# FCC TEST REPORT

**Test report**
**On Behalf of**
**KINGRAY ELECTRONICS Co., LTD**
**For**
**Wireless headphones**
**Model No.: BB991,FD4108**
**FCC ID: 2AML6BB991**

| | |
|---|---|
| **Prepared for :** | **KINGRAY ELECTRONICS Co., LTD**<br>3F, Building 13th, Xingwei the third Industrial Park, Fenghuang Village, Fuyong town, Baoan District, Shenzhen, Guangdong, China |
| **Prepared By :** | **Shenzhen HUAK Testing Technology Co., Ltd.**<br>**1F, B2 Building, Junfeng Zhongcheng Zhizao Innovation Park, Fuhai Street, Bao'an District, Shenzhen City, China** |

# TEST REPORT

| | |
|---|---|
| **Applicant's name**.....: | **KINGRAY ELECTRONICS Co., LTD** |
| Address.....: | 3F, Building 13th, Xingwei the third Industrial Park, Fenghuang Village, Fuyong town, Baoan District, Shenzhen, Guangdong, China |
| **Manufacture's Name** .....: | **KINGRAY ELECTRONICS Co., LTD** |
| Address.....: | 3F, Building 13th, Xingwei the third Industrial Park, Fenghuang Village, Fuyong town, Baoan District, Shenzhen, Guangdong, China |

**Product description**

| | |
|---|---|
| Trade Mark: | billboard |
| Product name.....: | Wireless headphones |
| Model and/or type reference ..: | BB991,FD4108 |
| **Standards**.....: | FCC Rules and Regulations Part 15 Subpart C Section 15.247<br>ANSI C63.10: 2013 |



| | |
|---|---|
| **Date of Test**..... : | |
| Date (s) of performance of tests ..... : | Dec. 25, 2019 ~. Jan.08, 2020 |
| Date of Issue..... : | Jan.09, 2020 |
| Test Result..... : | **Pass** |

Testing Engineer : 

(Gary Qian)

Technical Manager : 

(Eden Hu)

Authorized Signatory : 

(Jason Zhou)

# Contents

# 1. TEST STANDARDS

The tests were performed according to following standards:

FCC Rules Part 15.247: Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.
ANSI C63.10-2013: American National Standard for Testing Unlicensed Wireless Devices
DA 00-705: Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems

# 2. SUMMARY

## 2.1. Product Description

| | |
|---|---|
| Name of EUT | Wireless headphones |
| Trade Mark: | billboard |
| Model Number | BB991 |
| List Model: | FD4108 |
| Power Rating | DC 3.7V and DC 5V From Adapter |
| Adapter(Auxiliary test Provided by the laborator) | Mode:EP-TA20CBC<br>Input:AC100-240V-50/60Hz，0.5A<br>Output:DC 5V,2A |
| FCC ID | 2AML6BB991 |
| Bluetooth FCC Operation frequency | 2402MHz-2480MHz |
| Bluetooth Modulation | GFSK,π/4DQPSK |
| Antenna Type | Chip antenna |
| Antenna gain | -0.68dBi |

## 2.2. Equipment Under Test

**Power supply system utilised**

| | | | | | |
|---|---|---|---|---|---|
| Power supply voltage | : | ○ | 230V / 50 Hz | ○ | 120V / 60Hz |
| | | ○ | 12 V DC | ○ | 24 V DC |
| | | ● | Other (specified in blank below) | | |

DC 3.7V and DC 5V From Adapter

## 2.3. Short description of the Equipment under Test (EUT)

This is a Wireless headphones.

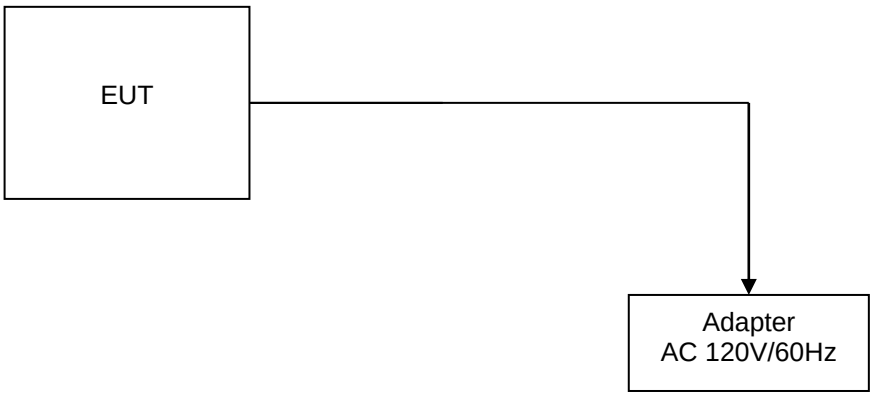
For more details, refer to the user's manual of the EUT.

## 2.4. EUT operation mode

The Applicant provides test software (AT directive ) to control the EUT for staying in continuous transmitting and receiving mode for testing .There are 79 channels provided to the EUT. Channel 00/39/78 was selected to test.

| Channel | Frequency(MHz) | Channel | Frequency(MHz) |
|---|---|---|---|
| **00** | **2402** | 40 | 2442 |
| 01 | 2403 | 41 | 2443 |
| 02 | 2404 | 42 | 2444 |
| 03 | 2405 | 43 | 2445 |
| 04 | 2406 | 44 | 2446 |
| 05 | 2407 | 45 | 2447 |
| 06 | 2408 | 46 | 2448 |
| 07 | 2409 | 47 | 2449 |
| 08 | 2410 | 48 | 2450 |
| 09 | 2411 | 49 | 2451 |
| 10 | 2412 | 50 | 2452 |
| 11 | 2413 | 51 | 2453 |
| 12 | 2414 | 52 | 2454 |
| 13 | 2415 | 53 | 2455 |
| 14 | 2416 | 54 | 2456 |
| 15 | 2417 | 55 | 2457 |
| 16 | 2418 | 56 | 2458 |
| 17 | 2419 | 57 | 2459 |
| 18 | 2420 | 58 | 2460 |
| 19 | 2421 | 59 | 2461 |
| 20 | 2422 | 60 | 2462 |
| 21 | 2423 | 61 | 2463 |
| 22 | 2424 | 62 | 2464 |
| 23 | 2425 | 63 | 2465 |
| 24 | 2426 | 64 | 2466 |
| 25 | 2427 | 65 | 2467 |
| 26 | 2428 | 66 | 2468 |
| 27 | 2429 | 67 | 2469 |
| 28 | 2430 | 68 | 2470 |
| 29 | 2431 | 69 | 2471 |
| 30 | 2432 | 70 | 2472 |
| 31 | 2433 | 71 | 2473 |
| 32 | 2434 | 72 | 2474 |
| 33 | 2435 | 73 | 2475 |
| 34 | 2436 | 74 | 2476 |
| 35 | 2437 | 75 | 2477 |
| 36 | 2438 | 76 | 2478 |
| 37 | 2439 | 77 | 2479 |
| 38 | 2440 | **78** | **2480** |
| **39** | **2441** | | |

## 2.5. Block Diagram of Test Setup




## 2.6. Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended for FCC ID: 2AML6BB991 filing to comply with Section 15.247 of the FCC Part 15, Subpart C Rules.

## 2.7. Modifications

No modifications were implemented to meet testing criteria.

# 3. TEST ENVIRONMENT

## 3.1. TEST FACILITY

Test Firm : Shenzhen HUAK Testing Technology Co., Ltd.

Address 1F, B2 Building, Junfeng Zhongcheng Zhizao Innovation Park, Fuhai Street, Bao'an District, Shenzhen City, China

## 3.2. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

| | |
|---|---|
| Temperature: | 15-35 ° C |
| | |
| Humidity: | 30-60 % |
| | |
| Atmospheric pressure: | 950-1050mbar |

## 3.3. Summary of measurement results

| Test Specification clause | Test case | Test Mode | Test Channel | Recorded In Report | | Pass | Fail | NA | NP | Remark |
|---|---|---|---|---|---|---|---|---|---|---|
| §15.247(a)(1) | Carrier Frequency separation | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK<br>Π/4DQPSK | ☒ Middle | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(a)(1) | Number of Hopping channels | GFSK<br>Π/4DQPSK | ☒ Full | GFSK | ☒ Full | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(a)(1) | Time of Occupancy (dwell time) | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK<br>Π/4DQPSK | ☒ Middle | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(a)(1) | Spectrum bandwidth of a FHSS system 20dB bandwidth | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(b)(1) | Maximum output power | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(d) | Band edge compliance conducted | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Highest | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Highest | ☒ | ☐ | ☐ | ☐ | complies |
| §15.205 | Band edge compliance radiated | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Highest | GFSK | ☒ Lowest<br>☒ Highest | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(d) | TX spurious emissions conducted | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | ☒ | ☐ | ☐ | ☐ | complies |
| §15.247(d) | TX spurious emissions radiated | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | ☒ | ☐ | ☐ | ☐ | complies |
| §15.209(a) | TX spurious Emissions radiated Below 1GHz | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK | ☒ Middle | ☒ | ☐ | ☐ | ☐ | complies |
| §15.107(a)<br>§15.207 | Conducted Emissions 9KHz-30 MHz | GFSK<br>Π/4DQPSK | ☒ Lowest<br>☒ Middle<br>☒ Highest | GFSK | ☒ Middle | ☒ | ☐ | ☐ | ☐ | complies |

Remark:
1. The measurement uncertainty is not included in the test result.
2. NA = Not Applicable; NP = Not Performed
3. We tested all test mode and recorded worst case in report

## 3.4. Statement of the measurement uncertainty

Measurement Uncertainty

| | | |
|---|---|---|
| Conducted Emission Expanded Uncertainty | = | 2.23dB, k=2 |
| Radiated emission expanded uncertainty(9kHz-30MHz) | = | 3.08dB, k=2 |
| Radiated emission expanded uncertainty(30MHz-1000MHz) | = | 4.42dB, k=2 |
| Radiated emission expanded uncertainty(Above 1GHz) | = | 4.06dB, k=2 |

## 3.5. Equipments Used during the Test

| Item | Equipment | Manufacturer | Model No. | Serial No. | Last Cal. | Cal. Interval |
|---|---|---|---|---|---|---|
| 1. | L.I.S.N. Artificial Mains Network | R&S | ENV216 | HKE-002 | Dec. 28, 2018 | 1 Year |
| 2. | L.I.S.N. | R&S | ENV216 | HKE-059 | Dec. 28, 2018 | 1 Year |
| 3. | Receiver | R&S | ESCI 7 | HKE-010 | Dec. 28, 2018 | 1 Year |
| 4. | RF automatic control unit | Tonscend | JS0806-2 | HKE-060 | Dec. 28, 2018 | 1 Year |
| 5. | Spectrum analyzer | R&S | FSP40 | HKE-025 | Dec. 28, 2018 | 1 Year |
| 6. | Spectrum analyzer | Agilent | N9020A | HKE-048 | Dec. 28, 2018 | 1 Year |
| 7. | High gain antenna | Schwarzbeck | LB-180400KF | HKE-054 | Dec. 28, 2018 | 1 Year |
| 8. | Preamplifier | Schwarzbeck | BBV 9743 | HKE-006 | Dec. 28, 2018 | 1 Year |
| 9. | Bilog Broadband Antenna | Schwarzbeck | VULB9163 | HKE-012 | Dec. 28, 2018 | 1 Year |
| 10. | Loop Antenna | Schwarzbeck | FMZB 1519 B | HKE-014 | Dec. 28, 2018 | 1 Year |
| 11. | Horn Antenna | Schewarzbeck | 9120D | HKE-013 | Dec. 28, 2018 | 1 Year |
| 12 | Pre-amplifier | EMCI | EMC051845 SE | HKE-015 | Dec. 28, 2018 | 1 Year |
| 13 | Pre-amplifier | Agilent | 83051A | HKE-016 | Dec. 28, 2018 | 1 Year |
| 14 | High pass filter unit | Tonscend | JS0806-F | HKE-055 | Dec. 28, 2018 | 1 Year |
| 15 | Conducted test software | Tonscend | TS+ Rev 2.5.0.0 | HKE-081 | N/A | N/A |
| 16 | Radiated test software | Tonscend | TS+ Rev 2.5.0.0 | HKE-082 | N/A | N/A |
| 17. | RF test software | Tonscend | JS1120-B Version 2.6 | HKE-083 | N/A | N/A |
| 18. | RF automatic control unit | Tonscend | JS0806-2 | HKE-060 | Dec. 28, 2017 | 3 Year |
| 19. | RF test software | Tonscend | JS1120-4 | HKE-113 | N/A | N/A |
| 20. | RF test software | Tonscend | JS1120-3 | HKE-114 | N/A | N/A |
| 21. | RF test software | Tonscend | JS1120-1 | HKE-115 | N/A | N/A |
| 22. | Spectrum analyzer | Agilent | N9020A | HKE-048 | Dec. 28, 2018 | 1 Year |
| 23. | Signal generator | Agilent | N5182A | HKE-029 | Dec. 28, 2018 | 1 Year |
| 24. | Signal Generator | Agilent | 83630A | HKE-028 | Dec. 28, 2018 | 1 Year |

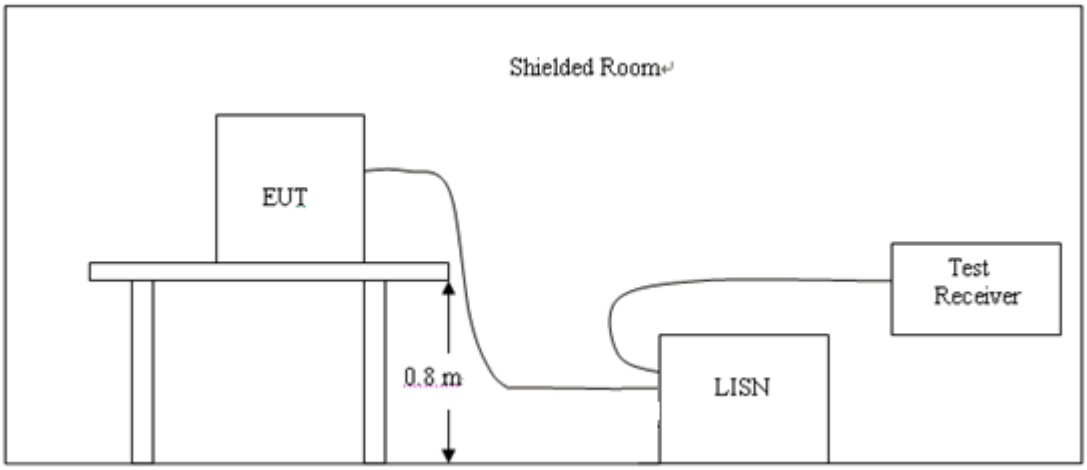
| | | | | | | |
|---|---|---|---|---|---|---|
| 25 | Power meter | Agilent | E4419B | HKE-085 | Dec. 28, 2018 | 1 Year |
| 26 | Power Sensor | Agilent | E9300A | HKE-086 | Dec. 28, 2018 | 1 Year |
| 27 | RF Cable(below1GHz) | Times | 9kHz-1GHz | HKE-117 | Dec. 28, 2018 | 1 Year |
| 28. | RF Cable(above 1GHz) | Times | 1-40G | HKE-034 | Dec. 28, 2018 | 1 Year |
| 29 | RF Cable (9KHz-40GHz) | Tonscend | 170660 | N/A | Dec. 28, 2018 | 1 Year |
| 30 | Shielded room | Shiel Hong | 4*3*3 | HKE-039 | Dec. 28, 2017 | 3 Year |

Note: 1. The Cal.Interval was one year.

# 4. TEST CONDITIONS AND RESULTS

## 4.1. AC Power Conducted Emission

**TEST CONFIGURATION**




**TEST PROCEDURE**

1, The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system, a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10.
2, Support equipment, if needed, was placed as per ANSI C63.10.
3, All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10.
4, If a EUT received DC power from the USB Port of Notebook PC, the PC's adapter received power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.
5, All support equipments received AC power from a second LISN, if any.
6, The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
7, Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.

**AC Power Conducted Emission Limit**

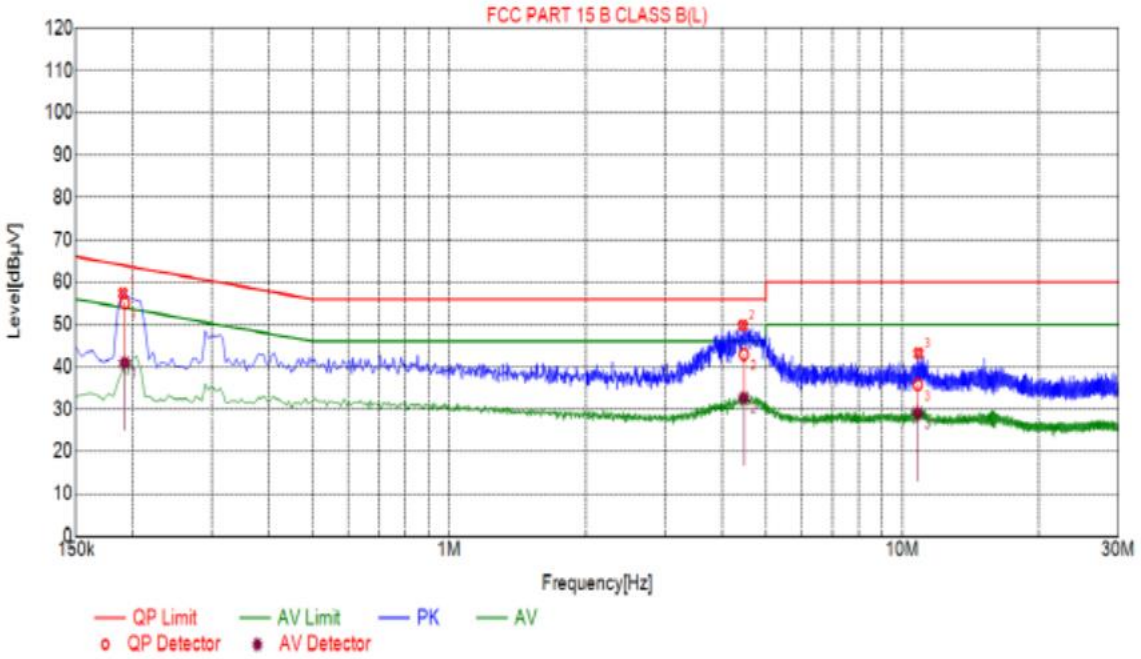
For intentional device, according to § 15.207(a) AC Power Conducted Emission Limits is as following：

| Frequency range (MHz) | Limit (dBuV) | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56* | 56 to 46* |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |
| * Decreases with the logarithm of the frequency. | | |

**TEST RESULTS**

Remark:
1. All modes of GFSK, Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK Middle Channel was reported as below:
2. Both 120 VAC, 50/60 Hz and 240 VAC, 50/60 Hz power supply have been tested, only the worst result of 120 VAC, 60 Hz was reported as below:.

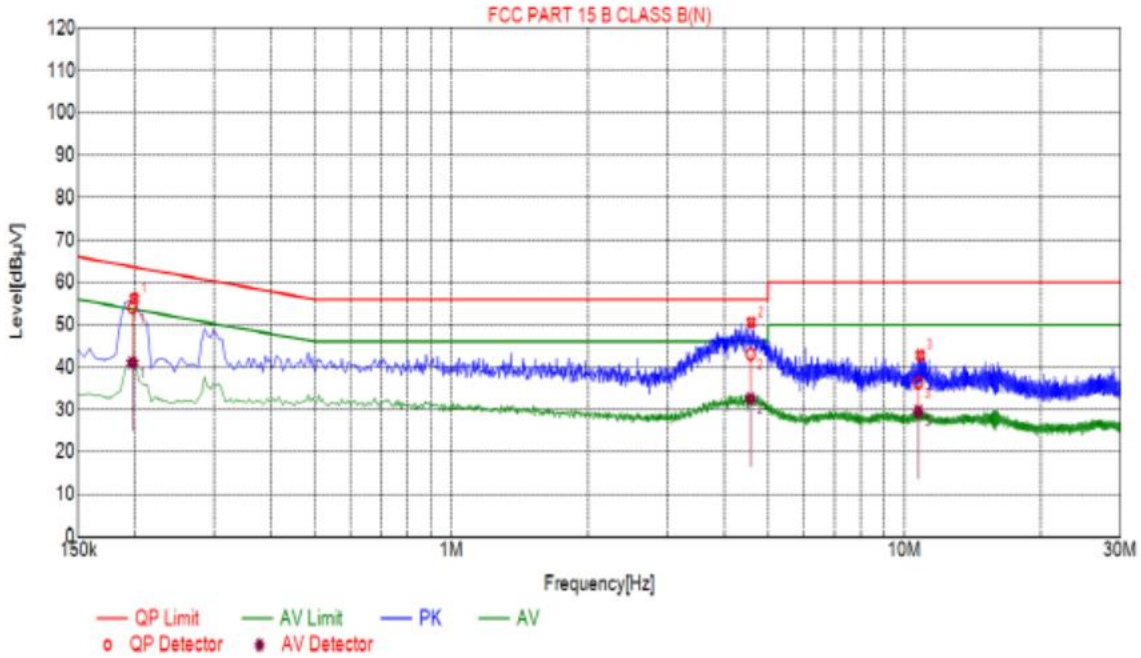
| Power supply: | DC 5V from Adapter AC 120V/60Hz | Polarization | L |
|---|---|---|---|




## Final Data List

| NO. | Freq. [MHz] | Correction factor[dB] | QP Value [dBµV] | QP Limit [dBµV] | QP Margin [dB] | QP Reading [dBµV] | AV Value [dBµV] | AV Limit [dBµV] | AV Margin [dB] | AV Reading [dBµV] | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.1924 | 10.04 | 55.11 | 63.93 | 8.82 | 45.07 | 40.88 | 53.93 | 13.05 | 30.84 | L |
| 2 | 4.4708 | 10.25 | 42.93 | 56.00 | 13.07 | 32.68 | 32.69 | 46.00 | 13.31 | 22.44 | L |
| 3 | 10.8159 | 10.02 | 35.83 | 60.00 | 24.17 | 25.81 | 29.08 | 50.00 | 20.92 | 19.06 | L |

| Power supply: | DC 5V from Adapter AC 120V/60Hz | Polarization | N |
|---|---|---|---|



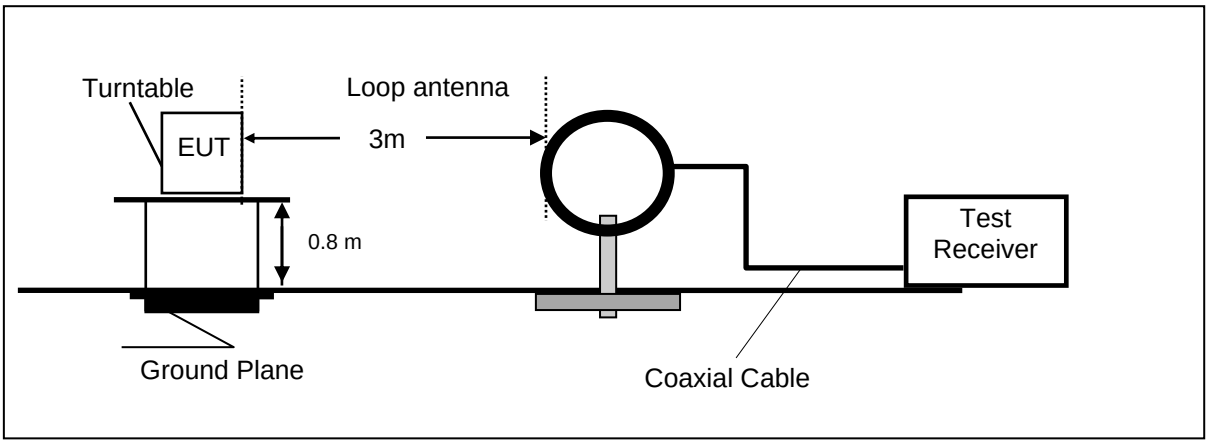

## Final Data List

| NO. | Freq. [MHz] | Correction factor[dB] | QP Value [dBµV] | QP Limit [dBµV] | QP Margin [dB] | QP Reading [dBµV] | AV Value [dBµV] | AV Limit [dBµV] | AV Margin [dB] | AV Reading [dBµV] | Type |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.1977 | 10.03 | 53.98 | 63.71 | 9.73 | 43.95 | 41.00 | 53.71 | 12.71 | 30.97 | N |
| 2 | 4.5769 | 10.25 | 43.01 | 56.00 | 12.99 | 32.76 | 32.55 | 46.00 | 13.45 | 22.30 | N |
| 3 | 10.7350 | 10.02 | 36.30 | 60.00 | 23.70 | 26.28 | 29.54 | 50.00 | 20.46 | 19.52 | N |

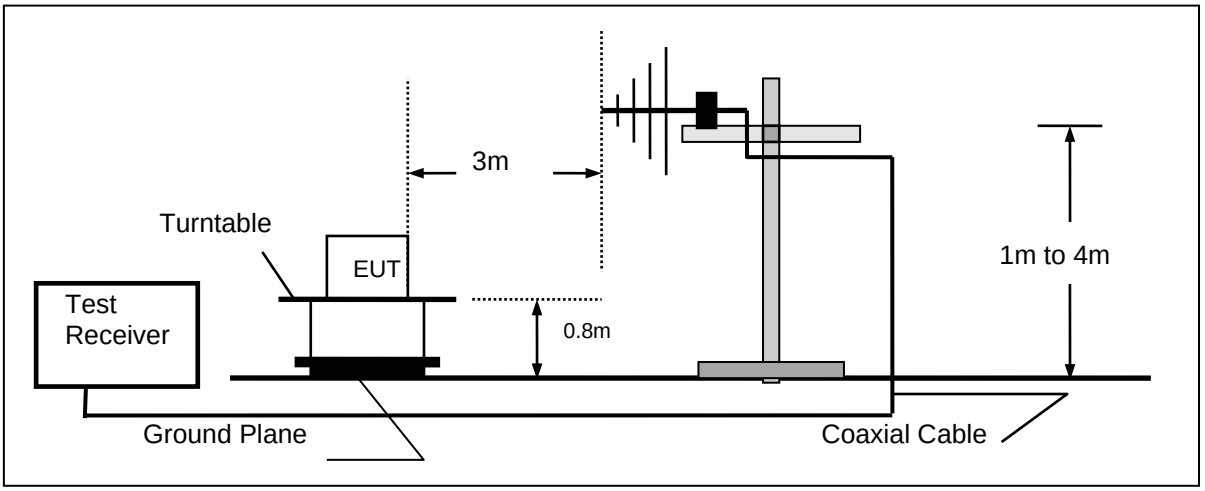
## 4.2. Radiated Emission

**TEST CONFIGURATION**

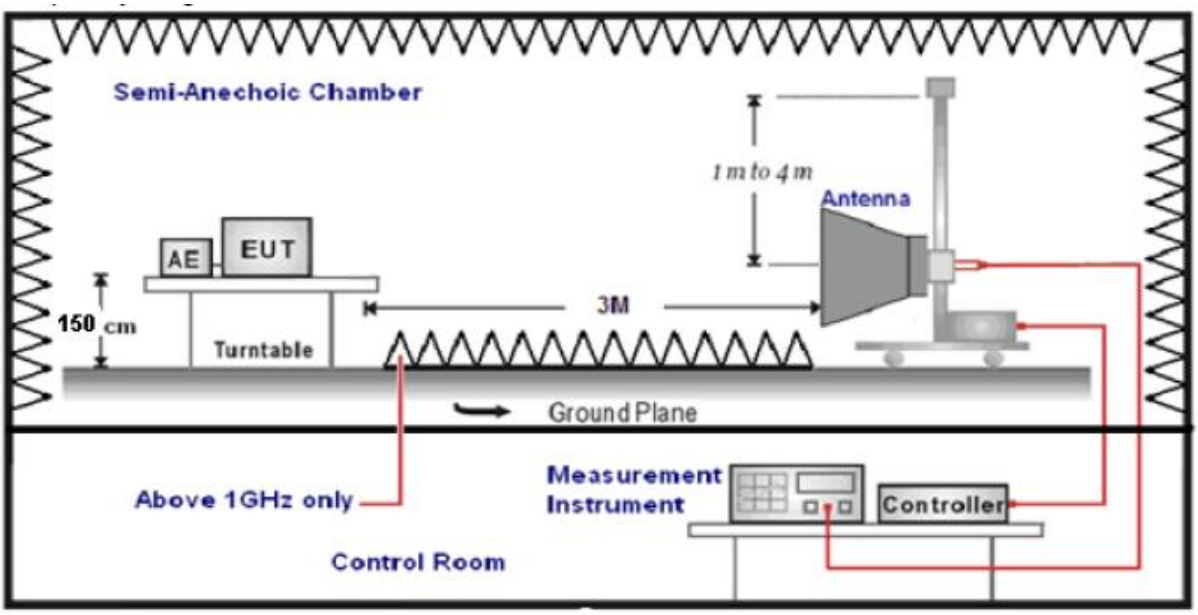
Frequency range 9 KHz – 30MHz




Frequency range 30MHz – 1000MHz




Frequency range above 1GHz-25GHz



**TEST PROCEDURE**

1. The EUT was placed on a turn table which is 12mm above ground plane when testing frequency range 9 KHz –25GHz.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0℃ to 360℃ to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed.
5. The EUT minimum operation frequency was 32.768KHz and maximum operation frequency was 2480MHz.so radiated emission test frequency band from 9KHz to 25GHz.
6. The distance between test antenna and EUT as following table states:

| Test Frequency range | Test Antenna Type | Test Distance |
|---|---|---|
| 9KHz-30MHz | Active Loop Antenna | 3 |
| 30MHz-1GHz | Ultra-Broadband Antenna | 3 |
| 1GHz-18GHz | Double Ridged Horn Antenna | 3 |
| 18GHz-25GHz | Horn Anternna | 1 |

7. Setting test receiver/spectrum as following table states:

| Test Frequency range | Test Receiver/Spectrum Setting | Detector |
|---|---|---|
| 9KHz-150KHz | RBW=200Hz/VBW=3KHz,Sweep time=Auto | QP |
| 150KHz-30MHz | RBW=9KHz/VBW=100KHz,Sweep time=Auto | QP |
| 30MHz-1GHz | RBW=120KHz/VBW=1000KHz,Sweep time=Auto | QP |
| 1GHz-40GHz | Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto<br>Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto | Peak |

**Field Strength Calculation**

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor(if any) from the measured reading. The basic equation with a sample calculation is as follows:

**FS = RA + AF + CL - AG**

| | |
|---|---|
| Where FS = Field Strength | CL = Cable Attenuation Factor (Cable Loss) |
| RA = Reading Amplitude | AG = Amplifier Gain |
| AF = Antenna Factor | |

Transd=AF +CL-AG

**RADIATION LIMIT**

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission from intentional radiators at a distance of 3 meters shall not exceed the following table. According to § 15.247(d), in any 100kHz bandwidth outside the frequency band in which the EUT is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the100kHz bandwidth within the band that contains the highest level of desired power.
The pre-test have done for the EUT in three axes and found the worst emission at position shown in test setup photos.

| Frequency (MHz) | Distance (Meters) | Radiated (dBμV/m) | Radiated (μV/m) |
|---|---|---|---|
| 0.009-0.49 | 3 | 20log(2400/F(KHz))+40log(300/3) | 2400/F(KHz) |
| 0.49-1.705 | 3 | 20log(24000/F(KHz))+ 40log(30/3) | 24000/F(KHz) |
| 1.705-30 | 3 | 20log(30)+ 40log(30/3) | 30 |
| 30-88 | 3 | 40.0 | 100 |
| 88-216 | 3 | 43.5 | 150 |
| 216-960 | 3 | 46.0 | 200 |
| Above 960 | 3 | 54.0 | 500 |

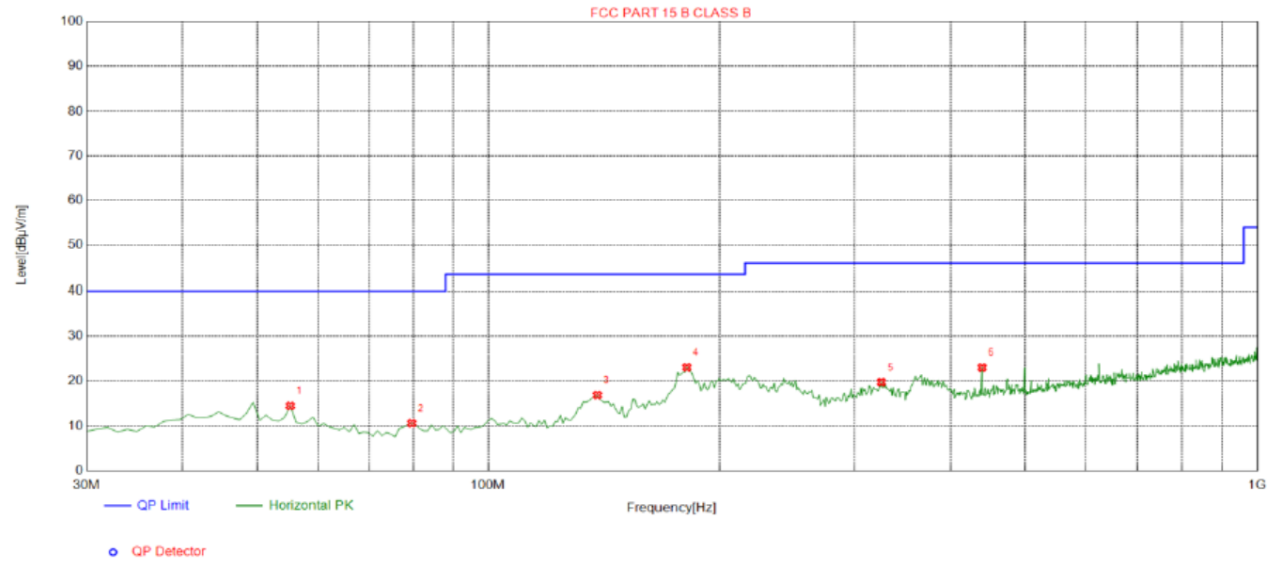
## TEST RESULTS

Remark: 1. Radiated emission test from 9 KHz to 10th harmonic of fundamental was verified, and no emission found except system noise floor in 9 KHz to 30MHz and not recorded in this report.

2.For test below 1GHz all modes of GFSK, and Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK Middle Channel was reported as below:

**For 30MHz-1GHz**

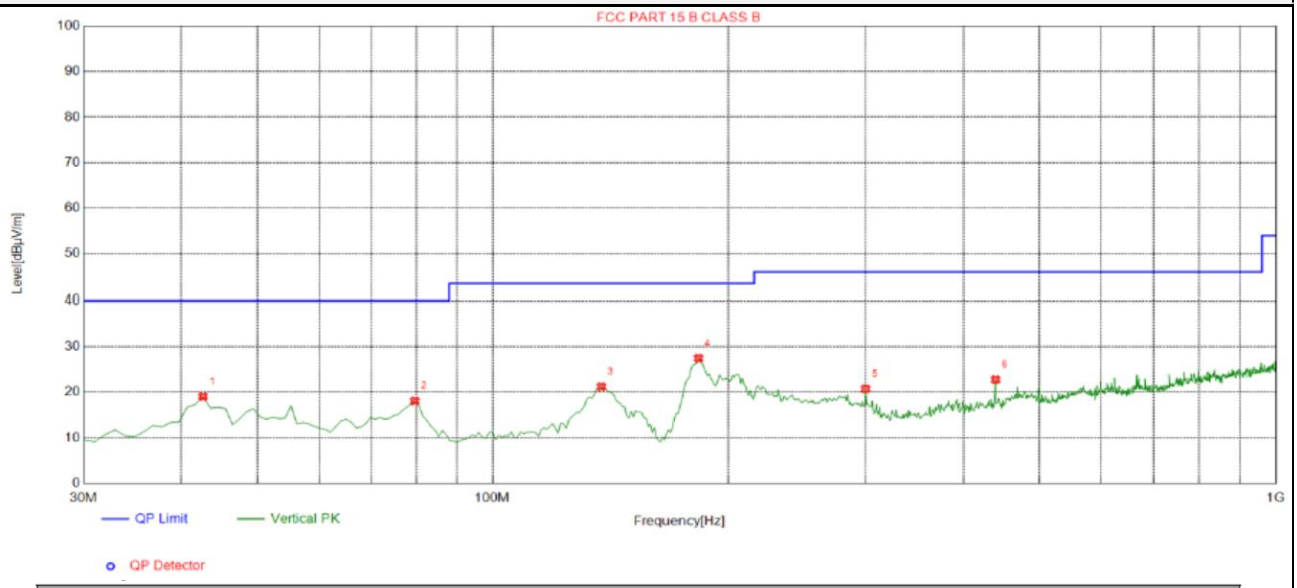
Horizontal




**Suspected List**

| NO. | Freq. [MHz] | Factor [dB] | Reading [dBµV/m] | Level [dBµV/m] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 55.2452 | -14.44 | 28.94 | 14.50 | 40.00 | 25.50 | 100 | 293 | Horizontal |
| 2 | 79.5195 | -19.38 | 30.01 | 10.63 | 40.00 | 29.37 | 100 | 348 | Horizontal |
| 3 | 138.7487 | -19.10 | 36.00 | 16.90 | 43.50 | 26.60 | 100 | 84 | Horizontal |
| 4 | 181.4715 | -16.73 | 39.85 | 23.12 | 43.50 | 20.38 | 100 | 329 | Horizontal |
| 5 | 325.1752 | -11.84 | 31.63 | 19.79 | 46.00 | 26.21 | 100 | 90 | Horizontal |
| 6 | 439.7498 | -9.43 | 32.50 | 23.07 | 46.00 | 22.93 | 100 | 81 | Horizontal |

Vertical




**Suspected List**

| NO. | Freq. [MHz] | Factor [dB] | Reading [dBµV/m] | Level [dBµV/m] | Limit [dBµV/m] | Margin [dB] | Height [cm] | Angle [°] | Polarity |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 42.6226 | -14.07 | 33.14 | 19.07 | 40.00 | 20.93 | 100 | 106 | Vertical |
| 2 | 79.5195 | -19.38 | 37.48 | 18.10 | 40.00 | 21.90 | 100 | 90 | Vertical |
| 3 | 137.7778 | -19.04 | 40.26 | 21.22 | 43.50 | 22.28 | 100 | 189 | Vertical |
| 4 | 183.4134 | -16.57 | 44.04 | 27.47 | 43.50 | 16.03 | 100 | 183 | Vertical |
| 5 | 299.9299 | -12.74 | 33.48 | 20.74 | 46.00 | 25.26 | 100 | 208 | Vertical |
| 6 | 439.7498 | -9.43 | 32.21 | 22.78 | 46.00 | 23.22 | 100 | 228 | Vertical |

**For 1GHz to 25GHz**

Remark: For test above 1GHz GFSK, Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK was reported as below:

CH Low (2402MHz)

Horizontal:

| Frequency (MHz) | Meter Reading (dBμV) | Factor (dB) | Emission Level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector Type |
|---|---|---|---|---|---|---|
| 4804 | 63.01 | -3.64 | 59.37 | 74 | -14.63 | peak |
| 4804 | 46.57 | -3.64 | 42.93 | 54 | -11.07 | AVG |
| 7206 | 56.29 | -0.95 | 55.34 | 74 | -18.66 | peak |
| 7206 | 43.52 | -0.95 | 42.57 | 54 | -11.43 | AVG |
| --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

Vertical:

| Frequency (MHz) | Meter Reading (dBμV) | Factor (dB) | Emission Level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector Type |
|---|---|---|---|---|---|---|
| 4804 | 64.11 | -3.64 | 60.47 | 74 | -13.53 | peak |
| 4804 | 46.82 | -3.64 | 43.18 | 54 | -10.82 | AVG |
| 7206 | 55.73 | -0.95 | 54.78 | 74 | -19.22 | peak |
| 7206 | 43.78 | -0.95 | 42.83 | 54 | -11.17 | AVG |
| --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

CH Middle (2441MHz)

Horizontal:

| Frequency (MHz) | Meter Reading (dBμV) | Factor (dB) | Emission Level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector Type |
|---|---|---|---|---|---|---|
| 4882 | 63.09 | -3.51 | 59.58 | 74 | -14.42 | peak |
| 4882 | 46.18 | -3.51 | 42.67 | 54 | -11.33 | AVG |
| 7326 | 55.92 | -0.82 | 55.1 | 74 | -18.9 | peak |
| 7326 | 42.35 | -0.82 | 41.53 | 54 | -12.47 | AVG |
| --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

Vertical:

| Frequency (MHz) | Meter Reading (dBμV) | Factor (dB) | Emission Level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector Type |
|---|---|---|---|---|---|---|
| 4882 | 64.02 | -3.51 | 60.51 | 74 | -13.49 | peak |
| 4882 | 46.52 | -3.51 | 43.01 | 54 | -10.99 | AVG |
| 7326 | 56.78 | -0.82 | 55.96 | 74 | -18.04 | peak |
| 7326 | 43.72 | -0.82 | 42.9 | 54 | -11.1 | AVG |
| --- | | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

CH High (2480MHz)

Horizontal:

| Frequency (MHz) | Meter Reading (dBμV) | Factor (dB) | Emission Level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector Type |
|---|---|---|---|---|---|---|
| 4960 | 63.97 | -3.43 | 60.54 | 74 | -13.46 | peak |
| 4960 | 45.62 | -3.43 | 42.19 | 54 | -11.81 | AVG |
| 7440 | 57.39 | -0.75 | 56.64 | 74 | -17.36 | peak |
| 7440 | 44.77 | -0.75 | 44.02 | 54 | -9.98 | AVG |
| --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

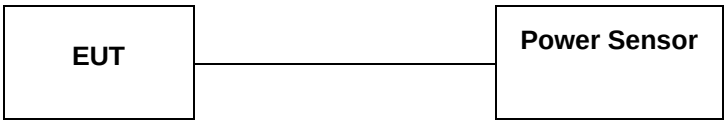
Vertical:

| Frequency (MHz) | Meter Reading (dBμV) | Factor (dB) | Emission Level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector Type |
|---|---|---|---|---|---|---|
| 4960 | 62.93 | -3.43 | 59.5 | 74 | -14.5 | peak |
| 4960 | 46.45 | -3.43 | 43.02 | 54 | -10.98 | AVG |
| 7440 | 56.69 | -0.75 | 55.94 | 74 | -18.06 | peak |
| 7440 | 43.72 | -0.75 | 42.97 | 54 | -11.03 | AVG |
| --- | --- | --- | --- | --- | --- | --- |
| --- | --- | --- | --- | --- | --- | --- |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

Remark：
(1) Data of measurement within this frequency range shown “--- ” in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.
(2) When the test results of Peak Detected below the limits of Average Detected, the Average Detected is not need completed.

## 4.3. Maximum Peak Output Power

**TEST CONFIGURATION**




**TEST PROCEDURE**

According to ANSI C63.10:2013 Maximum peak conducted output power for HFSS devices:
The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the HFSS bandwidth and shall utilize a fast-responding diode detector.

**LIMIT**

For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

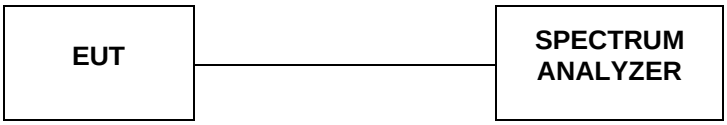
**TEST RESULTS**

| Type | Channel | Peak Output power (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|
| GFSK | 00 | 1.576 | 21 | Pass |
| | 39 | 0.752 | | |
| | 78 | 0.338 | | |
| π/4DQPSK | 00 | 1.057 | 21 | Pass |
| | 39 | 0.187 | | |
| | 78 | 0.048 | | |

Note: 1.The test results including the cable lose.

## 4.4. 20dB Bandwidth

**TEST CONFIGURATION**




**TEST PROCEDURE**

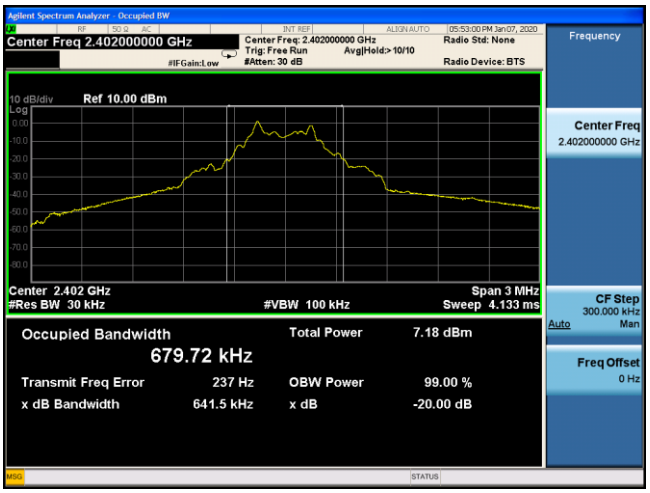
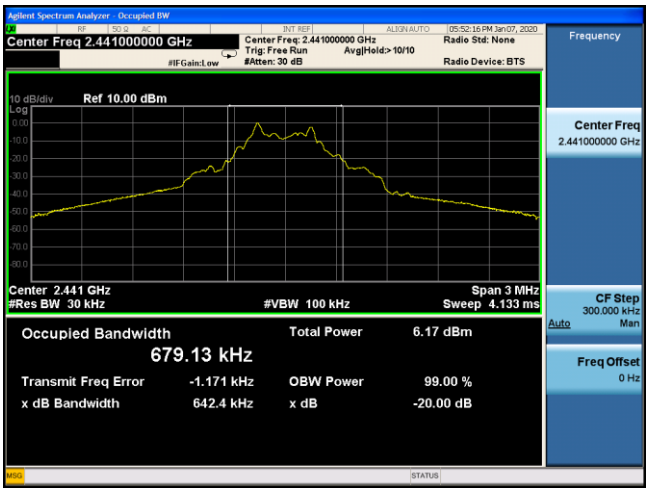
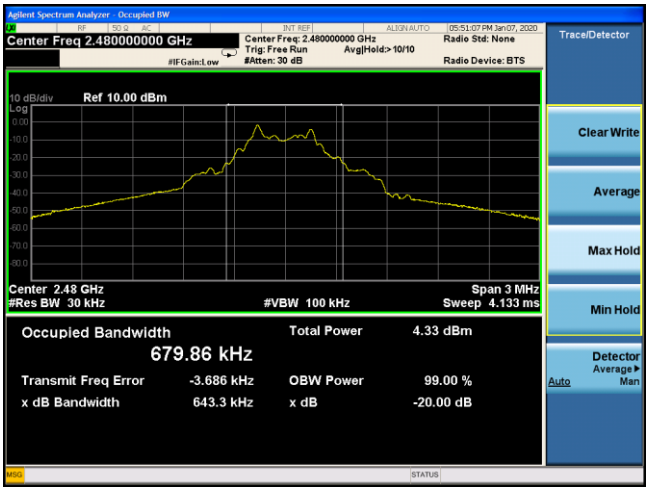
The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=30 KHz and VBW=100KHz.
The 20dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 20dB.

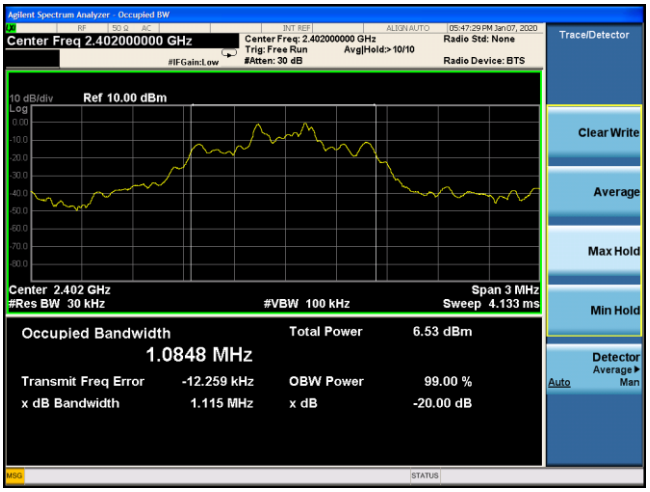
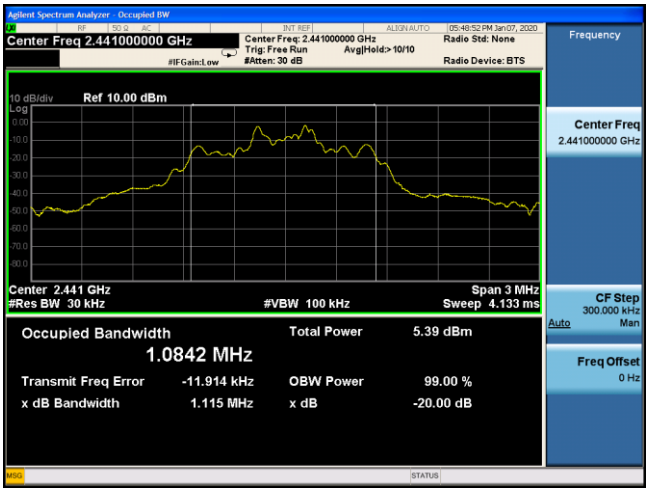
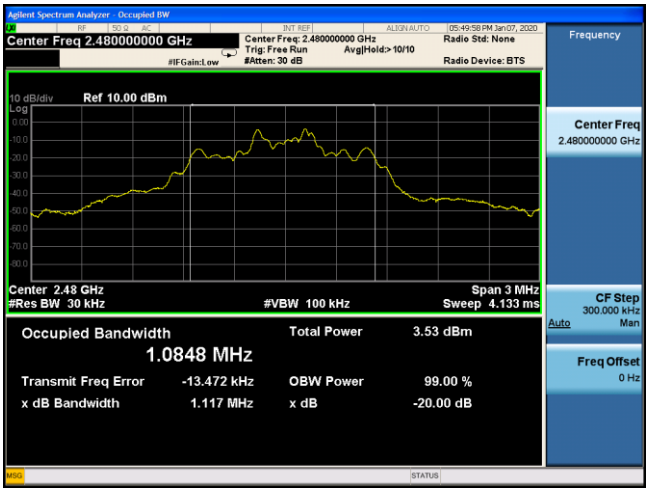
**LIMIT**

For frequency hopping systems operating in the 2400MHz-2483.5MHz no limit for 20dB bandwith.

**TEST RESULTS**

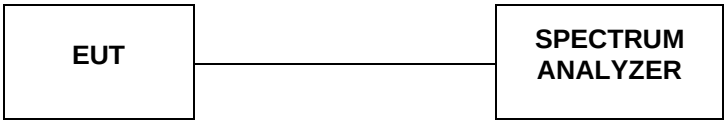
| Modulation | Channel | 20dB bandwidth (MHz) | Result |
|---|---|---|---|
| GFSK | CH00 | 0.6415 | Pass |
| | CH39 | 0.6424 | |
| | CH78 | 0.6433 | |
| π/4DQPSK | CH00 | 1.115 | |
| | CH39 | 1.115 | |
| | CH78 | 1.117 | |

| *GFSK Modulation* |
|---|
|  |
| *CH00* |
|  |
| *CH39* |
|  |
| *CH78* |

| π/4DQPSK Modulation |
| --- |
|  |
| CH00 |
|  |
| CH39 |
|  |
| CH78 |

## 4.5. Frequency Separation

**TEST CONFIGURATION**




**TEST PROCEDURE**

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=30 KHz and VBW=100KHz.

**LIMIT**

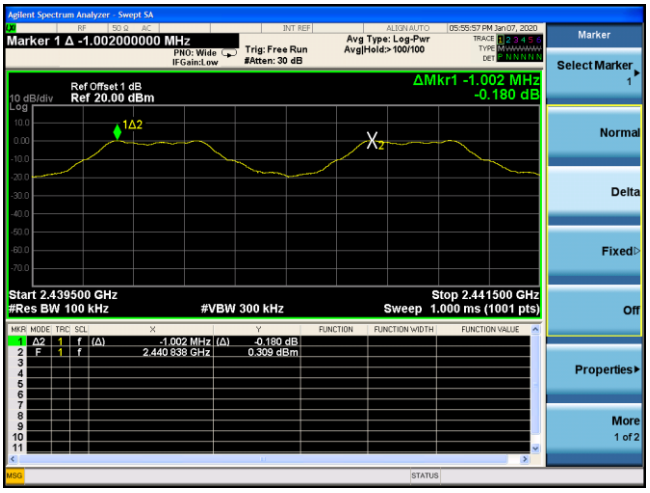
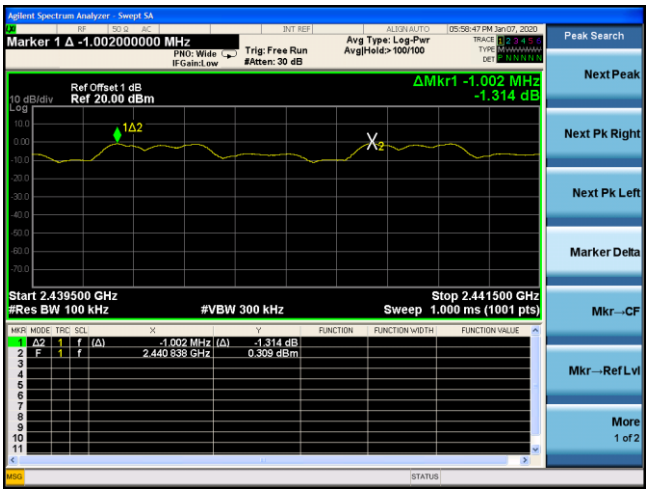
According to 15.247(a)(1),frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25KHz or the 2/3*20dB bandwidth of the hopping channel, whichever is greater.

**TEST RESULTS**

### 4.5.1 GFSK Test Mode

| Modulation | Channel | Channel Separation (MHz) | Limit(MHz) | Result |
|---|---|---|---|---|
| GFSK | CH38 | 1.002 | 2/3* 20dB BW or 20dB BW | Pass |
| | CH39 | | | |
| π/4DQPSK | CH38 | 1.002 | 2/3* 20dB BW or 20dB BW | Pass |
| | CH39 | | | |

Remark: We have tested all mode at high, middle and low channel, and recorded worst case at middle

| *GFSK Modulation* |
| --- |
|  |
| *π/4DQPSK Modulation* |
|  |

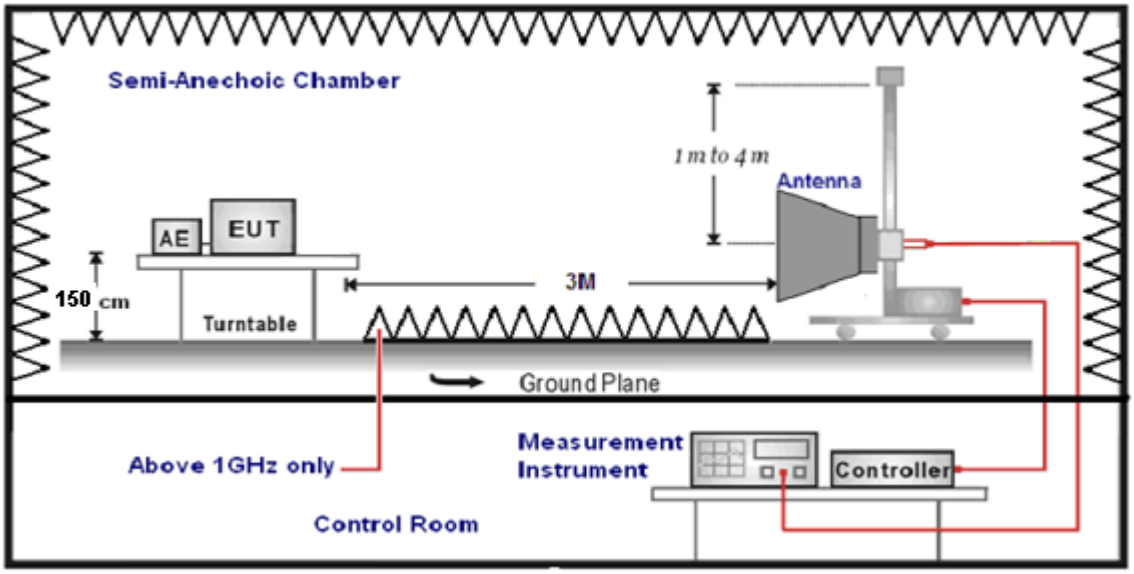
## 4.6. Band Edge Compliance of RF Emission

**TEST REQUIREMENT**

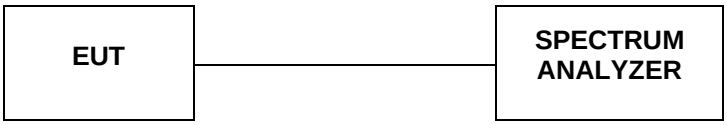
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the 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. Attenuation below the general limits specified in §15.209(a) is not required. 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)).

**TEST CONFIGURATION**

***For Radiated***




***For Conducted***




**TEST PROCEDURE**

1. The EUT was placed on a turn table which is 1.5m above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0℃ to 360℃ to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed..
5. The distance between test antenna and EUT was 3 meter:
6. Setting test receiver/spectrum as following table states:

| Test Frequency range | Test Receiver/Spectrum Setting | Detector |
|---|---|---|
| 1GHz-40GHz | Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto<br>Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto | Peak |

**LIMIT**

Below -20dB of the highest emission level in operating band.
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)

**TEST RESULTS**

**4.6.1 For Radiated Bandedge Measurement**

Remark: GFSK, Pi/4 DQPSK all have been tested, only worse case GFSK is reported.

Operation Mode: GFSK TX Low channel(2402MHz)
Horizontal (Worst case)

| Frequency | Meter Reading | Factor | Emission Level | Limits | Margin | Detector Type |
|---|---|---|---|---|---|---|
| (MHz) | (dBμV) | (dB) | (dBμV/m) | (dBμV/m) | (dB) | |
| 2390 | 61.21 | -5.81 | 55.4 | 74 | -18.6 | peak |
| 2390 | 42.92 | -5.81 | 37.11 | 54 | -16.89 | AVG |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

Vertical:

| Frequency | Meter Reading | Factor | Emission Level | Limits | Margin | Detector Type |
|---|---|---|---|---|---|---|
| (MHz) | (dBμV) | (dB) | (dBμV/m) | (dBμV/m) | (dB) | |
| 2390 | 63.87 | -5.81 | 58.06 | 74 | -15.94 | peak |
| 2390 | 45.03 | -5.81 | 39.22 | 54 | -14.78 | AVG |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

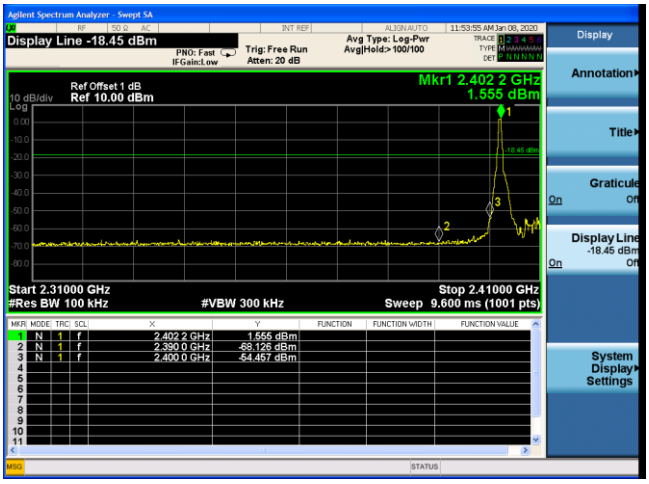
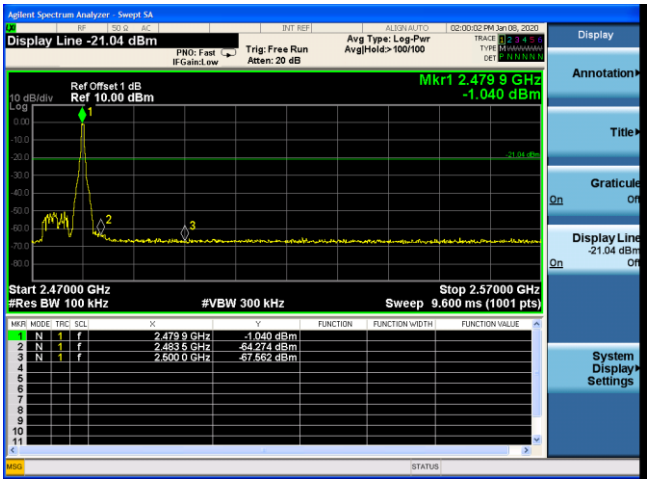
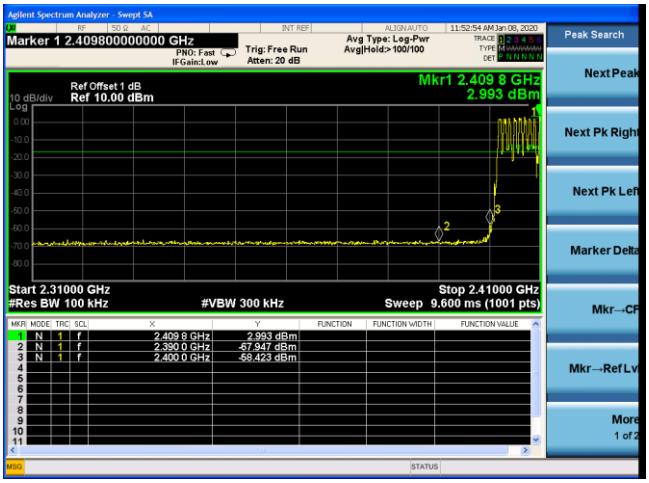
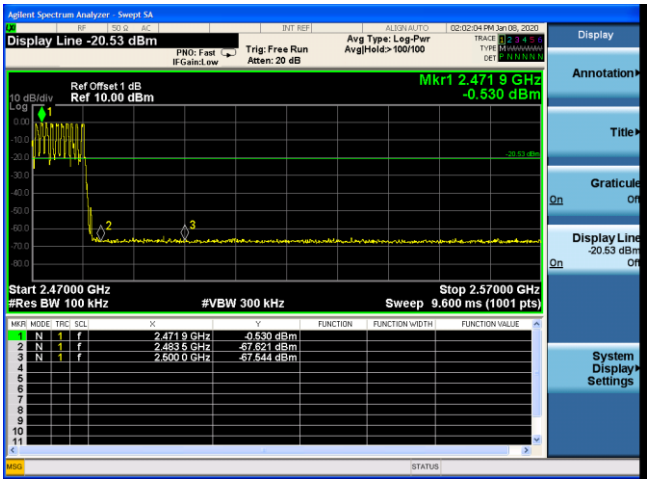
Operation Mode: GFSK TX High channel (2480MHz)
Horizontal (Worst case)

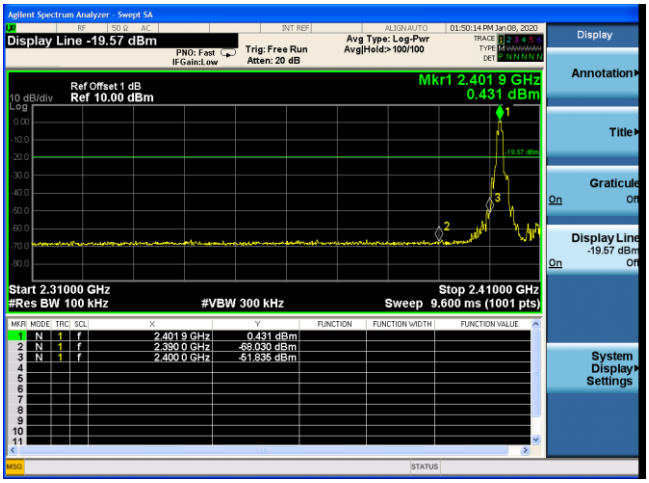
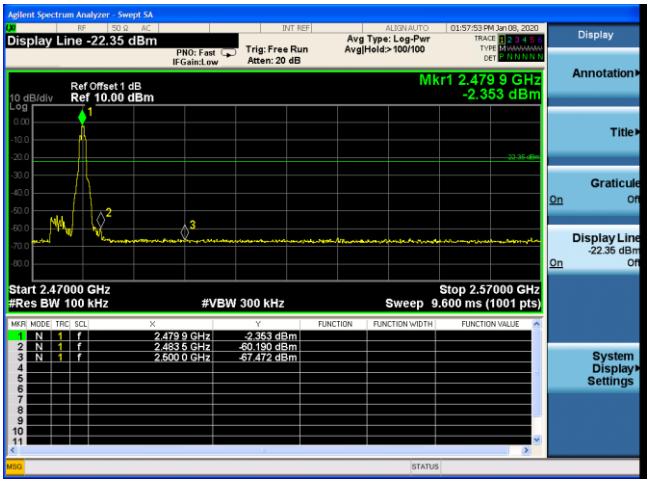
| Frequency | Meter Reading | Factor | Emission Level | Limits | Margin | Detector Type |
|---|---|---|---|---|---|---|
| (MHz) | (dBμV) | (dB) | (dBμV/m) | (dBμV/m) | (dB) | |
| 2483.5 | 62.15 | -5.65 | 56.5 | 74 | -17.5 | peak |
| 2483.5 | 42.93 | -5.65 | 37.28 | 54 | -16.72 | AVG |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |

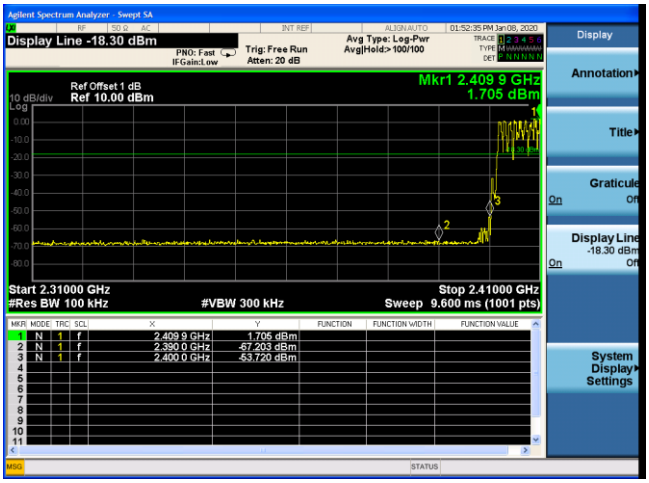
Vertical:

| Frequency | Meter Reading | Factor | Emission Level | Limits | Margin | Detector Type |
|---|---|---|---|---|---|---|
| (MHz) | (dBμV) | (dB) | (dBμV/m) | (dBμV/m) | (dB) | |
| 2483.5 | 64.21 | -5.65 | 58.56 | 74 | -15.44 | peak |
| 2483.5 | 45.48 | -5.65 | 39.83 | 54 | -14.17 | AVG |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. | | | | | | |
| Remark: All the other emissions not reported were too low to read and deemed to comply with FCC limit. | | | | | | |

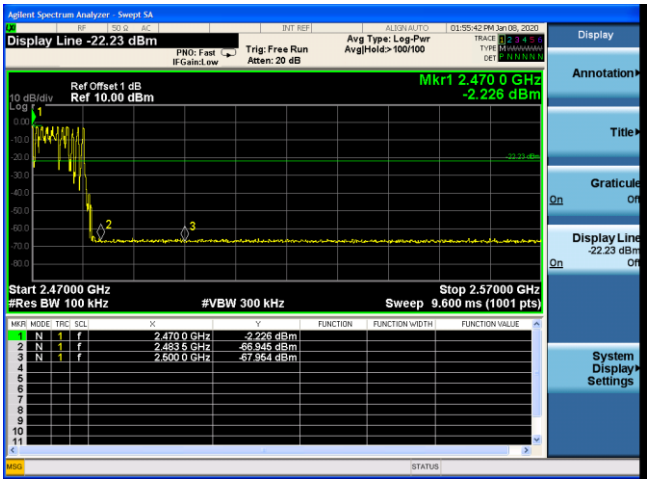
### 4.6.2 For Conducted Bandedge Measurement

| *GFSK* | |
|---|---|
|  |  |
| Left Band edge hoping off | Right Band edge hoping off |
|  |  |
| Left Band edge hoping on | Right Band edge hoping on |

| *π/4DQPSK* | |
|---|---|
|  |  |
| Left Band edge hoping off | Right Band edge hoping off |



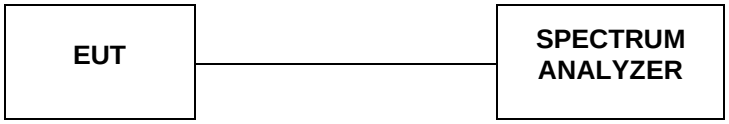

Left Band edge hoping on




Right Band edge hoping on

## 4.7. Spurious RF Conducted Emission

**TEST CONFIGURATION**




**TEST PROCEDURE**

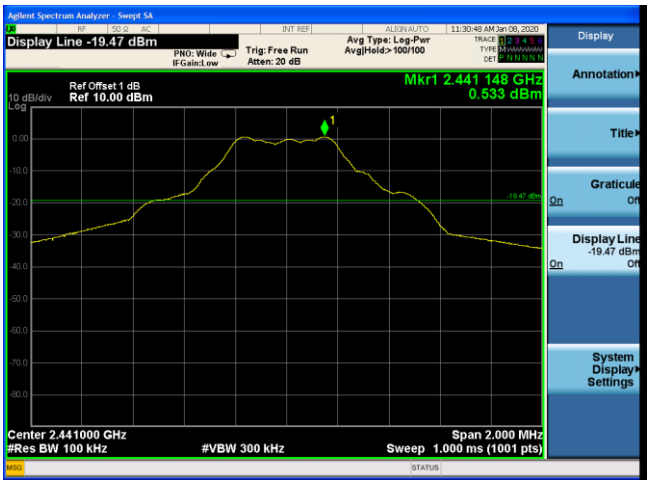
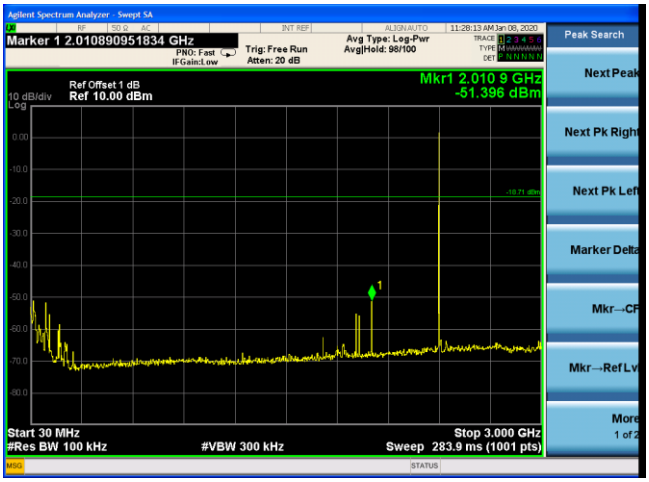
The Spurious RF conducted emissions compliance of RF radiated emission should be measured by following the guidance in ANSI C63.10-2013 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization etc. Set RBW=100kHz and VBW= 300KHz to measure the peak field strength , and mwasure frequeny range from 9KHz to 25GHz.

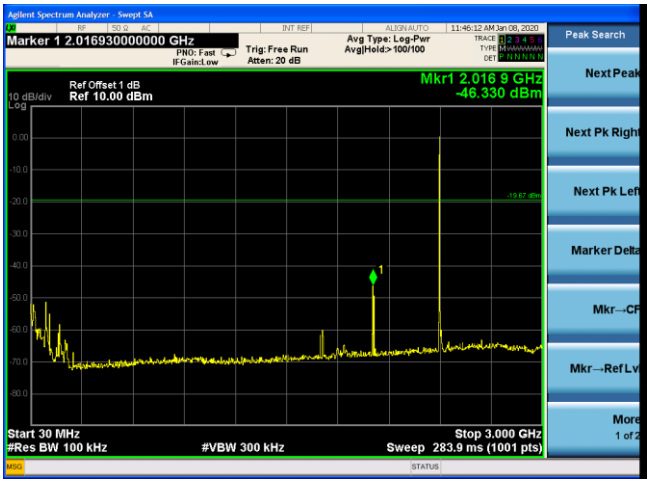
**LIMIT**

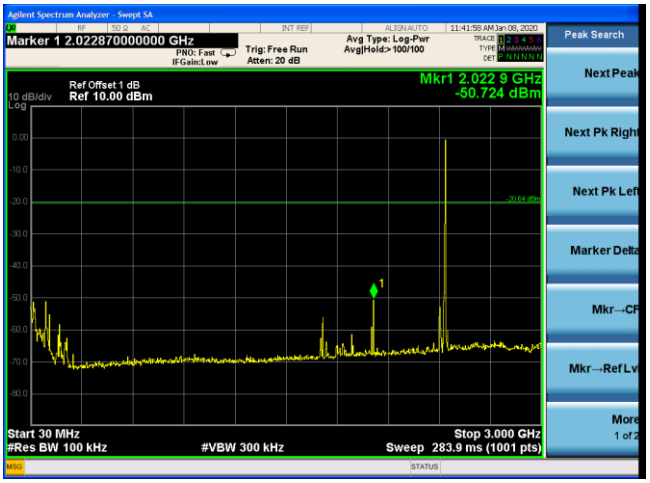
1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.

**TEST RESULTS**

Remark: The measurement frequency range is from 30MHz to the $10^{th}$ harmonic of the fundamental frequency. The lowest, middle and highest channels are tested to verify the spurious emissions and bandege measurement data.

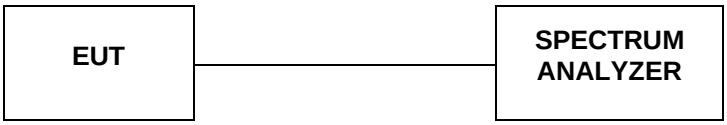
| *GFSK CH00* | *GFSK CH39* |
|---|---|
|  |  |
| Reference | Reference |
|  |  |
| 30MHz-3GHz | 30MHz-3GHz |
|  |  |
| 3GHz-25GHz | 3GHz-25GHz |

| GFSK CH78 | π/4DQPSK CH00 |
|---|---|
|  |  |
| Reference | Reference |
|  |  |
| 30MHz-3GHz | 30MHz-3GHz |
|  |  |
| 3GHz-25GHz | 3GHz-25GHz |

| π/4DQPSK CH39 | π/4DQPSK CH78 |
|---|---|
|  |  |
| Reference | Reference |
|  |  |
| 30MHz-3GHz | 30MHz-3GHz |
|  |  |
| 3GHz-25GHz | 3GHz-25GHz |

## 4.8. Number of hopping frequency

**TEST CONFIGURATION**



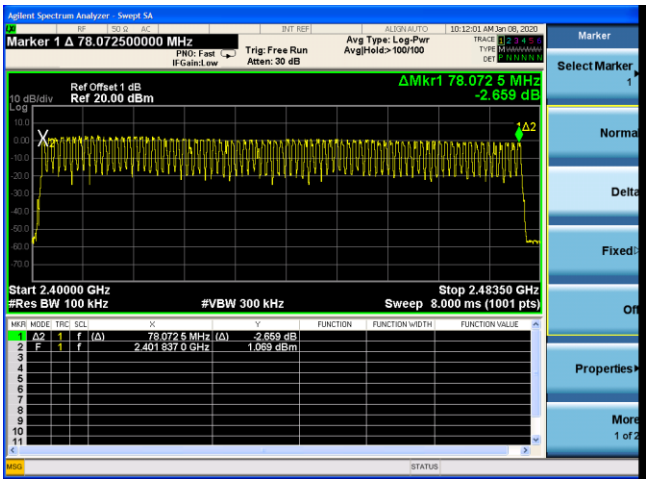
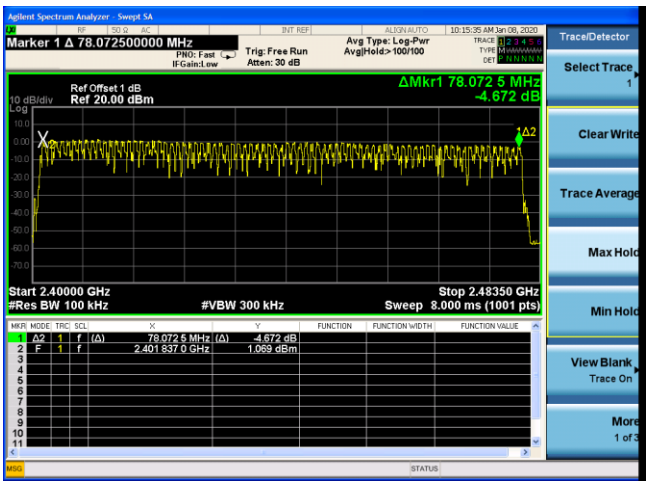

**TEST PROCEDURE**

The transmitter output was connected to the spectrum analyzer through an attenuator.Set spectrum analyzer start 2400MHz to 2483.5MHz with RBW=1MHz and VBW=3MHz.

**LIMIT**

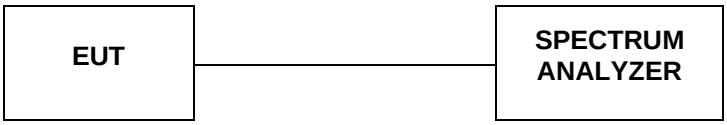
Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

| Modulation | Number of Hopping Channel | Limit | Result |
|---|---|---|---|
| GFSK | 79 | ≥15 | Pass |
| π/4 DQPSK | 79 | | |

| *GFSK Modulation* |
| --- |
|  |
| *π/4DQPSK Modulation* |
|  |

## 4.9. Time Of Occupancy(Dwell Time)

**TEST CONFIGURATION**




**TEST PROCEDURE**

The transmitter output was connected to the spectrum analyzer through an attenuator. Set center frequency of spectrum analyzer=operating frequency with RBW=1MHz and VBW=3MHz,Span=0Hz.

**LIMIT**

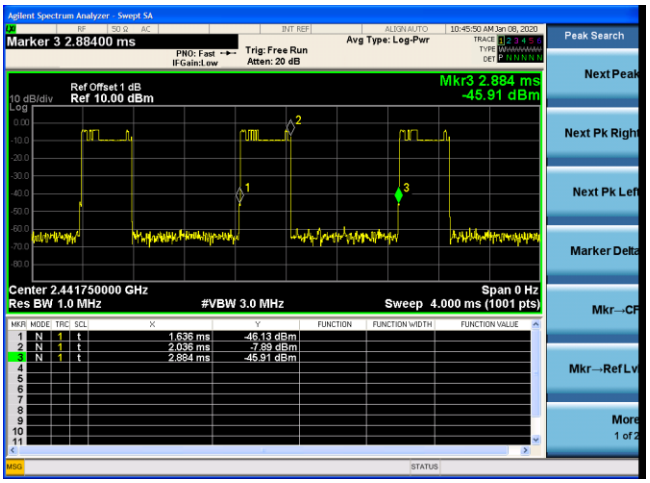
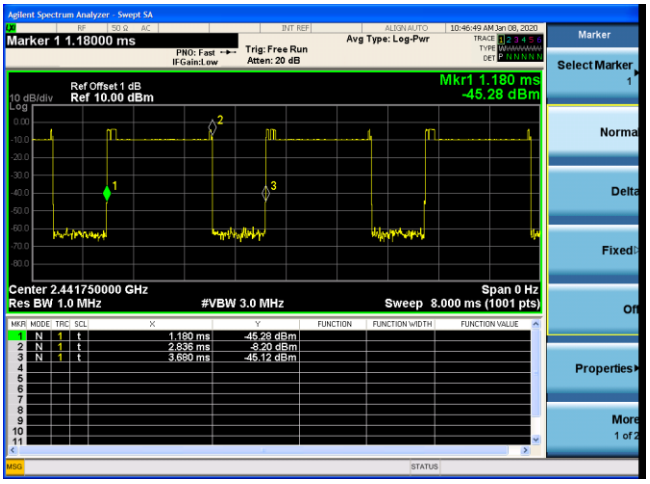
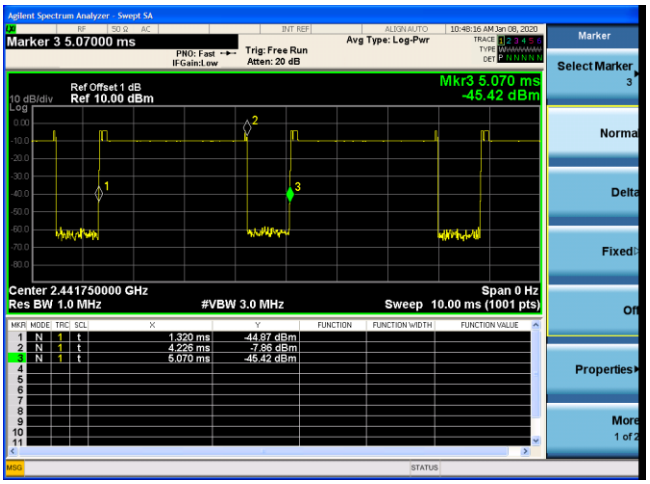
The average time of occupancy on any channel shall not be greater than 0.4 seconds within a pe-riod of 0.4 seconds multiplied by the number of hopping channels employed.

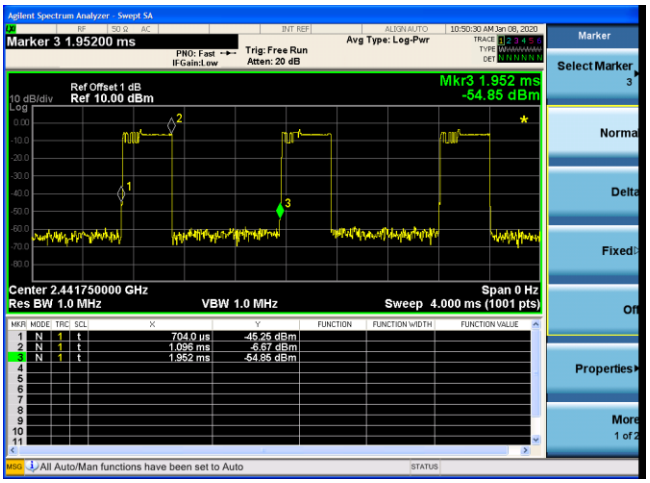
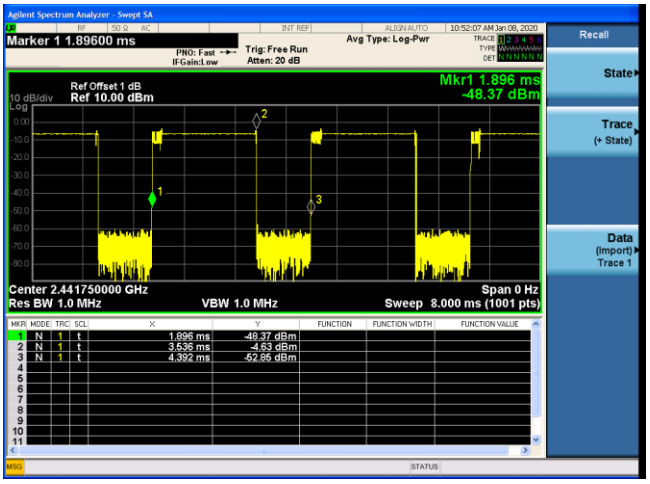
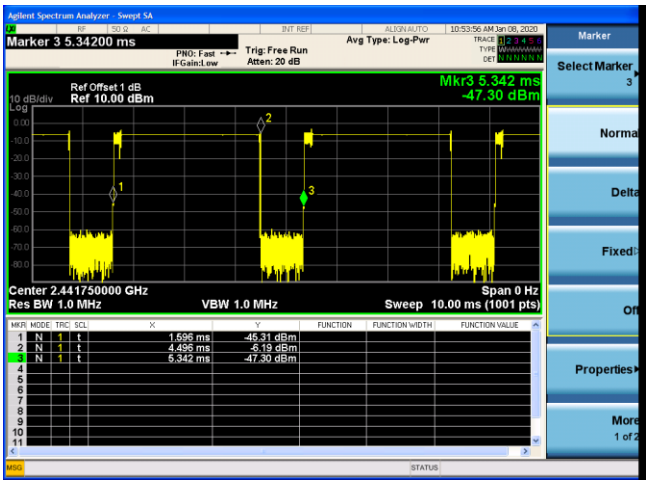
**TEST RESULTS**

| Modulation | Packet | Pulse time (ms) | Dwell time (second) | Limit (second) | Result |
|---|---|---|---|---|---|
| GFSK | DH1 | 0.400 | 0.128 | 0.40 | Pass |
| | DH3 | 1.656 | 0.265 | | |
| | DH5 | 2.906 | 0.310 | | |
| π/4 DQPSK | DH1 | 0.392 | 0.126 | 0.40 | Pass |
| | DH3 | 1.740 | 0.279 | | |
| | DH5 | 2.900 | 0.310 | | |

Note:

1. We have tested all mode at high,middle and low channel,and recoreded worst case at middle channel.
2. Dwell time=Pulse time (ms) × (1600 ÷ 2 ÷ 79) ×31.6 Second for DH1, 2-DH1, 3-DH1
   Dwell time=Pulse time (ms) × (1600 ÷ 4 ÷ 79) ×31.6 Second for DH3, 2-DH3, 3-DH3
   Dwell time=Pulse time (ms) × (1600 ÷ 6 ÷ 79) ×31.6 Second for DH5, 2-DH5, 3-DH5

| GFSK Modulation |
| --- |
|  |
| DH1 |
|  |
| DH3 |
|  |
| DH5 |

| π/4DQPSK Modulation |
| --- |
|  |
| 2-DH1 |
|  |
| 2-DH3 |
|  |
| 2-DH5 |

## 4.10. Pseudorandom Frequency Hopping Sequence

**TEST APPLICABLE**

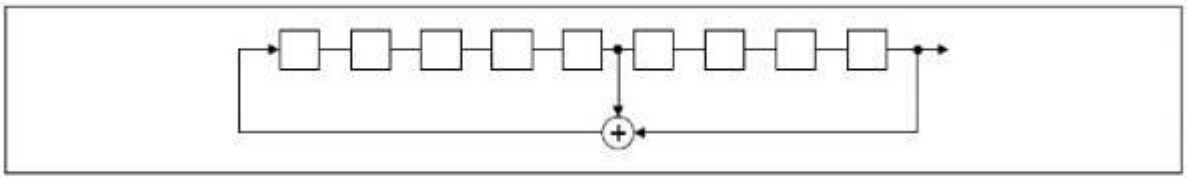
**For 47 CFR Part 15C section 15.247 (a)(1) requirement:**

Frequency hopping systems shall have hopping channel carrier fre-quencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hop-ping channel, whichever is greater. Al-ternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier fre-quencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to chan-nel frequencies that are selected at the system hopping rate from a pseudo ran-domly ordered list of hopping fre-quencies. Each frequency must be used equally on the average by each trans-mitter. The system receivers shall have input bandwidths that match the hop-ping channel bandwidths of their cor-responding transmitters and shall shift frequencies in synchronization with the transmitted signals.

**EUT Pseudorandom Frequency Hopping Sequence Requirement**

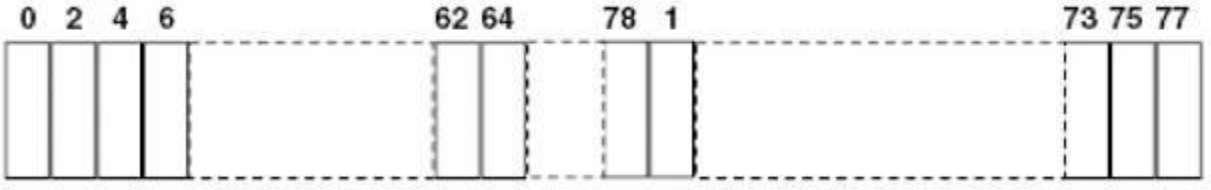
The pseudorandom frequency hopping sequence may be generated in a nice-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage.And the result is fed back to the input of the frist stage.The sequence begins with the frist one of 9 consecutive ones,for example:the shift register is initialized with nine ones.

- Number of shift register stages:9
- Length of pseudo-random sequence:29-1=511 bits
- Longest sequence of zeros:8(non-inverted signal)



*Linear Feedback Shift Register for Generation of the PRBS sequence*

An explame of pseudorandom frequency hopping sequence as follows:




Each frequency used equally one the average by each transmitter.
The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitter and shift frequencies in synchronization with the transmitted signals.

## 4.11. Antenna Requirement

**Standard Applicable**

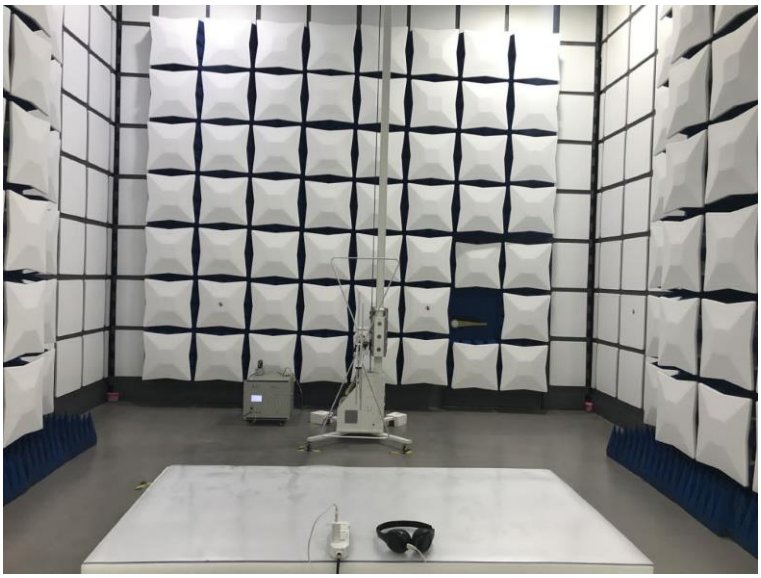
For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

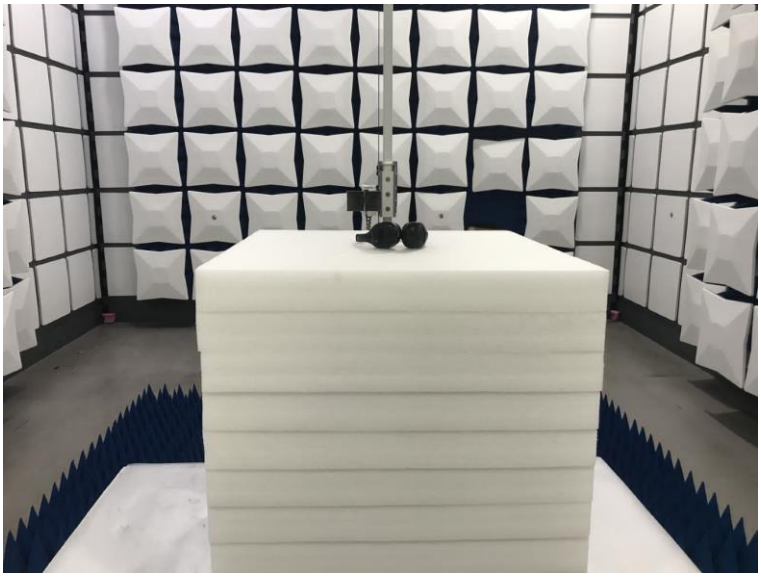
And according to FCC 47 CFR Section 15.247 (c), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

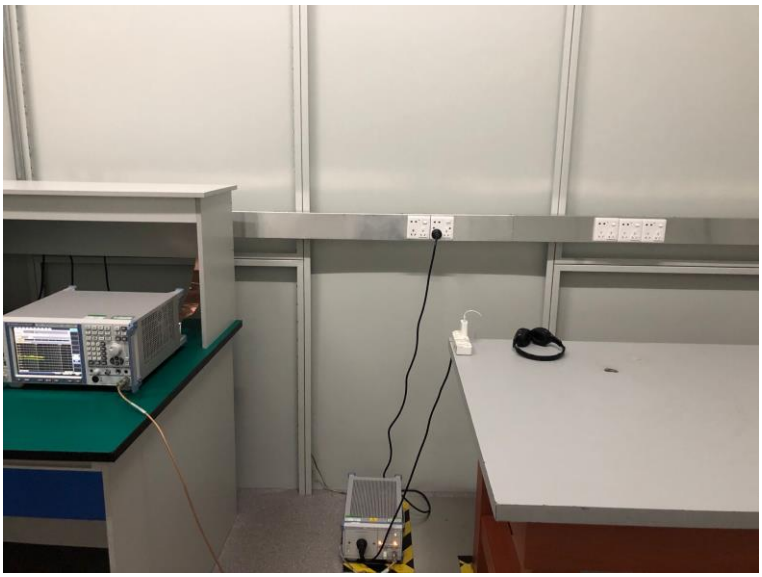
**Antenna Information**

The antenna is PCB antenna ,The directional gains of antenna used for transmitting is -0.68 dBi.

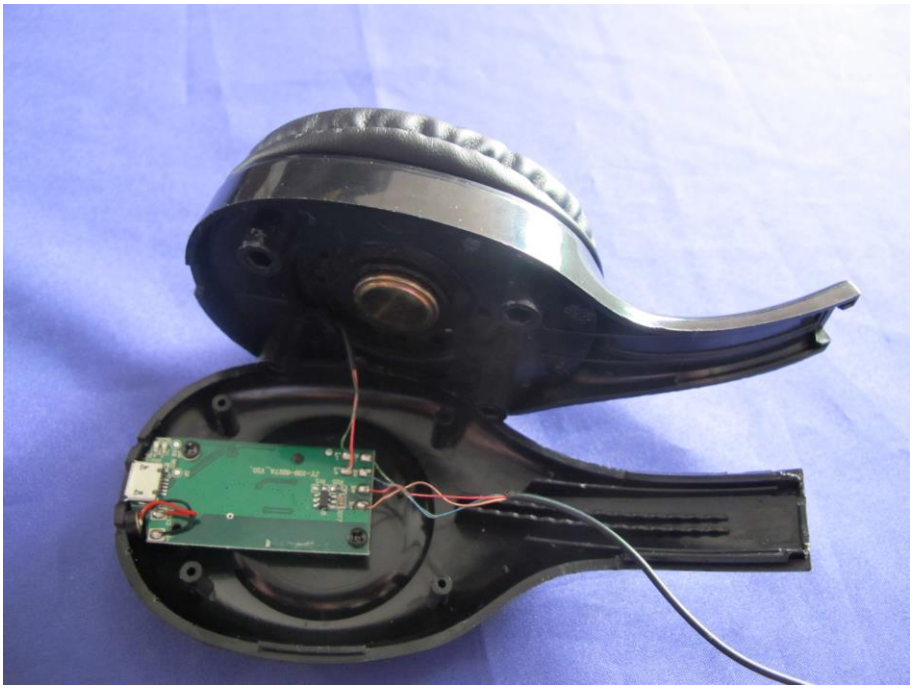
# 5. Test Setup Photos of the EUT

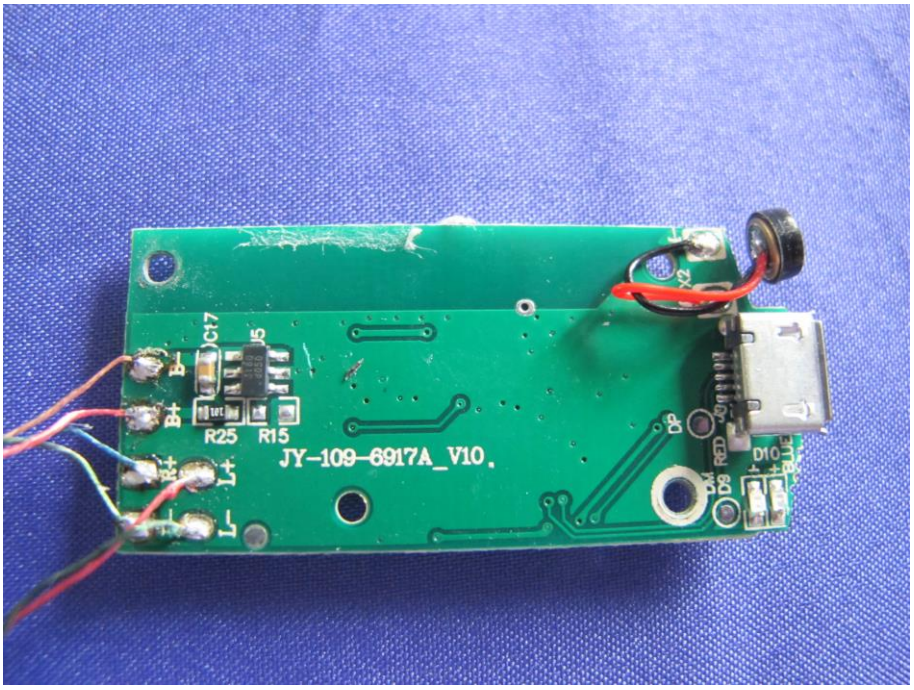


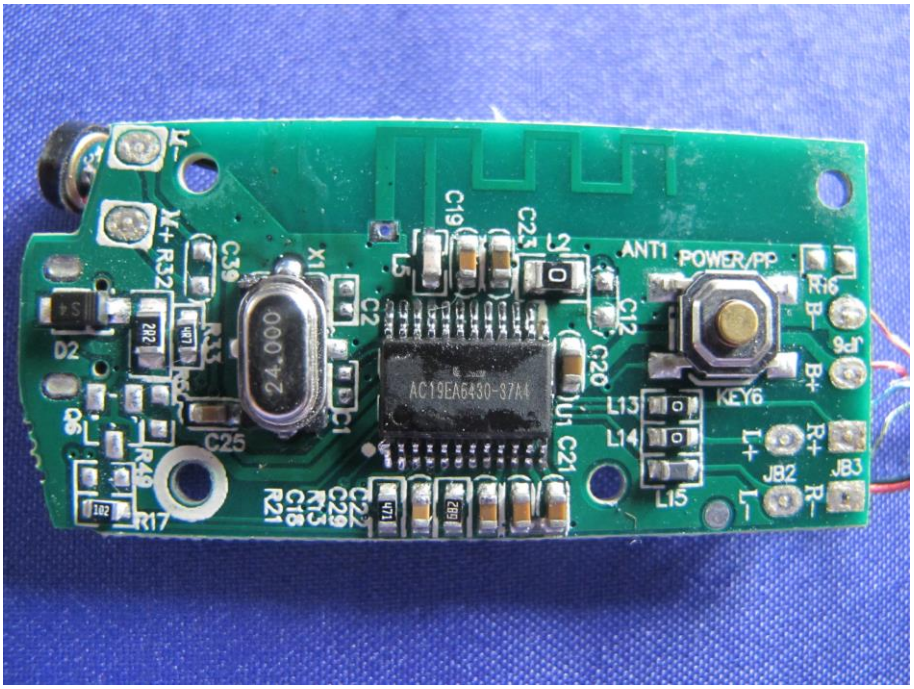




# 6. Photos of the EUT




JY-109-6917A_V10.
R25
R15
C17
B-
B+
L+
L-
D10


C19
C23
L2
ANT1
POWER/PP
C39
X1
C2
C12
C20
L13
L14
L15
KEY6
JB2
JB3
C25
C21
R17
24.000
AC19EA6430-37AA


**.....End of Report.....**