



FCC PART 15.247 TEST REPORT

For

Thundercomm Technology Co., Ltd

Building 4, No. 99, Data Valley Middle Road, Xiantao District, Yubei District, Chongqing, China

FCC ID: 2AOHH-TURBOXC865

Report Type: Original Report	Product Type: Robotics RB5
Report Number: <u>RSZ200701002-00B</u>	
Report Date: <u>2021-08-02</u>	
Reviewed By: <u>RF Engineer</u>	Jacob Kong
Prepared By: Bay Area Compliance Laboratories Corp. (Shenzhen) 5F(B-West) , 6F, 7F, the 3rd Phase of Wan Li Industrial Building D, Shihua Rd, FuTian Free Trade Zone, Shenzhen, China Tel: +86-755-33320018 Fax: +86-755-33320008 www.baclcorp.com.cn	

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

BACL 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.

TABLE OF CONTENTS

GENERAL INFORMATION.....	4
PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT).....	4
OBJECTIVE	4
TEST METHODOLOGY	4
MEASUREMENT UNCERTAINTY.....	5
TEST FACILITY	5
SYSTEM TEST CONFIGURATION.....	6
DESCRIPTION OF TEST CONFIGURATION	6
EUT EXERCISE SOFTWARE	6
SPECIAL ACCESSORIES.....	6
EQUIPMENT MODIFICATIONS	6
SUPPORT EQUIPMENT LIST AND DETAILS	6
EXTERNAL I/O CABLE.....	7
BLOCK DIAGRAM OF TEST SETUP	7
SUMMARY OF TEST RESULTS	8
TEST EQUIPMENT LIST	9
FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE).....	10
APPLICABLE STANDARD	10
RESULT	10
FCC §15.203 – ANTENNA REQUIREMENT.....	12
APPLICABLE STANDARD	12
ANTENNA CONNECTOR CONSTRUCTION	12
FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS	13
APPLICABLE STANDARD	13
EUT SETUP	13
EMI TEST RECEIVER SETUP.....	13
TEST PROCEDURE	13
CORRECTED FACTOR & MARGIN CALCULATION	14
TEST DATA	14
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS.....	17
APPLICABLE STANDARD	17
EUT SETUP	17
EMI TEST RECEIVER & SPECTRUM ANALYZER SETUP	18
TEST PROCEDURE	18
CORRECTED AMPLITUDE & MARGIN CALCULATION	18
TEST DATA	18
FCC §15.247(a) (1)-CHANNEL SEPARATION TEST	25
APPLICABLE STANDARD	25
TEST PROCEDURE	25
TEST DATA	25
FCC §15.247(a) (1) – 20 dB EMISSION BANDWIDTH.....	26
APPLICABLE STANDARD	26
TEST PROCEDURE	26
TEST DATA	26

FCC §15.247(a) (1) (iii)-QUANTITY OF HOPPING CHANNEL TEST27
 APPLICABLE STANDARD27
 TEST PROCEDURE27
 TEST DATA27

FCC §15.247(a) (1) (iii) - TIME OF OCCUPANCY (DWELL TIME).....28
 APPLICABLE STANDARD28
 TEST PROCEDURE28
 TEST DATA28

FCC §15.247(b) (1) - PEAK OUTPUT POWER MEASUREMENT29
 APPLICABLE STANDARD29
 TEST PROCEDURE29
 TEST DATA29

FCC §15.247(d) - BAND EDGES TESTING30
 APPLICABLE STANDARD30
 TEST PROCEDURE30
 TEST DATA30

APPENDIX31
 APPENDIX A: 20dB EMISSION BANDWIDTH.....31
 APPENDIX B: OCCUPIED CHANNEL BANDWIDTH35
 APPENDIX C: MAXIMUM CONDUCTED PEAK OUTPUT POWER.....39
 APPENDIX D: CARRIER FREQUENCY SEPARATION43
 APPENDIX E: TIME OF OCCUPANCY45
 APPENDIX F: NUMBER OF HOPPING CHANNELS52
 APPENDIX G: BAND EDGE MEASUREMENTS54

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	Robotics RB5
Tested Model	TurboX C865 Dev Kit
Frequency Range	Bluetooth: 2402~2480MHz
Maximum conducted Peak output power	Bluetooth: 1.63dBm
Modulation Technique	Bluetooth: GFSK, $\pi/4$ -DQPSK, 8DPSK
Antenna Specification*	PIFA Antenna: -3dBi(provided by the applicant)
Voltage Range	DC12V from adapter
Date of Test	2021-04-09 to 2021-07-20
Sample number	RSZ200701002-RF-S1(Assigned by BACL, Shenzhen)
Received date	2020-07-01
Sample/EUT Status	Good condition
Adapter Information	Model:LYD1202500B Input :100-240V,0.68A,50/60Hz Output:12.0V,2.5A

Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions 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 Bay Area Compliance Laboratories Corp. (Shenzhen). 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 Output Power with Power meter		±0.73dB
RF conducted test with spectrum		±1.6dB
AC Power Lines Conducted Emissions		±1.95dB
Emissions, Radiated	Below 1GHz	±4.75dB
	Above 1GHz	±4.88dB
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 Bay Area Compliance Laboratories Corp. (Shenzhen) to collect test data is located on the 5F(B-West) , 6F, 7F, the 3rd Phase of Wan Li Industrial Building D, Shihua Rd, FuTian Free Trade Zone, Shenzhen, 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.: 342867, the FCC Designation No.: CN1221.

The test site has been registered with ISED Canada under ISED Canada Registration Number 3062B.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode.

EUT Exercise Software

“QRCT” software was made to the EUT tested. The power level is 8*. The software and power level was provided by the applicant.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

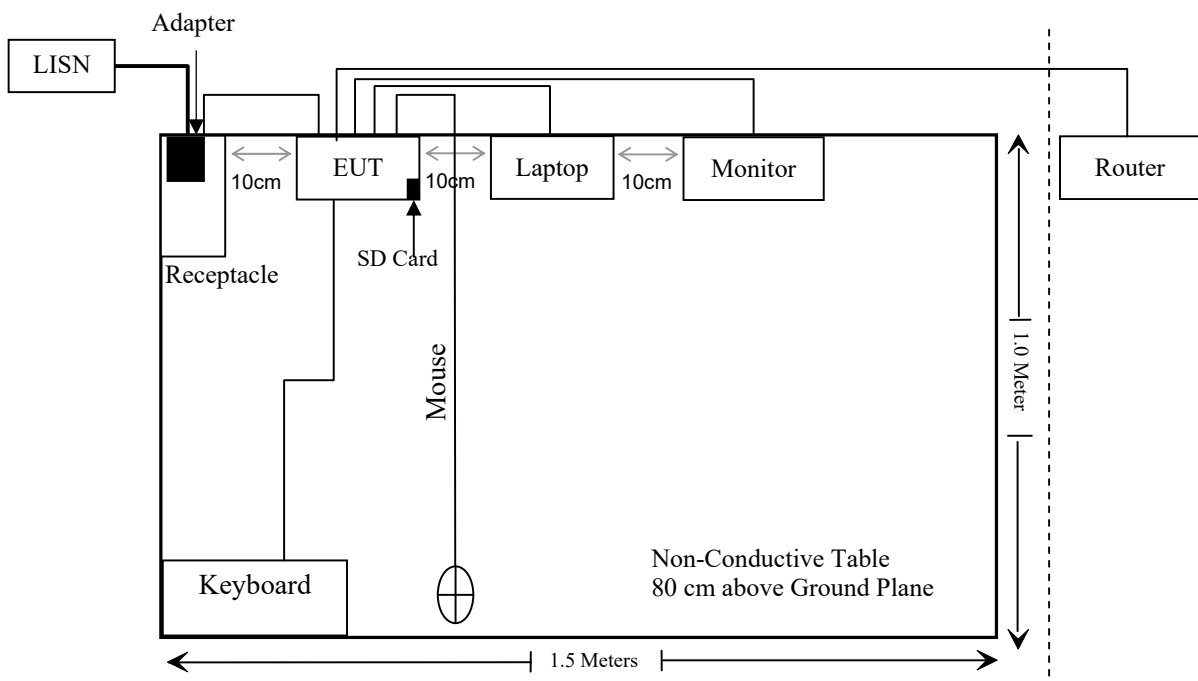
Manufacturer	Description	Model	Serial Number
DELL	Laptop	Latitude E6520	H067T A00
SAMSUNG	Monitor	S24E390HL	ZZFRH4ZN303357K
TCL	Monitor	L32F3301B	RD851P2
HIKVISION	Router	DS-3WR03-E	10021642429
maxin	Keyborad	KEY-663	1210001678
DELL	Mouse	M-U0026	DZL-M-U0026(B)
Sandisk	SD Card	SDSDUNG-128G-ZN61N	SD012463

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielding Un-Detachable AC Cable	1.0	Receptacle	LISN
Un-shielding Un-Detachable DC Cable	1.2	Adapter	EUT
Un-Shielding Detachable USB to Type-C Cable	1.0	EUT	Laptop
Un-Shielding Detachable HDMI Cable	2.5	EUT	Monitor
Un-Shielding Detachable RJ45 Cable	10	EUT	Router
Un-shielding Un-Detachable USB Cable	1.2	EUT	Mouse
Un-shielding Un-Detachable USB Cable	1.2	EUT	Keyboard

Block Diagram of Test Setup

For conducted emission:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (i), §2.1091	Maximum Permissible Exposure(MPE)	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	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
Conducted Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2020/08/04	2021/08/03
Rohde & Schwarz	LISN	ENV216	101613	2020/08/04	2021/08/03
Rohde & Schwarz	Transient Limiter	ESH3Z2	DE25985	2020/11/29	2021/11/28
Unknown	CE Cable	CE Cable	UF A210B-1-0720-504504	2020/11/29	2021/11/28
Rohde & Schwarz	CE Test software	EMC 32	V8.53.0	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2020/08/04	2021/08/03
Sonoma instrument	Pre-amplifier	310 N	186238	2020/08/04	2021/08/03
Sunol Sciences	Broadband Antenna	JB1	A040904-2	2020/12/22	2023/12/21
Unknown	Cable 2	RF Cable 2	F-03-EM197	2020/11/29	2021/11/28
Unknown	Cable	Chamber Cable 1	F-03-EM236	2020/11/29	2021/11/28
Rohde & Schwarz	Auto test software	EMC 32	V9.10	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40-N	102259	2020/08/04	2021/08/03
COM-POWER	Pre-amplifier	PA-122	181919	2020/11/29	2021/11/28
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2020/11/28	2021/11/27
Sunol Sciences	Horn Antenna	DRH-118	A052604	2017/12/22	2020/12/21
Insulated Wire Inc.	RF Cable	SPS-2503-3150	02222010	2020/11/29	2021/11/28
Unknown	RF Cable	W1101-EQ1 OUT	F-19-EM005	2020/11/29	2021/11/28
SNSD	Band Reject filter	BSF2402-2480MN-0898-001	2.4G filter	2020/04/20	2021/04/20
Ducommun Technologies	Horn antenna	ARH-4223-02	1007726-021304	2020/12/06	2023/12/05
RF Conducted Test					
Tonscend Corporation	RF control Unit	JS0806-2	19D8060154	2020/08/04	2021/08/03
Rohde & Schwarz	Signal and Spectrum Analyzer	FSV40	101473	2020/08/04	2021/08/03

* **Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Shenzhen) 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) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

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.

Limits for General Population/Uncontrolled Exposure

Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Power Density (mW/cm ²)	Averaging Time (Minutes)
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*(180/f ²)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz

* = Plane-wave equivalent power density

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm²)

P = power input to the antenna (in appropriate units, e.g., mW).

G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.

R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

Mode	Frequency (MHz)	Antenna Gain		Tune up conducted power		Evaluation Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)
		(dBi)	(numeric)	(dBm)	(mW)			
Bluetooth	2402-2480	-3.0	0.50	2.0	1.58	20	0.00016	1
BLE	2402-2480	-3.0	0.50	6.0	3.98	20	0.0004	1
2.4G Wi-Fi	2412-2462	-3.0	0.50	23.0	199.53	20	0.0198	1
5G Wi-Fi	5150-5250	0	1.0	17.0	51.12	20	0.0102	1
	5250-5350	0	1.0	17.0	51.12	20	0.0102	1
	5470-5725	0	1.0	19.0	79.43	20	0.0158	1
	5725-5850	0	1.0	15.0	31.62	20	0.0063	1

Note: 1. the tune up conducted power was declared by the applicant
 2. the 2.4G Wi-Fi can transmit at the same time with the 5G Wi-Fi. The Bluetooth can't transmit at the same time with Wi-Fi.

Simultaneous transmitting consideration:

The ratio= $MPE_{2.4G}/limit + MPE_{5G}/limit = 0.0198 + 0.0158 = 0.0356 < 1.0$

So simultaneous exposure comply with the limit.

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

Result: Compliance

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

The EUT has a PCB antenna arrangement which was permanently attached and the antenna gain is -3.0dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Result: Compliance.

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.

Corrected Factor & Margin Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

$$\text{Correction Factor} = \text{LISN VDF} + \text{Cable Loss} + \text{Transient Limiter Attenuation}$$

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

$$\text{Margin} = \text{Limit} - \text{Corrected Amplitude}$$

Test Data

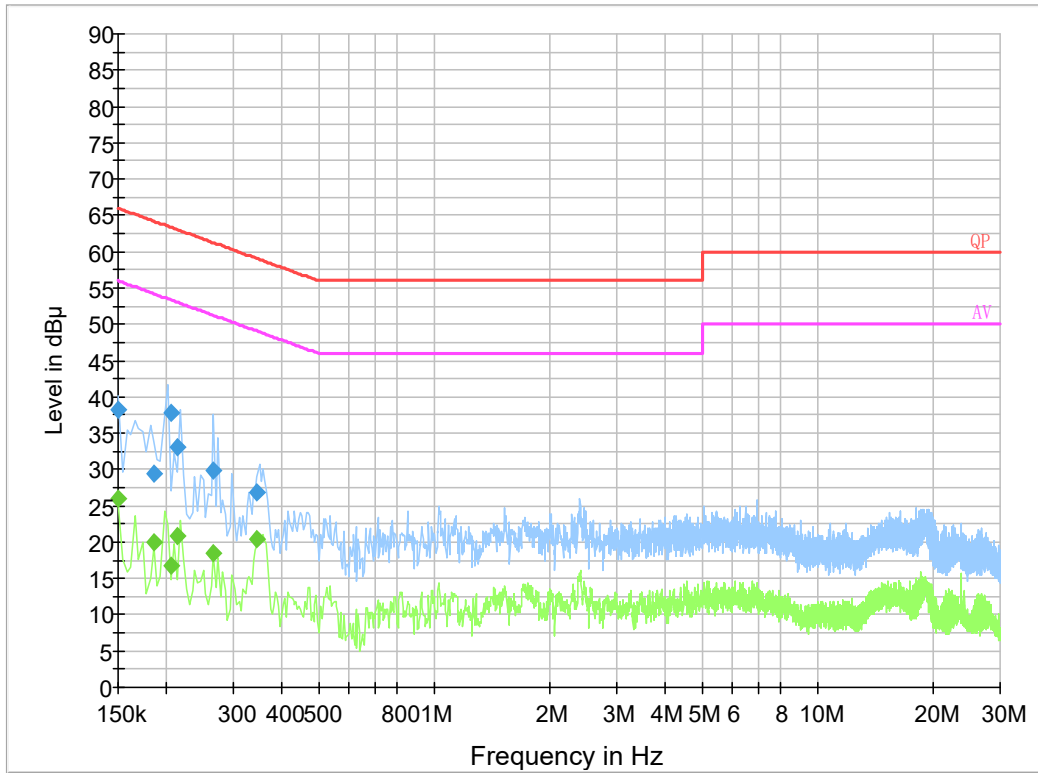
Environmental Conditions

Temperature:	25 °C
Relative Humidity:	70 %
ATM Pressure:	101.0 kPa

The testing was performed by Haiguo Li on 2021-07-20.

EUT operation mode: Transmitting (the worst case is GFSK Mode, High channel)

AC 120V/60 Hz, Line



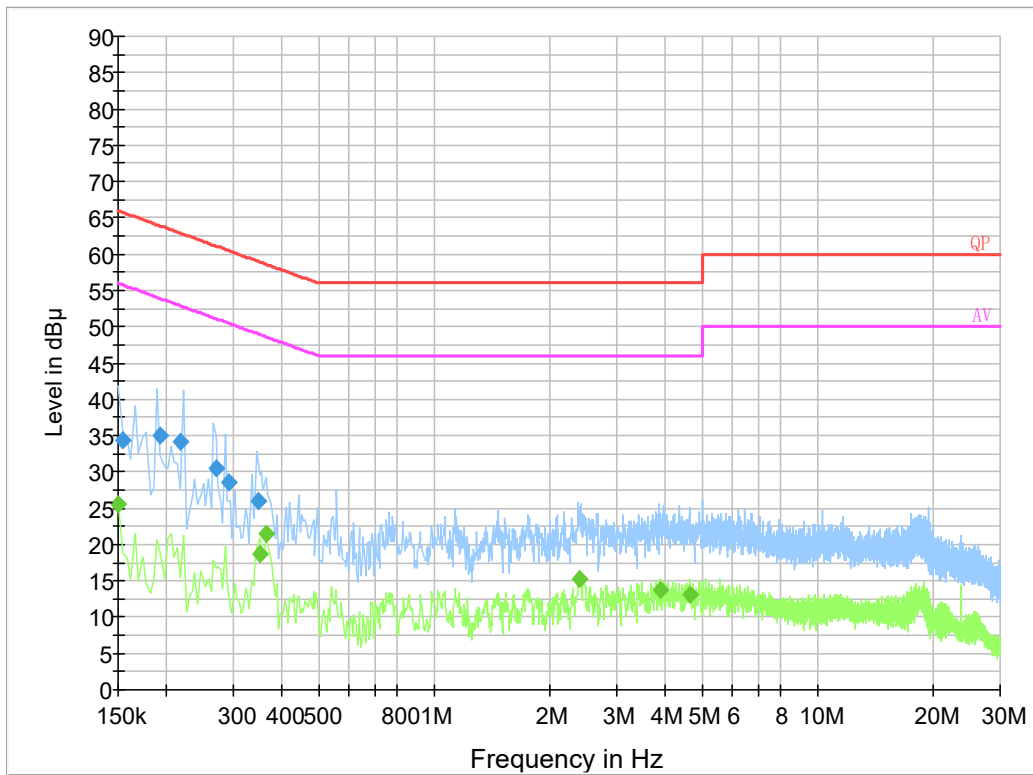
Final Result 1

Frequency (MHz)	QuasiPeak (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.150000	38.2	9.000	L1	19.8	27.8	66.0
0.185500	29.3	9.000	L1	19.8	34.9	64.2
0.206500	37.8	9.000	L1	19.8	25.5	63.3
0.213500	33.1	9.000	L1	19.8	30.0	63.1
0.265500	29.8	9.000	L1	19.8	31.5	61.3
0.344750	26.8	9.000	L1	19.9	32.3	59.1

Final Result 2

Frequency (MHz)	Average (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.150000	25.9	9.000	L1	19.8	30.1	56.0
0.185500	19.9	9.000	L1	19.8	34.3	54.2
0.206500	16.8	9.000	L1	19.8	36.5	53.3
0.213500	20.8	9.000	L1	19.8	32.3	53.1
0.265500	18.6	9.000	L1	19.8	32.7	51.3
0.344750	20.5	9.000	L1	19.9	28.6	49.1

AC 120V/60 Hz, Neutral



Final Result 1

Frequency (MHz)	QuasiPeak (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.154000	34.4	9.000	N	19.8	31.4	65.8
0.193500	34.9	9.000	N	19.8	29.0	63.9
0.217500	34.2	9.000	N	19.8	28.7	62.9
0.270500	30.5	9.000	N	19.7	30.6	61.1
0.290500	28.5	9.000	N	19.7	32.0	60.5
0.348810	26.1	9.000	N	19.9	32.9	59.0

Final Result 2

Frequency (MHz)	Average (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.150000	25.6	9.000	N	19.8	30.4	56.0
0.350000	18.6	9.000	N	19.9	30.4	49.0
0.366000	21.4	9.000	N	19.9	27.2	48.6
2.398000	15.4	9.000	N	19.8	30.6	46.0
3.898000	13.7	9.000	N	19.9	32.3	46.0
4.666000	13.1	9.000	N	19.9	32.9	46.0

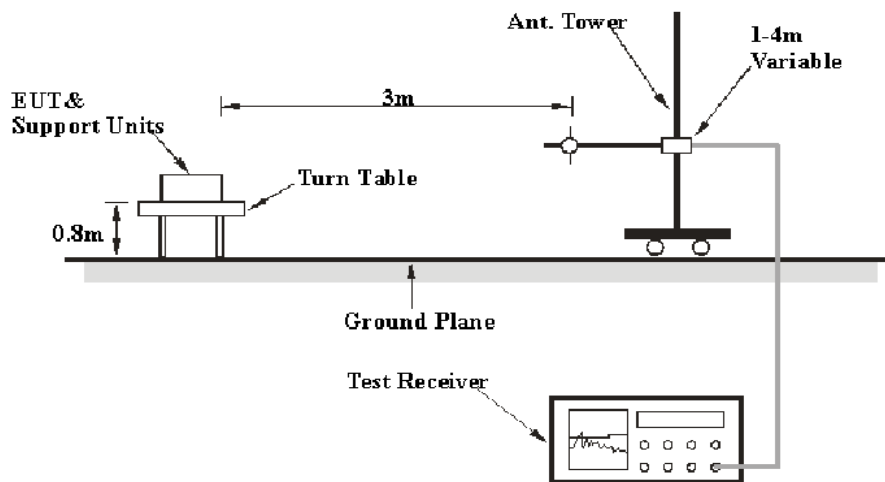
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

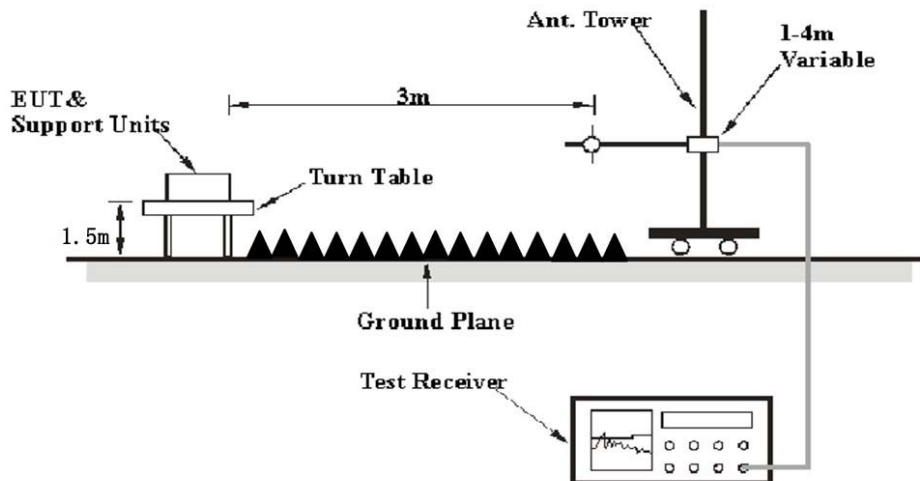
FCC §15.205; §15.209; §15.247(d)

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
	1 MHz	10 Hz	/	Average

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.

Corrected Amplitude & Margin Calculation

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

$$\text{Corrected Amplitude} = \text{Meter Reading} + \text{Antenna Factor} + \text{Cable Loss} - \text{Amplifier Gain}$$

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

$$\text{Margin} = \text{Limit} - \text{Corrected Amplitude}$$

Test Data

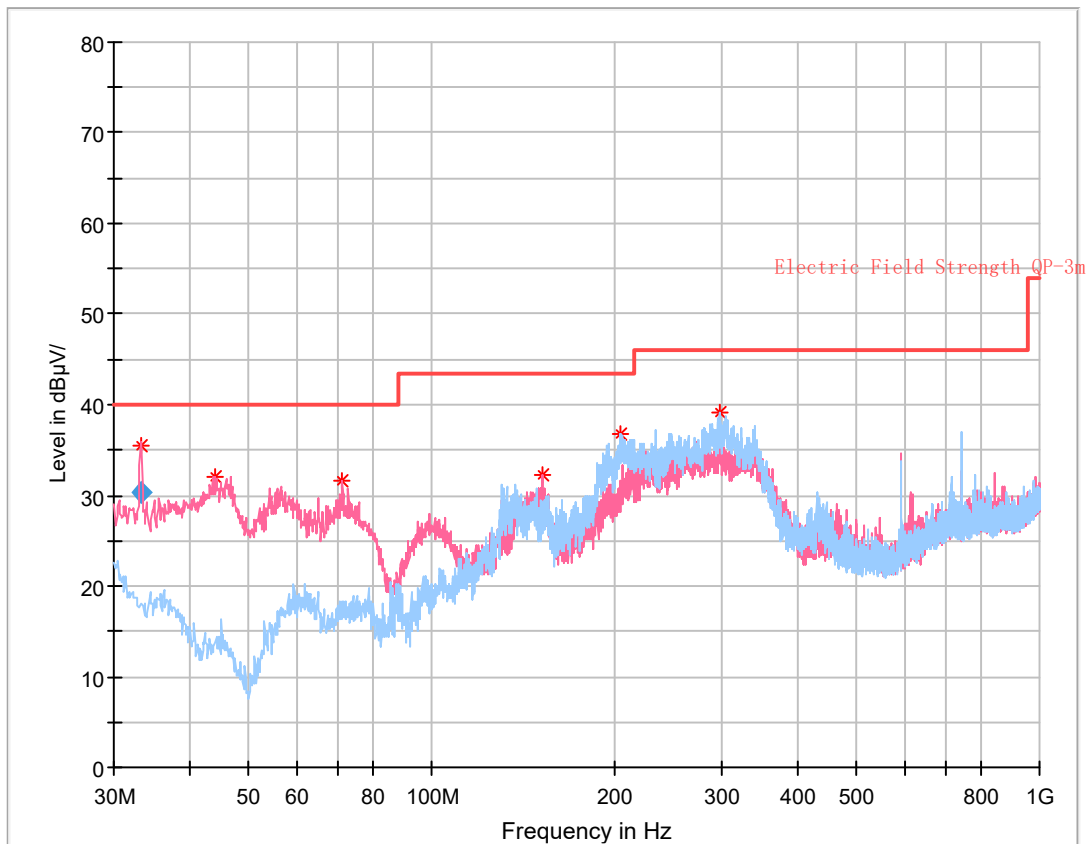
Environmental Conditions

Temperature:	26.8~29°C
Relative Humidity:	50~51 %
ATM Pressure:	101.0~101.2 kPa

The testing was performed by Harris He on 2021-07-19 for below 1GHz and Alan He on 2021-04-09 for above 1GHz.

EUT operation mode: Transmitting

30 MHz~1 GHz: (the worst case is GFSK Mode, High channel)



Final Result

Frequency (MHz)	QuasiPeak (dB µ V/m)	Limit (dB µ V/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
33.209875	30.30	40.00	9.70	191.0	V	207.0	-6.0

Critical Freqs

Frequency (MHz)	QuasiPeak (dB µ V/m)	Limit (dB µ V/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
44.065000	31.98	40.00	8.02	200.0	V	50.0	-13.2
71.346250	31.55	40.00	8.45	200.0	V	18.0	-16.3
151.977500	32.22	43.50	11.28	100.0	V	64.0	-11.5
204.478750	36.78	43.50	6.72	100.0	H	118.0	-11.1
296.992500	39.19	46.00	6.81	100.0	H	129.0	-10.1

1 GHz - 25 GHz: (Scan with GFSK, $\pi/4$ -DQPSK, 8DPSK mode, the worst case is 8DPSK Mode)

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dB μ V/m)	Limit (dB μ V/m)	Margin (dB)
	Reading (dB μ V)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2388.19	28.91	PK	256	2.3	H	31.87	60.78	74	13.22
2388.19	14.21	AV	256	2.3	H	31.87	46.08	54	7.92
2484.48	28.48	PK	201	2.3	H	32.13	60.61	74	13.39
2484.48	14.19	AV	201	2.3	H	32.13	46.32	54	7.68
4804.00	43.09	PK	306	1.7	H	6.28	49.37	74	24.63
4804.00	28.69	AV	306	1.7	H	6.28	34.97	54	19.03
Middle Channel (2441 MHz)									
4882.00	43.18	PK	252	2.2	H	6.76	49.94	74	24.06
4882.00	28.48	Ave.	252	2.2	H	6.76	35.24	54	18.76
High Channel (2480 MHz)									
2381.49	29.31	PK	25	1.1	H	31.87	61.18	74	12.82
2381.49	14.24	Ave.	25	1.1	H	31.87	46.11	54	7.89
2491.54	29.21	PK	314	1.3	H	32.13	61.34	74	12.66
2491.54	14.25	Ave.	314	1.3	H	32.13	46.38	54	7.62
4960.00	43.66	PK	146	1.4	H	6.80	50.46	74	23.54
4960.00	28.83	Ave.	265	1.0	H	6.80	35.63	54	18.37

Note:

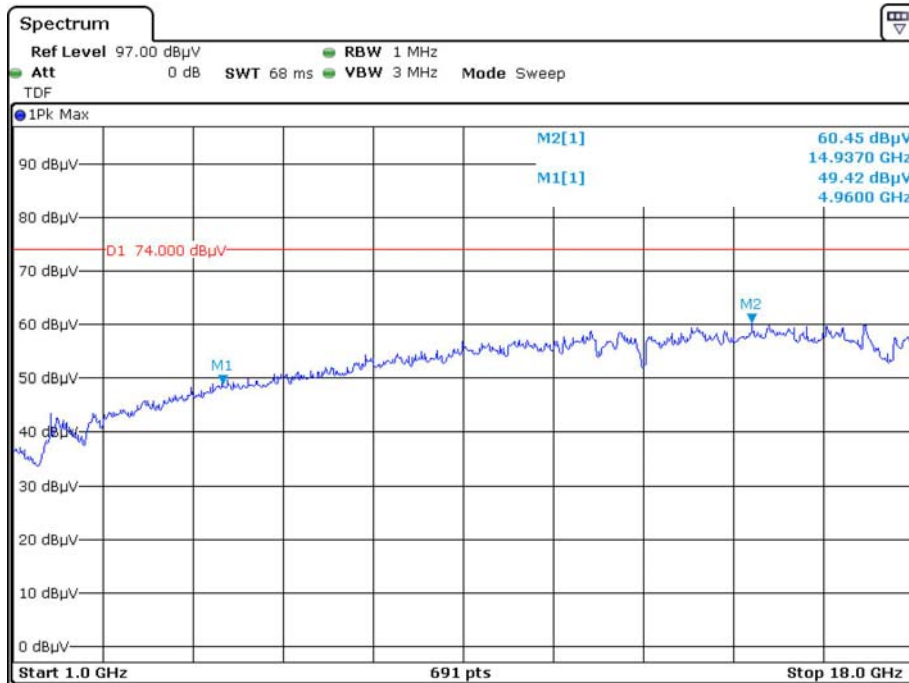
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor

Corrected Amplitude = Corrected Factor + Reading

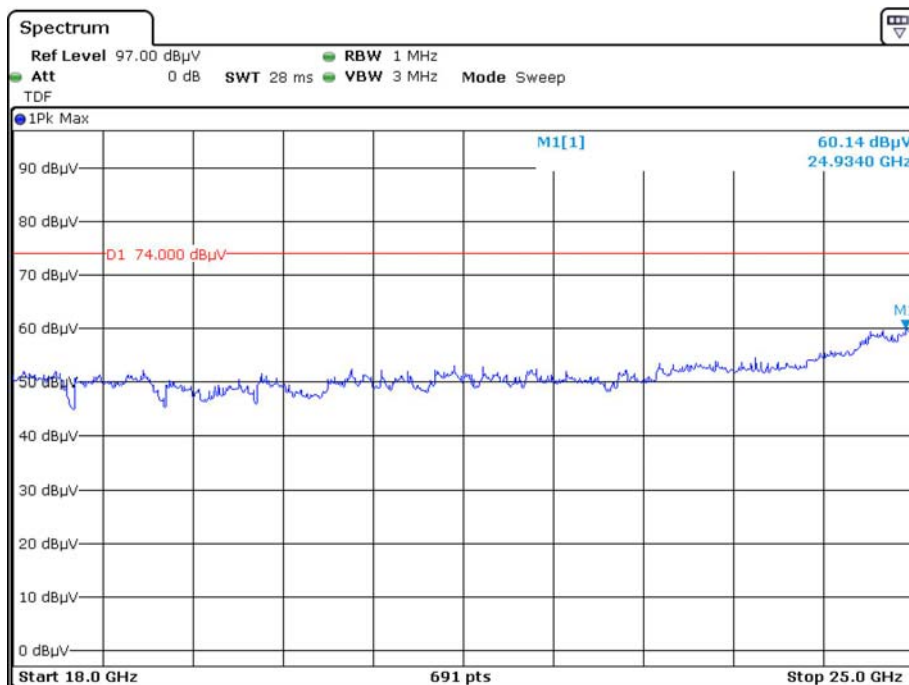
Margin = Limit - Corrected. Amplitude

The other spurious emission which is 20dB to the limit was not recorded.

**Pre-scan with high channel Peak
Horizontal**

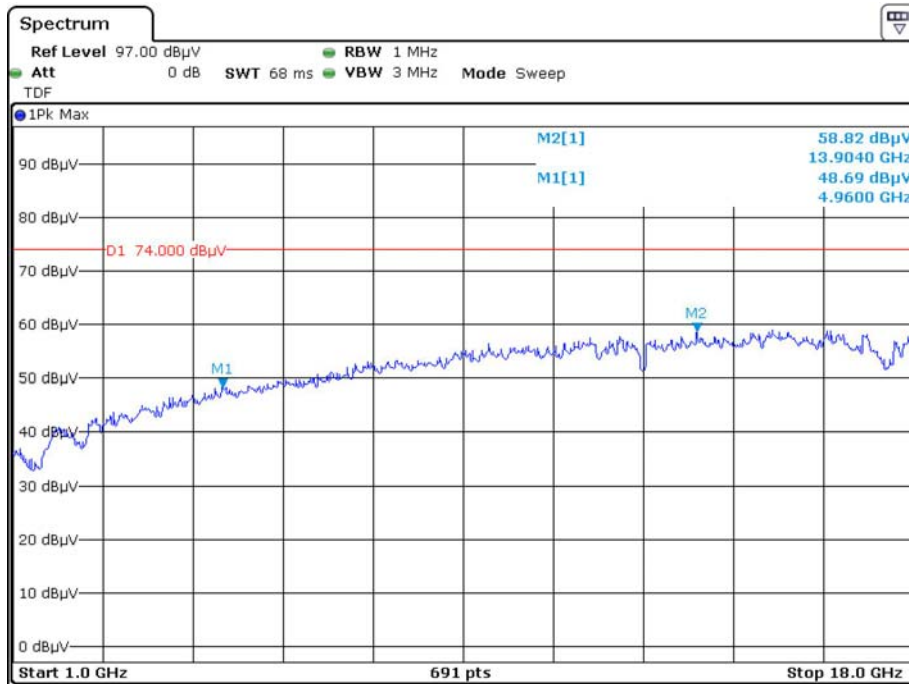


Date: 9.APR.2021 10:44:50

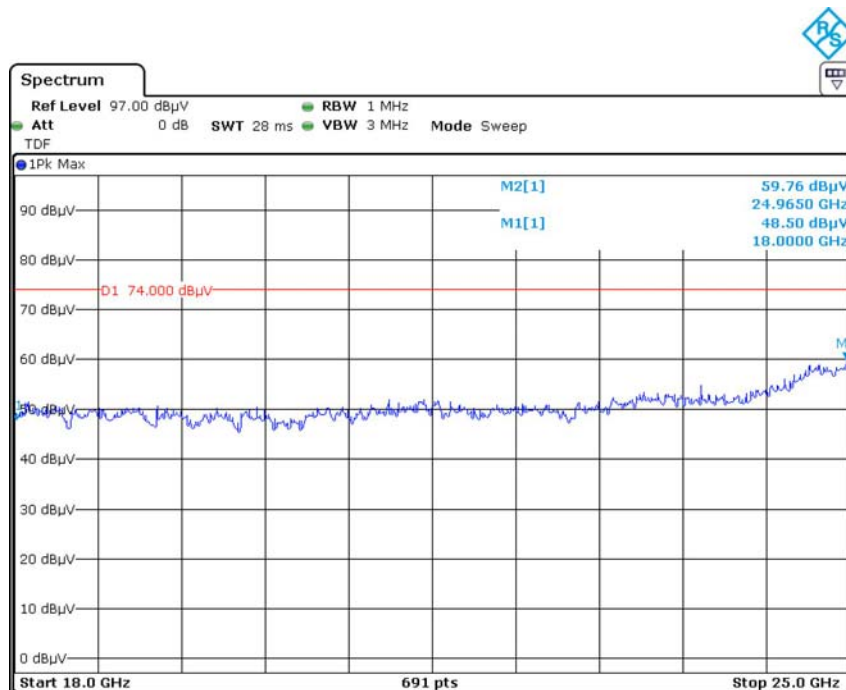


Date: 9.APR.2021 11:34:15

Vertical

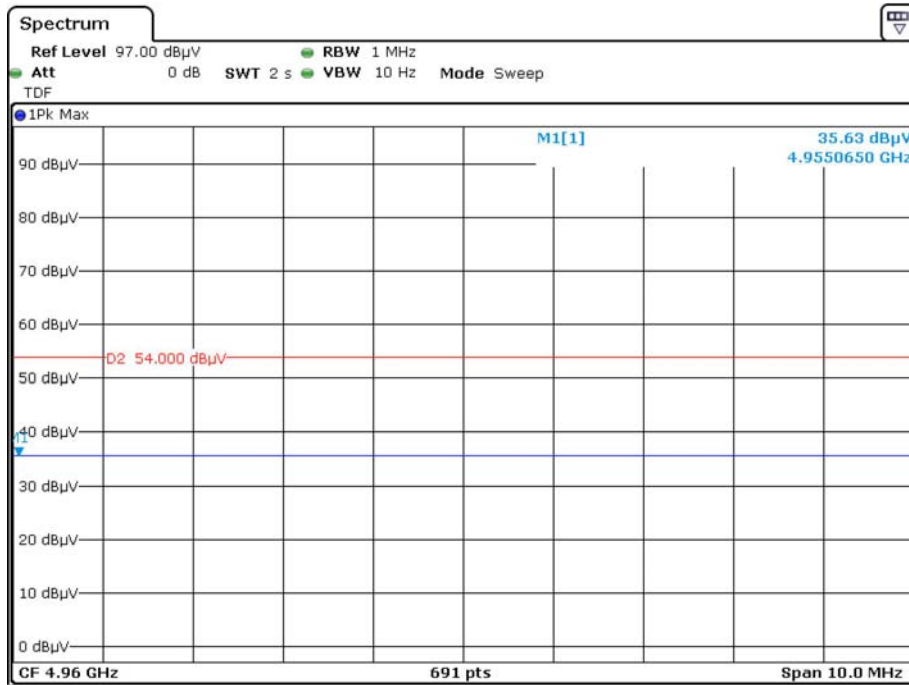


Date: 9.APR.2021 10:55:45

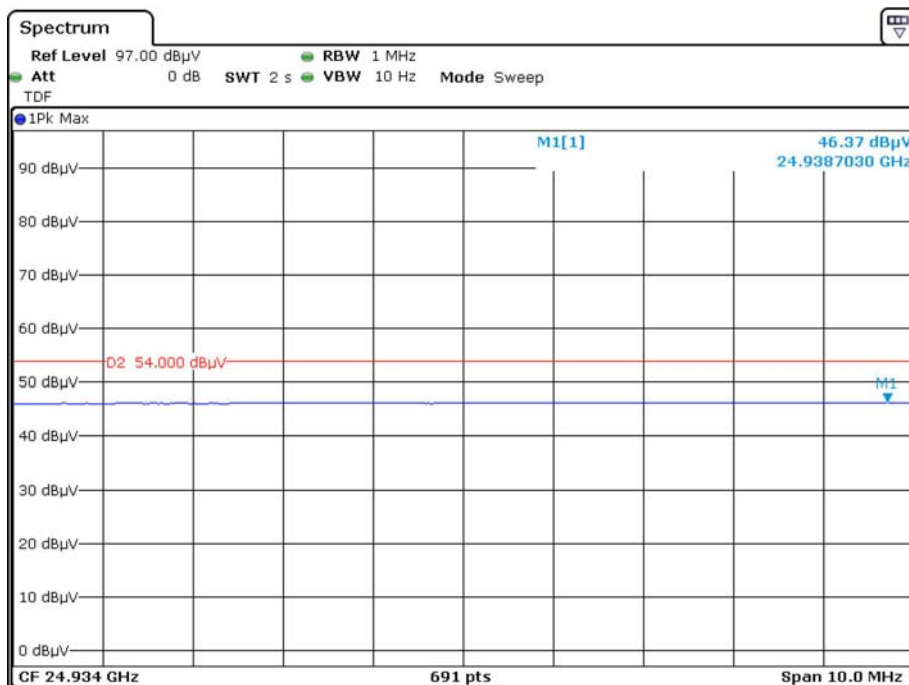


Date: 9.APR.2021 11:45:14

Pre-scan for Average Horizontal

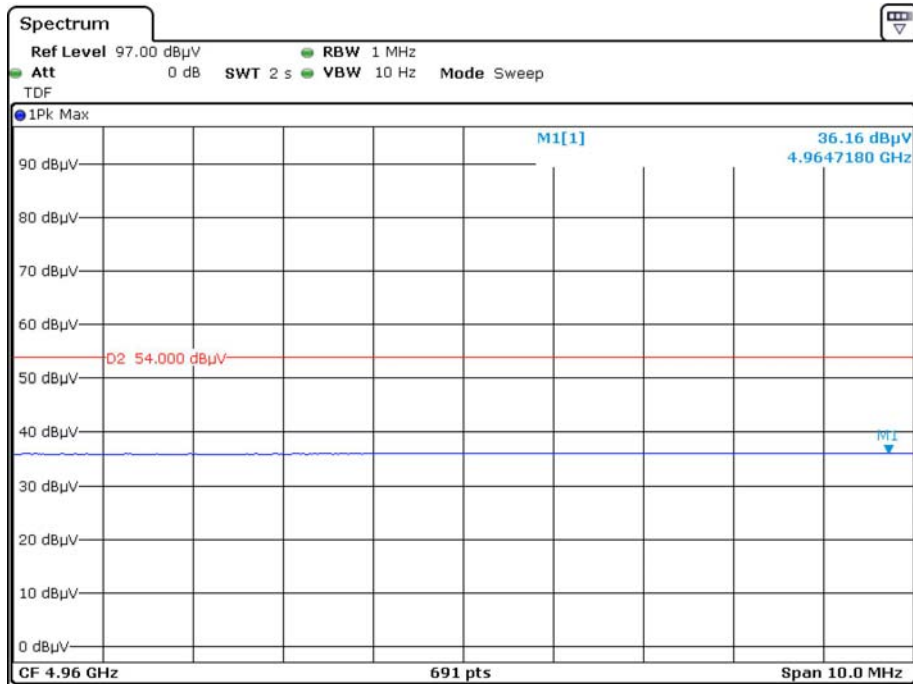


Date: 9.APR.2021 10:50:30

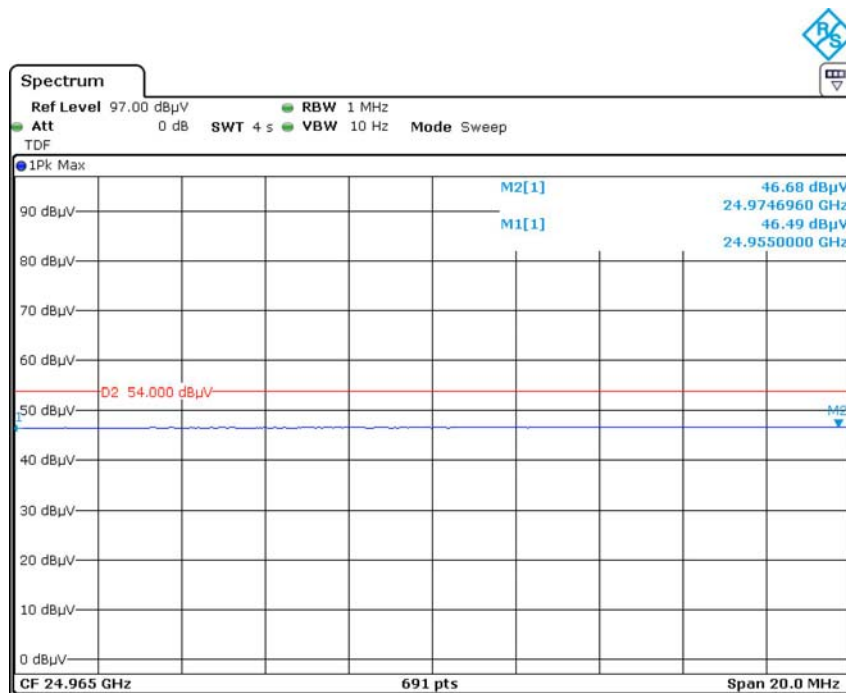


Date: 9.APR.2021 11:40:29

Vertical



Date: 9.APR.2021 11:01:23



Date: 9.APR.2021 11:50:26

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

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

Temperature:	25 °C
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(a) (1) – 20 dB EMISSION 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

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 20 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

Test Data

Environmental Conditions

Temperature:	25 °C
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13.

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

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**

Temperature:	25 °C
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13.

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

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**

Temperature:	25 °C
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13.

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

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

Temperature:	25 °C
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13.

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

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

Temperature:	25 °C
Relative Humidity:	55 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-07-13.

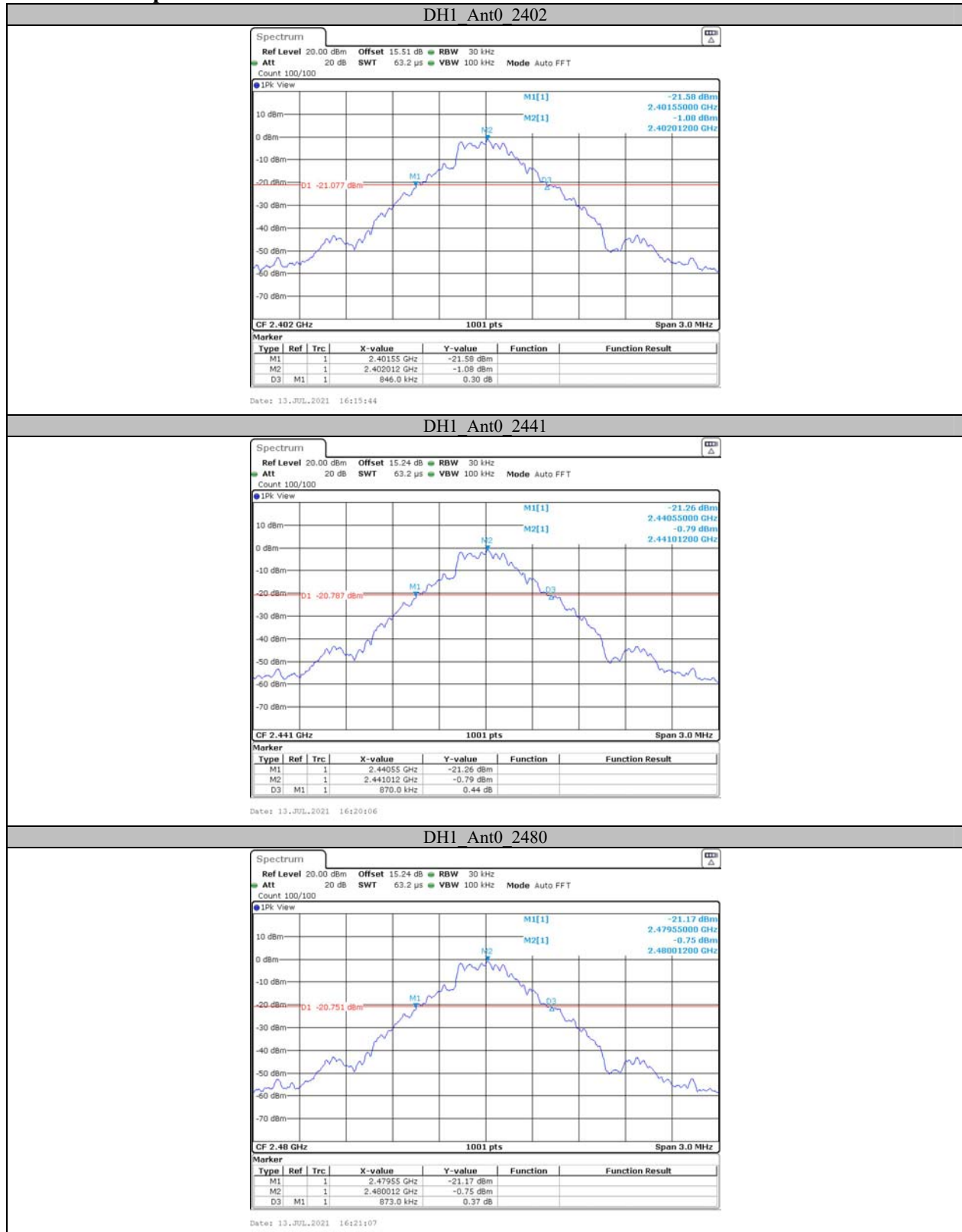
EUT operation mode: Transmitting

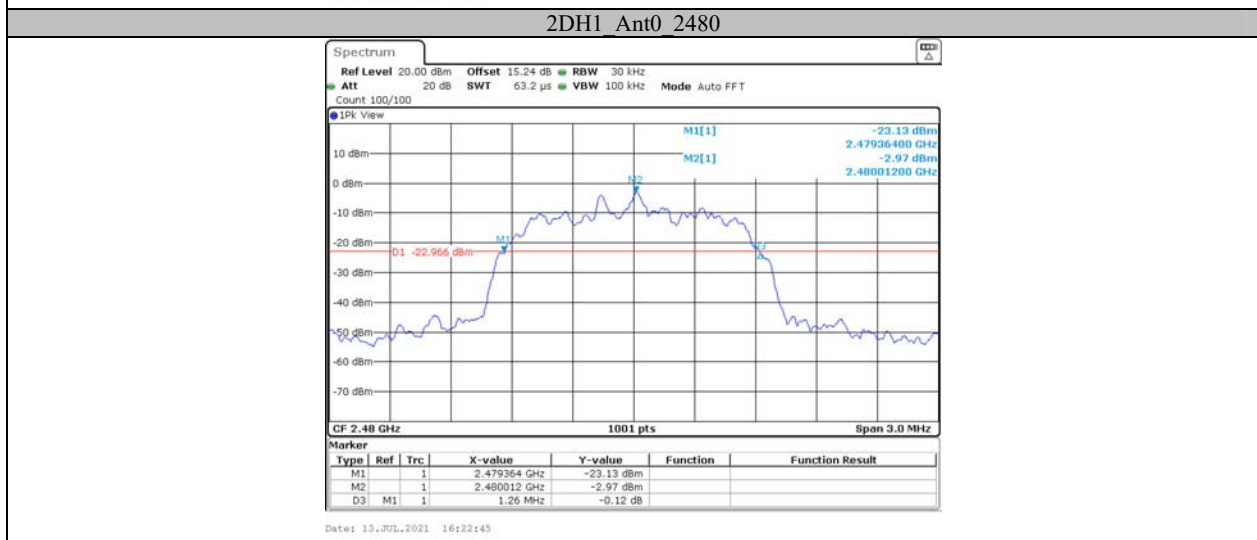
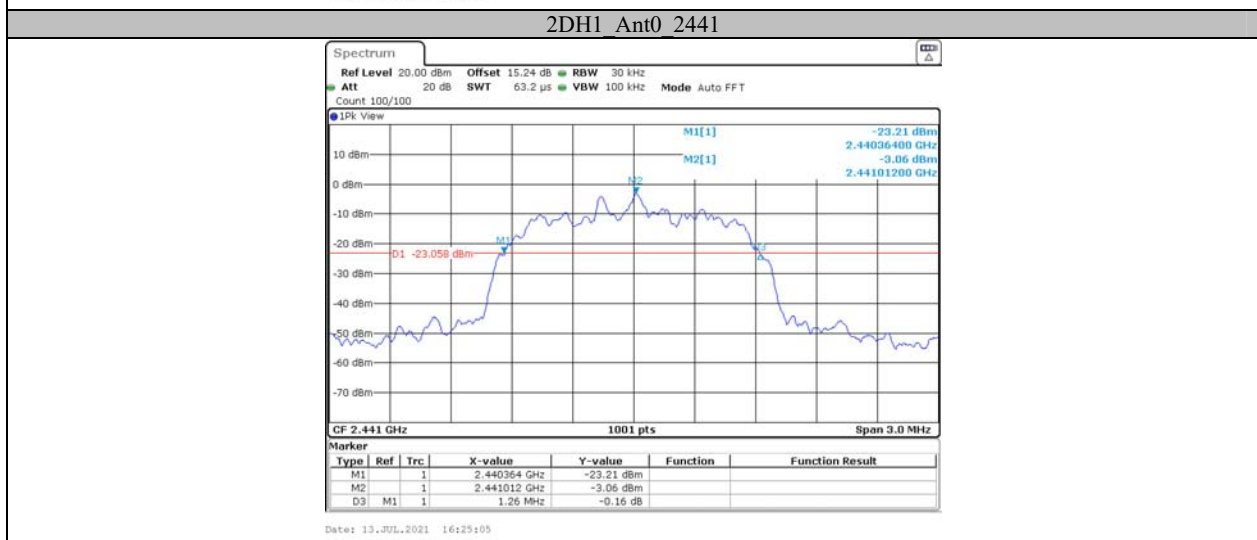
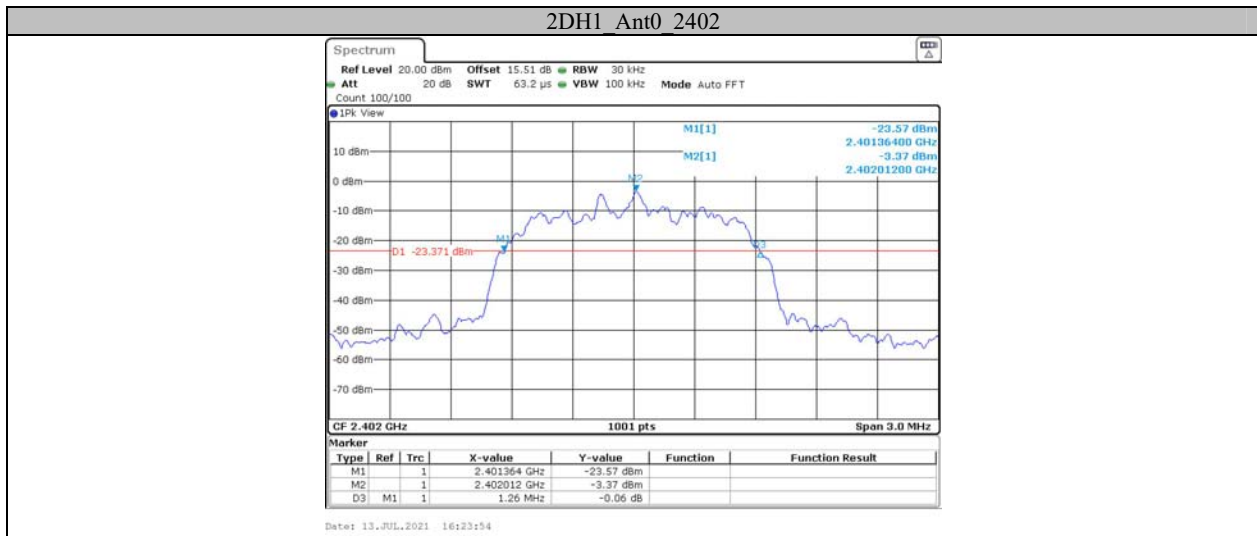
Test Result: Compliant. Please refer to the Appendix.

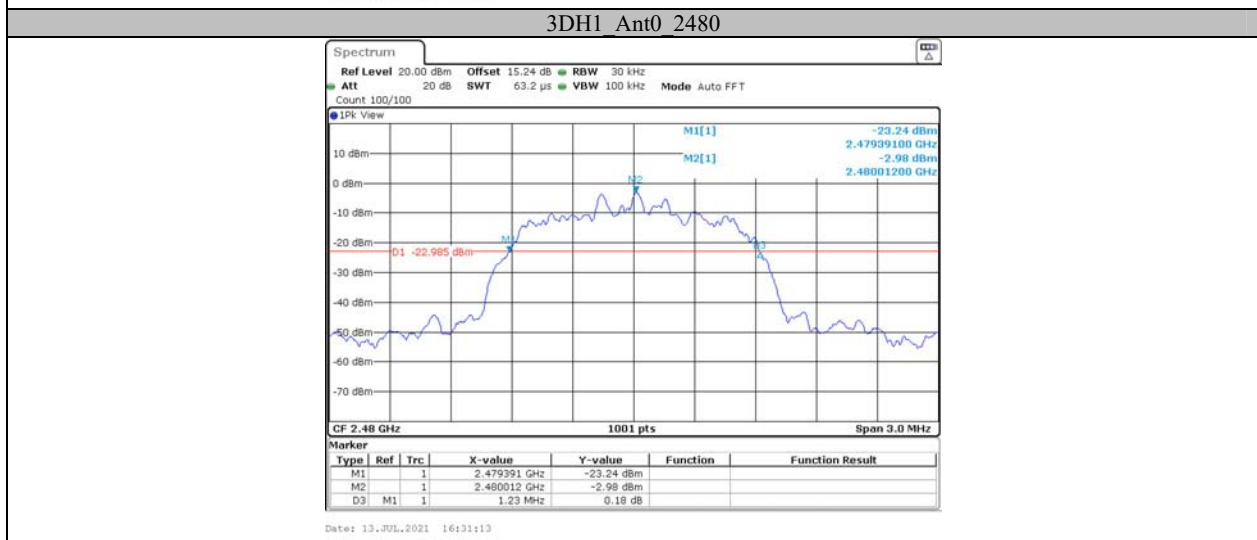
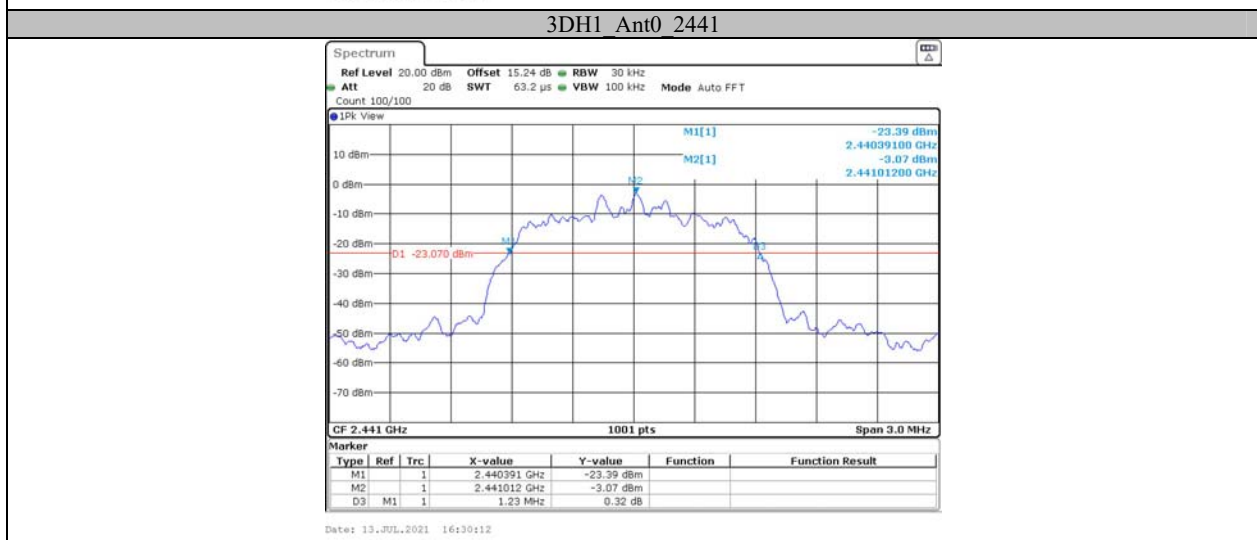
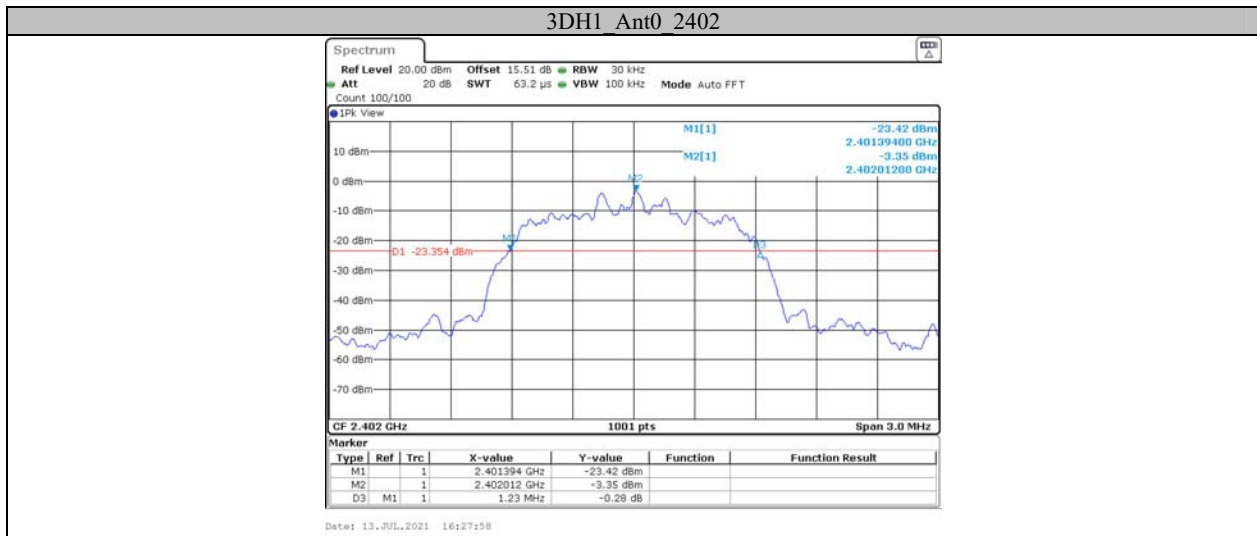
APPENDIX**Appendix A: 20dB Emission Bandwidth
Test Result**

Test Mode	Antenna	Channel	20db EBW[MHz]	Limit[MHz]	Verdict
DH1	Ant0	2402	0.846	---	PASS
		2441	0.870	---	PASS
		2480	0.873	---	PASS
2DH1	Ant0	2402	1.260	---	PASS
		2441	1.260	---	PASS
		2480	1.260	---	PASS
3DH1	Ant0	2402	1.230	---	PASS
		2441	1.230	---	PASS
		2480	1.230	---	PASS

Test Graphs



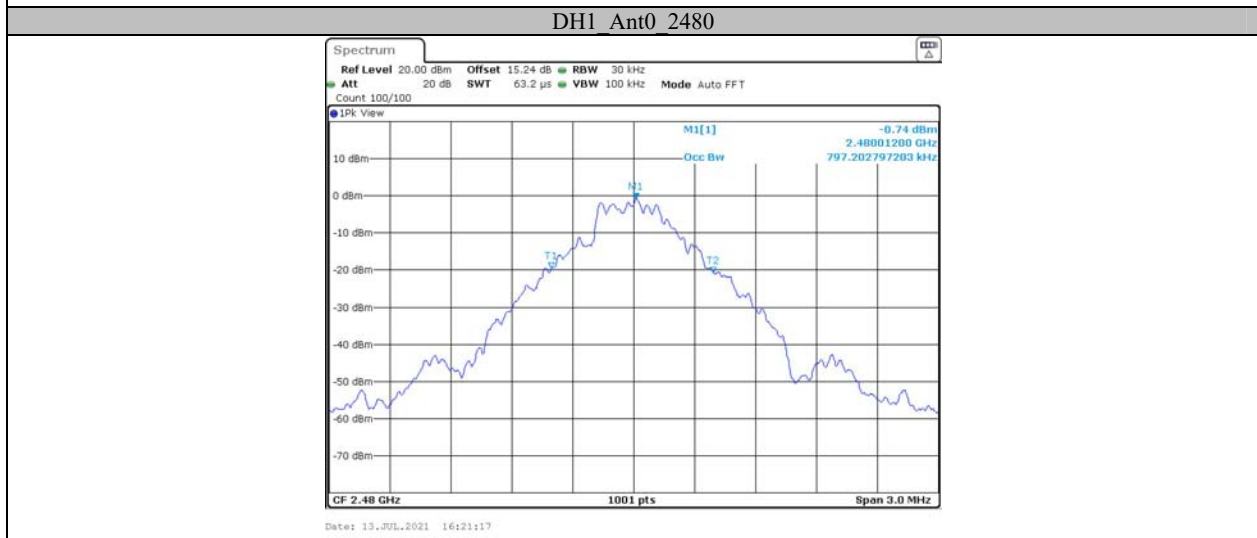
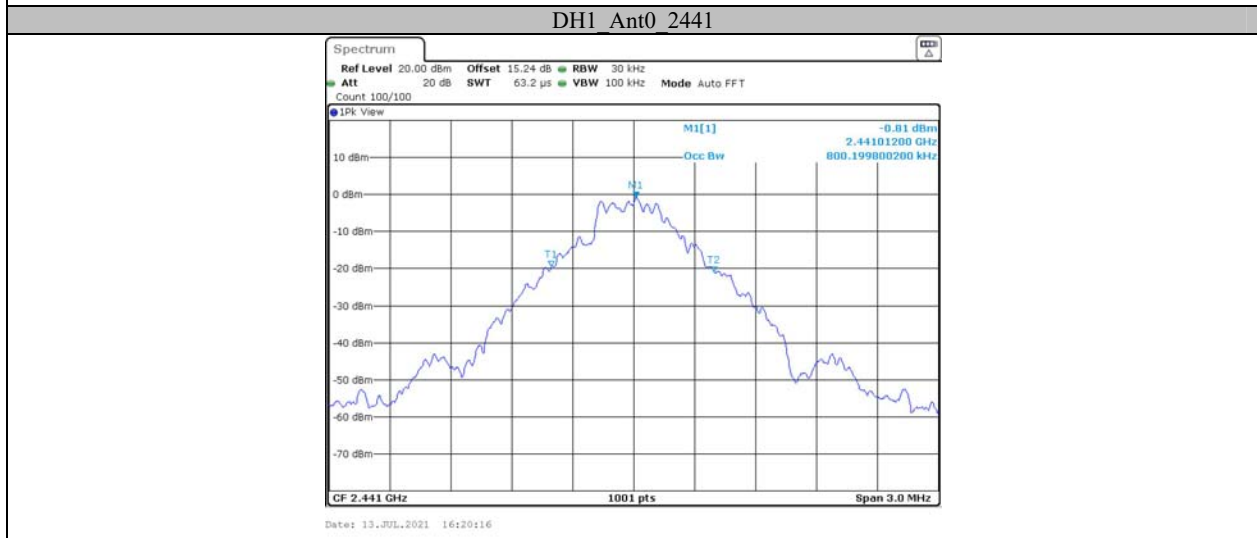
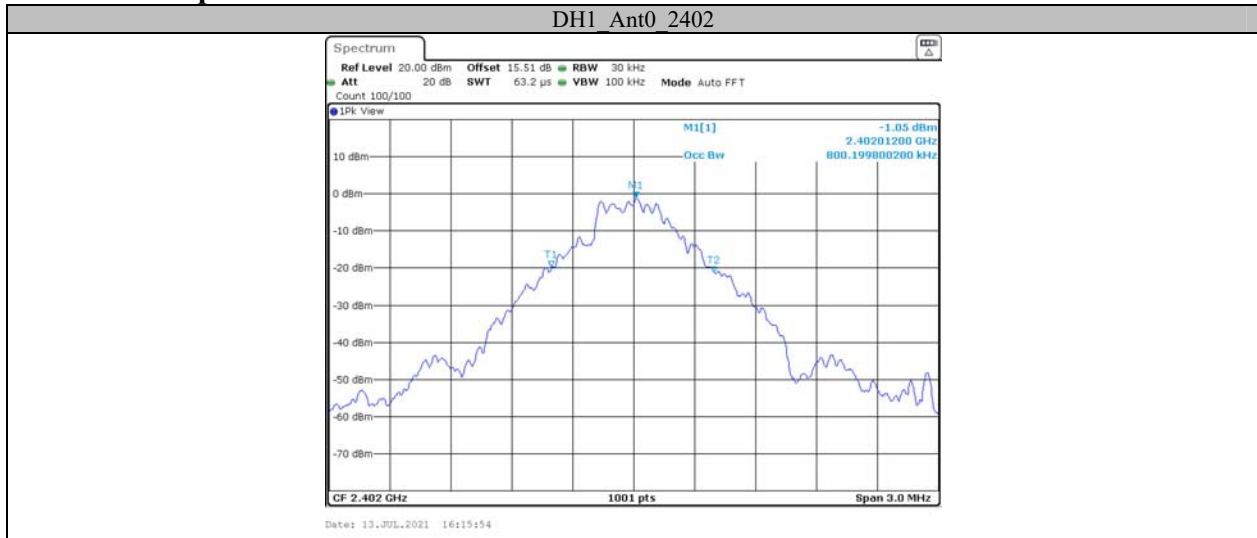


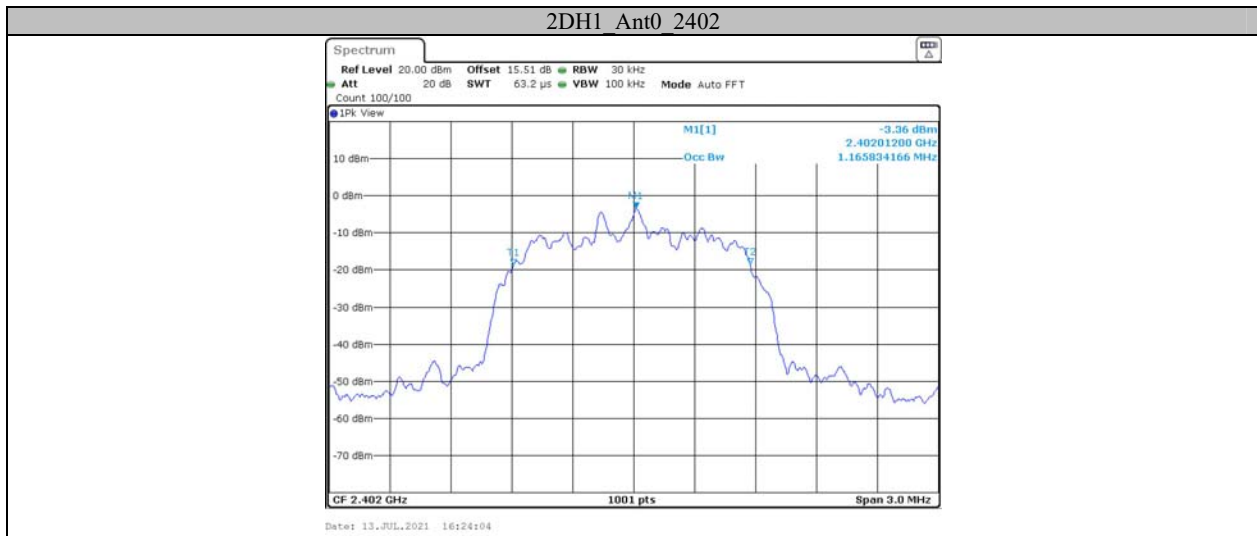


**Appendix B: Occupied Channel Bandwidth
Test Result**

Test Mode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
DH1	Ant0	2402	0.800	---	PASS
		2441	0.800	---	PASS
		2480	0.797	---	PASS
2DH1	Ant0	2402	1.166	---	PASS
		2441	1.166	---	PASS
		2480	1.169	---	PASS
3DH1	Ant0	2402	1.151	---	PASS
		2441	1.151	---	PASS
		2480	1.151	---	PASS

Test Graphs





3DH1 Ant0 2402



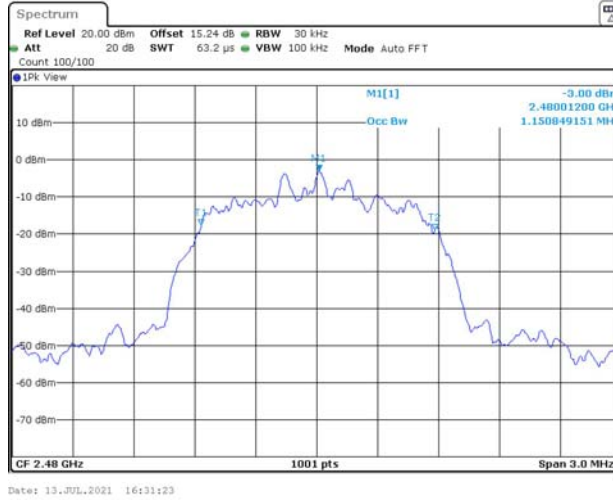
Date: 13.JUL.2021 16:28:08

3DH1 Ant0 2441



Date: 13.JUL.2021 16:30:22

3DH1 Ant0 2480

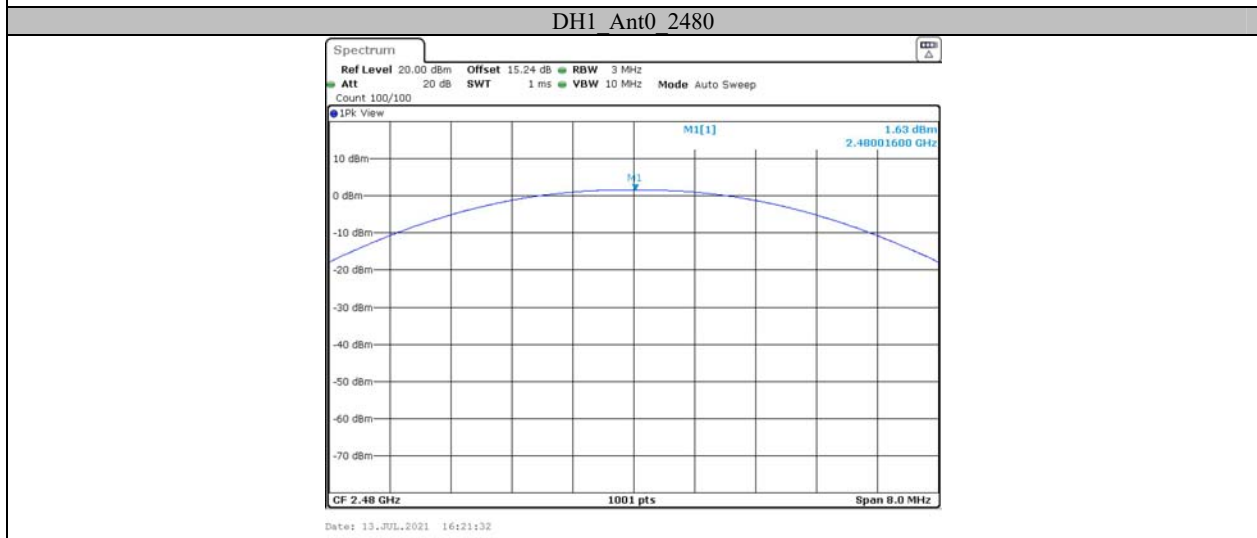
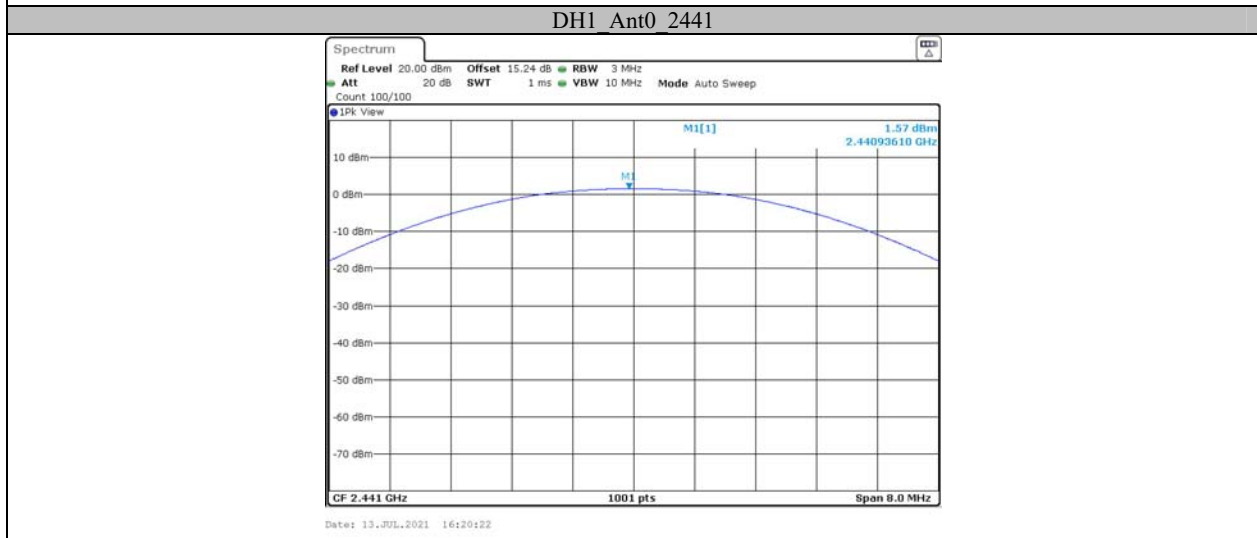
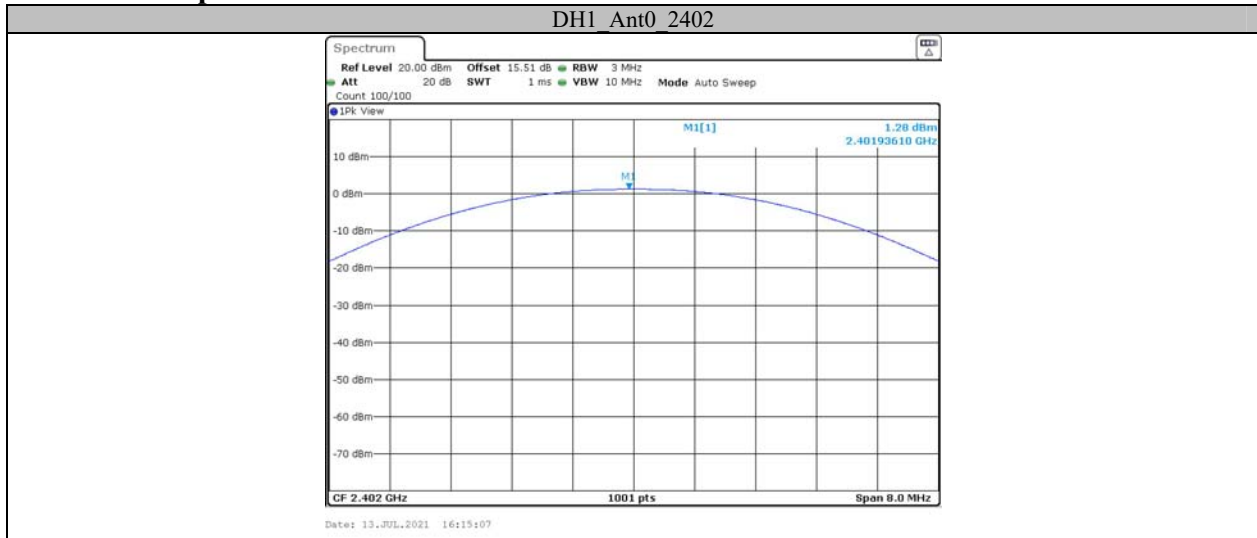


Date: 13.JUL.2021 16:31:23

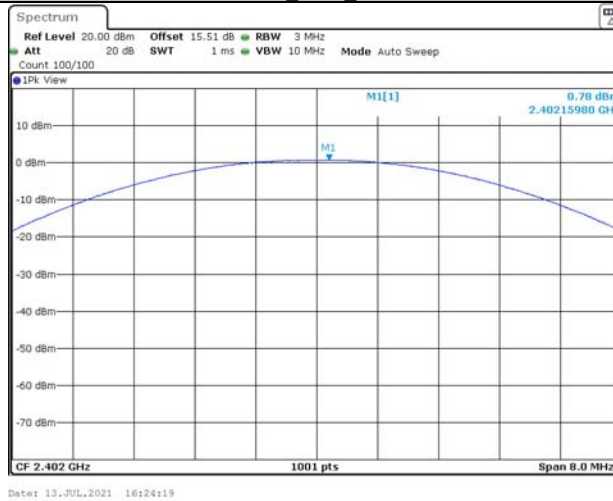
**Appendix C: Maximum conducted Peak output power
Test Result**

Test Mode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
DH1	Ant0	2402	1.28	≤ 30	PASS
		2441	1.57	≤ 30	PASS
		2480	1.63	≤ 30	PASS
2DH1	Ant0	2402	0.78	≤ 30	PASS
		2441	1.04	≤ 30	PASS
		2480	1.13	≤ 30	PASS
3DH1	Ant0	2402	1.27	≤ 30	PASS
		2441	1.53	≤ 30	PASS
		2480	1.63	≤ 30	PASS

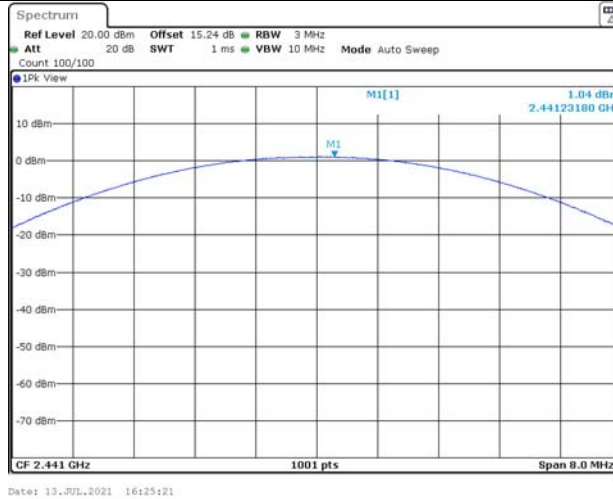
Test Graphs



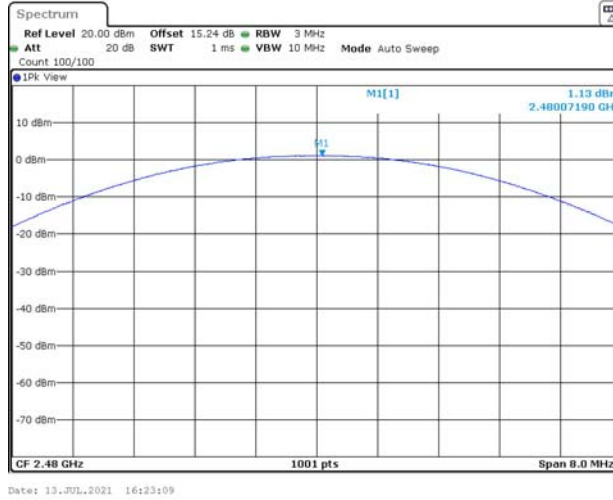
2DH1 Ant0 2402



2DH1 Ant0 2441



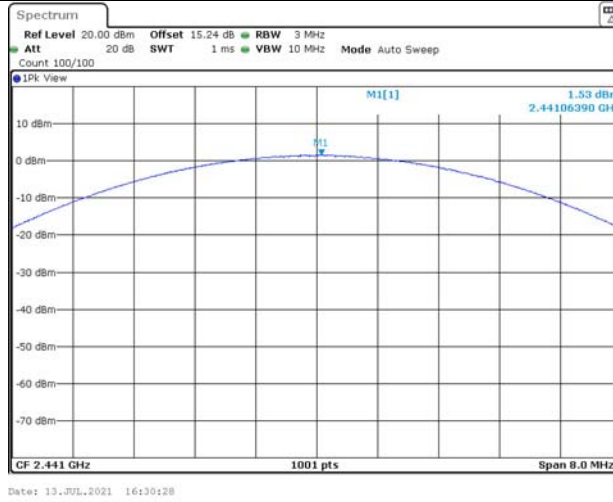
2DH1 Ant0 2480



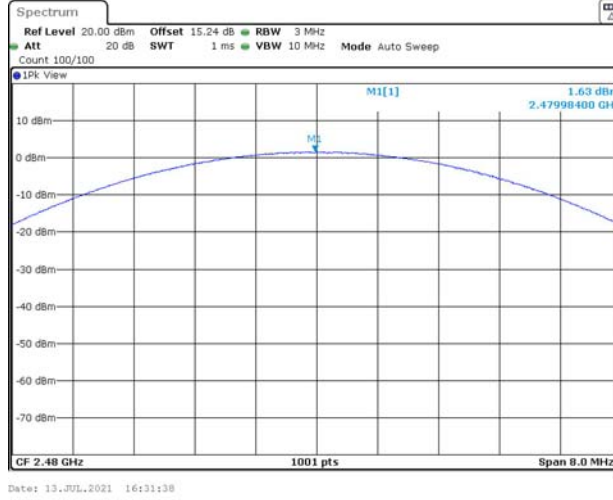
3DH1 Ant0 2402



3DH1 Ant0 2441



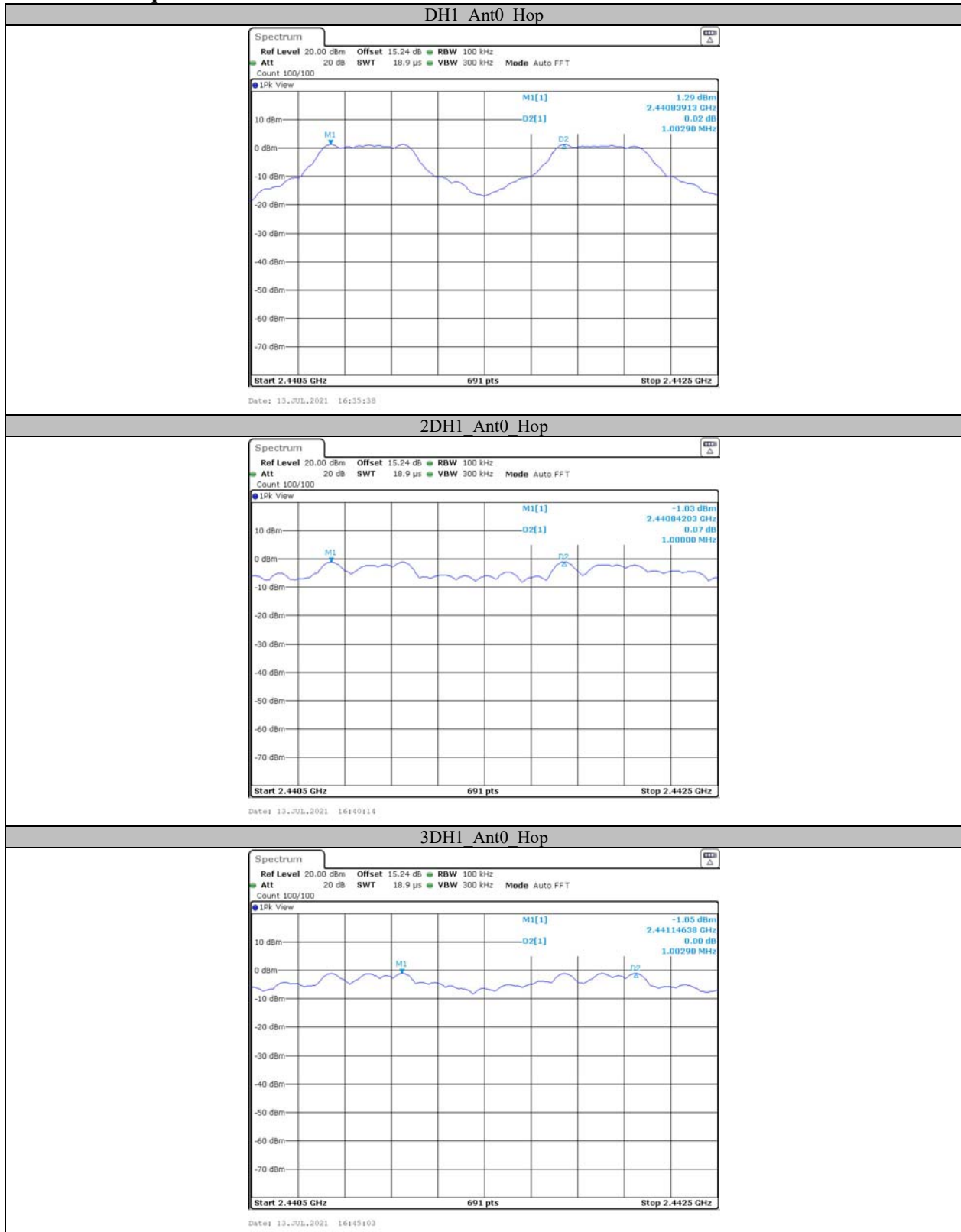
3DH1 Ant0 2480



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

Test Mode	Antenna	Channel	Result[MHz]	Limit[MHz]	Verdict
DH1	Ant0	Hop	1.003	≥ 0.580	PASS
2DH1	Ant0	Hop	1	≥ 0.840	PASS
3DH1	Ant0	Hop	1.003	≥ 0.820	PASS

Test Graphs



Appendix E: Time of occupancy Test Result

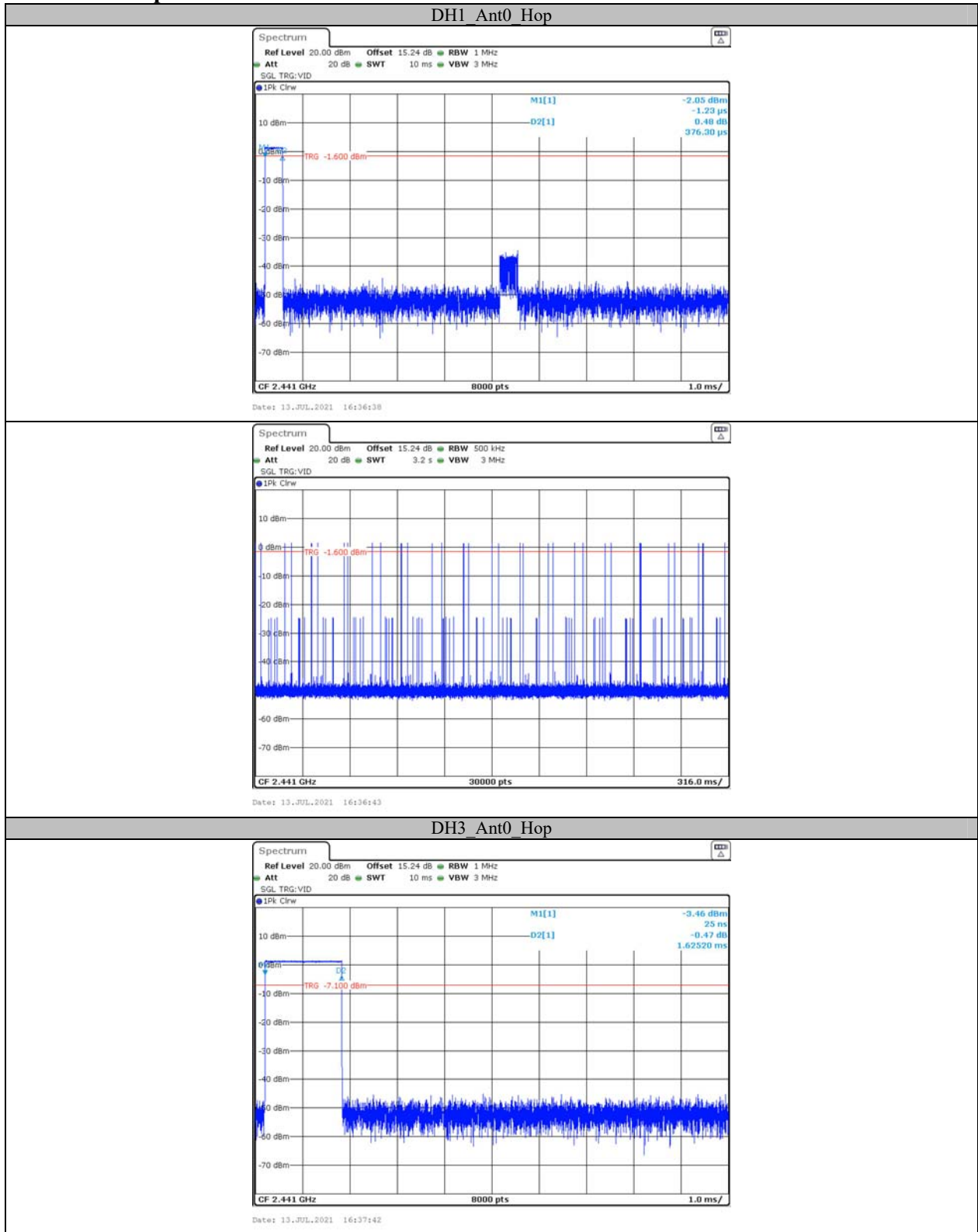
Test Mode	Antenna	Channel	Burst Width [ms]	Total Hops [Num]	Result[s]	Limit[s]	Verdict
DH1	Ant0	Hop	0.38	330	0.124	≤0.4	PASS
DH3	Ant0	Hop	1.63	150	0.244	≤0.4	PASS
DH5	Ant0	Hop	2.87	100	0.287	≤0.4	PASS
2DH1	Ant0	Hop	0.38	320	0.122	≤0.4	PASS
2DH3	Ant0	Hop	1.63	120	0.195	≤0.4	PASS
2DH5	Ant0	Hop	2.87	100	0.287	≤0.4	PASS
3DH1	Ant0	Hop	0.38	320	0.122	≤0.4	PASS
3DH3	Ant0	Hop	1.63	180	0.293	≤0.4	PASS
3DH5	Ant0	Hop	2.87	110	0.316	≤0.4	PASS

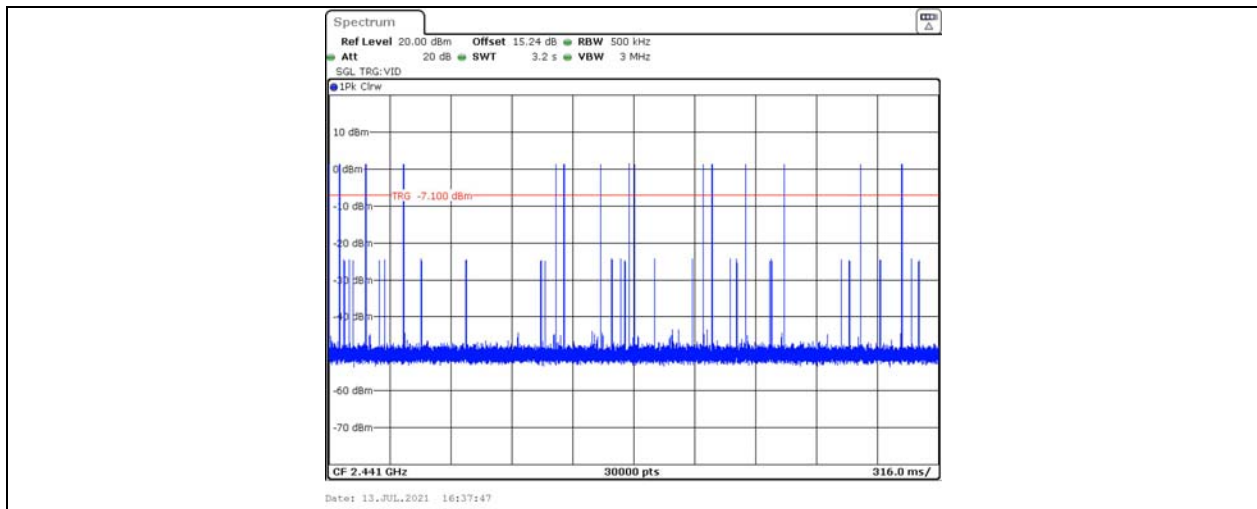
Note 1: A period time=0.4*79=31.6(S), Result=Burst Width*Total hops

Note 2: Total hops=Hopping Number in 3.16s*10

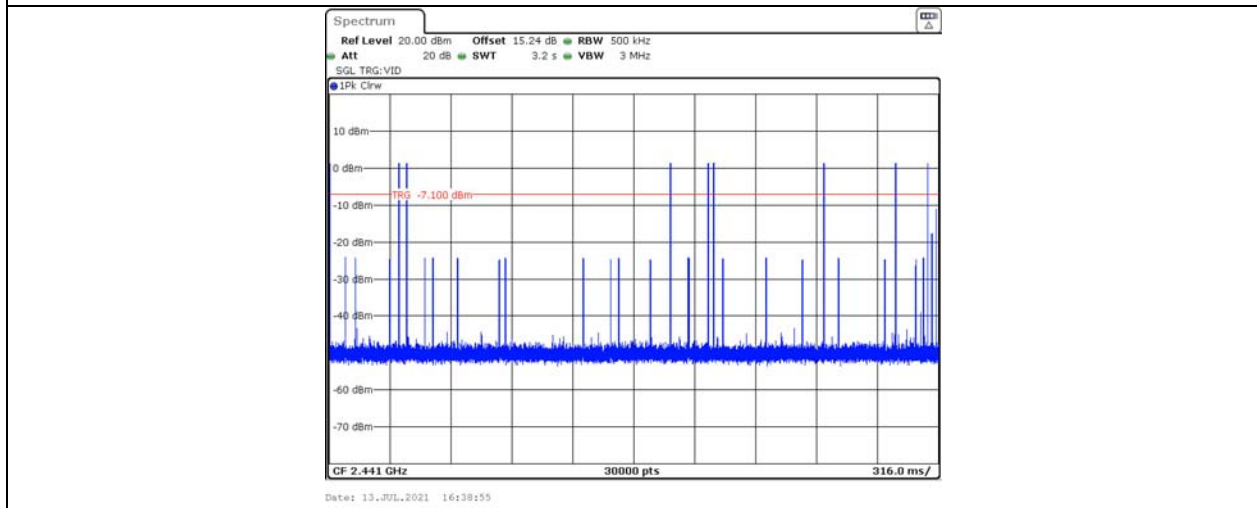
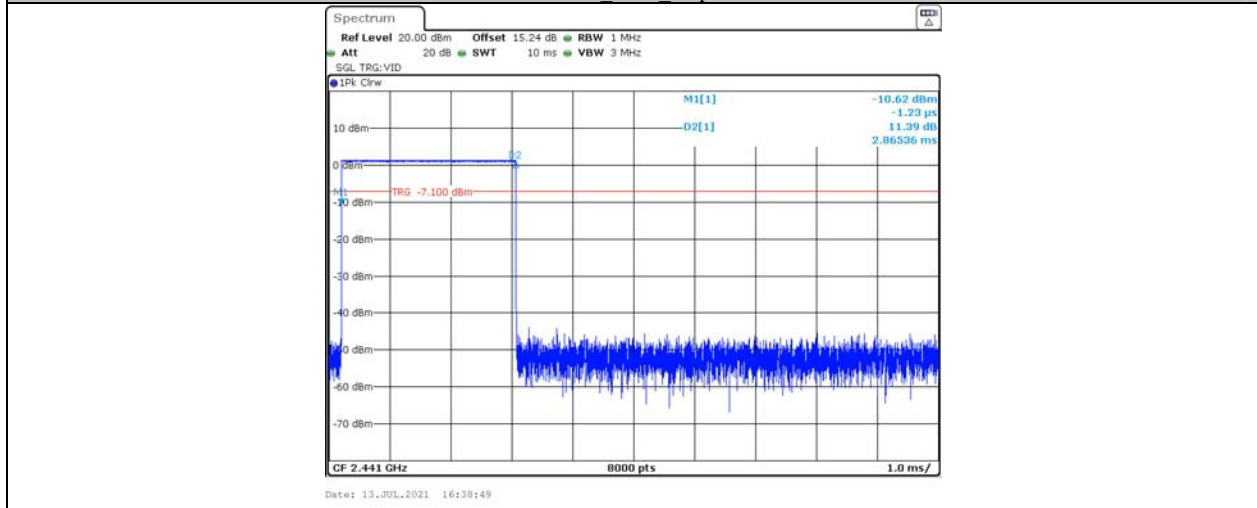
Note 3: Hopping Number in 3.16s=Total of highest signals in 3.16s(Second high signals were other channel)

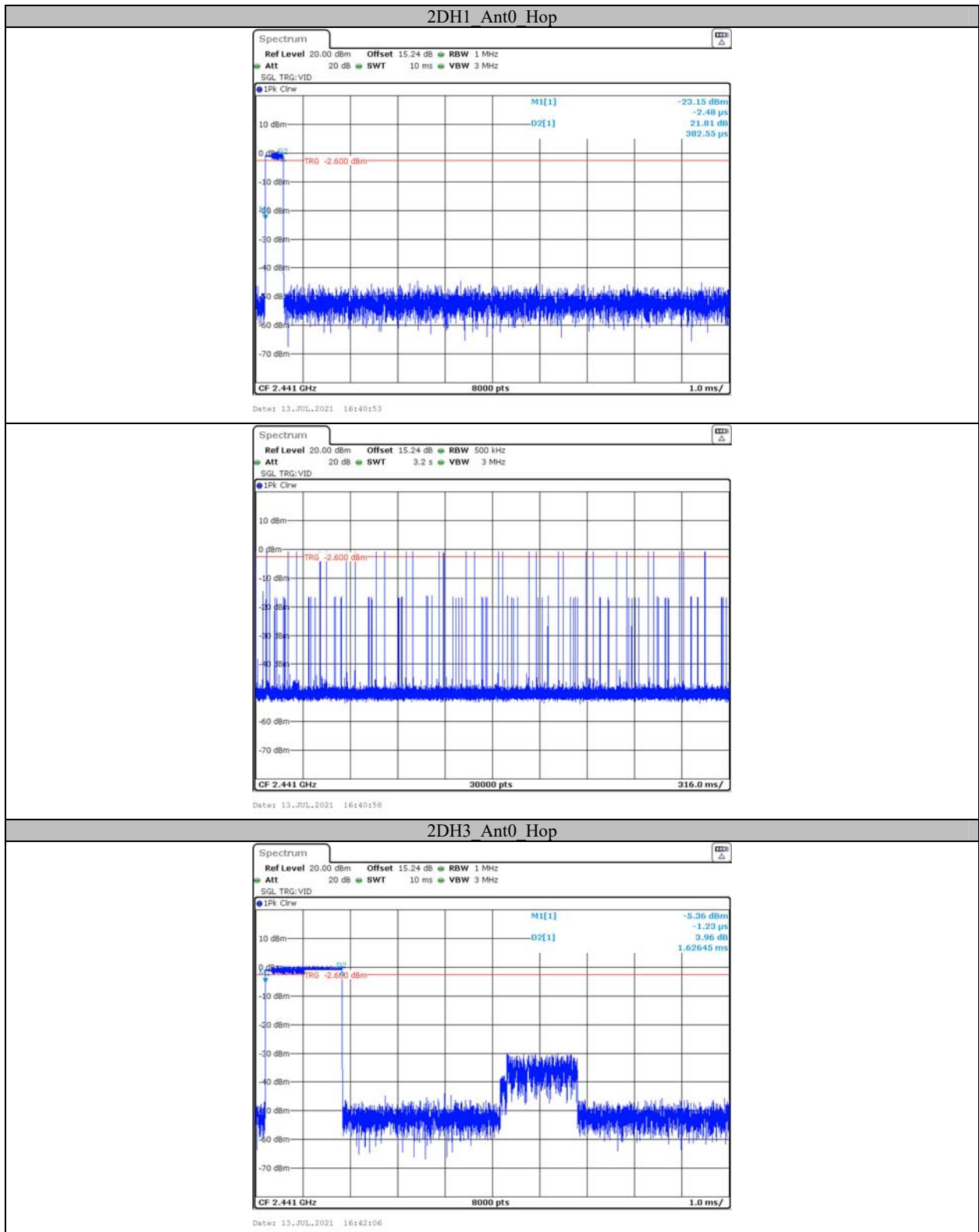
Test Graphs

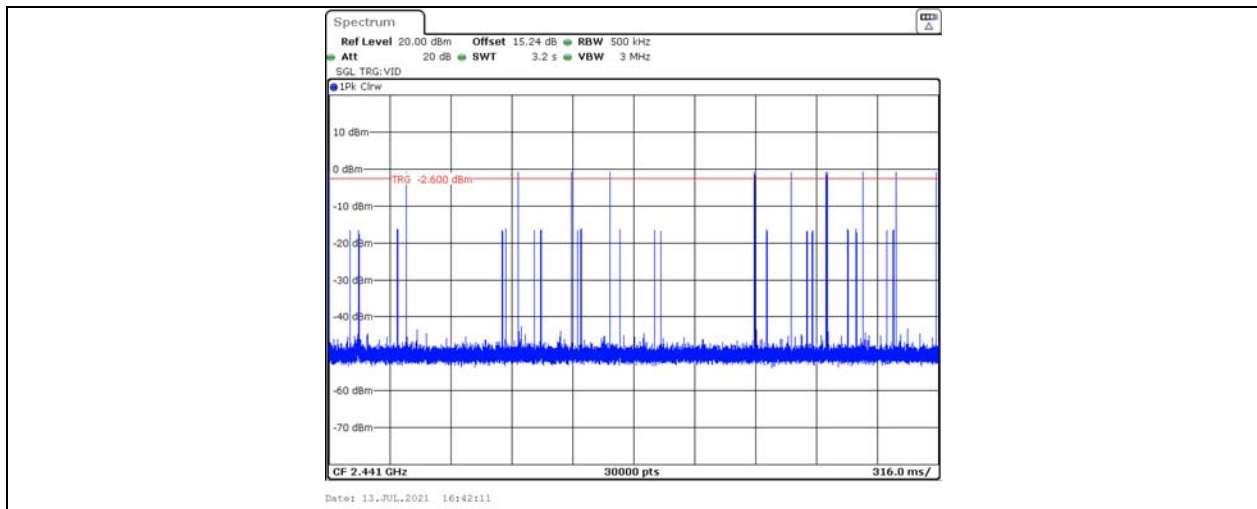




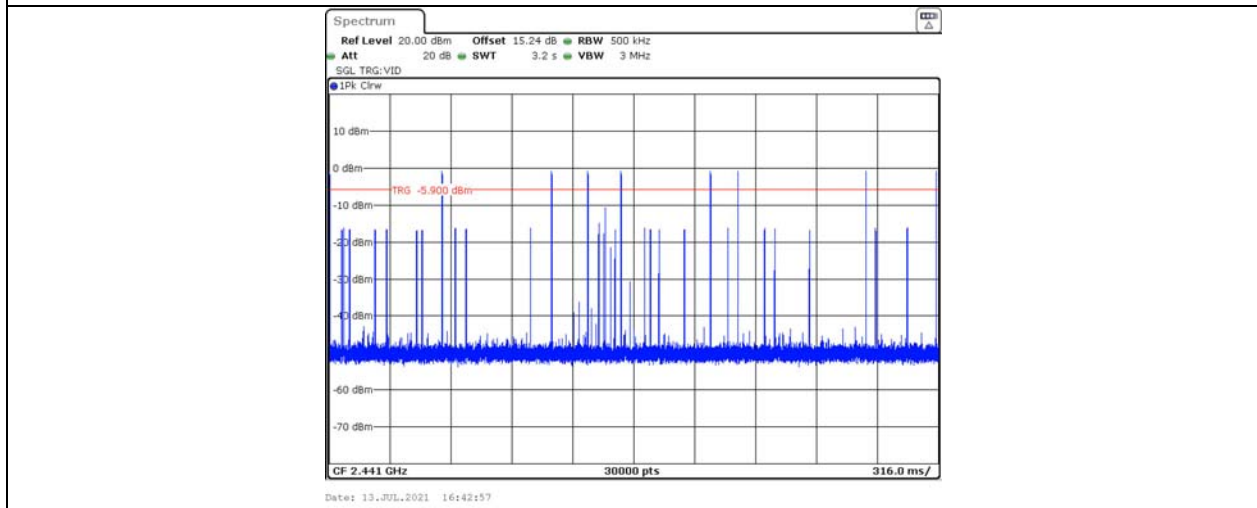
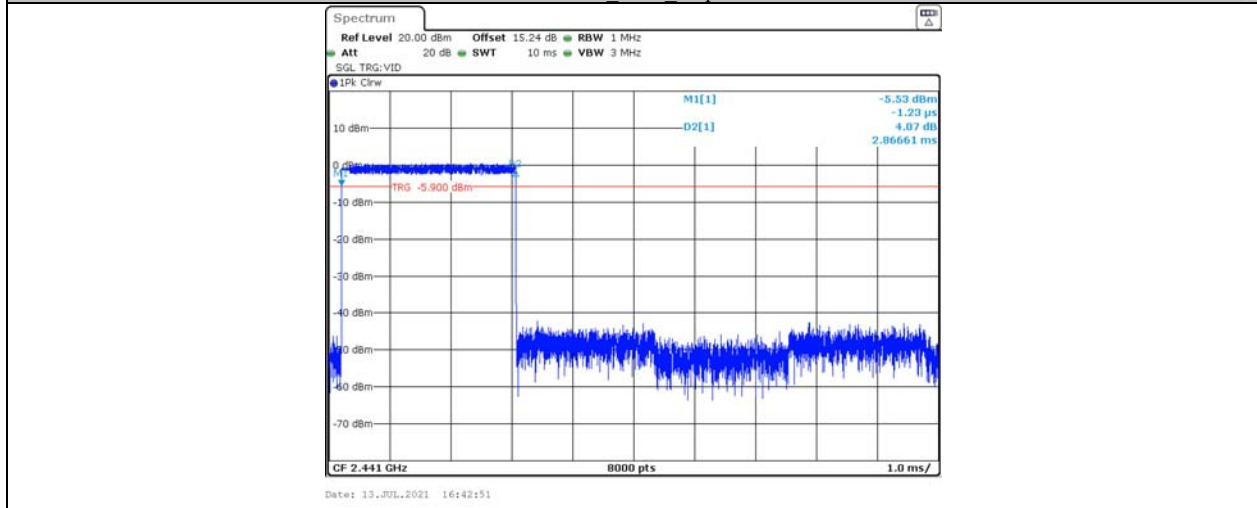
DH5 Ant0 Hop



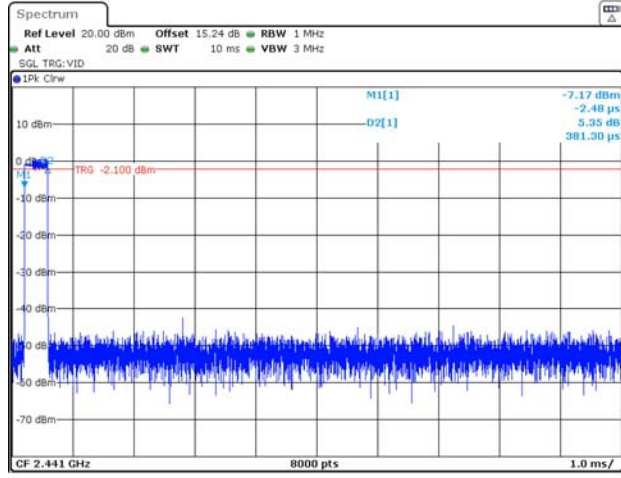




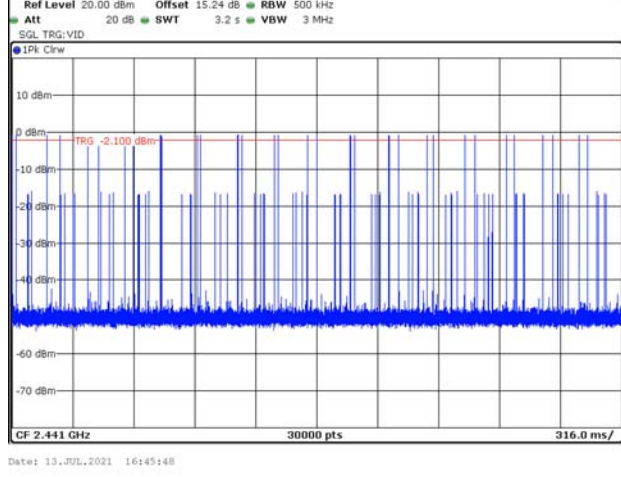
2DH5 Ant0 Hop



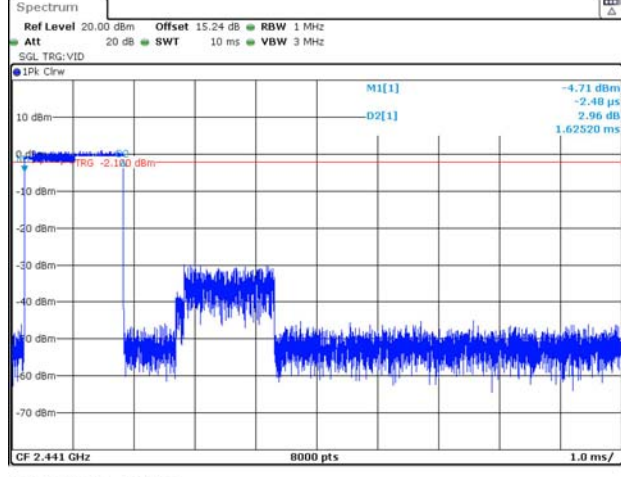
3DH1 Ant0 Hop

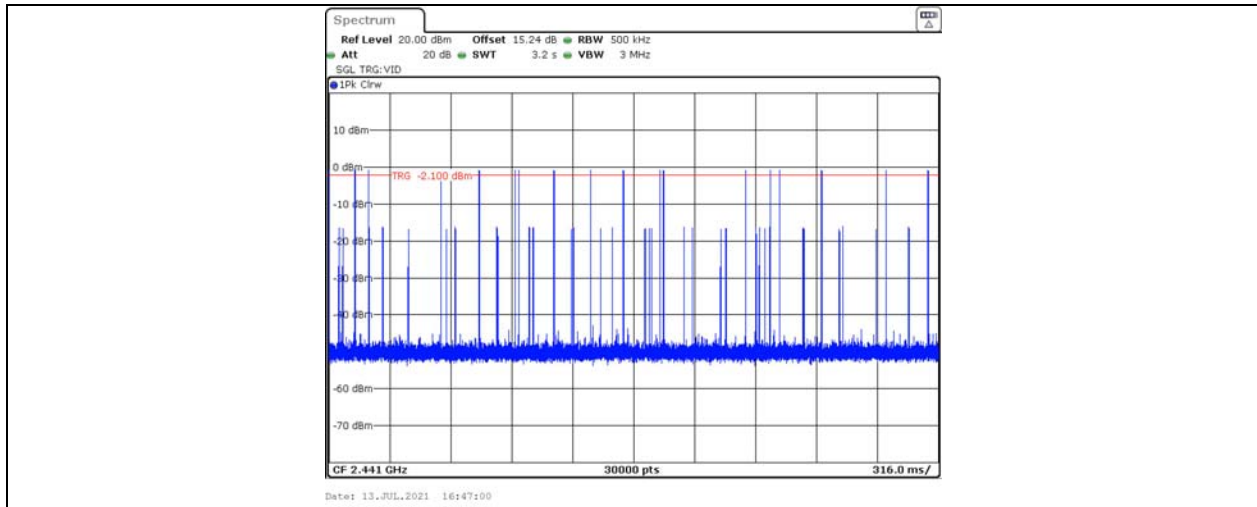


3DH3 Ant0 Hop

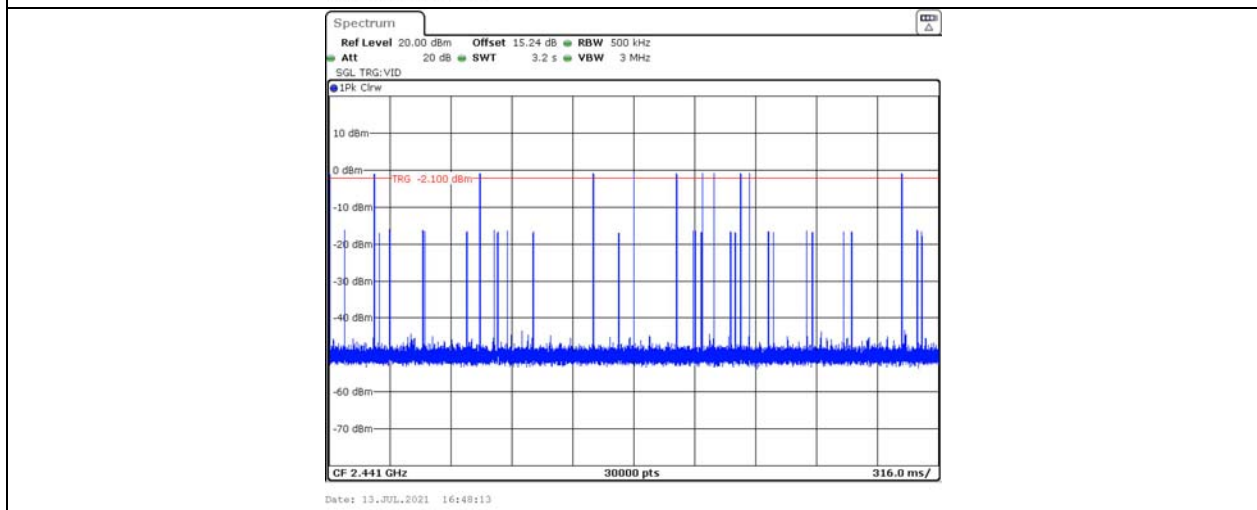
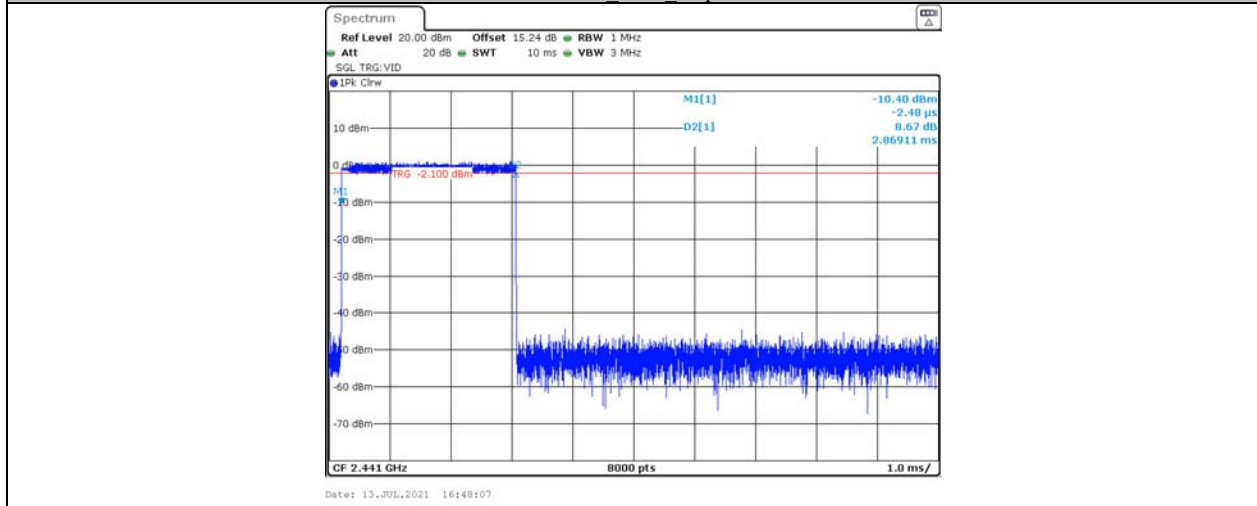


3DH1 Ant0 Hop





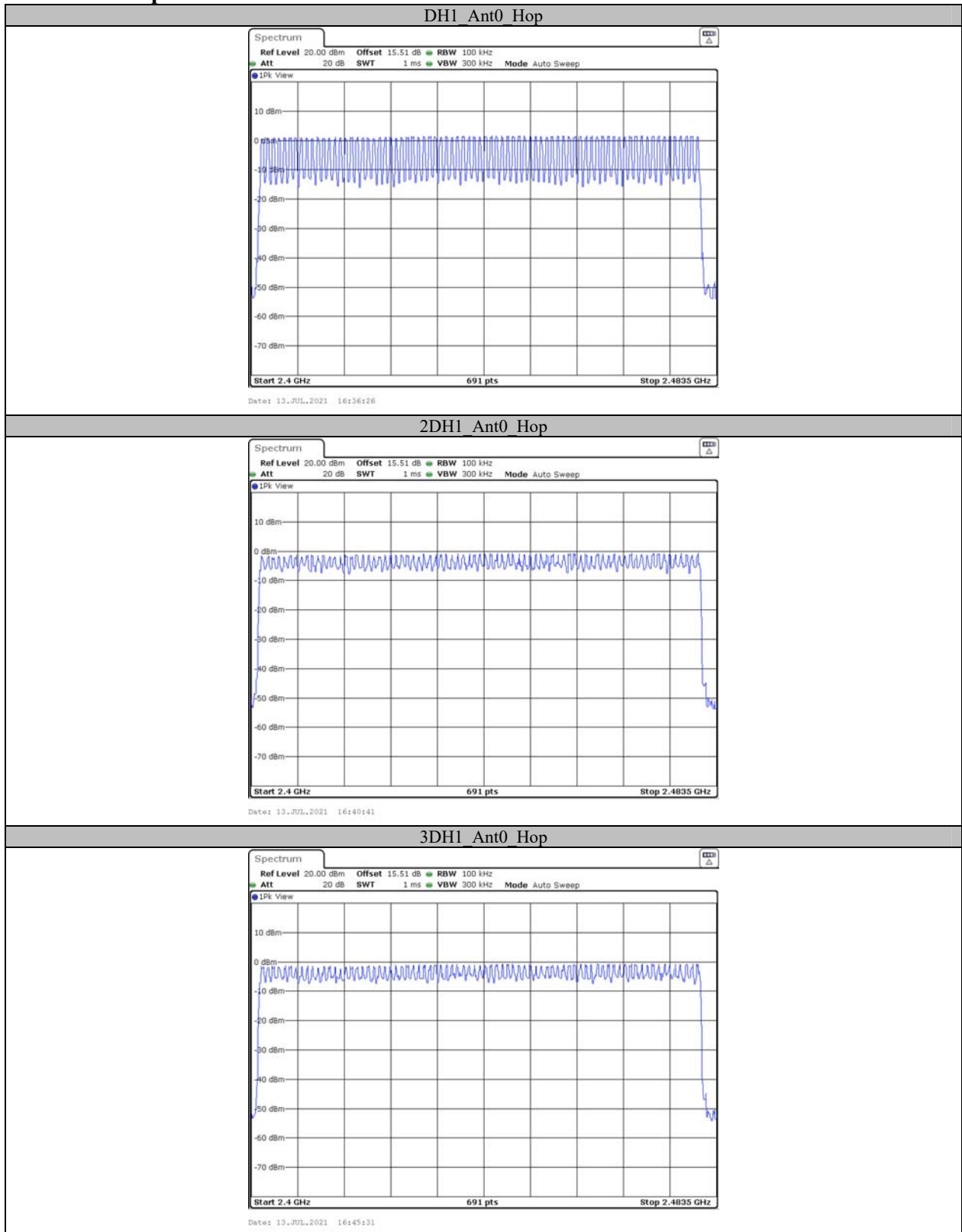
3DH5 Ant0 Hop



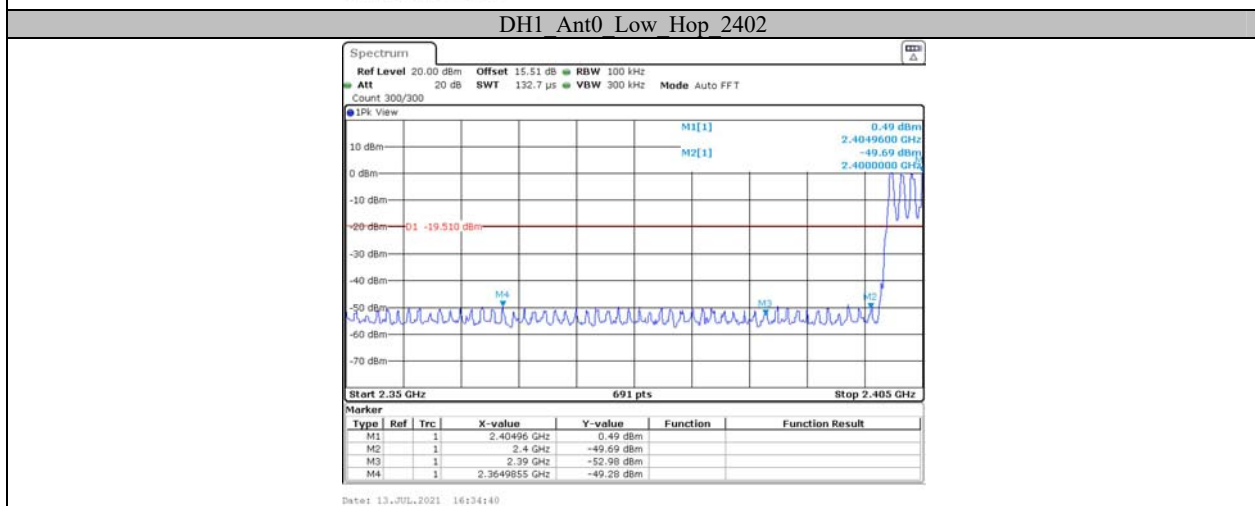
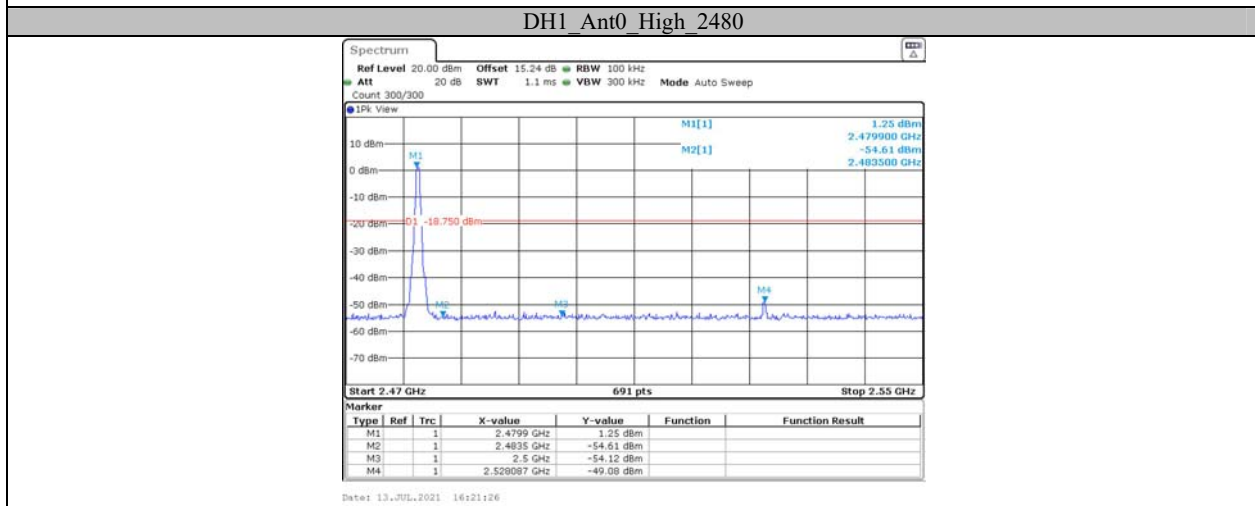
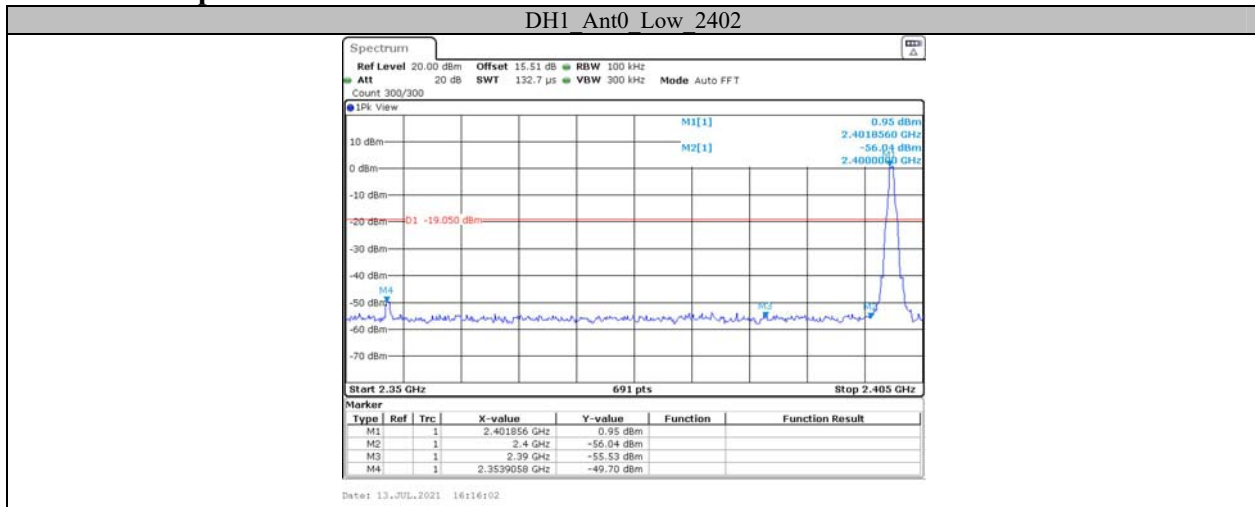
**Appendix F: Number of hopping channels
Test Result**

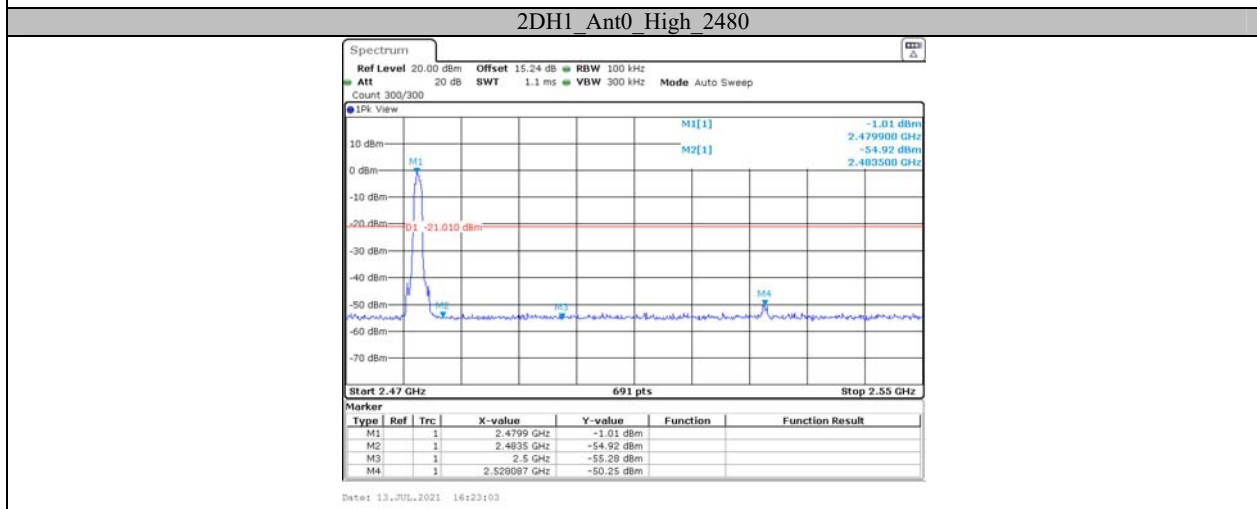
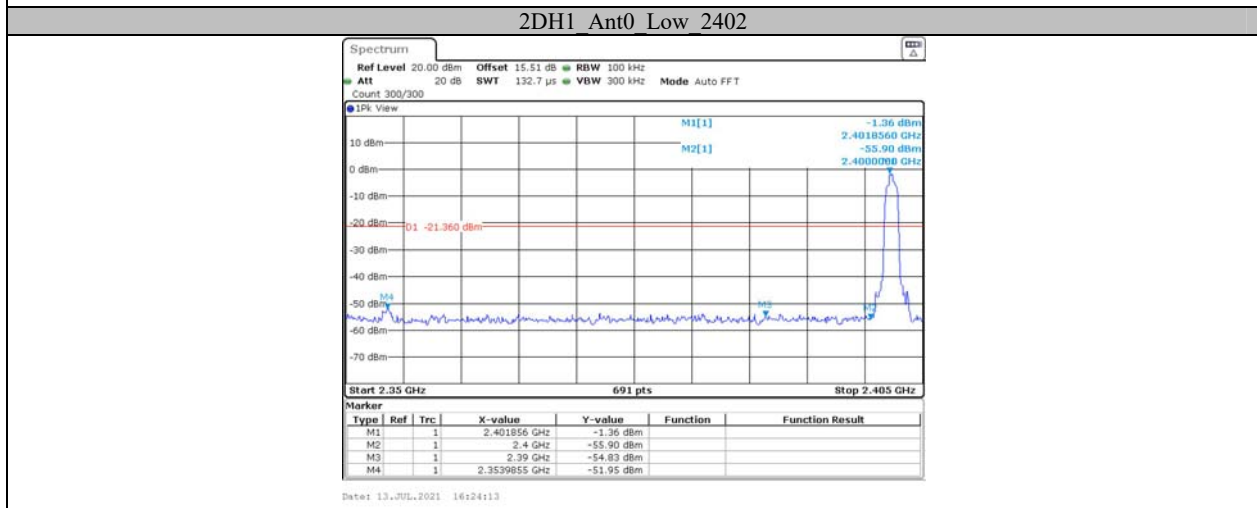
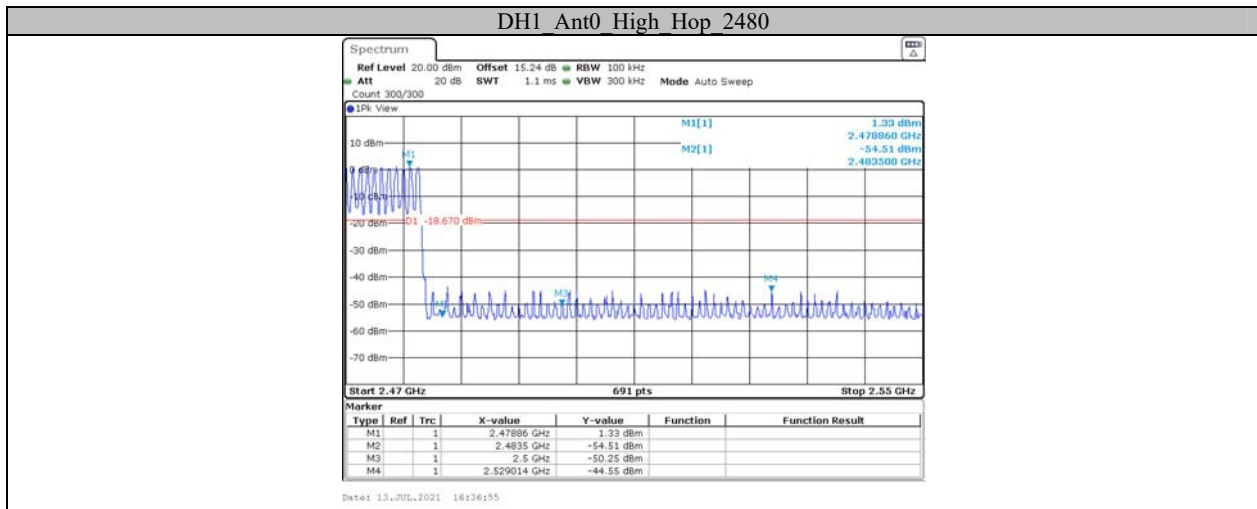
Test Mode	Antenna	Channel	Result[Num]	Limit[Num]	Verdict
DH1	Ant0	Hop	79	≥ 15	PASS
2DH1	Ant0	Hop	79	≥ 15	PASS
3DH1	Ant0	Hop	79	≥ 15	PASS

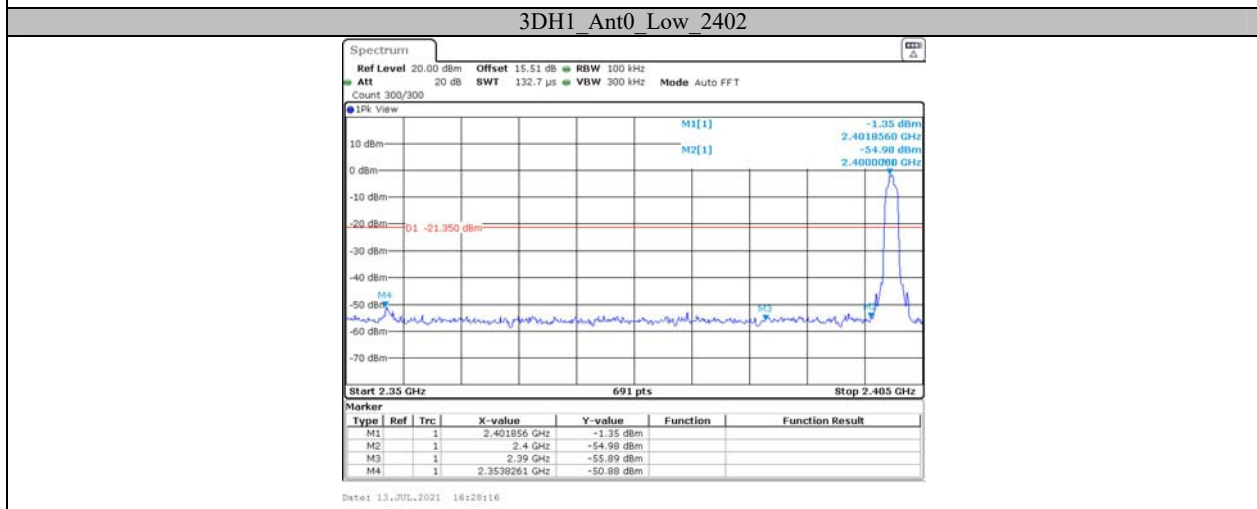
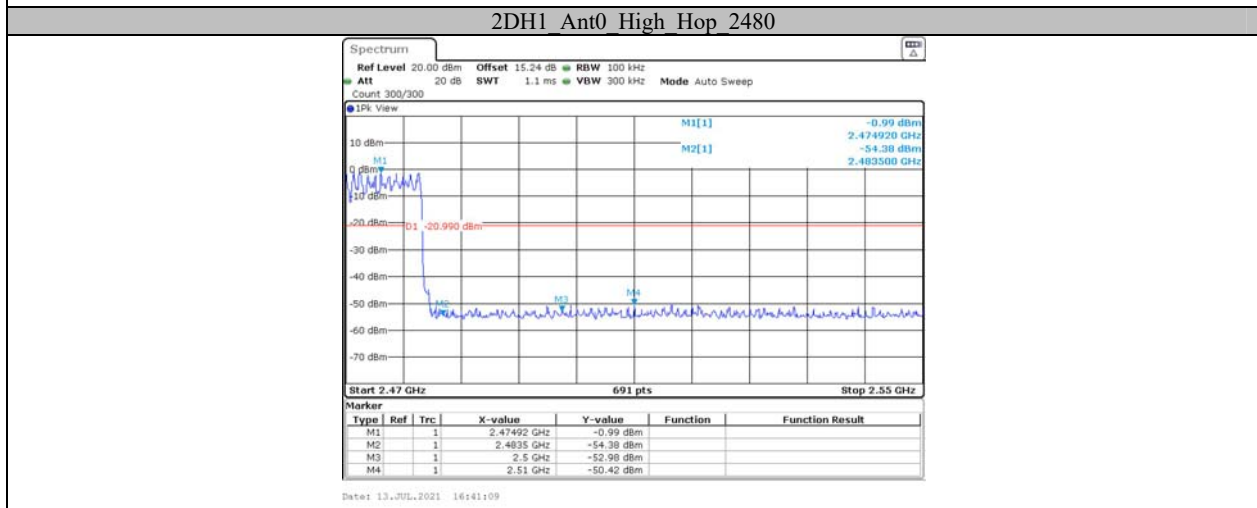
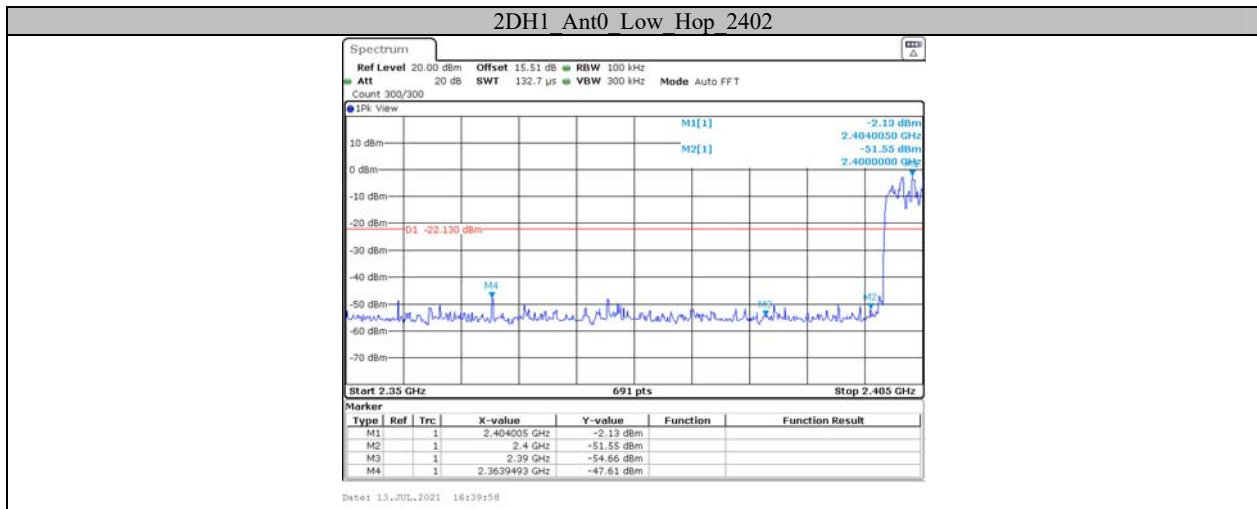
Test Graphs

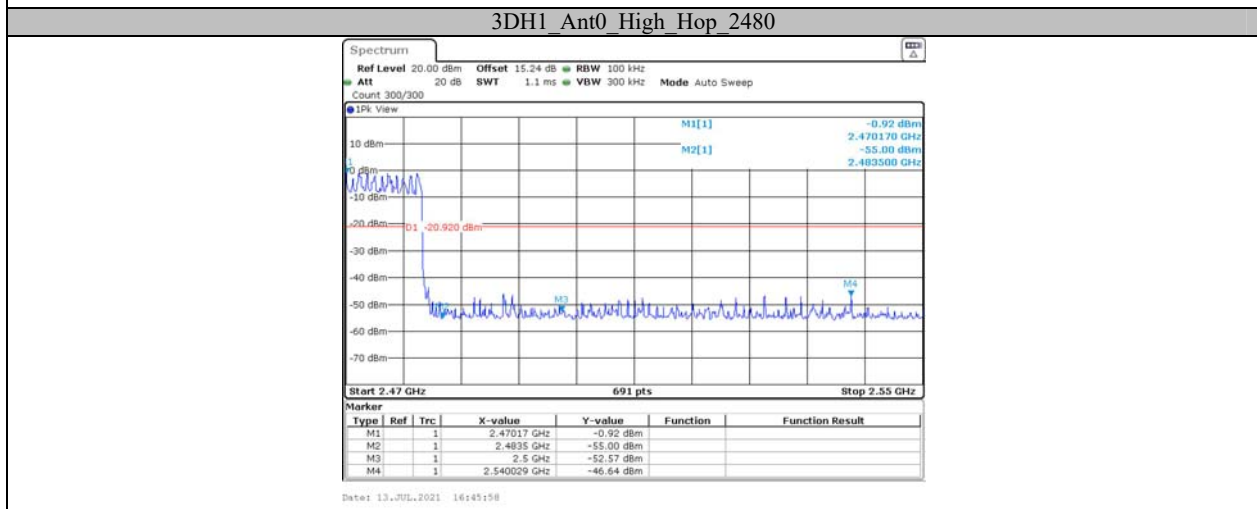
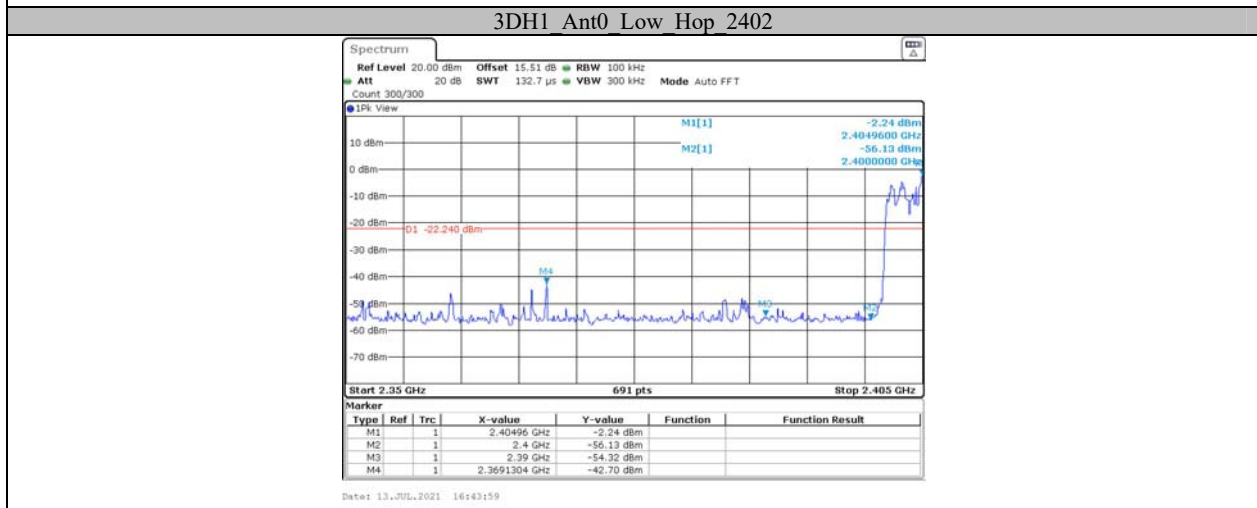
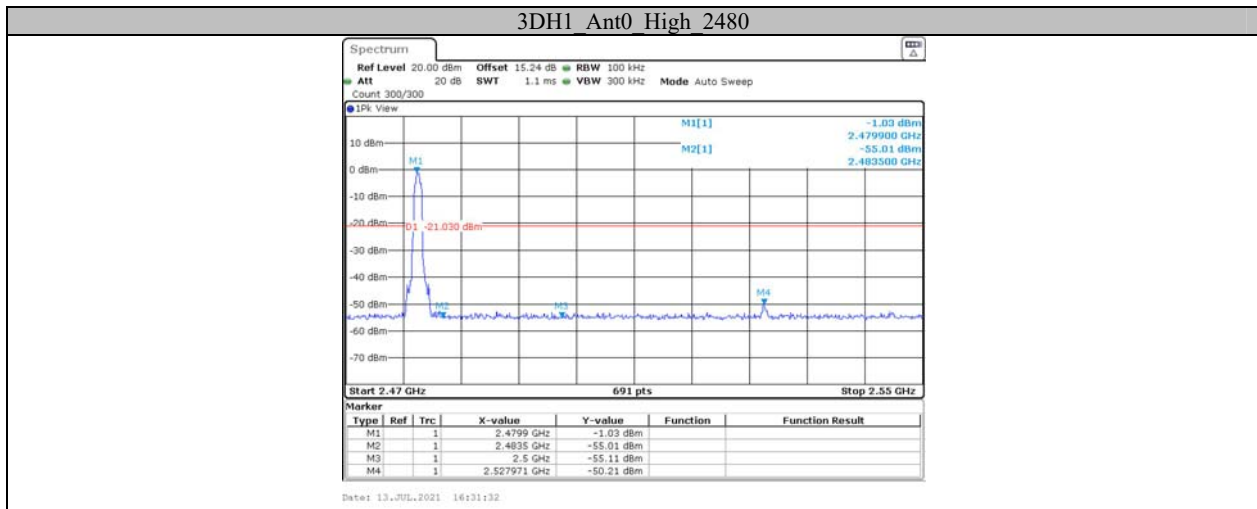


Appendix G: Band edge measurements Test Graphs









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