# RF TEST REPORT

| | |
|---|---|
| **Applicant** | Quectel Wireless Solutions Co., Ltd. |
| **FCC ID** | XMR202103FG50V |
| **Product** | Wi-Fi & BT Module |
| **Brand** | Quectel |
| **Model** | FG50V |
| **Report No.** | R2102A0150-R1 |
| **Issue Date** | May 25, 2021 |

TA Technology (Shanghai) Co., Ltd. tested the above equipment in accordance with the requirements in **FCC CFR47 Part 15C (2020)**. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

*Prepared by: Peng Tao* | *Approved by: Kai Xu*


**TA Technology (Shanghai) Co., Ltd.**

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# Summary of measurement results

| Number | Test Case | Clause in FCC rules | Verdict |
|---|---|---|---|
| 1 | Maximum output power | 15.247(b)(3) | PASS |
| 2 | 6 dB bandwidth | 15.247(a)(2) | PASS |
| 3 | Power spectral density | 15.247(e) | PASS |
| 4 | Band Edge | 15.247(d) | PASS |
| 5 | Spurious RF Conducted Emissions | 15.247(d) | PASS |
| 6 | Unwanted Emissions | 15.247(d),15.205,15.209 | PASS |
| 7 | Conducted Emissions | 15.207 | PASS |
| Date of Testing: March 1, 2021 ~ May 26, 2021<br>Date of Sample Received: February 24, 2021 | | | |
| Note: All indications of Pass/Fail in this report are opinions expressed by TA Technology (Shanghai) Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. | | | |


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# 1. Test Laboratory

## 1.1. Notes of the test report

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## 1.2. Test facility

**FCC (Designation number: CN1179, Test Firm Registration Number: 446626)**

TA Technology (Shanghai) Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform measurements.

**A2LA (Certificate Number: 3857.01)**

TA Technology (Shanghai) Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform measurement.

## 1.3. Testing Location

| | |
|---|---|
| Company: | TA Technology (Shanghai) Co., Ltd. |
| Address: | No.145, Jintang Rd, Tangzhen Industry Park, Pudong |
| City: | Shanghai |
| Post code: | 201201 |
| Country: | P. R. China |
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# 2. General Description of Equipment under Test

## 2.1. Applicant and Manufacturer Information

| | |
|---|---|
| Applicant | Quectel Wireless Solutions Co., Ltd. |
| Applicant address | Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233 |
| Manufacturer | Quectel Wireless Solutions Co., Ltd. |
| Manufacturer address | Building 5, Shanghai Business Park Phase III (Area B), No.1016 Tianlin Road, Minhang District, Shanghai, China, 200233 |

## 2.2. General information

| EUT Description | |
|---|---|
| Model | FG50V |
| SN | P1Q20LJ4C000067 |
| Hardware Version | R1.0 |
| Software Version | FG50VAAMD |
| Power Supply | External power supply |
| Antenna Type | The EUT don't have standard Antenna. The Antenna used for te sting in this report is the after-market accessory. |
| Antenna Connector | A permanently attached antenna (meet with the standard FCC Part 15.203 requirement) |
| Antenna Gain | Max 5.38 dBi |
| additional beamforming gain | 7 dBi |
| Test Mode | 802.11b, 802.11g, 802.11n(HT20/HT40), 802.11ax(HE20/HE40)<br>Bluetooth LE V5.1 |
| Modulation Type | 802.11b: DSSS<br>802.11g/n(HT20/HT40): OFDM<br>802.11ax(HE20/HE40): OFDMA<br>Bluetooth LE: GFSK |
| Max. Conducted Power | Wi-Fi 2.4G: 22.04 dBm<br>Bluetooth LE: 13.86 dBm |
| Operating Frequency Range(s) | 802.11b/g/n(HT20)/ax(HE20): 2412 ~ 2462 MHz<br>802.11n(HT40)/ax(HE40): 2422 ~ 2452 MHz<br>Bluetooth LE: 2402 ~2480 MHz |
| Note: 1. The EUT is sent from the applicant to TA and the information of the EUT is declared by the applicant. | |


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# 3. Applied Standards

According to the specifications of the manufacturer, it must comply with the requirements of the following standards:

**Test standards:**

**FCC CFR47 Part 15C (2020) Radio Frequency Devices**

**ANSI C63.10 (2013)**

**Reference standard:**

**KDB 558074 D01 15.247 Meas Guidance v05r02**

**KDB 662911 D01 Multiple Transmitter Output v02r01**


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# 4. Test Configuration

## Test Mode

The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application.

The radiated emission was measured in the following position: EUT stand-up position (Z axis), lie-down position (X, Y axis). The worst emission was found in lie-down position (X axis) and the loop antenna is vertical, the others are vertical and horizontal. and the worst case was recorded.

In order to find the worst case condition, Pre-tests are needed at the presence of different data rate. Preliminary tests have been done on all the configuration for confirming worst case. Data rate below means worst-case rate of each test item.

Worst-case data rates are shown as following table.

| Test Mode | Data Rate |
|---|---|
| Bluetooth (Low Energy) | 125Kbps, 1Mbps, 2Mbps |

| Test Mode | Data Rate | | |
|---|---|---|---|
| | Antenna 1 | Antenna 2 | MIMO |
| 802.11b | 1 Mbps | 1 Mbps | / |
| 802.11g | 6 Mbps | 6 Mbps | / |
| 802.11n HT20 | MCS0 | MCS0 | MCS8 |
| 802.11n HT40 | MCS0 | MCS0 | MCS8 |
| 802.11ax HE20 | MCS0 | MCS0 | MCS8 |
| 802.11ax HE40 | MCS0 | MCS0 | MCS8 |

The worst case Antenna mode for each of the following tests for Wi-Fi:

| Test Cases | Antenna 1 | Antenna 2 | MIMO |
|---|---|---|---|
| Maximum conducted output power | O | O | O |
| 6dB Bandwidth | -- | -- | O |
| Band Edge | -- | -- | O |
| Power Spectral Density | O | O | O |
| Spurious RF Conducted Emissions | -- | -- | O |
| Unwanted Emissions | -- | -- | O |
| Conducted Emission | -- | -- | O |
| Note: “O”: test all bands | | | |

**According to RF Output power results in chapter 5.1, MIMO was selected as the worst antenna.**


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# 5. Test Case Results

## 5.1. Maximum output power

### Ambient condition

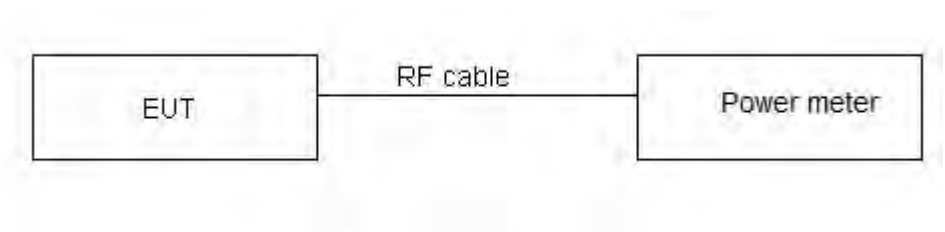
| Temperature | Relative humidity | Pressure |
|---|---|---|
| 23°C ~25°C | 45%~50% | 101.5kPa |

### Methods of Measurement

During the process of the testing, The EUT was connected to Power meter with a known loss. The EUT is max power transmission with proper modulation.

The conducted Power is measured at each antenna port. The measured results at the various antenna ports are then summed mathematically.

### Test Setup




### Limits

Rule Part 15.247 (b) (3) specifies that " For systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz: 1 Watt."

| | |
|---|---|
| Average Output Power | ≤ 1W (30dBm) |

### Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k$ = 2, $U$= 0.44 dB.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## Test Results

| SISO Antenna Power Index | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Antenna | Channel | 802.11b | 802.11g | 802.11n HT20 | 802.11ax HE20 | Channel | 802.11n HT40 | 802.11ax HE40 |
| Antenna 1 | CH1 | 20 | 18 | 18 | 17.5 | CH3 | 18 | 17.5 |
| | CH6 | 20 | 18 | 18 | 17.5 | CH6 | 18 | 17.5 |
| | CH11 | 20 | 18 | 18 | 17.5 | CH9 | 18 | 17.5 |
| Antenna 2 | CH1 | 20 | 18 | 18 | 17.5 | CH3 | 18 | 17.5 |
| | CH6 | 20 | 18 | 18 | 17.5 | CH6 | 18 | 17.5 |
| | CH11 | 20 | 18 | 18 | 17.5 | CH9 | 18 | 17.5 |
| MIMO Antenna Power Index | | | | | | | | |
| Antenna | Channel | 802.11b | 802.11g | 802.11n HT20 | 802.11ax HE20 | Channel | 802.11n HT40 | 802.11ax HE40 |
| Antenna 1 | CH1 | 20 | 18 | 18 | 17.5 | CH3 | 18 | 17.5 |
| | CH6 | 20 | 18 | 18 | 17.5 | CH6 | 18 | 17.5 |
| | CH11 | 20 | 18 | 18 | 17.5 | CH9 | 18 | 17.5 |
| Antenna 2 | CH1 | 20 | 18 | 18 | 17.5 | CH3 | 18 | 17.5 |
| | CH6 | 20 | 18 | 18 | 17.5 | CH6 | 18 | 17.5 |
| | CH11 | 20 | 18 | 18 | 17.5 | CH9 | 18 | 17.5 |

| Antenna | Test Mode | $T_{on}$ (ms) | $T_{(on+off)}$ (ms) | Duty cycle | Duty cycle correction Factor(dB) |
|---|---|---|---|---|---|
| Antenna 1 | 802.11b | 0.69 | 0.70 | 0.98 | NA |
| | 802.11g | 1.97 | 1.99 | 0.99 | NA |
| | 802.11n HT20 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11n HT40 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11ax HE20 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11ax HE40 | 1.00 | 1.00 | 1.00 | NA |
| Antenna 2 | 802.11b | 0.69 | 0.70 | 0.98 | NA |
| | 802.11g | 1.00 | 1.00 | 1.00 | NA |
| | 802.11n HT20 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11n HT40 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11ax HE20 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11ax HE40 | 1.00 | 1.00 | 1.00 | NA |
| MIMO | 802.11b | 0.69 | 0.70 | 0.98 | NA |
| | 802.11g | 1.00 | 1.00 | 1.00 | NA |
| | 802.11n HT20 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11n HT40 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11ax HE20 | 1.00 | 1.00 | 1.00 | NA |
| | 802.11ax HE40 | 1.00 | 1.00 | 1.00 | NA |


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| | | | | |
|---|---|---|---|---|
| Bluetooth LE (125K) | 0.39 | 0.62 | 0.620 | 2.075 |
| Bluetooth LE (1M) | 0.38 | 0.62 | 0.615 | 2.109 |
| Bluetooth LE (2M) | 0.20 | 0.62 | 0.322 | 4.920 |
| Note: when Duty cycle⩾0.98, Duty cycle correction Factor not required. | | | | |

| Test Mode | Carrier frequency (MHz) | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Limit (dBm) | Conclusion |
|---|---|---|---|---|---|
| Bluetooth (Low Energy) (125K) | 2402 | 9.79 | 11.86 | 30 | PASS |
| | 2440 | 11.35 | 13.42 | 30 | PASS |
| | 2480 | 7.73 | 9.80 | 30 | PASS |
| Bluetooth (Low Energy) (1M) | 2402 | 9.74 | 11.85 | 30 | PASS |
| | 2440 | 11.42 | 13.53 | 30 | PASS |
| | 2480 | 7.56 | 9.67 | 30 | PASS |
| Bluetooth (Low Energy) (2M) | 2402 | 7.13 | 12.05 | 30 | PASS |
| | 2440 | 8.94 | 13.86 | 30 | PASS |
| | 2480 | 5.45 | 10.37 | 30 | PASS |
| Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor | | | | | |


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**SISO**

**Antenna 1**

| Test Mode | Carrier frequency (MHz) | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Limit (dBm) | Conclusion |
|---|---|---|---|---|---|
| 802.11b | 2412 | 19.49 | 19.49 | 30 | PASS |
| | 2437 | 18.57 | 18.57 | 30 | PASS |
| | 2462 | 17.83 | 17.83 | 30 | PASS |
| 802.11g | 2412 | 16.92 | 16.92 | 30 | PASS |
| | 2437 | 16.17 | 16.17 | 30 | PASS |
| | 2462 | 15.72 | 15.72 | 30 | PASS |
| 802.11n HT20 | 2412 | 16.76 | 16.76 | 30 | PASS |
| | 2437 | 16.03 | 16.03 | 30 | PASS |
| | 2462 | 15.76 | 15.76 | 30 | PASS |
| 802.11n HT40 | 2422 | 16.43 | 16.43 | 30 | PASS |
| | 2437 | 16.28 | 16.28 | 30 | PASS |
| | 2452 | 16.06 | 16.06 | 30 | PASS |
| 802.11ax HE20 | 2412 | 18.34 | 18.34 | 30 | PASS |
| | 2437 | 17.54 | 17.54 | 30 | PASS |
| | 2462 | 17.22 | 17.22 | 30 | PASS |
| 802.11ax HE40 | 2422 | 18.01 | 18.01 | 30 | PASS |
| | 2437 | 17.62 | 17.62 | 30 | PASS |
| | 2452 | 17.45 | 17.45 | 30 | PASS |
| Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor | | | | | |

**Antenna 2**

| Test Mode | Carrier frequency (MHz) | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Limit (dBm) | Conclusion |
|---|---|---|---|---|---|
| 802.11b | 2412 | 19.10 | 19.10 | 30 | PASS |
| | 2437 | 18.95 | 18.95 | 30 | PASS |
| | 2462 | 18.13 | 18.13 | 30 | PASS |
| 802.11g | 2412 | 16.87 | 16.87 | 30 | PASS |
| | 2437 | 16.74 | 16.74 | 30 | PASS |
| | 2462 | 16.09 | 16.09 | 30 | PASS |
| 802.11n | 2412 | 16.68 | 16.68 | 30 | PASS |


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| | | | | | |
|---|---|---|---|---|---|
| HT20 | 2437 | 16.60 | 16.60 | 30 | PASS |
| | 2462 | 15.91 | 15.91 | 30 | PASS |
| 802.11n HT40 | 2422 | 16.66 | 16.66 | 30 | PASS |
| | 2437 | 16.63 | 16.63 | 30 | PASS |
| | 2452 | 16.34 | 16.34 | 30 | PASS |
| 802.11ax HE20 | 2412 | 17.75 | 17.75 | 30 | PASS |
| | 2437 | 17.77 | 17.77 | 30 | PASS |
| | 2462 | 17.36 | 17.36 | 30 | PASS |
| 802.11ax HE40 | 2422 | 17.68 | 17.68 | 30 | PASS |
| | 2437 | 17.62 | 17.62 | 30 | PASS |
| | 2452 | 17.55 | 17.55 | 30 | PASS |
| Note: Average Power with duty factor = Average Power Measured +Duty cycle correction factor | | | | | |

**MIMO**

**Without Beamforming**

| Test Mode | Carrier frequency (MHz) | MIMO Antenna 1 | | MIMO Antenna 2 | | Total Power (dBm) | Limit (dBm) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| | | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Average Power Measured (dBm) | Average Power with duty factor (dBm) | | | |
| 802.11b | 2412 | 19.27 | 19.27 | 18.78 | 18.78 | 22.04 | 30 | PASS |
| | 2437 | 18.26 | 18.26 | 18.47 | 18.47 | 21.38 | 30 | PASS |
| | 2462 | 17.71 | 17.71 | 17.66 | 17.66 | 20.70 | 30 | PASS |
| 802.11g | 2412 | 16.67 | 16.67 | 16.75 | 16.75 | 19.72 | 30 | PASS |
| | 2437 | 16.02 | 16.02 | 16.61 | 16.61 | 19.34 | 30 | PASS |
| | 2462 | 15.67 | 15.67 | 15.92 | 15.92 | 18.81 | 30 | PASS |
| 802.11n HT20 | 2412 | 16.48 | 16.48 | 16.53 | 16.53 | 19.52 | 30 | PASS |
| | 2437 | 15.68 | 15.68 | 16.37 | 16.37 | 19.05 | 30 | PASS |
| | 2462 | 15.59 | 15.59 | 15.69 | 15.69 | 18.65 | 30 | PASS |
| 802.11n HT40 | 2422 | 16.27 | 16.27 | 16.48 | 16.48 | 19.39 | 30 | PASS |
| | 2437 | 16.21 | 16.21 | 16.38 | 16.38 | 19.31 | 30 | PASS |
| | 2452 | 16.01 | 16.01 | 16.06 | 16.06 | 19.05 | 30 | PASS |
| 802.11ax HE20 | 2412 | 17.98 | 17.98 | 17.46 | 17.46 | 20.74 | 30 | PASS |
| | 2437 | 17.21 | 17.21 | 17.47 | 17.47 | 20.35 | 30 | PASS |
| | 2462 | 16.88 | 16.88 | 17.13 | 17.13 | 20.02 | 30 | PASS |
| 802.11ax HE40 | 2422 | 17.69 | 17.69 | 17.35 | 17.35 | 20.53 | 30 | PASS |
| | 2437 | 17.36 | 17.36 | 17.32 | 17.32 | 20.35 | 30 | PASS |
| | 2452 | 17.08 | 17.08 | 17.30 | 17.30 | 20.20 | 30 | PASS |
| Note: 1.Average Power with duty factor = Average Power Measured +Duty cycle correction factor | | | | | | | | |


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2. For Total Power, according to KDB 662911 D01 Multiple Transmitter Output v02r01 1),
The Total Power =10log($10^{(\text{Power antenna1 in dBm/10})}$+$10^{(\text{Power antenna2 in dBm/10})}$.
3. The manufacturer declared the transmitter output signals is CDD mode. And $N_{ss}$=1. According to KDB 662911 D01 Multiple Transmitter Output v02r01 2)f)(i): If all antennas have the same gain, Directional gain = $G_{ANT}$ + Array Gain,
For power measurements on IEEE 802.11 devices,
Array Gain = 0 dB (i.e., no array gain) for $N_{ANT} \leq 4$;
Array Gain = 0 dB (i.e., no array gain) for channel widths ≥ 40 MHz for any $N_{ANT}$;
Array Gain = 5 log($N_{ANT}$/$N_{SS}$) dB or 3 dB, whichever is less, for 20-MHz channel widths with $N_{ANT} \geq 5$.
So directional gain = $G_{ANT}$ + Array Gain <6dBi. So the power limt is 30dBm

**With Beamforming**

| Test Mode | Carrier frequency (MHz) | MIMO Antenna 1 | | MIMO Antenna 2 | | Total Power (dBm) | Limit (dBm) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| | | Average Power Measured (dBm) | Average Power with duty factor (dBm) | Average Power Measured (dBm) | Average Power with duty factor (dBm) | | | |
| 802.11b | 2412 | 19.21 | 19.21 | 18.74 | 18.74 | 21.99 | 27.61 | PASS |
| | 2437 | 18.22 | 18.22 | 18.42 | 18.42 | 21.33 | 27.61 | PASS |
| | 2462 | 17.65 | 17.65 | 17.65 | 17.65 | 20.66 | 27.61 | PASS |
| 802.11g | 2412 | 16.57 | 16.57 | 16.63 | 16.63 | 19.61 | 27.61 | PASS |
| | 2437 | 16.01 | 16.01 | 16.57 | 16.57 | 19.31 | 27.61 | PASS |
| | 2462 | 15.59 | 15.59 | 15.84 | 15.84 | 18.73 | 27.61 | PASS |
| 802.11n HT20 | 2412 | 16.44 | 16.44 | 16.46 | 16.46 | 19.46 | 27.61 | PASS |
| | 2437 | 15.61 | 15.61 | 16.33 | 16.33 | 19.00 | 27.61 | PASS |
| | 2462 | 15.56 | 15.56 | 15.62 | 15.62 | 18.60 | 27.61 | PASS |
| 802.11n HT40 | 2422 | 16.22 | 16.22 | 16.44 | 16.44 | 19.34 | 27.61 | PASS |
| | 2437 | 16.16 | 16.16 | 16.32 | 16.32 | 19.25 | 27.61 | PASS |
| | 2452 | 16.00 | 16.00 | 16.02 | 16.02 | 19.02 | 27.61 | PASS |
| 802.11ax HE20 | 2412 | 17.86 | 17.86 | 17.33 | 17.33 | 20.61 | 27.61 | PASS |
| | 2437 | 17.09 | 17.09 | 17.34 | 17.34 | 20.23 | 27.61 | PASS |
| | 2462 | 16.76 | 16.76 | 17.03 | 17.03 | 19.91 | 27.61 | PASS |
| 802.11ax HE40 | 2422 | 17.57 | 17.57 | 17.22 | 17.22 | 20.41 | 27.61 | PASS |
| | 2437 | 17.24 | 17.24 | 17.19 | 17.19 | 20.23 | 27.61 | PASS |
| | 2452 | 16.96 | 16.96 | 17.17 | 17.17 | 20.08 | 27.61 | PASS |

Note: 1.Average Power with duty factor = Average Power Measured +Duty cycle correction factor
2. For Total Power, according to KDB 662911 D01 Multiple Transmitter Output v02r01 1),
The Total Power =10log($10^{(\text{Power antenna1 in dBm/10})}$+$10^{(\text{Power antenna2 in dBm/10})}$.
3. Direction gain calculation according to KDB662911 D01 Multiple Transmitter Output v02r01 F) 2) e）(i),If all antennas have the same gain, directional gain = $G_{ANT}$ + 10 log($N_{ANT}$/NSS)= $G_{ANT}$ +10log（2/Nss）=8.39 dBi＞6dBi.
So the limt is 30+6-Max(directional gain, 6) = 27.61dBm.


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## 5.2. 99% Bandwidth and 6dB Bandwidth

### Ambient condition

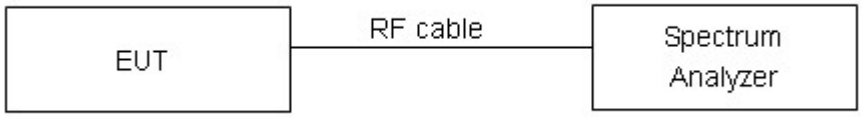
| Temperature | Relative humidity | Pressure |
|---|---|---|
| 23°C ~25°C | 45%~50% | 101.5kPa |

### Method of Measurement

The EUT was connected to the spectrum analyzer through an external attenuator (20dB) and a known loss cable. RBW is set to 100 kHz; VBW is set to 300 kHz on spectrum analyzer.
Dector=Peak, Trace mode=max hold.

The EUT was connected to the spectrum analyzer through a known loss cable. The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value.

### Test Setup




### Limits

Rule Part 15.247 (a) (2) specifies that “Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.”

| | |
|---|---|
| minimum 6 dB bandwidth | ≥ 500 kHz |

### Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k$ = 2, $U$= 936 Hz.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**Test Results:**

| Test Mode | Carrier frequency (MHz) | 99% bandwidth (MHz) | Minimum 6 dB bandwidth (MHz) | Limit (kHz) | Conclusion |
|---|---|---|---|---|---|
| 802.11b | 2412 | 12.8880 | 7.6340 | 500 | PASS |
| | 2437 | 13.4930 | 8.5690 | 500 | PASS |
| | 2462 | 13.6250 | 8.5950 | 500 | PASS |
| 802.11g | 2412 | 16.2800 | 15.7100 | 500 | PASS |
| | 2437 | 16.3740 | 16.1600 | 500 | PASS |
| | 2462 | 16.3930 | 15.7700 | 500 | PASS |
| 802.11n HT20 | 2412 | 17.4350 | 16.1100 | 500 | PASS |
| | 2437 | 17.5470 | 17.1700 | 500 | PASS |
| | 2462 | 17.5500 | 16.6800 | 500 | PASS |
| 802.11n HT40 | 2422 | 35.8260 | 35.1500 | 500 | PASS |
| | 2437 | 36.0540 | 36.3300 | 500 | PASS |
| | 2452 | 35.8110 | 33.9300 | 500 | PASS |
| 802.11ax HE20 | 2412 | 18.8170 | 18.4500 | 500 | PASS |
| | 2437 | 18.9230 | 18.8200 | 500 | PASS |
| | 2462 | 18.9150 | 18.6900 | 500 | PASS |
| 802.11ax HE40 | 2422 | 37.5150 | 33.9200 | 500 | PASS |
| | 2437 | 37.6600 | 37.9300 | 500 | PASS |
| | 2452 | 37.6300 | 34.0000 | 500 | PASS |
| Bluetooth (Low Energy) (125K) | 2402 | 1.02560 | 0.2485 | 500 | PASS |
| | 2440 | 1.02560 | 0.0156 | 500 | PASS |
| | 2480 | 1.02550 | 0.0203 | 500 | PASS |
| Bluetooth (Low Energy) (1M) | 2402 | 1.02630 | 0.6952 | 500 | PASS |
| | 2440 | 1.02560 | 0.6937 | 500 | PASS |
| | 2480 | 1.02550 | 0.6972 | 500 | PASS |
| Bluetooth (Low Energy) (2M) | 2402 | 2.0108 | 1.1800 | 500 | PASS |
| | 2440 | 2.0104 | 1.1760 | 500 | PASS |
| | 2480 | 2.0083 | 1.1800 | 500 | PASS |


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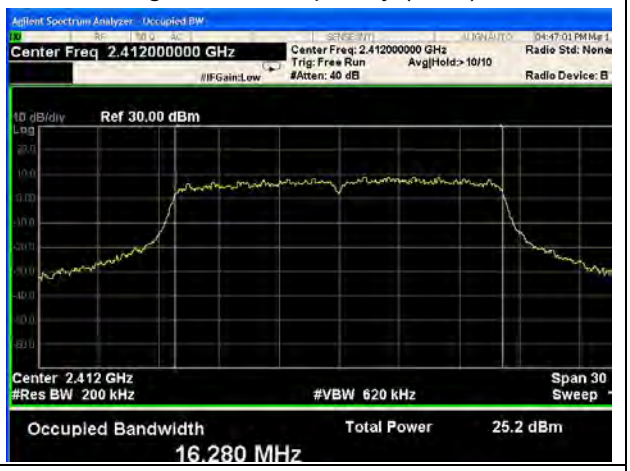
## 99%bandwidth

802.11b, Carrier frequency (MHz): 2412

802.11g, Carrier frequency (MHz): 2412

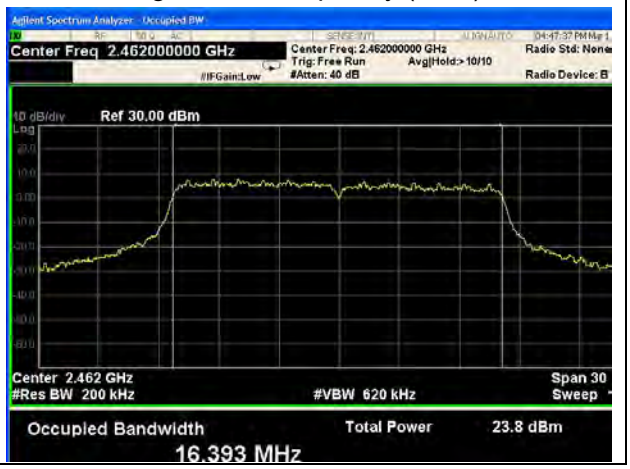



802.11b, Carrier frequency (MHz): 2437

802.11g, Carrier frequency (MHz): 2437

802.11b, Carrier frequency (MHz):2462

802.11g, Carrier frequency (MHz):2462





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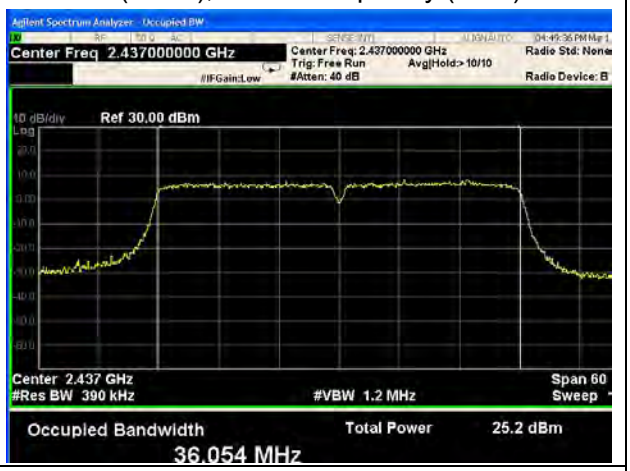
802.11n(HT20), Carrier frequency (MHz): 2412

802.11n(HT40), Carrier frequency (MHz): 2422

802.11n(HT20), Carrier frequency (MHz): 2437

802.11n(HT40), Carrier frequency (MHz): 2437




802.11n(HT20), Carrier frequency (MHz):2462

802.11n(HT40), Carrier frequency (MHz):2452

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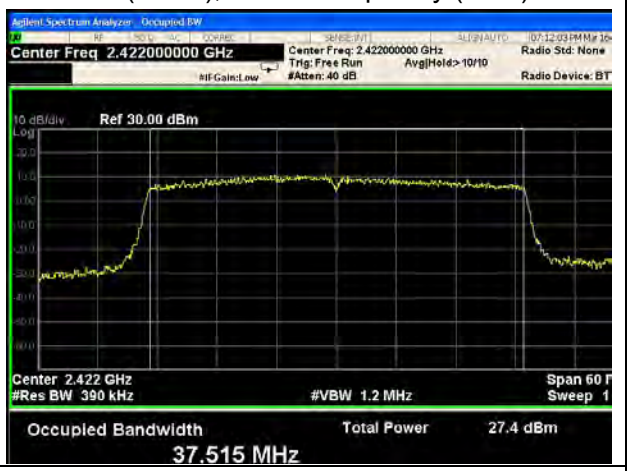
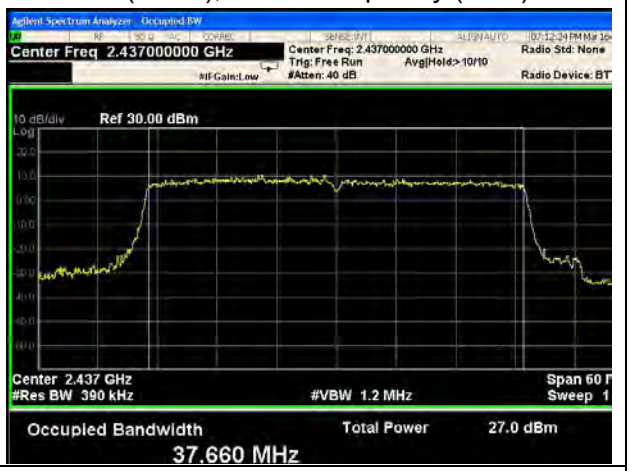
802.11ax(HE20), Carrier frequency (MHz): 2412

802.11ax(HE40), Carrier frequency (MHz): 2422



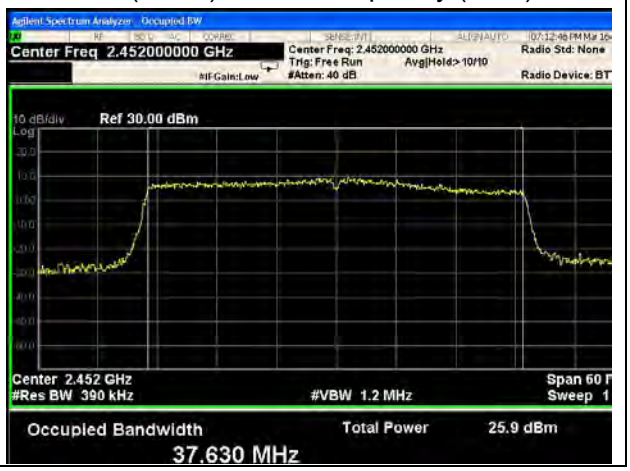

802.11ax(HE20), Carrier frequency (MHz): 2437

802.11ax(HE40), Carrier frequency (MHz): 2437




802.11ax(HE20), Carrier frequency (MHz): 2437

802.11ax(HE40), Carrier frequency (MHz):2452





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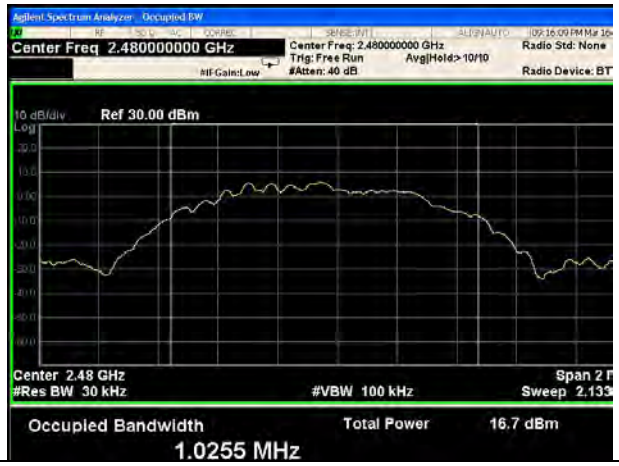
Bluetooth LE (125K) Carrier frequency (MHz): 2402

Bluetooth LE (125K) Carrier frequency (MHz): 2440

Bluetooth LE (125K) Carrier frequency (MHz): 2480





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Bluetooth LE (1M) Carrier frequency (MHz): 2402

Bluetooth LE (2M) Carrier frequency (MHz): 2402

Bluetooth LE (1M) Carrier frequency (MHz): 2440

Bluetooth LE (2M) Carrier frequency (MHz): 2440

Bluetooth LE (1M) Carrier frequency (MHz): 2480

Bluetooth LE (2M) Carrier frequency (MHz): 2480

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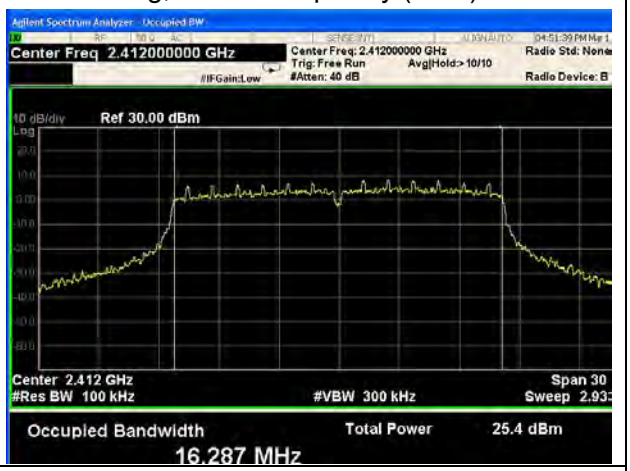
## 6 dB bandwidth

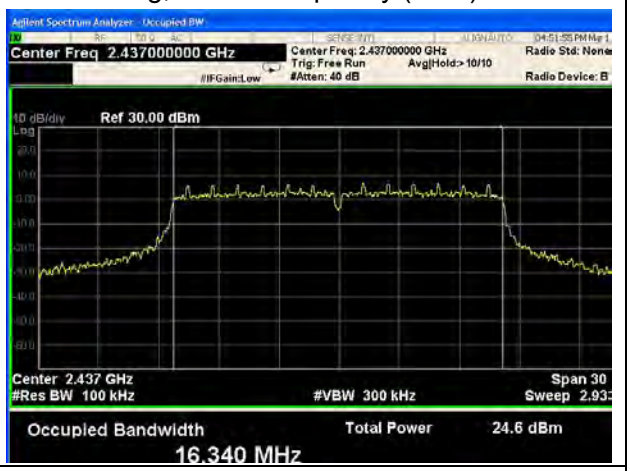
802.11b, Carrier frequency (MHz): 2412

802.11g, Carrier frequency (MHz): 2412



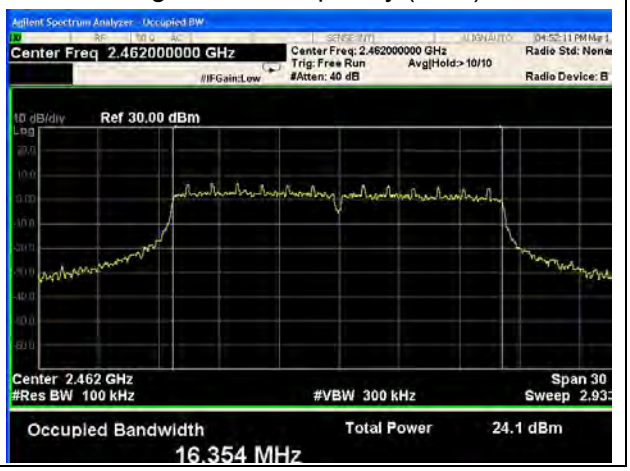

802.11b, Carrier frequency (MHz): 2437

802.11g, Carrier frequency (MHz): 2437




802.11b, Carrier frequency (MHz):2462

802.11g, Carrier frequency (MHz):2462





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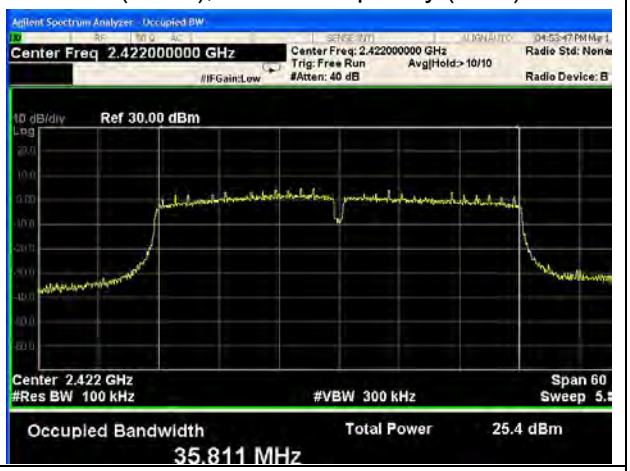
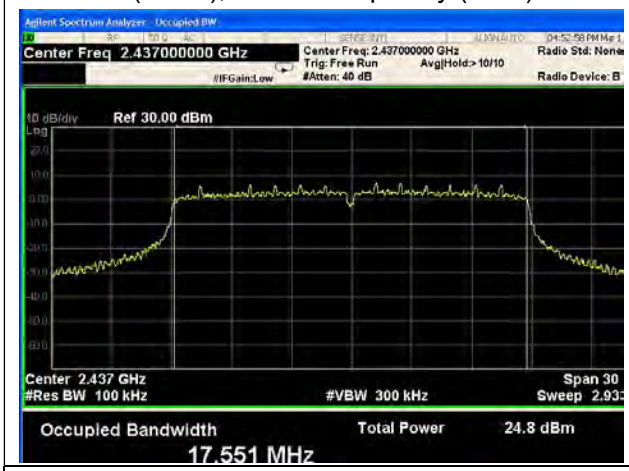
802.11n(HT20), Carrier frequency (MHz): 2412

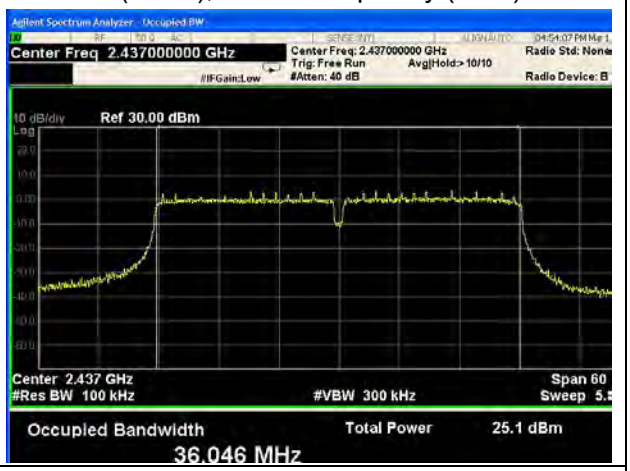
802.11n(HT40), Carrier frequency (MHz): 2422




802.11n(HT20), Carrier frequency (MHz): 2437

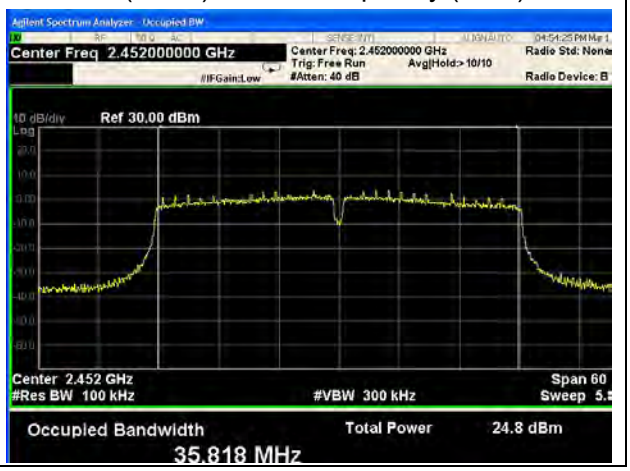



802.11n(HT40), Carrier frequency (MHz): 2437




802.11n(HT20), Carrier frequency (MHz):2462

802.11n(HT40), Carrier frequency (MHz):2452





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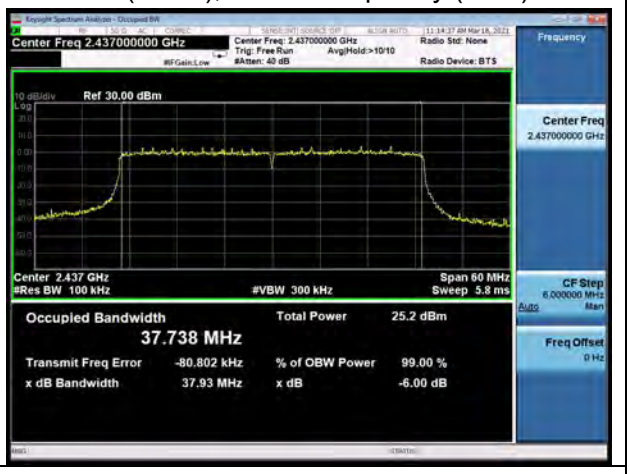
802.11ax(HE20), Carrier frequency (MHz): 2412

802.11ax(HE40), Carrier frequency (MHz): 2422

802.11ax(HE20), Carrier frequency (MHz): 2437

802.11ax(HE40), Carrier frequency (MHz): 2437




802.11ax(HE20), Carrier frequency (MHz): 2437

802.11ax(HE40), Carrier frequency (MHz):2452

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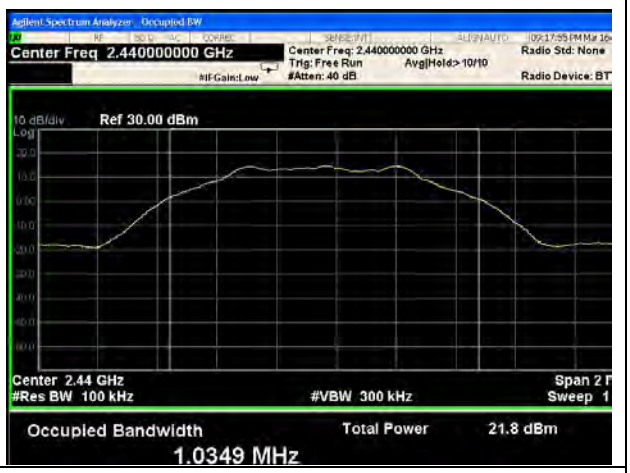
Bluetooth LE (125K) Carrier frequency (MHz): 2402

Bluetooth LE (125K) Carrier frequency (MHz): 2440




Bluetooth LE (125K) Carrier frequency (MHz): 2480

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Bluetooth LE (1M) Carrier frequency (MHz): 2402

Bluetooth LE (2M) Carrier frequency (MHz): 2402

Bluetooth LE (1M) Carrier frequency (MHz): 2440

Bluetooth LE (2M) Carrier frequency (MHz): 2440

Bluetooth LE (1M) Carrier frequency (MHz): 2480

Bluetooth LE (2M) Carrier frequency (MHz): 2480

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## 5.3. Band Edge

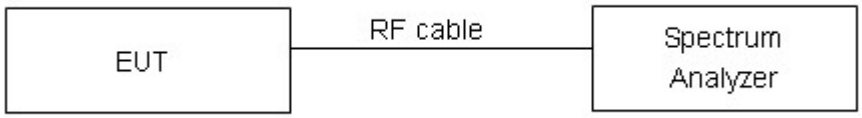
### Ambient condition

| Temperature | Relative humidity | Pressure |
|---|---|---|
| 23°C ~25°C | 45%~50% | 101.5kPa |

### Method of Measurement

The EUT was connected to the spectrum analyzer through an external attenuator (20dB) and a known loss cable the band edge of the lowest and highest channels were measured. The peak detector is used and RBW is set to 100 kHz and VBW is set to 300 kHz on spectrum analyzer. Spectrum analyzer plots are included on the following pages.

### Test Setup




### Limits

Rule Part 15.247(d) specifies that “In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.” If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.”

### Measurement Uncertainty

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor $k$ = 1.96.

| Frequency | Uncertainty |
|---|---|
| 2GHz-3GHz | 1.407 dB |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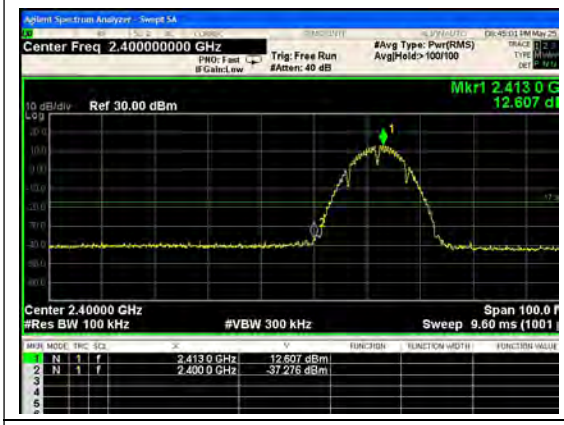
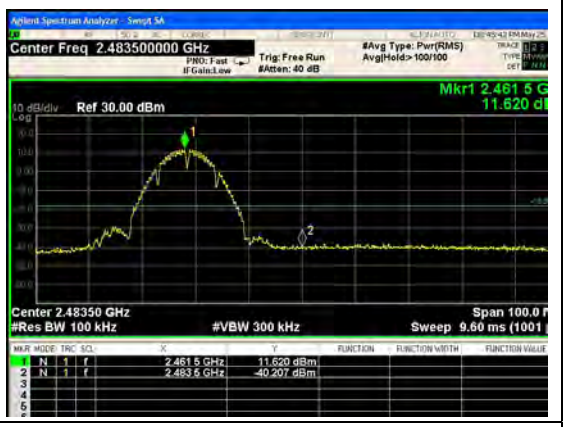
## Test Results: PASS

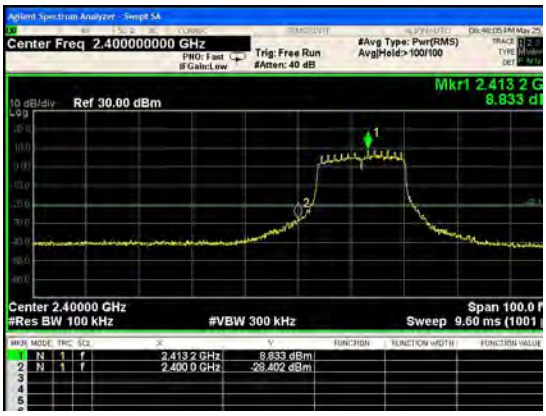
802.11b, Channel No.: 1



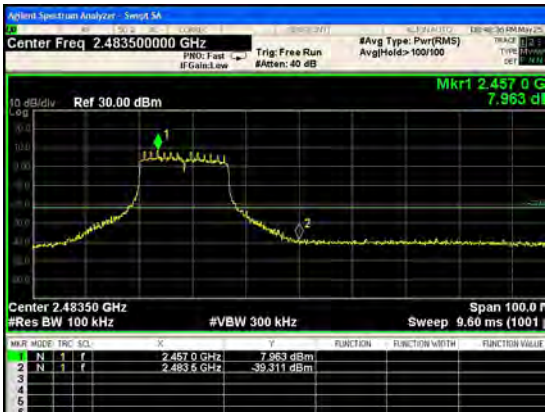

802.11b, Channel No.: 11



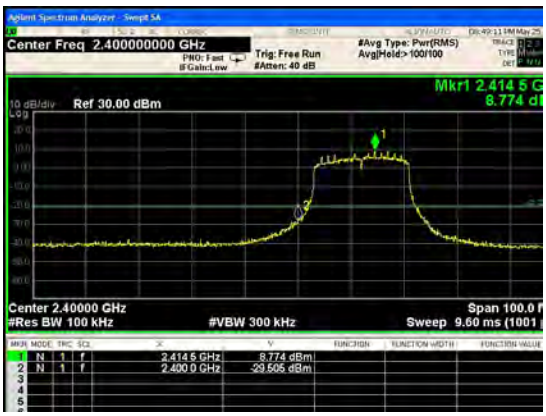

802.11g, Channel No.: 1



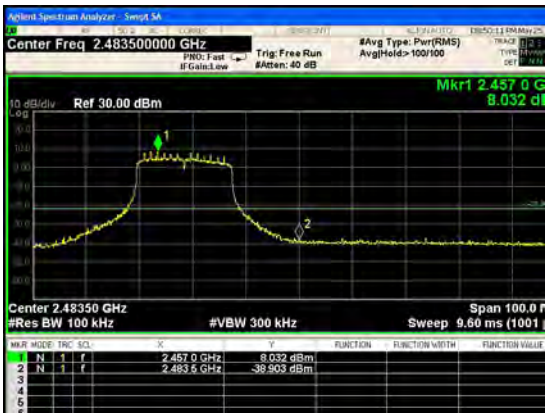

802.11g, Channel No.: 11




802.11n(HT20), Channel No.: 1

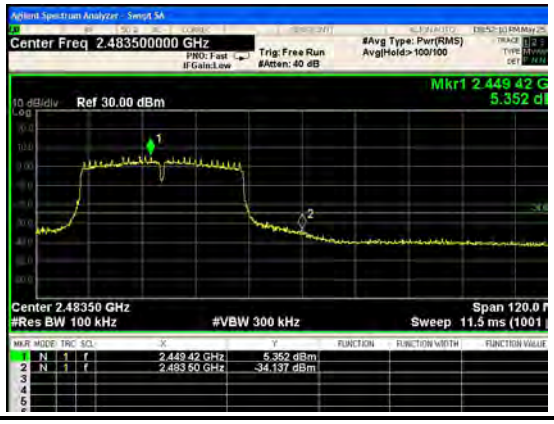



802.11n(HT20), Channel No.: 11




802.11n(HT40), Channel No.: 3

802.11n(HT40), Channel No.: 9





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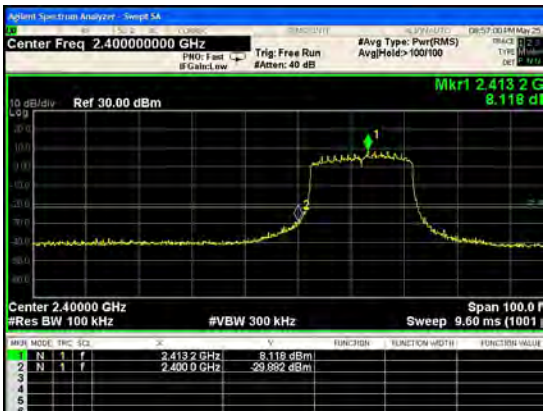
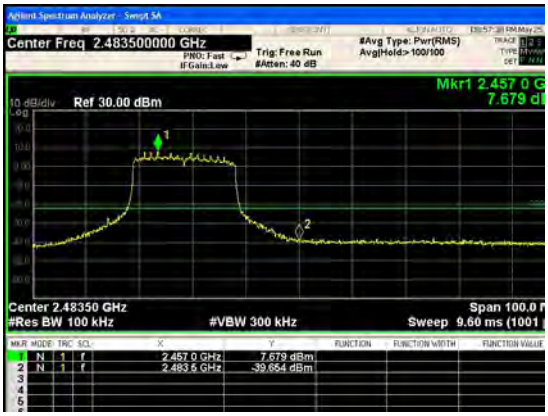
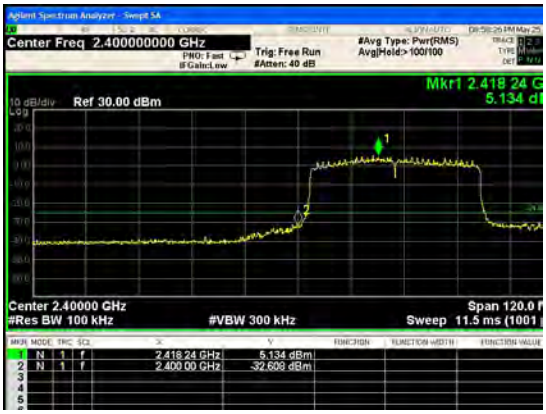
802.11ax(HE20), Channel No.: 1



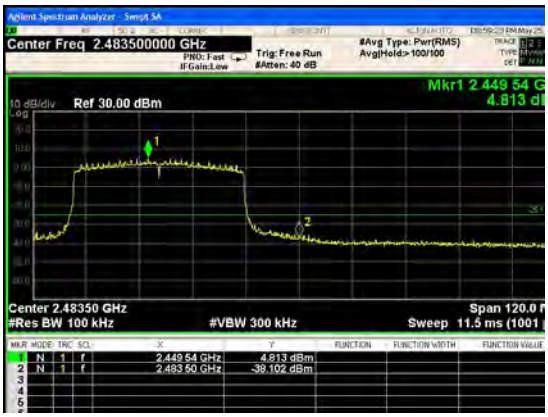

802.11 ax(HE20), Channel No.: 11



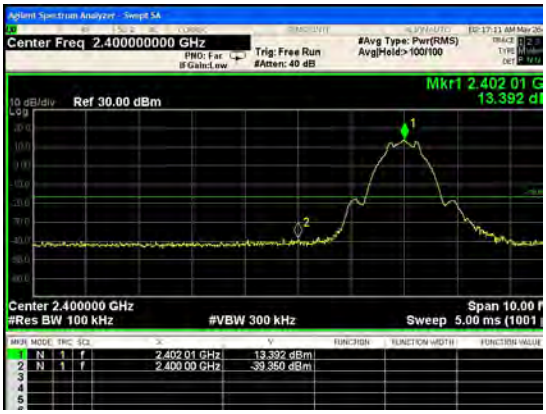

802.11 ax(HE40), Channel No.: 3




802.11 ax(HE40), Channel No.: 9



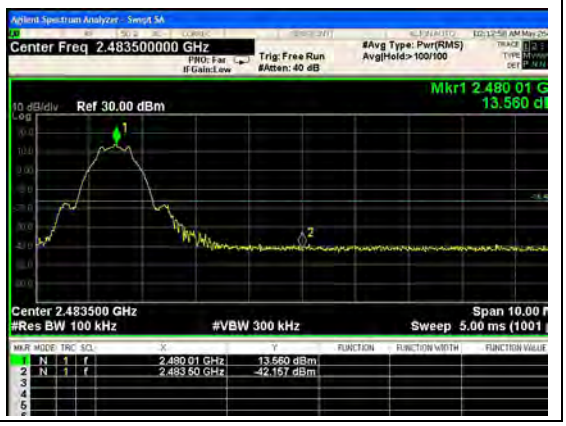

Bluetooth LE (125K), Channel No.: 0




Bluetooth LE (125K), Channel No.: 39

Bluetooth LE (1M), Channel No.: 0

Bluetooth LE (1M), Channel No.: 39





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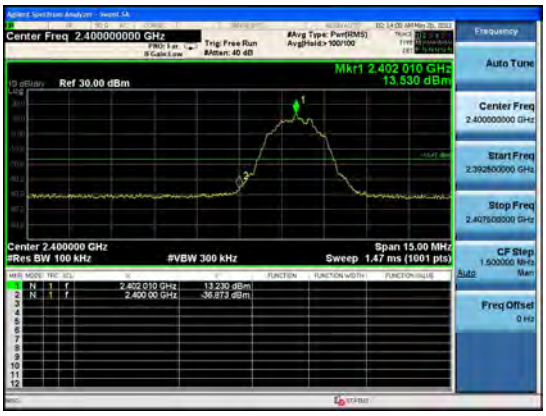
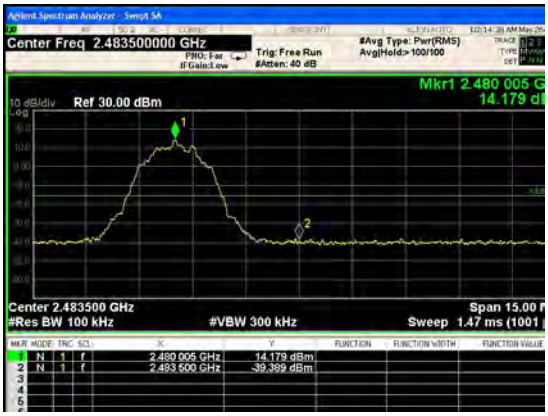
| Bluetooth LE (2M), Channel No.: 0 | Bluetooth LE (2M), Channel No.: 39 |
|---|---|
|  |  |

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## 5.4. Power Spectral Density

**Ambient condition**

| Temperature | Relative humidity | Pressure |
|---|---|---|
| 23°C ~25°C | 45%~50% | 101.5kPa |

**Method of Measurement**

During the process of the testing, The EUT was connected to Spectrum Analyzer with a known loss. The EUT is max power transmission with proper modulation.

Method AVGPSD-1 was used for this test.

a) Set instrument center frequency to DTS channel center frequency

b) Set span to at least 1.5 times the OBW

c) Set RBW to:3kHz≤RBW≤100kHz

d) Set VBW≥[3x RBW]

e) Detector=power averaging(rms) or sample detector(when rms not available)

f) Ensure that the number of measurement points in the sweep 2[2 X span/RBWT]

g)Sweep time auto couple

h) Employ trace averaging(rms) mode over a minimum of 100 traces

i) Use the peak marker function to determine the maximum amplitude level.

j) If the measured value exceeds requirement, then reduce RBW (but no less than 3 kHz) and repeat(note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced)

Method AVGPSD-2 was used for this test.

a) Measure the duty cycle(D)of the transmitter output signal as described in 11.6

b) Set instrument center frequency to DTS channel center frequency

c)Set span to at least 1.5 times the OBW

d) Set RBW to:3kHz≤RBW≤100Kh

e) Set VBW≥[3x RBW]

f )Detector= power averaging(rms) or sample detector (when rms not available)

g) Ensure that the number of measurement points in the sweep 2[2 X span/RBW]

h) Sweep time =auto couple

i) Do not use sweep triggering; allow sweep to "free run”

j) Employ trace averaging(rms) mode over a minimum of 100 traces

k) Use the peak marker function to determine the maximum amplitude level

l) Add [10 log(1/ D)], where D is the duty cycle measured in step a), to the measured PSD to


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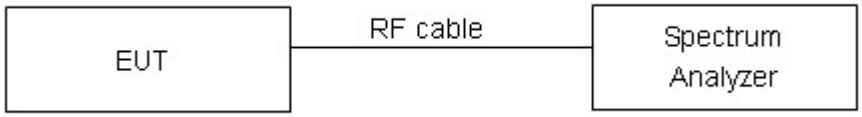
compute the average PSD during the actual transmission time

m) If measured value exceeds requirement specified by regulatory agency then reduce RBW(but o less than 3 kHz) and repeat(note that this may require zooming in on the emission of interest and reducing the span to meet the minimum measurement point requirement as the RBW is reduced)

The conducted Power is measured at each antenna port. The measured results at the various antenna ports are then summed mathematically.

**Test setup**




**Limits**

Rule Part 15.247(e) specifies that" For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. ''

| | |
|---|---|
| Limits | ≤ 8 dBm / 3kHz |

**Measurement Uncertainty**

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor *k* = 2, *U*= 0.75dB.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**Test Results:**

| Test Mode | Channel Number | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | Limit (dBm / 3kHz) | Conclusion |
|---|---|---|---|---|---|
| Bluetooth (Low Energy) (125K) | 0 | -4.57 | -2.50 | 8 | PASS |
| | 19 | -2.90 | -0.83 | 8 | PASS |
| | 39 | -7.14 | -5.06 | 8 | PASS |
| Bluetooth (Low Energy) (1M) | 0 | -4.43 | -2.32 | 8 | PASS |
| | 19 | -3.23 | -1.12 | 8 | PASS |
| | 39 | -7.64 | -5.53 | 8 | PASS |
| Bluetooth (Low Energy) (2M) | 0 | -7.45 | -2.53 | 8 | PASS |
| | 19 | -5.90 | -0.98 | 8 | PASS |
| | 39 | -9.16 | -4.24 | 8 | PASS |
| Note: Power Spectral Density =Read Value+Duty cycle correction factor | | | | | |

**SISO**

**Antenna 1**

| Test Mode | Channel Number | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | Limit (dBm / 3kHz) | Conclusion |
|---|---|---|---|---|---|
| 802.11b | 1 | -12.51 | -12.51 | 8 | PASS |
| | 6 | -13.36 | -13.36 | 8 | PASS |
| | 11 | -13.98 | -13.98 | 8 | PASS |
| 802.11g | 1 | -15.13 | -15.13 | 8 | PASS |
| | 6 | -16.29 | -16.29 | 8 | PASS |
| | 11 | -16.67 | -16.67 | 8 | PASS |
| 802.11n HT20 | 1 | -16.07 | -16.07 | 8 | PASS |
| | 6 | -17.25 | -17.25 | 8 | PASS |
| | 11 | -17.16 | -17.16 | 8 | PASS |
| 802.11n HT40 | 3 | -18.65 | -18.65 | 8 | PASS |
| | 6 | -19.69 | -19.69 | 8 | PASS |
| | 9 | -18.95 | -18.95 | 8 | PASS |
| 802.11ax HE20 | 1 | -18.16 | -18.16 | 8 | PASS |
| | 6 | -19.37 | -19.37 | 8 | PASS |
| | 11 | -19.40 | -19.40 | 8 | PASS |
| 802.11ax HE40 | 3 | -21.34 | -21.34 | 8 | PASS |
| | 6 | -22.06 | -22.06 | 8 | PASS |


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| | | | | | |
|---|---|---|---|---|---|
| | 9 | -21.19 | -21.19 | 8 | PASS |
| Note: Power Spectral Density =Read Value+Duty cycle correction factor | | | | | |

**Antenna 2**

| Test Mode | Channel Number | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | Limit (dBm / 3kHz) | Conclusion |
|---|---|---|---|---|---|
| 802.11b | 1 | -10.87 | -10.87 | 8 | PASS |
| | 6 | -10.70 | -10.70 | 8 | PASS |
| | 11 | -11.73 | -11.73 | 8 | PASS |
| 802.11g | 1 | -16.00 | -16.00 | 8 | PASS |
| | 6 | -16.22 | -16.22 | 8 | PASS |
| | 11 | -16.71 | -16.71 | 8 | PASS |
| 802.11n HT20 | 1 | -16.57 | -16.57 | 8 | PASS |
| | 6 | -16.93 | -16.93 | 8 | PASS |
| | 11 | -17.29 | -17.29 | 8 | PASS |
| 802.11n HT40 | 3 | -19.37 | -19.37 | 8 | PASS |
| | 6 | -19.73 | -19.73 | 8 | PASS |
| | 9 | -19.06 | -19.06 | 8 | PASS |
| 802.11ax HE20 | 1 | -18.67 | -18.67 | 8 | PASS |
| | 6 | -18.96 | -18.96 | 8 | PASS |
| | 11 | -19.39 | -19.39 | 8 | PASS |
| 802.11ax HE40 | 3 | -21.88 | -21.88 | 8 | PASS |
| | 6 | -22.39 | -22.39 | 8 | PASS |
| | 9 | -21.44 | -21.44 | 8 | PASS |
| Note: Power Spectral Density =Read Value+Duty cycle correction factor | | | | | |


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**MIMO**

**Without Beamforming**

| Test Mode | Channel Number | Power Spectral Density | | | | Total PSD | Limit (dBm / 3kHz) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| | | Antenna 1 | | Antenna 2 | | | | |
| | | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | (dBm / 3kHz) | | |
| 802.11b | 1 | -10.47 | -10.47 | -10.88 | -10.88 | -7.66 | 5.61 | PASS |
| | 6 | -12.02 | -12.02 | -11.03 | -11.03 | -8.49 | 5.61 | PASS |
| | 11 | -12.86 | -12.86 | -11.92 | -11.92 | -9.35 | 5.61 | PASS |
| 802.11g | 1 | -15.94 | -15.94 | -15.69 | -15.69 | -12.80 | 5.61 | PASS |
| | 6 | -16.89 | -16.89 | -15.97 | -15.97 | -13.39 | 5.61 | PASS |
| | 11 | -17.25 | -17.25 | -16.58 | -16.58 | -13.89 | 5.61 | PASS |
| 802.11n HT20 | 1 | -16.41 | -16.41 | -16.51 | -16.51 | -13.45 | 5.61 | PASS |
| | 6 | -17.65 | -17.65 | -16.75 | -16.75 | -14.17 | 5.61 | PASS |
| | 11 | -17.99 | -17.99 | -17.33 | -17.33 | -14.64 | 5.61 | PASS |
| 802.11n HT40 | 3 | -19.37 | -19.37 | -19.62 | -19.62 | -16.48 | 5.61 | PASS |
| | 6 | -20.25 | -20.25 | -20.53 | -20.53 | -17.38 | 5.61 | PASS |
| | 9 | -19.69 | -19.69 | -19.06 | -19.06 | -16.35 | 5.61 | PASS |
| 802.11ax HE20 | 1 | -20.10 | -20.10 | -18.41 | -18.41 | -16.16 | 5.61 | PASS |
| | 6 | -19.71 | -19.71 | -18.84 | -18.84 | -16.24 | 5.61 | PASS |
| | 11 | -19.84 | -19.84 | -19.39 | -19.39 | -16.60 | 5.61 | PASS |
| 802.11ax HE40 | 3 | -21.79 | -21.79 | -21.80 | -21.80 | -18.79 | 5.61 | PASS |
| | 6 | -22.67 | -22.67 | -22.47 | -22.47 | -19.56 | 5.61 | PASS |
| | 9 | -21.99 | -21.99 | -22.24 | -22.24 | -19.11 | 5.61 | PASS |

Note: 1.Power Spectral Density =Read Value+Duty cycle correction factor

2. For Total PSD, according to KDB 662911 D01 Multiple Transmitter Output v02r01 2)a),the power spectral density=10log($10^{(PSD\ antenna1\ in\ dBm/10)}$+$10^{(PSD\ antenna2\ in\ dBm/10)}$

3. The manufacturer declared the transmitter output signals is CDD mode. And $N_{ss}$=1. According to KDB 662911 D01 Multiple Transmitter Output v02r01 2)f)(i): If all antennas have the same gain, Directional gain = $G_{ANT}$ + Array Gain. For PSD measurements on all devices, Array Gain=10log(Nant/Nss)dB, so directional gain=GANT+Array Gain=5.38+10log(2/1)=8.39>6dBi.

So the power limt is 8+6-MAX(6, directional gain)dBm=5.61 dBm


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**With Beamforming**

| Test Mode | Channel Number | Power Spectral Density | | | | Total PSD | Limit (dBm / 3kHz) | Conclusion |
|---|---|---|---|---|---|---|---|---|
| | | Antenna 1 | | Antenna 2 | | | | |
| | | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | Read Value (dBm / 3kHz) | Power Spectral Density (dBm / 3kHz) | (dBm / 3kHz) | | |
| 802.11b | 1 | -11.60 | -11.60 | -12.10 | -12.10 | -8.83 | 5.61 | PASS |
| | 6 | -12.69 | -12.69 | -12.52 | -12.52 | -9.59 | 5.61 | PASS |
| | 11 | -13.75 | -13.75 | -13.34 | -13.34 | -10.53 | 5.61 | PASS |
| 802.11g | 1 | -16.27 | -16.27 | -17.01 | -17.01 | -13.61 | 5.61 | PASS |
| | 6 | -17.54 | -17.54 | -17.20 | -17.20 | -14.35 | 5.61 | PASS |
| | 11 | -17.90 | -17.90 | -17.73 | -17.73 | -14.80 | 5.61 | PASS |
| 802.11n HT20 | 1 | -16.83 | -16.83 | -17.01 | -17.01 | -13.91 | 5.61 | PASS |
| | 6 | -19.24 | -19.24 | -18.73 | -18.73 | -15.97 | 5.61 | PASS |
| | 11 | -19.10 | -19.10 | -18.79 | -18.79 | -15.93 | 5.61 | PASS |
| 802.11n HT40 | 3 | -20.42 | -20.42 | -20.31 | -20.31 | -17.36 | 5.61 | PASS |
| | 6 | -21.94 | -21.94 | -21.35 | -21.35 | -18.62 | 5.61 | PASS |
| | 9 | -19.63 | -19.63 | -19.41 | -19.41 | -16.51 | 5.61 | PASS |
| 802.11ax HE20 | 1 | -19.40 | -19.40 | -18.44 | -18.44 | -15.88 | 5.61 | PASS |
| | 6 | -19.90 | -19.90 | -19.35 | -19.35 | -16.61 | 5.61 | PASS |
| | 11 | -19.97 | -19.97 | -19.70 | -19.70 | -16.82 | 5.61 | PASS |
| 802.11ax HE40 | 3 | -22.07 | -22.07 | -21.69 | -21.69 | -18.86 | 5.61 | PASS |
| | 6 | -23.44 | -23.44 | -22.55 | -22.55 | -19.96 | 5.61 | PASS |
| | 9 | -22.01 | -22.01 | -21.71 | -21.71 | -18.85 | 5.61 | PASS |

Note: 1.Power Spectral Density =Read Value+Duty cycle correction factor

2. For Total PSD, according to KDB 662911 D01 Multiple Transmitter Output v02r01 2)a),the power spectral density=$10\log(10^{(\text{PSD antenna1 in dBm/10})}+10^{(\text{PSD antenna2 in dBm/10})}$

3. The manufacturer declared the transmitter output signals is CDD mode. And $N_{ss}$=1. According to KDB 662911 D01 Multiple Transmitter Output v02r01 2)f)(i): If all antennas have the same gain, Directional gain = $G_{ANT}$ + Array Gain. For PSD measurements on all devices, Array Gain=10log(Nant/Nss)dB, so directional gain=GANT+Array Gain=5.38+10log(2/1)=8.39>6dBi.

So the power limt is 8+6-MAX(6, directional gain)dBm=5.61 dBm


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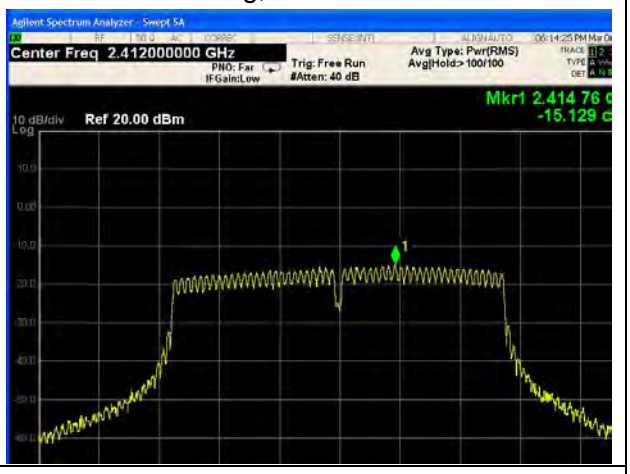
## SISO Antenna 1

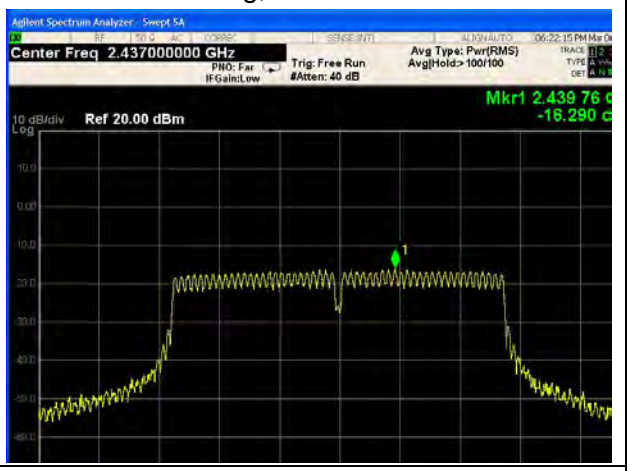
802.11b, Channel No.: 1

802.11g, Channel No.: 1



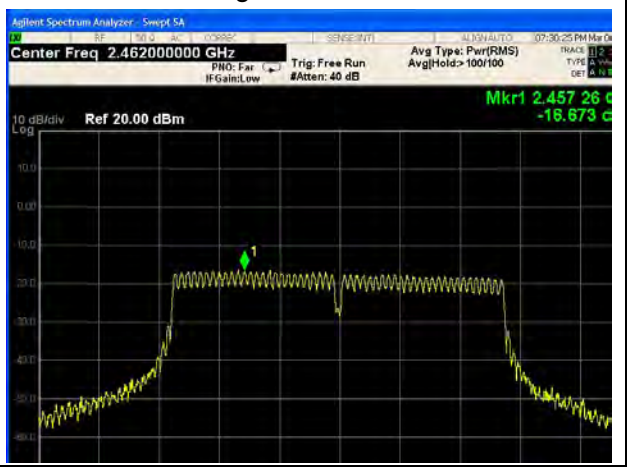

802.11b, Channel No.: 6

802.11g, Channel No.: 6




802.11b, Channel No.: 11

802.11g, Channel No.: 11





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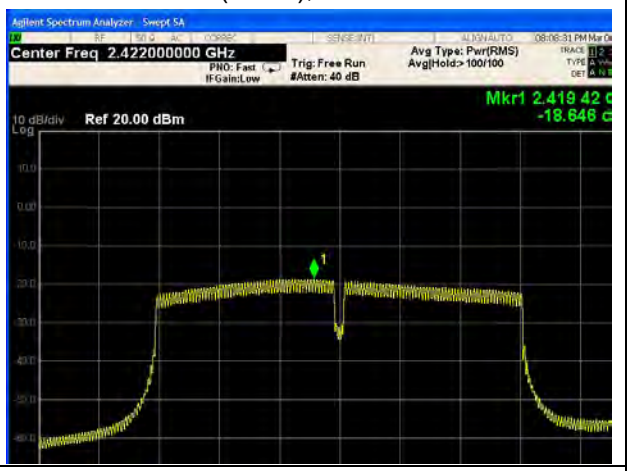
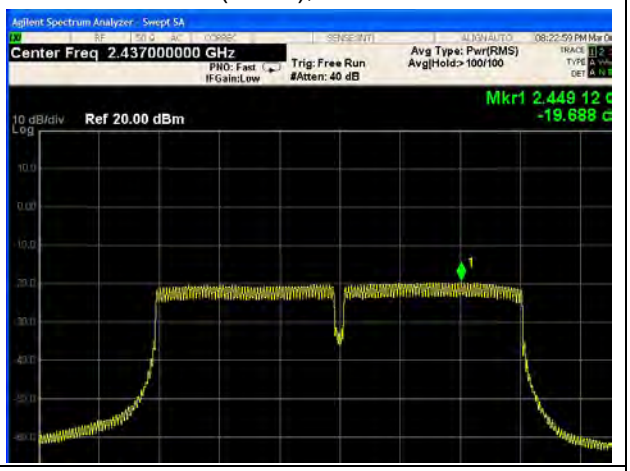
802.11n(HT20), Channel No. 1

802.11n(HT40), Channel No. 3



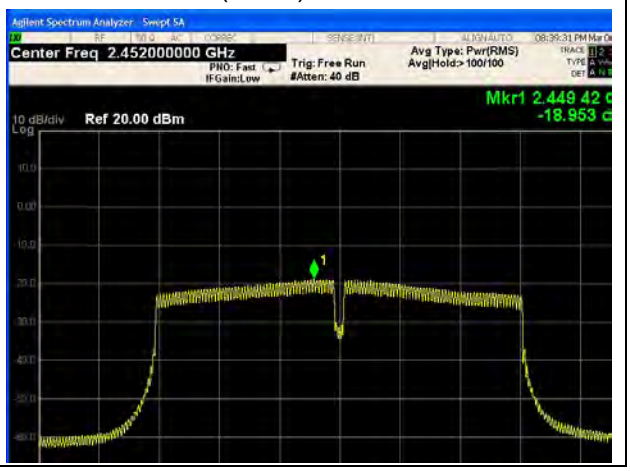

802.11n(HT20), Channel No. 6

802.11n(HT40), Channel No. 6




802.11n(HT20), Channel No. 11

802.11n(HT40), Channel No. 9





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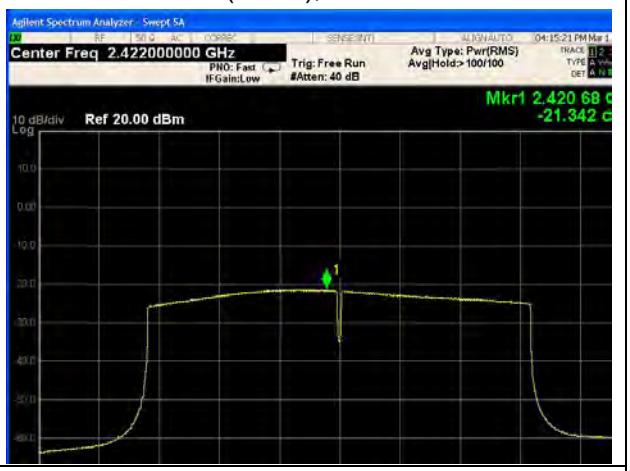
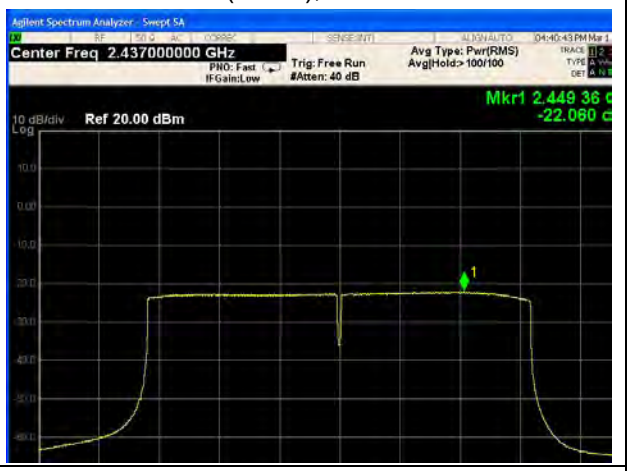
802.11ax(HE20), Channel No. 1

802.11ax(HE40), Channel No. 3



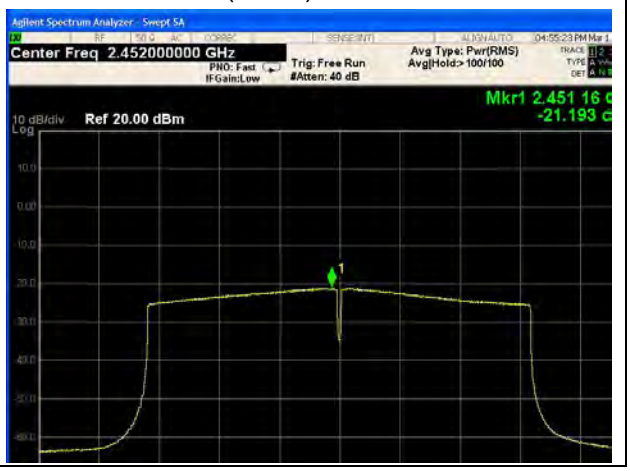

802.11ax(HE20), Channel No. 6

802.11ax(HE40), Channel No. 6




802.11ax(HE20), Channel No. 11

802.11ax(HE40), Channel No. 9





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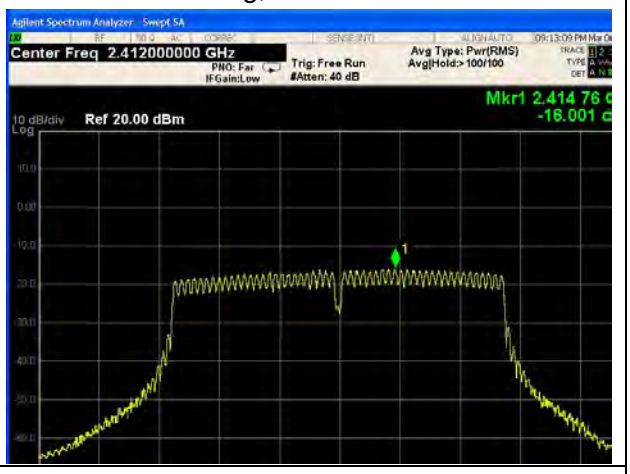
## SISO Antenna 2

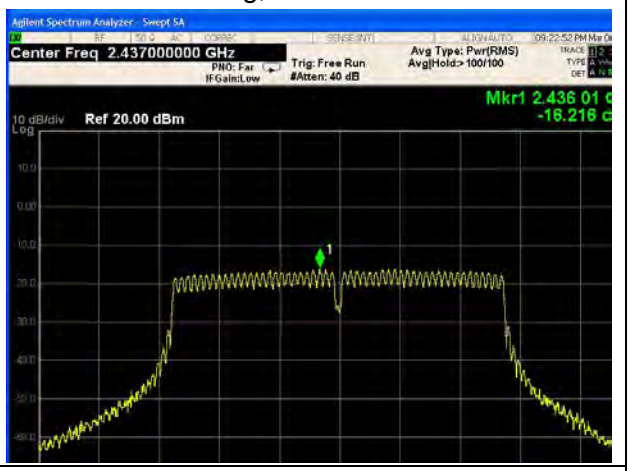
802.11b, Channel No.: 1

802.11g, Channel No.: 1



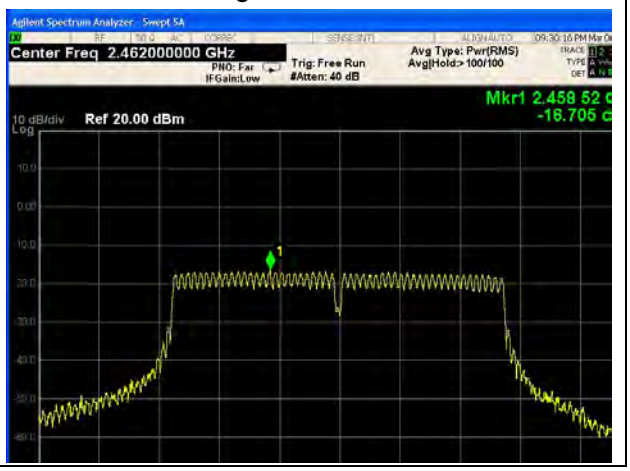

802.11b, Channel No.: 6

802.11g, Channel No.: 6




802.11b, Channel No.: 11

802.11g, Channel No.: 11





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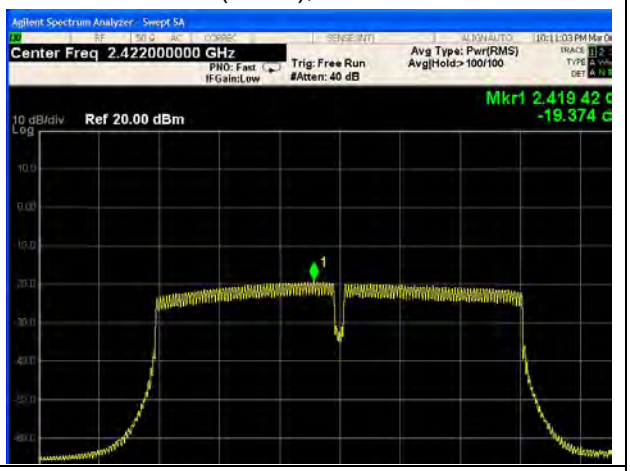
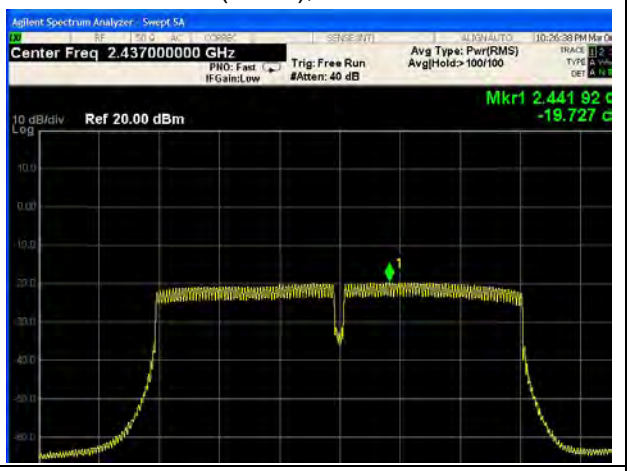
802.11n(HT20), Channel No. 1

802.11n(HT40), Channel No. 3

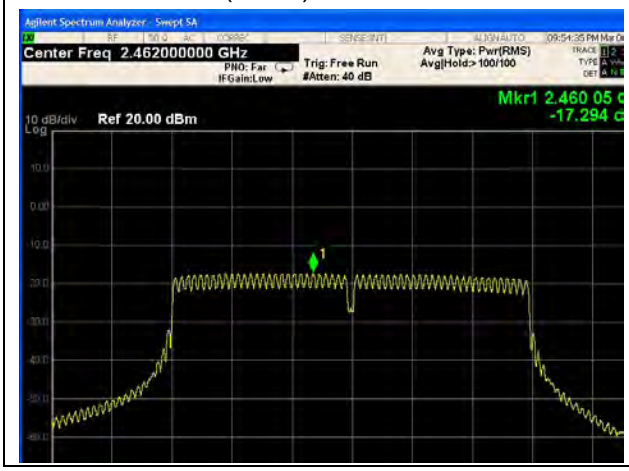



802.11n(HT20), Channel No. 6

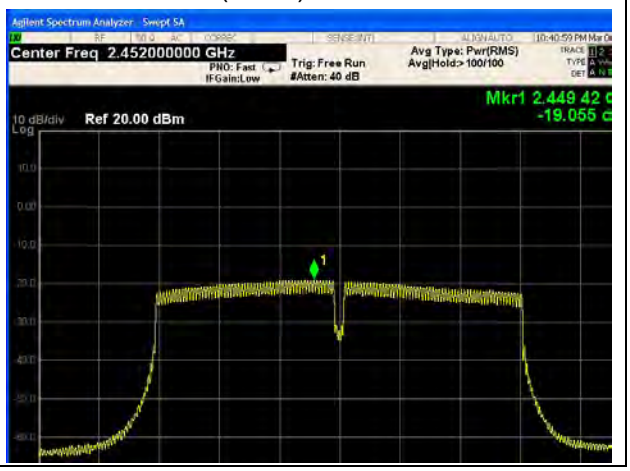
802.11n(HT40), Channel No. 6




802.11n(HT20), Channel No. 11




802.11n(HT40), Channel No. 9





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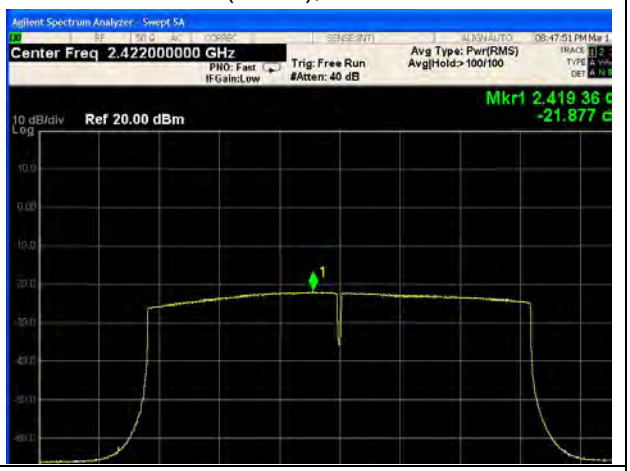
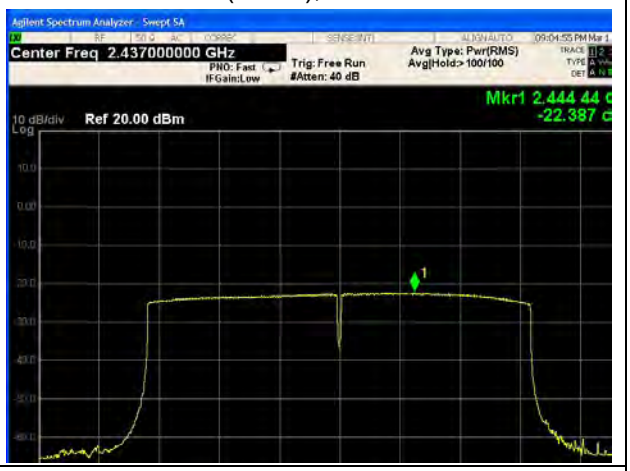
802.11ax(HE20), Channel No. 1

802.11ax(HE40), Channel No. 3



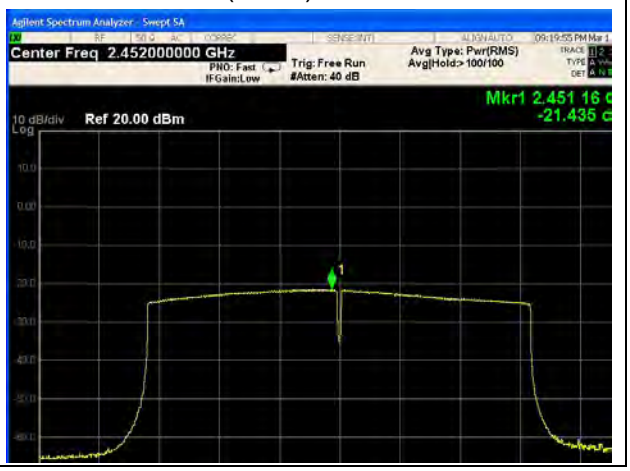

802.11ax(HE20), Channel No. 6

802.11ax(HE40), Channel No. 6




802.11ax(HE20), Channel No. 11

802.11ax(HE40), Channel No. 9





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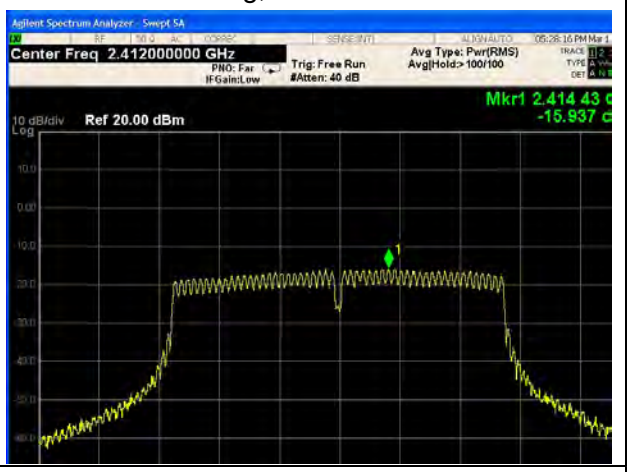
## MIMO Without Beamforming

### Antenna 1

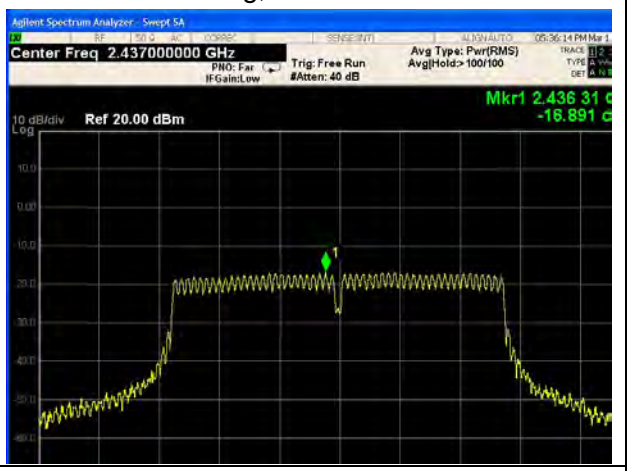
802.11b, Channel No.: 1

802.11g, Channel No.: 1



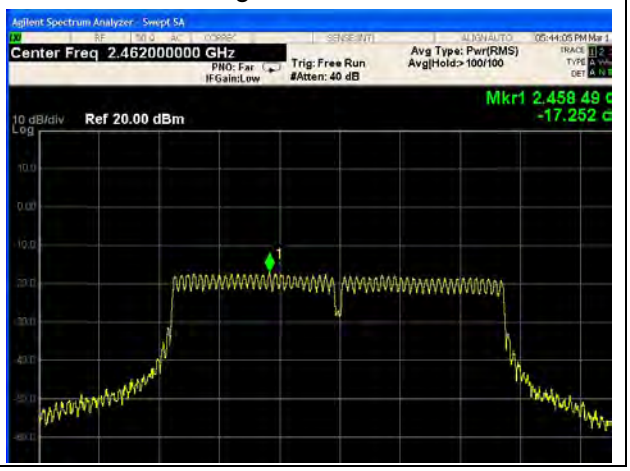

802.11b, Channel No.: 6

802.11g, Channel No.: 6




802.11b, Channel No.: 11

802.11g, Channel No.: 11





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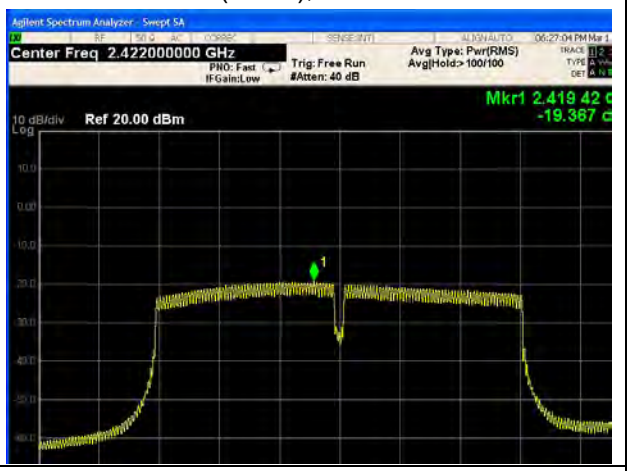
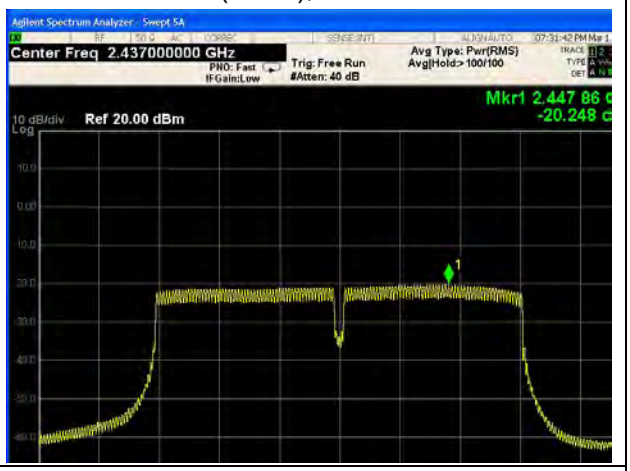
802.11n(HT20), Channel No. 1

802.11n(HT40), Channel No. 3



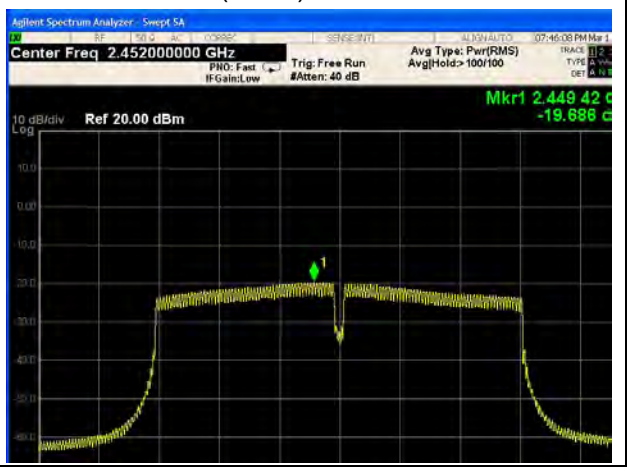

802.11n(HT20), Channel No. 6

802.11n(HT40), Channel No. 6




802.11n(HT20), Channel No. 11

802.11n(HT40), Channel No. 9





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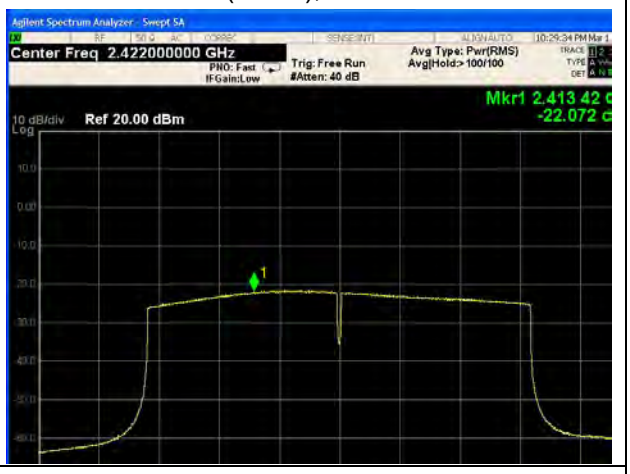
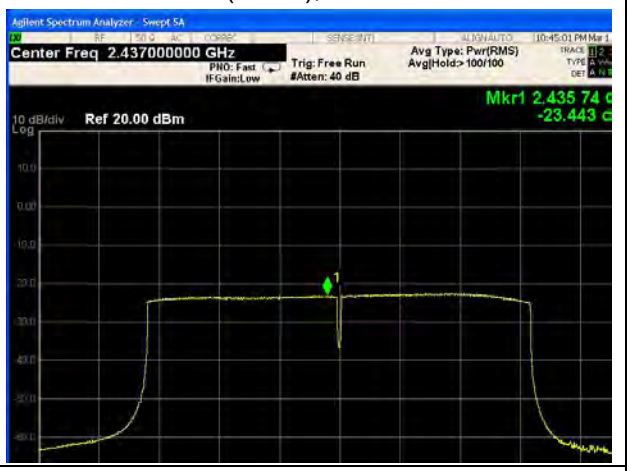
802.11ax(HE20), Channel No. 1

802.11ax(HE40), Channel No. 3



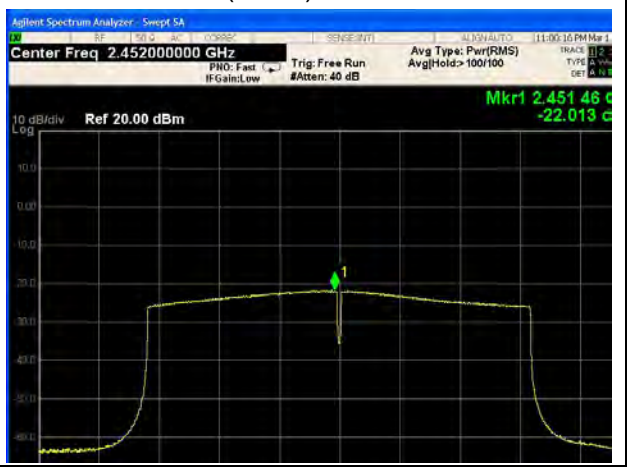

802.11ax(HE20), Channel No. 6

802.11ax(HE40), Channel No. 6




802.11ax(HE20), Channel No. 11

802.11ax(HE40), Channel No. 9





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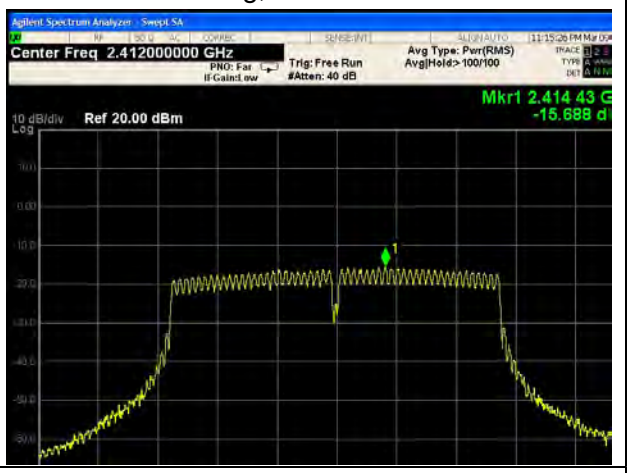
## Antenna 2

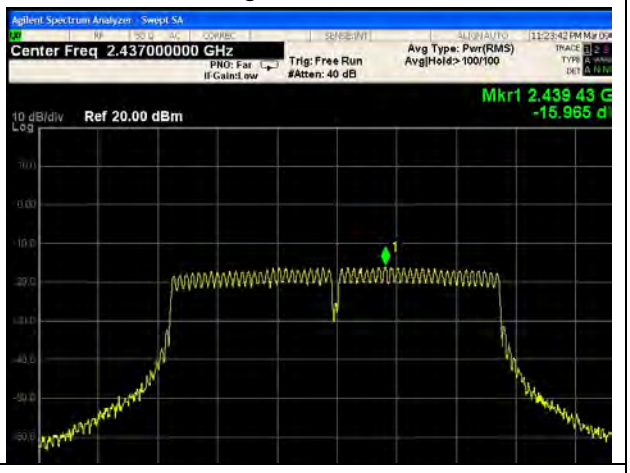
802.11b, Channel No.: 1

802.11g, Channel No.: 1



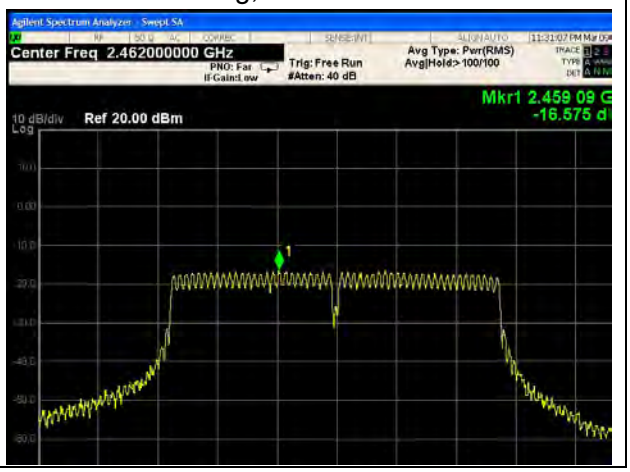

802.11b, Channel No.: 6

802.11g, Channel No.: 6




802.11b, Channel No.: 11

802.11g, Channel No.: 11





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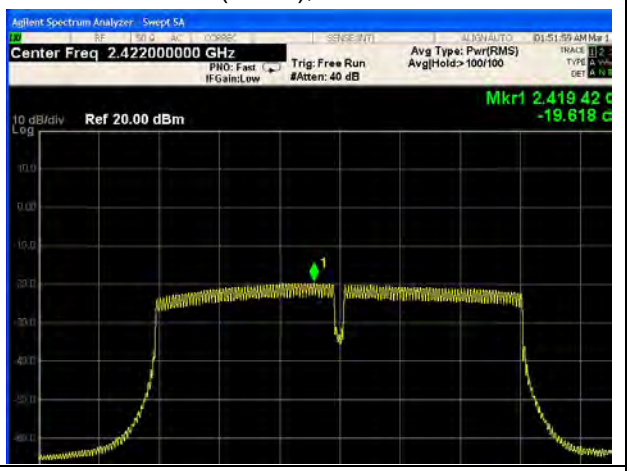
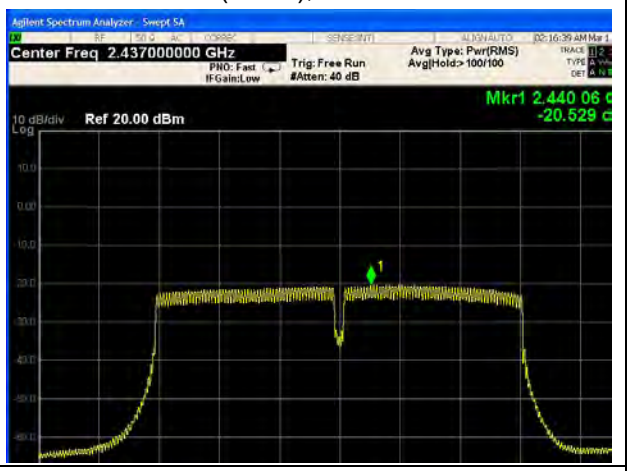
802.11n(HT20), Channel No. 1

802.11n(HT40), Channel No. 3



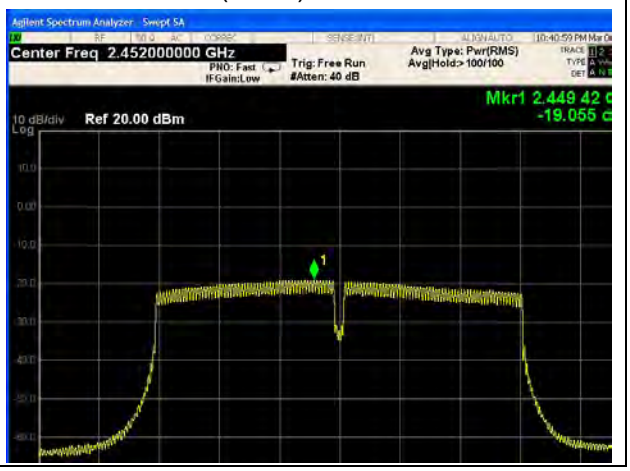

802.11n(HT20), Channel No. 6

802.11n(HT40), Channel No. 6




802.11n(HT20), Channel No. 11

802.11n(HT40), Channel No. 9





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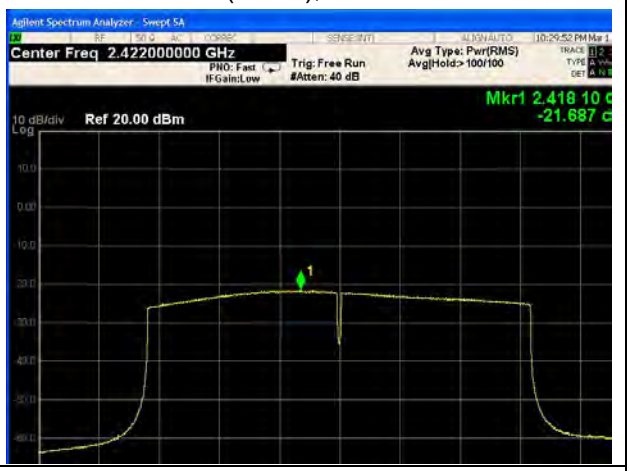
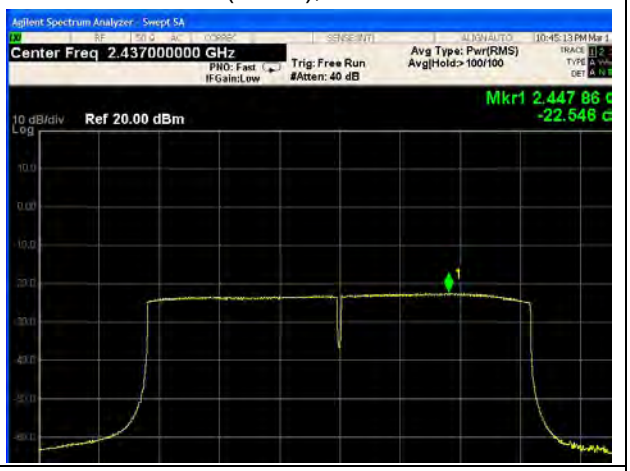
802.11ax(HE20), Channel No. 1

802.11ax(HE40), Channel No. 3



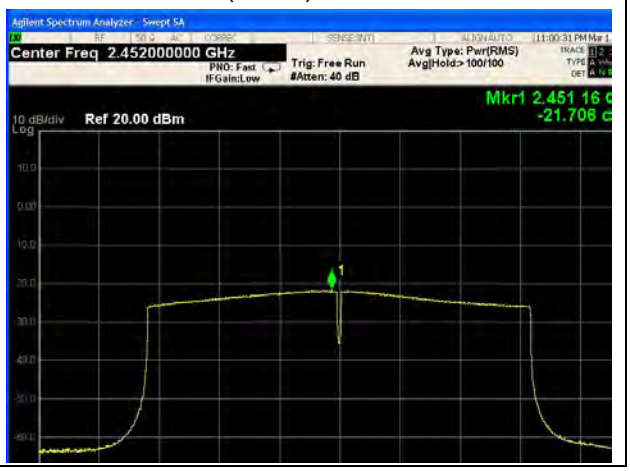

802.11ax(HE20), Channel No. 6

802.11ax(HE40), Channel No. 6




802.11ax(HE20), Channel No. 11

802.11ax(HE40), Channel No. 9





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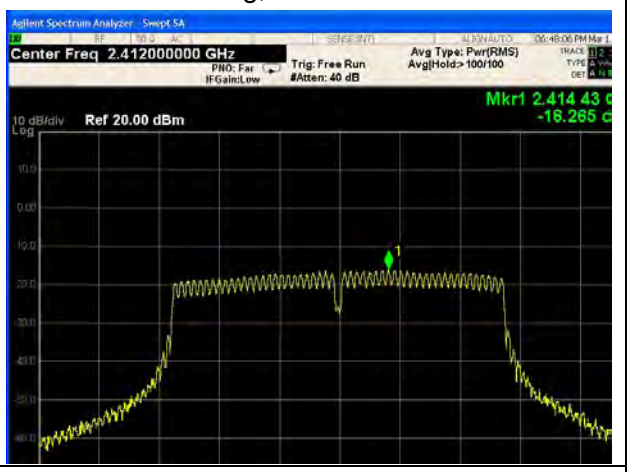
## MIMO With Beamforming

### Antenna 1

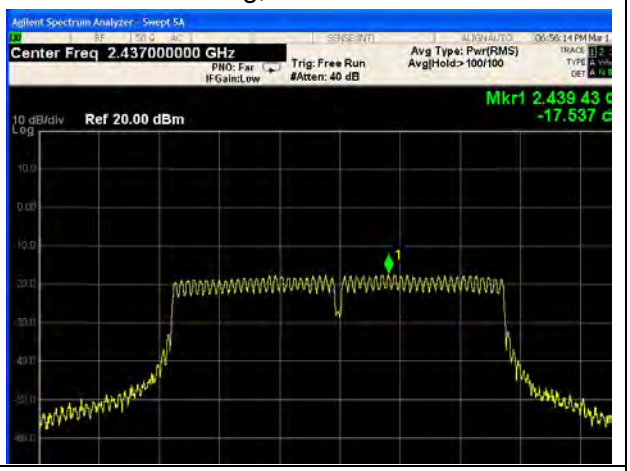
802.11b, Channel No.: 1

802.11g, Channel No.: 1



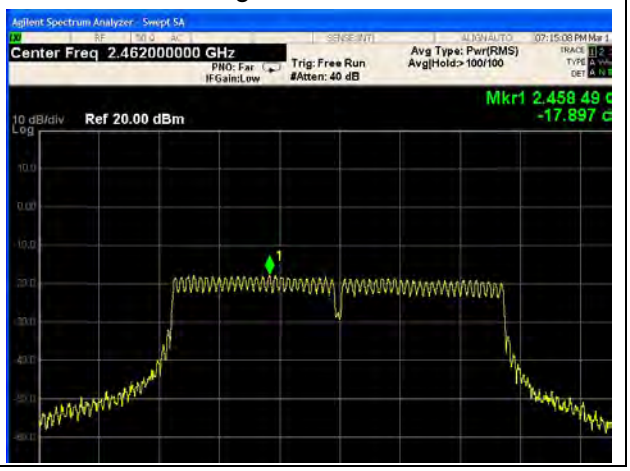

802.11b, Channel No.: 6

802.11g, Channel No.: 6




802.11b, Channel No.: 11

802.11g, Channel No.: 11





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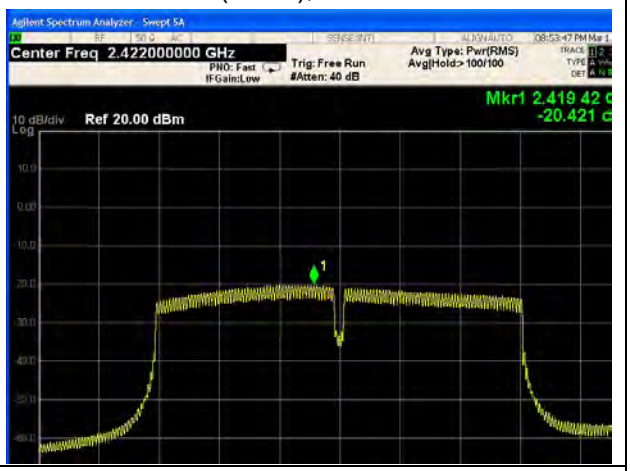
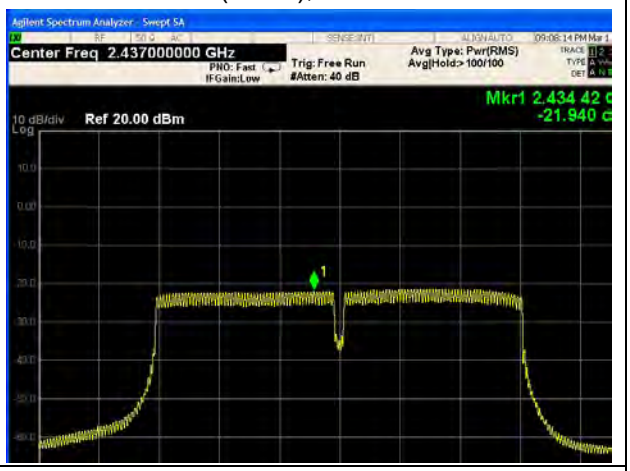
802.11n(HT20), Channel No. 1

802.11n(HT40), Channel No. 3



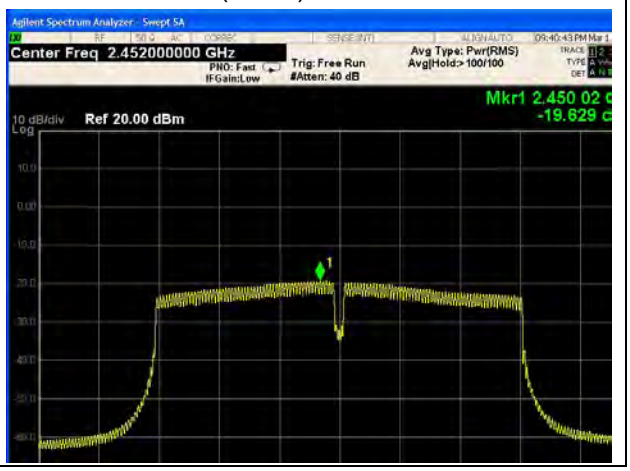

802.11n(HT20), Channel No. 6

802.11n(HT40), Channel No. 6




802.11n(HT20), Channel No. 11

802.11n(HT40), Channel No. 9





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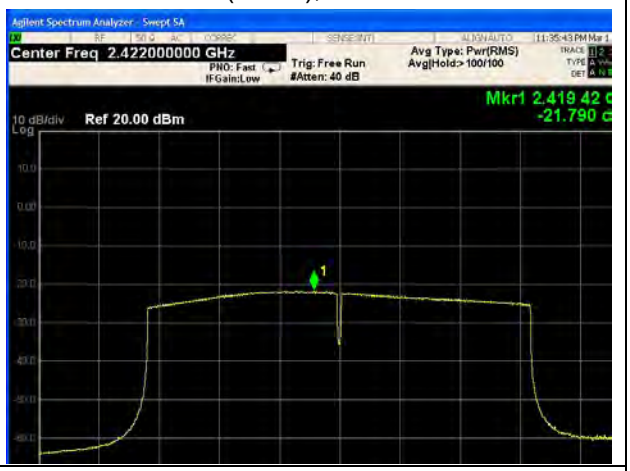
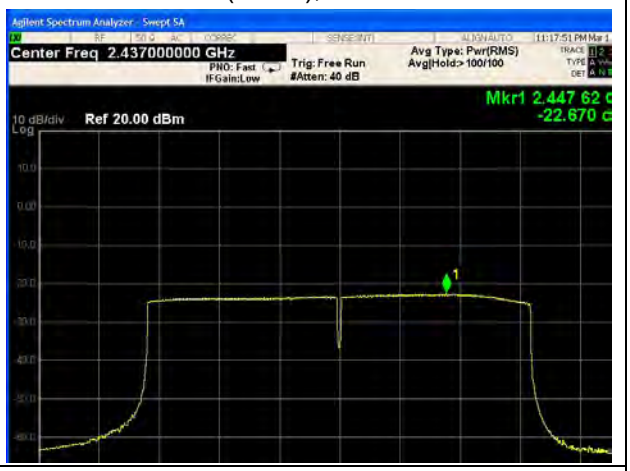
802.11ax(HE20), Channel No. 1

802.11ax(HE40), Channel No. 3



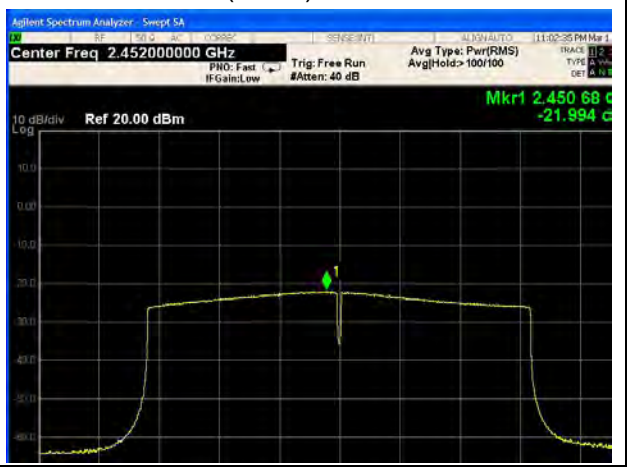

802.11ax(HE20), Channel No. 6

802.11ax(HE40), Channel No. 6




802.11ax(HE20), Channel No. 11

802.11ax(HE40), Channel No. 9





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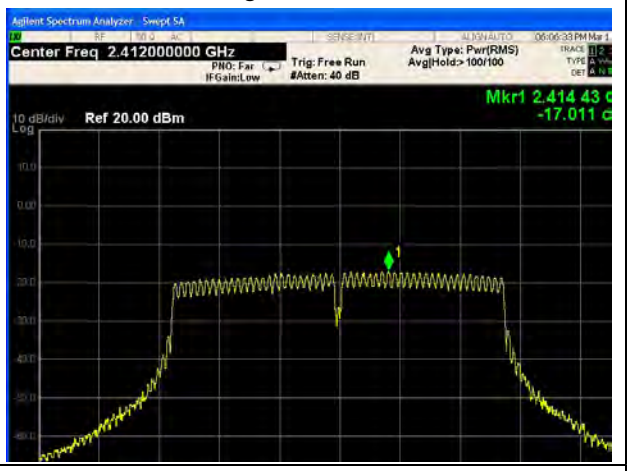
## Antenna 2

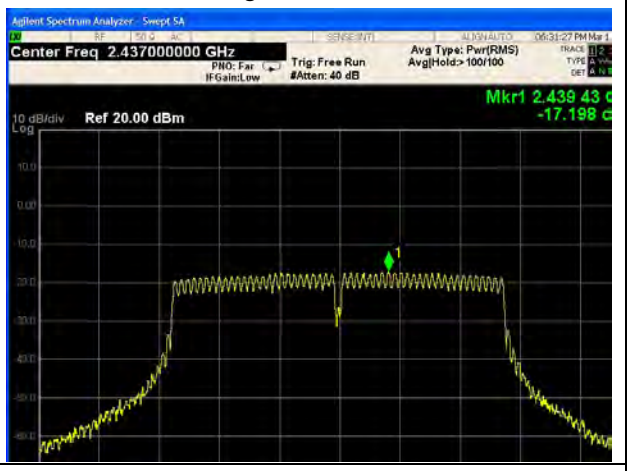
802.11b, Channel No.: 1

802.11g, Channel No.: 1



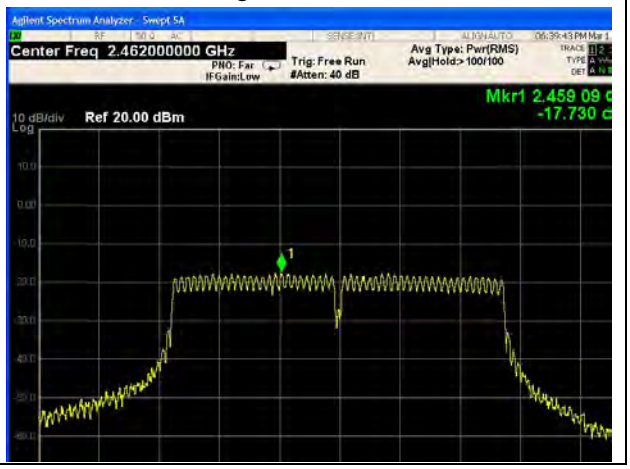

802.11b, Channel No.: 6

802.11g, Channel No.: 6




802.11b, Channel No.: 11

802.11g, Channel No.: 11





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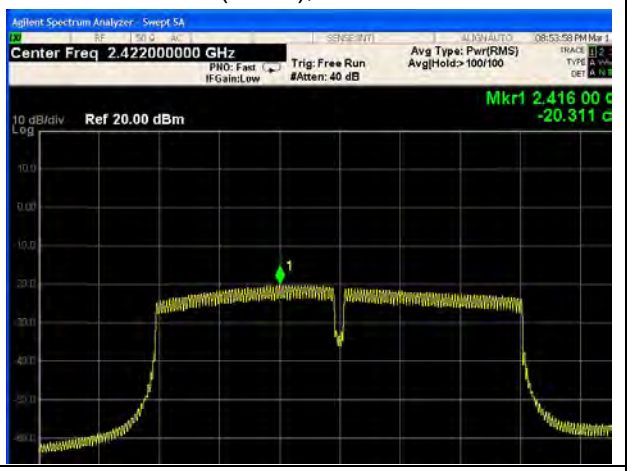
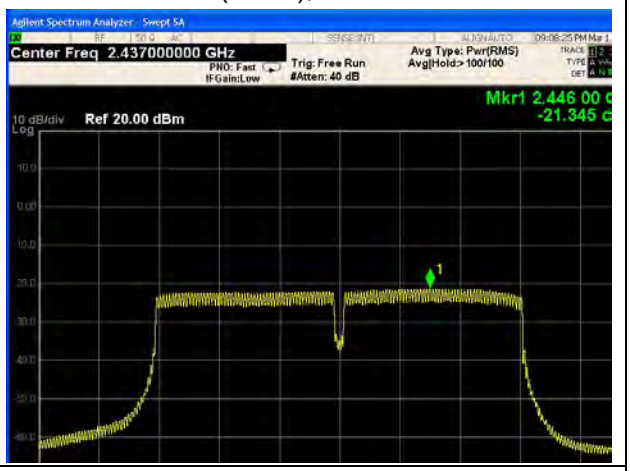
802.11n(HT20), Channel No. 1

802.11n(HT40), Channel No. 3



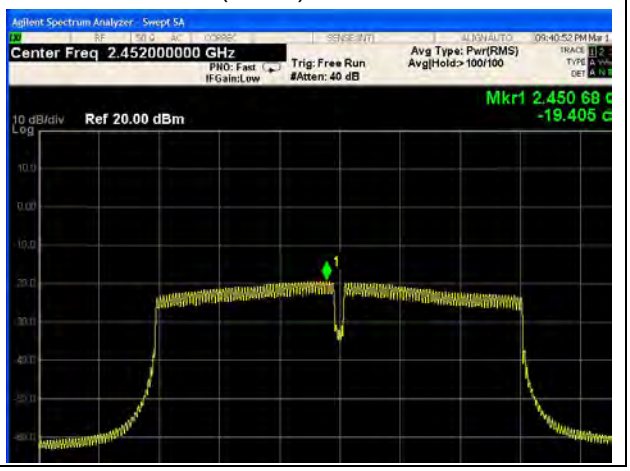

802.11n(HT20), Channel No. 6

802.11n(HT40), Channel No. 6




802.11n(HT20), Channel No. 11

802.11n(HT40), Channel No. 9





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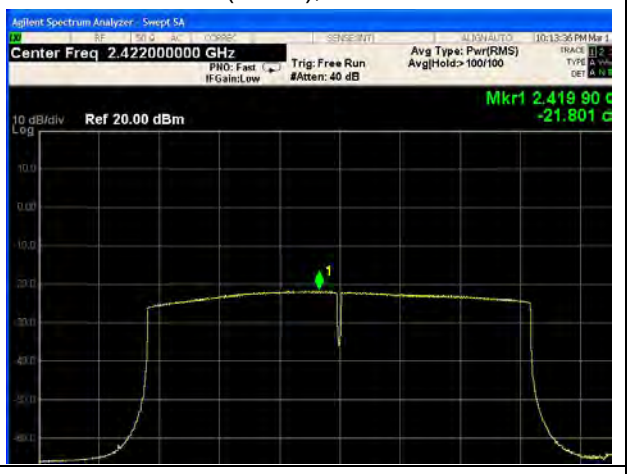
802.11ax(HE20), Channel No. 1

802.11ax(HE40), Channel No. 3

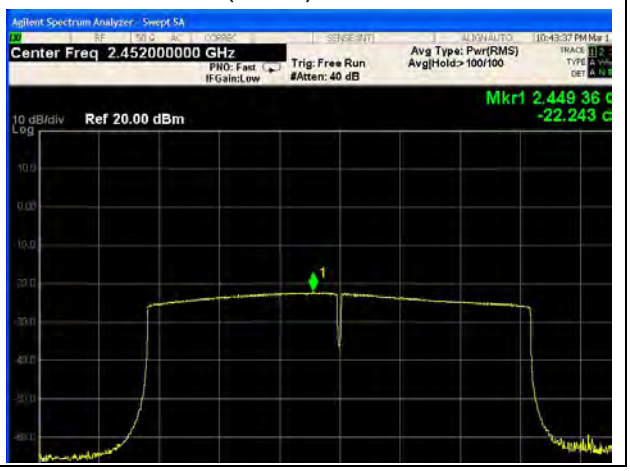



802.11ax(HE20), Channel No. 6

802.11ax(HE40), Channel No. 6

802.11ax(HE20), Channel No. 11

802.11ax(HE40), Channel No. 9





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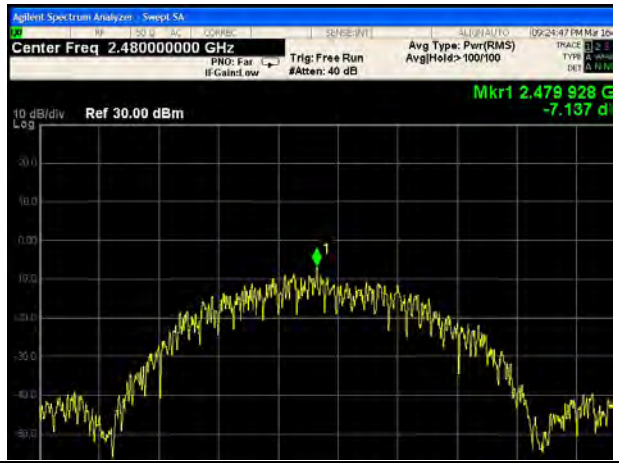
Bluetooth LE (125K), Channel No.: 0

Bluetooth LE (125K), Channel No.: 19

Bluetooth LE (125K), Channel No.: 39





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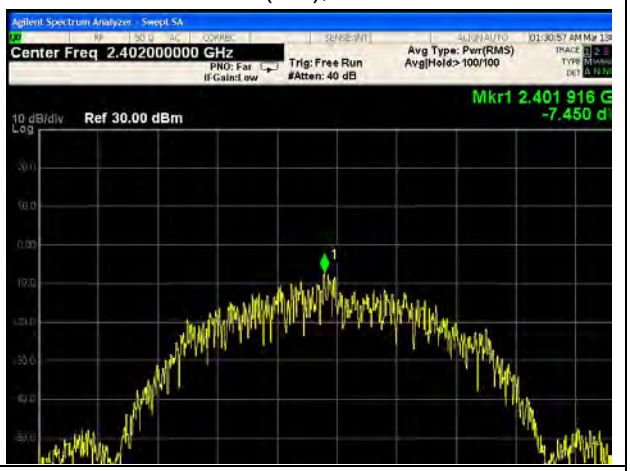
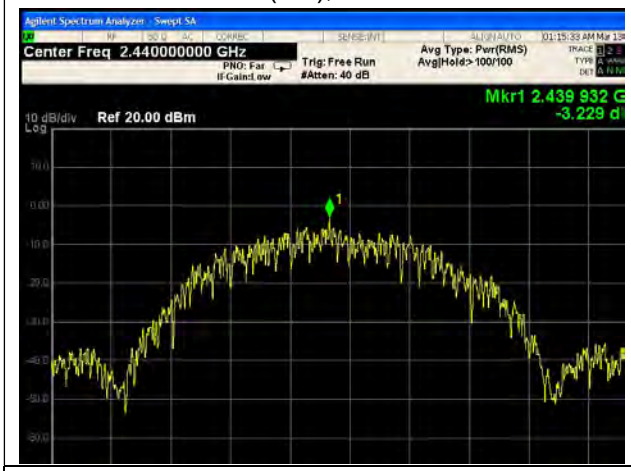
Bluetooth LE (1M), Channel No.: 0

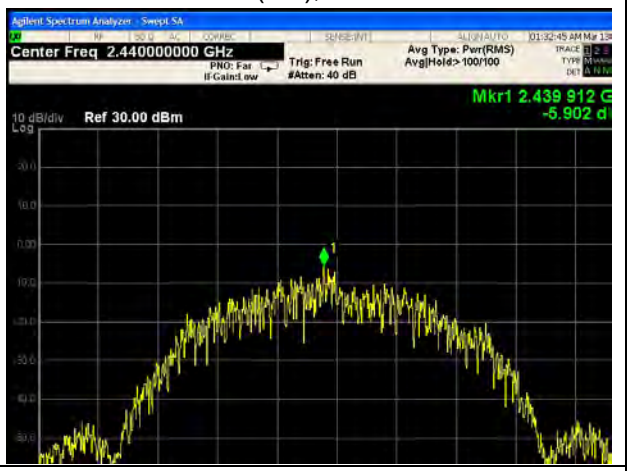
Bluetooth LE (2M), Channel No.: 0




Bluetooth LE (1M), Channel No.: 19

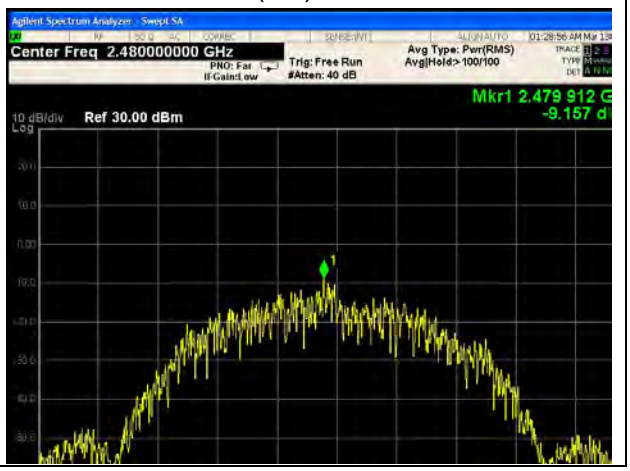



Bluetooth LE (2M), Channel No.: 19




Bluetooth LE (1M), Channel No.: 39

Bluetooth LE (2M), Channel No.: 39





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## 5.5. Spurious RF Conducted Emissions

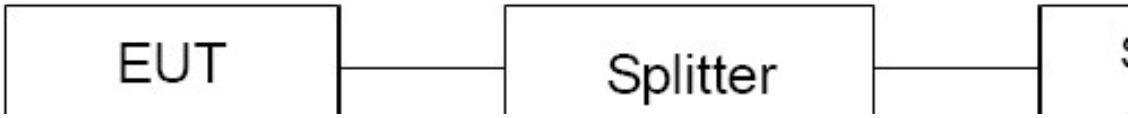
**Ambient condition**

| Temperature | Relative humidity | Pressure |
|---|---|---|
| 23°C ~25°C | 45%~50% | 101.5kPa |

**Method of Measurement**

The EUT was connected to the spectrum analyzer with a known loss. The spectrum analyzer scans from 30MHz to the 10th harmonic of the carrier. The peak detector is used. Set RBW to 100 kHz and VBW to 300 kHz, Sweep is set to ATUO.
The test is in transmitting mode.

**Test setup**




**Limits**

Rule Part 15.247(d) pacifies that "In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. "

| Test Mode | Carrier frequency (MHz) | Reference value (dBm) | Limit |
|---|---|---|---|
| 802.11b | 2412 | 11.91 | -18.09 |
| | 2437 | 10.72 | -19.28 |
| | 2462 | 10.22 | -19.78 |
| 802.11g | 2412 | 8.32 | -21.69 |
| | 2437 | 6.69 | -23.31 |
| | 2462 | 7.11 | -22.89 |
| 802.11n HT20 | 2412 | 7.80 | -22.20 |
| | 2437 | 6.11 | -23.90 |
| | 2462 | 5.23 | -24.78 |
| 802.11n HT40 | 2422 | 5.11 | -24.89 |
| | 2437 | 4.06 | -25.95 |
| | 2452 | 4.08 | -25.92 |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| | | | |
|---|---|---|---|
| 802.11ax HE20 | 2412 | 4.88 | -25.12 |
| | 2437 | 3.82 | -26.18 |
| | 2462 | 5.73 | -24.27 |
| 802.11ax HE40 | 2422 | 4.25 | -25.75 |
| | 2437 | 2.98 | -27.02 |
| | 2452 | 2.17 | -27.83 |
| Bluetooth (Low Energy) (125K) | 2402 | 13.94 | -16.06 |
| | 2440 | 14.95 | -15.05 |
| | 2480 | 11.87 | -18.13 |
| Bluetooth (Low Energy) (1M) | 2402 | 13.97 | -16.03 |
| | 2440 | 14.77 | -15.23 |
| | 2480 | 11.83 | -18.17 |
| Bluetooth (Low Energy) (2M) | 2402 | 14.29 | -15.71 |
| | 2440 | 15.20 | -14.80 |
| | 2480 | 11.85 | -18.16 |

**Measurement Uncertainty**

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor *k* = 1.96.

| Frequency | Uncertainty |
|---|---|
| 100kHz-2GHz | 0.684 dB |
| 2GHz-26GHz | 1.407 dB |


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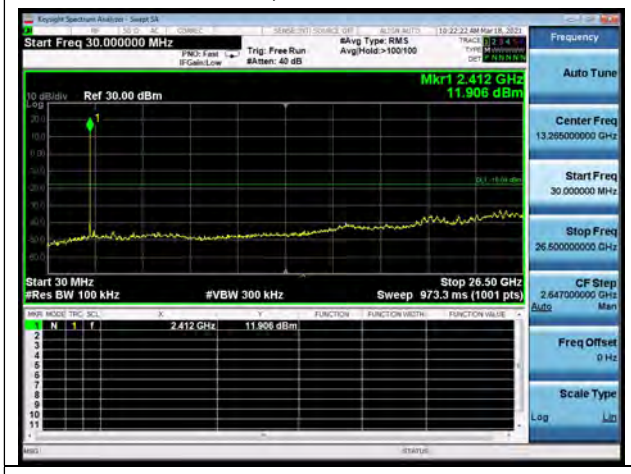
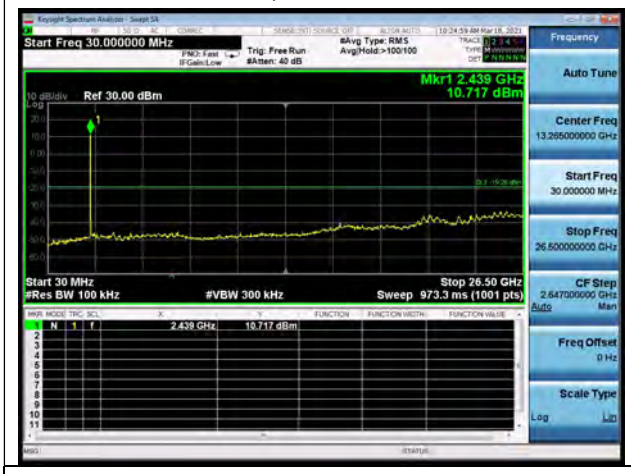
## Test Results:

802.11b, Channel No.: 1



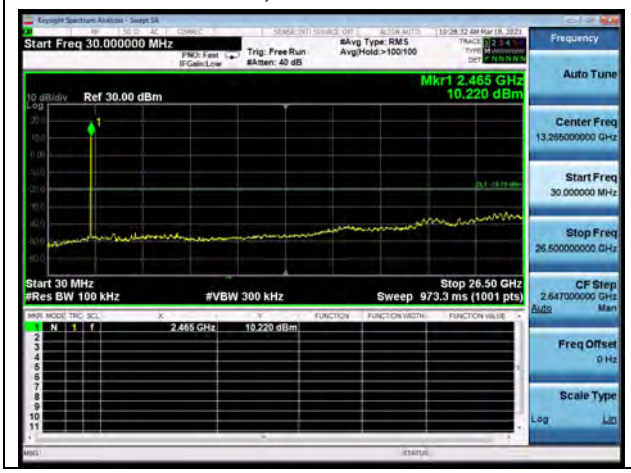

802.11g, Channel No.: 1

802.11b, Channel No.: 6




802.11g, Channel No.: 6

802.11b, Channel No.: 11




802.11g, Channel No.: 11

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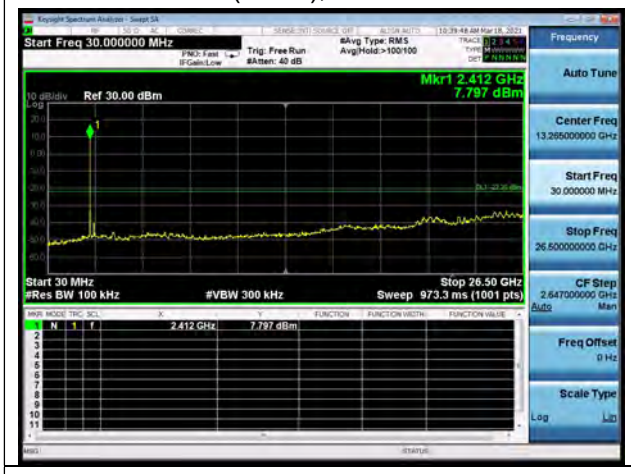
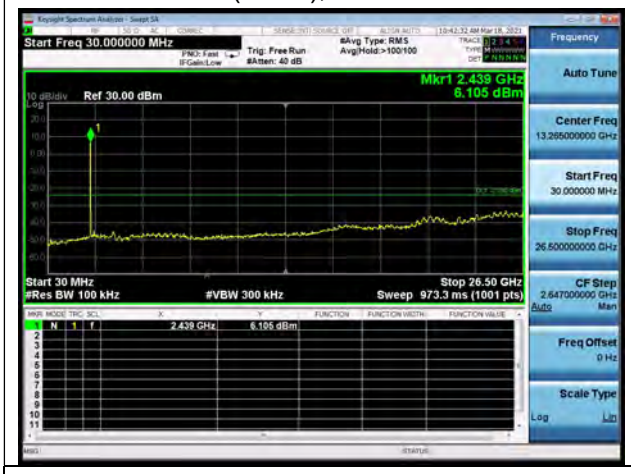
802.11n(HT20), Channel No. 1



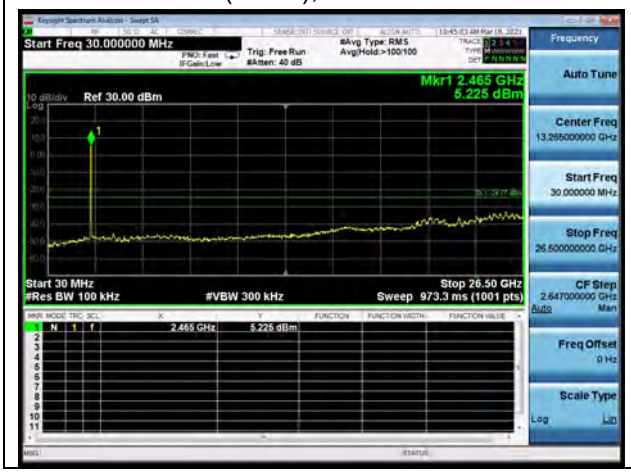

802.11n(HT40), Channel No. 3

802.11n(HT20), Channel No. 6




802.11n(HT40), Channel No. 6

802.11n(HT20), Channel No. 11




802.11n(HT40), Channel No. 9

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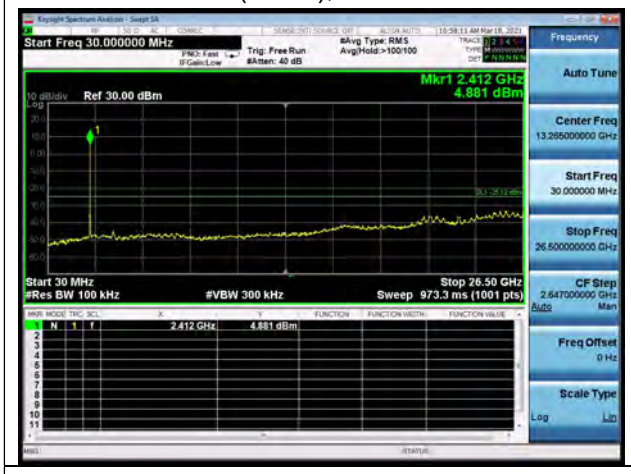
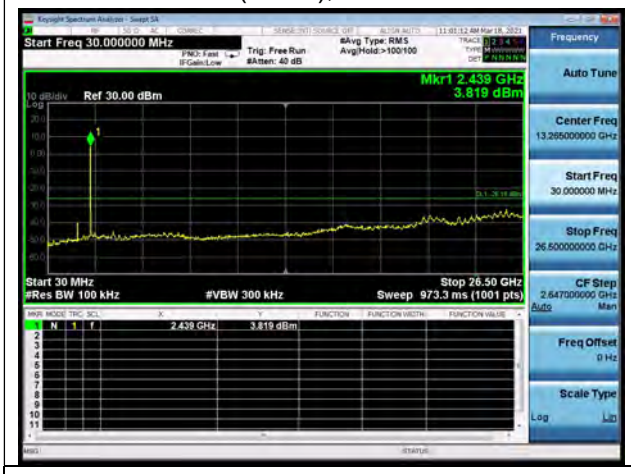
802.11ax(HE20), Channel No. 1



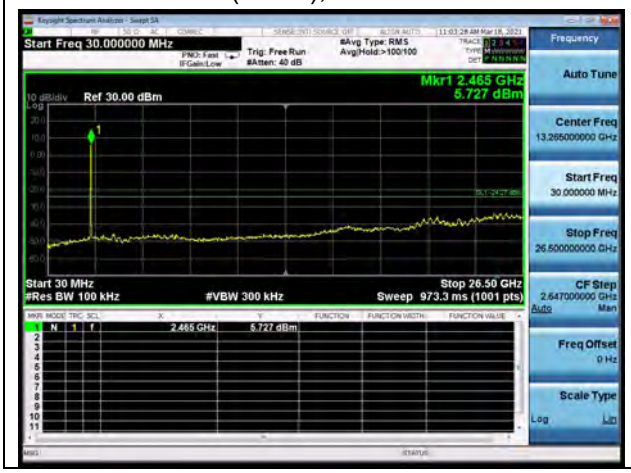

802.11ax(HE40), Channel No. 3

802.11ax(HE20), Channel No. 6




802.11ax(HE40), Channel No. 6

802.11ax(HE20), Channel No. 11




802.11ax(HE40), Channel No. 9

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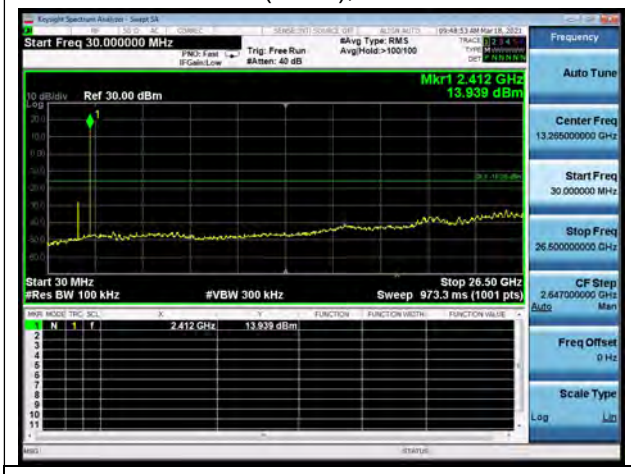
Bluetooth LE (125K), Channel No.: 0




Bluetooth LE (125K), Channel No.: 19

Bluetooth LE (125K), Channel No.: 39

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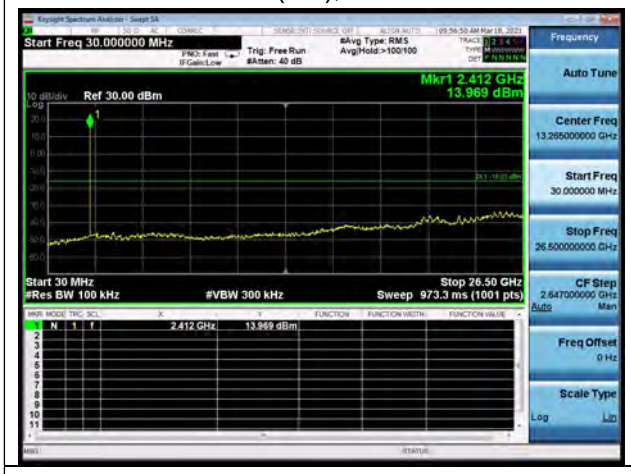
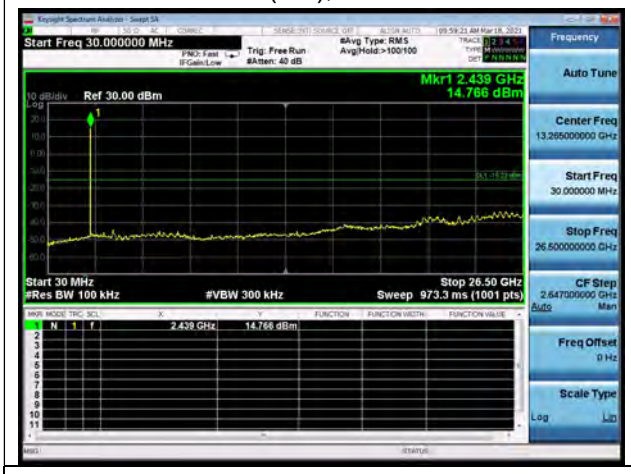
Bluetooth LE (1M), Channel No.: 0



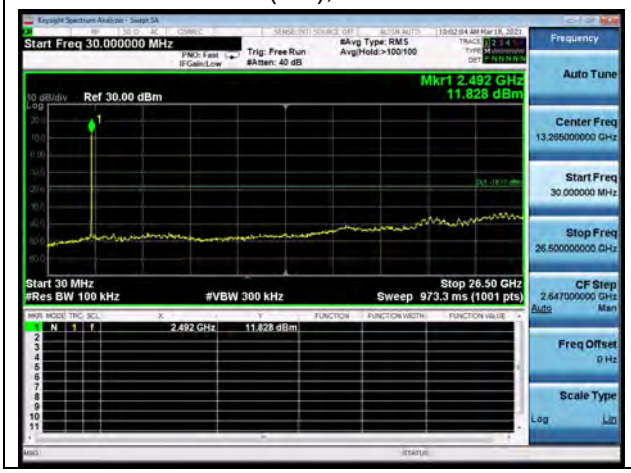

Bluetooth LE (2M), Channel No.: 0

Bluetooth LE (1M), Channel No.: 19




Bluetooth LE (2M), Channel No.: 19

Bluetooth LE (1M), Channel No.: 39




Bluetooth LE (2M), Channel No.: 39

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## 5.6. Unwanted Emission

**Ambient condition**

| Temperature | Relative humidity | Pressure |
|---|---|---|
| 23°C ~25°C | 45%~50% | 102.5kPa |

**Method of Measurement**

The test set-up was made in accordance to the general provisions of ANSI C63.10.
The Equipment Under Test (EUT) was set up on a non-conductive table in the semi-anechoic chamber. The test was performed at the distance of 3 m between the EUT and the receiving antenna.

The turntable shall be rotated from 0 to 360 degrees for detecting the maximum of radiated spurious signal level. The measurements shall be repeated with orthogonal polarization of the test antenna.The data of cable loss and antenna factor has been calibrated in full testing frequency range before the testing. Sweep the Restricted Band and the emissions less than 20 dB below the permissible value are reported.
The radiated emissions measurements were made in a typical installation configuration.
Sweep the whole frequency band through the range from 9 kHz to the 10th harmonic of the carrier, and the emissions less than 20 dB below the permissible value are reported.

This method refer to ANSI C63.10.
The procedure for peak unwanted emissions measurements above 1000 MHz is as follows:
Set the spectrum analyzer in the following:
9kHz~150 kHz
RBW=200Hz, VBW=1kHz/ Sweep=AUTO
150 kHz~30MHz
RBW=9KHz, VBW=30KHz,/ Sweep=AUTO
Below 1GHz
RBW=100kHz / VBW=300kHz / Sweep=AUTO
a) Peak emission levels are measured by setting the instrument as follows:
Above 1GHz
PEAK: RBW=1MHz VBW=3MHz/ Sweep=AUTO
b) Average emission levels are measured by setting the instrument as follows:
Above 1GHz
AVERAGE: RBW=1MHz / VBW=3MHz / Sweep=AUTO
c) Detector: The measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz, 110-490 kHz and above 1000 MHz. Radiated emission limits in these three bands are based on measurements employing an average detector.
d) Averaging type = power (i.e., rms) (As an alternative, the detector and averaging type may be set for linear voltage averaging. Some instruments require linear display mode to use linear voltage


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averaging. Log or dB averaging shall not be used.)

e) Sweep time = auto.

f) Perform a trace average of at least 100 traces if the transmission is continuous. If the transmission is not continuous, then the number of traces shall be increased by a factor of 1 / D, where D is the duty cycle. For example, with 50% duty cycle, at least 200 traces shall be averaged. (If a specific emission is demonstrated to be continuous—i.e., 100% duty cycle—then rather than turning ON and OFF with the transmit cycle, at least 100 traces shall be averaged.)

g) If tests are performed with the EUT transmitting at a duty cycle less than 98%, then a correction factor shall be added to the measurement results prior to comparing with the emission limit, to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as follows:

1) If power averaging (rms) mode was used in the preceding step e), then the correction factor is [10 log (1 / D)], where D is the duty cycle. For example, if the transmit duty cycle was 50%, then 3 dB shall be added to the measured emission levels.

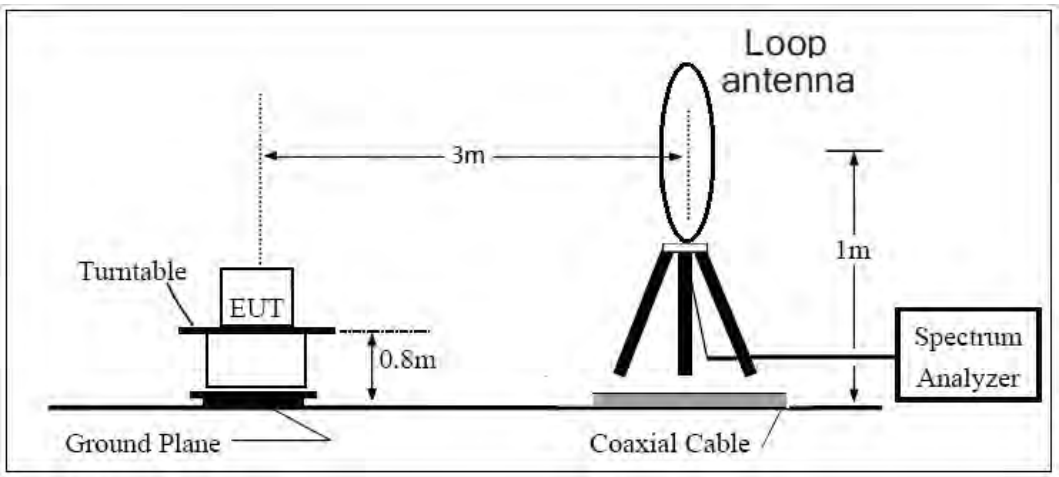
2) If linear voltage averaging mode was used in the preceding step e), then the correction factor is [20 log (1 / D)], where D is the duty cycle. For example, if the transmit duty cycle was 50%, then 6 dB shall be added to the measured emission levels.

3) If a specific emission is demonstrated to be continuous (100% duty cycle) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

The test is in transmitting mode.

**Test setup**

**9KHz ~ 30MHz**





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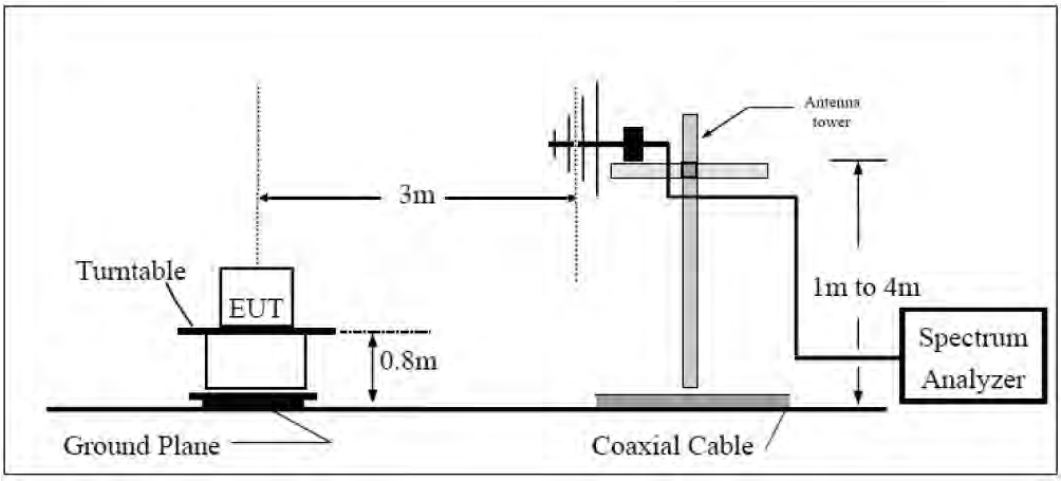
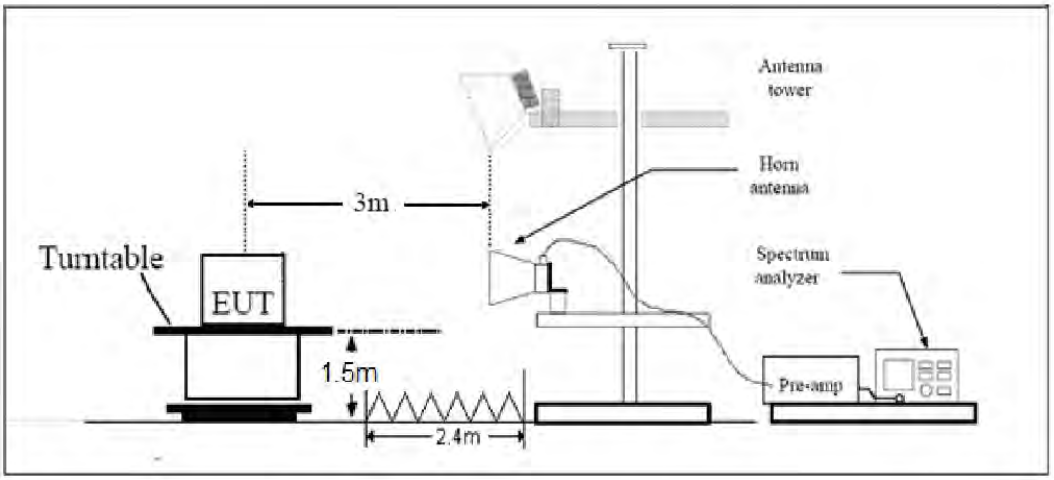
**30MHz ~ 1GHz**




**Above 1GHz**




Note: Area side:2.4mX3.6m

**Limits**

Rule Part 15.247(d) specifies that "In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c))."

Limit in restricted band

| Frequency of emission (MHz) | Field strength(uV/m) | Field strength(dBuV/m) |
|---|---|---|
| 0.009–0.490 | 2400/F(kHz) | / |
| 0.490–1.705 | 24000/F(kHz) | / |
| 1.705–30.0 | 30 | / |
| 30-88 | 100 | 40 |
| 88-216 | 150 | 43.5 |
| 216-960 | 200 | 46 |
| Above960 | 500 | 54 |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§15.35(b)

There is also a limit on the radio frequency emissions, as measured using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit.

Peak Limit=74 dBuV/m

Average Limit=54 dBuV/m

Spurious Radiated Emissions are permitted in any of the frequency bands listed below:

| MHz | MHz | MHz | GHz |
|---|---|---|---|
| 0.090 - 0.110 | 16.42 - 16.423 | 399.9 - 410 | 4.5 - 5.15 |
| [1]0.495 - 0.505 | 16.69475 - 16.69525 | 608 - 614 | 5.35 - 5.46 |
| 2.1735 - 2.1905 | 16.80425 - 16.80475 | 960 - 1240 | 7.25 - 7.75 |
| 4.125 - 4.128 | 25.5 - 25.67 | 1300 - 1427 | 8.025 - 8.5 |
| 4.17725 - 4.17775 | 37.5 - 38.25 | 1435 - 1626.5 | 9.0 - 9.2 |
| 4.20725 - 4.20775 | 73 - 74.6 | 1645.5 - 1646.5 | 9.3 - 9.5 |
| 6.215 - 6.218 | 74.8 - 75.2 | 1660 - 1710 | 10.6 - 12.7 |
| 6.26775 - 6.26825 | 108 - 121.94 | 1718.8 - 1722.2 | 13.25 - 13.4 |
| 6.31175 - 6.31225 | 123 - 138 | 2200 - 2300 | 14.47 - 14.5 |
| 8.291 - 8.294 | 149.9 - 150.05 | 2310 - 2390 | 15.35 - 16.2 |
| 8.362 - 8.366 | 156.52475 - 156.52525 | 2483.5 - 2500 | 17.7 - 21.4 |
| 8.37625 - 8.38675 | 156.7 - 156.9 | 2690 - 2900 | 22.01 - 23.12 |
| 8.41425 - 8.41475 | 162.0125 - 167.17 | 3260 - 3267 | 23.6 - 24.0 |
| 12.29 - 12.293 | 167.72 - 173.2 | 3332 - 3339 | 31.2 - 31.8 |
| 12.51975 - 12.52025 | 240 - 285 | 3345.8 - 3358 | 36.43 - 36.5 |
| 12.57675 - 12.57725 | 322 - 335.4 | 3600 - 4400 | ([2]) |
| 13.36 - 13.41 | | | |

**Measurement Uncertainty**

The assessed measurement uncertainty to ensure 95% confidence level for the normal distribution is with the coverage factor *k* = 1.96.

| Frequency | Uncertainty |
|---|---|
| 9KHz-30MHz | 3.55 dB |
| 30MHz-200MHz | 4.17 dB |
| 200MHz-1GHz | 4.84 dB |
| 1-18GHz | 4.35 dB |
| 18-26.5GHz | 5.90 dB |
| 26.5GHz~40GHz | 5.92 dB |


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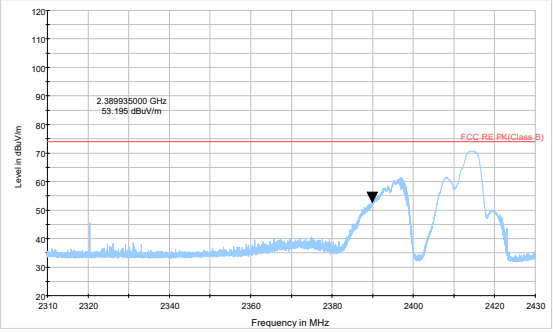
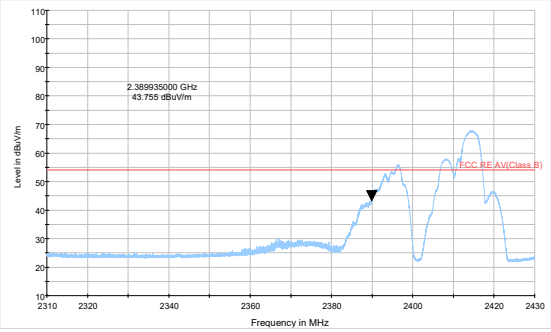
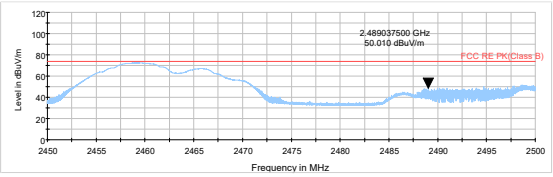
## Test Results:



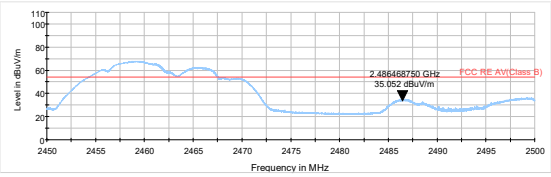

802.11b-Channel 1 Peak



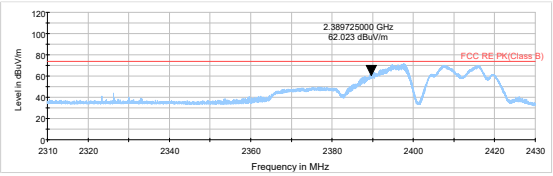

802.11b-Channel 1 Average



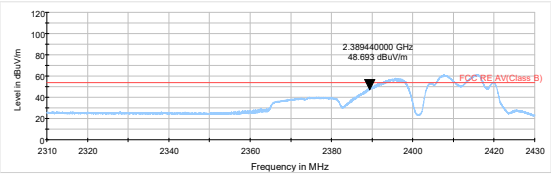

802.11b-Channel 11 Peak



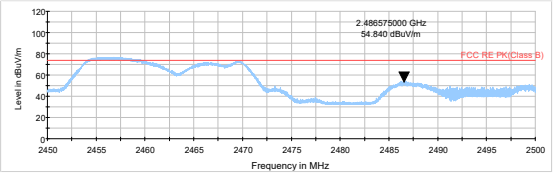

802.11b-Channel 11Average



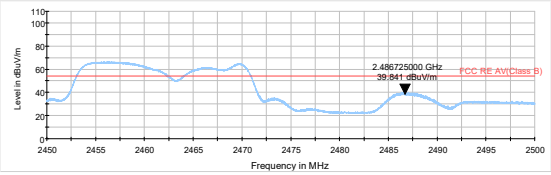

802.11g-Channel 1 Peak



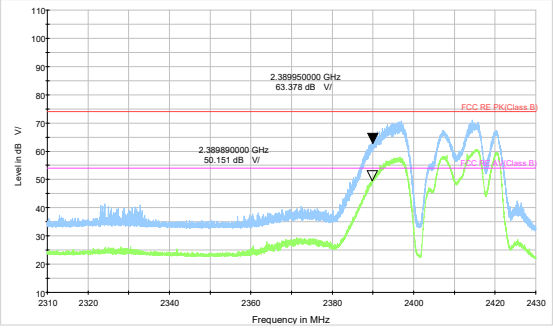

802.11g-Channel 1 Average




802.11g-Channel 11 Peak




802.11g-Channel 11 Average




802.11n HT20 -Channel 1 Peak+ Average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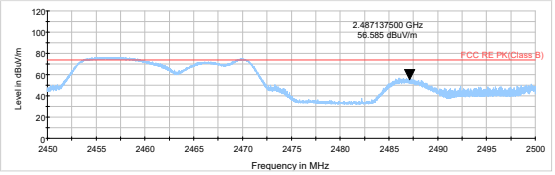
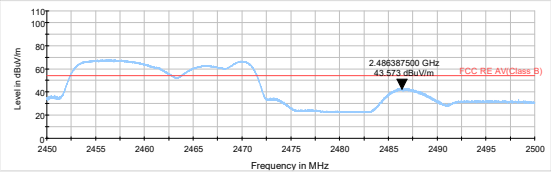
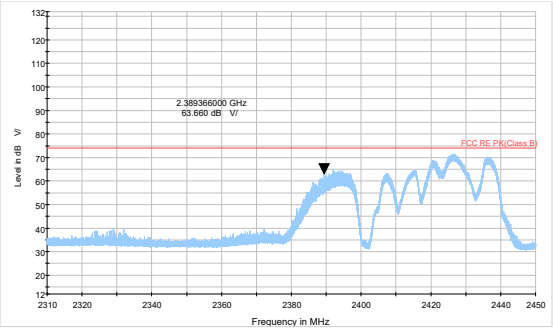


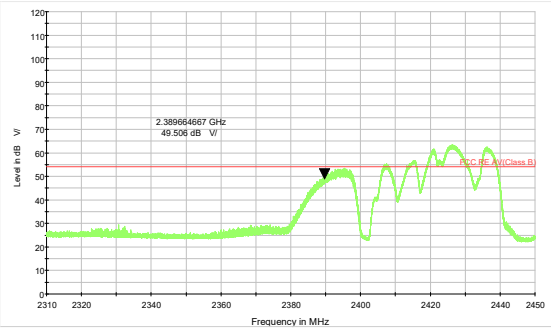

802.11n HT20 -Channel 11 Peak



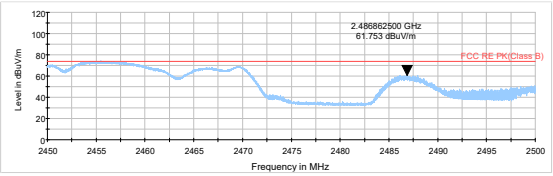

802.11n HT20 -Channel 11 Average



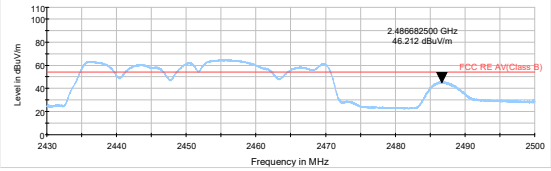

802.11n HT40 –Channel 3 Peak




802.11n HT40 -Channel 3 Average

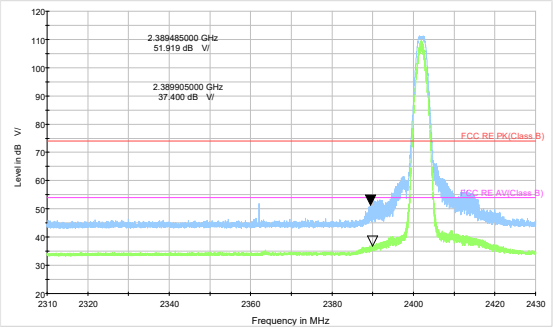



802.11n HT40 -Channel 9 Peak

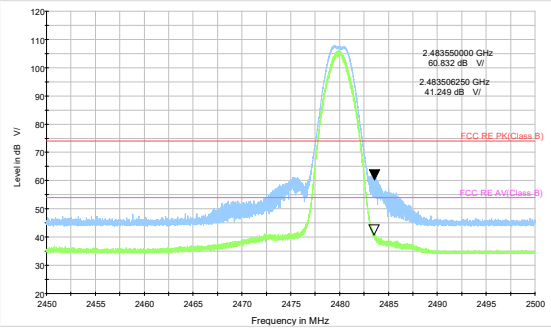



802.11n HT40 -Channel 9 Average

During the test, the preliminary test was performed in both data rate for BLE, 2Mbps was selected as the worst case. The test data of the worst-case condition was recorded in this report




Bluetooth LE (2M) Channel 0 Peak & Average




Bluetooth LE (2M) Channel 39 Peak & Average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**Result of RE**

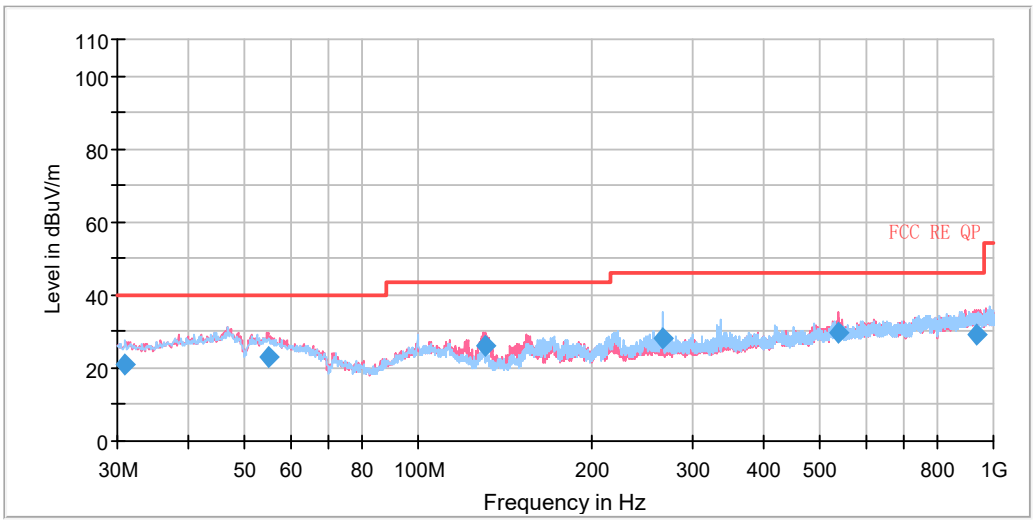
**Test result**

Sweep the whole frequency band through the range from 9kHz to the 10th harmonic of the carrier, the Emissions in the frequency band 9kHz-30MHz are more than 20dB below the limit are not reported.

The following graphs display the maximum values of horizontal and vertical by software.
For above 1GHz, Blue trace uses the peak detection, Green trace uses the average detection.
**After the pretest, MIMO was selected as the worst antenna.**

During the test, the Radiates Emission from 30MHz to 1GHz was performed in all modes with all channels, 802.11ax (HE20) CH6 are selected as the worst condition. The test data of the worst-case condition was recorded in this report.
A font ( Level in dBµV/ )in the test plot =(level in dB µ V/m)

**Continuous TX mode:**




Radiates Emission from 30MHz to 1GHz

| Frequency (MHz) | Quasi-Peak (dBuV/m) | Height (cm) | Polarization | Azimuth (deg) | Correct Factor (dB) | Margin (dB) | Limit (dBuV/m) |
|---|---|---|---|---|---|---|---|
| 30.963750 | 20.76 | 125.0 | H | 123.0 | -0.9 | 19.24 | 40.00 |
| 54.856250 | 22.85 | 225.0 | V | 128.0 | -1.8 | 17.15 | 40.00 |
| 130.390000 | 25.87 | 100.0 | V | 198.0 | -9.0 | 17.63 | 43.50 |
| 266.068750 | 28.05 | 100.0 | H | 234.0 | -5.1 | 17.95 | 46.00 |
| 536.096250 | 29.68 | 100.0 | V | 194.0 | 0.3 | 16.32 | 46.00 |
| 931.780000 | 29.01 | 225.0 | V | 1.0 | 5.1 | 16.99 | 46.00 |

**Remark: 1. Correction Factor = Antenna factor+ Insertion loss(cable loss+amplifier gain)**
**2. Margin = Limit – Quasi-Peak**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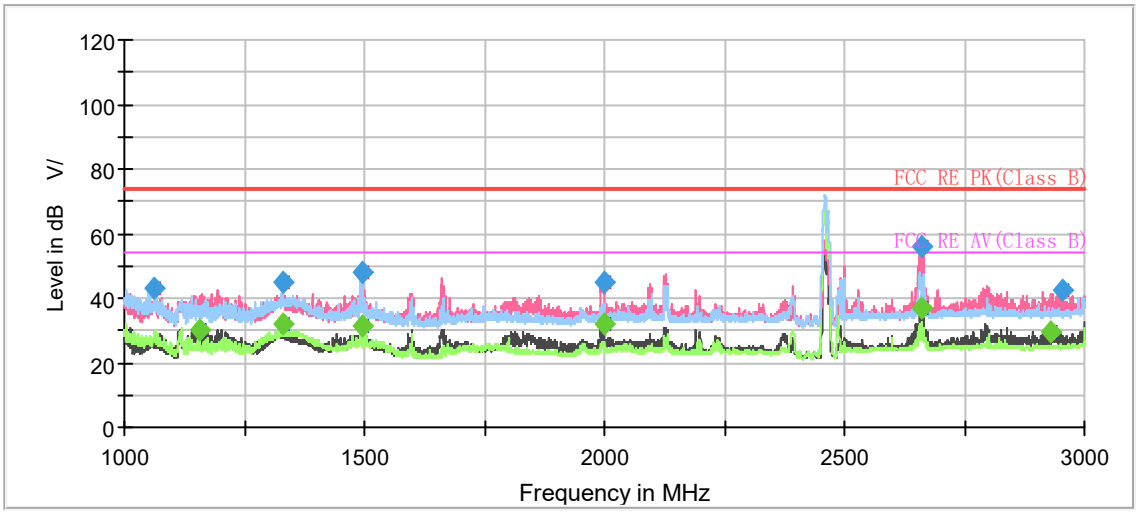
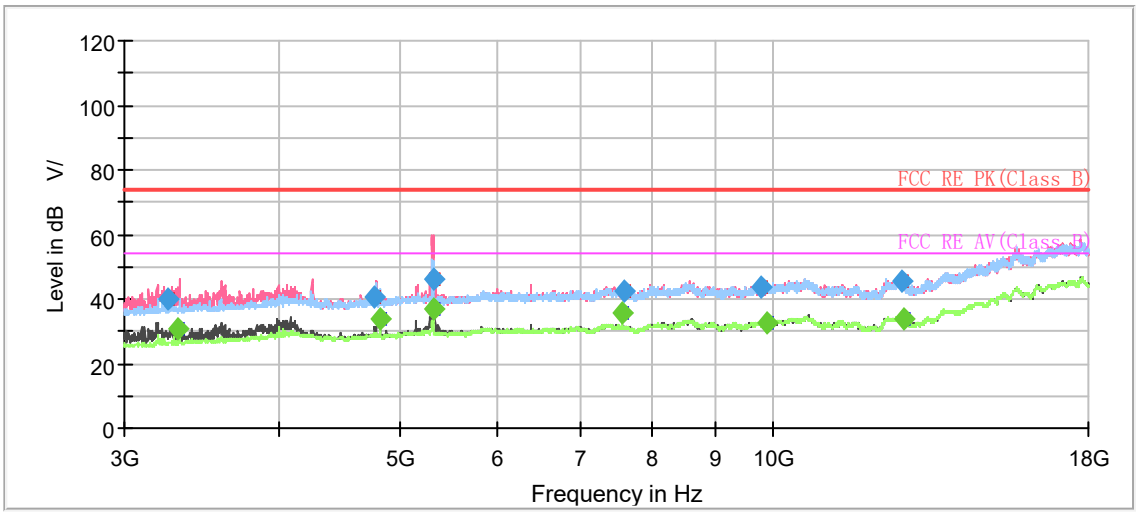
**802.11b CH1**




Note: The signal beyond the limit is carrier.

Radiates Emission from 1GHz to 3GHz




Radiates Emission from 3GHz to 18GHz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