# TEST REPORT

**CTK Co., Ltd.**
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Report No.: CTK-2019-04072


## 1. Client

◦ Name : HANKOOK Technology inc.

◦ Address : 1F, 30, Sowol-ro 2-gil, Jung-gu, Seoul, Republic of Korea

◦ Date of Receipt : 2019-09-21

## 2. Manufacturer

◦ Name : HANKOOK Technology inc.

◦ Address : 1F, 30, Sowol-ro 2-gil, Jung-gu, Seoul, Republic of Korea

**3. Use of Report :** For FCC Certification

**4. Test Sample / Model:** AVN / HTAVNC-200ADVN

**5. Date of Test :** 2019-10-18 to 2019-10-22

**6. Test Standard(method) used :** FCC 47 CFR part 15 subpart C 15.247

**7. Testing Environment:** Temp.: (24 ± 1) ℃, Humidity: (50 ± 3) % R.H.

**8. Test Results :** Compliance

The results shown in this test report refer only to the sample(s) tested unless otherwise stated. This Test Report cannot be reproduced, except in full.

| | | |
|---|---|---|
| Affirmation | Tested by<br>Ji-Hye, Kim: (Signature) | Technical Manager<br>Won-Jae, Hwang: (Signature) |

2019-10-22

Republic of KOREA **CTK Co., Ltd.**

# REPORT REVISION HISTORY

| Date | Revision | Page No |
|---|---|---|
| 2019-10-22 | Issued (CTK-2019-04072) | all |
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# CONTENTS

1. General Product Description ..... 4
1.1 Client Information ..... 4
1.2 Product Information ..... 4
1.3 Peripheral Devices ..... 4
2. Facility and Accreditations ..... 5
2.1 Test Facility ..... 5
2.2 Laboratory Accreditations and Listings ..... 5
2.3 Calibration Details of Equipment Used for Measurement ..... 5
3. Test Specifications ..... 6
3.1 Standards ..... 6
3.2 Mode of operation during the test ..... 7
3.3 Maximum Measurement Uncertainty ..... 8
3.4 Test Software ..... 8
4. Technical Characteristic Test ..... 9
4.1 Carrier Frequency Separation ..... 9
4.2 Number of Hopping Frequencies ..... 11
4.3 20 dB bandwidth & 99% Bandwidth ..... 14
4.4 Time of Occupancy ..... 20
4.5 Maximum peak Conducted Output Power ..... 26
4.6 Unwanted Emissions (Conducted) ..... 32
4.7 Radiated Emission ..... 43
4.8 AC Power Line Conducted Emissions ..... 53
4.9 Frequency Hopping System Requirements ..... 56
APPENDIX A – Test Equipment Used For Tests ..... 58

# 1. General Product Description

## 1.1 Client Information

| | |
|---|---|
| **Company** | HANKOOK Technology inc. |
| **Contact Point** | 1F, 30, Sowol-ro 2-gil, Jung-gu, Seoul, Republic of Korea |
| **Contact Person** | Name : Kim Sang Jin<br>E-mail : sjkim@myht.co.kr<br>Tel : +82-2-2106-7500<br>Fax : +82-2-2136-1379 |

## 1.2 Product Information

| | |
|---|---|
| **FCC ID** | 2AUVO-HTAVNC200ADVN |
| **Product Description** | AVN |
| **Model name** | HTAVNC-200ADVN |
| **Operating Frequency** | 2 402 MHz - 2 480 MHz |
| **RF Output Power** | GFSK : 3.046 dBm (2.017 mW)<br>8-DPSK : 2.119 dBm (1.629 mW) |
| **Antenna Specification** | Antenna type : Chip Antenna<br>Peak Gain : 0.0 dBi |
| **Number of channels** | 79 |
| **Channel Spacing** | 1 MHz |
| **Type of Modulation** | GFSK(1Mbps), π/4 DQPSK(2Mbps), 8DPSK(3Mbps) |
| **Power Source** | DC 12 V |
| **Hardware Rev** | V302 |
| **Software Rev** | V1030 |

## 1.3 Peripheral Devices

| Device | Manufacturer | Model No. | Serial No. |
|---|---|---|---|
| Note Computer | HP | 15-bs563TU | CND7253QPR |
| AC/DC Adapter | HP | HSTNN-LA40 | - |

# 2. Facility and Accreditations

## 2.1 Test Facility

The measurement facility is located at (Ho-dong), 113, Yejik-ro, Cheoin-gu, Yong-in-si, Gyeonggi-do, Korea.

## 2.2 Laboratory Accreditations and Listings

| Country | Agency | Registration Number |
|---|---|---|
| USA | FCC | 805871 |
| CANADA | ISED | 8737A-2 |
| KOREA | NRRA | KR0025 |

## 2.3 Calibration Details of Equipment Used for Measurement

Test equipment and test accessories are calibrated on regular basis. The maximum time between calibrations is one year or what is recommended by the manufacturer, whichever is less. All test equipment calibrations are traceable to the Korea Research Institute of Standards and Science (KRISS), therefore, all test data recorded in this report is traceable to KRISS.

# 3. Test Specifications

## 3.1 Standards

| Section in FCC | Requirement(s) | Status (Note 1) | Test Condition |
|---|---|---|---|
| 15.247(a) | Carrier Frequency Separation | C | Conducted |
| 15.247(a) | Number of Hopping Frequencies | C | |
| 15.247(a) | 20 dB Bandwidth | C | |
| 15.247(a) | Time of occupancy (Dwell Time) | C | |
| 15.247(b) | Maximum peak conducted output power | C | |
| 15.247(d) | Unwanted emission | C | |
| 15.209 | Transmitter emission | C | Radiated |
| 15.207(a) | AC Conducted Emission | NA | Line Conducted |
| *Note 1*: C=Complies NC=Not Complies NT=Not Tested NA=Not Applicable | | | |
| *Note 2*: The data in this test report are traceable to the national or international standards. | | | |
| *Note 3*: The sample was tested according to the following specification: FCC Part 15.247, ANSI C63.10-2013. | | | |

## 3.2 Mode of operation during the test

The EUT is operated in a manner representative of the typical of the equipments.
During at testing, system components were manipulated within the confines of typical usage to maximize each emission. All modulation modes were tests.
The results are only attached worst cases.

**Test Frequency**

| Lowest channel | Middle channel | Highest channel |
|---|---|---|
| 2 402 MHz | 2 441 MHz | 2 480 MHz |

**Test mode**

| Modulation | Packet type | Data rate | Duty Cycle |
|---|---|---|---|
| GFSK | DH5 | 1 Mbps | 77.3 % |
| 8-DPSK | 3-DH5 | 3 Mbps | 77.9 % |

## 3.3 Maximum Measurement Uncertainty

The value of the measurement uncertainty for the measurement of each parameter.
Coverage factor $k$ = 2, Confidence levels of 95 %

| Description | Uncertainty |
|---|---|
| Conducted RF Output Power | 1.5 dB |
| Occupied Bandwidth | 0.1 MHz |
| Unwanted Emission(conducted) | 3.0 dB |
| Radiated Emissions (f ≤ 1 GHz) | 4.0 dB |
| Radiated Emissions (f > 1 GHz) | 5.0 dB |

## 3.4 Test Software

| | |
|---|---|
| Conducted Test | Ics Pro Ver. 6.0.3 |
| Radiated Test | TOYO EMI software EP5RE Ver. 6.0.1.0 |
| Line Conducted Test | - |

# 4. Technical Characteristic Test

## 4.1 Carrier Frequency Separation

### Test Procedures

ANSI C63.10-2013 - Section 7.8.2

The carrier frequency separation was measured with a spectrum analyzer connected to the antenna terminal, while EUT has 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:

a) Span = 5 MHz (wide enough to capture the peaks of two adjacent channels)
b) RBW = 30 kHz (Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel)
c) VBW = 30 kHz (≥ RBW)
d) Sweep = auto
e) Detector function = peak
f) Trace = max hold

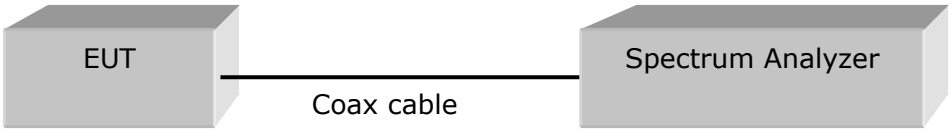



Figure 1 : Measurement setup for the carrier frequency separation

### Limit

FHSS operating in the band 2400-2483.5 MHz 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.

### Test Results

Test mode : GFSK

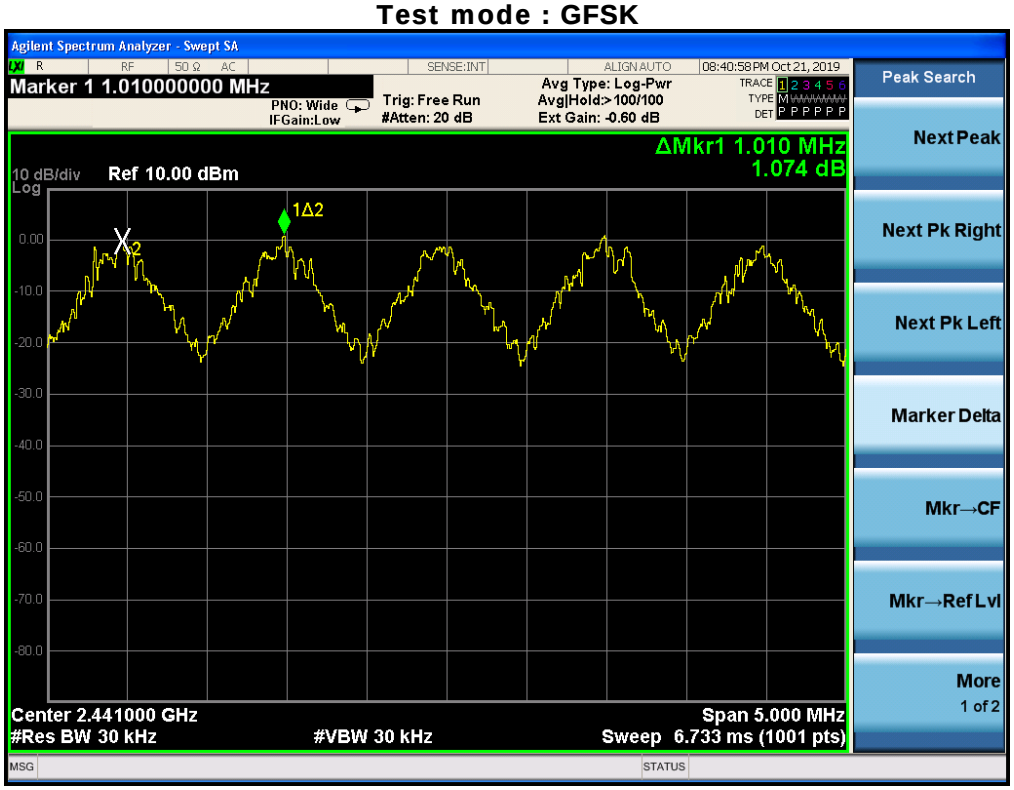
| Channel | Adjacent Hopping Channel Separation [kHz] | Two-third of 20dB bandwidth [kHz] | Minimum Bandwidth [kHz] | Result |
|---|---|---|---|---|
| Middle | 1 010 | 622.9 | 25 | Complies |

Test mode : 8-DPSK

| Channel | Adjacent Hopping Channel Separation [kHz] | Two-third of 20dB bandwidth [kHz] | Minimum Bandwidth [kHz] | Result |
|---|---|---|---|---|
| Middle | 1 010 | 849.3 | 25 | Complies |

See next pages for actual measured spectrum plots.

**Test mode : GFSK**




**Test mode : 8-DPSK**

## 4.2 Number of Hopping Frequencies

### Test Procedures

ANSI C63.10-2013 - Section 7.8.3

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

The spectrum analyzer is set to:

a) Frequency range 1: Start = 2389.5 MHz, Stop = 2439.5 MHz
2: Start = 2439.5 MHz, Stop = 2489.5 MHz

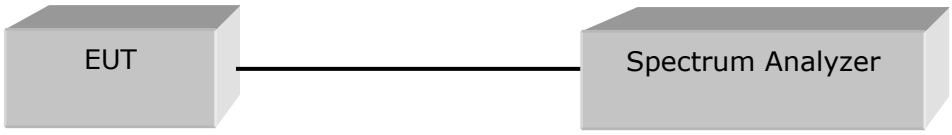
b) RBW = 300 kHz (To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller)

c) VBW = 300 kHz (≥ RBW)

d) Sweep = auto

e) Detector function = peak

f) Trace = max hold




### Limit

FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels.

### Test Results

Test mode : GFSK

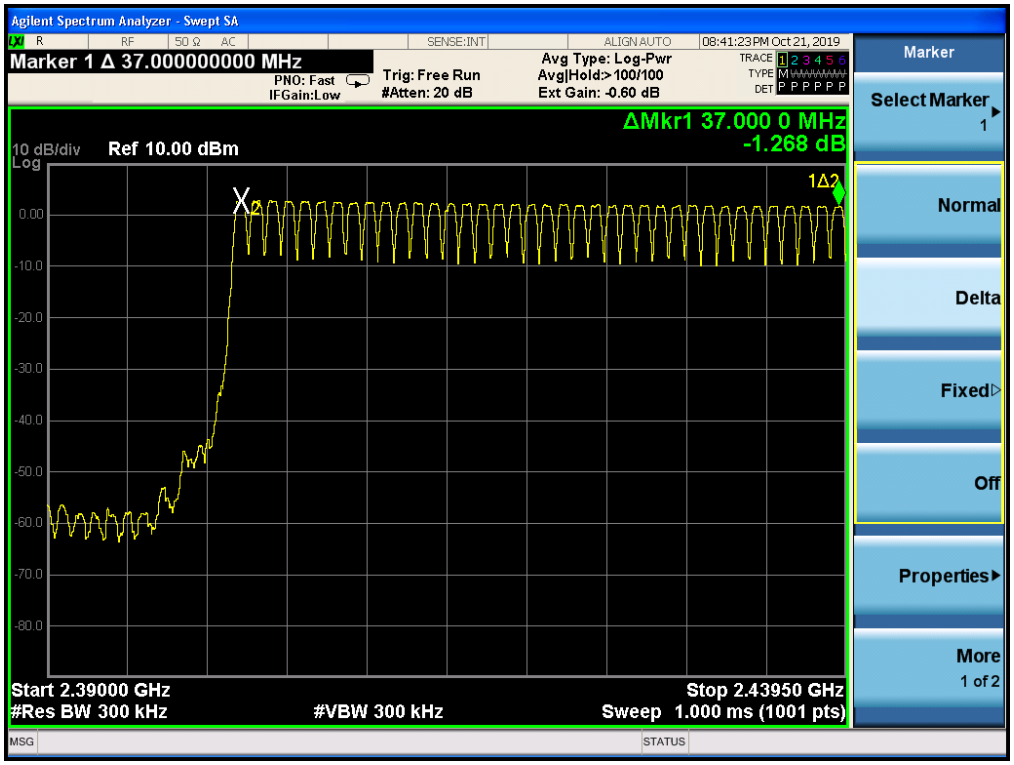
| Total number of Hopping Channels | Result |
|---|---|
| 79 | Complies |

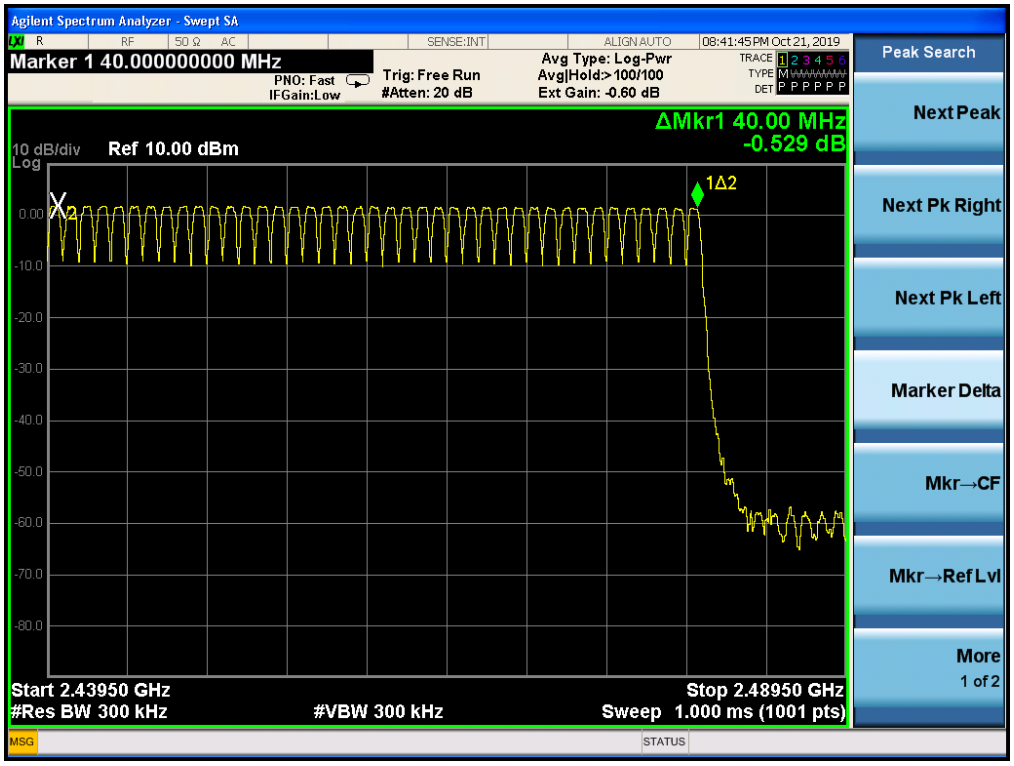
Test mode : 8-DPSK

| Total number of Hopping Channels | Result |
|---|---|
| 79 | Complies |

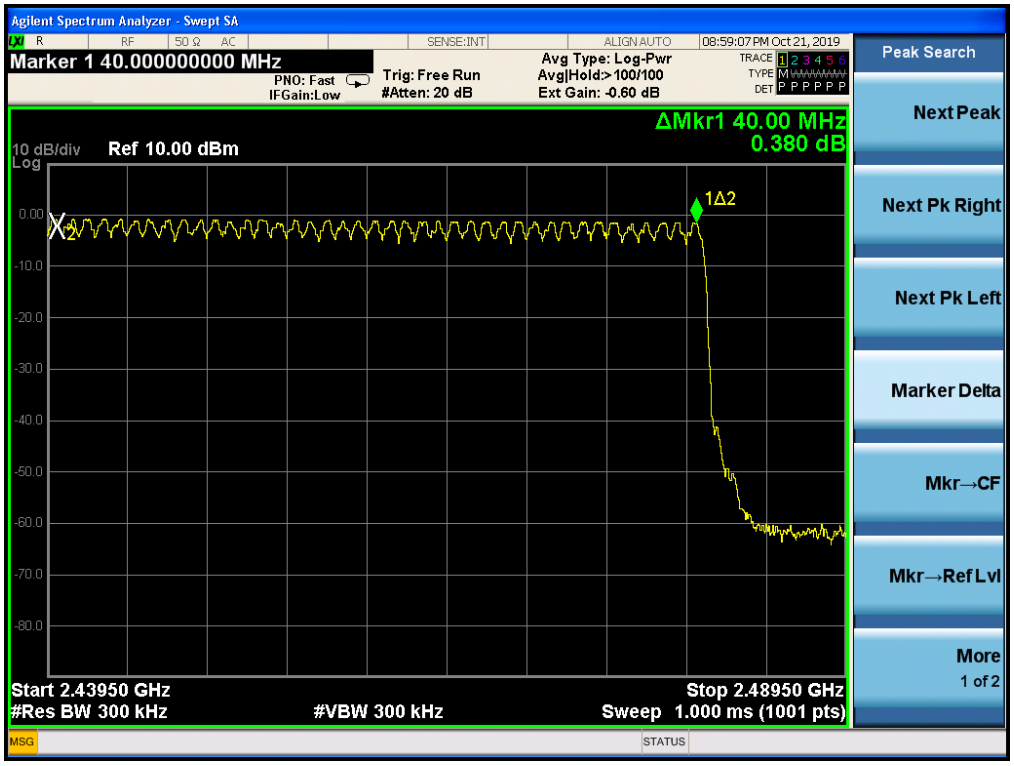
See next pages for actual measured spectrum plots.

## Test Mode : GFSK



## Test Mode : 8-DPSK



## 4.3 20 dB bandwidth & 99% Bandwidth

### Test Procedures

ANSI C63.10-2013 - Section 6.9.2

Measure the maximum width of the emission that is constrained by the frequencies associated with the two outermost amplitude points (upper and lower frequencies) that are attenuated by 20 dB relative to the maximum level measured in the fundamental emission.

### Test Procedures

ANSI C63.10-2013 - Section 6.9.3

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.
Use the 99% power bandwidth function of the instrument and report the measured bandwidth.

The spectrum analyzer is set to:

Center frequency = the highest, middle and the lowest channels

a) Span = 3 MHz (between 2 times and 5 times the OBW)

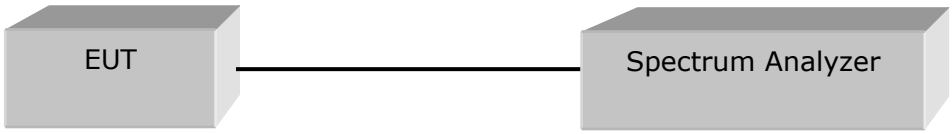
b) RBW = 30 kHz (1% to 5% of the OBW)

c) VBW = 100 kHz (approximately 3 times RBW)

d) Sweep = auto

e) Detector function = peak

f) Trace = max hold




### Limit

Limit : N/A

## Test Results

Test mode : GFSK

| Channel | Frequency [MHz] | 20 dB Bandwidth [MHz] | 99% Bandwidth [MHz] | Result |
|---|---|---|---|---|
| Low | 2 402 | 0.932 | 0.852 | Complies |
| Middle | 2 441 | 0.934 | 0.849 | Complies |
| High | 2 480 | 0.932 | 0.847 | Complies |

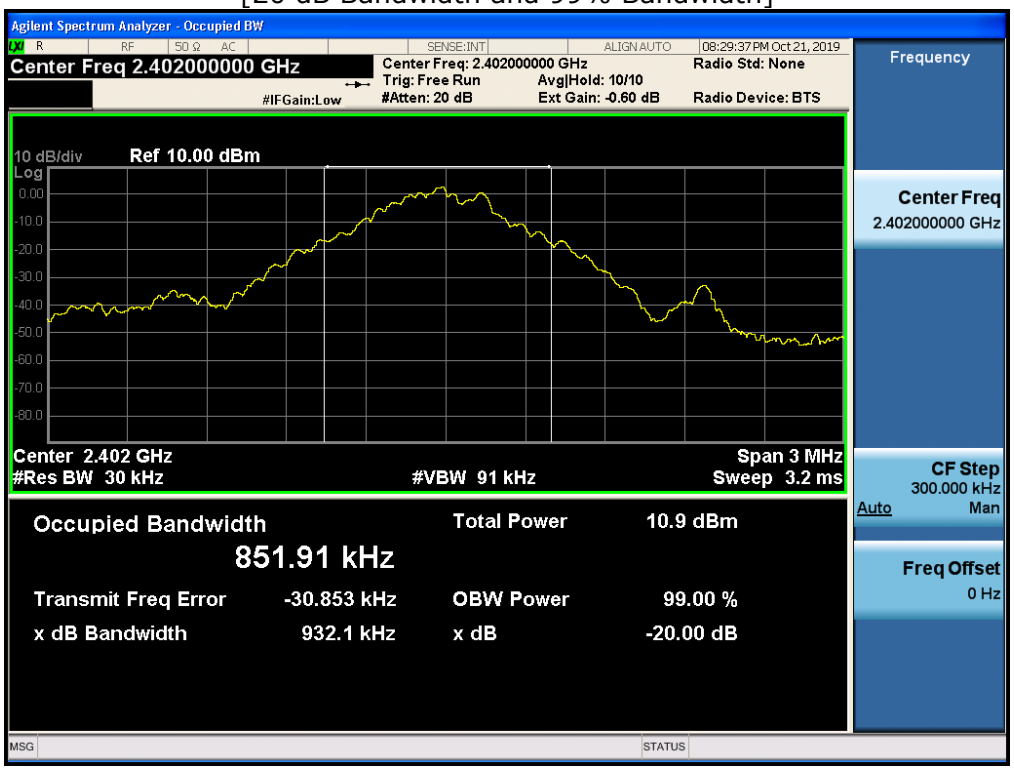
Test mode : 8-DPSK

| Channel | Frequency [MHz] | 20 dB Bandwidth [MHz] | 99% Bandwidth [MHz] | Result |
|---|---|---|---|---|
| Low | 2 402 | 1.274 | 1.166 | Complies |
| Middle | 2 441 | 1.263 | 1.153 | Complies |
| High | 2 480 | 1.260 | 1.151 | Complies |

See next pages for actual measured spectrum plots.

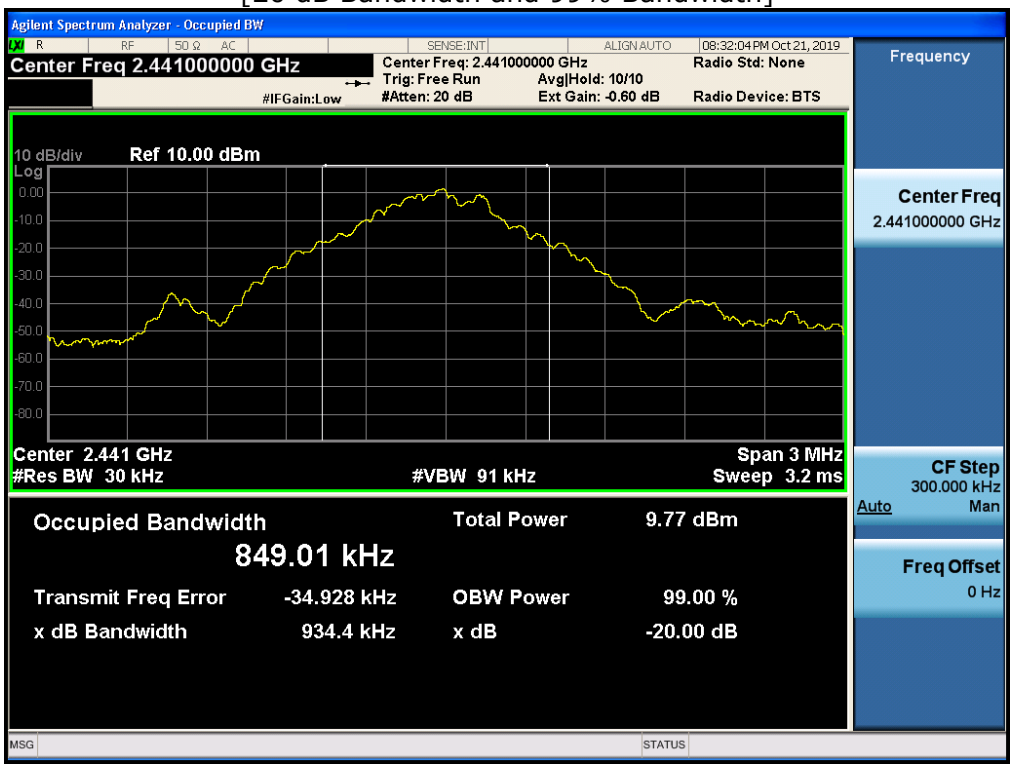
## GFSK - Lowest Frequency (2 402 MHz)

[20 dB Bandwidth and 99% Bandwidth]



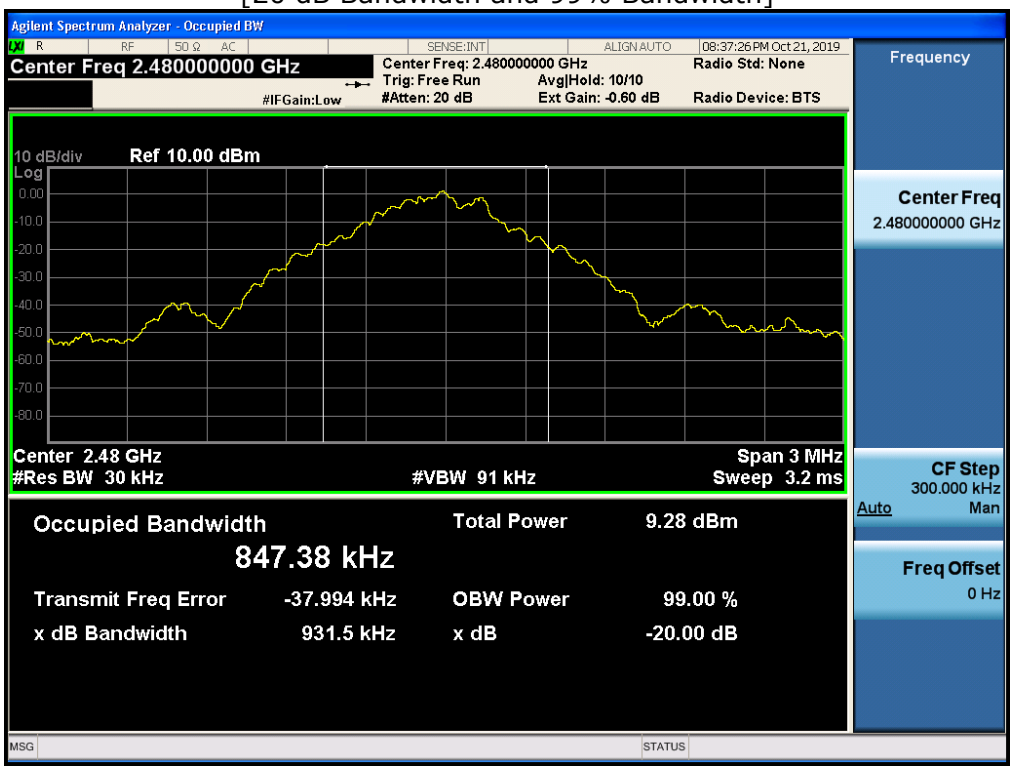

## GFSK - Middle Frequency (2 441 MHz)

[20 dB Bandwidth and 99% Bandwidth]



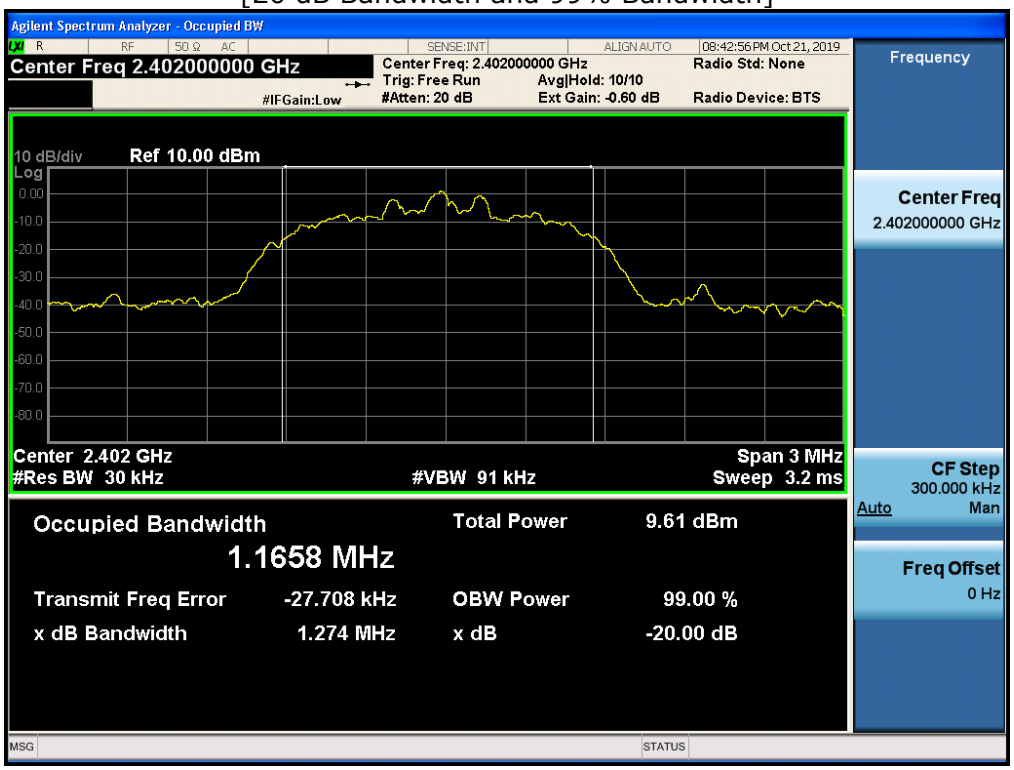
## GFSK - Highest Frequency (2 480 MHz)

[20 dB Bandwidth and 99% Bandwidth]



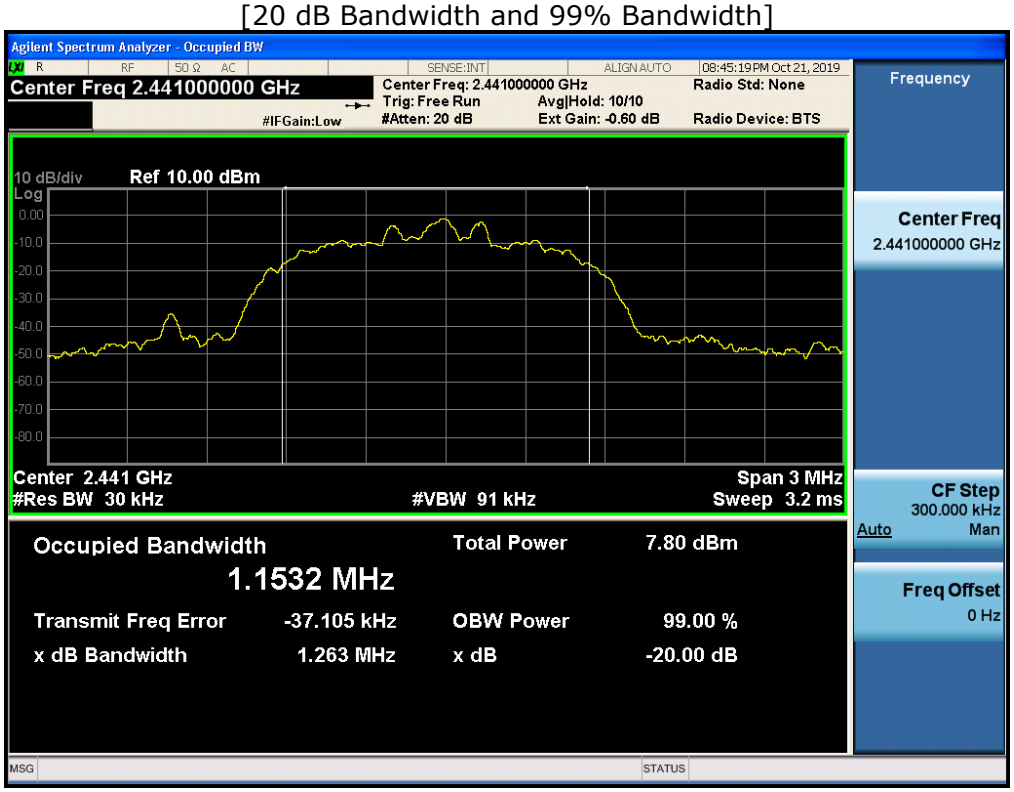
## 8-DPSK - Lowest Frequency (2 402 MHz)

[20 dB Bandwidth and 99% Bandwidth]



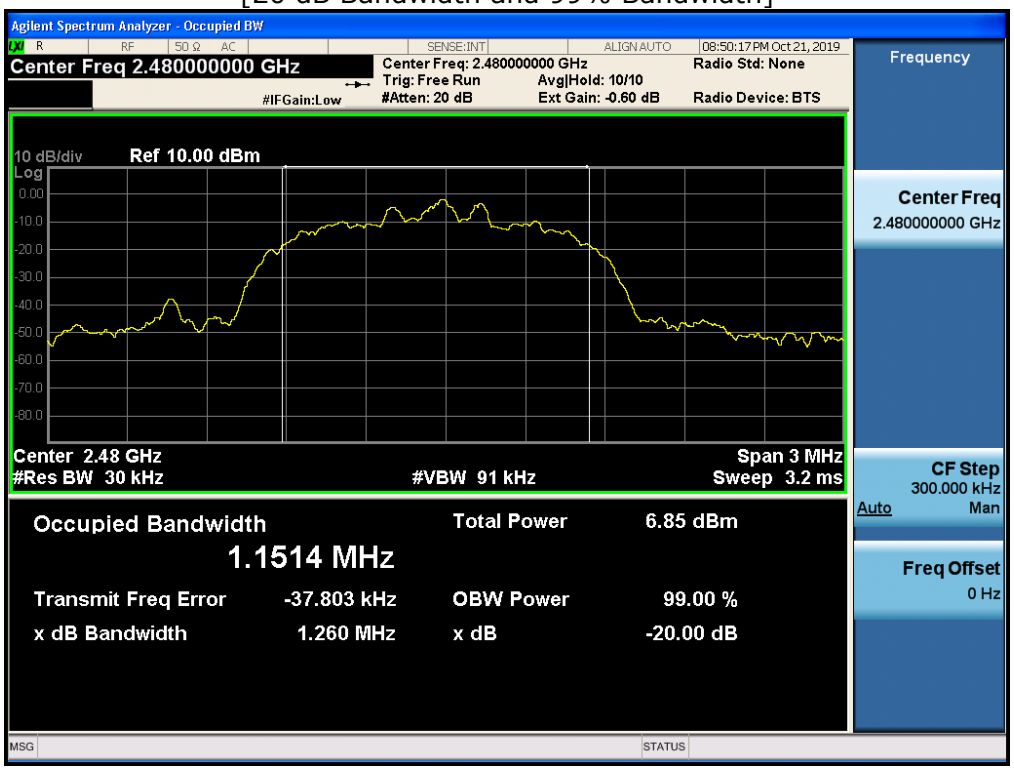

## 8-DPSK - Middle Frequency (2 441 MHz)

[20 dB Bandwidth and 99% Bandwidth]



## 8-DPSK - Highest Frequency (2 480 MHz)

[20 dB Bandwidth and 99% Bandwidth]



## 4.4 Time of Occupancy

### Test Procedures

ANSI C63.10-2013 - Section 7.8.4

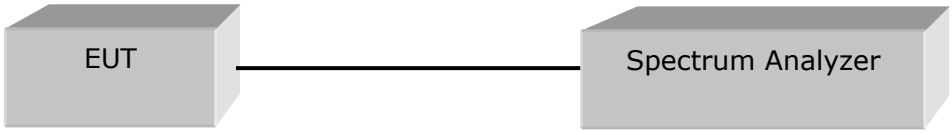
The dwell time was measured with a spectrum analyzer connected to the antenna terminal, while EUT has its hopping function enabled.

a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d) Detector function: Peak.
e) Trace: Max hold.

Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

Number of hops in the period specified in the requirements =
(number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)




### Limit

The average time of occupancy 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.

## Test Results

Test mode : GFSK

| Mode | Number of hops Channels | Transmit time per hop(msec) | Result (msec) | Limit (msec) |
|---|---|---|---|---|
| DH1 | 79 | 0.400 | **128.00** | 400 |
| DH3 | 79 | 1.655 | **264.80** | 400 |
| DH5 | 79 | 2.900 | **309.33** | 400 |

Test mode : 8-DPSK

| Mode | Number of hops Channels | Transmit time per hop(msec) | Result (msec) | Limit (msec) |
|---|---|---|---|---|
| 3-DH1 | 79 | 0.415 | **132.80** | 400 |
| 3-DH3 | 79 | 1.660 | **265.60** | 400 |
| 3-DH5 | 79 | 2.920 | **311.47** | 400 |

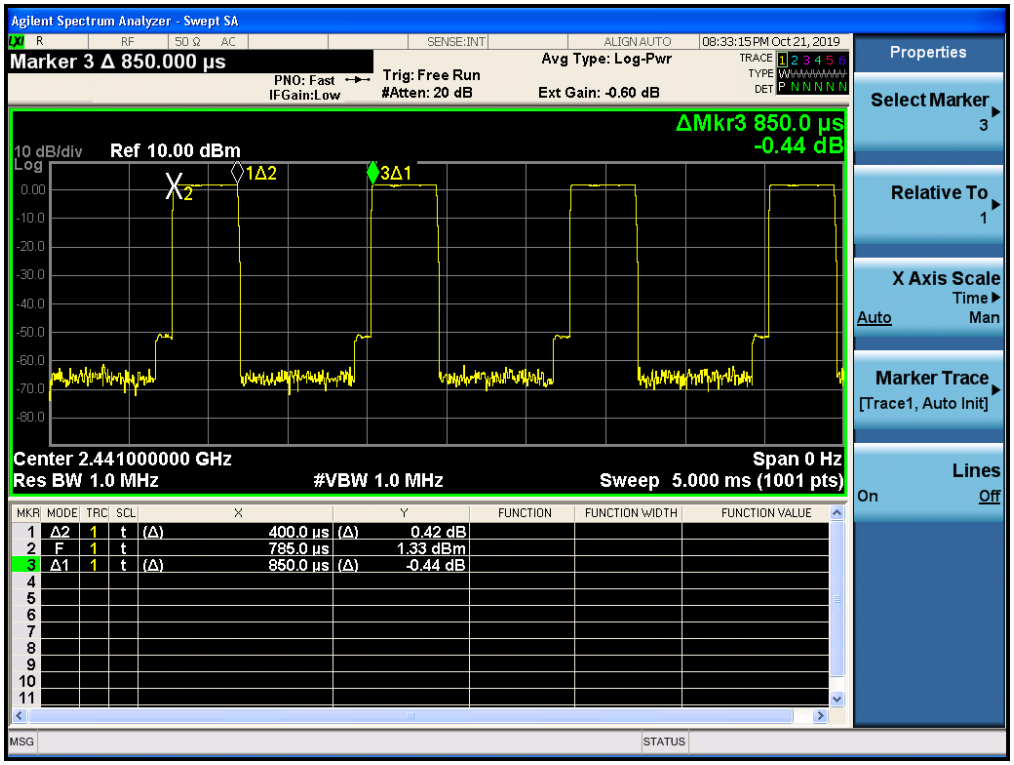
**※ Remark:**

**Average time of occupancy = Transmit time per hop * Number of hopping channels in 31.6s**

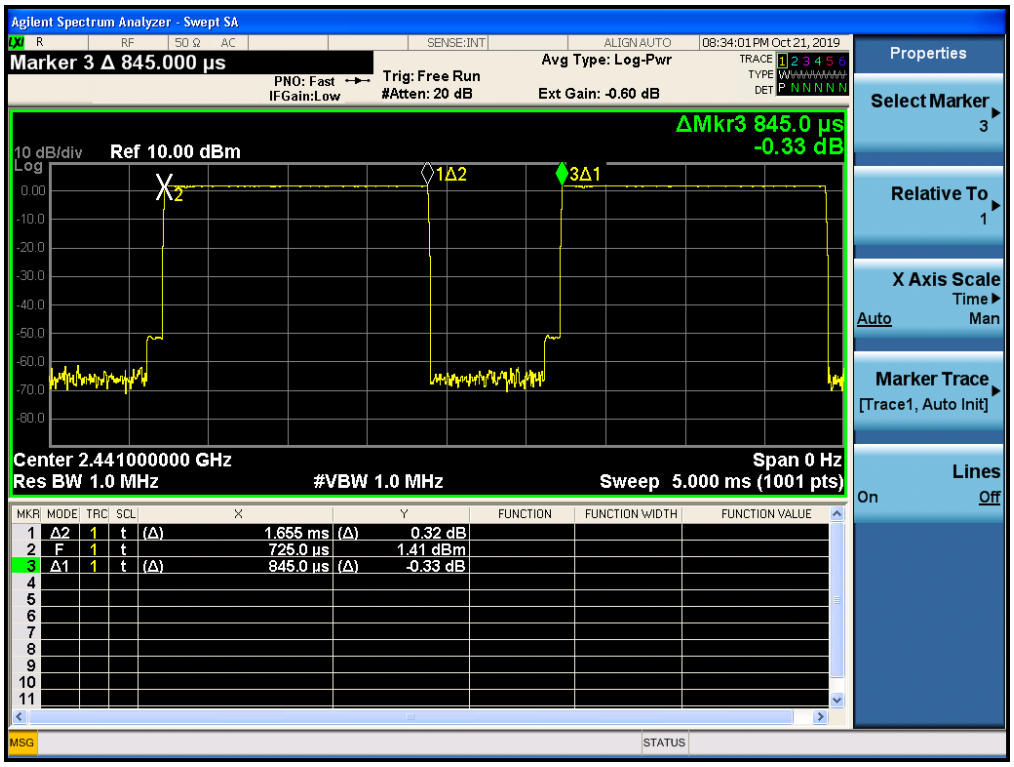
**According the BLUETOOTH STANDARD SPECIFICATION, the nominal hop rate is 1600 hop/s. All bluetooth units participating in the piconet are time and hop synchronized to the channel.**
**- The maximum number of hopping channels in 31.6s for DH1 = 1600 / 2 / 79 * 31.6 = 320**
**- The maximum number of hopping channels in 31.6s for DH3 = 1600 / 4 / 79 * 31.6 = 160**
**- The maximum number of hopping channels in 31.6s for DH5 = 1600 / 6 / 79 * 31.6 = 107**

See next pages for actual measured spectrum plots.

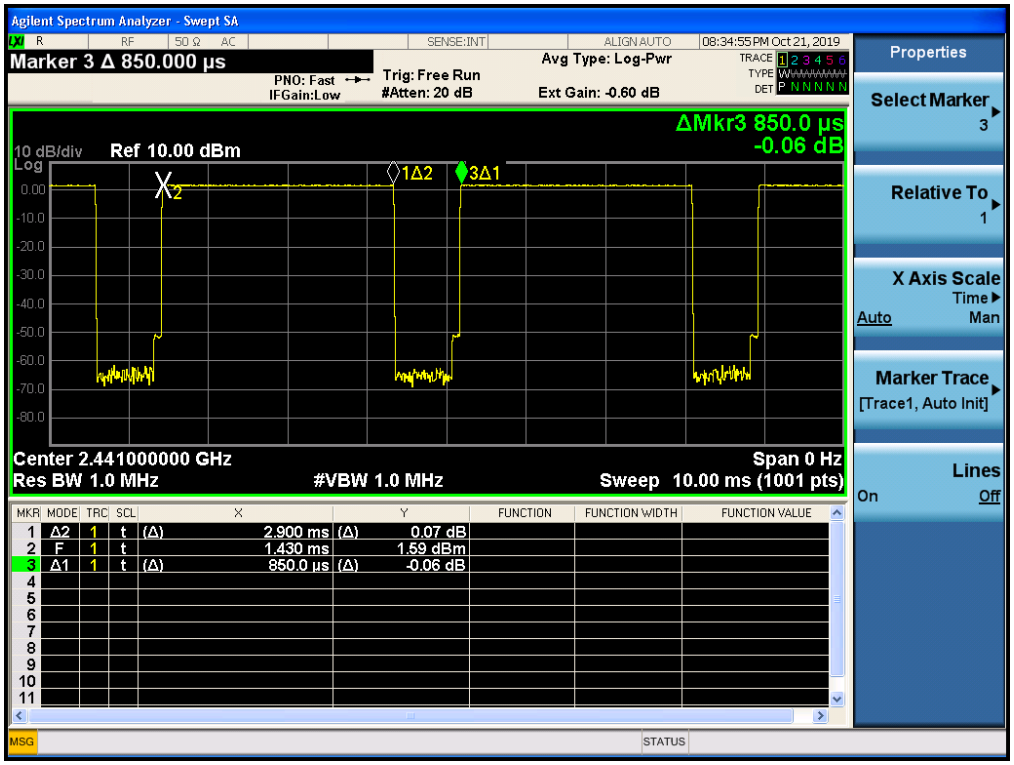
## Transmit time for PACKET Type DH1(GFSK)



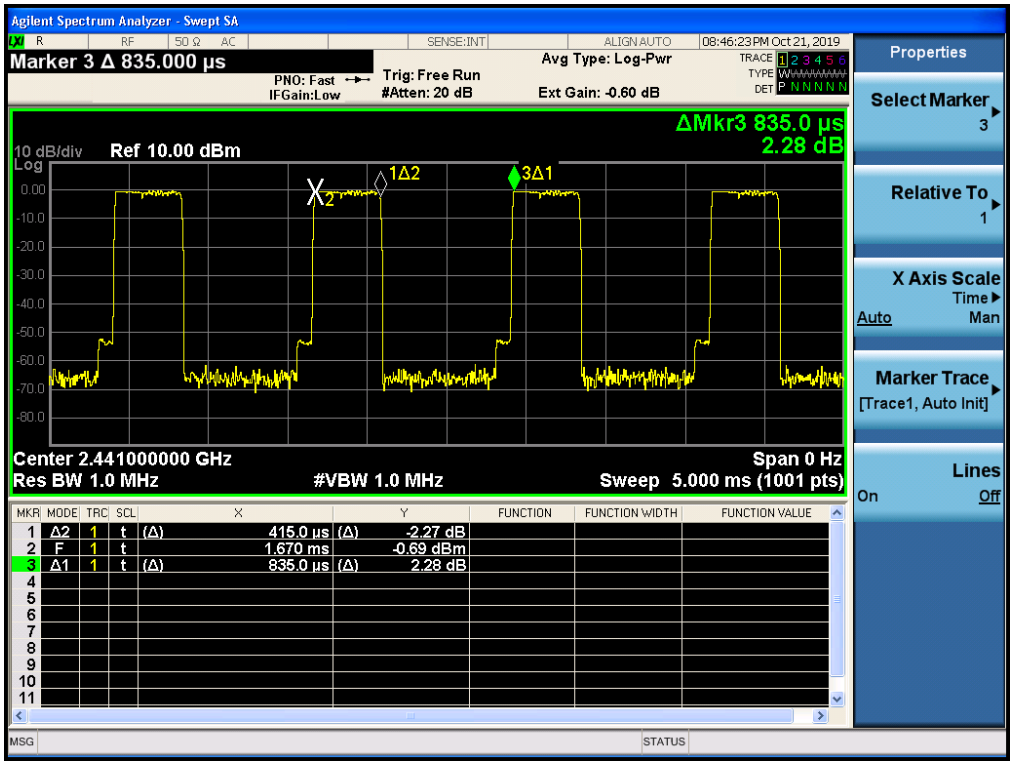

## Transmit time for PACKET Type DH3(GFSK)



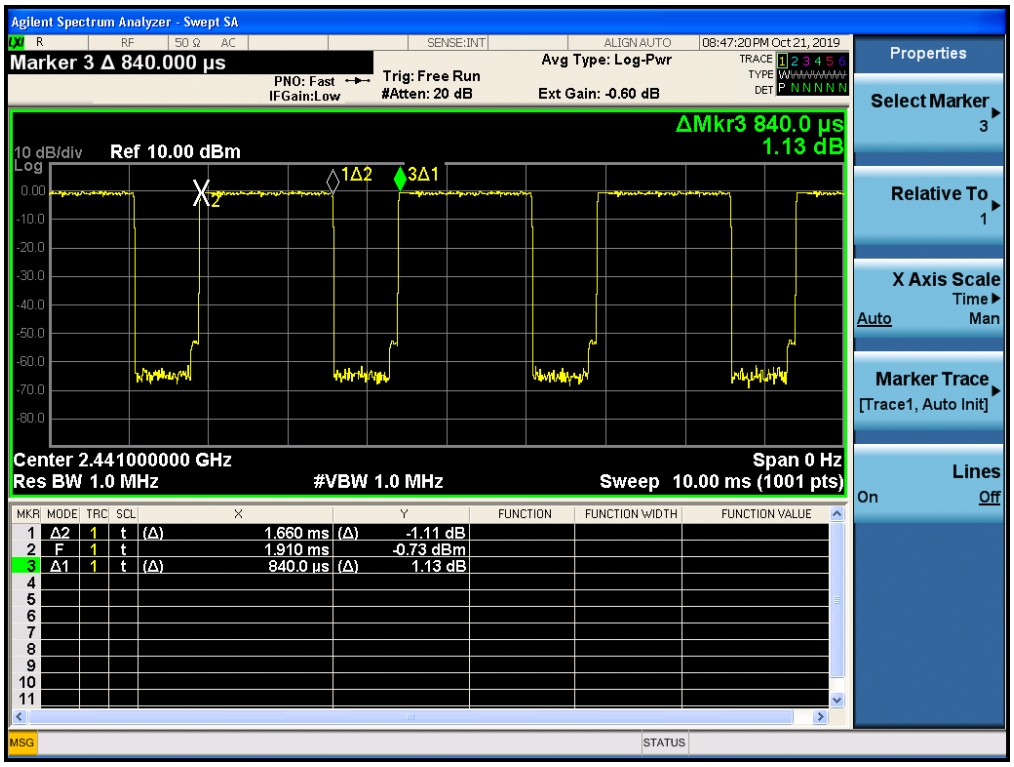
## Transmit time for PACKET Type DH5(GFSK)



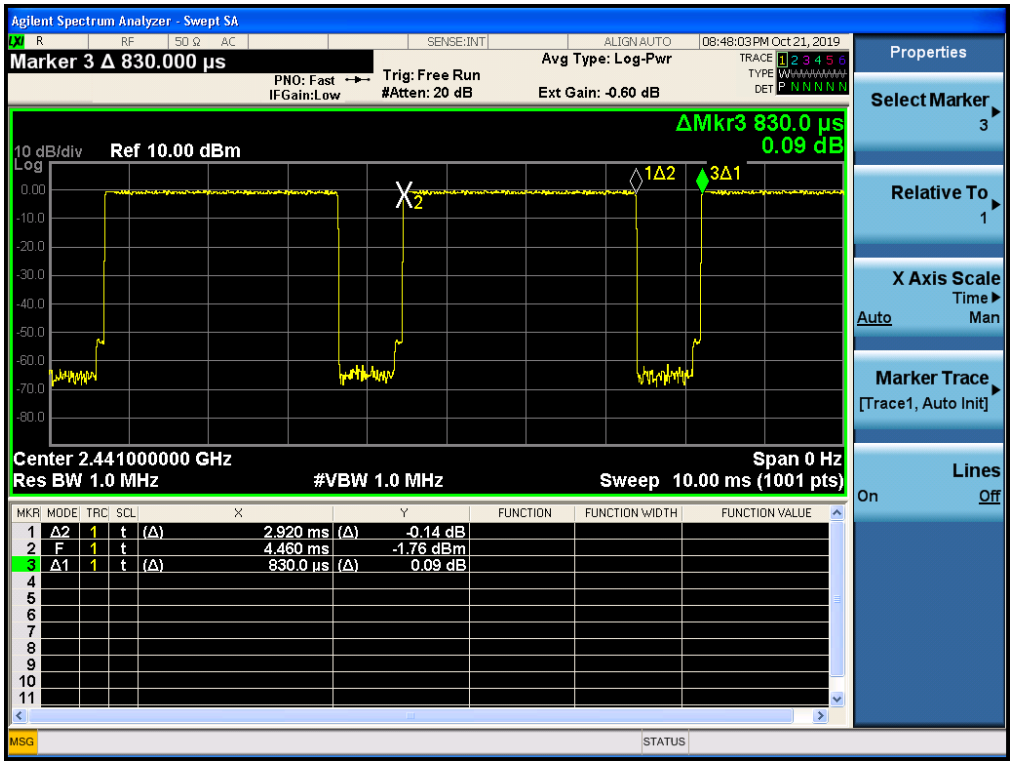
## Transmit time for PACKET Type 3-DH1(8-DPSK)




## Transmit time for PACKET Type 3-DH3(8-DPSK)



## Transmit time for PACKET Type 3-DH5(8-DPSK)



## 4.5 Maximum peak Conducted Output Power

### Test Procedures

ANSI C63.10-2013 - Section 7.8.5

This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping shall be disabled for this test.

The spectrum analyzer is set to:

Center frequency = the highest, middle and the lowest channels

a) Span = 5 MHz (approximately 5 times of the 20 dB bandwidth)

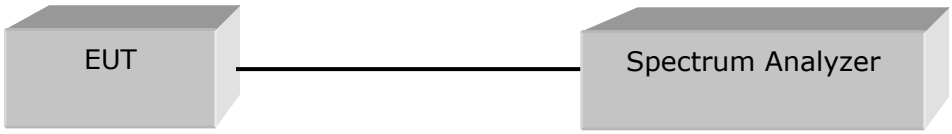
b) RBW = 3 MHz (greater than the 20 dB bandwidth of the emission being measured)

c) VBW = 3 MHz (≥ RBW)

d) Detector = peak

e) Trace = max hold

f) Sweep = auto




### Limit

For FHSs operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W and the e.i.r.p. shall not exceed 4 W if the hopset uses 75 or more hopping channels.

## Test Results

Test mode : GFSK

| Frequency [MHz] | Channel No. | Output Power [dBm] | Output power [mW] | Result |
|---|---|---|---|---|
| 2 402 | 0 | 3.046 | 2.017 | Complies |
| 2 441 | 39 | 1.772 | 1.504 | Complies |
| 2 480 | 78 | 1.528 | 1.422 | Complies |

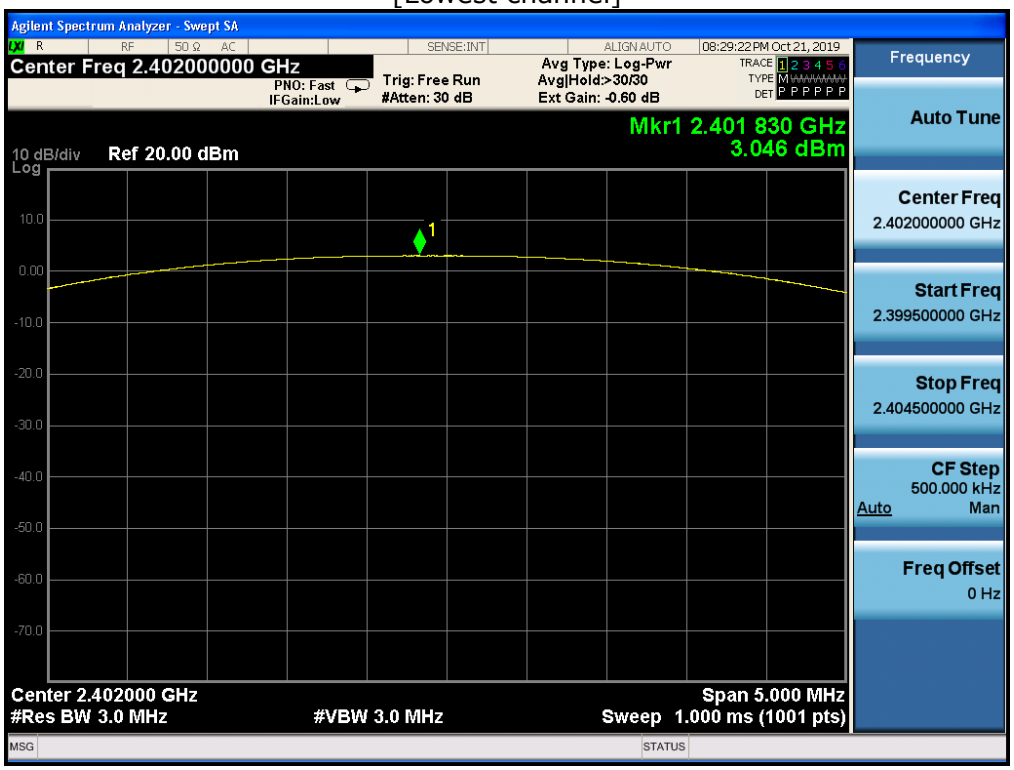
Test mode : 8-DPSK

| Frequency [MHz] | Channel No. | Output Power [dBm] | Output power [mW] | Result |
|---|---|---|---|---|
| 2 402 | 0 | 2.119 | 1.629 | Complies |
| 2 441 | 39 | 0.377 | 1.091 | Complies |
| 2 480 | 78 | -0.194 | 0.956 | Complies |

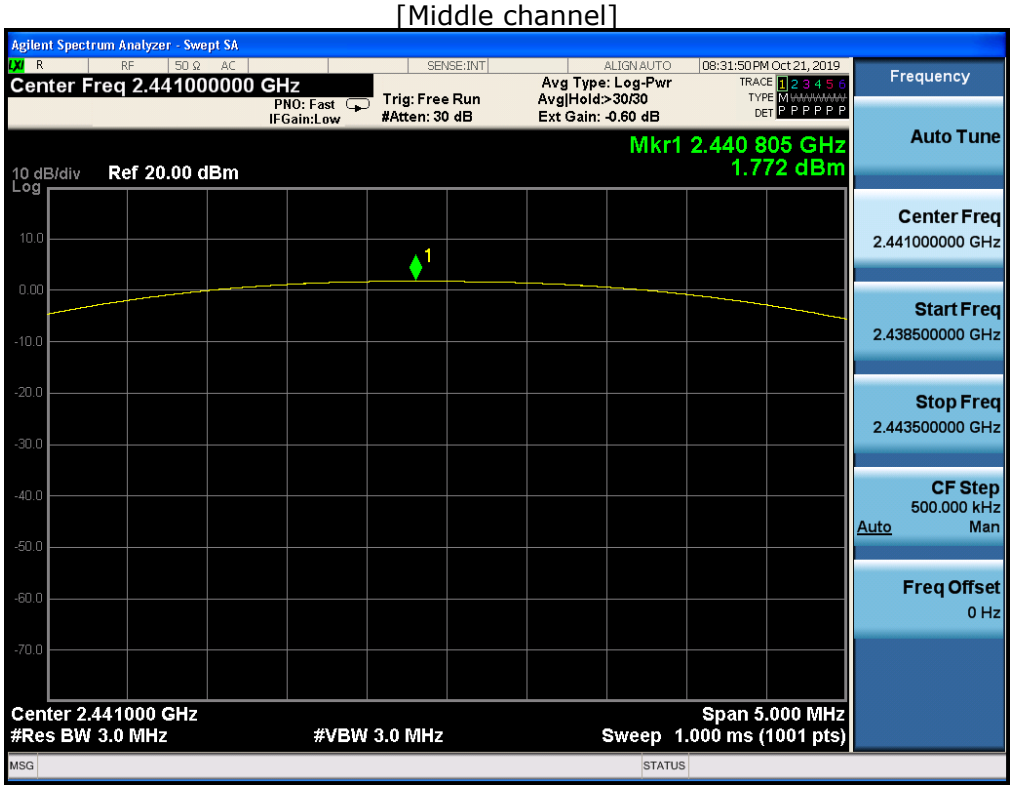
See next pages for actual measured spectrum plots.

## Test Mode : GFSK

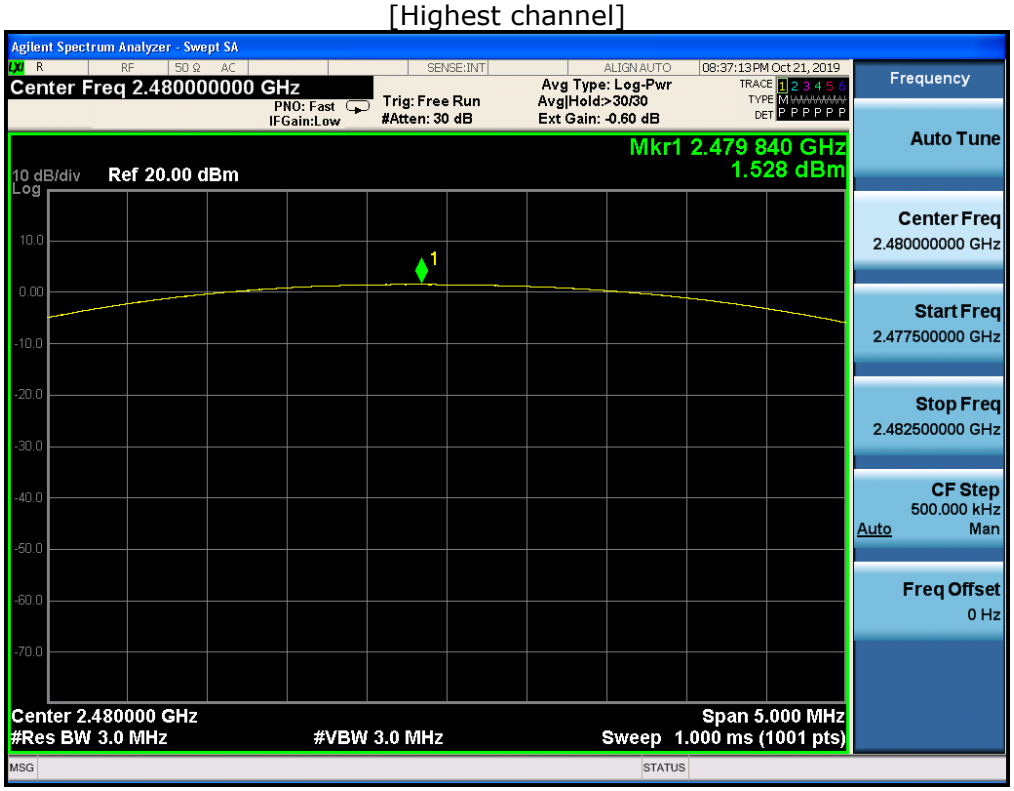
[Lowest channel]




[Middle channel]

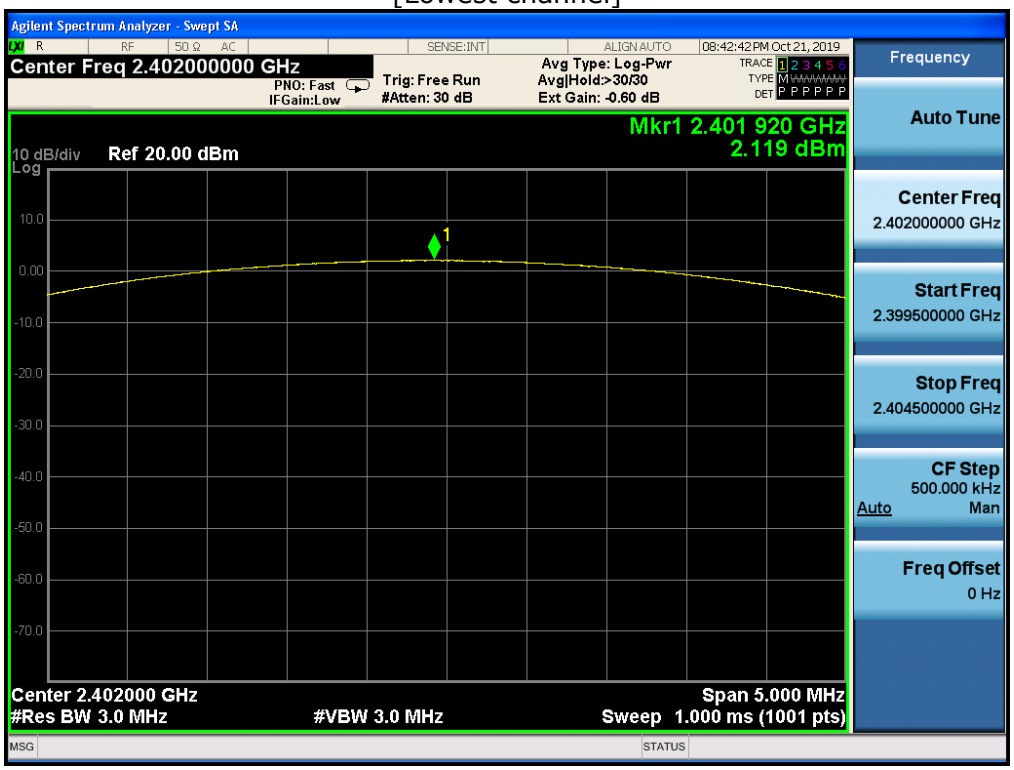


[Highest channel]

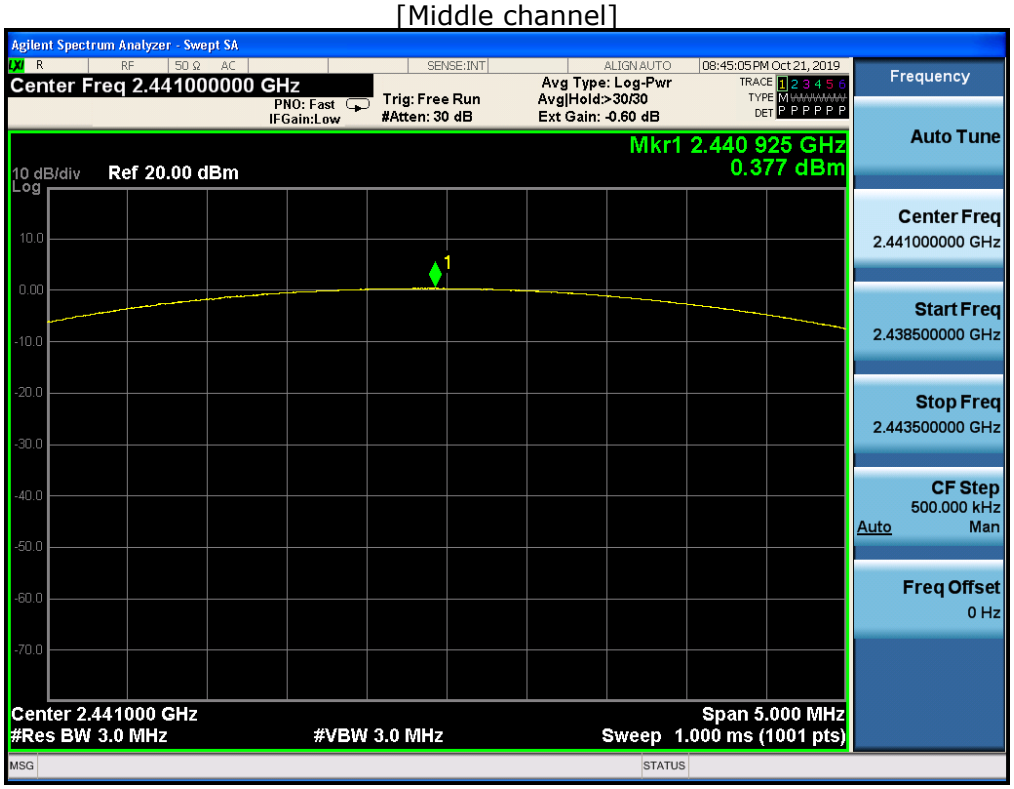


**Test Mode : 8-DPSK**

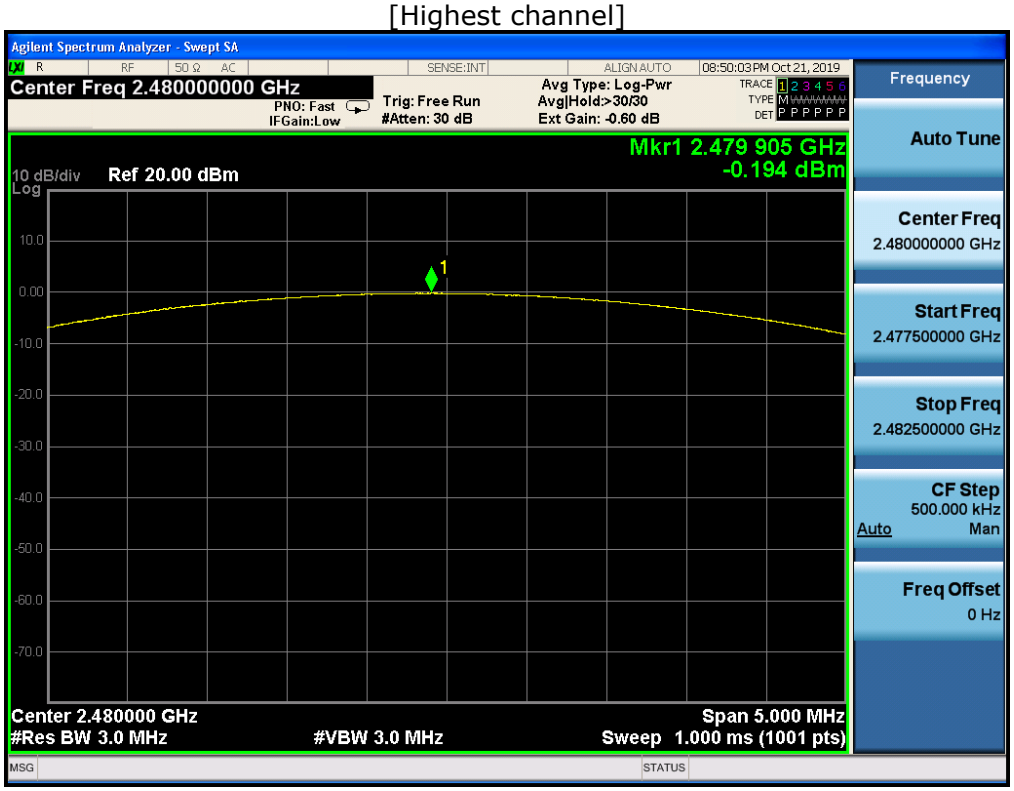
[Lowest channel]




[Middle channel]



[Highest channel]



## 4.6 Unwanted Emissions (Conducted)

### Test Procedures

ANSI C63.10-2013 - Section 7.8.6, 7.8.8

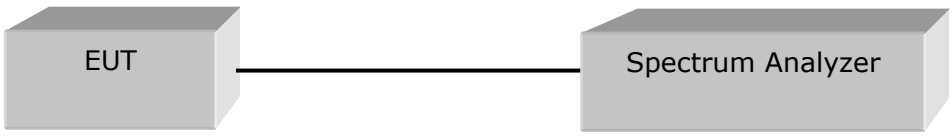
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB.

The bandwidth at 20 dB down from the highest inband spectral density was measured with a spectrum analyzer connected to the antenna terminal, while EUT has its hopping function disabled at the highest, middle and the lowest available channels.

The spectrum analyzer is set to:

Center frequency = the highest, middle and the lowest channels

a) RBW = 100 kHz
b) VBW = 300 kHz (≥ RBW)
c) Span = 10 MHz
d) Detector = peak
e) Trace = max hold
f) Sweep = auto




### Limit

> 20 dBc

### Test Results

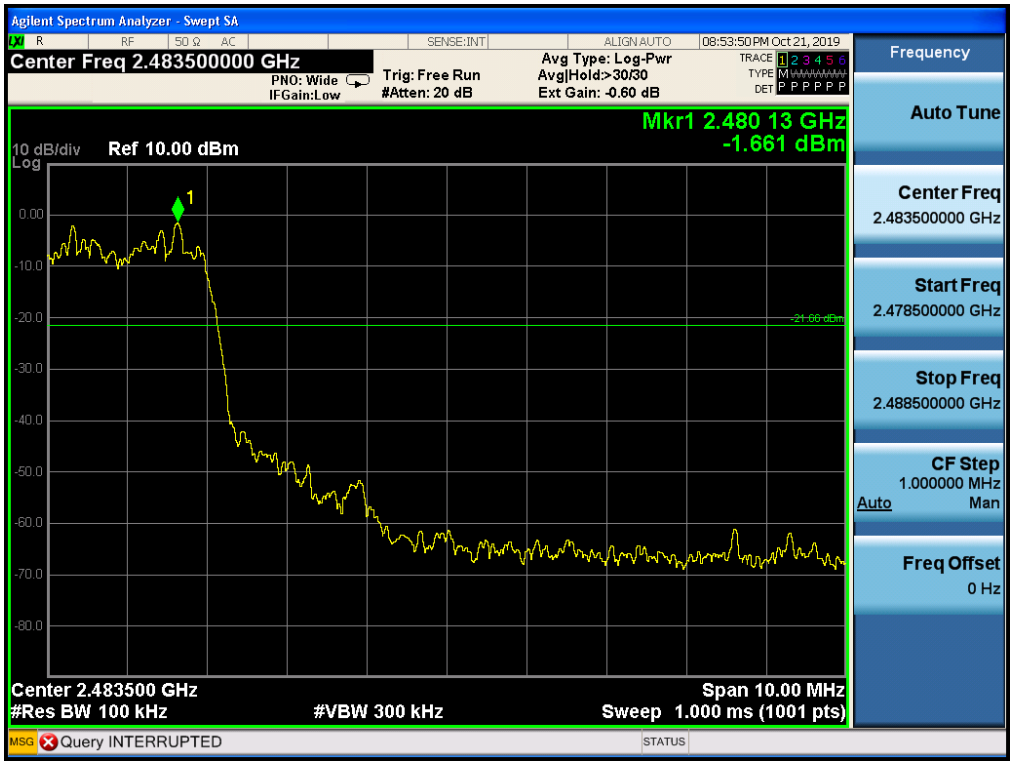
All conducted emission in any 100 kHz bandwidth outside of the spectrum band was at least 20 dB lower than the highest level of the in-band spectral density.
Therefore the applying equipment meets the requirement.

See next pages for actual measured spectrum plots.

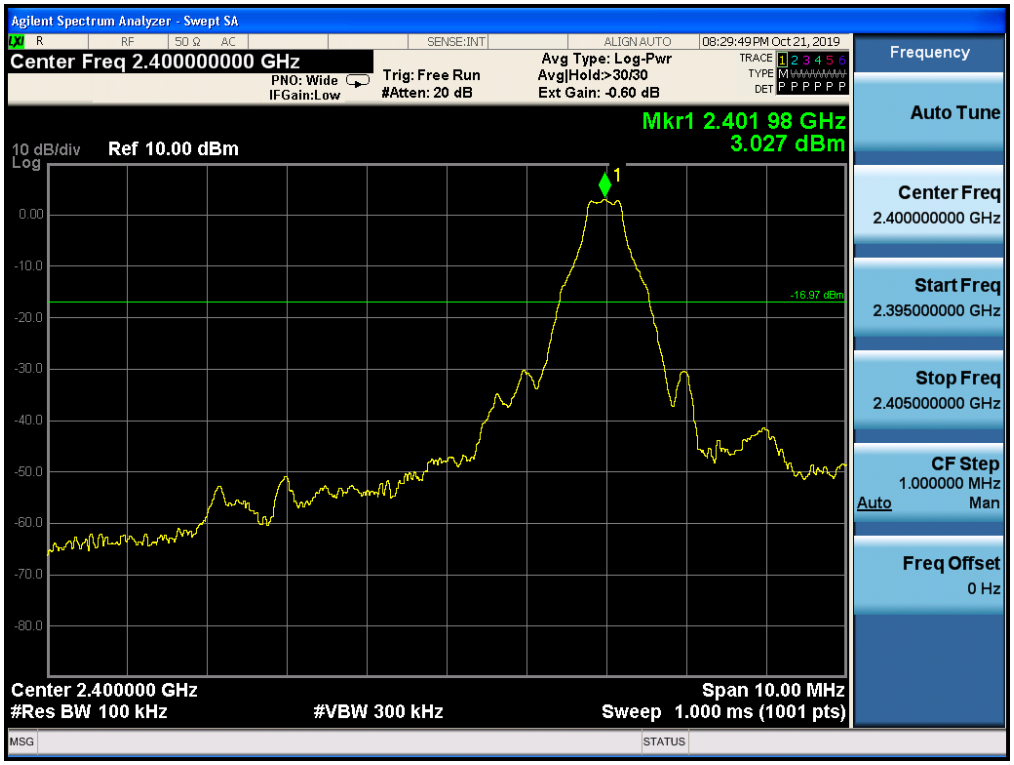
# Band Edge

Test Mode : Hopping mode, GFSK

Test Mode : Hopping mode, 8-DPSK



Test Mode : Non-Hopping mode, GFSK

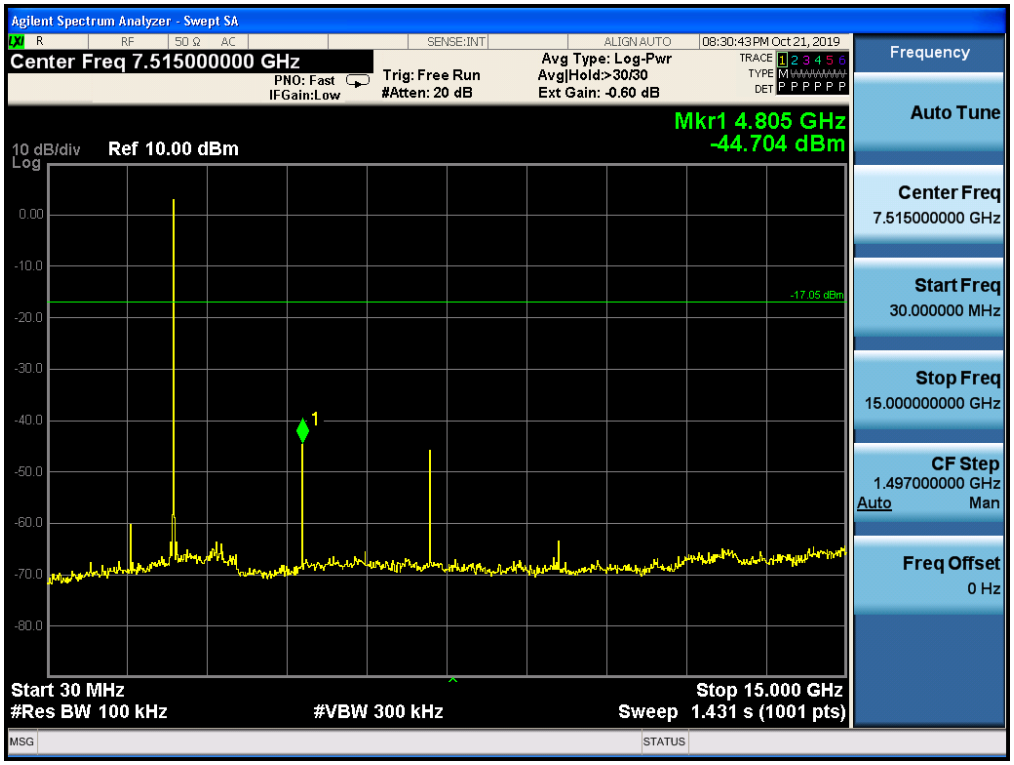


Test Mode : Non-Hopping mode, 8-DPSK

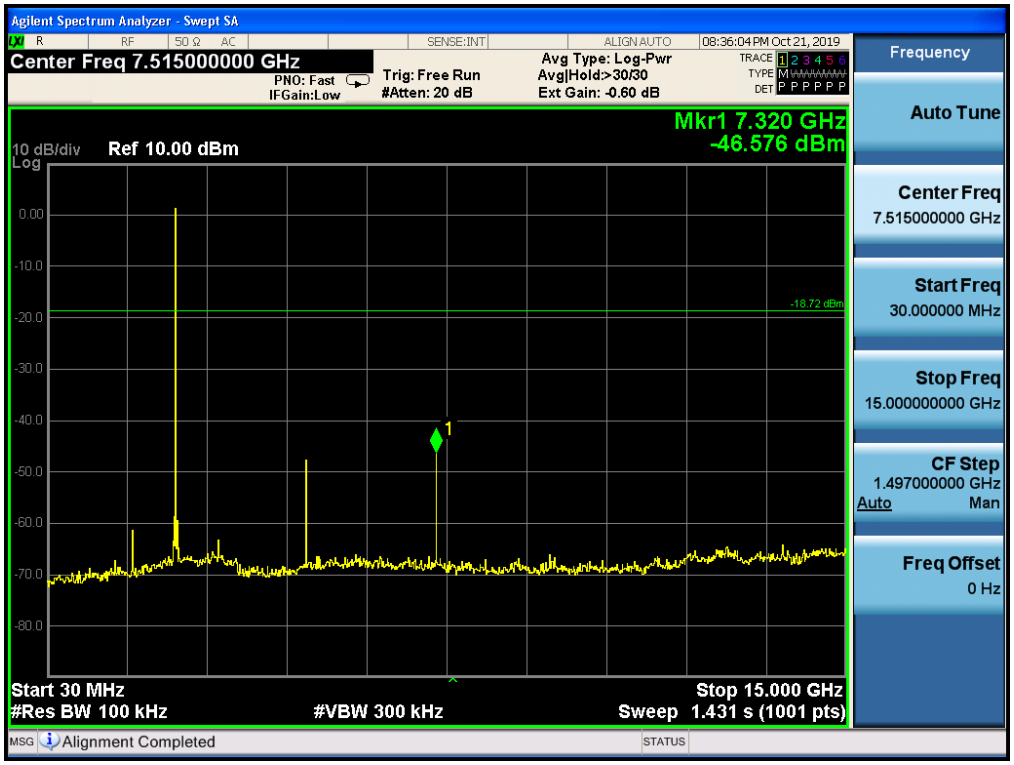
# Spurious Emission

## Test Mode : GFSK

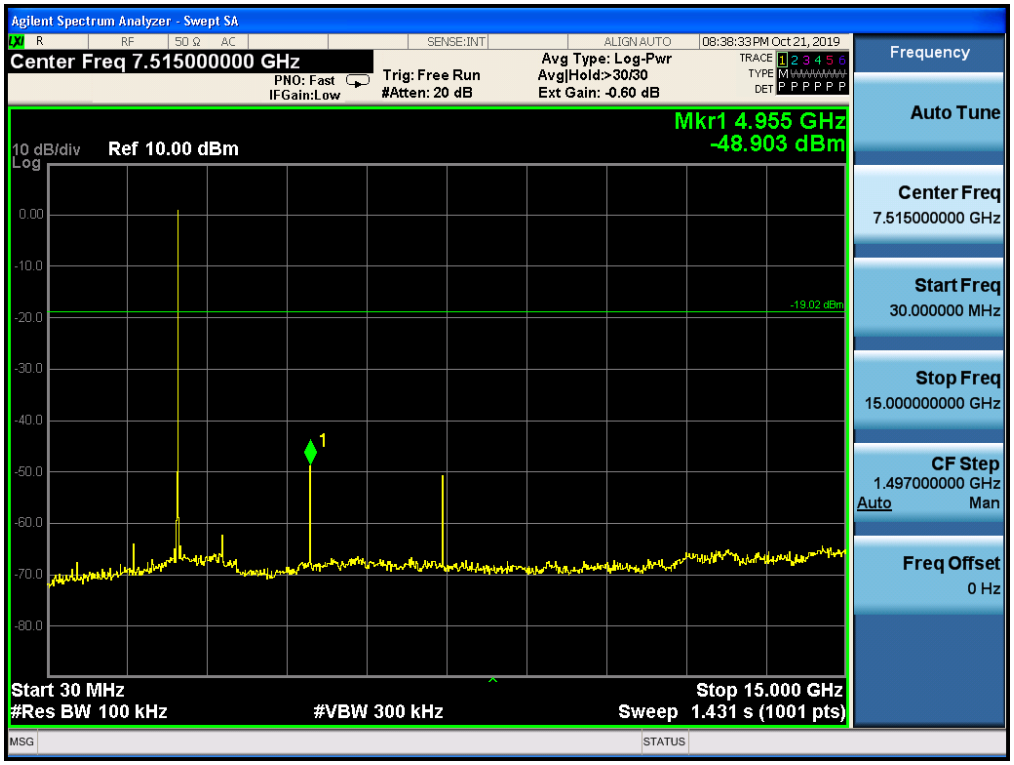
[Lowest channel]



[Middle Channel]

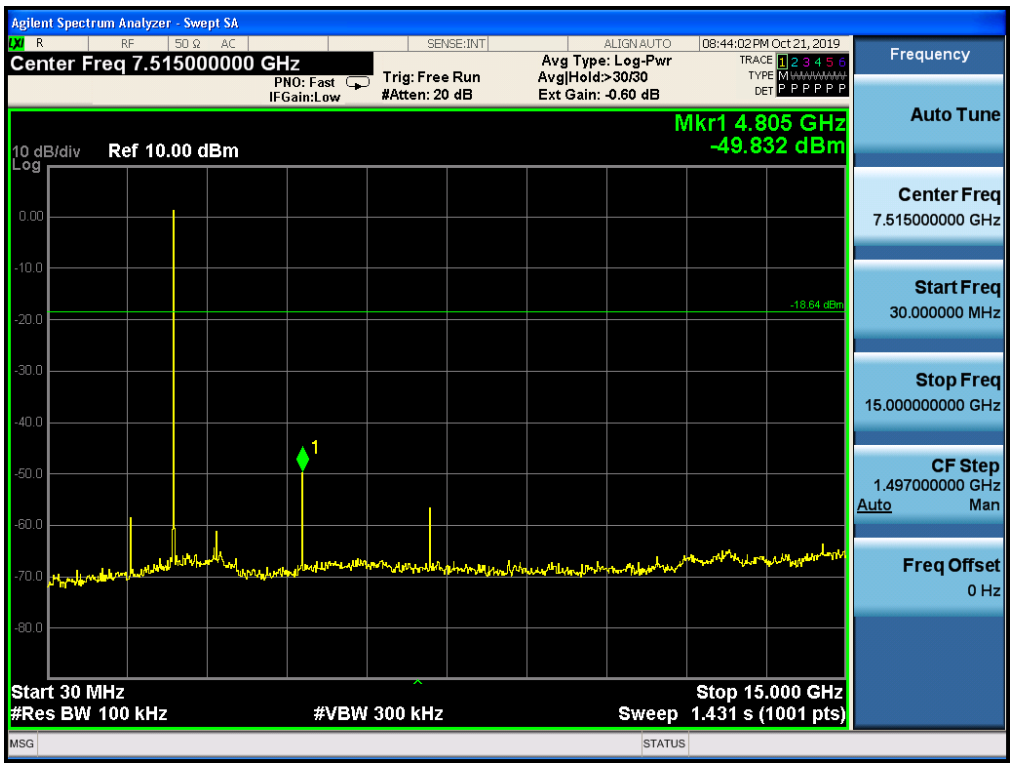


[Highest Channel]

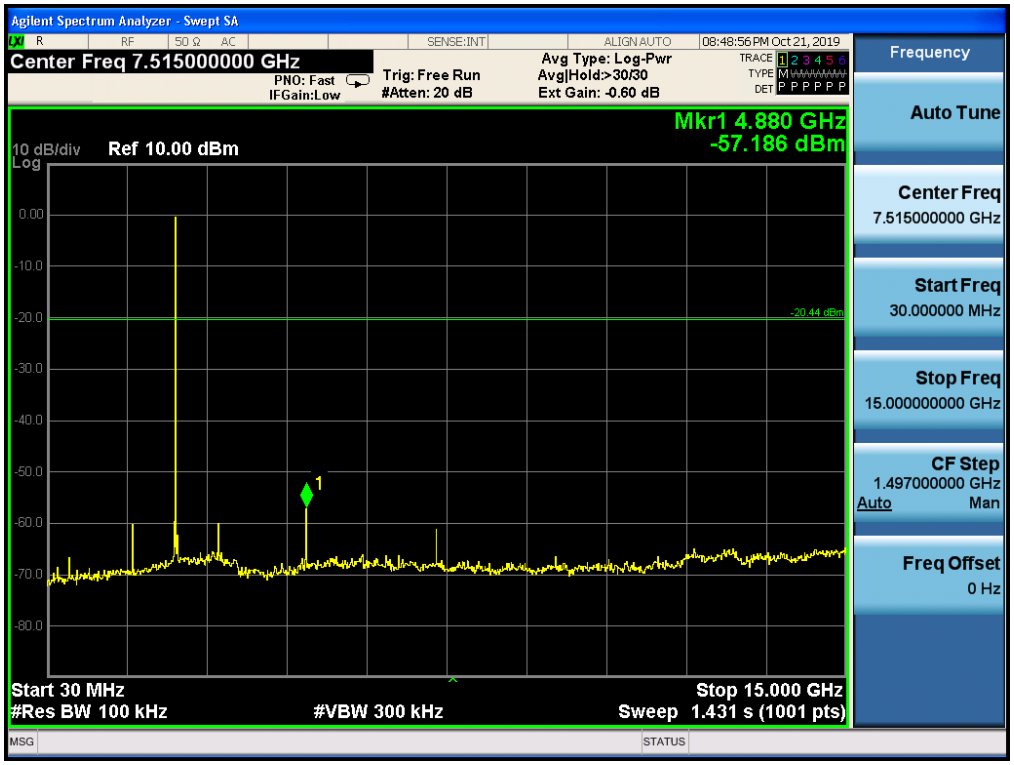


**Test Mode : 8-DPSK**

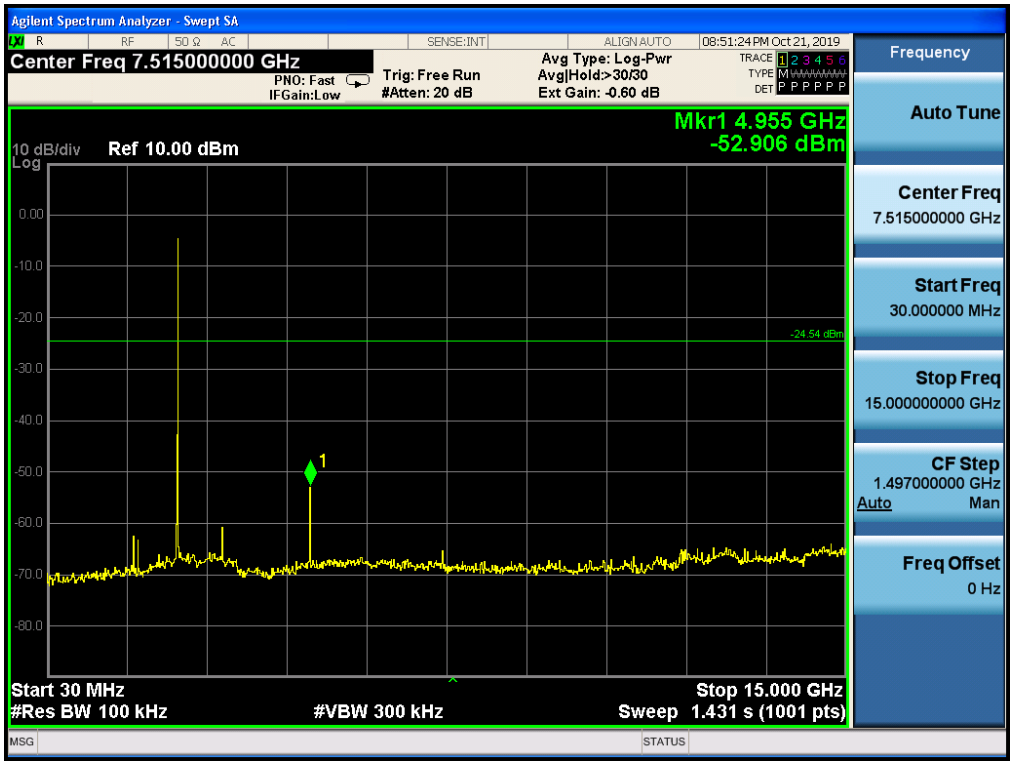
[Lowest channel]



[Middle Channel]



[Highest Channel]



## 4.7 Radiated Emission

### Test Location

☒ 10 m SAC (test distance : ☐ 10 m, ☒ 3 m)
☒ 3 m SAC (test distance : 3 m)

### Test Procedures

ANSI C63.10-2013 - Section 6.5, 6.6

1) In the frequency range of 9 kHz to 30 MHz, magnetic field is measured with Loop Antenna. The center of the Loop Test Antenna is 1m above the ground. During the measurement the Loop Test Antenna rotates about its vertical axis for maximum response at each azimuth about the EUT.
2) In the frequency rage above 30 MHz, Bi-Log Test Antenna(30 MHz to 1 GHz) and Horn Test Antenna(above 1 GHz) are used. Test Antenna is 3m away from the EUT. Test Antenna height is carried from 1m to 4m above the ground to determine the maximum value of the field strength. The emissions levels at both horizontal and vertical polarizations should be tested.

### Instrument Settings

Frequency Range = 9 kHz ~ 25 GHz (2.4 GHz $10^{th}$ harmonic)

a) RBW = 1 MHz for f ≥ 1 GHz, 100 kHz for f < 1 GHz, 9 kHz for f < 30 MHz

b) VBW ≥ RBW

c) Sweep time = auto couple

**Limit :**

Unwanted emissions that do not fall within the restricted frequency bands of Table 1 shall comply either with the limits specified in the applicable RSS or with those specified in this RSS-Gen.

FCC Part 15 § 15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

**Table 1. Restricted Frequency Bands**

| MHz | MHz | MHz | MHz | MHz | GHz |
|---|---|---|---|---|---|
| 0.09-0.11 | 8.37626-8.38675 | 73-74.6 | 399.9-410 | 2690-2900 | 10.6-12.7 |
| [1]0.495-0.505 | 8.41425-8.41475 | 74.8-75.2 | 608-614 | 3260-3267 | 13.25-13.4 |
| 2.1735-2.1905 | 12.29-12.293 | 108-121.94 | 960-1240 | 3332-3339 | 14.47-14.5 |
| 4.125-4.128 | 12.51975-12.52025 | 123-138 | 1300-1427 | 3345.8-3358 | 15.35-16.2 |
| 4.17725-4.17775 | 12.57675-12.57725 | 149.9-150.05 | 1435-1626.5 | 3600-4400 | 17.7-21.4 |
| 4.20725-4.20775 | 13.36-13.41 | 156.52475-156.52525 | 1645.5-1646.5 | 4500-5150 | 22.01-23.12 |
| 6.215-6.218 | 16.42-16.423 | 156.7-156.9 | 1660-1710 | 5350-5460 | 23.6-24 |
| 6.26775-6.26825 | 16.69475-16.69525 | 162.0125-167.17 | 1718.8-1722.2 | 7250-7750 | 31.2-31.8 |
| 6.31175-6.31225 | 16.80425-16.80475 | 167.72-173.2 | 2200-2300 | 8025-8500 | 36.43-36.5 |
| 8.291-8.294 | 25.5-25.67 | 240-285 | 2310-2390 | 9000-9200 | [2]Above 38.6 |
| 8.362-8.366 | 37.5-38.25 | 322-335.4 | 2483.5-2500 | 9300-9500 | |

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.

[2] Above 38.6

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

FCC Part 15 § 15.209 (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table :

Except when the requirements applicable to a given device state otherwise, emissions from licence-exempt transmitters shall comply with the field strength limits shown in Table 2 Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission.

**Table 2. General Field Strength Limits for Licence-Exempt Transmitters**

| Frequency(MHz) | Field Strength uV/m@3m | Field Strength dBuV/m@3m | Measurement Distance (meters) |
|---|---|---|---|
| 0.009-0.490 | 2400/F(kHz) | - | 300 |
| 0.490-1.705 | 24000/F(kHz) | - | 30 |
| 1.705-30 | 30 | - | 30 |
| 30-88 | 100** | 40 | 3 |
| 88-216 | 150** | 43.5 | 3 |
| 216-960 | 200** | 46 | 3 |
| Above 960 | 500 | 54 | 3 |

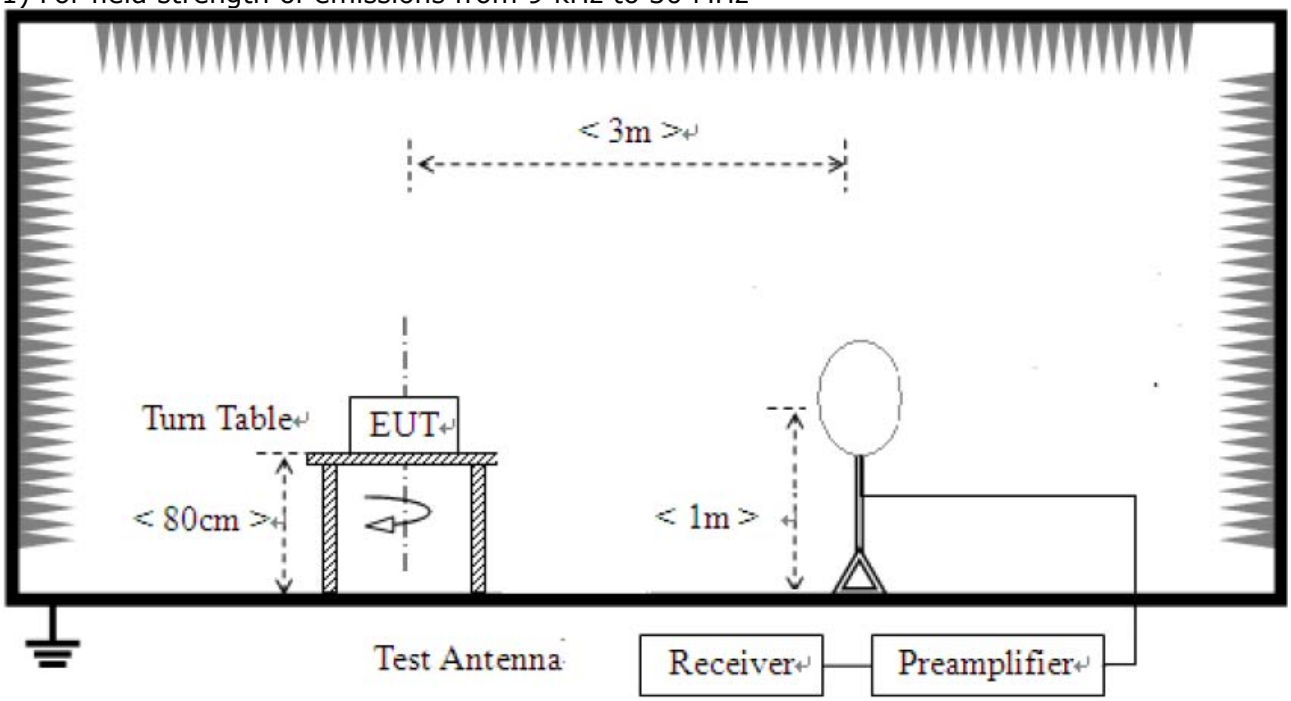
** Except as provided in 15.209(g).fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72MHz, 76-88MHz, 174-216MHz, 470-806MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g.15.231 and 15.241.

Note :

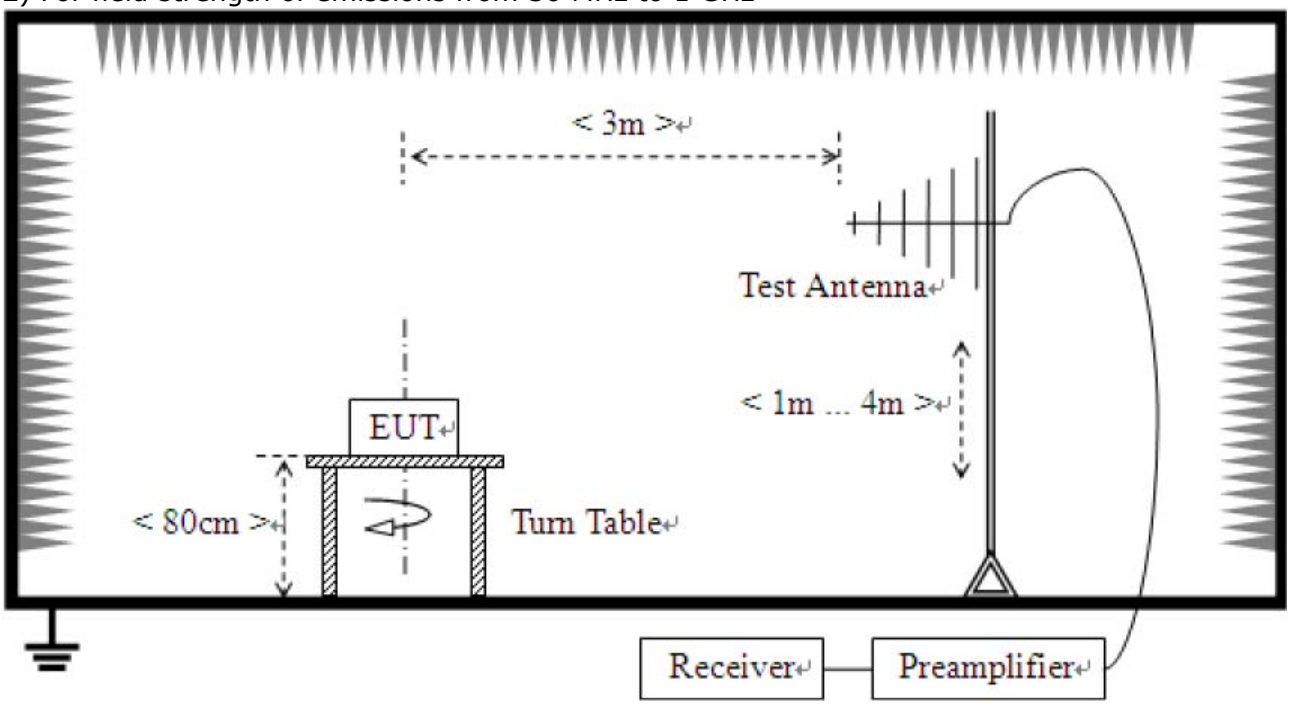
1) For above 1 GHz, the emission limit in this paragraph is based on measurement instrumentation employing an average detector, measurement using instrumentation with a peak detector function, corresponding to 20 dB above the maximum permitted average limit.
2) For above 1 GHz, limit field strength of harmonics : 54 dBuV/m@3m (AV) and 74 dBuV/m@3m (PK)
3) For measurement above 1GHz, the resolution bandwidth is set to 1 MHz and video bandwidth is set to 1 MHz for peak measurement and 10 Hz for average measurement.(Duty Cycle is > 98%,)
4) Duty Cycle is < 98%, VBW setting will need to > 1/T.
5) DCCF = Duty Cycle Correction Factor
   DCCF = 20*Log($T_{on}$/100 ms)
   $T_{on}$ = 2.901 ms(GFSK) / 2.912 ms(8-DPSK)
   DCCF = -30.75 dB(GFSK) / -30.72 dB(8-DPSK)
   Result Average = Result Peak + DCCF

**Test Setup:**

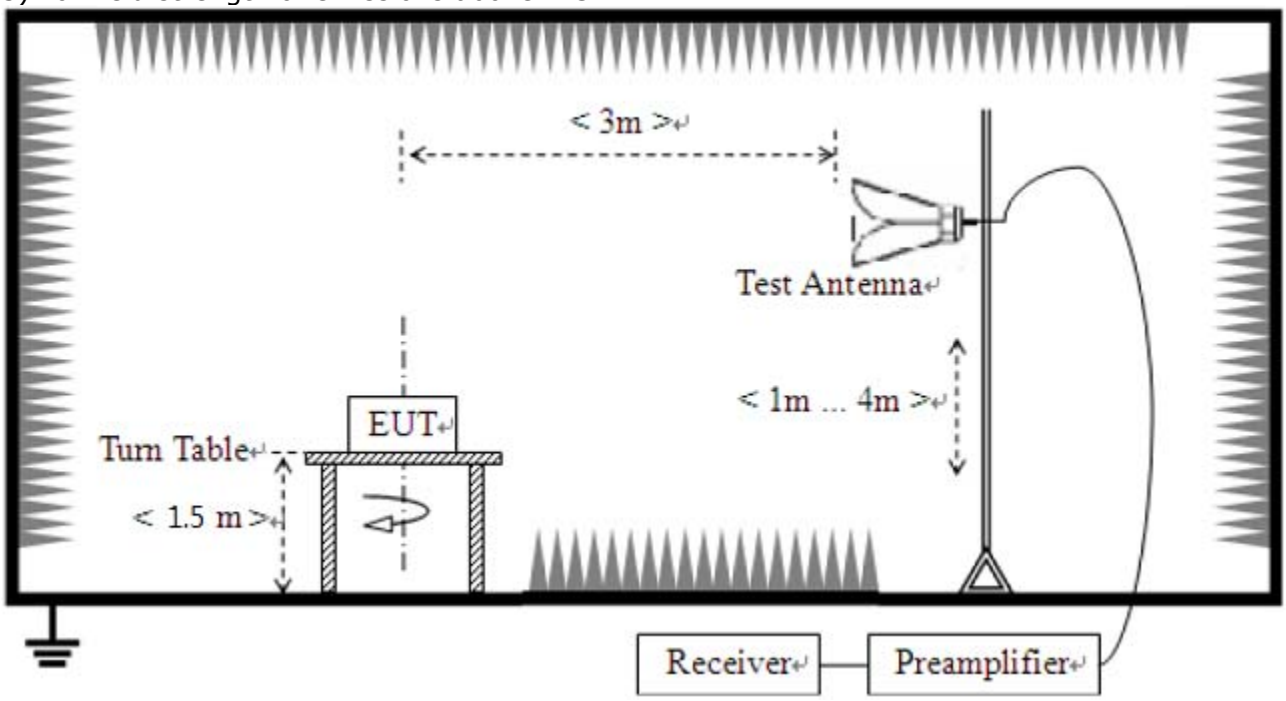
1) For field strength of emissions from 9 kHz to 30 MHz




2) For field strength of emissions from 30 MHz to 1 GHz



3) For field strength of emissions above 1 GHz



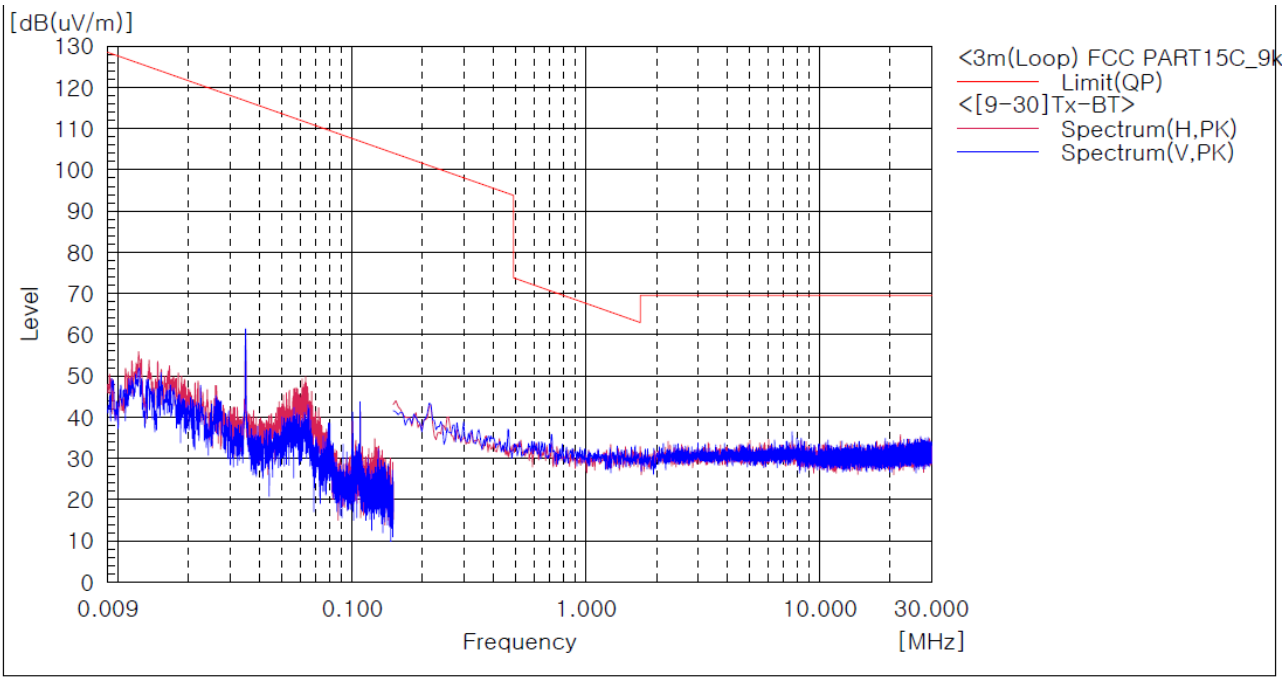
## Test results

### 1) 9 kHz to 30 MHz

**Test mode : Transmitter (Worst Case)**

The requirements are:
☒ Complies

### Test Data




| Frequency (MHz) | Measured Data (dBuV/m) | Margin (dB) | Remark |
|---|---|---|---|
| The emissions 9 kHz to 30 MHz were 20 dB lower than the limit. | | | |

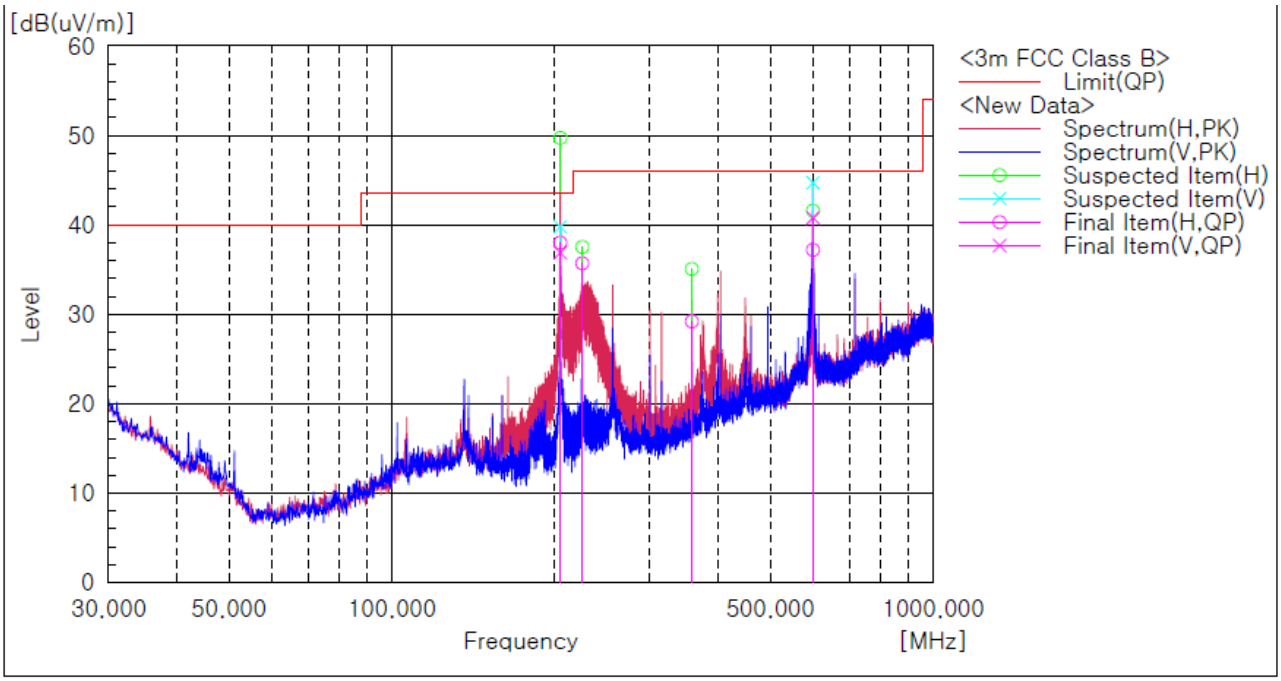
**Remark** :
1. The unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down positon(X,Y axis). The worst emission was found in stand-up position(Z axis) and the worst case was recorded.
2. Result = Reading + c.f(Correction factor)
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator - Amp Gain
4. This data is the Peak(PK) value.

## 2) 30 MHz to 1 GHz

**Test mode : Transmitter (Worst Case)**

The requirements are:
☒ Complies

**Test Data**




Final Result

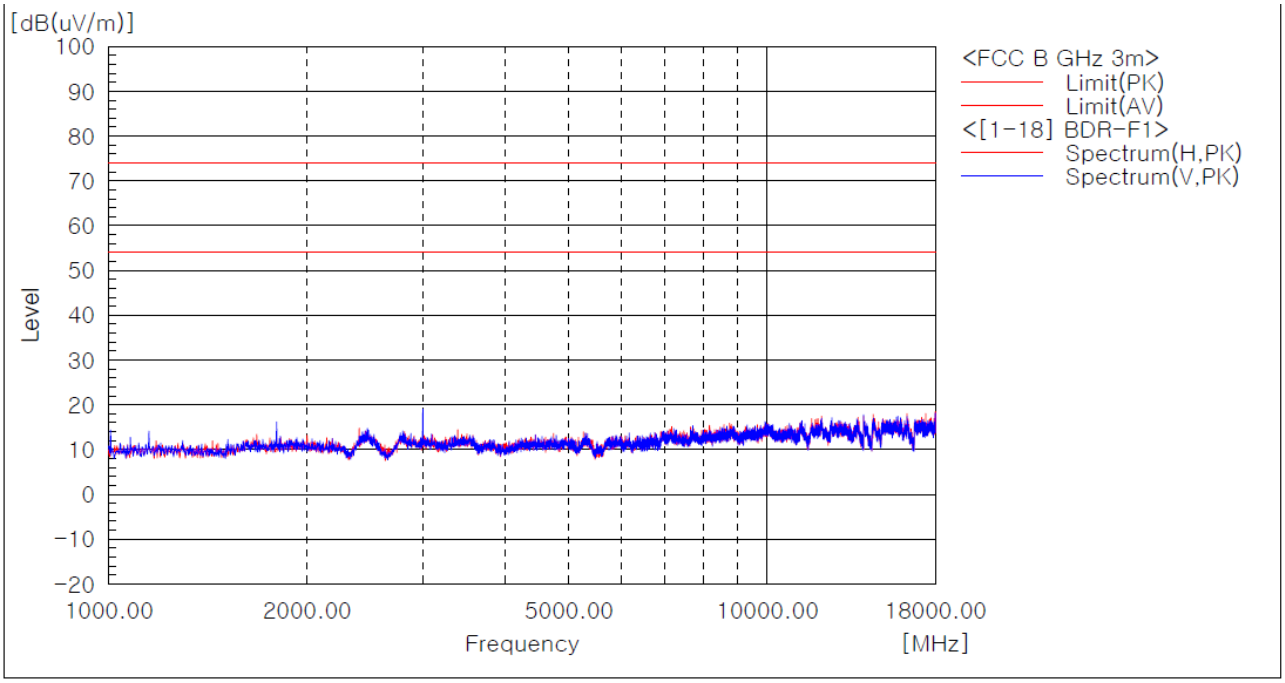
| No. | Frequency [MHz] | (P) | Reading QP [dB(uV)] | c.f [dB(1/m)] | Result QP [dB(uV/m)] | Limit QP [dB(uV/m)] | Margin QP [dB] | Height [cm] | Angle [deg] |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 204.721 | V | 50.2 | -13.3 | 36.9 | 43.5 | 6.6 | 194.0 | 161.0 |
| 2 | 204.843 | H | 51.3 | -13.3 | 38.0 | 43.5 | 5.5 | 100.0 | 40.0 |
| 3 | 224.970 | H | 48.2 | -12.5 | 35.7 | 46.0 | 10.3 | 100.0 | 11.0 |
| 4 | 358.466 | H | 35.8 | -6.6 | 29.2 | 46.0 | 16.8 | 100.0 | 288.0 |
| 5 | 599.996 | V | 41.2 | -0.4 | 40.8 | 46.0 | 5.2 | 101.0 | 94.0 |
| 6 | 599.996 | H | 37.6 | -0.4 | 37.2 | 46.0 | 8.8 | 209.0 | 54.0 |

**Remark** :
1. The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in stand-up position(Z axis) and the worst case was recorded.
2. Result = Reading + c.f(Correction factor)
3. Correction factor = Antenna factor + Cable loss + 6 dB attenuator - Amp Gain

### 3) above 1 GHz

The requirements are:
☒ Complies

**Test Data**



**Test mode : GFSK**

**Lowest frequency(2 402 MHz)**

| Frequency [MHz] | (P) | Limit AV [dBuV/m] | Limit PK [dBuV/m] | Result AV [dBuV/m] | Result PK [dBuV/m] | Margin AV [dB] | Margin PK [dB] |
|---|---|---|---|---|---|---|---|
| The emissions above 1 GHz were 20 dB lower than the limit. | | | | | | | |

**Middle frequency(2 441 MHz)**

| Frequency [MHz] | (P) | Limit AV [dBuV/m] | Limit PK [dBuV/m] | Result AV [dBuV/m] | Result PK [dBuV/m] | Margin AV [dB] | Margin PK [dB] |
|---|---|---|---|---|---|---|---|
| The emissions above 1 GHz were 20 dB lower than the limit. | | | | | | | |

**Highest frequency(2 480 MHz)**

| Frequency [MHz] | (P) | Limit AV [dBuV/m] | Limit PK [dBuV/m] | Result AV [dBuV/m] | Result PK [dBuV/m] | Margin AV [dB] | Margin PK [dB] |
|---|---|---|---|---|---|---|---|
| The emissions above 1 GHz were 20 dB lower than the limit. | | | | | | | |

**Remarks**

1. The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in stand-up position(Z axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor) + Duty cycle c.f
3. Correction factor = Antenna factor + Cable loss - Amp Gain
4. Result Average = Result Peak + DCCF

**Test mode : 8-DPSK**

**Lowest frequency(2 402 MHz)**

| Frequency [MHz] | (P) | Limit AV [dBuV/m] | Limit PK [dBuV/m] | Result AV [dBuV/m] | Result PK [dBuV/m] | Margin AV [dB] | Margin PK [dB] |
|---|---|---|---|---|---|---|---|
| The emissions above 1 GHz were 20 dB lower than the limit. | | | | | | | |

**Middle frequency(2 441 MHz)**

| Frequency [MHz] | (P) | Limit AV [dBuV/m] | Limit PK [dBuV/m] | Result AV [dBuV/m] | Result PK [dBuV/m] | Margin AV [dB] | Margin PK [dB] |
|---|---|---|---|---|---|---|---|
| The emissions above 1 GHz were 20 dB lower than the limit. | | | | | | | |

**Highest frequency(2 480 MHz)**

| Frequency [MHz] | (P) | Limit AV [dBuV/m] | Limit PK [dBuV/m] | Result AV [dBuV/m] | Result PK [dBuV/m] | Margin AV [dB] | Margin PK [dB] |
|---|---|---|---|---|---|---|---|
| The emissions above 1 GHz were 20 dB lower than the limit. | | | | | | | |

**Remarks**

1. The Unwanted emission was measured in the following position: EUT stand-up position(Z axis), lie-down position(X,Y axis). The worst emission was found in stand-up position(Z axis) and the worst case was recorded.
2. Result = Reading + c.f(correction factor) + Duty cycle c.f
3. Correction factor = Antenna factor + Cable loss - Amp Gain
4. Result Average = Result Peak + DCCF

## 4.8 AC Power Line Conducted Emissions

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz-30 MHz, shall not exceed the limits.

### Instrument Settings

IF Band Width: 9 kHz

### Test Procedures

The EUT was placed on a non-metallic table 0.8m above the metallic, grounded floor and 0.4m from the reference ground plane wall. The distance to other metallic surfaces was at least 0.8m.
Amplitude measurements were performed with a quasi-peak detector and an average detector.

### Limit

| Frequency (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 |

* The level decreases linearly with the logarithm of the frequency.
** A linear average detector is required.

### Test Results

The requirements are:
☒ Not Applicable

## Test Data

**[LINE]**

NA

**[NEUTRAL]**

NA

## 4.9 Frequency Hopping System Requirements

### Standard Applicable

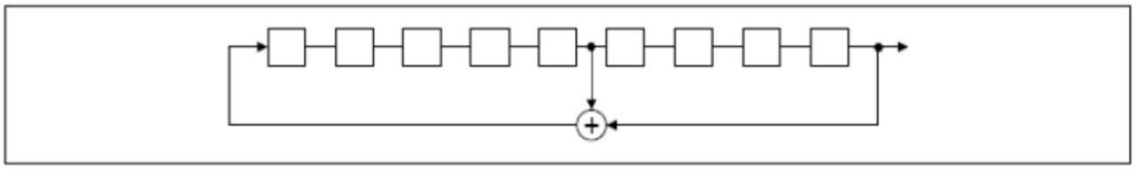
According to FCC Part 15.247(a)(1), The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(g) 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.

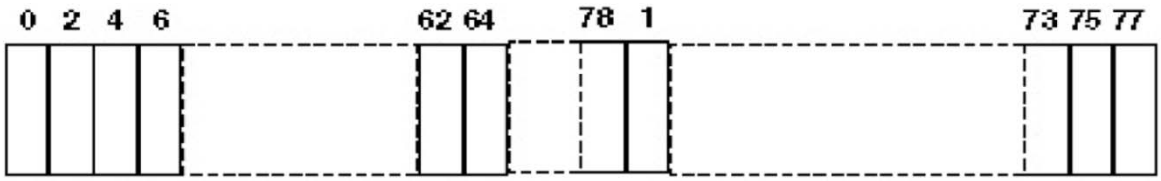
(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination 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.

### EUT Pseudorandom Frequency Hopping Sequence

The pseudo random 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*




Each frequency used equally on the average by each transmitter.  The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

## Frequency Hopping System

This transmitter device is frequency hopping device, and complies with FCC part 15.247 rule. This device uses Bluetooth radio which operates in 2400-2483.5 MHz band. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each; centred from 2402 to 2480 MHz) in the range 2,400-2,483.5 MHz. The transmitter switches hop frequencies 1,600 times per second to assure a high degree of data security. All Bluetooth devices participating in a given piconet are synchronized to the frequency-hopping channel for the piconet. The frequency hopping sequence is determined by the master's device address and the phase of the hopping sequence (the frequency to hop at a specific time) is determined by the master's internal clock. Therefore, all slaves in a piconet must know the master's device address and must synchronize their clocks with the master's clock.

Adaptive Frequency Hopping (AFH) was introduced in the Bluetooth specification to provide an effective way for a Bluetooth radio to counteract normal interference. AFH identifies "bad" channels, where either other wireless devices are interfering with the Bluetooth signal or the Bluetooth signal is interfering with another device. The AFH-enabled Bluetooth device will then communicate with other devices within its piconet to share details of any identified bad channels. The devices will then switch to alternative available "good" channels, away from the areas of interference, thus having no impact on the bandwidth used.

*Example for a Bluetooth device using channel numbers would be :
Ch 44, 35, 78, 03, 15, 21, 76, 40, 56, 13, 02, 19, 67, 39, 78, 20, 21, 64, 75 etc.

# APPENDIX A – Test Equipment Used For Tests

| | Name of Equipment | Manufacturer | Model No. | Serial No. | Date of Calibration | Due Date |
|---|---|---|---|---|---|---|
| 1 | Signal Analyzer | Agilent | N9020A | MY48011598 | 2019-10-16 | 2020-10-16 |
| 2 | Spectrum Analyzer | Rohde & Schwarz | FSV40 | 101574 | 2019-01-28 | 2020-01-28 |
| 3 | Signal Generator | Rohde & Schwarz | SMB100A | 175528 | 2019-10-16 | 2020-10-16 |
| 4 | EMI Test Receiver | Rohde & Schwarz | ESCI7 | 100814 | 2019-10-22 | 2020-10-22 |
| 5 | Bilog Antenna | Schaffner | CBL6111C | 2551 | 2018-05-10 | 2020-05-10 |
| 6 | Active Loop Antenna | SCHWARZBECK | FMZB 1513 | 1513-126 | 2018-05-27 | 2020-05-27 |
| 7 | 6dB Attenuator | R&S | DNF | 272.4110.50-2 | 2018-10-25 | 2019-10-25 |
| 8 | AMPLIFIER | SONOMA | 310 | 291721 | 2019-01-28 | 2020-01-28 |
| 9 | EMI Test Receiver | Rohde & Schwarz | ESU40 | 100336 | 2019-01-29 | 2020-01-29 |
| 10 | Preamplifier | Agilent | 8449B | 3008A02011 | 2018-12-03 | 2019-12-03 |
| 11 | Horn Antenna | ETS-Lindgren | 3115 | 00078894 | 2017-12-04 | 2019-12-04 |
| 12 | Horn Antenna | ETS-Lindgren | 3116 | 00062916 | 2017-12-04 | 2019-12-04 |
| 13 | Band Reject Filter | Micro Tronics | BRM50702 | G233 | 2019-01-28 | 2020-01-28 |
| 14 | LISN | Rohde & Schwarz | ENV216 | 101235 | 2019-01-29 | 2020-01-29 |
| 15 | Combiner/Divider | Weinschel | 1580 | SQ369 | 2019-10-18 | 2020-10-18 |
| 16 | DC Power Supply | HP | E3632A | KR94907541 | 2019-10-15 | 2020-10-15 |
| 17 | Dual-Tracking DC Power Supply | Topward Electric Instruments Co.,Ltd. | 6303D | 711196 | 2019-01-21 | 2020-01-21 |

| | Cable | Manufacturer | Model No. | Serial No. | Check Date |
|---|---|---|---|---|---|
| 1 | RF Cable | Canare Corporation | L-5D2W | N/A | 2018-12-19 |
| 2 | RF Cable | Junkosha Inc. | MWX221 | 1512S149 | 2019-10-19 |
| 3 | RF Cable | HUBER+SUHNER | SUCOFLEX 102 | MY073/2 | 2018-12-19 |
| 4 | RF Cable | HUBER+SUHNER | SUCOFLEX 102 | MY4728/2 | 2018-12-19 |
| 5 | RF Cable | HUBER+SUHNER | SUCOFLEX 104 | MY27558/4 | 2018-12-19 |
| 6 | RF Cable | HUBER+SUHNER | SUCOFLEX 104 | N/A | 2018-12-19 |
| 7 | RF Cable | HUBER+SUHNER | SUCOFLEX 104 | MY27573/4 | 2018-12-19 |
| 8 | RF Cable | HUBER+SUHNER | SUCOFLEX 106 | N/A | 2018-12-19 |