



中国认可  
国际互认  
检测  
**TESTING**  
**CNAS L6791**

# TEST REPORT

**Applicant:** Ugreen Group Limited  
**Address:** URGEEN Building, Longcheng Industrial Park,  
Longguanxi Road, Longhua, ShenZhen, China  
**Equipment Type:** UGREEN FitBuds  
**Model Name:** WS213  
**Brand Name:** **UGREEN**  
**FCC ID:** 2AQI5-WS213  
**Test Standard:** 47 CFR Part 15 Subpart C  
(refer to section 3.1)  
**Sample Arrival Date:** Apr. 09, 2025  
**Test Date:** Apr. 11, 2025 - Apr. 26, 2025  
**Date of Issue:** Jun. 19, 2025

**ISSUED BY:**

Shenzhen BALUN Technology Co., Ltd.

**Tested by:** Julie Zhu**Checked by:** Ye Hongji**Approved by:** Sunny Zou  
(Technical Director)

### Revision History

| Version        | Issue Date           | Revisions            |
|----------------|----------------------|----------------------|
| <u>Rev. 01</u> | <u>Jun. 19, 2025</u> | <u>Initial Issue</u> |

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# 1 GENERAL INFORMATION

## 1.1 Test Laboratory

|              |                                                                                                                              |
|--------------|------------------------------------------------------------------------------------------------------------------------------|
| Name         | Shenzhen BALUN Technology Co., Ltd.                                                                                          |
| Address      | Block B, 1/F, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China |
| Phone Number | +86 755 6685 0100                                                                                                            |

## 1.2 Test Location

|                           |                                                                                                                                                                                                                         |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Name                      | Shenzhen BALUN Technology Co., Ltd.                                                                                                                                                                                     |
| Location                  | <input checked="" type="checkbox"/> Block B, 1/F, Baisha Science and Technology Park, Shahe Xi Road, Nanshan District, Shenzhen, Guangdong Province, P. R. China                                                        |
|                           | <input type="checkbox"/> 1/F, Building B, Ganghongji High-tech Intelligent Industrial Park, No. 1008, Songbai Road, Yangguang Community, Xili Sub-district, Nanshan District, Shenzhen, Guangdong Province, P. R. China |
| Accreditation Certificate | The laboratory is a testing organization accredited by FCC as a accredited testing laboratory. The designation number is CN1196.                                                                                        |

## 2 PRODUCT INFORMATION

### 2.1 Applicant Information

|           |                                                                                         |
|-----------|-----------------------------------------------------------------------------------------|
| Applicant | Ugreen Group Limited                                                                    |
| Address   | UGREEN Building, Longcheng Industrial Park Longguanxi Road,<br>Longhua, ShenZhen, China |

### 2.2 Manufacturer Information

|              |                                                                                         |
|--------------|-----------------------------------------------------------------------------------------|
| Manufacturer | Ugreen Group Limited                                                                    |
| Address      | UGREEN Building, Longcheng Industrial Park Longguanxi Road,<br>Longhua, ShenZhen, China |

### 2.3 Factory Information

|         |                                                                                   |
|---------|-----------------------------------------------------------------------------------|
| Factory | DONGGUAN HARMONY ELECTRONIC TECHNOLOGY CO., LTD                                   |
| Address | No.3, Jiankai Road, Shipai Town, Dongguan City, Guangdong<br>Province, P.R. China |

### 2.4 General Description for Equipment under Test (EUT)

|                                              |                |
|----------------------------------------------|----------------|
| EUT Name                                     | UGREEN FitBuds |
| Model Name Under Test                        | WS213          |
| Series Model Name                            | N/A            |
| Description of Model<br>name differentiation | N/A            |
| Hardware Version                             | N/A            |
| Software Version                             | N/A            |
| Dimensions (Approx.)                         | N/A            |
| Weight (Approx.)                             | N/A            |

Remark:

- Product Number (P/N) code in the below table, for marketing purpose, will be marked on the marking plate.

|       |         |         |         |         |         |         |        |        |        |        |        |        |          |
|-------|---------|---------|---------|---------|---------|---------|--------|--------|--------|--------|--------|--------|----------|
| 65387 | 65387EU | 65387UK | 65387US | 65387JP | 65387CN | 65387KC | 65387A | 65387B | 65387C | 65387P | 65387X | 65387U | KC-65387 |
| 65655 | 65655EU | 65655UK | 65655US | 65655JP | 65655CN | 65655KC | 65655A | 65655B | 65655C | 65655P | 65655X | 65655U | KC-65655 |

## 2.5 Technical Information

|                                   |                        |
|-----------------------------------|------------------------|
| Network and Wireless connectivity | Bluetooth (BR+EDR+BLE) |
|-----------------------------------|------------------------|

The requirement for the following technical information of the EUT was tested in this report:

|                                     |                                                                                                                          |
|-------------------------------------|--------------------------------------------------------------------------------------------------------------------------|
| Modulation Technology               | FHSS                                                                                                                     |
| Modulation Type                     | GFSK, $\pi/4$ -DQPSK, 8-DPSK                                                                                             |
| Product Type                        | <input type="checkbox"/> Mobile<br><input checked="" type="checkbox"/> Portable<br><input type="checkbox"/> Fix Location |
| Transfer Rate                       | DH5: 1 Mbps<br>2DH5: 2 Mbps<br>3DH5: 3 Mbps                                                                              |
| Frequency Range                     | The frequency range used is 2400 MHz to 2483.5 MHz.                                                                      |
| Number of Channel                   | 79 (at intervals of 1 MHz)                                                                                               |
| Tested Channel                      | 0 (2402 MHz), 39 (2441 MHz), 78 (2480 MHz)                                                                               |
| Antenna Type                        | FPC Antenna                                                                                                              |
| Antenna Gain                        | -2.03 dBi                                                                                                                |
| Antenna Impedance                   | 50 $\Omega$                                                                                                              |
| Antenna System (MIMO Smart Antenna) | N/A                                                                                                                      |

All channel was listed on the following table:

| Channel number | Freq. (MHz) | Channel number | Freq. (MHz) | Channel number | Freq. (MHz) | Channel number | Freq. (MHz) |
|----------------|-------------|----------------|-------------|----------------|-------------|----------------|-------------|
| <b>0</b>       | <b>2402</b> | 21             | 2423        | 42             | 2444        | 63             | 2465        |
| 1              | 2403        | 22             | 2424        | 43             | 2445        | 64             | 2466        |
| 2              | 2404        | 23             | 2425        | 44             | 2446        | 65             | 2467        |
| 3              | 2405        | 24             | 2426        | 45             | 2447        | 66             | 2468        |
| 4              | 2406        | 25             | 2427        | 46             | 2448        | 67             | 2469        |
| 5              | 2407        | 26             | 2428        | 47             | 2449        | 68             | 2470        |
| 6              | 2408        | 27             | 2429        | 48             | 2450        | 69             | 2471        |
| 7              | 2409        | 28             | 2430        | 49             | 2451        | 70             | 2472        |
| 8              | 2410        | 29             | 2431        | 50             | 2452        | 71             | 2473        |
| 9              | 2411        | 30             | 2432        | 51             | 2453        | 72             | 2474        |
| 10             | 2412        | 31             | 2433        | 52             | 2454        | 73             | 2475        |
| 11             | 2413        | 32             | 2434        | 53             | 2455        | 74             | 2476        |
| 12             | 2414        | 33             | 2435        | 54             | 2456        | 75             | 2477        |
| 13             | 2415        | 34             | 2436        | 55             | 2457        | 76             | 2478        |
| 14             | 2416        | 35             | 2437        | 56             | 2458        | 77             | 2479        |
| 15             | 2417        | 36             | 2438        | 57             | 2459        | <b>78</b>      | <b>2480</b> |
| 16             | 2418        | 37             | 2439        | 58             | 2460        | -              | -           |
| 17             | 2419        | 38             | 2440        | 59             | 2461        | -              | -           |
| 18             | 2420        | <b>39</b>      | <b>2441</b> | 60             | 2462        | -              | -           |
| 19             | 2421        | 40             | 2442        | 61             | 2463        | -              | -           |
| 20             | 2422        | 41             | 2443        | 62             | 2464        | -              | -           |

### 3 SUMMARY OF TEST RESULTS

#### 3.1 Test Standards

| No.    | Identity                                      | Document Title                                                                                                                                                                           |
|--------|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | 47 CFR Part 15, Subpart C                     | Intentional radiators of radio frequency equipment                                                                                                                                       |
| 2      | ANSI C63.10-2013                              | American National Standard for Testing Unlicensed Wireless Devices                                                                                                                       |
| 3<br>☆ | KDB 558074 D01 15.247<br>Meas Guidance v05r02 | Guidance for compliance measurements on digital transmission system, frequency hopping spread spectrum system, and hybrid system devices operating under section 15.247 of the FCC rules |

#### 3.2 Test Verdict

| No. | Description                                             | FCC Part No.        | Channel                          | Test Result | Verdict | Remark            |
|-----|---------------------------------------------------------|---------------------|----------------------------------|-------------|---------|-------------------|
| 1   | Antenna Requirement                                     | 15.203              | N/A                              | --          | Pass    | Note <sup>1</sup> |
| 2   | Number of Hopping Frequencies                           | 15.247(a)           | Hopping Mode                     | 5.3.4       | Pass    | Note <sup>2</sup> |
| 3   | Peak Output Power                                       | 15.247(b)           | Low/Middle/High                  | 5.4.4       | Pass    | --                |
| 4   | Occupied Bandwidth                                      | 15.247(a)           | Low/Middle/High                  | 5.5.4       | Pass    | --                |
| 5   | Carrier Frequency Separation                            | 15.247(a)           | Hopping Mode                     | 5.6.4       | Pass    | Note <sup>2</sup> |
| 6   | Time of Occupancy (Dwell time)                          | 15.247(a)           | Hopping Mode                     | 5.7.4       | Pass    | Note <sup>2</sup> |
| 7   | Conducted Spurious Emission & Authorized-band band-edge | 15.247(d)           | Hopping Mode;<br>Low/Middle/High | 5.8.4       | Pass    | Note <sup>2</sup> |
| 8   | Conducted Emission                                      | 15.207              | Low/Middle/High                  | 5.9.4       | Pass    | Note <sup>2</sup> |
| 9   | Radiated Spurious Emission                              | 15.209<br>15.247(d) | Low/Middle/High                  | 5.10.4      | Pass    | Note <sup>2</sup> |
| 10  | Band Edge(Restricted-band band-edge)                    | 15.209<br>15.247(d) | Low/High                         | 5.11.4      | Pass    | Note <sup>2</sup> |

Note <sup>1</sup>: The EUT has a permanently and irreplaceable attached antenna, which complies with the requirement FCC 15.203.

Note <sup>2</sup>:  $\pi/4$ -DQPSK is the EDR 2M rate mode, 8-DPSK is the EDR 3M rate mode. The consistency of test results in  $\pi/4$ -DQPSK and 8-DPSK is very high. So we chose 8-DPSK as a typical representative to appear on the report. Another we will show all the modes on the RF output power test item.

## 4 GENERAL TEST CONFIGURATIONS

### 4.1 Test Environments

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

|                            |                         |                    |
|----------------------------|-------------------------|--------------------|
| Relative Humidity          | 40% to 54%              |                    |
| Atmospheric Pressure       | 100 kPa to 102 kPa      |                    |
| Temperature                | NT (Normal Temperature) | +16.8°C to +24.2°C |
| Working Voltage of the EUT | NV (Normal Voltage)     | 3.7 V              |

### 4.2 Test Equipment List

| Description         | Manufacturer               | Model             | Serial No.  | Cal. Date  | Cal. Due   |
|---------------------|----------------------------|-------------------|-------------|------------|------------|
| Spectrum Analyzer   | KEYSIGHT                   | N9020A            | MY56060183  | 2024.08.01 | 2025.07.31 |
| Spectrum Analyzer   | KEYSIGHT                   | N9020A            | MY46471071  | 2024.07.04 | 2025.07.03 |
| Spectrum Analyzer   | KEYSIGHT                   | N9020A            | MY50531259  | 2024.08.01 | 2025.07.31 |
| Test Antenna-Horn   | SCHWARZBECK                | BBHA 9120D        | 02460       | 2024.05.16 | 2027.05.15 |
| Test Antenna-Horn   | A-INFO                     | LB-180400KF       | J211060273  | 2024.06.15 | 2027.06.14 |
| Anechoic Chamber    | RAINFORD                   | 9m*6m*6m          | 140         | 2024.07.28 | 2027.07.27 |
| Amplifier           | COM-MV                     | LSCX_LNA1-12G-01  | 7210214     | 2024.08.01 | 2025.07.31 |
| Amplifier           | COM-MV                     | XKu_LNA7-18G-01   | 7210209     | 2024.08.01 | 2025.07.31 |
| EMI Receiver        | ROHDE&SCHWARZ              | ESRP              | 101036      | 2024.08.01 | 2025.07.31 |
| Test Antenna-Loop   | SCHWARZBECK                | FMZB 1519         | 1519-037    | 2024.01.23 | 2027.01.22 |
| Amplifier           | COM-MV                     | ZT30-1000M        | B2018054558 | 2024.11.28 | 2025.11.27 |
| Anechoic Chamber    | EMC Electronic Co., Ltd    | 20.10*11.60*7.35m | 130         | 2024.07.13 | 2027.07.12 |
| EMI Receiver        | KEYSIGHT                   | N9038A            | MY53220118  | 2024.08.01 | 2025.07.31 |
| Test Antenna-Bi-Log | SCHWARZBECK                | VULB 9163         | 9163-624    | 2024.07.06 | 2027.07.05 |
| Amplifier           | COM-MV                     | ZT30-1000M        | B2017119082 | 2024.11.28 | 2025.11.27 |
| Anechoic Chamber    | RAINFORD                   | 9m*6m*6m          | 101         | 2023.03.04 | 2026.03.03 |
| EMI Receiver        | KEYSIGHT                   | N9010B            | MY57110309  | 2024.08.01 | 2025.07.31 |
| LISN                | SCHWARZBECK                | NSLK 8127         | 8127-687    | 2024.05.09 | 2025.05.08 |
| Shielded Enclosure  | YiHeng Electronic Co., Ltd | 3.5m*3.1m*2.8m    | 112         | 2025.02.14 | 2028.02.13 |

### 4.3 Test Software List

| Description | Manufacturer | Software Version | Serial No. | Applicable test Setup               |
|-------------|--------------|------------------|------------|-------------------------------------|
| BL410R      | BALUN        | V2.1.1.488       | N/A        | The section 4.5.1                   |
| BL410E      | BALUN        | V22.930          | N/A        | The section 4.5.2&4.5.3&4.5.4&4.5.5 |

## 4.4 Measurement Uncertainty

The following measurement uncertainty levels have been estimated for tests performed on the EUT 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.

| Parameters                        | Uncertainty |
|-----------------------------------|-------------|
| Occupied Channel Bandwidth        | 2.8%        |
| RF output power, conducted        | 1.28 dB     |
| Power Spectral Density, conducted | 1.30 dB     |
| Unwanted Emissions, conducted     | 1.84 dB     |
| All emissions, radiated           | 5.36 dB     |
| Temperature                       | 0.8°C       |
| Humidity                          | 4%          |

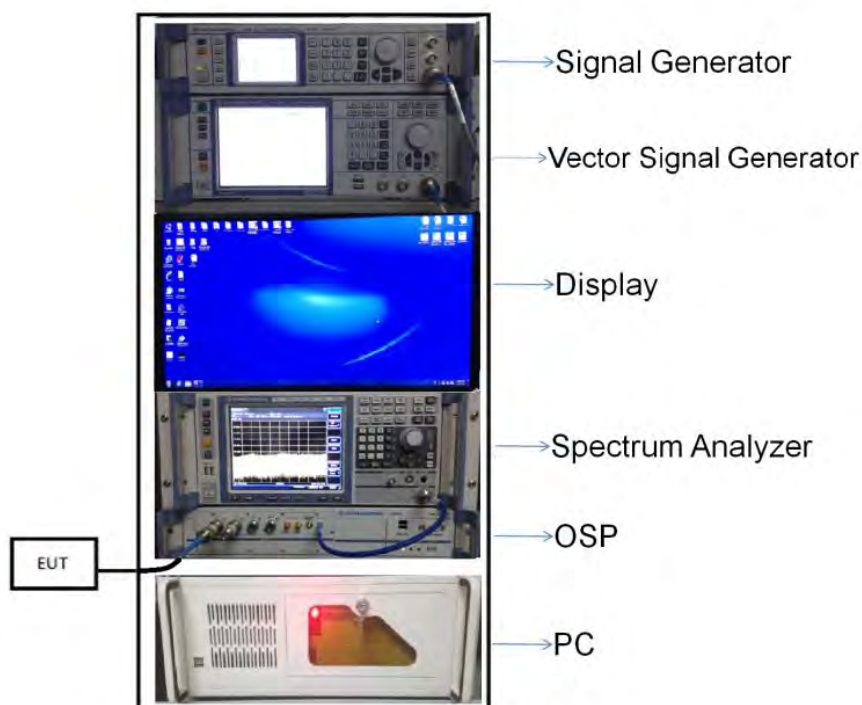
## 4.5 Description of Test Setup

### 4.5.1 For Antenna Port Test

Conducted value (dBm) = Measurement value (dBm) + cable loss (dB)

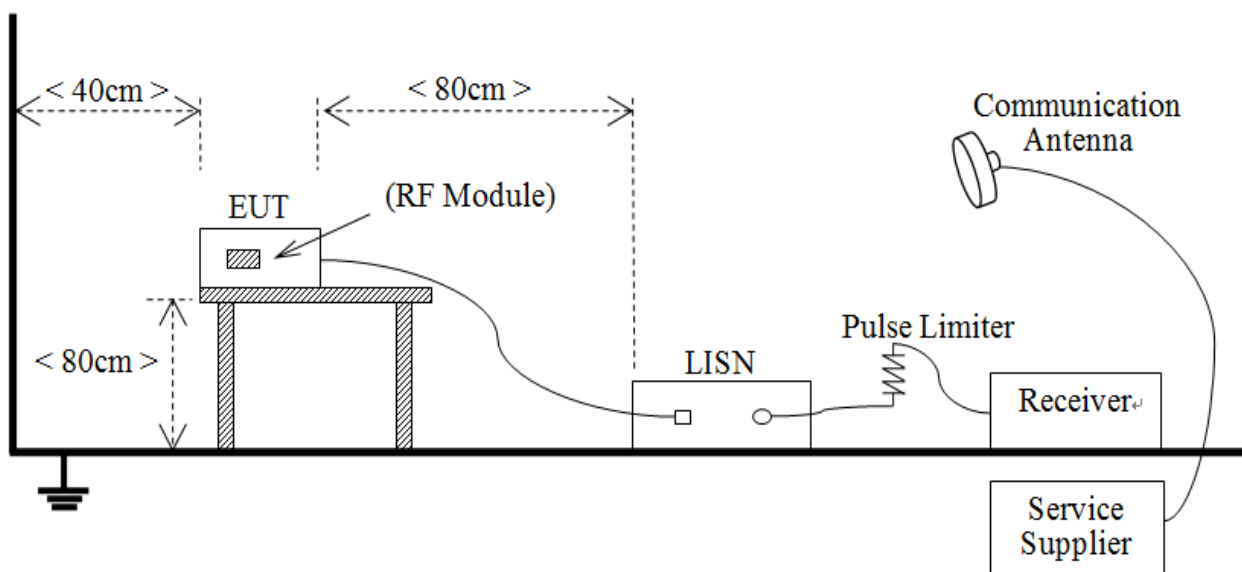
For example: the measurement value is 10 dBm and the cable 0.5dBm used, then the final result of EUT:

Conducted value (dBm) = 10 dBm + 0.5 dB = 10.5 dBm



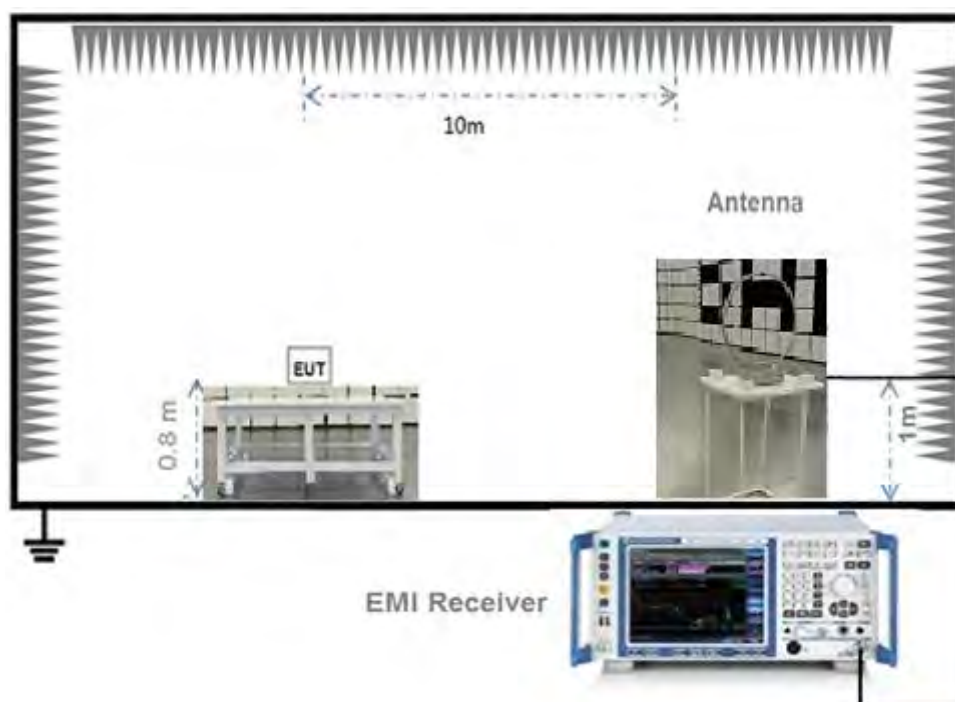
(Diagram 1)

## 4.5.2 For AC Power Supply Port Test



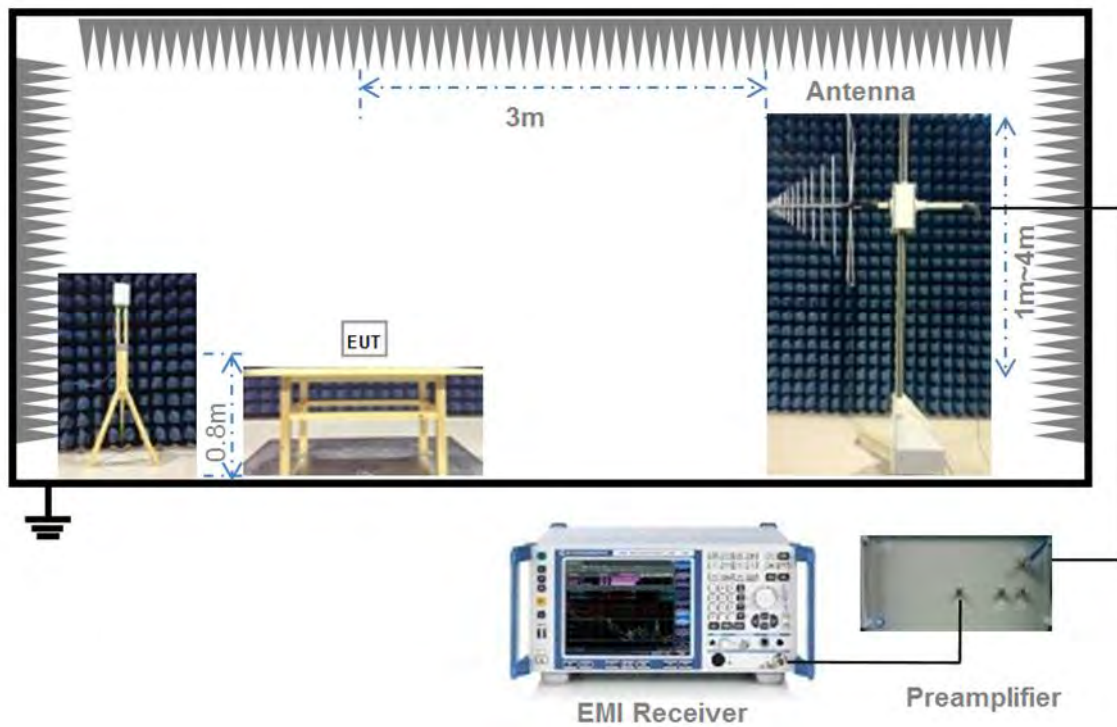
(Diagram 2)

## 4.5.3 For Radiated Test (Below 30 MHz)



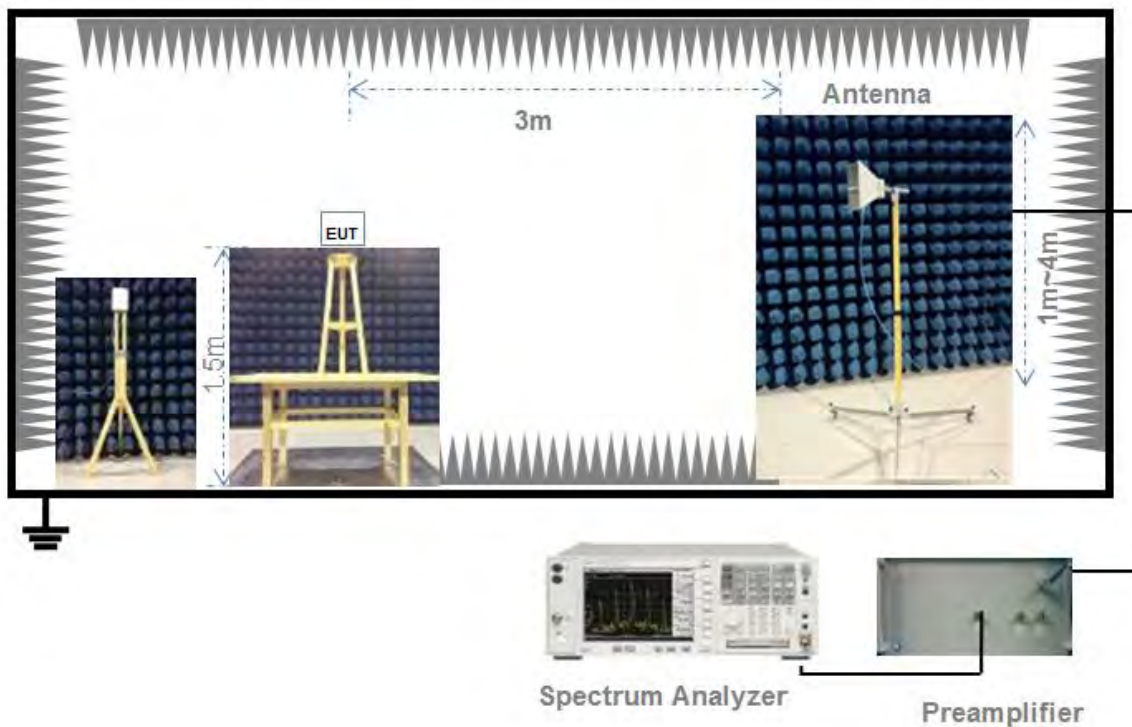
(Diagram 3)

#### 4.5.4 For Radiated Test (30 MHz-1 GHz)



(Diagram 4)

#### 4.5.5 For Radiated Test (Above 1 GHz)



(Diagram 5)

## 4.6 Measurement Results Explanation Example

### 4.6.1 For conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

Offset = RF cable loss + attenuator factor.

## 5 TEST ITEMS

### 5.1 Antenna Requirements

#### 5.1.1 Relevant Standards

FCC §15.203 & 15.247(b)

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 shall be considered sufficient to comply with the provisions of this section. 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. This requirement does not apply to carrier current devices or to devices operated under the provisions of § 15.211, § 15.213, § 15.217, § 15.219, or § 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

If directional gain of transmitting antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. For the fixed point-to-point operation, the power shall be reduced by one dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the FCC rule.

#### 5.1.2 Antenna Anti-Replacement Construction

The Antenna Anti-Replacement as following method:

| Protected Method                        | Description                            |
|-----------------------------------------|----------------------------------------|
| The antenna is embedded in the product. | An embedded-in antenna design is used. |

| Reference Documents | Item                                     |
|---------------------|------------------------------------------|
| Photo               | Please refer to the EUT Photo documents. |

#### 5.1.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

## 5.2 Frequency Hopping Systems

### 5.2.1 Relevant Standards

FCC §15.247(a) (1) (i) (ii) (iii) (iv); FCC §15.247(g); FCC §15.247(h)

Describe how the hopping sequence is generated. Provide an example of the hopping sequence channels, to demonstrate that the sequence meets the requirement specified in the definition of an FHSS system. Per the definition in Section 2.1(c), the hop set shall appear as random in the near term, shall appear as evenly distributed in the long term, and sequential hops shall be randomly distributed in both direction and magnitude of change.

Describe how each individual EUT meets the requirement that each of its hopping channels is used equally on average (e.g., that each new transmission event begins on the next channel in the hopping sequence after the final channel used in the previous transmission event).

Describe how the associated receiver(s) complies with the requirement that the input bandwidth (either RF or IF) matches the bandwidth of the transmitted signal.

Describe how the associated receiver(s) has the ability to shift frequencies in synchronization with the transmitted signals.

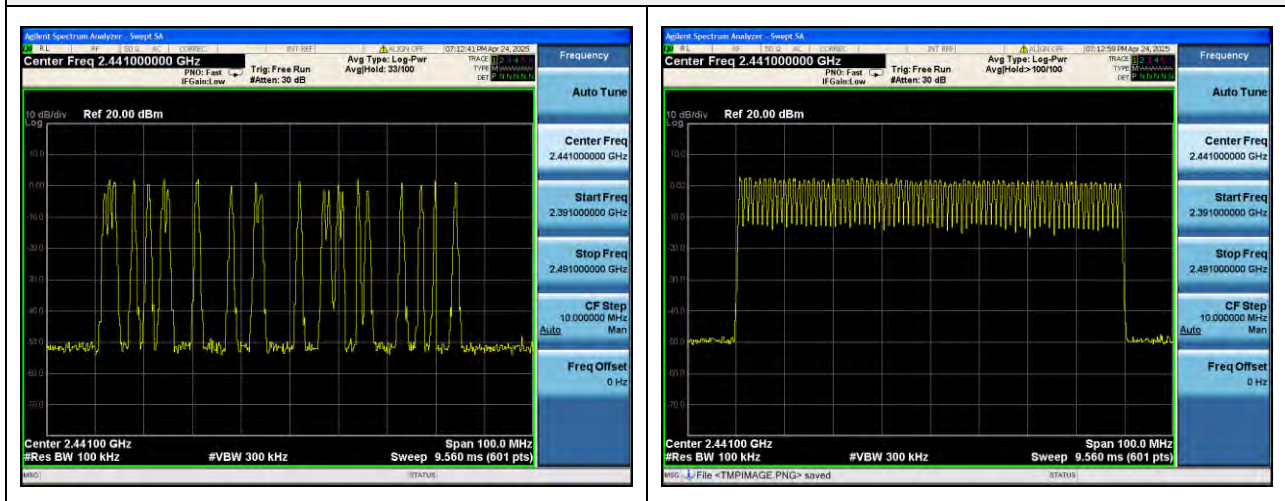
For short burst systems, describe how the EUT complies with the requirement that it be designed to be capable of operating as a true frequency hopping system. Specifically, the device shall comply with the equal frequency use and pseudorandom hopping sequence requirement when transmitting in short bursts, and shall be designed to comply when presented with continuous data (or information) stream.

Describe how the EUT complies with the requirement that it not have the ability to be coordinated with other FHSS systems in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitters.

## 5.2.2 Description of the systems

1. According to the preset procedure of the whole network, all the stations in the automatic control network synchronously change the frequency multiple times within one second, and temporarily stay on each frequency hopping channel. Periodic synchronization signaling is sent from the primary station, instructing all slaves to simultaneously change the operating frequency, then the hopping sequence is generated.
2. The hop set shall appear as random in the near term, shall appear as evenly distributed in the long term, and sequential hops shall be randomly distributed in both direction and magnitude of change.

### Reference Documents



3. Channels are classified into two categories, used and unused, where used channels are part of the hopping sequence and unused channels are replaced in the hopping sequence by used channels in a pseudo-random way. Make each individual EUT meets the requirement that each of its hopping channels is used equally on average.
4. The input bandwidth and transmitted bandwidth are both 1MHz, the associated receiver(s) complies with the requirement that the input bandwidth matches the bandwidth of the transmitted signal.
5. Connected devices communicate on the same physical channel by synchronizing with a common clock and hopping sequence.
6. EUT isn't short burst systems.
7. EUT can't have the ability to be coordinated with other FHSS systems in an effort.

## 5.3 Number of Hopping Frequencies

### 5.3.1 Limit

FCC §15.247(a) (1) (iii)

Frequency hopping systems operating in the 2400 MHz to 2483.5 MHz bands shall use at least 15 hopping frequencies.

### 5.3.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

### 5.3.3 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = The frequency band of operation

RBW = To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.

VBW  $\geq$  RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize

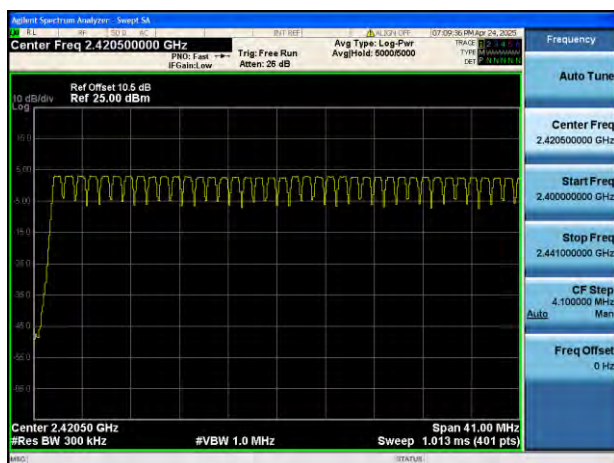
### 5.3.4 Test Result

#### Test Data

| Test Mode | Frequency Block (MHz) | Measured Channel Numbers | Min. Limit | Verdict |
|-----------|-----------------------|--------------------------|------------|---------|
| GFSK      | 2400 - 2483.5         | 79                       | 15         | Pass    |
| 8-DPSK    | 2400 - 2483.5         | 79                       | 15         | Pass    |

#### Test Plots

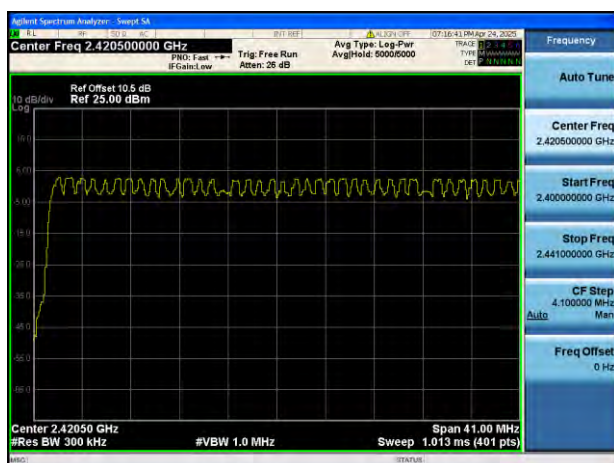
GFSK 2.4 GHz ~ 2.4415 GHz



GFSK 2.4415 GHz ~ 2.4835 GHz



8-DPSK 2.4 GHz ~ 2.4415 GHz



8-DPSK 2.4415 GHz ~ 2.4835 GHz



## 5.4 Peak Output Power

### 5.4.1 Test Limit

FCC § 15.247(b)

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

### 5.4.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

### 5.4.3 Test Procedure

The Module operates at hopping-off test mode. The lowest, middle and highest channels are selected to perform testing to verify the conducted RF output peak power of the Module.

Use the following spectrum analyzer settings:

Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel

RBW > the 20 dB bandwidth of the emission being measured

VBW  $\geq$  RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize.

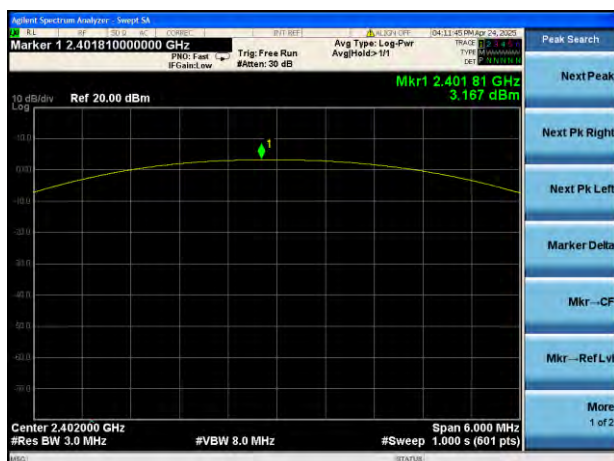
### 5.4.4 Test Result

#### Peak Power Test Data

| Channel | Measured Output Peak Power |      |                |      |        |      | Limit |     | Verdict |
|---------|----------------------------|------|----------------|------|--------|------|-------|-----|---------|
|         | GFSK                       |      | $\pi/4$ -DQPSK |      | 8-DPSK |      | dBm   | mW  |         |
|         | dBm                        | mW   | dBm            | mW   | dBm    | mW   |       |     |         |
| Low     | 3.17                       | 2.07 | 3.00           | 2.00 | 3.04   | 2.01 | 21    | 125 | Pass    |
| Middle  | 2.44                       | 1.75 | 2.40           | 1.74 | 2.39   | 1.73 |       |     | Pass    |
| High    | 1.56                       | 1.43 | 1.52           | 1.42 | 1.49   | 1.41 |       |     | Pass    |

## Test Plots

### GFSK LOW CHANNEL



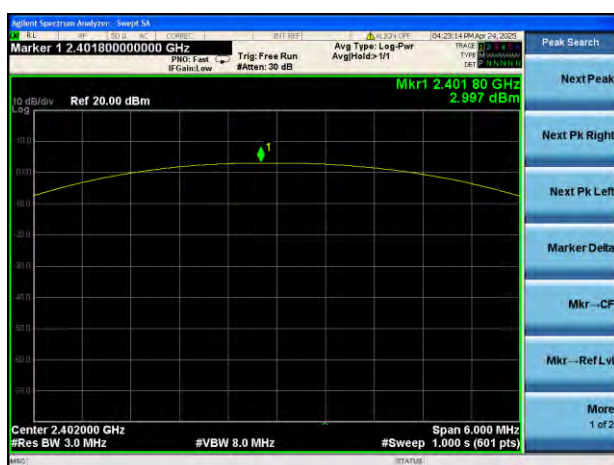
### GFSK MIDDLE CHANNEL



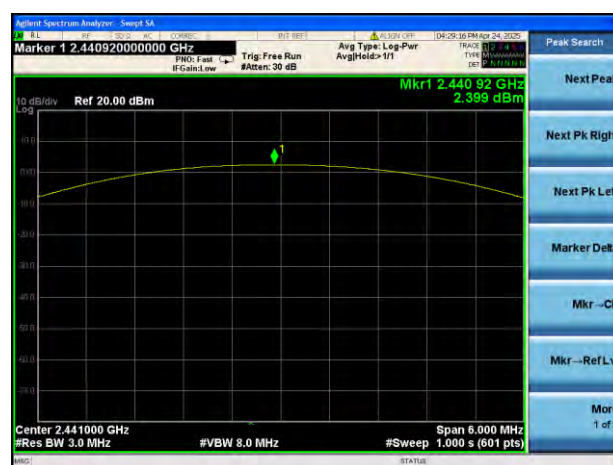
### GFSK HIGH CHANNEL



### $\pi/4$ -DQPSK LOW CHANNEL



### $\pi/4$ -DQPSK MIDDLE CHANNEL



### $\pi/4$ -DQPSK HIGH CHANNEL



### 8-DPSK LOW CHANNEL



### 8-DPSK MIDDLE CHANNEL



### 8-DPSK HIGH CHANNEL



## 5.5 Occupied Bandwidth

### 5.5.1 Limit

FCC §15.247(a)

Measurement of the 20dB bandwidth of the modulated signal.

### 5.5.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

### 5.5.3 Test Procedure

Use the following spectrum analyzer settings:

Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel

RBW = in the range of 1% to 5% of the OBW

VBW  $\geq$  RBW

Sweep = auto

Detector function = peak

Trace = max hold

The EUT should be transmitting at its maximum data rate, Allow the trace to stabilize.

### 5.5.4 Test Result

#### Test Data

| GFSK           |                       |                     |
|----------------|-----------------------|---------------------|
| Channel        | 20 dB Bandwidth (MHz) | 99% Bandwidth (MHz) |
| Low            | 0.952600              | 0.853400            |
| Middle         | 0.952600              | 0.851490            |
| High           | 0.952600              | 0.847380            |
| $\pi/4$ -DQPSK |                       |                     |
| Channel        | 20 dB Bandwidth (MHz) | 99% Bandwidth (MHz) |
| Low            | 1.185100              | 1.129400            |
| Middle         | 1.185100              | 1.139900            |
| High           | 1.185100              | 1.136100            |
| 8-DPSK         |                       |                     |
| Channel        | 20 dB Bandwidth (MHz) | 99% Bandwidth (MHz) |
| Low            | 1.177500              | 1.134300            |
| Middle         | 1.192400              | 1.119800            |
| High           | 1.192400              | 1.127600            |

## Test Plots

## 20 dB Bandwidth

## GFSK LOW CHANNEL



## GFSK MIDDLE CHANNEL



## GFSK HIGH CHANNEL

 $\pi/4$ -DQPSK LOW CHANNEL $\pi/4$ -DQPSK MIDDLE CHANNEL

### $\pi/4$ -DQPSK HIGH CHANNEL



### 8-DPSK LOW CHANNEL



### 8-DPSK MIDDLE CHANNEL



### 8-DPSK HIGH CHANNEL



## 99% Bandwidth

## GFSK LOW CHANNEL



## GFSK MIDDLE CHANNEL



## GFSK HIGH CHANNEL

 $\pi/4$ -DQPSK LOW CHANNEL $\pi/4$ -DQPSK MIDDLE CHANNEL

### $\pi/4$ -DQPSK HIGH CHANNEL



### 8-DPSK LOW CHANNEL



### 8-DPSK MIDDLE CHANNEL



### 8-DPSK HIGH CHANNEL



## 5.6 Carrier Frequency Separation

### 5.6.1 Limit

#### FCC §15.247(a)

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 2/3 of the 20 dB bandwidth of the hopping channel, whichever is greater.

### 5.6.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

### 5.6.3 Test Procedure

The EUT must have its hopping function enabled. Use the following spectrum analyzer settings:

Span = wide enough to capture the peaks of two adjacent channels

Resolution (or IF) Bandwidth (RBW)  $\geq 1\%$  of the span

Video (or Average) Bandwidth (VBW)  $\geq$  RBW

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

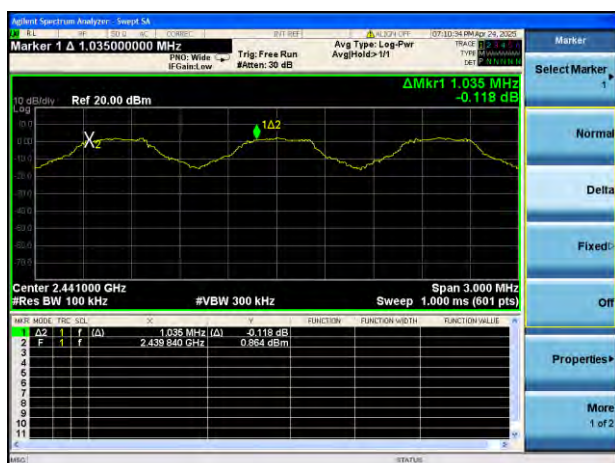
## 5.6.4 Test Result

### Test Data

| Mode   | Frequency separation (MHz) | 2/3 of the 20 dB Bandwidth (MHz) | Verdict |
|--------|----------------------------|----------------------------------|---------|
| GFSK   | 1.035                      | 0.635                            | Pass    |
| 8-DPSK | 1.025                      | 0.795                            | Pass    |

### Test Plots

#### GFSK



#### 8-DPSK



## 5.7 Time of Occupancy (Dwell time)

### 5.7.1 Limit

#### FCC §15.247(a)

Frequency hopping systems in the 2400 MHz - 2483.5 MHz band shall use at least 15 non-overlapping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

### 5.7.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

### 5.7.3 Test Procedure

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

Span: Zero span, centered on a hopping channel

RBW shall be  $\leq$  channel spacing and where possible RBW should be set  $\gg 1/T$ , where T is the expected dwell time per channel

Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel

Detector function: Peak

Trace: Max hold

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

The average time of occupancy on any channel within the Period can be calculated with formulas:

For GFSK and 8-DPSK:

For DH1 package type

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * (1600 / 2) / \{\text{Number of Hopping Frequency}\} * \{\text{Period}\}$$

$$\{\text{Period}\} = 0.4 \text{ s} * \{\text{Number of Hopping Frequency}\}$$

For DH3 package type

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * (1600 / 4) / \{\text{Number of Hopping Frequency}\} * \{\text{Period}\}$$

$$\{\text{Period}\} = 0.4 \text{ s} * \{\text{Number of Hopping Frequency}\}$$

For DH5 package type

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * (1600 / 6) / \{\text{Number of Hopping Frequency}\} * \{\text{Period}\}$$

$$\{\text{Period}\} = 0.4 \text{ s} * \{\text{Number of Hopping Frequency}\}$$

For AFH Mode:

For DH1 package type

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * (800 / 2) / \{\text{Number of Hopping Frequency}\} * \{\text{Period}\}$$

$$\{\text{Period}\} = 0.4 \text{ s} * \{\text{Number of Hopping Frequency}\}$$

For DH3 package type

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * (800 / 4) / \{\text{Number of Hopping Frequency}\} * \{\text{Period}\}$$

$$\{\text{Period}\} = 0.4 \text{ s} * \{\text{Number of Hopping Frequency}\}$$

For DH5 package type

$$\{\text{Total of Dwell}\} = \{\text{Pulse Time}\} * (800 / 6) / \{\text{Number of Hopping Frequency}\} * \{\text{Period}\}$$

$$\{\text{Period}\} = 0.4 \text{ s} * \{\text{Number of Hopping Frequency}\}$$

The lowest, middle and highest channels are selected to perform testing to record the dwell time of each occupation measured in this channel, which is called Pulse Time here.

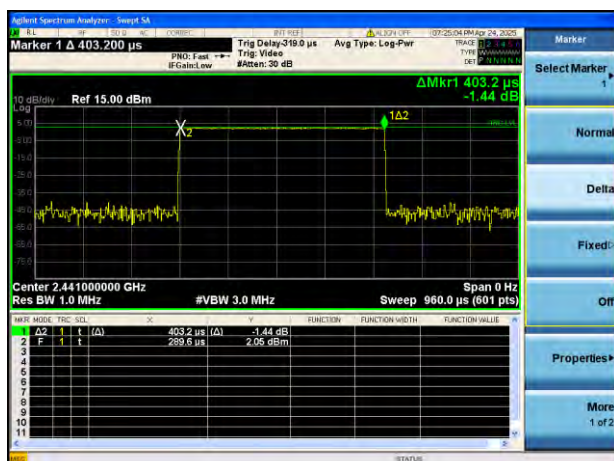
#### 5.7.4 Test Result

##### Test Data

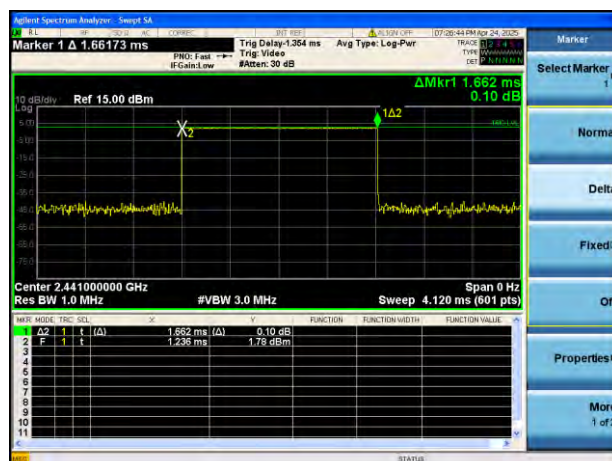
| GFSK      |                  |                     |             |         |
|-----------|------------------|---------------------|-------------|---------|
| DH Packet | Pulse Width (ms) | Total of Dwell (ms) | Limit (sec) | Verdict |
| DH 1      | 0.40320          | 129.024             | 0.4         | Pass    |
| DH 3      | 1.66200          | 265.920             | 0.4         | Pass    |
| DH 5      | 2.90000          | 309.333             | 0.4         | Pass    |
| 8-DPSK    |                  |                     |             |         |
| DH Packet | Pulse Width (ms) | Total of Dwell (ms) | Limit (sec) | Verdict |
| 3DH 1     | 0.40320          | 129.024             | 0.4         | Pass    |
| 3DH 3     | 1.66200          | 265.920             | 0.4         | Pass    |
| 3DH 5     | 2.91200          | 310.613             | 0.4         | Pass    |
| AFH Mode  |                  |                     |             |         |
| DH Packet | Pulse Width (ms) | Total of Dwell (ms) | Limit (sec) | Verdict |
| DH 1      | 0.40320          | 64.512              | 0.4         | Pass    |
| DH 3      | 1.66100          | 132.880             | 0.4         | Pass    |
| DH 5      | 2.90000          | 154.667             | 0.4         | Pass    |

## Test Plots

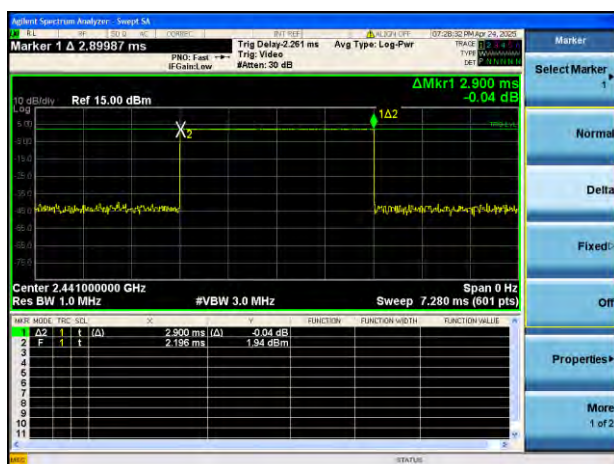
## GFSK DH1



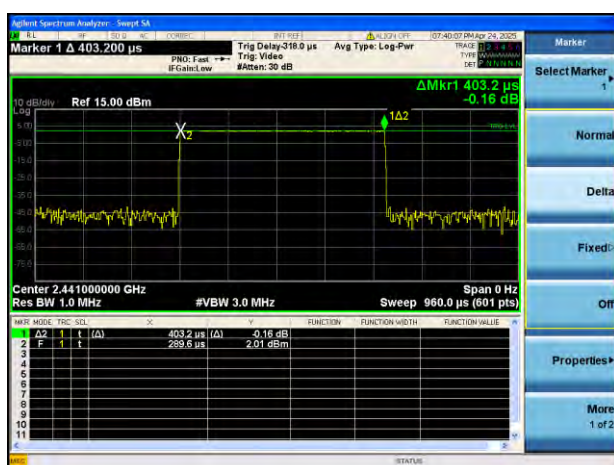
## GFSK DH3



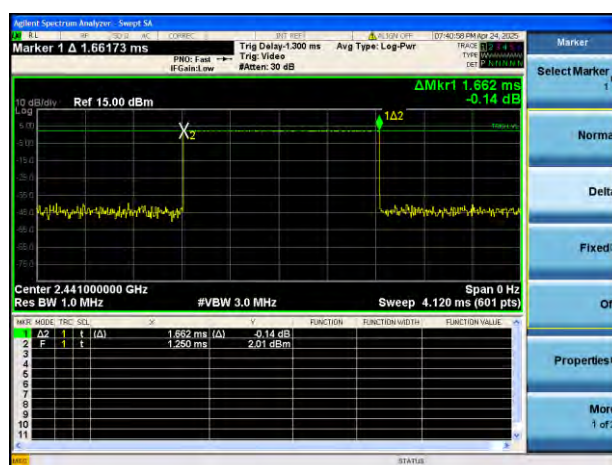
## GFSK DH5



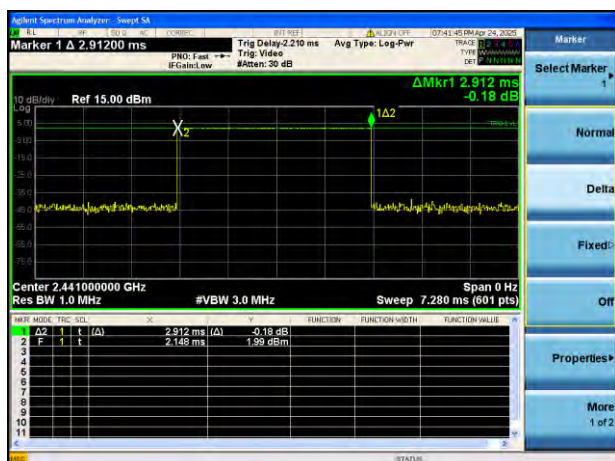
## 8-DPSK 3DH1



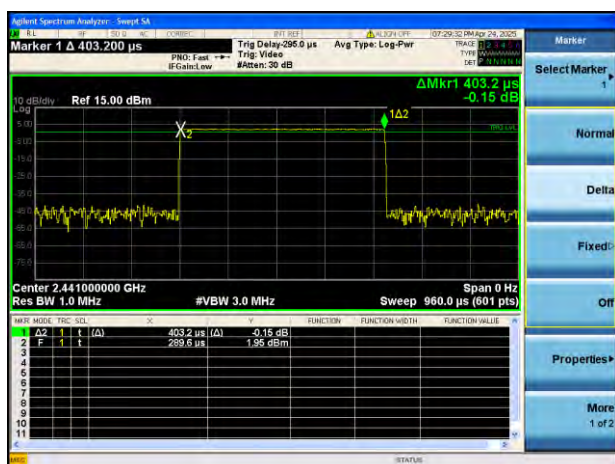
## 8-DPSK 3DH3



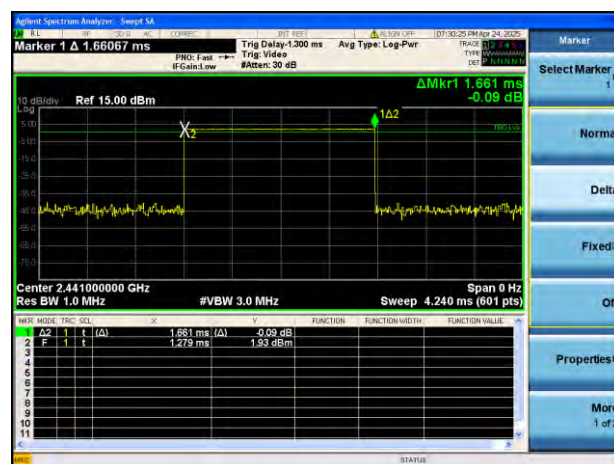
## 8-DPSK 3DH5



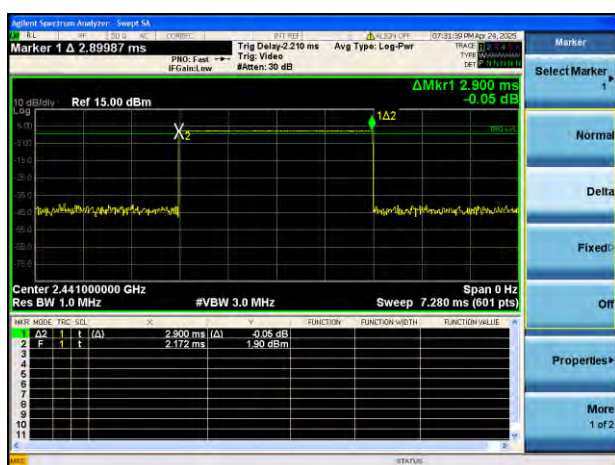
## AFH Mode DH1



## AFH Mode DH3



## AFH Mode DH5



## 5.8 Conducted Spurious Emission & Authorized-band band-edge

### 5.8.1 Limit

#### FCC §15.247(d)

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.

### 5.8.2 Test Setup

See section 4.5.1 for test setup description for the antenna port. The photo of test setup please refer to ANNEX A.

### 5.8.3 Test Procedure

Use the following spectrum analyzer settings:

Span = wide enough to capture the peak level of the in-band emission and all spurious emissions (e.g., harmonics) from the lowest frequency generated in the EUT up through the 10th harmonic. Typically, several plots are required to cover this entire span.

RBW = 100 kHz

VBW = 300 kHz

Sweep = auto

Detector function = peak

Trace = max hold

Allow the trace to stabilize

## 5.8.4 Test Result

Test Data

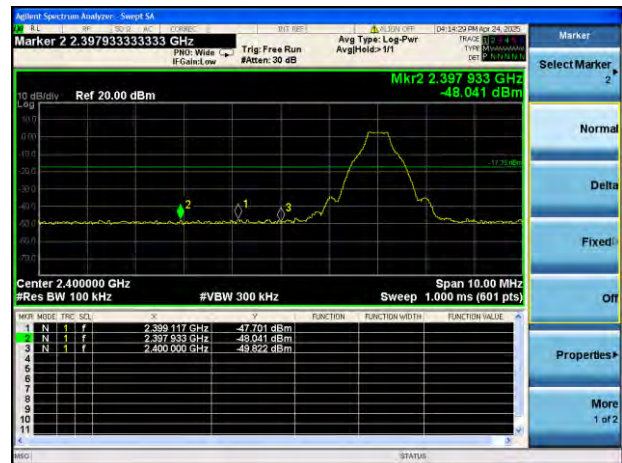
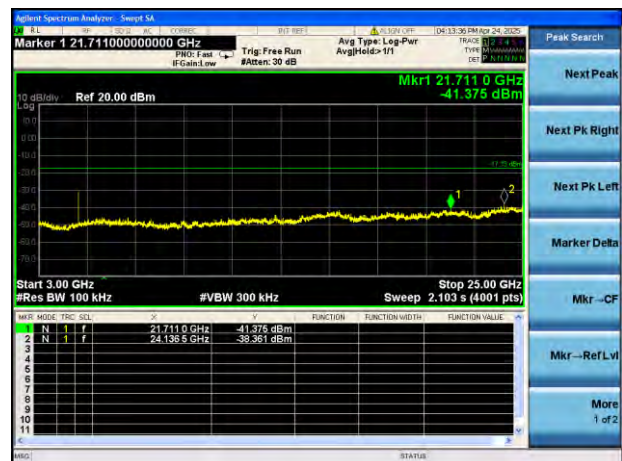
| GFSK         |                                                |               |                            |         |
|--------------|------------------------------------------------|---------------|----------------------------|---------|
| Channel      | Measured Max.<br>Out of Band<br>Emission (dBm) | Limit (dBm)   |                            | Verdict |
|              |                                                | Carrier Level | Calculated<br>20 dBc Limit |         |
| Low          | -39.36                                         | 2.67          | -17.33                     | Pass    |
| Middle       | -40.28                                         | 2.00          | -18.00                     | Pass    |
| High         | -39.01                                         | 1.11          | -18.89                     | Pass    |
| 8-DPSK       |                                                |               |                            |         |
| Channel      | Measured Max.<br>Out of Band<br>Emission (dBm) | Limit (dBm)   |                            | Verdict |
|              |                                                | Carrier Level | Calculated<br>20 dBc Limit |         |
| Low          | -40.39                                         | 2.61          | -17.39                     | Pass    |
| Middle       | -39.41                                         | 1.95          | -18.05                     | Pass    |
| High         | -38.15                                         | 1.06          | -18.94                     | Pass    |
| Hopping Mode |                                                |               |                            |         |
| Mode         | Measured Max.<br>Out of Band<br>Emission (dBm) | Limit (dBm)   |                            | Verdict |
|              |                                                | Carrier Level | Calculated<br>20 dBc Limit |         |
| GFSK         | -32.42                                         | 2.66          | -17.34                     | Pass    |
| 8-DPSK       | -33.93                                         | 2.38          | -17.62                     | Pass    |

## Test Plots

GFSK LOW CHANNEL, CARRIER LEVEL



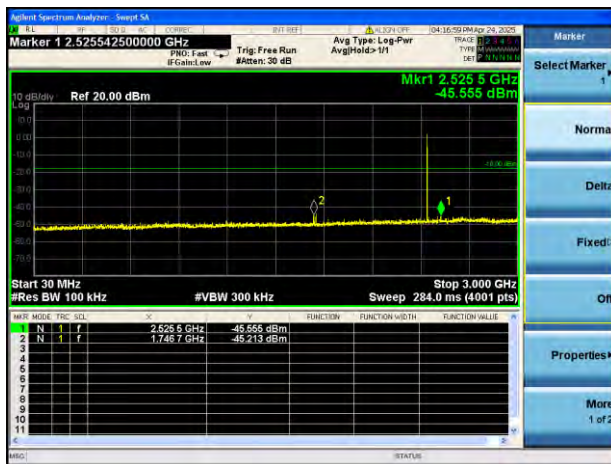
GFSK LOW CHANNEL, BAND EDGE

GFSK LOW CHANNEL, SPURIOUS  
30 MHz ~ 3 GHzGFSK LOW CHANNEL, SPURIOUS  
3 GHz ~ 25 GHz

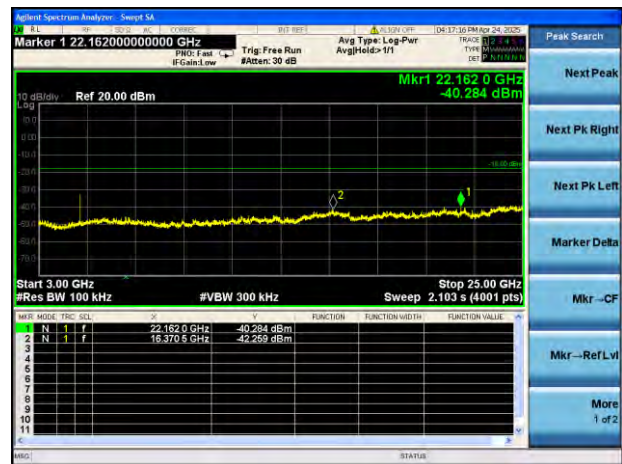
GFSK MIDDLE CHANNEL, CARRIER LEVEL



### GFSK MIDDLE CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



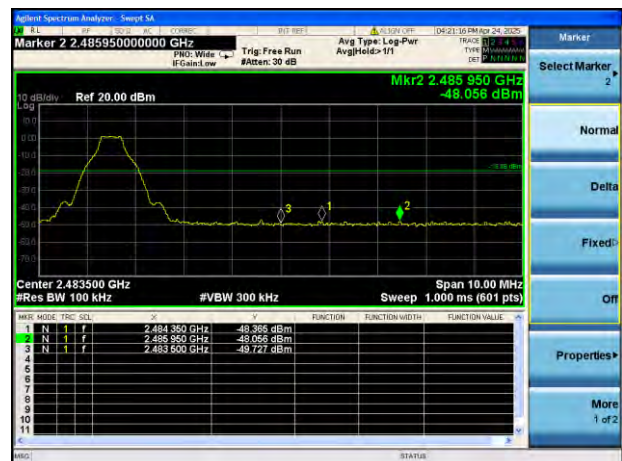
### GFSK MIDDLE CHANNEL, SPURIOUS 3 GHz ~ 25 GHz



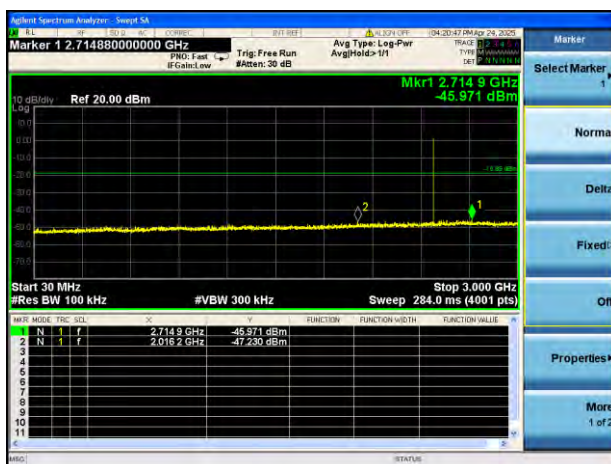
### GFSK HIGH CHANNEL, CARRIER LEVEL



### GFSK HIGH CHANNEL, BAND EDGE



### GFSK HIGH CHANNEL, SPURIOUS 30 MHz ~ 3 GHz



### GFSK HIGH CHANNEL, SPURIOUS 3 GHz ~ 25 GHz

