ELECTROMAGNETIC EMISSIONS COMPLIANCE REPORT
INTENTIONAL RADIATOR CERTIFICATION TO
FCC PART 15 SUBPART C REQUIREMENT

OF

TwinS TWS Bluetooth Sporty Earphone Set

Model No.: BH-289

Trademark: MANOVA

FCC ID: UKWMANOVABH289

Report No.: ED170717009E

Issue Date: July 11, 2017

Prepared for

MANOVA INTERNATIONAL LTD.
FLAT A, 13th FLOOR, CENTURY INDUSTRIAL CENTRE, 33-35 AU PUI WAN STREET, FO TAN, N.T., HONG KONG

Prepared by

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VERIFICATION OF COMPLIANCE

Applicant:	MANOVA INTERNATIONAL LTD. FLAT A, 13th FLOOR, CENTURY INDUSTRIAL CENTRE, 33-35 AU PUI WAN STREET, FO TAN, N.T., HONG KONG
Manufacturer:	MANOVA INTERNATIONAL LTD. FLAT A, 13th FLOOR, CENTURY INDUSTRIAL CENTRE, 33-35 AU PUI WAN STREET, FO TAN, N.T., HONG KONG
Product Description:	TwinS TWS Bluetooth Sporty Earphone Set
Trade Mark:	MANOVA
Model Number:	BH-289

We hereby certify that:

The above equipment was tested by EMTEK(DONGGUAN) CO., LTD. The test data, data evaluation, test procedures, and equipment configurations shown in this report were made in accordance with the procedures given in ANSI C63.10-2013 and the energy emitted by the sample EUT tested as described in this report is in compliance with conducted and radiated emission limits of FCC Rules Part 15.247(2016).

Date of Test : July 06, 2017 to July 11, 2017

Prepared by : Abby Li/Editor

Reviewer : Tomas Yang/Supervisor

Approved & Authorized Signer : Sam Lv/Manager

Modified Information

Version	Summary	Revision Date	Report No.
Ver.1.0	Original Report	/	ED170717009E

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1. GENERAL INFORMATION

1.1 Product Description

Characteristics	Description
Product Name	TwinS TWS Bluetooth Sporty Earphone Set
Model number	BH-289
Power Supply	DC 5V from adapter, DC 3.7V Battery
Kind of Device	Bluetooth Ver.4.2+EDR
Modulation	GFSK, π/4-DQPSK, 8DPSK
Operating Frequency Range	2402-2480MHz
Number of Channels	79
Transmit Power Max(PK)	-2.50dBm(0.000562W)
Antenna Type	Internal Antenna
Antenna Gain	3.09dBi

1.2 Test Methodology

Both conducted and radiated testing was performed according to the procedures in ANSI C63.10-2013. Radiated testing was performed at an antenna to EUT distance 3 meters.

1.3 Test Facility

Site Description

EMC Lab.	:	Registered on FCC, July 06, 2016 The Certificate Number is 247565. Registered on Industry Canada, January 13, 2017 The Certificate Number is 9444A
Name of Firm	:	EMTEK(DONGGUAN) CO., LTD.
Site Location	:	No.281, Guantai Road, Nancheng District, Dongguan, Guangdong, China

2. System Test Configuration

2.1 EUT Configuration

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner which intends to maximize its emission characteristics in a continuous normal application.

2.2 EUT Exercise

The Transmitter was operated in the normal operating mode. The Tx frequency was fixed which was for the purpose of the measurements.

2.3 Test Procedure

2.3.1 Conducted Emissions

The EUT is a placed on as turn table which is 0.8 m above ground plane. According to the requirements in Section 13.1.4.1 of ANSI C63.10-2013. Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-Peak and average detector mode.

2.3.2 Radiated Emissions

Below 1000MHz, The EUT was placed on a turn table which is 0.8m above ground plane. And above 1000MHz, The EUT was placed on a styrofoam table which is 1.5m above ground plane. The turn table shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3m away from the receiving antenna which varied from 1m to 4m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of EUT was rotated through three orthogonal axes according to the requirements in Section 13.1.4.1 of ANSI C63.10-2013.

2.4 Configuration of Tested System

Fig. 2-1 Configuration of Tested System

EUT

Table 2-1 Equipment Used in Tested System

Item	Equipment	Trademark	Model No.	FCC ID	Note
1.	TwinS TWS Bluetooth Sporty Earphone Set	MANOVA	BH-289	UKWMANOVABH289	***EUT***
2.	Adapter	N/A	YSV6-0501000	N/A	Support Equipment

Note:

(1) Unless otherwise denoted as EUT in『Remark』column , device(s) used in tested system is a support equipment.

3. Summary of Test Results

FCC Rules	Description Of Test	Result
§15.207	AC Power Conducted Emission	N/A(see note 1)
§15.247(d),§15.209	Radiated Emission	Compliant
§15.247(a)(1)	Channel Separation test	Compliant
§15.247(a)(1)	20dB Bandwidth	Compliant
§15.247(a)(1)(iii)	Quantity of Hopping Channel	Compliant
§15.247(a)(1)(iii)	Time of Occupancy(Dwell Time)	Compliant
§15.247(b)	Max Peak output Power test	Compliant
§15.247(d)	Band edge test	Compliant
§15.203	Antenna Requirement	Compliant

Remark: The product was tested under the battery fully charged.

Note 1: During the charging proceed, the Bluetooth function of this device is inactive and EUT can't operate. And the report of FCC VOC include test data of the AC Power Conducted Emission, so the radio report don't need to add the data of AC Power Conducted Emission.

4. Description of test modes

The EUT has been tested under its typical operating condition. Pre-defined engineering program for regulatory testing used to control the EUT for staying in continuous transmitting. Only the worst case data were reported.

The EUT has been associated with peripherals pursuant to ANSI C63.10-2013 and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: radiation (9 KHz to the 10th harmonics of the highest fundamental frequency or to 40 GHz, whichever is lower).

The EUT has been tested under TX operating condition.
This EUT is a FHSS system, were conducted to determine the final configuration from all possible combinations. We use software control the EUT, Let EUT hopping on and transmit with highest power, all the modes GFSK, Π/4-DQPSK, 8DPSK have been tested. 79 Channels are provided by EUT. The 3 channels of lower, medium and higher were chosen for test.

Channel	Frequency(MHz)
1	2402
40	2441
79	2480

5. TEST SYSTEM UNCERTAINTY

The following measurement uncertainty levels have been estimated for tests performed on the apparatus:

Parameter	Uncertainty
Radio Frequency	±1x10^-5
Maximum Peak Output Power Test	±1.0dB
Conducted Emissions Test	±2.0dB
Radiated Emission Test	±2.0dB
Power Density	±2.0dB
Occupied Bandwidth Test	±1.0dB
Band Edge Test	±3dB
All emission, radiated	±3dB
Antenna Port Emission	±3dB
Temperature	±0.5℃
Humidity	±3%

Remark: The coverage Factor (k=2), and measurement Uncertainty for a level of Confidence of 95%

6. Radiated Emission Test

6.1 Measurement Procedure

1. The testing follows the guidelines in Spurious Radiated Emissions of ANSI C63.10-2013.
2. Below 1000MHz, The EUT was placed on a turn table which is 0.8m above ground plane. And above 1000MHz, The EUT was placed on a styrofoam table which is 1.5m above ground plane.
3. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower.
4. For each suspected emission, the EUT was arranged to its worst case and then tune the Antenna tower (From 1m to 4m) and turntable (from 0 degree to 360 degree) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level to comply with the guidelines.
5. Set to the maximum power setting and enable the EUT transmit continuously.
6. Final measurement (Above 1GHz): The frequency range will be divided into different sub ranges depending of the frequency range of the used horn antenna. The EMI Receiver set to peak and average mode and a resolution bandwidth of 1MHz. The measurement will be performed in horizontal and vertical polarization of the measuring antenna and while rotating the EUT in its vertical axis in the range of 0 degree to 360 degree in order to have the antenna inside the cone of radiation.
7. Test Procedure of measurement (For Above 1GHz):
   1) Monitor the frequency range at horizontal polarization and move the antenna over all sides of the EUT(if necessary move the EUT to another orthogonal axis).
   2) Change the antenna polarization and repeat 1) with vertical polarization.
   3) Make a hardcopy of the spectrum.
   4) Measure the frequency of the detected emissions with a lower span and resolution bandwidth to increase the accuracy and note the frequency value.
   5) Change the analyser mode to Clear/ Write and found the cone of emission.
   6) Rotate and move the EUT, so that the measuring distance can be enlarged to 3m and the antenna will be still inside the cone of emission.
   7) Measure the level of the detected frequency with the correct resolution bandwidth, with the antenna polarization and azimuth and the peak and average detector, which causes the maximum emission.
   8) Repeat steps 1) to 7) for the next antenna spot if the EUT is larger than the antenna beamwidth.

Use the following spectrum analyzer settings:

When spectrum scanned from 30MHz to 1GHz setting resolution bandwidth 120KHz and video bandwidth 300KHz:

EMI Test Receiver	Setting
Attenuation	Auto
RB	120KHz
VB	300KHz
Detector	QP
Trace	Max hold

When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 3MHz:

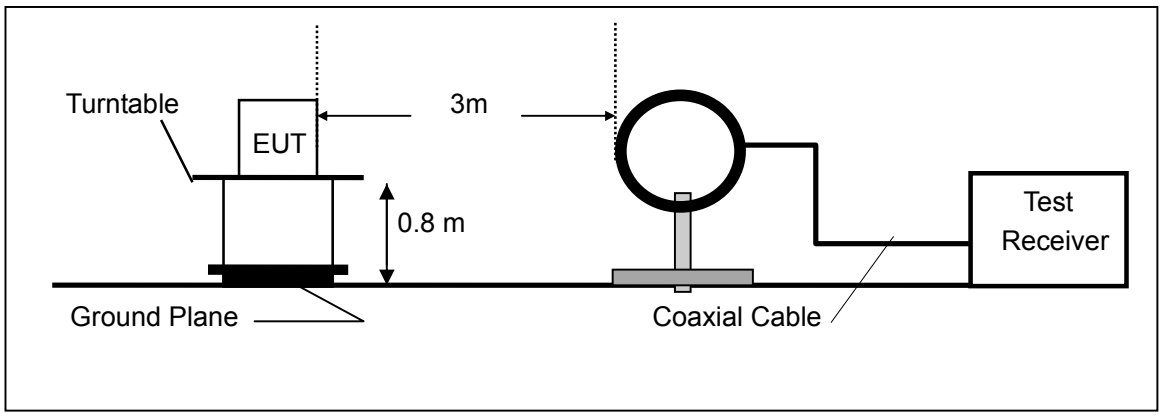
EMI Test Receiver	Setting
Attenuation	Auto
RB	1MHz
VB	3MHz
Detector	Peak+AV
Trace	Max hold

When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 10Hz:

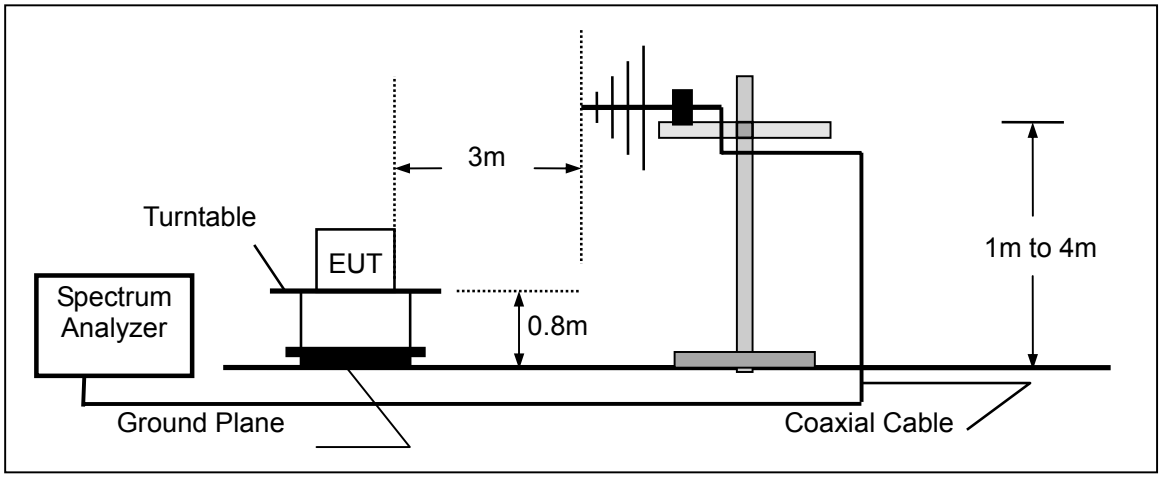
EMI Test Receiver	Setting
Attenuation	Auto
RB	1MHz
VB	10Hz
Detector	Peak
Trace	Max hold

6.2 Test SET-UP (Block Diagram of Configuration)

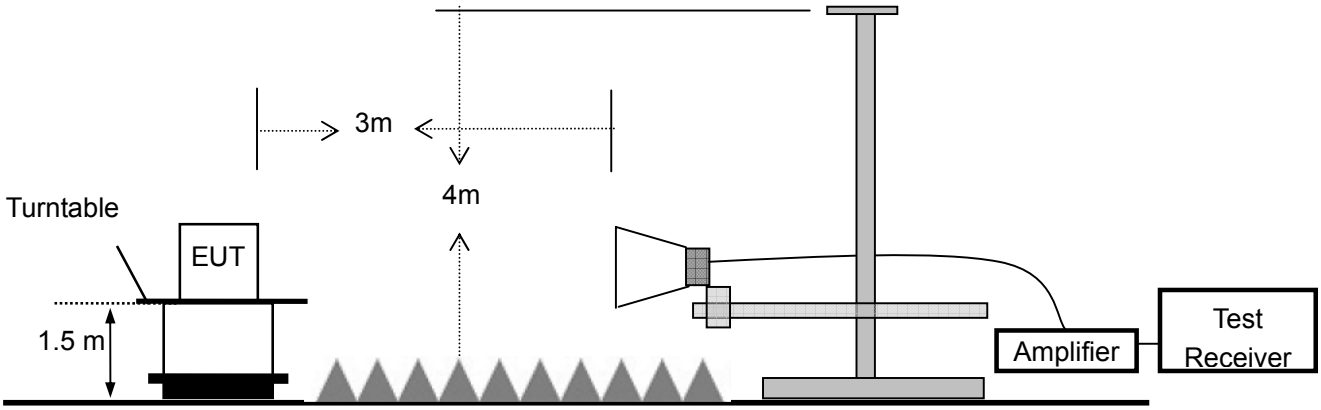
(A) Radiated Emission Test Set-Up, Frequency Below 30MHz



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



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



6.3 Measurement Equipment Used:

Item	Equipment	Manufacturer	Model No.	Serial No.	Characteristics	Last Cal.	Cal. Interval
1.	Test Receiver	Rohde & Schwarz	ESCI	1166.5950.03	9KHz-3GHz	5/16/2017	1 Year
2.	Loop Antenna	Schwarzbeck	FMZB 1519	012	9 KHz -30MHz	5/16/2017	1 Year
3.	Bilog Antenna	Schwarzbeck	VULB9163	000141	25MHz-2GHz	5/16/2017	1 Year
4.	Power Amplifier	CDS	RSU-M352	818	1MHz-1GHz	5/16/2017	1 Year
5.	Power Amplifier	HP	8447F	OPT H64	1GHz-26.5GHz	5/16/2017	1 Year
6.	Color Monitor	SUNSPO	SP-140A	N/A	--	5/16/2017	1 Year
7.	Single Line Filter	JIANLI	XL-3	N/A	--	5/16/2017	1 Year
8.	Single Phase Power Line Filter	JIANLI	DL-2X100B	N/A	--	5/16/2017	1 Year
9.	3 Phase Power Line Filter	JIANLI	DL-4X100B	N/A	--	5/16/2017	1 Year
10.	DC Power Filter	JIANLI	DL-2X50B	N/A	--	5/16/2017	1 Year
11.	Cable	Schwarzbeck	PLF-100	549489	9KHz-3GHz	5/16/2017	1 Year
12.	Cable	Rosenberger	CIL02	A0783566	9KHz-3GHz	5/16/2017	1 Year
13.	Cable	Rosenberger	RG 233/U	525178	9KHz-3GHz	5/16/2017	1 Year
14.	Signal Analyzer	Rohde & Schwarz	FSV30	103040	9KHz-40GHz	5/16/2017	1 Year
15.	Horn Antenna	Schwarzbeck	BBHA9120D	9120D-1272	1GHz-18GHz	5/16/2017	1 Year
16.	Horn Antenna	Schwarzbeck	BBHA 9170	BBHA9170399	14GHz -26.5GHz	5/16/2017	1 Year
17.	Power Amplifier	LUNAR EM	LNA1G18-40	J10100000081	1GHz-26.5GHz	5/16/2017	1 Year
18.	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	5/16/2017	1 Year
19.	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	5/16/2017	1 Year
20.	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	5/16/2017	1 Year

6.4 Radiated Emission Limit

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table 15.209(a):

Frequencies (MHz)	Field Strength (micorvolts/meter)	Measurement Distance (meters)
0.009~0.490	2400/F(KHz)	300
0.490~1.705	24000/F(KHz)	30
1.705~30.0	30	30
30~88	100	3
88~216	150	3
216~960	200	3
Above 960	500	3

15.205 Restricted bands of operation

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2690 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])

Remark : 1. Emission level in dBuV/m=20 log (uV/m)
2. Measurement was performed at an antenna to the closed point of EUT distance of meters.
3. Only spurious frequency is permitted to locate within the Restricted Bands specified in provision of ξ 15.205, and the emissions located in restricted bands also comply with 15.209 limit.

6.5 Measurement Result

Below 30MHz:

Operation Mode:	TX	Test Date :	July 11, 2017
Frequency Range:	9KHz~30MHz	Temperature :	28℃
Test Result:	PASS	Humidity :	65 %
Measured Distance:	3m	Test By:	Lin

Freq. (MHz)	Ant.Pol. H/V	Emission Level (dBuV/m)	Limit 3m (dBuV/m)	Over (dB)
--	--	--	--	--

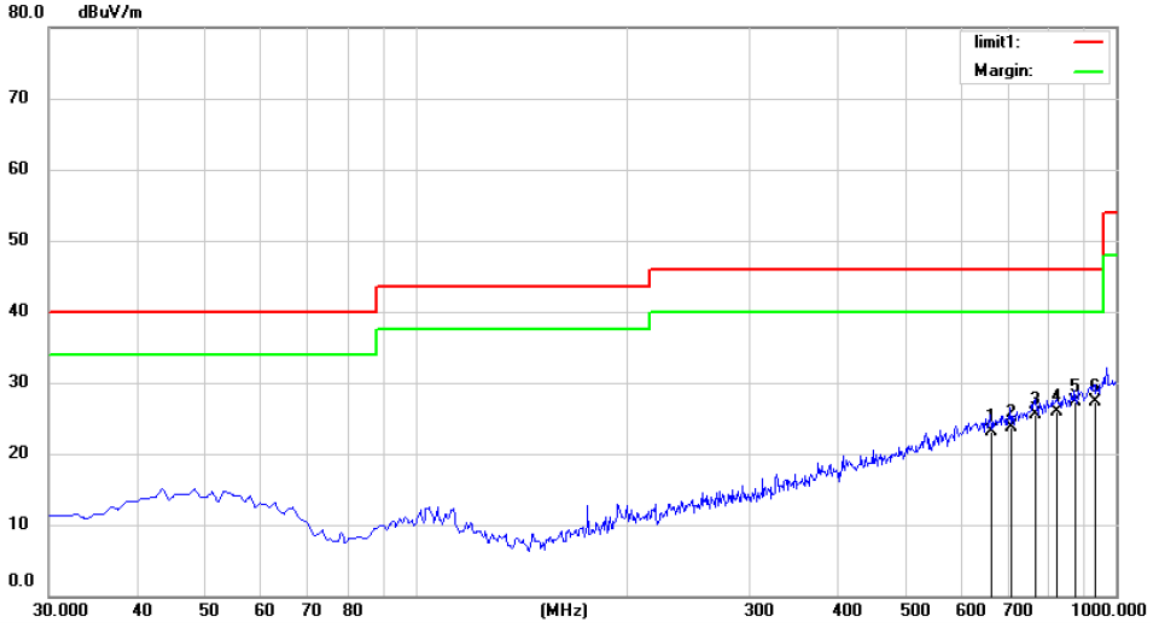
Note: The low frequency, which started from 9KHz-30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

Below 1000MHz:

Pass.

All the modulation modes were tested the data of the worst mode (TX GFSK) are recorded in the following pages and the others modulation methods do not exceed the limits.

Please refer to the following data.



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

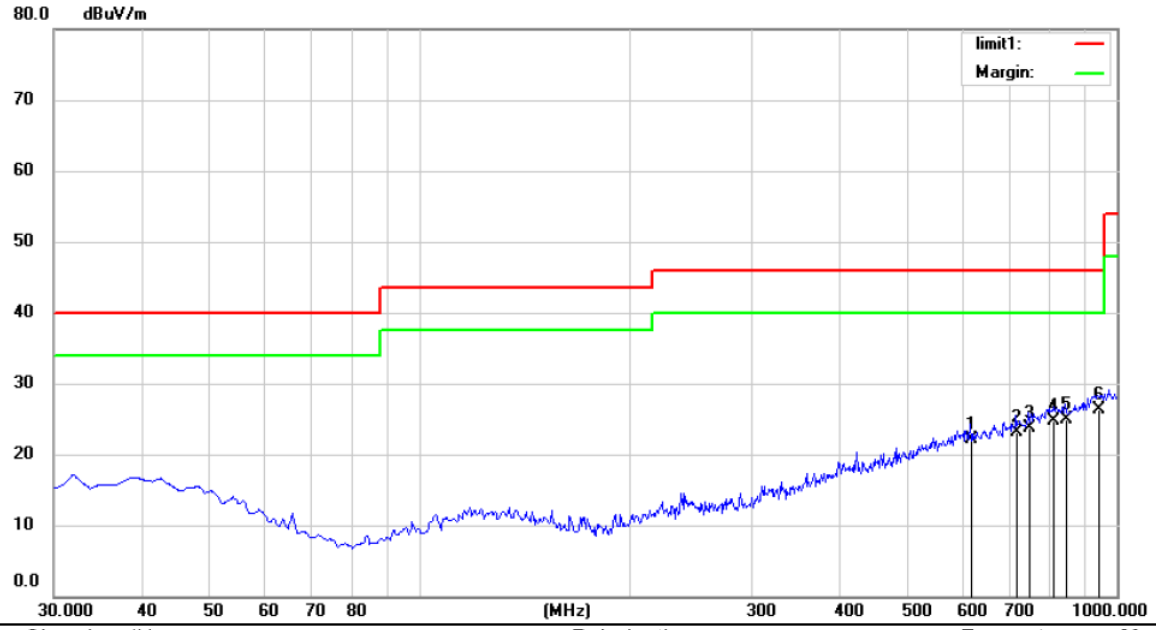
Limit: (RE)FCC PART 15 C 3m Power: Battery 3.7V Humidity: 55 %

Mode:TX2402

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		663.4100	28.30	-5.16	23.14	46.00	-22.86	QP			
2		707.0600	28.10	-4.42	23.68	46.00	-22.32	QP			
3		768.1700	28.50	-3.09	25.41	46.00	-20.59	QP			
4		822.4900	28.20	-2.24	25.96	46.00	-20.04	QP			
5		873.9000	28.60	-1.39	27.21	46.00	-18.79	QP			
6	*	930.1600	27.13	0.18	27.31	46.00	-18.69	QP			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: *Vertical* Temperature: 26

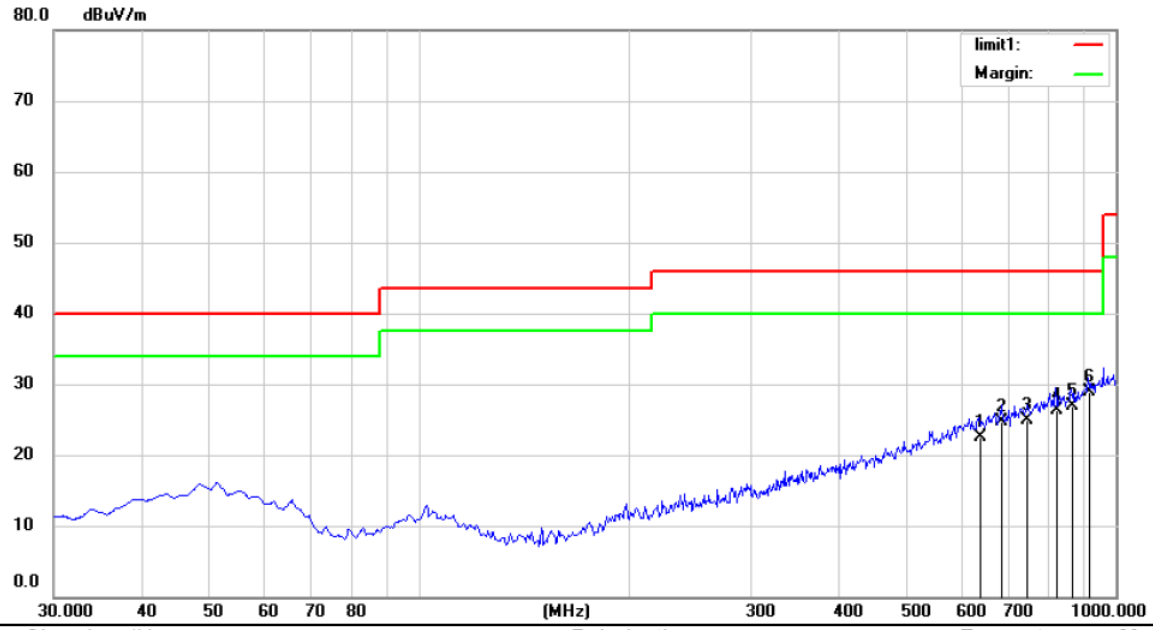
Limit: (RE)FCC PART 15 C 3m Power: Battery 3.7V Humidity: 55 %

Mode:TX2402

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		616.8500	29.35	-7.23	22.12	46.00	-23.88	QP			
2		717.7300	28.60	-5.53	23.07	46.00	-22.93	QP			
3		749.7400	28.22	-4.51	23.71	46.00	-22.29	QP			
4		810.8500	28.05	-3.38	24.67	46.00	-21.33	QP			
5		843.8300	28.23	-3.27	24.96	46.00	-21.04	QP			
6	*	941.8000	27.10	-0.83	26.27	46.00	-19.73	QP			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

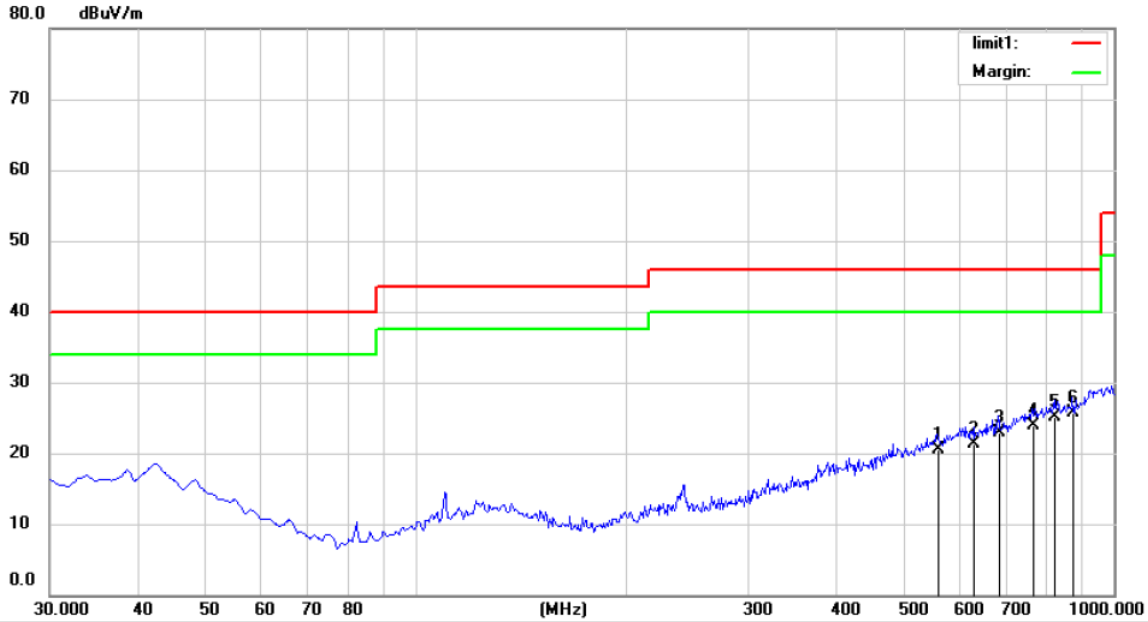
Limit: (RE)FCC PART 15 C 3m Power: Battery 3.7V Humidity: 55 %

Mode:TX2441

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		638.1900	28.11	-5.52	22.59	46.00	-23.41	QP			
2		684.7500	29.52	-4.85	24.67	46.00	-21.33	QP			
3		745.8600	28.30	-3.43	24.87	46.00	-21.13	QP			
4		821.5200	28.65	-2.25	26.40	46.00	-19.60	QP			
5		864.2000	28.45	-1.60	26.85	46.00	-19.15	QP			
6	*	915.6100	29.20	-0.20	29.00	46.00	-17.00	QP			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: *Vertical* Temperature: 26

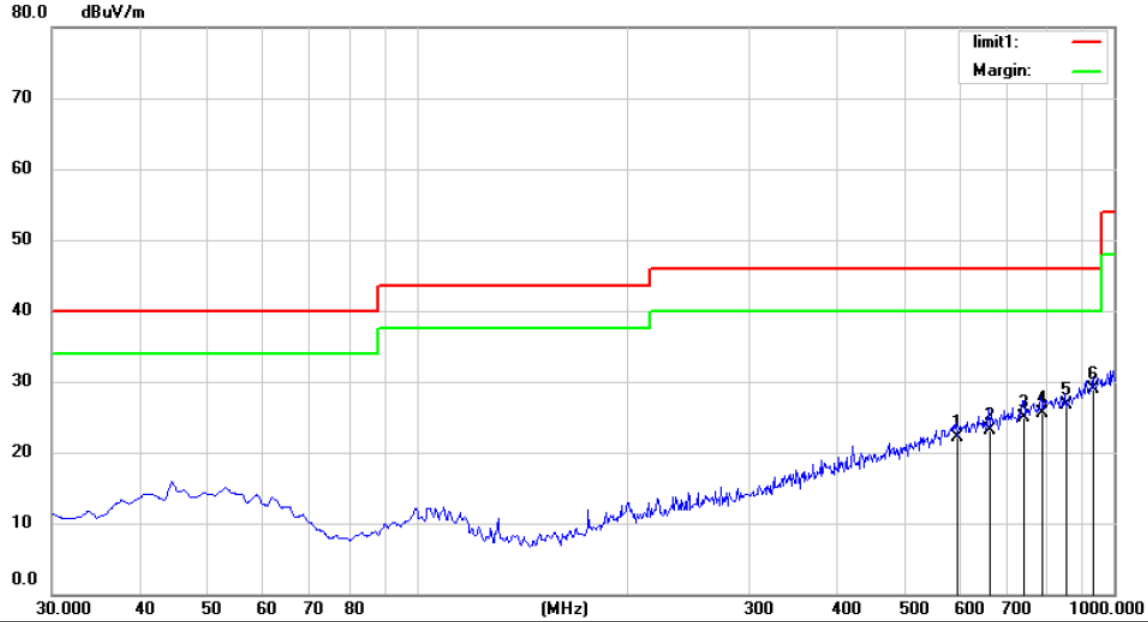
Limit: (RE)FCC PART 15 C 3m Power: Battery 3.7V Humidity: 55 %

Mode:TX2441

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		559.6200	28.56	-7.99	20.57	46.00	-25.43	QP			
2		630.4300	28.40	-7.08	21.32	46.00	-24.68	QP			
3		683.7800	29.35	-6.38	22.97	46.00	-23.03	QP			
4		765.2600	28.22	-4.41	23.81	46.00	-22.19	QP			
5		823.4600	28.23	-3.10	25.13	46.00	-20.87	QP			
6	*	874.8700	28.60	-2.94	25.66	46.00	-20.34	QP			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

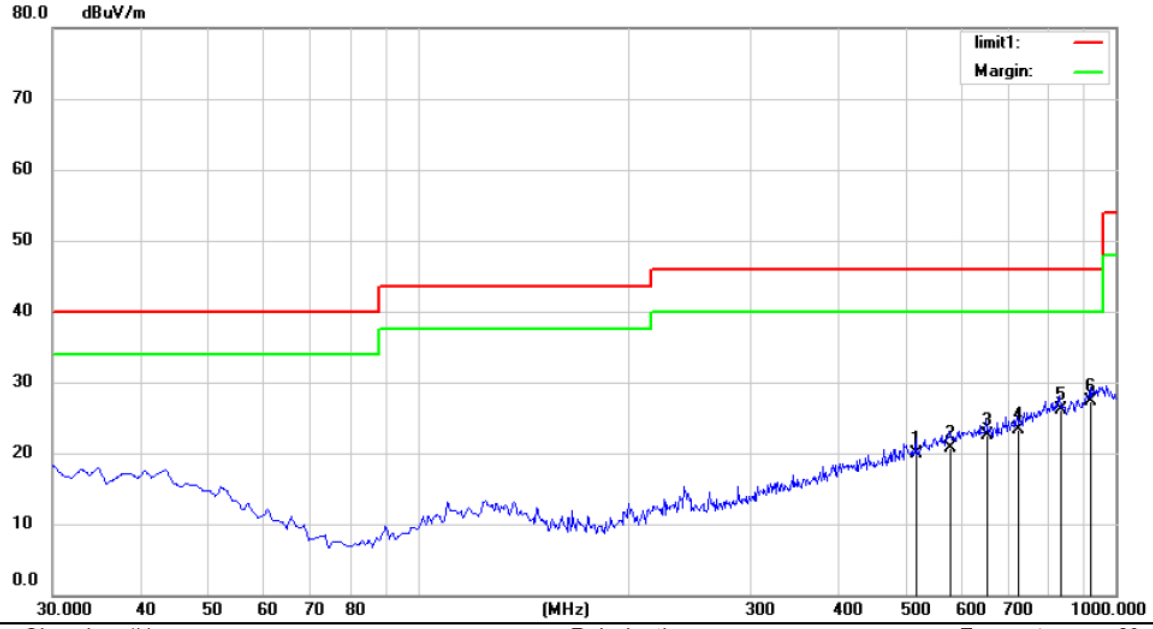
Limit: (RE)FCC PART 15 C 3m Power: Battery 3.7V Humidity: 55 %

Mode:TX2480

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		593.5700	28.59	-6.48	22.11	46.00	-23.89	QP			
2		662.4400	28.35	-5.18	23.17	46.00	-22.83	QP			
3		741.0100	28.55	-3.58	24.97	46.00	-21.03	QP			
4		786.6000	28.35	-2.78	25.57	46.00	-20.43	QP			
5		852.5600	28.59	-1.86	26.73	46.00	-19.27	QP			
6	*	935.0100	28.65	0.33	28.98	46.00	-17.02	QP			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: *Vertical* Temperature: 26

Limit: (RE)FCC PART 15 C 3m Power: Battery 3.7V Humidity: 55 %

Mode:TX2480

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		518.8800	29.12	-9.28	19.84	46.00	-26.16	QP			
2		578.0500	28.52	-7.72	20.80	46.00	-25.20	QP			
3		652.7400	29.30	-6.80	22.50	46.00	-23.50	QP			
4		723.5500	28.56	-5.34	23.22	46.00	-22.78	QP			
5		831.2200	29.35	-3.16	26.19	46.00	-19.81	QP			
6	*	919.4900	28.65	-1.33	27.32	46.00	-18.68	QP			

*:Maximum data x:Over limit !:over margin Operator: washington

Above 1000MHz~10th Harmonics:

Operation Mode: GFSK (CH1: 2402MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4804	V	95.55	75.85	-32.3	66.64	45.37	74	54	-7.36	-8.63
7206	V	103.11	81.48	-37.2	65.91	44.28	74	54	-8.09	-9.72
9608	V	104.26	83.17	-39.8	64.46	43.37	74	54	-9.54	-10.63
12010	V	104.44	83.45	-40.5	63.94	42.95	74	54	-10.06	-11.05
14412	V	104.04	83.34	-41.7	62.34	41.64	74	54	-11.66	-12.36
16814	V	101.46	80.95	-40	61.46	40.95	74	54	-12.54	-13.05
4804	H	96.95	75.95	-31.6	65.35	44.35	74	54	-8.65	-9.65
7206	H	100.18	79.45	-35.5	64.68	43.95	74	54	-9.32	-10.05
9608	H	102.26	81.29	-38.3	63.96	42.99	74	54	-10.04	-11.01
12010	H	101.37	81.01	-39	62.37	42.01	74	54	-11.63	-11.99
14412	H	103.82	83.36	-42	61.82	41.36	74	54	-12.18	-12.64
16814	H	99.97	80.19	-39.3	60.67	40.89	74	54	-13.33	-13.11

Operation Mode: GFSK (CH40: 2441MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4882	V	97.28	77.64	-32.3	64.98	45.34	74	54	-9.02	-8.66
7323	V	100.84	81.56	-37.2	63.64	44.36	74	54	-10.36	-9.64
9764	V	102.56	83.76	-39.8	62.76	43.96	74	54	-11.24	-10.04
12205	V	102.45	82.23	-40.5	61.95	41.73	74	54	-12.05	-12.27
14646	V	101.86	81.37	-41	60.86	40.37	74	54	-13.14	-13.63
17087	V	101.07	81.54	-41.1	59.97	40.44	74	54	-14.03	-13.56
4882	H	96.56	75.97	-31.6	64.96	44.37	74	54	-9.04	-9.63
7323	H	98.82	79.46	-35.5	63.32	43.96	74	54	-10.68	-10.04
9764	H	102.32	81.06	-38.3	64.02	42.76	74	54	-9.98	-11.24
12205	H	102.37	80.62	-39	63.37	41.62	74	54	-10.63	-12.38
14646	H	102.53	85.96	-42	60.53	43.96	74	54	-13.47	-10.04
17087	H	103.46	81.97	-41.5	61.96	40.47	74	54	-12.04	-13.53

Operation Mode: GFSK (CH79: 2480MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4960	V	96.99	77.62	-32.3	64.69	45.32	74	54	-9.31	-8.68
7440	V	101.06	81.16	-37.2	63.86	43.96	74	54	-10.14	-10.04
9920	V	102.66	84.66	-39.8	62.86	44.86	74	54	-11.14	-9.14
12400	V	101.45	83.46	-40.5	60.95	42.96	74	54	-13.05	-11.04
14880	V	104.85	82.67	-41	63.85	41.67	74	54	-10.15	-12.33
17360	V	102.44	81.47	-41.1	61.34	40.37	74	54	-12.66	-13.63
4960	H	95.69	76.56	-31.6	64.09	44.96	74	54	-9.91	-9.04
7440	H	99.32	79.26	-35.5	63.82	43.76	74	54	-10.18	-10.24
9920	H	101.34	80.26	-38.3	63.04	41.96	74	54	-10.96	-12.04
12400	H	101.43	81.95	-39	62.43	42.95	74	54	-11.57	-11.05
14880	H	105.66	82.35	-42	63.66	40.35	74	54	-10.34	-13.65
17360	H	104.08	82.26	-41.5	62.58	40.76	74	54	-11.42	-13.24

Operation Mode: Pi/4-DQPSK (CH1: 2402MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4804	V	98.26	76.92	-32.3	65.96	44.62	74	54	-8.04	-9.38
7206	V	101.57	80.16	-37.2	64.37	42.96	74	54	-9.63	-11
9608	V	103.56	83.56	-39.8	63.76	43.76	74	54	-10.24	-10.2
12010	V	104.58	82.14	-40.5	64.08	41.64	74	54	-9.92	-12.4
14412	V	105.13	82.32	-41.7	63.43	40.62	74	54	-10.57	-13.4
16814	V	102.85	81.95	-40	62.85	41.95	74	54	-11.15	-12.1
4804	H	96.59	75.56	-31.6	64.99	43.96	74	54	-9.01	-10
7206	H	98.26	78.14	-35.5	62.76	42.64	74	54	-11.24	-11.4
9608	H	103.26	81.67	-38.3	64.96	43.37	74	54	-9.04	-10.6
12010	H	99.37	83.86	-39	60.37	44.86	74	54	-13.63	-9.14
14412	H	106.38	85.76	-42	64.38	43.76	74	54	-9.62	-10.2
16814	H	100.23	79.97	-39.3	60.93	40.67	74	54	-13.07	-13.3

Operation Mode: Pi/4-DQPSK (CH40: 2441MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4882	V	96.26	76.3	-32.3	63.96	44	74	54	-10.04	-10
7323	V	98.93	80.82	-37.2	61.73	43.62	74	54	-12.27	-10.38
9764	V	104.41	82.83	-39.8	64.61	43.03	74	54	-9.39	-10.97
12205	V	102.87	82.65	-40.5	62.37	42.15	74	54	-11.63	-11.85
14646	V	104.86	82.32	-41	63.86	41.32	74	54	-10.14	-12.68
17087	V	102.74	81.47	-41.1	61.64	40.37	74	54	-12.36	-13.63
4882	H	95.6	75.23	-31.6	64	43.63	74	54	-10	-10.37
7323	H	99.26	77.83	-35.5	63.76	42.33	74	54	-10.24	-11.67
9764	H	101.22	81.97	-38.3	62.92	43.67	74	54	-11.08	-10.33
12205	H	102.76	80.96	-39	63.76	41.96	74	54	-10.24	-12.04
14646	H	104.37	82.76	-42	62.37	40.76	74	54	-11.63	-13.24
17087	H	101.96	80.69	-41.5	60.46	39.19	74	54	-13.54	-14.81

Operation Mode: Pi/4-DQPSK (CH79: 2480MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4960	V	96.67	75.94	-32.3	64.37	43.64	74	54	-9.63	-10.36
7440	V	101.16	79.54	-37.2	63.96	42.34	74	54	-10.04	-11.66
9920	V	104.19	82.17	-39.8	64.39	42.37	74	54	-9.61	-11.63
12400	V	103.26	83.66	-40.5	62.76	43.16	74	54	-11.24	-10.84
14880	V	105	82.91	-41	64	41.91	74	54	-10	-12.09
17360	V	102.95	81.45	-41.1	61.85	40.35	74	54	-12.15	-13.65
4960	H	95.71	74.65	-31.6	64.11	43.05	74	54	-9.89	-10.95
7440	H	98.36	78.14	-35.5	62.86	42.64	74	54	-11.14	-11.36
9920	H	102.06	79.64	-38.3	63.76	41.34	74	54	-10.24	-12.66
12400	H	100.24	79.37	-39	61.24	40.37	74	54	-12.76	-13.63
14880	H	102.96	82.36	-42	60.96	40.36	74	54	-13.04	-13.64
17360	H	100.87	81.26	-41.5	59.37	39.76	74	54	-14.63	-14.24

Operation Mode: 8DPSK (CH1: 2402MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4804	V	96.67	75.92	-32.3	64.37	43.62	74	54	-9.63	-10.4
7206	V	101.16	81.89	-37.2	63.96	44.69	74	54	-10.04	-9.31
9608	V	103.14	86.14	-39.8	63.34	46.34	74	54	-10.66	-7.66
12010	V	103.26	86.06	-40.5	62.76	45.56	74	54	-11.24	-8.44
14412	V	103.05	86.37	-41.7	61.35	44.67	74	54	-12.65	-9.33
16814	V	100.16	82.95	-40	60.16	42.95	74	54	-13.84	-11.1
4804	H	94.36	74.24	-31.6	62.76	42.64	74	54	-11.24	-11.4
7206	H	98.61	78.26	-35.5	63.11	42.76	74	54	-10.89	-11.2
9608	H	101.06	83.67	-38.3	62.76	45.37	74	54	-11.24	-8.63
12010	H	100.52	85.91	-39	61.52	46.91	74	54	-12.48	-7.09
14412	H	102.64	85.56	-42	60.64	43.56	74	54	-13.36	-10.4
16814	H	98.85	81.66	-39.3	59.55	42.36	74	54	-14.45	-11.6

Operation Mode: 8DPSK (CH40: 2441MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4882	V	96.67	76.66	-32.3	64.37	44.36	74	54	-9.63	-9.64
7323	V	99.96	80.82	-37.2	62.76	43.62	74	54	-11.24	-10.38
9764	V	104.53	82.96	-39.8	64.73	43.16	74	54	-9.27	-10.84
12205	V	104.38	83.17	-40.5	63.88	42.67	74	54	-10.12	-11.33
14646	V	105.96	83.16	-41	64.96	42.16	74	54	-9.04	-11.84
17087	V	103.68	81.86	-41.1	62.58	40.76	74	54	-11.42	-13.24
4882	H	92.06	74.03	-31.6	60.46	42.43	74	54	-13.54	-11.57
7323	H	97.06	78.87	-35.5	61.56	43.37	74	54	-12.44	-10.63
9764	H	102.06	80.91	-38.3	63.76	42.61	74	54	-10.24	-11.39
12205	H	103.02	79.25	-39	64.02	40.25	74	54	-9.98	-13.75
14646	H	102.56	82.37	-42	60.56	40.37	74	54	-13.44	-13.63
17087	H	102.93	81.27	-41.5	61.43	39.77	74	54	-12.57	-14.23

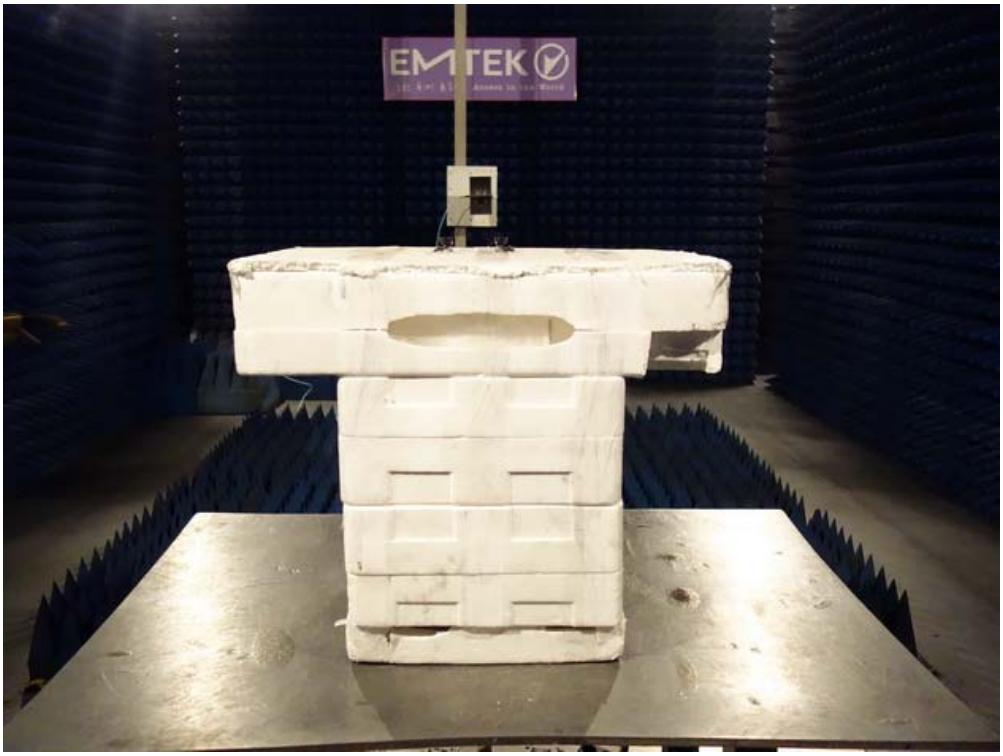
Operation Mode: 8DPSK (CH79: 2480MHz) Test Date : July 11, 2017

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4960	V	94.67	77.69	-32.3	62.37	45.39	74	54	-11.63	-8.61
7440	V	102.66	83.45	-37.2	65.46	46.25	74	54	-8.54	-7.75
9920	V	102.16	85.68	-39.8	62.36	45.88	74	54	-11.64	-8.12
12400	V	105.14	84.69	-40.5	64.64	44.19	74	54	-9.36	-9.81
14880	V	104.46	84.68	-41	63.46	43.68	74	54	-10.54	-10.32
17360	V	102.86	84.09	-41.1	61.76	42.99	74	54	-12.24	-11.01
4960	H	96.06	75.97	-31.6	64.46	44.37	74	54	-9.54	-9.63
7440	H	99.42	78.96	-35.5	63.92	43.46	74	54	-10.08	-10.54
9920	H	100.52	81.35	-38.3	62.22	43.05	74	54	-11.78	-10.95
12400	H	100.62	81.69	-39	61.62	42.69	74	54	-12.38	-11.31
14880	H	102.29	83.92	-42	60.29	41.92	74	54	-13.71	-12.08
17360	H	102.66	82.86	-41.5	61.16	41.36	74	54	-12.84	-12.64

Other harmonics emissions are lower than 20dB below the allowable limit.

Note: (1) All Readings are Peak Value and AV.
(2) Emission Level= Reading Level+ Probe Factor +Cable Loss.
(3) The average measurement was not performed when the peak measured data under the limit of average detection.
(4) Measuring frequencies from 1GHz to 25GHz.

6.5 Radiated Measurement Photos:

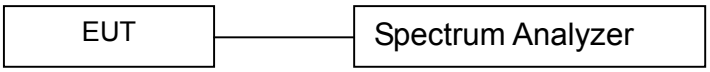


7. Channel Separation test

7.1 Measurement Procedure

The EUT was operating in hopping mode or could be controlled its channel. Printed out the test result from the spectrum by hard copy function.

7.2 Test SET-UP (Block Diagram of Configuration)



7.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/16/2017
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/16/2017
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/16/2017

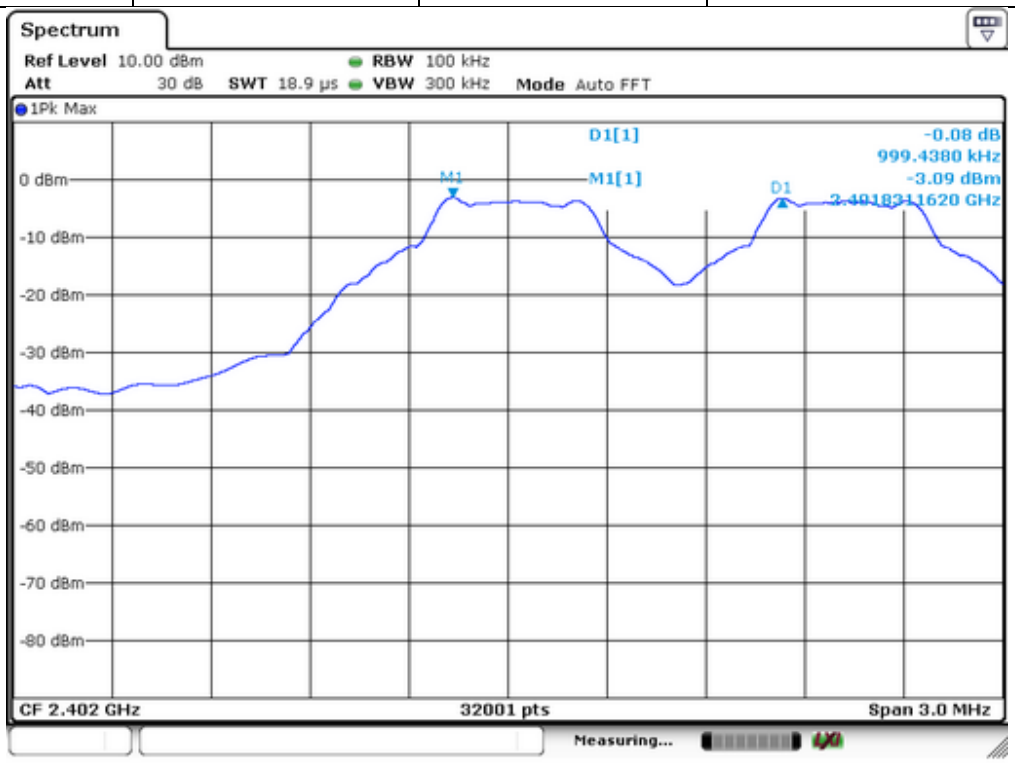
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

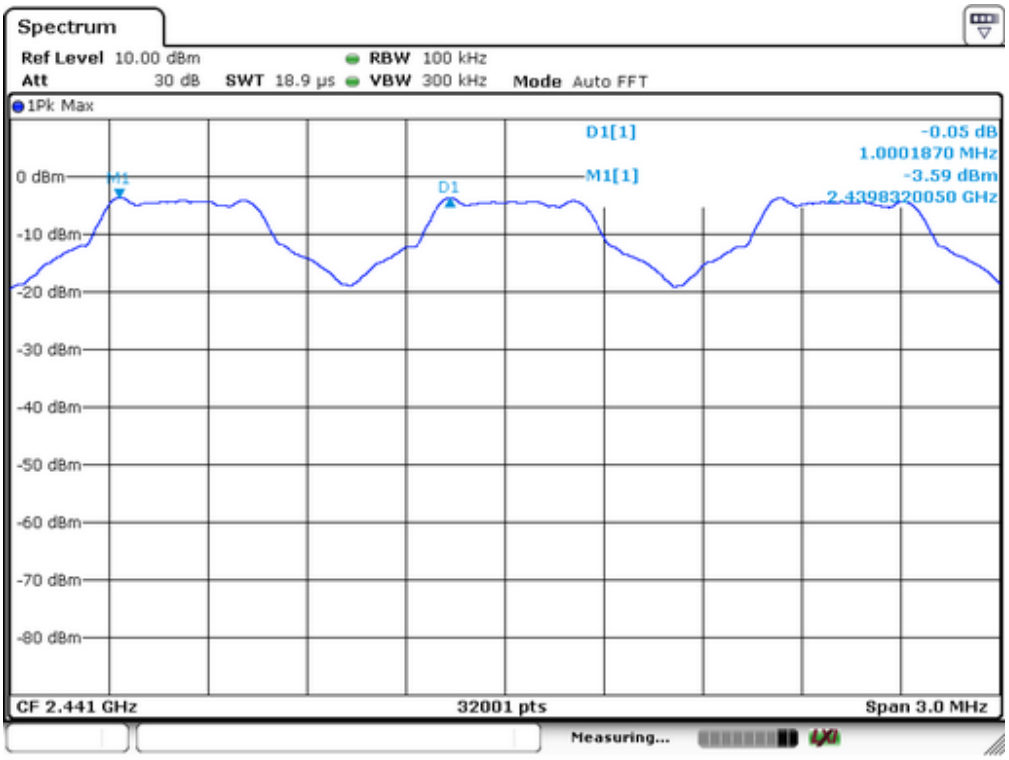
7.4 Measurement Results:

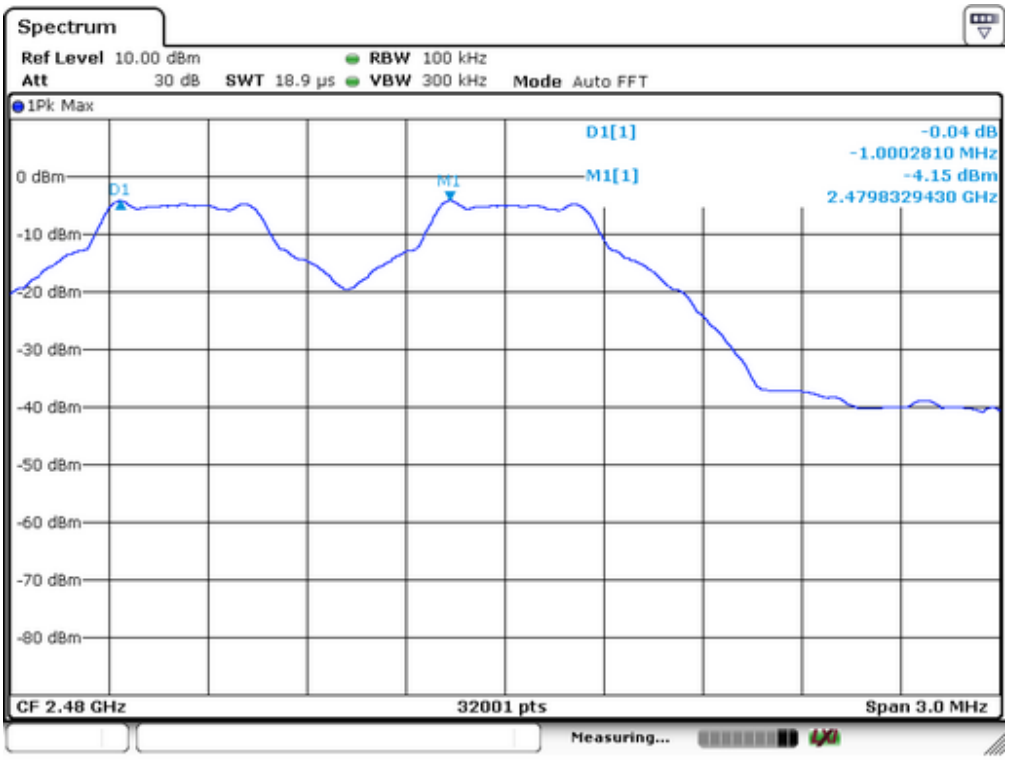
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	GFSK		

Channel number	Channel frequency (MHz)	Separation Read Value (kHz)	Separation Limit 2/3 20dB Down BW(kHz)
1	2402	999	>767
40	2441	1000	>765
79	2480	1000	>770

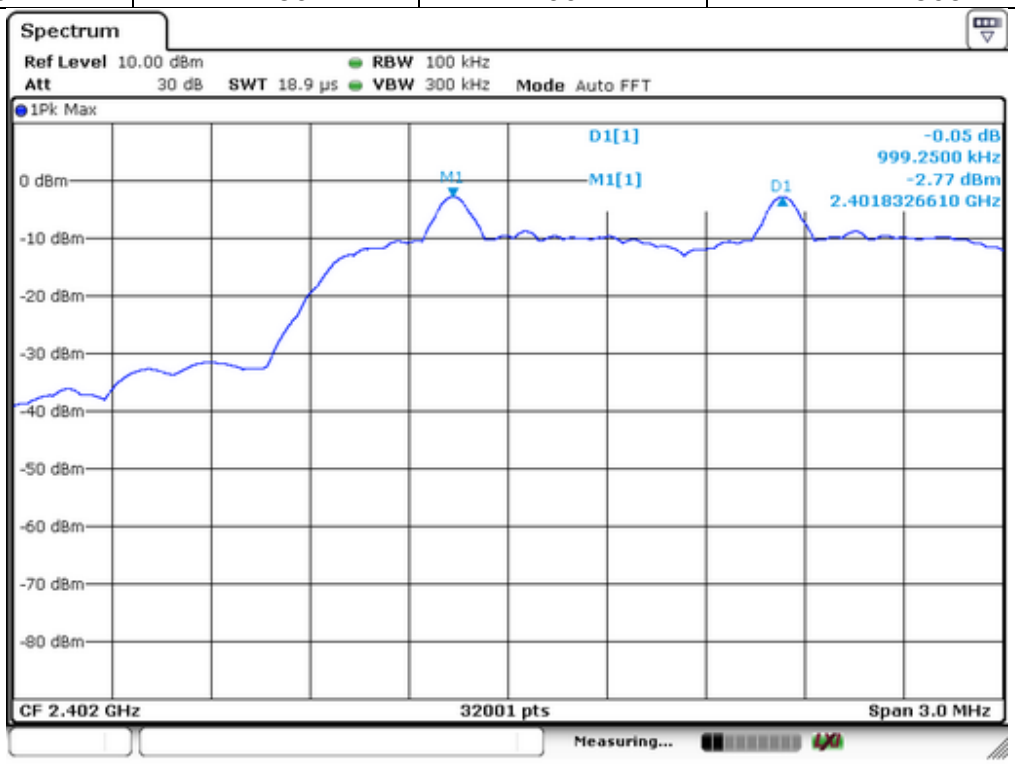


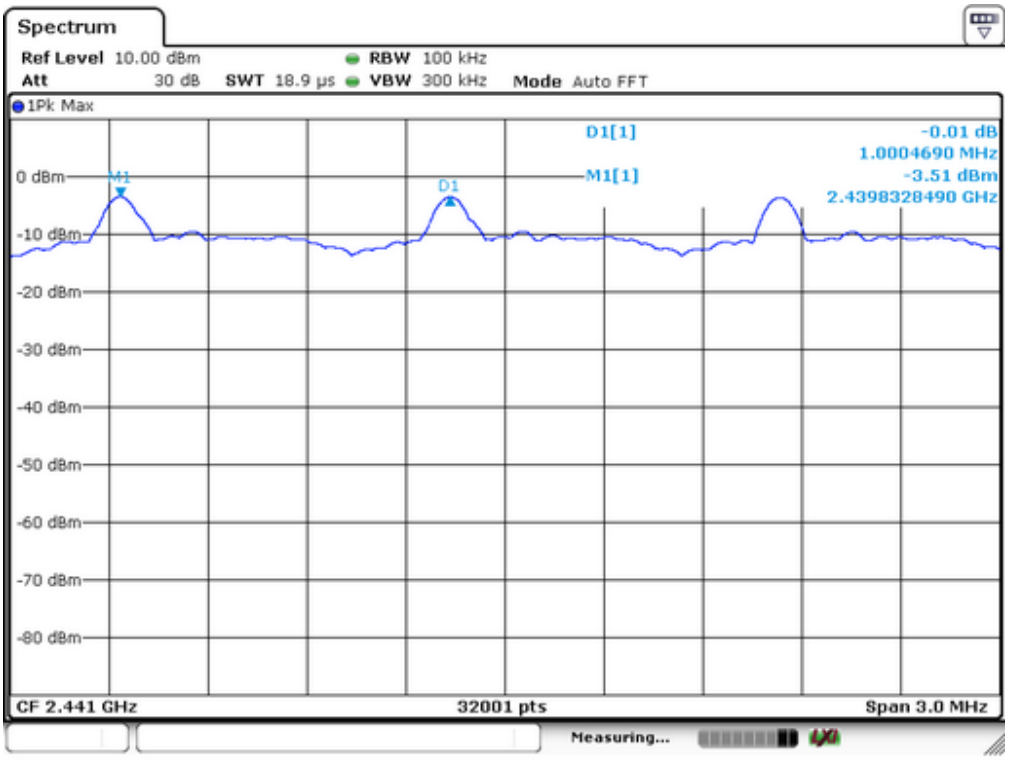

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
D1[1]
-0.05 dB
1.0001870 MHz
M1[1]
-3.59 dBm
2.4398320050 GHz
M1
D1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 3.0 MHz
Measuring...

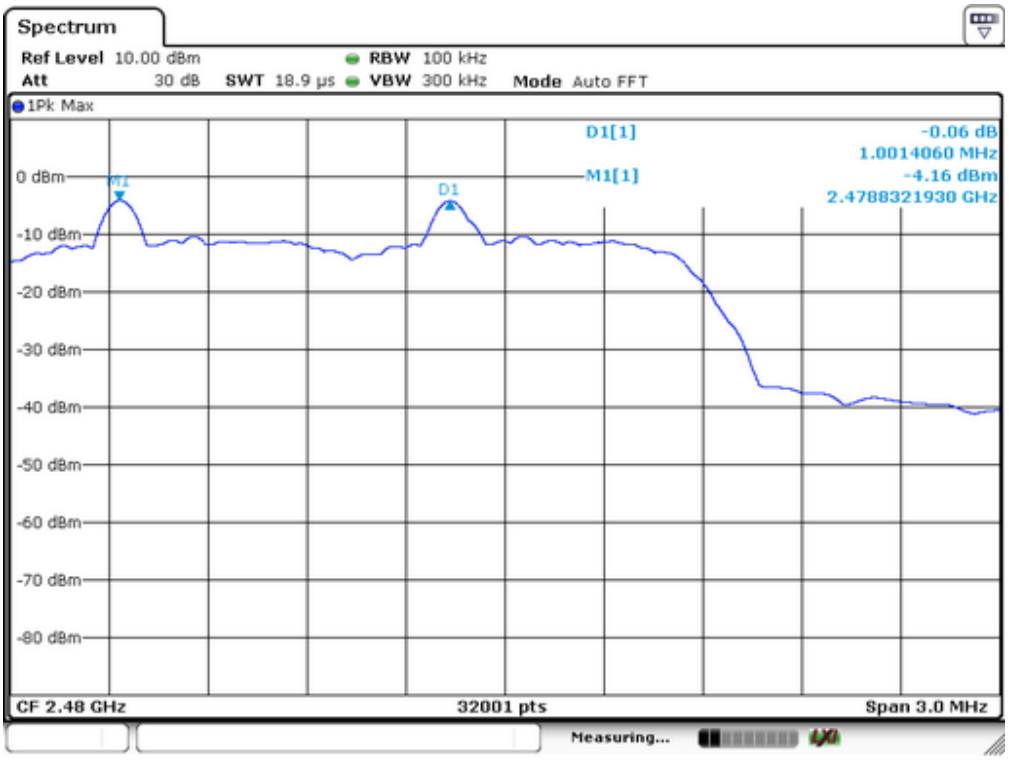

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
D1[1]
-0.04 dB
-1.0002810 MHz
M1[1]
-4.15 dBm
2.4798329430 GHz
D1
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
32001 pts
Span 3.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	Π/4-DQPSK		

Channel number	Channel frequency (MHz)	Separation Read Value (kHz)	Separation Limit 2/3 20dB Down BW(kHz)
1	2402	1000	>864
40	2441	999	>865
79	2480	1001	>863

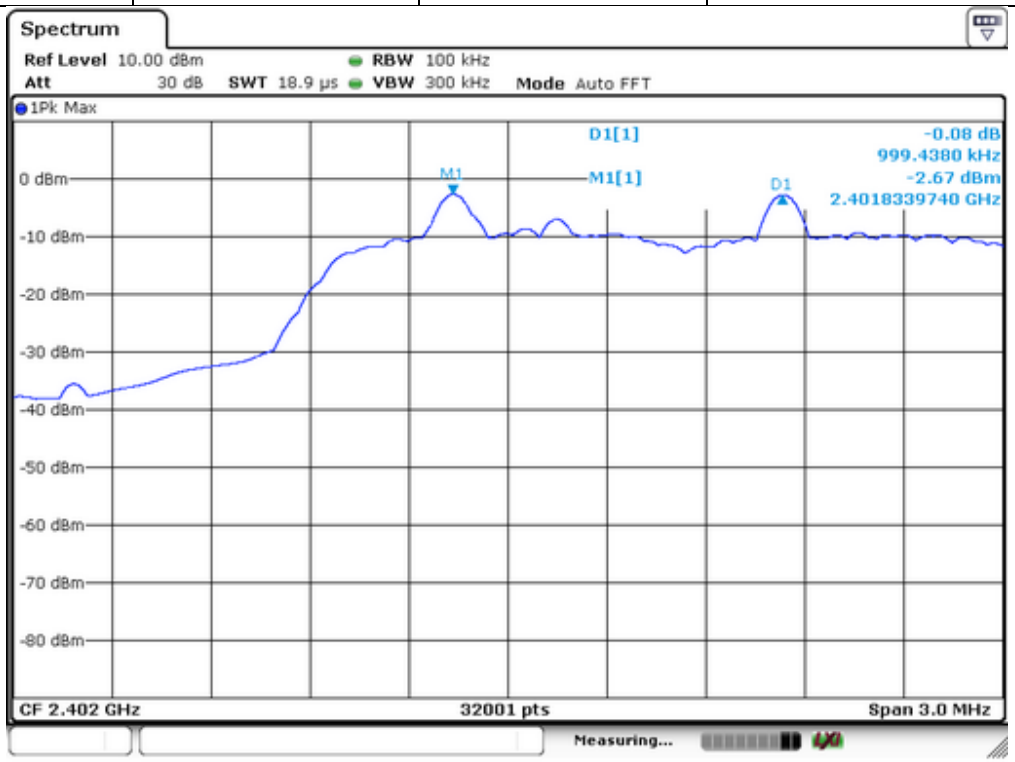


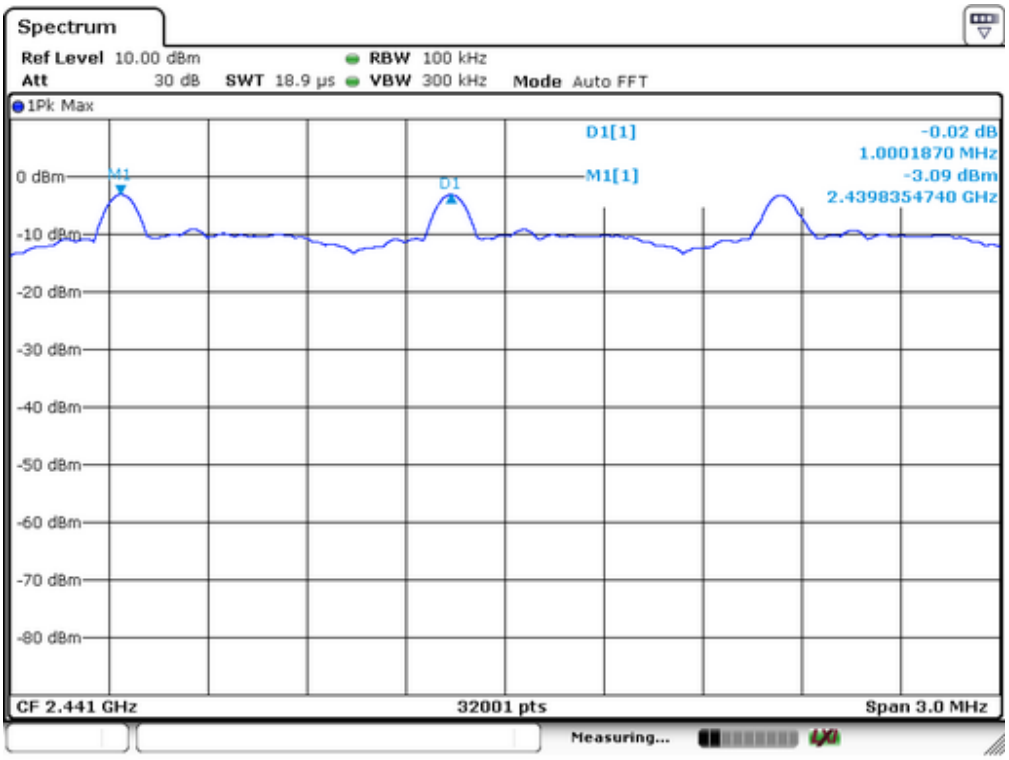

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
D1[1]
-0.01 dB
1.0004690 MHz
M1[1]
-3.51 dBm
2.4398328490 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 3.0 MHz
Measuring...

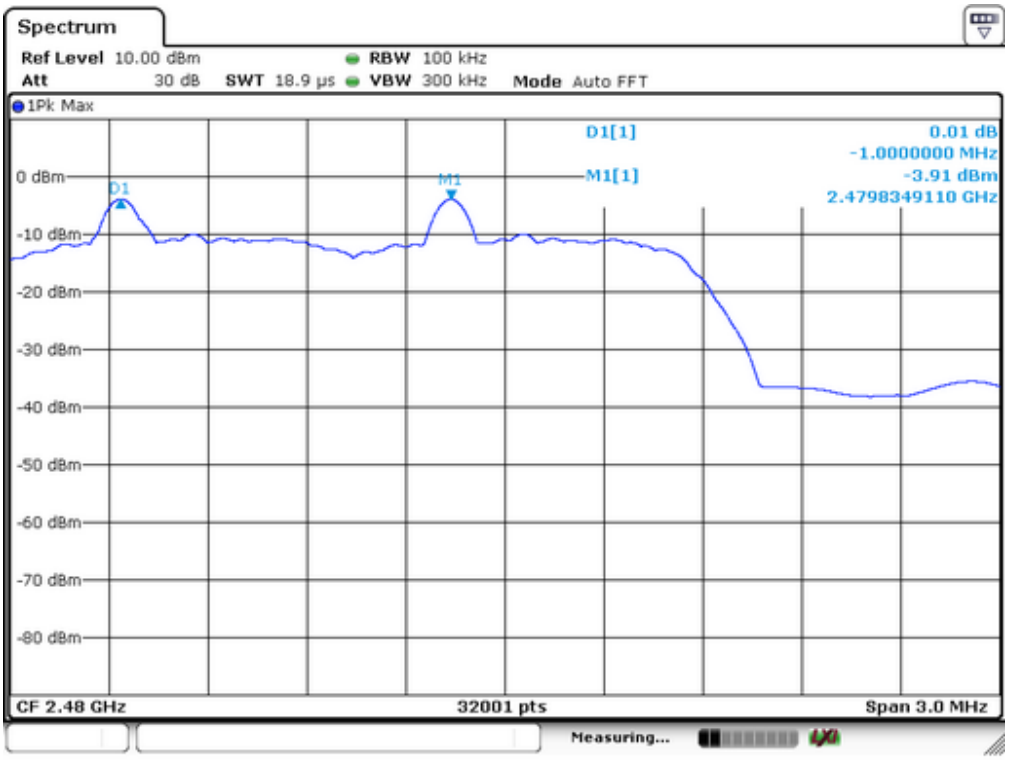

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
D1[1]
-0.06 dB
1.0014060 MHz
M1[1]
-4.16 dBm
2.4788321930 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
32001 pts
Span 3.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	8DPSK		

Channel number	Channel frequency (MHz)	Separation Read Value (kHz)	Separation Limit 2/3 20dB Down BW(kHz)
1	2402	999	>867
40	2441	1000	>865
79	2480	1000	>864




Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
D1[1]
-0.02 dB
1.0001870 MHz
M1[1]
-3.09 dBm
2.4398354740 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 3.0 MHz
Measuring...

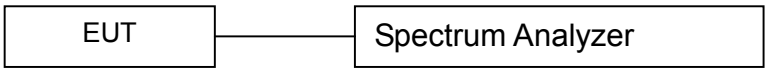

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
D1[1]
0.01 dB
-1.0000000 MHz
M1[1]
-3.91 dBm
2.4798349110 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
32001 pts
Span 3.0 MHz
Measuring...

8. 20dB Bandwidth test

8.1 Measurement Procedure

The EUT was operating in hopping mode or could be controlled its channel. Printed out the test result from the spectrum by hard copy function.

8.2 Test SET-UP (Block Diagram of Configuration)



8.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/16/2017
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/16/2017
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/16/2017

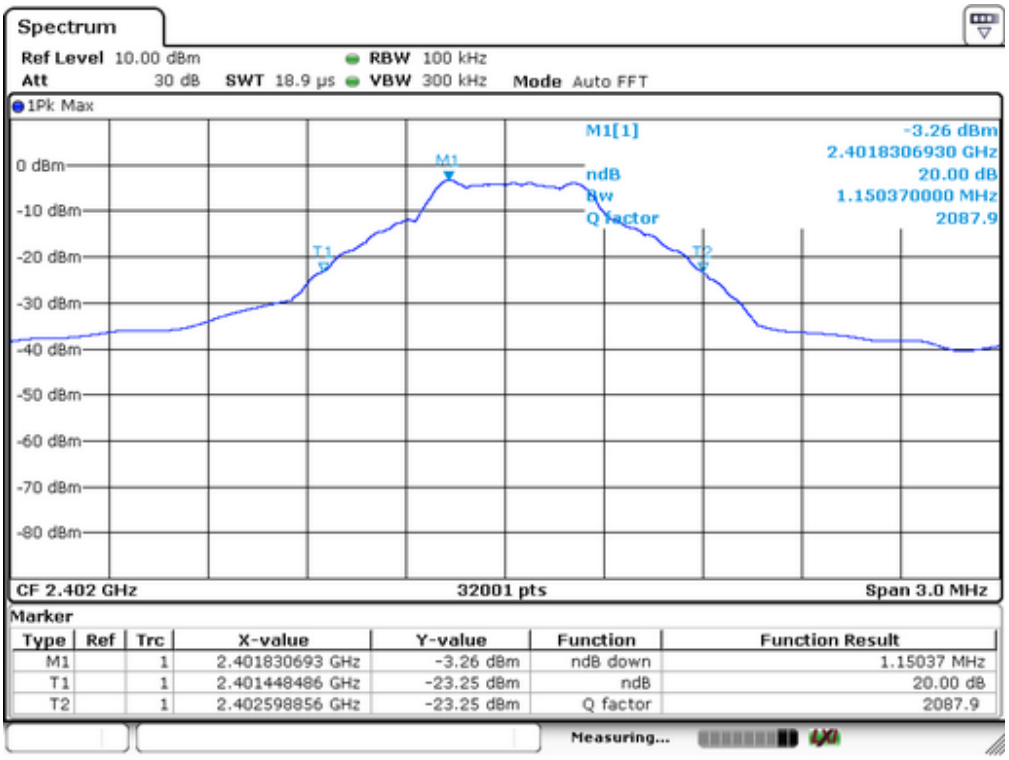
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

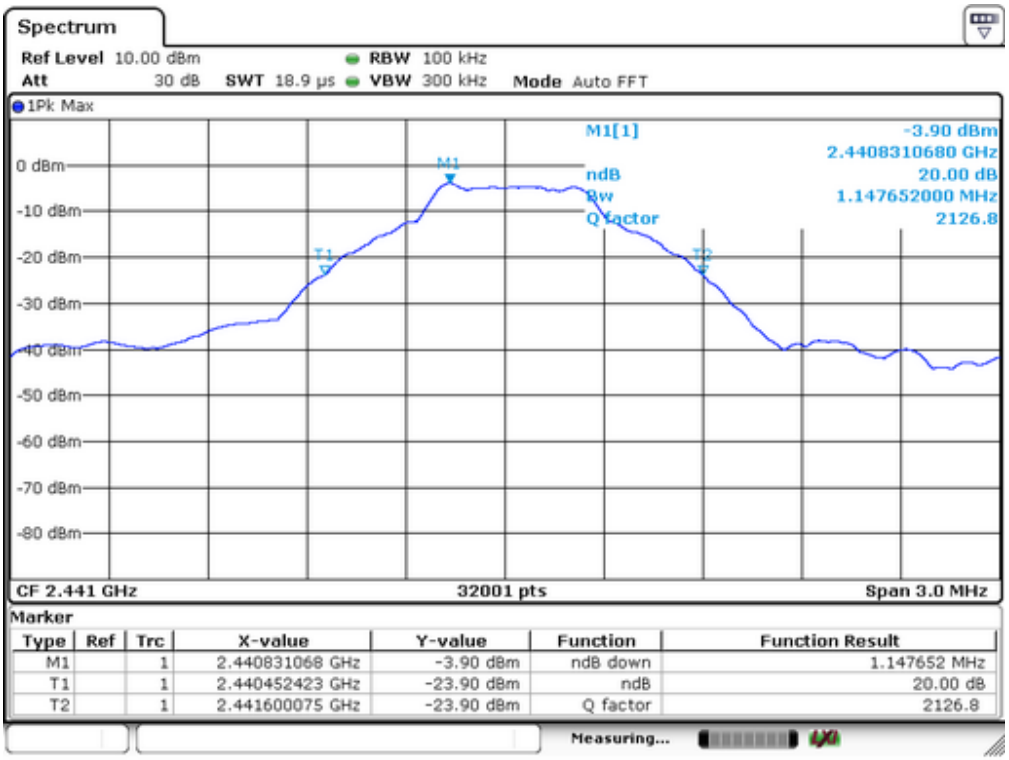
8.4 Measurement Results:

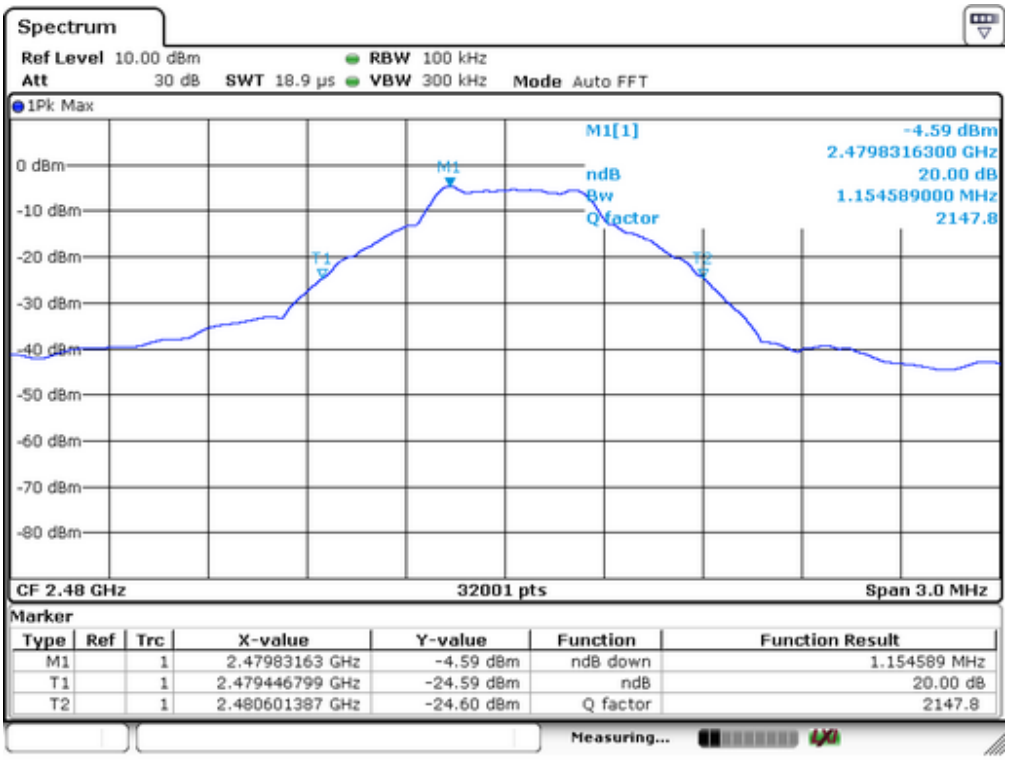
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	GFSK		

Channel number	Channel frequency (MHz)	20dB Down BW(kHz)
1	2402	1150
40	2441	1148
79	2480	1155

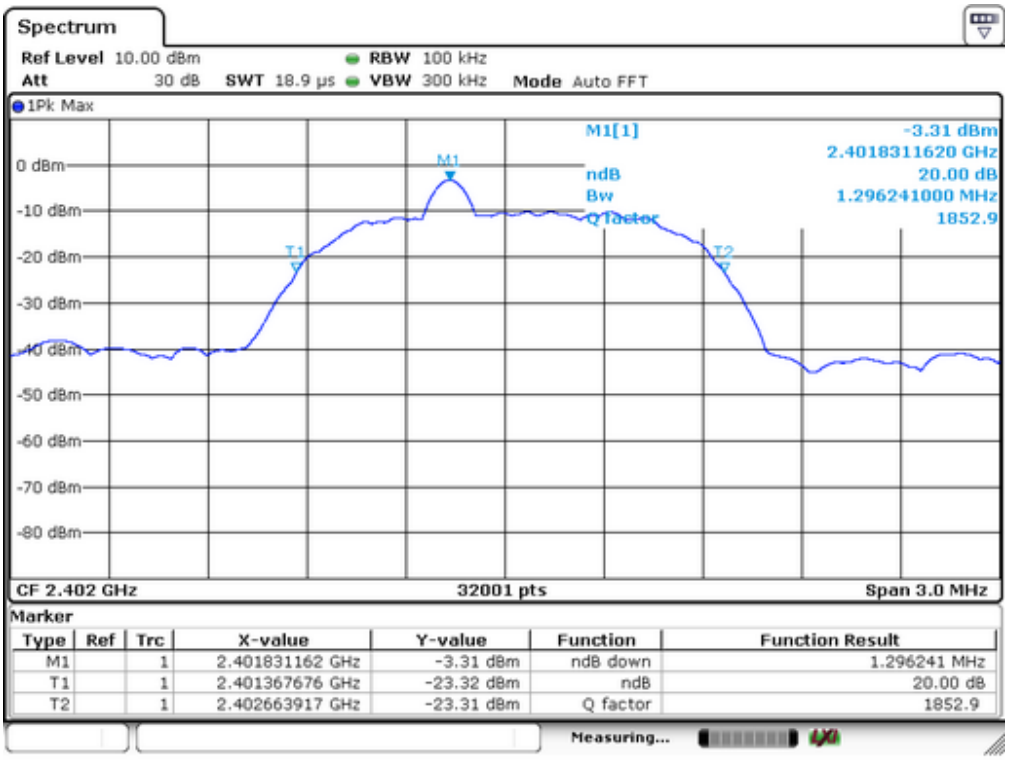

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-3.26 dBm
2.4018306930 GHz
ndB 20.00 dB
Bw 1.150370000 MHz
Q factor 2087.9
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.402 GHz
32001 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.401830693 GHz -3.26 dBm ndB down 1.15037 MHz
T1 1 2.401448486 GHz -23.25 dBm ndB 20.00 dB
T2 1 2.402598856 GHz -23.25 dBm Q factor 2087.9
Measuring...

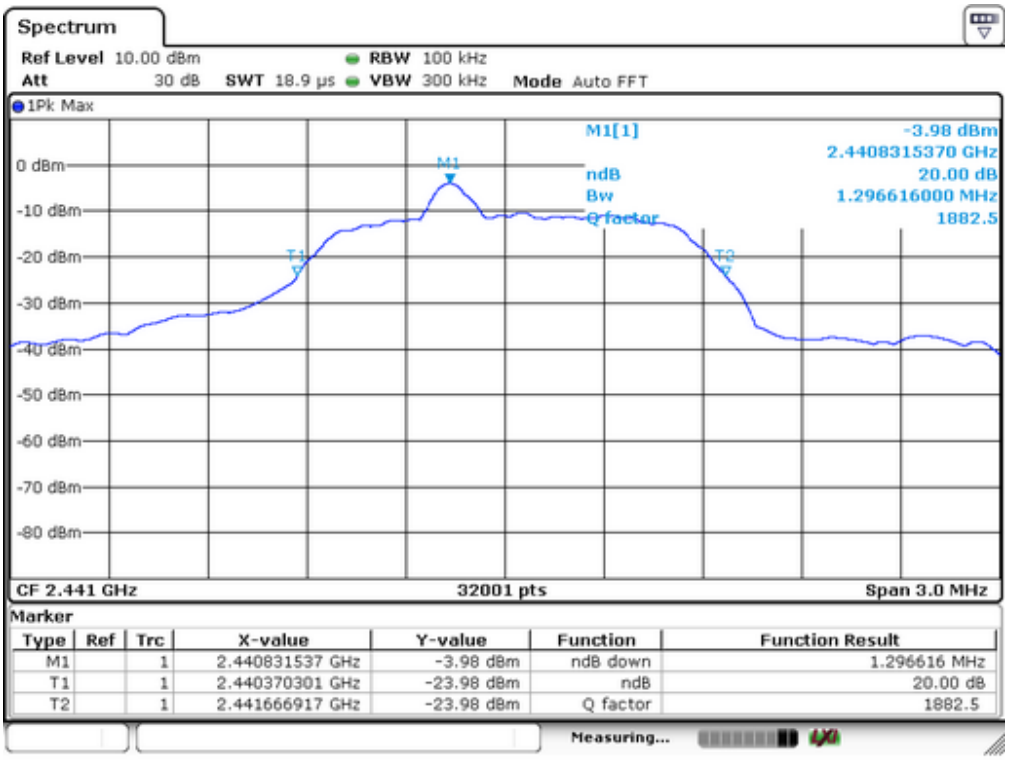

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-3.90 dBm
2.4408310680 GHz
ndB 20.00 dB
Bw 1.147652000 MHz
Q factor 2126.8
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.440831068 GHz -3.90 dBm ndB down 1.147652 MHz
T1 1 2.440452423 GHz -23.90 dBm ndB 20.00 dB
T2 1 2.441600075 GHz -23.90 dBm Q factor 2126.8
Measuring...

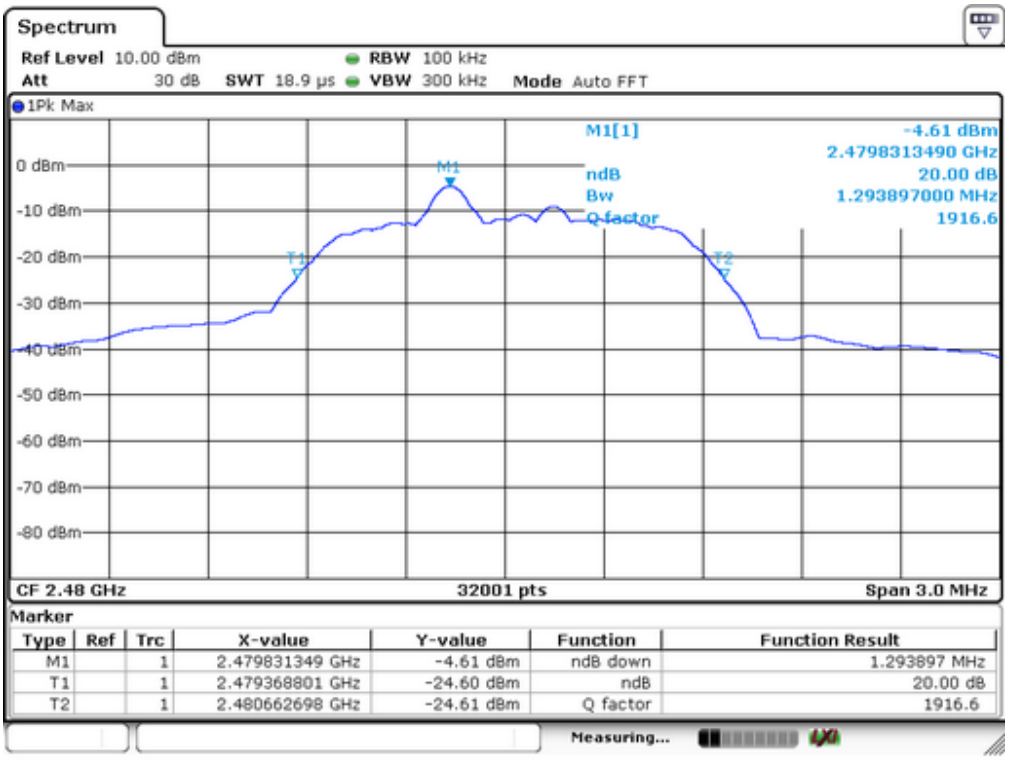


Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	Π/4-DQPSK		

Channel number	Channel frequency (MHz)	20dB Down BW(kHz)
1	2402	1296
40	2441	1297
79	2480	1294

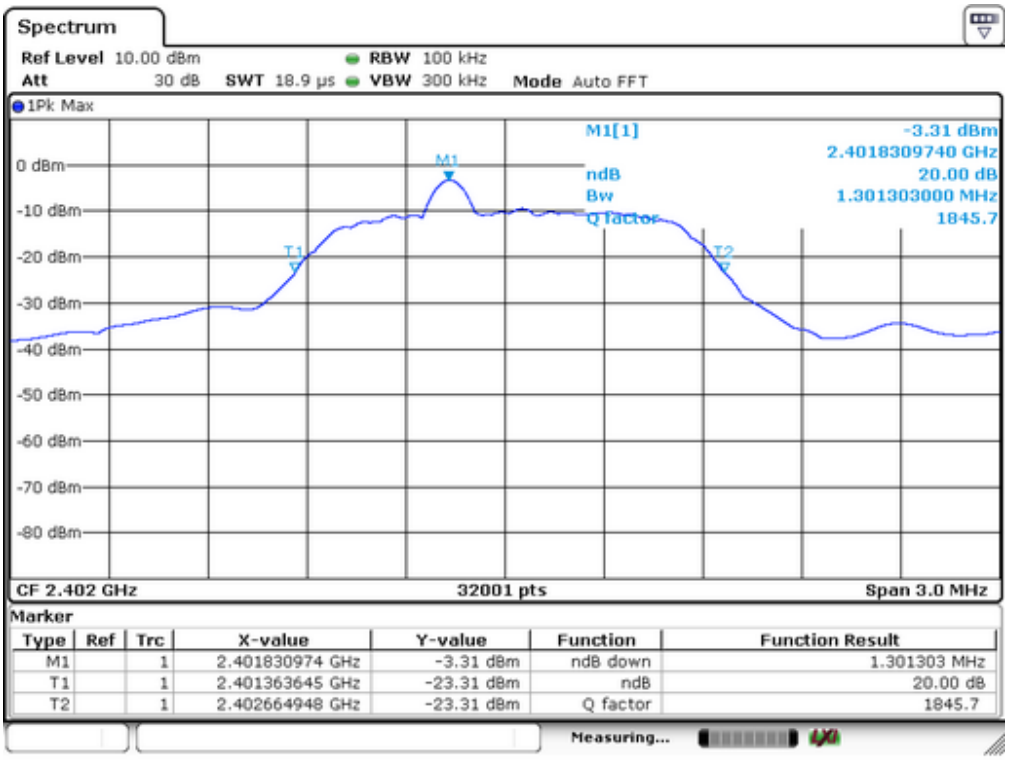

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-3.31 dBm
2.4018311620 GHz
ndB 20.00 dB
Bw 1.296241000 MHz
Q factor 1852.9
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.402 GHz
32001 pts
Span 3.0 MHz
Marker
Type | Ref | Trc | X-value | Y-value | Function | Function Result
M1 | | 1 | 2.401831162 GHz | -3.31 dBm | ndB down | 1.296241 MHz
T1 | | 1 | 2.401367676 GHz | -23.32 dBm | ndB | 20.00 dB
T2 | | 1 | 2.402663917 GHz | -23.31 dBm | Q factor | 1852.9
Measuring...

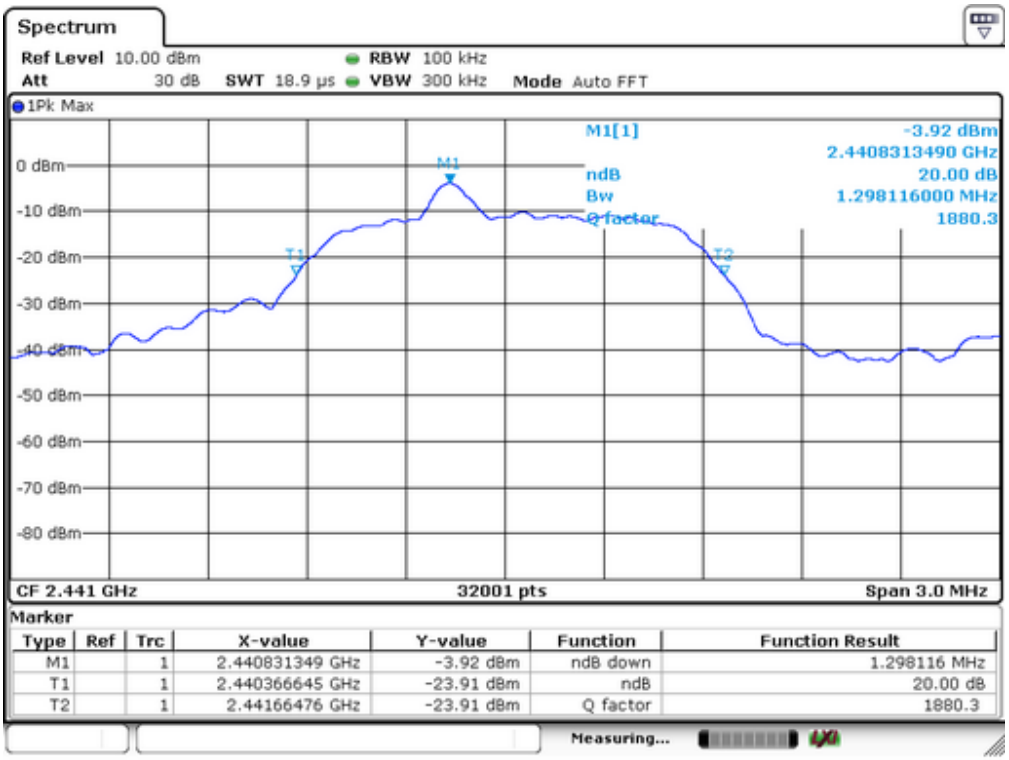

Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-3.98 dBm
2.4408315370 GHz
ndB 20.00 dB
Bw 1.296616000 MHz
Q factor 1882.5
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.441 GHz
32001 pts
Span 3.0 MHz
Marker
Type | Ref | Trc | X-value | Y-value | Function | Function Result
M1 | | 1 | 2.440831537 GHz | -3.98 dBm | ndB down | 1.296616 MHz
T1 | | 1 | 2.440370301 GHz | -23.98 dBm | ndB | 20.00 dB
T2 | | 1 | 2.441666917 GHz | -23.98 dBm | Q factor | 1882.5
Measuring...

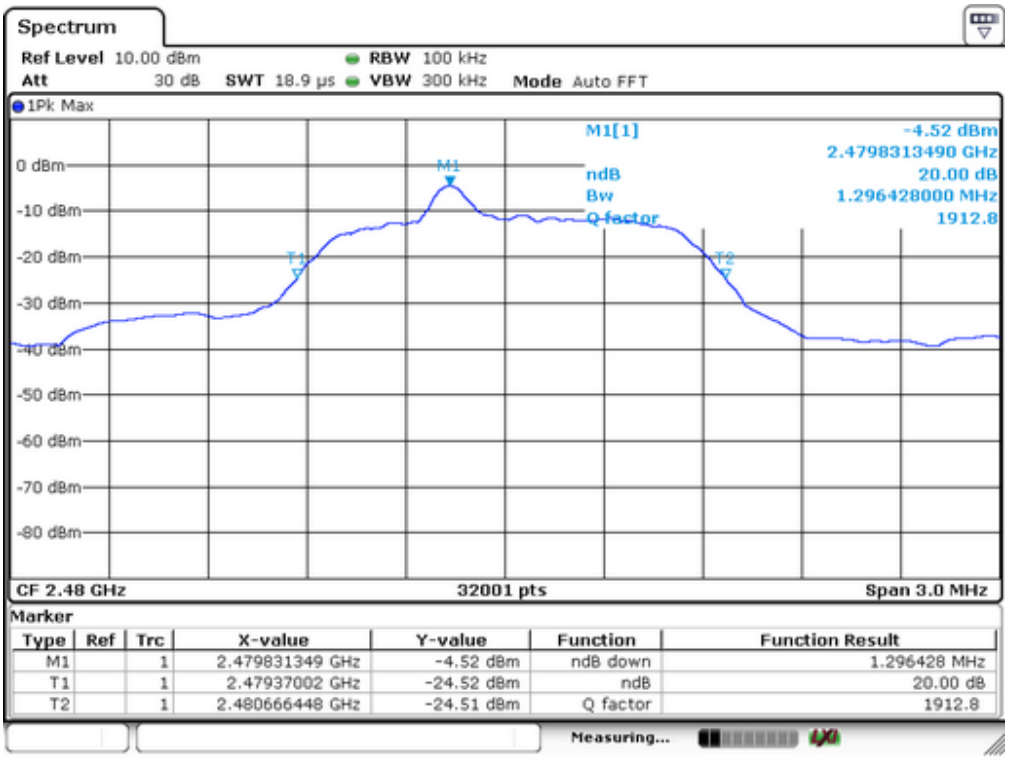


Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	8DPSK		

Channel number	Channel frequency (MHz)	20dB Down BW(kHz)
1	2402	1301
40	2441	1298
79	2480	1296


Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-3.31 dBm
2.4018309740 GHz
ndB 20.00 dB
Bw 1.301303000 MHz
Q factor 1845.7
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.402 GHz
32001 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.401830974 GHz -3.31 dBm ndB down 1.301303 MHz
T1 1 2.401363645 GHz -23.31 dBm ndB 20.00 dB
T2 1 2.402664948 GHz -23.31 dBm Q factor 1845.7
Measuring...


Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-3.92 dBm
2.4408313490 GHz
ndB 20.00 dB
Bw 1.298116000 MHz
Q factor 1880.3
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.441 GHz
32001 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.440831349 GHz -3.92 dBm ndB down 1.298116 MHz
T1 1 2.440366645 GHz -23.91 dBm ndB 20.00 dB
T2 1 2.44166476 GHz -23.91 dBm Q factor 1880.3
Measuring...


Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 18.9 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max
M1[1]
-4.52 dBm
2.4798313490 GHz
ndB 20.00 dB
Bw 1.296428000 MHz
Q factor 1912.8
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.48 GHz
32001 pts
Span 3.0 MHz
Marker
Type | Ref | Trc | X-value | Y-value | Function | Function Result
M1 | | 1 | 2.479831349 GHz | -4.52 dBm | ndB down | 1.296428 MHz
T1 | | 1 | 2.47937002 GHz | -24.52 dBm | ndB | 20.00 dB
T2 | | 1 | 2.480666448 GHz | -24.51 dBm | Q factor | 1912.8
Measuring...

9. Quantity of Hopping Channel Test

9.1 Measurement Procedure

The EUT was operating in hopping mode or could be controlled its channel. Printed out the test result from the spectrum by hard copy function.

9.2 Test SET-UP (Block Diagram of Configuration)

EUT ——— Spectrum Analyzer

9.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/16/2017
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/16/2017
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/16/2017

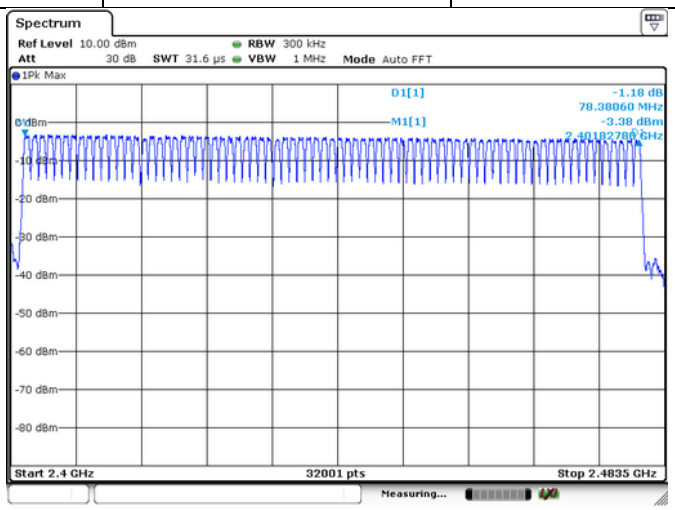
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

9.4 Measurement Results:

Refer to attached data chart.

Worst Test Mode	GFSK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %

Hopping Channel Frequency Range	Quantity of Hopping Channel	Quantity of Hopping Channel
2402-2480	79	＞15



10. Time of Occupancy (Dwell Time) test

10.1 Test Description

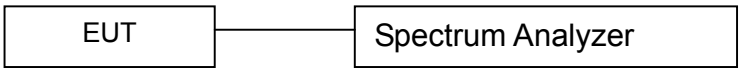
The Equipment Under Test (EUT) was set up to perform the dwell time measurements. The EUT was connected to the spectrum analyzer via a short coax cable. The dwell time is calculated by:

Dwell time = time slot length * hop rate / number of hopping channels * 31.6s

with:
- hop rate = 1600 * 1/s for DH1 packets = 1600 s^{-1}
- hop rate = 1600/3 * 1/s for DH3 packets = 533.33 s^{-1}
- number of hopping channels = 79
- 31.6 s = 0.4 seconds multiplied by the number of hopping channels = 0.4 s * 79

The highest value of the dwell time is reported.

10.2 Test SET-UP (Block Diagram of Configuration)



10.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/16/2017
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/16/2017
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/16/2017

Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

10.4 Test Requirements / Limits

FCC Part 15, Subpart C, §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. Since the Bluetooth technology uses 79 channels this period is calculated to be 31.6seconds. Refer to attached data chart.

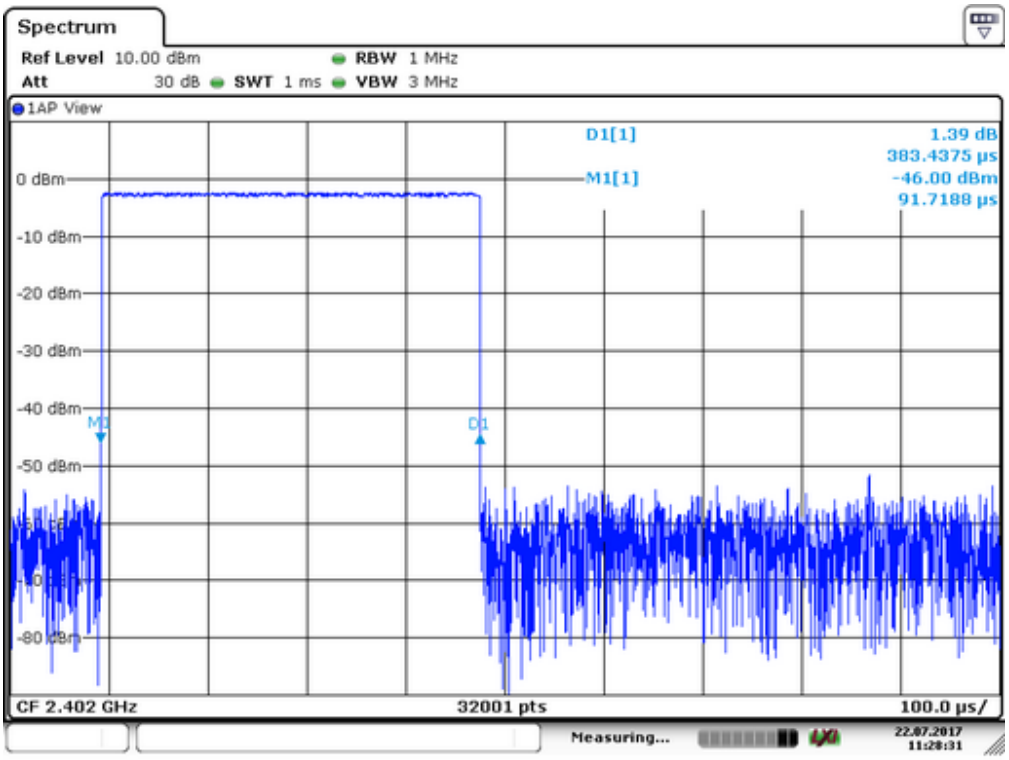
10.5 Test result

Mode	Number of transmission in a 31.6(79 Hopping*0.4)	Length of transmissions time(msec)	Result (msec)	Limit (msec)
DH1	1600/(2*79) x 31.6 = 320	0.383	122.56	400
DH3	1600/(4*79) x 31.6 =160	1.627	263.32	400
DH5	1600/(6*79) x 31.6 =106.67	2.907	310.09	400

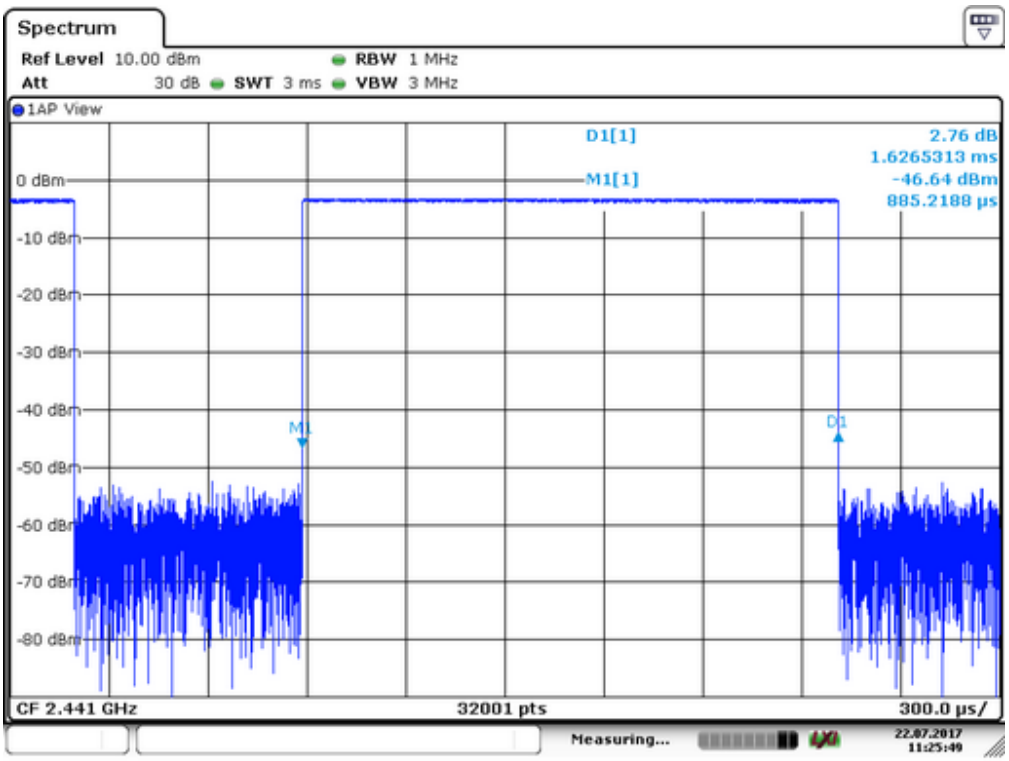
Remark: The results of worst cased was recorded.

.

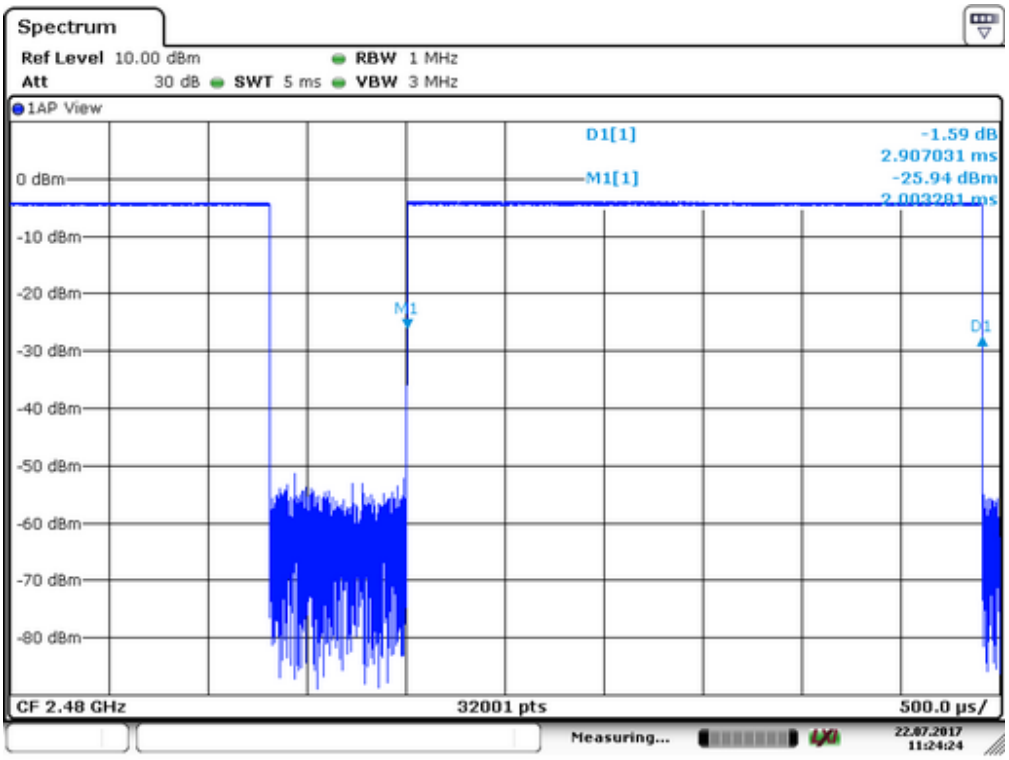
DH1:



DH3:


Spectrum
Ref Level 10.00 dBm
RBW 1 MHz
Att 30 dB
SWT 3 ms
VBW 3 MHz
1AP View
D1[1]
2.76 dB
1.6265313 ms
M1[1]
-46.64 dBm
885.2188 µs
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D1
CF 2.441 GHz
32001 pts
300.0 µs/
Measuring...
22.07.2017
11:25:49

DH5:

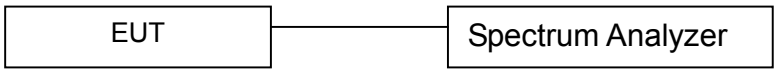

Spectrum
Ref Level 10.00 dBm
RBW 1 MHz
Att 30 dB
SWT 5 ms
VBW 3 MHz
1AP View
D1[1]
-1.59 dB
2.907031 ms
M1[1]
-25.94 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D1
CF 2.48 GHz
32001 pts
500.0 µs/
Measuring...
22.07.2017
11:24:24

11. MAXIMUM PEAK OUTPUT POWER TEST

11.1 Measurement Procedure

a. Check the calibration of the measuring instrument(SA) using either an internal calibrator or a known signal from an external generator.
b. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
c. The center frequency of the spectrum analyzer is set to the fundamental frequency and using proper RBW and VBW setting.
d. Measure the captured power within the band and recording the plot.
e. Repeat above procedures until all frequencies required were complete.

11.2 Test SET-UP (Block Diagram of Configuration)



11.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/16/2017
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/16/2017
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/16/2017

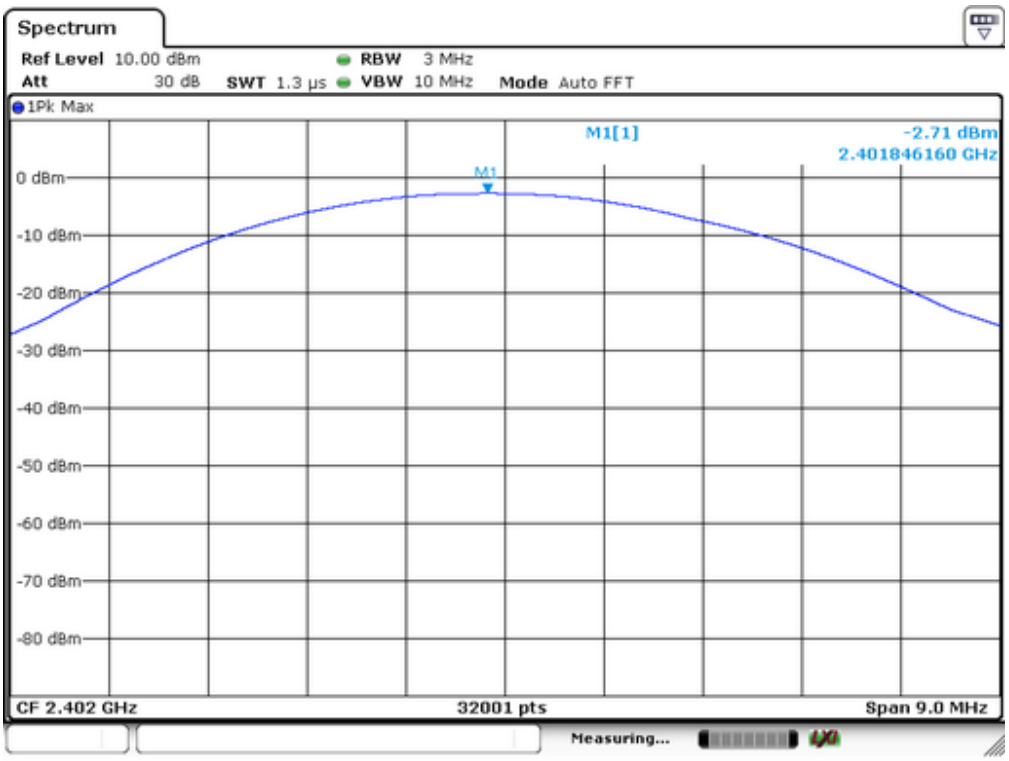
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

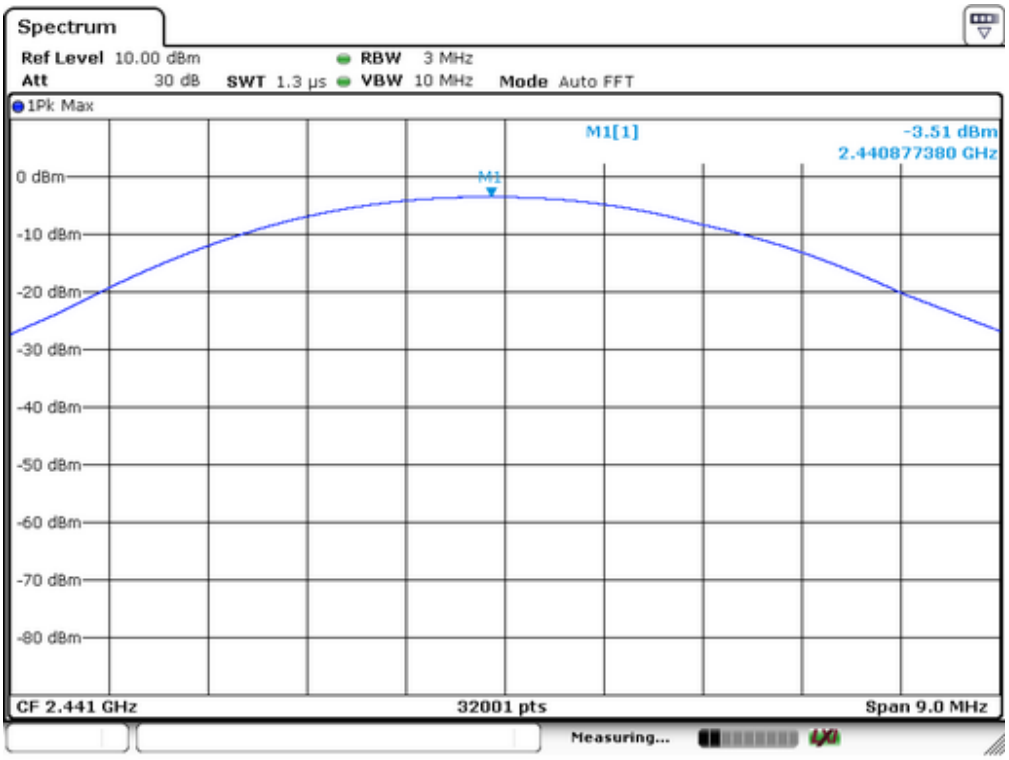
11.4 Measurement Results:

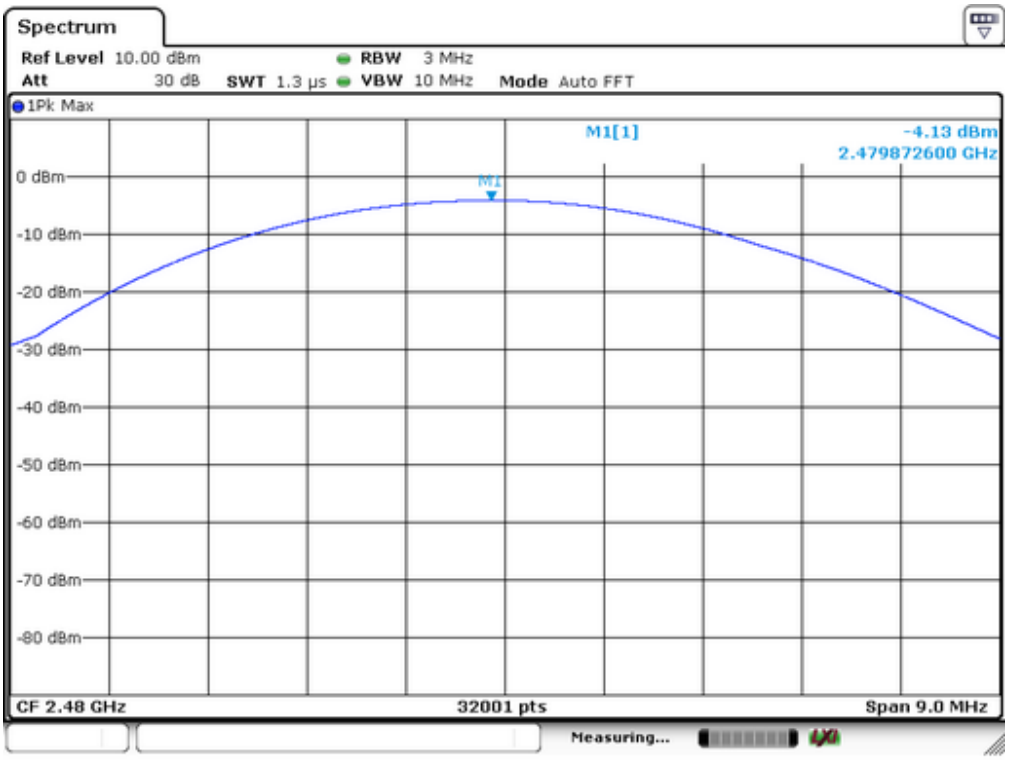
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %
Modulation:	GFSK		

Channel number	Channel Frequency (MHz)	Peak Power output(dBm)	Peak Power output(mW)	Peak Power Limit(mW)	Pass/Fail
01	2402	-2.71	0.536	1000	PASS
40	2441	-3.51	0.446	1000	PASS
79	2480	-4.13	0.386	1000	PASS

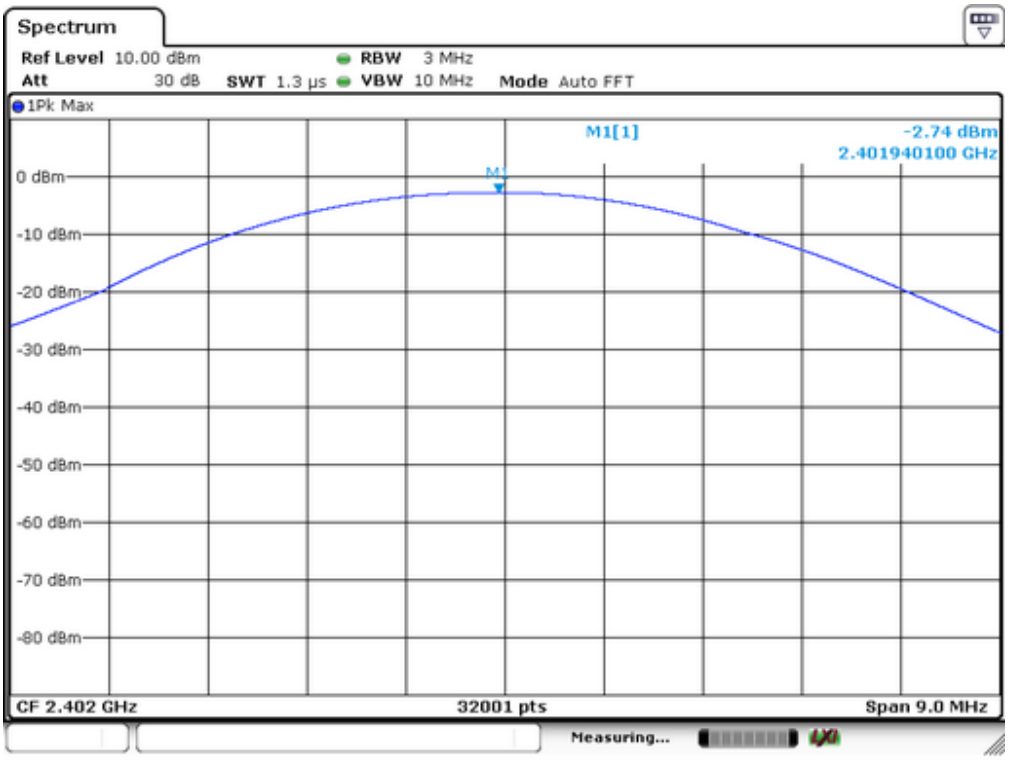


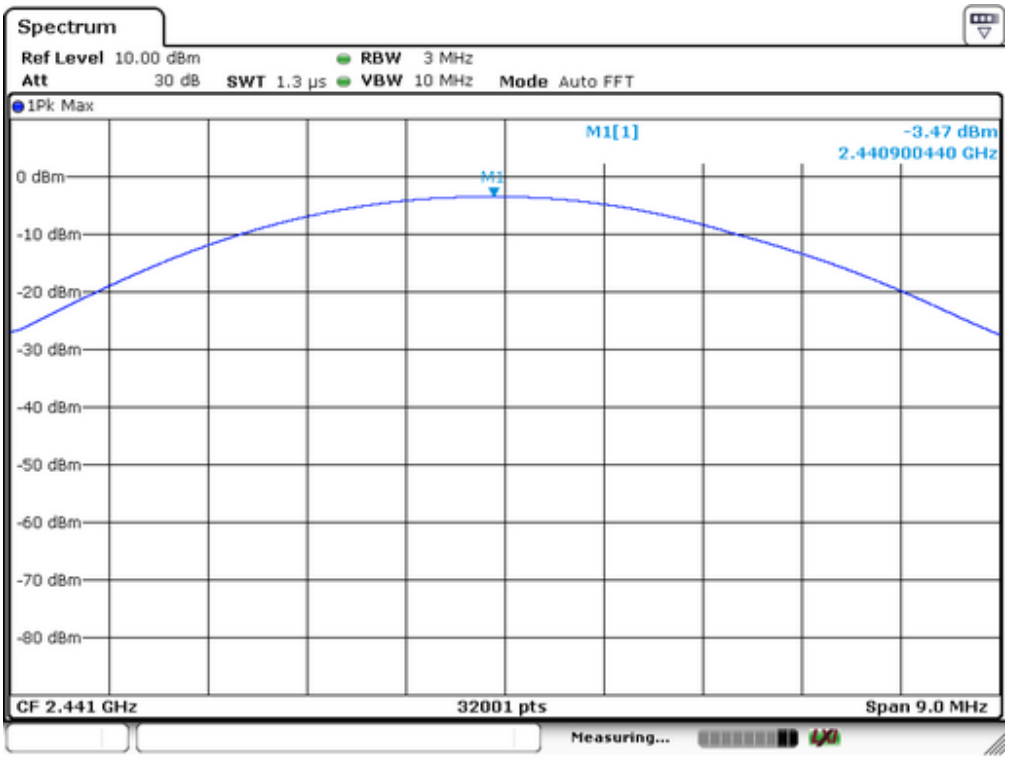

Spectrum
Ref Level 10.00 dBm
RBW 3 MHz
Att 30 dB
SWT 1.3 µs
VBW 10 MHz
Mode Auto FFT
1Pk Max
M1[1]
-3.51 dBm
2.440877380 GHz
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 9.0 MHz
Measuring...

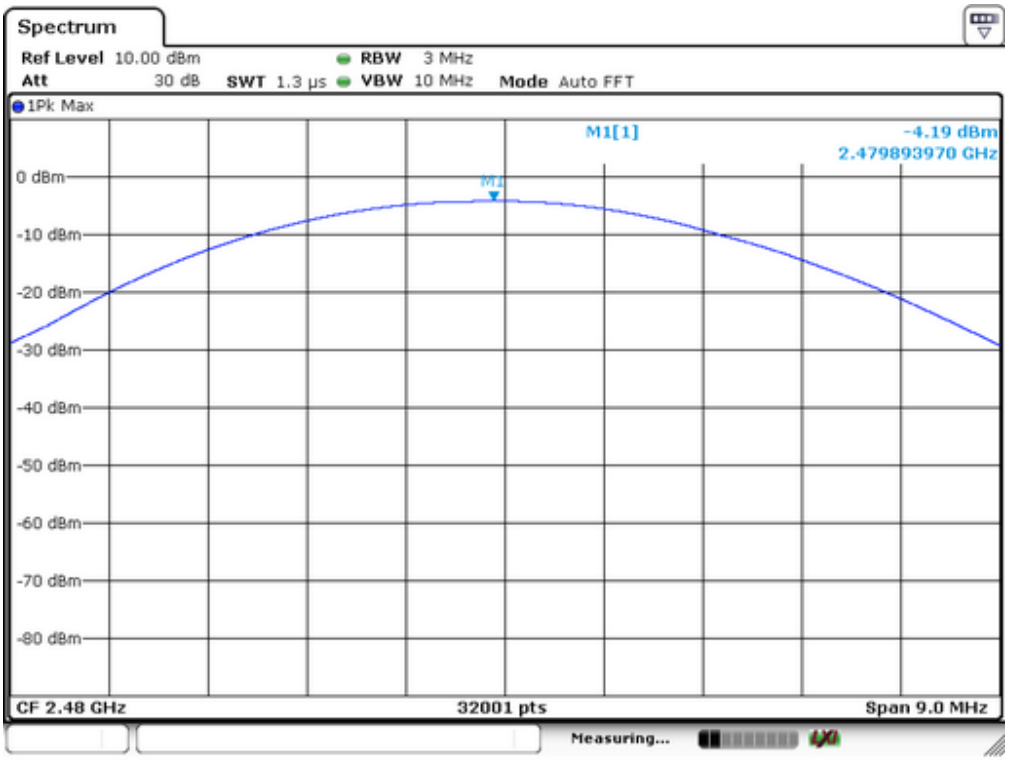

Spectrum
Ref Level 10.00 dBm
RBW 3 MHz
Att 30 dB
SWT 1.3 µs
VBW 10 MHz
Mode Auto FFT
1Pk Max
M1[1]
-4.13 dBm
2.479872600 GHz
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
32001 pts
Span 9.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %
Modulation:	Π/4-DQPSK		

Channel number	Channel Frequency (MHz)	Peak Power output(dBm)	Peak Power output(mW)	Peak Power Limit(mW)	Pass/Fail
01	2402	-2.74	0.532	125	PASS
40	2441	-3.47	0.450	125	PASS
79	2480	-4.19	0.381	125	PASS

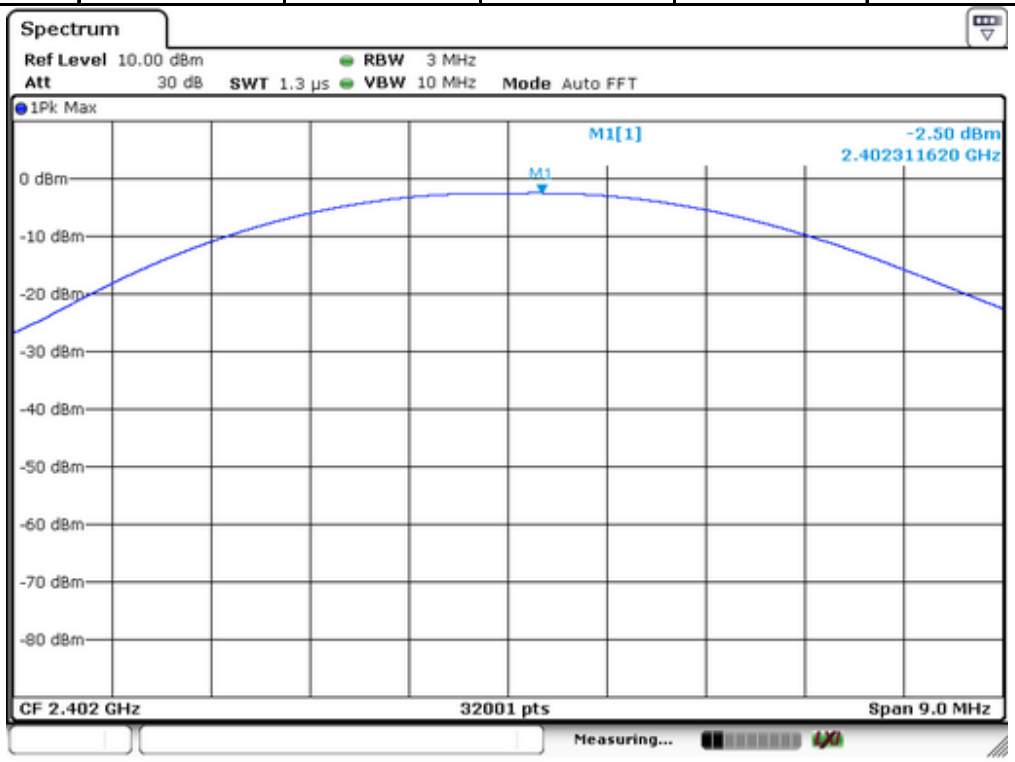


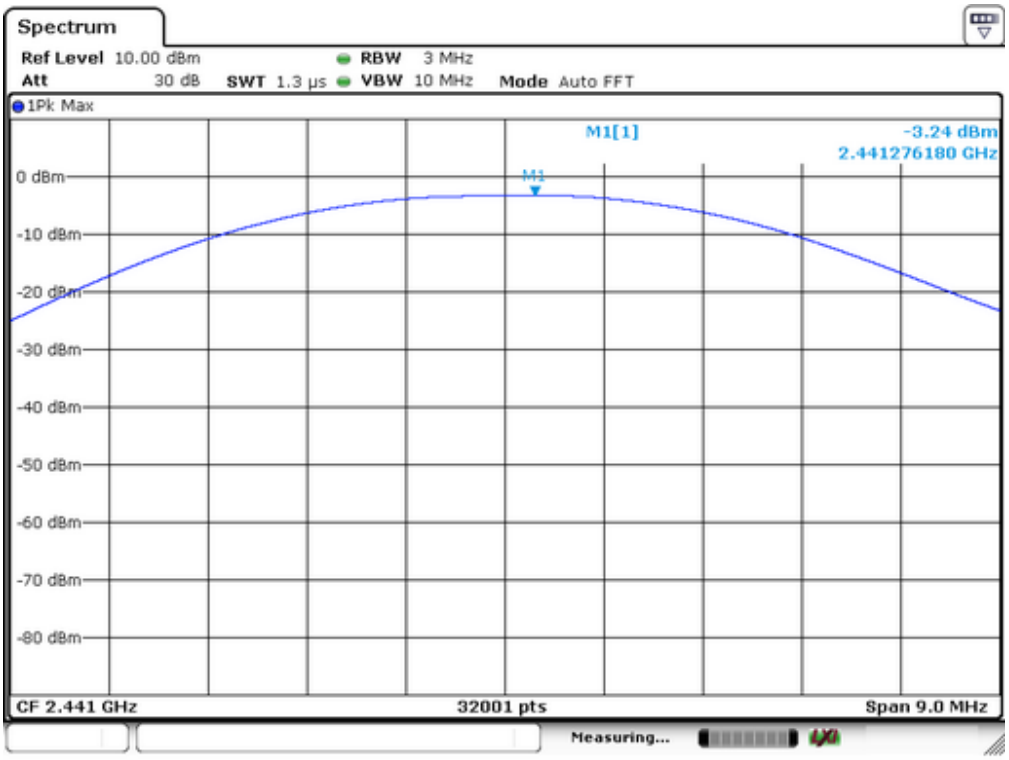

Spectrum
Ref Level 10.00 dBm
RBW 3 MHz
Att 30 dB
SWT 1.3 µs
VBW 10 MHz
Mode Auto FFT
1Pk Max
M1[1]
-3.47 dBm
2.440900440 GHz
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 9.0 MHz
Measuring...

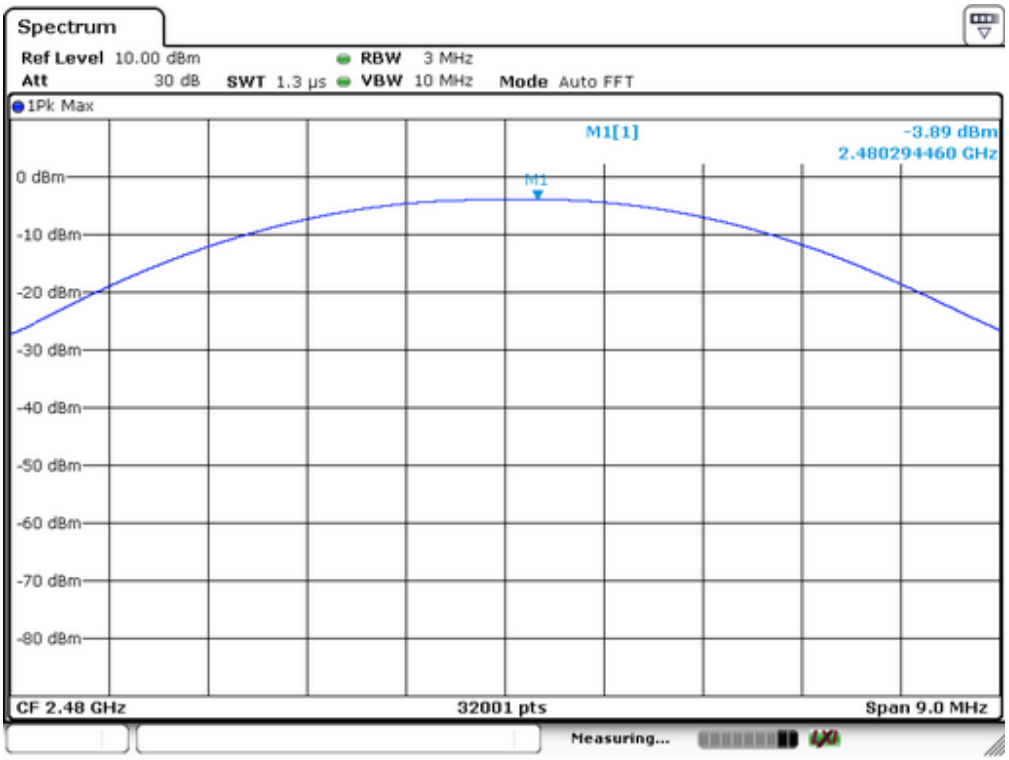

Spectrum
Ref Level 10.00 dBm
RBW 3 MHz
Att 30 dB
SWT 1.3 µs
VBW 10 MHz
Mode Auto FFT
1Pk Max
M1[1]
-4.19 dBm
2.479893970 GHz
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
32001 pts
Span 9.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %
Modulation:	8DPSK		

Channel number	Channel Frequency (MHz)	Peak Power output(dBm)	Peak Power output(mW)	Peak Power Limit(mW)	Pass/Fail
01	2402	**-2.5**	**0.562**	125	PASS
40	2441	-3.24	0.474	125	PASS
79	2480	-3.89	0.408	125	PASS




Spectrum
Ref Level 10.00 dBm
RBW 3 MHz
Att 30 dB
SWT 1.3 µs
VBW 10 MHz
Mode Auto FFT
1Pk Max
M1[1]
-3.24 dBm
2.441276180 GHz
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
32001 pts
Span 9.0 MHz
Measuring...


Spectrum
Ref Level 10.00 dBm
RBW 3 MHz
Att 30 dB
SWT 1.3 µs
VBW 10 MHz
Mode Auto FFT
1Pk Max
M1[1]
-3.89 dBm
2.480294460 GHz
M1
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
32001 pts
Span 9.0 MHz
Measuring...

12. Band EDGE test

12.1 Measurement Procedure

For Conducted Test

1. The transmitter output is connected to a spectrum analyzer. The resolution bandwidth is set to 100KHz. The video bandwidth is set to 300KHz.
2. The spectrum from 30MHz to 26 GHz is investigated with the transmitter set to the lowest, middle, and highest channels.

EMI Test Receiver	Setting
Attenuation	Auto
RBW	100KHz
VBW	300KHz
Detector	Peak
Trace	Max hold

For Radiated emission Test

The EUT was placed on a styrofoam table which is 1.5m above ground plane.

The measurement procedure at the ban edges was simplified by performing the measurement in just one plot. Both, the in-band-emission and the unwanted emission were be encompassed by the span. After trace stabilization, the maximum peak was be determined by a peak detector and the value was marked by an appropriate limit line. The second limit line, which is 20dB below the first, marks the limit for the emissions in the unrestricted band. A maximum-peak-detector marks the highest emission in the unrestricted band next to the band edge.

The measurements were performed at the lower end of the 2.4GHz band.

Use the following spectrum analyzer settings:

For Restricted Band, When spectrum scanned above 1GHz setting resolution bandwidth 1MHz, video bandwidth 3MHz:

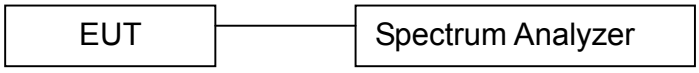
EMI Test Receiver	Setting
Attenuation	Auto
RBW	1MHz
VBW	3MHz
Detector	Peak
Trace	Max hold

For Non-Restricted Band, When spectrum scanned above 1GHz setting resolution bandwidth 100KHz, video bandwidth 300KHz:

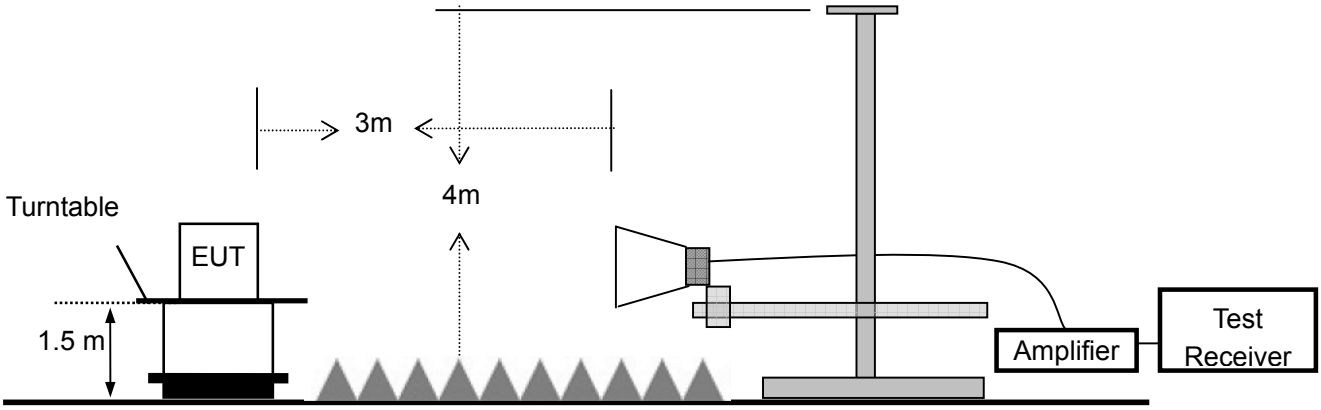
EMI Test Receiver	Setting
Attenuation	Auto
RBW	100KHz
VBW	300KHz
Detector	Peak
Trace	Max hold

12.2 Test SET-UP (Block Diagram of Configuration)

For Conducted Test



For Radiated emission Test



12.3 Measurement Equipment Used:

For Conducted Test

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/16/2017
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/16/2017
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/16/2017

Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

For Radiated emission Test

Item	Equipment	Manufacturer	Model No.	Serial No.	Characteristics	Last Cal.	Cal. Interval
1	Signal Analyzer	Rohde & Schwarz	FSV30	103040	9KHz-40GHz	5/16/2017	1 Year
2	Horn Antenna	Schwarzbeck	BBHA9120D	9120D-1272	1GHz-18GHz	5/16/2017	1 Year
3	Power Amplifier	LUNAR EM	LNA1G18-40	J10100000081	1GHz-26.5GHz	5/16/2017	1 Year
4	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	5/16/2017	1 Year
5	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	5/16/2017	1 Year
6	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	5/16/2017	1 Year

12.4 Measurement Results:

Refer to attached data chart.

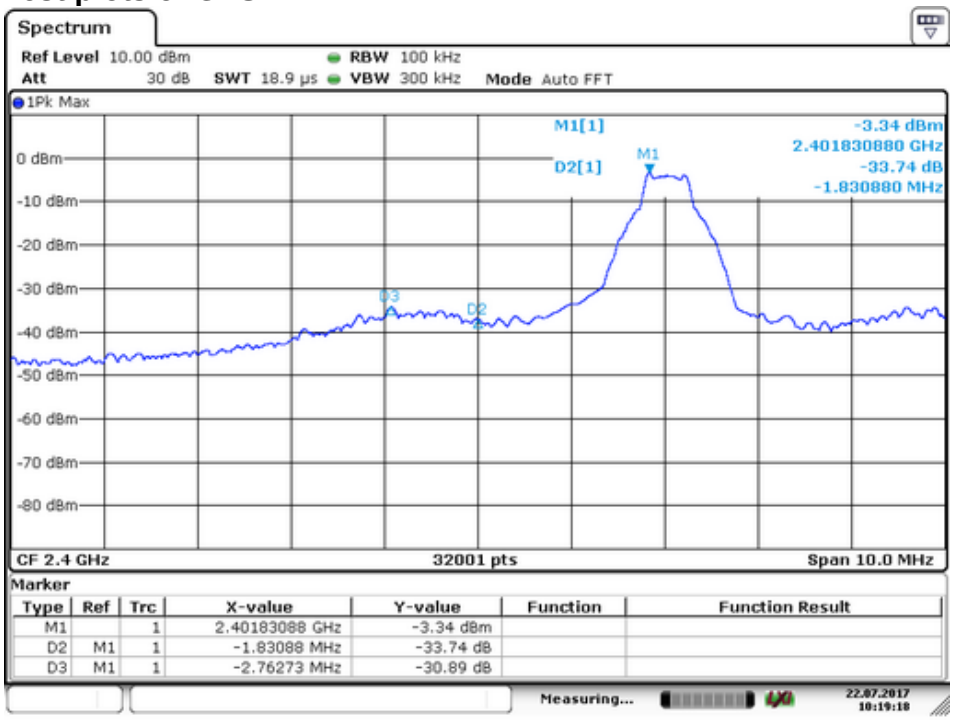
Spectrum Detector:	PK	Test Date :	July 11, 2017
Test By:	YF	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %

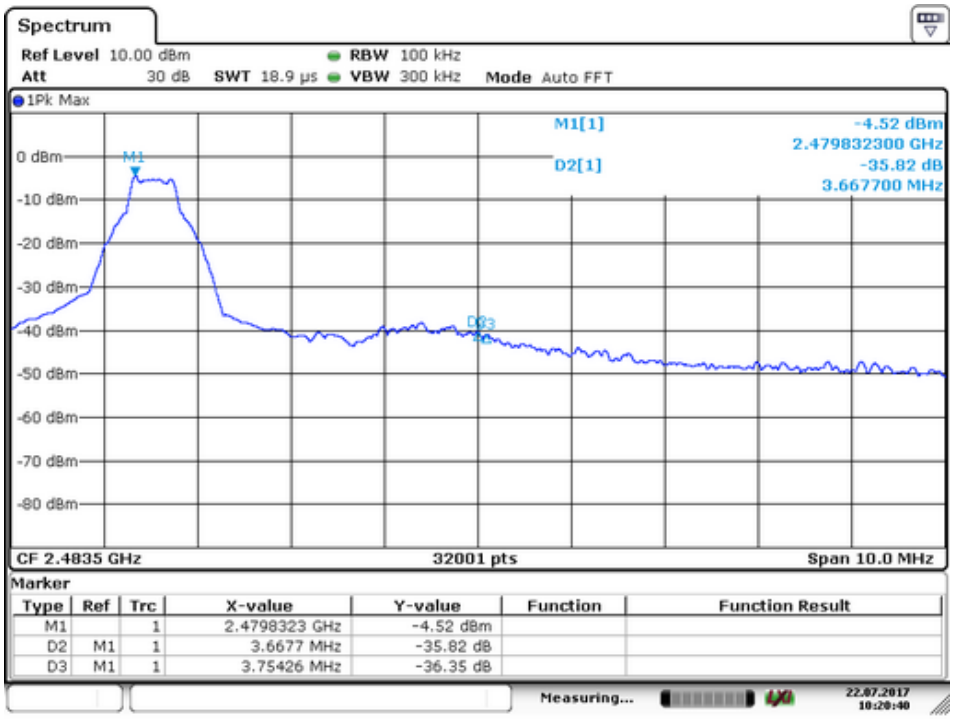
1. Conducted Test

For Non-Hopping Mode:

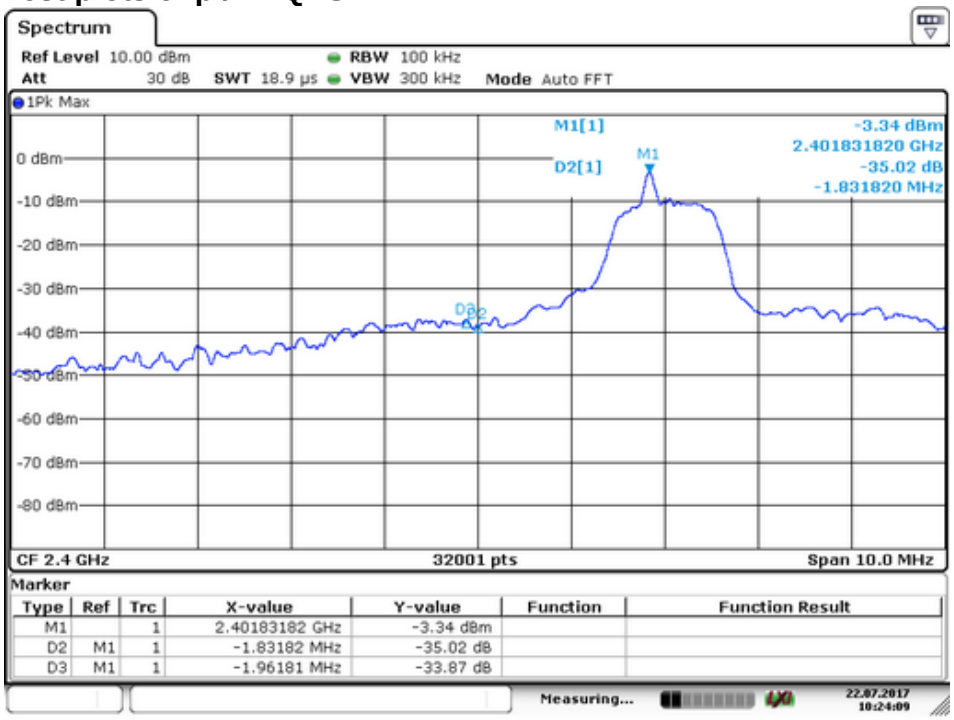
Frequency (MHz)	Modulation	Peak Power Output(dBm)	Result of Band edge(dBc)	Band edge Limit(dBc)
2399.07	GFSK	-3.34	30.89	>20dBc
2483.59	pi/4-DQPSK	-4.52	36.35	>20dBc
2399.87	8DPSK	-3.34	33.87	>20dBc
2483.61	GFSK	-4.59	39.18	>20dBc
2399.74	pi/4-DQPSK	-3.35	34.61	>20dBc
2483.78	8DPSK	-4.53	37.95	>20dBc

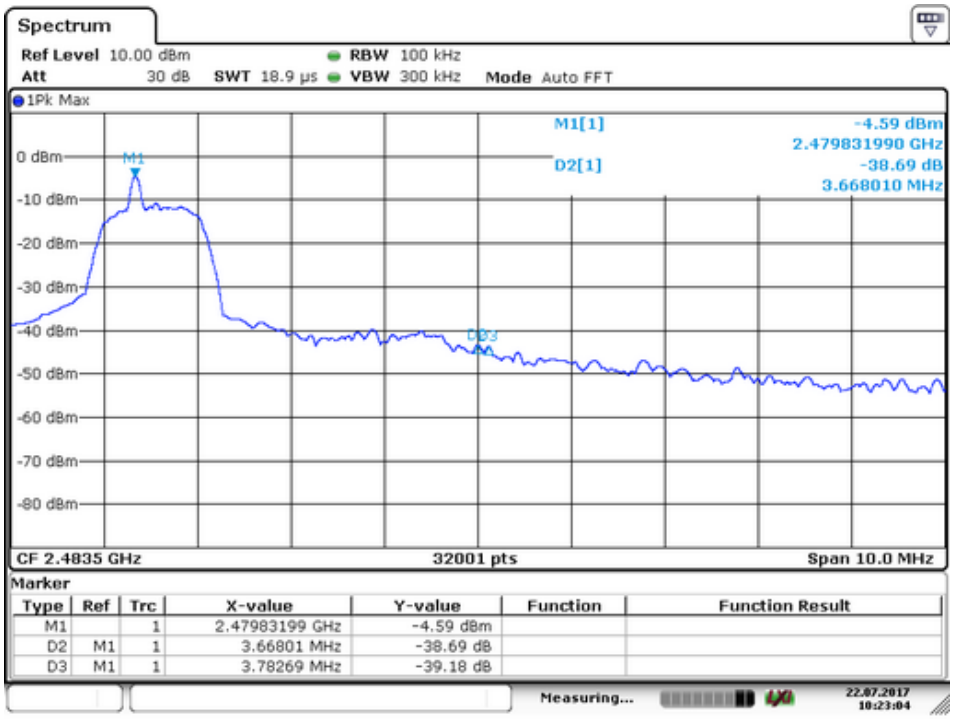
Test plots of GFSK



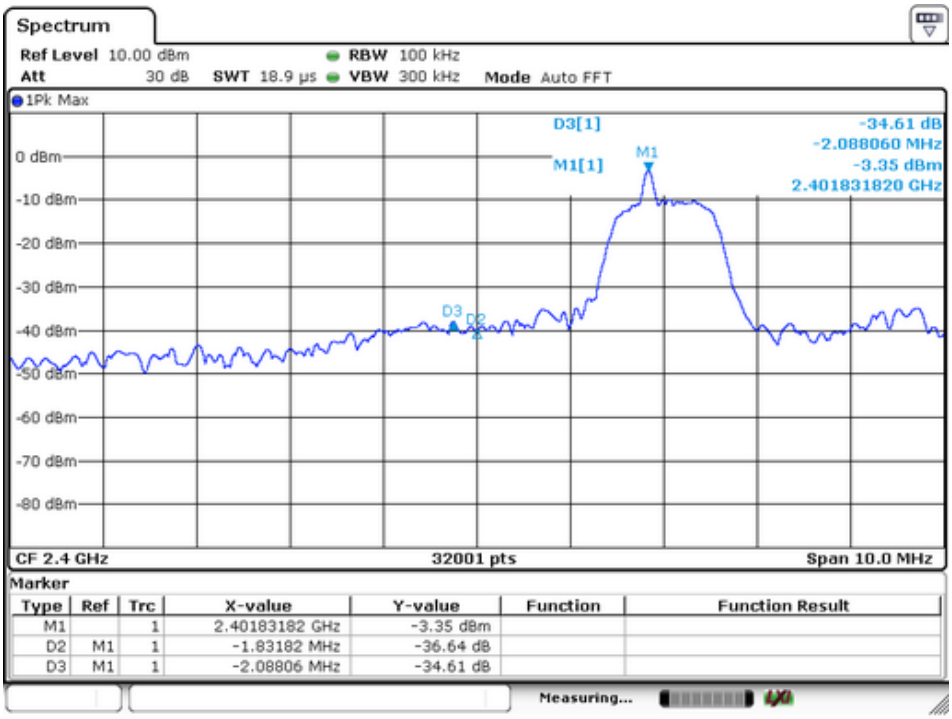


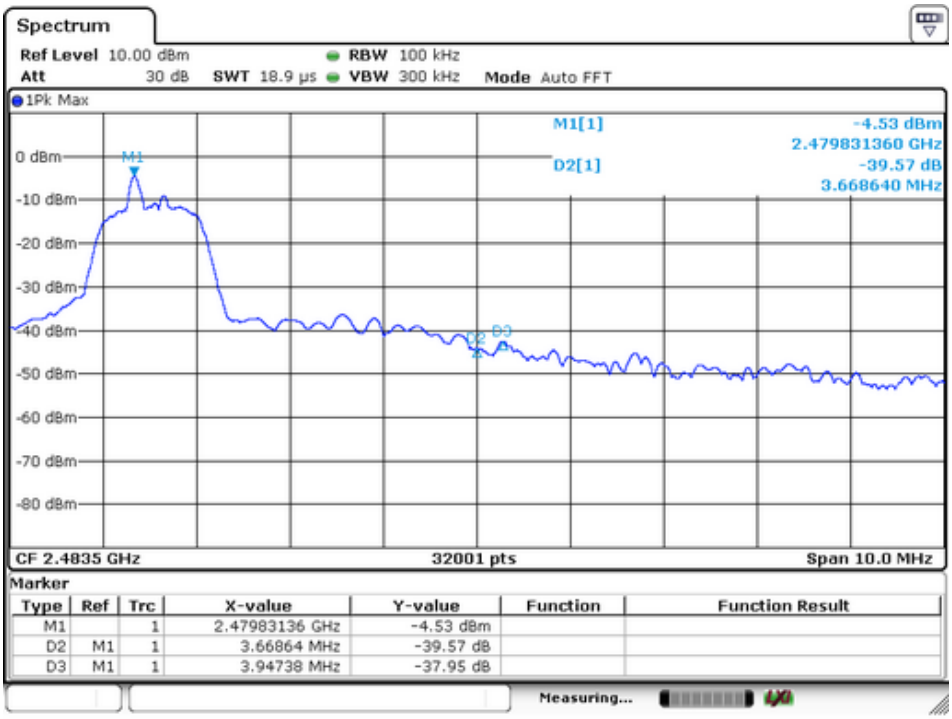
Test plots of pi/4-DQPSK





Test plots of 8DPSK

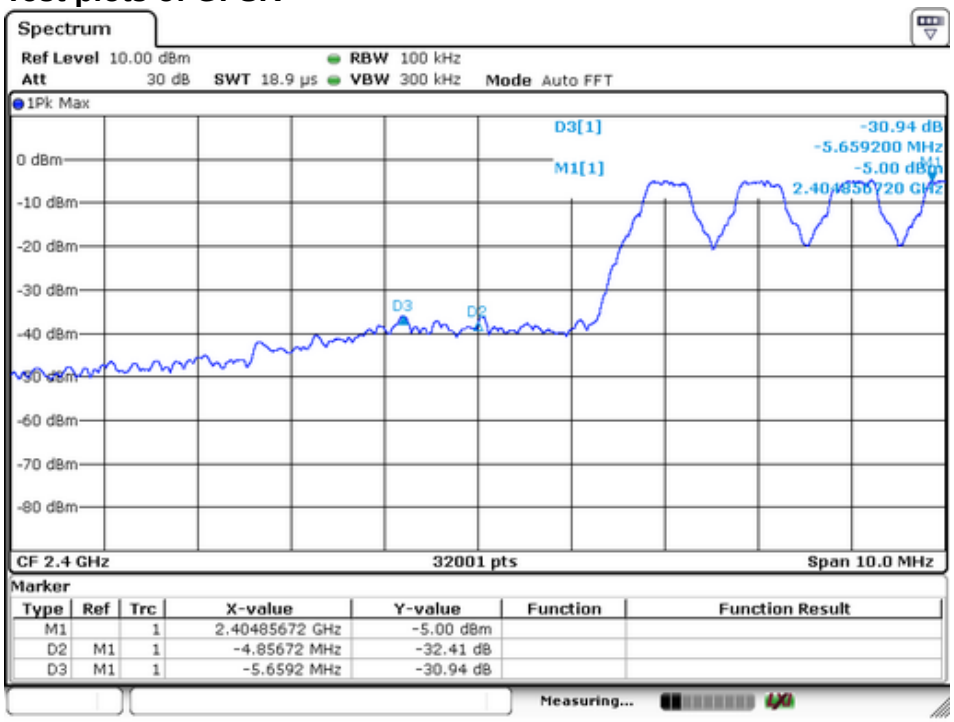


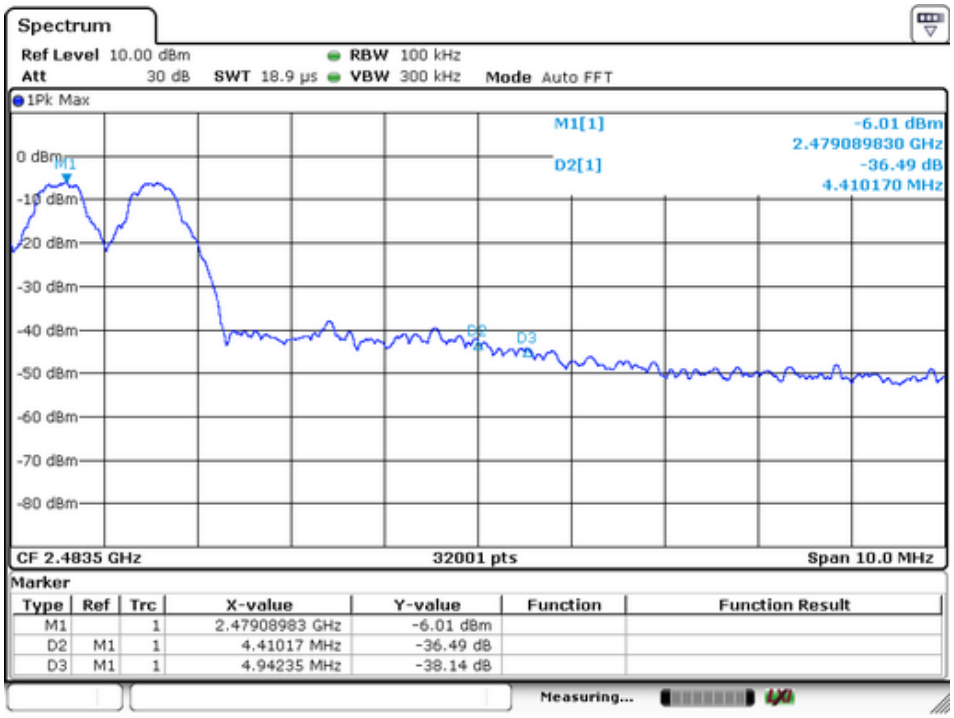


For Hopping Mode:

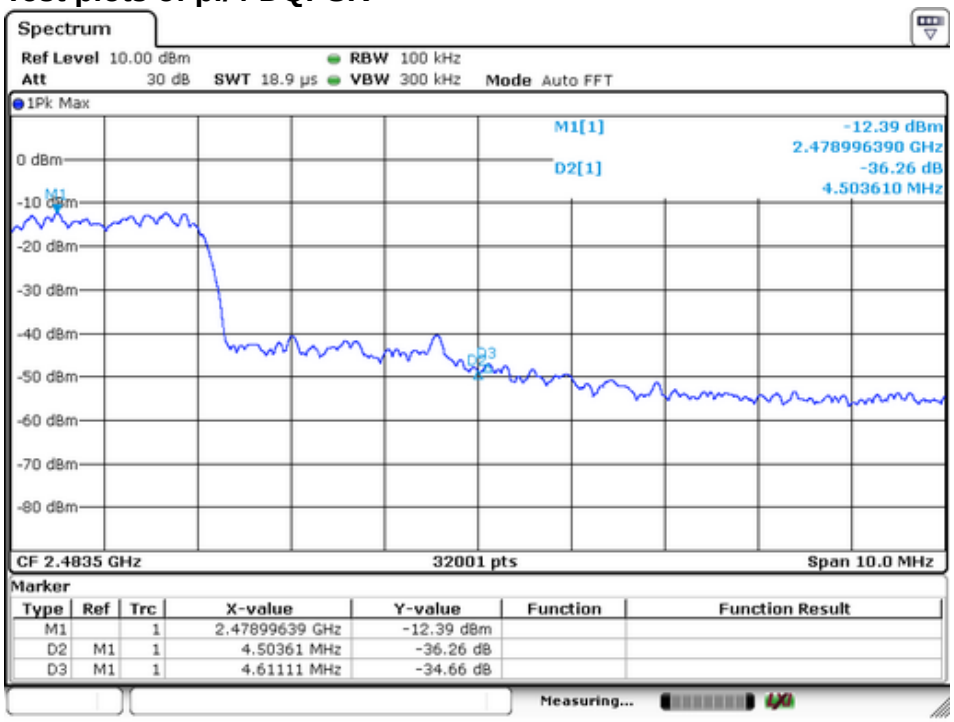
Frequency (MHz)	Modulation	Peak Power Output(dBm)	Result of Band edge(dBc)	Band edge Limit(dBc)
2399.2	GFSK	-5	30.94	>20dBc
2484.03	pi/4-DQPSK	-6.01	38.14	>20dBc
2483.61	8DPSK	-12.39	34.66	>20dBc
2399.14	GFSK	-10.75	30.88	>20dBc
2483.67	pi/4-DQPSK	-8.83	39.42	>20dBc
2399.51	8DPSK	-7.18	29.34	>20dBc

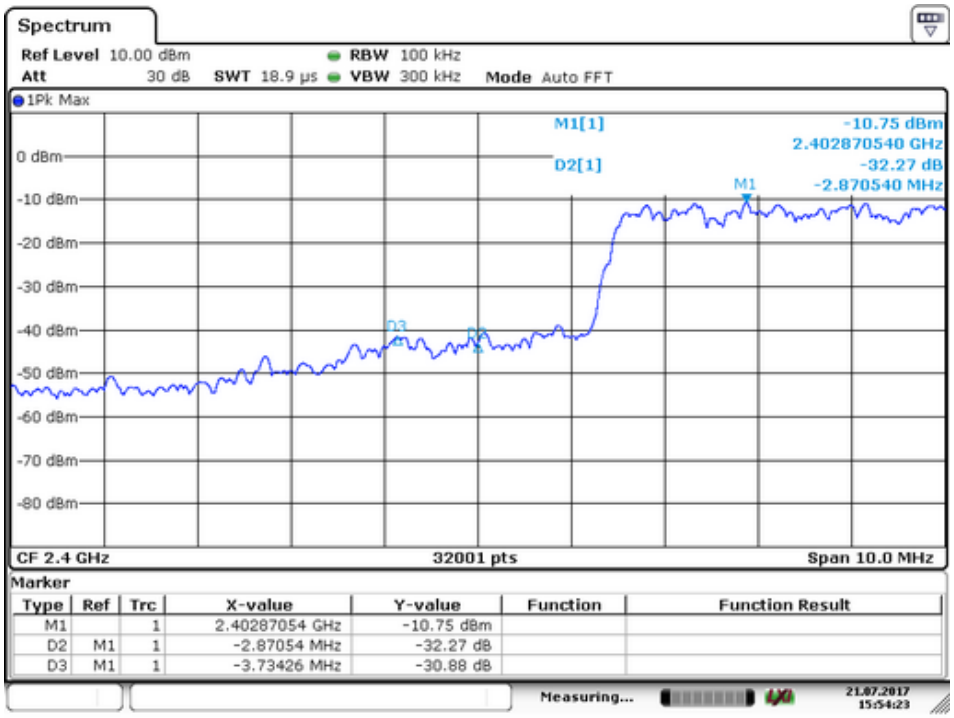
Test plots of GFSK



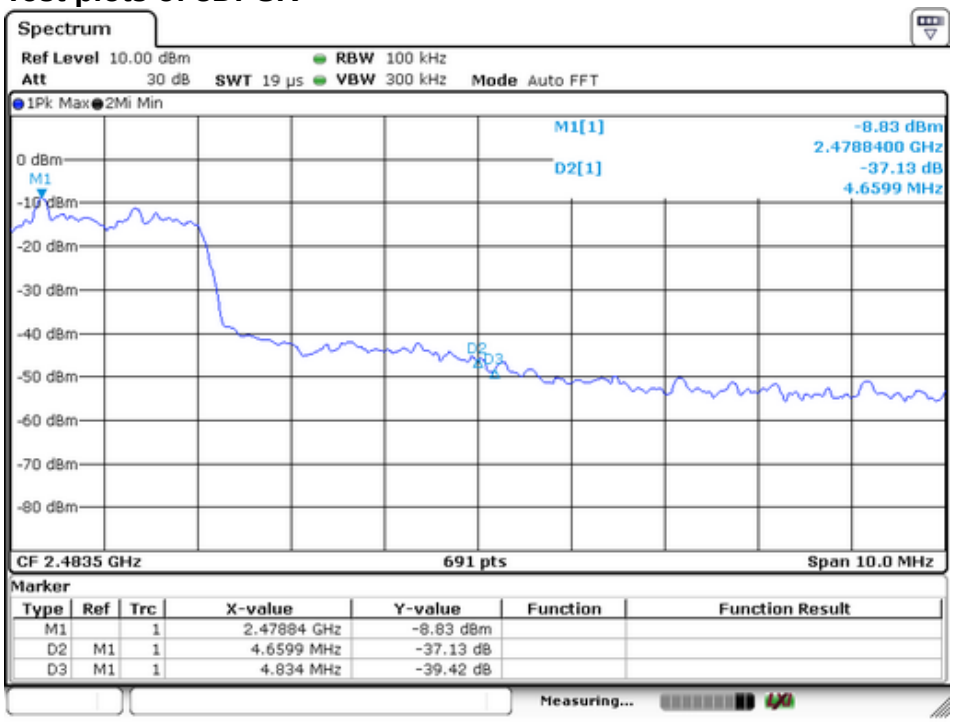


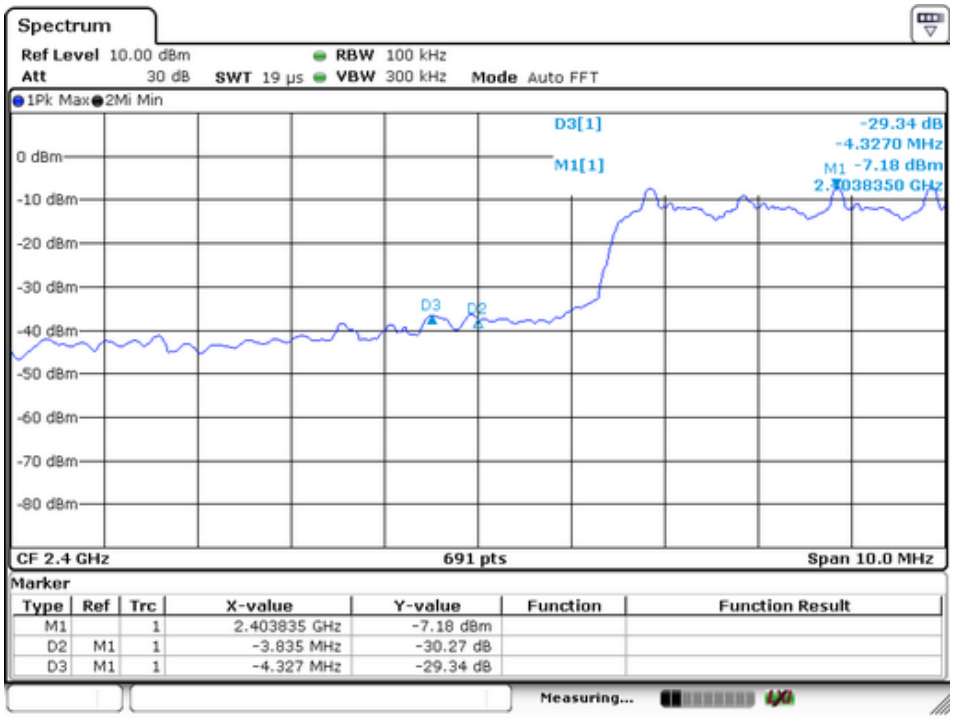
Test plots of pi/4-DQPSK





Test plots of 8DPSK

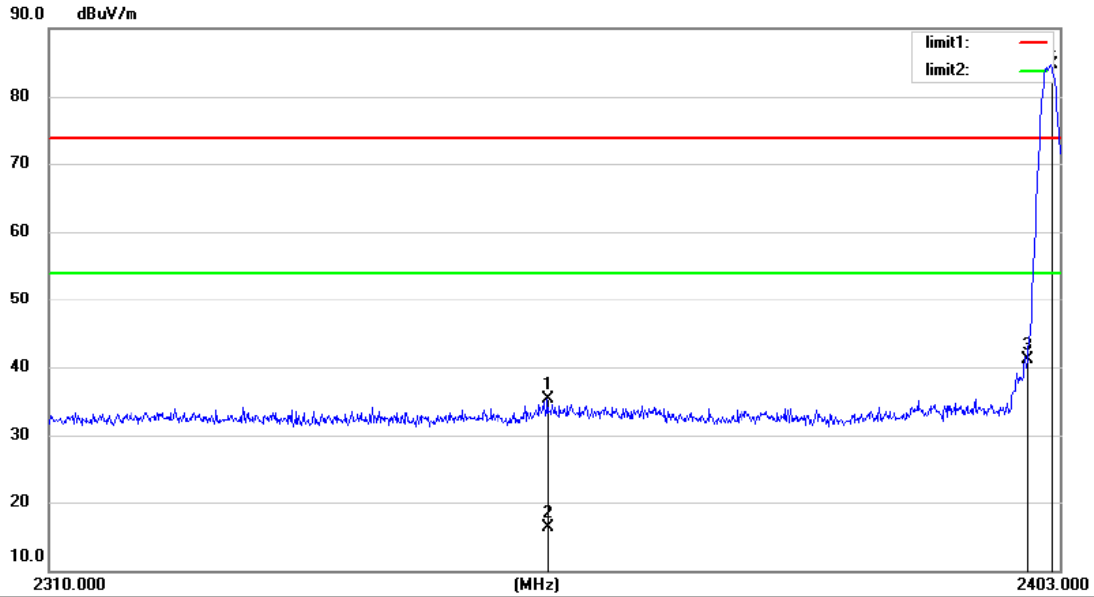



Spectrum
Ref Level 10.00 dBm
RBW 100 kHz
Att 30 dB
SWT 19 µs
VBW 300 kHz
Mode Auto FFT
1Pk Max 2Mi Min
D3[1]
-29.34 dB
-4.3270 MHz
M1[1]
M1 -7.18 dBm
2.4038350 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
D3
D2
CF 2.4 GHz
691 pts
Span 10.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.403835 GHz -7.18 dBm
D2 M1 1 -3.835 MHz -30.27 dB
D3 M1 1 -4.327 MHz -29.34 dB
Measuring...

2. Radiated emission Test

Worst test modulation GFSK

For Non-Hopping Mode:



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

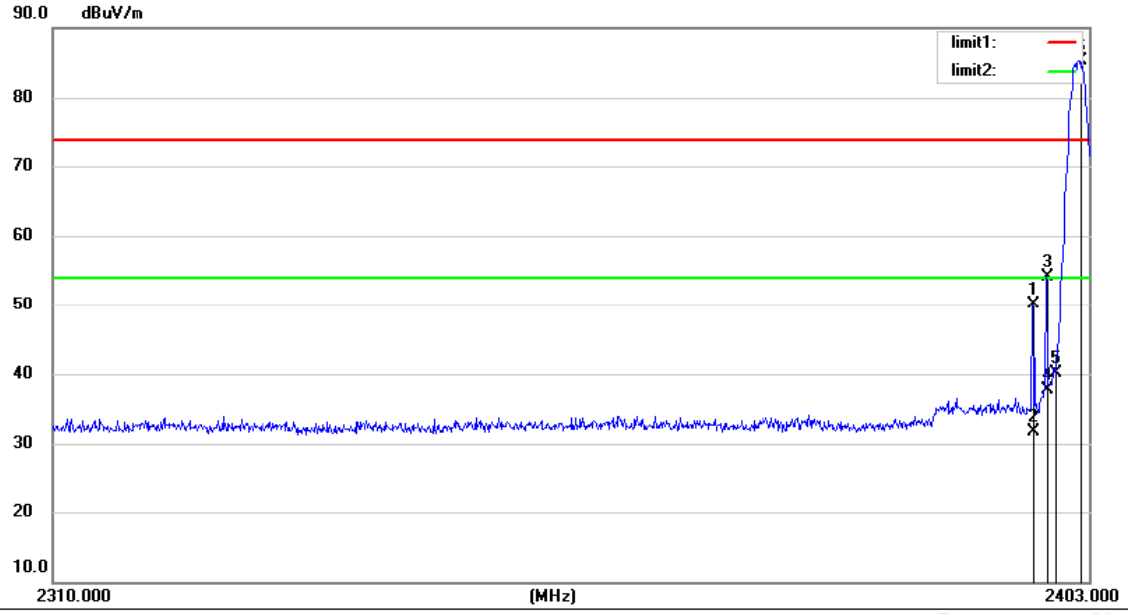
Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: TX2402

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		2355.477	54.01	-18.76	35.25	74.00	-38.75	peak			
2		2355.477	35.00	-18.76	16.24	54.00	-37.76	AVG			
3		2400.000	59.59	-18.50	41.09	74.00	-32.91	peak			
4	*	2402.163	103.11	-18.49	84.62	74.00	10.62	peak			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Vertical*** Temperature: 26

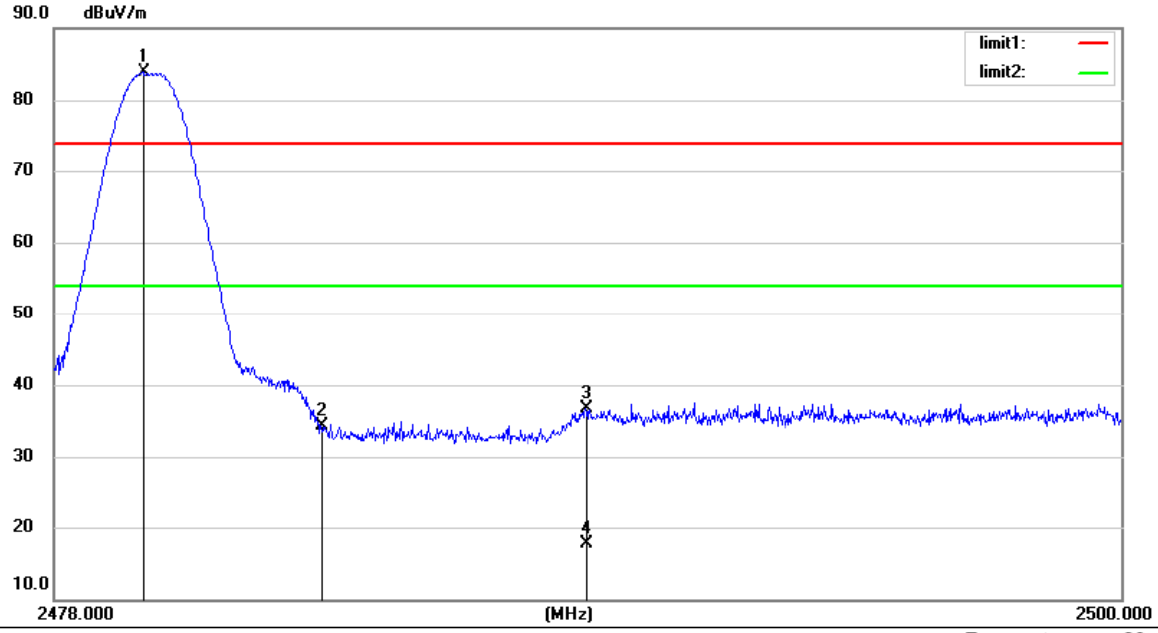
Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: TX2402

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		2397.885	68.53	-18.51	50.02	74.00	-23.98	peak			
2		2397.885	50.12	-18.51	31.61	54.00	-22.39	AVG			
3		2399.187	72.51	-18.50	54.01	74.00	-19.99	peak			
4		2399.187	56.25	-18.50	37.75	54.00	-16.25	AVG			
5		2400.000	58.55	-18.50	40.05	74.00	-33.95	peak			
6	*	2402.163	103.76	-18.49	85.27	74.00	11.27	peak			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

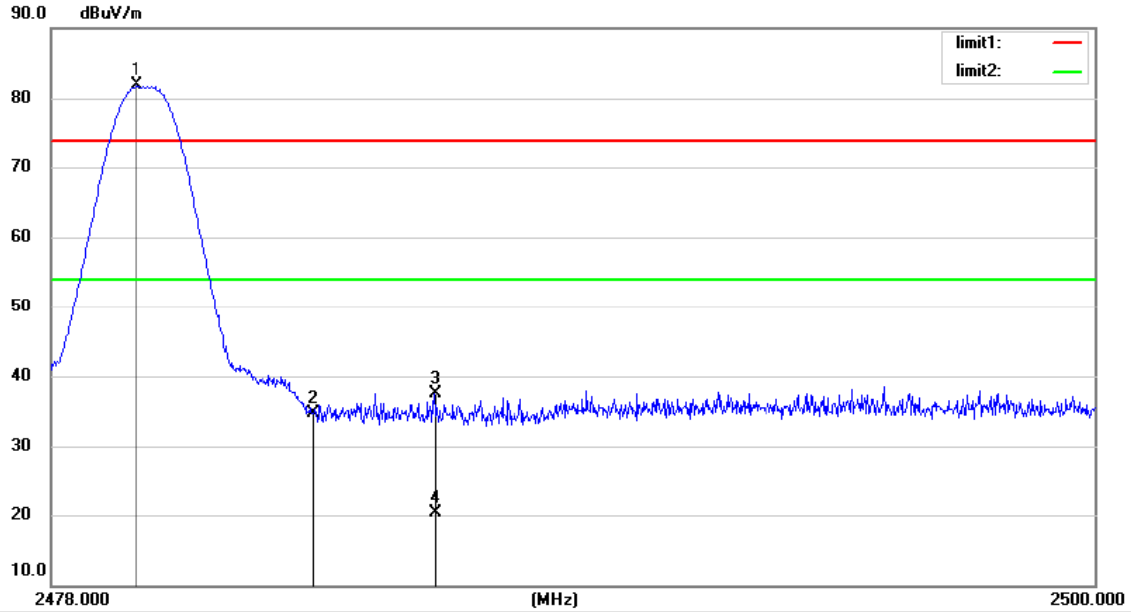
Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: TX2480

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	2479.826	101.89	-18.03	83.86	74.00	9.86	peak			
2		2483.500	52.21	-18.01	34.20	74.00	-39.80	peak			
3		2488.934	54.75	-17.98	36.77	74.00	-37.23	peak			
4		2488.934	35.69	-17.98	17.71	54.00	-36.29	AVG			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Vertical*** Temperature: 26

Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

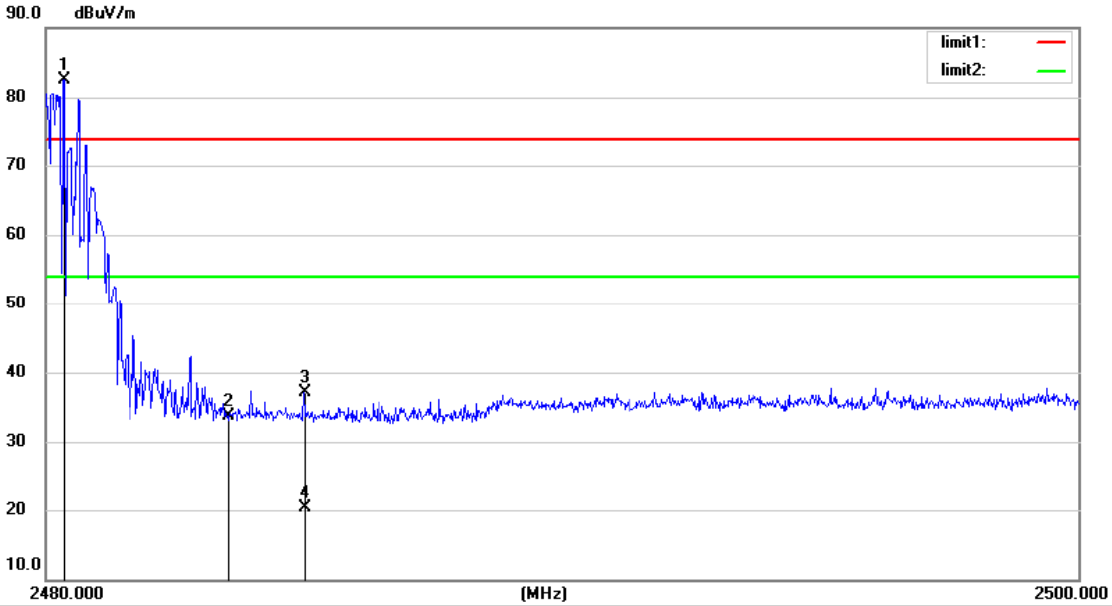
Mode: TX2480

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	2479.782	99.84	-18.03	81.81	74.00	7.81	peak			
2		2483.500	52.79	-18.01	34.78	74.00	-39.22	peak			
3		2486.052	55.52	-18.00	37.52	74.00	-36.48	peak			
4		2486.052	38.25	-18.00	20.25	54.00	-33.75	AVG			

*:Maximum data x:Over limit !:over margin Operator: washington

For Hopping Mode:



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

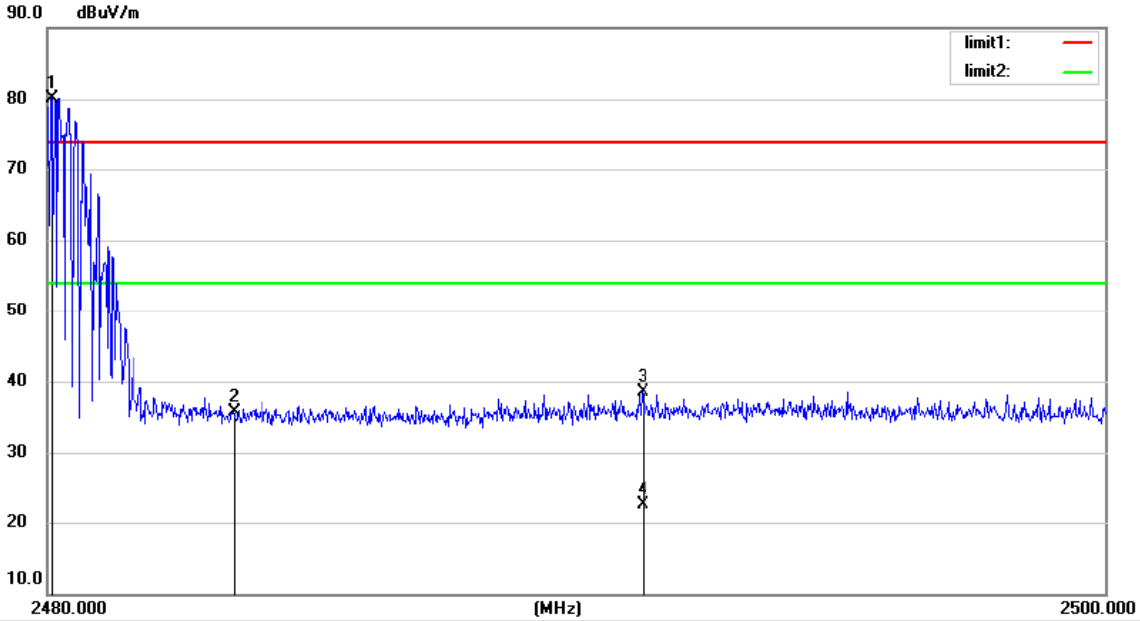
Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: Hopping

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	2480.340	100.53	-18.03	82.50	74.00	8.50	peak			
2		2483.500	51.78	-18.01	33.77	74.00	-40.23	peak			
3		2485.000	55.14	-18.00	37.14	74.00	-36.86	peak			
4		2485.000	38.26	-18.00	20.26	54.00	-33.74	AVG			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Vertical*** Temperature: 26

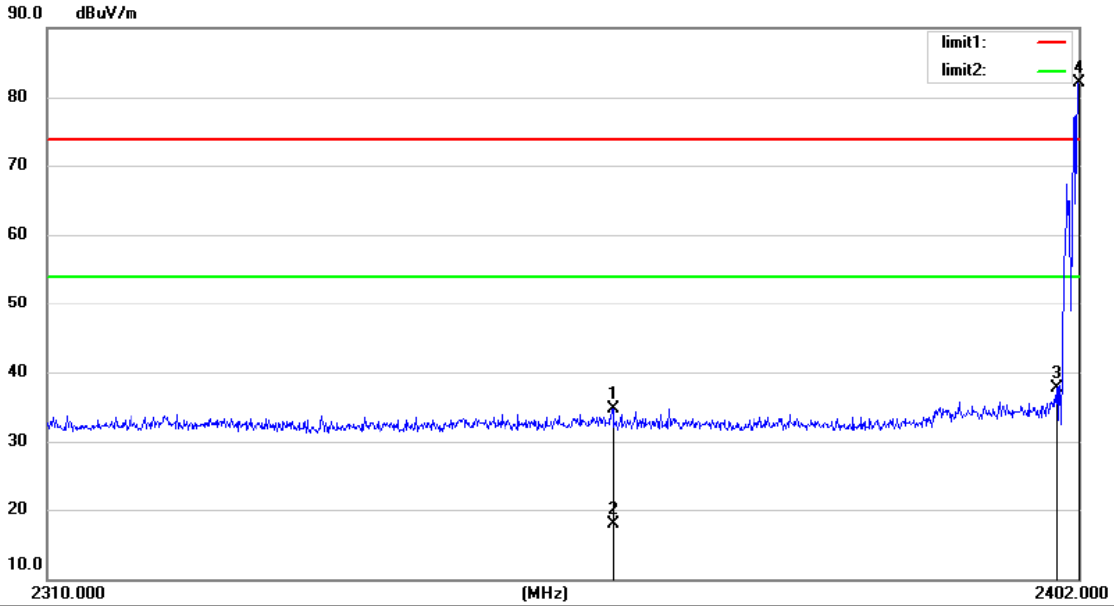
Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: Hopping

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	2480.080	98.18	-18.03	80.15	74.00	6.15	peak			
2		2483.500	53.72	-18.01	35.71	74.00	-38.29	peak			
3		2491.240	56.40	-17.96	38.44	74.00	-35.56	peak			
4		2491.240	40.50	-17.96	22.54	54.00	-31.46	AVG			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Horizontal*** Temperature: 26

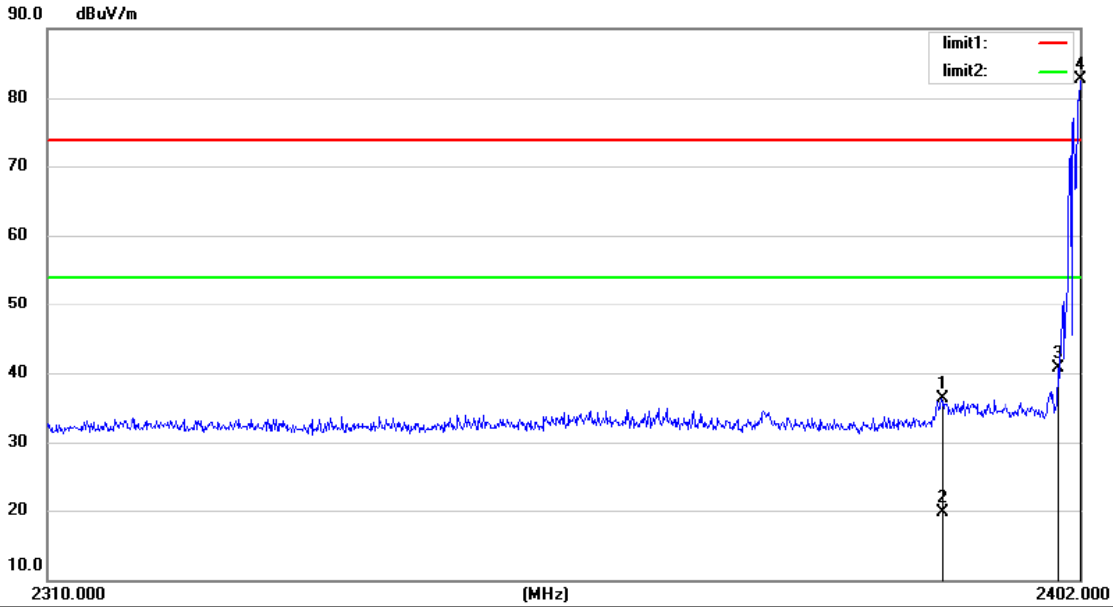
Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: Hopping

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		2359.956	53.48	-18.72	34.76	74.00	-39.24	peak			
2		2359.956	36.55	-18.72	17.83	54.00	-36.17	AVG			
3		2400.000	56.11	-18.50	37.61	74.00	-36.39	peak			
4	*	2402.000	100.67	-18.49	82.18	74.00	8.18	peak			

*:Maximum data x:Over limit !:over margin Operator: washington



Site Chamber #1 Polarization: ***Vertical*** Temperature: 26

Limit: (RE)FCC PART 15 C 3m_PEAK Power: Battery 3.7V Humidity: 55 %

Mode: Hopping

Note:

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1		2389.488	54.91	-18.56	36.35	74.00	-37.65	peak			
2		2389.488	38.22	-18.56	19.66	54.00	-34.34	AVG			
3		2400.000	59.22	-18.50	40.72	74.00	-33.28	peak			
4	*	2402.000	101.20	-18.49	82.71	74.00	8.71	peak			

*:Maximum data x:Over limit !:over margin Operator: washington

13. Antenna Port Emission

13.1 Test Equipment

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	LAST CAL.	CAL DUE.
Spectrum Analyzer	Agilent	FSV30	1321.3008K	05/16/2017	05/15/2018

13.2 Measuring Instruments and Setting

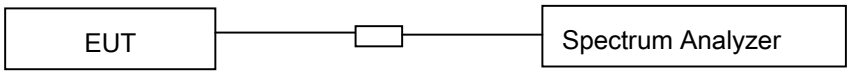
The following table is the setting of spectrum analyzer.

Spectrum analyzer	Setting
Attenuation	Auto
RB	100kHz
VB	300kHz
Detector	Peak
Trace	Max hold

13.3 Test Procedures

The conducted spurious emissions were measured conducted using a spectrum analyzer at low, Middle, and high channels, the limit was determined by attenuation 20dB of the RF peak power output.

13.4 Block Diagram of Test setup

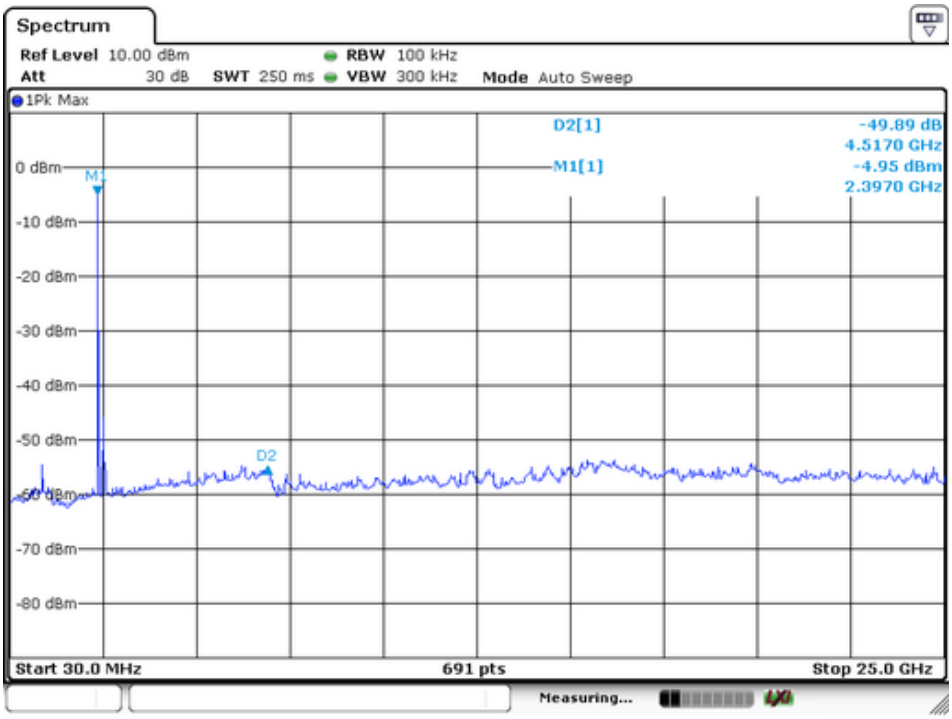


13.5 Test Result

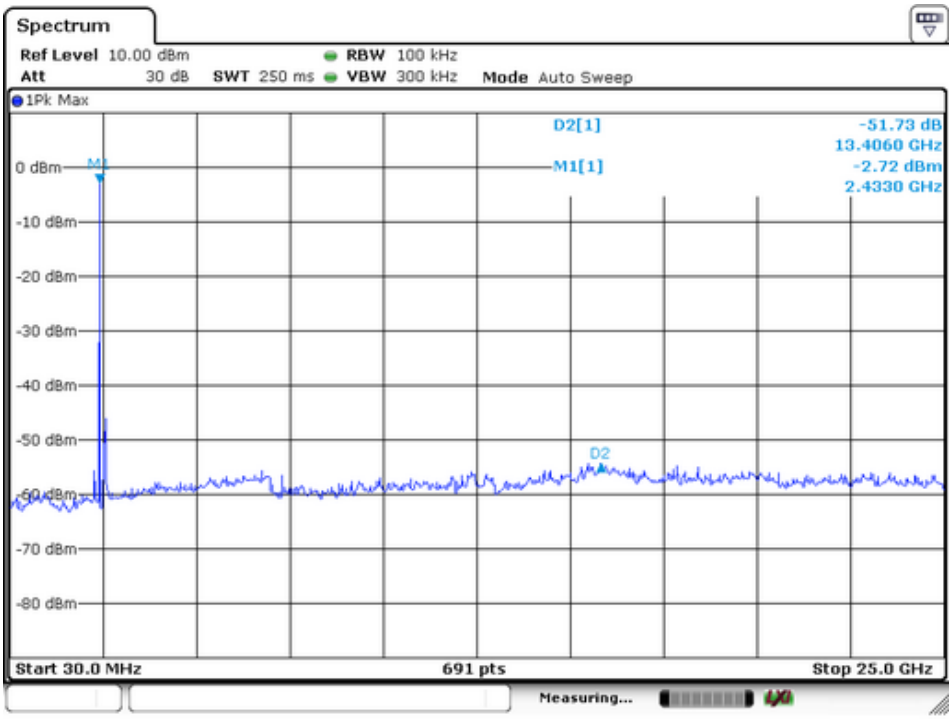
PASS.

Please refer to following pages.

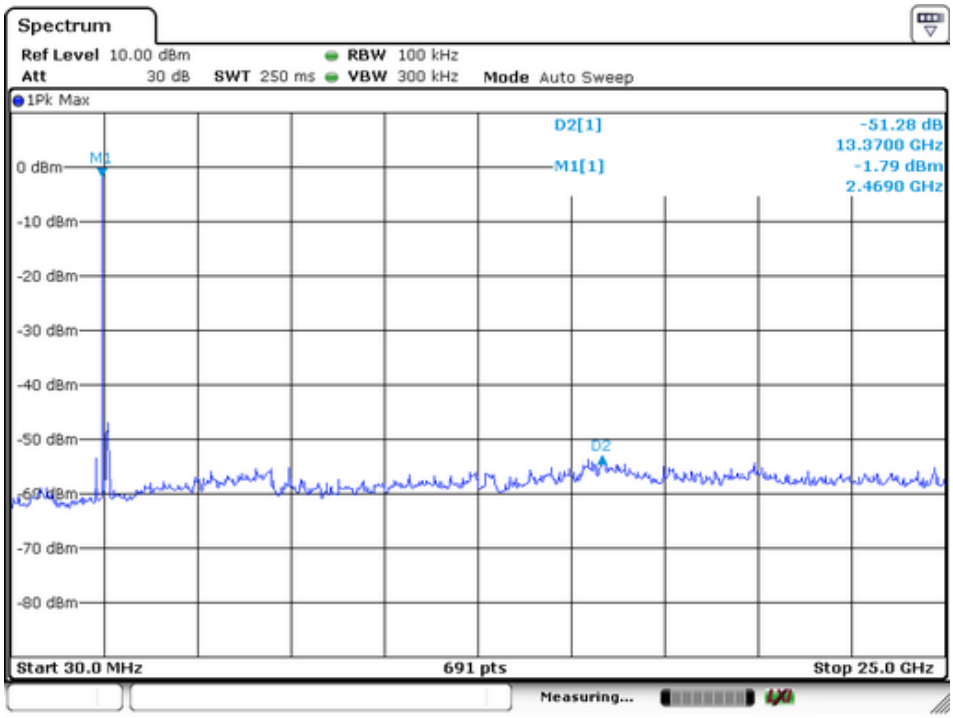
Test Mode: GFSK



Lowest Channel

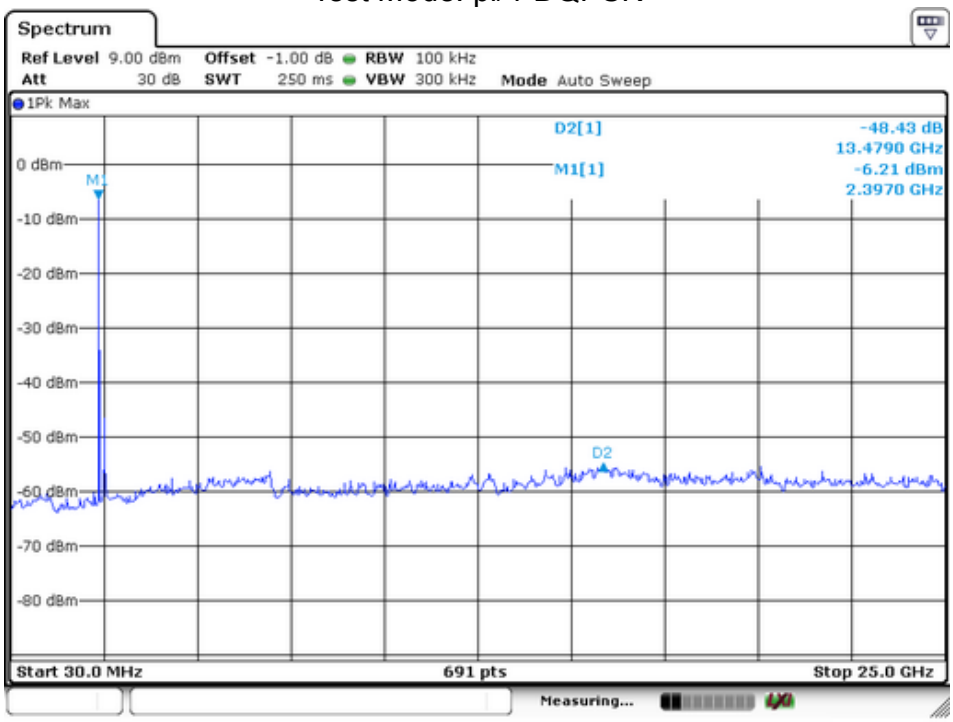


Middel Channel

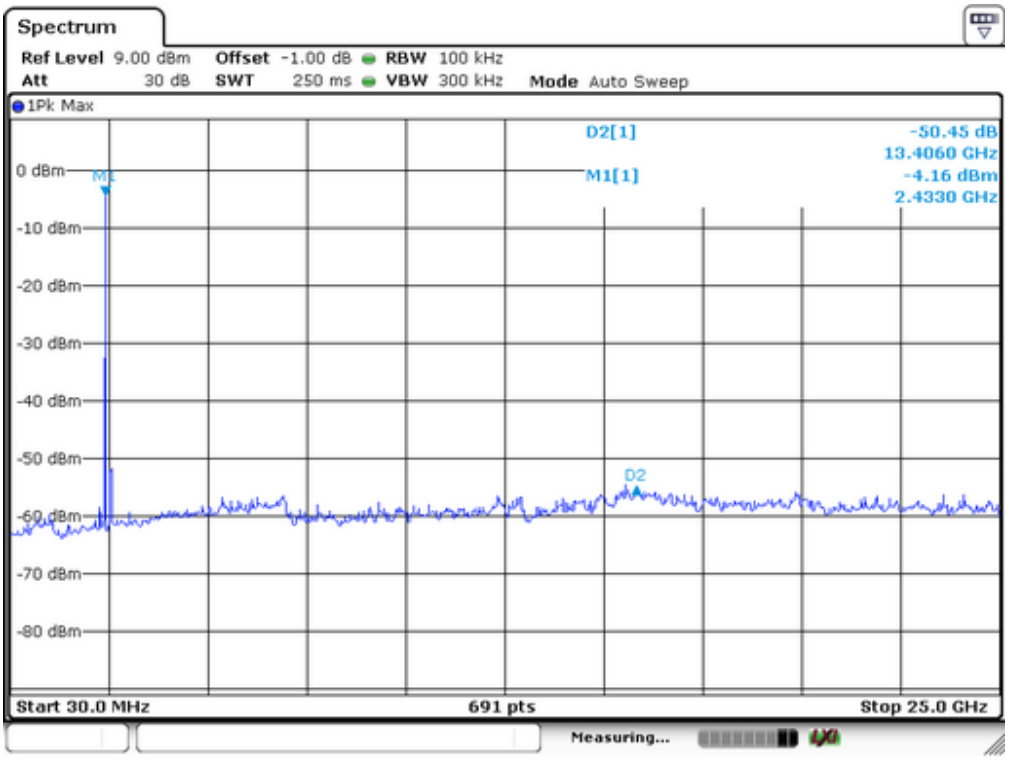


Highest Channel

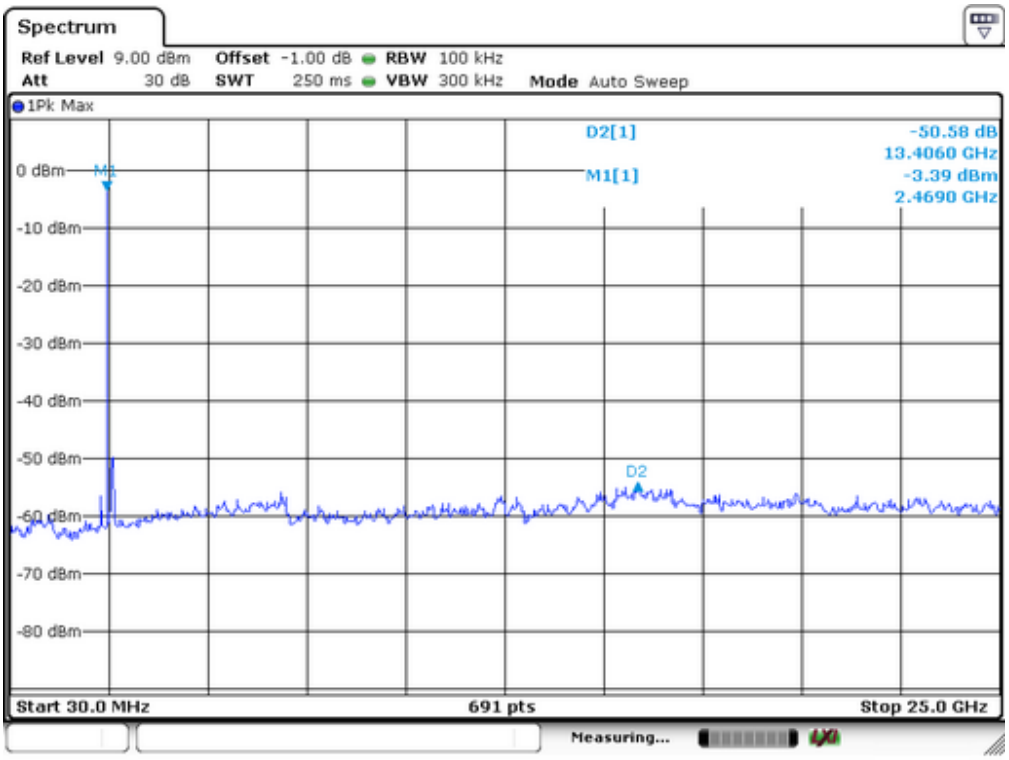
Test Mode: pi/4-DQPSK



Lowest Channel

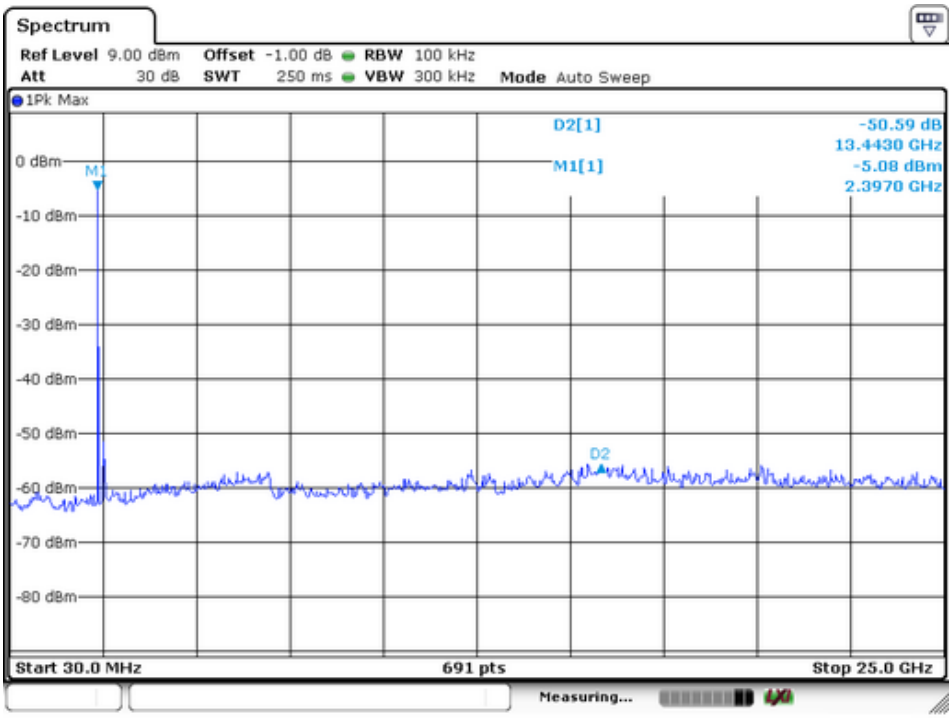


Middle Channel

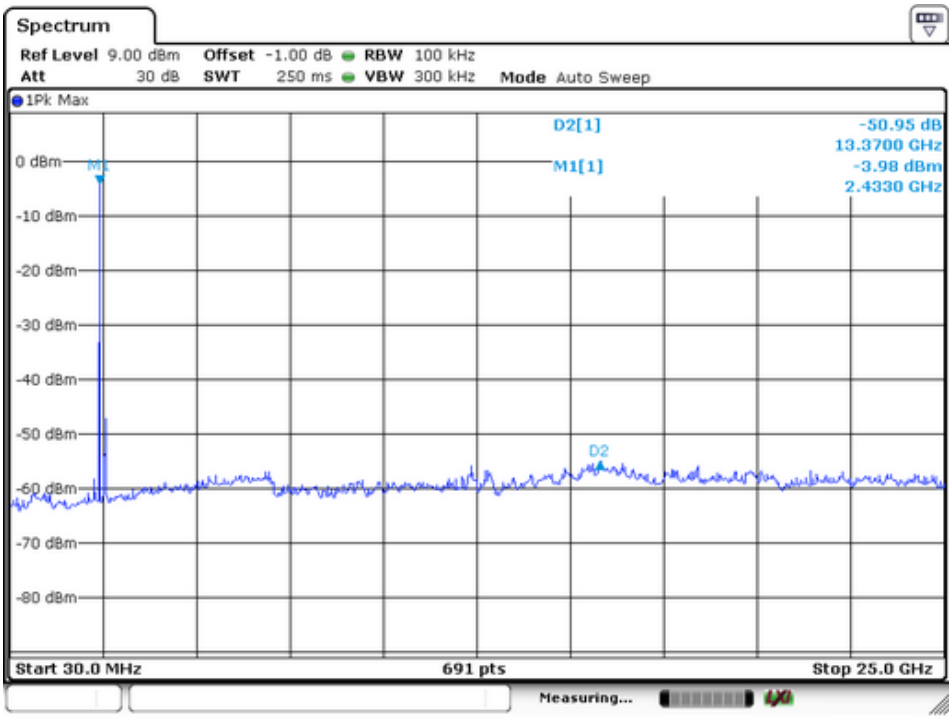


Highest Channel

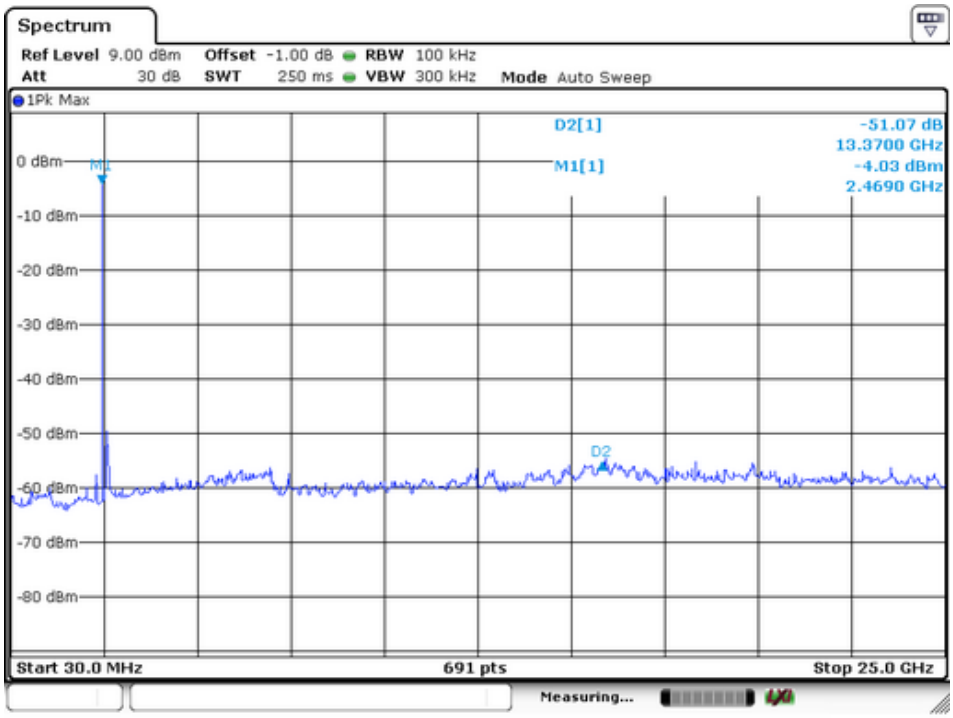
Test Mode: 8DPSK



Lowest Channel



Middle Channel



Highest Channel

14. Antenna Application

14.1 Antenna requirement

The EUT'S antenna is met the requirement of FCC part 15C section 15.203 and 15.247.

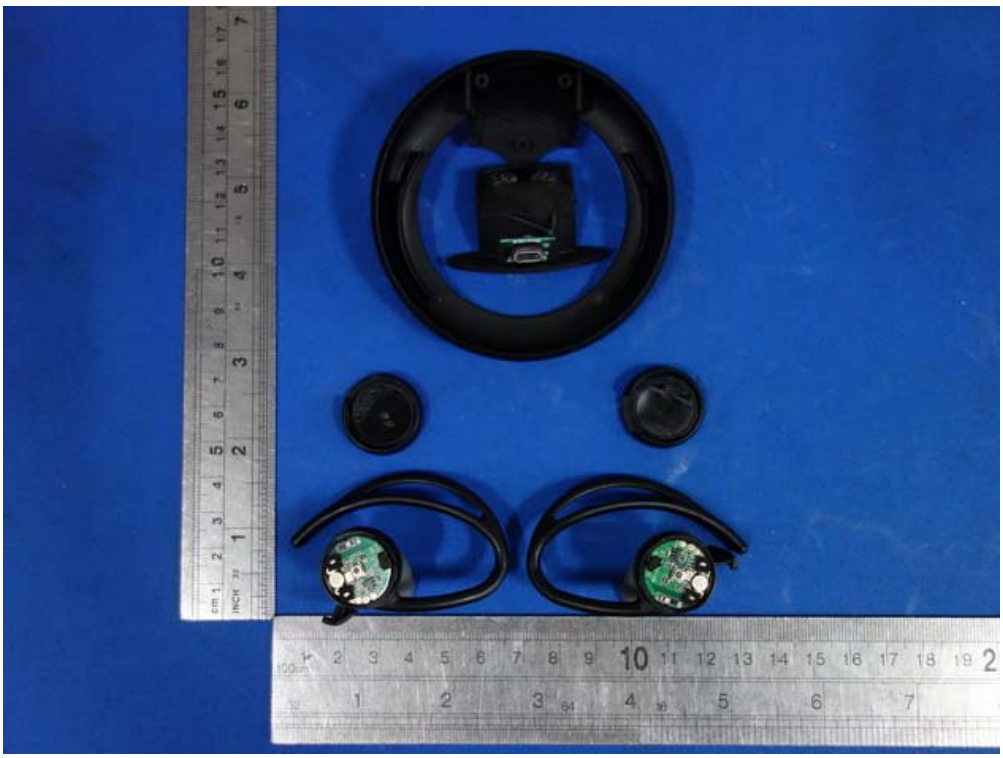
FCC part 15C section 15.247 requirements:
Systems operating in the 2402-2480MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1dB for every 3dB that the directional gain of the antenna exceeds 6dBi.

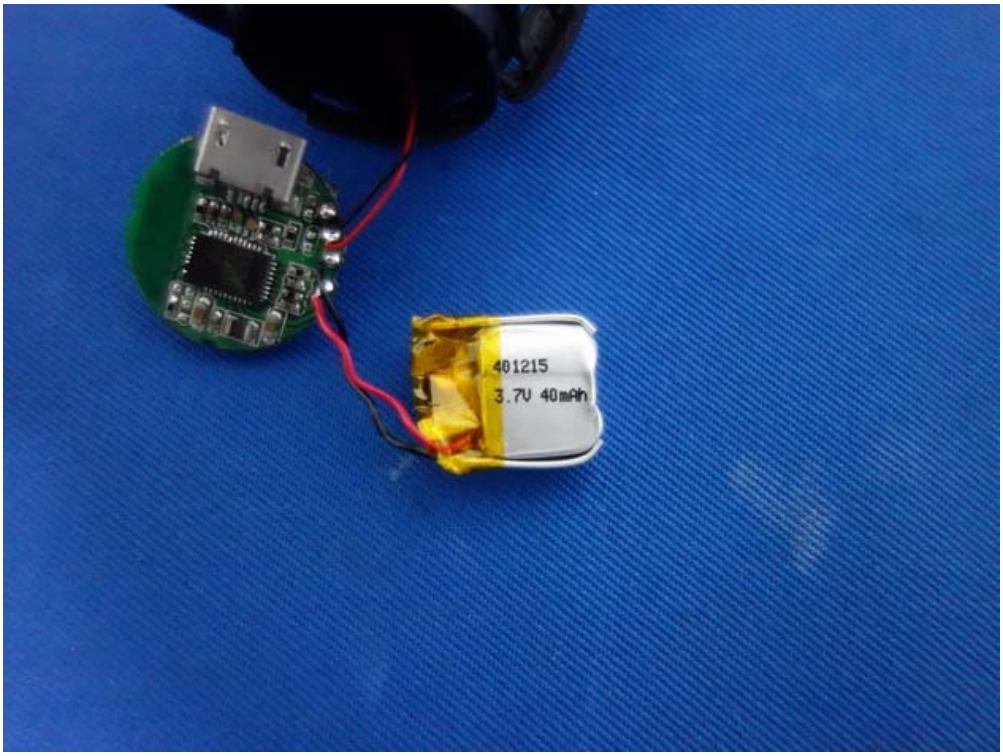
14.2 Result

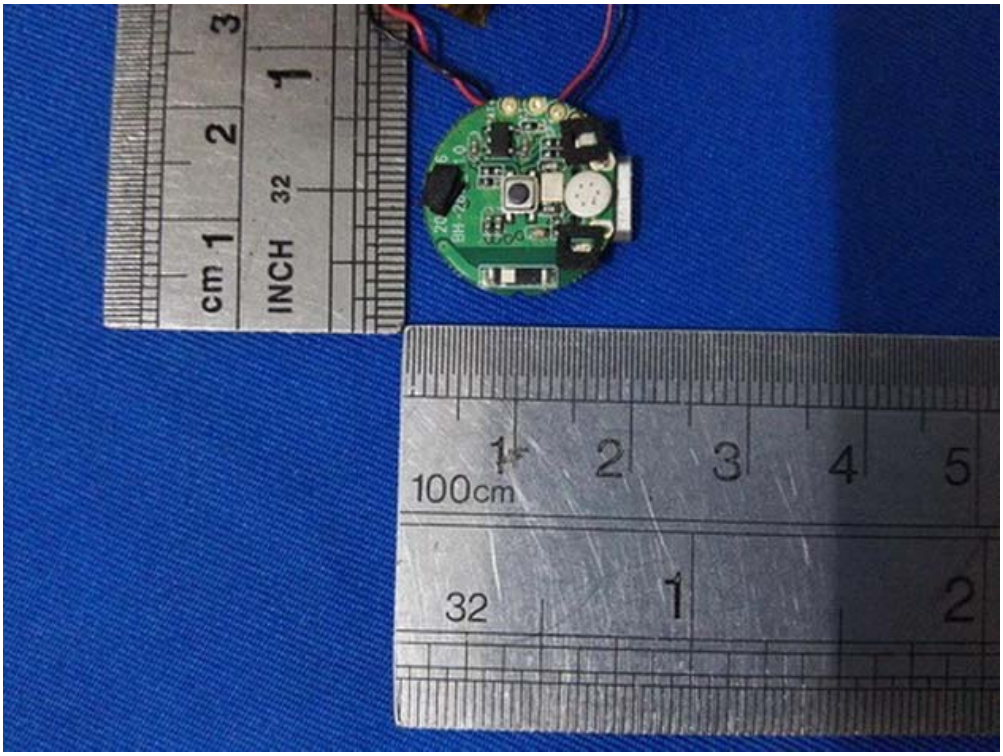
The EUT's antenna, permanent attached antenna, used a PCB antenna and integrated on PCB, The antenna's gain is 3.09dBi and meets the requirement.

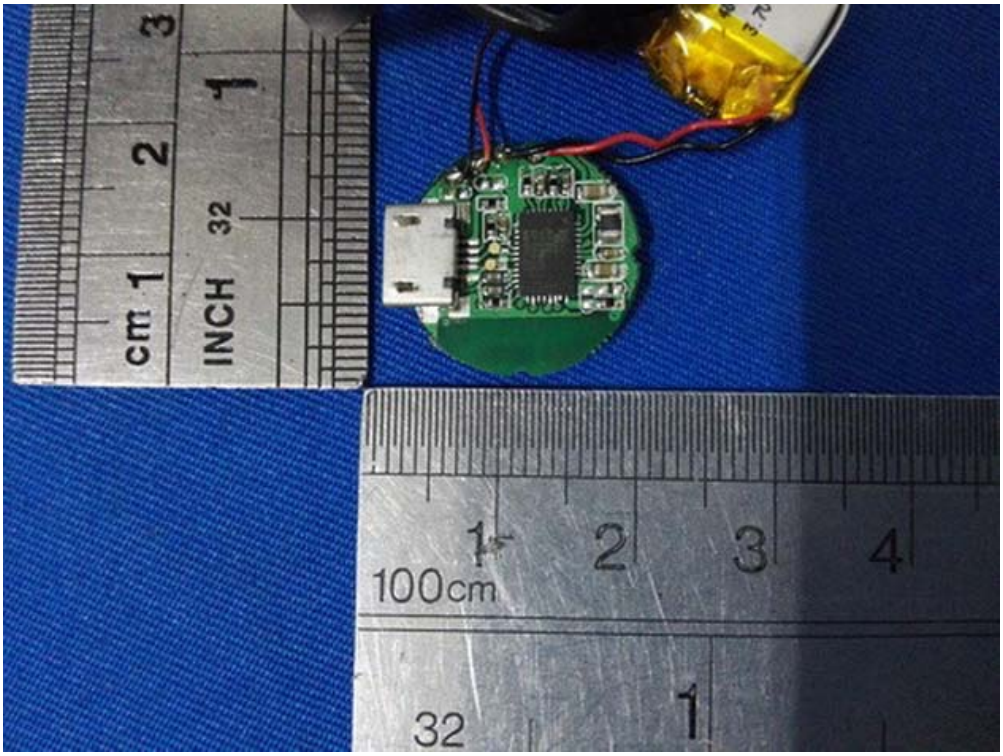
APPENDIX
(Photos of EUT)

TWS




401215
3.7V 40mAh


cm
INCH
100cm
32


cm
INCH
100cm
32