

# TEST REPORT

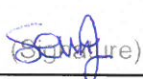


**DT&C Co., Ltd.**

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Tel : 031-321-2664, Fax : 031-321-1664

1. Report No : DRTFCC2208-0141
2. Customer
  - Name (FCC) : EMSONIC
  - Address (FCC) : 54-8, Cheomdangieop 3-ro, Sandong-eup, Gumi-si Gyeongsangbuk-do  
South Korea
3. Use of Report : FCC Original Grant
4. Product Name / Model Name : PORTABLE BLUETOOTH SPEAKER / SAVER  
FCC ID : 2A78WSAVER
5. FCC Regulation(s): Part 15.247  
Test Method used: KDB558074 D01v05r02, ANSI C63.10-2013
6. Date of Test : 2022.07.29 ~ 2022.08.16
7. Location of Test : ☒ Permanent Testing Lab ☐ On Site Testing
8. Testing Environment : See appended test report.
9. Test Result : Refer to the attached test result.

The results shown in this test report refer only to the sample(s) tested unless otherwise stated.  
This test report is not related to KOLAS accreditation.

|             |                                                                                                         |                                                                                                         |
|-------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|
| Affirmation | Tested by                                                                                               | Technical Manager                                                                                       |
|             | Name : SeungMin Gil  | Name : JaeJin Lee  |

2022 . 08 . 31 .

**DT&C Co., Ltd.**

If this report is required to confirmation of authenticity, please contact to [report@dtnc.net](mailto:report@dtnc.net)

## Test Report Version

| Test Report No. | Date          | Description   | Revised by   | Reviewed by |
|-----------------|---------------|---------------|--------------|-------------|
| DRTFCC2208-0141 | Aug. 31, 2022 | Initial issue | SeungMin Gil | JaeJin Lee  |
|                 |               |               |              |             |
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## 1. General Information

### 1.1. Description of EUT

|                                        |                                                                   |
|----------------------------------------|-------------------------------------------------------------------|
| Equipment Class                        | Spread Spectrum Transmitter(DSS)                                  |
| Product Name                           | PORTABLE BLUETOOTH SPEAKER                                        |
| Model Name                             | SAVER                                                             |
| Add Model Name                         | -                                                                 |
| Firmware Version Identification Number | B08093                                                            |
| EUT Serial Number                      | No Specified                                                      |
| Power Supply                           | DC 7.4 V                                                          |
| Frequency Range                        | 2 402 MHz ~ 2 480 MHz                                             |
| Max. RF Output Power                   | -1.16 dBm (0.001 W)                                               |
| Modulation Technique (Data rate)       | GFSK(1 Mbps), $\pi/4$ DQPSK(2 Mbps), 8DPSK(3 Mbps)                |
| Number of Channels                     | 79                                                                |
| Antenna Specification                  | Antenna Type: Pattern(Inverted F) Antenna<br>Gain: -0.68 dBi (PK) |

### 1.2. Declaration by the applicant / manufacturer

- NA

### 1.3. Testing Laboratory

|                                                                                                                                                                                      |   |                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---|------------------|
| <b>DT&amp;C Co., Ltd.</b>                                                                                                                                                            |   |                  |
| The 3 m test site and conducted measurement facility used to collect the radiated data are located at the 42, Yurim-ro, 154beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea 17042. |   |                  |
| The test site complies with the requirements of Part 2.948 according to ANSI C63.4-2014.                                                                                             |   |                  |
| - FCC & IC MRA Designation No. : KR0034                                                                                                                                              |   |                  |
| - ISED#: 5740A                                                                                                                                                                       |   |                  |
| <a href="http://www.dtnc.net">www.dtnc.net</a>                                                                                                                                       |   |                  |
| Telephone                                                                                                                                                                            | : | + 82-31-321-2664 |
| FAX                                                                                                                                                                                  | : | + 82-31-321-1664 |

### 1.4. Testing Environment

| Ambient Condition   |                 |
|---------------------|-----------------|
| ▪ Temperature       | +20 °C ~ +25 °C |
| ▪ Relative Humidity | 38 % ~ 45 %     |

### 1.5. Measurement Uncertainty

The measurement uncertainties shown below were calculated in accordance with requirements of ANSI C63.4-2014 and ANSI C63.10-2013. All measurement uncertainty values are shown with a coverage factor of  $k = 2$  to indicate a 95 % level of confidence.

| Parameter                          | Measurement uncertainty                               |
|------------------------------------|-------------------------------------------------------|
| Antenna-port conducted emission    | 0.9 dB (The confidence level is about 95 %, $k = 2$ ) |
| AC power-line conducted emission   | 3.4 dB (The confidence level is about 95 %, $k = 2$ ) |
| Radiated emission (1 GHz Below)    | 4.9 dB (The confidence level is about 95 %, $k = 2$ ) |
| Radiated emission (1 GHz ~ 18 GHz) | 4.9 dB (The confidence level is about 95 %, $k = 2$ ) |
| Radiated emission (18 GHz Above)   | 5.3 dB (The confidence level is about 95 %, $k = 2$ ) |

## 1.6. Information about the FHSS characteristics

- This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following :

A) The hopping sequence is pseudorandom

Note 1 : Pseudorandom Frequency Hopping Sequence Table as below:

Channel: 08, 24, 40, 56, 42, 54, 72, 09, 01, 11, 33, 41, 34, 42, 65, 73, 53, 69, 06, 22, 04, 20,  
36, 52, 38, 46, 70, 78, 68, 76, 21, 29, 10, 26, 41, 58, 44, 60, 76, 13, 03, 11, 35, 43,  
37, 45, 69, 77, 52, 71, 08, 24, 06, 24, 48, 56, 45, 46, 70, 01, 72, 06, 25, 33, 12, 28,  
49, 60, 45, 58, 74, 13, 05, 18, 37, 49 etc

The System receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchroniztation with the transmitted signals.

B) All channels are used equally on average

C) The receiver input bandwidth equals the transmit bandwidth

D) The receiver hops in sequenc e with the transmit signal

- 15.247(g) : In accordance with the Bluetooth Industry Standard, the system is designed to comply with all of the regulations in Section 15.247 when the transmitter is presented with a continuous data (or information) system.
- 15.247(h) : In accordance with the Bluetooth Industry Standard, the system does not coordinate its channels selection / hopping sequence with other frequency hopping systems for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters.
- 15.247(h) : The EUT employs Adaptive Frequency Hopping (AFH) which identifies sources of interference namely devices operating in 802.11 WLAN and excludes them from the list of available channels. The process of re-mapping reduces the number of test channels from 79 channels to a minimum number of 20 channels.

## 1.7. Conclusion of worst-case and operation mode

The EUT has three types of modulation (GFSK,  $\pi/4$ DQPSK and 8DPSK). Therefore all applicable requirements were tested with all the modulations. And packet type was tested at the worst case(DH5).

### EUT Operation test setup

Bluetooth tester was used to control the transmit parameters during test.

### Tested frequency information

- Hopping Function : Enable

|              | Tested Frequency (MHz) |
|--------------|------------------------|
| Hopping Band | 2 402 ~ 2 480          |

- Hopping Function : Disable

|                 | Tested Frequency (MHz) |
|-----------------|------------------------|
| Lowest Channel  | 2 402                  |
| Middle Channel  | 2 441                  |
| Highest Channel | 2 480                  |

## 1.8. Test Equipment List

| Type                                | Manufacturer           | Model                         | Cal.Date<br>(yy/mm/dd) | Next.Cal.Date<br>(yy/mm/dd) | S/N                |
|-------------------------------------|------------------------|-------------------------------|------------------------|-----------------------------|--------------------|
| Spectrum Analyzer                   | Agilent Technologies   | N9020A                        | 22/06/24               | 23/06/24                    | US47360812         |
| Spectrum Analyzer                   | Agilent Technologies   | N9020A                        | 21/12/16               | 22/12/16                    | MY48010133         |
| DC Power Supply                     | Agilent Technologies   | 66332A                        | 22/06/24               | 23/06/24                    | US37473422         |
| BlueTooth Tester                    | TESCOM                 | TC-3000C                      | 22/06/24               | 23/06/24                    | 3000C000563        |
| Power Splitter                      | Anritsu                | K241B                         | 21/12/16               | 22/12/16                    | 1301182            |
| Multimeter                          | FLUKE                  | 17B+                          | 21/12/16               | 22/12/16                    | 36390701WS         |
| Signal Generator                    | Rohde Schwarz          | SMBV100A                      | 21/12/16               | 22/12/16                    | 255571             |
| Signal Generator                    | ANRITSU                | MG3695C                       | 21/12/16               | 22/12/16                    | 173501             |
| Thermohygrometer                    | BODYCOM                | BJ5478                        | 21/12/16               | 22/12/16                    | 120612-2           |
| Thermohygrometer                    | BODYCOM                | BJ5478                        | 21/12/16               | 22/12/16                    | 120612-1           |
| Loop Antenna                        | ETS-Lindgren           | 6502                          | 21/01/28               | 23/01/28                    | 00226186           |
| Hybrid Antenna                      | Schwarzbeck            | VULB 9160                     | 21/12/16               | 22/12/16                    | 3362               |
| Horn Antenna                        | ETS-Lindgren           | 3117                          | 21/12/16               | 22/12/16                    | 00140394           |
| Horn Antenna                        | A.H.Systems Inc.       | SAS-574                       | 22/06/24               | 23/06/24                    | 155                |
| PreAmplifier                        | Agilent Technologies   | 8449B                         | 22/06/24               | 23/06/24                    | 3008A02108         |
| PreAmplifier                        | tsj                    | MLA-1840-J02-45               | 22/06/24               | 23/06/24                    | 16966-10728        |
| PreAmplifier                        | H.P                    | 8447D                         | 21/12/16               | 22/12/16                    | 2944A07774         |
| High Pass Filter                    | Wainwright Instruments | WHKX12-935-1000-15000-40SS    | 22/06/24               | 23/06/24                    | 7                  |
| High Pass Filter                    | Wainwright Instruments | WHKX10-2838-3300-18000-60SS   | 22/06/24               | 23/06/24                    | 2                  |
| High Pass Filter                    | Wainwright Instruments | WHKX6-6320-8000-26500-40CC    | 22/06/24               | 23/06/24                    | 2                  |
| Power Meter & Wide Bandwidth Sensor | Anritsu                | ML2496A<br>MA2490A            | 21/12/16               | 22/12/16                    | 1338004<br>1249303 |
| EMI Test Receiver                   | ROHDE&SCHWARZ          | ESU                           | 21/11/12               | 22/11/12                    | 100469             |
| PULSE LIMITER                       | Rohde Schwarz          | ESH3-Z2                       | 21/08/23               | 22/08/23                    | 101333             |
| LISN                                | SCHWARZBECK            | NSLK 8128 RC                  | 21/10/22               | 22/10/22                    | 8128 RC-387        |
| HYGROMETER                          | TESTO                  | 608-H1                        | 22/01/14               | 23/01/14                    | 34862883           |
| Cable                               | HUBER+SUHNER           | SUCOFLEX100                   | 22/01/04               | 23/01/04                    | M-01               |
| Cable                               | HUBER+SUHNER           | SUCOFLEX100                   | 22/01/04               | 23/01/04                    | M-02               |
| Cable                               | JUNFLON                | MWX241/B                      | 22/01/04               | 23/01/04                    | M-03               |
| Cable                               | JUNFLON                | MWX221                        | 22/01/04               | 23/01/04                    | M-04               |
| Cable                               | JUNFLON                | MWX221                        | 22/01/04               | 23/01/04                    | M-05               |
| Cable                               | JUNFLON                | J12J101757-00                 | 22/01/04               | 23/01/04                    | M-07               |
| Cable                               | HUBER+SUHNER           | SUCOFLEX104                   | 22/01/04               | 23/01/04                    | M-08               |
| Cable                               | HUBER+SUHNER           | SUCOFLEX106                   | 22/01/04               | 23/01/04                    | M-09               |
| Cable                               | DTNC                   | Cable                         | 22/06/08               | 23/06/08                    | M-10               |
| Cable                               | Junkosha               | MWX241                        | 22/01/04               | 23/01/04                    | mmW-1              |
| Cable                               | Junkosha               | MWX241                        | 22/01/04               | 23/01/04                    | mmW-4              |
| Cable                               | DT&C                   | Cable                         | 22/01/04               | 23/01/04                    | RFC-45             |
| Test Software                       | tsj                    | Noise Terminal Measurement    | NA                     | NA                          | Version 2.00.0170  |
| Test Software                       | tsj                    | Radiated Emission Measurement | NA                     | NA                          | Version 2.00.0177  |

Note1: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2017

Note2: The cable is not a regular calibration item, so it has been calibrated by DT & C itself.



## 2. Antenna 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 shall be considered sufficient to comply with the provisions.

**Conclusion: Comply**

**The antenna is permanently attached on the device.**

**Therefore this E.U.T complies with the requirement of Part 15.203**

### 3. Summary of Test Results

| FCC part section(s)                                                                                                                                                                                                                                                                                                                       | Test Description                    | Limit<br>(Using in 2 400~ 2 483.5 MHz)                                                                               | Test Condition    | Status<br>Note 1   |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------|--------------------|
| 15.247(a)<br>15.247(b)                                                                                                                                                                                                                                                                                                                    | Maximum Peak Conducted Output Power | =< 0.125 W(conducted)                                                                                                | Conducted         | C                  |
| 15.247(a)                                                                                                                                                                                                                                                                                                                                 | 20 dB Bandwidth                     | NA                                                                                                                   |                   | C                  |
|                                                                                                                                                                                                                                                                                                                                           | Carrier Frequency Separation        | >= 25 kHz or<br>>= Two thirds of the 20 dB BW,<br>whichever is greater.                                              |                   | C                  |
|                                                                                                                                                                                                                                                                                                                                           | Number of Hopping Channels          | >= 15 hops                                                                                                           |                   | C                  |
|                                                                                                                                                                                                                                                                                                                                           | Time of Occupancy                   | =< 0.4 seconds                                                                                                       |                   | C                  |
| 15.247(d)                                                                                                                                                                                                                                                                                                                                 | Unwanted Emissions (Conducted)      | The radiated emission to any 100 kHz of out-band shall be at least 20 dB below the highest in-band spectral density. |                   | C                  |
| 15.247(d)<br>15.205<br>15.209                                                                                                                                                                                                                                                                                                             | Unwanted Emissions (Radiated)       | Part 15.209 Limits (Refer to section 9)                                                                              | Radiated          | C <sup>Note3</sup> |
| 15.207                                                                                                                                                                                                                                                                                                                                    | AC Power-Line Conducted Emissions   | Part 15.207 Limits (Refer to section 10)                                                                             | AC Line Conducted | C                  |
| 15.203                                                                                                                                                                                                                                                                                                                                    | Antenna Requirement                 | Part 15.203 (Refer to section 2)                                                                                     | -                 | C                  |
| <p>Note 1: C = Comply    NC = Not Comply    NT = Not Tested    NA = Not Applicable</p> <p>Note 2: For radiated emission tests below 30 MHz were performed on semi-anechoic chamber which is correlated with OATS.</p> <p>Note 3: This test item was performed in three orthogonal EUT positions and the worst case data was reported.</p> |                                     |                                                                                                                      |                   |                    |

## 4. Maximum Peak Conducted Output Power

### 4.1. Test Setup

Refer to the APPENDIX I.

### 4.2. Limit

#### ■ FCC Requirements

The maximum peak output power of the intentional radiator shall not exceed the following :

1. §15.247(a)(1), Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2 400 MHz - 2 483.5 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.
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 – 2 483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 MHz – 5 805 MHz band : 1 Watt. For all other frequency hopping systems in the 2 400 MHz – 2 483.5 MHz band: 0.125 watts.

### 4.3. Test Procedure

1. The RF output power was measured with a spectrum analyzer connected to the RF Antenna connector (conducted measurement) while EUT was operating in transmit mode at the appropriate center frequency, A spectrum analyzer was used to record the shape of the transmit signal.
2. The peak output power of the fundamental frequency was measured with the spectrum analyzer using ;  
Span = approximately 5 times of the 20 dB bandwidth, centered on a hopping channel  
RBW  $\geq$  20 dB BW  
VBW  $\geq$  RBW  
Sweep = auto  
Detector function = peak  
Trace = max hold

#### 4.4. Test Results

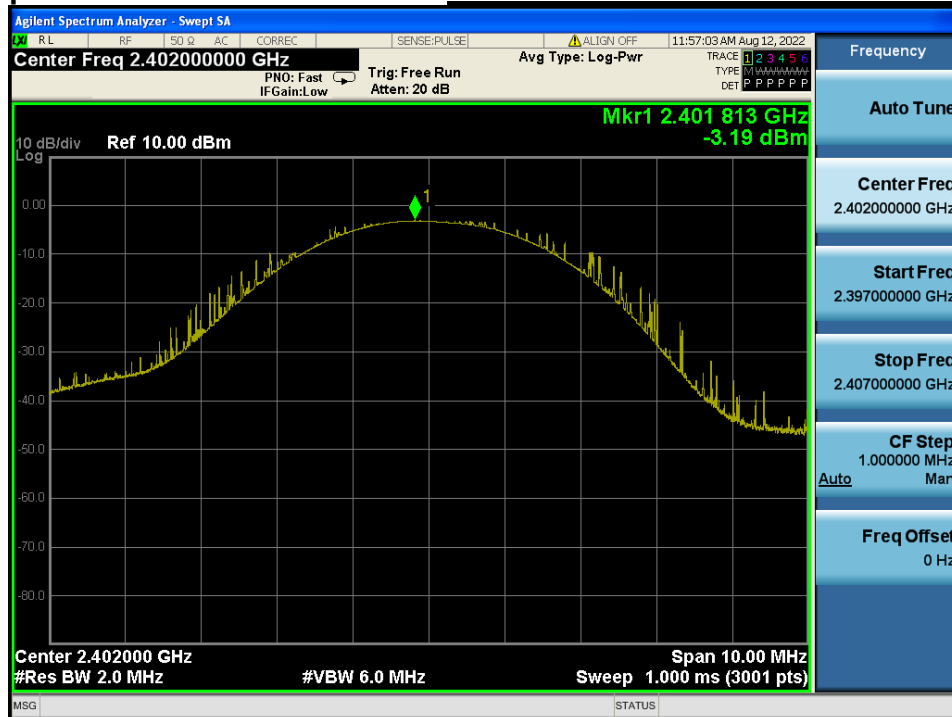
| Modulation                            | Tested Channel | Burst Average Output Power |      | Peak Output Power |             |
|---------------------------------------|----------------|----------------------------|------|-------------------|-------------|
|                                       |                | dBm                        | mW   | dBm               | mW          |
| <b><u>GFSK</u></b>                    | <b>Lowest</b>  | -3.80                      | 0.42 | -3.19             | 0.48        |
|                                       | <b>Middle</b>  | -2.82                      | 0.52 | -1.94             | 0.64        |
|                                       | <b>Highest</b> | -2.73                      | 0.53 | -2.05             | 0.62        |
| <b><u><math>\pi/4</math>DQPSK</u></b> | <b>Lowest</b>  | -5.27                      | 0.30 | -2.20             | 0.60        |
|                                       | <b>Middle</b>  | -4.13                      | 0.39 | <b>-1.16</b>      | <b>0.77</b> |
|                                       | <b>Highest</b> | -3.95                      | 0.40 | -1.39             | 0.73        |
| <b><u>8DPSK</u></b>                   | <b>Lowest</b>  | -5.25                      | 0.30 | -2.71             | 0.54        |
|                                       | <b>Middle</b>  | -4.10                      | 0.39 | -1.68             | 0.68        |
|                                       | <b>Highest</b> | -3.93                      | 0.40 | -1.89             | 0.65        |

Note 1: The average output power was tested using an average power meter for reference only.

Note 2: See next pages for actual measured spectrum plots.

## Peak Output Power

## Lowest Channel & Modulation : GFSK



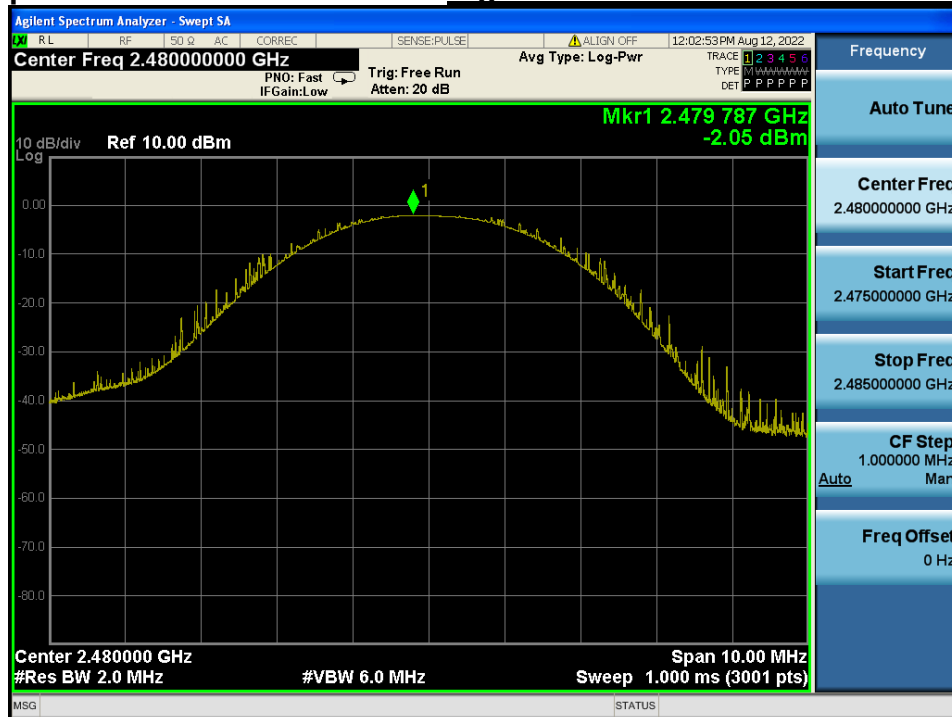
## Peak Output Power

## Middle Channel & Modulation : GFSK



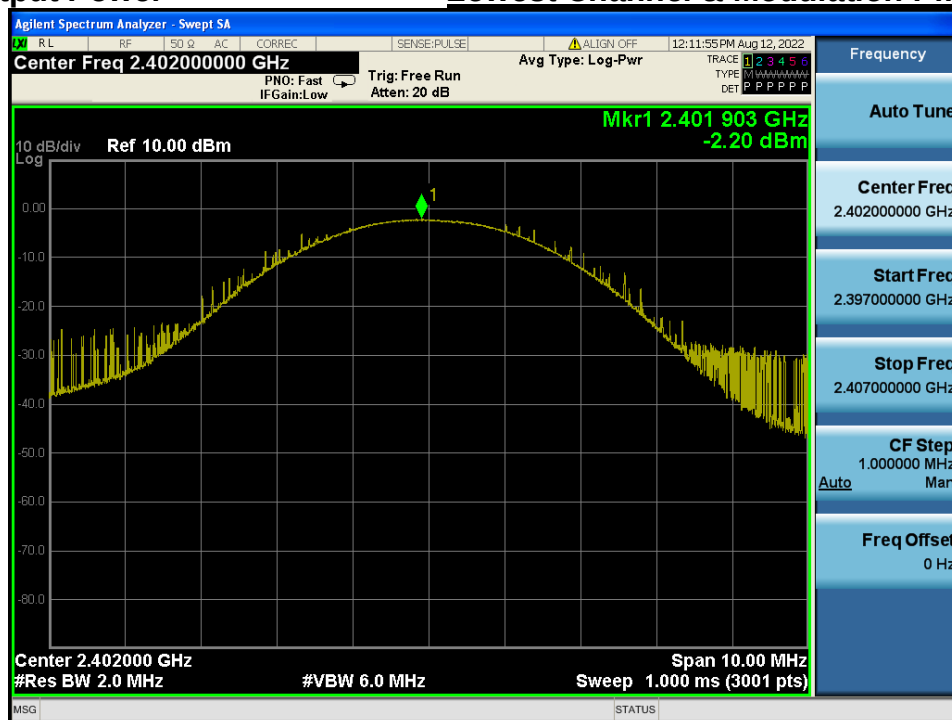
## Peak Output Power

## Highest Channel & Modulation : GFSK



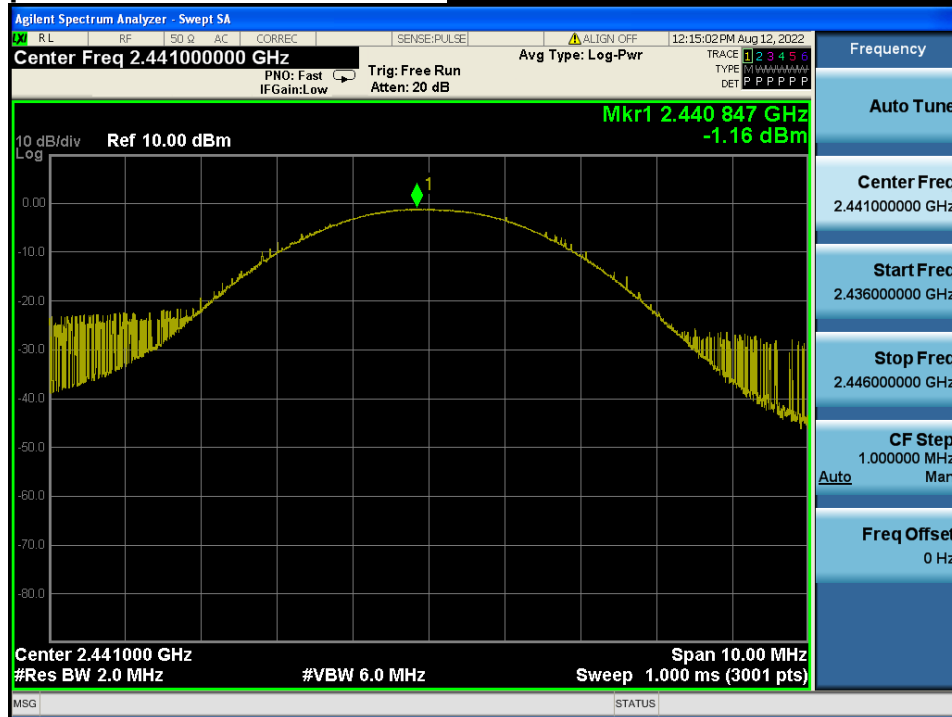
## Peak Output Power

## Lowest Channel & Modulation : $\pi/4$ DQPSK



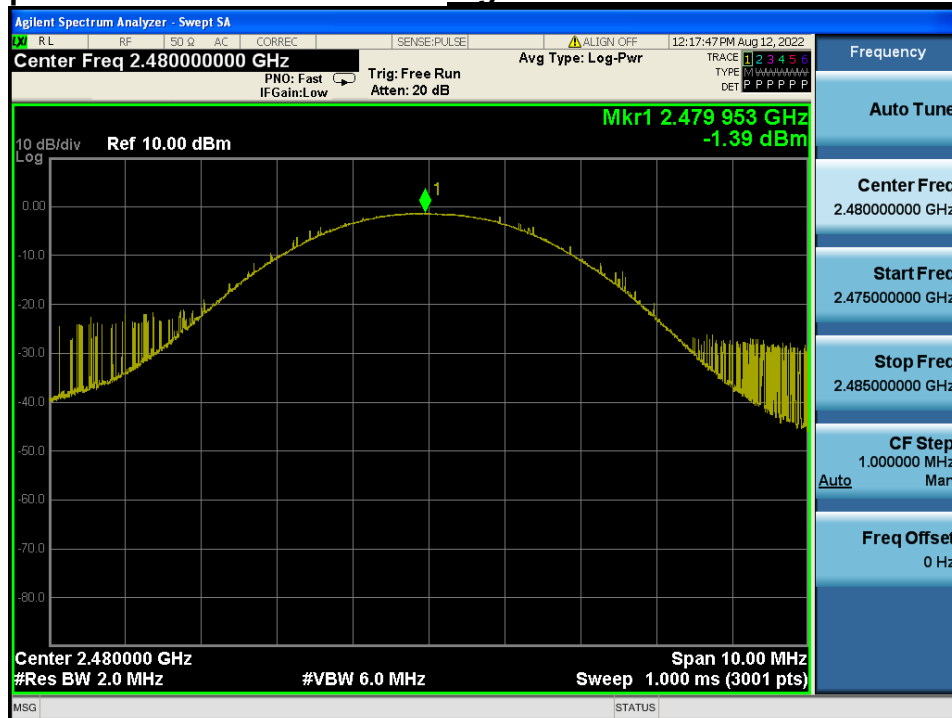
## Peak Output Power

## Middle Channel & Modulation : $\pi/4$ DQPSK



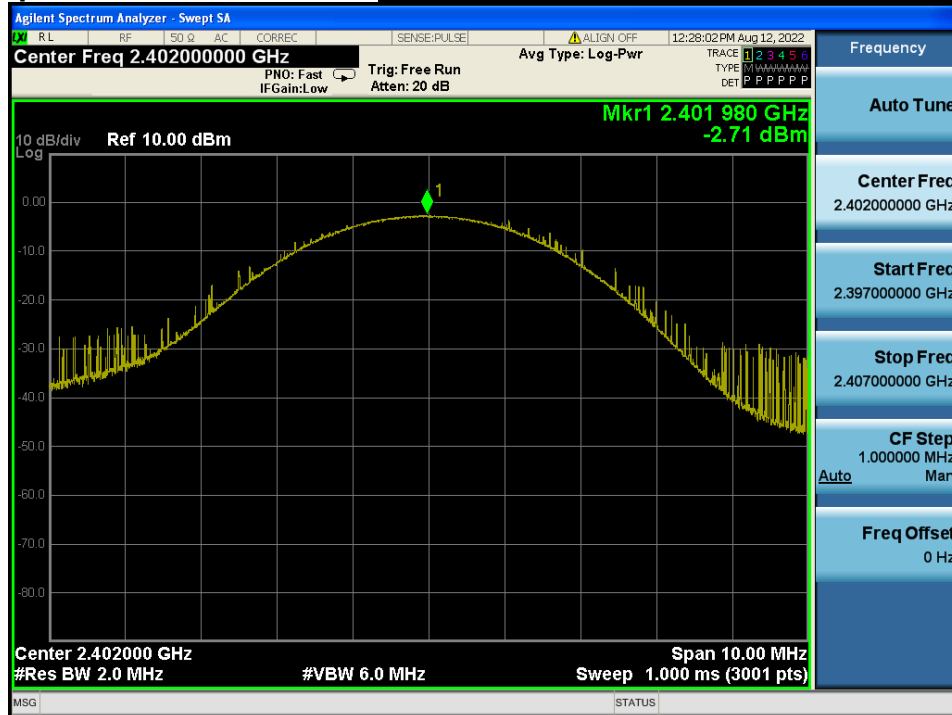
## Peak Output Power

## Highest Channel & Modulation : $\pi/4$ DQPSK



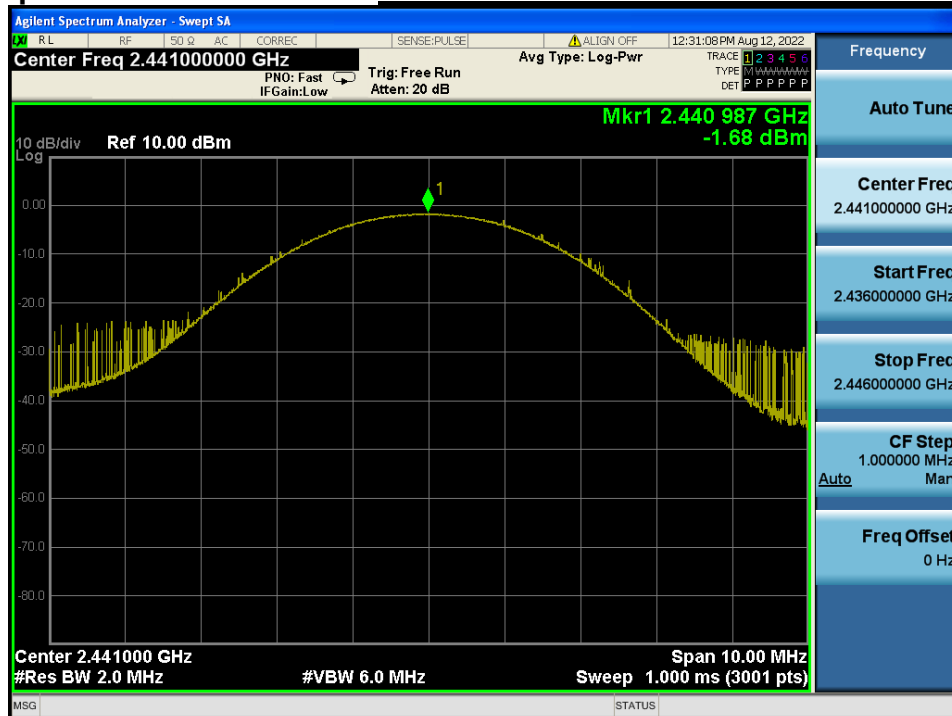
## Peak Output Power

## Lowest Channel & Modulation : 8DPSK



## Peak Output Power

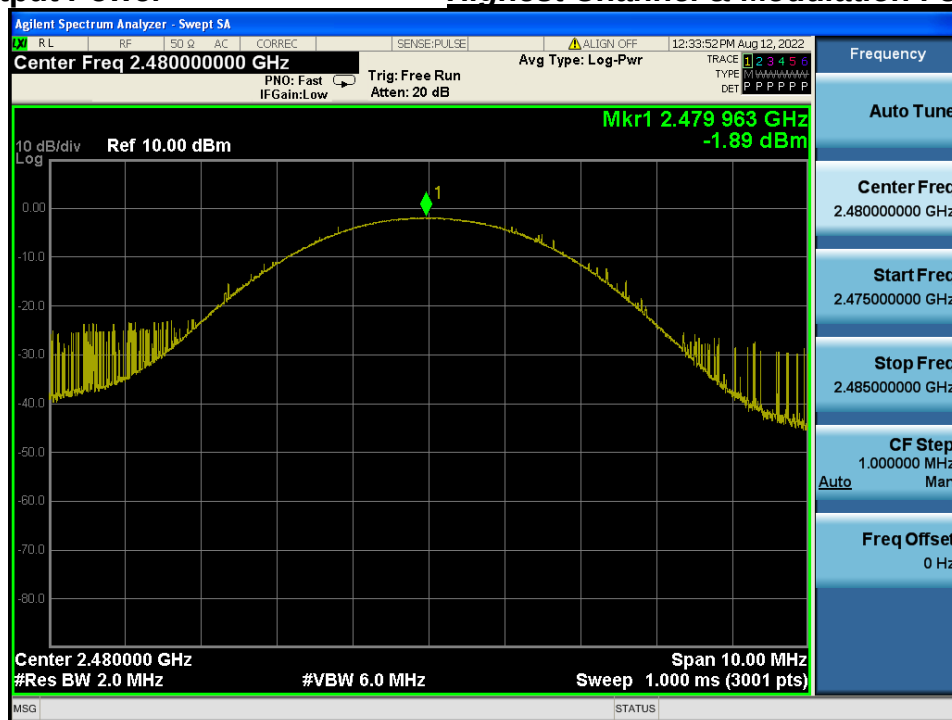
## Middle Channel & Modulation : 8DPSK





## Peak Output Power

## Highest Channel & Modulation : 8DPSK



## 5. 20 dB BW

### 5.1. Test Setup

Refer to the APPENDIX I.

### 5.2. Limit

Limit : Not Applicable

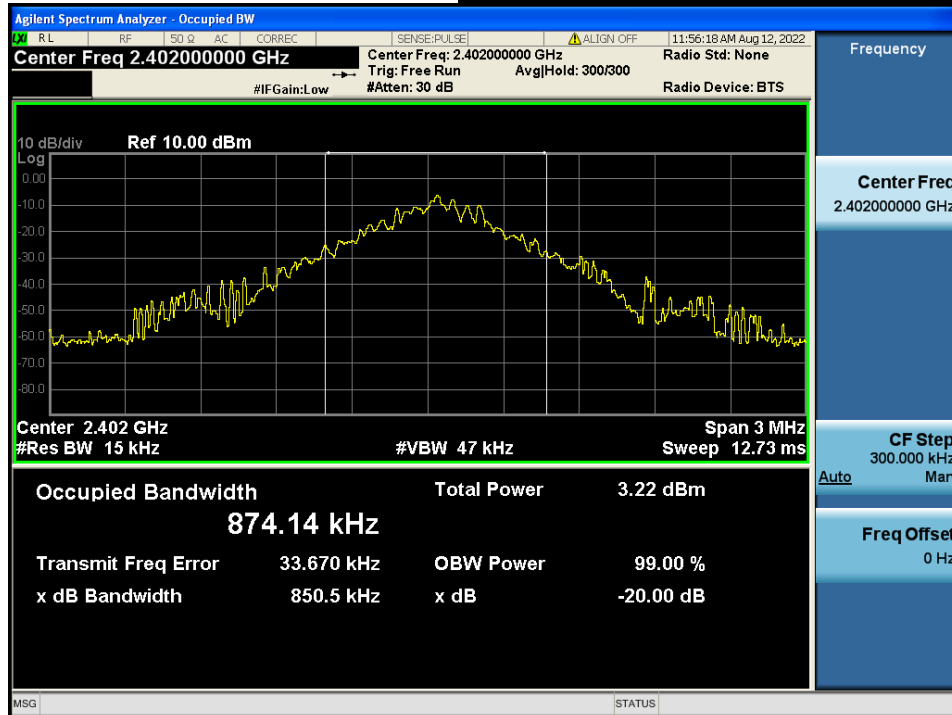
### 5.3. Test Procedure

1. The 20 dB bandwidth was measured with a spectrum analyzer connected to RF antenna Connector (conducted measurement) while EUT was operating in transmit mode. The analyzer center frequency was set to the EUT carrier frequency, using the analyzer.
2. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using below setting:  
RBW = 1 % to 5 % of the 20 dB BW & Occupied BW  
VBW  $\geq 3 \times$  RBW  
Span = between two times and five times the 20 dB bandwidth & Occupied BW  
Sweep = auto  
Detector function = peak  
Trace = max hold

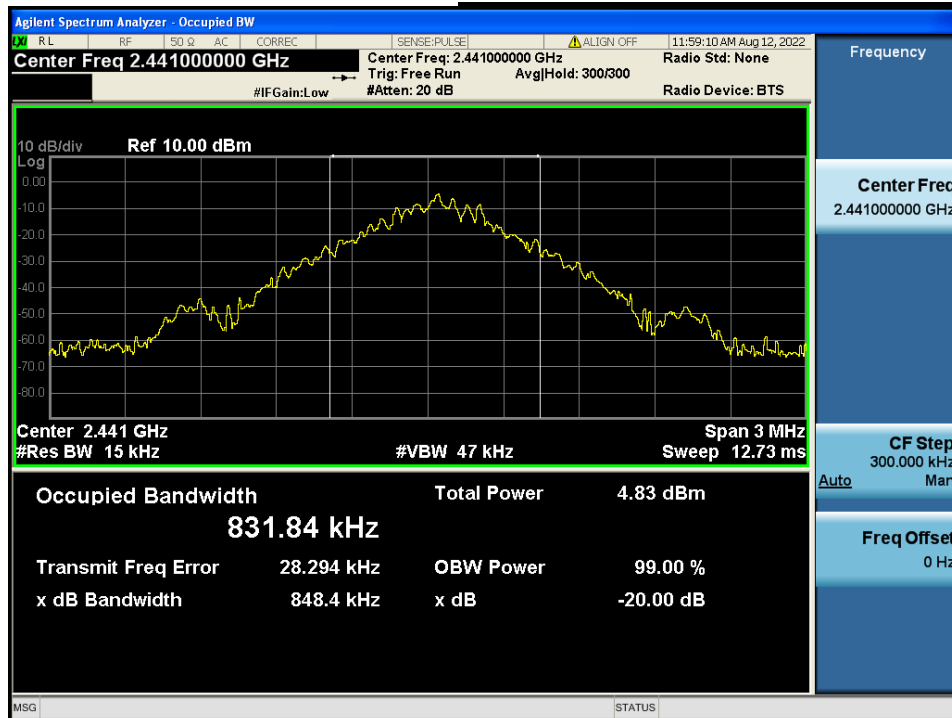
### 5.4. Test Results

| Modulation                     | Tested Channel | 20 dB BW (MHz) |
|--------------------------------|----------------|----------------|
| <u>GFSK</u>                    | Lowest         | <b>0.851</b>   |
|                                | Middle         | 0.848          |
|                                | Highest        | 0.847          |
| <u><math>\pi/4</math>DQPSK</u> | Lowest         | 1.189          |
|                                | Middle         | <b>1.214</b>   |
|                                | Highest        | 1.182          |
| <u>8DPSK</u>                   | Lowest         | 1.216          |
|                                | Middle         | 1.223          |
|                                | Highest        | <b>1.230</b>   |

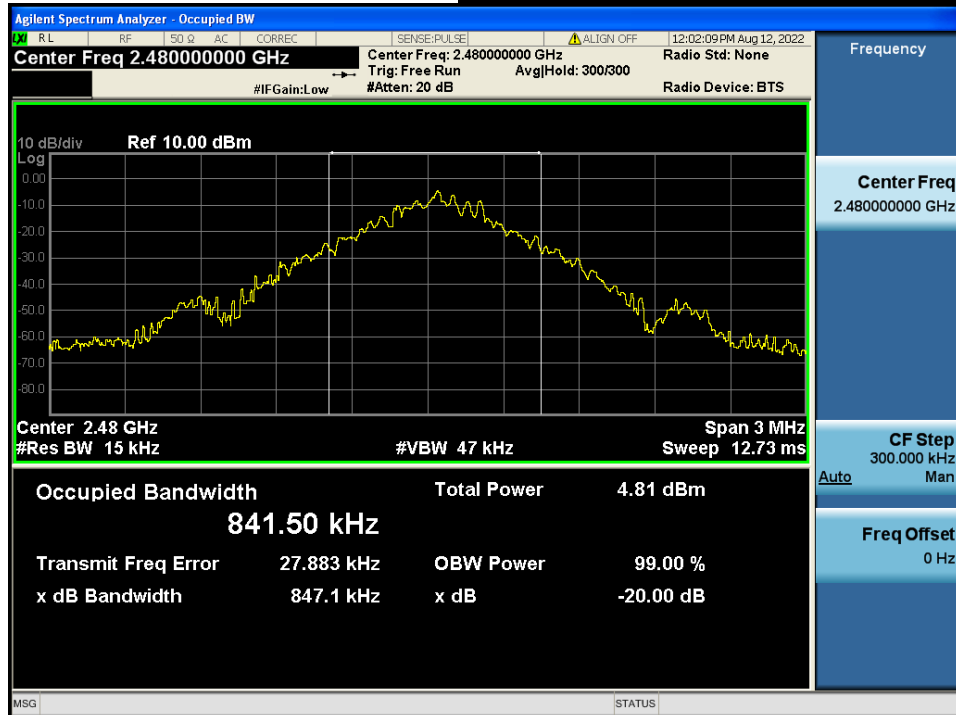
## 20 dB BW

**Lowest Channel & Modulation : GFSK**


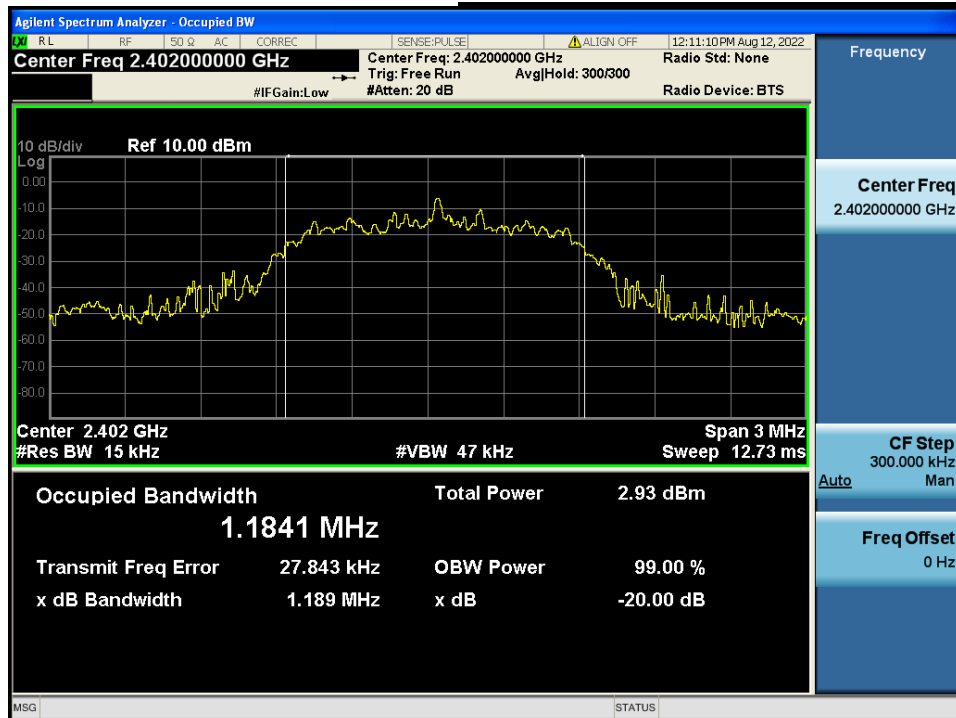
## 20 dB BW

**Middle Channel & Modulation : GFSK**


## 20 dB BW

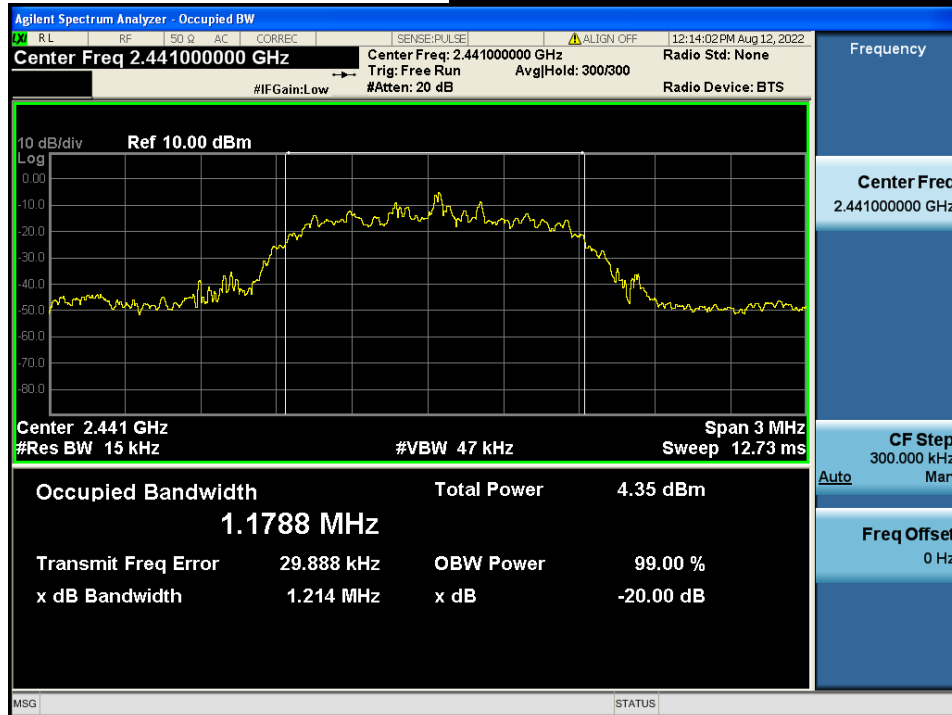
Highest Channel & Modulation : GFSK

## 20 dB BW

Lowest Channel & Modulation :  $\pi/4$ DQPSK

20 dB BW

Middle Channel & Modulation :  $\pi/4$ QPSK

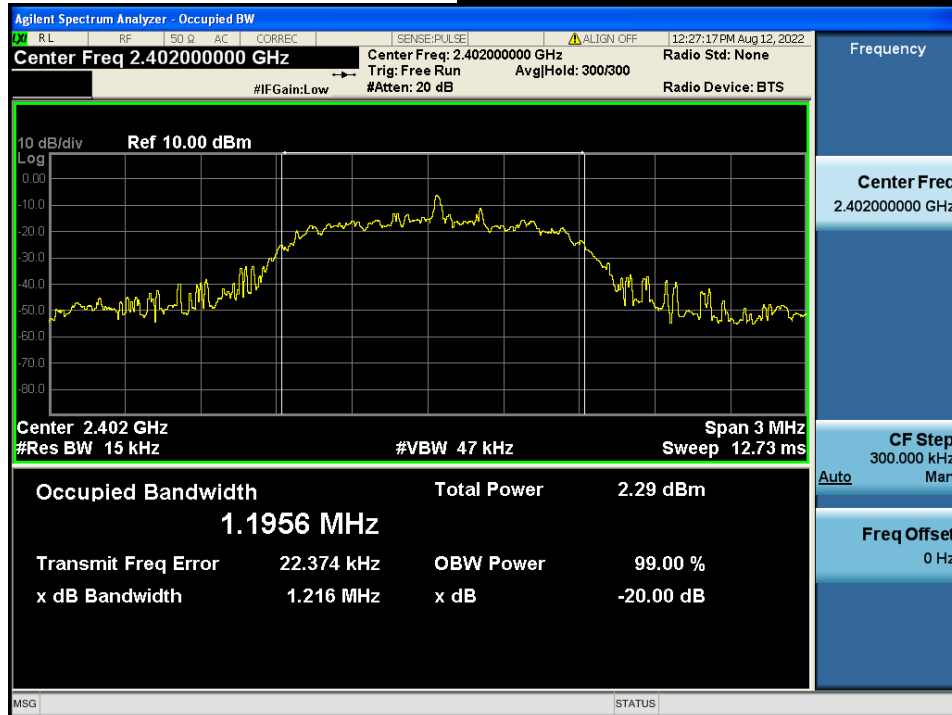


20 dB BW

Highest Channel & Modulation :  $\pi/4$ QPSK



20 dB BW

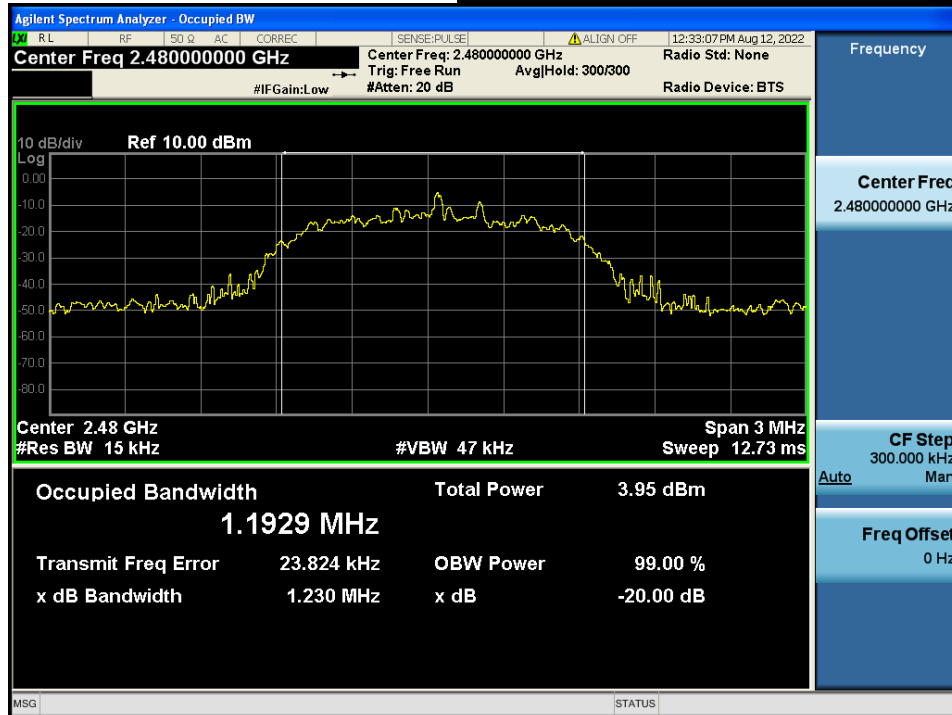
**Lowest Channel & Modulation : 8DPSK**


20 dB BW

**Middle Channel & Modulation : 8DPSK**


20 dB BW

Highest Channel &amp; Modulation : 8DPSK



## 6. Carrier Frequency Separation

### 6.1. Test Setup

Refer to the APPENDIX I.

### 6.2. Limit

Limit :  $\geq 25$  kHz or  $\geq$  Two-Thirds of the 20 dB BW whichever is greater.

### 6.3. Test Procedure

The carrier frequency separation was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

After the trace being stable, the reading value between the peaks of the adjacent channels using the marker-delta function was recorded as the measurement results.

The spectrum analyzer is set to :

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

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.

VBW  $\geq$  RBW

Sweep = auto

Detector function = peak

Trace = max hold

### 6.4. Test Results

#### FH mode

| Hopping Mode | Modulation    | Peak of reference channel(MHz) | Peak of adjacent Channel(MHz) | Test Result (MHz) |
|--------------|---------------|--------------------------------|-------------------------------|-------------------|
| Enable       | GFSK          | 2 441.042                      | 2 442.042                     | 1.000             |
|              | $\pi/4$ DQPSK | 2 440.041                      | 2 441.041                     | 1.000             |
|              | 8DPSK         | 2 440.040                      | 2 441.038                     | 0.998             |

#### AFH mode

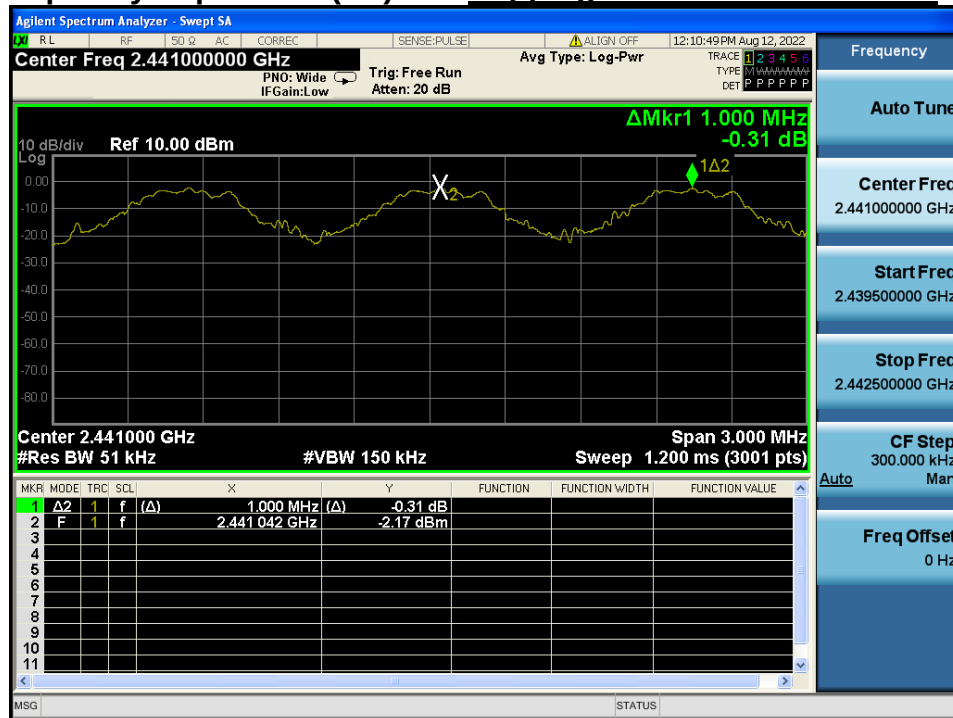
| Hopping Mode | Modulation    | Peak of reference channel(MHz) | Peak of adjacent Channel(MHz) | Test Result (MHz) |
|--------------|---------------|--------------------------------|-------------------------------|-------------------|
| Enable       | GFSK          | 2 441.041                      | 2 442.041                     | 1.000             |
|              | $\pi/4$ DQPSK | 2 441.043                      | 2 442.042                     | 0.999             |
|              | 8DPSK         | 2 441.041                      | 2 442.042                     | 1.001             |

Note 1 : See next pages for actual measured spectrum



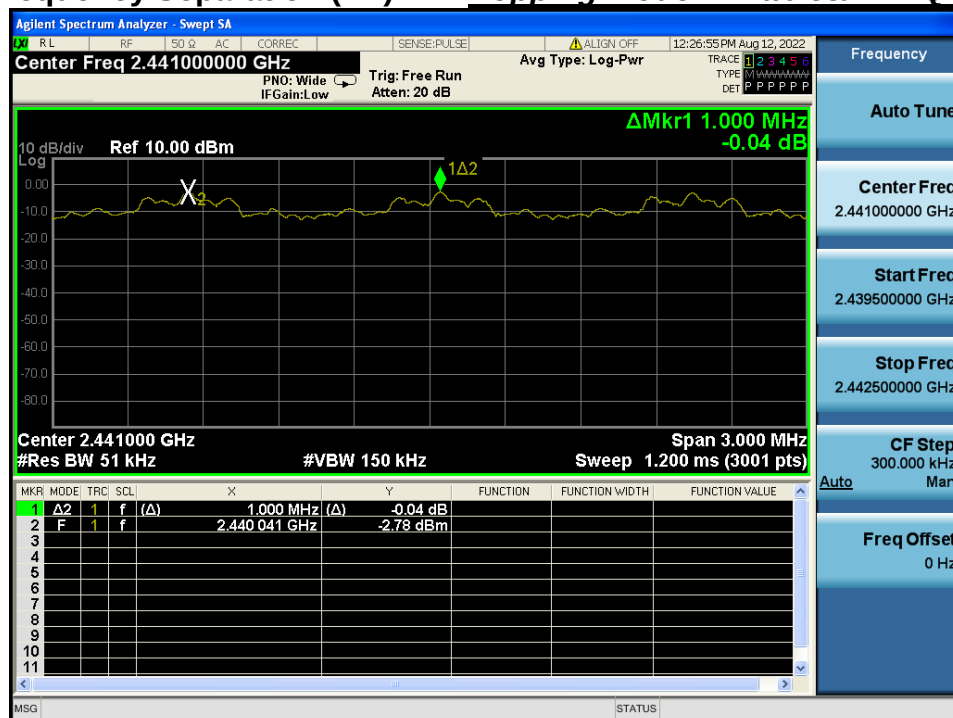
## Carrier Frequency Separation (FH)

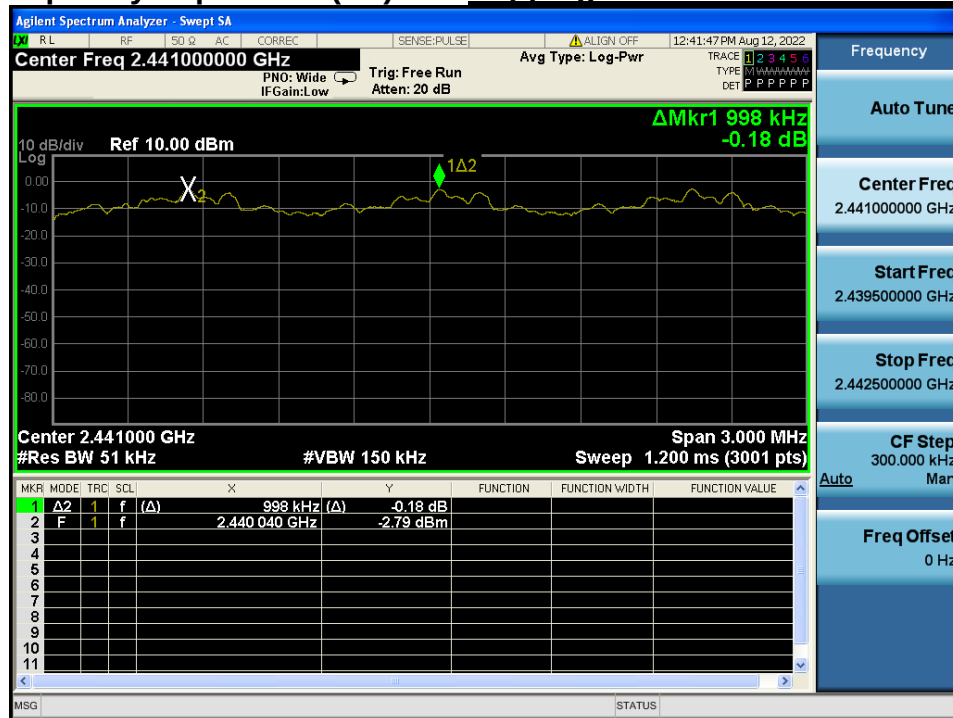
*Hopping mode : Enable&GFSK*



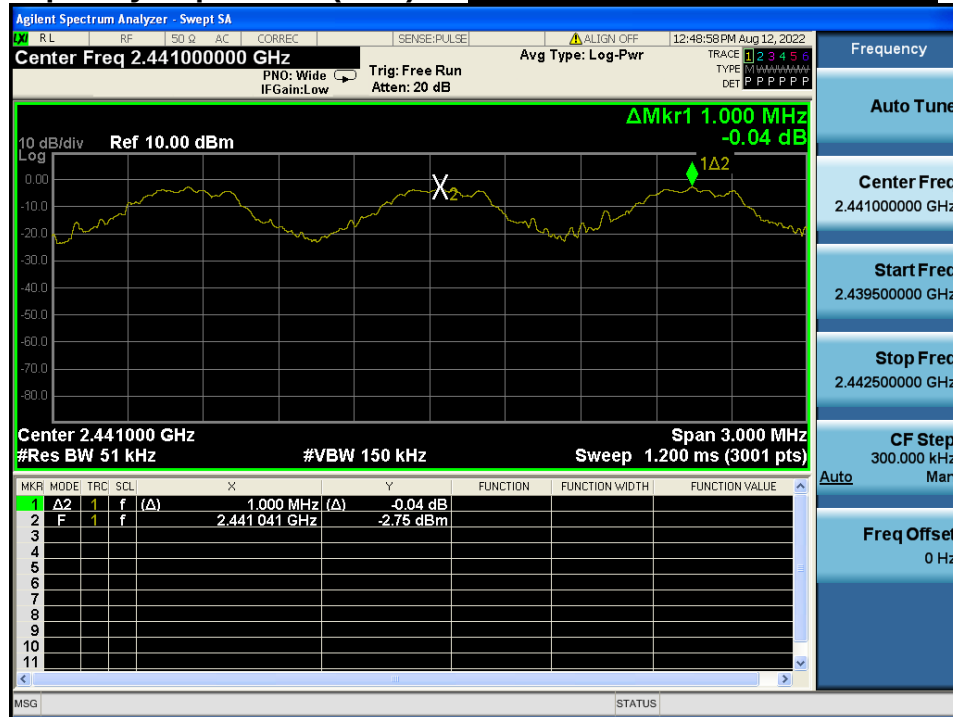
## Carrier Frequency Separation (FH)

*Hopping mode : Enable& $\pi/4$ DQPSK*

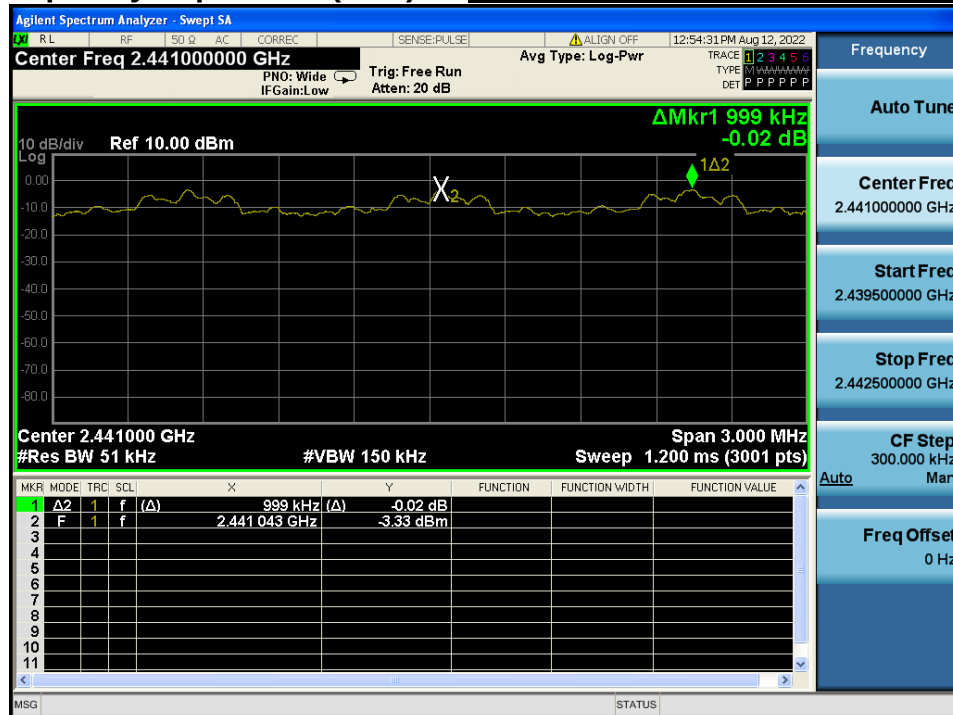


**Carrier Frequency Separation (FH)      *Hopping mode : Enable&8DPSK***

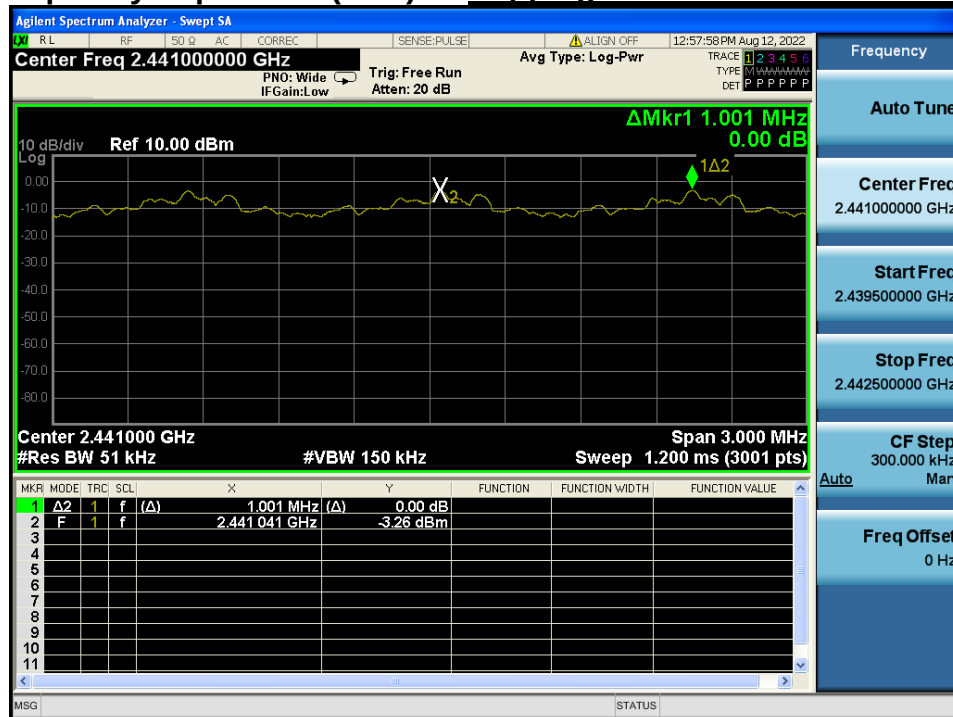
# Carrier Frequency Separation (AFH) *Hopping mode : Enable&GFSK*



# Carrier Frequency Separation (AFH) *Hopping mode : Enable& $\pi/4$ DQPSK*



# Carrier Frequency Separation (AFH) *Hopping mode : Enable&8DPSK*



## 7. Number of Hopping Channels

### 7.1. Test Setup

Refer to the APPENDIX I.

### 7.2. Limit

Limit :  $\geq 15$  hops

### 7.3. Test Procedure

The number of hopping frequencies was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

To get higher resolution, two frequency ranges for FH mode within the 2 400 MHz ~ 2 483.5 MHz were examined.

The spectrum analyzer is set to :

Span for FH mode = 50 MHz      Start Frequency = 2 391.5 MHz,   Stop Frequency = 2 441.5 MHz

Start Frequency = 2 441.5 MHz,   Stop Frequency = 2 491.5 MHz

Span for AFH mode = 30 MHz      Start Frequency = 2 426.0 MHz,   Stop Frequency = 2 456.0 MHz

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

### 7.4. Test Results

#### FH mode

| Hopping mode | Modulation    | Test Result (Total Hops) |
|--------------|---------------|--------------------------|
| Enable       | GFSK          | 79                       |
|              | $\pi/4$ DQPSK | 79                       |
|              | 8DPSK         | 79                       |

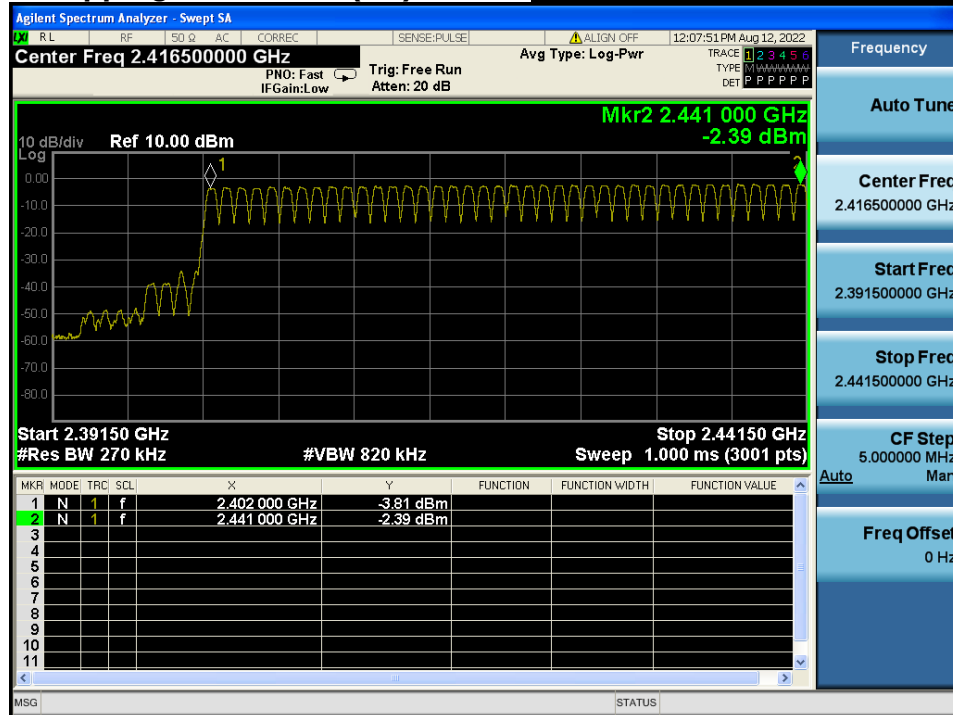
#### AFH mode

| Hopping mode | Modulation    | Test Result (Total Hops) |
|--------------|---------------|--------------------------|
| Enable       | GFSK          | 20                       |
|              | $\pi/4$ DQPSK | 20                       |
|              | 8DPSK         | 20                       |

Note 1 : See next pages for actual measured spectrum plots.

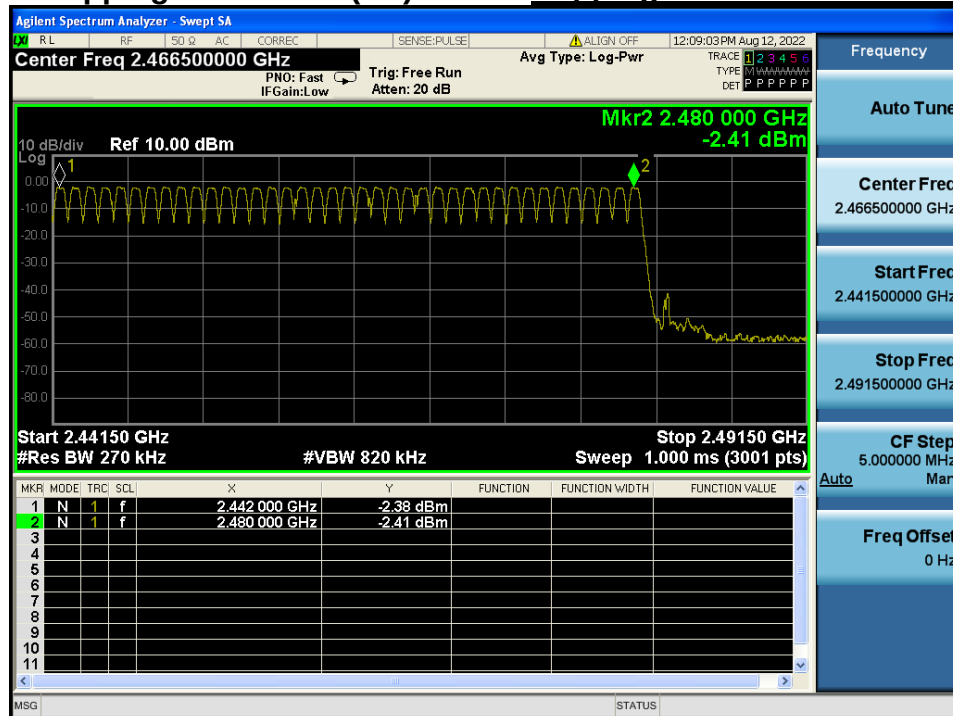
## Number of Hopping Channels 1(FH)

**Hopping mode : Enable & GFSK**



## Number of Hopping Channels 2(FH)

**Hopping mode : Enable & GFSK**



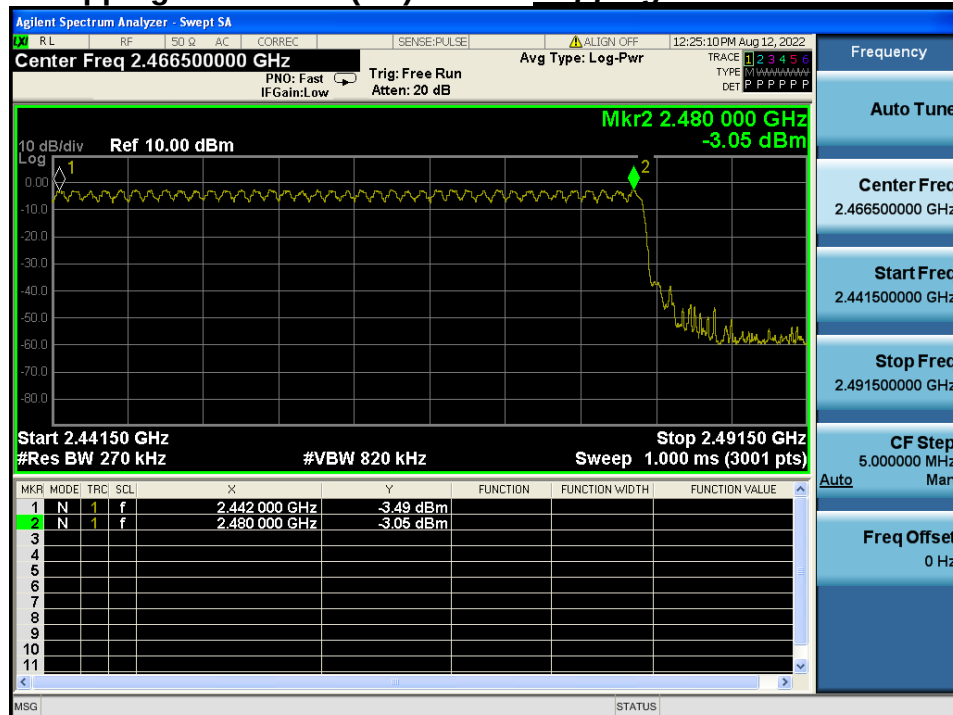
## Number of Hopping Channels 1(FH)

**Hopping mode : Enable &  $\pi/4$ DQPSK**



## Number of Hopping Channels 2(FH)

**Hopping mode : Enable &  $\pi/4$ DQPSK**



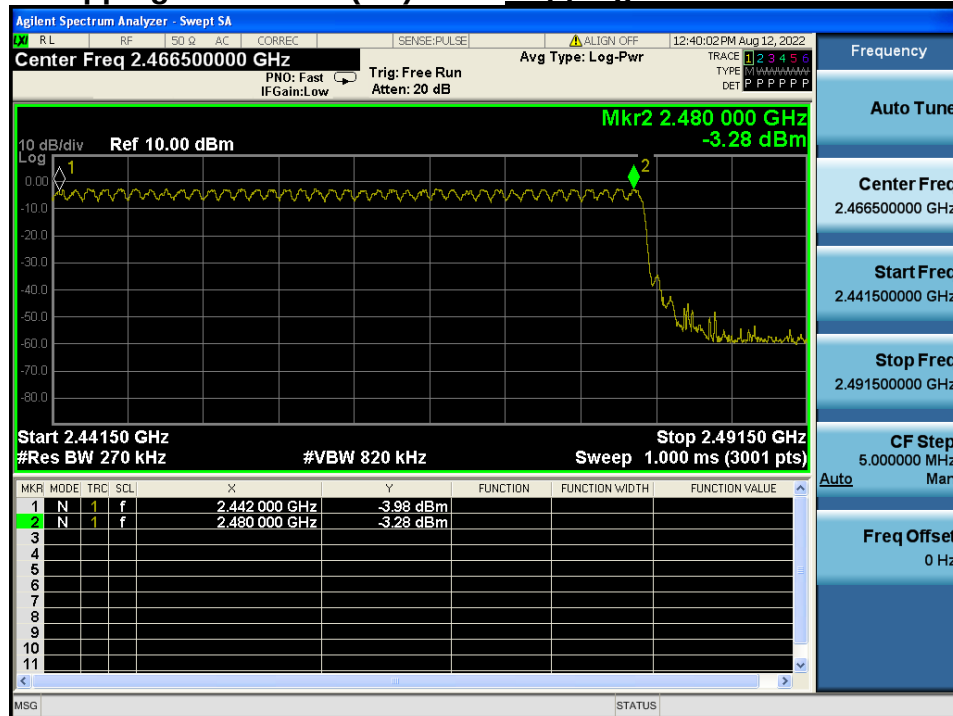
## Number of Hopping Channels 1(FH)

**Hopping mode : Enable&8DPSK**



## Number of Hopping Channels 2(FH)

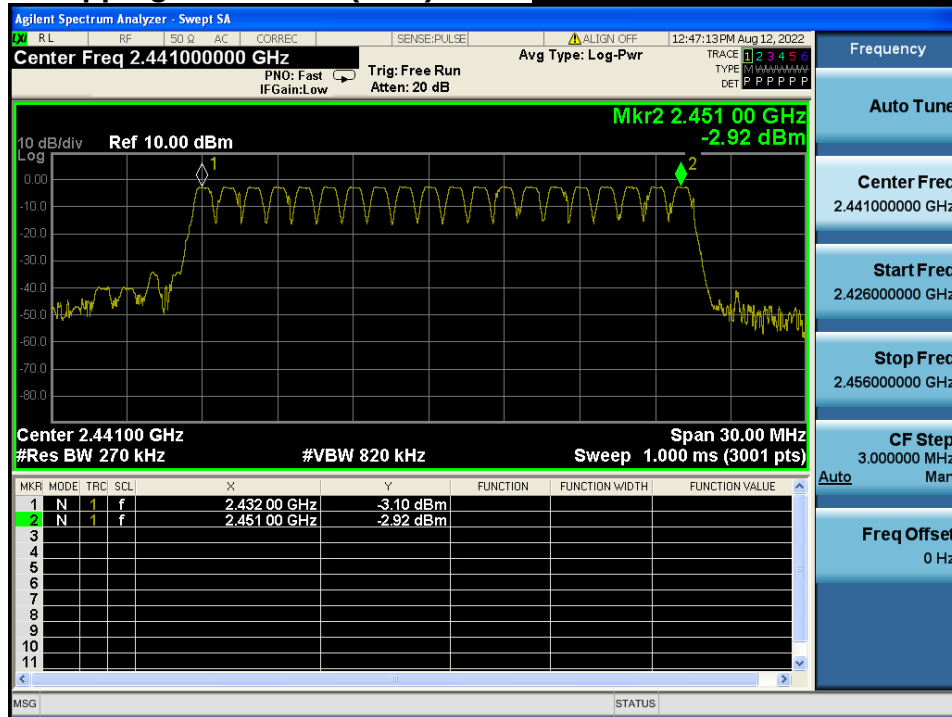
**Hopping mode : Enable & 8DPSK**





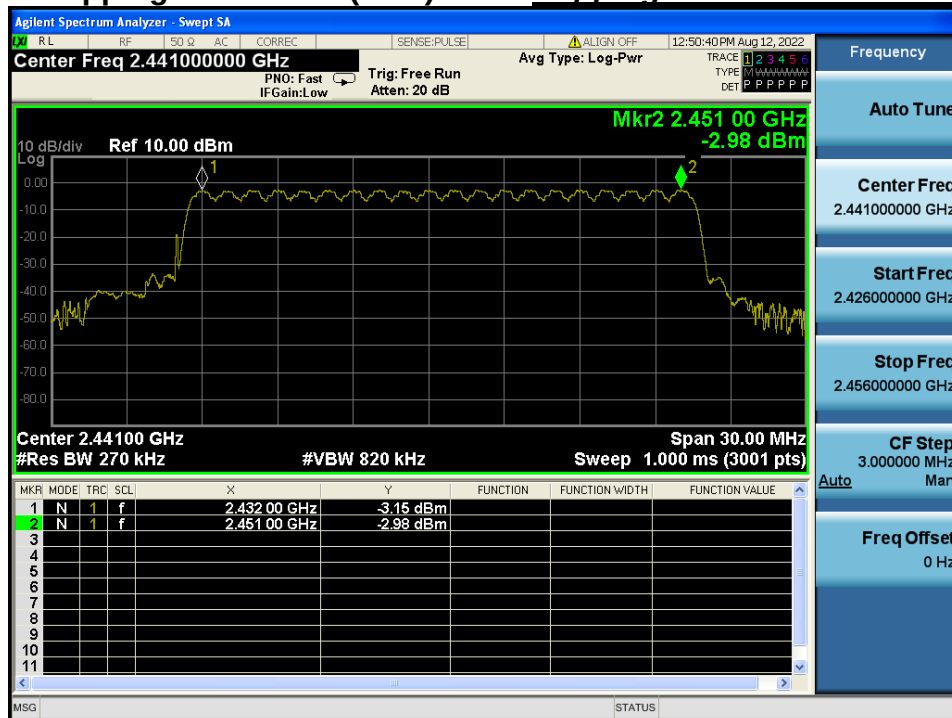
Number of Hopping Channels 1(AFH)

Hopping mode : Enable &GFSK



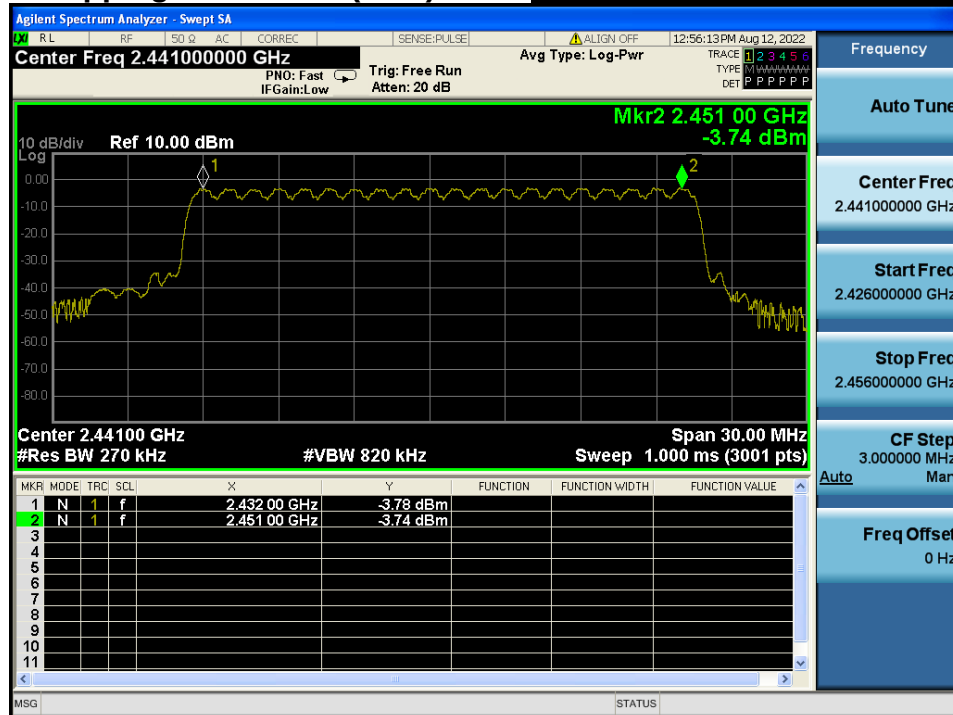
Number of Hopping Channels 1(AFH)

Hopping mode : Enable & $\pi/4$ DQPSK



Number of Hopping Channels 1(AFH)

Hopping mode : Enable & 8DPSK



## 8. Time of Occupancy

### 8.1. Test Setup

Refer to the APPENDIX I.

### 8.2. Limit

The maximum permissible time of occupancy is 400 ms within a period of 400 ms multiplied by the number of hopping channels employed.

### 8.3. Test Procedure

The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT had its hopping function enabled.

The spectrum analyzer is set to :

Center frequency = 2 441 MHz

Span = zero

RBW = 1 MHz (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)

VBW  $\geq$  RBW

Detector function = peak

Trace = max hold

### 8.4. Test Results

#### FH mode

| Hopping mode | Packet Type | Number of hopping Channels | Burst On Time (ms) | Period (ms) | Test Result (sec) |
|--------------|-------------|----------------------------|--------------------|-------------|-------------------|
| Enable       | DH 5        | 79                         | 2.880              | 3.750       | 0.307             |
|              | 2 DH 5      | 79                         | 2.880              | 3.750       | 0.307             |
|              | 3 DH 5      | 79                         | 2.880              | 3.750       | 0.307             |

#### AFH mode

| Hopping mode | Packet Type | Number of hopping Channels | Burst On Time (ms) | Period (ms) | Test Result (sec) |
|--------------|-------------|----------------------------|--------------------|-------------|-------------------|
| Enable       | DH 5        | 20                         | 2.880              | 3.750       | 0.154             |
|              | 2 DH 5      | 20                         | 2.880              | 3.750       | 0.154             |
|              | 3 DH 5      | 20                         | 2.880              | 3.750       | 0.154             |

Note 1 : Dwell Time =  $0.4 \times \text{Hopping channel} \times \text{Burst ON time} \times$

$((\text{Hopping rate} \div \text{Time slots}) \div \text{Hopping channel})$

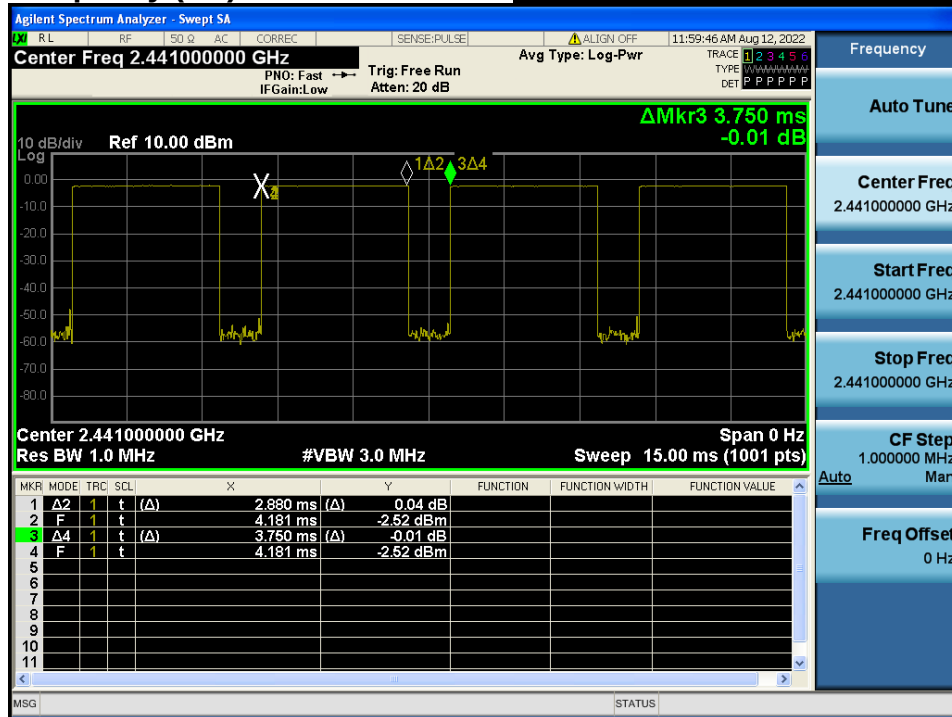
- Time slots for DH5 = 6 slots (TX = 5 slots / RX = 1 slot)

- Hopping Rate = 1 600 for FH mode & 800 for AFH mode

Note 2 : See next pages for actual measured spectrum plots.

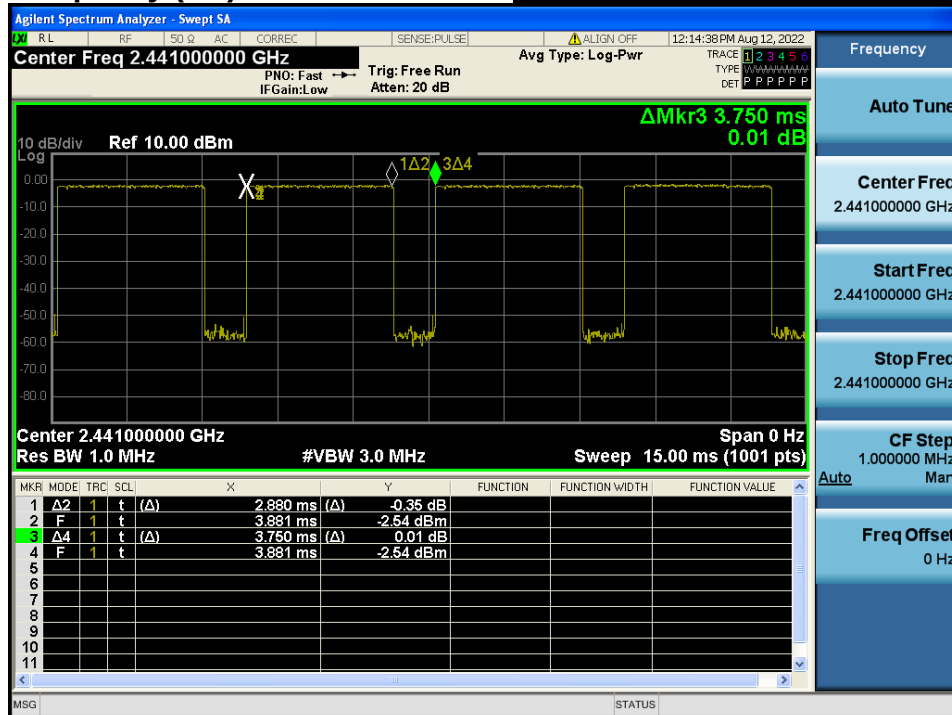
## Time of Occupancy (FH)

## Hopping mode : Enable&DH5



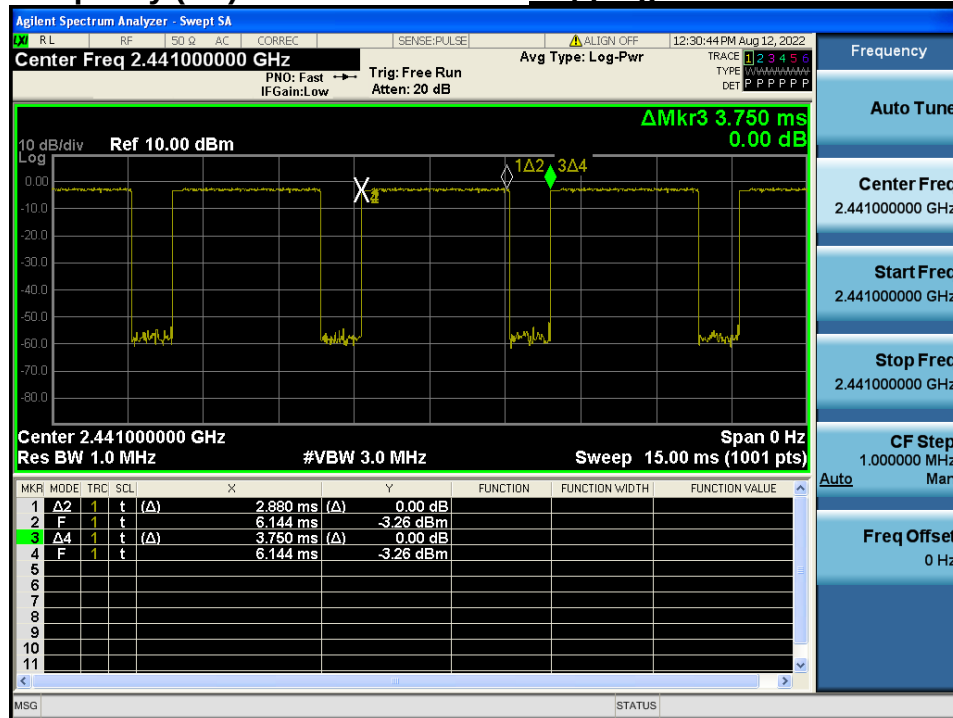
## Time of Occupancy (FH)

## Hopping mode : Enable&2-DH5



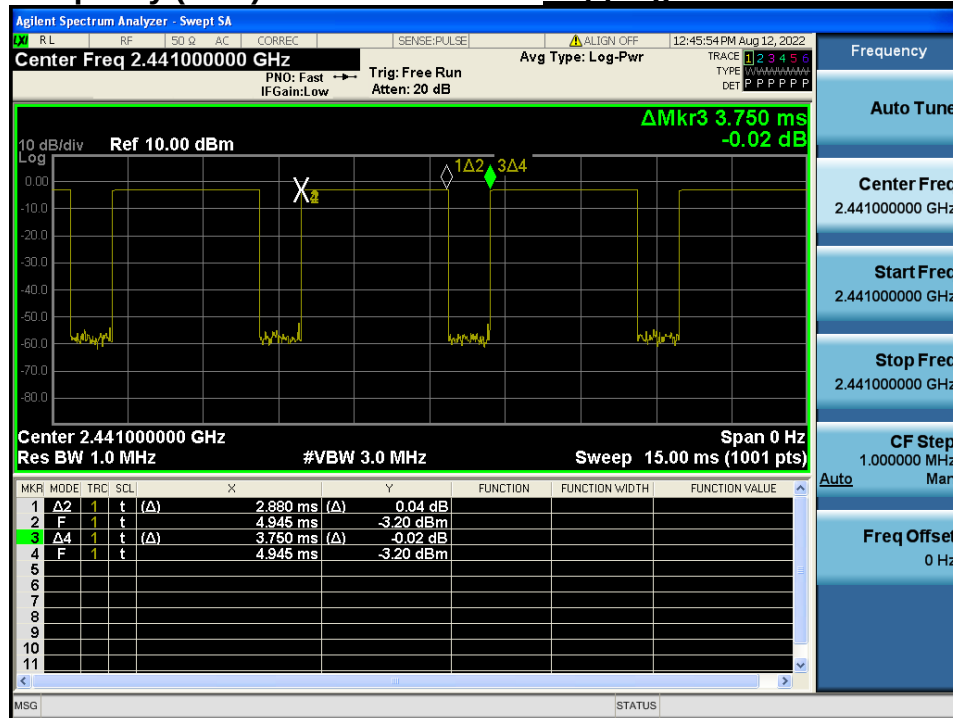
# Time of Occupancy (FH)

Hopping mode : Enable&3-DH5



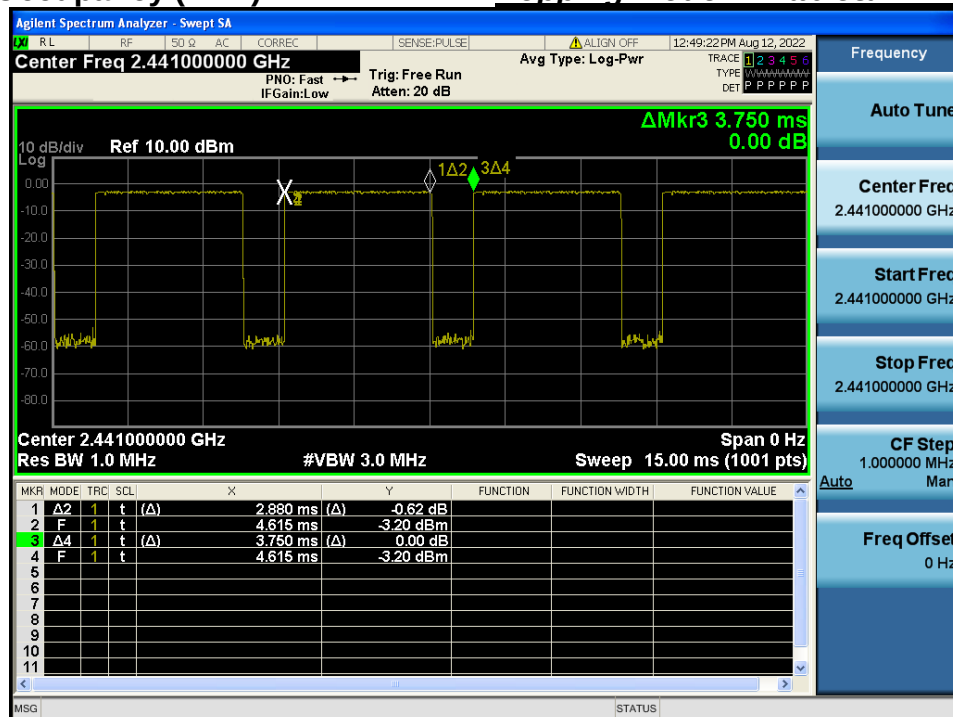
# Time of Occupancy (AFH)

*Hopping mode : Enable&DH5*



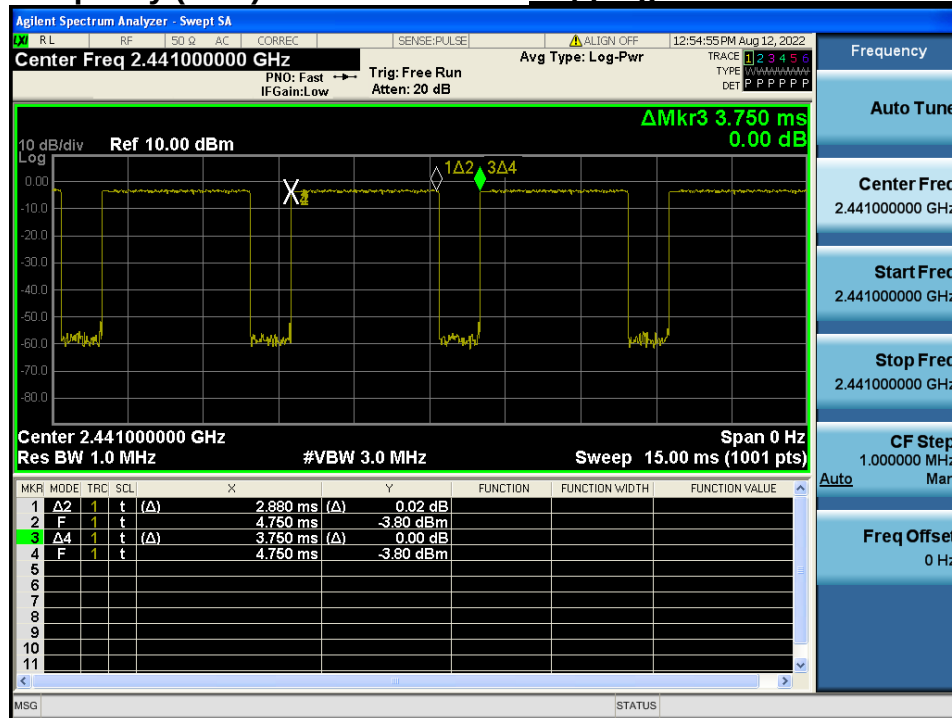
# Time of Occupancy (AFH)

*Hopping mode : Enable&2-DH5*



# Time of Occupancy (AFH)

Hopping mode : Enable&3-DH5



## 9. Unwanted Emissions

### 9.1. Test Setup

Refer to the APPENDIX I.

### 9.2. Limit

Part 15.247(d), Part 15.205, Part 15.209

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 Part 15.247 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)).

#### - Part 15.209: General requirement

| Frequency (MHz) | FCC Limit (uV/m) | Measurement Distance (m) |
|-----------------|------------------|--------------------------|
| 0.009 – 0.490   | 2 400 / F (kHz)  | 300                      |
| 0.490 – 1.705   | 24 000 / F (kHz) | 30                       |
| 1.705 – 30.0    | 30               | 30                       |

| Frequency (MHz) | FCC Limit (uV/m) | Measurement Distance (m) |
|-----------------|------------------|--------------------------|
| 30 ~ 88         | 100 **           | 3                        |
| 88 ~ 216        | 150 **           | 3                        |
| 216 ~ 960       | 200 **           | 3                        |
| Above 960       | 500              | 3                        |

\*\*Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §15.231 and 15.241.



**- Part 15.205(a): Restricted band of operation**

| MHz                 | MHz                   | MHz                     | MHz               | GHz          | GHz           |
|---------------------|-----------------------|-------------------------|-------------------|--------------|---------------|
| 0.009 ~ 0.110       | 8.414 25 ~ 8.414 75   | 108 ~ 121.94            | 1 300 ~ 1 427     | 4.5 ~ 5.15   | 14.47 ~ 14.5  |
| 0.495 ~ 0.505       | 12.29 ~ 12.293        | 123 ~ 138               | 1 435 ~ 1 626.5   | 5.35 ~ 5.46  | 15.35 ~ 16.2  |
| 2.173 5 ~ 2.190 5   | 12.519 75 ~ 12.520 25 | 149.9 ~ 150.05          | 1 645.5 ~ 1 646.5 | 7.25 ~ 7.75  | 17.7 ~ 21.4   |
| 4.125 ~ 4.128       | 12.576 75 ~ 12.577 25 | 156.524 75 ~ 156.525 25 | 1 660 ~ 1 710     | 8.025 ~ 8.5  | 22.01 ~ 23.12 |
| 4.177 25 ~ 4.177 75 | 13.36 ~ 13.41         | 156.7 ~ 156.9           | 1 718.8 ~ 1 722.2 | 9.0 ~ 9.2    | 23.6 ~ 24.0   |
| 4.207 25 ~ 4.207 75 | 16.42 ~ 16.423        | 162.012 5 ~ 167.17      | 2 200 ~ 2 300     | 9.3 ~ 9.5    | 31.2 ~ 31.8   |
| 6.215 ~ 6.218       | 16.694 75 ~ 16.695 25 | 167.72 ~ 173.2          | 2 310 ~ 2 390     | 10.6 ~ 12.7  | 36.43 ~ 36.5  |
| 6.267 75 ~ 6.268 25 | 16.804 25 ~ 16.804 75 | 240 ~ 285               | 2 483.5 ~ 2 500   | 13.25 ~ 13.4 | Above 38.6    |
| 6.311 75 ~ 6.312 25 | 25.5 ~ 25.67          | 322 ~ 335.4             | 2 655 ~ 2 900     |              |               |
| 8.291 ~ 8.294       | 37.5 ~ 38.25          | 399.90 ~ 410            | 3 260 ~ 3 267     |              |               |
| 8.362 ~ 8.366       | 73 ~ 74.6             | 608 ~ 614               | 3 332 ~ 3 339     |              |               |
| 8.376 25 ~ 8.386 75 | 74.8 ~ 75.2           | 960 ~ 1 240             | 3 345.8 ~ 3 358   |              |               |
|                     |                       |                         | 3 600 ~ 4 400     |              |               |

### 9.3. Test Procedures

#### 9.3.1. Test Procedures for Unwanted Emissions(Radiated)

1. The EUT is placed on a non-conductive table. For emission measurements at or below 1 GHz, the table height is 80 cm. For emission measurements above 1 GHz, the table height is 1.5 m.  
The table was rotated 360 degrees to determine the position of the highest radiation.
2. During performing radiated emission below 1 GHz, the EUT was set 3 meters away from the interference receiving antenna, which was mounted on the top of a variable-height antenna tower. During performing radiated emission above 1 GHz, the EUT was set 1 or 3 meter away from the interference-receiving antenna.
3. For measurements above 1 GHz absorbers are placed on the floor between the turn table and the antenna mast in such a way so as to maximize the reduction of reflections. For measurements below 1 GHz, the absorbers are removed.
4. The antenna is a broadband antenna, and its 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.
5. 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 and the table was turned from 0 degrees to 360 degrees to find the maximum reading.
6. The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
7. If the emission level of the EUT in peak mode was 10 dB 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 10 dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

#### Measurement Instrument Setting

- Frequencies less than or equal to 1 000 MHz  
The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-peak detection (QP) at frequency below 1 GHz.
- Frequencies above 1 000 MHz  
The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 1 MHz for Peak detection and frequency above 1 GHz.  
The result of Average measurement is calculated using PK result and duty correction factor.

### 9.3.2. Test Procedures for Unwanted Emissions(Conducted)

1. The transmitter output was connected to the spectrum analyzer.
2. The **reference level** of the fundamental frequency was measured with the spectrum analyzer using RBW = 100 kHz, VBW = 300 kHz.
3. The conducted spurious emission was tested each ranges were set as below.

**Frequency range : 9 kHz ~ 30 MHz**

RBW = 100 kHz, VBW = 300 kHz, SWEEP TIME = AUTO, DETECTOR = PEAK, TRACE = MAX HOLD, SWEEP POINT : 40 001

**Frequency range : 30 MHz ~ 10 GHz, 10 GHz ~ 25 GHz**

RBW = 1 MHz, VBW = 3 MHz, SWEEP TIME = AUTO, DETECTOR = PEAK, TRACE = MAX HOLD, SWEEP POINT : 40 001

**LIMIT LINE = 20 dB below of the reference level of above measurement procedure Step 2. (RBW = 100 kHz, VBW = 300 kHz)**

If the emission level with above setting was close to the limit (ie, less than 3 dB margin) then zoom scan is required using RBW = 100 kHz, VBW = 300 kHz, SPAN = 100 MHz and BINS = 2 001 to get accurate emission level within 100 kHz BW.

Also the path loss for conducted measurement setup was used as described on the Appendix I of this test report.

## 9.4. Test Results

### 9.4.1. Unwanted Emissions(Radiated)

#### ▪ Test Notes.

- The radiated emissions below 1GHz were investigated 9 kHz to 1 GHz and the worst case data was reported.
- Information of Distance Correction Factor  
For finding emissions, measurements may be performed at a distance closer than that specified in the regulations.  
In this case, the distance correction factor is applied to the result.  
- Calculation of distance factor  
At frequencies below 30 MHz =  $40 \log(\text{tested distance} / \text{specified distance})$   
At frequencies at or above 30 MHz =  $20 \log(\text{tested distance} / \text{specified distance})$   
When distance factor is "N/A", the measurements were performed at the specified distance and distance factor is not applied.
- DCCF Calculation. (DCCF = Duty Cycle Correction Factor)  
- Time to cycle through all channels =  $\Delta t = T [\text{ms}] \times 20$  minimum hopping channels , where T = pulse width = **2.88 ms**  
-  $100 \text{ ms} / \Delta t [\text{ms}] = H \rightarrow$  Round up to next highest integer, to account for worst case,  $H' = 100 / (2.88 \times 20) = 1.74 \approx 2$   
- The Worst Case Dwell Time =  $T [\text{ms}] \times H' = 2.88 \text{ ms} \times 2 = 5.76 \text{ ms}$   
- DCCF =  $20 \log(\text{The Worst Case Dwell Time} / 100 \text{ ms}) \text{ dB} = 20 \log(5.76 / 100) = -24.79 \text{ dB}$
- Sample Calculation.  
Margin = Limit – Result / Result = Reading + TF+ DCCF + DCF / TF = AF + CL + HL + AL – AG  
Where, TF = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain, HL = High pass filter Loss,  
AL = Attenuator Loss, DCCF = Duty Cycle Correction Factor, DCF = Distance Correction Factor

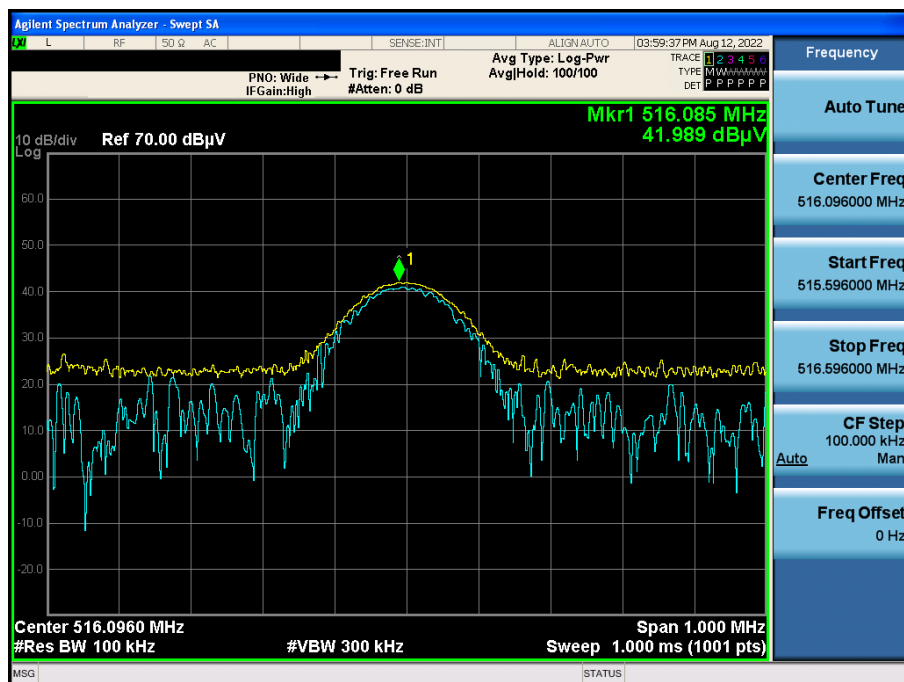
### 9 kHz ~ 1 GHz Data (Modulation : GFSK)

#### ▪ Middle Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 491.52          | H       | X                   | PK            | 41.12          | -0.50     | N/A       | N/A      | 40.62           | 46.00          | 5.38        |
| 516.09          | H       | X                   | PK            | 41.99          | 0.00      | N/A       | N/A      | 41.99           | 46.00          | 4.01        |
| 540.67          | H       | X                   | PK            | 40.95          | 0.40      | N/A       | N/A      | 41.35           | 46.00          | 4.65        |
| -               | -       | -                   | -             | -              | -         | -         | -        | -               | -              | -           |

### TM1 & Middle & X & Hor

### Detector Mode : PK



**▪ Test Notes.**

1. The radiated emissions above 1GHz were investigated up to 25 GHz. And no other spurious and harmonic emissions were found below listed frequencies.
2. Information of Distance Correction Factor  
For finding emissions, measurements may be performed at a distance closer than that specified in the regulations.  
In this case, the distance correction factor is applied to the result.
  - Calculation of distance factor  
At frequencies below 30 MHz =  $40 \log(\text{tested distance} / \text{specified distance})$   
At frequencies at or above 30 MHz =  $20 \log(\text{tested distance} / \text{specified distance})$   
When distance factor is "N/A", the measurements were performed at the specified distance and distance factor is not applied.
3. DCCF Calculation. (DCCF = Duty Cycle Correction Factor)
  - Time to cycle through all channels =  $\Delta t = T [\text{ms}] \times 20$  minimum hopping channels, where T = pulse width = **2.88 ms**
  - $100 \text{ ms} / \Delta t [\text{ms}] = H \rightarrow$  Round up to next highest integer, to account for worst case,  $H' = 100 / (2.88 \times 20) = 1.74 \approx 2$
  - The Worst Case Dwell Time =  $T [\text{ms}] \times H' = 2.88 \text{ ms} \times 2 = 5.76 \text{ ms}$
  - $\text{DCCF} = 20 \log(\text{The Worst Case Dwell Time} / 100 \text{ ms}) \text{ dB} = 20 \log(5.76 / 100) = \underline{\underline{-24.79 \text{ dB}}}$
4. Sample Calculation.  
 $\text{Margin} = \text{Limit} - \text{Result} \quad / \quad \text{Result} = \text{Reading} + \text{TF} + \text{DCCF} + \text{DCF} \quad / \quad \text{TF} = \text{AF} + \text{CL} + \text{HL} + \text{AL} - \text{AG}$   
Where, TF = Total Factor, AF = Antenna Factor, CL = Cable Loss, AG = Amplifier Gain, HL = High pass filter Loss,  
AL = Attenuator Loss, DCCF = Duty Cycle Correction Factor, DCF = Distance Correction Factor

# 1 GHz ~ 25 GHz Data (Modulation : GFSK)

## • Lowest Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 2 388.60        | H       | X                   | PK            | 43.67          | 3.43      | N/A       | N/A      | 47.10           | 74.00          | 26.90       |
| 2 388.60        | H       | X                   | AV            | 43.67          | 3.43      | -24.79    | N/A      | 22.31           | 54.00          | 31.69       |
| 4 803.79        | H       | X                   | PK            | 50.97          | 7.89      | N/A       | N/A      | 58.86           | 74.00          | 15.14       |
| 4 803.79        | H       | X                   | AV            | 50.97          | 7.89      | -24.79    | N/A      | 34.07           | 54.00          | 19.93       |
| 7 205.69        | V       | X                   | PK            | 53.16          | 10.54     | N/A       | N/A      | 63.70           | 74.00          | 10.30       |
| 7 205.69        | V       | X                   | AV            | 53.16          | 10.54     | -24.79    | N/A      | 38.91           | 54.00          | 15.09       |
| 9 607.65        | V       | Y                   | PK            | 50.88          | 13.76     | N/A       | N/A      | 64.64           | 74.00          | 9.36        |
| 9 607.65        | V       | Y                   | AV            | 50.88          | 13.76     | -24.79    | N/A      | 39.85           | 54.00          | 14.15       |
| 12 009.51       | V       | Y                   | PK            | 47.71          | 17.26     | N/A       | N/A      | 64.97           | 74.00          | 9.03        |
| 12 009.51       | V       | Y                   | AV            | 47.71          | 17.26     | -24.79    | N/A      | 40.18           | 54.00          | 13.82       |

## • Middle Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 4 881.75        | H       | X                   | PK            | 51.84          | 7.94      | N/A       | N/A      | 59.78           | 74.00          | 14.22       |
| 4 881.75        | H       | X                   | AV            | 51.84          | 7.94      | -24.79    | N/A      | 34.99           | 54.00          | 19.01       |
| 7 322.69        | V       | X                   | PK            | 58.44          | 10.67     | N/A       | N/A      | 69.11           | 74.00          | 4.89        |
| 7 322.69        | V       | X                   | AV            | 58.44          | 10.67     | -24.79    | N/A      | 44.32           | 54.00          | 9.68        |
| 9 763.65        | V       | Y                   | PK            | 54.33          | 14.22     | N/A       | N/A      | 68.55           | 74.00          | 5.45        |
| 9 763.65        | V       | Y                   | AV            | 54.33          | 14.22     | -24.79    | N/A      | 43.76           | 54.00          | 10.24       |
| 12 204.66       | V       | Y                   | PK            | 48.62          | 17.39     | N/A       | N/A      | 66.01           | 74.00          | 7.99        |
| 12 204.66       | V       | Y                   | AV            | 48.62          | 17.39     | -24.79    | N/A      | 41.22           | 54.00          | 12.78       |

## • Highest Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 2 483.62        | H       | X                   | PK            | 49.59          | 3.71      | N/A       | N/A      | 53.30           | 74.00          | 20.70       |
| 2 483.62        | H       | X                   | AV            | 49.59          | 3.71      | -24.79    | N/A      | 28.51           | 54.00          | 25.49       |
| 4 960.33        | H       | X                   | PK            | 51.22          | 8.04      | N/A       | N/A      | 59.26           | 74.00          | 14.74       |
| 4 960.33        | H       | X                   | AV            | 51.22          | 8.04      | -24.79    | N/A      | 34.47           | 54.00          | 19.53       |
| 7 439.66        | V       | X                   | PK            | 58.37          | 10.60     | N/A       | N/A      | 68.97           | 74.00          | 5.03        |
| 7 439.66        | V       | X                   | AV            | 58.37          | 10.60     | -24.79    | N/A      | 44.18           | 54.00          | 9.82        |
| 9 919.56        | V       | Y                   | PK            | 54.83          | 14.75     | N/A       | N/A      | 69.58           | 74.00          | 4.42        |
| 9 919.56        | V       | Y                   | AV            | 54.83          | 14.75     | -24.79    | N/A      | 44.79           | 54.00          | 9.21        |
| 12 399.61       | V       | Y                   | PK            | 49.17          | 17.53     | N/A       | N/A      | 66.70           | 74.00          | 7.30        |
| 12 399.61       | V       | Y                   | AV            | 49.17          | 17.53     | -24.79    | N/A      | 41.91           | 54.00          | 12.09       |

# 1 GHz ~ 25 GHz Data (Modulation : $\pi/4$ DQPSK)

## • Lowest Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 2 388.67        | H       | X                   | PK            | 44.23          | 3.43      | N/A       | N/A      | 47.66           | 74.00          | 26.34       |
| 2 388.67        | H       | X                   | AV            | 44.23          | 3.43      | -24.79    | N/A      | 22.87           | 54.00          | 31.13       |
| 4 803.84        | H       | X                   | PK            | 51.03          | 7.89      | N/A       | N/A      | 58.92           | 74.00          | 15.08       |
| 4 803.84        | H       | X                   | AV            | 51.03          | 7.89      | -24.79    | N/A      | 34.13           | 54.00          | 19.87       |
| 7 205.68        | V       | X                   | PK            | 57.94          | 10.54     | N/A       | N/A      | 68.48           | 74.00          | 5.52        |
| 7 205.68        | V       | X                   | AV            | 57.94          | 10.54     | -24.79    | N/A      | 43.69           | 54.00          | 10.31       |
| 9 607.86        | V       | Y                   | PK            | 52.67          | 13.76     | N/A       | N/A      | 66.43           | 74.00          | 7.57        |
| 9 607.86        | V       | Y                   | AV            | 52.67          | 13.76     | -24.79    | N/A      | 41.64           | 54.00          | 12.36       |
| 12 009.12       | V       | Y                   | PK            | 47.99          | 17.26     | N/A       | N/A      | 65.25           | 74.00          | 8.75        |
| 12 009.12       | V       | Y                   | AV            | 47.99          | 17.26     | -24.79    | N/A      | 40.46           | 54.00          | 13.54       |

## • Middle Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 4 882.07        | H       | X                   | PK            | 50.94          | 7.94      | N/A       | N/A      | 58.88           | 74.00          | 15.12       |
| 4 882.07        | H       | X                   | AV            | 50.94          | 7.94      | -24.79    | N/A      | 34.09           | 54.00          | 19.91       |
| 7 322.86        | V       | X                   | PK            | 61.06          | 10.67     | N/A       | N/A      | 71.73           | 74.00          | 2.27        |
| 7 322.86        | V       | X                   | AV            | 61.06          | 10.67     | -24.79    | N/A      | 46.94           | 54.00          | 7.06        |
| 9 763.65        | V       | Y                   | PK            | 54.61          | 14.22     | N/A       | N/A      | 68.83           | 74.00          | 5.17        |
| 9 763.65        | V       | Y                   | AV            | 54.61          | 14.22     | -24.79    | N/A      | 44.04           | 54.00          | 9.96        |
| 12 204.51       | V       | Y                   | PK            | 49.79          | 17.39     | N/A       | N/A      | 67.18           | 74.00          | 6.82        |
| 12 204.51       | V       | Y                   | AV            | 49.79          | 17.39     | -24.79    | N/A      | 42.39           | 54.00          | 11.61       |

## • Highest Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 2 483.61        | H       | X                   | PK            | 53.32          | 3.71      | N/A       | N/A      | 57.03           | 74.00          | 16.97       |
| 2 483.61        | H       | X                   | AV            | 53.32          | 3.71      | -24.79    | N/A      | 32.24           | 54.00          | 21.76       |
| 4 959.81        | H       | X                   | PK            | 50.96          | 8.04      | N/A       | N/A      | 59.00           | 74.00          | 15.00       |
| 4 959.81        | H       | X                   | AV            | 50.96          | 8.04      | -24.79    | N/A      | 34.21           | 54.00          | 19.79       |
| 7 439.86        | V       | X                   | PK            | 60.73          | 10.60     | N/A       | N/A      | 71.33           | 74.00          | 2.67        |
| 7 439.86        | V       | X                   | AV            | 60.73          | 10.60     | -24.79    | N/A      | 46.54           | 54.00          | 7.46        |
| 9 919.67        | V       | Y                   | PK            | 55.26          | 14.75     | N/A       | N/A      | 70.01           | 74.00          | 3.99        |
| 9 919.67        | V       | Y                   | AV            | 55.26          | 14.75     | -24.79    | N/A      | 45.22           | 54.00          | 8.78        |
| 12 399.36       | V       | Y                   | PK            | 50.03          | 17.53     | N/A       | N/A      | 67.56           | 74.00          | 6.44        |
| 12 399.36       | V       | Y                   | AV            | 50.03          | 17.53     | -24.79    | N/A      | 42.77           | 54.00          | 11.23       |

# 1 GHz ~ 25 GHz Data (Modulation : 8DPSK)

## • Lowest Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 2 389.61        | H       | X                   | PK            | 44.77          | 3.43      | N/A       | N/A      | 48.20           | 74.00          | 25.80       |
| 2 389.61        | H       | X                   | AV            | 44.77          | 3.43      | -24.79    | N/A      | 23.41           | 54.00          | 30.59       |
| 4 803.67        | H       | X                   | PK            | 50.86          | 7.89      | N/A       | N/A      | 58.75           | 74.00          | 15.25       |
| 4 803.67        | H       | X                   | AV            | 50.86          | 7.89      | -24.79    | N/A      | 33.96           | 54.00          | 20.04       |
| 7 205.97        | V       | X                   | PK            | 58.83          | 10.54     | N/A       | N/A      | 69.37           | 74.00          | 4.63        |
| 7 205.97        | V       | X                   | AV            | 58.83          | 10.54     | -24.79    | N/A      | 44.58           | 54.00          | 9.42        |
| 9 608.03        | V       | Y                   | PK            | 53.31          | 13.76     | N/A       | N/A      | 67.07           | 74.00          | 6.93        |
| 9 608.03        | V       | Y                   | AV            | 53.31          | 13.76     | -24.79    | N/A      | 42.28           | 54.00          | 11.72       |
| 12 009.69       | V       | Y                   | PK            | 47.98          | 17.26     | N/A       | N/A      | 65.24           | 74.00          | 8.76        |
| 12 009.69       | V       | Y                   | AV            | 47.98          | 17.26     | -24.79    | N/A      | 40.45           | 54.00          | 13.55       |

## • Middle Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 4 881.87        | H       | X                   | PK            | 51.52          | 7.94      | N/A       | N/A      | 59.46           | 74.00          | 14.54       |
| 4 881.87        | H       | X                   | AV            | 51.52          | 7.94      | -24.79    | N/A      | 34.67           | 54.00          | 19.33       |
| 7 323.00        | V       | X                   | PK            | 61.67          | 10.67     | N/A       | N/A      | 72.34           | 74.00          | 1.66        |
| 7 323.00        | V       | X                   | AV            | 61.67          | 10.67     | -24.79    | N/A      | 47.55           | 54.00          | 6.45        |
| 9 763.44        | V       | Y                   | PK            | 54.54          | 14.22     | N/A       | N/A      | 68.76           | 74.00          | 5.24        |
| 9 763.44        | V       | Y                   | AV            | 54.54          | 14.22     | -24.79    | N/A      | 43.97           | 54.00          | 10.03       |
| 12 204.75       | V       | Y                   | PK            | 50.27          | 17.39     | N/A       | N/A      | 67.66           | 74.00          | 6.34        |
| 12 204.75       | V       | Y                   | AV            | 50.27          | 17.39     | -24.79    | N/A      | 42.87           | 54.00          | 11.13       |

## • Highest Channel

| Frequency (MHz) | ANT Pol | EUT Position (Axis) | Detector Mode | Reading (dBuV) | TF (dB/m) | DCCF (dB) | DCF (dB) | Result (dBuV/m) | Limit (dBuV/m) | Margin (dB) |
|-----------------|---------|---------------------|---------------|----------------|-----------|-----------|----------|-----------------|----------------|-------------|
| 2 483.68        | H       | X                   | PK            | 56.54          | 3.71      | N/A       | N/A      | 60.25           | 74.00          | 13.75       |
| 2 483.68        | H       | X                   | AV            | 56.54          | 3.71      | -24.79    | N/A      | 35.46           | 54.00          | 18.54       |
| 4 959.96        | H       | X                   | PK            | 51.26          | 8.04      | N/A       | N/A      | 59.30           | 74.00          | 14.70       |
| 4 959.96        | H       | X                   | AV            | 51.26          | 8.04      | -24.79    | N/A      | 34.51           | 54.00          | 19.49       |
| 7 440.05        | V       | X                   | PK            | 61.08          | 10.60     | N/A       | N/A      | 71.68           | 74.00          | 2.32        |
| 7 440.05        | V       | X                   | AV            | 61.08          | 10.60     | -24.79    | N/A      | 46.89           | 54.00          | 7.11        |
| 9 919.77        | V       | Y                   | PK            | 55.43          | 14.75     | N/A       | N/A      | 70.18           | 74.00          | 3.82        |
| 9 919.77        | V       | Y                   | AV            | 55.43          | 14.75     | -24.79    | N/A      | 45.39           | 54.00          | 8.61        |
| 12 399.96       | V       | Y                   | PK            | 51.05          | 17.53     | N/A       | N/A      | 68.58           | 74.00          | 5.42        |
| 12 399.96       | V       | Y                   | AV            | 51.05          | 17.53     | -24.79    | N/A      | 43.79           | 54.00          | 10.21       |



## 9.4.2. Unwanted Emissions(Conducted)

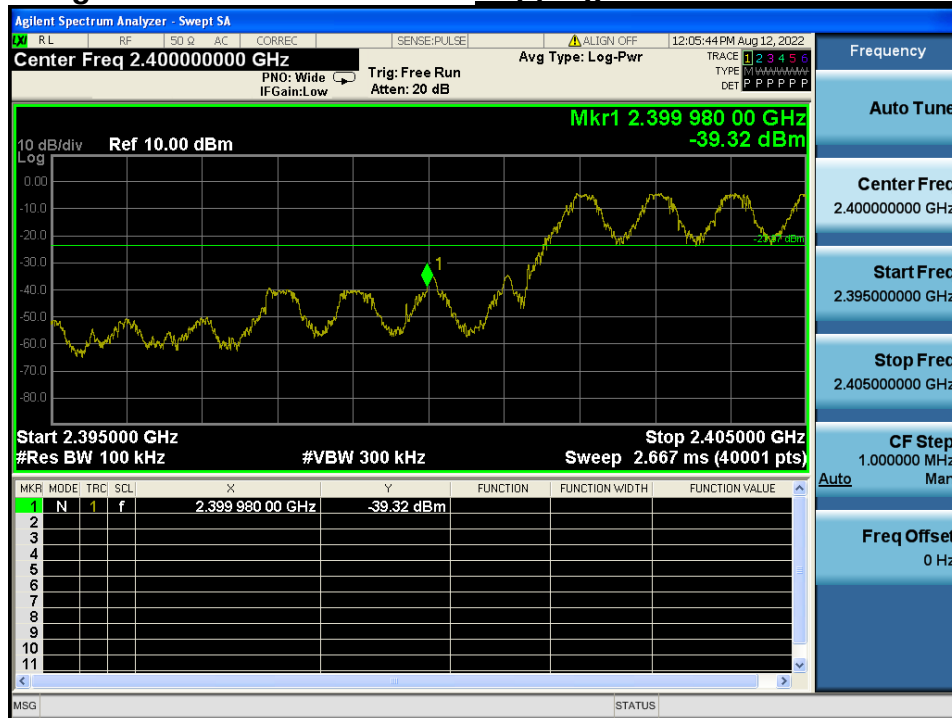
### Low Band-edge

### Lowest Channel & Modulation : GFSK



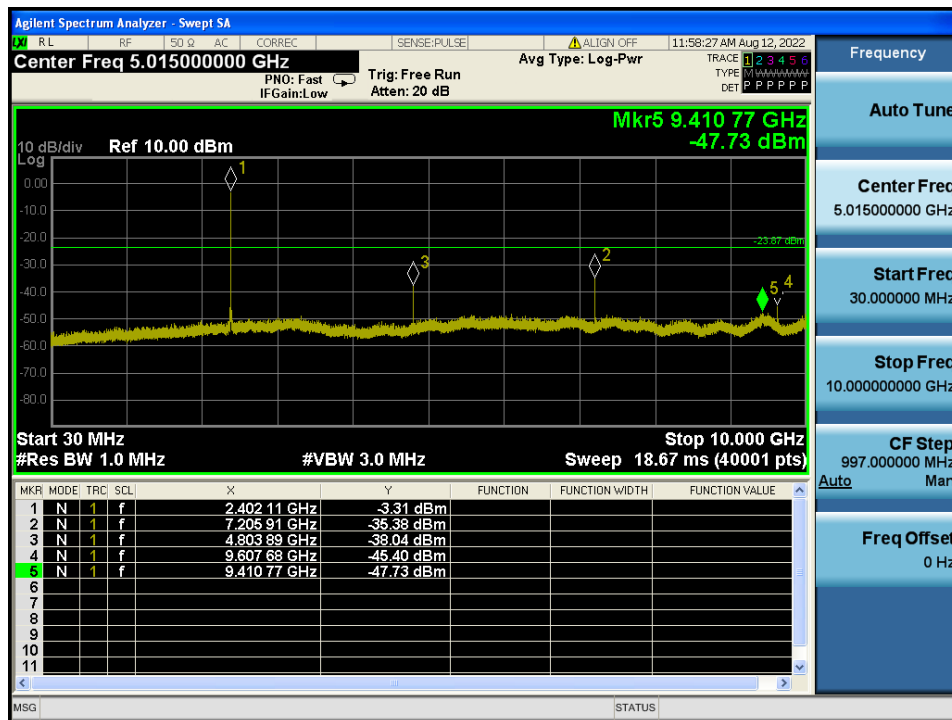
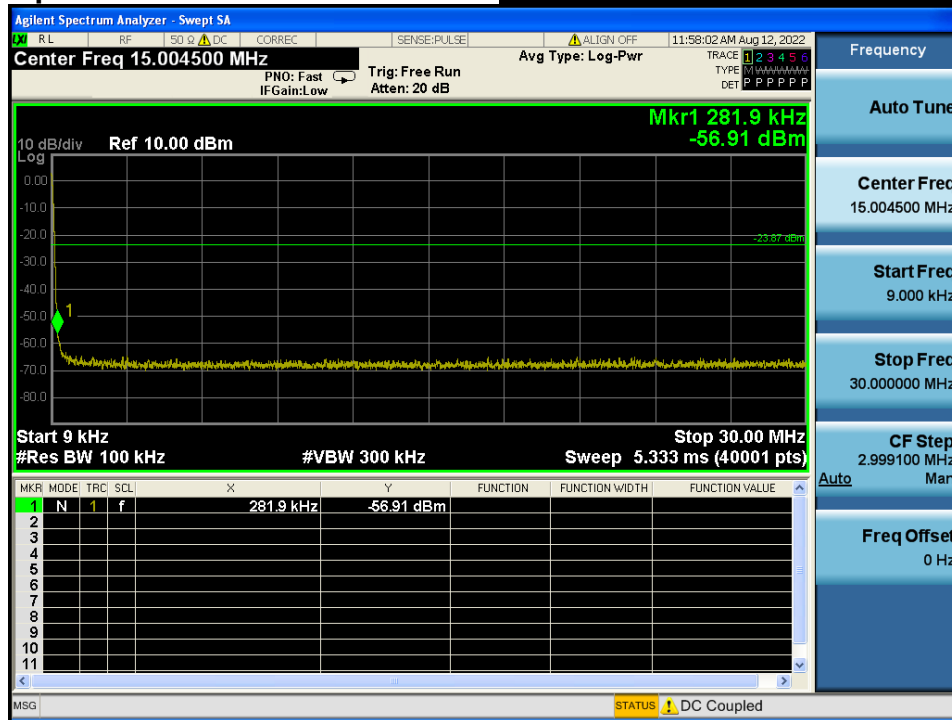
### Low Band-edge

### Hopping mode & Modulation : GFSK



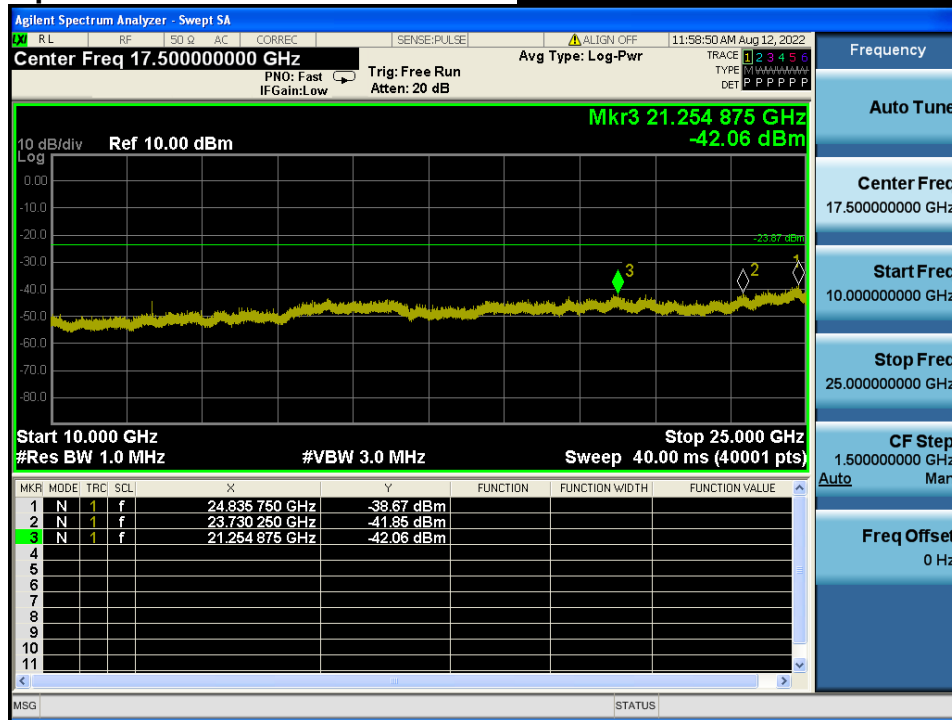
## Conducted Spurious Emissions

## Lowest Channel & Modulation : GFSK



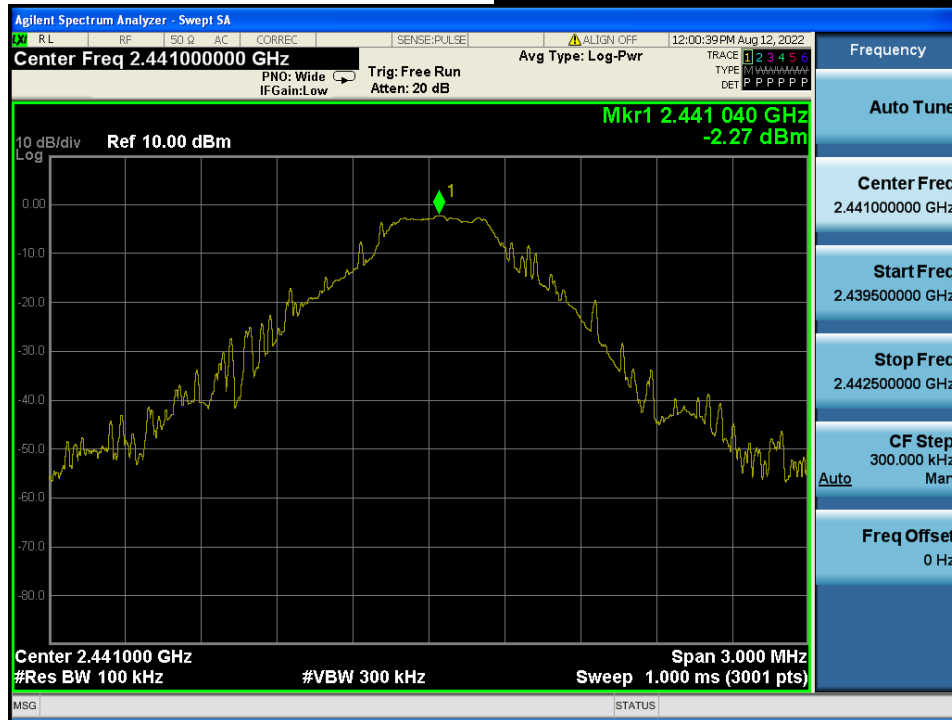
## Conducted Spurious Emissions

## Lowest Channel & Modulation : GFSK



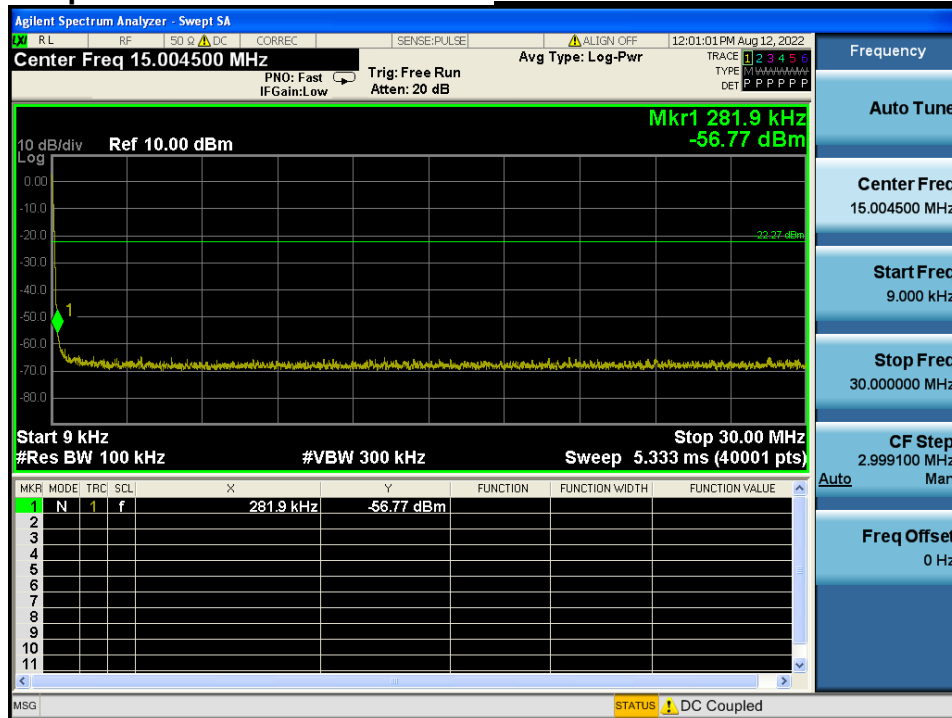
## Reference for limit

## Middle Channel & Modulation : GFSK



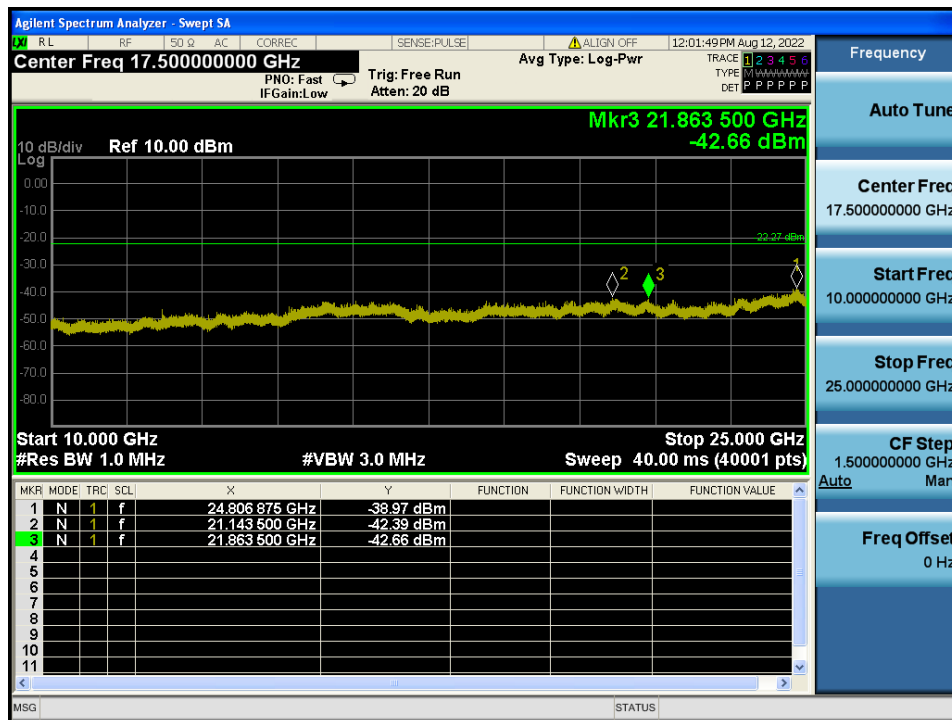
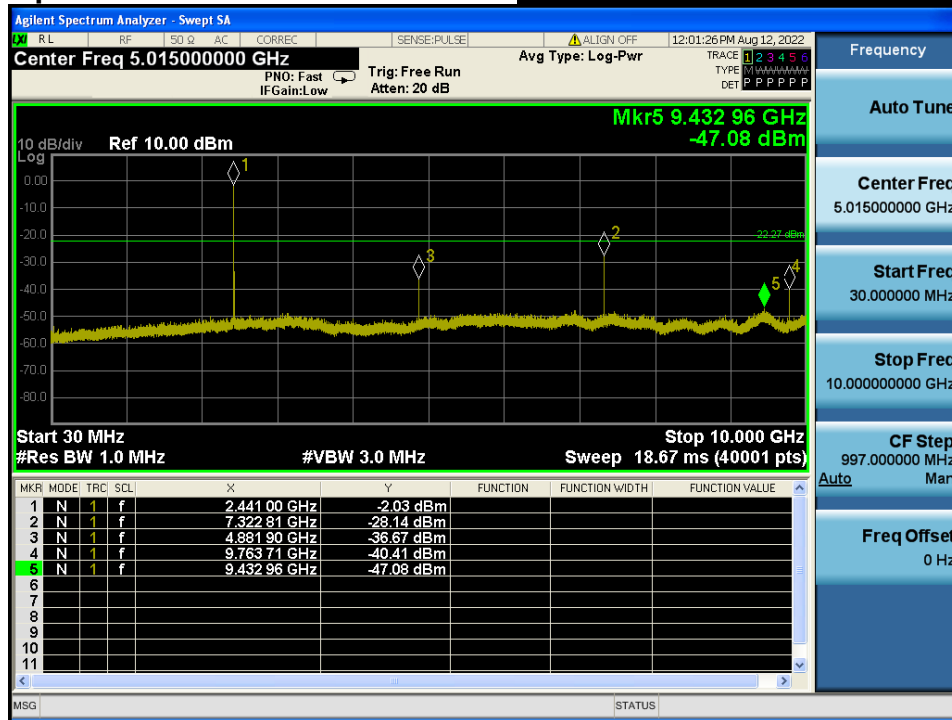
## Conducted Spurious Emissions

## Middle Channel & Modulation : GFSK



## Conducted Spurious Emissions

## Middle Channel & Modulation : GFSK



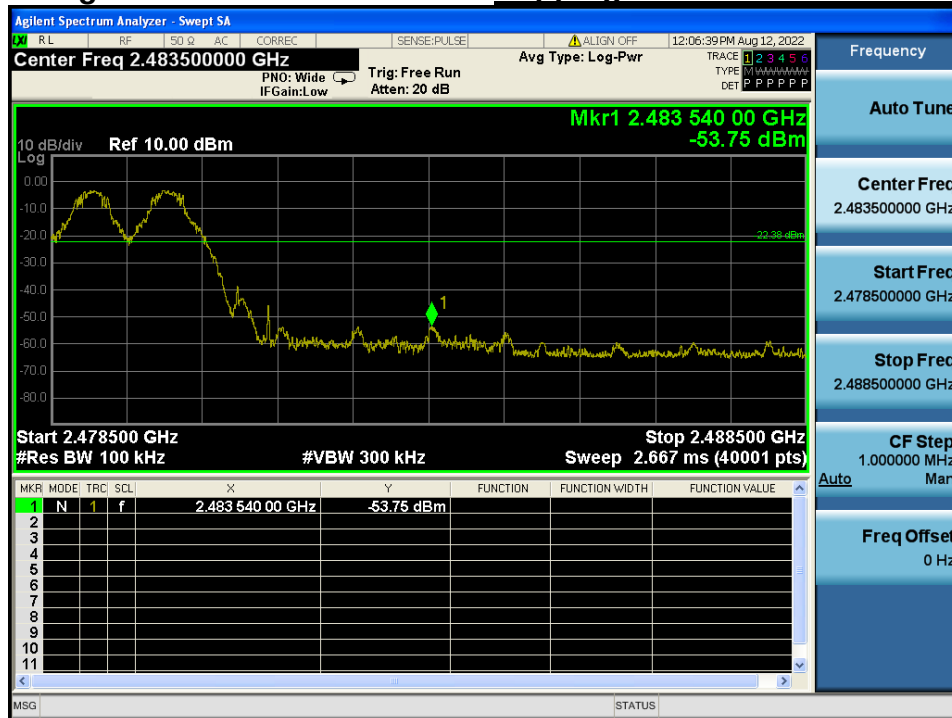
## High Band-edge

## Highest Channel & Modulation : GFSK



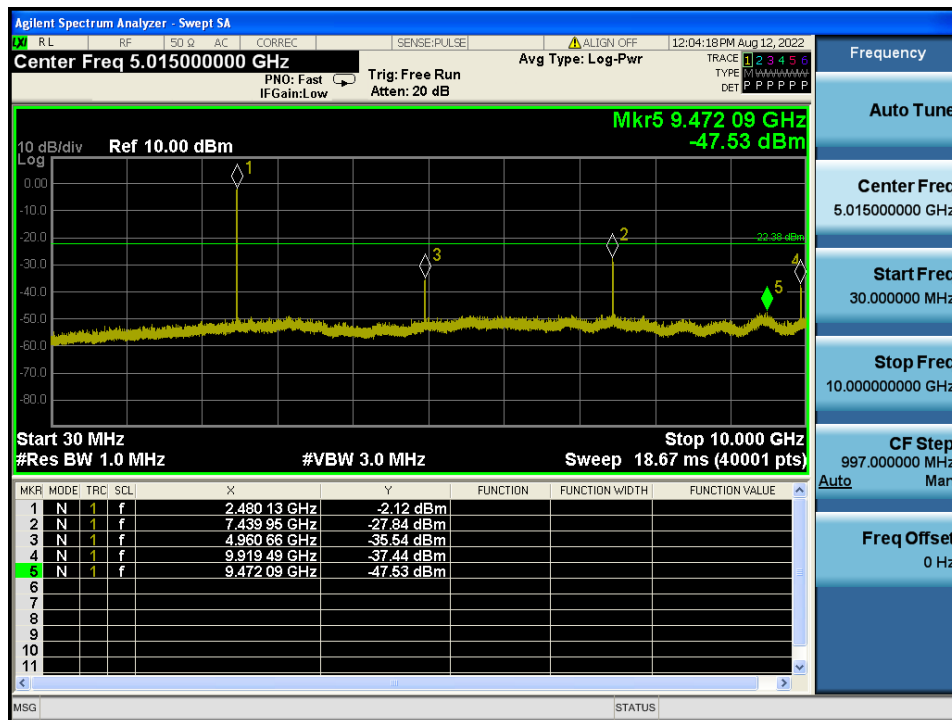
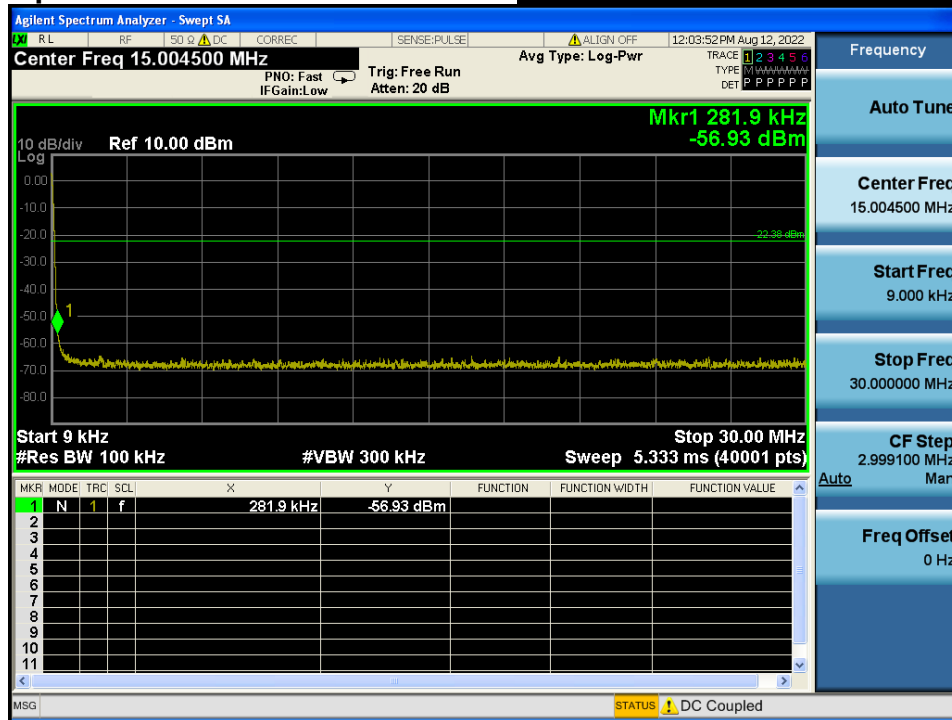
## High Band-edge

## Hopping mode & Modulation : GFSK



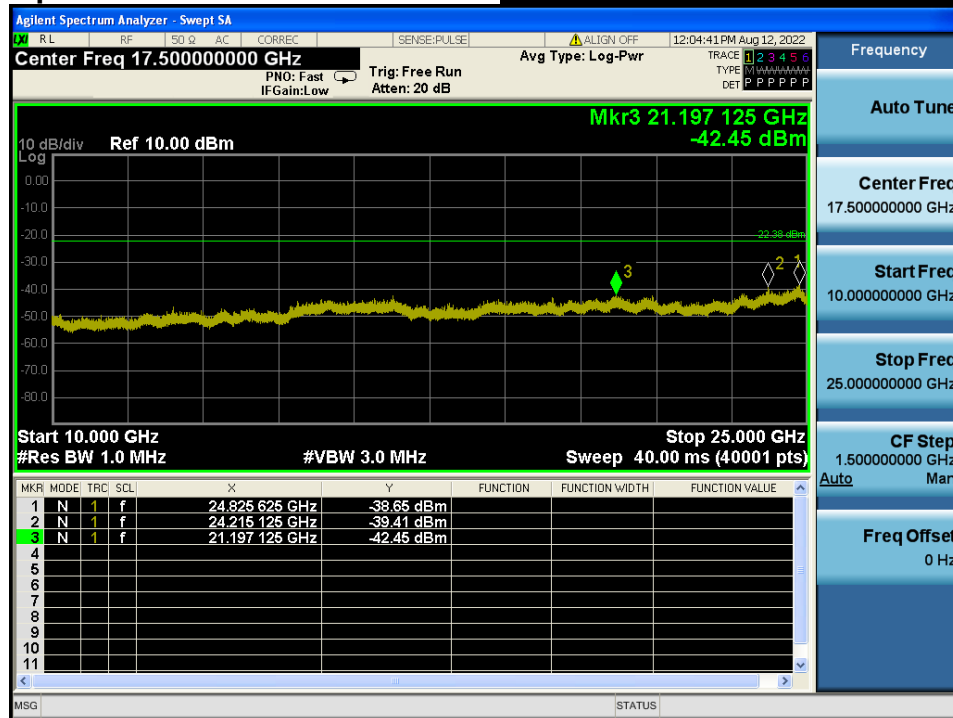
## Conducted Spurious Emissions

## Highest Channel & Modulation : GFSK



# Conducted Spurious Emissions

## Highest Channel & Modulation : GFSK





## Low Band-edge

## Lowest Channel & Modulation : $\pi/4$ DQPSK



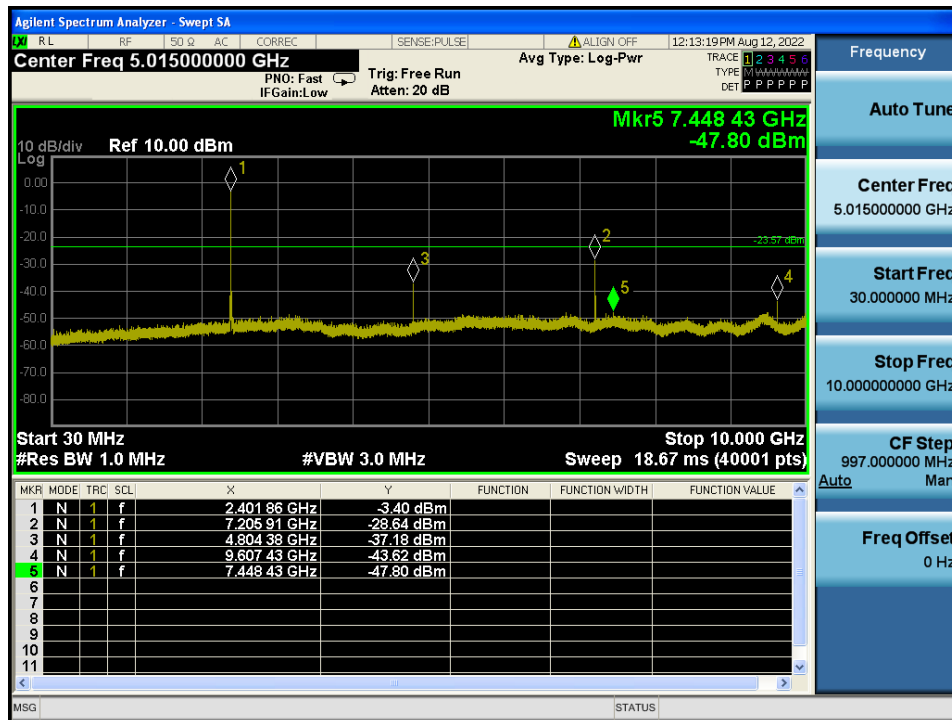
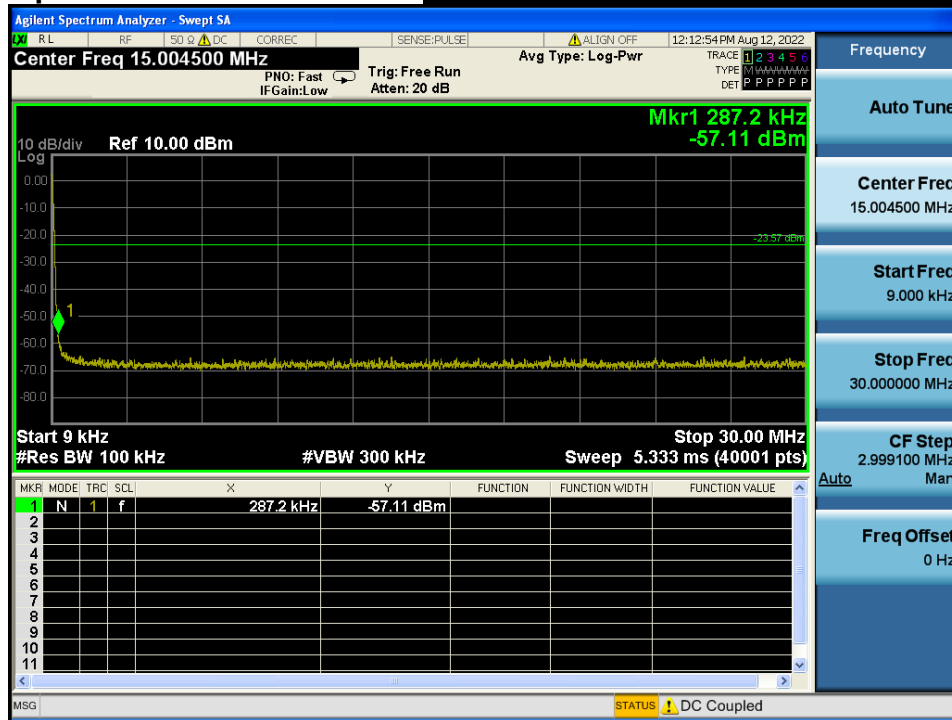
## Low Band-edge

## Hopping mode & Modulation : $\pi/4$ DQPSK



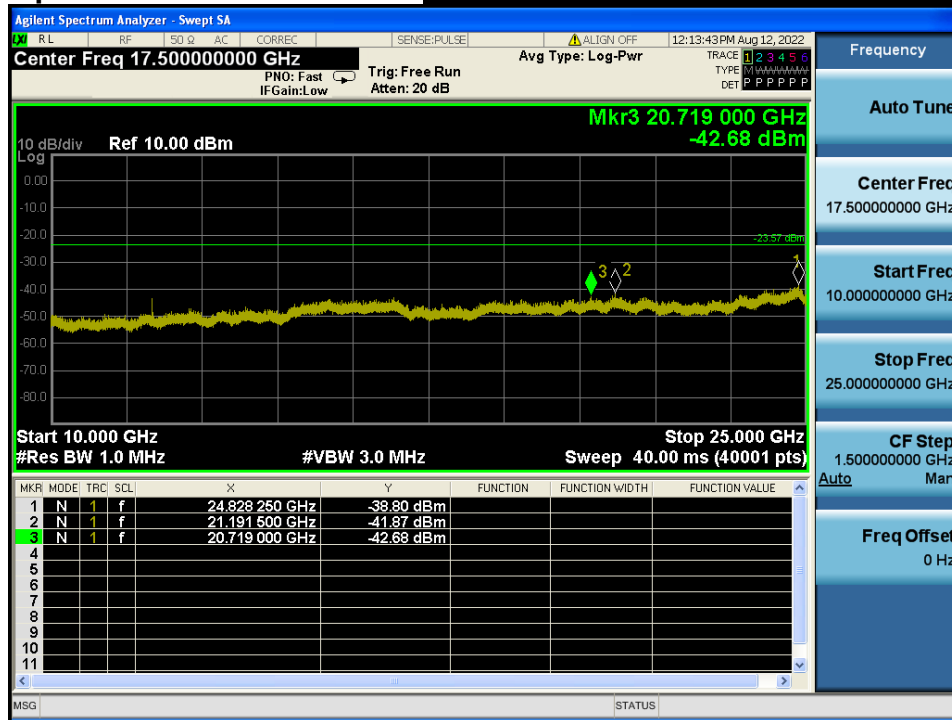
# Conducted Spurious Emissions

**Lowest Channel & Modulation :  $\pi/4$ DQPSK**



# Conducted Spurious Emissions

## Lowest Channel & Modulation : $\pi/4$ DQPSK



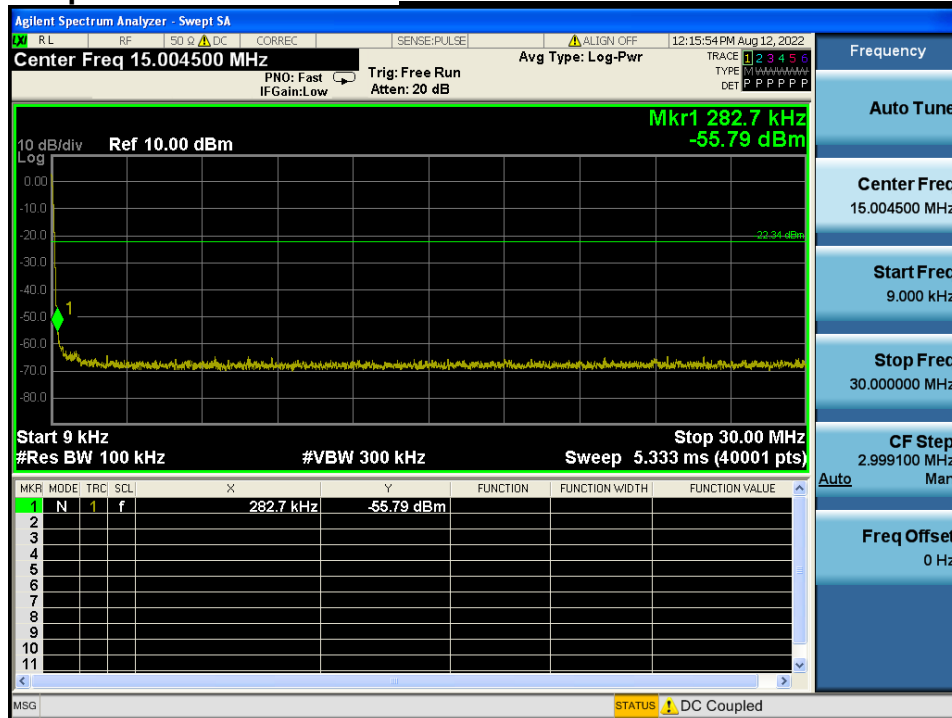
Reference for limit

Middle Channel & Modulation :  $\pi/4$ DQPSK



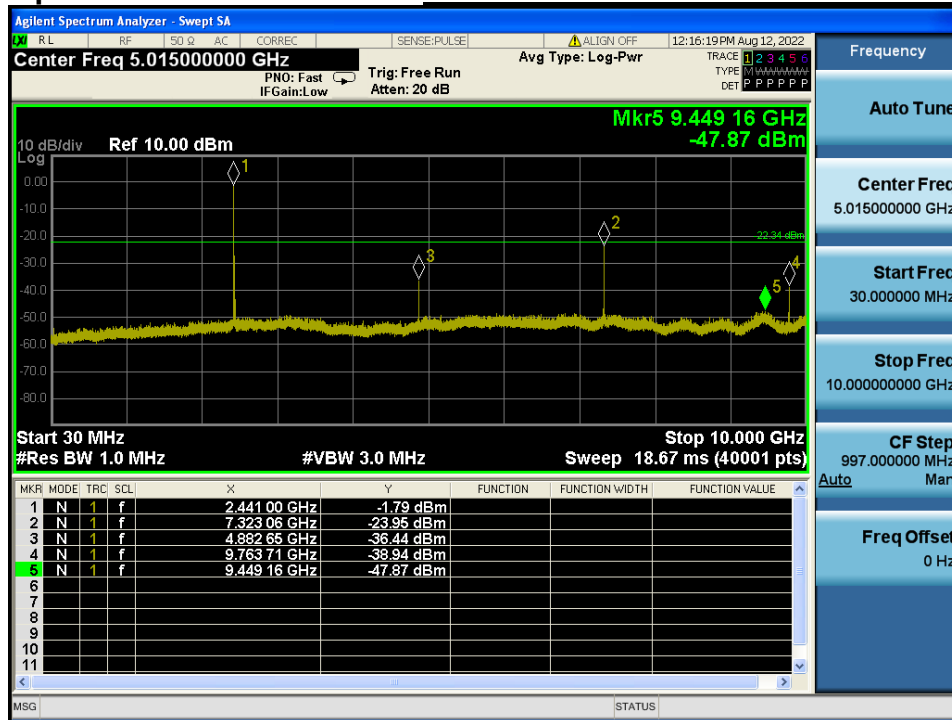
Conducted Spurious Emissions

Middle Channel & Modulation :  $\pi/4$ DQPSK



## Conducted Spurious Emissions

## Middle Channel & Modulation : $\pi/4$ DQPSK

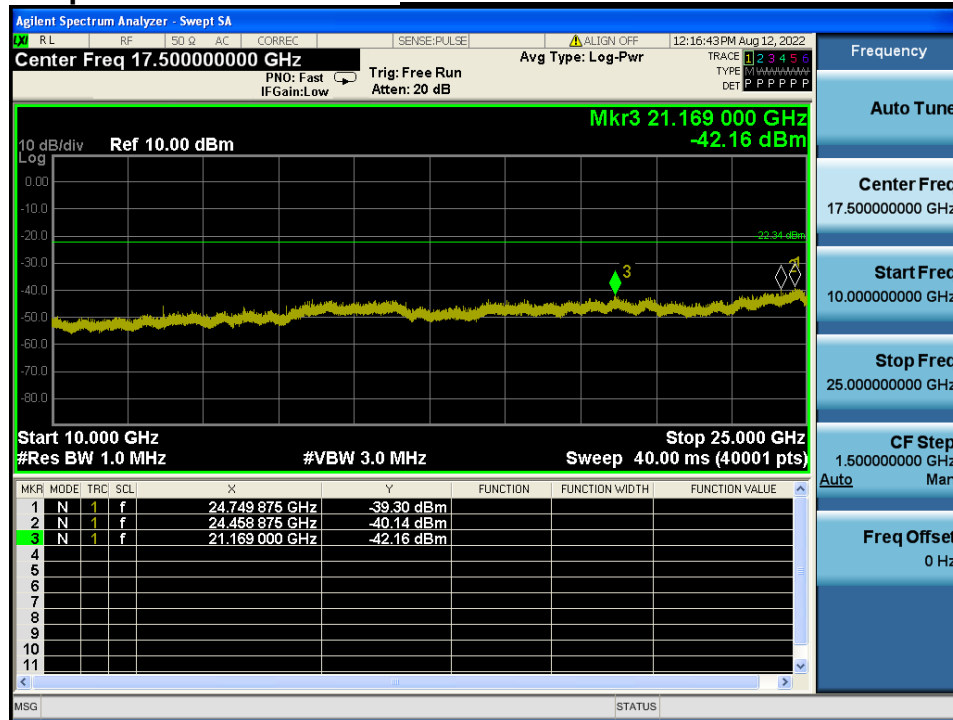


## Zoom scan

## Middle Channel & Modulation : $\pi/4$ DQPSK



# Conducted Spurious Emissions *Middle Channel & Modulation : $\pi/4$ DQPSK*



## High Band-edge

## Highest Channel & Modulation : $\pi/4$ DQPSK



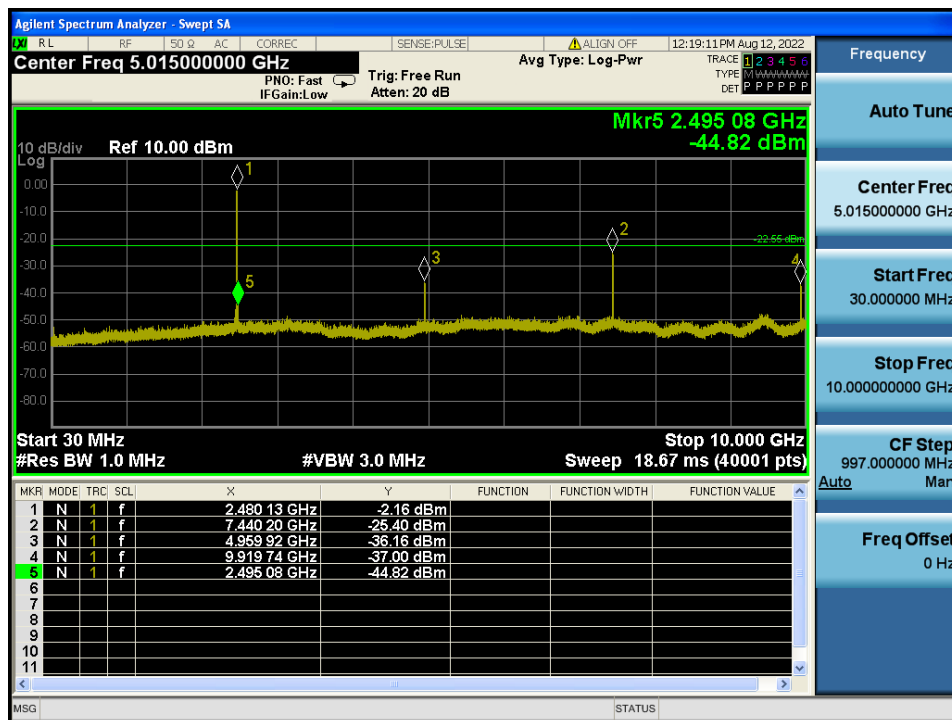
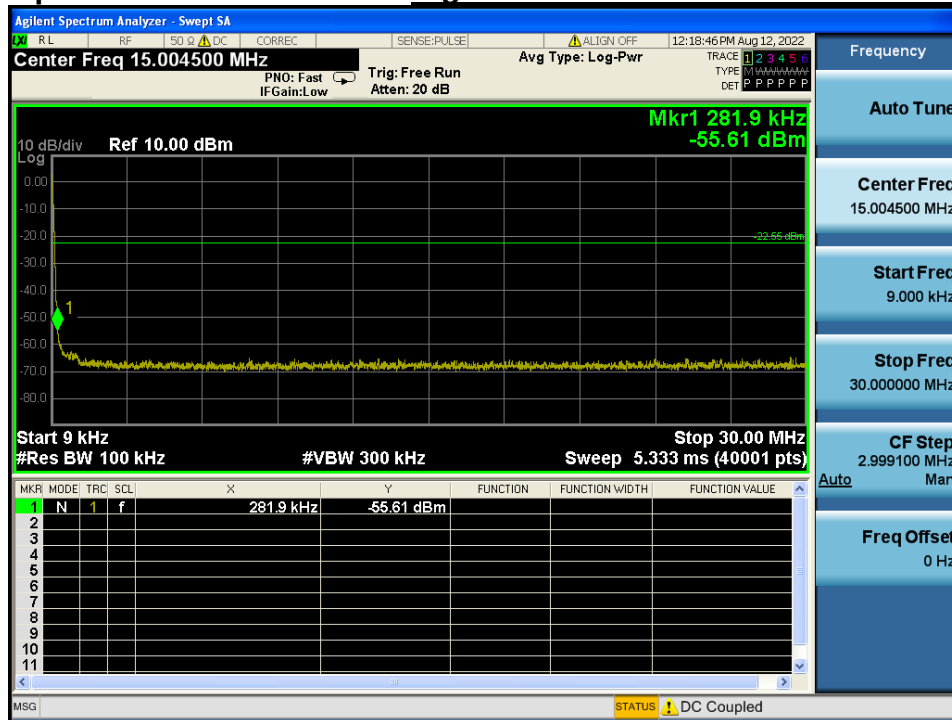
## High Band-edge

## Hopping mode & Modulation : $\pi/4$ DQPSK



# Conducted Spurious Emissions

## Highest Channel & Modulation : $\pi/4$ DQPSK





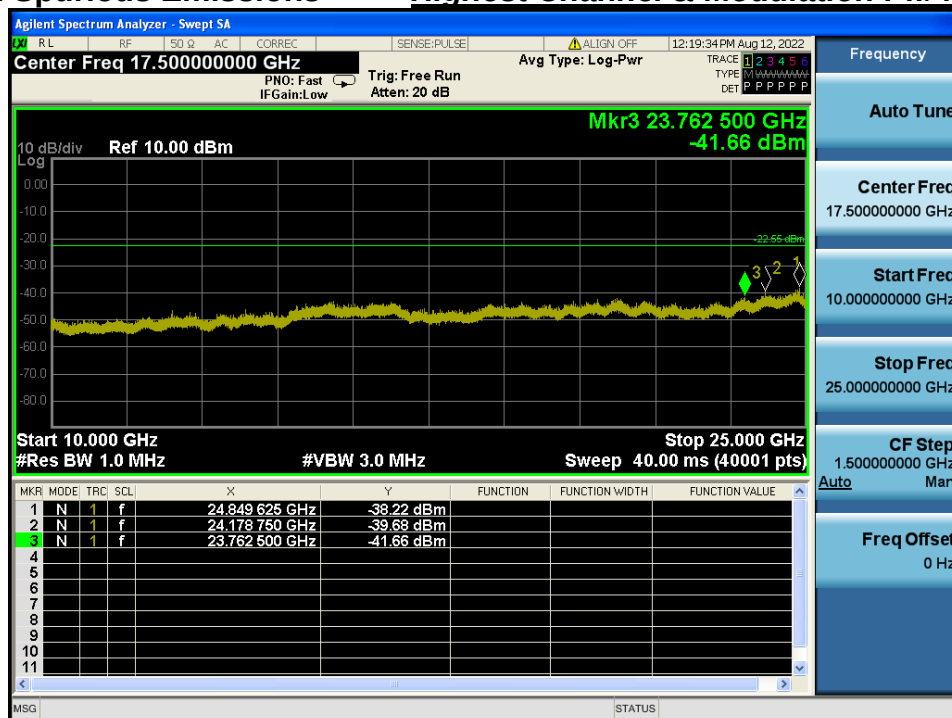
## Zoom scan

## Highest Channel & Modulation : $\pi/4$ DQPSK



## Conducted Spurious Emissions

## Highest Channel & Modulation : $\pi/4$ DQPSK



## Low Band-edge

## Lowest Channel & Modulation : 8DPSK



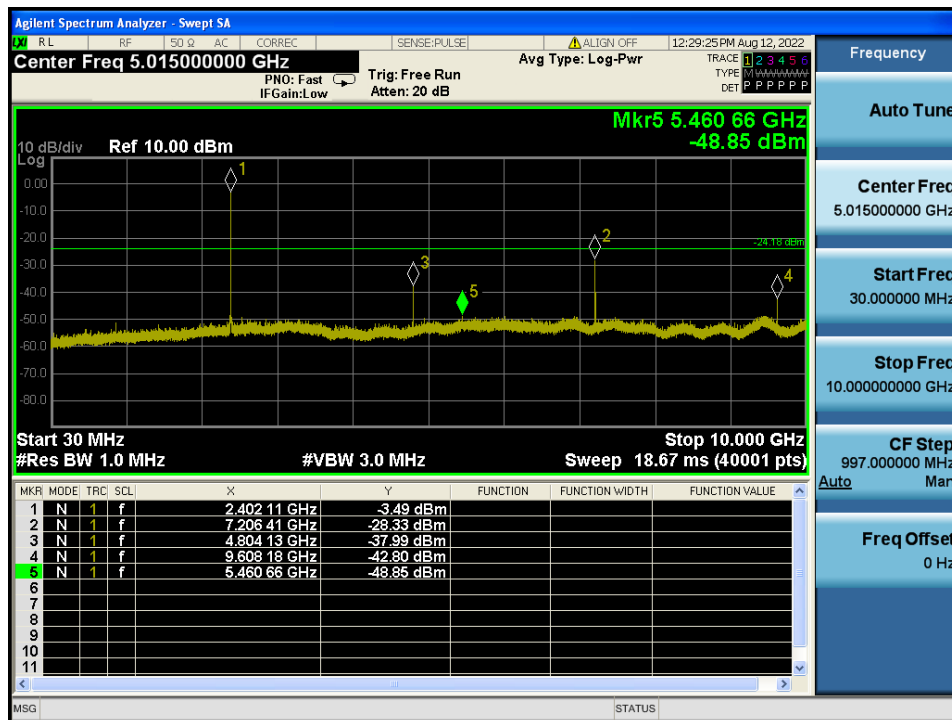
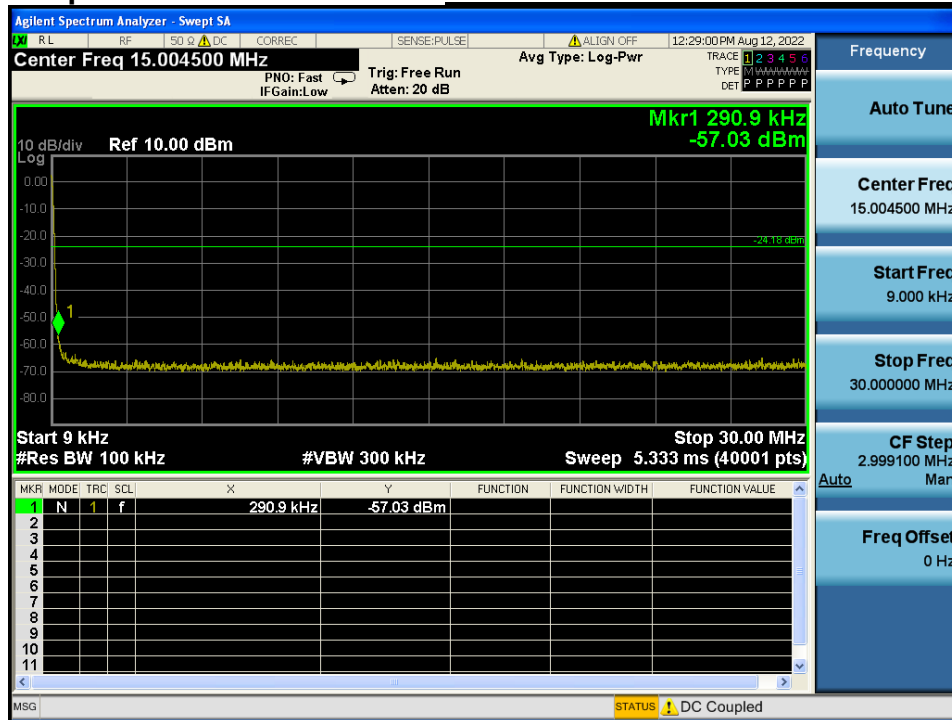
## Low Band-edge

## Hopping mode & Modulation : 8DPSK



## Conducted Spurious Emissions

## Lowest Channel & Modulation : 8DPSK



# Conducted Spurious Emissions

## Lowest Channel & Modulation : 8DPSK



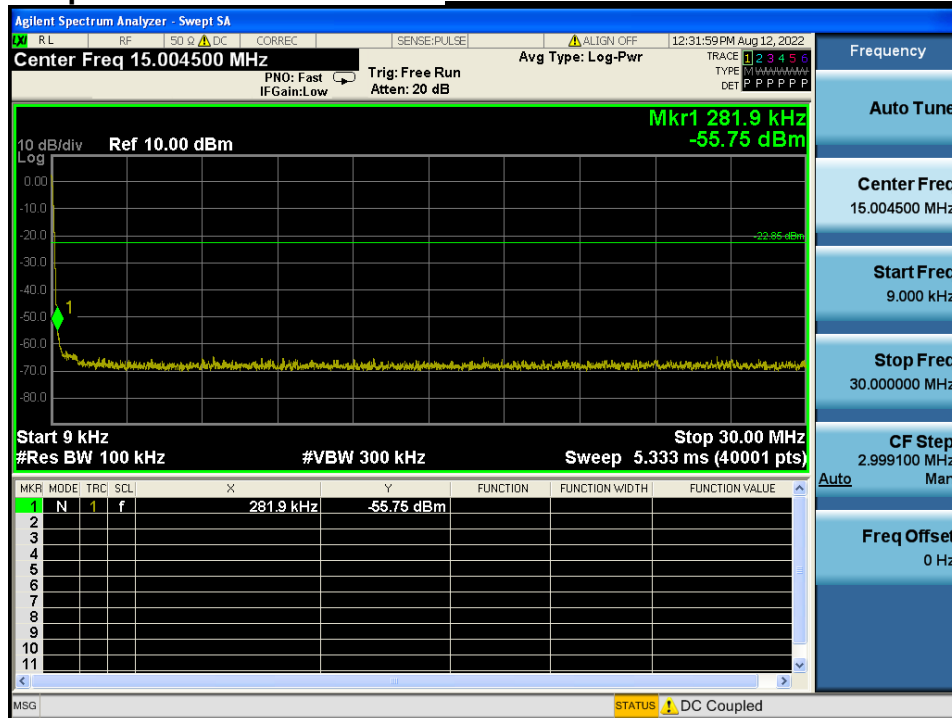
Reference for limit

Middle Channel & Modulation : 8DPSK



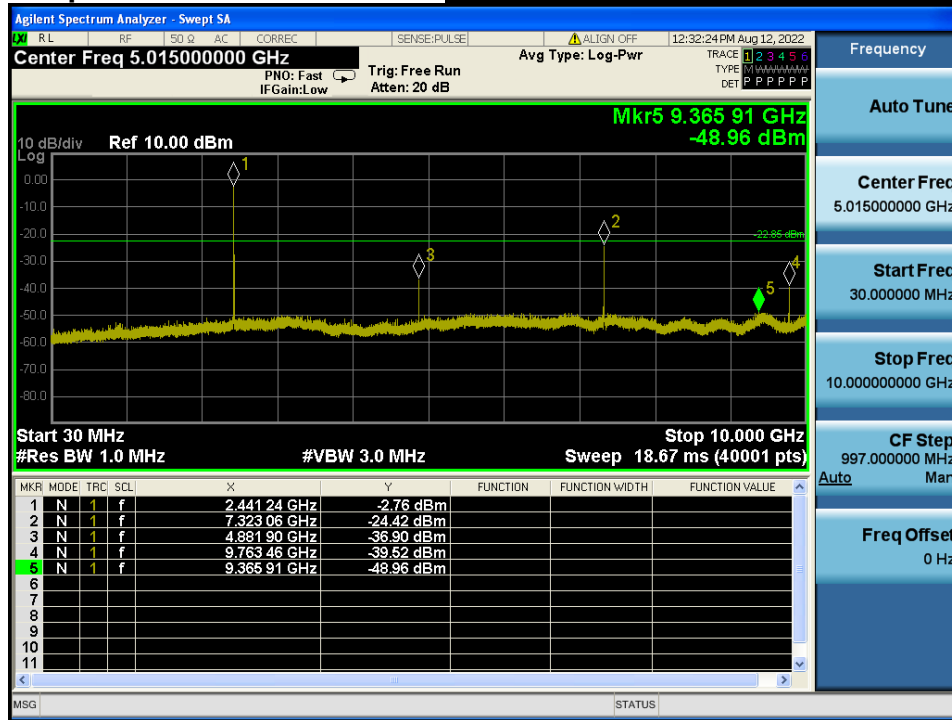
Conducted Spurious Emissions

Middle Channel & Modulation : 8DPSK



## Conducted Spurious Emissions

## Middle Channel & Modulation : 8DPSK



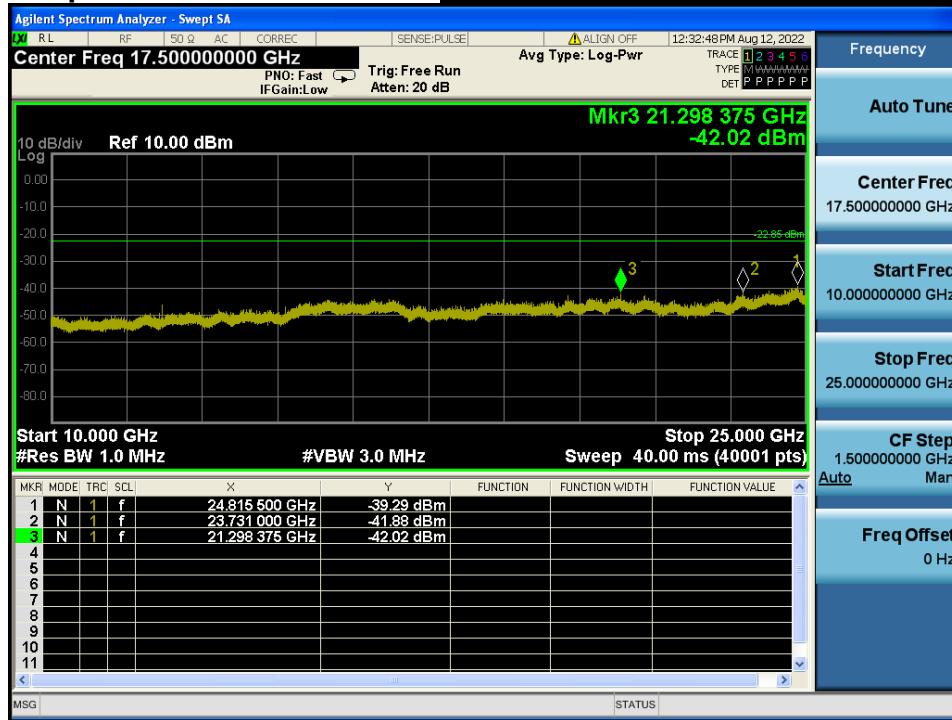
## Zoom scan (7 323 MHz)

## Middle Channel & Modulation : 8DPSK



Conducted Spurious Emissions

Middle Channel & Modulation : 8DPSK



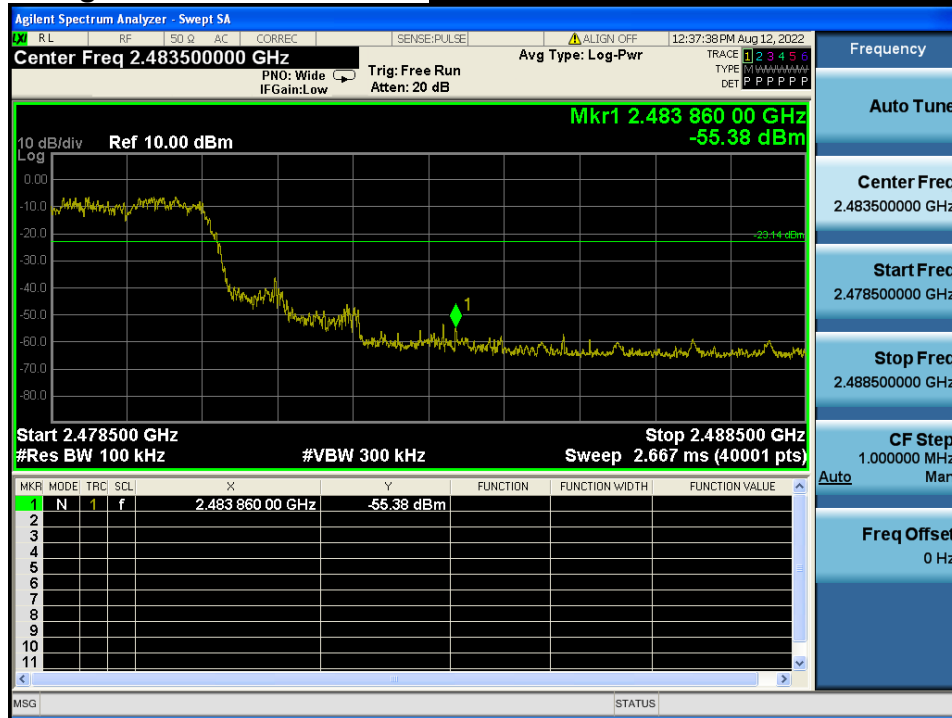
## High Band-edge

## Highest Channel & Modulation : 8DPSK



## High Band-edge

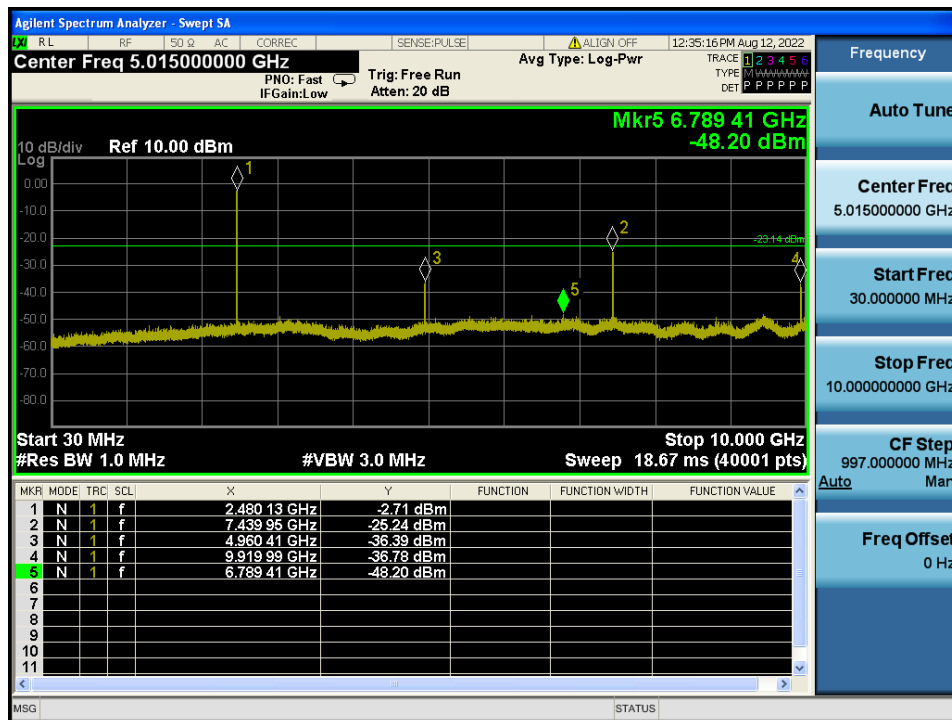
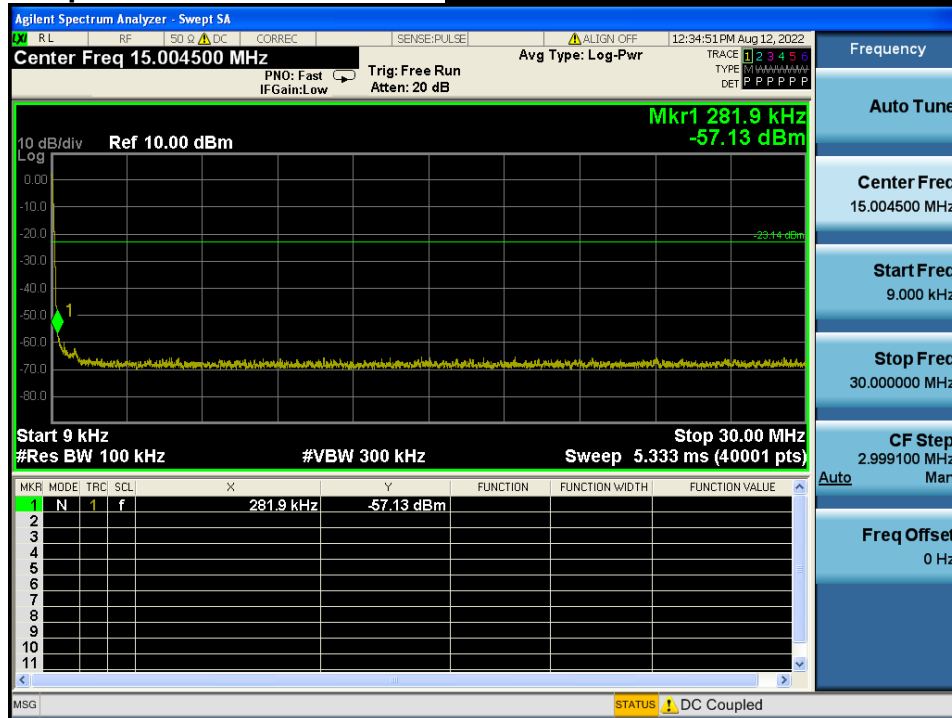
## Hopping mode & Modulation : 8DPSK





## Conducted Spurious Emissions

## Highest Channel & Modulation : 8DPSK



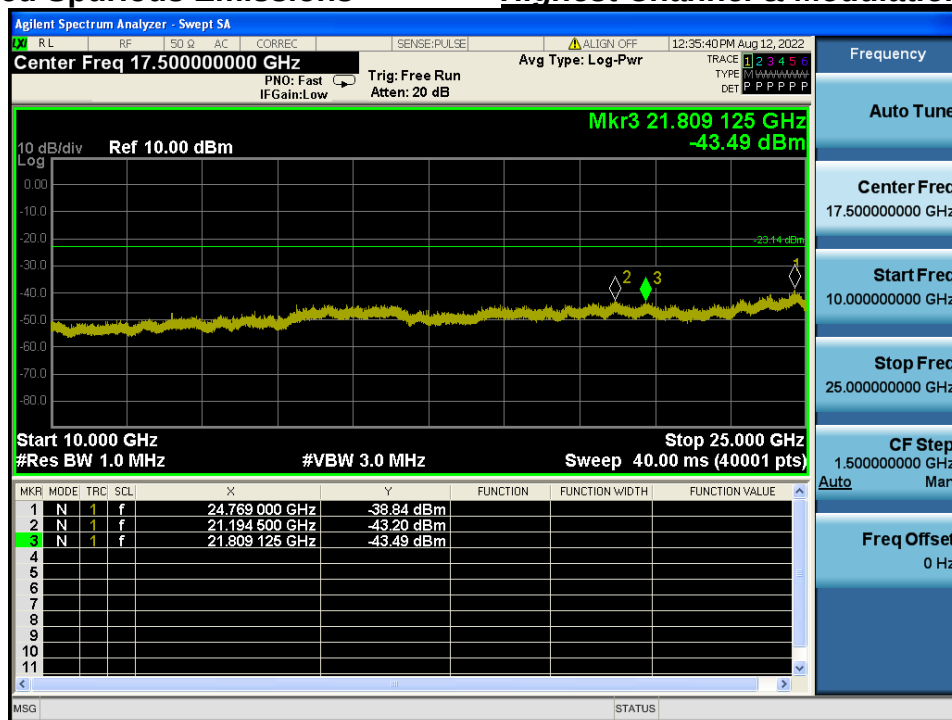
## Zoom scan (7 440 MHz)

## Highest Channel & Modulation : 8DPSK



## Conducted Spurious Emissions

## Highest Channel & Modulation : 8DPSK



## 10. AC Power-Line Conducted Emissions

### 10.1. Test Setup

See test photographs for the actual connections between EUT and support equipment.

### 10.2. Limit

According to §15.207(a) for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 uH/50 ohm line impedance stabilization network (LISN).

Compliance with the provision of this paragraph shall on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower applies at the boundary between the frequency ranges.

| Frequency Range (MHz) | Conducted Limit (dBuV) |            |
|-----------------------|------------------------|------------|
|                       | Quasi-Peak             | Average    |
| 0.15 ~ 0.50           | 66 to 56 *             | 56 to 46 * |
| 0.5 ~ 5.0             | 56                     | 46         |
| 5 ~ 30                | 60                     | 50         |

\* Decreases with the logarithm of the frequency

### 10.3. Test Procedure

Conducted emissions from the EUT were measured according to the ANSI C63.10.

1. The test procedure is performed in a 6.5 m × 3.5 m × 3.5 m (L × W × H) shielded room. The EUT along with its peripherals were placed on a 1.0 m (W) × 1.5 m (L) and 0.8 m in height wooden table and the EUT was adjusted to maintain a 0.4 meter space from a vertical reference plane.
2. The EUT was connected to power mains through a line impedance stabilization network (LISN) which provides 50 ohm coupling impedance for measuring instrument and the chassis ground was bounded to the horizontal ground plane of shielded room.
3. All peripherals were connected to the second LISN and the chassis ground also bounded to the horizontal ground plane of shielded room.
4. The excess power cable between the EUT and the LISN was bundled. The power cables of peripherals were unbundled. All connecting cables of EUT and peripherals were moved to find the maximum emission.

## 10.4. Test Results

AC Power-Line Conducted Emissions (Graph) = Modulation : GFSK

### Results of Conducted Emission

DTNC

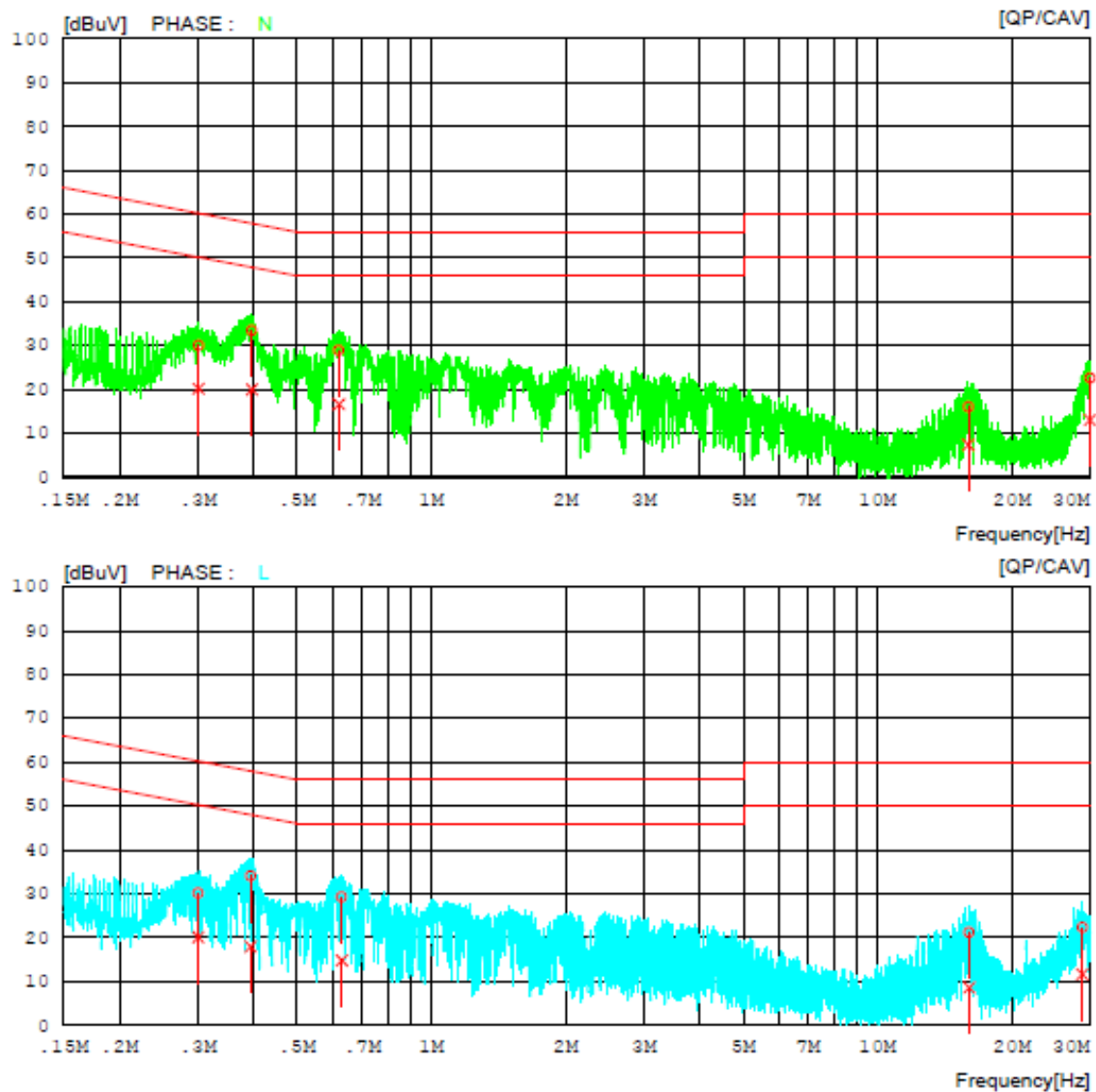
Date 2022-07-29

Order No.  
Model No. SAVER  
Serial No.  
Test Condition BT\_1M\_2402

Reference No.  
Power Supply  
Temp/Humi. 21 'C / 43 %  
Operator S.M.Gil

Memo

LIMIT : FCC P15.207 AV  
FCC P15.207 QP



# AC Power-Line Conducted Emissions (List) = Modulation : GFSK

## Results of Conducted Emission

DTNC

Date 2022-07-29

Order No.  
Model No. SAVER  
Serial No.  
Test Condition BT\_1M\_2402

Reference No.  
Power Supply  
Temp/Humi. 21 'C / 43 %  
Operator S.M.Gil

Memo

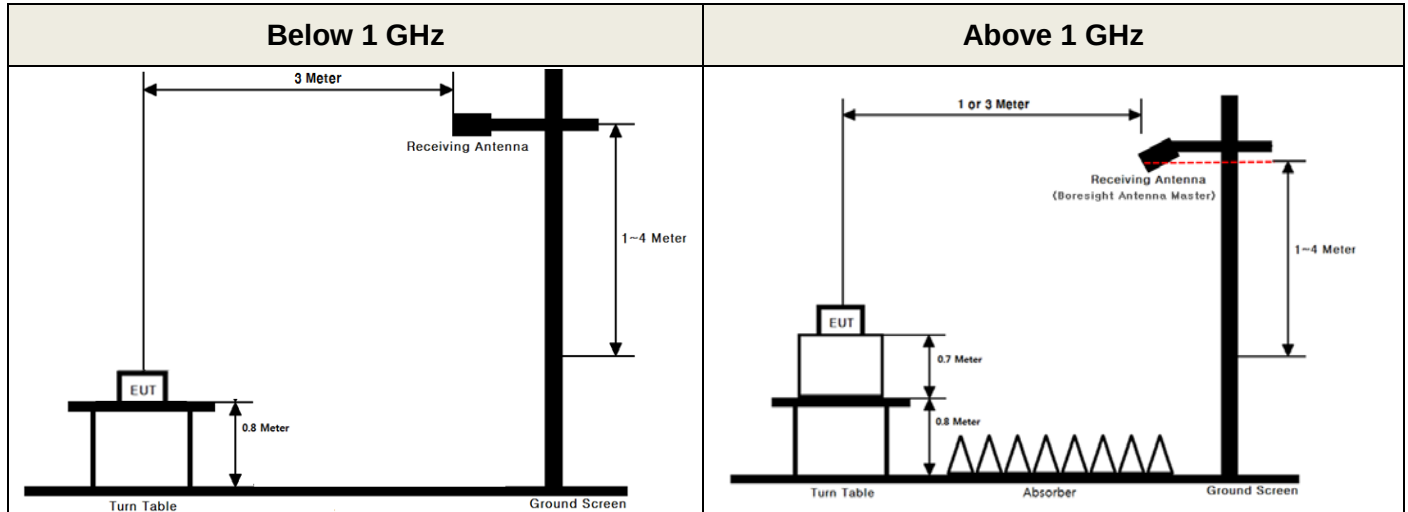
LIMIT : FCC P15.207 AV  
FCC P15.207 QP

| NO | FREQ<br>[MHz] | READING      |               | C.FACTOR<br>[dB] | RESULT       |               | LIMIT        |               | MARGIN       |               | PHASE |
|----|---------------|--------------|---------------|------------------|--------------|---------------|--------------|---------------|--------------|---------------|-------|
|    |               | QP<br>[dBuV] | CAV<br>[dBuV] |                  | QP<br>[dBuV] | CAV<br>[dBuV] | QP<br>[dBuV] | CAV<br>[dBuV] | QP<br>[dBuV] | CAV<br>[dBuV] |       |
| 1  | 0.30081       | 20.05        | 10.22         | 10.00            | 30.05        | 20.22         | 60.22        | 50.22         | 30.17        | 30.00         | N     |
| 2  | 0.39621       | 23.43        | 10.00         | 10.01            | 33.44        | 20.01         | 57.93        | 47.93         | 24.49        | 27.92         | N     |
| 3  | 0.62054       | 18.95        | 6.65          | 10.01            | 28.96        | 16.66         | 56.00        | 46.00         | 27.04        | 29.34         | N     |
| 4  | 15.99333      | 5.55         | -3.12         | 10.50            | 16.05        | 7.38          | 60.00        | 50.00         | 43.95        | 42.62         | N     |
| 5  | 29.97646      | 12.12        | 2.59          | 10.50            | 22.62        | 13.09         | 60.00        | 50.00         | 37.38        | 36.91         | N     |
| 6  | 0.30013       | 20.13        | 10.07         | 10.00            | 30.13        | 20.07         | 60.24        | 50.24         | 30.11        | 30.17         | L     |
| 7  | 0.39335       | 24.10        | 7.94          | 10.01            | 34.11        | 17.95         | 57.99        | 47.99         | 23.88        | 30.04         | L     |
| 8  | 0.62969       | 19.27        | 4.79          | 10.01            | 29.28        | 14.80         | 56.00        | 46.00         | 26.72        | 31.20         | L     |
| 9  | 16.05853      | 10.71        | -1.87         | 10.50            | 21.21        | 8.63          | 60.00        | 50.00         | 38.79        | 41.37         | L     |
| 10 | 28.81426      | 11.83        | 1.09          | 10.50            | 22.33        | 11.59         | 60.00        | 50.00         | 37.67        | 38.41         | L     |

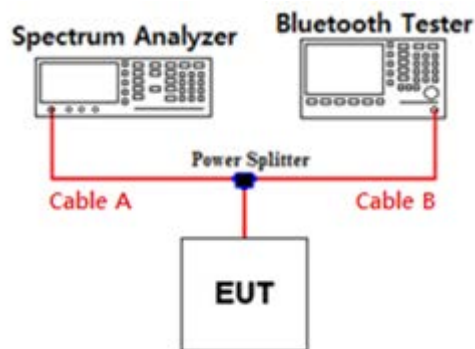
## APPENDIX I

### Test set up diagrams

#### ▪ Radiated Measurement



#### ▪ Conducted Measurement



Path loss information

| Frequency (GHz)       | Path Loss (dB) | Frequency (GHz) | Path Loss (dB) |
|-----------------------|----------------|-----------------|----------------|
| 0.03                  | 6.42           | 15              | 8.17           |
| 1                     | 6.48           | 20              | 8.42           |
| 2.402 & 2.441 & 2.480 | 7.36           | 25              | 9.02           |
| 5                     | 7.62           | -               | -              |
| 10                    | 7.95           | -               | -              |

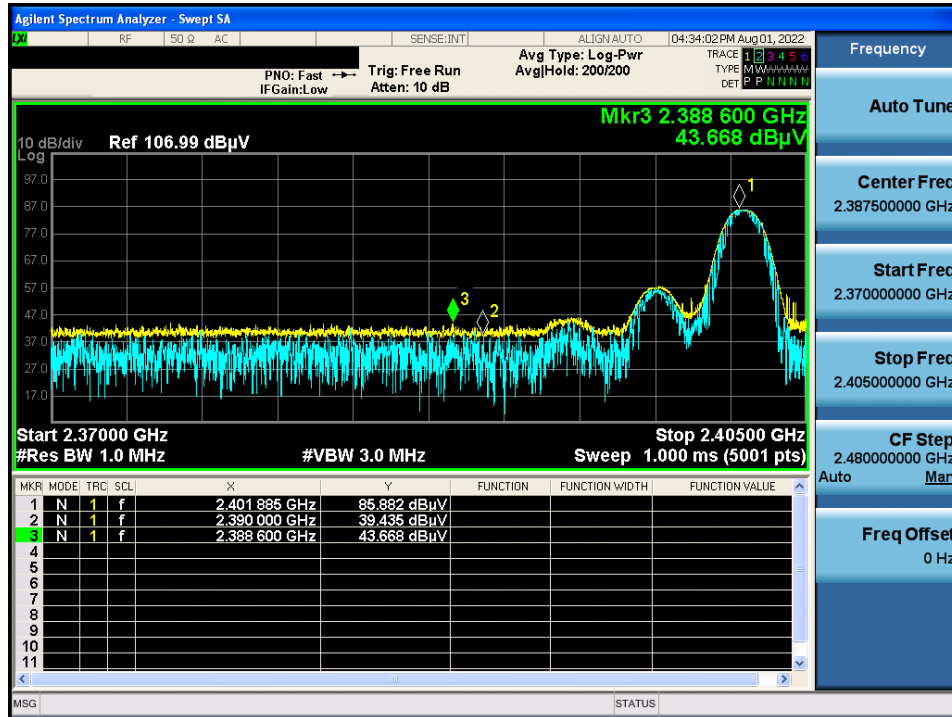
Note 1: The path loss from EUT to Spectrum analyzer was measured and used for test.  
 Path loss (S/A's correction factor) = Cable A + Power Splitter

## APPENDIX II

### Unwanted Emissions (Radiated) Test Plot

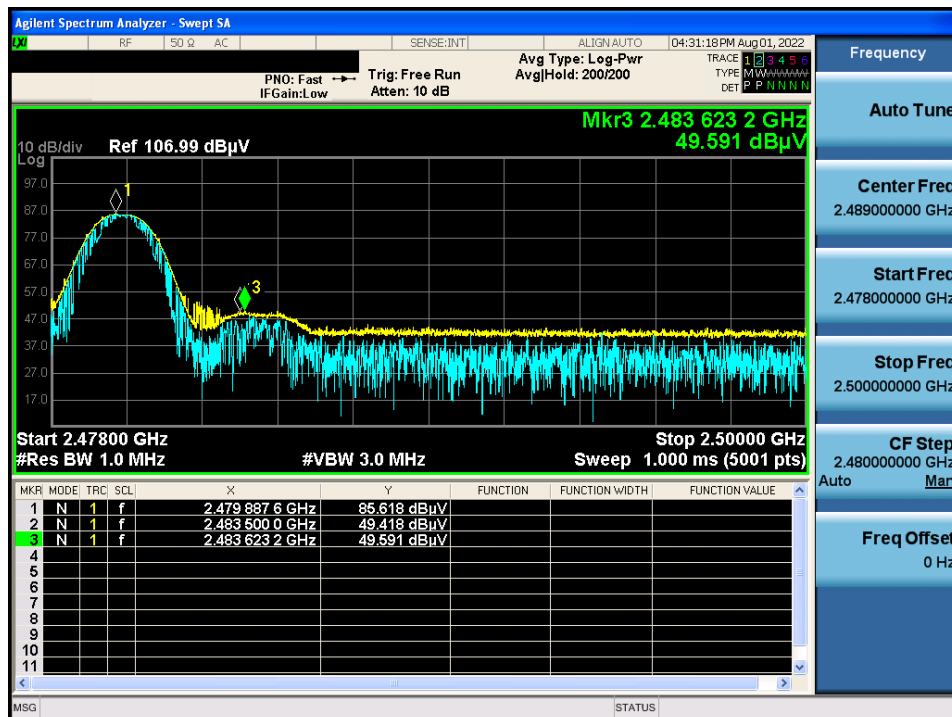
GFSK & Lowest & X & Hor

Detector Mode : PK



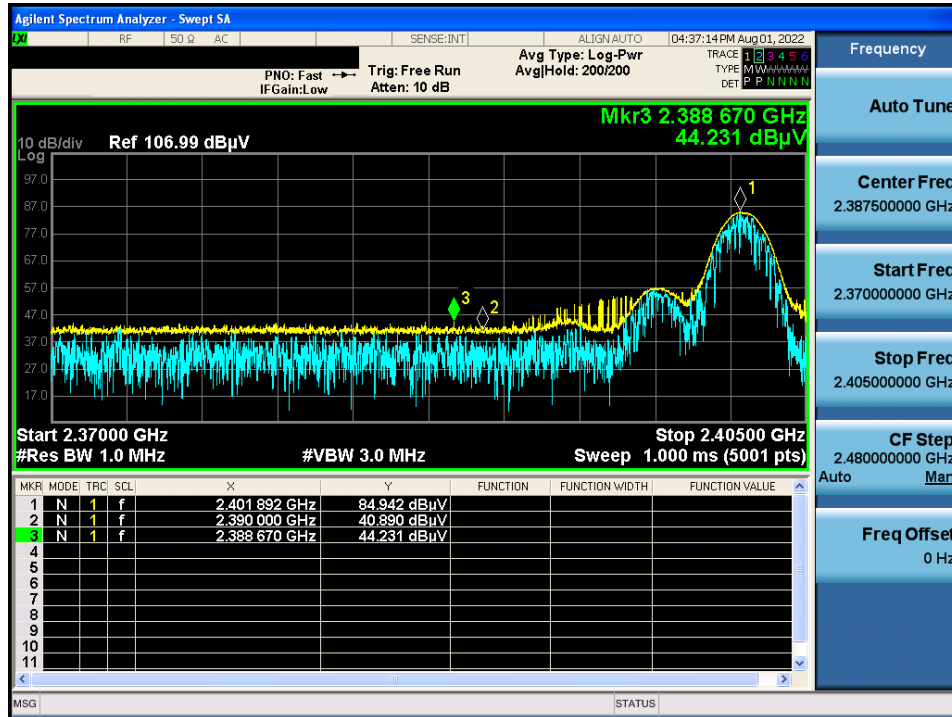
GFSK & Highest & X & Hor

Detector Mode : PK



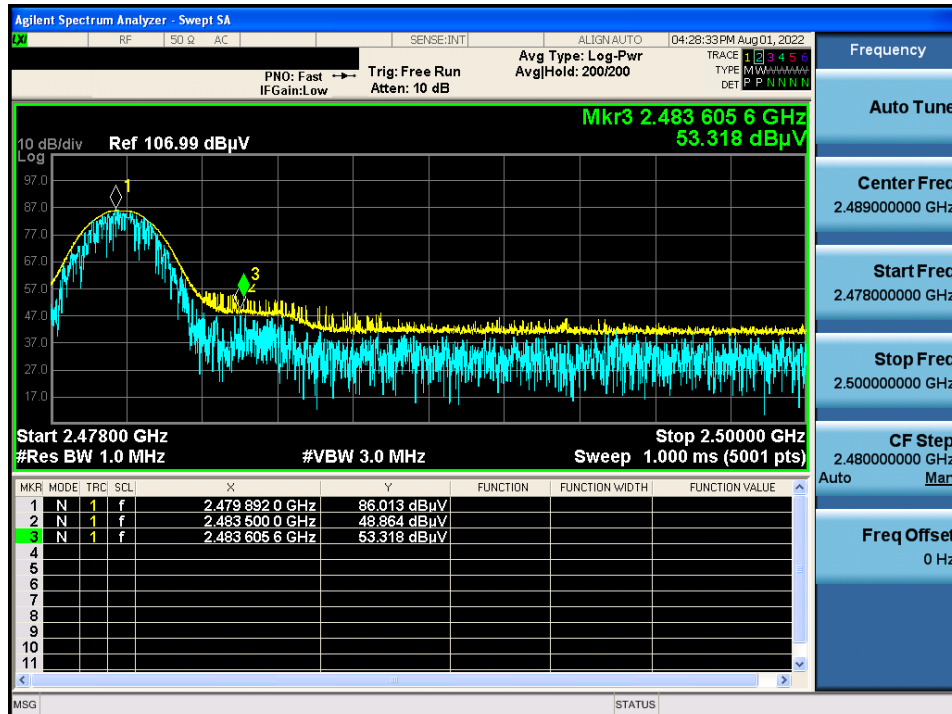
$\pi/4$ DQPSK & Lowest & X & Hor

Detector Mode : PK



$\pi/4$ DQPSK & Highest & X & Hor

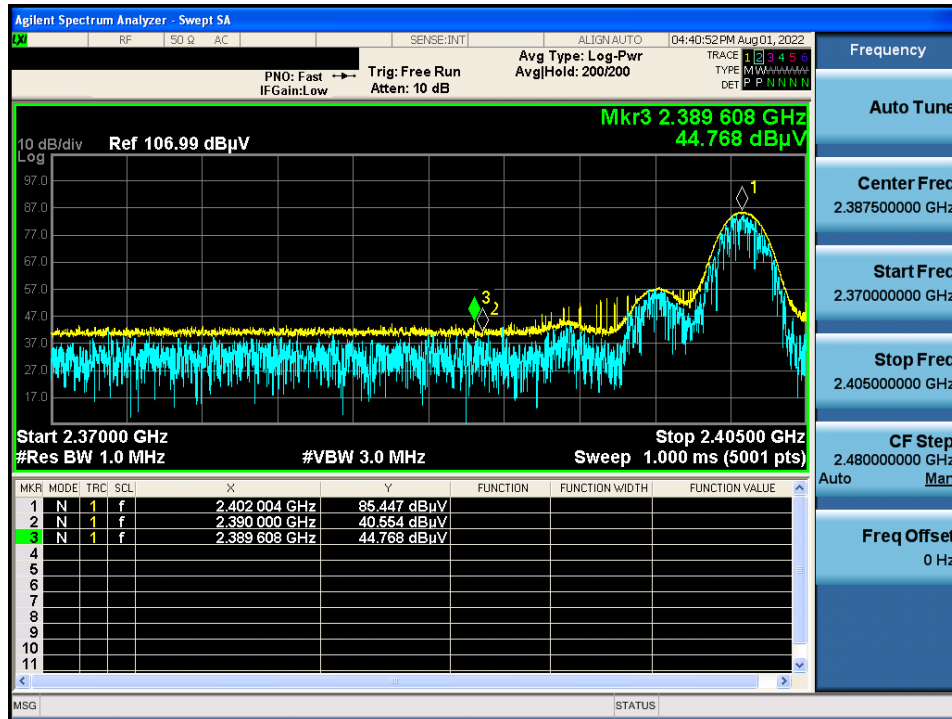
Detector Mode : PK





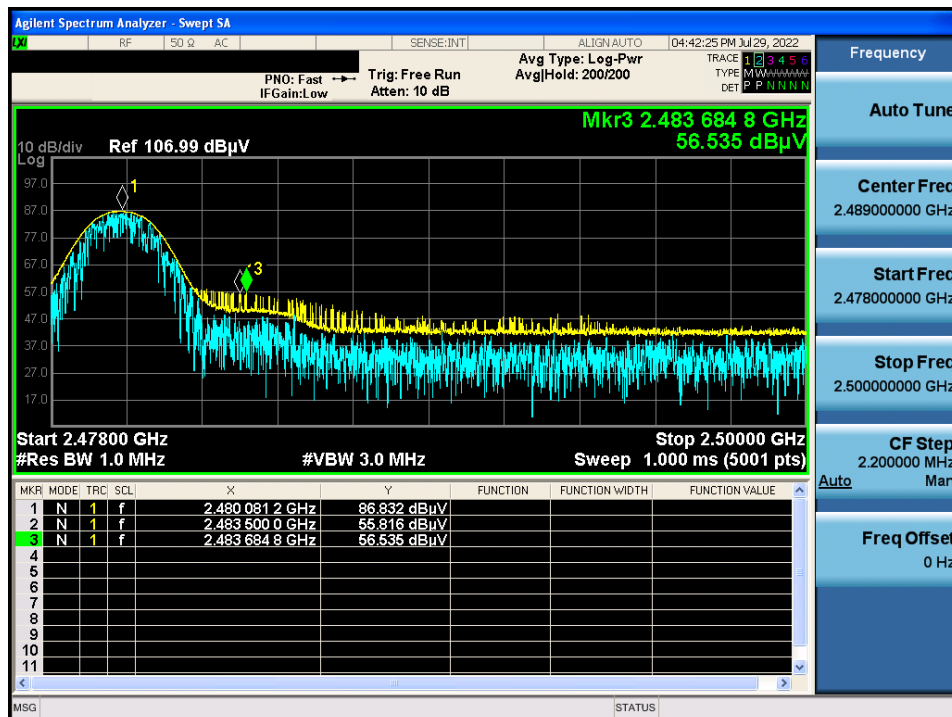
## 8DPSK &amp; Lowest &amp; X &amp; Hor

Detector Mode : PK



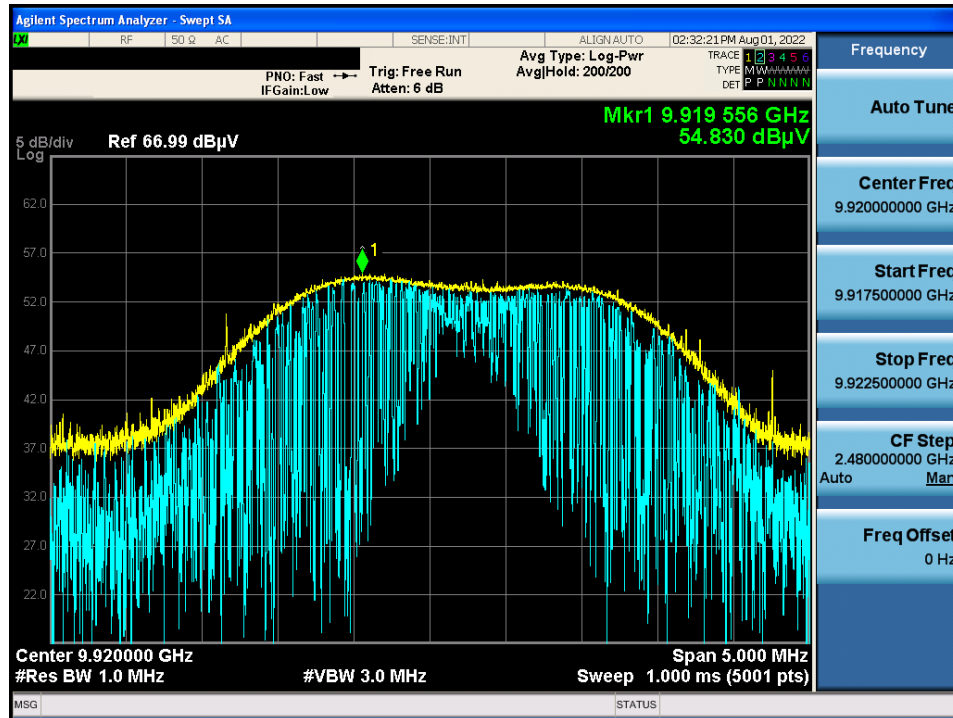
## 8DPSK &amp; Highest &amp; X &amp; Hor

Detector Mode : PK



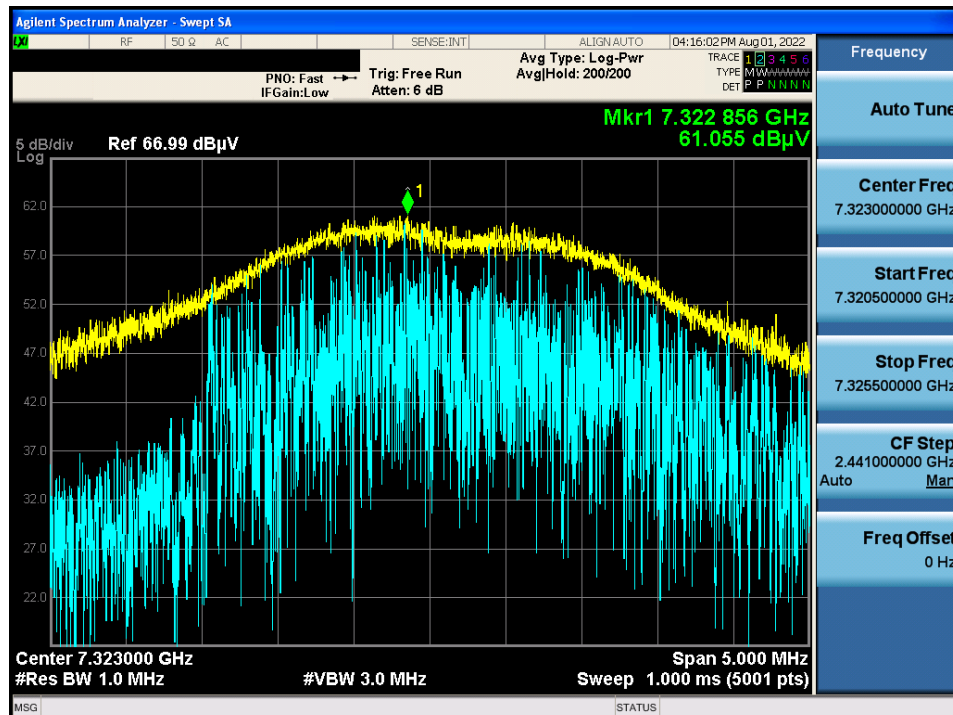
GFSK & Highest & Y & Ver

Detector Mode : PK



$\pi$ /4DQPSK & Middle & X & Ver

Detector Mode : PK



8DPSK & Middle & X & Ver

Detector Mode : PK

