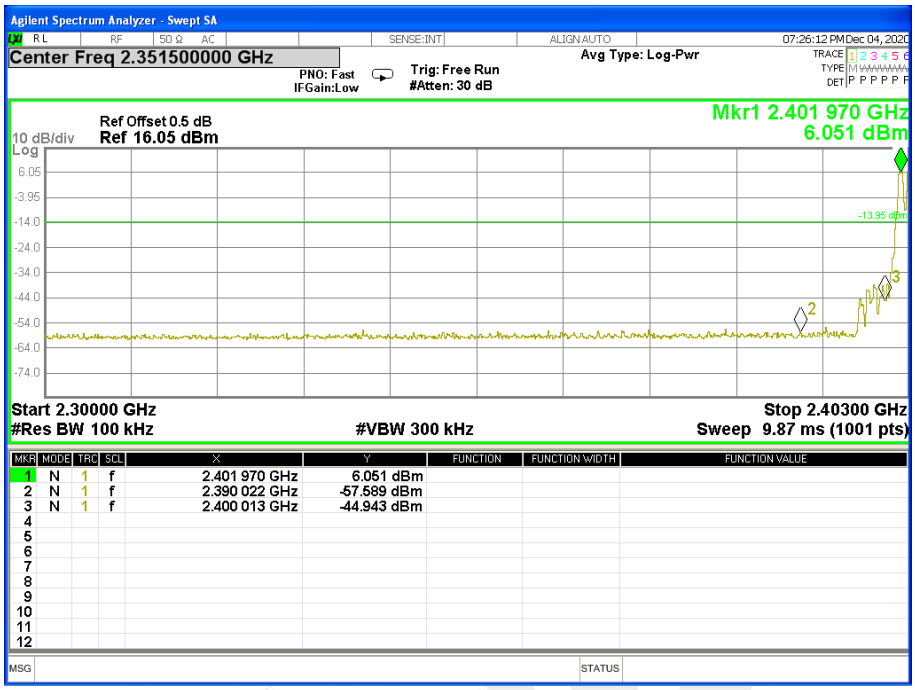
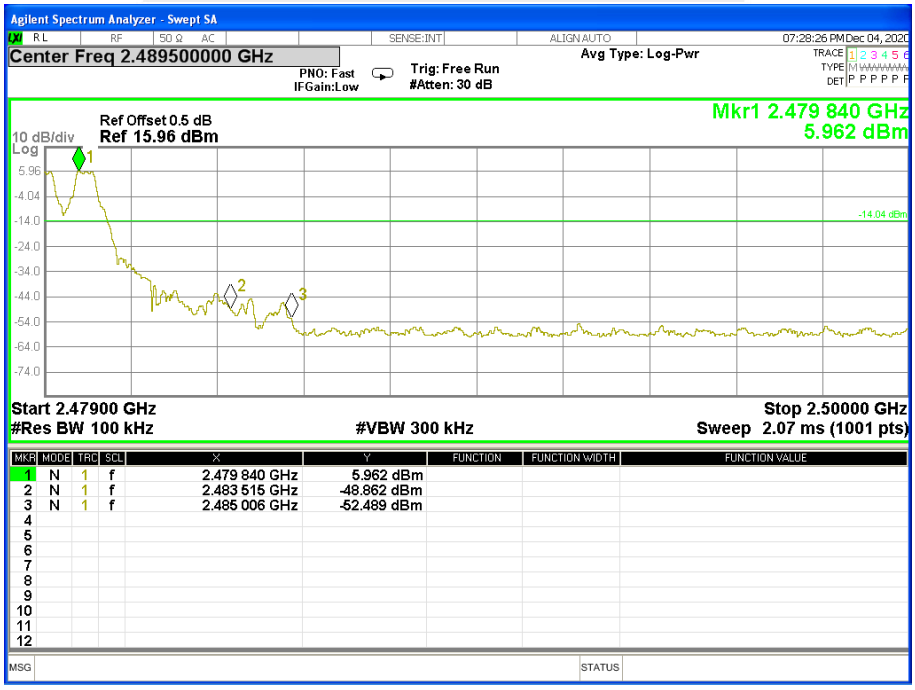
For Hopping Band edge

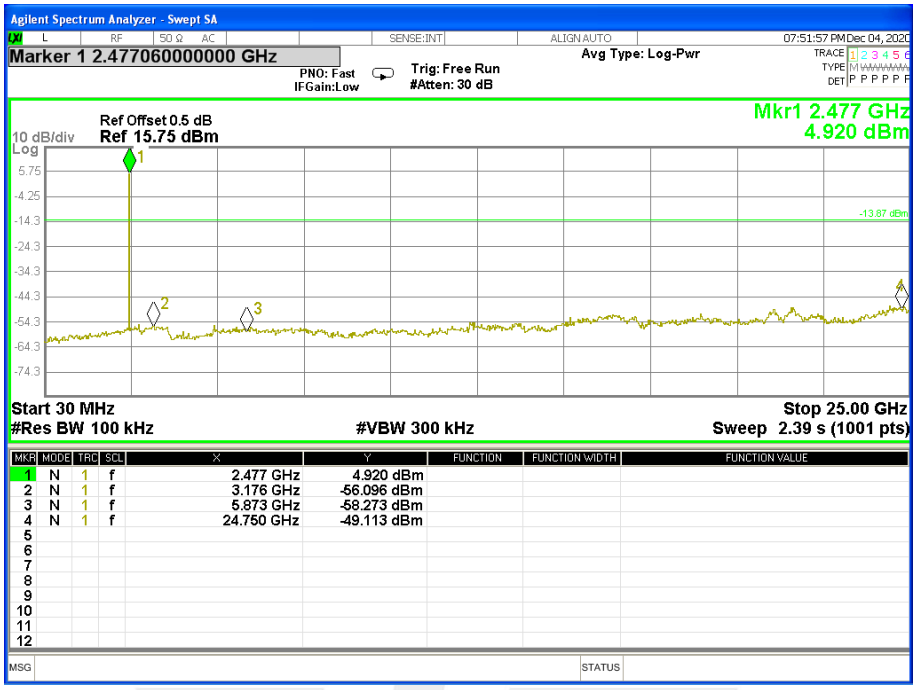
GFSK



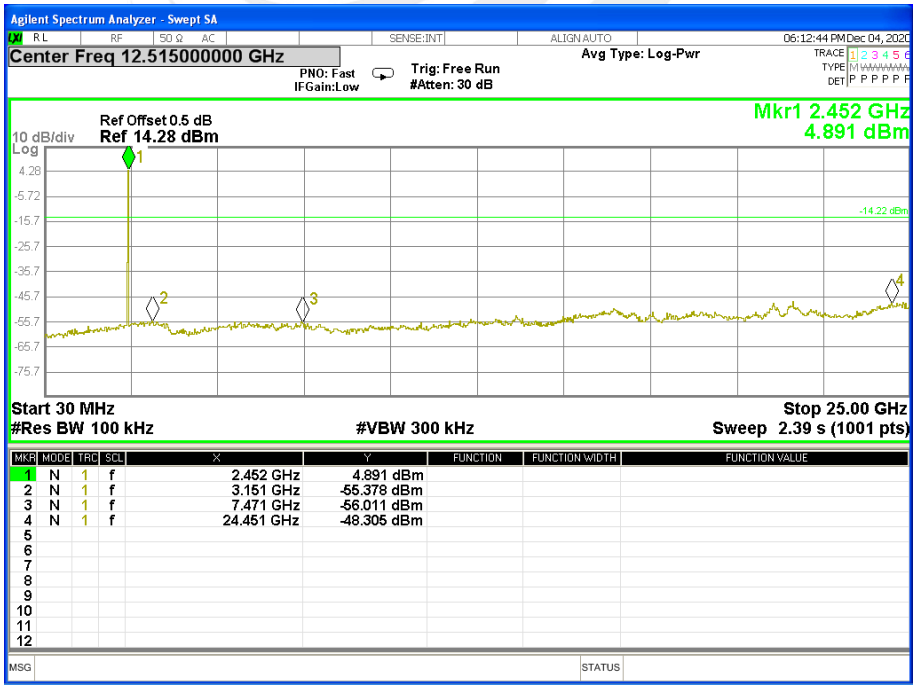



| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | π/4-DQPSK(2Mbps)–00/39/78 CH | Test Voltage: | DC 3.7V |

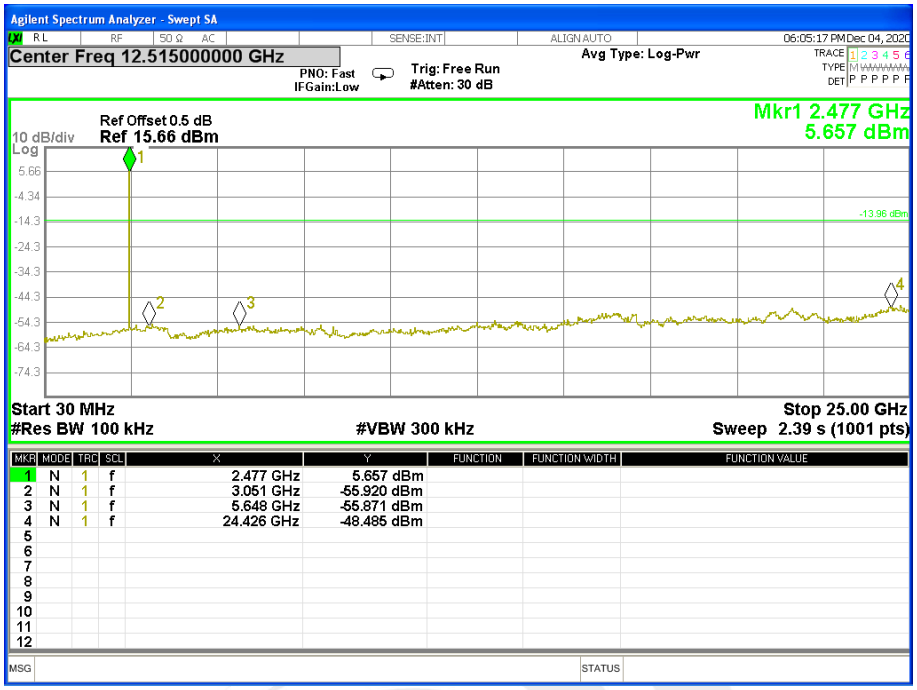
00 CH




39 CH

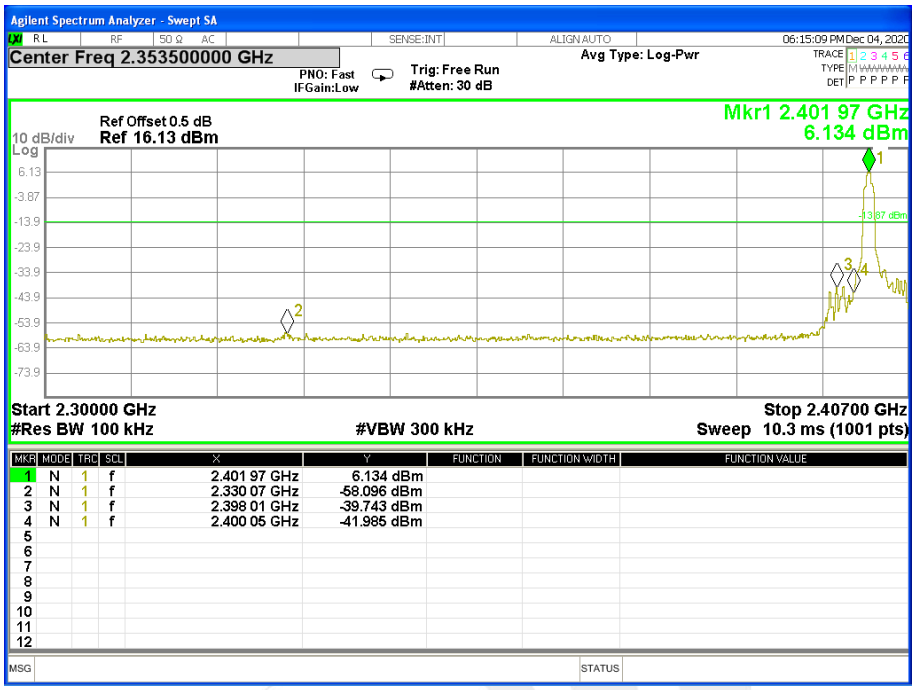


78 CH

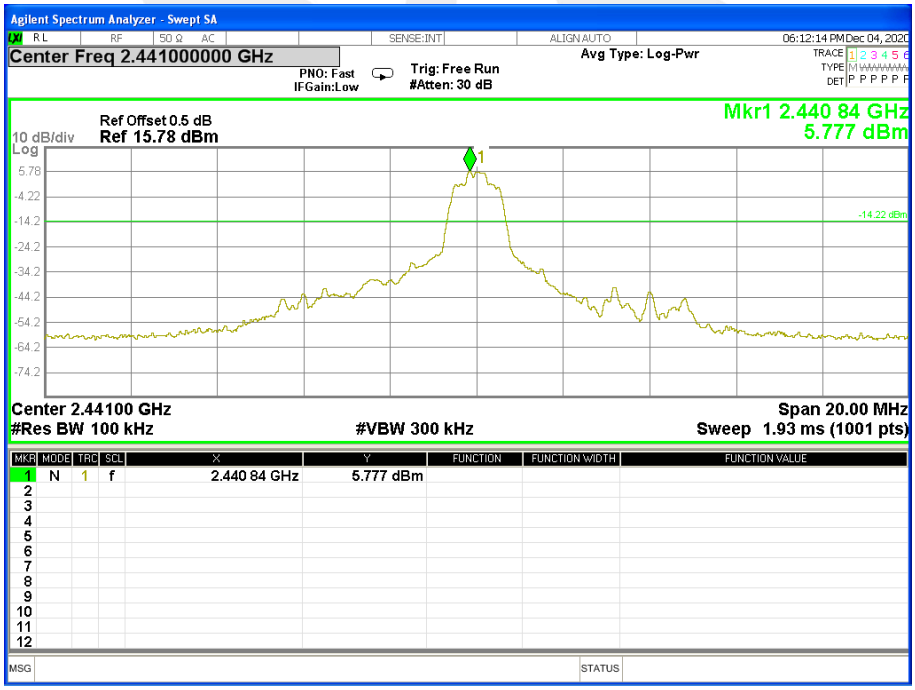

Agilent Spectrum Analyzer - Swept SA
RL
RF
50 Ω AC
SENSE:INT
ALIGN AUTO
06:05:17 PM Dec 04, 2020
Center Freq 12.515000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
TRACE 1 2 3 4 5 6
TYPE M
DET P P P P P
Ref Offset 0.5 dB
10 dB/div
Log
Ref 15.66 dBm
Mkr1 2.477 GHz
5.657 dBm
5.66
-4.34
-14.3
-24.3
-34.3
-44.3
-54.3
-64.3
-74.3
-13.96 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.00 GHz
Sweep 2.39 s (1001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 2.477 GHz 5.657 dBm
2 N 1 f 3.051 GHz -55.920 dBm
3 N 1 f 5.648 GHz -55.871 dBm
4 N 1 f 24.426 GHz -48.485 dBm
5
6
7
8
9
10
11
12
MSG
STATUS

For Band edge(it's also the reference level for conducted spurious emission)

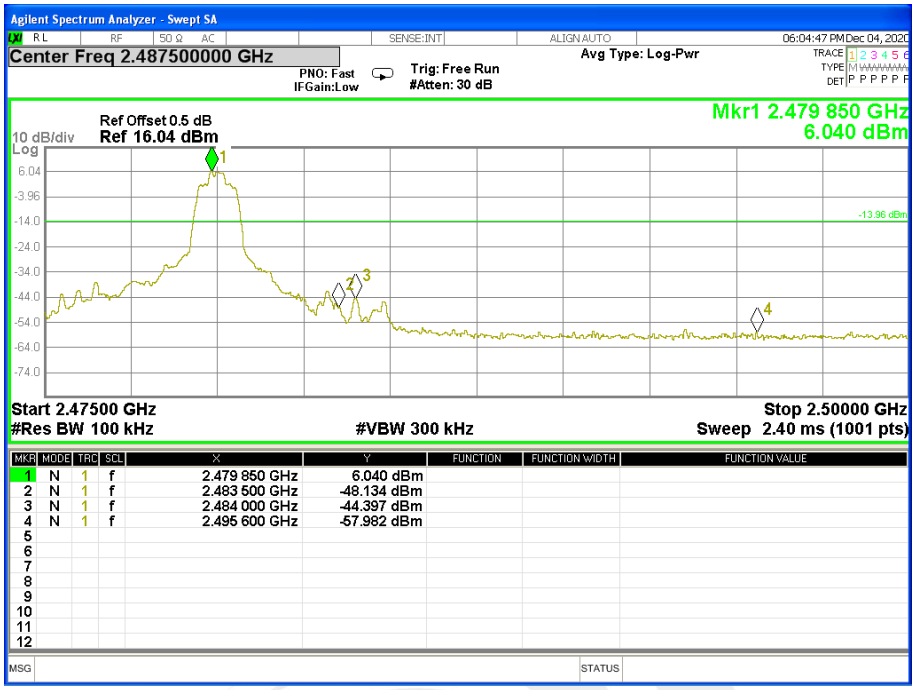
00 CH




39 CH

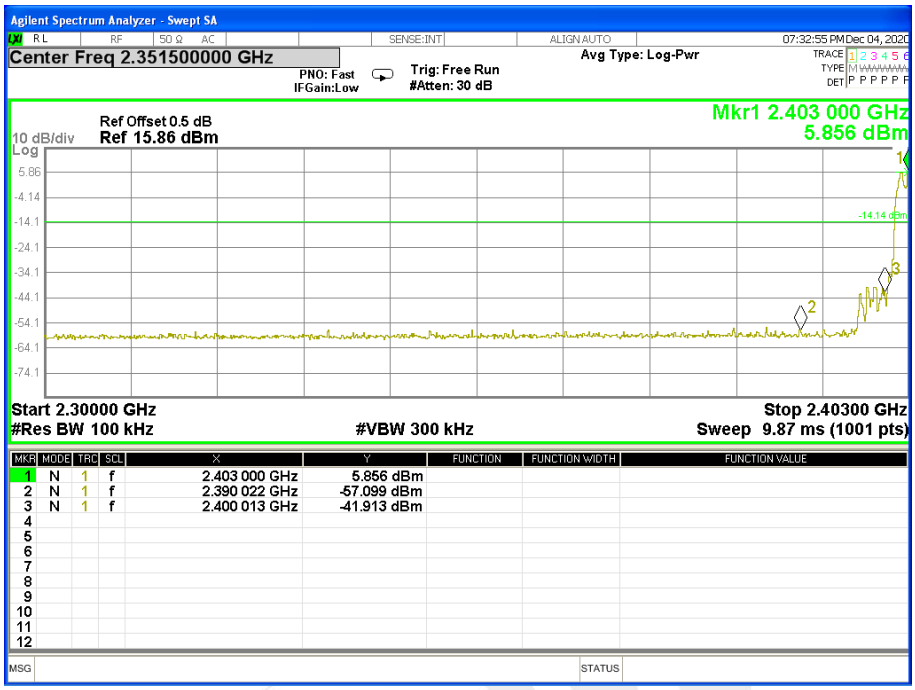


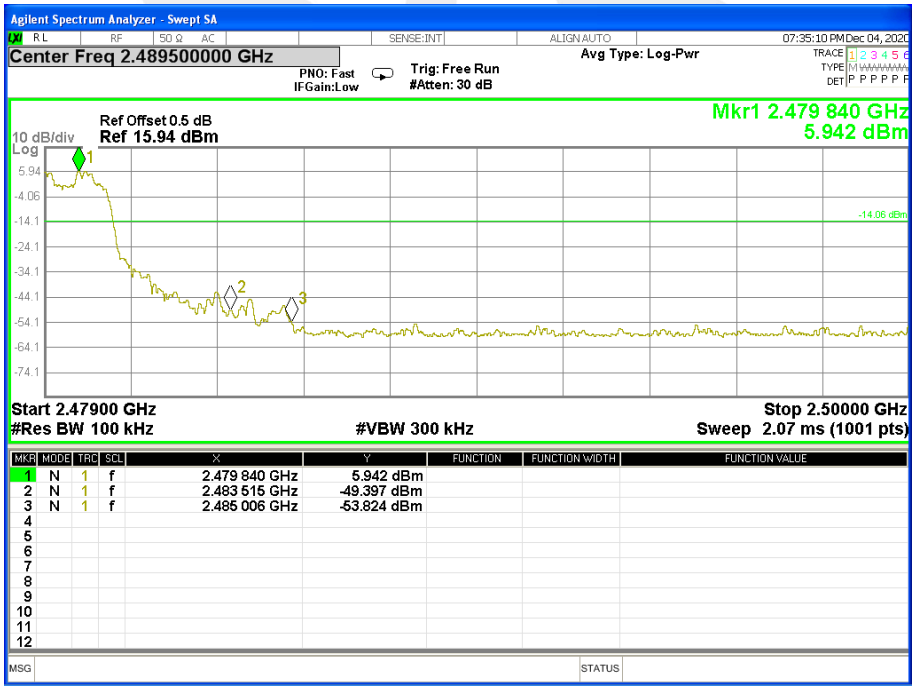
78 CH


Agilent Spectrum Analyzer - Swept SA
Center Freq 2.487500000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
06:04:47 PM Dec 04, 2020
Ref Offset 0.5 dB
10 dB/div
Ref 16.04 dBm
Log
Mkr1 2.479 850 GHz
6.040 dBm
-13.96 dBm
Start 2.47500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.50000 GHz
Sweep 2.40 ms (1001 pts)
1 N 1 f 2.479 850 GHz 6.040 dBm
2 N 1 f 2.483 500 GHz -48.134 dBm
3 N 1 f 2.484 000 GHz -44.397 dBm
4 N 1 f 2.495 600 GHz -57.982 dBm

For Hopping Band edge

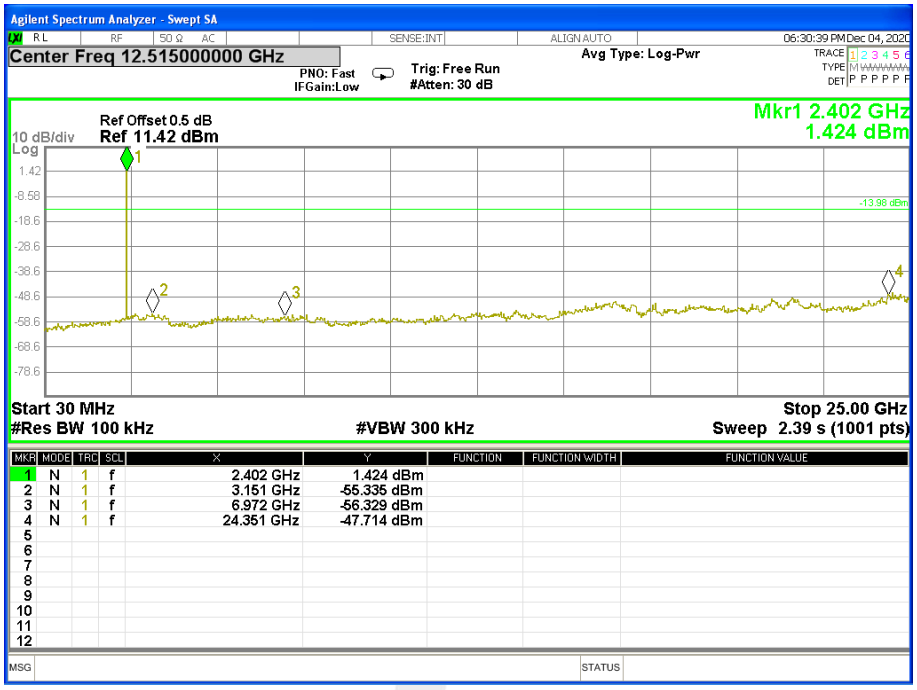
π/4-DQPSK



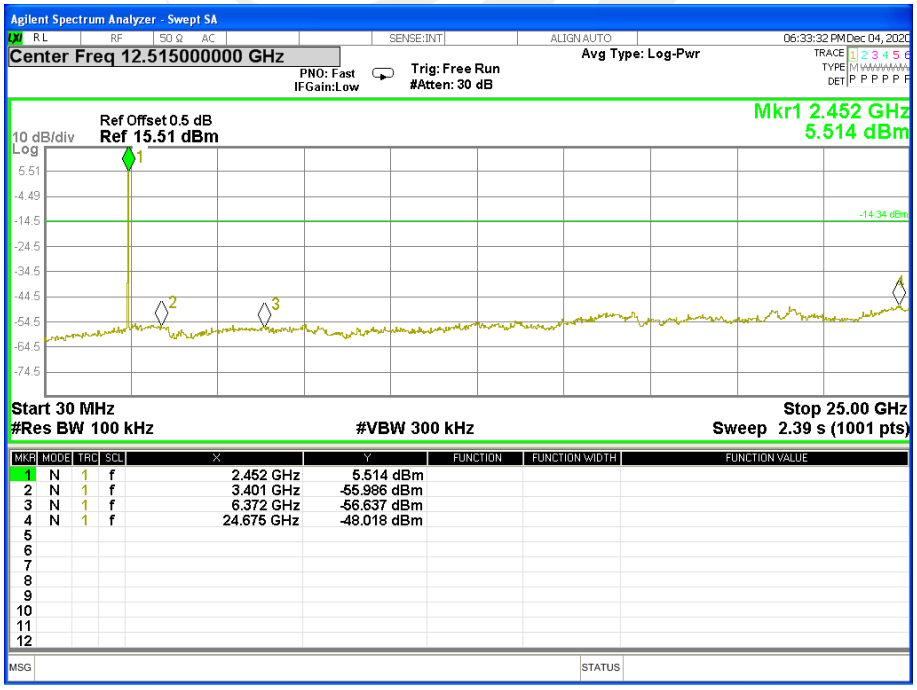



| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | 8DPSK(3Mbps) -00/39/78 CH | Test Voltage: | DC 3.7V |

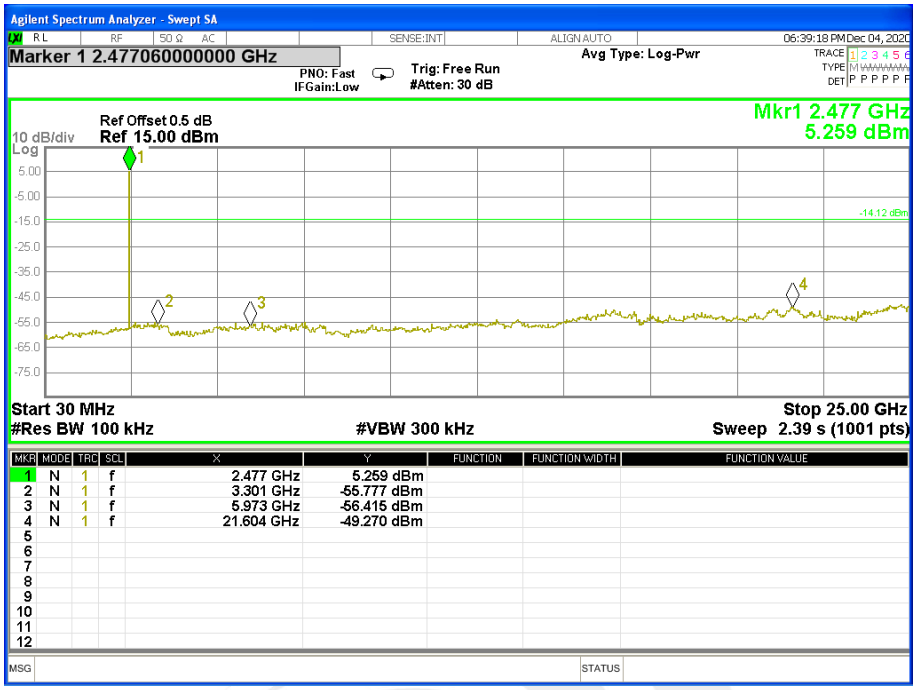
00 CH




39 CH

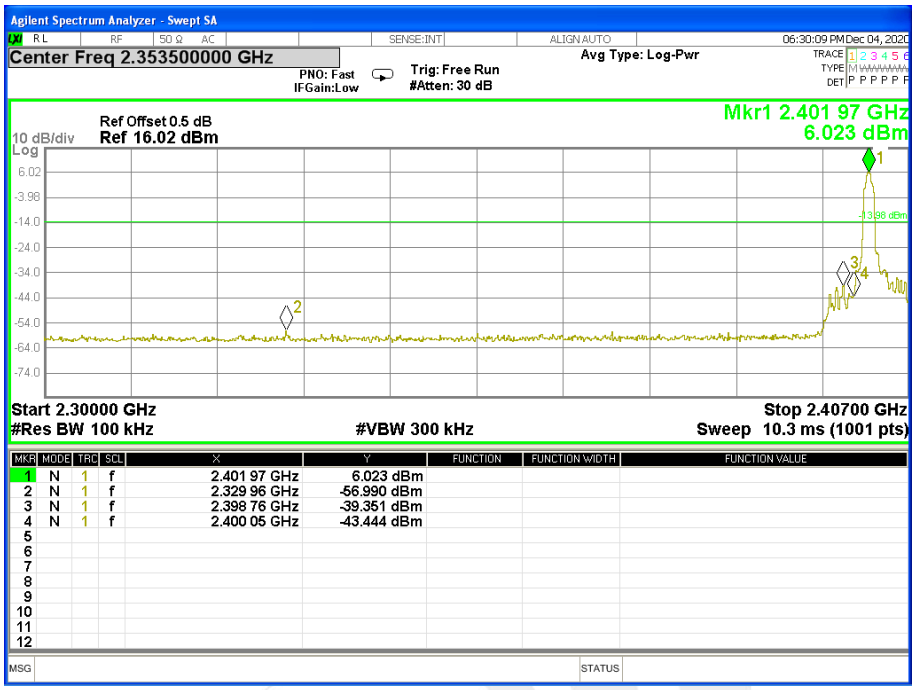


78 CH

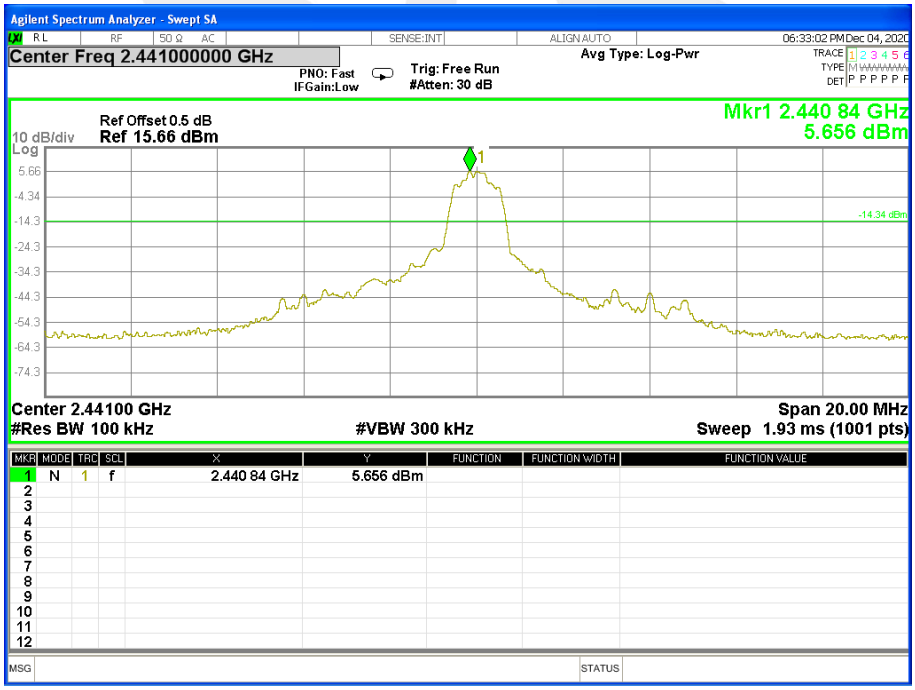

Agilent Spectrum Analyzer - Swept SA
RL
RF
50 Ω AC
SENSE:INT
ALIGN AUTO
06:39:18 PM Dec 04, 2020
Marker 1 2.477060000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
TRACE 1 2 3 4 5 6
TYPE M
DET P P P P P
Ref Offset 0.5 dB
10 dB/div
Log
Ref 15.00 dBm
Mkr1 2.477 GHz
5.259 dBm
5.00
-5.00
-15.0
-25.0
-35.0
-45.0
-55.0
-65.0
-75.0
-14.12 dBm
Start 30 MHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 25.00 GHz
Sweep 2.39 s (1001 pts)
MKR MODE TRC SCL X Y FUNCTION FUNCTION WIDTH FUNCTION VALUE
1 N 1 f 2.477 GHz 5.259 dBm
2 N 1 f 3.301 GHz -55.777 dBm
3 N 1 f 5.973 GHz -56.415 dBm
4 N 1 f 21.604 GHz -49.270 dBm
5
6
7
8
9
10
11
12
MSG
STATUS

For Band edge(it's also the reference level for conducted spurious emission)

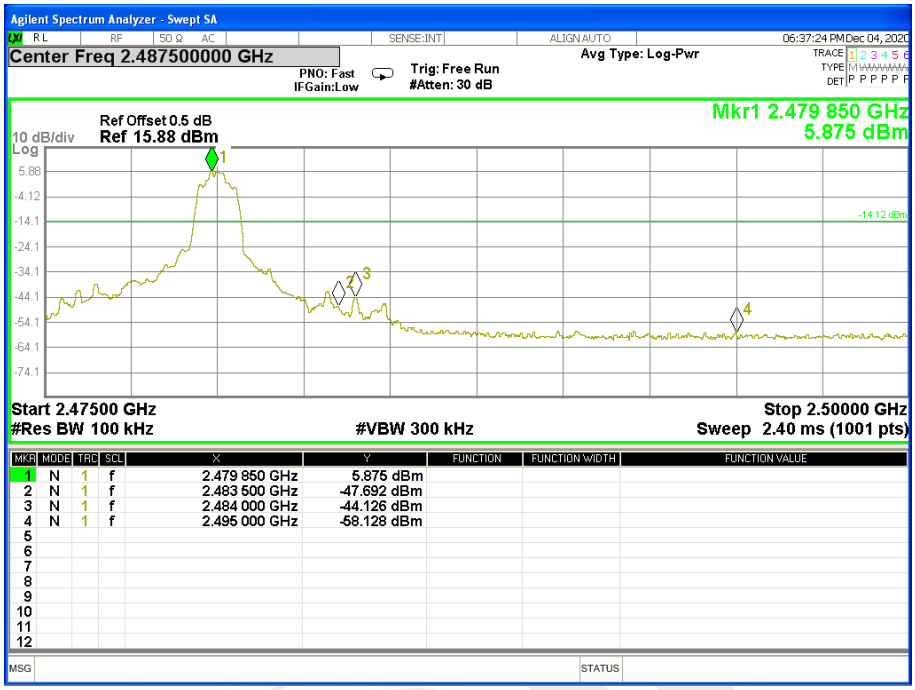
00 CH




39 CH

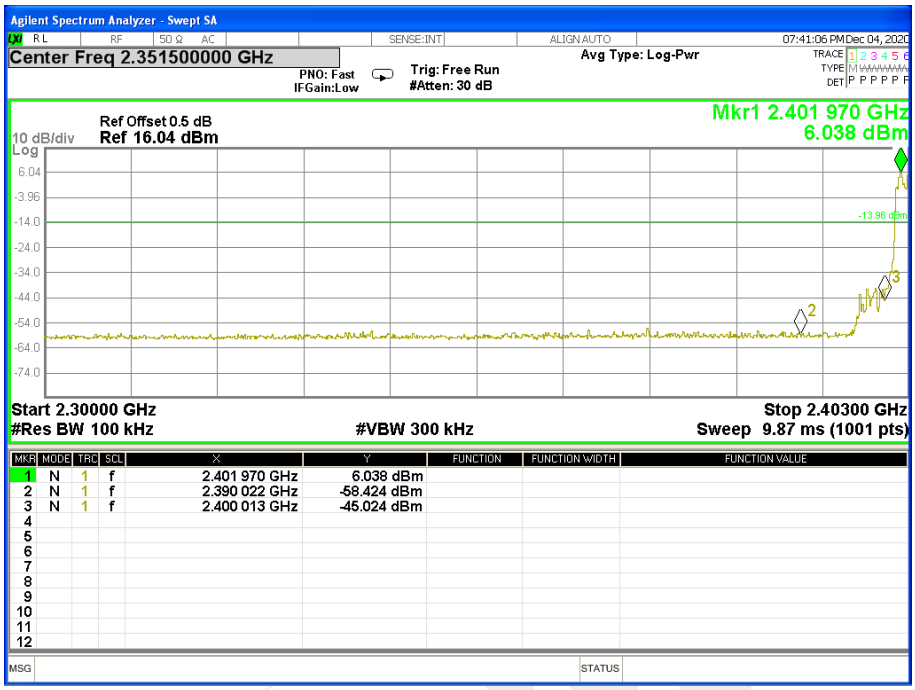


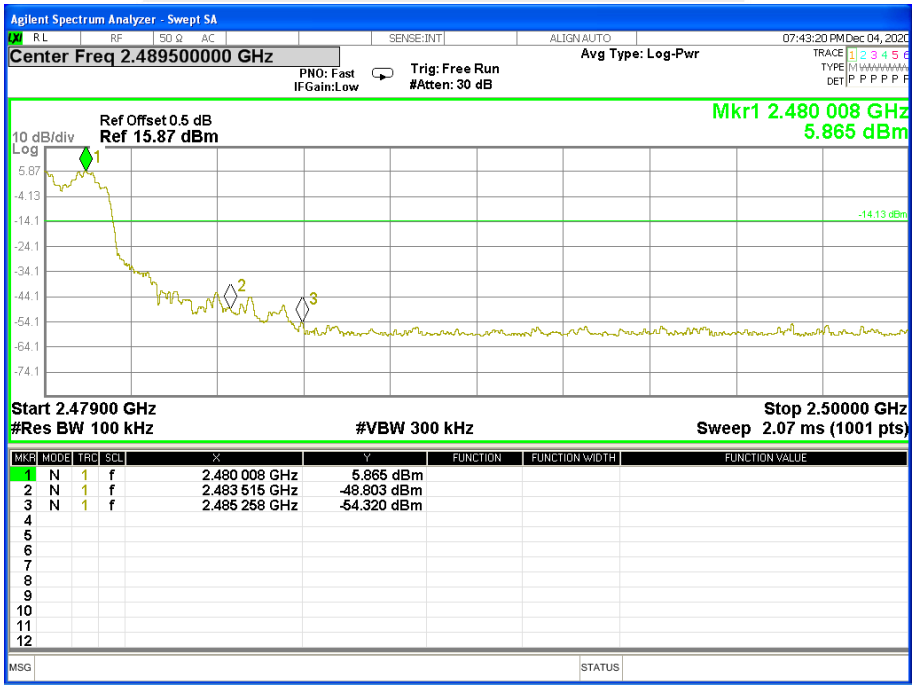
78 CH


Agilent Spectrum Analyzer - Swept SA
Center Freq 2.487500000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 30 dB
Avg Type: Log-Pwr
06:37:24 PM Dec 04, 2020
Ref Offset 0.5 dB
10 dB/div
Ref 15.88 dBm
Log
Mkr1 2.479 850 GHz
5.875 dBm
-14.12 dBm
Start 2.47500 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 2.50000 GHz
Sweep 2.40 ms (1001 pts)
1 N 1 f 2.479 850 GHz 5.875 dBm
2 N 1 f 2.483 500 GHz -47.692 dBm
3 N 1 f 2.484 000 GHz -44.126 dBm
4 N 1 f 2.495 000 GHz -58.128 dBm

For Hopping Band edge

8DPSK



# 5. NUMBER OF HOPPING CHANNEL

## 5.1 LIMIT

| FCC Part 15.247,Subpart C | | | | |
|---|---|---|---|---|
| Section | Test Item | Limit | FrequencyRange (MHz) | Result |
| 15.247 (a)(1)(iii) | Number of Hopping Channel | ≥15 | 2400-2483.5 | PASS |

| Spectrum Parameters | Setting |
|---|---|
| Attenuation | Auto |
| Span Frequency | > Operating FrequencyRange |
| RB | 300KHz |
| VB | 300KHz |
| Detector | Peak |
| Trace | Max Hold |
| Sweep Time | Auto |

## 5.2 TEST PROCEDURE

a. The EUT was directly connected to the spectrum analyzer and antenna output port as show in the block diagram below.
b. Spectrum Setting: RBW= 300KHz, VBW=300KHz, Sweep time = Auto.

## 5.3 TEST SETUP


## 5.4 EUT OPERATION CONDITIONS

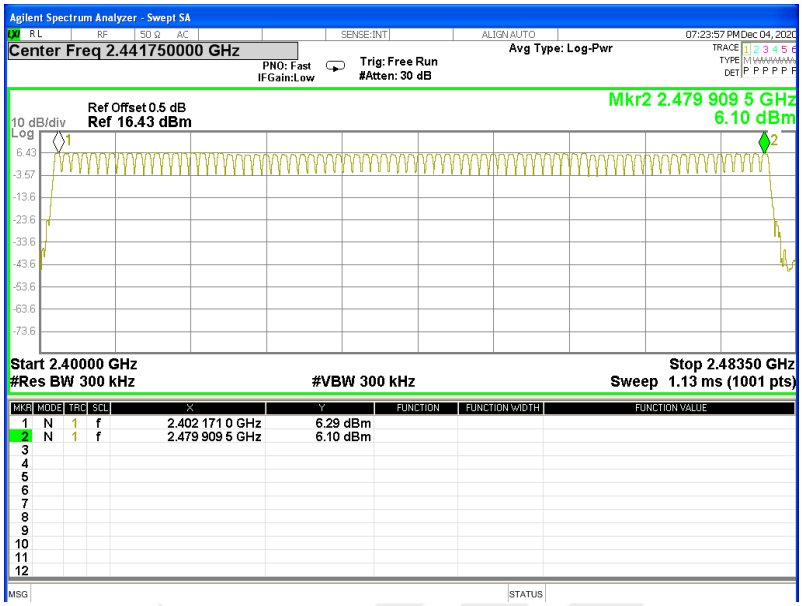
Please refer to section 3.1.4 of this report.

5.5 TEST RESULTS

| Temperature: | 25℃ | Relative Humidity: | 60% |
|---|---|---|---|
| Test Mode: | Hopping Mode -GFSK Mode | Test Voltage: | DC 3.7V |

Number of Hopping Channel 79

**Hopping channel**



# 6. AVERAGE TIME OF OCCUPANCY

## 6.1 LIMIT

| FCC Part 15.247,Subpart C | | | | |
|---|---|---|---|---|
| Section | Test Item | Limit | FrequencyRange (MHz) | Result |
| 15.247 (a)(1)(iii) | Average Time of Occupancy | 0.4sec | 2400-2483.5 | PASS |

## 6.2 TEST PROCEDURE

a. The transmitter output (antenna port) was connected to the spectrum analyzer.
b. Set RBW =1MHz/VBW =3MHz.
c. Use a video trigger with the trigger level set to enable triggering only on full pulses.
d. Sweep Time is more than once pulse time.
e. Set the center frequency on any frequency would be measure and set the frequency span to zero span.
f. Measure the maximum time duration of one single pulse.
g. Set the EUT for DH5, DH3 and DH1 packet transmitting.
h. Measure the maximum time duration of one single pulse.
i. DH5 Packet permit maximum 1600/ 79 / 6 = 3.37 hops per second in each channel (5 time slots RX, 1 time slot TX). So the number of pulses in the observation period of 31.6 seconds is 3.37 x 31.6 = 106.6.
j. DH3 Packet permit maximum 1600 / 79 / 4 = 5.06 hops per second in each channel (3 time slots RX, 1 time slot TX). So the number of pulses in the observation period of 31.6 seconds is 5.06 x 31.6 = 160.
k. DH1 Packet permit maximum 1600 / 79 / 2 = 10.12 hops per second in each channel (1 time slot RX, 1 time slot TX). So the number of pulses in the observation period of 31.6 seconds is 10.12 x 31.6 = 320.

## 6.3 TEST SETUP


## 6.4 EUT OPERATION CONDITIONS

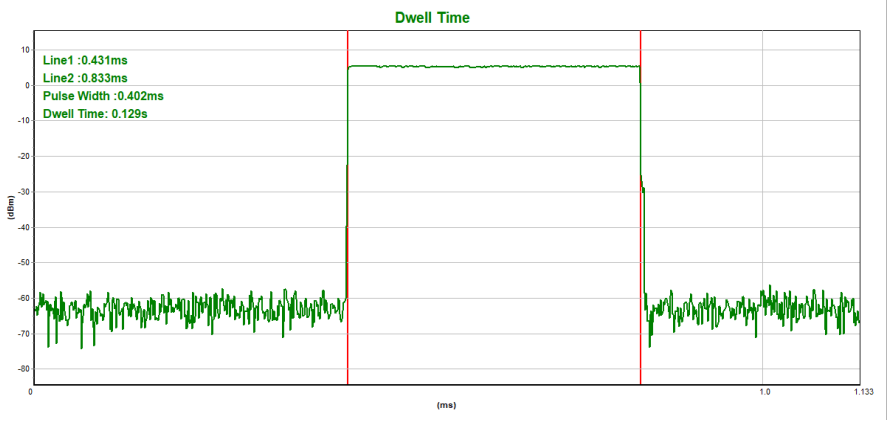
Please refer to section 3.1.4 of this report.

6.5 TEST RESULTS

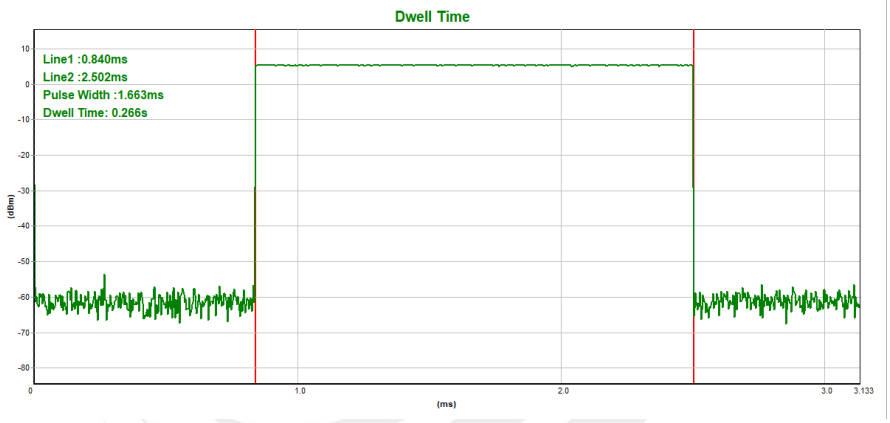
| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | GFSK(1Mbps)-DH1/DH3/DH5 | Test Voltage: | DC 3.7V |

| Data Packet | Channel | pulse time(ms) | Dwell Time(s) | Limits(s) |
|---|---|---|---|---|
| DH1 | middle | 0.402 | 0.129 | 0.4 |
| DH3 | middle | 1.663 | 0.266 | 0.4 |
| DH5 | middle | 2.908 | 0.310 | 0.4 |

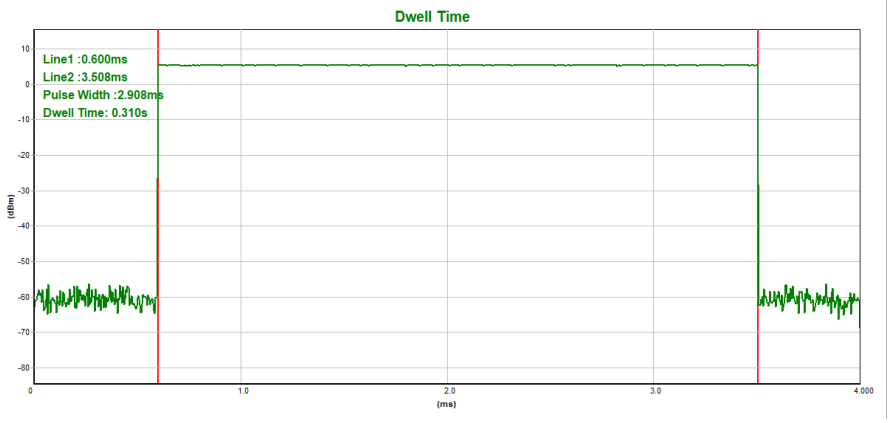
## CH39-DH1




## CH39-DH3



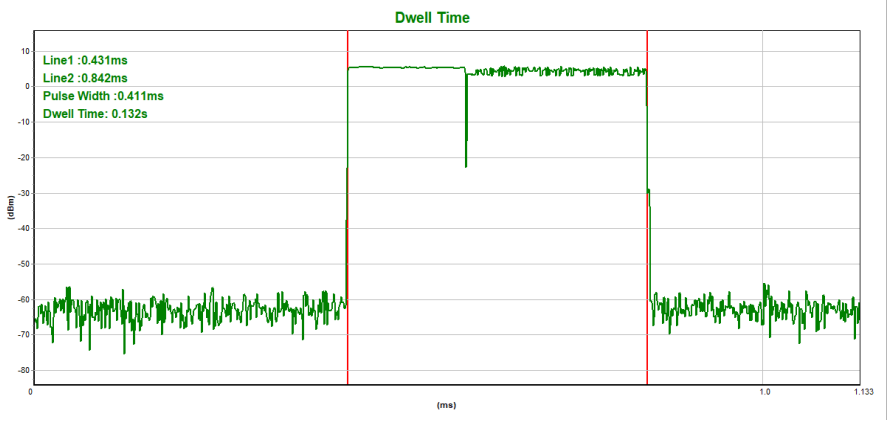

## CH39-DH5



| | | | |
|---|---|---|---|
| Temperature: | 25℃ | Relative Humidity: | 50% |
| Test Mode: | π/4-DQPSK(2Mbps)–2DH1/2DH3/2DH5 | Test Voltage: | DC 3.7V |

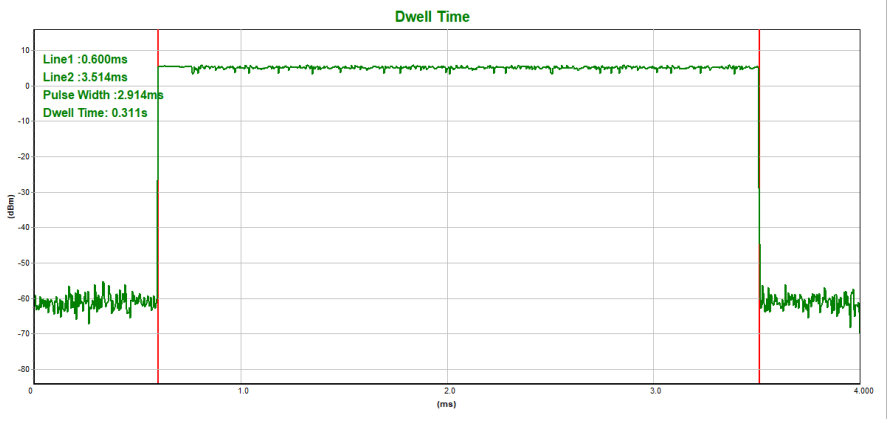
| Data Packet | Channel | pulse time(ms) | Dwell Time(s) | Limits(s) |
|---|---|---|---|---|
| 2DH1 | middle | 0.411 | 0.132 | 0.4 |
| 2DH3 | middle | 1.664 | 0.266 | 0.4 |
| 2DH5 | middle | 2.914 | 0.311 | 0.4 |

## CH39-2DH1




## CH39-2DH3

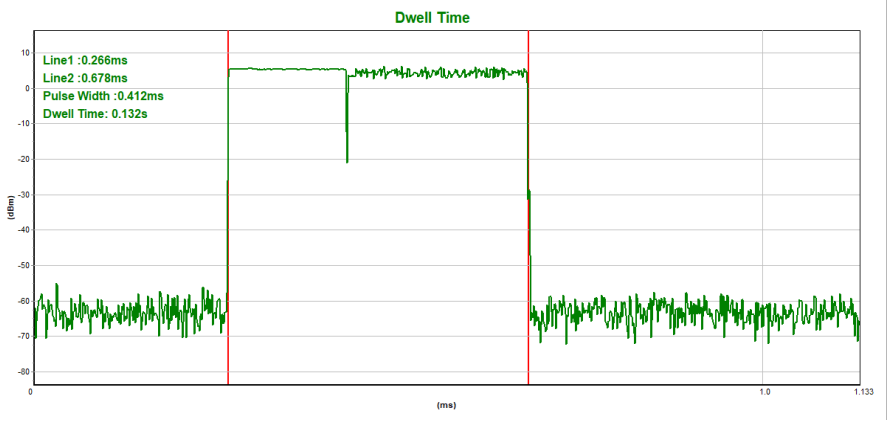

## CH39-2DH5



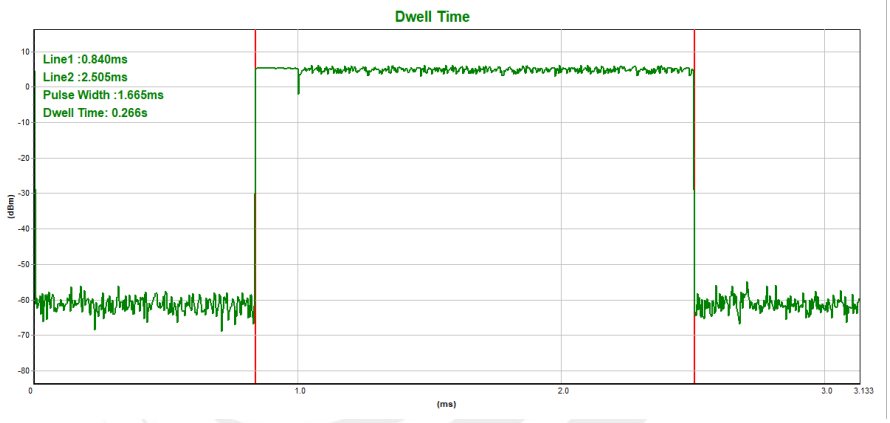
| | | | |
|---|---|---|---|
| Temperature: | 25℃ | Relative Humidity: | 50% |
| Test Mode: | 8DPSK(3Mbps)–3DH1/3DH3/3DH5 | Test Voltage: | DC 3.7V |

| Data Packet | Channel | pulse time(ms) | Dwell Time(s) | Limits(s) |
|---|---|---|---|---|
| 3DH1 | middle | 0.412 | 0.132 | 0.4 |
| 3DH3 | middle | 1.665 | 0.266 | 0.4 |
| 3DH5 | middle | 2.916 | 0.311 | 0.4 |

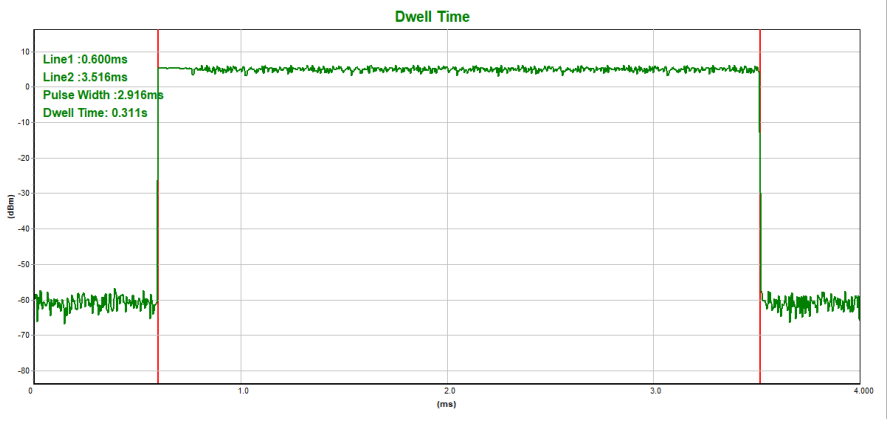
## CH39-3DH1




## CH39-3DH3




## CH39-3DH5



# 7. HOPPING CHANNEL SEPARATION MEASUREMEN

## 7.1 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. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

| Spectrum Parameter | Setting |
|---|---|
| Attenuation | Auto |
| Span Frequency | > 20 dB Bandwidth or Channel Separation |
| RB | 30 kHz (20dB Bandwidth) / 30 kHz (Channel Separation) |
| VB | 100 kHz (20dB Bandwidth) / 100 kHz (Channel Separation) |
| Detector | Peak |
| Trace | Max Hold |
| Sweep Time | Auto |

## 7.2 TEST PROCEDURE

a. The transmitter output (antenna port) was connected to the spectrum analyser in peak hold mode.
b. The resolution bandwidth of 30 kHz and the video bandwidth of 100 kHz were utilised for 20 dB bandwidth measurement.
c. The resolution bandwidth of 30 kHz and the video bandwidth of 100 kHz were utilised for channel separation measurement.

## 7.3 TEST SETUP


## 7.4 EUT OPERATION CONDITIONS

The EUT was programmed to be in continuously transmitting mode.

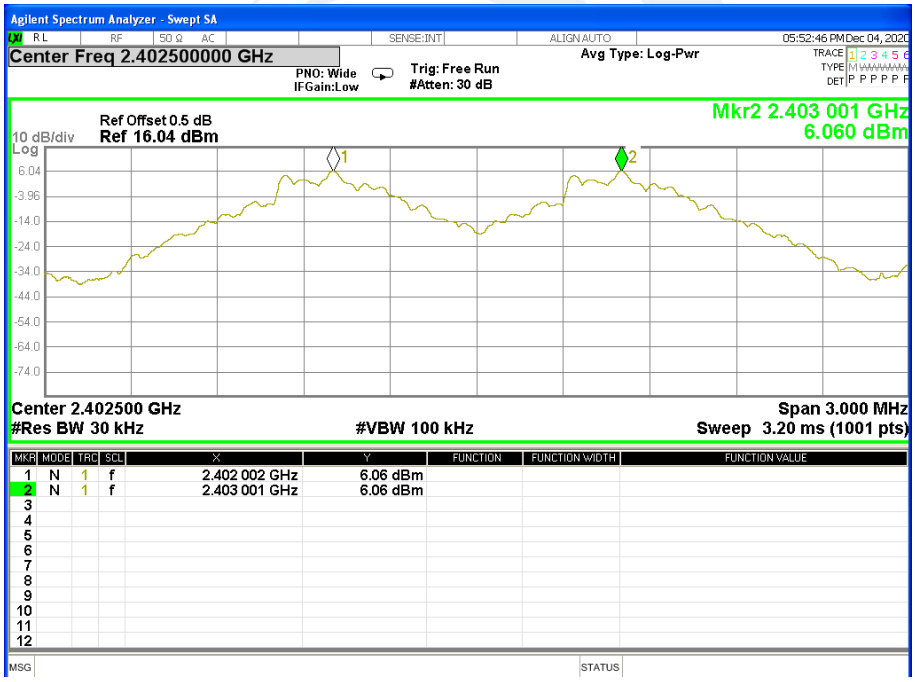
7.5 TEST RESULTS

| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | CH00 / CH39 / CH78 (GFSK(1Mbps) Mode) | Test Voltage: | DC 3.7V |

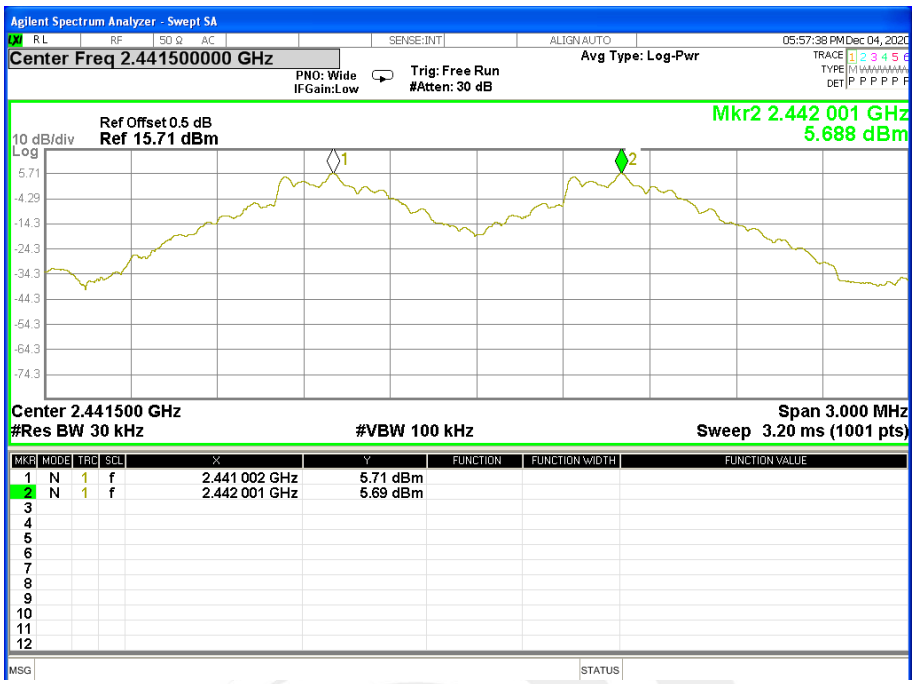
| Frequency | Mark1 Frequency （MHz） | Mark2 Frequency （MHz） | Ch. Separation (MHz) | Limit (MHz) | Result |
|---|---|---|---|---|---|
| 2402 MHz | 2402.002 | 2403.001 | 0.999 | 0.827 | Complies |
| 2441 MHz | 2441.002 | 2442.001 | 0.999 | 0.832 | Complies |
| 2480 MHz | 2479.002 | 2480.001 | 0.999 | 0.828 | Complies |

For GFSK: Ch. Separation Limits: > 20dB bandwidth

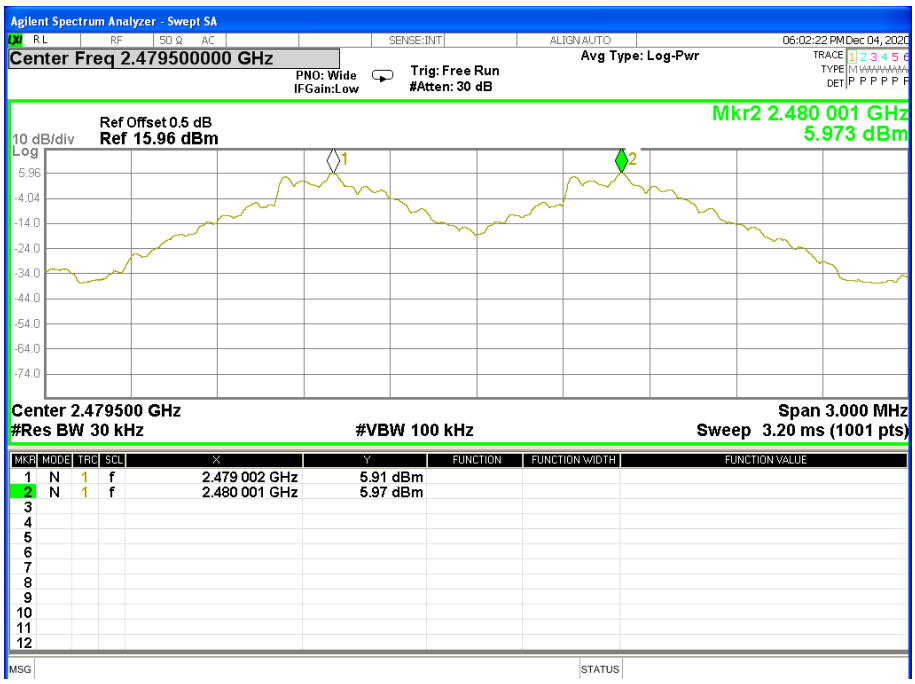
**CH00 -1Mbps**



## CH39 -1Mbps




## CH78 -1Mbps

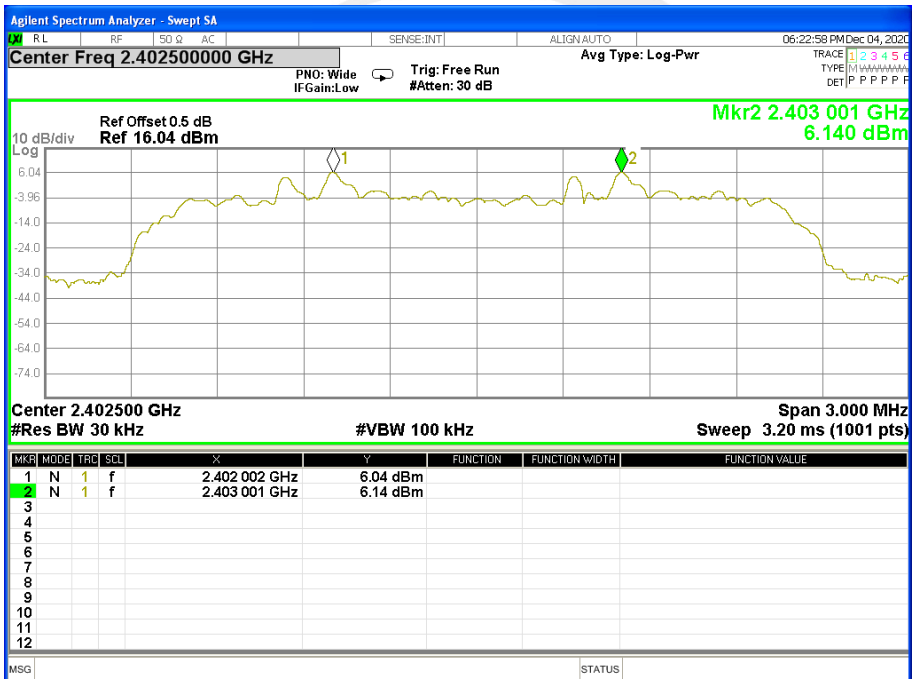


| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | CH00 / CH39 / CH78 (π/4-DQPSK(2Mbps) Mode) | Test Voltage: | DC 3.7V |

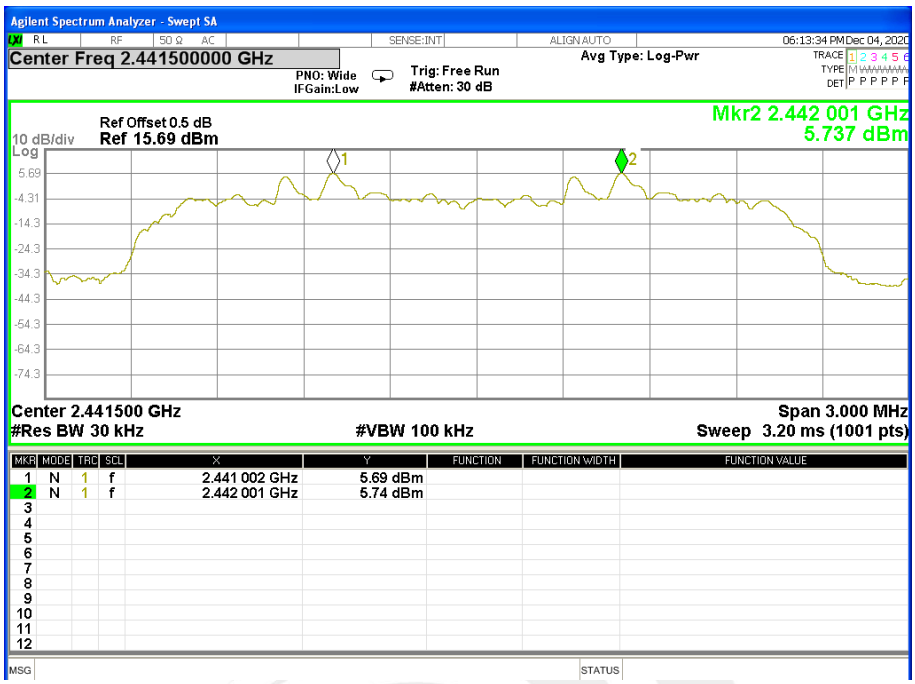
| Frequency | Mark1 Frequency （MHz） | Mark2 Frequency （MHz） | Ch. Separation (MHz) | Limit (MHz) | Result |
|---|---|---|---|---|---|
| 2402 MHz | 2402.002 | 2403.001 | 0.999 | 0.811 | Complies |
| 2441 MHz | 2441.002 | 2442.001 | 0.999 | 0.810 | Complies |
| 2480 MHz | 2479.005 | 2480.001 | 0.996 | 0.811 | Complies |

For π/4-DQPSK(2Mbps): Ch. Separation Limits: > two-thirds 20dB bandwidth

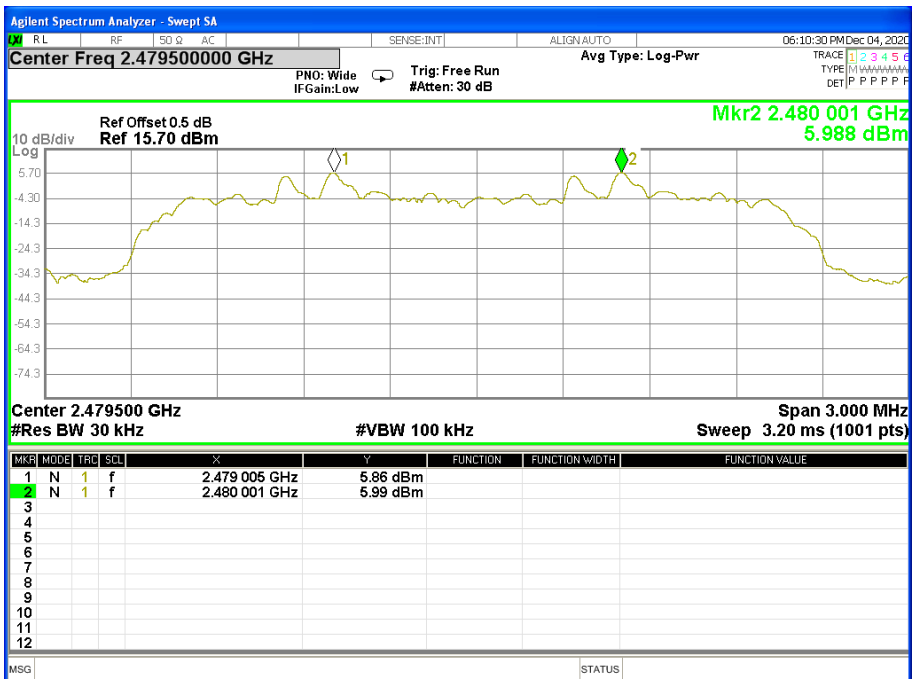
**CH00 -2Mbps**



## CH39 -2Mbps




## CH78 -2Mbps

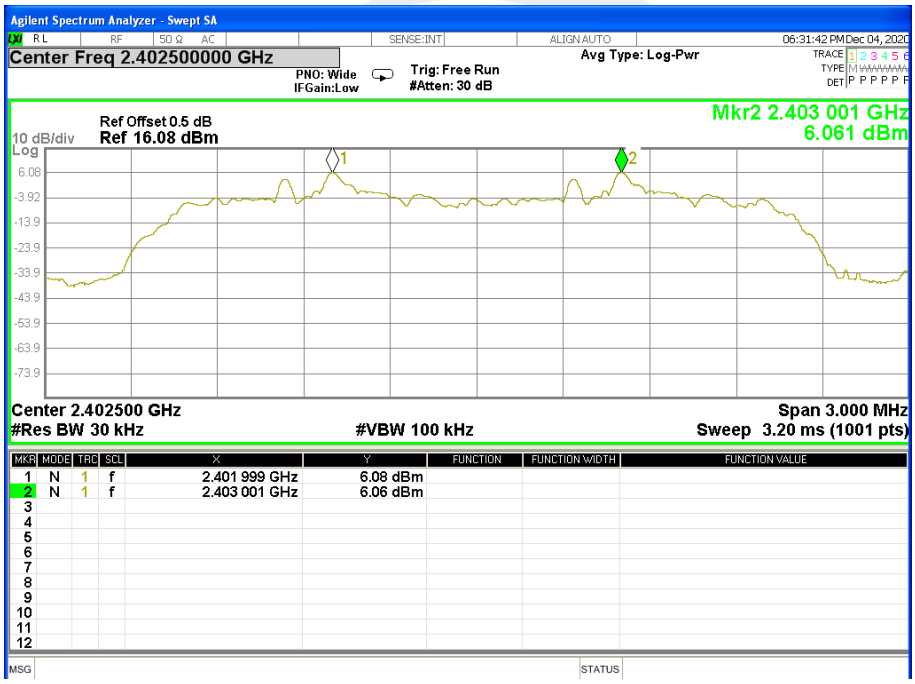


| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | CH00 / CH39 / CH78 (8DPSK(3Mbps)Mode) | Test Voltage: | DC 3.7V |

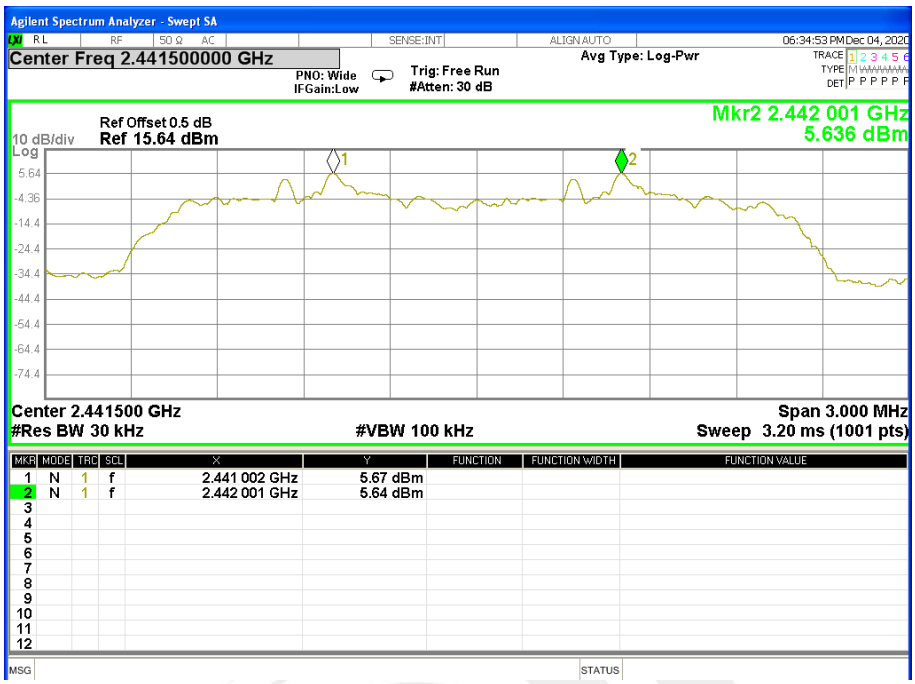
| Frequency | Mark1 Frequency （MHz） | Mark2 Frequency （MHz） | Ch. Separation (MHz) | Limit (MHz) | Result |
|---|---|---|---|---|---|
| 2402 MHz | 2401.999 | 2403.001 | 1.002 | 0.793 | Complies |
| 2441 MHz | 2441.002 | 2442.001 | 0.999 | 0.803 | Complies |
| 2480 MHz | 2479.002 | 2480.001 | 0.999 | 0.805 | Complies |

For 8DPSK(3Mbps):Ch. Separation Limits: > two-thirds 20dB bandwidth

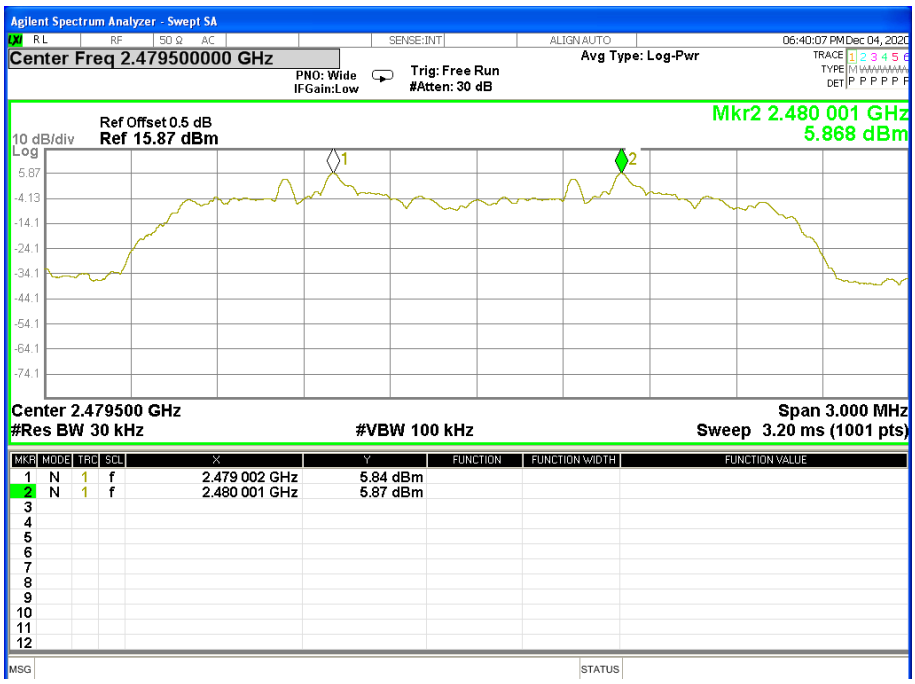
**CH00 -3Mbps**



## CH39 -3Mbps




## CH78 -3Mbps



# 8. BANDWIDTH TEST

## 8.1 LIMIT

| FCC Part15 15.247,Subpart C | | | | |
|---|---|---|---|---|
| Section | Test Item | Limit | FrequencyRange (MHz) | Result |
| 15.247 (a)(1) | Bandwidth | N/A | 2400-2483.5 | PASS |

| Spectrum Parameter | Setting |
|---|---|
| Attenuation | Auto |
| Span Frequency | > Measurement Bandwidth or Channel Separation |
| RB | 30 kHz (20dB Bandwidth) / 30 kHz (Channel Separation) |
| VB | 100 kHz (20dB Bandwidth) / 100 kHz (Channel Separation) |
| Detector | Peak |
| Trace | Max Hold |
| Sweep Time | Auto |

## 8.2 TEST PROCEDURE

a. The EUT was directly connected to the spectrum analyzer and antenna output port as show in the block diagram below.
b. Spectrum Setting: RBW= 30KHz, VBW=100KHz, Sweep time = Auto.

## 8.3 TEST SETUP


## 8.4 EUT OPERATION CONDITIONS

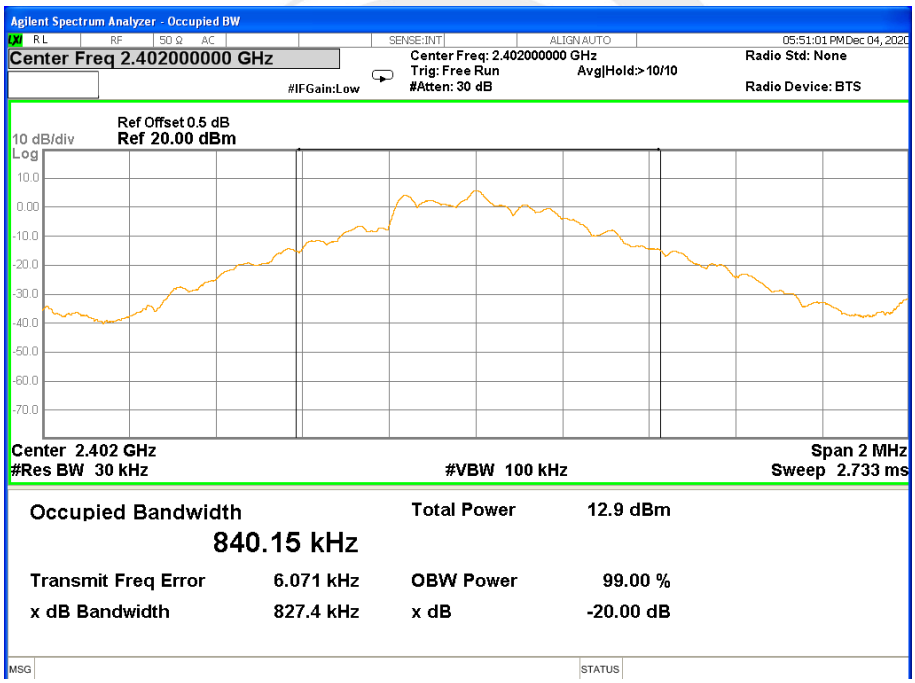
Please refer to section 3.1.4 of this report.

## 8.5 TEST RESULTS

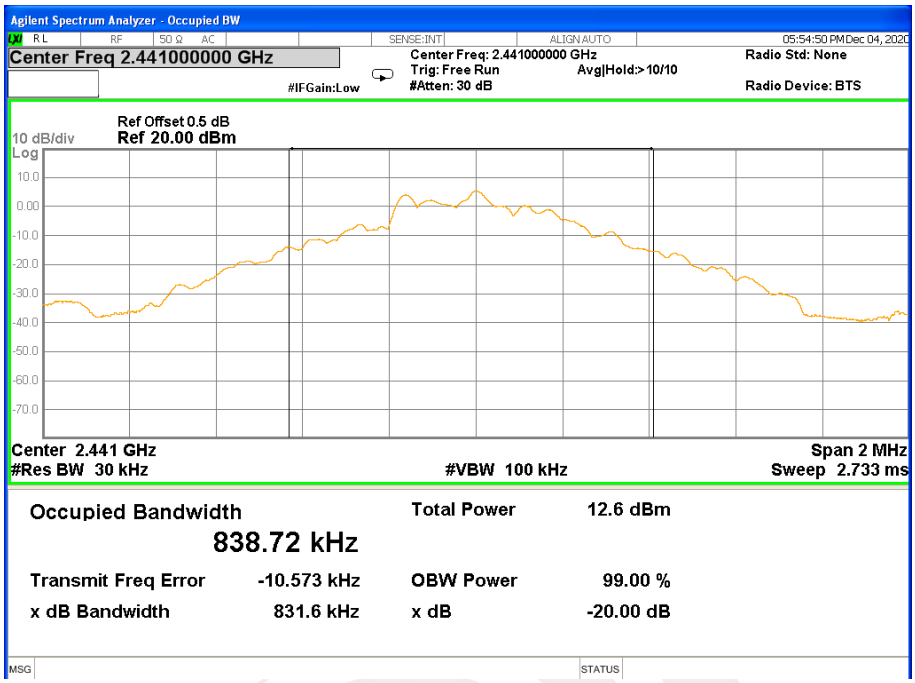
| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | GFSK(1Mbps)<br>CH00 / CH39 / C78 | Test Voltage: | DC 3.7V |

| Frequency | 20dB Bandwidth (MHz) | Result |
|---|---|---|
| 2402 MHz | 0.8274 | PASS |
| 2441 MHz | 0.8316 | PASS |
| 2480 MHz | 0.8282 | PASS |

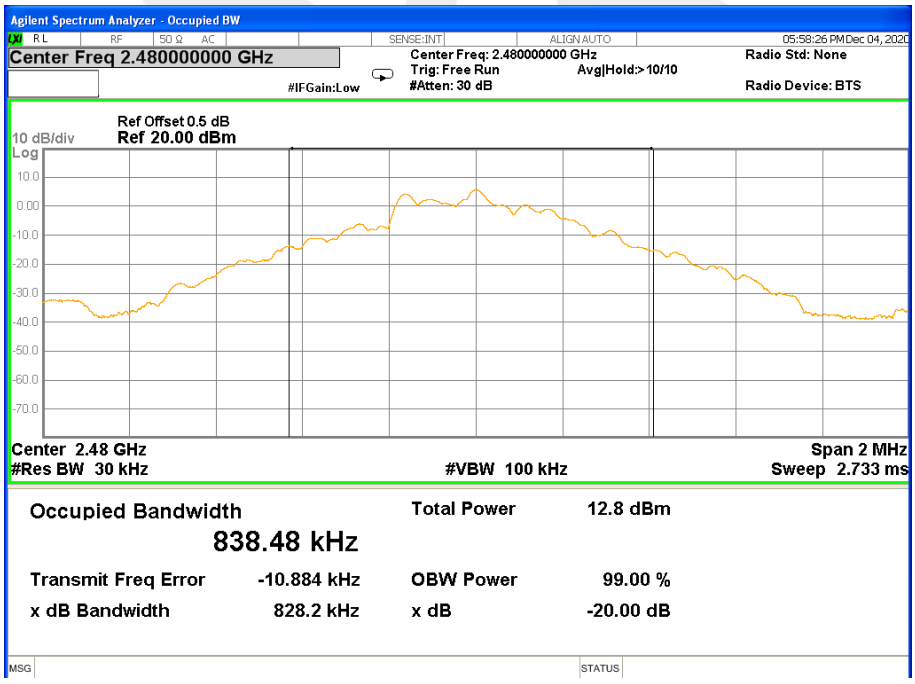
**CH00 -1Mbps**



## CH39 -1Mbps



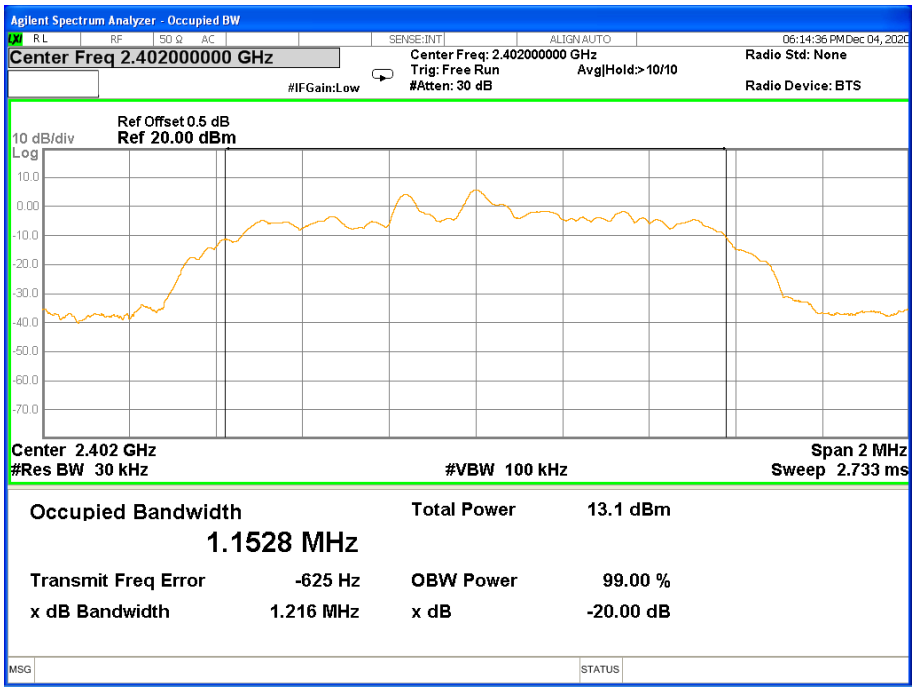

## CH78 -1Mbps



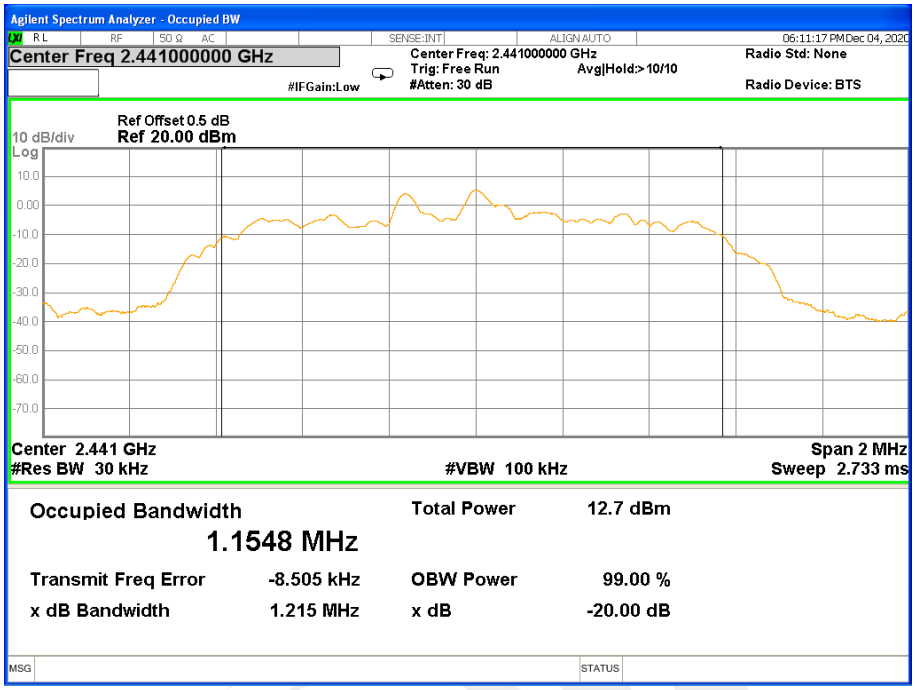
| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | π/4-DQPSK(2Mbps)<br>CH00 / CH39 / C78 | Test Voltage: | DC 3.7V |

| Frequency | 20dB Bandwidth (MHz) | Result |
|---|---|---|
| 2402 MHz | 1.216 | PASS |
| 2441 MHz | 1.215 | PASS |
| 2480 MHz | 1.216 | PASS |

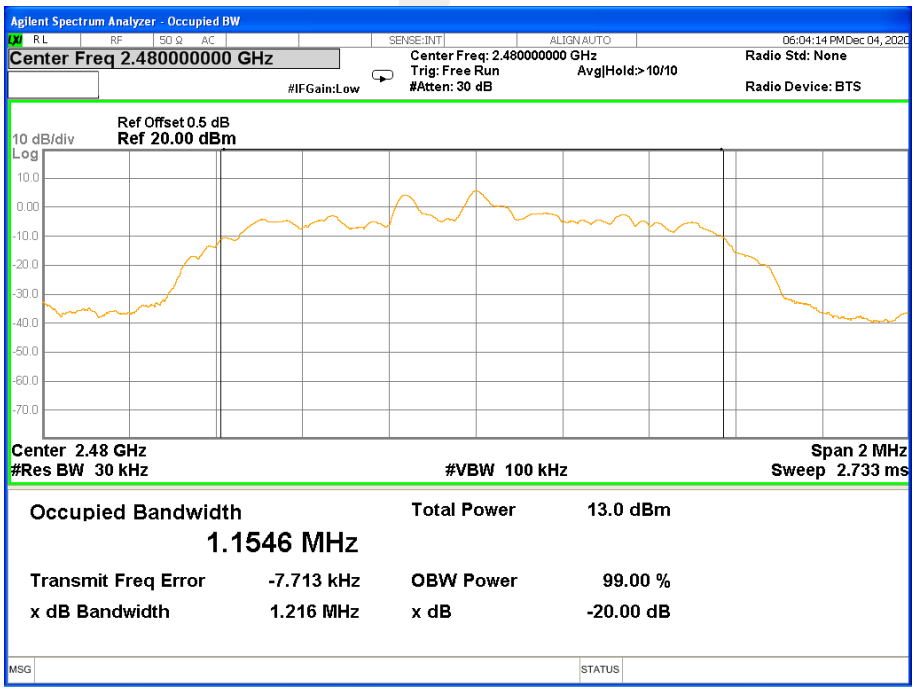
**CH00 -2Mbps**



## CH39 -2Mbps



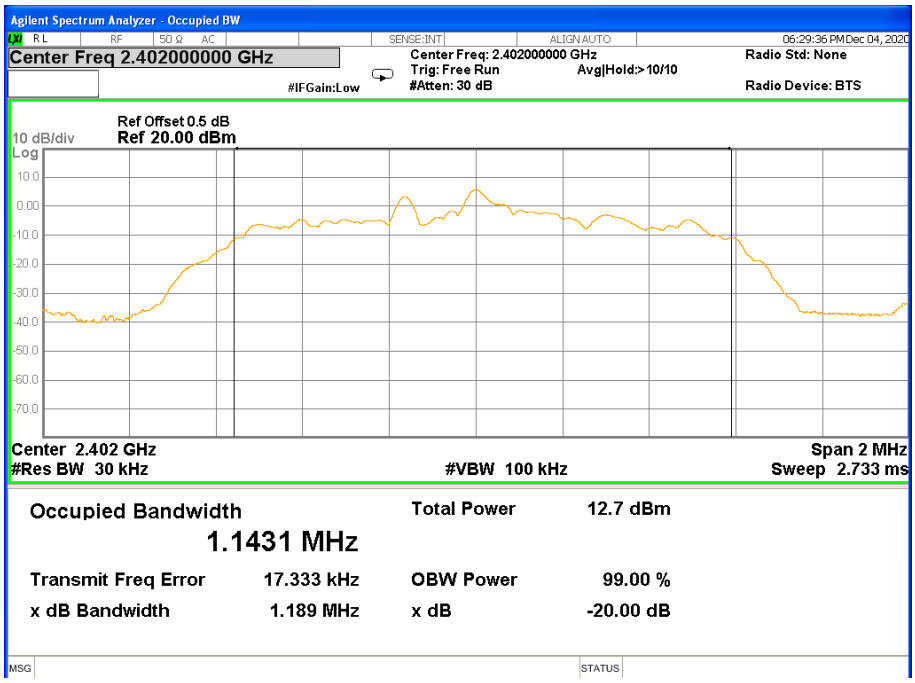

## CH78 -2Mbps



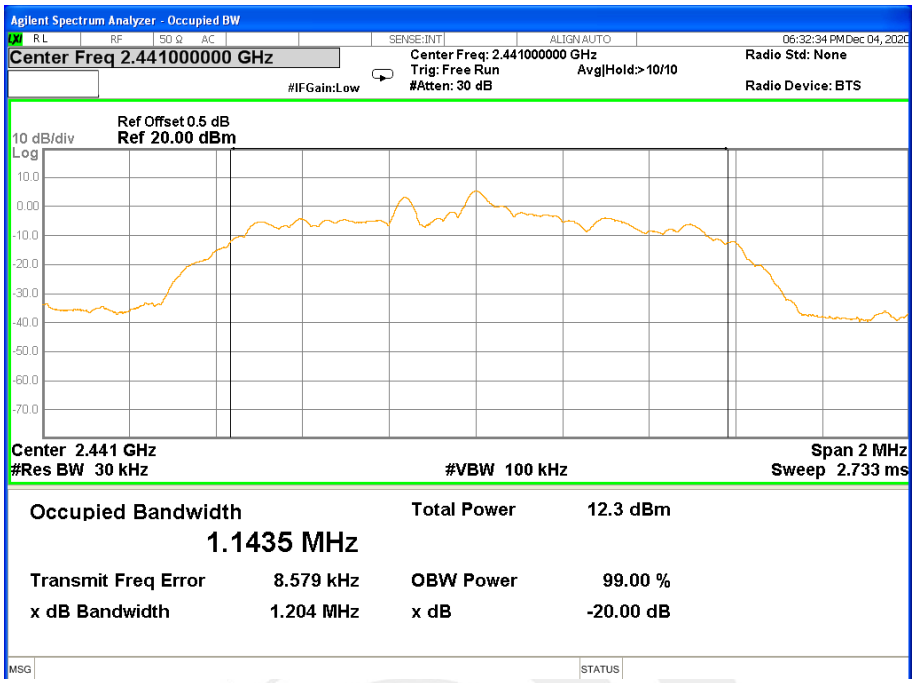
| Temperature: | 25℃ | Relative Humidity: | 50% |
|---|---|---|---|
| Test Mode: | 8DPSK(3Mbps)<br>CH00 / CH39 / CH78 | Test Voltage: | DC 3.7V |

| Frequency | 20dB Bandwidth (MHz) | Result |
|---|---|---|
| 2402 MHz | 1.189 | PASS |
| 2441 MHz | 1.204 | PASS |
| 2480 MHz | 1.207 | PASS |

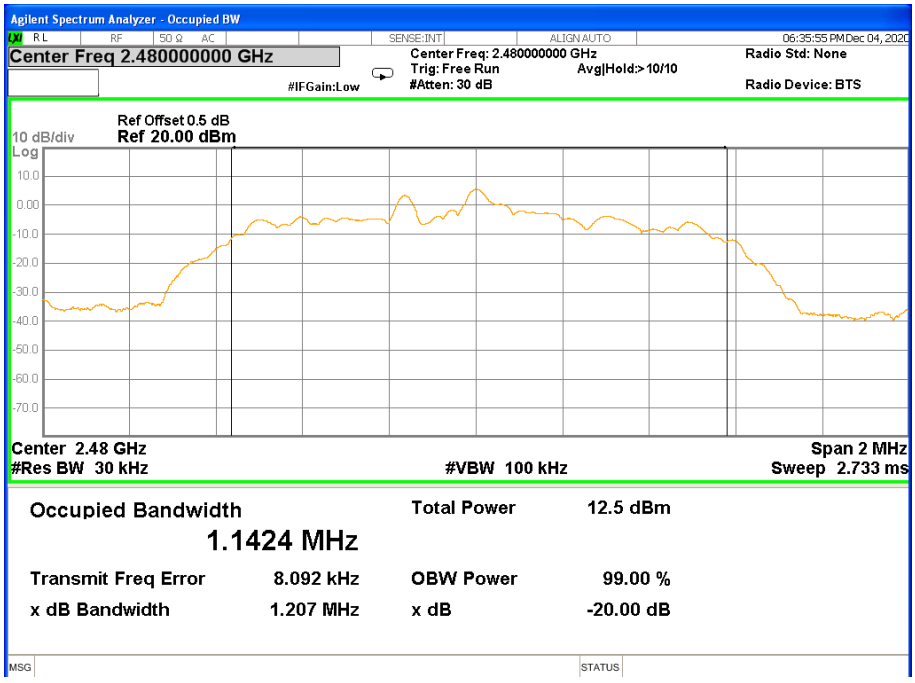
**CH00 -3Mbps**



## CH39 -3Mbps




## CH78 -3Mbps



# 9. OUTPUT POWER TEST

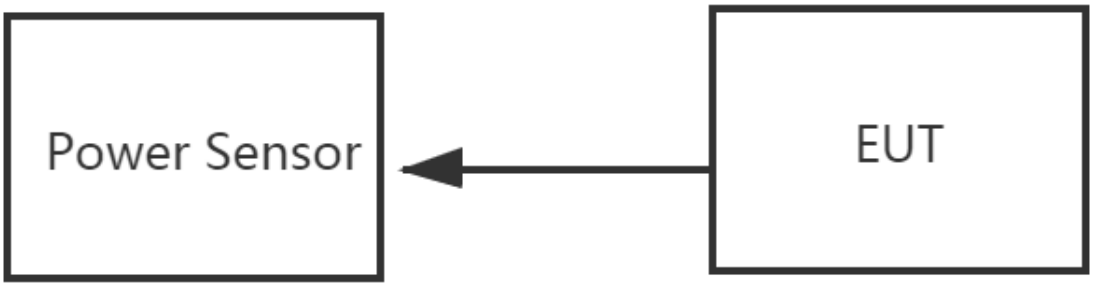
## 9.1 LIMIT

| FCC Part 15.247,Subpart C | | | | |
|---|---|---|---|---|
| Section | Test Item | Limit | FrequencyRange (MHz) | Result |
| 15.247 (a)(1)&(b)(1) | Output Power | 1 W or 0.125W<br>if channel separation > 2/3 bandwidthprovided thesystems operatewith an output power no greater than125 mW(20.97dBm) | 2400-2483.5 | PASS |

## 9.2 TEST PROCEDURE

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:
a) Use the following spectrum analyzer settings:
1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
2) RBW > 20 dB bandwidth of the emission being measured.
3) VBW ≥ RBW.
4) Sweep: Auto.
5) Detector function: Peak.
6) Trace: Max hold.
b) Allow trace to stabilize.
c) Use the marker-to-peak function to set the marker to the peak of the emission.
d) The indicated level is the peak output power, after any corrections for external attenuators and cables.
e) A plot of the test results and setup description shall be included in the test report.
NOTE—A peak responding power meter may be used, where the power meter and sensor system video bandwidth is greater than the occupied bandwidth of the unlicensed wireless device, rather than a spectrum analyzer.
PKPM1 Peak power meter method:
The maximum peak conducted output power may be measured using a broadband peak RF power meter. The power meter shall have a video bandwidth that is greater than or equal to the DSS bandwidth and shall use a fast-responding diode detector.

## 9.3 TEST SETUP




## 9.4 EUT OPERATION CONDITIONS

Please refer to section 3.1.4 of this report.

9.5 TEST RESULTS

| Temperature: | 25℃ | Relative Humidity: | 60% |
|---|---|---|---|
| Test Voltage: | DC 3.7V | | |

| Mode | Channel Number | Frequency (MHz) | Peak Power (dBm) | Average Power (dBm) | Limit (dBm) |
|---|---|---|---|---|---|
| GFSK(1M) | 0 | 2402 | 6.25 | 4.77 | 30.00 |
| | 39 | 2441 | 6.13 | 4.65 | 30.00 |
| | 78 | 2480 | 6.05 | 4.60 | 30.00 |

Note: the channel separation >20dB bandwidth

| Mode | Channel Number | Frequency (MHz) | Peak Power (dBm) | Average Power (dBm) | Limit (dBm) |
|---|---|---|---|---|---|
| π/4-DQPSK(2M) | 0 | 2402 | 7.36 | 3.54 | 20.97 |
| | 39 | 2441 | 7.24 | 3.44 | 20.97 |
| | 78 | 2480 | 7.17 | 3.36 | 20.97 |

Note: the channel separation >2/3 20dB bandwidth

| Mode | Channel Number | Frequency (MHz) | Peak Power (dBm) | Average Power (dBm) | Limit (dBm) |
|---|---|---|---|---|---|
| 8-DPSK(3M) | 0 | 2402 | 7.63 | 3.53 | 20.97 |
| | 39 | 2441 | 7.48 | 3.46 | 20.97 |
| | 78 | 2480 | 7.45 | 3.35 | 20.97 |

Note: the channel separation >2/3 20dB bandwidth

# 10. ANTENNA REQUIREMENT

## 10.1 STANDARD REQUIREMENT

15.203 requirement: For intentional device, according to 15.203: 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.

## 10.2 EUT ANTENNA

The EUT antenna is Chip Antenna. It comply with the standard requirement.

## APPENDIX-PHOTOS OF TEST SETUP

Note: See test photos in setup photo document for the actual connections between Product and support equipment.

※※※※※END OF THE REPORT※※※※※