

# TEST REPORT



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

42, Yurim-ro, 154Beon-gil, Cheoin-gu, Yongin-si, Gyeonggi-do, Korea, 17042

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

1. Report No : DRTFCC1904-0124

2. Customer

- Name (FCC) : Canon Korea Business Solutions Inc.
- Name (IC) : CANON KOREA BUSINESS SOLUTIONS INC.
- Address (FCC) : 575, Sihwabenchero-ro, Danwon-gu, Ansan-si, Gyeonggi-do, South Korea
- Address (IC) : 575, Sihwabenchero-ro, Danwon-gu, Ansan-si, Gyeonggi-do Korea (Republic Of)

3. Use of Report : FCC & IC Original Grant

4. Product Name / Model Name : Projector / Rayo S1

FCC ID : 2AR9TRAYOS1 / IC : 498G-RAYOS1

5. Test Method Used : ANSI C63.10-2013



Test Specification : FCC Part 15 Subpart C.247

RSS-247 Issue 2 (2017-02), RSS-GEN Issue 5 (2018-04)

6. Date of Test : 2018.12.26 ~ 2019.03.06

7. Testing Environment : See appended test report.

8. Test Result : Refer to the attached test result.

|             |  |   |
|-------------|--|---|
| Affirmation | Tested by  | Reviewed by   |
|             | Name : InHee Bae  | Name : GeunKi Son  (Signature) |

The test results presented in this test report are limited only to the sample supplied by applicant and the use of this test report is inhibited other than its purpose. This test report shall not be reproduced except in full, without the written approval of DT&C Co., Ltd.

2019 . 04 . 22 .

**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   |
|-----------------|---------------|---------------|
| DRTFCC1904-0124 | Apr. 22, 2019 | Initial issue |
|                 |               |               |
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## 1. General Information

### 1.1 Testing Laboratory

#### DT&C Co., Ltd.

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 § 2.948 according to ANSI C63.4-2014.

- FCC MRA Accredited Test Firm No. : KR0034

- IC Test site No. : 5740A

[www.dtnet.net](http://www.dtnet.net)

Telephone : + 82-31-321-2664

FAX : + 82-31-321-1664

### 1.2 Testing Environment

#### Ambient Condition

▪ Temperature +22 °C ~ +25 °C

▪ Relative Humidity 43 % ~ 46 %

### 1.3 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.

| Test items                                     | Measurement uncertainty                               |
|--|---|
| Transmitter Output Power                       | 0.9 dB (The confidence level is about 95 %, $k = 2$ ) |
| Conducted spurious emission                    | 0.9 dB (The confidence level is about 95 %, $k = 2$ ) |
| AC conducted emission                          | 2.4 dB (The confidence level is about 95 %, $k = 2$ ) |
| Radiated spurious emission<br>(1 GHz Below)    | 5.1 dB (The confidence level is about 95 %, $k = 2$ ) |
| Radiated spurious emission<br>(1 GHz ~ 18 GHz) | 5.4 dB (The confidence level is about 95 %, $k = 2$ ) |
| Radiated spurious emission<br>(18 GHz Above)   | 5.3 dB (The confidence level is about 95 %, $k = 2$ ) |

## 1.4 Details of Applicant

Applicant (FCC) : Canon Korea Business Solutions Inc.  
Applicant (IC) : CANON KOREA BUSINESS SOLUTIONS INC.  
Address (FCC) : 575, Sihwabenchero-ro, Danwon-gu, Ansan-si, Gyeonggi-do, South Korea  
Address (IC) : 575, Sihwabenchero-ro, Danwon-gu, Ansan-si, Gyeonggi-do Korea (Republic Of)  
Contact person : Junyoung Yoon

## 1.5 Description of EUT

|                             |                            |
|-----------------------------|----------------------------|
| <b>EUT</b>                  | Projector                  |
| <b>Model Name(HVIN)</b>     | Rayo S1                    |
| <b>Add Model Name</b>       | NA                         |
| <b>FVIN</b>                 | 3.10.X                     |
| <b>Serial Number</b>        | Identical prototype        |
| <b>Power Supply</b>         | DC 3.7 V                   |
| <b>Frequency Range</b>      | 2402 MHz ~ 2480 MHz        |
| <b>Modulation Technique</b> | GFSK, $\pi/4$ DQPSK, 8DPSK |
| <b>Number of Channels</b>   | 79                         |
| <b>Antenna Type</b>         | FPC Antenna                |
| <b>Antenna Gain</b>         | PK : 1.85 dBi              |

## 1.6 Declaration by the applicant / manufacturer

- NA

## 1.7 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 synchroniztion 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 sequence 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.

## 1.8 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                      | 18/12/19               | 19/12/19                    | MY48011700         |
| Spectrum Analyzer                   | Agilent Technologies   | N9020A                      | 18/12/19               | 19/12/19                    | MY50410357         |
| Horn Antenna                        | ETS-Lindgren           | 3115                        | 18/01/30               | 20/01/30                    | 6419               |
| Horn Antenna                        | Schwarzbeck            | BBHA 9120C                  | 17/12/04               | 19/12/04                    | 9120C-561          |
| Horn Antenna                        | A.H.Systems Inc.       | SAS-574                     | 17/07/31               | 19/07/31                    | 155                |
| Loop Antenna                        | Schwarzbeck            | FMZB1513                    | 18/01/30               | 20/01/30                    | 1513-128           |
| Biglog Antenna                      | Schwarzbeck            | VULB 9160                   | 18/07/13               | 20/07/13                    | 3359               |
| EMI Test Receiver                   | Rohde Schwarz          | ESCI7                       | 18/03/13               | 19/03/13                    | 100364             |
| EMI Test Receiver                   | Rohde Schwarz          | ESCI7                       | 18/02/12               | 19/02/12                    | 100910             |
|                                     |                        |                             | 19/01/30               | 20/01/30                    |                    |
| Multimeter                          | FLUKE                  | 17B                         | 18/12/18               | 19/12/18                    | 26030065WS         |
| Thermohygrometer                    | BODYCOM                | BJ5478                      | 18/07/09               | 19/07/09                    | NA                 |
| Thermohygrometer                    | BODYCOM                | BJ5478                      | 18/01/03               | 19/01/03                    | 120612-1           |
|                                     |                        |                             | 18/12/27               | 19/12/27                    |                    |
| Thermohygrometer                    | BODYCOM                | BJ5478                      | 18/01/03               | 19/01/03                    | 120612-2           |
|                                     |                        |                             | 18/12/27               | 19/12/27                    |                    |
| HYGROMETER                          | TESTO                  | 608-H1                      | 18/02/10               | 19/02/10                    | 34862883           |
|                                     |                        |                             | 19/01/31               | 20/01/31                    |                    |
| Signal Generator                    | Rohde Schwarz          | SMBV100A                    | 18/12/19               | 19/12/19                    | 255571             |
| PULSE LIMITER                       | Rohde Schwarz          | ESH3-Z2                     | 18/09/27               | 19/09/27                    | 101333             |
| LISN                                | SCHWARZBECK            | NNLK 8121                   | 18/03/20               | 19/03/20                    | 06183              |
| PreAmplifier                        | H.P                    | 8447D                       | 18/12/18               | 19/12/18                    | 2944A07774         |
| PreAmplifier                        | tsj                    | MLA-0118-J01-45             | 18/12/19               | 19/12/19                    | 17138              |
| PreAmplifier                        | tsj                    | MLA-1840-J02-45             | 18/07/06               | 19/07/06                    | 16966-10728        |
| Attenuator                          | SMAJK                  | SMAJK-2-3                   | 18/07/02               | 19/07/02                    | 3                  |
| Attenuator                          | Aeroflex/Weinschel     | 56-3                        | 18/07/02               | 19/07/02                    | Y2370              |
| Attenuator                          | SRTechnology           | F01-B0606-01                | 18/07/02               | 19/07/02                    | 13092403           |
| Attenuator                          | Hefei Shunze           | SS5T2.92-10-40              | 18/07/03               | 19/07/03                    | 16012202           |
| High Pass Filter                    | Wainwright Instruments | WHNX8.0/26.5-6SS            | 18/07/02               | 19/07/02                    | 3                  |
| High Pass Filter                    | Wainwright Instruments | WHKX12-935-1000-15000-40SS  | 18/07/02               | 19/07/02                    | 8                  |
| High Pass Filter                    | Wainwright Instruments | WHKX10-2838-3300-18000-60SS | 18/07/02               | 19/07/02                    | 1                  |
| Power Meter & Wide Bandwidth Sensor | Anritsu                | ML2495A<br>MA2490A          | 18/07/04               | 19/07/04                    | 1338003<br>1249304 |
| Cable                               | Radiall                | TESTPRO3                    | 18/07/06               | 19/07/06                    | M-01               |
| Cable                               | Junkosha               | MWX315                      | 18/11/19               | 19/11/19                    | M-05               |
| Cable                               | Junkosha               | MWX221                      | 18/11/19               | 19/11/19                    | M-06               |
| Cable                               | Junkosha               | MWX241                      | 18/06/25               | 19/06/25                    | G-07               |
| Cable                               | DT&C                   | Cable                       | 18/07/06               | 19/07/06                    | G-13               |
| Cable                               | DT&C                   | Cable                       | 18/07/06               | 19/07/06                    | G-14               |
| Cable                               | HUBER+SUHNER           | SUCOFLEX 104                | 18/07/06               | 19/07/06                    | G-15               |
| Cable                               | DT&C                   | CABLE                       | 18/06/25               | 19/06/25                    | RF-20              |
| Cable                               | DT&C                   | Cable                       | 18/07/05               | 19/07/05                    | RF-82              |

Note 1: The measurement antennas were calibrated in accordance to the requirements of ANSI C63.5-2017.

Note 2: The cable is not a regular calibration item, so it has been calibrated by DT & C itself.

## 1.9 Summary of Test Results

| FCC Part<br>RSS Std.   | Parameter                     | Limit<br>(Using in 2400~ 2483.5 MHz)  | Test<br>Condition    | Status<br>Note 1   |
|--|-------------------------------|---|----------------------|--------------------|
| 15.247(a)<br>RSS-247(5.1)  | Carrier Frequency Separation  | $\geq 25$ kHz or<br>$\geq$ Two thirds of the 20 dB BW,<br>whichever is greater.   | Conducted            | C                  |
|  | Number of Hopping Frequencies | $\geq 15$ hops  |                      | C                  |
|  | 20 dB Bandwidth               | N/A   |                      | C                  |
|  | Dwell Time                    | $\leq 0.4$ seconds  |                      | C                  |
| 15.247(b)<br>RSS-247(5.4)  | Transmitter Output Power      | <b>For FCC</b><br>$\leq 1$ Watt , if CHs $\geq 75$<br>Others $\leq 0.125$ W<br><b>For IC</b><br>if CHs $\geq 75$<br>$\leq 1$ Watt For Conducted Power<br>$\leq 4$ Watt For e.i.r.p,<br>Others<br>$\leq 0.125$ W For Conducted Power.<br>$\leq 0.5$ Watt For e.i.r.p |                      | C                  |
| 15.247(d)<br>RSS-247(5.5)  | Conducted Spurious Emissions  | The radiated emission to any<br>100 kHz of out-band shall be at<br>least 20 dB below the highest<br>in-band spectral density.   |                      | C                  |
| RSS Gen(6.7)   | Occupied Bandwidth (99 %)     | N/A   |                      | C                  |
| 15.247(d)<br>15.205 & 209<br>RSS-247(5.5)<br>RSS-Gen<br>(8.9 & 8.10) | Radiated Spurious Emissions   | FCC 15.209 Limits   | Radiated             | C <sup>Note3</sup> |
| 15.207<br>RSS-Gen(8.8)   | AC Conducted Emissions        | FCC 15.207 Limits   | AC Line<br>Conducted | C                  |
| 15.203   | Antenna Requirements          | FCC 15.203  | -                    | C                  |

Note 1 : C = Comply NC = Not Comply NT = Not Tested NA = Not Applicable

Note 2 : For radiated emission tests below 30 MHz were performed on semi-anechoic chamber which is correlated with OATS.

Note 3 : This test item was performed in each axis and the worst case data was reported.



### 1.10 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).

The field strength of spurious emission was measured in three orthogonal EUT positions (X-axis, Y-axis and Z-axis).

#### Tested frequency information,

- Hopping Function : Enable

|              | TX Frequency (MHz) | RX Frequency (MHz) |
|--------------|--------------------|--------------------|
| Hopping Band | 2402 ~ 2480        | 2402 ~ 2480        |

- Hopping Function : Disable

|                 | TX Frequency (MHz) | RX Frequency (MHz) |
|-----------------|--------------------|--------------------|
| Lowest Channel  | 2402               | 2402               |
| Middle Channel  | 2441               | 2441               |
| Highest Channel | 2480               | 2480               |

## 2. Maximum Peak Output Power Measurement

### 2.1 Test Setup

Refer to the APPENDIX I.

### 2.2 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 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.
2. §15.247(b)(1), For frequency hopping systems operating in the 2400 – 2483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725 – 5805 MHz band : 1 Watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

#### ■ IC Requirements

1. RSS-247(5.4) (b), For FHSS operating in the band 2400 - 2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels, the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p shall not exceed 4 W, except as provided in section 5.4(e)

### 2.3 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

## 2.4 Test Results

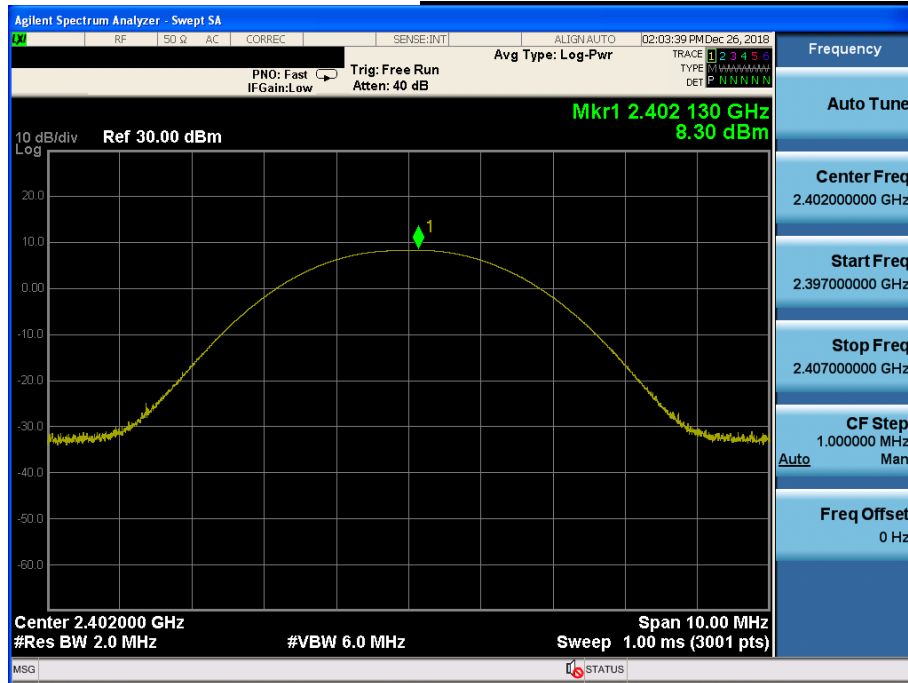
| Modulation                            | Tested Channel | Frame Average Output Power |             | Peak Output Power |             |
|---------------------------------------|----------------|----------------------------|-------------|-------------------|-------------|
|                                       |                | dBm                        | mW          | dBm               | mW          |
| <b><u>GFSK</u></b>                    | <b>Lowest</b>  | 7.28                       | 5.35        | 8.30              | 6.76        |
|                                       | <b>Middle</b>  | <b>8.61</b>                | <b>7.26</b> | <b>9.86</b>       | <b>9.68</b> |
|                                       | <b>Highest</b> | 8.48                       | 7.05        | 9.74              | 9.42        |
| <b><u><math>\pi/4</math>DQPSK</u></b> | <b>Lowest</b>  | 4.08                       | 2.56        | 7.04              | 5.06        |
|                                       | <b>Middle</b>  | <b>6.13</b>                | <b>4.10</b> | <b>9.07</b>       | <b>8.07</b> |
|                                       | <b>Highest</b> | 6.08                       | 4.06        | 8.83              | 7.64        |
| <b><u>8DPSK</u></b>                   | <b>Lowest</b>  | 4.11                       | 2.58        | 7.32              | 5.40        |
|                                       | <b>Middle</b>  | <b>6.18</b>                | <b>4.15</b> | <b>9.22</b>       | <b>8.36</b> |
|                                       | <b>Highest</b> | 6.12                       | 4.09        | 9.03              | 8.00        |

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

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

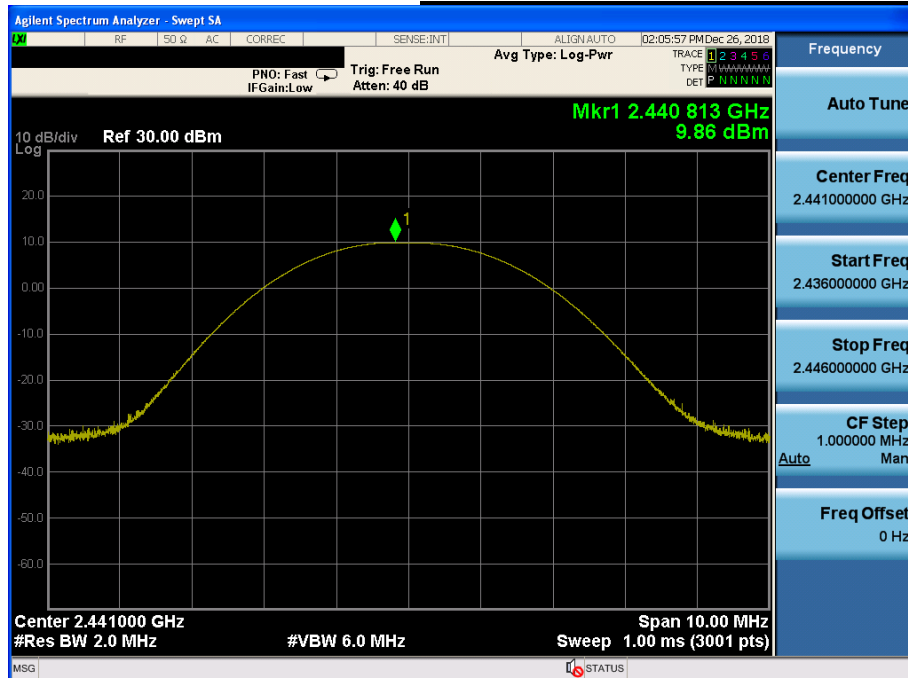
## Peak Output Power

## Lowest Channel & Modulation : GFSK



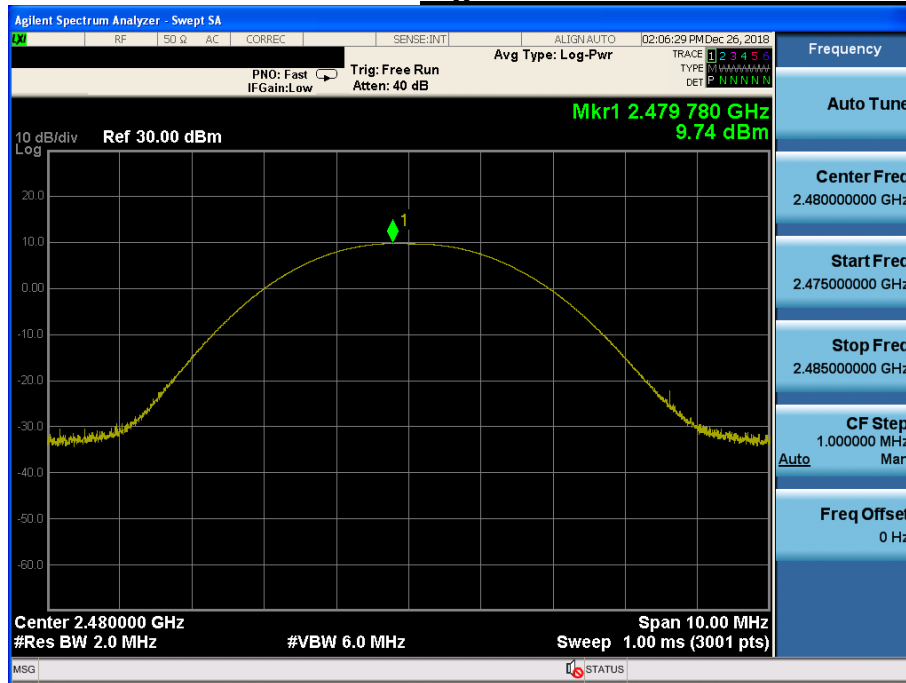
## Peak Output Power

## Middle Channel & Modulation : GFSK



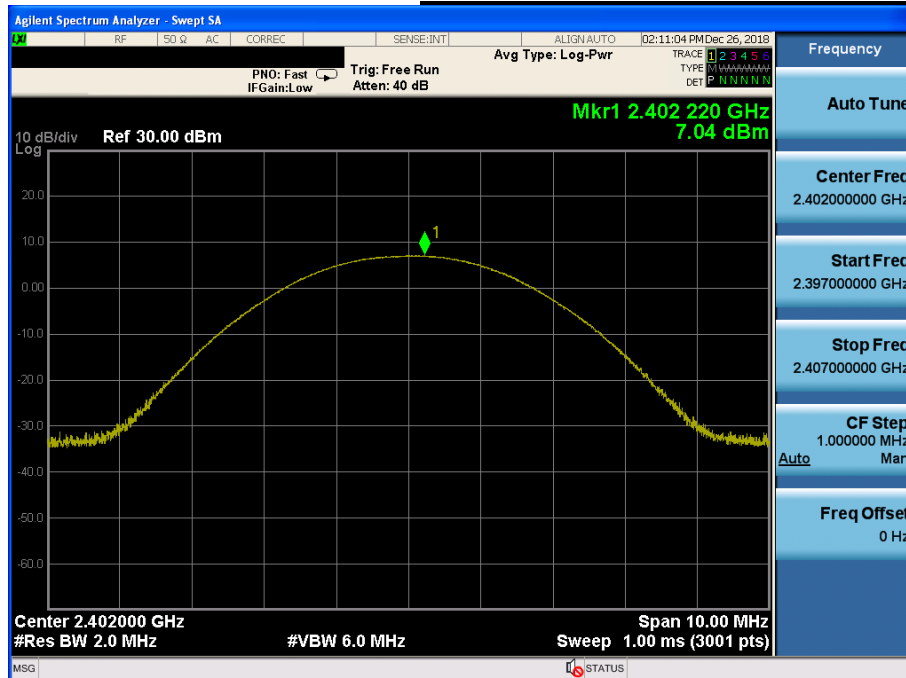
## Peak Output Power

## Highest Channel & Modulation : GFSK

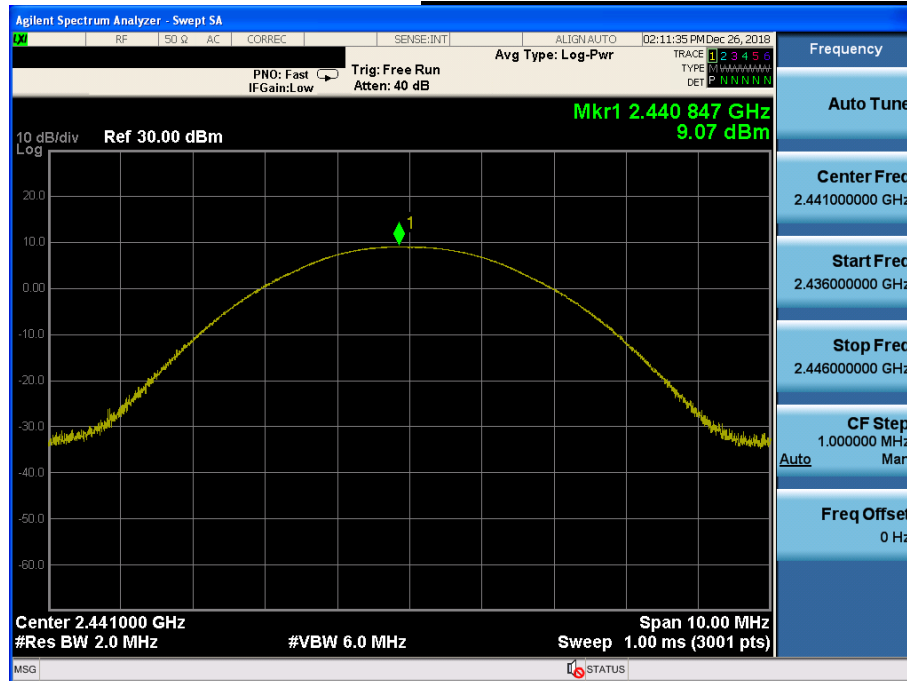


## Peak Output Power

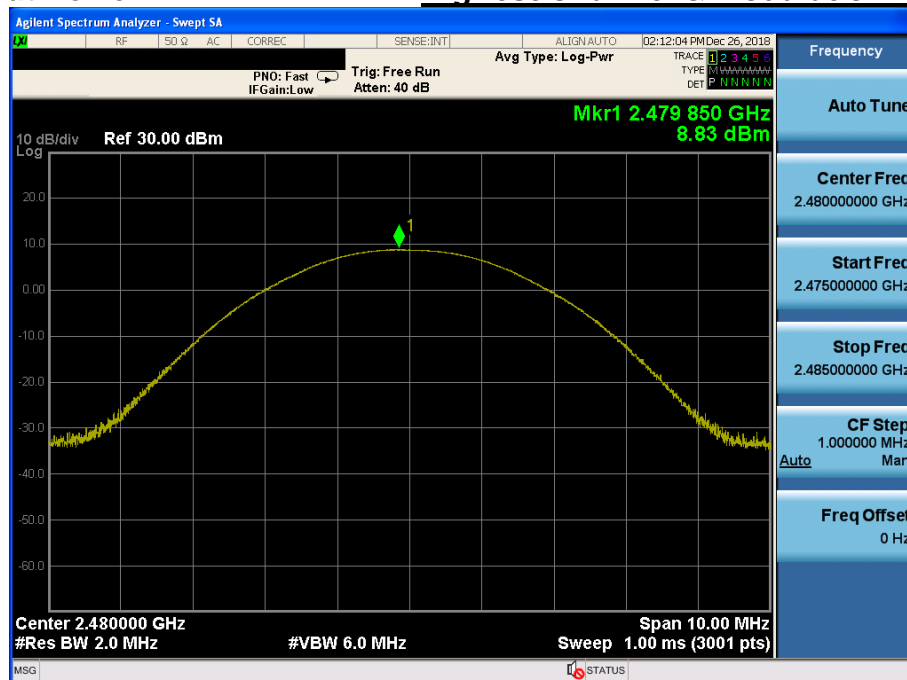
## Lowest Channel & Modulation : $\pi/4$ DQPSK



## Peak Output Power

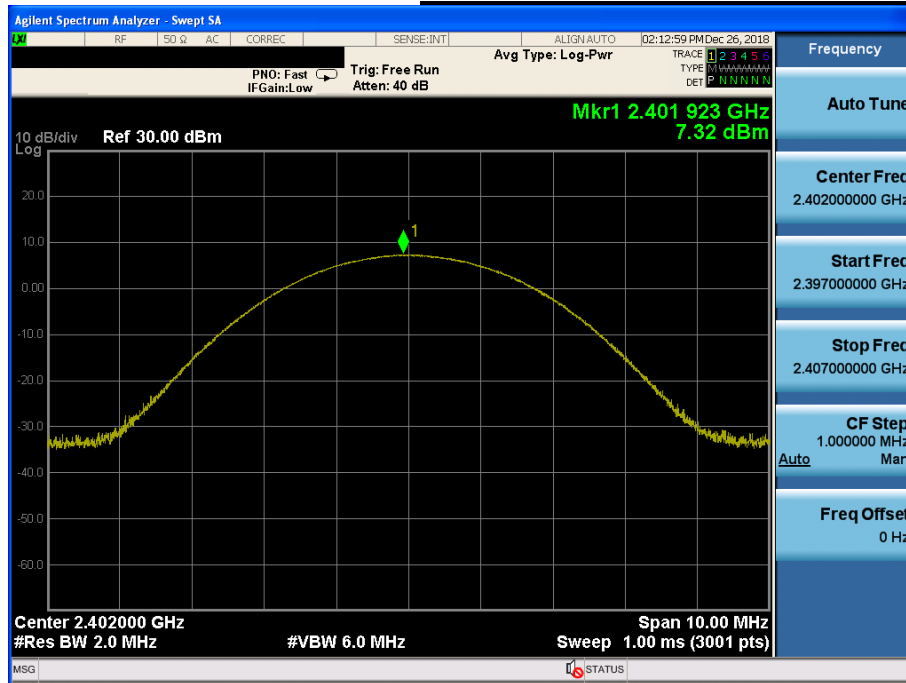
Middle Channel & Modulation :  $\pi/4$ DQPSK

## Peak Output Power

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

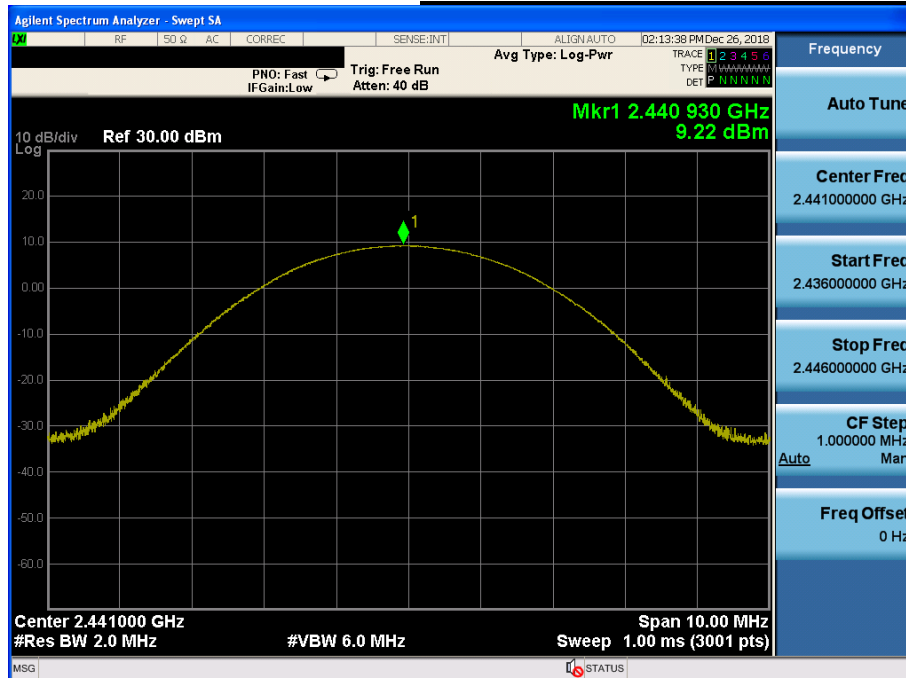
## Peak Output Power

## Lowest Channel & Modulation : 8DPSK



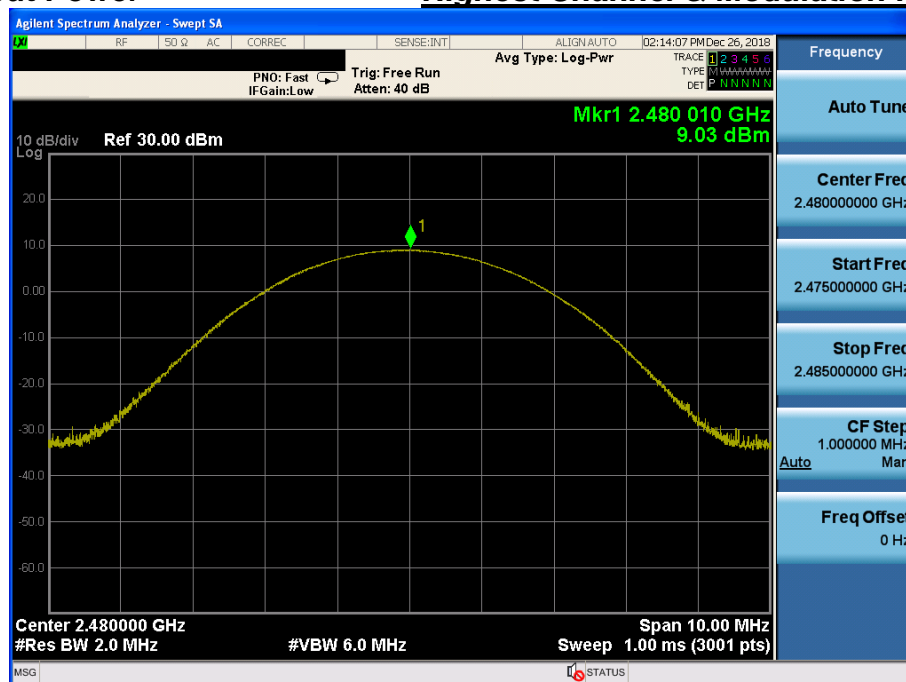
## Peak Output Power

## Middle Channel & Modulation : 8DPSK



## Peak Output Power

## Highest Channel & Modulation : 8DPSK





### 3. 20 dB BW & Occupied BW

#### 3.1 Test Setup

Refer to the APPENDIX I.

#### 3.2 Limit

Limit : Not Applicable

#### 3.3 Test Procedure

1. The 20 dB bandwidth & Occupied bandwidth were 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

#### 3.4 Test Results

| Modulation                            | Tested Channel | 20 dB BW (MHz) | Occupied BW (MHz) |
|---------------------------------------|----------------|----------------|-------------------|
| <b><u>GFSK</u></b>                    | Lowest         | <b>0.932</b>   | 0.853             |
|                                       | Middle         | 0.932          | <b>0.861</b>      |
|                                       | Highest        | 0.931          | 0.861             |
| <b><u><math>\pi/4</math>DQPSK</u></b> | Lowest         | 1.260          | 1.190             |
|                                       | Middle         | <b>1.281</b>   | <b>1.218</b>      |
|                                       | Highest        | 1.280          | 1.204             |
| <b><u>8DPSK</u></b>                   | Lowest         | 1.267          | 1.184             |
|                                       | Middle         | 1.259          | <b>1.211</b>      |
|                                       | Highest        | <b>1.270</b>   | 1.206             |

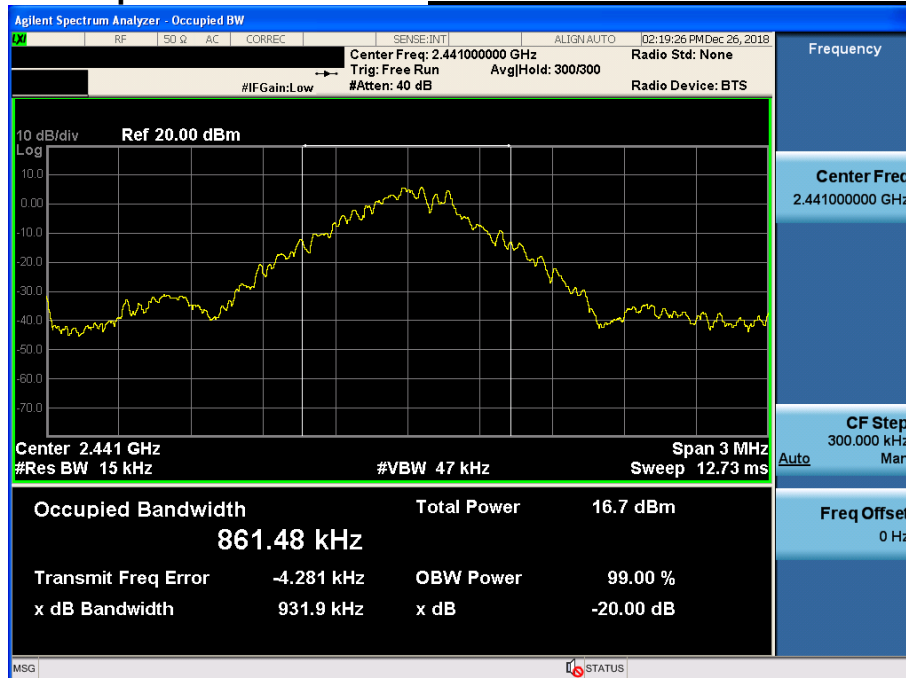
## 20 dB BW & Occupied BW

## Lowest Channel & Modulation : GFSK



## 20 dB BW & Occupied BW

## Middle Channel & Modulation : GFSK



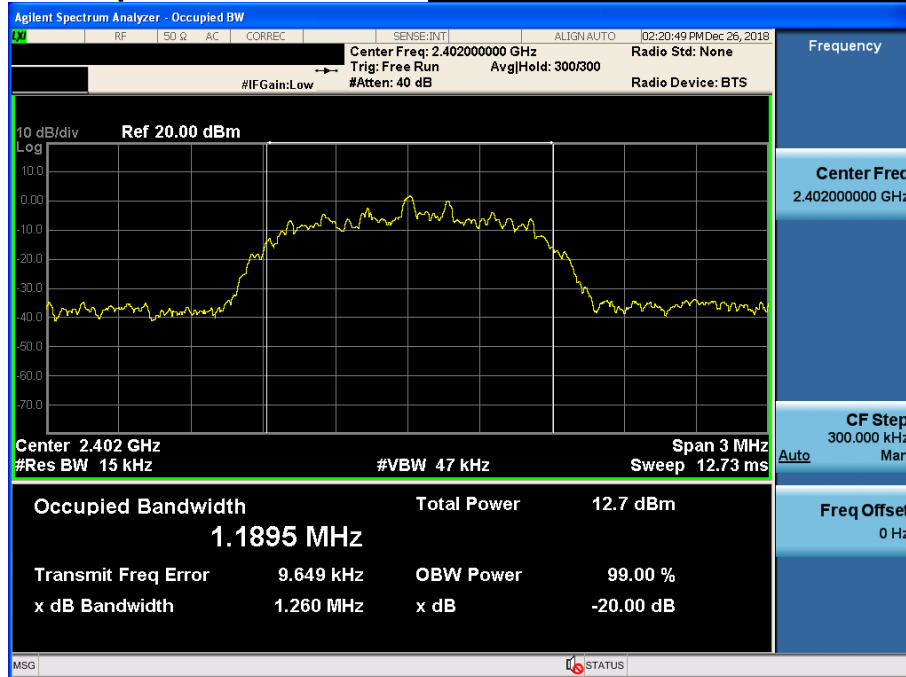
## 20 dB BW & Occupied BW

## Highest Channel & Modulation : GFSK



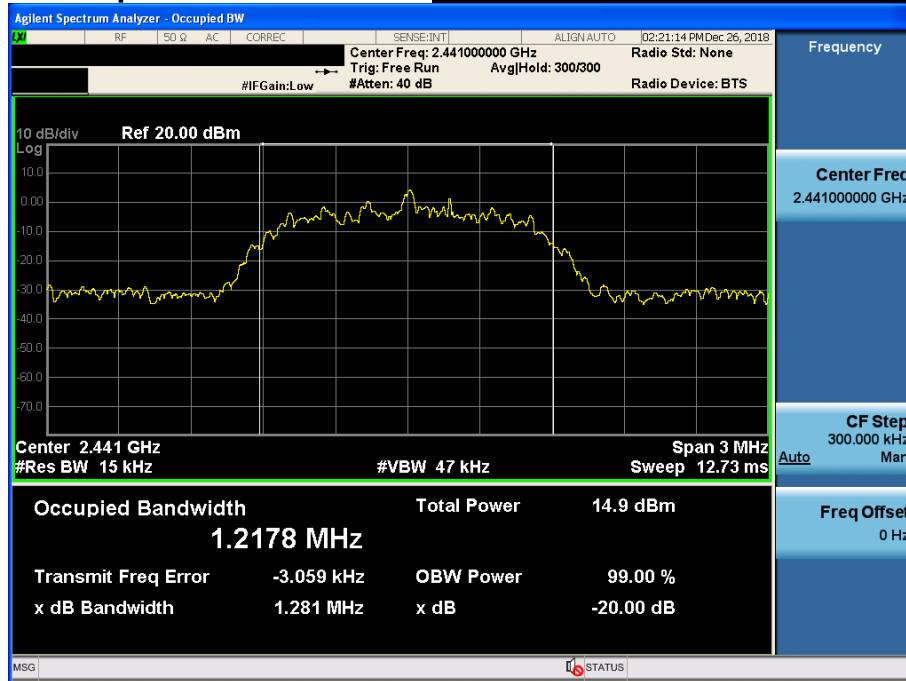
## 20 dB BW & Occupied BW

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



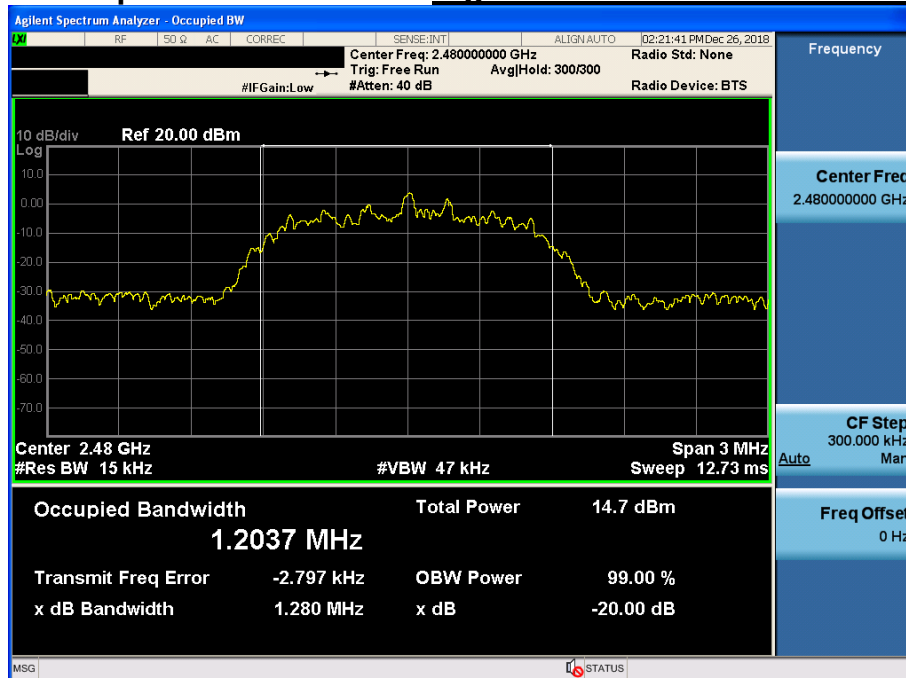
## 20 dB BW & Occupied BW

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



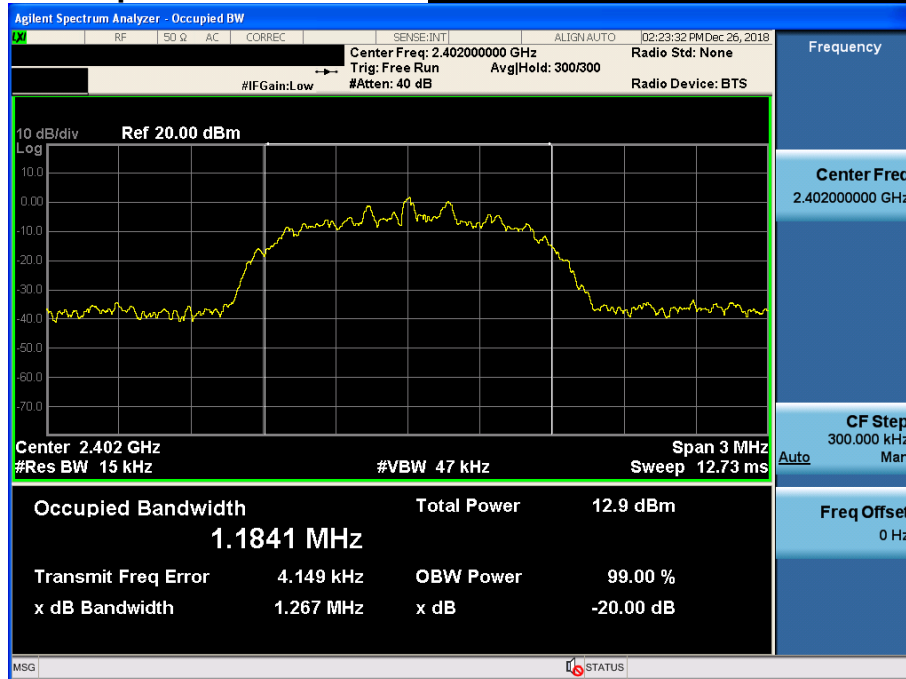
## 20 dB BW & Occupied BW

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



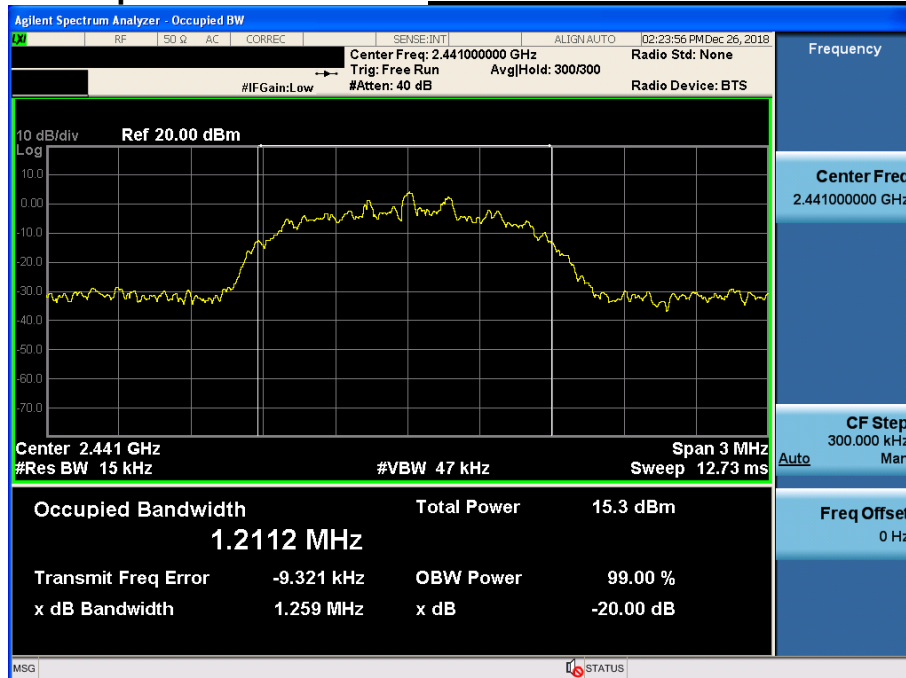
## 20 dB BW & Occupied BW

## Lowest Channel & Modulation : 8DPSK



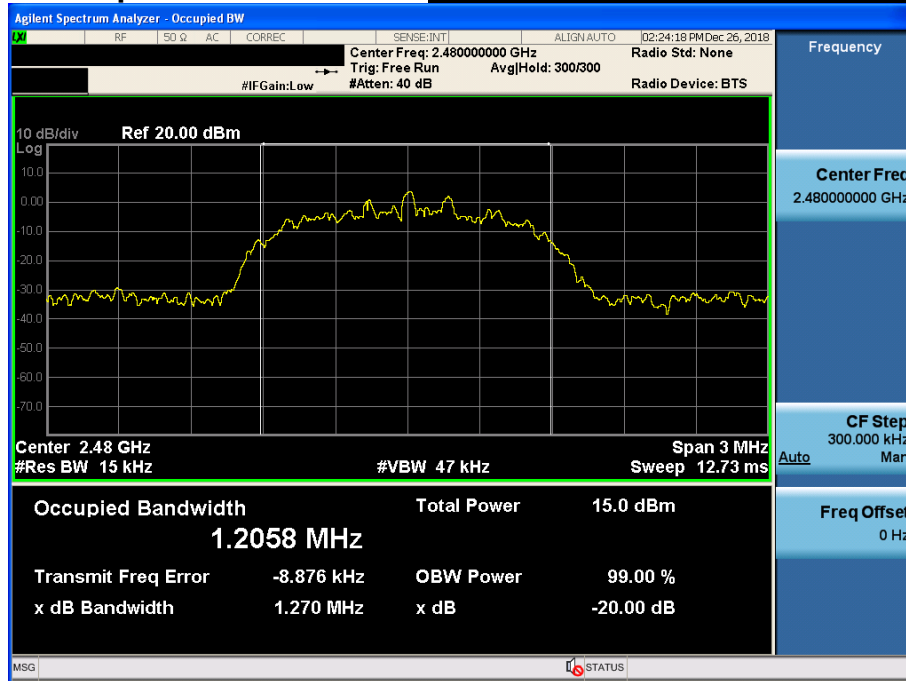
## 20 dB BW & Occupied BW

## Middle Channel & Modulation : 8DPSK



20 dB BW & Occupied BW

Highest Channel & Modulation : 8DPSK



## 4. Carrier Frequency Separation

### 4.1 Test Setup

Refer to the APPENDIX I.

### 4.2 Limit

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

### 4.3 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

### 4.4 Test Results

#### FH mode

| Hopping Mode | Modulation    | Peak of center channel (MHz) | Peak of adjacent Channel (MHz) | Test Result (MHz) |
|--------------|---------------|------------------------------|--------------------------------|-------------------|
| Enable       | GFSK          | 2441.010                     | 2442.012                       | 1.002             |
|              | $\pi/4$ DQPSK | 2441.007                     | 2442.007                       | 1.000             |
|              | 8DPSK         | 2441.007                     | 2442.009                       | 1.002             |

#### AFH mode

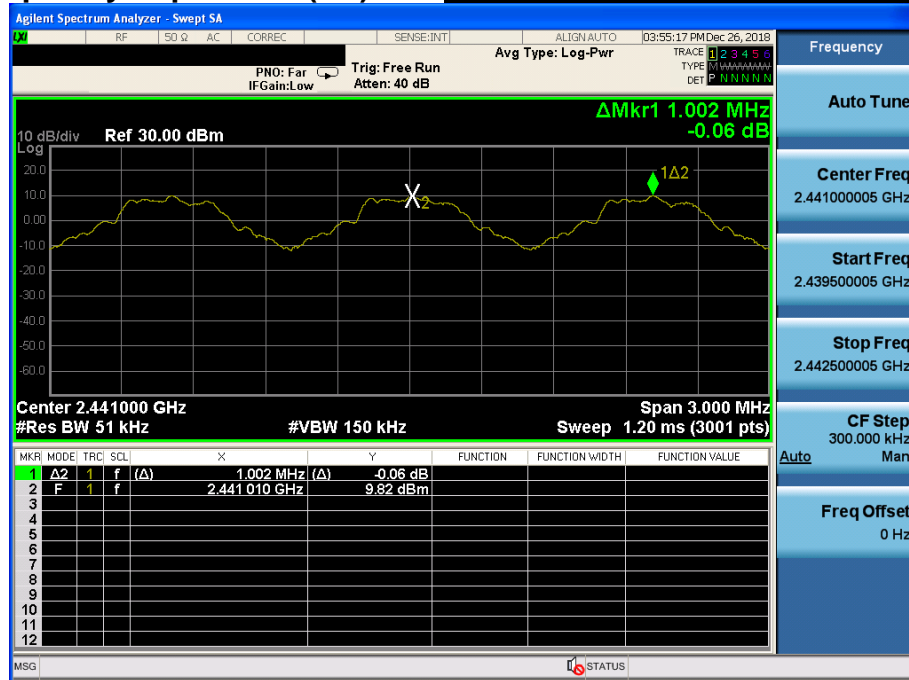
| Hopping Mode | Modulation    | Peak of center channel (MHz) | Peak of adjacent Channel (MHz) | Test Result (MHz) |
|--------------|---------------|------------------------------|--------------------------------|-------------------|
| Enable       | GFSK          | 2441.010                     | 2442.010                       | 1.000             |
|              | $\pi/4$ DQPSK | 2441.006                     | 2442.006                       | 1.000             |
|              | 8DPSK         | 2441.007                     | 2442.009                       | 1.002             |

Note 1 : See next pages for actual measured spectrum

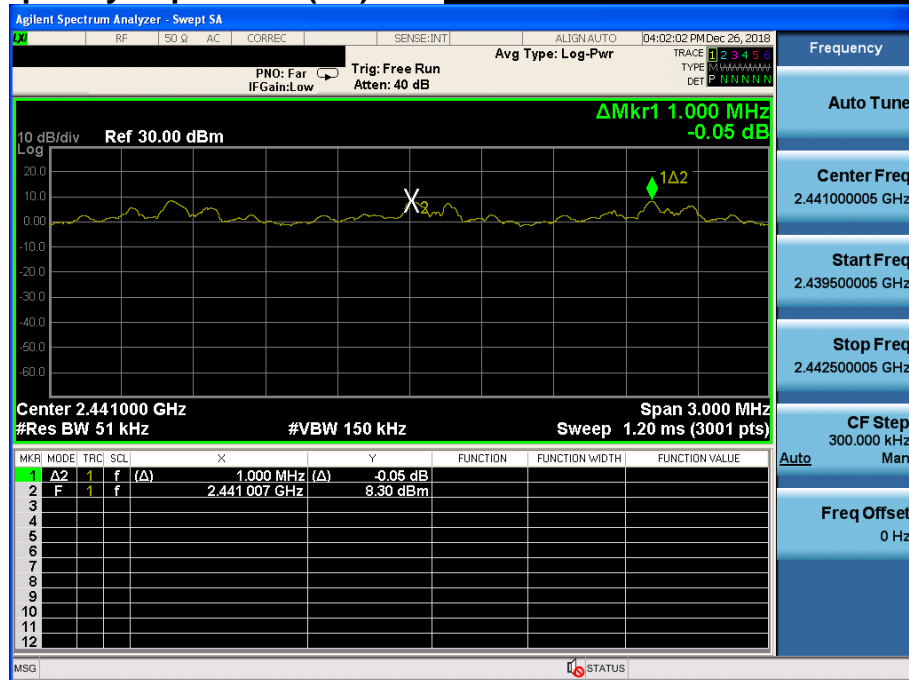
#### - Minimum Standard :

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 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

## Carrier Frequency Separation (FH)

Hopping mode : Enable & GFSK

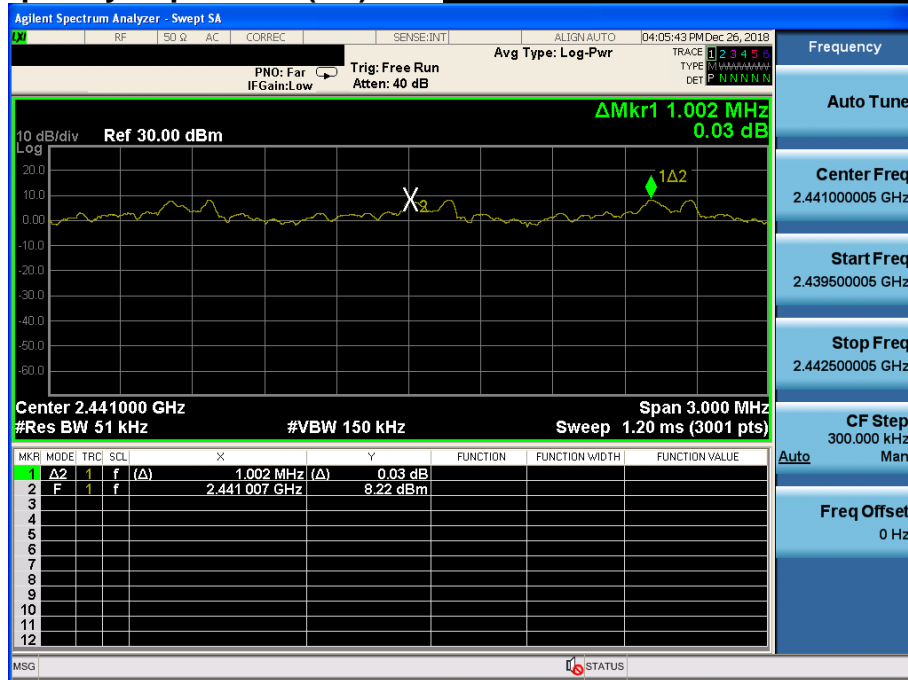
## Carrier Frequency Separation (FH)

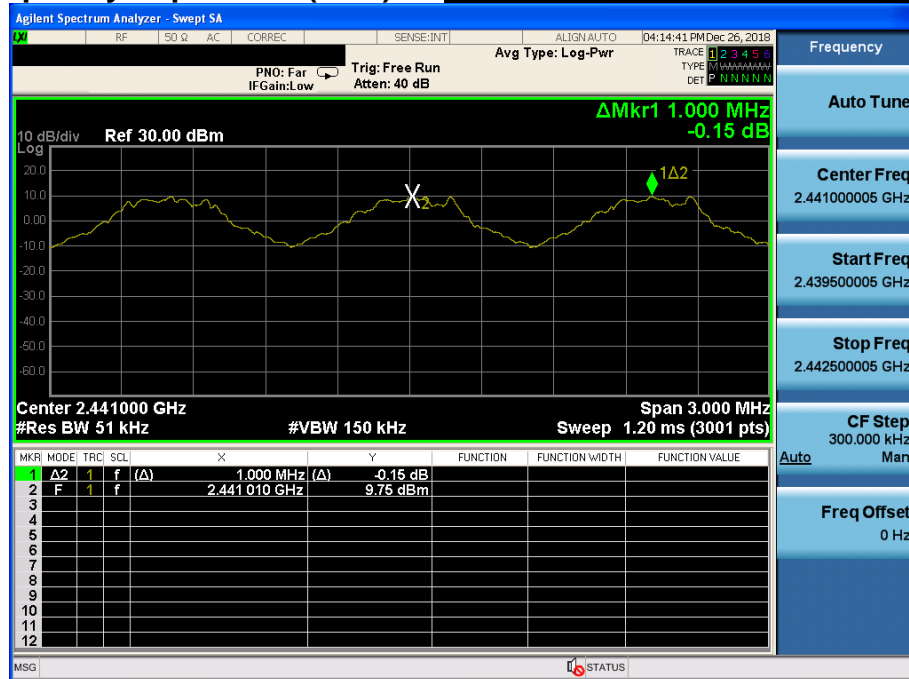
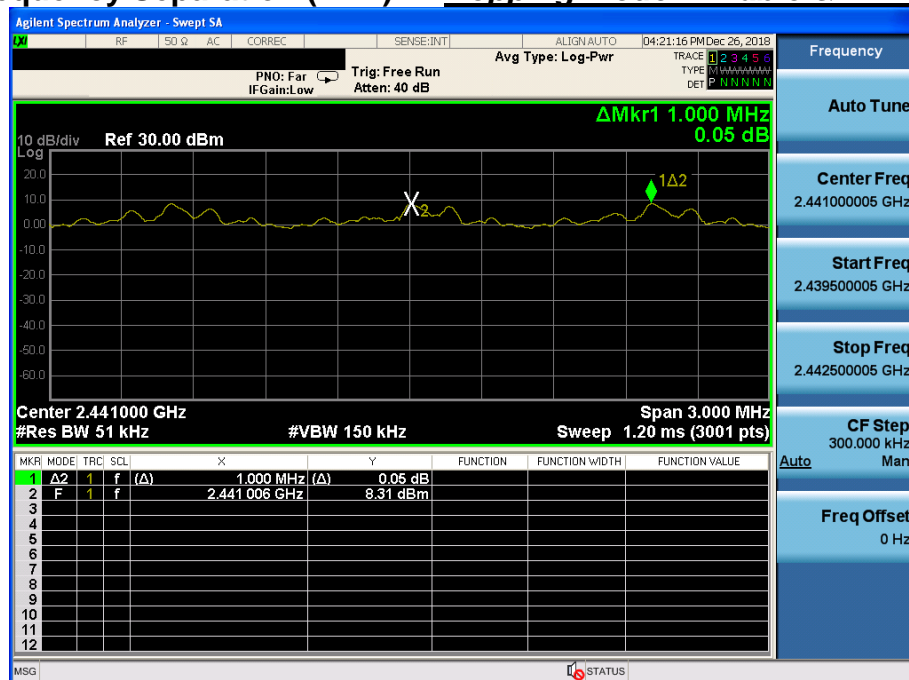
Hopping mode : Enable & π/4DQPSK

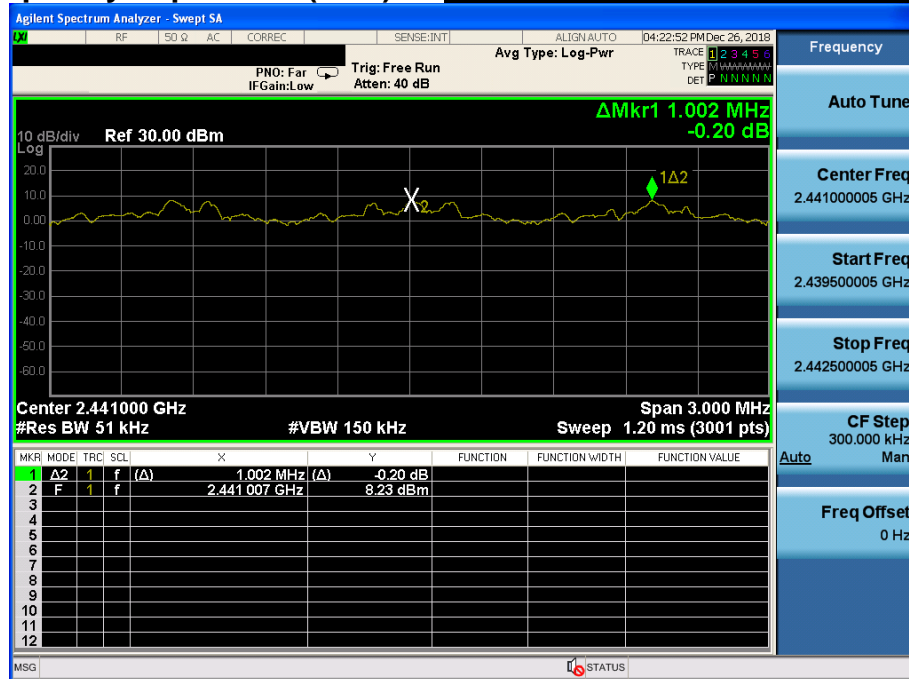


# Carrier Frequency Separation (FH)

# 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**

## 5. Number of Hopping Frequencies

### 5.1 Test Setup

Refer to the APPENDIX I.

### 5.2 Limit

Limit :  $\geq 15$  hops

### 5.3 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 2400 ~ 2483.5 MHz were examined.

The spectrum analyzer is set to :

Span for FH mode = 50 MHz      Start Frequency = 2391.5 MHz,      Stop Frequency = 2441.5 MHz

Start Frequency = 2441.5 MHz,      Stop Frequency = 2491.5 MHz

Span for AFH mode = 30 MHz      Start Frequency = 2426.0 MHz,      Stop Frequency = 2456.0 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

### 5.4 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                       |

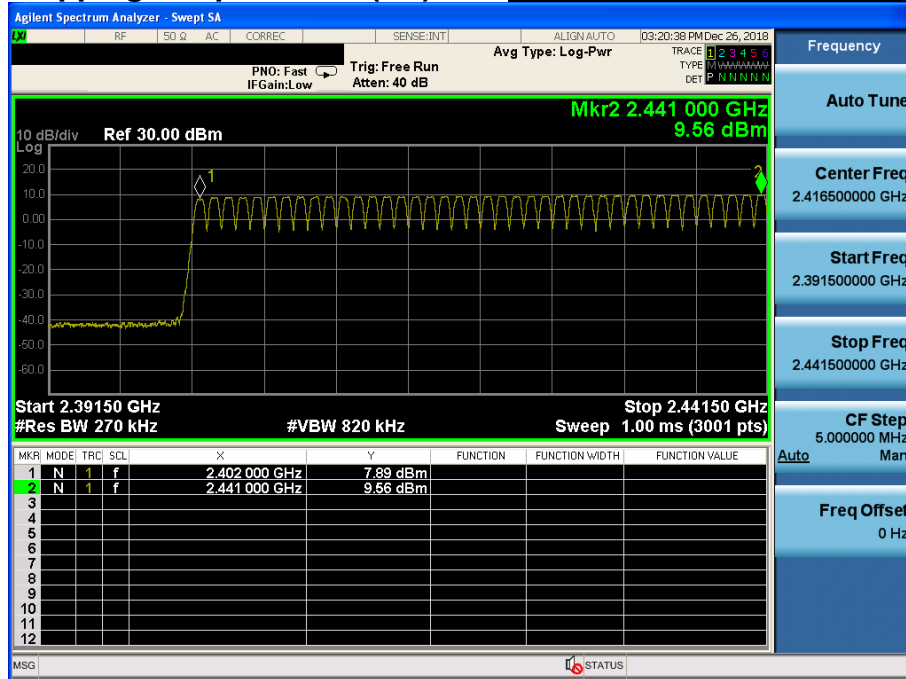
Note 1 : See next pages for actual measured spectrum plots.

#### - Minimum Standard :

At least 15 hops

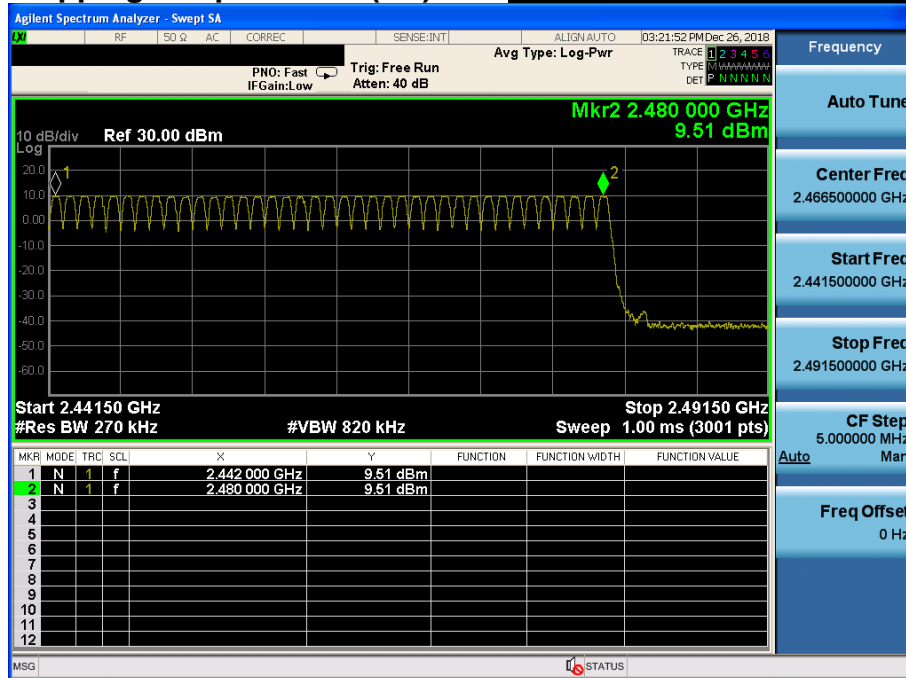
## Number of Hopping Frequencies 1(FH)

## Hopping mode : Enable & GFSK

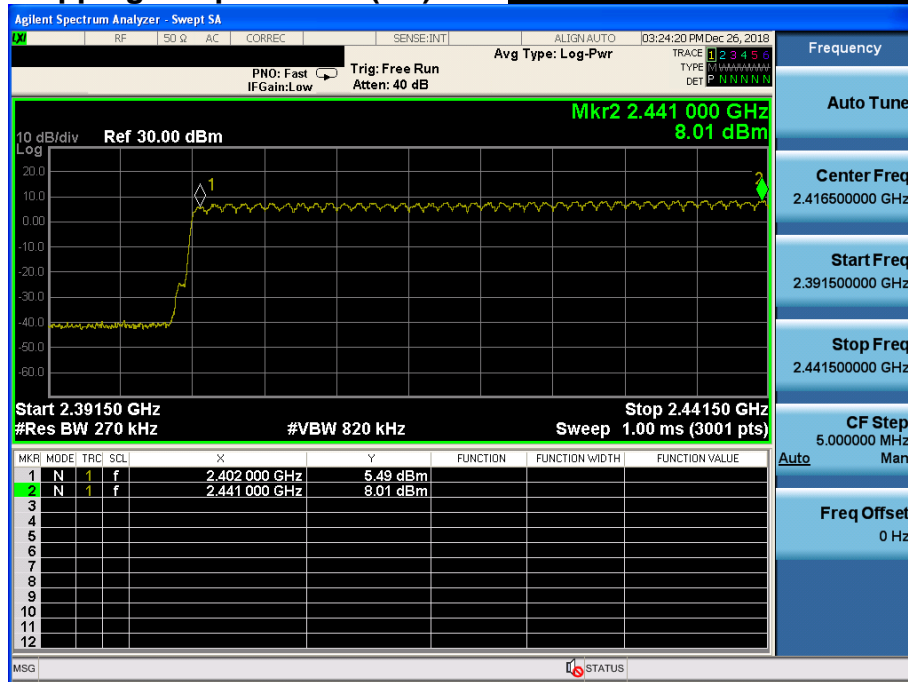


## Number of Hopping Frequencies 2(FH)

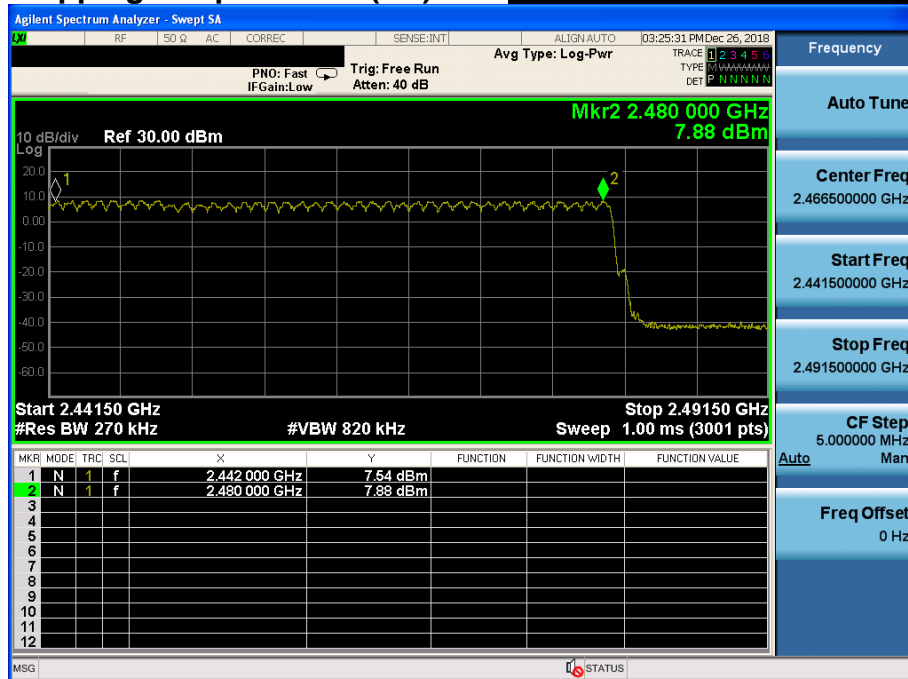
## Hopping mode : Enable & GFSK

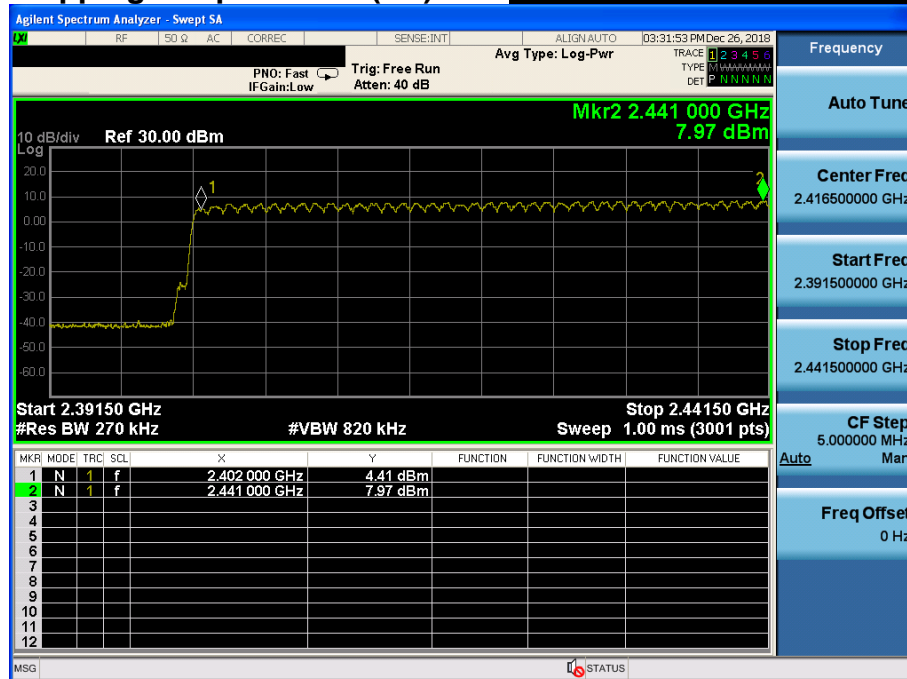
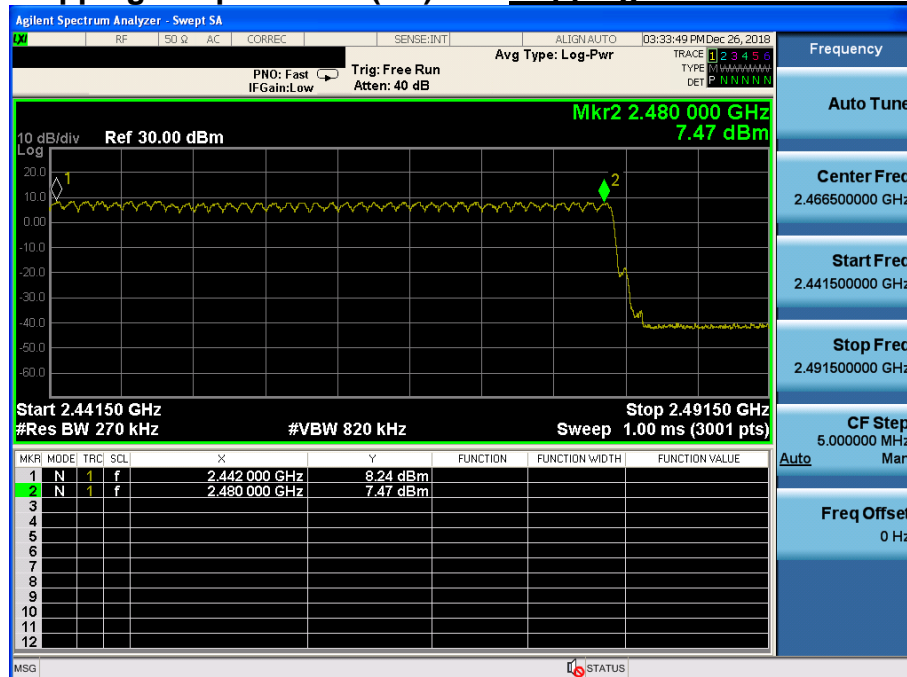


## Number of Hopping Frequencies 1(FH)

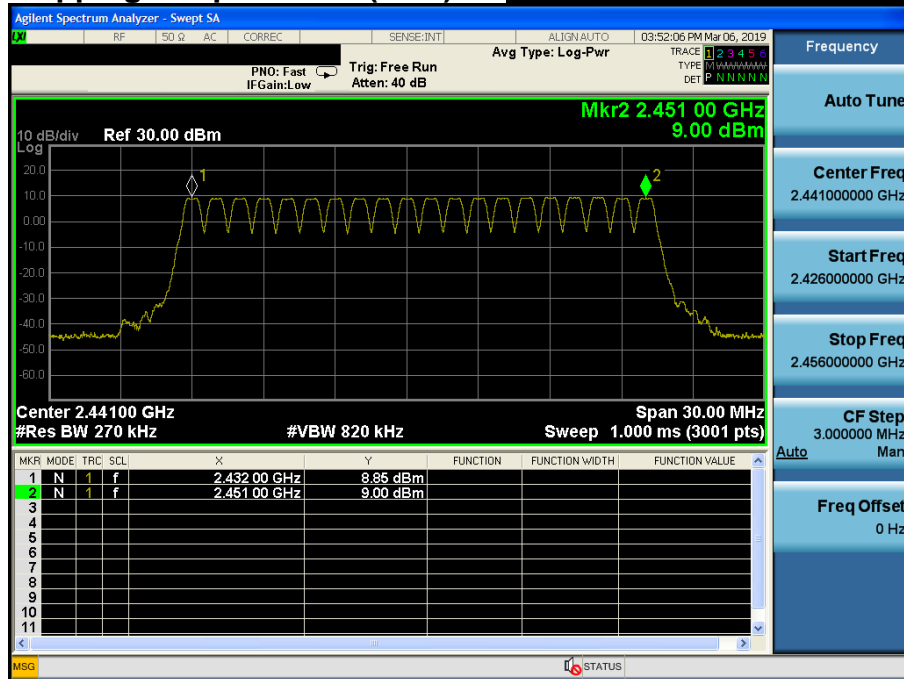
Hopping mode : Enable &  $\pi/4$ DQPSK

## Number of Hopping Frequencies 2(FH)

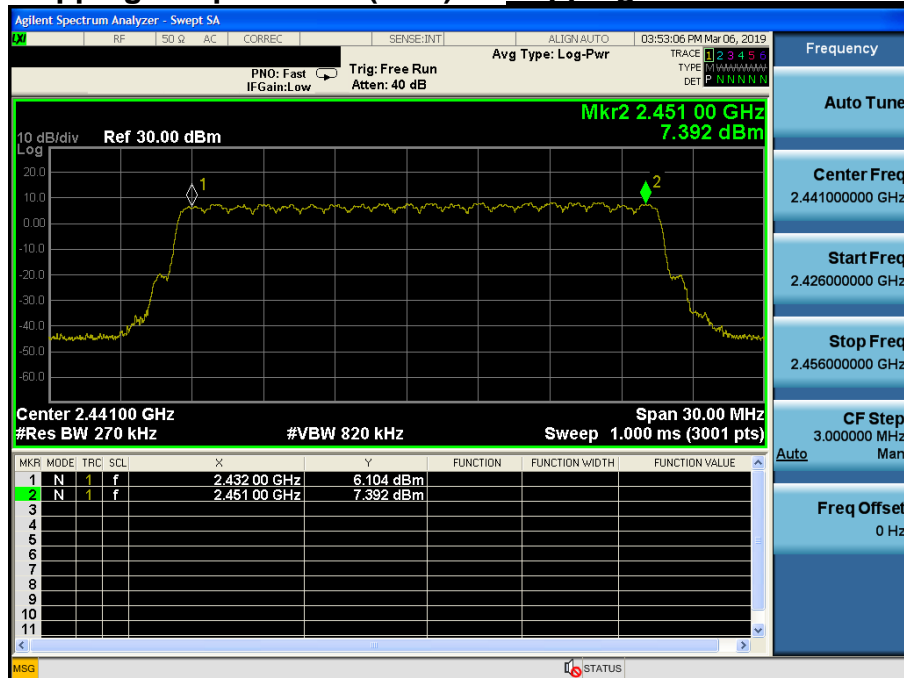
Hopping mode : Enable &  $\pi/4$ DQPSK

**Number of Hopping Frequencies 1(FH)      *Hopping mode : Enable & 8DPSK*****Number of Hopping Frequencies 2(FH)      *Hopping mode : Enable & 8DPSK***

# Number of Hopping Frequencies 1(AFH) *Hopping mode : Enable & GFSK*

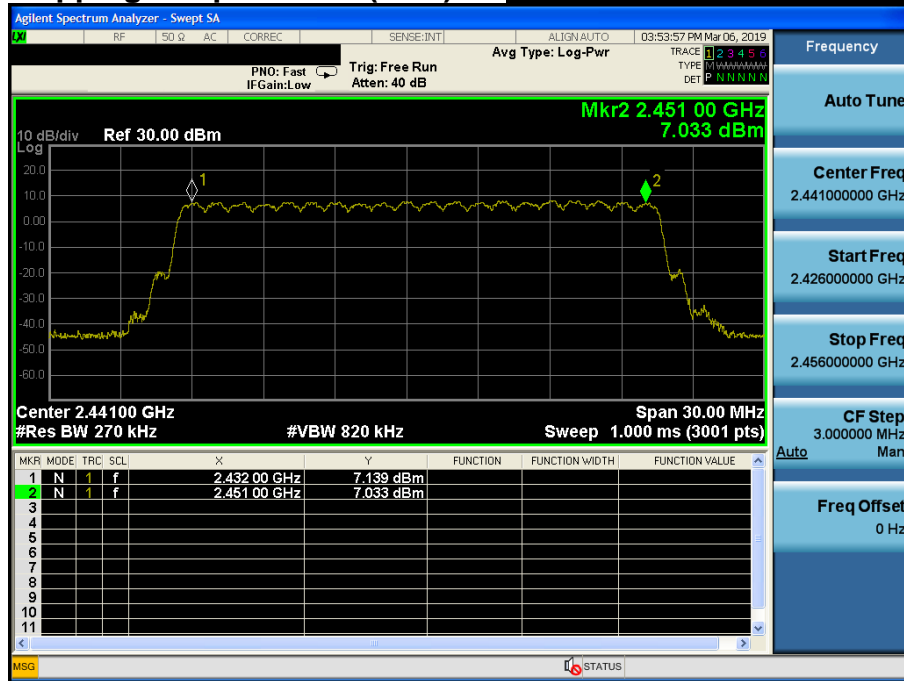


# Number of Hopping Frequencies 1(AFH) *Hopping mode : Enable & π/4DQPSK*





Number of Hopping Frequencies 1(AFH) Hopping mode : Enable & 8DPSK



## 6. Time of Occupancy (Dwell Time)

### 6.1 Test Setup

Refer to the APPENDIX I.

### 6.2 Limit

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

### 6.3 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 = 2441 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

### 6.4 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 =  $0.4 \times \text{Hopping channel} \times \text{Burst ON time} \times$

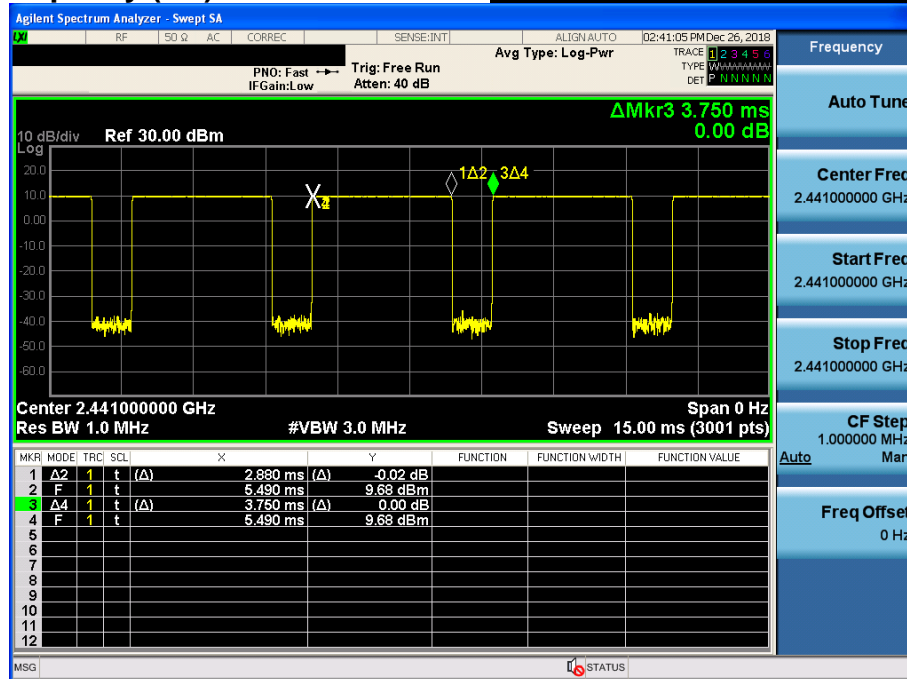
$((\text{Hopping rate} \div \text{Time slots}) \div \text{Hopping channel})$

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

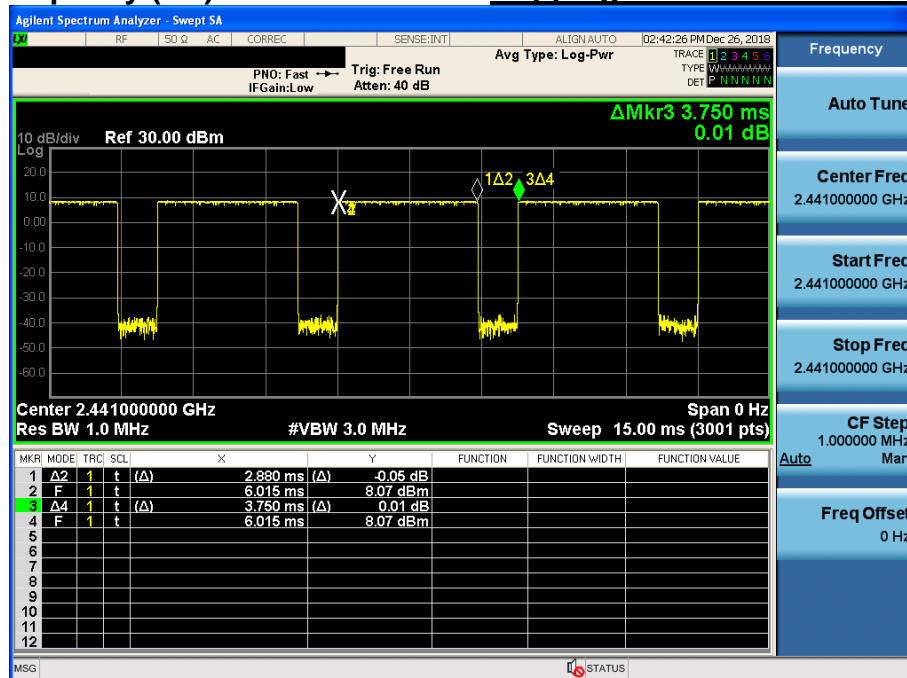
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

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

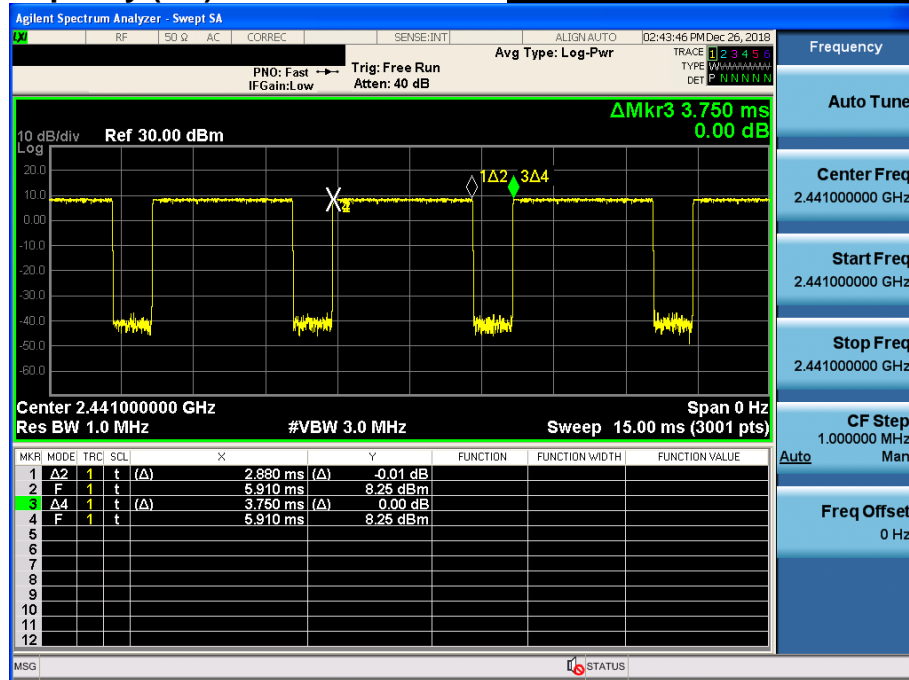
## Time of Occupancy (FH)

Hopping mode : Enable & DH5

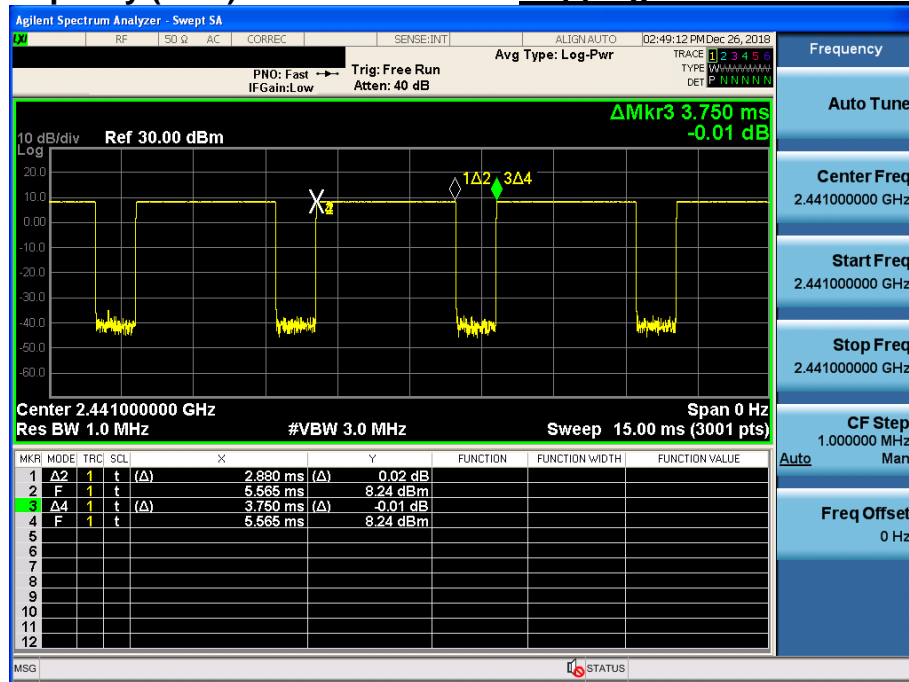
## Time of Occupancy (FH)

Hopping mode : Enable & 2-DH5

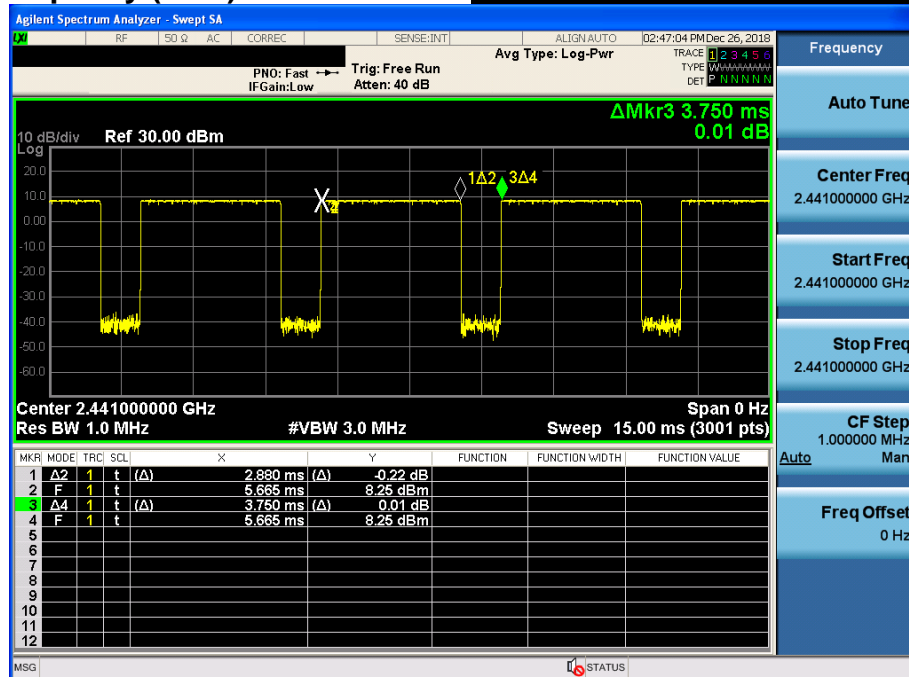
## Time of Occupancy (FH)

Hopping mode : Enable & 3-DH5

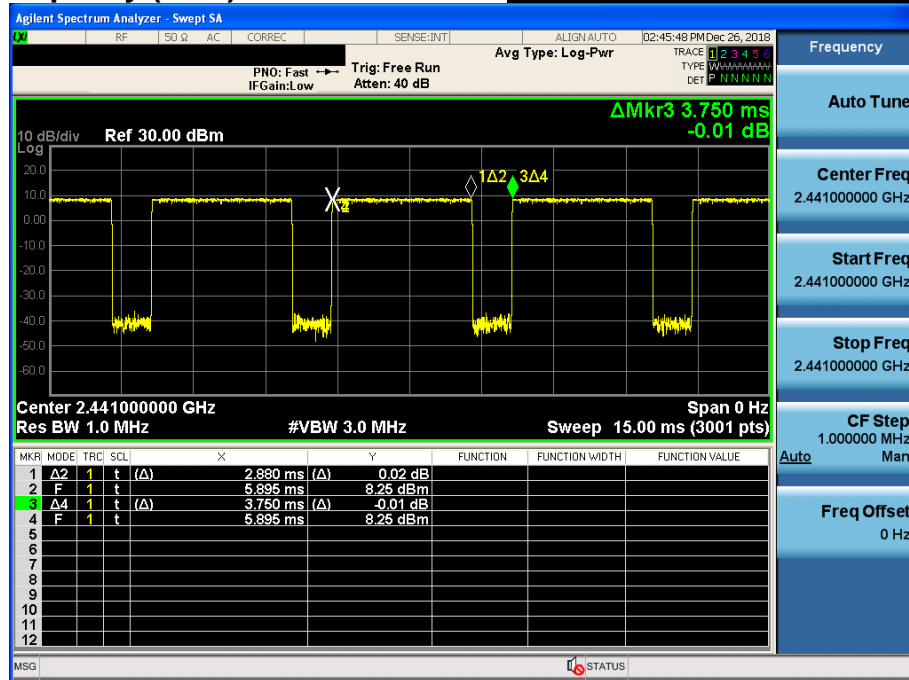
## Time of Occupancy (AFH)

Hopping mode : Enable & DH5

## Time of Occupancy (AFH)

Hopping mode : Enable & 2-DH5

## Time of Occupancy (AFH)

Hopping mode : Enable & 3-DH5

## 7. Transmitter Radiated Spurious Emissions and Conducted Spurious Emission

### 7.1 Test Setup

Refer to the APPENDIX I.

### 7.2 Limit

According to §15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph(b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in section §15.209(a) is not required. In addition, radiated emission which in the restricted band, as define in section §15.205(a), must also comply the radiated emission limits specified in section §15.209(a) (see section §15.205(c))

According to § 15.209(a), except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table

| Frequency (MHz) | Limit (uV/m)  | Measurement Distance (meter) |
|-----------------|---------------|------------------------------|
| 0.009 ~ 0.490   | 2400/F (kHz)  | 300                          |
| 0.490 ~ 1705    | 24000/F (kHz) | 30                           |
| 1705 ~ 30.0     | 30            | 30                           |
| 30 ~ 88         | 100 **        | 3                            |
| 88 ~ 216        | 150 **        | 3                            |
| 216 ~ 960       | 200 **        | 3                            |
| Above 960       | 500           | 3                            |

\*\* Except as provided in 15.209(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.

According to § 15.205(a) and (b), only spurious emissions are permitted in any of the frequency bands listed below :

| MHz                 | MHz                   | MHz             | GHz           |
|---------------------|-----------------------|-----------------|---------------|
| 0.009 ~ 0.110       | 16.42 ~ 16.423        | 399.90 ~ 410    | 4.5 ~ 5.15    |
| 0.495 ~ 0.505       | 16.69475 ~ 16.69525   | 608 ~ 614       | 5.35 ~ 5.46   |
| 2.1735 ~ 2.1905     | 16.80425 ~ 16.80475   | 960 ~ 1240      | 7.25 ~ 7.75   |
| 4.125 ~ 4.128       | 25.5 ~ 25.67          | 1300 ~ 1427     | 8.025 ~ 8.5   |
| 4.17725 ~ 4.17775   | 37.5 ~ 38.25          | 1435 ~ 1626.5   | 9.0 ~ 9.2     |
| 4.20725 ~ 4.20775   | 73 ~ 74.6             | 1645.5 ~ 1646.5 | 9.3 ~ 9.5     |
| 6.215 ~ 6.218       | 74.8 ~ 75.2           | 1660 ~ 1710     | 10.6 ~ 12.7   |
| 6.26775 ~ 6.26825   | 108 ~ 121.94          | 1718.8 ~ 1722.2 | 13.25 ~ 13.4  |
| 6.31175 ~ 6.31225   | 123 ~ 138             | 2200 ~ 2300     | 14.47 ~ 14.5  |
| 8.291 ~ 8.294       | 149.9 ~ 150.05        | 2310 ~ 2390     | 15.35 ~ 16.2  |
| 8.362 ~ 8.366       | 156.52475 ~ 156.52525 | 2483.5 ~ 2500   | 17.7 ~ 21.4   |
| 8.37625 ~ 8.38675   | 156.7 ~ 156.9         | 2690 ~ 2900     | 22.01 ~ 23.12 |
| 8.41425 ~ 8.41475   | 162.0125 ~ 167.17     | 3260 ~ 3267     | 23.6 ~ 24.0   |
| 12.29 ~ 12.293      | 167.72 ~ 173.2        | 3332 ~ 3339     | 31.2 ~ 31.8   |
| 12.51975 ~ 12.52025 | 240 ~ 285             | 3345.8 ~ 3358   | 36.43 ~ 36.5  |
| 12.57675 ~ 12.57725 | 322 ~ 335.4           | 3600 ~ 4400     | Above 38.6    |
| 13.36 ~ 13.41       |                       |                 |               |

The field strength of emissions appearing within these frequency bands shall not exceed the limits shown in §15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in §15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in §15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in §15.35 apply to these measurements.

## 7.3. Test Procedures

### 7.3.1. Test Procedures for Radiated Spurious Emissions

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 1GHz 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

1. Frequency Range Below 1GHz  
RBW = 100 or 120 kHz, VBW = 3 x RBW, Detector = Peak or Quasi Peak
2. Frequency Range Range > 1 GHz  
Peak Measurement  
RBW = 1 MHz, VBW = 3 MHz, Detector = Peak, Sweep time = Auto, Trace mode = Max Hold until the trace stabilizes  
Average Measurement> 1GHz  
RBW = 1MHz, VBW  $\geq 1/T$ , Detector = Peak, Sweep Time = Auto, Trace Mode = Max Hold until the trace stabilizes