

FCC TEST REPORT

FCC ID : O58-WLMS0002
Applicant : Carbon Audio, LLC
Address : 340 SE 6th Street Portland, Oregon 97204, United States
Manufacturer : Shenzhen 3nod Digital Technology Co., Ltd.
Address : Building D Park 8# Road Tangxiayong Village, Industrial Zone Songgang Town, Baoan District, Shenzhen City, China
Equipment Under Test (EUT) :
Product Name : Wireless Pocket Speaker
Model No. : WLMS-0002
Standards : FCC Part15.247:2012
Date of Test : August 14~19, 2013
Date of Issue : August 29, 2013

Test Result : PASS**Remark:**

* The sample described above has been tested to be in compliance with the requirements of ANSI C63.4:2003. The test results have been reviewed and comply with the rules listed above and found to meet their essential requirements.

The results shown in this test report refer only to the sample(s) tested, this test report cannot be reproduced, except in full, without prior written permission of the company.

The report would be invalid without specific stamp of test institute and the signatures of compiler and approver.

Prepared By:

Waltek Services (Shenzhen) Co., Ltd.

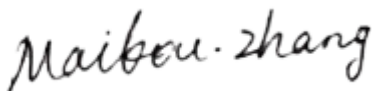
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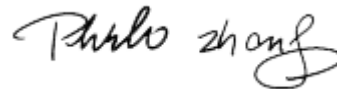
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Compiled by:

Approved by:



Maikou Zhang / Project Engineer



Philo Zhong / Manager

2 Test Summary

Test Items	Test Requirement	Result
Spurious Radiated Emissions	15.205(a) 15.209 15.247(d)	PASS
Band edge Emissions	15.247(d)	PASS
Spurious RF Conducted Emissions from out of band	15.247(d)	PASS
Duty Cycle	15.35	PASS
Conducted Emissions	15.207	PASS
20dB Bandwidth	15.215c 15.247(a)(1)	PASS
Maximum Peak Output Power	15.247(b)(1)	PASS
Frequency Separation	15.247(a)(1)	PASS
Number of Hopping Frequency	15.247(a)(1)(iii)	PASS
Dwell time	15.247(a)(1)(iii)	PASS
Maximum Permissible Exposure (Exposure of Humans to RF Fields)	1.1307(b)(1)	PASS

3 Contents

	Page
1 COVER PAGE	1
2 TEST SUMMARY.....	2
3 CONTENTS.....	3
4 GENERAL INFORMATION	5
4.1 GENERAL DESCRIPTION OF E.U.T.....	5
4.2 DETAILS OF E.U.T.....	5
4.3 CHANNEL LIST	5
4.4 DESCRIPTION OF SUPPORT UNITS.....	5
4.5 TEST FACILITY	6
4.6 TEST LOCATION.....	6
5 EQUIPMENT USED DURING TEST.....	7
5.1 EQUIPMENTS LIST	7
5.2 MEASUREMENT UNCERTAINTY.....	7
5.3 TEST EQUIPMENT CALIBRATION	7
6 CONDUCTED EMISSION.....	8
6.1 E.U.T. OPERATION.....	8
6.2 EUT SETUP	8
6.3 CONDUCTED EMISSION TEST RESULT.....	9
7 SPURIOUS RADIATED EMISSIONS.....	11
7.1 EUT OPERATION :	11
7.2 TEST SETUP	12
7.3 SPECTRUM ANALYZER SETUP	13
7.4 TEST PROCEDURE.....	14
7.5 CORRECTED AMPLITUDE & MARGIN CALCULATION	14
7.6 SUMMARY OF TEST RESULTS	15
8 SPURIOUS RF CONDUCTED EMISSIONS FROM OUT OF BAND	23
8.1 TEST PROCEDURE.....	23
8.2 TEST RESULT	23
9 DUTY CYCLE.....	33
9.1 TEST PROCEDURE.....	33
9.2 TEST RESULT	33
10 BAND EDGE MEASUREMENT	35
10.1 TEST PROCEDURE.....	35
10.2 TEST RESULT:.....	36
11 20 DB BANDWIDTH MEASUREMENT	40
11.1 TEST PROCEDURE:	40
11.2 TEST RESULT:.....	40
12 MAXIMUM PEAK OUTPUT POWER	46
12.1 TEST PROCEDURE:	46
12.2 TEST RESULT:.....	46
13 HOPPING CHANNEL SEPARATION.....	52
13.1 TEST PROCEDURE:	52
13.2 TEST RESULT:.....	52

14	NUMBER OF HOPPING FREQUENCY	58
14.1	TEST PROCEDURE:	58
14.2	TEST RESULT:	58
15	DWELL TIME.....	60
15.1	TEST PROCEDURE:	60
15.2	TEST RESULT:	60
16	ANTENNA REQUIREMENT.....	76
17	RF EXPOSURE	77
17.1	REQUIREMENTS:	77
17.2	TEST RESULT	77
18	PHOTOGRAPHS – TEST SETUP	78
18.1	CONDUCTED EMISSIONS	78
18.2	RADIATED EMISSIONS.....	78
19	PHOTOGRAPHS - CONSTRUCTIONAL DETAILS.....	80
19.1	EUT – EXTERNAL VIEW	80
19.2	EUT – INTERNAL VIEW	82

4 General Information

4.1 General Description of E.U.T.

Product Name	: Wireless Pocket Speaker
Model No.	: WLMS-0002
Model Description	: N/A
Operation Frequency	: 2402MHz ~ 2480MHz, 79 channels in total, separated by 1MHz
Type of Modulation	: GFSK, Pi/4DQPSK, 8DPSK
Oscillator	: Crystal 26MHz for RF module
Antenna installation	: PCB Printed Antenna
Antenna Gain	: 0dBi

4.2 Details of E.U.T.

Technical Data	: (1)DC 5V, 1A for USB Charging (2)DC 3.7V, 1000mAh for Internal lithium battery
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4.3 Channel List

Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)	Channel No.	Frequency (MHz)
1	2402	2	2403	3	2404	4	2405
5	2406	6	2407	7	2408	8	2409
9	2410	10	2411	11	2412	12	2413
13	2414	14	2415	15	2416	16	2417
17	2418	18	2419	19	2420	20	2421
21	2422	22	2423	23	2424	24	2425
25	2426	26	2427	27	2428	28	2429
29	2430	30	2431	31	2432	32	2433
33	2434	34	2435	35	2436	36	2437
37	2438	38	2439	39	2440	40	2441
41	2442	42	2443	43	2444	44	2445
45	2446	46	2447	47	2448	48	2449
49	2450	50	2451	51	2452	52	2453
53	2454	54	2455	55	2456	56	2457
57	2458	58	2459	59	2460	60	2461
61	2462	62	2463	63	2464	64	2465
65	2466	66	2467	67	2468	68	2469
69	2470	70	2471	71	2472	72	2473
73	2474	74	2475	75	2476	76	2477
77	2478	78	2479	79	2480	-	-

4.4 Description of Support Units

No.	Equipment	Manufacturer	Model No.	Serial No.
1.	Notebook	LENOVO	X201i	75Y4408

4.5 Test Facility

The test facility has a test site registered with the following organizations:

- **IC – Registration No.: 7760A**

Waltek Services(Shenzhen) Co., Ltd. has been registered and fully described in a report filed with the Industry Canada. The acceptance letter from the Industry Canada is maintained in our files. Registration 7760A, July 12, 2012.

- **FCC – Registration No.: 880581**

Waltek Services(Shenzhen) Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files. Registration 880581, May 26, 2011.

4.6 Test Location

All the tests were performed at:

Waltek Services(Shenzhen) Co., Ltd. at 1/F, Fukangtai Building, West Baima Rd., Songgang Street, Baoan District, Shenzhen, China

5 Equipment Used during Test

5.1 Equipments List

Conducted Emissions						
Item	Equipment	Manufacturer	Model No.	Serial No.	Last Calibration Date	Calibration Due Date
1.	EMI Test Receiver	R&S	ESCI	100947	Sep.21,2012	Sep.20,2013
2.	LISN	R&S	ENV216	101215	Sep.21,2012	Sep.20,2013
3.	Cable	Top	TYPE16(3.5M)	-	Sep.21,2012	Sep.20,2013
3m Semi-anechoic Chamber for Radiation Emissions						
Item	Equipment	Manufacturer	Model No.	Serial No.	Last Calibration Date	Calibration Due Date
1.	EMC Analyzer	Agilent	E7405A	MY45114943	Sep.21,2012	Sep.20,2013
2.	Active Loop Antenna	Beijing Dazhi	ZN30900A	-	Sep.21,2012	Sep.20,2013
3.	Trilog Broadband Antenna	SCHWARZBECK	VULB9163	336	Sep.21,2012	Sep.20,2013
4.	Broad-band Horn Antenna	SCHWARZBECK	BBHA 9120 D	667	Sep.21,2012	Sep.20,2013
5.	Broad-band Horn Antenna	SCHWARZBECK	BBHA 9170	399	Sep.21,2012	Sep.20,2013
6.	Broadband Preamplifier	COMPLIANCE DIRECTION	PAP-1G18	2004	Sep.21,2012	Sep.20,2013
7.	Broadband Preamplifier	SCHWARZBECK	BBV 9718	9718-148	Sep.21,2012	Sep.20,2013
8.	Cable	Top	EWO2014-7	-	Sep.21,2012	Sep.20,2013
9.	Cable	Top	TYPE16(13M)	-	Sep.21,2012	Sep.20,2013
10.	DC POWER SUPPLY	LWDQGS	PS-303D		Sep.21,2012	Sep.20,2013
11.	Humidity Chamber	GTH-225-40-1P	IAA061213		Sep.21,2012	Sep.20,2013
12.	Spectrum Analyzer	ROHDE & SCHWARZ	FSL6	100959	Sep.21,2012	Sep.20,2013

5.2 Measurement Uncertainty

Parameter	Uncertainty
Radio Frequency	$\pm 1 \times 10^{-6}$
Bandwidth	$\pm 1.5 \times 10^{-6}$
RF Power	± 1.0 dB
RF Power Density	± 2.2 dB
Temperature	± 1 °C
DC Source	$\pm 0.05\%$
Radiated Emissions test	± 5.03 dB (Bilog antenna 30M~1000MHz)
	± 4.74 dB (Horn antenna 1000M~25000MHz)
Conducted Spurious Emissions test	± 3.64 dB (150kHz~30MHz)

5.3 Test Equipment Calibration

All the test equipments used are valid and calibrated by CEPREI Certification Body that address is No.110 Dongguan Zhuang RD. Guangzhou, P.R.China.

6 Conducted Emission

Test Requirement:	FCC CFR 47 Part 15 Section 15.207
Test Method:	ANSI C63.4:2003
Test Result:	PASS
Frequency Range:	150kHz to 30MHz
Class:	Class B
Limit:	66-56 dB μ V between 0.15MHz & 0.5MHz 56 dB μ V between 0.5MHz & 5MHz 60 dB μ V between 5MHz & 30MHz
Detector:	Peak for pre-scan (9kHz Resolution Bandwidth) Quasi-Peak & Average if maximised peak within 6dB of Average Limit

6.1 E.U.T. Operation

Operating Environment:

Temperature: 25.5 °C

Humidity: 51 % RH

Atmospheric Pressure: 1012 mbar

EUT Operation:

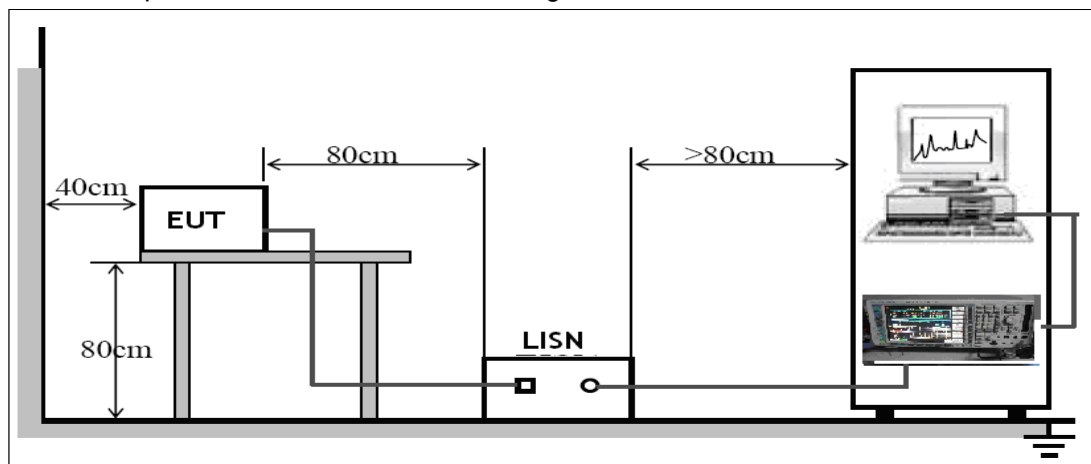
The pre-test was performed in bluetooth linking+USB charging, and the test data is not show in the report.

The EUT was tested according to ANSI C63.4:2003. The frequency spectrum from 150kHz to 30MHz was investigated.

The maximised peak emissions from the EUT was scanned and measured for both the Live and Neutral Lines. Quasi-peak & average measurements were performed if peak emissions were within 6dB of the average limit line.

6.2 EUT Setup

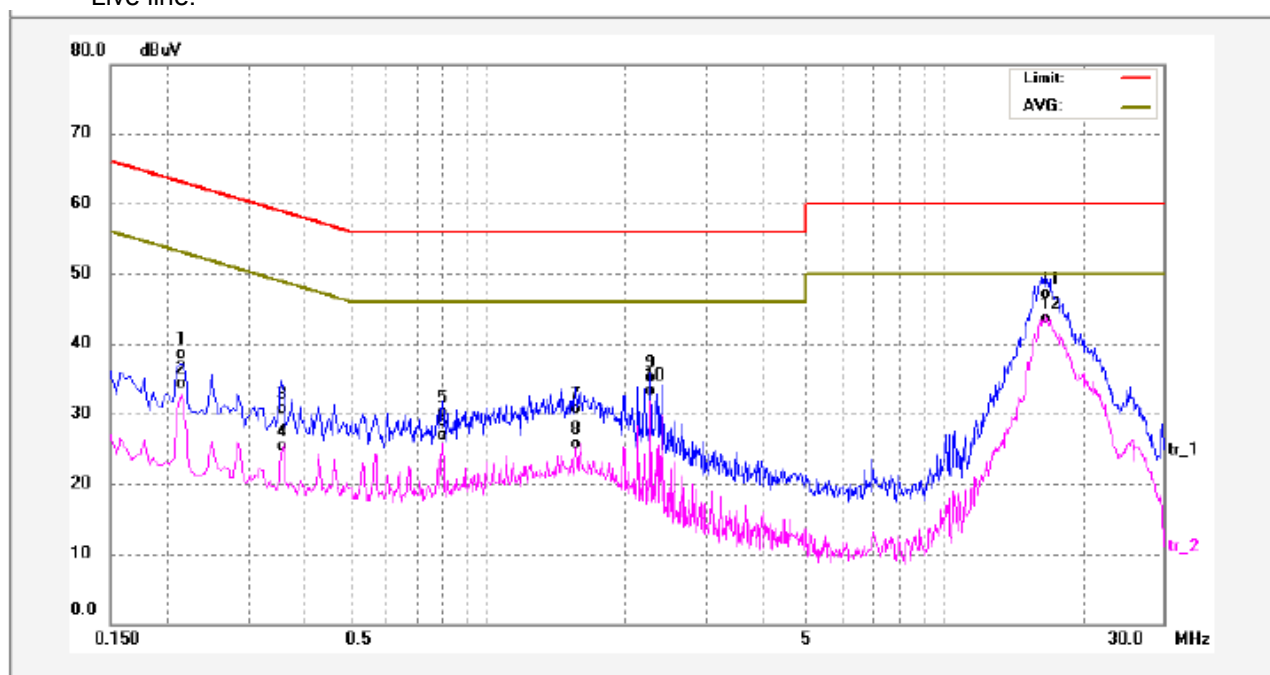
The EUT was placed on the test table in shielding room.



6.3 Conducted Emission Test Result

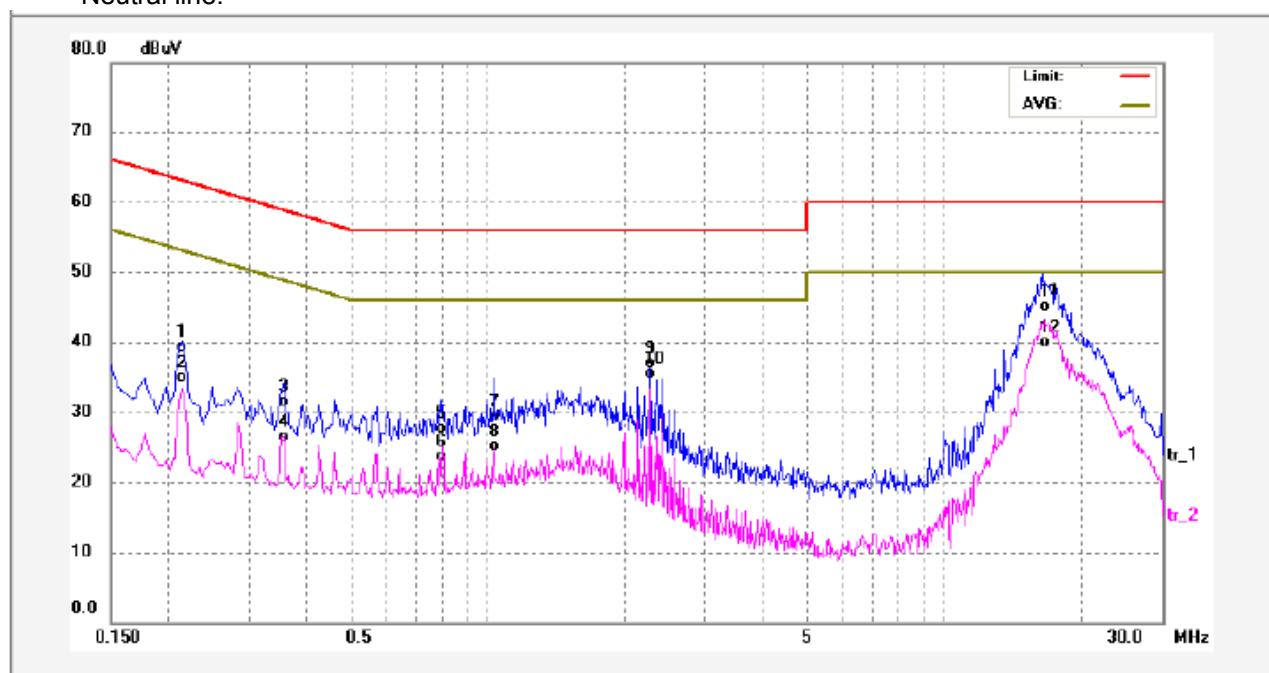
An initial pre-scan was performed on the live and neutral lines.

Live line:



No.	Freq. (MHz)	Reading (dBuV)	Factor (dB)	Result (dBuV)	Limit dBuV	Margin (dB)	Detector	Remark
1	0.2140	26.35	11.30	37.65	63.04	-25.39	QP	
2	0.2140	22.18	11.30	33.48	53.04	-19.56	AVG	
3	0.3540	18.59	11.31	29.90	58.87	-28.97	QP	
4	0.3540	13.14	11.31	24.45	48.87	-24.42	AVG	
5	0.7980	18.01	11.29	29.30	56.00	-26.70	QP	
6	0.7980	14.80	11.29	26.09	46.00	-19.91	AVG	
7	1.5660	18.74	11.19	29.93	56.00	-26.07	QP	
8	1.5660	13.72	11.19	24.91	46.00	-21.09	AVG	
9	2.2780	23.12	11.20	34.32	56.00	-21.68	QP	
10	2.2780	21.24	11.20	32.44	46.00	-13.56	AVG	
11	16.7180	34.74	11.47	46.21	60.00	-13.79	QP	
12	16.7180	31.22	11.47	42.69	50.00	-7.31	AVG	

Neutral line:



No.	Freq. (MHz)	Reading (dBuV)	Factor (dB)	Result (dBuV)	Limit dBuV	Margin (dB)	Detector	Remark
1	0.2140	27.15	11.30	38.45	63.04	-24.59	QP	
2	0.2140	22.85	11.30	34.15	53.04	-18.89	AVG	
3	0.3580	19.32	11.31	30.63	58.77	-28.14	QP	
4	0.3580	14.30	11.31	25.61	48.77	-23.16	AVG	
5	0.7940	15.56	11.29	26.85	56.00	-29.15	QP	
6	0.7940	11.70	11.29	22.99	46.00	-23.01	AVG	
7	1.0339	17.33	11.18	28.51	56.00	-27.49	QP	
8	1.0339	13.05	11.18	24.23	46.00	-21.77	AVG	
9	2.2780	24.93	11.20	36.13	56.00	-19.87	QP	
10	2.2780	23.46	11.20	34.66	46.00	-11.34	AVG	
11	16.4380	32.79	11.47	44.26	60.00	-15.74	QP	
12	16.4380	27.57	11.47	39.04	50.00	-10.96	AVG	

7 Spurious Radiated Emissions

Test Requirement: FCC CFR47 Part 15 Section 15.209 & 15.247

Test Method: DA 00-705

Test Result: PASS

Measurement Distance: 3m

Limit:

Frequency (MHz)	Field Strength		Field Strength Limit at 3m Measurement Dist	
	uV/m	Distance (m)	uV/m	dBuV/m
0.009 ~ 0.490	2400/F(kHz)	300	10000 * 2400/F(kHz)	$20\log^{(2400/F(kHz))} + 80$
0.490 ~ 1.705	24000/F(kHz)	30	100 * 24000/F(kHz)	$20\log^{(24000/F(kHz))} + 40$
1.705 ~ 30	30	30	100 * 30	$20\log^{(30)} + 40$
30 ~ 88	100	3	100	$20\log^{(100)}$
88 ~ 216	150	3	150	$20\log^{(150)}$
216 ~ 960	200	3	200	$20\log^{(200)}$
Above 960	500	3	500	$20\log^{(500)}$

7.1 EUT Operation :

Operating Environment:

Temperature: 25.5 °C

Humidity: 51 % RH

Atmospheric Pressure: 1007 mbar

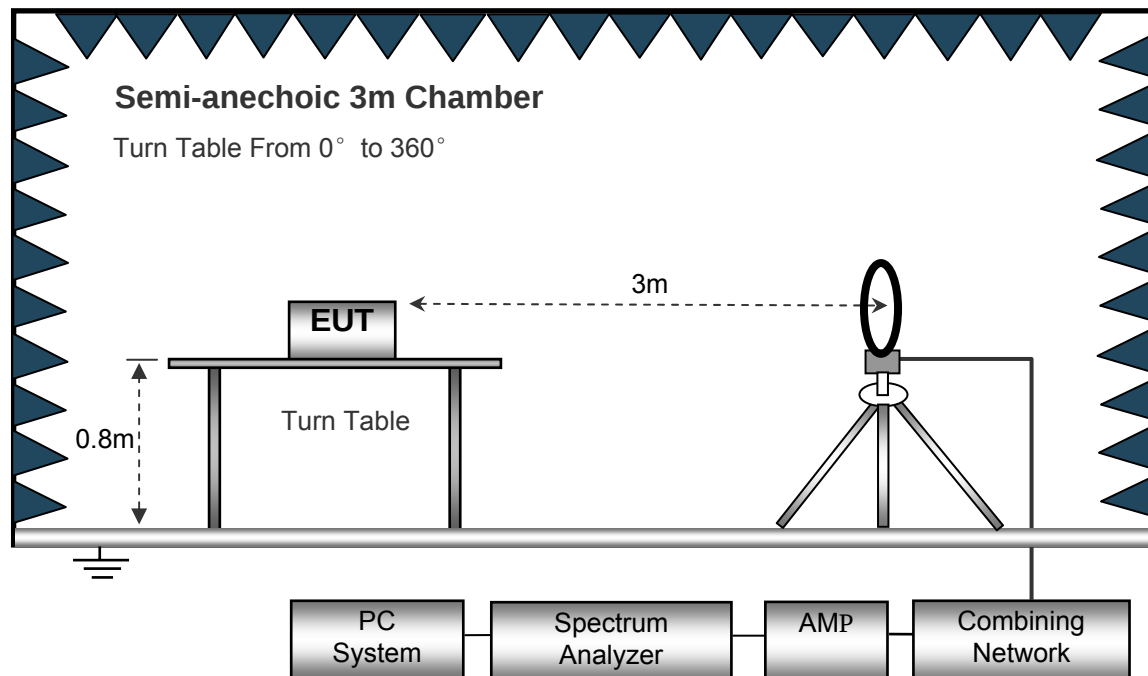
EUT Operation:

The pre-test was performed in bluetooth linking+USB charging and bluetooth linking(battery operation) mode, and the worse mode is bluetooth linking+USB charging mode, so the data show is that mode's only.

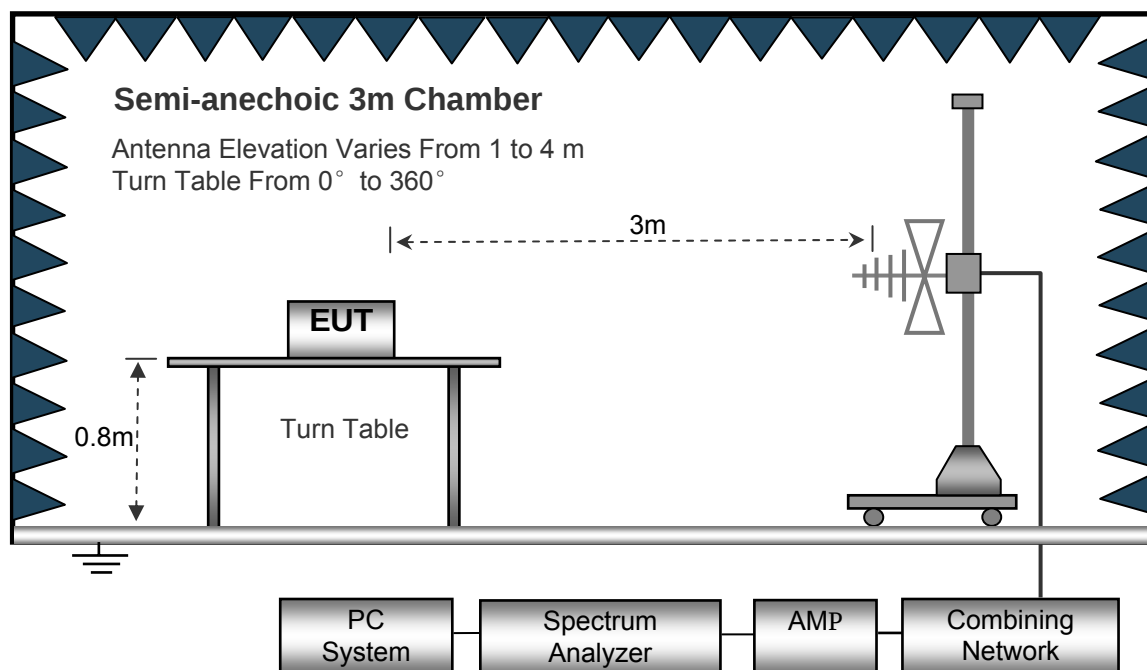
7.2 Test Setup

The radiated emission tests were performed in the 3m Semi- Anechoic Chamber test site, using the setup accordance with the ANSI C63.4: 2003.

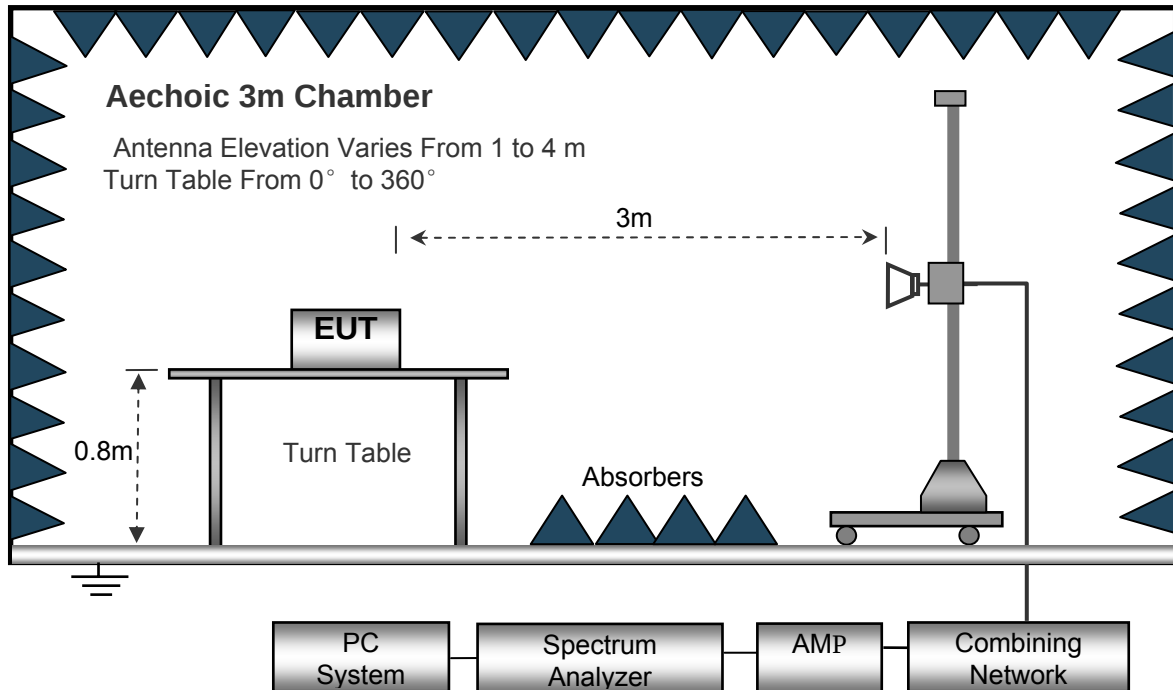
The test setup for emission measurement below 30MHz.



The test setup for emission measurement from 30 MHz to 1 GHz.



The test setup for emission measurement above 1 GHz.



7.3 Spectrum Analyzer Setup

According to FCC Part15 Rules, the system was tested 9kHz to 25000MHz.

Below 30MHz

Sweep SpeedAuto
 IF Bandwidth10KHz
 Video Bandwidth10KHz
 Resolution Bandwidth10KHz

30MHz ~ 1GHz

Sweep SpeedAuto
 IF Bandwidth120 KHz
 Video Bandwidth100KHz
 Quasi-Peak Adapter Bandwidth120 KHz
 Quasi-Peak Adapter ModeNormal
 Resolution Bandwidth100KHz

Above 1GHz

Sweep SpeedAuto
 IF Bandwidth120 KHz
 Video Bandwidth3MHz
 Quasi-Peak Adapter Bandwidth120 KHz
 Quasi-Peak Adapter ModeNormal
 Resolution Bandwidth1MHz

7.4 Test Procedure

1. The EUT is placed on a turntable, which is 0.8m above ground plane.
2. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
3. EUT is set 3m away from the receiving antenna, which is moved from 1m to 4m to find out the maximum emissions.
4. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
5. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
6. Repeat above procedures until the measurements for all frequencies are complete.
7. The radiation measurements are tested under 3-axes(X,Y,Z) position(X denotes lying on the table, Y denotes side stand and Z denotes vertical stand), After pre-test, It was found that the worse radiation emission was get at the X position. So the data shown was the X position only.

7.5 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

$$\text{Corr. Ampl.} = \text{Indicated Reading} + \text{Antenna Factor} + \text{Cable Factor} - \text{Amplifier Gain}$$

The "Margin" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -7dB means the emission is 7dB below the maximum limit for Class B.

The equation for margin calculation is as follows:

$$\text{Margin} = \text{Corr. Ampl.} - \text{Limit}$$

7.6 Summary of Test Results

Test Frequency :Below 30MHz

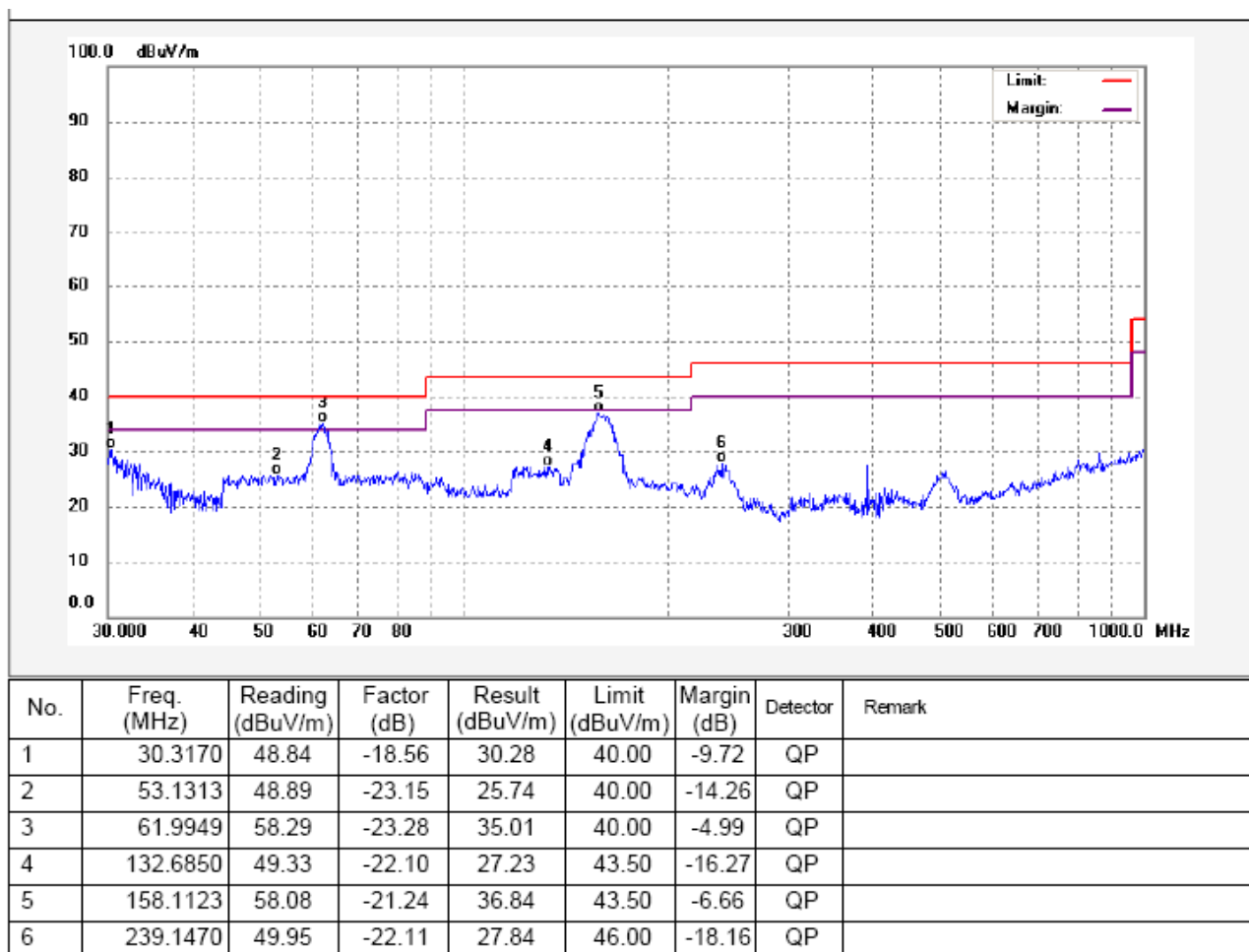
The measurements were more than 20 dB below the limit and not reported.

Test Frequency : 30MHz ~ 1000MHz

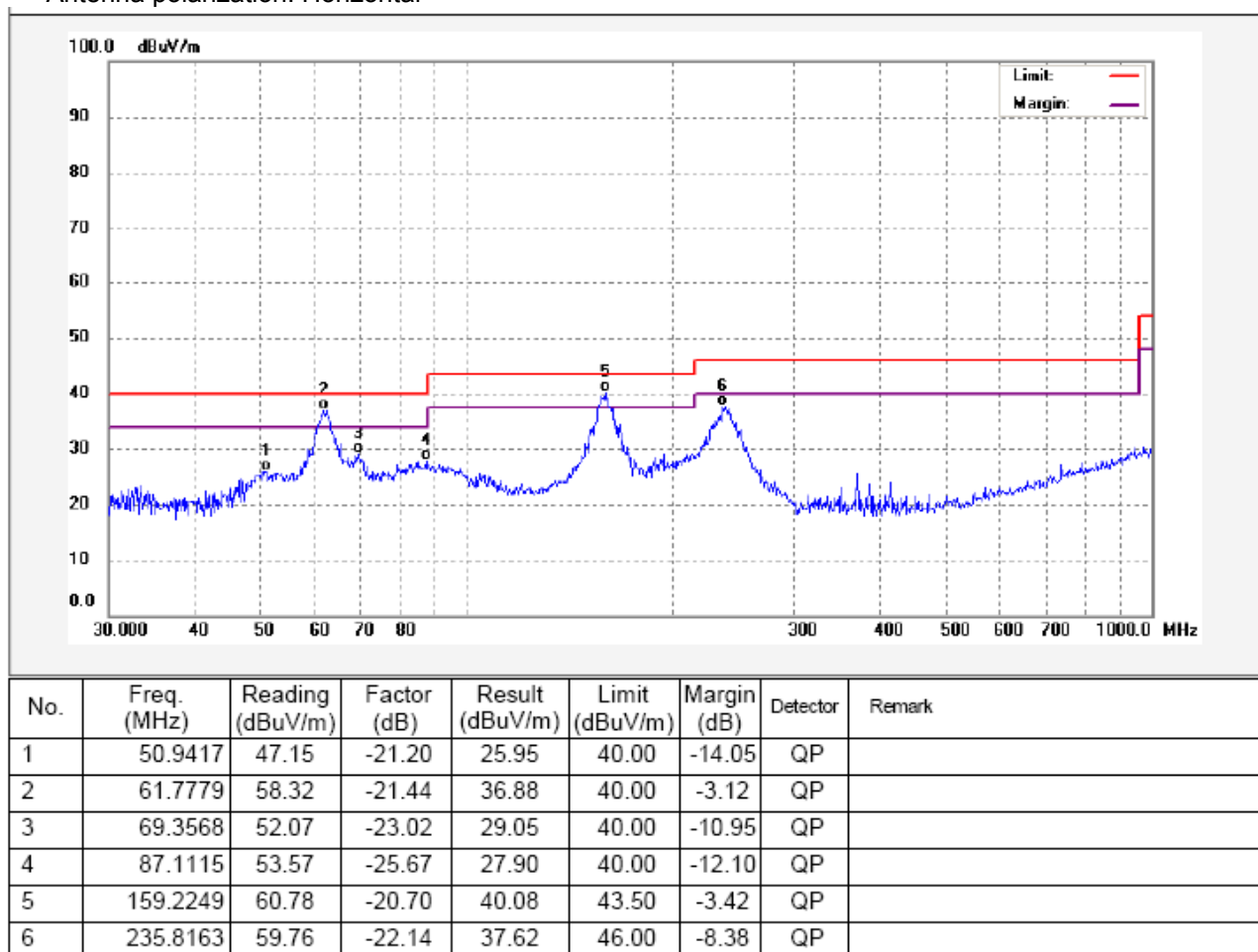
Remark: the EUT was pretested at the high, middle and low channel, and the worse case was the middle Channel, so the data show was the middle channel only.

Test Worst Mode: bluetooth linking(battery operation)

Antenna polarization: Vertical



Antenna polarization: Horizontal



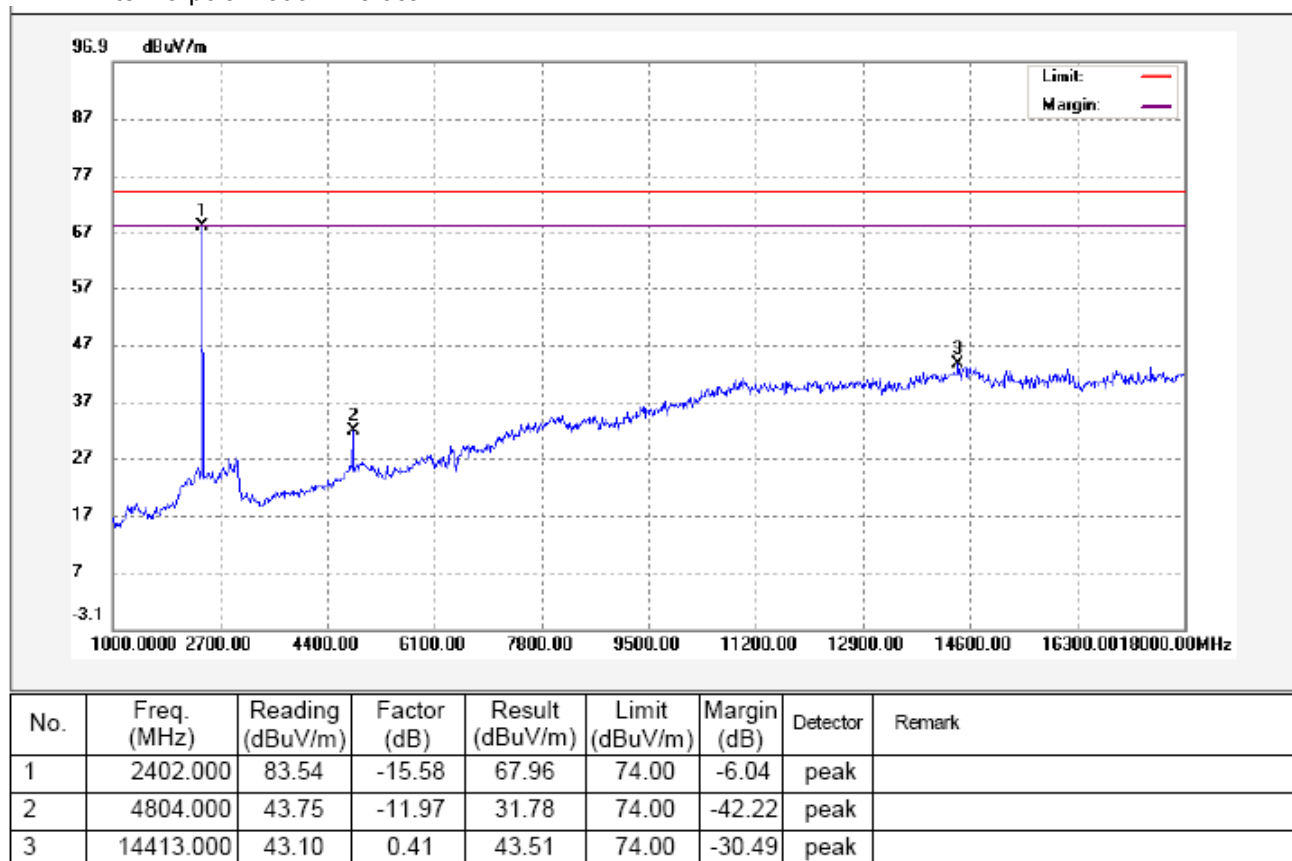
Test Frequency: 1GHz ~ 18GHz

All the modulation modes were tested, the data of the worst mode (GFSK) were recorded in the following pages.

AV = Peak +20Log₁₀(duty cycle) =PK+(-9)=PK-9 [refer to section 9 for more detail]

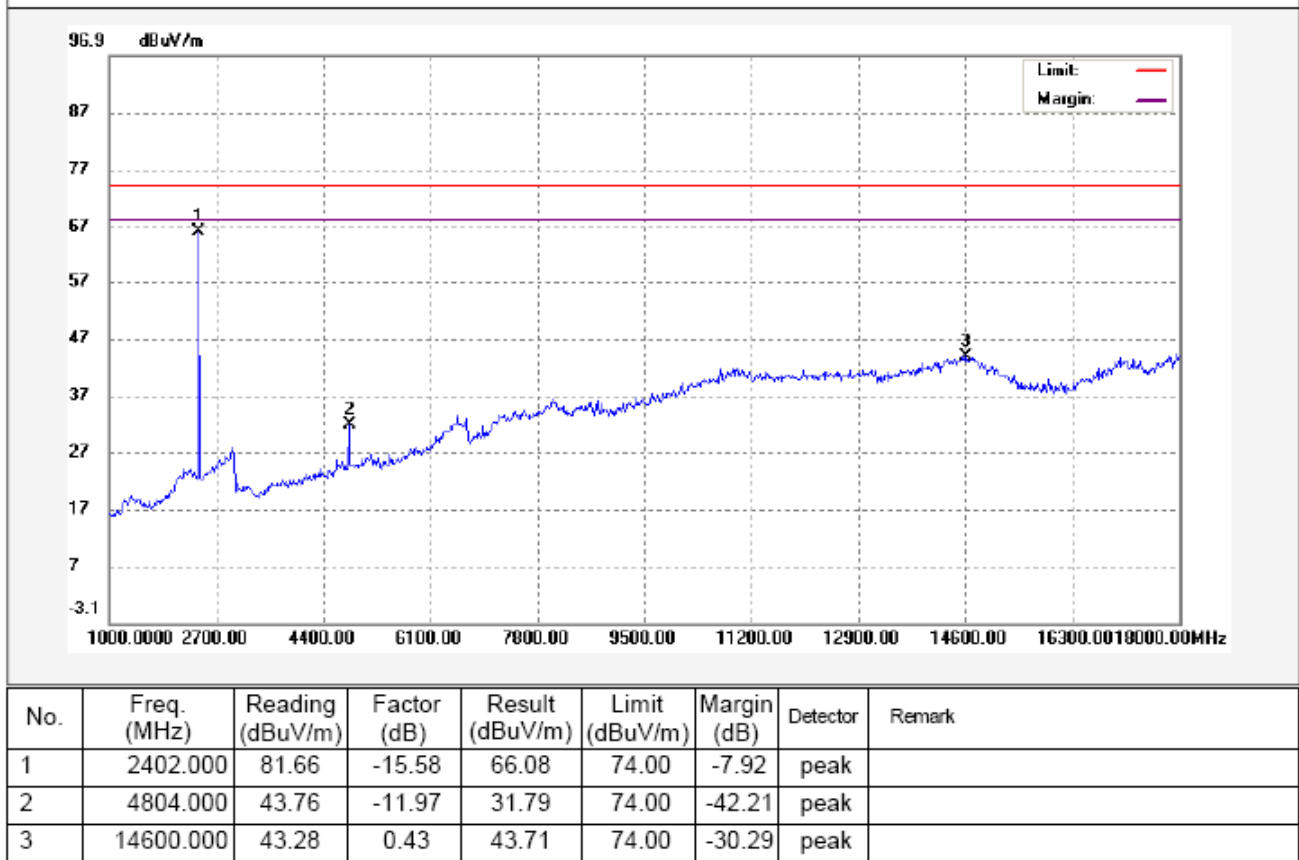
Test mode: transmitting at lower channel

Antenna polarization: Vertical



No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
2	4804.000	-9	22.78	54.00	-31.22	AV	
3	14413.000	-9	34.51	54.00	-19.49	AV	

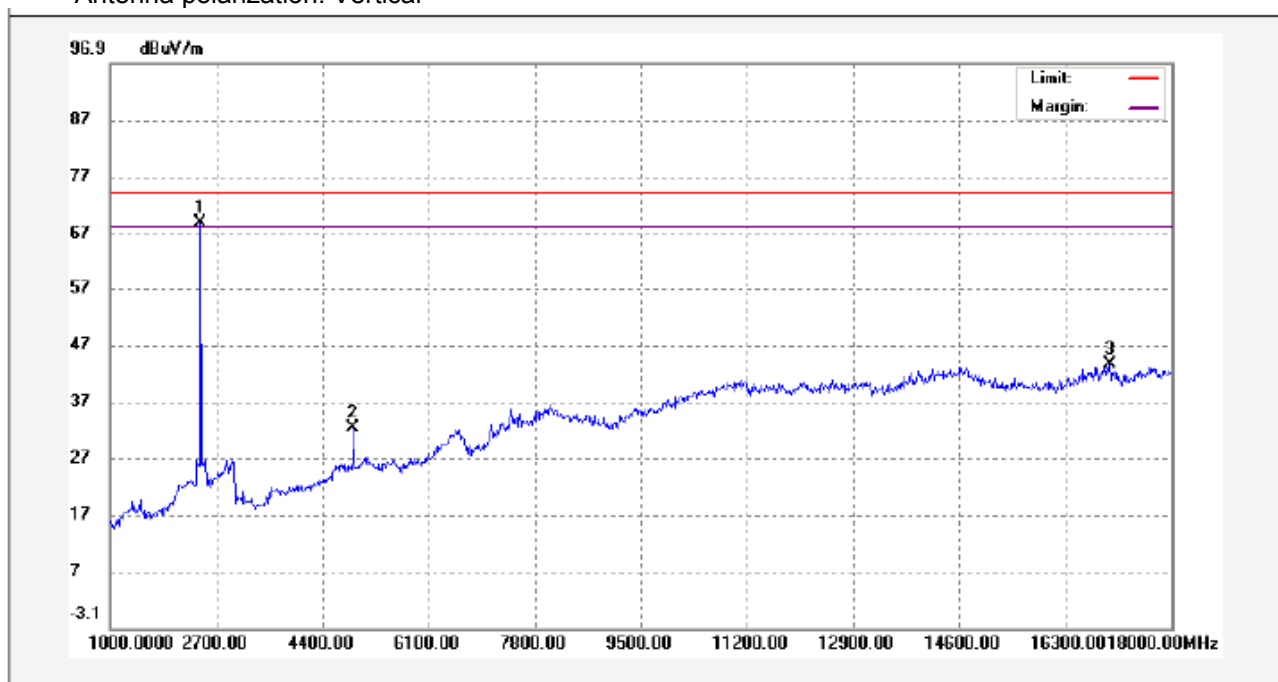
Antenna polarization: Horizontal



No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
2	4804.000	-9	22.79	54.00	-31.21	AV	
3	14600.000	-9	34.71	54.00	-19.29	AV	

Test mode: transmitting at middle channel

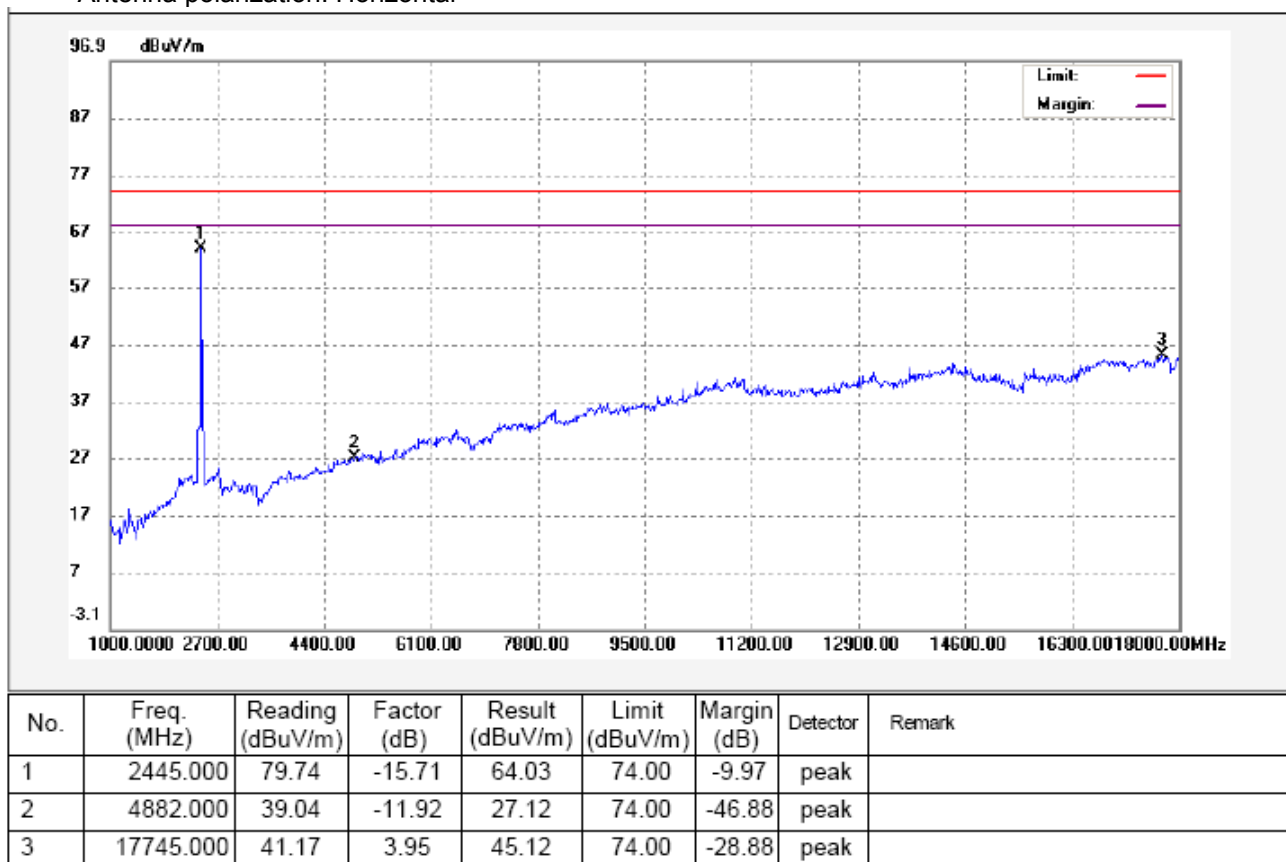
Antenna polarization: Vertical



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2441.000	84.43	-15.70	68.73	74.00	-5.27	peak	
2	4882.000	44.11	-11.92	32.19	74.00	-41.81	peak	
3	17014.000	43.04	0.45	43.49	74.00	-30.51	peak	

No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
2	4882.000	-9	23.19	54.00	-30.81	AV	
3	17014.000	-9	34.49	54.00	-19.51	AV	

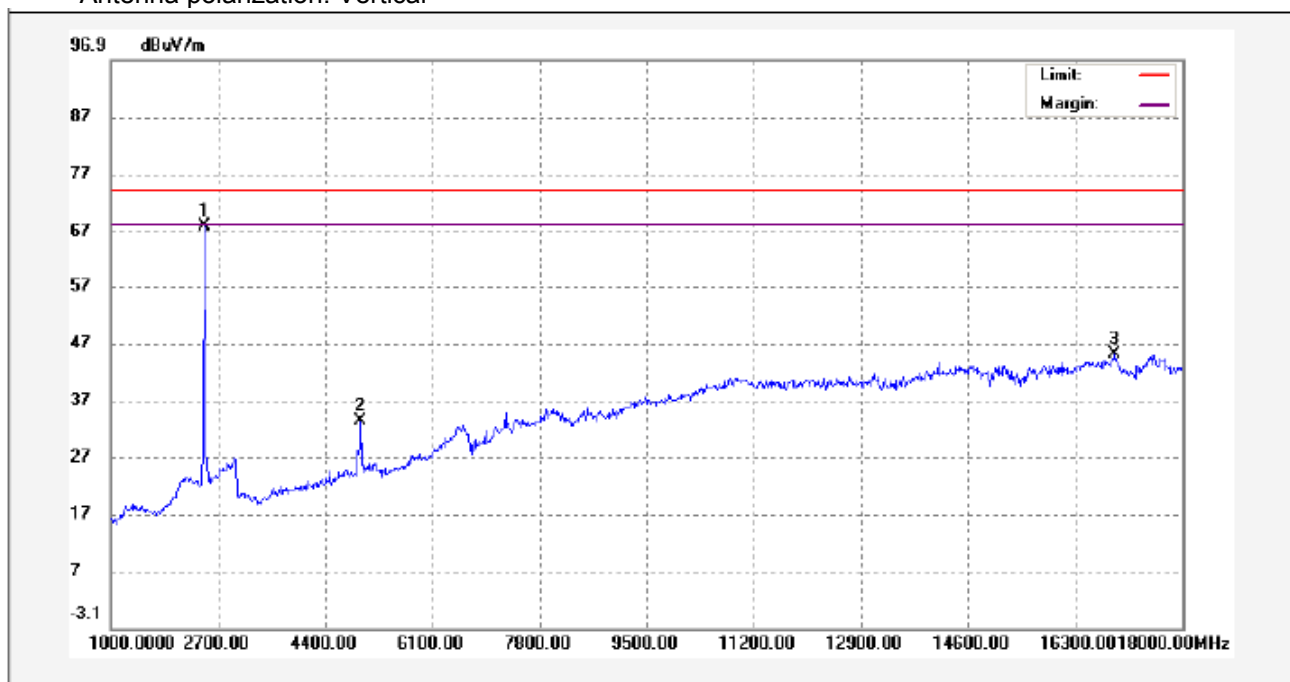
Antenna polarization: Horizontal



No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
2	4882.000	-9	18.12	54.00	-35.88	AV	
3	17745.000	-9	36.12	54.00	-17.88	AV	

Test mode: transmitting at upper channel

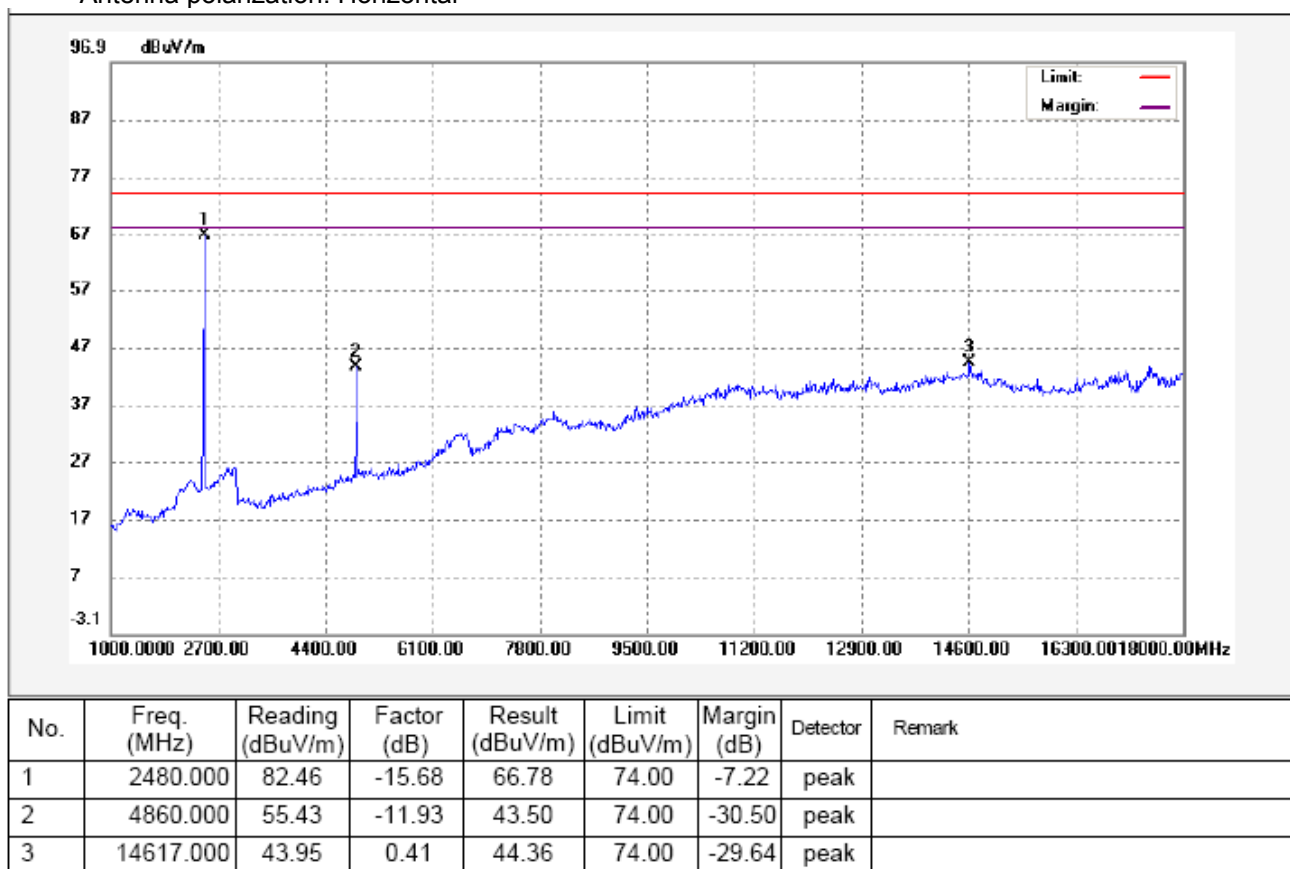
Antenna polarization: Vertical



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2480.000	83.39	-15.68	67.71	74.00	-6.29	peak	
2	4960.000	45.06	-11.77	33.29	74.00	-40.71	peak	
3	16929.000	44.77	0.24	45.01	74.00	-28.99	peak	

No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
2	4960.000	-9	24.29	54.00	-29.71	AV	
3	16929.000	-9	36.01	54.00	-17.99	AV	

Antenna polarization: Horizontal



No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
2	4860.000	-9	34.50	54.00	-19.5	AV	
3	14617.000	-9	35.36	54.00	-18.64	AV	

Test Frequency :Above 18GHz

The measurements were more than 20 dB below the limit and not reported.

8 Spurious RF Conducted Emissions from out of band

Test Requirement: FCC Part 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.

Test Method: DA 00-705

Test Status: TX mode

8.1 Test Procedure

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2. Set to span from the lowest frequency generated in the device up to and including the tenth harmonic of the highest fundamental frequency.
3. Set RBW = 100kHz and VBW = 300kHz.Sweep =auto.
4. mark the worst point and record.

8.2 Test Result

Test Frequency: Below 30MHz

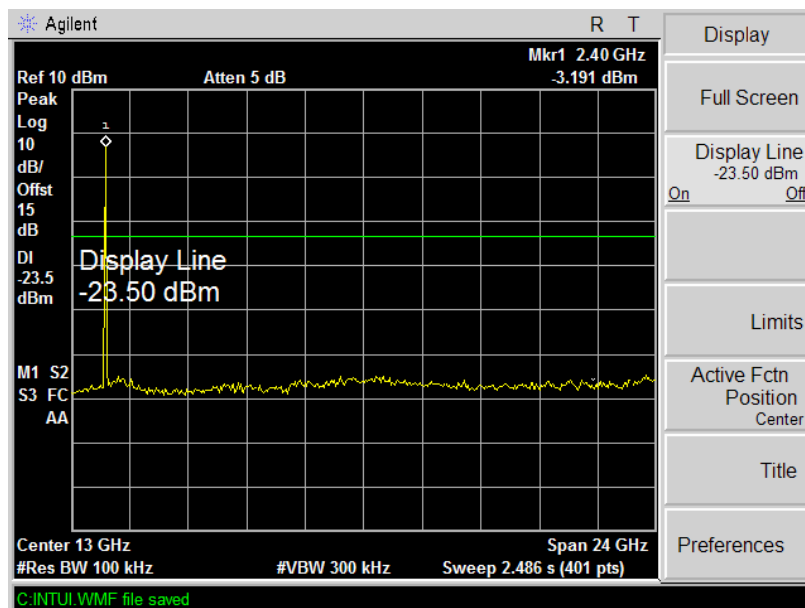
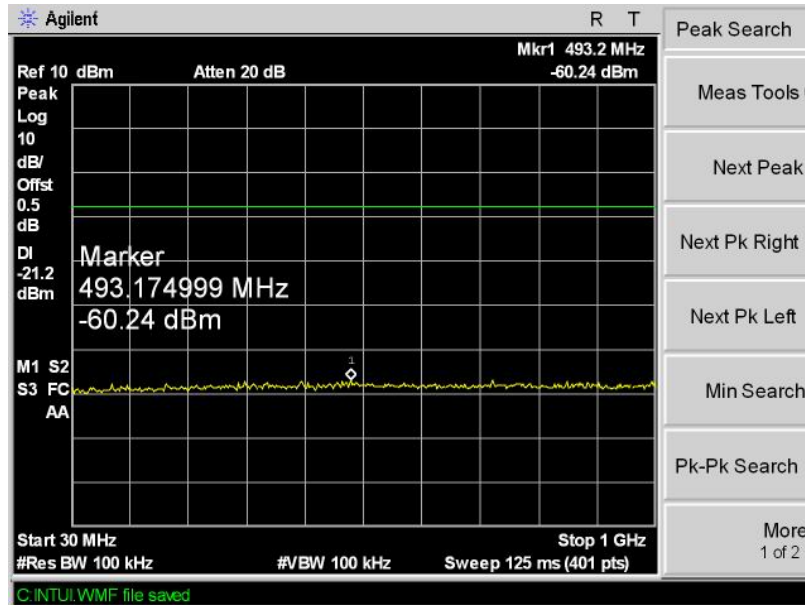
Remark: For emissions below 30MHz,no emission higher than background level, so the data does not show in the report.

Test Frequency: 30MHz ~ 25GHz

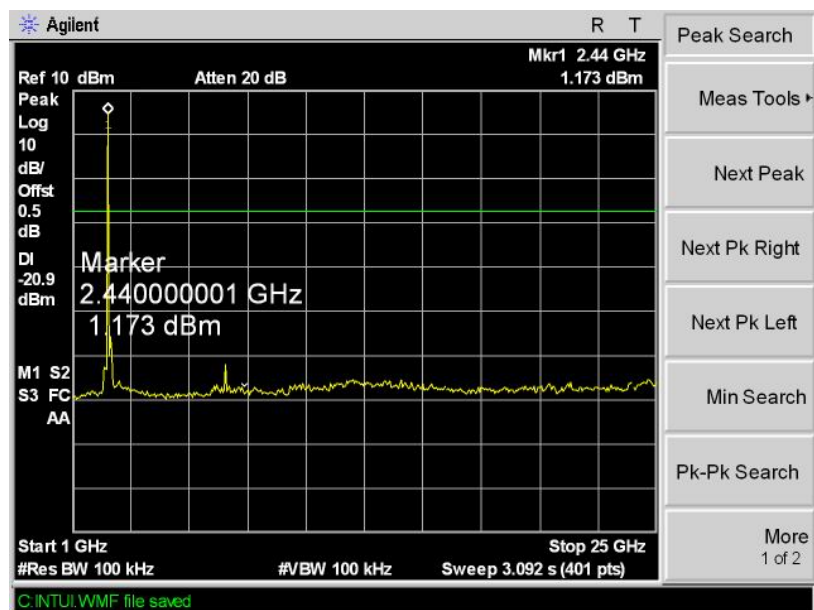
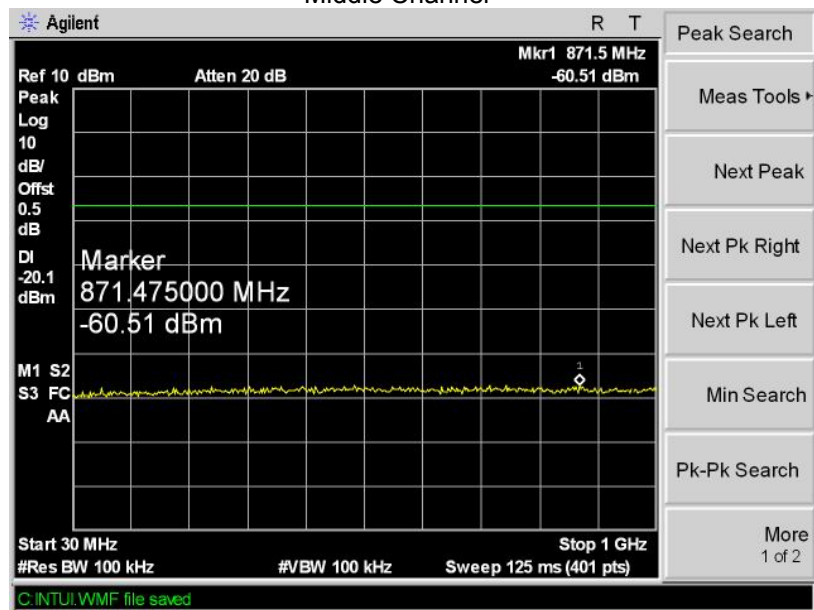
Test result plots shown as follows:

Modulation:GFSK

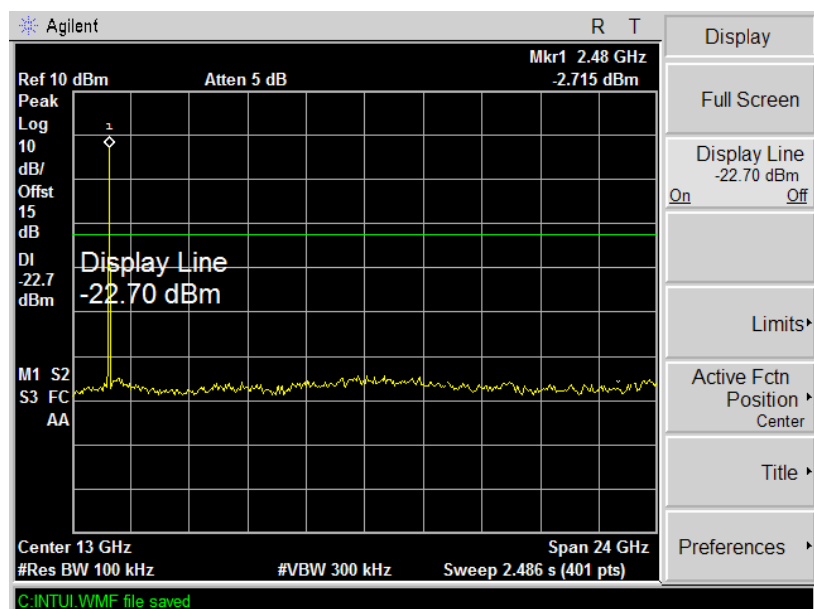
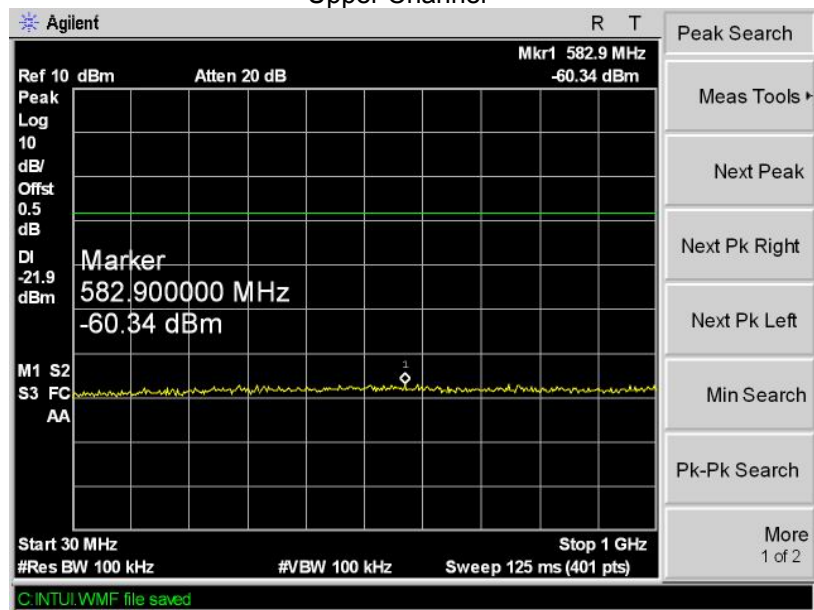
Lower Channel



Middle Channel

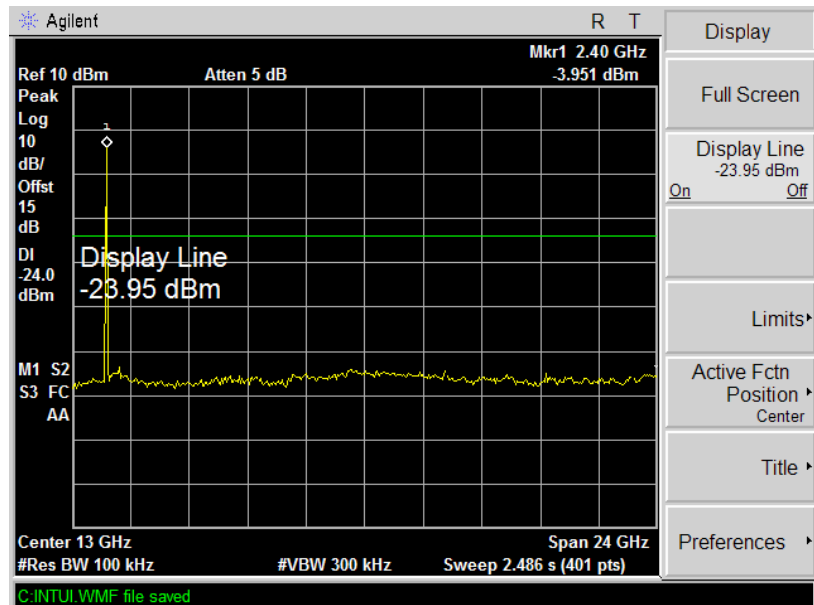
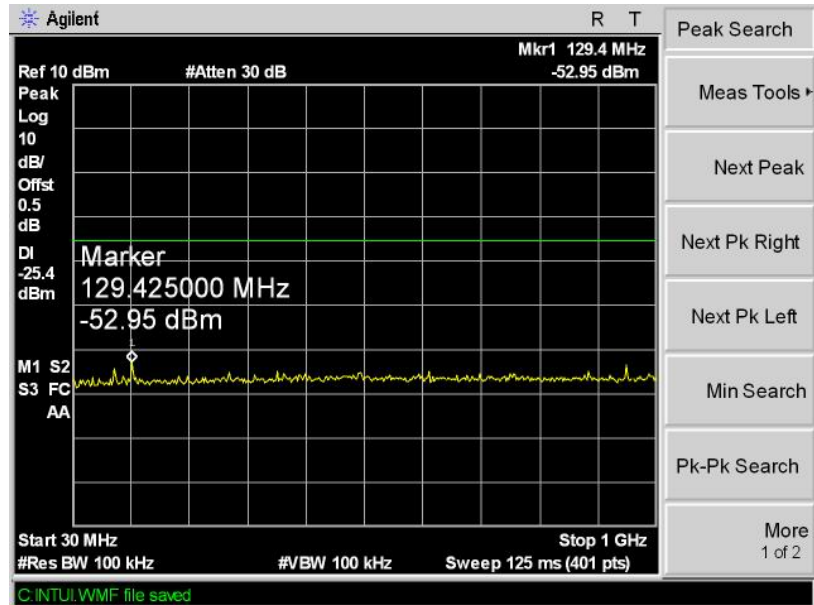


Upper Channel

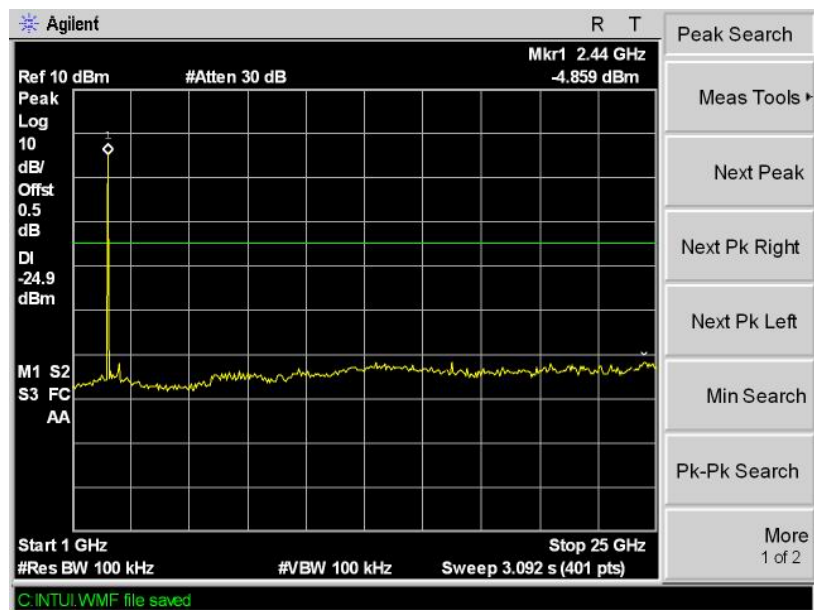
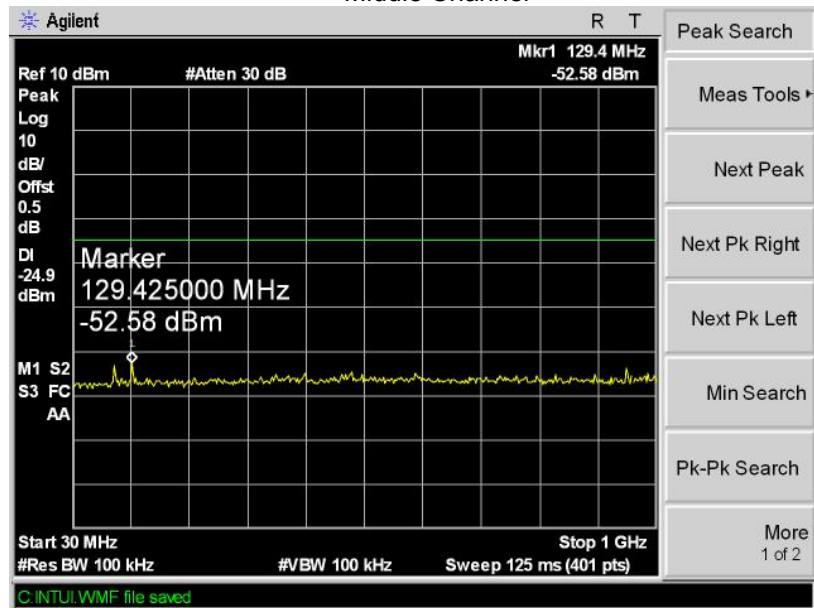


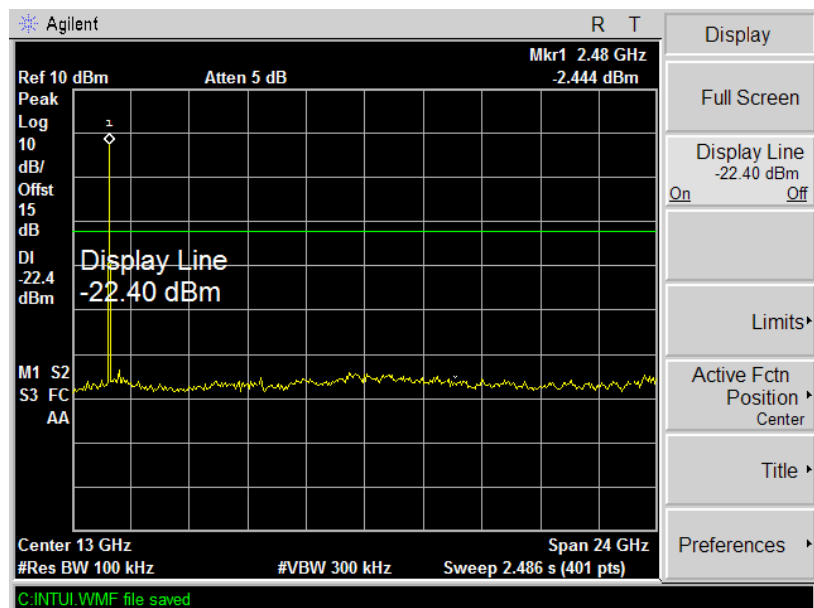
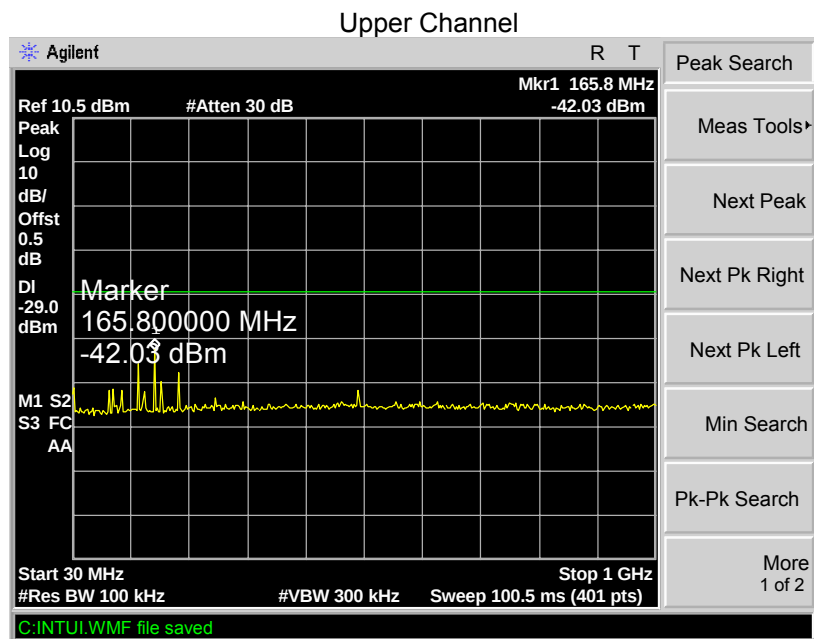
Modulation: Pi/4DQPSK

Lower Channel



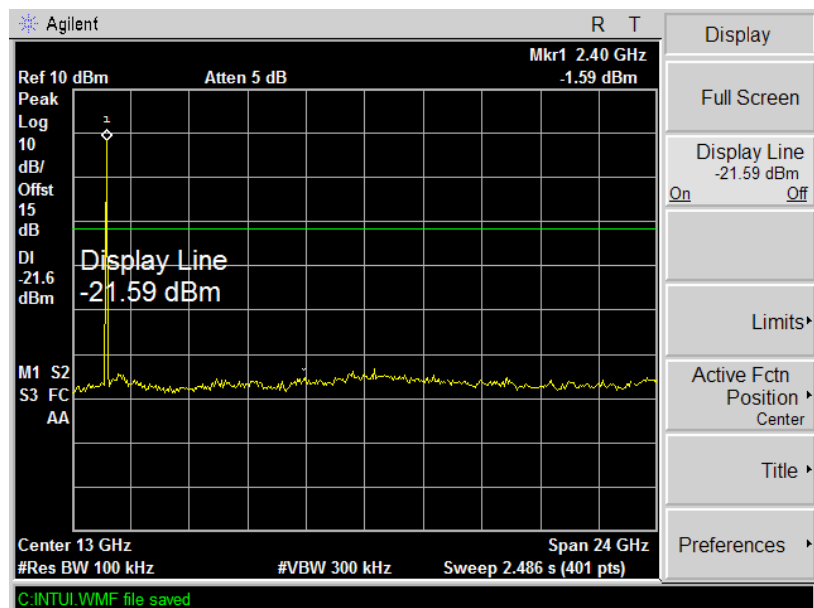
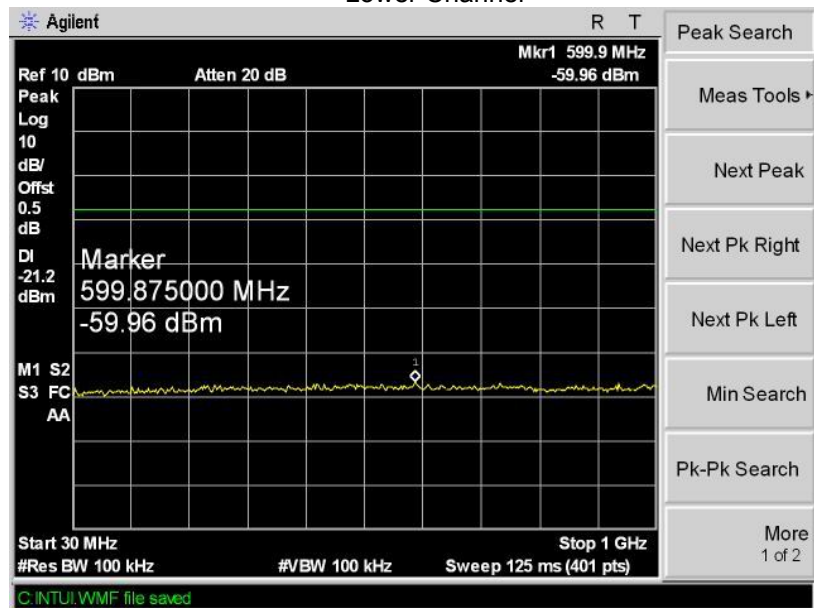
Middle Channel



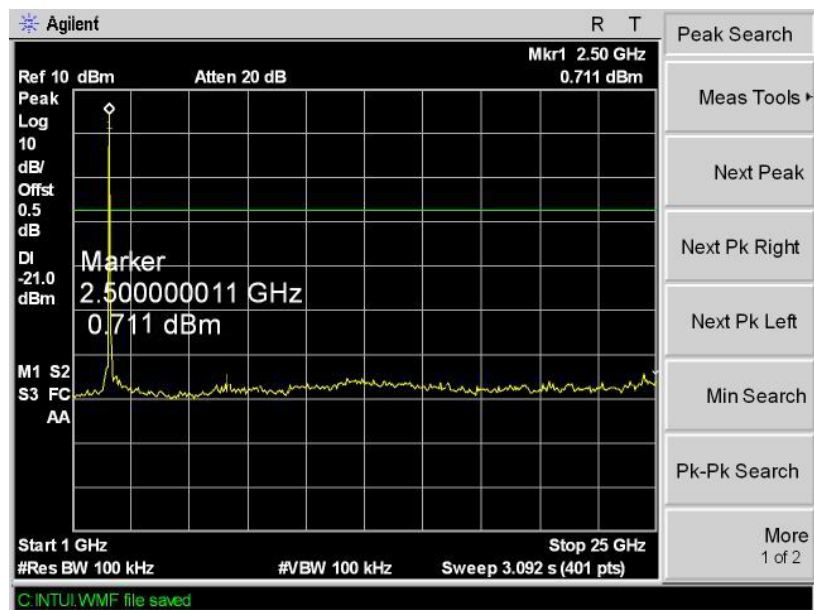
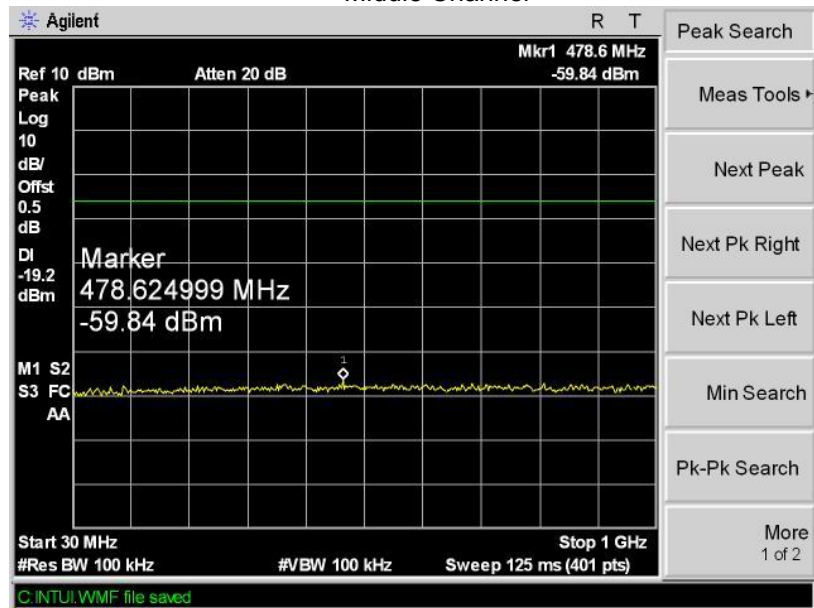


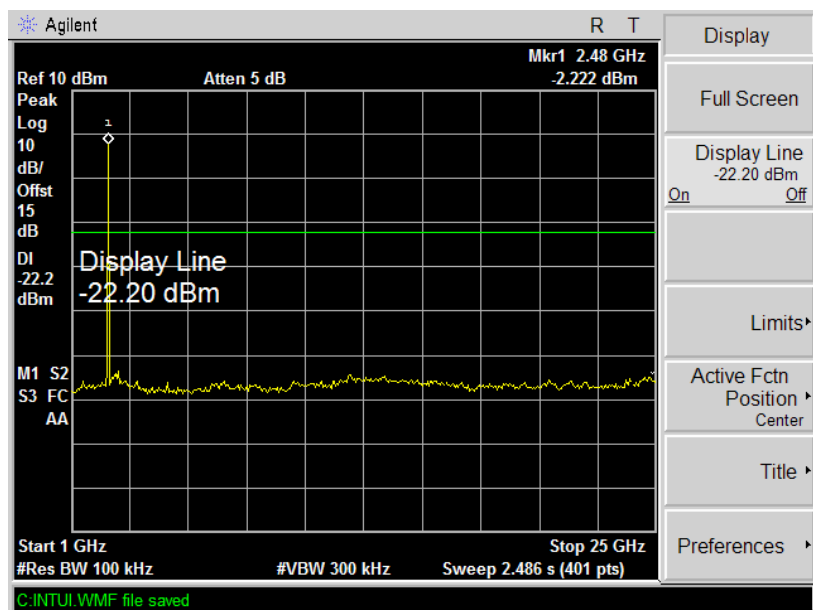
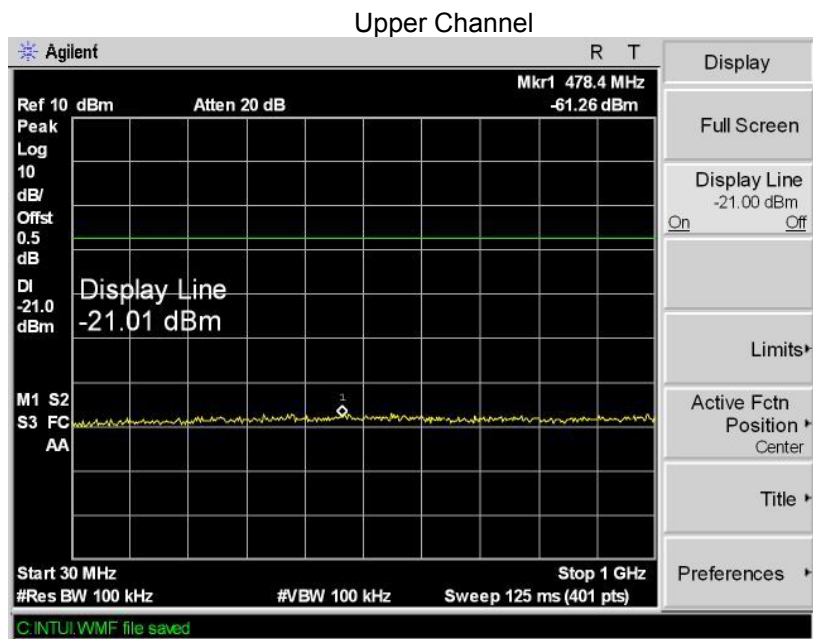
Modulation: 8DPSK

Lower Channel



Middle Channel





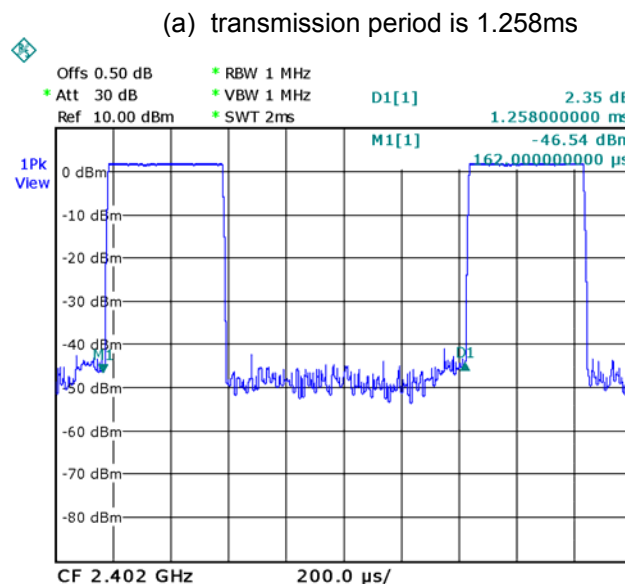
9 Duty Cycle

Test Requirement: FCC Part 15.35
Test Method: ANSI C63.4:2003
Test Status: TX mode.

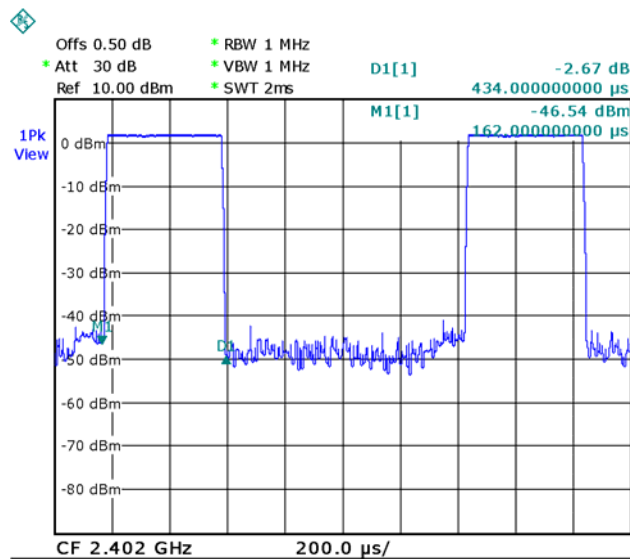
9.1 Test Procedure

1. The EUT was placed on a turntable which is 0.8m above ground plane
2. Set EUT as normal working mode
3. Set SPA center frequency = fundamental frequency, RBW = 1000 kHz, VBW = 1000 kHz, Span = 0 Hz, Adjacent sweep time.

9.2 Test Result



(b) Single pulse time is 0.434ms



The EUT is auto. operation for transmitter, it is declared by the manufacturer as a duty cycle ratio of less than 100%.

The EUT's work time : T_{on} = pulse time = 0.434 ms

The EUT's work period : $T = T_{ON} + T_{OFF}$ = transmission period = 1.258 ms

The EUT's duty cycle : $D = T_{on} / T = 0.434 / 1.258 * 100\% = 34.5\%$

Duty Cycle Correction Factor(dB) = $20 * \log_{10}(\text{Duty Cycle}) = 20 * \log_{10}(34.5\%)$
 = -9dB

10 Band Edge Measurement

Test Requirement:	Section 15.247(d) In addition, radiated emissions which fall in the restricted bands. as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 15.205(c)).
Test Method:	DA 00-705
Limit:	40.0 dBuV/m between 30MHz & 88MHz; 43.5 dBuV/m between 88MHz & 216MHz; 46.0 dBuV/m between 216MHz & 960MHz; 54.0 dBuV/m above 960MHz. 74.0 dBuV/m for peak above 1GHz 54.0 dBuV/m for AVG above 1GHz

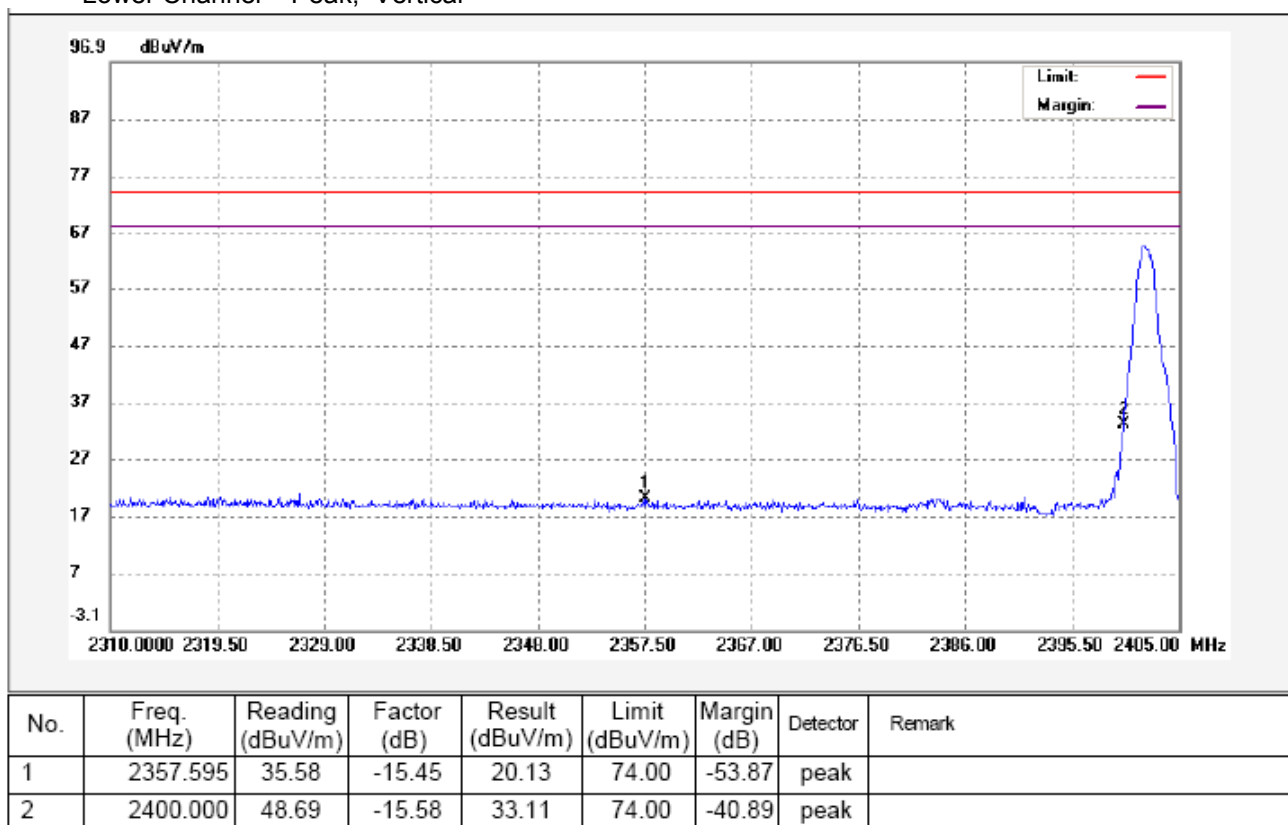
10.1 Test Procedure

1. The EUT was placed on a turntable which is 0.8m above ground plane
2. Measurement Distance is 3m
3. Detector:
 - For Peak value:
RBW = 1 MHz for $f \geq 1$ GHz
VBW $\geq$ RBW; Sweep = auto
Detector function = peak
Trace = max hold
 - For AVG value:
RBW = 1 MHz for $f \geq 1$ GHz
VBW = 10Hz; Sweep = auto
Detector function = AVG
Trace = max hold
- 4.continuous transmitting

10.2 Test Result:

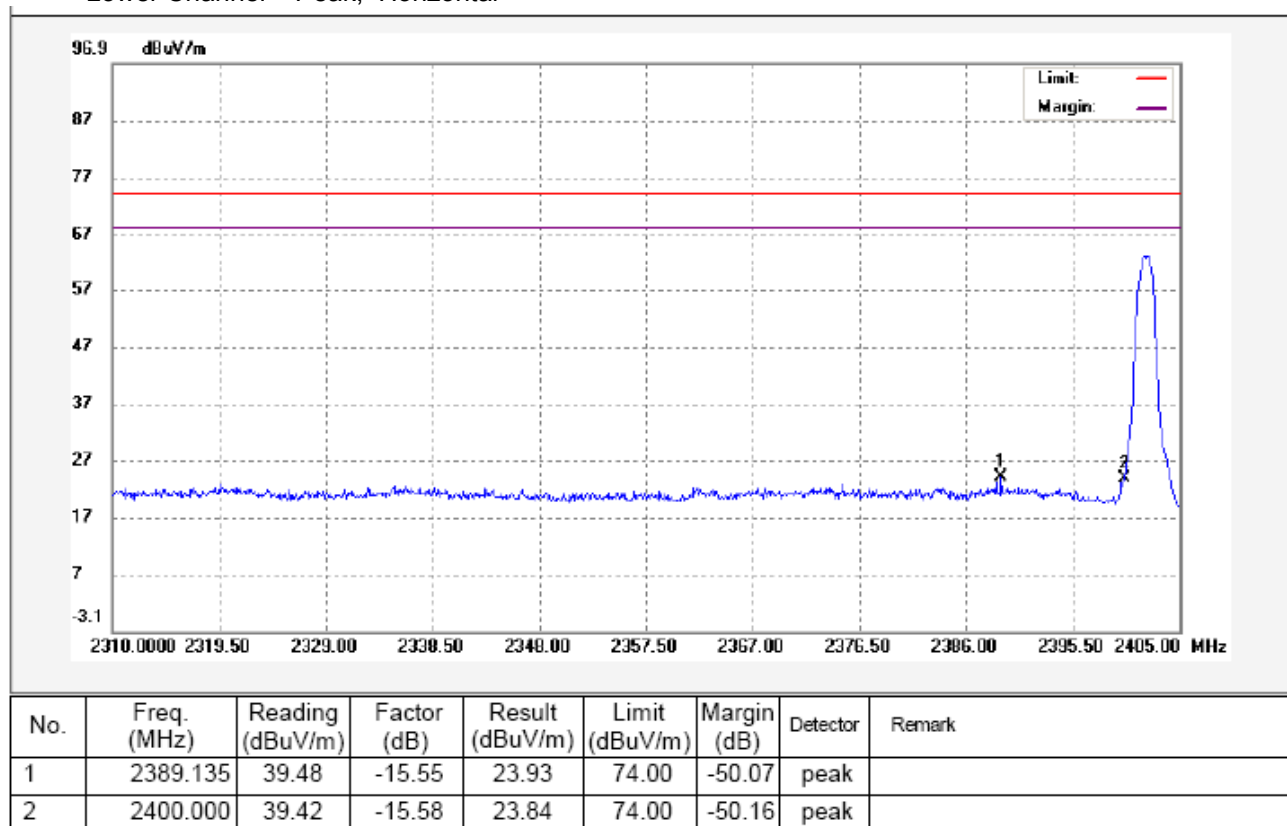
All the modulation modes were tested, the data of the worst mode (GFSK) were recorded in the following pages.

Modulation: GFSK
Lower Channel – Peak, Vertical



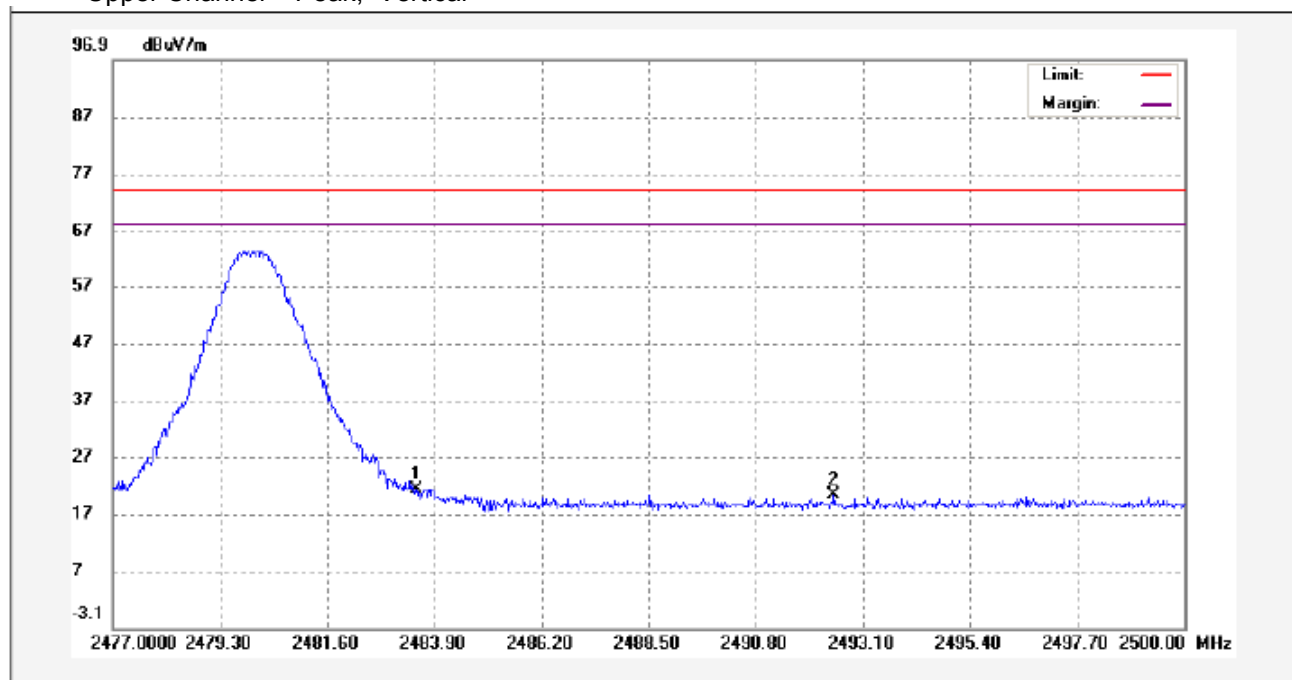
No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2357.000	-9	11.13	54.00	-42.87	AV	
2	2400.000	-9	24.11	54.00	-29.89	AV	

Lower Channel – Peak, Horizontal



No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2389.000	-9	14.93	54.00	-39.07	AV	
2	2400.000	-9	14.84	54.00	-39.16	AV	

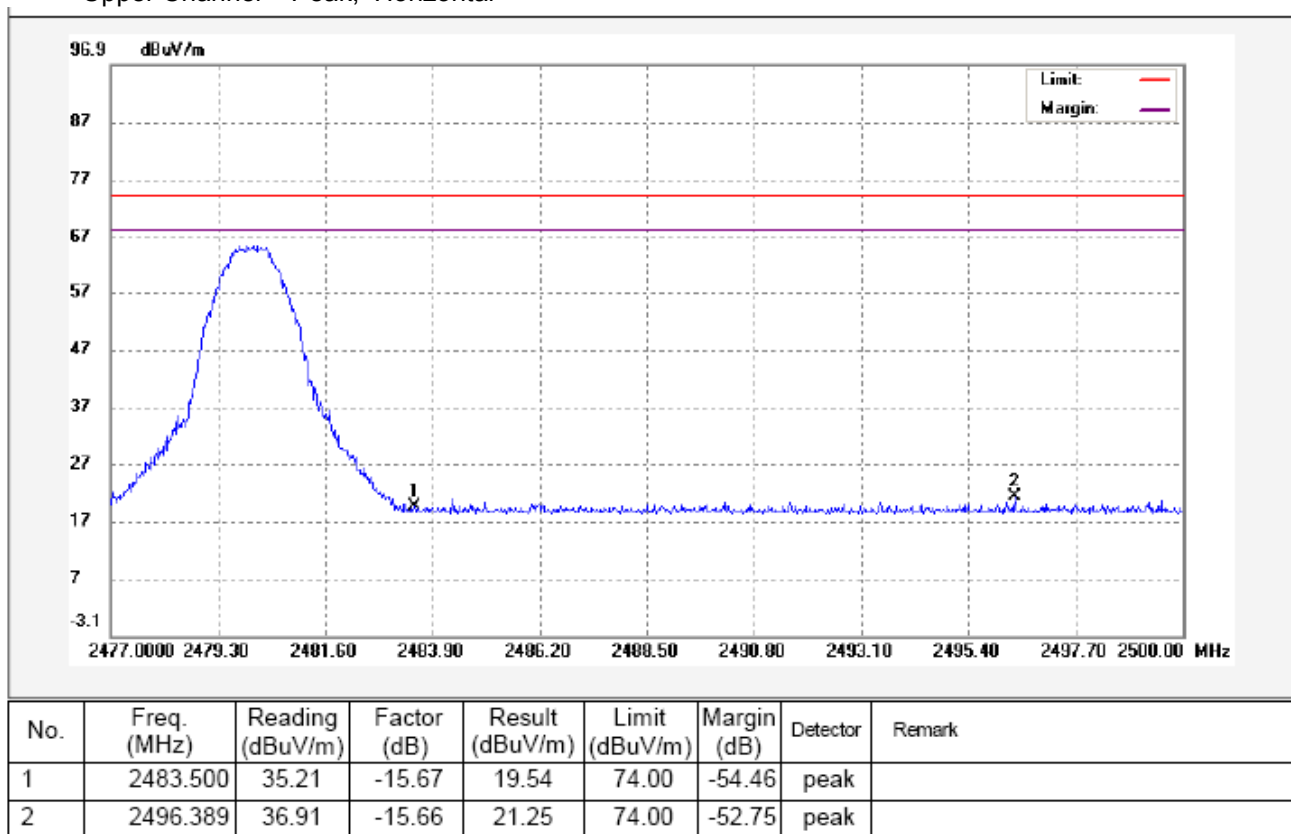
Upper Channel – Peak, Vertical



No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2483.500	36.91	-15.67	21.24	74.00	-52.76	peak	
2	2492.479	35.87	-15.66	20.21	74.00	-53.79	peak	

No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2483.500	-9	12.24	54.00	-41.76	AV	
2	2492.479	-9	11.21	54.00	-42.79	AV	

Upper Channel – Peak, Horizontal



No.	Freq. (MHz)	Duty Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Remark
1	2483.500	-9	10.54	54.00	-43.46	AV	
2	2496.389	-9	12.25	54.00	-41.75	AV	

11 20 dB Bandwidth Measurement

Test Requirement: FCC CFR47 Part 15 Section 15.247
Test Method: DA 00-705
Test Mode: Test in fixing operating frequency at low, Middle, high channel.

11.1 Test Procedure:

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum;
2. Set the spectrum analyzer: RBW = 100kHz, VBW = 100kHz

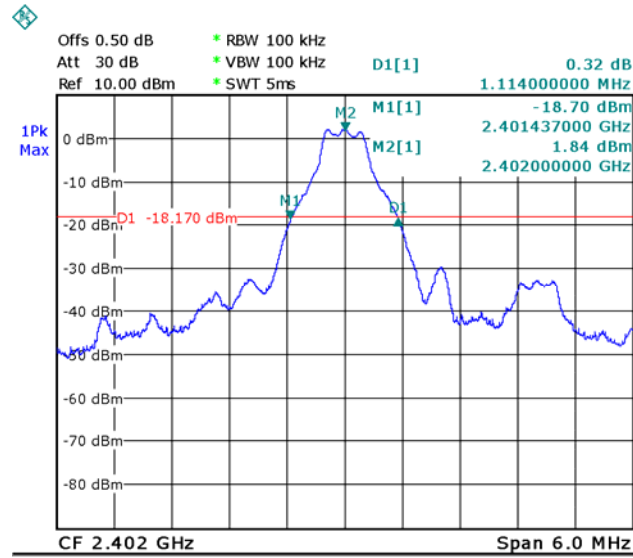
11.2 Test Result:

Modulation	Test Channel	Bandwidth(MHz)
GFSK	Lower	1.114
	Middle	1.114
	Upper	1.114
Pi/4DQPSK	Lower	1.349
	Middle	1.349
	Upper	1.333
8DPSK	Lower	1.377
	Middle	1.353
	Upper	1.353

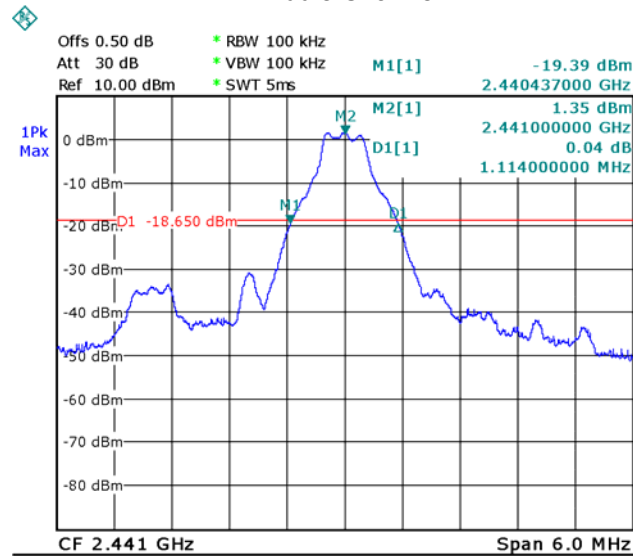
Test result plot as follows:

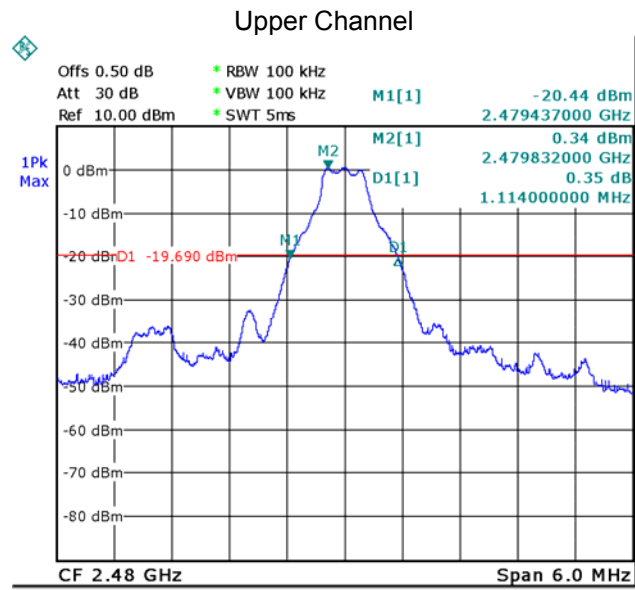
Modulation:GFSK

Lower Channel

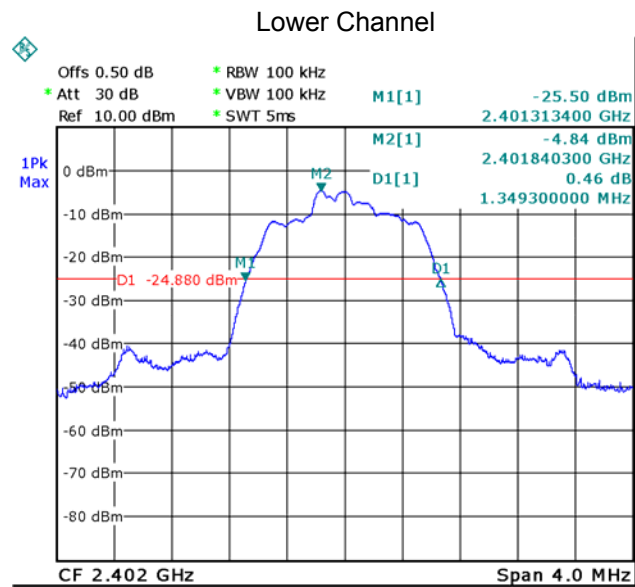


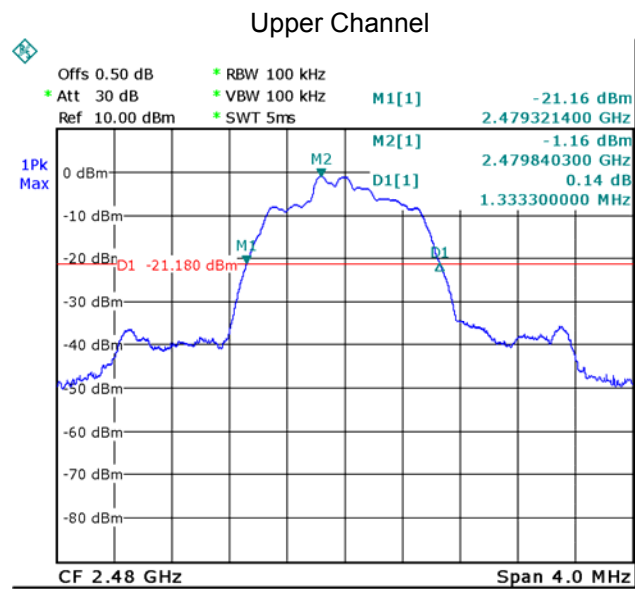
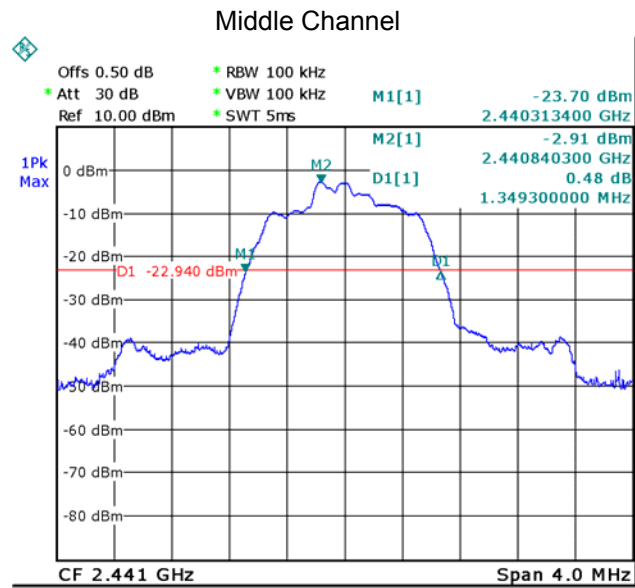
Middle Channel





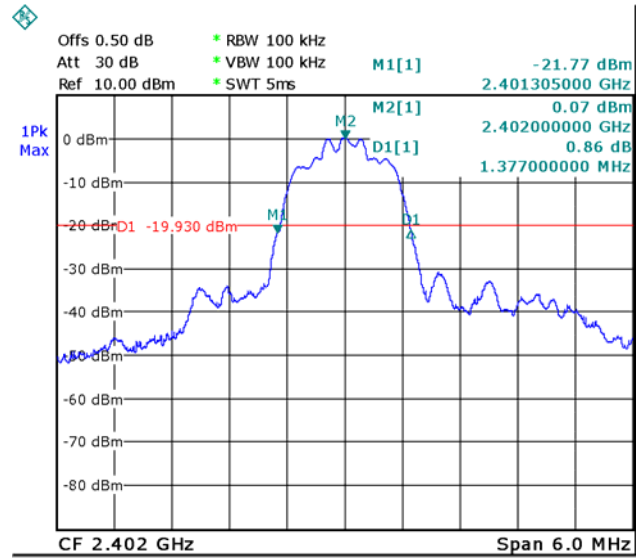
Modulation: Pi/4DQPSK



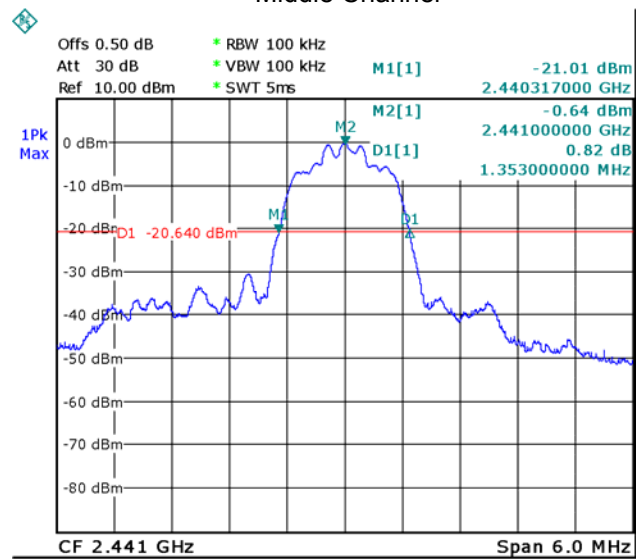


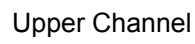
Modulation: 8DPSK

Lower Channel



Middle Channel





12 Maximum Peak Output Power

Test Requirement:	FCC CFR47 Part 15 Section 15.247
Test Method:	DA 00-705
Test Limit:	Regulation 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. Refer to the result "Number of Hopping Frequency" of this document. The 1watts (30 dBm) limit applies.
Test mode:	Test in fixing frequency transmitting mode.

12.1 Test Procedure:

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2. Set the spectrum analyzer: RBW = 3 MHz. VBW =3 MHz. Sweep = auto; Detector Function = Peak.
3. Keep the EUT in transmitting at lowest, medium and highest channel individually. Record the max value.

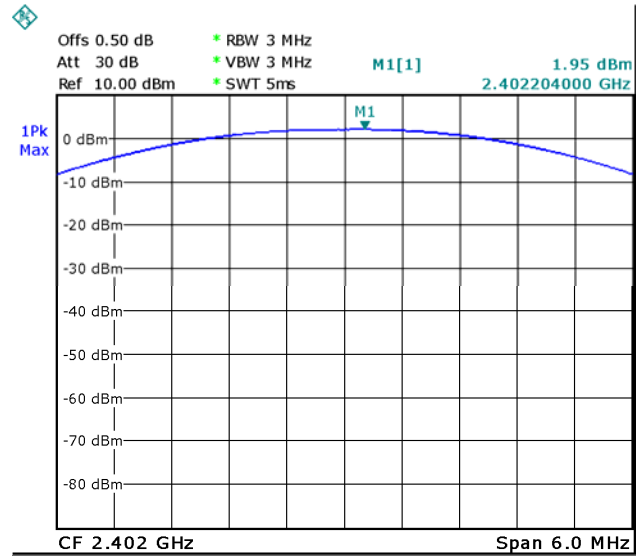
12.2 Test Result:

Modulation	Test Channel	Output Power (dBm)	Limit (dBm)
GFSK	Lower	1.95	30
	Middle	1.43	30
	Upper	0.46	30
Pi/4DQPSK	Lower	-4.22	30
	Middle	-2.27	30
	Upper	-0.64	30
8DPSK	Lower	1.07	30
	Middle	0.40	30
	Upper	-0.48	30

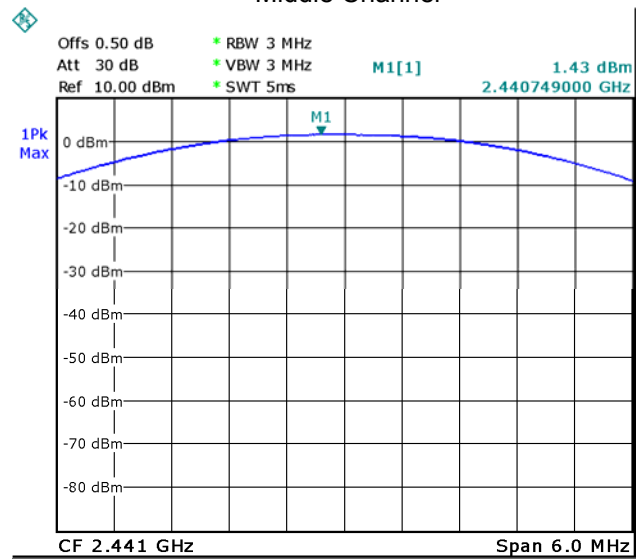
Test result plot as follows:

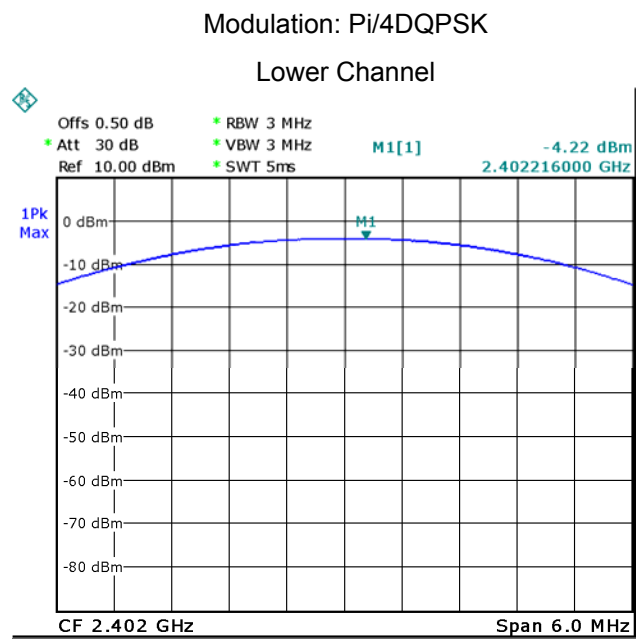
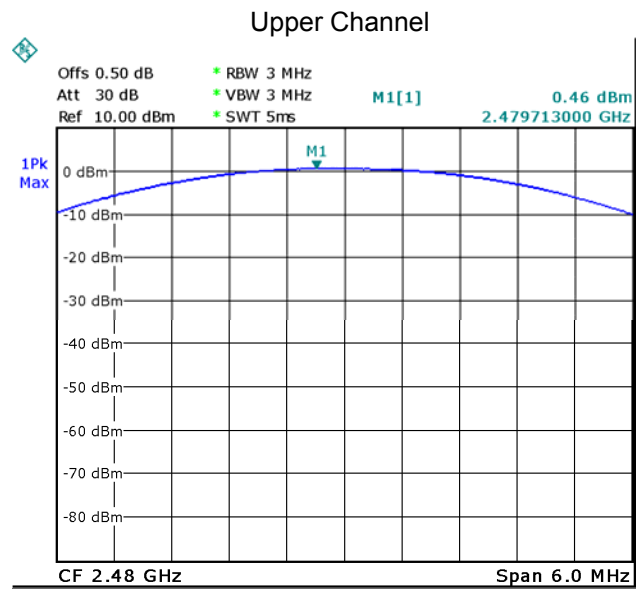
Modulation:GFSK

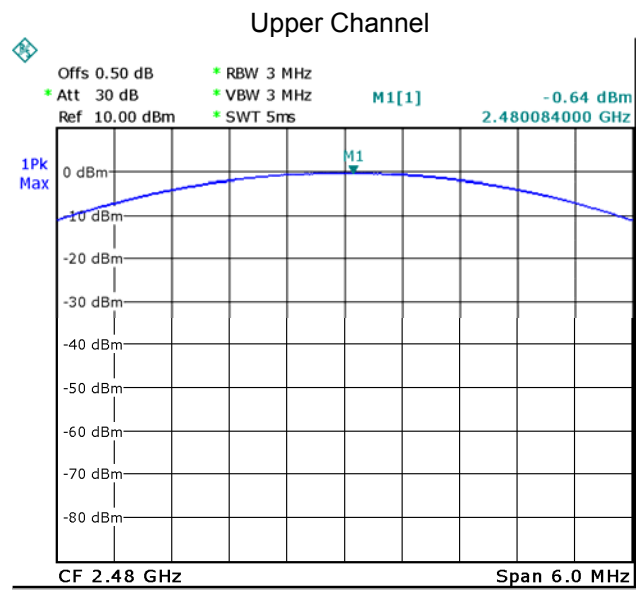
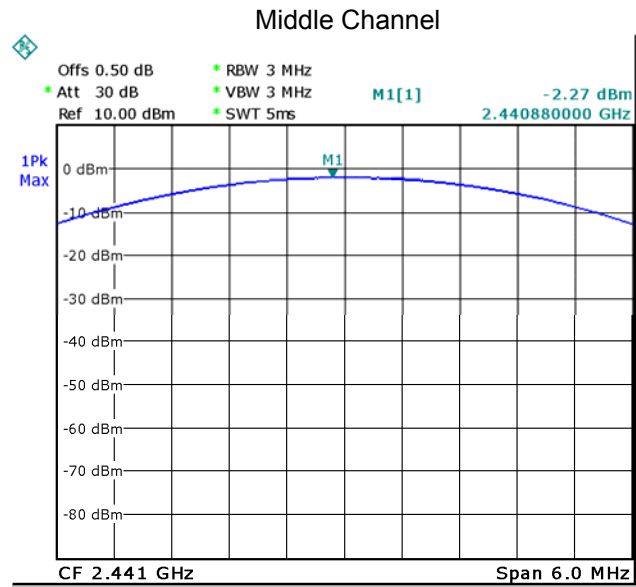
Lower Channel



Middle Channel

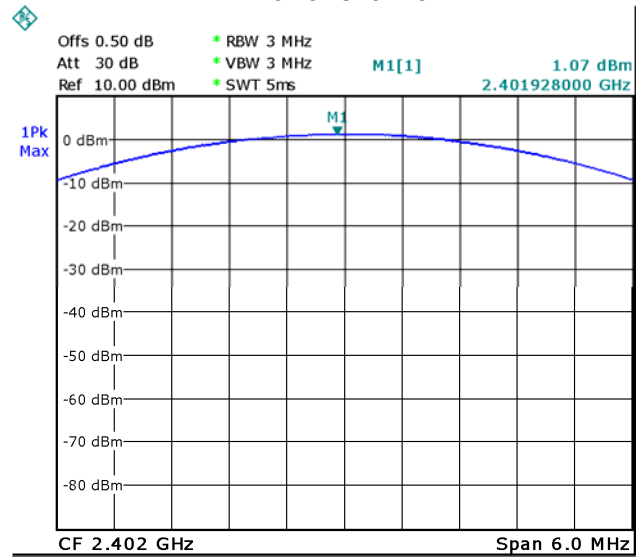




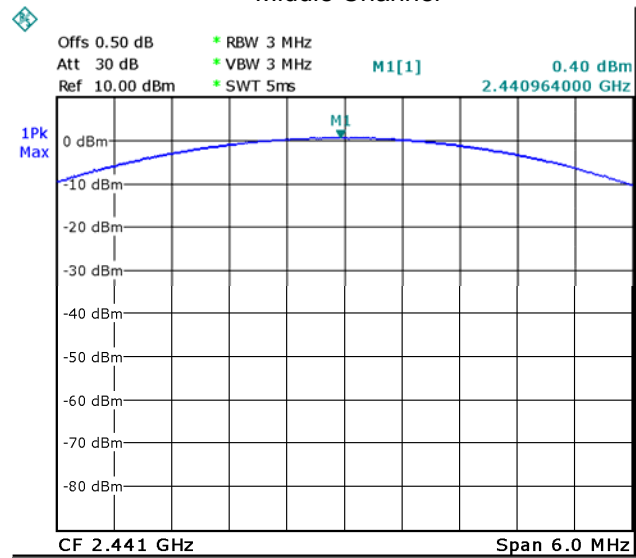


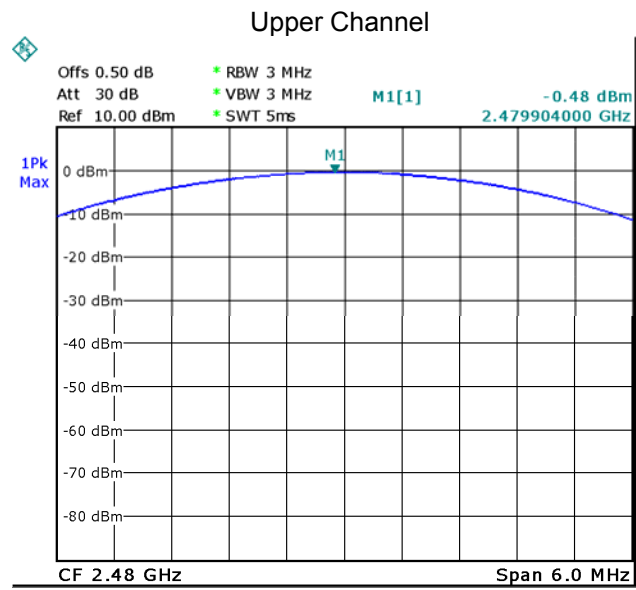
Modulation: 8DPSK

Lower Channel



Middle Channel





13 Hopping Channel Separation

Test Requirement: FCC CFR47 Part 15 Section 15.247

Test Method: DA 00-705

Test Limit: Regulation 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 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 1W.

Test Mode: Test in hopping transmitting operating mode.

13.1 Test Procedure:

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2. Set the spectrum analyzer: RBW = 100KHz. VBW = 100KHz , Span = 6MHz. Sweep = auto; Detector Function = Peak. Trace = Max hold.
3. Allow the trace to stabilize. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. The limit is specified in one of the subparagraphs of this Section Submit this plot.

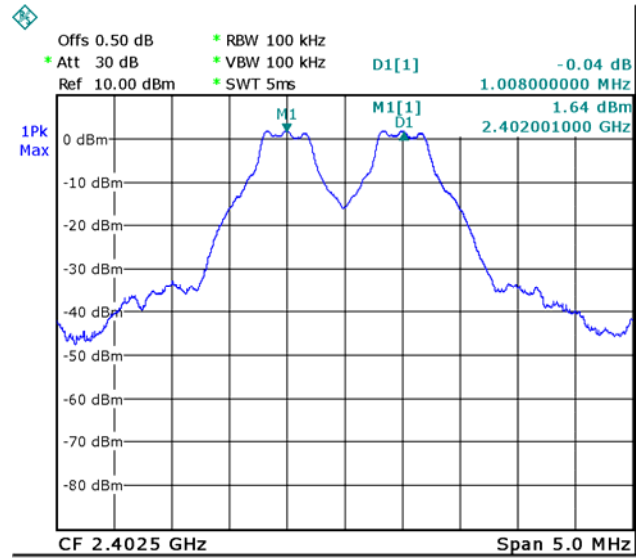
13.2 Test Result:

Modulation	Test Channel	Separation (MHz)
GFSK	Lower	1.008
	Middle	1.018
	Upper	1.008
Pi/4DQPSK	Lower	1.006
	Middle	1.006
	Upper	1.006
8DPSK	Lower	1.006
	Middle	1.006
	Upper	1.006

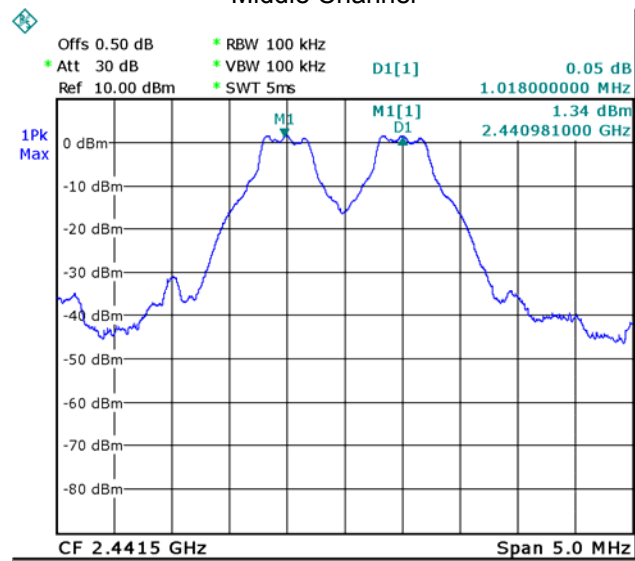
Test result plot as follows:

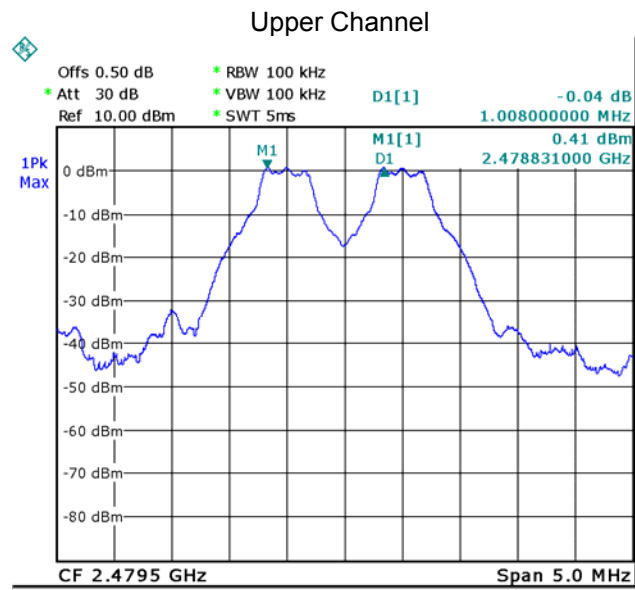
Modulation:GFSK

Lower Channel

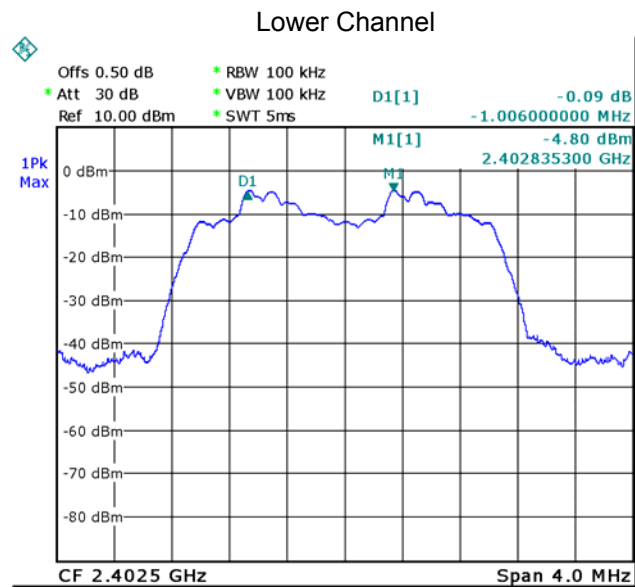


Middle Channel

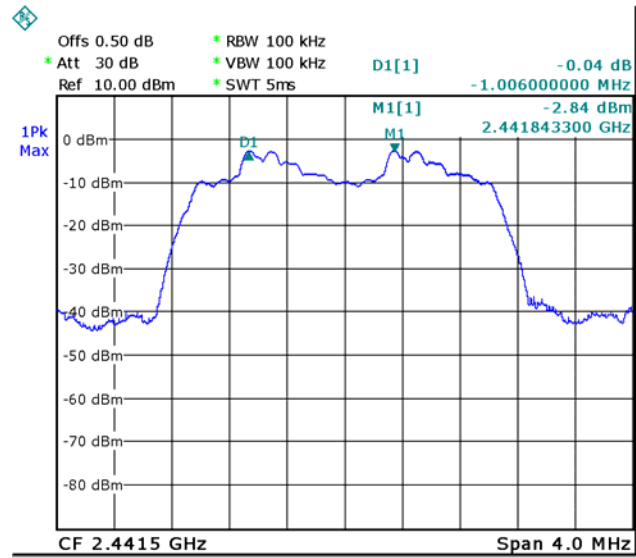




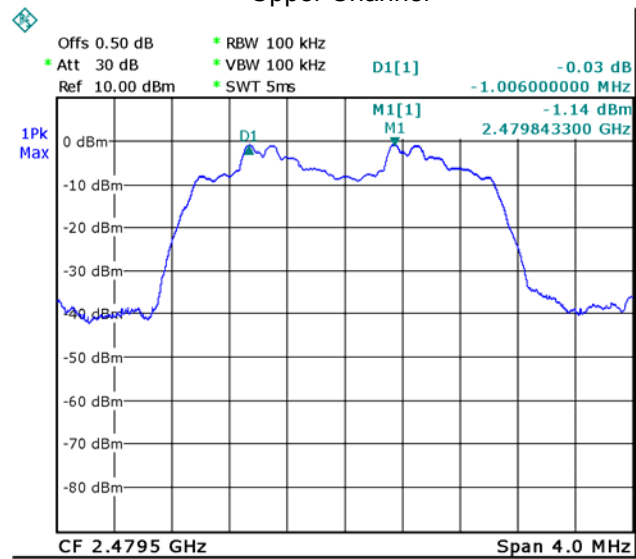
Modulation: Pi/4DQPSK



Middle Channel

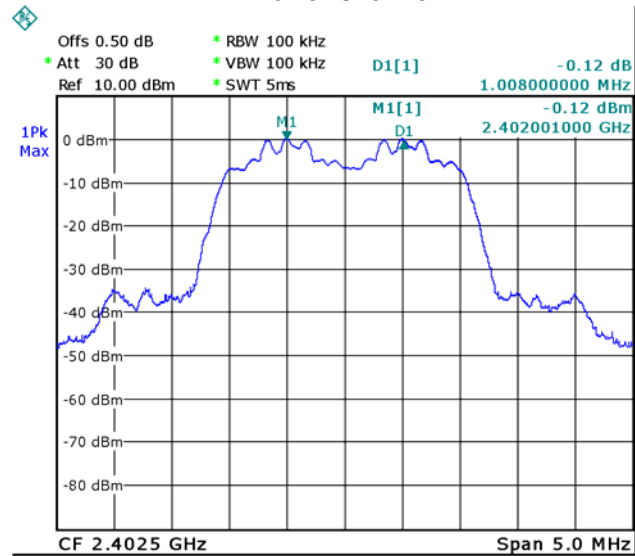


Upper Channel

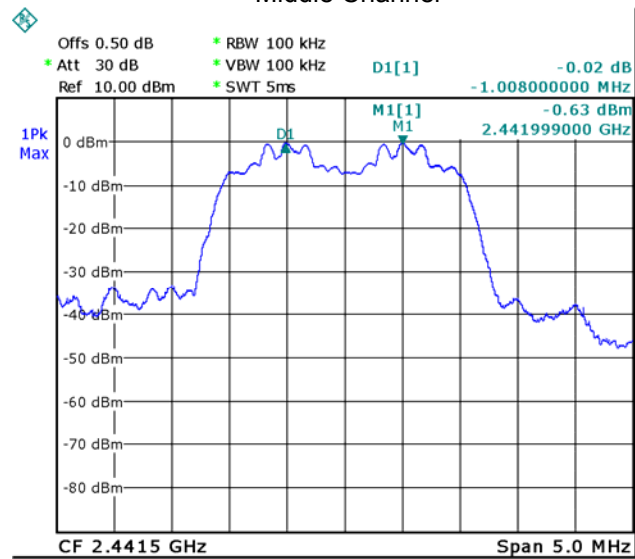


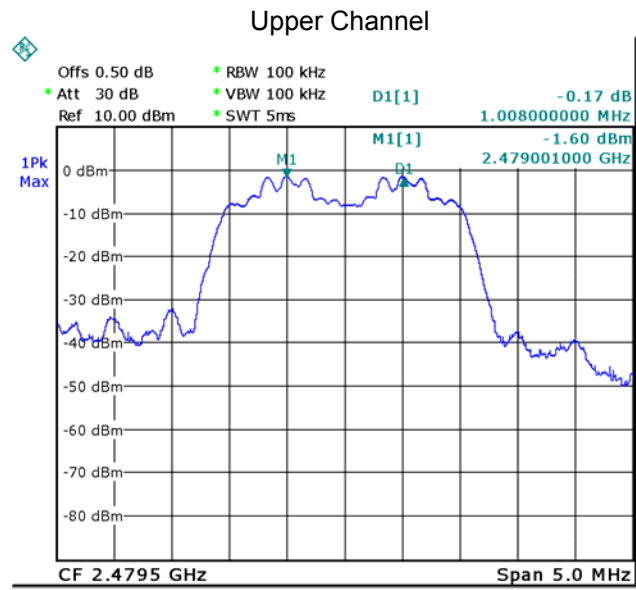
Modulation: 8DPSK

Lower Channel



Middle Channel





14 Number of Hopping Frequency

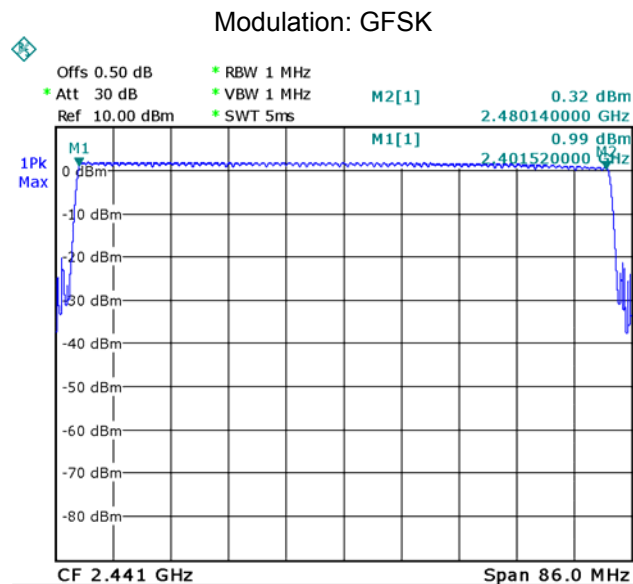
Test Requirement:	FCC CFR47 Part 15 Section 15.247
Test Method:	DA 00-705
Test Limit:	Regulation 15.247 (a)(1)(iii) Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.
Test Mode:	Test in hopping transmitting operating mode.

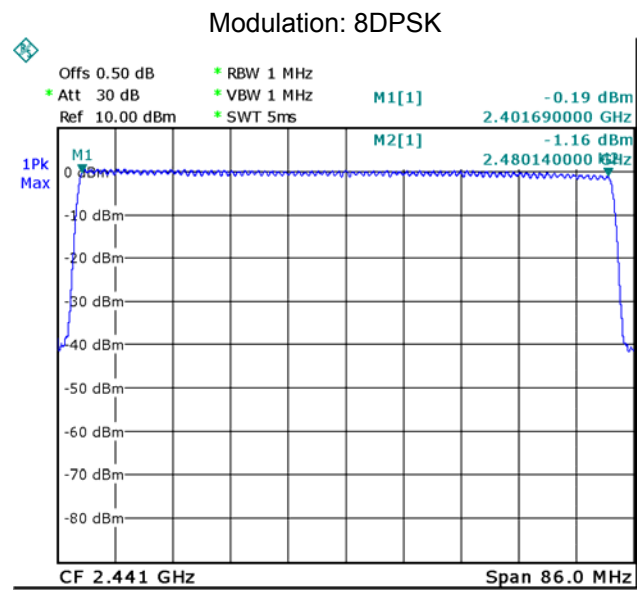
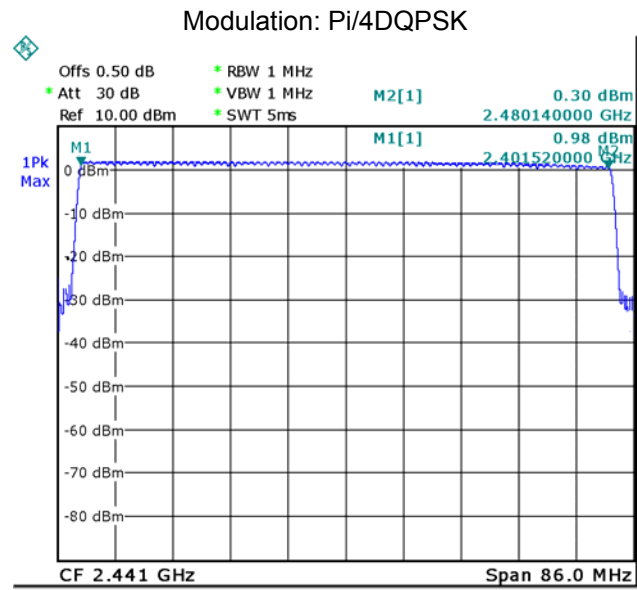
14.1 Test Procedure:

1. Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
2. Set the spectrum analyzer: RBW = 1MHz. VBW = 1MHz. Sweep = auto; Detector Function = Peak. Trace = Max hold.
3. Allow the trace to stabilize. It may prove necessary to break the span up to sections. in order to clearly show all of the hopping frequencies. The limit is specified in one of the subparagraphs of this Section.
4. Set the spectrum analyzer: Centre Frequency = 2.441GHz, Span = 86MHz. Sweep=auto;

14.2 Test Result:

Total Channels are 79 Channels.





15 Dwell Time

Test Requirement:	FCC CFR47 Part 15 Section 15.247
Test Method:	DA 00-705
Test Limit:	Regulation 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. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.
Test Mode:	Test in hopping transmitting operating mode.

15.1 Test Procedure:

- 1.Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum.
- 2.Set spectrum analyzer span = 0. centred on a hopping channel;
- 3.Set RBW = 1MHz and VBW = 1MHz. Sweep = as necessary to capture the entire dwell time per hopping channel.
- 4.Use the marker-delta function to determine the dwell time. If this value varies with different modes of operation (e.g.. data rate. modulation format. etc.). repeat this test for each variation. The limit is specified in one of the subparagraphs of this Section. Submit this plot(s).

15.2 Test Result:

Dwell time = Pulse wide x (Hopping rate / Number of channels) x Period

The test period: $T = 0.4(s) \times 79 = 31.6 (s)$

DH5 Packet permit maximum $1600 / 79 / 6$ hops per second in each channel (5 time slots RX, 1 time slot TX).

DH3 Packet permit maximum $1600 / 79 / 4$ hops per second in each channel (3 time slots RX, 1 time slot TX).

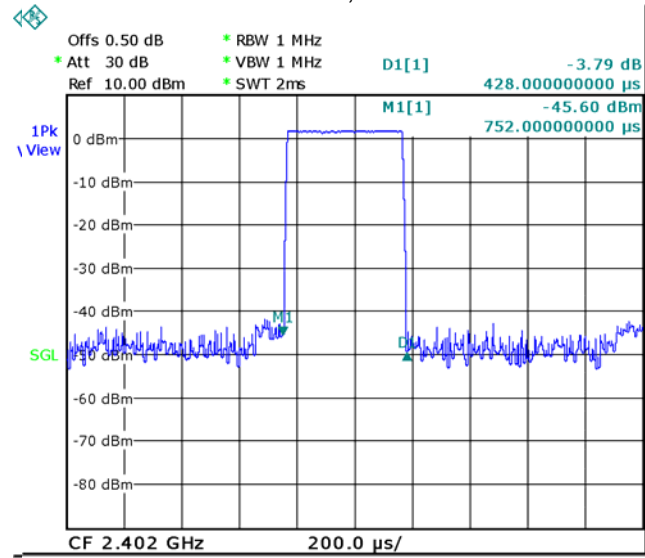
DH1 Packet permit maximum $1600 / 79 / 2$ hops per second in each channel (1 time slot RX, 1 time slot TX). So, the Dwell Time can be calculated as follows:

Data Packet	Dwell Time(s)
DH5	$1600/79/6 \times 31.6 \times (\text{MkrDelta}) / 1000$
DH3	$1600/79/4 \times 31.6 \times (\text{MkrDelta}) / 1000$
DH1	$1600/79/2 \times 31.6 \times (\text{MkrDelta}) / 1000$
Remark	Mkr Delta is single pulse time.

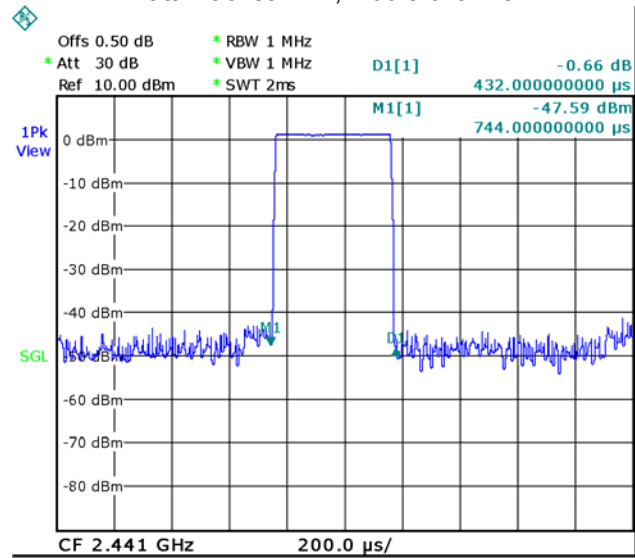
Modulation	Frequency	Data Packet	Mkr Delta(ms)	Dwell Time(s)	Limits(s)
GFSK	Lower channel	DH1	0.428	0.137	0.400
	Middle channel		0.432	0.138	0.400
	Upper channel		0.436	0.140	0.400
	Lower channel	DH3	1.704	0.273	0.400
	Middle channel		1.686	0.270	0.400
	Upper channel		1.692	0.271	0.400
	Lower channel	DH5	2.950	0.315	0.400
	Middle channel		2.958	0.316	0.400
	Upper channel		2.982	0.318	0.400
Pi/4DQPSK	Lower channel	DH1	0.444	0.142	0.400
	Middle channel		0.440	0.141	0.400
	Upper channel		0.440	0.141	0.400
	Lower channel	DH3	1.696	0.271	0.400
	Middle channel		1.684	0.269	0.400
	Upper channel		1.696	0.271	0.400
	Lower channel	DH5	2.970	0.317	0.400
	Middle channel		2.930	0.313	0.400
	Upper channel		2.938	0.313	0.400
8DPSK	Lower channel	DH1	0.440	0.141	0.400
	Middle channel		0.440	0.141	0.400
	Upper channel		0.444	0.142	0.400
	Lower channel	DH3	1.698	0.272	0.400
	Middle channel		1.716	0.275	0.400
	Upper channel		1.710	0.274	0.400
	Lower channel	DH5	2.966	0.316	0.400
	Middle channel		2.998	0.320	0.400
	Upper channel		2.982	0.318	0.400

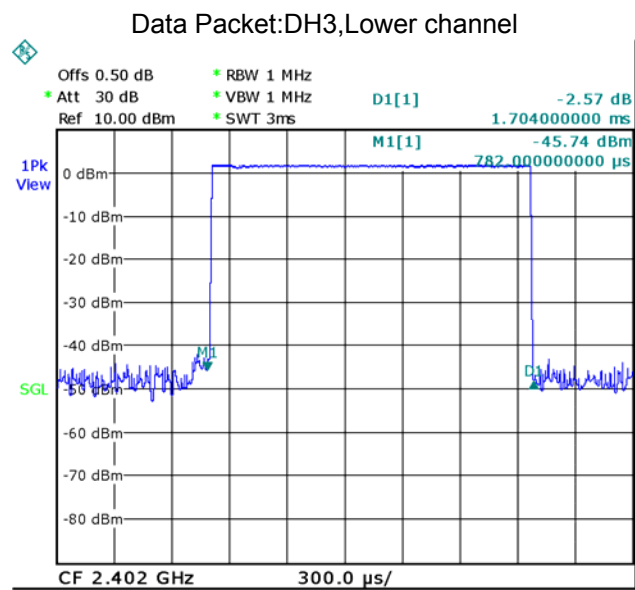
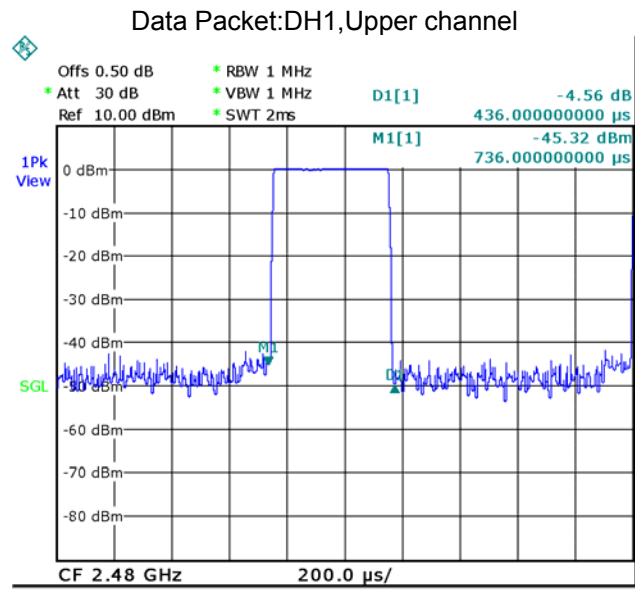
Modulation:GFSK

Data Packet:DH1,Lower channel

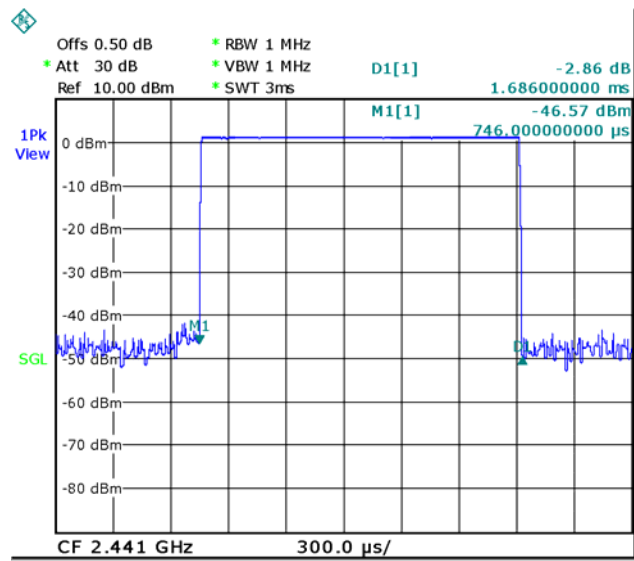


Data Packet:DH1,Middle channel

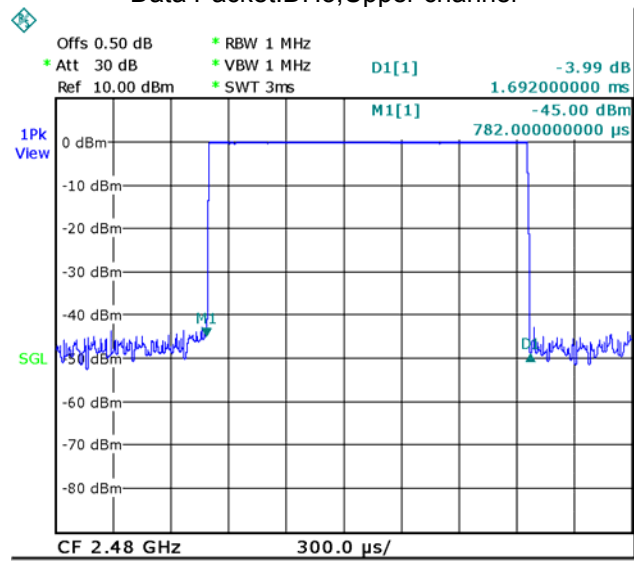




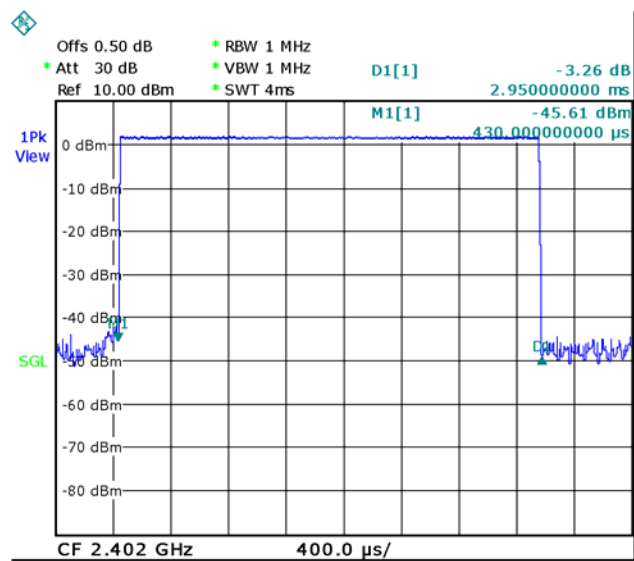
Data Packet:DH3,Middle channel



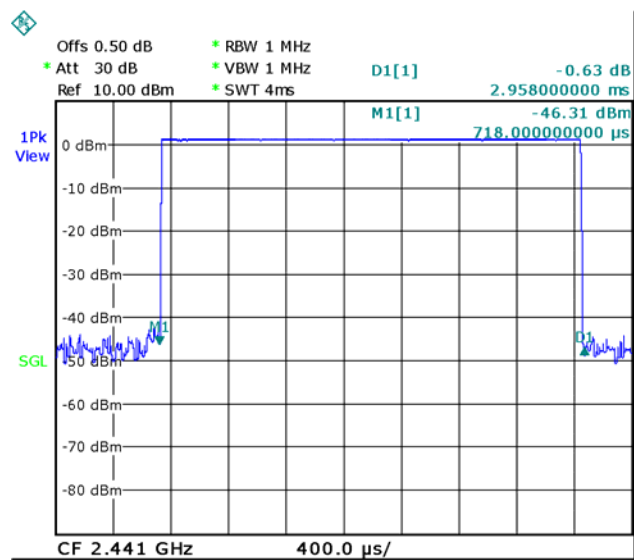
Data Packet:DH3,Upper channel



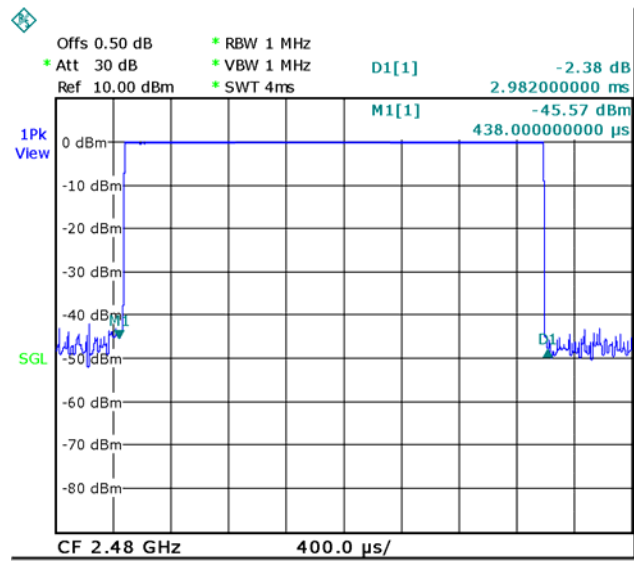
Data Packet:DH5,Lower channel



Data Packet:DH5,Middle channel

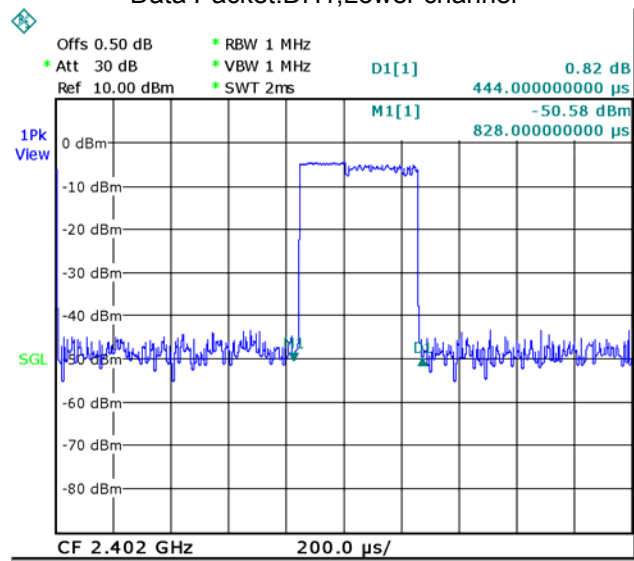


Data Packet:DH5,Upper channel

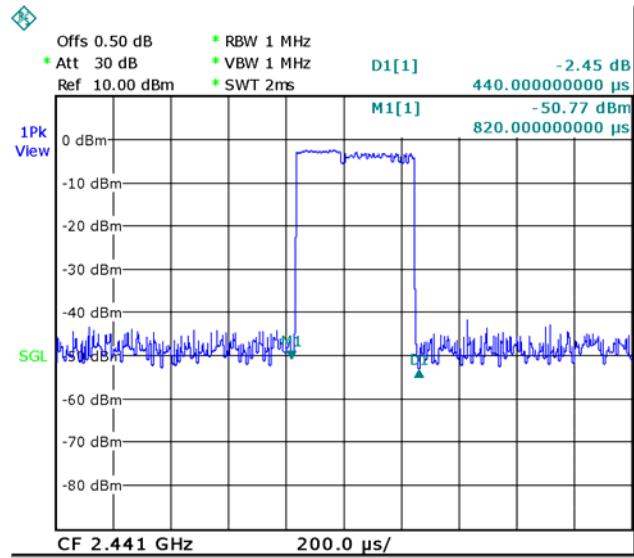


Modulation: Pi/4DQPSK

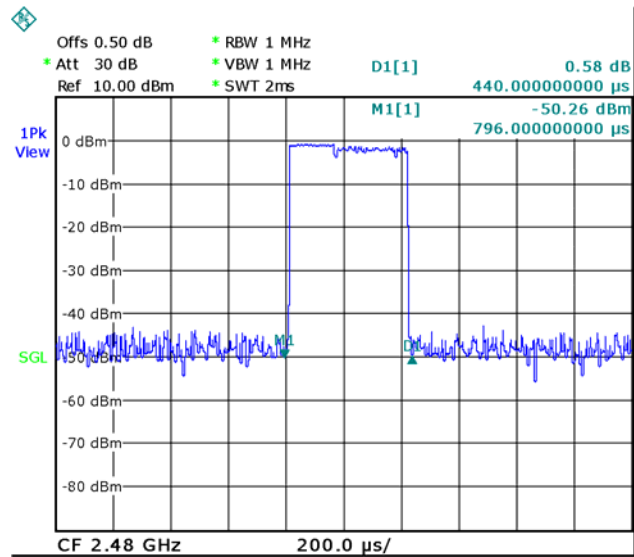
Data Packet:DH1,Lower channel

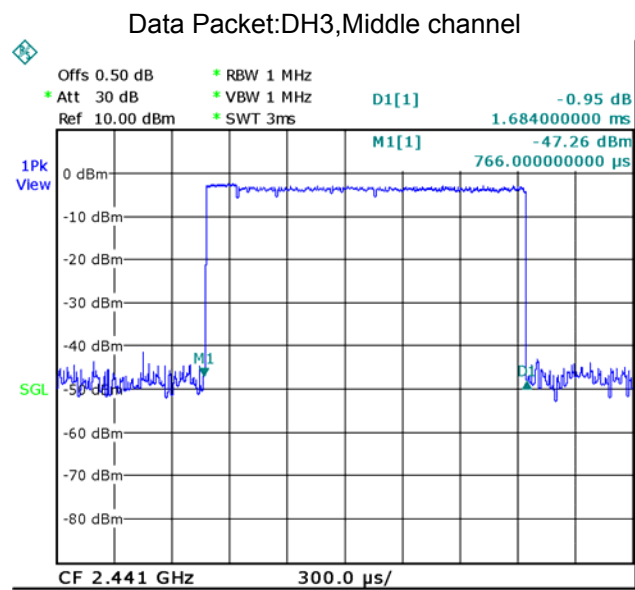
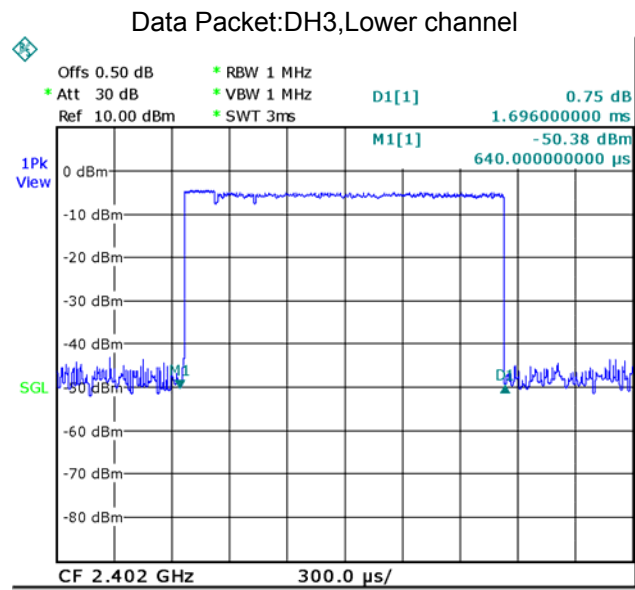


Data Packet:DH1,Middle channel

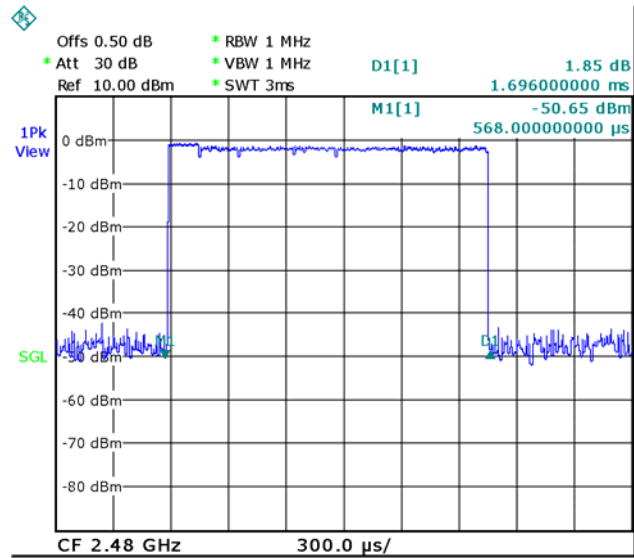


Data Packet:DH1,Upper channel

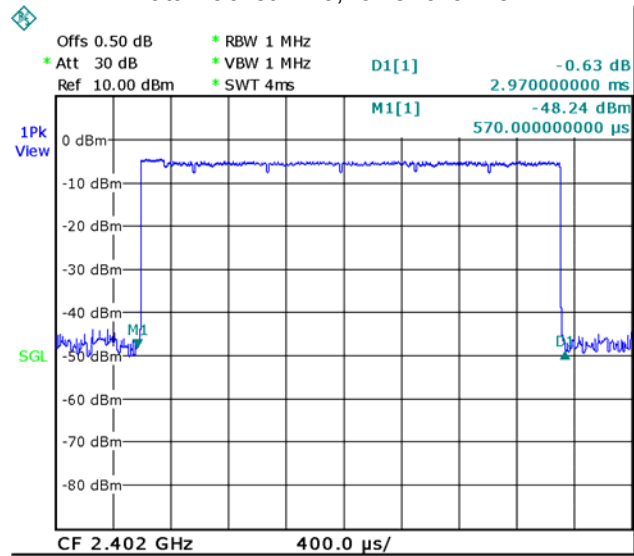




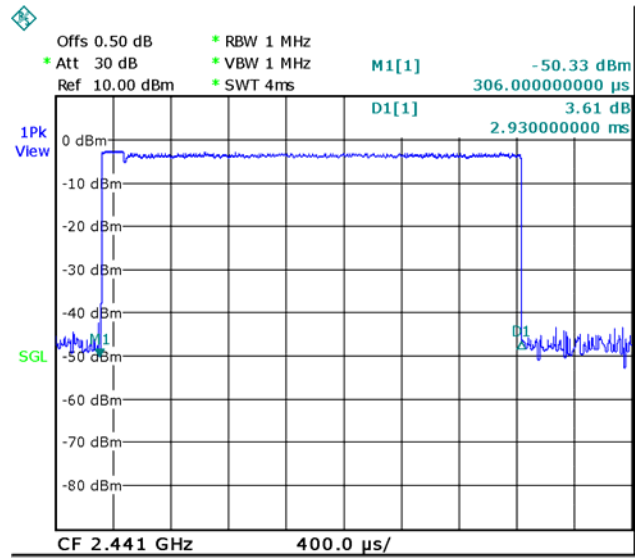
Data Packet:DH3,Upper channel



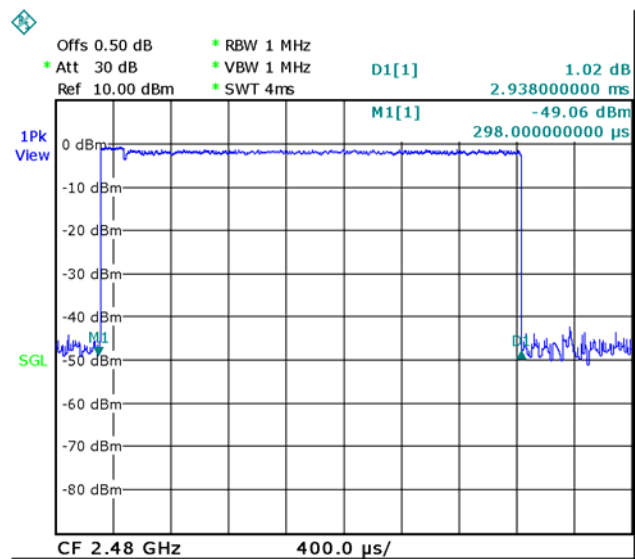
Data Packet:DH5,Lower channel



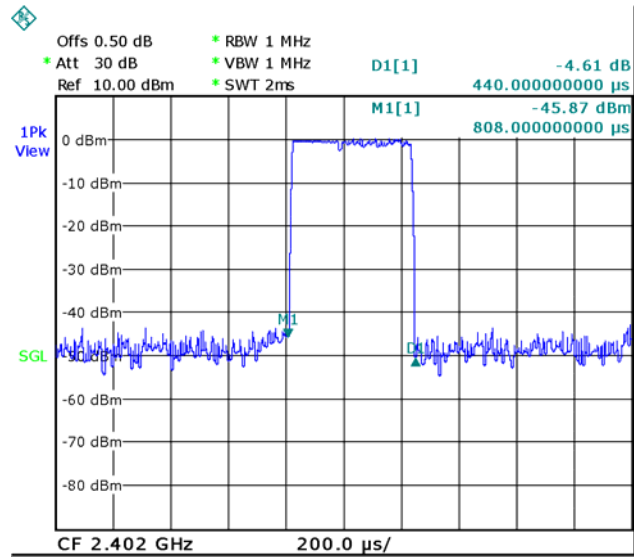
Data Packet:DH5,Middle channel



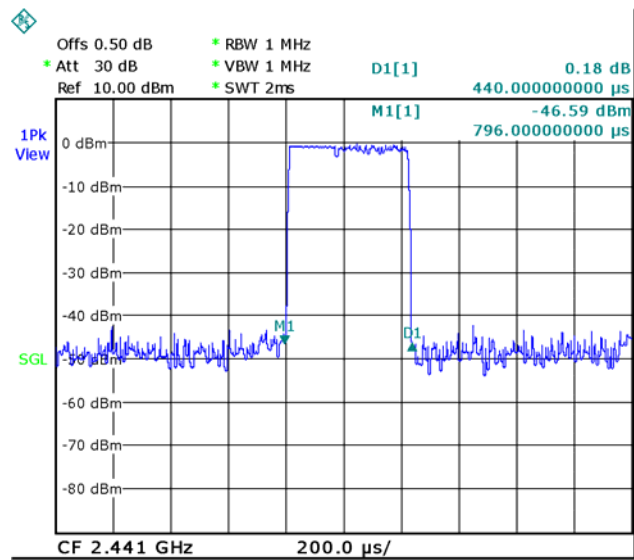
Data Packet:DH5,Upper channel

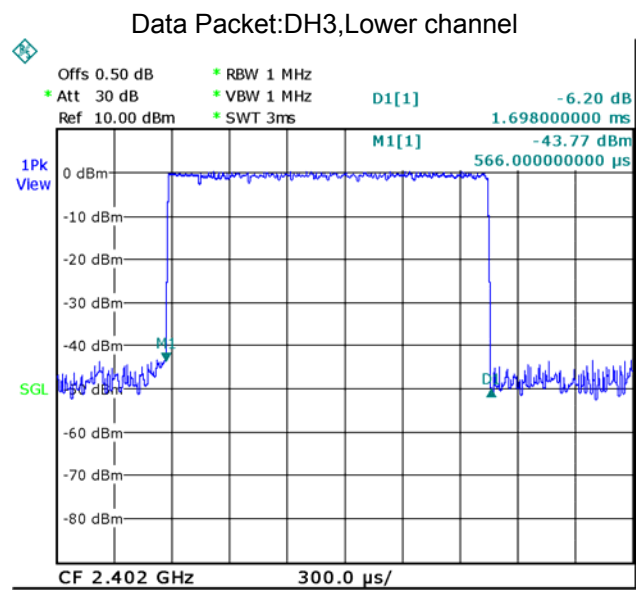
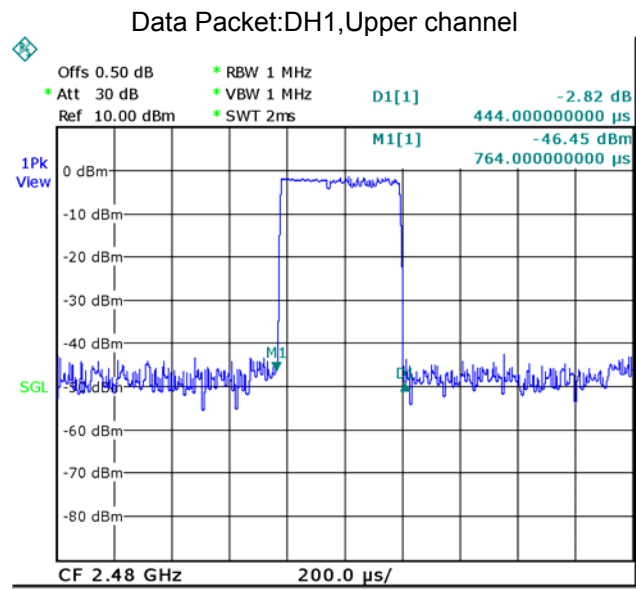


Modulation: 8DPSK
Data Packet:DH1,Lower channel

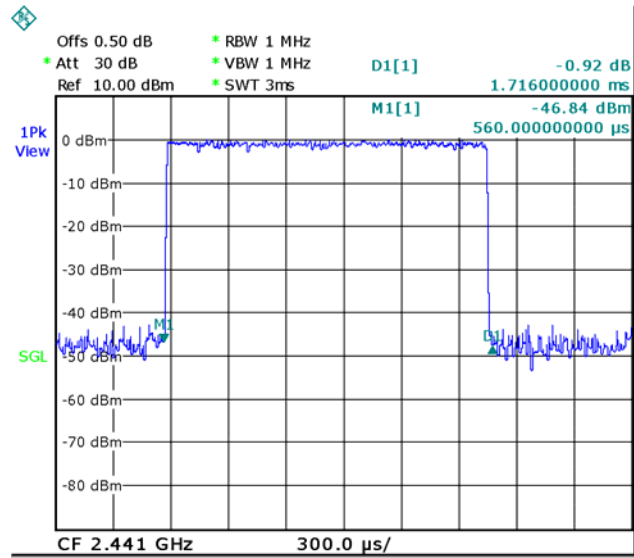


Data Packet:DH1,Middle channel

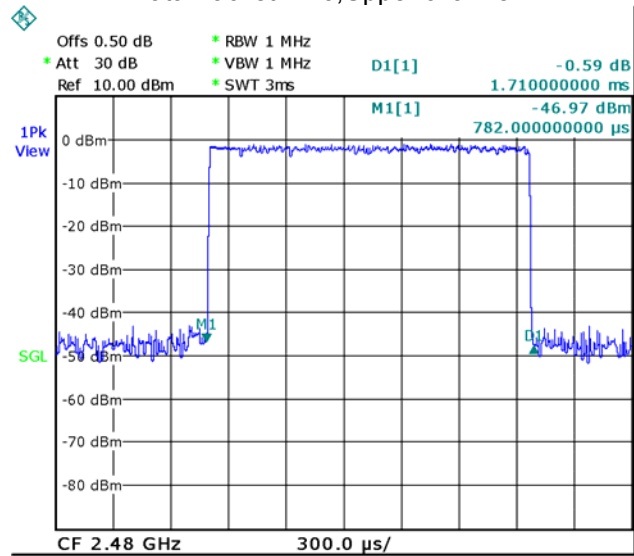




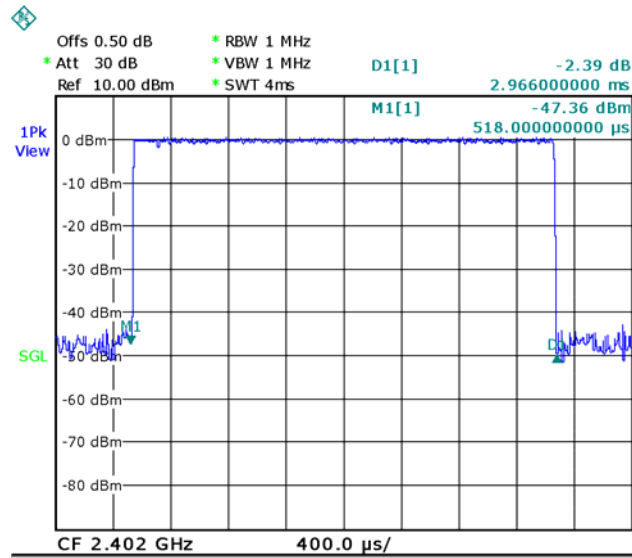
Data Packet:DH3,Middle channel



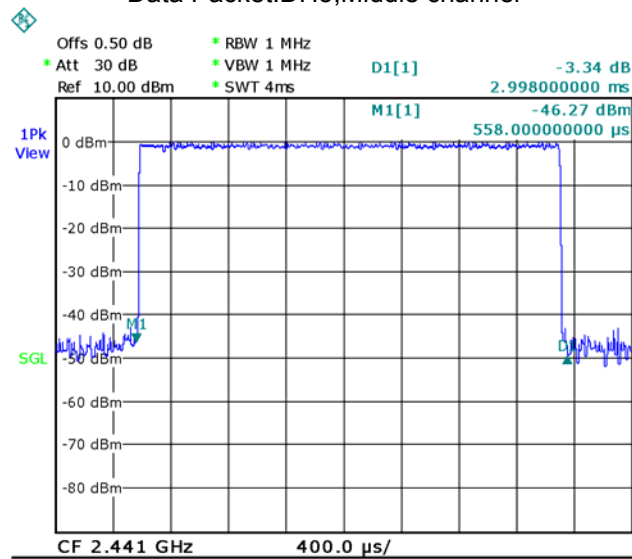
Data Packet:DH3,Upper channel



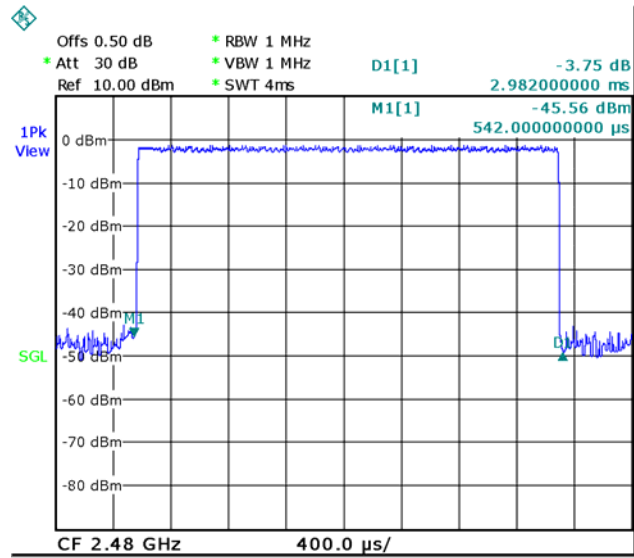
Data Packet:DH5,Lower channel



Data Packet:DH5,Middle channel



Data Packet:DH5,Upper channel



16 Antenna Requirement

According to the FCC Part 15 Paragraph 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. This product has a PCB printed antenna, fulfill the requirement of this section.

17 RF Exposure

Test Requirement:	FCC Part 1.1307
Test Method	KDB 447498 D01 General RF Exposure Guidance v05
Test Mode:	The EUT work in test mode(Tx).

17.1 Requirments:

1) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$[(\text{max. power of channel, including tune-up tolerance, mW})/(\text{min. test separation distance, mm})] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0$ for 1-g SAR and ≤ 7.5 for 10-g extremity SAR where

1. $f(\text{GHz})$ is the RF channel transmit frequency in GHz
2. Power and distance are rounded to the nearest mW and mm before calculation
3. The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

17.2 Test Result

Conducted Peak power(mW)	Source-based time-averaged maximum conducted output power(mW)	Minimum test separation distance required for the exposure conditions (mm)	SAR Test Exclusion Thresholds(mW)
0.695	0.240	5	10

Remark:Duty factor is 34.6%,refer to section 9 for more details.

Calculation formula: Source-based time-averaged maximum conducted output power(mW)
 =Conducted peak power(mW)*Duty factor

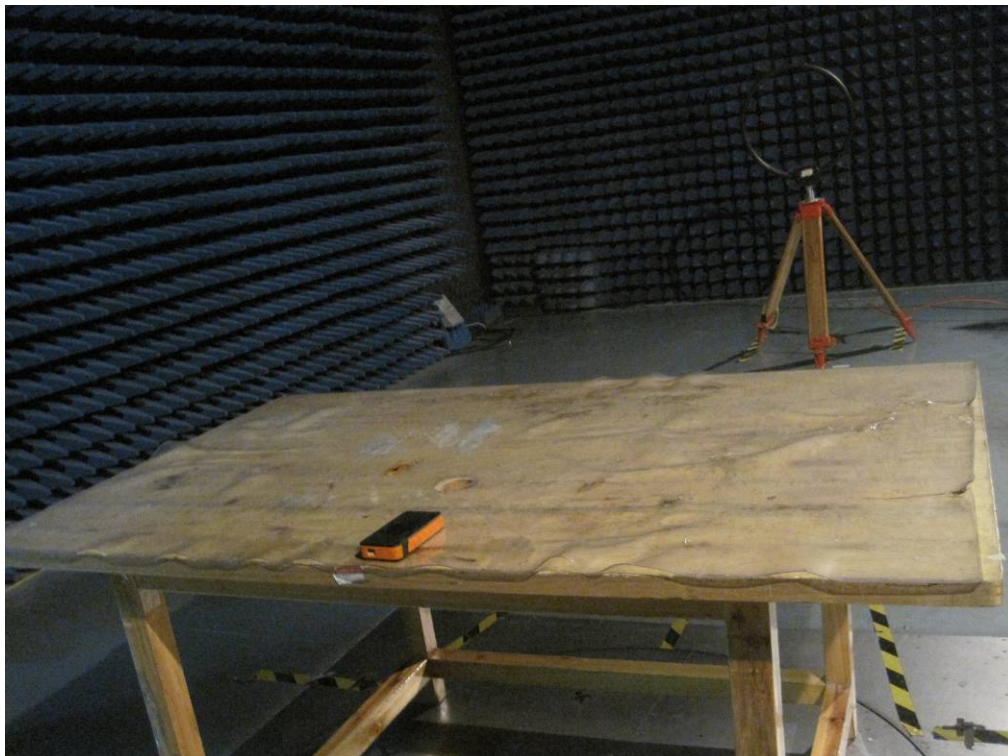
18 Photographs – Test Setup

18.1 Conducted Emissions

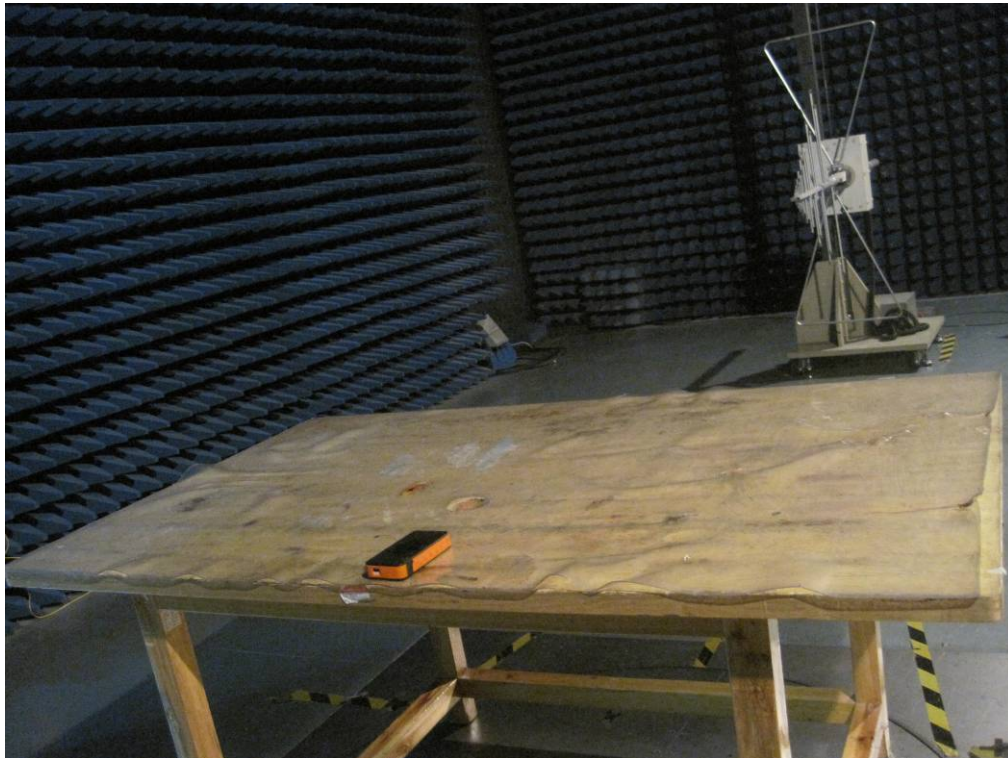


18.2 Radiated Emissions

Below 30MHz



From 30-1000MHz

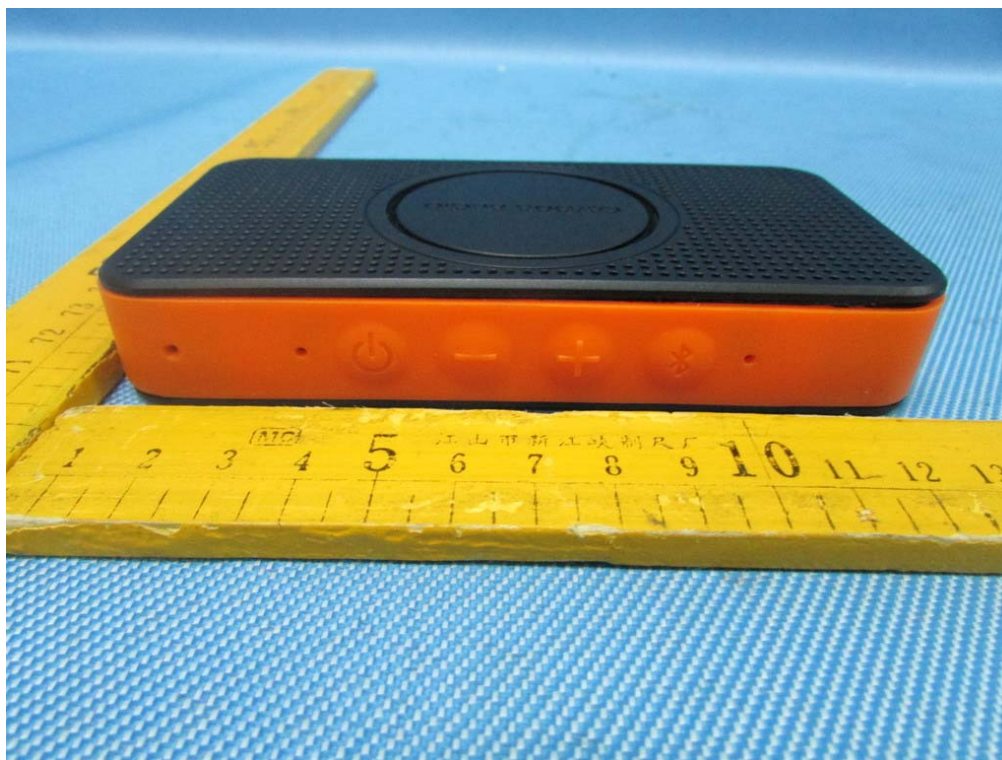


Above 1GHz



19 Photographs - Constructional Details

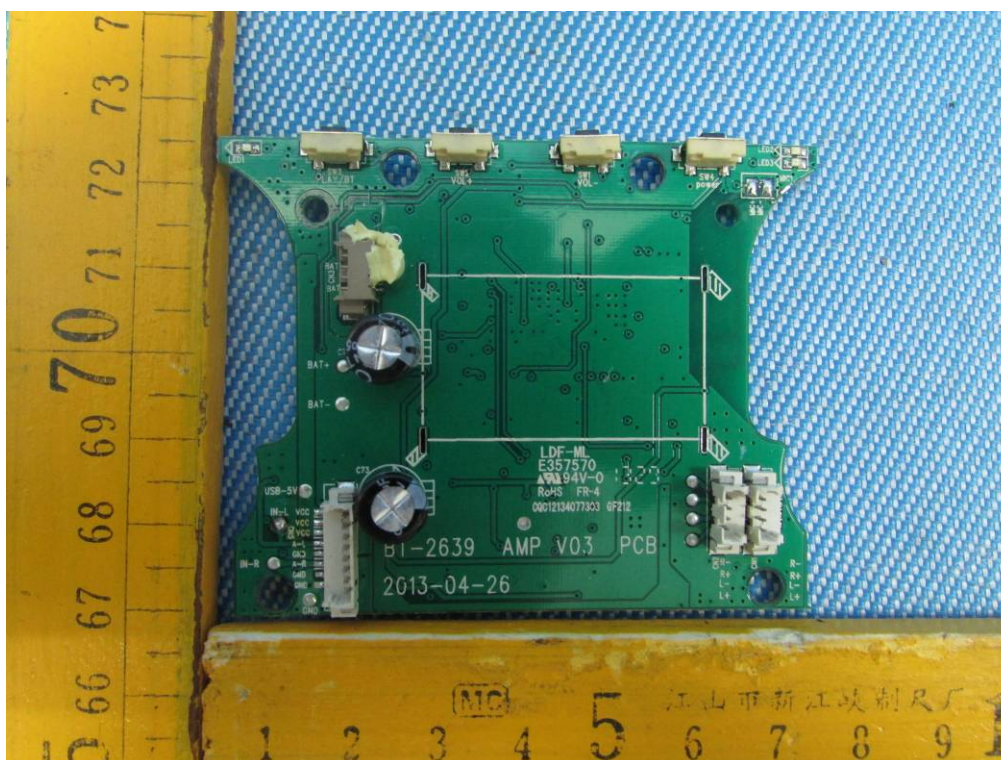
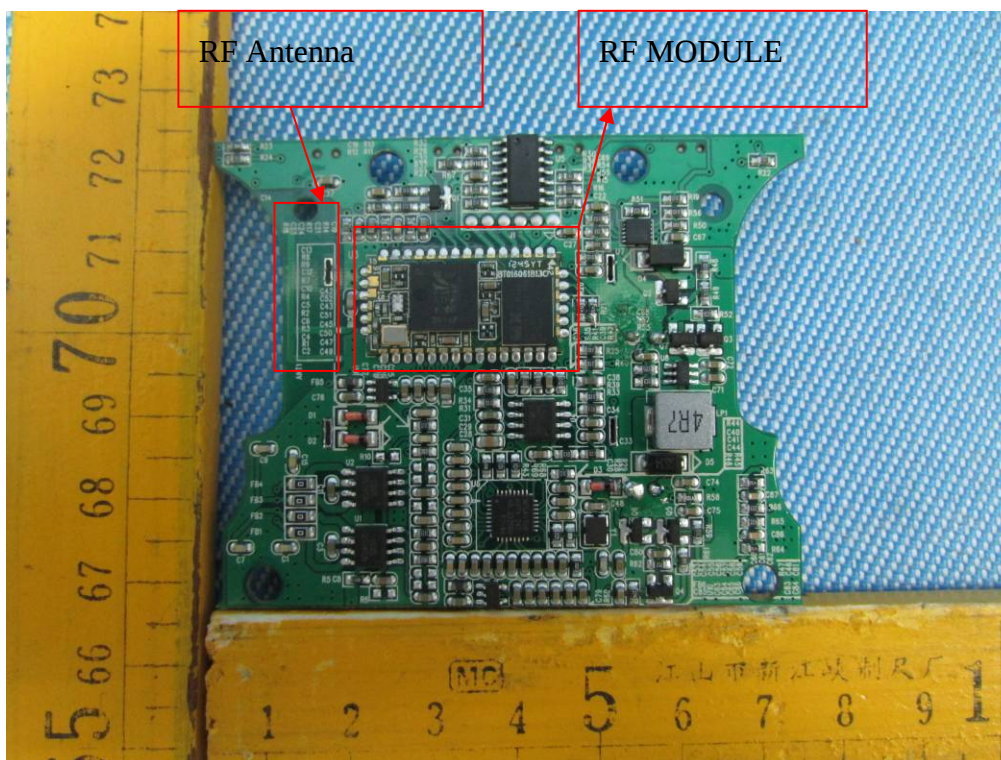
19.1 EUT – External View

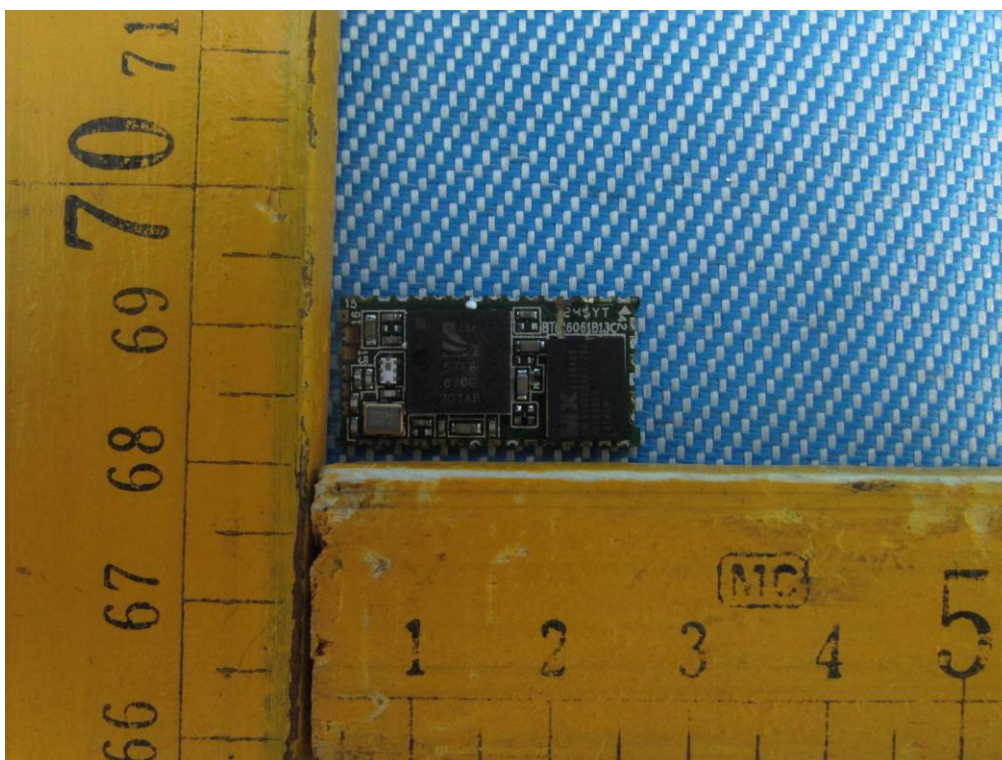


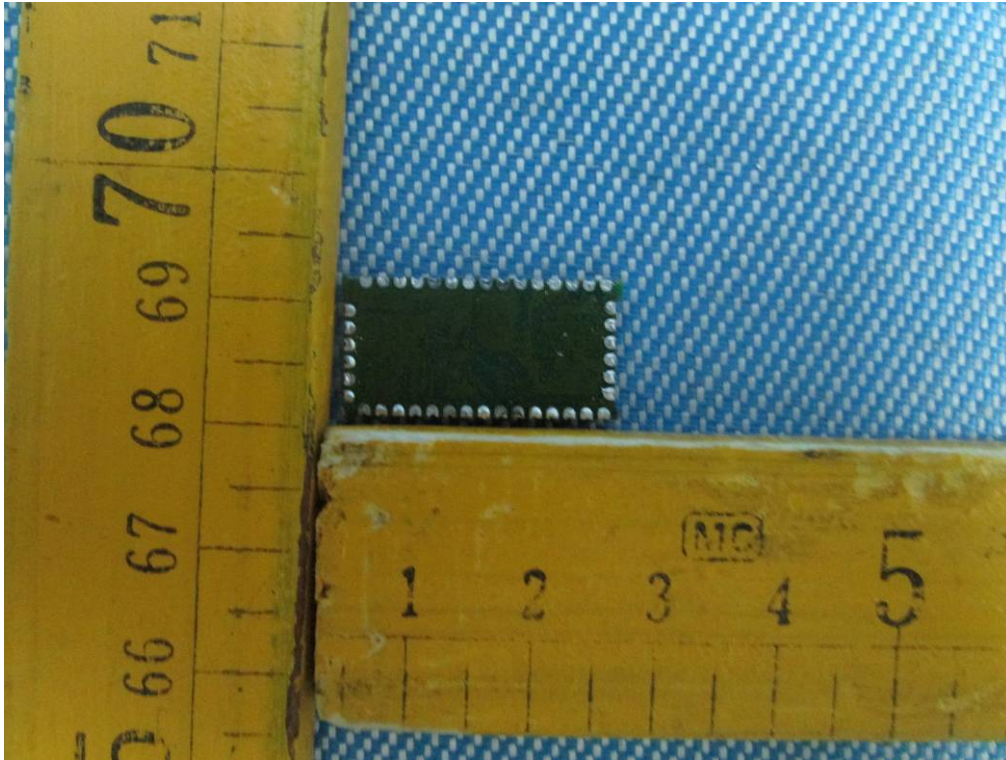


19.2 EUT – Internal View









==End of test report==