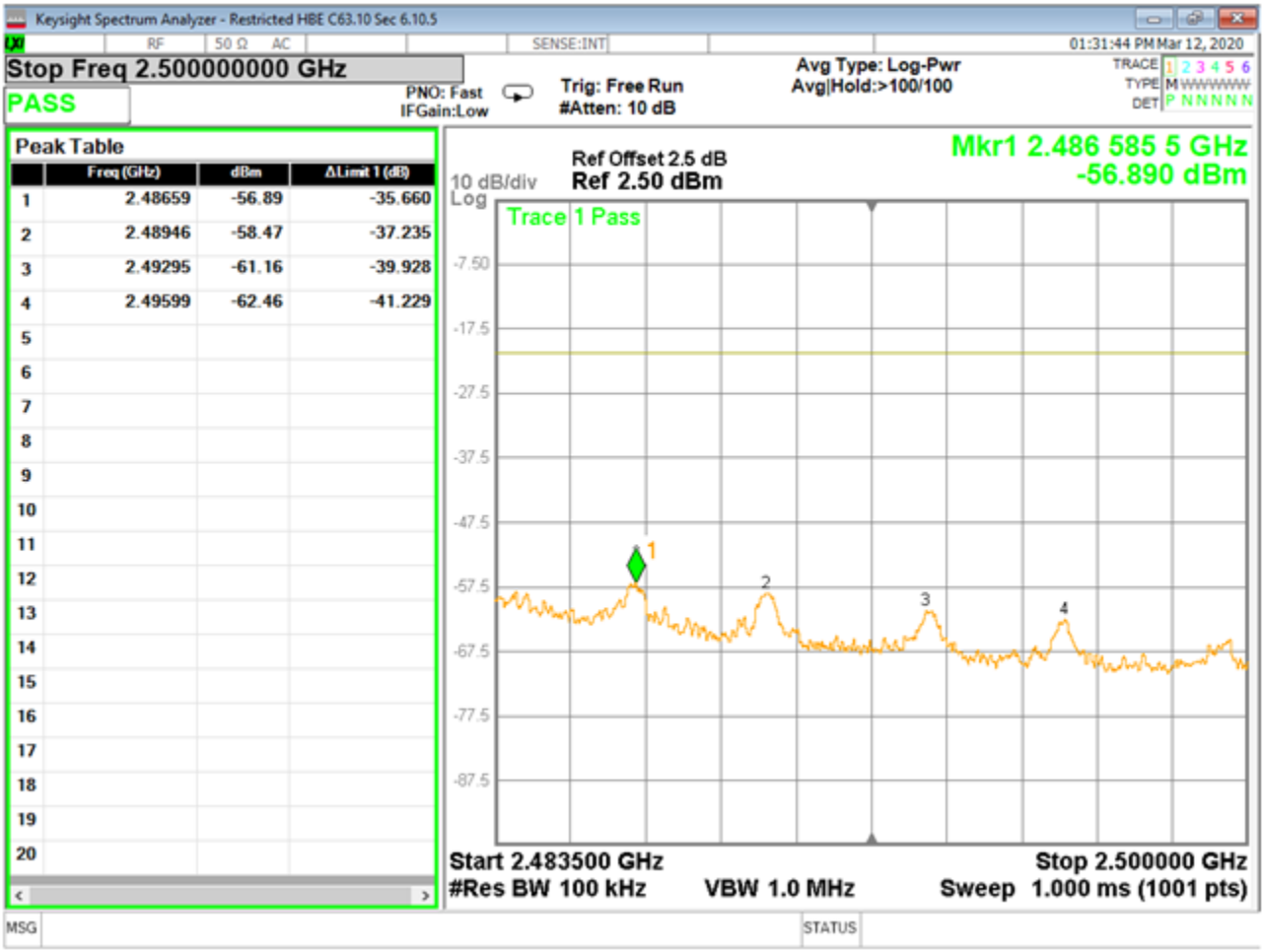

Bandwidth Plot, High Channel, BTBR



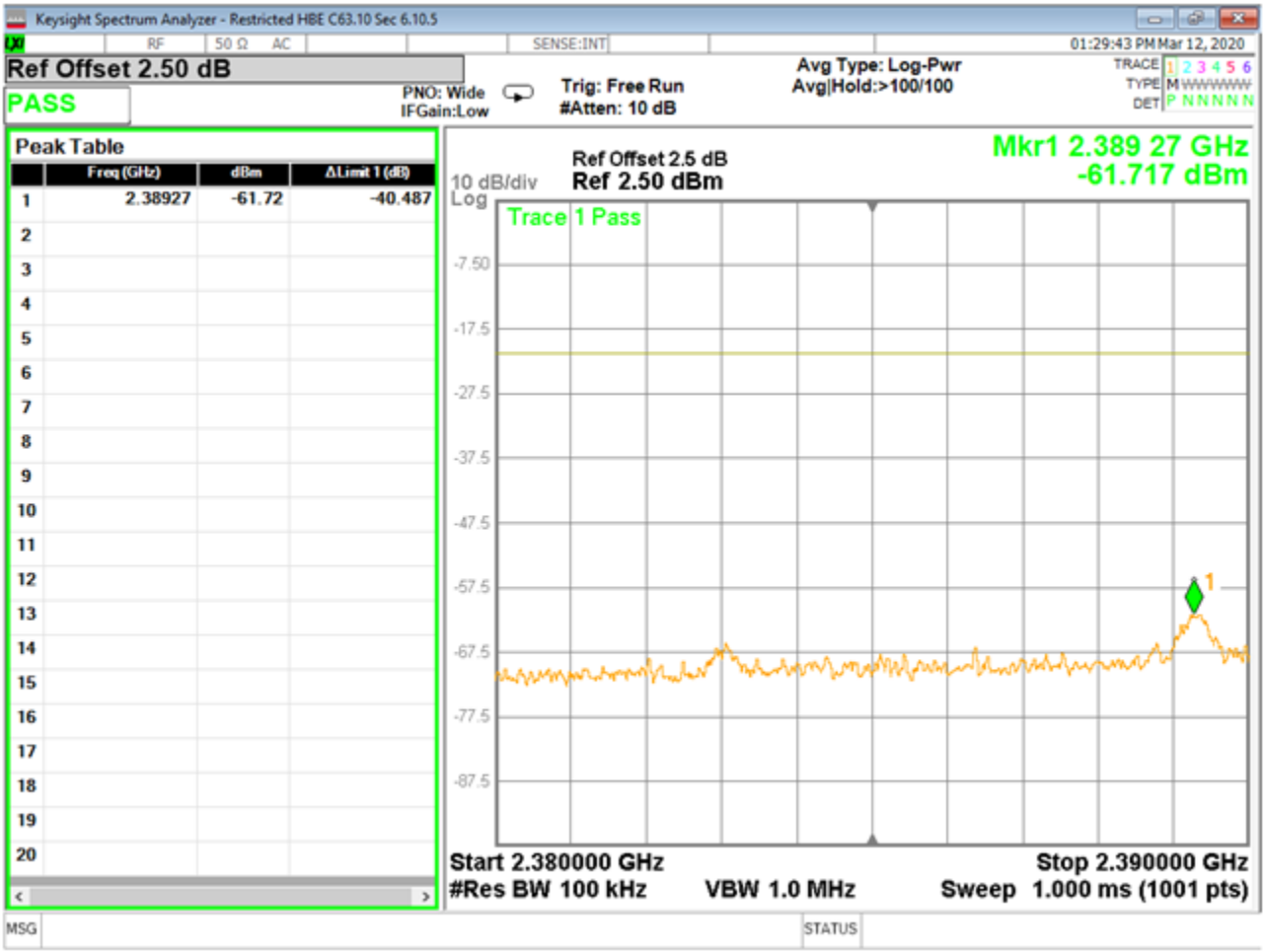

Bandwidth Plot, Low Channel, BTBR



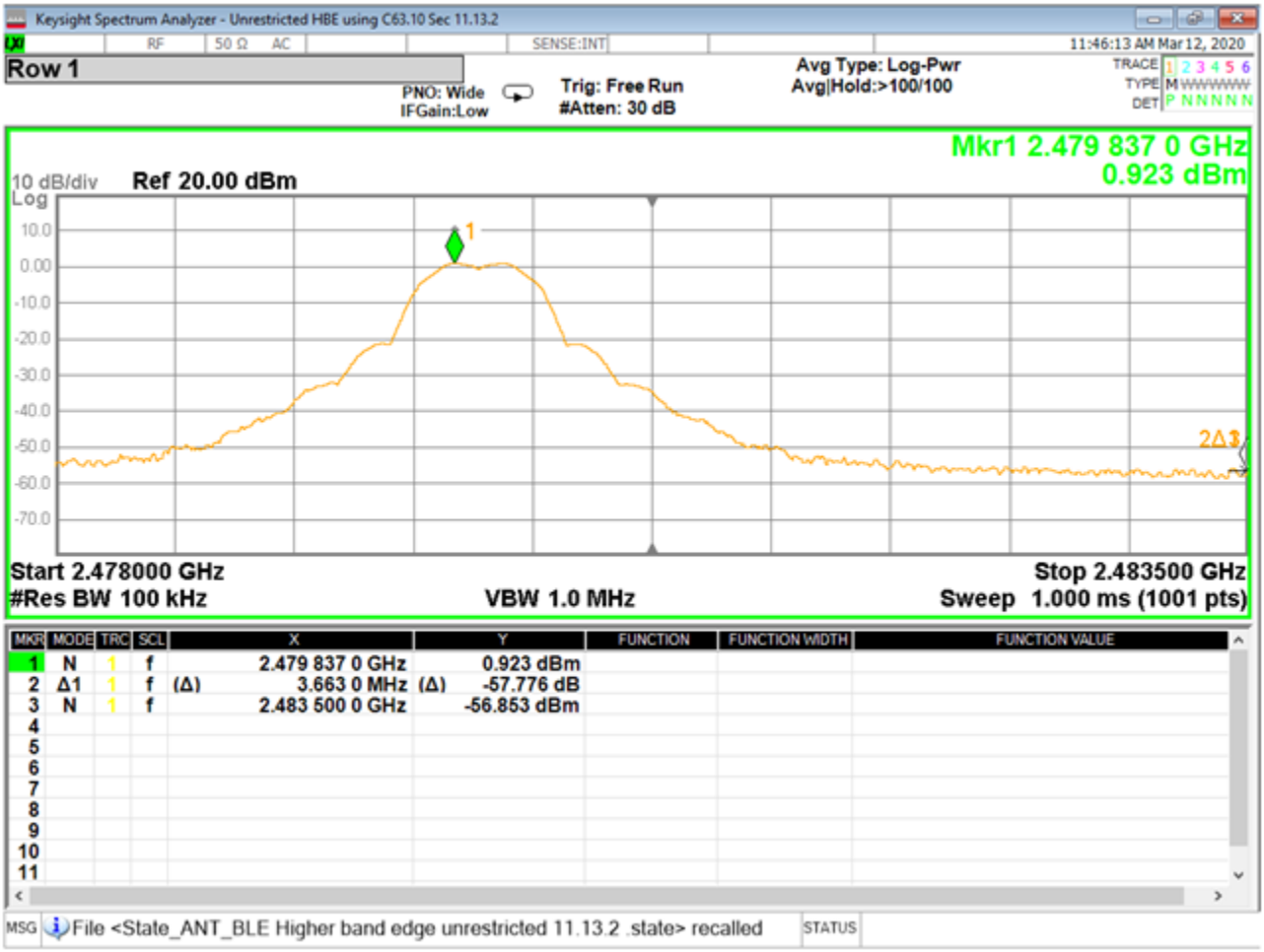

Bandwidth Plot, Mid Channel, BTBR



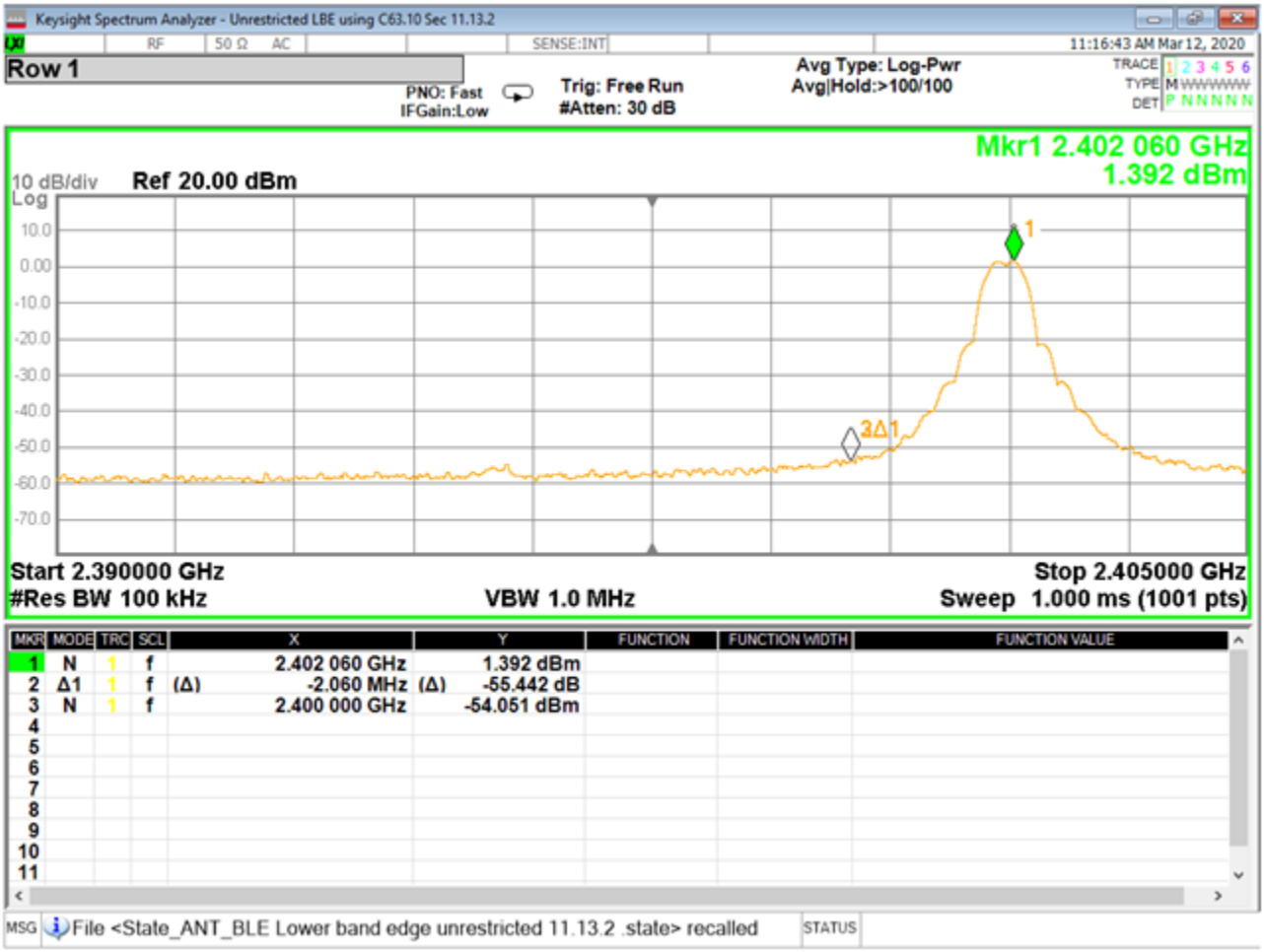

BLE Restricted Higher Band Edge with Antenna Gain



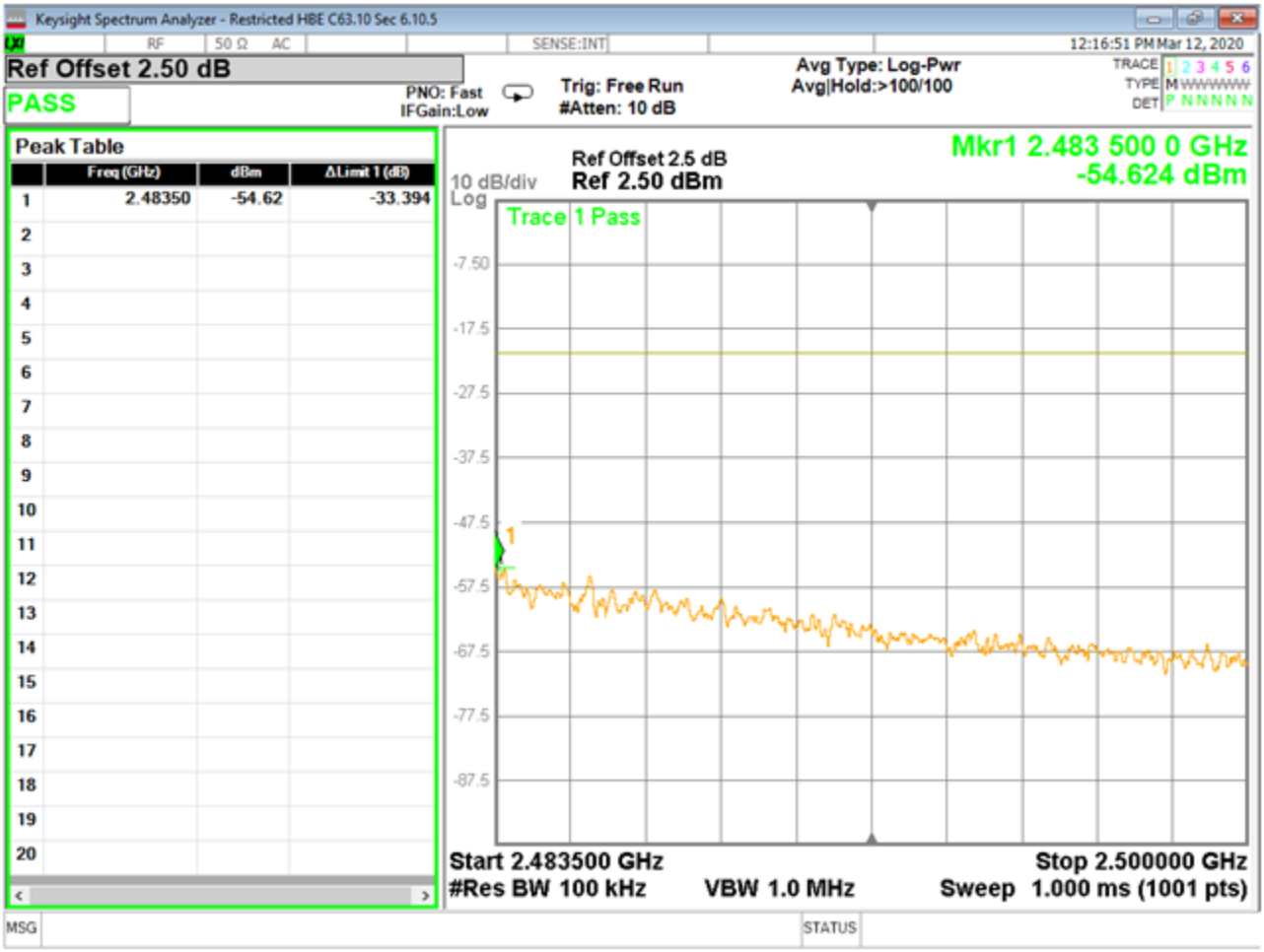

BLE Restricted Lower Band Edge with Antenna Gain



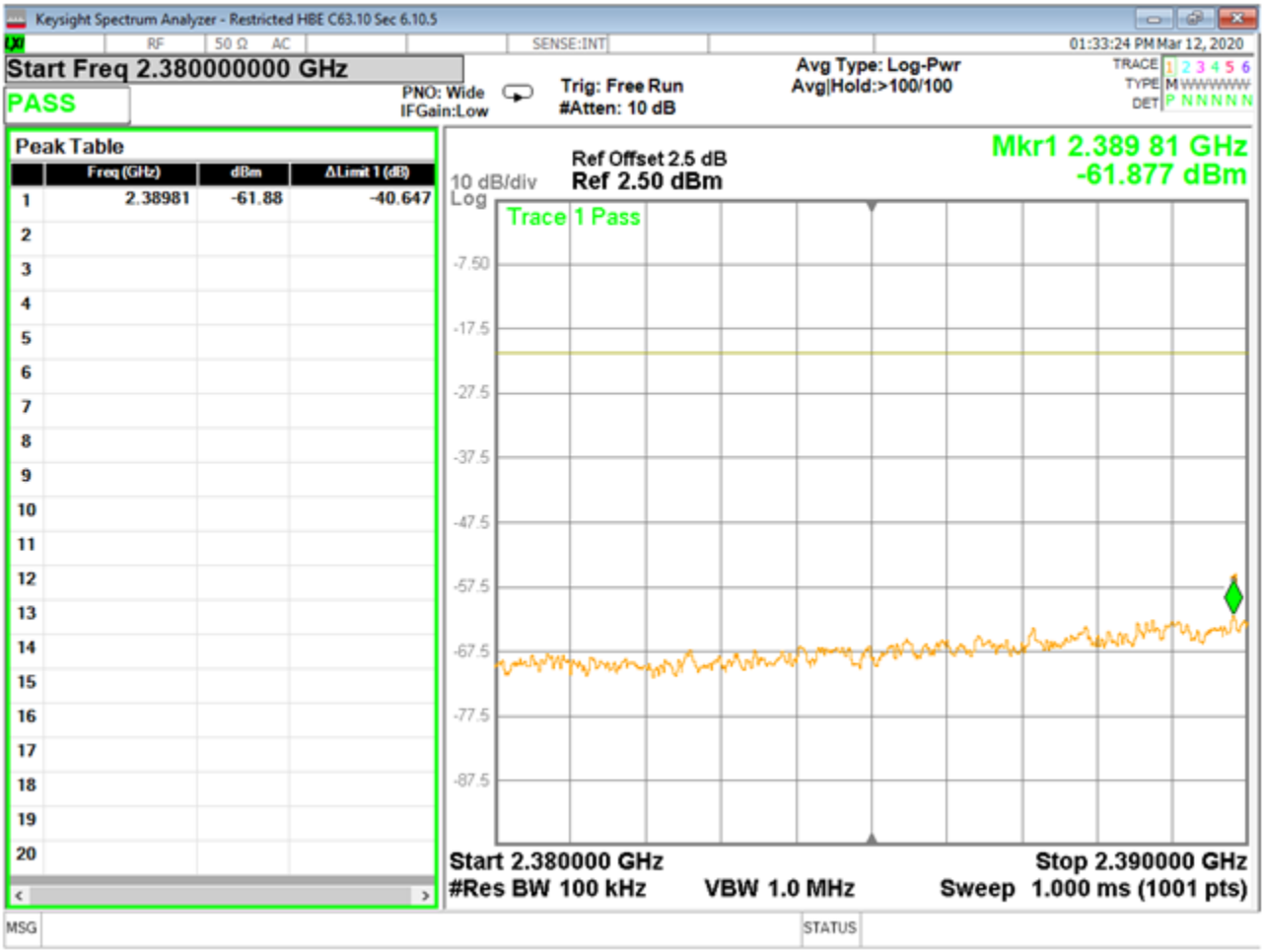

BLE Unrestricted Higher Band Edge with Antenna Gain




BLE Unrestricted Lower Band Edge with Antenna Gain




BTBR Restricted Higher Band Edge with Antenna Gain

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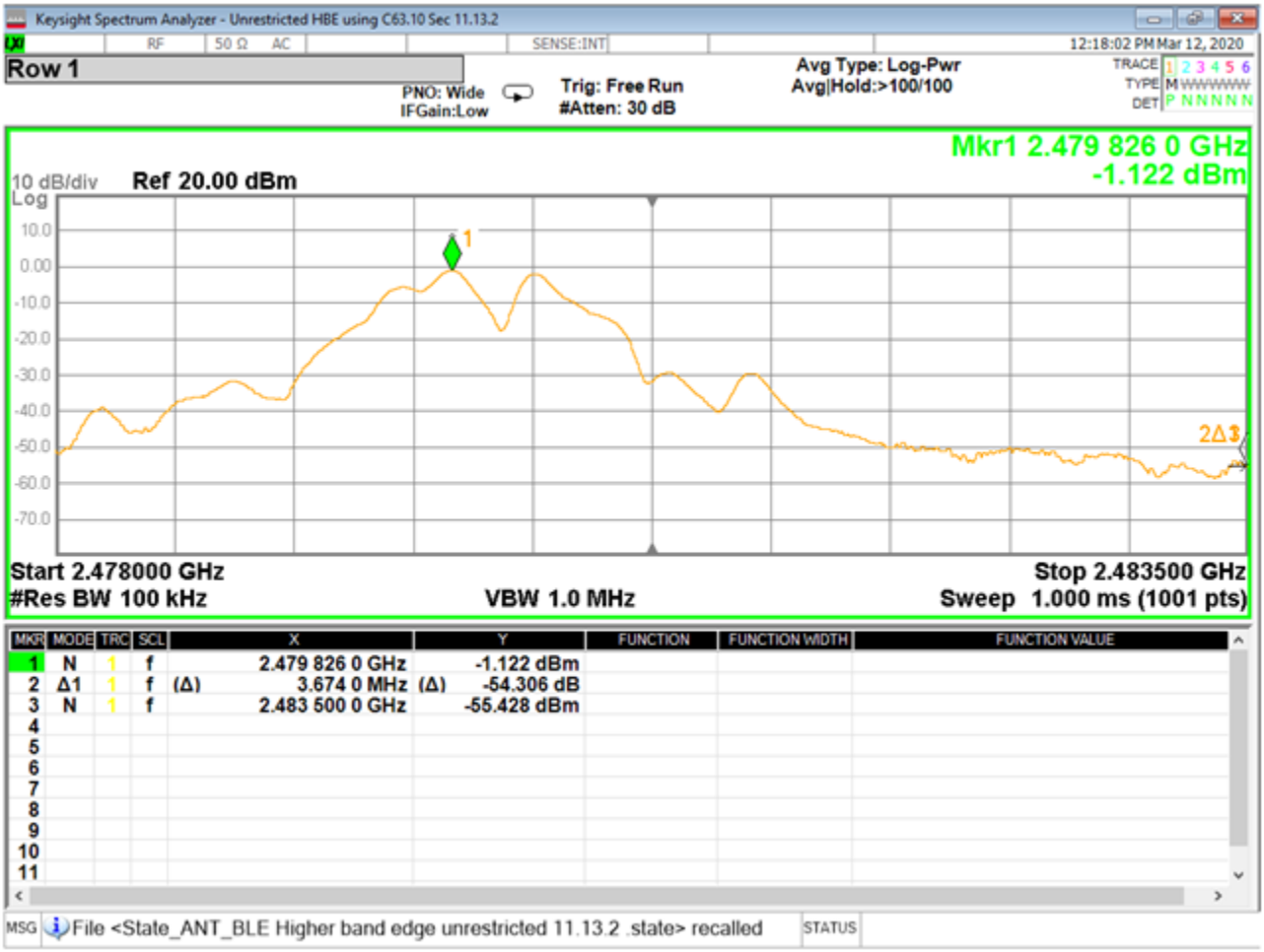
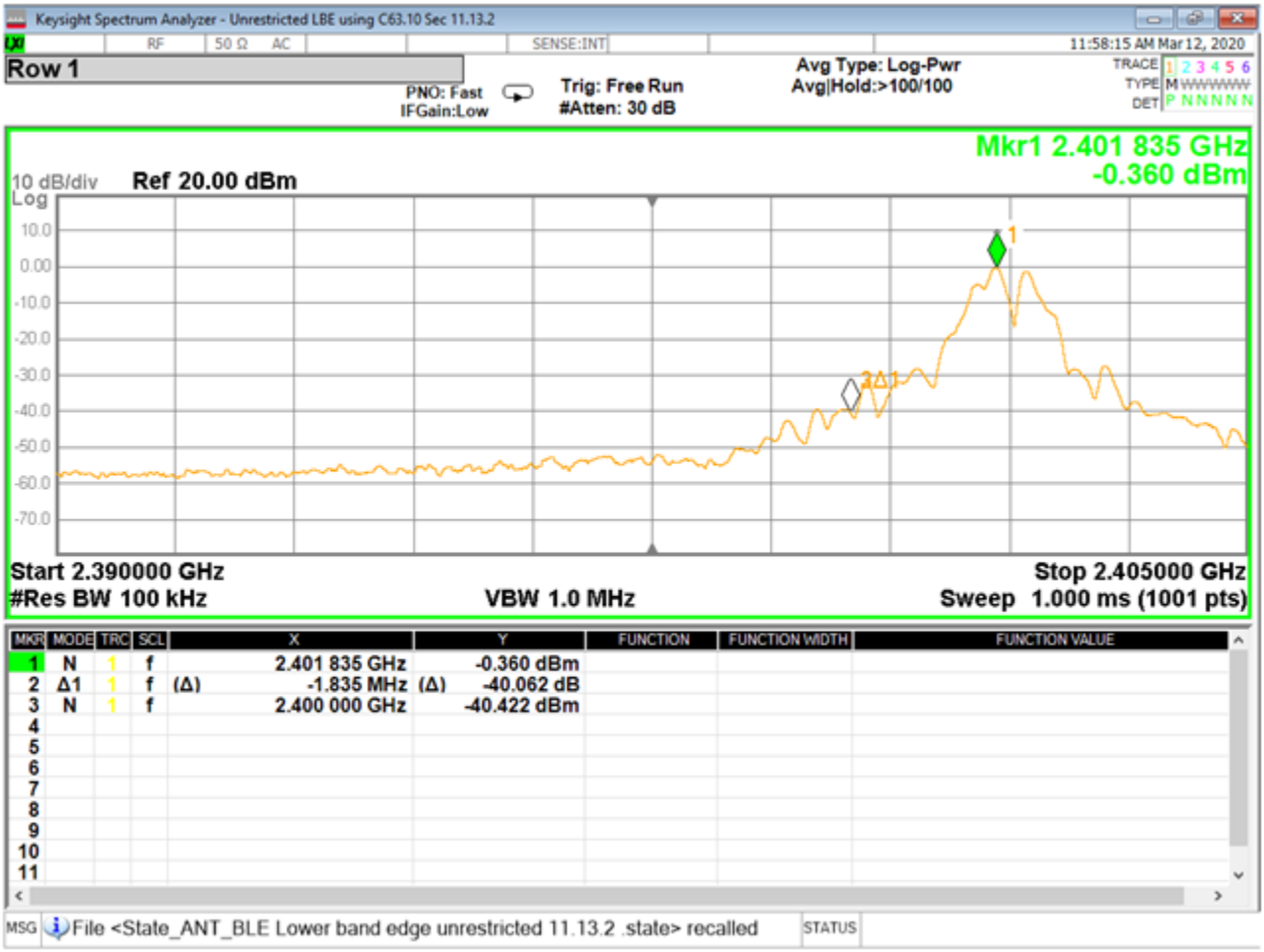
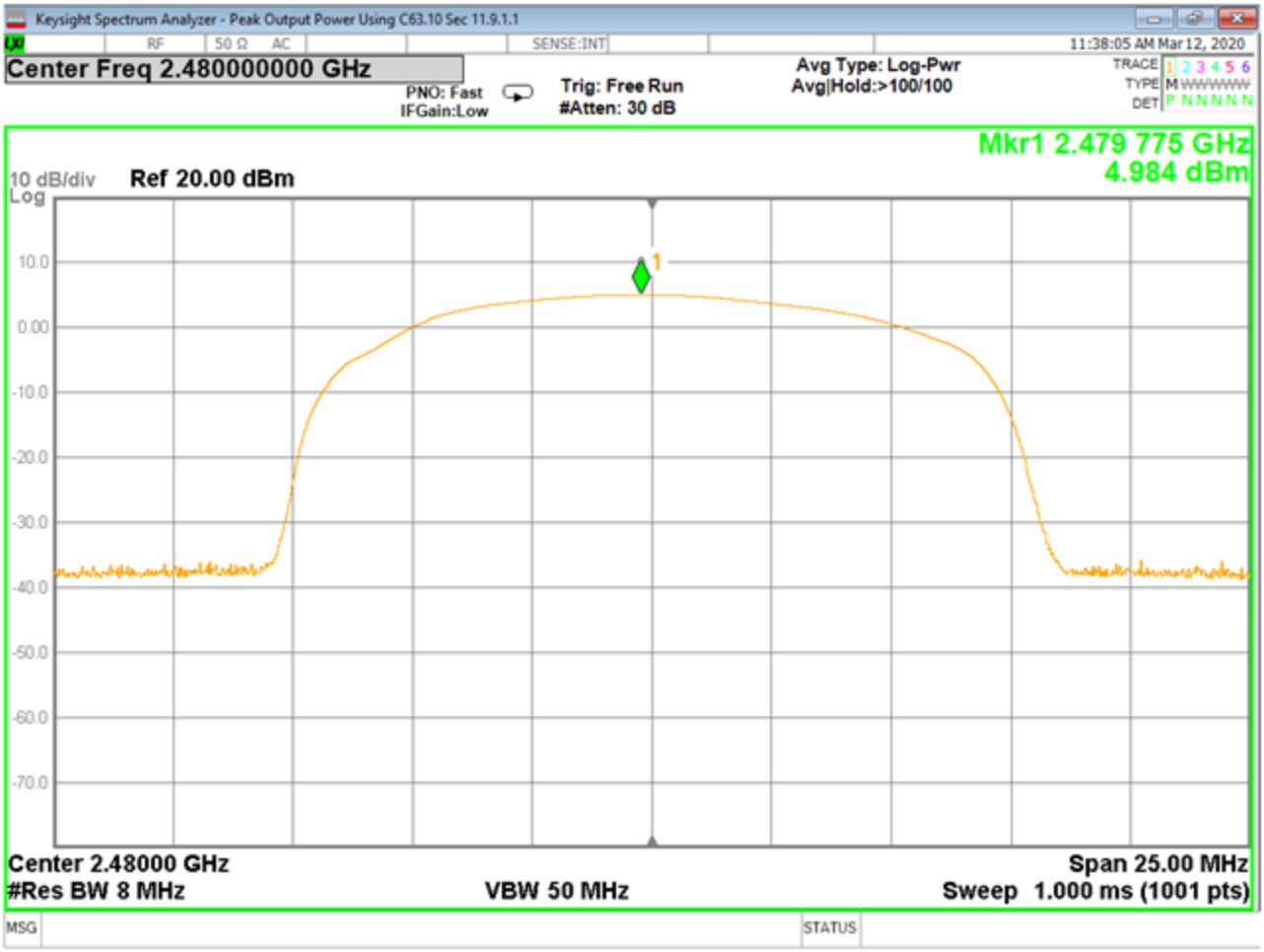


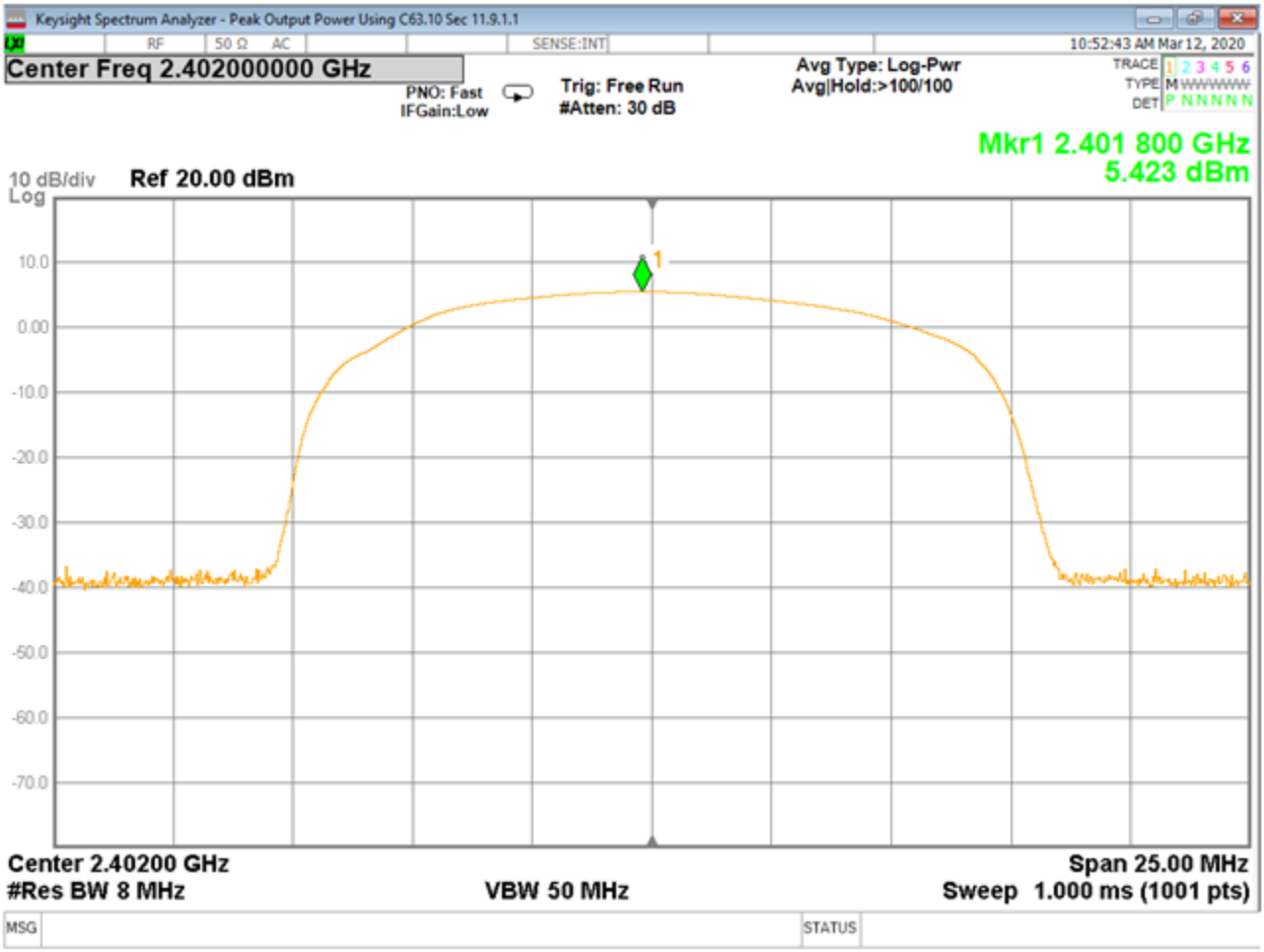

BTBR Unrestricted Higher Band Edge




BTBR Unrestricted Lower Band Edge with Antenna Gain




Power Plot, High Channel, BLE

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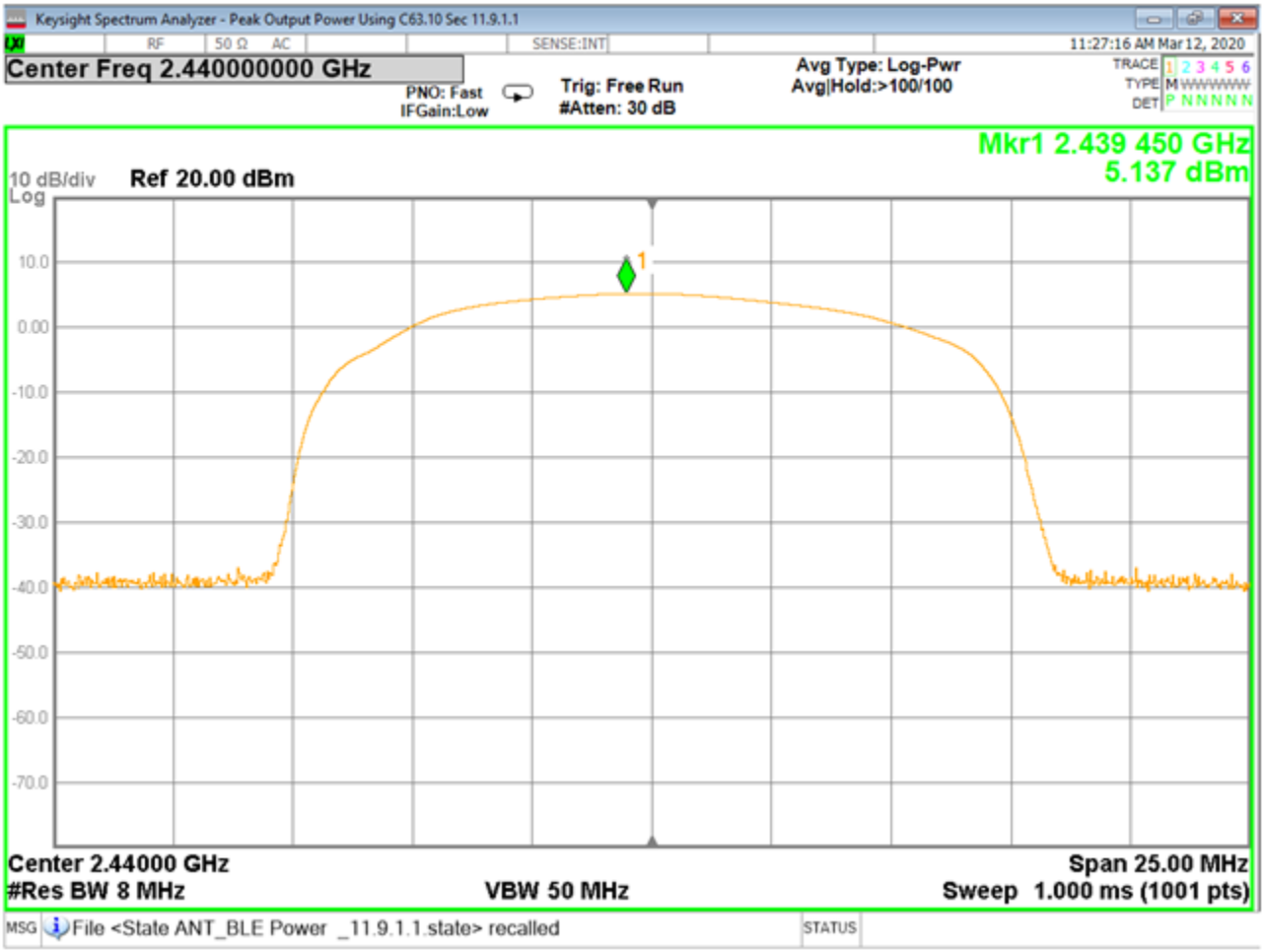
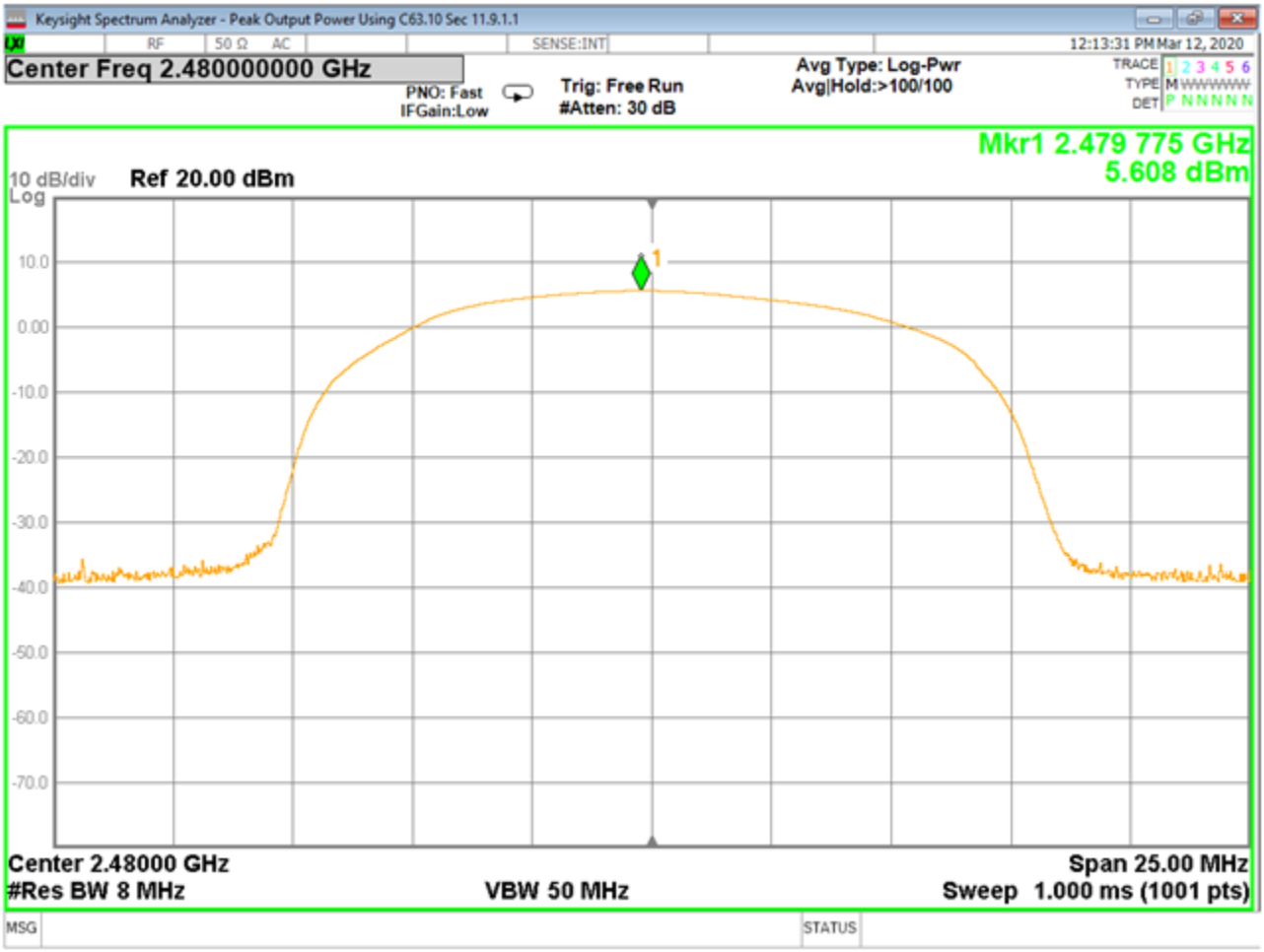
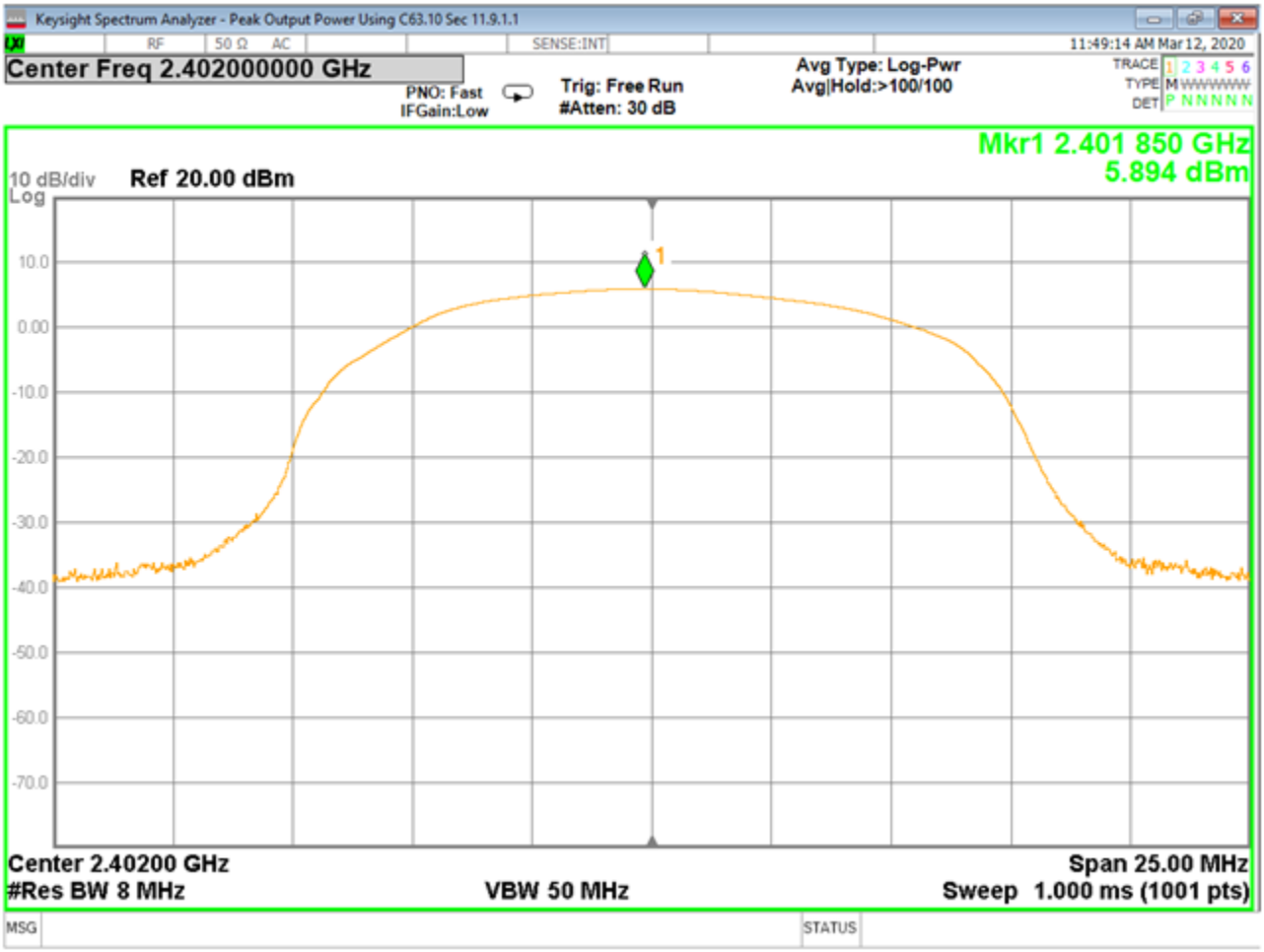


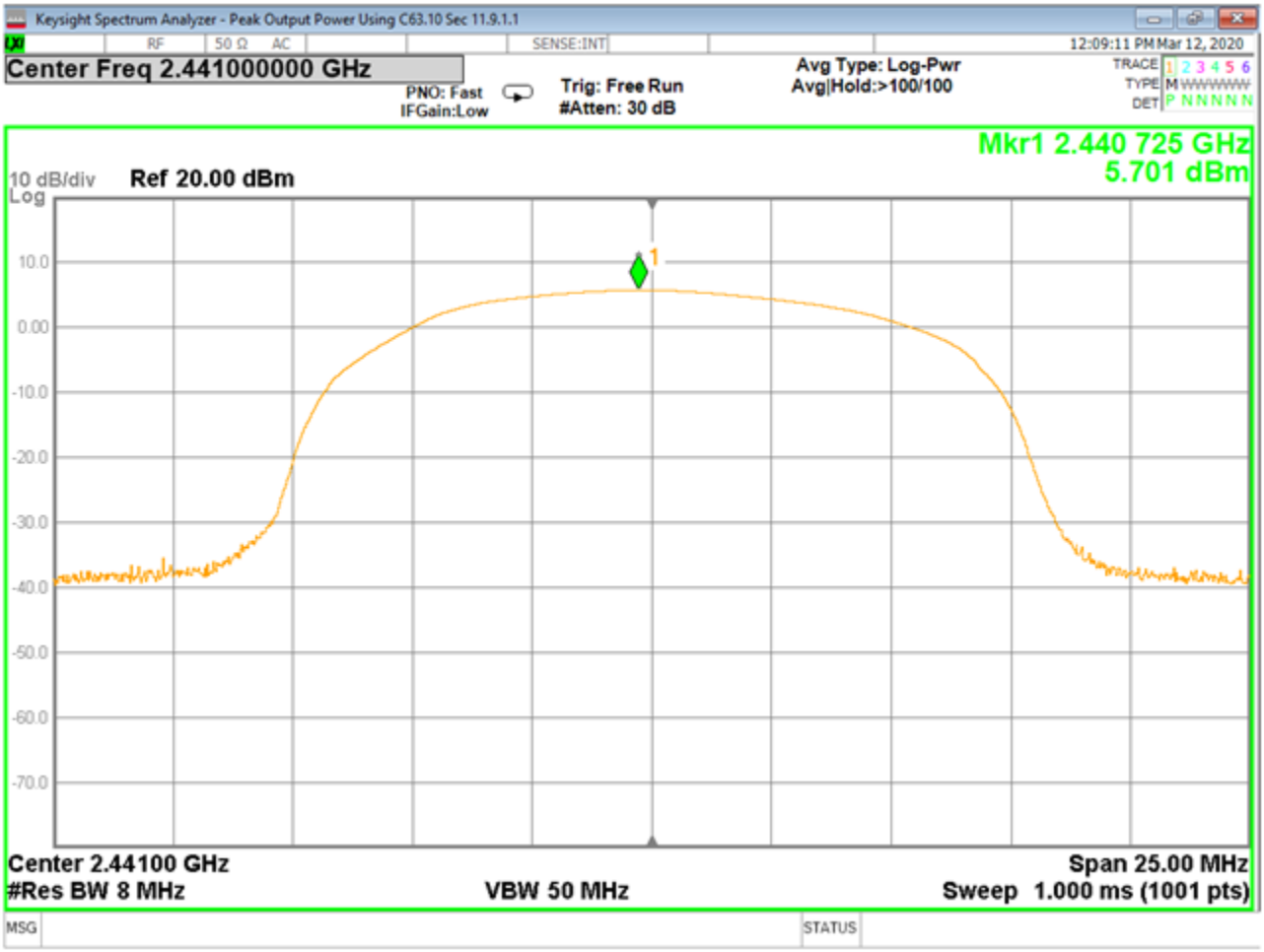

Power Plot, Mid Channel, BLE




Power Plot, High Channel, BTBR




Power Plot, Low Channel, BTBR




Power Plot, Mid Channel, BTBR

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REPORT END