TEST REPORT

Applicant Name:	SHENZHEN STARWAVE INDUSTRIAL TECHNOLOGY CO.,LTD
Address:	1505 Floor 15,Huaide International Building,No.73, Fuyong Section,Guangshen Road,Huaide Community, Fuyong Street, Bao'an District, Shenzhen, China
Report Number:	SZ3231226-78377E-RF-00
FCC ID:	2BDOP-UPT-1446

Test Standard (s)

FCC PART 15.247

Sample Description

Product Type:	WIRELESS KEYBOARD-Dongle
Model No.:	UPT-1448
Multiple Model(s) No.:	UPT-1446
Trade Mark:	N/A
Date Received:	2024/01/17
Report Date:	2024/03/11

Test Result:	Pass▲

▲ In the configuration tested, the EUT complied with the standards above.

Prepared and Checked By:

Michelle Zeng

Michelle Zeng
RF Engineer

Approved By:

Nancy Wang

Nancy Wang
RF Supervisor

Note: The information marked # is provided by the applicant, the laboratory is not responsible for its authenticity and this information can affect the validity of the result in the test report. Customer model name, addresses, names, trademarks etc. are included.

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DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	SZ3231226-78377E-RF-00	Original Report	2024/03/11

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	WIRELESS KEYBOARD-Dongle
Tested Model	UPT-1448
Multiple Model(s)	UPT-1446 (Please refer to the DoS# provided by the applicant)
Frequency Range	2402-2480MHz
Maximum conducted peak output power	-0.54dBm
Modulation Technique	GFSK
Antenna Specification#	2.58dBi (provided by the applicant)
Voltage Range	DC 5V
Sample serial number	2FSL-1 for RF Conducted Test 2FSL-2 for Radiated Emissions (Assigned by BACL, Shenzhen)
Sample/EUT Status	Good condition
Adapter Information	N/A
Note: the multiple modes UPT-1446 is electronic identical with the tested model UPT-1448 except the model number, please refer to the DOS letter for more details. So the UPT-1448 was chosen for the full test.	

Objective

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

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

Test Methodology

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

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

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		±5%
RF output power, conducted		0.72 dB(k=2, 95% level of confidence)
AC Power Lines Conducted Emissions	9kHz-150kHz	3.94dB(k=2, 95% level of confidence)
	150kHz-30MHz	3.84dB(k=2, 95% level of confidence)
Radiated Emissions	9kHz - 30MHz	2.06dB
	30MHz~200MHz (Horizontal)	4.48dB(k=2, 95% level of confidence)
	30MHz~200MHz (Vertical)	4.55dB(k=2, 95% level of confidence)
	200MHz~1000MHz (Horizontal)	4.85dB(k=2, 95% level of confidence)
	200MHz~1000MHz (Vertical)	5.05dB(k=2, 95% level of confidence)
	1GHz - 6GHz	5.35dB(k=2, 95% level of confidence)
	6GHz - 18GHz	5.44dB(k=2, 95% level of confidence)
	18GHz - 40GHz	5.16dB(k=2, 95% level of confidence)
Temperature		±1℃
Humidity		±1%
Supply voltages		±0.4%

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

Test Facility

The Test site used by Bay Area Compliance Laboratories Corp. (Shenzhen) to collect test data is located on the 5F(B-West) , 6F, 7F, the 3rd Phase of Wan Li Industrial Building D, Shihua Rd, FuTian Free Trade Zone, Shenzhen, China.

Each test item follows test standards and with no deviation.

The lab has been recognized as the FCC accredited lab under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No. : 715558, the FCC Designation No. : CN5045.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

The system was configured for testing in an engineering mode.

Channel list

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	40	2442
1	2403	41	2443
2	2404	42	2444
…	…	…	…
…	…	…	…
36	2438	75	2477
37	2439	76	2478
38	2440	77	2479
39	2441	78	2480

Channel 0, 38, 78 was tested.

EUT Exercise Software

“fcc_test_tool.exe[#]”EUT Exercise Software was used and the power level is 0(default) [#].

Special Accessories

No special accessory.

Equipment Modifications

No modification was made to the EUT tested.

Support Equipment List and Details

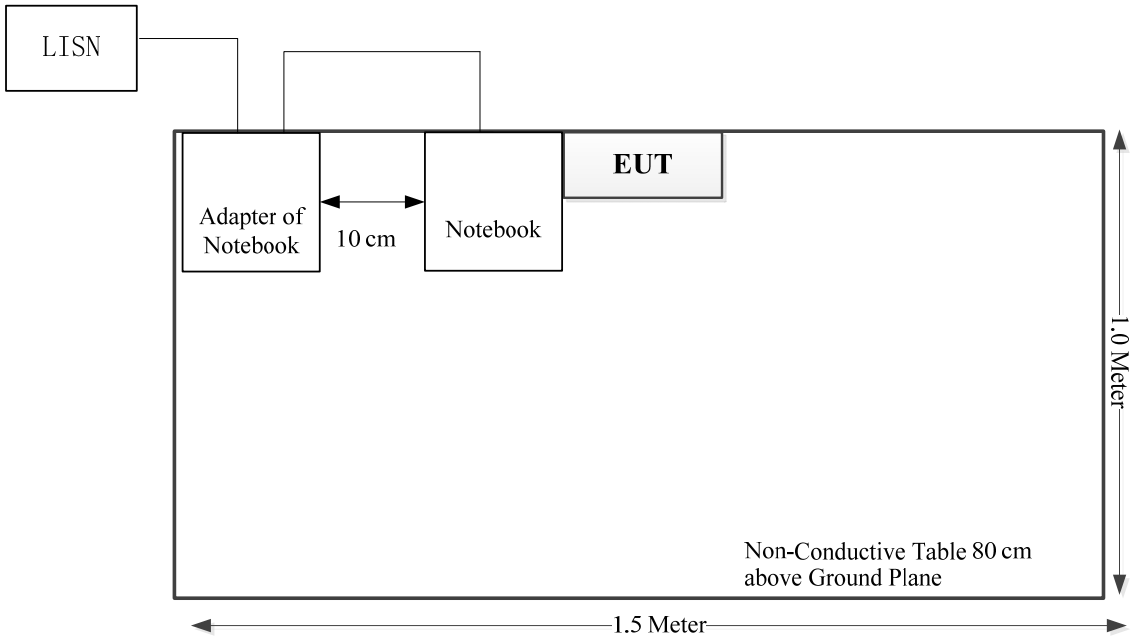
Manufacturer	Description	Model	Serial Number
Unknown	Notebook	Latitude E5430	11429208685
Unknown	Adapter of Notebook	PA-10	Unknown

External I/O Cable

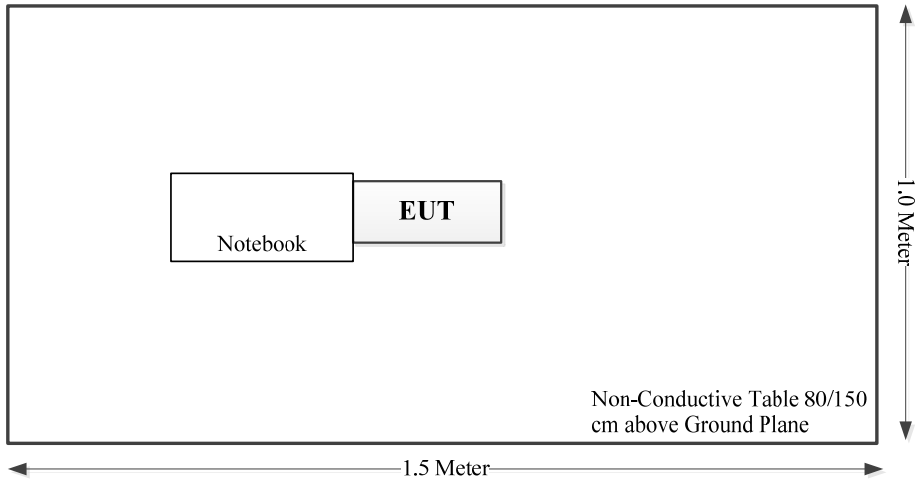
Cable Description	Length (m)	From/Port	To
Un-shielded Un-detachable Cable	1.5	Notebook	Adapter of Notebook
Un-shielded Un-detachable Cable	1.5	LISN	Adapter of Notebook

Block Diagram of Test Setup

For Conducted Emissions:



For Radiated Emissions:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC§15.247 (i), §1.1307 (b) (1) &§2.1093	RF EXPOSURE	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)	20dBEmission Bandwidth&99% Occupied Bandwidth	Compliant
§15.247(a)(1)	Channel Separation Test	Compliant
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	Compliant
§15.247(a)(1)(iii)	Quantity of hopping channel Test	Compliant
§15.247(b)(1)	Peak Output Power Measurement	Compliant
§15.247(d)	Band edges	Compliant

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2024/01/16	2025/01/15
Rohde & Schwarz	LISN	ENV216	101613	2024/01/16	2025/01/15
Rohde & Schwarz	Transient Limiter	ESH3Z2	DE25985	2023/08/03	2024/08/02
Unknown	CE Cable	CE Cable	UF A210B-1-0720-504504	2023/08/03	2024/08/02
Audix	EMI Test software	E3	191218	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2024/01/16	2025/01/15
Sonoma instrument	Pre-amplifier	310 N	186238	2023/06/08	2024/06/07
Sunol Sciences	Broadband Antenna	JB1	A040904-1	2023/07/20	2024/07/19
ETS	Passive Loop Antenna	6512	29604	2023/07/07	2024/07/06
Unknown	Cable	Chamber Cable 1	F-03-EM236	2023/08/03	2024/08/02
Unknown	Cable	Chamber Cable 4	EC-007	2023/08/03	2024/08/02
Audix	EMI Test software	E3	19821b(V9)	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40	101605	2023/04/18	2024/04/17
COM-POWER	Pre-amplifier	PA-122	181919	2023/06/29	2024/06/28
Schwarzbeck	Horn Anetenna	BBHA9120D(1201)	1143	2023/07/26	2024/07/25
Unknown	RF Cable	KMSE	0735	2023/10/08	2024/10/07
Unknown	RF Cable	UFA147	219661	2023/10/08	2024/10/07
Unknown	RF Cable	XH750A-N	J-10M	2023/10/08	2024/10/07
SNSD	2.4G Band Reject filter	BSF2402-2480MN-0898-001	2.4G filter	2023/08/03	2024/08/02
Audix	EMI Test software	E3	191218(V9)	NCR	NCR
A.H.System	Pre-amplifier	PAM-1840VH	190	2023/08/03	2024/08/02
Electro-Mechanics Co	Horn Antenna	3116	9510-2270	2023/09/18	2026/09/17
UTIFLEX	RF Cable	NO. 13	232308-001	2023/08/03	2024/08/02
RF Conducted Test					
Rohde & Schwarz	SPECTRUM ANALYZER	FSU26	200982	2023/12/18	2024/12/17
MARCONI	10dB Attenuator	6534/3	2942	2023/07/04	2024/07/03

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

FCC§15.247 (i)&§1.1307 (b) &§2.1093 – RF EXPOSURE

Applicable Standard

According to FCC §2.1093 and §1.1307(b)(1), systems operating under the provisions of this section shall be operated in a manner that ensure that the public is not exposed to radio frequency energy level in excess of the Commission's guideline.

According to KDB 447498 D01 General RF Exposure Guidance

The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
[(max. power of channel, including tune-up tolerance, mW)/(min. test separation distance, mm)] · [√f(GHz)] ≤ 3.0 for 1-g SAR and ≤ 7.5 for 10-g extremity SAR, where
1. f(GHz) is the RF channel transmit frequency in GHz.
2. Power and distance are rounded to the nearest mW and mm before calculation.
3. The result is rounded to one decimal place for comparison.
4. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test Exclusion.

Measurement Result

Frequency (MHz)	Maximum Tune-up power		Calculated Distance (mm)	Calculated Value	Threshold (1-g SAR)	SAR Test Exclusion
	(dBm)	(mW)				
2402-2480	-0.54	0.0009	5	0.278	3	**Exclusion**

Note: the maximum tune up power was declared by the applicant.

Result: Compliant

FCC §15.203 – ANTENNA REQUIREMENT

Applicable Standard

According to FCC § 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this Section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Antenna Connector Construction

The EUT has one internal antenna arrangement which was permanently attached and the antenna gain[#] is 2.58dBi, fulfill the requirement of this section. Please refer to the EUT photos.

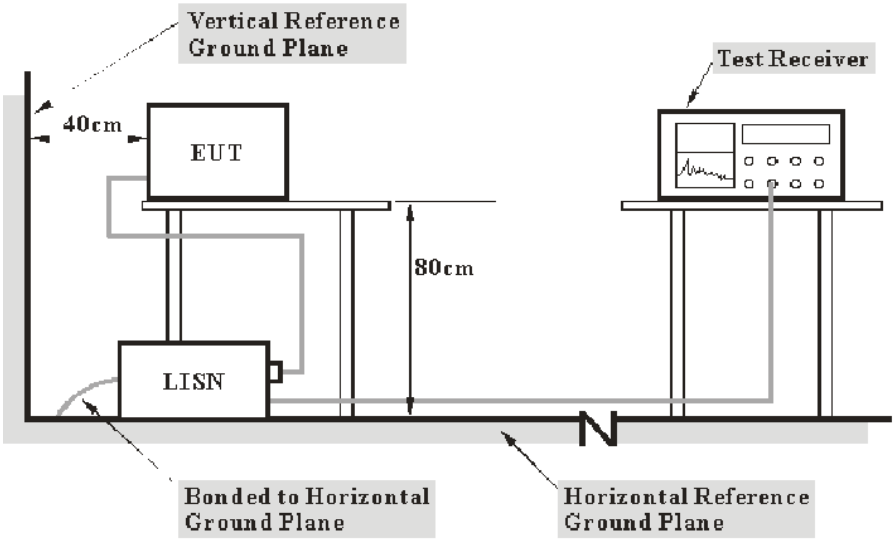
Result: Compliant

FCC §15.207 (a) – AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC §15.207(a)

EUT Setup



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

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

The spacing between the peripherals was 10 cm.

EMI Test Receiver Setup

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

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

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

Test Procedure

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

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

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

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:

Transd Factor = LISN VDF + 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:

Over Limit = Level – Limit
Level = Read Level + Factor

Test Data

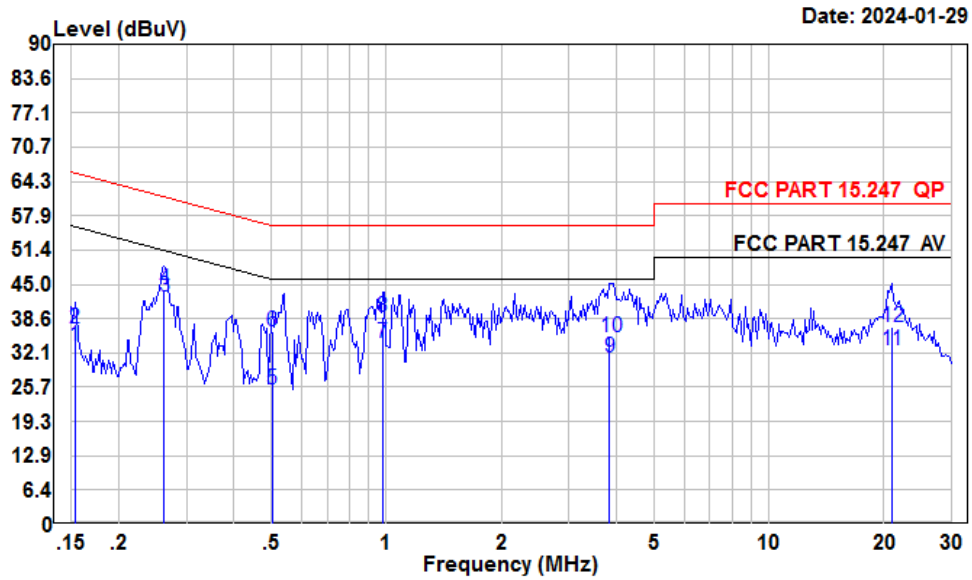
Environmental Conditions

Temperature:	25 °C
Relative Humidity:	45%
ATM Pressure:	101 kPa

The testing was performed by Macy Shi on 2024-01-29.

EUT operation mode: Transmitting (worst case is low channel)

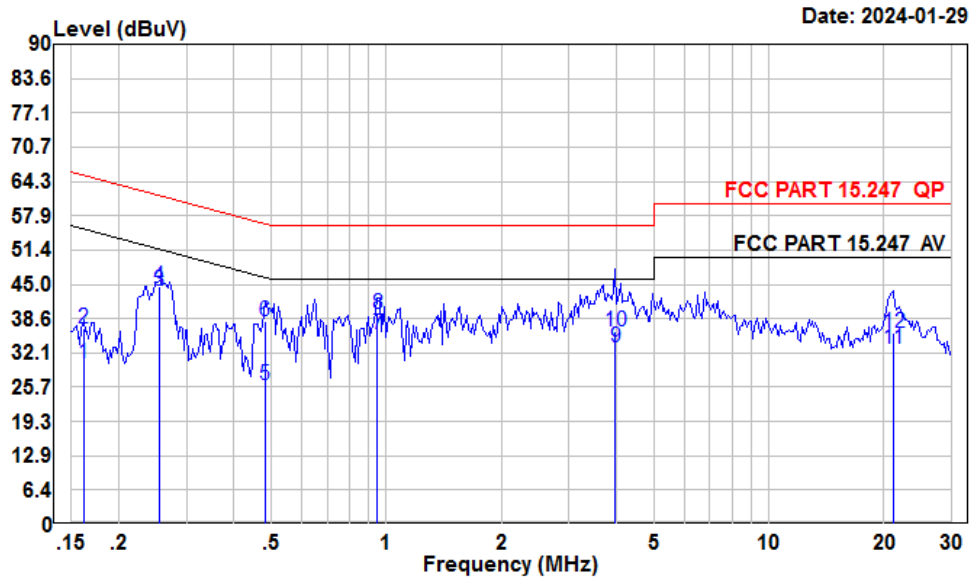
AC 120V/60 Hz, Line



Condition: Line
Project : SZ3231226-78377E-RF
Tester : Macy shi
Note : 2.4G

	Freq	Read Level	LISN Level	Factor	Cable Loss	Limit Line	Over Limit	Remark
	MHz	dBuV	dBuV	dB	dB	dBuV	dB	
1	0.15	12.98	33.33	10.20	10.15	55.82	-22.49	Average
2	0.15	16.49	36.84	10.20	10.15	65.82	-28.98	QP
3	0.26	22.42	42.81	10.20	10.19	51.34	-8.53	Average
4	0.26	23.79	44.18	10.20	10.19	61.34	-17.16	QP
5	0.50	4.94	25.29	10.20	10.15	46.00	-20.71	Average
6	0.50	15.85	36.20	10.20	10.15	56.00	-19.80	QP
7	0.98	13.72	34.13	10.21	10.20	46.00	-11.87	Average
8	0.98	18.49	38.90	10.21	10.20	56.00	-17.10	QP
9	3.84	10.78	31.33	10.29	10.26	46.00	-14.67	Average
10	3.84	14.60	35.15	10.29	10.26	56.00	-20.85	QP
11	20.92	12.66	32.52	9.73	10.13	50.00	-17.48	Average
12	20.92	17.17	37.03	9.73	10.13	60.00	-22.97	QP

AC 120V/60 Hz, Neutral



Condition: Neutral
Project : SZ3231226-78377E-RF
Tester : Macy shi
Note : 2.4G

	Freq	Read Level	LISN Level	Factor	Cable Loss	Limit Line	Over Limit	Remark
	MHz	dBuV	dBuV	dB	dB	dBuV	dB	
1	0.16	9.82	30.20	10.23	10.15	55.38	-25.18	Average
2	0.16	16.24	36.62	10.23	10.15	65.38	-28.76	QP
3	0.25	23.26	43.73	10.27	10.20	51.60	-7.87	Average
4	0.25	24.25	44.72	10.27	10.20	61.60	-16.88	QP
5	0.48	5.65	26.01	10.20	10.16	46.32	-20.31	Average
6	0.48	17.60	37.96	10.20	10.16	56.32	-18.36	QP
7	0.95	15.14	35.54	10.21	10.19	46.00	-10.46	Average
8	0.95	19.00	39.40	10.21	10.19	56.00	-16.60	QP
9	3.96	12.72	33.18	10.20	10.26	46.00	-12.82	Average
10	3.96	15.83	36.29	10.20	10.26	56.00	-19.71	QP
11	21.15	13.06	33.03	9.83	10.14	50.00	-16.97	Average
12	21.15	15.97	35.94	9.83	10.14	60.00	-24.06	QP

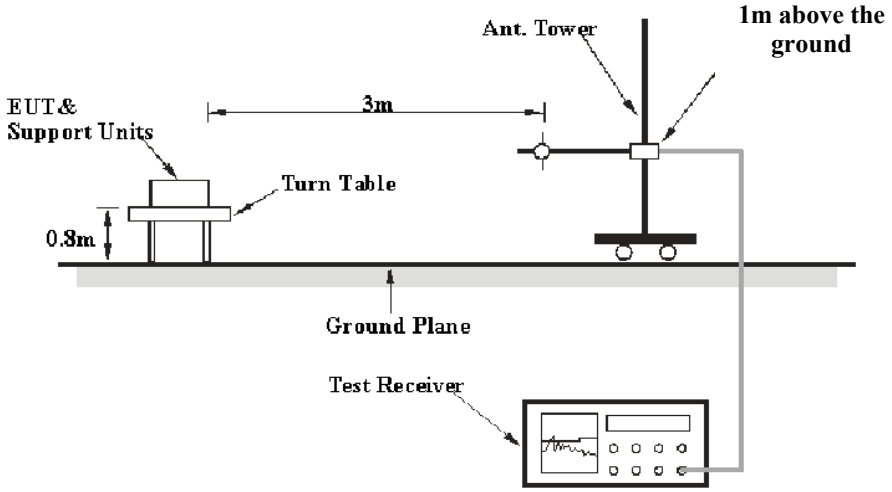
FCC §15.205, §15.209&§15.247(d) – RADIATED EMISSIONS

Applicable Standard

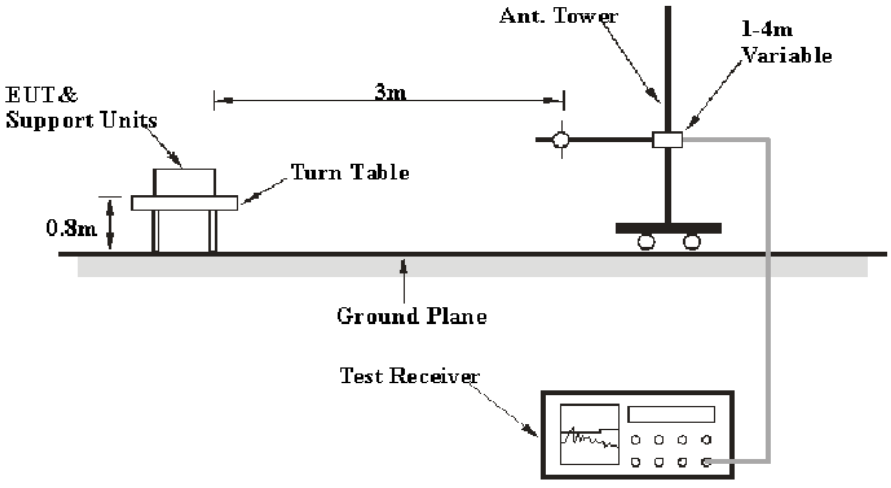
FCC §15.205; §15.209; §15.247(d)

EUT Setup

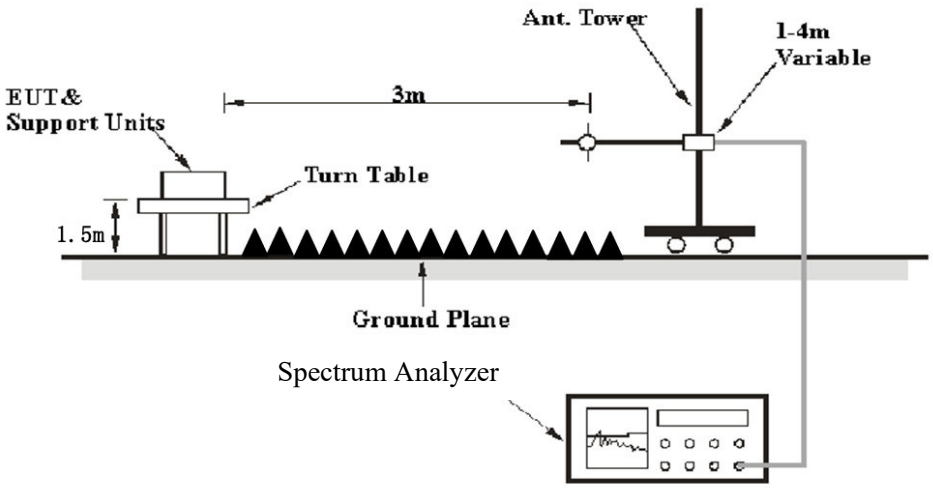
9 kHz-30MHz:



30MHz-1GHz:



Above 1GHz:



The radiated emission tests were performed in the 3meters, 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 EMI test receiver &Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
9 kHz – 150 kHz	/	/	200 Hz	QP
	300 Hz	1 kHz	/	PK
150 kHz – 30 MHz	/	/	9 kHz	QP
	10 kHz	30 kHz	/	PK
30 MHz – 1000 MHz	/	/	120 kHz	QP
	100 kHz	300 kHz	/	PK
Above 1 GHz	1MHz	3 MHz	/	PK
	1MHz	10 Hz	/	AV

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 except for the frequency bands 9–90 kHz, 110–490 kHz and above 1000 MHz, average detection modes for frequency bands 9–90 kHz and 110–490 kHz, peak and average detection modes for frequencies above 1 GHz.

If the maximized peak measured value complies with under the QP/Average limit more than 6dB, then it is unnecessary to perform an QP/Average measurement.

Factor & Over Limit/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:

Factor = Antenna Factor + Cable Loss - Amplifier Gain

The "**Over Limit or 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 margin calculation is as follows:

Margin/Over Limit = Corrected Amplitude/Level-Limit
Corrected Amplitude/Level = Reading + Factor

Test Data

Environmental Conditions

Temperature:	22~25.0 ℃
Relative Humidity:	50~70 %
ATM Pressure:	101 kPa

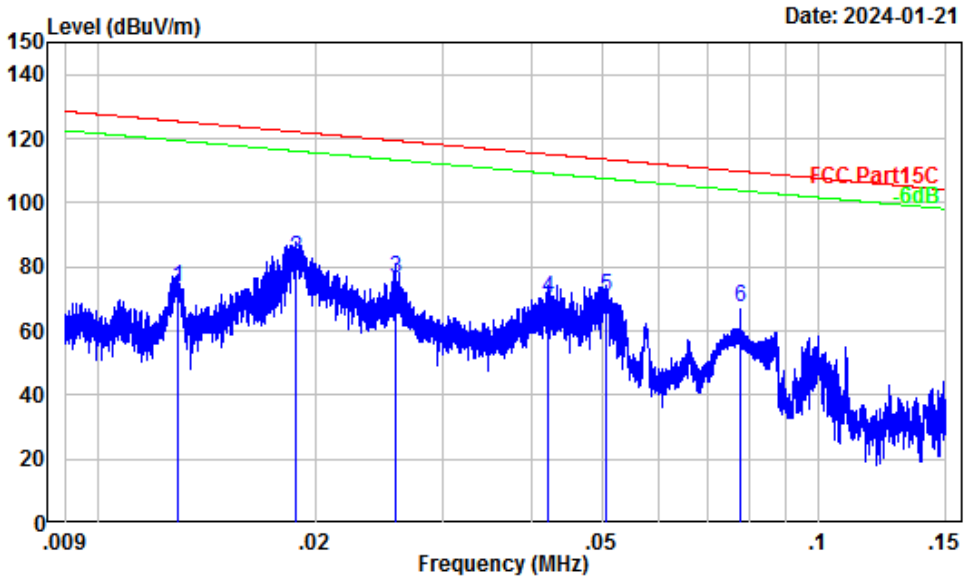
The testing was performed by Warren Huang on 2024-01-21 for below 1GHz and Dylan Yang from2024-01-29 to 2024-03-11 and Tyler Wu from 2024-02-27 to 2024-02-29 for above 1GHz.

EUT operation mode: Transmitting

Note: For 9 kHz-30MHz, The amplitude of spurious emissions attenuated more than 20 dB below the limit was not be recorded.
Pre-scan in the X, Y and Z axes of orientation, the worst case X-axis of orientation was recorded.

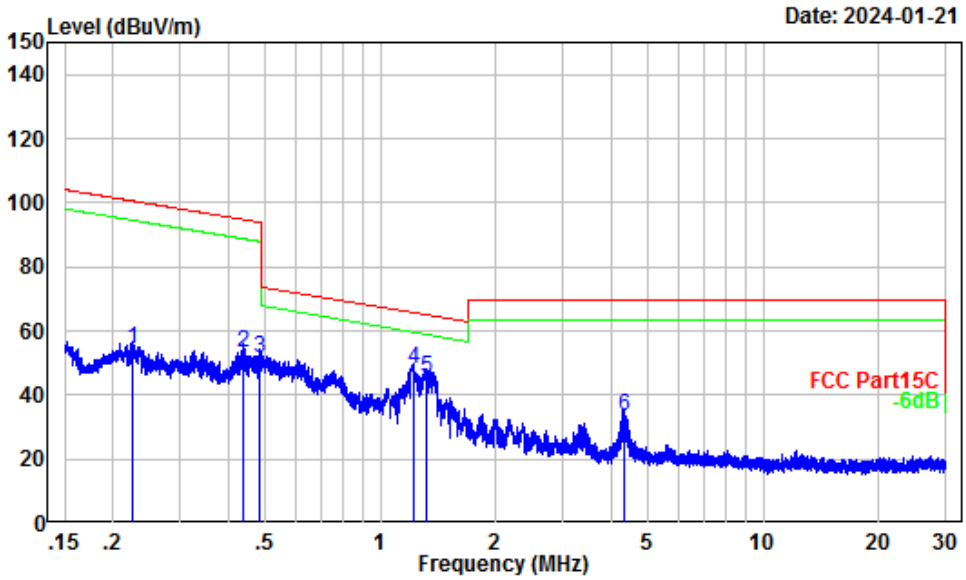
Below 30MHz:

Parellel



Site : chamber
Condition : 3m
Project Number: SZ3231226-78377E-RF
Note : 2.4G
Tester : Warren Huang

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	0.01	52.41	21.35	73.76	125.38	-51.62	Peak
2	0.02	50.59	32.20	82.79	122.11	-39.32	Peak
3	0.03	48.44	27.85	76.29	119.36	-43.07	Peak
4	0.04	43.41	26.55	69.96	115.11	-45.15	Peak
5	0.05	40.92	29.80	70.72	113.53	-42.81	Peak
6	0.08	37.19	30.21	67.40	109.79	-42.39	Peak

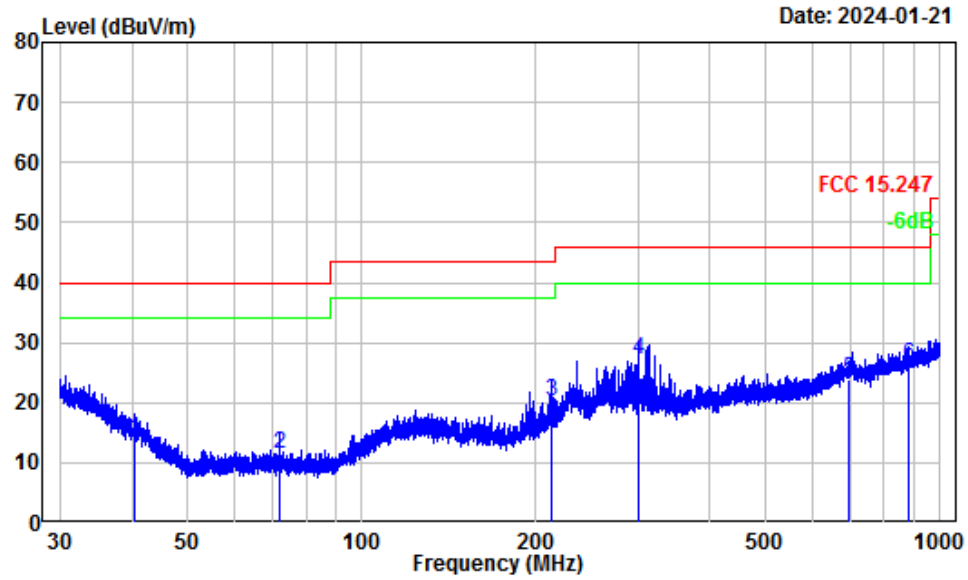


Site : chamber
Condition : 3m
Project Number: SZ3231226-78377E-RF
Note : 2.4G
Tester : Warren Huang

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	0.22	28.13	26.19	54.32	100.59	-46.27	Peak
2	0.44	21.82	31.60	53.42	94.79	-41.37	Peak
3	0.49	21.15	30.19	51.34	93.87	-42.53	Peak
4	1.22	14.34	33.51	47.85	65.70	-17.85	Peak
5	1.32	13.88	31.40	45.28	65.04	-19.76	Peak
6	4.34	5.96	27.39	33.35	69.54	-36.19	Peak

30MHz-1GHz: *(worst case is Middle channel)*
Note: When the test result of Peak was less than the limit of QP, just the peak value was recorded.

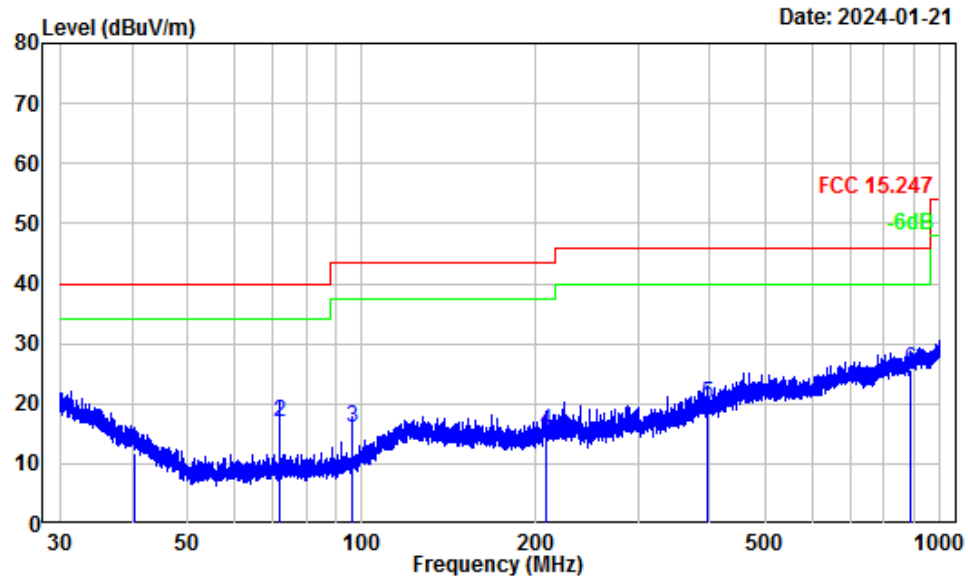
Horizontal



Site : chamber
Condition : 3m Horizontal
Project Number: SZ3231226-78377E-RF
Note : 2.4G
Tester : Warren Huang

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	40.51	-10.71	24.73	14.02	40.00	-25.98	QP
2	71.99	-16.30	27.91	11.61	40.00	-28.39	QP
3	213.02	-11.24	31.57	20.33	43.50	-23.17	QP
4	301.55	-9.96	37.19	27.23	46.00	-18.77	QP
5	693.20	-1.63	25.63	24.00	46.00	-22.00	QP
6	883.34	0.73	25.57	26.30	46.00	-19.70	QP

Vertical



Site : chamber
Condition : 3m Vertical
Project Number: SZ3231226-78377E-RF
Note : 2.4G
Tester : Warren Huang

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	40.54	-12.19	24.04	11.85	40.00	-28.15	QP
2	71.99	-17.28	34.04	16.76	40.00	-23.24	QP
3	95.97	-16.09	32.10	16.01	43.50	-27.49	QP
4	207.85	-12.23	27.77	15.54	43.50	-27.96	QP
5	396.42	-7.75	27.63	19.88	46.00	-26.12	QP
6	890.34	0.47	25.24	25.71	46.00	-20.29	QP

Above 1GHz:

Frequency (MHz)	Receiver		Polar (H/V)	Factor (dB/m)	Corrected Ampitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave					
Low Channel(2402MHz)							
4804.00	53.58	PK	H	2.42	56.00	74	-18.00
4804.00	42.42	AV	H	2.42	44.84	54	-9.16
4804.00	51.49	PK	V	2.42	53.91	74	-20.09
4804.00	39.87	AV	V	2.42	42.29	54	-11.71
Middle Channel(2440MHz)							
4880.00	49.75	PK	H	2.58	52.33	74	-21.67
4880.00	40.19	AV	H	2.58	42.77	54	-11.23
4880.00	52.24	PK	V	2.58	54.82	74	-19.18
4880.00	39.89	AV	V	2.58	42.47	54	-11.53
High Channel(2480MHz)							
4960.00	50.32	PK	H	2.68	53.00	74	-21.00
4960.00	40.99	AV	H	2.68	43.67	54	-10.33
4960.00	52.31	PK	V	2.68	54.99	74	-19.01
4960.00	40.76	AV	V	2.68	43.44	54	-10.56

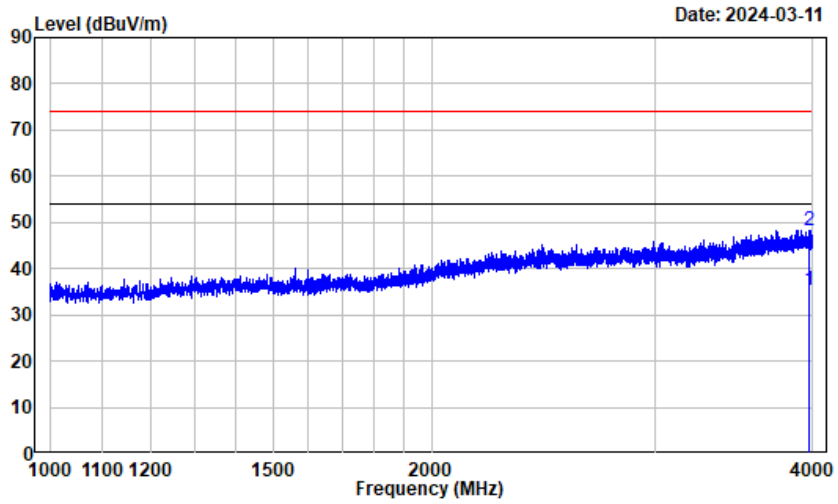
Note:

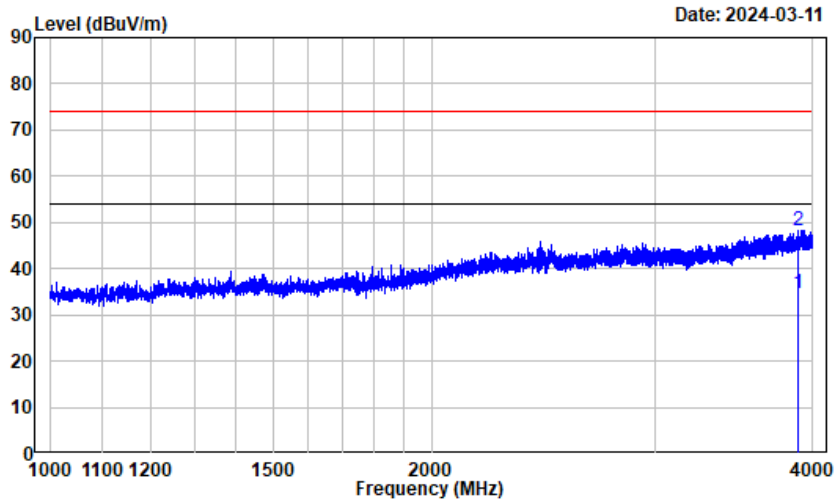
Absolute Level = Corrected Factor + Reading

Margin = Corrected. Amplitude - Limit

Listed with the worst harmonic margin test plot:

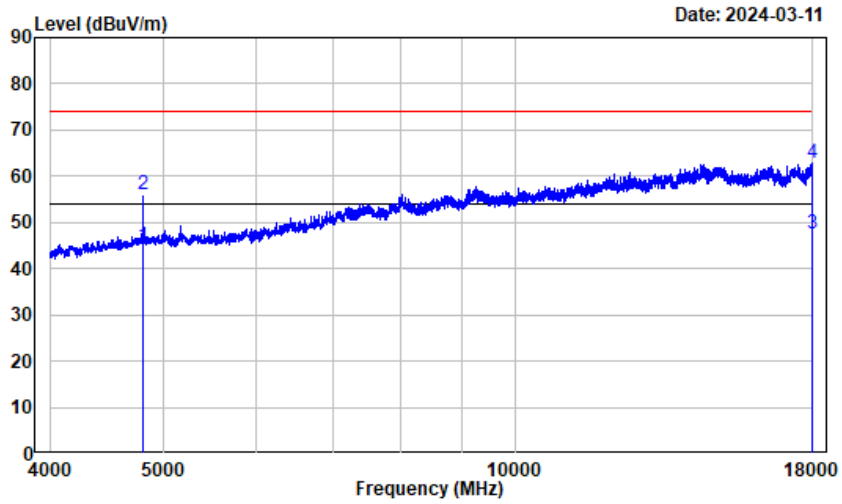
Pre-scan, GFSK Low Channel (worst case)

Horizontal	
1-4GHz	 Condition : Horizontal Project No.: SZ3231226-78377E Tester : Dylan Note : 2.4G_FHSS | | Freq | Factor | Read Level | Limit Level | Limit Line | Remark | Over Limit | | | MHz | dB/m | dBuV | dBuV/m | dBuV/m | | dB | | 1 | 3978.250 | -0.20 | 35.63 | 35.43 | 54.00 | Average | -18.57 | | 2 | 3978.250 | -0.20 | 48.47 | 48.27 | 74.00 | Peak | -25.73 |

Vertical	
1-4GHz	 Condition : Vertical Project No.: SZ3231226-78377E Tester : Dylan Note : 2.4G_FHSS | | Freq | Factor | Read Level | Level | Limit Line | Remark | Over Limit | | | MHz | dB/m | dBuV | dBuV/m | dBuV/m | | dB | | 1 | 3897.250 | -0.54 | 35.28 | 34.74 | 54.00 | Average | -19.26 | | 2 | 3897.250 | -0.54 | 48.84 | 48.30 | 74.00 | Peak | -25.70 |

Horizontal

4-18GHz

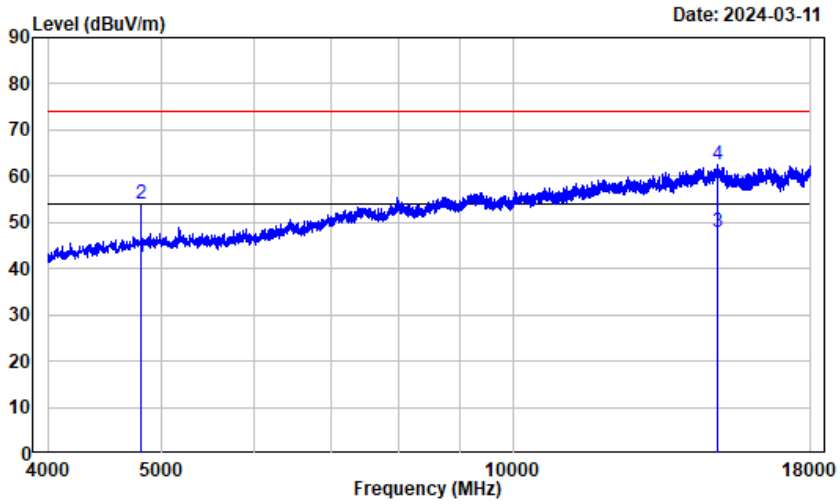


Condition : Horizontal
Project No.: SZ3231226-78377E
Tester : Dylan
Note : 2.4G_FHSS

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	4804.000	2.42	42.42	44.84	54.00	Average	-9.16
2	4804.000	2.42	53.58	56.00	74.00	Peak	-18.00
3	17995.750	24.59	23.02	47.61	54.00	Average	-6.39
4	17995.750	24.59	38.35	62.94	74.00	Peak	-11.06

Vertical

4-18GHz

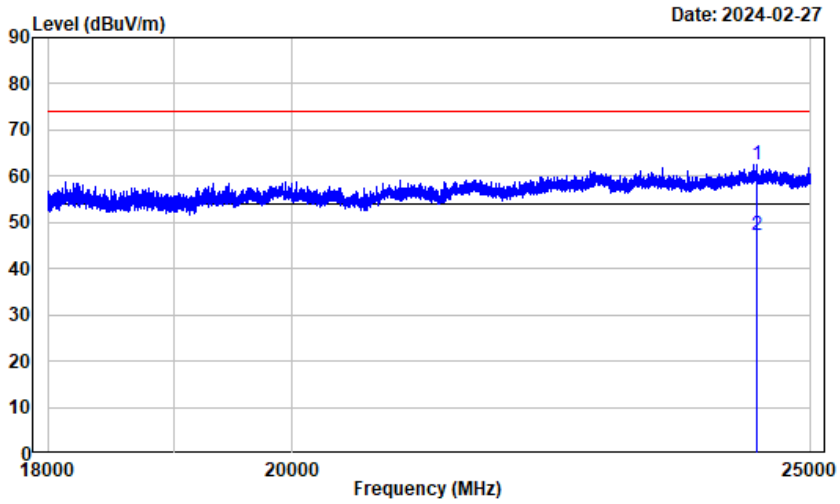


Condition : Vertical
Project No.: SZ3231226-78377E
Tester : Dylan
Note : 2.4G_FHSS

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	4804.000	2.42	39.87	42.29	54.00	Average	-11.71
2	4804.000	2.42	51.49	53.91	74.00	Peak	-20.09
3	14969.750	16.39	31.43	47.82	54.00	Average	-6.18
4	14969.750	16.39	46.00	62.39	74.00	Peak	-11.61

Horizontal

18-25GHz

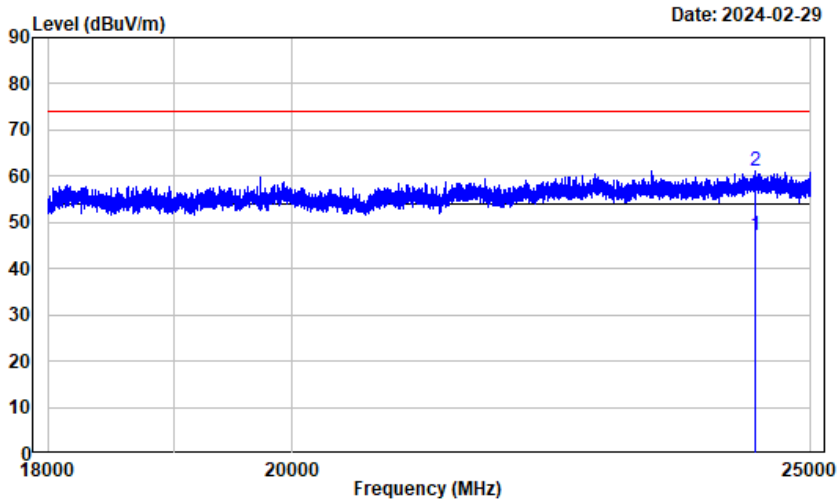


Condition : Horizontal
Project No.: SZ3231226-78377E
Tester : Tyler
Note : 2.4g FHSS

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	24430.380	18.83	43.79	62.62	74.00	Peak	-11.38
2	24430.380	18.83	28.35	47.18	54.00	Average	-6.82

Vertical

18-25GHz

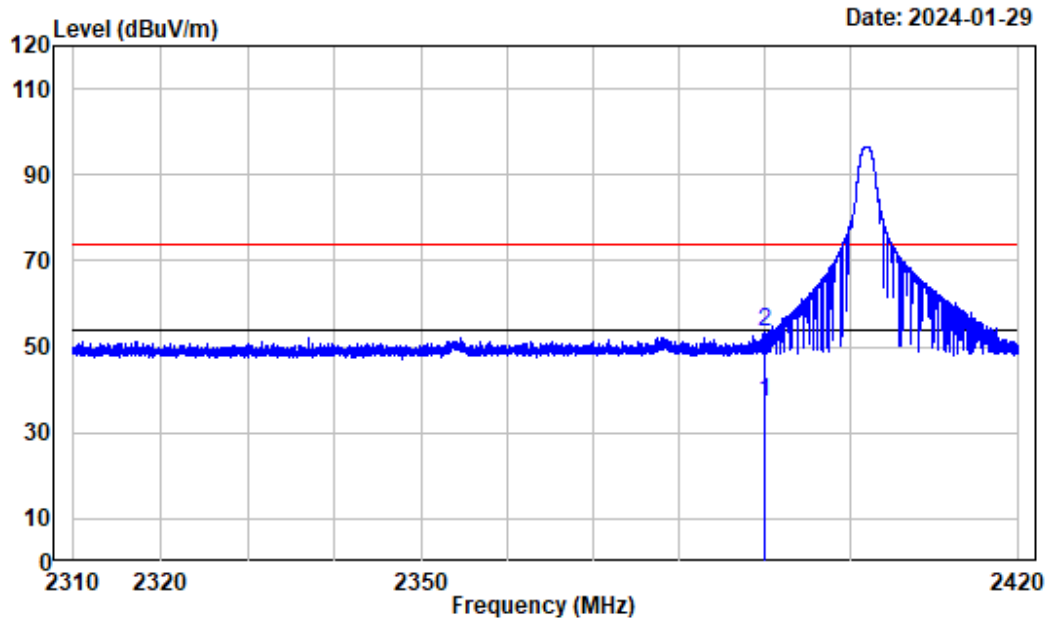


Condition : Vertical
Project No.: SZ3231226-78377E
Tester : Tyler
Note : 2.4g FHSS

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	24406.750	18.78	28.32	47.10	54.00	Average	-6.90
2	24406.750	18.78	42.39	61.17	74.00	Peak	-12.83

Test plots for Band Edge Measurements (Radiated):

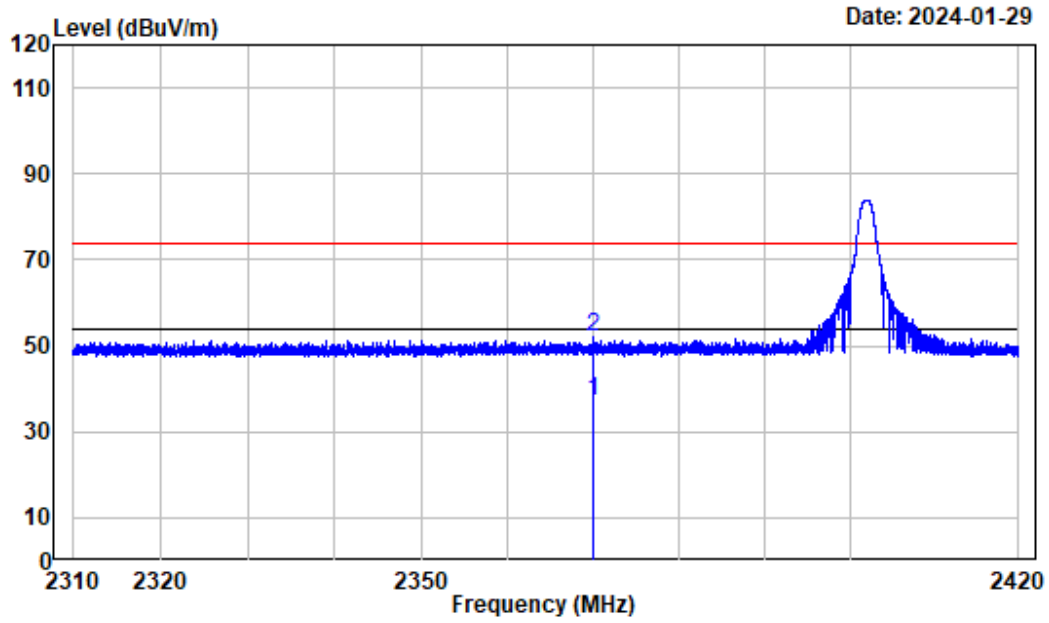
GFSK			
Test Channel:	**2402MHz**	**Ant. Polar. :**	**Horizontal**



Project No. : SZ3231226-78377E
Tester : Dylan
Polarization: Horizontal
Note : 2.4G FHSS 2402

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	2389.915	-3.20	40.46	37.26	54.00	Average	-16.74
2	2389.915	-3.20	56.66	53.46	74.00	peak	-20.54

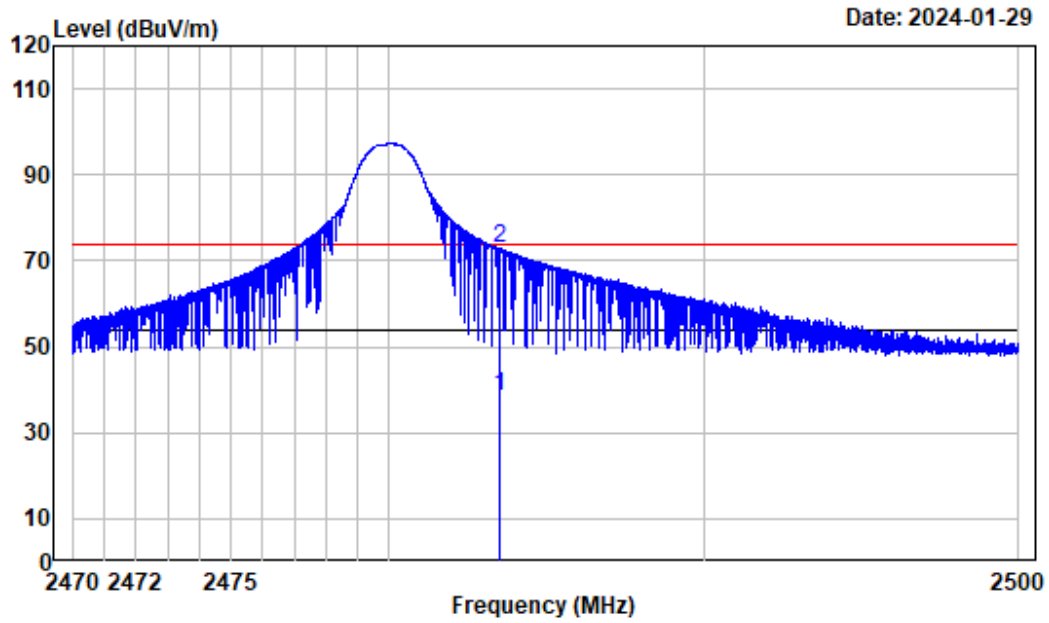
GFSK			
Test Channel:	**2402MHz**	**Ant. Polar. :**	**Vertical**



Project No. : SZ3231226-78377E
Tester : Dylan
Polarization: Vertical
Note : 2.4G FHSS 2402

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	2369.826	-3.17	40.35	37.18	54.00	Average	-16.82
2	2369.826	-3.17	55.07	51.90	74.00	peak	-22.10

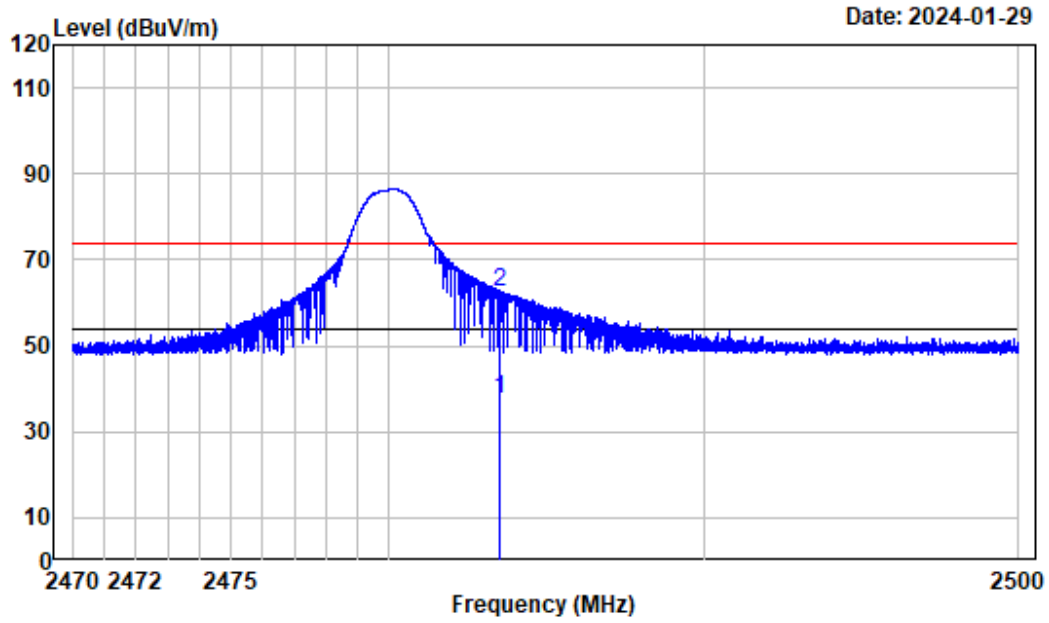
GFSK			
Test Channel:	**2480MHz**	**Ant. Polar. :**	**Horizontal**



Project No. : SZ3231226-78377E
Tester : Dylan
Polarization: Horizontal
Note : 2.4G FHSS 2480

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	2483.519	-3.17	41.62	38.45	54.00	Average	-15.55
2	2483.519	-3.17	75.99	72.82	74.00	peak	-1.18

GFSK			
Test Channel:	**2480MHz**	**Ant. Polar. :**	**Vertical**



Project No. : SZ3231226-78377E
Tester : Dylan
Polarization: Vertical
Note : 2.4G FHSS 2480

	Freq	Factor	Read Level	Level	Limit Line	Remark	Over Limit
	MHz	dB/m	dBuV	dBuV/m	dBuV/m		dB
1	2483.526	-3.17	40.71	37.54	54.00	Average	-16.46
2	2483.526	-3.17	65.87	62.70	74.00	peak	-11.30

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

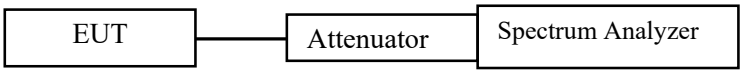
Applicable Standard

Frequency hopping systems shall have hoping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.2

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



Test Data

Environmental Conditions

Temperature:	25.1 ℃
Relative Humidity:	45 %
ATM Pressure:	101 kPa

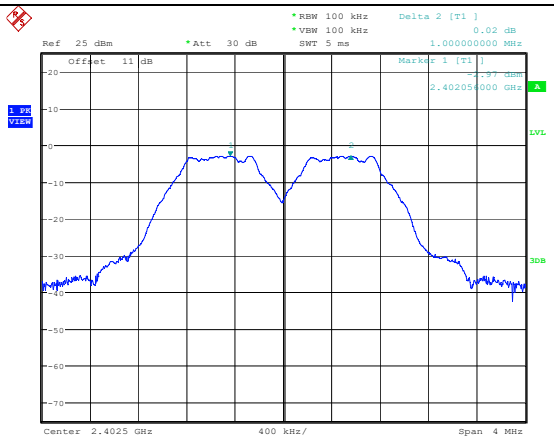
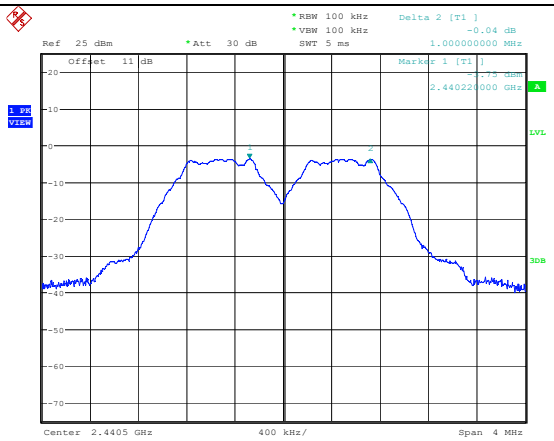
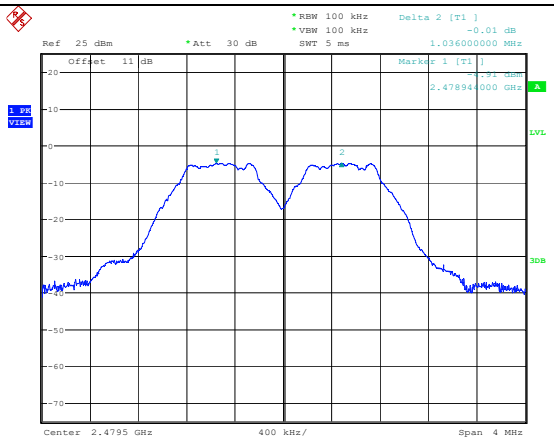
The testing was performed by Cheeb Huang on 2024-01-29.

EUT operation mode: Transmitting

Test Result: Compliant

Test Channel	Test Frequency (MHz)	Channel Separation (MHz)	Limits (MHz)
Lowest	2402	1.000	0.762
Middle	2440	1.000	0.766
Highest	2480	1.036	0.760

Please refer to the below plots:

GFSK	
Low Channel	 ProjectNo.:SZ3231226-78377E-RF Tester:Cheeb Huang Date: 29.JAN.2024 15:50:59
Middle Channel	 ProjectNo.:SZ3231226-78377E-RF Tester:Cheeb Huang Date: 29.JAN.2024 15:52:06
High Channel	 ProjectNo.:SZ3231226-78377E-RF Tester:Cheeb Huang Date: 29.JAN.2024 15:52:58

FCC §15.247(a) (1)–20dBEMISSION BANDWIDTH&99% OCCUPIED BANDWIDTH

Applicable Standard

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

Test Procedure

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

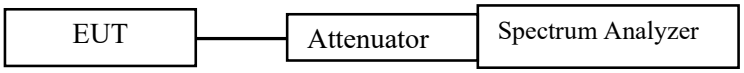
The following conditions shall be observed for measuring the occupied bandwidth and 20 dB bandwidth:
• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

• The detector of the spectrum analyzer shall be set to “Sample”. However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or “Max Hold”) may be necessary to determine the occupied / 20 dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / 20 dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.
For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).



Test Data

Environmental Conditions

Temperature:	25.1 ℃
Relative Humidity:	45 %
ATM Pressure:	101 kPa

The testing was performed by Cheeb Huang on 2024-01-29.

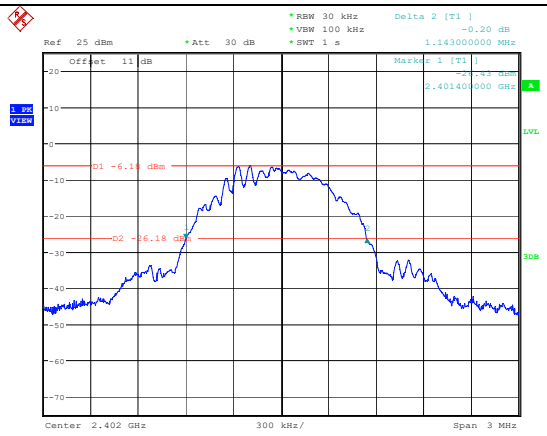
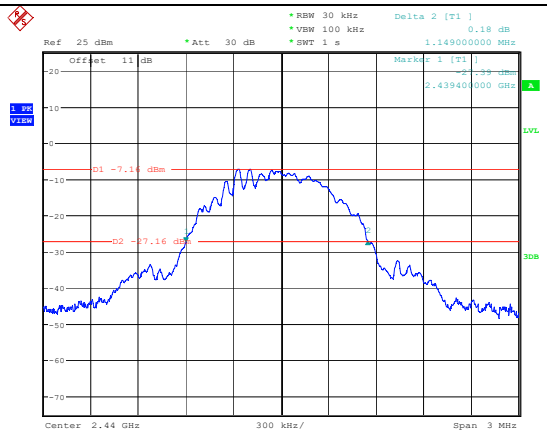
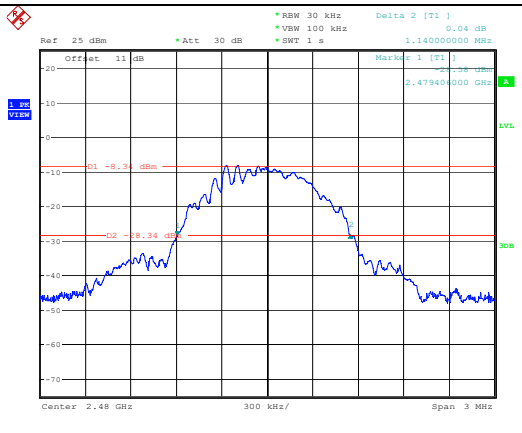
EUT operation mode: Transmitting

Test Result: Compliant

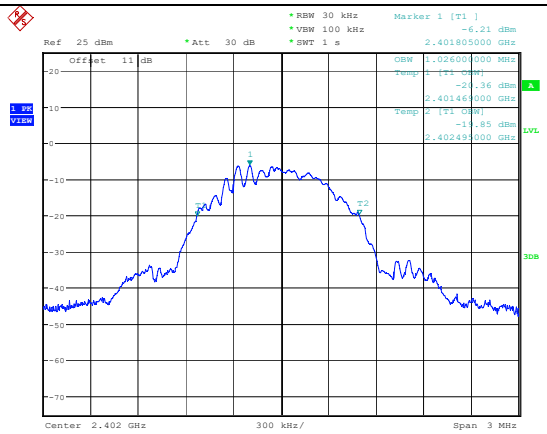
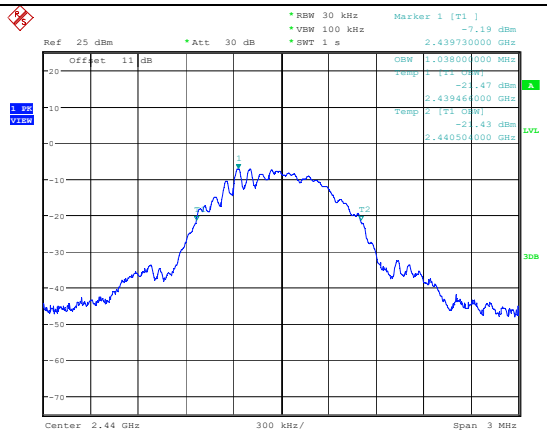
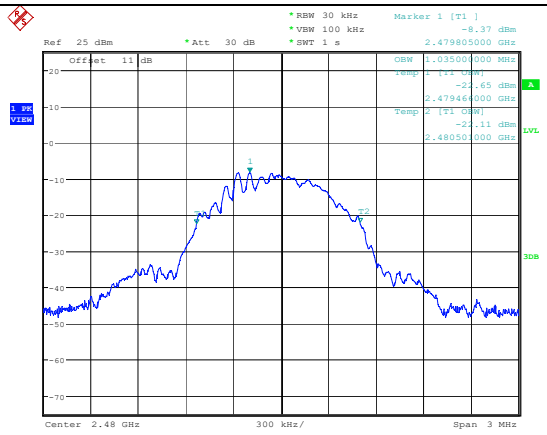
Test Channel	Test Frequency (MHz)	20 dB Bandwidth (MHz)	99% Occupied Bandwidth (MHz)
Lowest	2402	1.143	1.026
Middle	2440	1.149	1.038
Highest	2480	1.140	1.035

Please refer to the below plots:

20 dB Bandwidth

GFSK	
Low Channel	
Middle Channel	
High Channel	

99% Occupied Bandwidth

GFSK	
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.

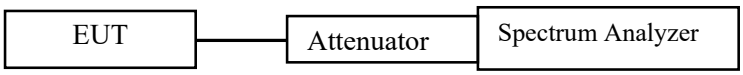
Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.3

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

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

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



Test Data

Environmental Conditions

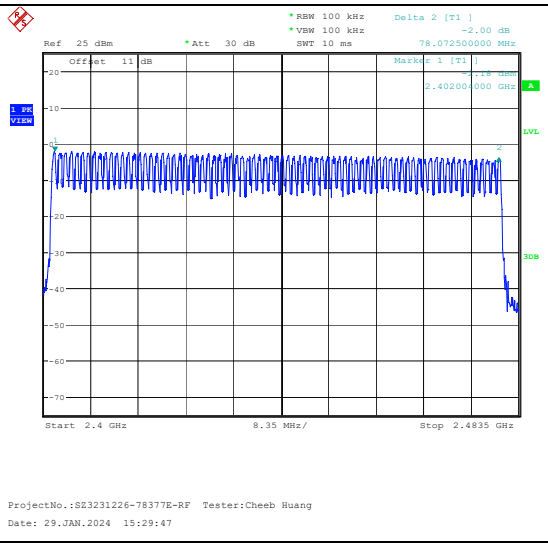
Temperature:	25.1 ℃
Relative Humidity:	45 %
ATM Pressure:	101 kPa

The testing was performed by Cheeb Huang on 2024-01-29.

EUT operation mode: Transmitting

Test Result: Compliant

Mode	Frequency Range (MHz)	Number of Hopping Channel (CH)	Limit (CH)
GFSK	2400-2483.5	79	≥15

Hopping Channel	
GFSK	

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

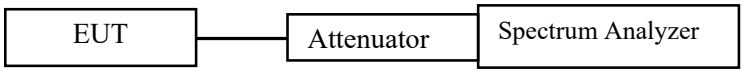
Applicable Standard

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

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.4

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



Test Data

Environmental Conditions

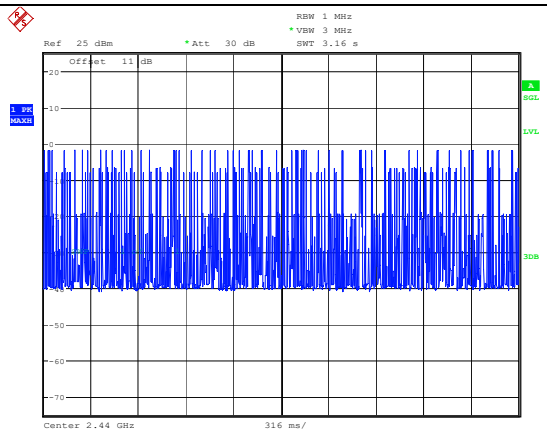
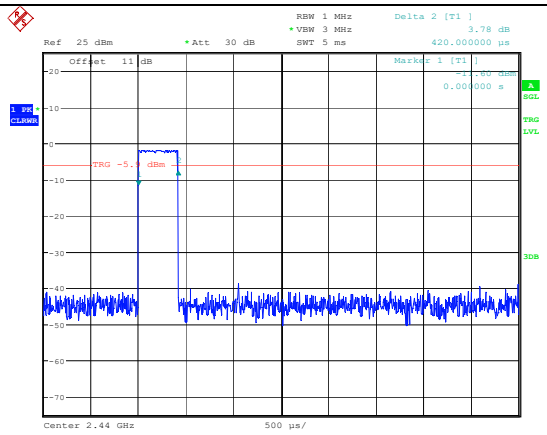
Temperature:	25.1 ℃
Relative Humidity:	45 %
ATM Pressure:	101 kPa

The testing was performed by Cheeb Huang on 2024-01-29.

EUT operation mode: Transmitting

Test Result: Compliant

Test Frequency (MHz)	Pulse width (ms)	Observation time (s)	Hopping Numbers in Observation time	Dwell Time (s)	Limit (s)
2440	0.420	32	690	0.290	0.400
Note: Observation time= Hopping Channel Number× 0.4					

GFSK	
Dwell time	
Pulse time	

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

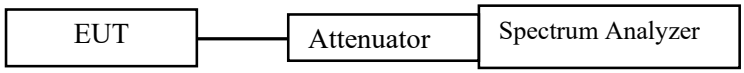
Applicable Standard

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

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.5

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



Test Data

Environmental Conditions

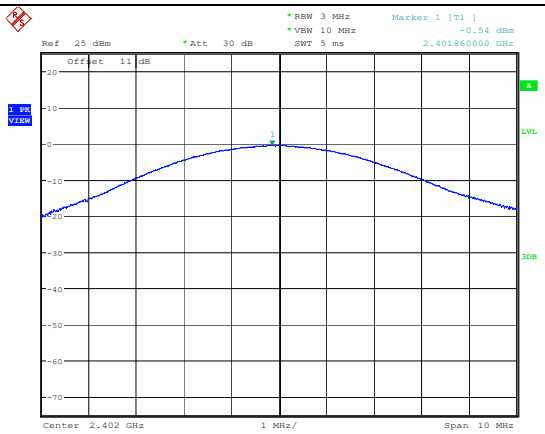
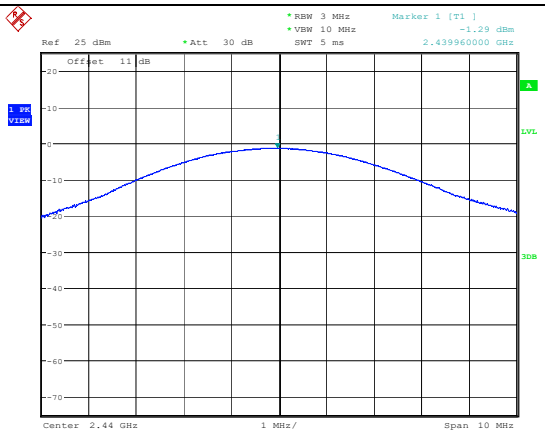
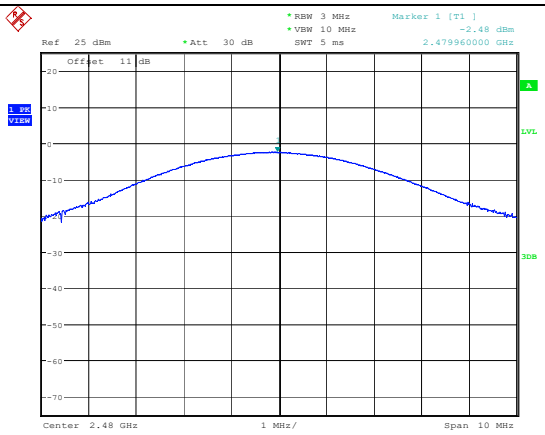
Temperature:	25.1 ℃
Relative Humidity:	45 %
ATM Pressure:	101 kPa

The testing was performed by Cheeb Huang on 2024-01-29.

EUT operation mode: Transmitting

Test Result: Compliant

Mode	Channel	Test Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	Limits (dBm)
GFSK	Low	2402	-0.54	21
	Middle	2440	-1.29	21
	High	2480	-2.48	21

GFSK	
Low Channel	 ProjectNo.:SZ3231226-78377E-RF Tester:Cheeb Huang Date: 29.JAN.2024 15:15:38
Middle Channel	 ProjectNo.:SZ3231226-78377E-RF Tester:Cheeb Huang Date: 29.JAN.2024 15:20:14
High Channel	 ProjectNo.:SZ3231226-78377E-RF Tester:Cheeb Huang Date: 29.JAN.2024 15:23:48

FCC §15.247(d) - BAND EDGES TESTING

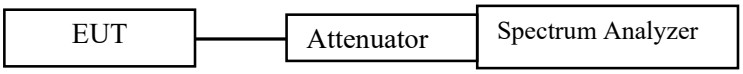
Applicable Standard

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

Test Procedure

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

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



Test Data

Environmental Conditions

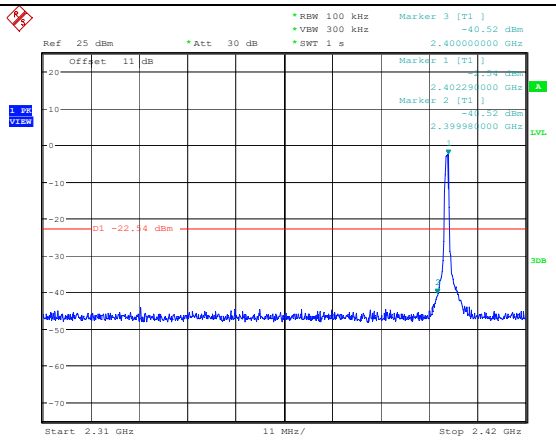
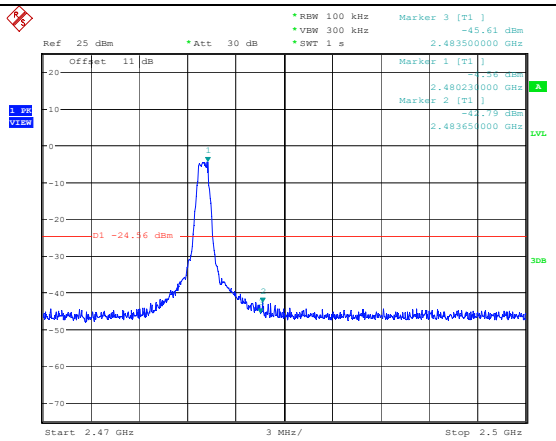
Temperature:	25.1 ℃
Relative Humidity:	45 %
ATM Pressure:	101 kPa

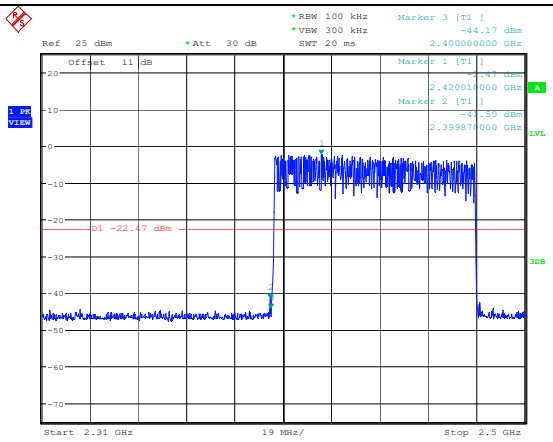
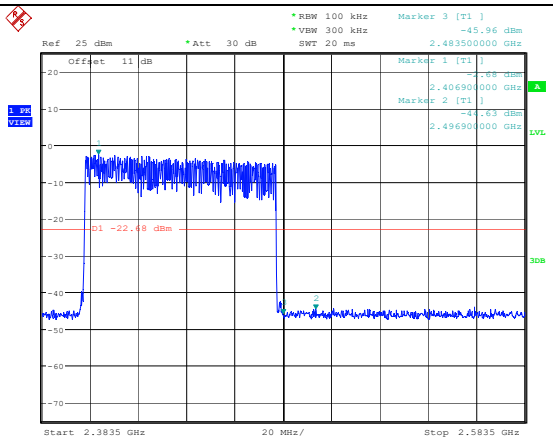
The testing was performed by Cheeb Huang on 2024-01-29.

EUT operation mode: Transmitting

Test Result: Compliant

Conducted Band Edge Result:

Band Edge, Single Channel	
Left Side	
Right Side	

Band Edge, Hopping Channel	
Left Side	
Right Side	

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