



# FCC Test Report

**Test Report  
On Behalf of  
Shenzhen Hotop Technology Co.,Ltd  
For  
headphone**

**Model No.: ST89M, ST99, ST95, ST78M, BT850, i10 pro max, AK-67,  
AK-65, BT600, MJ-6966**

**FCC ID: 2BEP2-ST89M**

**Prepared For:** Shenzhen Hotop Technology Co.,Ltd  
Room 1113, Building 3, Futong Haizi Technology Park, Bulan Road, Nanwan  
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**Prepared By:** Shenzhen HUAK Testing Technology Co., Ltd.  
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**Date of Test:** Jan. 12, 2024 ~ Jan. 25, 2024

**Date of Report:** Jan. 25, 2024

**Report Number:** HK2401120233-2E



## Test Result Certification

**Applicant's Name** .....: Shenzhen Hotop Technology Co.,Ltd

Address .....: Room 1113, Building 3, Futong Haizi Technology Park, Bulan Road, Nanwan Streete, Longgang District, Shenzhen, China

**Manufacturer's Name** .....: Shenzhen Hotop Technology Co.,Ltd

Address .....: Room 1113, Building 3, Futong Haizi Technology Park, Bulan Road, Nanwan Streete, Longgang District, Shenzhen, China

### Product Description

Trade Mark .....: N/A

Product Name .....: headphone

Model and/or Type Reference....: ST89M, ST99, ST95, ST78M, BT850, i10 pro max, AK-67, AK-65, BT600, MJ-6966

**Standards** .....: **47 CFR FCC Part 15 Subpart C 15.247**

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**Date of Test** .....

Date (s) of Performance of Tests ..... **Jan. 12, 2024 ~ Jan. 25, 2024**

Date of Issue ..... **Jan. 25, 2024**

Test Result..... **Pass**

Testing Engineer

Len Liao

Technical Manager

Sliver Wan

Authorized Signatory

Jason Zhou

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**\*\* Modified History \*\***

Revision	Description	Issued Data	Remark
Revision 1.0	Initial Test Report Release	Jan. 25, 2024	Jason Zhou

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## 1. Summary

### 1.1. 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

### 1.2. Test Description

FCC PART 15.247		
FCC Part 15.207	AC Power Conducted Emission	PASS
FCC Part 15.215	20dB Bandwidth& 99% Bandwidth	PASS
FCC Part 15.247(d)	Spurious RF Conducted Emission	PASS
FCC Part 15.247(b)	Maximum Peak Output Power	PASS
FCC Part 15.247 (a) (1)	Pseudorandom Frequency Hopping Sequence	PASS
FCC Part 15.247(a)(1)(iii)	Number of Hopping Frequency& Time of Occupancy	PASS
FCC Part 15.247(a)(1)	Frequency Separation	PASS
FCC Part 15.205/15.209	Radiated Emissions	PASS
FCC Part 15.247(d)	Band Edge Compliance of RF Emission	PASS



### 1.3. Information of the Test Laboratory

Shenzhen HUAK Testing Technology Co., Ltd.

Address: 1-2/F., Building B2, Junfeng Zhongcheng Zhizao Innovation Park, Heping, Fuhai Street, Bao'an District, Shenzhen, Guangdong, China

Testing Laboratory Authorization :

A2LA Accreditation Code is 4781.01.

FCC Designation Number is CN1229.

Canada IC CAB identifier is CN0045.

CNAS Registration Number is L9589.

### 1.4. Statement of the Measurement Uncertainty

The data and results referenced in this document are true and accurate. The reader is cautioned that there may be errors within the calibration limits of the equipment and facilities. The measurement uncertainty was calculated for all measurements listed in this test report acc. to CISPR 16 - 4 "Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainty in EMC Measurements" and is documented in the Shenzhen HUAK Testing Technology Co., Ltd. quality system acc. to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for HUAK laboratory is reported:

Test	Measurement Uncertainty	Notes
Transmitter power conducted	±0.37dB	(1)
Transmitter power Radiated	±3.35dB	(1)
Conducted spurious emission 9KHz-40 GHz	±2.20dB	(1)
Occupied Bandwidth	±3.68%	(1)
Radiated Emission 30~1000MHz	±3.90dB	(1)
Radiated Emission Above 1GHz	±4.28dB	(1)
Conducted Disturbance 0.15~30MHz	±2.71dB	(1)

(1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.



## 2. General Information

### 2.1. Environmental Conditions

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

Normal Temperature:	25°C
Relative Humidity:	55 %
Air Pressure:	101 kPa

### 2.2. General Description of EUT

Product Name:	headphone
Model/Type Reference:	ST89M
Series Model:	ST99, ST95, ST78M, BT850, i10 pro max, AK-67, AK-65, BT600, MJ-6966
Model Difference:	All model's the function, software and electric circuit are the same, only with product color and model named different. Test sample model: ST89M.
Power Supply:	DC5V from Type-C or DC3.7V from battery
Version:	Supported EDR
Modulation:	GFSK, π/4DQPSK
Operation Frequency:	2402MHz~2480MHz
Channel Number:	79
Channel Separation:	1MHz
Antenna Type:	PCB Antenna
Antenna Gain:	-0.58dBi
Hardware Version:	V1.0
Software Version:	V1.0

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



### 2.3. Description of Test Modes and Test Frequency

The Applicant provides communication tools software to control the EUT for staying in continuous transmitting and receiving mode for testing.

There are 79 channels provided to the EUT and Channel 00/39/78 was selected for testing.

#### Operation Frequency:

Channel	Frequency (MHz)
00	2402
01	2403
:	:
38	2440
39	2441
40	2442
:	:
77	2479
78	2480

Note: The line display in grey were the channel selected for testing

Preliminary tests were performed in each mode and packet length of BT, and found worst case as bellow, finally test were conducted at those mode and recorded in this report.

Test Items	Worst Case
Conducted Emissions	Charging mode
Radiated Emissions and Band Edge	DH5 low channel
Maximum Conducted Output Power	DH5/2DH5
20dB Bandwidth & 99% Bandwidth	DH5/2DH5
Frequency Separation	DH5/2DH5 Middle channel
Number of hopping frequency	DH5/2DH5
Time of Occupancy (Dwell Time)	DH1/DH3/DH5 Middle channel 2DH1/2DH3/2DH5 Middle channel
Out-of-band Emissions	DH5/2DH5



## 2.4. 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	Feb. 17, 2023	1 Year
2.	Receiver	R&S	ESR-7	HKE-005	Feb. 17, 2023	1 Year
3.	RF automatic control unit	Tonscend	JS0806-2	HKE-060	Feb. 17, 2023	1 Year
4.	Spectrum analyzer	R&S	FSP40	HKE-025	Feb. 17, 2023	1 Year
5.	Spectrum analyzer	Agilent	N9020A	HKE-048	Feb. 17, 2023	1 Year
6.	Preamplifier	Schwarzbeck	BBV 9743	HKE-006	Feb. 17, 2023	1 Year
7.	EMI Test Receiver	Rohde & Schwarz	ESR-7	HKE-010	Feb. 17, 2023	1 Year
8.	Bilog Broadband Antenna	Schwarzbeck	VULB9163	HKE-012	Feb. 17, 2023	1 Year
9.	Loop Antenna	Schwarzbeck	FMZB 1519 B	HKE-014	Feb. 17, 2023	1 Year
10.	Horn Antenna	Schwarzbeck	9120D	HKE-013	Feb. 17, 2023	1 Year
11.	Pre-amplifier	EMCI	EMC051845 SE	HKE-015	Feb. 17, 2023	1 Year
12.	Pre-amplifier	Agilent	83051A	HKE-016	Feb. 17, 2023	1 Year
13.	EMI Test Software EZ-EMC	Tonscend	JS1120-B Version	HKE-083	N/A	N/A
14.	Power Sensor	Agilent	E9300A	HKE-086	Feb. 17, 2023	1 Year
15.	Spectrum analyzer	Agilent	N9020A	HKE-048	Feb. 17, 2023	1 Year
16.	Signal generator	Agilent	N5182A	HKE-029	Feb. 17, 2023	1 Year
17.	Signal Generator	Agilent	83630A	HKE-028	Feb. 17, 2023	1 Year
18.	Shielded room	Shiel Hong	4*3*3	HKE-039	Dec. 09, 2021	3 Year
19.	Power meter	Agilent	E4419B	HKE-085	Feb. 17, 2023	1 Year
20.	Horn Antenna	Schwarzbeck	BBHA 9170	HKE-017	Feb. 17, 2023	1 Year
21.	10dB Attenuator	Schwarzbeck	VTSD9561F	HKE-153	Feb. 17, 2023	1 Year

The calibration interval was one year



## 2.5. Related Submittal(s) / Grant (s)

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

## 2.6. Modifications

No modifications were implemented to meet testing criteria.

## 2.7. Description of Test Setup

Operation of EUT during Conducted and Radiation below 1GHz testing:



Operation of EUT during Radiation Above1GHz testing:



The sample was placed (0.8m below 1GHz, 1.5m above 1GHz) above the ground plane of 3m chamber. Measurements in both horizontal and vertical polarities were performed. During the test, each emission was maximized by: having the EUT continuously working, investigated all operating modes, rotated about all 3 axis (X, Y & Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, rotating the turntable, varying antenna height from 1m to 4m in both horizontal and vertical polarizations. The emissions worst-case are shown in Test Results of the following pages. The worst case is X position.



## 2.8. Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

Item	Equipment	Trade Mark	Model/Type No.	Specification	Note
1	headphone	N/A	ST89M	N/A	EUT
2	Laptop	Lenovo	TP00096A	Input: DC 20V, 2.25~3.25A Output: 5VDC, 0.5A	Peripheral

**Note:**

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.
2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.
3. For conducted measurements (Output Power, 6dB Emission Bandwidth, Power Spectral Density, Spurious Emissions), the antenna of EUT is connected to the test equipment via temporary antenna connector, the antenna connector is soldered on the antenna port of EUT, and the temporary antenna connector is listed in the Test Instruments.



### 3. Test Conditions and Results

#### 3.1. Conducted Emissions Test

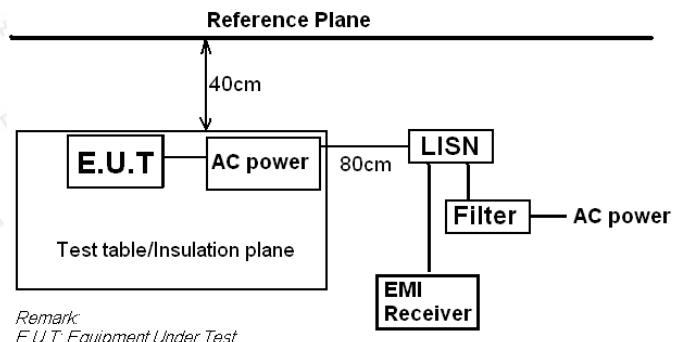
##### Limit

According to FCC CFR Title 47 Part 15 Subpart C Section 15.207 and RSS Gen 8.8, AC Power Line Conducted Emissions Limits for License-Exempt Radio Apparatus as below:

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 Configuration



*Remark:*  
E.U.T: Equipment Under Test  
LISN: Line Impedance Stabilization Network  
Test table height=0.8m

##### 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. The adapter received AC120V/60Hz 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.
8. During the above scans, the emissions were maximized by cable manipulation.

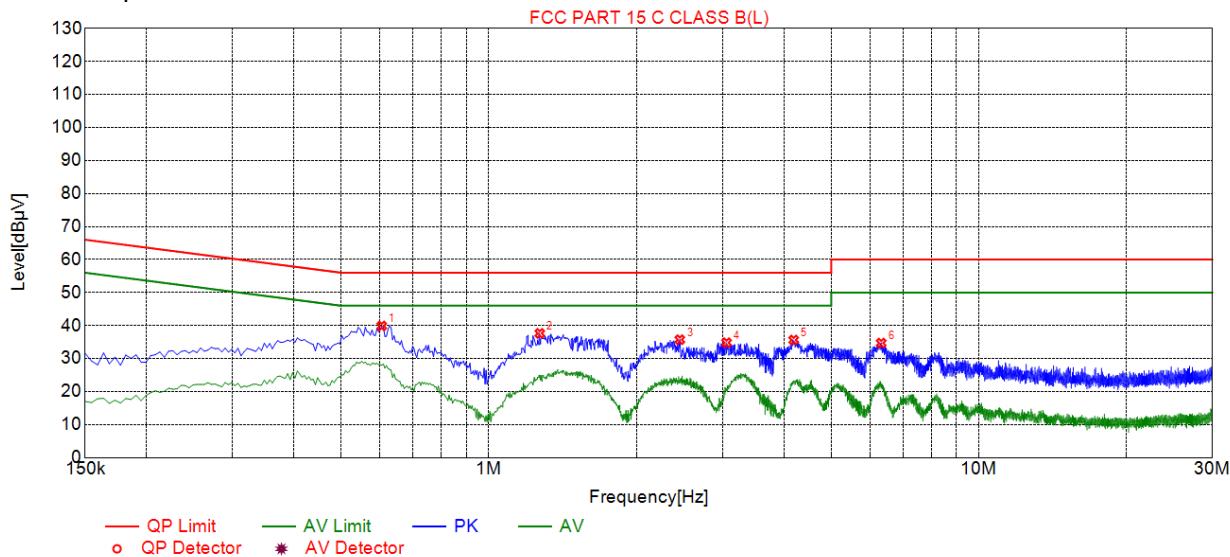
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## Test Results

All modes have been tested, only the worst result was reported as below:

Test Specification: Line



## Suspected List

NO.	Freq. [MHz]	Level [dBμV]	Factor [dB]	Limit [dBμV]	Margin [dB]	Reading [dBμV]	Detector	Type
1	0.6045	39.89	20.05	56.00	16.11	19.84	PK	L
2	1.2705	37.64	20.09	56.00	18.36	17.55	PK	L
3	2.4540	35.72	20.19	56.00	20.28	15.53	PK	L
4	3.0570	34.81	20.22	56.00	21.19	14.59	PK	L
5	4.1910	35.63	20.25	56.00	20.37	15.38	PK	L
6	6.3240	34.70	20.22	60.00	25.30	14.48	PK	L

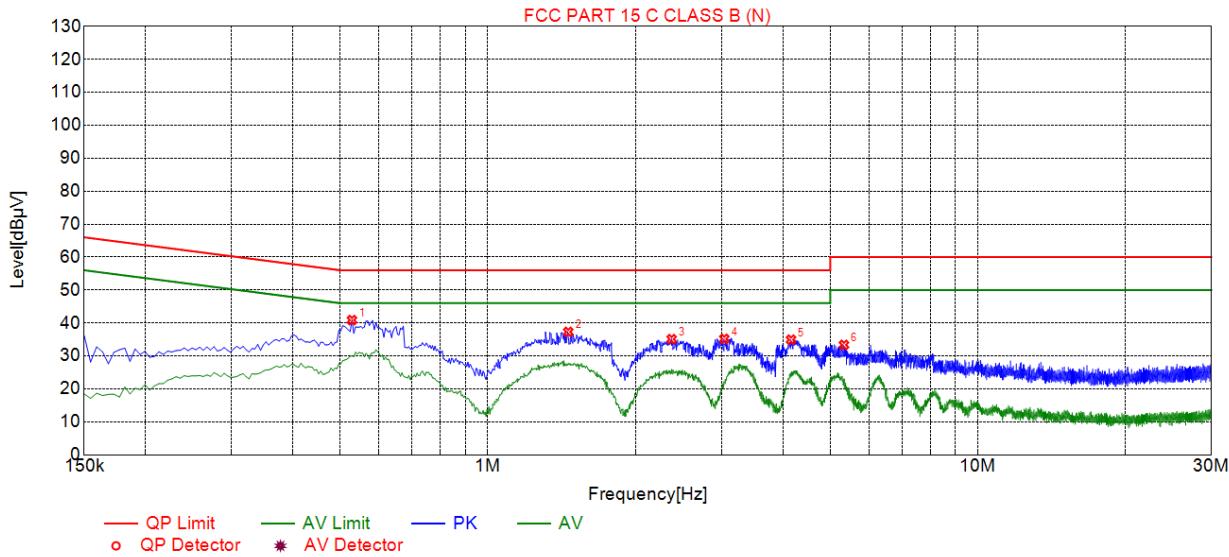
Remark: Margin = Limit – Level

Correction factor = Cable lose + LISN insertion loss

Level=Test receiver reading + correction factor



Test Specification: Neutral



## Suspected List

NO.	Freq. [MHz]	Level [dBμV]	Factor [dB]	Limit [dBμV]	Margin [dB]	Reading [dBμV]	Detector	Type
1	0.5280	40.88	20.04	56.00	15.12	20.84	PK	N
2	1.4595	37.30	20.10	56.00	18.70	17.20	PK	N
3	2.3730	35.09	20.18	56.00	20.91	14.91	PK	N
4	3.0390	35.18	20.22	56.00	20.82	14.96	PK	N
5	4.1595	34.93	20.25	56.00	21.07	14.68	PK	N
6	5.3340	33.35	20.26	60.00	26.65	13.09	PK	N

Remark: Margin = Limit – Level

Correction factor = Cable lose + LISN insertion loss

Level=Test receiver reading + correction factor



## 3.2. Radiated Emissions and Band Edge

### Limit

For intentional device, according to § 15.209(a), the general requirement of field strength of radiated emission out of authorized band shall not exceed the following table at a 3 meters measurement distance.

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)

Except when the requirements applicable to a given device state otherwise, emissions from License-Exempt transmitters shall comply with the field strength limits shown in table below. Additionally, the level of any transmitter emission shall not exceed the level of the transmitter's fundamental emission

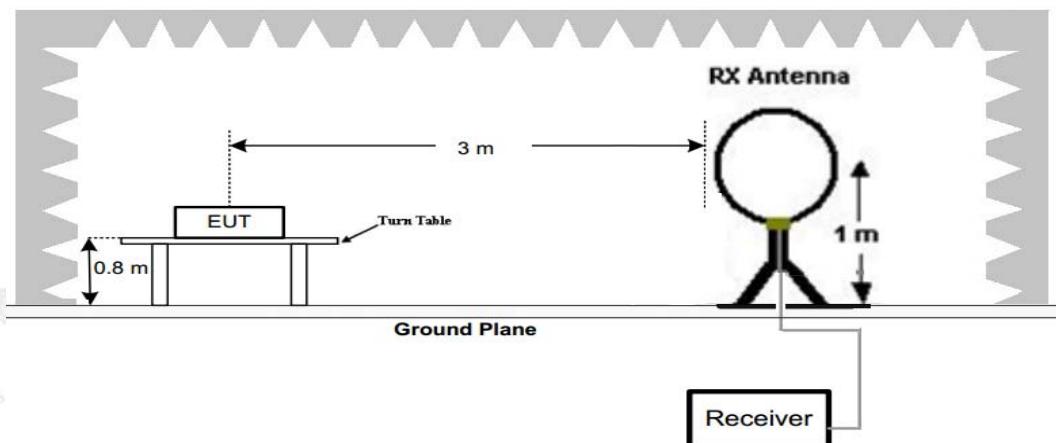
Unwanted emissions that fall into restricted bands shall comply with the limits specified in RSS-Gen; and Unwanted emissions that do not fall within the restricted frequency bands shall comply either with the limits specified in the applicable RSS or with those specified in this RSS-Gen.

Radiated Emission Limits

Frequency (MHz)	Distance (Meters)	Radiated (dB $\mu$ V/m)	Radiated ( $\mu$ V/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

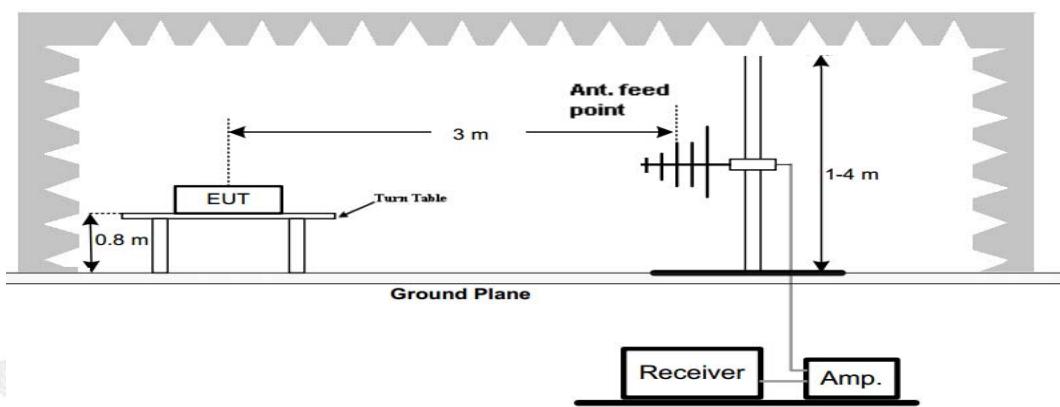
### Test Configuration

(A) Radiated Emission Test Set-Up, Frequency Below 30MHz

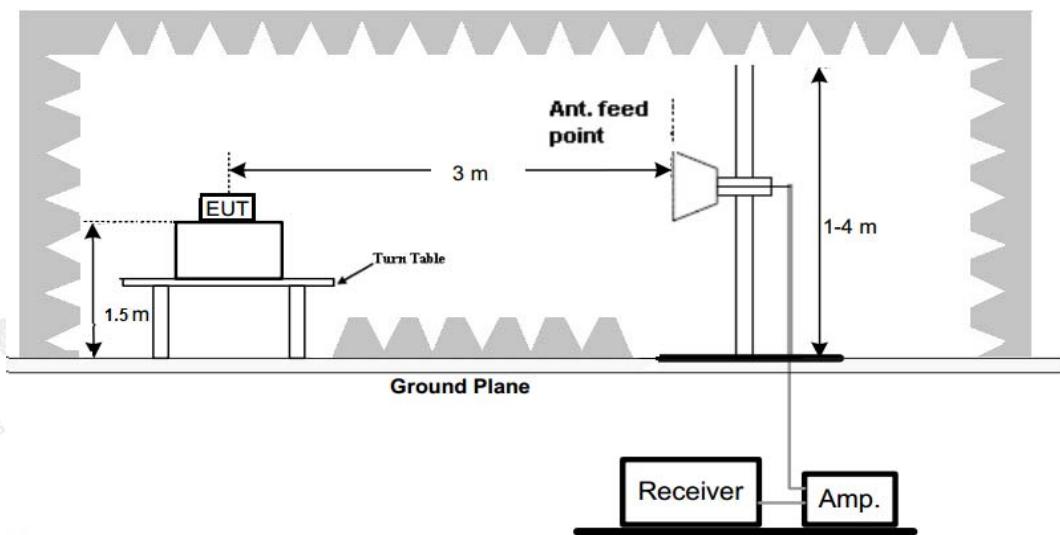




(B) Radiated Emission Test Set-Up, Frequency below 1000MHz



(C) Radiated Emission Test Set-Up, Frequency above 1000MHz



### Test Procedure

1. The EUT was placed on turn table which is 0.8m above ground plane for below 1GHz test, and on a low permittivity and low loss tangent turn table which is 1.5m above ground plane for above 1GHz test.
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.

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## Test Results

### Remark:

1. Radiated Emission measured at GFSK,  $\pi/4$  DQPSK mode from 9 KHz to 10th harmonic of fundamental and recorded worst case at GFSK DH5 mode.
2. There is no emission found except system noise floor in 9 KHz to 30MHz and not recorded in this report.
3. For below 1GHz testing recorded worst at GFSK DH5 low channel.

### Below 1GHz Test Results:

Antenna polarity: H

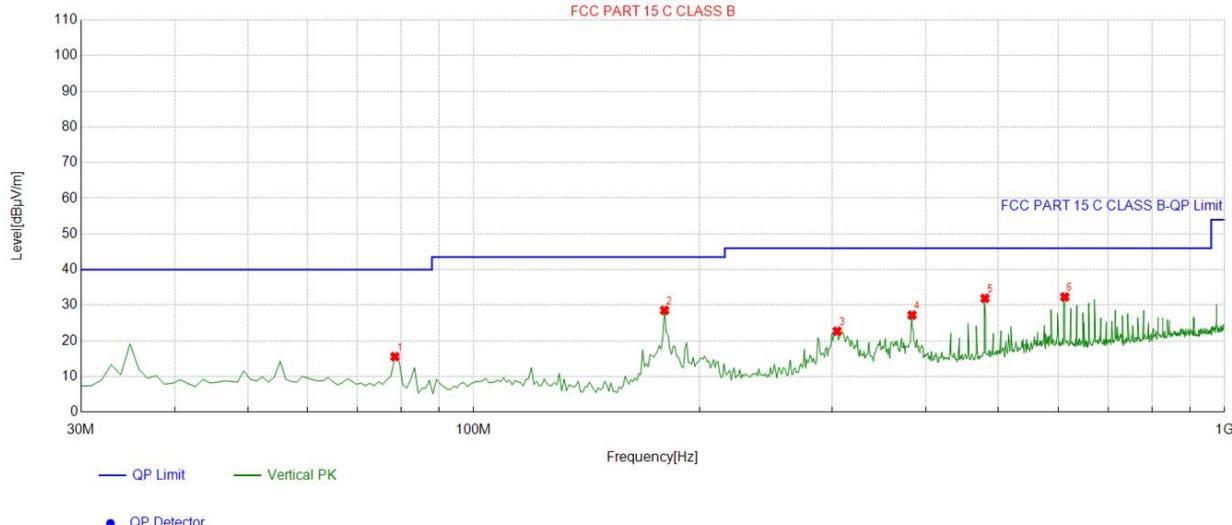


Suspected List									
NO.	Freq. [MHz]	Factor [dB]	Reading [dB $\mu$ V/m]	Level [dB $\mu$ V/m]	Limit [dB $\mu$ V/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	179.52953	-17.28	55.79	38.51	43.50	4.99	100	47	Horizontal
2	308.66866	-11.86	44.75	32.89	46.00	13.11	100	121	Horizontal
3	383.43343	-10.48	47.12	36.64	46.00	9.36	100	267	Horizontal
4	479.55956	-7.79	45.35	37.56	46.00	8.44	100	197	Horizontal
5	671.81181	-4.12	42.96	38.84	46.00	7.16	100	305	Horizontal
6	840.76076	-1.42	42.67	41.25	46.00	4.75	100	80	Horizontal

Remark: Factor = Cable loss + Antenna factor – Preamplifier; Level = Reading + Factor; Margin = Limit – Level;



Antenna polarity: V



Suspected List									
NO.	Freq. [MHz]	Factor [dB]	Reading [dB $\mu$ V/m]	Level [dB $\mu$ V/m]	Limit [dB $\mu$ V/m]	Margin [dB]	Height [cm]	Angle [°]	Polarity
1	78.548549	-17.29	32.87	15.58	40.00	24.42	100	28	Vertical
2	179.52953	-17.28	45.85	28.57	43.50	14.93	100	135	Vertical
3	304.78478	-11.92	34.64	22.72	46.00	23.28	100	3	Vertical
4	383.43343	-10.48	37.69	27.21	46.00	18.79	100	359	Vertical
5	479.55956	-7.79	39.72	31.93	46.00	14.07	100	112	Vertical
6	612.58258	-4.69	37.01	32.32	46.00	13.68	100	195	Vertical

Remark: Factor = Cable loss + Antenna factor – Preamplifier; Level = Reading + Factor; Margin = Limit – Level;

## Harmonics and Spurious Emissions

### Frequency Range (9 kHz-30MHz)

Frequency (MHz)	Level@3m (dB $\mu$ V/m)	Limit@3m (dB $\mu$ V/m)
--	--	--
--	--	--
--	--	--
--	--	--

**Note:** 1. Emission Level=Reading+ Cable loss+ Antenna factor-Amp factor

2. The emission levels are 20 dB below the limit value, which are not reported. It is deemed to comply with the requirement



For 1GHz to 25GHz

CH Low (2402MHz)

Horizontal:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
4804.00	51.12	-3.65	47.47	74.00	-26.53	peak
4804.00	45.56	-3.65	41.91	54.00	-12.09	AVG
7206.00	52.89	-0.95	51.94	74.00	-22.06	peak
7206.00	42.33	-0.95	41.38	54.00	-12.62	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
4804.00	53.46	-3.65	49.81	74.00	-24.19	peak
4804.00	46.19	-3.65	42.54	54.00	-11.46	AVG
7206.00	52.38	-0.95	51.43	74.00	-22.57	peak
7206.00	41.52	-0.95	40.57	54.00	-13.43	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.



CH Middle (2441MHz)

Horizontal:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
4882.00	54.16	-3.54	50.62	74.00	-23.38	peak
4882.00	44.21	-3.54	40.67	54.00	-13.33	AVG
7323.00	53.47	-0.81	52.66	74.00	-21.34	peak
7323.00	43.82	-0.81	43.01	54.00	-10.99	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
4882.00	51.09	-3.54	47.55	74.00	-26.45	peak
4882.00	43.27	-3.54	39.73	54.00	-14.27	AVG
7323.00	52.38	-0.81	51.57	74.00	-22.43	peak
7323.00	43.52	-0.81	42.71	54.00	-11.29	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.



CH High (2480MHz)

Horizontal:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
4960.00	54.16	-3.43	50.73	74.00	-23.27	peak
4960.00	46.07	-3.43	42.64	54.00	-11.36	AVG
7440.00	53.29	-0.77	52.52	74.00	-21.48	peak
7440.00	42.34	-0.77	41.57	54.00	-12.43	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
4960.00	51.29	-3.43	47.86	74.00	-26.14	peak
4960.00	46.21	-3.43	42.78	54.00	-11.22	AVG
7440.00	51.33	-0.77	50.56	74.00	-23.44	peak
7440.00	42.96	-0.77	42.19	54.00	-11.81	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Remark :

- (1) Measuring frequencies from 1 GHz to the 25 GHz.
- (2) "F" denotes fundamental frequency; "H" denotes spurious frequency. "E" denotes band edge frequency.
- (3) \* denotes emission frequency which appearing within the Restricted Bands specified in provision of 15.205, then the general radiated emission limits in 15.209 apply.
- (4) The emissions are attenuated more than 20dB below the permissible limits are not recorded in the report.
- (5) The IF bandwidth of EMI Test Receiver between 30MHz to 1GHz was 120KHz, 1 MHz for measuring above 1 GHz, below 30MHz was 10KHz. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 3MHz for peak measurement with peak detector at frequency above 1GHz. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 10Hz for Average measurement with peak detection at frequency above 1GHz.
- (6) When the test results of Peak Detected below the limits of Average Detected, the Average Detected is not need completed. For example: Top Channel at Fundamental 73.16dB $\mu$ V/m (PK Value) <93.98(AV Limit), at harmonic 53.20 dB $\mu$ V/m (PK Value) <54 dB $\mu$ V/m (AV Limit), the Average Detected not need to completed.
- (7) All modes of operation were investigated and the worst-case emissions are reported.



## Radiated Band Edge Test:

## Hopping

## Horizontal (Worst case):

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2310.00	53.08	-5.81	47.27	74	-26.73	peak
2310.00	/	-5.81	/	54	/	AVG
2390.00	54.15	-5.84	48.31	74	-25.69	peak
2390.00	/	-5.84	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

## Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2310.00	53.96	-5.81	48.15	74	-25.85	peak
2310.00	/	-5.81	/	54	/	AVG
2390.00	54.27	-5.84	48.43	74	-25.57	peak
2390.00	/	-5.84	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.



## Horizontal (Worst case):

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2483.50	54.83	-5.81	49.02	74	-24.98	peak
2483.50	/	-5.81	/	54	/	AVG
2500.00	55.71	-6.06	49.65	74	-24.35	peak
2500.00	/	-6.06	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

## Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2483.50	54.42	-5.81	48.61	74	-25.39	peak
2483.50	/	-5.81	/	54	/	AVG
2500.00	55.49	-6.06	49.43	74	-24.57	peak
2500.00	/	-6.06	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Remark: All the other emissions not reported were too low to read and deemed to comply with FCC limit.



NO Hopping

Operation Mode: TX CH Low (2402MHz)

Horizontal (Worst case):

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2310.00	53.58	-5.81	47.77	74	-26.23	peak
2310.00	/	-5.81	/	54	/	AVG
2390.00	53.17	-5.84	47.33	74	-26.67	peak
2390.00	/	-5.84	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2310.00	53.92	-5.81	48.11	74	-25.89	peak
2310.00	/	-5.81	/	54	/	AVG
2390.00	53.38	-5.84	47.54	74	-26.46	peak
2390.00	/	-5.84	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.



Operation Mode: TX CH High (2480MHz)

Horizontal (Worst case):

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2483.50	53.06	-5.81	47.25	74	-26.75	peak
2483.50	/	-5.81	/	54	/	AVG
2500.00	53.15	-6.06	47.09	74	-26.91	peak
2500.00	/	-6.06	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Vertical:

Frequency (MHz)	Meter Reading (dB $\mu$ V)	Factor (dB)	Emission Level (dB $\mu$ V/m)	Limits (dB $\mu$ V/m)	Margin (dB)	Detector Type
2483.50	53.29	-5.81	47.48	74	-26.52	peak
2483.50	/	-5.81	/	54	/	AVG
2500.00	55.48	-6.06	49.42	74	-24.58	peak
2500.00	/	-6.06	/	54	/	AVG

Remark: Factor = Antenna Factor + Cable Loss – Pre-amplifier; Level = Reading + Factor; Margin = Level - Limit.

Remark: All the other emissions not reported were too low to read and deemed to comply with FCC limit.

Remark:

1. If the PK measured levels comply with average limit, then the average level were deemed to comply with average limit.
2. In restricted bands of operation, the spurious emissions below the permissible value more than 20dB.
3. The amplitude of spurious emissions which are attenuated by more than 20dB below the permissible value has no need to be reported.



### 3.3. Maximum Peak Conducted Output Power

#### Limit

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

#### Test Procedure

Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the power sensor.

#### Test Configuration



#### Test Results

Type	Channel	Maximum Peak Conducted Output Power (dBm)	Limit (dBm)	Result
GFSK	00	-6.56	21.00	Pass
	39	-6.17		
	78	-6.36		
$\pi/4$ DQPSK	00	-6.17	21.00	Pass
	39	-5.73		
	78	-5.71		

Note: The test results including the cable loss.



### 3.4. 20dB Bandwidth

#### Limit

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

#### 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 30 KHz RBW and 100 KHz VBW.

The 20dB bandwidth is defined as the total spectrum the power of which is higher than peak power minus 20dB.

The occupied bandwidth is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission. The following procedure shall be used for measuring 99% power bandwidth:

RBW=1% to 5% of the OBW

VBW=approximately 3 X RBW

Detector=Peak

Trace Mode: Max Hold

Use the 99% power bandwidth function of the instrument to measure the Occupied Bandwidth and recoded.

#### Test Configuration



#### Test Results

Modulation	Channel	20dB Bandwidth (MHz)	Result
GFSK	CH00	0.954	Pass
	CH39	0.957	
	CH78	0.957	
$\pi/4$ DQPSK	CH00	1.374	Pass
	CH39	1.374	
	CH78	1.338	

**Test plot as follows:**

20dB Bandwidth

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

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*π/4DQPSK Modulation*

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### 3.5. Frequency Separation

#### Limit

Frequency hopping systems shall have hopping channel carrier frequencies separated by minimum of 25 KHz or the  $2/3 \times 20$ dB bandwidth of the hopping channel, whichever is greater.

#### 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 30 KHz RBW and 100 KHz VBW.

#### Test Configuration



#### Test Results

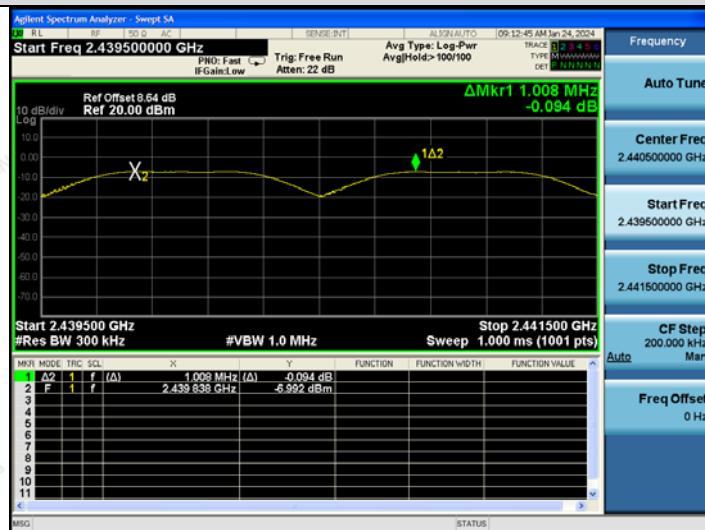
Modulation	Channel	Channel Separation (MHz)	Limit(MHz)	Result
GFSK	CH39	1.008	0.638	Pass
	CH40			
$\pi/4$ DQPSK	CH39	1.002	0.916	Pass
	CH40			

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

#### Test plot as follows:



## Frequency Separation



## GFSK



## π/4DQPSK

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### 3.6. Number of Hopping Frequency

#### Limit

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

#### Test Procedure

The transmitter output was connected to the spectrum analyzer through an attenuator. Set spectrum analyzer start 2400MHz to 2483.5MHz.

#### Test Configuration



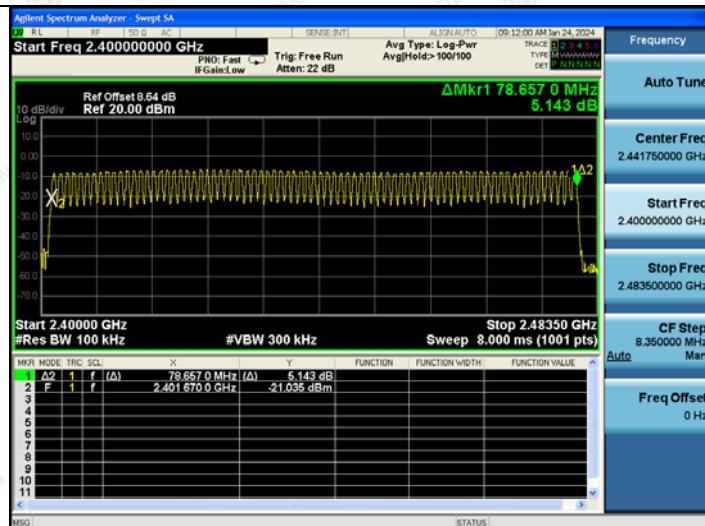
#### Test Results

Modulation	Number of Hopping Channel	Limit	Result
GFSK	79	≥15	Pass
π/4DQPSK	79		

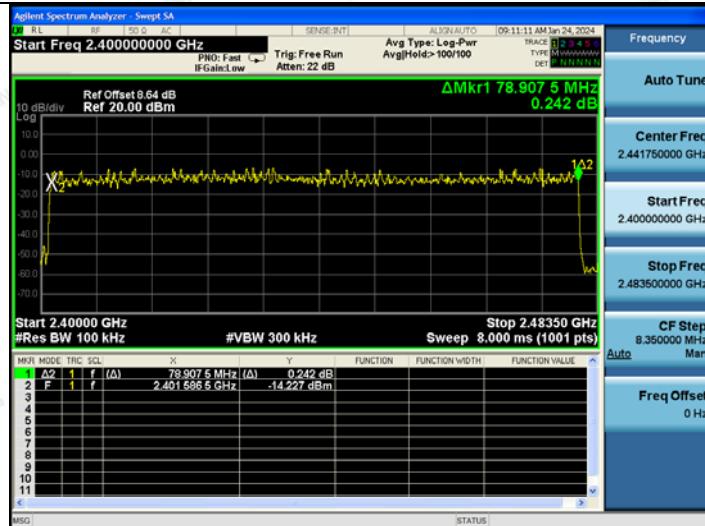
Test plot as follows:



## GFSK Modulation



## π/4DQPSK Modulation



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### 3.7. Time of Occupancy (Dwell Time)

#### Limit

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.

#### Test Procedure

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

#### Test Configuration



#### Test Results

Modulation	Packet	Pulse time (ms)	Dwell time (second)	Limit (second)	Result
GFSK	DH1	0.375	0.120	0.40	Pass
	DH3	1.630	0.261		
	DH5	2.878	0.307		
$\pi/4$ DQPSK	2-DH1	0.385	0.123	0.40	Pass
	2-DH3	1.637	0.262		
	2-DH5	2.884	0.308		

Note:

1. We have tested all mode at high, middle and low channel, and recorded worst case at middle channel.
2. Dwell time= Pulse time (ms)  $\times$  (1600  $\div$  2  $\div$  79)  $\times$  31.6 Second for DH1, 2-DH1

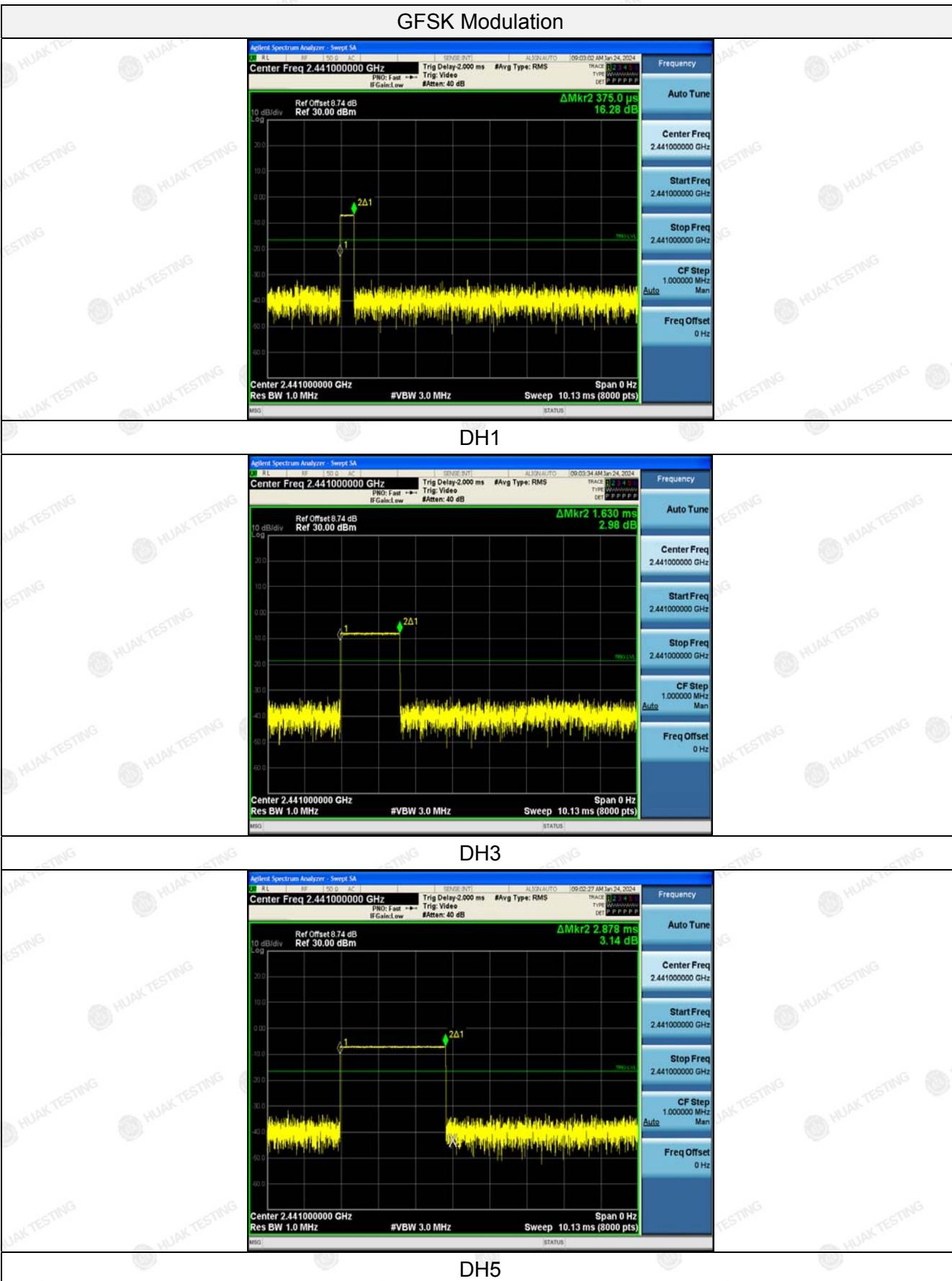
Dwell time= Pulse time (ms)  $\times$  (1600  $\div$  4  $\div$  79)  $\times$  31.6 Second for DH3, 2-DH3

Dwell time= Pulse time (ms)  $\times$  (1600  $\div$  6  $\div$  79)  $\times$  31.6 Second for DH5, 2-DH5

Test plot as follows:



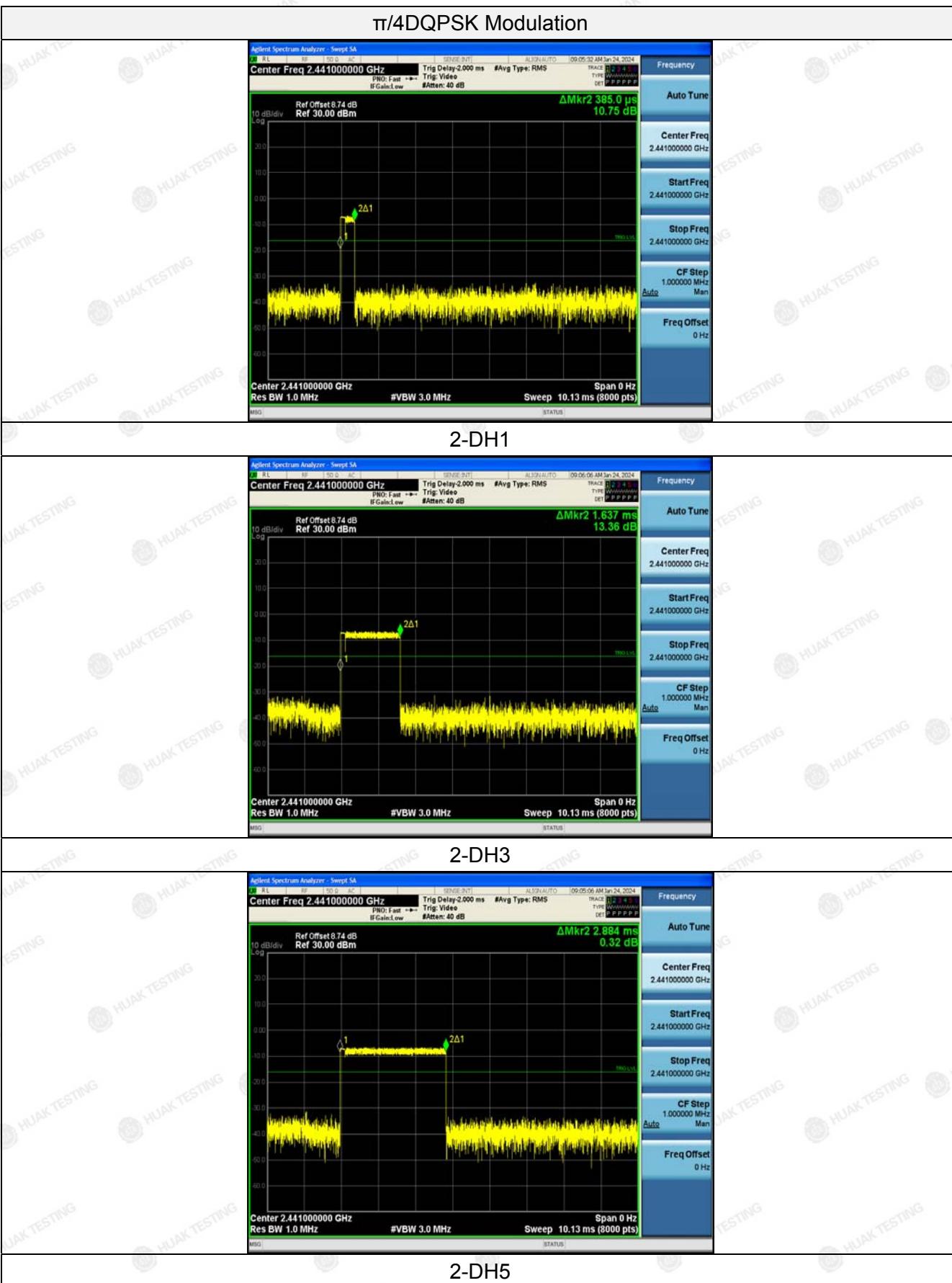
## GFSK Modulation



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### π/4DQPSK Modulation



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### 3.8. Out-of-Band Emissions

#### Limit

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 any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

#### Test Procedure

Connect the transmitter output to spectrum analyzer using a low loss RF cable, and set the spectrum analyzer to RBW=100 kHz, VBW= 300 kHz, peak detector , and max hold. Measurements utilizing these setting are made of the in-band reference level, band edge and out-of-band emissions.

#### Test Configuration



#### 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 bandage measurement data.

We measured all conditions (DH1, DH3, DH5) and recorded worst case at DH5 and 2DH5

Test plot as follows:

## GFSK

CHOO



CH39



The screenshot displays the Agilent Spectrum Analyzer software interface. The main window shows a signal plot with a central frequency of 148.01 MHz and a power level of -60.285 dBm. The plot includes a reference offset of 8.74 dB and a reference level of 18.74 dBm. The x-axis represents frequency from 30.000 MHz to 10.000 GHz, and the y-axis represents power from -110 to 0 dB. The software interface includes several panels and status bars. The top status bar shows the date and time (08:47:12 AM Jun 24, 2024). The left panel shows the center frequency as 515.000000 MHz. The bottom status bar displays the start frequency (30.000000 MHz), stop frequency (10.000000 GHz), center frequency (148.01 MHz), resolution bandwidth (100 kHz), and sweep width (30001 pnts). The right side of the interface shows various configuration buttons and status indicators for frequency, power, and signal processing.

The screenshot shows a spectrum analysis interface. The center frequency is set to 515.000000 MHz. A signal is detected at 287.99 MHz with a power level of -56.549 dBm. The signal is labeled 'Mkr1' with a green diamond marker. The x-axis represents frequency from 30.000000 MHz to 1.0000000 GHz, and the y-axis represents power from -12.00 to 0.00 dB. The 'Freq Offset' is set to 0 Hz. The 'Stop Freq' is at 1.0000000 GHz, and the 'CF Step' is at 97.000000 MHz. The 'Start Freq' is at 30.000000 MHz. The 'Center Freq' is at 515.000000 MHz. The 'Ref Offset' is 8.74 dB, and the 'Ref' level is 18.74 dBm. The 'Sweep' parameters are Stop 1.0000 GHz, Sweep 94.00 ms (30001 pts), and Res BW 100 kHz. The 'VBW' is 300 kHz. The 'Trig' settings include Trig Type: Run, Trig Source: Internal, and Trig Level: 20 dB. The 'Averaging' settings are Avg Type: RMS, Avg Hold: 10/10, and Det: FPPPP. The 'Status' bar at the bottom shows the date and time as 09/31/2014 10:14:24.

The screenshot shows the Agilent Spectrum Analyzer software interface. The main window displays a spectrum plot with a yellow signal line. The plot includes markers for 'Ref Offset 8.74 dB' and 'Ref 18.74 dBm'. The right side of the interface shows a summary table with the following data:

Parameter	Value
Avg Type	RMS
Avg Hold	10/10
Type	DET
DET	P F P P P P
Mkr2	2.586 10 GHz -43.296 dBm
Start Freq	13.750000000 GHz
Stop Freq	1.000000000 GHz
CF Step	26.500000000 GHz
Auto	Man
Freq Offset	0 Hz

Below the plot, a table lists various parameters:

MRB MODE	TRC SDI	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	2.401 65 GHz	-7.737 dBm		
2	N	1	2.586 10 GHz	-43.296 dBm		
3						
4						
5						
6						
7						
8						
9						
10						
11						
0						

At the bottom, there are 'MSG' and 'STATUS' buttons.

Center Freq 13.750000000 GHz

Ref Offset 9.74 dB

Ref 18.74 dBm

Marker 2 25.24285 GHz -48.585 dBm

Start 1.00 GHz #Res BW 100 kHz #VBW 300 kHz Stop 26.50 GHz Sweep 2.438 s (3001 pts)

CF Step 2.550000000 GHz Auto

Freq Offset 0 Hz

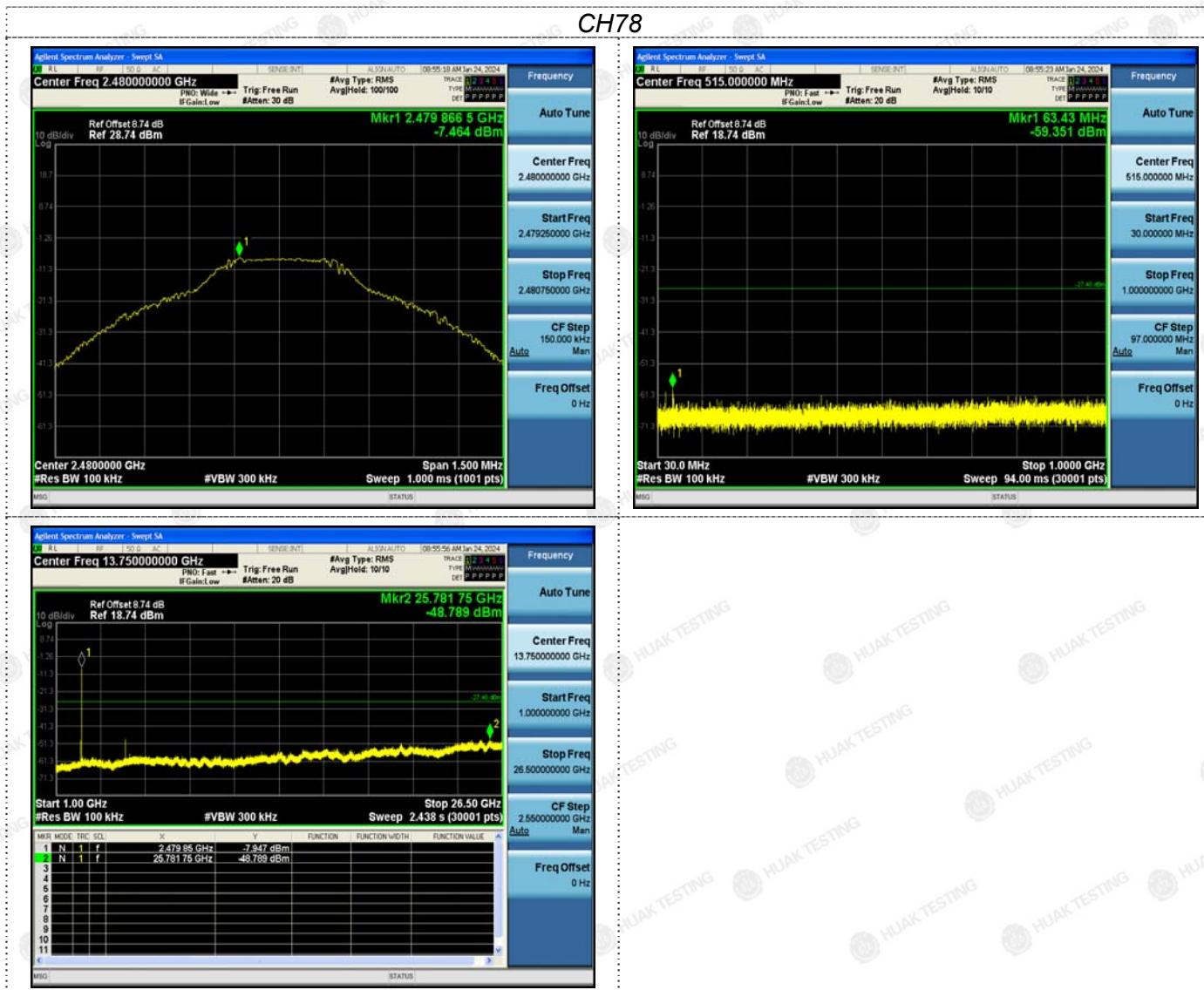
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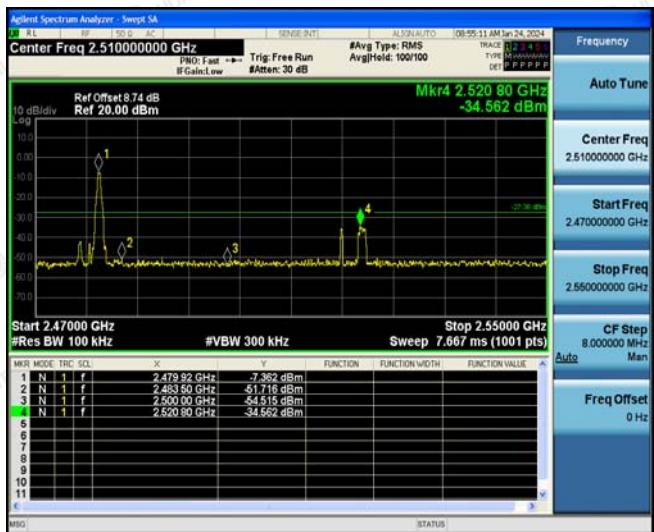
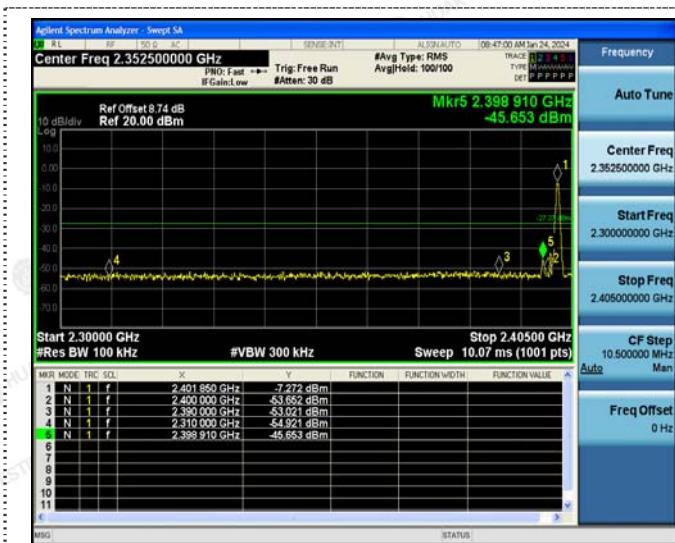
## CH78



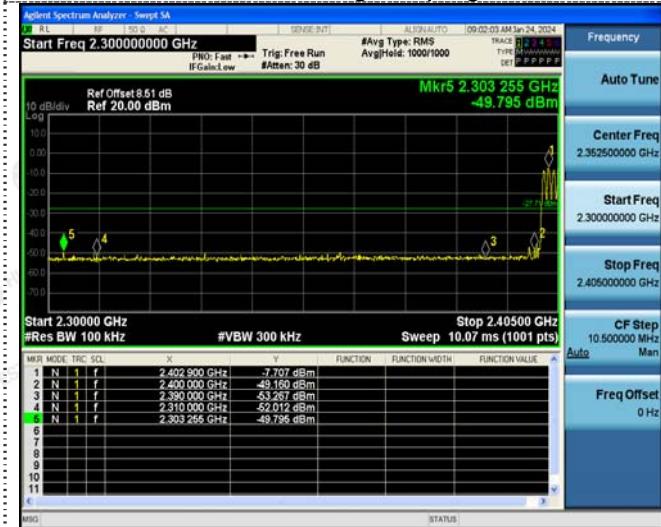
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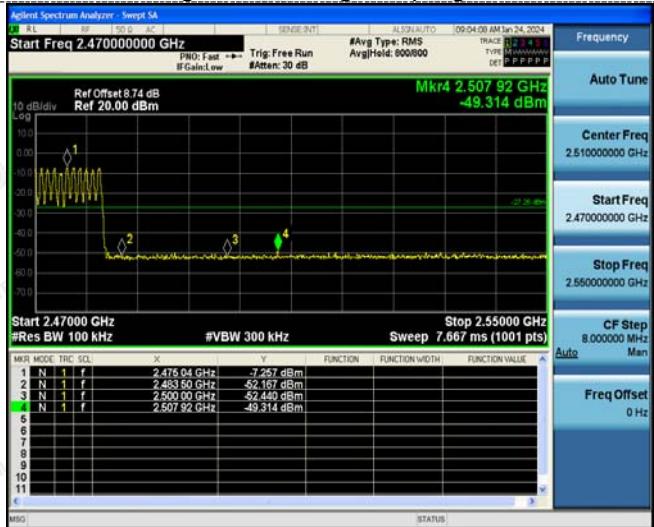
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Left Band edge hoping off



Left Band edge hoping on

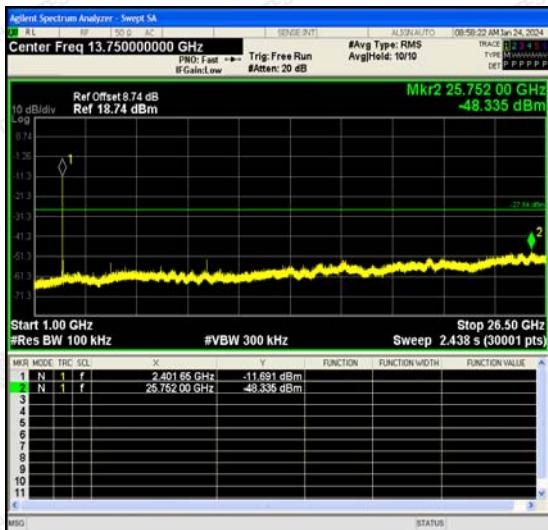
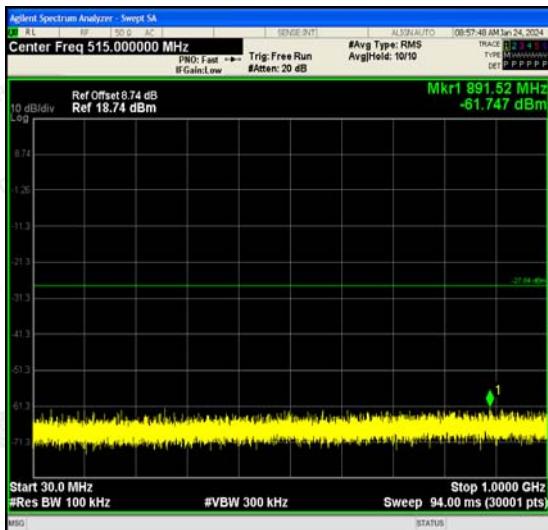


Right Band edge hoping on

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**π/4DQPSK****CH00****CH39**

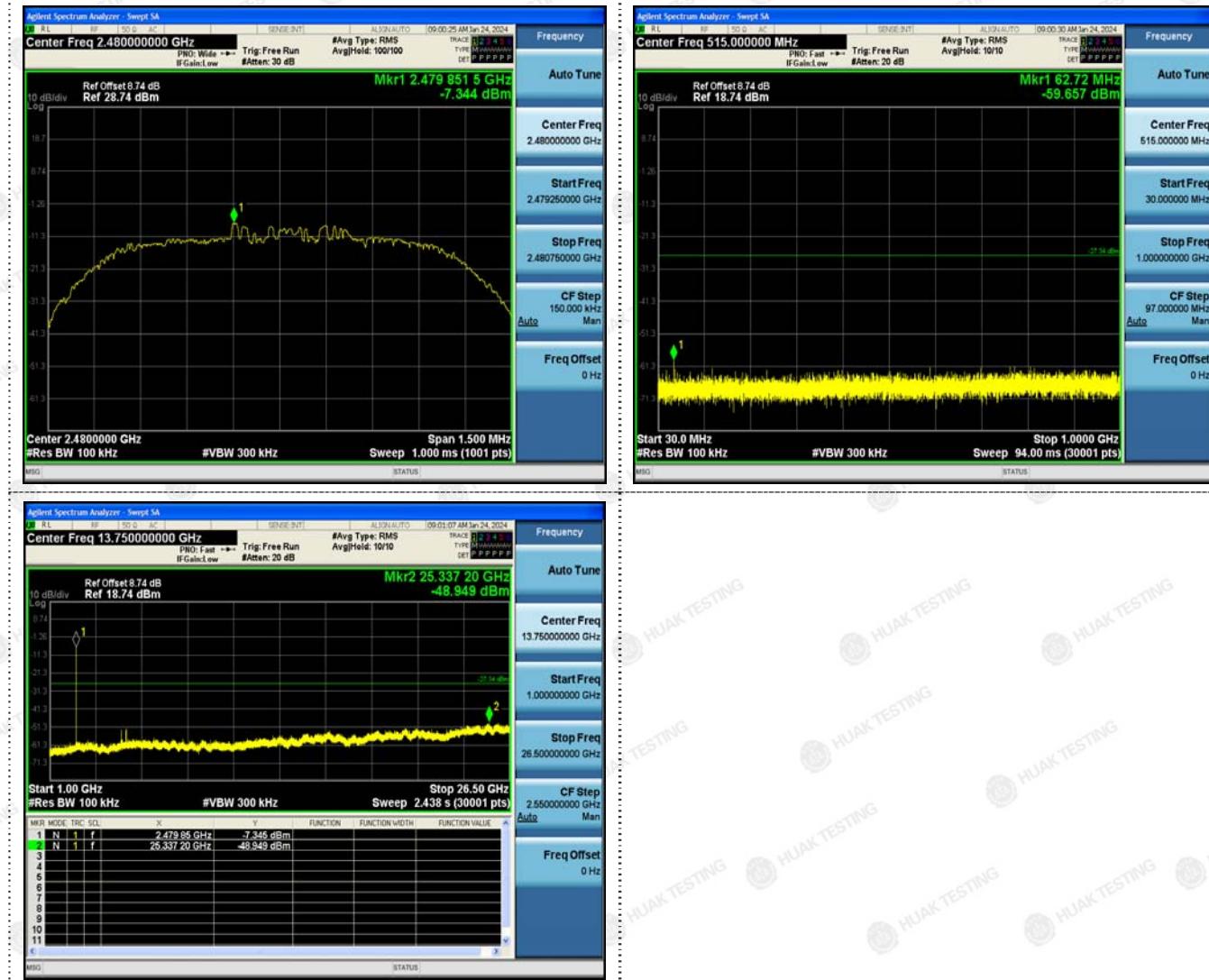
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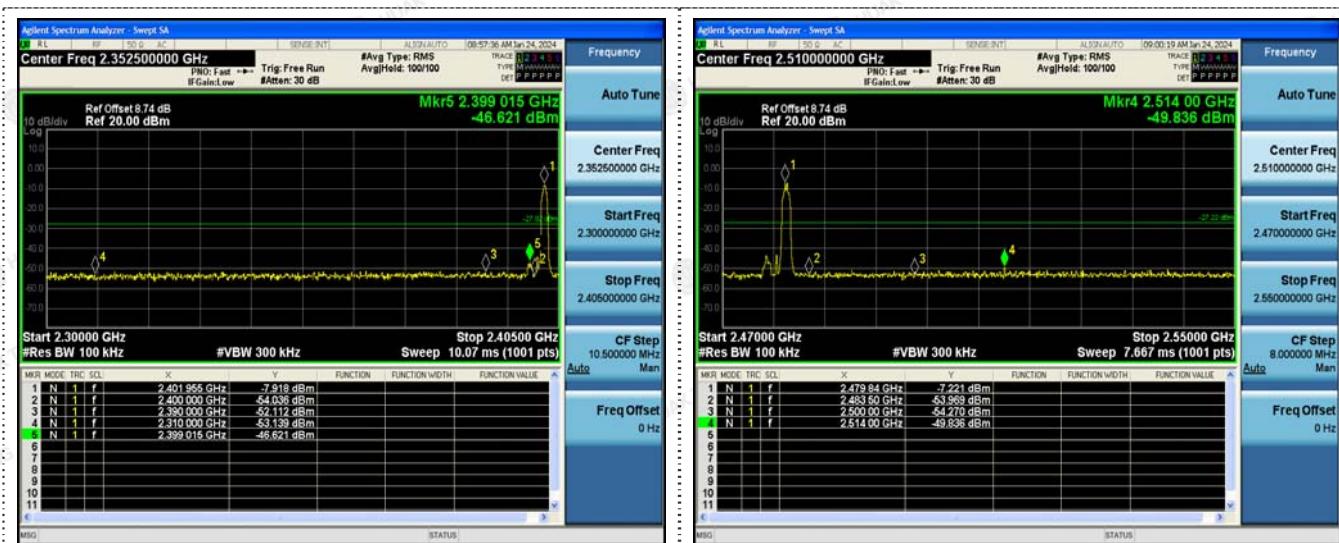
## CH78



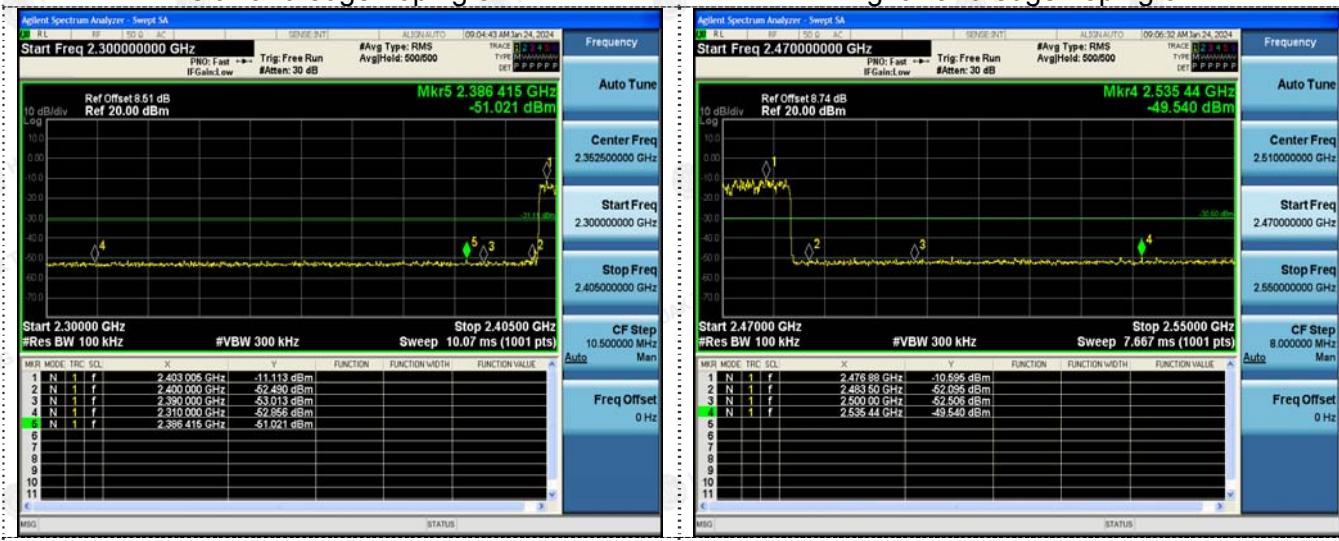
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Left Band edge hoping off



Left Band edge hoping on

Right Band edge hoping on

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### 3.9. Pseudorandom Frequency Hopping Sequence

#### Test Applicable

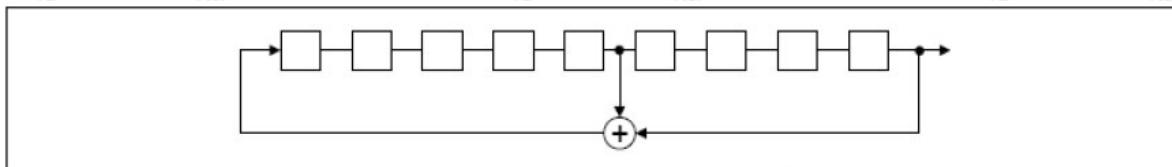
##### **For 47 CFR Part 15C section 15.247 (a) (1):**

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

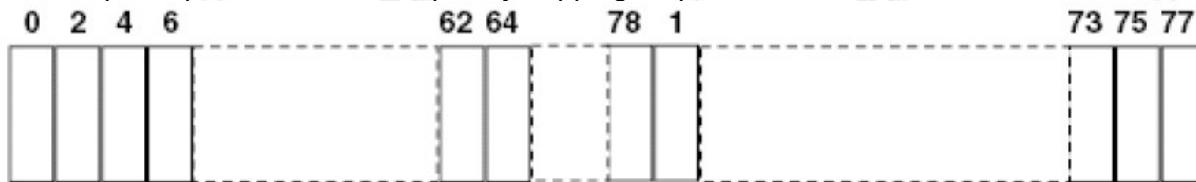
The pseudorandom frequency hopping sequence may be generated in a nine-stage shift register whose 5<sup>th</sup> and 9<sup>th</sup> stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive 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 example 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.



### 3.10. 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, 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.

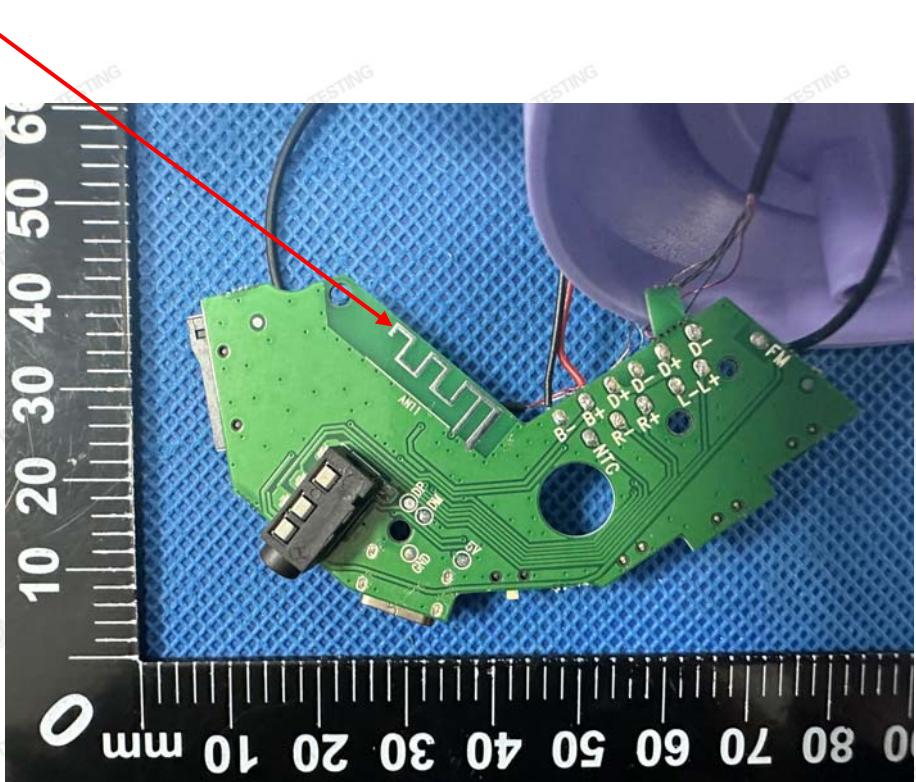
#### Refer to Statement below for Compliance

The manufacturer may design the unit so that the user can replace a broken antenna, 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.

#### Antenna Connected Construction

The antenna used in this product is a PCB Antenna, is a permanently attached antenna on the PCB. It conforms to the standard requirements. The directional gains of antenna used for transmitting is -0.58dBi.

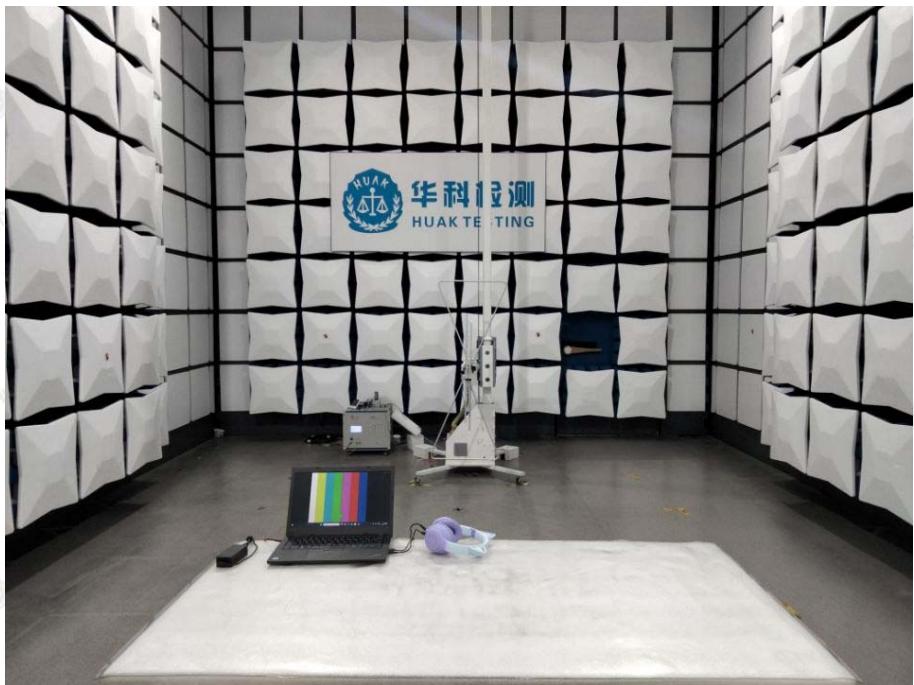
#### Antenna





## 4. Test Setup Photos of the EUT

Radiated Emission



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**Conducted Emission**

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## 5. Photos of the EUT

Reference to the report: ANNEX A of external photos and ANNEX B of internal photos

-----End of test report-----