# FCC PART 15.247
# TEST REPORT

## On Behalf of

## CLICKWIN LLC.

530 S. Los Angeles St. Unit 2, Los Angeles, CA 90013. United States

**FCC ID:** 2BEF7-KB-TWS-C29
**Model:** KB-TWS-C29

March 11, 2024

| **This Report Concerns:** | **Equipment Type:** |
|---|---|
| ☒ Original Report | TWS Earphone |

| | |
|---|---|
| **Test Engineer:** | LBi Li / LBi Li |
| **Report Number:** | **QCT24CR-1332E-01** |
| **Test Date:** | March 4~6, 2024 |
| **Reviewed By:** | Gordon Tan/ Gordon.Tan |
| **Approved By:** | Kendy Wang / Kendy Wang |
| **Prepared By:** | **Shenzhen QC Testing Laboratory Co., Ltd.**<br>East of 1/F., Building E, Xinghong Science Park, No.111, Shuiku Road, Fenghuanggang, Xixiang Street, Bao'an District, Shenzhen, Guangdong, China<br>**Tel: 0755-23008269**<br>**Fax: 0755-23726780** |



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# Revision History of This Test Report

| Report Number | Description | Issued Date |
|---|---|---|
| QCT24CR-1332E-01 | Initial Issue | 2024-3-11 |
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# 1. GENERAL INFORMATION

## 1.1 Product Description for Equipment under Test (EUT)

| | |
|---|---|
| EUT Description: | TWS Earphone |
| Model No.: | KB-TWS-C29 |
| Tested Model: | KB-TWS-C29 |
| Sample(s) Status: | Engineer sample |
| Operation Frequency: | 2402MHz~2480MHz |
| Channel numbers: | 79 |
| Channel separation: | 1MHz |
| Modulation type: | GFSK, π/4-DQPSK, 8-DPSK |
| Antenna Type: | Chip Antenna |
| Antenna gain*1: | 2.78dBi |
| Power supply: | DC 5V(Powered by adapter)<br>DC 3.7V(Powered by battery) |
| Trade Mark: | KB KBOD |
| Applicant: | CLICKWIN LLC. |
| Address: | 530 S. Los Angeles St. Unit 2, Los Angeles, CA 90013. United States |
| Manufacturer: | GUANGDONG YILIAN INDUSTRIAL CO., LTD |
| Address: | No.319, Shipai Section, Dongyuan Avenue, Shipai Town, Dongguan City, Guangdong Province |
| Sample No.: | Y24C1332E01LY |

Note: *1This information provided by Manufacturer, SZ QC Lab is not responsible for the accuracy of this information.



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## 1.2 System Test Configuration

### 1.2.1 Channel List

| Operation Frequency each of channel | | | | | | | |
|---|---|---|---|---|---|---|---|
| Channel | Frequency | Channel | Frequency | Channel | Frequency | Channel | Frequency |
| 1 | 2402MHz | 21 | 2422MHz | 41 | 2442MHz | 61 | 2462MHz |
| 2 | 2403MHz | 22 | 2423MHz | 42 | 2443MHz | 62 | 2463MHz |
| 3 | 2404MHz | 23 | 2424MHz | 43 | 2444MHz | 63 | 2464MHz |
| 4 | 2405MHz | 24 | 2425MHz | 44 | 2445MHz | 64 | 2465MHz |
| 5 | 2406MHz | 25 | 2426MHz | 45 | 2446MHz | 65 | 2466MHz |
| 6 | 2407MHz | 26 | 2427MHz | 46 | 2447MHz | 66 | 2467MHz |
| 7 | 2408MHz | 27 | 2428MHz | 47 | 2448MHz | 67 | 2468MHz |
| 8 | 2409MHz | 28 | 2429MHz | 48 | 2449MHz | 68 | 2469MHz |
| 9 | 2410MHz | 29 | 2430MHz | 49 | 2450MHz | 69 | 2470MHz |
| 10 | 2411MHz | 30 | 2431MHz | 50 | 2451MHz | 70 | 2471MHz |
| 11 | 2412MHz | 31 | 2432MHz | 51 | 2452MHz | 71 | 2472MHz |
| 12 | 2413MHz | 32 | 2433MHz | 52 | 2453MHz | 72 | 2473MHz |
| 13 | 2414MHz | 33 | 2434MHz | 53 | 2454MHz | 73 | 2474MHz |
| 14 | 2415MHz | 34 | 2435MHz | 54 | 2455MHz | 74 | 2475MHz |
| 15 | 2416MHz | 35 | 2436MHz | 55 | 2456MHz | 75 | 2476MHz |
| 16 | 2417MHz | 36 | 2437MHz | 56 | 2457MHz | 76 | 2477MHz |
| 17 | 2418MHz | 37 | 2438MHz | 57 | 2458MHz | 77 | 2478MHz |
| 18 | 2419MHz | 38 | 2439MHz | 58 | 2459MHz | 78 | 2479MHz |
| 19 | 2420MHz | 39 | 2440MHz | 59 | 2460MHz | 79 | 2480MHz |
| 20 | 2421MHz | 40 | 2441MHz | 60 | 2461MHz | | |

Note: In section 15.31(m), regards to the operating frequency range over 10 MHz, the Lowest frequency, the middle frequency, and the highest frequency of channel were selected to perform the test, and the selected channel see below:

| Channel | Frequency | Channel | Frequency |
|---|---|---|---|
| The lowest channel | 2402MHz | The middle channel | 2441MHz |
| The Highest channel | 2480MHz | | |

### 1.2.2 EUT Exercise Software

" BT_Tool V1.1.0 " software was used to test, The power level is default. The software and power level was provided by the applicant.

### 1.2.3 Support Equipment

| Manufacturer | Description | Model | Serial Number |
|---|---|---|---|
| MDY | Adapter | Input: 100-240V~ 50/60Hz<br>Output: 5V ⎓ 1A | / |

### 1.2.4 Test mode

Transmitting mode: Keep the EUT in continuously transmitting.



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## 1.3 Test Facility

Test Firm : Shenzhen QC Testing Laboratory Co., Ltd.

The testing quality ability of our laboratory meet with "Quality Law of People's Republic of China" Clause 19. The testing quality system of our laboratory meets with ISO/IEC-17025 requirements. This approval result is accepted by MRA of APLAC.

Our test facility is recognized, certified, or accredited by the following organizations:

CNAS – Registration No.: L8464

The EMC Laboratory has been accredited by CNAS, and in compliance with ISO/IEC 17025:2017 General Requirements for testing Laboratories.

A2LA Certificate Number: 6759.01

The EMC Laboratory has been accredited by A2LA, and in compliance with ISO/IEC 17025:2017 General Requirements for testing Laboratories.

FCC Registration Number: 561109

The EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications commission.

IC Registration Number: 29628

CAB identifier: CN0141

The EMC Laboratory has been registered and fully described in a report filed with the (IC) Industry Canada.

## 1.4 Measurement Uncertainty

| Parameter | Uncertainty |
|---|---|
| Occupied Channel Bandwidth | ±1.42 x$10^{-4}$% |
| RF output power, conducted | ±1.06dB |
| Power Spectral Density, conducted | ±1.06dB |
| Unwanted Emissions, conducted | ±2.51dB |
| AC Power Line Conducted Emission | ±1.80dB |
| Radiated Spurious Emission test (9kHz-30MHz) | ±2.66dB |
| Radiated Spurious Emission test (30MHz-1000MHz) | ±4.04dB |
| Radiated Spurious Emission test (1000MHz-18000MHz) | ±4.70 dB |
| Radiated Spurious Emission test (18GHz-40GHz) | ±4.80dB |
| Temperature | ±0.8℃ |
| Humidity | ±3.2% |
| DC and low frequency voltages | ±0.1% |
| Time | ±5% |
| Duty cycle | ±5% |

Note: This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2



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## 2. Summary of Test Results

| Test Item | Section | Result |
|---|---|---|
| Antenna Requirement | 15.203/15.247 (c) | Pass |
| AC Power Line Conducted Emission | 15.207 | Pass |
| Conducted Peak Output Power | 15.247 (b)(1) | Pass |
| 20dB Occupied Bandwidth | 15.247 (a)(1) | Pass |
| Carrier Frequencies Separation | 15.247 (a)(1) | Pass |
| Hopping Channel Number | 15.247 (b)(1) | Pass |
| Dwell Time | 15.247 (a)(1)(iii) | Pass |
| Radiated Emission | 15.205/15.209 | Pass |
| Band Edge | 15.247(d) | Pass |

Note: 1. Pass: The EUT complies with the essential requirements in the standard.

2. All indications of Pass/Fail in this report are opinions expressed by Shenzhen QC Testing Laboratory Co., Ltd. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only.



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# 3. List of Test and Measurement Instruments

## 3.1 Conducted Emission Test

| Item | Equipment | Manufacturer | Model No. | Serial No. | Last Cal. | Cal.Due |
|---|---|---|---|---|---|---|
| 1 | EMI Test Receiver | R&S | ESIB 7 | 2277573376 | 2023.03.21 | 2024.03.20 |
| 2 | Artificial Mains Network | SCHWARZBECK | NSLK8126 | 8126200 | 2023.03.21 | 2024.03.20 |
| 3 | PULSE LIMITER | R&S | ESH3-Z2 | 100058 | 2023.03.21 | 2024.03.20 |
| 4 | EMITEST RECEIVER | ROHDE & SCHWARZ | ESCS30 | 834115/014 | 2023.03.21 | 2024.03.20 |
| Conducted Emission Measurement Software: TS | | | | | | |

## 3.2 Radiated Emission Test

| Item | Equipment | Manufacturer | Model No. | Serial No. | Last Cal. | Cal.Due |
|---|---|---|---|---|---|---|
| 1. | Spectrum Analyzer | ROHDE&SCHWARZ | FSV 40 | 101458 | 2023.04.12 | 2024.04.11 |
| 2. | Loop Antenna | EMCO | 6502 | 2133 | 2022.07.23 | 2024.07.22 |
| 3. | Logarithmic compound broadband Antenna | SCKWARZBECK | VULB9168 | VULB9168-1-588 | 2023.04.01 | 2025.03.31 |
| 4. | EMI TEST RECEIVER | ROHDE & SCHWARZ | ESIB 7 | 2277573376 | 2023.04.12 | 2024.04.11 |
| 5. | EMI Test Receiver | R&S | ESPI | 101131 | 2023.03.21 | 2024.03.20 |
| 6. | Horn Antenna | SCHWARZBECK | BBHA9120D | 02069 | 2023.04.01 | 2025.03.31 |
| 7. | Horn Antenna | COM-MW | ZLB7-18-40G -950 | 12221225 | 2023.01.12 | 2025.01.09 |
| 8. | Amplifier | R&S | BBV9721 | 9721-031 | 2023.03.21 | 2024.03.20 |
| 9. | Amplifier | HPX | BP-01G-18G | 210902 | 2023.03.21 | 2024.03.20 |
| 10. | Pre-amplifier | COM-MW | DLAN-18000 -40000-02 | 10229104 | 2023.03.21 | 2024.03.20 |
| 11. | 966 Chamber | ZhongYu Electron | 9*6*6 | / | 2022.07.25 | 2025.07.24 |
| Radiated Emission Measurement Software: EZ_EMC | | | | | | |


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## 3.3 RF Conducted test

| Item | Equipment | Manufacturer | Model No. | Serial No. | Last Cal. | Cal.Due |
|---|---|---|---|---|---|---|
| 1. | Wideband Radio Communication Tester | Rohde & Schwarz | CW500 | 151583 | 2023.03.21 | 2024.03.20 |
| 2. | Spectrum Analyzer | ROHDE& SCHWARZ | FSV 40 | 101458 | 2023.04.12 | 2024.04.11 |
| 3. | Signal Generator | Agilent | N5182A | MY50141563 | 2023.03.21 | 2024.03.20 |
| 4. | RF Automatic Test System | MW | MW100-RFCB/ MW100-PSB | MW2007004 | 2023.03.21 | 2024.03.20 |
| RF Conducted Measurement Software: MTS 8310 | | | | | | |


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# 4. Antenna requirement

**Standard requirement:** FCC Part15 C Section 15.203 /247(c)

15.203 requirement:
An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.
15.247(c) (1)(i) requirement:
(i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

**EUT Antenna:** The Ant is Chip Antenna, the best case gain of the antenna is 2.78dBi, reference to the Internal photo for details.


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# 5. Conducted Emissions

## 5.1 Applicable Standard

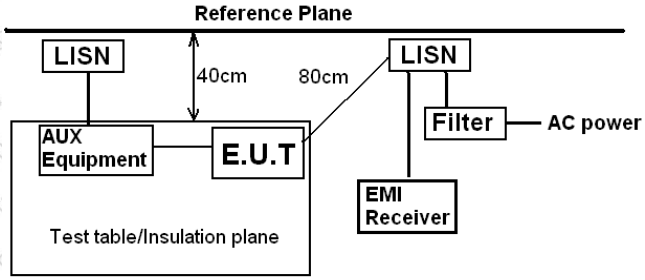
FCC Part15 C Section 15.207

## 5.2 Limit

| Frequency range (MHz) | Limit (dBμV) | |
|---|---|---|
| | Quasi-peak | Average |
| 0.15-0.5 | 66 to 56* | 56 to 46* |
| 0.5-5 | 56 | 46 |
| 5-30 | 60 | 50 |

Note *: The level decreases linearly with the logarithm of the frequency.

## 5.3 Test setup




*Remark:*
*E.U.T: Equipment Under Test*
*LISN: Line Impedence Stabilization Network*
*Test table height=0.8m*

## 5.4 EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.
RBW=9 kHz, VBW=30 kHz, Sweep time=auto

## 5.5 Test procedure

1. The E.U.T and simulators are connected to the main power through a line impedance stabilization network (L.I.S.N.). This provides a 50ohm/50uH coupling impedance for the measuring equipment.
2. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm/50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs).
3. Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10 on conducted measurement.

## 5.6 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23℃ | Humidity | 50% |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Test voltage: AC 120V/60Hz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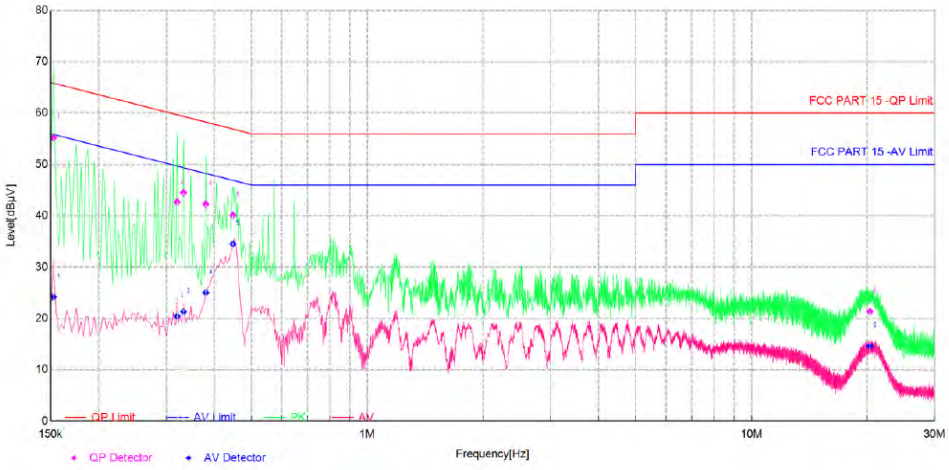
**Measurement data:**

Pre-scan all test modes, found worst case at GFSK 2402MHz, and so only show the test result of GFSK 2402MHz.

**Line:**




| Final Data List | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Factor[dB] | QP Value [dBμV] | QP Limit [dBμV] | QP Margin [dB] | AV Value [dBμV] | AV Limit [dBμV] | AV Margin [dB] | Phase | Verdict |
| 1 | 0.1525 | 10.02 | 55.22 | 65.86 | 10.64 | 24.19 | 55.86 | 31.67 | L | PASS |
| 2 | 0.3200 | 10.43 | 42.71 | 59.71 | 17.00 | 20.44 | 49.71 | 29.27 | L | PASS |
| 3 | 0.3325 | 10.37 | 44.53 | 59.39 | 14.86 | 21.32 | 49.39 | 28.07 | L | PASS |
| 4 | 0.3800 | 10.13 | 42.27 | 58.28 | 16.01 | 25.01 | 48.28 | 23.27 | L | PASS |
| 5 | 0.4475 | 10.15 | 40.11 | 56.92 | 16.81 | 34.52 | 46.92 | 12.40 | L | PASS |
| 6 | 20.3465 | 10.35 | 21.36 | 60.00 | 38.64 | 14.62 | 50.00 | 35.38 | L | PASS |



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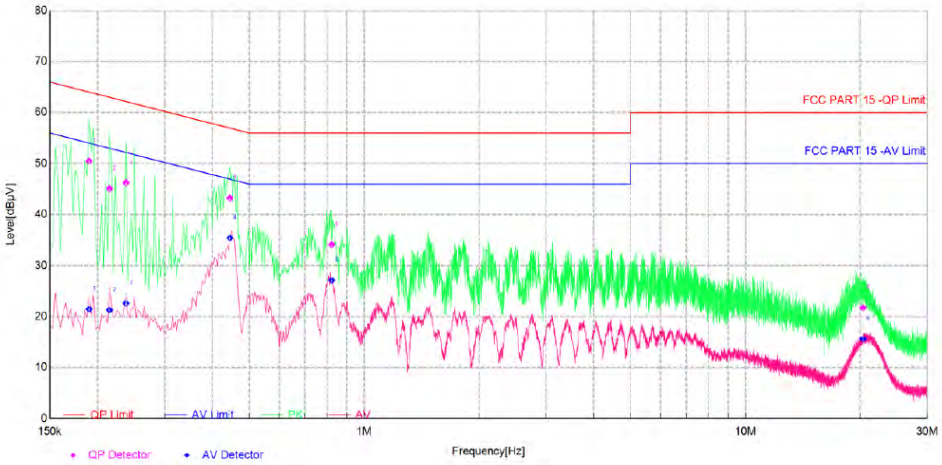
**Neutral:**




| Final Data List | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| NO. | Freq. [MHz] | Factor[dB] | QP Value [dBμV] | QP Limit [dBμV] | QP Margin [dB] | AV Value [dBμV] | AV Limit [dBμV] | AV Margin [dB] | Phase | Verdict |
| 1 | 0.1900 | 10.25 | 50.52 | 64.04 | 13.52 | 21.47 | 54.04 | 32.57 | N | PASS |
| 2 | 0.2150 | 10.35 | 45.10 | 63.01 | 17.91 | 21.27 | 53.01 | 31.74 | N | PASS |
| 3 | 0.2375 | 10.38 | 46.26 | 62.18 | 15.92 | 22.64 | 52.18 | 29.54 | N | PASS |
| 4 | 0.4450 | 10.36 | 43.25 | 56.97 | 13.72 | 35.43 | 46.97 | 11.54 | N | PASS |
| 5 | 0.8225 | 10.08 | 34.11 | 56.00 | 21.89 | 27.15 | 46.00 | 18.85 | N | PASS |
| 6 | 20.3330 | 10.40 | 21.72 | 60.00 | 38.28 | 15.61 | 50.00 | 34.39 | N | PASS |

Notes:

1. An initial pre-scan was performed on the line and neutral lines with peak detector.
2. Quasi-Peak and Average measurement were performed at the frequencies with maximized peak emission.



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# 6. Conducted Peak Output Power

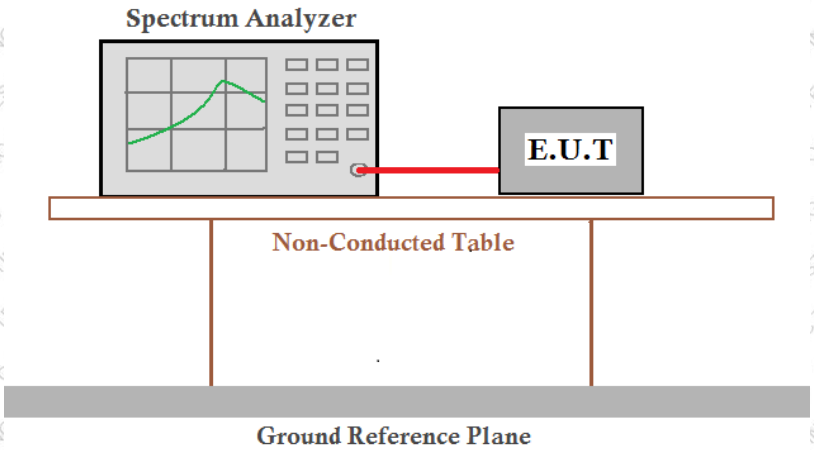
## 6.1 Applicable Standard

FCC Part15 C Section 15.247 (a)(1)

## 6.2 Limit

For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

## 6.3 Test setup




## 6.4 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23.5 ℃ | Humidity | 50 % |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Please refer to following table and plots.



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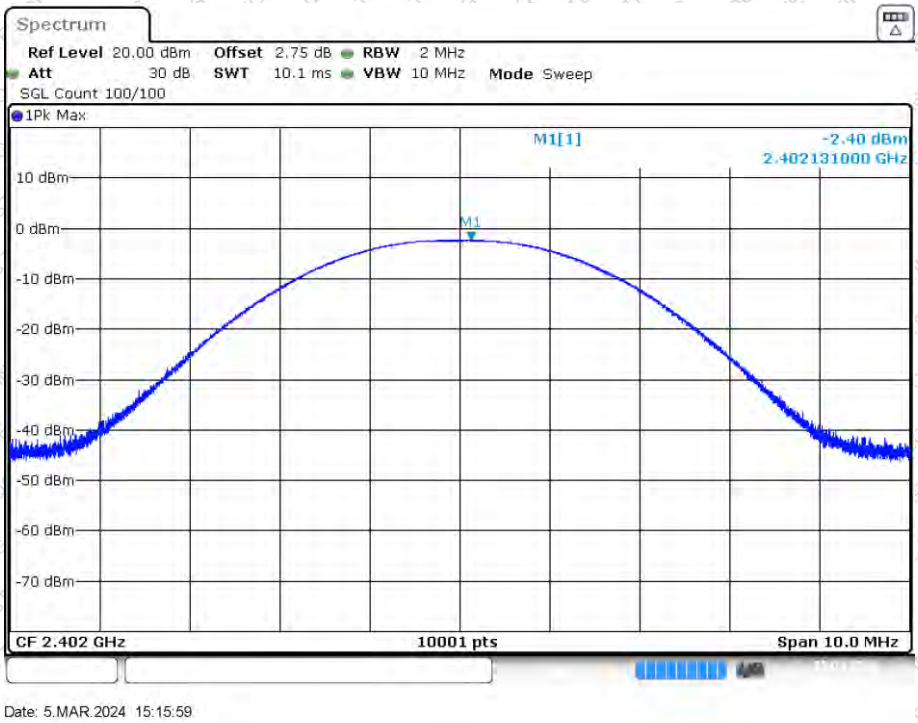
**Output Power:**

| Mode | Test channel | Peak Output Power (dBm) | Limit (dBm) | Result |
|---|---|---|---|---|
| GFSK | Lowest | -2.40 | 20.97 | Pass |
| | Middle | -1.18 | | |
| | Highest | -1.91 | | |
| π/4-DQPSK | Lowest | -1.44 | 20.97 | Pass |
| | Middle | **-0.22** | | |
| | Highest | -0.93 | | |
| 8-DPSK | Lowest | -1.40 | 20.97 | Pass |
| | Middle | **-0.22** | | |
| | Highest | -0.92 | | |

Power NVNT 1-DH1 2402MHz Ant1



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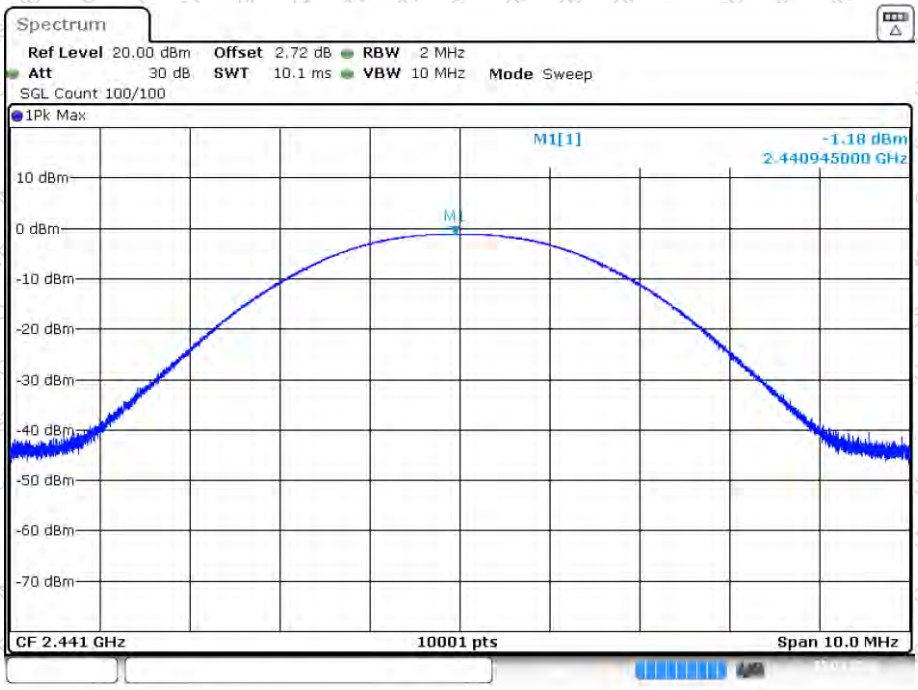
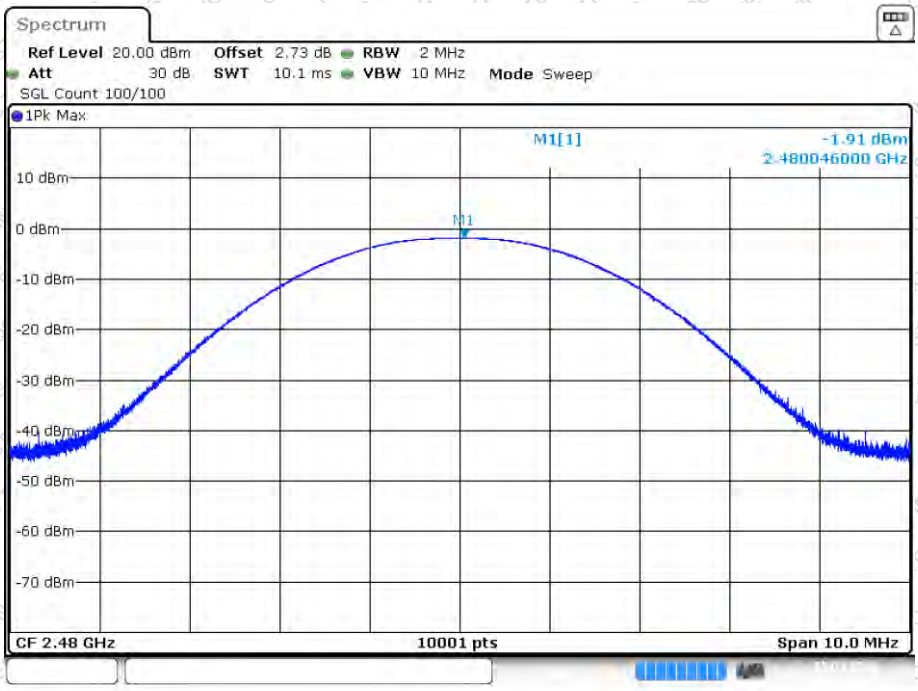
Power NVNT 1-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:12:45

Power NVNT 1-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:13:33



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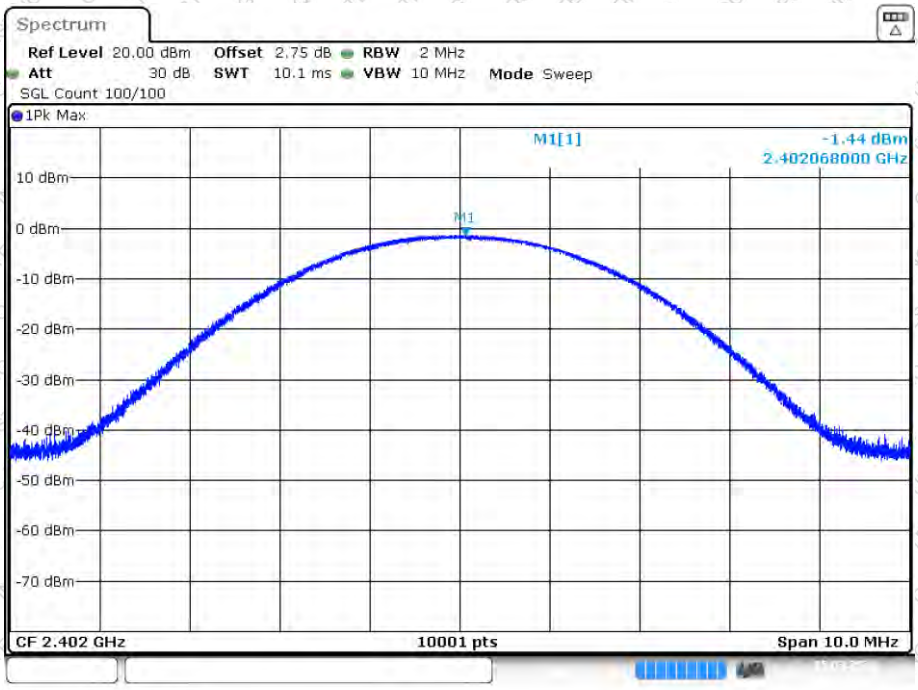
Power NVNT 2-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:22:49

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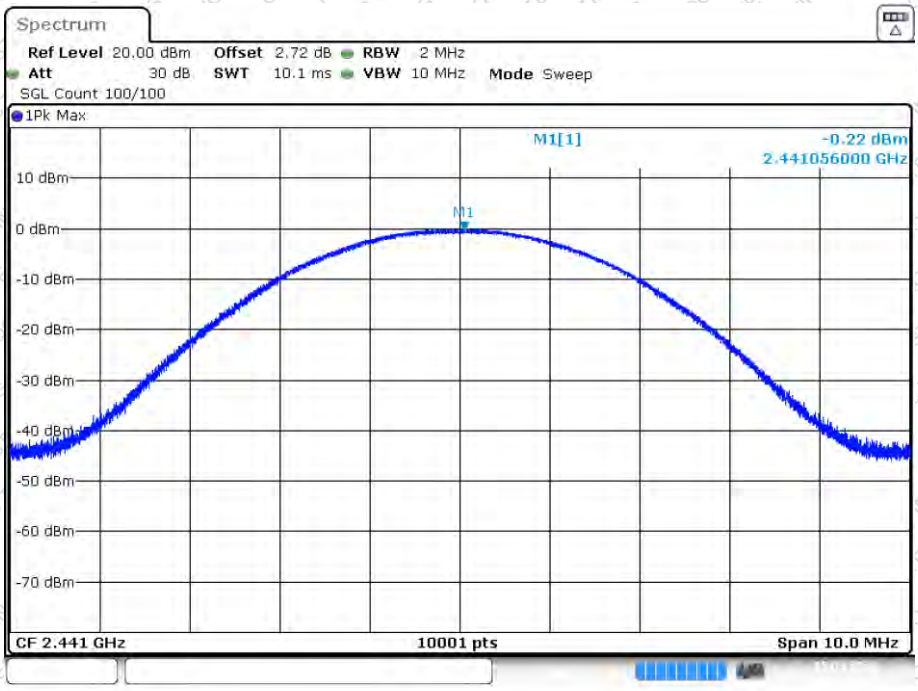


Date: 5.MAR.2024 15:23:51



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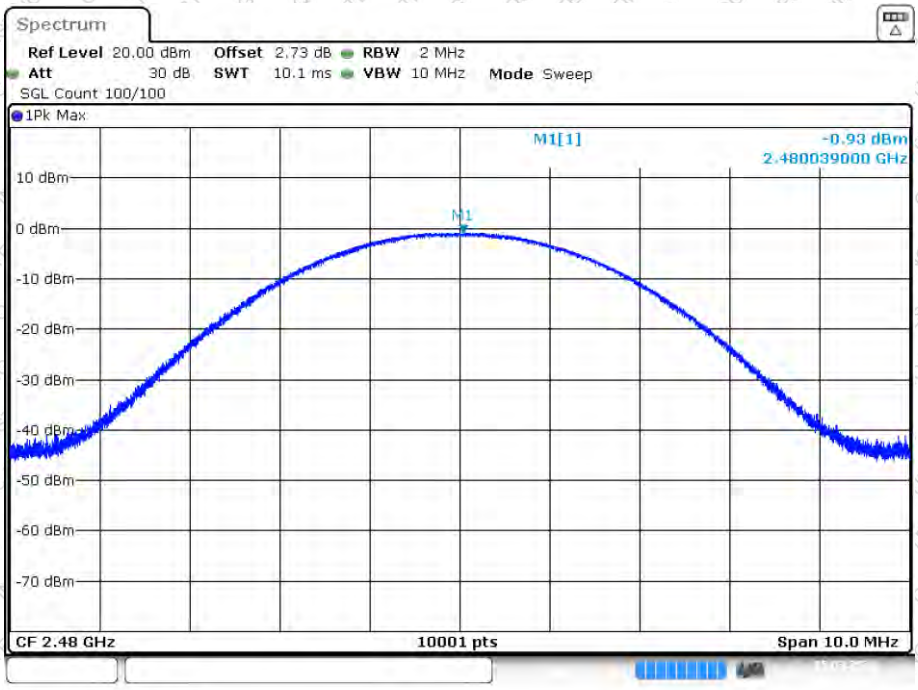
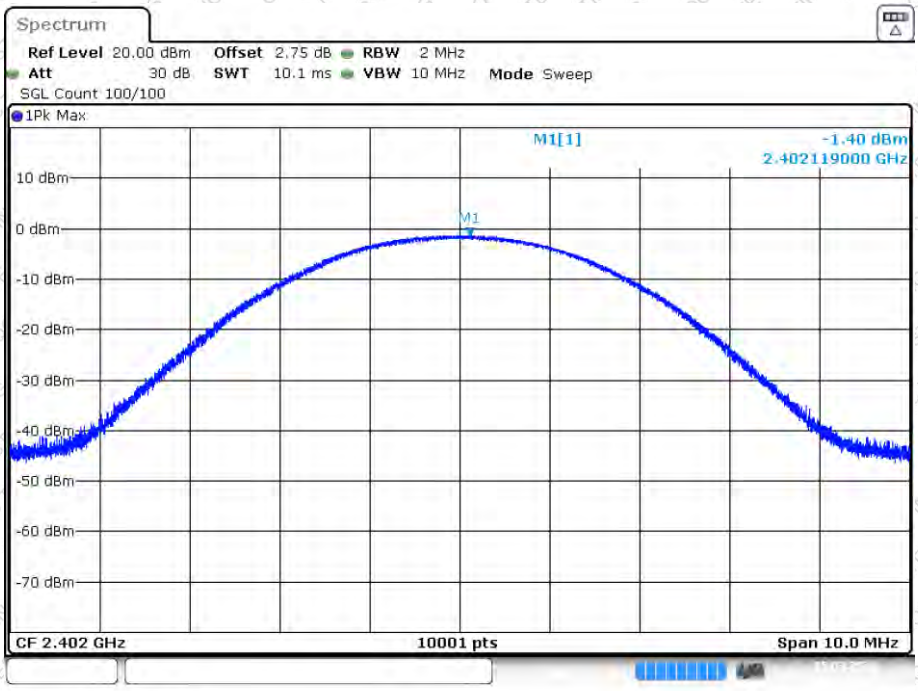
Power NVNT 2-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:24:44

Power NVNT 3-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:31:37



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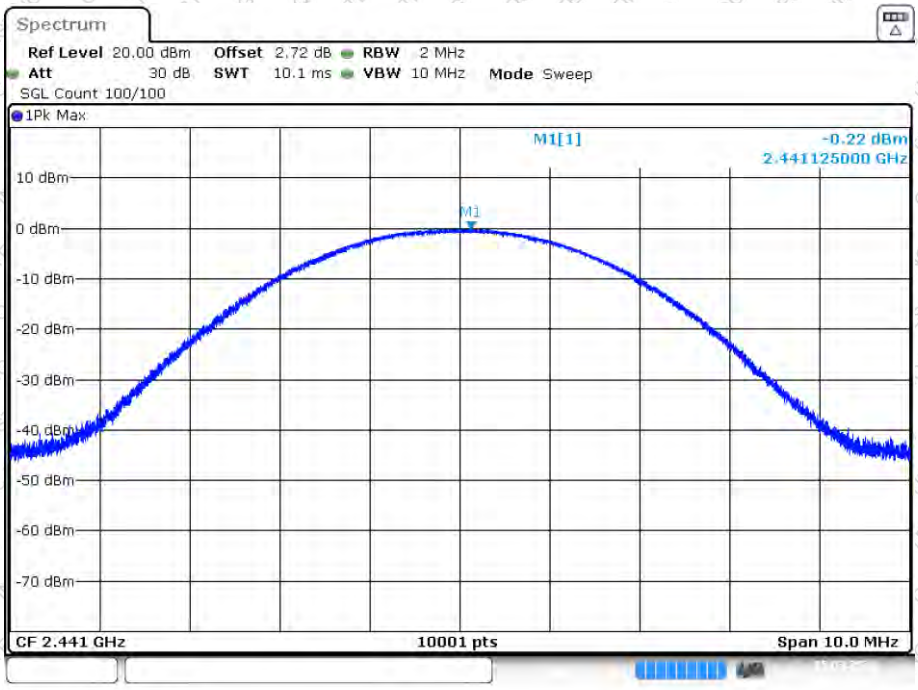
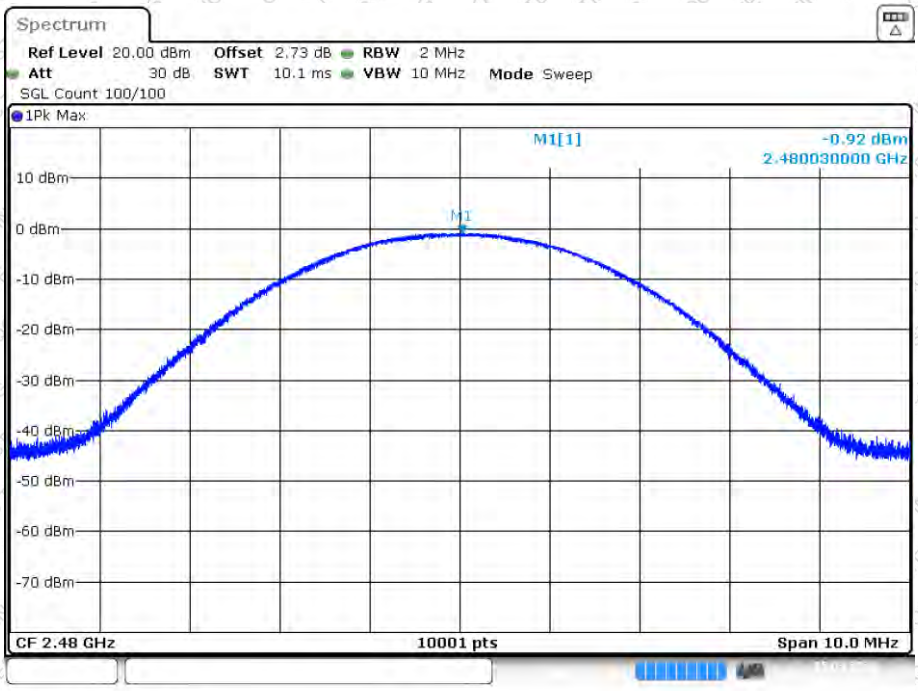
Power NVNT 3-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:32:40

Power NVNT 3-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:33:37



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# 7. 20dB Emission Bandwidth

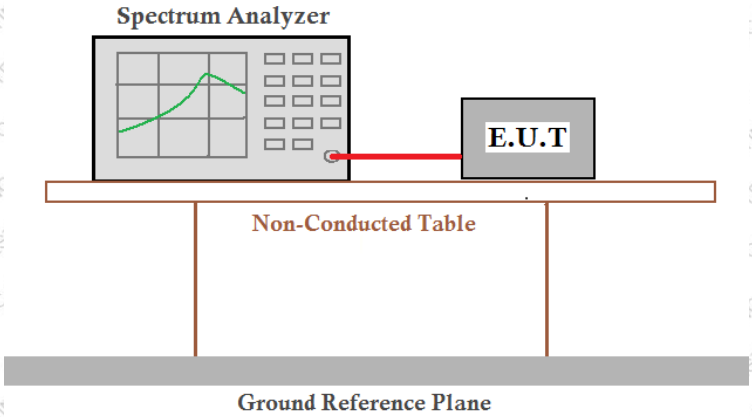
## 7.1 Applicable Standard

FCC Part15 C Section 15.247 (a)(1)

## 7.2 Limit

N/A

## 7.3 Test setup




## 7.4 Test Procedure

The following conditions shall be observed for measuring the occupied bandwidth and x dB bandwidth:

• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / x dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / x dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).

## 7.5 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23.5 ℃ | Humidity | 50 % |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Please refer to following table and plots.



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## Measurement Data

| Test CH | 20dB Emission Bandwidth (MHz) | | | Result |
|---|---|---|---|---|
| | GFSK | π/4-DQPSK | 8-DPSK | |
| Lowest | 0.855 | 1.235 | 1.241 | Pass |
| Middle | 0.876 | 1.237 | 1.237 | |
| Highest | 0.866 | 1.238 | 1.231 | |

| Test CH | 99% Occupy Bandwidth (MHz) | | | Result |
|---|---|---|---|---|
| | GFSK | π/4-DQPSK | 8-DPSK | |
| Lowest | 0.836 | 1.164 | 1.163 | Pass |
| Middle | 0.825 | 1.158 | 1.157 | |
| Highest | 0.830 | 1.158 | 1.157 | |


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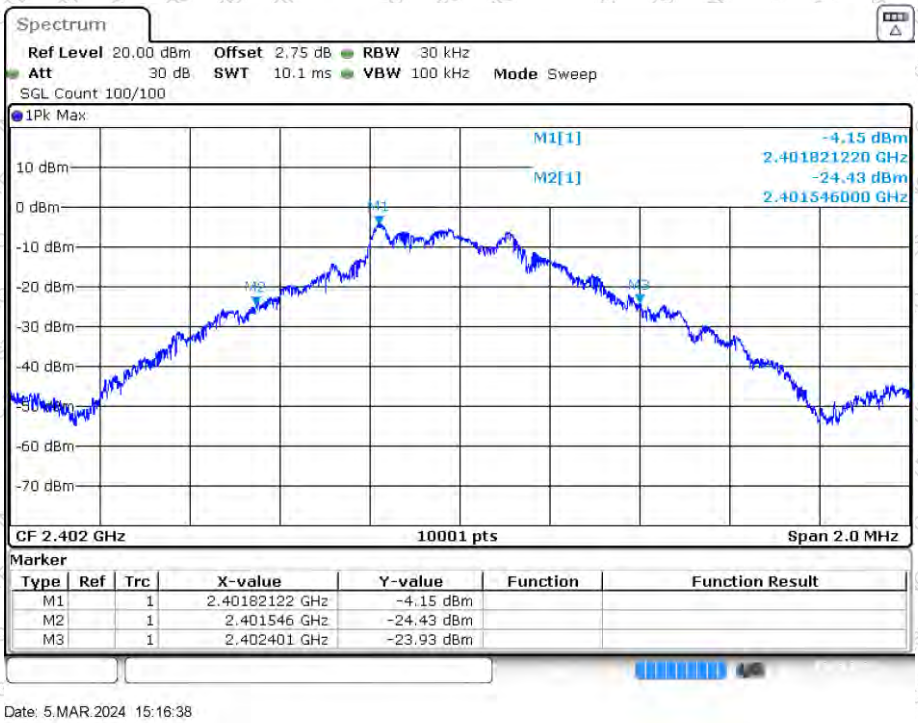
**-20dB Bandwidth:**

-20dB Bandwidth NVNT 1-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:16:38

-20dB Bandwidth NVNT 1-DH1 2441MHz Ant1

Date: 5.MAR.2024 15:13:16



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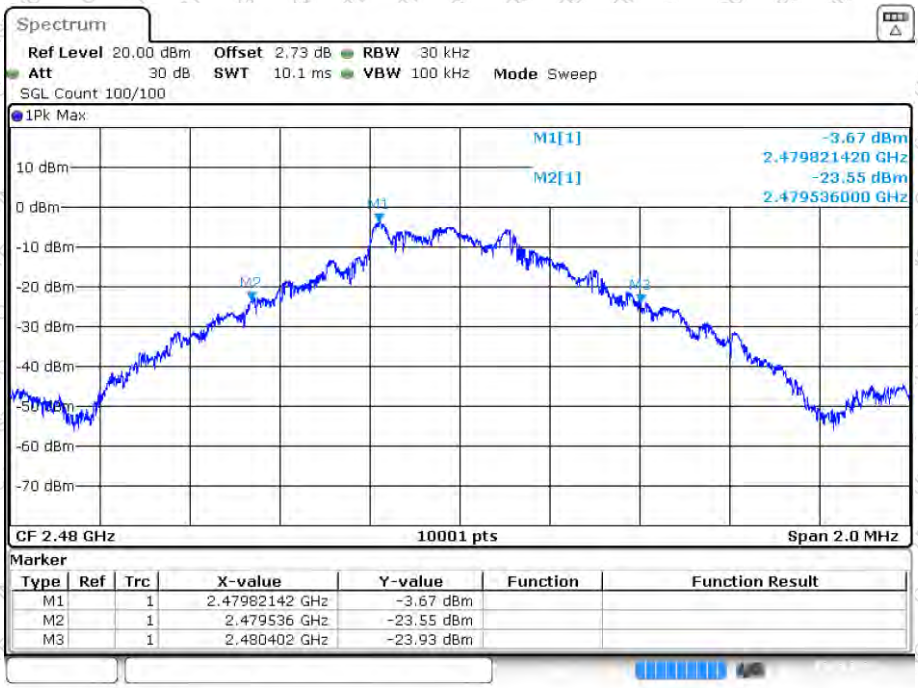
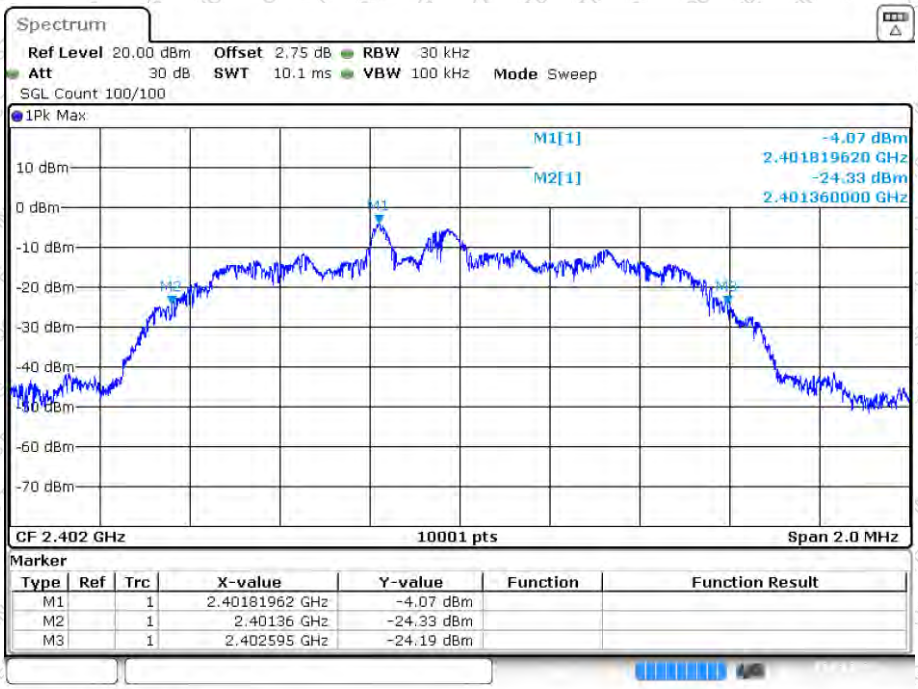
## -20dB Bandwidth NVNT 1-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:14:10

## -20dB Bandwidth NVNT 2-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:23:30



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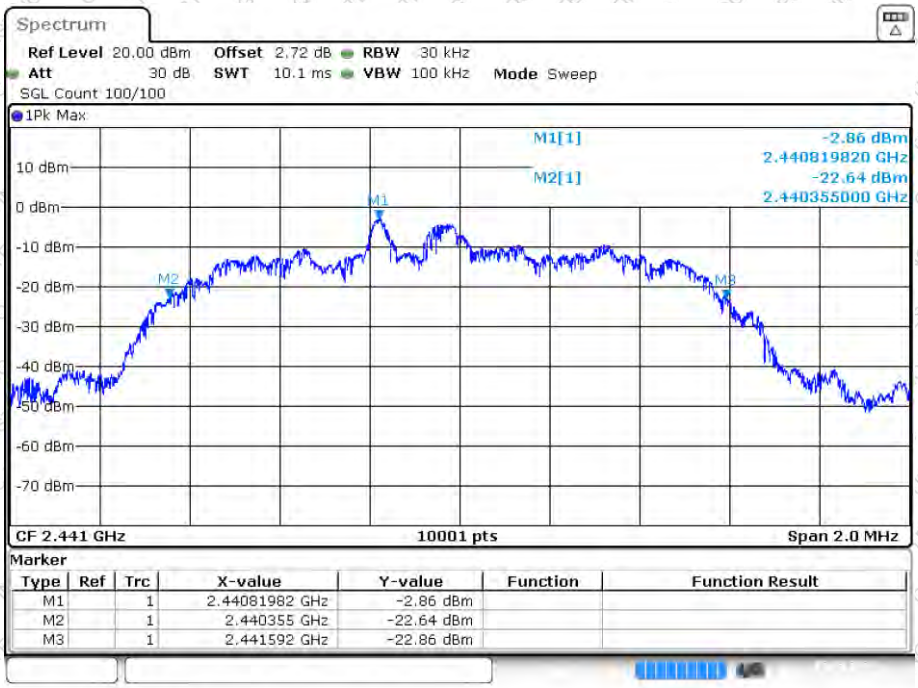
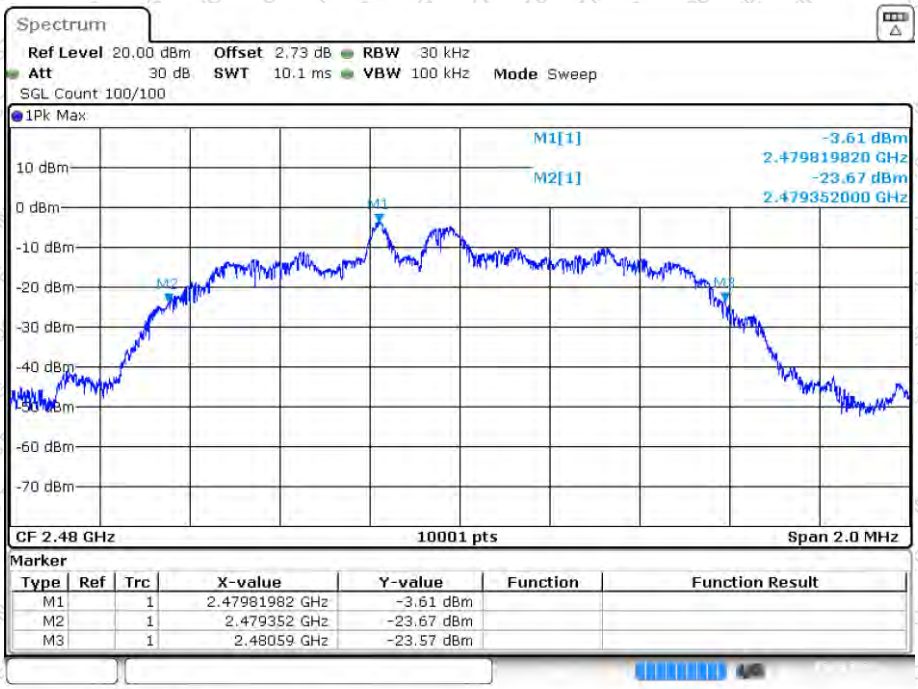
-20dB Bandwidth NVNT 2-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:24:26

-20dB Bandwidth NVNT 2-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:25:26



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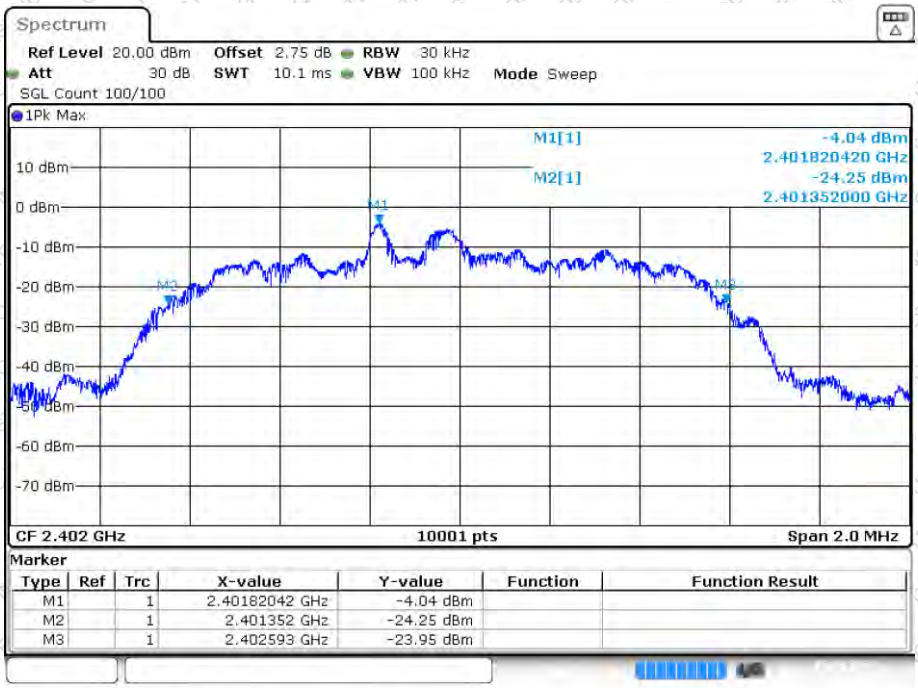
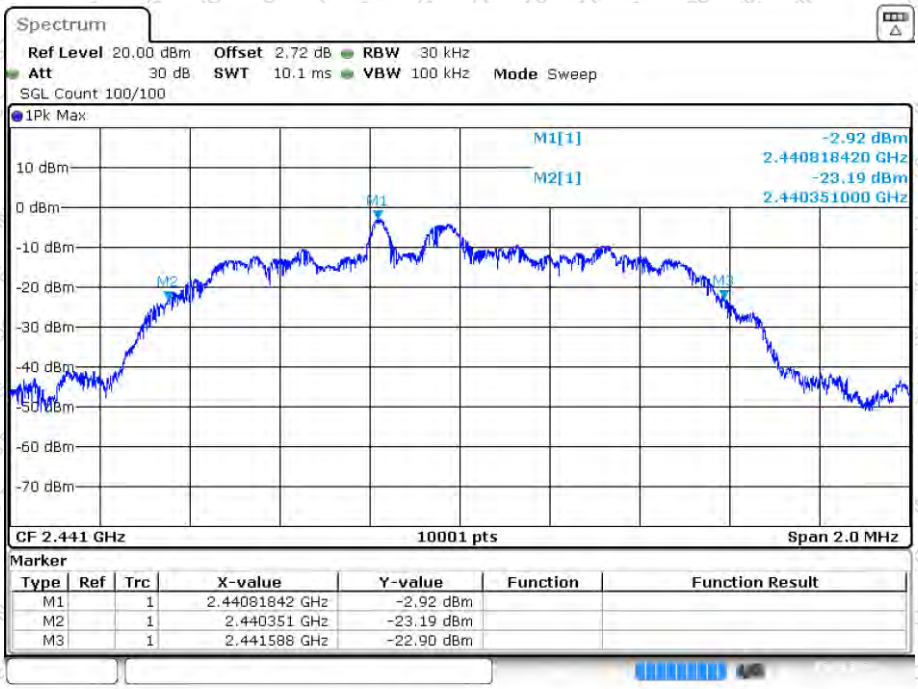
-20dB Bandwidth NVNT 3-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:32:22

-20dB Bandwidth NVNT 3-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:33:18



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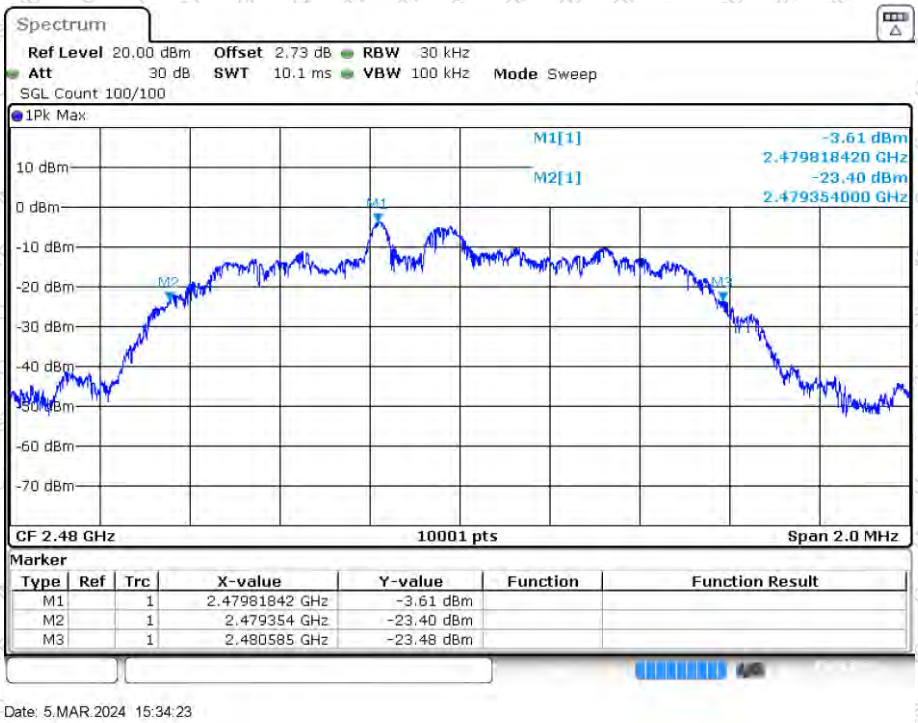
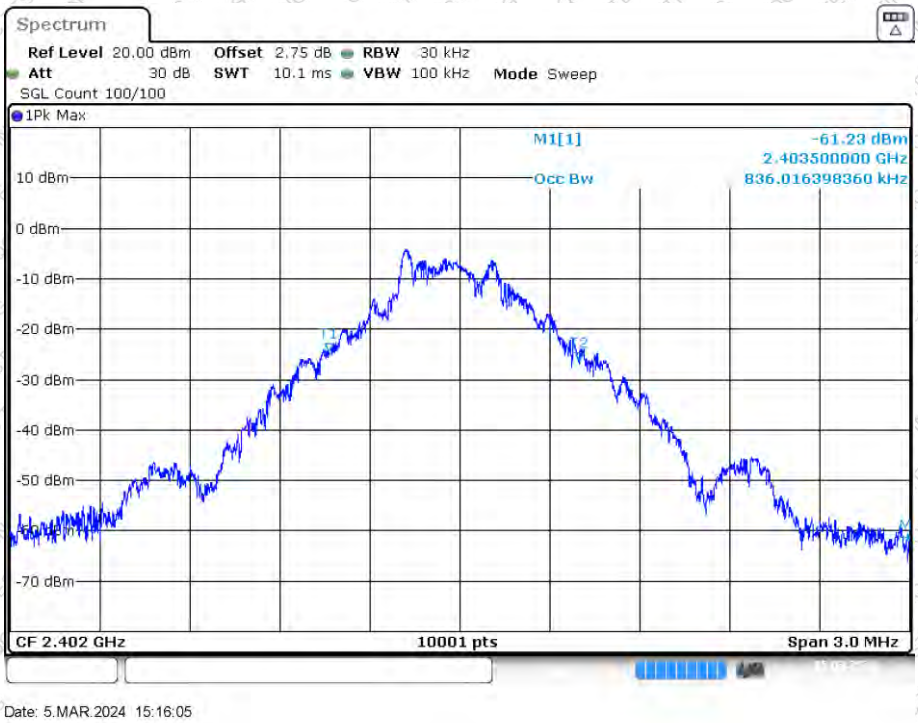
-20dB Bandwidth NVNT 3-DH1 2480MHz Ant1




**99% Occupied Bandwidth:**

OBW NVNT 1-DH1 2402MHz Ant1



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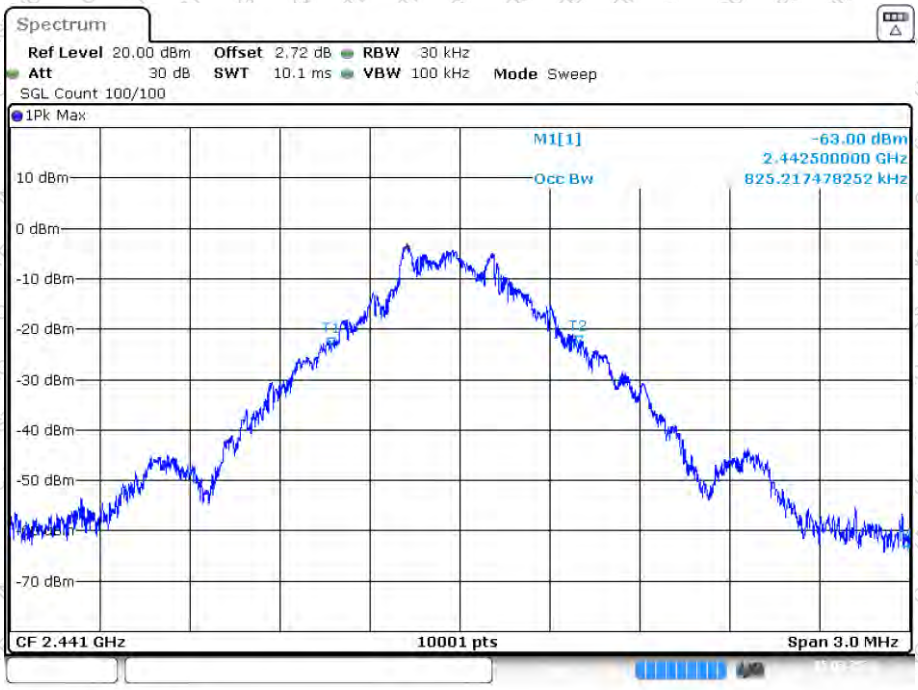
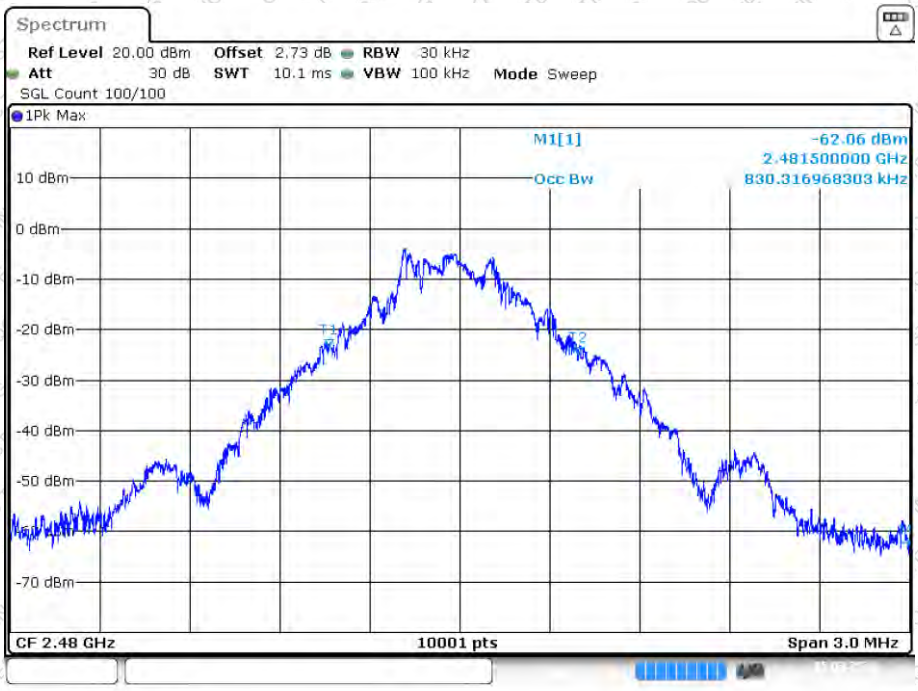
OBW NVNT 1-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:12:50

OBW NVNT 1-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:13:38



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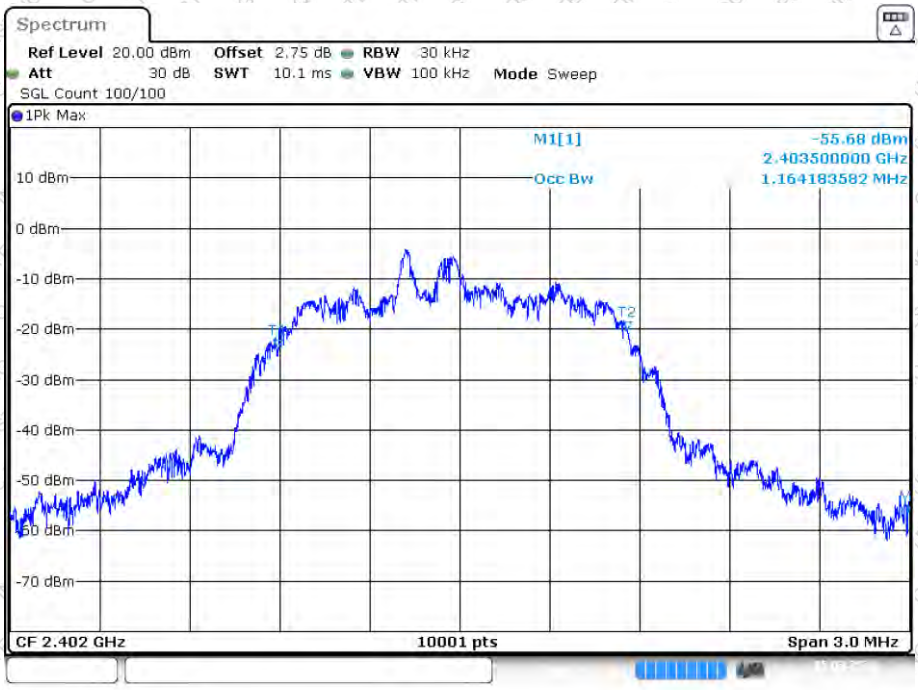
OBW NVNT 2-DH1 2402MHz Ant1

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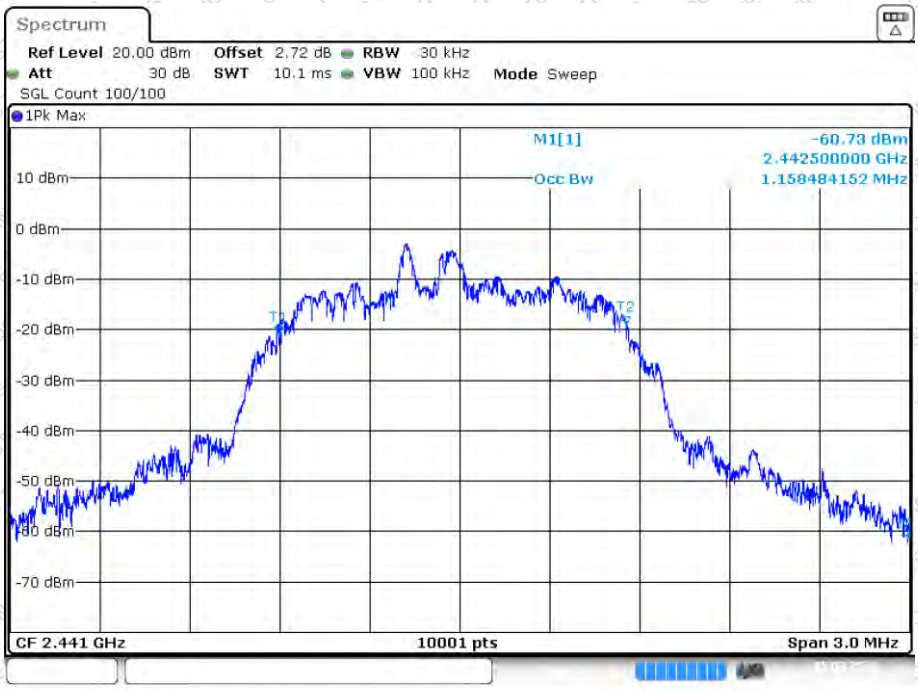


Date: 5.MAR.2024 15:23:58



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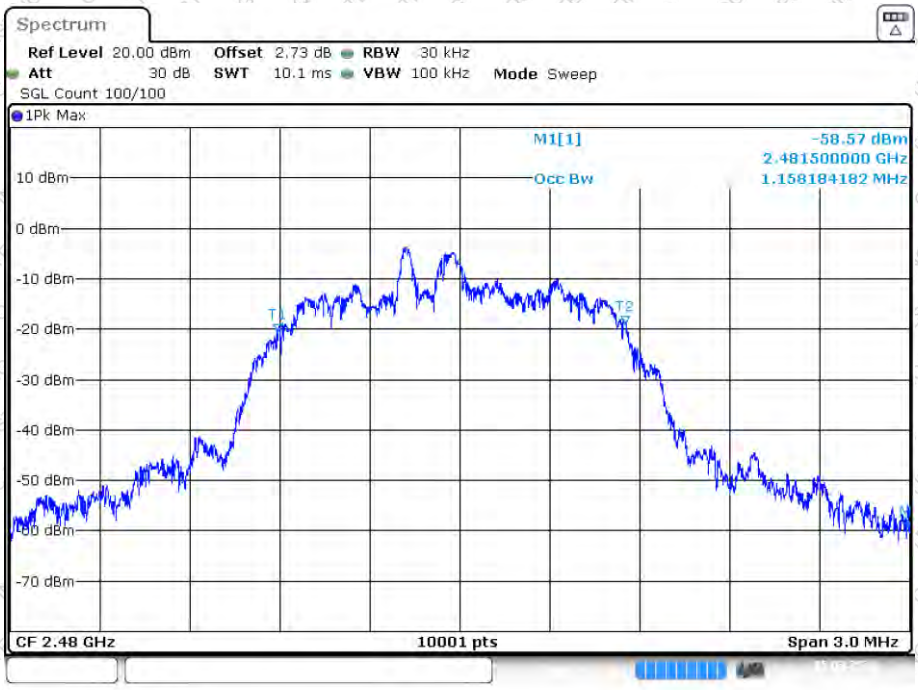
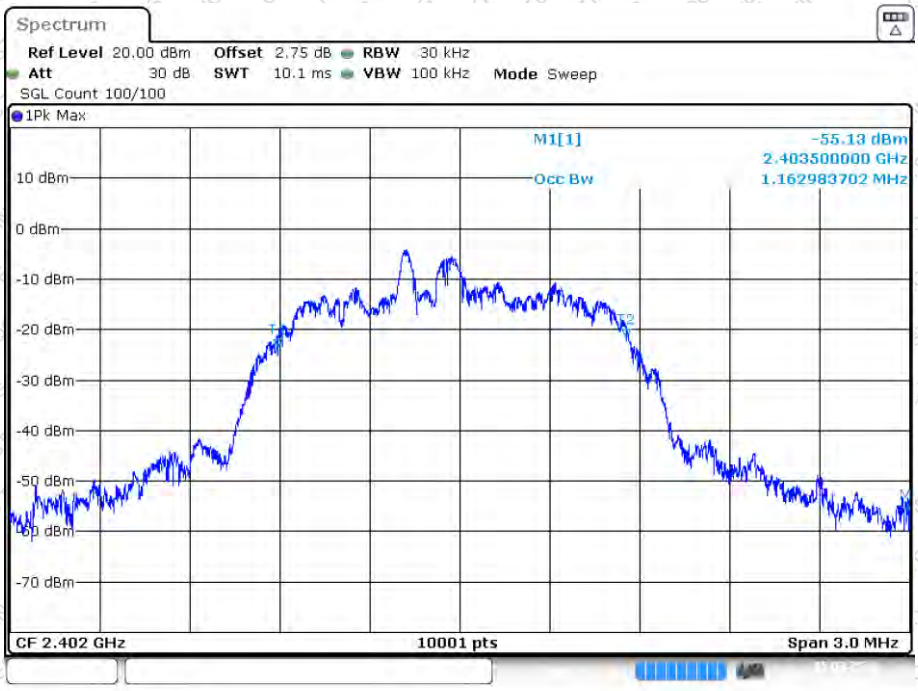
OBW NVNT 2-DH1 2480MHz Ant1




Date: 5.MAR.2024 15:24:50

OBW NVNT 3-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:31:44



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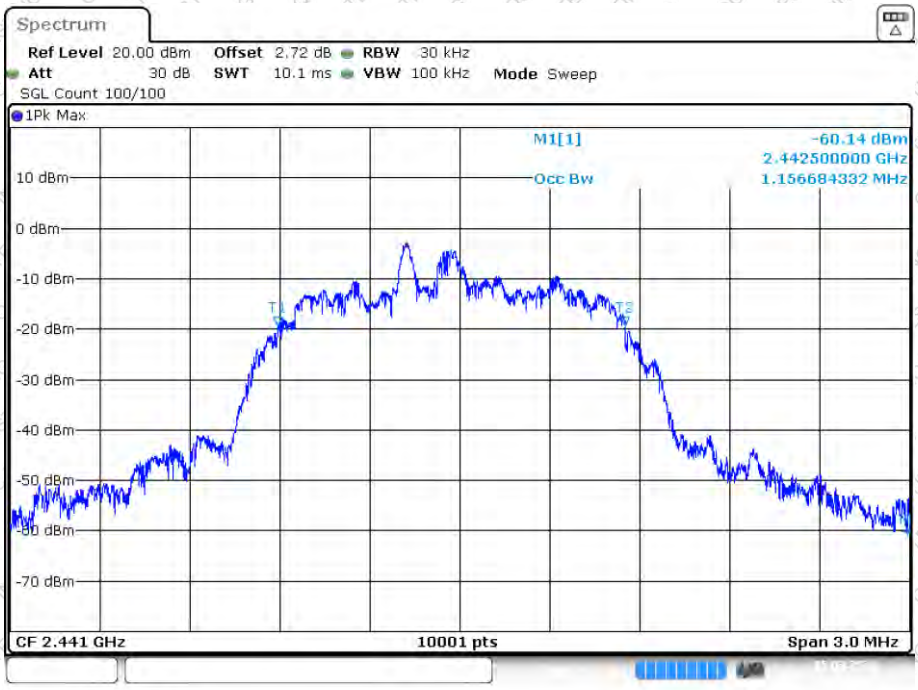
OBW NVNT 3-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:32:47

OBW NVNT 3-DH1 2480MHz Ant1

Date: 5.MAR.2024 15:33:44



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# 8. Carrier Frequencies Separation

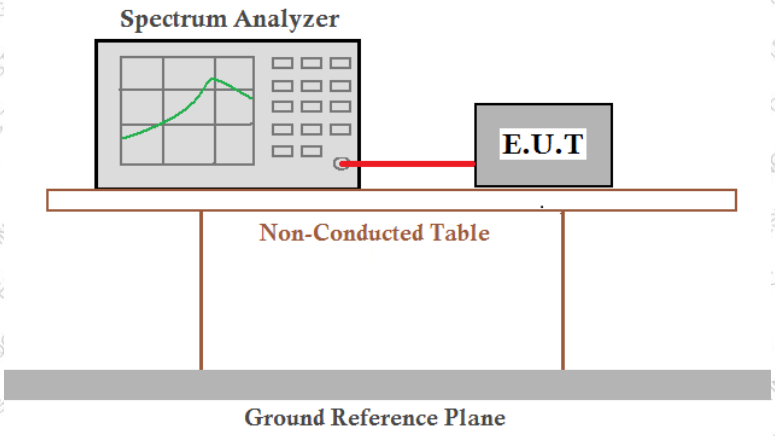
## 8.1 Applicable Standard

FCC Part15 C Section 15.247 (a)(1)

## 8.2 Limit

Frequency hopping systems shall have hoping 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. 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.

## 8.3 Test setup




## 8.4 Test Procedure

1. Set the EUT in transmitting mode, max hold the channel.
2. Set the adjacent channel of the EUT and max hold another trace.
3. Measure the channel separation.

## 8.5 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23.5 ℃ | Humidity | 50 % |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Please refer to following table and plots.



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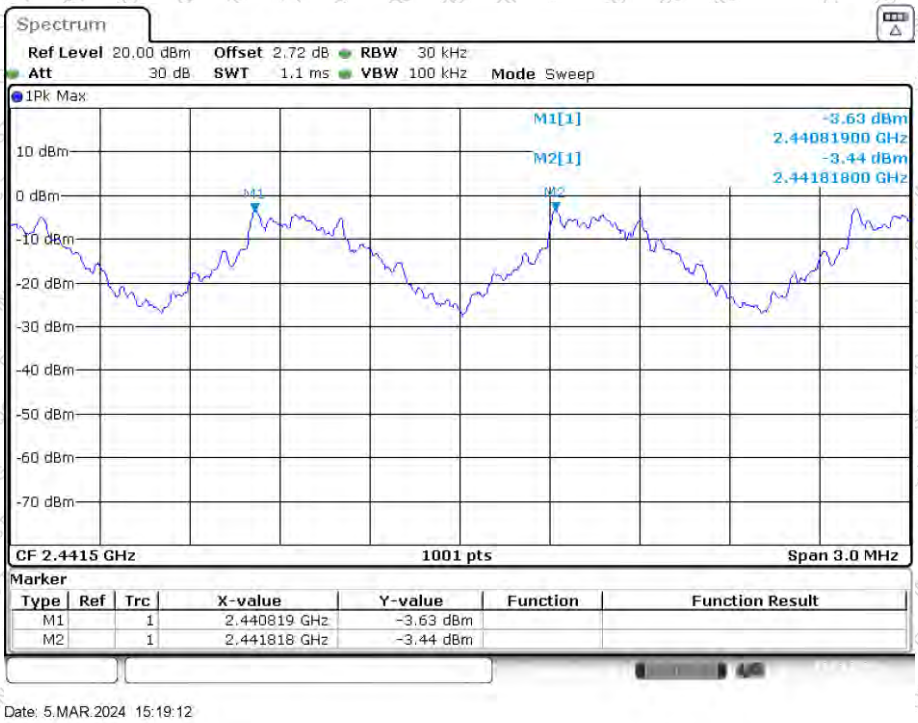
**Measurement Data**

| Mode | Test channel | Carrier Frequencies Separation (kHz) | Limit (kHz) | Result |
|---|---|---|---|---|
| GFSK | Middle | 999 | 557.33 | Pass |
| π/4-DQPSK | Middle | 1002 | 776.00 | Pass |
| 8-DPSK | Middle | 999 | 775.33 | Pass |

| Mode | 20dB bandwidth (kHz) (worse case) | Limit (kHz) (Carrier Frequencies Separation) |
|---|---|---|
| GFSK | 836 | 557.33 |
| π/4-DQPSK | 1164 | 776.00 |
| 8-DPSK | 1163 | 775.33 |

*Note: According to section 7.5*
*Limit = (2/3) * 20dB bandwidth*

CFS NVNT 1-DH1 2441MHz Ant1





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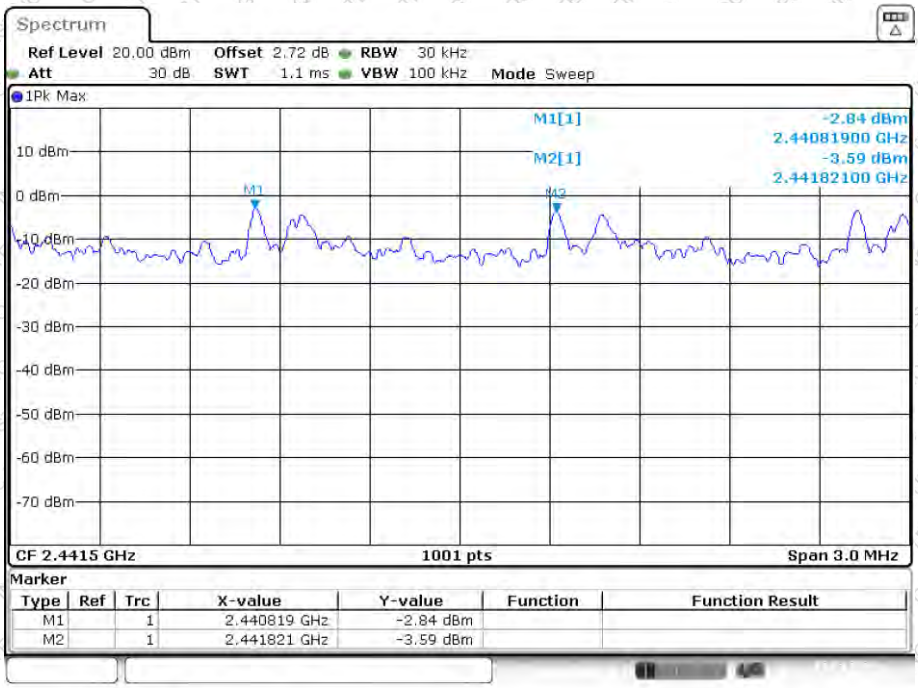
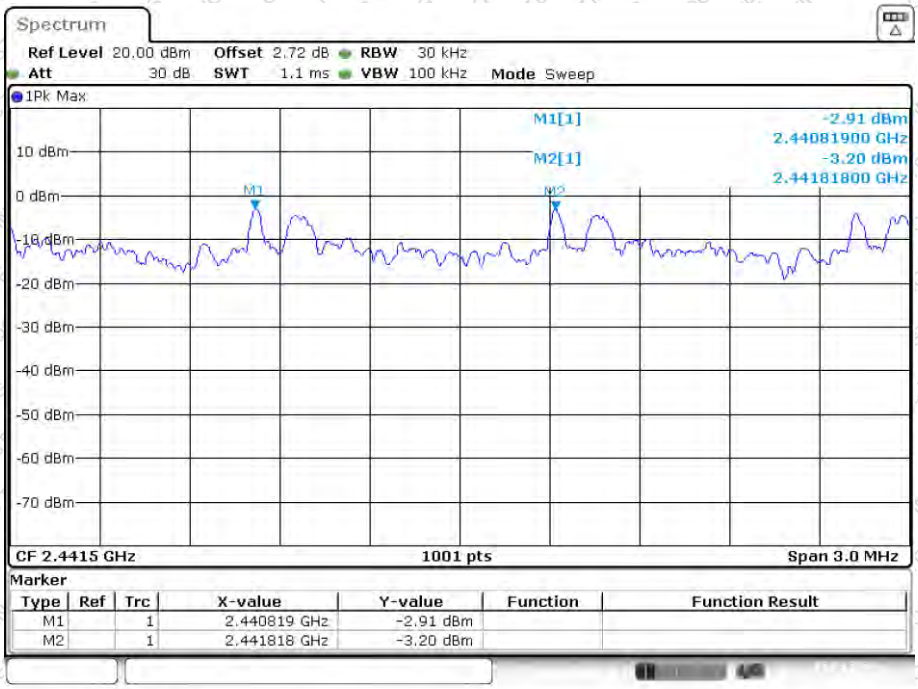
CFS NVNT 2-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:27:43

CFS NVNT 3-DH1 2441MHz Ant1




Date: 5.MAR.2024 15:36:57



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# 9. Hopping Channel Number

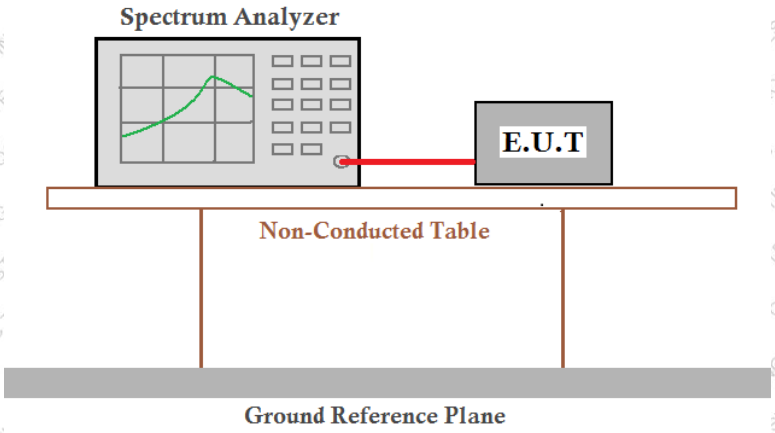
## 9.1 Applicable Standard

FCC Part15 C Section 15.247 (a) (1) (iii)

## 9.2 Limit

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

## 9.3 Test setup




## 9.4 Test Procedure

1. Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.
2. Set the EUT in hopping mode from first channel to last.
3. By using the max-hold function record the quantity of the channel.

## 9.5 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23.5 ℃ | Humidity | 50 % |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Please refer to following table and plots.

**Measurement Data:**

| Mode | Hopping channel numbers | Limit | Result |
|---|---|---|---|
| GFSK | 79 | 15 | Pass |
| π/4-DQPSK | 79 | 15 | Pass |
| 8-DPSK | 79 | 15 | Pass |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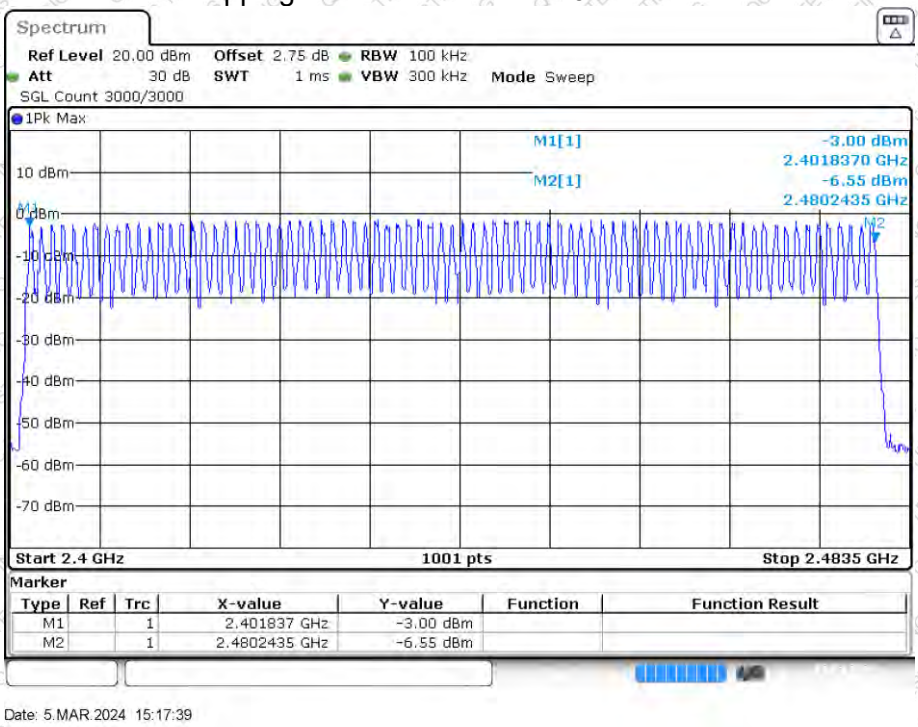
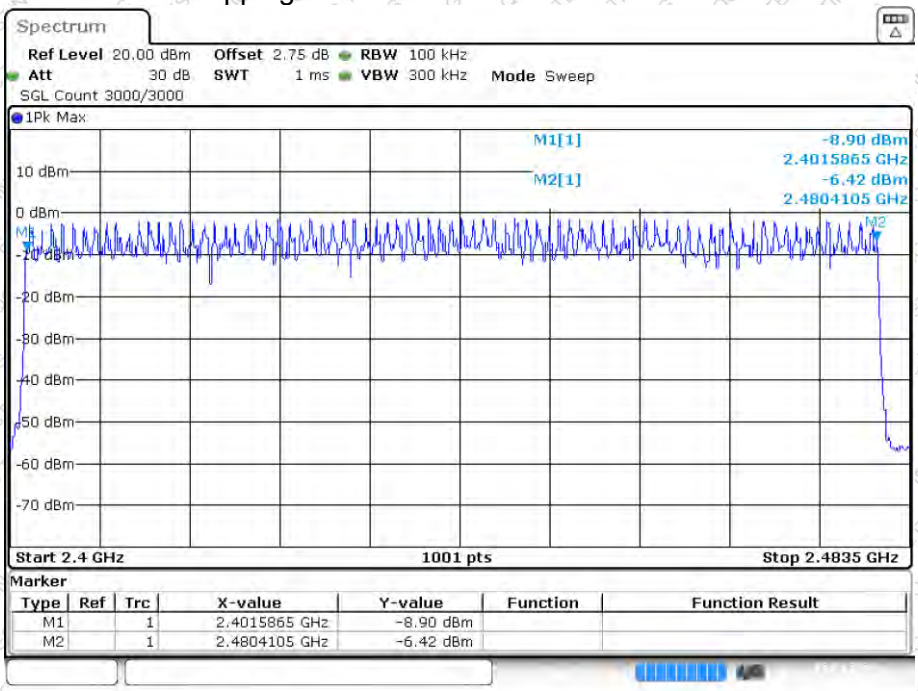
Hopping No. NVNT 1-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:17:39

Hopping No. NVNT 2-DH1 2402MHz Ant1




Date: 5.MAR.2024 15:26:18



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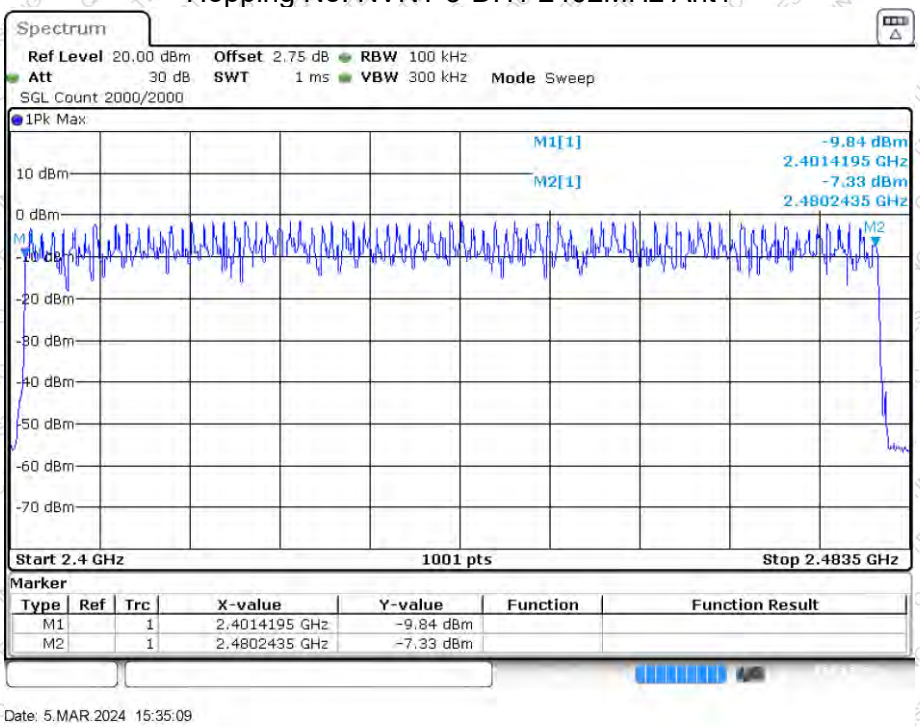
Hopping No. NVNT 3-DH1 2402MHz Ant1



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# 10. Dwell Time

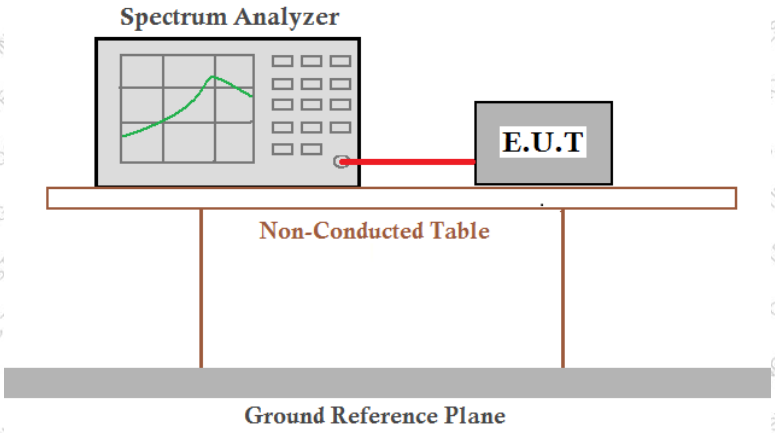
## 10.1 Applicable Standard

FCC Part15 C Section 15.247 (a)(1)(iii)

## 10.2 Limit

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

## 10.3 Test setup




## 10.4 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23.5 ℃ | Humidity | 50 % |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Please refer to following table and plots.



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| Mode | Channel | Burst Width [ms] | Total Hops [Num] | Result[s] | Limit[s] | Result |
|---|---|---|---|---|---|---|
| DH1 | Hop | 0.381 | 318 | 0.121 | <=0.4 | PASS |
| DH3 | Hop | 1.637 | 160 | 0.262 | <=0.4 | PASS |
| DH5 | Hop | 2.886 | 103 | 0.297 | <=0.4 | PASS |
| 2DH1 | Hop | 0.392 | 316 | 0.124 | <=0.4 | PASS |
| 2DH3 | Hop | 1.643 | 158 | 0.260 | <=0.4 | PASS |
| 2DH5 | Hop | 2.891 | 107 | 0.309 | <=0.4 | PASS |
| 3DH1 | Hop | 0.391 | 315 | 0.123 | <=0.4 | PASS |
| 3DH3 | Hop | 1.644 | 163 | 0.267 | <=0.4 | PASS |
| 3DH5 | Hop | 2.891 | 112 | 0.324 | <=0.4 | PASS |

Note: The test period: T= 0.4 Second/Channel x 79 Channel = 31.6 s.



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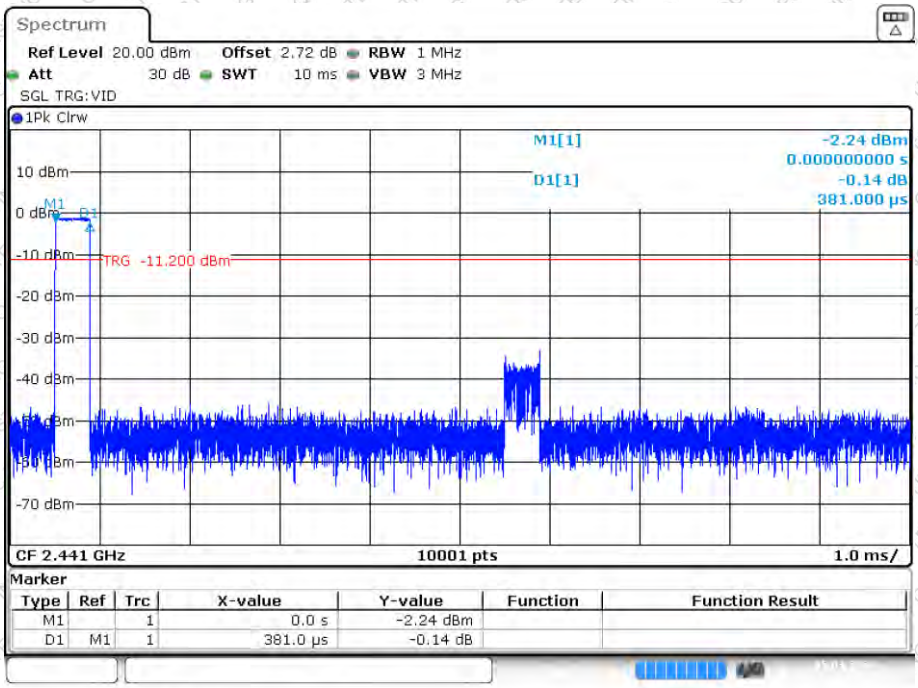
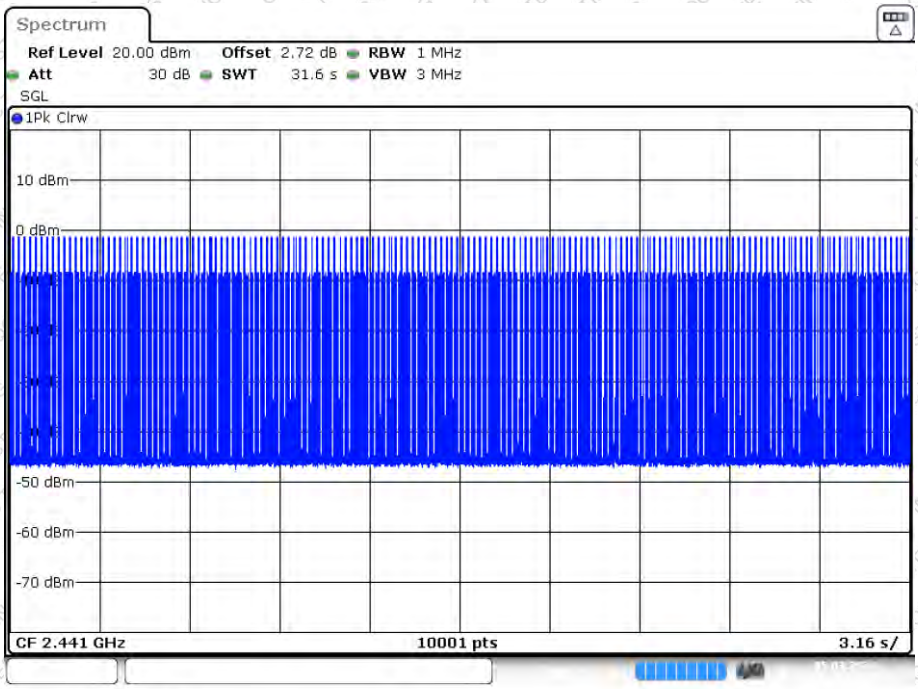
Dwell NVNT 1-DH1 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:18:06

Dwell NVNT 1-DH1 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:18:39



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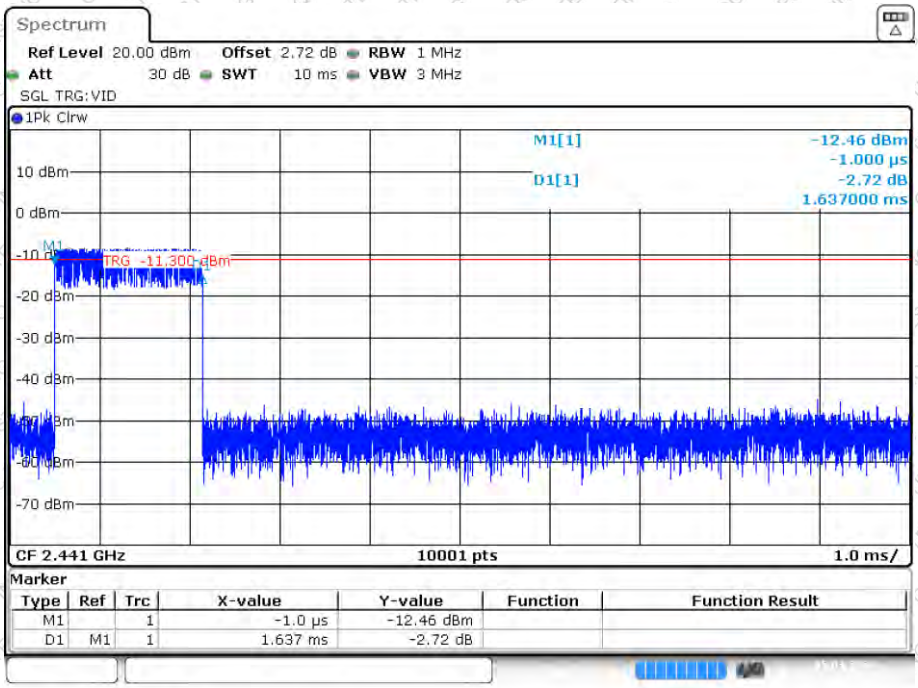
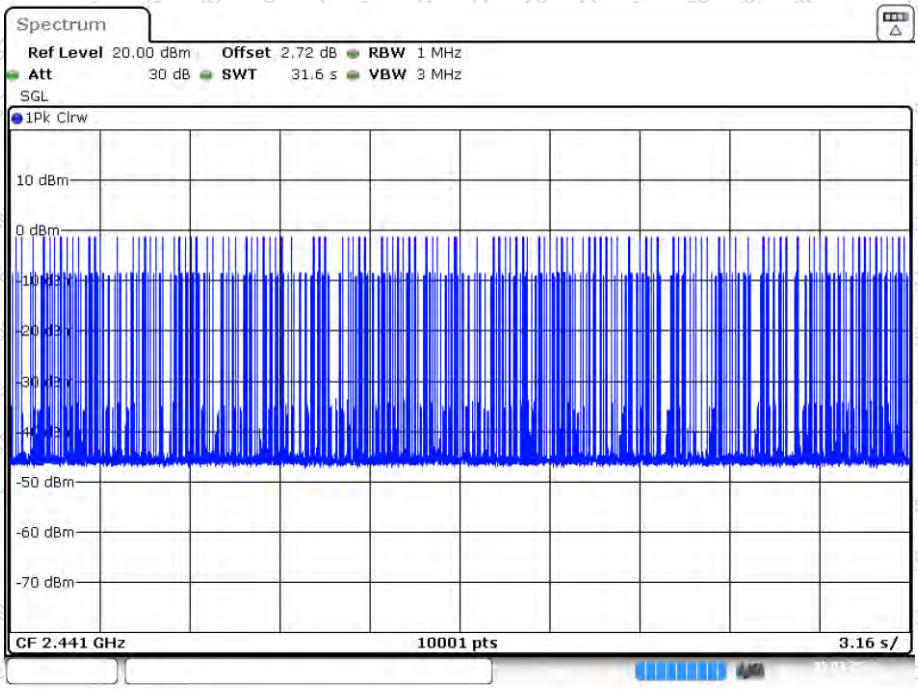
Dwell NVNT 1-DH3 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:19:58

Dwell NVNT 1-DH3 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:20:31



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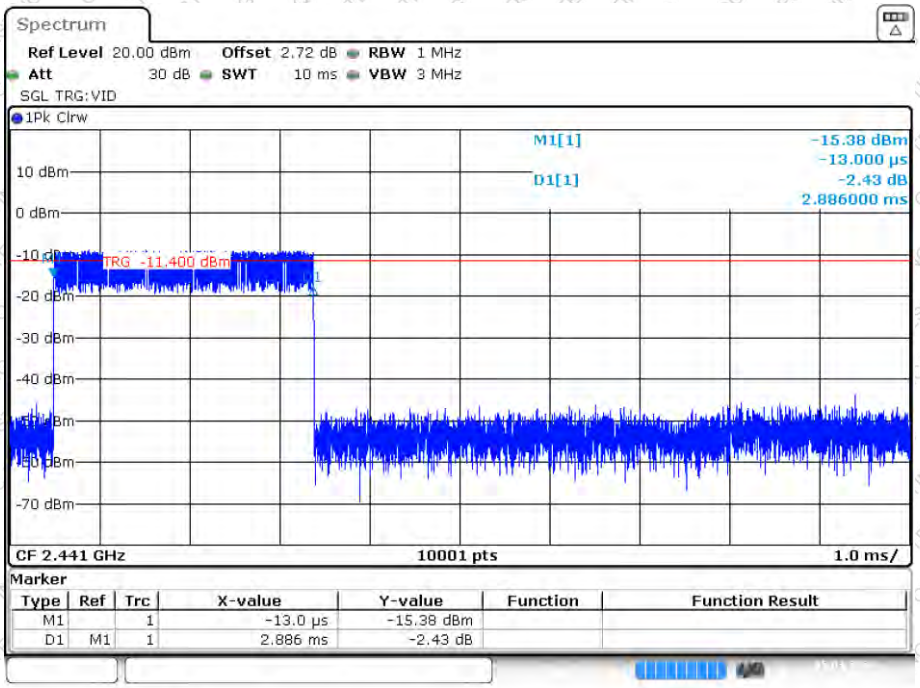
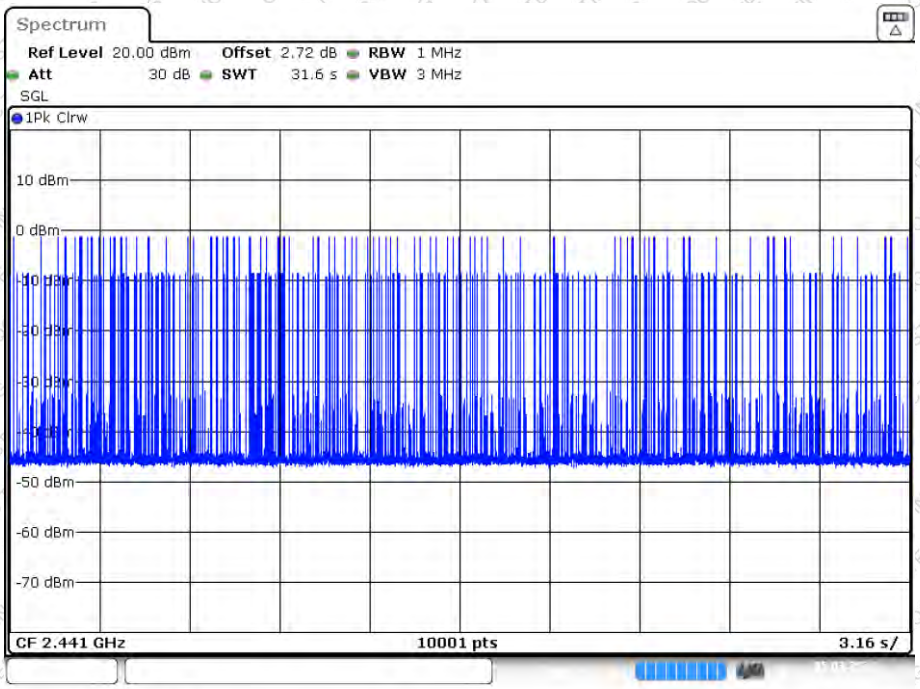
Dwell NVNT 1-DH5 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:20:51

Dwell NVNT 1-DH5 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:21:24



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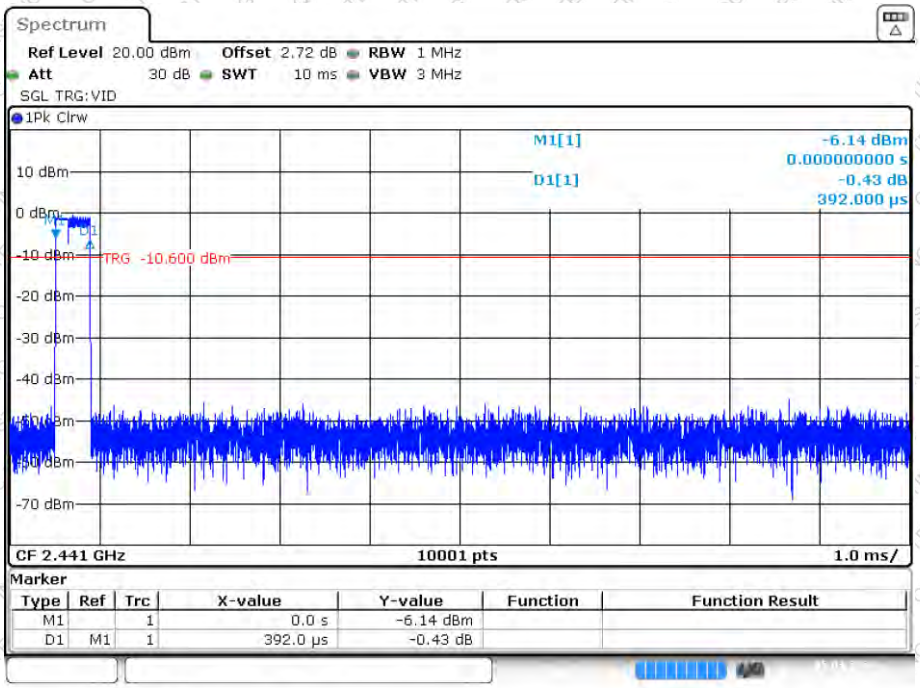
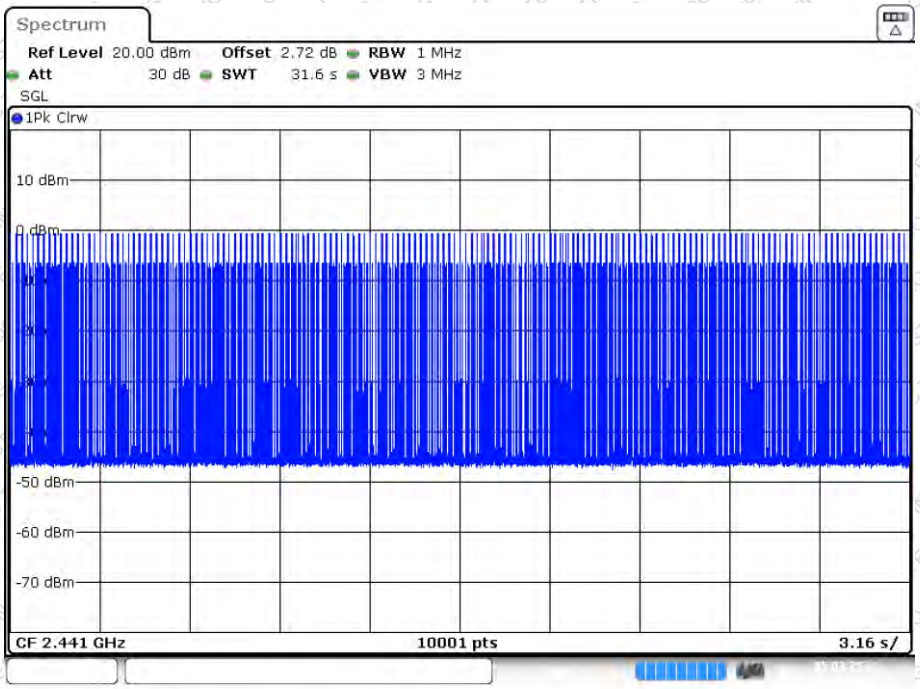
Dwell NVNT 2-DH1 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:26:46

Dwell NVNT 2-DH1 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:27:19



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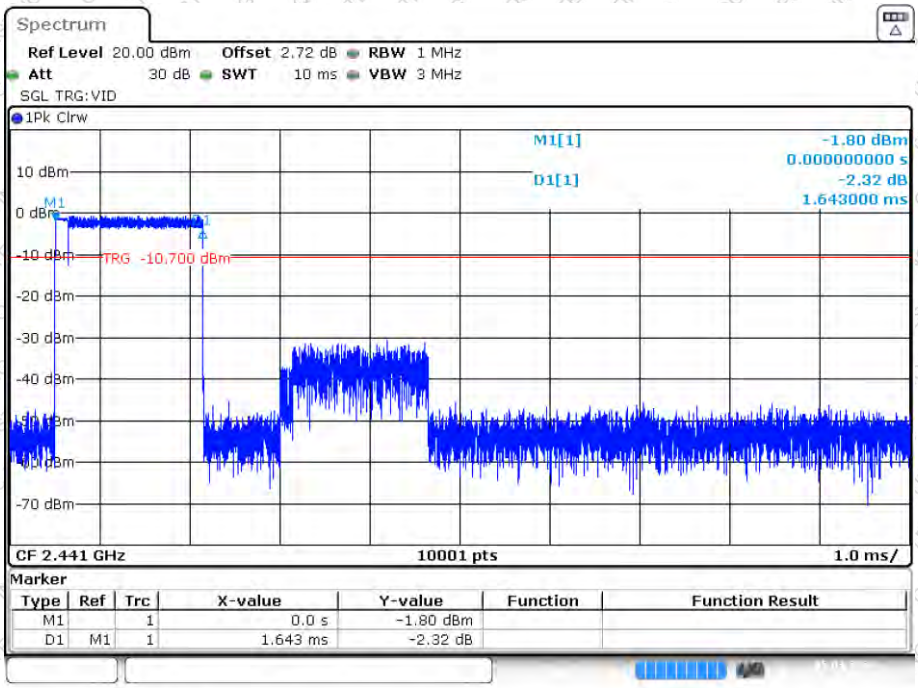
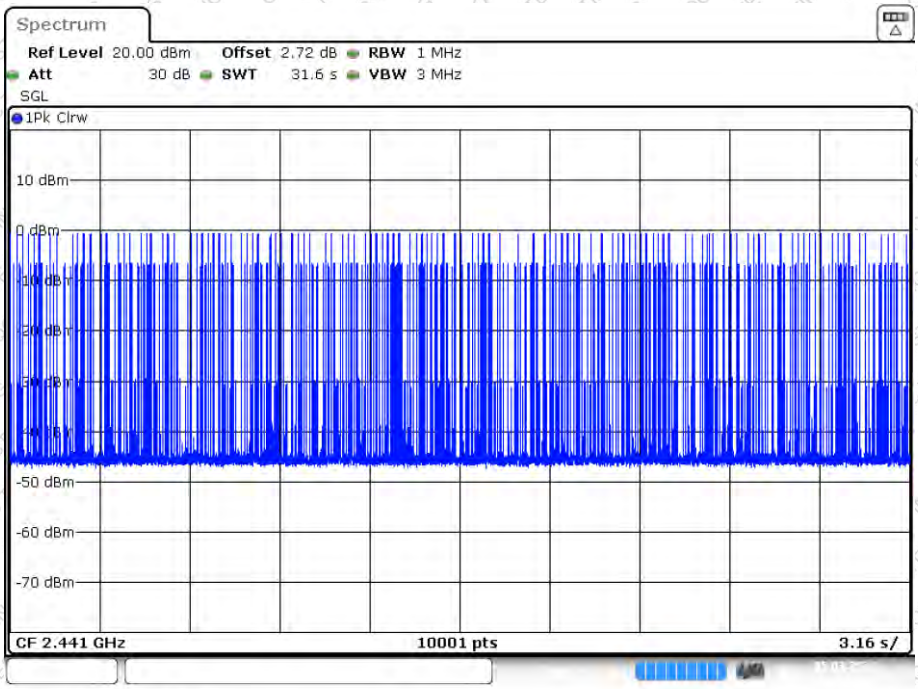
Dwell NVNT 2-DH3 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:28:17

Dwell NVNT 2-DH3 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:28:50



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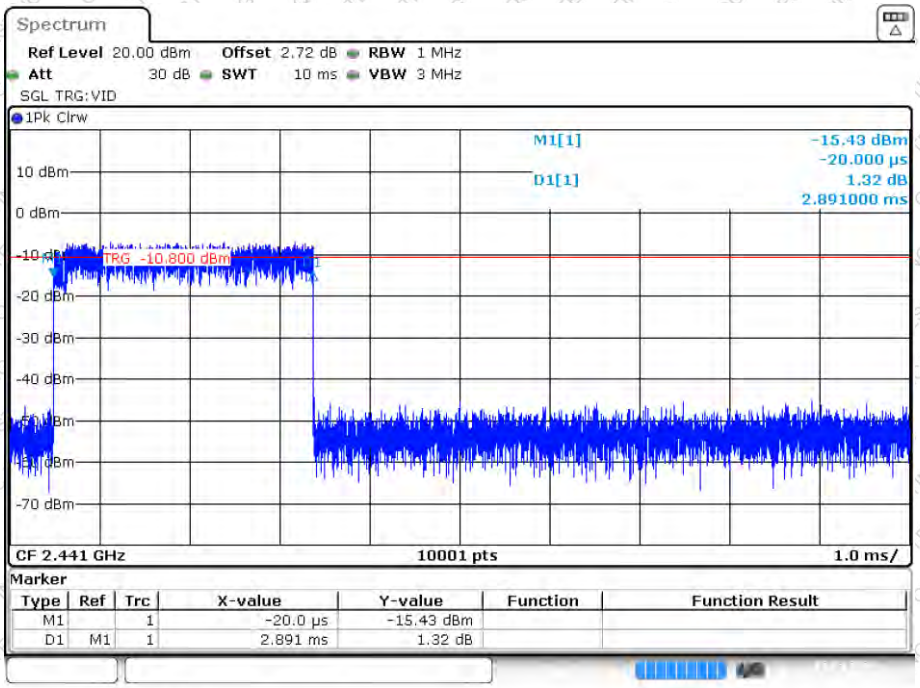
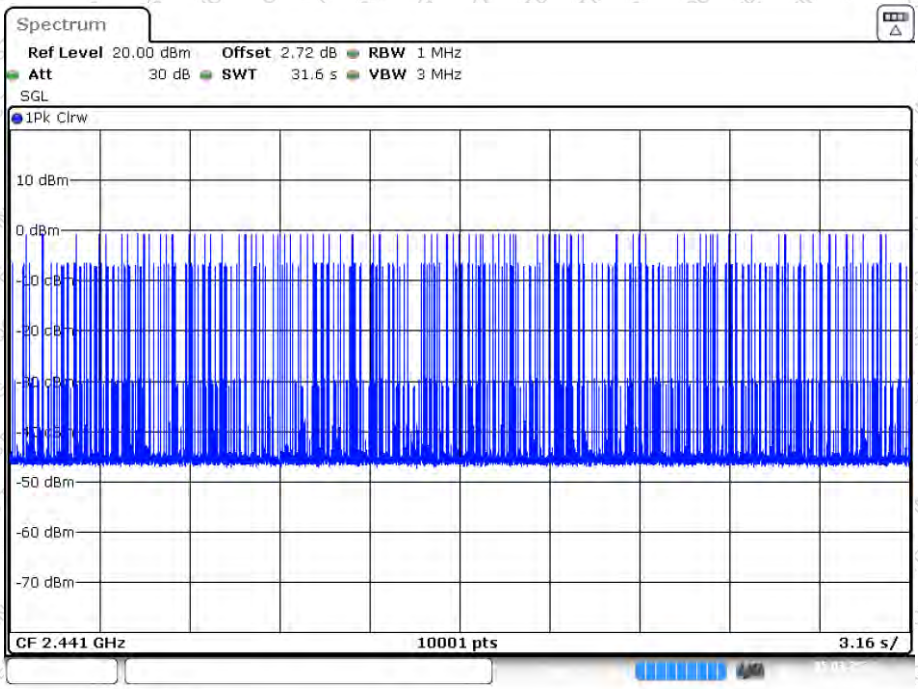
Dwell NVNT 2-DH5 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:29:02

Dwell NVNT 2-DH5 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:29:34



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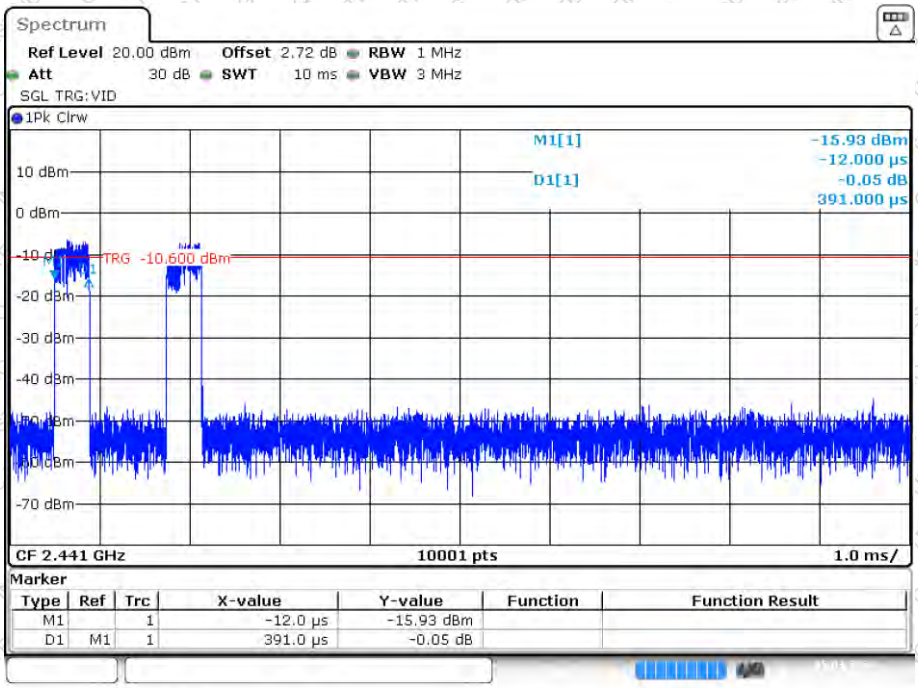
Dwell NVNT 3-DH1 2441MHz Ant1 One Burst

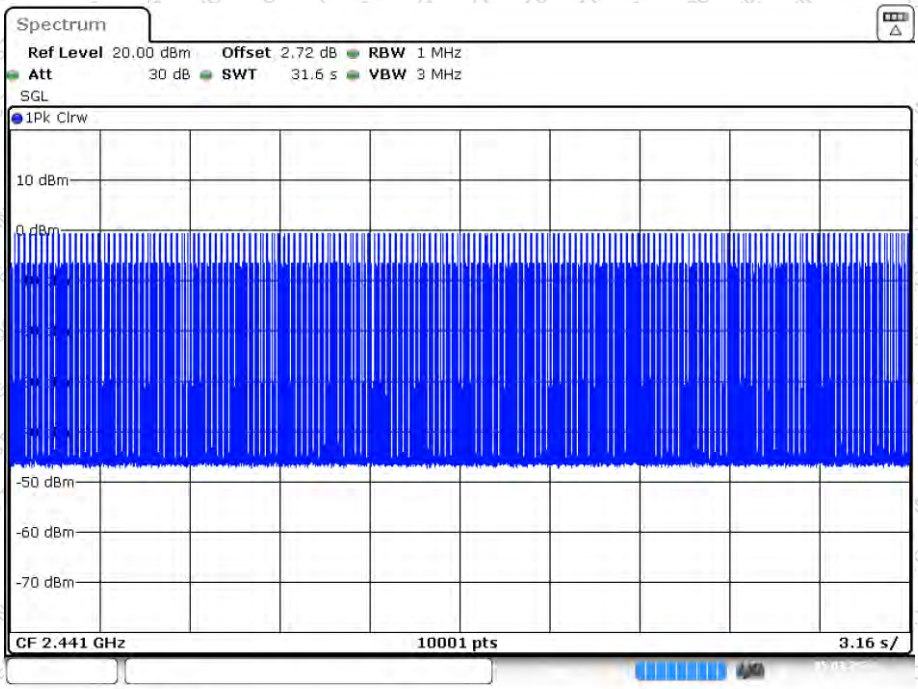



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | -12.0 µs | -15.93 dBm | | |
| D1 | M1 | 1 | 391.0 µs | -0.05 dB | | |

Date: 5.MAR.2024 15:35:41

Dwell NVNT 3-DH1 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:36:14



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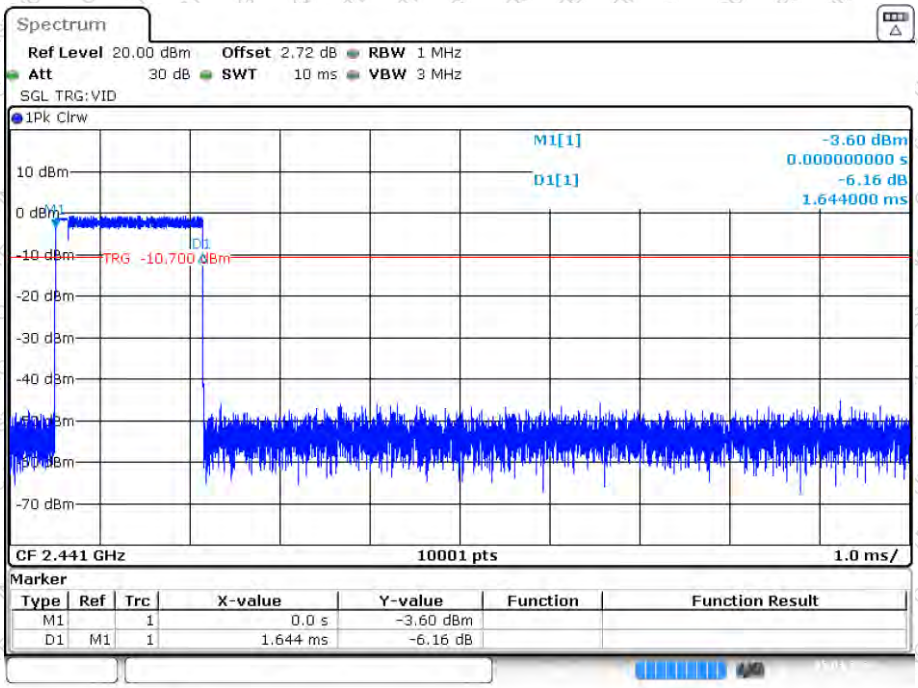
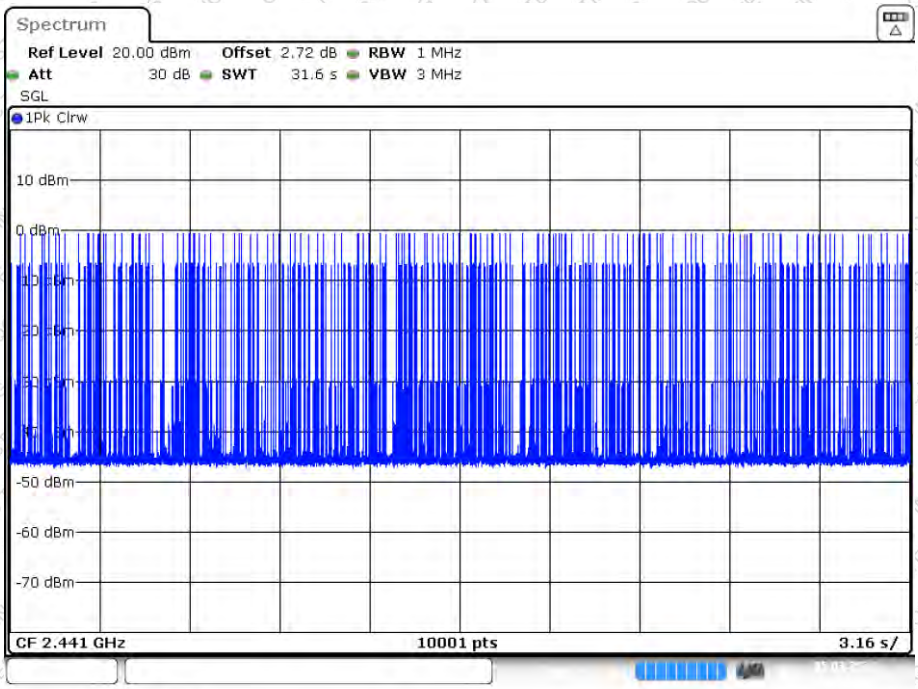
Dwell NVNT 3-DH3 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:37:42

Dwell NVNT 3-DH3 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:38:14



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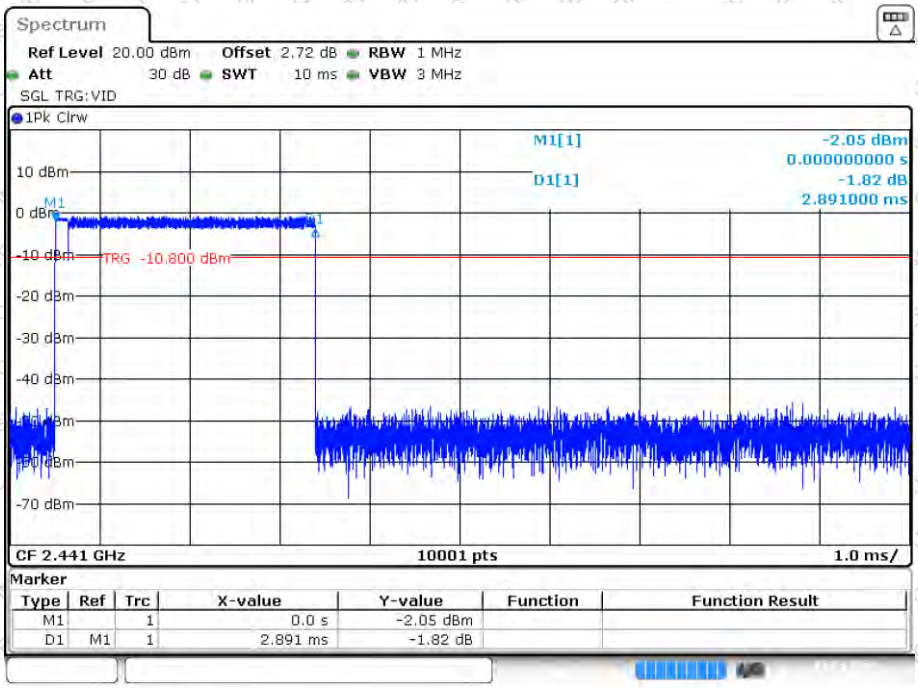
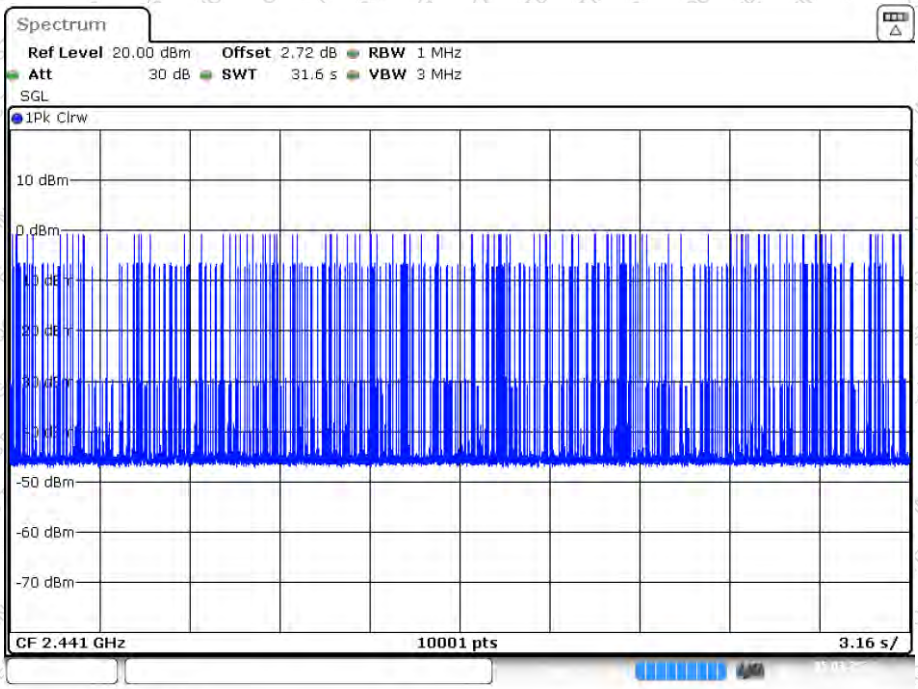
Dwell NVNT 3-DH5 2441MHz Ant1 One Burst




Date: 5.MAR.2024 15:38:28

Dwell NVNT 3-DH5 2441MHz Ant1 Accumulated




Date: 5.MAR.2024 15:39:01



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# 11. Spurious Emission in Non-restricted & restricted Bands

## 11.1 Conducted Emission Method

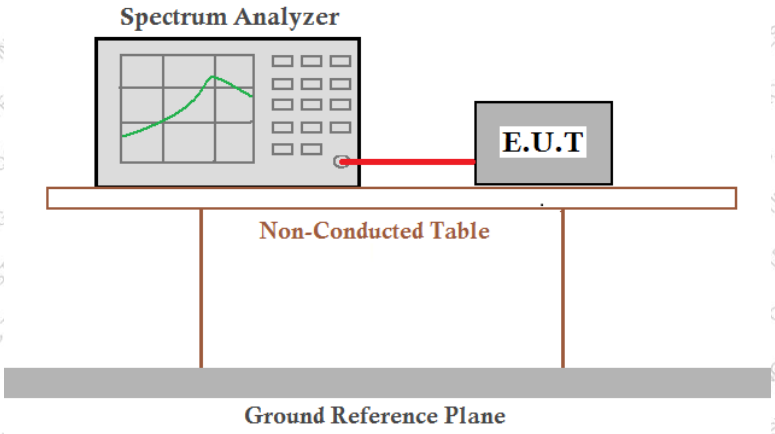
### 11.1.1 Applicable Standard

FCC Part15 C Section 15.247 (d)

### 11.1.2 Limit

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

### 11.1.3 Test setup




### 11.1.4 Test Procedure

- Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
- Position the EUT without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range, and make sure the instrument is operated in its linear range.
- Set RBW to 100 kHz and VBW of spectrum analyzer to 300 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
- Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
- Repeat above procedures until all measured frequencies were complete.

### 11.1.5 Test Data

| | | | |
|---|---|---|---|
| Temperature | 23.5 ℃ | Humidity | 50 % |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Please refer to following plots.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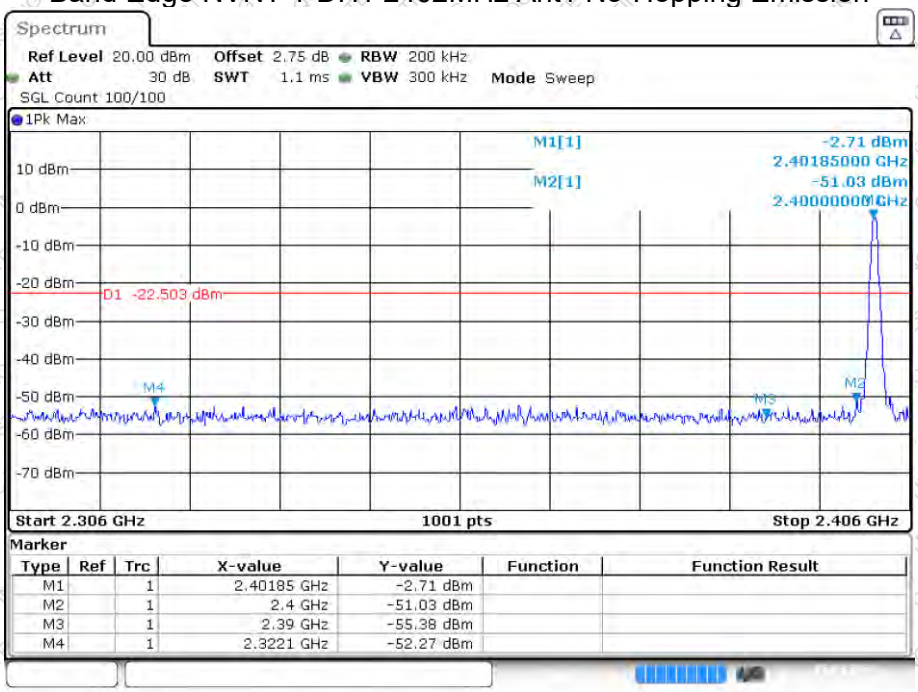
## Band Edge NVNT 1-DH1 2402MHz Ant1 No-Hopping Emission

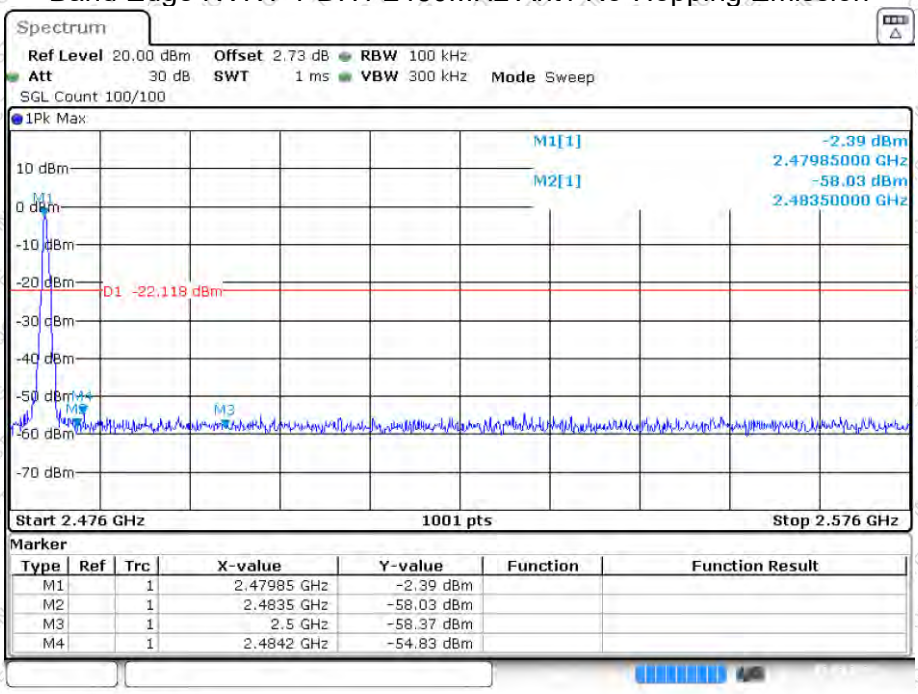



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.40185 GHz | -2.71 dBm | | |
| M2 | | 1 | 2.4 GHz | -51.03 dBm | | |
| M3 | | 1 | 2.39 GHz | -55.38 dBm | | |
| M4 | | 1 | 2.3221 GHz | -52.27 dBm | | |

Date: 5.MAR.2024 15:16:10

## Band Edge NVNT 1-DH1 2480MHz Ant1 No-Hopping Emission




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.47985 GHz | -2.39 dBm | | |
| M2 | | 1 | 2.4835 GHz | -58.03 dBm | | |
| M3 | | 1 | 2.5 GHz | -58.37 dBm | | |
| M4 | | 1 | 2.4842 GHz | -54.83 dBm | | |

Date: 5.MAR.2024 15:13:43



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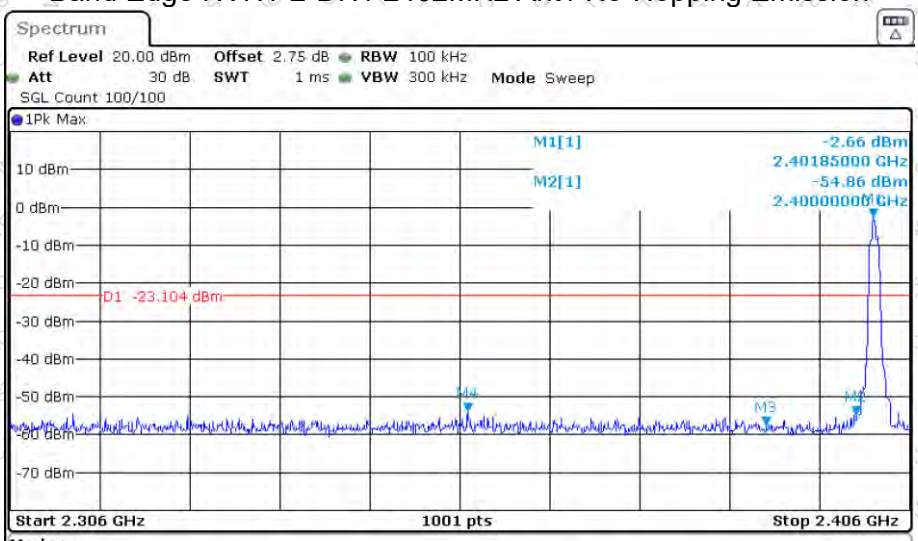
Band Edge NVNT 2-DH1 2402MHz Ant1 No-Hopping Emission

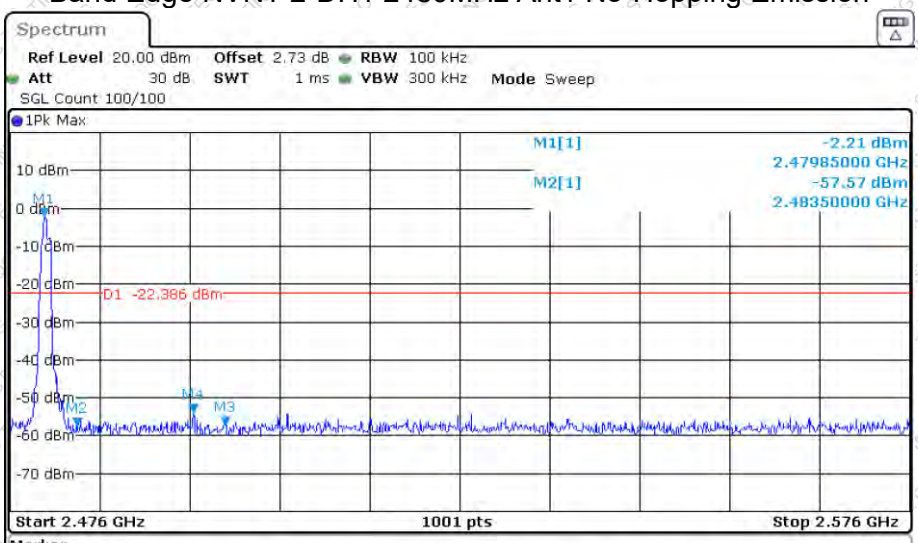



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.40185 GHz | -2.66 dBm | | |
| M2 | | 1 | 2.4 GHz | -54.86 dBm | | |
| M3 | | 1 | 2.39 GHz | -57.50 dBm | | |
| M4 | | 1 | 2.3569 GHz | -54.00 dBm | | |

Date: 5.MAR.2024 15:23:01

Band Edge NVNT 2-DH1 2480MHz Ant1 No-Hopping Emission




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.47985 GHz | -2.21 dBm | | |
| M2 | | 1 | 2.4835 GHz | -57.57 dBm | | |
| M3 | | 1 | 2.5 GHz | -57.27 dBm | | |
| M4 | | 1 | 2.4964 GHz | -53.85 dBm | | |

Date: 5.MAR.2024 15:24:56



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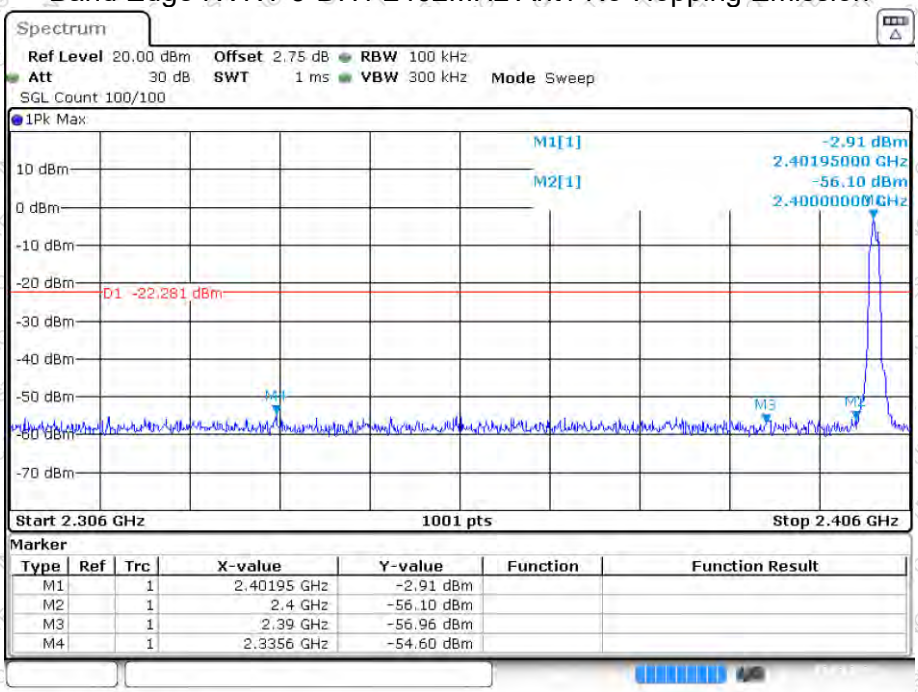
Band Edge NVNT 3-DH1 2402MHz Ant1 No-Hopping Emission

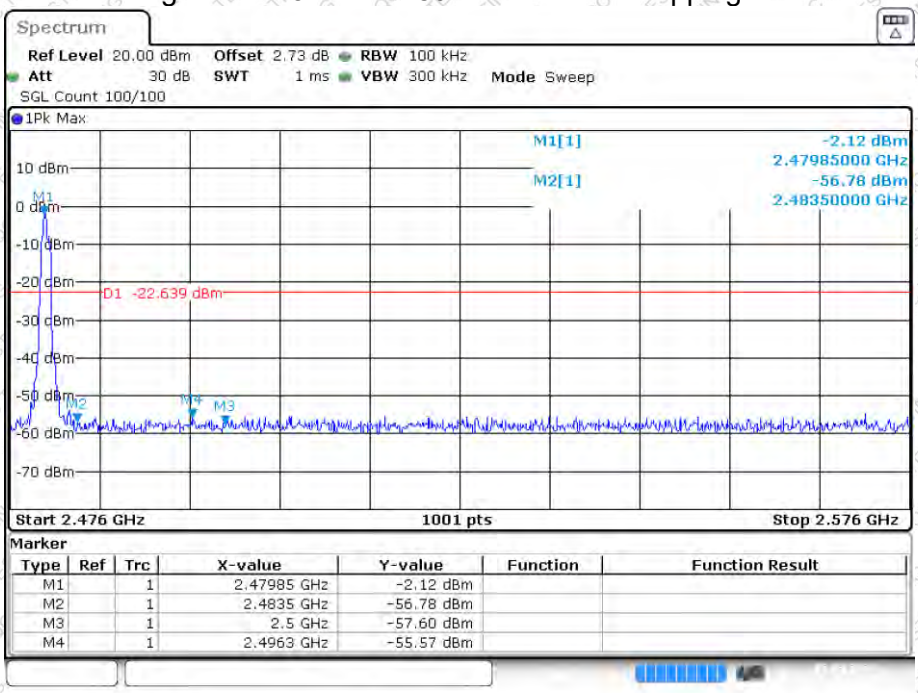



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.40195 GHz | -2.91 dBm | | |
| M2 | | 1 | 2.4 GHz | -56.10 dBm | | |
| M3 | | 1 | 2.39 GHz | -56.96 dBm | | |
| M4 | | 1 | 2.3356 GHz | -54.60 dBm | | |

Date: 5.MAR.2024 15:31:51

Band Edge NVNT 3-DH1 2480MHz Ant1 No-Hopping Emission




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.47985 GHz | -2.12 dBm | | |
| M2 | | 1 | 2.4835 GHz | -56.78 dBm | | |
| M3 | | 1 | 2.5 GHz | -57.60 dBm | | |
| M4 | | 1 | 2.4963 GHz | -55.57 dBm | | |

Date: 5.MAR.2024 15:33:52



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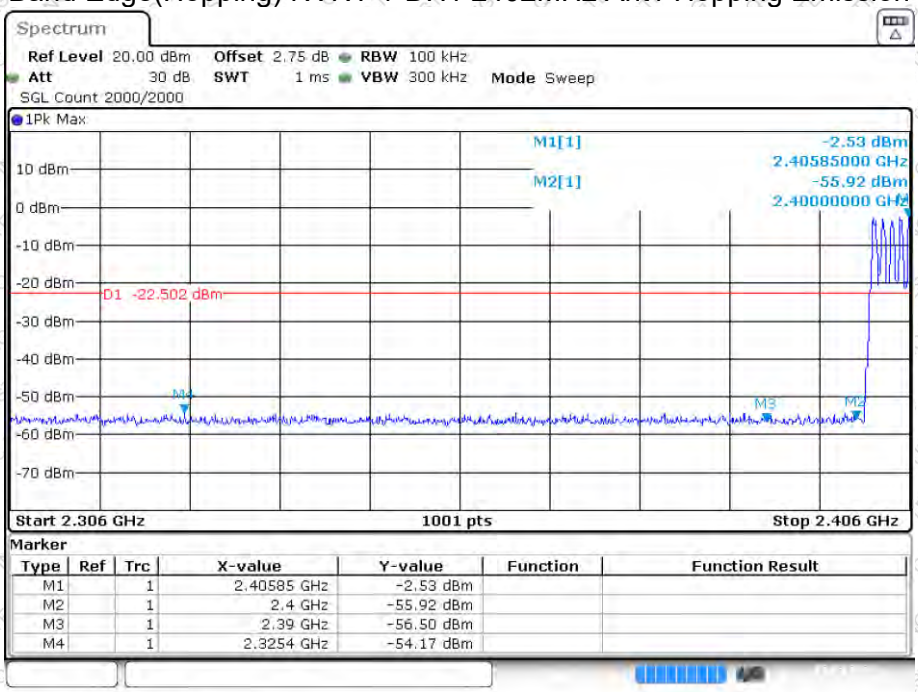
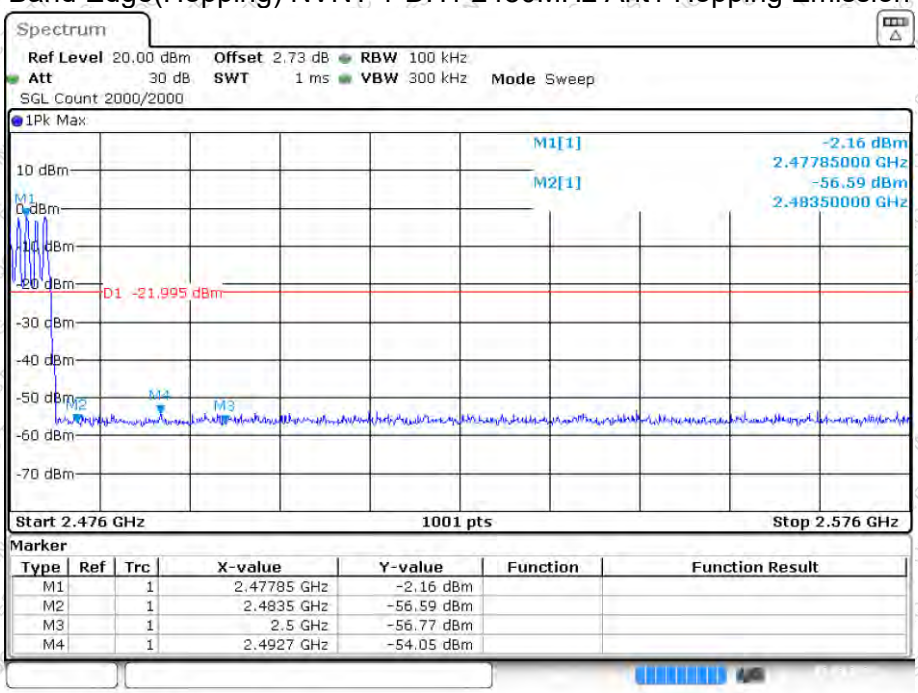
Band Edge(Hopping) NVNT 1-DH1 2402MHz Ant1 Hopping Emission




Date: 5.MAR.2024 15:17:58

Band Edge(Hopping) NVNT 1-DH1 2480MHz Ant1 Hopping Emission




Date: 5.MAR.2024 15:19:41



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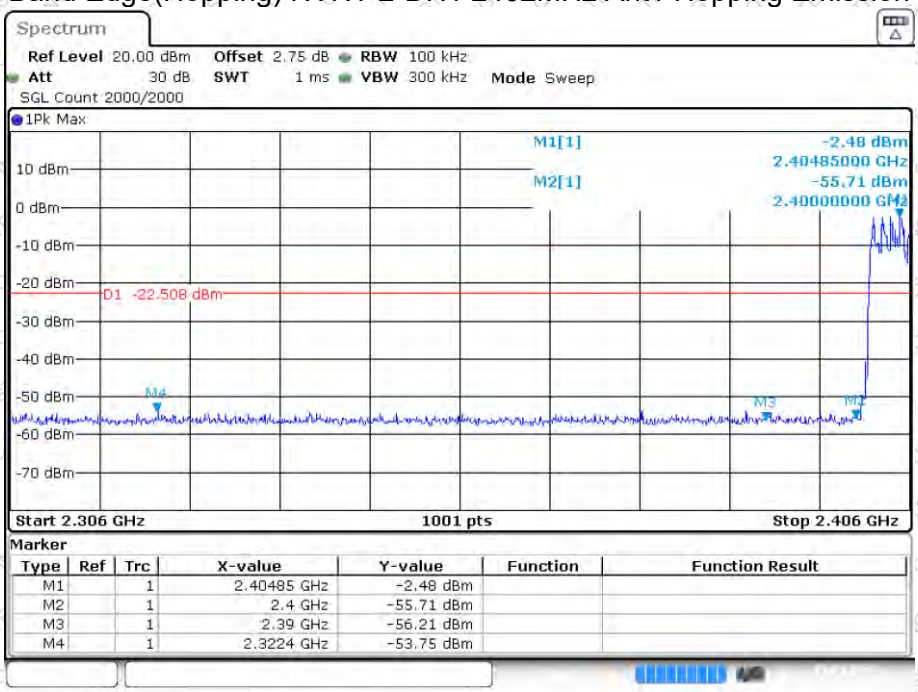
Band Edge(Hopping) NVNT 2-DH1 2402MHz Ant1 Hopping Emission

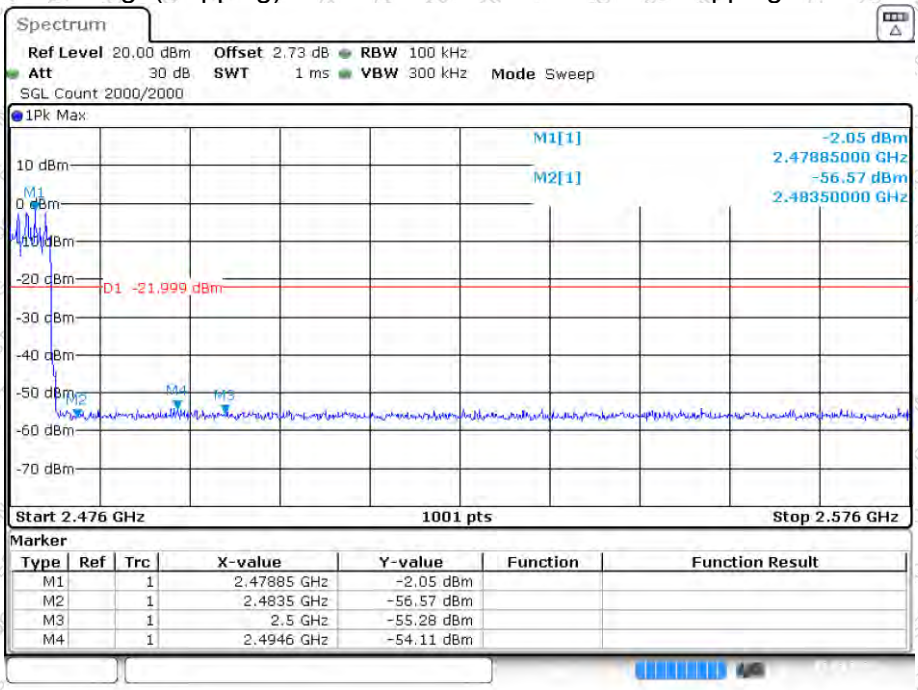



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.40485 GHz | -2.48 dBm | | |
| M2 | | 1 | 2.4 GHz | -55.71 dBm | | |
| M3 | | 1 | 2.39 GHz | -56.21 dBm | | |
| M4 | | 1 | 2.3224 GHz | -53.75 dBm | | |

Date: 5.MAR.2024 15:26:37

Band Edge(Hopping) NVNT 2-DH1 2480MHz Ant1 Hopping Emission




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.47885 GHz | -2.05 dBm | | |
| M2 | | 1 | 2.4835 GHz | -56.57 dBm | | |
| M3 | | 1 | 2.5 GHz | -55.28 dBm | | |
| M4 | | 1 | 2.4946 GHz | -54.11 dBm | | |

Date: 5.MAR.2024 15:28:01



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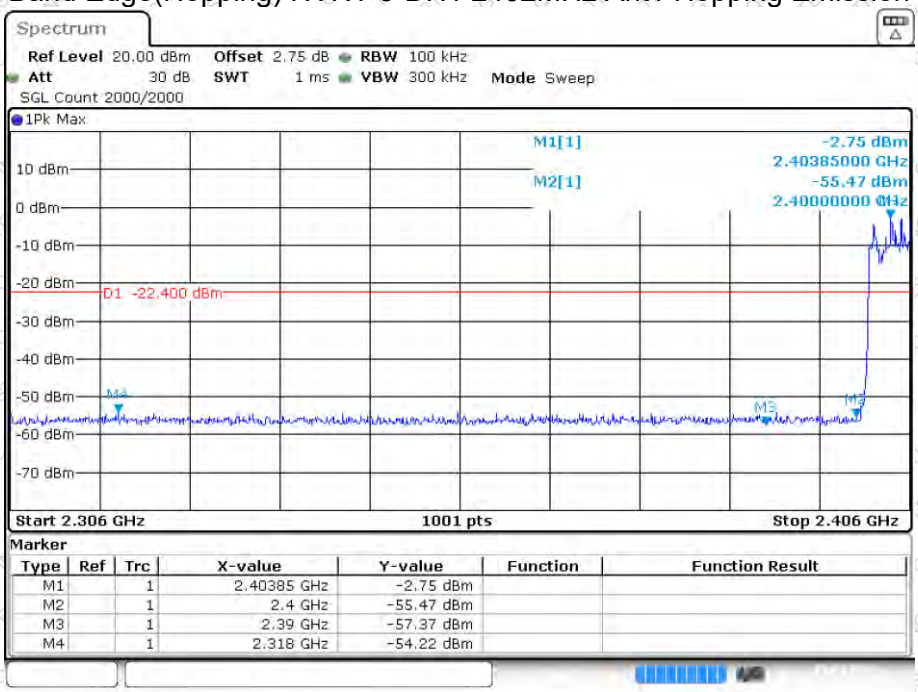
Band Edge(Hopping) NVNT 3-DH1 2402MHz Ant1 Hopping Emission

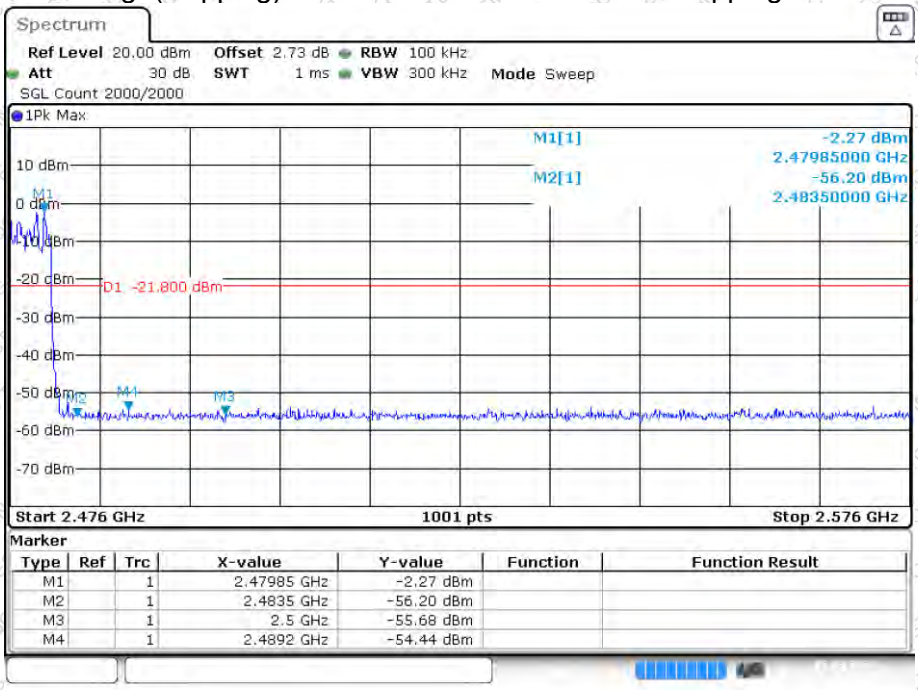



Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.40385 GHz | -2.75 dBm | | |
| M2 | | 1 | 2.4 GHz | -55.47 dBm | | |
| M3 | | 1 | 2.39 GHz | -57.37 dBm | | |
| M4 | | 1 | 2.318 GHz | -54.22 dBm | | |

Date: 5.MAR.2024 15:35:30

Band Edge(Hopping) NVNT 3-DH1 2480MHz Ant1 Hopping Emission




Marker

| Type | Ref | Trc | X-value | Y-value | Function | Function Result |
|---|---|---|---|---|---|---|
| M1 | | 1 | 2.47985 GHz | -2.27 dBm | | |
| M2 | | 1 | 2.4835 GHz | -56.20 dBm | | |
| M3 | | 1 | 2.5 GHz | -55.68 dBm | | |
| M4 | | 1 | 2.4892 GHz | -54.44 dBm | | |

Date: 5.MAR.2024 15:37:24



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## 11.2 Radiated Emission Method

### 11.2.1 Applicable Standard

FCC Part15 C Section 15.209 and 15.205

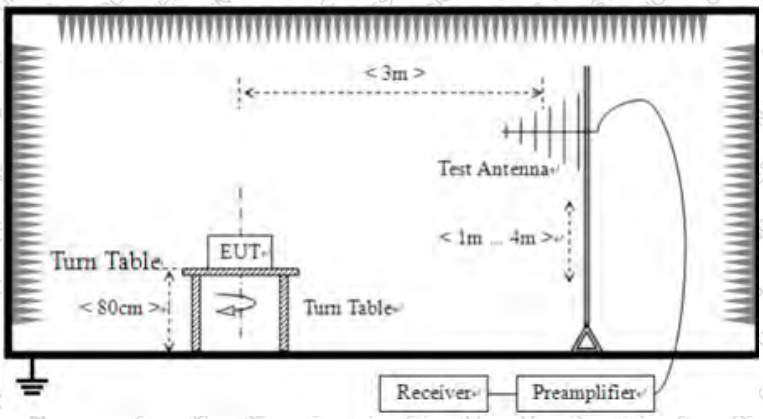
### 11.2.2 Limit

| Frequency | Field Strengths Limits (μV/m at 3 m) | Field Strengths Limits (dBμV/m at 3 m) | Remark |
|---|---|---|---|
| 30 – 88 | 100 | 40.0 | Quasi-peak |
| 88 – 216 | 150 | 43.5 | Quasi-peak |
| 216 – 960 | 200 | 46.0 | Quasi-peak |
| Above 960 | 500 | 54.0 | Quasi-peak |
| Above 1GHz | / | 54.0 | Peak |
| | | 74.0 | Average |

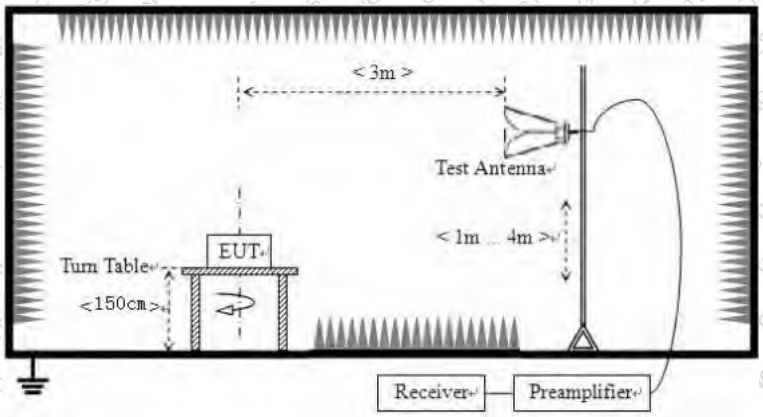
Note: dBμV/m =20log(μV/m)

### 11.2.3 Test setup

For radiated emissions from 30MHz to1GHz




For radiated emissions from above 1GHz



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### 11.2.4 EMI Test Receiver Setup

| Frequency | RBW | VBW | IF B/W | Measurement |
|---|---|---|---|---|
| 30 MHz – 1000 MHz | 100 kHz | 300 kHz | 120 kHz | QP |
| Above 1 GHz | 1 MHz | 3 MHz | / | Peak |
| | 1 MHz | 10 Hz | / | Average |

### 11.2.5 Test procedure

- The EUT was placed on the top of a rotating table (0.8m for below 1G and 1.5m for above 1G) above the ground at a 3 meter camber. The table was rotated 360 degrees to determine the position of the highest radiation.
- The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- The antenna height is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rota table was turned from 0 degrees to 360 degrees to find the maximum reading.
- The test-receiver system was set to Peak Detect Function and Specified Bandwidth with Maximum Hold Mode.
- If the emission level of the EUT in peak mode was 10dB lower than the limit specified, then testing could be stopped and the peak values of the EUT would be reported. Otherwise the emissions that did not have 10dB margin would be re-tested one by one using peak, quasi-peak or average method as specified and then reported in a data sheet.

### 11.2.6 Test Data

| | | | |
|---|---|---|---|
| Temperature | 25 ℃ | Humidity | 49% |
| ATM Pressure | 101.1kPa | Antenna Gain | 2.78dBi |
| Test by | LBi Li | Test result | PASS |

Test voltage: DC 3.7V.

Remarks:

1. Pre-scan all kind of the place mode (X-axis, Y-axis, Z-axis), and found the Y-axis which it is worse case.
2. The low frequency, which started from 9 kHz to 30 MHz, was pre-scanned and the result which was 20 dB lower than the limit line per 15.31(o) was not reported.



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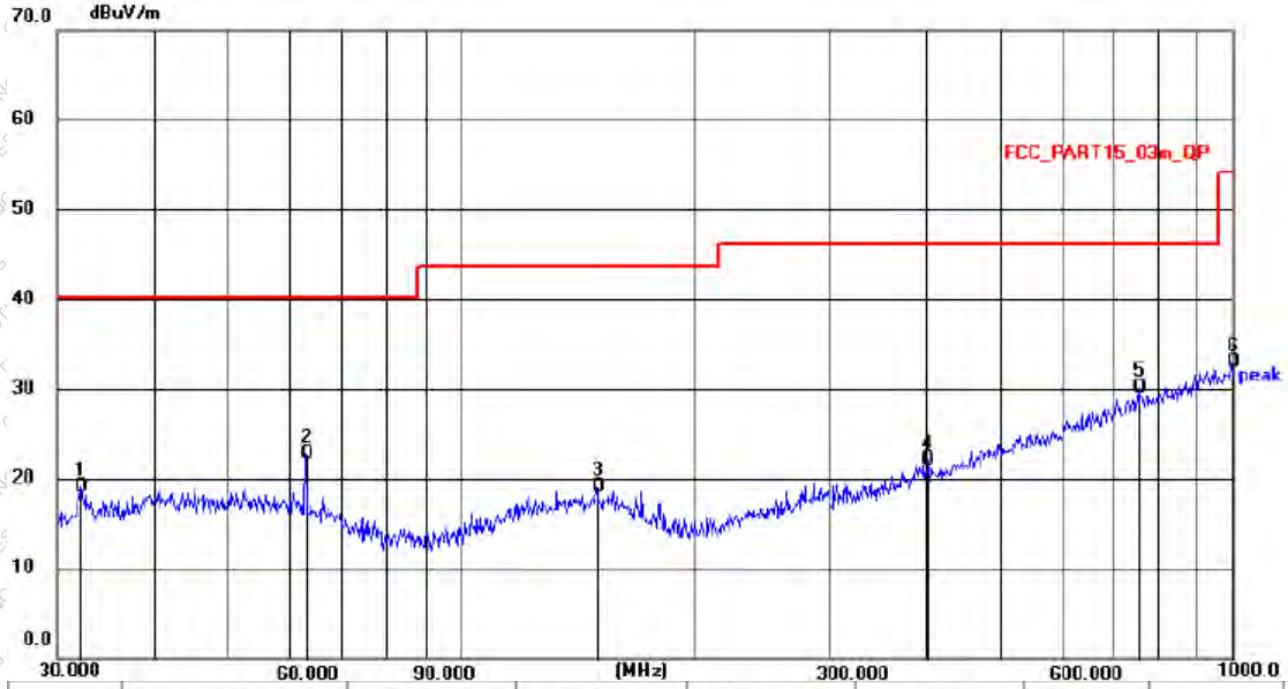
**Below 1GHz**

Pre-scan all test modes, found worst case at GFSK 2402MHz, and so only show the test result of GFSK 2402MHz.

**Horizontal:**




| No. | Frequency (MHz) | Reading (dBuV) | Factor (dB/m) | Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| 1 | 32.1795 | 5.90 | 13.29 | 19.19 | 40.00 | 20.81 | QP |
| 2 | 62.8708 | 9.43 | 13.45 | 22.88 | 40.00 | 17.12 | QP |
| 3 | 150.0108 | 4.57 | 14.57 | 19.14 | 43.50 | 24.36 | QP |
| 4 | 403.2500 | 4.31 | 17.88 | 22.19 | 46.00 | 23.81 | QP |
| 5 * | 755.3873 | 6.41 | 23.81 | 30.22 | 46.00 | 15.78 | QP |
| 6 | 996.4996 | 6.07 | 26.98 | 33.05 | 54.00 | 20.95 | QP |



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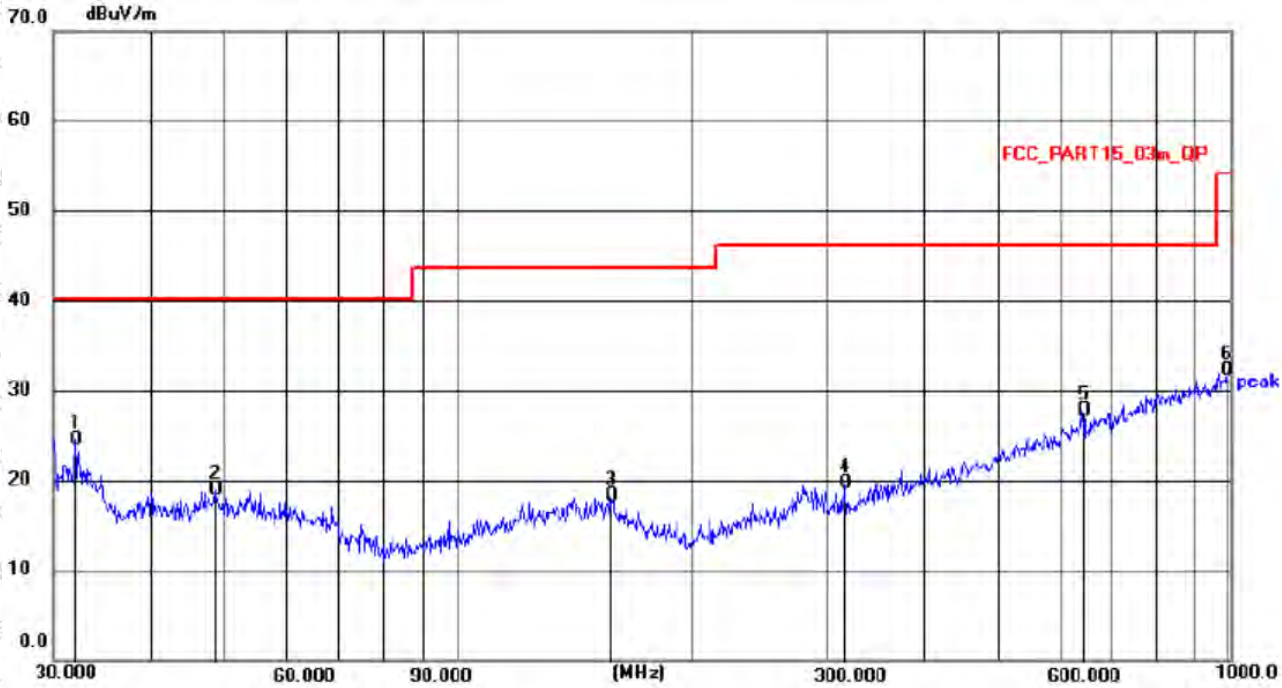
**Vertical:**




| No. | Frequency (MHz) | Reading (dBuV) | Factor (dB/m) | Level (dBuV/m) | Limit (dBuV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| 1 * | 32.0667 | 11.82 | 12.84 | 24.66 | 40.00 | 15.34 | QP |
| 2 | 48.6719 | 4.60 | 14.46 | 19.06 | 40.00 | 20.94 | QP |
| 3 | 157.5588 | 3.88 | 14.41 | 18.29 | 43.50 | 25.21 | QP |
| 4 | 316.5890 | 4.95 | 14.82 | 19.77 | 46.00 | 26.23 | QP |
| 5 | 642.8613 | 5.74 | 21.95 | 27.69 | 46.00 | 18.31 | QP |
| 6 | 986.0717 | 5.43 | 26.88 | 32.31 | 54.00 | 21.69 | QP |



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**Above 1GHz**

Pre-scan all test modes, found worst case at GFSK Mode, and so only show the test result of GFSK Mode.

Test channel: Lowest channel

| Frequency (MHz) | Read Level (dBμV) | polarization | Factor (dB/m) | Level (dBμV/m) | Limit Line (dBμV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| 2310 | 49.62 | H | -11.14 | 38.48 | 74 | 35.52 | peak |
| 2310 | 51.65 | V | -11.16 | 40.49 | 74 | 33.51 | peak |
| 2390 | 51.31 | H | -10.9 | 40.41 | 74 | 33.59 | peak |
| 2390 | 55.24 | V | -10.96 | 44.28 | 74 | 29.72 | peak |
| 4804 | 51.01 | H | -4.37 | 46.64 | 74 | 27.36 | peak |
| 4804 | 53.38 | V | -4.51 | 48.87 | 74 | 25.13 | peak |

Test channel: Middle channel

| Frequency (MHz) | Read Level (dBμV) | polarization | Factor (dB/m) | Level (dBμV/m) | Limit Line (dBμV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| 4882 | 54.64 | H | -4.1 | 50.54 | 74 | 23.46 | peak |
| 4882 | 54.2 | V | -4.23 | 49.97 | 74 | 24.03 | peak |

Test channel: Highest channel

| Frequency (MHz) | Read Level (dBμV) | polarization | Factor (dB/m) | Level (dBμV/m) | Limit Line (dBμV/m) | Margin (dB) | Detector |
|---|---|---|---|---|---|---|---|
| 2483.5 | 50.6 | H | -10.61 | 39.99 | 74 | 34.01 | peak |
| 2483.5 | 51.16 | V | -10.71 | 40.45 | 74 | 33.55 | peak |
| 2500 | 48.77 | H | -10.57 | 38.2 | 74 | 35.8 | peak |
| 2500 | 48 | V | -10.67 | 37.33 | 74 | 36.67 | peak |
| 4960 | 53.94 | H | -3.82 | 50.12 | 74 | 23.88 | peak |
| 4960 | 53.26 | V | -3.93 | 49.33 | 74 | 24.67 | peak |

Remarks:

1. Level =Receiver Read level + Factor
2. The emission levels of other frequencies are very lower than the limit and not show in test report.

---------- THE END OF TEST REPORT ----------



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