FCC TEST REPORT

FCC ID:2BG8S-WL65

Report No.	:	SSP24060118-2E
Applicant	:	Shenzhen Hantu Electronics Co., Ltd.
Product Name	:	3D hologram fan
Model Name	:	WL-65
Test Standard	:	FCC Part 15.247
Date of Issue	:	2024-07-15

Shenzhen CCUT Quality Technology Co., Ltd.
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This test report is limited to the above client company and the product model only. It may not be duplicated without prior permitted by Shenzhen CCUT Quality Technology Co., Ltd.

Test Report Basic Information

Applicant.....:	Shenzhen Hantu Electronics Co., Ltd.
Address of Applicant.....:	Room 203, Building B3-2, No. 41, Gangtou Road, Ganggang Community, Shajing Street, Bao'an District, Shenzhen, China
Manufacturer.....:	Shenzhen Hantu Electronics Co., Ltd.
Address of Manufacturer.....:	Room 203, Building B3-2, No. 41, Gangtou Road, Ganggang Community, Shajing Street, Bao'an District, Shenzhen, China
Product Name.....:	3D hologram fan
Brand Name.....:	Twotrees
Main Model.....:	WL-65
Series Models.....:	WL-42, WL-30-Z, WL-65-S, WL-80, WL-11, WL-30, WL-45, WL-49, WL-52, WL-56, WL-73, WL-85, WL-130, WL-100, WL-23, WL-150, WL-180, WL-196, WL-23-Z, WL-11-Z, WL-73-S
Test Standard.....:	FCC Part 15 Subpart C ANSI C63.4-2014 ANSI C63.10-2013
Date of Test .....:	2024-06-18 to 2024-07-15
Test Result.....:	PASS
Tested By .....:	Coke Huang (Coke Huang)
Reviewed By.....:	Lieber Ouyang (Lieber Ouyang)
Authorized Signatory.....:	Lahm Peng (Lahm Peng)

Shenzhen CCUT Quality Technology Co., Ltd. APPROVED

Note : This test report is limited to the above client company and the product model only. It may not be duplicated without prior permitted by Shenzhen CCUT Quality Technology Co., Ltd.. All test data presented in this test report is only applicable to presented test sample.

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Revision History

Revision	Issue Date	Description	Revised By
V1.0	2024-07-15	Initial Release	Lahm Peng

1. General Information

1.1 Product Information

Product Name:	3D hologram fan
Trade Name:	Twotrees
Main Model:	WL-65
Series Models:	WL-42, WL-30-Z, WL-65-S, WL-80, WL-11, WL-30, WL-45, WL-49, WL-52, WL-56, WL-73, WL-85, WL-130, WL-100, WL-23, WL-150, WL-180, WL-196, WL-23-Z, WL-11-Z, WL-73-S
Rated Voltage:	DC24V by adapter
Battery:	-
Power Adaptor:	INPUT: 100-240V~50/60Hz 1.5A, OUTPUT:24V⎓4A
Hardware Version:	V2.2.2
Software Version:	2.0.1.1
Note 1: The test data is gathered from a production sample, provided by the manufacturer. Note 2: The color of appearance and model name of series models listed are different from the main model, but the circuit and the electronic construction are the same, declared by the manufacturer.	

Wireless Specification	
Wireless Standard:	Bluetooth BR
Operating Frequency:	2402MHz ~ 2480MHz
RF Output Power:	4.81dBm
Number of Channel:	79
Channel Separation:	1MHz
Modulation:	GFSK
Antenna Gain:	0dBi
Type of Antenna:	Integral Antenna
Type of Device:	☐ Portable Device ☒ Mobile Device ☐ Modular Device

1.2 Test Setup Information

List of Test Modes		
Test Mode	Description	Remark
TM1	Lowest Channel	2402MHz(DH5)
TM2	Middle Channel	2441MHz(DH5)
TM3	Highest Channel	2480MHz(DH5)
TM4	Hopping	2402MHz~2480MHz

List and Details of Auxiliary Cable			
Description	Length (cm)	Shielded/Unshielded	With/Without Ferrite
-	-	-	-
-	-	-	-

List and Details of Auxiliary Equipment			
Description	Manufacturer	Model	Serial Number
-	-	-	-
-	-	-	-

List of Channels							
No. of Channel	Frequency (MHz)	No. of Channel	Frequency (MHz)	No. of Channel	Frequency (MHz)	No. of Channel	Frequency (MHz)
01	2402	21	2422	41	2442	61	2462
02	2403	22	2423	42	2443	62	2463
03	2404	23	2424	43	2444	63	2464
04	2405	24	2425	44	2445	64	2465
05	2406	25	2426	45	2446	65	2466
~	~	~	~	~	~	~	~
16	2417	36	2437	56	2457	76	2477
17	2418	37	2438	57	2458	77	2478
18	2419	38	2439	58	2459	78	2479
19	2420	39	2440	59	2460	79	2480
20	2421	40	2441	60	2461		

1.3 Compliance Standards

Compliance Standards	
FCC Part 15 Subpart C	FEDERAL COMMUNICATIONS COMMISSION, RADIO FREQUENCY DEVICES, Intentional Radiators
All measurements contained in this report were conducted with all above standards	
According to standards for test methodology	
FCC Part 15 Subpart C	FEDERAL COMMUNICATIONS COMMISSION, RADIO FREQUENCY DEVICES, Intentional Radiators
ANSI C63.4-2014	American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz.
ANSI C63.10-2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
Maintenance of compliance is the responsibility of the manufacturer or applicant. Any modification of the product, which result is lowering the emission, should be checked to ensure compliance has been maintained.	

1.4 Test Facilities

Laboratory Name:	**Shenzhen CCUT Quality Technology Co., Ltd.** 1F, Building 35, Changxing Technology Industrial Park, Yutang Street, Guangming District, Shenzhen, Guangdong, China
CNAS Laboratory No.:	L18863
A2LA Certificate No.:	6893.01
FCC Registration No:	583813
ISED Registration No.:	CN0164
All measurement facilities used to collect the measurement data are located at 1F, Building 35, Changxing Technology Industrial Park, Yutang Street, Guangming District, Shenzhen, Guangdong, China.	

1.5 List of Measurement Instruments

Description	Manufacturer	Model	Serial Number	Cal. Date	Due. Date
Conducted Emissions					
AMN	ROHDE&SCHWARZ	ENV216	101097	2023-10-21	2024-10-20
EMI Test Receiver	ROHDE&SCHWARZ	ESPI	100242	2023-07-31	2024-07-30
Radiated Emissions					
EMI Test Receiver	ROHDE&SCHWARZ	ESPI	100154	2023-07-31	2024-07-30
Spectrum Analyzer	KEYSIGHT	N9020A	MY48030972	2023-07-31	2024-07-30
Spectrum Analyzer	ROHDE&SCHWARZ	FSV40-N	101692	2023-07-31	2024-07-30
Amplifier	SCHWARZBECK	BBV 9743B	00251	2023-07-31	2024-07-30
Amplifier	HUABO	YXL0518-2.5-45	--	2023-07-31	2024-07-30
Amplifier	COM-MW	DLAN-18G-4G-02	10229104	2023-07-31	2024-07-30
Loop Antenna	DAZE	ZN30900C	21104	2023-08-07	2024-08-06
Broadband Antenna	SCHWARZBECK	VULB 9168	01320	2023-08-07	2024-08-06
Horn Antenna	SCHWARZBECK	BBHA 9120D	02553	2023-08-07	2024-08-06
Horn Antenna	COM-MW	ZLB7-18-40G-950	12221225	2023-08-07	2024-08-06
Conducted RF Testing					
RF Test System	MWRFTest	MW100-RFCB	220418SQS-37	2023-07-31	2024-07-30
Spectrum Analyzer	KEYSIGHT	N9020A	ATO-90521	2023-07-31	2024-07-30

1.6 Measurement Uncertainty

Test Item	Conditions	Uncertainty
Conducted Emissions	9kHz ~ 30MHz	±1.64 dB
Radiated Emissions	9kHz ~ 30MHz	±2.88 dB
	30MHz ~ 1GHz	±3.32 dB
	1GHz ~ 18GHz	±3.50 dB
	18GHz ~ 40GHz	±3.66 dB
Conducted Output Power	9kHz ~ 26GHz	±0.50 dB
Occupied Bandwidth	9kHz ~ 26GHz	±4.0 %
Conducted Spurious Emission	9kHz ~ 26GHz	±1.32 dB

2. Summary of Test Results

FCC Rule	Description of Test Item	Result
FCC Part 15.203	Antenna Requirement	Passed
FCC Part 15.247(i)	RF Exposure(see the RF exposure report)	Passed
FCC Part 15.207	Conducted Emissions	Passed
FCC Part 15.209, 15.247(d)	Radiated Emissions	Passed
FCC Part 15.247(d)	Band-edge Emissions(Radiated)	Passed
FCC Part 15.247(a)(1), (g), (h)	Frequency Hopping System	Passed
FCC Part 15.247(a)(1)(iii)	Dwell Time	Passed
FCC Part 15.247(b)(1)	Maximum Peak Conducted Output Power	Passed
FCC Part 15.215(c)	Occupied Bandwidth(-20dB)	Passed
FCC Part 15.247(a)(1)	Carrier Frequencies Separation	Passed
FCC Part 15.247(a)(1)(iii)	Number of Hopping Channel	Passed
FCC Part 15.247(d)	Band-edge Emissions(Conducted)	Passed
FCC Part 15.247(d)	Conducted RF Spurious Emissions	Passed
Passed: The EUT complies with the essential requirements in the standard Failed: The EUT does not comply with the essential requirements in the standard N/A: Not applicable		

3. Antenna Requirement

3.1 Standard and Limit

According to FCC Part 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.

3.2 Test Result

This product has an Integral Antenna, fulfill the requirement of this section.

4. Conducted Emissions

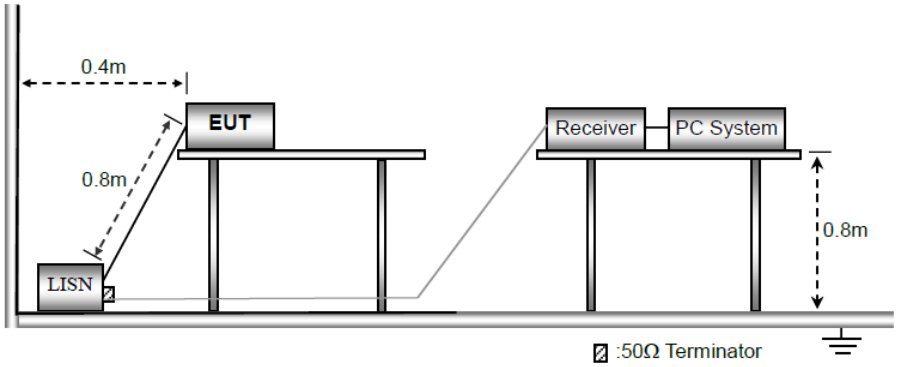
4.1 Standard and Limit

According to the rule FCC Part 15.207, Conducted emissions limit, the limit for a wireless device as below:

Frequency of Emission (MHz)	Conducted emissions (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56	56 to 46
0.5-5	56	46
5-30	60	50
Note 1: Decreases with the logarithm of the frequency in the range 0.15 MHz to 0.5 MHz Note 2: The lower limit applies at the band edges		

4.2 Test Procedure

Test is conducting under the description of ANSI C63.10 - 2013 section 6.2.



Test Setup Block Diagram

a) The EUT was configured for testing in a typical fashion (as a customer would normally use it). The EUT has been programmed to continuously transmit during test. This operating condition was tested and used to collect the included data.

b) The following is the setting of the receiver
Attenuation: 10dB
Start Frequency: 0.15MHz
Stop Frequency: 30MHz
IF Bandwidth: 9kHz

c) The EUT was placed 0.8 meters from the horizontal ground plane with EUT being connected to the power mains through a line impedance stabilization network (LISN). All other support equipment powered from additional LISN(s). The LISN provide 50 Ohm/ 50uH of coupling impedance for the measuring instrument.

d) Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth in the center forming a bundle 30 to 40 cm long.
e) I/O cables that are not connected to a peripheral shall be bundled in the center. The end of the cable may be terminated, if required, using the correct terminating impedance. The overall length shall not exceed 1 m.

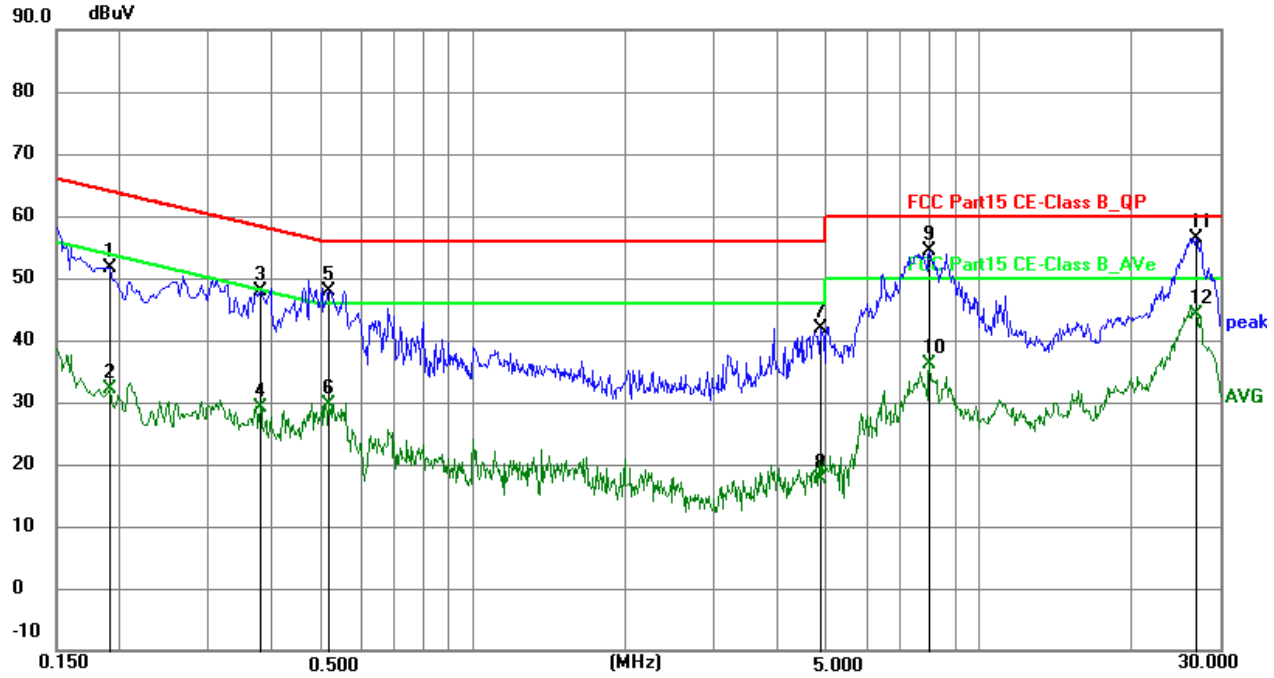
f) LISN is at least 80 cm from nearest part of EUT chassis.

g) For the actual test configuration, please refer to the related Item - photographs of the test setup.

4.3 Test Data and Results

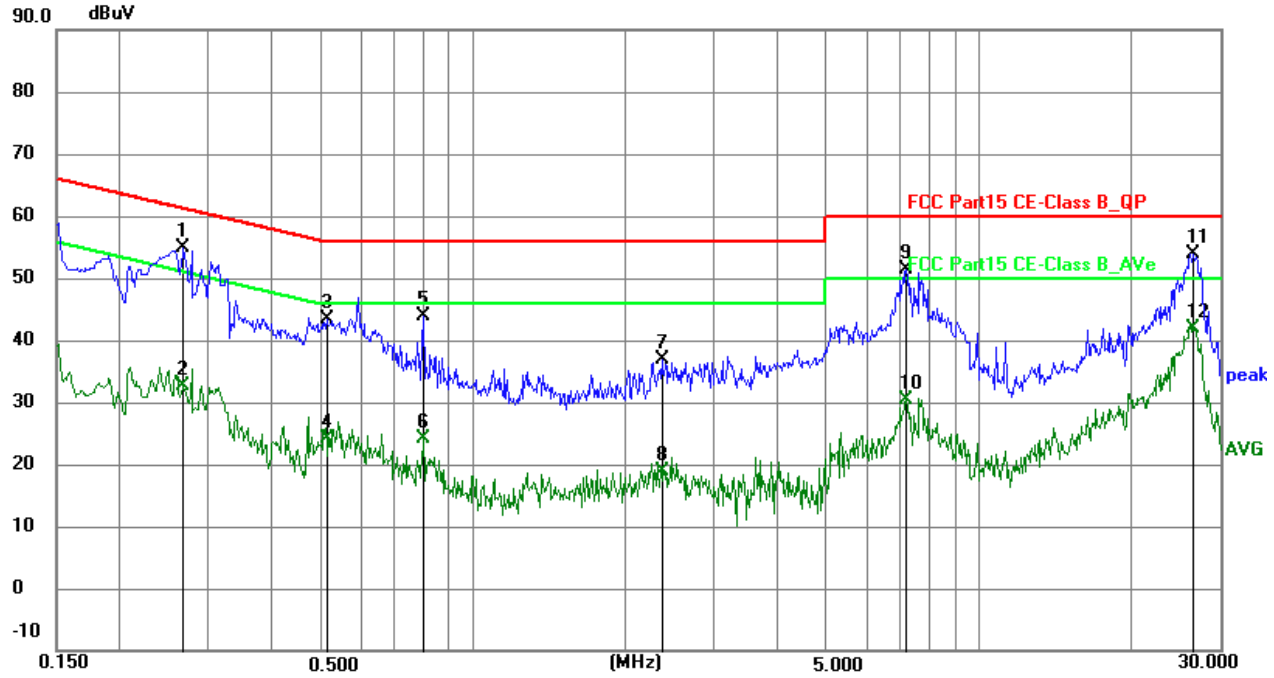
Based on all tested data, the EUT complied with the FCC Part 15.207 standard limit for a wireless device, and with the worst case as below:
Remark: Level = Reading + Factor, Margin = Level - Limit

Test Plots and Data of Conducted Emissions	
Tested Mode:	TM1
Test Voltage:	AC 120V/60Hz
Test Power Line:	Neutral
Remark:	



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1905	42.65	8.98	51.63	64.01	-12.38	QP	P	
2	0.1905	23.05	8.98	32.03	54.01	-21.98	AVG	P	
3	0.3790	38.03	9.87	47.90	58.30	-10.40	QP	P	
4	0.3790	19.26	9.87	29.13	48.30	-19.17	AVG	P	
5	0.5190	37.96	9.94	47.90	56.00	-8.10	QP	P	
6	0.5190	19.69	9.94	29.63	46.00	-16.37	AVG	P	
7	4.8883	31.73	10.22	41.95	56.00	-14.05	QP	P	
8	4.8883	7.40	10.22	17.62	46.00	-28.38	AVG	P	
9	7.9980	44.17	10.20	54.37	60.00	-5.63	QP	P	
10	7.9980	25.99	10.20	36.19	50.00	-13.81	AVG	P	
11 *	26.9651	46.17	10.26	56.43	60.00	-3.57	QP	P	
12	26.9651	33.90	10.26	44.16	50.00	-5.84	AVG	P	

Test Plots and Data of Conducted Emissions	
Tested Mode:	TM1
Test Voltage:	AC 120V/60Hz
Test Power Line:	Live
Remark:	



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.2670	45.35	9.61	54.96	61.21	-6.25	QP	P	
2	0.2670	23.05	9.61	32.66	51.21	-18.55	AVG	P	
3	0.5127	33.53	9.93	43.46	56.00	-12.54	QP	P	
4	0.5127	14.30	9.93	24.23	46.00	-21.77	AVG	P	
5	0.7980	33.84	9.93	43.77	56.00	-12.23	QP	P	
6	0.7980	14.26	9.93	24.19	46.00	-21.81	AVG	P	
7	2.3640	26.71	10.07	36.78	56.00	-19.22	QP	P	
8	2.3640	8.85	10.07	18.92	46.00	-27.08	AVG	P	
9	7.2103	41.02	10.25	51.27	60.00	-8.73	QP	P	
10	7.2103	20.21	10.25	30.46	50.00	-19.54	AVG	P	
11 *	26.4840	43.63	10.26	53.89	60.00	-6.11	QP	P	
12	26.4840	31.70	10.26	41.96	50.00	-8.04	AVG	P	

5. Radiated Emissions

5.1 Standard and Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

According to the rule FCC Part 15.209, Radiated emission limit for a wireless device as below:

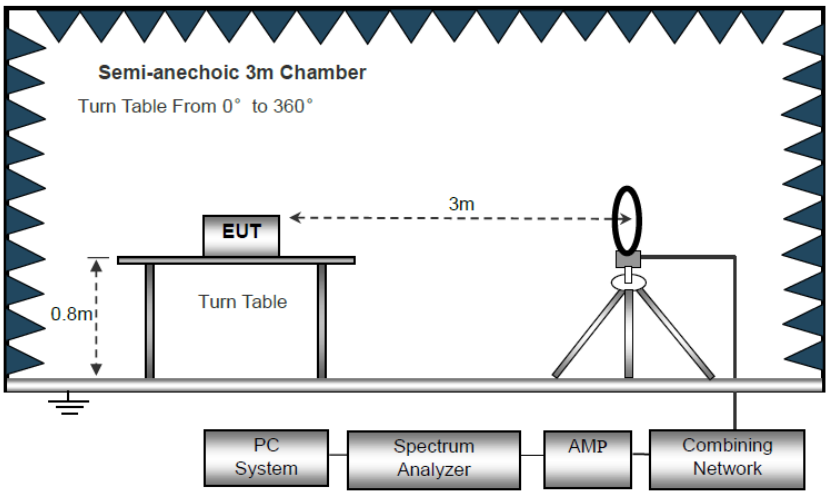
Frequency of emission (MHz)	Radiated emissions (3m)
	Quasi-peak (dBuV/m)
30-88	40
88-216	43.5
216-960	46
Above 960	54
Note: The more stringent limit applies at transition frequencies.	

The emission limit in this paragraph is based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply. Spurious Radiated Emissions measurements starting below or at the lowest crystal frequency.

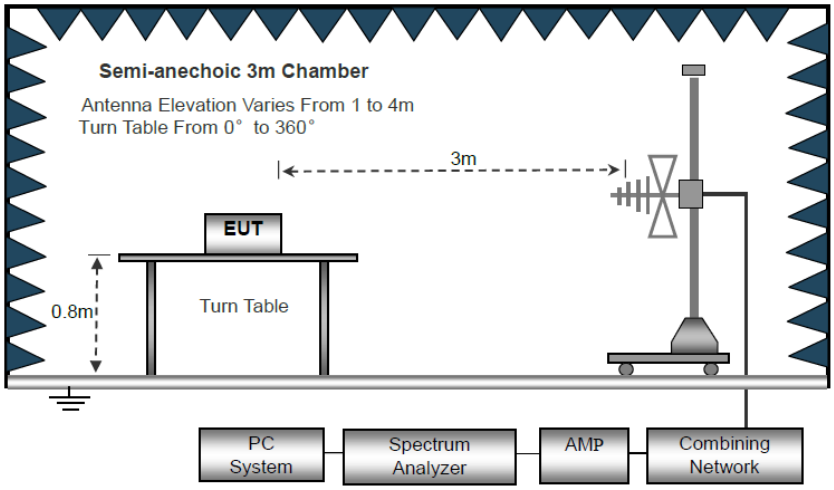
Note: Spurious Radiated Emissions measurements starting below or at the lowest crystal frequency.

5.2 Test Procedure

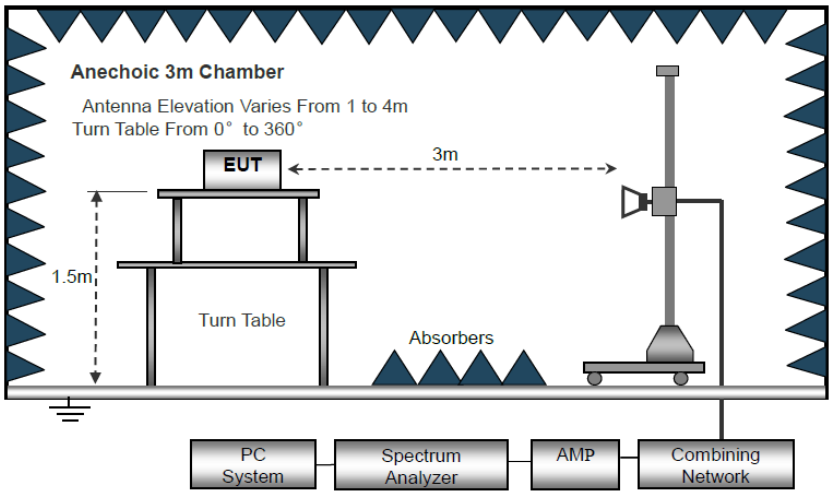
Test is conducting under the description of ANSI C63.10 - 2013 section 6.3 to 6.6.



Block Diagram of Radiated Emission Below 30MHz



Block Diagram of Radiated Emission From 30MHz to 1GHz



Block Diagram of Radiated Emission Above 1GHz

a) The EUT is placed on a turntable, which is 0.8m above ground plane for test frequency range blew 1GHz, and 1.5m above ground plane for test frequency range above 1GHz.

b) EUT is set 3m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.

c) Use the following spectrum analyzer settings:
Span = wide enough to fully capture the emission being measured
RBW = 1 MHz for f ≥ 1GHz, 100 kHz for f < 1 GHz, 10kHz for f < 30MHz
VBW ≥ RBW, Sweep = auto
Detector function = peak
Trace = max hold

d) Follow the guidelines in ANSI C63.4-2014 with respect to maximizing the emission by rotating the EUT, adjusting the measurement antenna height and polarization, etc. The peak reading of the emission, after being corrected by the antenna factor, cable loss, pre-amp gain, etc., is the peak field strength, submit this data. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.

e) The peak level, once corrected, must comply with the limit specified in Section 15.209. Set the RBW = 1MHz, VBW = 10Hz, Detector = PK for AV value, while maintaining all of the other instrument settings.

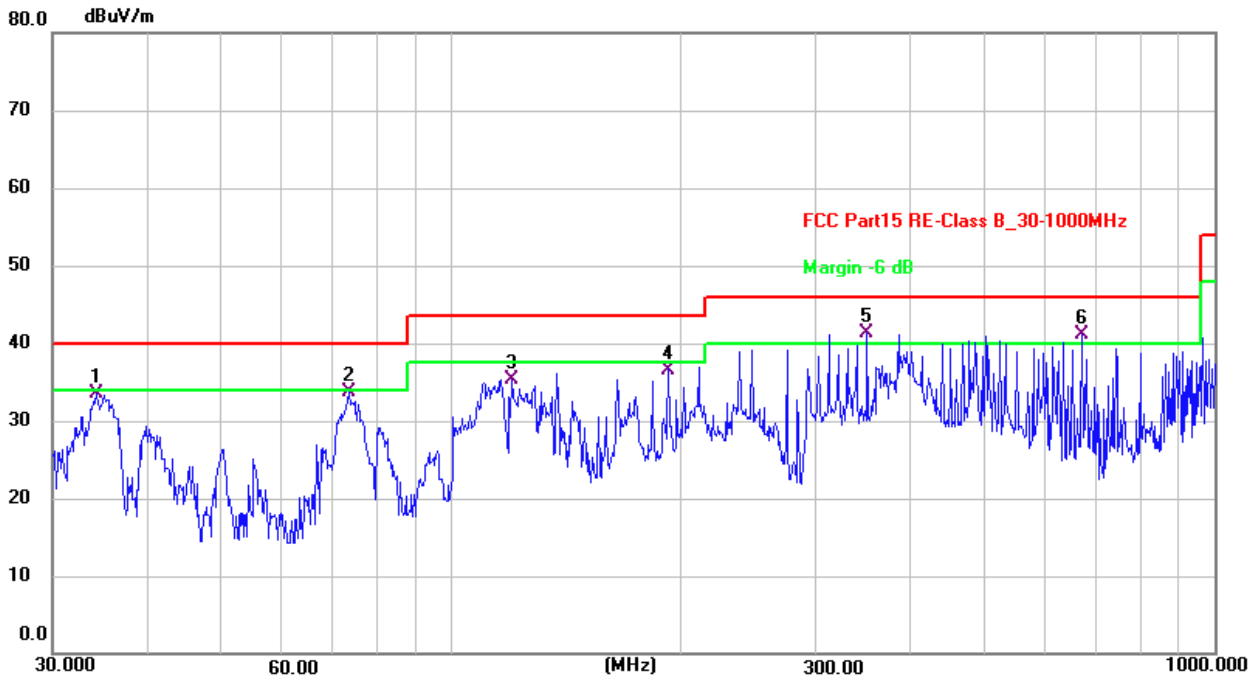
f) For the actual test configuration, please refer to the related item - EUT test photos.

5.3 Test Data and Results

All of the GFSK modes have been tested, the EUT complied with the FCC Part 15.247 standard limit for a wireless device, and with the worst case GFSK_2402MHz as below:

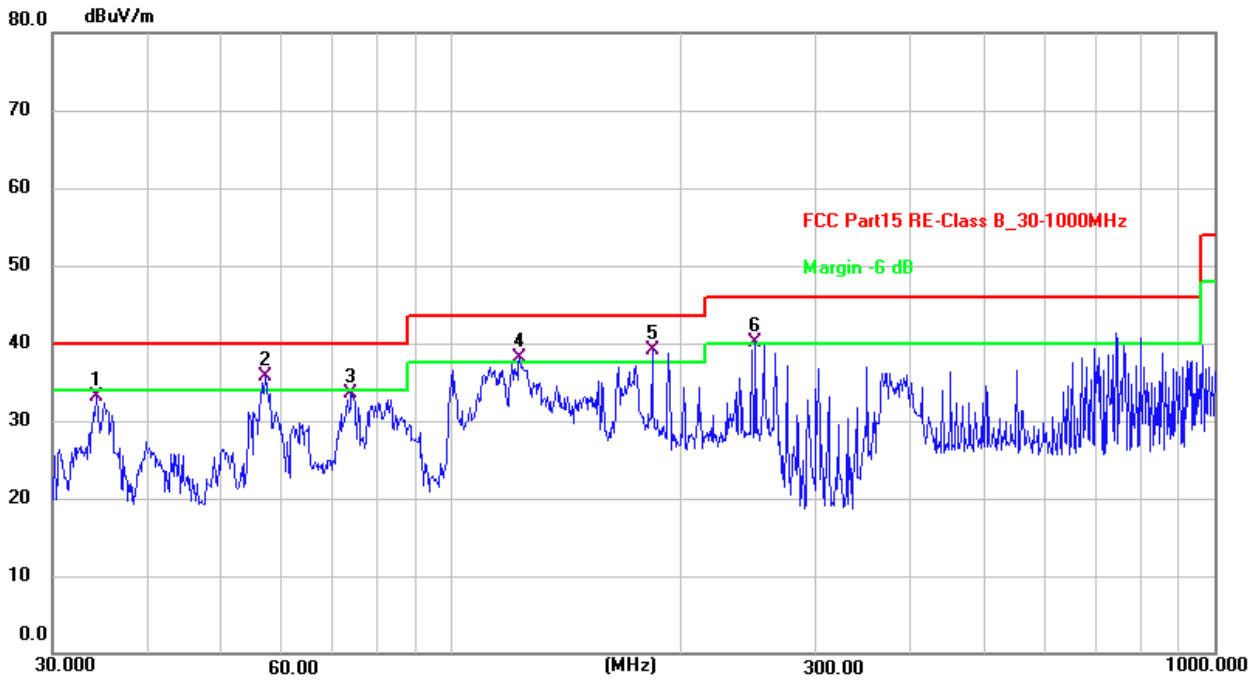
Remark: Level = Reading + Factor, Margin = Level - Limit

Radiated Emission Test Data (30MHz to 1GHz)	
Tested Mode:	TM1
Test Antenna Polarization:	Horizontal
Remark:	



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	34.2760	42.31	-8.76	33.55	40.00	-6.45	QP	100	324	P	
2	73.3593	45.37	-11.74	33.63	40.00	-6.37	QP	100	85	P	
3	119.8555	45.91	-10.61	35.30	43.50	-8.20	QP	100	195	P	
4	192.4183	48.76	-12.16	36.60	43.50	-6.90	QP	100	7	P	
5 *	350.4766	48.84	-7.51	41.33	46.00	-4.67	QP	100	124	P	
6 !	670.4891	41.08	-0.05	41.03	46.00	-4.97	QP	100	58	P	

Radiated Emission Test Data (30MHz to 1GHz)	
Tested Mode:	TM1
Test Antenna Polarization:	Vertical
Remark:	



No.	Frequency (MHz)	Reading (dBuV)	Factor (dB/m)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	34.2760	41.81	-8.76	33.05	40.00	-6.95	QP	100	321	P	
2 *	56.9911	45.14	-9.49	35.65	40.00	-4.35	QP	100	48	P	
3	73.8756	45.33	-11.86	33.47	40.00	-6.53	QP	100	95	P	
4 !	122.8340	48.53	-10.41	38.12	43.50	-5.38	QP	100	269	P	
5 !	183.2005	50.19	-11.17	39.02	43.50	-4.48	QP	100	74	P	
6 !	250.3010	49.94	-9.75	40.19	46.00	-5.81	QP	100	1	P	

Radiated Emission Test Data (Above 1GHz)							
Frequency	Reading	Correct	Result	Limit	Margin	Polar	Detector
MHz	dBuV/m	dB/m	dBuV/m	dBuV/m	dB	H/V	PK/AV
Lowest Channel (2402MHz)							
4804	79.78	-14.72	65.06	74	-8.94	H	PK
4804	59.23	-14.72	44.51	54	-9.49	H	AV
7206	62.1	-8.41	53.69	74	-20.31	H	PK
7206	46.57	-8.41	38.16	54	-15.84	H	AV
4804	73.68	-14.72	58.96	74	-15.04	V	PK
4804	57.52	-14.72	42.8	54	-11.2	V	AV
7206	64.92	-8.41	56.51	74	-17.49	V	PK
7206	50.4	-8.41	41.99	54	-12.01	V	AV
Middle Channel (2441MHz)							
4882	79.93	-14.64	65.29	74	-8.71	H	PK
4882	61.5	-14.64	46.86	54	-7.14	H	AV
7323	65.53	-8.28	57.25	74	-16.75	H	PK
7323	47.22	-8.28	38.94	54	-15.06	H	AV
4882	74.23	-14.64	59.59	74	-14.41	V	PK
4882	59.61	-14.64	44.97	54	-9.03	V	AV
7323	62.2	-8.28	53.92	74	-20.08	V	PK
7323	49	-8.28	40.72	54	-13.28	V	AV
Highest Channel (2480MHz)							
4960	78.23	-14.53	63.7	74	-10.3	H	PK
4960	60.47	-14.53	45.94	54	-8.06	H	AV
7440	65.14	-8.13	57.01	74	-16.99	H	PK
7440	45.93	-8.13	37.8	54	-16.2	H	AV
4960	73	-14.53	58.47	74	-15.53	V	PK
4960	60.88	-14.53	46.35	54	-7.65	V	AV
7440	62.31	-8.13	54.18	74	-19.82	V	PK
7440	47.04	-8.13	38.91	54	-15.09	V	AV

Note 1: this EUT was tested in 3 orthogonal positions and the worst case position data was reported.

Note 2: Testing is carried out with frequency rang 9kHz to the tenth harmonics. The measurements greater than 20dB below the limit from 9kHz to 30MHz.

Note3: Other emissions are attenuated 20dB below the limits from 9kHz to 30MHz, so it does not recorded in report.18GHz-26GHz not recorded for no spurious point have a margin of less than 6 dB with respect to the limits.

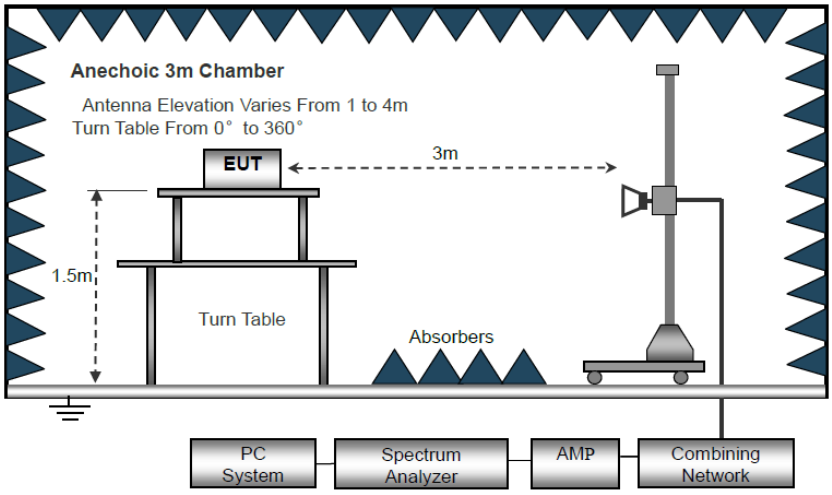
6. Band-edge Emissions(Radiated)

6.1 Standard and Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

6.2 Test Procedure

Test is conducting under the description of ANSI C63.10 - 2013 section 6.3 to 6.6 and section 6.10.



Test Setup Block Diagram

As the radiated emissions testing, set the Lowest and Highest Transmitting Channel, observed the outside band of 2310MHz to 2400MHz and 2483.5MHz to 2500MHz, than mark the higher-level emission for comparing with the FCC rules.

6.3 Test Data and Results

All of the GFSK and π/4 DQPSK modes have been tested, the EUT complied with the FCC Part 15.247 standard limit, and with the worst case as below:

Test Mode	Frequency	Limit	Result
	MHz	dBuV/dBc	
Lowest	2310.00	<54 dBuV	Pass
	2390.00	<54 dBuV	Pass
Highest	2483.50	<54 dBuV	Pass
	2500.00	<54 dBuV	Pass

Radiated Emission Test Data (Band edge emissions)							
Frequency	Reading	Correct	Result	Limit	Margin	Polar	Detector
MHz	dBuV/m	dB/m	dBuV/m	dBuV/m	dB	H/V	PK/AV
Lowest Channel GFSK (2402MHz)							
2310	68.22	-21.34	46.88	74	-27.12	H	PK
2310	51.4	-21.34	30.06	54	-23.94	H	AV
2390	66.41	-20.96	45.45	74	-28.55	H	PK
2390	51.99	-20.96	31.03	54	-22.97	H	AV
2400	67.01	-20.91	46.1	74	-27.9	H	PK
2400	56.3	-20.91	35.39	54	-18.61	H	AV
2310	69.64	-21.34	48.3	74	-25.7	V	PK
2310	49.51	-21.34	28.17	54	-25.83	V	AV
2390	67.05	-20.96	46.09	74	-27.91	V	PK
2390	51	-20.96	30.04	54	-23.96	V	AV
2400	68.58	-20.91	47.67	74	-26.33	V	PK
2400	56.99	-20.91	36.08	54	-17.92	V	AV
Highest Channel GFSK (2480MHz)							
2483.50	70.17	-20.51	49.66	74	-24.34	H	PK
2483.50	52.49	-20.51	31.98	54	-22.02	H	AV
2500	64.71	-20.43	44.28	74	-29.72	H	PK
2500	49.26	-20.43	28.83	54	-25.17	H	AV
2483.50	72.31	-20.51	51.8	74	-22.2	V	PK
2483.50	54.87	-20.51	34.36	54	-19.64	V	AV
2500	65.48	-20.43	45.05	74	-28.95	V	PK
2500	50.08	-20.43	29.65	54	-24.35	V	AV

Remark: Level = Reading + Factor, Margin = Level - Limit

7. Frequency Hopping System

7.1 Standard and Limit

According to FCC Part 15.247(a)(1), 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.

(g) Frequency hopping spread spectrum systems are not required to employ all available hopping channels during each transmission. However, the system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this section should the transmitter be presented with a continuous data (or information) stream. In addition, a system employing short transmission bursts must comply with the definition of a frequency hopping system and must distribute its transmissions over the minimum number of hopping channels specified in this section.

(h) The incorporation of intelligence within a frequency hopping spread spectrum system that permits the system to recognize other users within the spectrum band so that it individually and independently chooses and adapts its hopsets to avoid hopping on occupied channels is permitted. The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

7.2 Test Procedure

This device uses Bluetooth radio which operates in 2400-2483.5 MHz band. Bluetooth uses a radio technology called frequency-hopping spread spectrum, which chops up the data being sent and transmits chunks of it on up to 79 bands (1 MHz each; centred from 2402 to 2480 MHz) in the range 2,400-2,483.5 MHz. The transmitter switches hop frequencies 1,600 times per second to assure a high degree of data security. All Bluetooth devices participating in a given piconet are synchronized to the frequency-hopping channel for the piconet. The frequency hopping sequence is determined by the master's device address and the phase of the hopping sequence (the frequency to hop at a specific time) is determined by the master's internal clock. Therefore, all slaves in a piconet must know the master's device address and must synchronize their clocks with the master's clock.

Adaptive Frequency Hopping (AFH) was introduced in the Bluetooth specification to provide an effective way for a Bluetooth radio to counteract normal interference. AFH identifies "bad" channels, where either other wireless devices are interfering with the Bluetooth signal or the Bluetooth signal is interfering with another device. The AFH-enabled Bluetooth device will then communicate with other devices within its piconet to share details of any identified bad channels. The devices will then switch to alternative available "good" channels, away from the areas of interference, thus having no impact on the bandwidth used.

This device was tested with an bluetooth system receiver to check that the device maintained hopping synchronization, and the device complied with these requirements for DA 00-705 and FCC Part 15.247 rule.

7.3 Test Data and Results

Pseudorandom Frequency Hopping Sequence Table as below:
Channel: 08, 24, 40, 56, 40, 56, 72, 09, 01, 09, 33, 41, 33, 41, 65, 73, 53, 69, 06, 22, 04, 20, 36, 52, 38, 46, 70, 78, 68, 76, 21, 29, 10, 26, 42, 58, 44, 60, 76, 13, 03, 11, 35, 43, 37, 45, 69, 77, 55, 71, 08, 24, 08, 24, 40, 56, 40, 48, 72, 01, 72, 01, 25, 33, 12, 28, 44, 60, 42, 58, 74, 11, 05, 13, 37, 45 etc.

The system receiver have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

8. Dwell Time

8.1 Standard and Limit

According to 15.247 (a)(1)(iii), Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed..

8.2 Test Procedure

1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Spectrum Setting: RBW=1MHz, VBW=3MHz, Span=0Hz, Detector=Peak
3) Use video trigger with the trigger level set to enable triggering only on full pulses.
4) Sweep Time is more than once pulse time.
5) Set the center frequency on any frequency would be measure and set the frequency span to zero span.
6) Measure the maximum time duration of one single pulse.
7) Set the EUT for packet transmitting.
8) Measure the maximum time duration of one single pulse.
9) The EUT was set to the Hopping Mode for Dwell Time Test.

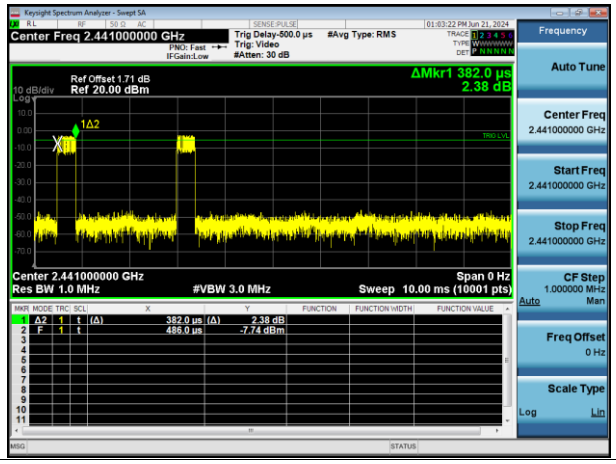
Test Setup Block Diagram

8.3 Test Data and Results

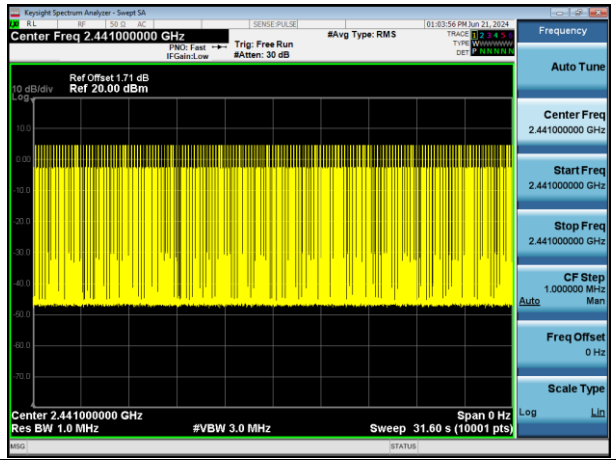
Test Mode	Data Packet	Channel (MHz)	Pulse Duration (ms)	Dwell Time (ms)	Limit (ms)	Result
GFSK	DH1	2441	0.382	121.094	<400	Pass
	DH3	2441	1.639	267.157	<400	Pass
	DH5	2441	2.886	291.486	<400	Pass

GFSK (2441MHz)

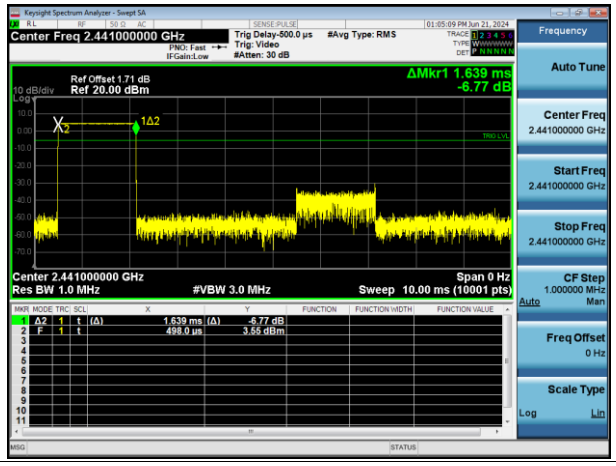
Burst(DH1)



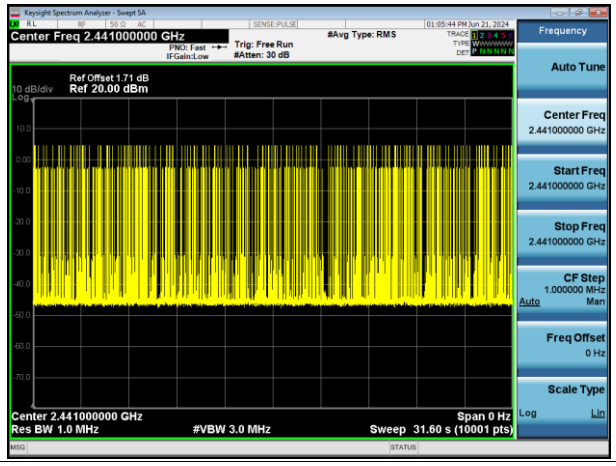
Accumulate(DH1)



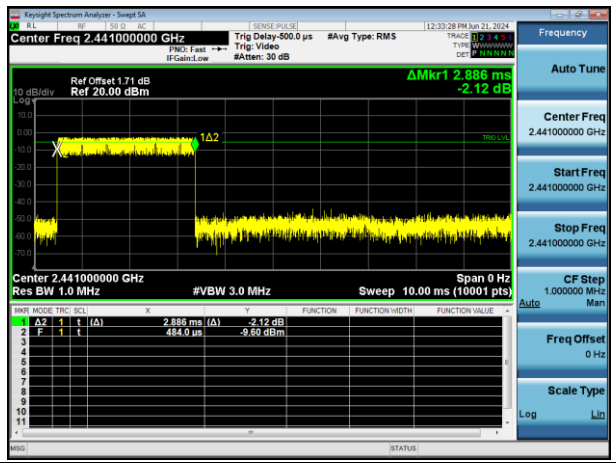
Burst(DH3)



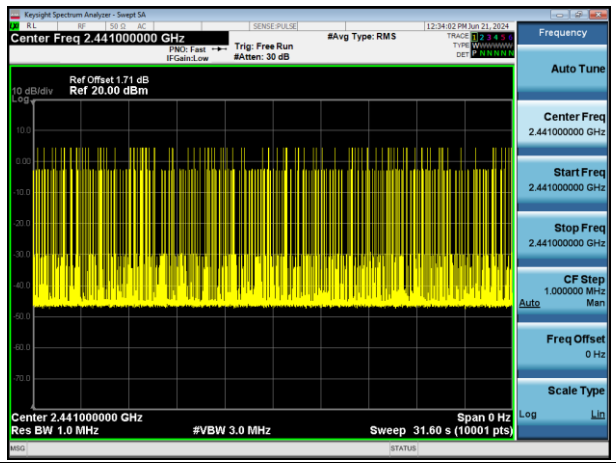
Accumulate(DH3)



Burst(DH5)



Accumulate(DH5)



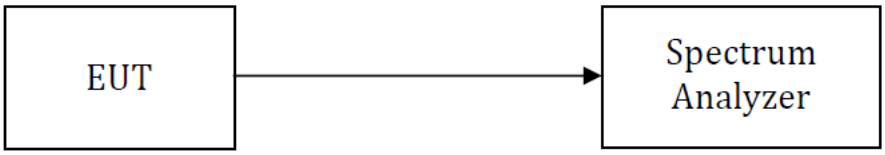
9. Maximum Peak Conducted Output Power

9.1 Standard and Limit

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. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

9.2 Test Procedure

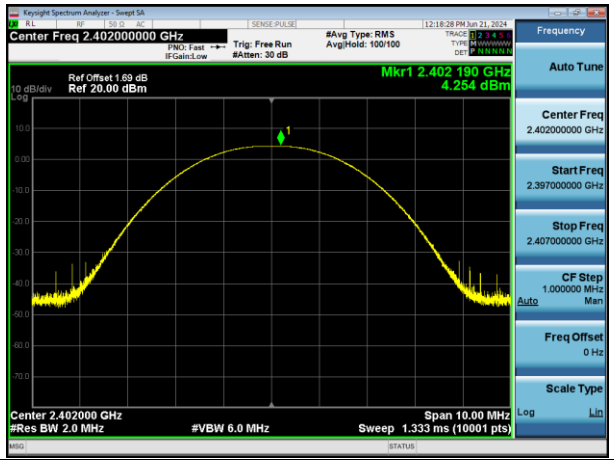
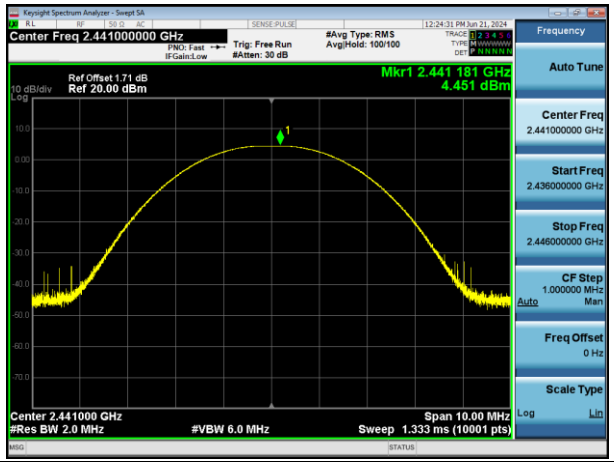
1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Set the spectrum analyzer to any one measured frequency within its operating range.
3) Set RBW = 2MHz, VBW = 6MHz, Sweep = Auto, Detector = Peak.
4) Measure the highest amplitude appearing on spectral display and mark the value.
5) Repeat the above procedures until all frequencies measured were complete.



Test Setup Block Diagram

9.3 Test Data and Results

Test Mode	Test Channel MHz	Conducted Output Power (dBm)	Limit (dBm)	Test Result
GFSK	2402	4.25	21	Pass
	2441	4.45	21	Pass
	2480	4.81	21	Pass

GFSK
2402MHz 
2441MHz 
2480MHz

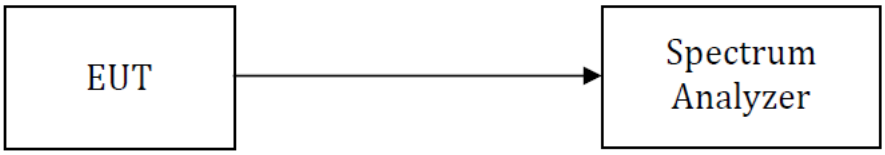
10. Occupied Bandwidth(-20dB)

10.1 Standard and Limit

According to 15.215 (c), intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

10.2 Test Procedure

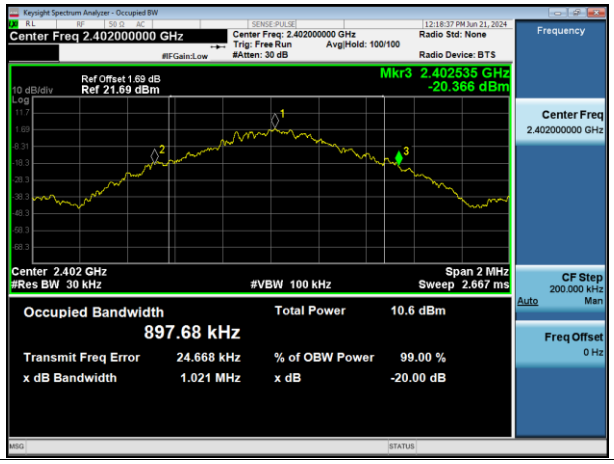
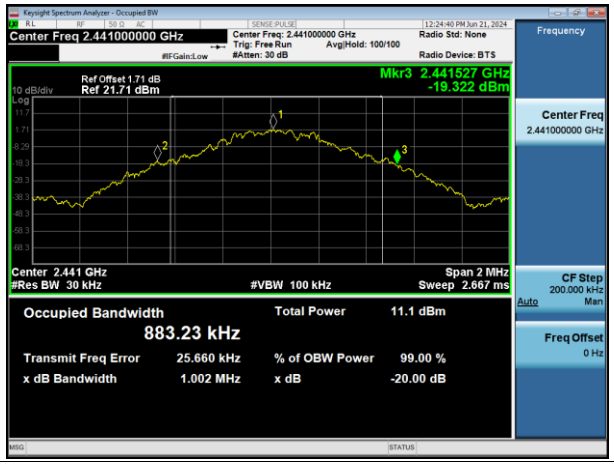
According to the ANSI 63.10-2013, section 6.9, the emission bandwidth test method as follows.
1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Set the spectrum analyzer to any one measured frequency within its operating range.
3) Set RBW = 30kHz, VBW = 100kHz, Sweep = Auto.
4) Set a reference level on the measuring instrument equal to the highest peak value.
5) Measure the frequency difference of two frequencies that were attenuated 20dB from the reference level. Record the frequency difference as the emission bandwidth.
6) Repeat the above procedures until all frequencies measured were complete.



Test Setup Block Diagram

10.3 Test Data and Results

Test Mode	Test Channel (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (kHz)
GFSK	2402	1.021	897.68
	2441	1.002	883.23
	2480	1.005	901.16

GFSK
2402MHz 
2441MHz 
2480MHz

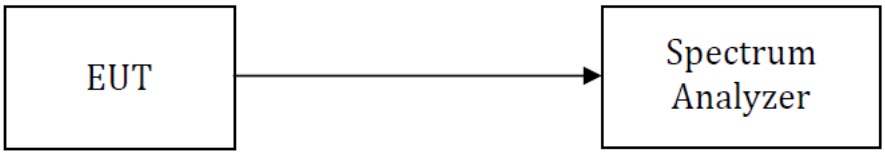
11. Carrier Frequencies Separation

11.1 Standard and Limit

According to FCC 15.247(a)(1), 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, and frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

11.2 Test Procedure

1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Set the spectrum analyzer to any one measured frequency within its operating range.
3) Set RBW = 30kHz, VBW = 100kHz, Sweep = Auto, Detector = Peak.
4) By using the Max Hold function, record the separation of two adjacent channels.
5) Measure the frequency difference of these two adjacent channels by spectrum analyzer mark function. and then plot the result on the screen of the spectrum analyzer.
6) Repeat above procedures until all frequencies measured were complete.

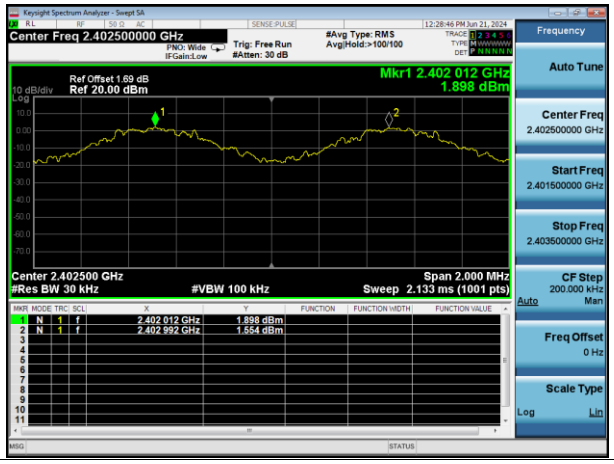
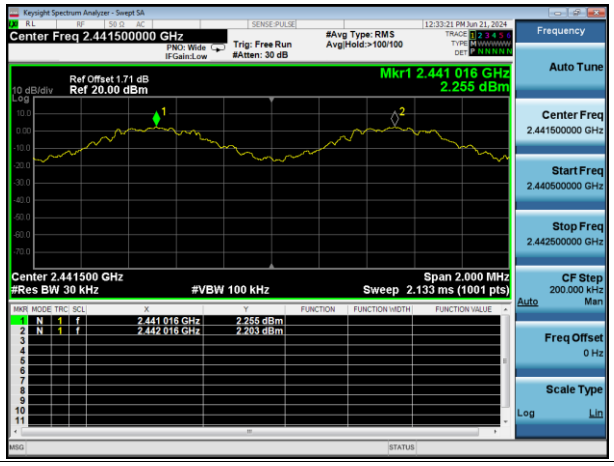
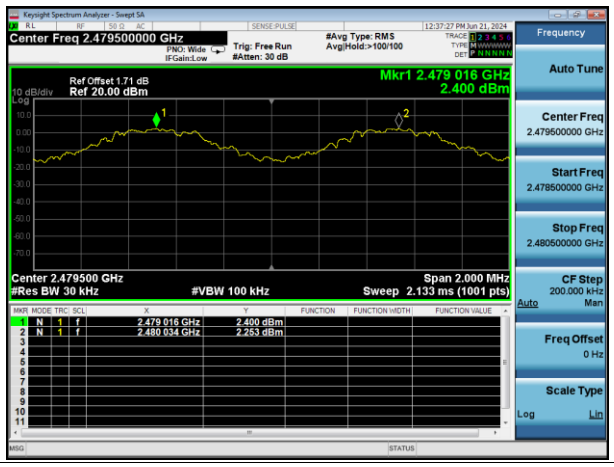


Test Setup Block Diagram

11.3 Test Data and Results

Test Mode	Test Channel	Test Freq. 1 (MHz)	Test Freq. 2 (MHz)	CFS (MHz)	Limit (MHz)
GFSK	Lowest	2402.012	2402.992	0.98	0.681
	Middle	2441.016	2442.016	1	0.668
	Highest	2479.016	2480.034	1.018	0.67

Note: CFS(Channel Frequency Separation) = Test Freq. 2 - Test Freq. 1

GFSK
Lowest 
Middle 
Highest 

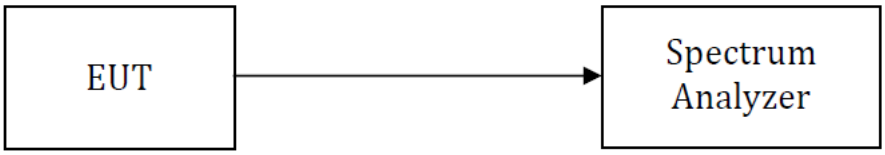
12. Number of Hopping Channel

12.1 Standard and Limit

According to FCC 15.247(a)(1), 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, and frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.

12.2 Test Procedure

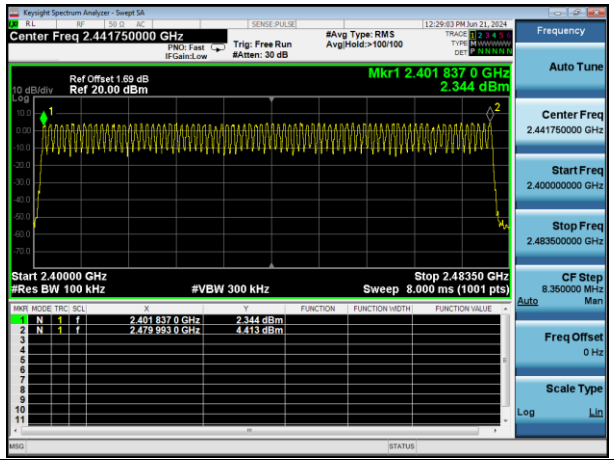
1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Set the spectrum analyzer to any one measured frequency within its operating range.
3) Set RBW = 100kHz, VBW = 300kHz, Sweep = Auto, Detector = Peak.
4) Set the spectrum analyzer on Max hold mode, and then keep the EUT in hopping mode. Record all the signals from each channel until each one has been recorded.
5) Set the spectrum analyzer on View mode and then plot the result on the screen of the spectrum analyzer.
6) Repeat the above procedures until all frequencies measured were complete.



Test Setup Block Diagram

12.3 Test Data and Results

Test Mode	Number of Hopping Channel	Limit	Test Result
GFSK	79	15	Pass

Number of Hopping Channel
GFSK 

13. Band-edge Emission(Conducted)

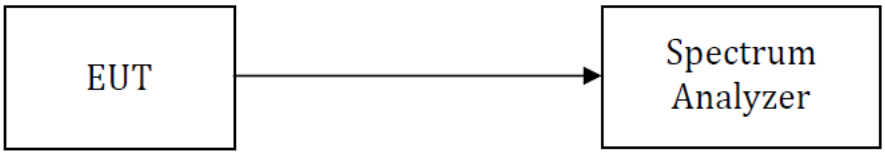
13.1 Standard and Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

13.2 Test Procedure

Test is conducting under the description of ANSI C63.10 - 2013 section 6.10.

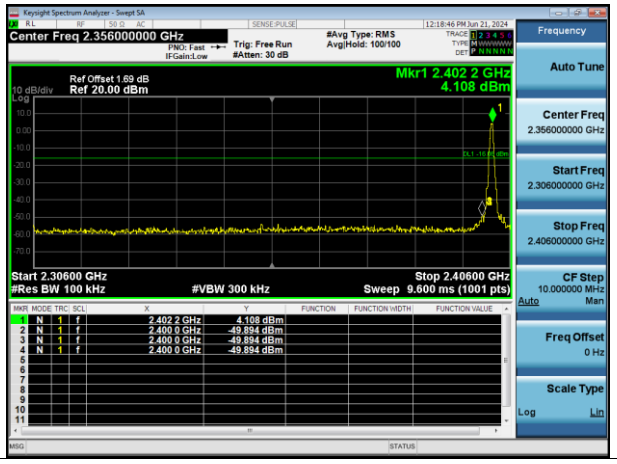
1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Set the spectrum analyzer to any one measured frequency within its operating range.
3) Set RBW = 100kHz, VBW = 300kHz, Sweep = Auto, Detector = Peak.
4) Measure the highest amplitude appearing on spectral display and set it as a reference level.
5) Set a convenient frequency span including 100 kHz bandwidth from band edge.
6) Measure the emission and marking the edge frequency.
7) Repeat above procedures until all frequencies measured were complete.

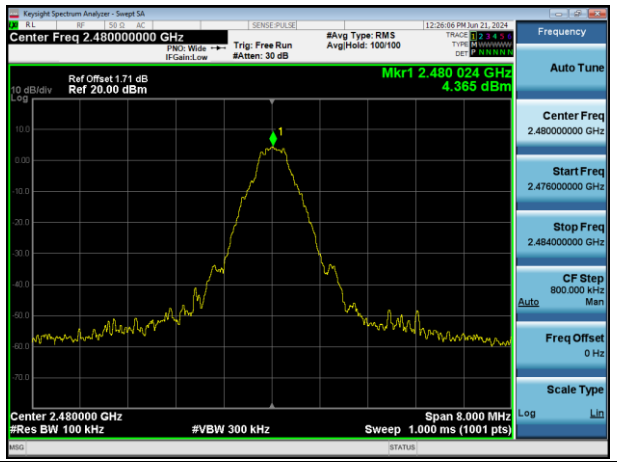
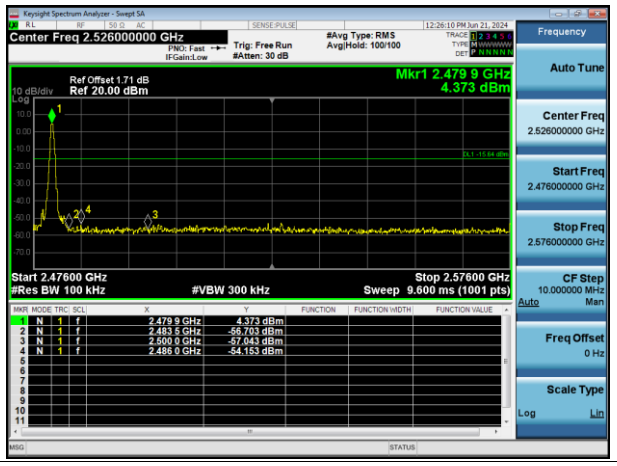


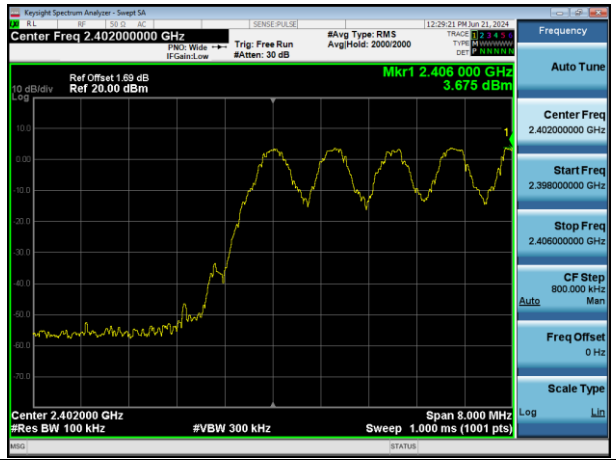
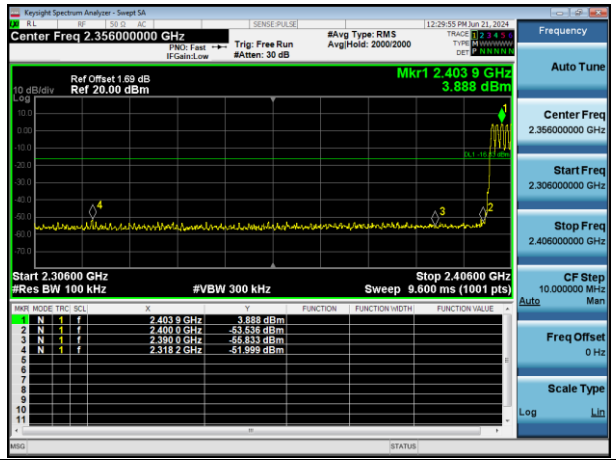
Test Setup Block Diagram

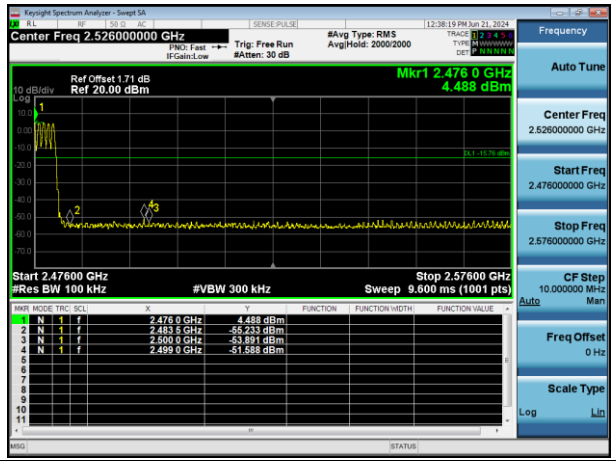
13.3 Test Data and Results

Test Mode	Band-edge	Test Channel (MHz)	Max. Value (dBc)	Limit (dBc)	Test Result
No-Hopping					
GFSK	Lowest	2402	-53.83	-20	Pass
	Highest	2480	-58.52	-20	Pass
Hopping					
GFSK	Lowest	2402	-55.67	-20	Pass
	Highest	2480	-55.82	-20	Pass

No-Hopping GFSK Lowest	
Reference Power	Band-edge Emission
	

No-Hopping GFSK Highest	
Reference Power	Band-edge Emission
	

Hopping GFSK Lowest	
Reference Power	Band-edge Emission
	

Hopping GFSK Highest	
Reference Power	Band-edge Emission
	

14. Conducted RF Spurious Emissions

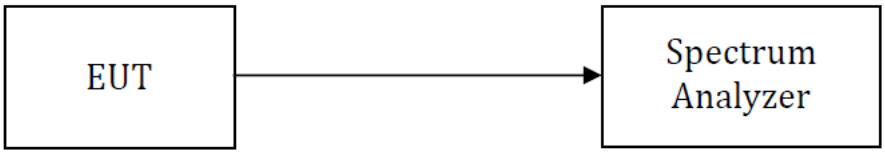
14.1 Standard and Limit

According to §15.247(d), In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a) (see § 15.205(c)).

14.2 Test Procedure

Test is conducting under the description of ANSI C63.10 - 2013 section 6.7.

1) Remove the antenna from the EUT and connect to the spectrum analyzer via a low loss RF cable.
2) Set the spectrum analyzer to any one measured frequency within its operating range.
3) Set RBW = 100kHz, VBW = 300kHz, Sweep = Auto, Detector = Peak.
4) Measure the highest amplitude appearing on spectral display and set it as a reference level.
5) Measure the spurious emissions with frequency range from 9kHz to 26.5GHz.
6) Repeat above procedures until all measured frequencies were complete.



Test Setup Block Diagram

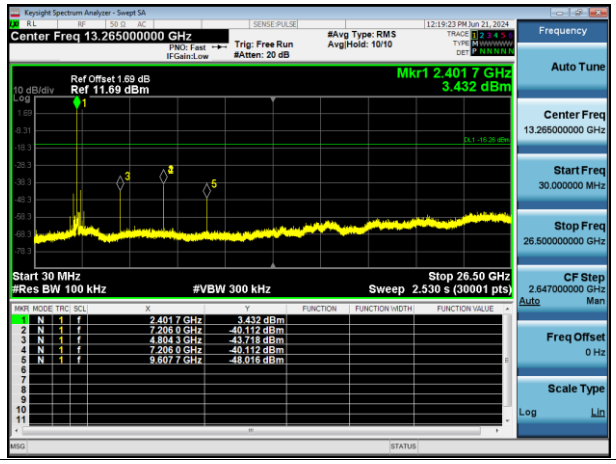
14.3 Test Data and Results

Note: The measurement frequency range is from 9kHz to the 10th harmonic of the fundamental frequency. The lowest, middle and highest channels are tested to verify the spurious emissions measurement data.

GFSK Lowest

Reference Power

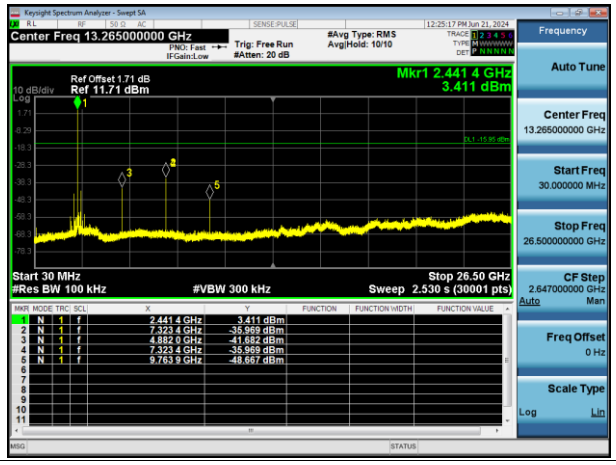
Spurious Emissions



GFSK Middle

Reference Power

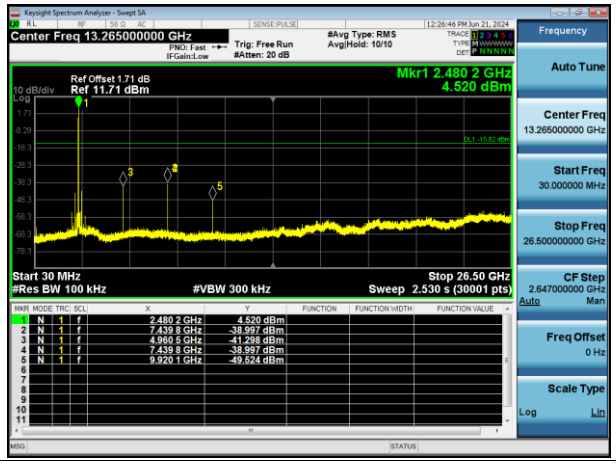
Spurious Emissions



GFSK Highest

Reference Power

Spurious Emissions



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