TECHNICAL REPORT

Report No.: TW2203195-01E
File Reference No.: 2022-03-31

Applicant: Shenzhen Liangming Technology Co., Ltd.

Product: Wireless module

Model No.: DX2002, DX2002A, DX2002B

Trademark: N/A

Test Standards: FCC Part 15.247

Test Result: It is herewith confirmed and found to comply with the requirements set up by ANSI C63.10, FCC Part 15.247 for the evaluation of electromagnetic compatibility

Approved By

Terry Tang

Manager

Dated: March 31, 2022

Results appearing herein relate only to the sample tested
The technical reports is issued errors and omissions exempt and is subject to withdrawal at

SHENZHEN TIMEWAY TESTING LABORATORIES

Zone C, 1st Floor, Block B, Jun Xiang Da Building, Zhongshan Park Road West, Tong Le Village, Nanshan District, Shenzhen, China
Tel (755) 83448688, Fax (755) 83442996, E-Mail:info@timeway-lab.com

Special Statement：

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 meet with ISO/IEC-17025 requirements, which is approved by CNAS. This approval result is accepted by MRA of APLAC.

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

CNAS-LAB Code: L2292

The EMC Laboratory has been assessed and in compliance with CNAS-CL01 accreditation criteria for testing Laboratories (identical to ISO/IEC 17025:2005 General Requirements) for the Competence of testing Laboratories.

FCC-Registration No.: 744189

The EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications commission. The acceptance letter from the FCC is maintained in our files. Registration No.: 744189.

Industry Canada (IC) —Registration No.:5205A

The EMC Laboratory has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing with Registration No.: 5205A.

A2LA (Certification Number:5013.01)

The EMC Laboratory has been accredited by the American Association for Laboratory Accreditation (A2LA). Certification Number:5013.01

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Test Report Conclusion

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1.0 **General Details**

1.1 Test Lab Details

Name : SHENZHEN TIMEWAY TESTING LABORATORIES.

Address: Zone C, 1st Floor, Block B, Jun Xiang Da Building, Zhongshan Park Road West, Tong Le Village, Nanshan District, Shenzhen, China

Telephone: (755) 83448688

Fax: (755) 83442996

Site Listed with Federal Communications commission (FCC)

Registration Number:744189

For 3m Anechoic Chamber

Site Listed with Industry Canada of Ottawa, Canada

Registration Number: IC: 5205A

For 3m Anechoic Chamber

1.2 Applicant Details

Applicant: Shenzhen Liangming Technology Co., Ltd.

Address: 808, Building 1, Optoelectronic R&D Building, Hangcheng Avenue, Xixiang Street,Baoan District, Shenzhen, China.

Telephone: 057

Fax: 057

1.3 Description of EUT

Product: Wireless module

Manufacturer: Shenzhen Liangming Technology Co., Ltd.

Address: 808, Building 1, Optoelectronic R&D Building, Hangcheng Avenue, Xixiang Street,Baoan District, Shenzhen, China.

Trademark: N/A

Model Number: DX2002

Additional Model Number: DX2002A, DX2002B

Hardware Version: V1.1

Software Version: V1.0.7

Serial No.: 00000001

Type of Modulation GFSK, Л/4D-QPSK, 8DPSK for Bluetooth

Frequency range 2402-2480MHz for Bluetooth

Channel Spacing 1MHz for Bluetooth

Frequency Selection By software

Channel Number 79 channels for Bluetooth

Antenna: 1.PCB antenna. The gain of the antennas is 2.0dBi (get from the antenna specification provided the applicant)

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2.Male IPEX connector with integral antenna. The gain of the antennas is 0.8dBi (get from the antenna specification provided the applicant)

Rating: DC3.3V

1.4 Submitted Sample: 2 Samples

1.5 Test Duration

2022-03-10 to 2022-03-31

1.6 Test Uncertainty

Conducted Emissions Uncertainty =3.6dB

Radiated Emissions below 1GHz Uncertainty =4.7dB

Radiated Emissions above 1GHz Uncertainty =6.0dB

Conducted Power Uncertainty =6.0dB

Occupied Channel Bandwidth Uncertainty =5%

Note: The measurement uncertainty is for coverage factor of k=2 and a level of confidence of 95%.

1.7 Test Engineer

The sample tested by Andy

Print Name: Andy Xing

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2.0 Test Equipment					
Instrument Type	Manufacturer	Model	Serial No.	Date of Cal.	Due Date
ESPI Test Receiver	R&S	ESPI 3	100379	2021-06-18	2022-06-17
Impuls-Begrenzer	R&S	ESH3-Z2	100281	2021-06-18	2022-06-17
Loop Antenna	EMCO	6507	00078608	2021-06-18	2024-06-17
Spectrum	R&S	FSIQ26	100292	2021-06-18	2022-06-17
Horn Antenna	A-INFO	LB-180400-KF	J211060660	2021-07-02	2024-07-01
Horn Antenna	R&S	BBHA 9120D	9120D-631	2021-07-02	2024-07-01
Power meter	Anritsu	ML2487A	6K00003613	2021-06-18	2022-06-17
Power sensor	Anritsu	MA2491A	32263	2021-06-18	2022-06-17
Bilog Antenna	Schwarebeck	VULB9163	9163/340	2021-07-02	2024-07-01
9*6*6 Anechoic	--	--	N/A	2021-07-02	2022-07-01
EMI Test Receiver	RS	ESVB	826156/011	2021-06-18	2022-06-17
EMI Test Receiver	RS	ESH3	860904/006	2021-06-18	2022-06-17
Spectrum	HP/Agilent	ESA-L1500A	US37451154	2021-06-18	2022-06-17
Spectrum	HP/Agilent	E4407B	MY50441392	2021-06-18	2022-06-17
Spectrum	RS	FSP	1164.4391.38	2022-01-15	2023-01-14
RF Cable	Zhengdi	ZT26-NJ-NJ-8 M/FA	--	2021-06-18	2022-06-17
RF Cable	Zhengdi	7m	--	2021-06-18	2022-06-17
RF Switch	EM	EMSW18	060391	2021-06-18	2022-06-17
Pre-Amplifier	Schwarebeck	BBV9743	#218	2021-06-18	2022-06-17
Pre-Amplifier	HP/Agilent	8449B	3008A00160	2021-06-18	2022-06-17
LISN	SCHAFFNER	NNB42	00012	2022-01-05	2023-01-04

2.2 Automation Test Software

For Conducted Emission Test

Name	Version
EZ-EMC	Ver.EMC-CON 3A1.1

For Radiated Emissions

Name	Version
EMI Test Software BL410-EV18.91	V18.905
EMI Test Software BL410-EV18.806 High Frequency	V18.06

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3.0 Technical Details

3.1 Summary of test results

The EUT has been tested according to the following specifications:

Requirement	CFR 47 Section	Result	Notes
Antenna Requirement	15.203, 15.247(b)(4)	Pass	Complies
Maximum Peak Out Power	15.247 (b)(1), (4)	Pass	Complies
Carrier Frequency Separation	15.247(a)(1)	Pass	Complies
20dB Channel Bandwidth	15.247 (a)(1)	Pass	Complies
Number of Hopping Channels	15.247(a)(iii), 15.247(b)(1)	Pass	Complies
Time of Occupancy (Dwell Time)	15.247(a)(iii)	Pass	Complies
Spurious Emission, Band Edge, and Restricted bands	15.247(d),15.205(a), 15.209 (a),15.109	Pass	Complies
Conducted Emissions	15.207	Pass	Complies
RF Exposure	15.247(i), 1.1307(b)(1)	Pass	Complies

Note: the multi-functional base and simple base were tested and only the worst case was reported. The multi-functional base was the worst case.

3.2 Test Standards

FCC Part 15 Subpart & Subpart C, Paragraph 15.247

4.0 EUT Modification

No modification by SHENZHEN TIMEWAY TESTING LABORATORIES.

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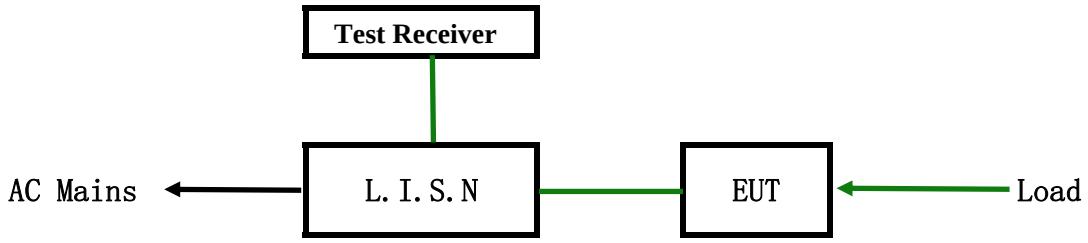
5. Power Line Conducted Emission Test

5.1 Schematics of the test



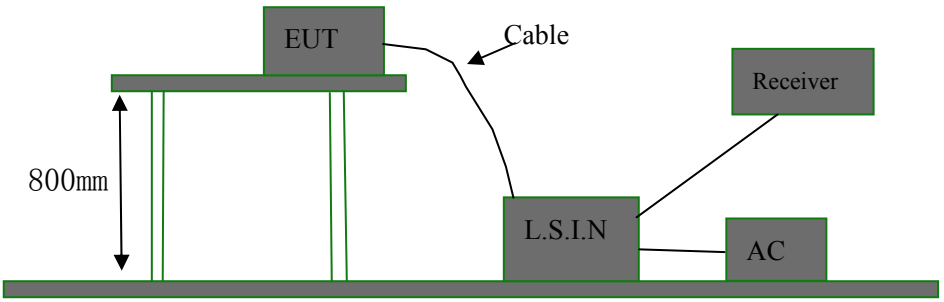
EUT: Equipment Under Test

5.2 Test Method and test Procedure

The EUT was tested according to ANSI C63.10-2013.The Frequency spectrum From 0.15MHz to 30MHz was investigated. The LISN used was 50ohm/50uH as specified by section 5.1 of ANSI C63.10–2013.

Test Voltage: 120V~ 60Hz

Block diagram of Test setup



5.3 Configuration of the EUT

The EUT was configured according to ANSI C63.10-2013. All interface ports were connected to the appropriate peripherals. All peripherals and cables are listed below.

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A. EUT

Device	Manufacturer	Model	FCC ID
Wireless module	Shenzhen Liangming Technology Co., Ltd.	DX2002, DX2002A, DX2002B	2AQJL-DX2002

B. Internal Device

Device	Manufacturer	Model	Rating
N/A			

C. Peripherals

Device	Manufacturer	Model	Rating
PC	ThinkPad	R4	--

5.4 EUT Operating Condition

Operating condition is according to ANSI C63.10-2013.

A Setup the EUT and simulators as shown on follow

B Enable AF signal and confirm EUT active to normal condition

5.5 Power line conducted Emission Limit according to Paragraph 15.207

Frequency (MHz)	Limits (dB μ V)	
	Quasi-peak Level	Average Level
0.15 ～ 0.50	66.0～56.0*	56.0～46.0*
0.50 ～ 5.00	56.0	46.0
5.00 ～ 30.00	60.0	50.0

Notes: 1. *Decreasing linearly with logarithm of frequency.

2. The tighter limit shall apply at the transition frequencies

5.6 Test Results

The frequency spectrum from 0.15MHz to 30MHz was investigated. All reading are quasi-peak values with a resolution bandwidth of 9kHz.

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A: Conducted Emission on Live Terminal (150kHz to 30MHz)

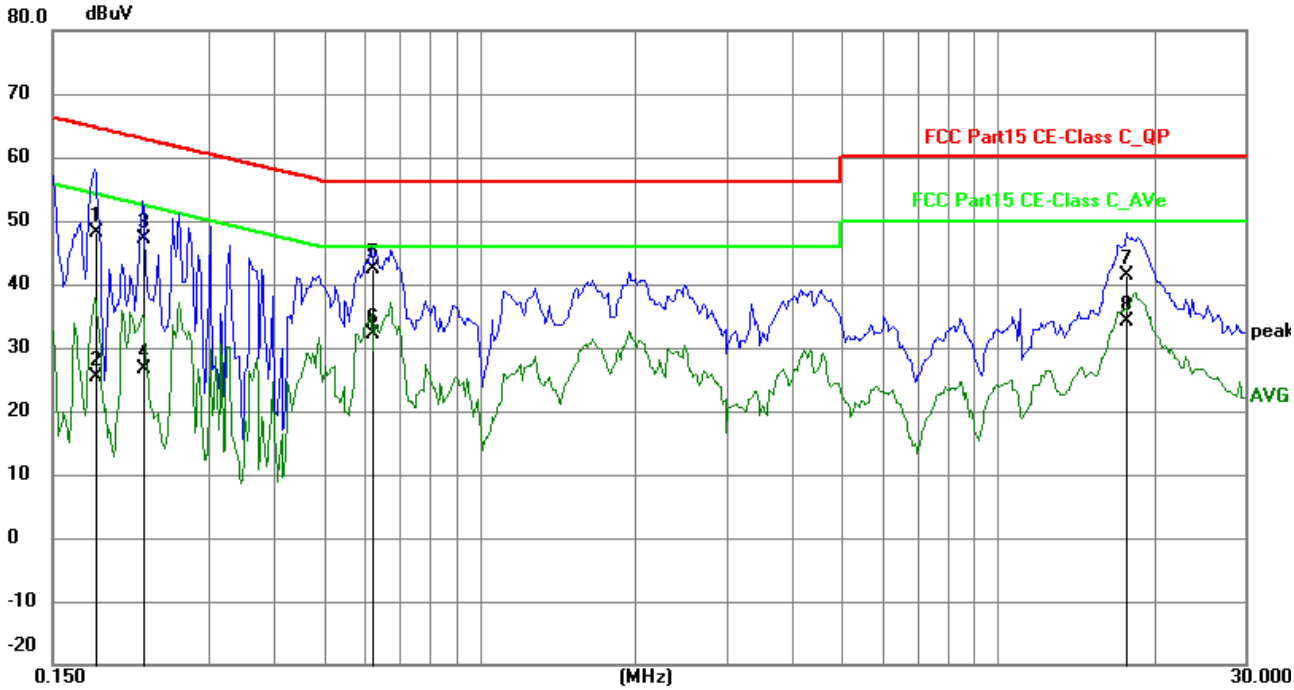
EUT Operating Environment

Temperature: 26℃ Humidity: 65%RH Atmospheric Pressure: 101 kPa

EUT set Condition: Keep Bluetooth Transmitting

Results: Pass

Please refer to following diagram for individual



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F
1	0.1812	38.42	9.76	48.18	64.43	-16.25	QP	P
2	0.1812	15.52	9.76	25.28	54.43	-29.15	AVG	P
3	0.2241	37.30	9.75	47.05	62.67	-15.62	QP	P
4	0.2241	16.96	9.75	26.71	52.67	-25.96	AVG	P
5	0.6180	32.70	9.78	42.48	56.00	-13.52	QP	P
6	0.6180	22.36	9.78	32.14	46.00	-13.86	AVG	P
7	17.6718	30.81	10.54	41.35	60.00	-18.65	QP	P
8	17.6718	23.52	10.54	34.06	50.00	-15.94	AVG	P

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B: Conducted Emission on Neutral Terminal (150kHz to 30MHz)

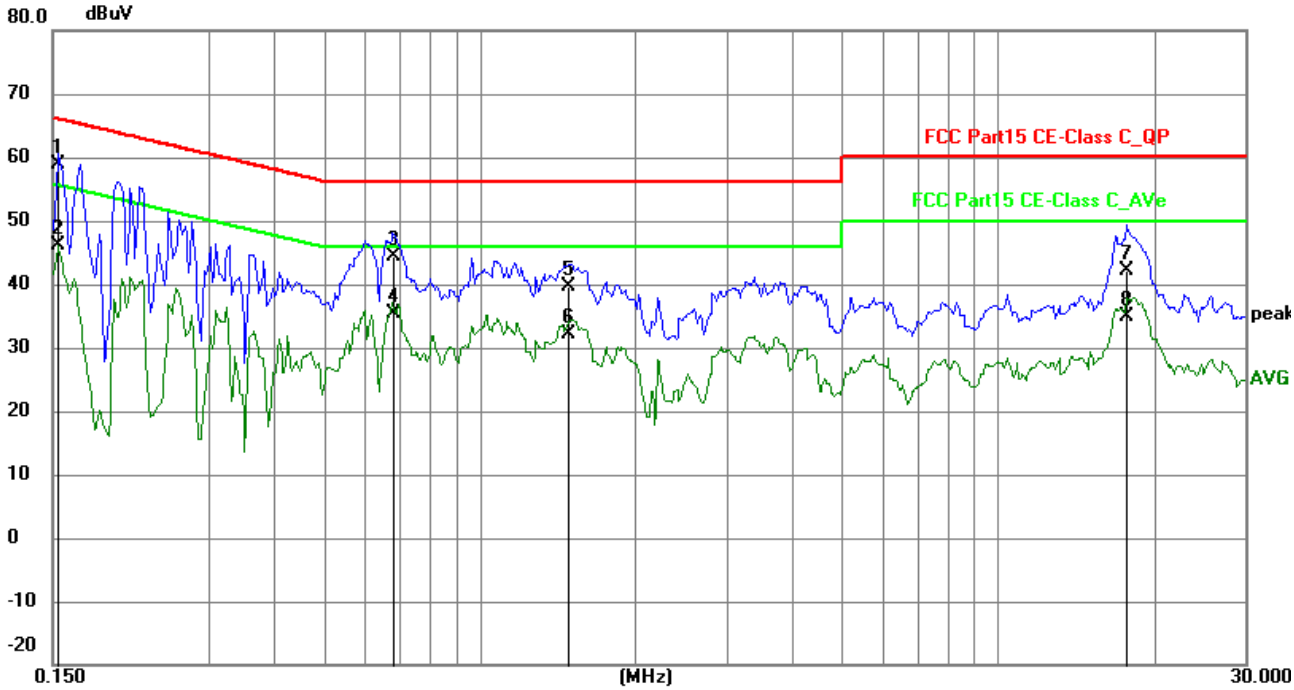
EUT Operating Environment

Temperature: 26℃ Humidity: 65%RH Atmospheric Pressure: 101 kPa

EUT set Condition: Keep Bluetooth Transmitting

Results: Pass

Please refer to following diagram for individual



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F
1	0.1539	49.06	9.78	58.84	65.79	-6.95	QP	P
2	0.1539	36.34	9.78	46.12	55.79	-9.67	AVG	P
3	0.6804	34.66	9.78	44.44	56.00	-11.56	QP	P
4	0.6804	25.49	9.78	35.27	46.00	-10.73	AVG	P
5	1.4838	29.77	9.79	39.56	56.00	-16.44	QP	P
6	1.4838	22.41	9.79	32.20	46.00	-13.80	AVG	P
7	17.7069	31.53	10.54	42.07	60.00	-17.93	QP	P
8	17.7069	24.42	10.54	34.96	50.00	-15.04	AVG	P

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6 Radiated Emission Test

6.1 Test Method and test Procedure:

(1) The EUT was tested according to ANSI C63.10-2013. The radiated test was performed at Timeway EMC Laboratory. This site is on file with the FCC laboratory division, Registration No. 744189

(2) The EUT, peripherals were put on the turntable which table size is 1m x 1.5 m, table high 0.8 m. All set up is according to ANSI C63.10-2013.

(3) The frequency spectrum from 30 MHz to 25GHz was investigated. All readings from 30 MHz to 1 GHz are quasi-peak values with a resolution bandwidth of 120 kHz. For measurement above 1GHz, peak values with RBW=VBW=1MHz and PK detector. AV value with RBW=1MHz, VBW=10Hz and PK detector. Measurements were made at 3 meters.

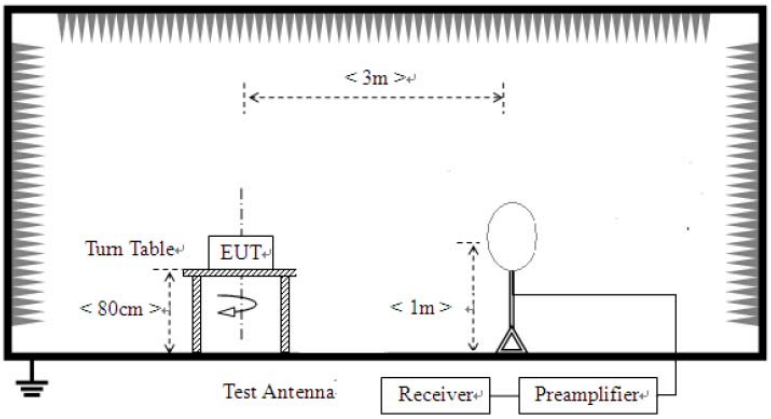
(4) The antenna high is varied from 1 m to 4 m high to find the maximum emission for each frequency.

(5) Maximizing procedure was performed on the six (6) highest emissions to ensure EUT compliance is with all installation combinations. All data was recorded in the peak detection mode. Quasi-peak readings was performed only when an emission was found to be marginal (within -4 dB of specification limit), and are distinguished with a "**QP**" in the data table.

(6) The antenna polarization : Vertical polarization and Horizontal polarization.

Block diagram of Test setup

For radiated emissions from 9kHz to 30MHz



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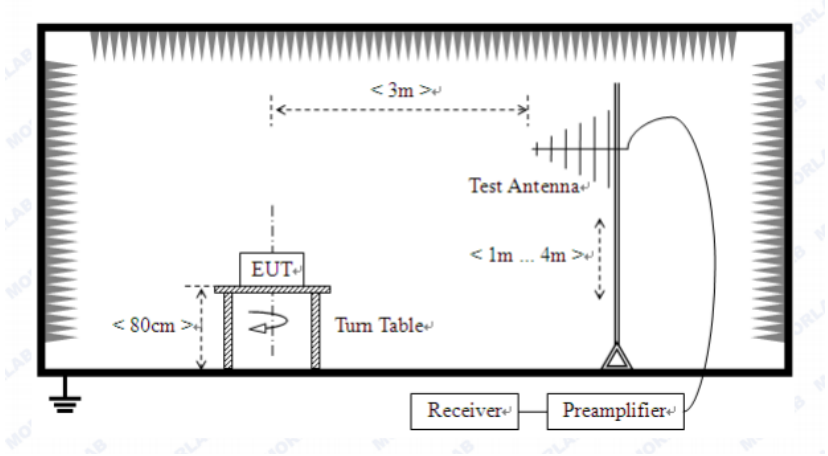
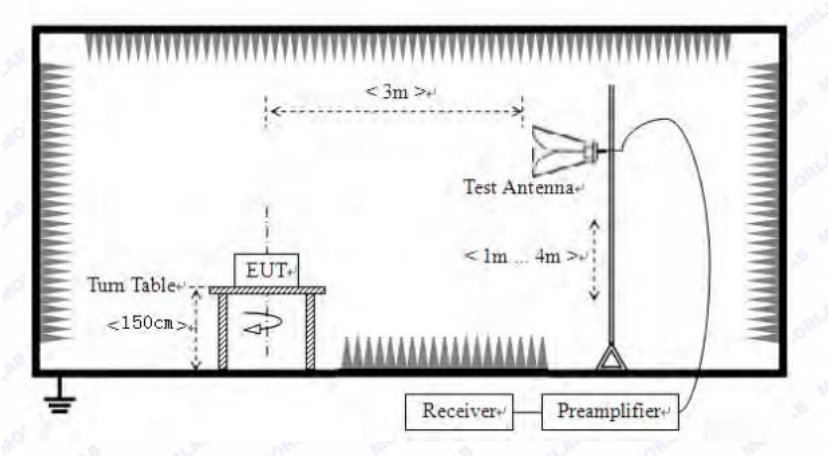
For radiated emissions from 30MHz to1GHz



For radiated emissions above 1GHz



6.2 Configuration of The EUT

Same as section 5.3 of this report

6.3 EUT Operating Condition

Same as section 5.4 of this report.

6.4 Radiated Emission Limit

All emission from a digital device, including any network of conductors and apparatus connected thereto, shall not exceed the level of field strength specified below:

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Frequencies in restricted band are complied to limit on Paragraph 15.209

Frequency Range (MHz)	Distance (m)	Field strength (dB μ V/m)
0.009-0.049	3	20log(2400/F(kHz)) +40log (300/3)
0.490-1.705	3	20log(24000/F(kHz)) +40log (30/3)
1.705-30	3	69.5
30-88	3	40.0
88-216	3	43.5
216-960	3	46.0
Above 960	3	54.0

Note: 1. RF Voltage (dBuV) = 20 log RF Voltage (uV)

2. In the Above Table, the higher limit applies at the band edges.

3. Distance refers to the distance in meters between the measuring instrument antenna and the EUT

4. GFSK was the worst case because it has highest output power

5. Two type of antennas were tested and only the worst cases were recorded in the test report. The antenna with high gain was the worst case.

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Test result

General Radiated Emission Data and Harmonics Radiated Emission Data

Radiated Emission In Horizontal/Vertical (30MHz----1000MHz)

EUT set Condition: Keep Bluetooth Transmitting

Results: Pass

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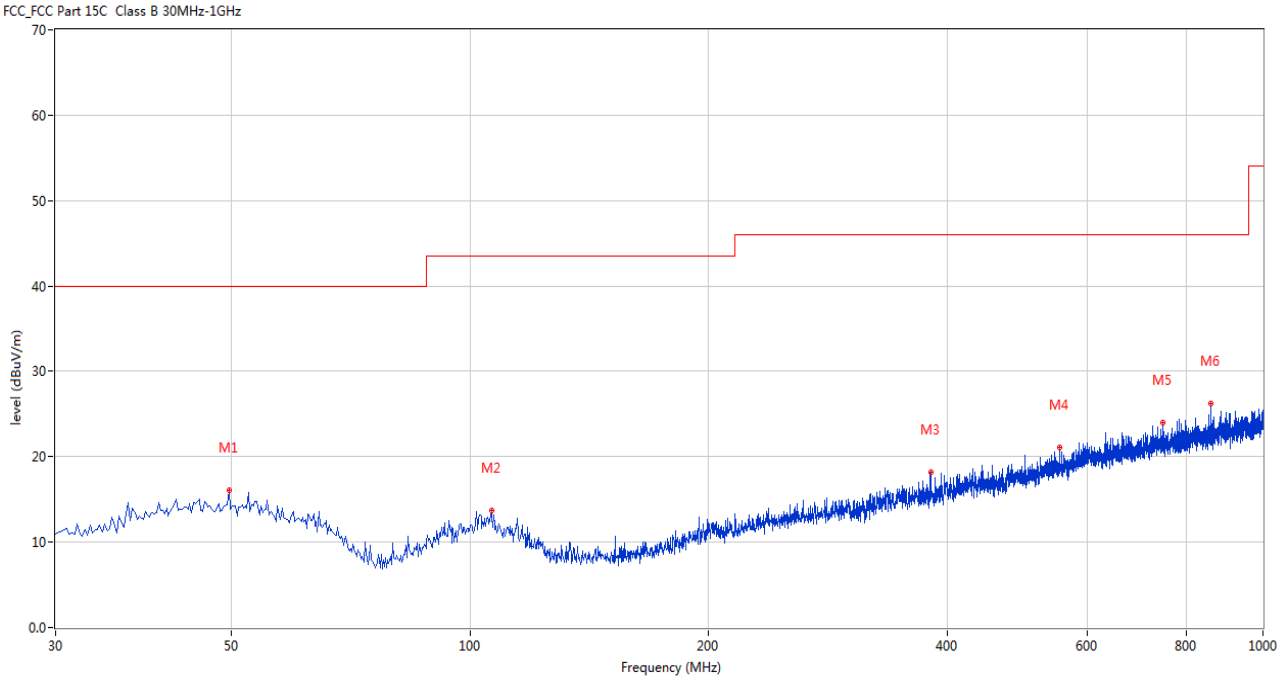
Test Figure:

H



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	49.638	16.08	-11.32	40.0	-23.92	Peak	282.00	100	Horizontal	Pass
2	106.368	13.76	-13.34	43.5	-29.74	Peak	27.00	100	Horizontal	Pass
3	381.295	18.19	-9.18	46.0	-27.81	Peak	81.00	100	Horizontal	Pass
4	554.396	21.07	-6.23	46.0	-24.93	Peak	70.00	100	Horizontal	Pass
5	748.590	24.00	-3.38	46.0	-22.00	Peak	75.00	100	Horizontal	Pass
6	860.355	26.21	-2.38	46.0	-19.79	Peak	19.00	100	Horizontal	Pass

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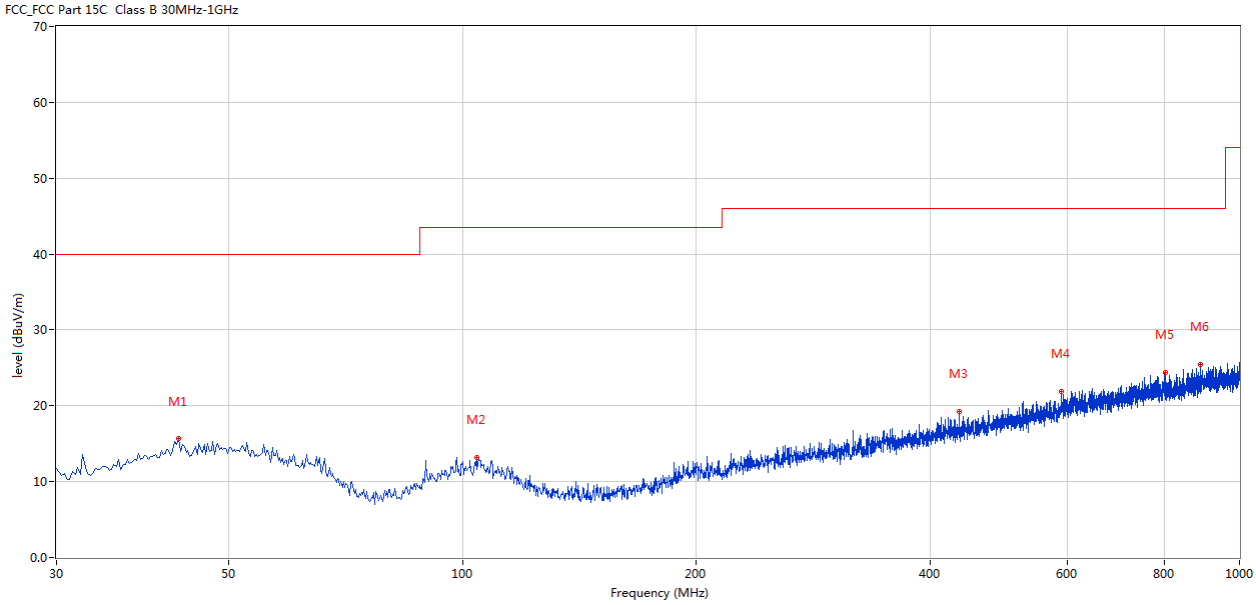
Test Figure:

V



No.	Frequency (MHz)	Results (dBuV/m)	Factor (dB)	Limit (dBuV/m)	Over Limit (dB)	Detector	Table (o)	Height (cm)	ANT	Verdict
1	43.092	15.73	-11.50	40.0	-24.27	Peak	128.00	100	Vertical	Pass
2	104.186	13.23	-13.30	43.5	-30.27	Peak	136.00	100	Vertical	Pass
3	435.601	19.23	-8.01	46.0	-26.77	Peak	178.00	100	Vertical	Pass
4	590.035	21.93	-5.09	46.0	-24.07	Peak	109.00	100	Vertical	Pass
5	802.412	24.34	-2.95	46.0	-21.66	Peak	274.00	100	Vertical	Pass
6	891.630	25.42	-1.93	46.0	-20.58	Peak	33.00	100	Vertical	Pass

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Operation Mode: Transmitting under Low Channel (2402MHz)

Frequency (MHz)	Level@3m (dB μ V/m)	Antenna Polarity	Limit@3m (dB μ V/m)
4804	50.26	H	74(Peak)/ 54(AV)
4804	46.83	V	74(Peak)/ 54(AV)
7206	--	H/V	74(Peak)/ 54(AV)
9608	--	H/V	74(Peak)/ 54(AV)
12010	--	H/V	74(Peak)/ 54(AV)
14412	--	H/V	74(Peak)/ 54(AV)
16814	--	H/V	74(Peak)/ 54(AV)
19216	--	H/V	74(Peak)/ 54(AV)
21618	--	H/V	74(Peak)/ 54(AV)
24020	--	H/V	74(Peak)/ 54(AV)

Operation Mode: Transmitting g under Middle Channel (2441MHz)

Frequency (MHz)	Level@3m (dB μ V/m)	Antenna Polarity	Limit@3m (dB μ V/m)
4882	50.12	H	74(Peak)/ 54(AV)
4882	47.29	V	74(Peak)/ 54(AV)
7323	--	H/V	74(Peak)/ 54(AV)
9764	--	H/V	74(Peak)/ 54(AV)
12205	--	H/V	74(Peak)/ 54(AV)
14646	--	H/V	74(Peak)/ 54(AV)
17087	--	H/V	74(Peak)/ 54(AV)
19528	--	H/V	74(Peak)/ 54(AV)
21969	--	H/V	74(Peak)/ 54(AV)
24410	--	H/V	74(Peak)/ 54(AV)

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Operation Mode: Transmitting under High Channel (2480MHz)

Frequency (MHz)	Level@3m (dB μ V/m)	Antenna Polarity	Limit@3m (dB μ V/m)
4960	49.62	H	74(Peak)/ 54(AV)
4960	44.35	V	74(Peak)/ 54(AV)
7440	--	H/V	74(Peak)/ 54(AV)
9920	--	H/V	74(Peak)/ 54(AV)
12400	--	H/V	74(Peak)/ 54(AV)
14880	--	H/V	74(Peak)/ 54(AV)
17360	--	H/V	74(Peak)/ 54(AV)
19840	--	H/V	74(Peak)/ 54(AV)
22320	--	H/V	74(Peak)/ 54(AV)
24800	--	H/V	74(Peak)/ 54(AV)

Note: 1. Level = Reading + AF + Cable - Preamp

2. For the radiated emissions above 18G and Below 30MHz, it is the floor noise.

3. The measured PK value less than the AV limit, no necessary to take down the AV measurement result.

4. Remark “---” means that the emissions level is too low to be measured

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7.0 20dB Bandwidth Measurement

7.1 Regulation

Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§ 15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated.

7.2 Limits of 20dB Bandwidth Measurement

N/A

7.3 Test Procedure.

1. Check the calibration of the measuring instrument (spectrum analyzer) using either an internal calibrator or a known signal from an external generator.
2. Set the spectrum analyzer as follows: Span =2 or 2.4MHz, RBW =30 or 36 kHz, VBW=91or 110 kHz, Sweep = auto Detector function = peak, Trace = max hold
3. Measure the highest amplitude appearing on spectral display and record the level to calculate results. 6. Repeat above procedures until all frequencies measured were complete.

7.4 Test Result

Type of Modulation: GFSK

EUT	Wireless module		Model	DX2002
Mode	Keep Transmitting		Input Voltage	DC3.3V
Temperature	24 deg. C,		Humidity	56% RH
Channel	Channel Frequency (MHz)	20 dB Bandwidth (MHz)	Minimum Limit (kHz)	Pass/ Fail
Low	2402	0.963	--	Pass
Middle	2441	0.962	--	Pass
High	2480	0.963	--	Pass

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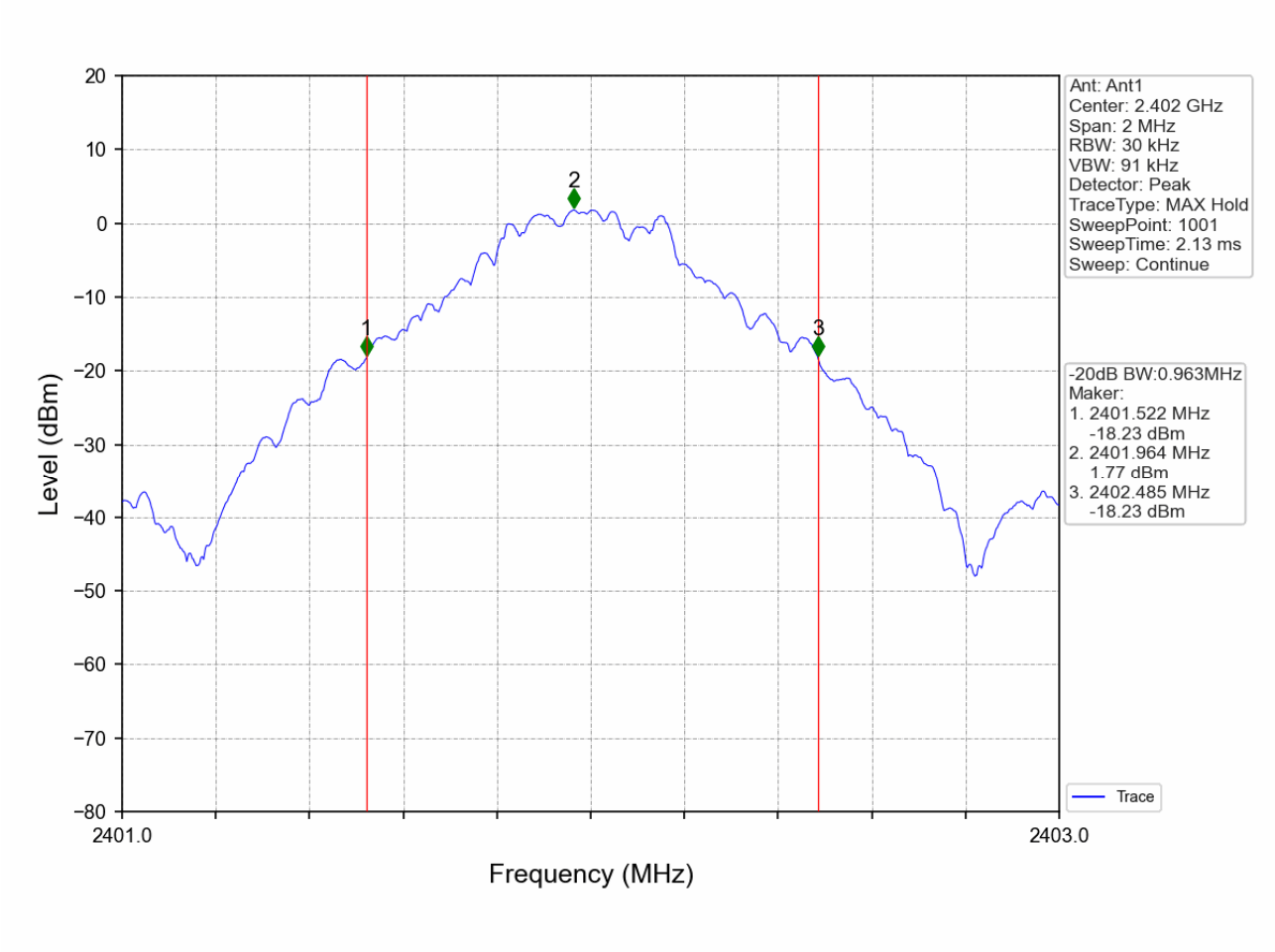
Test Figure:

1. Condition: Low Channel



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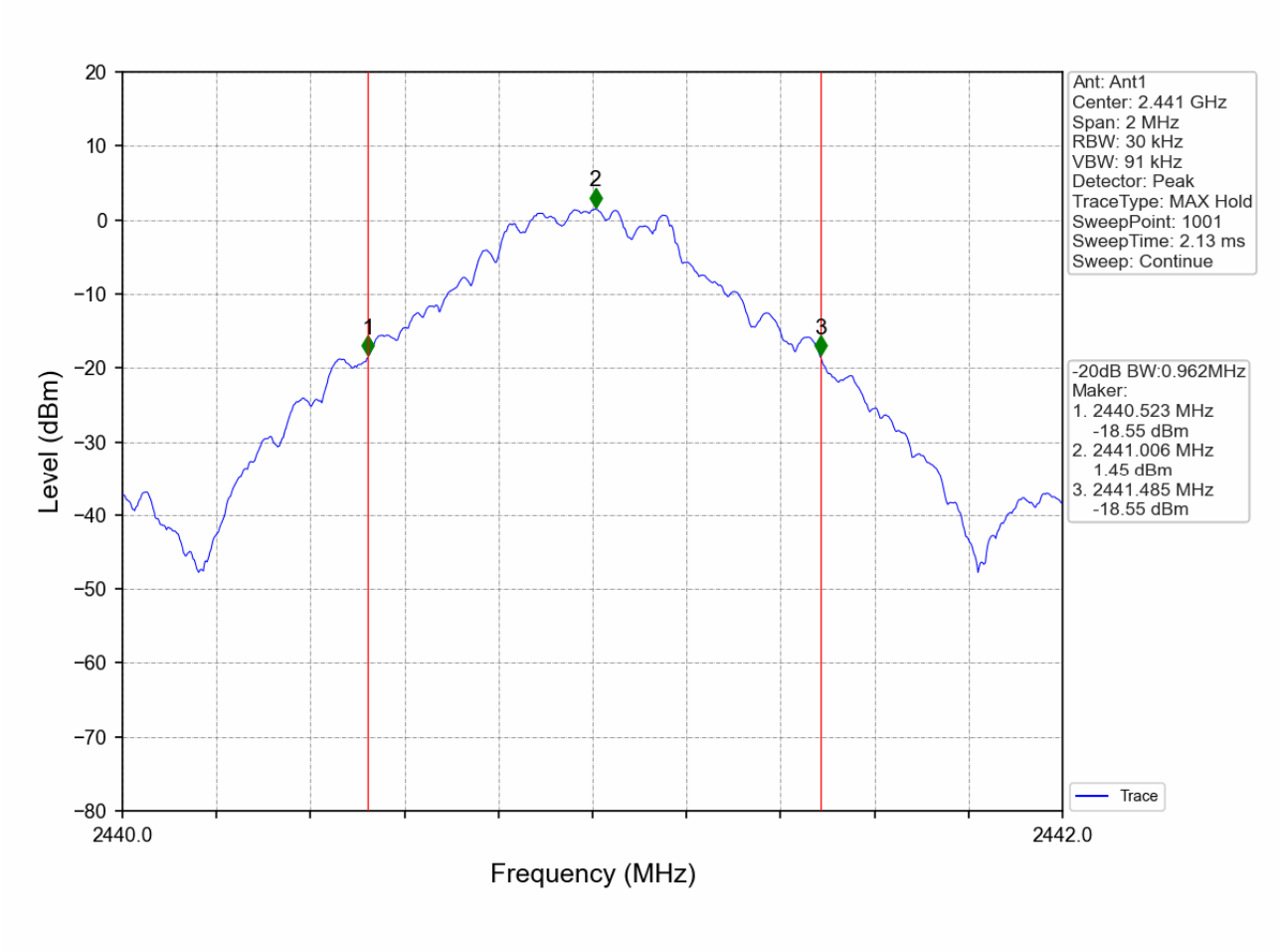
2. Condition: Middle Channel



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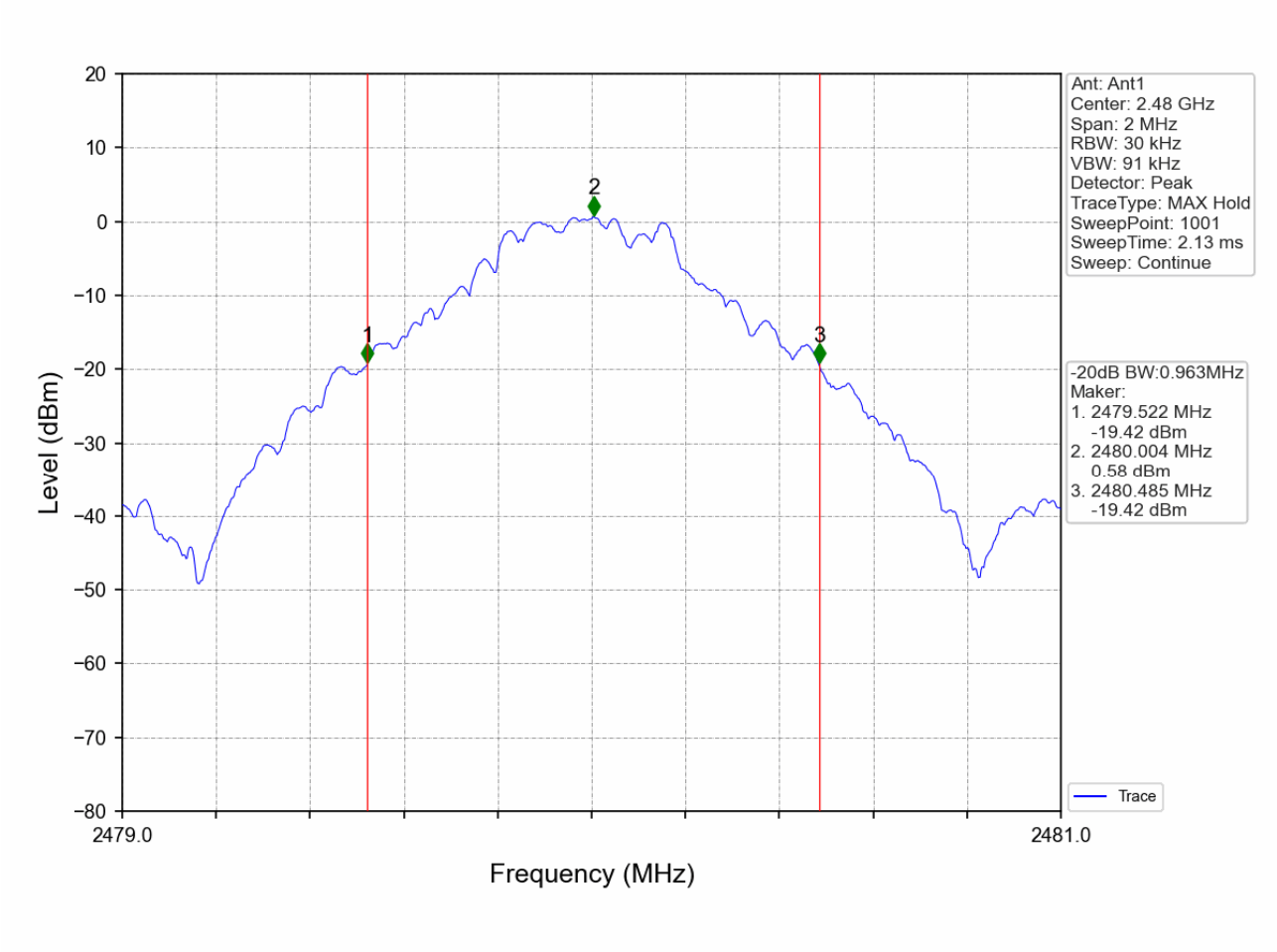
3. High Channel



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Test Result

Type of Modulation: Л/4D-QPSK

EUT	Wireless module	Model	DX2002
Mode	Keep Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Channel	Channel Frequency (MHz)	20 dB Bandwidth (MHz)	Maximum Limit (kHz)	Pass/ Fail
Low	2402	1.493	--	Pass
Middle	2441	1.491	--	Pass
High	2480	1.496	--	Pass

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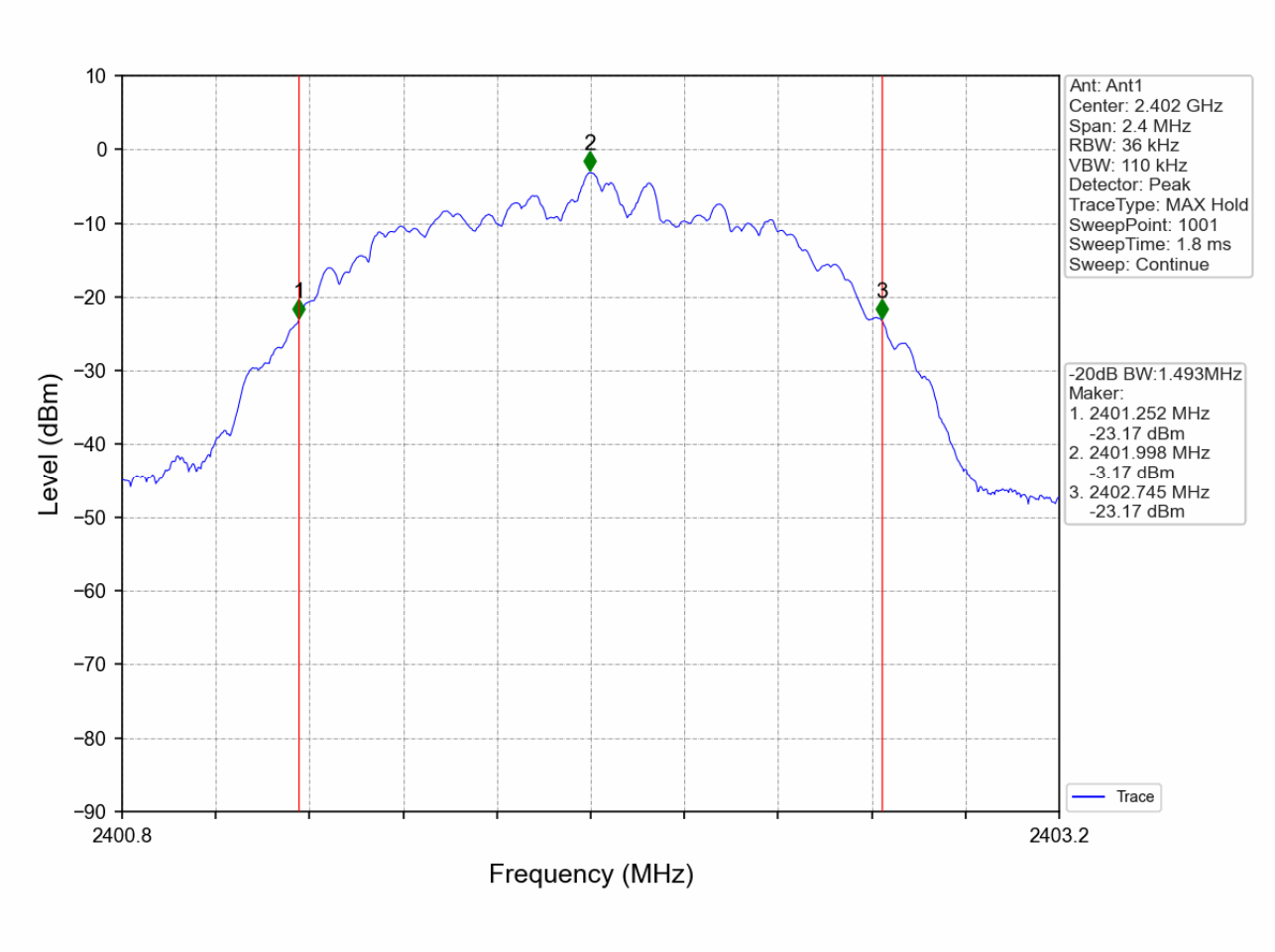
Test Figure:

1. Condition: Low Channel



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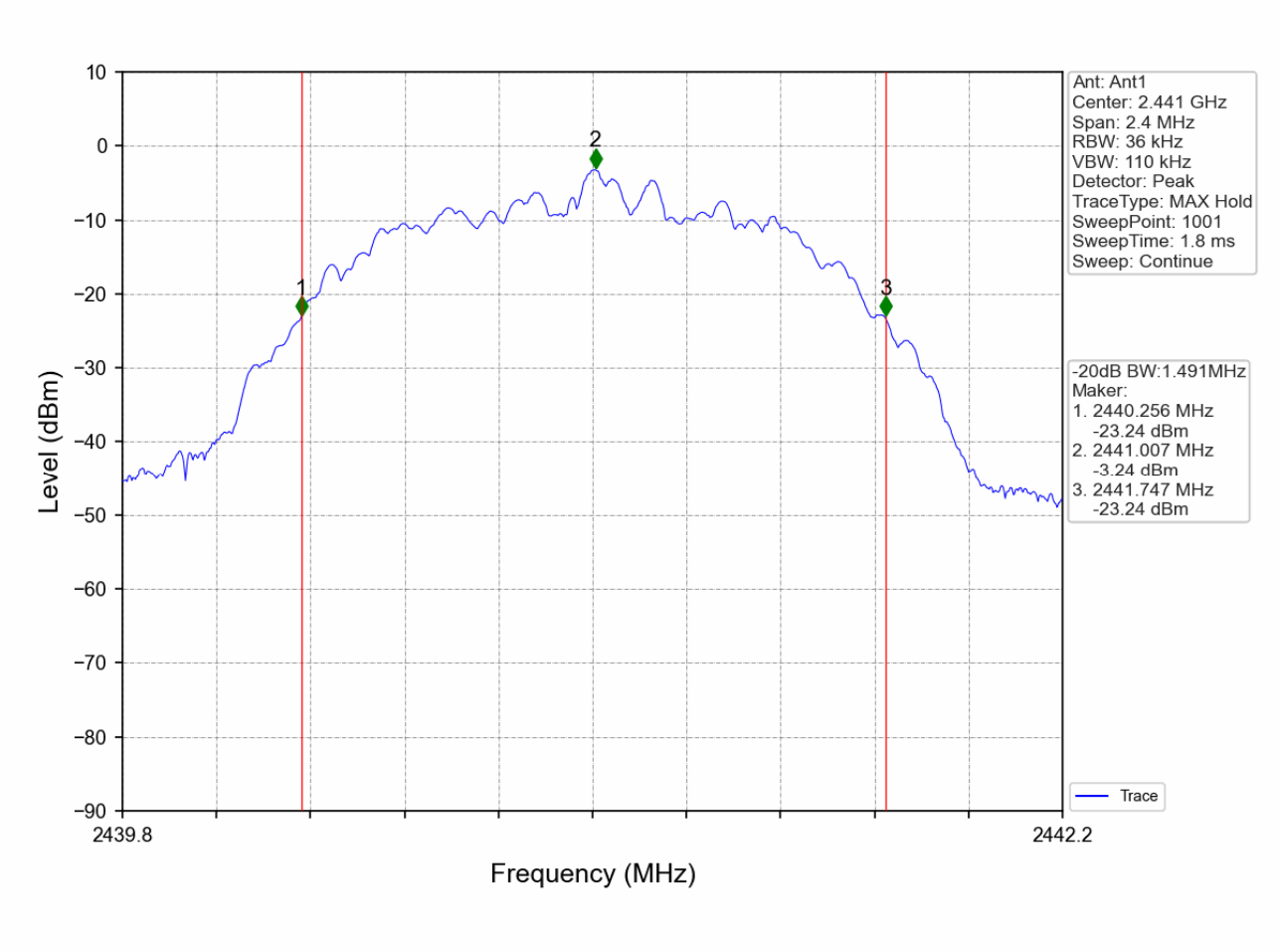
2. Condition: Middle Channel



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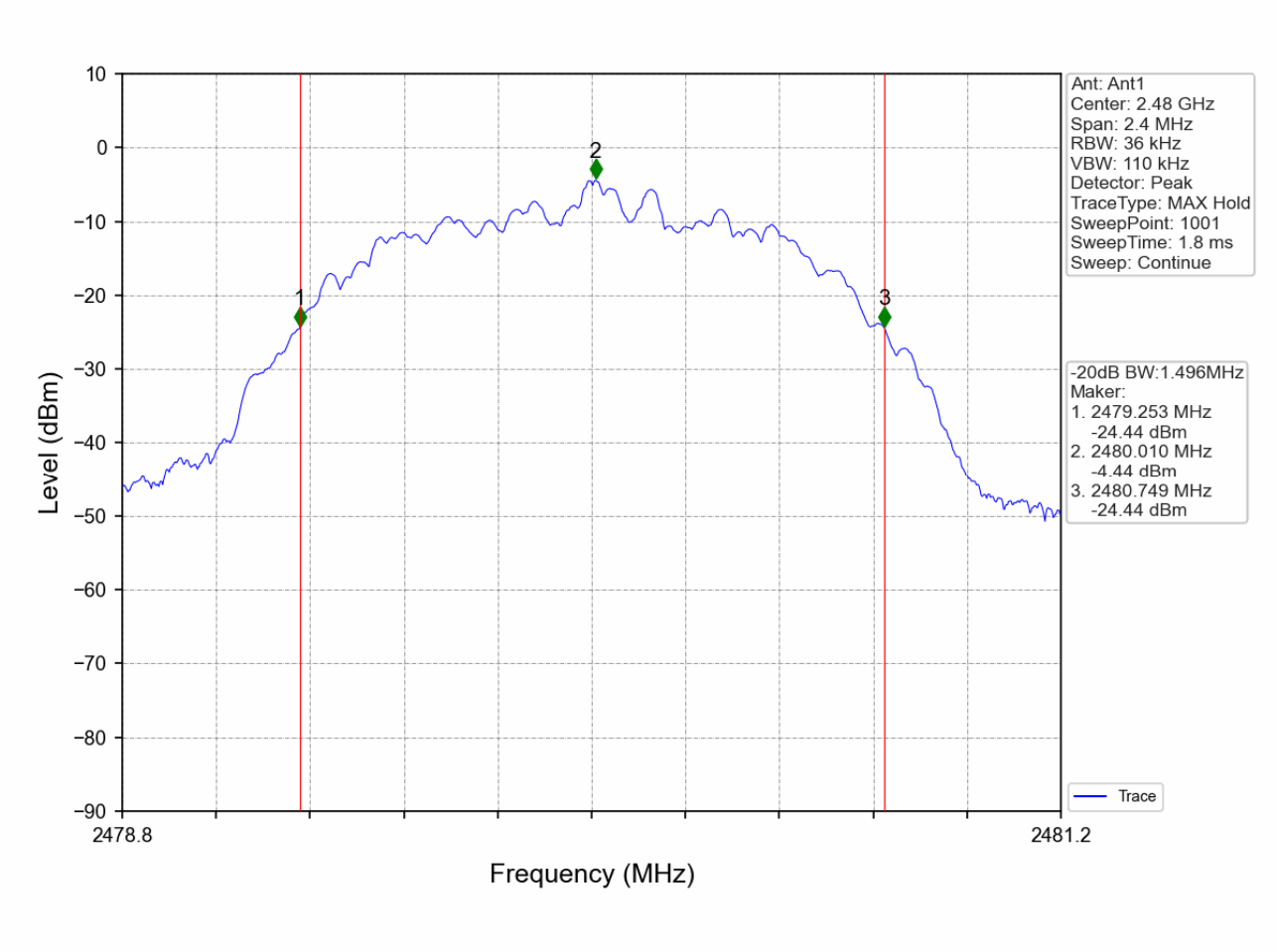
3. High Channel



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Test Result

Type of Modulation: 8DPSK

EUT	Wireless module	Model	DX2002
Mode	Keep Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Channel	Channel Frequency (MHz)	20 dB Bandwidth (MHz)	Maximum Limit (kHz)	Pass/ Fail
Low	2402	1.491	--	Pass
Middle	2441	1.491	--	Pass
High	2480	1.491	--	Pass

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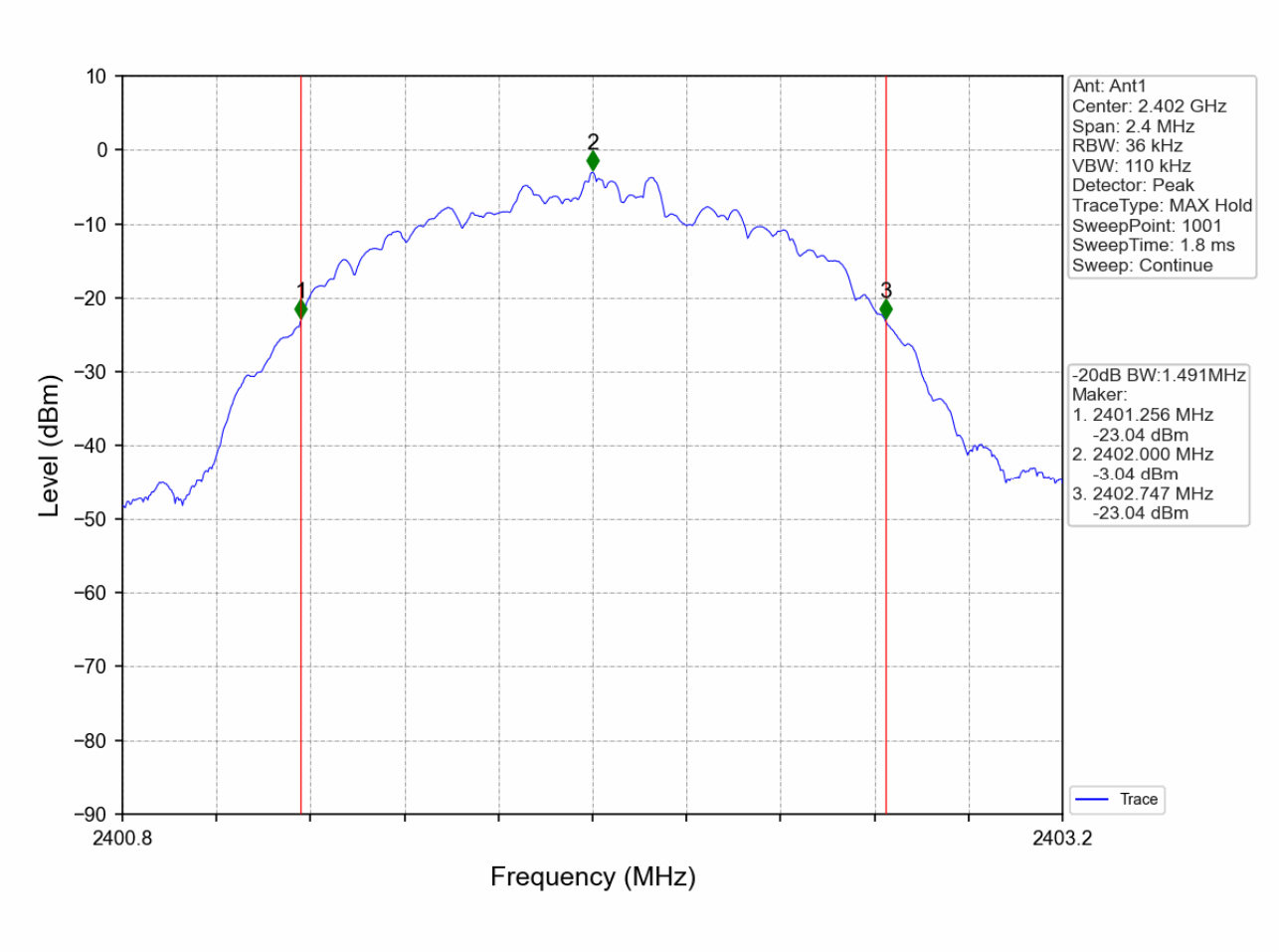
Test Figure:

1. Condition: Low Channel



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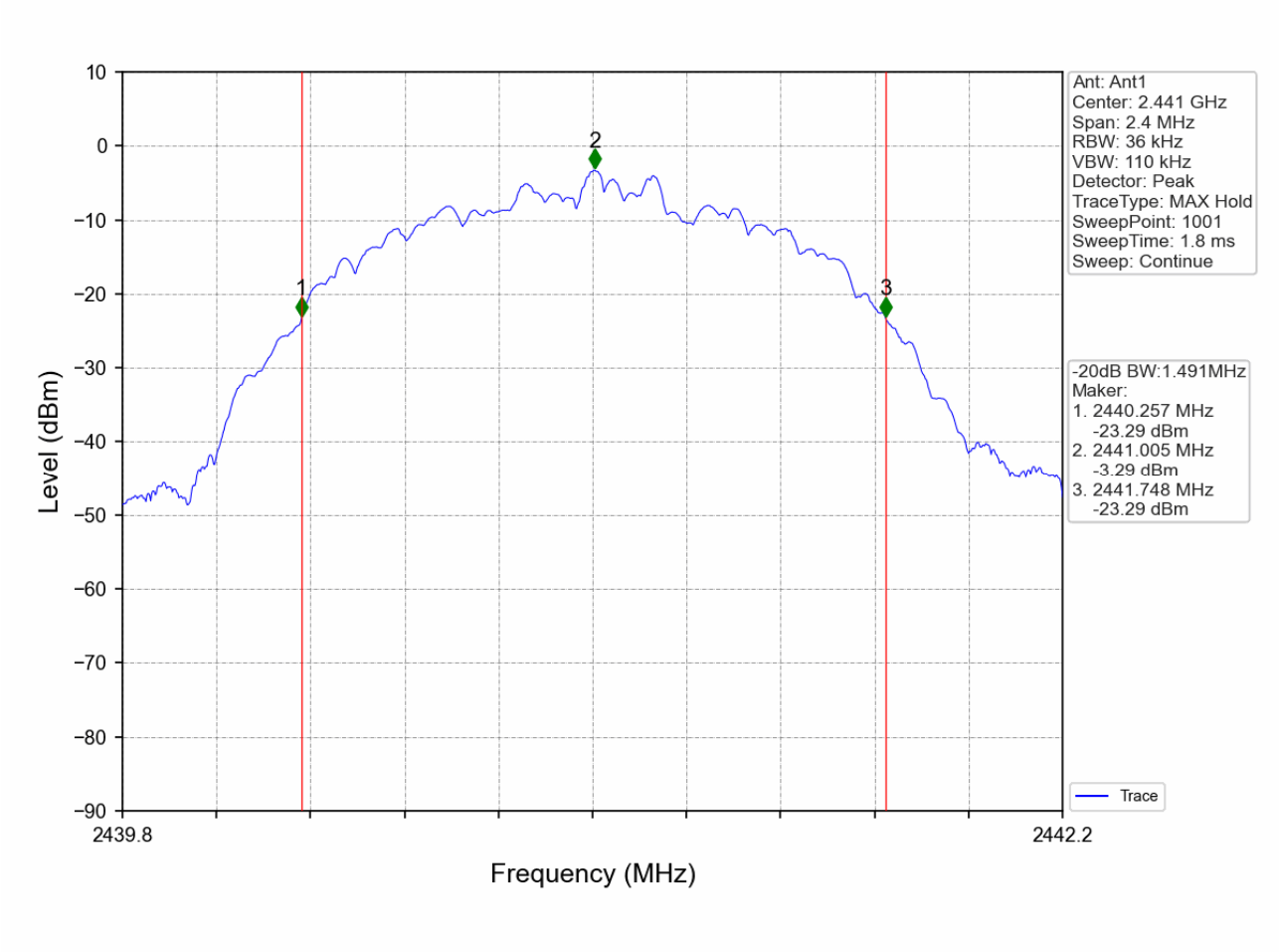
2. Condition: Middle Channel



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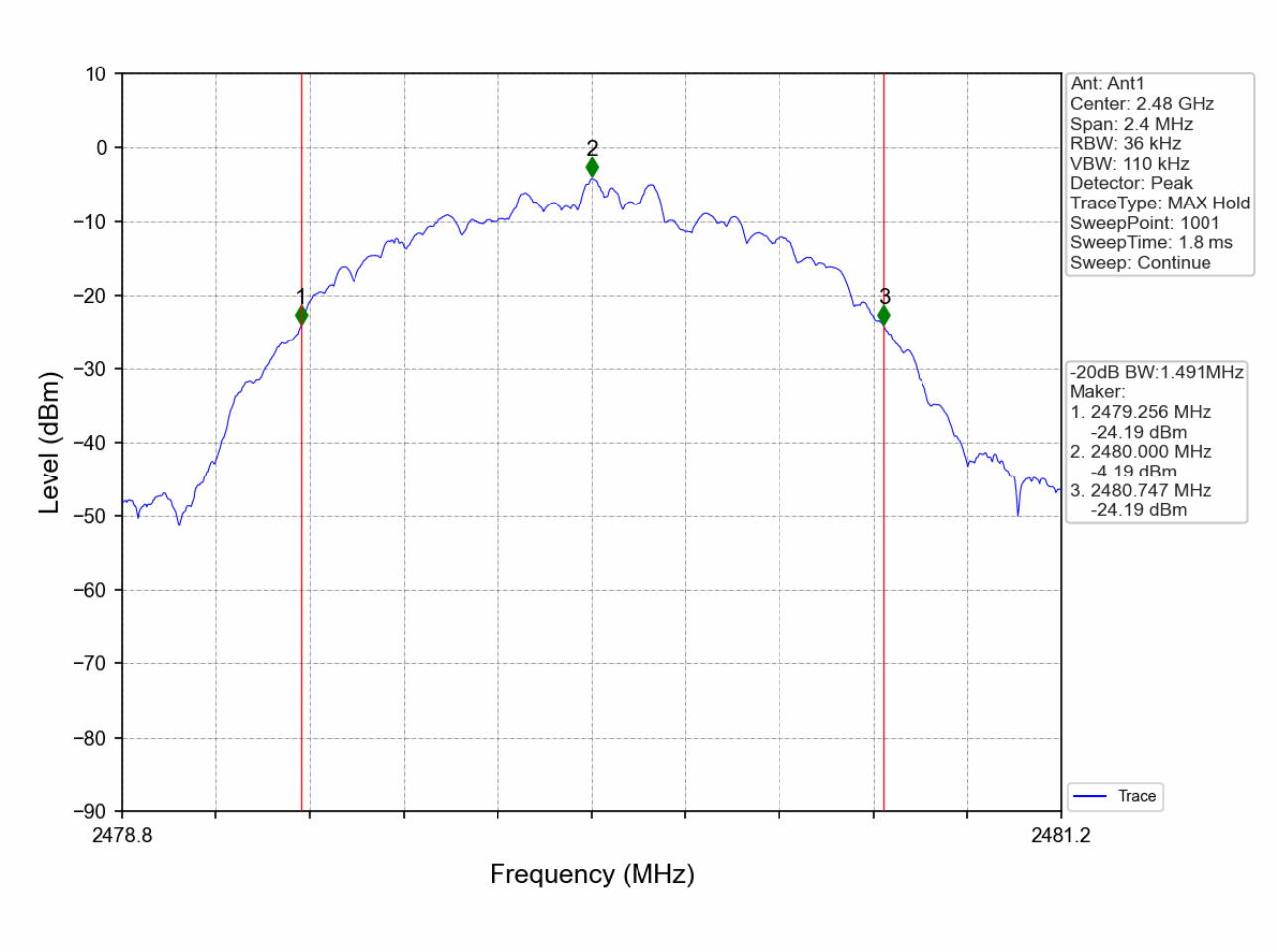
3. High Channel



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8. Maximum Output Power

8.1 Regulation

According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5MHz band:0.125 watts. According to §15.247(b)(4), the conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

8.2 Limits of Maximum Output Power

The Maximum Output Power Measurement is 30dBm.

8.3 Test Procedure

1. Check the calibration of the measuring instrument (spectrum analyzer) using either an internal calibrator or a known signal from an external generator.
2. Set the spectrum analyzer as follows: Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel; RBW > the 20 dB bandwidth of the emission being measured; VBW = 10MHz, RBW=3MHz; Sweep = 60s; Detector function = PK; Trace = max hold
3. Measure the highest amplitude appearing on spectral display and record the level to calculate results.
4. Repeat above procedures until all frequencies measured were complete.

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8.4Test Results

Type of Modulation: GFSK

EUT	Wireless module	Model	DX2002
Mode	Keep Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Channel	Channel Frequency (MHz)	Max. Power Output (dBm)	Peak Power Limit (dBm)	Pass/ Fail
		Peak		
Low	2402	4.30	30	Pass
Middle	2441	3.96	30	Pass
High	2480	3.05	30	Pass

Note: 1. the result basic equation calculation as follow:

Max. Power Output = Power Reading + Cable loss + Attenuator

2. The worst case was recorded

3. The Peak power was measured

Type of Modulation: Л/4D-QPSK

EUT	Wireless module	Model	DX2002
Mode	Keep Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Channel	Channel Frequency (MHz)	Max. Power Output (dBm)	Peak Power Limit (dBm)	Pass/ Fail
		Peak		
Low	2402	0.37	30	Pass
Middle	2441	0.37	30	Pass
High	2480	-0.68	30	Pass

Note: 1. the result basic equation calculation as follow:

Max. Power Output = Power Reading + Cable loss + Attenuator

2. The worst case was recorded

3. The Peak power was measured

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Type of Modulation: 8DPSK

EUT	Wireless module	Model	DX2002
Mode	Keep Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Channel	Channel Frequency (MHz)	Max. Power Output (dBm)	Peak Power Limit (dBm)	Pass/ Fail
		Peak		
Low	2402	0.84	30	Pass
Middle	2441	0.50	30	Pass
High	2480	-0.53	30	Pass

Note: 1. the result basic equation calculation as follow:

Max. Power Output = Power Reading + Cable loss + Attenuator

2. The worst case was recorded

3. The Peak power was measured

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9. Carrier Frequency Separation

9.1 Regulation

According to §15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

9.2 Limits of Carrier Frequency Separation

The Maximum Power Spectral Density Measurement is 25kHz or two-thirds of the 20dB bandwidth of the hopping Channel which is great.

9.3 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Set the spectrum analyzer as follows: Span = wide enough to capture the peaks of two adjacent channels: Resolution (or IF) Bandwidth (RBW) ⩾ 1% of the span; Video (or Average) Bandwidth (VBW) ⩾ RBW; Sweep = auto; Detector function = peak; Trace = max hold
3. Measure the separation between the peaks of the adjacent channels using the marker-delta function.
4. Repeat above procedures until all frequencies measured were complete.

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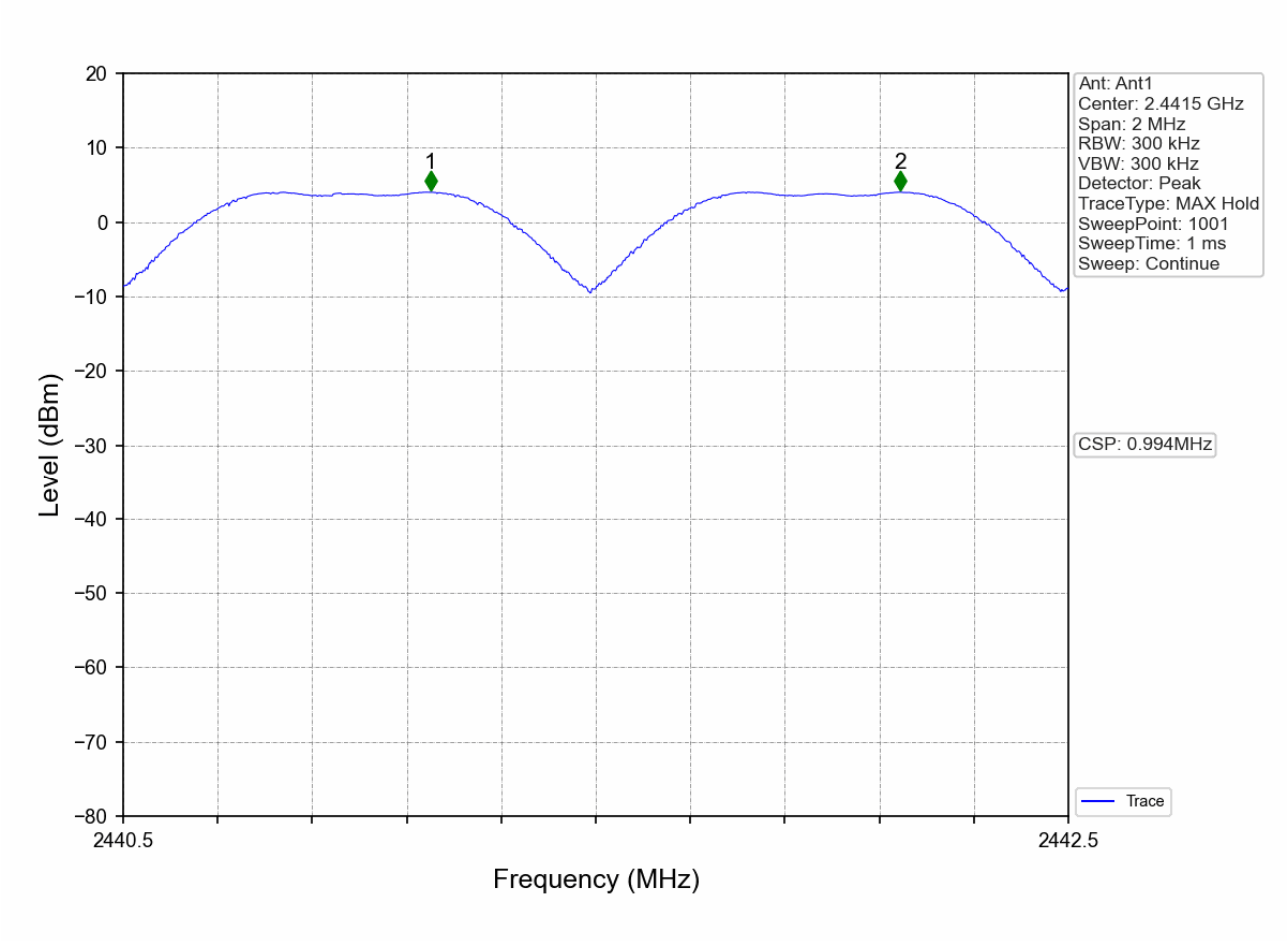
9.4Test Result

Type of Modulation: GFSK

EUT	Wireless module	Model	DX2002
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Carrier Frequency Separation	Limit	Pass/ Fail
0.994MHz	⩾ 25 kHz or 2/3 of the 20 dB bandwidth	Pass

Test Plots



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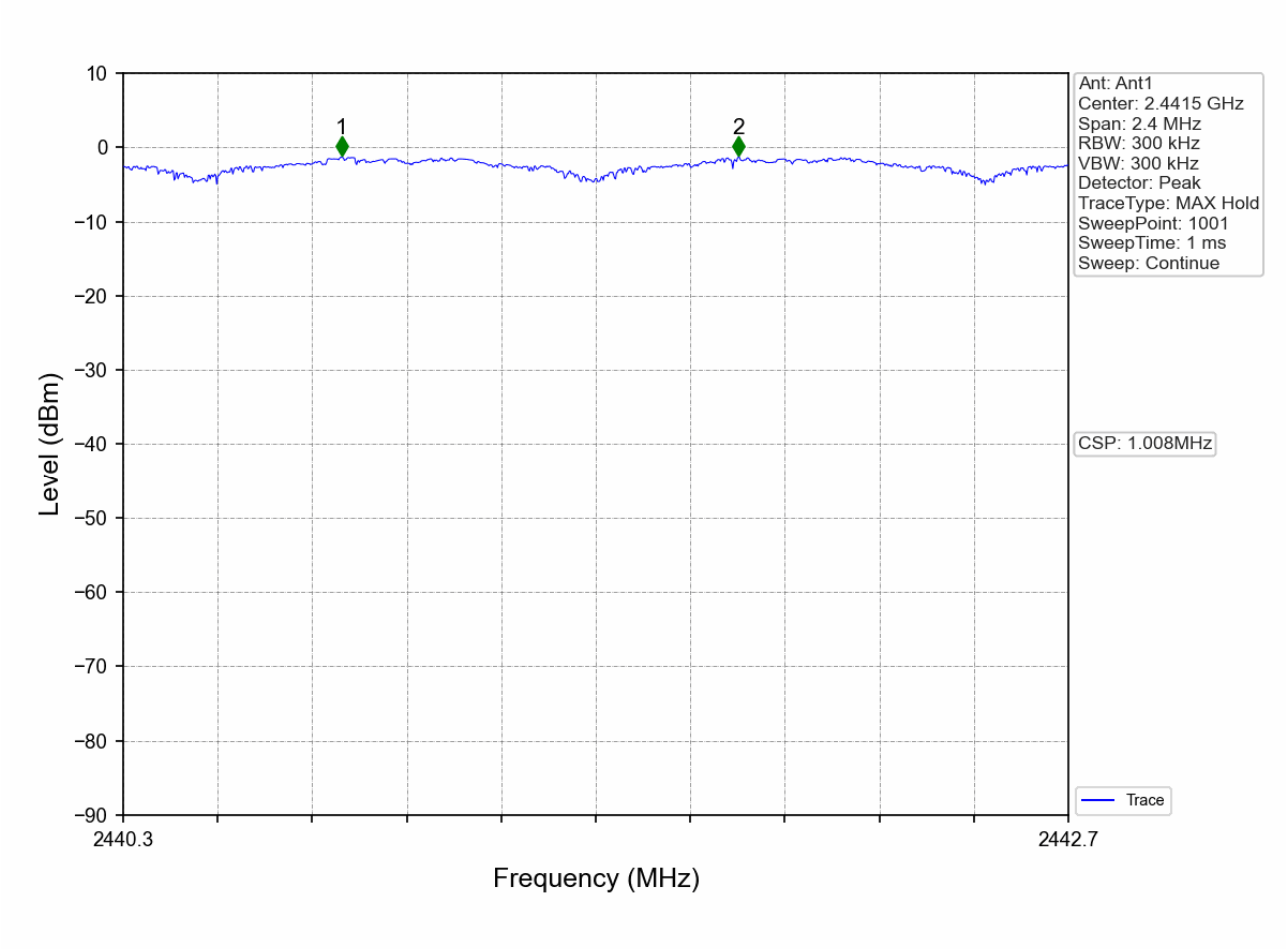
Type of Modulation: Л/4D-QPSK

EUT	Wireless module	Model	DX2002
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Carrier Frequency Separation	Limit	Pass/ Fail
1.008MHz	⩾ 25 kHz or 2/3 of 20 dB bandwidth	Pass

Test Plots



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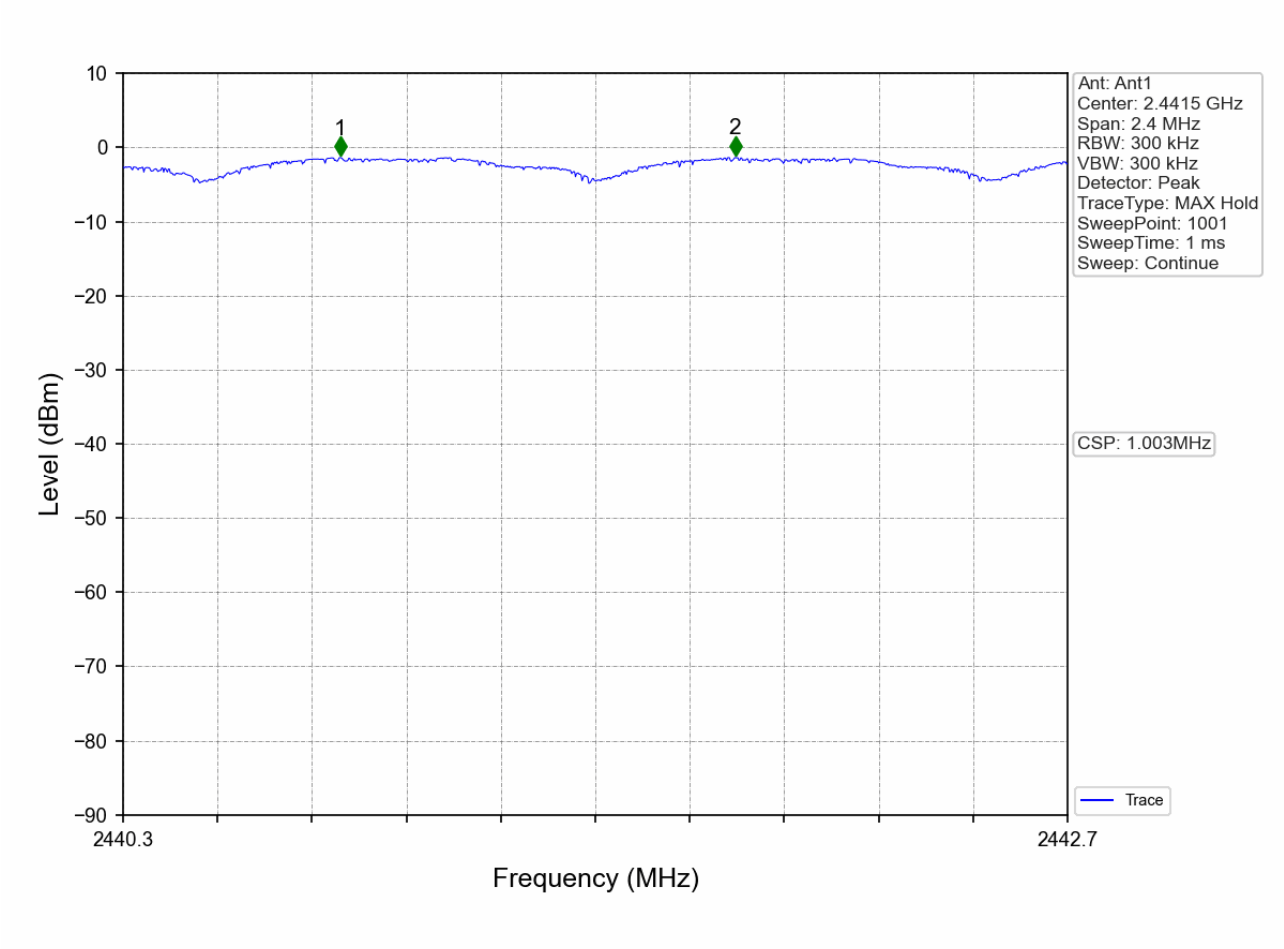
Type of Modulation: 8DPSK

EUT	Wireless module	Model	DX2002
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Carrier Frequency Separation	Limit	Pass/ Fail
1.003MHz	⩾ 25 kHz or 2/3 of 20 dB bandwidth	Pass

Test Plots



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10. Number of Hopping Channels

10.1 Regulation

According to §15.247(a)(1)(iii), 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. According to §15.247(b)(1), for frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

10.2 Limits of Number of Hopping Channels

The frequency hopping systems in the 2400-2483.5MHz band shall use at least 15 channels.

10.3 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Set the spectrum analyzer as follows: Span = the frequency band of operation; RBW=300 kHz, VBW=300 kHz; Sweep = auto; Detector function = peak; Trace = max hold
3. Record the number of hopping channels.

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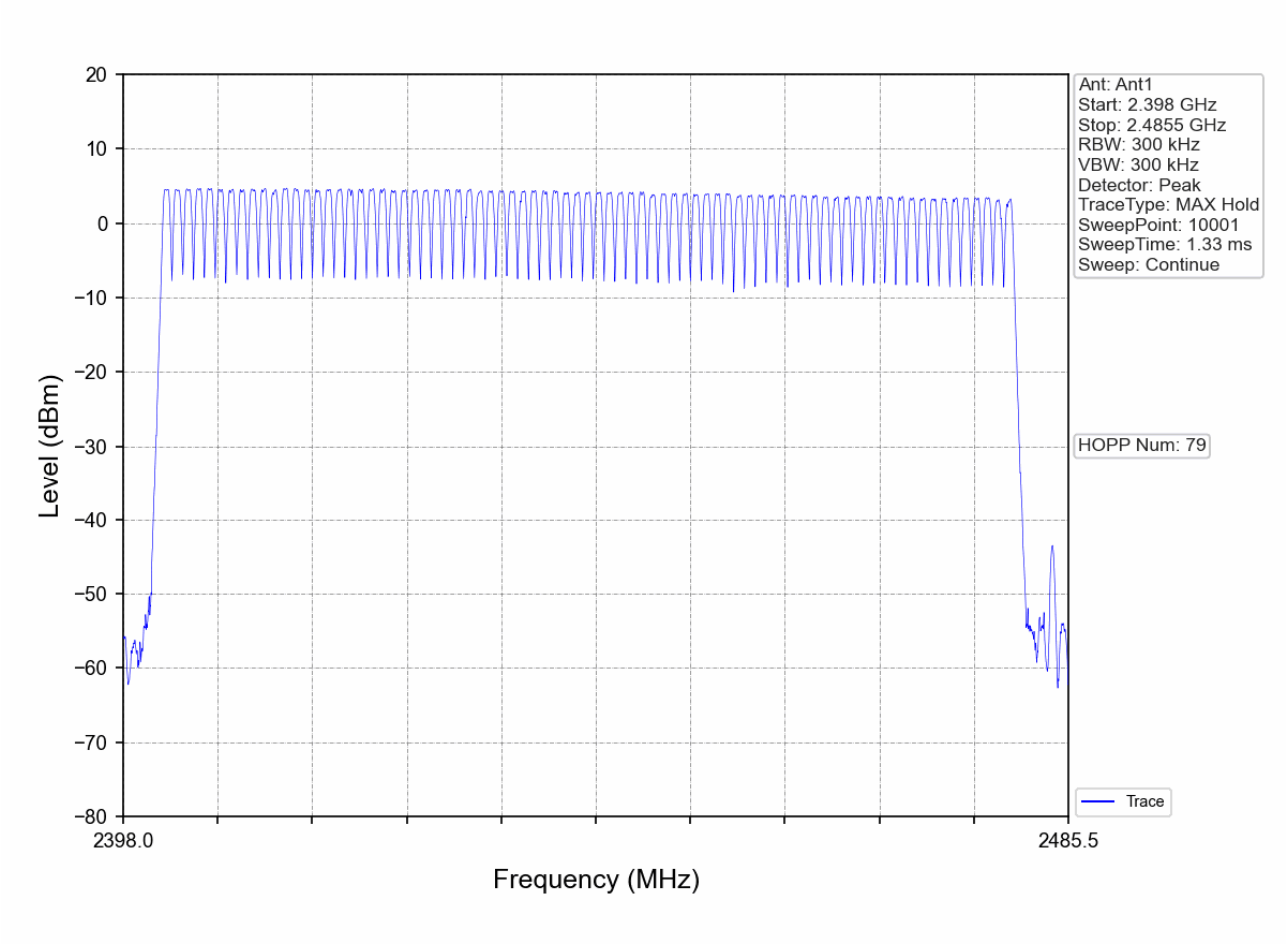
10.4Test Result

Type of Modulation: GFSK

EUT	Wireless module	Model	DX2002
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Operating Frequency	Number of hopping channels	Limit	Pass/ Fail
2402-2480MHz	79	≥ 15	Pass

Test Plot



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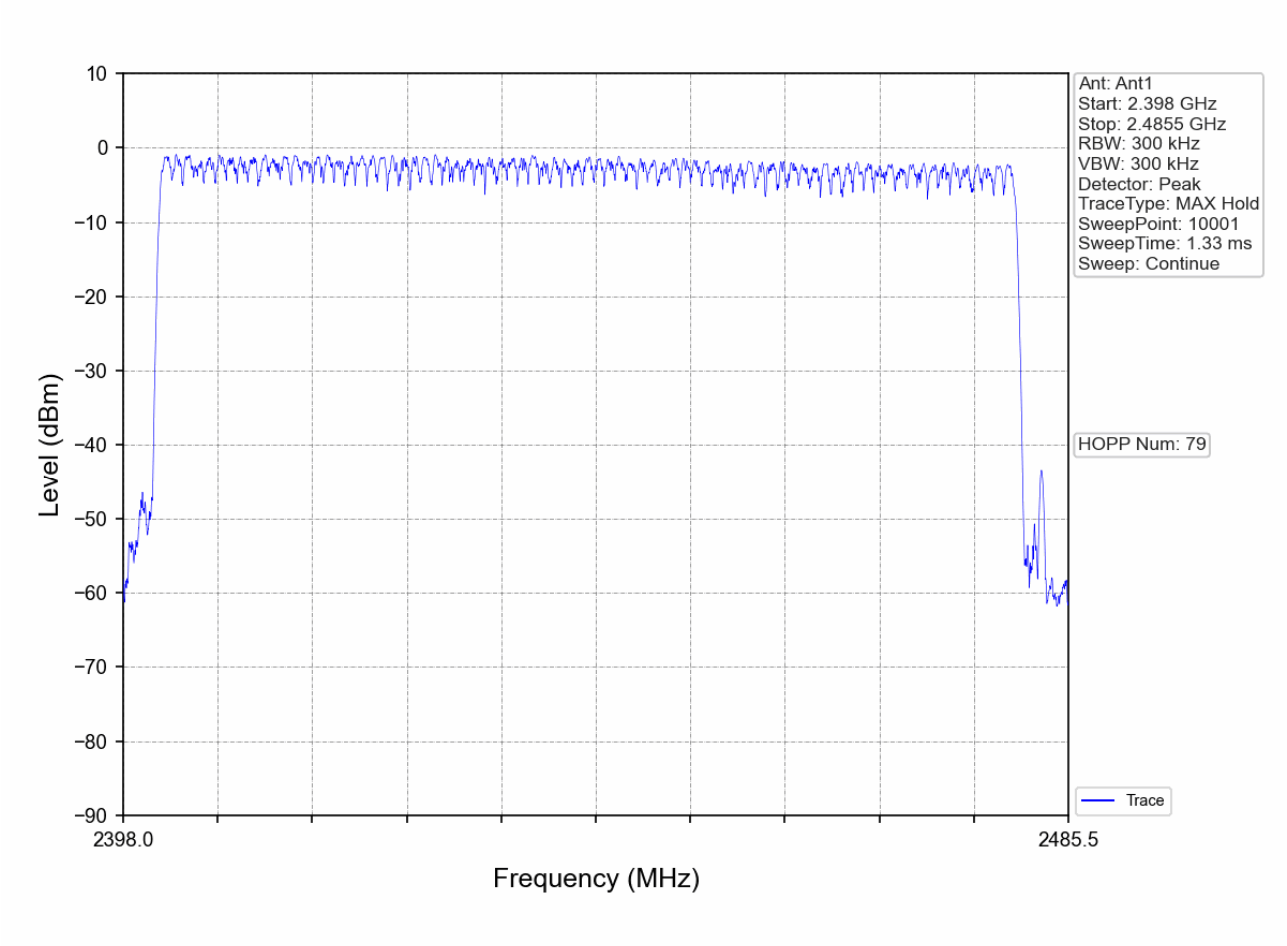
Type of Modulation: Л/4D-QPSK

EUT	Wireless module	Model	DX2002
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Operating Frequency	Number of hopping channels	Limit	Pass/ Fail
2402-2480MHz	79	≥ 15	Pass

Test Plot



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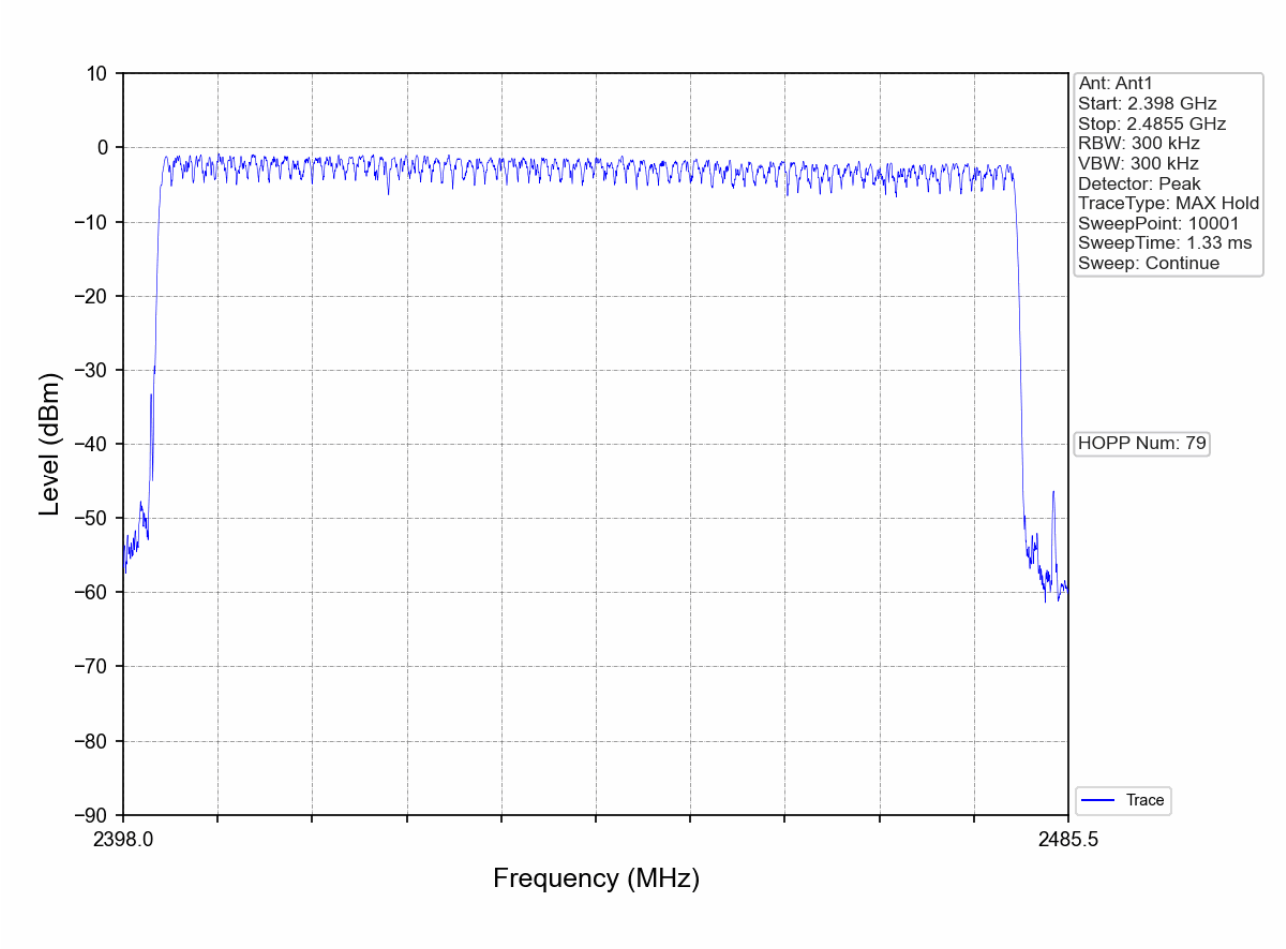
Type of Modulation: 8DPSK

EUT	Wireless module	Model	DX2002
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH

Operating Frequency	Number of hopping channels	Limit	Pass/ Fail
2402-2480MHz	79	≥ 15	Pass

Test Plot



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11. Time of Occupancy (Dwell Time)

11.1 Regulation

According to §15.247(a)(1)(iii), 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.

11.2 Limits of Carrier Frequency Separation

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

11.3 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Set the spectrum analyzer as follows: Span = zero span, centered on a hopping channel; RBW = 1 MHz; VBW ⩾ RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold
3. Measure the dwell time using the marker-delta function.
4. Repeat above procedures until all frequencies measured were complete.
5. Repeat this test for different modes of operation (e.g., data rate, modulation format, etc.), if applicable.

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11.4 Test Result

Type of Modulation: GFSK

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	0.380	31.600	319	121.220	<=400	Pass
			DH3	1.636	31.600	155	253.580	<=400	Pass
			DH5	2.884	31.600	110	317.240	<=400	Pass
Pi/4DQPSK	SISO	HOPP	2DH1	0.394	31.600	319	125.686	<=400	Pass
			2DH3	1.642	31.600	155	254.510	<=400	Pass
			2DH5	2.892	31.600	106	306.552	<=400	Pass
8DPSK	SISO	HOPP	3DH1	0.390	31.600	320	124.800	<=400	Pass
			3DH3	1.642	31.600	153	251.226	<=400	Pass
			3DH5	2.892	31.600	103	297.876	<=400	Pass

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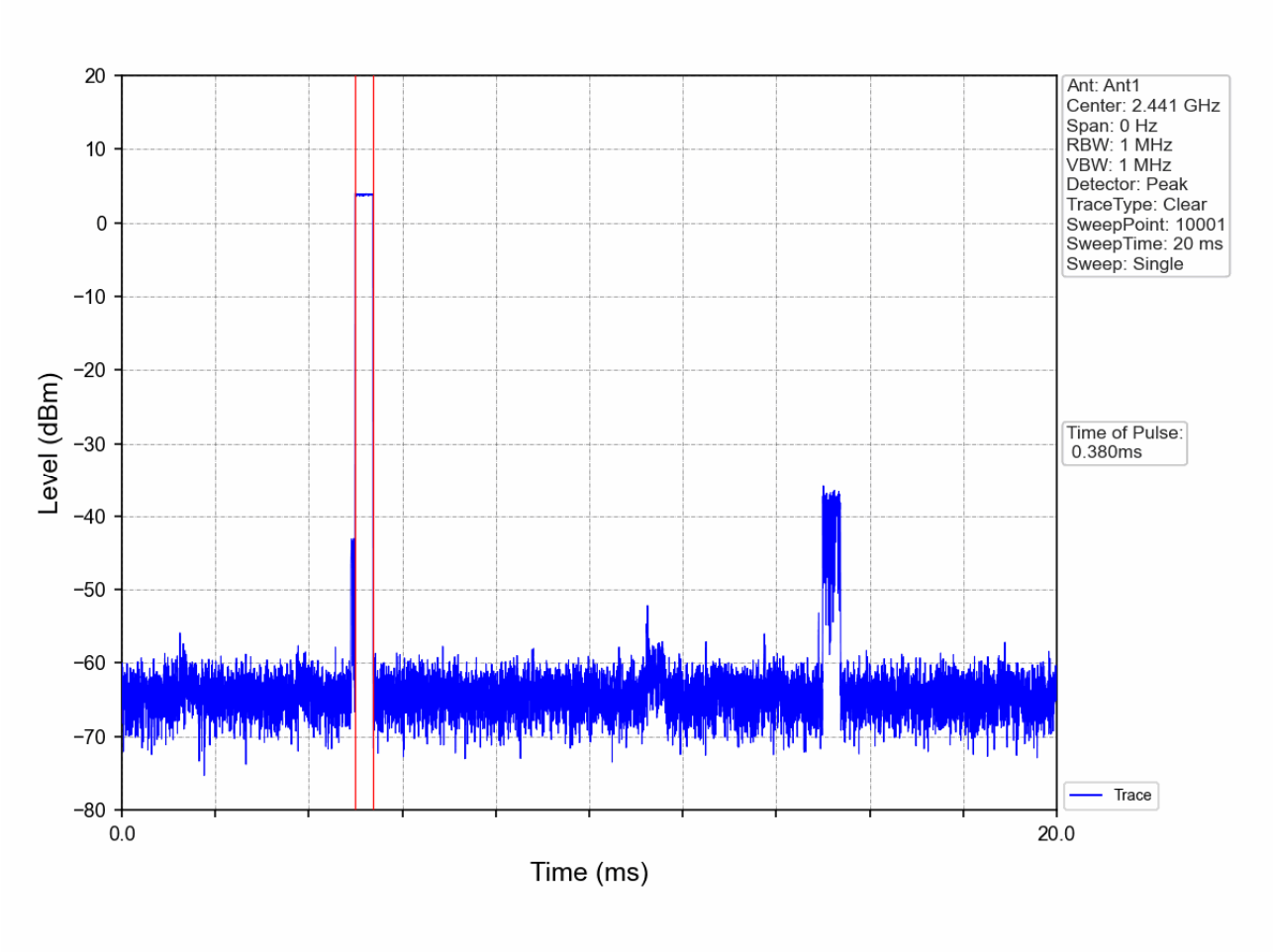
Test Plots:

DH1



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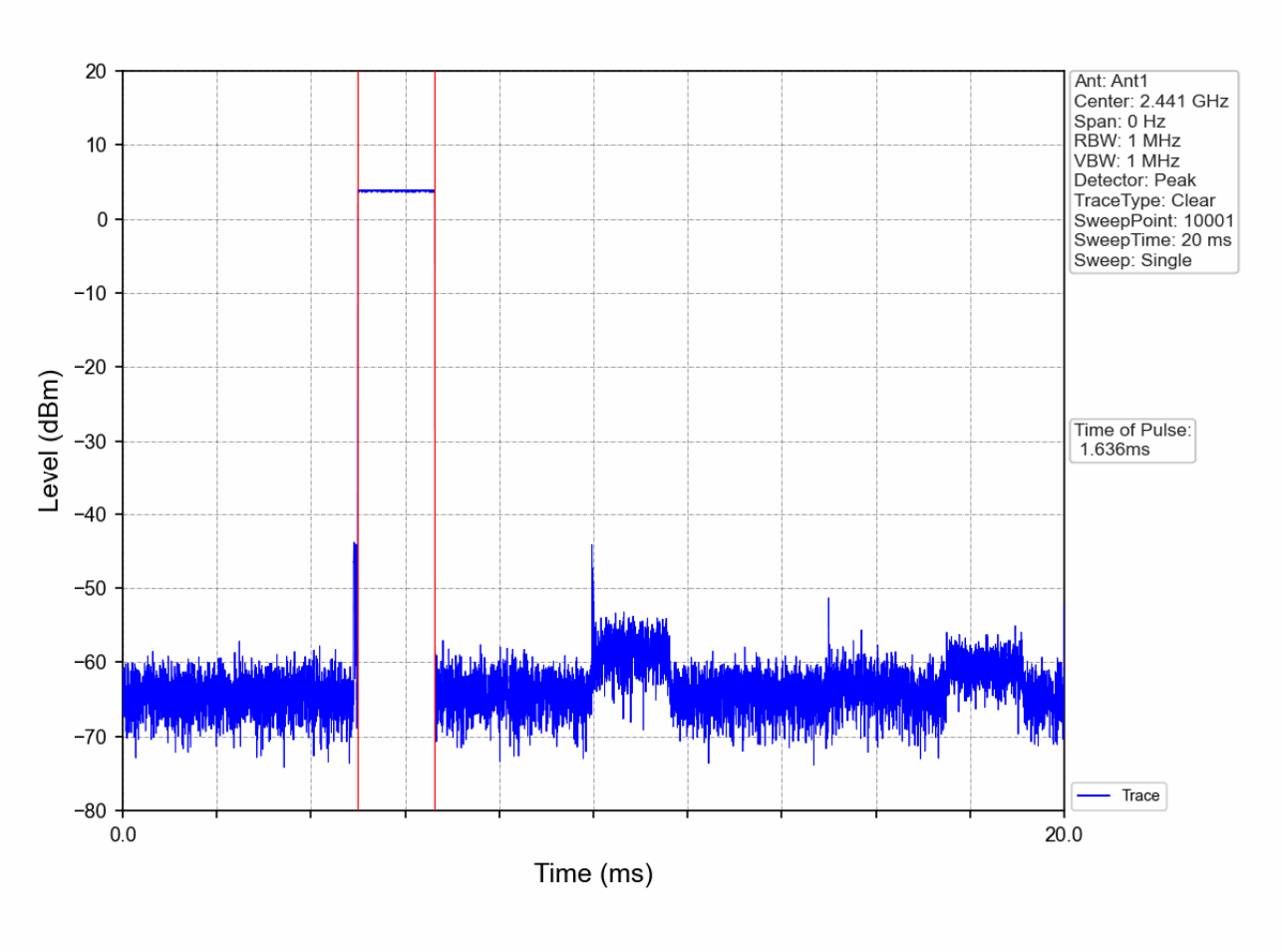
Test Plots:

DH3



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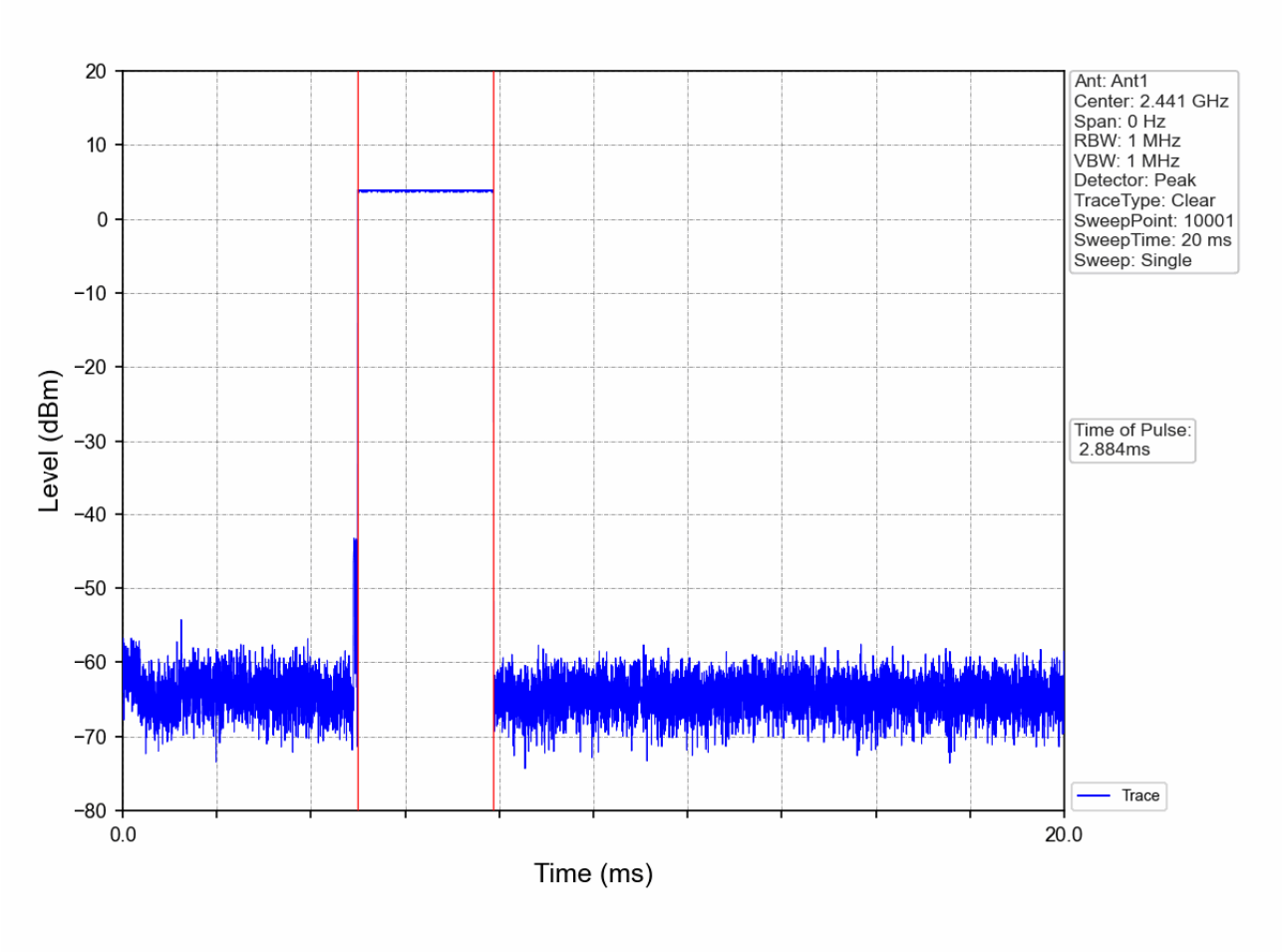
Test Plots:

DH5



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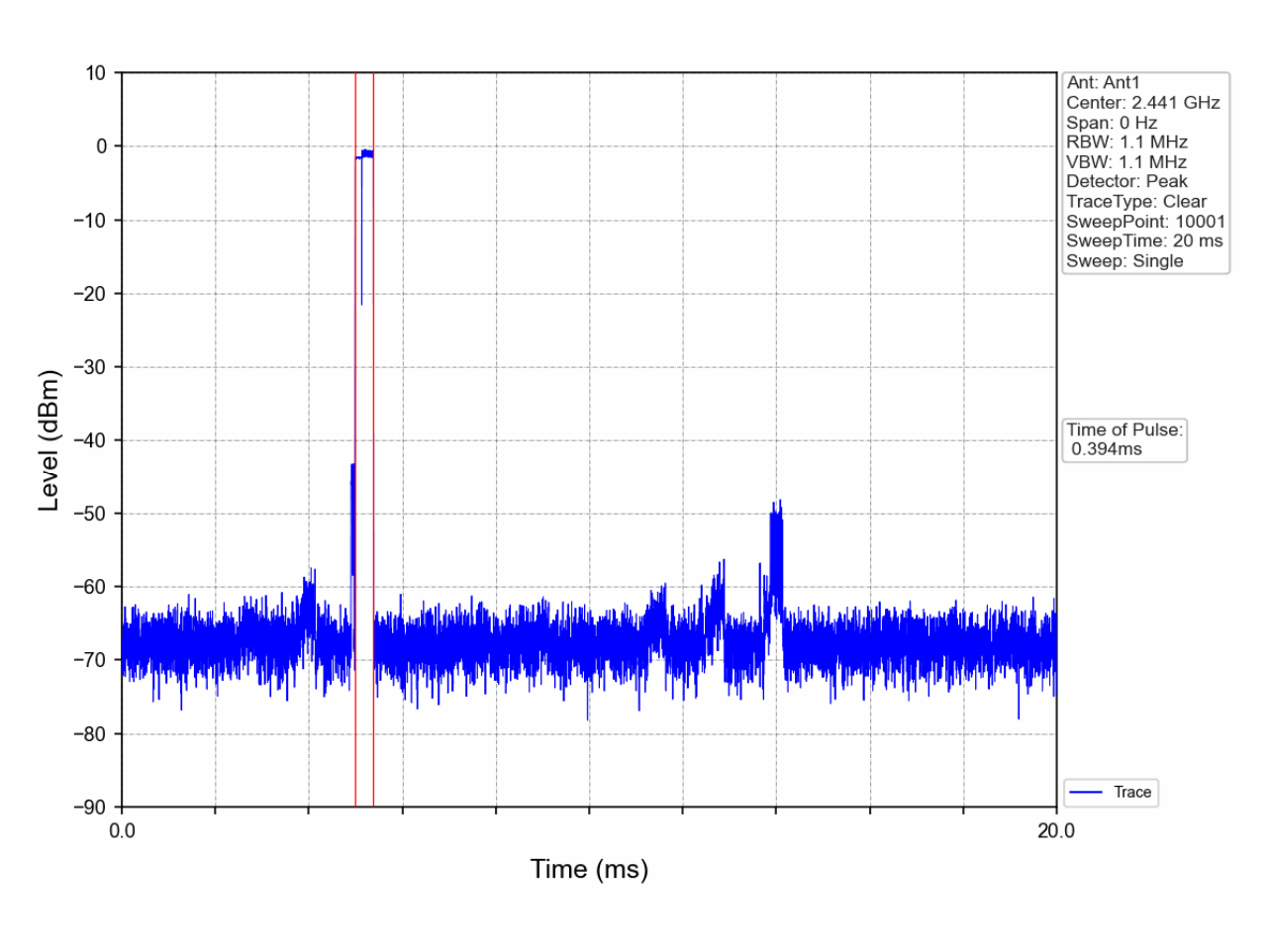
Test Result

Type of Modulation: Л/4D-QPSK

Test Plots:

2DH1



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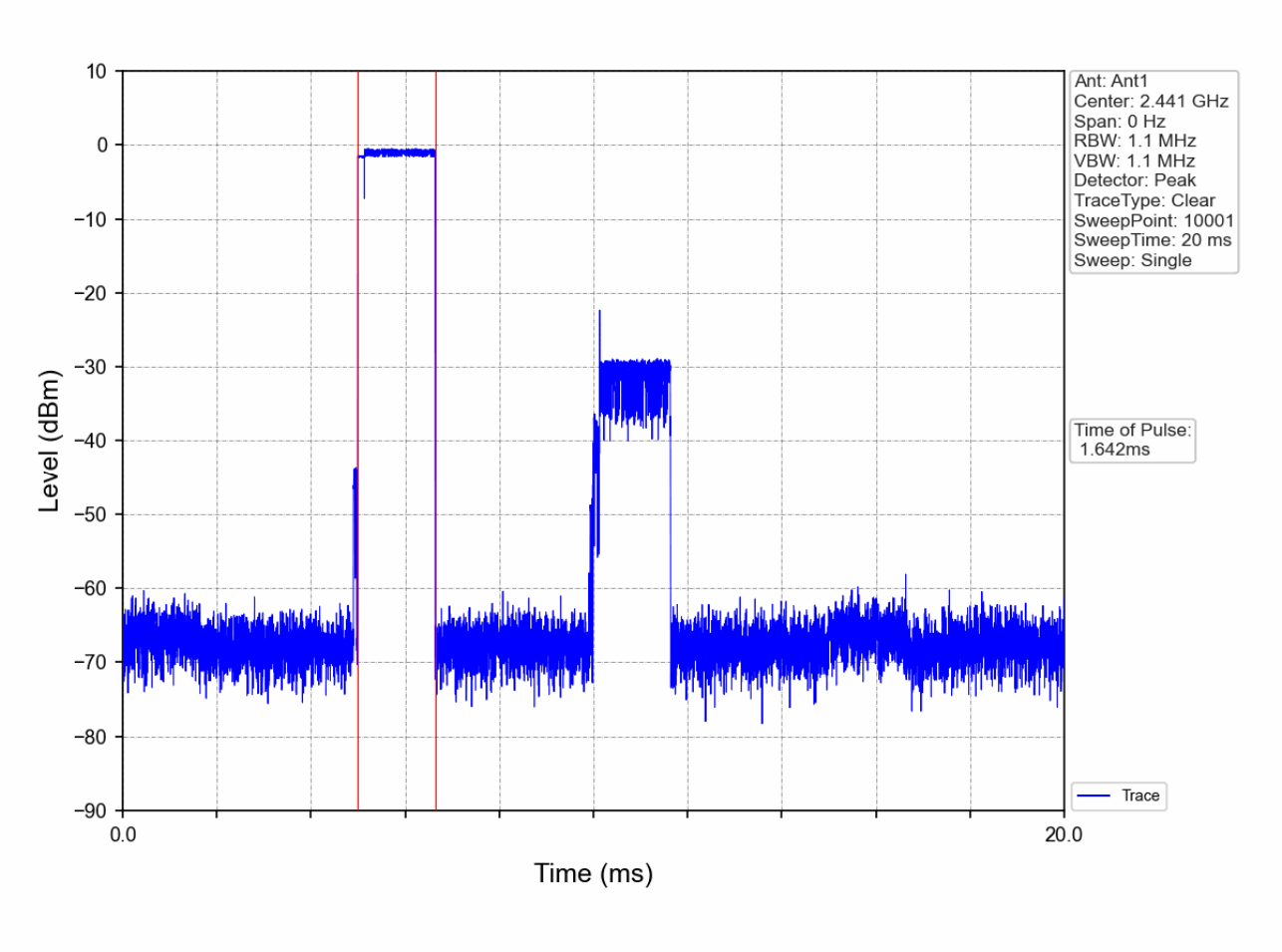
Test Plots:

2DH3



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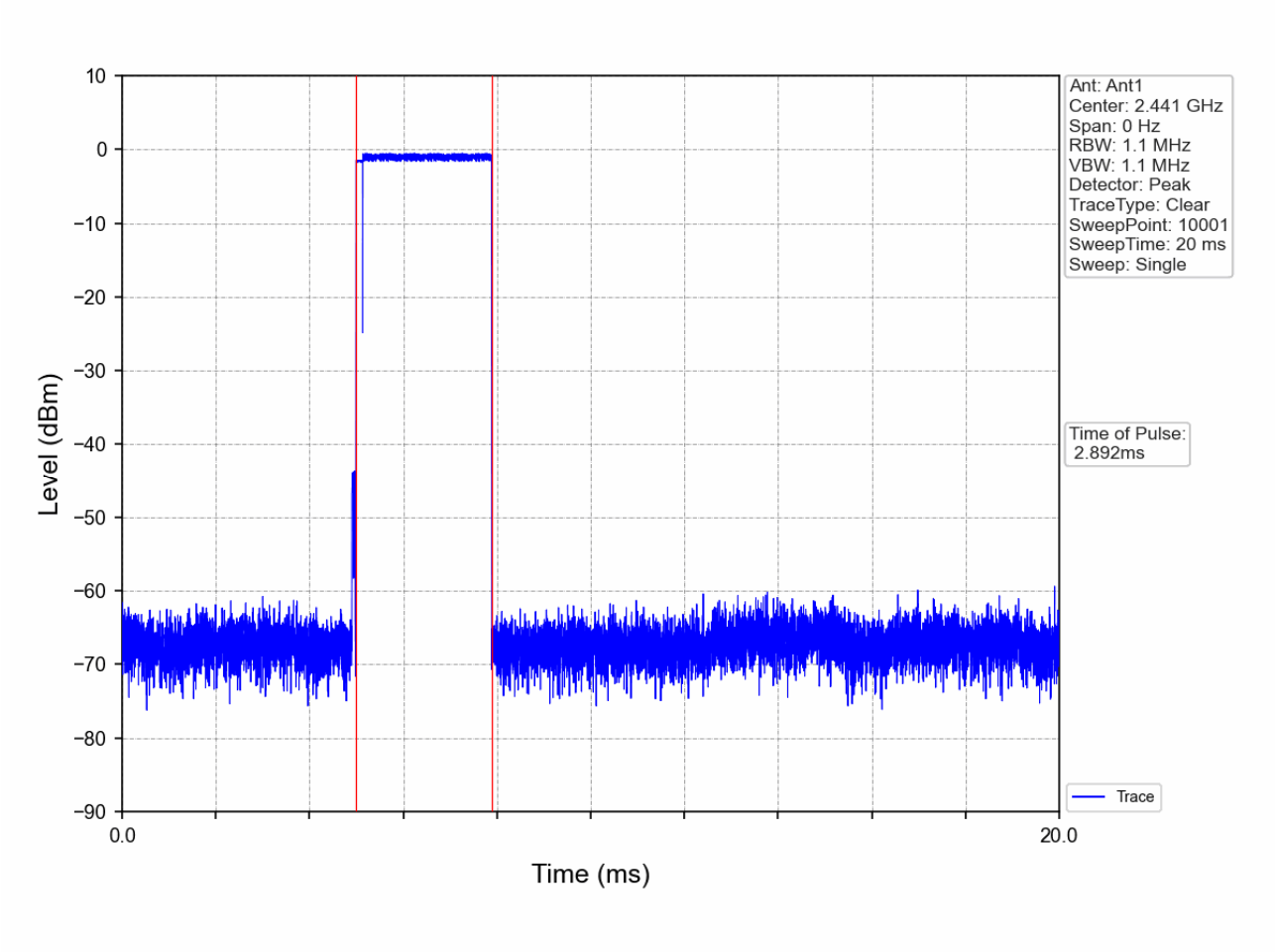
Test Plots:

2DH5



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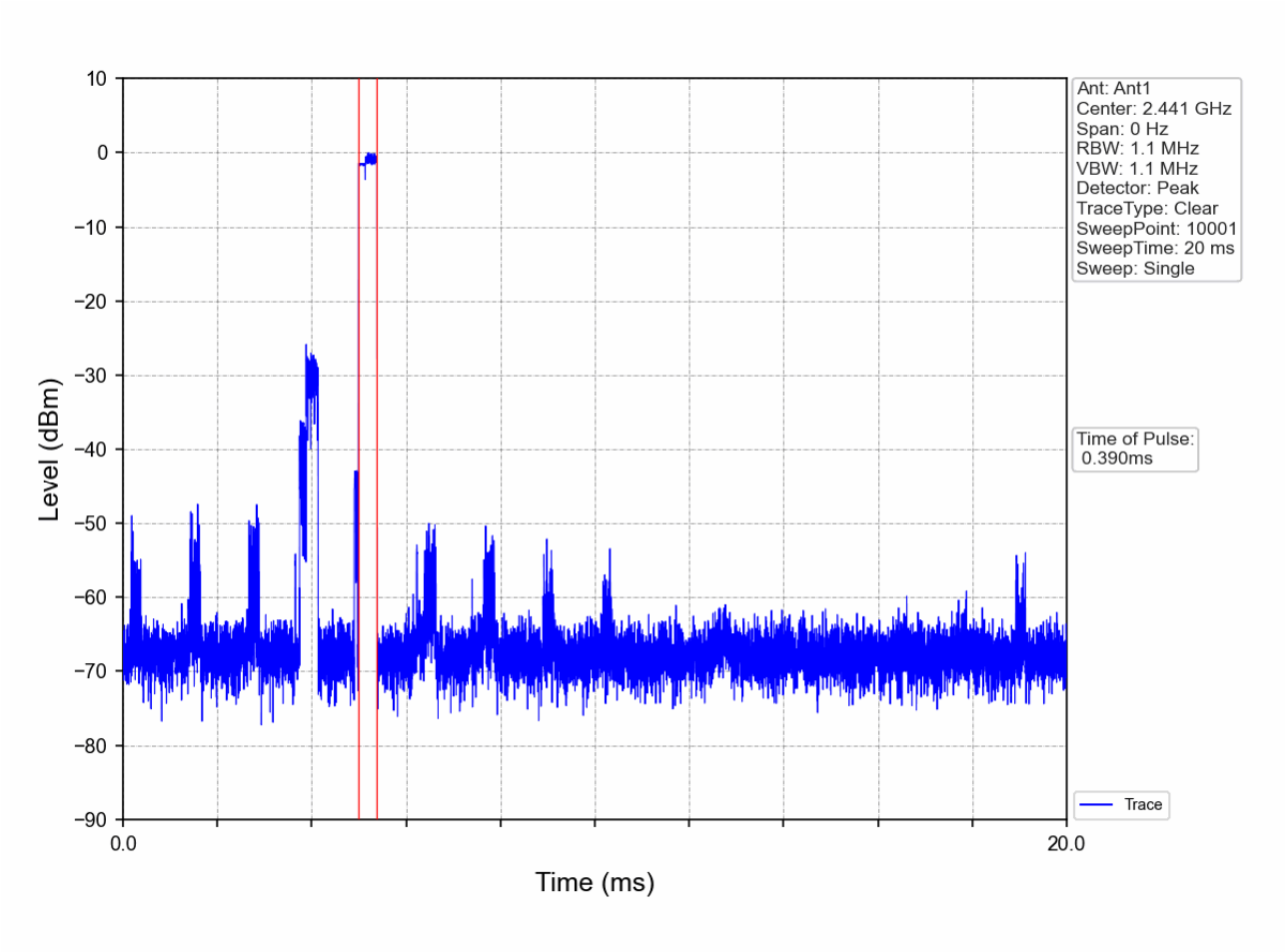
Type of Modulation: 8DPSK

Test Plots:

3DH1



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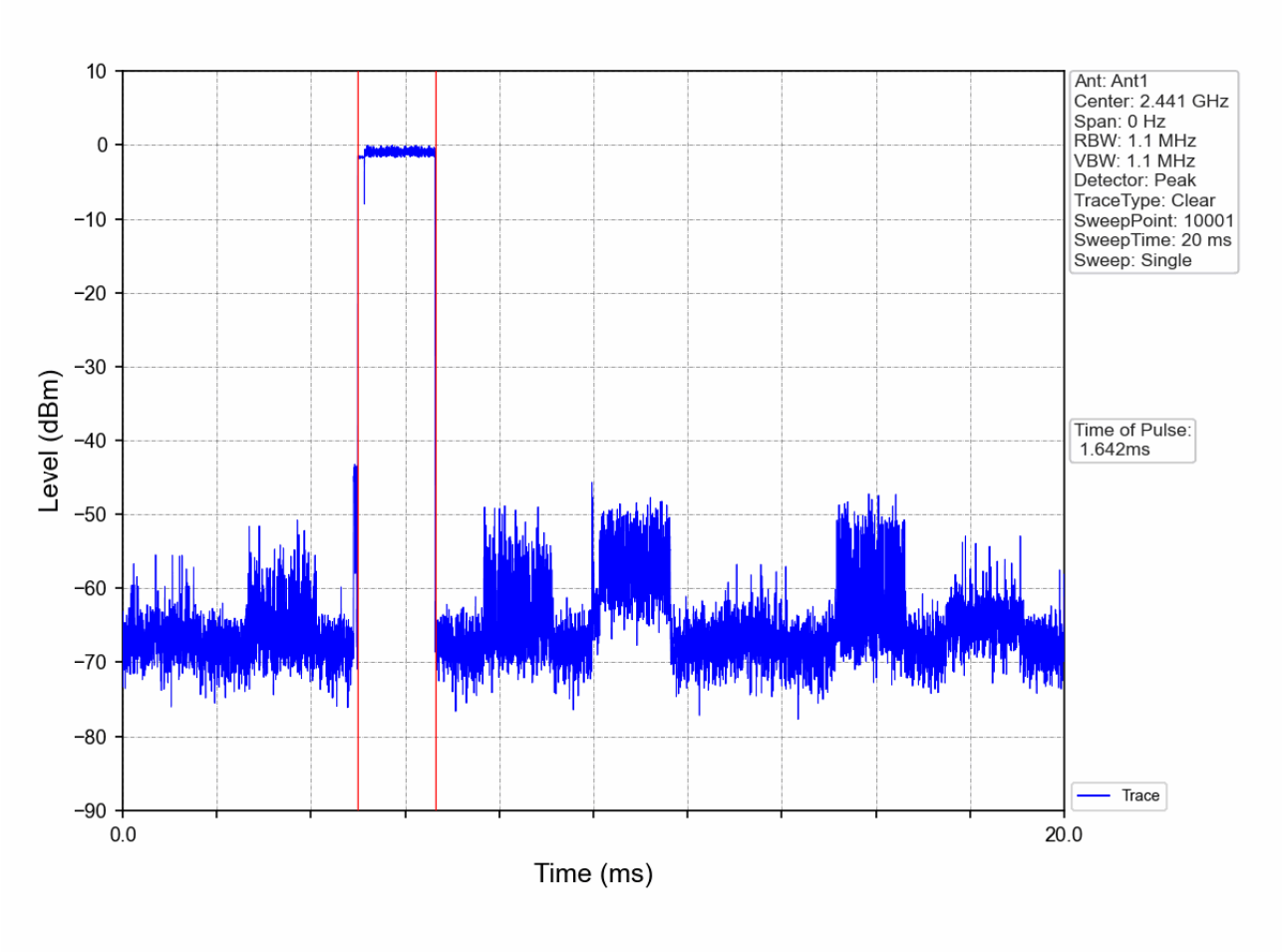
Test Plots:

3DH3



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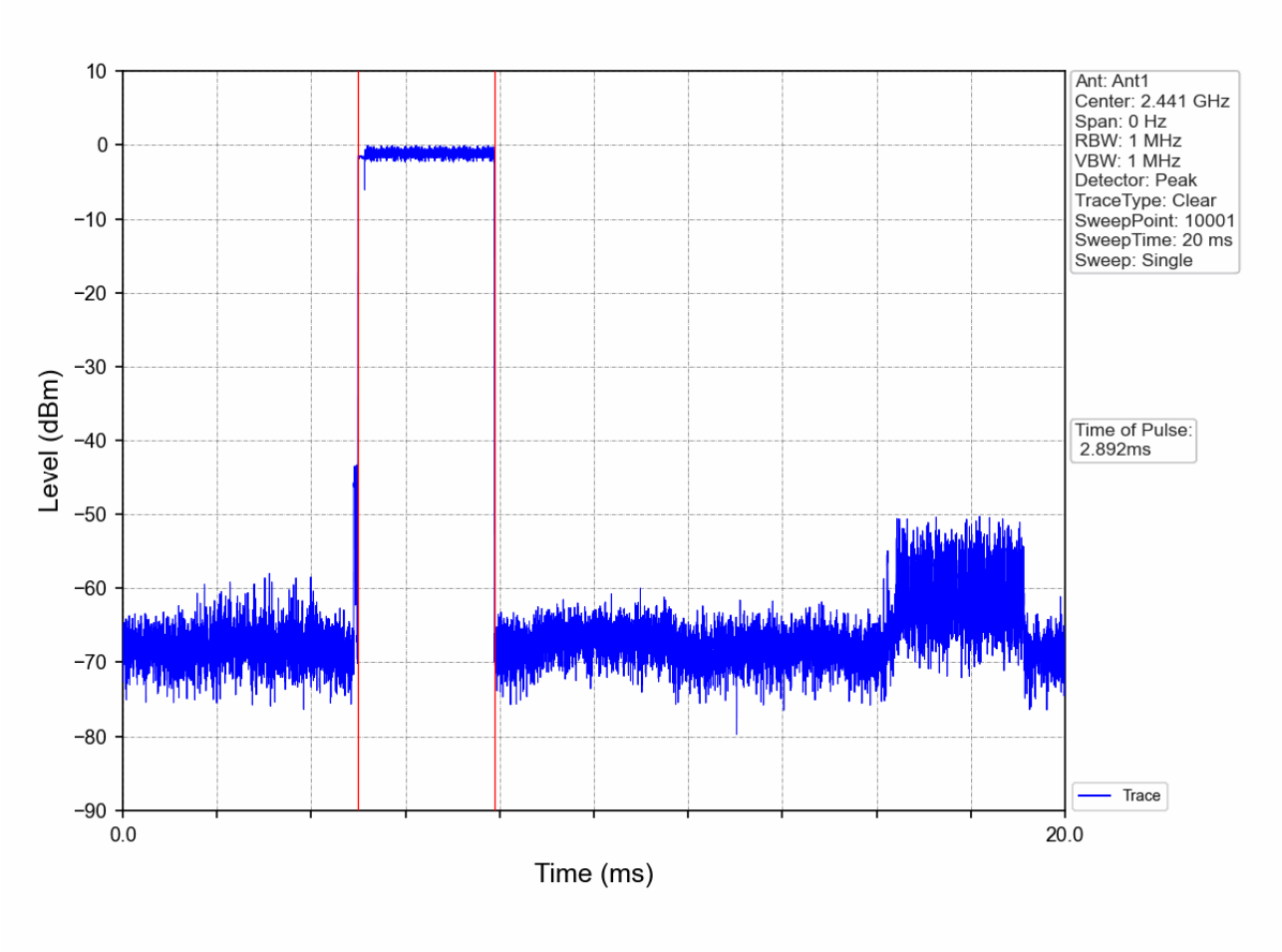
Test Plots:

3DH5



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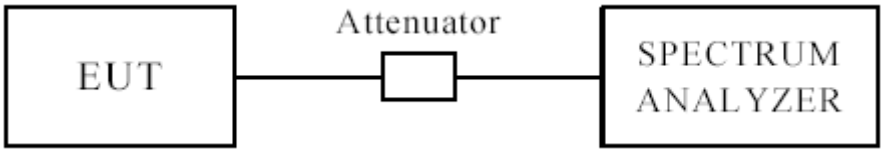
12 Out of Band Measurement

12.1 Test Setup



The restricted band requirement based on radiated emission test; please see the clause 6 for the test setup

12.2 Limits of Out of Band Emissions Measurement

1. Below –20dB of the highest emission level of operating band (in 100kHz Resolution Bandwidth).
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.

12.3 Test Procedure

For signals in the restricted bands above and below the 2.4-2.483GHz allocated band a measurement was made of radiated emission test. Peak values with RBW=VBW=1MHz and PK detector.

For bandage test, the spectrum set as follows: RBW=100 kHz, VBW=300 kHz. A conducted measurement used

Note: 1. For band-edge measurement, the frequency from 30MHz-25GHz was tested. And It met the FCC rule.

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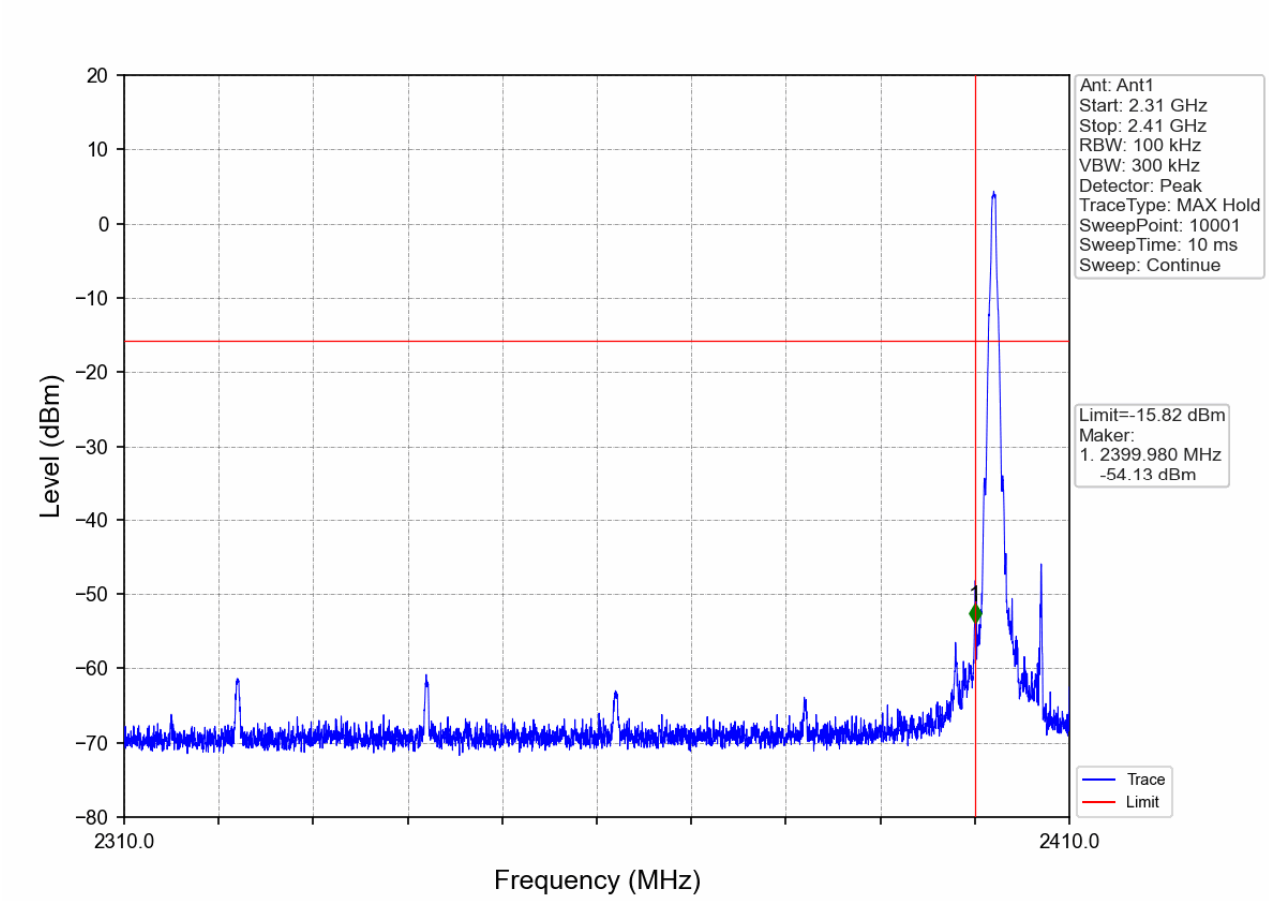
Type of Modulation: GFSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	Low Channel
Mode	Keeping Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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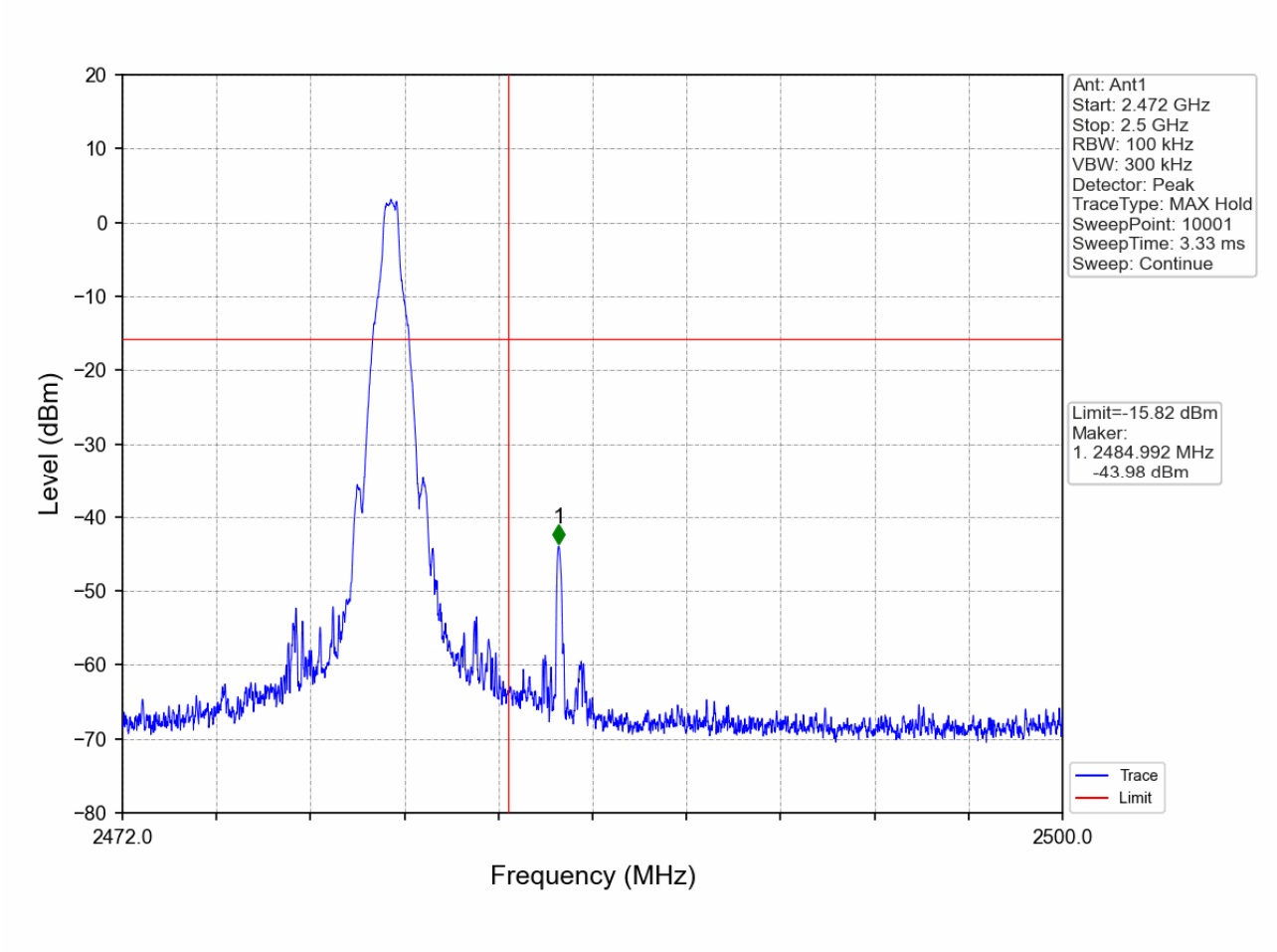
Type of Modulation: GFSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	High Channel
Mode	Keeping Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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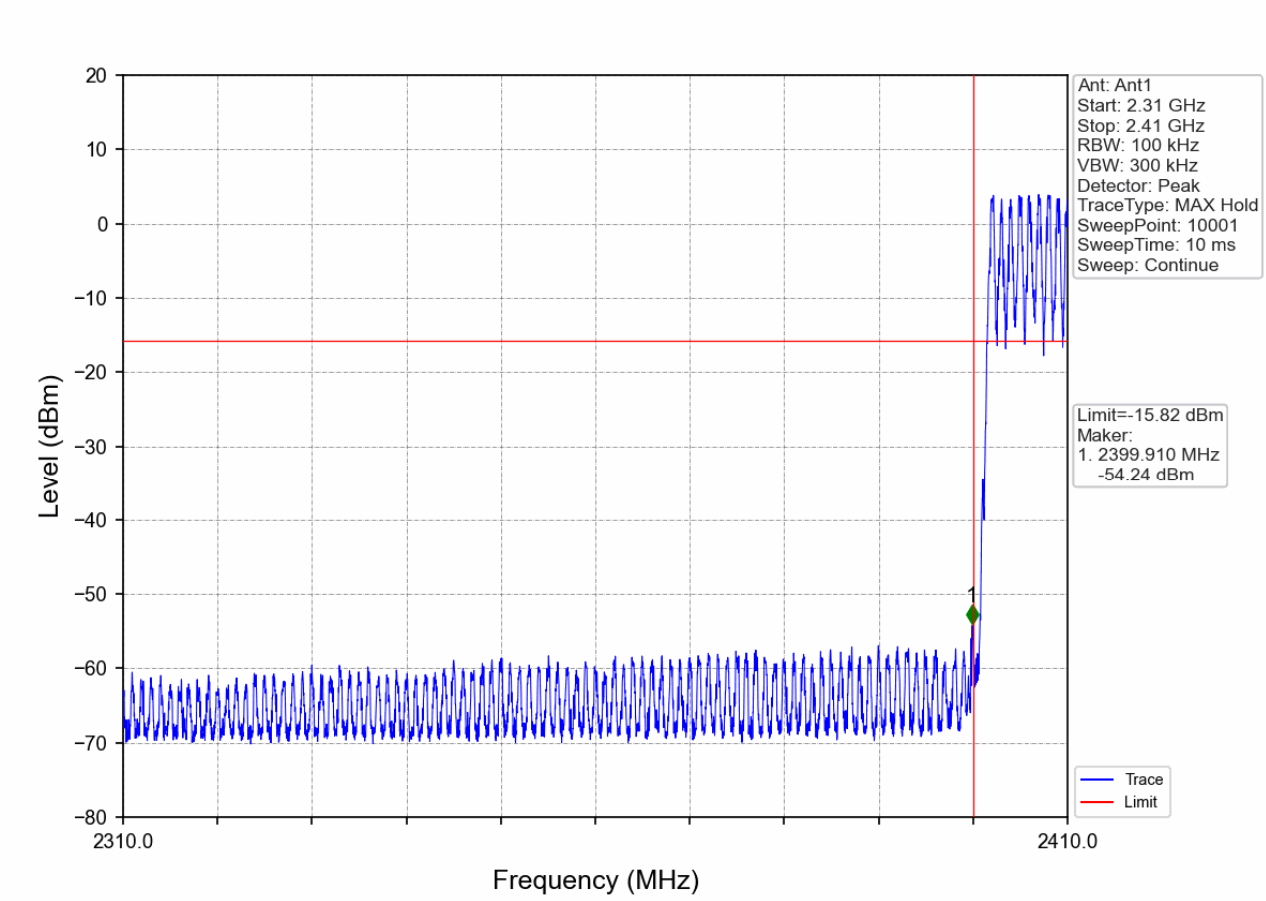
Type of Modulation: GFSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	Hopping mode
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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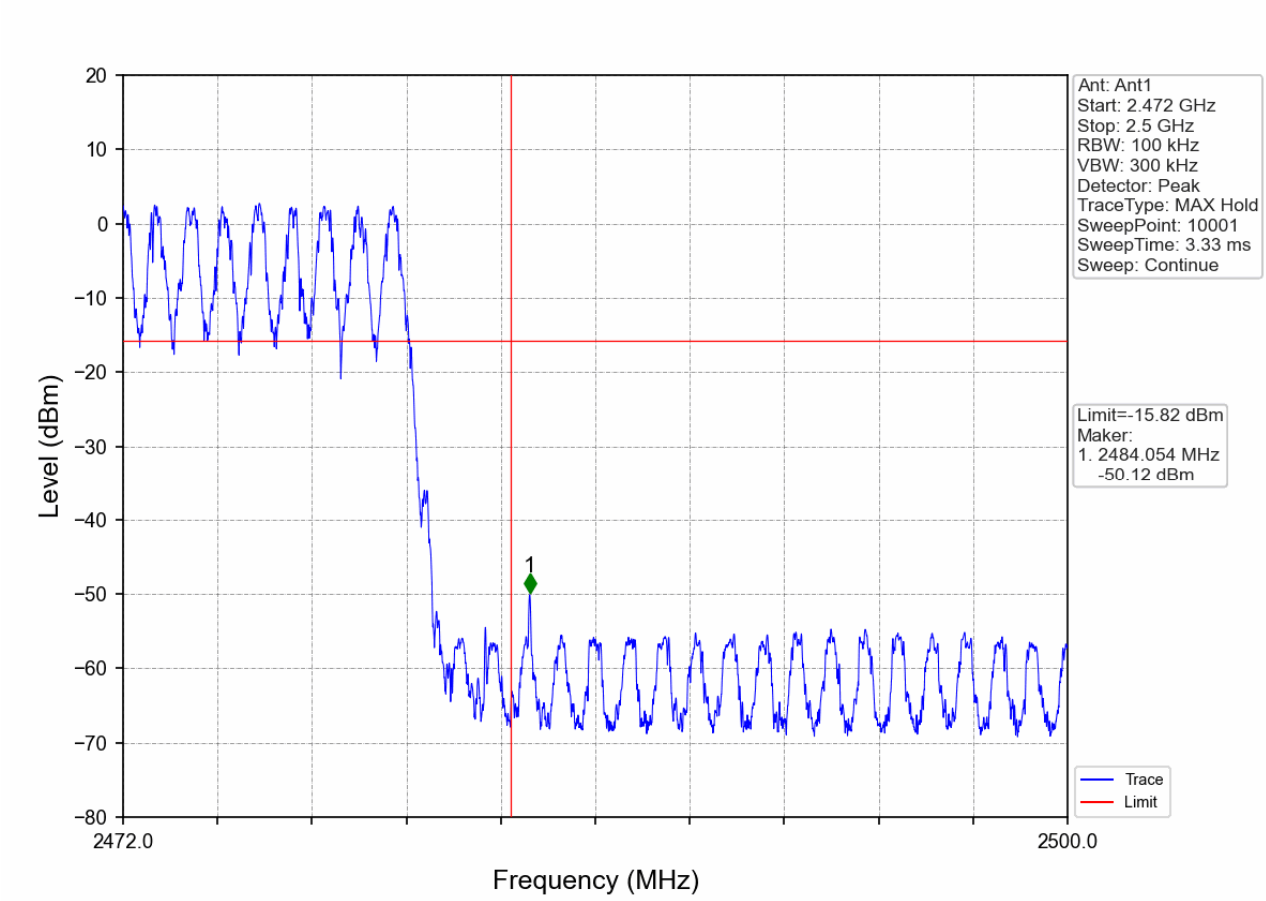
Type of Modulation: GFSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	Hopping mode
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C,	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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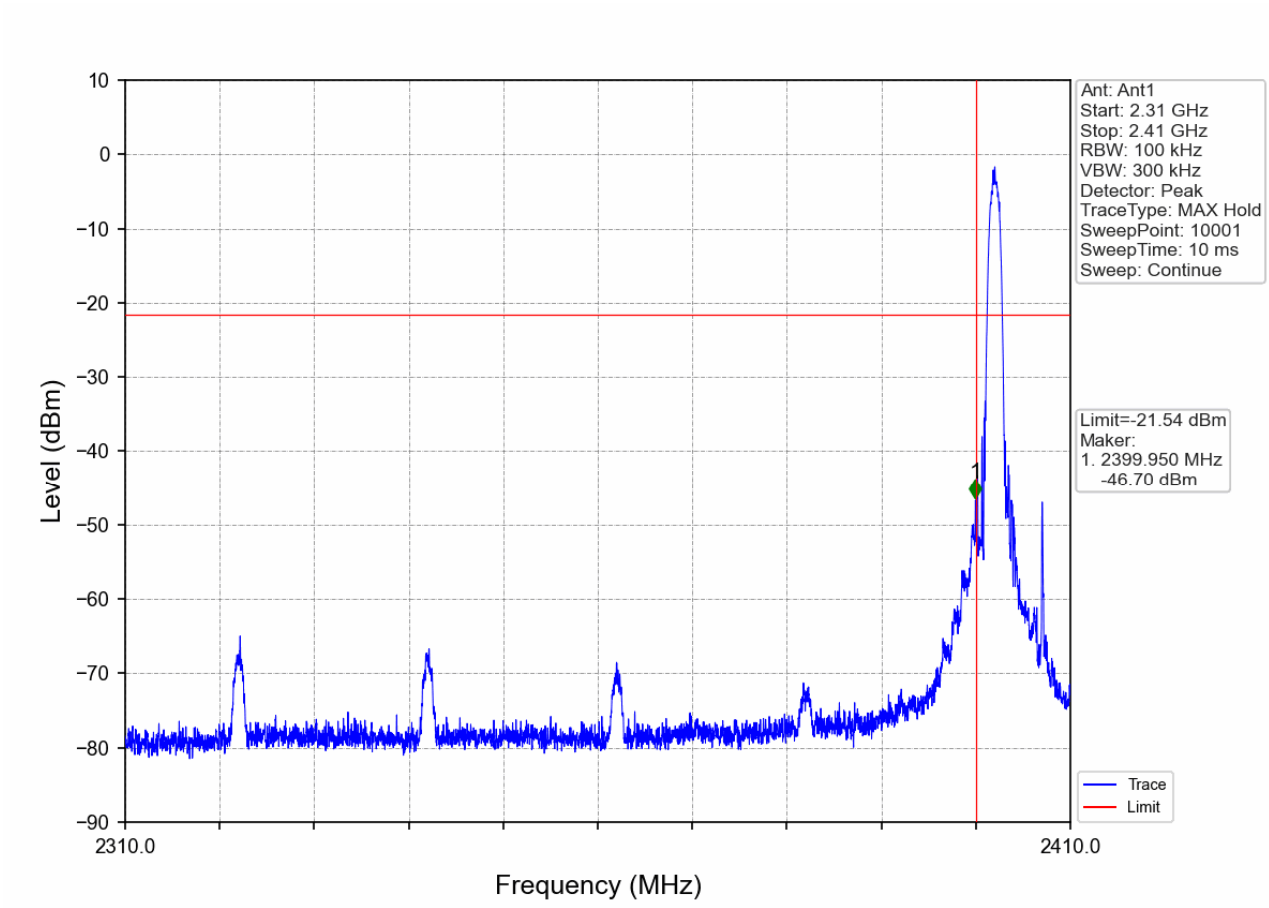
Type of Modulation: Л/4D-QPSK

12.4 Out of Band Test Result

Product:	Wireless module	Test Mode:	Low Channel
Mode	Keeping Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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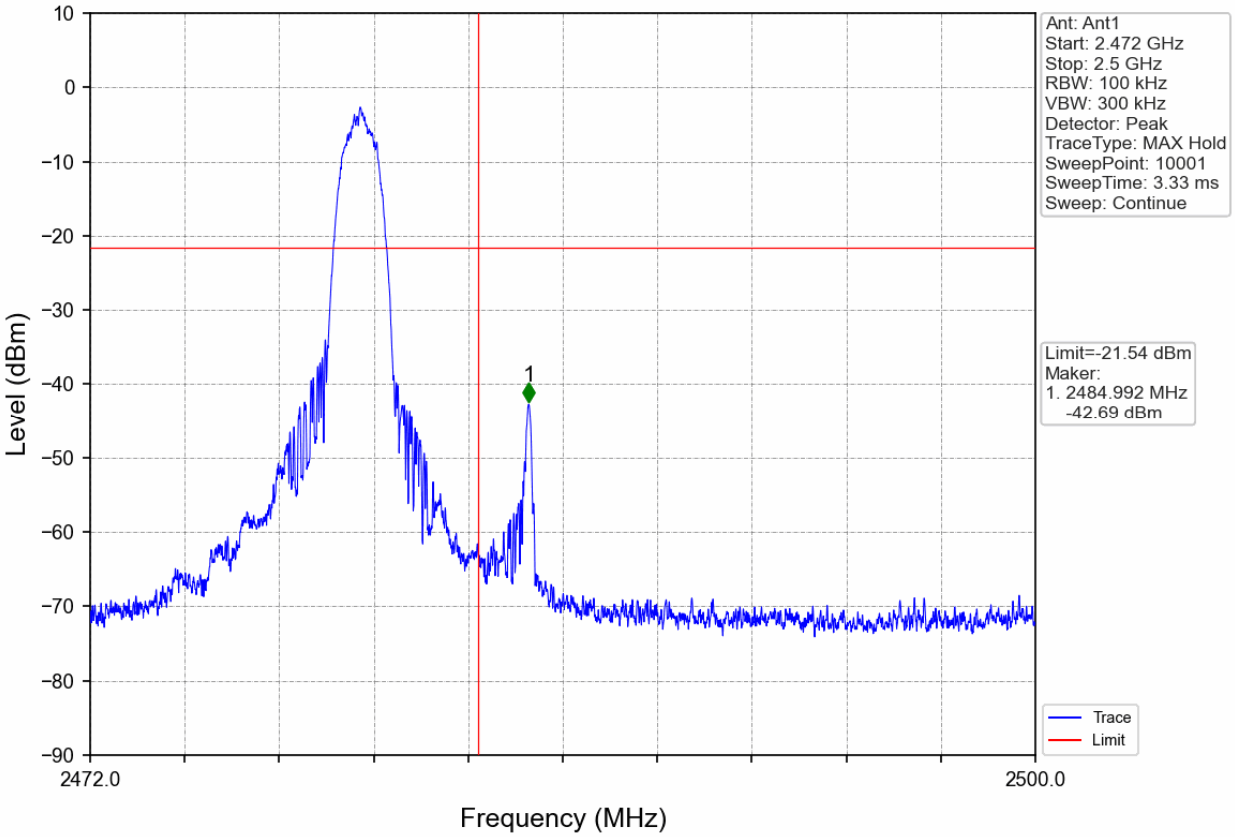
Type of Modulation: Л/4D-QPSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	High Channel
Mode	Keeping Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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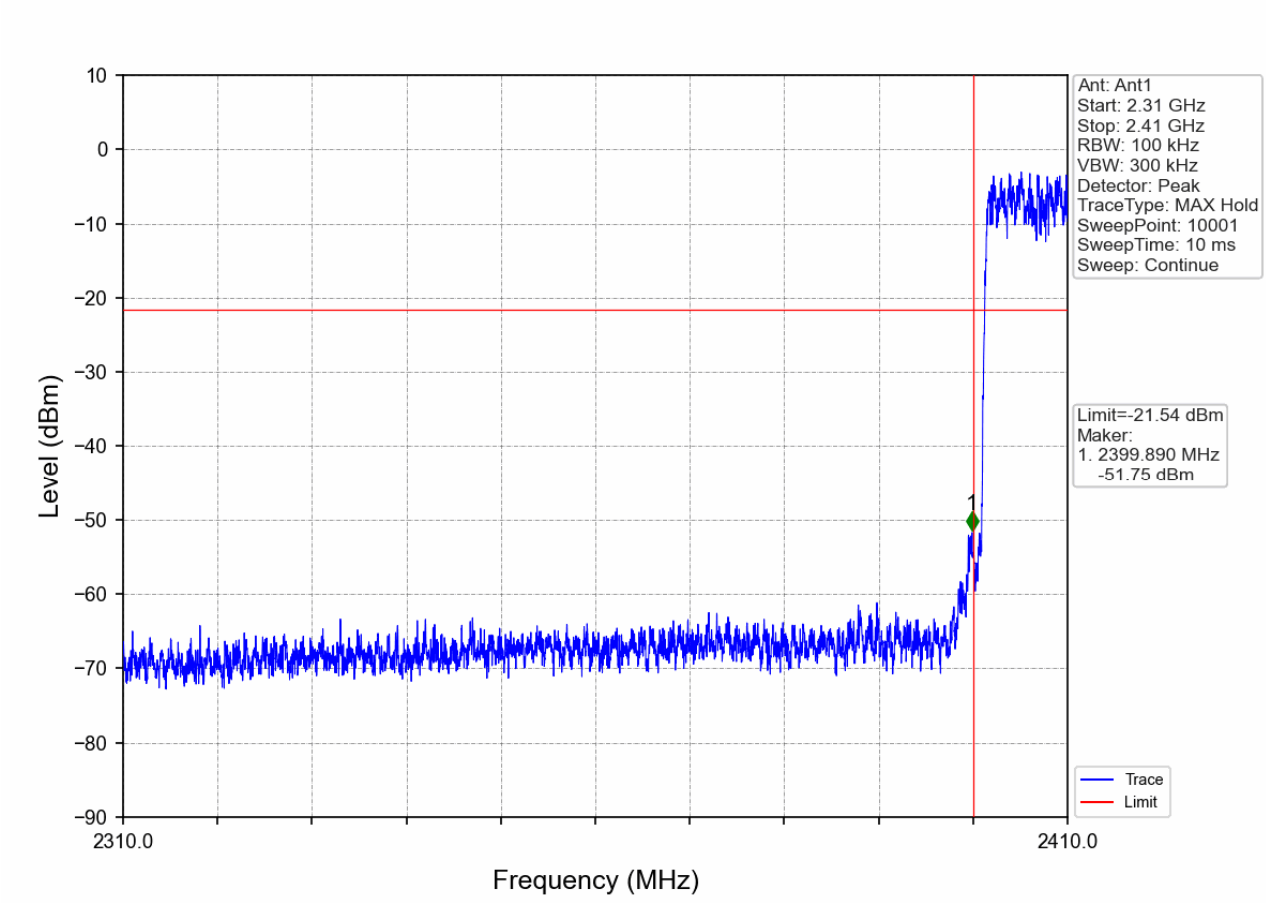
Type of Modulation: Л/4D-QPSK

12.4 Out of Band Test Result

Product:	Wireless module	Test Mode:	Hopping mode
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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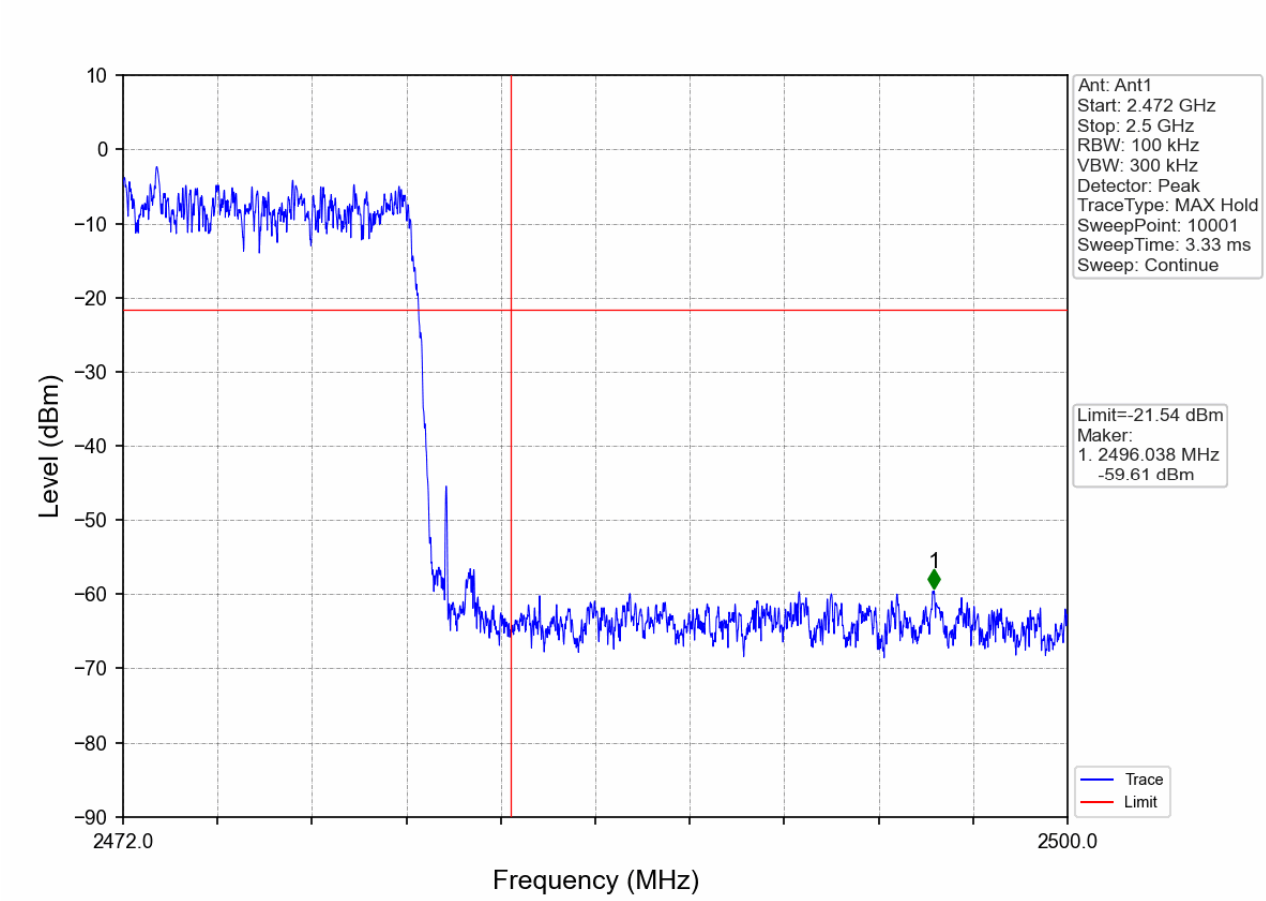
Type of Modulation: Л/4D-QPSK

12.4 Out of Band Test Result

Product:	Wireless module	Test Mode:	Hopping mode
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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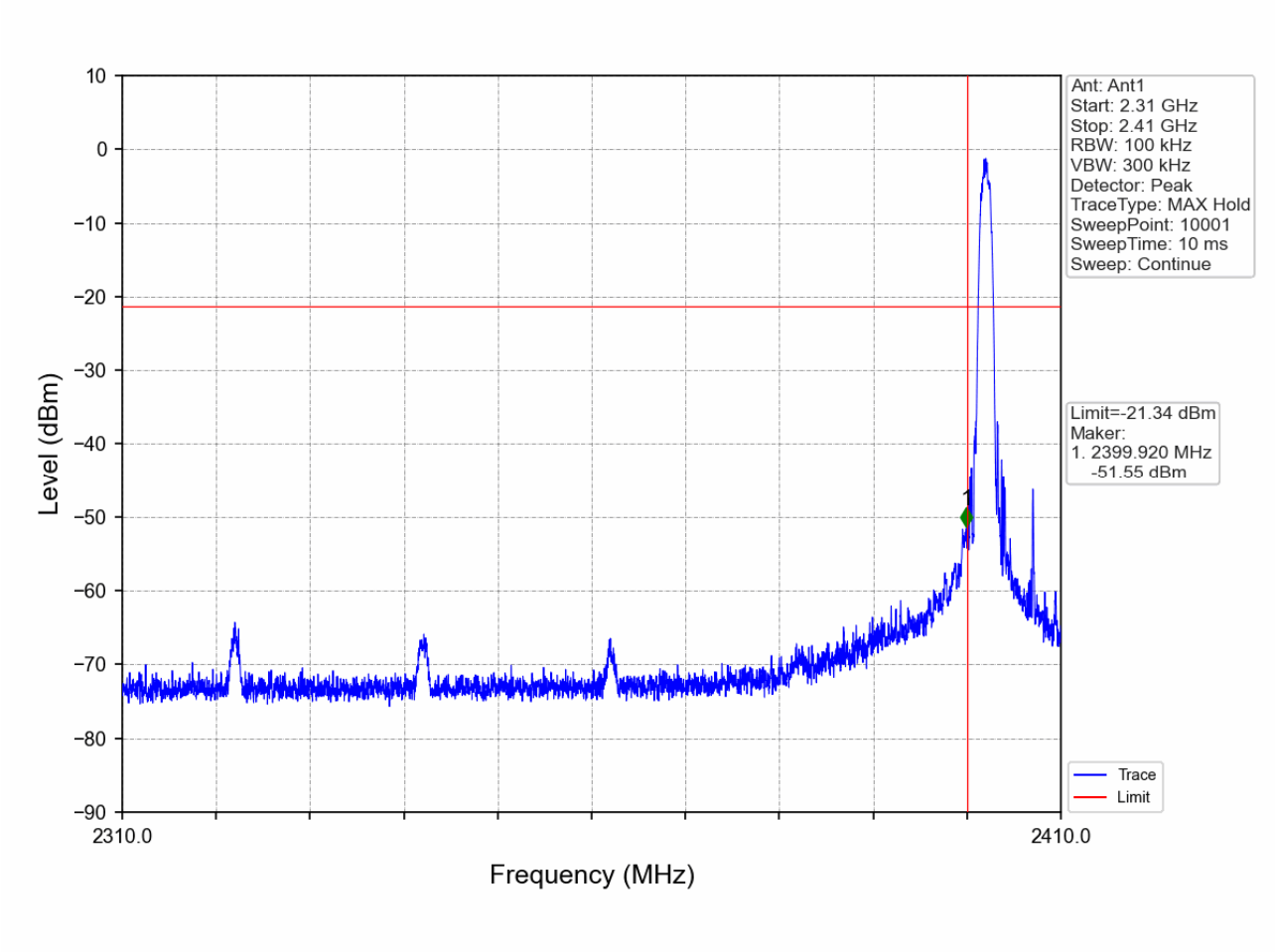
Type of Modulation: 8DPSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	Low Channel
Mode	Keeping Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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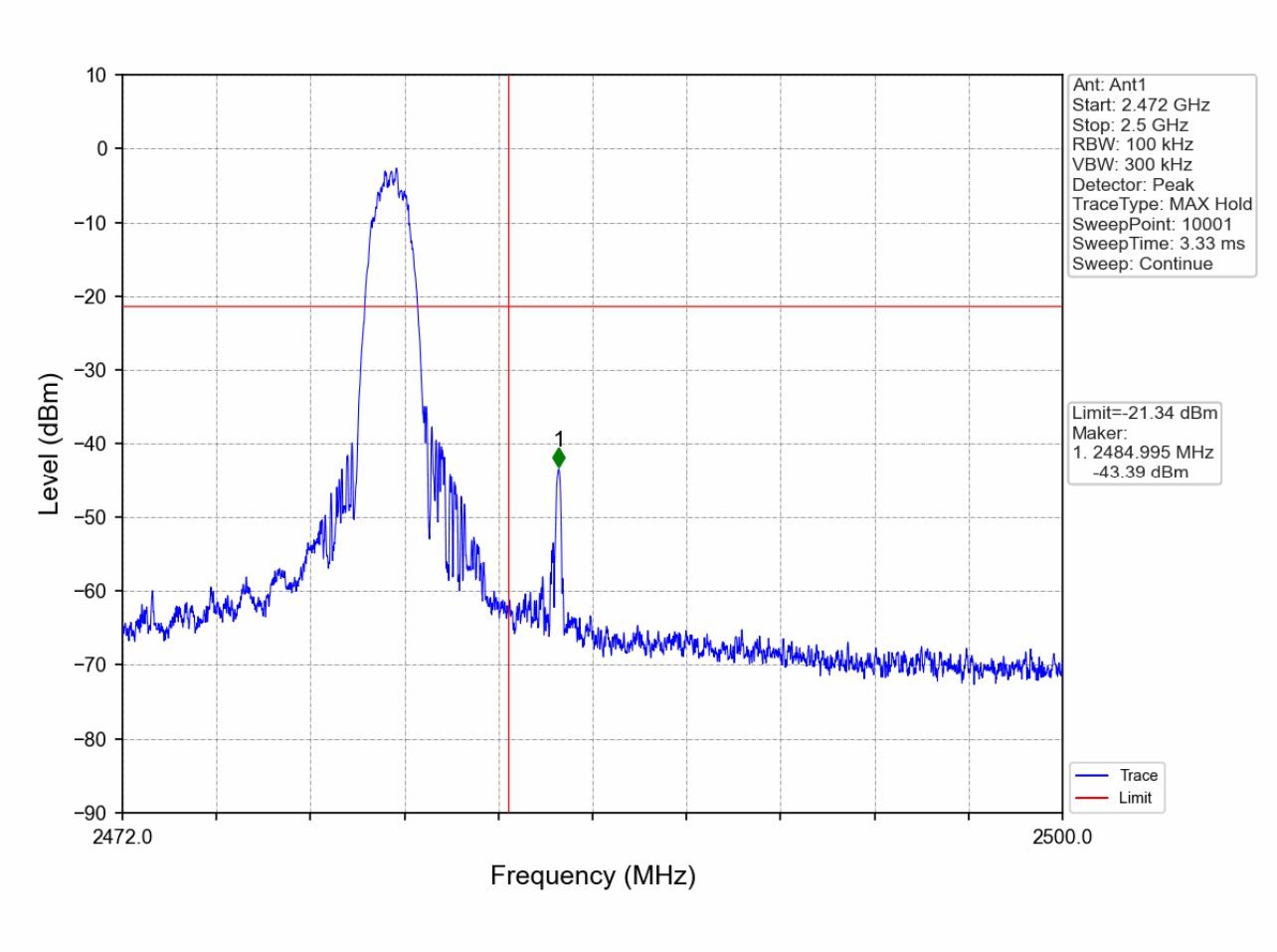
Type of Modulation: 8DPSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	High Channel
Mode	Keeping Transmitting	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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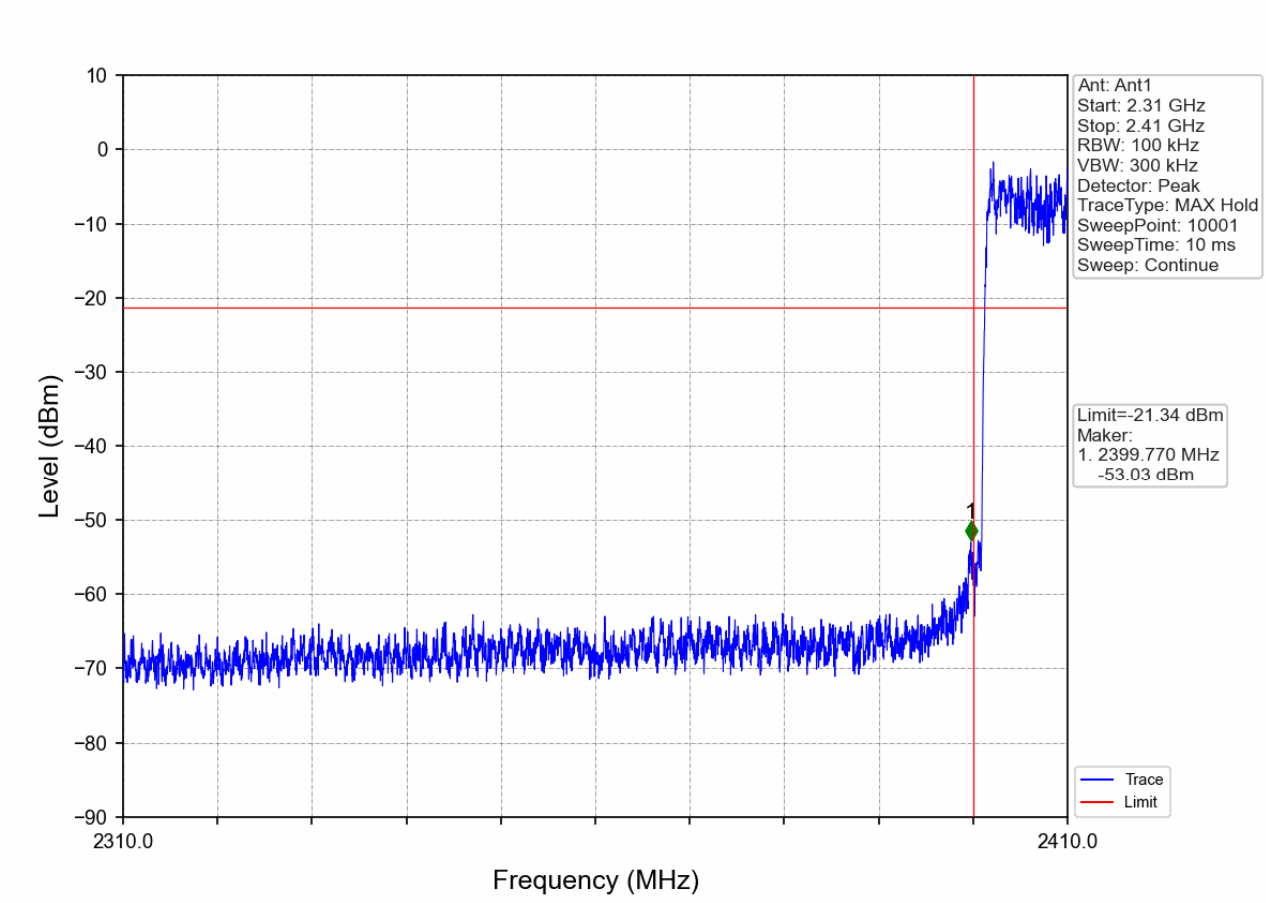
Type of Modulation: 8DPSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	Hopping mode
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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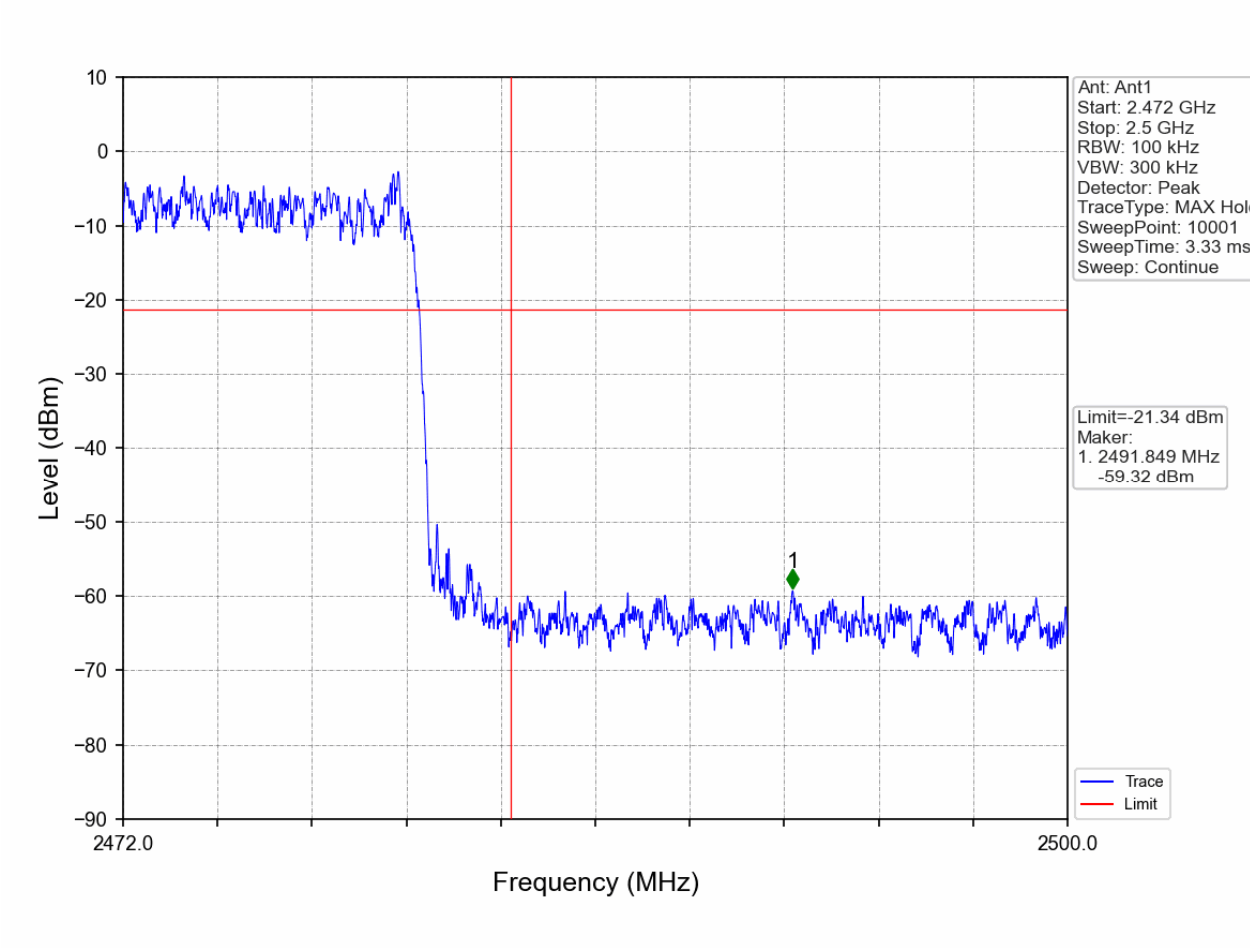
Type of Modulation: 8DPSK

12.4 Band Edge Test Result

Product:	Wireless module	Test Mode:	Hopping mode
Mode	Hopping On	Input Voltage	DC3.3V
Temperature	24 deg. C	Humidity	56% RH
Test Result:	Pass	Detector	PK

Test Figure:



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12.4 Restricted band Measurement

EUT	Wireless module		Model	DX2002
Mode	Keep Transmitting		Input Voltage	DC3.3V
Temperature	24 deg. C,		Humidity	56% RH
Test Result:	Pass		Detector	PK
Low Channel, Horizontal				
2390	PK (dBμV/m)	42.86	Limit	74(dBμV/m)
	AV (dBμV/m)	--		54(dBμV/m)
Low Channel, Vertical				
2390	PK (dBμV/m)	42.03	Limit	74(dBμV/m)
	AV (dBμV/m)	--		54(dBμV/m)

12.4 Restricted band Measurement

EUT	Wireless module		Model	DX2002
Mode	Keep Transmitting		Input Voltage	DC3.3V
Temperature	24 deg. C,		Humidity	56% RH
Test Result:	Pass		Detector	PK
High Channel, Horizontal				
2483.5	PK (dBμV/m)	55.26	Limit	74(dBμV/m)
	AV (dBμV/m)	46.86		54(dBμV/m)
High Channel, Vertical				
2483.5	PK (dBμV/m)	50.37	Limit	74(dBμV/m)
	AV (dBμV/m)	--		54(dBμV/m)

Note: 1. For Restricted band test, All modulation mode was tested and only the worst case was reported. GFSK was the worst case.

2. The measured PK value less than the AV limit, no necessary to take down the AV measurement result.

3. Two type of antennas were tested and only the worst cases were recorded in the test report. The antenna with high gain was the worst case.

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13.0 Antenna Requirement

13.1 Standard Applicable

For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

And according to FCC 47 CFR Section 15.247 (b), if transmitter antennas of directional gain greater than 6 dBi are used, the power shall be reduced by the mount in dB that the directional gain of the antenna exceeds 6 dBi.

13.2 Antenna Connected constructions

PCB antenna with gain 2.0dBi maximum or Male IPEX connector with integral antenna (Gain: 0.8dBi Maximum)

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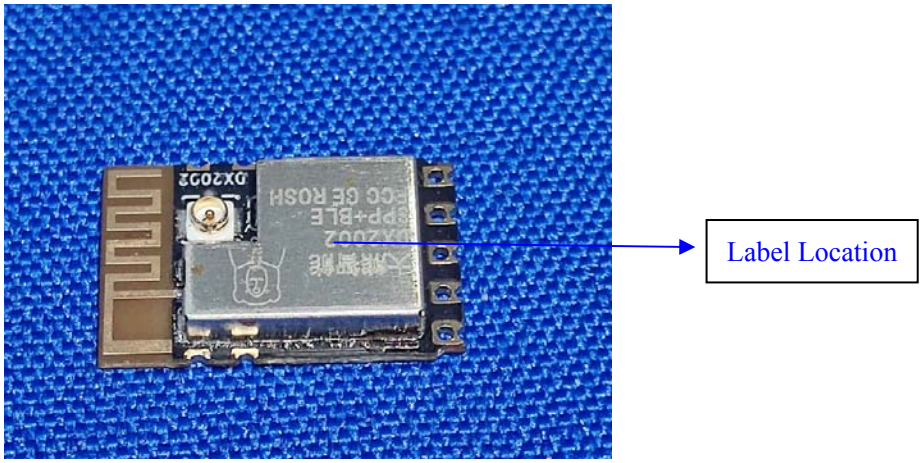
14.0 FCC ID Label

FCC ID: 2AQJL-DX2002

The label must not be a stick-on paper label. The label on these products must be permanently affixed to the product and readily visible at the time of purchase and must last the expected lifetime of the equipment not be readily detachable.

Mark Location:



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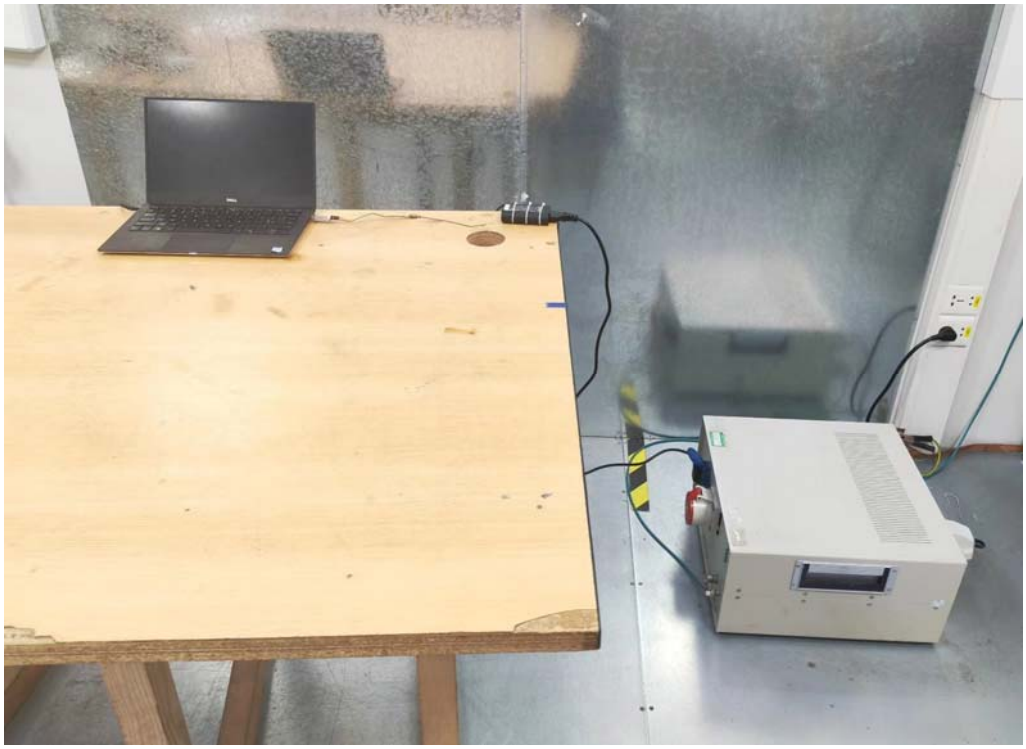
15.0 Photo of testing

Conducted Emission Test Setup:



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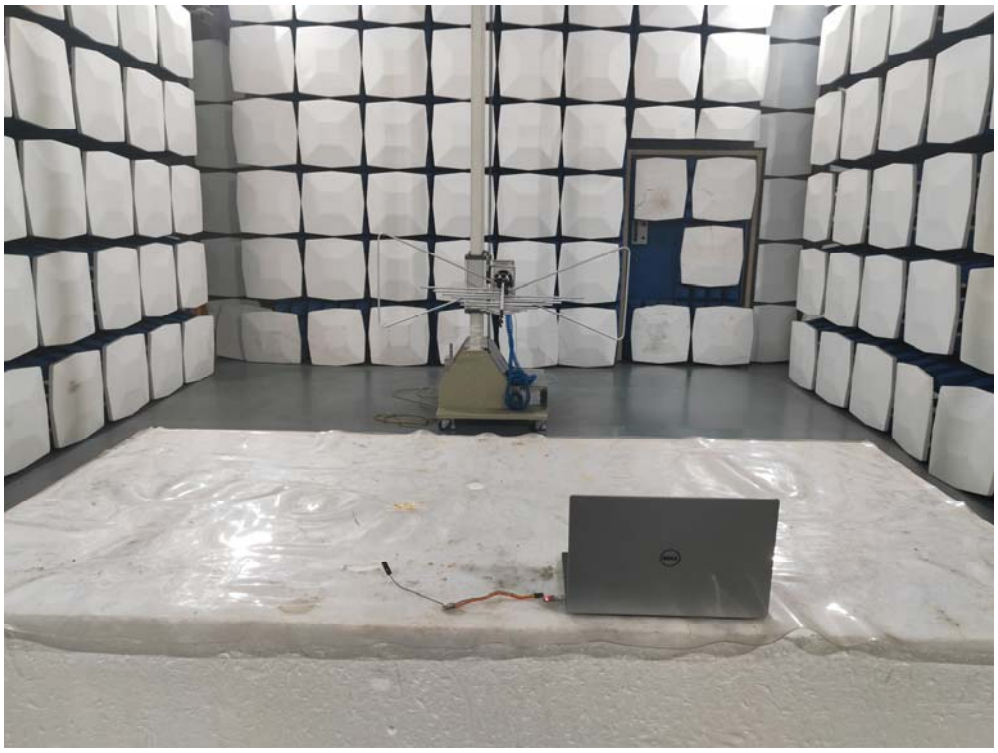
Radiated Emission Test Setup:



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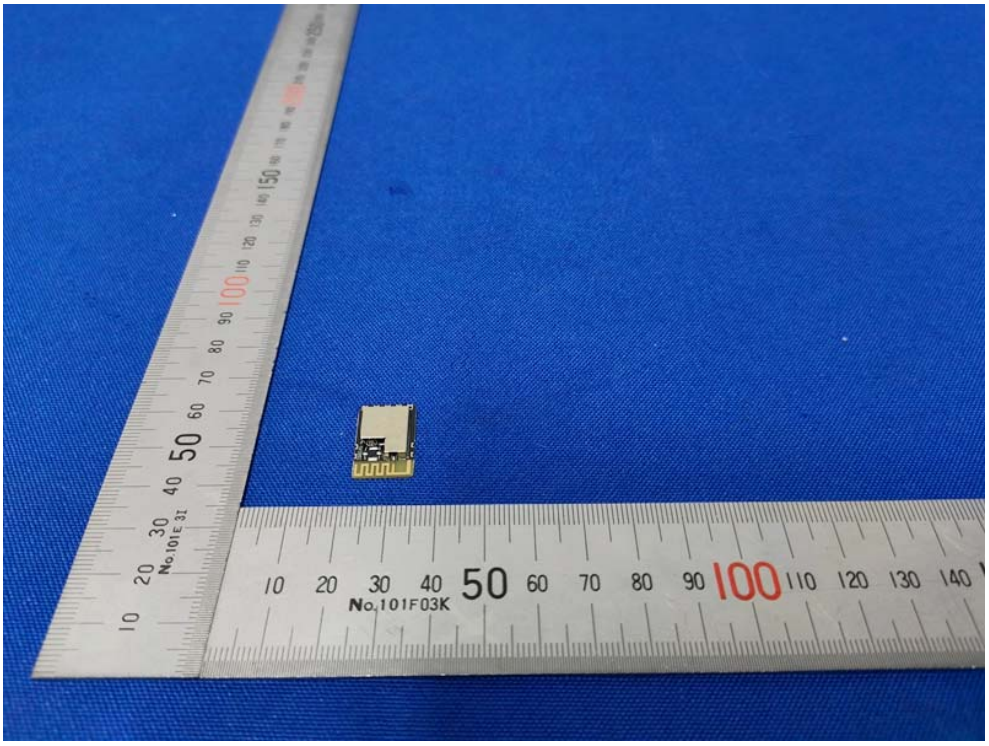

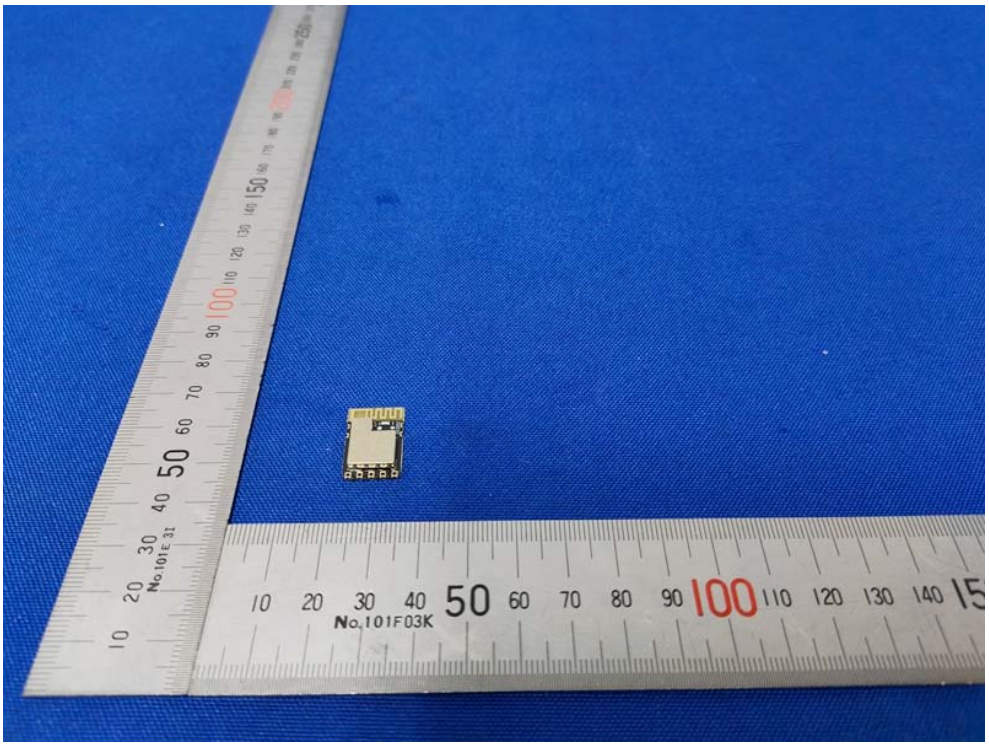

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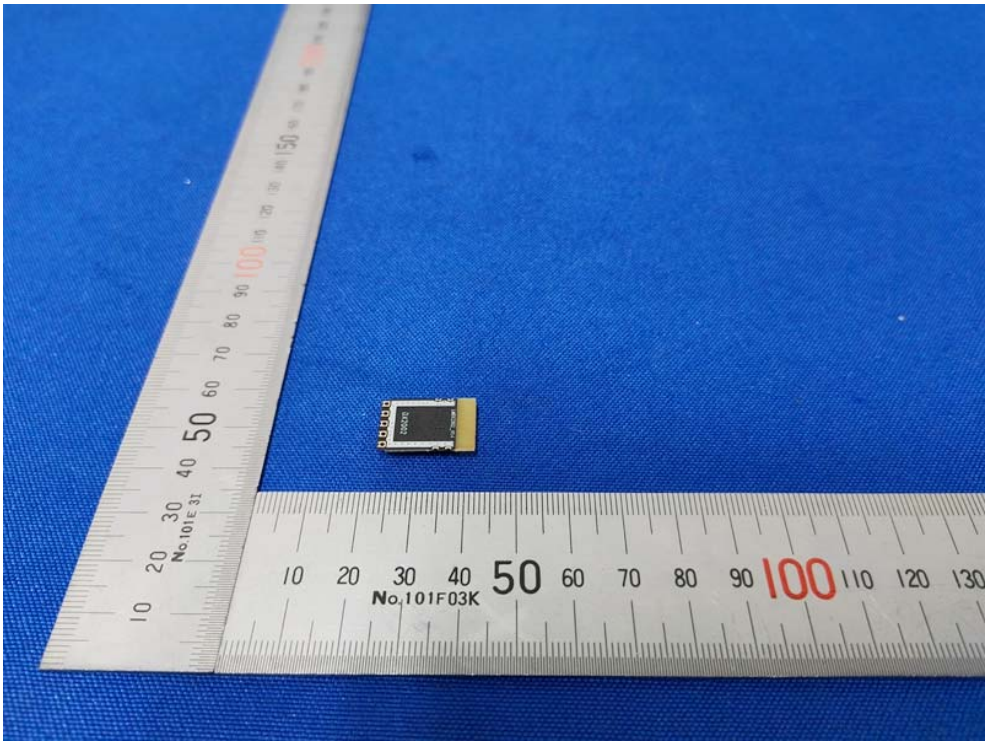

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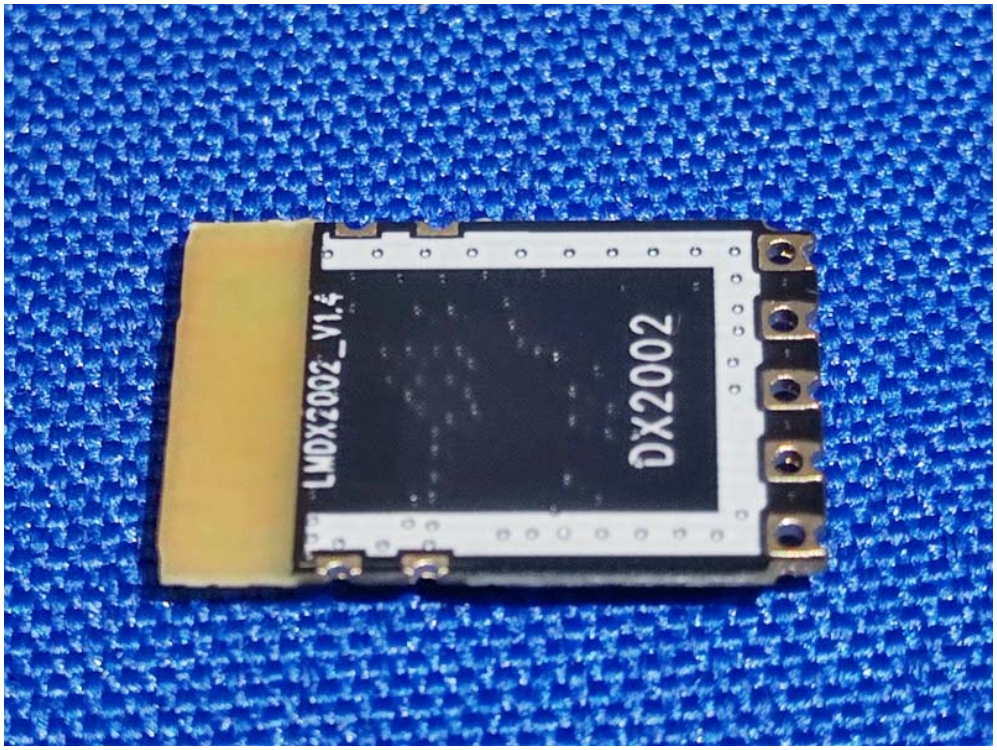

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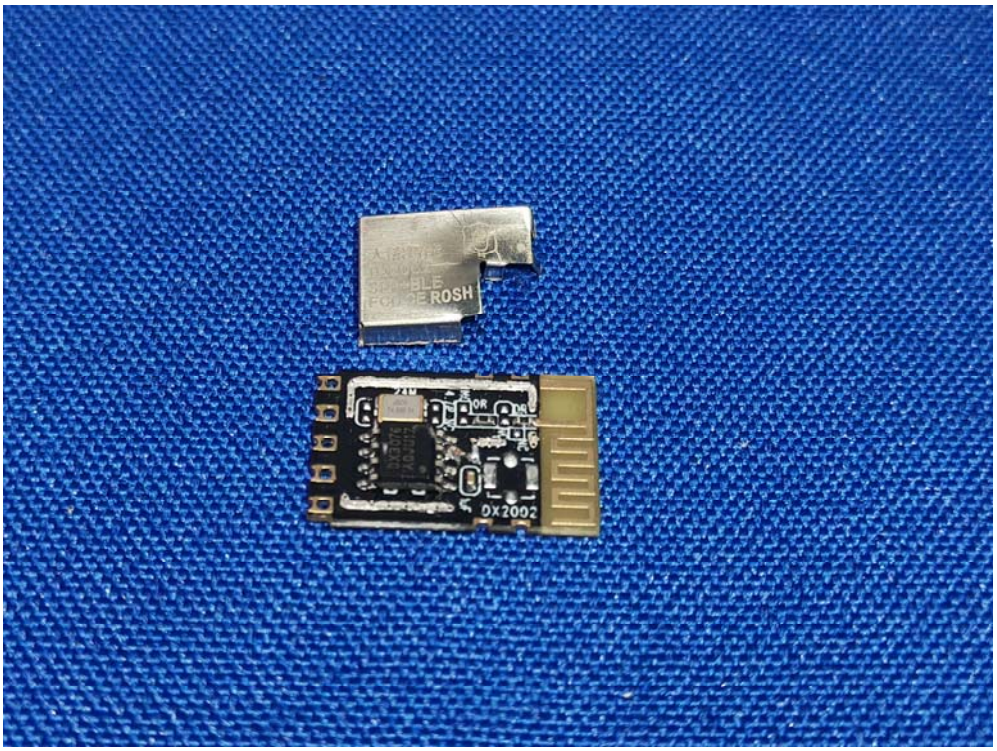

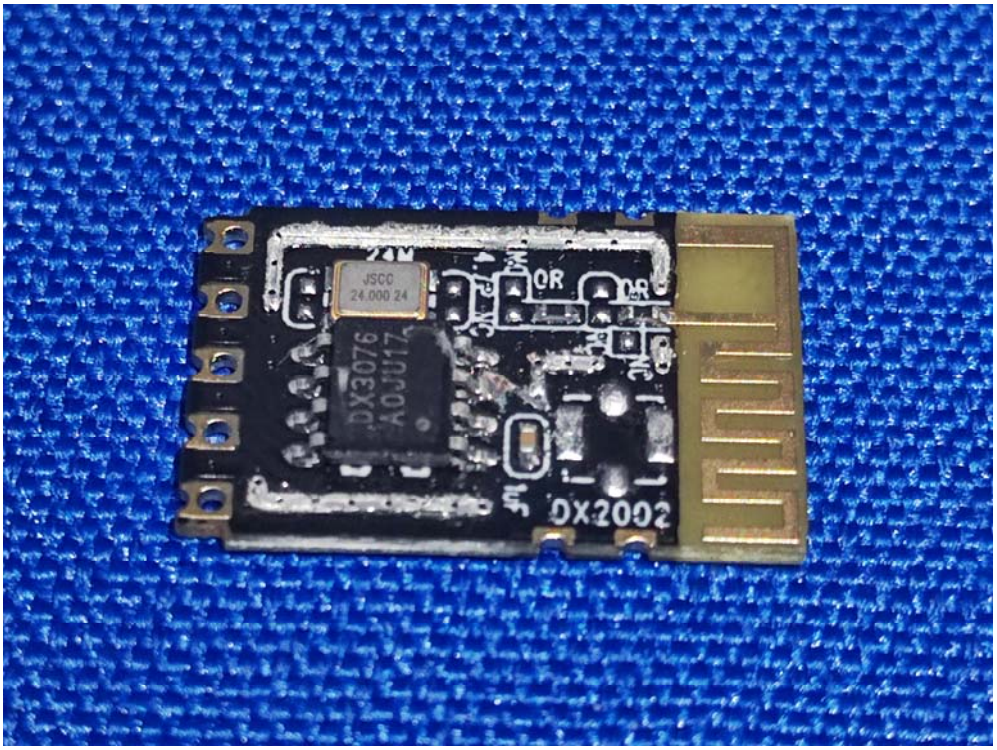

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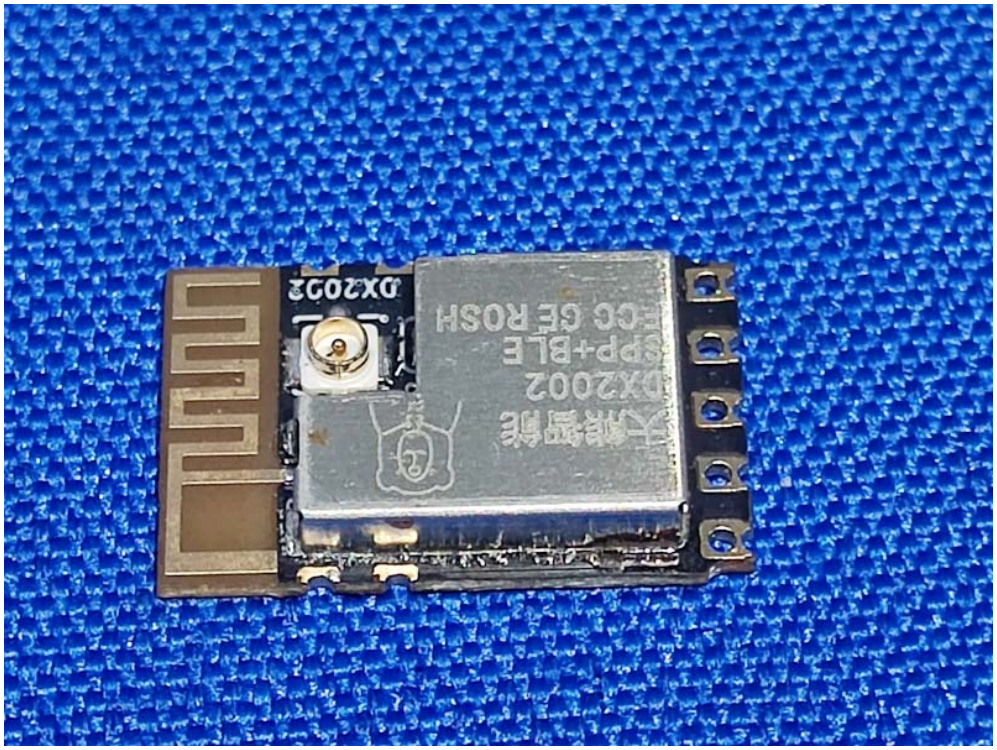

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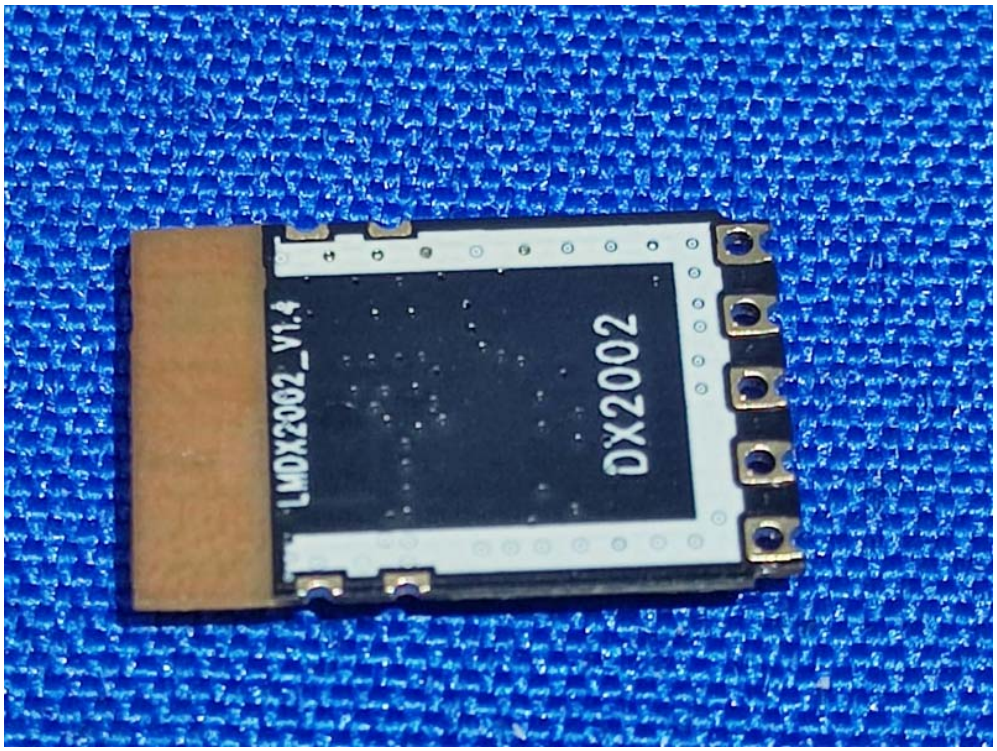

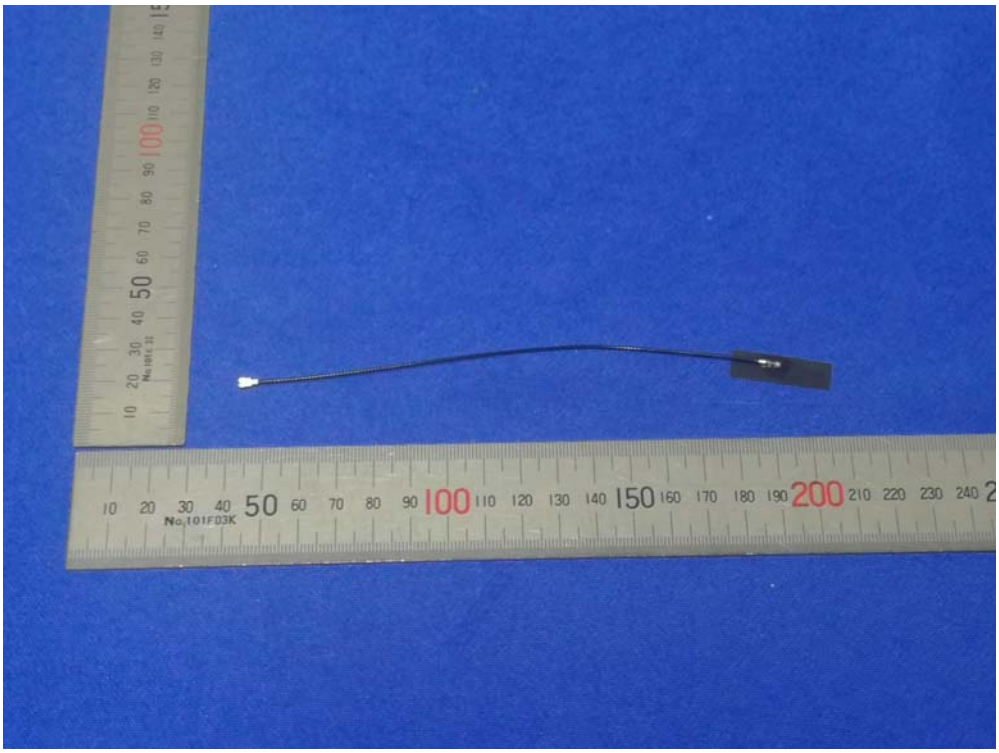

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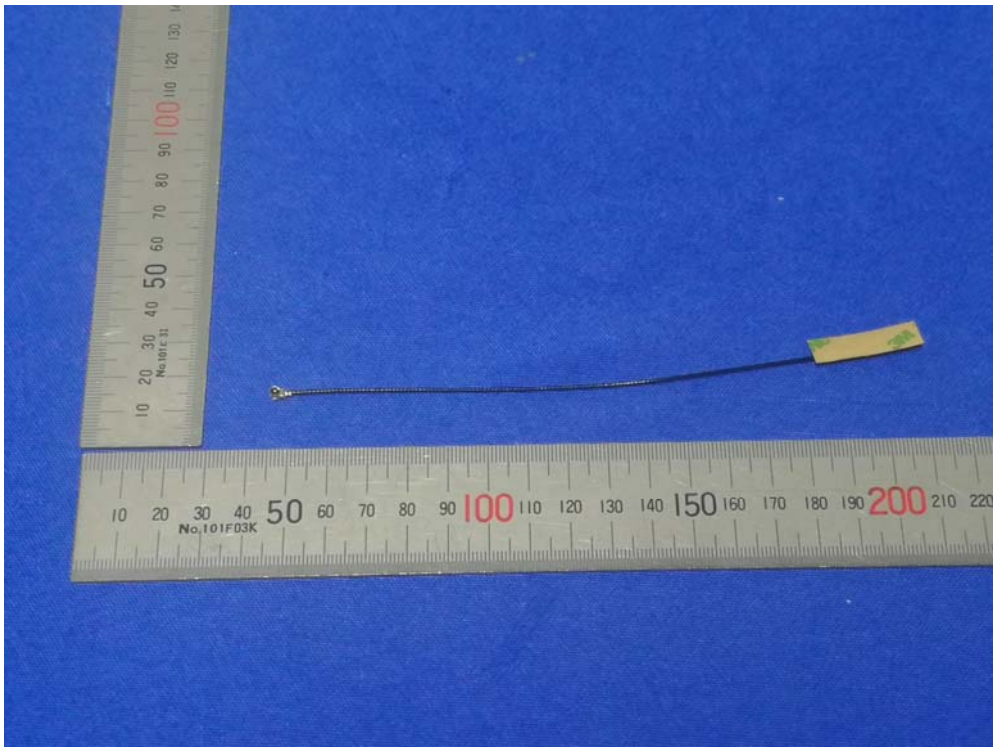

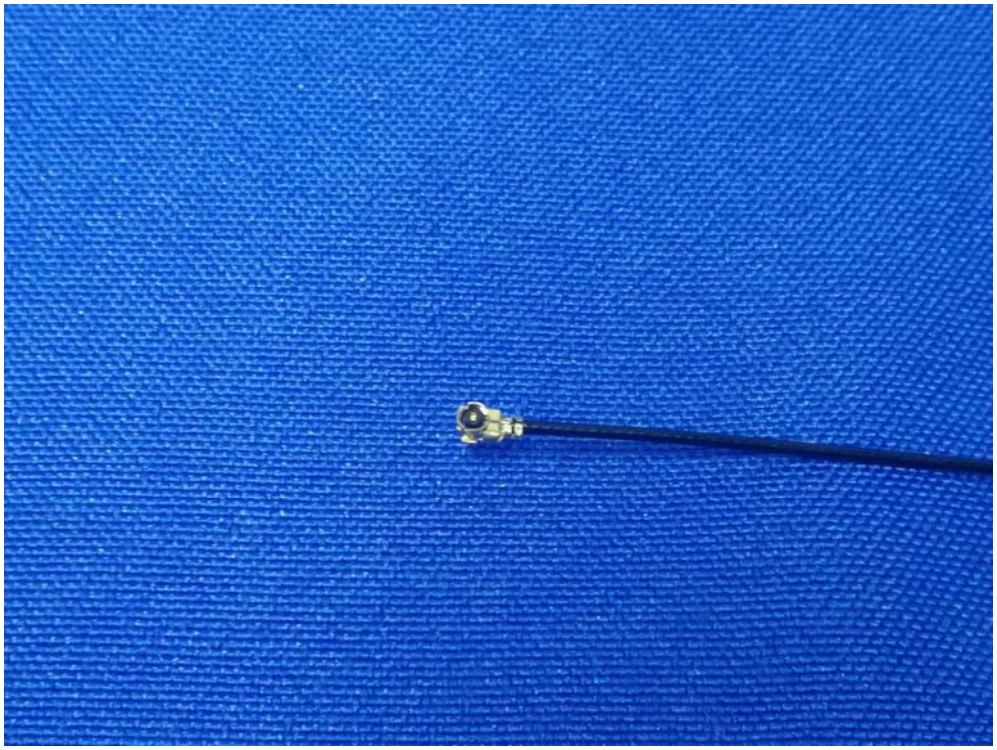

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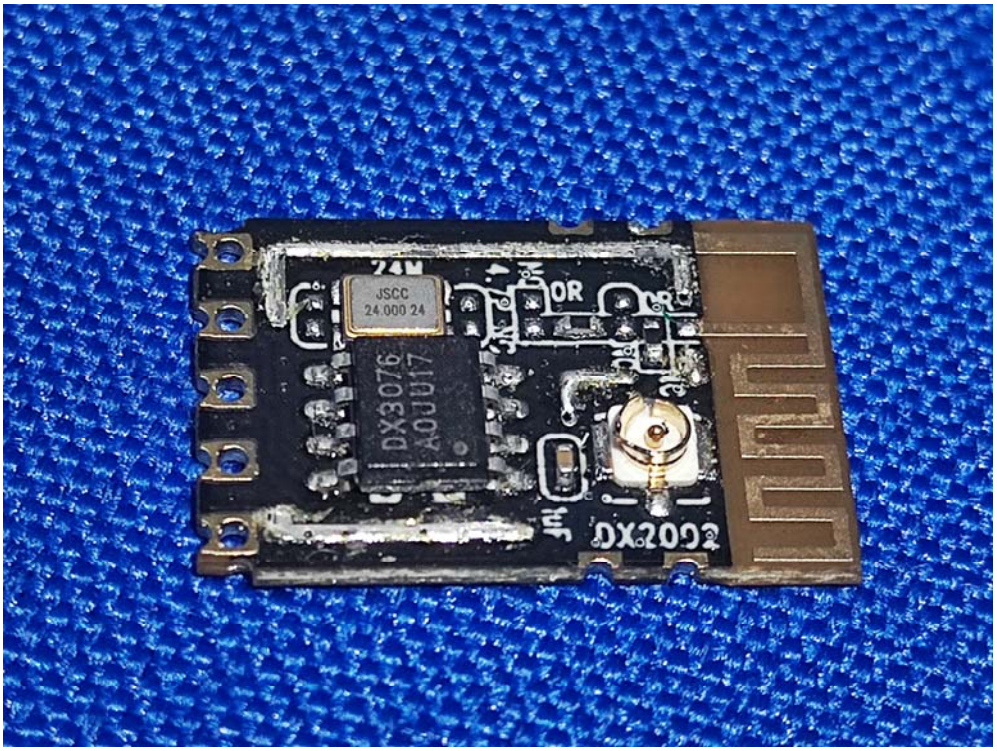

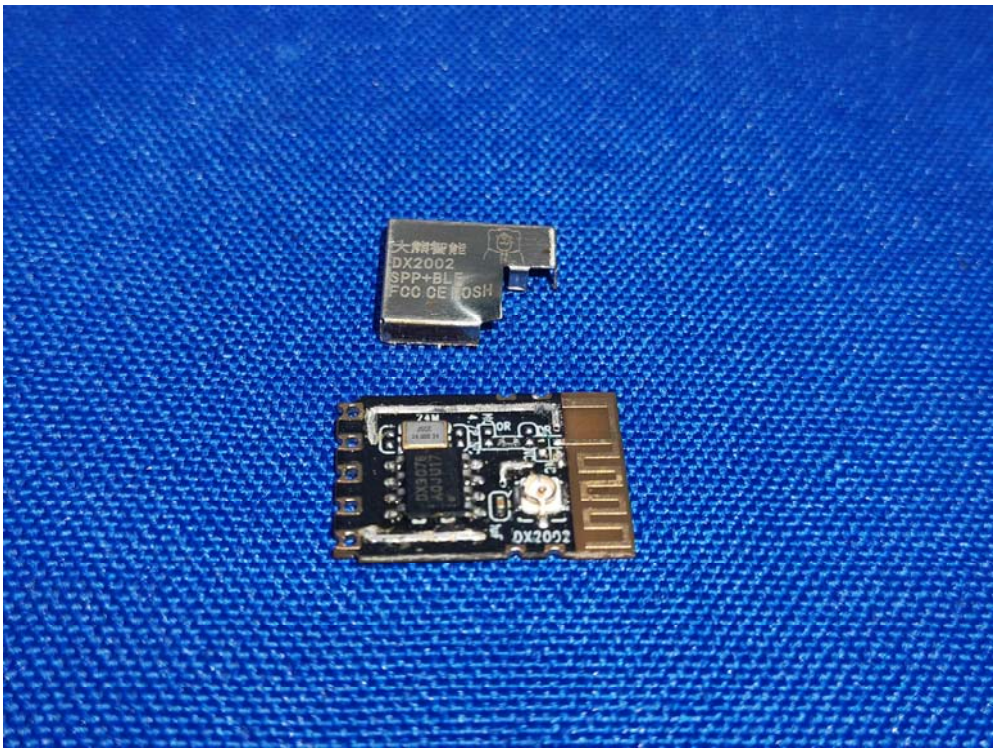

--End of Report--

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