



FCC TEST REPORT

Test report
On Behalf of
KINGRAY ELECTRONICS Co., LTD
For
Wireless headphones
Model No.: BB991,FD4108
FCC ID: 2AML6BB991

Prepared for : **KINGRAY ELECTRONICS Co., LTD**
3F, Building 13th, Xingwei the third Industrial Park, Fenghuang Village, Fuyong town, Baoan District, Shenzhen, Guangdong, China

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TEST REPORT

Applicant's name.....: **KINGRAY ELECTRONICS Co., LTD**
3F, Building 13th, Xingwei the third Industrial Park, Fenghuang
Address.....: Village, Fuyong town, Baoan District, Shenzhen, Guangdong,
China
Manufacture's Name: **KINGRAY ELECTRONICS Co., LTD**
3F, Building 13th, Xingwei the third Industrial Park, Fenghuang
Address.....: Village, Fuyong town, Baoan District, Shenzhen, Guangdong,
China

Product description

Trade Mark: billboard
Product name.....: Wireless headphones
Model and/or type reference ..: BB991,FD4108

Standards.....: FCC Rules and Regulations Part 15 Subpart C Section 15.247
ANSI C63.10: 2013

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Date of Test..... :
Date (s) of performance of tests : Dec. 25, 2019 ~. Jan.08, 2020
Date of Issue..... : Jan.09, 2020
Test Result..... : **Pass**

Testing Engineer :

(Gary Qian)

Technical Manager :

(Eden Hu)

Authorized Signatory :

(Jason Zhou)



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1. TEST STANDARDS

The tests were performed according to following standards:

[FCC Rules Part 15.247](#): Frequency Hopping, Direct Spread Spectrum and Hybrid Systems that are in operation within the bands of 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz.

[ANSI C63.10-2013](#): American National Standard for Testing Unlicensed Wireless Devices

[DA 00-705](#): Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems



2. SUMMARY

2.1. Product Description

Name of EUT	Wireless headphones
Trade Mark:	billboard
Model Number	BB991
List Model:	FD4108
Power Rating	DC 3.7V and DC 5V From Adapter
Adapter(Auxiliary test Provided by the laborator)	Mode:EP-TA20CBC Input:AC100-240V-50/60Hz, 0.5A Output:DC 5V,2A
FCC ID	2AML6BB991
Bluetooth FCC Operation frequency	2402MHz-2480MHz
Bluetooth Modulation	GFSK,π/4DQPSK
Antenna Type	Chip antenna
Antenna gain	-0.68dBi

2.2. Equipment Under Test

Power supply system utilised

Power supply voltage	:	☐ 230V / 50 Hz	☐ 120V / 60Hz
		☐ 12 V DC	☐ 24 V DC
		☒ Other (specified in blank below)	

DC 3.7V and DC 5V From Adapter

2.3. Short description of the Equipment under Test (EUT)

This is a Wireless headphones.

For more details, refer to the user's manual of the EUT.



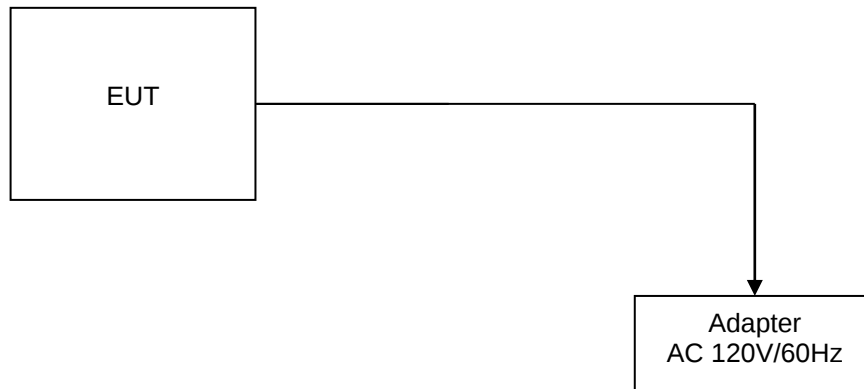
2.4. EUT operation mode

The Applicant provides test software (AT directive) to control the EUT for staying in continuous transmitting and receiving mode for testing .There are 79 channels provided to the EUT. Channel 00/39/78 was selected to test.

Channel	Frequency(MHz)	Channel	Frequency(MHz)
00	2402	40	2442
01	2403	41	2443
02	2404	42	2444
03	2405	43	2445
04	2406	44	2446
05	2407	45	2447
06	2408	46	2448
07	2409	47	2449
08	2410	48	2450
09	2411	49	2451
10	2412	50	2452
11	2413	51	2453
12	2414	52	2454
13	2415	53	2455
14	2416	54	2456
15	2417	55	2457
16	2418	56	2458
17	2419	57	2459
18	2420	58	2460
19	2421	59	2461
20	2422	60	2462
21	2423	61	2463
22	2424	62	2464
23	2425	63	2465
24	2426	64	2466
25	2427	65	2467
26	2428	66	2468
27	2429	67	2469
28	2430	68	2470
29	2431	69	2471
30	2432	70	2472
31	2433	71	2473
32	2434	72	2474
33	2435	73	2475
34	2436	74	2476
35	2437	75	2477
36	2438	76	2478
37	2439	77	2479
38	2440	78	2480
39	2441		



2.5. Block Diagram of Test Setup



2.6. Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended for FCC ID: 2AML6BB991 filing to comply with Section 15.247 of the FCC Part 15, Subpart C Rules.

2.7. Modifications

No modifications were implemented to meet testing criteria.



3. TEST ENVIRONMENT

3.1. TEST FACILITY

Test Firm : Shenzhen HUAK Testing Technology Co., Ltd.

Address 1F, B2 Building, Junfeng Zhongcheng Zhizao Innovation Park, Fuhai Street, Bao'an District, Shenzhen City, China

3.2. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Temperature:	15-35 ° C
Humidity:	30-60 %
Atmospheric pressure:	950-1050mbar

3.3. Summary of measurement results

Test Specification clause	Test case	Test Mode	Test Channel	Recorded In Report		Pass	Fail	NA	NP	Remark
§15.247(a)(1)	Carrier Frequency separation	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK Π/4DQPSK	☒ Middle	☒	☐	☐	☐	complies
§15.247(a)(1)	Number of Hopping channels	GFSK Π/4DQPSK	☒ Full	GFSK	☒ Full	☒	☐	☐	☐	complies
§15.247(a)(1)	Time of Occupancy (dwell time)	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK Π/4DQPSK	☒ Middle	☒	☐	☐	☐	complies
§15.247(a)(1)	Spectrum bandwidth of a FHSS system 20dB bandwidth	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	☒	☐	☐	☐	complies
§15.247(b)(1)	Maximum output power	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	☒	☐	☐	☐	complies
§15.247(d)	Band edge compliance conducted	GFSK Π/4DQPSK	☒ Lowest ☒ Highest	GFSK Π/4DQPSK	☒ Lowest ☒ Highest	☒	☐	☐	☐	complies
§15.205	Band edge compliance radiated	GFSK Π/4DQPSK	☒ Lowest ☒ Highest	GFSK	☒ Lowest ☒ Highest	☒	☐	☐	☐	complies
§15.247(d)	TX spurious emissions conducted	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	☒	☐	☐	☐	complies
§15.247(d)	TX spurious emissions radiated	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK	☒ Lowest ☒ Middle ☒ Highest	☒	☐	☐	☐	complies
§15.209(a)	TX spurious Emissions radiated Below 1GHz	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK	☒ Middle	☒	☐	☐	☐	complies
§15.107(a) §15.207	Conducted Emissions 9KHz-30 MHz	GFSK Π/4DQPSK	☒ Lowest ☒ Middle ☒ Highest	GFSK	☒ Middle	☒	☐	☐	☐	complies

Remark:

1. The measurement uncertainty is not included in the test result.
2. NA = Not Applicable; NP = Not Performed
3. We tested all test mode and recorded worst case in report



3.4. Statement of the measurement uncertainty

Measurement Uncertainty

Conducted Emission Expanded Uncertainty	= 2.23dB, k=2
Radiated emission expanded uncertainty(9kHz-30MHz)	= 3.08dB, k=2
Radiated emission expanded uncertainty(30MHz-1000MHz)	= 4.42dB, k=2
Radiated emission expanded uncertainty(Above 1GHz)	= 4.06dB, k=2

3.5. Equipments Used during the Test

Item	Equipment	Manufacturer	Model No.	Serial No.	Last Cal.	Cal. Interval
1.	L.I.S.N. Artificial Mains Network	R&S	ENV216	HKE-002	Dec. 28, 2018	1 Year
2.	L.I.S.N.	R&S	ENV216	HKE-059	Dec. 28, 2018	1 Year
3.	Receiver	R&S	ESCI 7	HKE-010	Dec. 28, 2018	1 Year
4.	RF automatic control unit	Tonscend	JS0806-2	HKE-060	Dec. 28, 2018	1 Year
5.	Spectrum analyzer	R&S	FSP40	HKE-025	Dec. 28, 2018	1 Year
6.	Spectrum analyzer	Agilent	N9020A	HKE-048	Dec. 28, 2018	1 Year
7.	High gain antenna	Schwarzbeck	LB-180400KF	HKE-054	Dec. 28, 2018	1 Year
8.	Preamplifier	Schwarzbeck	BBV 9743	HKE-006	Dec. 28, 2018	1 Year
9.	Bilog Broadband Antenna	Schwarzbeck	VULB9163	HKE-012	Dec. 28, 2018	1 Year
10.	Loop Antenna	Schwarzbeck	FMZB 1519 B	HKE-014	Dec. 28, 2018	1 Year
11.	Horn Antenna	Schwarzbeck	9120D	HKE-013	Dec. 28, 2018	1 Year
12.	Pre-amplifier	EMCI	EMC051845 SE	HKE-015	Dec. 28, 2018	1 Year
13.	Pre-amplifier	Agilent	83051A	HKE-016	Dec. 28, 2018	1 Year
14.	High pass filter unit	Tonscend	JS0806-F	HKE-055	Dec. 28, 2018	1 Year
15.	Conducted test software	Tonscend	TS+ Rev 2.5.0.0	HKE-081	N/A	N/A
16.	Radiated test software	Tonscend	TS+ Rev 2.5.0.0	HKE-082	N/A	N/A
17.	RF test software	Tonscend	JS1120-B Version 2.6	HKE-083	N/A	N/A
18.	RF automatic control unit	Tonscend	JS0806-2	HKE-060	Dec. 28, 2017	3 Year
19.	RF test software	Tonscend	JS1120-4	HKE-113	N/A	N/A
20.	RF test software	Tonscend	JS1120-3	HKE-114	N/A	N/A
21.	RF test software	Tonscend	JS1120-1	HKE-115	N/A	N/A
22.	Spectrum analyzer	Agilent	N9020A	HKE-048	Dec. 28, 2018	1 Year
23.	Signal generator	Agilent	N5182A	HKE-029	Dec. 28, 2018	1 Year
24.	Signal Generator	Agilent	83630A	HKE-028	Dec. 28, 2018	1 Year



25	Power meter	Agilent	E4419B	HKE-085	Dec. 28, 2018	1 Year
26	Power Sensor	Agilent	E9300A	HKE-086	Dec. 28, 2018	1 Year
27	RF Cable(below1GHz)	Times	9kHz-1GHz	HKE-117	Dec. 28, 2018	1 Year
28.	RF Cable(above 1GHz)	Times	1-40G	HKE-034	Dec. 28, 2018	1 Year
29	RF Cable (9KHz-40GHz)	Tonscend	170660	N/A	Dec. 28, 2018	1 Year
30	Shielded room	Shiel Hong	4*3*3	HKE-039	Dec. 28, 2017	3 Year

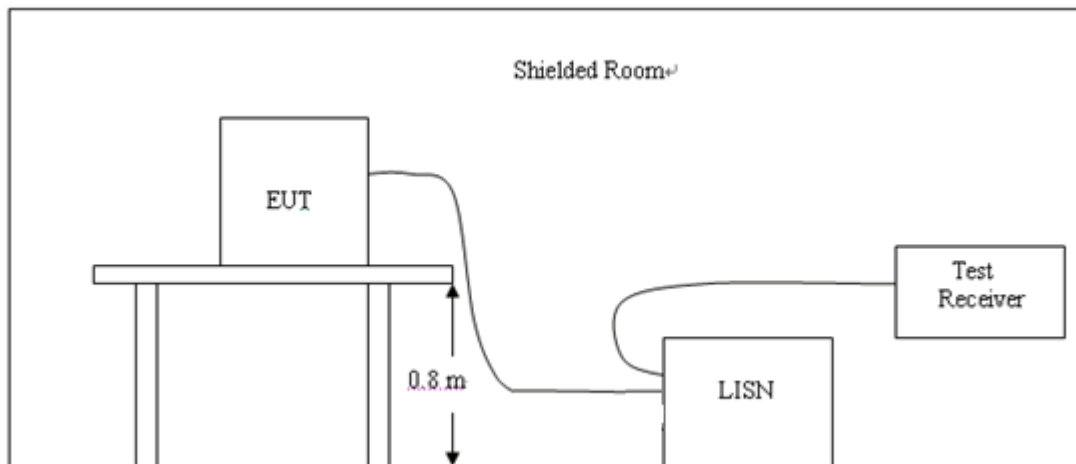
Note: 1. The Cal.Interval was one year.



4. TEST CONDITIONS AND RESULTS

4.1. AC Power Conducted Emission

TEST CONFIGURATION



TEST PROCEDURE

- 1, The equipment was set up as per the test configuration to simulate typical actual usage per the user's manual. The EUT is a tabletop system, a wooden table with a height of 0.8 meters is used and is placed on the ground plane as per ANSI C63.10.
- 2, Support equipment, if needed, was placed as per ANSI C63.10.
- 3, All I/O cables were positioned to simulate typical actual usage as per ANSI C63.10.
- 4, If a EUT received DC power from the USB Port of Notebook PC, the PC's adapter received power through a Line Impedance Stabilization Network (LISN) which supplied power source and was grounded to the ground plane.
- 5, All support equipments received AC power from a second LISN, if any.
- 6, The EUT test program was started. Emissions were measured on each current carrying line of the EUT using a spectrum Analyzer / Receiver connected to the LISN powering the EUT. The LISN has two monitoring points: Line 1 (Hot Side) and Line 2 (Neutral Side). Two scans were taken: one with Line 1 connected to Analyzer / Receiver and Line 2 connected to a 50 ohm load; the second scan had Line 1 connected to a 50 ohm load and Line 2 connected to the Analyzer / Receiver.
- 7, Analyzer / Receiver scanned from 150 KHz to 30MHz for emissions in each of the test modes.

AC Power Conducted Emission Limit

For intentional device, according to § 15.207(a) AC Power Conducted Emission Limits is as following :

Frequency range (MHz)	Limit (dBuV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

* Decreases with the logarithm of the frequency.

TEST RESULTS

Remark:

1. All modes of GFSK, Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK Middle Channel was reported as below:
2. Both 120 VAC, 50/60 Hz and 240 VAC, 50/60 Hz power supply have been tested, only the worst result of 120 VAC, 60 Hz was reported as below:.

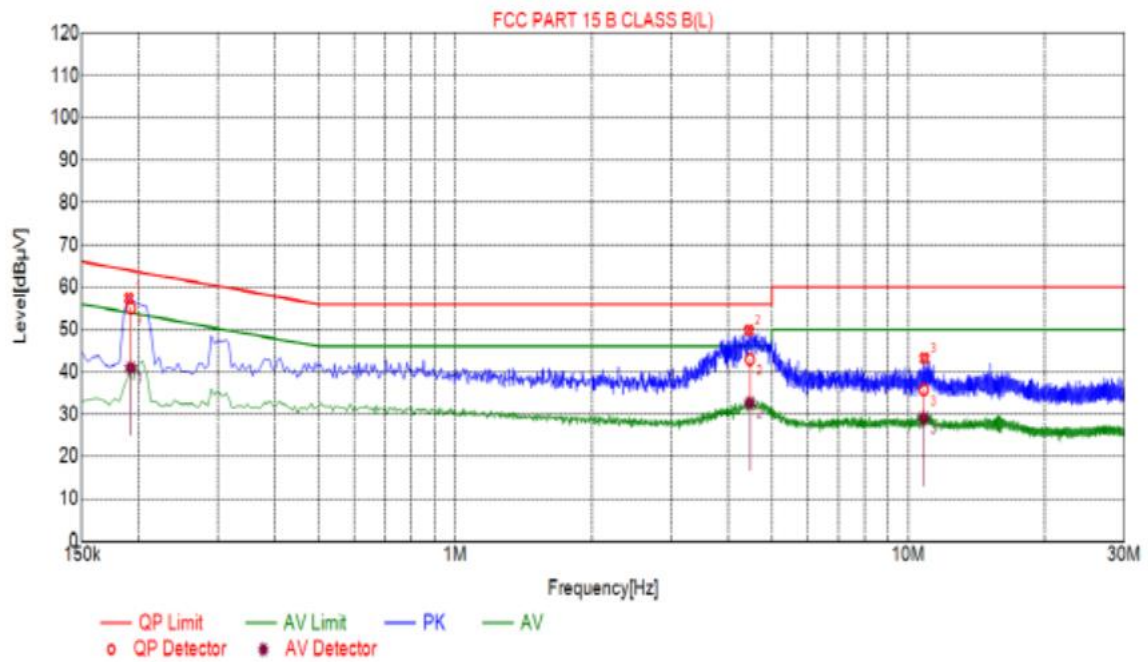


Power supply:

DC 5V from Adapter
AC 120V/60Hz

Polarization

L



Final Data List

NO.	Freq. [MHz]	Correction factor[dB]	QP Value [$\text{dB}\mu\text{V}$]	QP Limit [$\text{dB}\mu\text{V}$]	QP Margin [dB]	QP Reading [$\text{dB}\mu\text{V}$]	AV Value [$\text{dB}\mu\text{V}$]	AV Limit [$\text{dB}\mu\text{V}$]	AV Margin [dB]	AV Reading [$\text{dB}\mu\text{V}$]	Type
1	0.1924	10.04	55.11	63.93	8.82	45.07	40.88	53.93	13.05	30.84	L
2	4.4708	10.25	42.93	56.00	13.07	32.68	32.69	46.00	13.31	22.44	L
3	10.8159	10.02	35.83	60.00	24.17	25.81	29.08	50.00	20.92	19.06	L

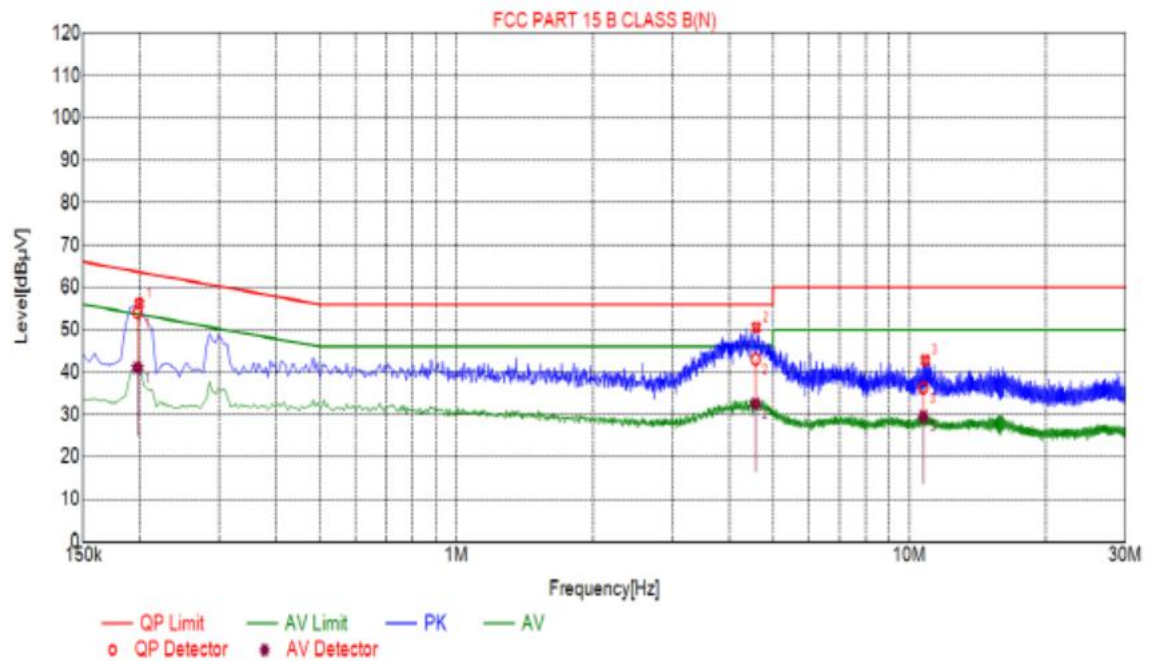


Power supply:

DC 5V from Adapter
AC 120V/60Hz

Polarization

N



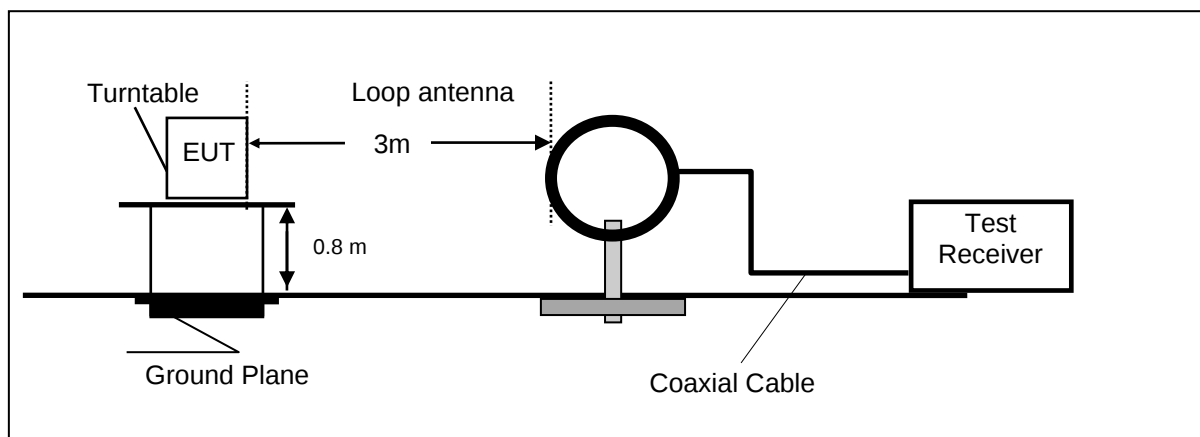
Final Data List

NO.	Freq. [MHz]	Correction factor[dB]	QP Value [dBμV]	QP Limit [dBμV]	QP Margin [dB]	QP Reading [dBμV]	AV Value [dBμV]	AV Limit [dBμV]	AV Margin [dB]	AV Reading [dBμV]	Type
1	0.1977	10.03	53.98	63.71	9.73	43.95	41.00	53.71	12.71	30.97	N
2	4.5789	10.25	43.01	56.00	12.99	32.76	32.55	46.00	13.45	22.30	N
3	10.7350	10.02	36.30	60.00	23.70	26.28	29.54	50.00	20.46	19.52	N

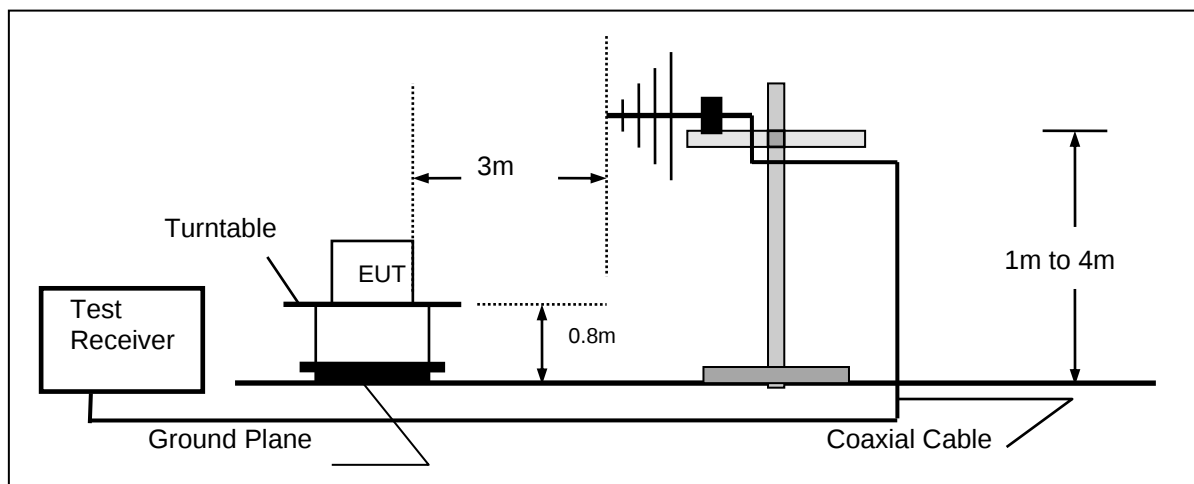
4.2. Radiated Emission

TEST CONFIGURATION

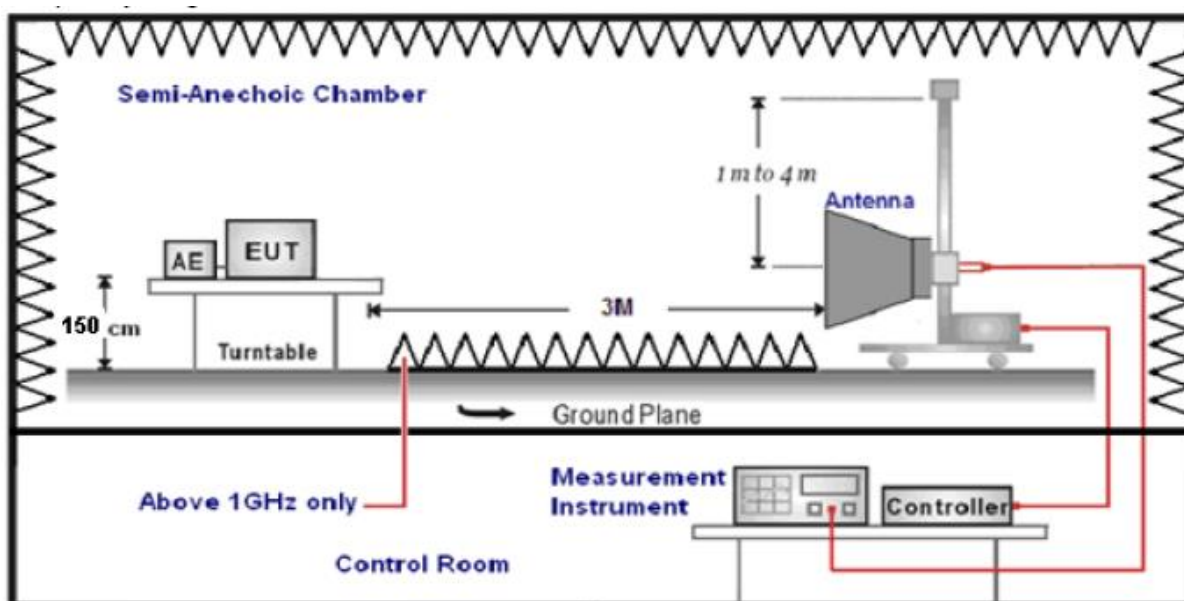
Frequency range 9 KHz – 30MHz



Frequency range 30MHz – 1000MHz



Frequency range above 1GHz-25GHz



**TEST PROCEDURE**

1. The EUT was placed on a turn table which is 12mm above ground plane when testing frequency range 9 KHz –25GHz.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0°C to 360°C to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed.
5. The EUT minimum operation frequency was 32.768KHz and maximum operation frequency was 2480MHz.so radiated emission test frequency band from 9KHz to 25GHz.
6. The distance between test antenna and EUT as following table states:

Test Frequency range	Test Antenna Type	Test Distance
9KHz-30MHz	Active Loop Antenna	3
30MHz-1GHz	Ultra-Broadband Antenna	3
1GHz-18GHz	Double Ridged Horn Antenna	3
18GHz-25GHz	Horn Antenna	1

7. Setting test receiver/spectrum as following table states:

Test Frequency range	Test Receiver/Spectrum Setting	Detector
9KHz-150KHz	RBW=200Hz/VBW=3KHz, Sweep time=Auto	QP
150KHz-30MHz	RBW=9KHz/VBW=100KHz, Sweep time=Auto	QP
30MHz-1GHz	RBW=120KHz/VBW=1000KHz, Sweep time=Auto	QP
1GHz-40GHz	Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto	Peak

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor and subtracting the Amplifier Gain and Duty Cycle Correction Factor(if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF + CL - AG$$

Where FS = Field Strength	CL = Cable Attenuation Factor (Cable Loss)
RA = Reading Amplitude	AG = Amplifier Gain
AF = Antenna Factor	

$$\text{Transd} = \text{AF} + \text{CL} - \text{AG}$$

RADIATION LIMIT

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission from intentional radiators at a distance of 3 meters shall not exceed the following table. According to § 15.247(d), in any 100kHz bandwidth outside the frequency band in which the EUT is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100kHz bandwidth within the band that contains the highest level of desired power.

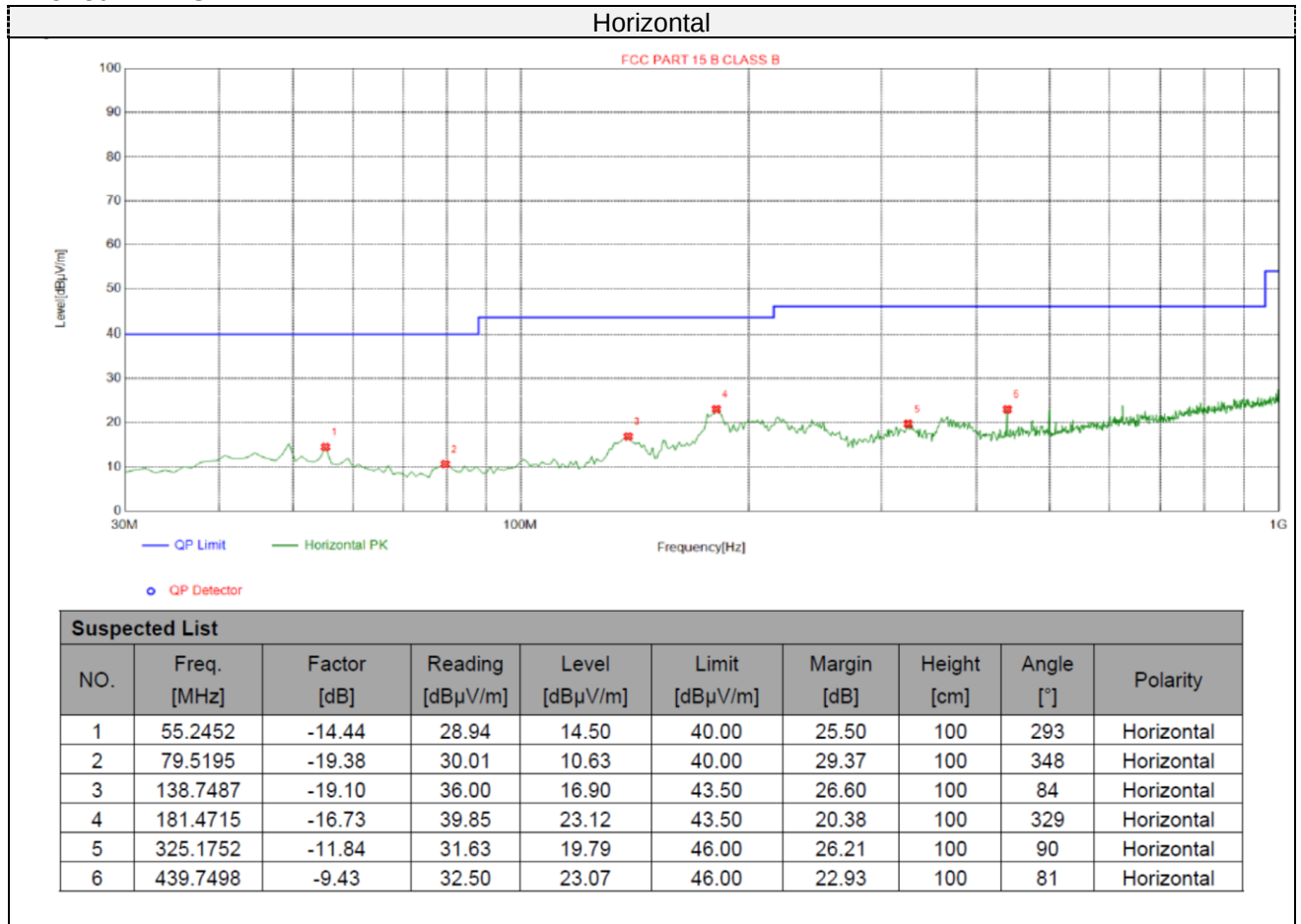
The pre-test have done for the EUT in three axes and found the worst emission at position shown in test setup photos.

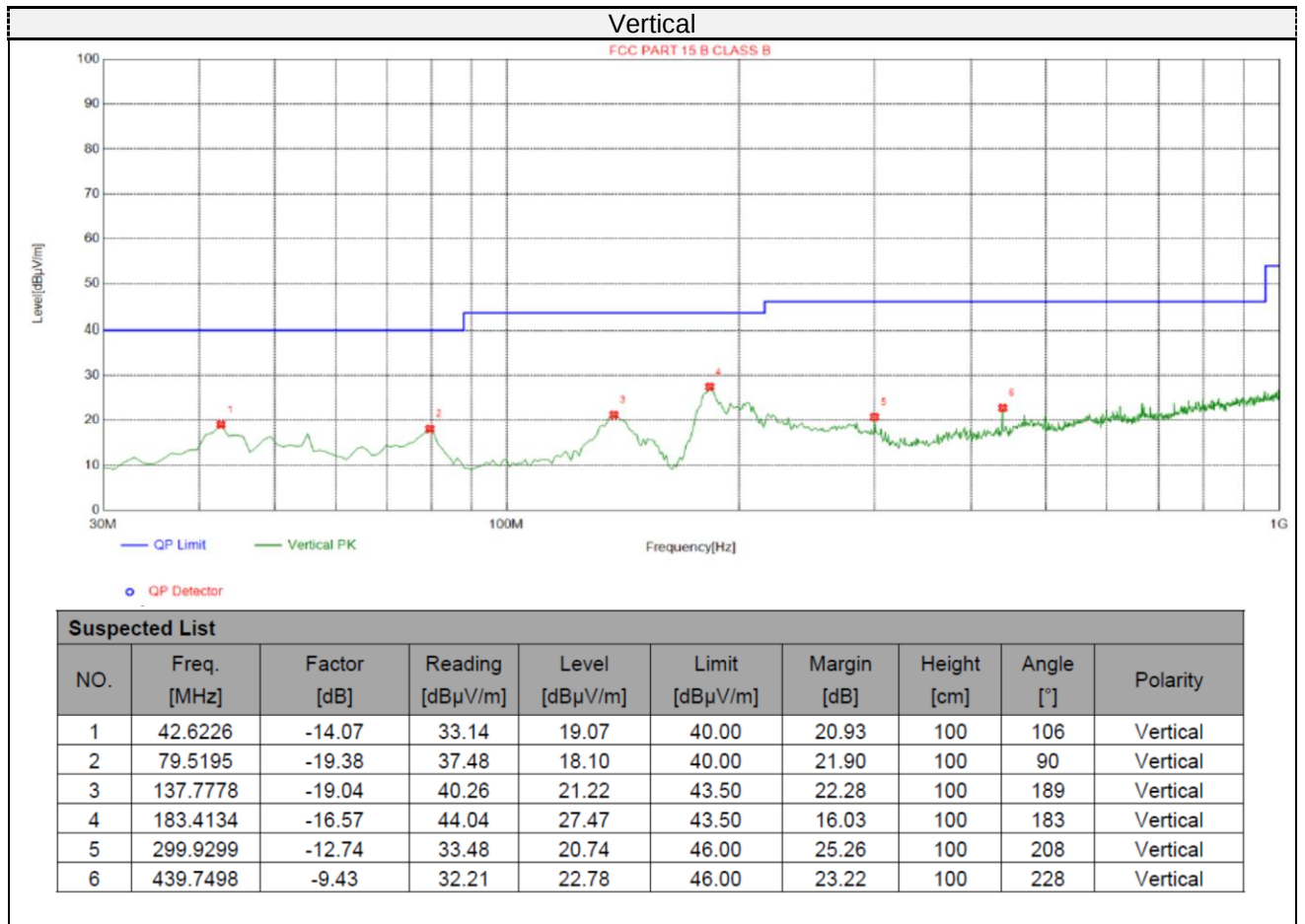
Frequency (MHz)	Distance (Meters)	Radiated (dBμV/m)	Radiated (μV/m)
0.009-0.49	3	$20\log(2400/F(\text{KHz})) + 40\log(300/3)$	$2400/F(\text{KHz})$
0.49-1.705	3	$20\log(24000/F(\text{KHz})) + 40\log(30/3)$	$24000/F(\text{KHz})$
1.705-30	3	$20\log(30) + 40\log(30/3)$	30
30-88	3	40.0	100
88-216	3	43.5	150
216-960	3	46.0	200
Above 960	3	54.0	500

**TEST RESULTS**

Remark: 1. Radiated emission test from 9 KHz to 10th harmonic of fundamental was verified, and no emission found except system noise floor in 9 KHz to 30MHz and not recorded in this report.

2. For test below 1GHz all modes of GFSK, and Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK Middle Channel was reported as below:

For 30MHz-1GHz



**For 1GHz to 25GHz**

Remark: For test above 1GHz GFSK, Pi/4 DQPSK were test at Low, Middle, and High channel; only the worst result of GFSK was reported as below:

CH Low (2402MHz)

Horizontal:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
4804	63.01	-3.64	59.37	74	-14.63	peak
4804	46.57	-3.64	42.93	54	-11.07	AVG
7206	56.29	-0.95	55.34	74	-18.66	peak
7206	43.52	-0.95	42.57	54	-11.43	AVG
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---	---	---	---	---	---	---

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
4804	64.11	-3.64	60.47	74	-13.53	peak
4804	46.82	-3.64	43.18	54	-10.82	AVG
7206	55.73	-0.95	54.78	74	-19.22	peak
7206	43.78	-0.95	42.83	54	-11.17	AVG
---	---	---	---	---	---	---
---	---	---	---	---	---	---

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.



CH Middle (2441MHz)

Horizontal:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
4882	63.09	-3.51	59.58	74	-14.42	peak
4882	46.18	-3.51	42.67	54	-11.33	AVG
7326	55.92	-0.82	55.1	74	-18.9	peak
7326	42.35	-0.82	41.53	54	-12.47	AVG
---	---	---	---	---	---	---
---	---	---	---	---	---	---

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
4882	64.02	-3.51	60.51	74	-13.49	peak
4882	46.52	-3.51	43.01	54	-10.99	AVG
7326	56.78	-0.82	55.96	74	-18.04	peak
7326	43.72	-0.82	42.9	54	-11.1	AVG
---	---	---	---	---	---	---
---	---	---	---	---	---	---

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.



CH High (2480MHz)

Horizontal:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
4960	63.97	-3.43	60.54	74	-13.46	peak
4960	45.62	-3.43	42.19	54	-11.81	AVG
7440	57.39	-0.75	56.64	74	-17.36	peak
7440	44.77	-0.75	44.02	54	-9.98	AVG
---	---	---	---	---	---	---
---	---	---	---	---	---	---

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Vertical:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
4960	62.93	-3.43	59.5	74	-14.5	peak
4960	46.45	-3.43	43.02	54	-10.98	AVG
7440	56.69	-0.75	55.94	74	-18.06	peak
7440	43.72	-0.75	42.97	54	-11.03	AVG
---	---	---	---	---	---	---
---	---	---	---	---	---	---

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Remark:

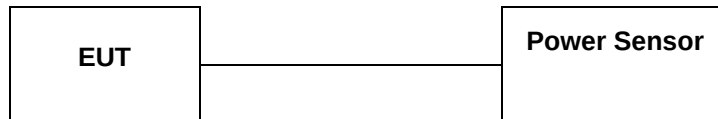
(1) Data of measurement within this frequency range shown “---” in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

(2) When the test results of Peak Detected below the limits of Average Detected, the Average Detected is not need completed.



4.3. Maximum Peak Output Power

TEST CONFIGURATION



TEST PROCEDURE

According to ANSI C63.10:2013 Maximum peak conducted output power for HFSS devices:
The maximum peak conducted output power may be measured using a broadband peak RF power meter.
The power meter shall have a video bandwidth that is greater than or equal to the HFSS bandwidth and shall utilize a fast-responding diode detector.

LIMIT

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.

TEST RESULTS

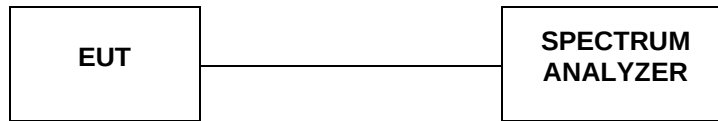
Type	Channel	Peak Output power (dBm)	Limit (dBm)	Result
GFSK	00	1.576	21	Pass
	39	0.752		
	78	0.338		
$\pi/4$ DQPSK	00	1.057	21	Pass
	39	0.187		
	78	0.048		

Note: 1.The test results including the cable lose.



4.4. 20dB Bandwidth

TEST CONFIGURATION



TEST PROCEDURE

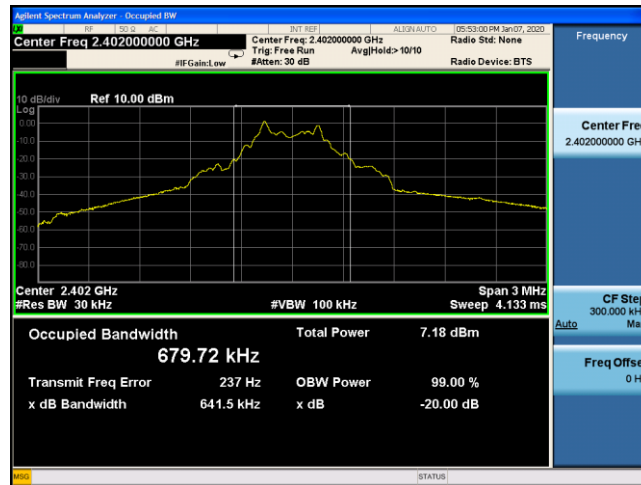
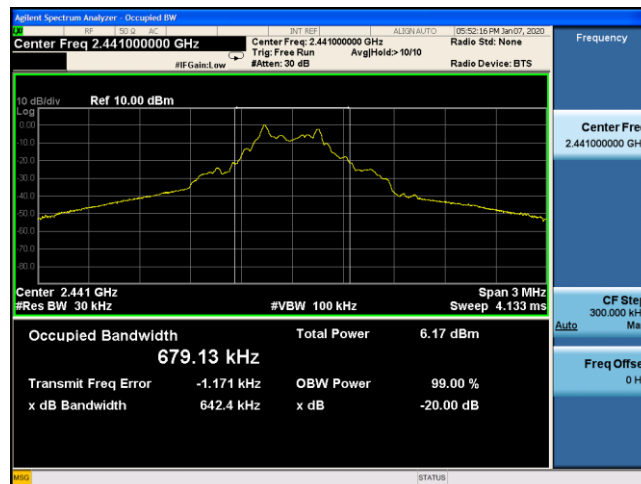
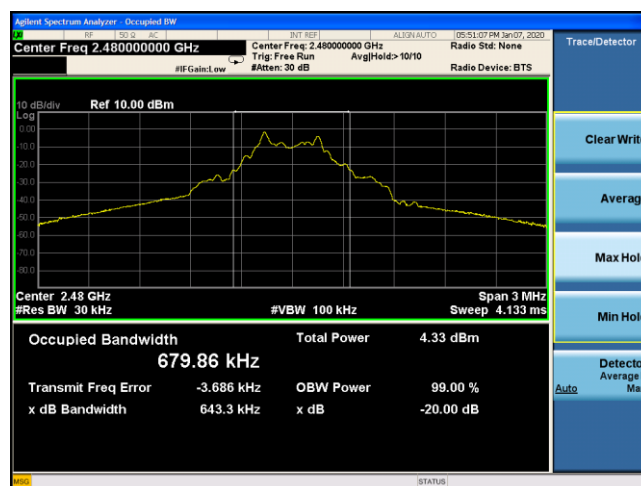
The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=30 KHz and VBW=100KHz. The 20dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 20dB.

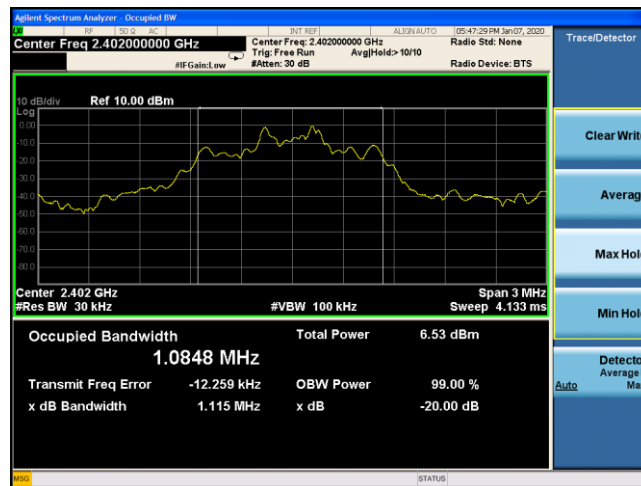
LIMIT

For frequency hopping systems operating in the 2400MHz-2483.5MHz no limit for 20dB bandwidth.

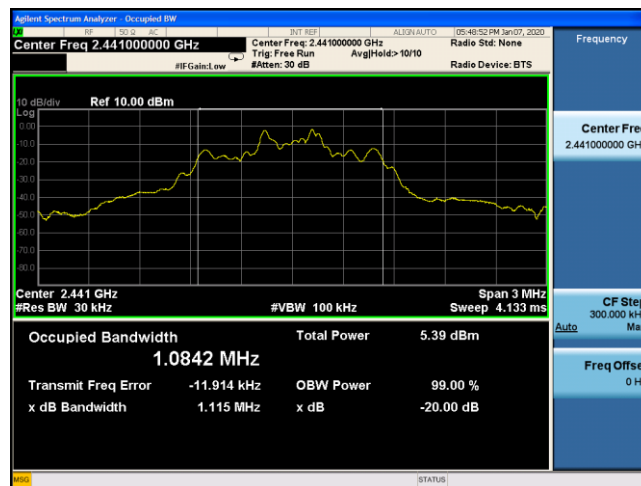
TEST RESULTS

Modulation	Channel	20dB bandwidth (MHz)	Result
GFSK	CH00	0.6415	Pass
	CH39	0.6424	
	CH78	0.6433	
$\pi/4$ DQPSK	CH00	1.115	
	CH39	1.115	
	CH78	1.117	

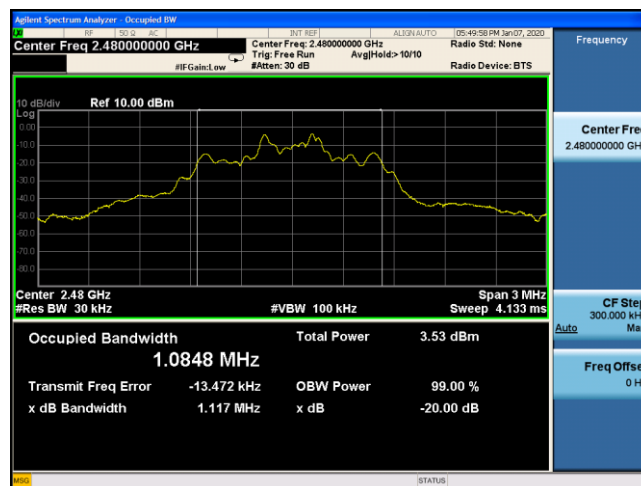
*GFSK Modulation**CH00**CH39**CH78*

 $\pi/4$ DQPSK Modulation

CH00



CH39

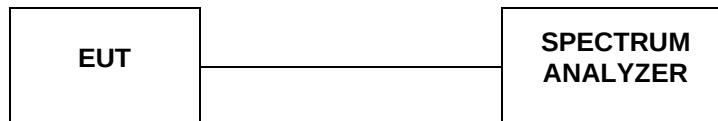


CH78



4.5. Frequency Separation

TEST CONFIGURATION



TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured by spectrum analyzer with RBW=30 KHz and VBW=100KHz.

LIMIT

According to 15.247(a)(1), frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25KHz or the $2/3 \times 20\text{dB}$ bandwidth of the hopping channel, whichever is greater.

TEST RESULTS

4.5.1 GFSK Test Mode

Modulation	Channel	Channel Separation (MHz)	Limit(MHz)	Result
GFSK	CH38	1.002	$2/3 \times 20\text{dB BW}$ or 20dB BW	Pass
	CH39			
$\pi/4\text{DQPSK}$	CH38	1.002	$2/3 \times 20\text{dB BW}$ or 20dB BW	Pass
	CH39			

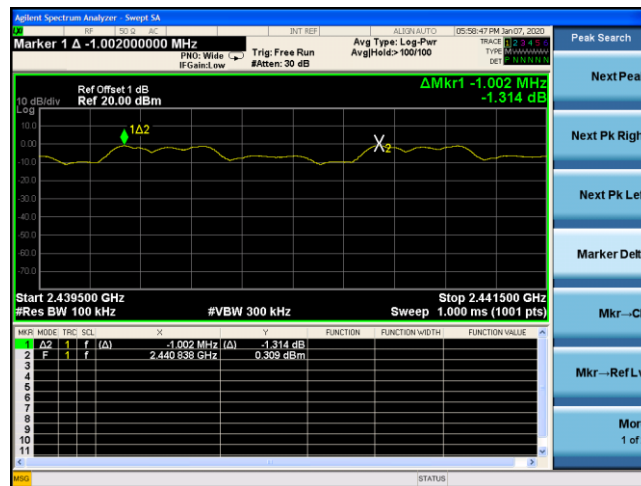
Remark: We have tested all mode at high, middle and low channel, and recorded worst case at middle



GFSK Modulation



$\pi/4$ DQPSK Modulation



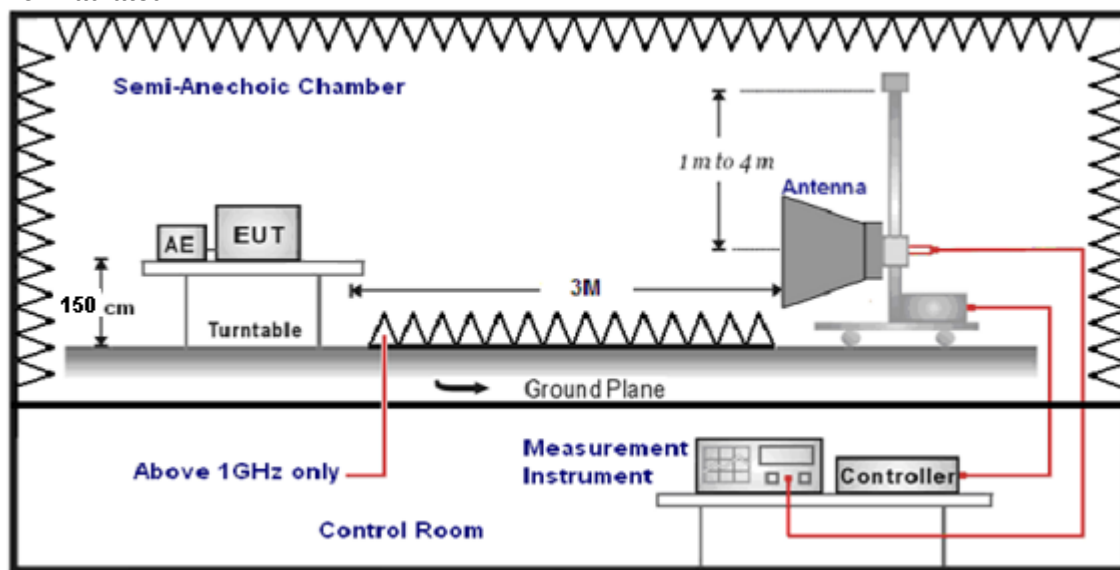
4.6. Band Edge Compliance of RF Emission

TEST REQUIREMENT

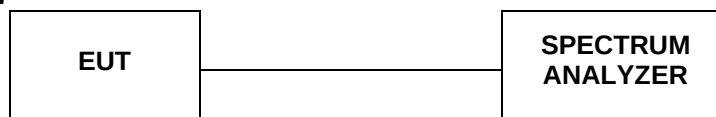
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the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

For Radiated



For Conducted



TEST PROCEDURE

1. The EUT was placed on a turn table which is 1.5m above ground plane.
2. Maximum procedure was performed by raising the receiving antenna from 1m to 4m and rotating the turn table from 0° to 360° to acquire the highest emissions from EUT.
3. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
4. Repeat above procedures until all frequency measurements have been completed..
5. The distance between test antenna and EUT was 3 meter:
6. Setting test receiver/spectrum as following table states:

Test Frequency range	Test Receiver/Spectrum Setting	Detector
1GHz-40GHz	Peak Value: RBW=1MHz/VBW=3MHz, Sweep time=Auto Average Value: RBW=1MHz/VBW=10Hz, Sweep time=Auto	Peak

LIMIT

Below -20dB of the highest emission level in operating band.

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)

TEST RESULTS

4.6.1 For Radiated Bandedge Measurement

Remark: GFSK, Pi/4 DQPSK all have been tested, only worse case GFSK is reported.

Operation Mode: GFSK TX Low channel(2402MHz)

Horizontal (Worst case)

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
2390	61.21	-5.81	55.4	74	-18.6	peak
2390	42.92	-5.81	37.11	54	-16.89	AVG
Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.						

Vertical:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
2390	63.87	-5.81	58.06	74	-15.94	peak
2390	45.03	-5.81	39.22	54	-14.78	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

Operation Mode: GFSK TX High channel (2480MHz)

Horizontal (Worst case)

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
2483.5	62.15	-5.65	56.5	74	-17.5	peak
2483.5	42.93	-5.65	37.28	54	-16.72	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.

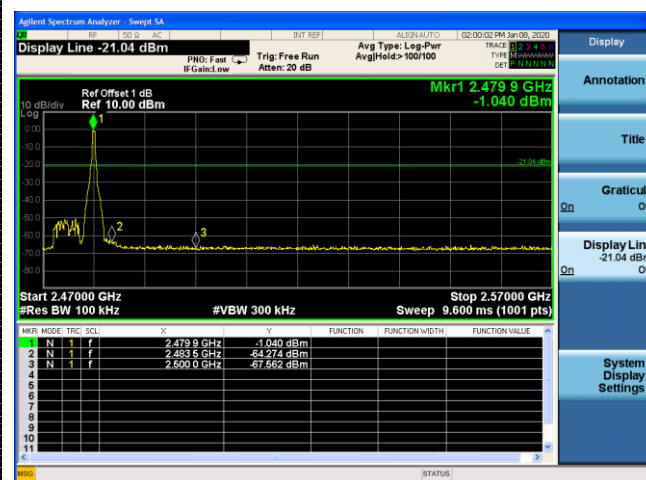
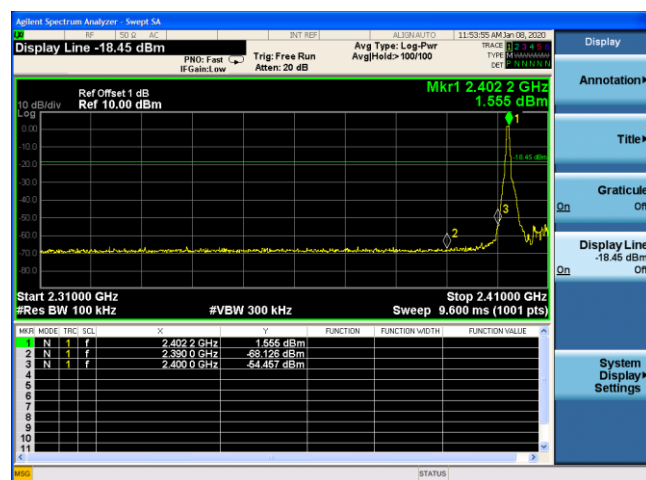
Vertical:

Frequency	Meter Reading	Factor	Emission Level	Limits	Margin	Detector Type
(MHz)	(dBμV)	(dB)	(dBμV/m)	(dBμV/m)	(dB)	
2483.5	64.21	-5.65	58.56	74	-15.44	peak
2483.5	45.48	-5.65	39.83	54	-14.17	AVG
Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier.						
Remark: All the other emissions not reported were too low to read and deemed to comply with FCC limit.						



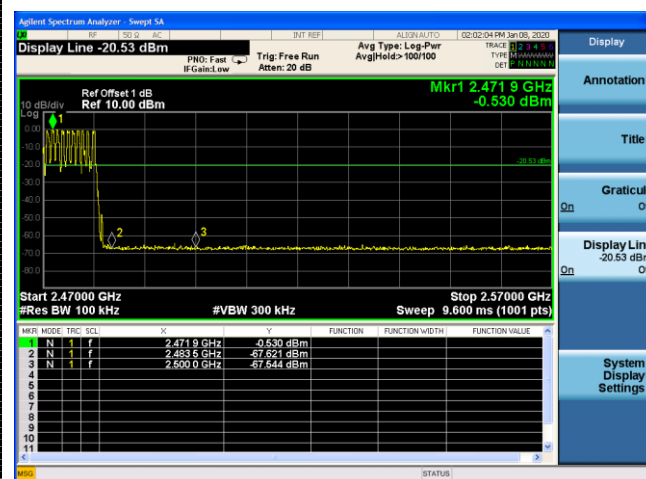
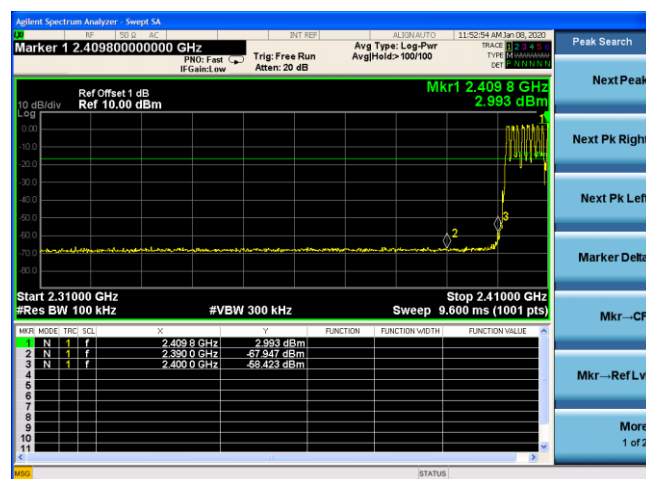
4.6.2 For Conducted Bandedge Measurement

GFSK



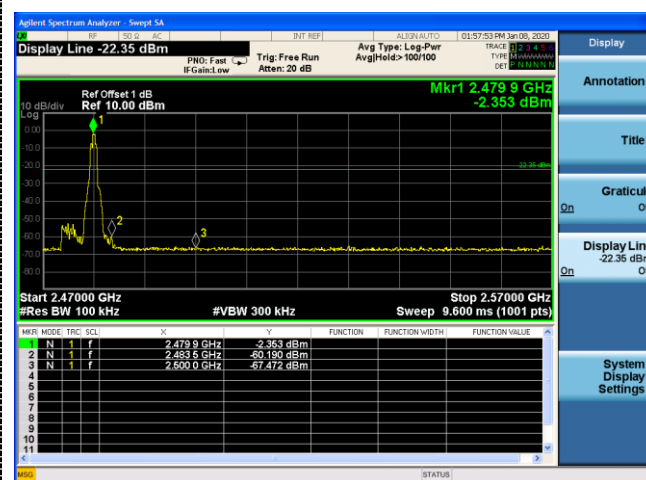
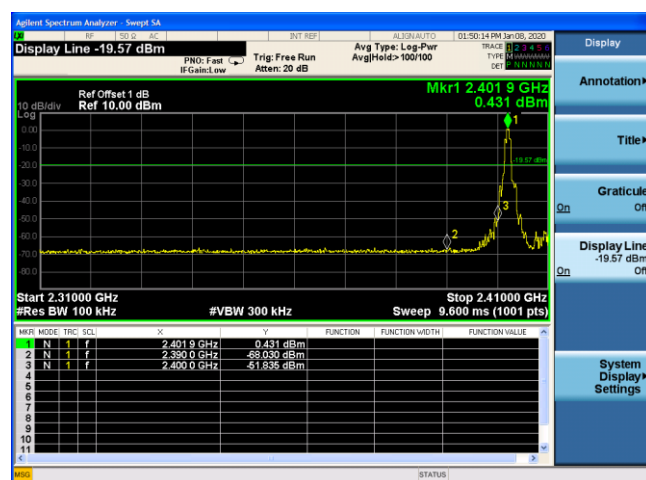
Left Band edge hopping off

Right Band edge hopping off



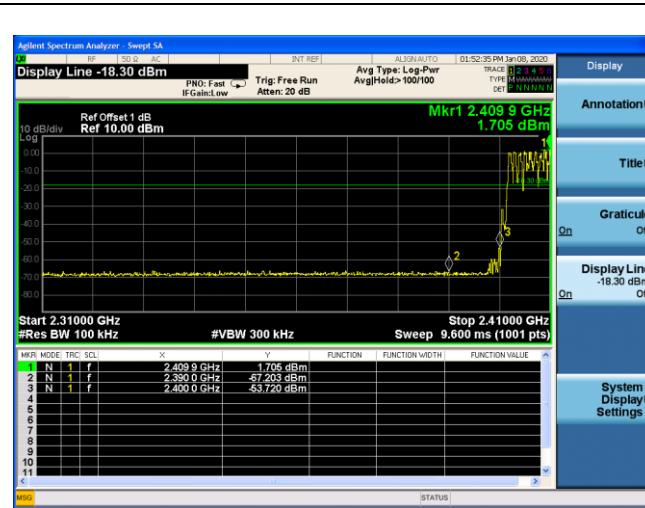
Left Band edge hopping on

Right Band edge hopping on

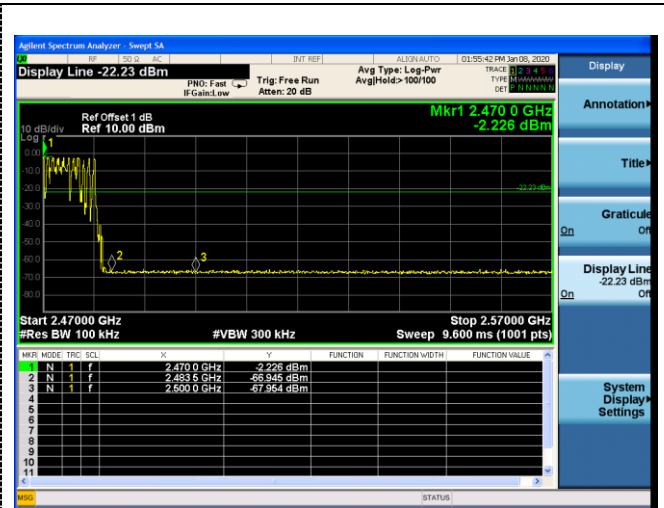
 $\pi/4$ DQPSK

Left Band edge hopping off

Right Band edge hopping off



Left Band edge hopping on

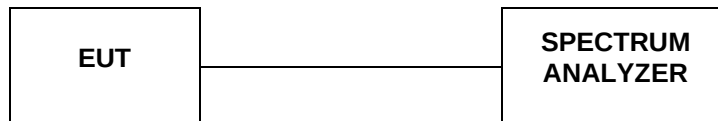


Right Band edge hopping on



4.7. Spurious RF Conducted Emission

TEST CONFIGURATION



TEST PROCEDURE

The Spurious RF conducted emissions compliance of RF radiated emission should be measured by following the guidance in ANSI C63.10-2013 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization etc. Set RBW=100kHz and VBW= 300kHz to measure the peak field strength, and measure frequency range from 9kHz to 25GHz.

LIMIT

1. Below -20dB of the highest emission level in operating band.
2. Fall in the restricted bands listed in section 15.205. The maximum permitted average field strength is listed in section 15.209.

TEST RESULTS

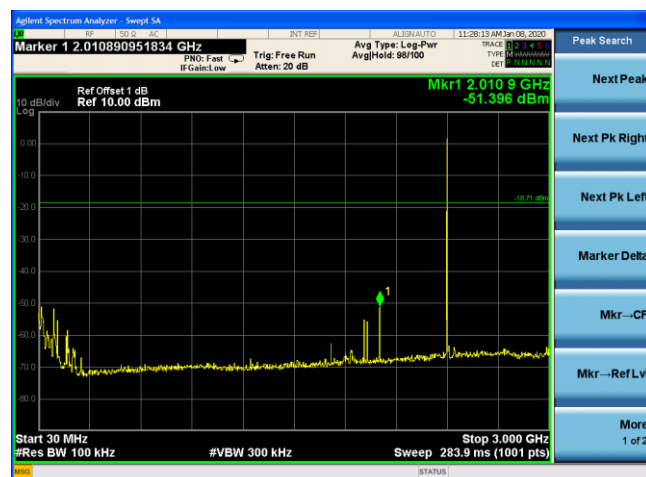
Remark: The measurement frequency range is from 30MHz to the 10th harmonic of the fundamental frequency. The lowest, middle and highest channels are tested to verify the spurious emissions and band edge measurement data.



GFSK CH00



Reference

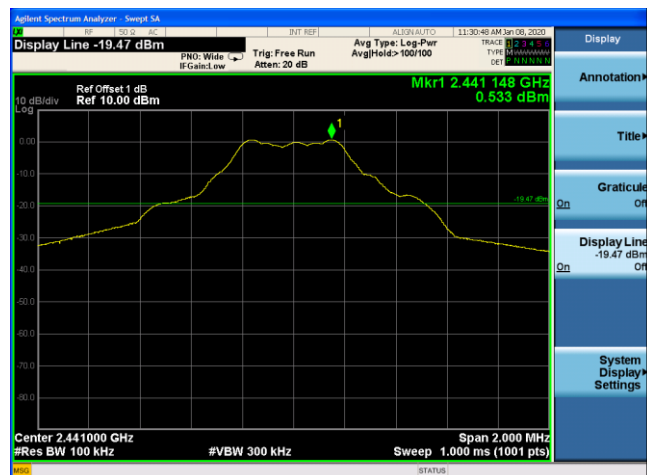


30MHz-3GHz

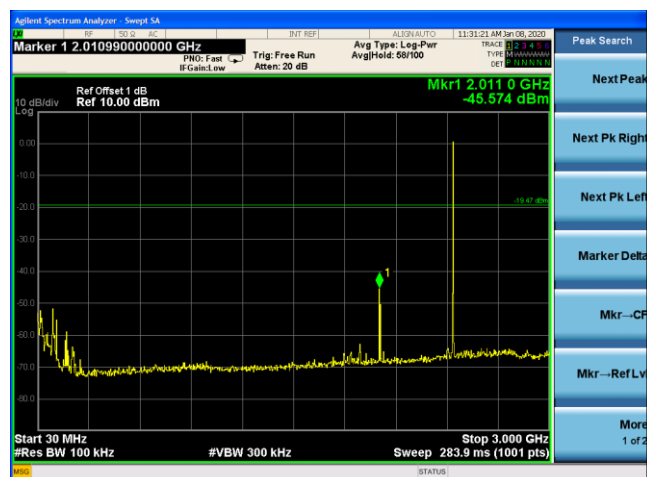


3GHz-25GHz

GFSK CH39



Reference



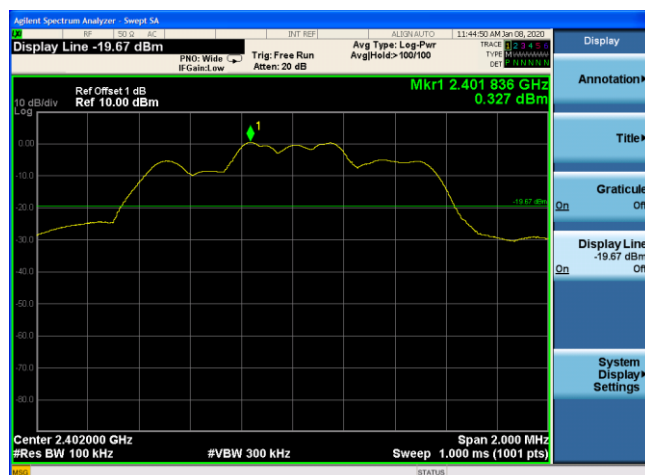
30MHz-3GHz



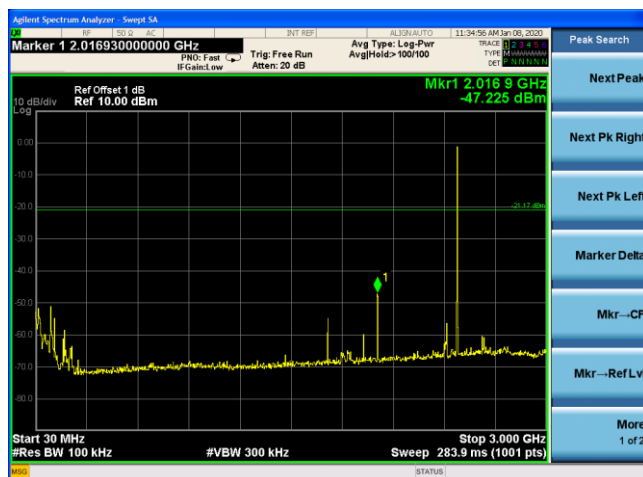
3GHz-25GHz



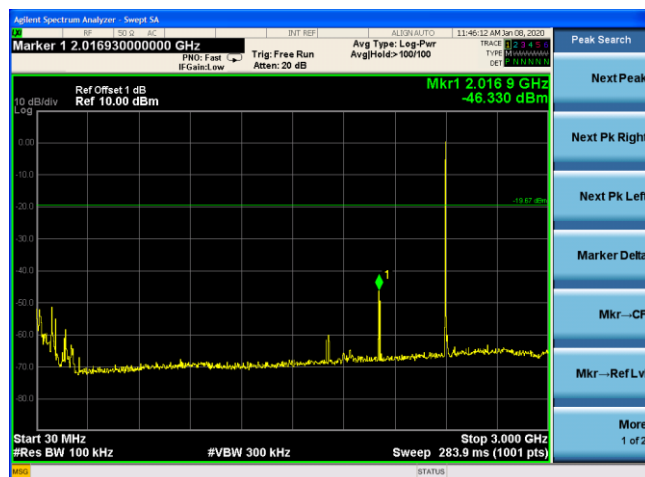
GFSK CH78

 π /4DQPSK CH00

Reference



Reference



30MHz-3GHz

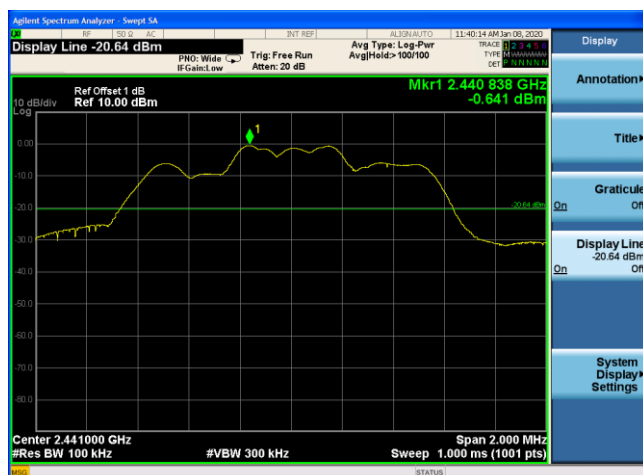


30MHz-3GHz

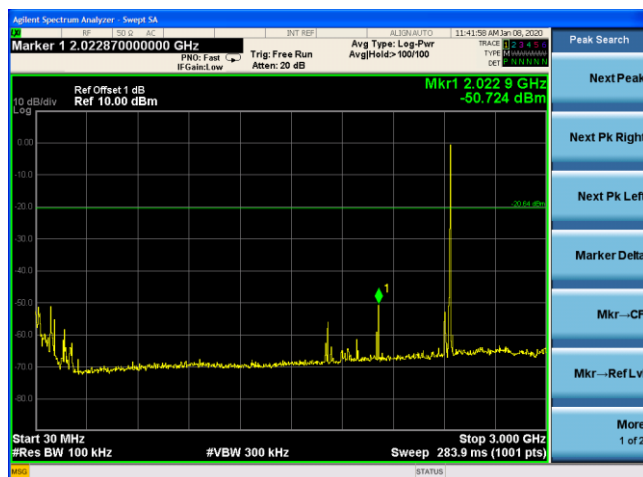


3GHz-25GHz

3GHz-25GHz

 π /4DQPSK CH39

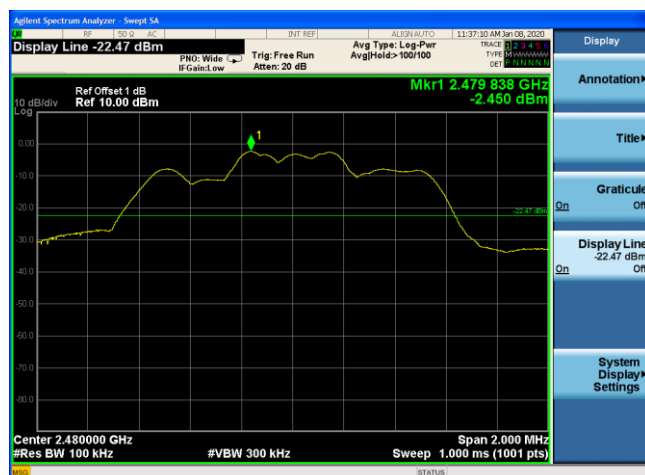
Reference



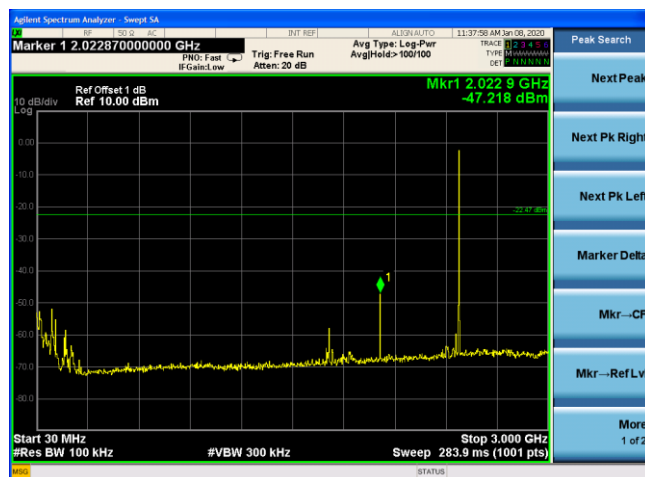
30MHz-3GHz



3GHz-25GHz

 π /4DQPSK CH78

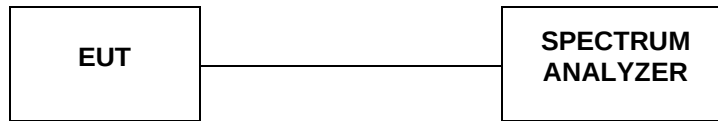
Reference



30MHz-3GHz



3GHz-25GHz

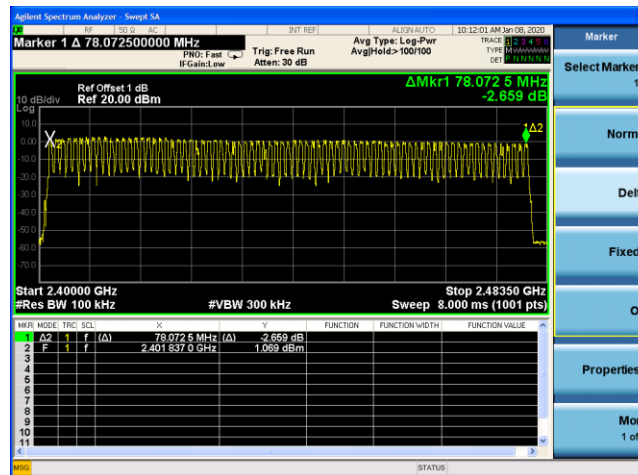
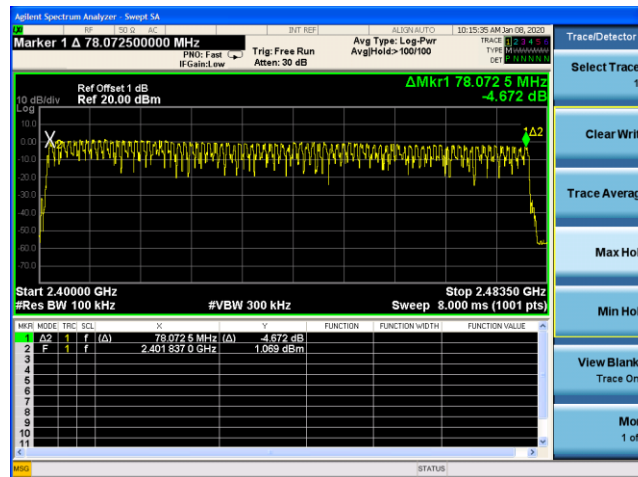
**4.8. Number of hopping frequency****TEST CONFIGURATION****TEST PROCEDURE**

The transmitter output was connected to the spectrum analyzer through an attenuator. Set spectrum analyzer start 2400MHz to 2483.5MHz with RBW=1MHz and VBW=3MHz.

LIMIT

Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels.

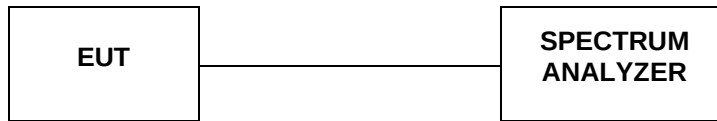
Modulation	Number of Hopping Channel	Limit	Result
GFSK	79	≥15	Pass
$\pi/4$ DQPSK	79		

*GFSK Modulation* *$\pi/4$ DQPSK Modulation*



4.9. Time Of Occupancy(Dwell Time)

TEST CONFIGURATION



TEST PROCEDURE

The transmitter output was connected to the spectrum analyzer through an attenuator. Set center frequency of spectrum analyzer=operating frequency with RBW=1MHz and VBW=3MHz,Span=0Hz.

LIMIT

The average time of occupancy on any channel shall not be greater than 0.4 seconds within a pe-riod of 0.4 seconds multiplied by the number of hopping channels employed.

TEST RESULTS

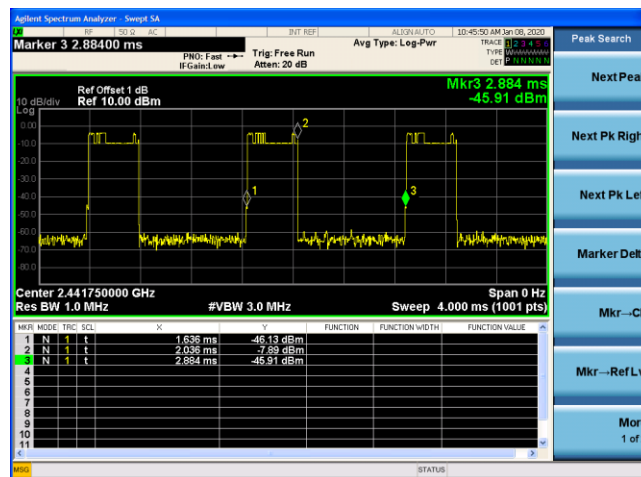
Modulation	Packet	Pulse time (ms)	Dwell time (second)	Limit (second)	Result
GFSK	DH1	0.400	0.128	0.40	Pass
	DH3	1.656	0.265		
	DH5	2.906	0.310		
π/4 DQPSK	DH1	0.392	0.126	0.40	Pass
	DH3	1.740	0.279		
	DH5	2.900	0.310		

Note:

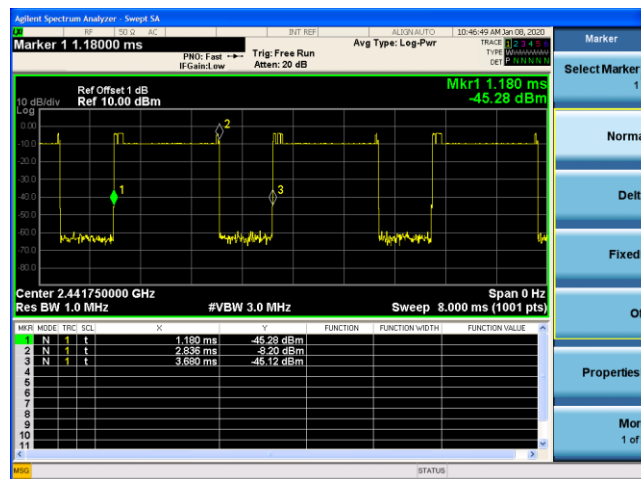
1. We have tested all mode at high,middle and low channel,and recoreded worst case at middle channel.
2. Dwell time=Pulse time (ms) × (1600 ÷ 2 ÷ 79) ×31.6 Second for DH1, 2-DH1, 3-DH1
Dwell time=Pulse time (ms) × (1600 ÷ 4 ÷ 79) ×31.6 Second for DH3, 2-DH3, 3-DH3
Dwell time=Pulse time (ms) × (1600 ÷ 6 ÷ 79) ×31.6 Second for DH5, 2-DH5, 3-DH5



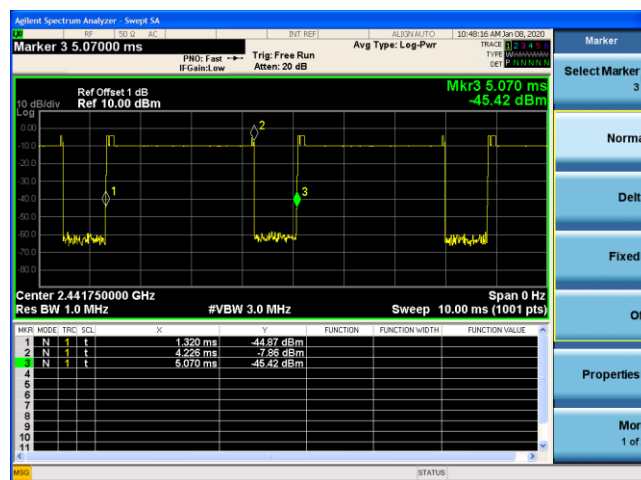
GFSK Modulation



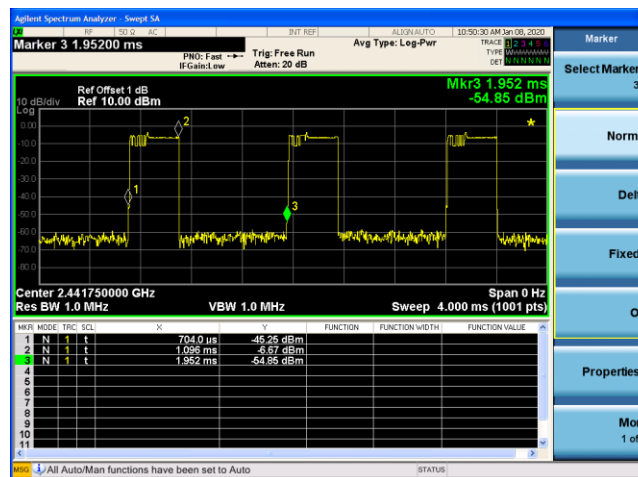
DH1



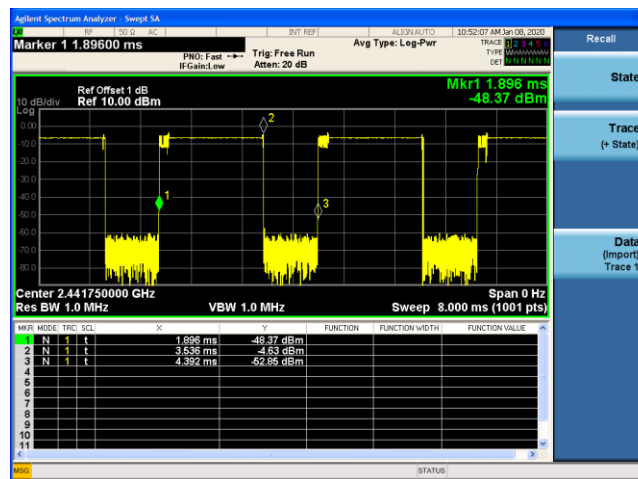
DH3



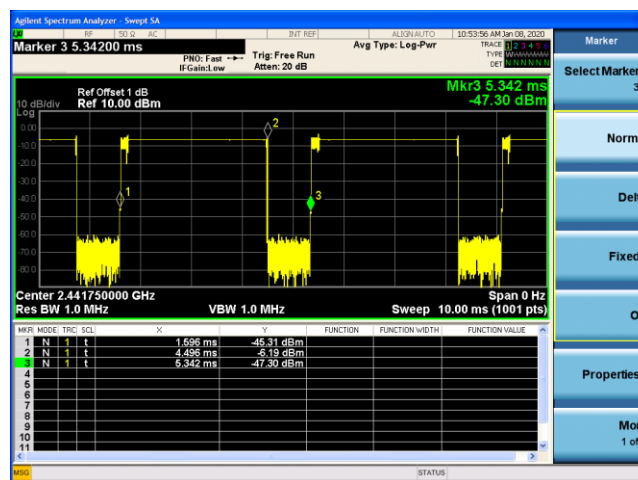
DH5

 $\pi/4$ DQPSK Modulation

2-DH1



2-DH3



2-DH5



4.10. Pseudorandom Frequency Hopping Sequence

TEST APPLICABLE

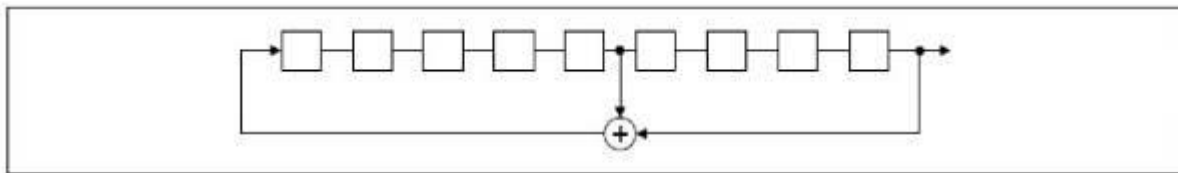
For 47 CFR Part 15C section 15.247 (a)(1) requirement:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hop-ping 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 hop-ping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

EUT Pseudorandom Frequency Hopping Sequence Requirement

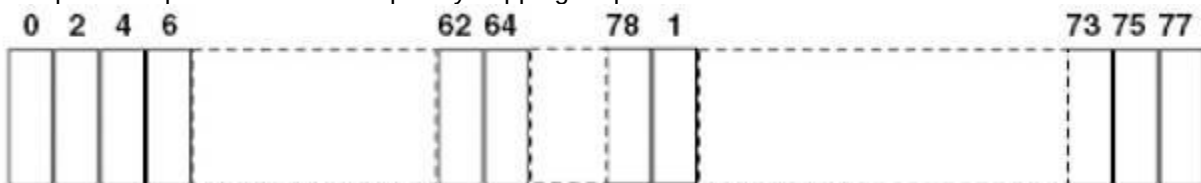
The pseudorandom frequency hopping sequence may be generated in a nice-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the frist stage. The sequence begins with the frist one of 9 consecutive ones, for example: the shift register is initialized with nine ones.

- Number of shift register stages:9
- Length of pseudo-random sequence: $2^9-1=511$ bits
- Longest sequence of zeros:8(non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

An expleme of pseudorandom frequency hopping sequence as follows:



Each frequency used equally one the average by each transmitter.

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



4.11. Antenna Requirement

Standard Applicable

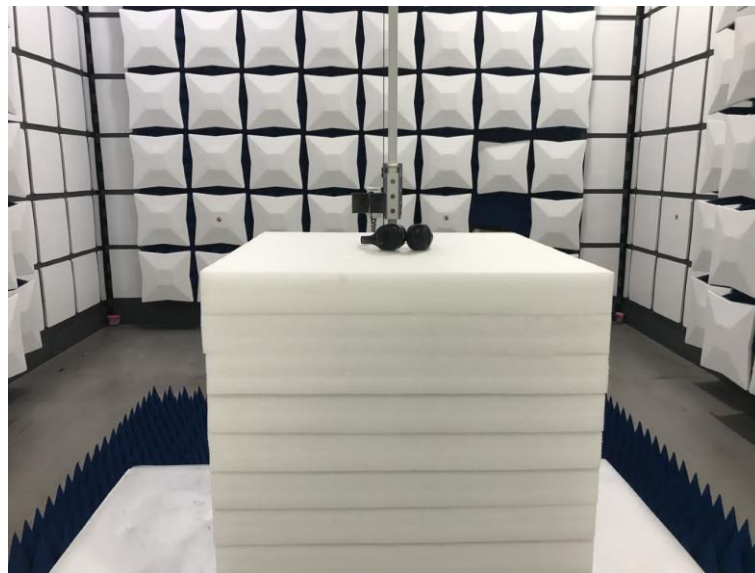
For intentional device, according to FCC 47 CFR Section 15.203, an intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device.

And according to FCC 47 CFR Section 15.247 (c), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

Antenna Information

The antenna is PCB antenna ,The directional gains of antenna used for transmitting is -0.68 dBi.

5. Test Setup Photos of the EUT



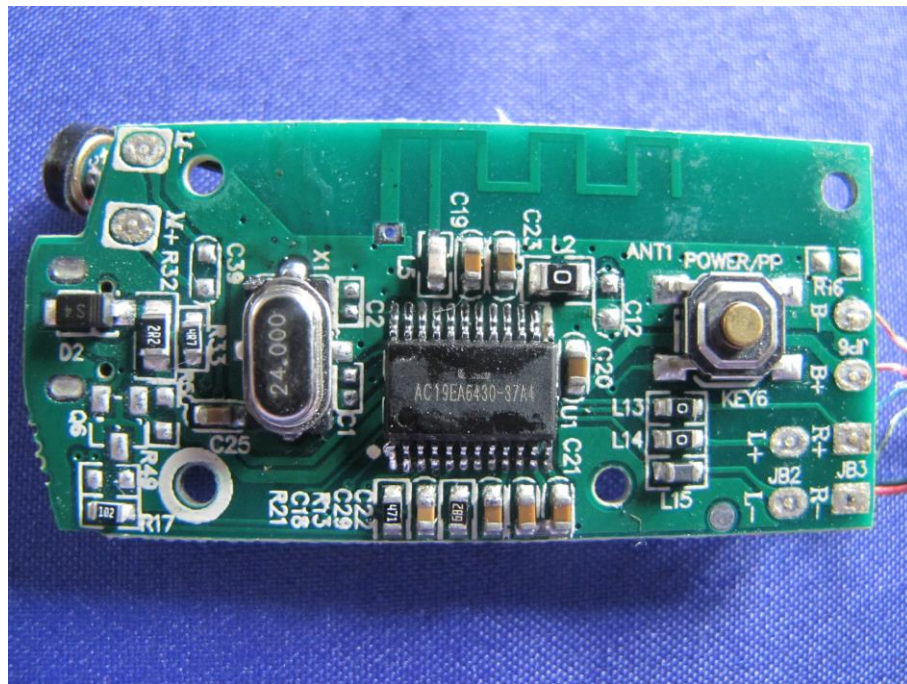
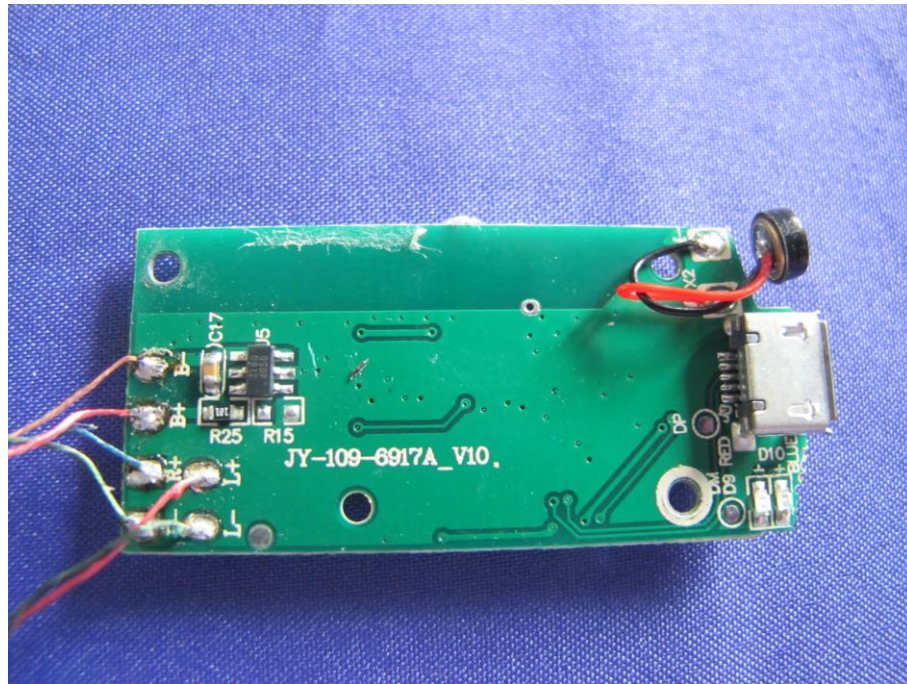
6. Photos of the EUT













.....End of Report.....