

# 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 : DRTFCC1909-0258(1)
2. Customer
  - Name (FCC) : SENA TECHNOLOGIES, Inc.
  - Name (IC) : Sena Technologies, Inc.
  - Address (FCC) : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, South Korea
  - Address (IC) : 210 Yangjae-dong, Seocho-gu Seoul 137-130 Korea (Republic Of)
3. Use of Report : FCC & IC Original Grant
4. Product Name / Model Name : SMART HJC 20B / SP71  
FCC ID : S7A-SP71 / IC : 8154A-SP71
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 (2019-03)
6. Date of Test : 2019.08.26 ~ 2019.09.03
7. Testing Environment : See appended test report.
8. Test Result : Refer to the attached test result.

|             |                   |                                                                                                    |                   |                                                                                                      |
|-------------|-------------------|----------------------------------------------------------------------------------------------------|-------------------|------------------------------------------------------------------------------------------------------|
| Affirmation | Tested by         | <br>(Signature) | Reviewed by       | <br>(Signature) |
|             | Name : JaeJin Lee |                                                                                                    | Name : GeunKi Son |                                                                                                      |

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 . 10 . 01 .

**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                      |
|--------------------|---------------|----------------------------------|
| DRTFCC1909-0258    | Sep. 26, 2019 | Initial issue                    |
| DRTFCC1909-0258(1) | Oct. 01, 2019 | Revised the section 1.5 and 1.10 |
|                    |               |                                  |
|                    |               |                                  |
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## 1. General Information

### 1.1 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.<br>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-4, 5740A-5                                                                                                                                                                                                                                         |   |                  |
| <a href="http://www.dtnet.net">www.dtnet.net</a>                                                                                                                                                                                                                              |   |                  |
| Telephone                                                                                                                                                                                                                                                                     | : | + 82-31-321-2664 |
| FAX                                                                                                                                                                                                                                                                           | : | + 82-31-321-1664 |

### 1.2 Testing Environment

| Ambient Condition   |                 |
|---------------------|-----------------|
| ▪ Temperature       | +20 °C ~ +25 °C |
| ▪ Relative Humidity | 35 % ~ 45 %     |

### 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                       | 1.1 dB (The confidence level is about 95 %, $k = 2$ ) |
| Conducted spurious emission                    | 1.1 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) : SENA TECHNOLOGIES.Inc  
 Applicant(IC) : Sena Technologies, Inc.  
 Address(FCC) : 19, Heolleung-ro 569-gil, Gangnam-gu, Seoul, South Korea  
 Address(IC) : 210 Yangjae-dong, Seocho-gu Seoul 137-130 Korea (Republic Of)  
 Contact person : Seunghyun Kim

## 1.5 Description of EUT

|                                              |                                                                            |
|----------------------------------------------|----------------------------------------------------------------------------|
| <b>EUT</b>                                   | SMART HJC 20B                                                              |
| <b>Model Name(HVIN)</b>                      | SP71                                                                       |
| <b>Add Model Name</b>                        | NA                                                                         |
| <b>FVIN</b>                                  | 1.0                                                                        |
| <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 (1 Msymbol/s),<br>$\pi/4$ DQPSK (2 Msymbol/s),<br>8DPSK (3 Msymbol/s) |
| <b>Number of Channels</b>                    | 79                                                                         |
| <b>Antenna Type /Antenna Gain (Module 1)</b> | Internal Antenna (Pattern Antenna) / PK : -0.13 dBi                        |
| <b>Antenna Type /Antenna Gain (Module 2)</b> | Internal Antenna (Pattern Antenna) / PK : -0.05 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 synchroniztation with the transmit ted 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                    | MY48010133         |
| Spectrum Analyzer                   | Agilent Technologies   | N9020A                      | 19/06/26               | 20/06/26                    | MY48011700         |
| DC Power Supply                     | Agilent Technologies   | 66332A                      | 18/12/19               | 19/12/19                    | US37476998         |
| Multimeter                          | FLUKE                  | 17B                         | 18/12/18               | 19/12/18                    | 26030065WS         |
| Signal Generator                    | Rohde Schwarz          | SMBV100A                    | 18/12/19               | 19/12/19                    | 255571             |
| Signal Generator                    | ANRITSU                | MG3695C                     | 18/12/10               | 19/12/10                    | 173501             |
| Thermohygrometer                    | BODYCOM                | BJ5478                      | 18/12/27               | 19/12/27                    | 120612-1           |
| Thermohygrometer                    | BODYCOM                | BJ5478                      | 18/12/27               | 19/12/27                    | 120612-2           |
| HYGROMETER                          | TESTO                  | 608-H1                      | 19/01/31               | 20/01/31                    | 34862883           |
| Loop Antenna                        | ETS                    | 6502                        | 19/03/21               | 21/03/21                    | 3471               |
| BILOG ANTENNA                       | Schwarzbeck            | VULB 9160                   | 18/07/13               | 20/07/13                    | 3359               |
| Horn Antenna                        | ETS-Lindgren           | 3117                        | 18/05/10               | 20/05/10                    | 00140394           |
| Horn Antenna                        | A.H.Systems Inc.       | SAS-574                     | 19/04/23               | 21/04/23                    | 154                |
| PreAmplifier                        | tsj                    | 8447D                       | 18/12/18               | 19/12/18                    | 2944A07774         |
| PreAmplifier                        | tsj                    | 8449B                       | 19/06/27               | 20/06/27                    | 3008A02108         |
| Attenuator                          | Cernexwave             | CFADC2603U5                 | 19/06/27               | 20/06/27                    | C11729             |
| Attenuator                          | SRTechnology           | F01-B0620-01                | 19/06/25               | 20/06/25                    | 13092401           |
| High Pass Filter                    | Wainwright Instruments | WHKX12-2580-3000-18000-80SS | 19/06/24               | 20/06/24                    | 3                  |
| Power Meter & Wide Bandwidth Sensor | Anritsu                | ML2496A<br>ML2495A          | 18/12/20               | 19/12/20                    | 1338004<br>1306007 |
| LISN                                | SCHWARZBECK            | NNLK 8121                   | 19/05/23               | 20/05/23                    | 06183              |
| RECEIVER                            | ROHDE&SCHWARZ          | ESCI7                       | 19/01/30               | 20/01/30                    | 100910             |
| PULSE LIMITER                       | ROHDE&SCHWARZ          | ESH3-Z2                     | 19/09/17               | 20/09/17                    | 101333             |
| Cable                               | RADIALL                | TESTPRO3                    | 19/08/13               | 20/08/13                    | N/A                |
| Cable                               | DTNC                   | Cable                       | 18/07/06               | 19/07/06                    | M-01               |
| Cable                               | HUBER+SUHNER           | SUCOFLEX 104                | 19/01/16               | 20/01/16                    | M-03               |
| Cable                               | Junkosha               | MWX315                      | 18/11/19               | 19/11/19                    | M-05               |
| Cable                               | Junkosha               | MWX221                      | 18/11/19               | 19/11/19                    | M-06               |

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 for each antenna of EUT.

### 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               |

#### Operation test setup for EUT

- Software: Bluetest 3 v2.5.8

|                      | Power Setting |          |
|----------------------|---------------|----------|
| Modulation           | Module 1      | Module 2 |
| GFSK                 | 8             | 16       |
| $\pi/4$ DQPSK, 8DPSK | 4             | 4        |

## 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

### <Module 1>

| Modulation                            | Tested Channel | Frame Average Output Power |             | Peak Output Power |             |
|---------------------------------------|----------------|----------------------------|-------------|-------------------|-------------|
|                                       |                | dBm                        | mW          | dBm               | mW          |
| <u><b>GFSK</b></u>                    | Lowest         | 5.00                       | 3.16        | 6.14              | 4.11        |
|                                       | Middle         | <b>6.76</b>                | <b>4.74</b> | <b>9.06</b>       | <b>8.05</b> |
|                                       | Highest        | 6.58                       | 4.55        | 8.49              | 7.06        |
| <u><b><math>\pi/4</math>DQPSK</b></u> | Lowest         | 1.62                       | 1.45        | 5.08              | 3.22        |
|                                       | Middle         | <b>2.81</b>                | <b>1.91</b> | <b>7.65</b>       | <b>5.82</b> |
|                                       | Highest        | 2.51                       | 1.81        | 6.95              | 4.95        |
| <u><b>8DPSK</b></u>                   | Lowest         | 1.52                       | 1.42        | 5.67              | 3.69        |
|                                       | Middle         | <b>2.70</b>                | <b>1.86</b> | <b>8.28</b>       | <b>6.73</b> |
|                                       | Highest        | 4.49                       | 1.77        | 7.58              | 5.73        |

### <Module 2>

| Modulation                            | Tested Channel | Frame Average Output Power |              | Peak Output Power |              |
|---------------------------------------|----------------|----------------------------|--------------|-------------------|--------------|
|                                       |                | dBm                        | mW           | dBm               | mW           |
| <u><b>GFSK</b></u>                    | Lowest         | 13.15                      | 20.65        | 14.90             | 30.90        |
|                                       | Middle         | <b>15.72</b>               | <b>37.33</b> | <b>17.55</b>      | <b>56.89</b> |
|                                       | Highest        | 15.08                      | 32.21        | 16.74             | 47.21        |
| <u><b><math>\pi/4</math>DQPSK</b></u> | Lowest         | 2.10                       | 1.62         | 6.19              | 4.16         |
|                                       | Middle         | <b>3.44</b>                | <b>2.21</b>  | <b>8.45</b>       | <b>7.00</b>  |
|                                       | Highest        | 2.75                       | 1.88         | 7.71              | 5.90         |
| <u><b>8DPSK</b></u>                   | Lowest         | 2.07                       | 1.61         | 6.71              | 4.69         |
|                                       | Middle         | <b>3.39</b>                | <b>2.18</b>  | <b>9.01</b>       | <b>7.96</b>  |
|                                       | Highest        | 2.68                       | 1.85         | 8.23              | 6.65         |

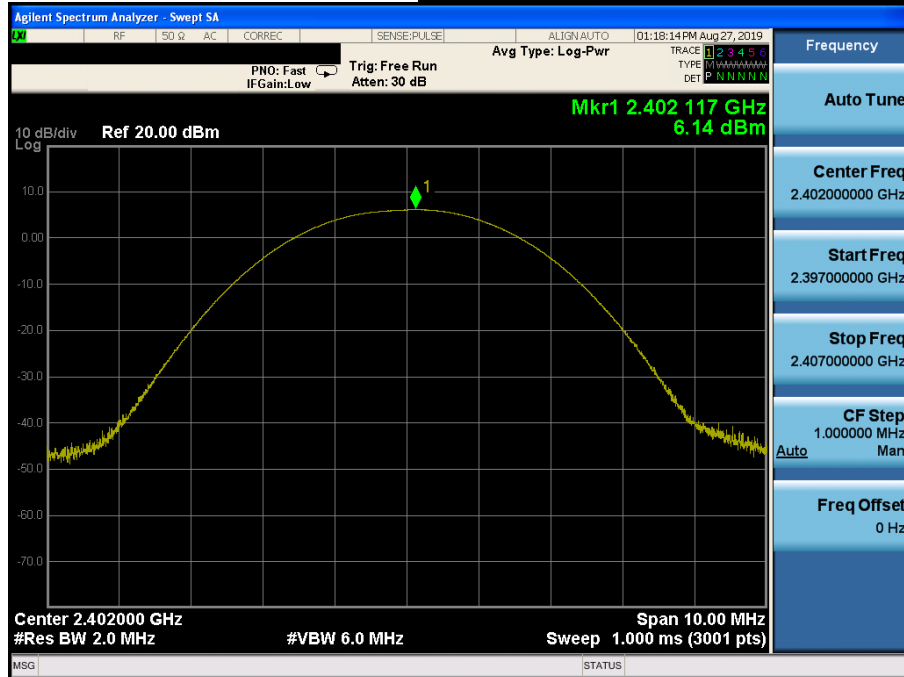
Note 1 : The frame average output power was tested using an average power meter for reference only.

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

<Module 1>

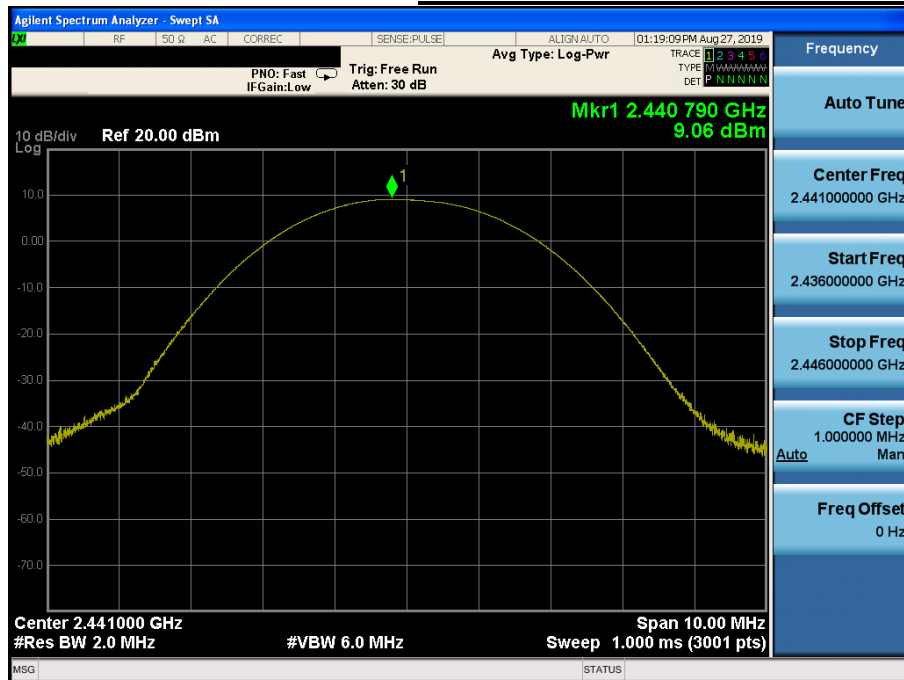
Peak Output Power

Lowest Channel & Modulation : GFSK



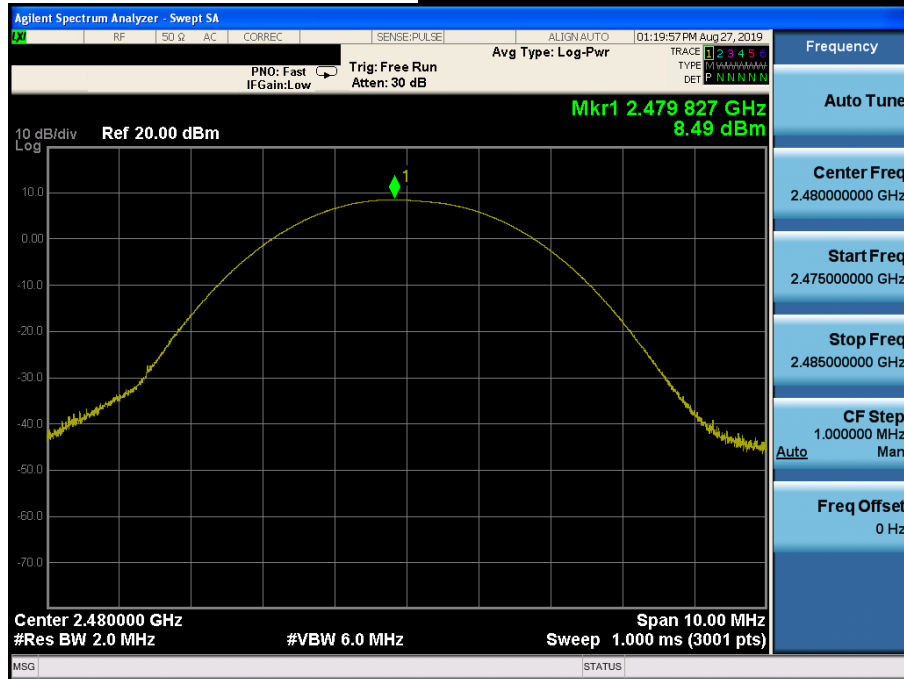
Peak Output Power

Middle Channel & Modulation : GFSK



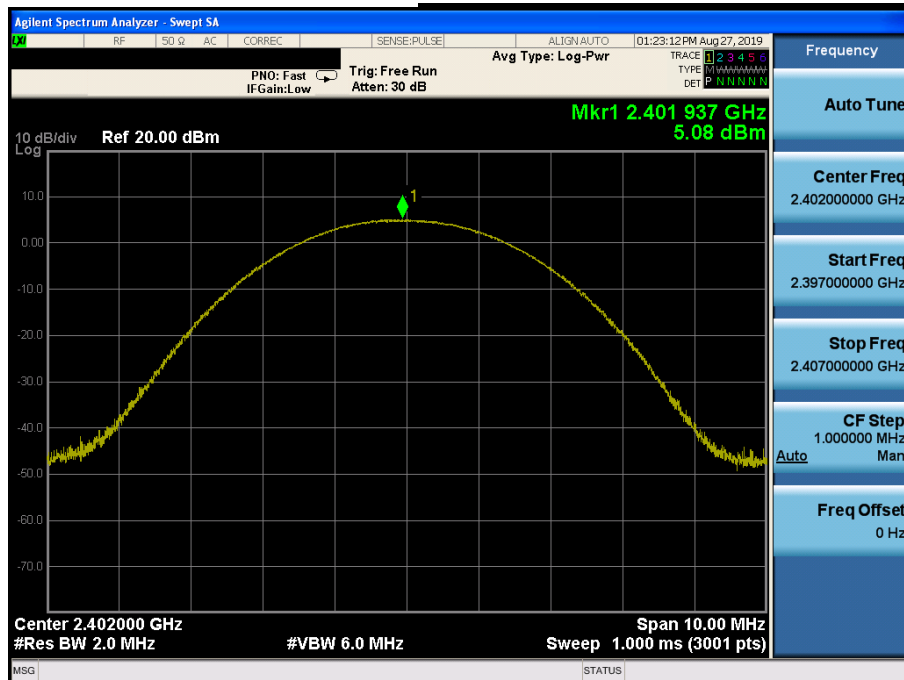
## Peak Output Power

## Highest Channel & Modulation : GFSK



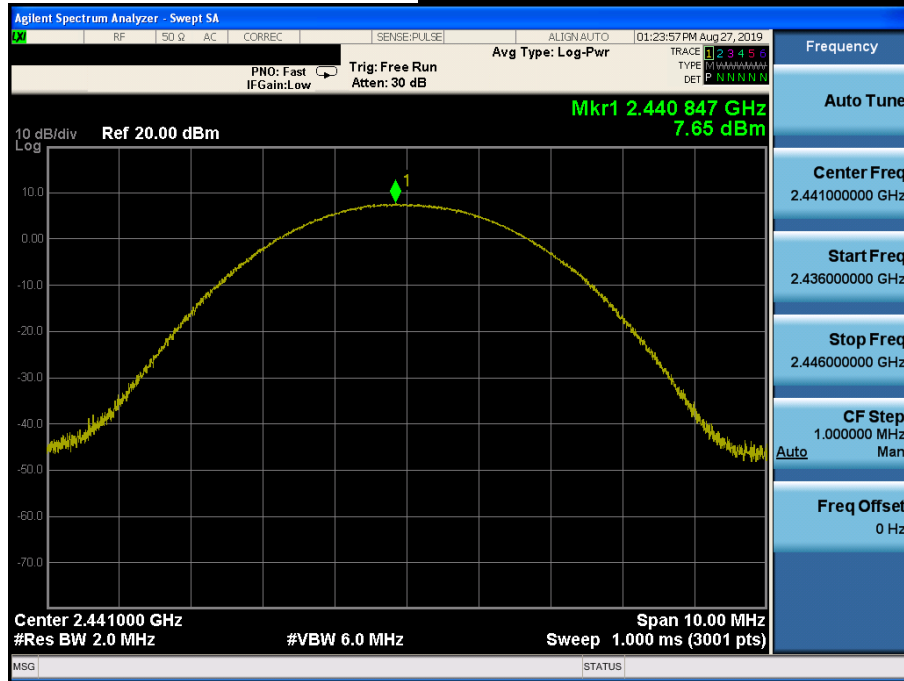
## Peak Output Power

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



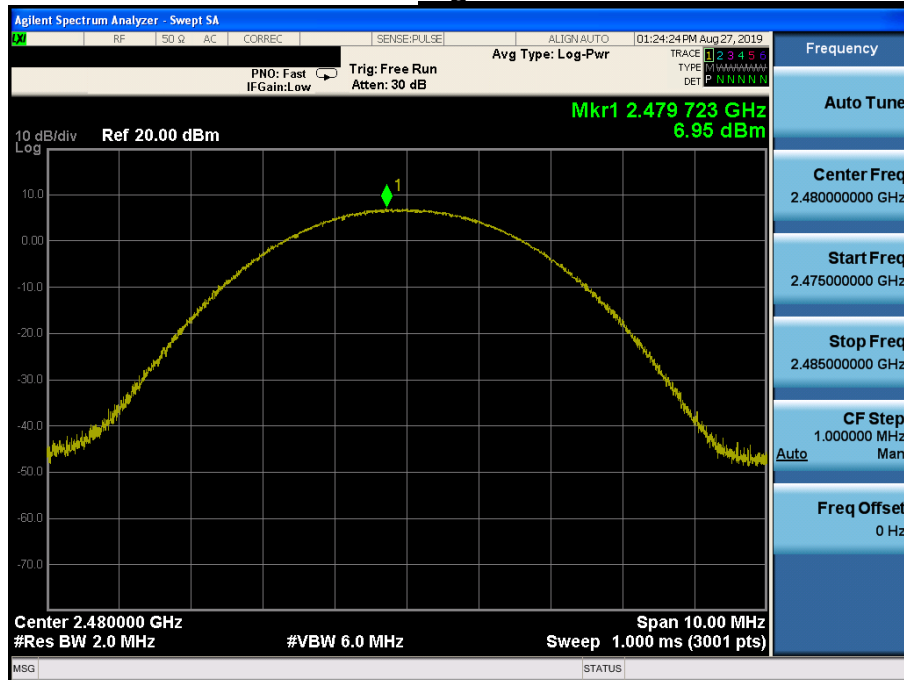
## Peak Output Power

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



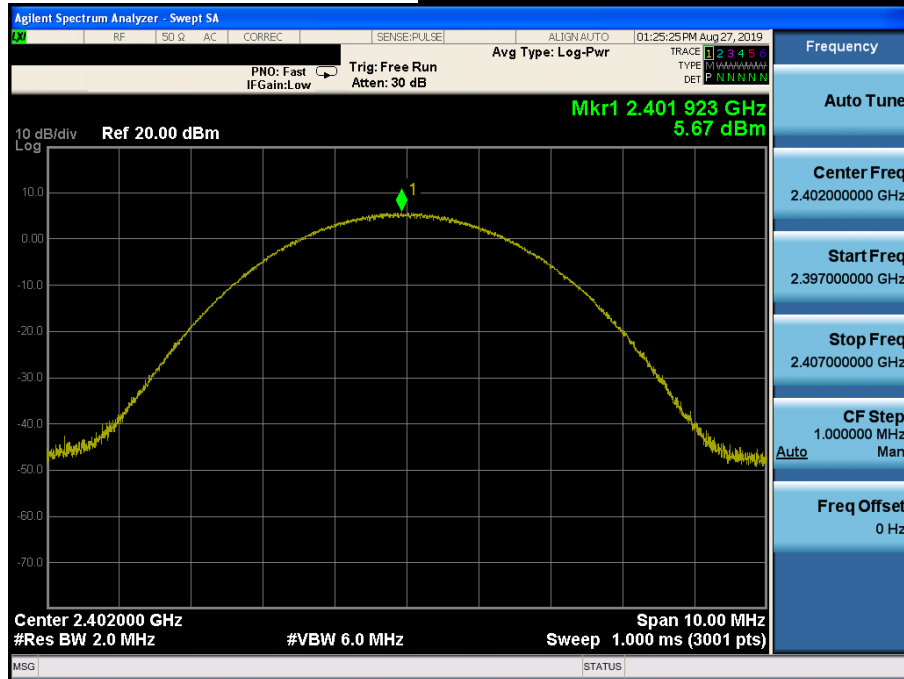
## Peak Output Power

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



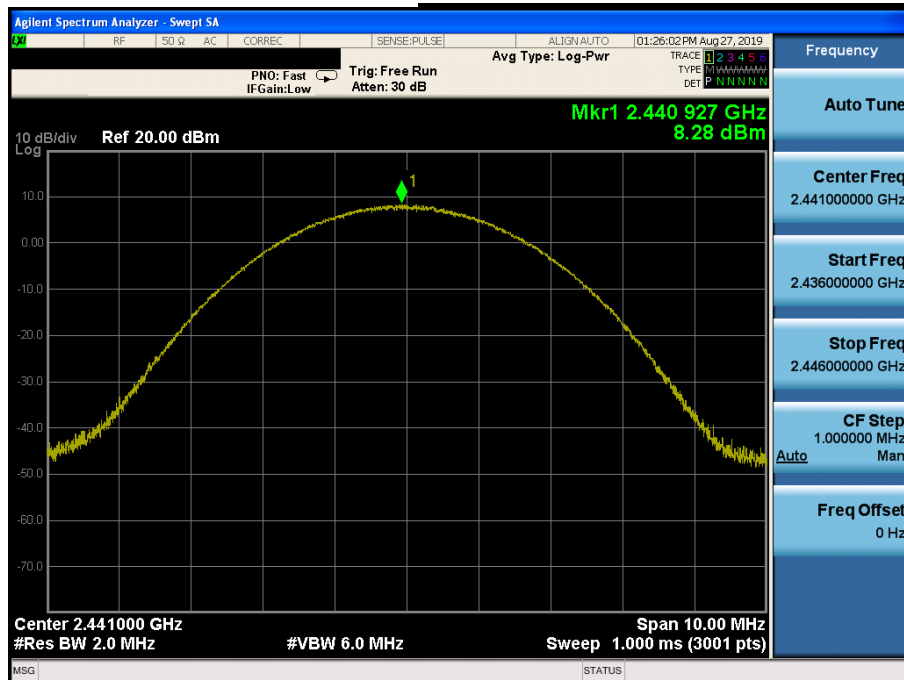
## Peak Output Power

## Lowest Channel & Modulation : 8DPSK



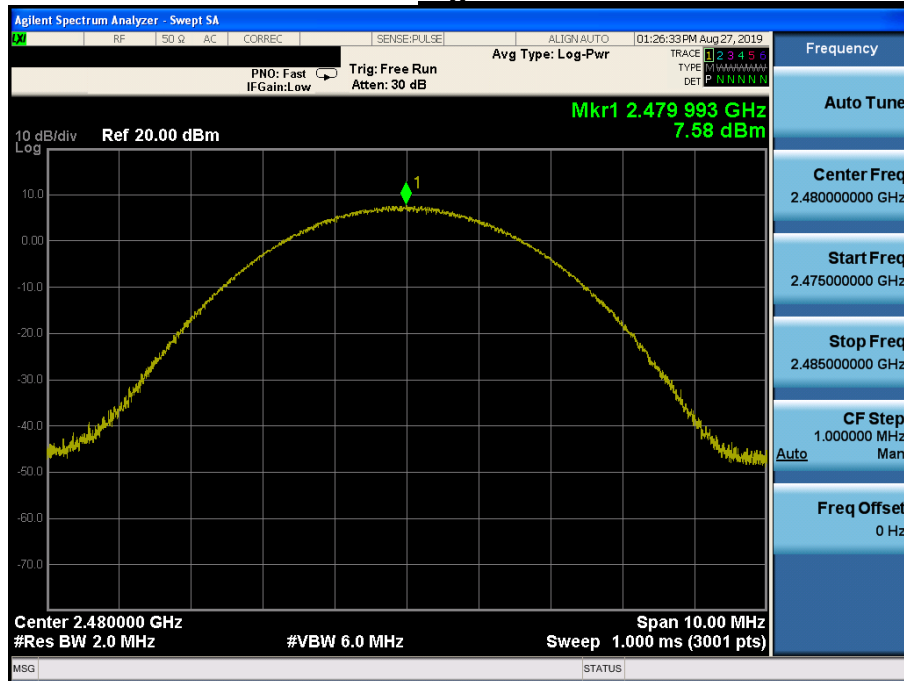
## Peak Output Power

## Middle Channel & Modulation : 8DPSK



## Peak Output Power

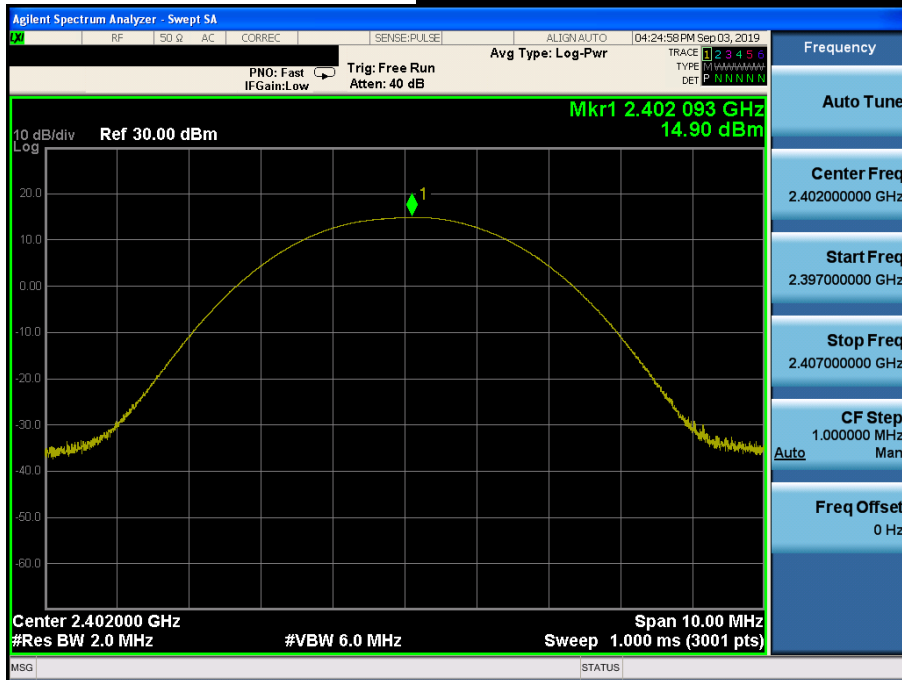
## Highest Channel & Modulation : 8DPSK



<Module 2>

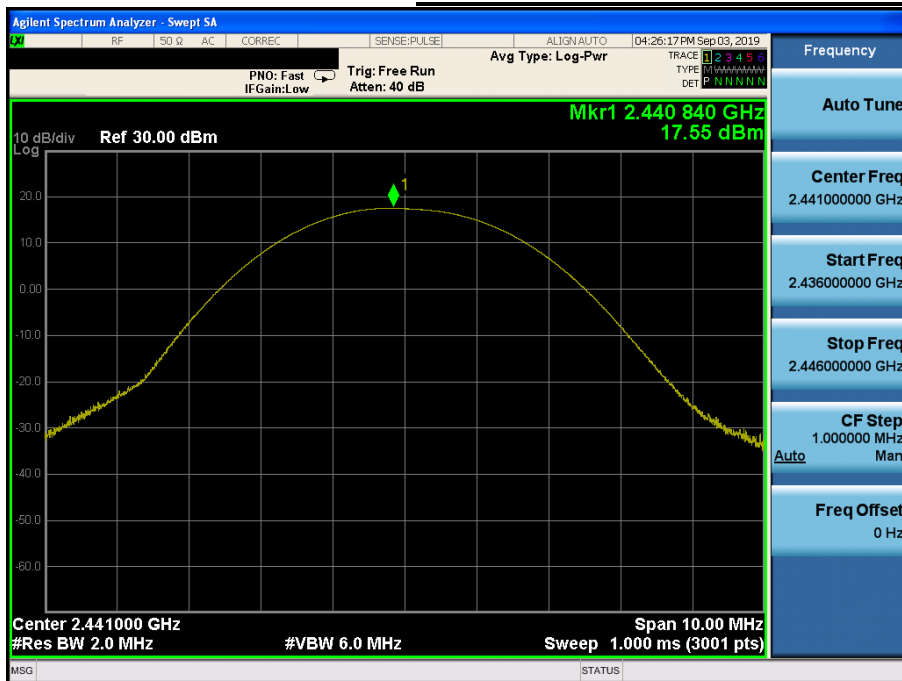
Peak Output Power

Lowest Channel & Modulation : GFSK



Peak Output Power

Middle Channel & Modulation : GFSK



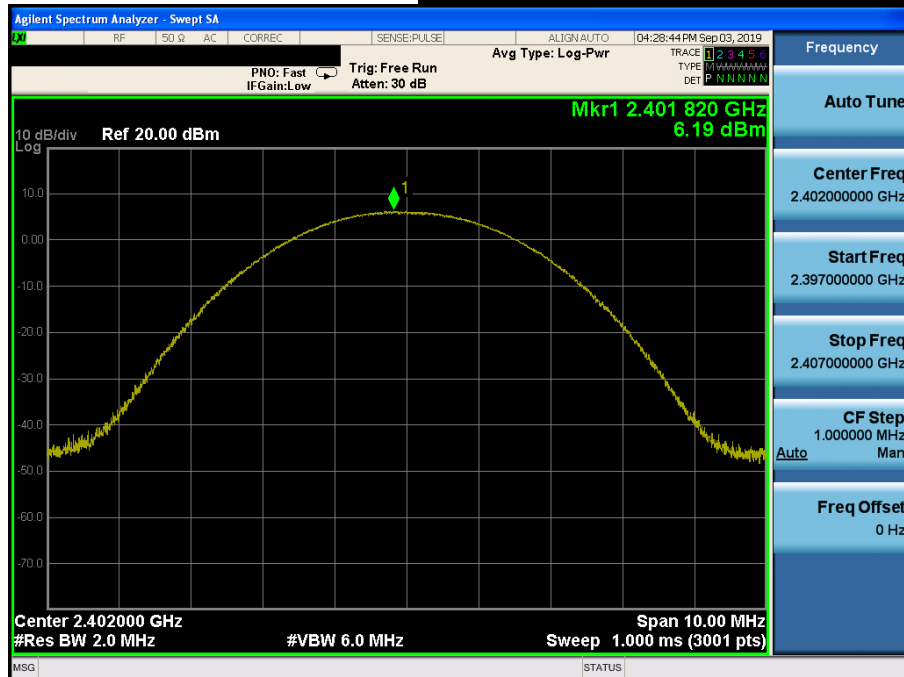
## Peak Output Power

## Highest Channel & Modulation : GFSK



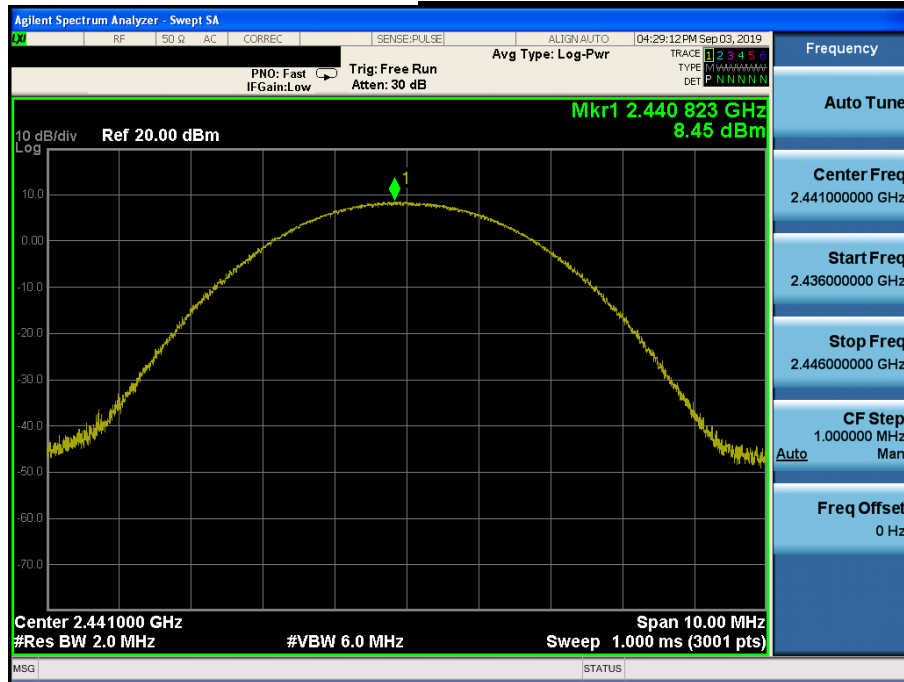
## Peak Output Power

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



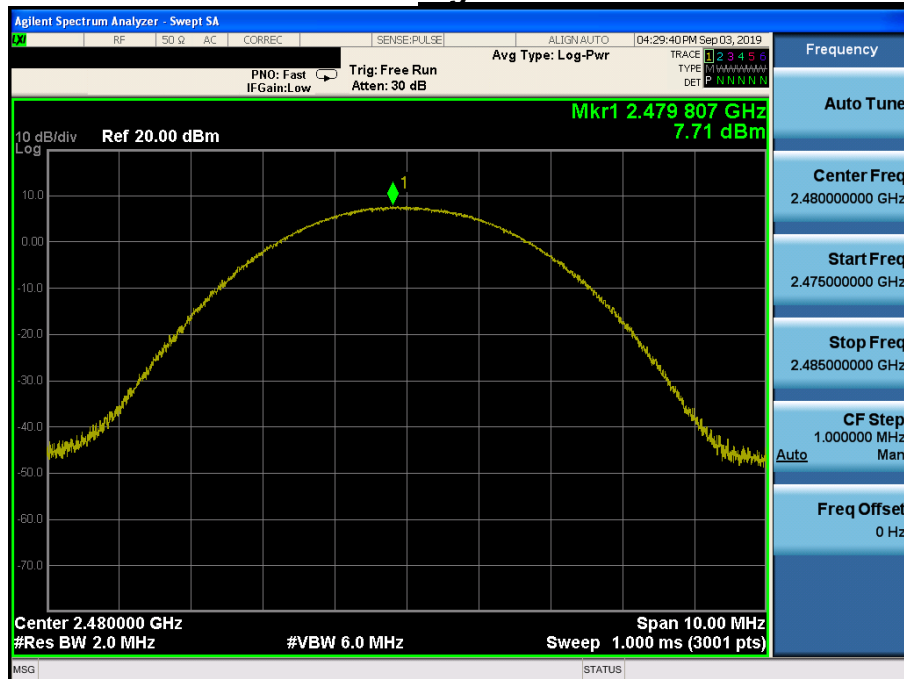
## Peak Output Power

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



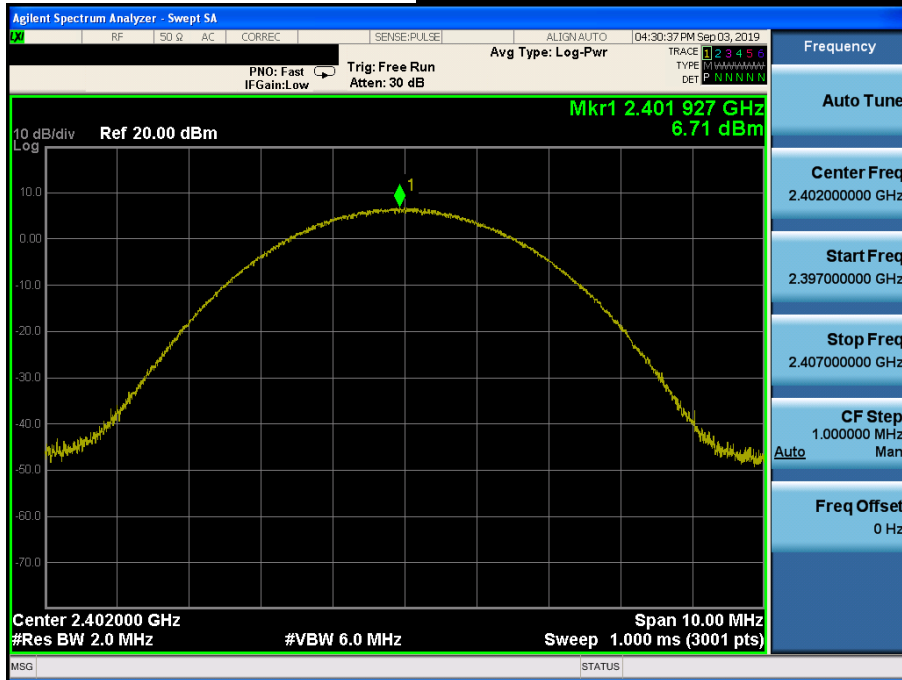
## Peak Output Power

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



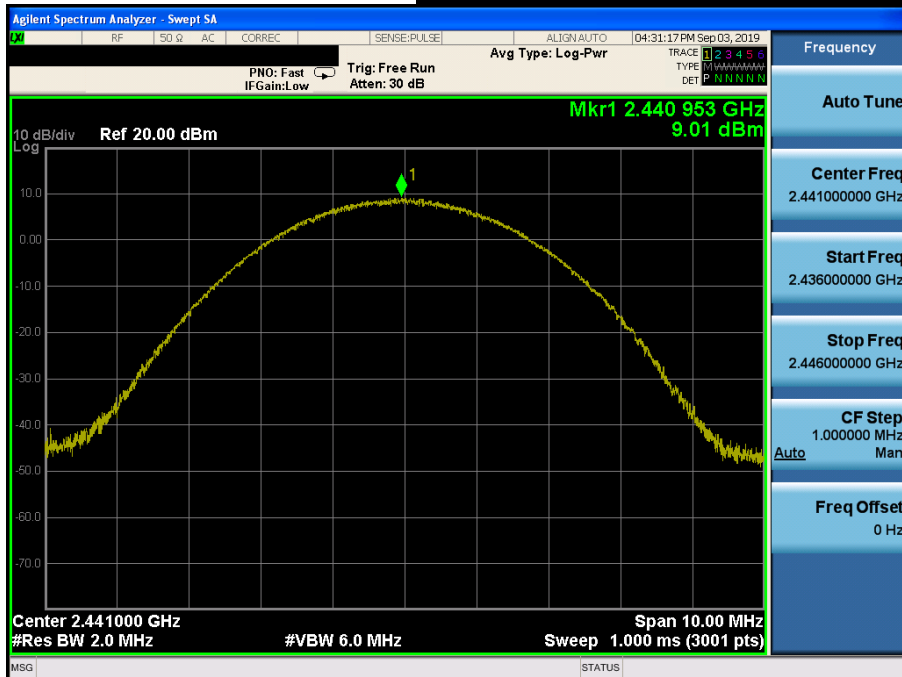
## Peak Output Power

## Lowest Channel & Modulation : 8DPSK



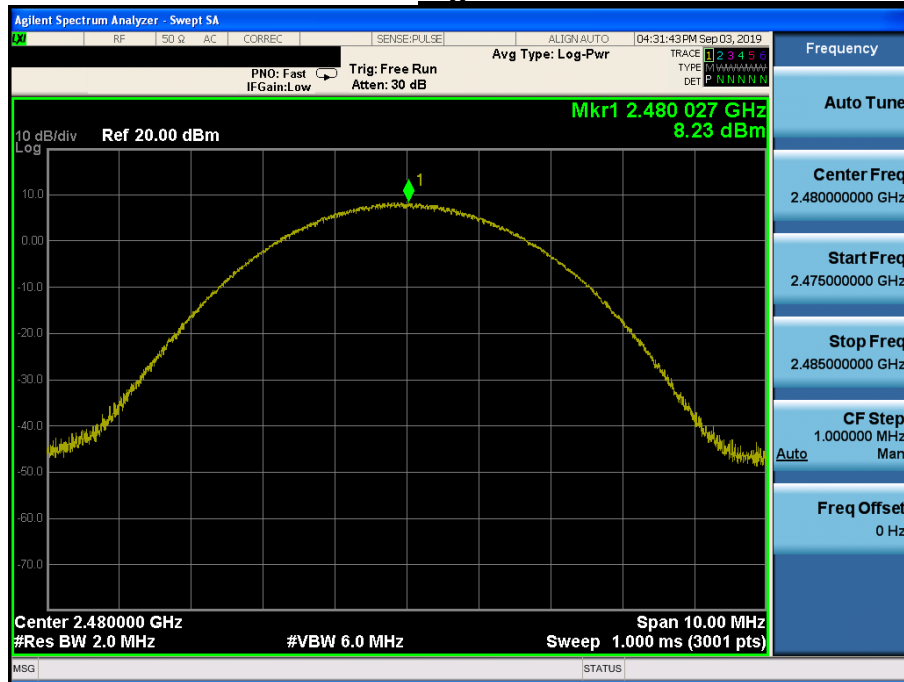
## Peak Output Power

## 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

#### <Module 1>

| Modulation                            | Tested Channel | 20 dB BW (MHz) | Occupied BW (MHz) |
|---------------------------------------|----------------|----------------|-------------------|
| <u><b>GFSK</b></u>                    | Lowest         | <b>0.933</b>   | 0.843             |
|                                       | Middle         | 0.895          | 0.856             |
|                                       | Highest        | 0.929          | <b>0.858</b>      |
| <u><b><math>\pi/4</math>DQPSK</b></u> | Lowest         | <b>1.276</b>   | <b>1.166</b>      |
|                                       | Middle         | 1.254          | 1.164             |
|                                       | Highest        | 1.239          | 1.166             |
| <u><b>8DPSK</b></u>                   | Lowest         | <b>1.251</b>   | 1.161             |
|                                       | Middle         | 1.249          | 1.162             |
|                                       | Highest        | 1.250          | <b>1.163</b>      |

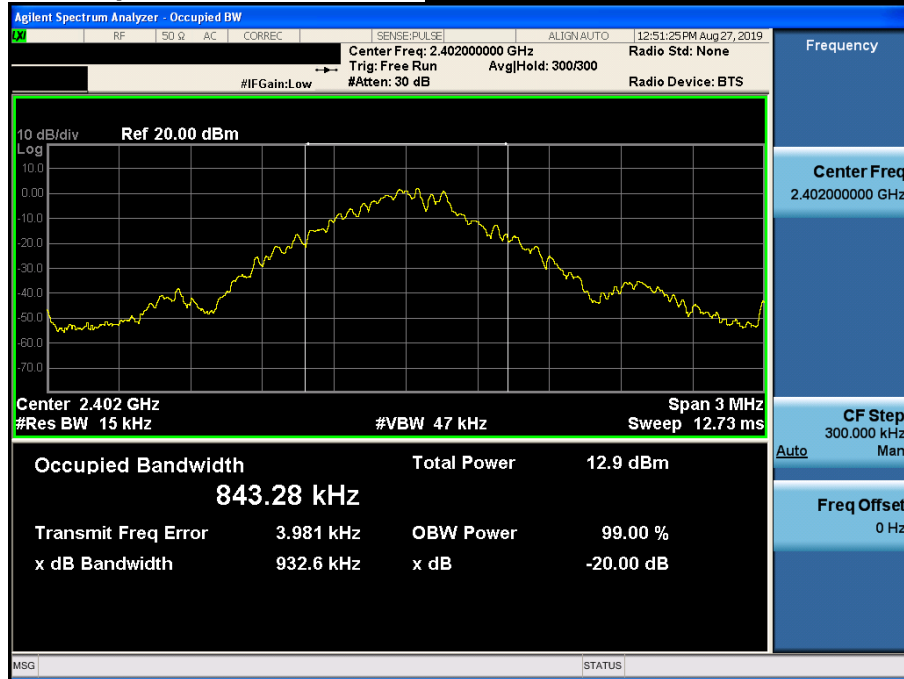
#### <Module 2>

| Modulation                            | Tested Channel | 20 dB BW (MHz) | Occupied BW (MHz) |
|---------------------------------------|----------------|----------------|-------------------|
| <u><b>GFSK</b></u>                    | Lowest         | <b>0.933</b>   | 0.853             |
|                                       | Middle         | 0.926          | 0.854             |
|                                       | Highest        | 0.925          | <b>0.856</b>      |
| <u><b><math>\pi/4</math>DQPSK</b></u> | Lowest         | 1.253          | 1.166             |
|                                       | Middle         | 1.239          | 1.166             |
|                                       | Highest        | <b>1.269</b>   | <b>1.168</b>      |
| <u><b>8DPSK</b></u>                   | Lowest         | 1.252          | 1.165             |
|                                       | Middle         | <b>1.262</b>   | <b>1.166</b>      |
|                                       | Highest        | 1.251          | 1.163             |

# <Module 1>

## 20 dB BW & Occupied BW

## Lowest Channel & Modulation : GFSK



## 20 dB BW & Occupied BW

## Middle Channel & Modulation : GFSK



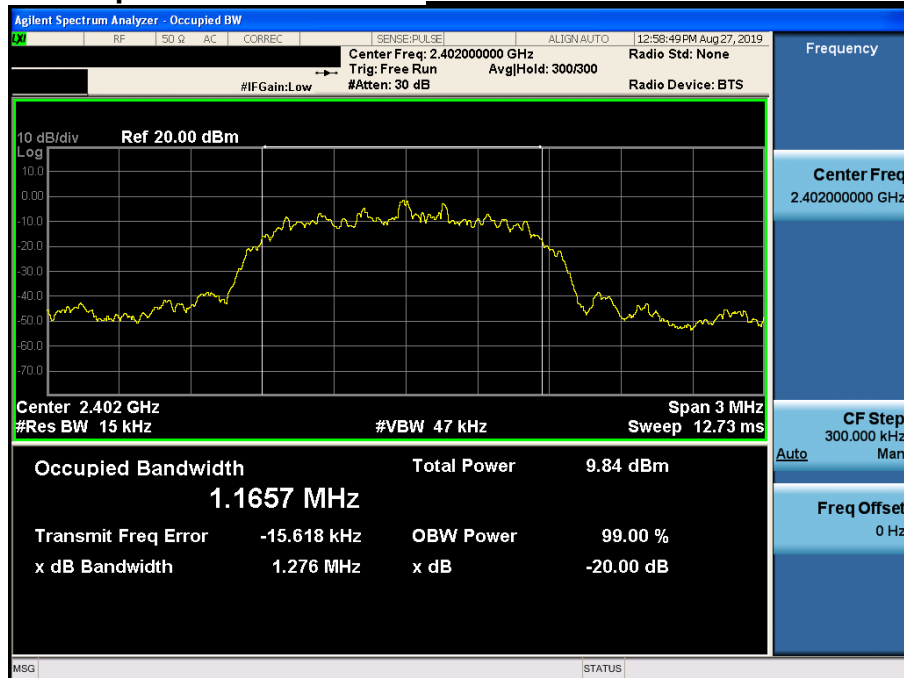
## 20 dB BW & Occupied BW

## Highest Channel & Modulation : GFSK



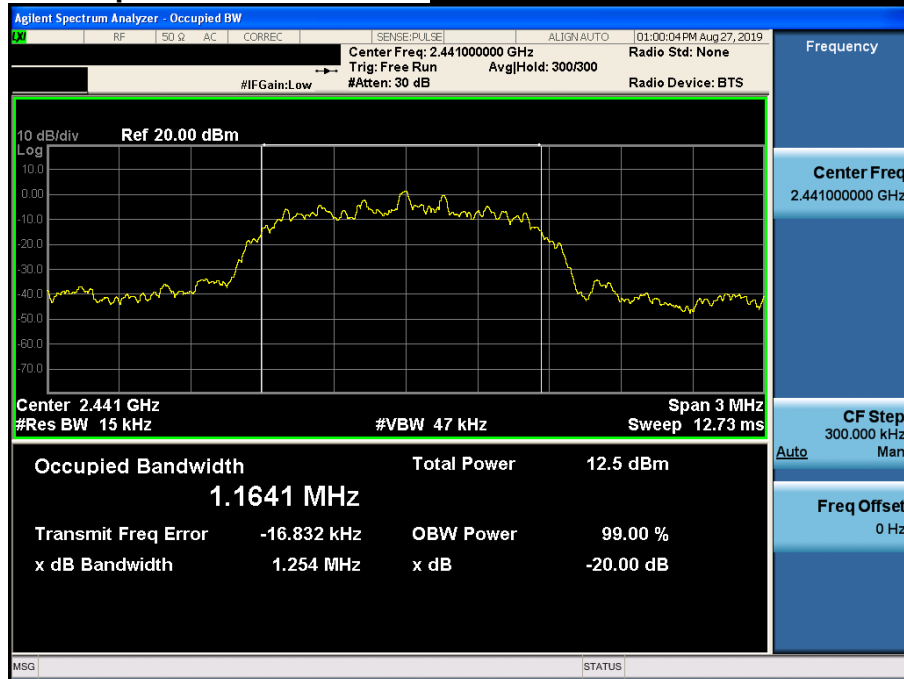
## 20 dB BW & Occupied BW

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



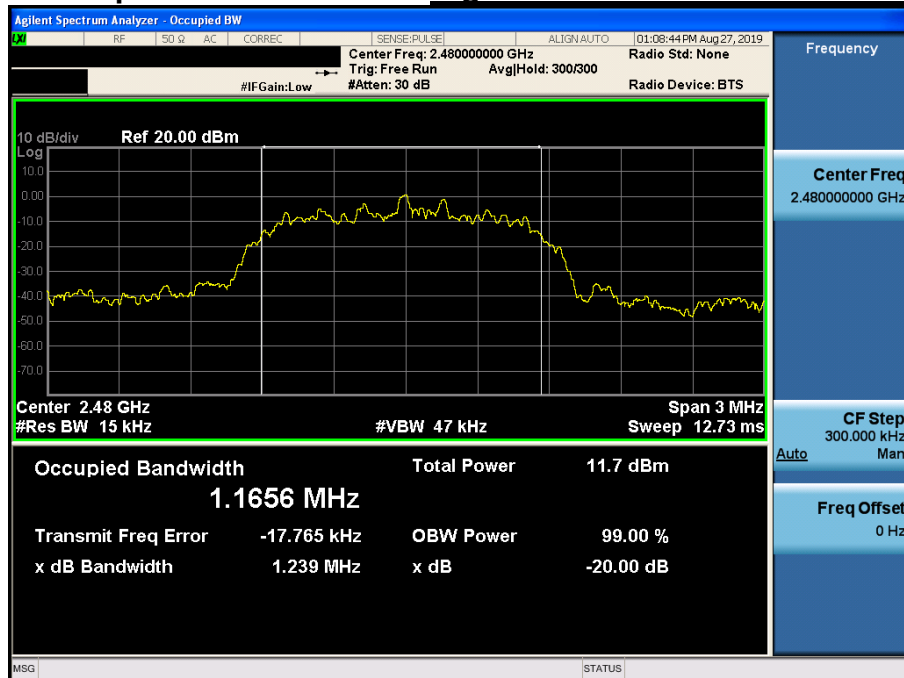
## 20 dB BW & Occupied BW

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



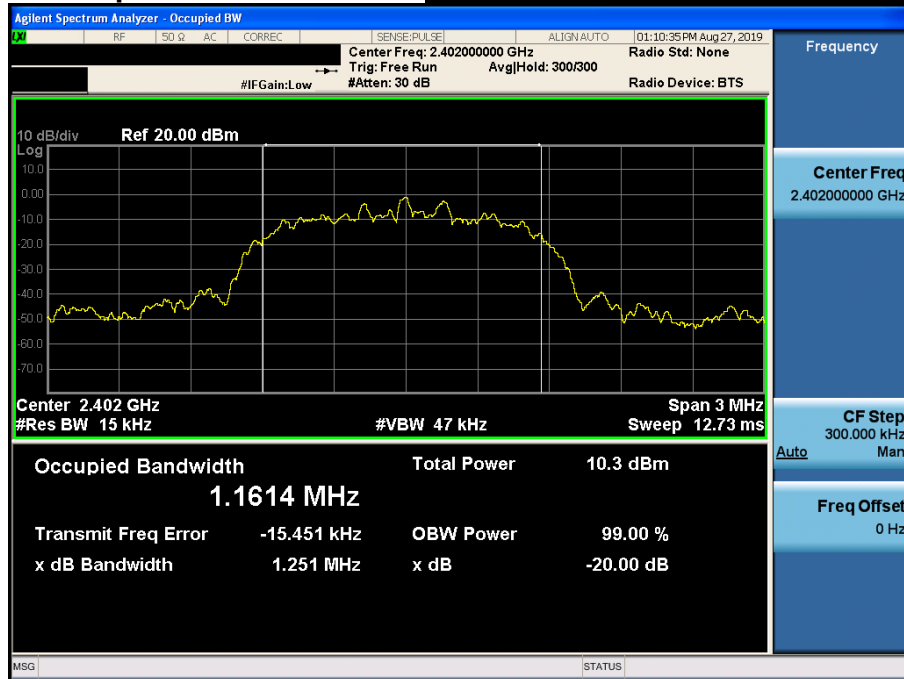
## 20 dB BW & Occupied BW

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



## 20 dB BW & Occupied BW

## Lowest Channel & Modulation : 8DPSK



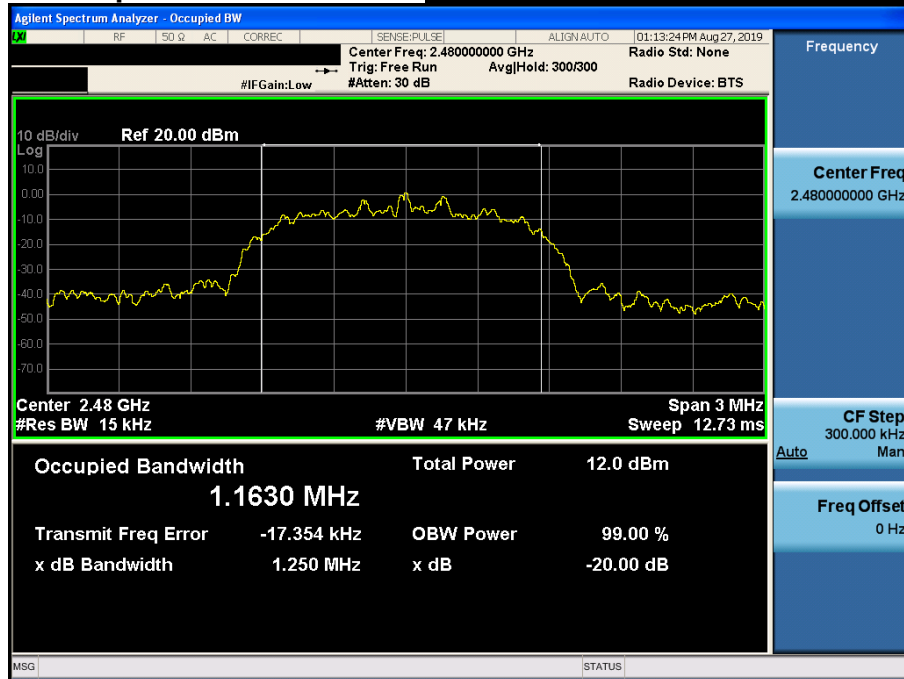
## 20 dB BW & Occupied BW

## Middle Channel & Modulation : 8DPSK



## 20 dB BW & Occupied BW

## Highest Channel & Modulation : 8DPSK



## <Module 2>

### 20 dB BW & Occupied BW

### Lowest Channel & Modulation : GFSK



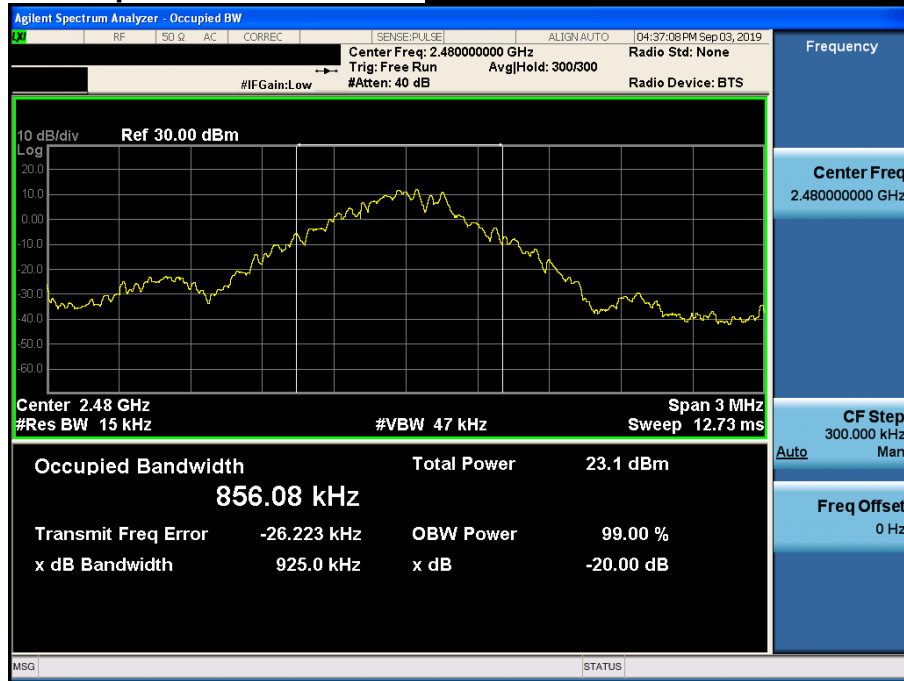
### 20 dB BW & Occupied BW

### Middle Channel & Modulation : GFSK



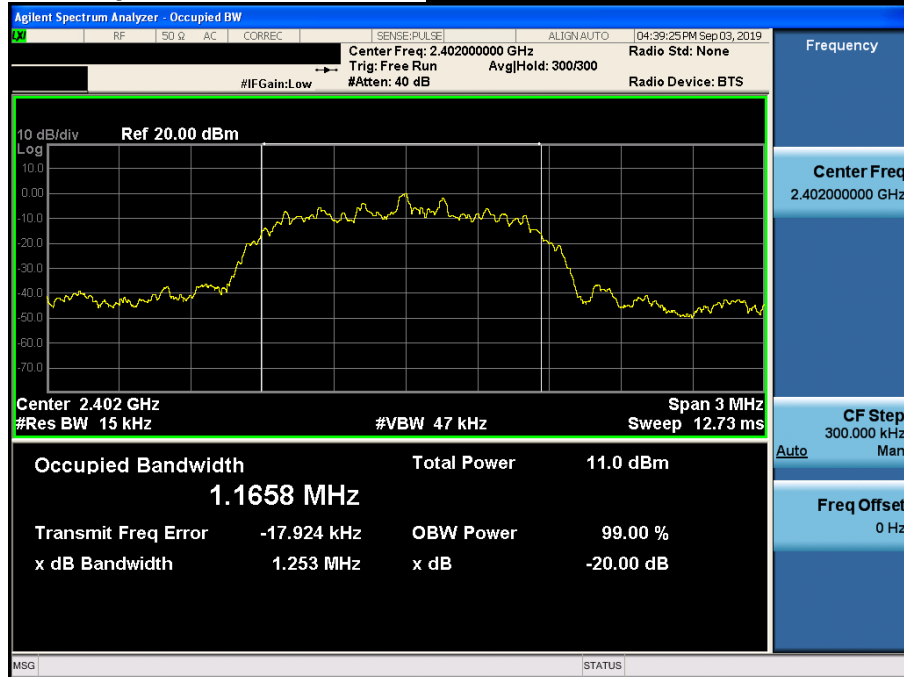
## 20 dB BW & Occupied BW

## Highest Channel & Modulation : GFSK



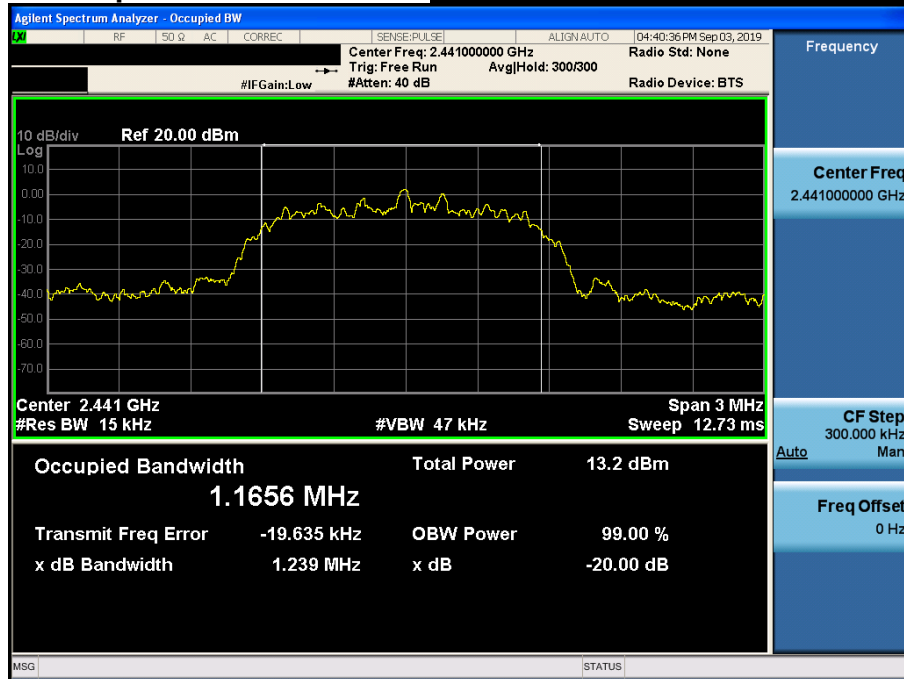
## 20 dB BW & Occupied BW

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



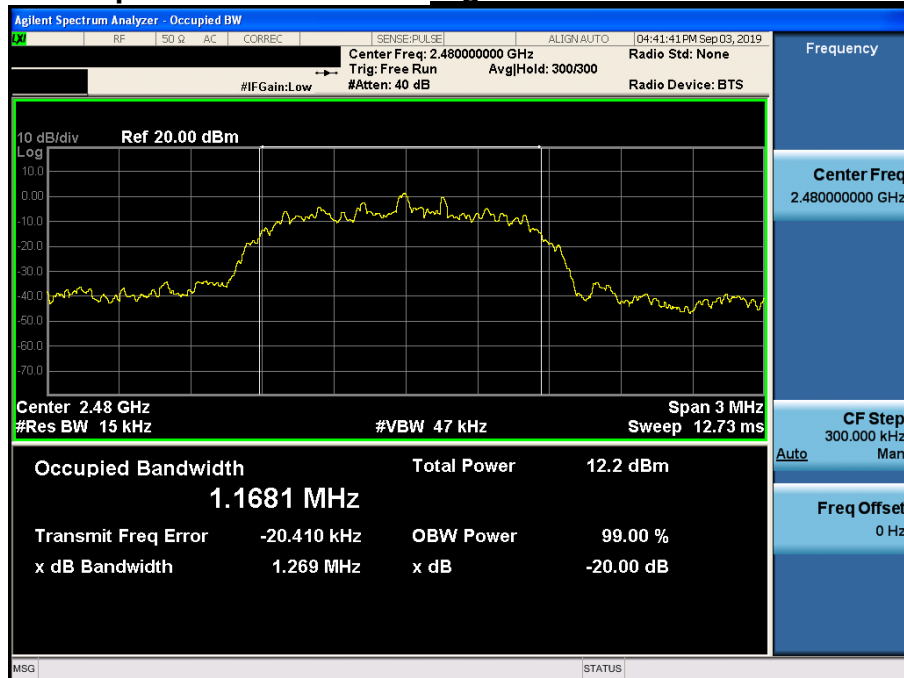
## 20 dB BW & Occupied BW

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



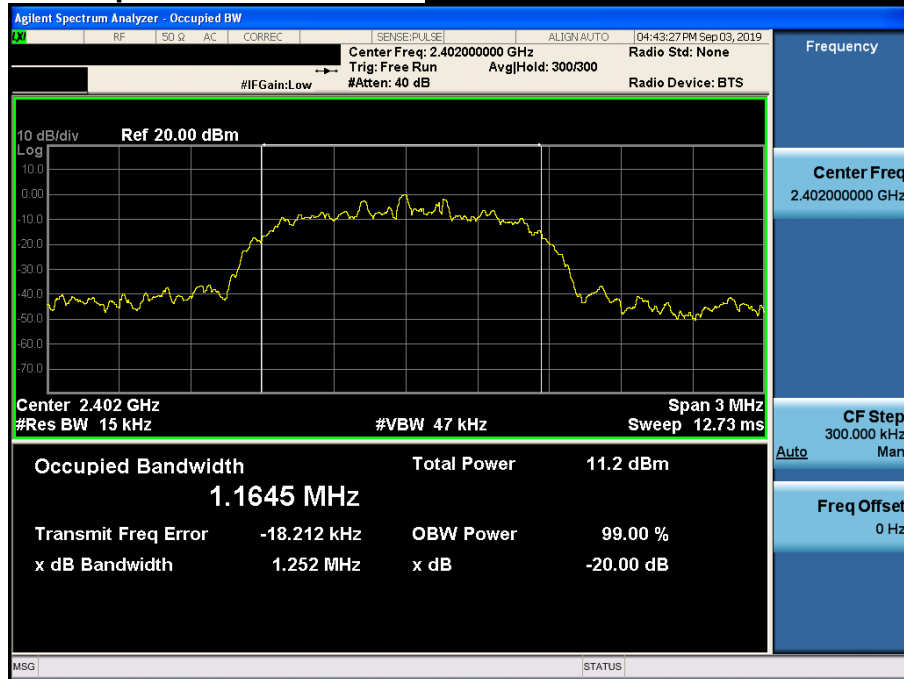
## 20 dB BW & Occupied BW

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



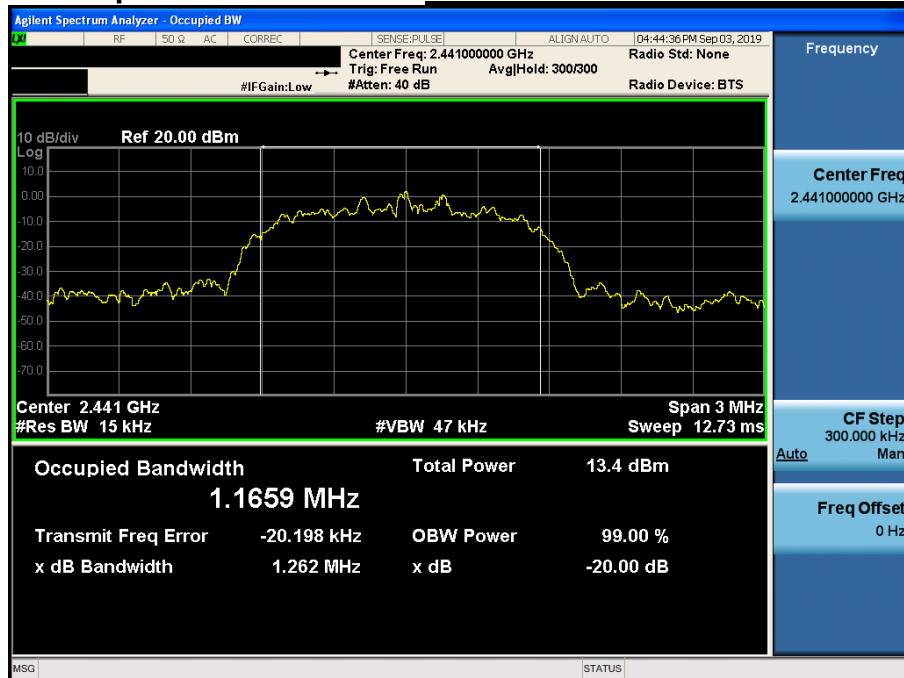
## 20 dB BW & Occupied BW

## Lowest Channel & Modulation : 8DPSK



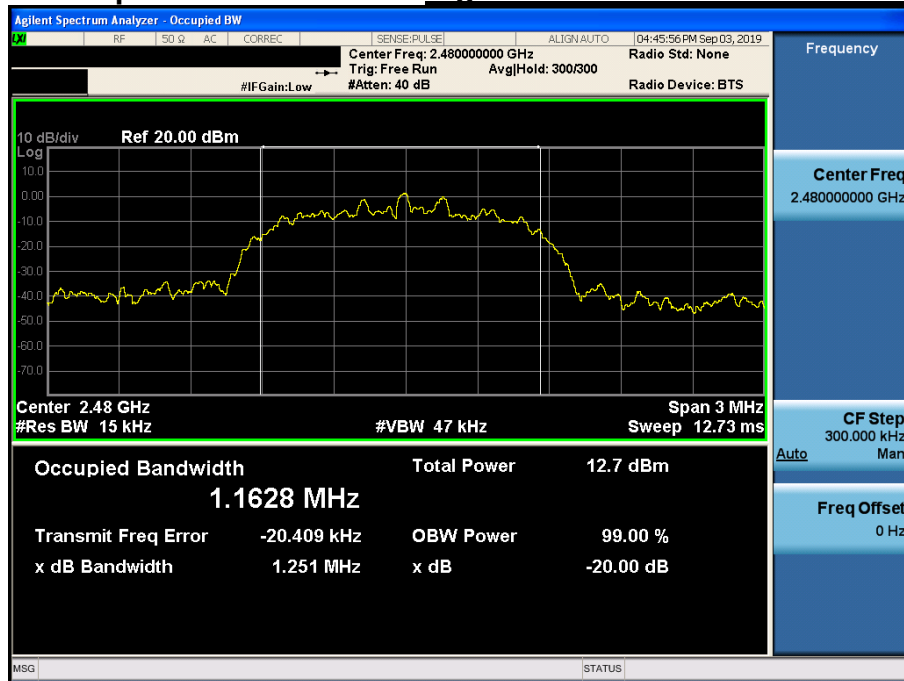
## 20 dB BW & Occupied BW

## 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\_Module 1

| Hopping Mode | Modulation    | Peak of center channel (MHz) | Peak of adjacent Channel (MHz) | Test Result (MHz) |
|--------------|---------------|------------------------------|--------------------------------|-------------------|
| Enable       | GFSK          | 2440.995                     | 2441.994                       | 0.999             |
|              | $\pi/4$ DQPSK | 2440.996                     | 2442.013                       | 1.017             |
|              | 8DPSK         | 2440.976                     | 2441.990                       | 1.014             |

#### AFH mode\_Module 1

| Hopping Mode | Modulation    | Peak of center channel (MHz) | Peak of adjacent Channel (MHz) | Test Result (MHz) |
|--------------|---------------|------------------------------|--------------------------------|-------------------|
| Enable       | GFSK          | 2440.876                     | 2441.875                       | 0.999             |
|              | $\pi/4$ DQPSK | 2441.106                     | 2442.103                       | 0.997             |
|              | 8DPSK         | 2440.995                     | 2441.995                       | 1.000             |

Note 1 : See next pages for actual measured spectrum

### FH mode\_Module 2

| Hopping Mode | Modulation    | Peak of center channel (MHz) | Peak of adjacent Channel (MHz) | Test Result (MHz) |
|--------------|---------------|------------------------------|--------------------------------|-------------------|
| Enable       | GFSK          | 2441.039                     | 2442.027                       | 0.988             |
|              | $\pi/4$ DQPSK | 2440.971                     | 2441.971                       | 1.000             |
|              | 8DPSK         | 2441.099                     | 2442.107                       | 1.008             |

### AFH mode\_Module 2

| Hopping Mode | Modulation    | Peak of center channel (MHz) | Peak of adjacent Channel (MHz) | Test Result (MHz) |
|--------------|---------------|------------------------------|--------------------------------|-------------------|
| Enable       | GFSK          | 2440.994                     | 2441.994                       | 1.000             |
|              | $\pi/4$ DQPSK | 2441.015                     | 2442.015                       | 1.000             |
|              | 8DPSK         | 2440.983                     | 2441.990                       | 1.007             |

Note 1 : See next pages for actual measured spectrum

#### - Minimum Standard :

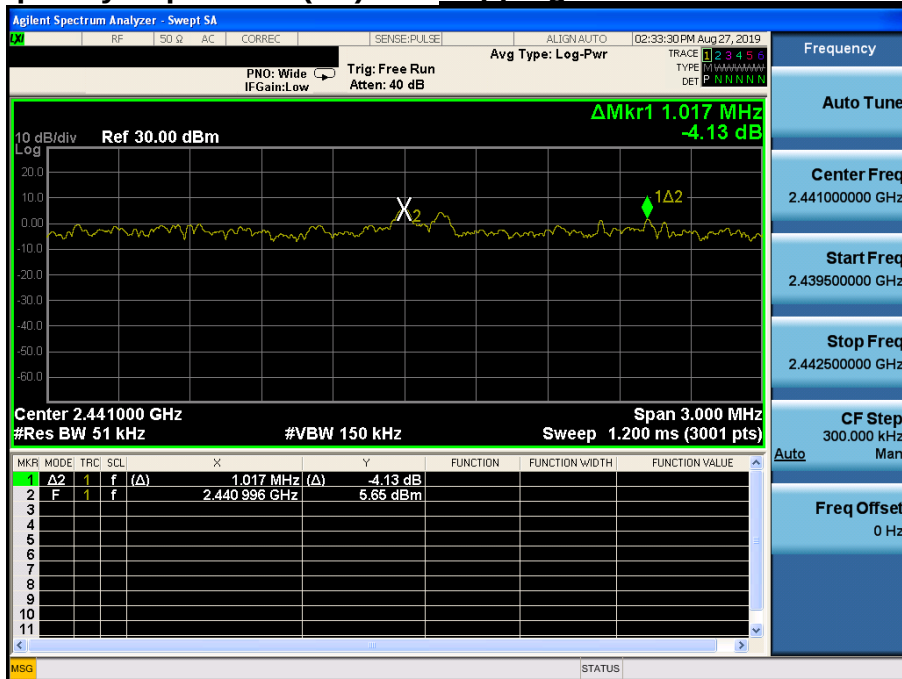
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.  
Alternatively, frequency hopping systems operating in the 2400 - 2483.5 MHz band may have hopping channel carrier frequencies 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

<Module 1>

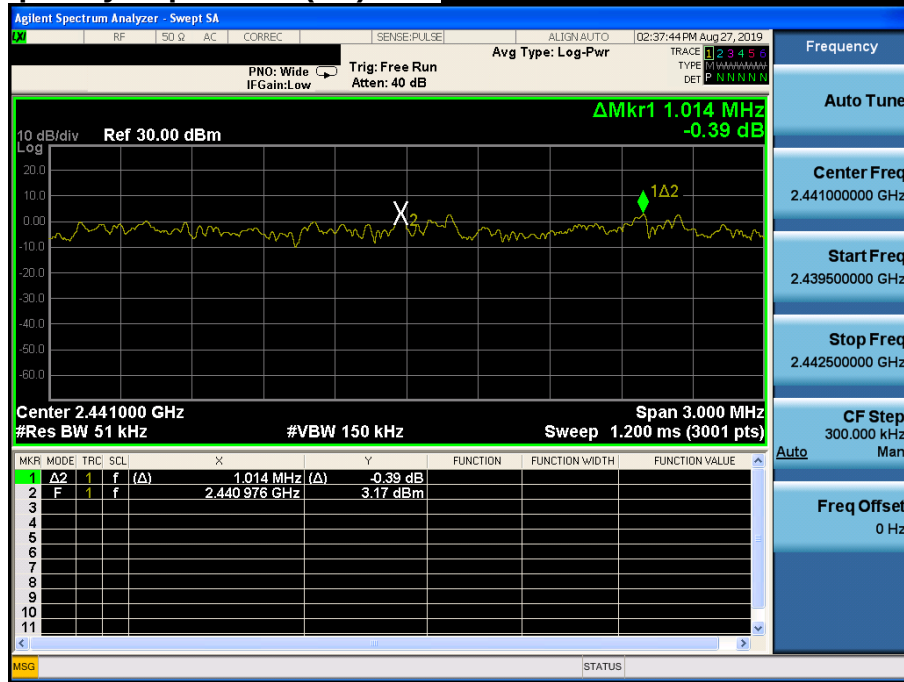
Carrier Frequency Separation (FH) *Hopping mode : Enable & GFSK*



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



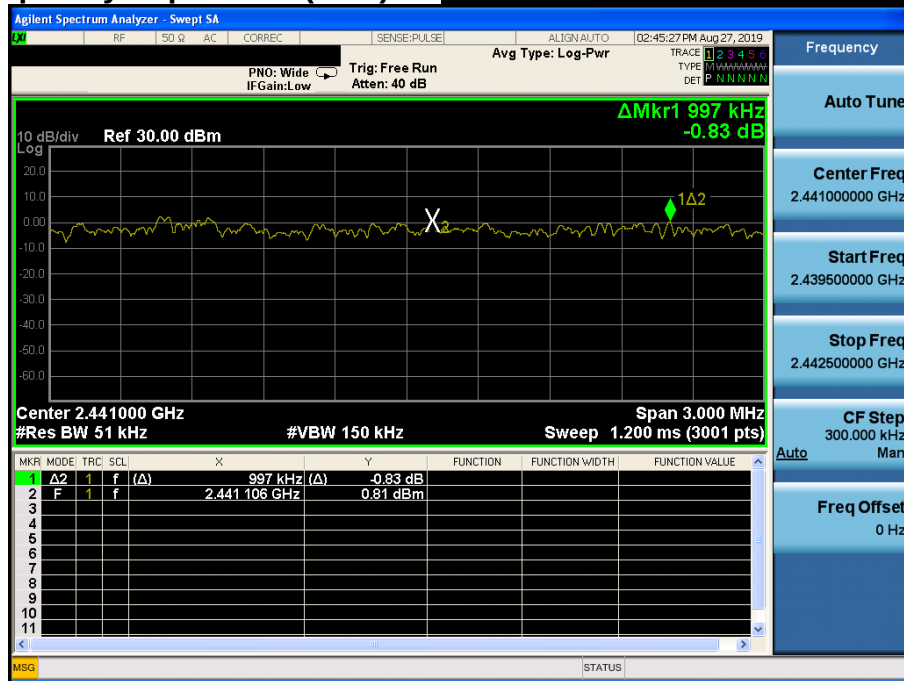
# Carrier Frequency Separation (FH) *Hopping mode : Enable & 8DPSK*



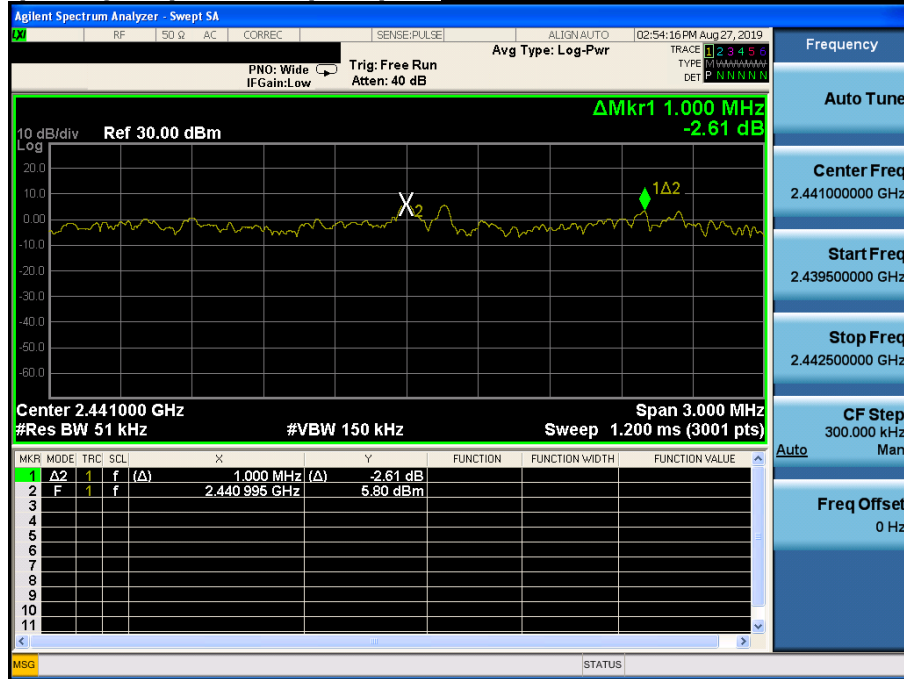
# Carrier Frequency Separation (AFH) *Hopping mode : Enable & GFSK*



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

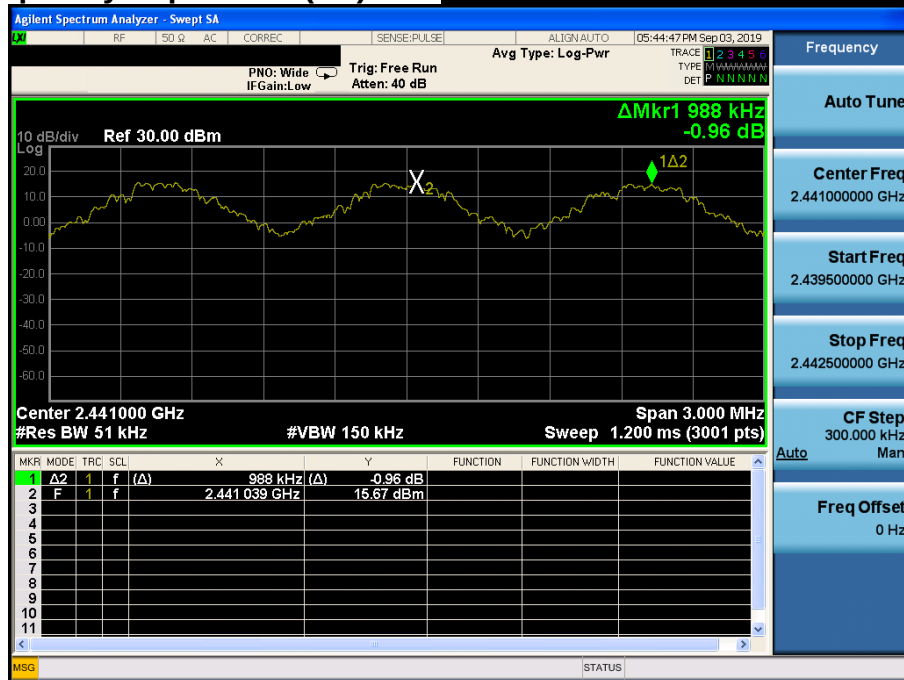


**Carrier Frequency Separation (AFH) *Hopping mode : Enable & 8DPSK***

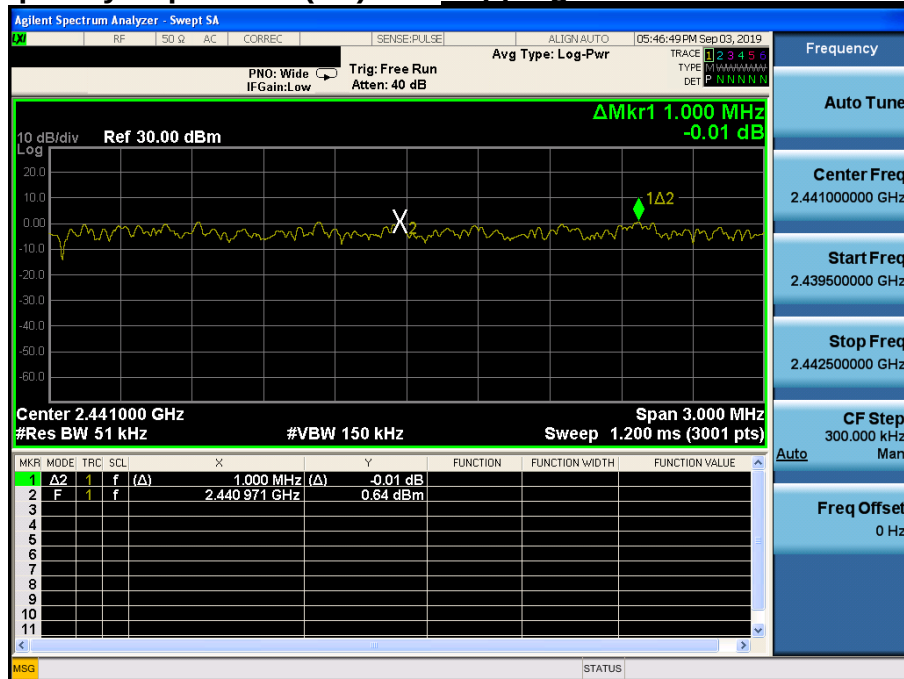


<Module 2>

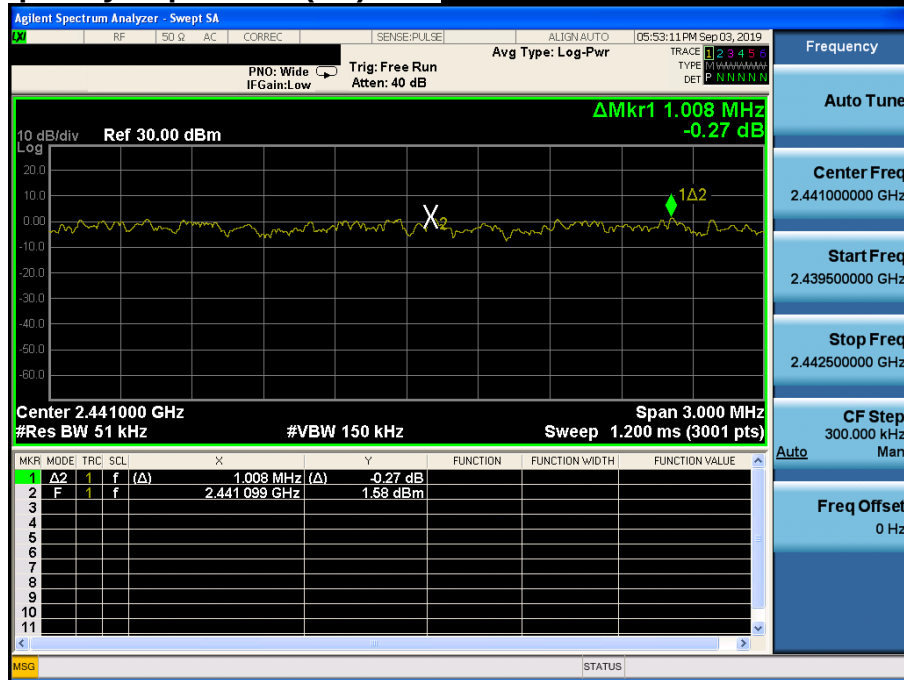
Carrier Frequency Separation (FH) *Hopping mode : Enable & GFSK*



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



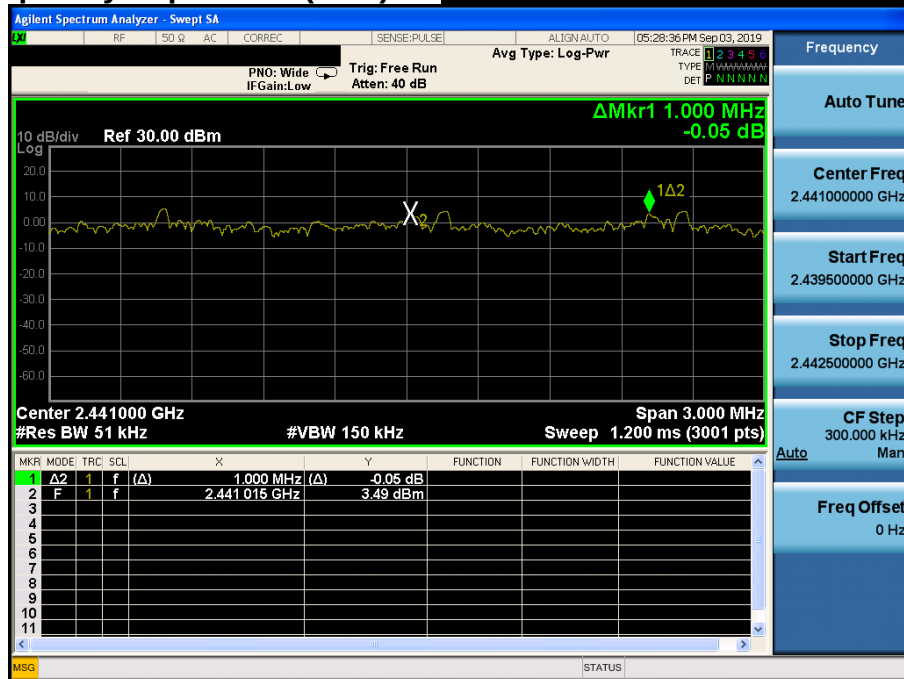
# Carrier Frequency Separation (FH) *Hopping mode : Enable & 8DPSK*



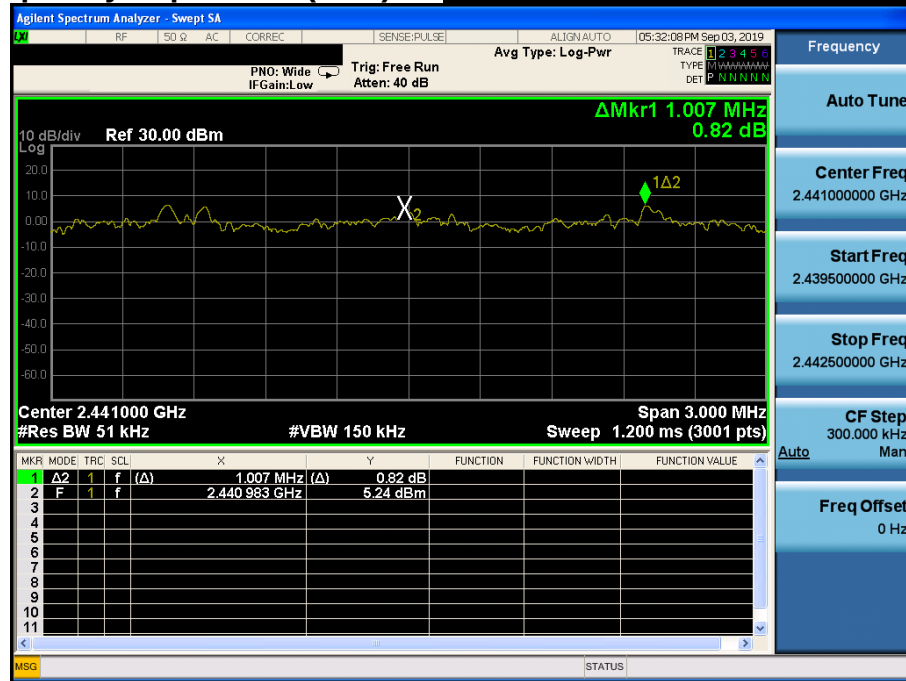
## Carrier Frequency Separation (AFH) *Hopping mode : Enable & GFSK*



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



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



## 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\_Module 1

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

#### AFH mode\_Module 1

| 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.

### FH mode\_Module 2

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

### AFH mode\_Module 2

| 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.

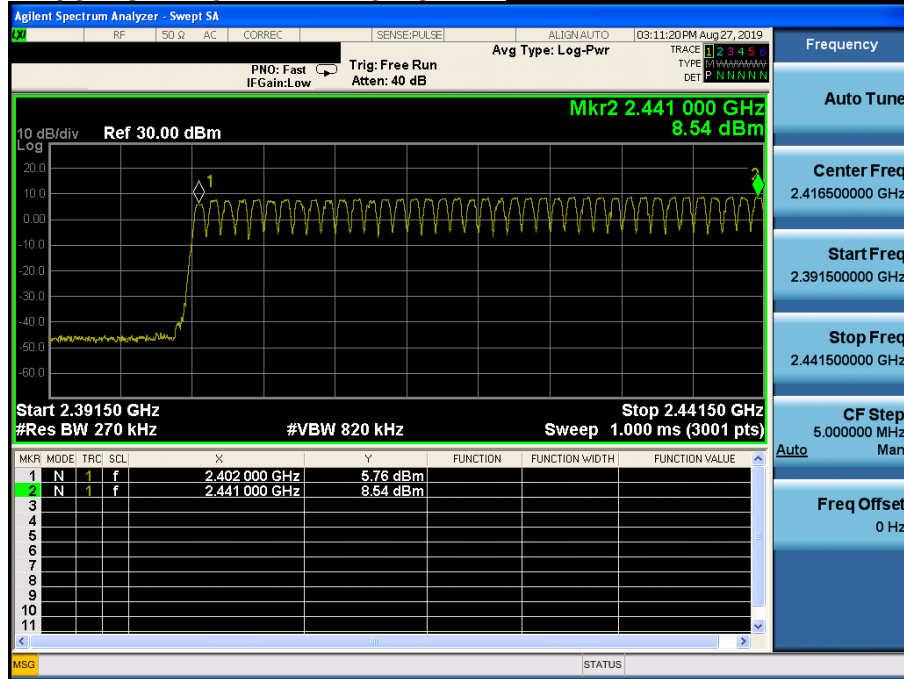
### - Minimum Standard :

At least 15 hops

<Module 1>

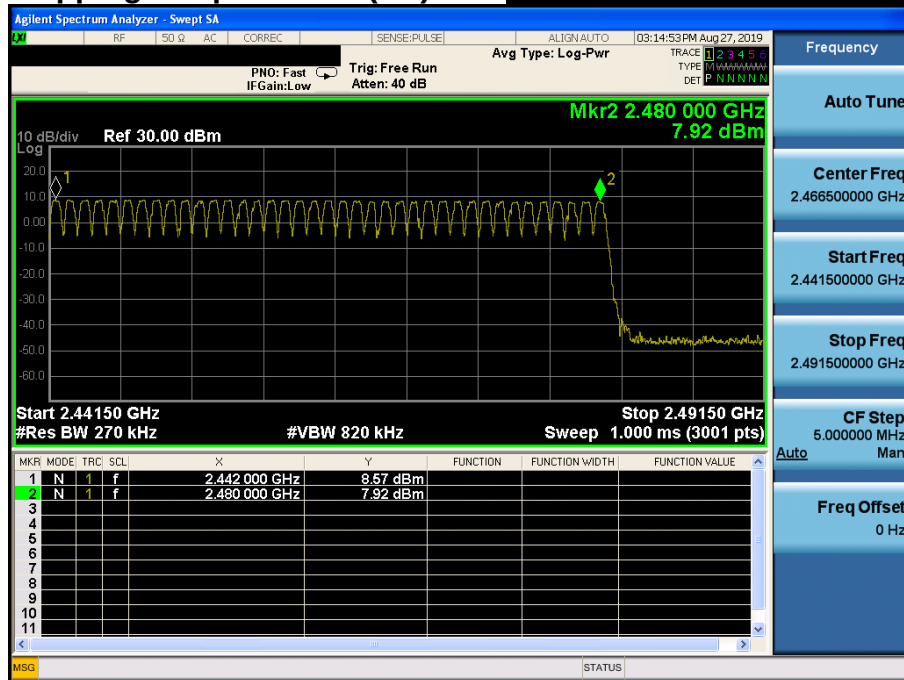
Number of Hopping Frequencies 1(FH)

Hopping mode : Enable & GFSK



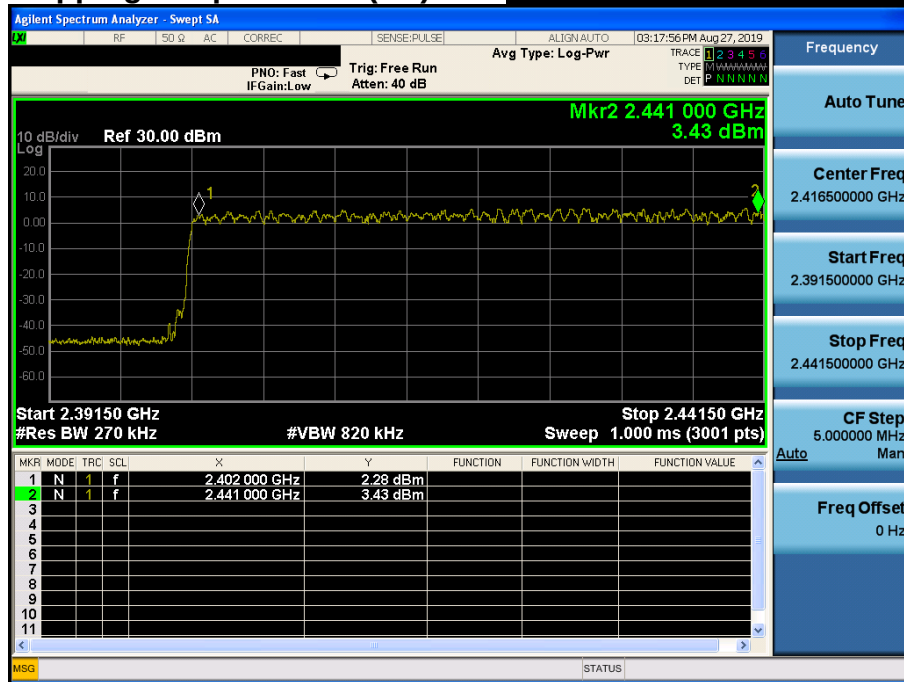
Number of Hopping Frequencies 2(FH)

Hopping mode : Enable & GFSK



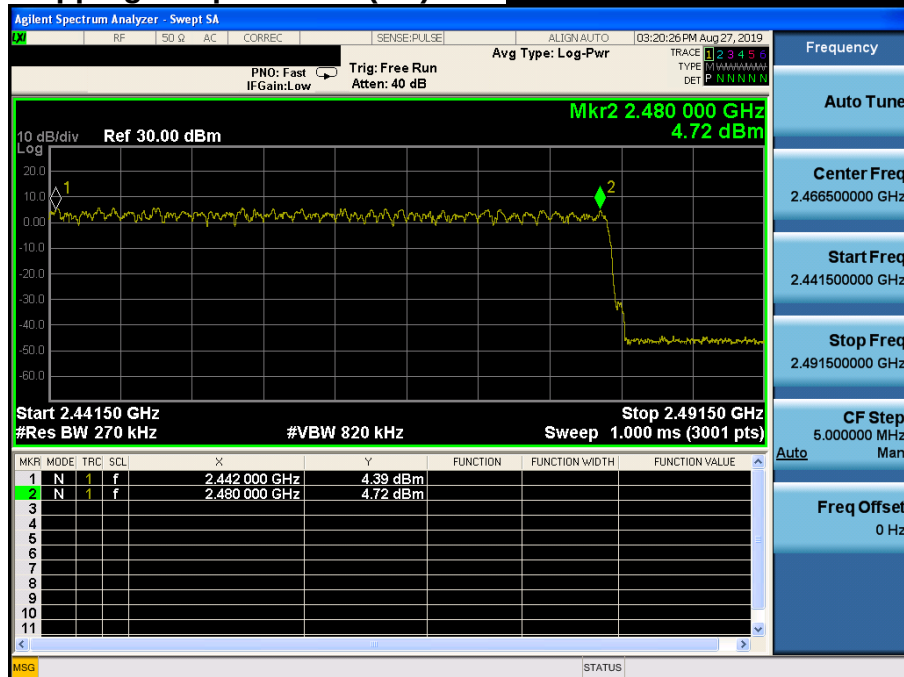
## Number of Hopping Frequencies 1(FH)

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

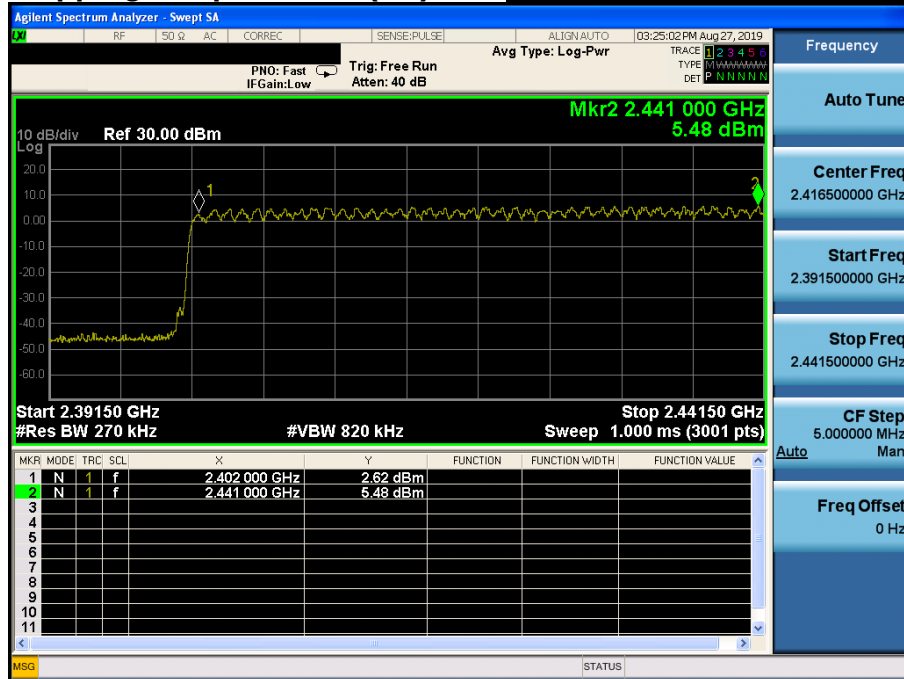


## Number of Hopping Frequencies 2(FH)

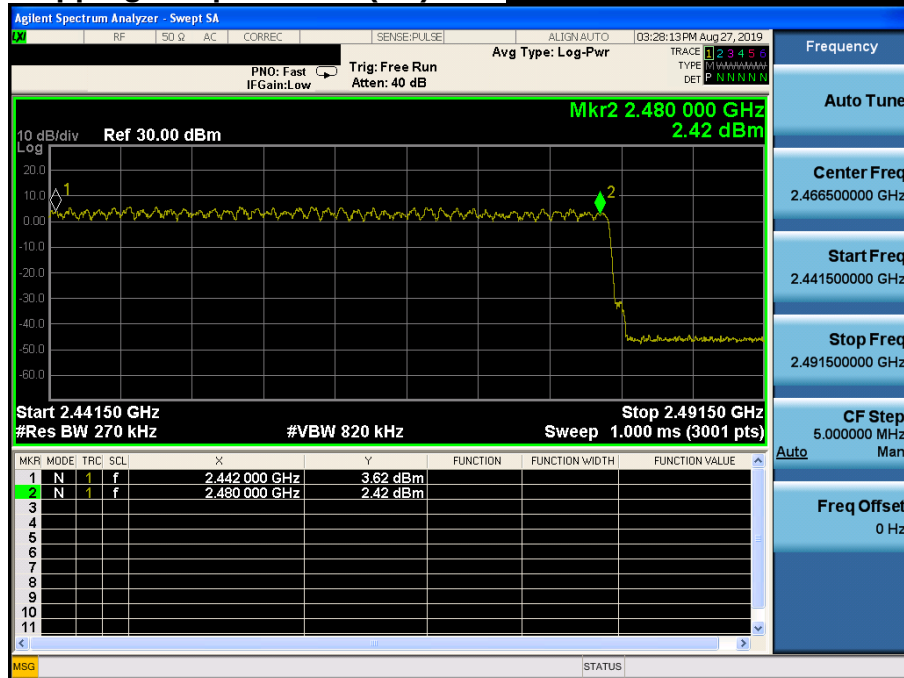
**Hopping mode : Enable &  $\pi/4$ DQPSK**



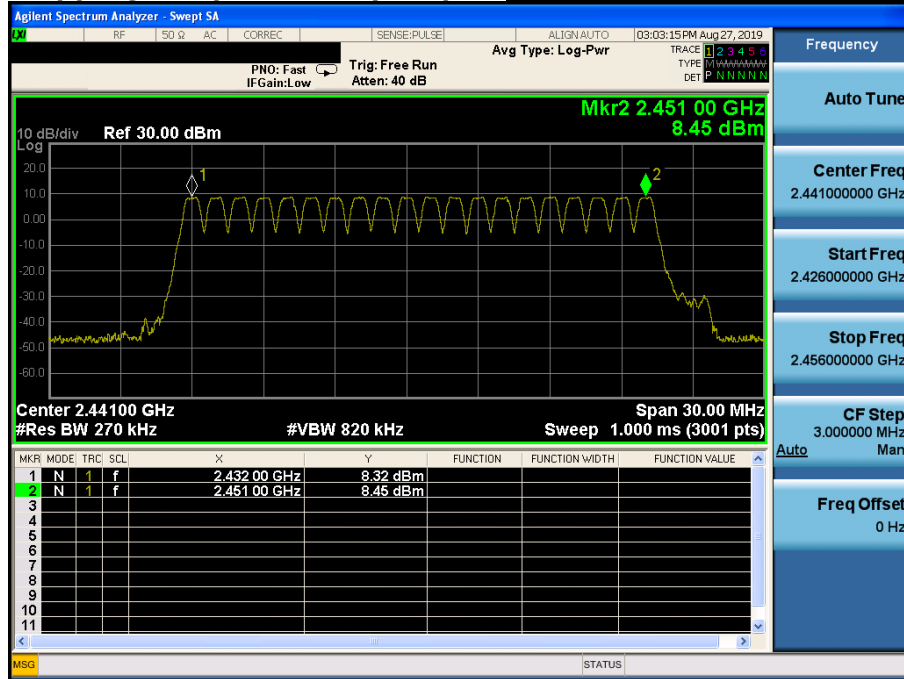
## Number of Hopping Frequencies 1(FH) *Hopping mode : Enable & 8DPSK*



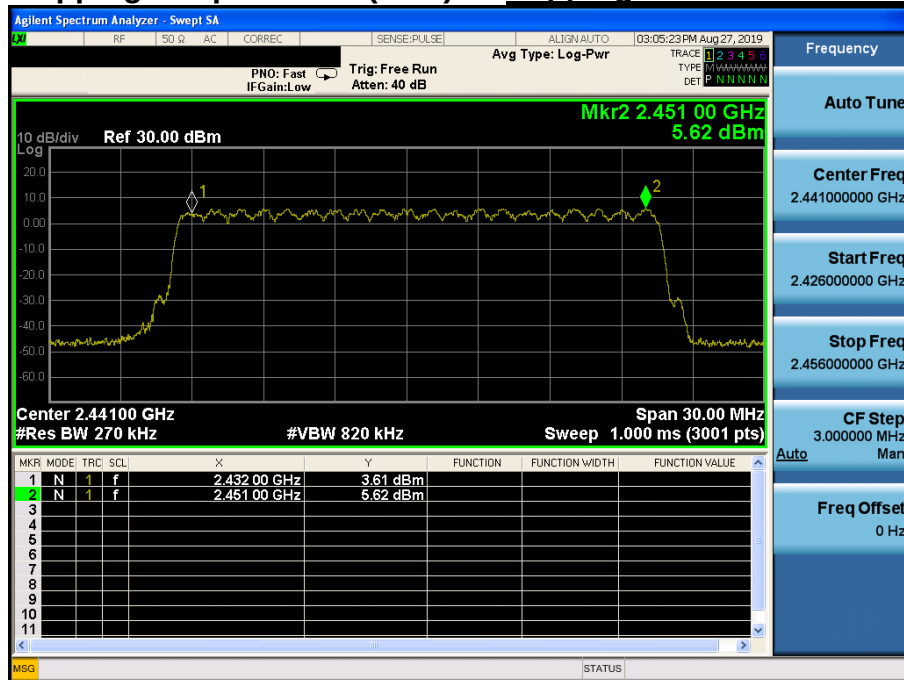
## Number of Hopping Frequencies 2(FH) *Hopping mode : Enable & 8DPSK*



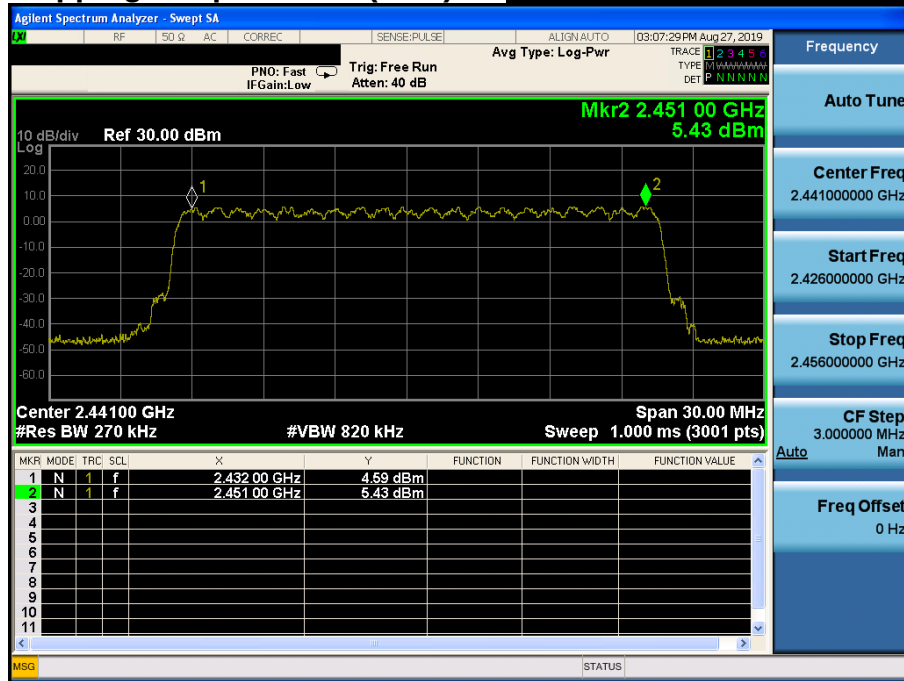
Number of Hopping Frequencies 1(AFH) Hopping mode : Enable & GFSK



Number of Hopping Frequencies 1(AFH) Hopping mode : Enable &  $\pi/4$ DQPSK

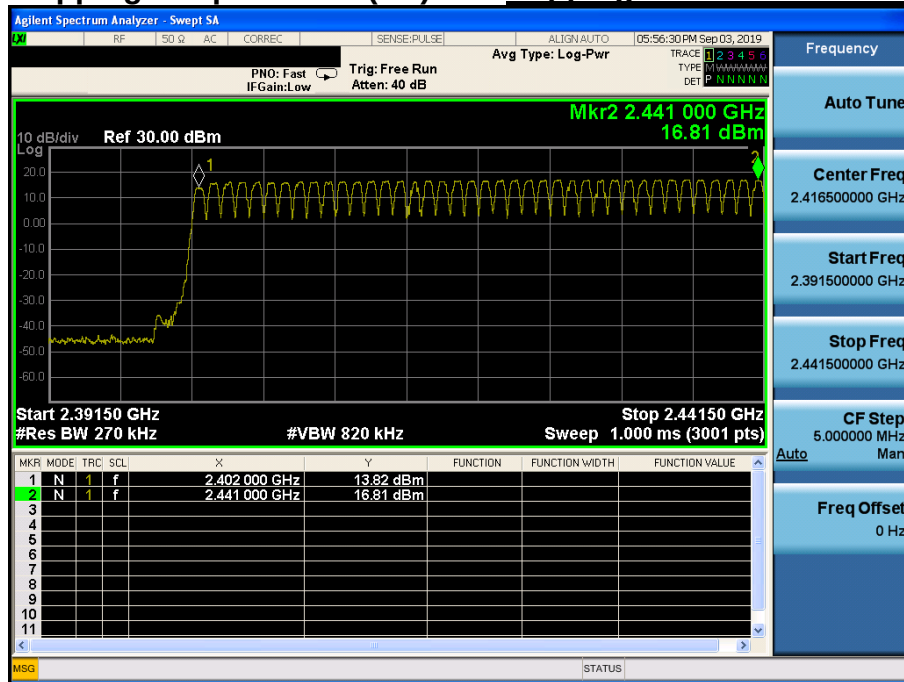


Number of Hopping Frequencies 1(AFH) Hopping mode : Enable & 8DPSK

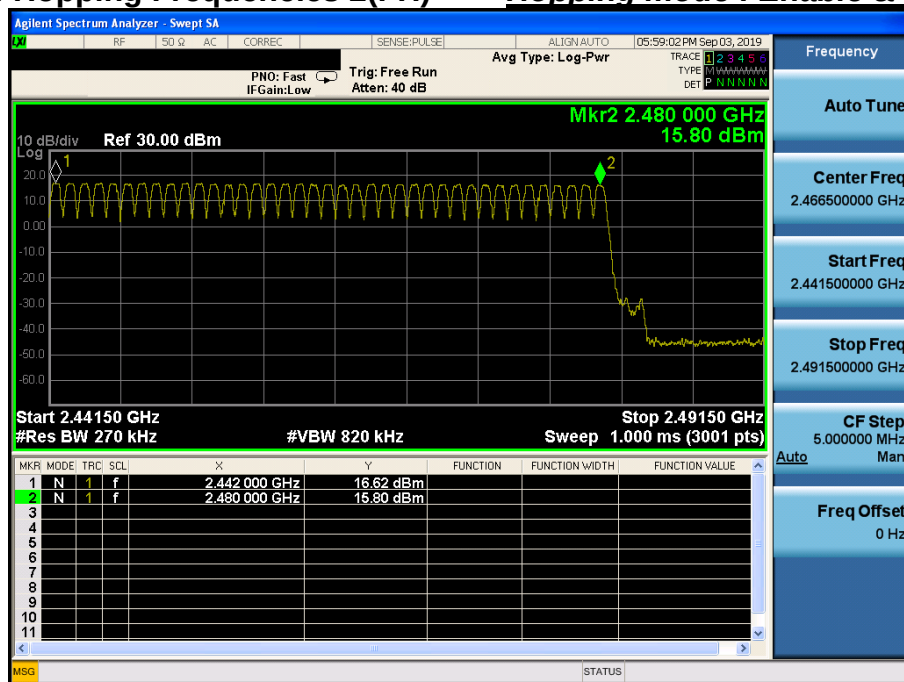


<Module 2>

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

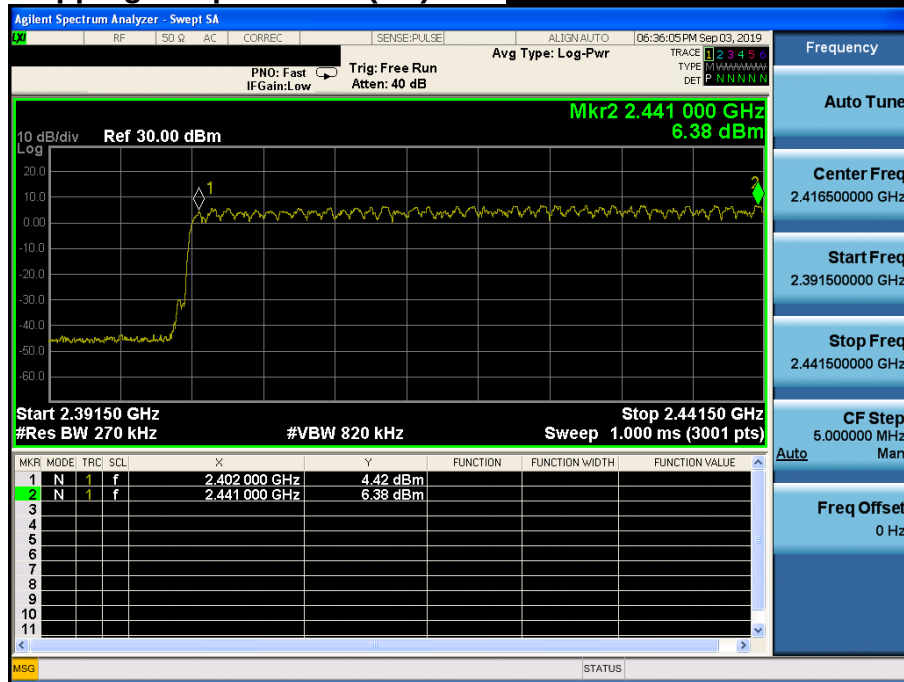


Number of Hopping Frequencies 2(FH) *Hopping mode : Enable & GFSK*



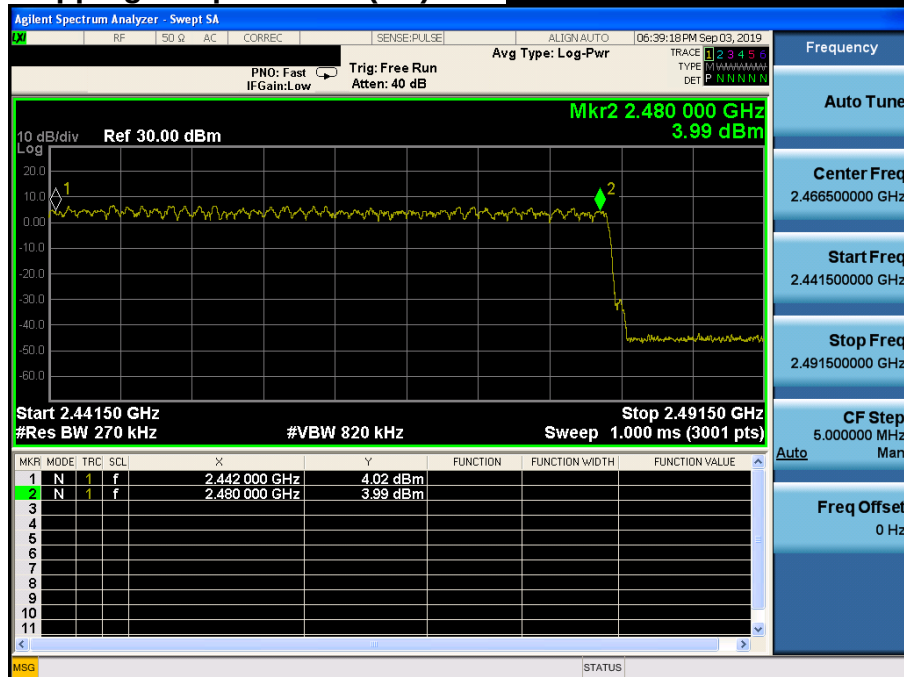
## Number of Hopping Frequencies 1(FH)

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

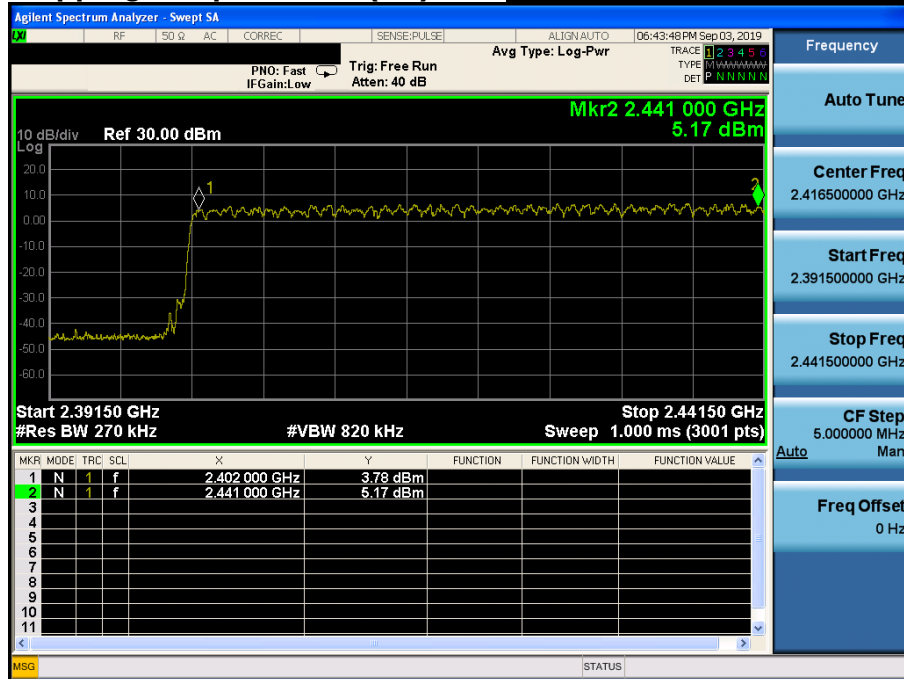


## Number of Hopping Frequencies 2(FH)

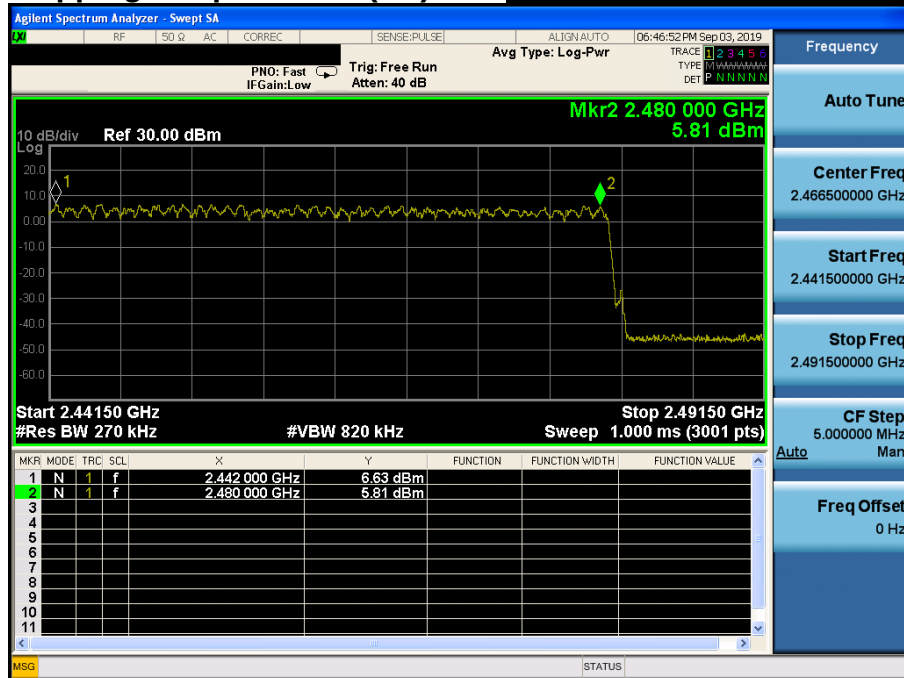
**Hopping mode : Enable &  $\pi/4$ -DQPSK**



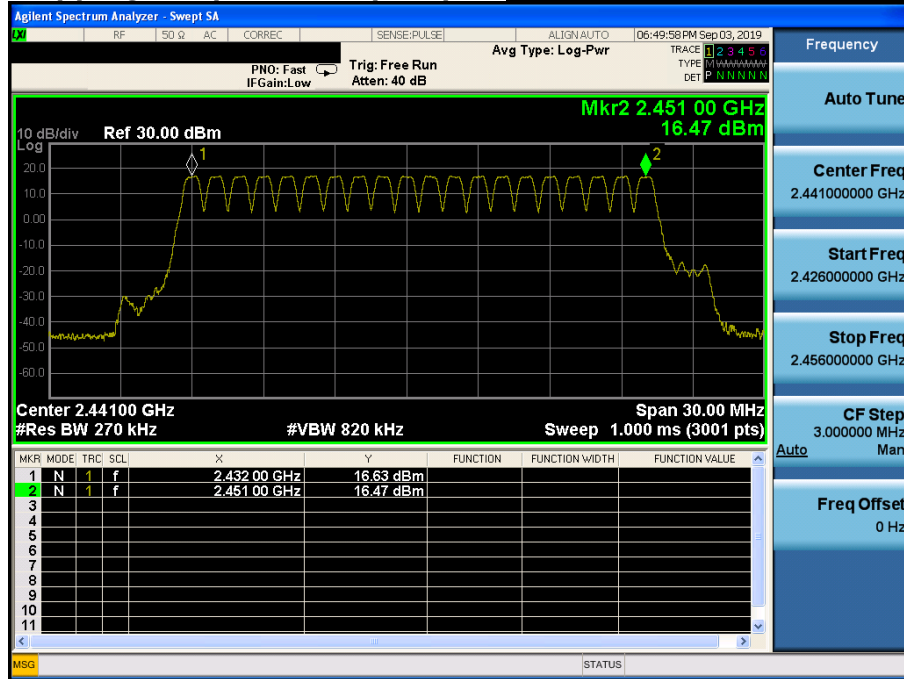
Number of Hopping Frequencies 1(FH) *Hopping mode : Enable & 8DPSK*



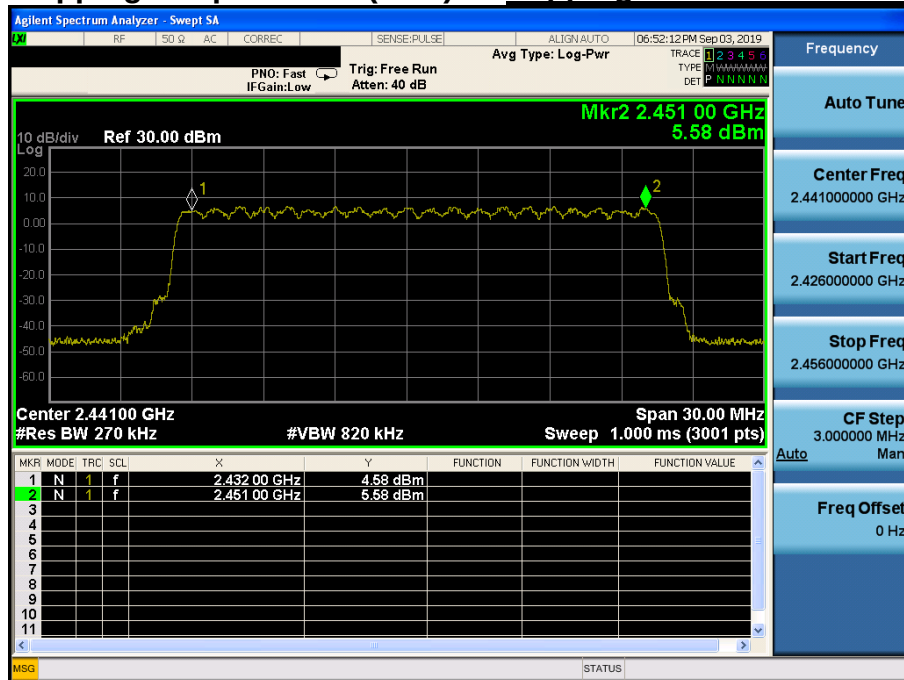
Number of Hopping Frequencies 2(FH) *Hopping mode : Enable & 8DPSK*



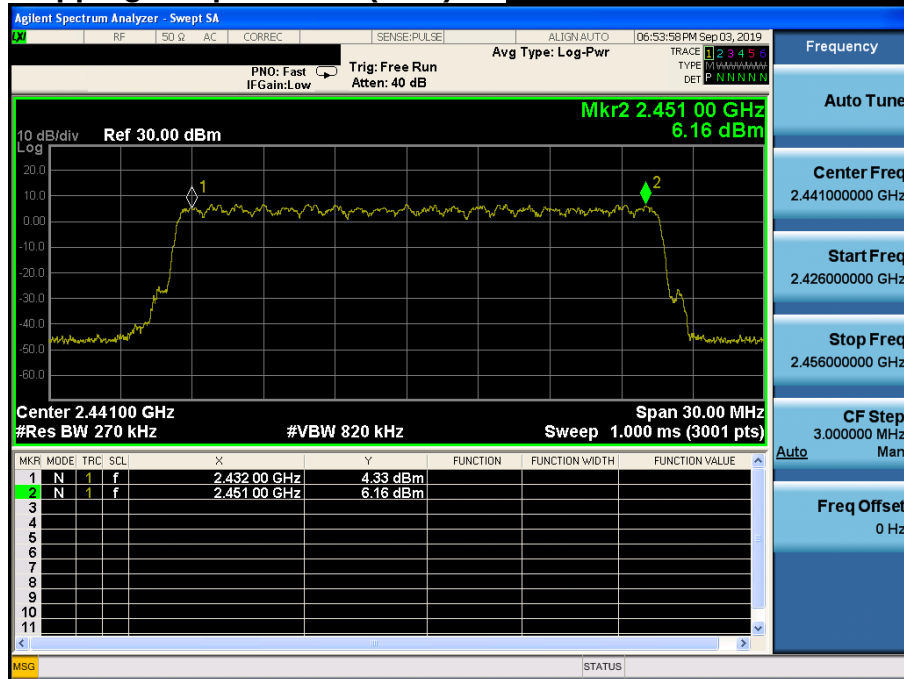
Number of Hopping Frequencies 1(AFH) **Hopping mode : Enable & GFSK**



Number of Hopping Frequencies 1(AFH) **Hopping mode : Enable &  $\pi/4$ -DQPSK**



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\_Module 1

| 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\_Module 1

| 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.

### FH mode\_Module 2

| 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\_Module 2

| 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 =  $0.4 \times \text{Hopping channel} \times \text{Burst ON time} \times ((\text{Hopping rate} \div \text{Time slots}) \div \text{Hopping channel})$

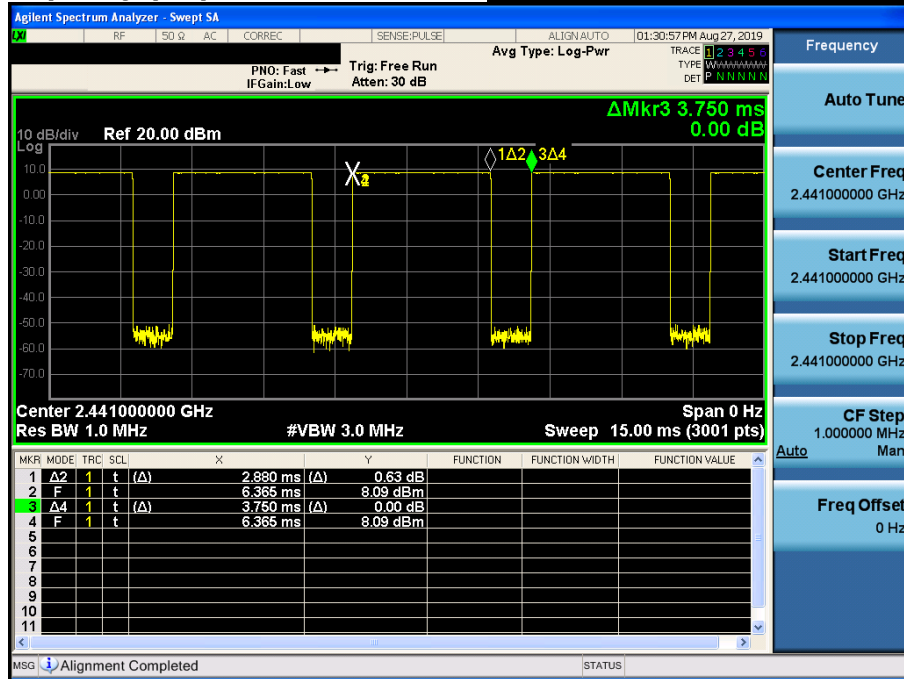
- Time slots for DH5 = 6 slots (TX = 5 slot / RX = 1 slot)
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

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

<Module 1>

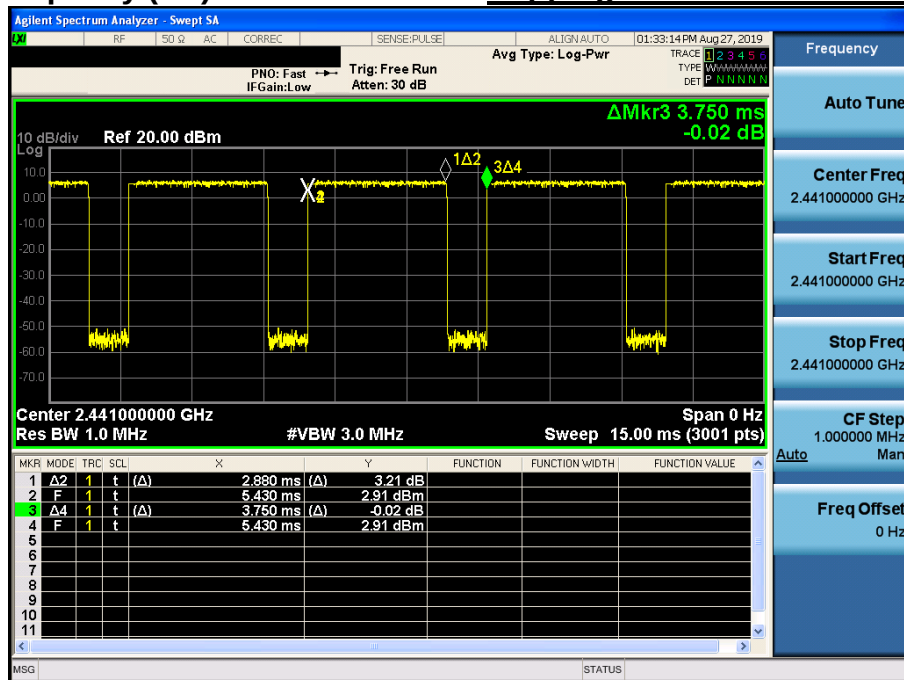
Time of Occupancy (FH)

Hopping mode : Enable & DH5



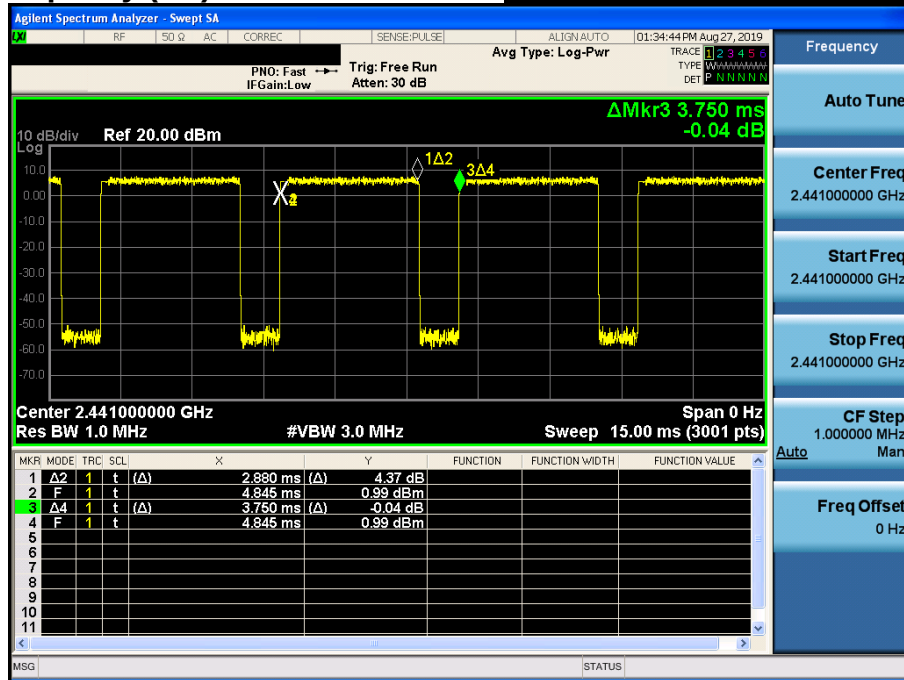
Time of Occupancy (FH)

Hopping mode : Enable & 2-DH5



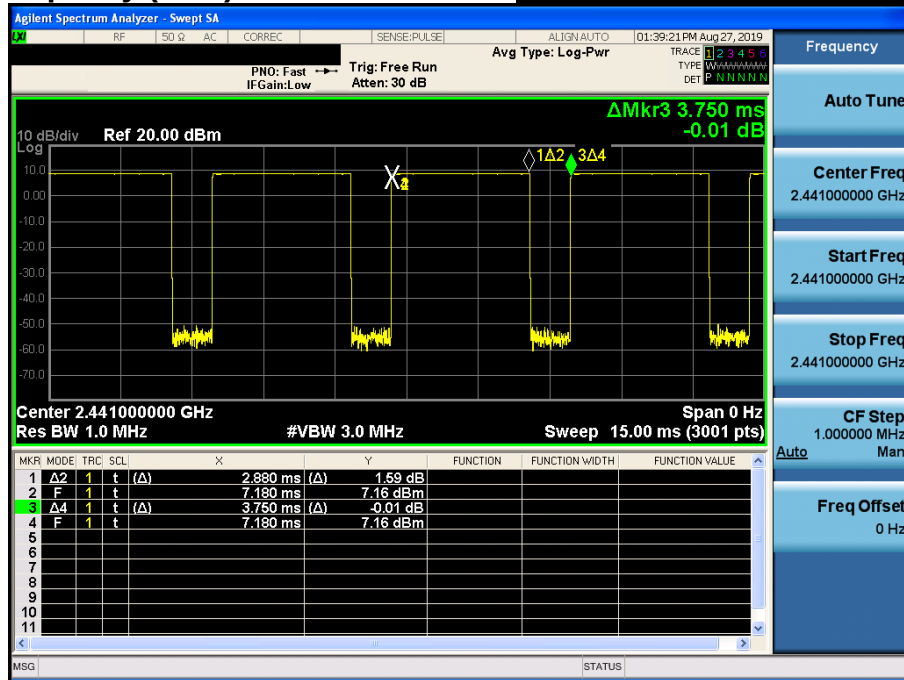
# Time of Occupancy (FH)

## Hopping mode : Enable & 3-DH5



## Time of Occupancy (AFH)

## Hopping mode : Enable & DH5



## Time of Occupancy (AFH)

## Hopping mode : Enable & 2-DH5

