

FCC PART 15.247 TEST REPORT

For

FrSky Electronic Co., Ltd.

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FCC ID: XYFTDMR2409

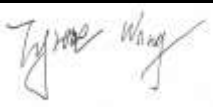
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Project Engineer: <u>Tyrone Wang</u> 	
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GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Applicant:	FrSky Electronic Co., Ltd.
Tested Model:	TD-Module
Product Type:	Radio system
Power Supply:	DC 5.0V
I/O	SISO
RF Function:	SRD
Operating Band/Frequency:	2403.985-2472.985 MHz
Channel Number:	47
Modulation Type:	FSK
Maximum Output Power:	19.97dBm
Antenna Type:	Antenna 1 & Antenna 3: Single-band Antenna, Antenna 2: Omni Antenna
*Maximum Antenna Gain:	Antenna 1 & Antenna 3:2.0 dBi, Antenna 2: 4.0 dBi

Note: The maximum antenna gain was provided by the manufacturer. The EUT has three antennas that can't transmit simultaneously for 2.4 GHz SRD function. Three antenna ports are fully identical for 2.4 GHz radio based on the declaration of manufacturer, we have verified each port, the worst case emission was recorded at antenna port 2#, and the data following was presented for antenna 2#.*

**All measurement and test data in this report was gathered from production sample serial number: RSHD201102003-1.(Assigned by BACL, Kunshan). The EUT was received on 2020-11-02.*

Objective

This test report is prepared on behalf of *FrSky Electronic Co., Ltd.* 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.

Related Submittal(s)/Grant(s)

FCC Part 15.247 DTS submissions with FCC ID: XYFTDMR2409

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliant Testing of Unlicensed Wireless Devices and FCC 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed at Bay Area Compliant Laboratories Corp. (Kunshan). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.

Measurement Uncertainty

Item		Uncertainty
AC Power Lines Conducted Emissions		3.19dB
RF conducted test with spectrum		0.9dB
RF Output Power with Power meter		0.5dB
Radiated emission	30MHz~1GHz	6.11 dB
	1GHz~6GHz	4.45dB
	6GHz~18GHz	5.23dB
	18GHz~40GHz	5.65dB
Occupied Bandwidth		0.5kHz
Temperature		1.0℃
Humidity		6%

Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Kunshan) to collect test data is located on the No.248 Chenghu Road, Kunshan, Jiangsu province, China.

Bay Area Compliance Laboratories Corp. (Kunshan) Lab is accredited to ISO/IEC 17025 by A2LA (Lab code: 4323.01), the FCC designation No. CN1185 under the FCC KDB 974614 D01 and CAB identifier CN0004 under the ISED requirement. The facility also complies with the radiated and AC line conducted test site criteria set forth in ANSI C63.4-2014.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

Channel list:

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2403.985	24	2439.985
1	2405.485	25	2441.485
2	2406.985	26	2442.985
3	2408.485	27	2444.485
4	2409.985	28	2445.985
5	2411.485	29	2447.485
6	2412.985	30	2448.985
7	2414.485	31	2450.485
8	2415.985	32	2451.985
9	2417.485	33	2453.485
10	2418.985	34	2454.985
11	2420.485	35	2456.485
12	2421.985	36	2457.985
13	2423.485	37	2459.485
14	2424.985	38	2460.985
15	2426.485	39	2462.485
16	2427.985	40	2463.985
17	2429.485	41	2465.485
18	2431.585	42	2466.985
19	2432.485	43	2468.485
20	2433.985	44	2470.585
21	2435.485	45	2471.485
22	2436.985	46	2472.985
23	2438.485		

EUT was tested with Channel 0, 23 and 46.

EUT Exercise Software

RF test software: X20 RF system

*FSK Power level: default.

Note: The power level setting was declared by the applicant.

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

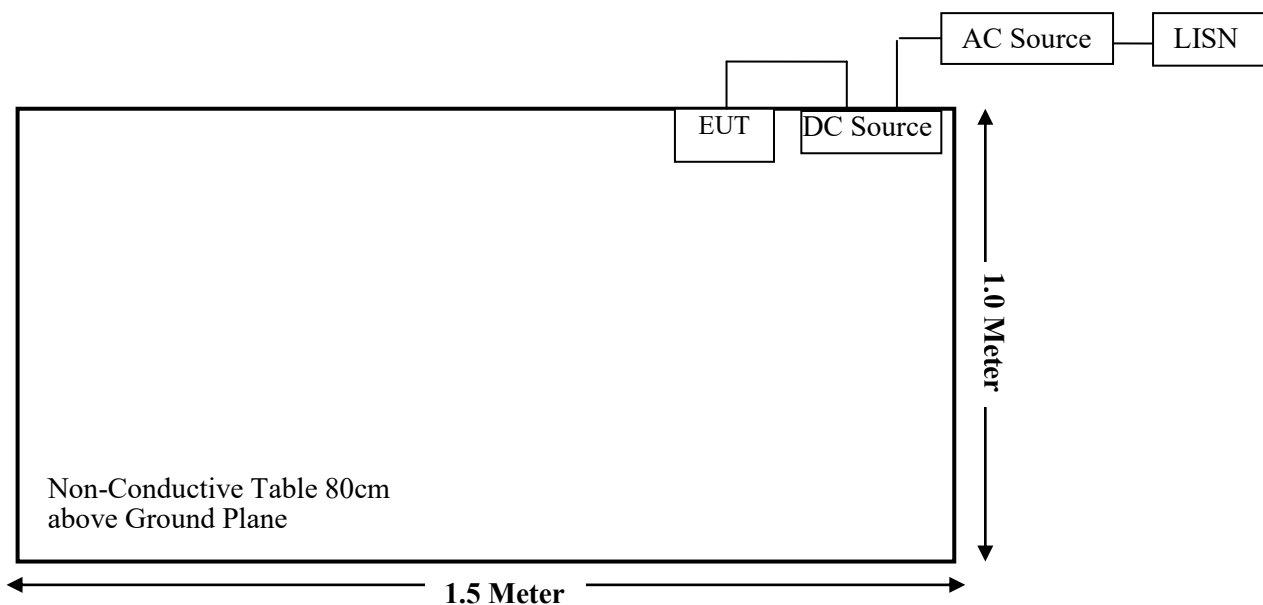
Manufacturer	Description	Model	Serial Number
ZHAOXIN	DC Source	RXN-605D	DC002

External I/O Cable

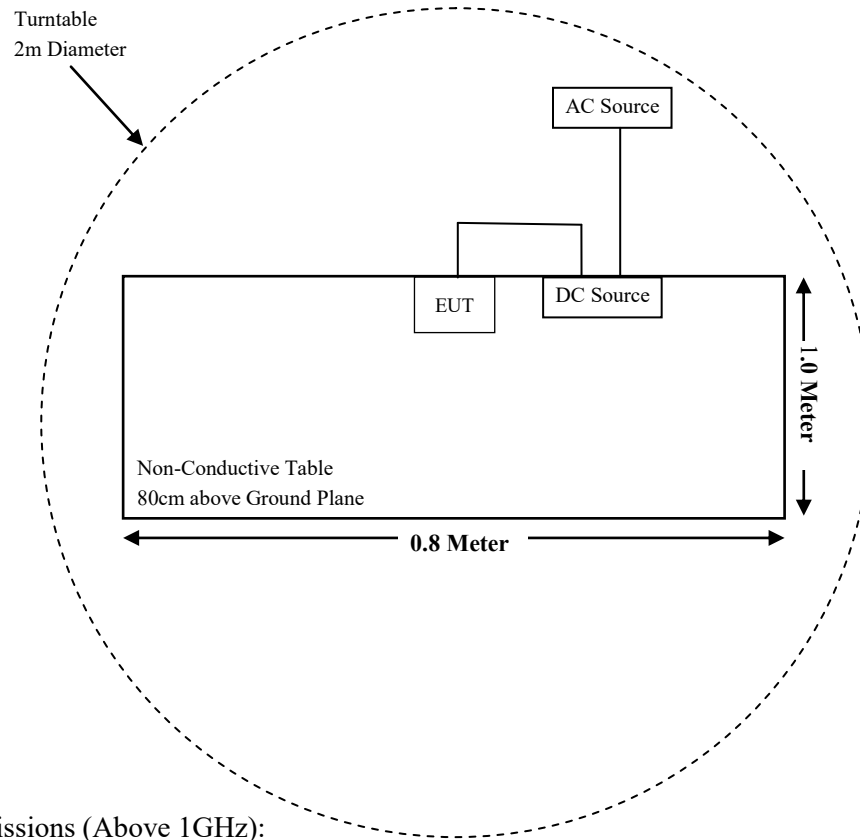
Cable Description	Length (m)	From Port	To
Power Cable	1.0	EUT	DC Source

Block Diagram of Test Setup

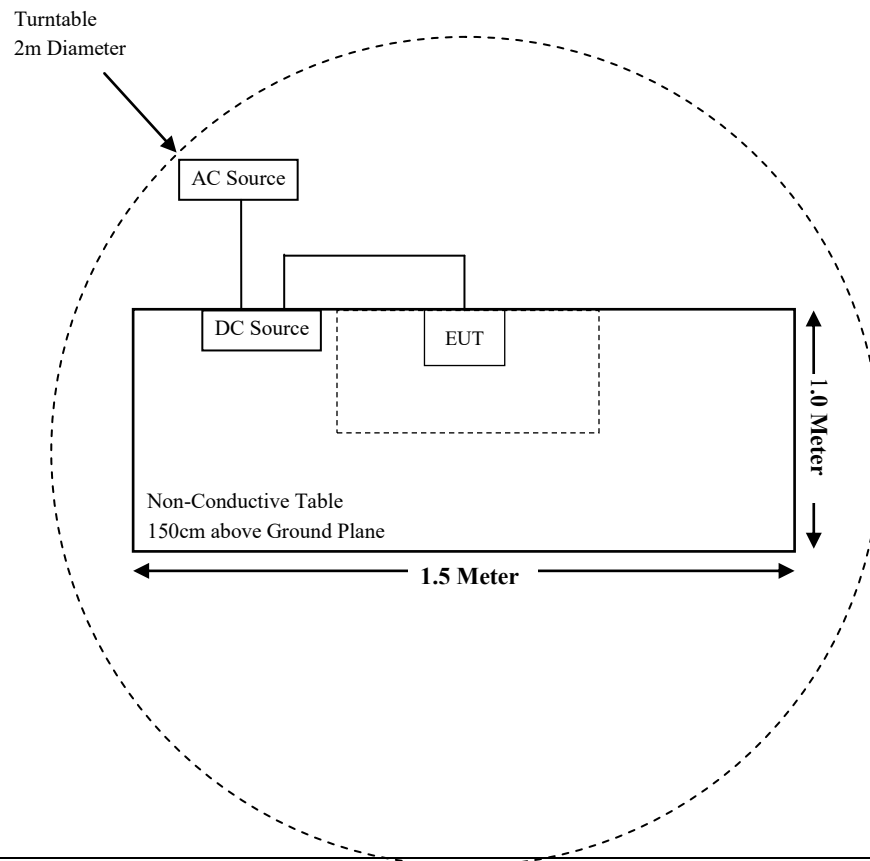
For Conducted Emissions:



For Radiated Emissions (Below 1GHz):



For Radiated Emissions (Above 1GHz):



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
§15.247 (I), §1.1310 & §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
Radiated Emission Test (Chamber 2#)					
Rohde & Schwarz	EMI Test Receiver	ESU40	100207	2020-08-27	2021-08-26
ETS-LINDGREN	Horn Antenna	3115	9207-3900	2020-07-15	2023-07-14
ETS-LINDGREN	Horn Antenna	3116	00084159	2019-12-12	2022-12-11
A.H.Systems, inc	Amplifier	2641-1	491	2020-02-20	2021-02-19
MICRO-TRONICS	Band Reject Filter	BRM50702	G024	2020-08-05	2021-08-04
Narda	Attenuator	10dB	010	2020-08-15	2021-08-14
Rohde & Schwarz	Auto test Software	EMC32	100361	/	/
MICRO-COAX	Coaxial Cable	Cable-6	006	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-11	011	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-12	012	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-13	013	2020-08-15	2021-08-14
Radiated Emission Test (Chamber 3#)					
Rohde & Schwarz	EMI Test Receiver	ESR	102454	2020-11-27	2021-11-26
Sunol Sciences	Hybrid Antenna	JB3	A090314-1	2020-08-05	2023-08-04
Sonoma Instrument	Pre-amplifier	310N	171205	2020-08-14	2021-08-13
Audix	Test Software	e3	V9	/	/
MICRO-TRONICS	Band Reject Filter	BRM50702	G024	2020-08-05	2021-08-04
MICRO-COAX	Coaxial Cable	Cable-8	8	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-9	9	2020-08-15	2021-08-14
MICRO-COAX	Coaxial Cable	Cable-10	10	2020-08-15	2021-08-14
RF Conducted Test					
Rohde & Schwarz	Signal Analyzer	FSIQ26	836131/009	2020-11-30	2021-11-29
Rohde & Schwarz	FSV40 Signal Analyzer	FSV40	101116	2020-07-23	2021-07-22
Narda	Attenuator	2dB	002	2020-08-15	2021-08-14
FrSky Electronic Co., Ltd.	RF Cable	FrSky Electronic Co., Ltd. 01	C01	Each Time	/
Conducted Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESCS30	834115/007	2020-11-30	2021-11-29
Rohde & Schwarz	LISN	ENV216	3560655016	2020-11-30	2021-11-29
Audix	Test Software	e3	V9	/	/
Rohde & Schwarz	Pulse limiter	ESH3-Z2	0357.8810.54	2020-08-10	2021-08-09
MICRO-COAX	Coaxial Cable	Cable-15	015	2020-08-15	2021-08-14

*** Statement of Traceability:** Bay Area Compliance Laboratories Corp. (Kunshan) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §1.1310 & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 1.1310, 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				
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

Calculated Formulary:

Predication of MPE limit at a given distance

$S = PG/4\pi R^2$ = 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:

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

Calculated Data (worst case):

Mod e	Frequency Range (MHz)	Maximum Antenna Gain		Tune-up Conducted Power		Evaluatio n Distance (cm)	Power Density (mW/cm ²)	MPE Limit (mW/cm ²)	MPE ratio
		(dBi)	(numerical)	(dBm)	(mW)				
SRD	904-925	4.00	2.51	14.00	25.12	20	0.0125	0.60	0.0209
	2403.985-2472.985	4.00	2.51	20.00	100.00	20	0.0499	1.00	0.0499

Note:

(1) The Tune-up output power was declared by the Manufacturer.

(2) 2.4G SRD and 900MHz SRD can transmit simultaneously, the worst condition as below:

$$\sum_i \frac{S_i}{S_{Limit,i}} = 0.0209 + 0.0499 = 0.07 < 1.0$$

Conclusion: The EUT meets exemption requirement- RF exposure evaluation greater than 20cm distance specified in § 2.1091. If the device built into a host as a portable usage, the additional RF exposure evaluation may be required as specified by § 2.1093.

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 Information

The EUT has three antennas for 2.4G SRD. Antenna use a unique type of connector to attach to the EUT.

Function	Manufacturer	Antenna No.	Antenna Type	Model number	Max. Antenna Gain
2.4G SRD	Angeei	1	Single-band	S2420R01-T4-180G13U1S	2.0
	Feiyuxin	2	Omni	3.10.0405001457	4.0
	Angeei	3	Single-band	S2420R01-T4-150W13U1S	2.0

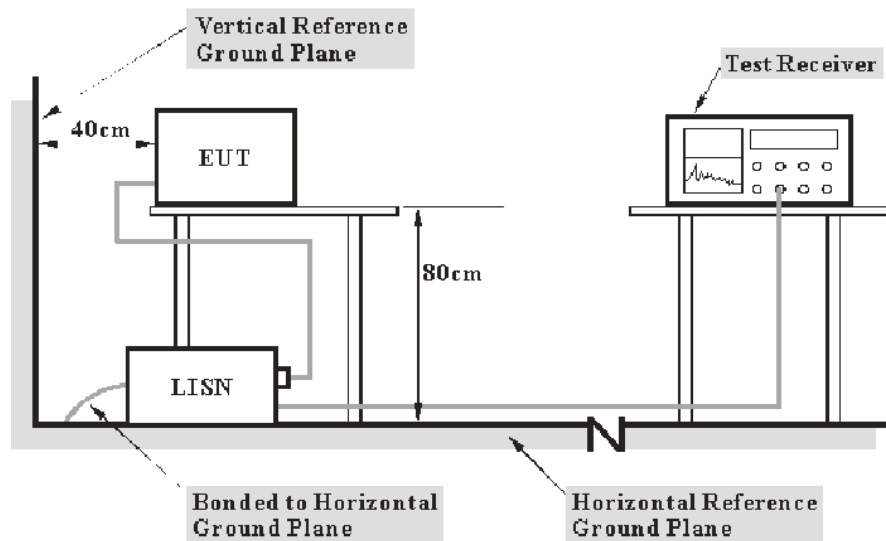
Result: Compliant.

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

EUT Setup



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

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

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

ANSI C63.10-2013 clause 6.2

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

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

Factor & Margin Calculation

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

$$\text{Factor (dB)} = \text{LISN VDF (dB)} + \text{Cable Loss (dB)} + \text{Transient Limiter Attenuation (dB)}$$

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

$$\text{Over Limit (dB)} = \text{Read level (dB}\mu\text{V)} + \text{Factor (dB)} - \text{Limit (dB}\mu\text{V)}$$

Test Results Summary

According to the recorded data in following table, the EUT complied with the FCC Part 15.207.

Test Data

Environmental Conditions

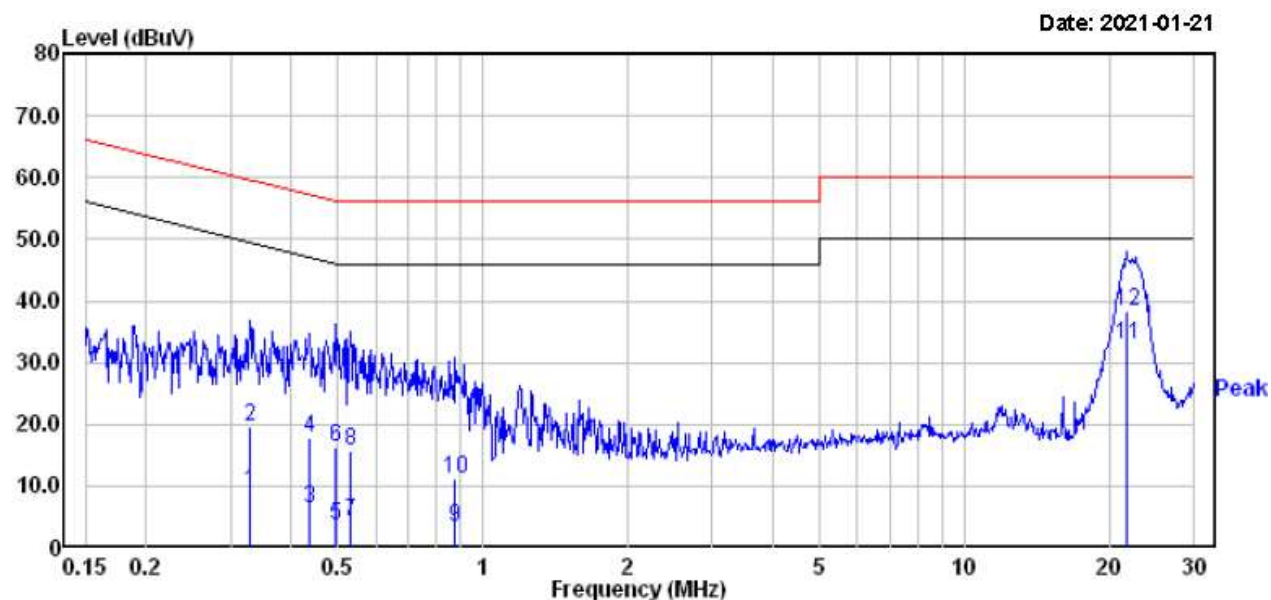
Temperature:	25.3 °C
Relative Humidity:	54 %
ATM Pressure:	101.3 kPa

The testing was performed by Tyrone Wang on 2021-01-21.

EUT operation mode: Transmitting in middle channel by Antenna 2 (worst case)

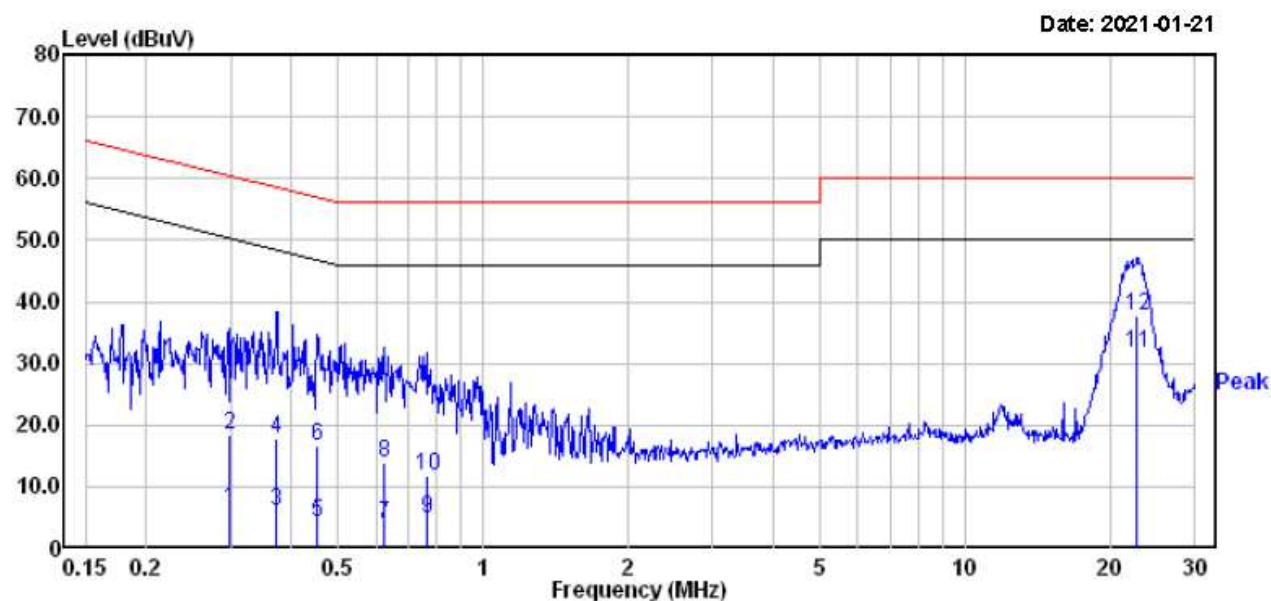
Note: We only select Antenna 2 tested for the conducted emissions since the Antenna2's gain is greater than other antennas.

AC 120V/60 Hz, Line



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.329	-10.71	19.82	9.11	49.49	-40.38	Average
2	0.329	-0.21	19.82	19.61	59.49	-39.88	QP
3	0.437	-13.40	19.75	6.35	47.11	-40.76	Average
4	0.437	-2.00	19.75	17.75	57.11	-39.36	QP
5	0.494	-16.00	19.76	3.76	46.10	-42.34	Average
6	0.494	-3.40	19.76	16.36	56.10	-39.74	QP
7	0.529	-15.39	19.75	4.36	46.00	-41.64	Average
8	0.529	-4.19	19.75	15.56	56.00	-40.44	QP
9	0.876	-16.51	19.73	3.22	46.00	-42.78	Average
10	0.876	-8.71	19.73	11.02	56.00	-44.98	QP
11	21.715	13.00	19.86	32.86	50.00	-17.14	Average
12	21.715	18.40	19.86	38.26	60.00	-21.74	QP

AC 120V/60 Hz, Neutral



	Freq	Read Level	Factor	Level	Limit Line	Over Limit	Remark
	MHz	dBuV	dB	dBuV	dBuV	dB	
1	0.297	-13.40	19.83	6.43	50.32	-43.89	Average
2	0.297	-1.40	19.83	18.43	60.32	-41.89	QP
3	0.373	-13.81	19.78	5.97	48.43	-42.46	Average
4	0.373	-2.01	19.78	17.77	58.43	-40.66	QP
5	0.454	-15.50	19.75	4.25	46.80	-42.55	Average
6	0.454	-3.00	19.75	16.75	56.80	-40.05	QP
7	0.624	-15.70	19.75	4.05	46.00	-41.95	Average
8	0.624	-6.00	19.75	13.75	56.00	-42.25	QP
9	0.763	-14.80	19.72	4.92	46.00	-41.08	Average
10	0.763	-8.00	19.72	11.72	56.00	-44.28	QP
11	22.775	11.90	19.80	31.70	50.00	-18.30	Average
12	22.775	17.80	19.80	37.60	60.00	-22.40	QP

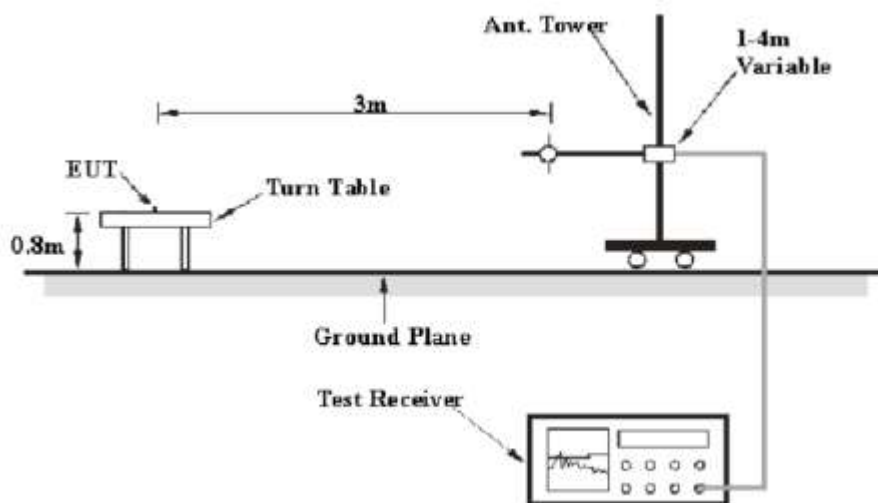
FCC §15.205, §15.209 & §15.247(d) – RADIATED EMISSIONS

Applicable Standard

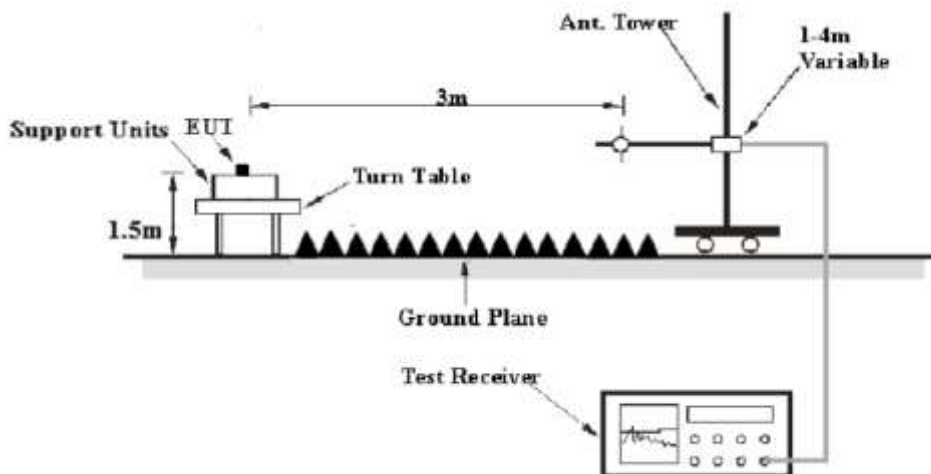
FCC §15.205; §15.209; §15.247(d)

EUT Setup

Below 1 GHz:



Above 1GHz:



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

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 25 GHz.

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

Frequency Range	RBW	Video B/W	IF B/W	Detector
30 MHz - 1000 MHz	120 kHz	300 kHz	120 kHz	QP
Above 1GHz	1MHz	3 MHz	/	PK
	1MHz	3 MHz	/	Ave

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 Results Summary

According to the recorded data in following table, the EUT complied with the FCC Title 47, Part 15, Subpart C, section 15.205, 15.209 and 15.247.

Test Data

Environmental Conditions

Temperature:	23.5 °C~25°C
Relative Humidity:	50%~64%
ATM Pressure:	101.1 kPa~101.5kPa

The testing was performed by Tyrone Wang from 2020-11-20 to 2021-01-18.

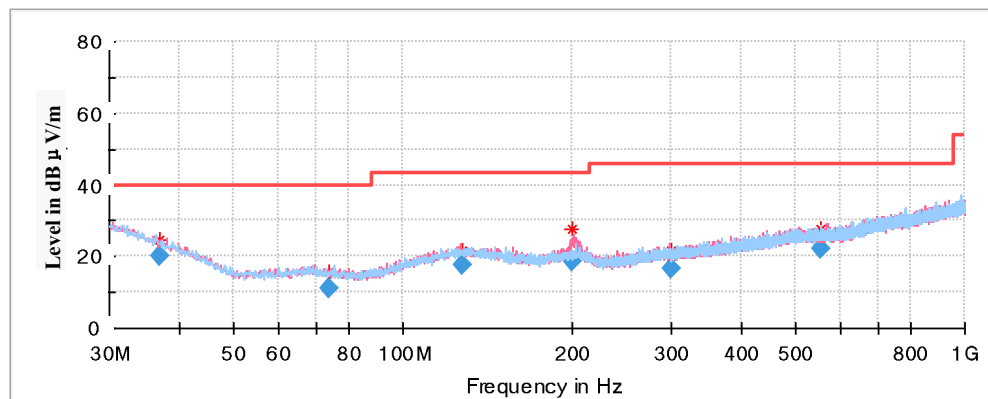
EUT operation mode: Transmitting

For antenna 1&3:

Spurious Emission Test:

30MHz-1GHz:

Pre-Scan with low, middle and high channels in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded



Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	QuasiPeak (dBμV/m)	Height (cm)	Polar (H/V)				
36.905400	19.97	100.0	V	234.0	-8.5	40.00	20.03
74.093150	11.25	100.0	H	62.0	-16.5	40.00	28.75
127.693700	17.83	100.0	V	0.0	-10.5	43.50	25.67
200.260150	18.85	100.0	V	258.0	-10.8	43.50	24.65
299.763700	16.82	200.0	V	12.0	-10.4	46.00	29.18
555.488100	22.11	200.0	H	117.0	-5.1	46.00	23.89

1GHz-18GHz

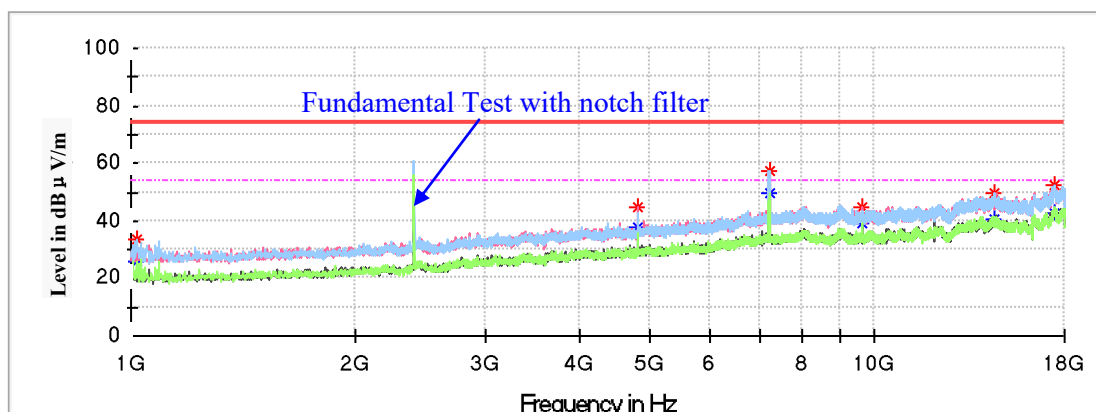
(Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.)

Note:

1. This test was performed with the 2.4 - 2.5GHz notch filter.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) - Amplifier Factor (dB)
 Corrected Amplitude (dB μ V/m) = Corrected Factor (dB/m) + Reading (dB μ V)
 Margin (dB) = Limit (dB μ V/m) - Corrected Amplitude (dB μ V/m)

Low Channel: 2403.985MHz

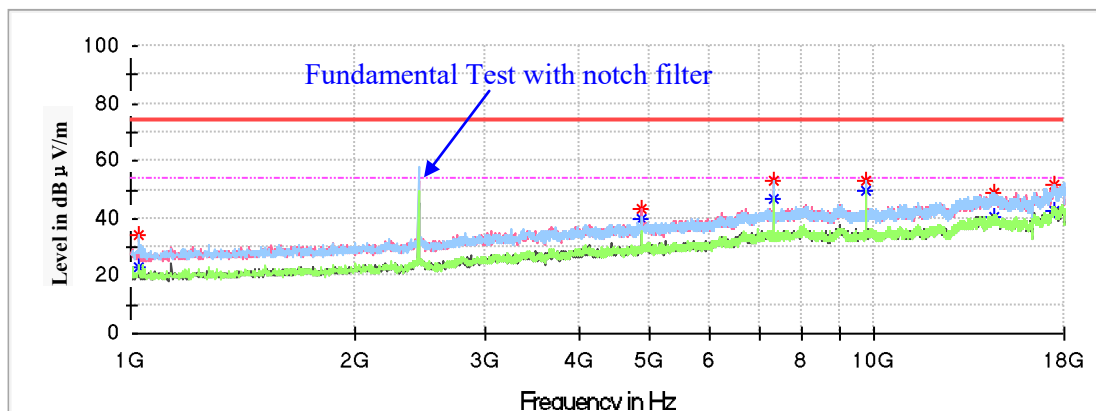
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dB μ V/m)	Margin (dB)
	MaxPeak (dB μ V/m)	Average (dB μ V/m)	Height (cm)	Polar (H/V)				
1017.000000	33.66	---	150.0	H	310.0	-19.0	74.00	40.34
1017.000000	---	26.12	150.0	H	310.0	-19.0	54.00	27.88
4807.970000	---	38.06	150.0	V	313.0	-5.6	54.00	15.94
4807.970000	44.49	---	150.0	V	313.0	-5.6	74.00	29.51
7211.955000	---	49.67	150.0	H	14.0	0.4	54.00	4.33
7211.955000	57.35	---	150.0	H	14.0	0.4	74.00	16.65
9615.600000	---	39.08	150.0	H	14.0	2.1	54.00	14.92
9615.600000	45.05	---	150.0	H	14.0	2.1	74.00	28.95
14475.900000	---	40.87	150.0	V	39.0	6.5	54.00	13.13
14475.900000	49.85	---	150.0	V	39.0	6.5	74.00	24.15
17396.500000	---	42.77	150.0	V	324.0	8.5	54.00	11.23
17396.500000	52.56	---	150.0	V	324.0	8.5	74.00	21.44

Middle Channel: 2438.485MHz

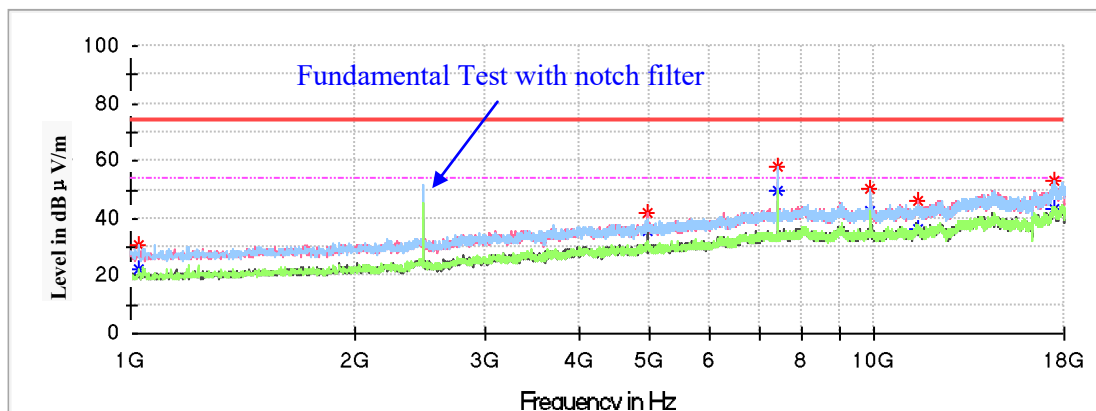
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1025.500000	---	23.16	150.0	H	314.0	-18.9	54.00	30.84
1025.500000	34.17	---	150.0	H	314.0	-18.9	74.00	39.83
4876.970000	---	39.87	150.0	V	323.0	-5.4	54.00	14.13
4876.970000	43.30	---	150.0	V	323.0	-5.4	74.00	30.70
7315.455000	---	47.17	150.0	H	108.0	0.6	54.00	6.83
7315.455000	53.20	---	150.0	H	108.0	0.6	74.00	20.80
9753.300000	---	49.41	150.0	H	275.0	2.0	54.00	4.59
9753.300000	52.94	---	150.0	H	275.0	2.0	74.00	21.06
14492.900000	---	40.61	150.0	V	222.0	6.5	54.00	13.39
14492.900000	49.21	---	150.0	V	222.0	6.5	74.00	24.79
17396.500000	---	42.91	150.0	V	301.0	8.5	54.00	11.09
17396.500000	51.98	---	150.0	V	301.0	8.5	74.00	22.02

High Channel: 2472.985MHz

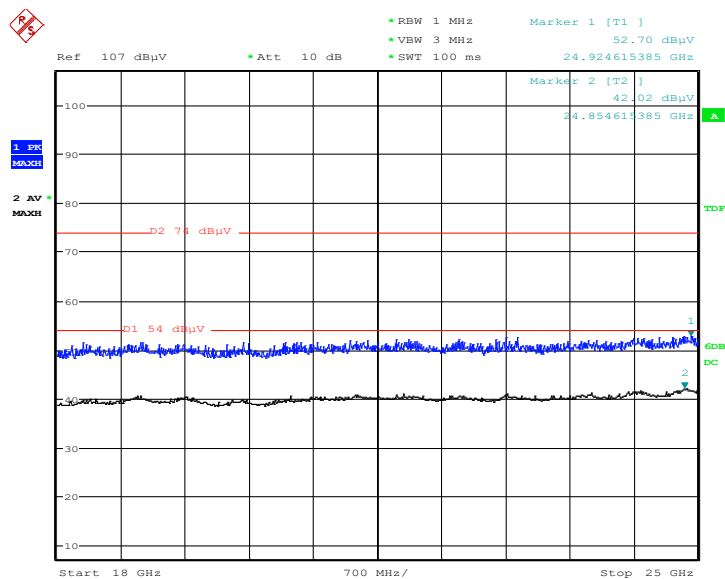
Full Spectrum



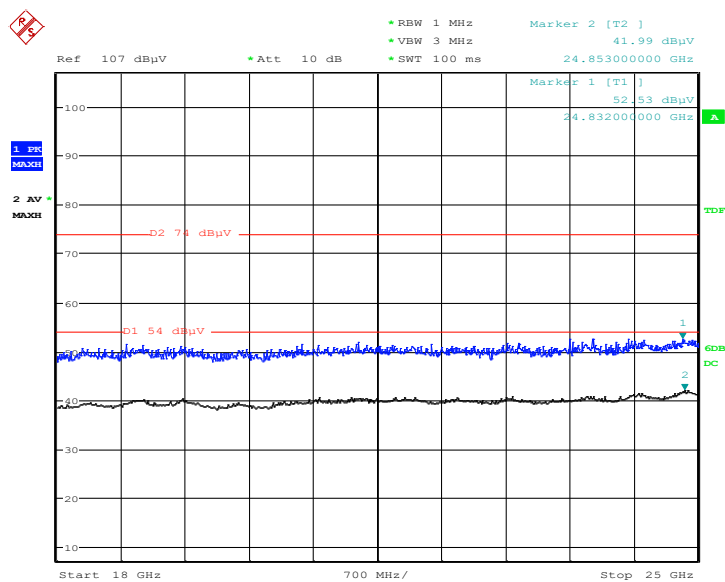
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dB μ V/m)	Margin (dB)
	MaxPeak (dB μ V/m)	Average (dB μ V/m)	Height (cm)	Polar (H/V)				
1025.500000	---	22.71	150.0	H	312.0	-18.9	54.00	31.29
1025.500000	30.61	---	150.0	H	312.0	-18.9	74.00	43.39
4945.970000	---	35.84	150.0	V	331.0	-5.3	54.00	18.16
4945.970000	41.67	---	150.0	V	331.0	-5.3	74.00	32.33
7418.955000	---	49.59	150.0	H	172.0	0.9	54.00	4.41
7418.955000	58.15	---	150.0	H	172.0	0.9	74.00	15.85
9891.000000	---	42.61	150.0	H	325.0	2.0	54.00	11.39
9891.000000	50.26	---	150.0	H	325.0	2.0	74.00	23.74
11441.400000	---	36.03	150.0	V	239.0	2.8	54.00	17.97
11441.400000	46.00	---	150.0	V	239.0	2.8	74.00	28.00
17411.800000	---	43.63	150.0	H	37.0	8.6	54.00	10.37
17411.800000	52.93	---	150.0	H	37.0	8.6	74.00	21.07

18GHz-25GHz:

*Pre-Scan with low, middle and high channels in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded*

Horizontal

Date: 13.JAN.2021 10:29:28

Vertical

Date: 13.JAN.2021 10:19:53

Fundamental Test & Restricted Bands Emissions:

Pre-Scan in the X,Y and Z axes of orientation, the worst case in X-axis of orientation was recorded

Note:

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

Corrected Amplitude = Corrected Factor + Reading

Margin = Limit - Corrected. Amplitude

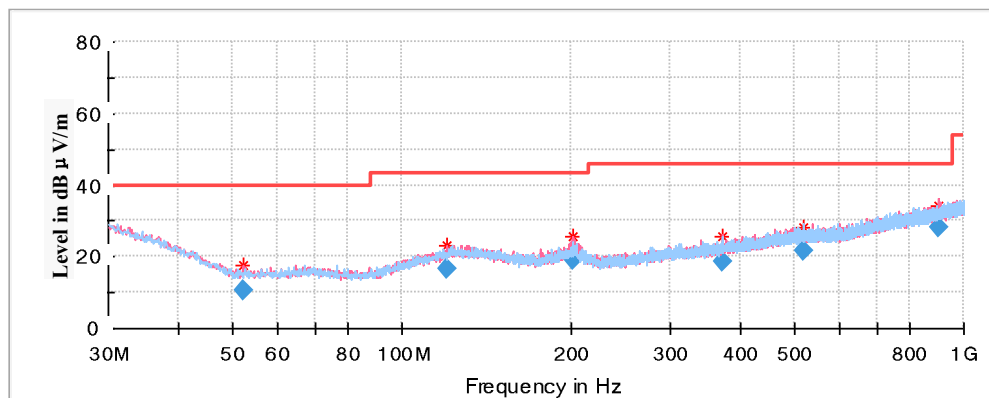
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV /m)	Height (cm)	Polar (H/V)				
Low Channel								
2390.00	47.33	---	150.0	H	190.0	-2.9	74.00	26.67
2390.00	---	40.91	150.0	H	190.0	-2.9	54.00	13.09
2390.00	47.52	---	150.0	V	109.0	-2.9	74.00	26.48
2390.00	---	40.78	150.0	V	109.0	-2.9	54.00	13.22
High Channel								
2483.50	---	46.53	150.0	V	113.0	-2.5	54.00	7.47
2483.50	48.94	---	150.0	V	113.0	-2.5	74.00	25.06
2483.50	50.11	---	150.0	H	167.0	-2.5	74.00	23.89
2483.50	---	45.26	150.0	H	167.0	-2.5	54.00	8.74

For antenna 2:

Spurious Emission Test:

30MHz-1GHz:

Pre-Scan with low, middle and high channels in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded



Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	QuasiPeak (dBμV/m)	Height (cm)	Polar (H/V)				
52.311100	10.75	100.0	V	235.0	-17.2	40.00	29.25
120.615450	16.60	200.0	V	194.0	-11.1	43.50	26.90
201.734600	18.87	100.0	V	240.0	-10.9	43.50	24.63
371.690650	18.45	100.0	V	76.0	-8.7	46.00	27.55
519.739600	21.71	200.0	H	163.0	-5.3	46.00	24.29
899.823800	28.12	100.0	V	0.0	1.1	46.00	17.88

1GHz-18GHz

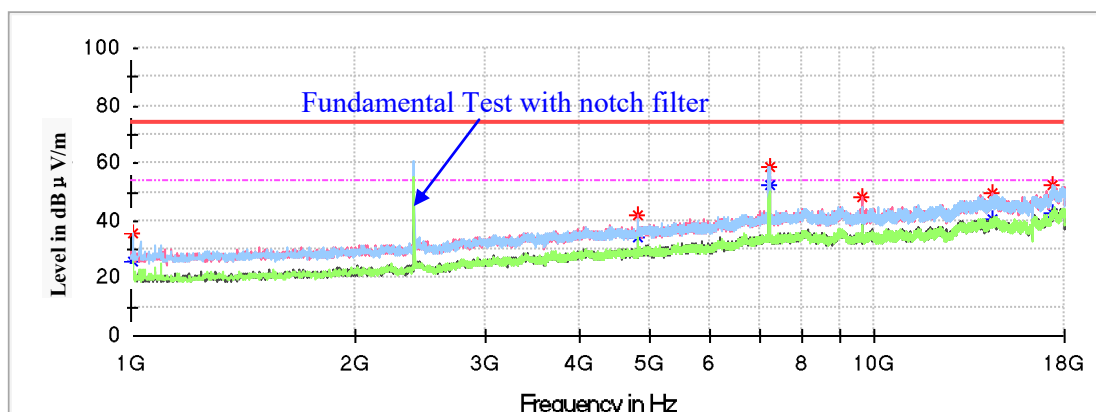
(Pre-scan in the X,Y and Z axes of orientation, the worst case **X-axis of orientation** was recorded.)

Note:

1. This test was performed with the 2.4 - 2.5GHz notch filter.
2. Corrected Factor (dB/m) = Antenna factor (RX) (dB/m) + Cable Loss (dB) - Amplifier Factor (dB)
 Corrected Amplitude (dBμV/m) = Corrected Factor (dB/m) + Reading (dBμV)
 Margin (dB) = Limit (dBμV/m) - Corrected Amplitude (dBμV/m)

Low Channel: 2403.985MHz

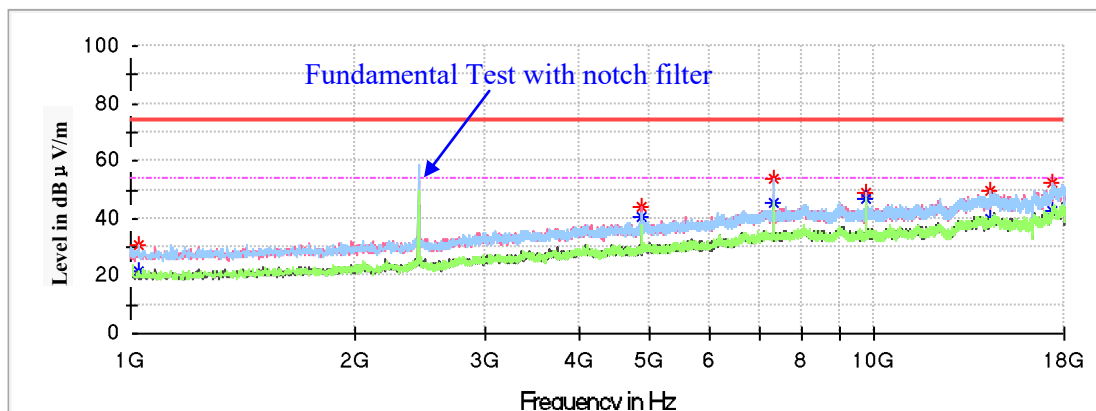
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1005.100000	35.77	---	150.0	H	288.0	-19.0	74.00	38.23
1005.100000	---	25.57	150.0	H	288.0	-19.0	54.00	28.43
4807.970000	---	34.15	150.0	V	148.0	-5.6	54.00	19.85
4807.970000	42.04	---	150.0	V	148.0	-5.6	74.00	31.96
7211.955000	---	52.35	150.0	V	147.0	0.4	54.00	1.65
7211.955000	58.78	---	150.0	V	147.0	0.4	74.00	15.22
9615.600000	---	41.98	150.0	H	256.0	2.1	54.00	12.02
9615.600000	48.16	---	150.0	H	256.0	2.1	74.00	25.84
14399.400000	---	40.40	150.0	V	84.0	6.5	54.00	13.60
14399.400000	49.37	---	150.0	V	84.0	6.5	74.00	24.63
17389.700000	---	42.39	150.0	H	349.0	8.5	54.00	11.61
17389.700000	52.11	---	150.0	H	349.0	8.5	74.00	21.89

Middle Channel: 2438.485MHz

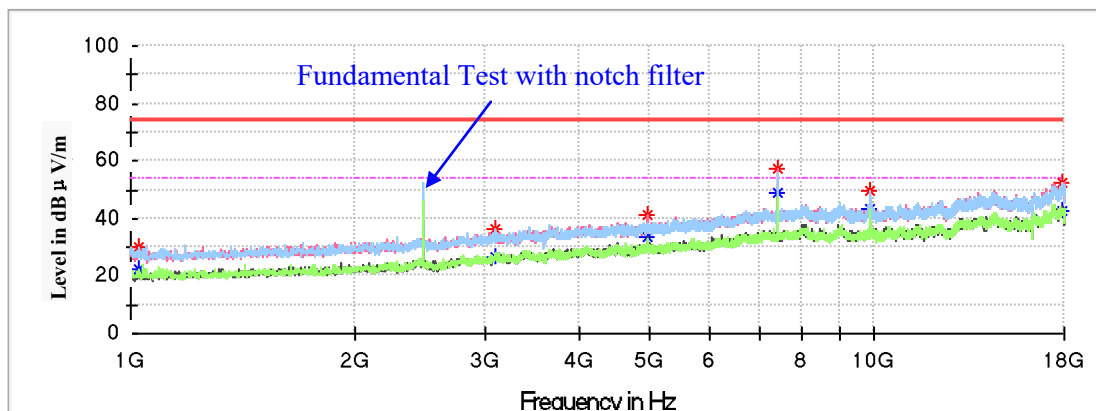
Full Spectrum



Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dB μ V/m)	Margin (dB)
	MaxPeak (dB μ V/m)	Average (dB μ V/m)	Height (cm)	Polar (H/V)				
1023.800000	---	21.76	150.0	H	129.0	-18.9	54.00	32.24
1023.800000	30.95	---	150.0	H	129.0	-18.9	74.00	43.05
4876.970000	44.29	---	150.0	V	345.0	-5.4	74.00	29.71
4876.970000	---	40.57	150.0	V	345.0	-5.4	54.00	13.43
7315.455000	---	45.26	150.0	H	116.0	0.6	54.00	8.74
7315.455000	53.94	---	150.0	H	116.0	0.6	74.00	20.06
9753.300000	49.29	---	150.0	H	245.0	2.0	74.00	24.71
9753.300000	---	46.81	150.0	H	245.0	2.0	54.00	7.19
14338.200000	---	39.65	150.0	V	239.0	6.4	54.00	14.35
14338.200000	49.38	---	150.0	V	239.0	6.4	74.00	24.62
17389.700000	---	42.96	150.0	H	258.0	8.5	54.00	11.04
17389.700000	52.12	---	150.0	H	258.0	8.5	74.00	21.88

High Channel: 2472.985MHz

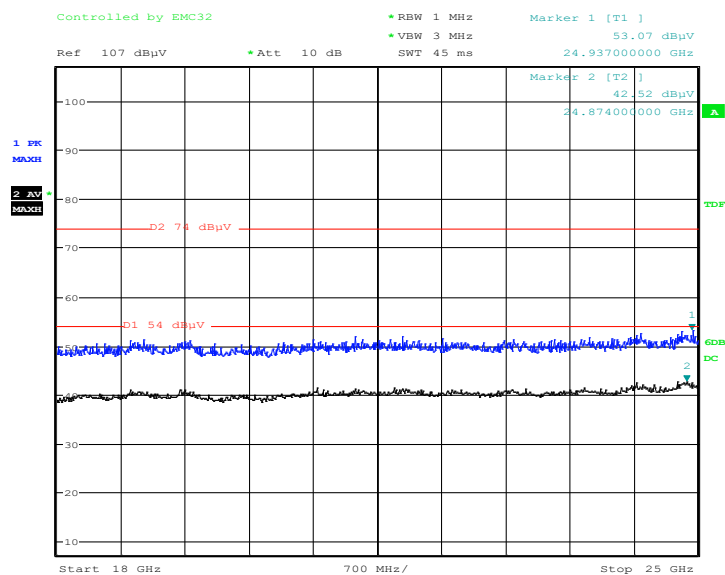
Full Spectrum



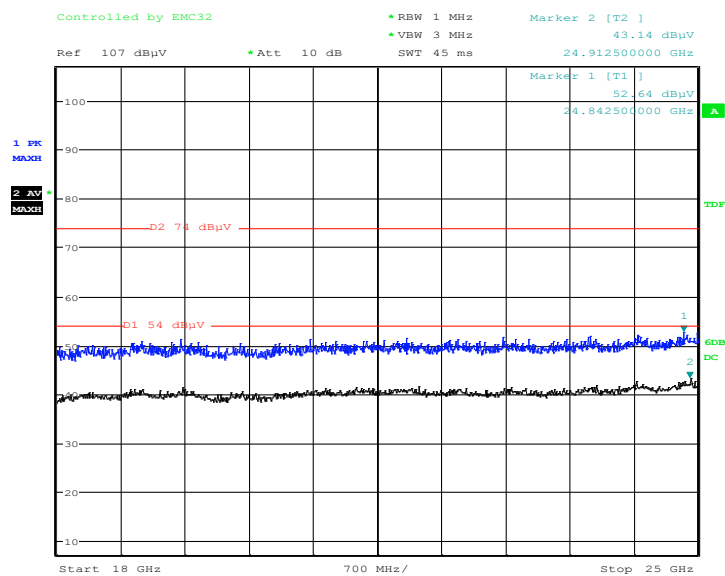
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1027.200000	---	22.54	150.0	H	284.0	-18.9	54.00	31.46
1027.200000	30.37	---	150.0	H	284.0	-18.9	74.00	43.63
3099.500000	---	26.60	150.0	V	115.0	-9.8	54.00	27.40
3099.500000	36.32	---	150.0	V	115.0	-9.8	74.00	37.68
4945.970000	---	33.74	150.0	V	297.0	-5.3	54.00	20.26
4945.970000	41.44	---	150.0	V	297.0	-5.3	74.00	32.56
7418.955000	---	48.75	150.0	V	89.0	0.9	54.00	5.25
7418.955000	57.04	---	150.0	V	89.0	0.9	74.00	16.96
9891.000000	---	43.14	150.0	H	296.0	2.0	54.00	10.86
9891.000000	49.77	---	150.0	H	296.0	2.0	74.00	24.23
17841.900000	---	42.38	150.0	H	284.0	8.8	54.00	11.62
17841.900000	52.49	---	150.0	H	284.0	8.8	74.00	21.51

18GHz-25GHz:

*Pre-Scan with low, middle and high channels in the X,Y and Z axes of orientation, the worst case **low channel in X-axis of orientation** was recorded*

Horizontal

Date: 18.JAN.2021 10:39:52

Vertical

Date: 18.JAN.2021 10:48:33

Fundamental Test & Restricted Bands Emissions:

Pre-Scan in the X,Y and Z axes of orientation, the worst case in X-axis of orientation was recorded

Note:

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

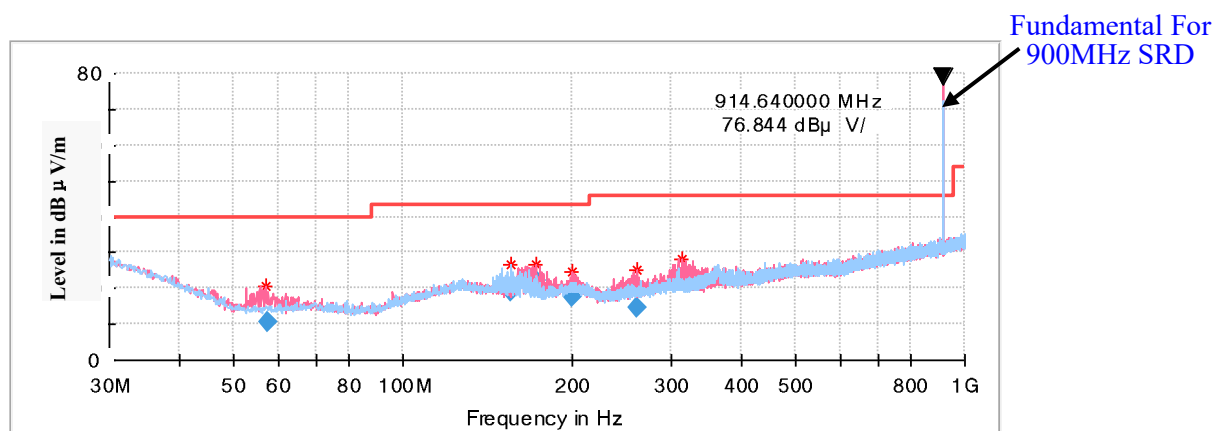
Corrected Amplitude = Corrected Factor + Reading

Margin = Limit - Corrected. Amplitude

Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV /m)	Height (cm)	Polar (H/V)				
Low Channel								
2390.00	47.02	---	150.0	H	210.0	-2.9	74.00	26.98
2390.00	---	41.80	150.0	H	210.0	-2.9	54.00	12.20
2390.00	47.14	---	150.0	V	135.0	-2.9	74.00	26.86
2390.00	---	41.65	150.0	V	135.0	-2.9	54.00	12.35
High Channel								
2483.50	---	46.04	150.0	V	101.0	-2.5	54.00	7.96
2483.50	49.87	---	150.0	V	101.0	-2.5	74.00	24.13
2483.50	50.22	---	150.0	H	115.0	-2.5	74.00	23.78
2483.50	---	45.71	150.0	H	115.0	-2.5	54.00	8.29

Transmitting simultaneously test:**30MHz-1GHz**

(The worst case 900MHz SRD and 2.4G SRD mode transmitting simultaneously in Z-axis of orientation was recorded)

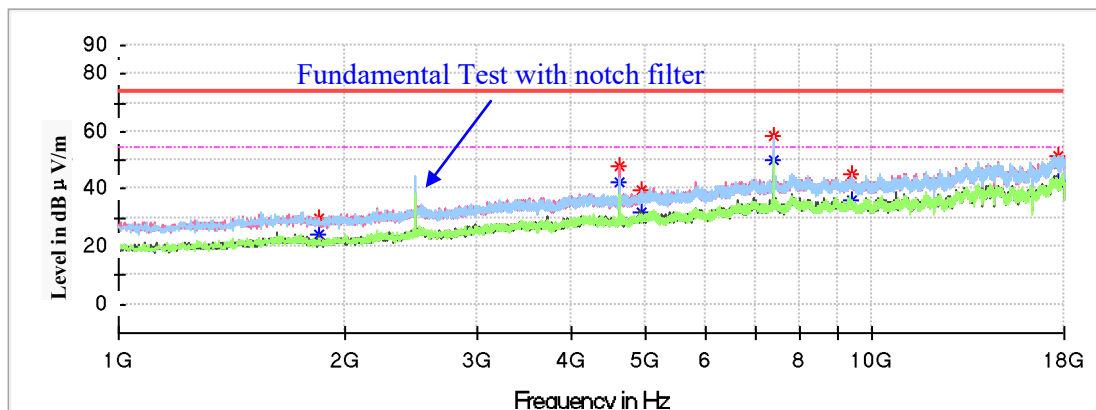


Frequency (MHz)	Corrected Amplitude	Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dB μ V/m)	Margin (dB)
	QuasiPeak (dB μ V/m)	Height (cm)	Polar (H/V)				
57.412800	10.54	100.0	V	83.0	-18.0	40.00	29.46
155.352850	19.00	200.0	H	254.0	-12.6	43.50	24.50
172.630550	22.00	100.0	V	95.0	-13.3	43.50	21.50
199.789500	17.55	100.0	V	345.0	-11.5	43.50	25.95
261.470050	14.74	100.0	V	108.0	-12.7	46.00	31.26
314.450300	22.12	200.0	V	174.0	-10.7	46.00	23.88

1GHz-18GHz

(The worst case 900Mhz SRD and 2.4G SRD mode transmitting simultaneously in Z-axis of orientation was recorded)

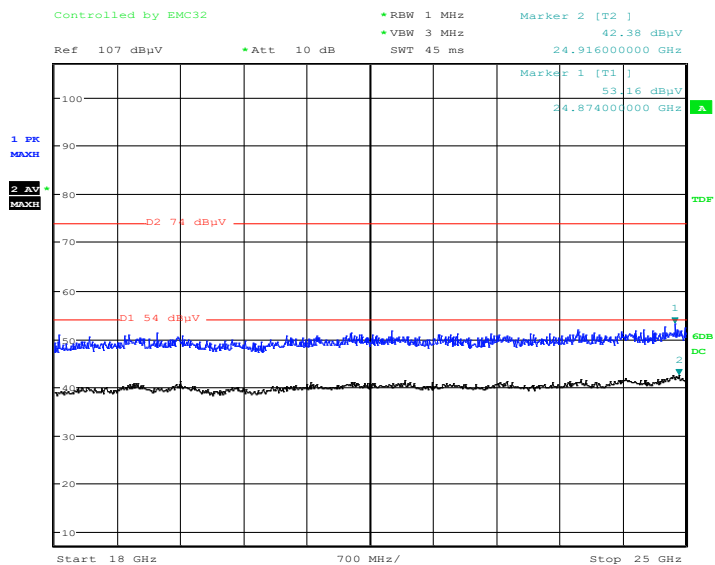
Full Spectrum



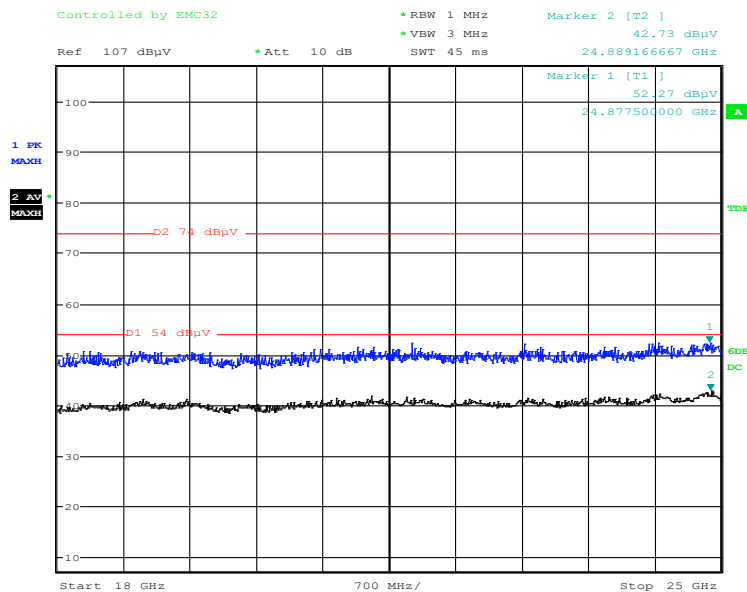
Frequency (MHz)	Corrected Amplitude		Rx Antenna		Turntable Degree	Corrected Factor (dB/m)	Limit (dBμV/m)	Margin (dB)
	MaxPeak (dBμV/m)	Average (dBμV/m)	Height (cm)	Polar (H/V)				
1848.300000	---	24.59	150.0	V	143.0	-15.0	54.00	29.41
1848.300000	30.05	---	150.0	V	143.0	-15.0	74.00	43.95
4622.700000	---	42.52	150.0	V	130.0	-6.0	54.00	11.48
4622.700000	48.11	---	150.0	V	130.0	-6.0	74.00	25.89
4945.970000	---	32.27	150.0	V	43.0	-5.3	54.00	21.73
4945.970000	39.41	---	150.0	V	43.0	-5.3	74.00	34.59
7418.955000	---	50.29	150.0	H	248.0	0.9	54.00	3.71
7418.955000	58.63	---	150.0	H	248.0	0.9	74.00	15.37
9396.300000	---	36.27	150.0	H	152.0	2.1	54.00	17.73
9396.300000	45.48	---	150.0	H	152.0	2.1	74.00	28.52
17653.200000	---	42.21	150.0	H	99.0	8.9	54.00	11.79
17653.200000	51.64	---	150.0	H	99.0	8.9	74.00	22.36

18GHz-25GHz:

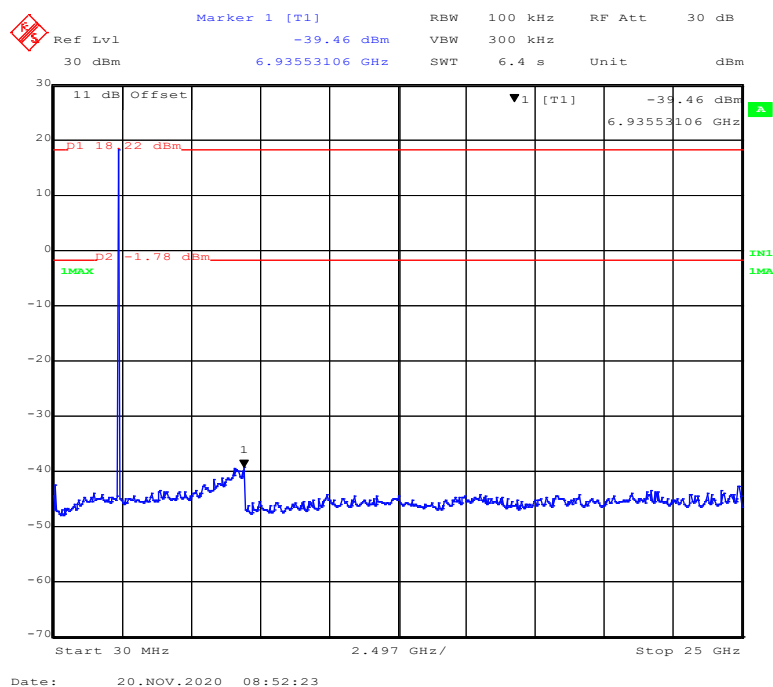
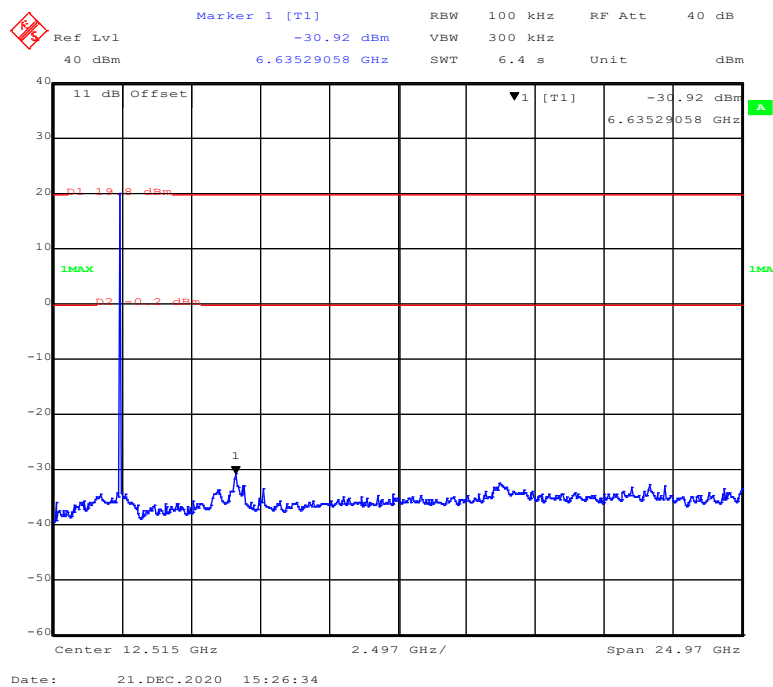
(The worst case 900MHz SRD and 2.4G SRD mode transmitting simultaneously in Z-axis of orientation was recorded)

Vertical

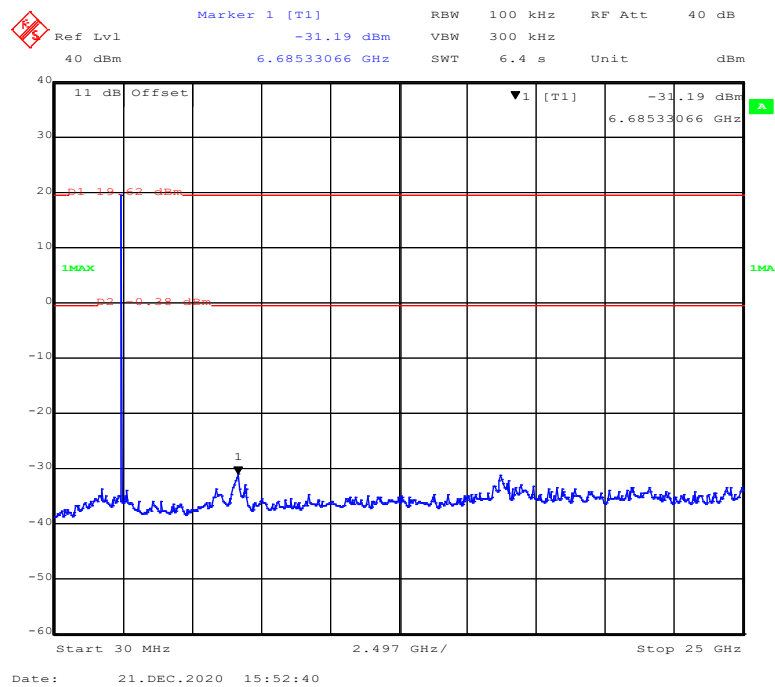
Date: 9.JAN.2021 09:19:24

Horizontal

Date: 9.JAN.2021 09:26:21

Conducted Spurious Emissions at Antenna Port:**Low Channel****Middle Channel**

High Channel



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.

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:	23.2-25.3 °C
Relative Humidity:	48-55 %
ATM Pressure:	101.1-101.7 kPa

The testing was performed by Tyrone Wang from 2020-11-21 to 2021-01-19.

EUT operation mode: Hopping

Test Result: Compliant.

Mode	Channel	Frequency (MHz)	Channel Separation (MHz)	Limit (MHz)	Result
FSK	Low	2403.985	1.498	0.167	Pass
	Adjacent	2405.485			
	Middle	2438.485	1.502	0.167	Pass
	Adjacent	2436.985			
	High	2471.485	1.498	0.167	Pass
	Adjacent	2472.985			

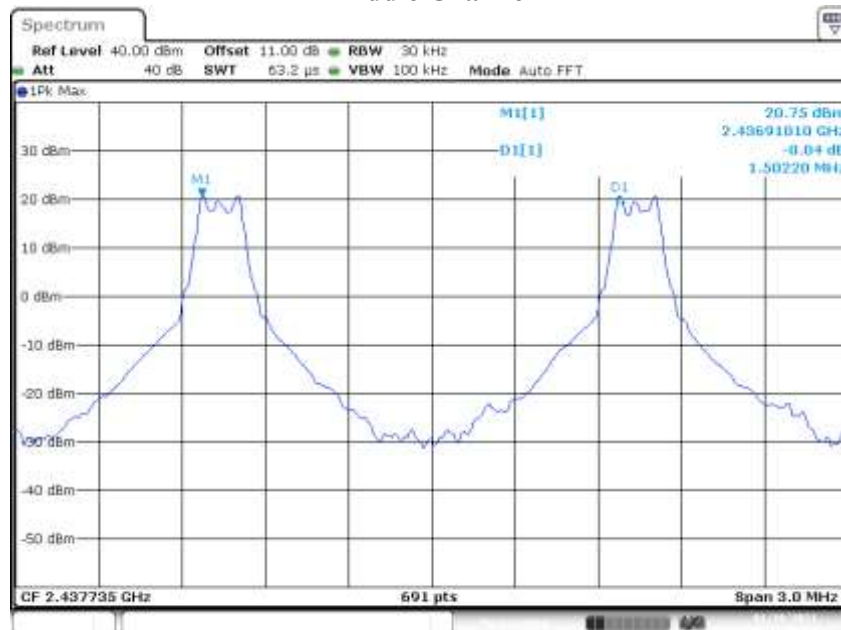
The limit = 20dB Bandwidth*2/3

Low Channel



Date: 21 NOV 2020 16:53:51

Middle Channel



Date: 19 JAN 2021 21:13:46

High Channel



Date: 21 NOV 2020 17:10:16

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:	24.4-25.3 °C
Relative Humidity:	50-51 %
ATM Pressure:	101.1-101.2 kPa

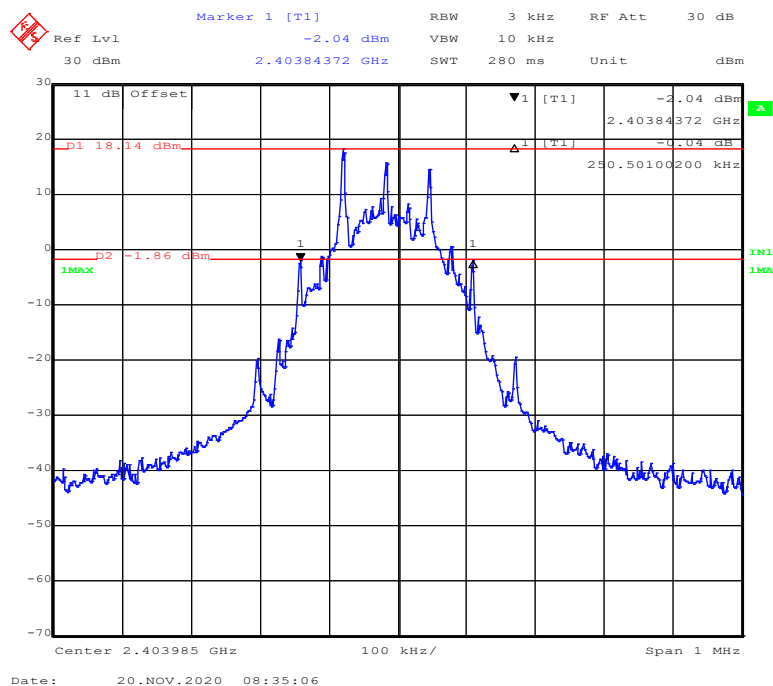
The testing was performed by Tyrone Wang from 2020-11-20 to 2020-12-21.

EUT operation mode: Transmitting

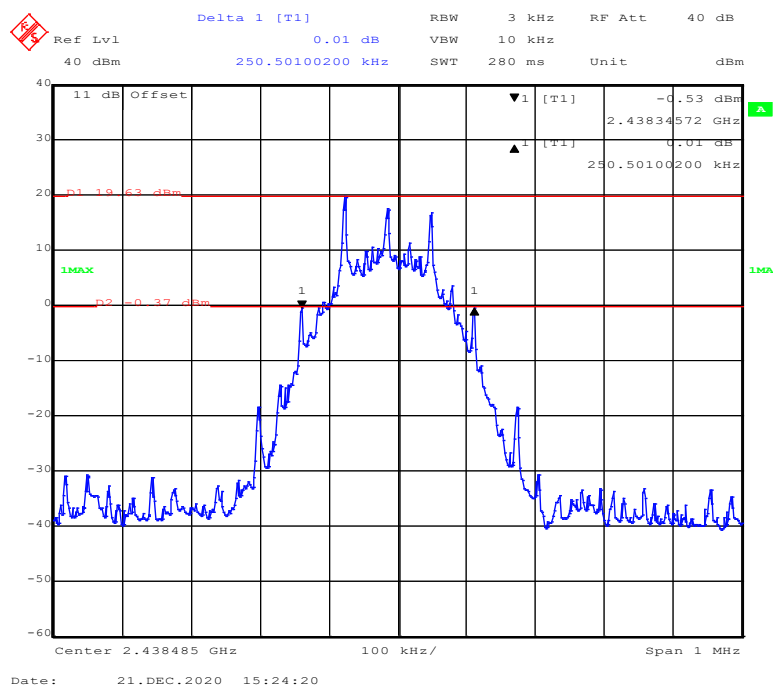
Test Result: Compliant.

Modulation	Channel	Frequency (MHz)	20 dB Emission Bandwidth (kHz)
FSK	Low	2403.985	250.5
	Middle	2438.485	250.5
	High	2472.985	250.5

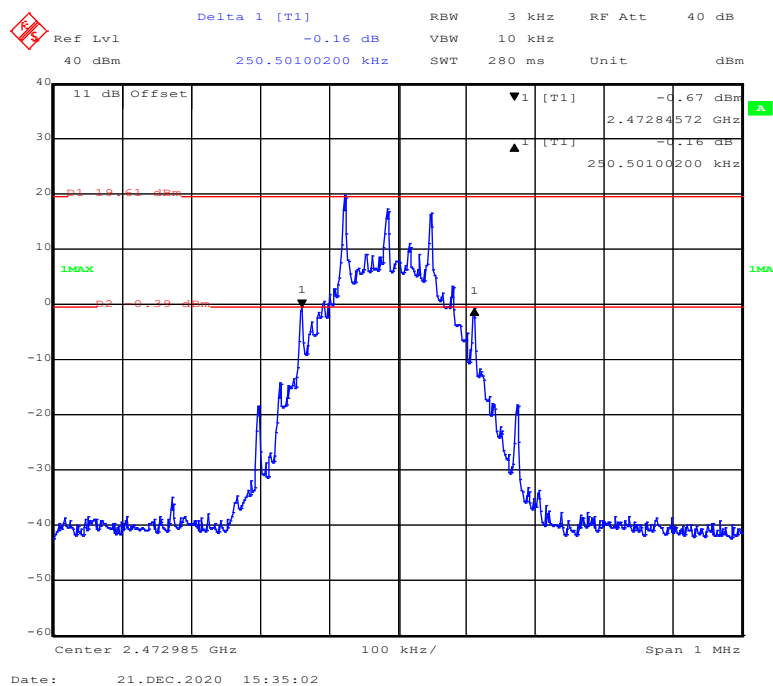
Low Channel



Middle Channel



High Channel



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:	25.4 °C
Relative Humidity:	53 %
ATM Pressure:	101.2 kPa

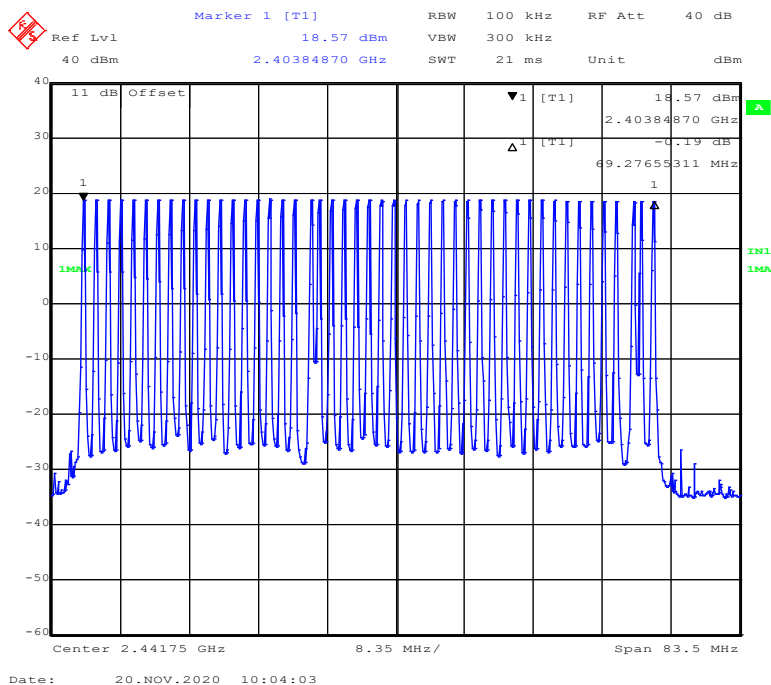
The testing was performed by Tyrone Wang on 2020-11-20.

EUT operation mode: Hopping

Test Result: Compliant.

Modulation	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
FSK	2403.985-2472.985	47	≥ 15

Number of Hopping Channels



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

The EUT was worked in channel hopping; Spectrum SPAN was set as 0. Sweep was set as 0.4 X channel no. (s), the quantity of pulse was get from single sweep. In addition, the time of single pulses was tested.

Test Data

Environmental Conditions

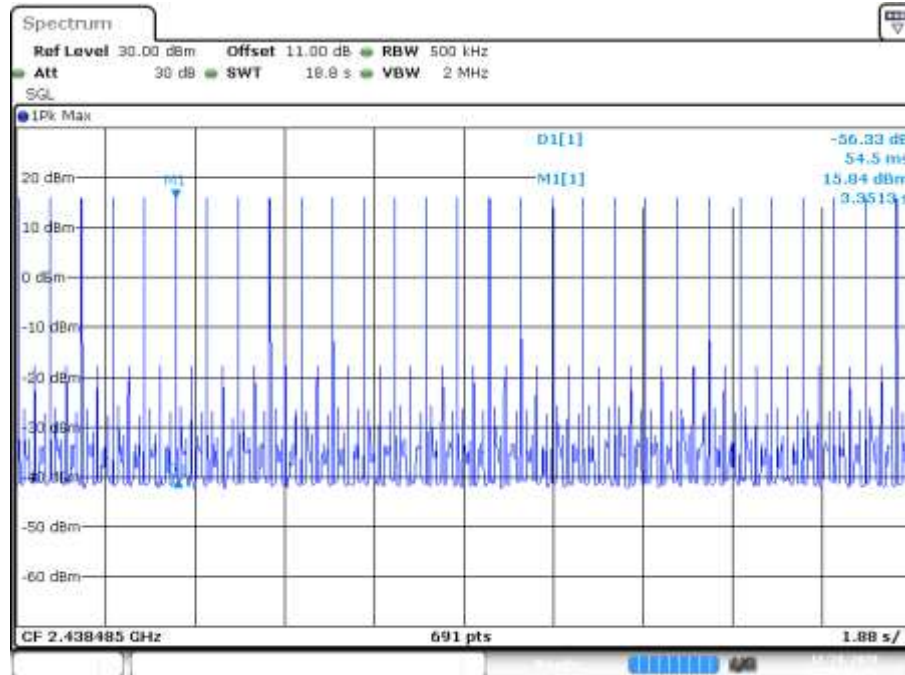
Temperature:	23.2-25.4 °C
Relative Humidity:	48-54 %
ATM Pressure:	101.1-101.5 kPa

The testing was performed by Tyrone Wang from 2020-11-20 to 2020-12-28.

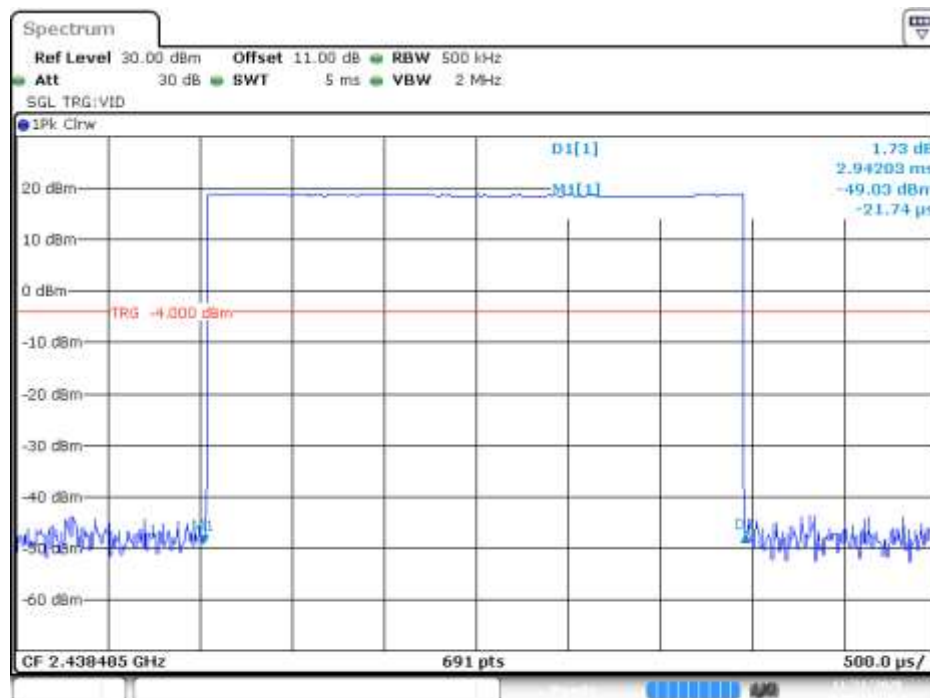
EUT operation mode: Hopping

Test Result: Compliant.

Modulation	Frequency (MHz)	Pulse Time	Pulse Number	Dwell Time	Limit	Result
		(ms)		(s)	(s)	
FSK	2438.485	2.942	29	0.085	≤0.4	Pass
	Note: Dwell time = Pulse time * N Observed time = 0.4s * hopping number = 0.4s * 47 = 18.8s					

Pulse Number, Middle Channel

Date: 28 DEC 2020 11:00:38

Pulse time, Middle Channel

Date: 21 NOV 2020 16:28:37

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:	23.2-25.3 °C
Relative Humidity:	48-54 %
ATM Pressure:	101.1-101.5 kPa

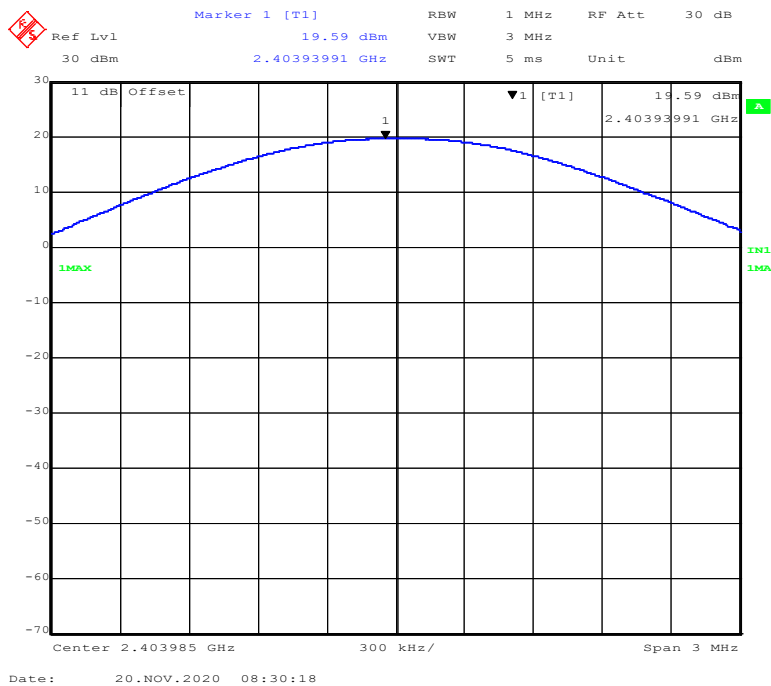
The testing was performed by Tyrone Wang from 2020-11-20 to 2020-12-21.

EUT operation mode: Transmitting

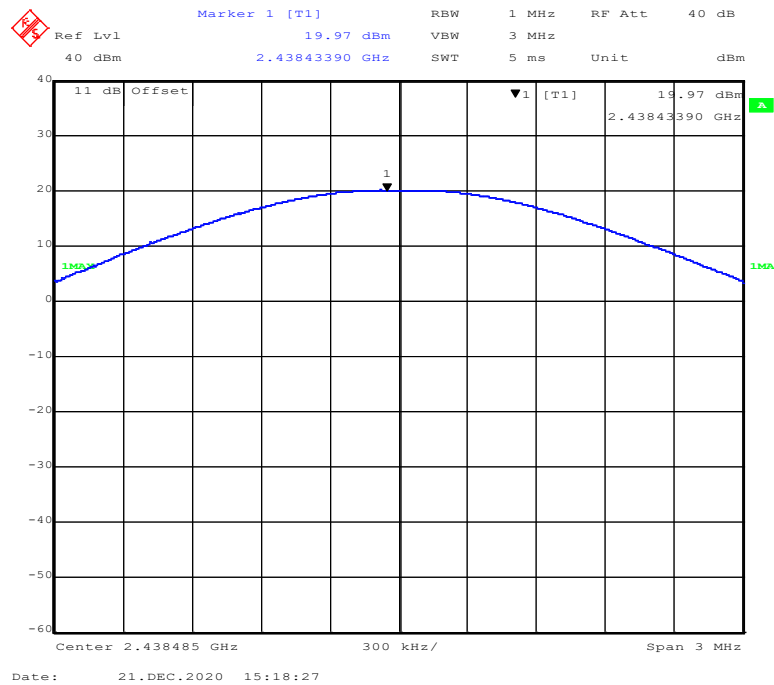
Test Result: Compliant.

Modulation	Channel	Frequency (MHz)	Output Power		Limit (mW)
			(dBm)	(mW)	
FSK	Low	2403.985	19.59	90.99	125
	Middle	2438.485	19.97	99.31	125
	High	2472.985	19.83	96.16	125

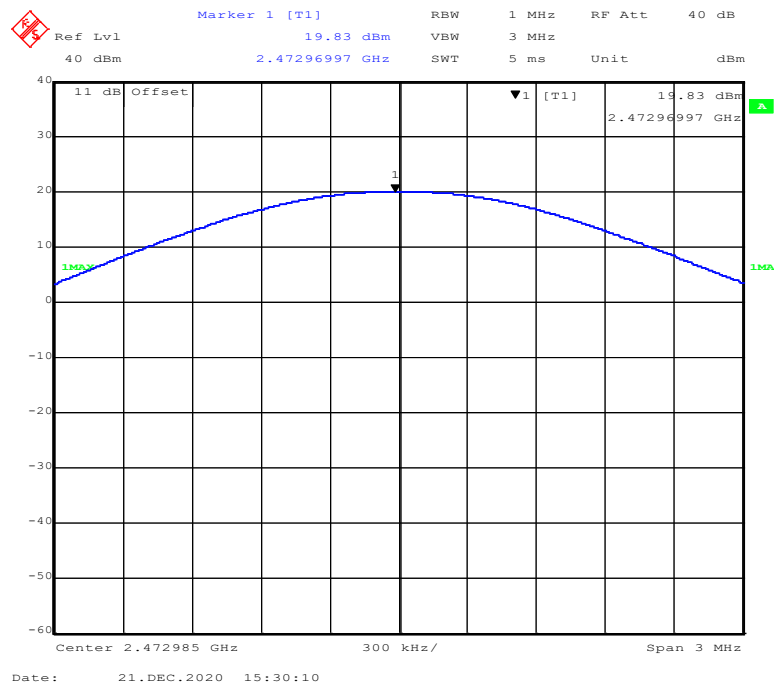
Low Channel



Middle Channel



High Channel



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:	24.4-25.3 °C
Relative Humidity:	50-51 %
ATM Pressure:	101.1-101.2 kPa

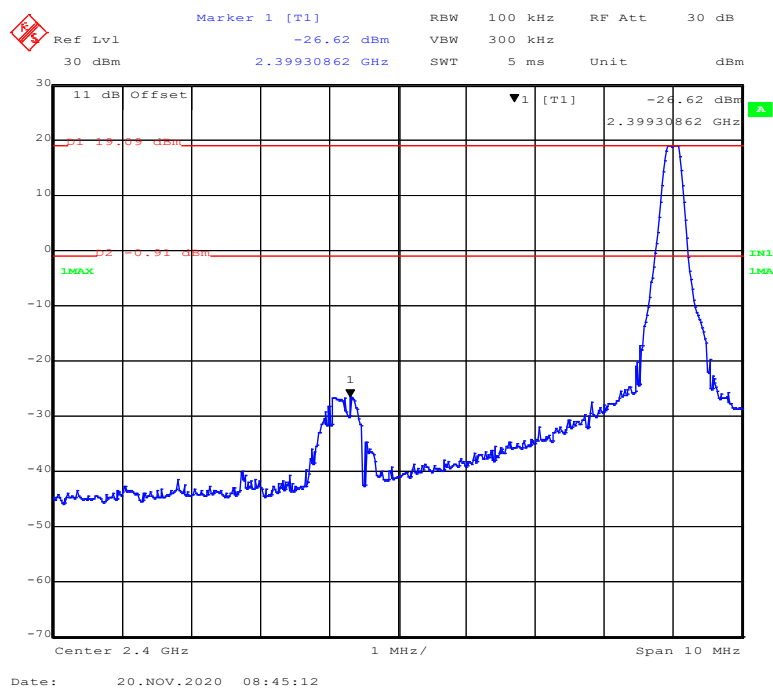
The testing was performed by Tyrone Wang from 2020-11-20 to 2020-12-21.

EUT operation mode: Transmitting&Hopping

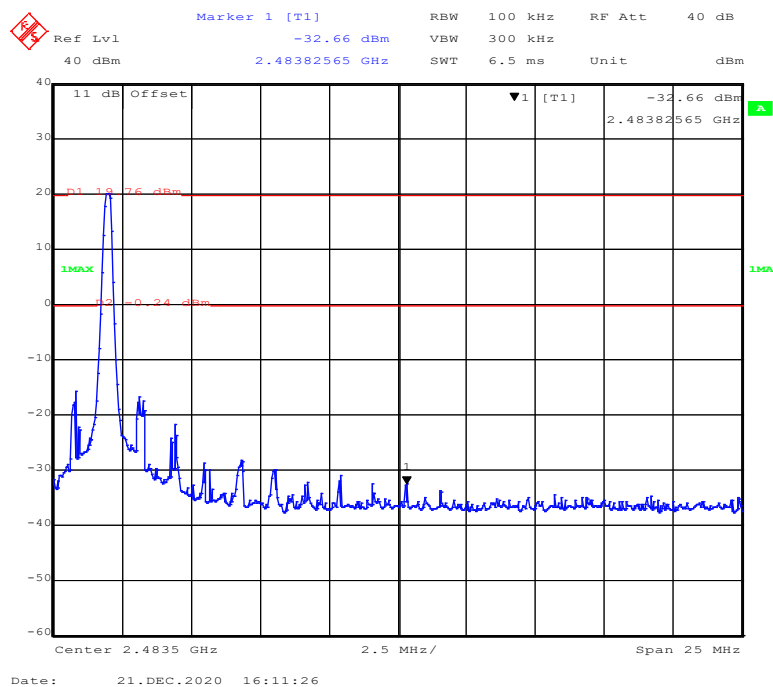
Test Result: Compliant.

Band Edge

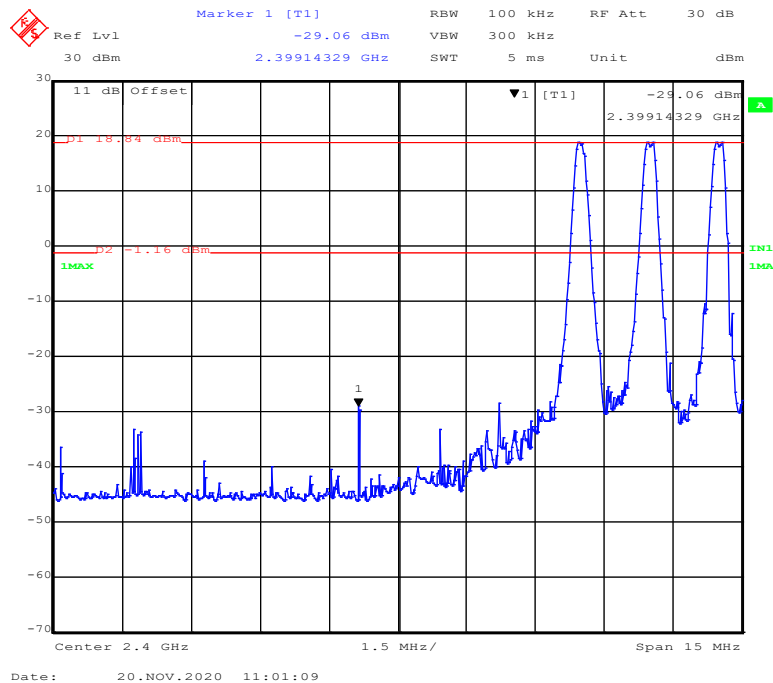
Left Side



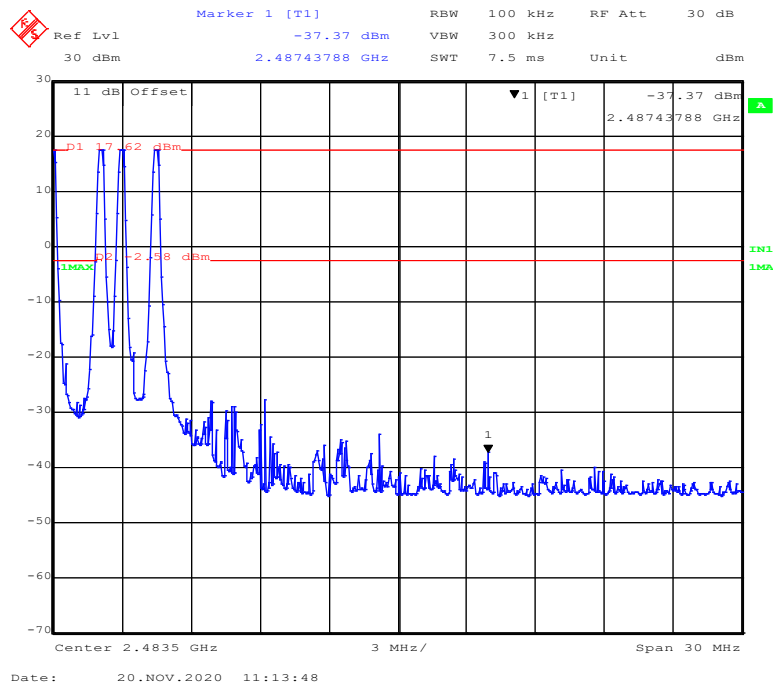
Right Side



Left Side-Hopping



Right Side-Hopping



Declarations

- 1: 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.
- 2: Unless otherwise stated the results shown in this test report refer only to the sample(s) tested.
- 3: Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.
- 4: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval.
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******* END OF REPORT *******