TEST REPORT

Applicant Name:	Dragino Technology Co., Limited.
Address:	Room 202,BaoChengTai industrial park,No.8 CaiYun LongCheng Street, LongGang District, Shenzhen China
Report Number:	2401V31126E-RF-00A
FCC ID:	ZHZLTC2

Test Standard (s)

FCC PART 15.247

Sample Description

Product Type:	LoRaWAN IoT Sensor
Model No.:	LTC2-SI2
Multiple Model(s) No.:	LTC2-SI, LTC2-LT, LTC2-FSA, LTC2-FT, LTC2-HT, LTC2-NA
Trade Mark:	DRAGINO
Date Received:	2024/07/25
Issue Date:	2024/09/11

Test Result:	Pass▲

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

Prepared and Checked By:

Ekko Wu
RF Engineer

Approved By:

Michelle Zeng
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.

This report may contain data that are not covered by the NVLAP accreditation and are marked with an asterisk "▼".

TABLE OF CONTENTS

DOCUMENT REVISION HISTORY

Revision Number	Report Number	Description of Revision	Date of Revision
0	2401V31126E-RF-00A	Original Report	2024/09/11

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	LoRaWAN IoT Sensor
Tested Model	LTC2-SI2
Multiple Model(s)	LTC2-SI, LTC2-LT, LTC2-FSA, LTC2-FT, LTC2-HT, LTC2-NA
Frequency Range	902.3-914.9MHz
Maximum Conducted Peak Output Power	4.63dBm
Technique	Hybrid System
Antenna Specification#	1.19dBi (provided by the applicant)
Voltage Range	DC 3.6V from battery
Sample serial number	2OYM-1 for Radiated Emissions Test 2OYM-2 for RF Conducted Test (Assigned by BACL, Shenzhen)
Sample/EUT Status	Good condition
Adapter Information	N/A
Note: The multiple models are electrically identical with the test model except for sensor probe. Please refer to the declaration letter# for more detail, which was provided by manufacturer.	

Objective

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

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

And KDB 558074 D01 15.247 Meas Guidance v05r02.

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)
Unwanted Emission, conducted		1.75 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	3.30dB(k=2, 95% level of confidence)
	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.

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 engineering mode.

Channel List

Channel	Freq.(MHz)	Channel	Freq.(MHz)	Channel	Freq.(MHz)	Channel	Freq.(MHz)
0	**902.3**	16	905.5	**32**	**908.7**	48	911.9
1	902.5	17	905.7	33	908.9	49	912.1
2	902.7	18	905.9	34	909.1	50	912.3
3	902.9	19	906.1	35	909.3	51	912.5
4	903.1	20	906.3	36	909.5	52	912.7
5	903.3	21	906.5	37	909.7	53	912.9
6	903.5	22	906.7	38	909.9	54	913.1
7	903.7	23	906.9	39	910.1	55	913.3
8	903.9	24	907.1	40	910.3	56	913.5
9	904.1	25	907.3	41	910.5	57	913.7
10	904.3	26	907.5	42	910.7	58	913.9
11	904.5	27	907.7	43	910.9	59	914.1
12	904.7	28	907.9	44	911.1	60	914.3
13	904.9	29	908.1	45	911.3	61	914.5
14	905.1	30	908.3	46	911.5	62	914.7
15	905.3	31	908.5	47	911.7	**63**	**914.9**

EUT was test with channel 0/32/63.

Equipment Modifications

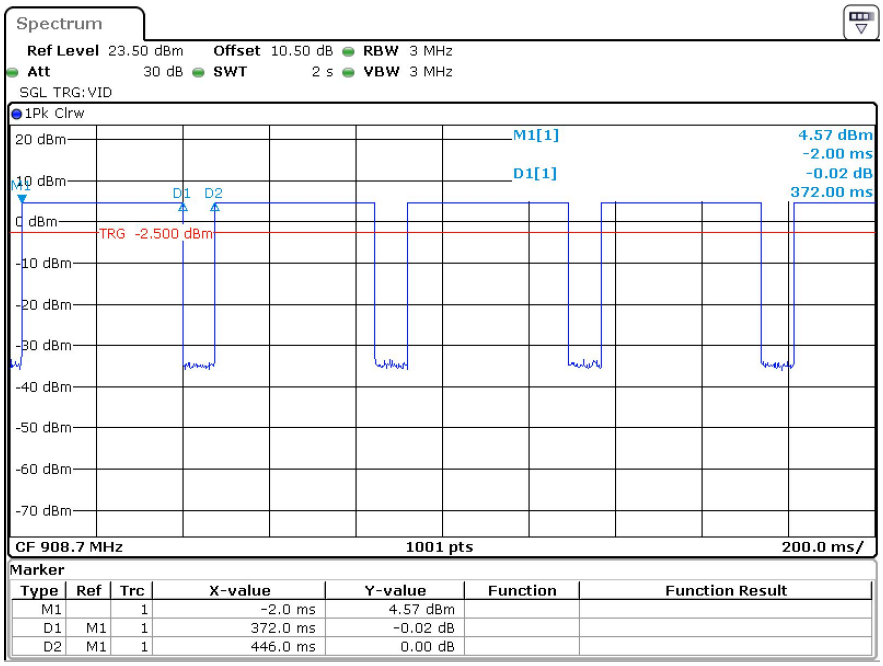
No modification was made to the EUT tested.

EUT Exercise Software

"EspRFTestTool_v3.6_manual.exe #" exercise software was used and the power level is 13#. The software and power level was provided by the manufacturer.

Duty cycle

Test Band Width (kHz)	T_{on} (ms)	T_{on+off} (ms)	Duty cycle (%)	$1/T_{on}$ (Hz)	VBW Setting (Hz)
125	372	446	83.41	2.7	10



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 14.AUG.2024 23:48:41

Support Equipment List and Details

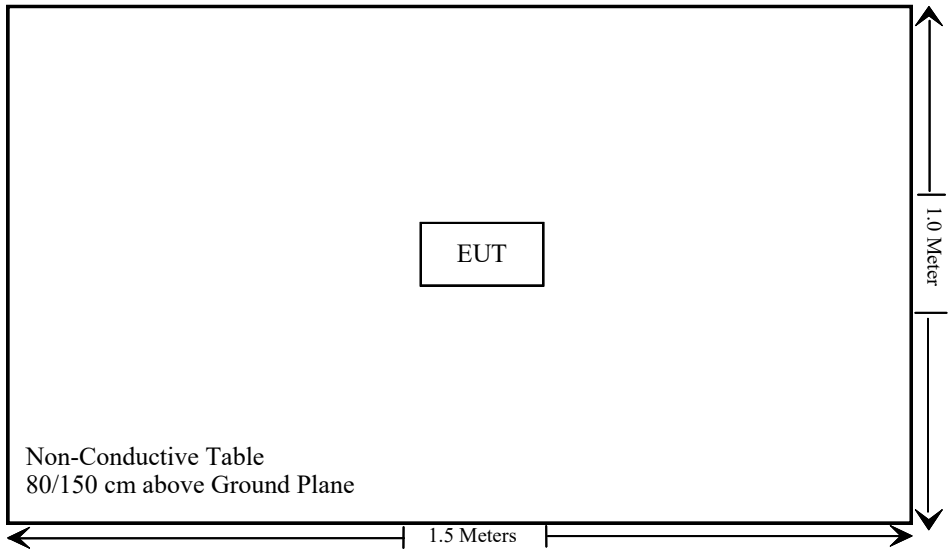
Manufacturer	Description	Model	Serial Number
/	/	/	/

External I/O Cable

Cable Description	Length (m)	From Port	To
/	/	/	/

Block Diagram of Test Setup

For Radiated Emissions:



SUMMARY OF TEST RESULTS

FCC Rules	Description of Test	Result
FCC §15.247 (i) & §1.1307 (b) (3) & §2.1091	Maximum Permissible Exposure (MPE)	Compliant
FCC §15.203	Antenna Requirement	Compliant
FCC §15.207(a)	AC Line Conducted Emissions	Not Applicable
FCC §15.209, §15.205 & §15.247(d)	Spurious Emissions	Compliant
§15.247(a)(1)(i)	20 dB Emission Bandwidth	Compliant
§15.247(a)(1)	Channel Separation Test	Compliant
§15.247(f)	Time of Occupancy (Dwell Time)	Compliant
§15.247(b)(3)	Peak Output Power Measurement	Compliant
§15.247(d)	Band edges	Compliant
§15.247(f)	Power Spectral Density	Compliant

Not Applicable: The EUT is powered by battery, so this test item was not required.

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Radiated Emission Test					
Rohde & Schwarz	EMI Test Receiver	ESR3	102455	2024/01/16	2025/01/15
Sonoma instrument	Pre-amplifier	310 N	186238	2024/05/21	2025/05/20
Sunol Sciences	Broadband Antenna	JB1	A040904-1	2023/07/20	2026/07/19
Unknown	Cable	Chamber A Cable 1	N/A	2024/06/18	2025/06/17
Unknown	Cable	XH500C	J-10M-A	2024/06/18	2025/06/17
BACL	Active Loop Antenna	1313-1A	4031911	2024/05/14	2027/05/13
Unknown	Cable	2Y194	0735	2024/05/21	2025/05/20
Unknown	Cable	PNG214	1354	2024/05/21	2025/05/20
Audix	EMI Test software	E3	19821b(V9)	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40	101605	2024/03/27	2025/03/26
COM-POWER	Pre-amplifier	PA-122	181919	2024/06/18	2025/06/17
Schwarzbeck	Horn Antenna	BBHA9120D(1201)	1143	2023/07/26	2026/07/25
Unknown	RF Cable	KMSE	735	2024/06/18	2025/06/17
Unknown	RF Cable	UFA147	219661	2024/06/18	2025/06/17
Unknown	RF Cable	XH750A-N	J-10M	2024/06/18	2025/06/17
JD	Multiplex Switch Test Control Set	DT7220FSU	DQ77926	2024/06/18	2025/06/17
Audix	EMI Test software	E3	191218(V9)	NCR	NCR
RF Conducted Test					
Rohde &Schwarz	Spectrum Analyzer	FSV40	101473	2024/01/16	2025/01/15
Unknown	10dB Attenuator	Unknown	F-03-EM190	2024/06/27	2025/06/26

*** 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) (3) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

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

According to KDB 447498 D04 Interim General RF Exposure Guidance

MPE-Based Exemption:

General frequency and separation-distance dependent MPE-based effective radiated power(ERP) thresholds are in Table B.1 [Table 1 of § 1.1307(b)(3)(i)(C)] to support an exemption from further evaluation from 300 kHz through 100 GHz.

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

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

Ris the minimum separation distance in meters
f = frequency in MHz

Result

Mode	Frequency (MHz)	Tune up conducted power# (dBm)	Antenna Gain#		ERP		Evaluation Distance (m)	ERP Limit (W)
			(dBi)	(dBd)	(dBm)	(W)		
Lora-Hybrid	902.3-914.9	5.00	1.19	-0.96	4.04	0.003	0.2	0.462
Lora-DTS	903-914.2	15.00	1.19	-0.96	14.04	0.025	0.2	0.462

Note: The tune up conducted power and antenna gain was declared by the applicant.
Lora- Hybrid and Lora-DTS can't transmit simultaneously.

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

Result: Compliant.

FCC §15.203 - ANTENNA REQUIREMENT

Applicable Standard

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

Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with § 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

Antenna Connector Construction

The EUT has dipole antenna with unique antenna connector, and the maximum antenna gain[#] is 1.19dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Result: Compliant.

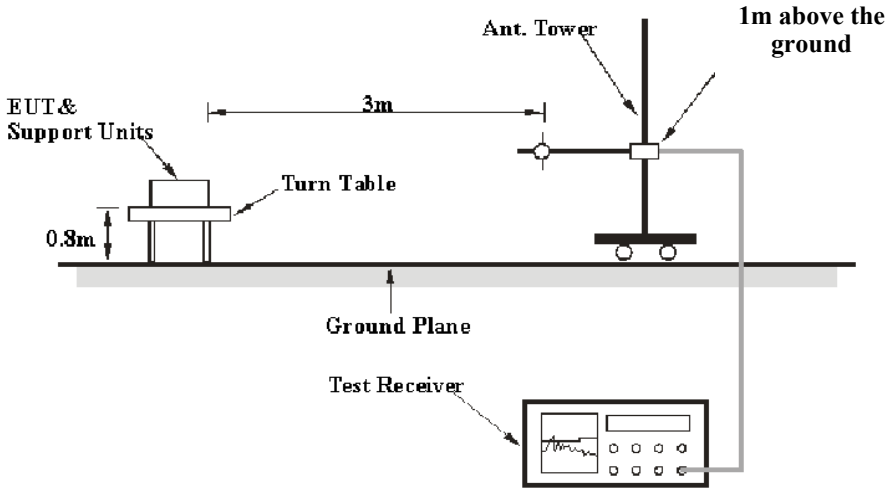
FCC §15.209, §15.205 & §15.247(d) - SPURIOUS EMISSIONS

Applicable Standard

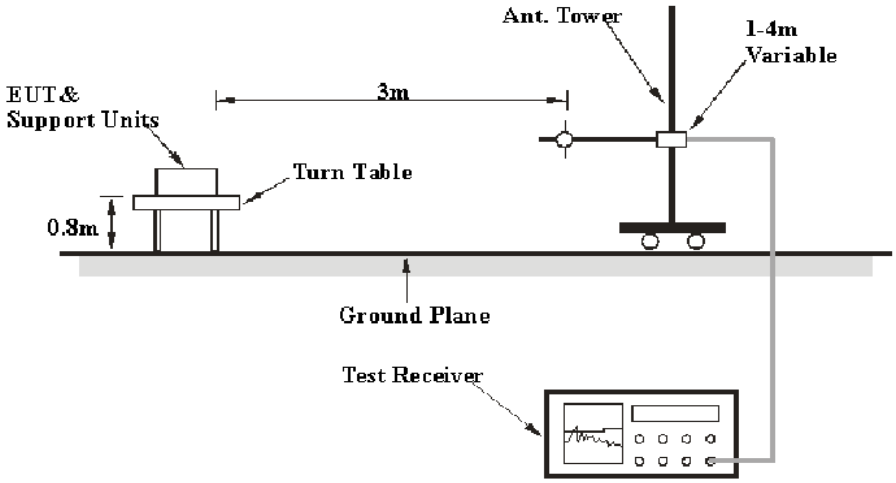
FCC §15.247 (d); §15.209; §15.205;

EUT Setup

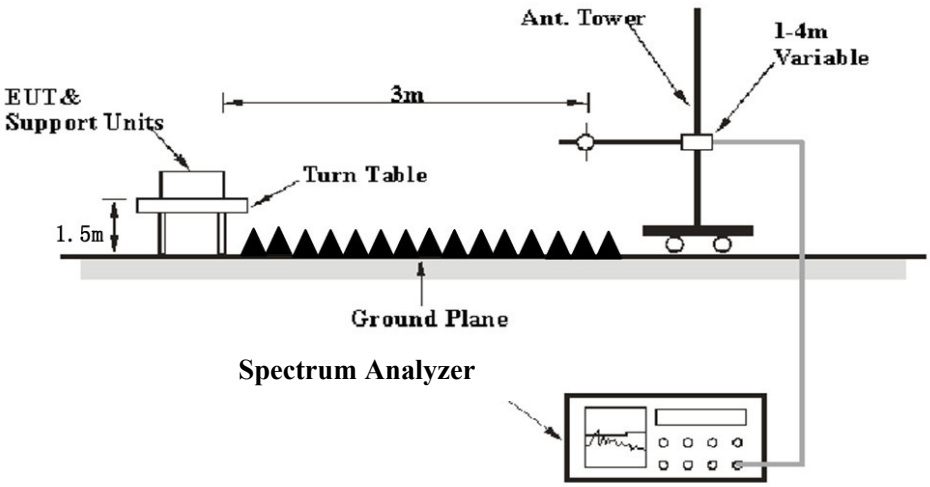
9 kHz-30MHz:



30MHz-1GHz:



Above 1GHz:



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

EMI Test Receiver & Spectrum Analyzer Setup

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

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1MHz	3 MHz	/	PK
	1MHz	10 Hz Note 1	/	Average
	1MHz	＞1/T Note 2	/	Average

Note 1: when duty cycle is no less than 98%
Note 2: when duty cycle is less than 98%

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.

For 9 kHz-30MHz, the report shall list the six emissions with the smallest margin relative to the limit, for each of the three antenna orientations (parallel, perpendicular, and ground-parallel) unless the margin is greater than 20 dB.

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.

All emissions under the average limit and under the noise floor have not recorded in the report.

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/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:

Over Limit/Margin = Level/Corrected Amplitude – Limit
Level / Corrected Amplitude = Read Level + Factor

Test Data

Environmental Conditions

Temperature:	24~25.6 ℃
Relative Humidity:	50~58 %
ATM Pressure:	101.0 kPa

The testing was performed by Jack Liu on 2024-09-10 for below 1GHz and Sadow Tan on 2024-09-05 for above 1GHz.

EUT operation mode: Transmitting

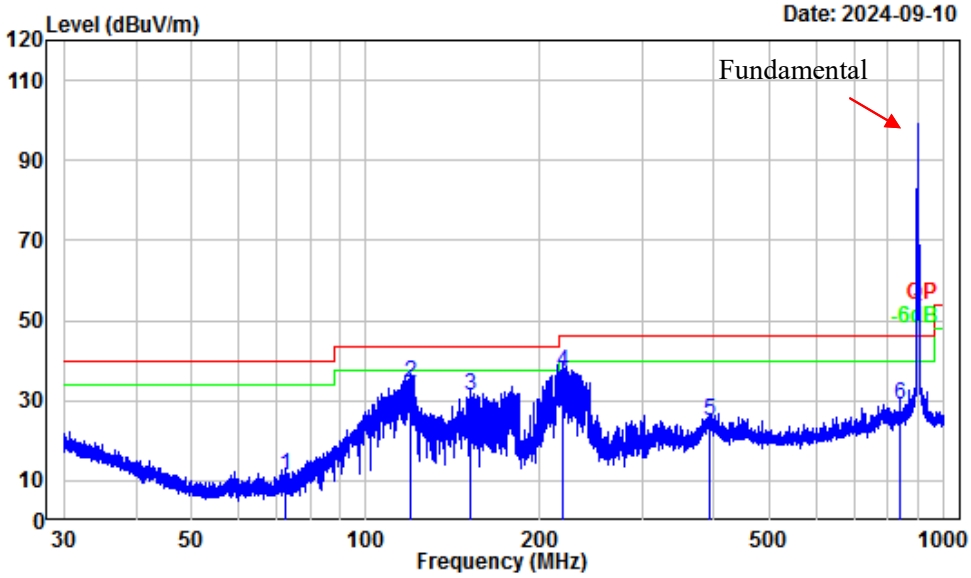
Note: Pre-scan in the X, Y and Z axes of orientation, the worst case Z-axis of orientation was recorded.

9 kHz-30 MHz (Maximum output power mode, Low channel):

The amplitude of spurious emissions attenuated more than 20 dB below the limit was not recorded.

30 MHz~1 GHz: (Maximum output power mode, Low channel)

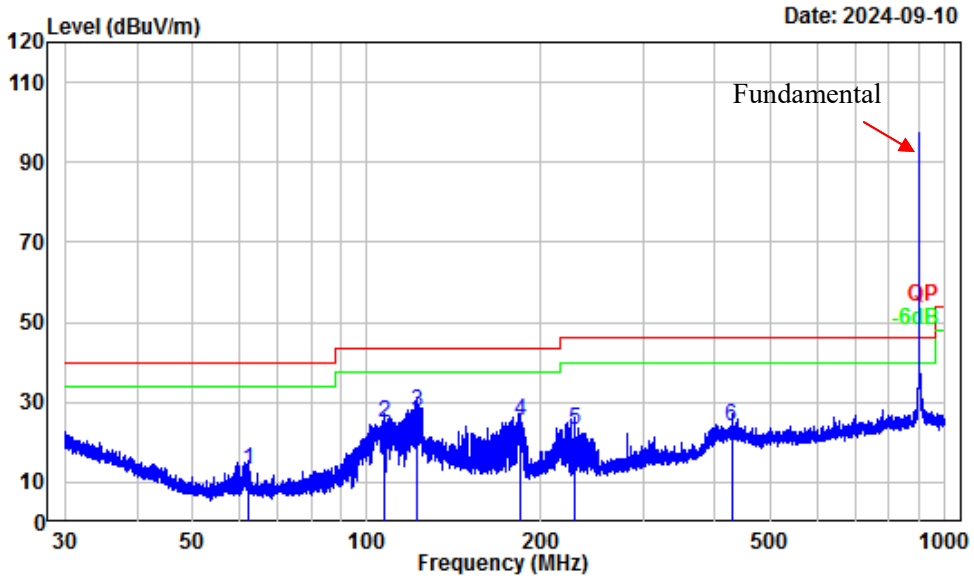
Horizontal



Site : Chamber A
Condition : 3m Horizontal
Project Number: 2401V31126E-RF
Test Mode : Transmitting
Tester : Jack Liu

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	72.53	-17.88	29.23	11.35	40.00	-28.65	QP
2	119.17	-11.58	46.18	34.60	43.50	-8.90	QP
3	151.33	-12.50	43.53	31.03	43.50	-12.47	QP
4	219.08	-13.08	50.34	37.26	46.00	-8.74	QP
5	394.34	-8.61	33.53	24.92	46.00	-21.08	QP
6	838.81	-1.82	30.80	28.98	46.00	-17.02	QP

Vertical



Site : Chamber A
Condition : 3m Vertical
Project Number: 2401V31126E-RF
Test Mode : Transmitting
Tester : Jack Liu

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	62.43	-18.06	31.37	13.31	40.00	-26.69	QP
2	107.42	-13.82	38.79	24.97	43.50	-18.53	QP
3	122.35	-11.39	38.95	27.56	43.50	-15.94	QP
4	183.92	-13.87	39.13	25.26	43.50	-18.24	QP
5	228.79	-13.08	36.21	23.13	46.00	-22.87	QP
6	427.27	-7.94	32.12	24.18	46.00	-21.82	QP

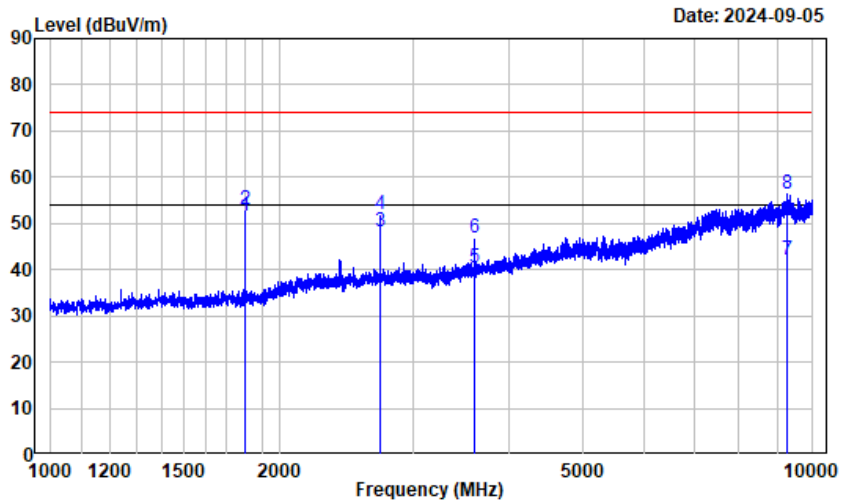
Above 1 GHz:

Frequency (MHz)	Receiver		Polar (H/V)	Factor (dB/m)	Absolute Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/Ave					
Low Channel 902.3MHz							
1804.60	59.62	PK	H	-6.60	53.02	74	-20.98
1804.60	58.13	AV	H	-6.60	51.53	54	-2.47
1804.60	54.44	PK	V	-6.60	47.84	74	-26.16
1804.60	50.41	AV	V	-6.60	43.81	54	-10.19
2706.90	54.39	PK	H	-2.49	51.90	74	-22.10
2706.90	50.71	AV	H	-2.49	48.22	54	-5.78
2706.90	49.72	PK	V	-2.49	47.23	74	-26.77
2706.90	44.42	AV	V	-2.49	41.93	54	-12.07
3609.20	48.84	PK	H	-2.04	46.80	74	-27.20
3609.20	42.50	AV	H	-2.04	40.46	54	-13.54
3609.20	46.46	PK	V	-2.04	44.42	74	-29.58
3609.20	35.91	AV	V	-2.04	33.87	54	-20.13
Middle Channel 908.7MHz							
1817.40	58.12	PK	H	-6.50	51.62	74	-22.38
1817.40	55.13	AV	H	-6.50	48.63	54	-5.37
1817.40	55.17	PK	V	-6.50	48.67	74	-25.33
1817.40	53.43	AV	V	-6.50	46.93	54	-7.07
2726.10	54.53	PK	H	-2.49	52.04	74	-21.96
2726.10	52.02	AV	H	-2.49	49.53	54	-4.47
2726.10	50.08	PK	V	-2.49	47.59	74	-26.41
2726.10	42.78	AV	V	-2.49	40.29	54	-13.71
3634.80	50.67	PK	H	-1.94	48.73	74	-25.27
3634.80	45.74	AV	H	-1.94	43.80	54	-10.20
3634.80	46.76	PK	V	-1.94	44.82	74	-29.18
3634.80	32.12	AV	V	-1.94	30.18	54	-23.82

Frequency (MHz)	Receiver		Polar (H/V)	Factor (dB/m)	Absolute Level (dBµV/m)	Limit (dBµV/m)	Margin (dB)
	Reading (dBµV)	PK/Ave					
High Channel 914.9MHz							
1829.80	56.97	PK	H	-6.40	50.57	74	-23.43
1829.80	55.51	AV	H	-6.40	49.11	54	-4.89
1829.80	53.48	PK	V	-6.40	47.08	74	-26.92
1829.80	48.15	AV	V	-6.40	41.75	54	-12.25
2744.70	55.71	PK	H	-2.49	53.22	74	-20.78
2744.70	53.57	AV	H	-2.49	51.08	54	-2.92
2744.70	49.72	PK	V	-2.49	47.23	74	-26.77
2744.70	44.06	AV	V	-2.49	41.57	54	-12.43
3659.60	50.99	PK	H	-1.84	49.15	74	-24.85
3659.60	45.96	AV	H	-1.84	44.12	54	-9.88
3659.60	47.58	PK	V	-1.84	45.74	74	-28.26
3659.60	39.56	AV	V	-1.84	37.72	54	-16.28

Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude/Level = Corrected Factor + Reading
Margin = Corrected Amplitude/Level - Limit
The other spurious emission which is in the noise floor level was not recorded.

Listed with the harmonic margin test plot (worst case, low channel):

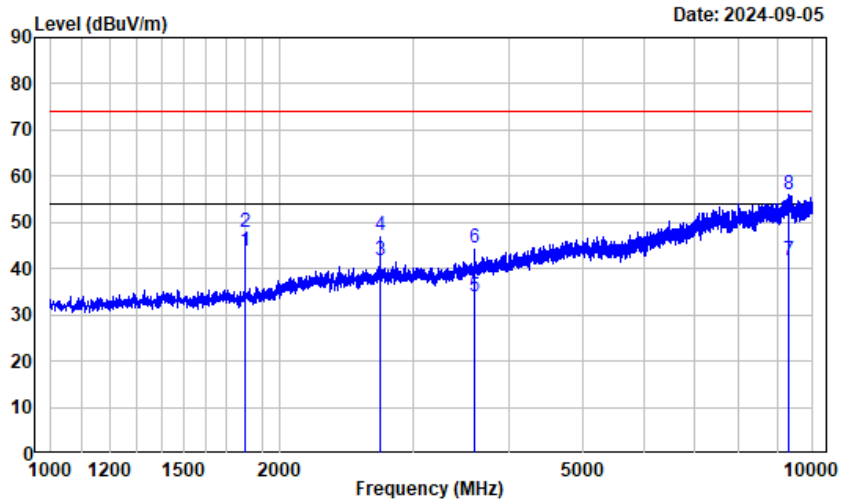
Horizontal	
1-10GHz	

Condition : Horizontal
Project No.: 2401V31126E-RF
Tester : Sadow Tan
Note : 125K_902.3

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	1804.600	-6.60	58.13	51.53	54.00	-2.47	Average
2	1804.600	-6.60	59.62	53.02	74.00	-20.98	Peak
3	2706.900	-2.49	50.71	48.22	54.00	-5.78	Average
4	2706.900	-2.49	54.39	51.90	74.00	-22.10	Peak
5	3609.200	-2.04	42.50	40.46	54.00	-13.54	Average
6	3609.200	-2.04	48.84	46.80	74.00	-27.20	Peak
7	9271.000	11.79	30.27	42.06	54.00	-11.94	Average
8	9271.000	11.79	44.72	56.51	74.00	-17.49	Peak

Vertical

1-10GHz



Condition : Vertical
Project No.: 2401V31126E-RF
Tester : Sadow Tan
Note : 125K_902.3

	Freq	Factor	Read Level	Level	Limit Line	Over Limit	Remark
	MHz	dB/m	dBuV	dBuV/m	dBuV/m	dB	
1	1804.600	-6.60	50.41	43.81	54.00	-10.19	Average
2	1804.600	-6.60	54.44	47.84	74.00	-26.16	Peak
3	2706.900	-2.49	44.42	41.93	54.00	-12.07	Average
4	2706.900	-2.49	49.72	47.23	74.00	-26.77	Peak
5	3609.200	-2.04	35.91	33.87	54.00	-20.13	Average
6	3609.200	-2.04	46.46	44.42	74.00	-29.58	Peak
7	9294.625	11.80	29.89	41.69	54.00	-12.31	Average
8	9294.625	11.80	44.11	55.91	74.00	-18.09	Peak

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

Applicable Standard

FCC § 15.247(a) (1)

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.

FCC § 15.247(a) (1) (i)
For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

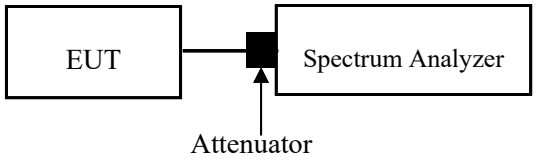
Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.2

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: Wide enough to capture the peaks of two adjacent channels.
b) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
c) Video (or average) bandwidth (VBW) ≥ RBW.
d) Sweep: Auto.
e) Detector function: Peak.
f) Trace: Max hold.
g) Allow the trace to stabilize.

Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined.



Test Data

Environmental Conditions

Temperature:	26.1 ℃
Relative Humidity:	55 %
ATM Pressure:	101 kPa

The testing was performed by KunfuMaster Liang on 2024-08-14.

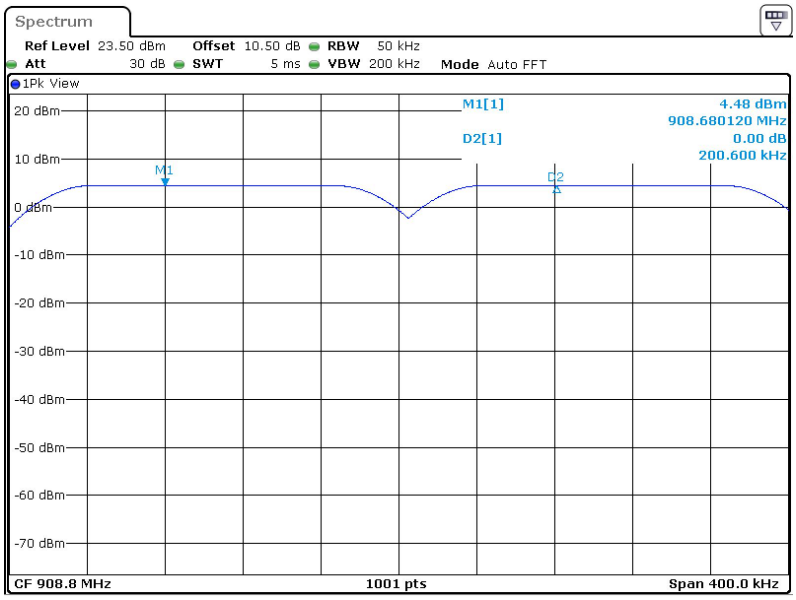
EUT operation mode: Transmitting

Test Result: Compliant*. Please refer to following table and plots*

Test Mode	Channel Separation (MHz)	Limit (MHz)	Verdict
Hop	0.2	0.14	Pass

Note: Limit ≥ 20 dB bandwidth

Middle Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 14.AUG.2024 23:55:03

FCC §15.247(a) (1) (i) - 20 dB EMISSION BANDWIDTH

Applicable Standard

According to §15.247(a) (1) (i) For frequency hopping systems operating in the 902-928 MHz band: if the 20 dB bandwidth of the hopping channel is less than 250 kHz, the system shall use at least 50 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 20 second period; if the 20 dB bandwidth of the hopping channel is 250 kHz or greater, the system shall use at least 25 hopping frequencies and the average time of occupancy on any frequency shall not be greater than 0.4 seconds within a 10 second period. The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Procedure

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

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The span range for the EMI receiver or spectrum analyzer shall be between two times and five times the OBW.

b) The nominal IF filter bandwidth (3 dB RBW) shall be in the range of 1% to 5% of the OBW and video bandwidth (VBW) shall be approximately three times RBW, unless otherwise specified by the applicable requirement.

c) Set the reference level of the instrument as required, keeping the signal from exceeding the maximum input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.

d) Steps a) through c) might require iteration to adjust within the specified tolerances.

e) The dynamic range of the instrument at the selected RBW shall be more than 10 dB below the target "−xx dB down" requirement; that is, if the requirement calls for measuring the −20 dB OBW, the instrument noise floor at the selected RBW shall be at least 30 dB below the reference value.

f) Set detection mode to peak and trace mode to max hold.

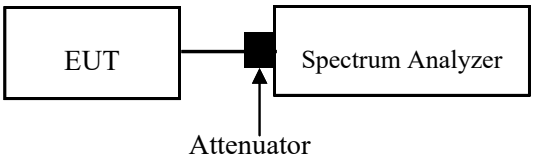
g) Determine the reference value: Set the EUT to transmit an un-modulated carrier or modulated signal, as applicable. Allow the trace to stabilize. Set the spectrum analyzer marker to the highest level of the displayed trace (this is the reference value).

h) Determine the "−xx dB down amplitude" using [(reference value) − xx]. Alternatively, this calculation may be made by using the marker-delta function of the instrument.

i) If the reference value is determined by an un-modulated carrier, then turn the EUT modulation on, and either clear the existing trace or start a new trace on the spectrum analyzer and allow the new trace to stabilize. Otherwise, the trace from step g) shall be used for step j).

j) Place two markers, one at the lowest frequency and the other at the highest frequency of the envelope of the spectral display, such that each marker is at or slightly below the "− xx dB down amplitude" determined in step h). If a marker is below this "−xx dB down amplitude" value, then it shall be as close as possible to this value. The occupied bandwidth is the frequency difference between the two markers. Alternatively, set a marker at the lowest frequency of the envelope of the spectral display, such that the marker is at or slightly below the "− xx dB down amplitude" determined in step h). Reset the marker-delta function and move the marker to the other side of the emission until the delta marker amplitude is at the same level as the reference marker amplitude. The marker-delta frequency reading at this point is the specified emission bandwidth.

k) The occupied bandwidth shall be reported by providing plot(s) of the measuring instrument display; the plot axes and the scale units per division shall be clearly labeled. Tabular data may be reported in addition to the plot(s).



Test Data

Environmental Conditions

Temperature:	26.1 ℃
Relative Humidity:	55 %
ATM Pressure:	101 kPa

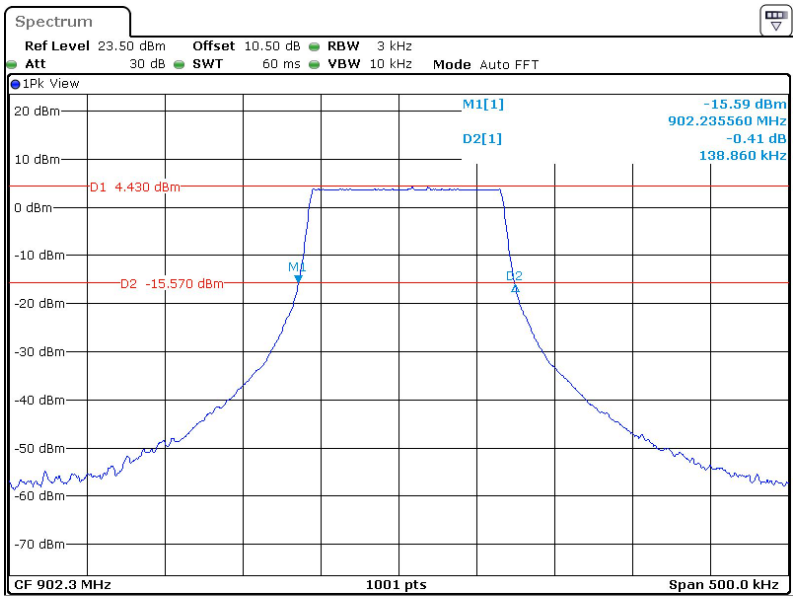
The testing was performed by KunfuMaster Liang on 2024-08-14.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the following table and plots.

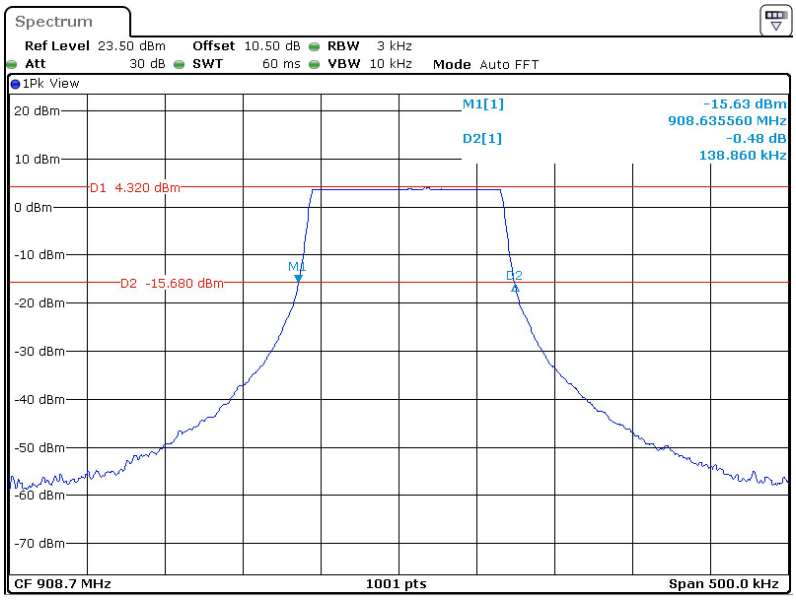
Test Channel	Test Frequency (MHz)	20 dB Bandwidth (MHz)	Limit (MHz)
Low	902.3	0.139	-
Middle	908.7	0.139	-
High	914.9	0.139	-

Low Channel



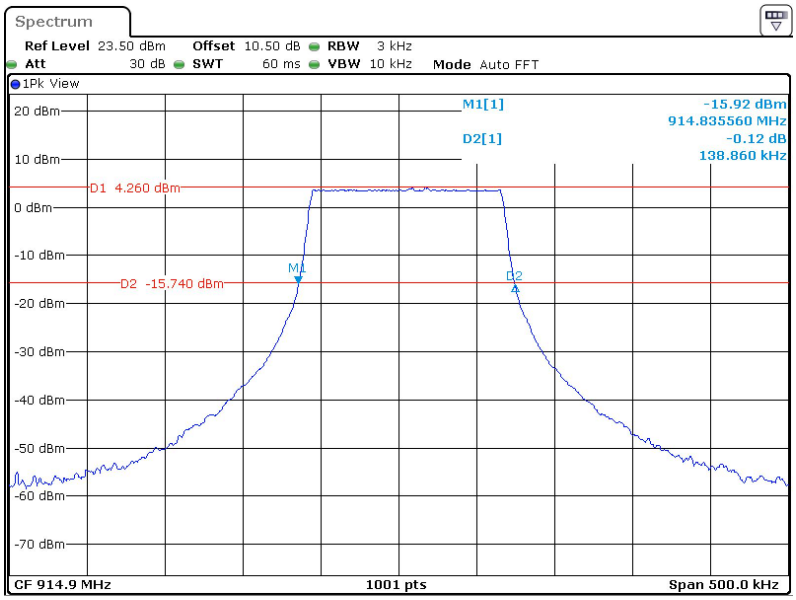
ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 14.AUG.2024 23:32:00

Middle Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 14.AUG.2024 23:38:50

High Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 14.AUG.2024 23:41:12

FCC §15.247(f) - TIME OF OCCUPANCY (DWELL TIME)

Applicable Standard

FCC §15.247(f)
For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.4

The EUT shall have its hopping function enabled. Use the following spectrum analyzer settings:

a) Span: Zero span, centered on a hopping channel.
b) RBW shall be ⩽ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
c) Sweep: As necessary to capture the entire dwell time per hopping channel; where possible use a video trigger and trigger delay so that the transmitted signal starts a little to the right of the start of the plot. The trigger level might need slight adjustment to prevent triggering when the system hops on an adjacent channel; a second plot might be needed with a longer sweep time to show two successive hops on a channel.
d) Detector function: Peak.
e) Trace: Max hold.

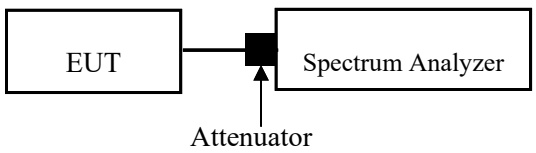
Use the marker-delta function to determine the transmit time per hop. If this value varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation in transmit time.

Repeat the measurement using a longer sweep time to determine the number of hops over the period specified in the requirements. The sweep time shall be equal to, or less than, the period specified in the requirements. Determine the number of hops over the sweep time and calculate the total number of hops in the period specified in the requirements, using the following equation:

(Number of hops in the period specified in the requirements) =(number of hops on spectrum analyzer) × (period specified in the requirements / analyzer sweep time)

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the requirements. If the number of hops in a specific time varies with different modes of operation (data rate, modulation format, number of hopping channels, etc.), then repeat this test for each variation.

The measured transmit time and time between hops shall be consistent with the values described in the operational description for the EUT.



Test Data

Environmental Conditions

Temperature:	25~25.6 ℃
Relative Humidity:	50~55 %
ATM Pressure:	101 kPa

The testing was performed by KunfuMaster Liang on 2024-08-15 and Cheeb Huang on 2024-09-11.

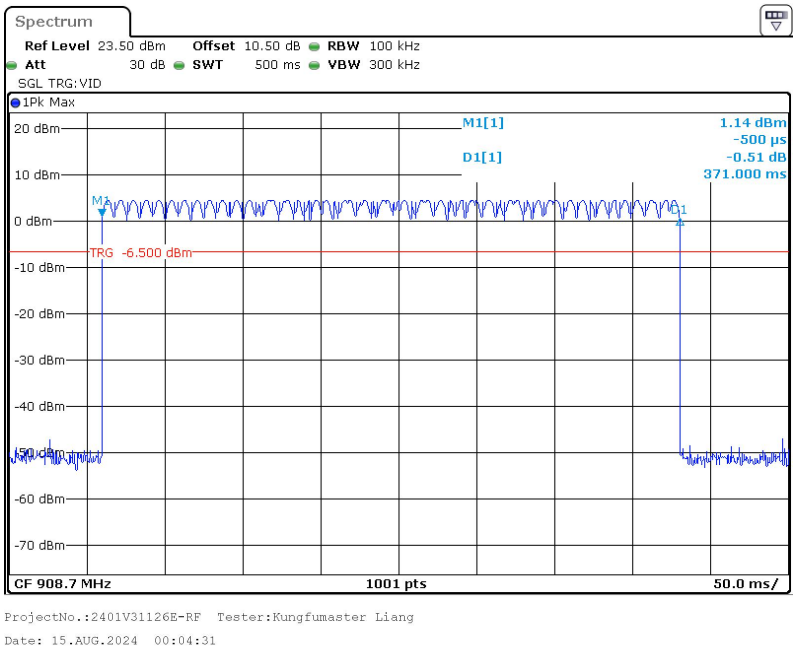
EUT operation mode: Transmitting

Test Result: Compliant. *Please refer to following table and plots.*

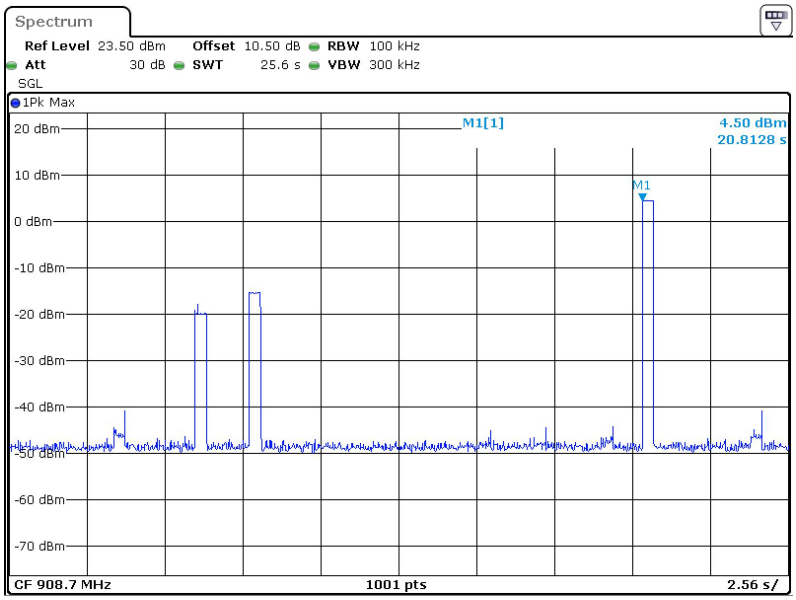
Test Frequency (MHz)	Pulse width (ms)	Observation time(s)	Hopping Number in Observation time	Dwell Time (s)	Limit (s)	Result
908.7	371.00	25.6	1	0.371	0.400	Pass

Note: A period time=0.4*64=25.6(s), Total of Dwell Time=Pulse Width*Hopping Number

Pulse Width

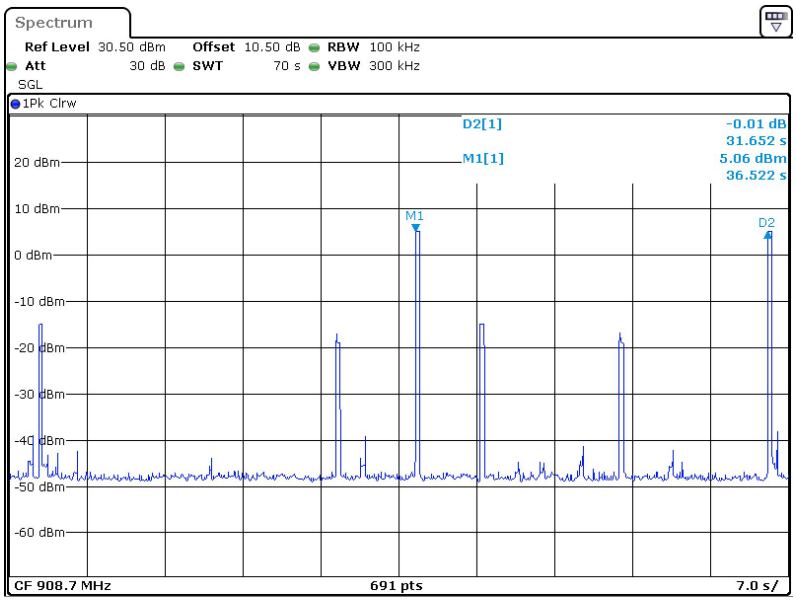


Hopping Numbers in Observation time



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 15.AUG.2024 00:06:43



ProjectNo.:2401V31126E-RF Tester:Cheeb Huang

Date: 11.SEP.2024 09:22:29

FCC §15.247(b) (3) - MAXIMUM CONDUCTED OUTPUT POWER

Applicable Standard

FCC §15.247(b) (3)

For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 7.8.5

This is an RF-conducted test to evaluate maximum peak output power. Use a direct connection between the antenna port of the unlicensed wireless device and the spectrum analyzer, through suitable attenuation. The hopping shall be disabled for this test:

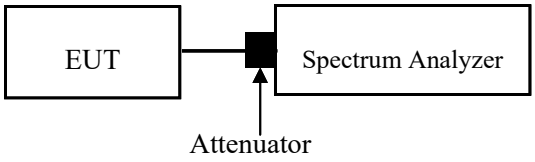
a) Use the following spectrum analyzer settings:

1) Span: Approximately five times the 20 dB bandwidth, centered on a hopping channel.
2) RBW > 20 dB bandwidth of the emission being measured.
3) VBW ≥ RBW.
4) Sweep: Auto.
5) Detector function: Peak.
6) Trace: Max hold.

b) Allow trace to stabilize.

c) Use the marker-to-peak function to set the marker to the peak of the emission.

d) The indicated level is the peak output power, after any corrections for external attenuators and cables.



Test Data

Environmental Conditions

Temperature:	25.8~26.1 ℃
Relative Humidity:	50~55 %
ATM Pressure:	101 kPa

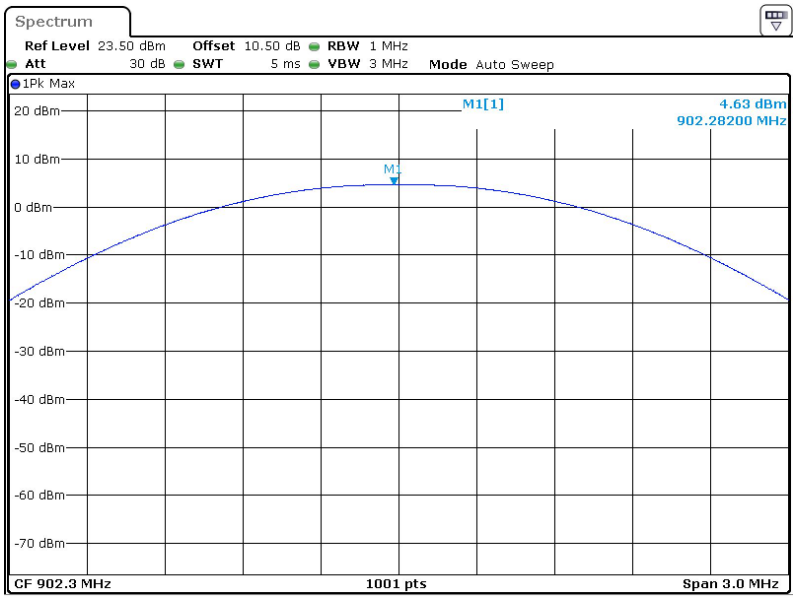
The testing was performed by KunfuMaster Liang from 2024-08-14 to 2024-08-22.

EUT operation mode: Transmitting

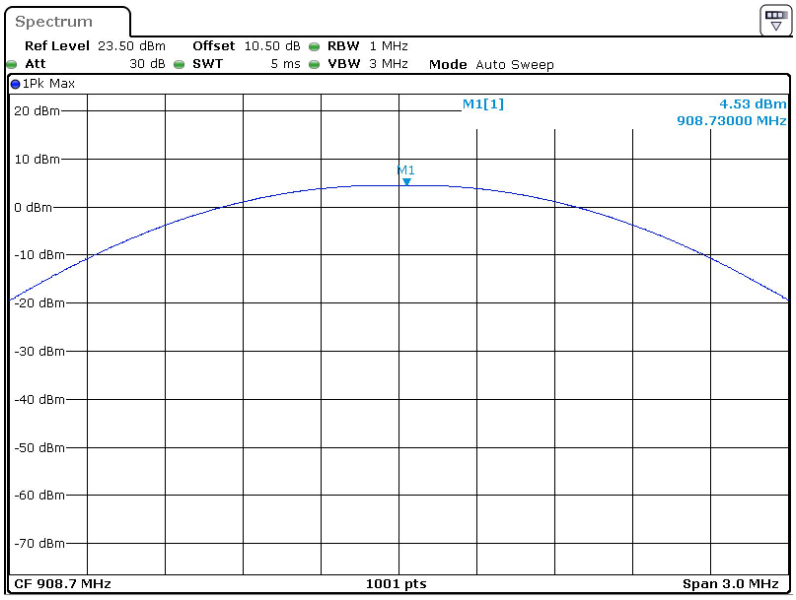
Test Result: Compliant. Please refer to the following table and plots.

Test Channel	Test Frequency (MHz)	Maximum Peak Conducted Output Power (dBm)	Limit (dBm)
Low	902.3	4.63	≤30
Middle	908.7	4.53	≤30
High	914.9	4.55	≤30

Low Channel



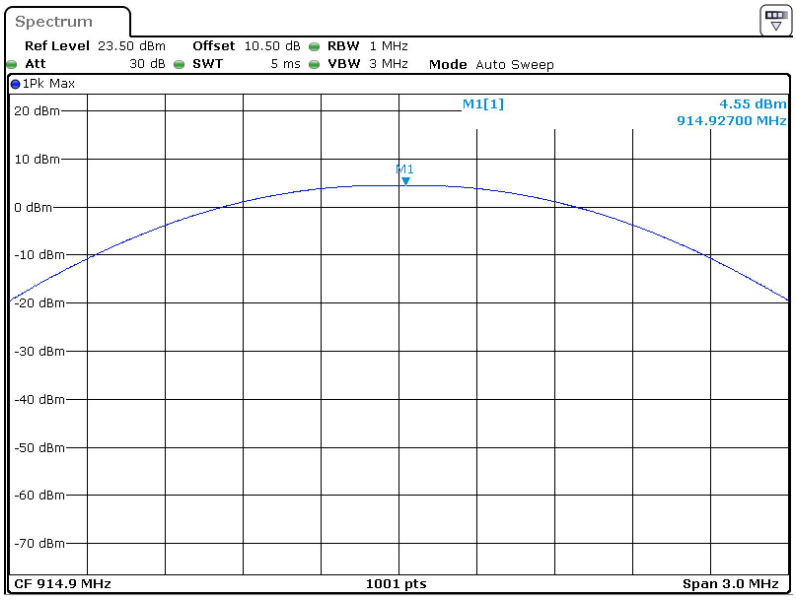
Middle Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 14.AUG.2024 23:22:05

High Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 22.AUG.2024 20:33:19

FCC §15.247(d) - 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

Applicable Standard

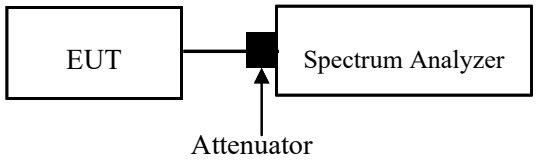
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the 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

For band-edge measurements, use the band-edge procedure in 6.10. Band-edge measurements shall be tested both on single channels, and with the EUT hopping

a) Set the center frequency and span to encompass frequency range to be measured.
b) Set the RBW = 100 kHz.
c) Set the VBW ⩾ [3 × RBW].
d) Detector = peak.
e) Sweep time = auto couple.
f) Trace mode = max hold.
g) Allow trace to fully stabilize.
h) Use the peak marker function to determine the maximum amplitude level.
Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) is attenuated by at least the minimum requirements. Report the three highest emissions relative to the limit.



Test Data

Environmental Conditions

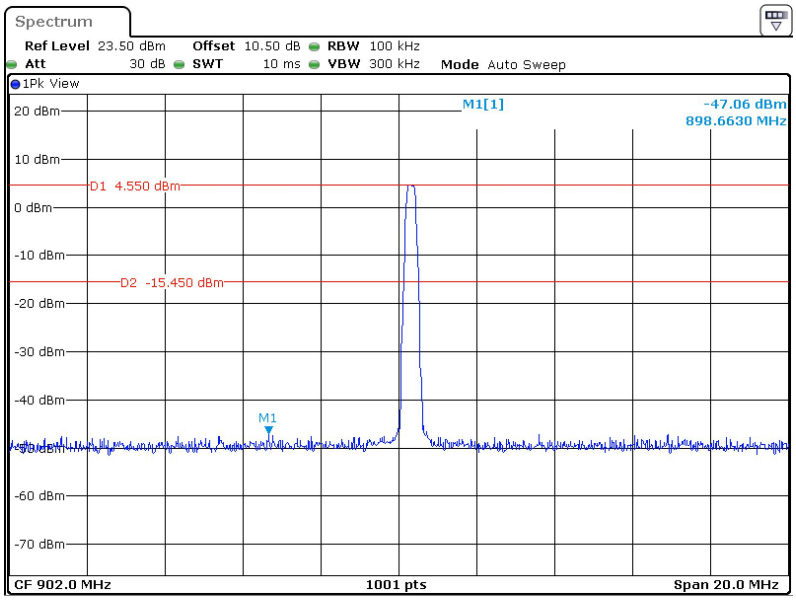
Temperature:	25.6℃
Relative Humidity:	55 %
ATM Pressure:	101 kPa

The testing was performed by KunfuMaster Liang on 2024-08-15.

EUT operation mode: Transmitting

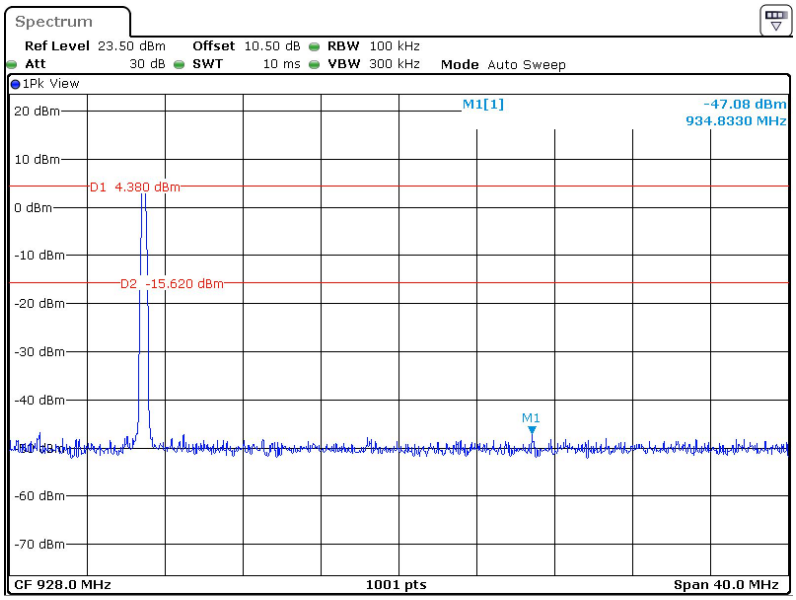
Test Result: Compliant. Please refer to the following plots.

Single Mode Band Edge, Left Side



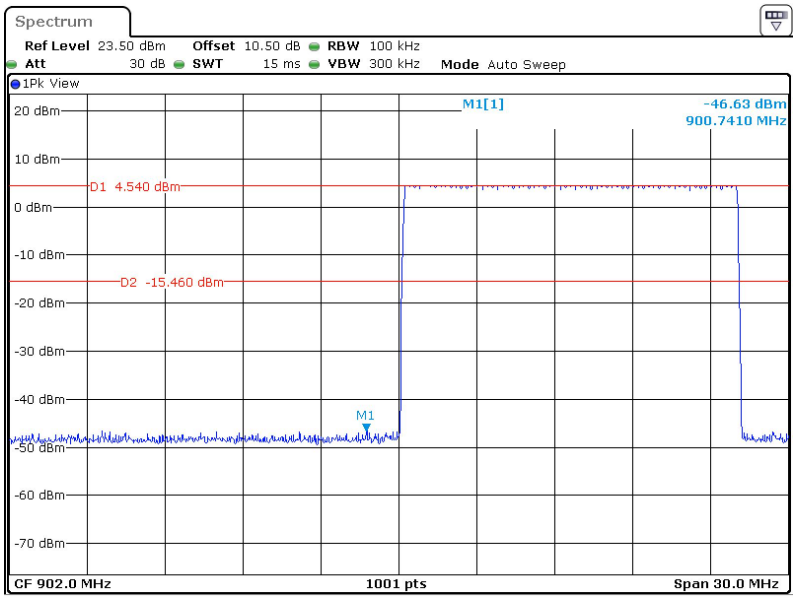
ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 15.AUG.2024 00:22:54

Single Mode Band Edge, Right Side



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 15.AUG.2024 00:25:32

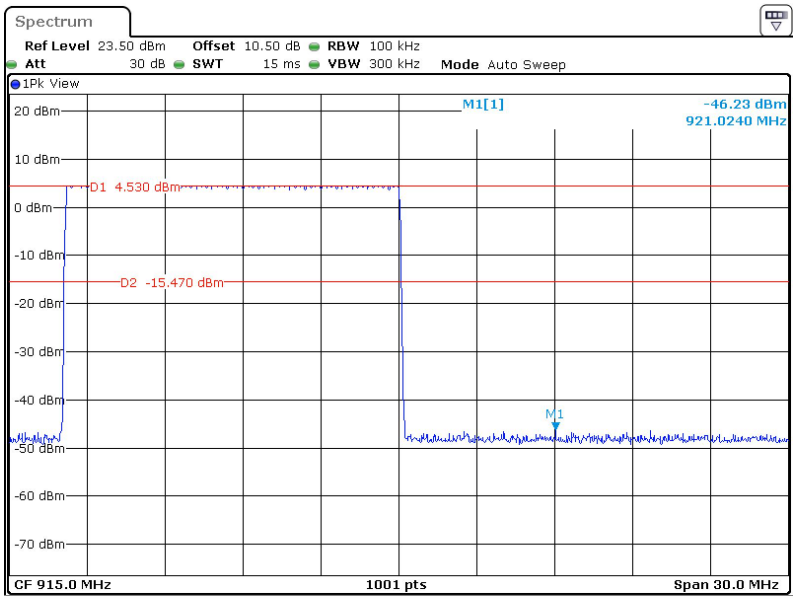
Hopping mode Band Edge, Left Side



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 15.AUG.2024 00:14:15

Hopping mode Band Edge, Right Side



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

Date: 15.AUG.2024 00:18:42

FCC §15.247(f) - POWER SPECTRAL DENSITY

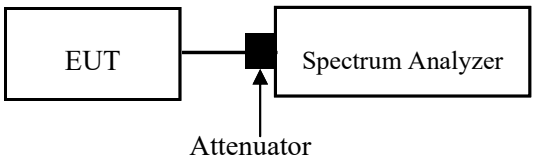
Applicable Standard

(f) For the purposes of this section, hybrid systems are those that employ a combination of both frequency hopping and digital modulation techniques. The frequency hopping operation of the hybrid system, with the direct sequence or digital modulation operation turned-off, shall have an average time of occupancy on any frequency not to exceed 0.4 seconds within a time period in seconds equal to the number of hopping frequencies employed multiplied by 0.4. The power spectral density conducted from the intentional radiator to the antenna due to the digital modulation operation of the hybrid system, with the frequency hopping operation turned off, shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure

Test Method: ANSI C63.10-2013 Clause 11.10.2

1. Use this procedure when the maximum peak conducted output power in the fundamental emission is used to demonstrate compliance.
2. Set the RBW to: 3kHz≤ RBW≤100 kHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to 1.5 times the DTS bandwidth.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.



Test Data

Environmental Conditions

Temperature:	26.1℃
Relative Humidity:	55 %
ATM Pressure:	101 kPa

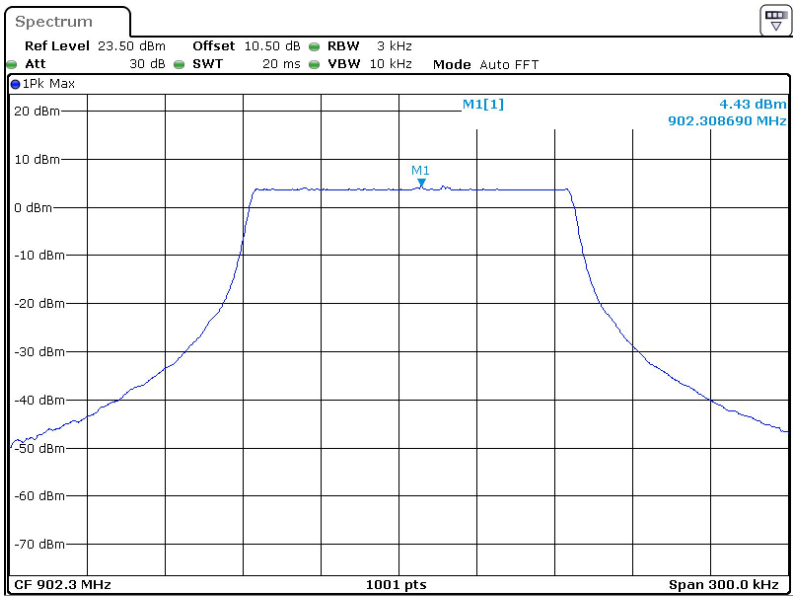
The testing was performed by KunfuMaster Liang on 2024-08-14.

EUT operation mode: Transmitting

Test Result: Compliant. Please refer to the following table and plots.

Test Channel	Test Frequency (MHz)	Power Spectral Density (dBm/3kHz)	Limit (dBm/3kHz)
Low	902.3	4.43	≤8.00
Middle	908.7	4.35	≤8.00
High	914.9	4.25	≤8.00

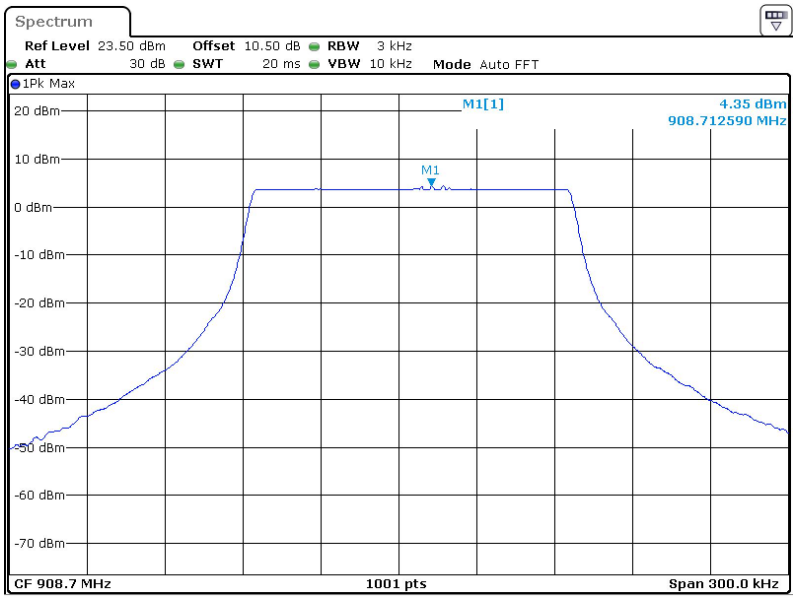
Low Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang

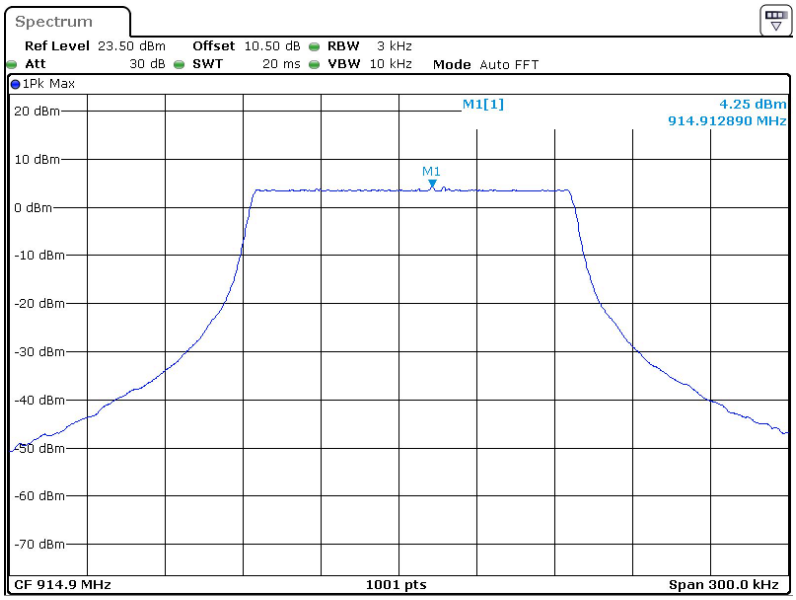
Date: 14.AUG.2024 23:29:19

Middle Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 14.AUG.2024 23:27:35

High Channel



ProjectNo.:2401V31126E-RF Tester:Kungfumaster Liang
Date: 14.AUG.2024 23:26:09

EUT PHOTOGRAPHS

Please refer to the attachment2401V31126E-RF External photo and 2401V31126E-RF Internal photo.

TEST SETUP PHOTOGRAPHS

Please refer to the attachment 2401V31126E-RF Test Setup photo.

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