# FCC TEST REPORT

| | |
|---|---|
| **Product Name:** | Noise Canceling True Wireless Earbuds |
| **Trade Mark:** | GEMS |
| **Model No.:** | TWS05 |
| **Report Number:** | 200902001RFC-1 |
| **Test Standards:** | FCC 47 CFR Part 15 Subpart C |
| **FCC ID:** | 2AO23-TWS05 |
| **Test Result:** | PASS |
| **Date of Issue:** | September 11, 2020 |

Prepared for:

**Chug,Inc.**
**7157 Shady Oak Road Eden Prairie,Washington Minnesota United States**

Prepared by:

**Shenzhen UnionTrust Quality and Technology Co., Ltd.**
**16/F, Block A, Building 6, Baoneng Science and Technology Park, Qingxiang Road No.1, Longhua New District, Shenzhen, China**
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Date: September 11, 2020

# Version

| Version No. | Date | Description |
|---|---|---|
| V1.0 | September 11, 2020 | Original |

# CONTENTS

# 1. GENERAL INFORMATION

## 1.1 CLIENT INFORMATION

| | |
|---|---|
| **Applicant:** | Chug,Inc. |
| **Address of Applicant:** | 7157 Shady Oak Road Eden Prairie, Washington Minnesota United States |
| **Manufacturer:** | Dongguan Kuyi Electronic Technology Co., Ltd |
| **Address of Manufacturer:** | 8 private industrial zones in Shichung, Hengli Town, Dongguan City, Guangdong Province 523465, China |

## 1.2 EUT INFORMATION

### 1.2.1 General Description of EUT

| | | |
|---|---|---|
| **Product Name:** | Noise Canceling True Wireless Earbuds | |
| **Model No.:** | TWS05 | |
| **Trade Mark:** | GEMS | |
| **DUT Stage:** | Production Unit | |
| **EUT Supports Function:** | 2.4 GHz ISM Band: | Bluetooth 5.1 |
| **Software Version:** | V2.0 | |
| **Hardware Version:** | V1.0 | |
| **Sample Received Date:** | September 3, 2020 | |
| **Sample Tested Date:** | September 9, 2020 to September 9, 2020 | |

### 1.2.2 Description of Accessories

| Cable | |
|---|---|
| **Description:** | USB Type-C Plug Cable |
| **Cable Type:** | Unshielded without ferrite |
| **Length:** | 0.3 Meter |

## 1.3 PRODUCT SPECIFICATION SUBJECTIVE TO THIS STANDARD

| | |
|---|---|
| **Frequency Band:** | 2400 MHz to 2483.5 MHz |
| **Frequency Range:** | 2402 MHz to 2480 MHz |
| **Bluetooth Version:** | Bluetooth BR + EDR |
| **Modulation Technique:** | Frequency Hopping Spread Spectrum(FHSS) |
| **Type of Modulation:** | GFSK, π/4DQPSK, 8DPSK |
| **Number of Channels:** | 79 |
| **Channel Separation:** | 1 MHz |
| **Hopping Channel Type:** | Adaptive Frequency Hopping Systems |
| **Antenna Type:** | FPC Antenna |
| **Antenna Gain:** | 1.9 dBi |
| **Maximum Peak Power:** | 2.47 dBm |
| **Normal Test Voltage:** | 3.7Vdc |

## 1.4 OTHER INFORMATION

| Operation Frequency Each of Channel |
|---|
| **f = 2402 + k MHz, k = 0,…,78** |
| Note:<br>**f** is the operating frequency (MHz);<br>**k** is the operating channel. |

| Modulation Configure | | | |
|---|---|---|---|
| **Modulation** | **Packet** | **Packet Type** | **Packet Size** |
| GFSK | 1-DH1 | 4 | 27 |
| | 1-DH3 | 11 | 183 |
| | 1-DH5 | 15 | 339 |
| π/4 DQPSK | 2-DH1 | 20 | 54 |
| | 2-DH3 | 26 | 367 |
| | 2-DH5 | 30 | 679 |
| 8DPSK | 3-DH1 | 24 | 83 |
| | 3-DH3 | 27 | 552 |
| | 3-DH5 | 31 | 1021 |

## 1.5 DESCRIPTION OF SUPPORT UNITS

The EUT has been tested with associated equipment below.

1) Support Equipment

| Description | Manufacturer | Model No. | Serial Number | Supplied by |
|---|---|---|---|---|
| Notebook | DELL | Latitude 3400 | 6GJQKT2 | N/A |

2) Support Cable

| Cable No. | Description | Connector | Length | Supplied by |
|---|---|---|---|---|
| 1 | Antenna Cable | SMA | 0.30 Meter | UnionTrust |

## 1.6 TEST LOCATION

**Shenzhen UnionTrust Quality and Technology Co., Ltd.**

Address: 16/F, Block A, Building 6, Baoneng Science and Technology Park, Qingxiang Road No.1, Longhua New District, Shenzhen, China 518109
Telephone: +86 (0) 755 2823 0888
Fax: +86 (0) 755 2823 0886

## 1.7 TEST FACILITY

The test facility is recognized, certified, or accredited by the following organizations:

**CNAS-Lab Code: L9069**
The measuring equipment utilized to perform the tests documented in this report has been calibrated once a year or in accordance with the manufacturer's recommendations, and is traceable under the ISO/IEC/EN 17025 to international or national standards. Equipment has been calibrated by accredited calibration laboratories.

**A2LA-Lab Certificate No.: 4312.01**
Shenzhen UnionTrust Quality and Technology Co., Ltd. has been accredited by A2LA for technical competence in the field of electrical testing, and proved to be in compliance with ISO/IEC 17025: 2005 General Requirements for the Competence of Testing and Calibration Laboratories and any additional program requirements in the identified field of testing.

**ISED Wireless Device Testing Laboratories**
CAB identifier: CN0032

**FCC Accredited Lab.**
Designation Number: CN1194
Test Firm Registration Number: 259480

## 1.8 DEVIATION FROM STANDARDS

None.

## 1.9 ABNORMALITIES FROM STANDARD CONDITIONS

None.

## 1.10 OTHER INFORMATION REQUESTED BY THE CUSTOMER

None.

## 1.11 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.

| No. | Item | Measurement Uncertainty |
|---|---|---|
| 1 | Conducted emission 9KHz-150KHz | ±3.2 dB |
| 2 | Conducted emission 150KHz-30MHz | ±2.7 dB |
| 3 | Radiated emission 9KHz-30MHz | ± 4.7 dB |
| 4 | Radiated emission 30MHz-1GHz | ± 4.6 dB |
| 5 | Radiated emission 1GHz-18GHz | ± 4.4 dB |
| 6 | Radiated emission 18GHz-26GHz | ± 4.6 dB |
| 7 | Radiated emission 26GHz-40GHz | ± 4.6 dB |

## 2. TEST SUMMARY

| FCC 47 CFR Part 15 Subpart C Test Cases | | | |
|---|---|---|---|
| **Test Item** | **Test Requirement** | **Test Method** | **Result** |
| **Antenna Requirement** | FCC 47 CFR Part 15 Subpart C Section 15.203/15.247 (c) | N/A | PASS |
| **AC Power Line Conducted Emission** | FCC 47 CFR Part 15 Subpart C Section 15.207 | ANSI C63.10-2013 Section 6.2 | N/A NOTE 2 |
| **Conducted Peak Output Power** | FCC 47 CFR Part 15 Subpart C Section 15.247 (b)(1) | ANSI C63.10-2013 Section 7.8.5 | PASS |
| **20 dB Bandwidth** | FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1) | ANSI C63.10-2013 Section 6.9.2 | PASS |
| **Carrier Frequencies Separation** | FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1) | ANSI C63.10-2013 Section 7.8.2 | PASS |
| **Number of Hopping Channel** | FCC 47 CFR Part 15 Subpart C Section 15.247 (b)(1) | ANSI C63.10-2013 Section 7.8.3 | PASS |
| **Dwell Time** | FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1) | ANSI C63.10-2013 Section 7.8.4 | PASS |
| **Conducted Out of Band Emission** | FCC 47 CFR Part 15 Subpart C Section 15.247(d) | ANSI C63.10-2013 Section 6.10.4 & Section 7.8.8 | PASS |
| **Radiated Emissions** | FCC 47 CFR Part 15 Subpart C Section 15.205/15.209 | ANSI C63.10-2013 Section 6.3 & 6.5 & 6.6 | PASS |
| **Band Edge Measurement** | FCC 47 CFR Part 15 Subpart C Section 15.205/15.209 | ANSI C63.10-2013 Section 6.10.5 | PASS |

**Note:**

1) N/A: In this whole report not applicable.
2) Place earbud's into the charging case, they will turn off automatically, and the Bluetooth does not work.

# 3. EQUIPMENT LIST

| Radiated Emission Test Equipment List | | | | | | |
|---|---|---|---|---|---|---|
| **Used** | **Equipment** | **Manufacturer** | **Model No.** | **Serial Number** | **Cal. date (mm dd, yyyy)** | **Cal. Due date (mm dd, yyyy)** |
| ☒ | 3M Chamber & Accessory Equipment | ETS-LINDGREN | 3M | N/A | Dec. 03, 2018 | Dec. 03, 2021 |
| ☒ | Receiver | R&S | ESIB26 | 100114 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☐ | Loop Antenna | ETS-LINDGREN | 6502 | 00202525 | Nov. 16, 2019 | Nov. 15, 2020 |
| ☒ | Broadband Antenna | ETS-LINDGREN | 3142E | 00201566 | Nov. 16, 2019 | Nov. 15, 2020 |
| ☒ | 6dB Attenuator | Talent | RA6A5-N-18 | 18103001 | Nov. 16, 2019 | Nov. 15, 2020 |
| ☒ | Preamplifier | HP | 8447F | 2805A02960 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☐ | Broadband Antenna (Pre-amplifier) | ETS-LINDGREN | 3142E-PA | 00201891 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☐ | 6dB Attenuator | Talent | RA6A5-N-18 | 18103002 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☐ | Horn Antenna | ETS-LINDGREN | 3117 | 00164202 | Nov. 16, 2019 | Nov. 15, 2020 |
| ☒ | Horn Antenna (Pre-amplifier) | ETS-LINDGREN | 3117-PA | 00201874 | May. 30, 2020 | May. 29, 2021 |
| ☐ | Horn Antenna | ETS-LINDGREN | 3116C | 00200180 | Jun. 19, 2020 | Jun. 18, 2021 |
| ☒ | Horn Antenna (Pre-amplifier) | ETS-LINDGREN | 3116C-PA | 00202652 | Nov. 16, 2019 | Nov. 15, 2020 |
| ☒ | Multi device Controller | ETS-LINDGREN | 7006-001 | 00160105 | N/A | N/A |
| ☒ | Test Software | Audix | e3 | Software Version: 9.160323 | | |

| Conducted RF test Equipment List | | | | | | |
|---|---|---|---|---|---|---|
| **Used** | **Equipment** | **Manufacturer** | **Model No.** | **Serial Number** | **Cal. date (mm dd, yyyy)** | **Cal. Due date (mm dd, yyyy)** |
| ☒ | EXA Spectrum Analyzer | KEYSIGHT | N9010A | MY51440197 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☒ | USB Wideband Power Sensor | KEYSIGHT | U2021XA | MY55430035 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☐ | USB Wideband Power Sensor | KEYSIGHT | U2021XA | MY55430023 | Nov. 24, 2019 | Nov. 23, 2020 |
| ☐ | Wideband Radio Communication Tester | R&S | CMW500 | 120932 | Jul. 20, 2020 | Jul. 19, 2021 |

# 4. TEST CONFIGURATION

## 4.1 ENVIRONMENTAL CONDITIONS FOR TESTING

### 4.1.1 Normal or Extreme Test Conditions

| Environment Parameter | Selected Values During Tests | | |
|---|---|---|---|
| Test Condition | Ambient | | |
| | Temperature (°C) | Voltage (V) | Relative Humidity (%) |
| NT/NV | +15 to +35 | 3.7 | 20 to 75 |
| **Remark:**<br>1) NV: Normal Voltage; NT: Normal Temperature | | | |

### 4.1.2 Record of Normal Environment

| Test Item | Temperature (°C) | Relative Humidity (%) | Pressure (kPa) | Tested by |
|---|---|---|---|---|
| Conducted Peak Output Power | 25.1 | 60.0 | 99.9 | Swift Liu |
| 20 dB Bandwidth | 25.1 | 60.0 | 99.9 | Swift Liu |
| Carrier Frequencies Separation | 25.1 | 60.0 | 99.9 | Swift Liu |
| Number of Hopping Channel | 25.1 | 60.0 | 99.9 | Swift Liu |
| Dwell Time | 25.1 | 60.0 | 99.9 | Swift Liu |
| Conducted Out of Band Emission | 25.1 | 60.0 | 99.9 | Swift Liu |
| Radiated Emissions | 25.3 | 54.6 | 99.6 | Aisa Ya |
| Band Edge Measurement | 25.3 | 54.6 | 99.6 | Aisa Ya |

## 4.2 TEST CHANNELS

| Mode | Tx/Rx Frequency | Test RF Channel Lists | | |
|---|---|---|---|---|
| | | Lowest(L) | Middle(M) | Highest(H) |
| GFSK (DH1, DH3, DH5) | 2402 MHz to 2480 MHz | Channel 0 | Channel 39 | Channel 78 |
| | | 2402 MHz | 2441 MHz | 2480 MHz |
| π/4DQPSK (DH1, DH3, DH5) | 2402 MHz to 2480 MHz | Channel 0 | Channel 39 | Channel 78 |
| | | 2402 MHz | 2441 MHz | 2480 MHz |
| 8DPSK (DH1, DH3, DH5) | 2402 MHz to 2480 MHz | Channel 0 | Channel 39 | Channel 78 |
| | | 2402 MHz | 2441 MHz | 2480 MHz |

## 4.3 EUT TEST STATUS

| Type of Modulation | Tx Function | Description |
|---|---|---|
| GFSK/π/4DQPSK/ 8DPSK | 1Tx | 1. Keep the EUT in continuously transmitting with Modulation test single<br>2. Keep the EUT in continuously transmitting with Modulation test Hopping Frequency. |

| Power Setting |
|---|
| Power Setting: 0 |

| Test Software |
|---|
| Test software name: RTLBTAPP.exe; |

## 4.4 PRE-SCAN

### 4.4.1 Pre-scan under all packets at middle channel

| Conducted Average Power (dBm) for packets | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Type of Modulation** | **GFSK** | | | **π/4DQPSK** | | | **8DPSK** | | |
| Packets | 1-DH1 | 1-DH3 | 1-DH5 | 2-DH1 | 2-DH3 | 2-DH5 | 3-DH1 | 3-DH3 | 3-DH5 |
| Power (dBm) | -6.68 | -3.52 | -2.79 | -6.90 | -3.90 | -3.28 | -6.36 | -3.41 | -2.75 |

### 4.4.2 Worst-case data packets

| Type of Modulation | Worst-case data rates |
|---|---|
| **GFSK** | 1-DH5 |
| **π/4DQPSK** | 2-DH5 |
| **8DPSK** | 3-DH5 |

### 4.4.3 Tested channel detail

Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, data packets and antenna ports (if EUT with antenna diversity architecture). Following channel(s) was (were) selected for the final test as listed below.

| **Type of Modulation** | **GFSK** | | | **π/4DQPSK** | | | **8DPSK** | | |
|---|---|---|---|---|---|---|---|---|---|
| Data Packets | 1-DH 1 | 1-DH 3 | 1-DH 5 | 2-DH 1 | 2-DH 3 | 2-DH 5 | 3-DH 1 | 3-DH 3 | 3-DH 5 |
| Available Channel | 0 to 78 | | | | | | | | |
| **Test Item** | **Test channel and choose of data packets** | | | | | | | | |
| AC Power Line Conducted Emission | Frequency Hopping Channel 0 to 78 | | | | | | | | |
| | Link | | | | | | | | |
| Conducted Peak Output Power | Channel 0 & 39 & 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ |
| 20 dB Bandwidth | Channel 0 & 39 & 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ |
| Carrier Frequencies Separation | Frequency Hopping Channel 0 to 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ |
| Number of Hopping Channel | Frequency Hopping Channel 0 to 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ |
| Dwell Time | Channel 39 | | | | | | | | |
| | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ | ☒ |
| Conducted Out of Band Emission | Channel 0 & 39 & 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ | ☐ | ☐ | ☒ |
| Radiated Emissions | Channel 0 & 39 & 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Band Edge Measurements (Radiated) | Channel 0 & 78 | | | | | | | | |
| | ☐ | ☐ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

Remark:
1. The mark "☒" means is chosen for testing;
2. The mark "☐" means is not chosen for testing.

## 4.5 TEST SETUP

### 4.5.1 For Radiated Emissions test setup

**Figure 1. Below 30MHz**

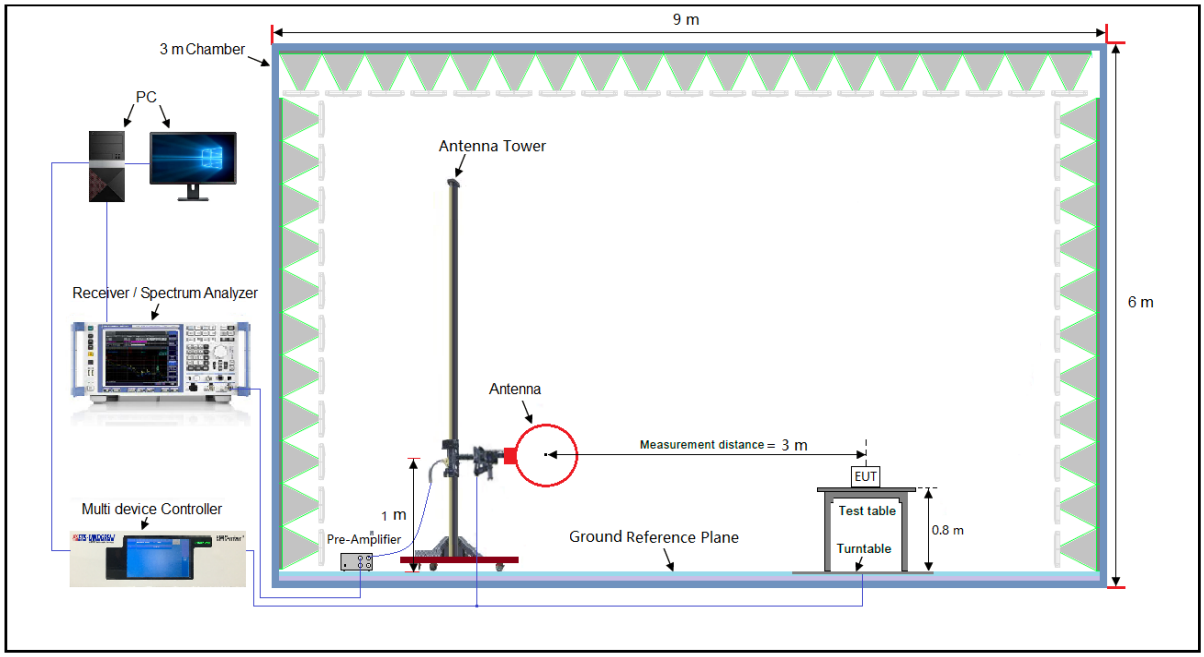



**Figure 2. 30MHz to 1GHz**

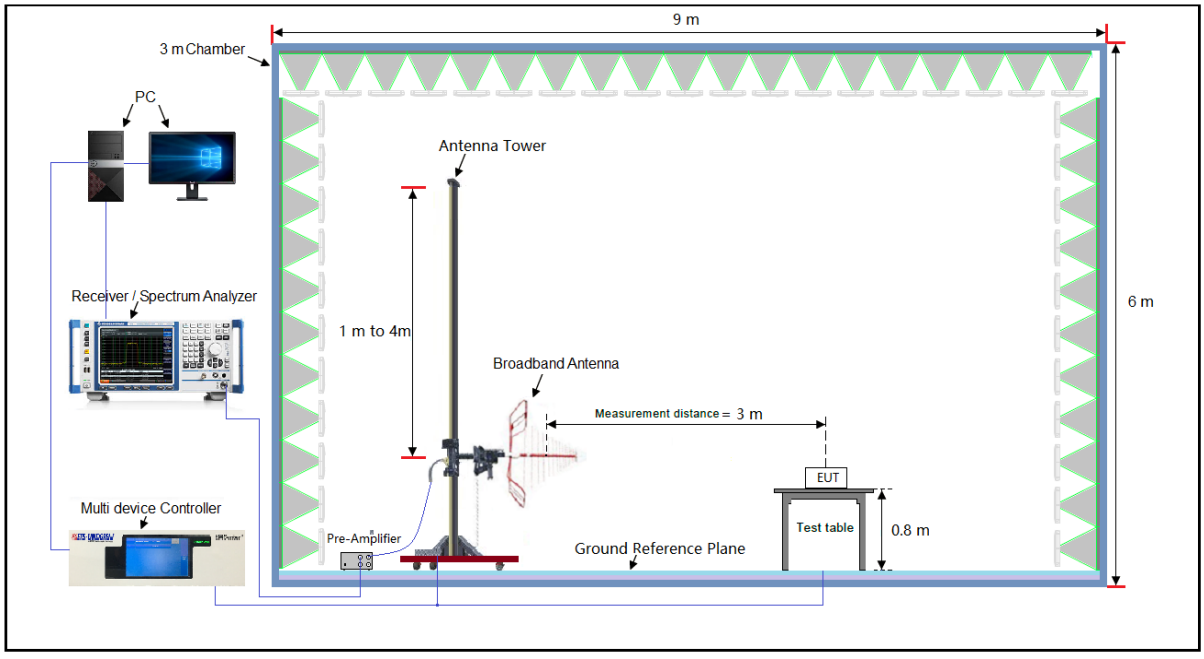
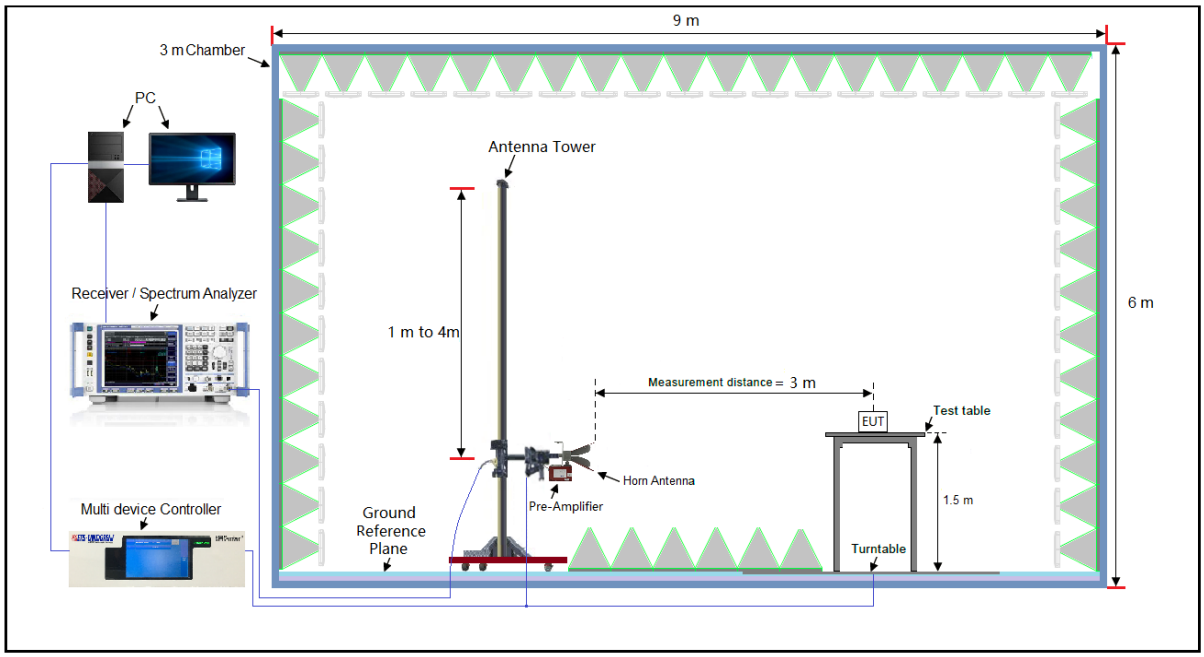
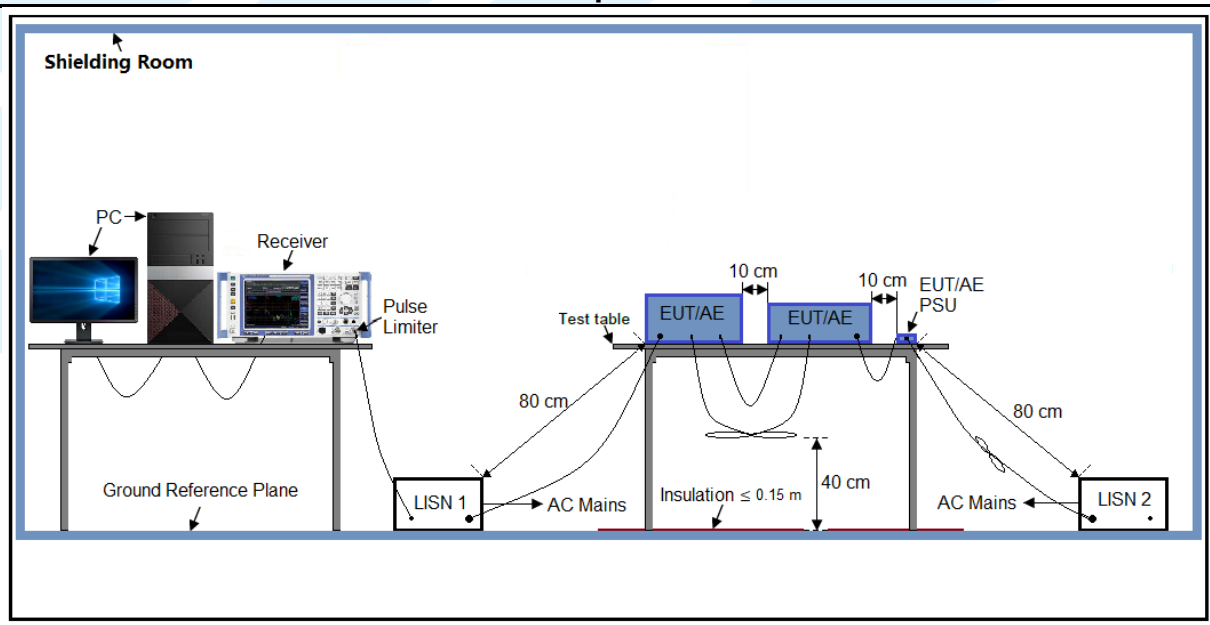


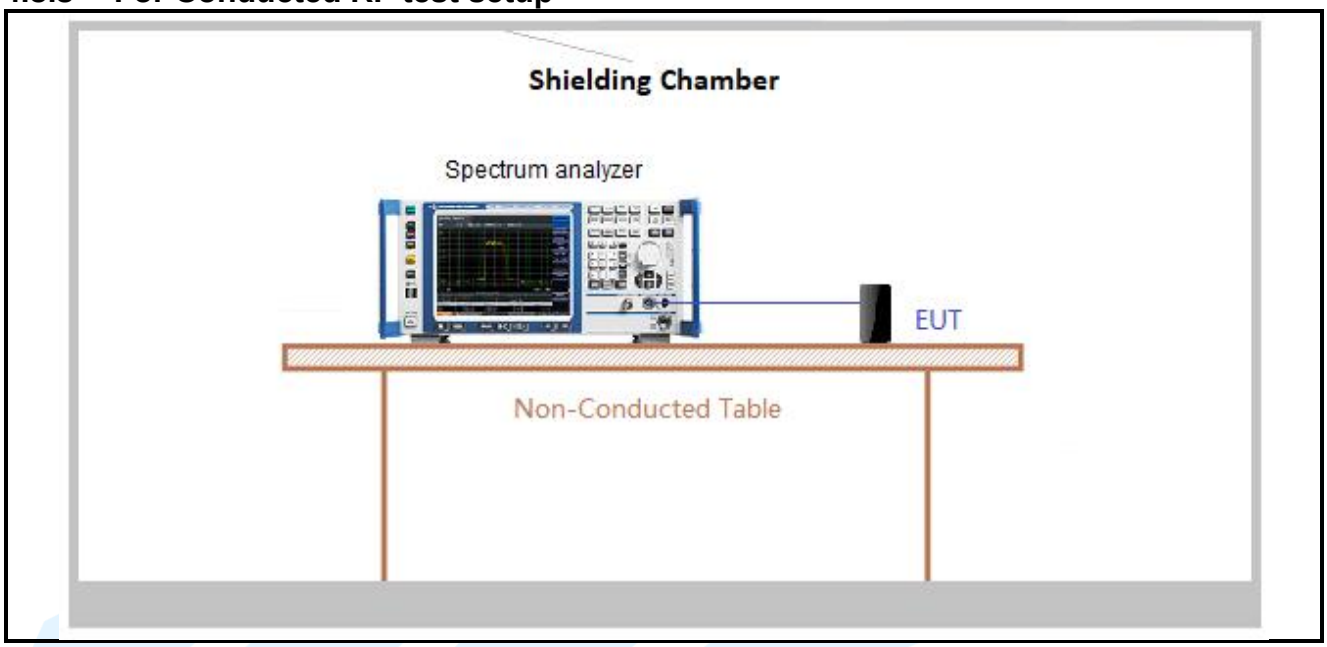
**Figure 3. Above 1GHz**




## 4.5.2 For Conducted Emissions test setup



### 4.5.3 For Conducted RF test setup




## 4.6 SYSTEM TEST CONFIGURATION

For emissions testing, the equipment under test (EUT) setup to transmit continuously to simplify the measurement methodology. Care was taken to ensure proper power supply voltages during testing. During testing, radiated emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario. It was powered by a 3.7V battery. Only the worst case data were recorded in this test report.

The signal is maximized through rotation and placement in the three orthogonal axes. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters. Radiated emissions are taken at three meters unless the signal level is too low for measurement at that distance. If necessary, a pre-amplifier is used and/or the test is conducted at a closer distance. Therefore, all final radiated testing was performed with the EUT in (see table below) orientation.

| Frequency | Mode | Antenna Port | Worst-case axis positioning |
|---|---|---|---|
| Above 1GHz | 1TX | Chain 0 | X axis |

All readings are extrapolated back to the equivalent three meter reading using inverse scaling with distance. Analyzer resolution is 100 kHz or greater for frequencies below 1000 MHz. The resolution is 1 MHz or greater for frequencies above 1000 MHz. The spurious emissions more than 20 dB below the permissible value are not reported.

Radiated emission measurement were performed from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

## 4.7 DUTY CYCLE

**Test Procedure:** ANSI C63.10-2013 Clause 11.6.

**Test Results**

| Type of Modulation | Packets | On Time (msec) | Period (msec) | Duty Cycle (linear) | Duty Cycle (%) | Duty Cycle Factor (dB) | 1/ T Minimum VBW (kHz) | Average Factor (dB) |
|---|---|---|---|---|---|---|---|---|
| GFSK | 1-DH5 | 2.8500 | 3.7350 | 0.76 | 76.31 | 1.17 | 0.35 | -2.35 |

**Remark:**

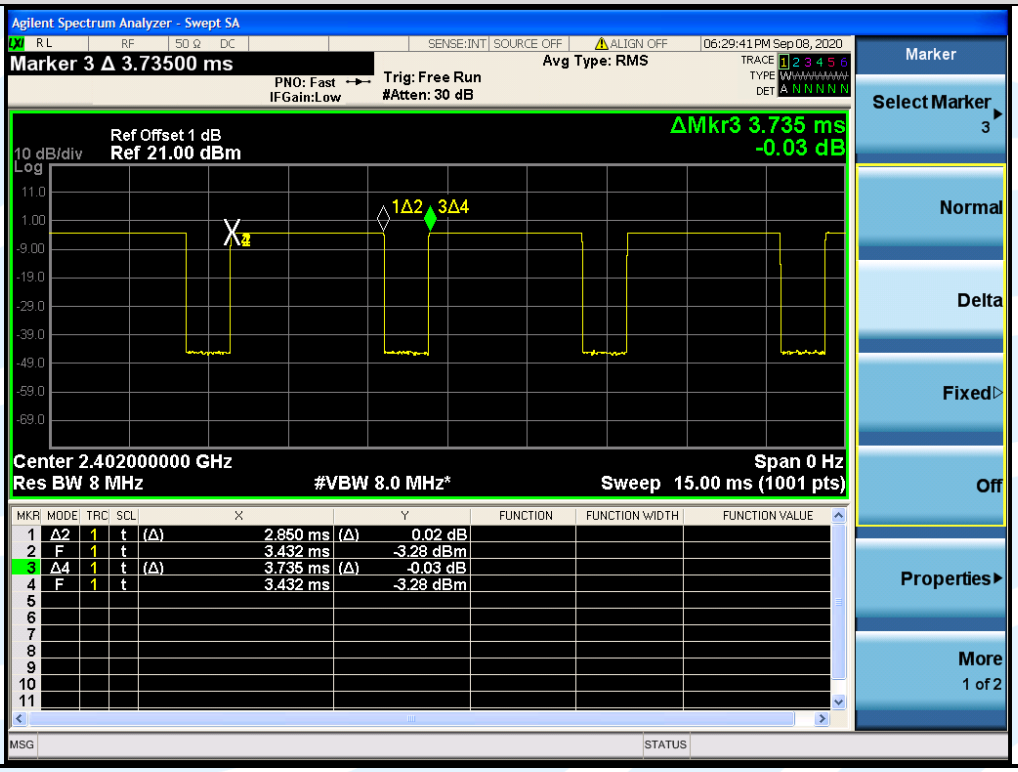
1) Duty cycle= On Time/ Period;

2) Duty Cycle factor = 10 * log(1/ Duty cycle);

3) Average factor = 20 $\log_{10}$ Duty Cycle.

**The test plots as follows**

**GFSK_ 1-DH5**



# 5. RADIO TECHNICAL REQUIREMENTS SPECIFICATION

## 5.1 REFERENCE DOCUMENTS FOR TESTING

| No. | Identity | Document Title |
|---|---|---|
| 1 | FCC 47 CFR Part 2 | Frequency allocations and radio treaty matters; general rules and regulations |
| 2 | FCC 47 CFR Part 15 | Radio Frequency Devices |
| 3 | ANSI C63.10-2013 | American National Standard for Testing Unlicesed Wireless Devices |
| 4 | KDB 558074 D01 15.247 Meas Guidance v05r02 | Guidance for compliance measurements on Digital Transmission Systems, Frequency Hopping Spread Spectrum system, and Hybrid system devices operating under Section 15.247 of the FCC rules |

## 5.2 ANTENNA REQUIREMENT

| Standard Requirement |
|---|
| **15.203 requirement:**<br>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.<br>**15.247(b) (4) requirement:**<br>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:** |
| Antenna in the interior of the equipment and no consideration of replacement. The gain of the antenna is 1.9 dBi. |

## 5.3 CONDUCTED PEAK OUTPUT POWER

**Test Requirement:** FCC 47 CFR Part 15 Subpart C Section15.247 (b)(1)

**Test Method:** ANSI C63.10-2013 Section 7.8.5

**Limit:** For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt.
Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

**Test Procedure:** Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

a) Use the following spectrum analyzer settings:
1) Span: Approximately 5 x 20 dB bandwidth, centered on a hopping channel.
2) RBW > 20 dB bandwidth of the emission being measured.
3) VBW ≥ RBW.
4) Sweep: Auto.
5) Detector function: Peak.
6) Trace: Max hold.

b) Allow trace to stabilize.
c) Use the marker-to-peak function to set the marker to the peak of the emission.
d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
e) A plot of the test results and setup description shall be included in the test report.

**Test Setup:** Refer to section 4.5.3 for details.

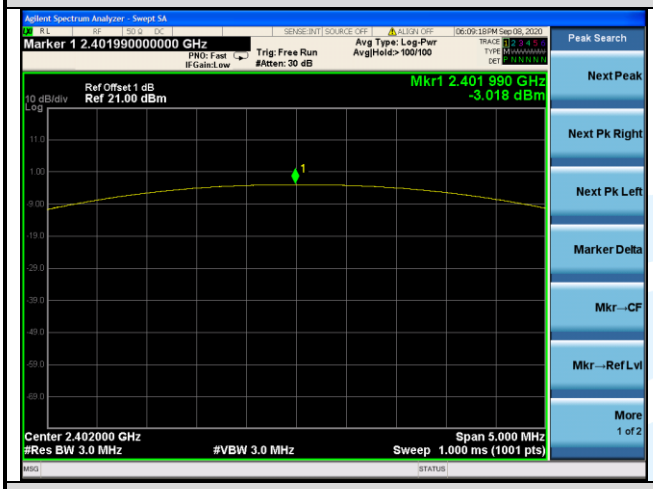
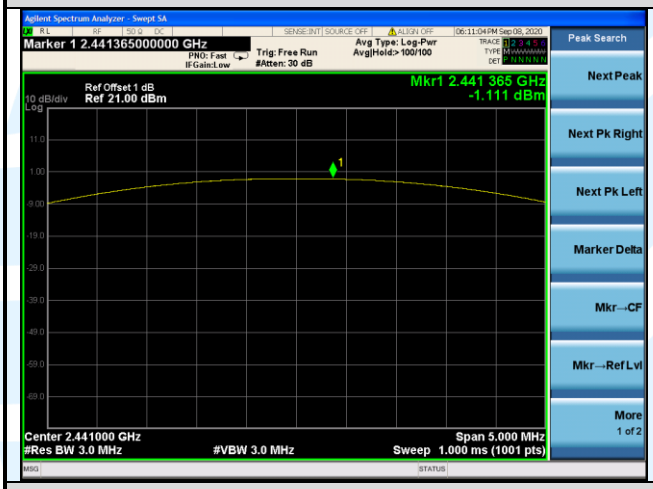
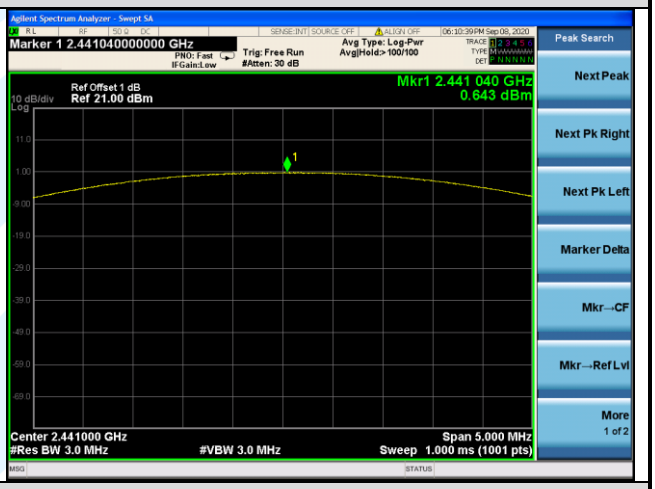
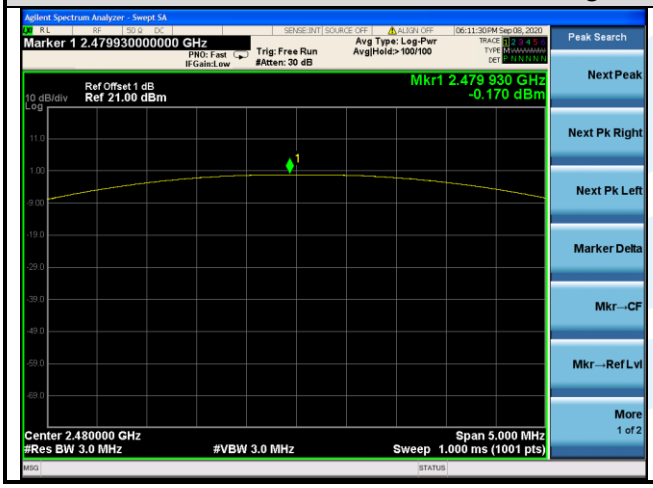
**Instruments Used:** Refer to section 3 for details

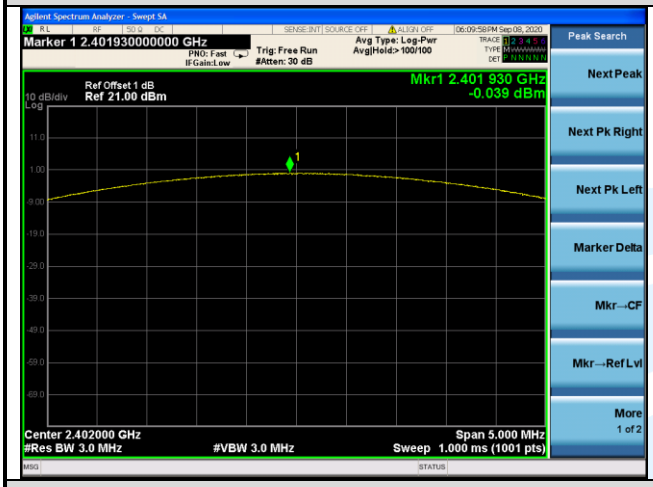
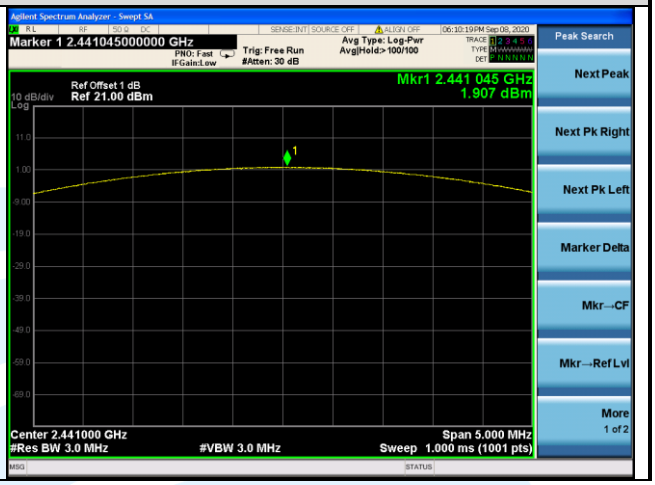
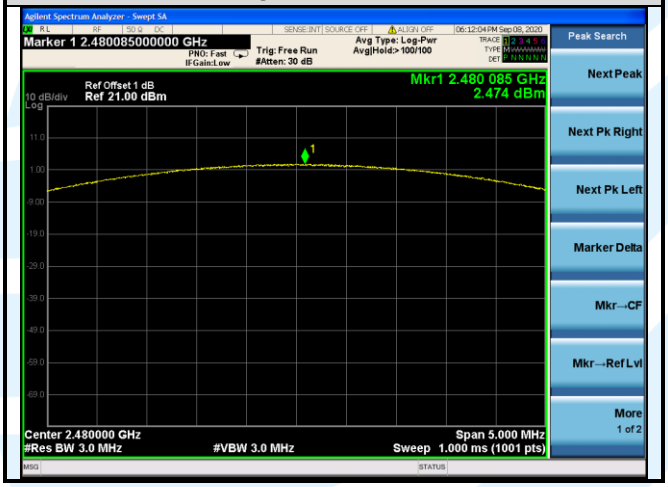
**Test Results:** Pass

| Type of Modulation | Peak Output Power (dBm) | | | Peak Output Power (mW) | | |
|---|---|---|---|---|---|---|
| | Channel 0 | Channel 39 | Channel 78 | Channel 0 | Channel 39 | Channel 78 |
| GFSK | -3.02 | -1.11 | -0.17 | 0.50 | 0.77 | 0.96 |
| π/4 DQPSK | -1.15 | 0.64 | 1.75 | 0.77 | 1.16 | 1.50 |
| 8DPSK | -0.04 | 1.91 | 2.47 | 0.99 | 1.55 | **1.77** |

Note: The antenna gain of 1.9 dBi less than 6dBi maximum permission antenna gain value based on 125 mW peak output power limit.

**The test plots as follows:**

| GFSK | π/4 DQPSK |
|---|---|
| **Lowest Channel** | |
|  |  |
| **Middle Channel** | |
|  |  |
| **Highest Channel** | |
|  |  |

| 8DPSK | |
|---|---|
| **Lowest Channel** | **Middle Channel** |
|  |  |
| **Highest Channel** | |
|  | |

## 5.4 20 DB BANDWIDTH

**Test Requirement:** FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)

**Test Method:** ANSI C63.10-2013 Section 6.9.2

**Limit:** None; for reporting purposes only.

**Test Procedure:** Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
Use the following spectrum analyzer settings:

a) Span = approximately 2 to 5 times the OBW, centered on a hopping channel.
b) RBW = 1% to 5% of the OBW.
c) VBW ≥ 3 x RBW
d) Sweep = auto;
e) Detector function = peak
f) Trace = max hold
g) All the trace to stabilize, use the marker-to-peak function to set the marker to the peak of the emission, use the marker-delta function to measure and record the 20dB down bandwidth of the emission.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

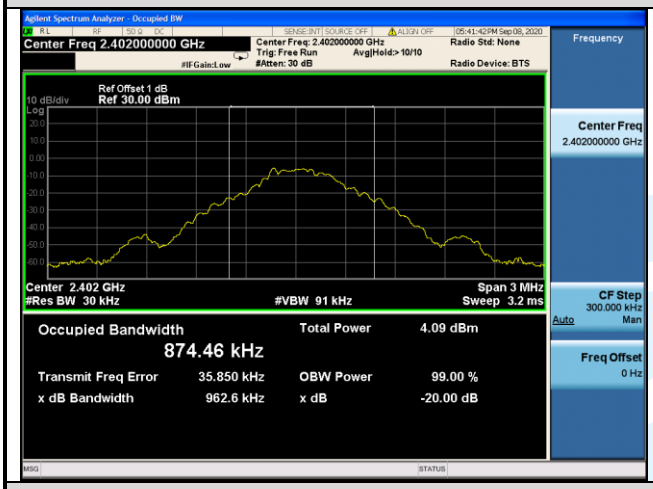
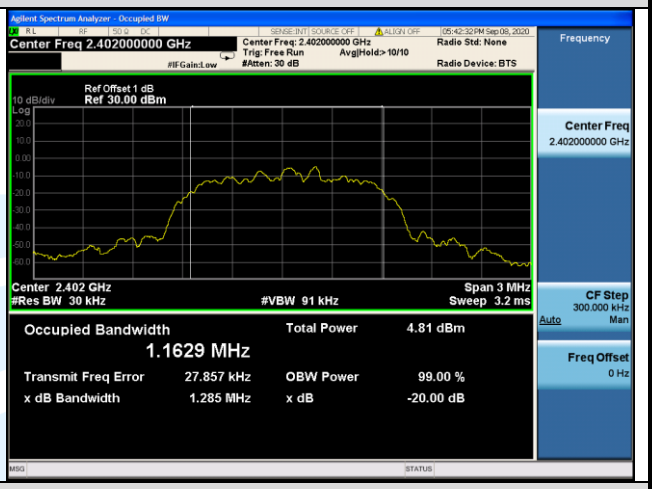
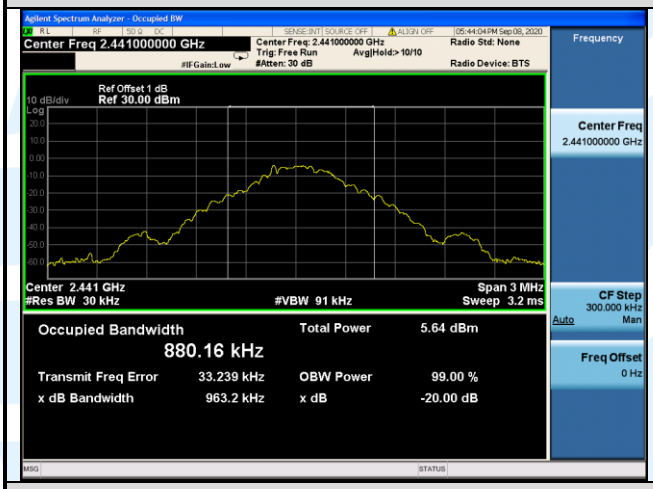
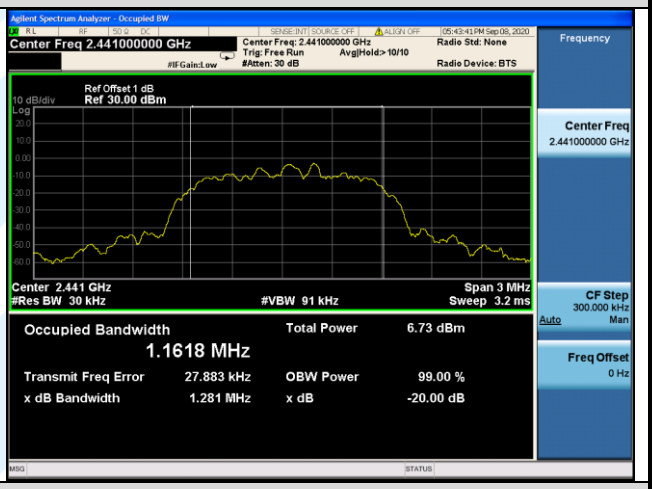
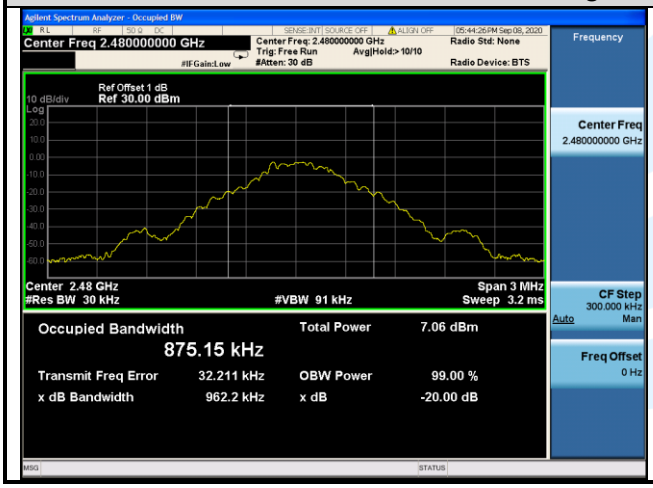
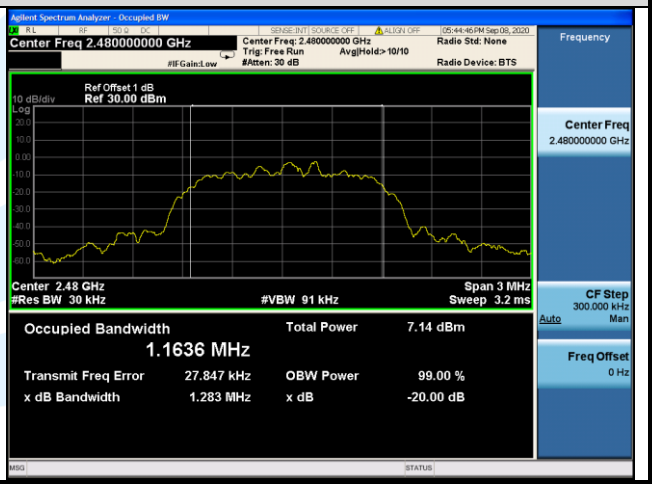
**Test Setup:** Refer to section 4.5.3 for details.

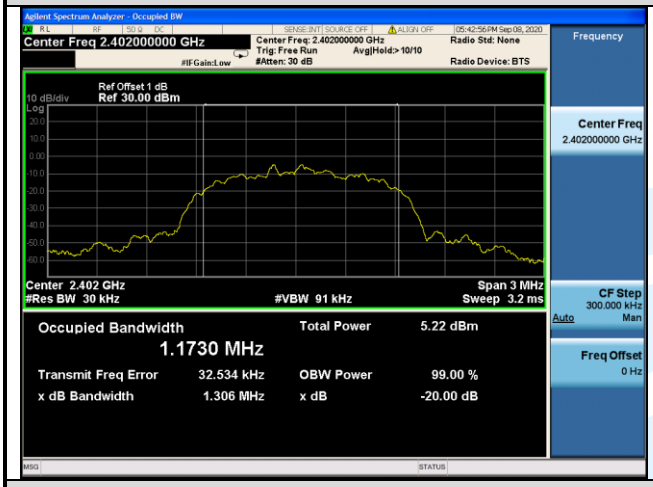
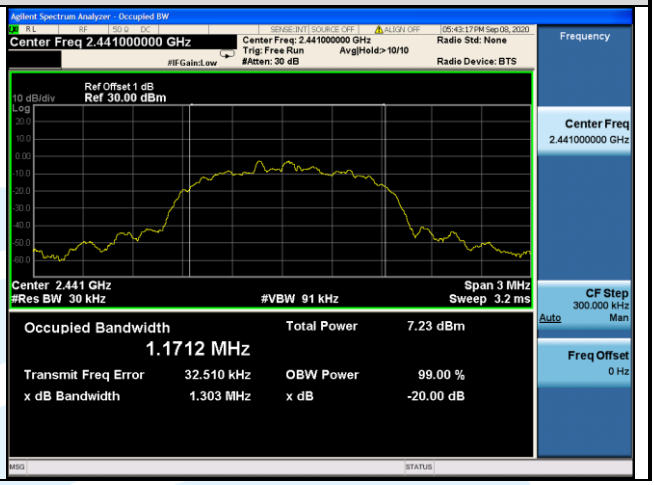
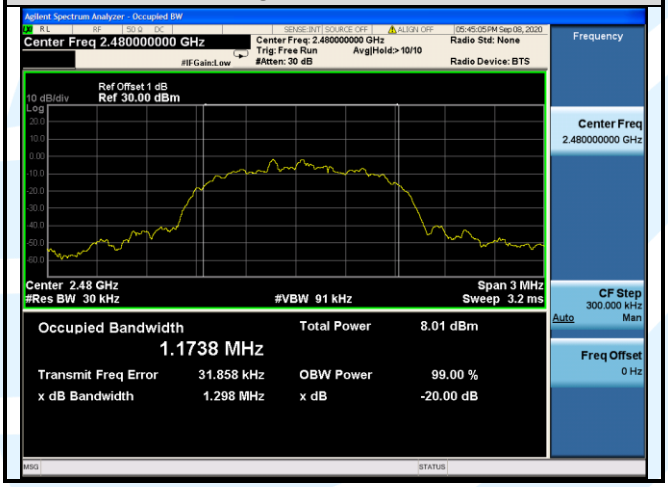
**Instruments Used:** Refer to section 3 for details

**Test Results:** Pass

| Type of Modulation | 20 dB Bandwidth (MHz) | | | 99% Bandwidth (MHz) | | |
|---|---|---|---|---|---|---|
| | Channel 0 | Channel 39 | Channel 78 | Channel 0 | Channel 39 | Channel 78 |
| GFSK | 0.96260 | 0.96320 | 0.96220 | 0.87446 | 0.88016 | 0.87515 |
| π/4 DQPSK | 1.2850 | 1.2810 | 1.2830 | 1.1629 | 1.1618 | 1.1636 |
| 8DPSK | 1.3060 | 1.3030 | 1.2980 | 1.1730 | 1.1712 | 1.1738 |

**The test plots as follows:**

| GFSK | π/4 DQPSK |
|---|---|
| **Lowest Channel** | |
|  |  |
| **Middle Channel** | |
|  |  |
| **Highest Channel** | |
|  |  |

| 8DPSK | |
|---|---|
| Lowest Channel | Middle Channel |
|  |  |
| Highest Channel | |
|  | |

## 5.5 CARRIER FREQUENCIES SEPARATION

**Test Requirement:** FCC 47 CFR Part 15 Subpart C Section 15.247 (a)(1)

**Test Method:** ANSI C63.10-2013 Section 7.8.2

**Limit:** Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.
Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

**Test Procedure:** Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
Use the following spectrum analyzer settings:

a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c) Video (or average) bandwidth (VBW) ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.
h) Use the marker-delta function to determine the separation between the peaks of the adjacent channels.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

**Test Setup:** Refer to section 4.5.3 for details.

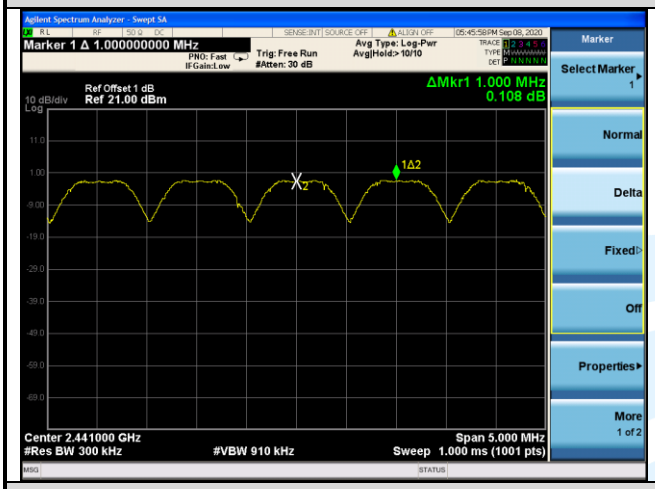
**Instruments Used:** Refer to section 3 for details

**Test Results:** Pass

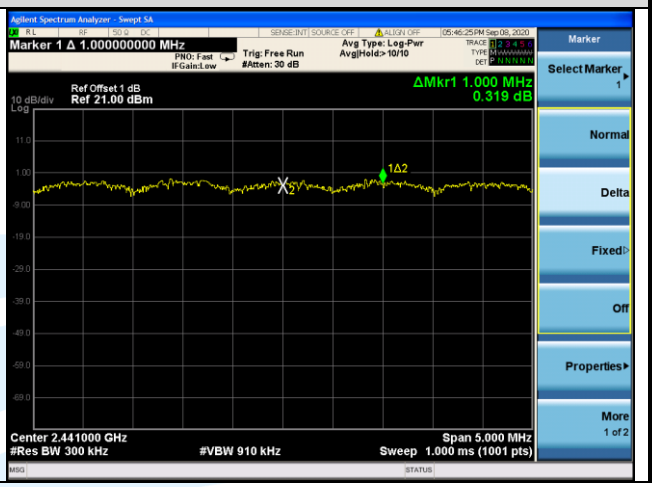
| Type of Modulation | Adjacent Channel Separation (MHz) | Minimum Limit (MHz) |
|---|---|---|
| | Channel 39 | Channel 39 |
| GFSK | 1.000 | 0.642 |
| π/4 DQPSK | 1.000 | 0.854 |
| 8DPSK | 1.000 | 0.869 |
| Note: The minimum limit is two-third 20 dB bandwidth. | | |

**The test plots as follows:**

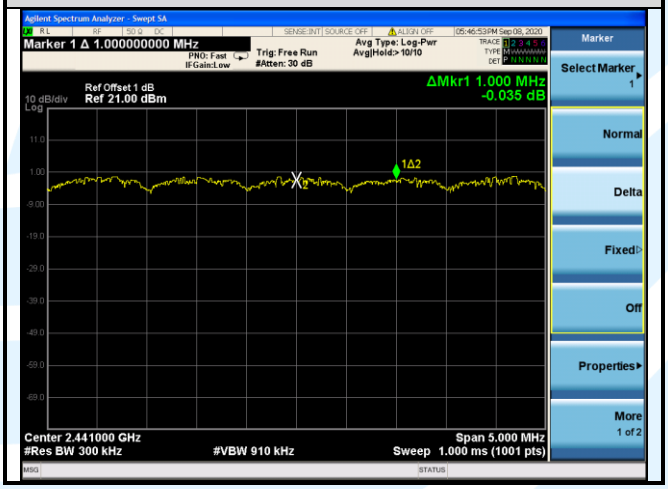
GFSK




π/4 DQPSK




8DPSK



## 5.6 NUMBER OF HOPPING CHANNEL

**Test Requirement:** FCC 47 CFR Part 15 Subpart C Section 15.247(b)(1)

**Test Method:** ANSI C63.10-2013 Section 7.8.3

**Limit:** Frequency hopping systems in the 2400 – 2483.5 MHz band shall use at least 15 non-overlapping channels.

**Test Procedure:** Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.
Use the following spectrum analyzer settings:

a) Span: The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
b) RBW < 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
c) VBW ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

Note: The cable loss and attenuator loss were offset into measure device as an amplitude offset.

**Test Setup:** Refer to section 4.5.3 for details.

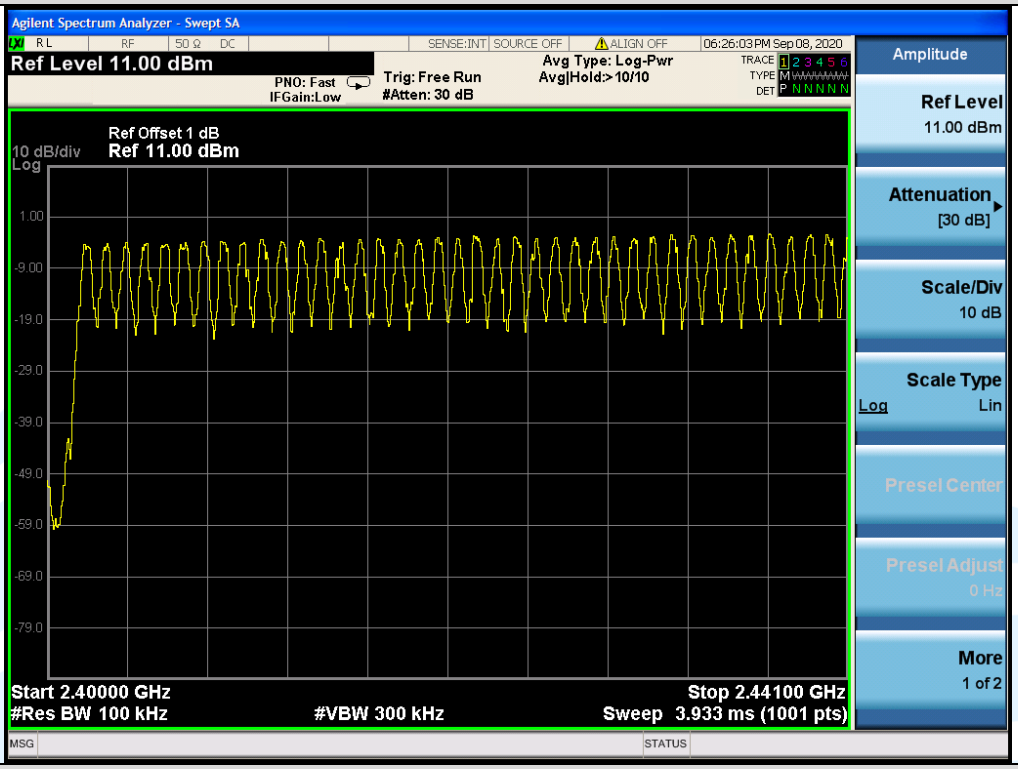
**Instruments Used:** Refer to section 3 for details

**Test Results:** Pass

| Type of Modulation | Number of Hopping Channel |
|---|---|
| GFSK | 79 |
| π /4 DQPSK | 79 |
| 8DPSK | 79 |

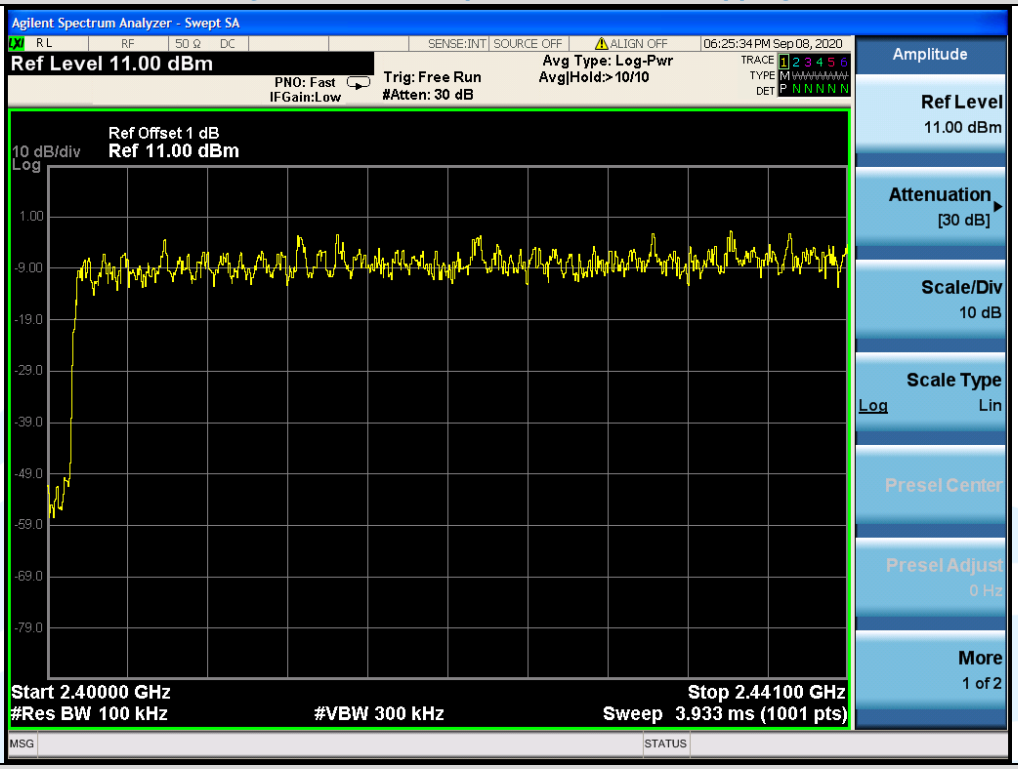
**The test plots as follows:**

GFSK_Low End Spectrum Channel Hopping Plot

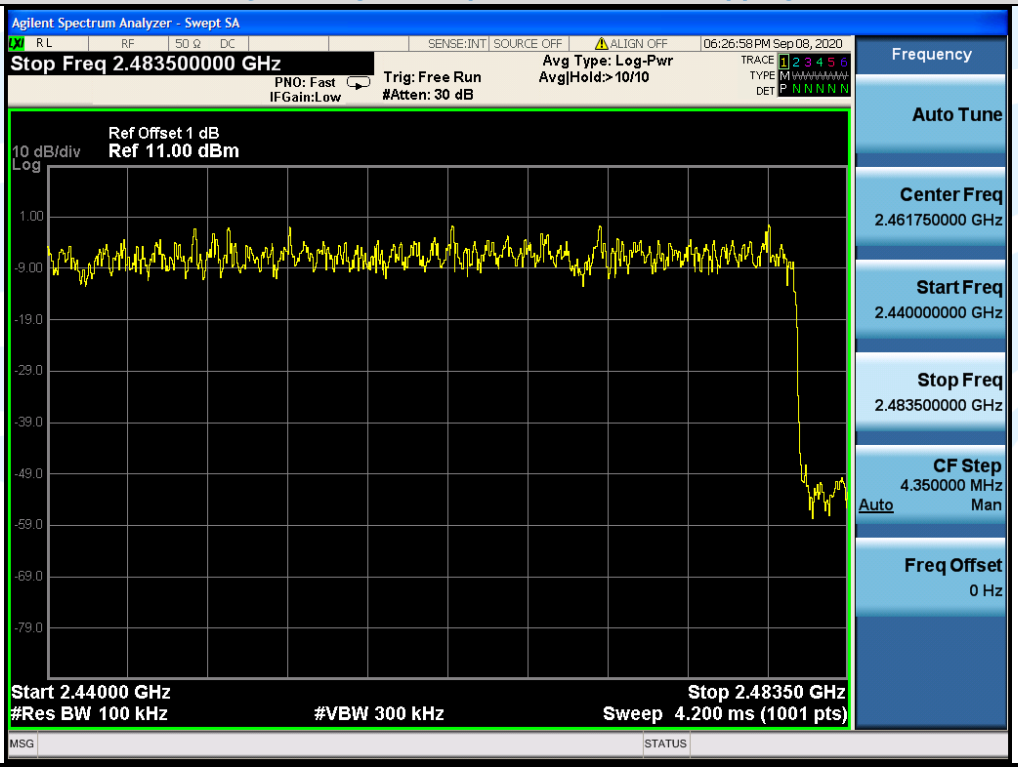



GFSK_High End Spectrum Channel Hopping Plot

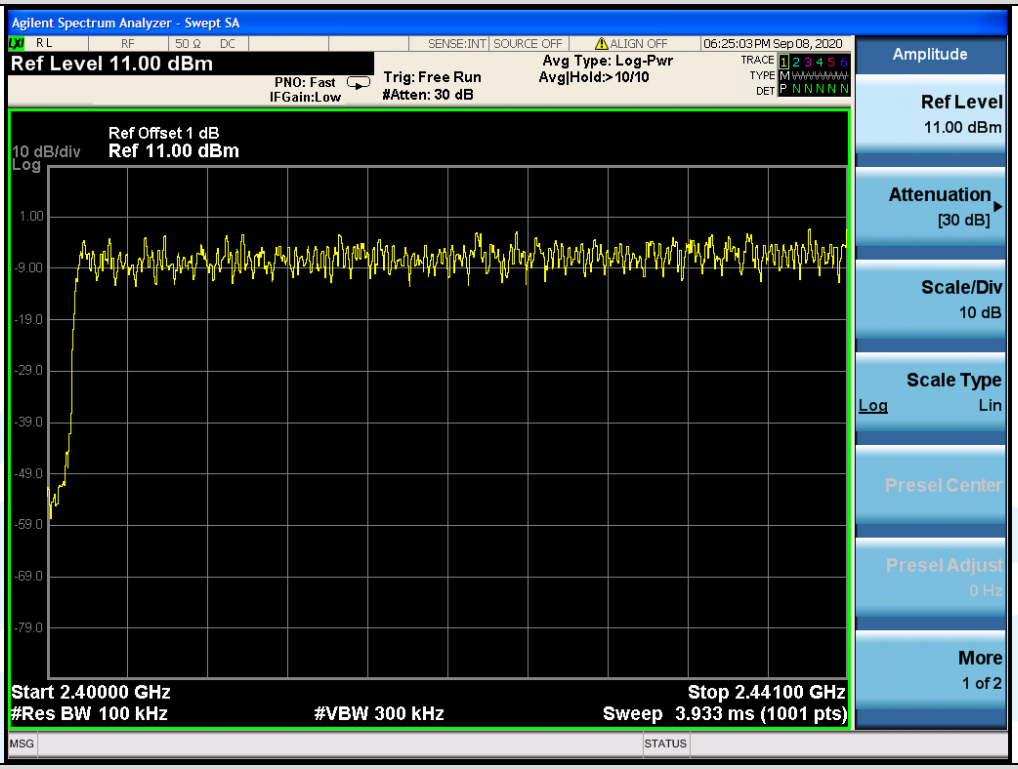
π /4 DQPSK_Low End Spectrum Channel Hopping Plot




π /4 DQPSK_High End Spectrum Channel Hopping Plot



8DPSK_Low End Spectrum Channel Hopping Plot




8DPSK_High End Spectrum Channel Hopping Plot