

TEST REPORT

Applicant Name : Vuzix Corporation
Address : FCC: 25 Hendrix Rd, West Henrietta, New York, United States
14586
ISED: 25 Hendrix Road West Henrietta NY 14586 United
States Of America (Excluding The States Of Alaska
Report Number : SZNS220425-16463E-RFA
FCC ID: 2AA9D-514
IC: 11503A-514

Test Standard (s)

FCC PART 15.247; RSS-GEN ISSUE 5, FEBRUARY 2021 AMENDMENT 2; RSS-247, ISSUE 2,
FEBRUARY 2017

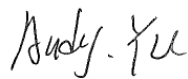
Sample Description

Product Type: Blade 2
Model No.: Model 514
Multiple Model(s) No.: N/A
Trade Mark: Vuzix
Date Received: 2022/04/25
Report Date: 2022/07/12

Test Result:	Pass*
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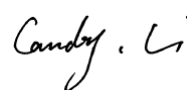
* In the configuration tested, the EUT complied with the standards above.

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 "★".

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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.....	6
BLOCK DIAGRAM OF TEST SETUP	7
SUMMARY OF TEST RESULTS	8
TEST EQUIPMENT LIST	9
FCC §1.1307&§2.1093 - RF EXPOSURE	10
APPLICABLE STANDARD	10
TEST RESULT	10
RSS-102– RF EXPOSURE.....	11
APPLICABLE STANDARD	11
FCC §15.203 & RSS-GEN §6.8 – ANTENNA REQUIREMENT.....	12
APPLICABLE STANDARD	12
ANTENNA CONNECTOR CONSTRUCTION	12
FCC §15.207 (A) & RSS-GEN § 8.8 – 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 §15.209, §15.205 & §15.247(D) & RSS-247§ 5.5 - SPURIOUS EMISSIONS	17
APPLICABLE STANDARD	17
EUT SETUP	17
EMI TEST RECEIVER & SPECTRUM ANALYZER SETUP	18
TEST PROCEDURE	18
FACTOR & MARGIN CALCULATION	18
TEST DATA	18
FCC §15.247(A) (1) & RSS-247 § 5.1 (B) -CHANNEL SEPARATION TEST	24
APPLICABLE STANDARD	24
TEST PROCEDURE	24
TEST DATA	24

FCC §15.247(A) (1) & RSS-247 § 5.1 (A), RSS-GEN § 6.7 – 20 DB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH	25
APPLICABLE STANDARD	25
TEST PROCEDURE	25
TEST DATA	26
TEST RESULT: COMPLIANT. PLEASE REFER TO THE APPENDIX.....	26
FCC §15.247(A) (1) (III) & RSS-247 § 5.1 (D) - QUANTITY OF HOPPING CHANNEL TEST.....	27
APPLICABLE STANDARD	27
TEST PROCEDURE	27
TEST DATA	27
FCC §15.247(A) (1) (III) & RSS-247 § 5.1 (D) - TIME OF OCCUPANCY (DWELL TIME)	28
APPLICABLE STANDARD	28
TEST PROCEDURE	28
TEST DATA	28
FCC §15.247(B) (1) & RSS-247§ 5.1(B) & § 5.4(B) - PEAK OUTPUT POWER MEASUREMENT.....	29
APPLICABLE STANDARD	29
TEST PROCEDURE	29
TEST DATA	29
FCC §15.247(D) & RSS-247 § 5.5 - BAND EDGES TESTING	30
APPLICABLE STANDARD	30
TEST PROCEDURE	30
TEST DATA	31
APPENDIX	32
APPENDIX A: 20dB EMISSION BANDWIDTH.....	32
APPENDIX B: OCCUPIED CHANNEL BANDWIDTH	36
APPENDIX C: MAXIMUM CONDUCTED PEAK OUTPUT POWER.....	40
APPENDIX D: CARRIER FREQUENCY SEPARATION	44
APPENDIX E: TIME OF OCCUPANCY	46
APPENDIX F: NUMBER OF HOPPING CHANNELS	53
APPENDIX G: BAND EDGE MEASUREMENTS	55

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

HVIN	514
FVIN	514
Frequency Range	Bluetooth: 2402~2480MHz
Transmit Peak Power	6.72dBm
Modulation Technique	Bluetooth: GFSK, $\pi/4$ -DQPSK, 8DPSK
Antenna Specification*	2.1dBi (It is provided by the applicant)
Voltage Range	DC3.7V from battery
Sample serial number	SZNS220425-16463E-RF-S1 for Conducted and Radiated Emissions SZNS220425-16463E-RF-S2 for RF Conducted Test (Assigned by ATC)
Sample/EUT Status	Good condition

Objective

This test report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commissions rules and RSS-247, Issue 2, February 2017, RSS-GEN Issue 5, Feb. 2021 Amendment 2 of the Innovation, Science and Economic Development Canada 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 and RSS-247, Issue 2, February 2017, RSS-GEN Issue 5, Feb. 2021 Amendment 2 of the Innovation, Science and Economic Development Canada rules.

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		0.082×10^{-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℃
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 4297.01

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier: CN0016. 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 10*. The 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

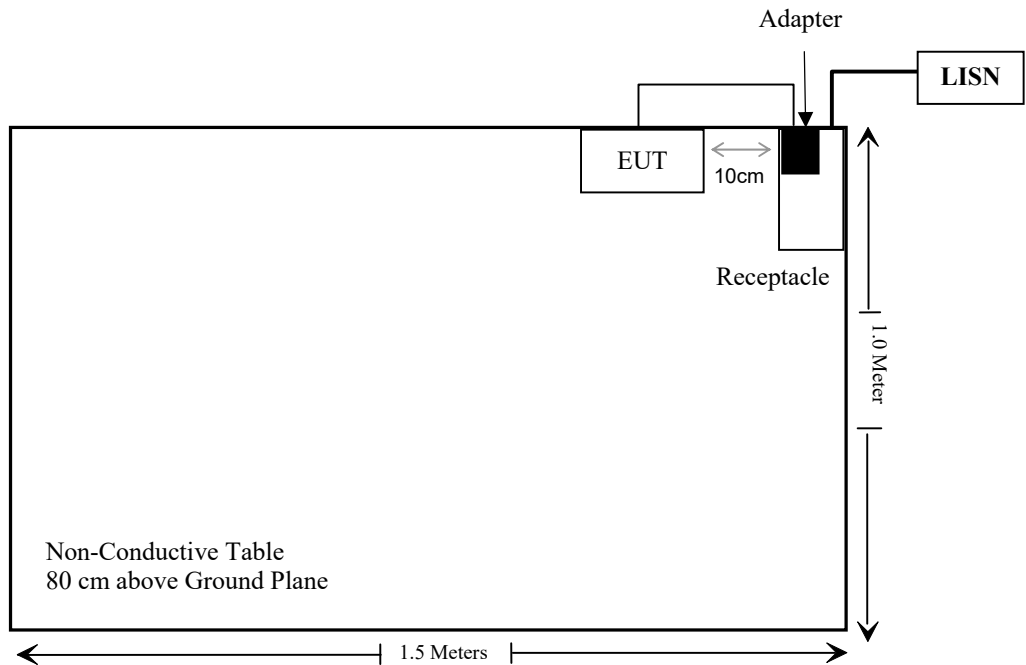
Manufacturer	Description	Model	Serial Number
Chillax Care Limited	Adapter	S005CAU0500100	Unknown

External I/O Cable

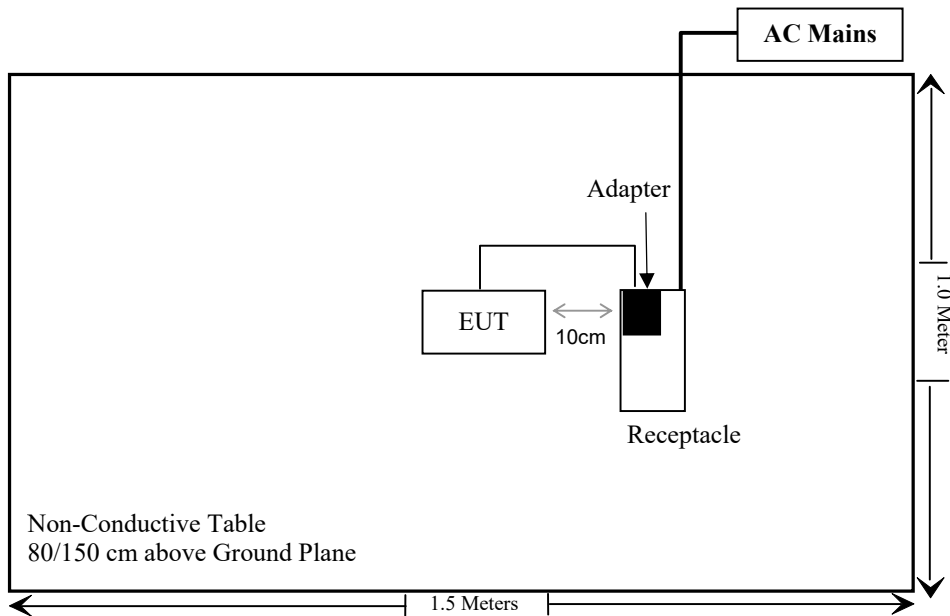
Cable Description	Length (m)	From Port	To
Un-shielding Detachable USB Cable	1.0	EUT	Adapter

Block Diagram of Test Setup

For conducted emission



For Radiated Emissions:



SUMMARY OF TEST RESULTS

Rules	Description of Test	Result
FCC §1.1307&§2.1093	RF EXPOSURE	Compliant
RSS-102	RF EXPOSURE	Compliant
FCC §15.203 RSS-Gen §6.8	Antenna Requirement	Compliant
FCC §15.207(a) RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
FCC §15.205, §15.209, §15.247(d) RSS-247 § 5.5, RSS-GEN § 8.10	Radiated Emissions	Compliant
FCC §15.247(a)(1) RSS-247 § 5.1(a), RSS-GEN § 6.7	20 dB Emission Bandwidth & 99% Occupied Bandwidth	Compliant
FCC §15.247(a)(1) RSS-247 § 5.1 (b)	Channel Separation Test	Compliant
FCC §15.247(a)(1)(iii) RSS-247 § 5.1 (d)	Time of Occupancy (Dwell Time)	Compliant
FCC §15.247(a)(1)(iii) RSS-247 § 5.1 (d)	Quantity of hopping channel Test	Compliant
FCC §15.247(b)(1) RSS-247 § 5.1(b) & § 5.4(b)	Peak Output Power Measurement	Compliant
FCC §15.247(d) RSS-247 § 5.5	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	100784	2021/12/13	2022/12/12
Rohde & Schwarz	L.I.S.N.	ENV216	101314	2021/12/13	2022/12/12
NARDA	Magnetic field tester	2300/90.10	B-0137	2021/12/22	2022/12/21
Unknown	RF Coaxial Cable	No.17	N0350	2021/12/14	2022/12/13
Conducted Emission Test Software: e3 19821b (V9)					
Radiated Emissions Test					
Rohde& Schwarz	Test Receiver	ESR	102725	2021/12/13	2022/12/12
Rohde&Schwarz	Spectrum Analyzer	FSV40	101949	2021/12/13	2022/12/12
SONOMA INSTRUMENT	Amplifier	310 N	186131	2021/11/09	2022/11/08
A.H. Systems, inc.	Preamplifier	PAM-0118P	135	2021/11/09	2022/11/08
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2021/11/11	2022/11/10
Schwarzbeck	Bilog Antenna	VULB9163	9163-323	2021/07/06	2024/07/05
Schwarzbeck	Horn Antenna	BBHA9120D	9120D-1067	2020/01/05	2023/01/04
Schwarzbeck	HORN ANTENNA	BBHA9170	9170-359	2020/01/05	2023/01/04
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.11	N1000	2021/12/14	2022/12/13
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
Unknown	RF Coaxial Cable	No.15	N600	2021/12/14	2022/12/13
Unknown	RF Coaxial Cable	No.16	N650	2021/12/14	2022/12/13
Wainwright	High Pass Filter	WHKX3.6/18 G-10SS	5	2021/12/14	2022/12/13
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
Unknown	RF Coaxial Cable	No.31	RF-01	Each time	
Unknown	RF Cable	Unknown	1	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 §1.1307&§2.1093 - RF EXPOSURE

Applicable Standard

FCC§1.1310 and §2.1093.

Test Result

Compliance, please refer to the SAR report: SZNS220425-16463E-20

RSS-102– RF EXPOSURE

Applicable Standard

According to RSS-102, systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

Result: Compliance.

Please refer to SAR Report Number : SZNS220425-16463E-20. .

FCC §15.203 & RSS-GEN §6.8 – 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.

According to FCC § 15.203, the applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device. Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

Antenna Connector Construction

The EUT has one internal antenna arrangement which was permanently attached and the maximum antenna gain is 2.1dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Antenna Type	Antenna Gain	Impedance	Frequency Range
Integral	2.1 dBi	50 Ω	2.4~2.5GHz

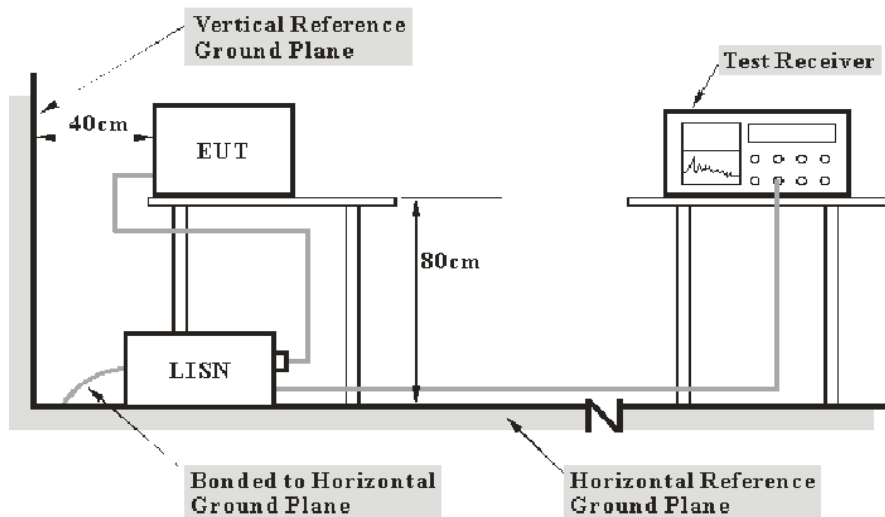
Result: Compliance

FCC §15.207 (a) & RSS-GEN § 8.8 – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a), RSS-GEN § 8.8

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 & RSS-Gen.

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

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 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

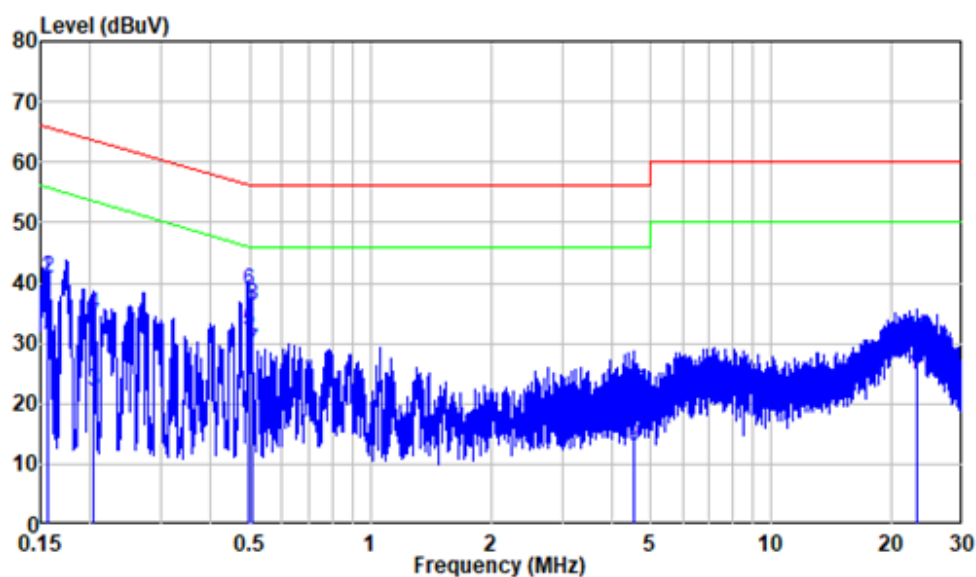
Environmental Conditions

Temperature:	23°C
Relative Humidity:	55%
ATM Pressure:	101.0 kPa

The testing was performed by Jason Liu on 2022-06-14.

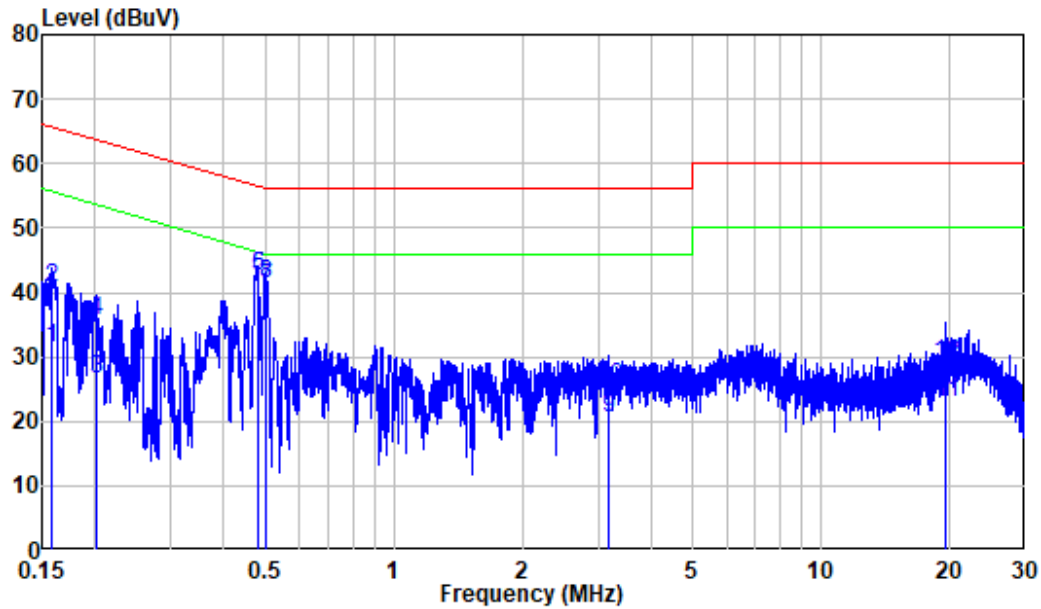
EUT operation mode: Transmitting (the worst case is 8DPSK Mode, low channel)

AC 120V/60 Hz, Line



Site : Shielding Room
 Condition: Line
 Mode : BT
 Model : Model 514
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.156	9.80	19.64	29.44	55.66	-26.22	Average
2	0.156	9.80	31.03	40.83	65.66	-24.83	QP
3	0.203	9.80	12.16	21.96	53.50	-31.54	Average
4	0.203	9.80	24.87	34.67	63.50	-28.83	QP
5	0.494	9.80	22.35	32.15	46.10	-13.95	Average
6	0.494	9.80	28.91	38.71	56.10	-17.39	QP
7	0.506	9.80	18.90	28.70	46.00	-17.30	Average
8	0.506	9.80	26.39	36.19	56.00	-19.81	QP
9	4.552	9.85	3.13	12.98	46.00	-33.02	Average
10	4.552	9.85	11.75	21.60	56.00	-34.40	QP
11	23.171	10.03	14.62	24.65	50.00	-25.35	Average
12	23.171	10.03	20.81	30.84	60.00	-29.16	QP

AC 120V/60 Hz, Neutral

Site : Shielding Room
 Condition: Neutral
 Mode : BT
 Model : Model 514
 Power : AC 120V 60Hz

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB	dBuV	dBuV	dBuV	dB	
1	0.158	9.80	21.65	31.45	55.58	-24.13	Average
2	0.158	9.80	31.01	40.81	65.58	-24.77	QP
3	0.200	9.80	16.82	26.62	53.60	-26.98	Average
4	0.200	9.80	25.86	35.66	63.60	-27.94	QP
5	0.480	9.80	32.64	42.44	46.34	-3.90	Average
6	0.480	9.80	32.68	42.48	56.34	-13.86	QP
7	0.500	9.80	30.94	40.74	46.00	-5.26	Average
8	0.500	9.80	31.43	41.23	56.00	-14.77	QP
9	3.165	9.83	10.82	20.65	46.00	-25.35	Average
10	3.165	9.83	15.50	25.33	56.00	-30.67	QP
11	19.583	10.10	12.73	22.83	50.00	-27.17	Average
12	19.583	10.10	18.77	28.87	60.00	-31.13	QP

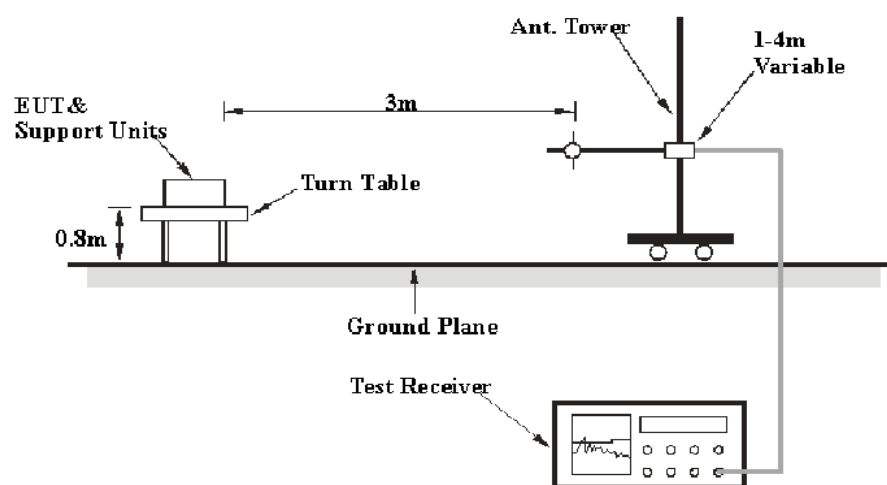
FCC §15.209, §15.205 & §15.247(d) & RSS-247§ 5.5 - SPURIOUS EMISSIONS

Applicable Standard

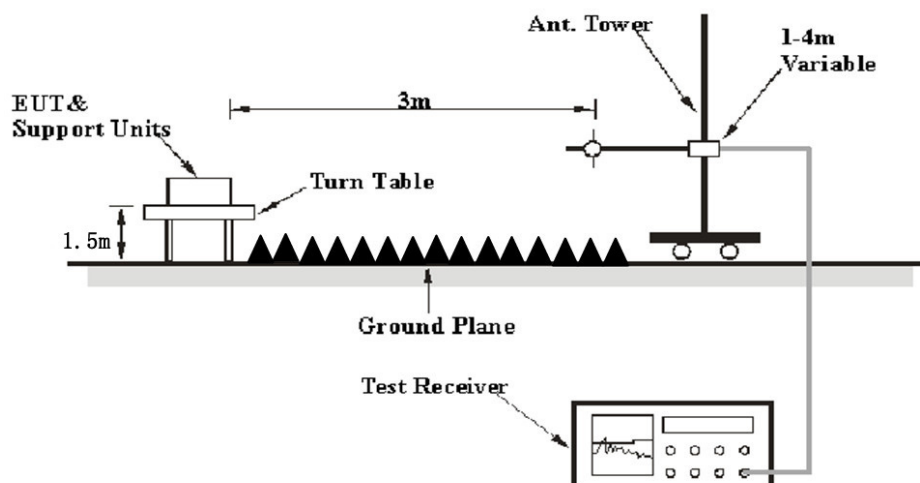
FCC §15.205; §15.209; §15.247(d); RSS-247§ 5.5; RSS-GEN § 8.10

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters test site, using the setup accordance with the ANSI C63.10-2013 & RSS-Gen. The specification used was the FCC 15.209, and FCC 15.247/RSS-247 limits.

EMI Test Receiver & Spectrum Analyzer Setup

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.

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:	25~28 °C
Relative Humidity:	55~61%
ATM Pressure:	101.0 kPa

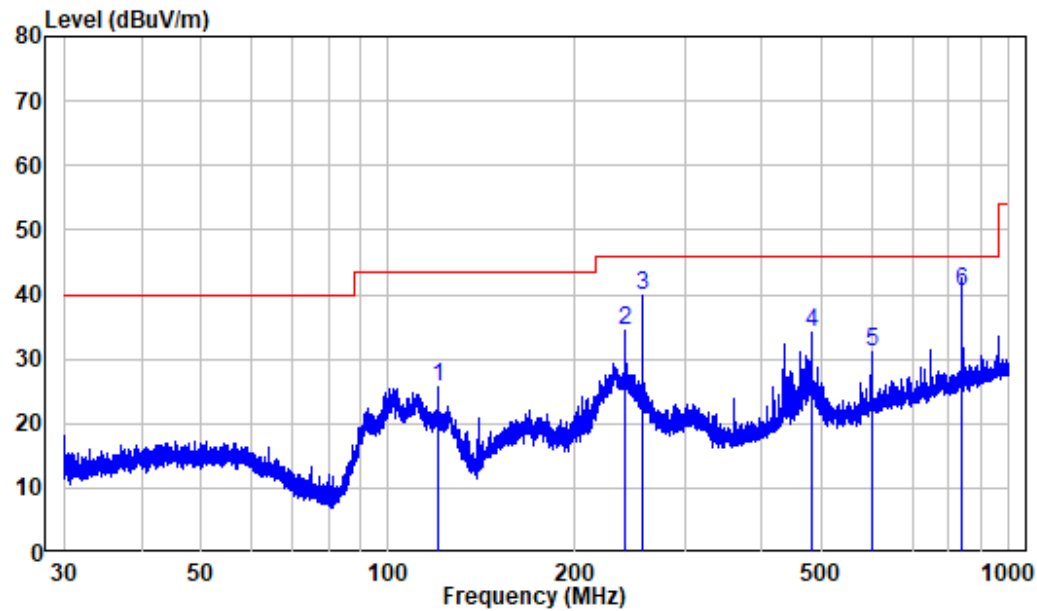
The testing was performed by Level Li on 2022-06-17 for below 1GHz, Zeki Ma on 2022-07-06 for above 1GHz.

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

Below 1GHz: (the worst case is 8DPSK Mode, Middle channel)

Note: When the test result of Peak was more than 6dB below the limit of QP, just the Peak value was recorded.

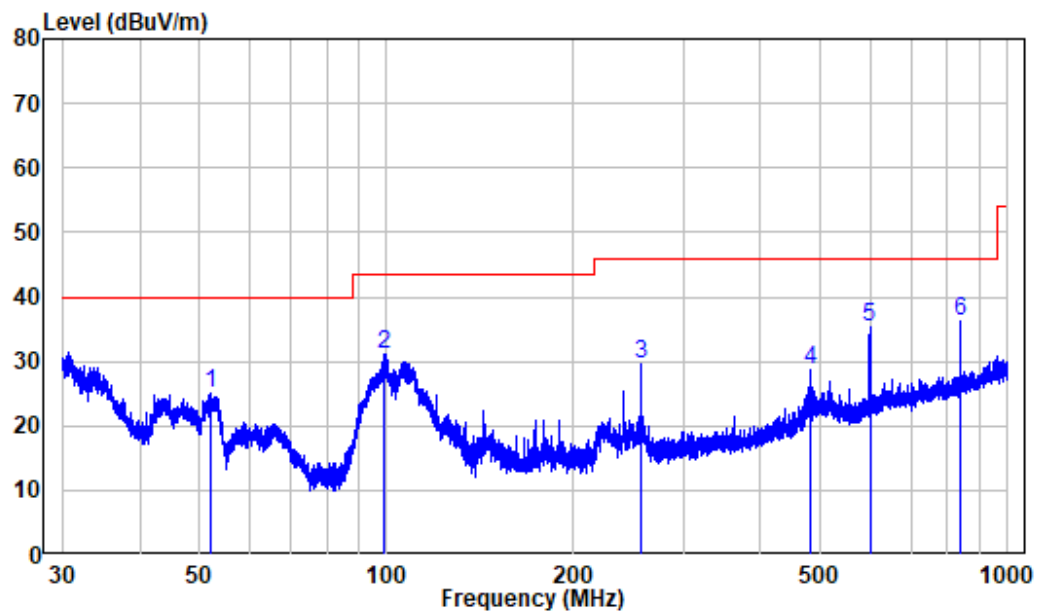
Horizontal



Site : chamber
Condition: 3m HORIZONTAL
Job No. : SZNS220425-16463E-RF
Test Mode: BT

	Freq	Factor	Read Level	Level	Limit	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	119.908	-13.51	39.18	25.67	43.50	-17.83	Peak
2	240.198	-10.90	45.43	34.53	46.00	-11.47	Peak
3	257.309	-10.59	50.31	39.72	46.00	-6.28	Peak
4	480.107	-5.00	39.25	34.25	46.00	-11.75	Peak
5	600.110	-2.43	33.54	31.11	46.00	-14.89	Peak
6	840.286	0.28	40.21	40.49	46.00	-5.51	QP

Vertical



Site : chamber

Condition: 3m VERTICAL

Job No. : SZNS220425-16463E-RF

Test Mode: BT

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	52.002	-9.97	34.89	24.92	40.00	-15.08	Peak
2	99.180	-11.99	43.08	31.09	43.50	-12.41	Peak
3	256.634	-10.60	40.16	29.56	46.00	-16.44	Peak
4	480.107	-5.00	33.70	28.70	46.00	-17.30	Peak
5	599.847	-2.44	37.73	35.29	46.00	-10.71	Peak
6	839.918	0.27	35.97	36.24	46.00	-9.76	Peak

Above 1GHz: (worst case for 8DPSK)

Frequency (MHz)	Receiver		Turntable Angle Degree	Rx Antenna		Factor (dB/m)	Absolute Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)
	Reading (dBuV)	PK/AV		Height (m)	Polar (H/V)				
Low Channel									
2310	68.35	PK	50	2.3	H	-7.24	61.11	74	-12.89
2310	54.34	AV	50	2.3	H	-7.24	47.10	54	-6.90
2310	68.75	PK	209	1	V	-7.24	61.51	74	-12.49
2310	55.03	AV	209	1	V	-7.24	47.79	54	-6.21
2390	69.42	PK	214	1.4	H	-7.22	62.20	74	-11.80
2390	55.64	AV	214	1.4	H	-7.22	48.42	54	-5.58
2390	69.63	PK	172	2.4	V	-7.22	62.41	74	-11.59
2390	55.73	AV	172	2.4	V	-7.22	48.51	54	-5.49
4804	54.64	PK	202	1.4	H	-3.51	51.13	74	-22.87
4804	54.67	PK	23	1.9	V	-3.51	51.16	74	-22.84
Middle Channel									
4882	54.66	PK	16	1.3	H	-3.37	51.29	74	-22.71
4882	54.81	PK	344	2.2	V	-3.37	51.44	74	-22.56
High Channel									
2483.5	69.79	PK	199	1.5	H	-7.2	62.59	74	-11.41
2483.5	54.99	AV	199	1.5	H	-7.2	47.79	54	-6.21
2483.5	69.52	PK	260	1.8	V	-7.2	62.32	74	-11.68
2483.5	55.08	AV	260	1.8	V	-7.2	47.88	54	-6.12
2500	68.97	PK	258	1.8	H	-7.18	61.79	74	-12.21
2500	55.04	AV	258	1.8	H	-7.18	47.86	54	-6.14
2500	69.21	PK	10	2	V	-7.18	62.03	74	-11.97
2500	54.91	AV	10	2	V	-7.18	47.73	54	-6.27
4960	54.43	PK	321	2.3	H	-3.01	51.42	74	-22.58
4960	54.53	PK	144	2.4	V	-3.01	51.52	74	-22.48

Note:

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

Corrected Amplitude = Corrected Factor + Reading

Margin = Corrected. Amplitude - Limit

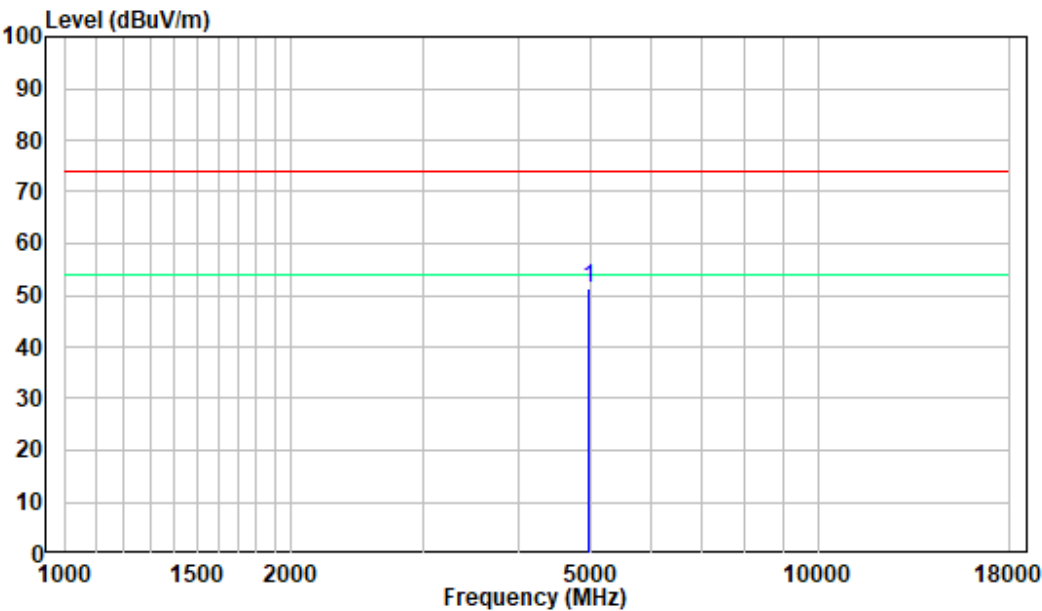
The other spurious emission which is 20dB to the limit or in noise floor level was not recorded.

The test result of Peak was below the limit of average, just the Peak value was recorded.

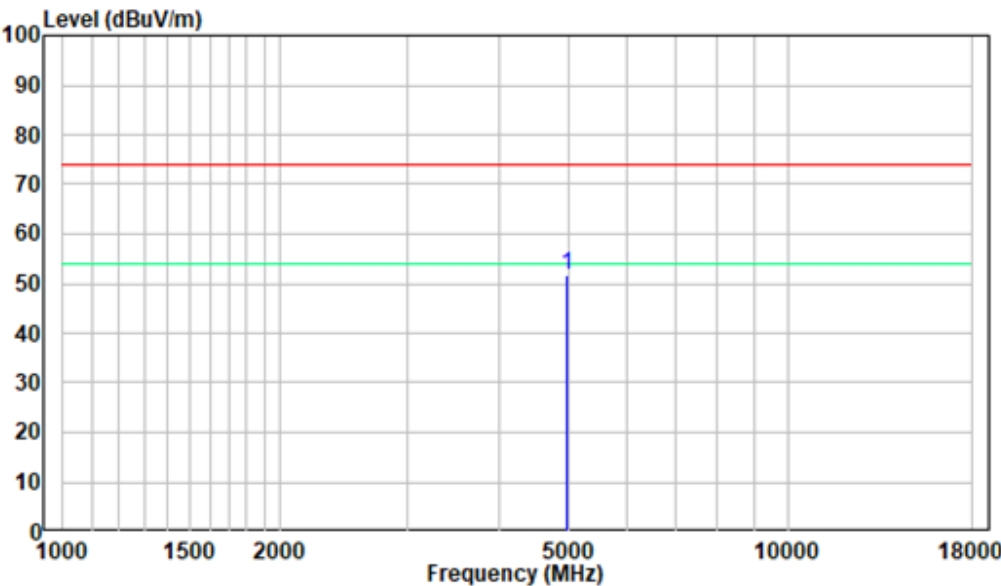
1 GHz - 18 GHz: (Pre-Scan plots)

High channel

Horizontal



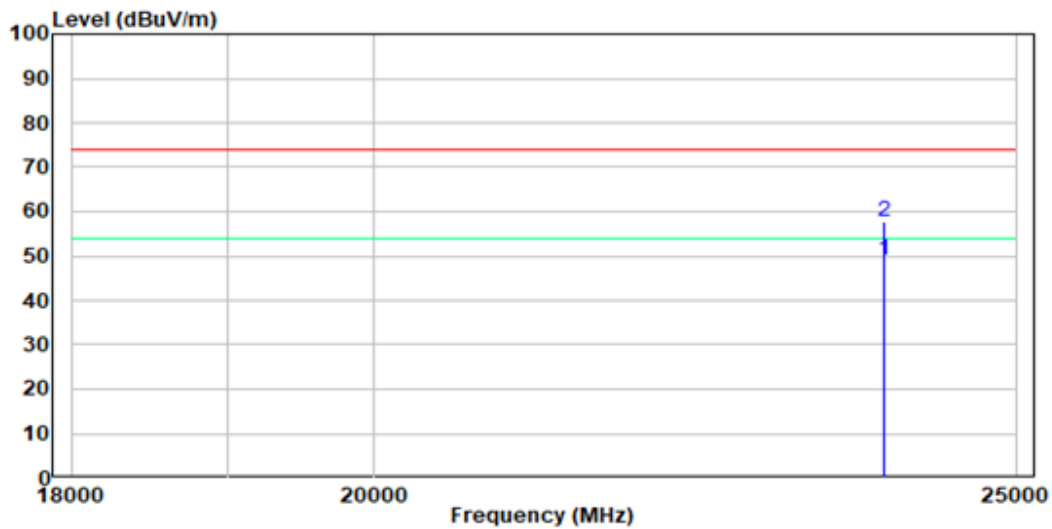
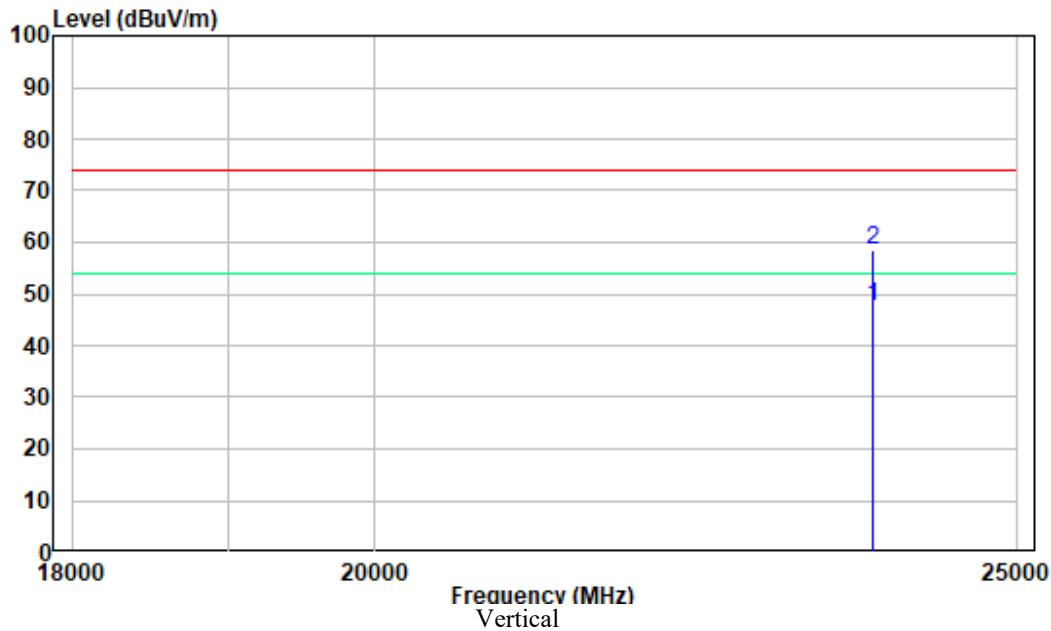
Vertical



18-25GHz: (Pre-Scan plots)

High channel

Horizontal



FCC §15.247(a) (1) & RSS-247 § 5.1 (b) -CHANNEL SEPARATION TEST

Applicable Standard

According to FCC §15.247(a) (1):

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

According to RSS-247 § 5.1 (b):

Frequency hopping systems (FHSs) 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, FHSs operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W. 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

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



Test Data

Environmental Conditions

Temperature:	26 °C
Relative Humidity:	60 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-05-19.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(a) (1) & RSS-247 § 5.1 (a), RSS-GEN § 6.7 – 20 dB EMISSION BANDWIDTH & 99% OCCUPIED BANDWIDTH

Applicable Standard

According to FCC §15.247(a) (1):

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.

According to RSS-247 § 5.1 (a), RSS-GEN § 6.7:

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the “20 dB bandwidth” is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 20 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

Test Procedure

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

Temperature:	26 °C
Relative Humidity:	60 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-05-19.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix

FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - QUANTITY OF HOPPING CHANNEL TEST

Applicable Standard

According to FCC §15.247(a) (1) (iii):

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

According to RSS-247 § 5.1 (d):

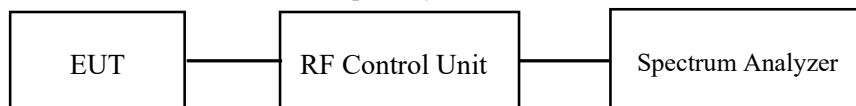
Frequency hopping systems (FHSS) operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test Procedure

Check the calibration of the measuring instrument (SA) using either an internal calibrator or a known signal from an external generator.

Set the EUT in hopping mode from first channel to last.

By using the max-hold function record the quantity of the channel.



Test Data

Environmental Conditions

Temperature:	26 °C
Relative Humidity:	60 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-05-19.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(a) (1) (iii) & RSS-247 § 5.1 (d) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

According to FCC §15.247(a) (1) (iii):

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.

According to RSS-247 § 5.1 (d):

Frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz shall use at least 15 hopping 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. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

Test Procedure

The EUT was worked in channel hopping.

Set the RBW to: 1MHz.

Set the VBW $\geq 3 \times$ RBW.

Set the span to 0Hz.

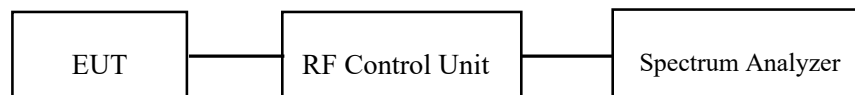
Detector = peak.

Sweep time = auto couple.

Trace mode = max hold.

Allow trace to fully stabilize.

Recorded the time of single pulses



Test Data

Environmental Conditions

Temperature:	26 °C
Relative Humidity:	60 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-05-19.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(b) (1) & RSS-247§ 5.1(b) &§ 5.4(b) - PEAK OUTPUT POWER MEASUREMENT

Applicable Standard

According to FCC §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.

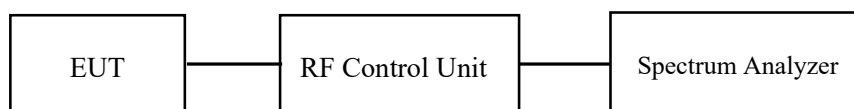
According to RSS-247§ 5.1(b) &§ 5.4(b):

For frequency hopping systems (FHSs) operating in the band 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W (see Section 5.4(e) for exceptions).

Frequency hopping systems (FHSs) 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, FHSs operating in the band 2400-2483.5 MHz 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 that the systems operate with an output power no greater than 0.125 W.

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:	26 °C
Relative Humidity:	60 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-05-19.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

FCC §15.247(d) & RSS-247 § 5.5 - BAND EDGES TESTING

Applicable Standard

According to FCC §15.247(d).

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)).

According to RSS-247 § 5.5.

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(e), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Test Procedure

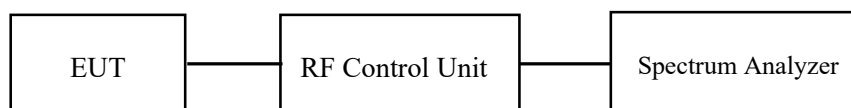
Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.

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.

Set RBW of spectrum analyzer to 100 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.

Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.

Repeat above procedures until all measured frequencies were complete.



Test Data**Environmental Conditions**

Temperature:	26 °C
Relative Humidity:	60 %
ATM Pressure:	101.0 kPa

The testing was performed by Roger Ling on 2022-05-19.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the Appendix.

APPENDIX

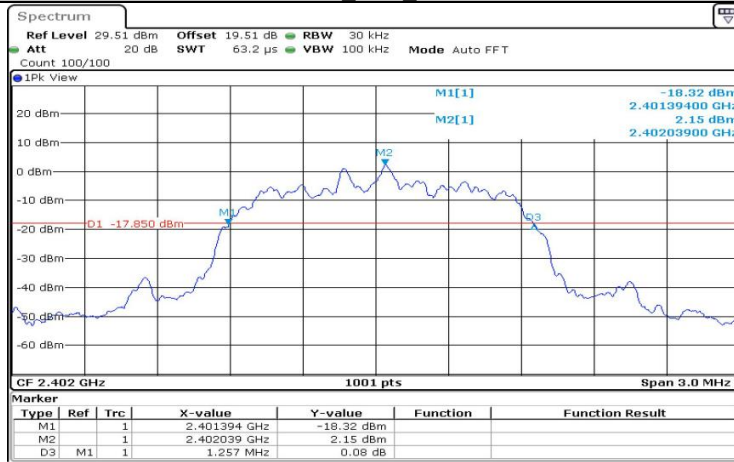
Appendix A: 20dB Emission Bandwidth Test Result

Test Mode	Antenna	Channel	20db EBW[MHz]	Limit[MHz]	Verdict
DH1	Ant1	2402	0.93	---	---
		2441	0.93	---	---
		2480	0.93	---	---
2DH1	Ant1	2402	1.26	---	---
		2441	1.26	---	---
		2480	1.26	---	---
3DH1	Ant1	2402	1.22	---	---
		2441	1.22	---	---
		2480	1.22	---	---

Test Graphs

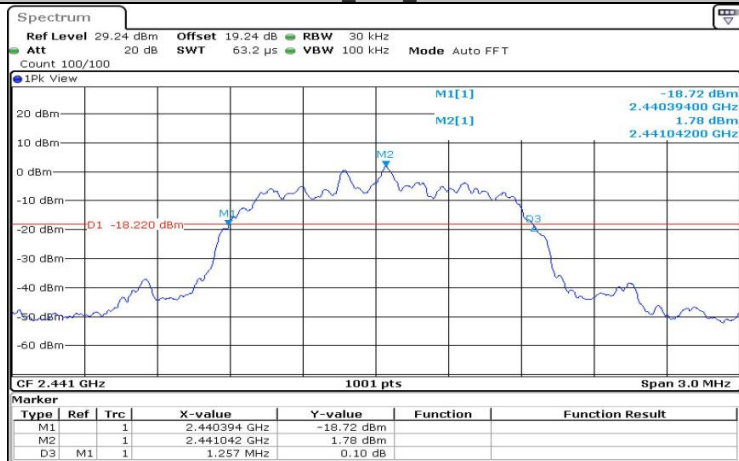


2DH1_Ant1_2402



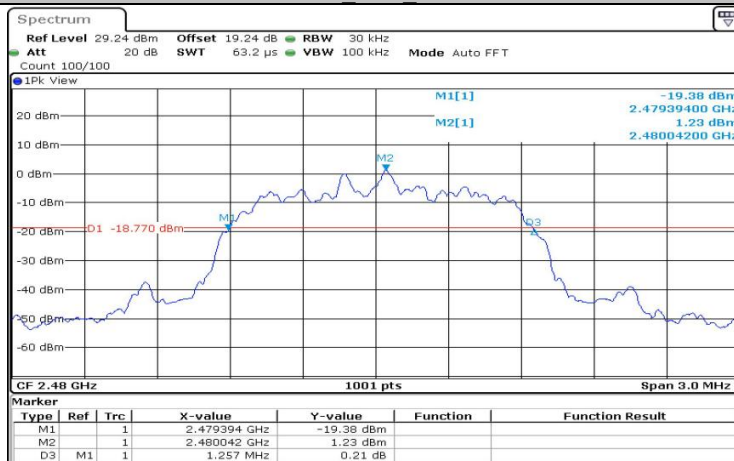
Date: 19.MAY.2022 19:12:05

2DH1_Ant1_2441



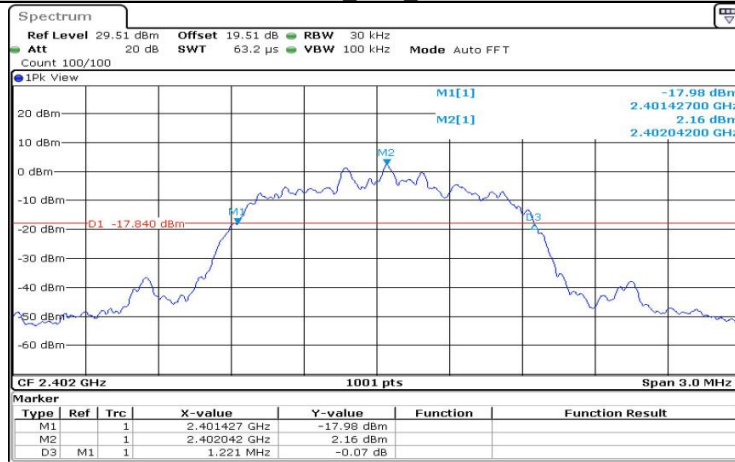
Date: 19.MAY.2022 19:11:03

2DH1_Ant1_2480



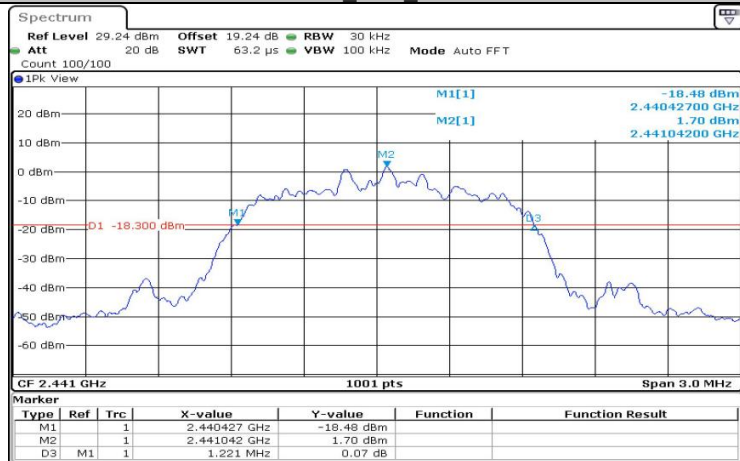
Date: 19.MAY.2022 19:09:41

3DH1_Ant1_2402



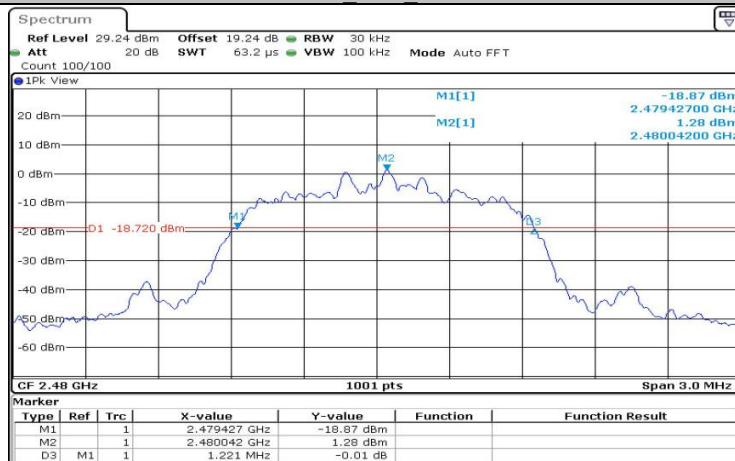
Date: 19.MAY.2022 19:13:25

3DH1_Ant1_2441



Date: 19.MAY.2022 19:14:40

3DH1_Ant1_2480

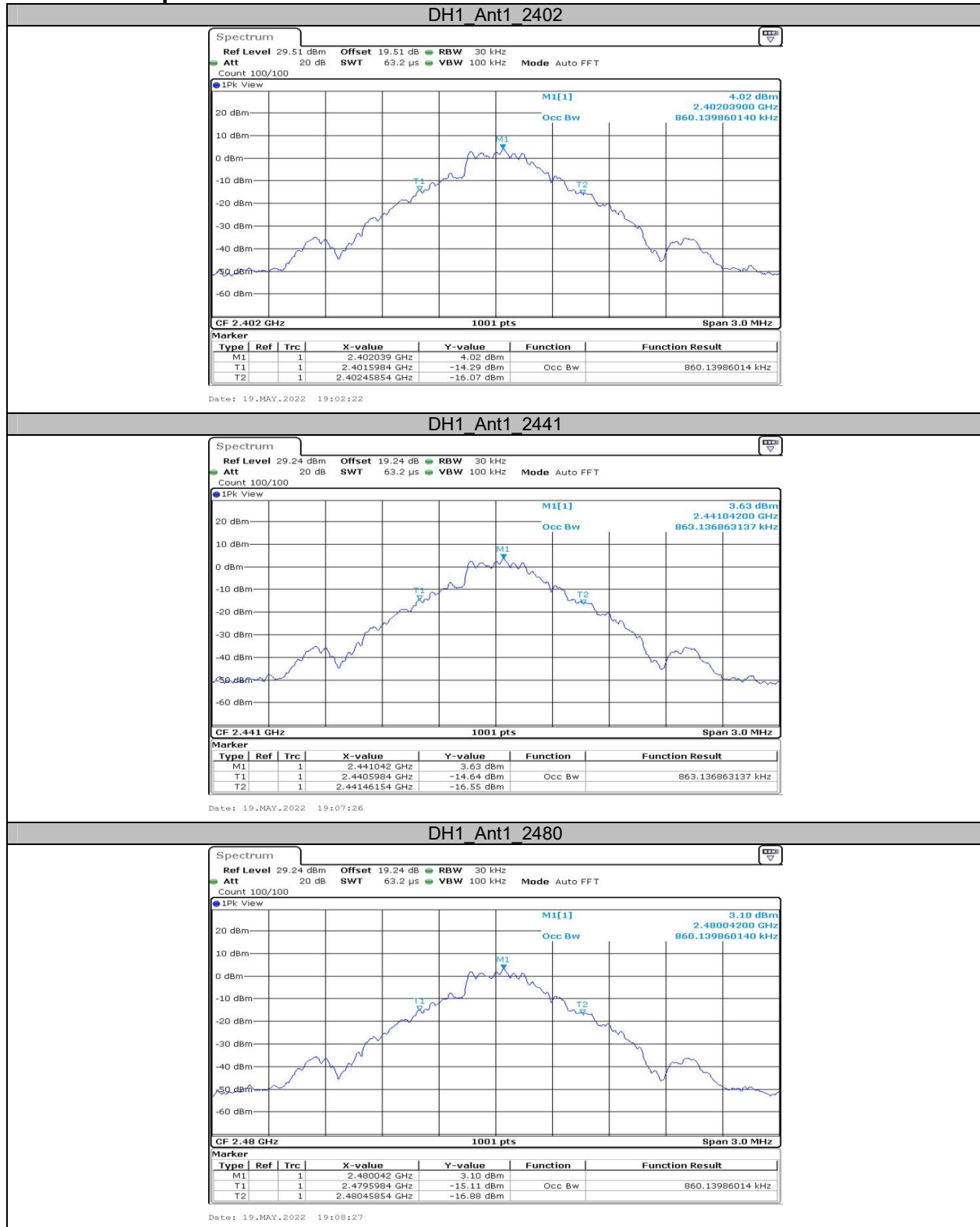


Date: 19.MAY.2022 19:15:40

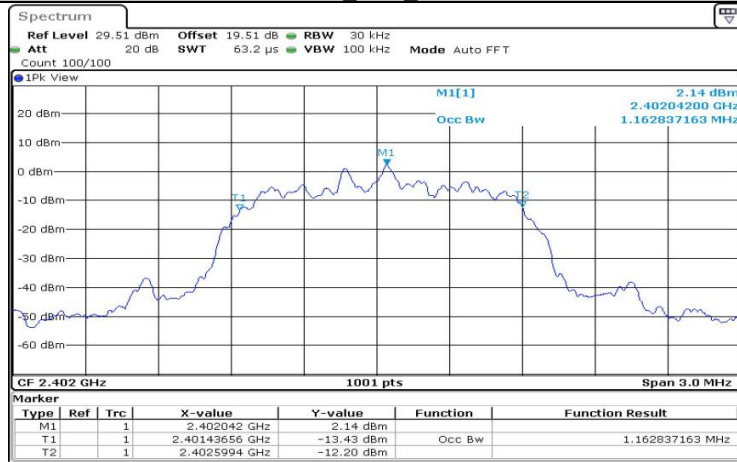
**Appendix B: Occupied Channel Bandwidth
Test Result**

Test Mode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
DH1	Ant1	2402	0.860	---	---
		2441	0.863	---	---
		2480	0.860	---	---
2DH1	Ant1	2402	1.163	---	---
		2441	1.160	---	---
		2480	1.163	---	---
3DH1	Ant1	2402	1.145	---	---
		2441	1.145	---	---
		2480	1.148	---	---

Test Graphs

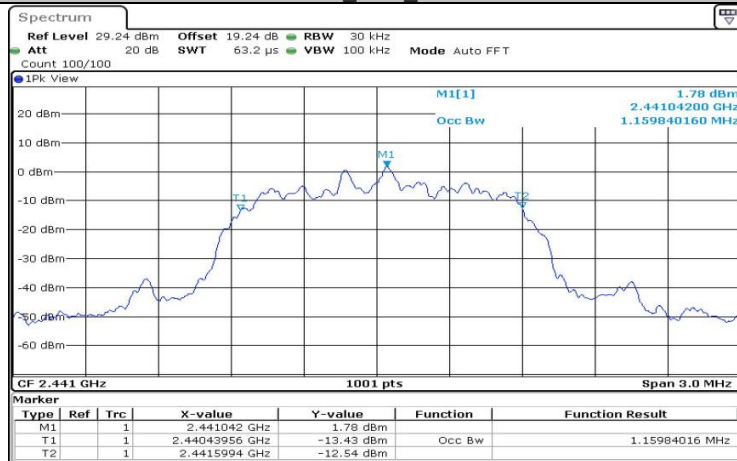


2DH1_Ant1_2402



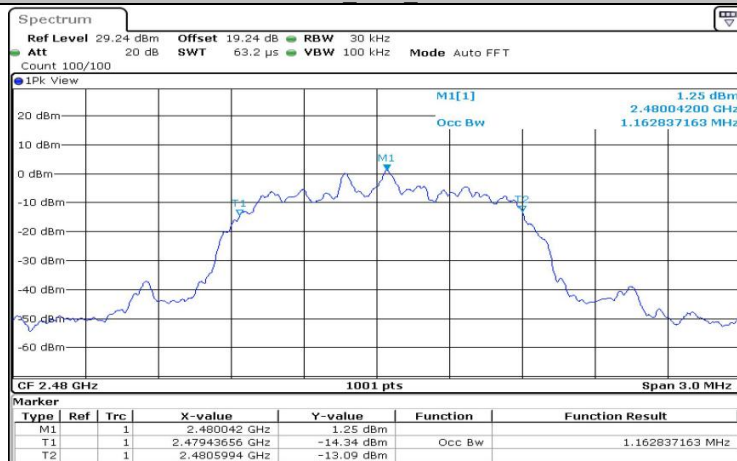
Date: 19.MAY.2022 19:12:15

2DH1_Ant1_2441



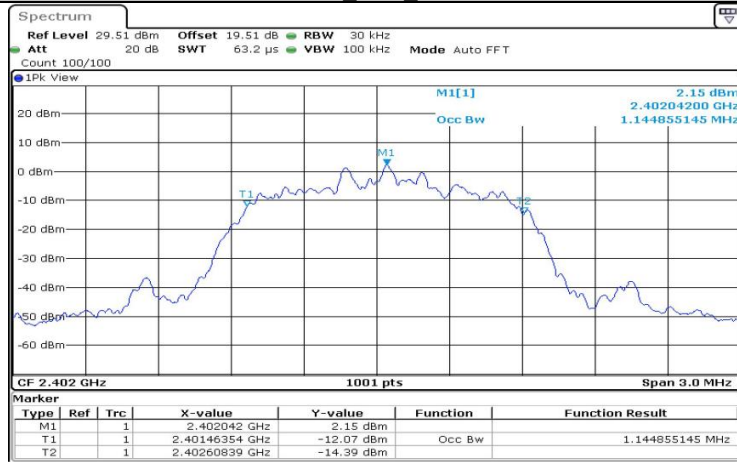
Date: 19.MAY.2022 19:11:14

2DH1_Ant1_2480



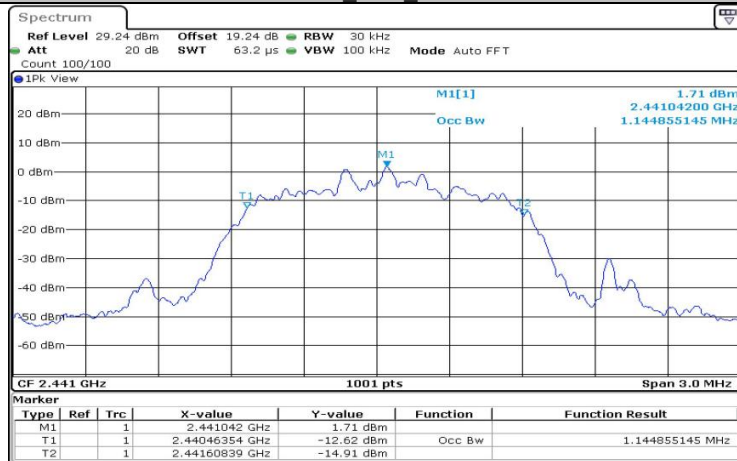
Date: 19.MAY.2022 19:09:52

3DH1_Ant1_2402



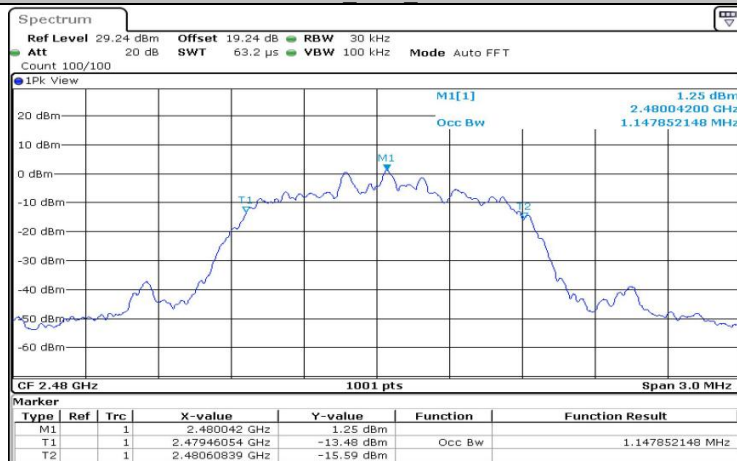
Date: 19.MAY.2022 19:13:36

3DH1_Ant1_2441



Date: 19.MAY.2022 19:14:51

3DH1_Ant1_2480

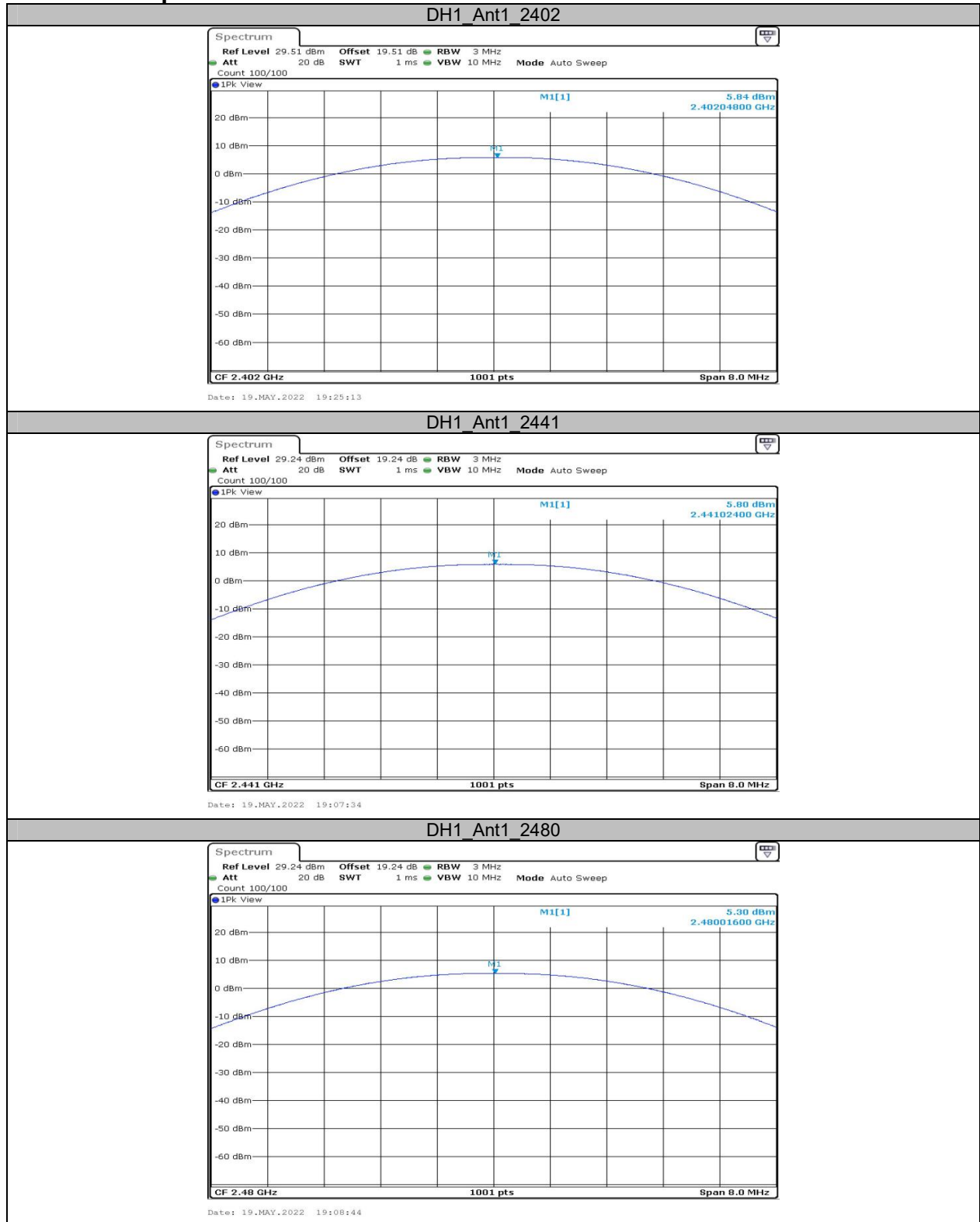


Date: 19.MAY.2022 19:15:51

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

Test Mode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
DH1	Ant1	2402	5.84	≤20.97	PASS
		2441	5.80	≤20.97	PASS
		2480	5.30	≤20.97	PASS
2DH1	Ant1	2402	6.17	≤20.97	PASS
		2441	5.81	≤20.97	PASS
		2480	5.29	≤20.97	PASS
3DH1	Ant1	2402	6.72	≤20.97	PASS
		2441	6.29	≤20.97	PASS
		2480	5.87	≤20.97	PASS
Note: the antenna gain is 2.1dBi, the maximum EIRP=8.82dBm<36dBm					

Test Graphs



2DH1_Ant1_2402



2DH1_Ant1_2441



2DH1_Ant1_2480



3DH1_Ant1_2402



3DH1_Ant1_2441



3DH1_Ant1_2480



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

Test Mode	Antenna	Channel	Result[MHz]	Limit[MHz]	Verdict
DH1	Ant1	Hop	1.003	≥ 0.620	PASS
2DH1	Ant1	Hop	1.000	≥ 0.840	PASS
3DH1	Ant1	Hop	1.003	≥ 0.813	PASS

Test Graphs



**Appendix E: Time of occupancy
Test Result**

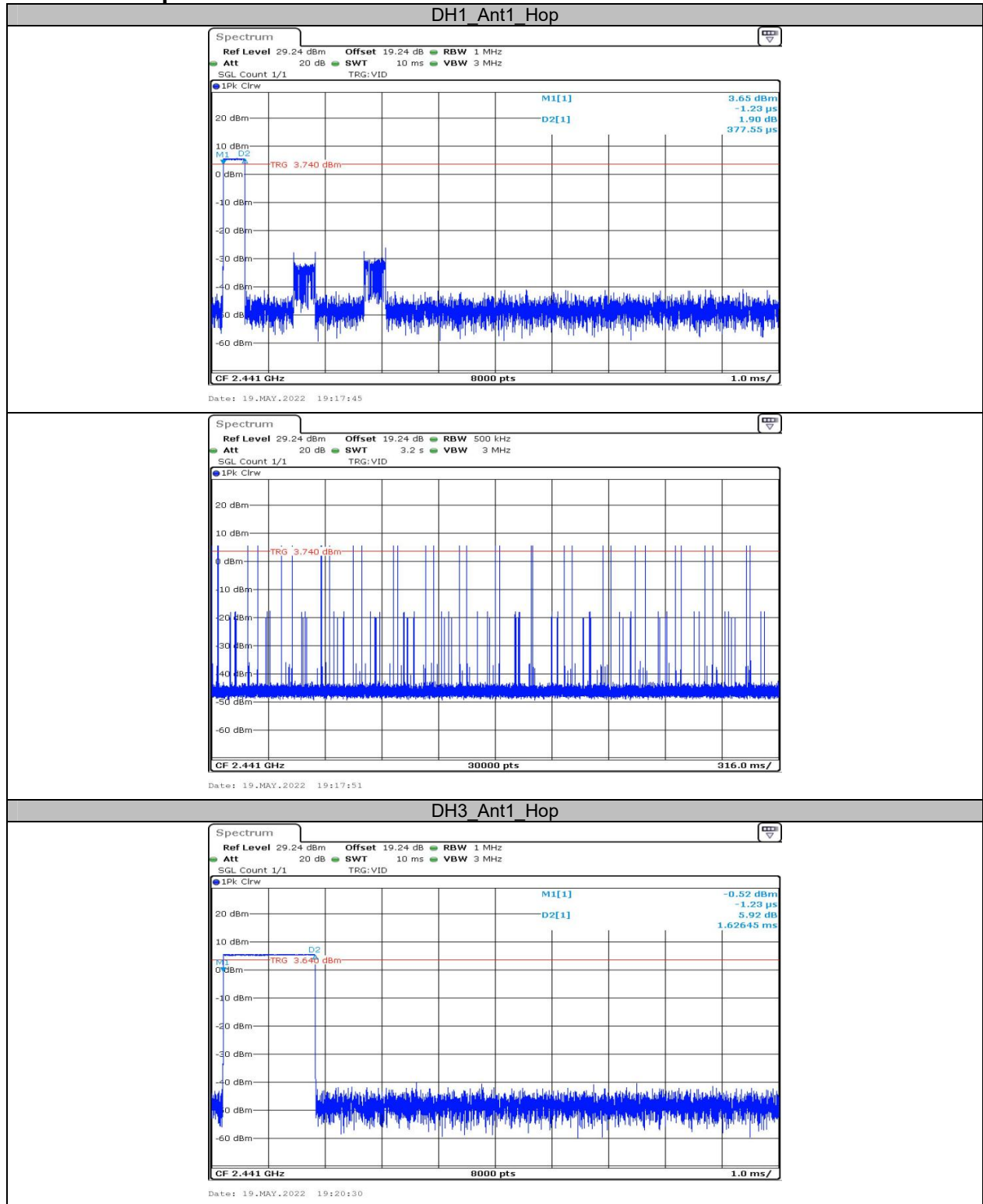
Test Mode	Antenna	Channel	BurstWidth [ms]	TotalHops [Num]	Result[s]	Limit[s]	Verdict
DH1	Ant1	Hop	0.38	320	0.122	≤0.4	PASS
DH3	Ant1	Hop	1.63	170	0.277	≤0.4	PASS
DH5	Ant1	Hop	2.87	110	0.316	≤0.4	PASS
2DH1	Ant1	Hop	0.38	320	0.122	≤0.4	PASS
2DH3	Ant1	Hop	1.63	150	0.245	≤0.4	PASS
2DH5	Ant1	Hop	2.87	130	0.373	≤0.4	PASS
3DH1	Ant1	Hop	0.38	320	0.122	≤0.4	PASS
3DH3	Ant1	Hop	1.63	150	0.245	≤0.4	PASS
3DH5	Ant1	Hop	2.87	130	0.373	≤0.4	PASS

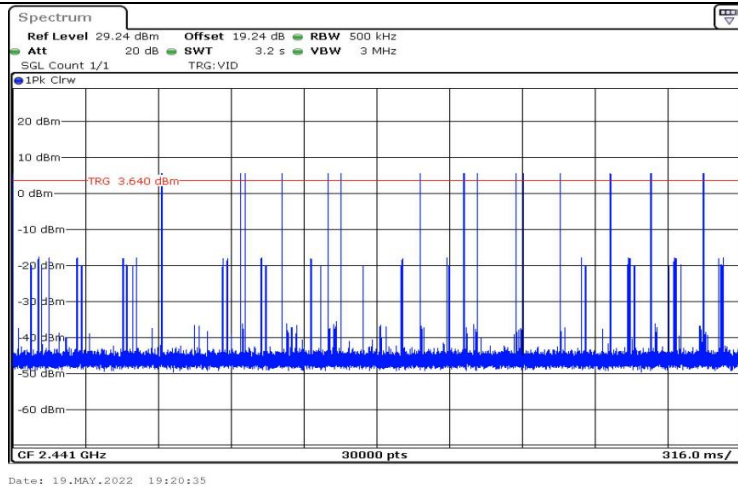
Note 1: A period time= $0.4 \times 79 = 31.6$ (S), Result=BurstWidth*Totalhops

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

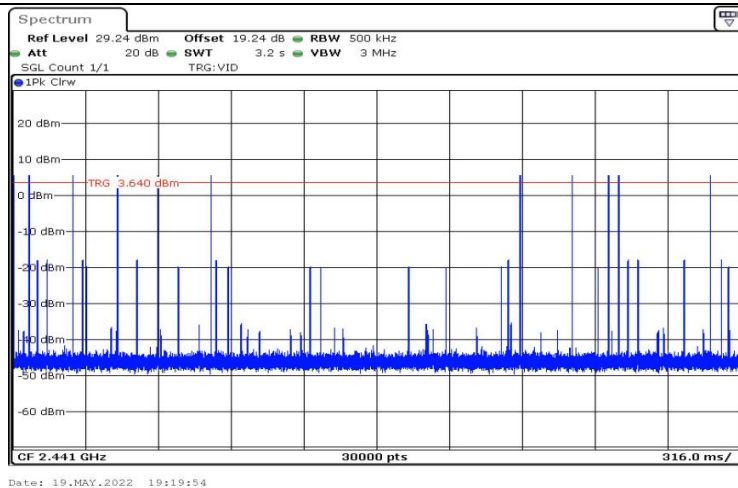
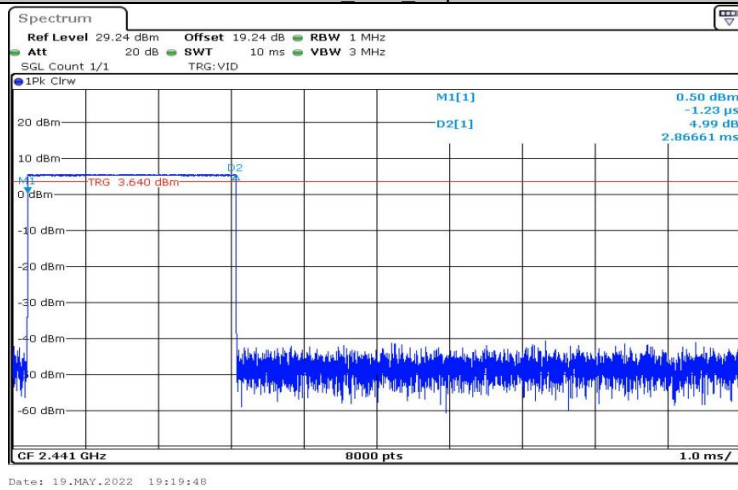
Note 3: Hopping Number in $3.16s$ =Total of highest signals in $3.16s$ (Second high signals were other channel)

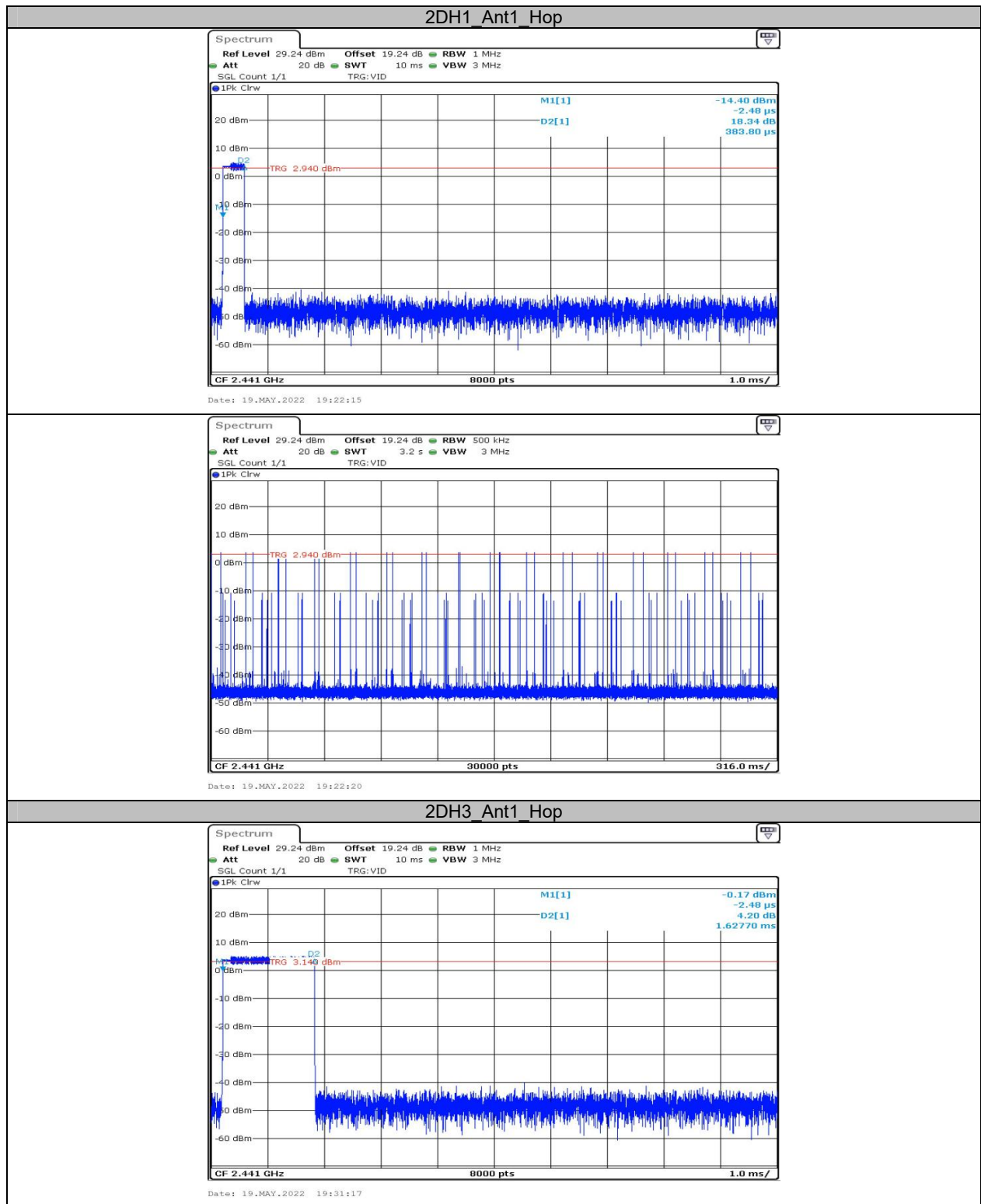
Test Graphs

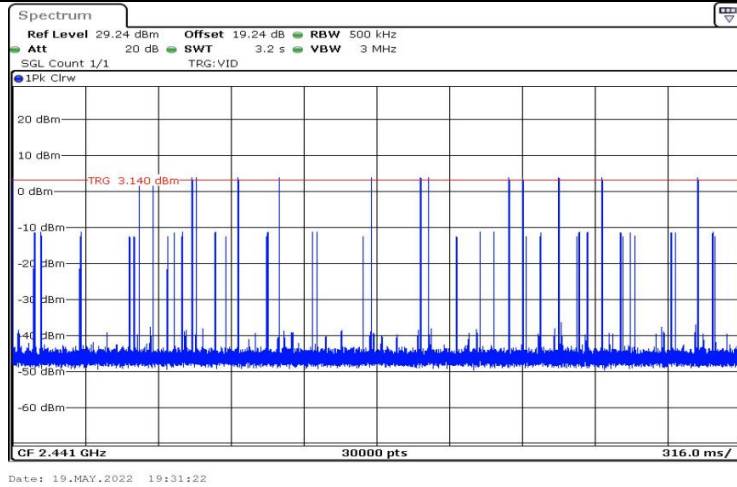




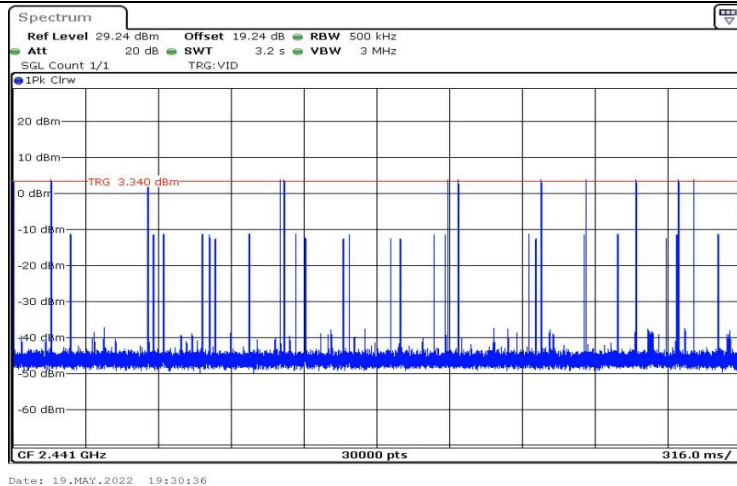
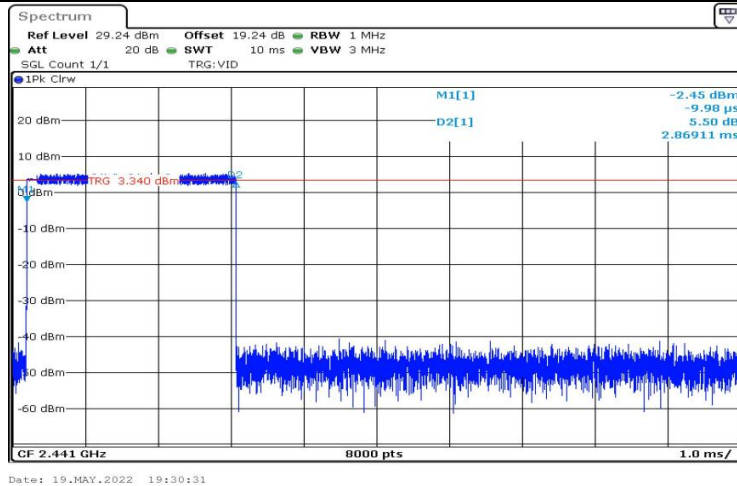
DH5 Ant1 Hop



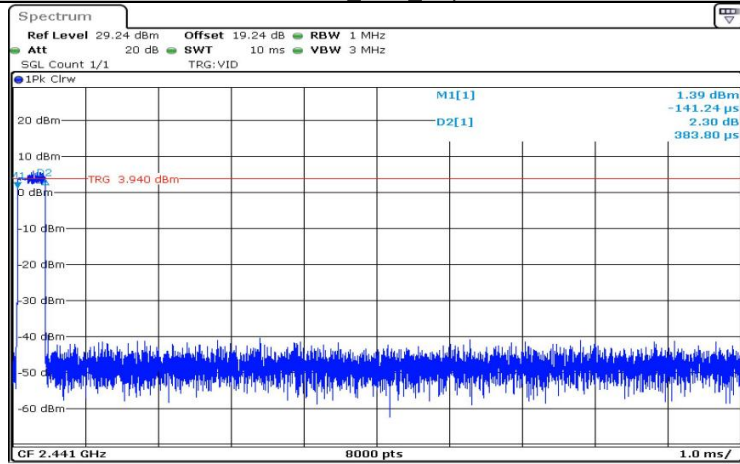




2DH5 Ant1 Hop

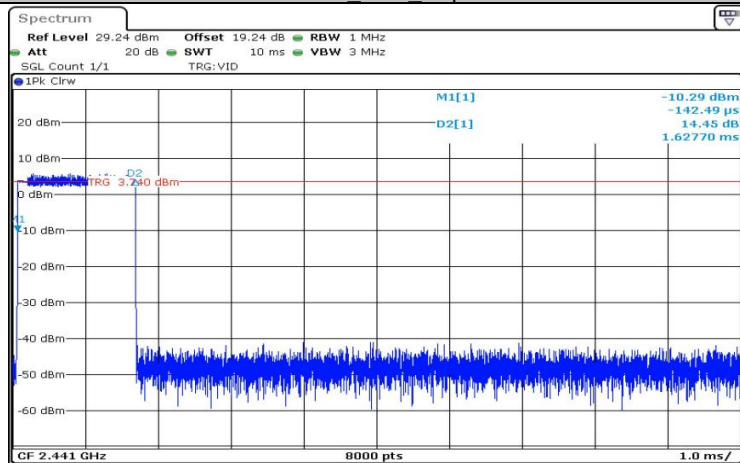


3DH1_Ant1_Hop

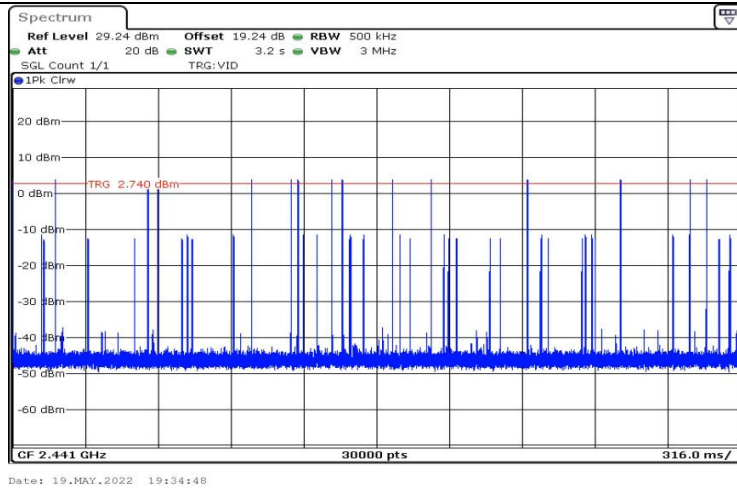


Date: 19.MAY.2022 19:33:21

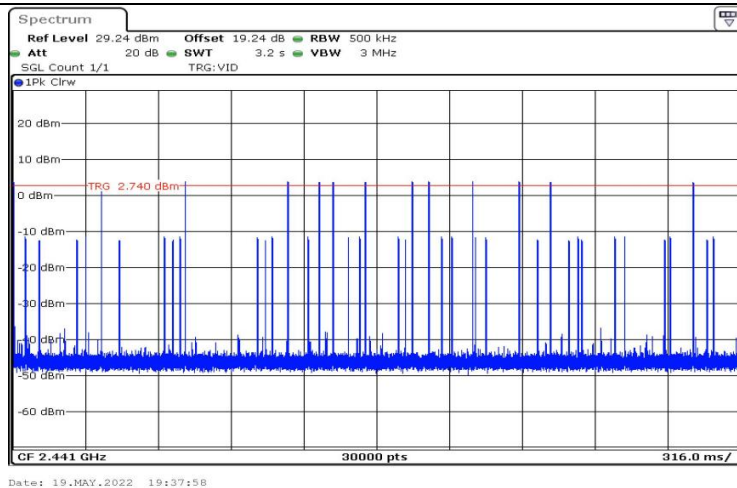
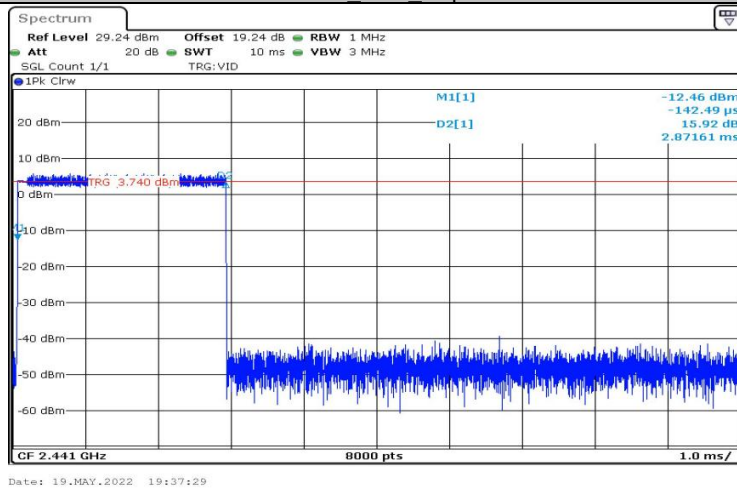
3DH3_Ant1_Hop



Date: 19.MAY.2022 19:34:37



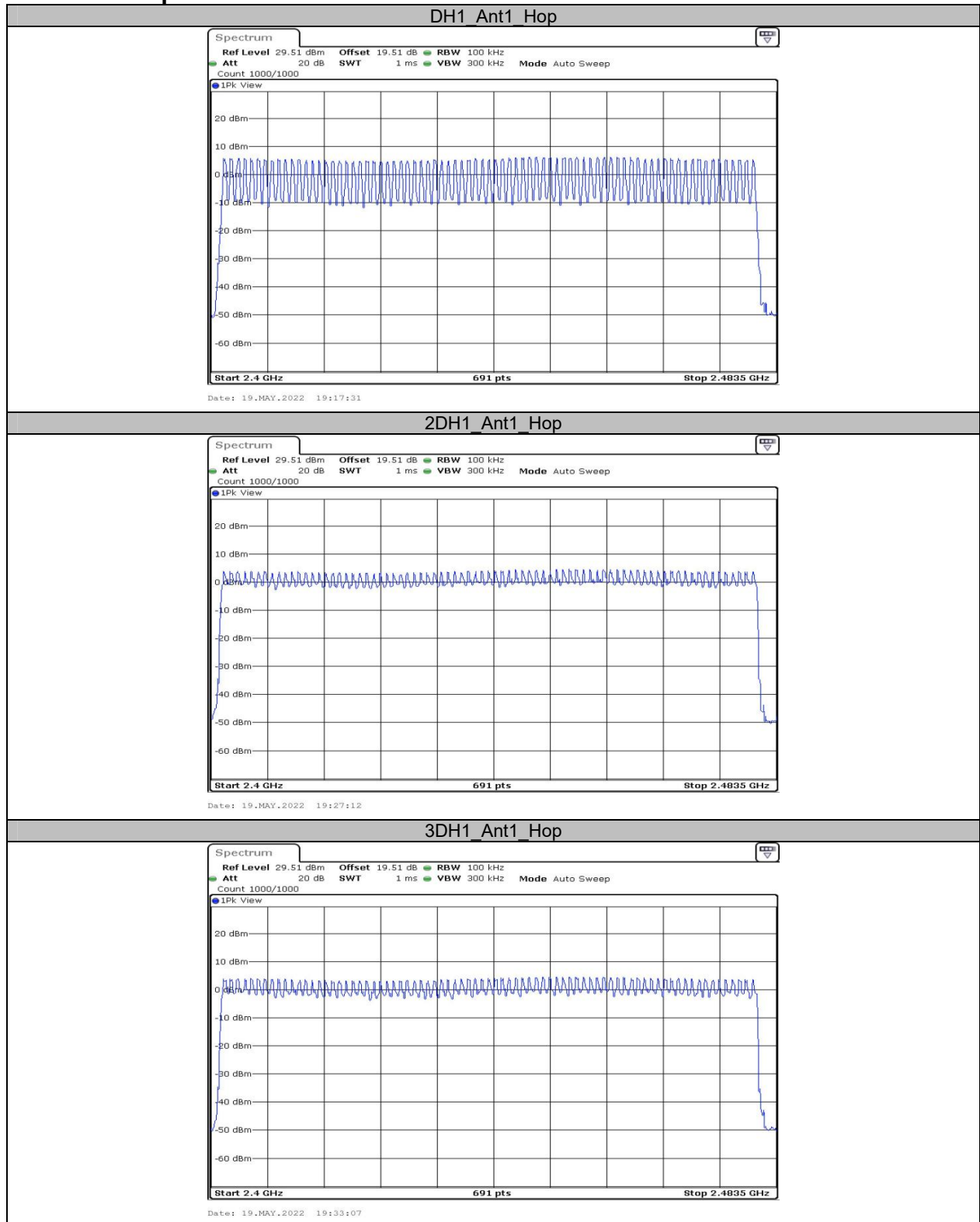
3DH5 Ant1 Hop



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

Test Mode	Antenna	Channel	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

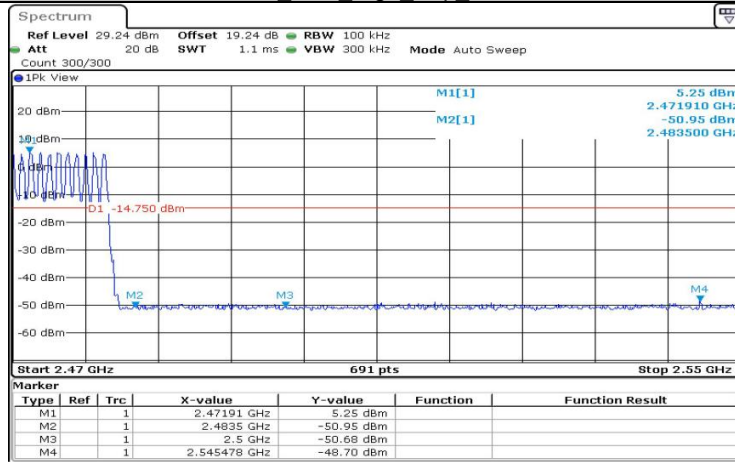


Appendix G: Band edge measurements

Test Graphs

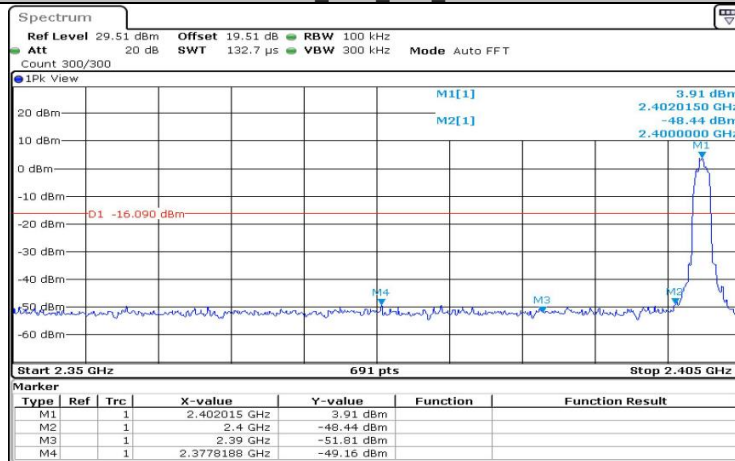


DH1 Ant1 High Hop 2480



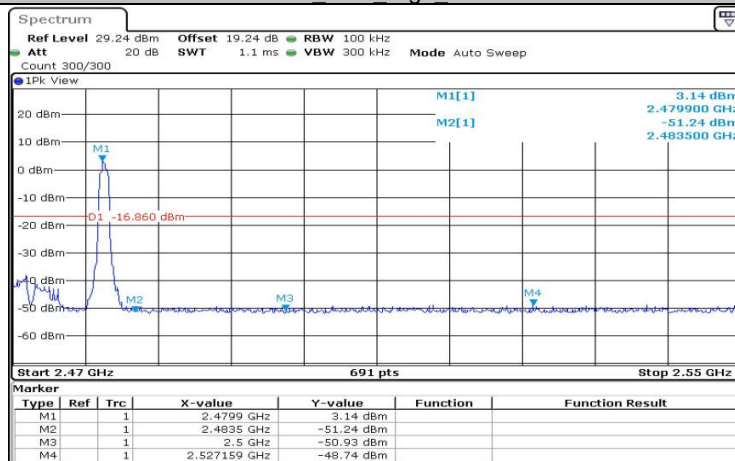
Date: 19.MAY.2022 19:18:02

2DH1 Ant1 Low 2402



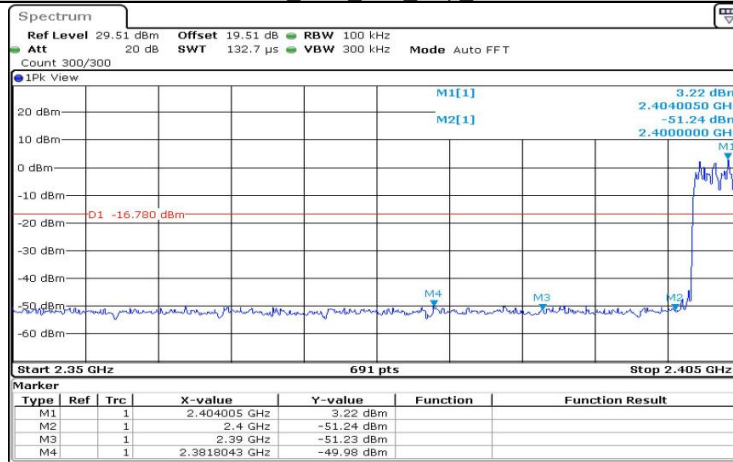
Date: 19.MAY.2022 19:12:24

2DH1 Ant1 High 2480



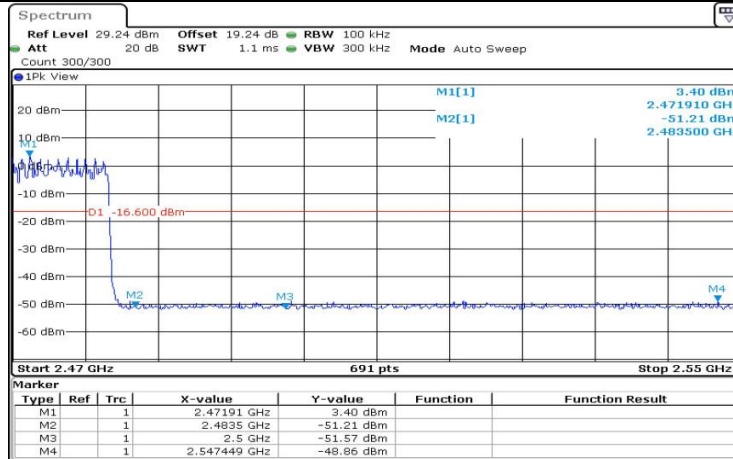
Date: 19.MAY.2022 19:10:01

2DH1 Ant1 Low Hop 2402



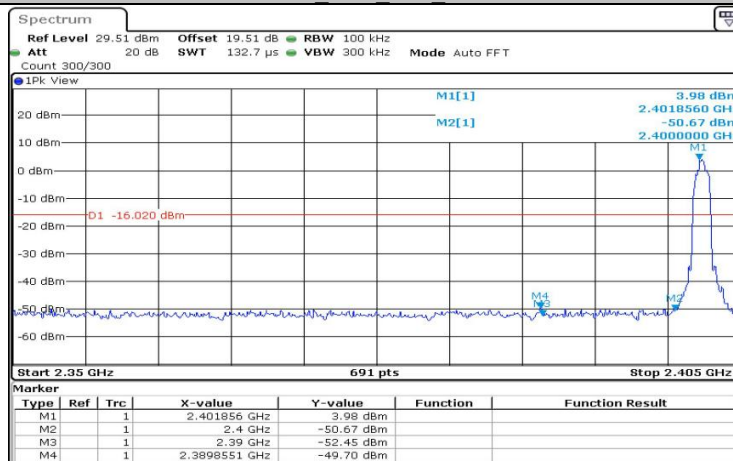
Date: 19.MAY.2022 19:21:09

2DH1 Ant1 High Hop 2480



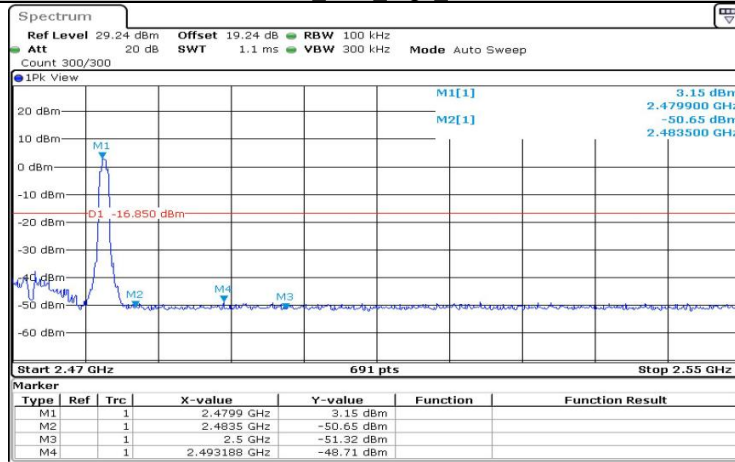
Date: 19.MAY.2022 19:22:31

3DH1 Ant1 Low 2402

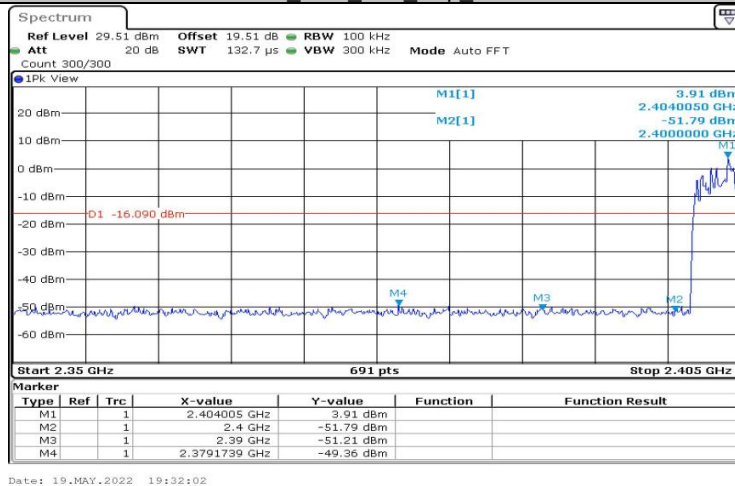


Date: 19.MAY.2022 19:13:45

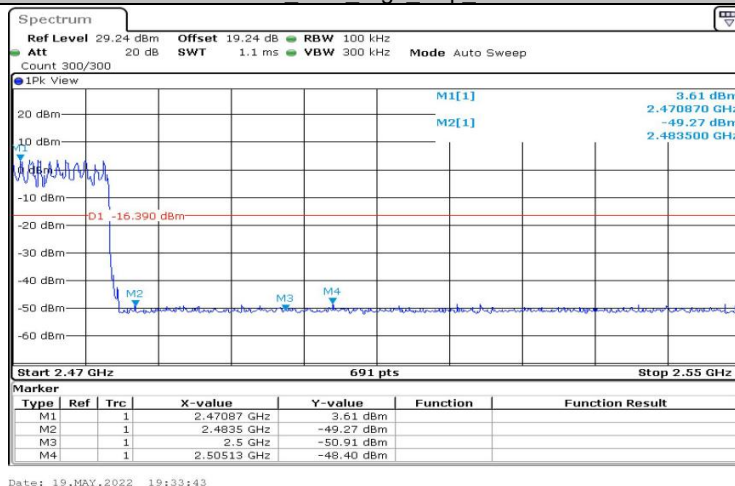
3DH1 Ant1 High 2480



3DH1 Ant1 Low Hop 2402



3DH1 Ant1 High Hop 2480



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