

# TEST REPORT

Product Name: Bluetooth WiFi wireless development board module  
FCC ID: 2A6GS-ESP32  
Trademark: Teyleten Robot, Songhe, MainKos  
Model Number: ESP32, D1 Mini, LUA, ESP8266, wireless module  
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Sample Received Date: Apr. 10, 2022  
Sample tested Date: Apr. 10, 2022 to Apr. 14, 2022  
Issue Date: Apr. 14, 2022  
Report No.: CTB220414019RFX  
Test Standards: FCC Part15.247  
ANSI C63.10:2013  
Test Results: PASS  
Remark: This is Bluetooth radio test report.

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Reviewed by:

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Approved by:

Bin Mei / Director

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*(Note: N/A means not applicable)*

## 1. VERSION

| Report No.      | Issue Date    | Description | Approved |
|-----------------|---------------|-------------|----------|
| CTB220414019RFX | Apr. 14, 2022 | Original    | Valid    |

## 2. TEST SUMMARY

The Product has been tested according to the following specifications:

| Test Item                                     | Test Requirement                                     | Test method                                  | Result |
|-----------------------------------------------|------------------------------------------------------|----------------------------------------------|--------|
| AC Power Line Conducted Emission              | 47 CFR Part 15 Subpart C Section 15.207              | ANSI C63.10-2013                             | Pass   |
| Radiated Spurious emissions                   | 47 CFR Part 15 Subpart C Section 15.205/15.209       | ANSI C63.10-2013                             | PASS   |
| Band edge and RF Conducted Spurious Emissions | 47 CFR Part 15 Subpart C Section 15.247(d)/15.205(a) | ANSI C63.10-2013                             | PASS   |
| Conducted Peak Output Power                   | 47 CFR Part 15 Subpart C Section 15.247 (b)(3)       | ANSI C63.10-2013                             | PASS   |
| Bandwidth                                     | 47 CFR Part 15 Subpart C Section 15.247 (a)(2)       | ANSI C63.10-2013                             | PASS   |
| Power Spectral Density                        | 47 CFR Part 15 Subpart C Section 15.247 (e)          | ANSI C63.10-2013/<br>KDB 558074<br>D01v05r02 | PASS   |
| Antenna Requirement                           | 47 CFR Part 15 Subpart C Section 15.203/15.247 (b)   | ANSI C63.10-2013                             | PASS   |

Remark:

Test according to ANSI C63.4-2014 & ANSI C63.10-2013.

### 3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the Product as specified in CISPR 16-4-2. This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of  $k=2$ .

| Item                                                  | Uncertainty        |
|-------------------------------------------------------|--------------------|
| Occupancy bandwidth                                   | 54.3kHz            |
| Conducted output power<br>Above 1G                    | 0.9dB              |
| Conducted output power<br>below 1G                    | 0.9dB              |
| Power Spectral Density , Conduction                   | 0.9dB              |
| Conduction spurious emissions                         | 2.0dB              |
| Out of band emission                                  | 2.0dB              |
| 3m chamber Radiated spurious<br>emission(9K-30MHz)    | 4.8dB              |
| 3m chamber Radiated spurious<br>emission(30MHz-1GHz)  | 4.6dB              |
| 3m chamber Radiated spurious<br>emission(1GHz-18GHz)  | 5.1dB              |
| 3m chamber Radiated spurious<br>emission(18GHz-40GHz) | 3.4dB              |
| humidity uncertainty                                  | 5.5%               |
| Temperature uncertainty                               | 0.63°C             |
| frequency                                             | $1 \times 10^{-7}$ |
| Conducted Emission (150KHz-30MHz)                     | 3.2 dB             |
| Radiated Emission(30MHz ~ 1000MHz)                    | 4.8 dB             |
| Radiated Emission(1GHz ~6GHz)                         | 4.9 dB             |

## 4. PRODUCT INFORMATION AND TEST SETUP

### 4.1 Product Information

|                       |                                                                                                 |
|-----------------------|-------------------------------------------------------------------------------------------------|
| Model(s):             | ESP32, D1 Mini, LUA, ESP8266, wireless module                                                   |
| Model Description:    | All the model are the same circuit and RF module, only for model name. Test sample model: ESP32 |
| Bluetooth Version:    | Bluetooth V5.0                                                                                  |
| Hardware Version:     | V1.0                                                                                            |
| Software Version:     | V1.0                                                                                            |
| Operation Frequency:  | Bluetooth: 2402-2480MHz                                                                         |
| Max. RF output power: | Bluetooth: -0.058dBm                                                                            |
| Type of Modulation:   | Bluetooth: GFSK                                                                                 |
| Antenna installation: | PCB antenna                                                                                     |
| Antenna Gain:         | Bluetooth:1.0dBi                                                                                |
| Ratings:              | DC 3.0V~DC3.6V.                                                                                 |

### 4.2 Test Setup Configuration

See test photographs attached in EUT TEST SETUP PHOTOGRAPHS for the actual connections between Product and support equipment.

### 4.3 Support Equipment

| Item | Equipment | Mfr/Brand | Model/Type No. | Series No. | Note |
|------|-----------|-----------|----------------|------------|------|
| 1.   | PC        | lenovo    | V130           | N/A        | AC   |

#### Notes:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

#### 4.4 Channel List

| CH No. | Frequency (MHz) | CH No. | Frequency (MHz) | CH No. | Frequency (MHz) | CH No. | Frequency (MHz) |
|--------|-----------------|--------|-----------------|--------|-----------------|--------|-----------------|
| 0      | 2402            | 1      | 2404            | 2      | 2406            | 3      | 2408            |
| 4      | 2410            | 5      | 2412            | 6      | 2414            | 7      | 2416            |
| 8      | 2418            | 9      | 2420            | 10     | 2422            | 11     | 2424            |
| 12     | 2426            | 13     | 2428            | 14     | 2430            | 15     | 2432            |
| 16     | 2434            | 17     | 2436            | 18     | 2438            | 19     | 2440            |
| 20     | 2442            | 21     | 2444            | 22     | 2446            | 23     | 2448            |
| 24     | 2450            | 25     | 2452            | 26     | 2454            | 27     | 2456            |
| 28     | 2458            | 29     | 2460            | 30     | 2462            | 31     | 2464            |
| 32     | 2466            | 33     | 2468            | 34     | 2470            | 35     | 2472            |
| 36     | 2474            | 37     | 2476            | 38     | 2478            | 39     | 2480            |

#### 4.5 Test Mode

All test mode(s) and condition(s) mentioned were considered and evaluated respectively by performing full tests, the worst data were recorded and reported.

| Test mode              | Low channel | Middle channel | High channel |
|------------------------|-------------|----------------|--------------|
| Transmitting<br>(GFSK) | 2402MHz     | 2440MHz        | 2480MHz      |

#### 4.6 Test Environment

|                            |       |
|----------------------------|-------|
| Humidity(%):               | 55    |
| Atmospheric Pressure(kPa): | 101.1 |
| Normal Voltage(DC):        | 3.0V  |
| Normal Temperature(°C)     | 25    |
| Low Temperature(°C)        | 0     |
| High Temperature(°C)       | 40    |

## 5. TEST FACILITY AND TEST INSTRUMENT USED

### 5.1 Test Facility

All measurement facilities used to collect the measurement data are located at Floor 1&2, Building A, No. 26 of Xinhe Road, Xinqiao Street, Baoan District, Shenzhen China. The site and apparatus are constructed in conformance with the requirements of ANSI C63.4 and CISPR 16-1-1 other equivalent standards.

### 5.2 Test Instrument Used

| No. | Equipment                                 | Manufacturer | Model No.             | Serial No.   | Calibrated date | Calibrated until |
|-----|-------------------------------------------|--------------|-----------------------|--------------|-----------------|------------------|
| 1   | Spectrum Analyzer                         | Agilent      | N9020A                | MY52090073   | 2021.09.27      | 2022.08.05       |
| 2   | Power Sensor                              | Agilent      | U2021XA               | MY56120032   | 2021.09.27      | 2022.08.05       |
| 3   | Power Sensor                              | Agilent      | U2021XA               | MY56120034   | 2021.09.27      | 2022.08.05       |
| 4   | Communication test set                    | R&S          | CMW500                | 108058       | 2021.09.27      | 2022.08.05       |
| 5   | Spectrum Analyzer                         | R&S          | FSP40                 | 100550       | 2021.09.27      | 2022.08.05       |
| 6   | Signal Generator                          | Agilent      | N5181A                | MY49060920   | 2021.09.27      | 2022.08.16       |
| 7   | Signal Generator                          | Agilent      | N5182A                | MY47420195   | 2021.09.27      | 2022.08.05       |
| 8   | Communication test set                    | Agilent      | E5515C                | MY50102567   | 2021.09.27      | 2022.08.16       |
| 9   | band rejection filter                     | Shenxiang    | MSF2400-2483.5MS-1154 | 20181015001  | 2021.09.27      | 2022.08.05       |
| 10  | band rejection filter                     | Shenxiang    | MSF5150-5850MS-1155   | 20181015001  | 2021.09.27      | 2022.08.05       |
| 11  | band rejection filter                     | Xingbo       | XBLBQ-DZA120          | 190821-1-1   | 2021.09.27      | 2022.08.05       |
| 12  | BT&Wi-Fi Automatic test software          | Microwave    | MTS8310               | Ver. 2.0.0.0 | 2021.09.27      | 2022.08.05       |
| 13  | Rohde & Schwarz SFU Broadcast Test System | R&S          | SFU                   | 101017       | 2021.09.27      | 2022.08.05       |
| 14  | Temperature humidity chamber              | Hongjing     | TH-80CH               | DG-15174     | 2021.09.27      | 2022.08.05       |
| 15  | 234G Automatic test software              | Microwave    | MTS8200               | Ver. 2.0.0.0 | 2021.09.27      | 2022.08.05       |

|    |                          |             |           |            |            |            |
|----|--------------------------|-------------|-----------|------------|------------|------------|
| 16 | 966 chamber              | C.R.T.      | 966 Room  | 966        | 2021.09.27 | 2024.08.11 |
| 17 | Receiver                 | R&S         | ESPI      | 100362     | 2021.09.27 | 2022.08.05 |
| 18 | Amplifier                | HP          | 8447E     | 2945A02747 | 2021.09.27 | 2022.08.05 |
| 19 | Amplifier                | Agilent     | 8449B     | 3008A01838 | 2021.09.27 | 2022.08.05 |
| 20 | TRILOG Broadband Antenna | Schwarzbeck | VULB 9163 | 869        | 2021.09.27 | 2022.08.07 |
| 21 | Horn Antenna             | Schwarzbeck | BBHA9120D | 1911       | 2021.09.27 | 2022.08.08 |
| 22 | Software                 | Fala        | EZ-EMC    | FA-03A2 RE | 2021.09.27 | 2022.08.05 |
| 23 | 3-Loop Antenna           | Daze        | ZN30401   | 17014      | 2021.09.27 | 2022.08.05 |
| 24 | loop antenna             | ZHINAN      | ZN30900A  | /          | 2021.09.27 | 2022.08.05 |
| 25 | Horn antenna             | A/H/System  | SAS-574   | 588        | 2021.09.27 | 2022.08.05 |
| 26 | Amplifier                | AEROFLEX    | /         | S/N/ 097   | 2021.09.27 | 2022.08.05 |

## Continuous disturbance

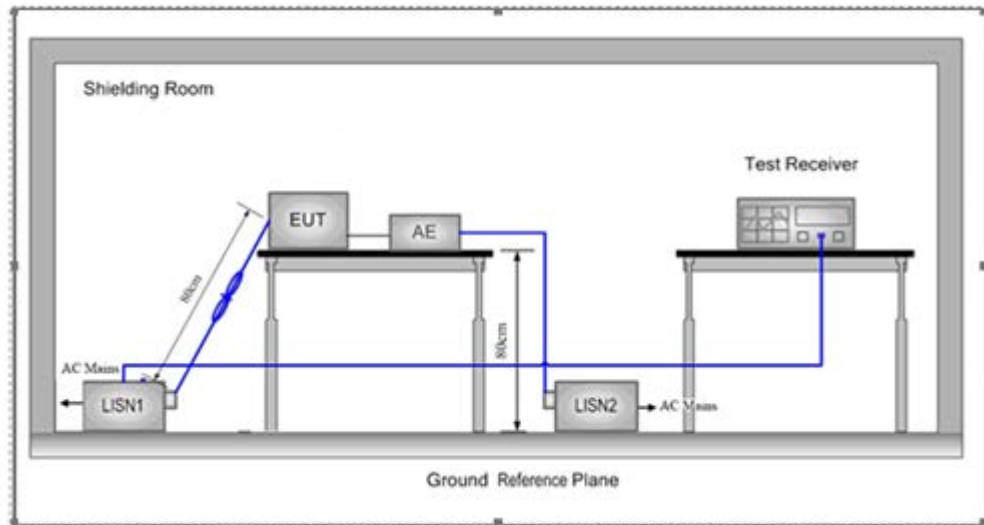
| No. | Equipment              | Manufacturer  | Model No.    | Serial No. | Calibrated date | Calibrated until |
|-----|------------------------|---------------|--------------|------------|-----------------|------------------|
| 1   | AMN                    | ROHDE&SCHWARZ | ESH3-Z5      | 831551852  | 2021.09.27      | 2022.08.05       |
| 2   | Pulse limiter          | ROHDE&SCHWARZ | ESH3Z2       | 357881052  | 2021.09.27      | 2022.08.05       |
| 3   | EMI TEST RECEIVER      | ROHDE&SCHWARZ | ESCI         | 100428/003 | 2021.09.27      | 2022.08.05       |
| 4   | Coaxial cable          | ZDECL         | Z302S        | 18091904   | 2021.09.27      | 2022.08.05       |
| 5   | AAN                    | Schwarzbeck   | NTFM8158     | 183        | 2021.09.27      | 2022.08.05       |
| 6   | Communication test set | Agilent       | E5515C       | MY50102567 | 2021.09.27      | 2022.08.16       |
| 7   | Communication test set | R&S           | CMW500       | 108058     | 2021.09.27      | 2022.08.05       |
| 8   | EZ-EMC                 | Frad          | EMC-con3A1.1 | /          | /               | /                |

## Radiated emission

| No. | Equipment                            | Manufacturer  | Model No.              | Serial No. | Calibrated date | Calibrated until |
|-----|--------------------------------------|---------------|------------------------|------------|-----------------|------------------|
| 1   | Double Ridged Broadband Horn Antenna | Schwarzbeck   | BBHA 9120D             | 1911       | 2021.09.27      | 2022.08.08       |
| 2   | TRILOG Broadband Antenna             | Schwarzbeck   | VULB 9168              | 869        | 2021.09.27      | 2022.08.05       |
| 3   | Amplifier                            | Agilent       | 8449B                  | 3008A01838 | 2021.09.27      | 2022.08.05       |
| 4   | Amplifier                            | HP            | 8447E                  | 2945A02747 | 2021.09.27      | 2022.08.05       |
| 5   | EMI TEST RECEIVER                    | ROHDE&SCHWARZ | ESPI7                  | 100362     | 2021.09.27      | 2022.08.05       |
| 6   | Coaxial cable                        | ETS           | RFC-SNS-100-NMS-80 NI  | /          | 2021.09.27      | 2022.08.05       |
| 7   | Coaxial cable                        | ETS           | RFC-SNS-100-NMS-20 NI  | /          | 2021.09.27      | 2022.08.05       |
| 8   | Coaxial cable                        | ETS           | RFC-SNS-100-SMS-20 NI  | /          | 2021.09.27      | 2022.08.05       |
| 9   | Coaxial cable                        | ETS           | RFC-NNS-100-NMS-300 NI | /          | 2021.09.27      | 2022.08.05       |
| 10  | Communication test set               | Agilent       | E5515C                 | MY50102567 | 2021.09.27      | 2022.08.16       |
| 11  | Communication test set               | R&S           | CMW500                 | 108058     | 2021.09.27      | 2022.08.05       |
| 12  | EZ-EMC                               | Frad          | EMC-con3A1.1           | /          | /               | /                |

## 6. AC POWER LINE CONDUCTED EMISSION

### 6.1 Block Diagram Of Test Setup



### 6.2 Limit

Table 4 – AC power-line conducted emissions limits

| Frequency (MHz) | Conducted limit (dB $\mu$ V) |                            |
|-----------------|------------------------------|----------------------------|
|                 | Quasi-peak                   | Average                    |
| 0.15 - 0.5      | 66 to 56 <sup>Note 1</sup>   | 56 to 46 <sup>Note 1</sup> |
| 0.5 - 5         | 56                           | 46                         |
| 5 - 30          | 60                           | 50                         |

**Note 1:** The level decreases linearly with the logarithm of the frequency.

\* Decreasing linearly with the logarithm of the frequency

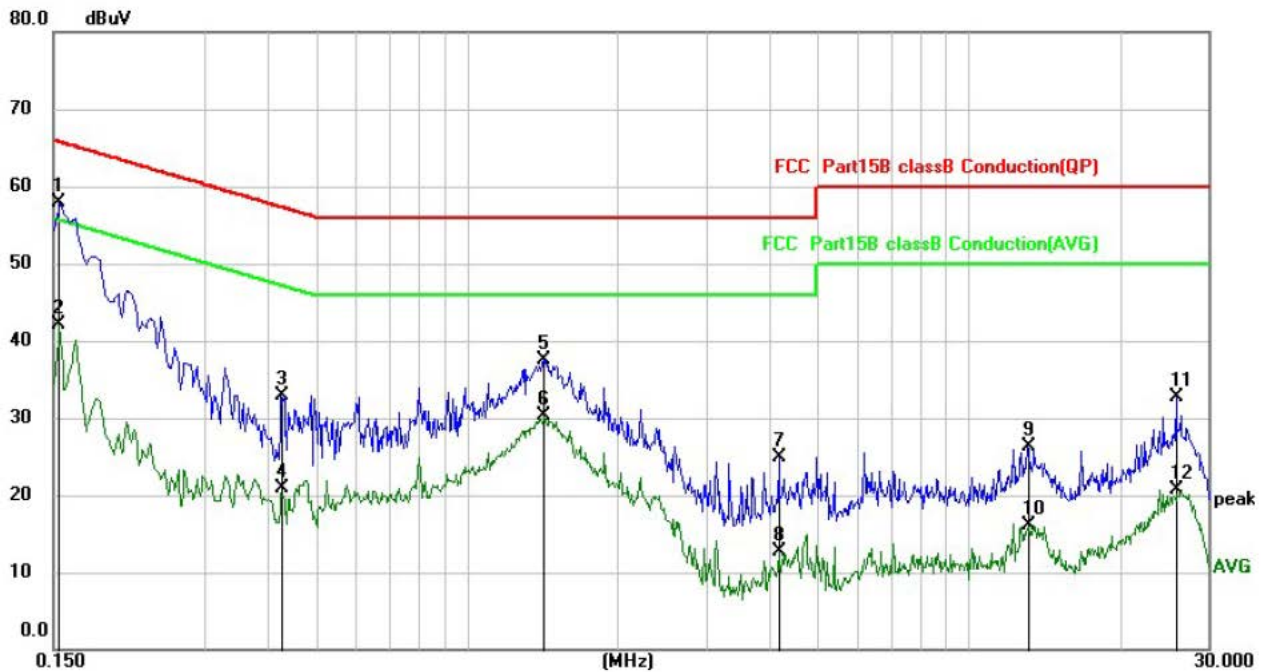
### 6.3 Test procedure

- 1) The mains terminal disturbance voltage test was conducted in a shielded room.
- 2) The EUT was connected to AC power source through a LISN 1 (Line Impedance Stabilization Network) which provides a  $50\Omega/50\mu\text{H} + 5\Omega$  linear impedance. The power cables of all other units of the EUT were connected to a second LISN 2, which was bonded to the ground reference plane in the same way as the LISN 1 for the unit being measured. A multiple socket outlet strip was used to connect multiple power cables to a single LISN provided the rating of the LISN was not exceeded.
- 3) The tabletop EUT was placed upon a non-metallic table 0.8m above the ground reference plane. And for floor-standing arrangement, the EUT was placed on the horizontal ground reference plane,

- 4) The test was performed with a vertical ground reference plane. The rear of the EUT shall be 0,4 m from the vertical ground reference plane. The vertical ground reference plane was bonded to the horizontal ground reference plane. The LISN 1 was placed 0,8 m from the boundary of the unit under test and bonded to a ground reference plane for LISNs mounted on top of the ground reference plane. This distance was between the closest points of the LISN 1 and the EUT. All other units of the EUT and associated equipment was at least 0,8 m from the LISN 2.
- 5) In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10 on conducted measurement.
- 6) All modes were tested at AC 120V and 240V, only the worst result of AC 120V 60Hz was reported.
- 7) If a EUT received DC power from the USB Port of Notebook PC, the PC's adapter received AC120V/60Hz power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.

## 6.4 Test Result

L:

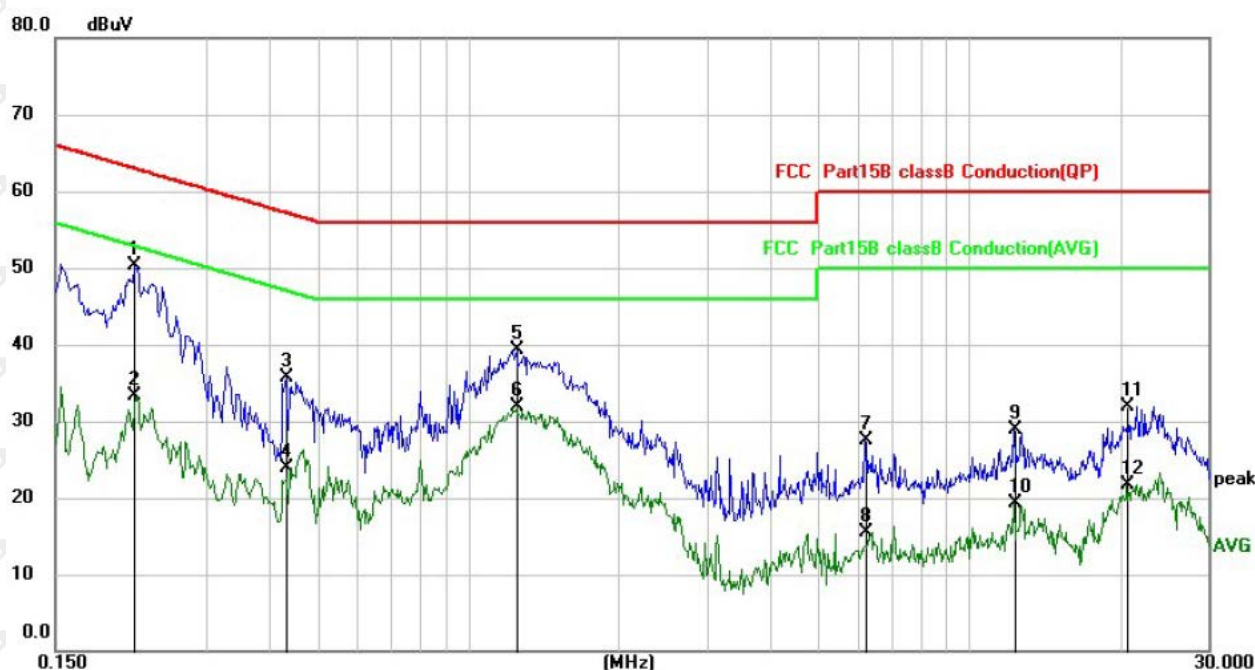


| No. | Mk. | Freq.<br>MHz | Reading<br>Level<br>dBuV | Correct<br>Factor<br>dB | Measure-<br>ment<br>dBuV | Limit<br>dBuV | Margin<br>dB | Detector |
|-----|-----|--------------|--------------------------|-------------------------|--------------------------|---------------|--------------|----------|
| 1   | *   | 0.1539       | 47.28                    | 10.72                   | 58.00                    | 65.79         | -7.79        | QP       |
| 2   |     | 0.1539       | 31.29                    | 10.72                   | 42.01                    | 55.79         | -13.78       | AVG      |
| 3   |     | 0.4260       | 22.30                    | 10.56                   | 32.86                    | 57.33         | -24.47       | QP       |
| 4   |     | 0.4260       | 10.35                    | 10.56                   | 20.91                    | 47.33         | -26.42       | AVG      |
| 5   |     | 1.4220       | 26.89                    | 10.62                   | 37.51                    | 56.00         | -18.49       | QP       |
| 6   |     | 1.4220       | 19.67                    | 10.62                   | 30.29                    | 46.00         | -15.71       | AVG      |
| 7   |     | 4.1819       | 14.31                    | 10.64                   | 24.95                    | 56.00         | -31.05       | QP       |
| 8   |     | 4.1819       | 2.01                     | 10.64                   | 12.65                    | 46.00         | -33.35       | AVG      |
| 9   |     | 13.0819      | 15.38                    | 10.87                   | 26.25                    | 60.00         | -33.75       | QP       |
| 10  |     | 13.0819      | 5.29                     | 10.87                   | 16.16                    | 50.00         | -33.84       | AVG      |
| 11  |     | 25.9100      | 21.66                    | 11.01                   | 32.67                    | 60.00         | -27.33       | QP       |
| 12  |     | 25.9100      | 9.70                     | 11.01                   | 20.71                    | 50.00         | -29.29       | AVG      |

Remark:

Factor = Cable loss + LISN factor, Margin = Measurement – Limit

N:



| No. | Mk. | Freq.   | Reading | Correct | Measure- | Limit | Margin | Detector |
|-----|-----|---------|---------|---------|----------|-------|--------|----------|
|     |     | MHz     | Level   | Factor  | ment     |       |        |          |
| 1   | *   | 0.2151  | 39.67   | 10.68   | 50.35    | 63.01 | -12.66 | QP       |
| 2   |     | 0.2151  | 22.70   | 10.68   | 33.38    | 53.01 | -19.63 | AVG      |
| 3   |     | 0.4340  | 25.08   | 10.56   | 35.64    | 57.18 | -21.54 | QP       |
| 4   |     | 0.4340  | 13.41   | 10.56   | 23.97    | 47.18 | -23.21 | AVG      |
| 5   |     | 1.2540  | 28.60   | 10.62   | 39.22    | 56.00 | -16.78 | QP       |
| 6   |     | 1.2540  | 21.37   | 10.62   | 31.99    | 46.00 | -14.01 | AVG      |
| 7   |     | 6.2179  | 16.75   | 10.69   | 27.44    | 60.00 | -32.56 | QP       |
| 8   |     | 6.2179  | 4.90    | 10.69   | 15.59    | 50.00 | -34.41 | AVG      |
| 9   |     | 12.2619 | 18.00   | 10.86   | 28.86    | 60.00 | -31.14 | QP       |
| 10  |     | 12.2619 | 8.42    | 10.86   | 19.28    | 50.00 | -30.72 | AVG      |
| 11  |     | 20.6860 | 20.96   | 10.99   | 31.95    | 60.00 | -28.05 | QP       |
| 12  |     | 20.6860 | 10.68   | 10.99   | 21.67    | 50.00 | -28.33 | AVG      |

Remark:

Factor = Cable loss + LISN factor, Margin = Measurement – Limit

## 7. RADIATED SPURIOUS EMISSION

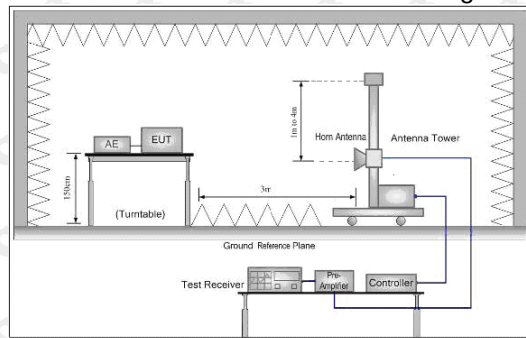
### 7.1 Block Diagram Of Test Setup



Figure 1. Below 30MHz



Figure 2. 30MHz to 1GHz



### 7.2 Limit

Spurious Emissions:

| Frequency         | Field strength<br>(microvolt/meter) | Limit<br>(dB $\mu$ V/m) | Remark     | Measurement<br>distance (m) |
|-------------------|-------------------------------------|-------------------------|------------|-----------------------------|
| 0.009MHz-0.490MHz | 2400/F (kHz)                        | -                       | -          | 300                         |
| 0.490MHz-1.705MHz | 24000/F (kHz)                       | -                       | -          | 30                          |
| 1.705MHz-30MHz    | 30                                  | -                       | -          | 30                          |
| 30MHz-88MHz       | 100                                 | 40.0                    | Quasi-peak | 3                           |
| 88MHz-216MHz      | 150                                 | 43.5                    | Quasi-peak | 3                           |
| 216MHz-960MHz     | 200                                 | 46.0                    | Quasi-peak | 3                           |
| 960MHz-1GHz       | 500                                 | 54.0                    | Quasi-peak | 3                           |
| Above 1GHz        | 500                                 | 54.0                    | Average    | 3                           |

Note: 15.35(b), Unless otherwise specified, the limit on peak radio frequency emissions is 20dB above the maximum permitted average emission limit applicable to the equipment under test. This peak limit applies to the total peak emission level radiated by the device.

### 7.3 Test procedure

**Below 1GHz test procedure as below:**

- a. The EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter semi-anechoic chamber. The table was rotated 360 degrees to determine the position of the highest radiation.
- b. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- c. The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- d. For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters (for the test frequency of below 30MHz, the antenna was tuned to heights 1 meter) and the rota table table was turned from 0 degrees to 360 degrees to find the maximum reading.
- e. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
- f. If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

**Above 1GHz test procedure as below:**

- g. Different between above is the test site, change from Semi- Anechoic Chamber to fully Anechoic Chamber and change form table 0.8 meter to 1.5 meter( Above 18GHz the distance is 1 meter and table is 1.5 meter).
- h. Test the EUT in the lowest channel ,the middle channel ,the Highest channel
- j. Repeat above procedures until all frequencies measured was complete.
- j. Full battery is used during test

Receiver set:

| Frequency         | Detector   | RBW     | VBW    | Remark     |
|-------------------|------------|---------|--------|------------|
| 0.009MHz-0.090MHz | Peak       | 10kHz   | 30KHz  | Peak       |
| 0.009MHz-0.090MHz | Average    | 10kHz   | 30KHz  | Average    |
| 0.090MHz-0.110MHz | Quasi-peak | 10kHz   | 30KHz  | Quasi-peak |
| 0.110MHz-0.490MHz | Peak       | 10kHz   | 30KHz  | Peak       |
| 0.110MHz-0.490MHz | Average    | 10kHz   | 30KHz  | Average    |
| 0.490MHz -30MHz   | Quasi-peak | 10kHz   | 30kHz  | Quasi-peak |
| 30MHz-1GHz        | Quasi-peak | 120 kHz | 300KHz | Quasi-peak |
| Above 1GHz        | Peak       | 1MHz    | 3MHz   | Peak       |
|                   | Peak       | 1MHz    | 10Hz   | Average    |

## 7.4 Test Result

Below 1GHz Test Results:  
Antenna polarity: H



| No. | Mk. | Freq.<br>MHz | Reading<br>Level<br>dBuV | Correct<br>Factor<br>dB | Measure-<br>ment<br>dBuV/m | Limit<br>dB/m | Over<br>dB | Detector |
|-----|-----|--------------|--------------------------|-------------------------|----------------------------|---------------|------------|----------|
| 1   |     | 40.7730      | 31.30                    | -5.30                   | 26.00                      | 40.00         | -14.00     | QP       |
| 2   |     | 81.4970      | 40.13                    | -9.76                   | 30.37                      | 40.00         | -9.63      | QP       |
| 3   |     | 213.7634     | 42.36                    | -7.18                   | 35.18                      | 43.50         | -8.32      | QP       |
| 4   |     | 319.9370     | 38.20                    | -4.51                   | 33.69                      | 46.00         | -12.31     | QP       |
| 5   | *   | 483.0618     | 40.38                    | 0.31                    | 40.69                      | 46.00         | -5.31      | QP       |
| 6   |     | 861.5444     | 28.06                    | 6.14                    | 34.20                      | 46.00         | -11.80     | QP       |

Remark: Factor = Cable lose + Antenna factor - Pre-amplifier; Margin = Measurement – Limit

Antenna polarity: V



| No. | Mk. | Freq.<br>MHz | Reading<br>Level<br>dBuV | Correct<br>Factor<br>dB | Measure-<br>ment<br>dBuV/m | Limit<br>dB/m | Over<br>dB | Detector |
|-----|-----|--------------|--------------------------|-------------------------|----------------------------|---------------|------------|----------|
| 1   |     | 41.1320      | 28.47                    | -5.31                   | 23.16                      | 40.00         | -16.84     | QP       |
| 2   |     | 82.2146      | 43.01                    | -9.76                   | 33.25                      | 40.00         | -6.75      | QP       |
| 3   |     | 184.1667     | 41.98                    | -7.92                   | 34.06                      | 43.50         | -9.44      | QP       |
| 4   |     | 319.9370     | 32.26                    | -4.51                   | 27.75                      | 46.00         | -18.25     | QP       |
| 5   | *   | 483.0618     | 41.79                    | 0.31                    | 42.10                      | 46.00         | -3.90      | QP       |
| 6   |     | 639.4888     | 32.10                    | 3.12                    | 35.22                      | 46.00         | -10.78     | QP       |

Remark: Factor = Cable lose + Antenna factor - Pre-amplifier; Margin = Measurement – Limit

Above 1 GHz Test Results:  
CH Low (2402MHz)  
Horizontal:

| Frequency<br>(MHz)                                            | Meter Reading<br>(dBμV) | Factor<br>(dB) | Emission Level<br>(dBμV/m) | Limits<br>(dBμV/m) | Margin<br>(dB) | Detector<br>Type |
|---------------------------------------------------------------|-------------------------|----------------|----------------------------|--------------------|----------------|------------------|
| 2402                                                          | 109.15                  | -5.84          | 103.31                     | N/A                | N/A            | peak             |
| 2402                                                          | 93.46                   | -5.84          | 87.62                      | N/A                | N/A            | AVG              |
| 4804                                                          | 57.63                   | -3.64          | 53.99                      | 74                 | -20.01         | peak             |
| 4804                                                          | 47.78                   | -3.64          | 44.14                      | 54                 | -9.86          | AVG              |
| 7206                                                          | 58.77                   | -0.95          | 57.82                      | 74                 | -16.18         | peak             |
| 7206                                                          | 50.14                   | -0.95          | 49.19                      | 54                 | -4.81          | AVG              |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. |                         |                |                            |                    |                |                  |

Vertical:

| Frequency<br>(MHz)                                            | Meter Reading<br>(dBμV) | Factor<br>(dB) | Emission Level<br>(dBμV/m) | Limits<br>(dBμV/m) | Margin<br>(dB) | Detector<br>Type |
|---------------------------------------------------------------|-------------------------|----------------|----------------------------|--------------------|----------------|------------------|
| 2402                                                          | 109.72                  | -5.84          | 103.88                     | N/A                | N/A            | peak             |
| 2402                                                          | 93.44                   | -5.84          | 87.60                      | N/A                | N/A            | AVG              |
| 4804                                                          | 58.97                   | -3.64          | 55.33                      | 74                 | -18.67         | peak             |
| 4804                                                          | 48.56                   | -3.64          | 44.92                      | 54                 | -9.08          | AVG              |
| 7206                                                          | 60.15                   | -0.95          | 59.20                      | 74                 | -14.80         | peak             |
| 7206                                                          | 48.81                   | -0.95          | 47.86                      | 54                 | -6.14          | AVG              |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. |                         |                |                            |                    |                |                  |

CH Middle (2440MHz)  
Horizontal:

| Frequency                                                     | Meter Reading | Factor | Emission Level | Limits   | Margin | Detector Type |
|---------------------------------------------------------------|---------------|--------|----------------|----------|--------|---------------|
| (MHz)                                                         | (dBμV)        | (dB)   | (dBμV/m)       | (dBμV/m) | (dB)   |               |
| 2440                                                          | 107.03        | -5.71  | 101.32         | N/A      | N/A    | peak          |
| 2440                                                          | 92.84         | -5.71  | 87.13          | N/A      | N/A    | AVG           |
| 4880                                                          | 55.58         | -3.51  | 52.07          | 74       | -21.93 | peak          |
| 4880                                                          | 45.63         | -3.51  | 42.12          | 54       | -11.88 | AVG           |
| 7320                                                          | 56.50         | -0.82  | 55.68          | 74       | -18.32 | peak          |
| 7320                                                          | 46.39         | -0.82  | 45.57          | 54       | -8.43  | 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)   |               |
| 2440                                                          | 107.96        | -5.71  | 102.25         | N/A      | N/A    | peak          |
| 2440                                                          | 91.79         | -5.71  | 86.08          | N/A      | N/A    | AVG           |
| 4880                                                          | 55.55         | -3.51  | 52.04          | 74       | -21.96 | peak          |
| 4880                                                          | 45.27         | -3.51  | 41.76          | 54       | -12.24 | AVG           |
| 7320                                                          | 56.15         | -0.82  | 55.33          | 74       | -18.67 | peak          |
| 7320                                                          | 47.49         | -0.82  | 46.67          | 54       | -7.33  | AVG           |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. |               |        |                |          |        |               |

CH High (2480MHz)  
Horizontal:

| Frequency                                                     | Meter Reading | Factor | Emission Level | Limits   | Margin | Detector Type |
|---------------------------------------------------------------|---------------|--------|----------------|----------|--------|---------------|
| (MHz)                                                         | (dBμV)        | (dB)   | (dBμV/m)       | (dBμV/m) | (dB)   |               |
| 2480                                                          | 108.11        | -5.65  | 102.46         | N/A      | N/A    | peak          |
| 2480                                                          | 92.52         | -5.65  | 86.87          | N/A      | N/A    | AVG           |
| 4960                                                          | 55.55         | -3.43  | 52.12          | 74       | -21.88 | peak          |
| 4960                                                          | 46.25         | -3.43  | 42.82          | 54       | -11.18 | AVG           |
| 7440                                                          | 55.89         | -0.75  | 55.14          | 74       | -18.86 | peak          |
| 7440                                                          | 47.06         | -0.75  | 46.31          | 54       | -7.69  | 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)   |               |
| 2480                                                          | 105.61        | -5.65  | 99.96          | N/A      | N/A    | peak          |
| 2480                                                          | 91.32         | -5.65  | 85.67          | N/A      | N/A    | AVG           |
| 4960                                                          | 54.46         | -3.43  | 51.03          | 74       | -22.97 | peak          |
| 4960                                                          | 46.70         | -3.43  | 43.27          | 54       | -10.73 | AVG           |
| 7440                                                          | 55.35         | -0.75  | 54.60          | 74       | -19.40 | peak          |
| 7440                                                          | 45.97         | -0.75  | 45.22          | 54       | -8.78  | AVG           |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. |               |        |                |          |        |               |

Remark:

- (1) Measuring frequencies from 9KHz to the 25 GHz.
- (2) All modes of GFSK were test at Low, Middle, and High channel, only the worst result of GFSK Low Channel was reported for below 1GHz test.
- (3) For BT above 1GHz test all modes of GFSK were test at Low, Middle, and High channel, only the worst result of GFSK Low Channel was reported.
- (4) By preliminary testing and verifying three axis (X, Y and Z) position of EUT transmitted status, it was found that "Z axis" position was the worst, and test data recorded in this report.
- (5) Radiated emission test from 9kHz to 10th harmonic of fundamental was verified, and no emission found except system noise floor in 9kHz to 30MHz and not recorded in this report.

**Restricted bands around fundamental frequency (Radiated)**

Operation Mode: TX CH Low (2402MHz)

Horizontal (Worst case)

| Frequency<br>(MHz) | Meter Reading<br>(dBμV) | Factor<br>(dB) | Emission Level<br>(dBμV/m) | Limits<br>(dBμV/m) | Margin<br>(dB) | Detector<br>Type |
|--------------------|-------------------------|----------------|----------------------------|--------------------|----------------|------------------|
| 2310               | 53.61                   | -5.81          | 47.80                      | 74                 | -26.20         | peak             |
| 2310               | /                       | -5.81          | /                          | 54                 | /              | AVG              |
| 2390               | 53.07                   | -5.84          | 47.23                      | 74                 | -26.77         | peak             |
| 2390               | /                       | -5.84          | /                          | 54                 | /              | AVG              |
| 2400               | 54.83                   | -5.84          | 48.99                      | 74                 | -25.01         | peak             |
| 2400               | /                       | -5.84          | /                          | 54                 | /              | AVG              |

Vertical:

| Frequency<br>(MHz) | Meter Reading<br>(dBμV) | Factor<br>(dB) | Emission Level<br>(dBμV/m) | Limits<br>(dBμV/m) | Margin<br>(dB) | Detector<br>Type |
|--------------------|-------------------------|----------------|----------------------------|--------------------|----------------|------------------|
| 2310               | 56.76                   | -5.81          | 50.95                      | 74                 | -23.05         | peak             |
| 2310               | /                       | -5.81          | /                          | 54                 | /              | AVG              |
| 2390               | 53.41                   | -5.84          | 47.57                      | 74                 | -26.43         | peak             |
| 2390               | /                       | -5.84          | /                          | 54                 | /              | AVG              |
| 2400               | 58.00                   | -5.84          | 52.16                      | 74                 | -21.84         | peak             |
| 2400               | /                       | -5.84          | /                          | 54                 | /              | AVG              |

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

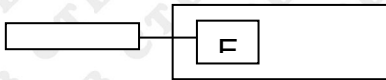
| Frequency                                                     | Reading Result | Factor | Emission Level | Limits   | Margin | Detector Type |
|---------------------------------------------------------------|----------------|--------|----------------|----------|--------|---------------|
| (MHz)                                                         | (dBμV)         | (dB)   | (dBμV/m)       | (dBμV/m) | (dB)   |               |
| 2483.50                                                       | 55.26          | -5.65  | 49.61          | 74       | -24.39 | peak          |
| 2483.50                                                       | /              | -5.65  | /              | 54       | /      | AVG           |
| 2500.00                                                       | 53.93          | -5.65  | 48.28          | 74       | -25.72 | peak          |
| 2500.00                                                       | /              | -5.65  | /              | 54       | /      | AVG           |
| Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier. |                |        |                |          |        |               |

Vertical:

| Frequency                                                                                              | Reading Result | Factor | Emission Level | Limits   | Margin | Detector Type |
|--------------------------------------------------------------------------------------------------------|----------------|--------|----------------|----------|--------|---------------|
| (MHz)                                                                                                  | (dBμV)         | (dB)   | (dBμV/m)       | (dBμV/m) | (dB)   |               |
| 2483.50                                                                                                | 55.60          | -5.65  | 49.95          | 74       | -24.05 | peak          |
| 2483.50                                                                                                | /              | -5.65  | /              | 54       | /      | AVG           |
| 2500.00                                                                                                | 55.73          | -5.65  | 50.08          | 74       | -23.92 | peak          |
| 2500.00                                                                                                | /              | -5.65  | /              | 54       | /      | 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. |                |        |                |          |        |               |

## 8. BAND EDGE AND RF CONDUCTED SPURIOUS EMISSIONS

### 8.1 Block Diagram Of Test Setup



### 8.2 Limit

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)).

### 8.3 Test procedure

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;

2. Set the spectrum analyzer:

Below 30MHz:

RBW = 100kHz, VBW = 300kHz, Sweep = auto

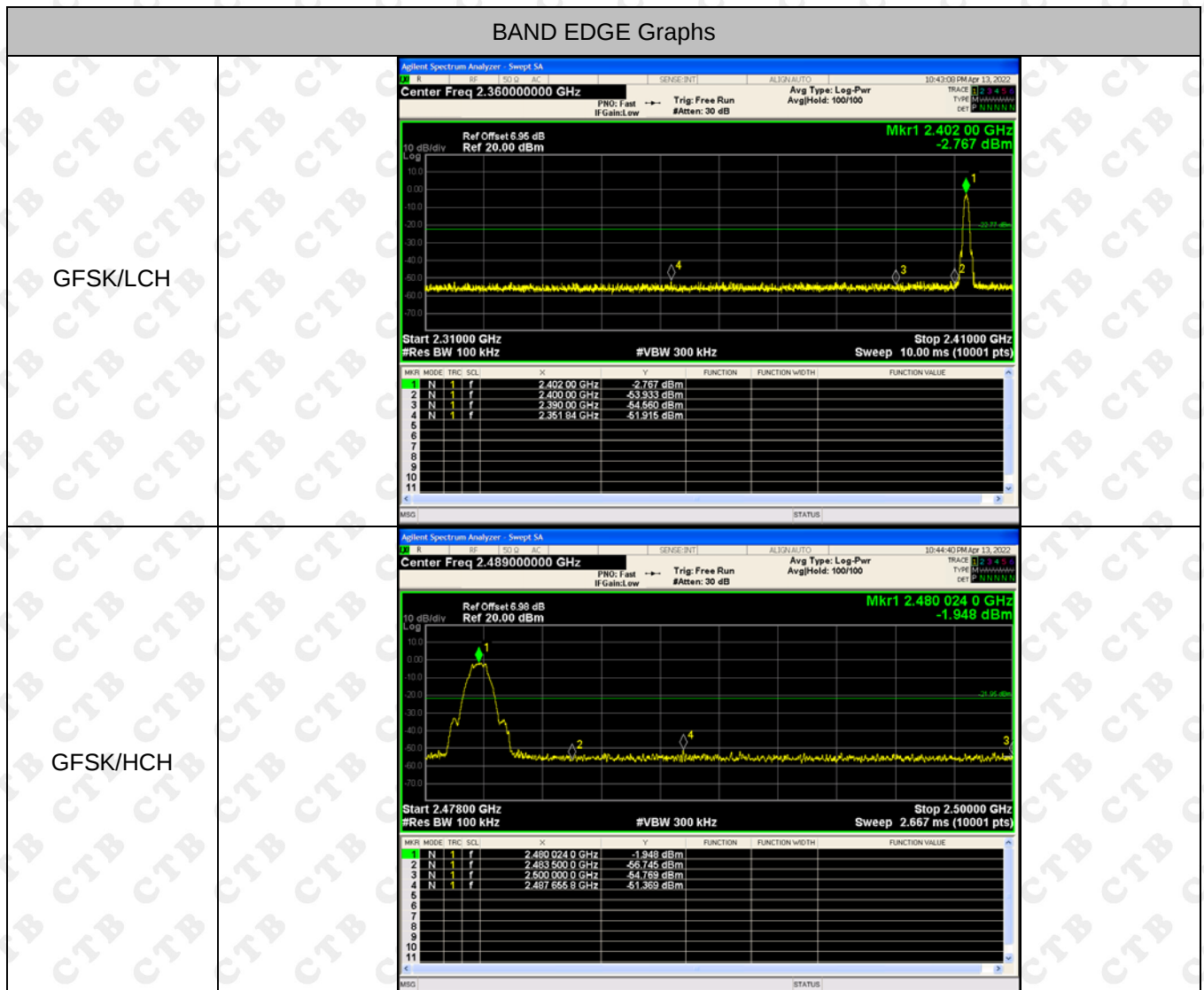
Detector function = peak, Trace = max hold

Above 30MHz:

RBW = 100KHz, VBW = 300KHz, Sweep = auto

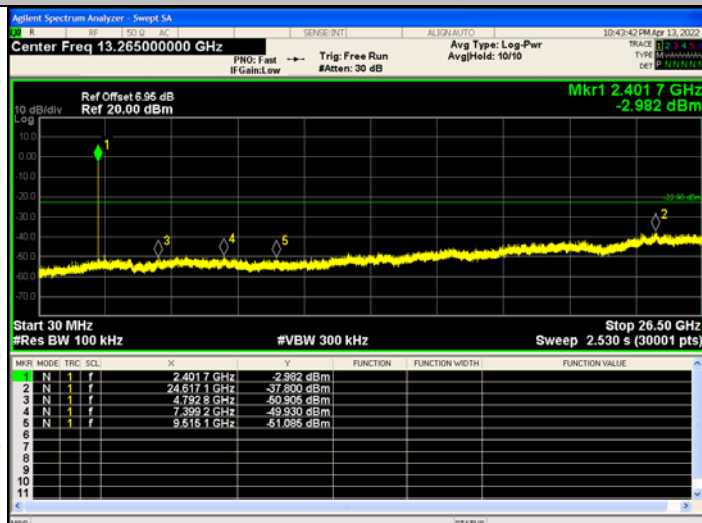
Detector function = peak, Trace = max hold

## 8.4 Test Result

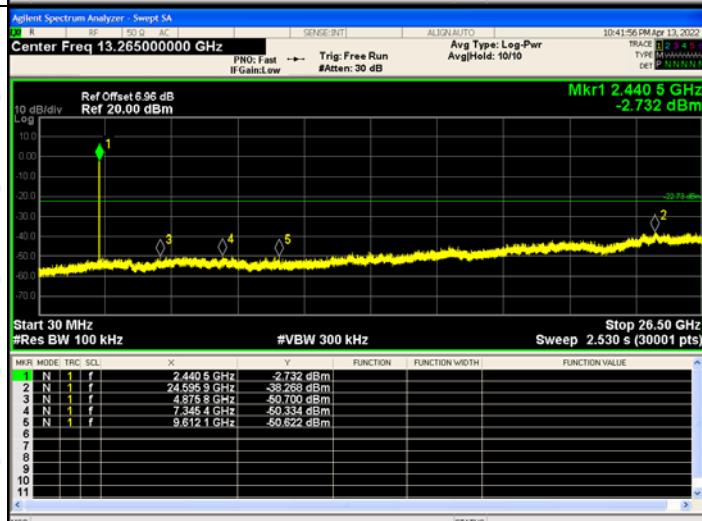


## RF Conducted Spurious Emissions Graphs

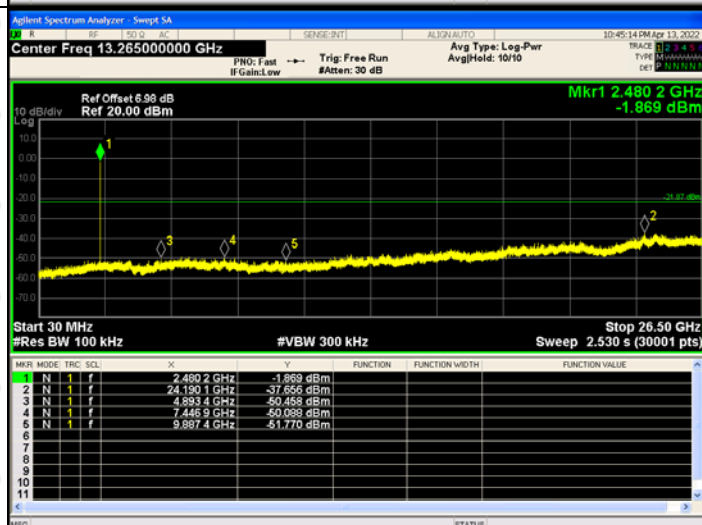
GFSK/LCH



GFSK/MCH

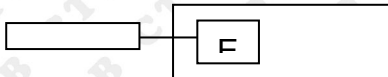


GFSK/HCH



## 9. COUDUCTED OUTPUT POWER

### 9.1 Block Diagram Of Test Setup



### 9.2 Limit

| FCC Part15 (15.247) , Subpart C |              |                 |                       |        |
|---------------------------------|--------------|-----------------|-----------------------|--------|
| Section                         | Test Item    | Limit           | Frequency Range (MHz) | Result |
| 15.247(b)(3)                    | Output Power | 1 watt or 30dBm | 2400-2483.5           | PASS   |

### 9.3 Test procedure

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2. Set the spectrum analyzer: RBW = 2MHz. VBW = 6MHz. Channel power measurement. Sweep = auto; Detector Function = peak.
3. Keep the EUT in transmitting at lowest, middle and highest channel individually. Record the max value.

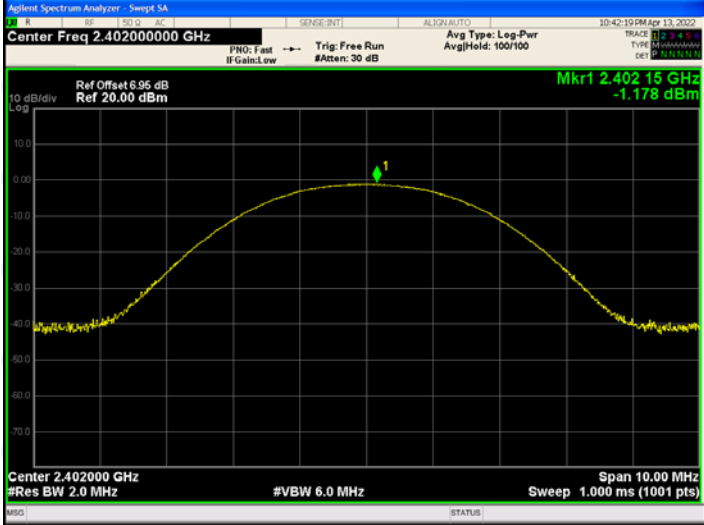
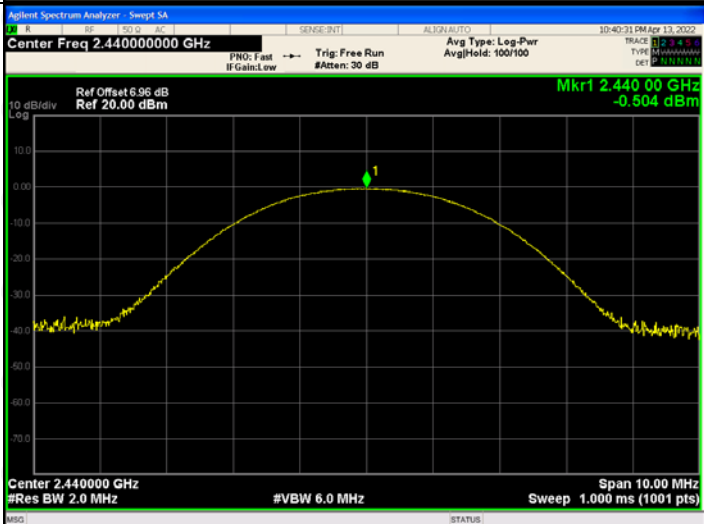
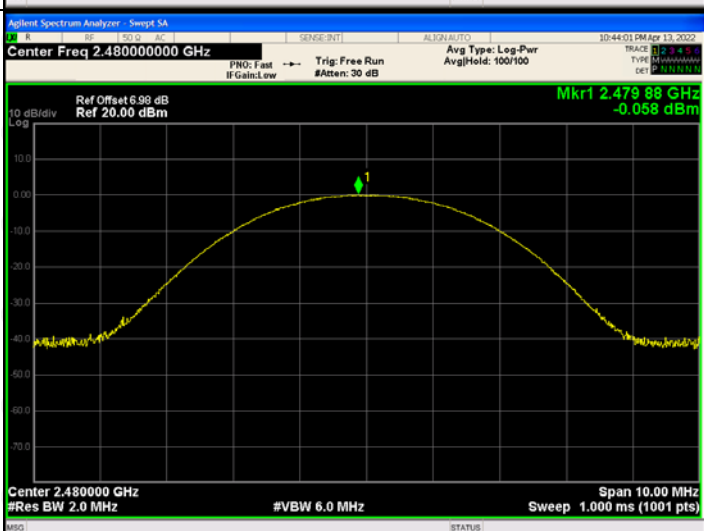
## 9.4 Test Result

| Mode | Channel. | Maximum Output Power [dBm] | Limit[dBm] | Verdict |
|------|----------|----------------------------|------------|---------|
| GFSK | LCH      | -1.178                     | 30         | PASS    |
|      | MCH      | -0.504                     | 30         | PASS    |
|      | HCH      | -0.058                     | 30         | PASS    |

## Duty Cycle

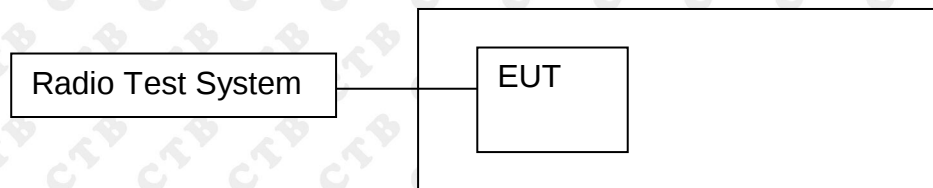
| Mode | Channel. | Duty Cycle(%) | Correction Factor (dB) |
|------|----------|---------------|------------------------|
| GFSK | LCH      | 100           | 0                      |
|      | MCH      | 100           | 0                      |
|      | HCH      | 100           | 0                      |

### Test Graph:

|                              |                                                                                                                                                                                                                                                                                                |
|------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>GFSK<br/>Low channel</p>  |  <p>Agilent Spectrum Analyzer - Sweep SA<br/>Center Freq 2.402000000 GHz<br/>Ref Offset 6.95 dB<br/>Ref 20.00 dBm<br/>Mkr1 2.40215 GHz<br/>-1.178 dBm<br/>Span 10.00 MHz<br/>Sweep 1.000 ms (1001 pts)</p>   |
| <p>GFSK<br/>Mid channel</p>  |  <p>Agilent Spectrum Analyzer - Sweep SA<br/>Center Freq 2.440000000 GHz<br/>Ref Offset 6.95 dB<br/>Ref 20.00 dBm<br/>Mkr1 2.44000 GHz<br/>-0.504 dBm<br/>Span 10.00 MHz<br/>Sweep 1.000 ms (1001 pts)</p>  |
| <p>GFSK<br/>High channel</p> |  <p>Agilent Spectrum Analyzer - Sweep SA<br/>Center Freq 2.480000000 GHz<br/>Ref Offset 6.95 dB<br/>Ref 20.00 dBm<br/>Mkr1 2.47988 GHz<br/>-0.058 dBm<br/>Span 10.00 MHz<br/>Sweep 1.000 ms (1001 pts)</p> |

## 10. 6DB OCCUPIED BANDWIDTH

### 10.1 Block Diagram Of Test Setup



### 10.2 Limit

| FCC Part15 (15.247) , Subpart C |           |                                         |                       |        |
|---------------------------------|-----------|-----------------------------------------|-----------------------|--------|
| Section                         | Test Item | Limit                                   | Frequency Range (MHz) | Result |
| 15.247(a)(2)                    | Bandwidth | $\geq 500\text{KHz}$<br>(6dB bandwidth) | 2400-2483.5           | PASS   |

### 10.3 Test procedure

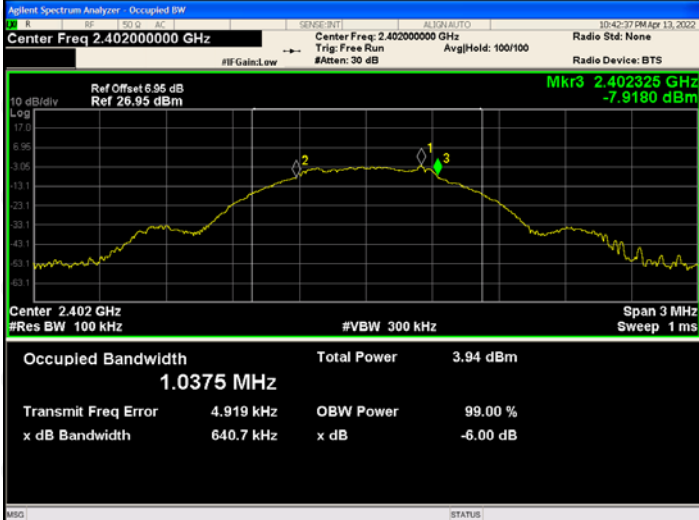
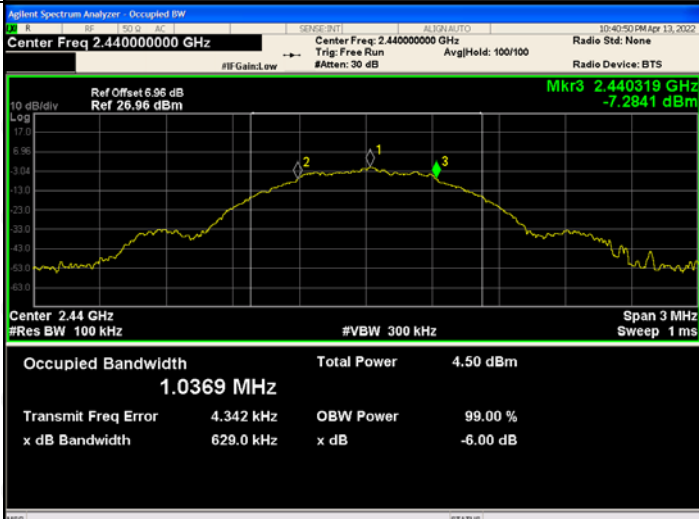
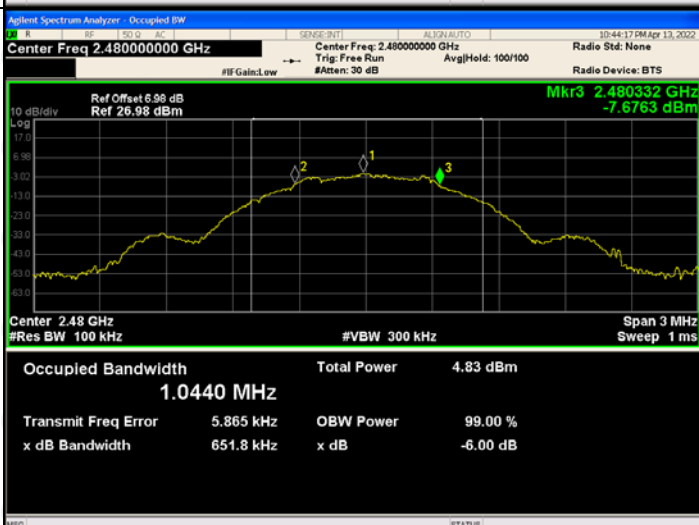
1. Rem1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW)  $\geq 3 \times \text{RBW}$ .
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 6 dB relative to the maximum level measured in the fundamental emission.

### 10.4 Test Result

| Test Mode | Frequency    | 6dB Bandwidth (MHz) | Result |
|-----------|--------------|---------------------|--------|
| GFSK      | Low channel  | 0.641               | PASS   |
|           | Mid channel  | 0.629               | PASS   |
|           | High channel | 0.652               | PASS   |

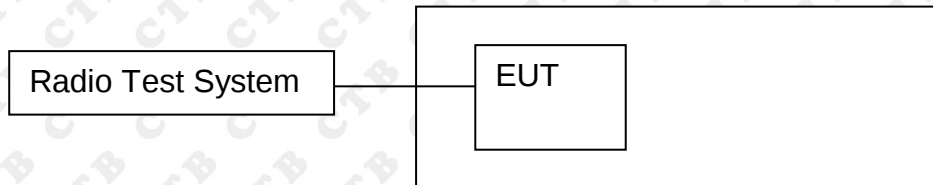
Note: All modes of operation were Pre-scan and the worst-case emissions are reported.

## Test Graph:

|                              |                                                                                      |
|------------------------------|--------------------------------------------------------------------------------------|
| <p>GFSK<br/>Low channel</p>  |    |
| <p>GFSK<br/>Mid channel</p>  |   |
| <p>GFSK<br/>High channel</p> |  |

## 11. POWER SPECTRAL DENSITY

### 11.1 Block Diagram Of Test Setup



### 11.2 Limit

| FCC Part15 (15.247) , Subpart C |                        |                        |                       |        |
|---------------------------------|------------------------|------------------------|-----------------------|--------|
| Section                         | Test Item              | Limit                  | Frequency Range (MHz) | Result |
| 15.247                          | Power Spectral Density | 8 dBm<br>(in any 3KHz) | 2400-2483.5           | PASS   |

### 11.3 Test procedure

1. Set analyzer center frequency to DTS channel center frequency.
2. Set the span to 1.5 times the DTS bandwidth.
3. Set the RBW to:  $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$ .
4. Set the VBW  $\geq 3 \times \text{RBW}$ .
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.

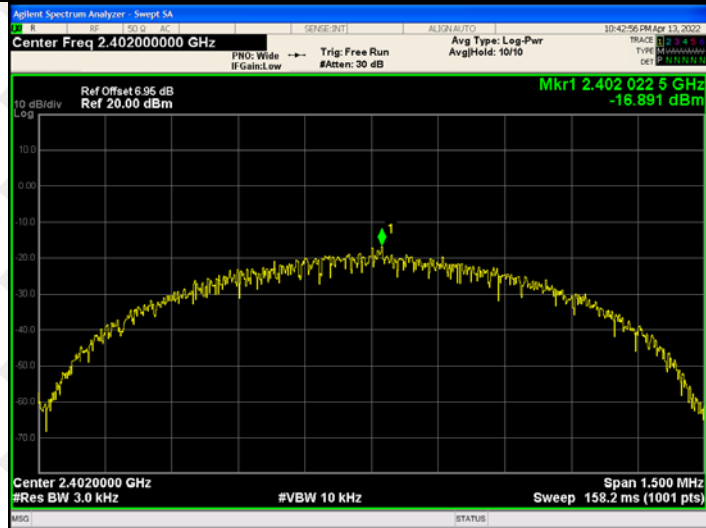
### 11.4 Test Result

| Mode | Channel. | Power Spectral Density (dBm/3KHz) | Limit(dBm/3KHz) | Verdict |
|------|----------|-----------------------------------|-----------------|---------|
| GFSK | LCH      | -16.891                           | 8               | PASS    |
| GFSK | MCH      | -16.219                           | 8               | PASS    |
| GFSK | HCH      | -15.797                           | 8               | PASS    |

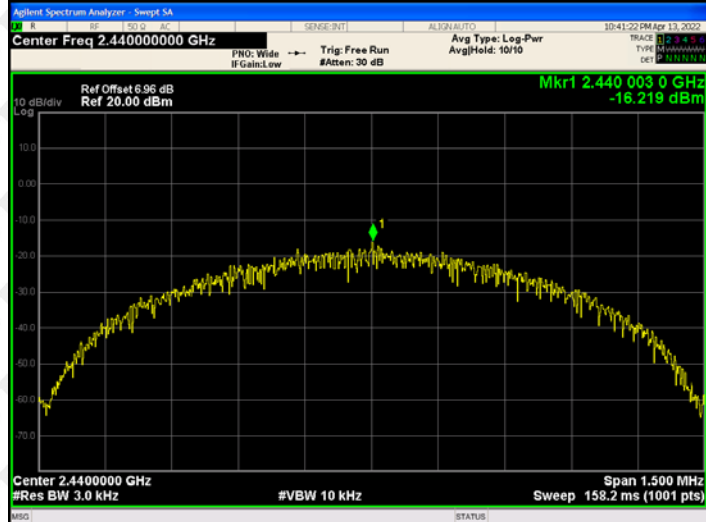
# Test Graph

## Graphs

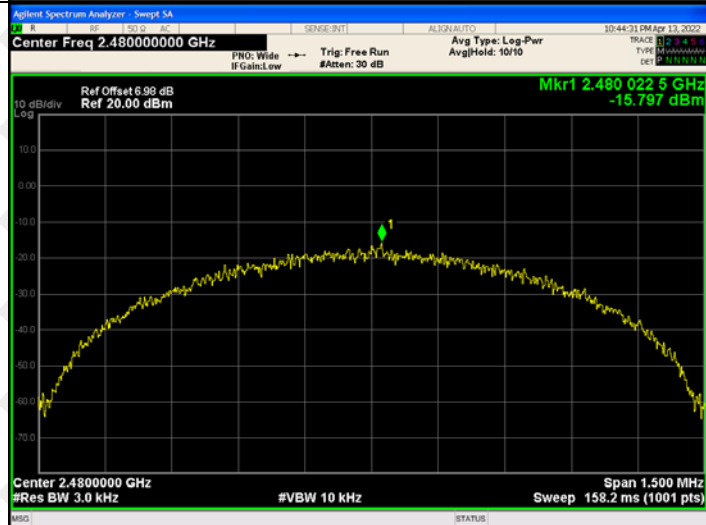
GFSK/LCH



GFSK/MCH



GFSK/HCH



## 12. ANTENNA REQUIREMENT

### 15.203 requirement:

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. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

### 15.247(b) (4) requirement:

The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

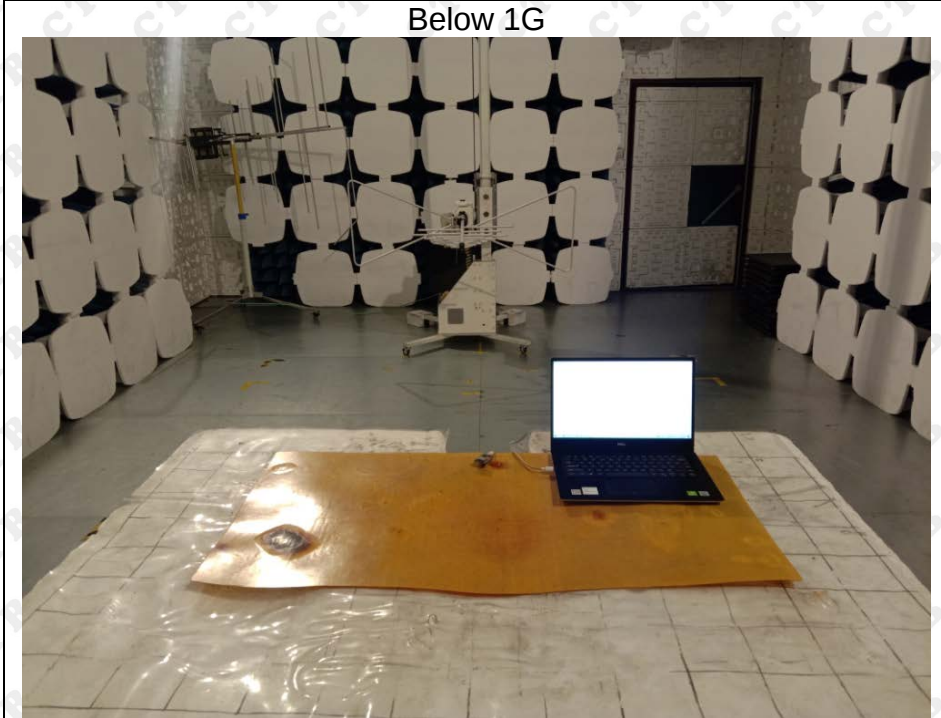
### EUT Antenna:

The EUT antenna is PCB antenna. The best case gain of the antenna is 1.0dBi.

### 13. EUT TEST SETUP PHOTOGRAPHS

#### Radiated Emissions

Below 1G



Above 1G



## Conducted emission



\*\*\*\*\* END OF REPORT \*\*\*\*\*