

# TEST REPORT

Applicant Name : Thundercomm Technology Co., Ltd □  
 Address : No. 107, Middle Datagu Road, Xiantao Street, Yubei District, Chongqing, China, 401122  
 Report Number : SZNS220928-44462E-RF-00A  
 FCC ID: 2AOHHTURBOX-C6490

## Test Standard (s)

FCC PART 15.247

## Sample Description

Product Type: C6490  
 Model No.: C6490-U4A  
 Multiple Model(s) No.: C6490-U46,C6490-U4AS,C6490-U46S  
 Trade Mark: TurboX  
 Date Received: 2022/09/28  
 Report Date: 2023/03/16

Test Result:	Pass*
--------------	-------

\* In the configuration tested, the EUT complied with the standards above.

## Prepared and Checked By:



Andy Yu  
EMC Engineer

## Approved By:



Candy Li  
EMC Engineer

Note: This report may contain data that are not covered by the A2LA accreditation and are marked with an asterisk "★".

Shenzhen Accurate Technology Co., Ltd. is not responsible for the authenticity of any test data provided by the applicant. Data included from the applicant that may affect test results are marked with an asterisk "\*". Customer model name, addresses, names, trademarks etc. are not considered data.

This report cannot be reproduced except in full, without prior written approval of the Company. Unless otherwise stated the results shown in this test report refer only to the sample(s) tested. This report is valid only with a valid digital signature. The digital signature may be available only under the Adobe software above version 7.0.

### Shenzhen Accurate Technology Co., Ltd.

1/F., Building A, Changyuan New Material Port, Science & Industry Park, Nanshan District, Shenzhen, Guangdong, P.R. China  
 Tel: +86 755-26503290 Fax: +86 755-26503396 Web: www.atc-lab.com

## TABLE OF CONTENTS

<b>DOCUMENT REVISION HISTORY .....</b>	<b>4</b>
<b>GENERAL INFORMATION.....</b>	<b>5</b>
PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT) .....	5
OBJECTIVE .....	5
TEST METHODOLOGY .....	5
MEASUREMENT UNCERTAINTY .....	6
TEST FACILITY .....	6
<b>SYSTEM TEST CONFIGURATION.....</b>	<b>7</b>
DESCRIPTION OF TEST CONFIGURATION .....	7
EUT EXERCISE SOFTWARE .....	7
SPECIAL ACCESSORIES .....	7
EQUIPMENT MODIFICATIONS .....	7
SUPPORT EQUIPMENT LIST AND DETAILS .....	7
EXTERNAL I/O CABLE.....	7
BLOCK DIAGRAM OF TEST SETUP .....	8
<b>SUMMARY OF TEST RESULTS .....</b>	<b>9</b>
<b>TEST EQUIPMENT LIST .....</b>	<b>10</b>
<b>FCC §15.247 (I) &amp; §1.1307 (B) (3) &amp; §2.1091- MPE-BASED EXEMPTION .....</b>	<b>12</b>
<b>FCC §15.203 – ANTENNA REQUIREMENT .....</b>	<b>14</b>
APPLICABLE STANDARD .....	14
ANTENNA CONNECTOR CONSTRUCTION .....	14
<b>FCC §15.207 (A) – AC LINE CONDUCTED EMISSIONS .....</b>	<b>15</b>
APPLICABLE STANDARD .....	15
EUT SETUP.....	15
EMI TEST RECEIVER SETUP.....	15
TEST PROCEDURE .....	15
TRANSD FACTOR & MARGIN CALCULATION .....	16
TEST DATA .....	16
<b>FCC §15.205, §15.209 &amp; §15.247(D) – RADIATED EMISSIONS .....</b>	<b>19</b>
APPLICABLE STANDARD .....	19
EUT SETUP.....	19
EMI TEST RECEIVER & SPECTRUM ANALYZER SETUP .....	20
TEST PROCEDURE .....	20
FACTOR & MARGIN CALCULATION .....	20
TEST DATA .....	20
<b>FCC §15.247(A) (1)-CHANNEL SEPARATION TEST .....</b>	<b>27</b>
APPLICABLE STANDARD .....	27
TEST PROCEDURE .....	27
TEST DATA .....	27
<b>FCC §15.247(A) (1) – 20 DB EMISSION BANDWIDTH &amp; 99% OCCUPIED BANDWIDTH .....</b>	<b>28</b>
APPLICABLE STANDARD .....	28
TEST PROCEDURE .....	28
TEST DATA .....	29

**FCC §15.247(A) (1) (III)-QUANTITY OF HOPPING CHANNEL TEST .....30**  
    APPLICABLE STANDARD .....30  
    TEST PROCEDURE .....30  
    TEST DATA .....30

**FCC §15.247(A) (1) (III) - TIME OF OCCUPANCY (DWELL TIME).....31**  
    APPLICABLE STANDARD .....31  
    TEST PROCEDURE .....31  
    TEST DATA .....31

**FCC §15.247(B) (1) - PEAK OUTPUT POWER MEASUREMENT .....32**  
    APPLICABLE STANDARD .....32  
    TEST PROCEDURE .....32  
    TEST DATA .....32

**FCC §15.247(D) - BAND EDGES TESTING.....33**  
    APPLICABLE STANDARD .....33  
    TEST PROCEDURE .....33  
    TEST DATA .....33

**APPENDIX .....34**  
    APPENDIX A: 20dBEMISSION BANDWIDTH .....34  
    APPENDIX B: OCCUPIED CHANNEL BANDWIDTH .....38  
    APPENDIX C: MAXIMUM CONDUCTED OUTPUT POWER .....42  
    APPENDIX D: CARRIER FREQUENCY SEPARATION .....46  
    APPENDIX E: TIME OF OCCUPANCY .....48  
    APPENDIX F: NUMBER OF HOPPING CHANNELS .....55  
    APPENDIX G: BAND EDGE MEASUREMENTS .....57

**DOCUMENT REVISION HISTORY**

<b>Revision Number</b>	<b>Report Number</b>	<b>Description of Revision</b>	<b>Date of Revision</b>
0	SZNS220928-44462E-RF-00A	Original Report	2023-03-16

## GENERAL INFORMATION

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

Product	C6490
Tested Model	C6490-U4A
Multiple Models	C6490-U46,C6490-U4AS,C6490-U46S (model difference see product declaration letter of similarity)
Frequency Range	Bluetooth: 2402~2480MHz
Maximum conducted Peak output power	Bluetooth: 2.41dBm
Modulation Technique	Bluetooth: GFSK, $\pi/4$ -DQPSK, 8DPSK
Antenna Specification*	2.5dBi (provided by the applicant)
Voltage Range	DC 3.8V
Sample serial number	SZNS220928-44462E-RF-S1 for Conducted and Radiated Emissions SZNS220928-44462E-RF-S2 RF Conducted Test (Assigned by ATC)
Sample/EUT Status	Good condition
Note: Pre-scan all models, the worst case model C6490-U4A was selected to test.	

### Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, section 15.203, 15.205, 15.207, 15.209 and 15.247 rules.

### Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.

All emissions measurement was performed at Shenzhen Accurate Technology Co., Ltd. The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Each test item follows test standards and with no deviation.

## Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		5%
RF Frequency		$0.082 \times 10^{-7}$
RF output power, conducted		0.73dB
Unwanted Emission, conducted		1.6dB
AC Power Lines Conducted Emissions		2.72dB
Emissions, Radiated	9kHz - 30MHz	2.66dB
	30MHz - 1GHz	4.28dB
	1GHz - 18GHz	4.98dB
	18GHz - 26.5GHz	5.06dB
	26.5GHz - 40GHz	4.72dB
Temperature		1°C
Humidity		6%
Supply voltages		0.4%

*Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.*

## Test Facility

The test site used by Shenzhen Accurate Technology Co., Ltd. to collect test data is located on the 1/F., Building A, Changyuan New Material Port, Science & Industry Park, Nanshan District, Shenzhen, Guangdong, P.R. China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 708358, the FCC Designation No.: CN1189. Accredited by American Association for Laboratory Accreditation (A2LA) The Certificate Number is 429 7.01.

Listed by Innovation, Science and Economic Development Canada (ISED), the Registration Number is 5077A.

## SYSTEM TEST CONFIGURATION

### Description of Test Configuration

The system was configured for testing in an engineering mode.

### EUT Exercise Software

“QRCT \*\*” exercise software was used and the power level is 7\*, which provided by applicant.

### Special Accessories

No special accessory.

### Equipment Modifications

No modification was made to the EUT tested.

### Support Equipment List and Details

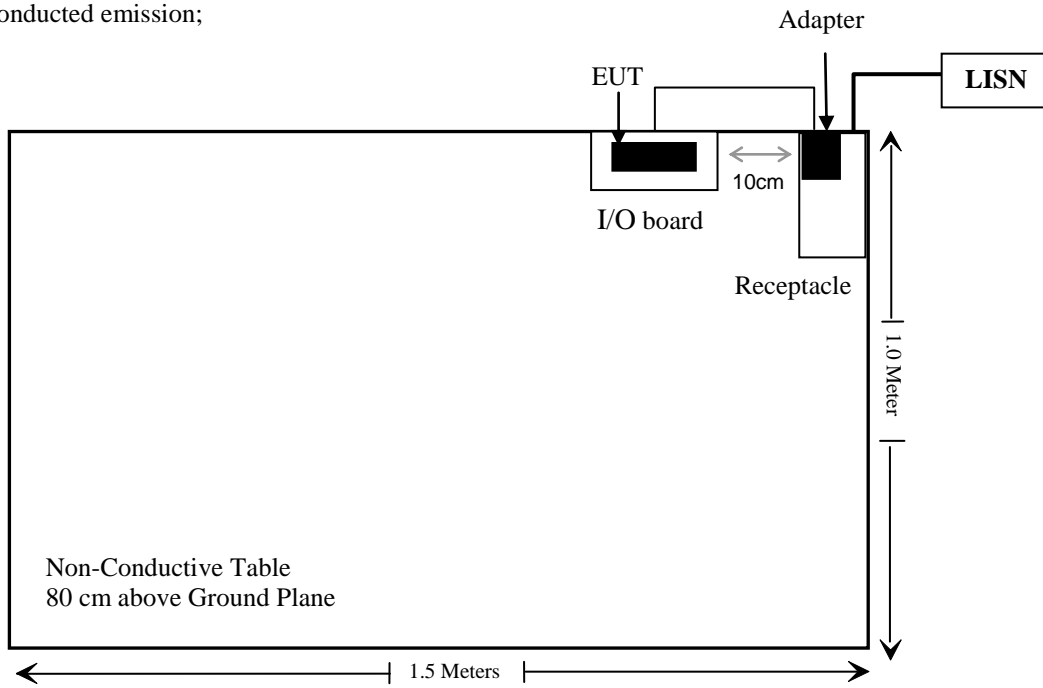
Manufacturer	Description	Model	Serial Number
LIANYUNDA	Adapter	LYD120200B	Unkown
Thundercomm Technology Co., Ltd	Test jig	I/O board	Unkown

### External I/O Cable

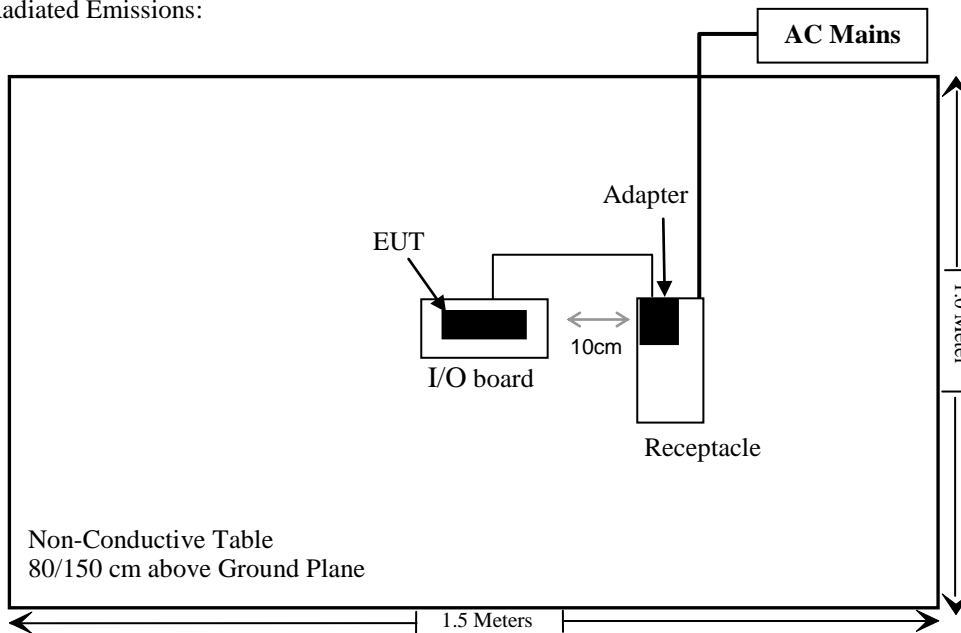
Cable Description	Length (m)	From Port	To
Un-shielding Un-Detachable DC Cable	1.0	EUT	Adapter

### Block Diagram of Test Setup

For conducted emission;



For Radiated Emissions:





**SUMMARY OF TEST RESULTS**

<b>FCC Rules</b>	<b>Description of Test</b>	<b>Result</b>
§15.247 (i) & §1.1307 (b) (3) & §2.1091	MPE-Based Exemption	Compliant
§15.203	Antenna Requirement	Compliant
§15.207(a)	AC Line Conducted Emissions	Compliant
§15.205, §15.209 & §15.247(d)	Radiated Emissions	Compliant
§15.247(a)(1)	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliant
§15.247(a)(1)	Channel Separation Test	Compliant
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliant
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliant
§15.247(b)(1)	Peak Output Power Measurement	Compliant
§15.247(d)	Band edges	Compliant

**TEST EQUIPMENT LIST**

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
<b>Conducted Emissions Test</b>					
Rohde& Schwarz	EMI Test Receiver	ESCI	100784	2021/12/13	2022/12/12
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2021/12/13	2022/12/12
Anritsu Corp	50 Coaxial Switch	MP59B	6100237248	2021/12/13	2022/12/12
Unknown	RF Coaxial Cable	No.17	N0350	2021/12/14	2022/12/13
Conducted Emission Test Software: e3 19821b (V9)					
<b>Radiated Emissions Test (30MHz-1GHz)</b>					
Rohde& Schwarz	Test Receiver	ESR	102725	2021/12/13	2022/12/12
SONOMA INSTRUMENT	Amplifier	310 N	186131	2021/11/09	2022/11/08
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/05
Unknown	RF Coaxial Cable	No.12	N040	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.13	N300	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.14	N800	2021/12/14	2022/12/13
Radiated Emission Test Software: e3 19821b (V9)					
<b>Radiated Emissions Test (Above 1GHz)</b>					
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2021/12/13	2022/12/12
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2022/11/25	2023/11/24
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2021/11/09	2022/11/08
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2022/11/08	2023/11/07
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2021/11/11	2022/11/10
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2022/11/08	2023/11/07
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2020/01/05	2023/01/04
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2022/11/30	2025/11/29
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2020/01/05	2023/01/04
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2022/12/26	2025/12/25
Radiated Emission Test Software: e3 19821b (V9)					
Unknown	RF Coaxial Cable	No.10	N050	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.10	N050	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.11	N1000	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.11	N1000	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.15	N600	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.15	N600	2022/11/25	2023/11/24
Unknown	RF Coaxial Cable	No.16	N650	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.16	N650	2022/11/25	2023/11/24
Wainwright	High Pass Filter	WHKX3.6/18 G-10SS	5	2021/12/14	2022/12/13
Wainwright	High Pass Filter	WHKX3.6/18 G-10SS	5	2022/11/25	2023/11/24

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
RF conducted test					
Rohde&Schwarz	Spectrum Analyzer	FSV-40	101590	2022/01/19	2023/01/18
Tonscend	RF Control Unit	JS0806-2	19G8060182	2021/10/26	2022/10/25
HP	20dB Attenuator	8491A	53857	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.31	RF-01	Each time	Each time

\* **Statement of Traceability:** Shenzhen Accurate Technology Co., Ltd. attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

## FCC §15.247 (i) & §1.1307 (b) (3) & §2.1091- MPE-Based Exemption

### Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

According to KDB 447498 D04 Interim General RF Exposure Guidance

MPE-Based Exemption:

General frequency and separation-distance dependent MPE-based effective radiated power(ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(1)(i)(C)] to support an exemption from further evaluation from 300 kHz through 100 GHz.

Table 1 to § 1.1307(b)(3)(i)(C) - Single RF Sources Subject to Routine Environmental Evaluation

RF Source frequency (MHz)	Threshold ERP (watts)
0.3-1.34	$1,920 R^2$ .
1.34-30	$3,450 R^2/f^2$ .
30-300	$3.83 R^2$ .
300-1,500	$0.0128 R^2f$ .
1,500-100,000	$19.2R^2$ .

$R$  is the minimum separation distance in meters

$f$  = frequency in MHz

For multiple RF sources: Multiple RF sources are exempt if:

in the case of fixed RF sources operating in the same time-averaging period, or of multiple mobile or portable RF sources within a device operating in the same time averaging period, if the sum of the fractional contributions to the applicable thresholds is less than or equal to 1 as indicated in the following equation:

$$\sum_{i=1}^a \frac{P_i}{P_{th,i}} + \sum_{j=1}^b \frac{ERP_j}{ERP_{th,j}} + \sum_{k=1}^c \frac{Evaluated_k}{Exposure Limit_k} \leq 1$$

## Result

For worst case:

Mode	Frequency (MHz)	Tune up conducted power	Antenna Gain		ERP		Evaluation Distance (m)	ERP Limit (W)
		(dBm)	(dBi)	(dBd)	(dBm)	(W)		
BT	2402-2480	2.5	2.5	0.35	2.85	0.002	0.2	0.768
BLE	2402-2480	11.0	2.5	0.35	11.35	0.014	0.2	0.768
2.4G Wi-Fi	2412-2462	20.5	5.5	3.35	23.85	0.243	0.2	0.768
5G Wi-Fi	5150-5250	18.5	5.6	3.45	21.95	0.157	0.2	0.768
	5250-5350	19.0	5.6	3.45	22.45	0.176	0.2	0.768
	5470-5725	18.5	5.6	3.45	21.95	0.157	0.2	0.768
	5725-5850	16.0	5.6	3.45	19.45	0.088	0.2	0.768
	5850-5895	18.0	5.6	3.45	21.45	0.140	0.2	0.768
6G Wi-Fi	5925-6425	11.0	5.6	3.45	14.45	0.028	0.2	0.768
	6425-6525	9.5	5.6	3.45	12.95	0.020	0.2	0.768
	6525-6875	10.0	5.6	3.45	13.45	0.022	0.2	0.768
	6875-7125	9.5	5.6	3.45	12.95	0.020	0.2	0.768

- Note: 1. The tune up conducted power and antenna gain was declared by the applicant.  
 2. The BT, 2.4G Wi-Fi, 5G Wi-Fi and 6G Wi-Fi can Simultaneous transmitting.  
 3. For the 2.4G Wi-Fi, as it can support the beam-forming function, so the directional antenna gain should add the  $10\lg 2$ ,  $2.5\text{dBi}+10\lg 2=5.5\text{dBi}$ .  
 4. For the 5G Wi-Fi & 6G Wi-Fi, as it can support the beam-forming function, so the directional antenna gain should add the  $10\lg 2$ ,  $2.6\text{dBi}+10\lg 2=5.6\text{dBi}$ .  
 5.  $0\text{dBd}=2.15\text{dBi}$

Simultaneous transmitting consideration (worst case):

The ratio= $\text{ERP}_{\text{BLE}}/\text{limit}+\text{ERP}_{\text{2.4G Wi-Fi}}/\text{limit}+\text{ERP}_{\text{5G Wi-Fi}}/\text{limit}+\text{ERP}_{\text{6G Wi-Fi}}/\text{limit}$   
 $=0.014/0.768+0.243/0.768+0.176/0.768+0.028/0.768=0.600<1.0$ , so simultaneous exposure is compliant.

To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

**Result: Compliant.**

## **FCC §15.203 – ANTENNA REQUIREMENT**

### **Applicable Standard**

According to FCC § 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. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. 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.

### **Antenna Connector Construction**

No standard antenna connect port with this module, The EUT tested with one FPC antenna arrangement which was integrated on the main PCB use the MHF-Type connector and no consideration of replacement, fulfill the requirement of this section. Please refer to the EUT photos.

<b>Antenna Type</b>	<b>Antenna Gain</b>	<b>Impedance</b>	<b>Frequency Range</b>
FPC	2.5dBi	50Ω	2.4~2.5GHz

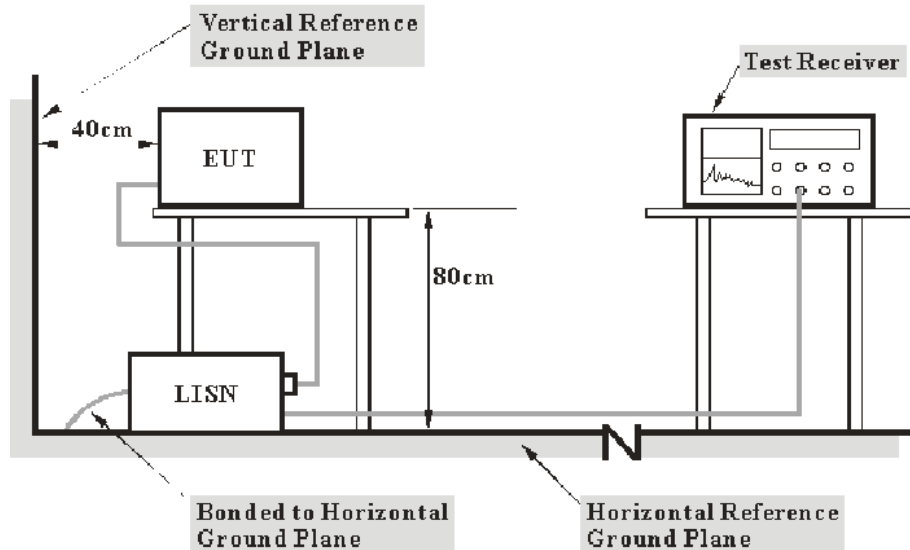
**Result:** Compliant.

## FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

### Applicable Standard

FCC §15.207(a)

### EUT Setup



- Note: 1. Support units were connected to second LISN.  
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The measurement procedure of EUT setup is according with ANSI C63.10-2013. The related limit was specified in FCC Part 15.207.

The spacing between the peripherals was 10 cm.

### EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

During the conducted emission test, the EMI test receiver was set with the following configurations:

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

### Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

## Transd Factor & Margin Calculation

The Transd factor is calculated by adding LISN VDF (Voltage Division Factor) and Cable Loss. The basic equation is as follows:

$$\text{Transd Factor} = \text{LISN VDF} + \text{Cable Loss}$$

The “**Over limit**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an Over limit of -7 dB means the emission is 7 dB below the limit. The equation for calculation is as follows:

$$\begin{aligned} \text{Over Limit} &= \text{Level} - \text{Limit} \\ \text{Level} &= \text{Read Level} + \text{Factor} \end{aligned}$$

## Test Data

### Environmental Conditions

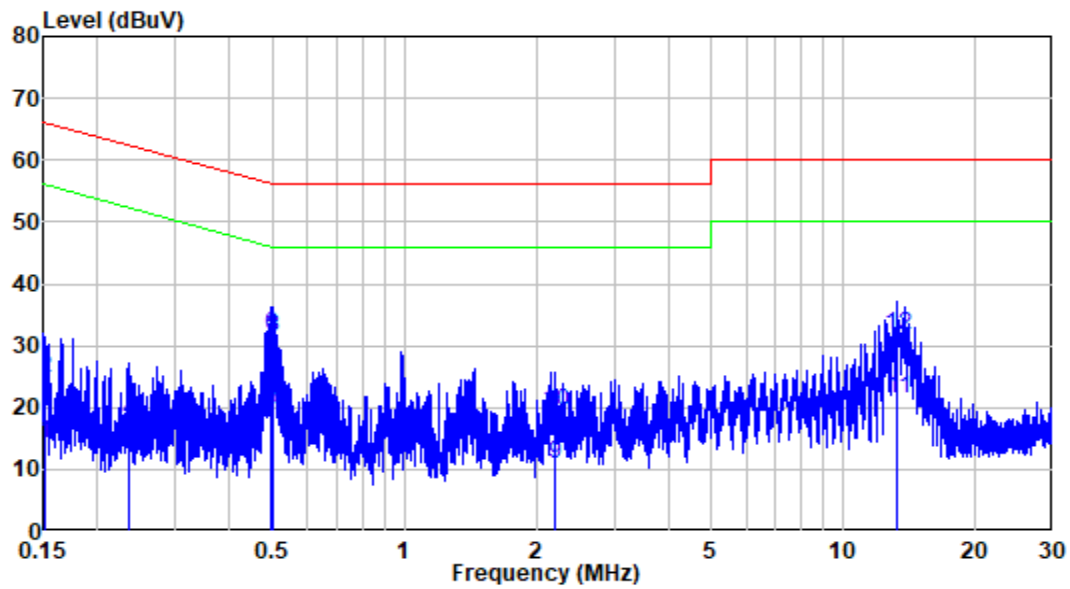
<b>Temperature:</b>	23 °C
<b>Relative Humidity:</b>	41%
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Jason Liu on 2022-11-01.*

*EUT operation mode: Transmitting (the worst case is 8DPSK Mode, high channel)*



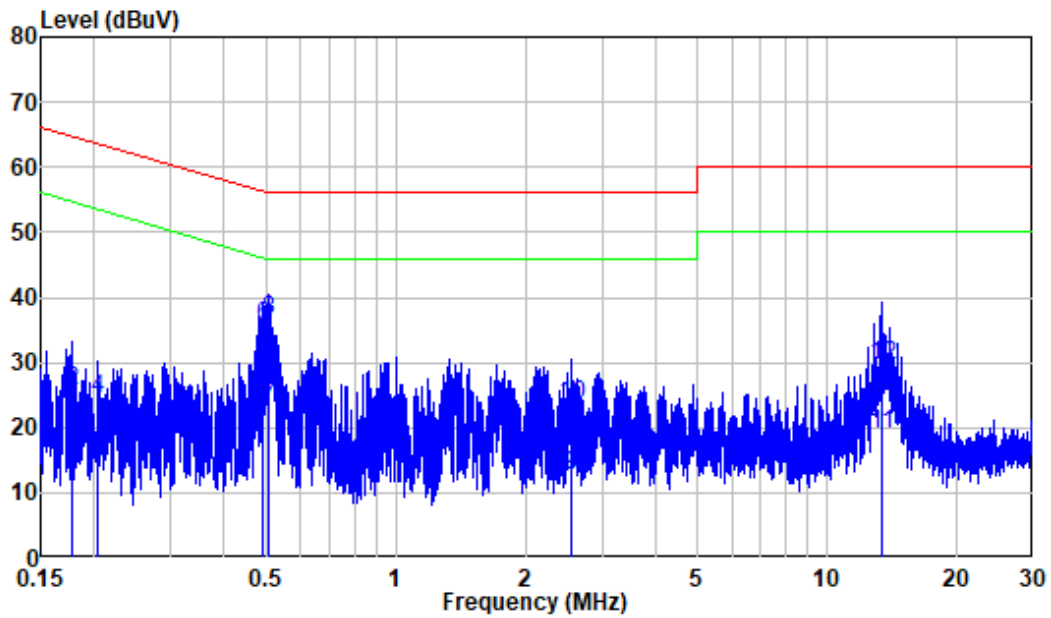
AC 120V/60 Hz, Line



Site : Shielding Room  
 Condition: Line  
 Job No. : SZNS220928-44462E-RF  
 Mode : BT  
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.152	9.80	4.46	14.26	55.88	-41.62	Average
2	0.152	9.80	15.02	24.82	65.88	-41.06	QP
3	0.237	9.80	2.50	12.30	52.22	-39.92	Average
4	0.237	9.80	7.89	17.69	62.22	-44.53	QP
5	0.498	9.80	9.89	19.69	46.03	-26.34	Average
6	0.498	9.80	21.91	31.71	56.03	-24.32	QP
7	0.501	9.80	9.91	19.71	46.00	-26.29	Average
8	0.501	9.80	21.71	31.51	56.00	-24.49	QP
9	2.209	9.82	1.12	10.94	46.00	-35.06	Average
10	2.209	9.82	9.41	19.23	56.00	-36.77	QP
11	13.284	9.93	11.61	21.54	50.00	-28.46	Average
12	13.284	9.93	21.72	31.65	60.00	-28.35	QP

AC 120V/60 Hz, Neutral



Site : Shielding Room  
 Condition: Neutral  
 Job No. : SZNS220928-44462E-RF  
 Mode : BT  
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.178	9.80	5.41	15.21	54.59	-39.38	Average
2	0.178	9.80	15.92	25.72	64.59	-38.87	QP
3	0.204	9.80	4.65	14.45	53.44	-38.99	Average
4	0.204	9.80	14.56	24.36	63.44	-39.08	QP
5	0.489	9.80	12.79	22.59	46.19	-23.60	Average
6	0.489	9.80	25.97	35.77	56.19	-20.42	QP
7	0.508	9.80	13.51	23.31	46.00	-22.69	Average
8	0.508	9.80	26.81	36.61	56.00	-19.39	QP
9	2.552	9.83	2.97	12.80	46.00	-33.20	Average
10	2.552	9.83	13.79	23.62	56.00	-32.38	QP
11	13.346	10.03	8.86	18.89	50.00	-31.11	Average
12	13.346	10.03	19.55	29.58	60.00	-30.42	QP

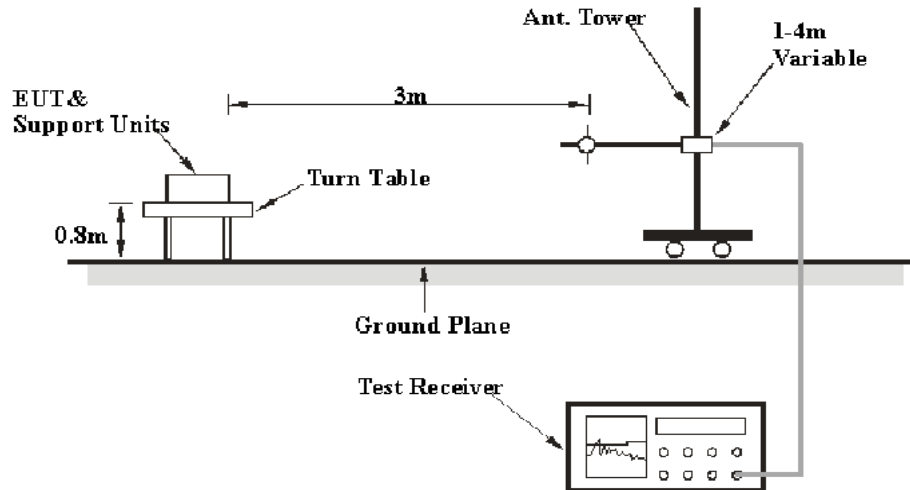
## FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

### Applicable Standard

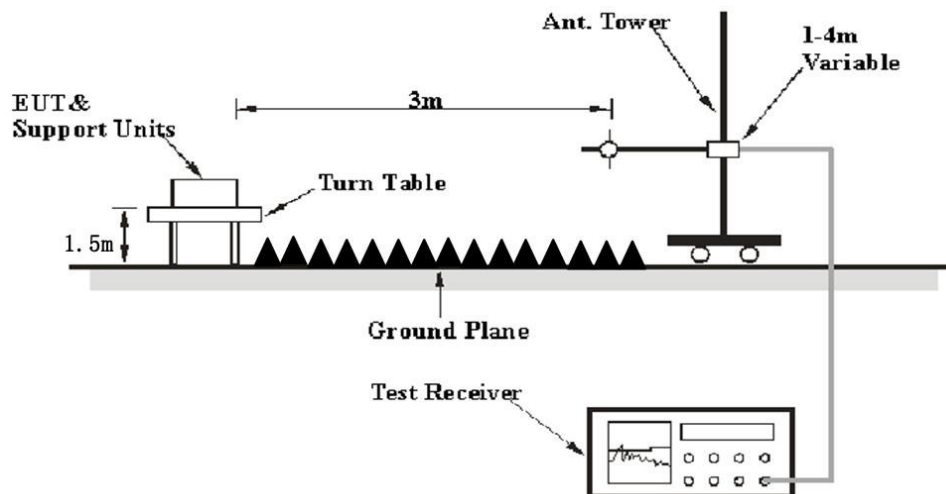
FCC §15.205; §15.209; §15.247(d)

### EUT Setup

#### Below 1 GHz:



#### Above 1GHz:



The radiated emission tests were performed in the 3 meters, using the setup accordance with the ANSI C63.10-2013. The specification used was the FCC 15.209 and FCC 15.247 limits.

## EMI Test Receiver & Spectrum Analyzer Setup

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1 MHz	3 MHz	/	PK

For average measurement:

Use the duty cycle factor correction factor method per 15.35(c).

Duty cycle=On time/100milliseconds, On time= $N1*L1+N2*L2+\dots+Nn-1*Ln-1+Nn*Ln$ ,

where N1 is number of type 1 pulses, L1 is length of type 1 pulse, etc.

Average Emission Level=Peak Emission Level+20\*log(Duty cycle)

## Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

All final data was recorded in Quasi-peak detection mode for frequency range of 30 MHz -1 GHz and peak and Average detection modes for frequencies above 1 GHz.

## Factor & Margin Calculation

The Factor is calculated by adding the Antenna Factor and Cable Loss, and subtracting the Amplifier Gain. The basic equation is as follows:

$$\text{Factor} = \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

The “**Over Limit/Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, an Over Limit/margin of -7dB means the emission is 7dB below the limit. The equation for calculation is as follows:

$$\begin{aligned} \text{Over Limit/Margin} &= \text{Level} / \text{Corrected Amplitude} - \text{Limit} \\ \text{Level} / \text{Corrected Amplitude} &= \text{Read Level} + \text{Factor} \end{aligned}$$

## Test Data

### Environmental Conditions

Temperature:	24~25.6°C
Relative Humidity:	50~57%
ATM Pressure:	101.0 kPa

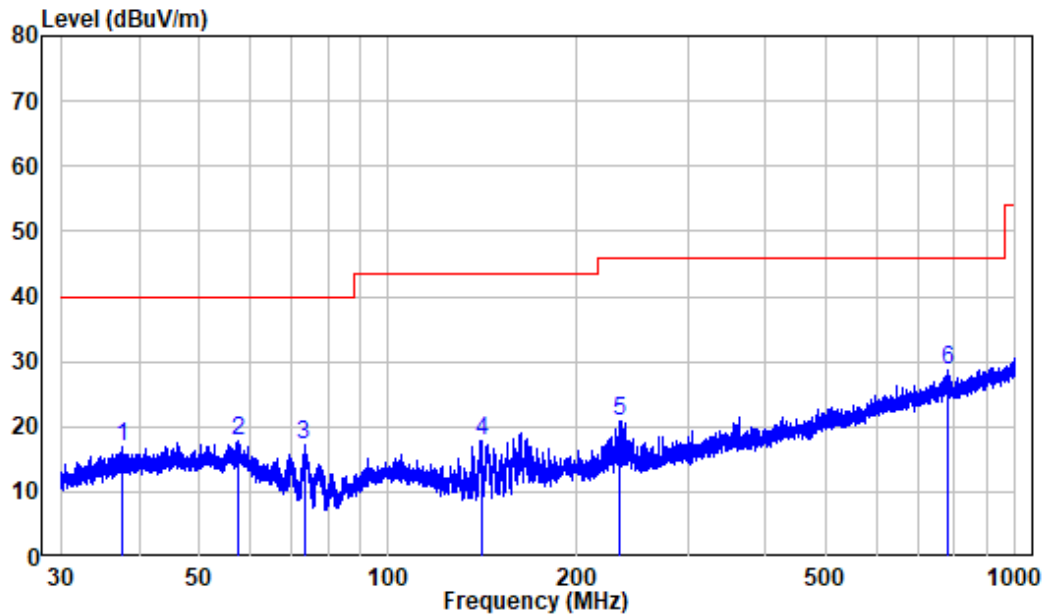
The testing was performed by Level Li on 2022-10-31 for below 1GHz, Jimi Zheng from 2022-10-18 to 2023-03-16 for above 1GHz.

EUT operation mode: Transmitting (Pre-scan in the X, Y and Z axes of orientation, the worst case X-axis of orientation was recorded)

**30MHz-1GHz:** (worst case is 8DPSK Mode, high channel)

Note: When the test result of peak was less than the limit of QP more than 6dB, just peak value were recorded.

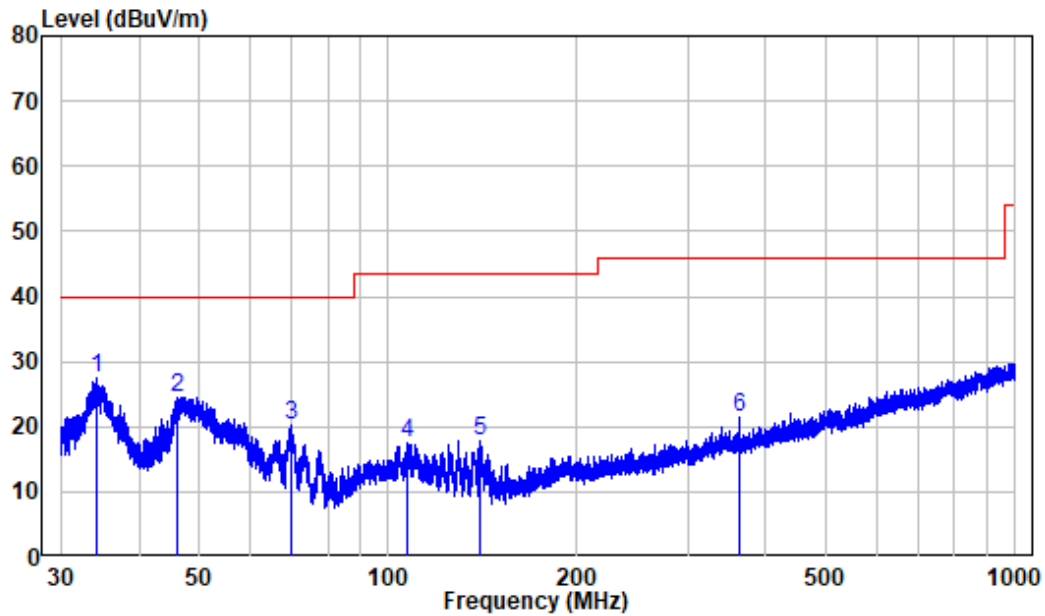
**Horizontal:**



Site : chamber  
 Condition: 3m HORIZONTAL  
 Job No. : SZNS220928-44462E-RF  
 Test Mode: BT

	Freq	Factor	Read Level	Limit Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	37.515	-10.90	27.84	16.94	40.00	-23.06	Peak
2	57.644	-9.95	27.67	17.72	40.00	-22.28	Peak
3	73.359	-15.92	32.98	17.06	40.00	-22.94	Peak
4	140.527	-15.48	33.33	17.85	43.50	-25.65	Peak
5	233.656	-11.00	31.87	20.87	46.00	-25.13	Peak
6	779.949	0.08	28.52	28.60	46.00	-17.40	Peak

Vertical



Site : chamber  
 Condition: 3m VERTICAL  
 Job No. : SZNS220928-44462E-RF  
 Test Mode: BT

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	34.336	-11.75	39.23	27.48	40.00	-12.52	Peak
2	46.138	-9.99	34.48	24.49	40.00	-15.51	Peak
3	70.060	-14.81	35.16	20.35	40.00	-19.65	Peak
4	107.134	-11.97	29.58	17.61	43.50	-25.89	Peak
5	139.851	-15.44	33.18	17.74	43.50	-25.76	Peak
6	362.031	-7.62	29.04	21.42	46.00	-24.58	Peak

**Above 1GHz:** (worst case is 8DPSK Mode)

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Factor (dB/m)	Corrected Amplitude (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)
	Reading (dB $\mu$ V)	PK/Ave		Height (m)	Polar (H/V)				
Low Channel 2402MHz									
2310	68.07	PK	97	1.6	H	-7.24	60.83	74	-13.17
2310	68.13	PK	299	1.4	V	-7.24	60.89	74	-13.11
2390	69.36	PK	142	2.4	H	-7.22	62.14	74	-11.86
2390	69.72	PK	255	1.7	V	-7.22	62.50	74	-11.50
4804	54.85	PK	189	1.3	H	-3.51	51.34	74	-22.66
4804	55.48	PK	268	2.5	V	-3.51	51.97	74	-22.03
Middle Channel 2441MHz									
4882	55.71	PK	349	1.2	H	-3.37	52.34	74	-21.66
4882	56	PK	39	1.2	V	-3.37	52.63	74	-21.37
High Channel 2480MHz									
2483.5	70.92	PK	341	2.1	H	-7.2	63.72	74	-10.28
2483.5	70.86	PK	238	1.4	V	-7.2	63.66	74	-10.34
2500	68.87	PK	81	1.9	H	-7.18	61.69	74	-12.31
2500	69.19	PK	169	1.5	V	-7.18	62.01	74	-11.99
4960	55.41	PK	47	2.3	H	-3.01	52.40	74	-21.60
4960	55.05	PK	329	1.3	V	-3.01	52.04	74	-21.96

Field Strength of Average							
Frequency (MHz)	Peak Measurement @3m (dB $\mu$ V/m)	Polar (H/V)	Duty Cycle Correction Factor (dB)	Corrected Amplitude (dB $\mu$ V/m)	Limit (dB $\mu$ V/m)	Margin (dB)	Comment
Low Channel 2402MHz							
2310	60.83	H	-24.76	36.07	54	-17.93	Band Edge
2310	60.89	V	-24.76	36.13	54	-17.87	Band Edge
2390	62.14	H	-24.76	37.38	54	-16.62	Band Edge
2390	62.5	V	-24.76	37.74	54	-16.26	Band Edge
4804	51.34	H	-24.76	26.58	54	-27.42	Harmonic
4804	51.97	V	-24.76	27.21	54	-26.79	Harmonic
Middle Channel 2441MHz							
4882	52.34	H	-24.76	27.58	54	-26.42	Harmonic
4882	52.63	V	-24.76	27.87	54	-26.13	Harmonic
High Channel 2480MHz							
2483.5	63.72	H	-24.76	38.96	54	-15.04	Band Edge
2483.5	63.66	V	-24.76	38.90	54	-15.10	Band Edge
2500	61.69	H	-24.76	36.93	54	-17.07	Band Edge
2500	62.01	V	-24.76	37.25	54	-16.75	Band Edge
4960	52.4	H	-24.76	27.64	54	-26.36	Harmonic
4960	52.04	V	-24.76	27.28	54	-26.72	Harmonic

Note:

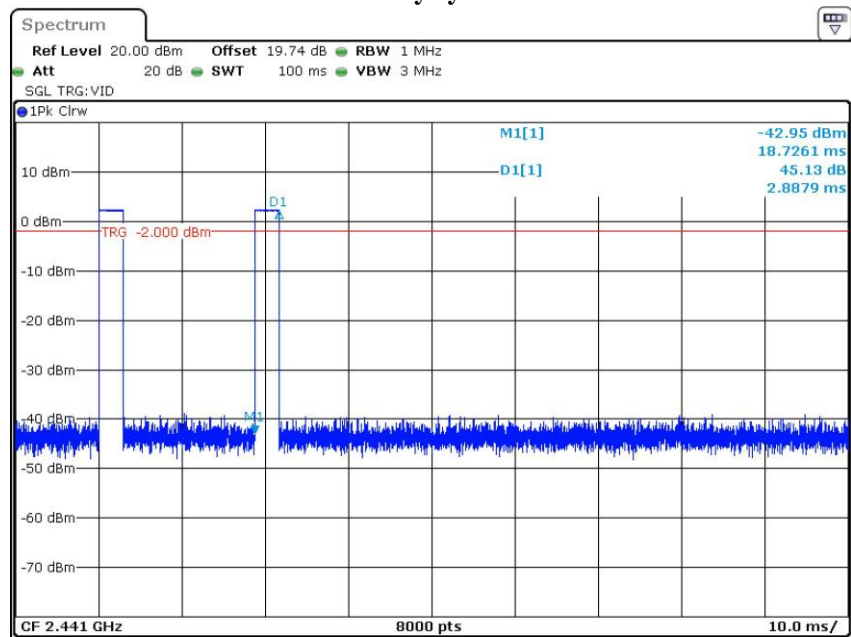
Corrected Amplitude= Factor + Reading  
 Margin = Corrected. Amplitude - Limit  
 Average level= Peak level+ Duty Cycle Corrected Factor

The worst case duty cycle as below:

$$\text{Duty cycle} = \text{Ton}/100\text{ms} = 2.89*2/100=0.0578$$

$$\text{Duty Cycle Corrected Factor} = 20\lg(\text{Duty cycle}) = 20\lg 0.0578 = -24.76$$

### Duty cycle



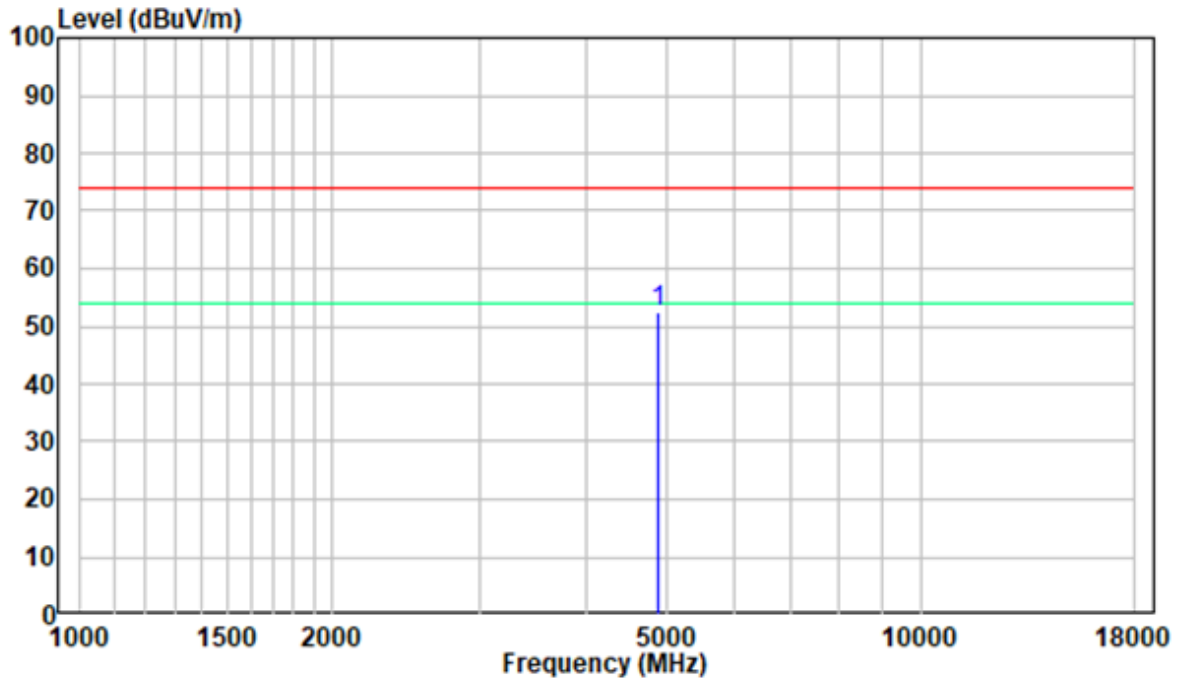
Date: 16.MAR.2023 00:55:33



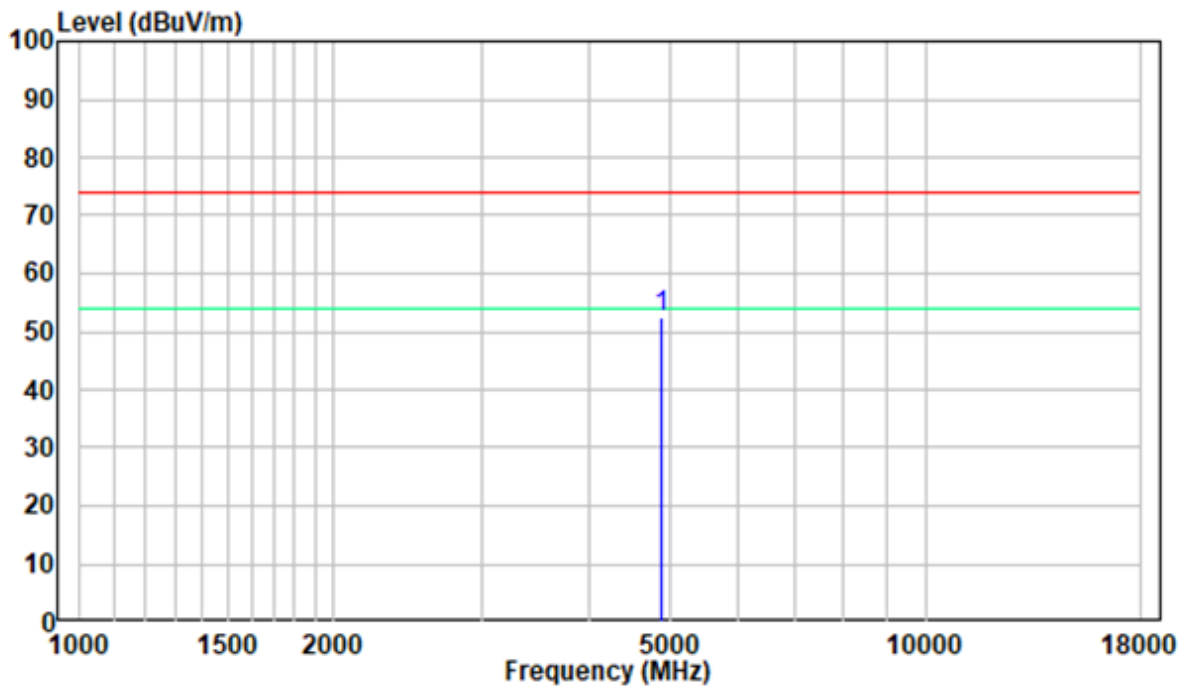
### 1-18GHz

#### Pre-scan for Middle Channel

Horizontal:



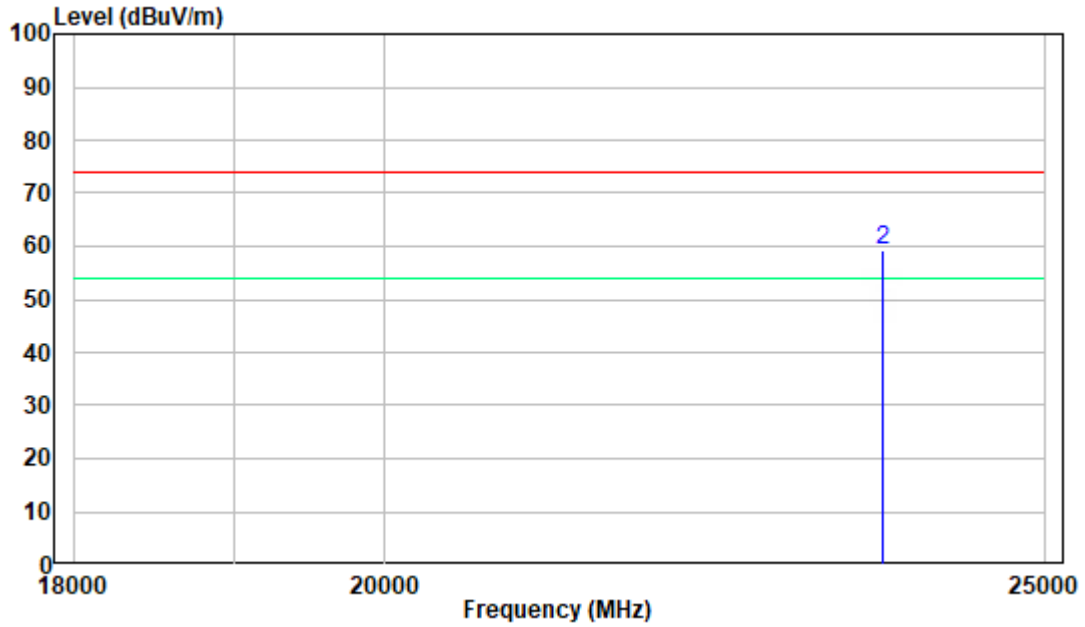
Vertical:



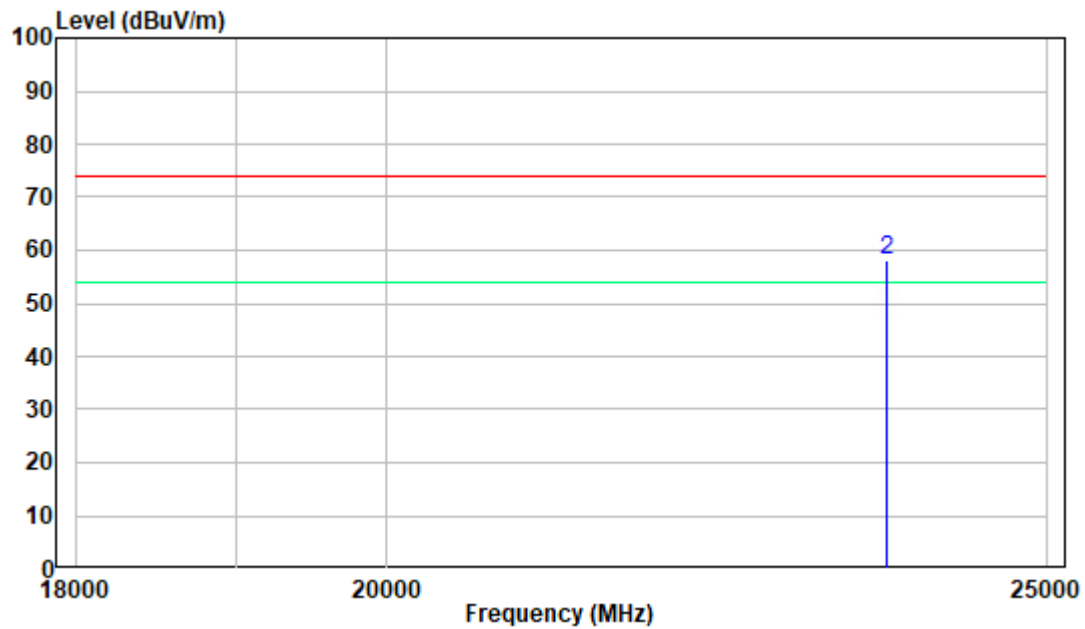
### 18-25GHz

#### Pre-scan for Middle Channel

Horizontal:



Vertical:



## FCC §15.247(a) (1)-CHANNEL SEPARATION TEST

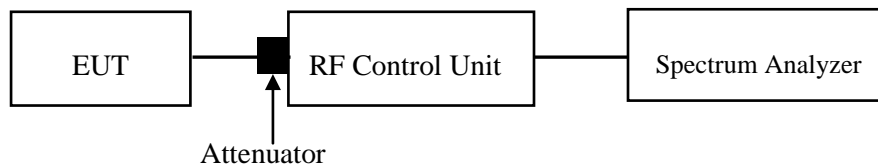
### Applicable Standard

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. 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.

### Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.2

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



### Test Data

#### Environmental Conditions

<b>Temperature:</b>	25.5 °C
<b>Relative Humidity:</b>	55 %
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Glenn Jiang on 2022-10-19.*

*EUT operation mode: Transmitting*

Test Result: Compliant. Please refer to the Appendix.

## FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

### Applicable Standard

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.

### Test Procedure

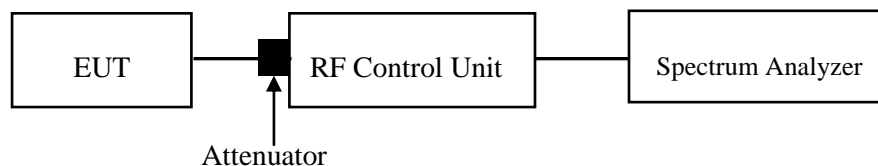
Test Method: ANSI C63.10-2013 Clause 7.8.7 & Clause 6.9.2

The following conditions shall be observed for measuring the occupied bandwidth and 20 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 / 20 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 / 20 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).



**Test Data****Environmental Conditions**

<b>Temperature:</b>	25.5 °C
<b>Relative Humidity:</b>	55 %
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Glenn Jiang on 2022-10-19.*

*EUT operation mode: Transmitting*

Test Result: Compliant. Please refer to the Appendix.

## FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST

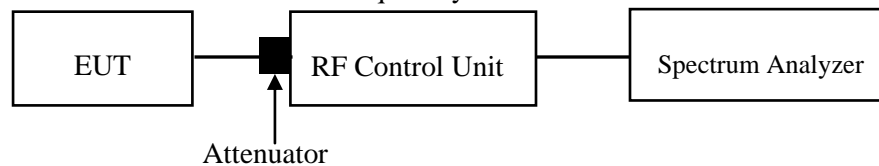
### Applicable Standard

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.

### Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.3

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.



### Test Data

#### Environmental Conditions

<b>Temperature:</b>	25.5 °C
<b>Relative Humidity:</b>	55 %
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Glenn Jiang on 2022-10-19.*

*EUT operation mode: Transmitting*

Test Result: Compliant. Please refer to the Appendix.

## FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME)

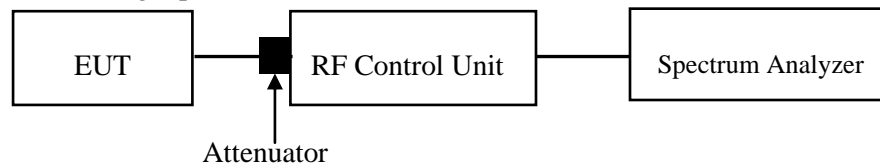
### Applicable Standard

Frequency hopping systems in the 2400-2483.5 MHz 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.

### Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.4

1. The EUT was worked in channel hopping.
2. Set the RBW to: 1MHz.
3. Set the VBW  $\geq 3 \times$  RBW.
4. Set the span to 0Hz.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Recorded the time of single pulses



### Test Data

#### Environmental Conditions

<b>Temperature:</b>	25.5 °C
<b>Relative Humidity:</b>	55 %
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Glenn Jiang on 2022-10-19.*

*EUT operation mode: Transmitting*

Test Result: Compliant. Please refer to the Appendix.

## FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT

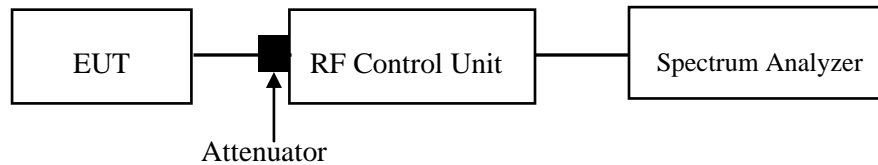
### Applicable Standard

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. And for all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

### Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.5

1. Place the EUT on a bench and set in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



### Test Data

#### Environmental Conditions

<b>Temperature:</b>	25.5 °C
<b>Relative Humidity:</b>	55 %
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Glenn Jiang on 2022-10-19.*

*EUT operation mode: Transmitting*

Test Result: Compliant. Please refer to the Appendix.



## FCC §15.247(d) - BAND EDGES TESTING

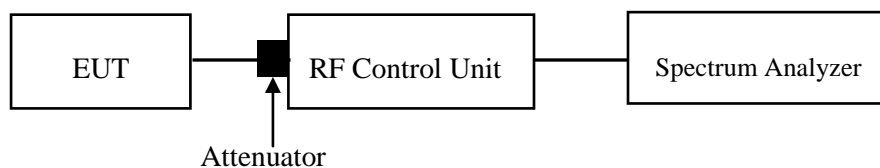
### Applicable Standard

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated 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, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

### Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.6 & Clause 6.10

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Remove the antenna from the EUT and then connect to a low loss RF cable from the antenna port to a EMI test receiver, then turn on the EUT and make it operate in transmitting mode. Then set it to Low Channel and High Channel within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. 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.
5. Repeat above procedures until all measured frequencies were complete.



### Test Data

#### Environmental Conditions

<b>Temperature:</b>	25.5 °C
<b>Relative Humidity:</b>	55 %
<b>ATM Pressure:</b>	101.0 kPa

*The testing was performed by Glenn Jiang on 2022-10-19.*

*EUT operation mode: Transmitting*

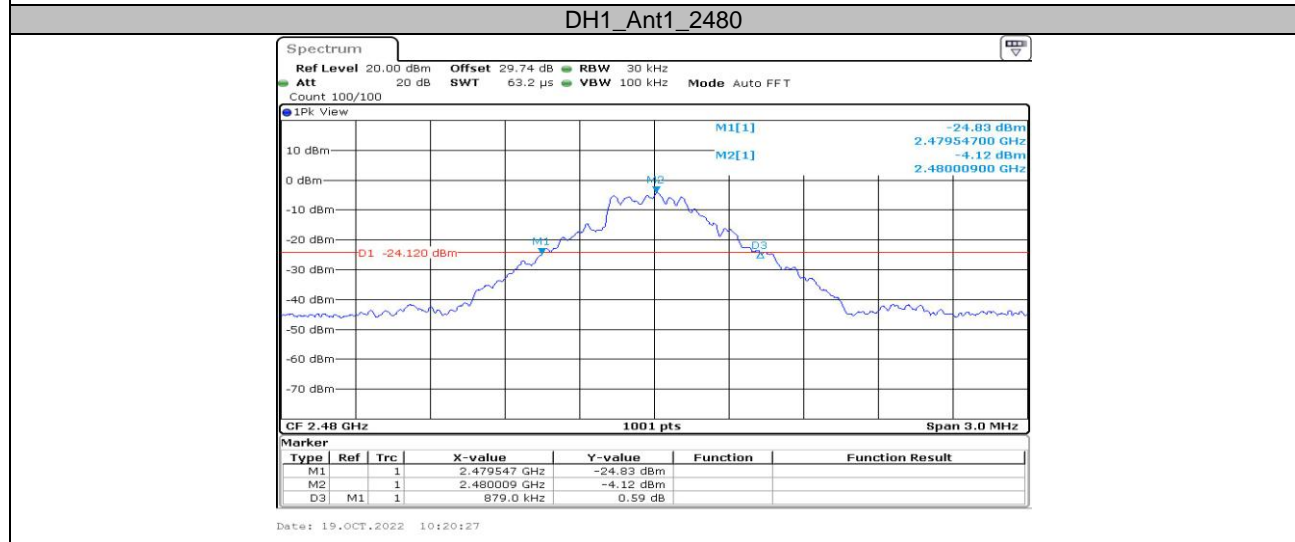
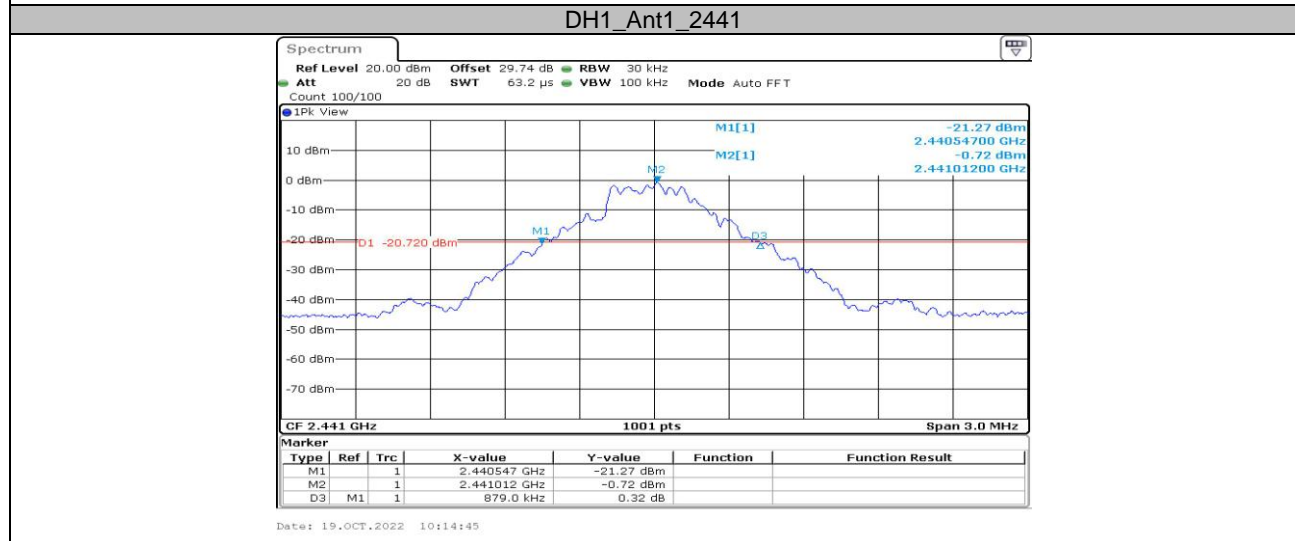
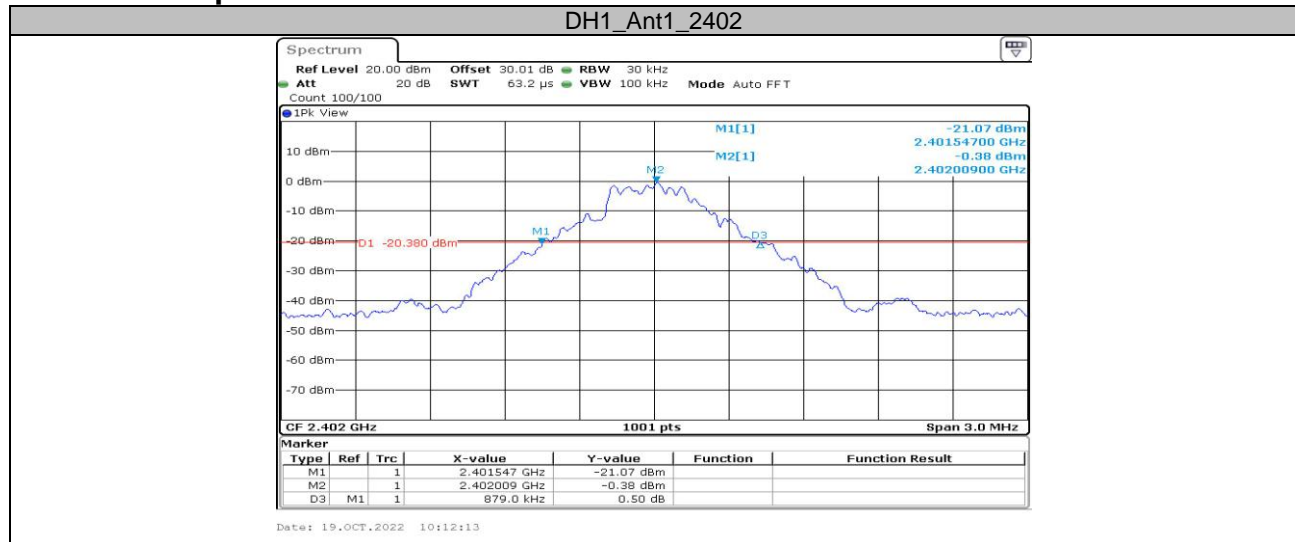
Test Result: Compliant. Please refer to the Appendix.

## APPENDIX

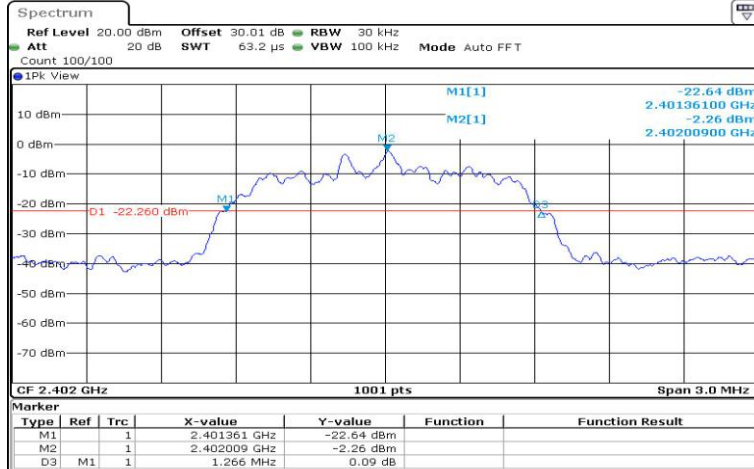
### Appendix A: 20dB Emission Bandwidth Test Result

Test Mode	Antenna	Frequency[MHz]	20db EBW[MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
DH1	Ant1	2402	0.88	2401.55	2402.43	---	---
		2441	0.88	2440.55	2441.43	---	---
		2480	0.88	2479.55	2480.43	---	---
2DH1	Ant1	2402	1.27	2401.36	2402.63	---	---
		2441	1.28	2440.35	2441.62	---	---
		2480	1.28	2479.35	2480.63	---	---
3DH1	Ant1	2402	1.25	2401.38	2402.63	---	---
		2441	1.23	2440.39	2441.63	---	---
		2480	1.26	2479.37	2480.63	---	---

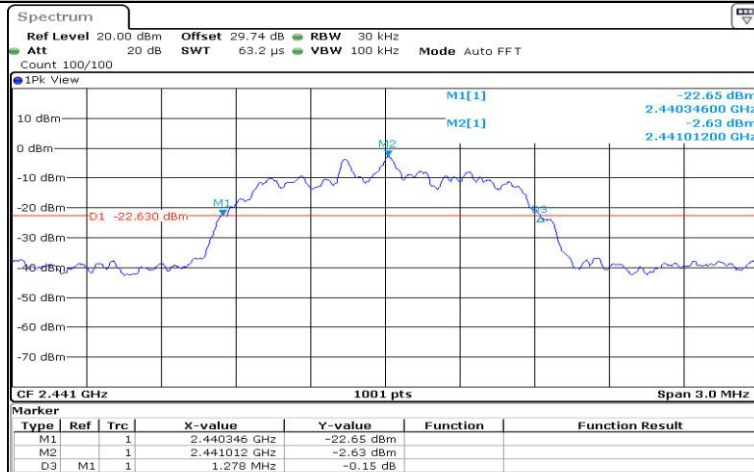
### Test Graphs



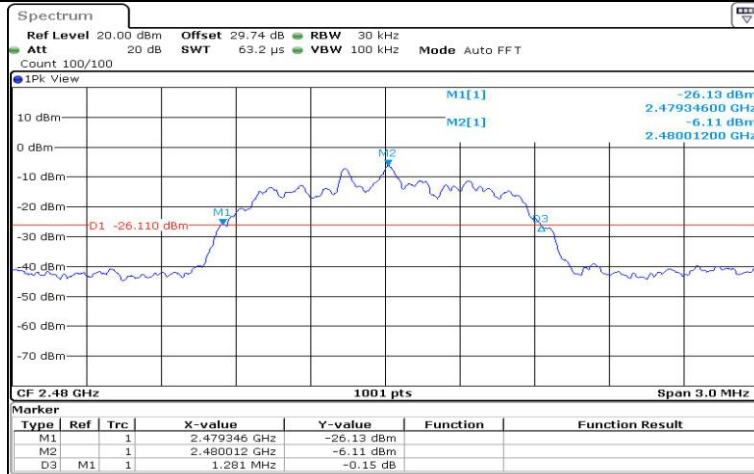
2DH1\_Ant1\_2402



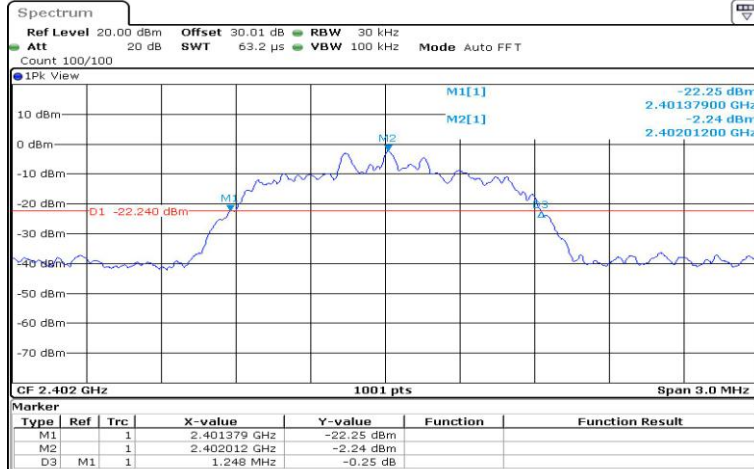
2DH1\_Ant1\_2441



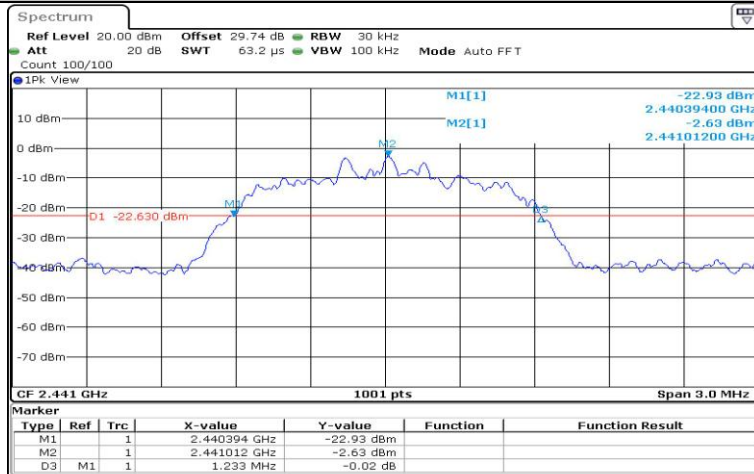
2DH1\_Ant1\_2480



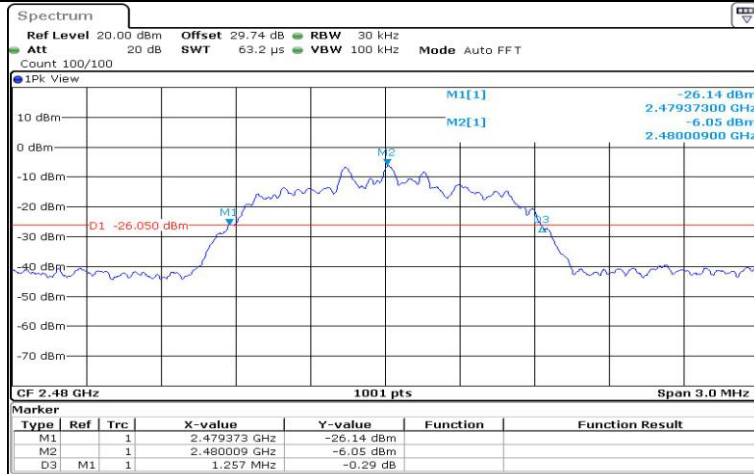
3DH1\_Ant1\_2402



3DH1\_Ant1\_2441



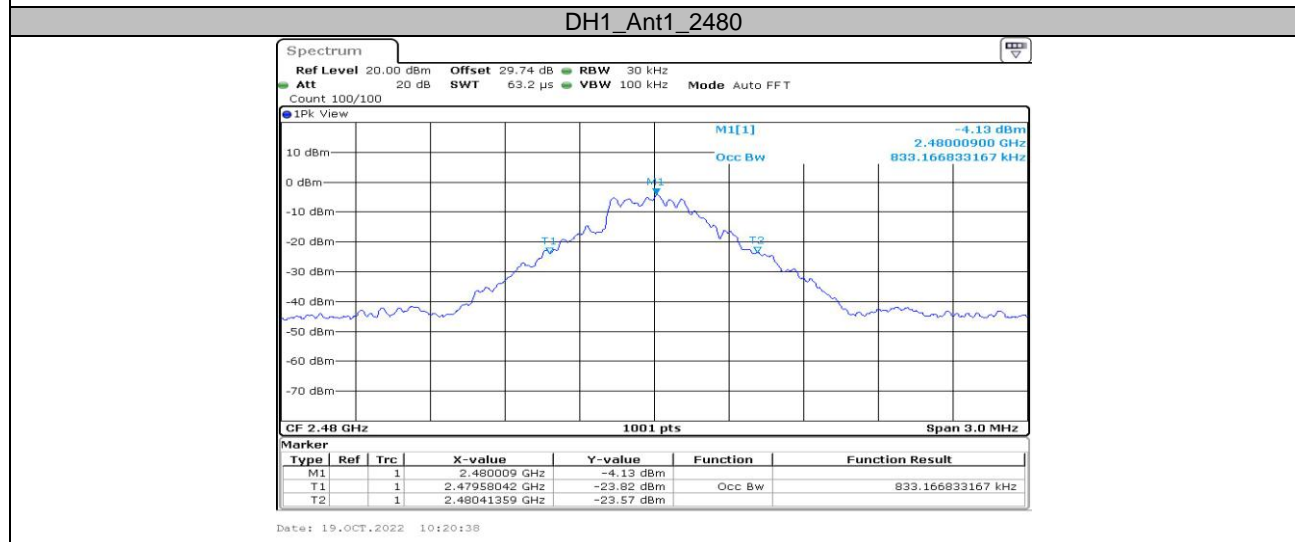
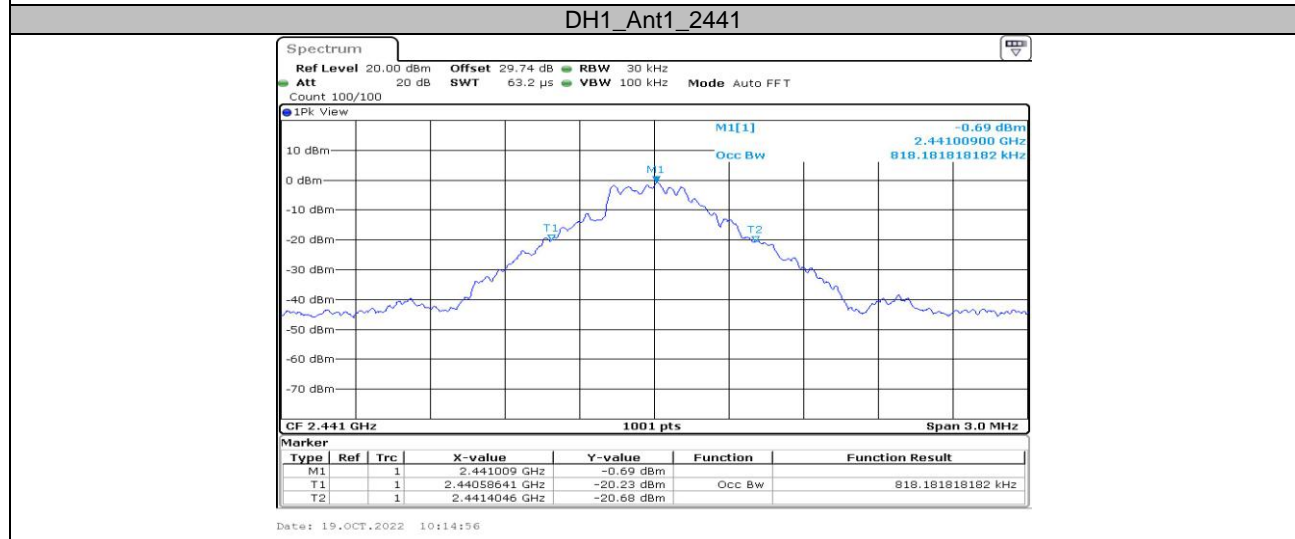
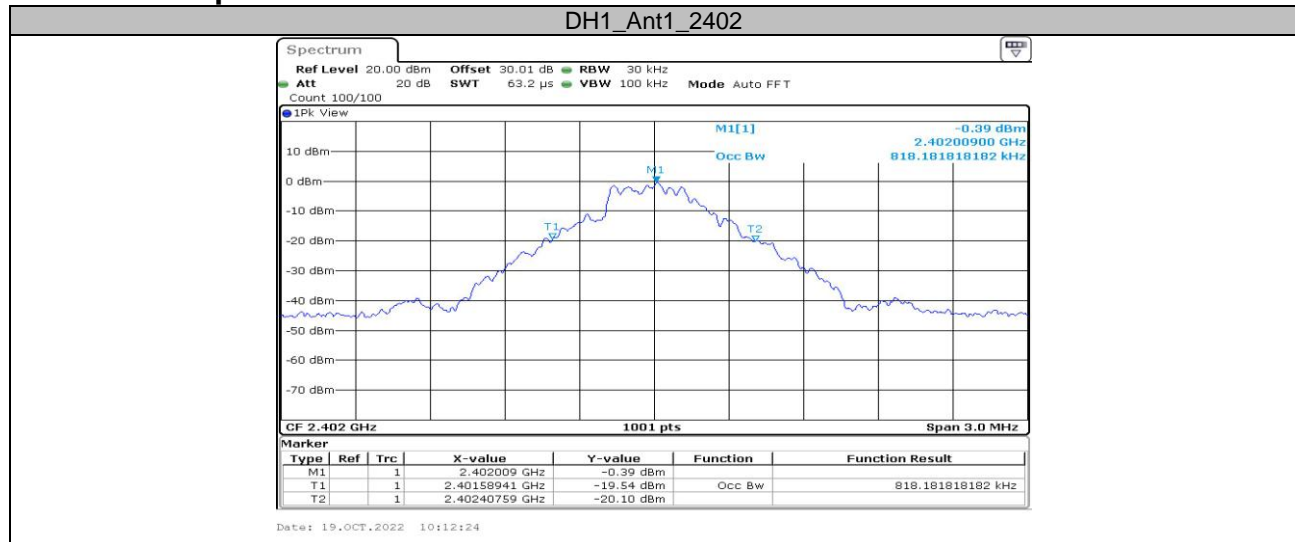
3DH1\_Ant1\_2480

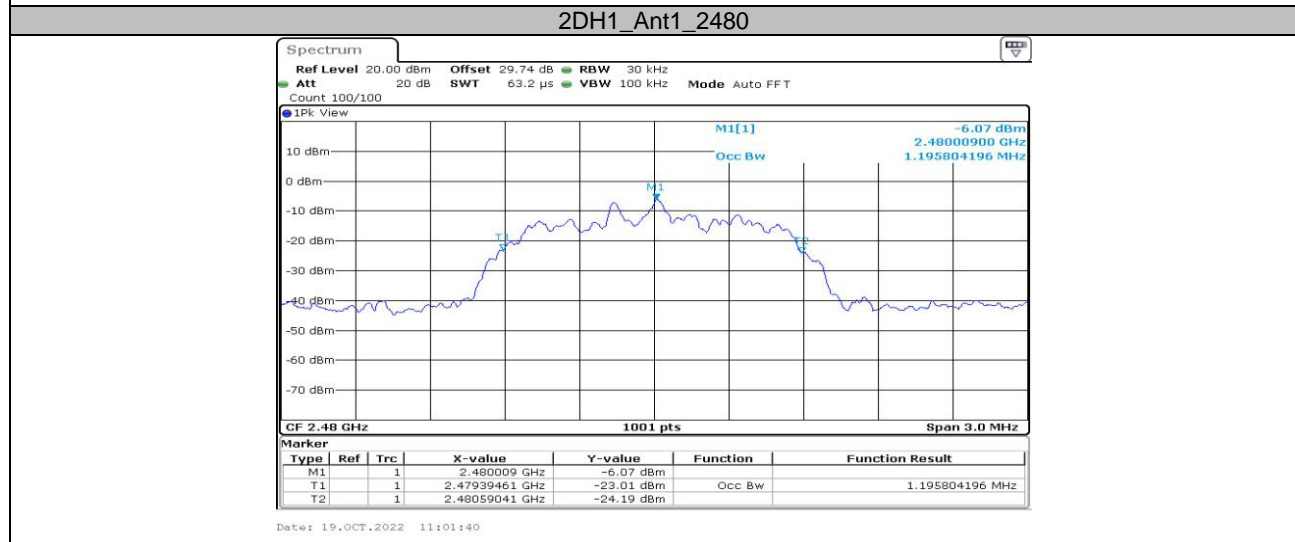
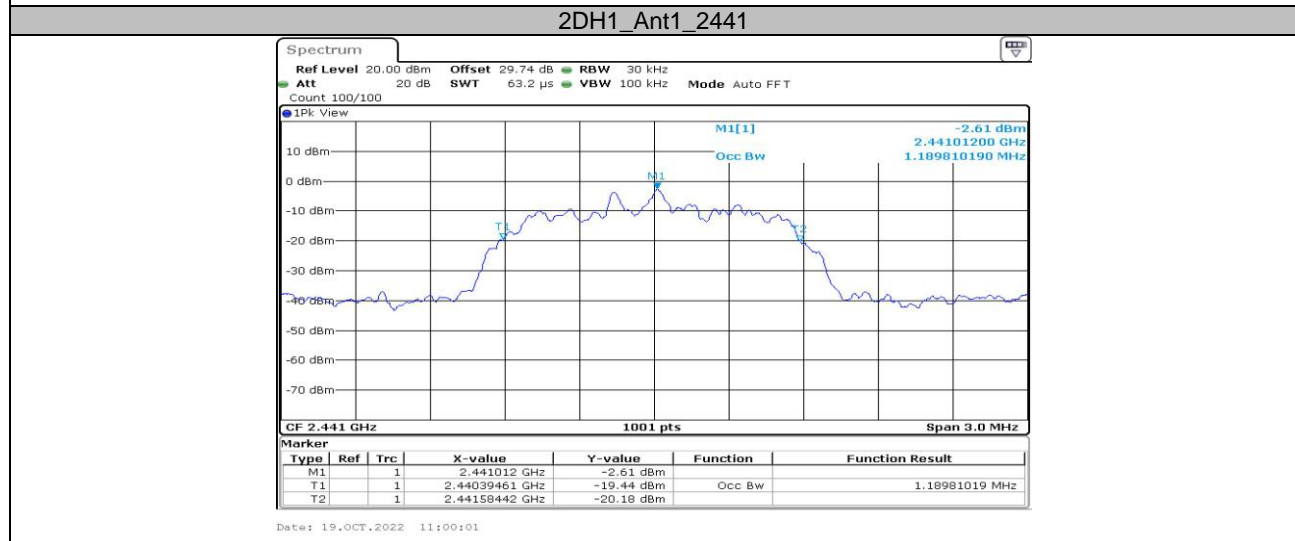
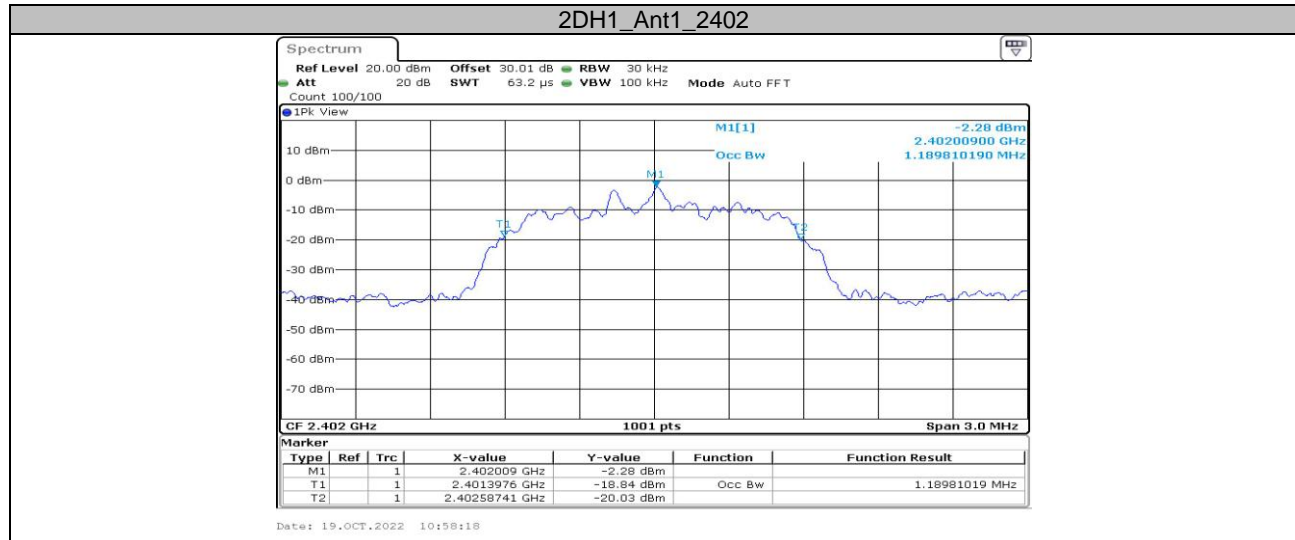


**Appendix B: Occupied Channel Bandwidth  
Test Result**

Test Mode	Antenna	Frequency[MHz]	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
DH1	Ant1	2402	0.818	2401.589	2402.408	---	---
		2441	0.818	2440.586	2441.405	---	---
		2480	0.833	2479.580	2480.414	---	---
2DH1	Ant1	2402	1.190	2401.398	2402.587	---	---
		2441	1.190	2440.395	2441.584	---	---
		2480	1.196	2479.395	2480.590	---	---
3DH1	Ant1	2402	1.169	2401.425	2402.593	---	---
		2441	1.166	2440.425	2441.590	---	---
		2480	1.172	2479.422	2480.593	---	---

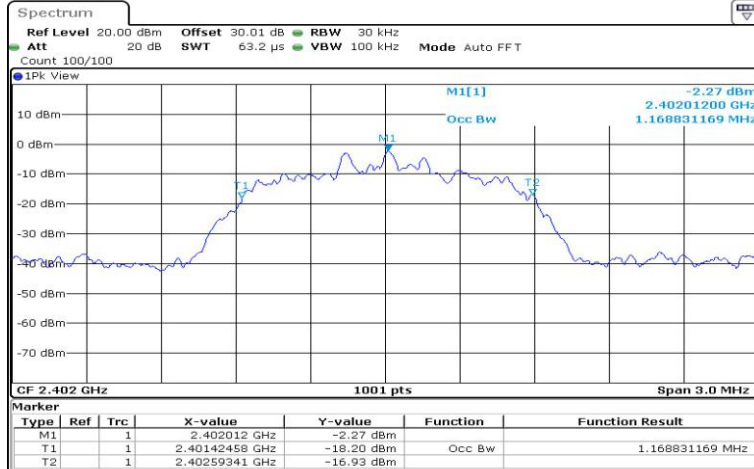
### Test Graphs



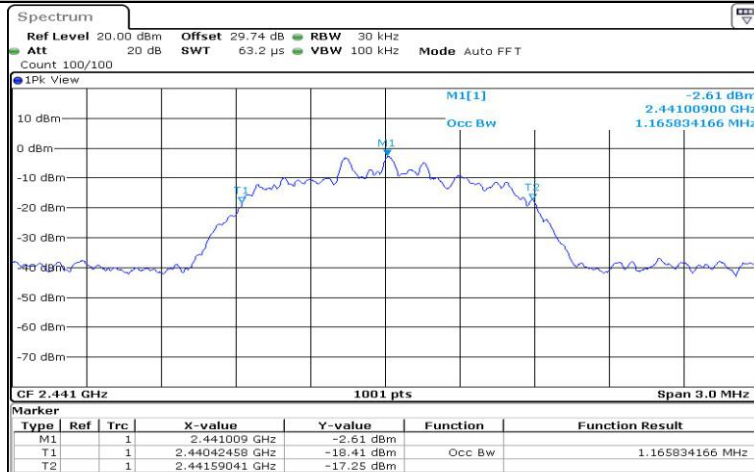




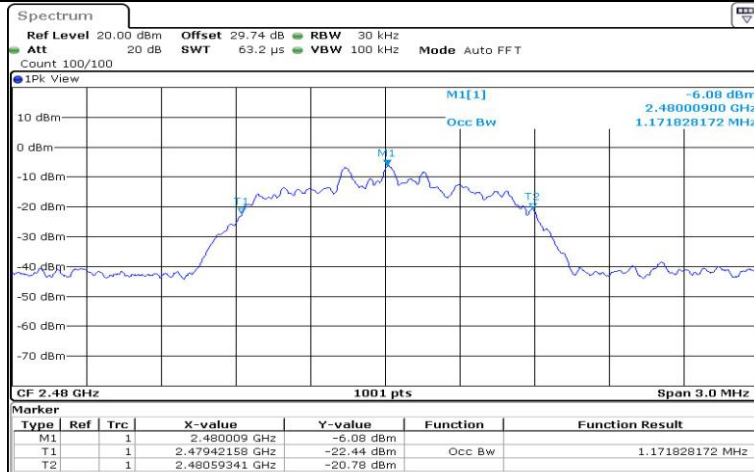
3DH1\_Ant1\_2402



3DH1\_Ant1\_2441



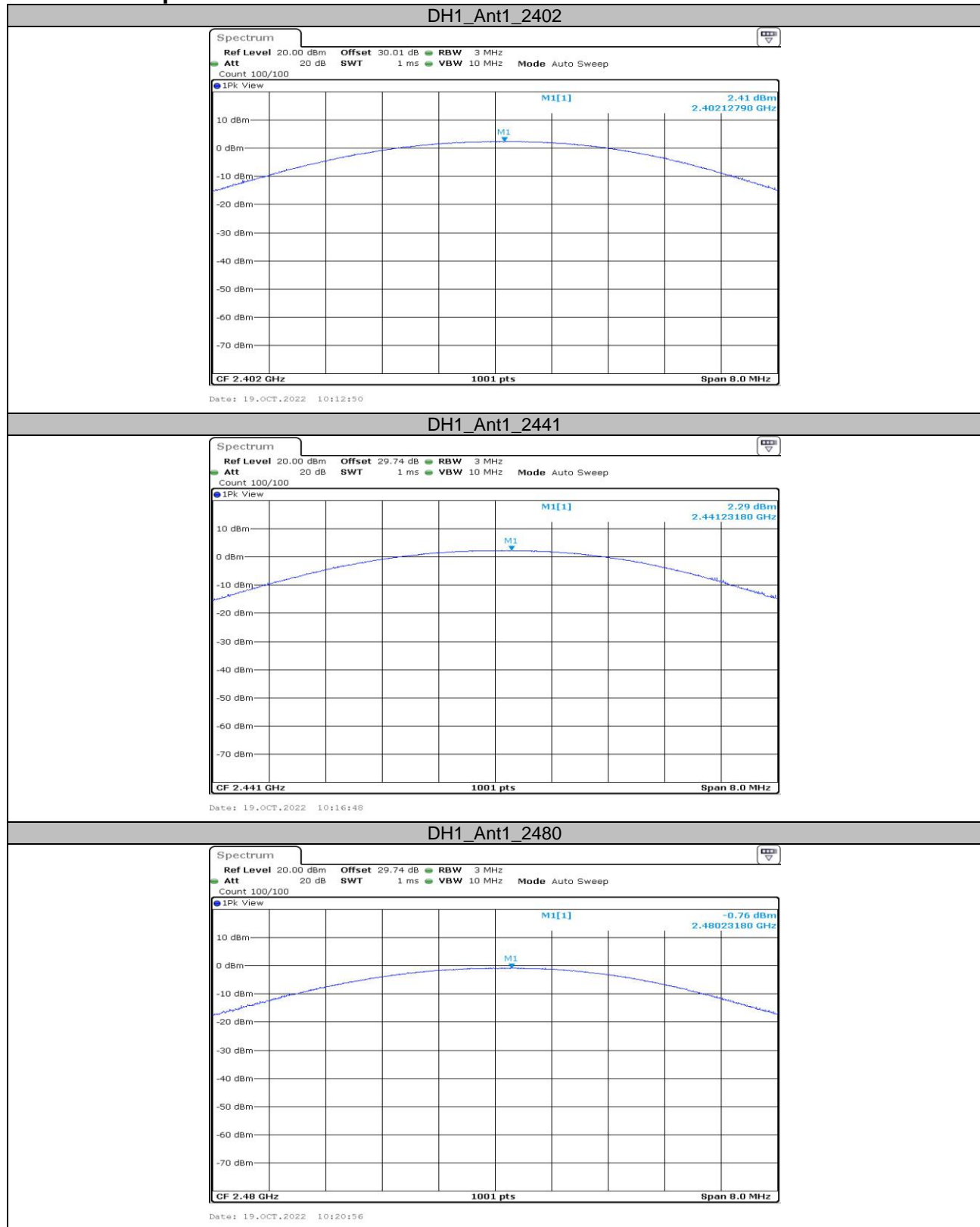
3DH1\_Ant1\_2480

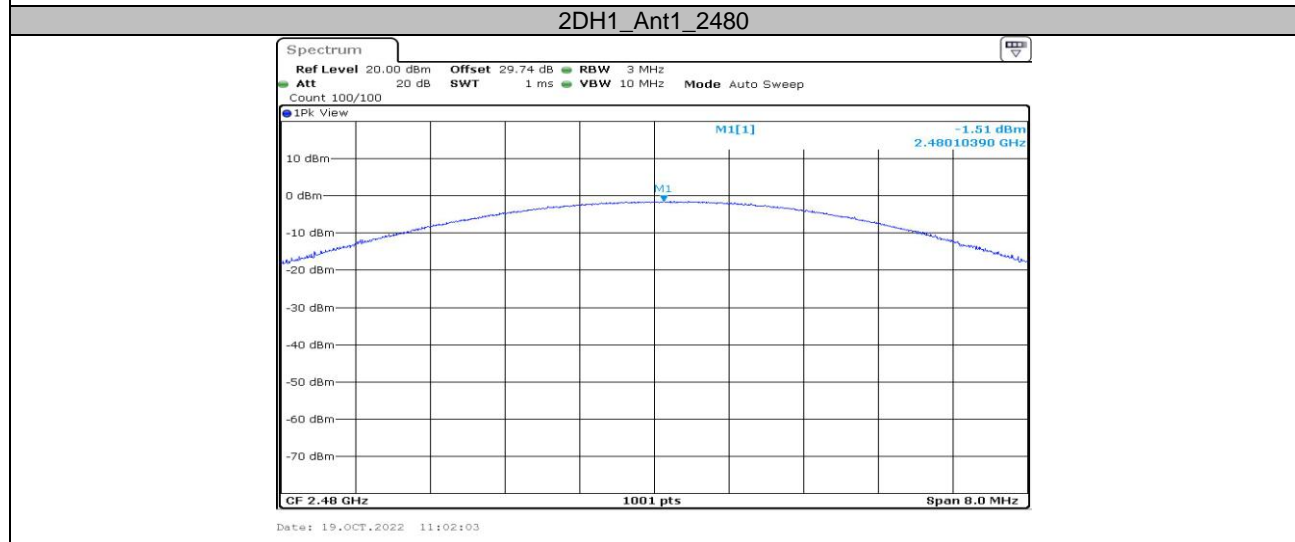
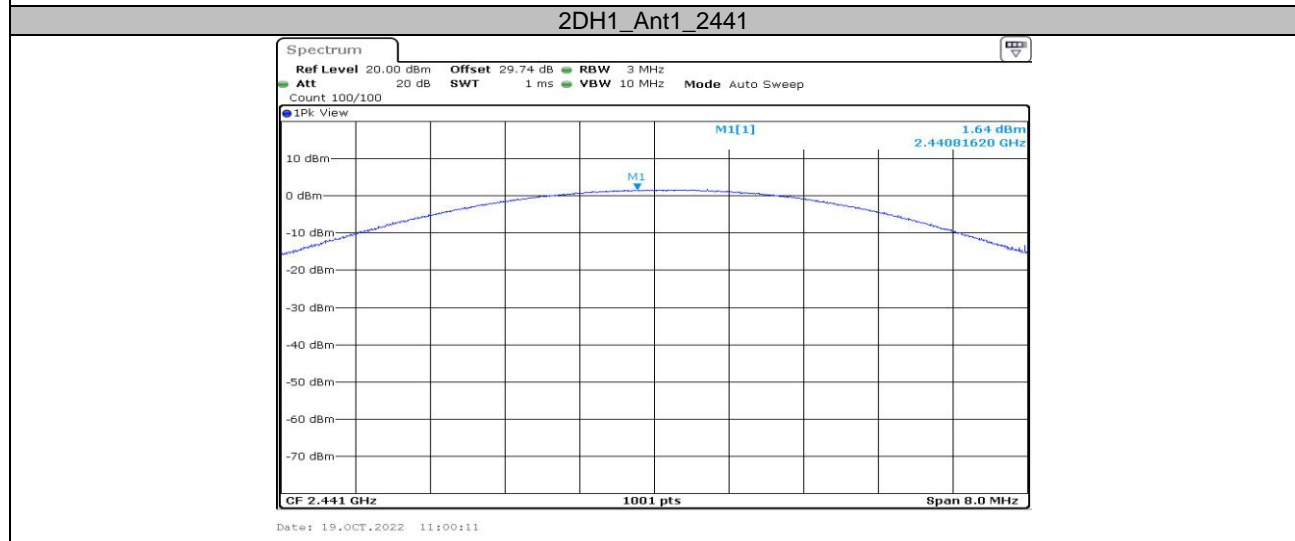
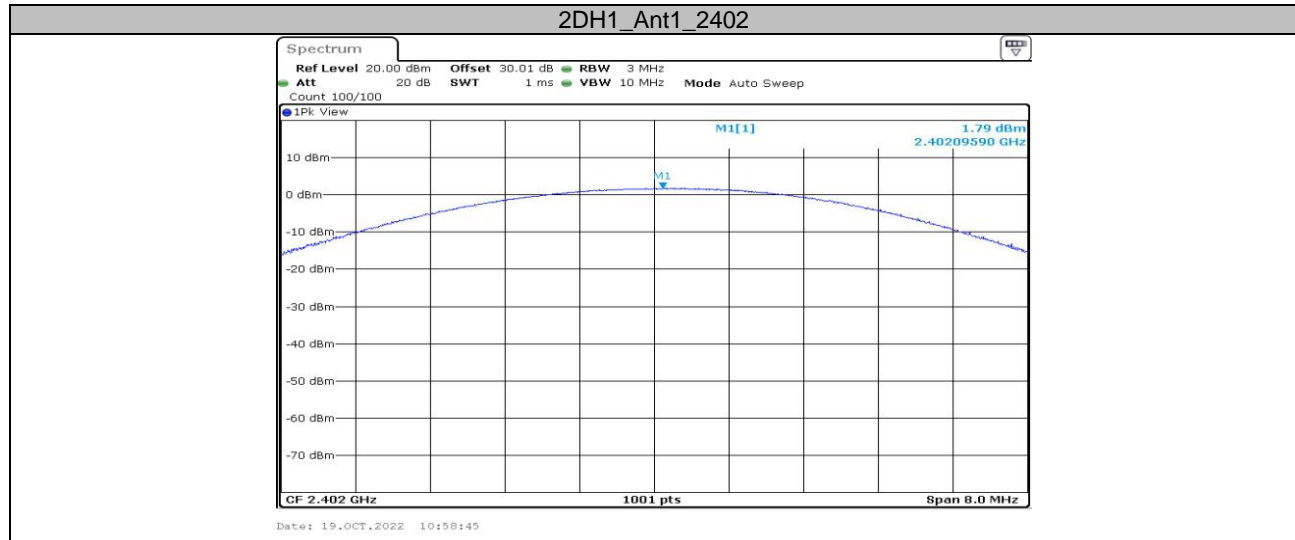


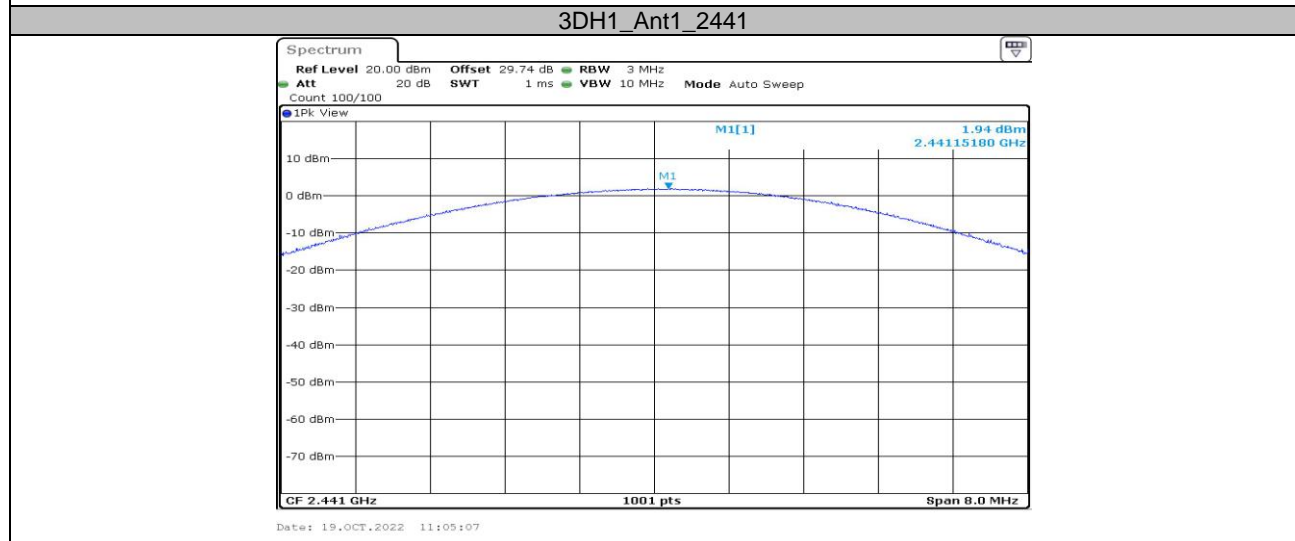
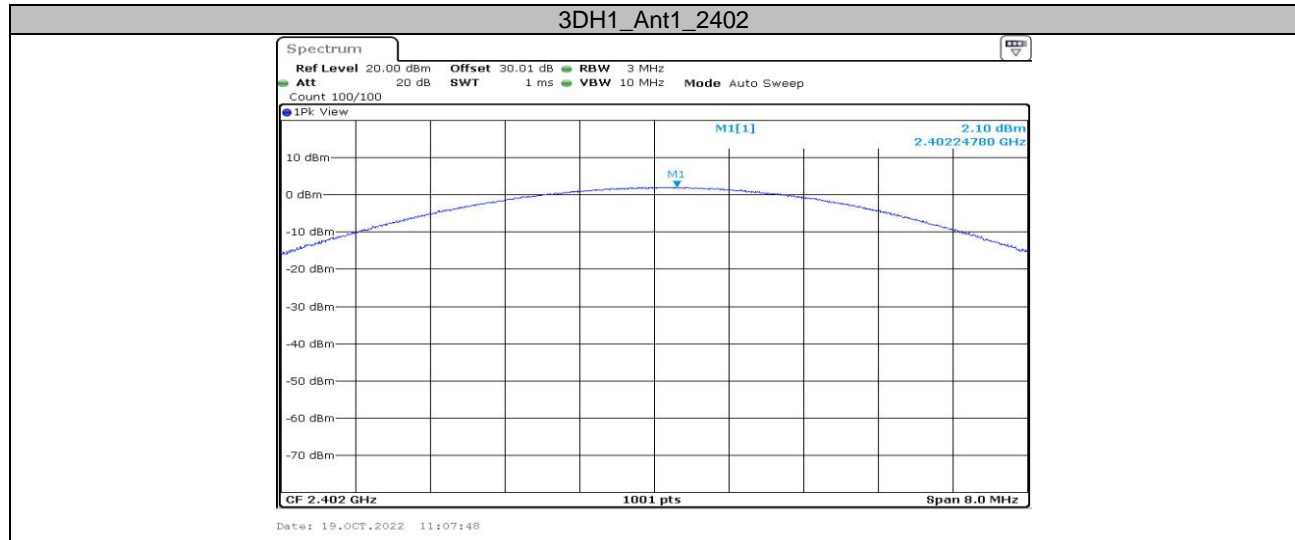
**Appendix C: Maximum conducted output power  
Test Result**

Test Mode	Antenna	Frequency[MHz]	Conducted Peak Power [dBm]	Conducted Limit [dBm]	Verdict
DH1	Ant1	2402	2.41	≤20.97	PASS
		2441	2.29	≤20.97	PASS
		2480	-0.76	≤20.97	PASS
2DH1	Ant1	2402	1.79	≤20.97	PASS
		2441	1.64	≤20.97	PASS
		2480	-1.51	≤20.97	PASS
3DH1	Ant1	2402	2.10	≤20.97	PASS
		2441	1.94	≤20.97	PASS
		2480	-1.19	≤20.97	PASS

### Test Graphs



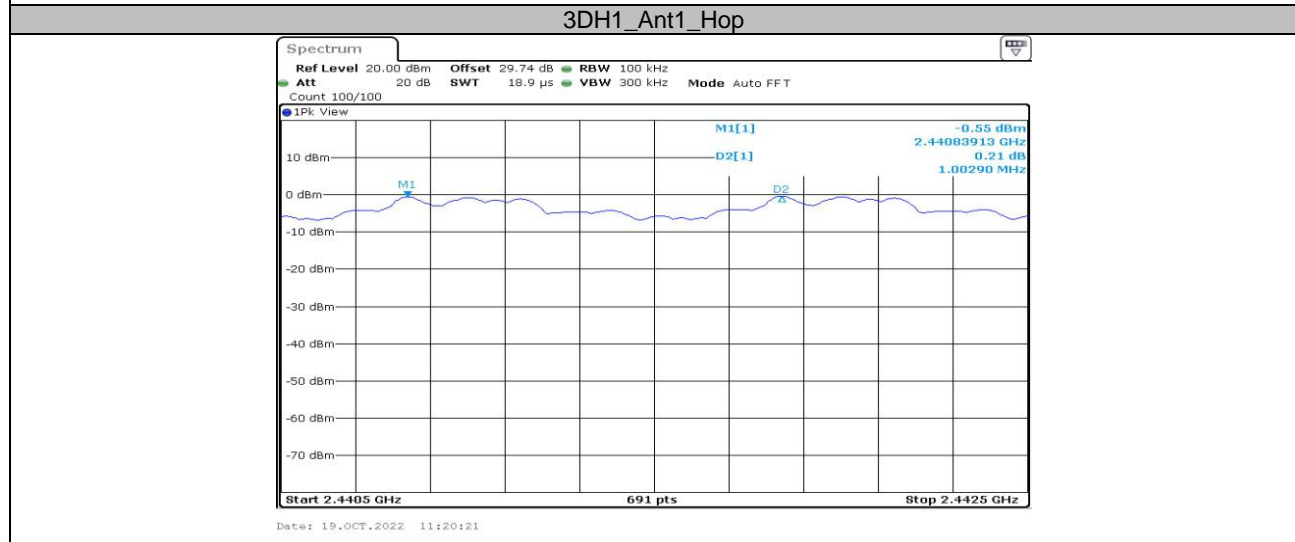
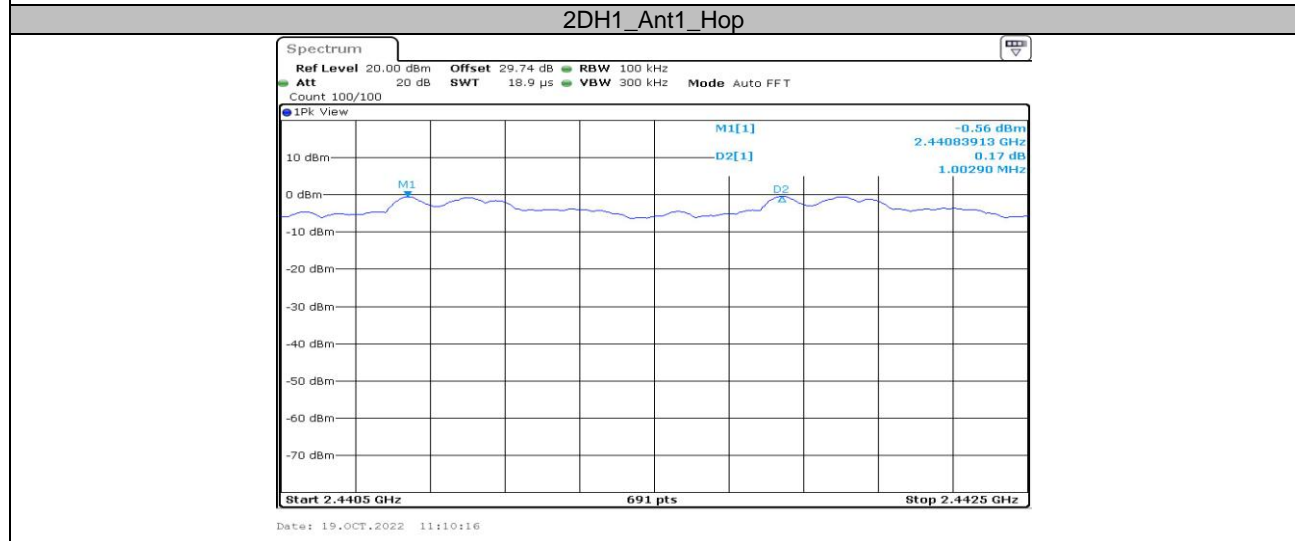
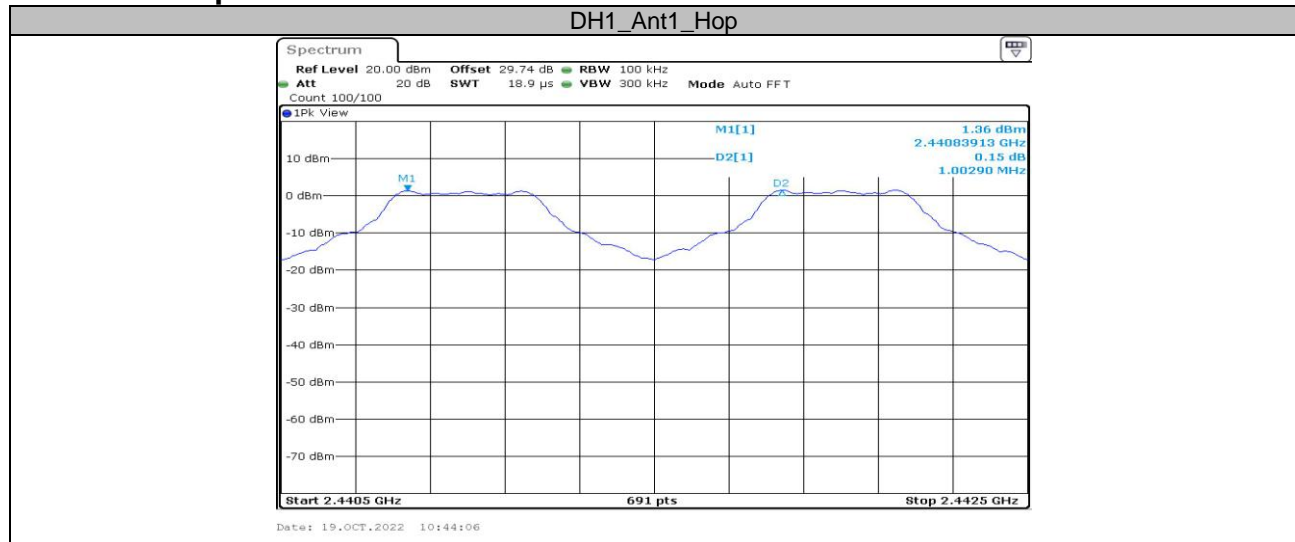




**Appendix D: Carrier frequency separation  
Test Result**

Test Mode	Antenna	Frequency[MHz]	Result[MHz]	Limit[MHz]	Verdict
DH1	Ant1	Hop	1.003	$\geq 0.587$	PASS
2DH1	Ant1	Hop	1.003	$\geq 0.853$	PASS
3DH1	Ant1	Hop	1.003	$\geq 0.840$	PASS

### Test Graphs



### Appendix E: Time of occupancy Test Result

Test Mode	Antenna	Frequency[MHz]	BurstWidth [ms]	TotalHops [Num]	Result[s]	Limit[s]	Verdict
DH1	Ant1	Hop	0.38	320	0.122	≤0.4	PASS
DH3	Ant1	Hop	1.63	150	0.245	≤0.4	PASS
DH5	Ant1	Hop	2.87	110	0.316	≤0.4	PASS
2DH1	Ant1	Hop	0.38	330	0.125	≤0.4	PASS
2DH3	Ant1	Hop	1.63	180	0.293	≤0.4	PASS
2DH5	Ant1	Hop	2.87	130	0.373	≤0.4	PASS
3DH1	Ant1	Hop	0.38	330	0.125	≤0.4	PASS
3DH3	Ant1	Hop	1.63	160	0.261	≤0.4	PASS
3DH5	Ant1	Hop	2.87	110	0.316	≤0.4	PASS

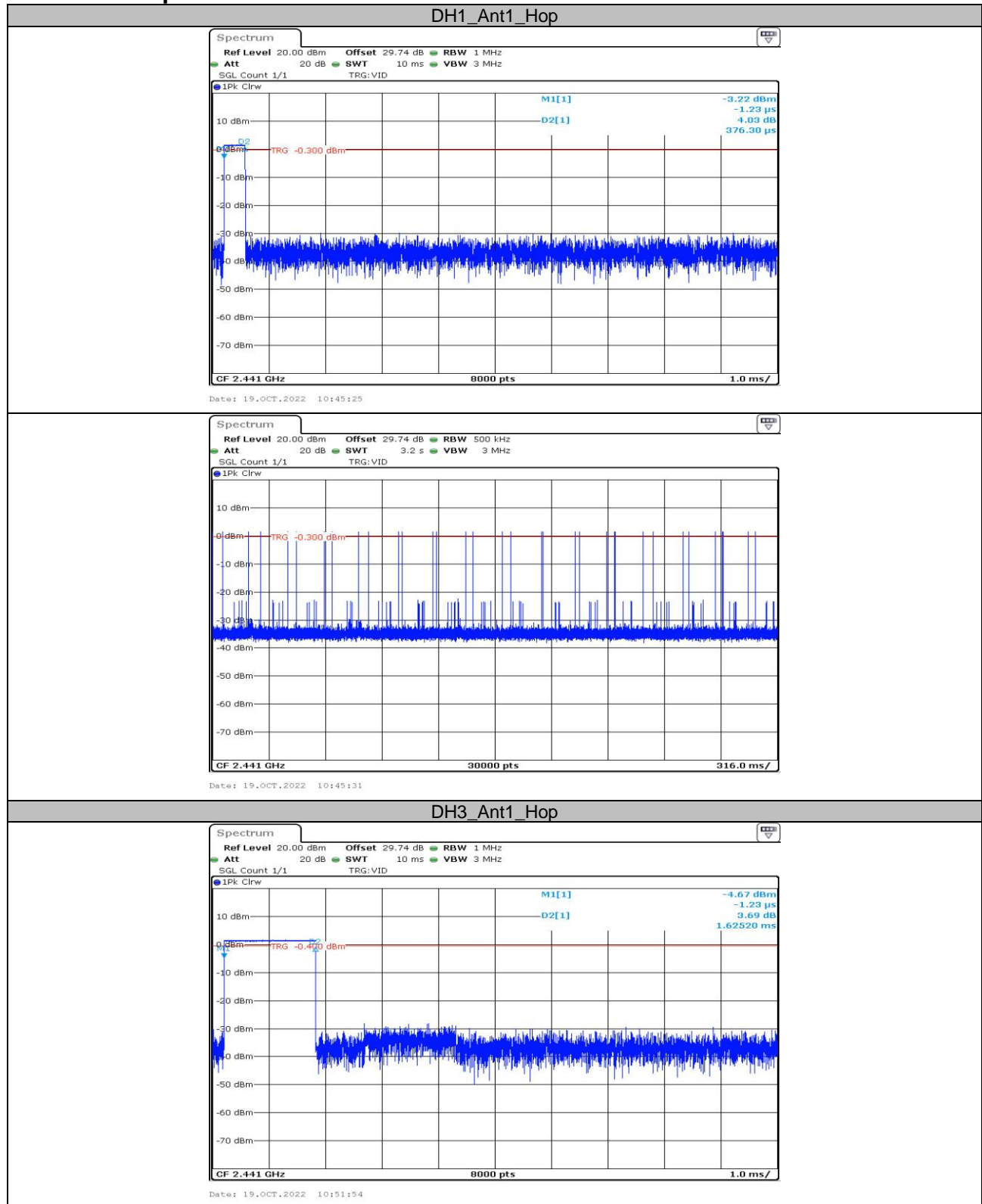
Note 1: A period time=0.4\*79=31.6(S), Result=BurstWidth\*Totalhops

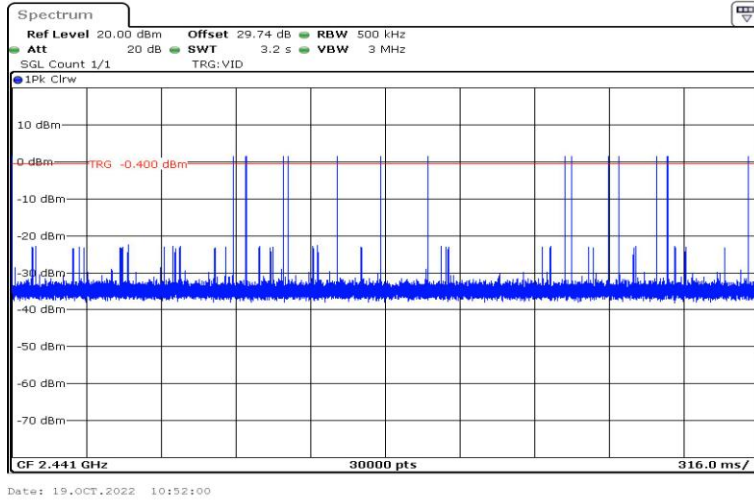
Note 2: Totalhops=Hopping Number in 3.16s\*10

Note 3: Hopping Number in 3.16s=Total of highest signals in 3.16s(Second high signals were other channel)

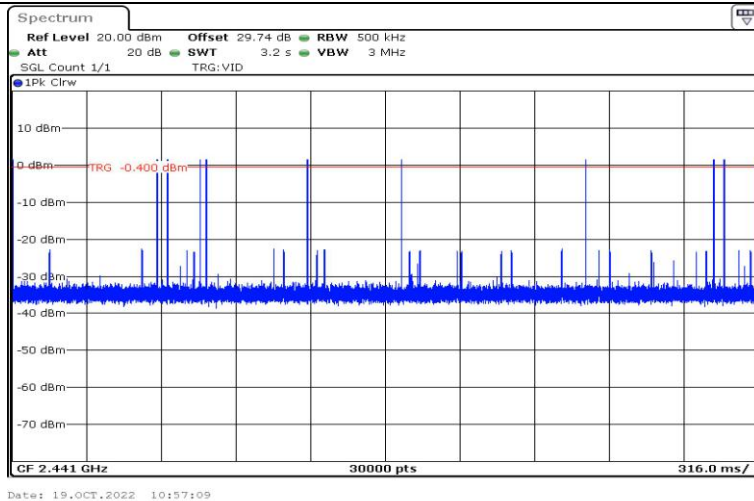
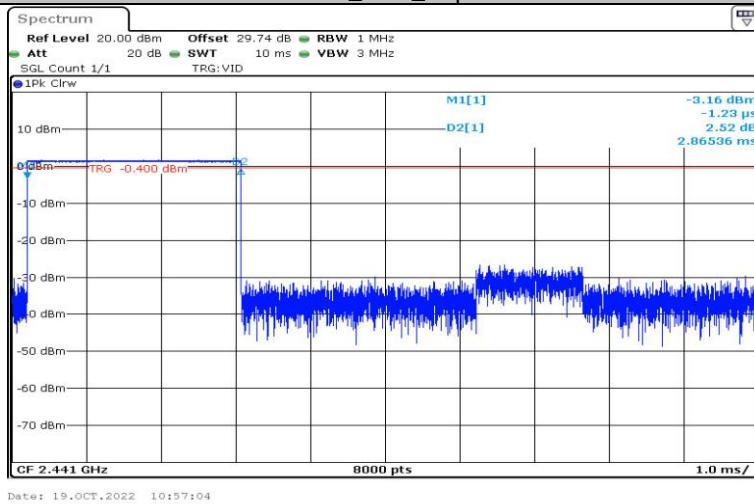


### Test Graphs

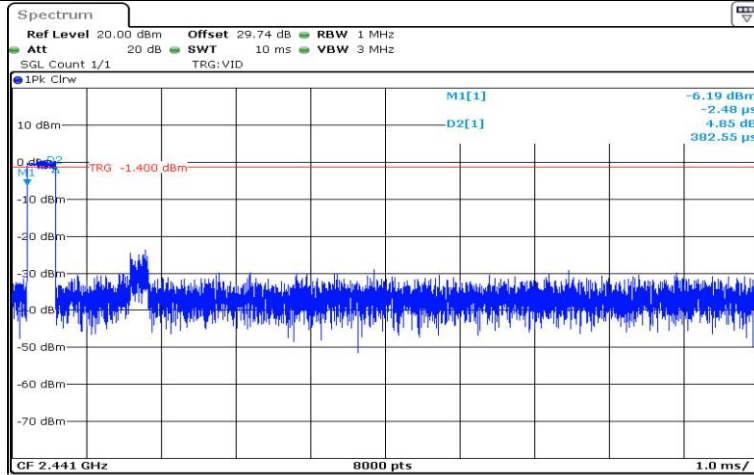




DH5\_Ant1\_Hop

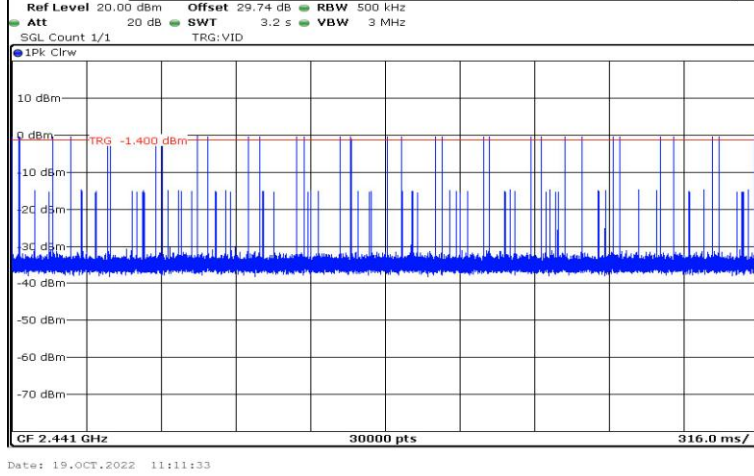


### 2DH1\_Ant1\_Hop



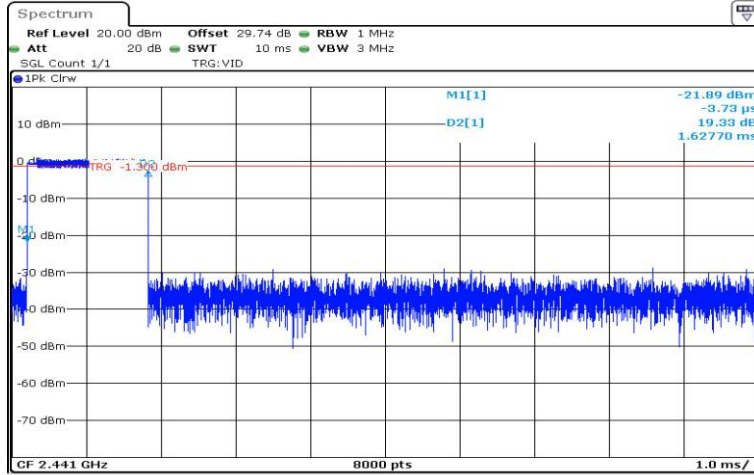
Date: 19.OCT.2022 11:11:27

### 2DH3\_Ant1\_Hop

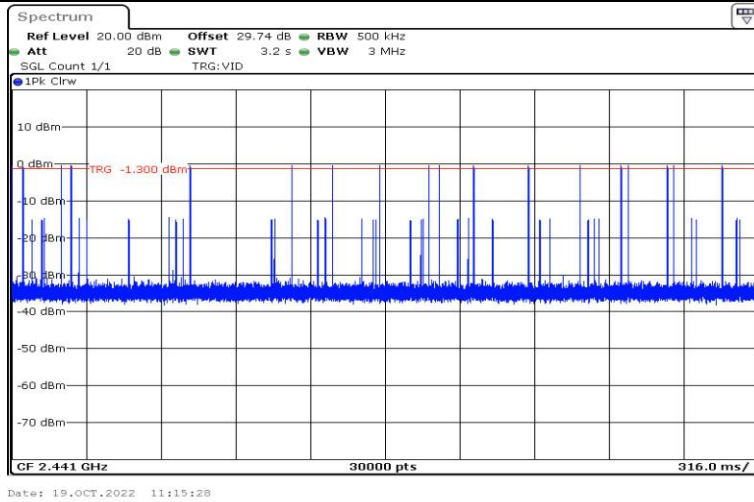


Date: 19.OCT.2022 11:11:33

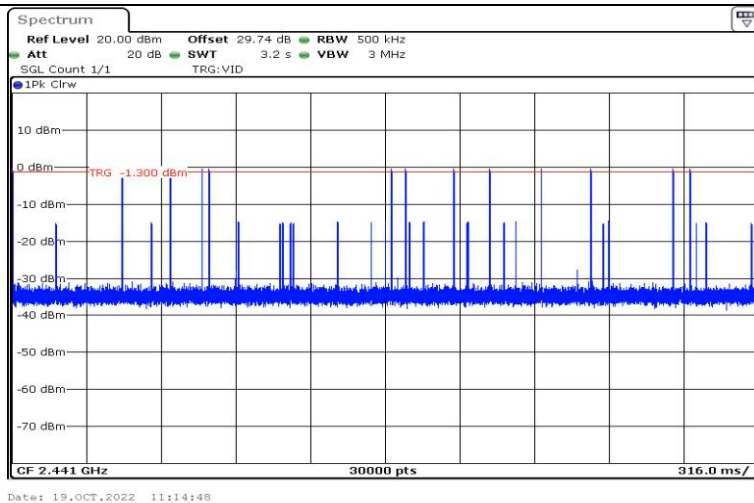
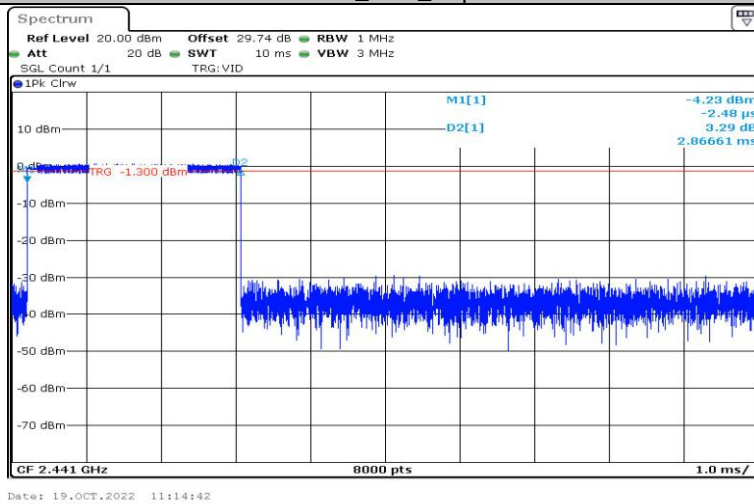
### 2DH1\_Ant1\_Hop



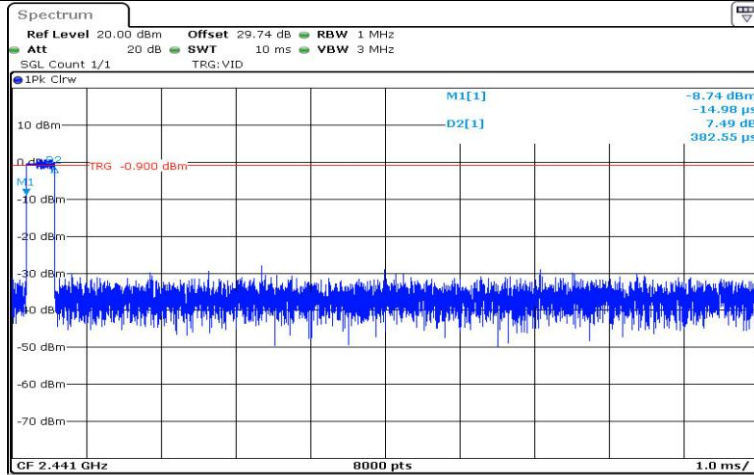
Date: 19.OCT.2022 11:15:23



2DH5\_Ant1\_Hop

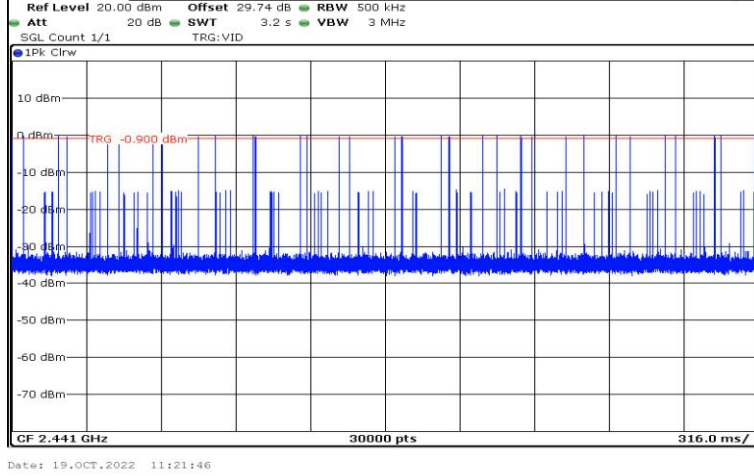


### 3DH1\_Ant1\_Hop



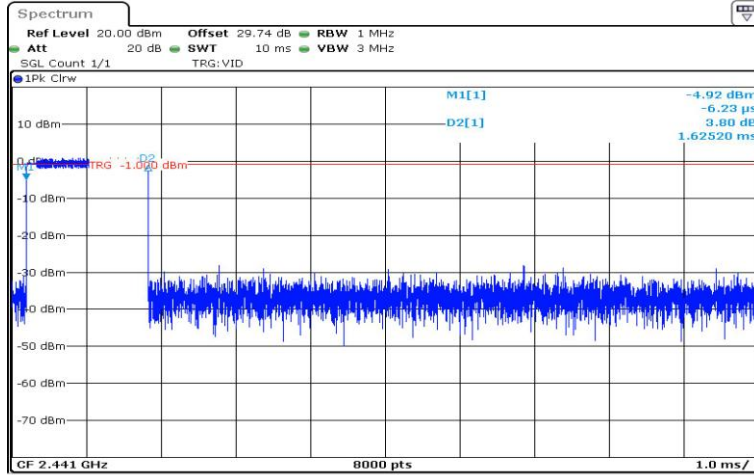
Date: 19.OCT.2022 11:21:40

### 3DH3\_Ant1\_Hop

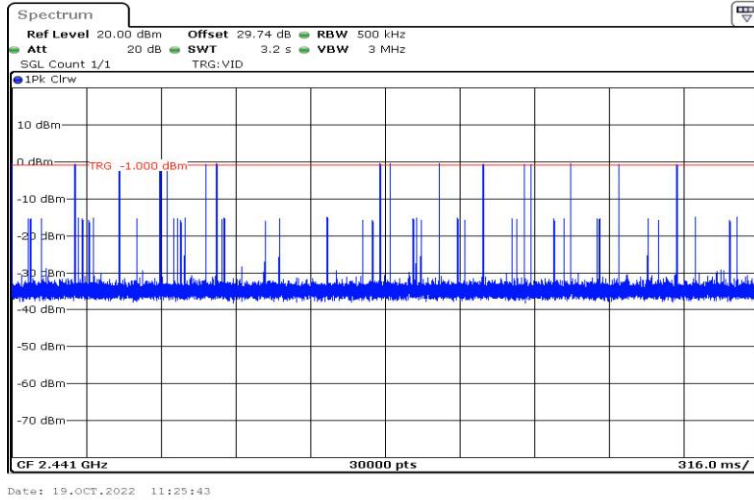


Date: 19.OCT.2022 11:21:46

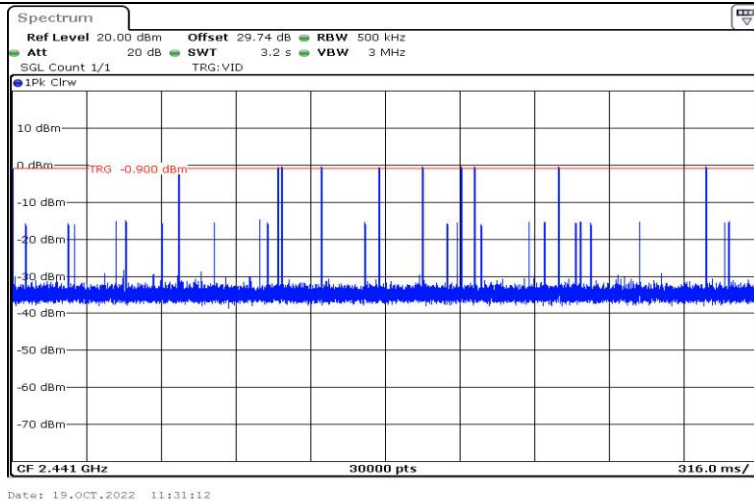
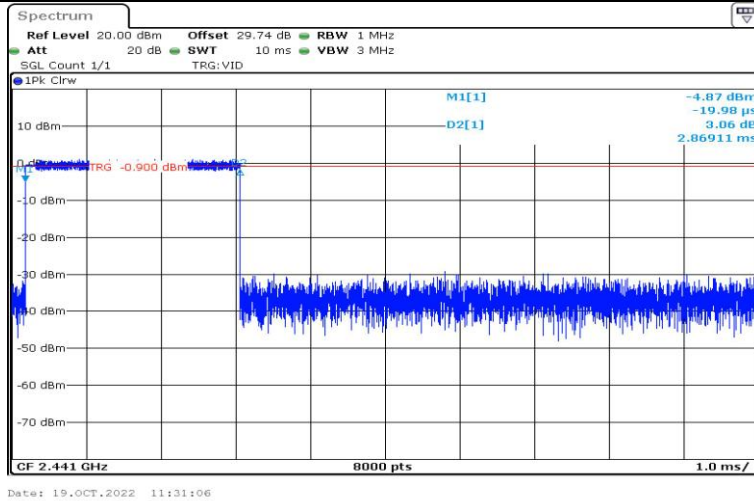
### 3DH1\_Ant1\_Hop



Date: 19.OCT.2022 11:25:38



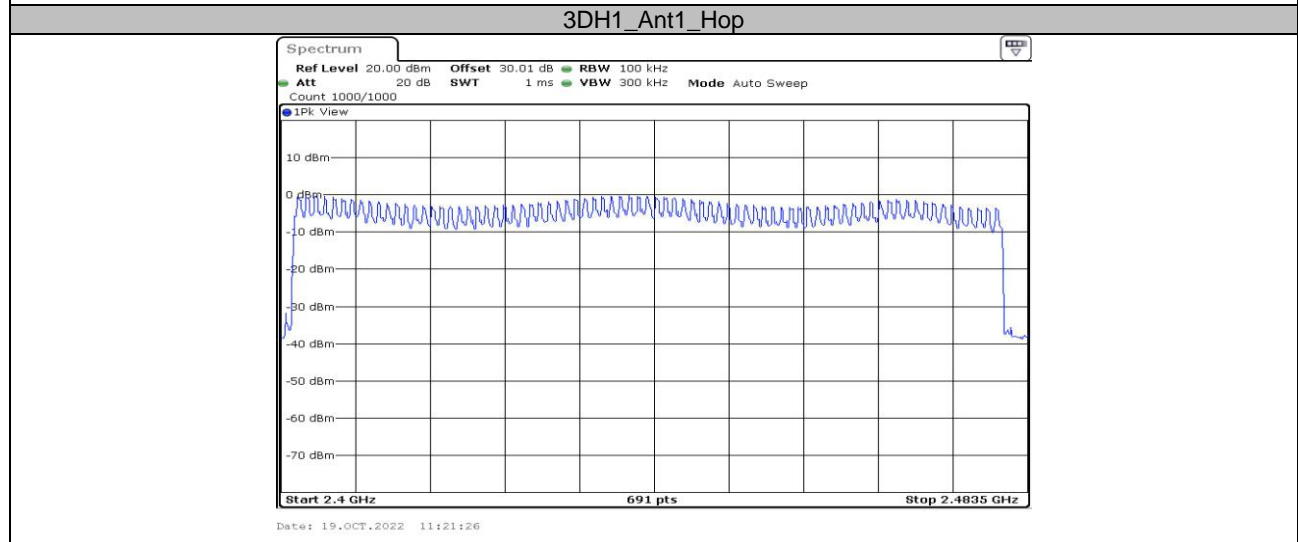
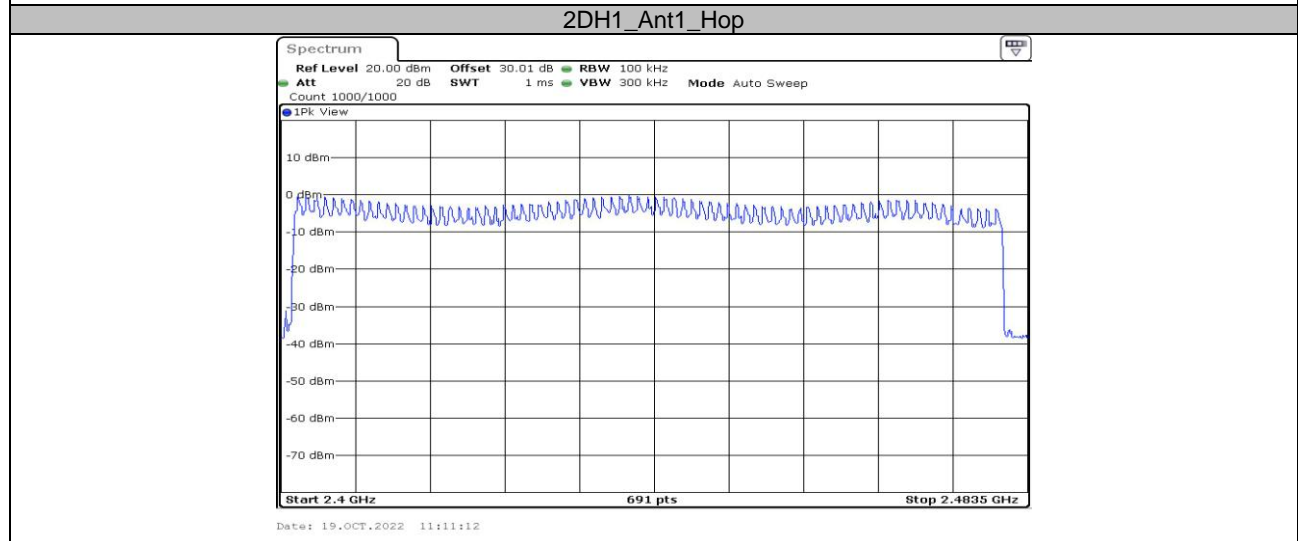
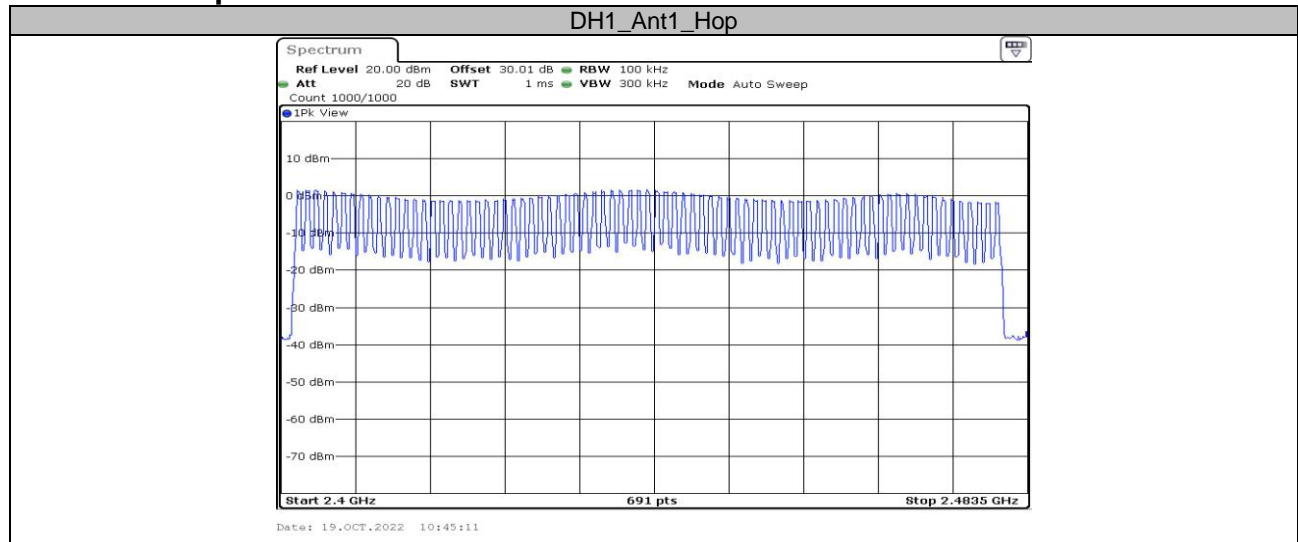
3DH5\_Ant1\_Hop



**Appendix F: Number of hopping channels  
Test Result**

Test Mode	Antenna	Frequency[MHz]	Result[Num]	Limit[Num]	Verdict
DH1	Ant1	Hop	79	≥15	PASS
2DH1	Ant1	Hop	79	≥15	PASS
3DH1	Ant1	Hop	79	≥15	PASS

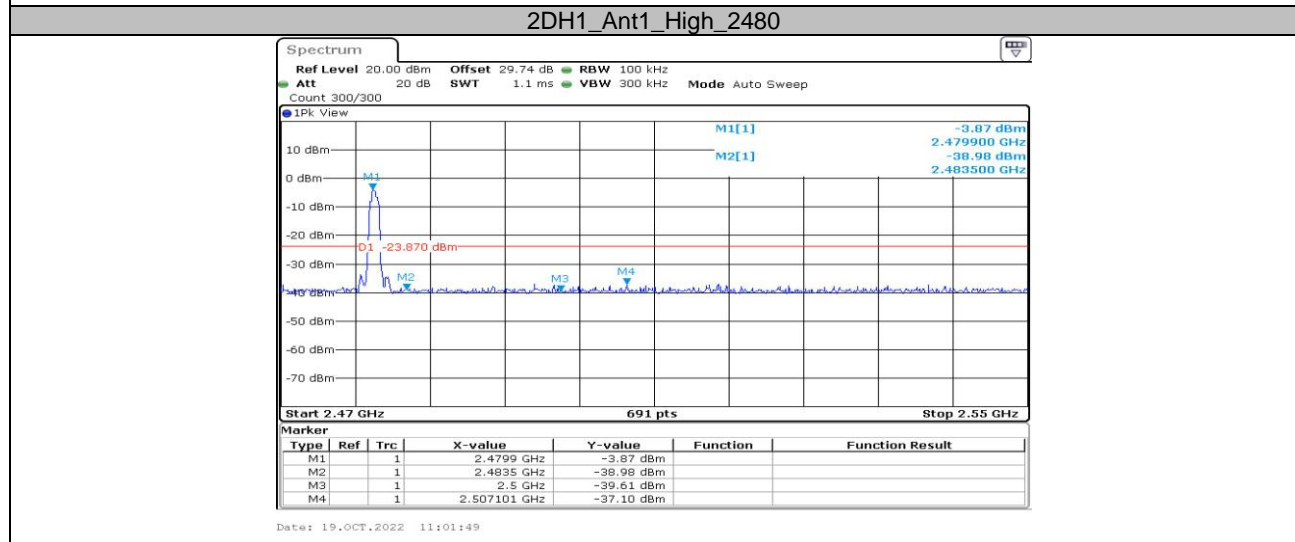
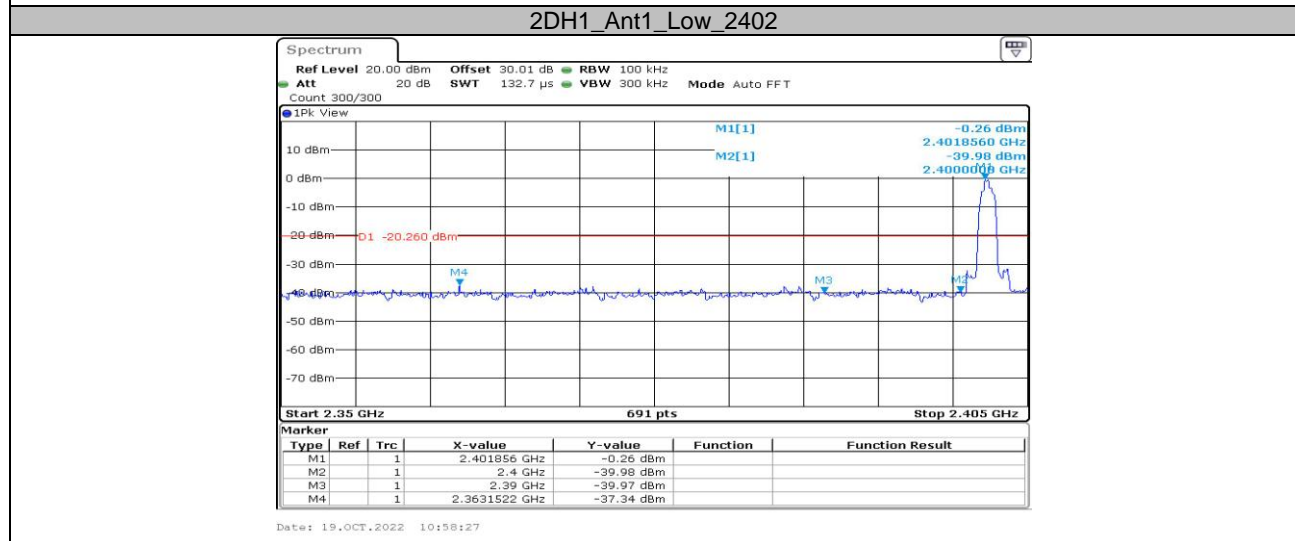
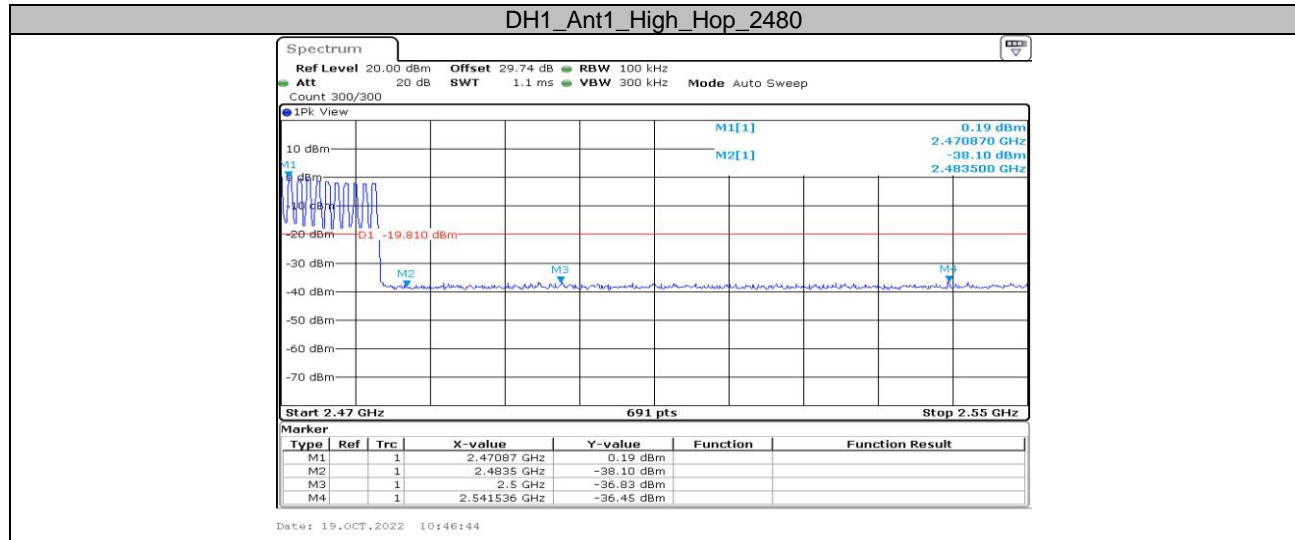
### Test Graphs



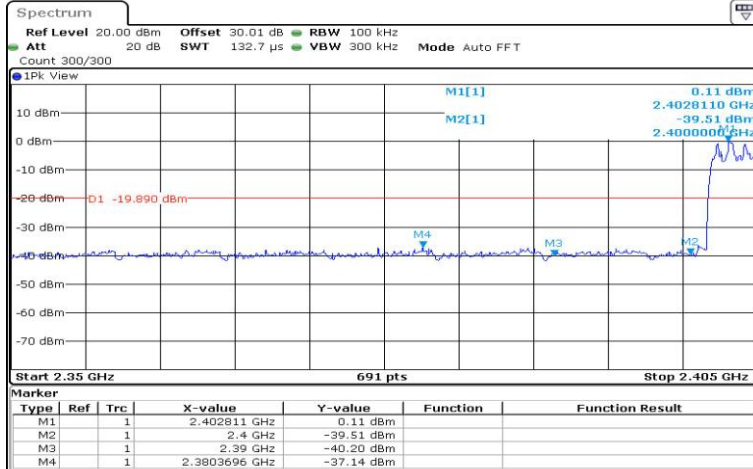


### Appendix G: Band edge measurements Test Graphs

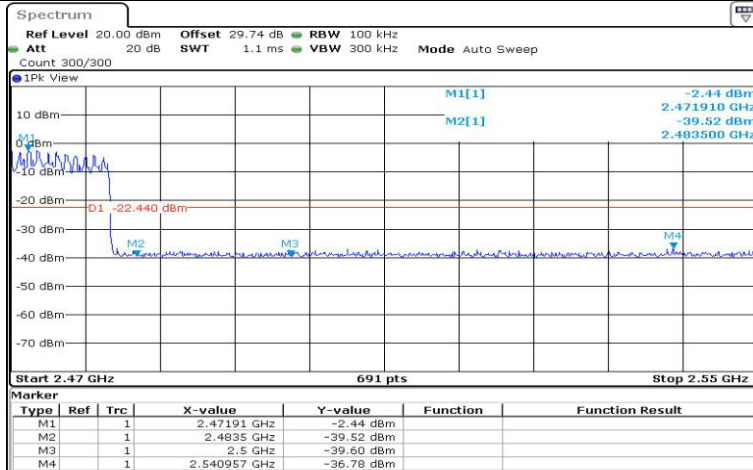




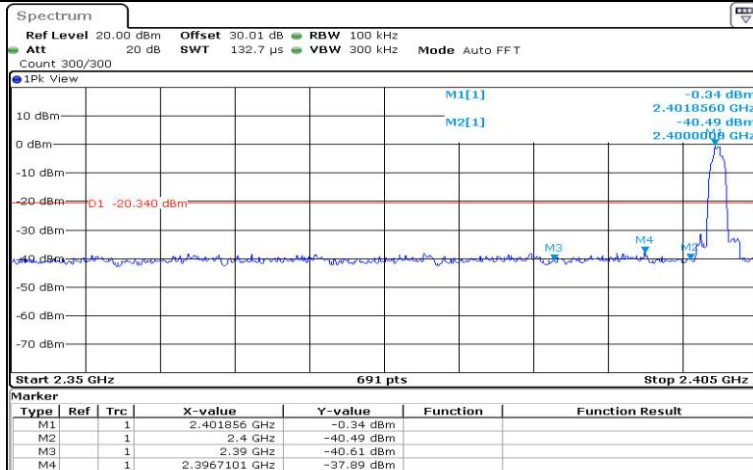
2DH1\_Ant1\_Low\_Hop\_2402

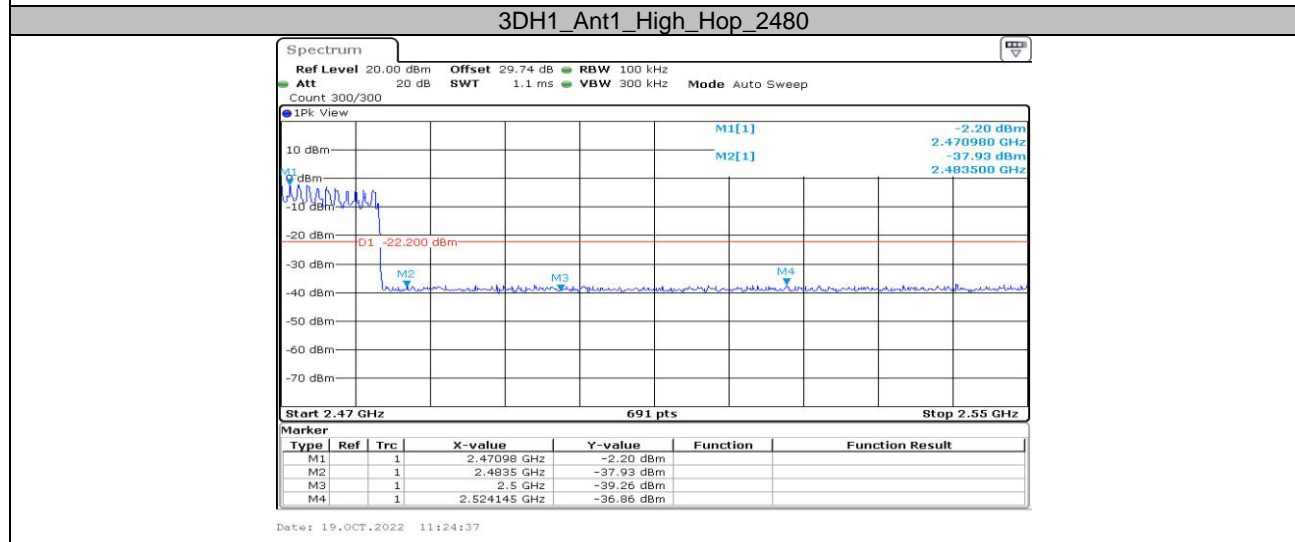
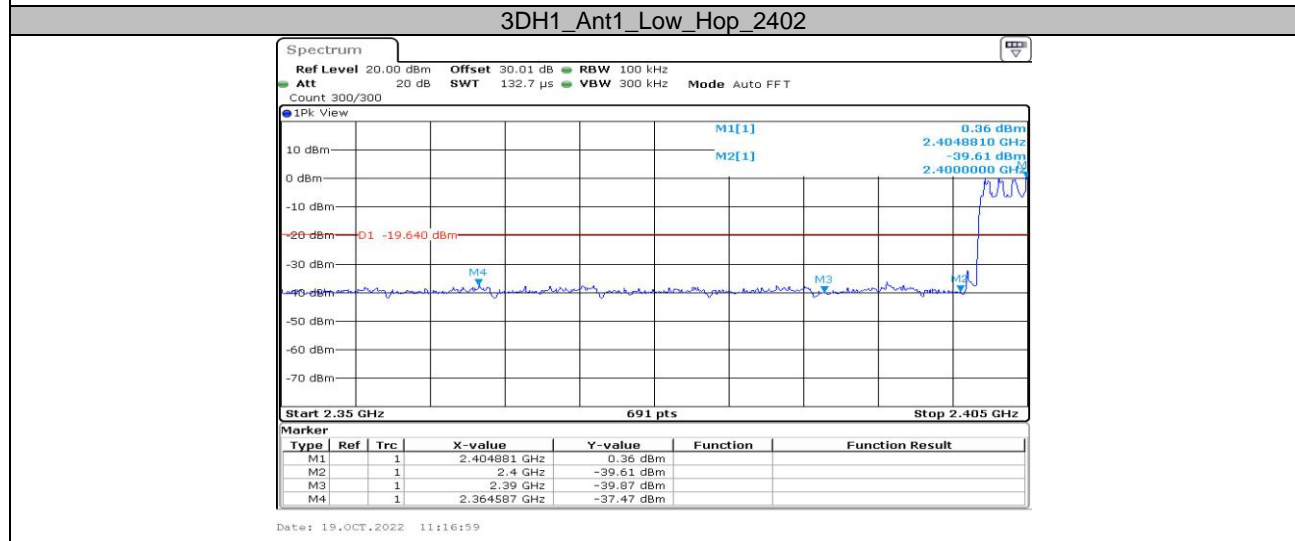
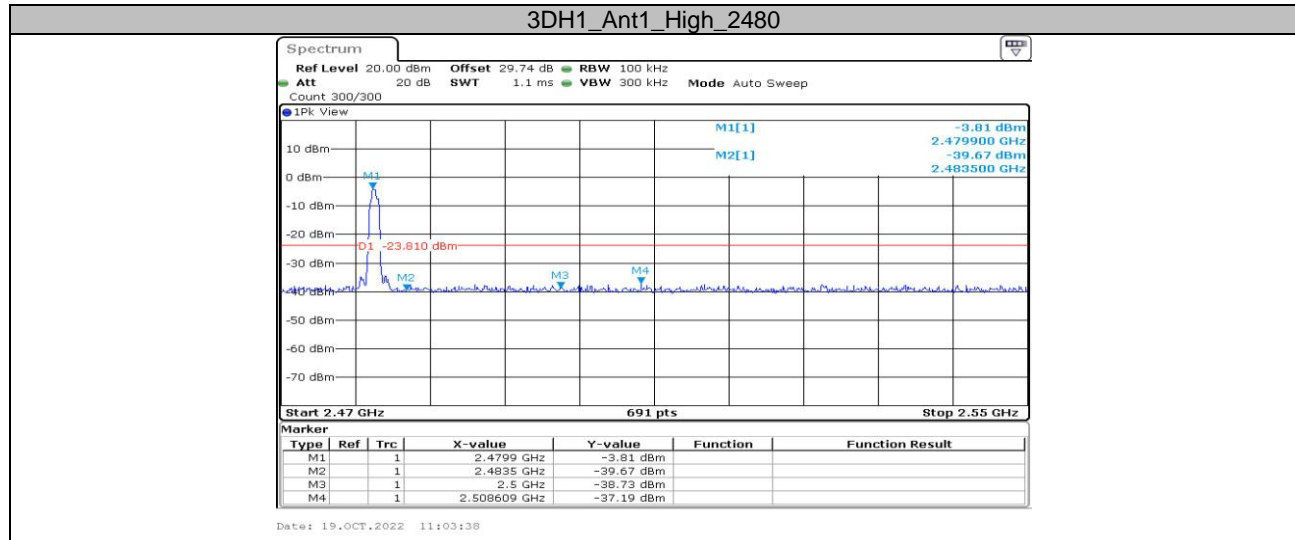


2DH1\_Ant1\_High\_Hop\_2480



3DH1\_Ant1\_Low\_2402





**\*\*\*\*\* END OF REPORT \*\*\*\*\***