

**FCC/ISED - TEST REPORT**

Report Number : **68.950.24.0617.01** Date of Issue: **2025-01-16**

Model/HVIN : **FS2345**

Product Type : AURIA module

Applicant : Frontier Smart Technologies Ltd

Address : Harston, Harston Mill, Cambridge, CB22 7GG, UNITED KINGDOM

Manufacturer : Frontier Smart Technologies Ltd

Address : Harston, Harston Mill, Cambridge, CB22 7GG, UNITED KINGDOM

Test Result : ☒ **Positive** ☐ **Negative**

Total pages including Appendices : **109**

*Any use for advertising purposes must be granted in writing. This technical report may only be quoted in full. This report is the result of a single examination of the object in question and is not generally applicable evaluation of the quality of other products in regular production. For further details, please see testing and certification regulation, chapter A-3.4.*

## 1 Table of Contents

|     |                                                  |     |
|-----|--------------------------------------------------|-----|
| 1   | Table of Contents.....                           | 2   |
| 2   | Details about the Test Laboratory .....          | 3   |
| 3   | Description of the Equipment Under Test .....    | 4   |
| 4   | Summary of Test Standards .....                  | 5   |
| 5   | Summary of Test Results .....                    | 6   |
| 6   | General Remarks.....                             | 7   |
| 7   | Test Setups.....                                 | 8   |
| 8   | Systems Test Configuration.....                  | 10  |
| 9   | Technical Requirement.....                       | 11  |
| 9.1 | Conducted Emission.....                          | 11  |
| 9.2 | Conducted Output Power & EIRP .....              | 14  |
| 9.3 | 20 dB Bandwidth and 99% Occupied Bandwidth.....  | 16  |
| 9.4 | Carrier Frequency Separation.....                | 30  |
| 9.5 | Number of Hopping Frequencies .....              | 33  |
| 9.6 | Dwell Time .....                                 | 36  |
| 9.7 | Spurious RF Conducted Emissions .....            | 50  |
| 9.8 | Band Edge Testing .....                          | 71  |
| 9.9 | Spurious Radiated Emissions for Transmitter..... | 85  |
| 10  | Test Equipment List.....                         | 113 |
| 11  | System Measurement Uncertainty .....             | 115 |

## 2 Details about the Test Laboratory

### Details about the Test Laboratory

#### Test Site 1

Company name: TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch  
Building 12&13, Zhiheng Wisdomland Business Park, Guankou Erlu, Nantou,  
Nanshan District, Shenzhen City, 518052, P. R. China

Telephone: 86 755 8828 6998

Fax: 86 755 828 5299

FCC Registration No.: 514049

FCC Designation No.: CN5009

IC Registration No.: 10320A

ISED CAB identifier: CN0077

### 3 Description of the Equipment Under Test

|                            |                                                                                                                                                                                                                                                   |
|----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Product Type:              | AURIA module                                                                                                                                                                                                                                      |
| Model no.:                 | FS2345                                                                                                                                                                                                                                            |
| FCC ID:                    | YYX-FS2345                                                                                                                                                                                                                                        |
| IC:                        | 11458A-FS2345                                                                                                                                                                                                                                     |
| PMN:                       | AURIA                                                                                                                                                                                                                                             |
| HVIN:                      | FS2345                                                                                                                                                                                                                                            |
| Rating:                    | 5VDC                                                                                                                                                                                                                                              |
| RF Transmission Frequency: | 2402MHz-2480MHz                                                                                                                                                                                                                                   |
| No. of Operated Channel:   | 79                                                                                                                                                                                                                                                |
| Modulation:                | GFSK, $\pi/4$ -DQPSK, 8DPSK                                                                                                                                                                                                                       |
| Antenna Type:              | Ant 1: Internal PIFA Antenna<br>Ant 2: External PIFA Antenna                                                                                                                                                                                      |
| Antenna Gain:              | Ant 1: 1.86dBi<br>Ant 2: 2.21dBi                                                                                                                                                                                                                  |
|                            | FS2345 does not support MIMO, only one of Ant 1 or Ant 2 can transmit through a switch selection                                                                                                                                                  |
| S/N                        | Conducted Method Module: 241500278RYA02<br>Conducted Method Platform: FS2345032403053<br>Radiated Method Module: 241500246RYA02<br>Radiated Method Platform: FS2345032403028<br>Normal Module: 240100004RYA02<br>Normal Platform: FS2345032403037 |
| Description of the EUT:    | The Equipment Under Test (EUT) is a AURIA supports Bluetooth Low Energy / Bluetooth BR+EDR/ Wi-Fi function                                                                                                                                        |
| Remark:                    | This report is only for Bluetooth BR+EDR.                                                                                                                                                                                                         |

## 4 Summary of Test Standards

| Test Standards                                                                         |                                                                                                                                    |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------|
| FCC Part 15 Subpart C<br>10-1-2023 Edition                                             | PART 15 - RADIO FREQUENCY DEVICES<br>Subpart C - Intentional Radiators                                                             |
| RSS-Gen Issue 5, April 2018<br>Amendment 1, March 2019 +<br>Amendment 2, February 2021 | General Requirements for Compliance of Radio<br>Apparatus                                                                          |
| RSS-247<br>Issue 3 August 2023                                                         | Digital Transmission Systems (DTSS), Frequency<br>Hopping Systems (FHSS) and License-Exempt Local<br>Area Network (LE-LAN) Devices |

All the test methods were according to KDB 558074 D01 15.247 Meas Guidance v05r02 Measurement Guidance and ANSI C63.10-2020.

## 5 Summary of Test Results

| Technical Requirements                                      |                                                                |            |             |
|-------------------------------------------------------------|----------------------------------------------------------------|------------|-------------|
| FCC Part 15 Subpart C/ RSS-247 Issue 3/RSS-Gen Issue 5      |                                                                |            |             |
| Test Condition                                              |                                                                | Test Site  | Test Result |
| §15.207 & RSS-Gen 8.8                                       | Conducted emission AC power port                               | Site 1     | Pass        |
| §15.247(b)(1)                                               | Conducted output power                                         | Site 1     | Pass        |
| RSS-247 5.4(b)                                              | Conducted output power and Equivalent Isotropic Radiated Power | Site 1     | Pass        |
| §15.247(a)(1) & RSS-247 5.1(a) & RSS-Gen 6.7                | 20dB bandwidth and 99% occupied bandwidth                      | Site 1     | Pass        |
| §15.247(a)(1) & RSS-247 5.1(b)                              | Carrier channel frequency separation                           | Site 1     | Pass        |
| §15.247(a)(1)(iii) & RSS-247 5.1(d)                         | Number of hopping frequencies                                  | Site 1     | Pass        |
| §15.247(a)(1)(iii) & RSS-247 5.1(d)                         | Dwell Time - Average Time of Occupancy                         | Site 1     | Pass        |
| §15.247(d) & RSS-247 5.5                                    | Spurious RF conducted emissions                                | Site 1     | Pass        |
| §15.247(d) & RSS-247 5.5                                    | Band edge                                                      | Site 1     | Pass        |
| §15.247(d) & §15.209 & §15.205 & RSS-247 5.5 & RSS-Gen 6.13 | Spurious radiated emissions for transmitter                    | Site 1     | Pass        |
| §15.203 & RSS-Gen 6.8                                       | Antenna requirement                                            | See note 2 | Pass        |

Note 1: N/A=Not Applicable.

Note 2: The EUT uses an Internal Integrated PIFA Antenna, which gain is 1.86dBi and an External Integrated PIFA Antenna, which gain is 2.21dBi. In accordance to §15.203 & RSS-Gen 6.8, it is considered sufficiently to comply with the provisions of this section.

## 6 General Remarks

### Remarks

This submittal(s) (test report) is intended for FCC ID: YYX-FS2345, complies with Section 15.207, 15.209, 15.205, 15.247 of the FCC Part 15, Subpart C.

This submittal(s) (test report) is intended for IC:11458A-FS2345, complies with RSS-247, RSS-GEN.

The Model: FS2345 supports Bluetooth Low Energy/Bluetooth BR+EDR/Wi-Fi functions, power by 5VDC.

The TX and RX range is 2402MHz-2480MHz for Bluetooth, 2412MHz – 2462MHz for 2.4GHz Wi-Fi, 5180MHz – 5320MHz, 5500MHz – 5700MHz, 5745MHz – 5825MHz for 5GHz Wi-Fi. (This device shall not be capable of transmitting in the band 5600-5650MHz for Canada. This restriction is for the protection of Terminal Doppler Weather Radar (TDWR) operating in this band.)

Note: The report is for BR+EDR only.

### SUMMARY:

All tests according to the regulations cited on page 6 were

■ - Performed

□ - **Not** Performed

The Equipment Under Test

■ - **Fulfills** the general approval requirements.

□ - **Does not** fulfill the general approval requirements.

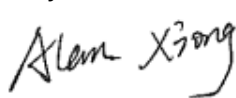
Sample Received Date: 2024-07-02

Testing Start Date: 2024-07-02

Testing End Date: 2024-08-05

- TÜV SÜD Certification and Testing (China) Co., Ltd. Shenzhen Branch

Reviewed by:



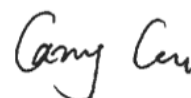
Alan Xiong  
Project Manager

Prepared by:



Henry Chen  
Project Engineer

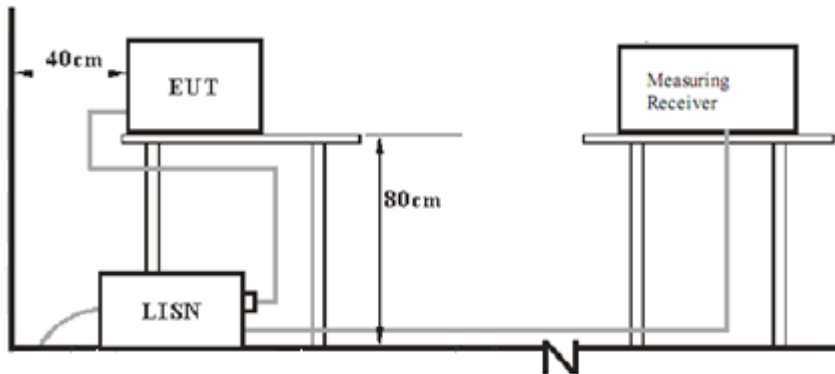
Tested by:



Carry Cai  
Test Engineer

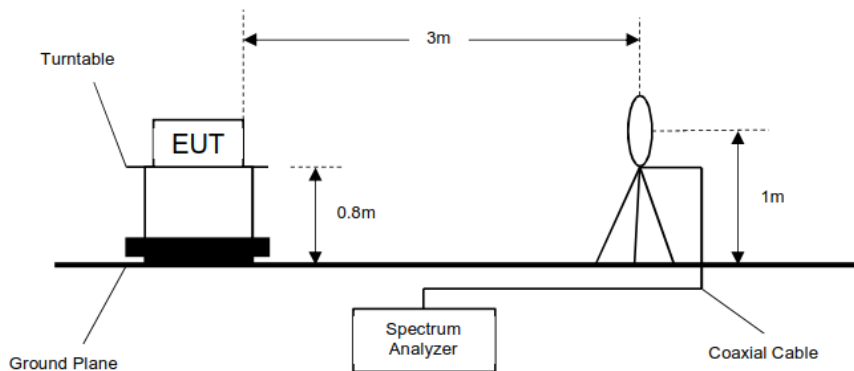
## 7 Test Setups

### 7.1 AC Power Line Conducted Emission test setups

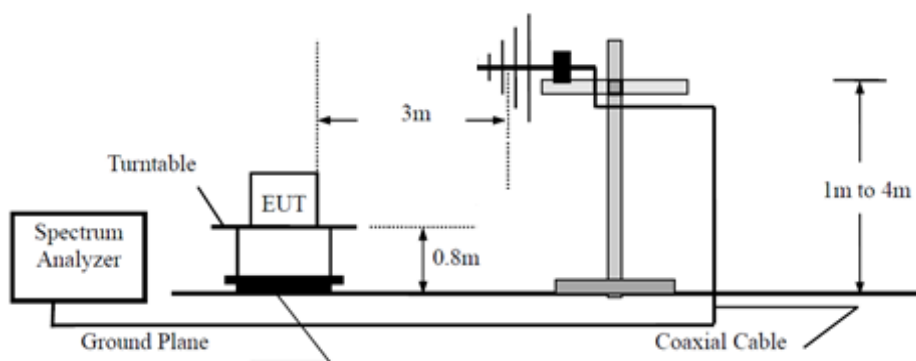


### 7.2 Radiated test setups

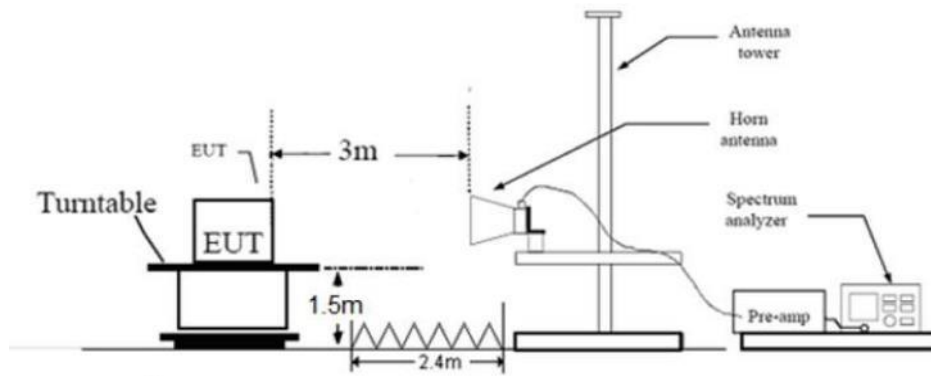
#### 9KHz - 30MHz



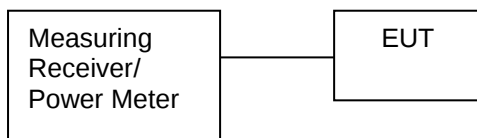
#### 30MHz - 1GHz



## Above 1GHz



## 7.3 Conducted RF test setups



## 8 Systems Test Configuration

### Auxiliary Equipment Used during Test:

| Description | Manufacturer | Model NO. | S/N     |
|-------------|--------------|-----------|---------|
| Laptop      | Thinkpad     | X230      | 0A72162 |

### Test software information:

|                       |                  |
|-----------------------|------------------|
| Test Software Version | RTLBAPP          |
| Modulation            | Setting TX Power |
| GFSK                  | Default          |
| $\pi/4$ -DQPSK        | Default          |
| 8-DPSK                | Default          |

The system was configured to hopping mode and non-hopping mode.

Hopping mode: typical working mode (normal hopping status)

Non-hopping mode: The system was configured to operate at a signal channel transmitting. The test software allows the configuration and operation at the worst-case duty and the highest transmit power.

## 9 Technical Requirement

### 9.1 Conducted Emission

#### Test Method

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. Both sides of AC line were checked for maximum conducted interference.
6. The frequency range from 150 kHz to 30 MHz was searched.
7. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

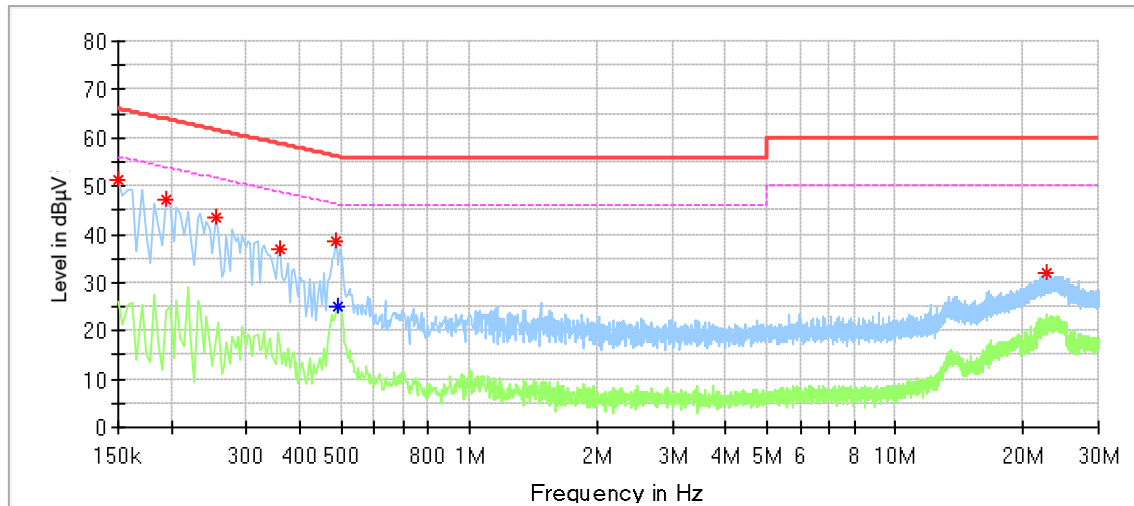
#### Limit

| Frequency<br>MHz | QP Limit<br>dB $\mu$ V | AV Limit<br>dB $\mu$ V |
|------------------|------------------------|------------------------|
| 0.150-0.500      | 66-56*                 | 56-46*                 |
| 0.500-5          | 56                     | 46                     |
| 5-30             | 60                     | 50                     |

\*Decreases with the logarithm of the frequency.

## Conducted Emission

Product Type : AURIA  
 M/N : FS2345  
 Operating Condition : Transmit  
 Test Specification : Line  
 Comment : 5VDC Power by Laptop (AC 120V/60Hz)



## Critical\_Freqs

| Frequency (MHz) | MaxPeak (dBμV) | Average (dBμV) | Limit (dBμV) | Margin (dB) | Line | Corr. (dB) |
|-----------------|----------------|----------------|--------------|-------------|------|------------|
| 0.150000        | 51.14          | ---            | 66.00        | 14.86       | L1   | 9.52       |
| 0.194000        | 47.09          | ---            | 63.86        | 16.77       | L1   | 9.54       |
| 0.254000        | 43.55          | ---            | 61.63        | 18.08       | L1   | 9.56       |
| 0.358000        | 36.85          | ---            | 58.78        | 21.93       | L1   | 9.57       |
| 0.486000        | 38.65          | ---            | 56.24        | 17.58       | L1   | 9.59       |
| 0.494000        | ---            | 24.97          | 46.10        | 21.13       | L1   | 9.59       |
| 22.726000       | 31.80          | ---            | 60.00        | 28.20       | L1   | 10.05      |

Remark:

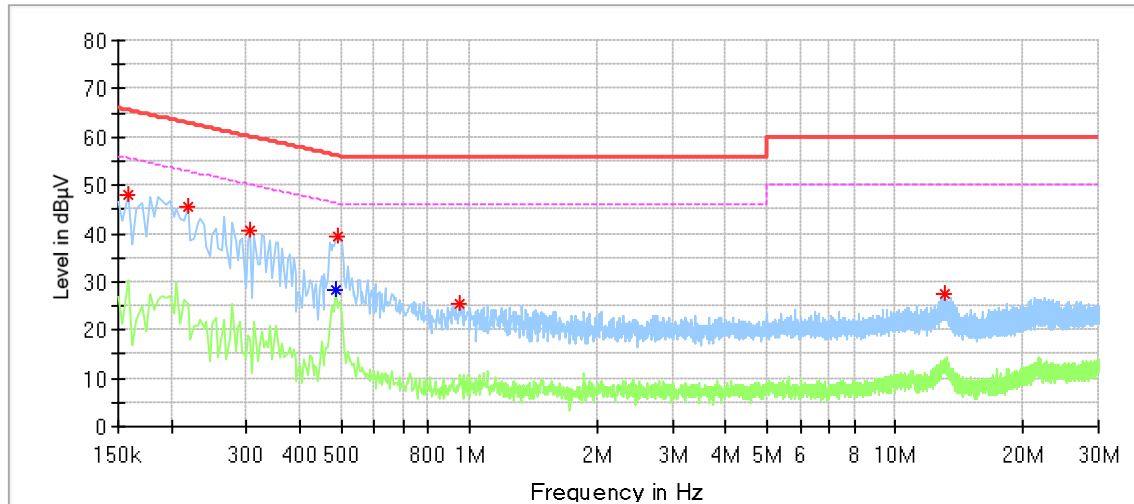
Level=Reading Level + Correction Factor

Correction Factor=Cable Loss + LISN Factor

(The Reading Level is recorded by software which is not shown in the sheet)

## Conducted Emission

Product Type : AURIA  
 M/N : FS2345  
 Operating Condition : Transmit  
 Test Specification : Neutral  
 Comment : 5VDC Power by Laptop (AC 120V/60Hz)



## Critical Freqs

| Frequency (MHz) | MaxPeak (dBμV) | Average (dBμV) | Limit (dBμV) | Margin (dB) | Line | Corr. (dB) |
|-----------------|----------------|----------------|--------------|-------------|------|------------|
| 0.158000        | 47.93          | ---            | 65.57        | 17.64       | N    | 9.56       |
| 0.218000        | 45.35          | ---            | 62.90        | 17.55       | N    | 9.58       |
| 0.306000        | 40.82          | ---            | 60.08        | 19.26       | N    | 9.60       |
| 0.486000        | ---            | 28.35          | 46.24        | 17.89       | N    | 9.62       |
| 0.490000        | 39.57          | ---            | 56.17        | 16.60       | N    | 9.62       |
| 0.950000        | 25.38          | ---            | 56.00        | 30.62       | N    | 9.63       |
| 13.042000       | 27.39          | ---            | 60.00        | 32.61       | N    | 9.99       |

Remark:

Level=Reading Level + Correction Factor

Correction Factor=Cable Loss + LISN Factor

(The Reading Level is recorded by software which is not shown in the sheet)

## 9.2 Conducted Output Power & EIRP

### Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously
3. Use the following test receiver settings:  
Span = approximately 5 times the 20dB bandwidth, centered on a hopping channel  
RBW > the 20dB bandwidth of the emission being measured, VBW ≥ RBW,  
Sweep = auto, Detector function = peak, Trace = max hold
4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. The indicated level is the peak output power and record the results in the test report.
5. Repeat above procedures until all frequencies measured were complete.

### Limits

According to §15.247 (b) (1) & RSS-247 5.4(b), conducted output power limit as below:

| Frequency Range<br>MHz | Limit<br>W | Limit<br>dBm |
|------------------------|------------|--------------|
| 2400-2483.5            | ≤0.125     | ≤30          |

According to & RSS-247 5.4(b), EIRP limit as below:

| Frequency Range<br>MHz | Limit<br>W | Limit<br>dBm |
|------------------------|------------|--------------|
| 2400-2483.5            | ≤4         | ≤36          |

Remark: EIRP=Conducted output power + Antenna Gain

## Conducted Output Power & EIRP

| Mode      | TX Type | Frequency (MHz) | Packet Type | Maximum Peak Conducted Output Power (dBm) |       | Verdict |
|-----------|---------|-----------------|-------------|-------------------------------------------|-------|---------|
|           |         |                 |             | ANT1                                      | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 5.28                                      | <=30  | Pass    |
|           |         | 2441            | DH5         | 5.11                                      | <=30  | Pass    |
|           |         | 2480            | DH5         | 4.64                                      | <=30  | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 6.49                                      | <=30  | Pass    |
|           |         | 2441            | 2DH5        | 6.40                                      | <=30  | Pass    |
|           |         | 2480            | 2DH5        | 5.97                                      | <=30  | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | 7.09                                      | <=30  | Pass    |
|           |         | 2441            | 3DH5        | 6.98                                      | <=30  | Pass    |
|           |         | 2480            | 3DH5        | 6.50                                      | <=30  | Pass    |

| Mode      | TX Type | Frequency (MHz) | Packet Type | Maximum Peak Conducted Output Power (dBm) |       | Verdict |
|-----------|---------|-----------------|-------------|-------------------------------------------|-------|---------|
|           |         |                 |             | ANT2                                      | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 5.20                                      | <=30  | Pass    |
|           |         | 2441            | DH5         | 5.06                                      | <=30  | Pass    |
|           |         | 2480            | DH5         | 4.68                                      | <=30  | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 6.48                                      | <=30  | Pass    |
|           |         | 2441            | 2DH5        | 6.33                                      | <=30  | Pass    |
|           |         | 2480            | 2DH5        | 5.98                                      | <=30  | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | 7.04                                      | <=30  | Pass    |
|           |         | 2441            | 3DH5        | 6.94                                      | <=30  | Pass    |
|           |         | 2480            | 3DH5        | 6.56                                      | <=30  | Pass    |

| Mode      | TX Type | Frequency (MHz) | Packet Type | EIRP (dBm)  |       | Verdict |
|-----------|---------|-----------------|-------------|-------------|-------|---------|
|           |         |                 |             | ANT1        | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 7.14        | <=36  | Pass    |
|           |         | 2441            | DH5         | 6.97        | <=36  | Pass    |
|           |         | 2480            | DH5         | 6.5         | <=36  | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 8.35        | <=36  | Pass    |
|           |         | 2441            | 2DH5        | 8.26        | <=36  | Pass    |
|           |         | 2480            | 2DH5        | 7.83        | <=36  | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | <b>8.95</b> | <=36  | Pass    |
|           |         | 2441            | 3DH5        | 8.84        | <=36  | Pass    |
|           |         | 2480            | 3DH5        | 8.36        | <=36  | Pass    |

Note: ANT1 gain is 1.86 dBi

| Mode      | TX Type | Frequency (MHz) | Packet Type | EIRP (dBm)  |       | Verdict |
|-----------|---------|-----------------|-------------|-------------|-------|---------|
|           |         |                 |             | ANT2        | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 7.41        | <=36  | Pass    |
|           |         | 2441            | DH5         | 7.27        | <=36  | Pass    |
|           |         | 2480            | DH5         | 6.89        | <=36  | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 8.69        | <=36  | Pass    |
|           |         | 2441            | 2DH5        | 8.54        | <=36  | Pass    |
|           |         | 2480            | 2DH5        | 8.19        | <=36  | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | <b>9.25</b> | <=36  | Pass    |
|           |         | 2441            | 3DH5        | 9.15        | <=36  | Pass    |
|           |         | 2480            | 3DH5        | 8.77        | <=36  | Pass    |

Note: ANT2 gain is 2.21 dBi

### 9.3 20 dB Bandwidth and 99% Occupied Bandwidth

#### Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Use the following test receiver settings:  
Span = approximately 2 to 3 times the 20 dB bandwidth, centered on a hopping channel  
RBW = 1% to 5% of the OBW, VBW $\geq$ 3RBW,  
Sweep = auto, Detector function = peak, Trace = max hold
4. Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission. Measure the frequency difference of two frequencies that were attenuated 20 dB/99% OBW from the reference level. Record the frequency difference as the emission bandwidth. Record the results.
5. Repeat above procedures until all frequencies measured were complete.

#### Limit

Limit [kHz]

---

N/A

## 20 dB bandwidth and 99% Occupied Bandwidth

### Test result

| Mode      | TX Type | Frequency (MHz) | Packet Type | ANT | 20dB Bandwidth (MHz) |       | Verdict |
|-----------|---------|-----------------|-------------|-----|----------------------|-------|---------|
|           |         |                 |             |     | Result               | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 1   | 0.969                | /     | Pass    |
|           |         | 2441            | DH5         | 1   | 0.974                | /     | Pass    |
|           |         | 2480            | DH5         | 1   | 0.969                | /     | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 1   | 1.304                | /     | Pass    |
|           |         | 2441            | 2DH5        | 1   | 1.312                | /     | Pass    |
|           |         | 2480            | 2DH5        | 1   | 1.319                | /     | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | 1   | 1.289                | /     | Pass    |
|           |         | 2441            | 3DH5        | 1   | 1.306                | /     | Pass    |
|           |         | 2480            | 3DH5        | 1   | 1.300                | /     | Pass    |

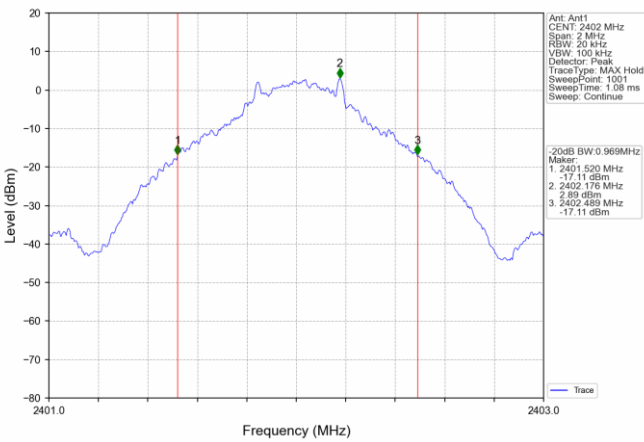
| Mode      | TX Type | Frequency (MHz) | Packet Type | ANT | 20dB Bandwidth (MHz) |       | Verdict |
|-----------|---------|-----------------|-------------|-----|----------------------|-------|---------|
|           |         |                 |             |     | Result               | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 2   | 0.960                | /     | Pass    |
|           |         | 2441            | DH5         | 2   | 0.991                | /     | Pass    |
|           |         | 2480            | DH5         | 2   | 0.971                | /     | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 2   | 1.309                | /     | Pass    |
|           |         | 2441            | 2DH5        | 2   | 1.304                | /     | Pass    |
|           |         | 2480            | 2DH5        | 2   | 1.307                | /     | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | 2   | 1.294                | /     | Pass    |
|           |         | 2441            | 3DH5        | 2   | 1.299                | /     | Pass    |
|           |         | 2480            | 3DH5        | 2   | 1.318                | /     | Pass    |

| Mode      | TX Type | Frequency (MHz) | Packet Type | ANT | 99% Occupied Bandwidth (MHz) |       | Verdict |
|-----------|---------|-----------------|-------------|-----|------------------------------|-------|---------|
|           |         |                 |             |     | Result                       | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 1   | 0.884                        | /     | Pass    |
|           |         | 2441            | DH5         | 1   | 0.880                        | /     | Pass    |
|           |         | 2480            | DH5         | 1   | 0.879                        | /     | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 1   | 1.180                        | /     | Pass    |
|           |         | 2441            | 2DH5        | 1   | 1.177                        | /     | Pass    |
|           |         | 2480            | 2DH5        | 1   | 1.171                        | /     | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | 1   | 1.179                        | /     | Pass    |
|           |         | 2441            | 3DH5        | 1   | 1.185                        | /     | Pass    |
|           |         | 2480            | 3DH5        | 1   | 1.184                        | /     | Pass    |

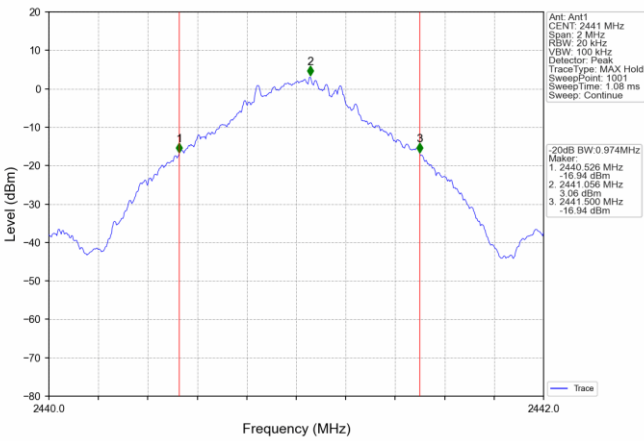
| Mode      | TX Type | Frequency (MHz) | Packet Type | ANT | 99% Occupied Bandwidth (MHz) |       | Verdict |
|-----------|---------|-----------------|-------------|-----|------------------------------|-------|---------|
|           |         |                 |             |     | Result                       | Limit |         |
| GFSK      | SISO    | 2402            | DH5         | 2   | 0.876                        | /     | Pass    |
|           |         | 2441            | DH5         | 2   | 0.873                        | /     | Pass    |
|           |         | 2480            | DH5         | 2   | 0.879                        | /     | Pass    |
| Pi/4DQPSK | SISO    | 2402            | 2DH5        | 2   | 1.168                        | /     | Pass    |
|           |         | 2441            | 2DH5        | 2   | 1.181                        | /     | Pass    |
|           |         | 2480            | 2DH5        | 2   | 1.173                        | /     | Pass    |
| 8DPSK     | SISO    | 2402            | 3DH5        | 2   | 1.178                        | /     | Pass    |
|           |         | 2441            | 3DH5        | 2   | 1.178                        | /     | Pass    |
|           |         | 2480            | 3DH5        | 2   | 1.177                        | /     | Pass    |

20 dB Bandwidth

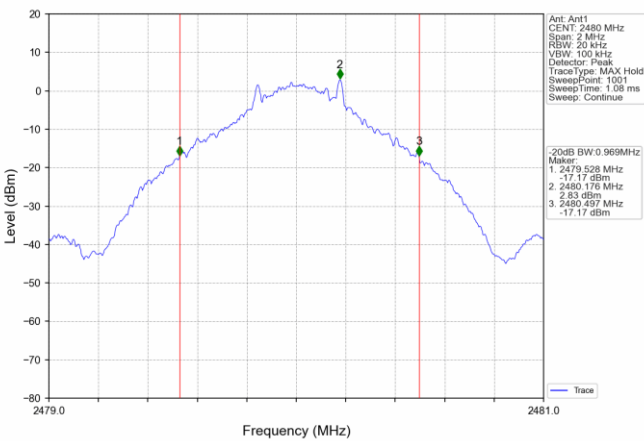
GFSK\_DH5\_LCH\_2402MHz\_Ant1\_NTNV



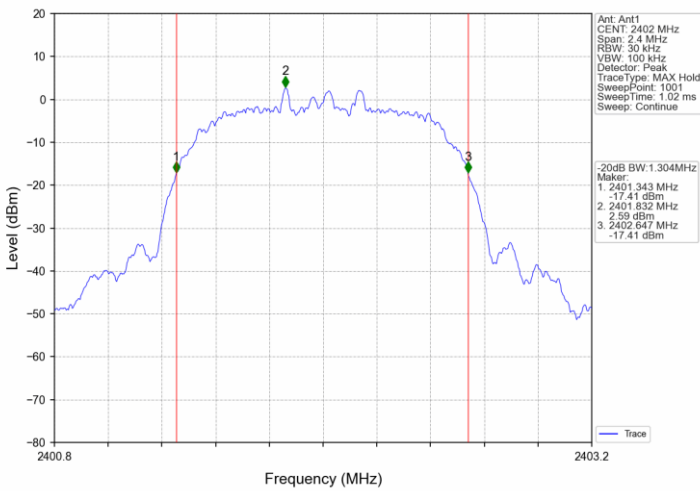
GFSK\_DH5\_MCH\_2441MHz\_Ant1\_NTNV



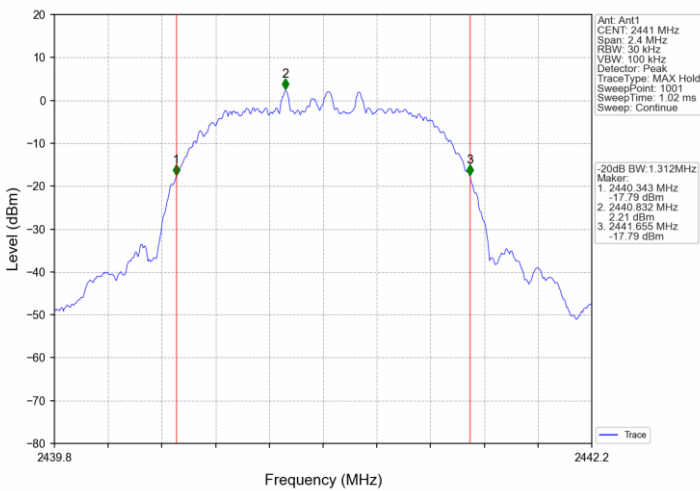
GFSK\_DH5\_HCH\_2480MHz\_Ant1\_NTNV



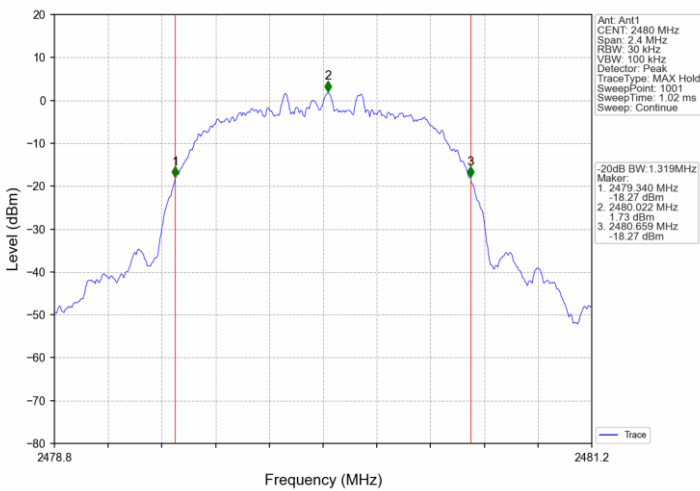
Pi/4DQPSK\_2DH5\_LCH\_2402MHz\_Ant1\_NTNV



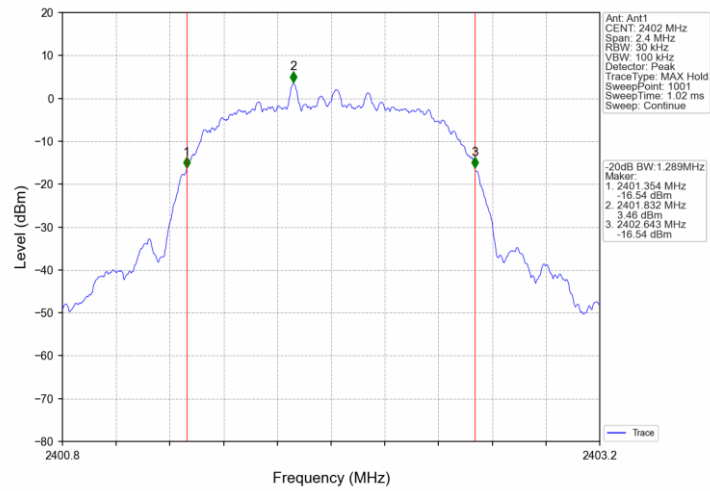
Pi/4DQPSK\_2DH5\_MCH\_2441MHz\_Ant1\_NTNV



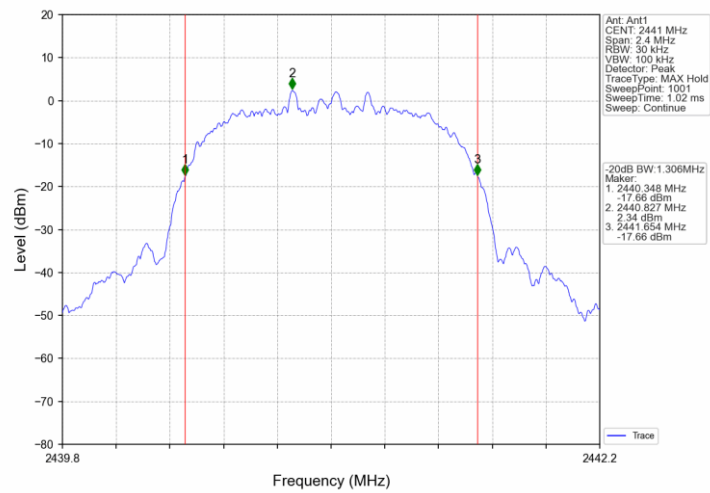
Pi/4DQPSK\_2DH5\_HCH\_2480MHz\_Ant1\_NTNV



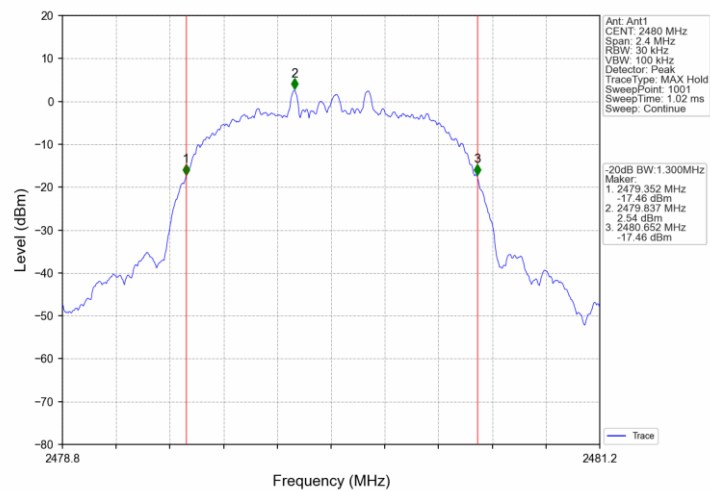
## 8DPSK\_3DH5\_LCH\_2402MHz\_Ant1\_NTNV



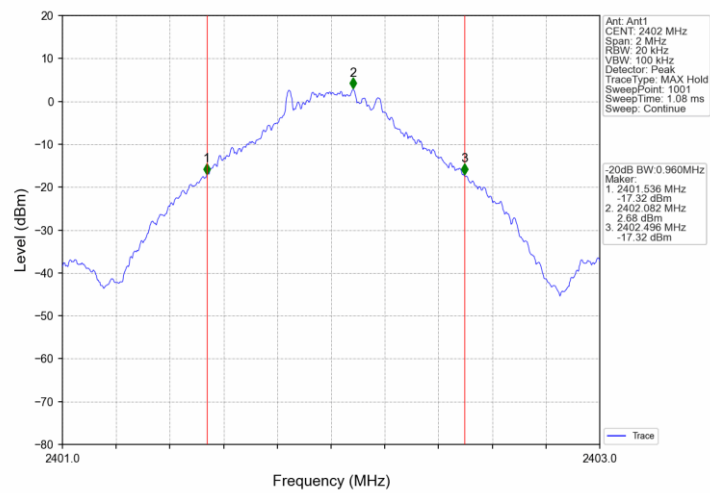
## 8DPSK\_3DH5\_MCH\_2441MHz\_Ant1\_NTNV



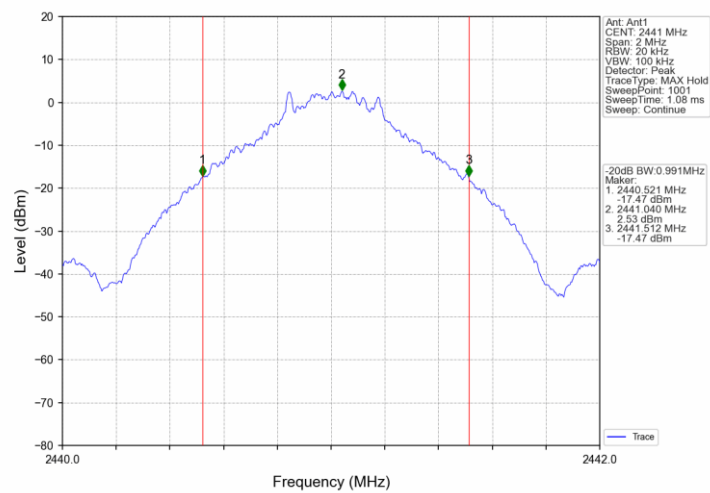
## 8DPSK\_3DH5\_HCH\_2480MHz\_Ant1\_NTNV



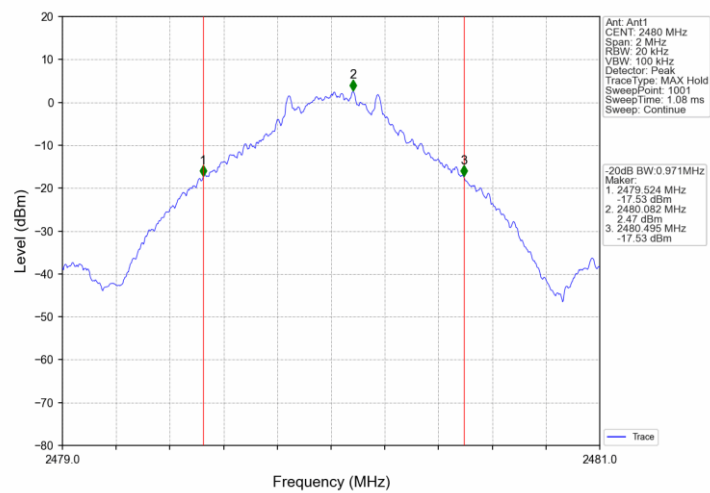
GFSK\_DH5\_LCH\_2402MHz\_Ant2\_NTNV



GFSK\_DH5\_MCH\_2441MHz\_Ant2\_NTNV

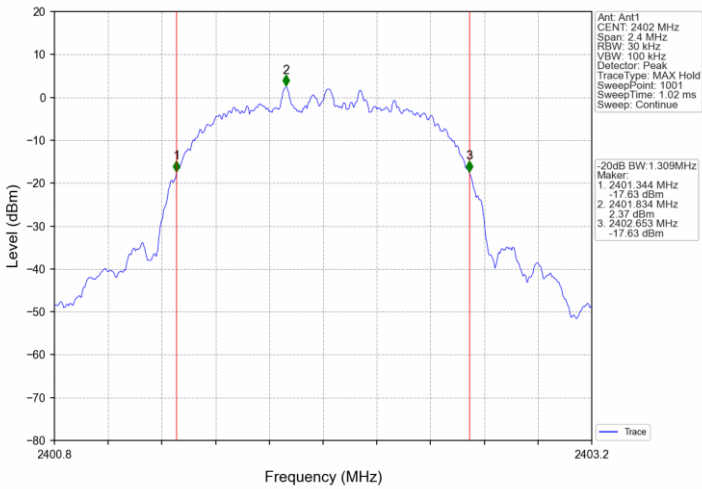


GFSK\_DH5\_HCH\_2480MHz\_Ant2\_NTNV

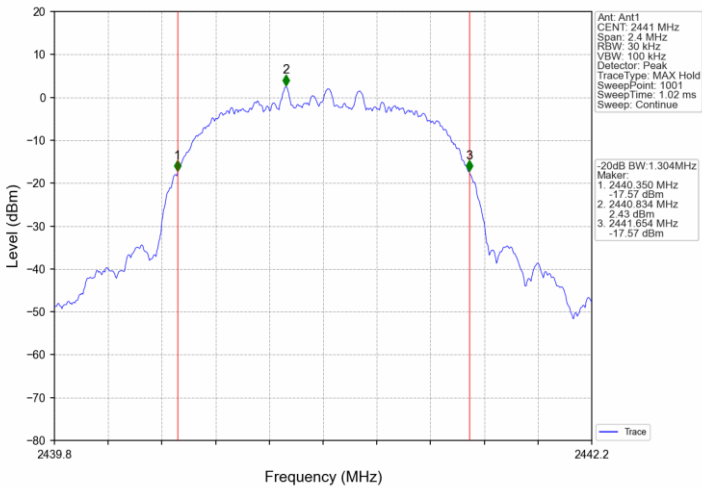




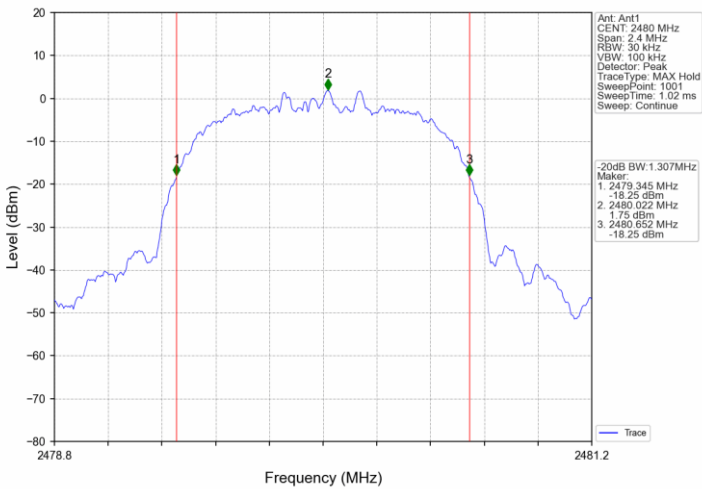
Pi/4DQPSK\_2DH5\_LCH\_2402MHz\_Ant2\_NTNV



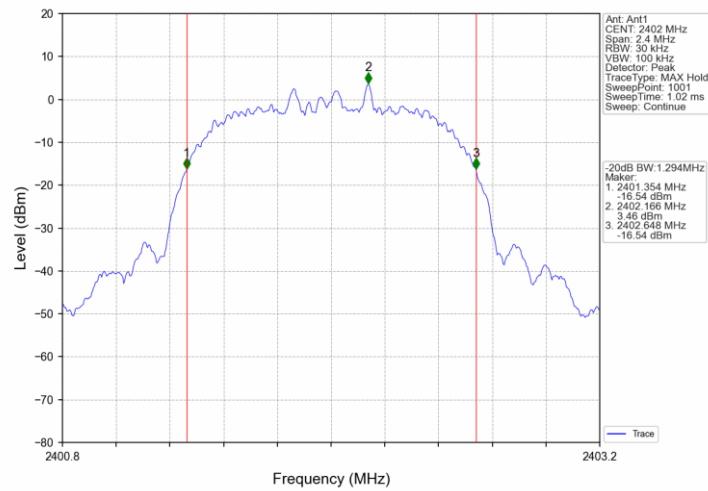
Pi/4DQPSK\_2DH5\_MCH\_2441MHz\_Ant2\_NTNV



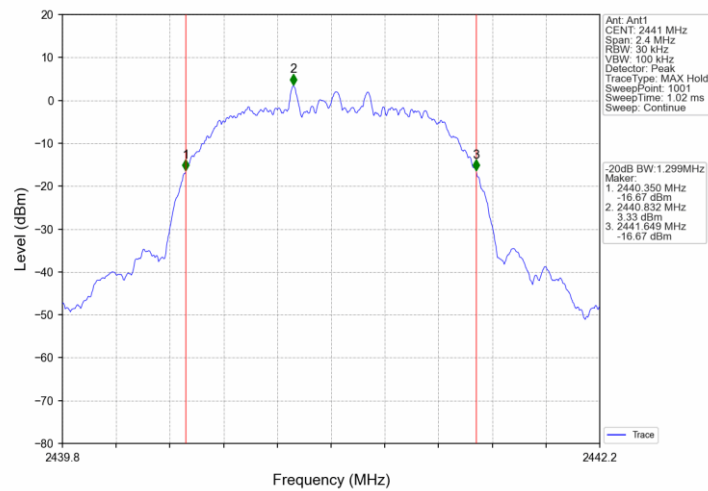
Pi/4DQPSK\_2DH5\_HCH\_2480MHz\_Ant2\_NTNV



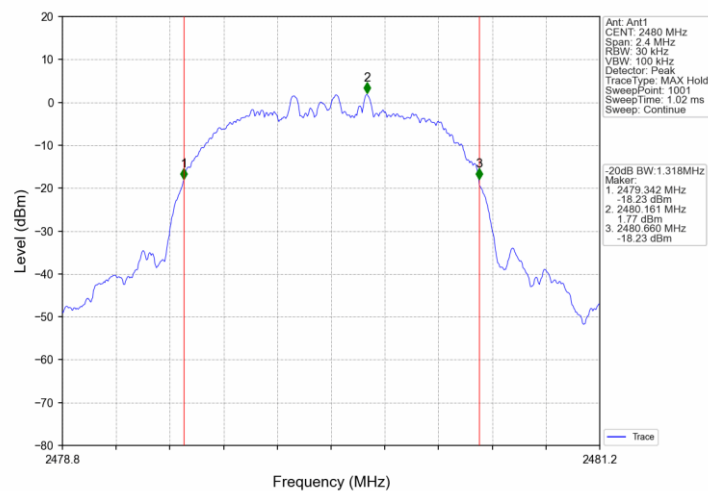
## 8DPSK\_3DH5\_LCH\_2402MHz\_Ant2\_NTNV



## 8DPSK\_3DH5\_MCH\_2441MHz\_Ant2\_NTNV

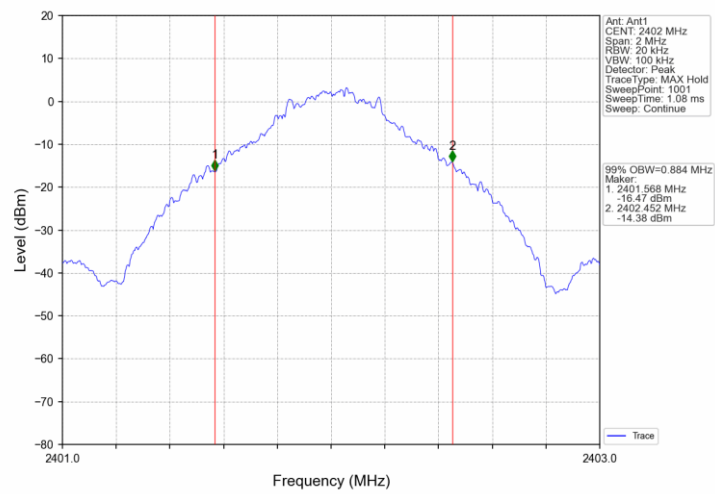


## 8DPSK\_3DH5\_HCH\_2480MHz\_Ant2\_NTNV

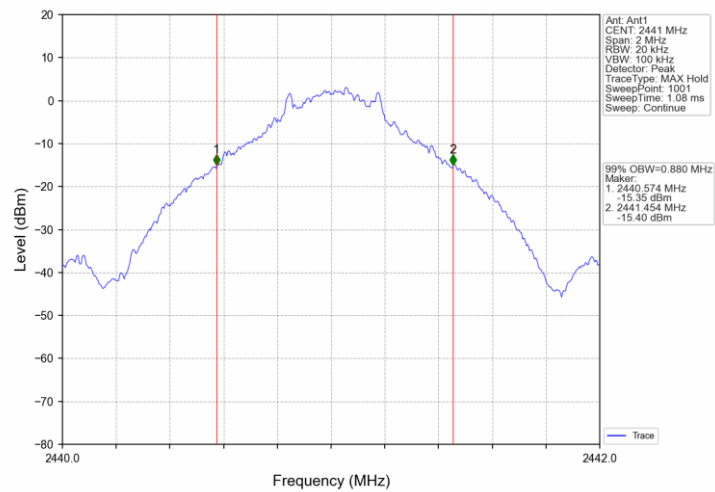


**99% Occupied Bandwidth**

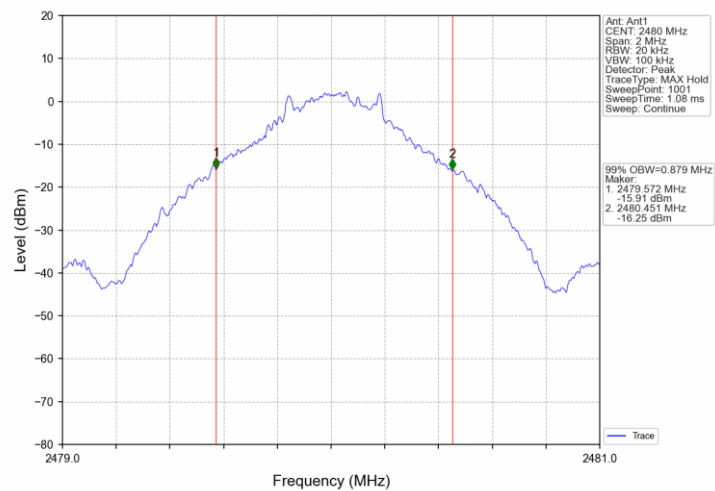
GFSK\_DH5\_LCH\_2402MHz\_Ant1\_NTNV



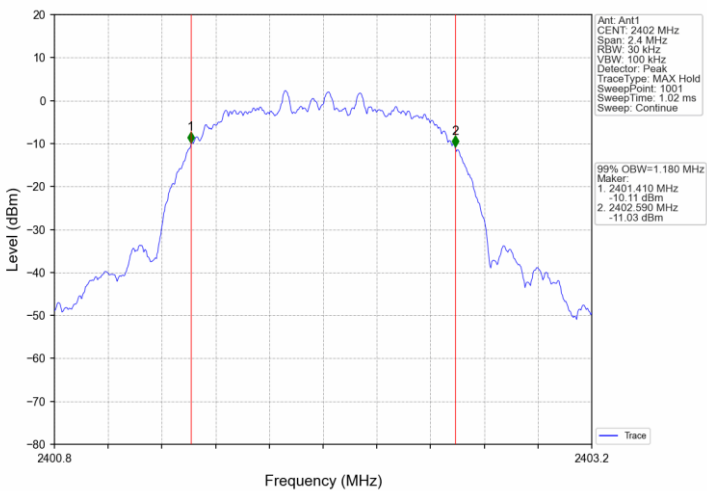
GFSK\_DH5\_MCH\_2441MHz\_Ant1\_NTNV



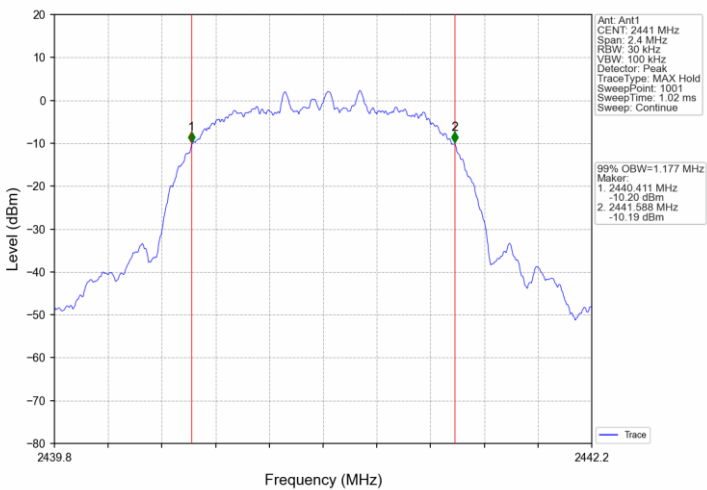
GFSK\_DH5\_HCH\_2480MHz\_Ant1\_NTNV



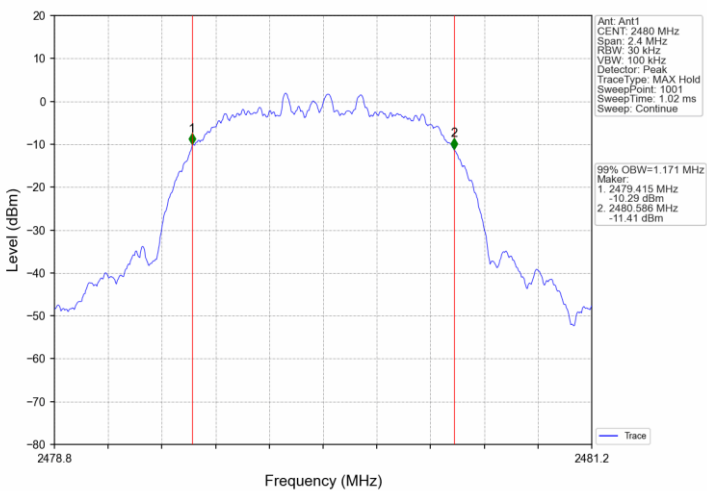
Pi/4DQPSK\_2DH5\_LCH\_2402MHz\_Ant1\_NTNV



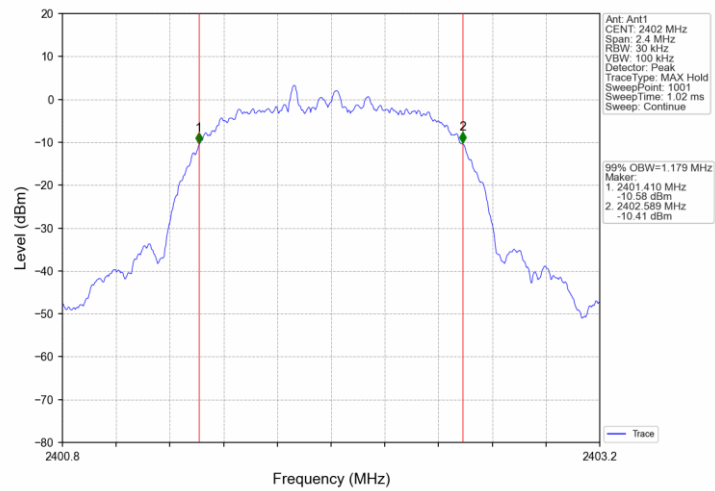
Pi/4DQPSK\_2DH5\_MCH\_2441MHz\_Ant1\_NTNV



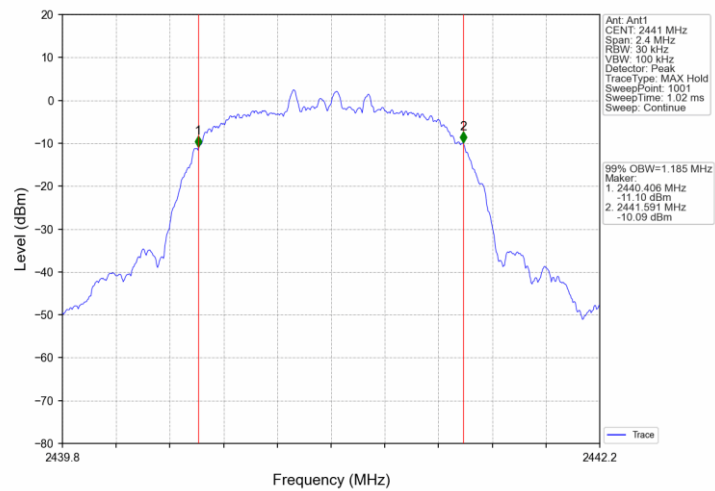
Pi/4DQPSK\_2DH5\_HCH\_2480MHz\_Ant1\_NTNV



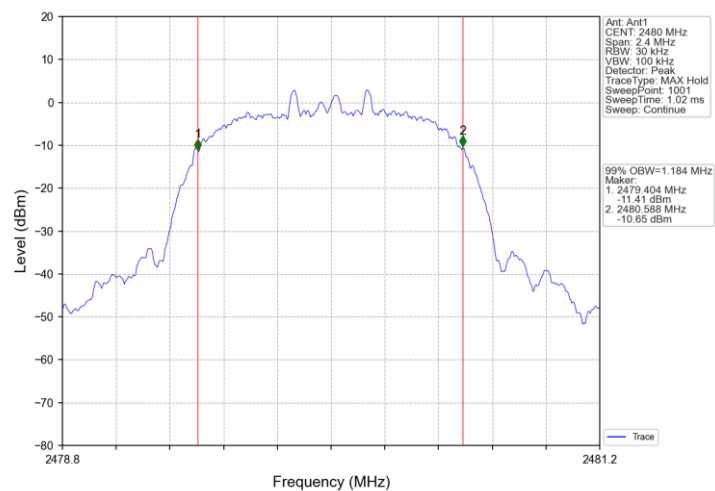
## 8DPSK\_3DH5\_LCH\_2402MHz\_Ant1\_NTNV



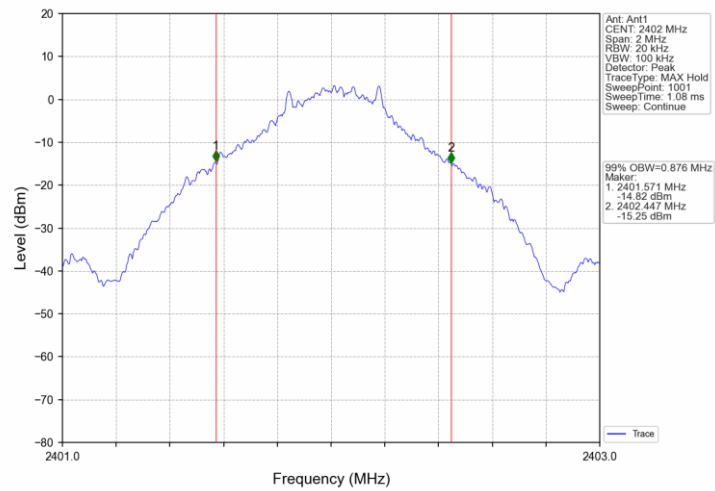
## 8DPSK\_3DH5\_MCH\_2441MHz\_Ant1\_NTNV



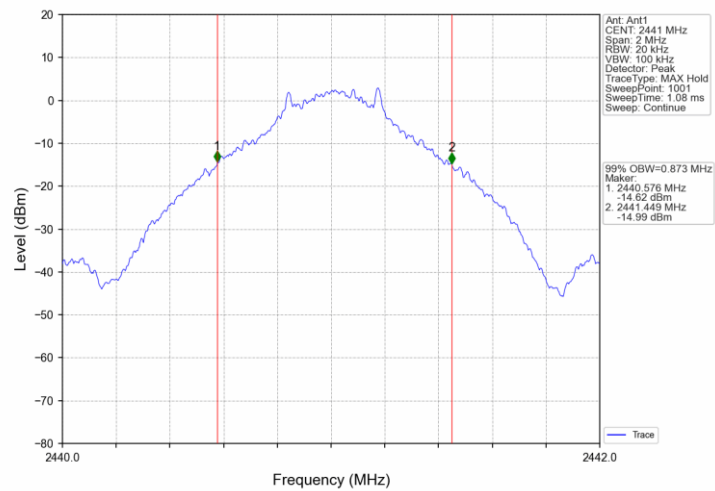
## 8DPSK\_3DH5\_HCH\_2480MHz\_Ant1\_NTNV



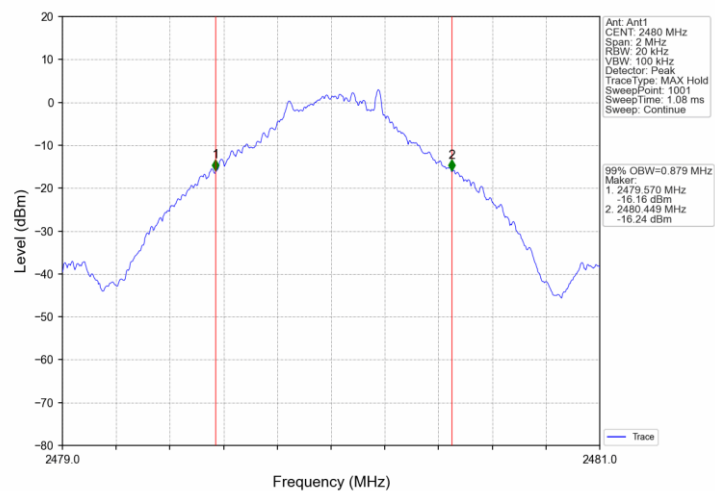
## GFSK\_DH5\_LCH\_2402MHz\_Ant2\_NTNV



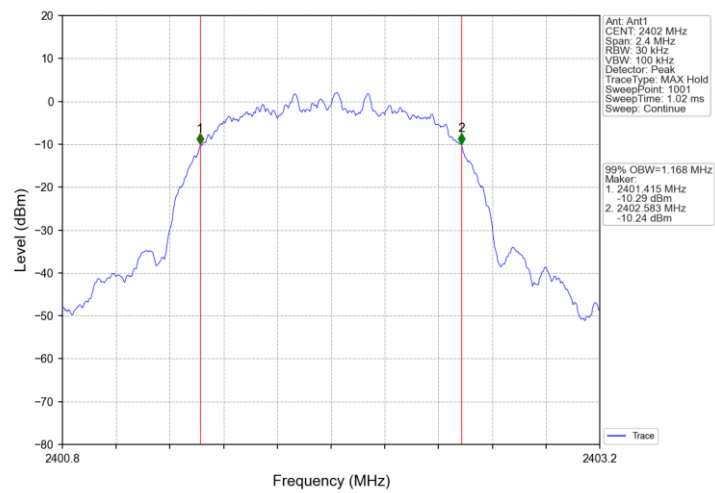
## GFSK\_DH5\_MCH\_2441MHz\_Ant2\_NTNV



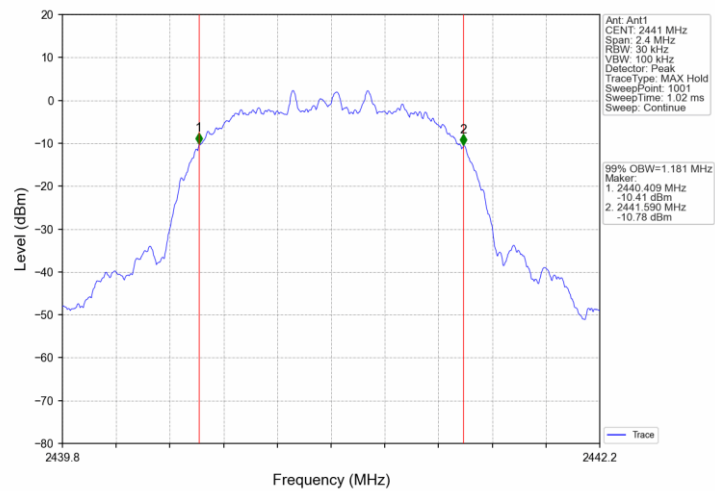
## GFSK\_DH5\_HCH\_2480MHz\_Ant2\_NTNV



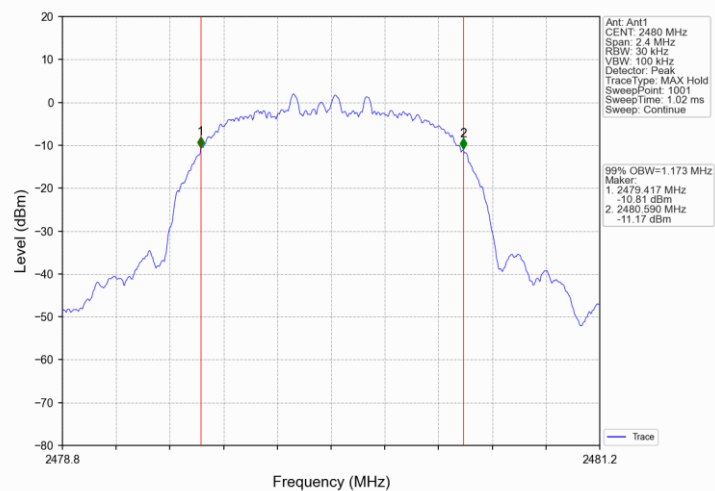
## Pi/4DQPSK\_2DH5\_LCH\_2402MHz\_Ant2\_NTNV



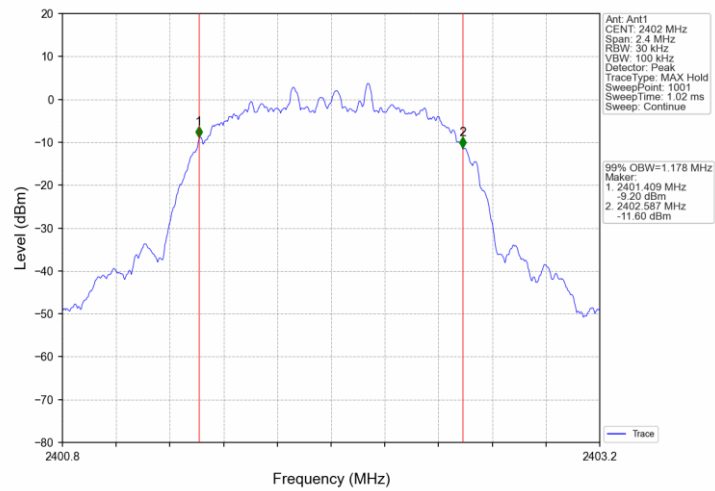
## Pi/4DQPSK\_2DH5\_MCH\_2441MHz\_Ant2\_NTNV



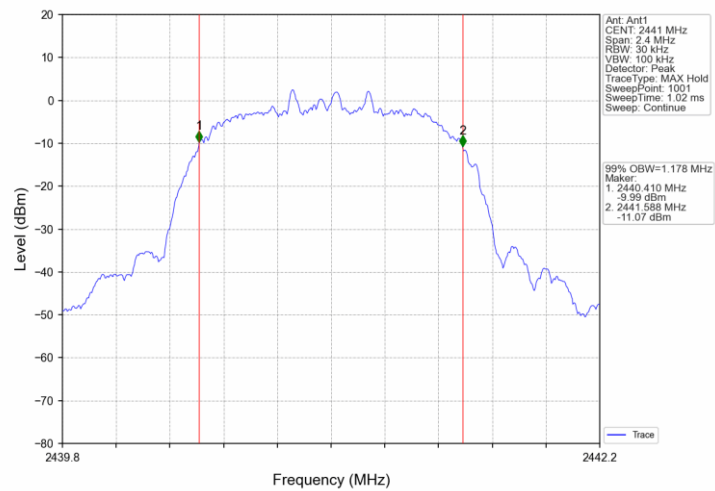
## Pi/4DQPSK\_2DH5\_HCH\_2480MHz\_Ant2\_NTNV



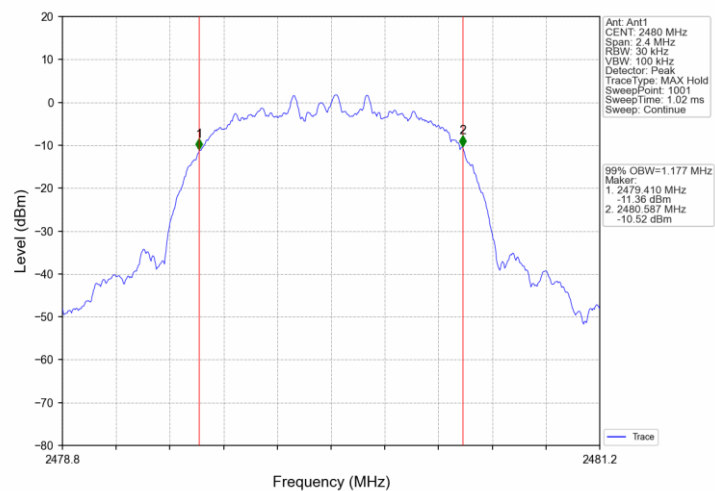
## 8DPSK\_3DH5\_LCH\_2402MHz\_Ant2\_NTNV



## 8DPSK\_3DH5\_MCH\_2441MHz\_Ant2\_NTNV



## 8DPSK\_3DH5\_HCH\_2480MHz\_Ant2\_NTNV



## 9.4 Carrier Frequency Separation

### Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Use the following spectrum analyzer settings:  
Span = wide enough to capture the peaks of two adjacent channels, RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel. VBW  $\geq$  RBW, Sweep = auto, Detector function = peak.
4. By using the Max-Hold function record the separation of two adjacent channels.
5. Measure the frequency difference of these two adjacent channels by spectrum analyzer marker function. Record the results.
6. Repeat above procedures until all frequencies measured were complete.

### Limit

Limit  
kHz

---

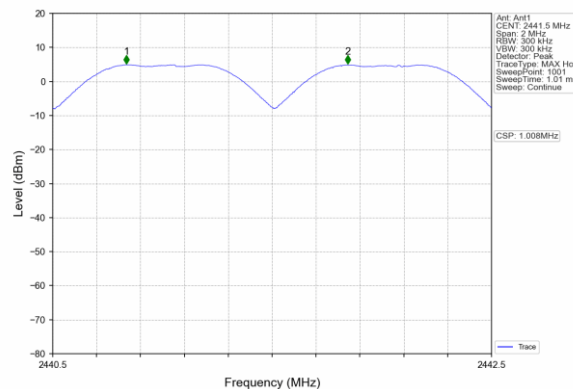
$\geq 25\text{kHz}$  or  $2/3$  of the 20 dB bandwidth which is greater

## Carrier Frequency Separation

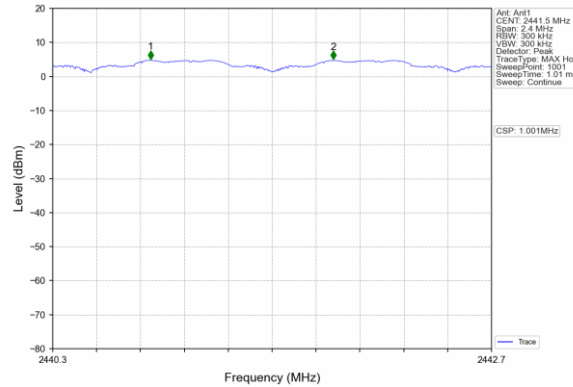
Test result: The measurement was performed with the typical configuration (normal hopping status).

| Ant1      |         |                 |             |                          |                      |              |         |
|-----------|---------|-----------------|-------------|--------------------------|----------------------|--------------|---------|
| Mode      | TX Type | Frequency (MHz) | Packet Type | Channel Separation (MHz) | 20dB Bandwidth (MHz) | Limit (MHz)  | Verdict |
| GFSK      | SISO    | HOPP            | DH5         | 1.008                    | 0.974                | $\geq 0.649$ | Pass    |
| Pi/4DQPSK | SISO    | HOPP            | 2DH5        | 1.001                    | 1.319                | $\geq 0.879$ | Pass    |
| 8DPSK     | SISO    | HOPP            | 3DH5        | 1.001                    | 1.306                | $\geq 0.871$ | Pass    |

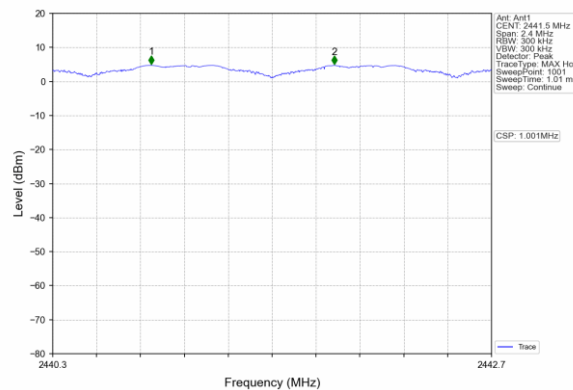
GFSK\_DH5\_HOPP\_Ant1\_NTNV



Pi/4DQPSK\_2DH5\_HOPP\_Ant1\_NTNV

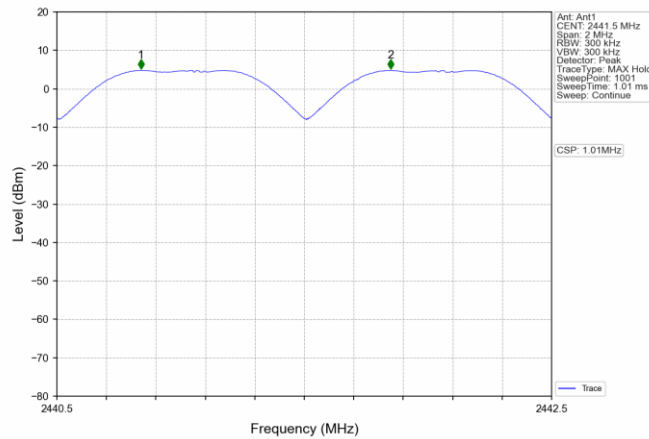


8DPSK\_3DH5\_HOPP\_Ant1\_NTNV

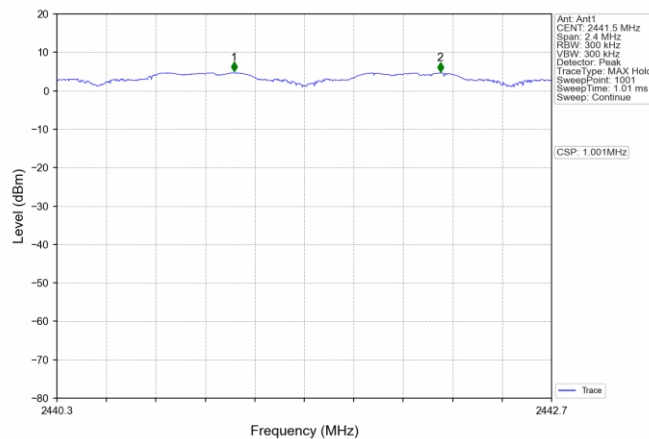


| Ant2      |         |                 |             |                          |                      |              |         |
|-----------|---------|-----------------|-------------|--------------------------|----------------------|--------------|---------|
| Mode      | TX Type | Frequency (MHz) | Packet Type | Channel Separation (MHz) | 20dB Bandwidth (MHz) | Limit (MHz)  | Verdict |
| GFSK      | SISO    | HOPP            | DH5         | 1.010                    | 0.991                | $\geq 0.660$ | Pass    |
| Pi/4DQPSK | SISO    | HOPP            | 2DH5        | 1.001                    | 1.309                | $\geq 0.873$ | Pass    |
| 8DPSK     | SISO    | HOPP            | 3DH5        | 1.001                    | 1.318                | $\geq 0.879$ | Pass    |

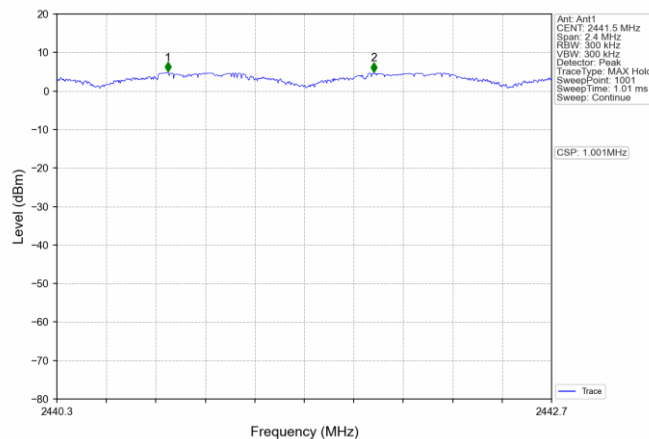
## GFSK\_DH5\_HOPP\_Ant2\_NTNV



## Pi/4DQPSK\_2DH5\_HOPP\_Ant2\_NTNV



## 8DPSK\_3DH5\_HOPP\_Ant2\_NTNV



## 9.5 Number of Hopping Frequencies

### Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Use the following spectrum analyzer settings:  
Span = the frequency band of operation, RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller, VBW  $\geq$  RBW, Sweep = auto, Detector function = peak, Trace=Max hold.
4. Allow the trace to stabilize. It may prove necessary to break the span up to sections, in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

### Limit

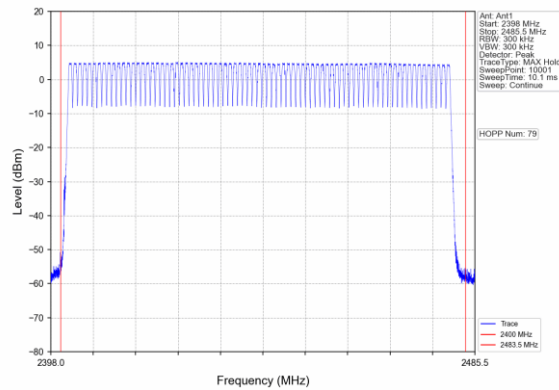
Limit  
number  
\_\_\_\_\_

$\geq 15$

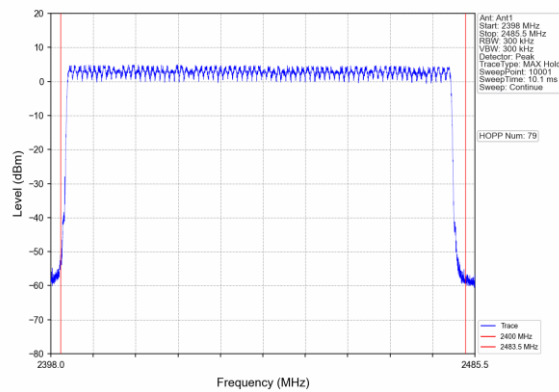
## Number of Hopping Frequencies

| Mode      | TX Type | Frequency (MHz) | Packet Type | Num of Hopping Frequencies |           | Verdict |
|-----------|---------|-----------------|-------------|----------------------------|-----------|---------|
|           |         |                 |             | ANT1                       | Limit     |         |
| GFSK      | SISO    | HOPP            | DH5         | 79                         | $\geq 15$ | Pass    |
| Pi/4DQPSK | SISO    | HOPP            | 2DH5        | 79                         | $\geq 15$ | Pass    |
| 8DPSK     | SISO    | HOPP            | 3DH5        | 79                         | $\geq 15$ | Pass    |

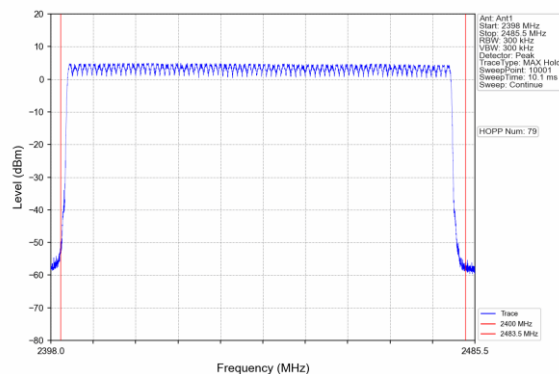
GFSK\_DH5\_HOPP\_Ant1\_NTNV



Pi/4DQPSK\_2DH5\_HOPP\_Ant1\_NTNV

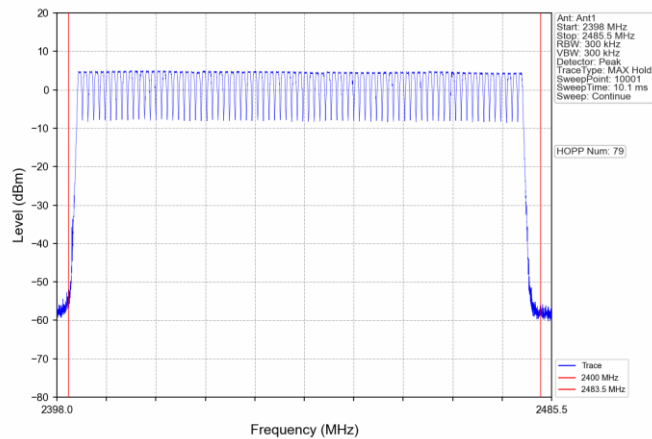


8DPSK\_3DH5\_HOPP\_Ant1\_NTNV

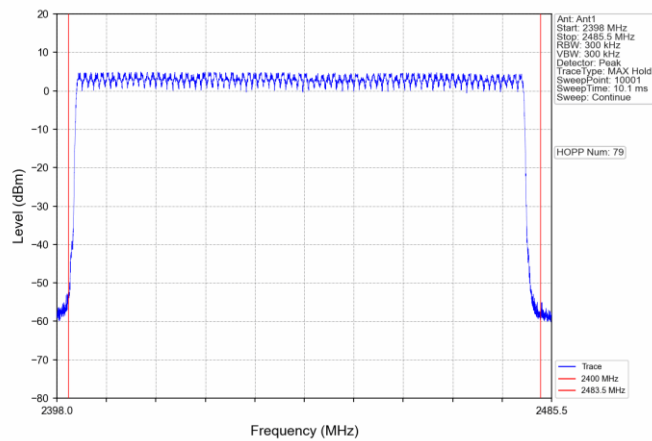


| Mode      | TX Type | Frequency (MHz) | Packet Type | Num of Hopping Frequencies |           | Verdict |
|-----------|---------|-----------------|-------------|----------------------------|-----------|---------|
|           |         |                 |             | ANT2                       | Limit     |         |
| GFSK      | SISO    | HOPP            | DH5         | 79                         | $\geq 15$ | Pass    |
| Pi/4DQPSK | SISO    | HOPP            | 2DH5        | 79                         | $\geq 15$ | Pass    |
| 8DPSK     | SISO    | HOPP            | 3DH5        | 79                         | $\geq 15$ | Pass    |

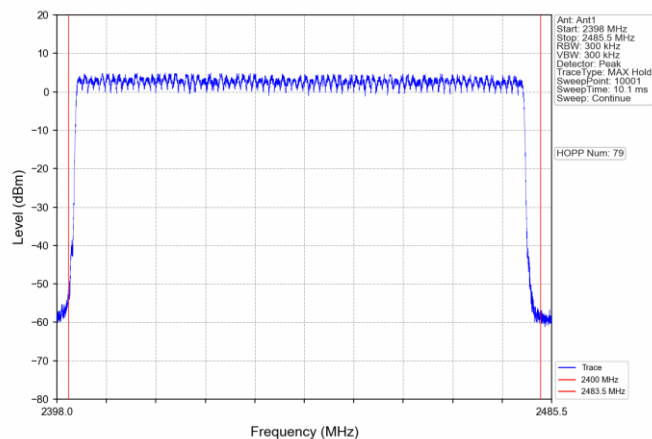
GFSK DH5 HOPP Ant2 NTN



Pi/4DQPSK 2DH5 HOPP Ant2 NTN



8DPSK 3DH5 HOPP Ant2 NTN



## 9.6 Dwell Time

### Test Method

1. The RF output of EUT was connected to the spectrum analyzer by RF cable. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit to hopping mode.
3. Span: Zero span, centered on a hopping channel.
4. RBW shall be  $\leq$  channel spacing and where possible RBW should be set  $\gg 1 / T$ , where  $T$  is the expected dwell time per channel.
5. 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.
6. Detector function: Peak.
7. 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.

### Limit

The average time of occupancy on any frequency shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed.

## Dwell Time

### Dwell time

The maximum dwell time shall be 0.4 s.

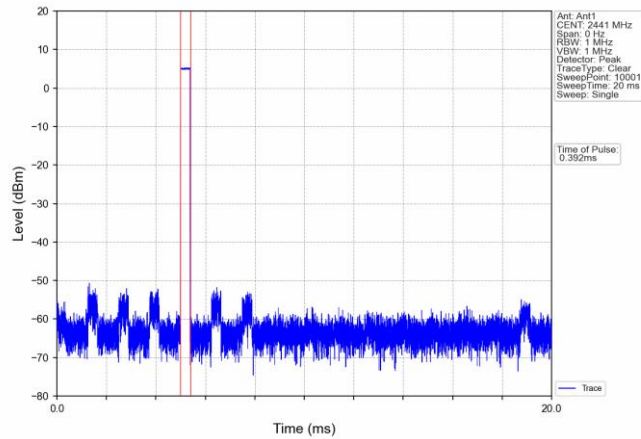
According to the Bluetooth Core Specification, the worse result (DH5, 2DH5, 3DH5 mode) was reported to show compliance.

The duration for dwell time calculation:  $0.4 \text{ [s]} * \text{hopping number} = 0.4 \text{ [s]} * 79 \text{ [ch]} = 31.6 \text{ [s]}$

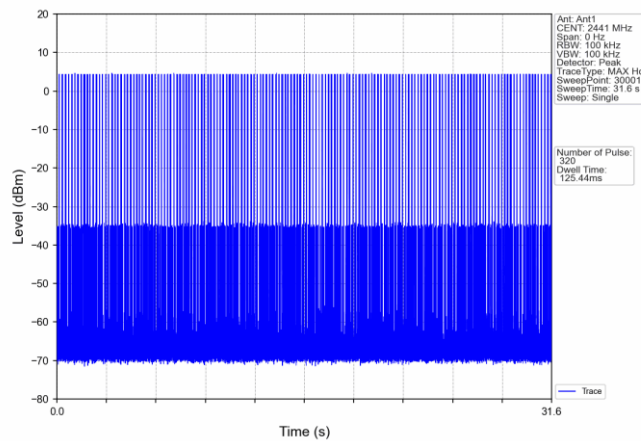
The Dwell Time = Burst Width \* Total Hops.

| Ant1      |         |                 |             |                               |                        |                                    |                 |            |         |
|-----------|---------|-----------------|-------------|-------------------------------|------------------------|------------------------------------|-----------------|------------|---------|
| Mode      | TX Type | Frequency (MHz) | Packet Type | Duration of Single Pulse (ms) | Observation Period (s) | Num of Pulse in Observation Period | Dwell Time (ms) | Limit (ms) | Verdict |
| GFSK      | SISO    | HOPP            | DH1         | 0.392                         | 31.600                 | 320                                | 125.440         | <=400      | Pass    |
|           |         |                 | DH3         | 1.640                         | 31.600                 | 164                                | 268.960         | <=400      | Pass    |
|           |         |                 | DH5         | 2.896                         | 31.600                 | 101                                | 292.496         | <=400      | Pass    |
| Pi/4DQPSK | SISO    | HOPP            | 2DH1        | 0.400                         | 31.600                 | 320                                | 128.000         | <=400      | Pass    |
|           |         |                 | 2DH3        | 1.648                         | 31.600                 | 168                                | 276.864         | <=400      | Pass    |
|           |         |                 | 2DH5        | 2.902                         | 31.600                 | 120                                | 348.240         | <=400      | Pass    |
| 8DPSK     | SISO    | HOPP            | 3DH1        | 0.396                         | 31.600                 | 320                                | 126.720         | <=400      | Pass    |
|           |         |                 | 3DH3        | 1.646                         | 31.600                 | 149                                | 245.254         | <=400      | Pass    |
|           |         |                 | 3DH5        | 2.904                         | 31.600                 | 100                                | 290.400         | <=400      | Pass    |

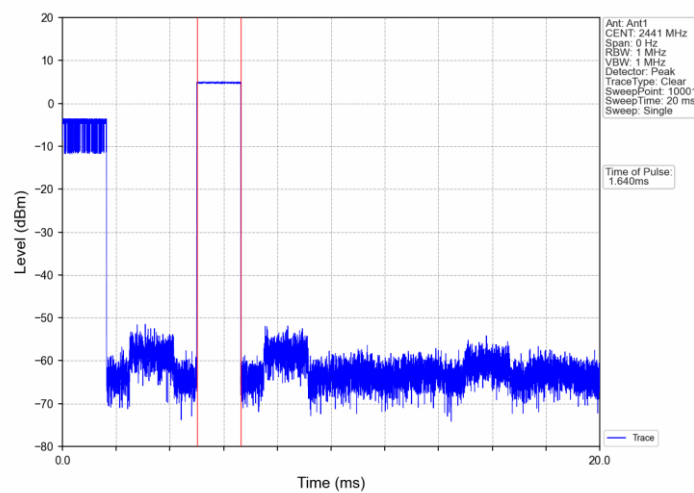
## GFSK\_DH1\_HOPP\_Ant1\_NTNV



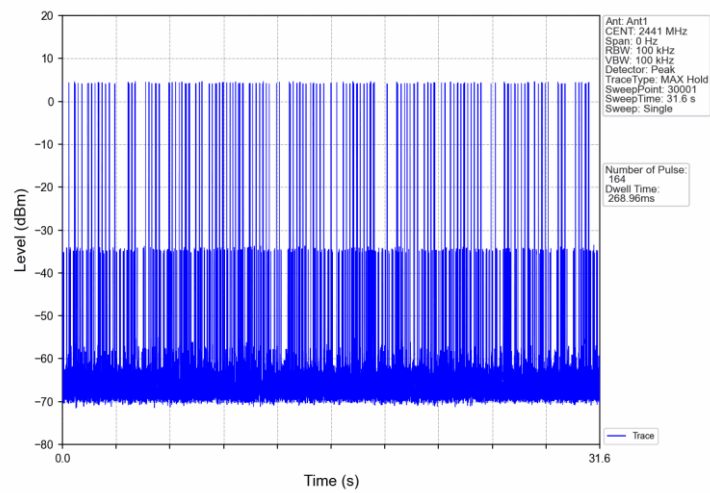
## GFSK\_DH1\_HOPP\_Ant1\_NTNV



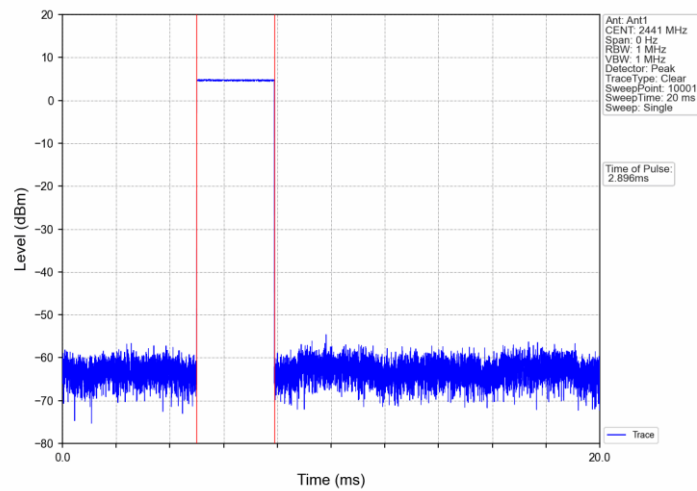
## GFSK\_DH3\_HOPP\_Ant1\_NTNV



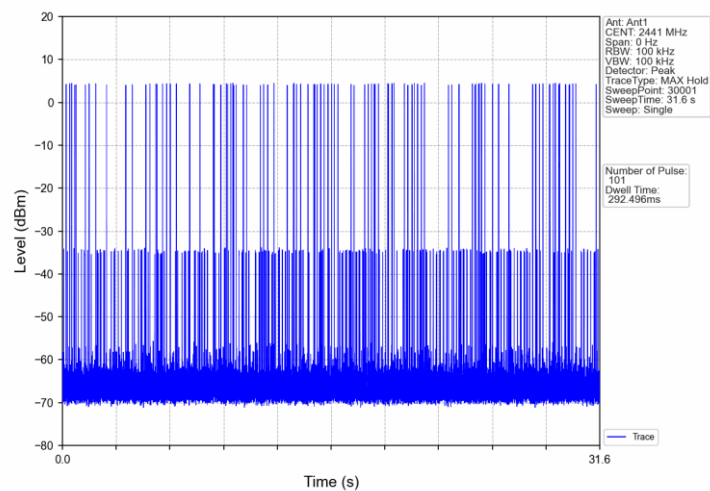
## GFSK\_DH3\_HOPP\_Ant1\_NTNV



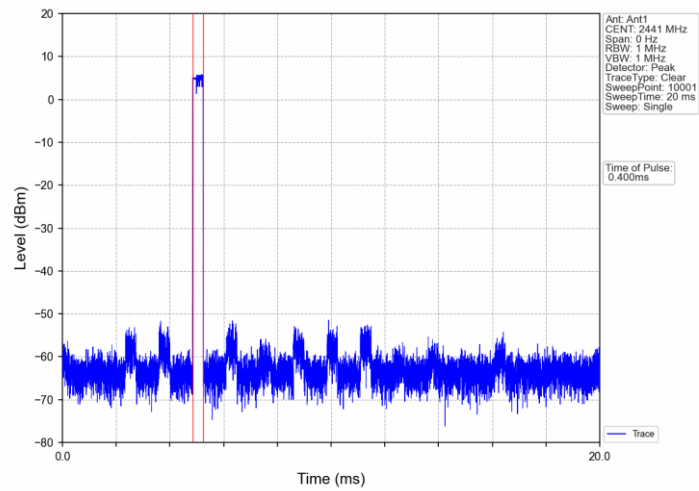
## GFSK\_DH5\_HOPP\_Ant1\_NTNV



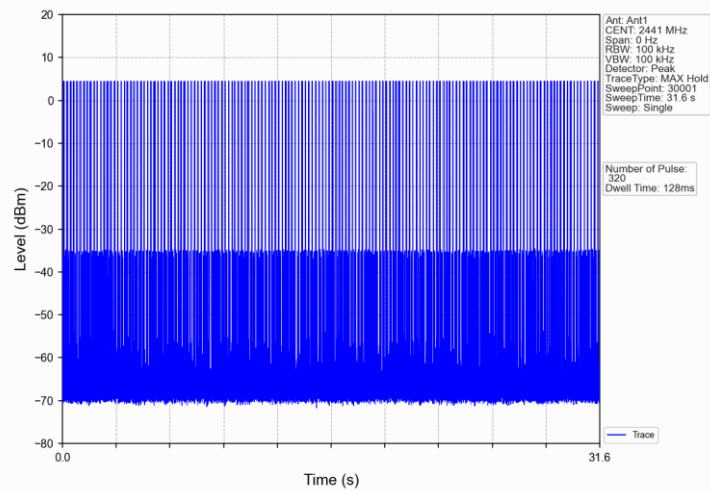
## GFSK\_DH5\_HOPP\_Ant1\_NTNV



## Pi/4DQPSK\_2DH1\_HOPP\_Ant1\_NTNV



## Pi/4DQPSK\_2DH1\_HOPP\_Ant1\_NTNV



## Pi/4DQPSK\_2DH3\_HOPP\_Ant1\_NTNV

