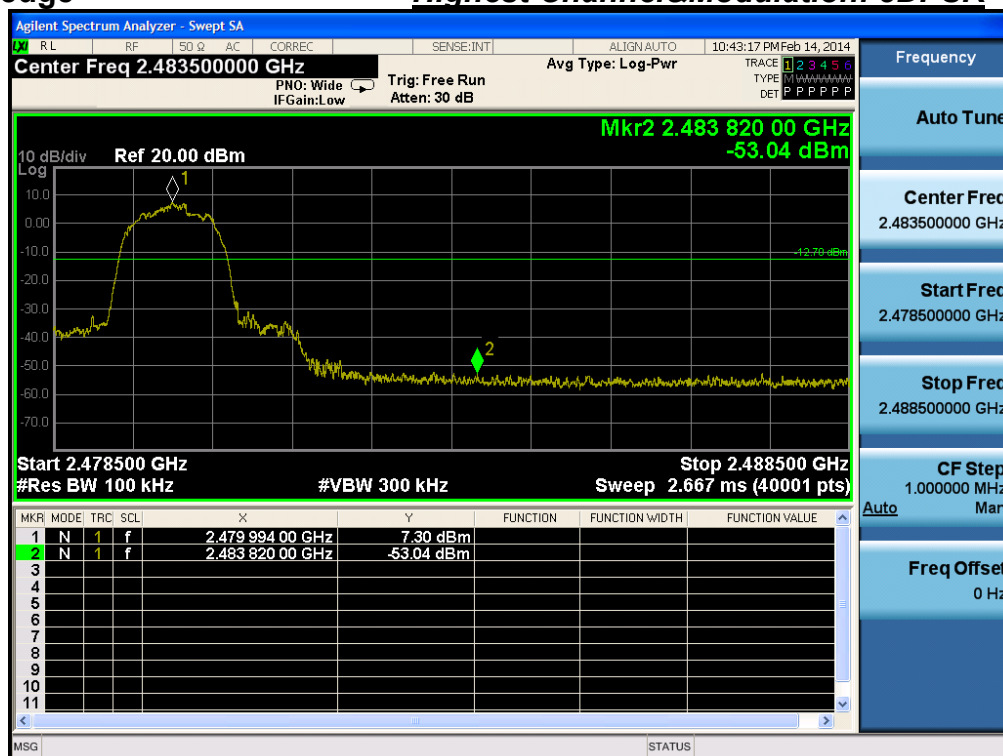


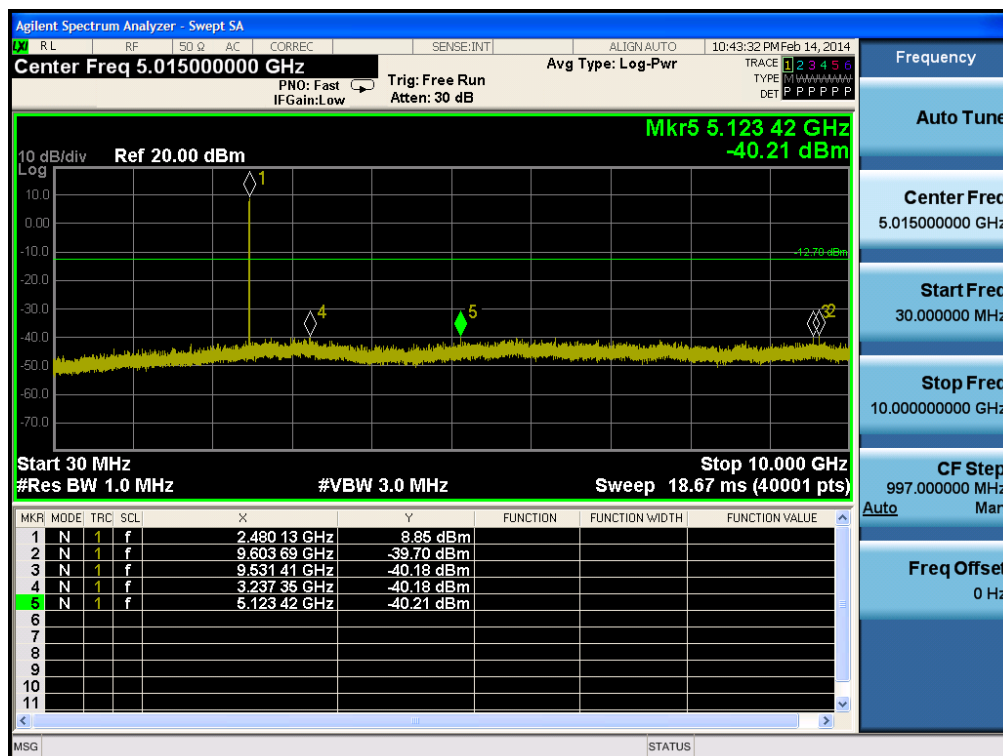
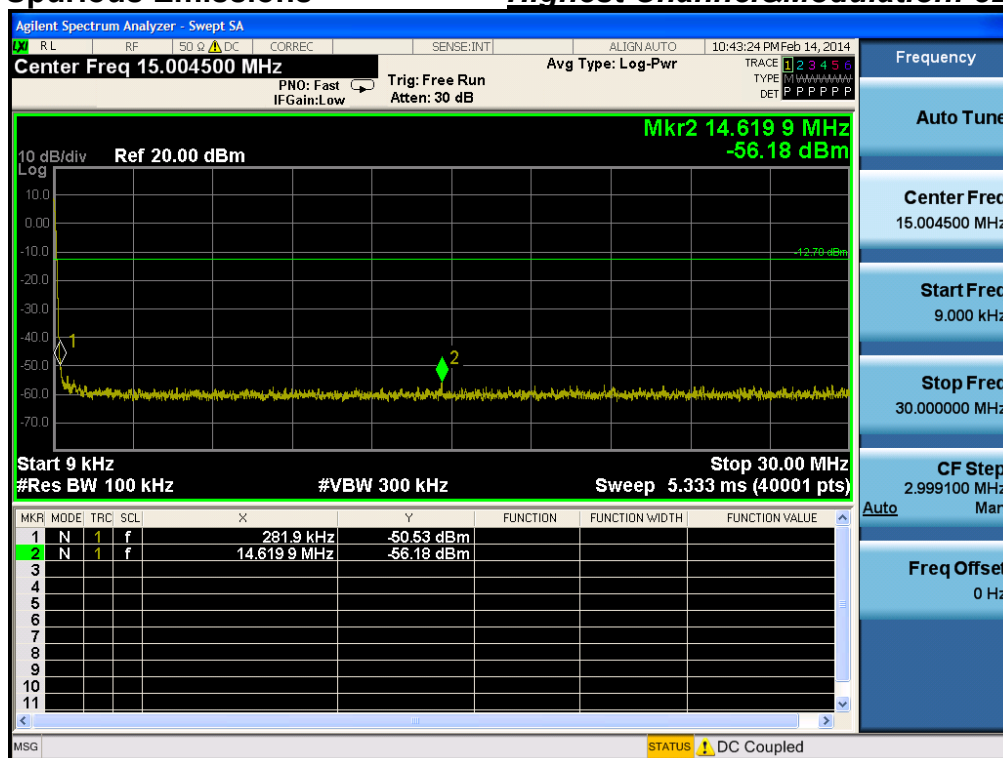
## High Band-edge

**Highest Channel&Modulation: 8DPSK**

## High Band-edge

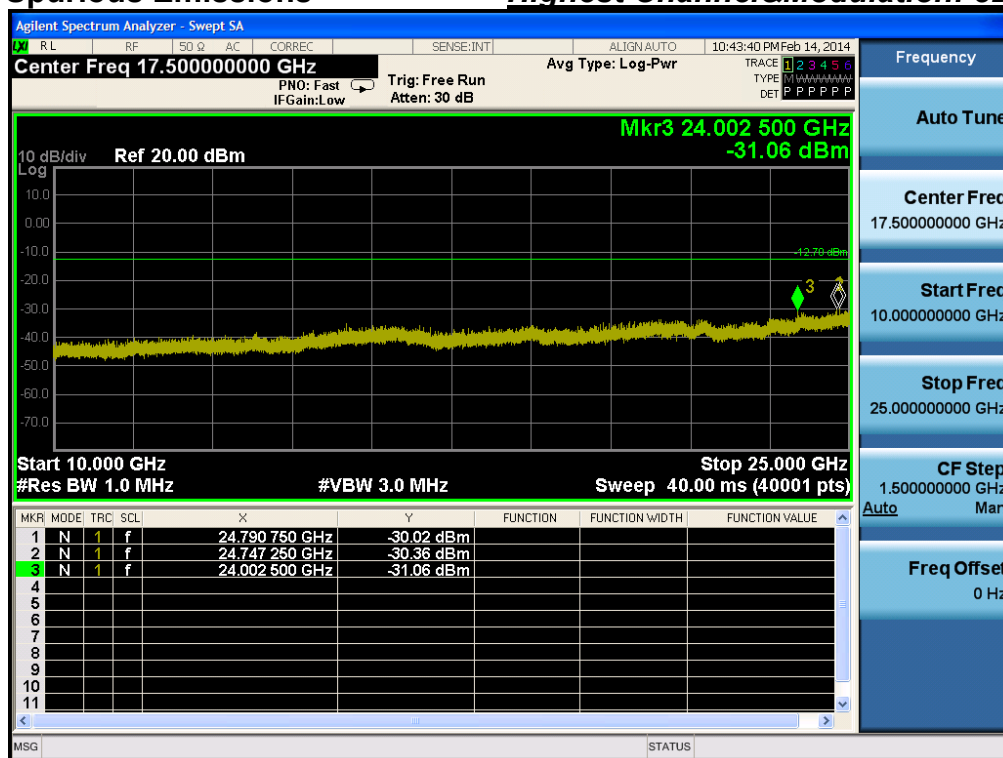
**Hopping mode&Modulation: 8DPSK**

## Conducted Spurious Emissions

Highest Channel&Modulation: 8DPSK

# Conducted Spurious Emissions

***Highest Channel&Modulation: 8DPSK***



### 3. Carrier Frequency Separation

#### 3.1. Test Setup

Refer to the APPENDIX I.

#### 3.2. Limit

Limit:  $\geq 20\text{dB BW}$  or  $\geq \text{Two-Thirds of the } 20\text{dB BW}$

#### - 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 = 1% of the span

Sweep = auto

VBW =  $\geq$  RBW

Detector function = peak

Trace = max hold

#### - Measurement Data: **Comply**

#### - FH mode

| Hopping Mode | Test Mode      | Peak of adjacent Channel (MHz) | Peak of center channel (MHz) | Test Result (MHz) |
|--------------|----------------|--------------------------------|------------------------------|-------------------|
| Enable       | GFSK           | 2439.989                       | 2440.994                     | 1.005             |
|              | $\pi/4$ -DQPSK | 2440.148                       | 2441.156                     | 1.008             |
|              | 8DPSK          | 2440.151                       | 2441.159                     | 1.008             |

#### - AFH mode

| Hopping Mode | Test Mode      | Peak of adjacent Channel (MHz) | Peak of center channel (MHz) | Test Result (MHz) |
|--------------|----------------|--------------------------------|------------------------------|-------------------|
| Enable       | GFSK           | 2401.013                       | 2411.015                     | 1.002             |
|              | $\pi/4$ -DQPSK | 2410.988                       | 2411.993                     | 1.005             |
|              | 8DPSK          | 2411.153                       | 2412.155                     | 1.002             |

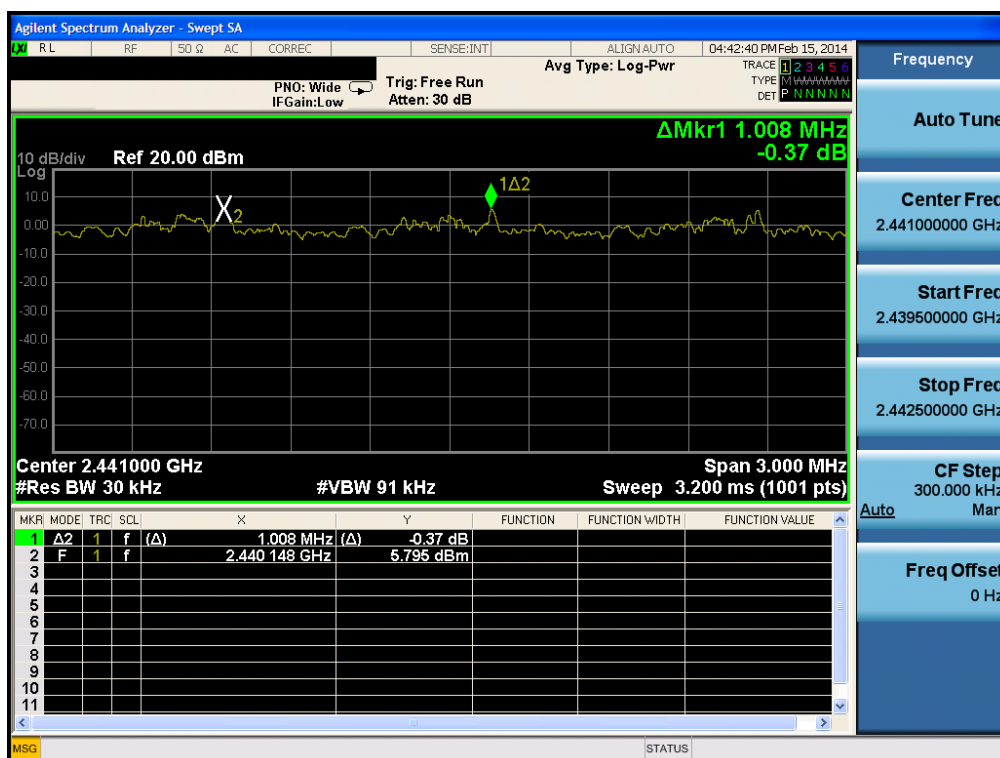
Note 1: See next pages for actual measured spectrum plots.

#### - Minimum Standard:

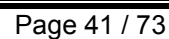
Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.

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

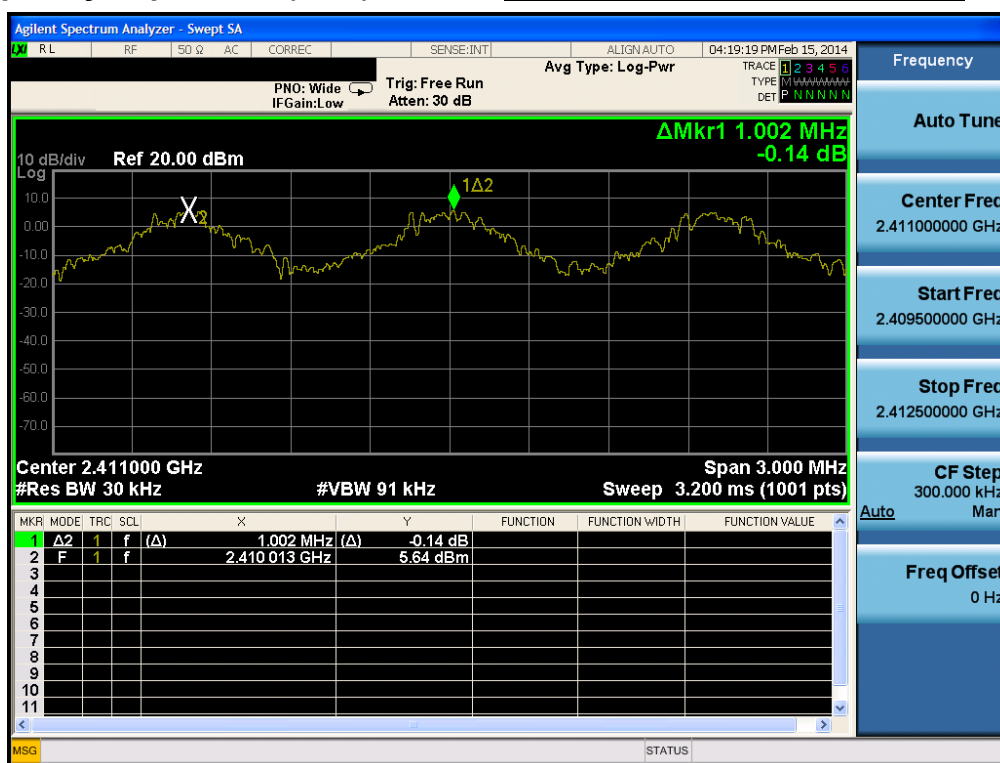
**Hopping mode: Enable&GFSK**



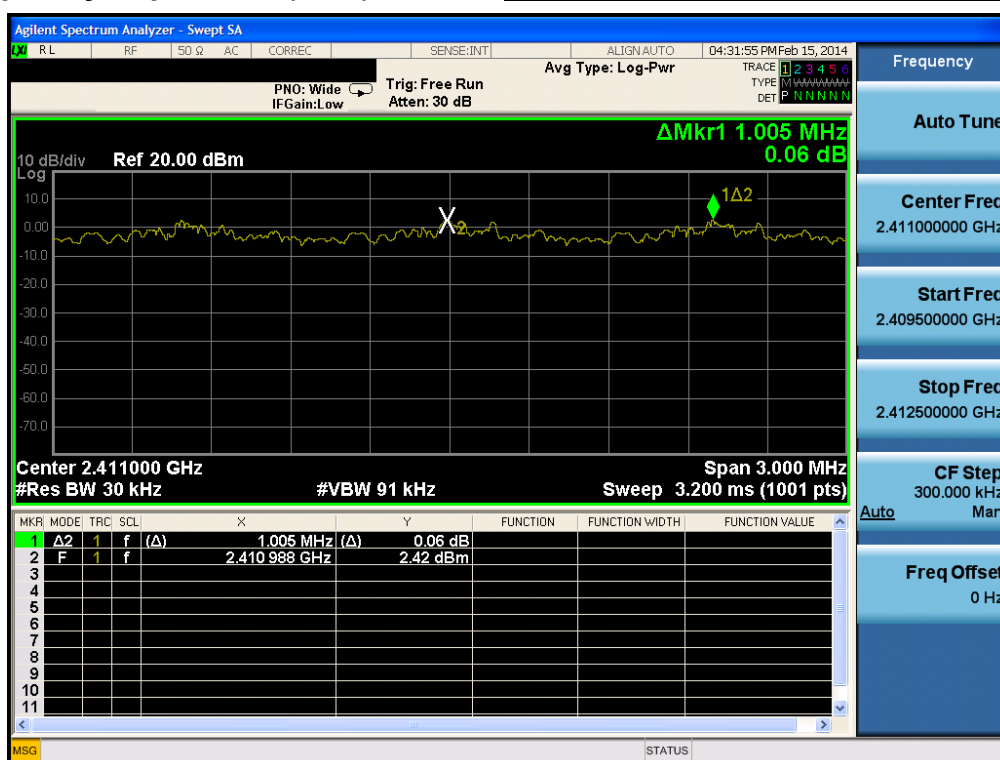
**Hopping mode: Enable&8DPSK**



## Carrier Frequency Separation (AFH)

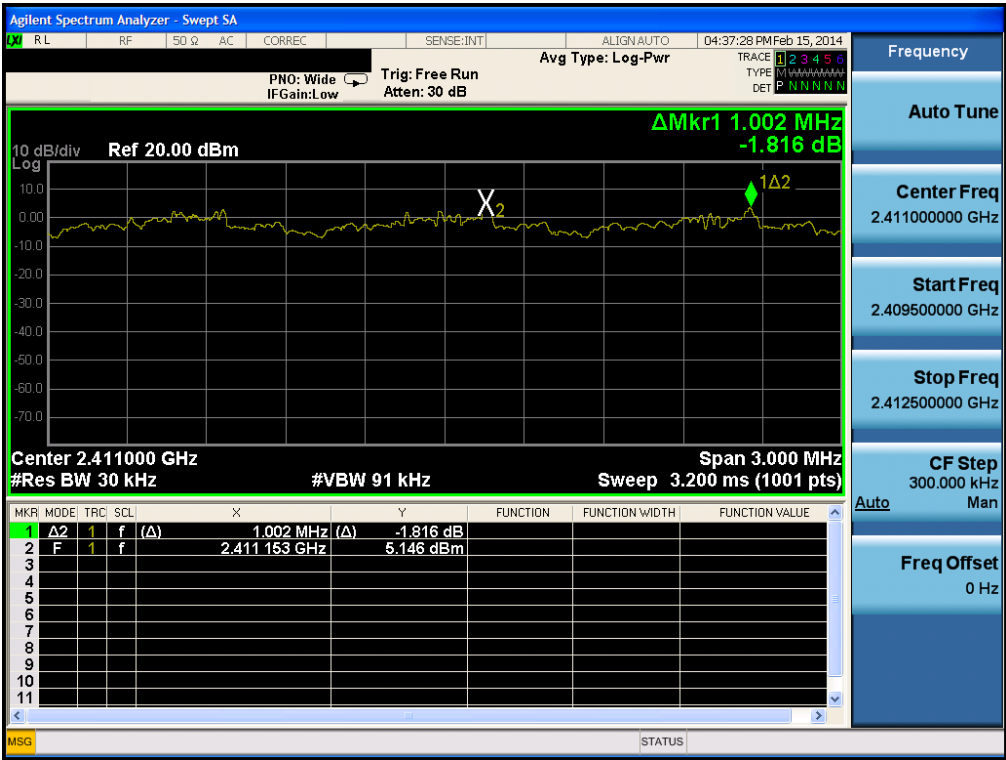
Hopping mode: Enable&GFSK

## Carrier Frequency Separation (AFH)

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

Carrier Frequency Separation (AFH)

Hopping mode: Enable&8DPSK



## 4. Number of Hopping Frequencies

### 4.1. Test Setup

Refer to the APPENDIX I.

### 4.2. Limit

Limit:  $\geq 15$  hops

#### - 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 = 50MHz      Plot 1: Start Frequency = 2391.5MHz,   Stop Frequency = 2441.5 MHz  
Plot 2: Start Frequency = 2441.5MHz,   Stop Frequency = 2491.5 MHz

RBW = 1% of the span or more

Sweep = auto

VBW =  $\geq$  RBW

Detector function = peak

Trace = max hold

#### - Measurement Data: **Comply**

##### - FH mode

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

##### - AFH mode

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

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

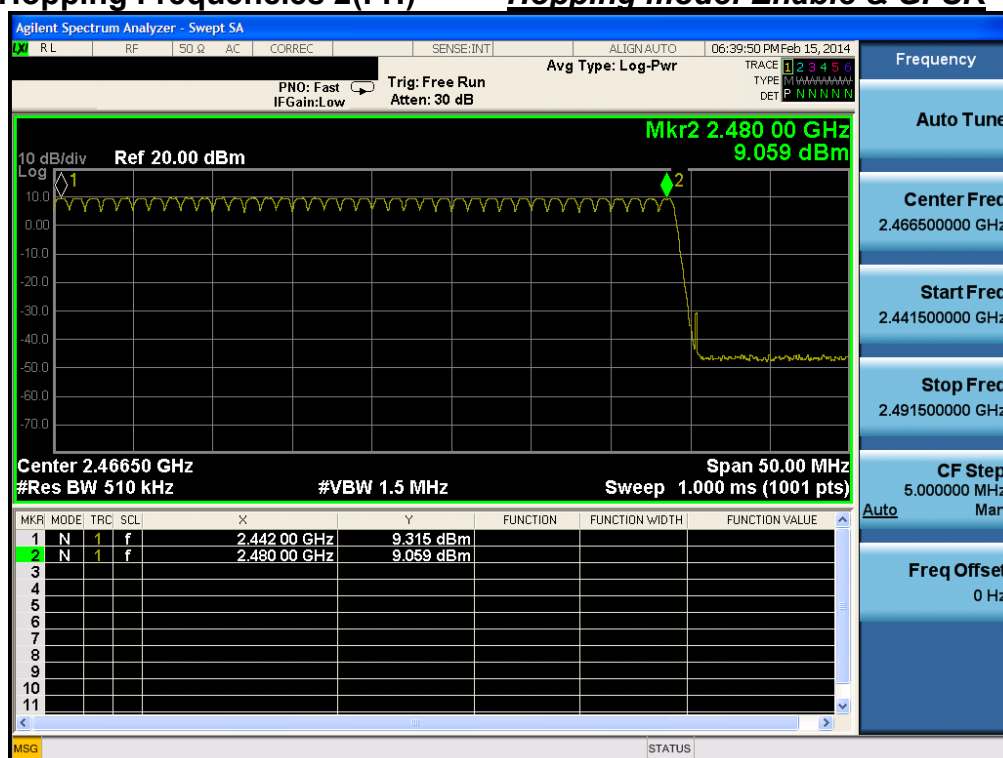
#### - Minimum Standard:

At least 15 hops

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

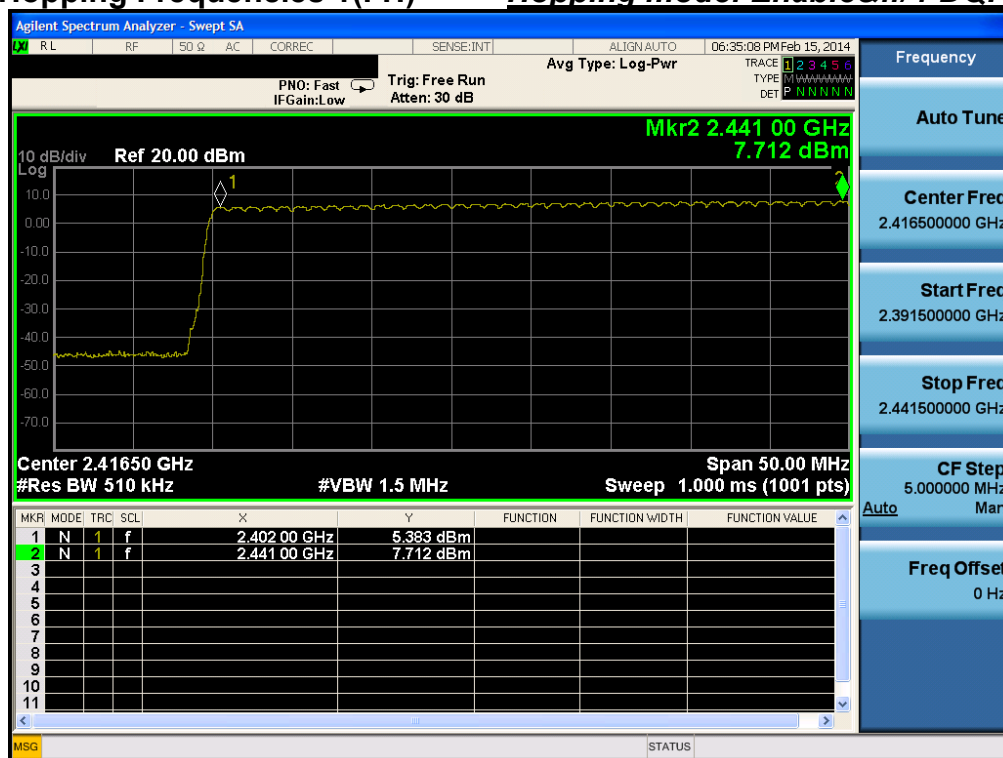


## Number of Hopping Frequencies 2(FH) *Hopping mode: Enable & GFSK*



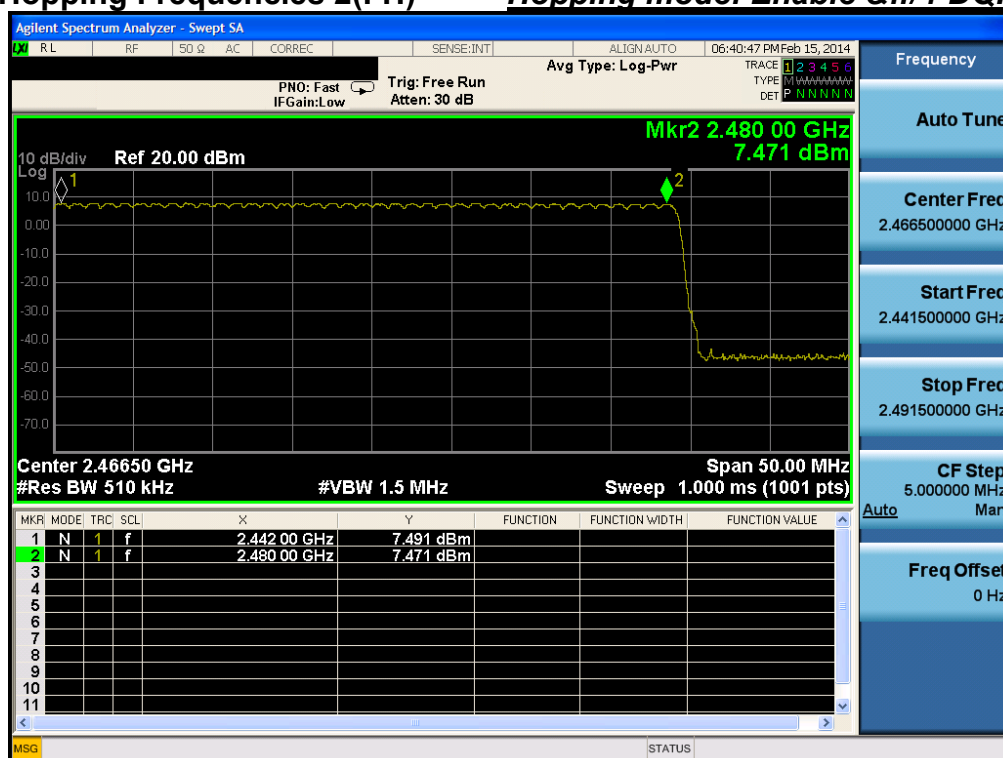
## Number of Hopping Frequencies 1(FH)

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

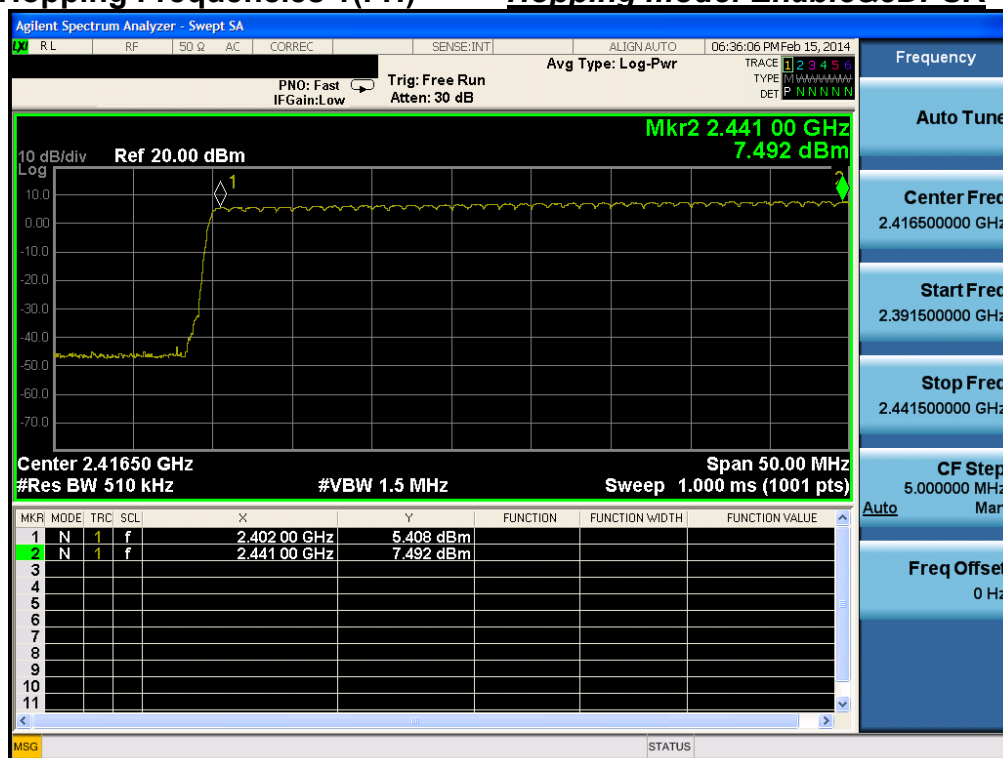


## Number of Hopping Frequencies 2(FH)

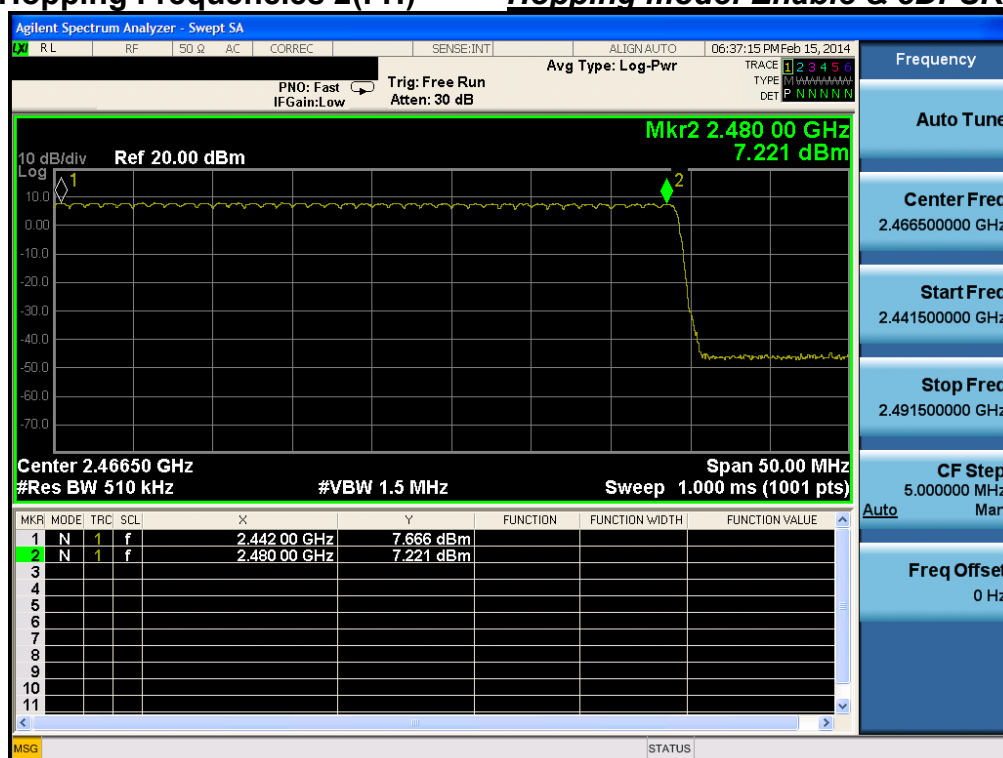
*Hopping mode: Enable &  $\pi/4$ -DQPSK*



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

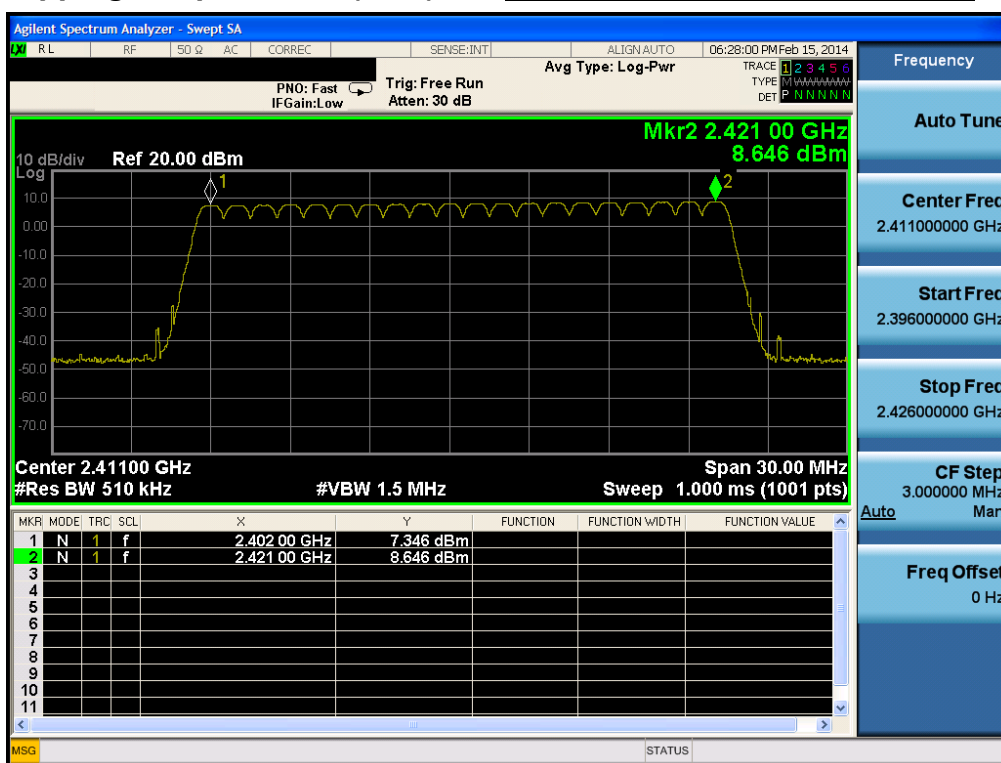


# Number of Hopping Frequencies 2(FH) *Hopping mode: Enable & 8DPSK*



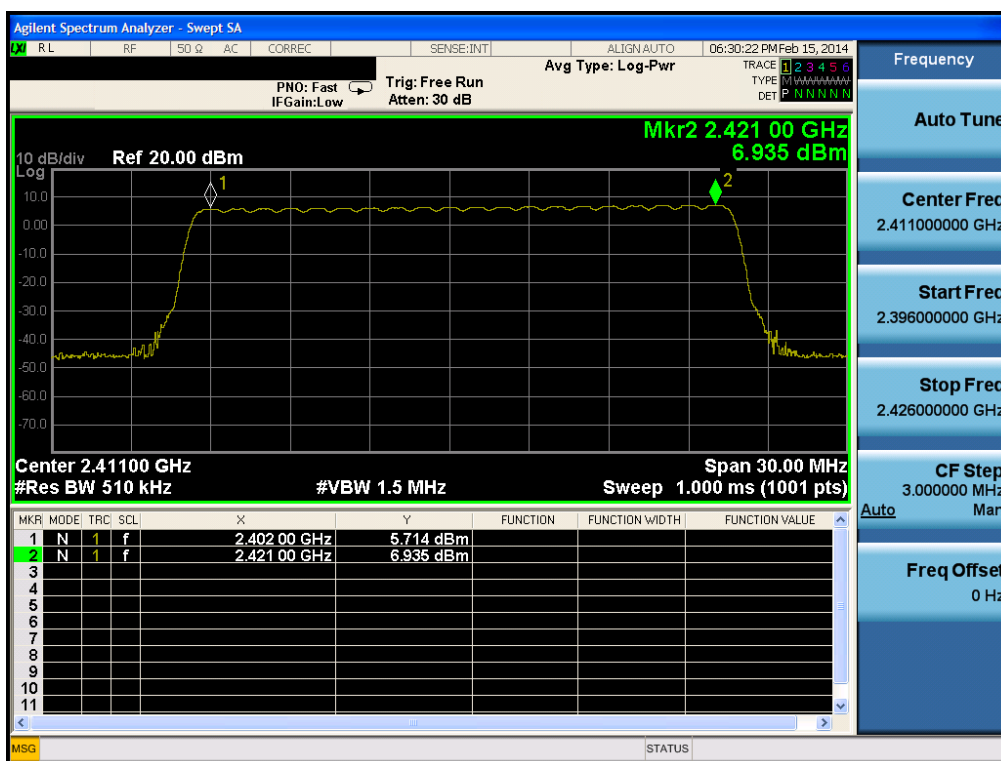
# Number of Hopping Frequencies 1(AFH)

Hopping mode: Enable &GFSK

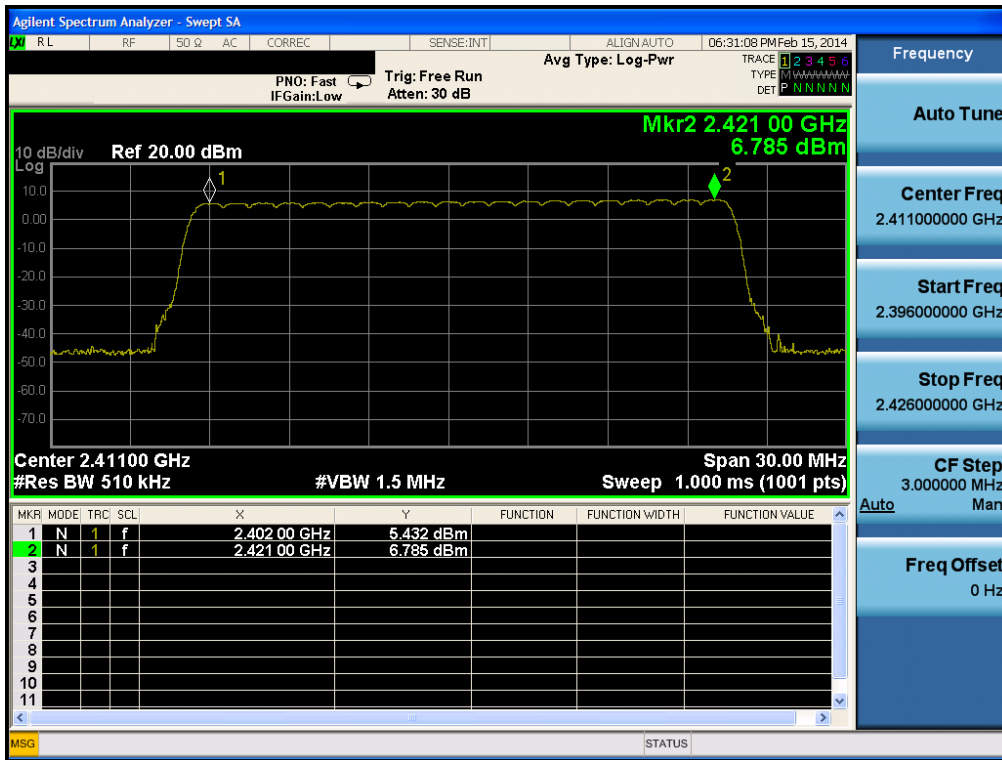


# Number of Hopping Frequencies 1(AFH)

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



**Hopping mode: Enable & 8DPSK**



## 5. 20dBc BW

### 5.1. Test Setup

Refer to the APPENDIX I.

### 5.2. Limit

Limit: Not Applicable

### 5.3. Test Procedure

1. The 20dBc 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  $RBW \geq 1\%$  of the 20 dB bandwidth,  $VBW \geq RBW$ , Span = 3MHz.

### 5.4. Test Results

Ambient temperature : 23°C  
Relative humidity : 39%

| Modulation                            | Tested Channel | 20dBc BW (MHz) |
|---------------------------------------|----------------|----------------|
| <b><u>GFSK</u></b>                    | Lowest         | 0.890          |
|                                       | Middle         | 0.930          |
|                                       | Highest        | 0.890          |
| <b><u><math>\pi/4</math>DQPSK</u></b> | Lowest         | 1.300          |
|                                       | Middle         | 1.320          |
|                                       | Highest        | 1.320          |
| <b><u>8DPSK</u></b>                   | Lowest         | 1.280          |
|                                       | Middle         | 1.280          |
|                                       | Highest        | 1.280          |

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

## 20dBc Bandwidth

## Lowest Channel &amp; Modulation: GFSK



## 20dBc Bandwidth

## Middle Channel &amp; Modulation: GFSK



## 20dBc Bandwidth

Highest Channel&Modulation: GFSK

## 20dBc Bandwidth

Lowest Channel&Modulation: π/4DQPSK

## 20dBc Bandwidth

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

## 20dBc Bandwidth

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

## 20dBc Bandwidth

## Lowest Channel&amp;Modulation: 8DPSK



## 20dBc Bandwidth

## Middle Channel&amp;Modulation: 8DPSK



# 20dBc Bandwidth

## Highest Channel & Modulation: 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

RBW = 1 MHz

Trace = max hold

Span = zero

VBW =  $\geq$  RBW

Detector function = peak

### 6.4. Test Results

Ambient temperature : 22°C

Relative humidity : 36%

#### - FH mode

| Hopping mode | Packet Type | Number of hopping Channels | Burst On Time (ms) | Period (ms) | Test Result (sec) |
|--------------|-------------|----------------------------|--------------------|-------------|-------------------|
| Enable       | DH 5        | 79                         | 2.88               | 3.75        | 0.307             |
|              | 2 DH 5      | 79                         | 2.88               | 3.75        | 0.307             |
|              | 3 DH 5      | 79                         | 2.88               | 3.75        | 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                         | 2.88               | 3.75        | 0.154             |
|              | 2 DH 5      | 20                         | 2.88               | 3.75        | 0.154             |
|              | 3 DH 5      | 20                         | 2.88               | 3.75        | 0.154             |

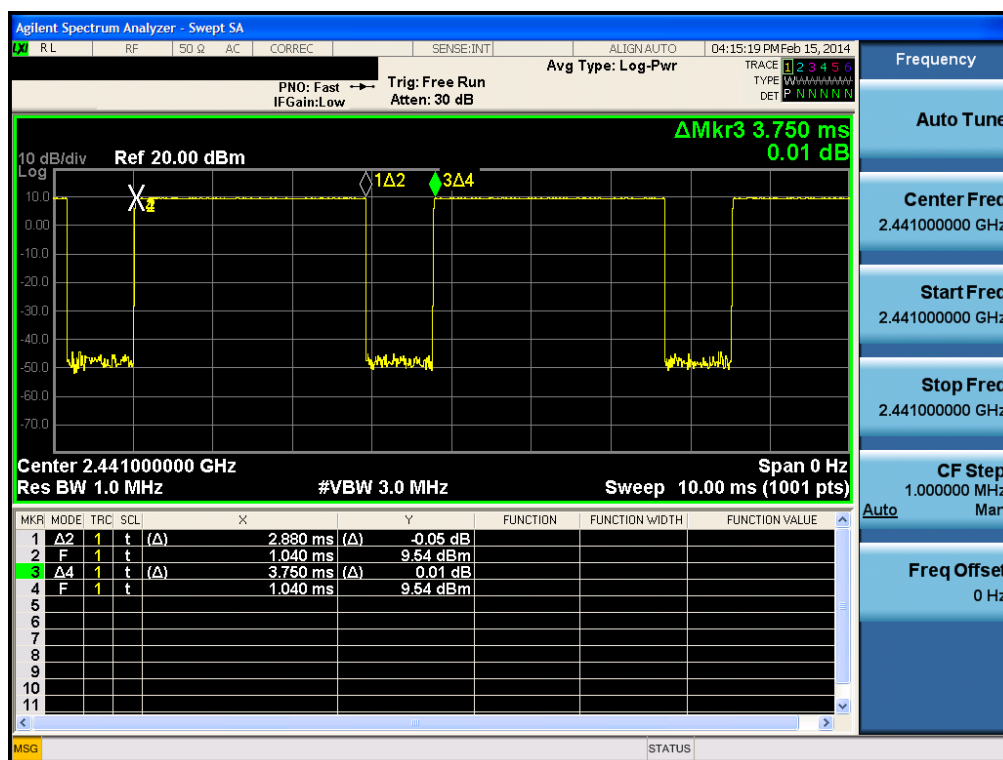
Note 1: Dwell Time =  $0.4 \times \text{Hopping channel} \times \text{Burst ON time} \times ((\text{Hopping rate} \div \text{Time slots}) \div \text{Hopping channel})$

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

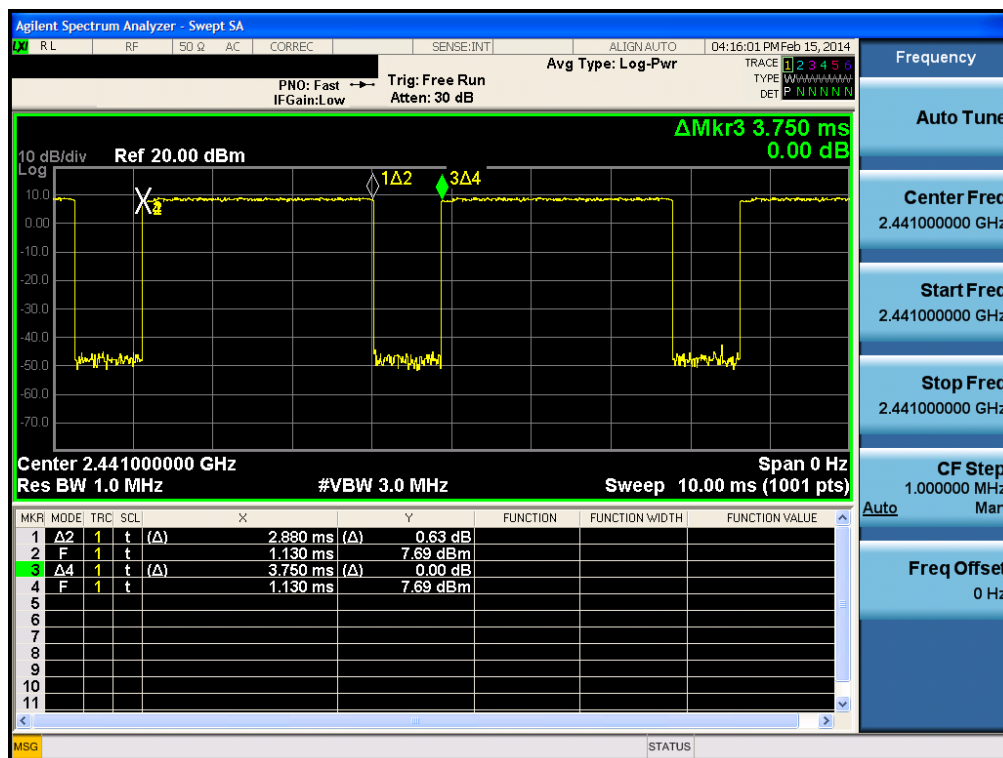
- Hopping Rate = 1600 for FH mode & 800 for AFH mode

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

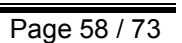
## Time of Occupancy (FH)

Hopping mode: Enable&GFSK

## Time of Occupancy (FH)

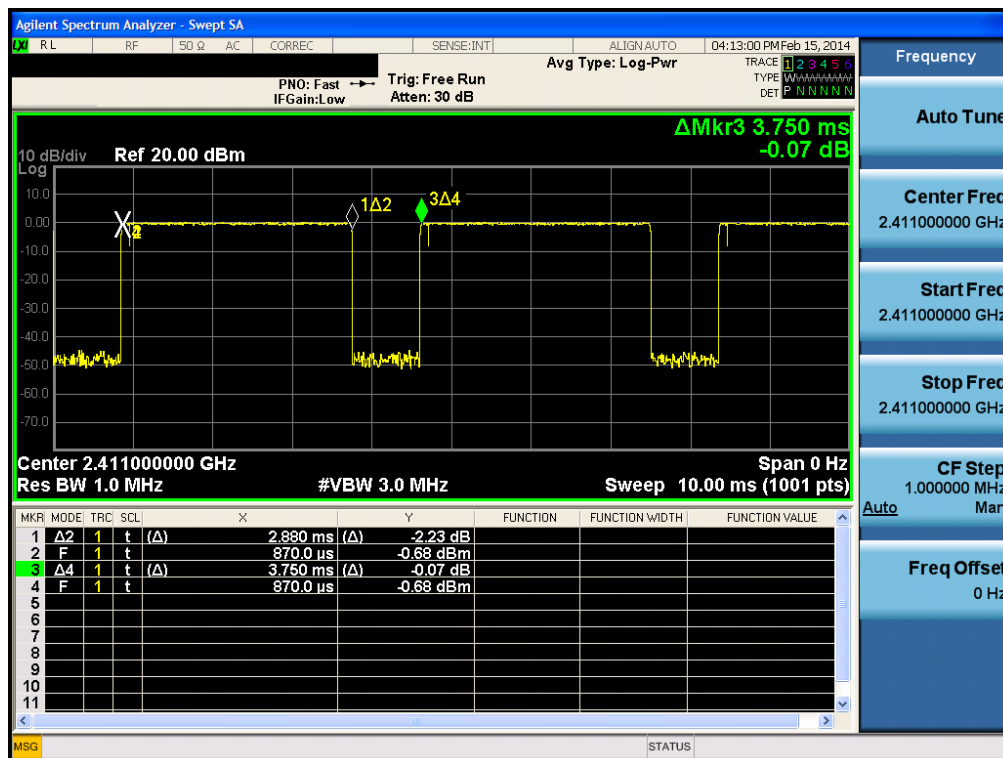
Hopping mode: Enable& $\pi/4$ -DQPSK

**Hopping mode: Enable&8DPSK**



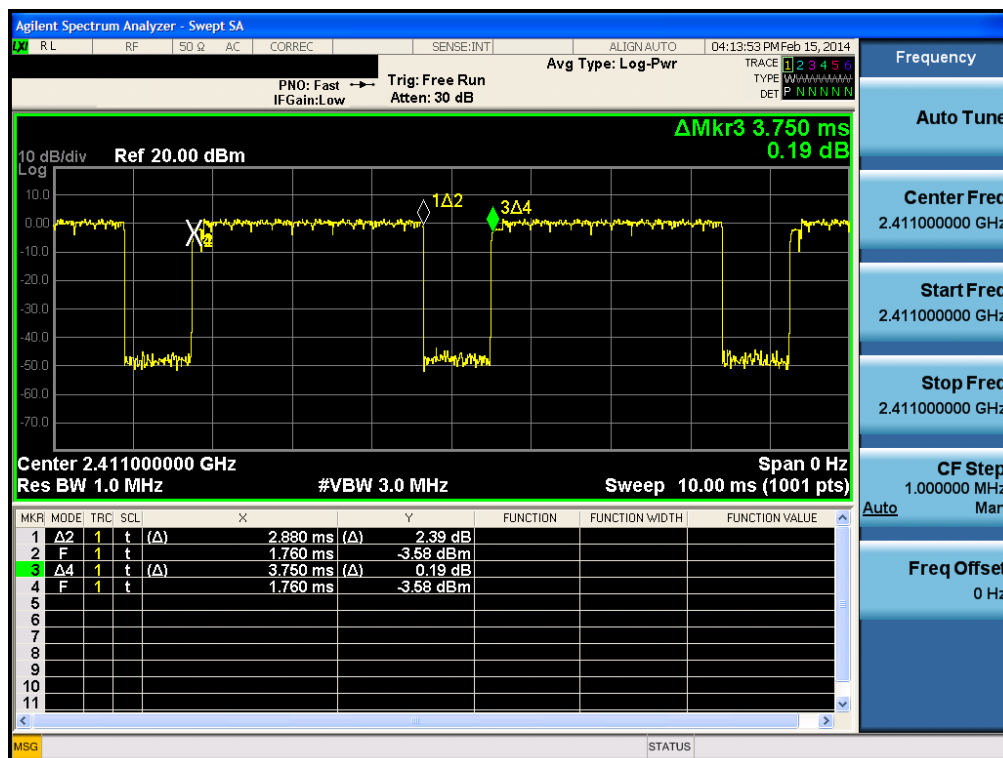
# Time of Occupancy (AFH)

## Hopping mode: Enable&GFSK

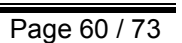


# Time of Occupancy (AFH)

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



**Hopping mode: Enable&8DPSK**



## 7. Maximum Peak Output Power Measurement

### 7.1. Test Setup

Refer to the APPENDIX I.

### 7.2. Limit

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, provided the systems operate with an output power no greater than 125 mW.
2. §15.247(b)(1), For frequency hopping systems operating in the 2 400 – 2 483.5 MHz employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5 725 – 5 805 MHz band: 1 Watt.

### 7.3. Test Procedure

1. The RF power output 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 bandwidth 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  $\geq$  20dB BW  
VBW  $\geq$  RBW  
Sweep = auto  
Detector function = peak  
Trace = max hold

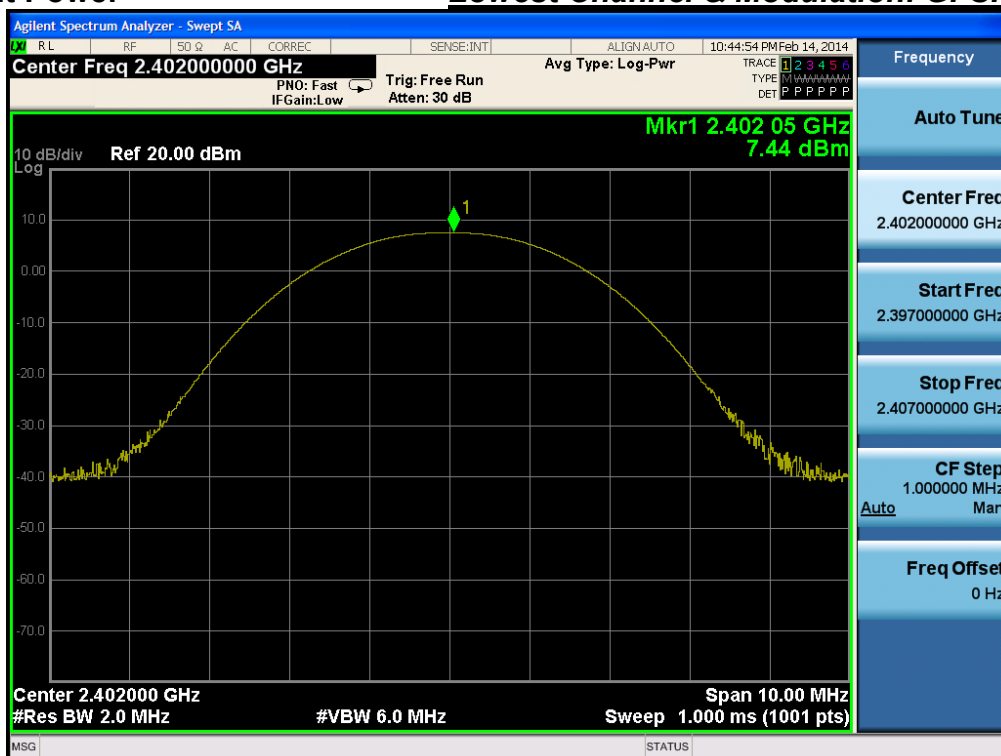
## 7.4. Test Results

Ambient temperature : 22°C  
Relative humidity : 36 %

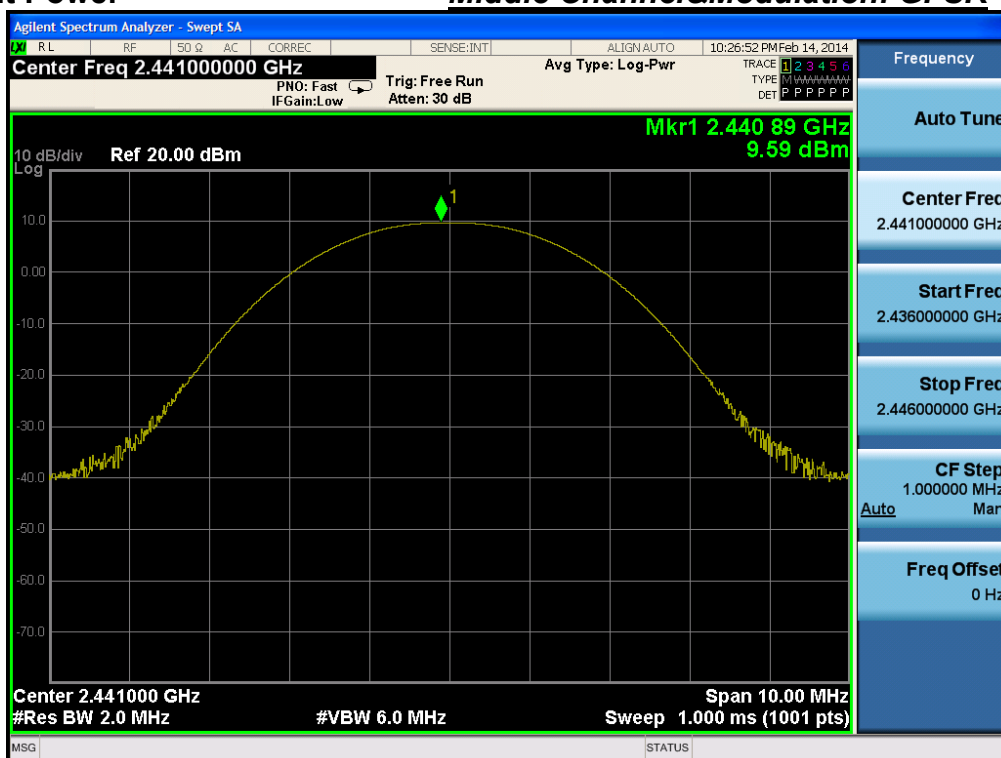
| Modulation                            | Tested Channel | Peak Output Power |              |
|---------------------------------------|----------------|-------------------|--------------|
|                                       |                | dBm               | mW           |
| <b><u>GFSK</u></b>                    | Lowest         | 7.44              | 5.546        |
|                                       | Middle         | <b>9.59</b>       | <b>9.099</b> |
|                                       | Highest        | 9.41              | 8.730        |
| <b><u><math>\pi/4</math>DQPSK</u></b> | Lowest         | 7.56              | 5.702        |
|                                       | Middle         | <b>9.63</b>       | <b>9.183</b> |
|                                       | Highest        | 9.45              | 8.810        |
| <b><u>8DPSK</u></b>                   | Lowest         | 7.60              | 5.754        |
|                                       | Middle         | <b>9.72</b>       | <b>9.376</b> |
|                                       | Highest        | 9.56              | 9.036        |

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

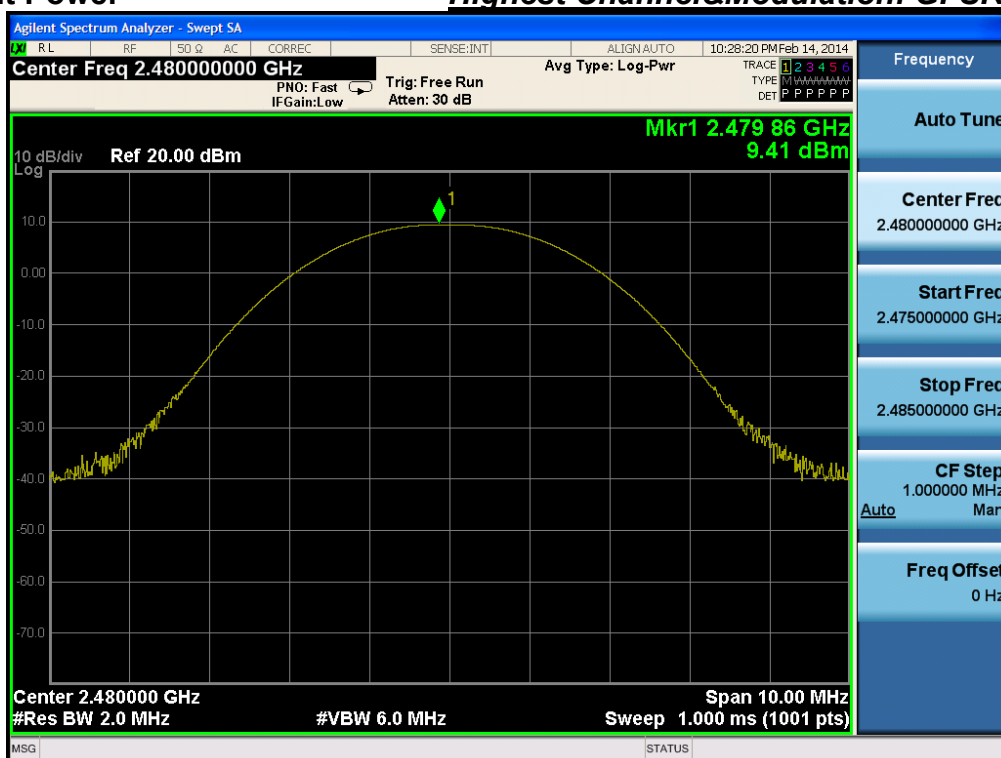
## Peak Output Power

Lowest Channel & Modulation: GFSK

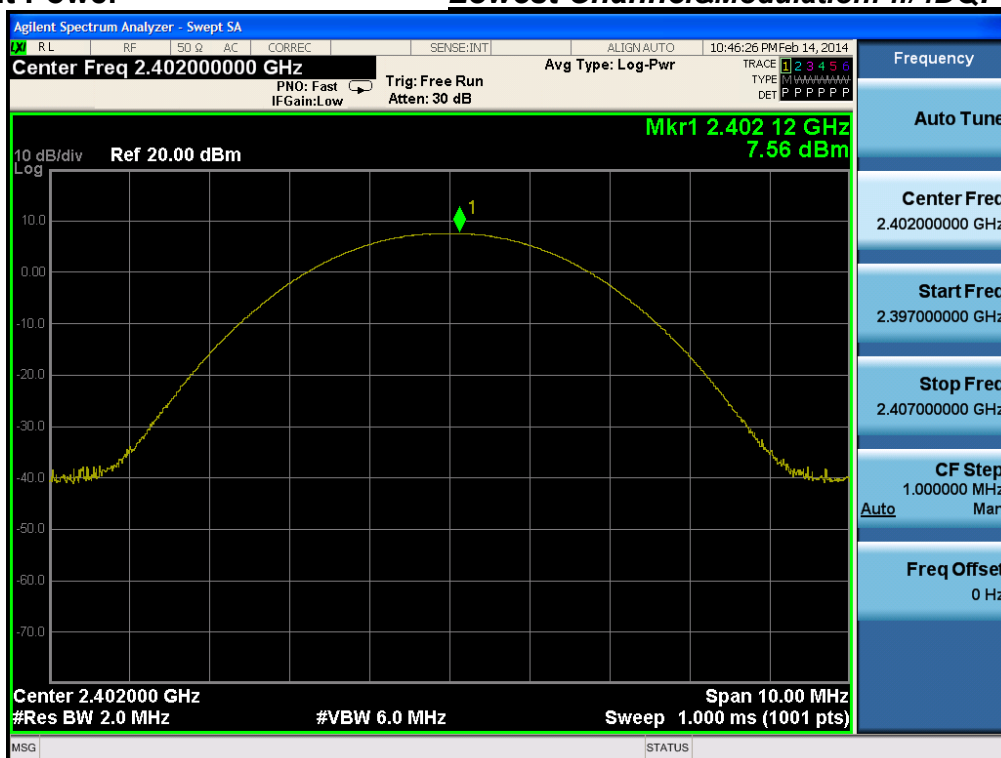
## Peak Output Power

Middle Channel & Modulation: GFSK

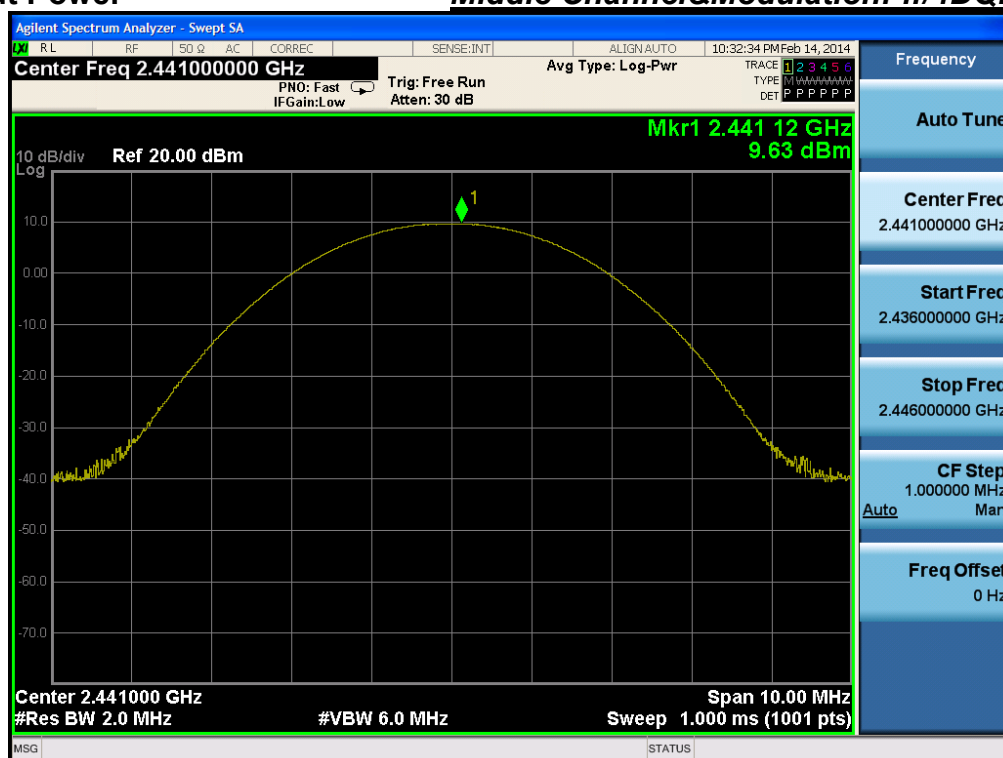
## Peak Output Power

Highest Channel&Modulation: GFSK

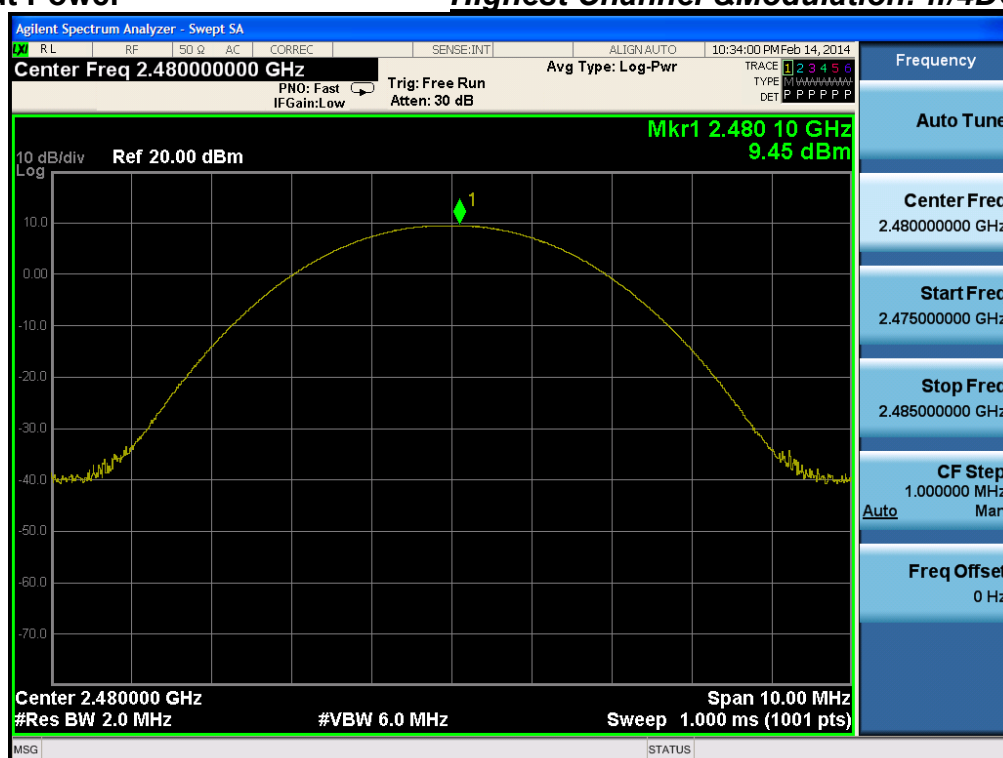
## Peak Output Power

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

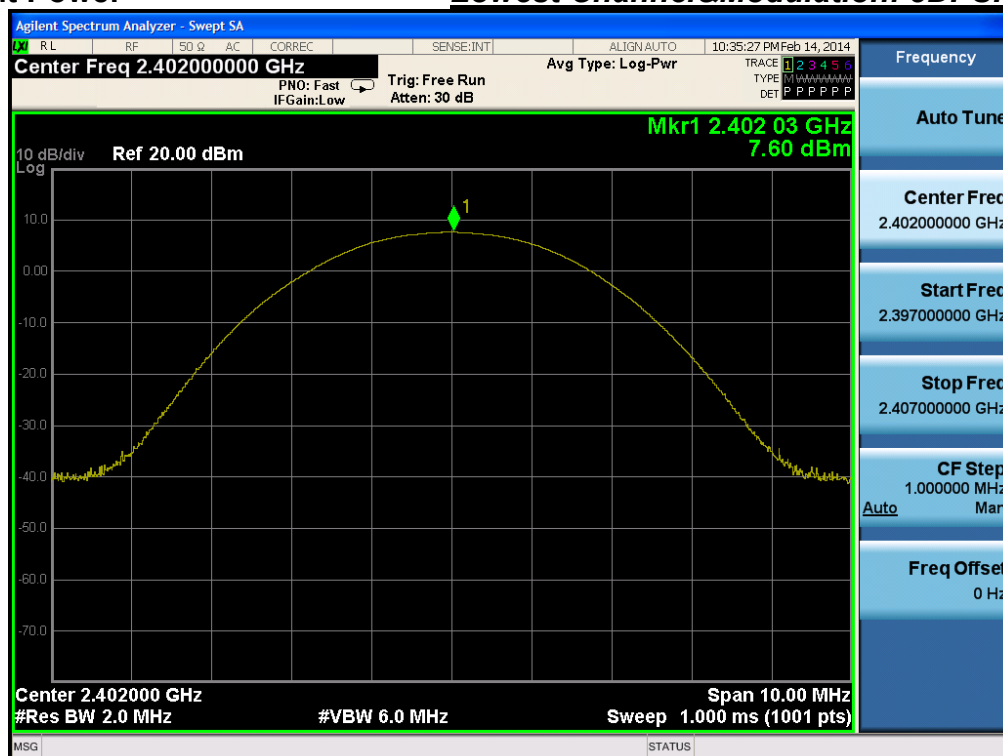
## Peak Output Power

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

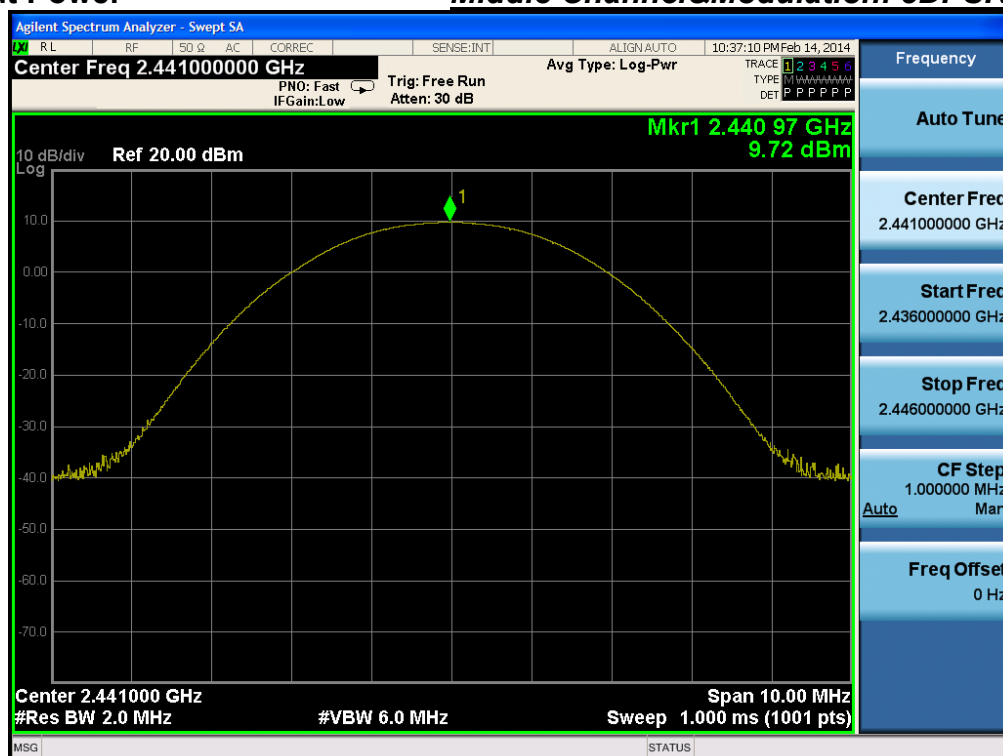
## Peak Output Power

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

## Peak Output Power

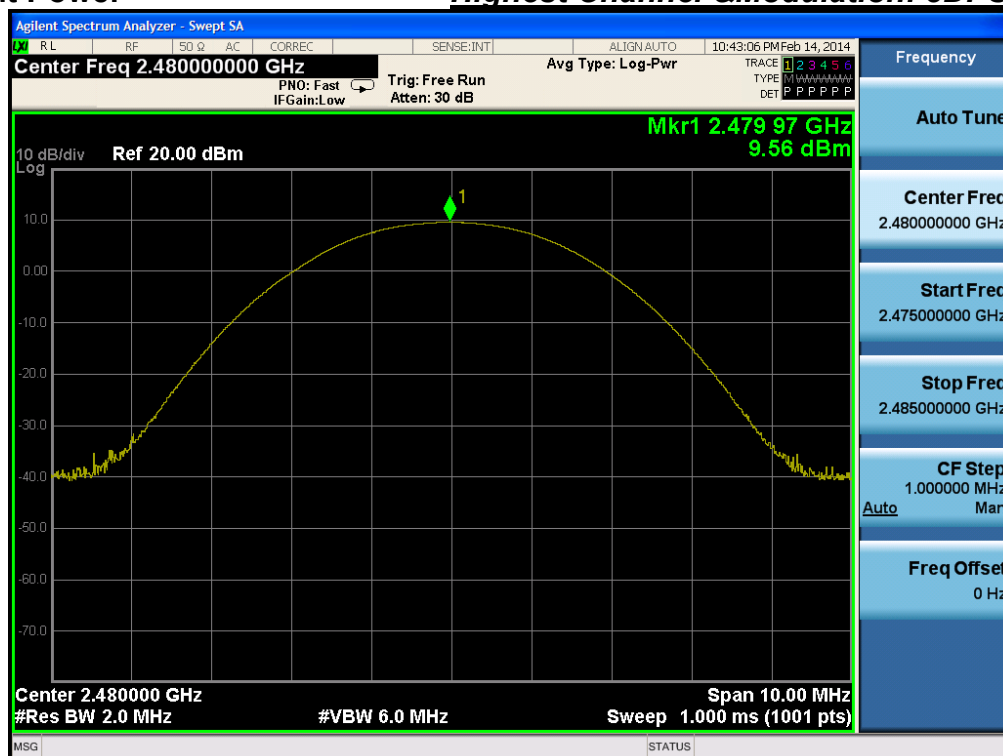
Lowest Channel&Modulation: 8DPSK

## Peak Output Power

Middle Channel&Modulation: 8DPSK

## Peak Output Power

***Highest Channel & Modulation: 8DPSK***



## 8. Transmitter AC Power Line Conducted Emission

### 8.1. Test Setup

Refer to test setup photo.

### 8.2. Limit

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

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

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

\* Decreases with the logarithm of the frequency

### 8.3. Test Procedures

Conducted emissions from the EUT were measured according to the section 6.2 of the ANSI C63.10-2009

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

## 8.4. Test Results

### AC Line Conducted Emissions (Graph)& Modulation: **GFSK**

#### Results of Conducted Emission

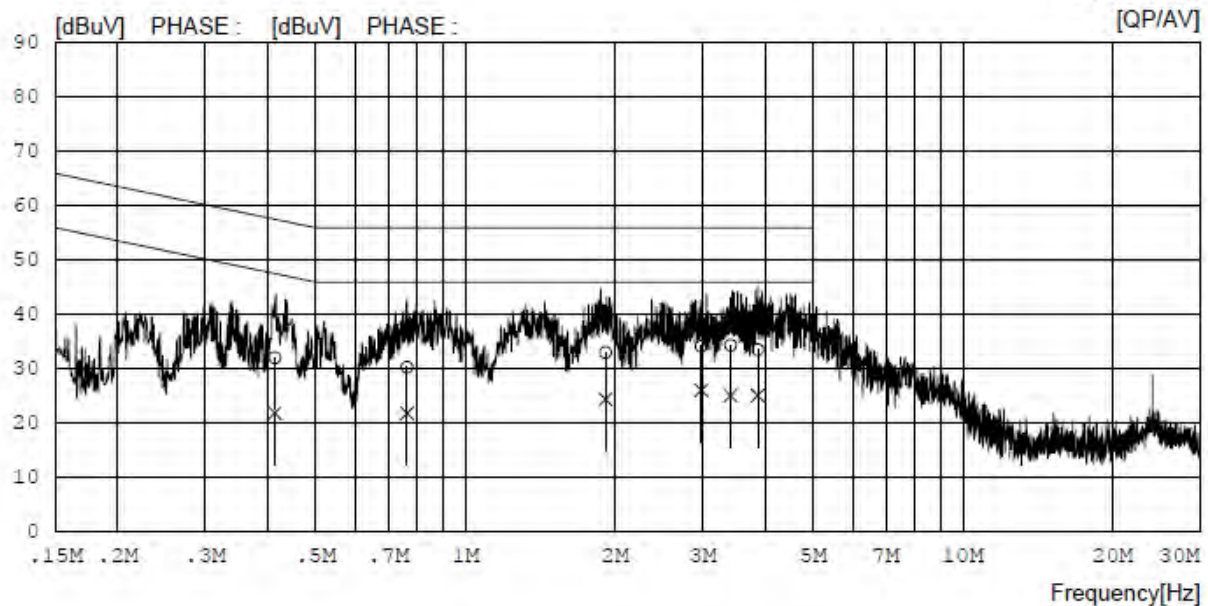
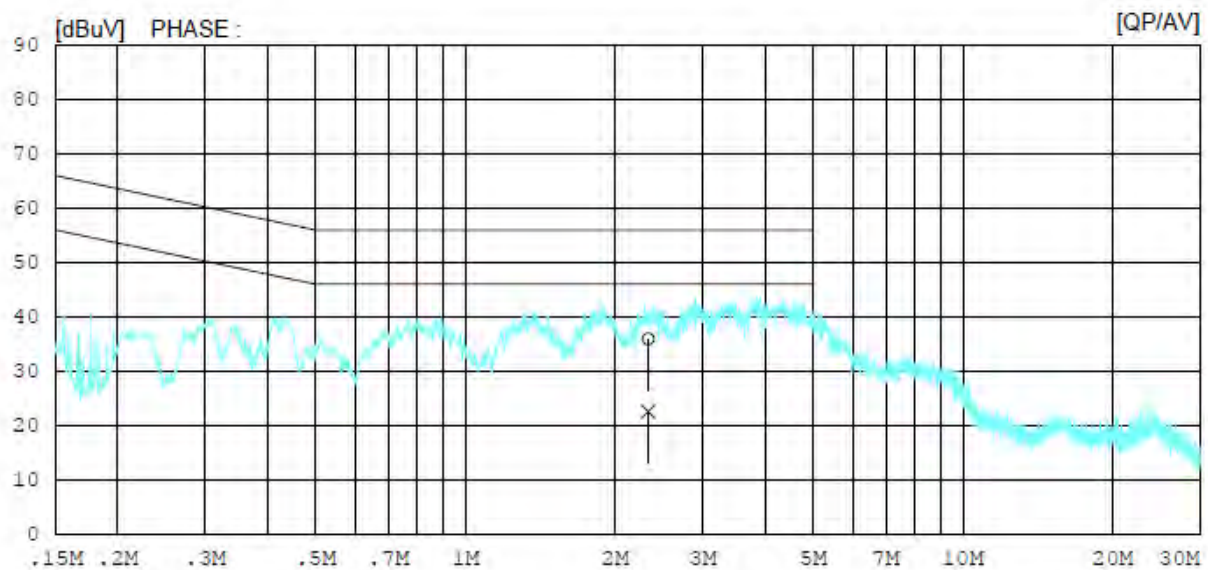
Digital EMC  
Date : 2014-02-21

Model No. : LG-D160f  
Type :  
Serial No. : Identical prototype  
Test Condition : BT

Reference No. :  
Power Supply : 120 V 60 Hz  
Temp/Humi. : 24 °C 44 % R.H.  
Operator : C.M KIM

Memo : FINAL

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



**AC Line Conducted Emissions (List)& Modulation: GFSK****Results of Conducted Emission**Digital EMC  
Date : 2014-02-21

Model No. : LG-D160f  
 Type :  
 Serial No. : Identical prototype  
 Test Condition : BT

Reference No. :  
 Power Supply : 120 V 60 Hz  
 Temp/Humi. : 24 'C 44 % R.H.  
 Operator : C.M KIM

Memo : FINAL

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

| NO | FREQ<br>[MHz] | READING      |              | C.FACTOR<br>[dB] | RESULT       |              | LIMIT        |              | MARGIN       |              | PHASE |
|----|---------------|--------------|--------------|------------------|--------------|--------------|--------------|--------------|--------------|--------------|-------|
|    |               | QP<br>[dBuV] | AV<br>[dBuV] |                  | QP<br>[dBuV] | AV<br>[dBuV] | QP<br>[dBuV] | AV<br>[dBuV] | QP<br>[dBuV] | AV<br>[dBuV] |       |
| 1  | 2.33250       | 35.6         | 22.3         | 0.3              | 35.9         | 22.6         | 56.0         | 46.0         | 20.1         | 23.4         |       |
| 2  | 0.41409       | 31.8         | 21.7         | 0.2              | 32.0         | 21.9         | 57.6         | 47.6         | 25.6         | 25.7         |       |
| 3  | 0.76364       | 30.1         | 21.6         | 0.2              | 30.3         | 21.8         | 56.0         | 46.0         | 25.7         | 24.2         |       |
| 4  | 1.91400       | 32.7         | 24.1         | 0.3              | 33.0         | 24.4         | 56.0         | 46.0         | 23.0         | 21.6         |       |
| 5  | 2.98000       | 33.9         | 25.8         | 0.3              | 34.2         | 26.1         | 56.0         | 46.0         | 21.8         | 19.9         |       |
| 6  | 3.41450       | 34.1         | 24.8         | 0.3              | 34.4         | 25.1         | 56.0         | 46.0         | 21.6         | 20.9         |       |
| 7  | 3.87200       | 33.2         | 24.8         | 0.3              | 33.5         | 25.1         | 56.0         | 46.0         | 22.5         | 20.9         |       |

## 9. Antenna Requirement

### ■ Procedure:

Describe how the EUT complies with the requirement that either its antenna is permanently attached, or that it employs a unique antenna connector, for every antenna proposed for use with the EUT.

### ■ Conclusion: **Comply**

**The internal antenna is attached on the main PCB using the special spring tension. (Refer to Internal Photo file.)**

### ■ Minimum Standard:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions.

## 10. Occupied Bandwidth(99%)

- **Procedure:(RSS-Gen Issue 3)**

- The 99% power bandwidth was measured with a calibrated spectrum analyzer.
- Spectrum analyzer plots are included on the following pages.

- **Measurement Data: NA**

- **Minimum Standard:**

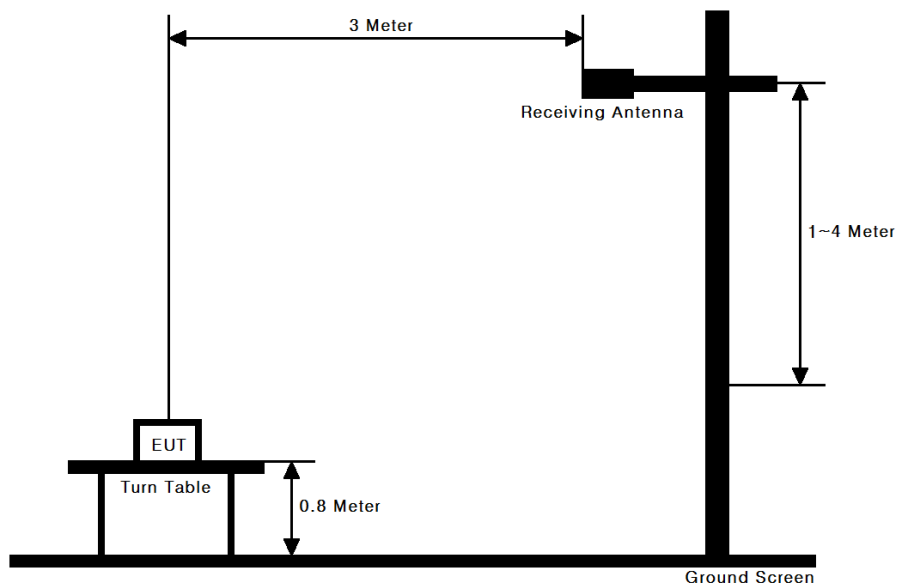
|     |
|-----|
| N/A |
|-----|

## APPENDIX I

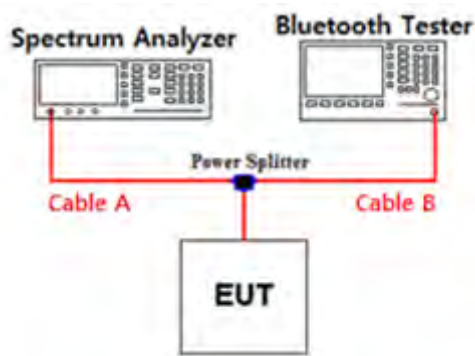
### Test set up Diagrams&Path lossInformation

#### ▪Radiated Measurement

The diagram below shows the test setup that is utilized to make the measurements for emission from 9kHz to 25GHz Emissions.



#### ▪Conducted Measurement



Path loss information

| Frequency (GHz)       | Path Loss (dB) | Frequency (GHz) | Path Loss (dB) |
|-----------------------|----------------|-----------------|----------------|
| 0.03                  | 5.72           | 15              | 8.58           |
| 1                     | 6.39           | 20              | 8.30           |
| 2.402 & 2.441 & 2.480 | 7.10           | 25              | 9.63           |
| 5                     | 7.06           | -               | -              |
| 10                    | 8.21           | -               | -              |

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