# RF TEST REPORT for Intentional Radiator

# No. 170501164SHA-001

| | | |
|---|---|---|
| Applicant | : | VENOM COMMUNICATIONS LTD.<br>Solution House, Sandon Road, Therfield, Hertfordshire, SG8 9RE,UK |
| Manufacturer | : | VENOM COMMUNICATIONS LTD.<br>Solution House, Sandon Road, Therfield, Hertfordshire, SG8 9RE,UK |
| Product Name | : | Bluetooth Speaker |
| Type/Model | : | CO9200, CO9201 |
| **TEST RESULT** | **:** | **PASS** |

## SUMMARY

The equipment complies with the requirements according to the following standard(s):

**47CFR Part 15 (2016):** Radio Frequency Devices

**ANSI C63.10 (2013):** American National Standard for Testing Unlicensed Wireless Devices

Date of issue: Jul 6, 2017

Prepared by:

Teddy Yin (*Project Engineer*)

Reviewed by:

Daniel Zhao (*Reviewer*)

# Description of Test Facility

Name: Intertek Testing Services Limited Shanghai
Address: Building No.86, 1198 Qinzhou Road (North), Shanghai 200233, P.R. China

FCC Registration Number: 236597
IC Assigned Code: 2042B-1

Name of contact: Jonny Jing
Tel: +86 21 64956565 ext. 271
Fax: +86 21 54262335 ext. 271

# Content

# 1. General Information

## 1.1 Applicant Information

| | | |
|---|---|---|
| Applicant | : | VENOM COMMUNICATIONS LTD.<br>Solution House, Sandon Road, Therfield, Hertfordshire, SG8 9RE,UK |
| Name of contact | : | Kiki Luo |
| Tel | : | |
| Fax | : | |
| Manufacturer | : | VENOM COMMUNICATIONS LTD.<br>Solution House, Sandon Road, Therfield, Hertfordshire, SG8 9RE,UK |

## 1.2 Identification of the EUT

| | | |
|---|---|---|
| Equipment | : | Bluetooth Speaker |
| Type/model | : | CO9200, CO9201 |
| FCC ID | : | 2AFVJCO9200 |
| Description of EUT | : | The EUT is a speaker which supports BT4.1 function(only BR & EDR), and both models are same except the enclosure picture. We tested CO9200 and listed the BT Base Rate and EDR results in this report. |
| Rating | : | DC 5V |
| Category of EUT | : | Class B |
| EUT type | : | ☒ Table top☐ Floor standing |
| Sample received date | : | May 25, 2017 |
| Date of test | : | Jun 16, 2017 |

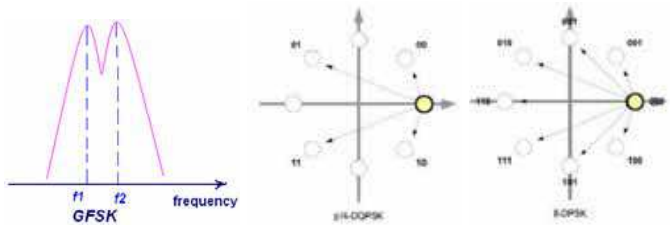
## 1.3 Technical specification

Operation Frequency Band: 2402 - 2480 MHz

Protocol: BT 4.1 (BR+EDR)

Modulation: GFSK, π/4 DQPSK, 8DPSK

Technology:




GFSK is different from π/4DQPSK and 8DPSK. 8DPSK is similar with π/4DQPSK but more complex, and with a bigger data rate. So all the tests except output power, occupied bandwidth, dwell time and number of hopping frequencies were performed with GFSK modulation and 8DPSK modulation for representative.

Antenna Designation: PCB antenna

Gain of Antenna: 3.0 dBi

Channel Description: There are 79 channels in all. The designed channel spacing is 1MHz.

| Channel Identifier | Frequency (MHz) |
|---|---|
| low | 2402 |
| middle | 2441 |
| high | 2480 |

**Antenna Requirement:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

**The manufacturer used a PCB antenna, so fulfill this requirement.**

## 1.4 Mode of operation during the test / Test peripherals used

While testing the transmitter mode of the EUT, the internal modulation is applied.
All the functions of the host device except the BT module were set on stand-by mode.

The test setting software is offered by the manufactory. The pre-scan for the conducted power with all rates in each modulation and bands was used, and the worst case was found and used in all test cases.

The EUT is a handheld device, so three axes (X, Y, Z) were observed while the test receiver worked as “max hold” continuously and the highest reading (X axis)among the whole test procedure was recorded.

Radiated test mode:
Mode 1: EUT transmitted signal with BT antenna;

Conducted test mode:
Mode 2: EUT transmitted signal from BT RF port connected to SPA directly;

The worst case modulation configuration:

| **Worst Modulation Used for Conformance Testing** | | | |
|---|---|---|---|
| **Bluetooth Mode** | **Data Rate** | **Packet Type** | **Worst Mode** |
| GFSK | BR-1Mbps | DH1,DH3,DH5 | BR-1Mbps DH5<br>EDR-2Mbps 2DH5<br>EDR-3Mbps 3DH5 |
| π /4 DQPSK | EDR-2Mbps | 2DH1,2DH3,2DH5 | |
| 8DPSK | EDR-3Mbps | 3DH1,3DH3,3DH5 | |
| Note: The BR-1Mbps 3DH5 mode was chosen for radiation emission bellow 1GHz and Conducted emission testing as representative in this report. | | | |

Test Peripherals:

| Equipment | Brand Name | Model | Note |
|---|---|---|---|
| Notebook | HP | 6470b | |
| | | | |
| Note: The accessories are used for configuration only and not used during test. | | | |

# 2. Test Specification

## 2.1 Instrument list

| Selected | Equipment | Type | Manu. | Internal no. | Cal. Date | Due date |
|---|---|---|---|---|---|---|
| ☒ | PXA Analyzer | N9030A | Agilent | EC5338 | 2017/3/4 | 2018/3/3 |
| ☒ | Vector SG | N5182B | Agilent | EC5175 | 2017/3/4 | 2018/3/3 |
| ☒ | Power sensor | U2021XA | Agilent | EC5338-1 | 2017/3/4 | 2018/3/3 |
| ☒ | MXG Analog SG | N5181A | Agilent | EC5338-2 | 2017/3/4 | 2018/3/3 |
| ☒ | Power meter | N1911A/N1921A | Agilent | EC4318 | 2017/4/10 | 2018/4/9 |
| ☒ | EMI Receiver | ESCS 30 | R&S | EC 2107 | 2016/10/20 | 2017/10/19 |
| ☒ | A.M.N. | ESH2-Z5 | R&S | EC 3119 | 2016/12/16 | 2017/12/15 |
| ☒ | I.S.N. | FCC-TLISN-T8-02 | FCC | EC3756 | 2017/2/16 | 2018/2/15 |
| ☒ | EMI chamber | 3m | Albatross | EC 3048 | 2017/5/5 | 2018/5/4 |
| ☒ | Test Receiver | ESIB 26 | R&S | EC 3045 | 2016/10/20 | 2017/10/19 |
| ☒ | Test Receiver | ESCI 7 | R&S | EC4501 | 2017/2/24 | 2018/2/23 |
| ☒ | Bilog Antenna | CBL 6112D | TESEQ | EC 4206 | 2017/5/30 | 2018/5/29 |
| ☒ | Horn antenna | HF 906 | R&S | EC 3049 | 2016/9/11 | 2017/9/10 |
| ☒ | Horn antenna | HAP18-26W | TOYO | EC 4792-3 | 2017/6/12 | 2020/6/11 |
| ☒ | Pre-amplifier | Pre-amp 18 | R&S | EC 5262 | 2017/5/24 | 2018/5/23 |
| ☒ | Pre-amplifier | Tpa0118-40 | R&S | EC 4792-2 | 2017/4/11 | 2018/4/10 |
| ☒ | Shielded room | - | Zhongyu | EC 2838 | 2017/1/9 | 2018/1/8 |

## 2.2 Test Standard

47CFR Part 15 (2016)
ANSI C63.10 (2013)
DA 00-705

## 2.3 Test Summary

**This report applies to tested sample only. This report shall not be reproduced in part without written approval of Intertek Testing Service Shanghai Limited.**

| TEST ITEM | FCC REFERANCE | IC REFERANCE | RESULT |
|---|---|---|---|
| 20 dB Bandwidth | 15.247(a)(1) | | Tested |
| Carrier Frequency Separation | 15.247(a)(1) | | Pass |
| Output power | 15.247(b)(1) | | Pass |
| Radiated Spurious Emissions | 15.205 & 15.209 | | Pass |
| Conducted Spurious Emissions & Band Edge | 15.247(d) | | Pass |
| Power line conducted emission | 15.207 | | NA |
| Number of Hopping Frequencies | 15.247(a)(1)(iii) | | Pass |
| Dwell time | 15.247(a)(1)(iii) | | Pass |
| Occupied bandwidth | - | | NA |
| Spurious emission for receiver | 15B | | NA |

Notes: 1: NA =Not Applicable

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## 2.4 Frequency Hopping System Requirement

**Test Requirement: Section 15.247 (a)(1), (g), (h) requirement:**

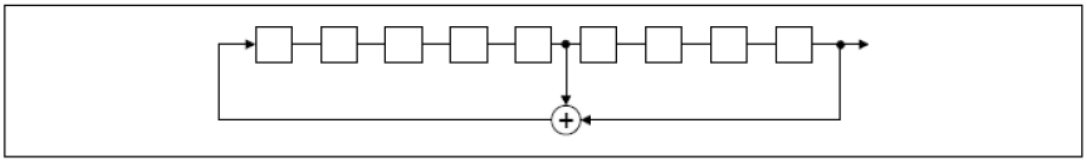
The system shall hop to channel frequencies that are selected at the system hopping rate from a Pseudorandom ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hop sets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

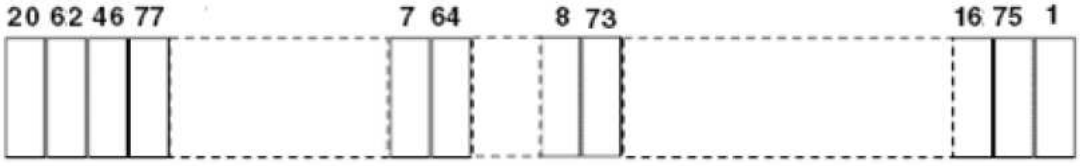
**Compliance for section 15.247(a)(1)**

According to Bluetooth Core Specification, the pseudorandom sequence may be generated in a nine stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first ONE of 9 consecutive ONEs;
i.e. the shift register is initialized with nine ones.
• Number of shift register stages: 9
• Length of pseudo-random sequence: $2^9$ -1 = 511 bits
• Longest sequence of zeros: 8 (non-inverted signal)



*Linear Feedback Shift Register for Generation of the PRBS sequence*

An example of Pseudorandom Frequency Hopping Sequence as follow:




Each frequency used equally on the average by each transmitter.
According to Bluetooth Core Specification, Bluetooth receivers are designed to have input and IF bandwidths that match the hopping channel bandwidths of any Bluetooth transmitters and shift frequencies in synchronization with the transmitted signals.

**Compliance for section 15.247(g)**

According to Bluetooth Core Specification, the Bluetooth system transmits the packet with the pseudorandom hopping frequency with a continuous data and the short burst transmission from the Bluetooth system is also transmitted under the frequency hopping system with the pseudorandom hopping frequency system.

**Compliance for section 15.247(h)**

According to Bluetooth Core specification, the Bluetooth system incorporates with an adaptive system to detect other user within the spectrum band so that it individually and independently to avoid hopping on the occupied channels.
According to the Bluetooth Core specification, the Bluetooth system is designed not have the ability to coordinate with other FHSS System in an effort to avoid the simultaneous occupancy of individual hopping frequencies by multiple transmitter.

# 3. 20 dB Bandwidth

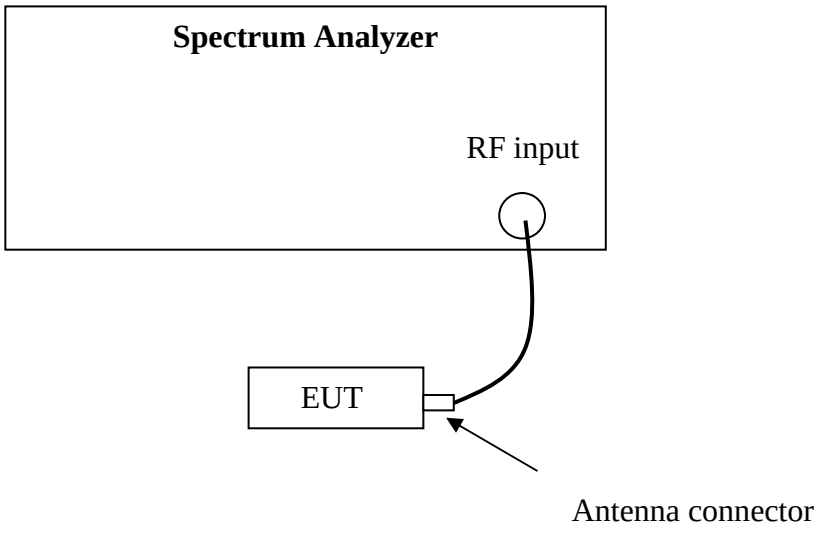
**Test result: Tested**

## 3.1 Limit

☐ 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.

☒ 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 125mW.

## 3.2 Test Configuration




## 3.3 Test Procedure and test setup

The 20 bandwidth per FCC § 15.247(a)(1) is measured using the Spectrum Analyzer with Span = 2 to 3 times the 20 dB bandwidth, RBW≥1% of the 20 dB bandwidth, VBW≥RBW, Sweep = auto, Detector = peak, Trace = max hold.
The test was performed at 3 channels (lowest, middle and highest channel).
The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems)

## 3.4 Test Protocol

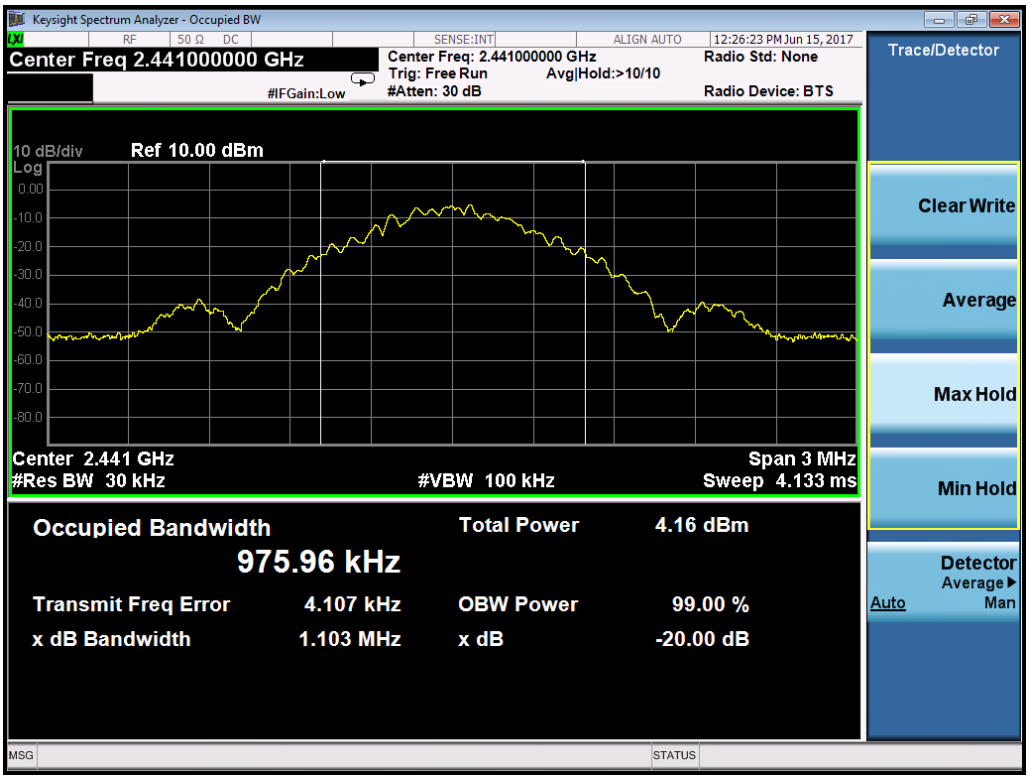
Temperature : 25°C

Relative Humidity : 55 %

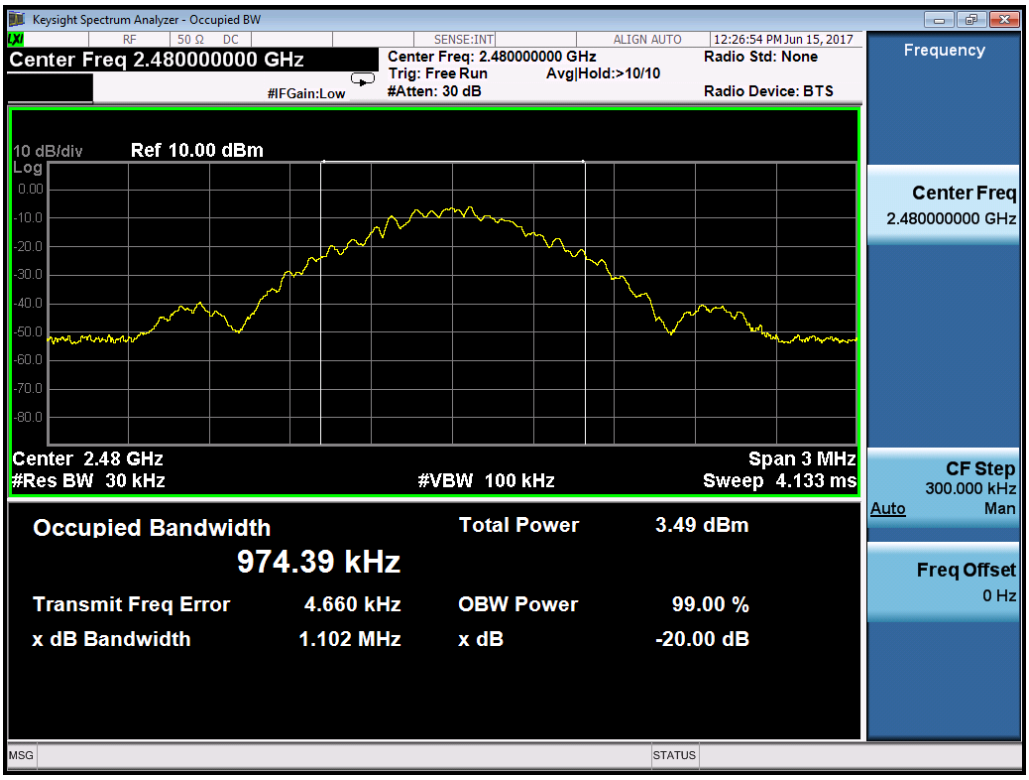
| Modulation | CH | Bandwidth (kHz) | Two-thirds of Bandwidth (kHz) |
|---|---|---|---|
| GFSK | L | 1103 | 735 |
| | M | 1103 | 735 |
| | H | 1102 | 735 |

Channel L

Channel M

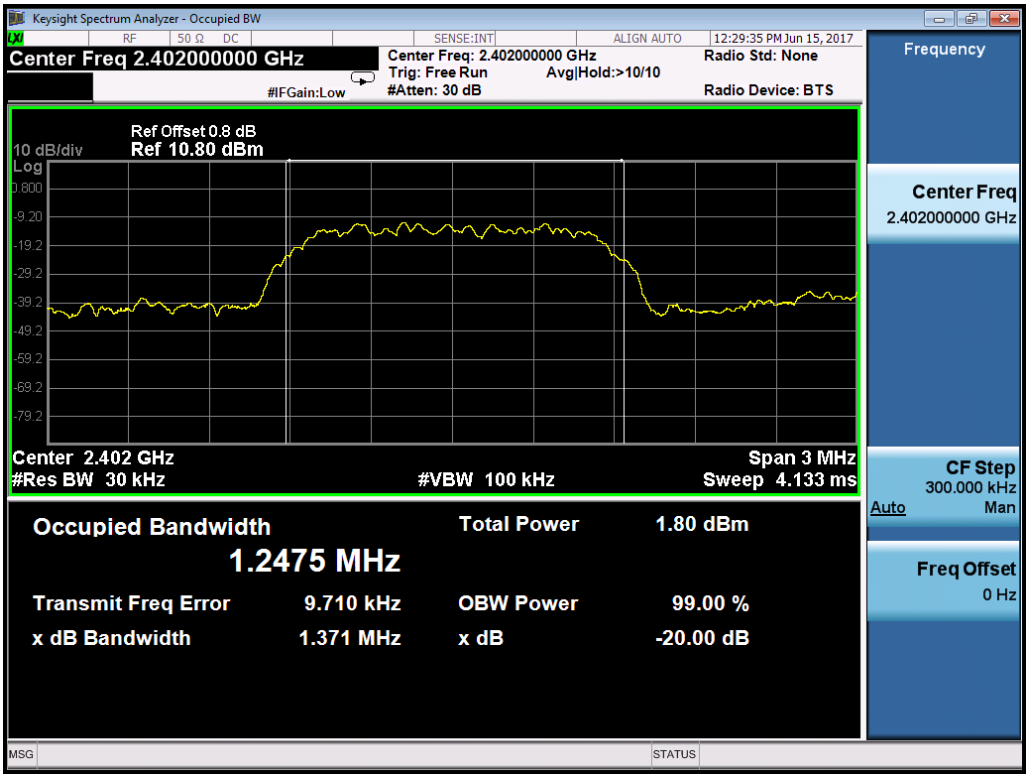



Channel H

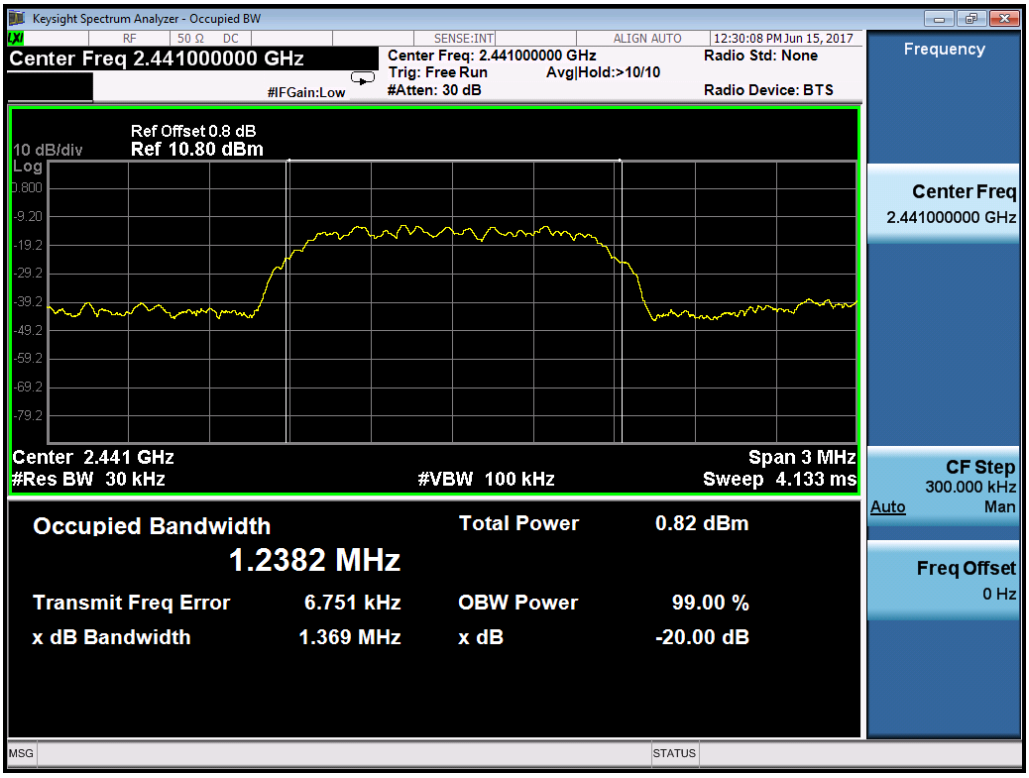


| Modulation | CH | Bandwidth (kHz) | Two-thirds of Bandwidth (kHz) |
|---|---|---|---|
| π /4 DQPSK | L | 1371 | 914 |
| | M | 1369 | 913 |
| | H | 1369 | 913 |

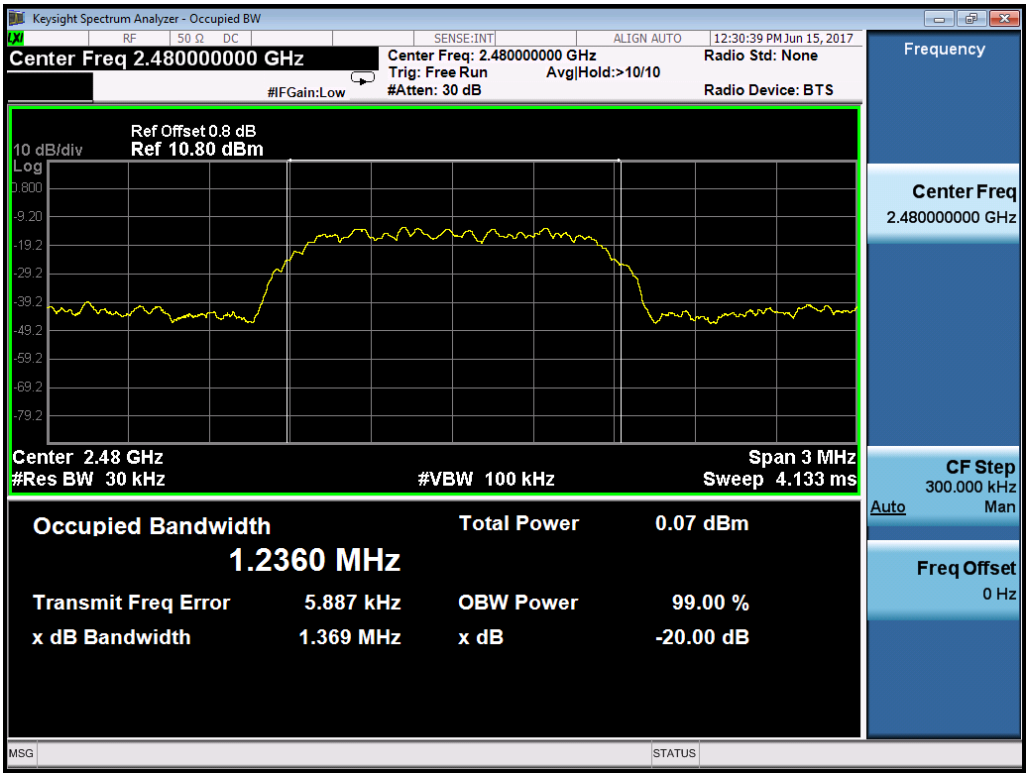
Channel L



Channel M

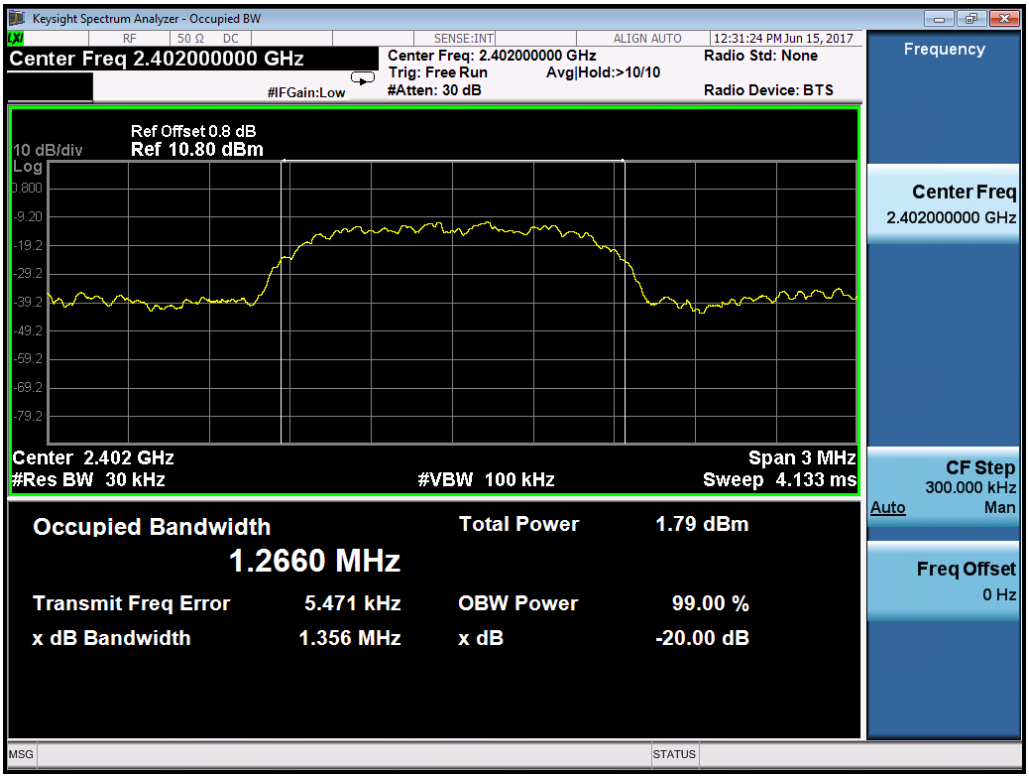



Channel H

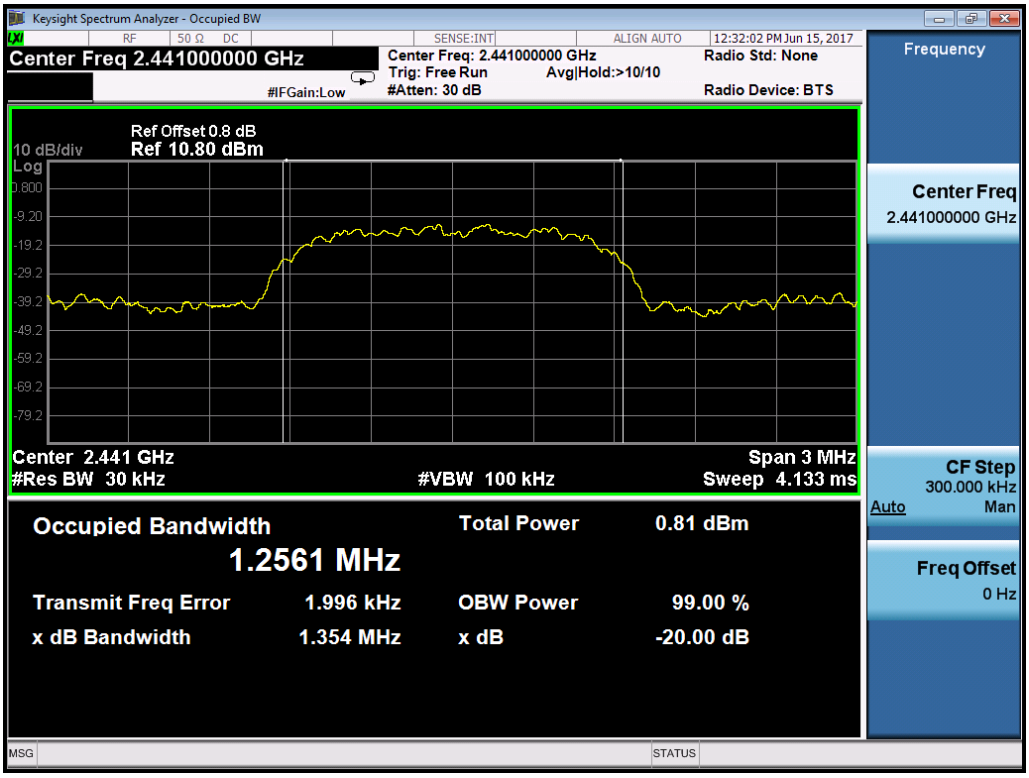


| Modulation | CH | Bandwidth (kHz) | Two-thirds of Bandwidth (kHz) |
|---|---|---|---|
| 8DPSK | L | 1356 | 904 |
| | M | 1354 | 903 |
| | H | 1353 | 902 |

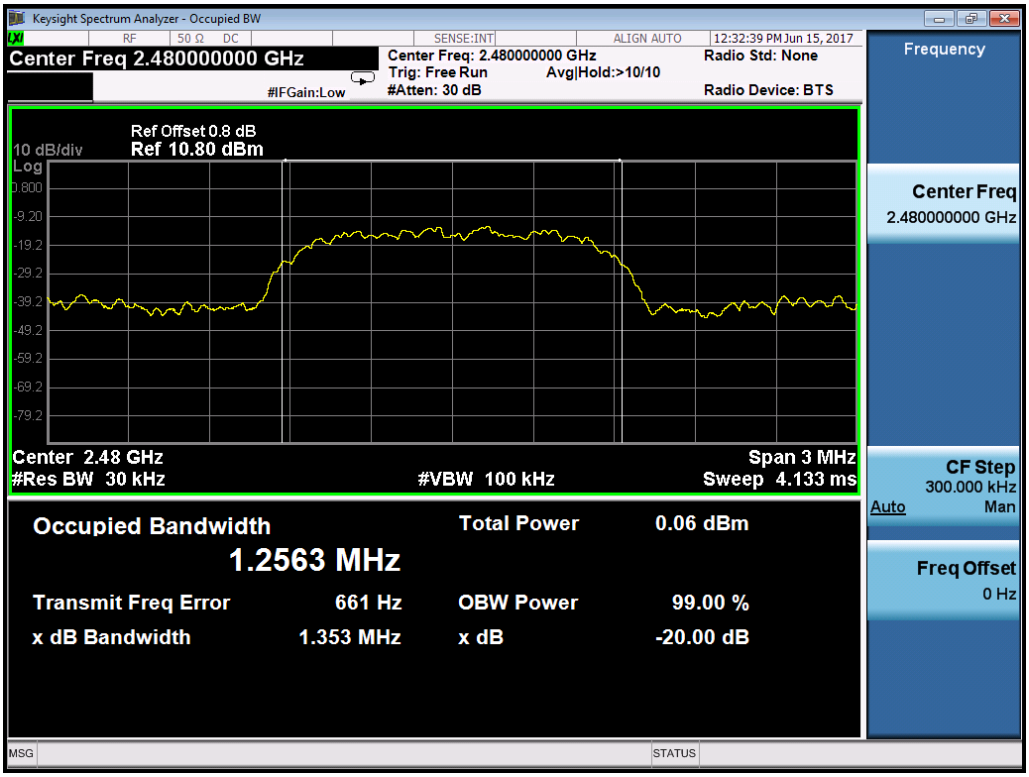
Channel L



Channel M




Channel H



# 4. Carrier Frequency Separation

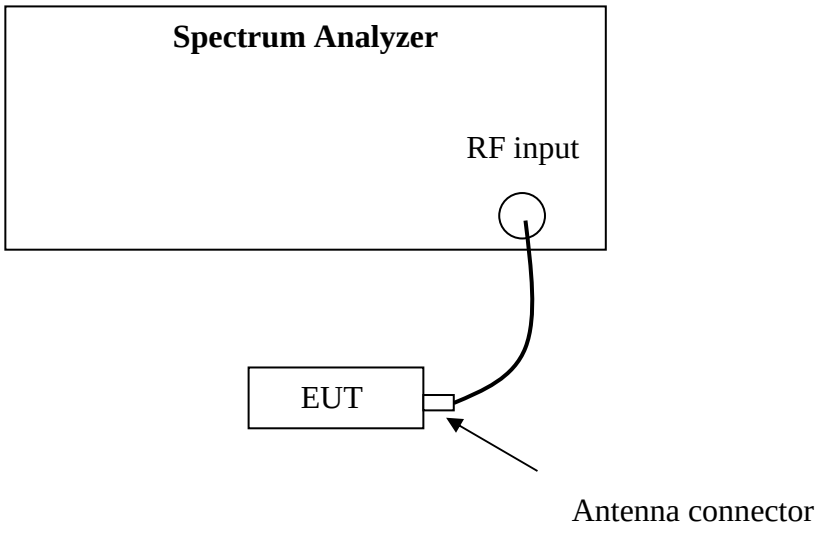
**Test result: Pass**

## 4.1 Limit

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

☒ 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 125mW.

## 4.2 Test Configuration




## 4.3 Test Procedure and test setup

The Carrier Frequency Separation per FCC § 15.247(a)(1) is measured using the Spectrum Analyzer with Span can capture two adjacent channels, RBW≥1% of the span, VBW≥RBW, Sweep = auto, Detector = peak, Trace = max hold.
The test was performed at 3 channels (lowest, middle and highest channel).
The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems)

## 4.4 Test Protocol

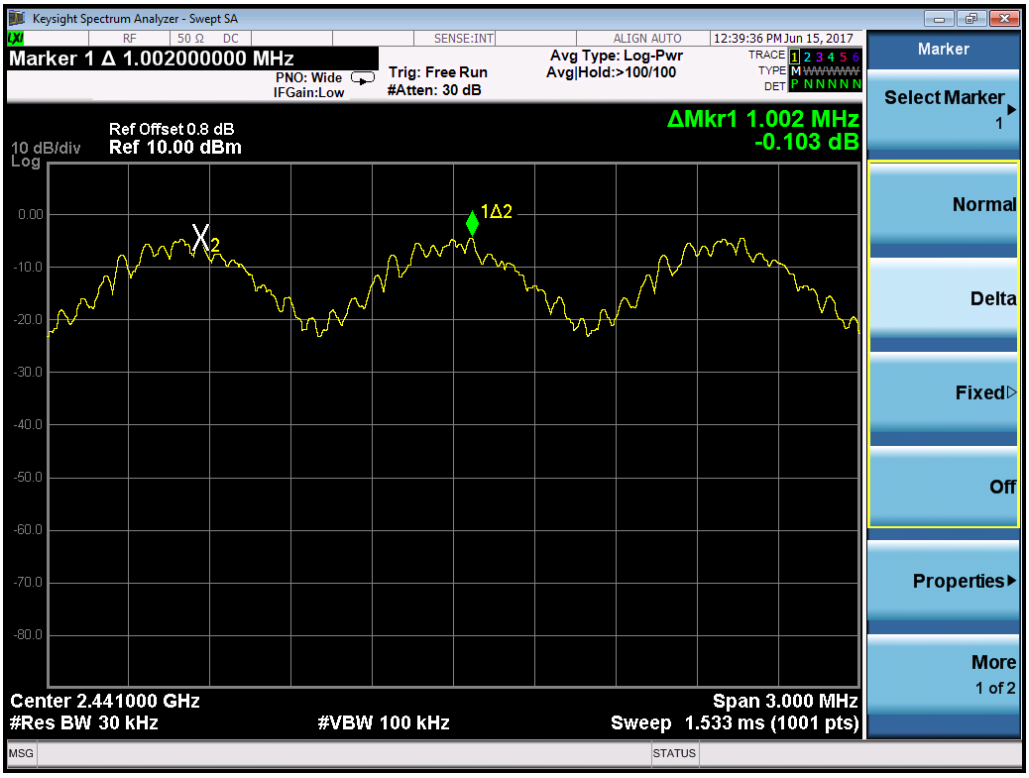
Temperature : 25°C

Relative Humidity : 55 %

| Mode | CH | Frequency Separation (kHz) | Limit (kHz) |
|---|---|---|---|
| GFSK | L | 1002 | ≥ 735 |
| | M | 1002 | ≥ 735 |
| | H | 1002 | ≥ 735 |

Channel L

Channel M



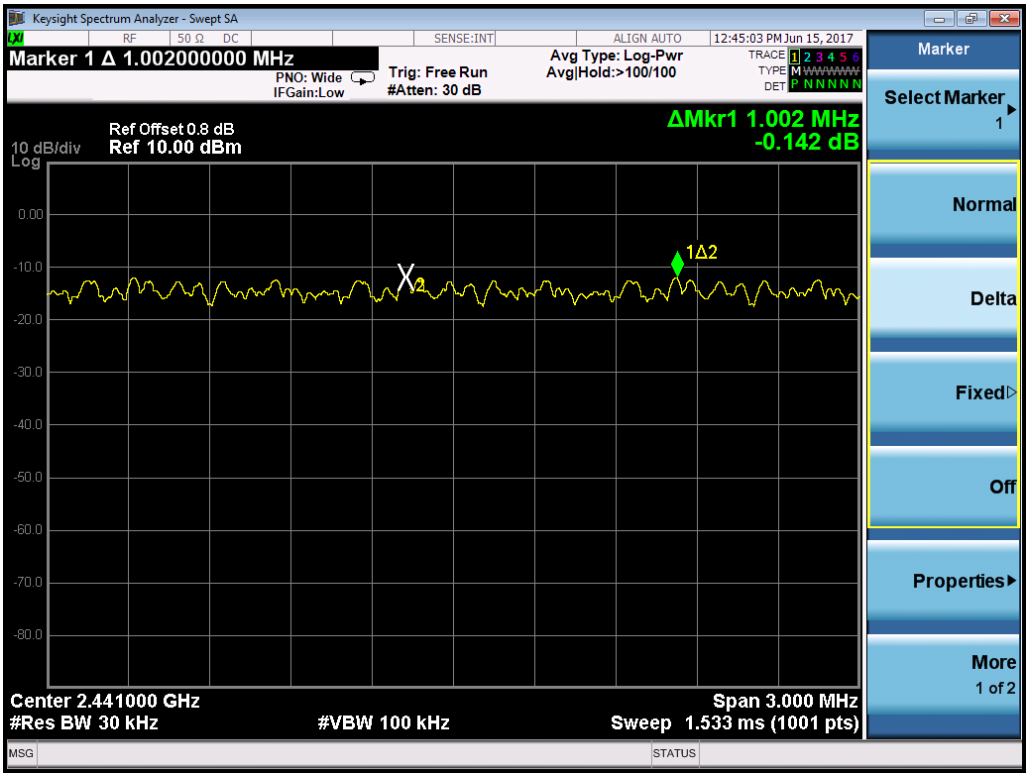

Channel H


,

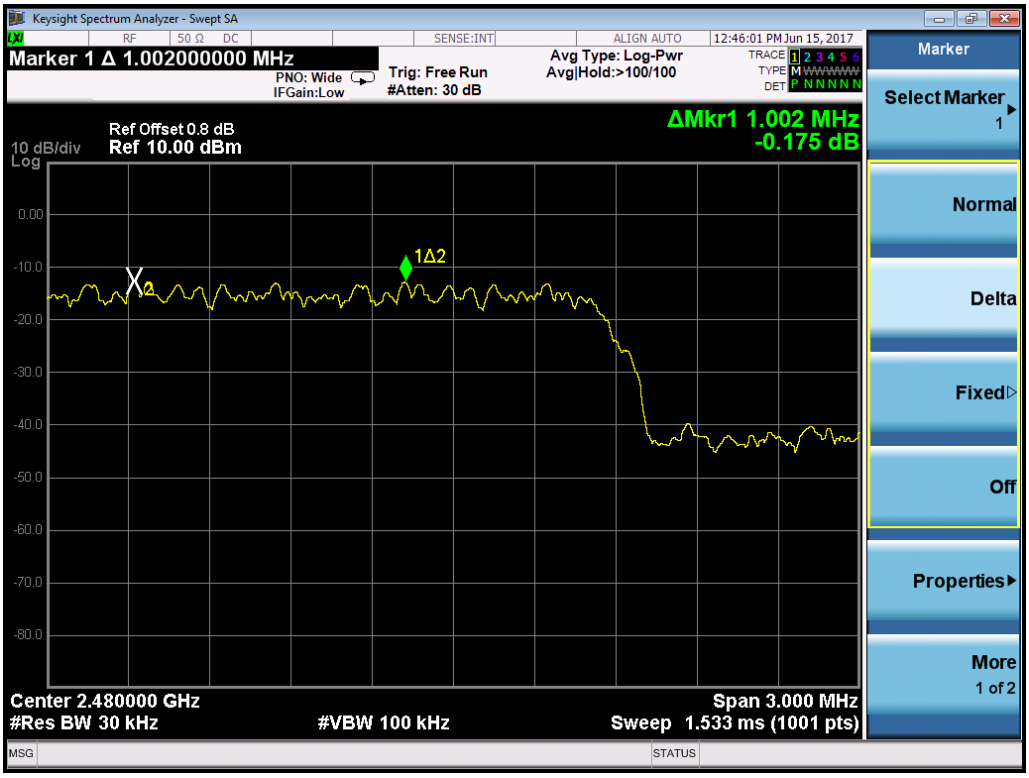
| Mode | CH | Frequency Separation (kHz) | Limit (kHz) |
|---|---|---|---|
| π /4 DQPSK | L | 1002 | ≥ 914 |
| | M | 1002 | ≥ 913 |
| | H | 1002 | ≥ 913 |

Channel L

Channel M

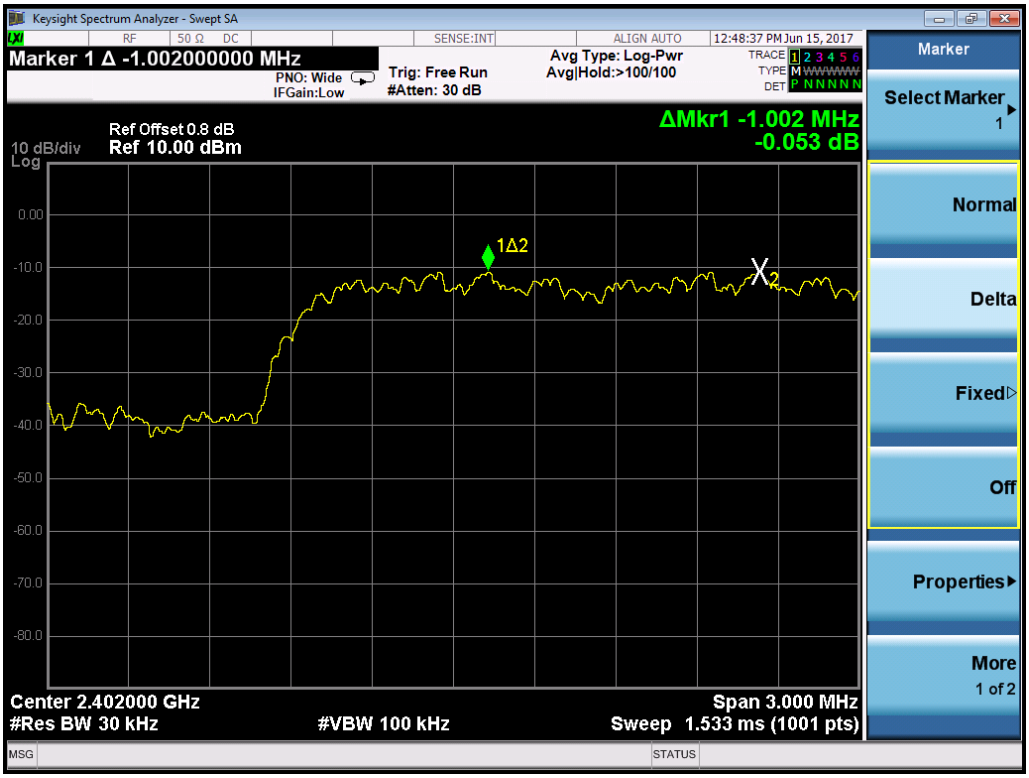



Channel H

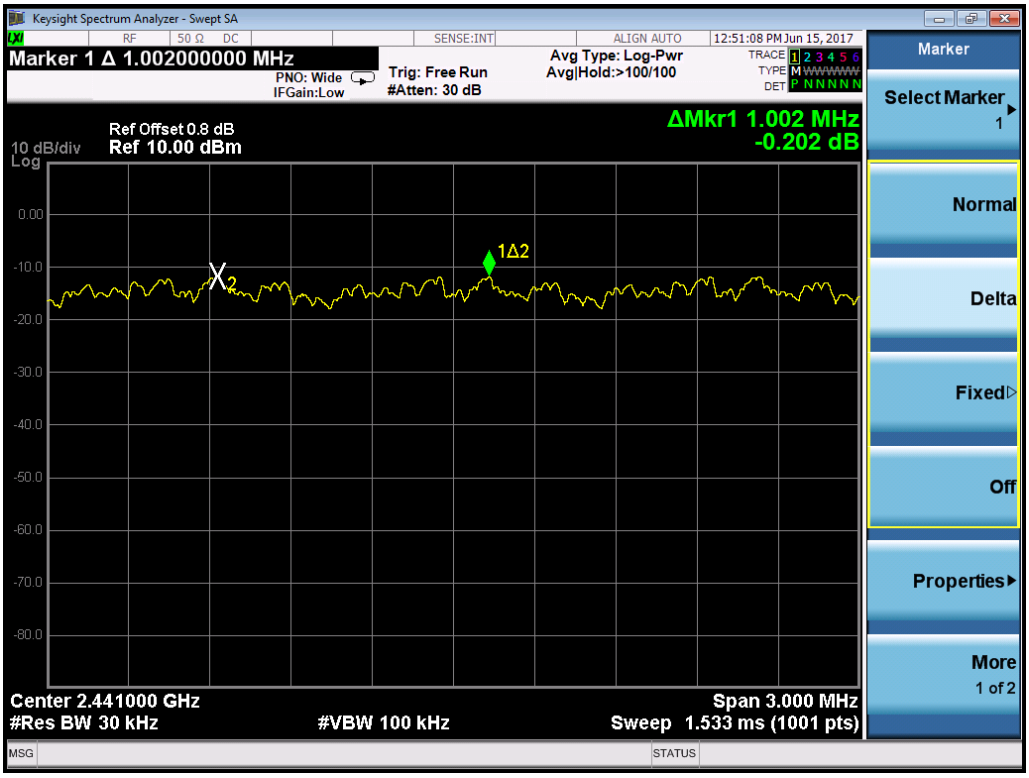


| Mode | CH | Frequency Separation (kHz) | Limit (kHz) |
|---|---|---|---|
| 8DPSK | L | 1002 | ≥ 904 |
| | M | 1002 | ≥ 903 |
| | H | 1002 | ≥ 902 |

Channel L



Channel M




Channel H

# 5. Maximum peak output power

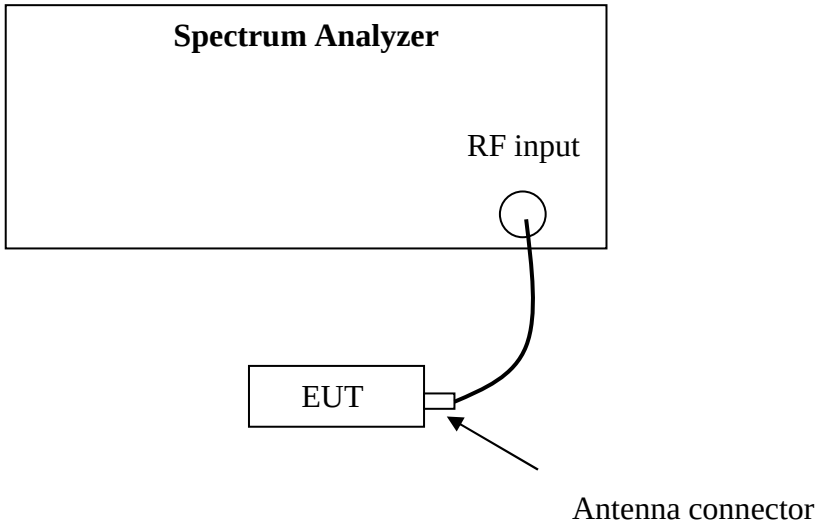
**Test result: Pass**

## 5.1 Test limit

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt

For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts
If the transmitting antenna of directional gain greater than 6dBi is used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.
For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt.

## 5.2 Test Configuration




## 5.3 Test procedure and test setup

The power output per FCC § 15.247(b) is measured using the Spectrum Analyzer with Span = 5 times the 20 dB bandwidth, RBW≥ the 20 dB bandwidth, VBW≥RBW, Sweep = auto, Detector = peak, Trace = max hold.
The test was performed at 3 channels (lowest, middle and highest channel).
The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems)

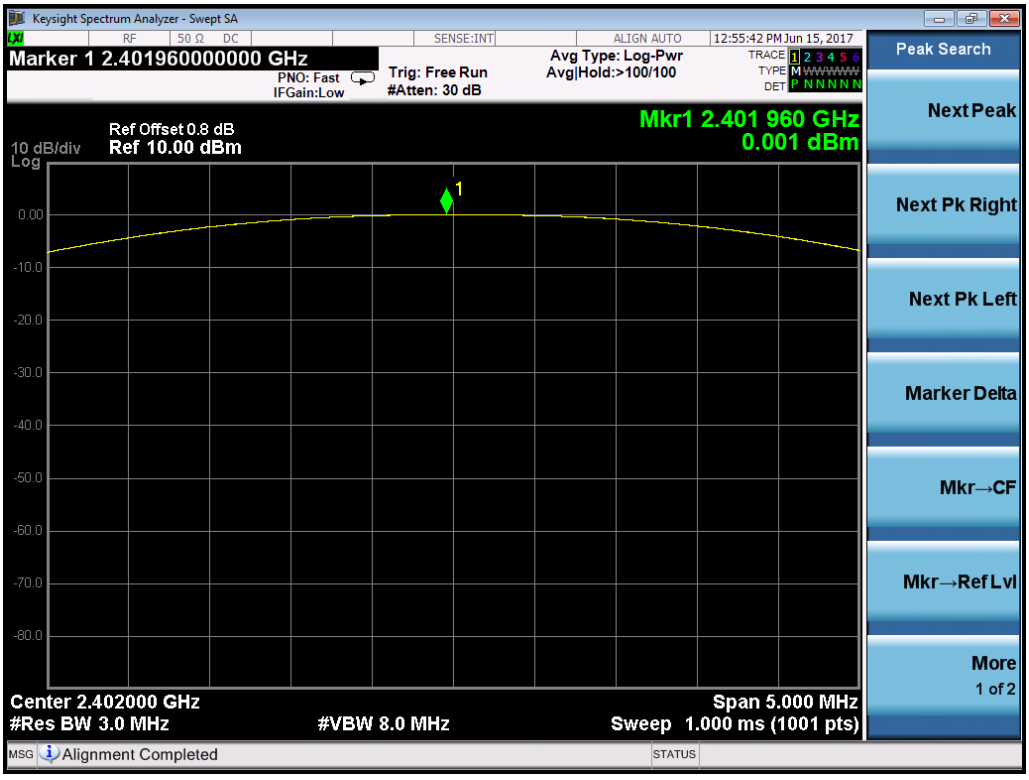
## 5.4 Test protocol

Temperature : 25 °C

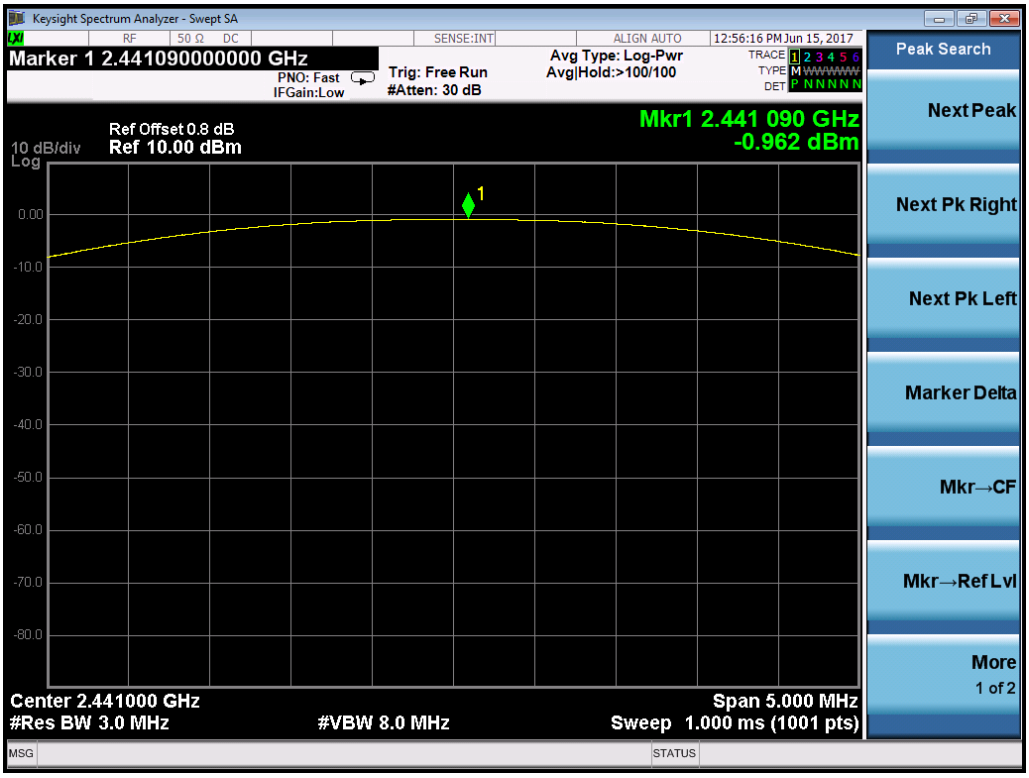
Relative Humidity : 55 %

| Mode | CH | Cable loss (dB) | Corrected reading (dBm) | Limit (dBm) |
|---|---|---|---|---|
| GFSK (DH5) | L | 0.8 | 0.001 | ≤21.00 |
| | M | 0.8 | -0.962 | |
| | H | 0.8 | -1.727 | |

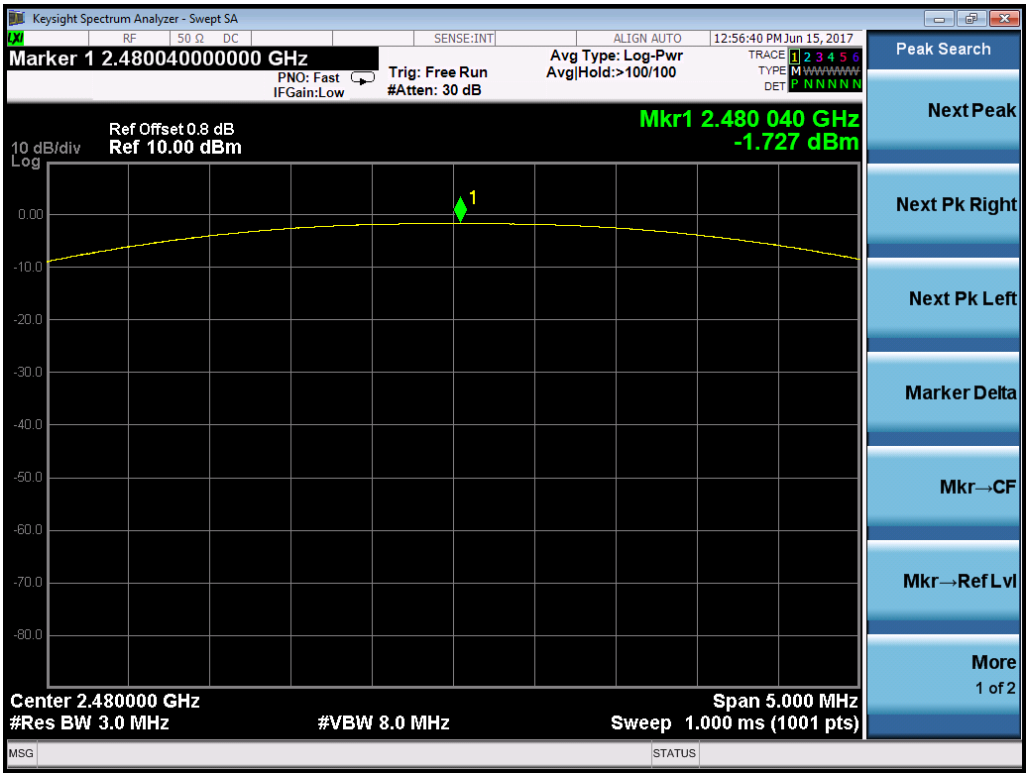
Channel L



Channel M

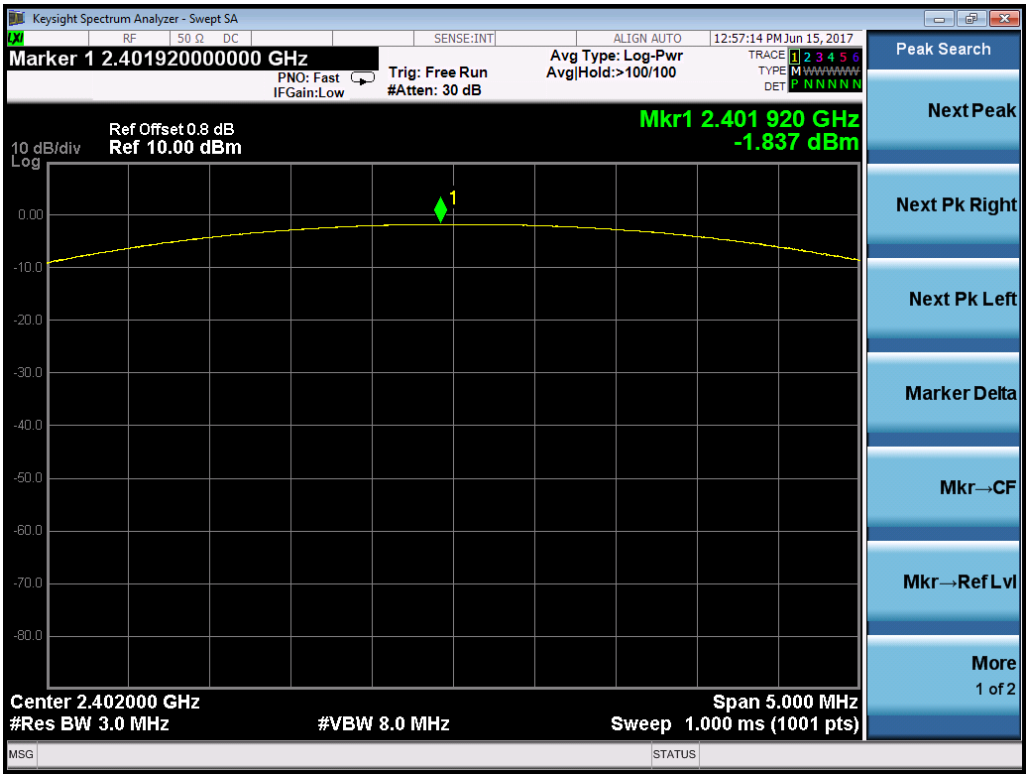



Channel H

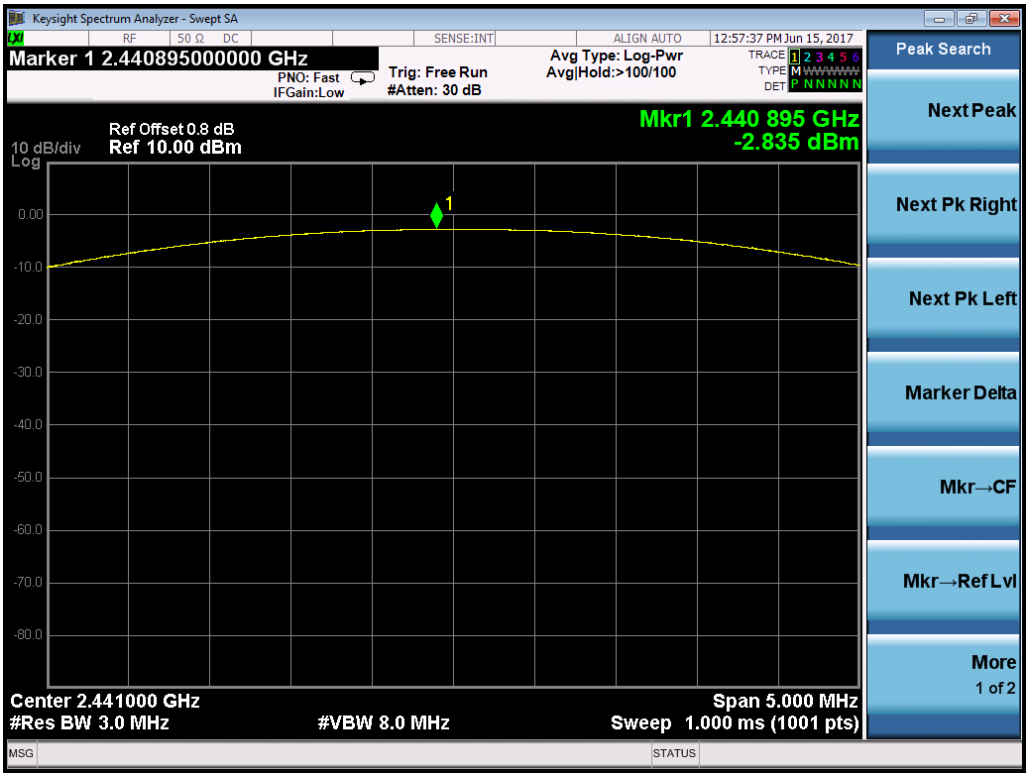


| Mode | CH | Cable loss (dB) | Corrected reading (dBm) | Limit (dBm) |
|---|---|---|---|---|
| π /4 DQPSK (2DH5) | L | 0.8 | -1.837 | ≤21.00 |
| | M | 0.8 | -2.835 | |
| | H | 0.8 | -3.624 | |

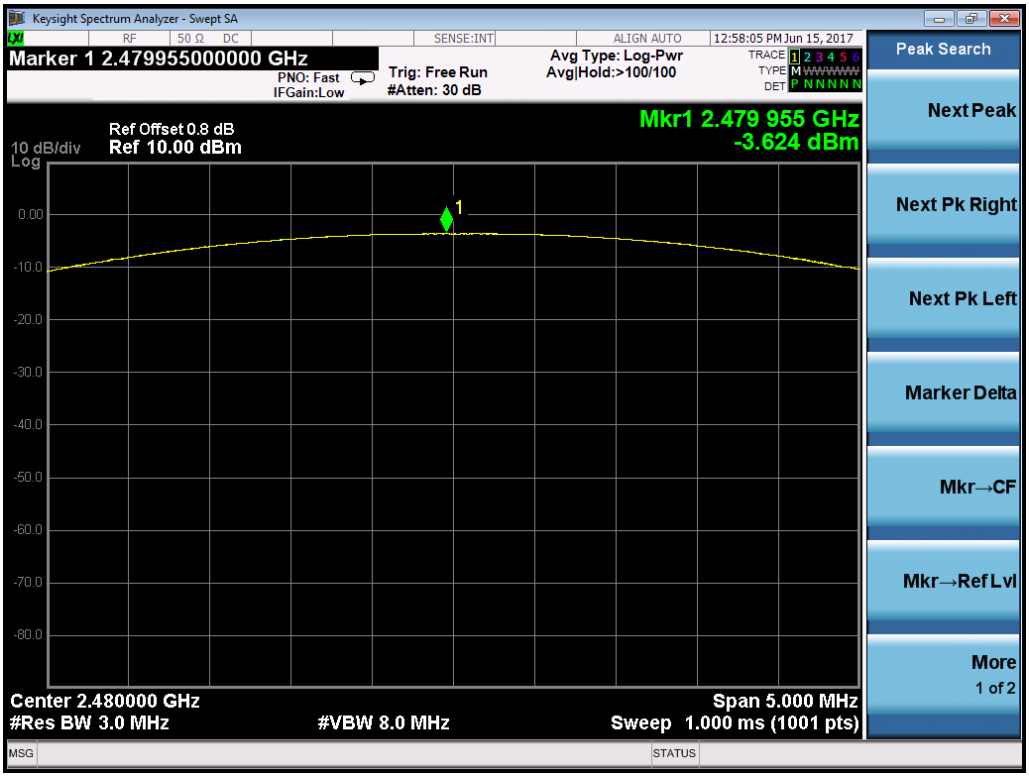
Channel L



Channel M

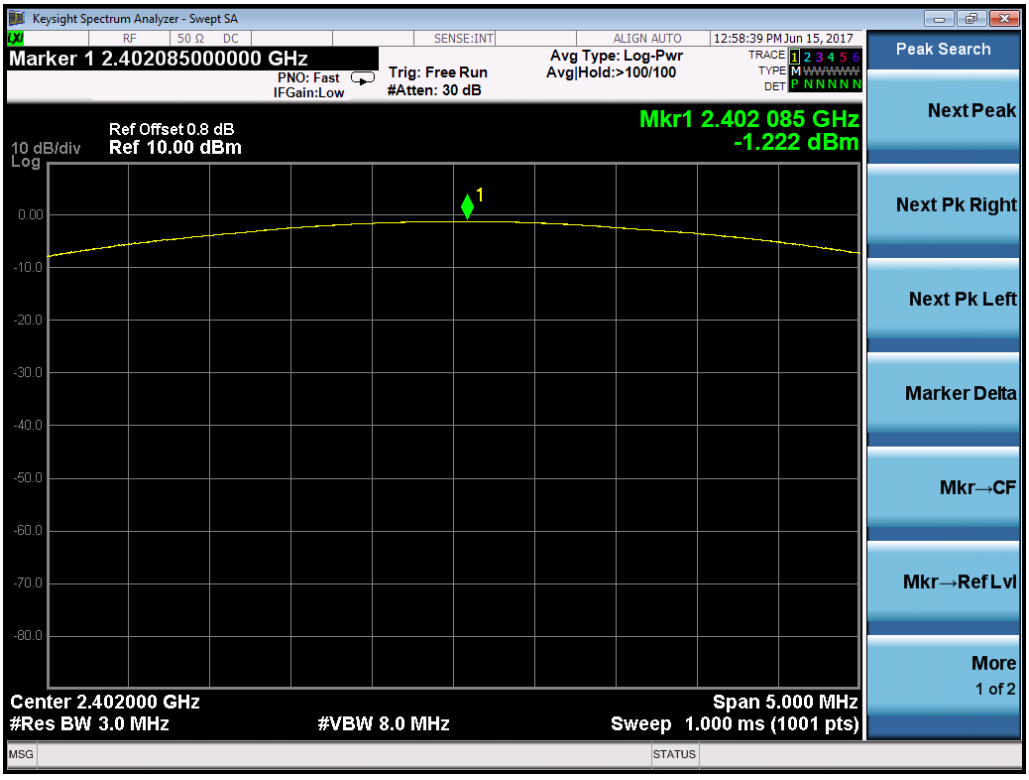



Channel H

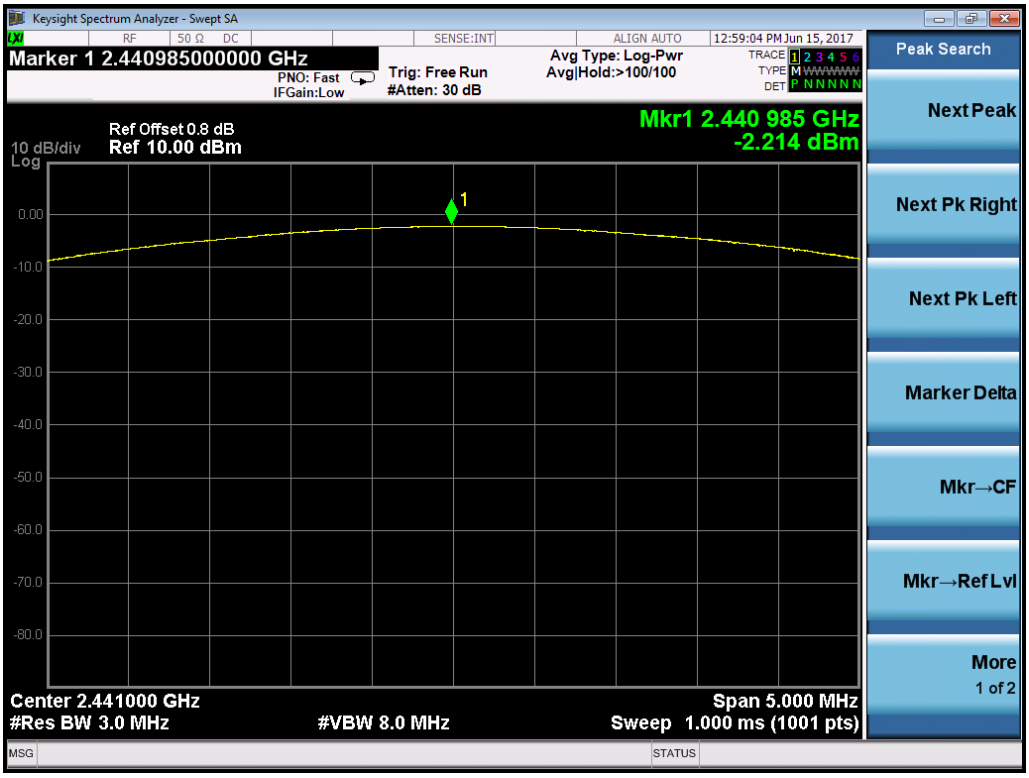


| Mode | CH | Cable loss (dB) | Corrected reading (dBm) | Limit (dBm) |
|---|---|---|---|---|
| 8DPSK (3DH5) | L | 0.8 | -1.222 | ≤21.00 |
| | M | 0.8 | -2.214 | |
| | H | 0.8 | -3.000 | |

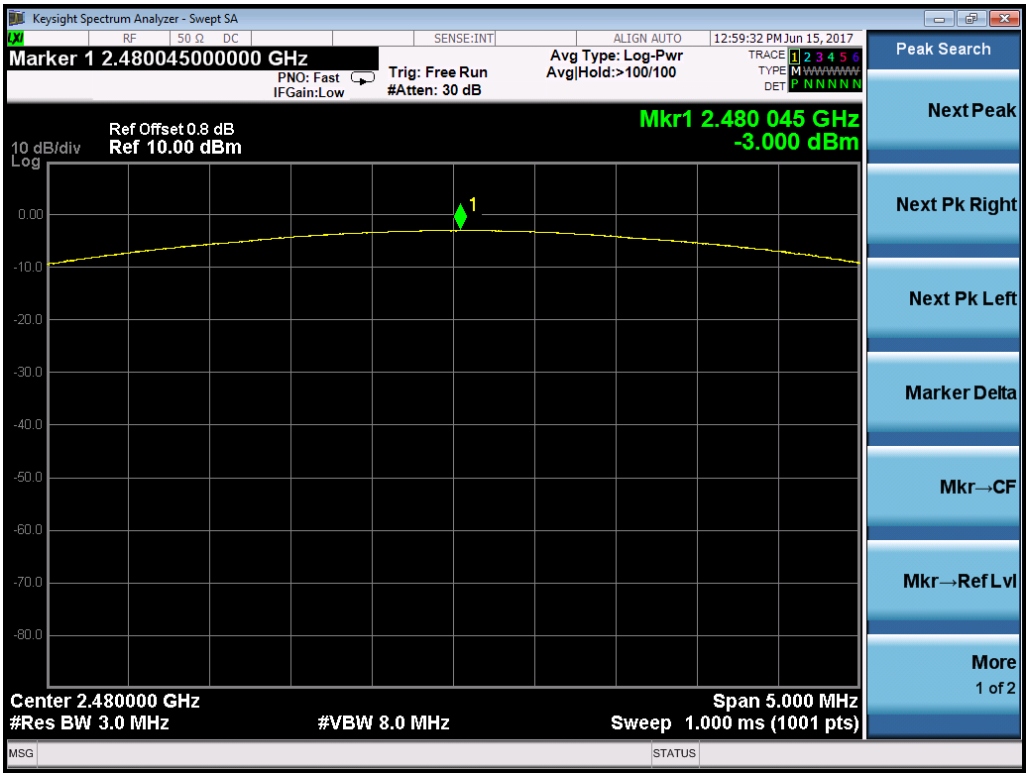
Channel L



Channel M




Channel H



# 6. Radiated Spurious Emissions

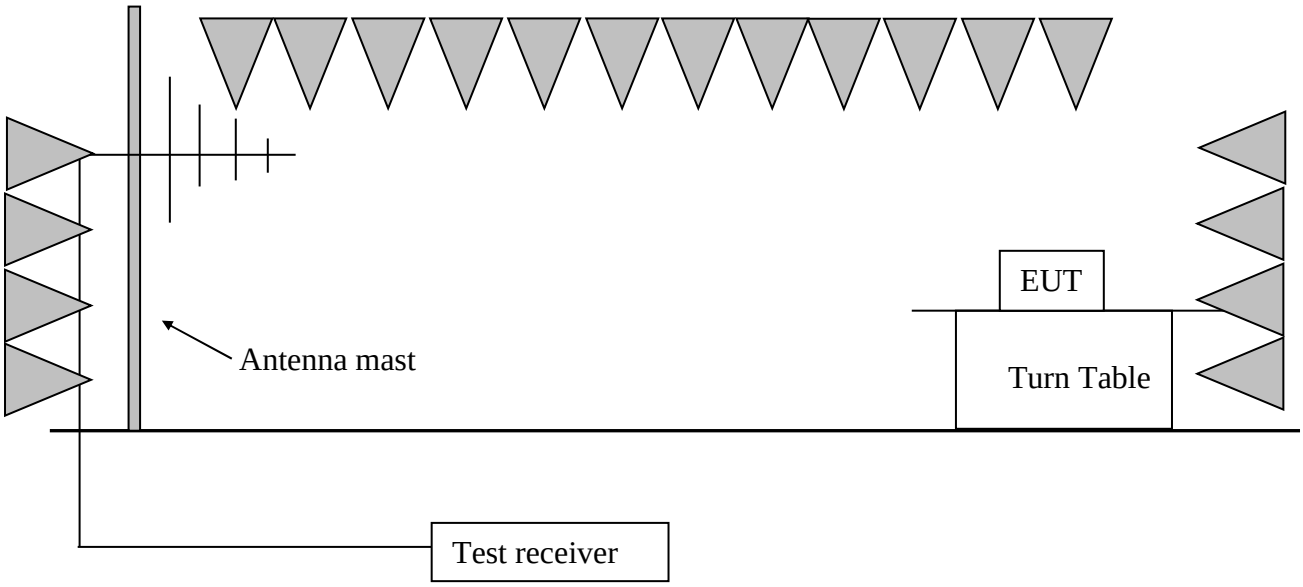
**Test result: Pass**

## 6.1 Test limit

The radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) showed as below:

| Frequency (MHz) | Field Strength (dBuV/m) | Measurement Distance (m) |
|---|---|---|
| 30 - 88 | 40.0 | 3 |
| 88 - 216 | 43.5 | 3 |
| 216 - 960 | 46.0 | 3 |
| Above 960 | 54.0 | 3 |

## 6.2 Test Configuration



### 6.3 Test procedure and test setup

The measurement was applied in a semi-anechoic chamber. While testing for spurious emission higher than 1GHz, if applied, the pre-amplifier would be equipped just at the output terminal of the antenna.

Tabletop devices shall be placed on a nonconducting platform with nominal top surface dimensions 1 m by 1.5 m. For emissions testing at or below 1 GHz, the table height shall be 80 cm above the reference ground plane. For emission measurements above 1 GHz, the table height shall be 1.5 m.

The turn table rotated 360 degrees to determine the position of the maximum emission level. The EUT was set 3 meters away from the receiving antenna which was mounted on an antenna mast. The antenna moved up and down between from 1meter to 4 meters to find out the maximum emission level.

The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems)

The radiated emission was measured using the Spectrum Analyzer with the resolutions bandwidth set as:

RBW = 100 kHz, VBW = 300 kHz (30MHz~1GHz)
RBW = 1MHz, VBW = 3MHz (>1GHz for PK);

Remark: 1. For fundamental emission, no amplifier is employed.
2. Correct Factor = Antenna Factor + Cable Loss (-Amplifier, is employed)
3. Corrected Reading = Original Receiver Reading + Correct Factor
4. Margin = limit – Corrected Reading
5. If the PK reading is lower than AV limit, the AV test can be elided.
6. The emission was conducted from 30MHz to 25GHz.

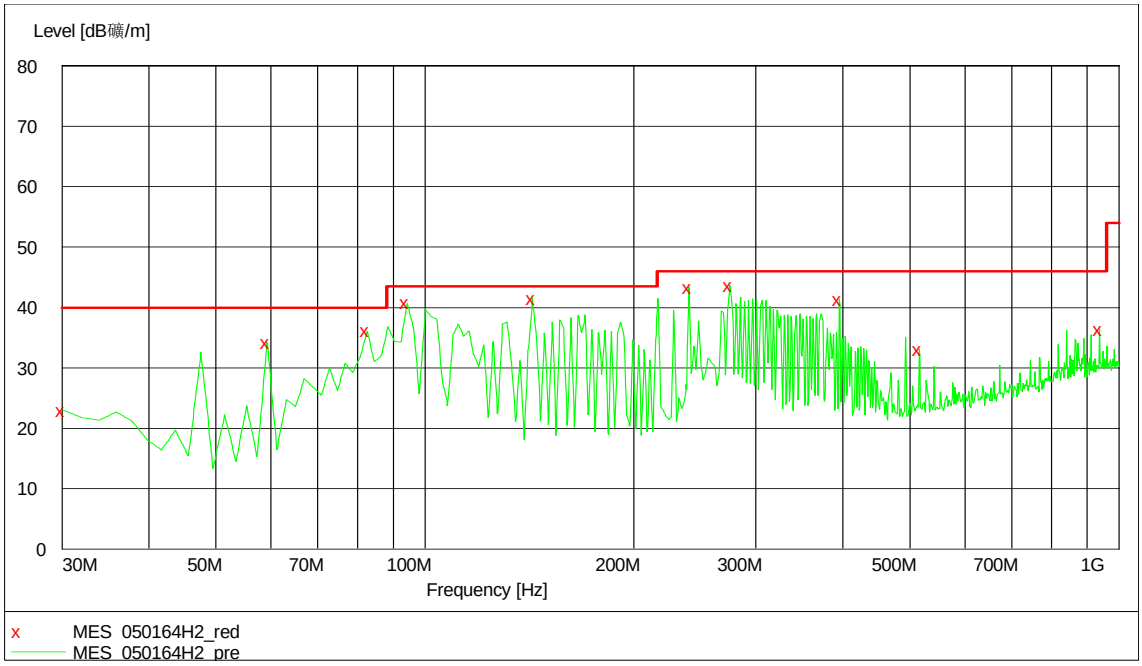
Example: Assuming Antenna Factor = 30.20dB/m, Cable Loss = 2.00dB,
Gain of Preamplifier = 32.00dB, Original Receiver Reading = 10dBuV.
Then Correct Factor = 30.20 + 2.00 – 32.00 = 0.20dB/m; Corrected Reading = 10dBuV + 0.20dB/m = 10.20dBuV/m
Assuming limit = 54dBuV/m, Corrected Reading = 10.20dBuV/m, then Margin = 54 -10.20 = 43.80dBuV/m

## 6.4 Test protocol

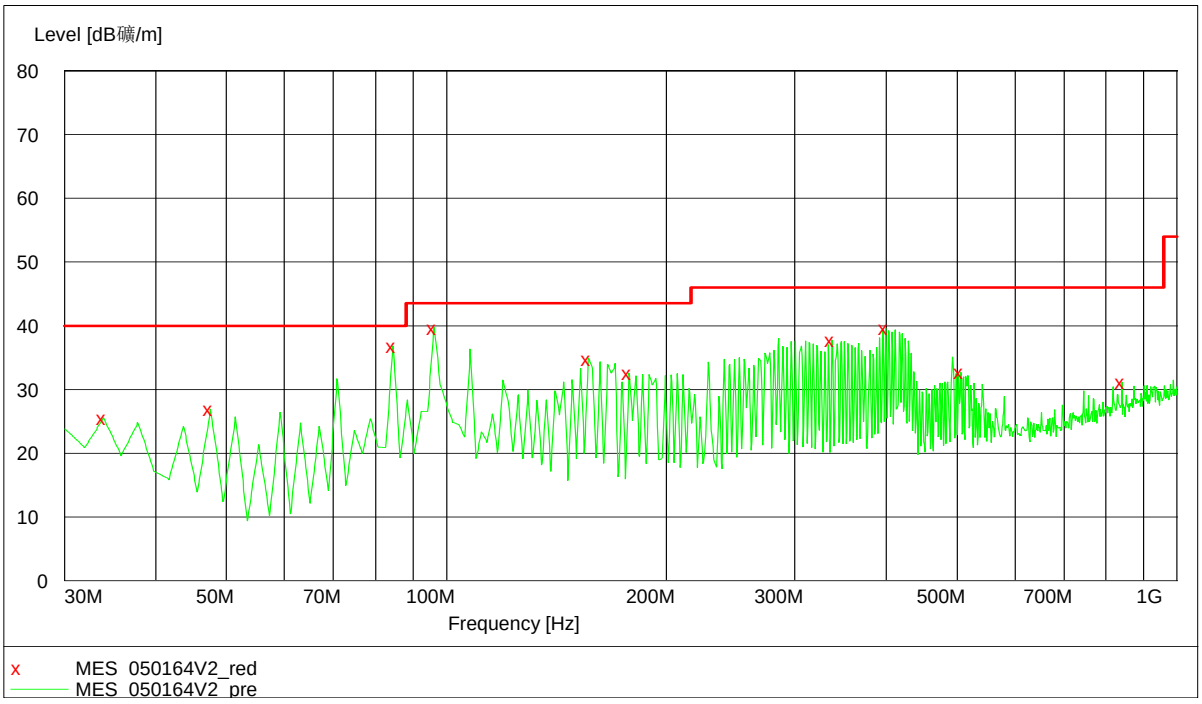
| | | |
|---|---|---|
| Temperature | : | 25 °C |
| Relative Humidity | : | 55 % |

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

Horizontal




Vertical



**Test data (30MHz~1GHz, GFSK (DH5) Mode):**

Horizontal

| Frequency (MHz) | Measured level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector |
|---|---|---|---|---|
| 82.42 | 36.2 | 40.0 | 3.8 | PK |
| 94.09 | 40.9 | 43.5 | 2.6 | PK |
| 142.74 | 41.5 | 43.5 | 2.0 | PK |
| 239.93 | 43.3 | 46.0 | 2.7 | PK |
| 274.92 | 43.7 | 46.0 | 2.3 | PK |
| Remark: If the margin higher than 10dB, it would be marked as *. | | | | |

Vertical

| Frequency (MHz) | Measured level (dBμV/m) | Limits (dBμV/m) | Margin (dB) | Detector |
|---|---|---|---|---|
| 84.42 | 36.8 | 40.0 | 3.2 | PK |
| 96.09 | 39.7 | 43.5 | 3.8 | PK |
| 337.13 | 37.7 | 46.0 | 8.3 | PK |
| 399.33 | 39.6 | 46.0 | 6.4 | PK |
| Remark: If the margin higher than 10dB, it would be marked as *. | | | | |

**Test Data (>1GHz):**

GFSK (DH5) Modulation:

| **H** | **Antenna** | **Frequency (MHz)** | **Correct Factor (dB/m)** | **Corrected Reading (dBuV/m)** | **Limit (dBuV/m)** | **Margin (dB)** | **Detector** |
|---|---|---|---|---|---|---|---|
| L | H | 2402.00 | 30.70 | 56.20 | Fundamental | / | PK |
| | H | 2389.90 | 30.20 | 41.50 | 74.00 | 32.50 | PK |
| | H | 2389.90 | 30.20 | 30.10 | 54.00 | 23.90 | AV |
| | H | 4804.00 | -1.50 | 44.50 | 74.00 | 29.50 | PK |
| M | V | 2441.00 | 30.70 | 62.50 | Fundamental | / | PK |
| | V | 4882.00 | -1.10 | 42.50 | 74.00 | 31.50 | PK |
| H | H | 2480.00 | 30.70 | 55.70 | Fundamental | / | PK |
| | V | 2483.50 | 31.52 | 41.40 | 74.00 | 32.60 | PK |
| | V | 2483.50 | 31.52 | 30.50 | 54.00 | 23.50 | AV |
| | V | 4960.00 | -0.80 | 37.60 | 74.00 | 36.40 | PK |

π /4DQPSK (2DH5) Modulation:

| CH | Antenna | Frequency (MHz) | Correct Factor (dB/m) | Corrected Reading (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| L | H | 2402.00 | 30.70 | 59.10 | Fundamental | / | PK |
| | H | 2389.98 | 30.20 | 45.90 | 74.00 | 29.10 | PK |
| | H | 2389.98 | 30.20 | 30.10 | 54.00 | 23.90 | AV |
| | H | 4804.00 | -1.50 | 32.80 | 74.00 | 41.20 | PK |
| M | V | 2441.00 | 30.70 | 63.90 | Fundamental | / | PK |
| | V | 4882.00 | -1.10 | 33.60 | 74.00 | 40.40 | PK |
| H | H | 2480.00 | 30.70 | 57.50 | Fundamental | / | PK |
| | V | 2483.50 | 31.52 | 42.90 | 74.00 | 31.10 | PK |
| | V | 2483.50 | 31.52 | 31.20 | 54.00 | 22.80 | AV |
| | V | 4960.00 | -0.80 | 36.60 | 74.00 | 37.40 | PK |

8DPSK (3DH5) Modulation:

| CH | Antenna | Frequency (MHz) | Correct Factor (dB/m) | Corrected Reading (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| L | H | 2402.00 | 30.70 | 60.80 | Fundamental | / | PK |
| | H | 2389.93 | 30.20 | 47.10 | 74.00 | 26.90 | PK |
| | H | 2389.93 | 30.20 | 32.70 | 54.00 | 21.30 | AV |
| | H | 4804.00 | -1.50 | 30.20 | 74.00 | 43.80 | PK |
| M | V | 2441.00 | 30.70 | 65.40 | Fundamental | / | PK |
| | V | 4882.00 | -1.10 | 34.30 | 74.00 | 39.70 | PK |
| H | H | 2480.00 | 30.70 | 61.10 | Fundamental | / | PK |
| | V | 2483.50 | 31.52 | 42.50 | 74.00 | 31.50 | PK |
| | V | 2483.50 | 31.52 | 30.60 | 54.00 | 23.40 | AV |
| | V | 4960.00 | -0.80 | 36.90 | 74.00 | 37.10 | PK |

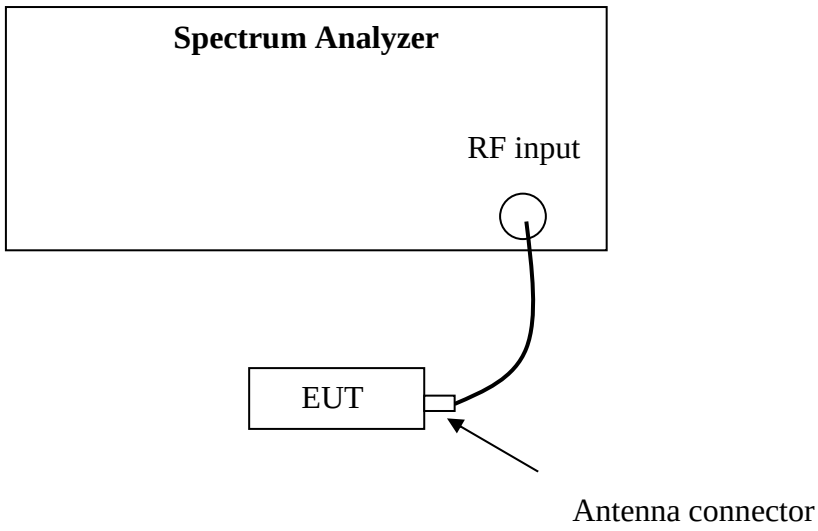
# 7. Conducted Spurious Emissions & Band Edge

**Test result: Pass**

## 7.1 Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum 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.

## 7.2 Test Configuration




## 7.3 Test procedure and test setup

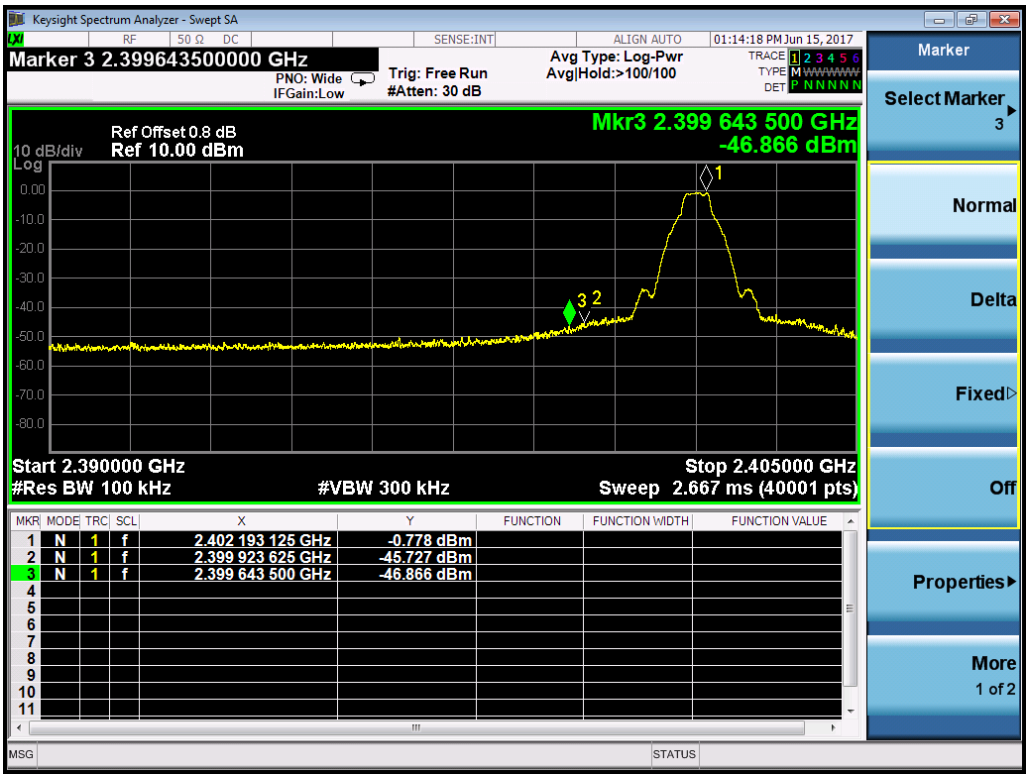
The Conducted Spurious Emissions per FCC § 15.247(d) is measured using the Spectrum Analyzer with Span wide enough capturing all spurious from the lowest emission frequency of the EUT up to 10th harmonics, RBW = 100kHz, VBW≥RBW, Sweep = auto, Detector = peak, Trace = max hold.
The test was performed at 3 channels (lowest, middle and highest channel).
The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems)

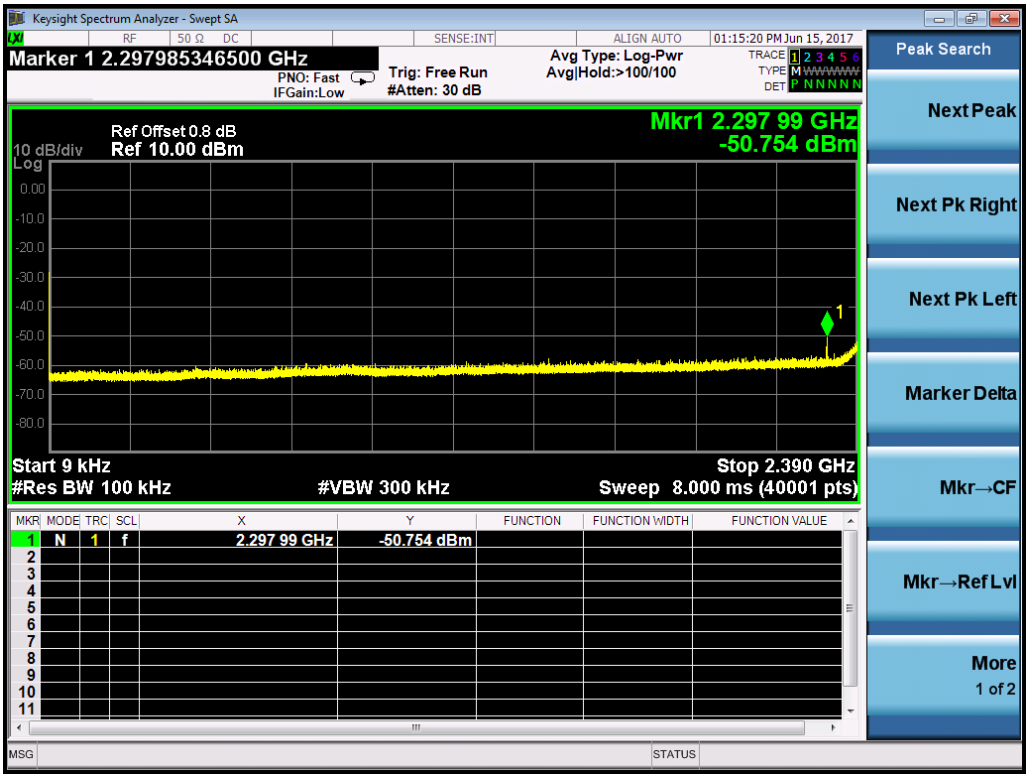
## 7.4 Test protocol

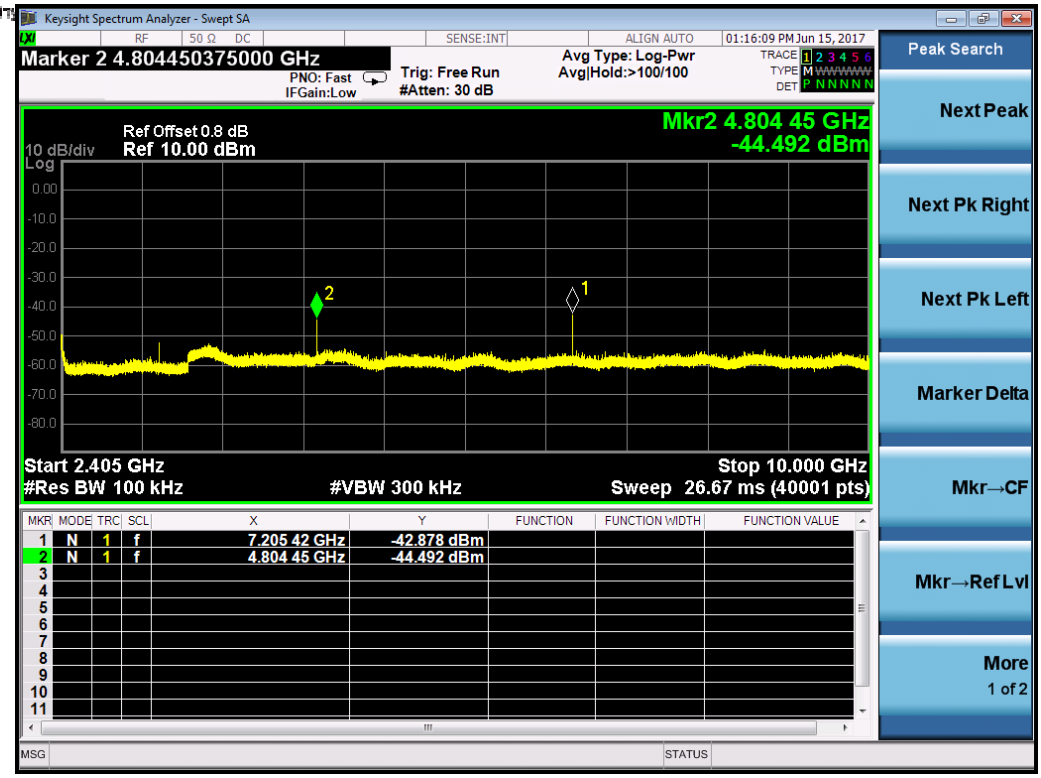
Temperature : 25 °C

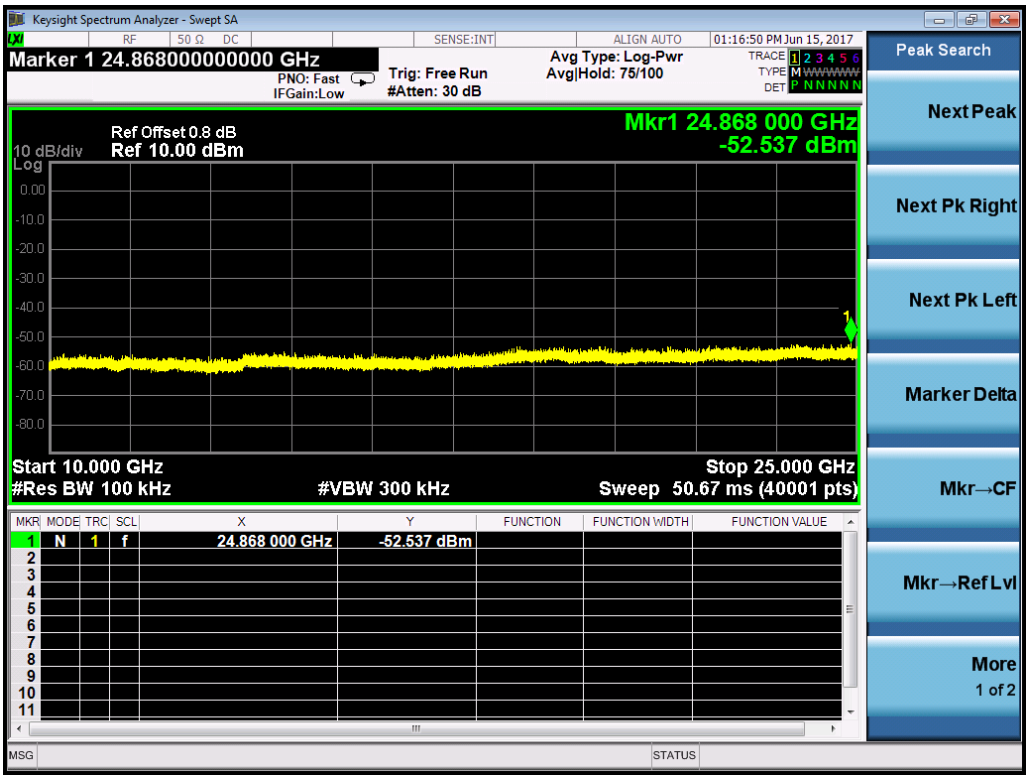
Relative Humidity : 55 %

GFSK Channel- L

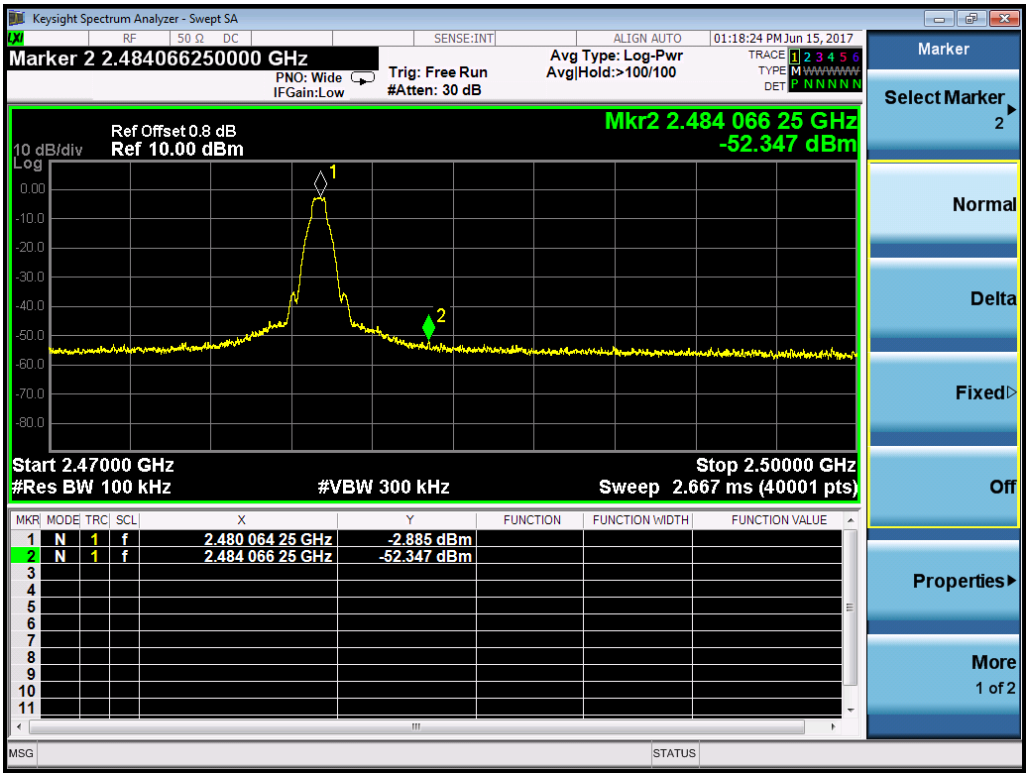


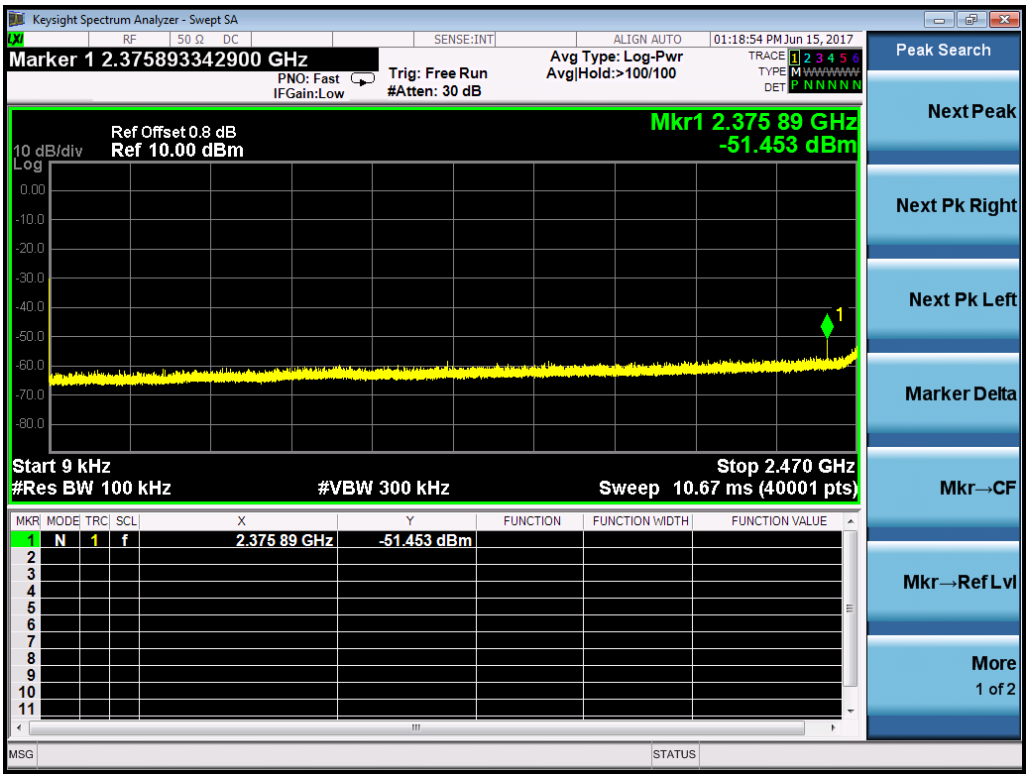



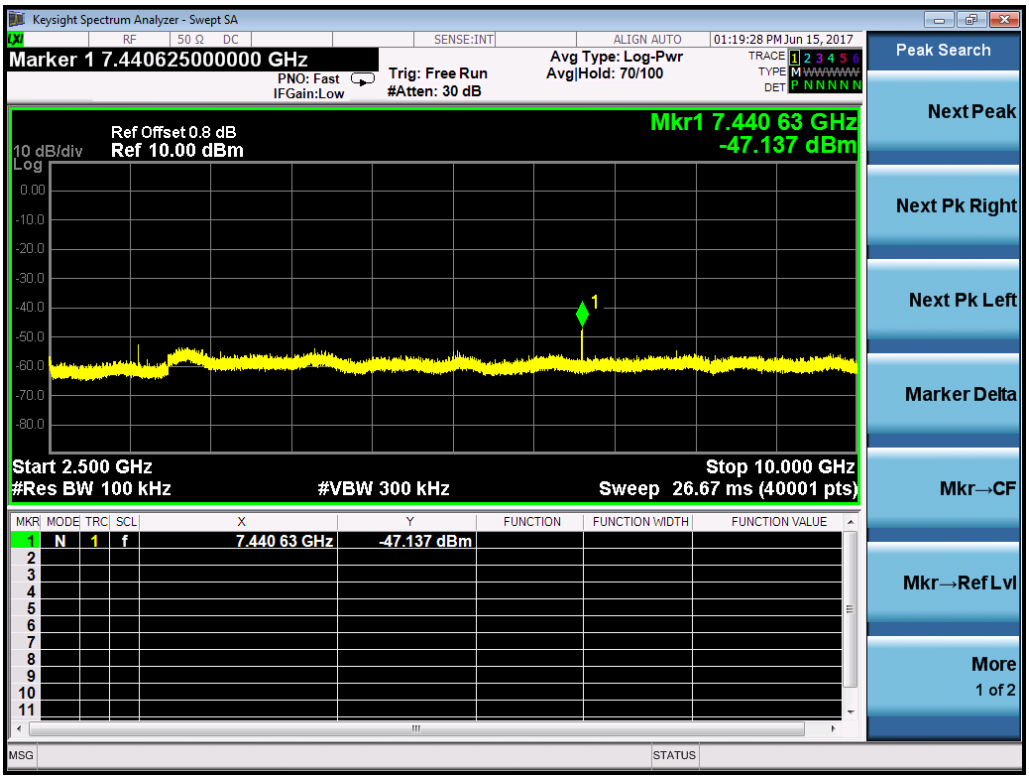


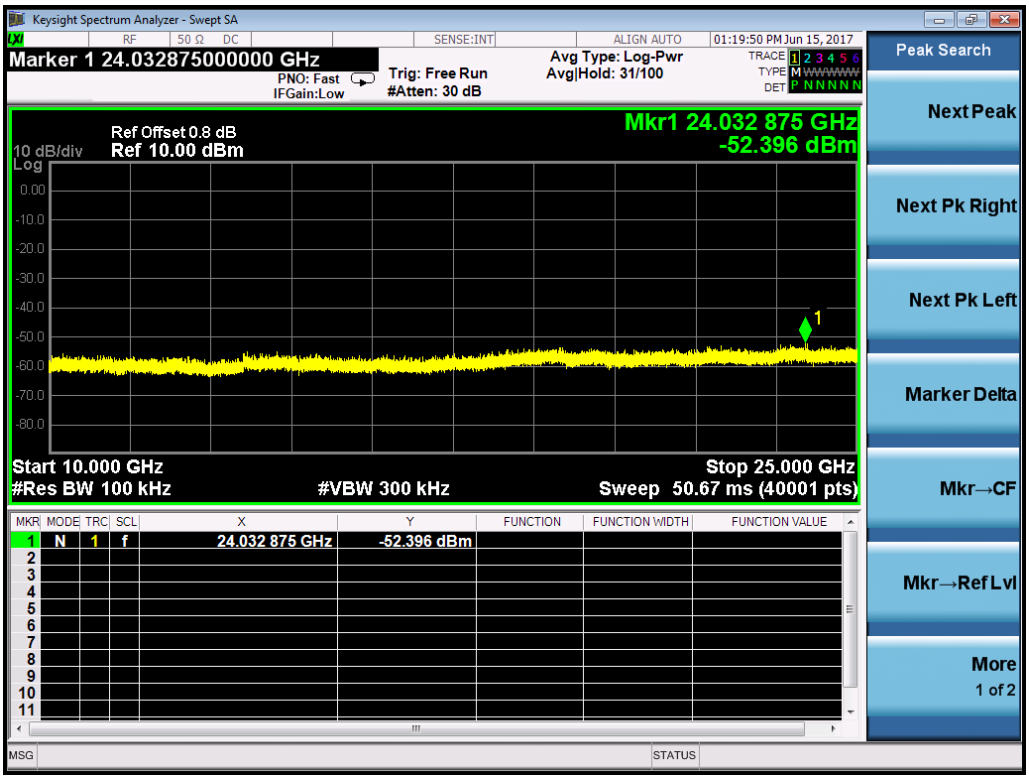



GFSK Channel- H

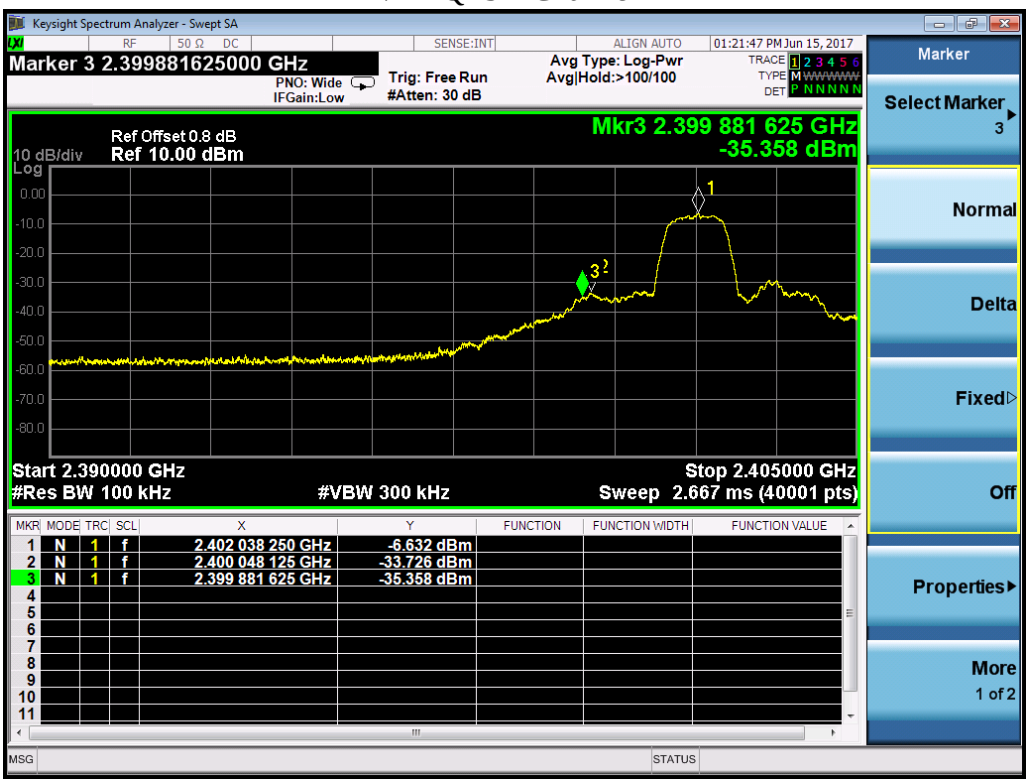


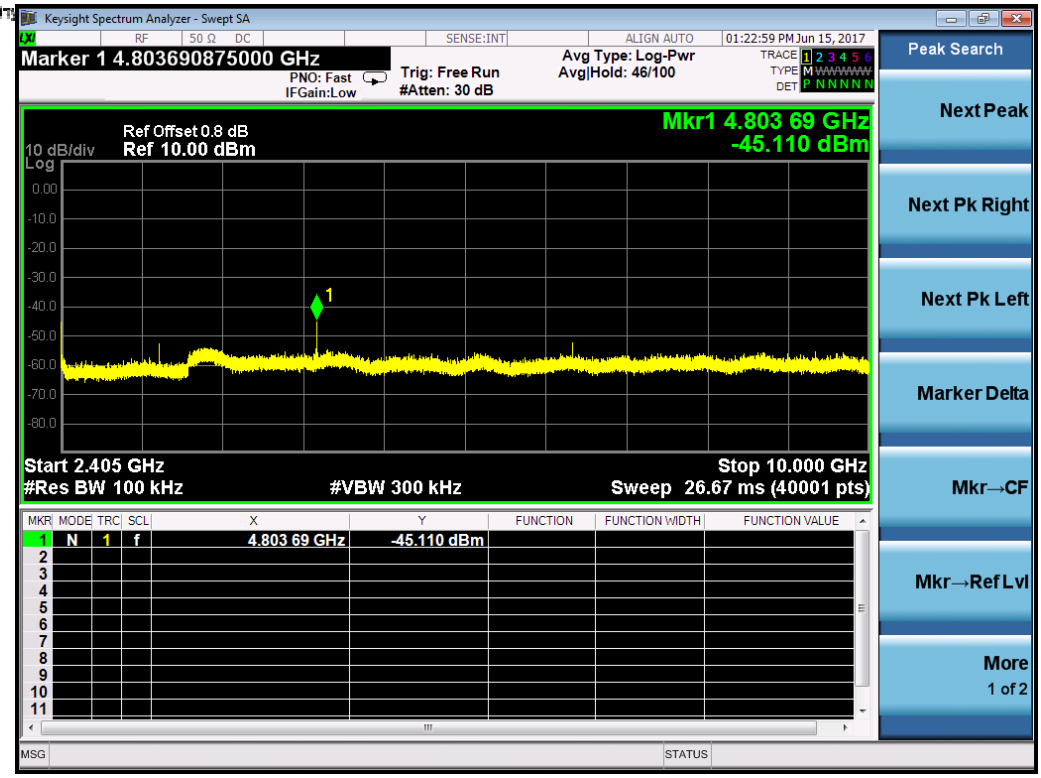



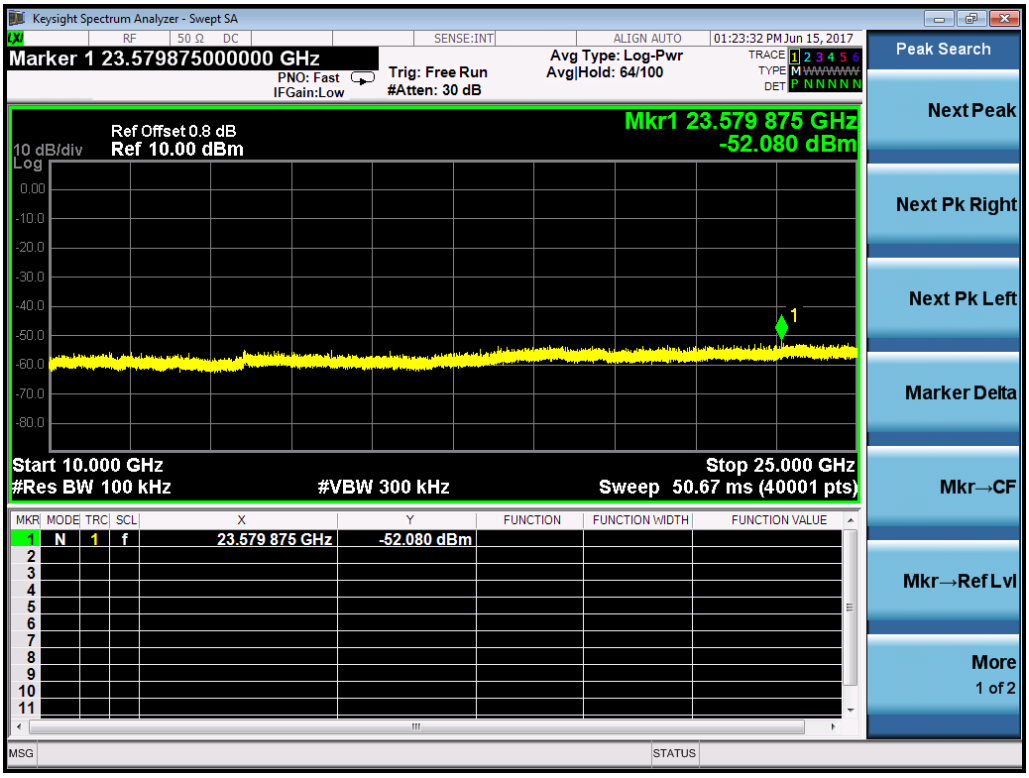


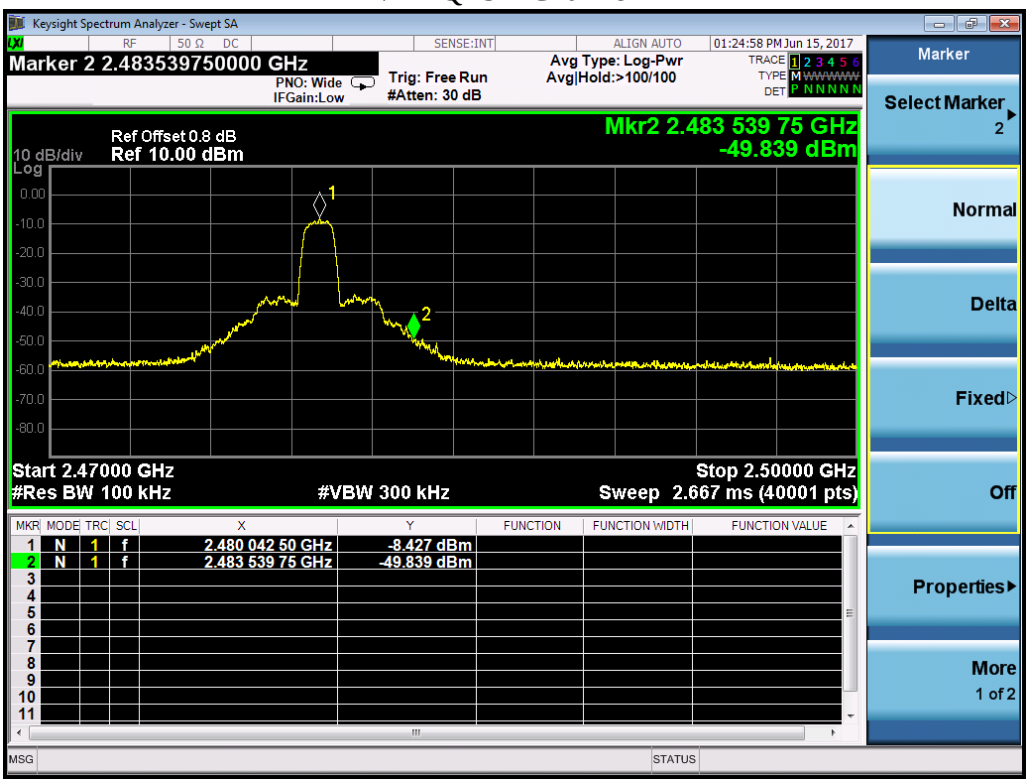
π /4 DQPSK Channel- L

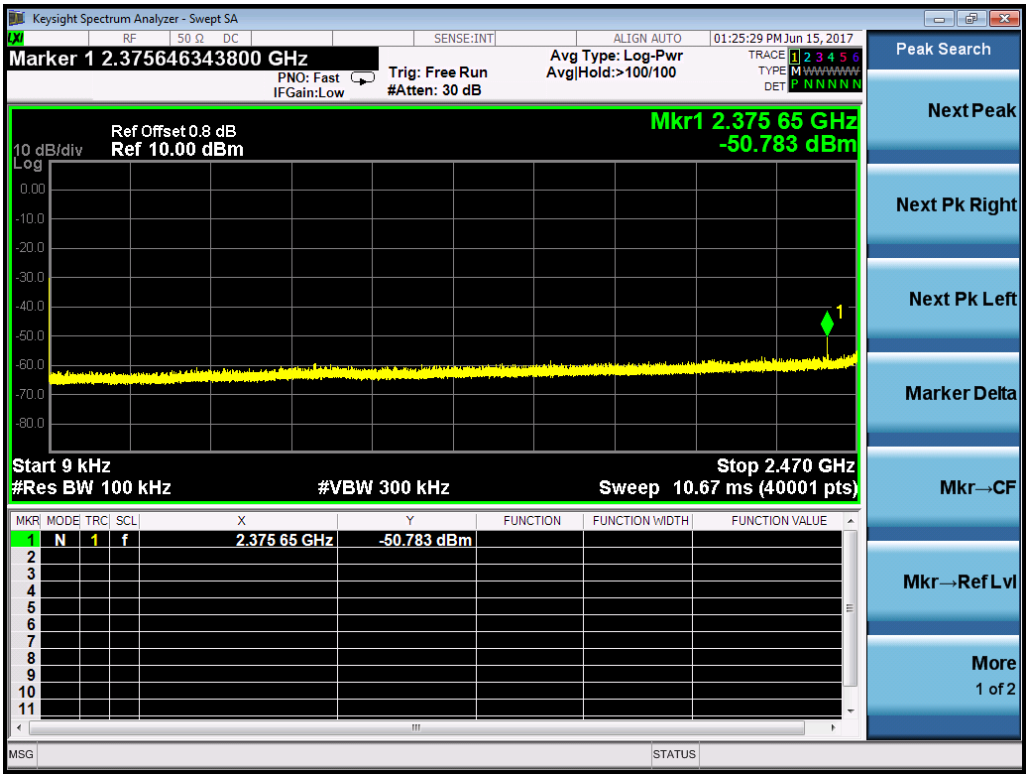


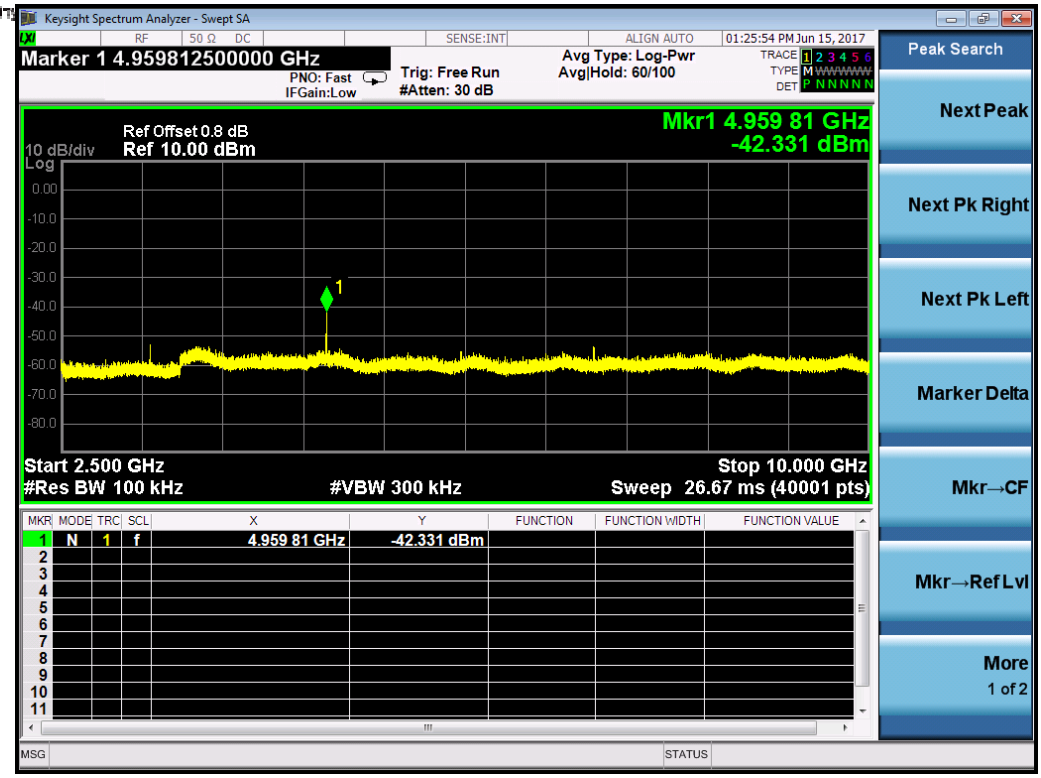


Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:22:59 PM Jun 15, 2017
Marker 1 4.803690875000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 46/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 4.803 69 GHz
-45.110 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 2.405 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 10.000 GHz
Sweep 26.67 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 4.803 69 GHz -45.110 dBm
MSG
STATUS
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

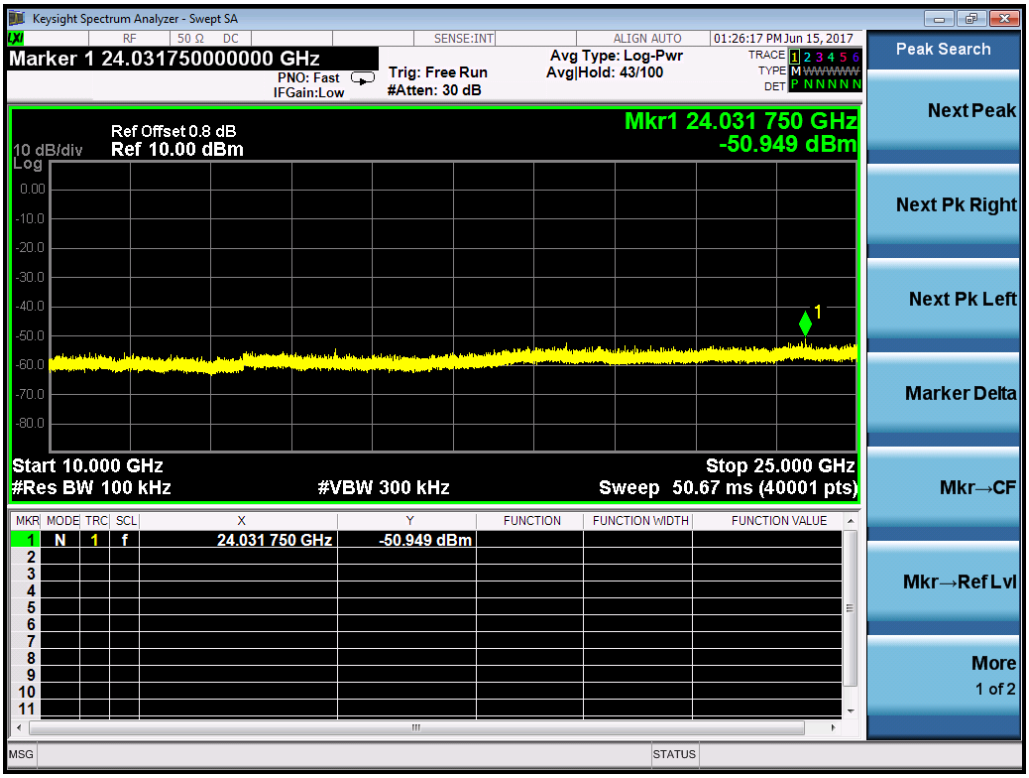

Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:23:32 PM Jun 15, 2017
Marker 1 23.579875000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 64/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 23.579 875 GHz
-52.080 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 10.000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.000 GHz
Sweep 50.67 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 23.579 875 GHz -52.080 dBm
MSG
STATUS
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2

π /4 DQPSK Channel- H

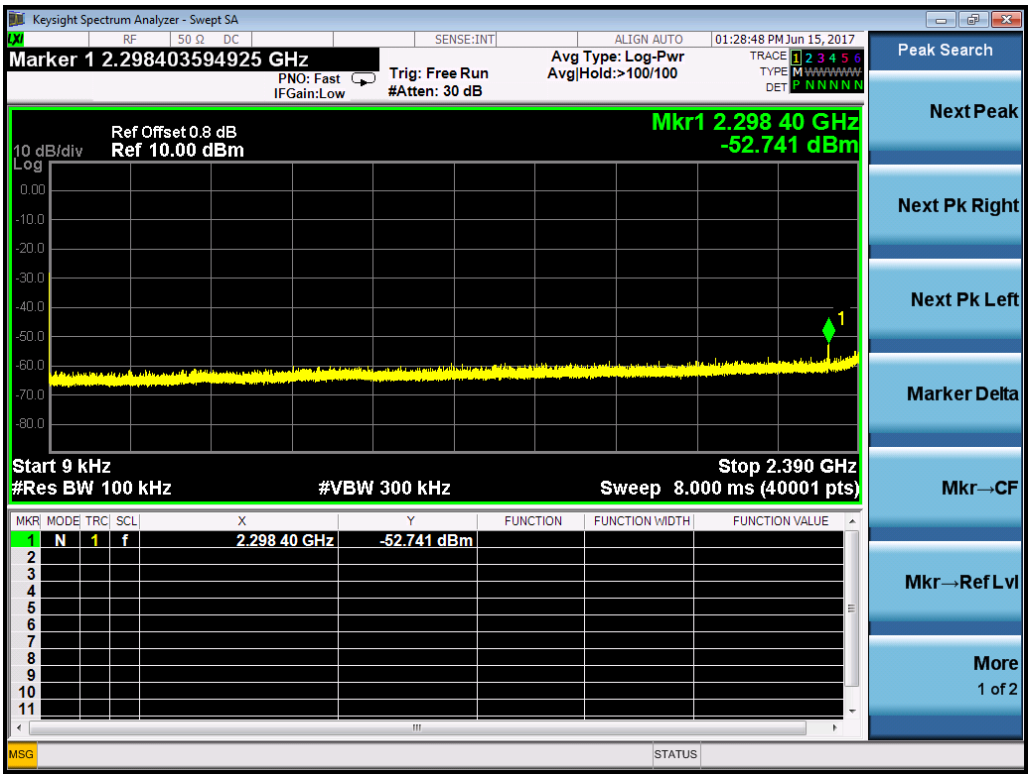


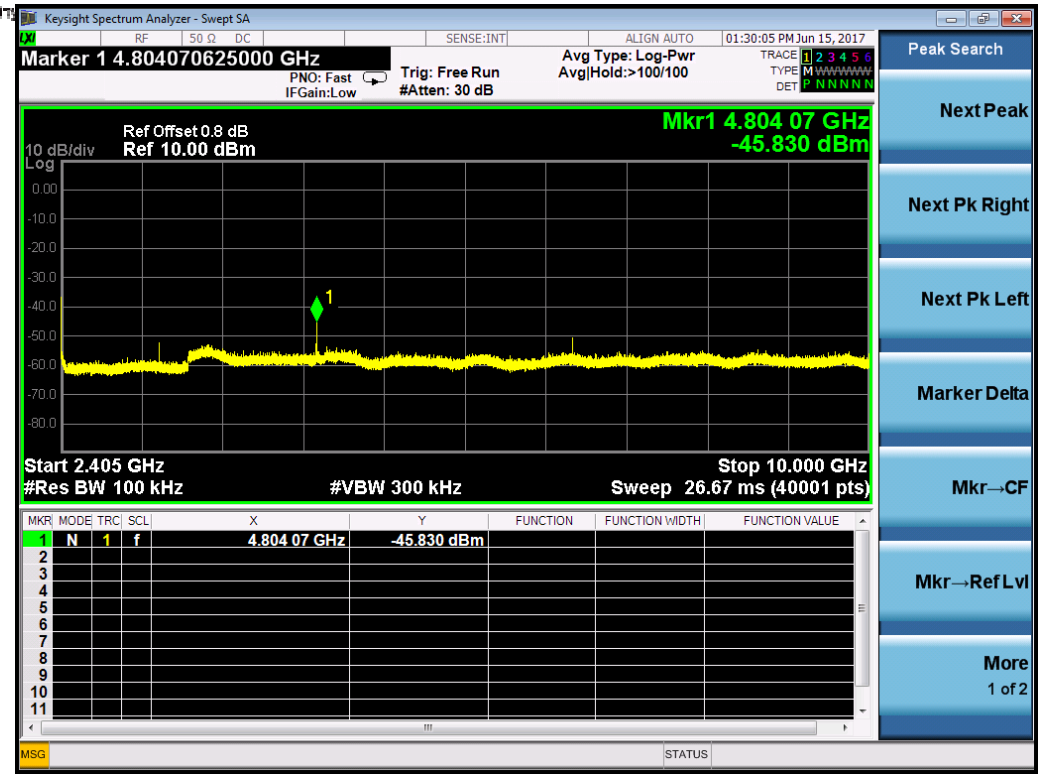



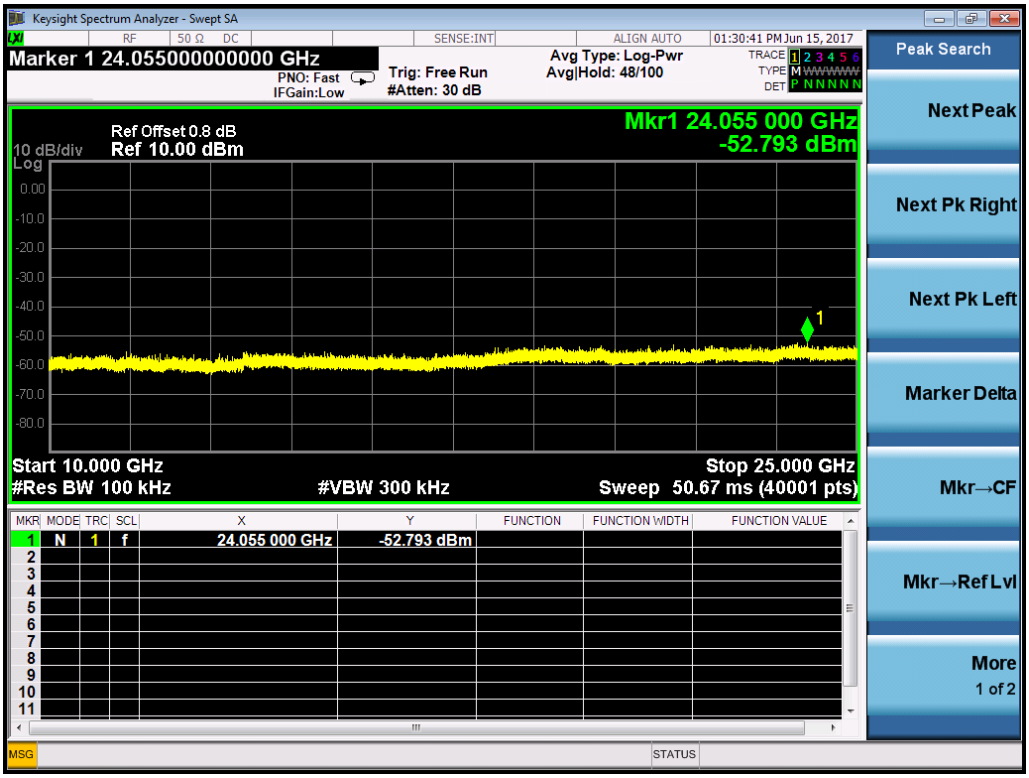

Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:25:54 PM Jun 15, 2017
Marker 1 4.959812500000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 60/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 4.959 81 GHz
-42.331 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 2.500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 10.000 GHz
Sweep 26.67 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 4.959 81 GHz -42.331 dBm
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2
MSG
STATUS


Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:26:17 PM Jun 15, 2017
Marker 1 24.031750000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 43/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 24.031 750 GHz
-50.949 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 10.000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.000 GHz
Sweep 50.67 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 24.031 750 GHz -50.949 dBm
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2
MSG
STATUS

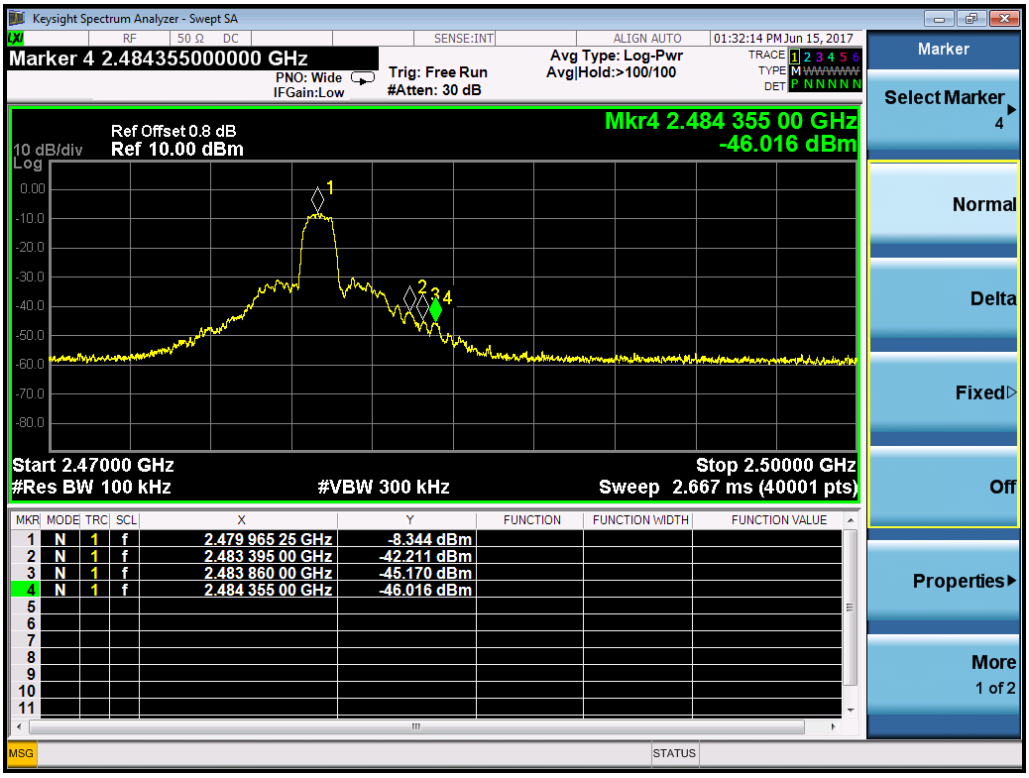
8DPSK Channel- L

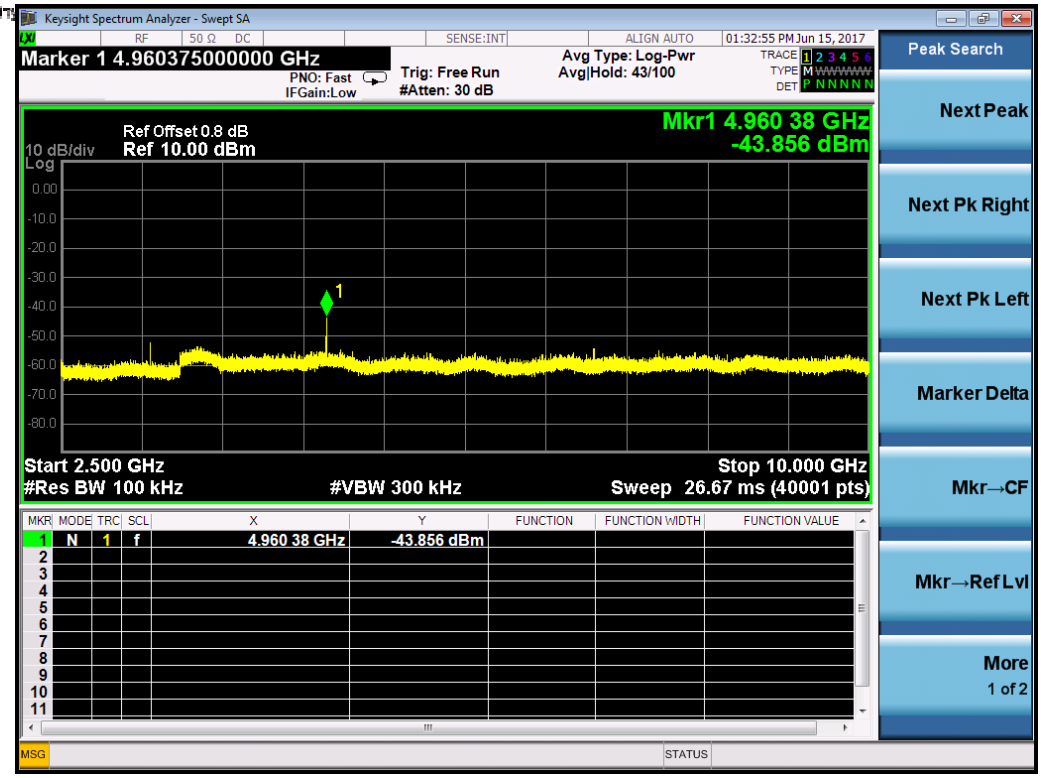



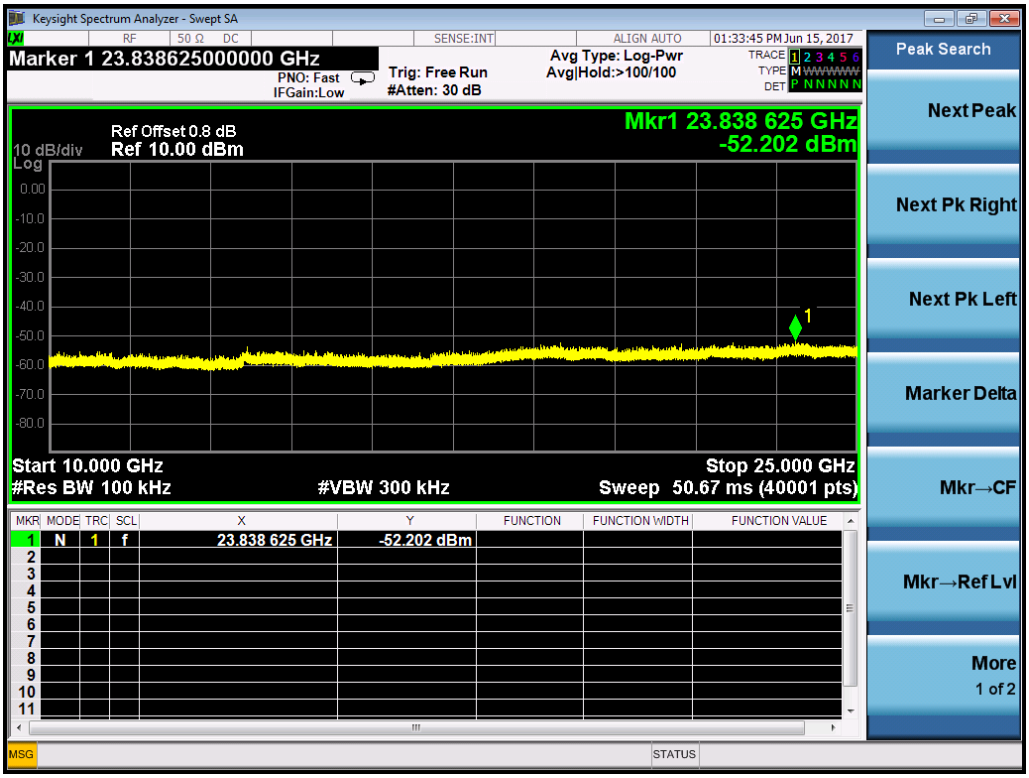

Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:30:05 PM Jun 15, 2017
Marker 1 4.804070625000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 4.804 07 GHz
-45.830 dBm
Start 2.405 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 10.000 GHz
Sweep 26.67 ms (40001 pts)
1 N 1 f 4.804 07 GHz -45.830 dBm
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2
MSG
STATUS


Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:30:41 PM Jun 15, 2017
Marker 1 24.055000000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 48/100
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 24.055 000 GHz
-52.793 dBm
Start 10.000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.000 GHz
Sweep 50.67 ms (40001 pts)
1 N 1 f 24.055 000 GHz -52.793 dBm
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2
MSG
STATUS

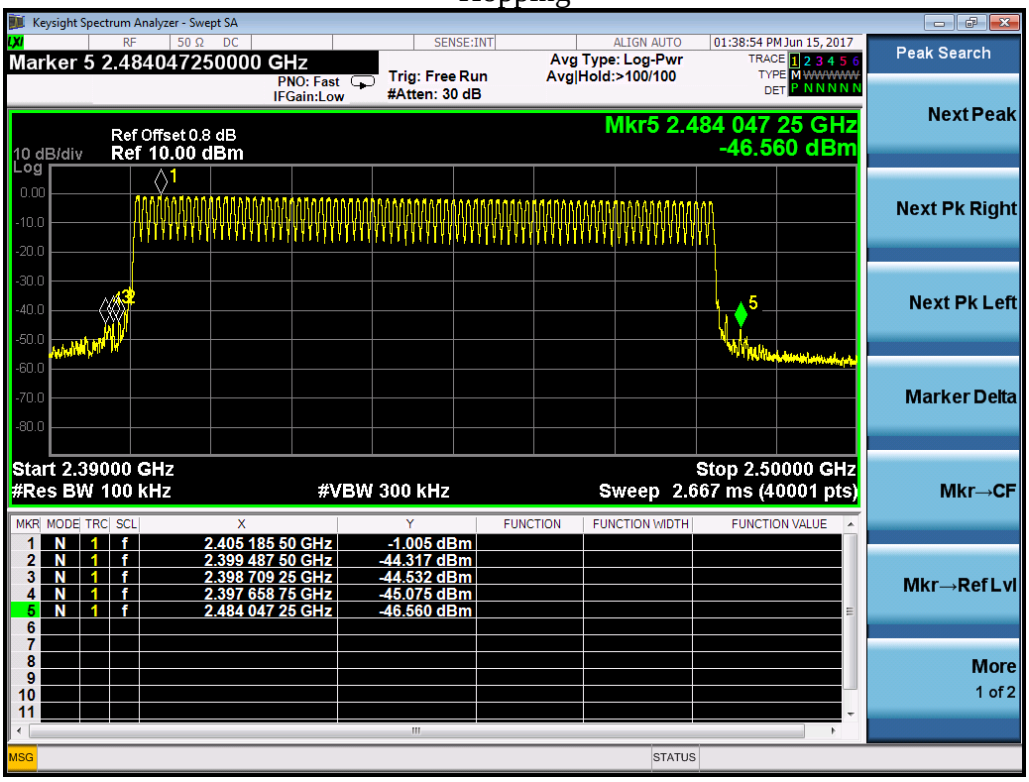
8DPSK Channel- H

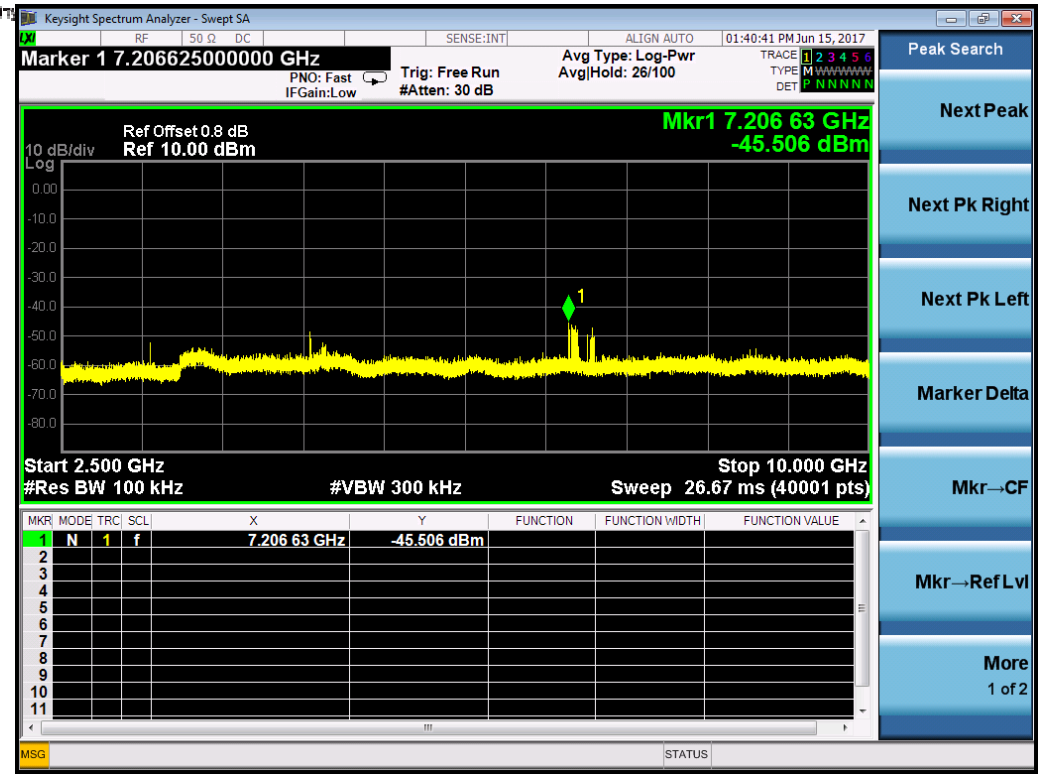


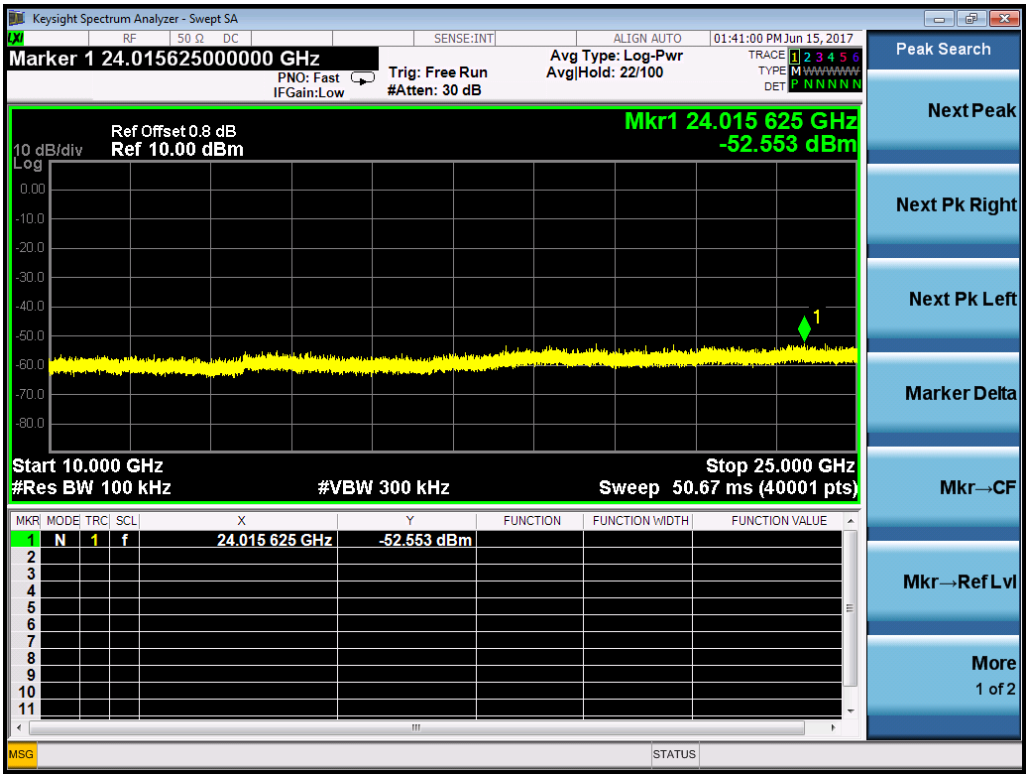


Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:32:55 PM Jun 15, 2017
Marker 1 4.960375000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold: 43/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 4.960 38 GHz
-43.856 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 2.500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 10.000 GHz
Sweep 26.67 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 4.960 38 GHz -43.856 dBm
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2
MSG
STATUS


Keysight Spectrum Analyzer - Swept SA
RF 50 Ω DC
SENSE:INT
ALIGN AUTO
01:33:45 PM Jun 15, 2017
Marker 1 23.838625000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Log
Ref 10.00 dBm
Mkr1 23.838 625 GHz
-52.202 dBm
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 10.000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.000 GHz
Sweep 50.67 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 23.838 625 GHz -52.202 dBm
Peak Search
Next Peak
Next Pk Right
Next Pk Left
Marker Delta
Mkr→CF
Mkr→Ref Lvl
More
1 of 2
MSG
STATUS

Hopping



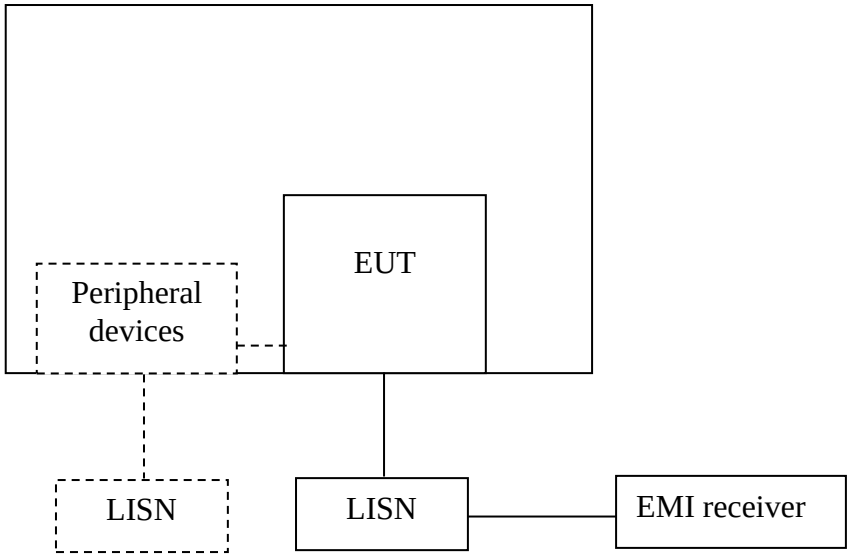
# 8. Power line conducted emission

**Test result:** **NA**

## 8.1 Limit

| Frequency of Emission (MHz) | Conducted Limit (dBuV) | |
|---|---|---|
| | QP | AV |
| 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. | | |

## 8.2 Test configuration




☒ For table top equipment, wooden support is 0.8m height table

☐ For floor standing equipment, wooden support is 0.12m height rack.

### 8.3 Test procedure and test set up

The EUT are connected to the main power through a line impedance stabilization network (LISN). This provides a 50Ω/50uH coupling impedance for the measuring equipment. The peripheral devices are also connected to the main power through a LISN that provides a 50Ω/50uH coupling impedance with 50Ω termination.
Both sides (Line and Neutral) of AC line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.4 on conducted measurement.
The bandwidth of the test receiver is set at 9 kHz.
The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems)

## 8.4 Test protocol

| | | |
|---|---|---|
| Temperature | : | °C |
| Relative Humidity | : | % |

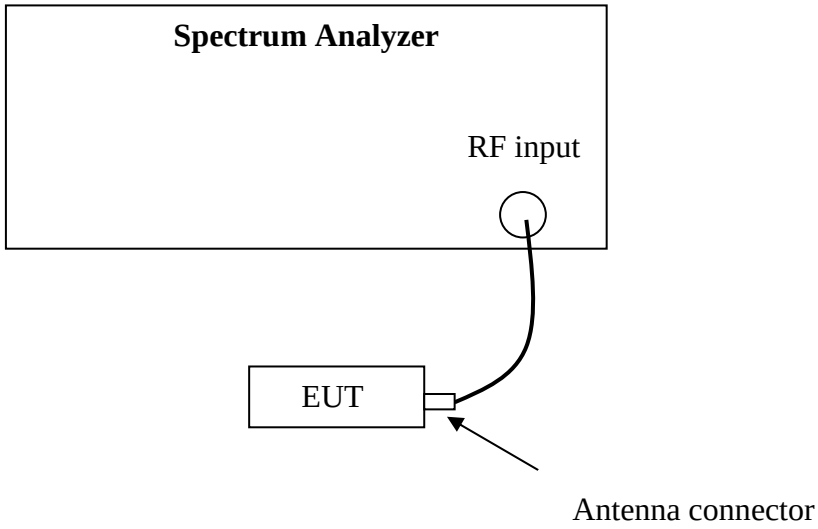
# 9. Number of Hopping Frequencies

**Test result:** **Pass**

## 9.1 Limit

Number of Hopping Frequencies in the 2400-2483.5 MHz band shall use at least 15 channels.

## 9.2 Test Configuration




## 9.3 Test procedure and test setup

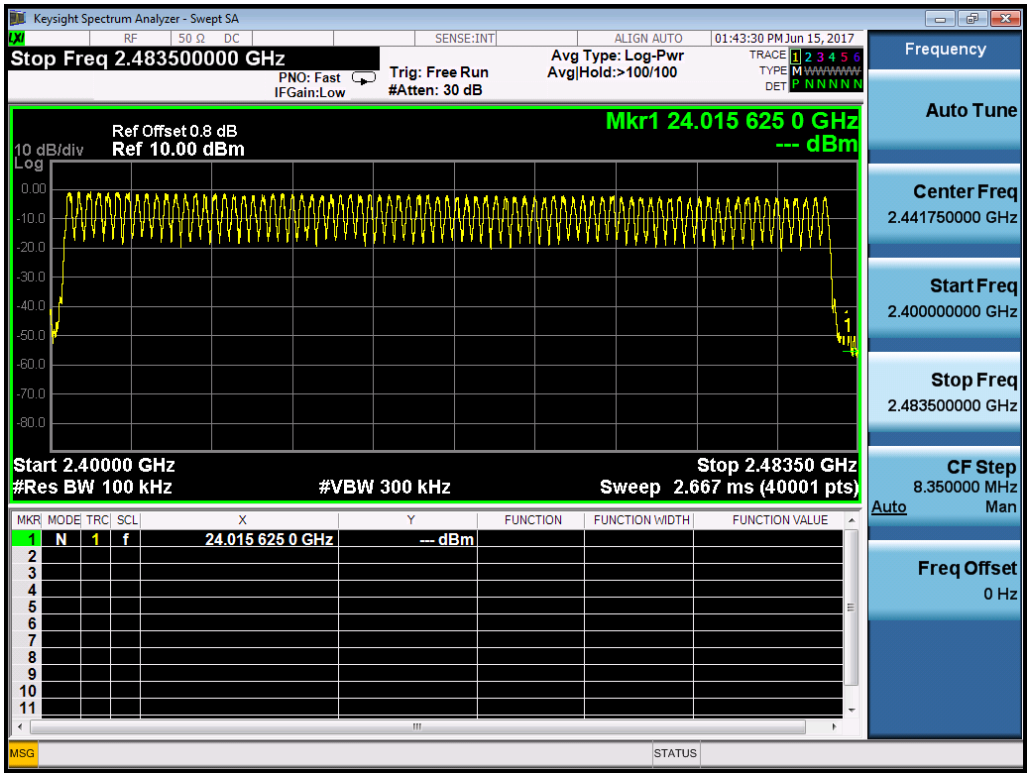
The channel number per FCC §15.247(a)(1)(iii) is measured using the Spectrum Analyzer with RBW=100kHz, VBW≥RBW, Sweep = auto, Detector = peak, Trace = max hold. The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems).

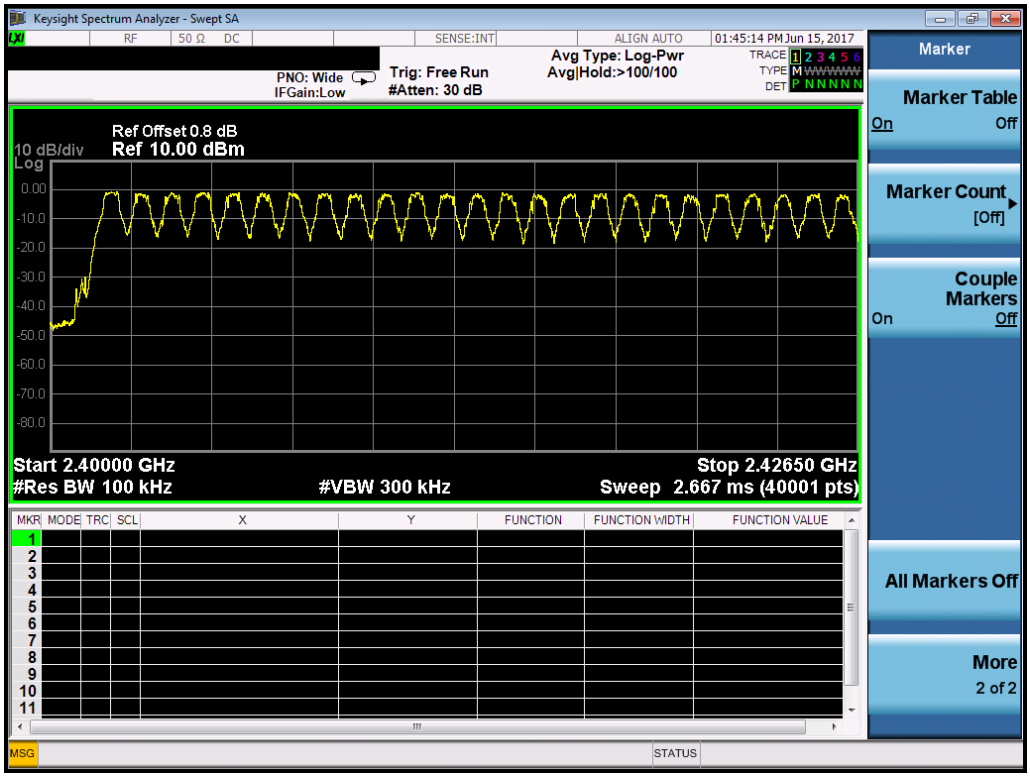
## 9.4 Test protocol

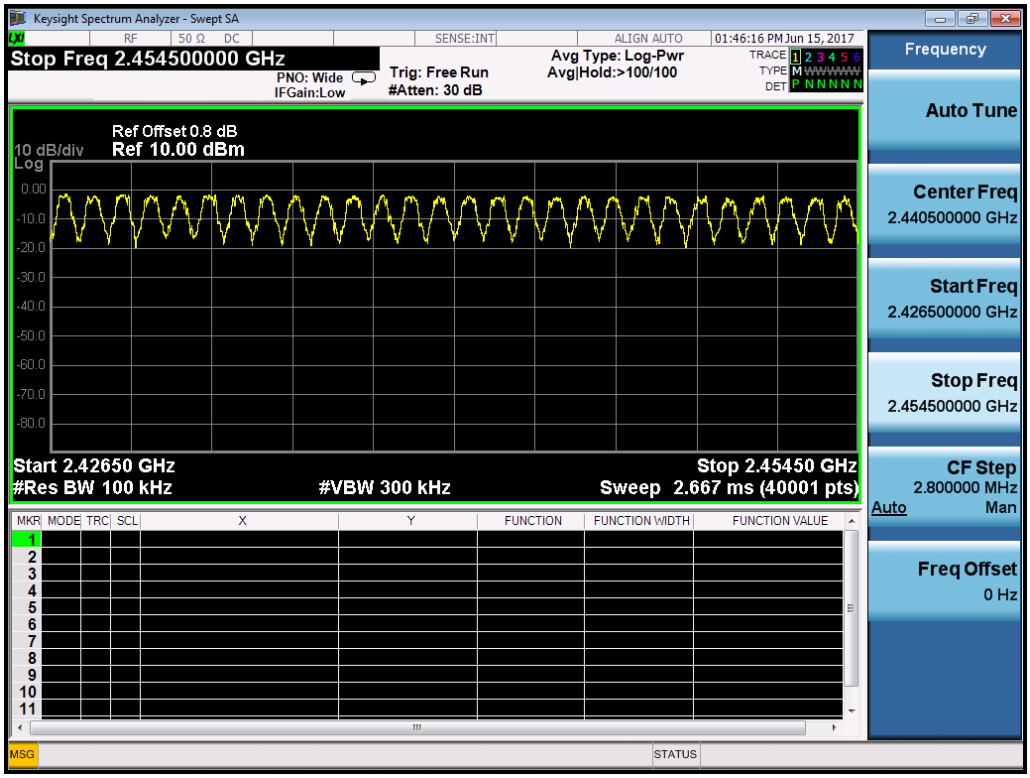
Temperature : 25 °C

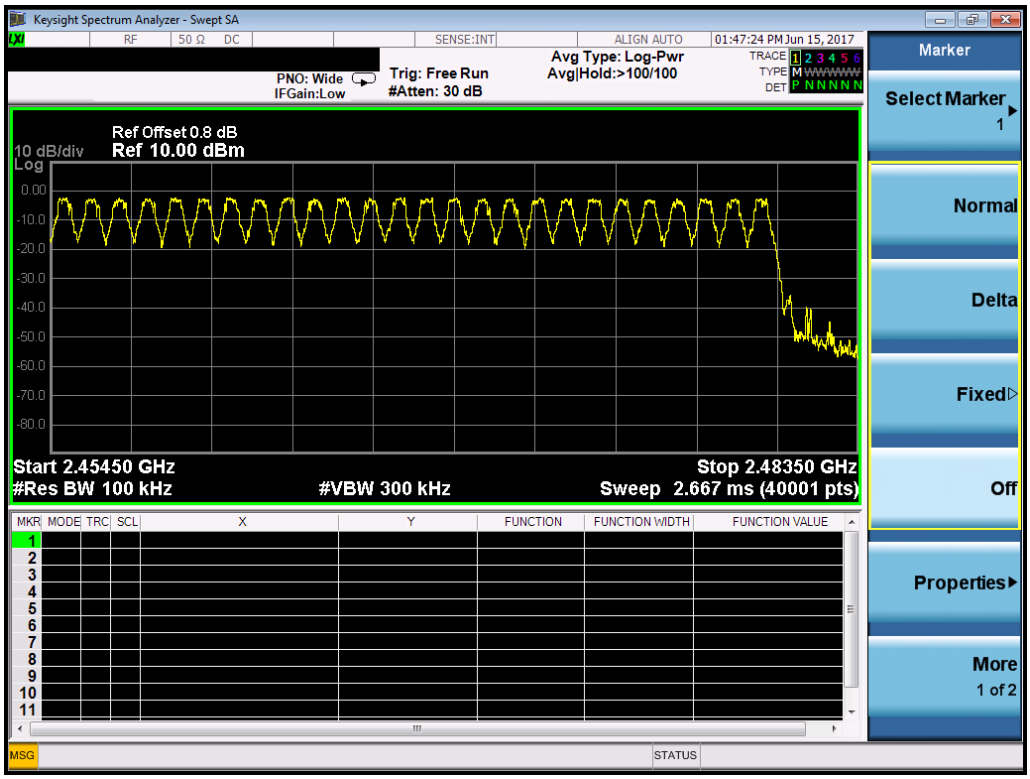
Relative Humidity : 55 %

| Channel Number | Limit |
|---|---|
| 79 | ≥15 |




Keysight Spectrum Analyzer - Swept SA
RF
50 Ω DC
SENSE:INT
ALIGN AUTO
01:46:16 PM Jun 15, 2017
Stop Freq 2.454500000 GHz
PNO: Wide
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Ref 10.00 dBm
Log
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 2.42650 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.45450 GHz
Sweep 2.667 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1
2
3
4
5
6
7
8
9
10
11
MSG
STATUS
Frequency
Auto Tune
Center Freq
2.440500000 GHz
Start Freq
2.426500000 GHz
Stop Freq
2.454500000 GHz
CF Step
2.800000 MHz
Auto
Man
Freq Offset
0 Hz


Keysight Spectrum Analyzer - Swept SA
RF
50 Ω DC
SENSE:INT
ALIGN AUTO
01:47:24 PM Jun 15, 2017
PNO: Wide
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
Avg|Hold:>100/100
TRACE 1 2 3 4 5 6
TYPE M WWWWW
DET P N N N N N
Ref Offset 0.8 dB
10 dB/div
Ref 10.00 dBm
Log
0.00
-10.0
-20.0
-30.0
-40.0
-50.0
-60.0
-70.0
-80.0
Start 2.45450 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.48350 GHz
Sweep 2.667 ms (40001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1
2
3
4
5
6
7
8
9
10
11
MSG
STATUS
Marker
Select Marker
1
Normal
Delta
Fixed
Off
Properties
More
1 of 2

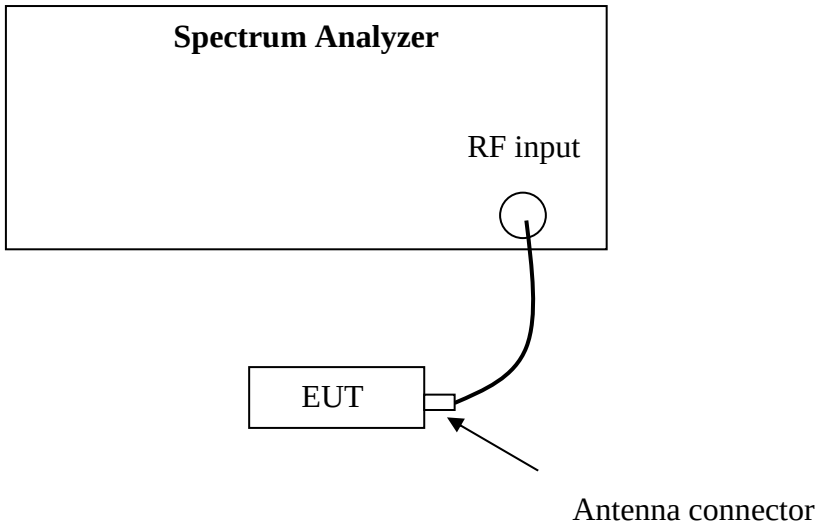
# 10. Dwell Time

**Test result: Pass**

## 10.1 Limit

The dwell time on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

## 10.2 Test Configuration




## 10.3 Test procedure and test setup

Dwell time per FCC § 15.247(a)(1)(iii) is measured using the Spectrum Analyzer with Span = 0, RBW=1MHz, VBW≥RBW, Sweep can capture the entire dwell time, Detector = peak, Trace = max hold.
The EUT was tested according to DA 00-705 (Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems).

### 10.4 Test protocol

Temperature : 25 °C

Relative Humidity : 55 %

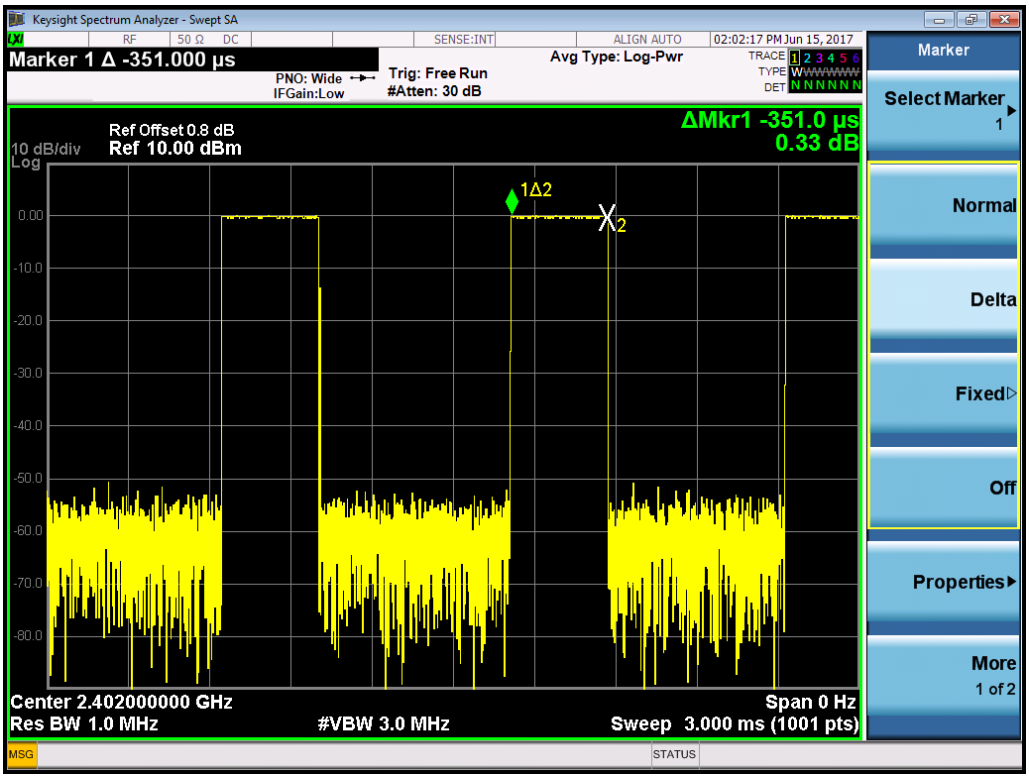
8DPSK Modulation:

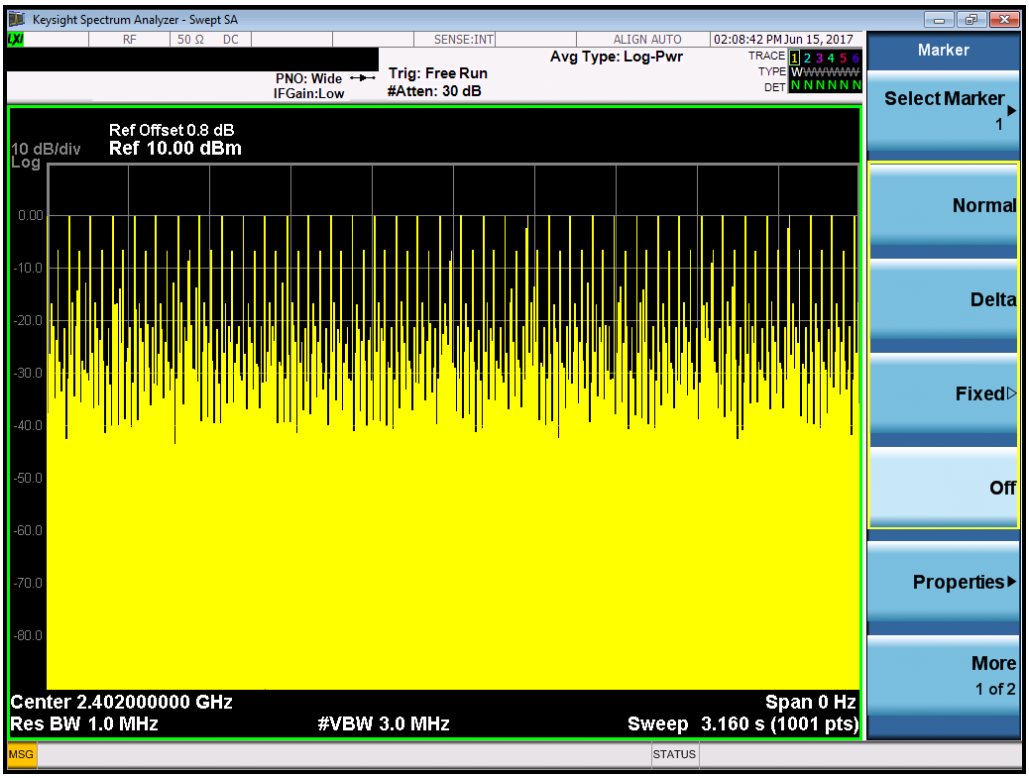
| Packet | Occupancy time for single hop (ms) **O** | CH | Real observed period (s) **P** | Hops among Observed period **I** | Dwell time (ms) **T** | Limit (s) |
|---|---|---|---|---|---|---|
| DH1 | 0.351 | L | 3.16 | 38 | 133.38 | ≤0.4 |
| | | M | 3.16 | 38 | 133.38 | |
| | | H | 3.16 | 38 | 133.38 | |
| DH3 | 1.655 | L | 3.16 | 17 | 281.35 | |
| | | M | 3.16 | 17 | 281.35 | |
| | | H | 3.16 | 17 | 281.35 | |
| DH5 | 2.910 | L | 3.16 | 11 | 320.10 | |
| | | M | 3.16 | 11 | 320.10 | |
| | | H | 3.16 | 11 | 320.10 | |

Remark: 1. There are 79 channels in all. So the complete observed period P = 0.4 * 79 = 31.6 s.

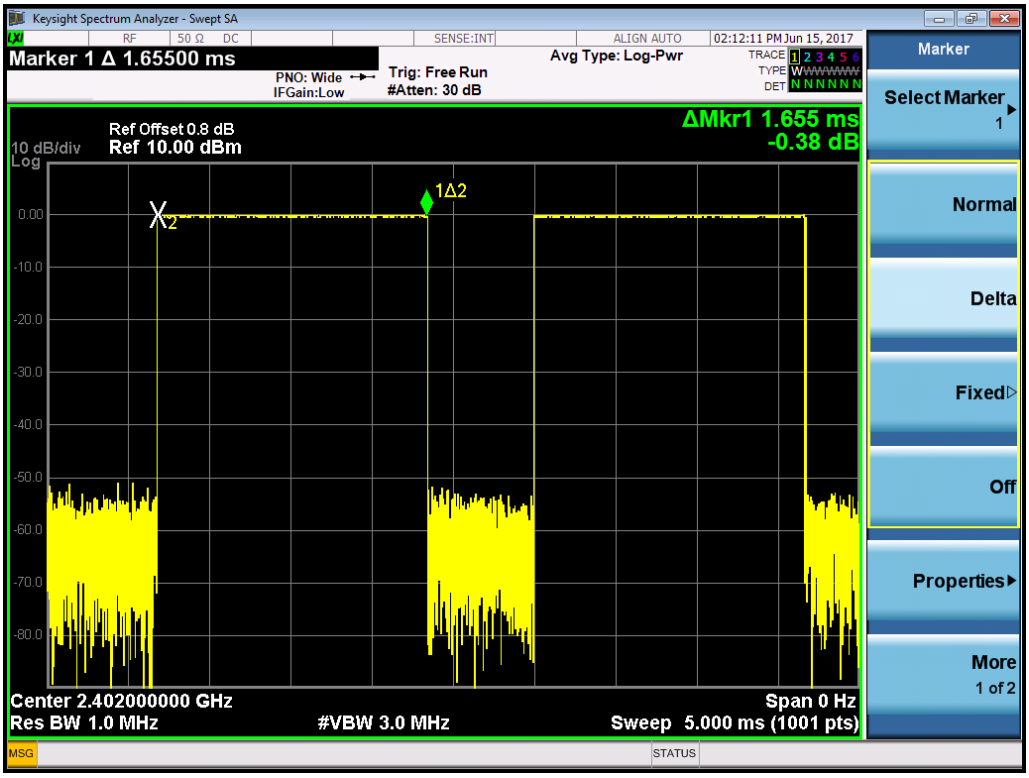
2. Average time of occupancy **T = O *I * 31.6 / P**

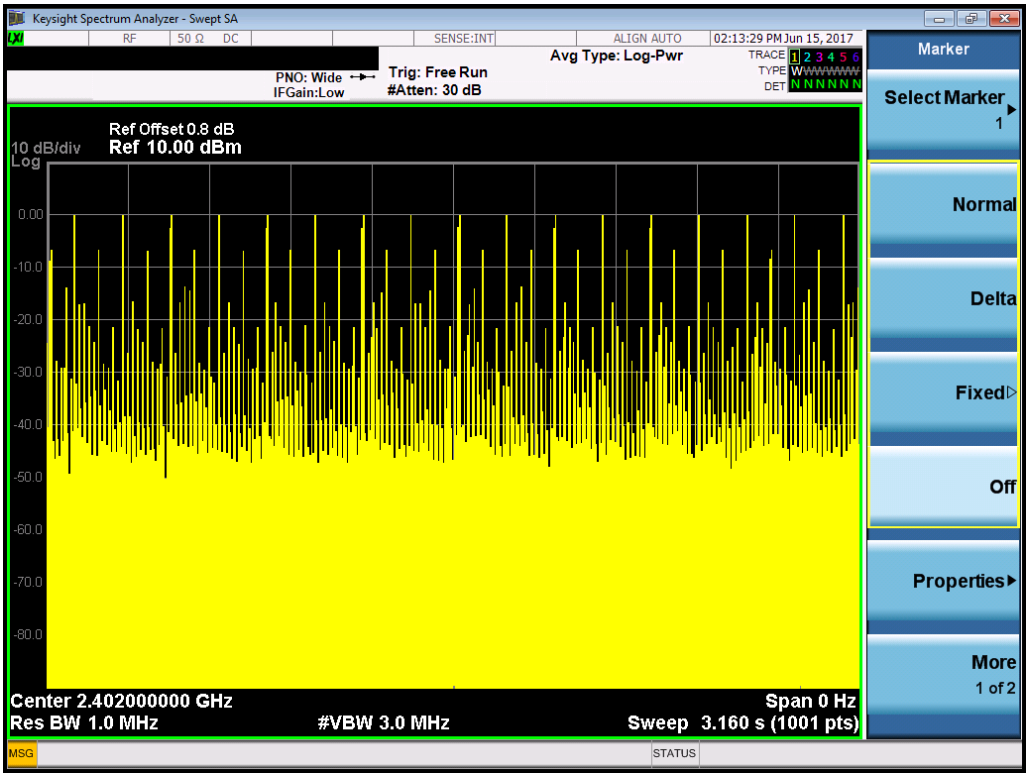
DH1



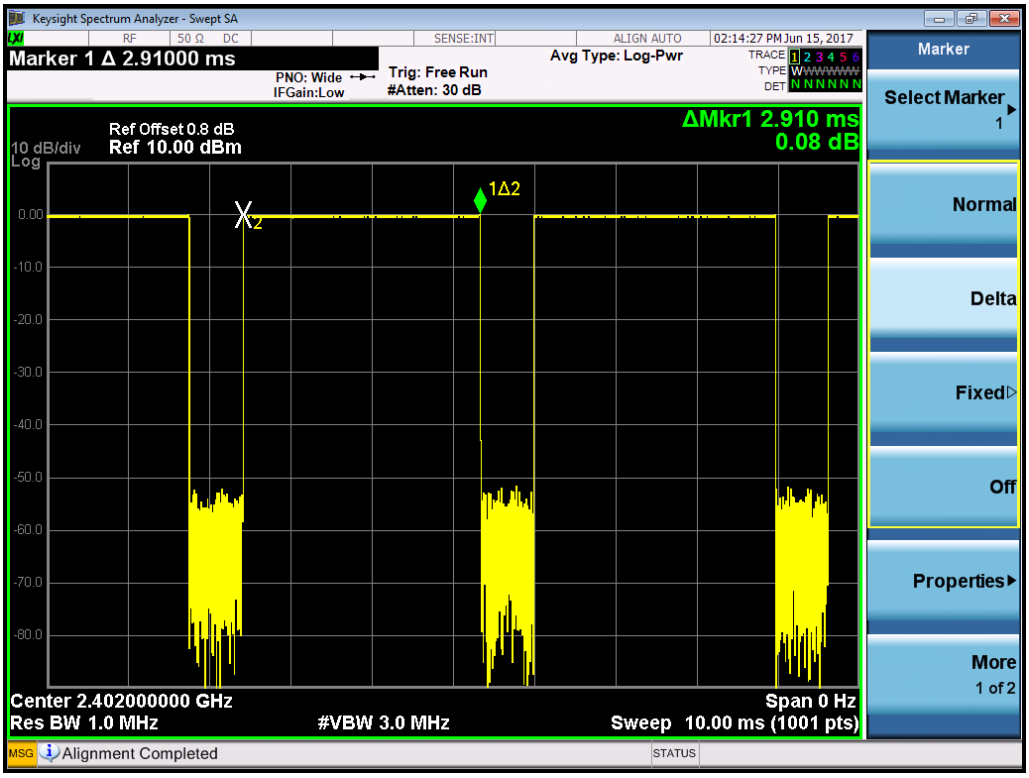



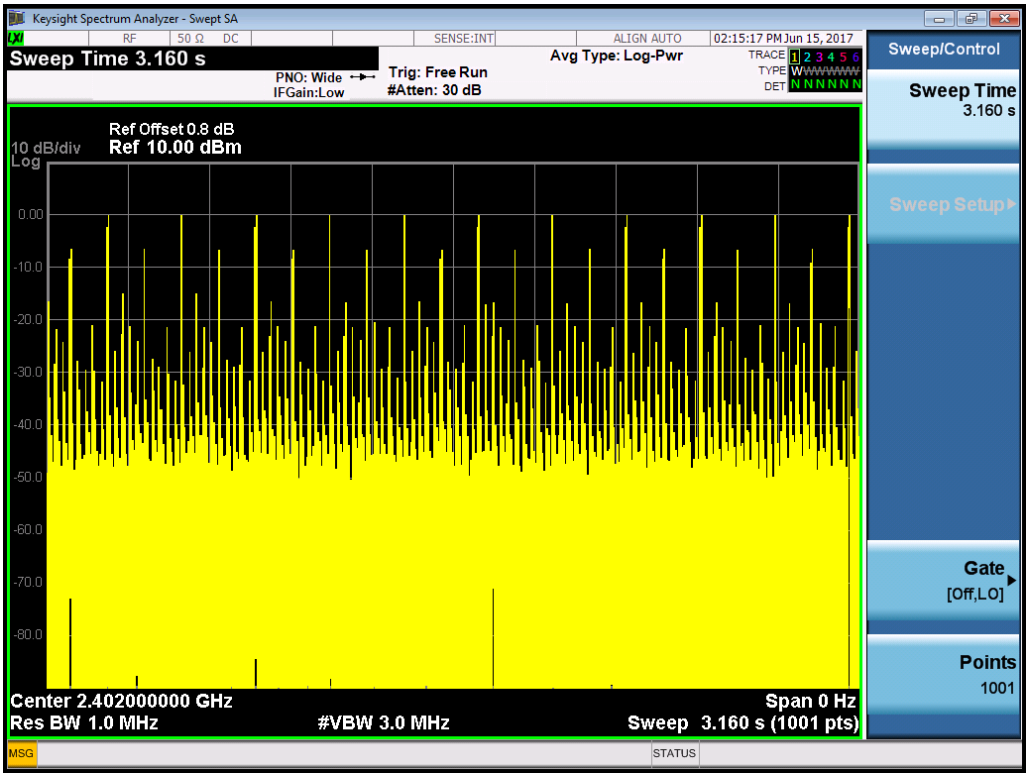
DH3



DH5



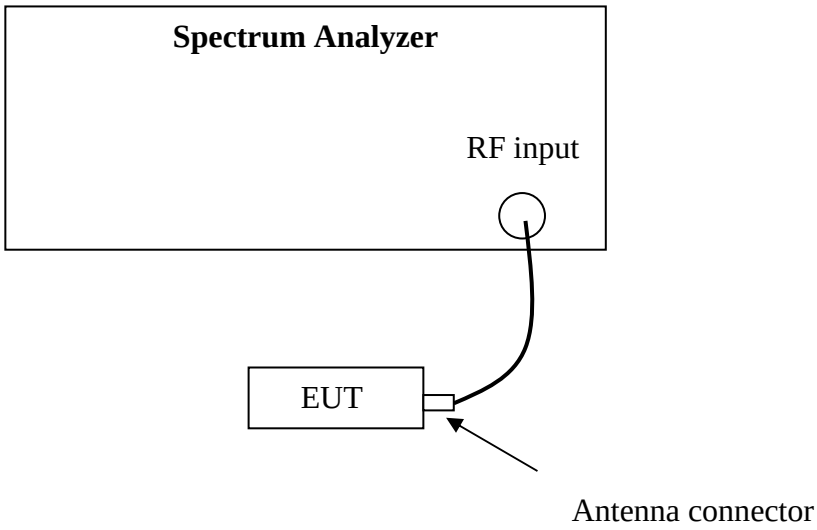
# 11. Occupied Bandwidth

**Test result: NA**

## 11.1 Test limit

None

## 11.2 Test Configuration




## 11.3 Test procedure and test setup

The occupied bandwidth per RSS-Gen Issue 4 Clause 6.6 was measured using the Spectrum Analyzer with the RBW close to 1% of the selected span, VBW = 3 * RBW
Detector = Sample, Sweep = Auto.

## 11.4 Test protocol

Temperature : °C
Relative Humidity : %

| Modulation | Channel | 99% Occupied Bandwidth (kHz) |
|---|---|---|
| GFSK | L | |
| | M | |
| | H | |

Channel L

Channel M

Channel H

| Modulation | Channel | 99% Occupied Bandwidth (kHz) |
|---|---|---|
| π /4 DQPSK | L | |
| | M | |
| | H | |

Channel L

Channel M

Channel H

| Modulation | Channel | 99% Occupied Bandwidth (kHz) |
|---|---|---|
| 8DPSK | L | |
| | M | |
| | H | |

Channel L

Channel M

Channel H

# 12. Spurious emission for receiver

**Test result: NA**

## 12.1 Test limit

The spurious emission shall test through 3 times tuneable or local oscillator frequency whichever is the higher, without exceeding 40 GHz.

☐ If a conducted measurement is made, no spurious output signals appearing at the antenna terminals shall exceed 2nW per any 4 kHz spurious frequency in the band 30-1000 MHz, or 5nW above 1 GHz.

☐ If a radiated measurement is made, all spurious emissions shall comply with the limits of Table below:

| Frequency (MHz) | Field Strength (dBuV/m) | Measurement Distance (m) |
|---|---|---|
| | | 3 |
| 88 - 216 | 43.5 | 3 |
| 216 - 960 | 46.0 | 3 |
| Above 960 | 54.0 | 3 |

## 12.2 Test Configuration

Please refer to clause 6.2

## 12.3 Test procedure and test setup

Please refer to clause 6.3.

## 12.4 Test protocol

| Polarization | Frequency (MHz) | Correct Factor (dB/m) | Corrected Reading (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |
| - | - | - | - | - | - | - |

Remark: 1. Correct Factor = Antenna Factor + Cable Loss (-Amplifier, is employed)
2. Corrected Reading = Original Receiver Reading + Correct Factor
3. Margin = limit – Corrected Reading

Example: Assuming Antenna Factor = 30.20dB/m, Cable Loss = 2.00dB,
Original Receiver Reading = 10dBuV.
Then Correct Factor = 30.20 + 2.00 = 32.20dB/m; Corrected Reading = 10dBuV + 32.20dB/m = 42.20dBuV/m
Assuming limit = 54dBuV/m, Corrected Reading = 42.20dBuV/m, then Margin = 54 -42.20 = 11.80dBuV/m