TEST REPORT

Product Name	:	**Wireless in-ear headphones**
Model Number	:	**TAE4205,TAE4205xx/yy(xx=AA-ZZ or blank denoted different color;yy=00-99 denoted different country destination)**
FCC ID	:	**2AR2STAE4205**

Prepared for	:	MMD Hong Kong Holding Limited
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Report Number	:	ES200523001W1
Date(s) of Tests	:	May 23, 2020 to June 19, 2020
Date of issue	:	June 19, 2020

VERIFICATION OF COMPLIANCE

Applicant:	MMD Hong Kong Holding Limited
Manufacturer:	MMD Hong Kong Holding Limited
Factory:	Innovation Sound Technology Co.,Ltd
Product Description:	Wireless in-ear headphones
Trade Mark:	PHILIPS,
Model Number:	TAE4205,TAE4205xx/yy(xx=AA-ZZ or blank denoted different color;yy=00-99 denoted different country destination)

We hereby certify that:

The above equipment was tested by EMTEK(SHENZHEN) 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(2018).

Date of Test	:	May 23, 2020 to June 19, 2020
Prepared by	:	Loren Luo /Editor
Reviewer	:	Tim Dong /Supervisor
Approved & Authorized Signer	:	Lisa Wang /Manager

Modified Information

Version	Summary	Revision Date	Report No.
Ver.1.0	Original Report	/	ES200523001W1

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1. GENERAL INFORMATION

1.1 Product Description

Characteristics	Description
Product Name	Wireless in-ear headphones
Model number	TAE4205,TAE4205xx/yy(xx=AA-ZZ or blank denoted different color;yy=00-99 denoted different country destination)
Power Supply	DC 3.7V Battery
Kind of Device	Bluetooth Ver.5.0
Modulation	GFSK, π/4-DQPSK, 8DPSK
Operating Frequency Range	2402-2480MHz
Number of Channels	79
Transmit Power Max(PK)	2.76dBm(0.00189W)
Antenna Type	Internal PCB antenna
Antenna Gain	0.5dBi

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.	:	Accredited by CNAS, 2016.10.24 The certificate is valid until 2022.10.28 The Laboratory has been assessed and proved to be in compliance with CNAS-CL01:2006 (identical to ISO/IEC 17025:2005) The Certificate Registration Number is L2291. Accredited by TUV Rheinland Shenzhen 2016.05.19 The Laboratory has been assessed according to the requirements ISO/IEC 17025. Accredited by FCC, August 06, 2018 Designation Number: CN1204 Test Firm Registration Number: 882943 Accredited by A2LA, August 31, 2020 The Certificate Registration Number is 4321.01. Accredited by Industry Canada, November 09, 2018 The Conformity Assessment Body Identifier is CN0008.
Name of Firm	:	EMTEK(SHENZHEN) CO., LTD.
Site Location	:	Building 69, Majialong Industry Zone, Nanshan District, Shenzhen, 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 fixed in a particular direction 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

Table 2-1 Equipment Used in Tested System

Item	Equipment	Model No.	FCC ID	Note
1.	Wireless in-ear headphones	TAE4205	2AR2STAE4205	***EUT***

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
§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

4. Description of test modes

The EUT has been tested under its typical operating condition and fully-charged battery for EUT tested alone. 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 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%

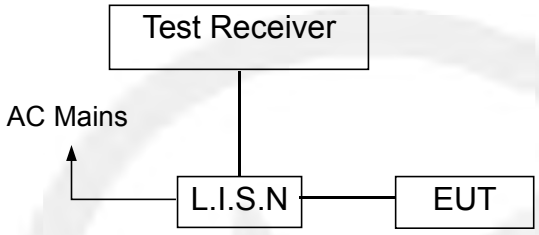
Remark: The coverage Factor (k=2), and measurement Uncertainty for a level of Confidence of 95%

6. Conducted Emissions Test

6.1 Measurement Procedure:

1. The EUT was placed on a table, which is 0.8m above ground plane.
2. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
3. Repeat above procedures until all frequency measured was complete.

6.2 Test SET-UP (Block Diagram of Configuration)



6.3 Measurement Equipment Used:

Conducted Emission Test Site						
EQUIPMENT TYPE	**MFR**	**MODEL NUMBER**	**SERIAL NUMBER**	**Characteristics**	**Last Cal.**	**Due date**
Test Receiver	Rohde & Schwarz	ESCS30	100018	9kHz~3GHz	05/22/2020	05/21/2021
L.I.S.N	Rohde & Schwarz	ENV216	100017	9KHz-300MHz	05/22/2020	05/21/2021
RF Switching Unit	CDS	RSU-M2	38401	9KHz-300MHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	9kHz~3GHz	05/22/2020	05/21/2021

6.4 Measurement Result:

N/A.

Note: Bluetooth does not work while charging

7. Radiated Emission Test

7.1 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:

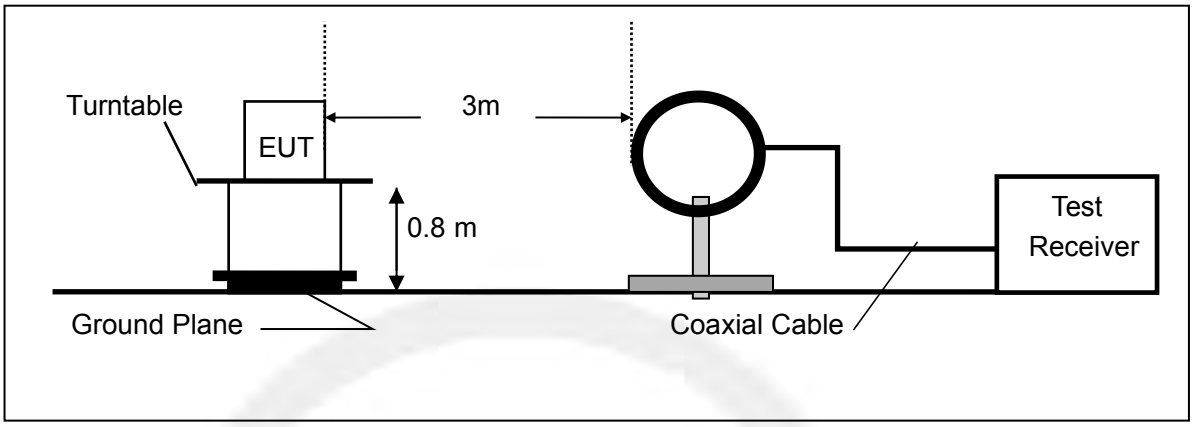
EMI Test Receiver	Setting
Attenuation	Auto
RB	1MHz
VB	3MHz
Detector	Peak
Trace	Max hold

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

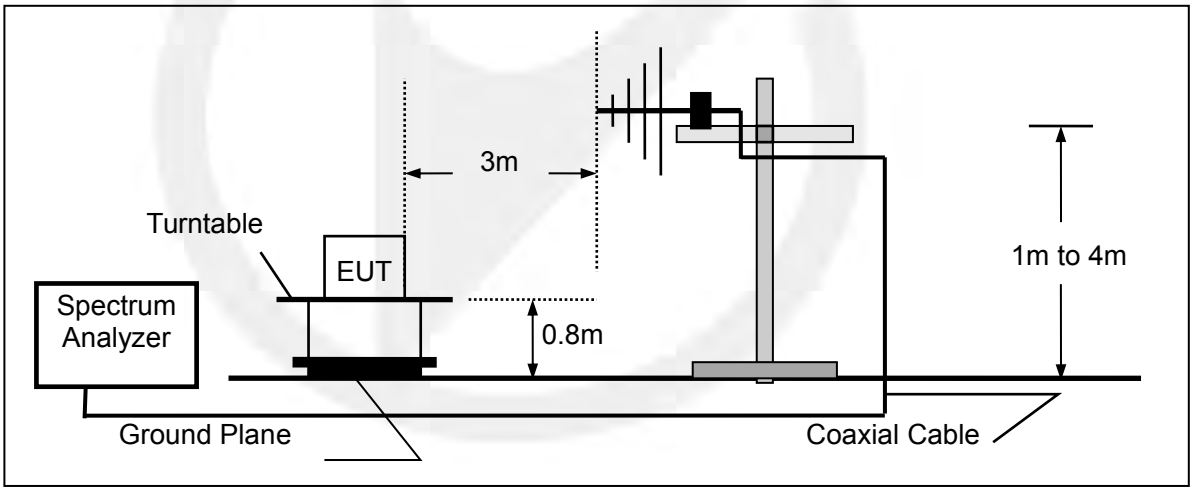
EMI Test Receiver	Setting
Attenuation	Auto
RB	1MHz
VB	10Hz
Detector	Average
Trace	Max hold

7.2 Test SET-UP (Block Diagram of Configuration)

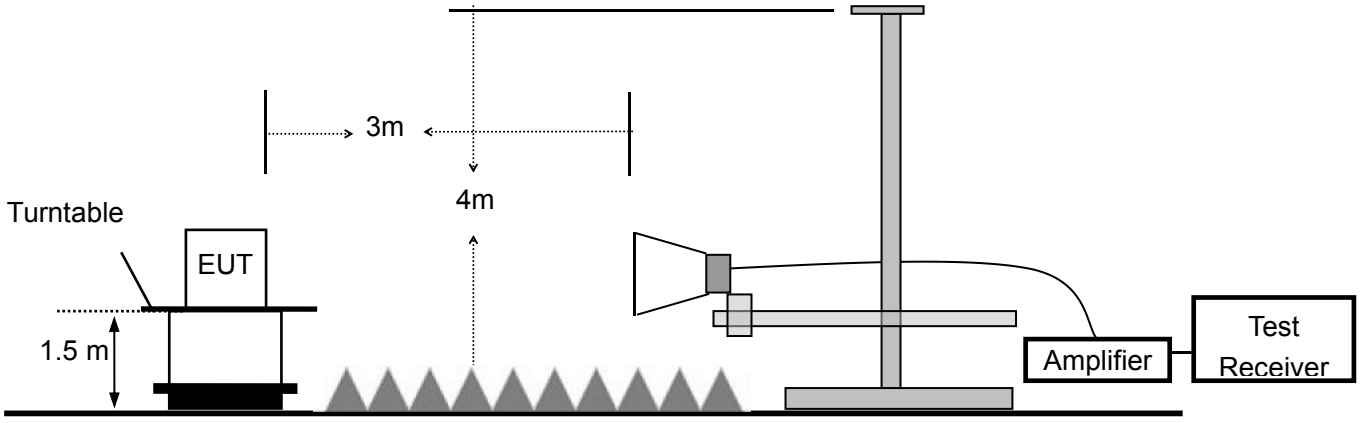
(A) Radiated Emission Test Set-Up, Frequency Below 30MHz



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



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



7.3 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	05/22/2020	1 Year
2.	Loop Antenna	Schwarzbeck	FMZB 1519	012	9 KHz -30MHz	05/22/2020	1 Year
3.	Bilog Antenna	Schwarzbeck	VULB9163	000141	25MHz-2GHz	05/22/2020	1 Year
4.	Power Amplifier	CDS	RSU-M352	818	1MHz-1GHz	05/22/2020	1 Year
5.	Power Amplifier	HP	8447F	OPT H64	1GHz-26.5GHz	05/22/2020	1 Year
6.	Color Monitor	SUNSPO	SP-140A	N/A	--	05/22/2020	1 Year
7.	Single Line Filter	JIANLI	XL-3	N/A	--	05/22/2020	1 Year
8.	Single Phase Power Line Filter	JIANLI	DL-2X100B	N/A	--	05/22/2020	1 Year
9.	3 Phase Power Line Filter	JIANLI	DL-4X100B	N/A	--	05/22/2020	1 Year
10.	DC Power Filter	JIANLI	DL-2X50B	N/A	--	05/22/2020	1 Year
11.	Cable	Schwarzbeck	PLF-100	549489	9KHz-3GHz	05/22/2020	1 Year
12.	Cable	Rosenberger	CIL02	A0783566	9KHz-3GHz	05/22/2020	1 Year
13.	Cable	Rosenberger	RG 233/U	525178	9KHz-3GHz	05/22/2020	1 Year
14.	Signal Analyzer	Rohde & Schwarz	FSV30	103040	9KHz-40GHz	05/22/2020	1 Year
15.	Horn Antenna	Schwarzbeck	BBHA9120D	9120D-1272	1GHz-18GHz	05/22/2020	1 Year
16.	Horn Antenna	Schwarzbeck	BBHA 9170	BBHA9170399	14GHz -26.5GHz	05/22/2020	1 Year
17.	Power Amplifier	LUNAR EM	LNA1G18-40	J10100000081	1GHz-26.5GHz	05/22/2020	1 Year
18.	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	05/22/2020	1 Year
19.	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	05/22/2020	1 Year
20.	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	05/22/2020	1 Year

7.4 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.

7.5 Measurement Result

Operation Mode:	TX	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	28℃
Test Result:	PASS	Humidity :	65 %
Measured Distance:	3m		

Below 30MHz:

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

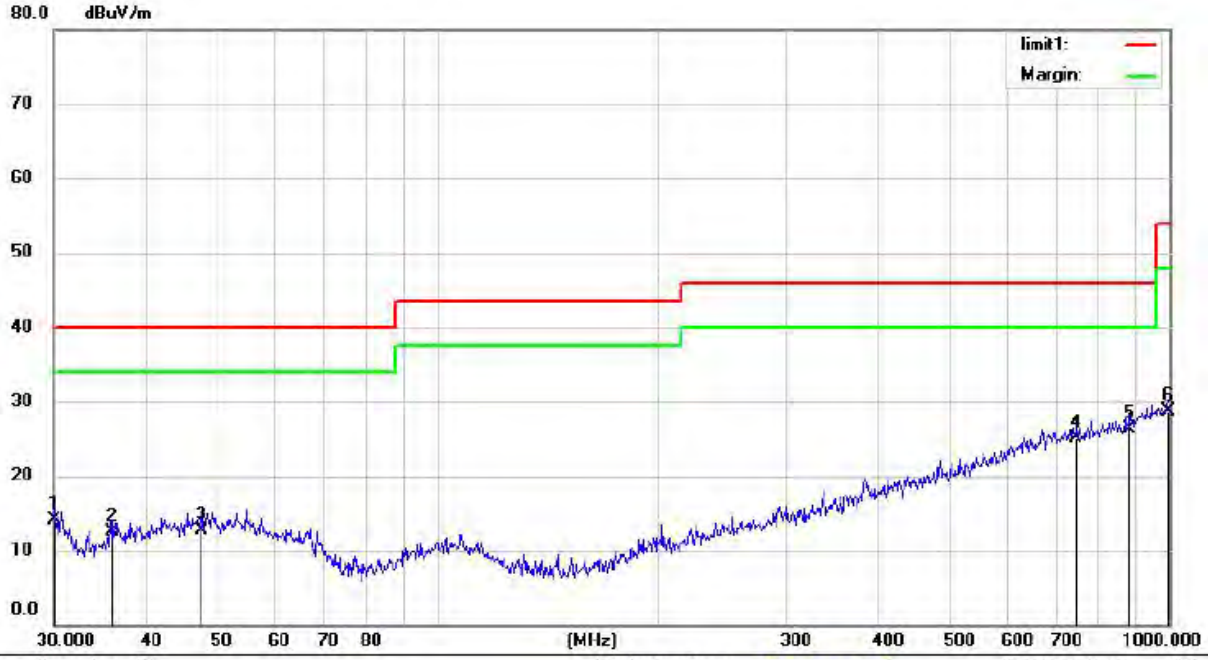
Note: The low frequency, which started from 9KHz-30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

Below 1000MHz:

Pass.

All modulation modes have been tested, the worst mode is (GFSK TX 2402MHz), the data is recorded on the following page, other modulation modes do not exceed this limit.

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:BT 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		30.0000	32.89	-18.76	14.13	40.00	-25.87	QP			
2		36.0007	30.74	-18.20	12.54	40.00	-27.46	QP			
3		47.6584	28.36	-15.68	12.68	40.00	-27.32	QP			
4		747.4825	28.70	-3.60	25.10	46.00	-20.90	QP			
5	*	884.5028	28.49	-2.19	26.30	46.00	-19.70	QP			
6		996.4995	28.36	0.33	28.69	54.00	-25.31	QP			

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

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

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

Mode:BT 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		43.6584	29.60	-16.01	13.59	40.00	-26.41	QP			
2		55.2207	30.47	-15.97	14.50	40.00	-25.50	QP			
3		68.1514	33.85	-18.94	14.91	40.00	-25.09	QP			
4		250.3012	32.74	-15.54	17.20	46.00	-28.80	QP			
5		316.5890	30.63	-13.53	17.10	46.00	-28.90	QP			
6	*	771.4486	29.54	-3.54	26.00	46.00	-20.00	QP			

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

Above 1000MHz~10th Harmonics:

All modulation modes have been tested, the worst mode is (GFSK), the data is recorded on the following page, other modulation modes do not exceed this limit.Please refer to the following data.

Operation Mode: GFSK (CH1: 2402MHz) Test Date : June 05, 2020

Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4804	V	91.38	74.19	-32.3	59.08	41.89	74	54	-14.92	-12.11
7206	V	93.44	76.86	-37.2	56.24	39.66	74	54	-17.76	-14.34
9608	V	91.93	70.67	-39.8	52.13	30.87	74	54	-21.87	-23.13
12010	V	93.94	71.31	-40.5	53.44	30.81	74	54	-20.56	-23.19
14412	V	92.23	70.17	-41.7	50.53	28.47	74	54	-23.47	-25.53
16814	V	96.31	71.58	-40.0	56.31	31.58	74	54	-17.69	-22.42
4804	H	92.80	76.73	-31.6	61.20	45.13	74	54	-12.80	-8.87
7206	H	93.71	76.74	-35.5	58.21	41.24	74	54	-15.79	-12.76
9608	H	91.20	73.40	-38.3	52.90	35.10	74	54	-21.10	-18.90
12010	H	95.53	72.70	-39.0	56.53	33.70	74	54	-17.47	-20.30
14412	H	94.78	75.97	-42.0	52.78	33.97	74	54	-21.22	-20.03
16814	H	95.61	71.02	-39.3	56.31	31.72	74	54	-17.69	-22.28

Operation Mode: GFSK (CH40: 2441MHz) Test Date : June 05, 2020

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	96.36	70.53	-32.3	64.06	38.23	74	54	-9.94	-15.77
7323	V	93.50	74.16	-37.2	56.3	36.96	74	54	-17.70	-17.04
9764	V	92.04	70.93	-39.8	52.24	31.13	74	54	-21.76	-22.87
12205	V	95.11	75.46	-40.5	54.61	34.96	74	54	-19.39	-19.04
14646	V	92.49	74.69	-41.0	51.49	33.69	74	54	-22.51	-20.31
17087	V	93.95	72.34	-41.1	52.85	31.24	74	54	-21.15	-22.76
4882	H	95.02	70.68	-31.6	63.42	39.08	74	54	-10.58	-14.92
7323	H	91.87	72.06	-35.5	56.37	36.56	74	54	-17.63	-17.44
9764	H	96.36	76.25	-38.3	58.06	37.95	74	54	-15.94	-16.05
12205	H	96.10	72.85	-39.0	57.1	33.85	74	54	-16.90	-20.15
14646	H	94.19	70.35	-42.0	52.19	28.35	74	54	-21.81	-25.65
17087	H	98.34	71.49	-41.5	56.84	29.99	74	54	-17.16	-24.01

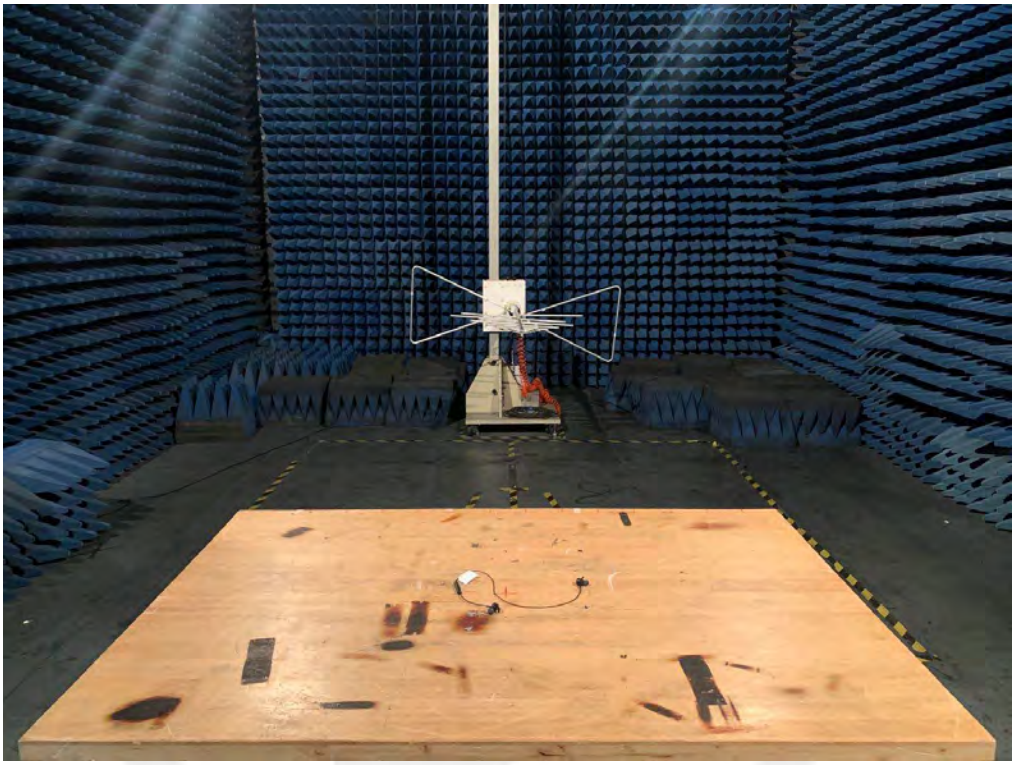
Operation Mode: GFSK (CH79: 2480MHz) Test Date : June 05, 2020

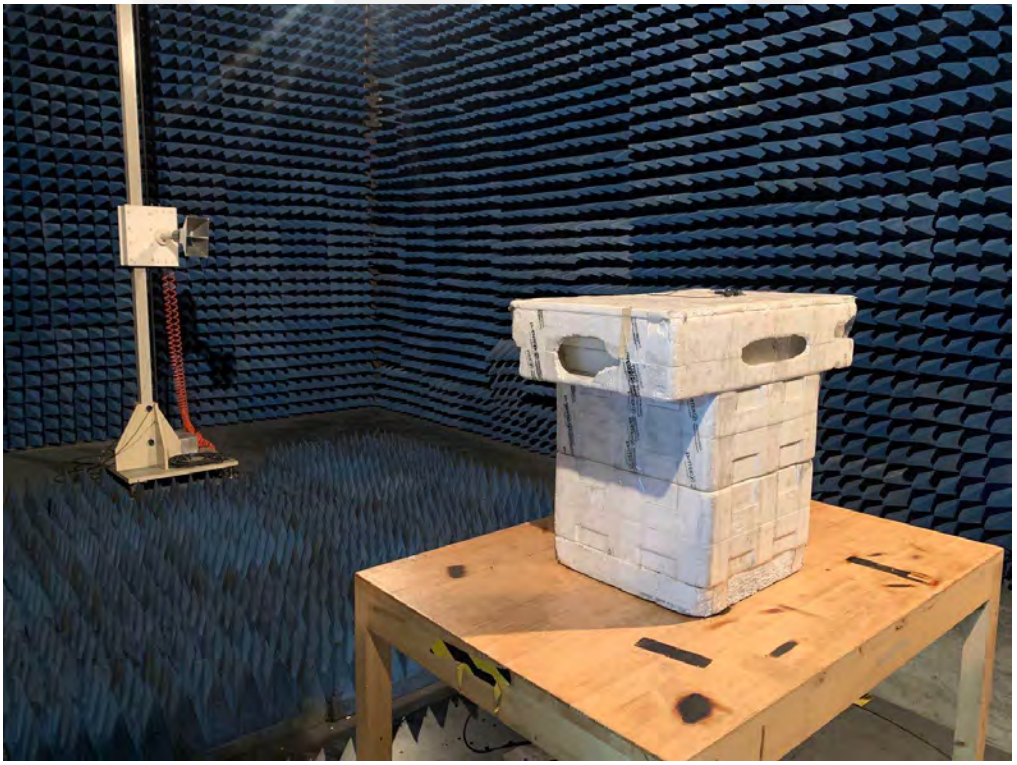
Freq.	Ant. Pol.	Reading Level(dBuV/m)		Correct Factor	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Margin(dB)	
(MHz)	H/V	PK	AV	dB	PK	AV	PK	AV	PK	AV
4960	V	95.78	70.36	-32.3	63.48	38.06	74	54	-10.52	-15.94
7440	V	98.83	73.97	-37.2	61.63	36.77	74	54	-12.37	-17.23
9920	V	92.99	74.76	-39.8	53.19	34.96	74	54	-20.81	-19.04
12400	V	96.80	70.51	-40.5	56.3	30.01	74	54	-17.70	-23.99
14880	V	97.77	74.84	-41.0	56.77	33.84	74	54	-17.23	-20.16
17360	V	97.91	75.02	-41.1	56.81	33.92	74	54	-17.19	-20.08
4960	H	97.63	70.27	-31.6	66.03	38.67	74	54	-7.97	-15.33
7440	H	95.75	76.44	-35.5	60.25	40.94	74	54	-13.75	-13.06
9920	H	98.32	70.56	-38.3	60.02	32.26	74	54	-13.98	-21.74
12400	H	93.41	71.42	-39.0	54.41	32.42	74	54	-19.59	-21.58
14880	H	91.62	72.77	-42.0	49.62	30.77	74	54	-24.38	-23.23
17360	H	93.16	74.50	-41.5	51.66	33	74	54	-22.34	-21.00

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.

7.5 Radiated Measurement Photos:



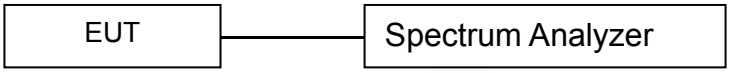


8. Channel Separation test

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.	CAL DUE.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/22/2020	05/21/2021
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/22/2020	05/21/2021

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.

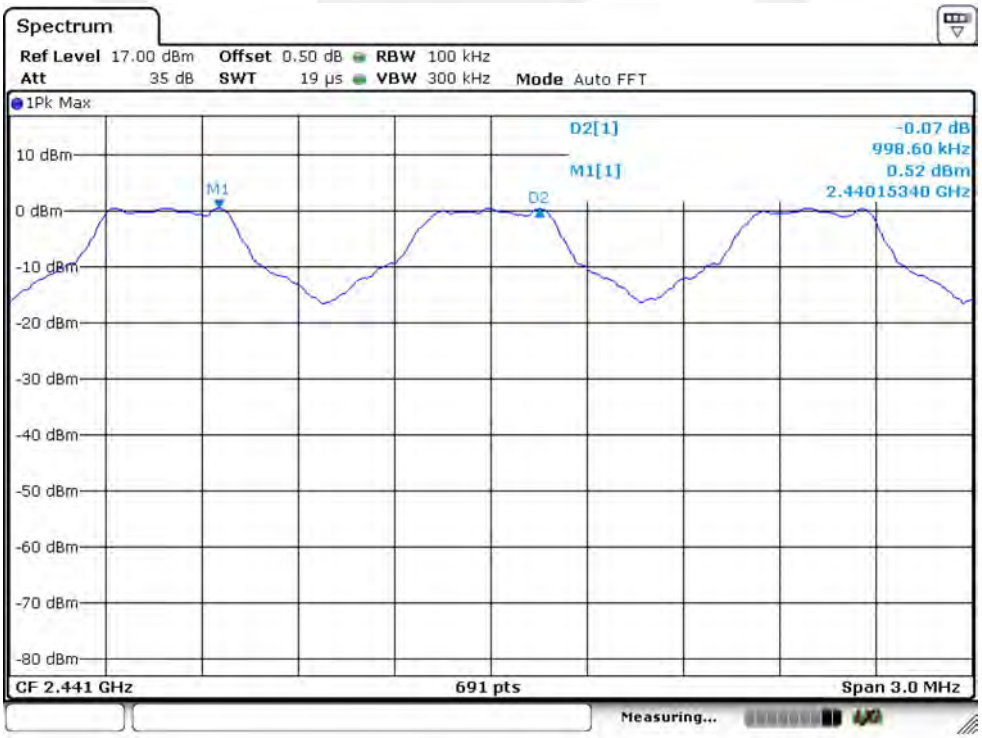
8.4 Measurement Results:

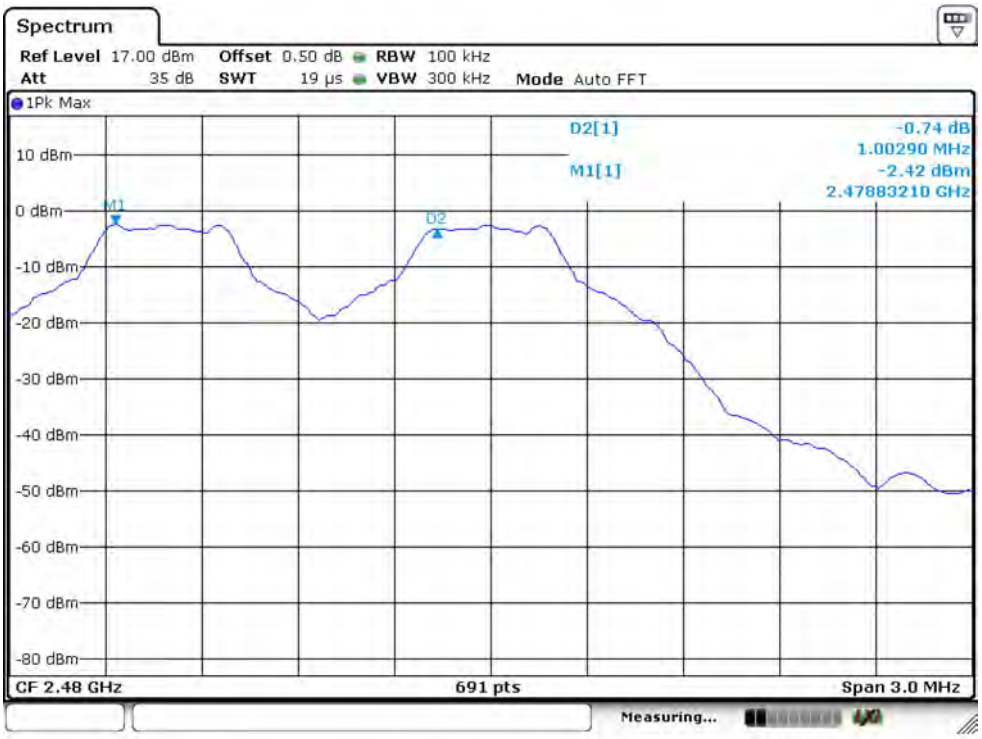
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	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	1003	>753
40	2441	998.6	>753
79	2480	1003	>750

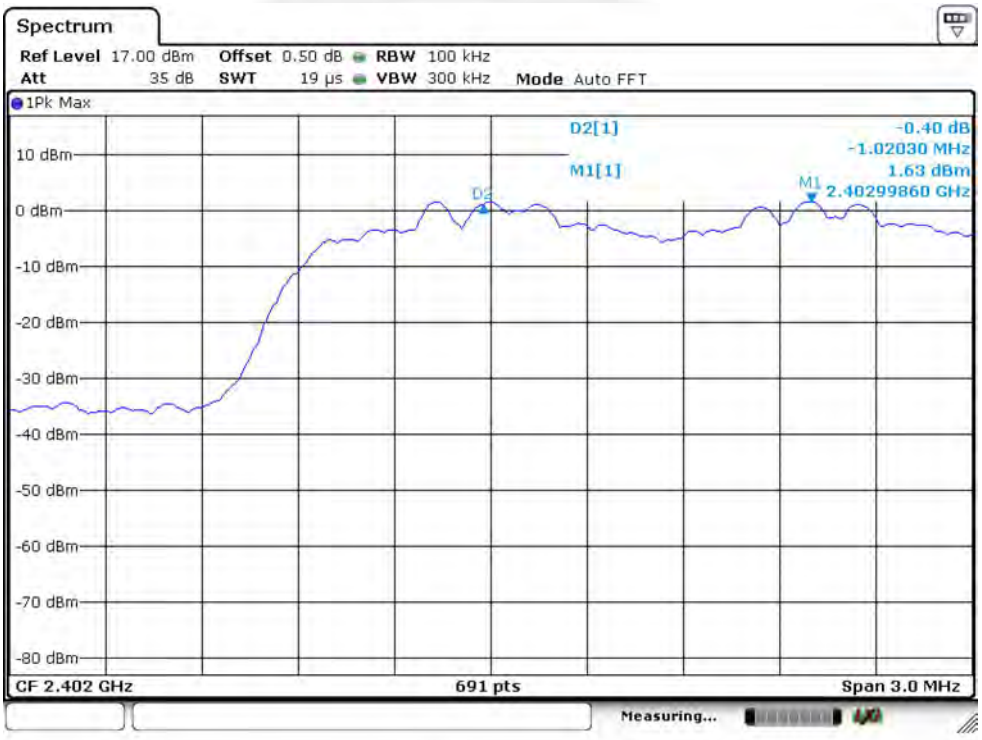

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.01 dB
1.00290 MHz
M1[1] 1.81 dBm
2.402215200 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.402 GHz
691 pts
Span 3.0 MHz
Measuring...

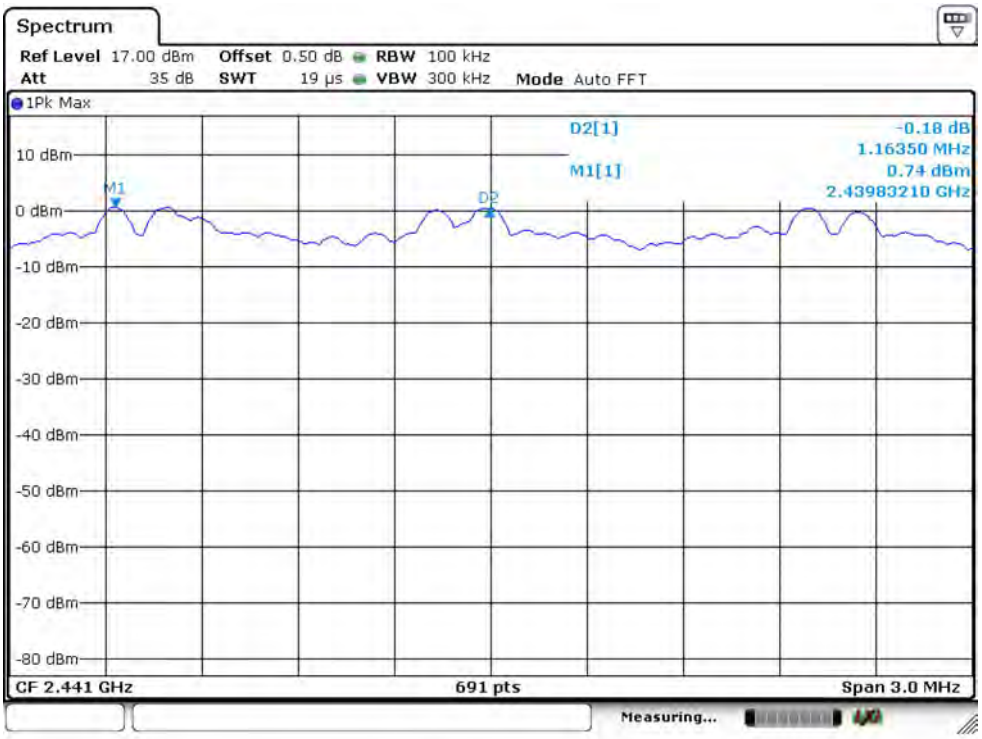

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.07 dB
998.60 kHz
M1[1] 0.52 dBm
2.44015340 GHz
M1
D2
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
Span 3.0 MHz
Measuring...


Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.74 dB
1.00290 MHz
M1[1] -2.42 dBm
2.47883210 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
CF 2.48 GHz
691 pts
Span 3.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	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	1020	>952
40	2441	1164	>949
79	2480	1007	>949

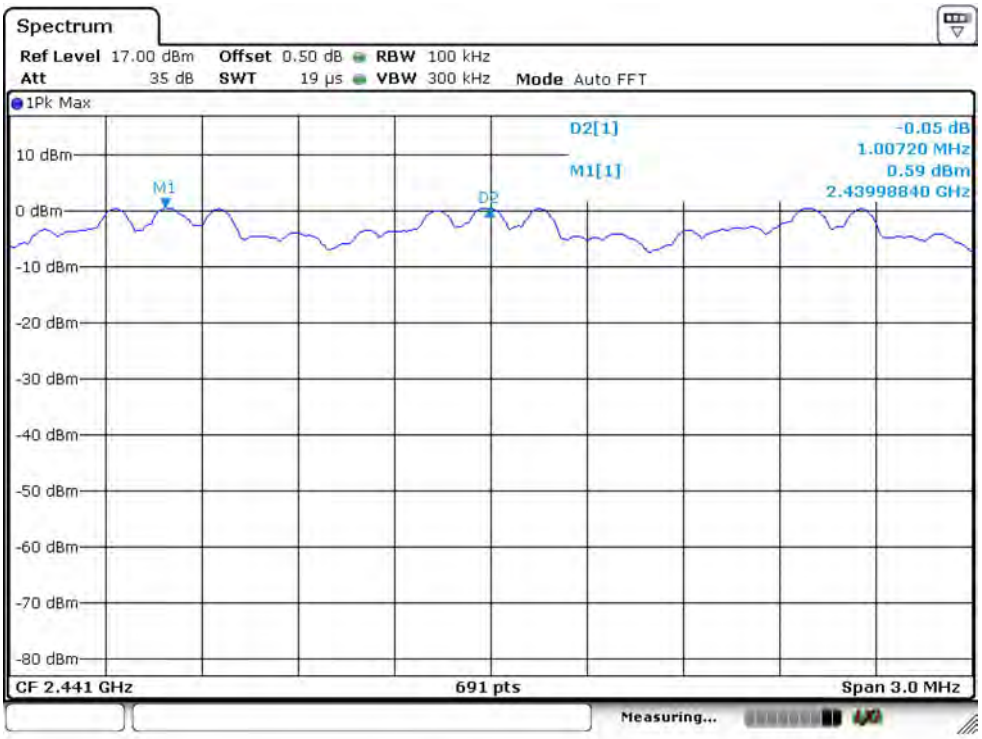


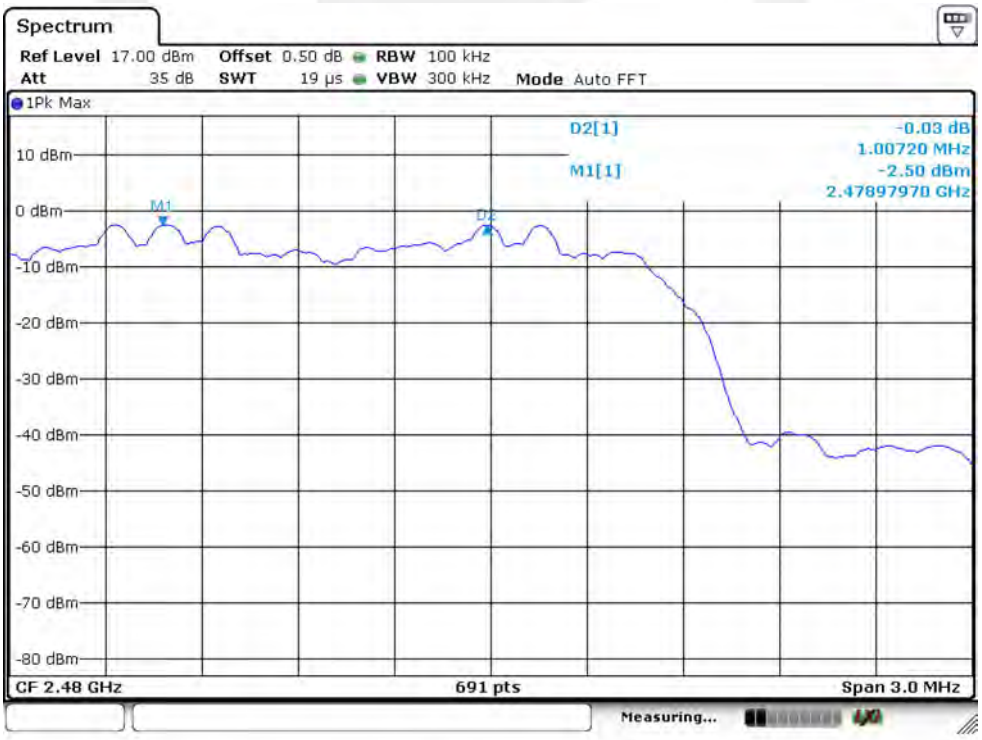

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.18 dB
1.16350 MHz
M1[1] 0.74 dBm
2.43983210 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
CF 2.441 GHz
691 pts
Span 3.0 MHz
Measuring...


Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.11 dB
1.00720 MHz
M1[1] -2.27 dBm
2.47882780 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
CF 2.48 GHz
691 pts
Span 3.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	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	1003	>949
40	2441	1007	>949
79	2480	1007	>947


Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.05 dB
1.00720 MHz
M1[1] 0.59 dBm
2.43998840 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
CF 2.441 GHz
691 pts
Span 3.0 MHz
Measuring...

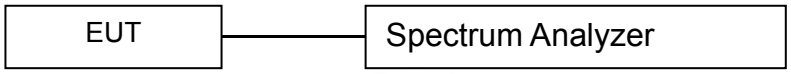

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D2[1] -0.03 dB
1.00720 MHz
M1[1] -2.50 dBm
2.47897970 GHz
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
CF 2.48 GHz
691 pts
Span 3.0 MHz
Measuring...

9. 20dB Bandwidth 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)



9.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.	CAL DUE.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/22/2020	05/21/2021
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/22/2020	05/21/2021

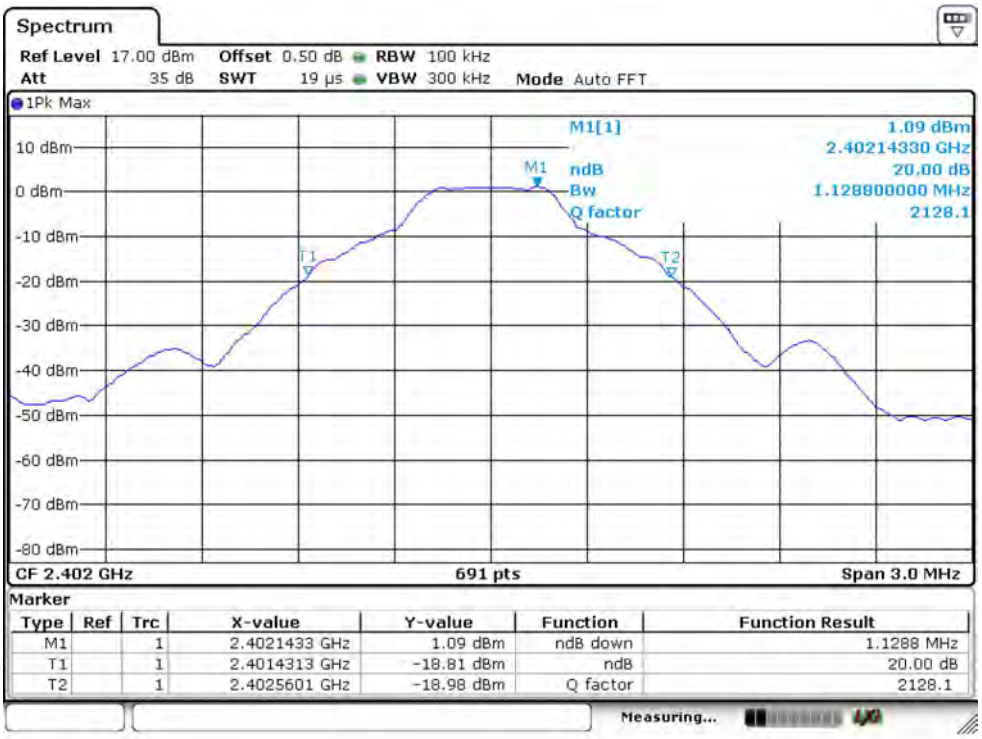
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

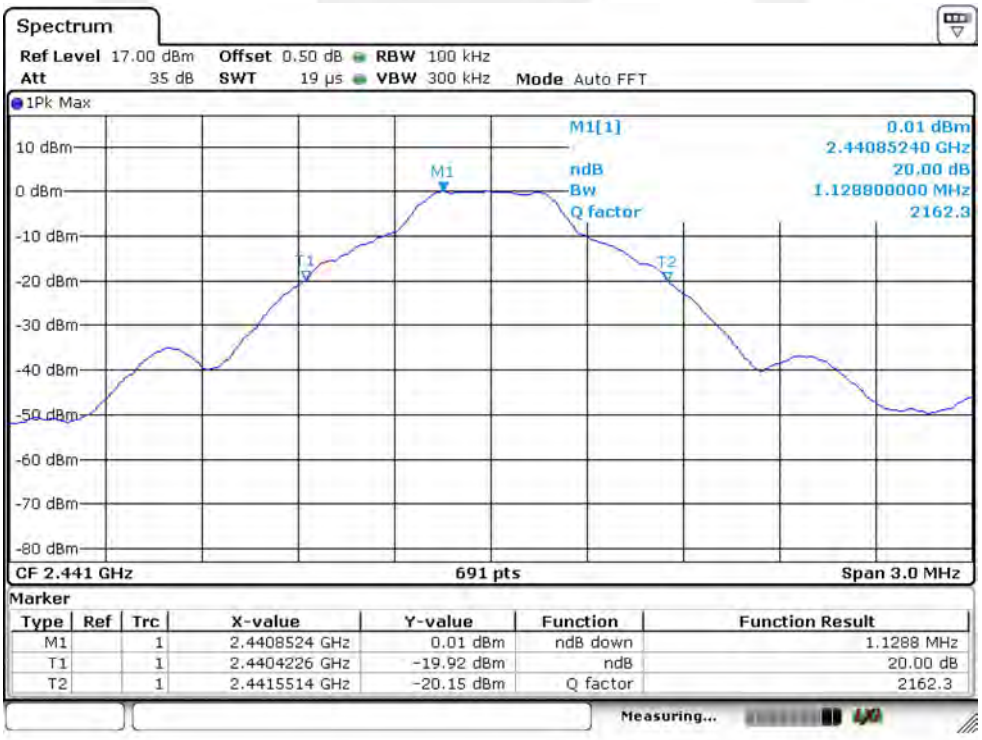
9.4 Measurement Results:

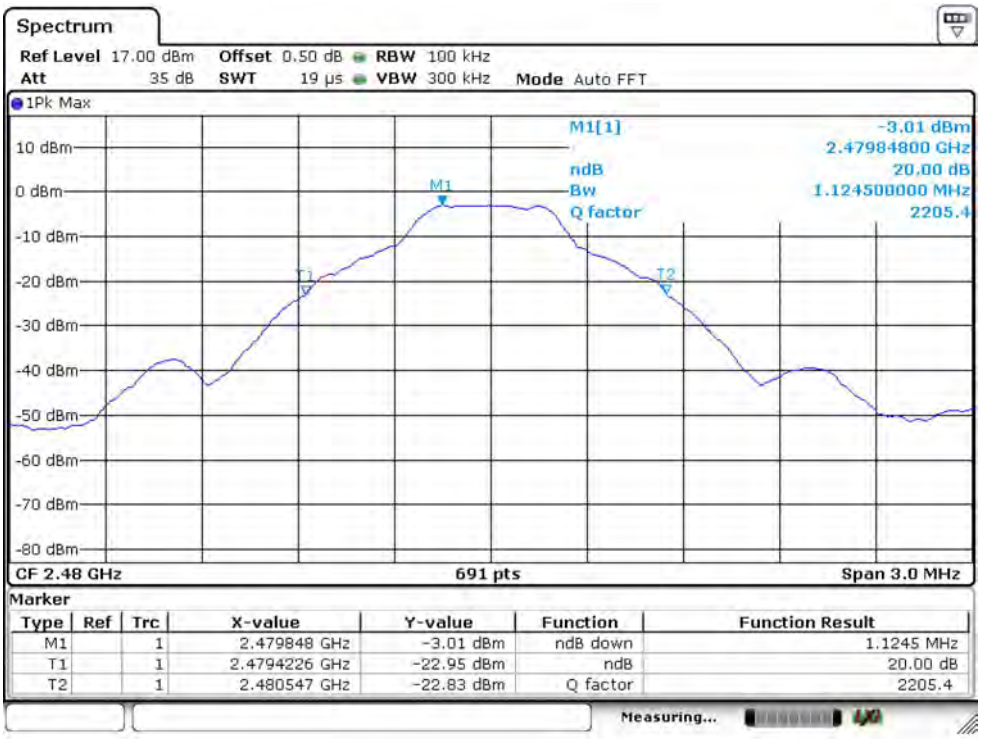
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	GFSK		

Channel number	Channel frequency (MHz)	20dB Down BW(kHz)
1	2402	1129
40	2441	1129
79	2480	1125

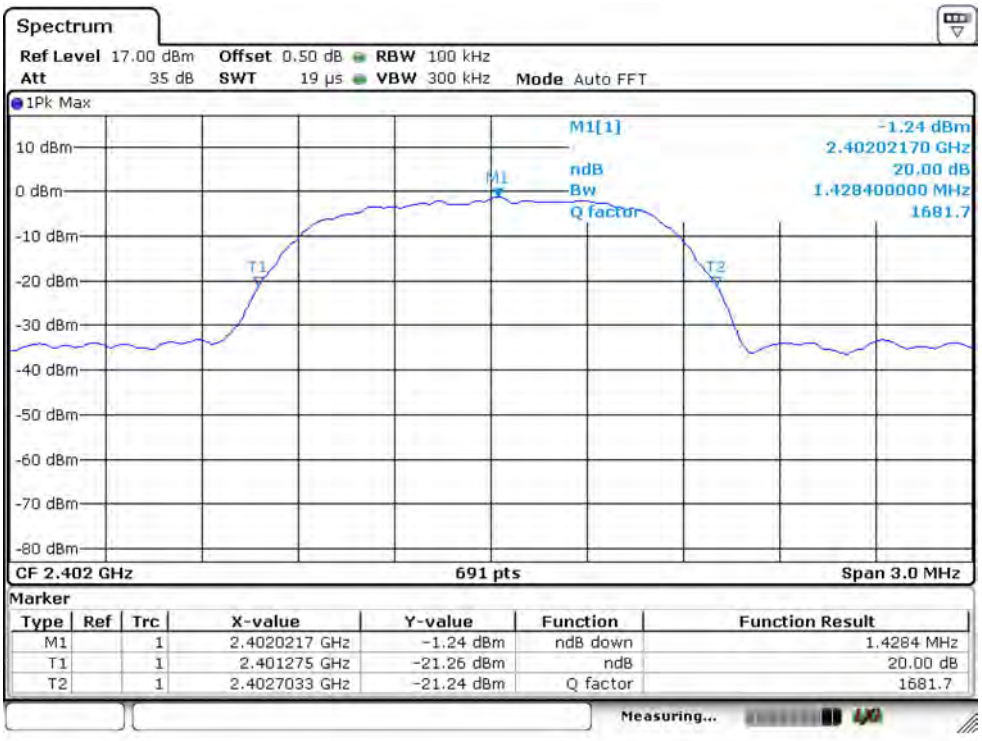

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] 1.09 dBm
2.40214330 GHz
M1 ndB 20.00 dB
Bw 1.128800000 MHz
Q factor 2128.1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
T1
T2
CF 2.402 GHz
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.4021433 GHz 1.09 dBm ndB down 1.1288 MHz
T1 1 2.4014313 GHz -18.81 dBm ndB 20.00 dB
T2 1 2.4025601 GHz -18.98 dBm Q factor 2128.1
Measuring...

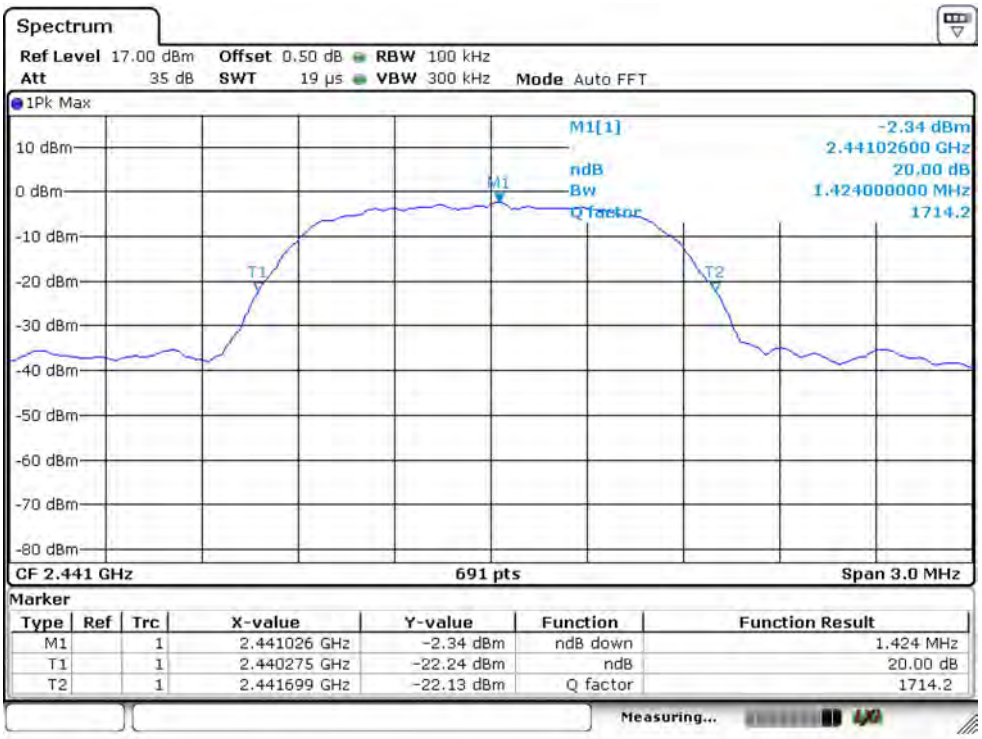

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] 0.01 dBm
2.44085240 GHz
M1 ndB 20.00 dB
Bw 1.128800000 MHz
Q factor 2162.3
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
T1
T2
CF 2.441 GHz
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.4408524 GHz 0.01 dBm ndB down 1.1288 MHz
T1 1 2.4404226 GHz -19.92 dBm ndB 20.00 dB
T2 1 2.4415514 GHz -20.15 dBm Q factor 2162.3
Measuring...

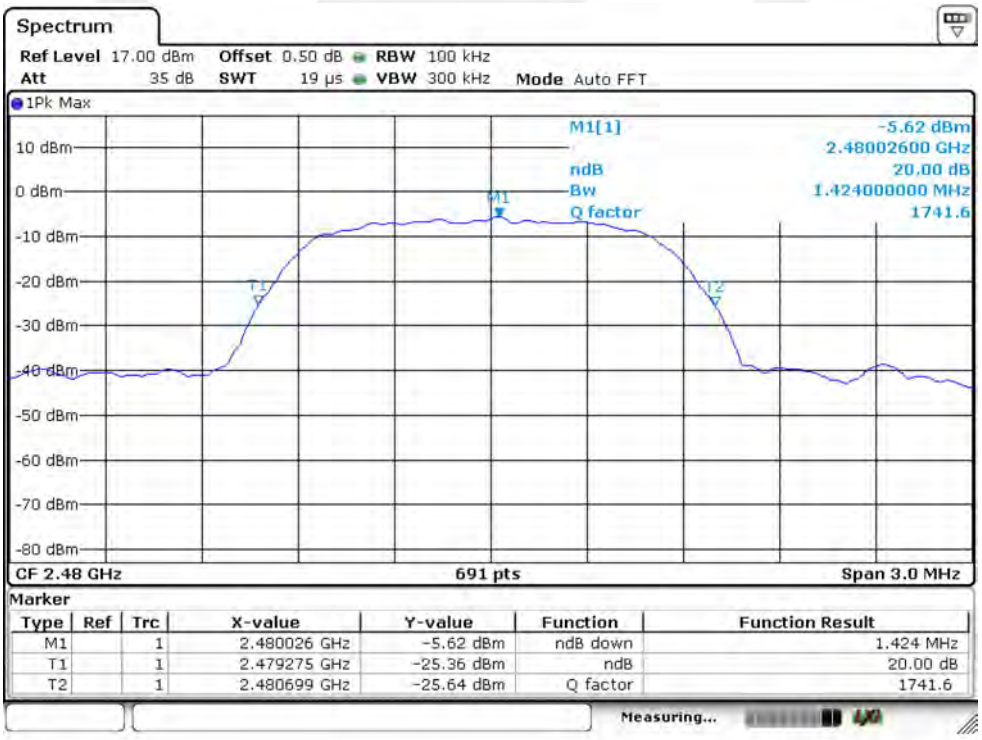

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] -3.01 dBm
2.47984800 GHz
ndB 20.00 dB
Bw 1.124500000 MHz
Q factor 2205.4
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.48 GHz
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.479848 GHz -3.01 dBm ndB down 1.1245 MHz
T1 1 2.4794226 GHz -22.95 dBm ndB 20.00 dB
T2 1 2.480547 GHz -22.83 dBm Q factor 2205.4
Measuring...

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	Π/4-DQPSK		

Channel number	Channel frequency (MHz)	20dB Down BW(kHz)
1	2402	1428
40	2441	1424
79	2480	1424

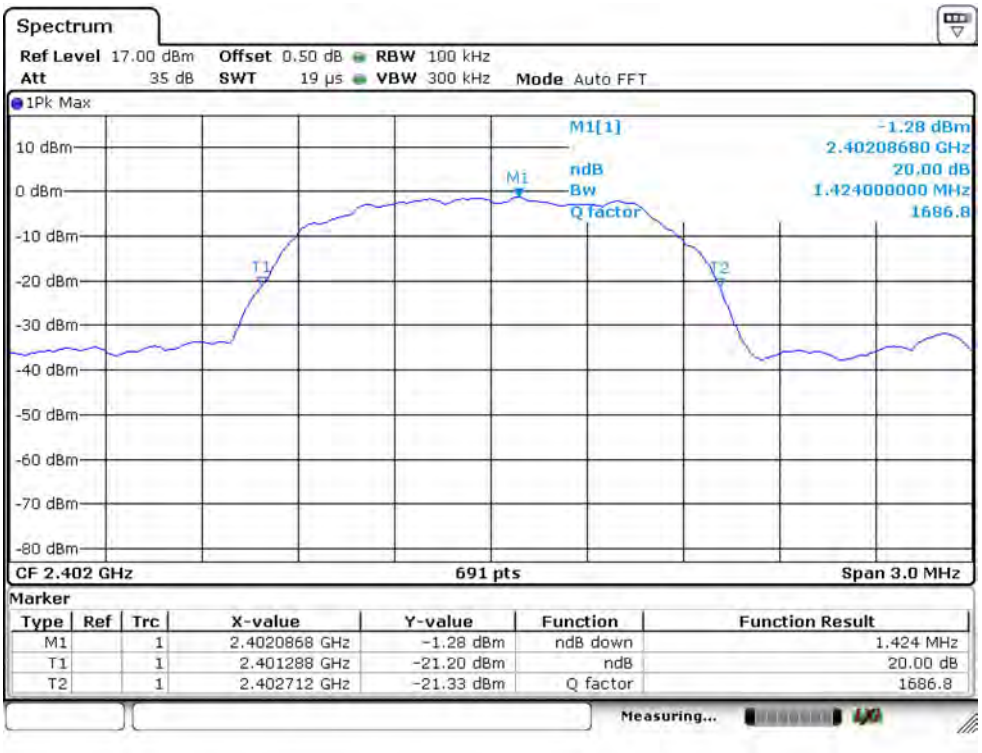


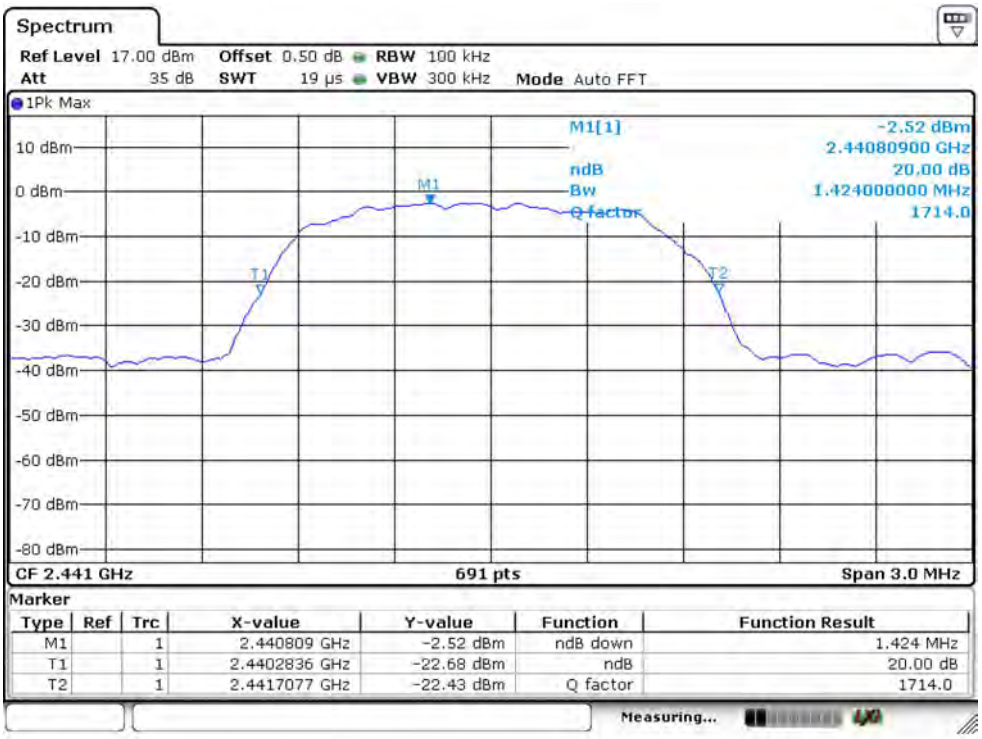

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] -2.34 dBm
2.44102600 GHz
ndB 20.00 dB
Bw 1.424000000 MHz
Q factor 1714.2
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.441 GHz
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.441026 GHz -2.34 dBm ndB down 1.424 MHz
T1 1 2.440275 GHz -22.24 dBm ndB 20.00 dB
T2 1 2.441699 GHz -22.13 dBm Q factor 1714.2
Measuring...

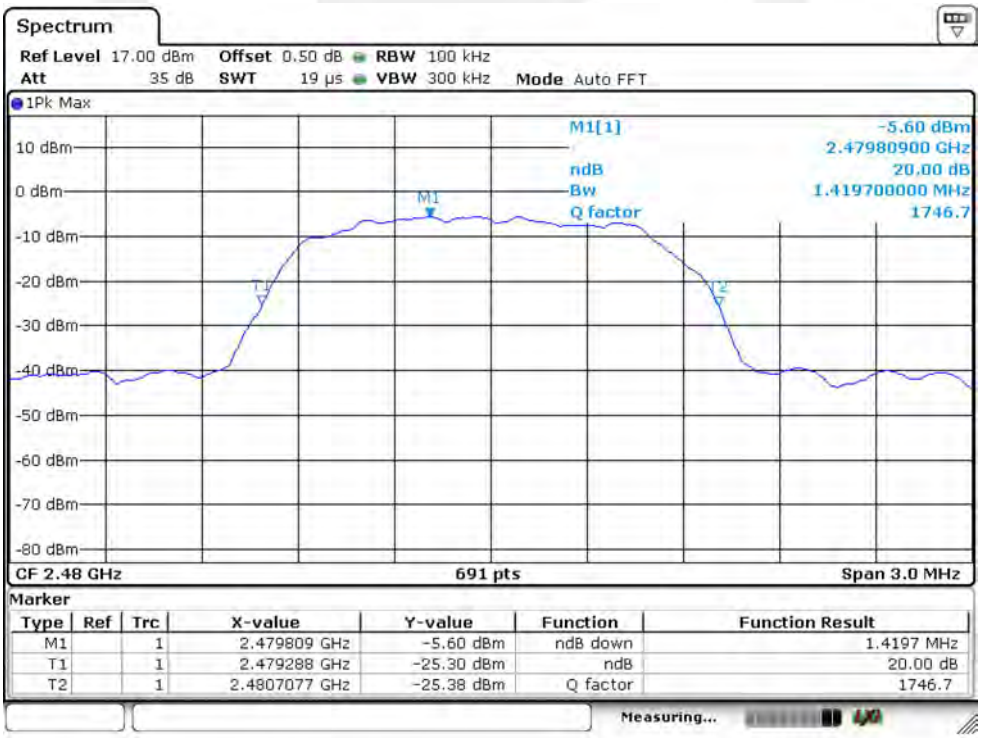

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] -5.62 dBm
2.48002600 GHz
ndB 20.00 dB
Bw 1.424000000 MHz
Q factor 1741.6
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.48 GHz
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.480026 GHz -5.62 dBm ndB down 1.424 MHz
T1 1 2.479275 GHz -25.36 dBm ndB 20.00 dB
T2 1 2.480699 GHz -25.64 dBm Q factor 1741.6
Measuring...

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	24℃
Test Result:	PASS	Humidity :	53 %
Modulation:	8DPSK		

Channel number	Channel frequency (MHz)	20dB Down BW(kHz)
1	2402	1424
40	2441	1424
79	2480	1420




Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] -2.52 dBm
2.44080900 GHz
ndB 20.00 dB
Bw 1.424000000 MHz
Q factor 1714.0
10 dBm
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
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.440809 GHz -2.52 dBm ndB down 1.424 MHz
T1 1 2.4402836 GHz -22.68 dBm ndB 20.00 dB
T2 1 2.4417077 GHz -22.43 dBm Q factor 1714.0
Measuring...

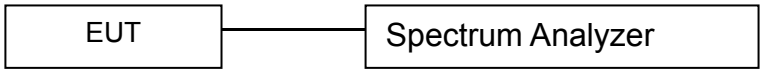

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
M1[1] -5.60 dBm
2.47980900 GHz
ndB 20.00 dB
Bw 1.419700000 MHz
Q factor 1746.7
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
T1
T2
CF 2.48 GHz
691 pts
Span 3.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.479809 GHz -5.60 dBm ndB down 1.4197 MHz
T1 1 2.479288 GHz -25.30 dBm ndB 20.00 dB
T2 1 2.4807077 GHz -25.38 dBm Q factor 1746.7
Measuring...

10. Quantity of Hopping Channel Test

10.1 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.

10.2 Test SET-UP (Block Diagram of Configuration)



10.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.	CAL DUE.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/22/2020	05/21/2021
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/22/2020	05/21/2021

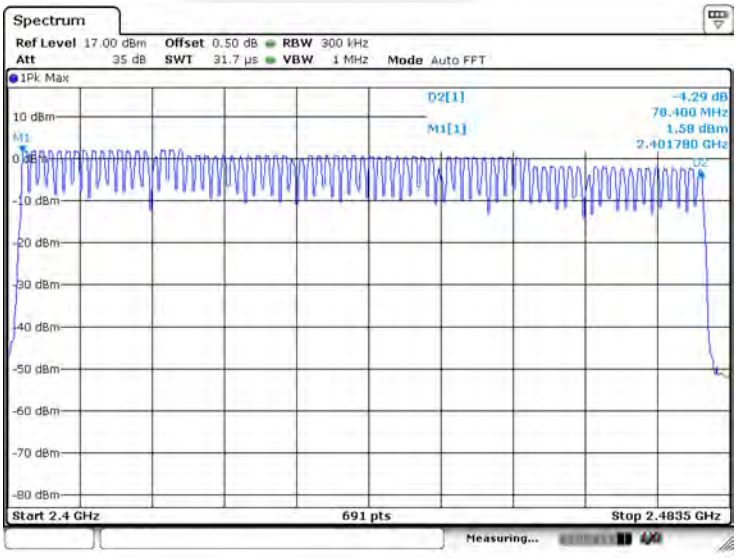
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

10.4 Measurement Results:

Refer to attached data chart.

Worst Test Mode	GFSK	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %

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



11. Time of Occupancy (Dwell Time) test

11.1 Test Description

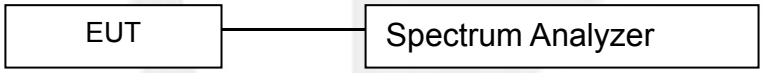
The Equipment Under Test (EUT) was set up to perform the dwell time measurements. The EUT was connected to the spectrum analyzer via a short coax cable. The dwell time is calculated by:

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.

11.2 Test SET-UP (Block Diagram of Configuration)



11.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.	CAL DUE.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/22/2020	05/21/2021
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/22/2020	05/21/2021

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 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

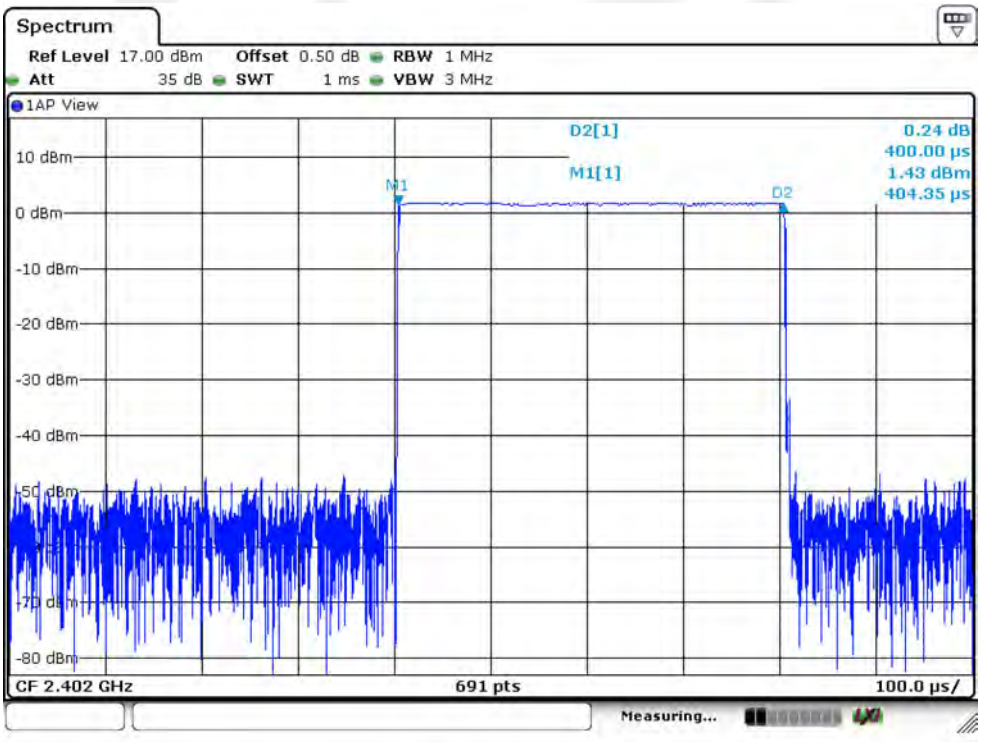
Modulation:	GFSK	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %

11.5 Test result

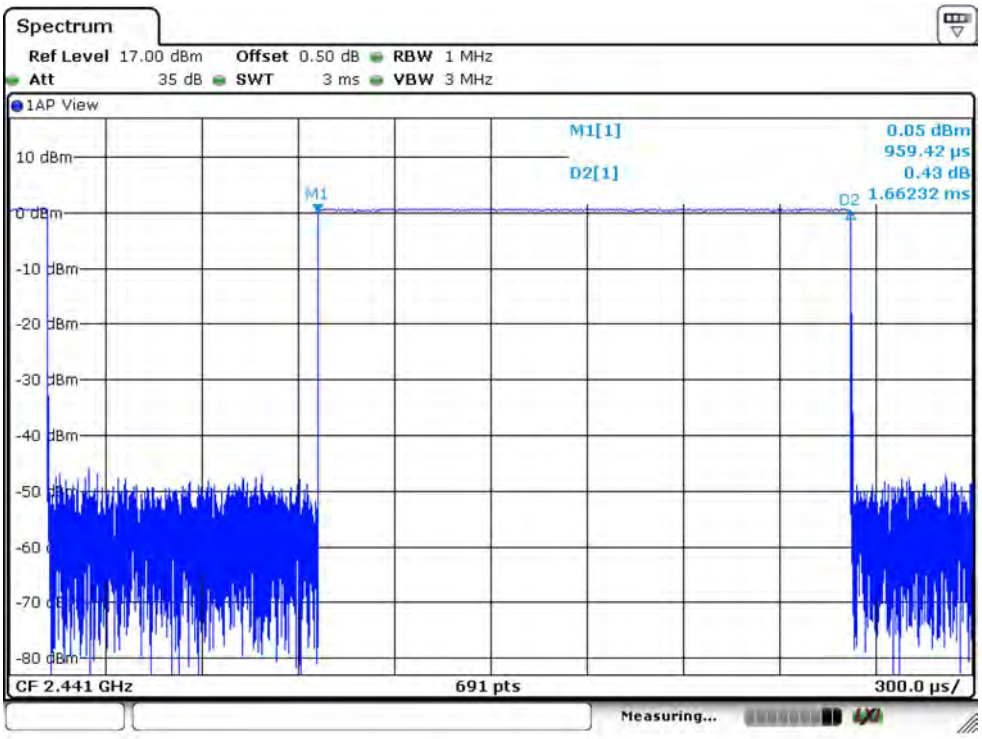
Mode	Number of transmission in a 31.6(79 Hopping*0.4)	Length of transmissions time(msec)	Result (msec)	Limit (msec)
DH1	1600/(2*79) x 31.6 = 320	0.400	128	400
DH3	1600/(4*79) x 31.6 =160	1.662	265.92	400
DH5	1600/(6*79) x 31.6 =106.67	2.906	309.98	400

Remark: The results of worst cased was recorded.

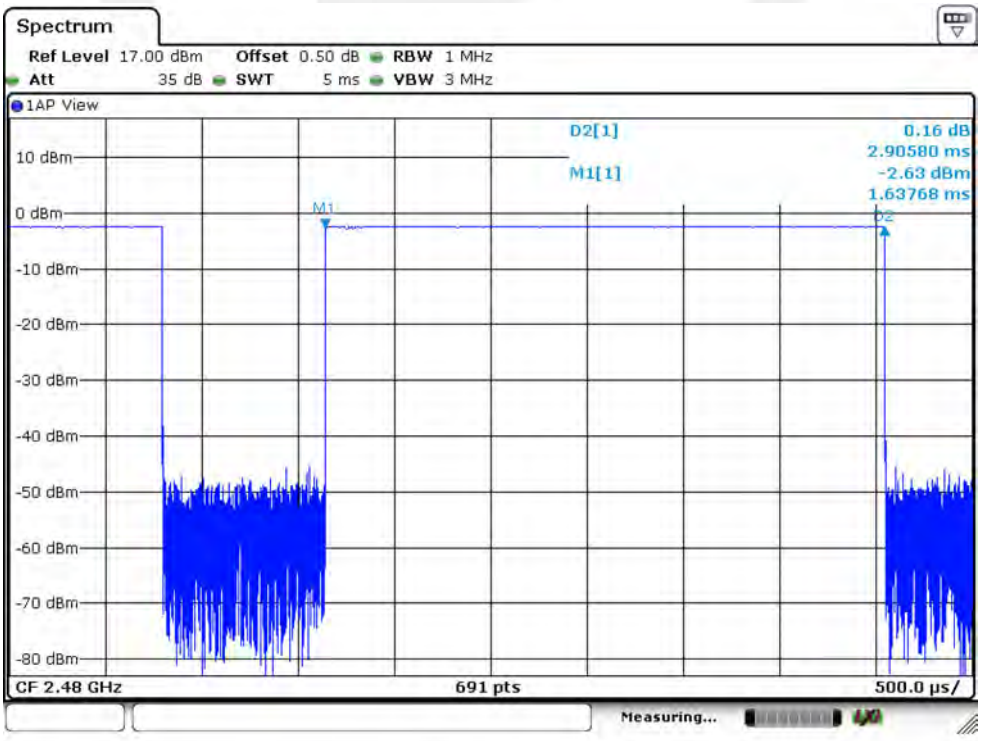
DH1:



DH3:


Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 1 MHz
Att 35 dB SWT 3 ms VBW 3 MHz
1AP View
M1[1] 0.05 dBm
959.42 µs
D2[1] 0.43 dB
1.66232 ms
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
300.0 µs/
Measuring...

DH5:


Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 1 MHz
Att 35 dB SWT 5 ms VBW 3 MHz
1AP View
D2[1] 0.16 dB
2.90580 ms
M1[1] -2.63 dBm
1.63768 ms
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
691 pts
500.0 µs/
Measuring...

12. MAXIMUM PEAK OUTPUT POWER TEST

12.1 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.

12.2 Test SET-UP (Block Diagram of Configuration)

12.3 Measurement Equipment Used:

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.	CAL DUE.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/22/2020	05/21/2021
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/22/2020	05/21/2021

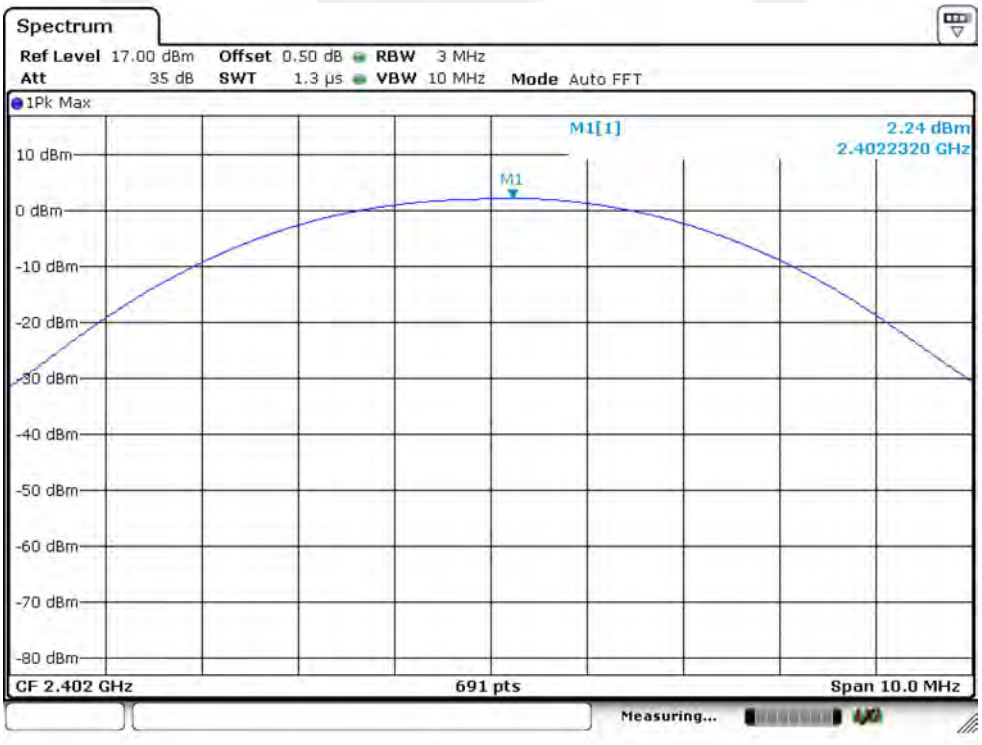
Remark: The temporary antenna connector is soldered on the PCB board in order to perform conducted tests and this temporary antenna connector is listed in the equipment list.

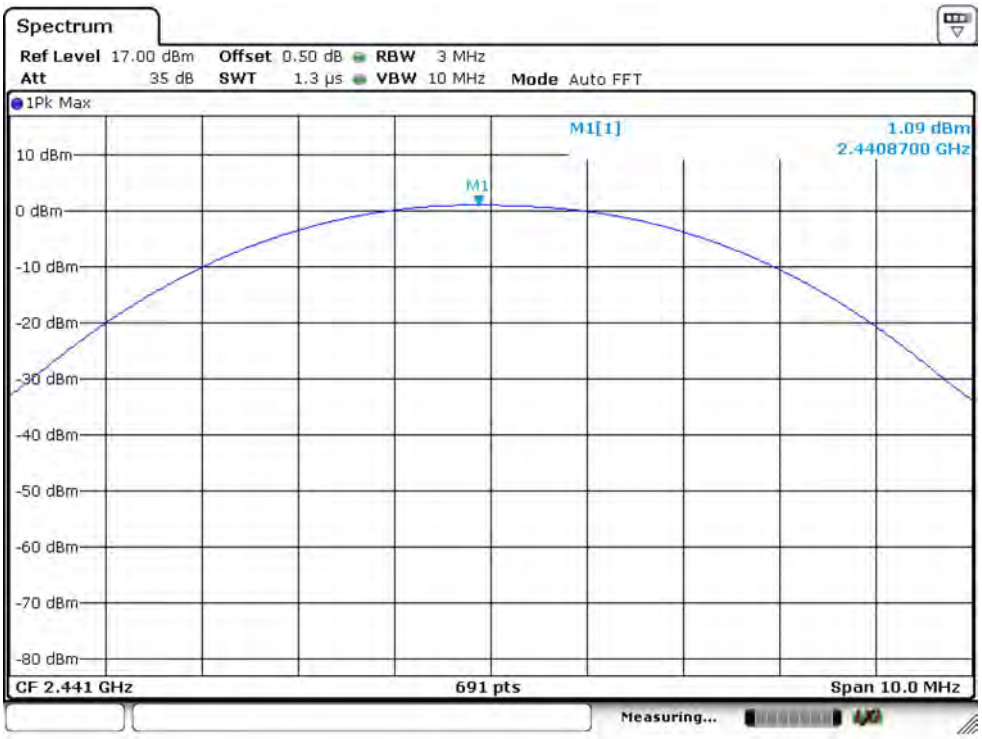
12.4 Measurement Results:

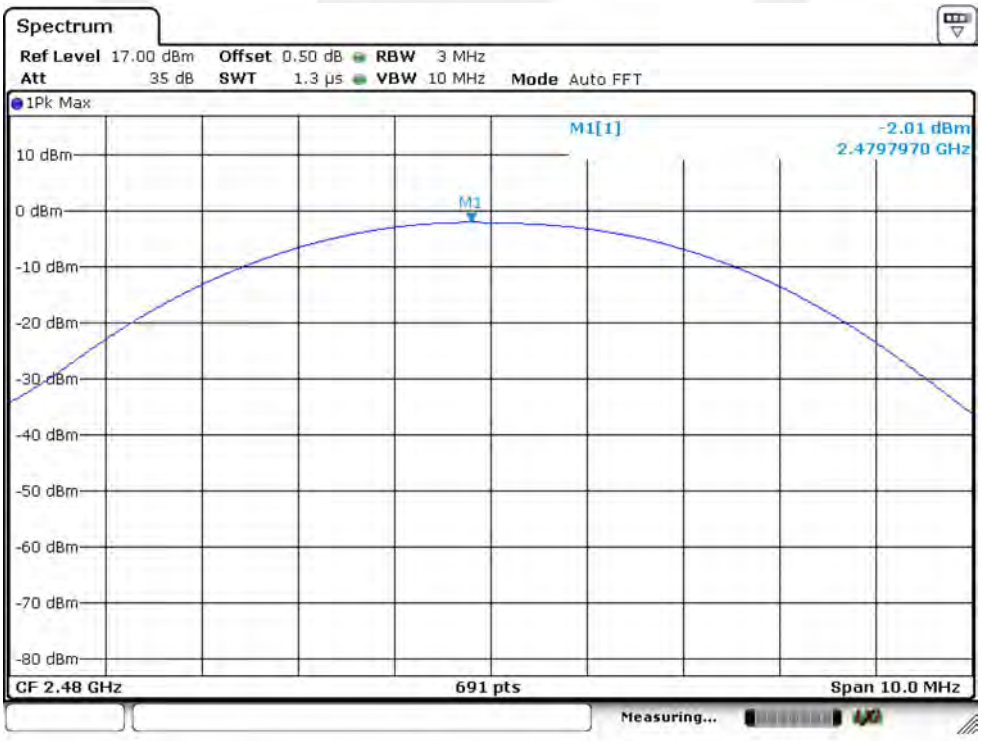
Refer to attached data chart.

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	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	2.24	1.675	1000	PASS
40	2441	1.09	1.285	1000	PASS
79	2480	-2.01	0.630	1000	PASS

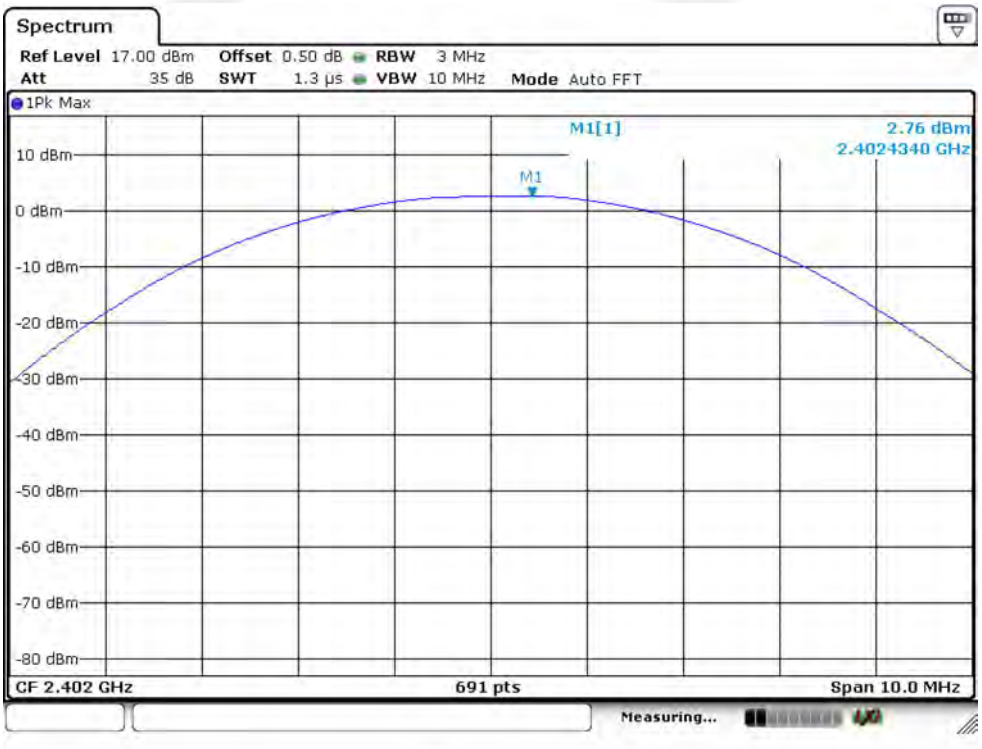


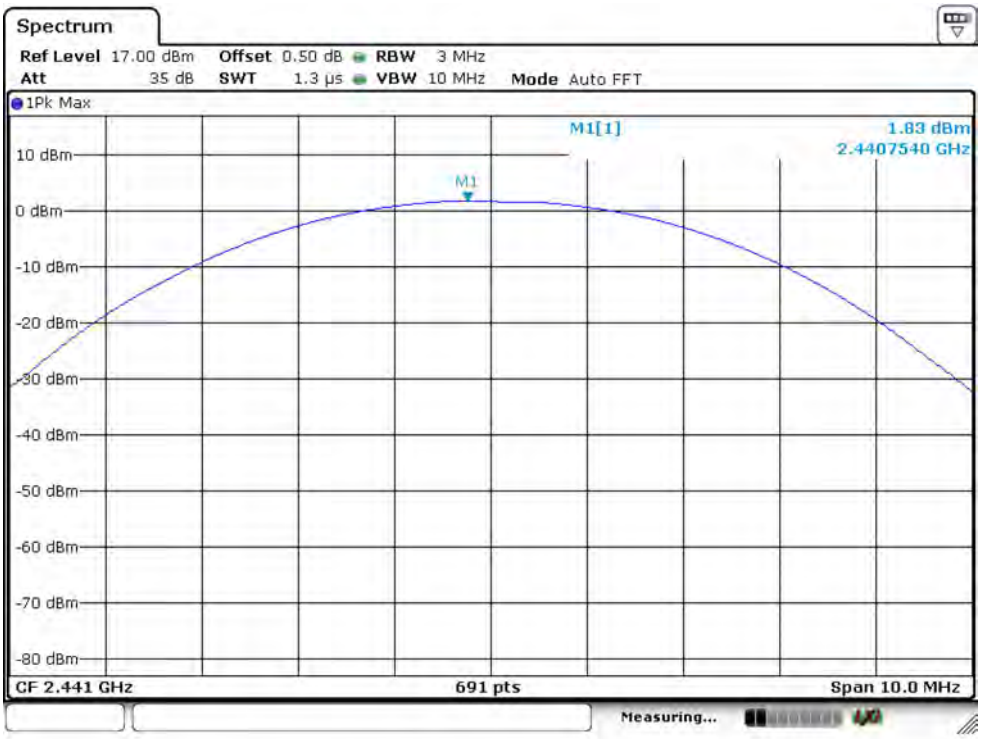

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 3 MHz
Att 35 dB SWT 1.3 µs VBW 10 MHz Mode Auto FFT
1Pk Max
M1[1] 1.09 dBm
2.4408700 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
Span 10.0 MHz
Measuring...

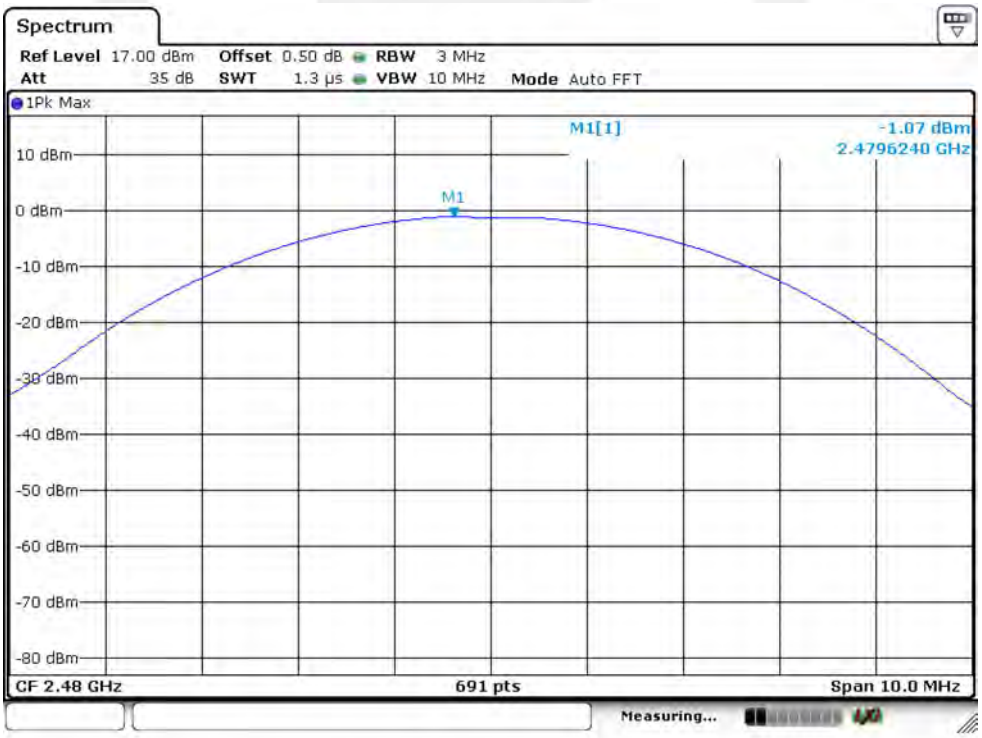

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 3 MHz
Att 35 dB SWT 1.3 µs VBW 10 MHz Mode Auto FFT
1Pk Max
M1[1] -2.01 dBm
2.4797970 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
691 pts
Span 10.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	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	2.76	1.888	125	PASS
40	2441	1.83	1.524	125	PASS
79	2480	-1.07	0.782	125	PASS

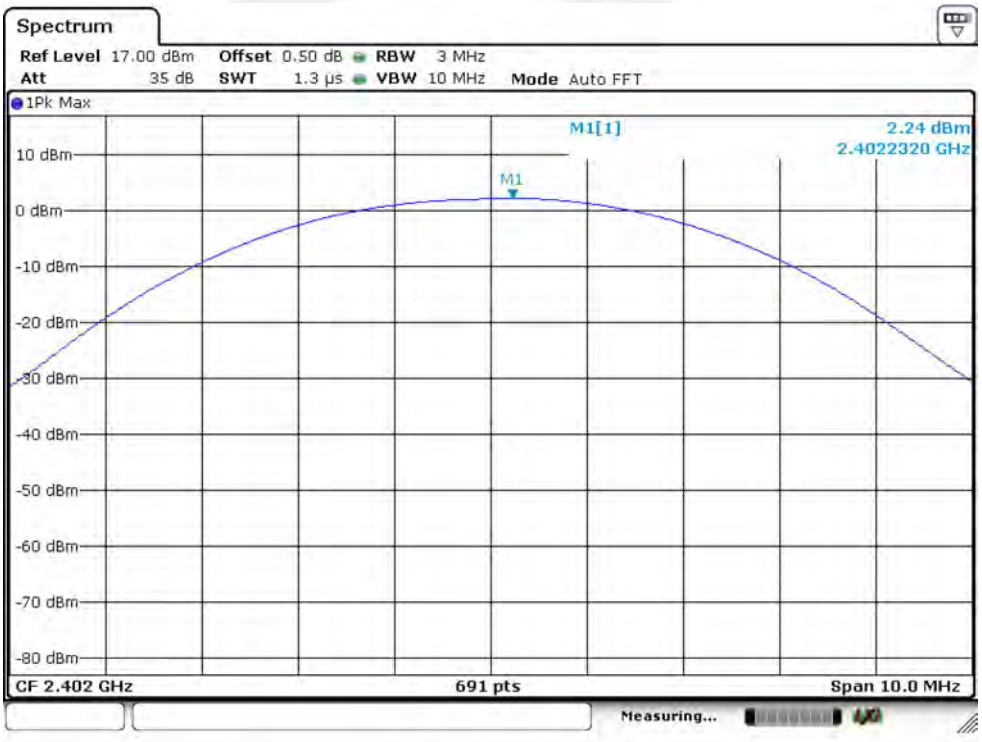


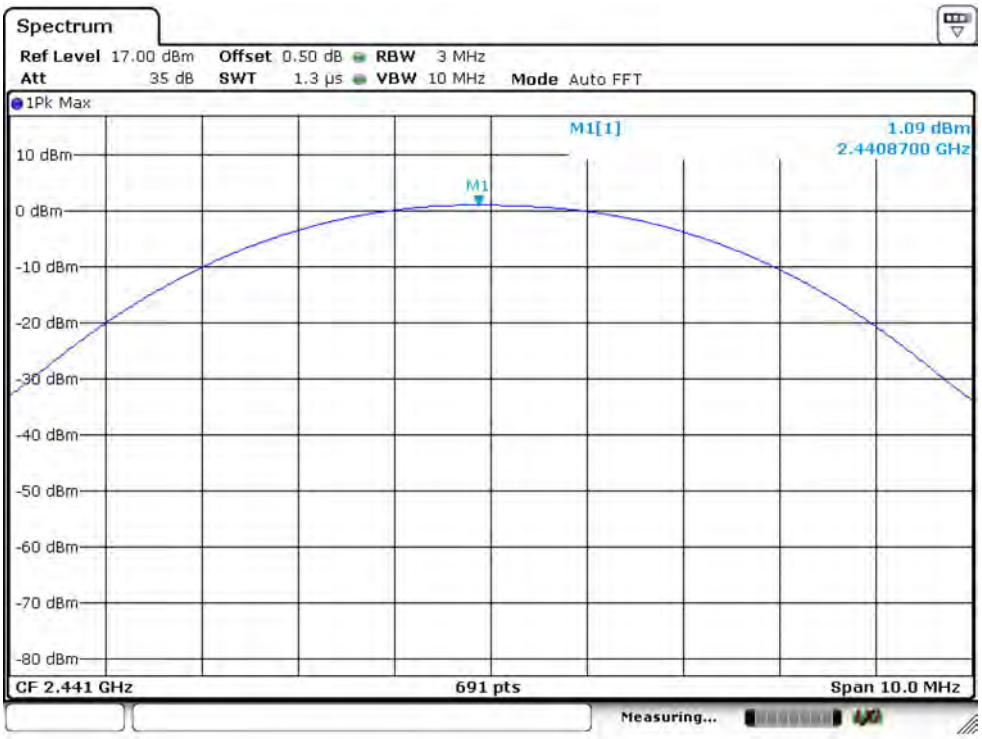

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 3 MHz
Att 35 dB SWT 1.3 µs VBW 10 MHz Mode Auto FFT
1Pk Max
M1[1] 1.83 dBm
2.4407540 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
Span 10.0 MHz
Measuring...

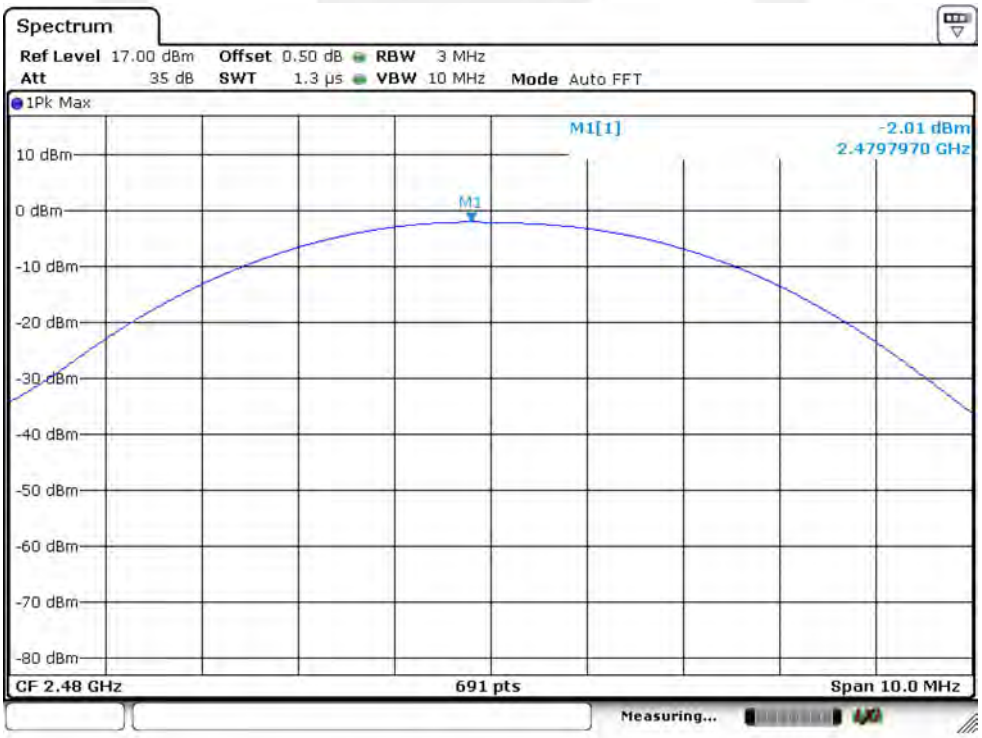

Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 3 MHz
Att 35 dB SWT 1.3 µs VBW 10 MHz Mode Auto FFT
1Pk Max
M1[1] -1.07 dBm
2.4796240 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
691 pts
Span 10.0 MHz
Measuring...

Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	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	2.24	1.675	125	PASS
40	2441	1.09	1.285	125	PASS
79	2480	-2.01	0.630	125	PASS




Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 3 MHz
Att 35 dB SWT 1.3 µs VBW 10 MHz Mode Auto FFT
1Pk Max
M1[1] 1.09 dBm
2.4408700 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.441 GHz
691 pts
Span 10.0 MHz
Measuring...


Spectrum
Ref Level 17.00 dBm Offset 0.50 dB RBW 3 MHz
Att 35 dB SWT 1.3 µs VBW 10 MHz Mode Auto FFT
1Pk Max
M1[1] -2.01 dBm
2.4797970 GHz
M1
10 dBm
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
CF 2.48 GHz
691 pts
Span 10.0 MHz
Measuring...

13. Band EDGE test

13.1 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:

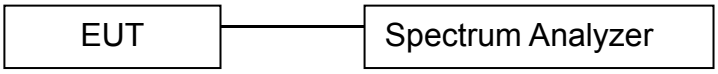
EMI Test Receiver	Setting
Attenuation	Auto
RBW	1MHz
VBW	3MHz
Detector	Peak
Trace	Max hold

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

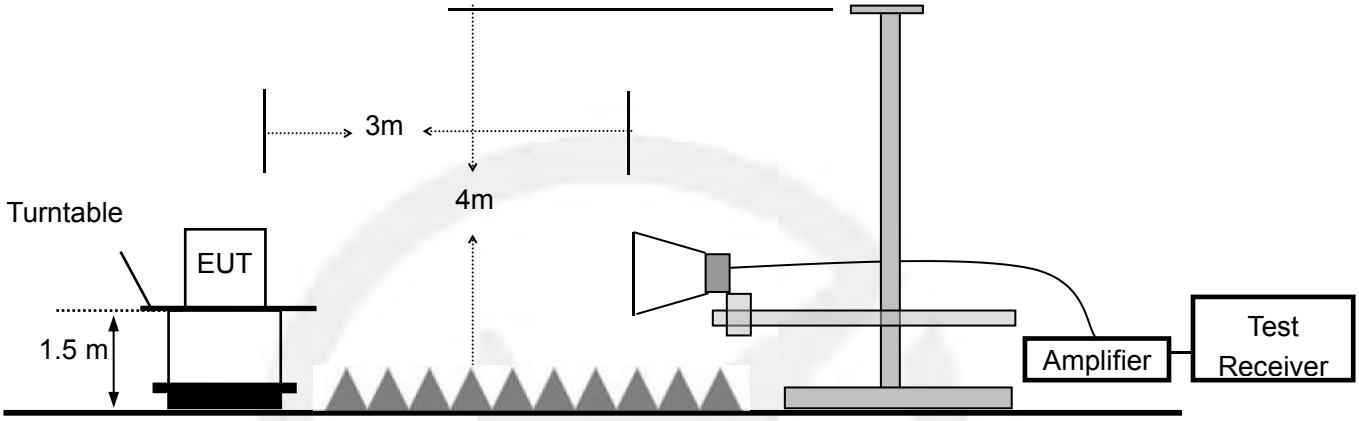
EMI Test Receiver	Setting
Attenuation	Auto
RBW	100KHz
VBW	300KHz
Detector	Peak
Trace	Max hold

13.2 Test SET-UP (Block Diagram of Configuration)

For Conducted Test



For Radiated emission Test



13.3 Measurement Equipment Used:

For Conducted Test

EQUIPMENT TYPE	MFR	MODEL NUMBER	SERIAL NUMBER	Characteristics	LAST CAL.	CAL DUE.
Spectrum Analyzer	Rohde & Schwarz	FSV30	1321.3008K	10Hz-30GHz	05/22/2020	05/21/2021
Coaxial Cable	CDS	79254	46107086	10Hz-30GHz	05/22/2020	05/21/2021
Antenna Connector	ARTHUR-YANG	2244-N1TG1	N/A	10Hz-30GHz	05/22/2020	05/21/2021

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	05/22/2020	1 Year
2	Horn Antenna	Schwarzbeck	BBHA9120D	9120D-1272	1GHz-18GHz	05/22/2020	1 Year
3	Power Amplifier	LUNAR EM	LNA1G18-40	J10100000081	1GHz-26.5GHz	05/22/2020	1 Year
4	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	05/22/2020	1 Year
5	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	05/22/2020	1 Year
6	Cable	H+S	CBL-26	N/A	1GHz-26.5GHz	05/22/2020	1 Year

13.4 Measurement Results:

Refer to attached data chart.

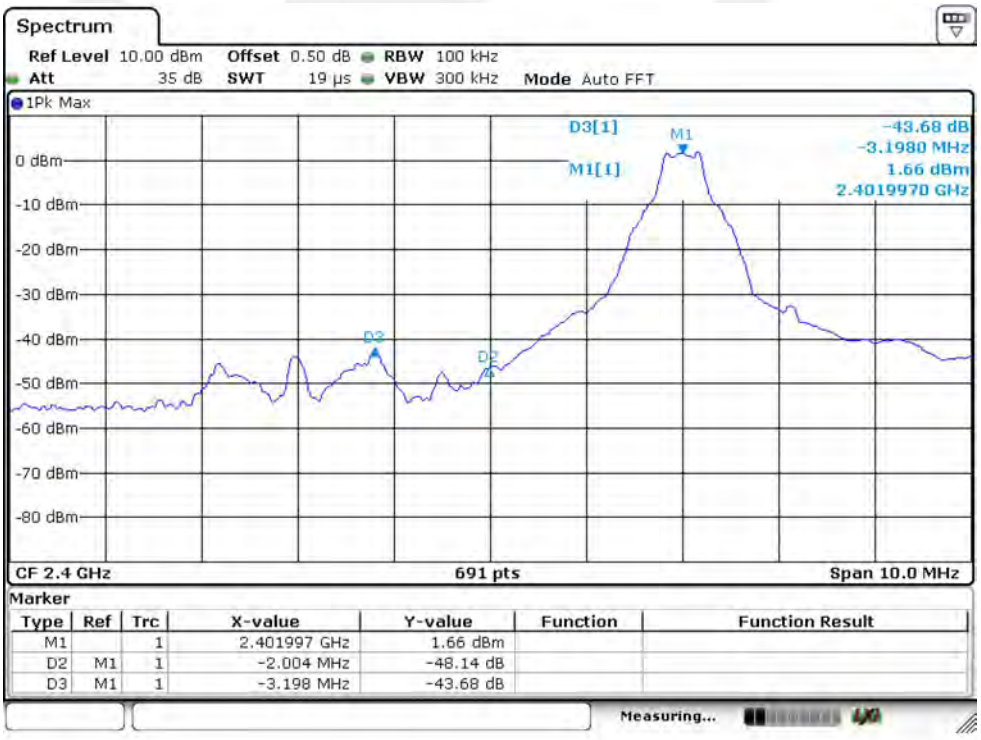
Spectrum Detector:	PK	Test Date :	June 05, 2020
Test By:	Loren	Temperature :	25 ℃
Test Result:	PASS	Humidity :	50 %

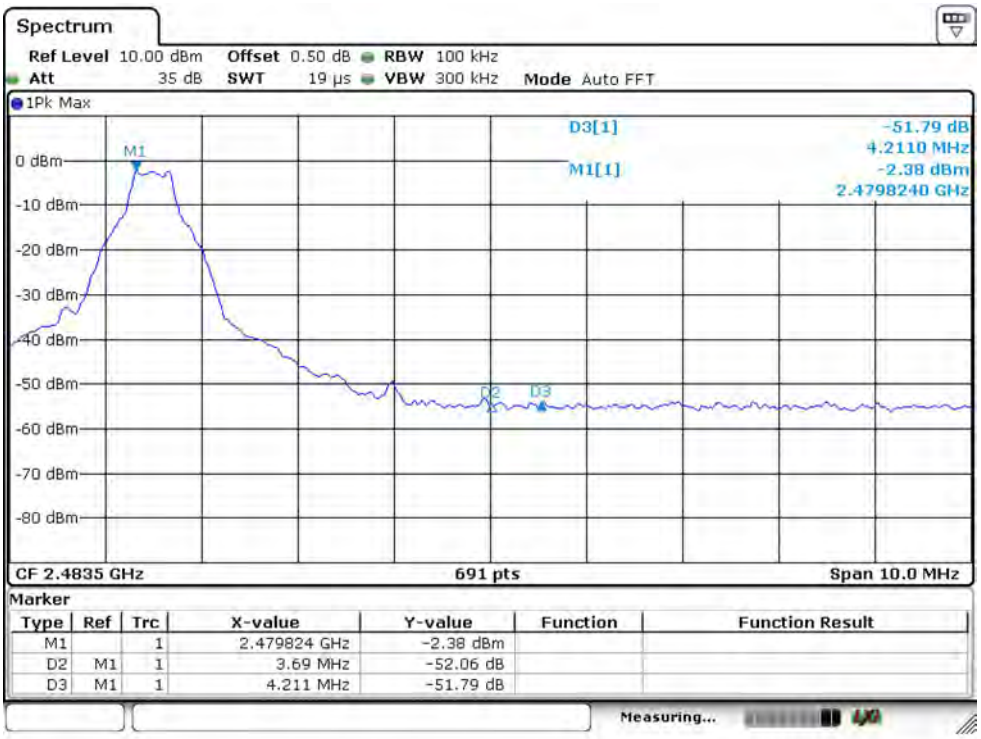
1. Conducted Test

For Non-Hopping Mode:

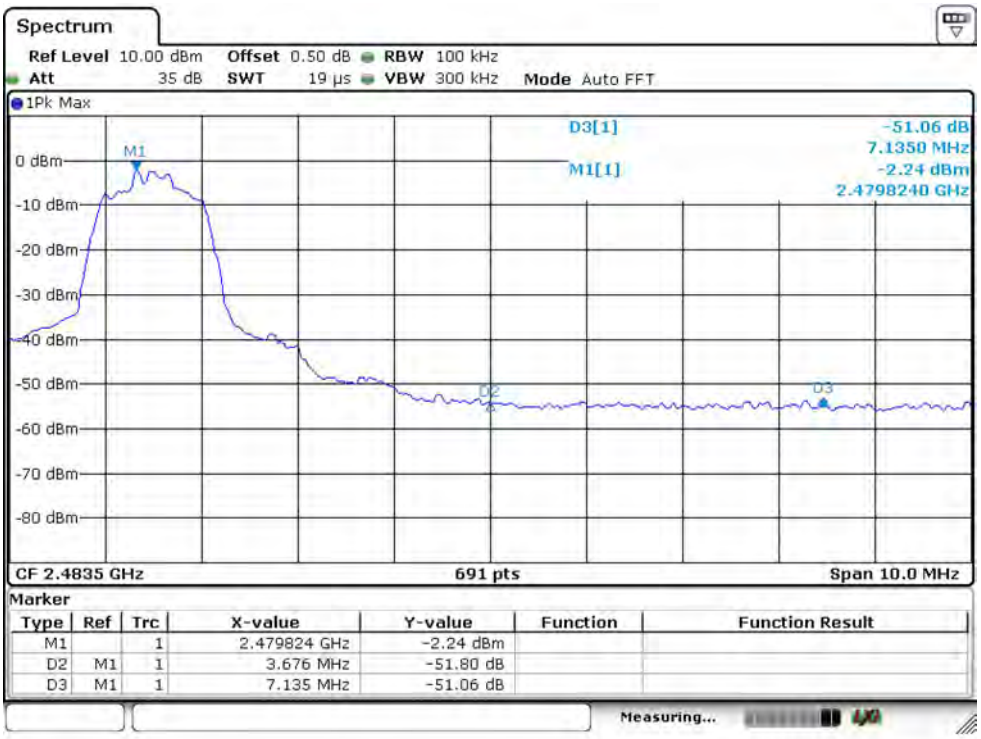
Frequency (MHz)	Modulation	Peak Power Output(dBm)	Result of Band edge(dBc)	Band edge Limit(dBc)
2401.99	GFSK	1.66	43.68	>20dBc
2401.99	pi/4-DQPSK	1.65	44.56	>20dBc
2402.15	8DPSK	1.80	43.49	>20dBc
2479.82	GFSK	-2.38	51.79	>20dBc
2479.82	pi/4-DQPSK	-2.24	51.06	>20dBc

Test plots of GFSK

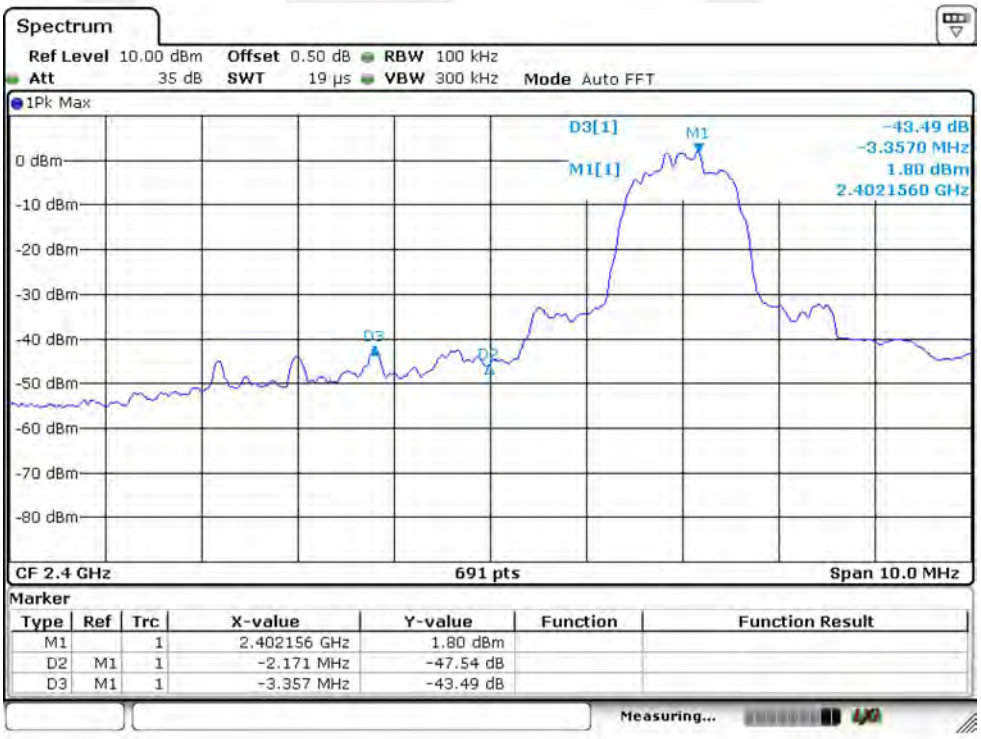


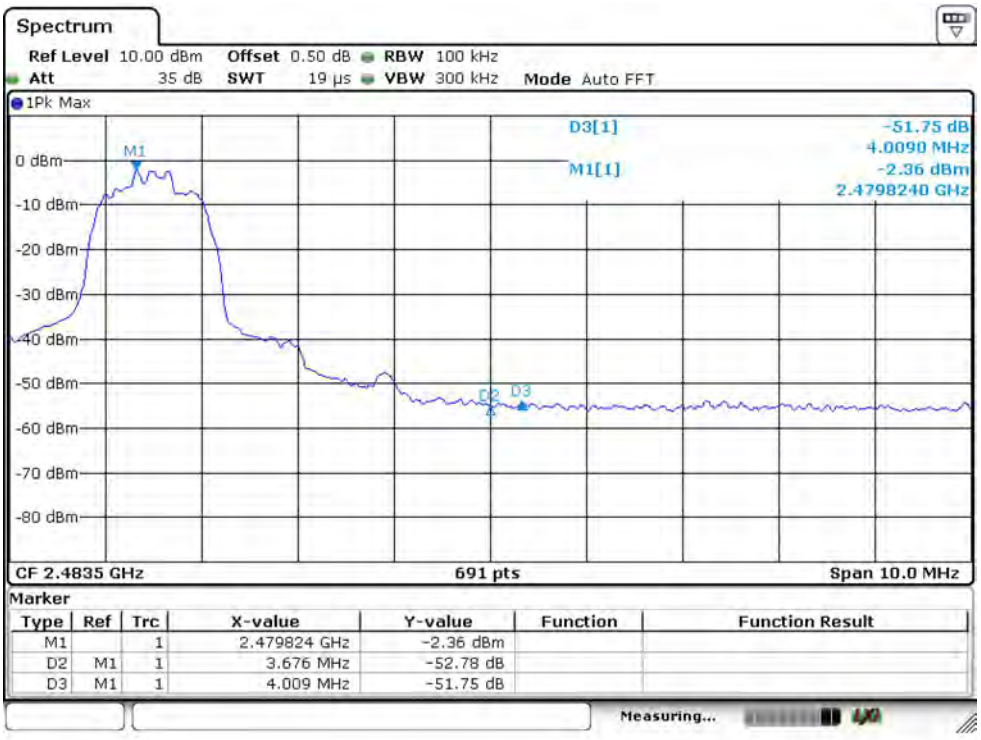


Test plots of pi/4-DQPSK



Test plots of 8DPSK

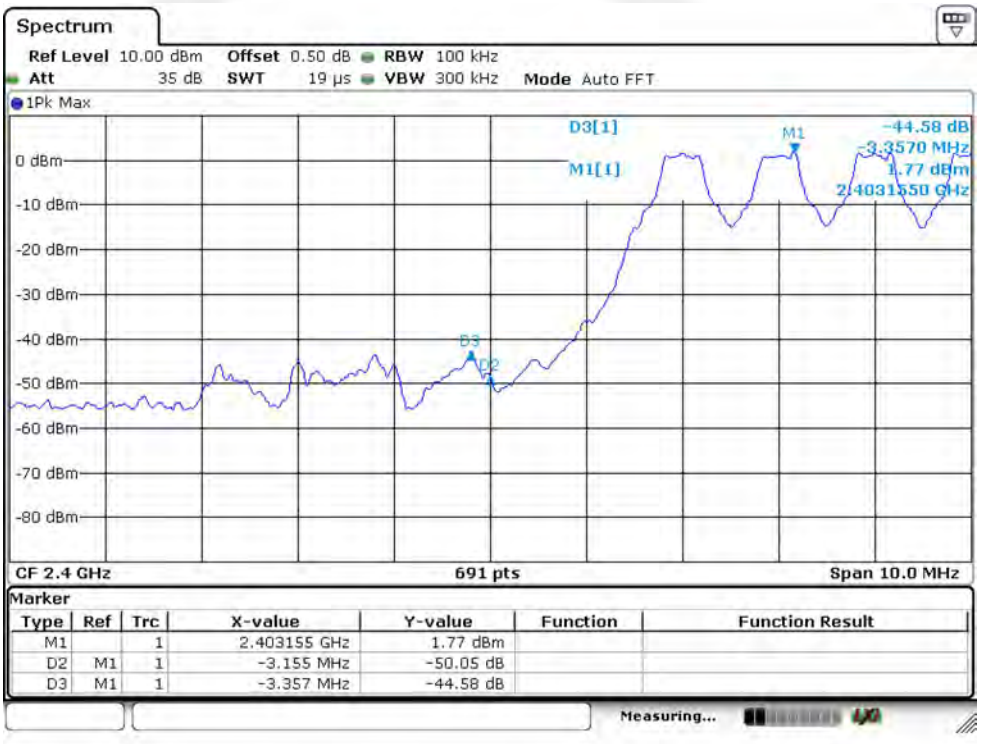


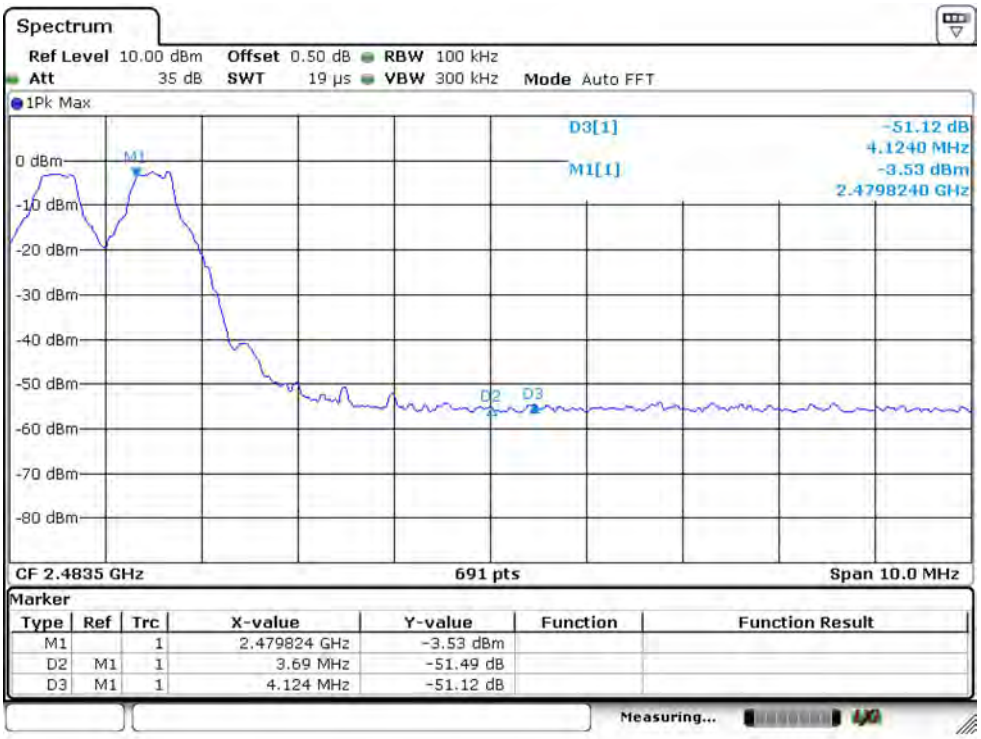

Spectrum
Ref Level 10.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D3[1] -51.75 dB
4.0090 MHz
M1[1] -2.36 dBm
2.4798240 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
D3
CF 2.4835 GHz
691 pts
Span 10.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.479824 GHz -2.36 dBm
D2 M1 1 3.676 MHz -52.78 dB
D3 M1 1 4.009 MHz -51.75 dB
Measuring...

For Hopping Mode:

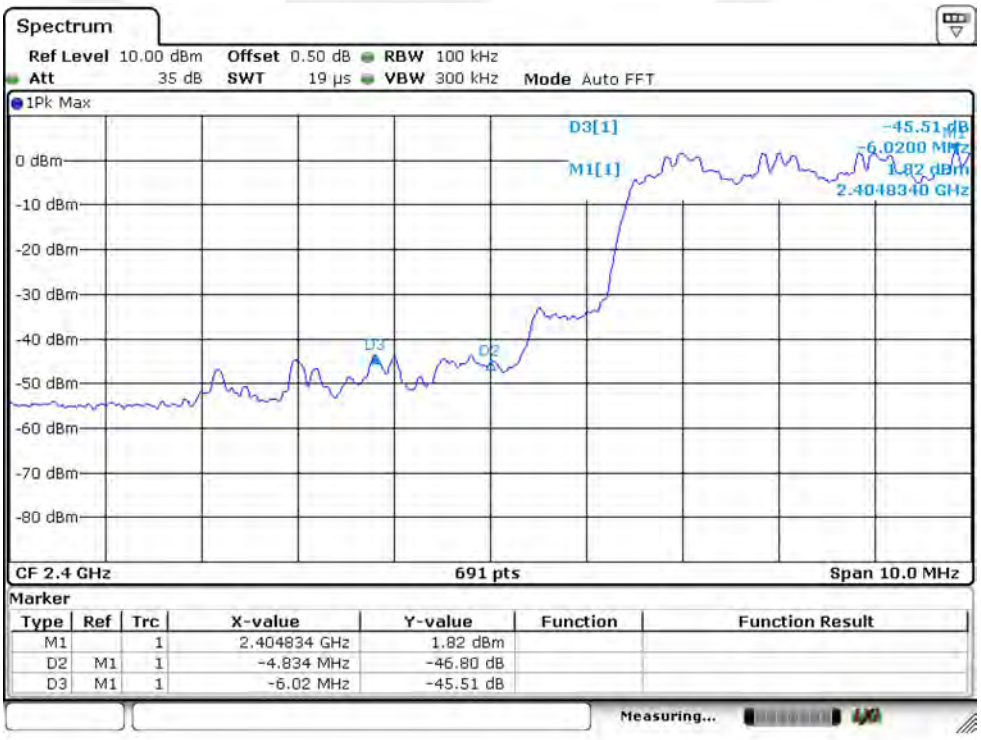
Frequency (MHz)	Modulation	Peak Power Output(dBm)	Result of Band edge(dBc)	Band edge Limit(dBc)
2403.15	GFSK	1.77	44.58	>20dBc
2404.83	pi/4-DQPSK	1.82	45.51	>20dBc
2402.15	8DPSK	1.75	44.2	>20dBc
2479.82	GFSK	-3.53	51.12	>20dBc
2480.12	pi/4-DQPSK	-3.58	49.99	>20dBc
2479.99	8DPSK	-2.47	50.85	>20dBc

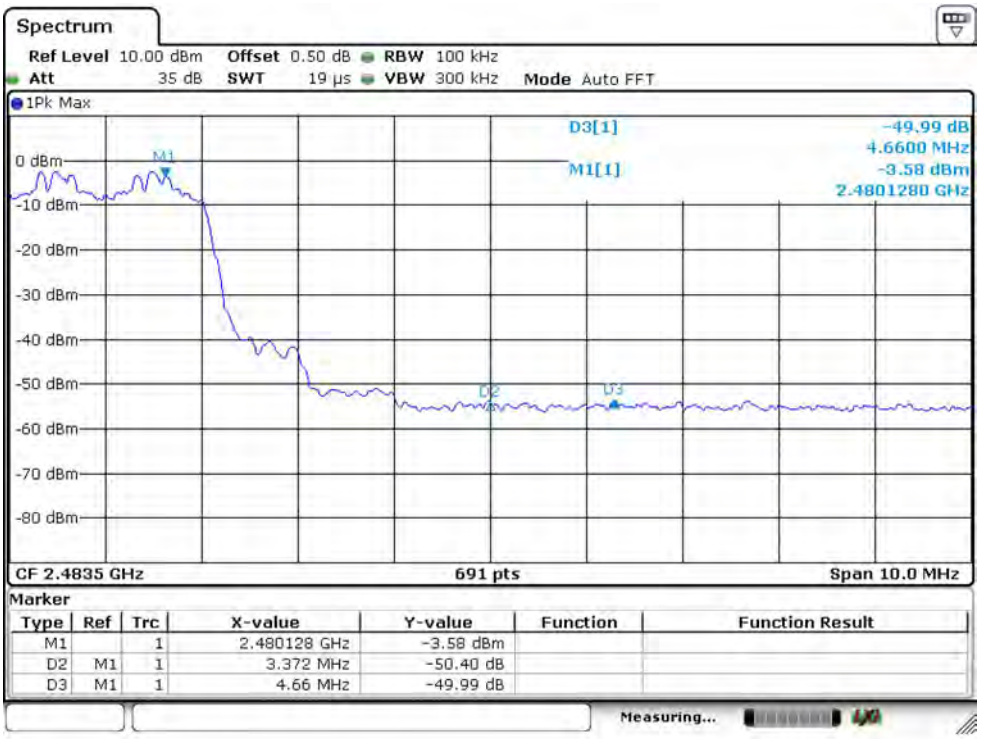
Test plots of GFSK



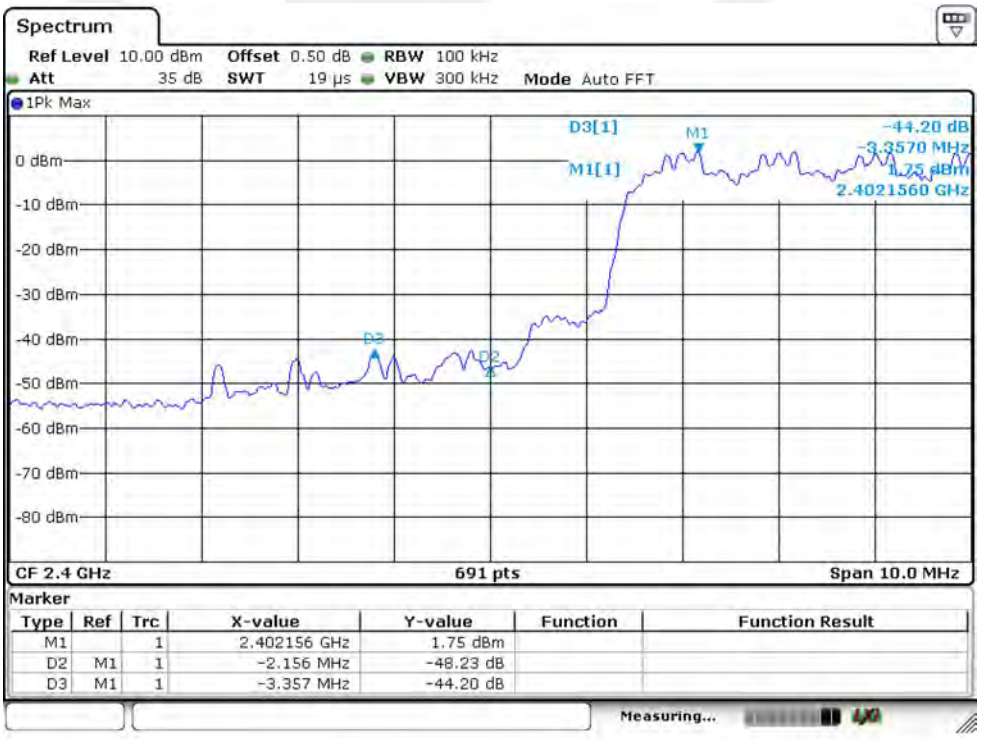


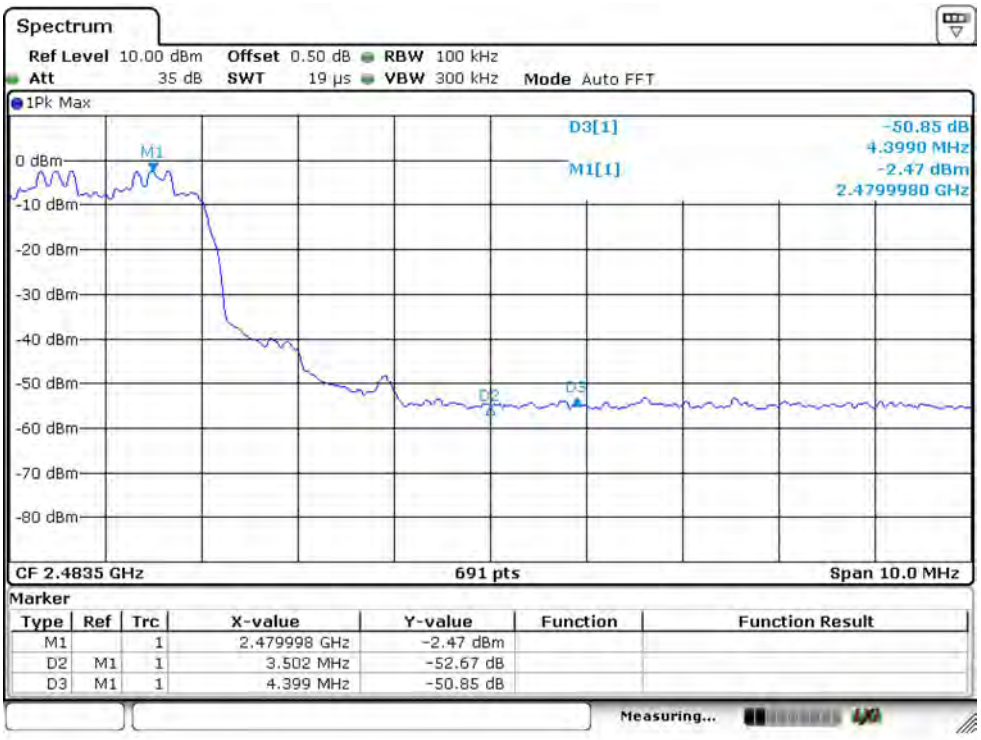
Test plots of pi/4-DQPSK





Test plots of 8DPSK

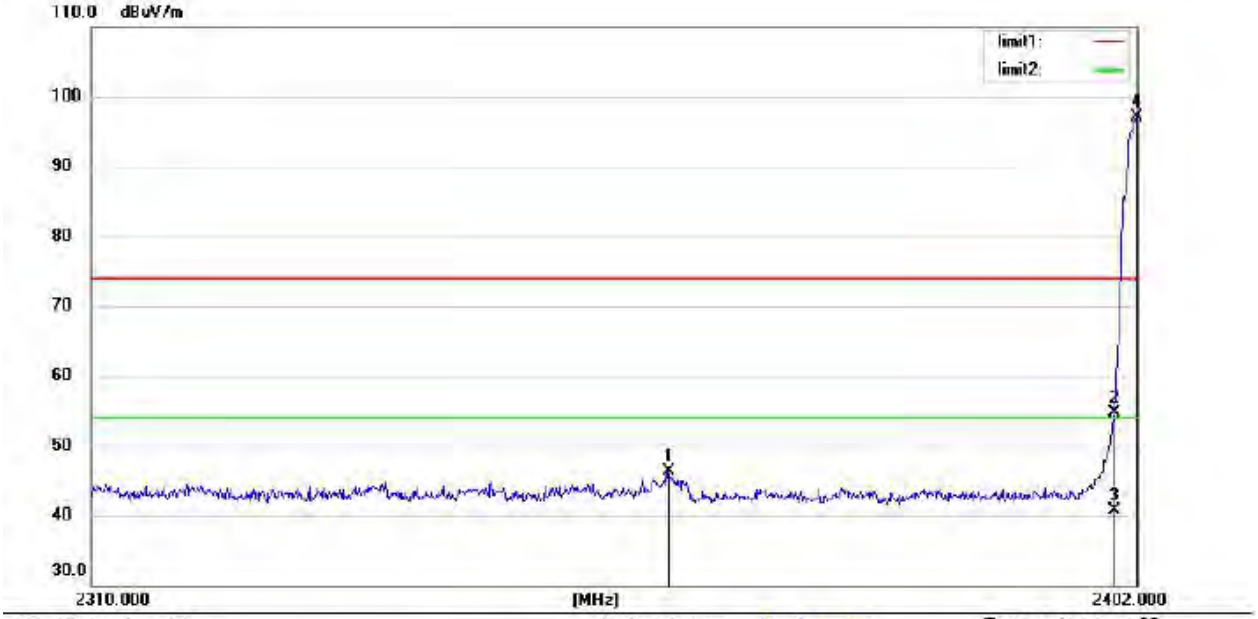



Spectrum
Ref Level 10.00 dBm Offset 0.50 dB RBW 100 kHz
Att 35 dB SWT 19 µs VBW 300 kHz Mode Auto FFT
1Pk Max
D3[1] -50.85 dB
4.3990 MHz
M1[1] -2.47 dBm
2.4799980 GHz
0 dBm
-10 dBm
-20 dBm
-30 dBm
-40 dBm
-50 dBm
-60 dBm
-70 dBm
-80 dBm
M1
D2
D3
CF 2.4835 GHz
691 pts
Span 10.0 MHz
Marker
Type Ref Trc X-value Y-value Function Function Result
M1 1 2.479998 GHz -2.47 dBm
D2 M1 1 3.502 MHz -52.67 dB
D3 M1 1 4.399 MHz -50.85 dB
Measuring...

2. Radiated emission Test

Worst test modulation GFSK

For Non-Hopping Mode:



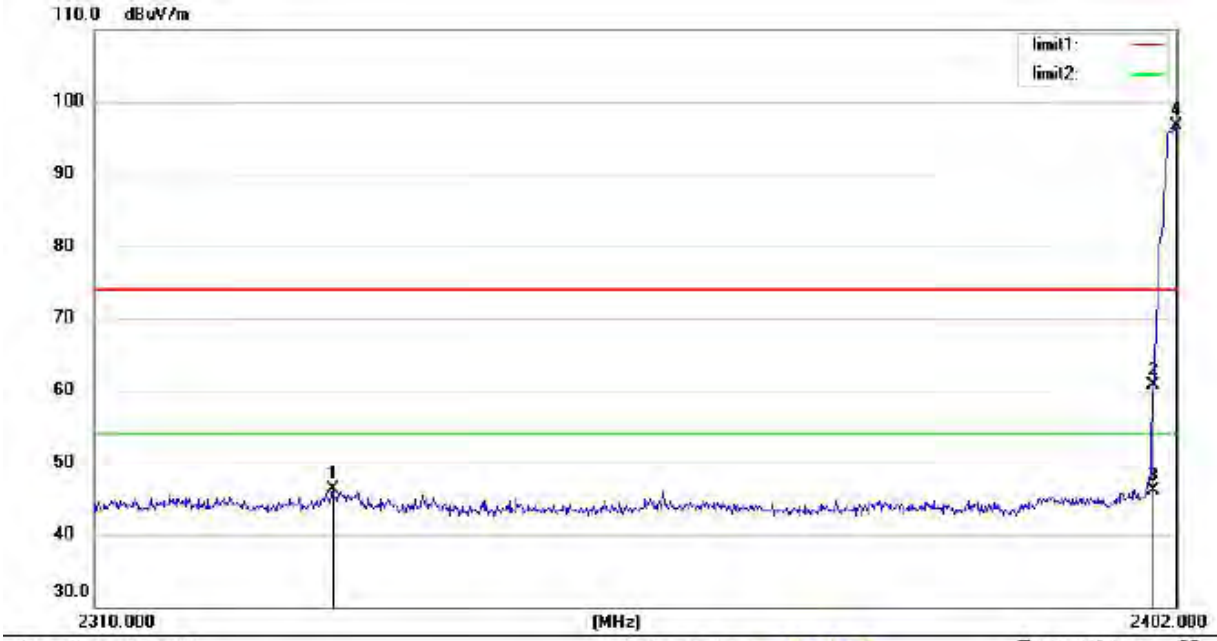
Site Chamber #1 Polarization: *Horizontal* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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		2360.324	57.95	-11.71	46.24	74.00	-27.76	peak			
2		2400.000	66.31	-11.63	54.68	74.00	-19.32	peak			
3		2400.000	52.36	-11.63	40.73	54.00	-13.27	AVG			
4	*	2402.000	108.83	-11.63	97.20	74.00	23.20	peak			



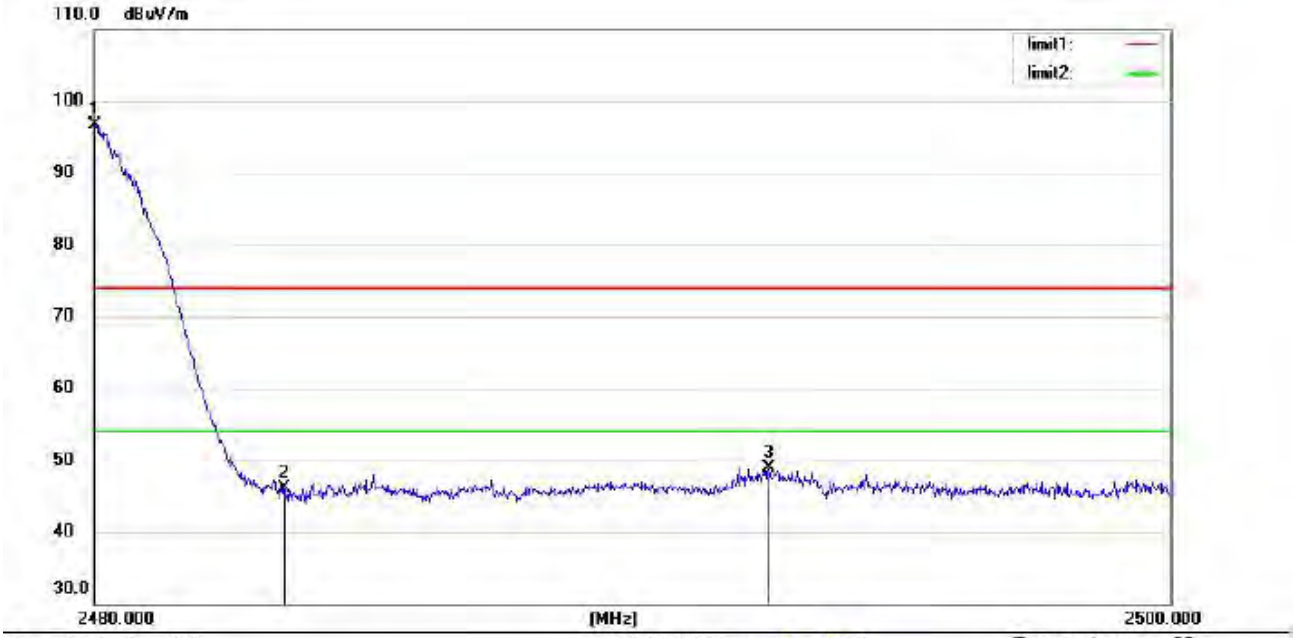
Site Chamber #1 Polarization: *Vertical* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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		2329.964	57.15	-10.85	46.30	74.00	-27.70	peak			
2		2400.000	71.15	-10.47	60.68	74.00	-13.32	peak			
3		2400.000	56.65	-10.47	46.18	54.00	-7.82	AVG			
4	*	2401.908	107.25	-10.46	96.79	74.00	22.79	peak			



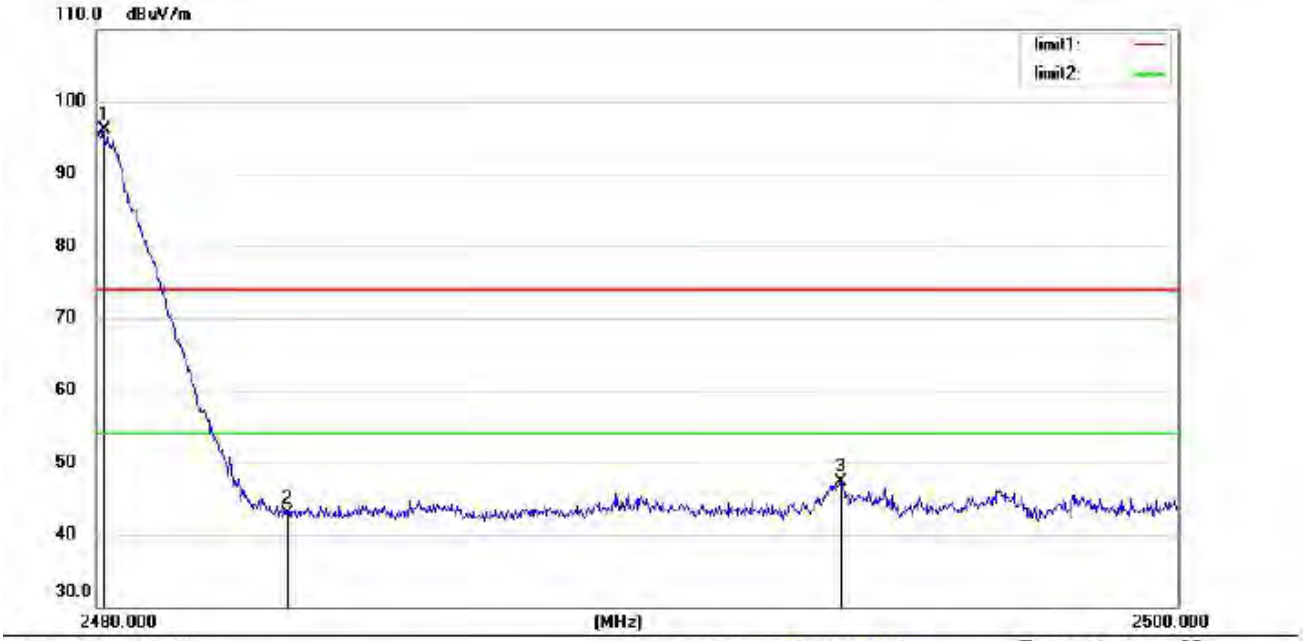
Site Chamber #1 Polarization: *Vertical* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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	*	2480.000	106.81	-10.02	96.79	74.00	22.79	peak			
2		2483.500	56.05	-10.01	46.04	74.00	-27.96	peak			
3		2492.520	58.85	-9.95	48.90	74.00	-25.10	peak			



Site Chamber #1 Polarization: *Horizontal* Temperature: 25

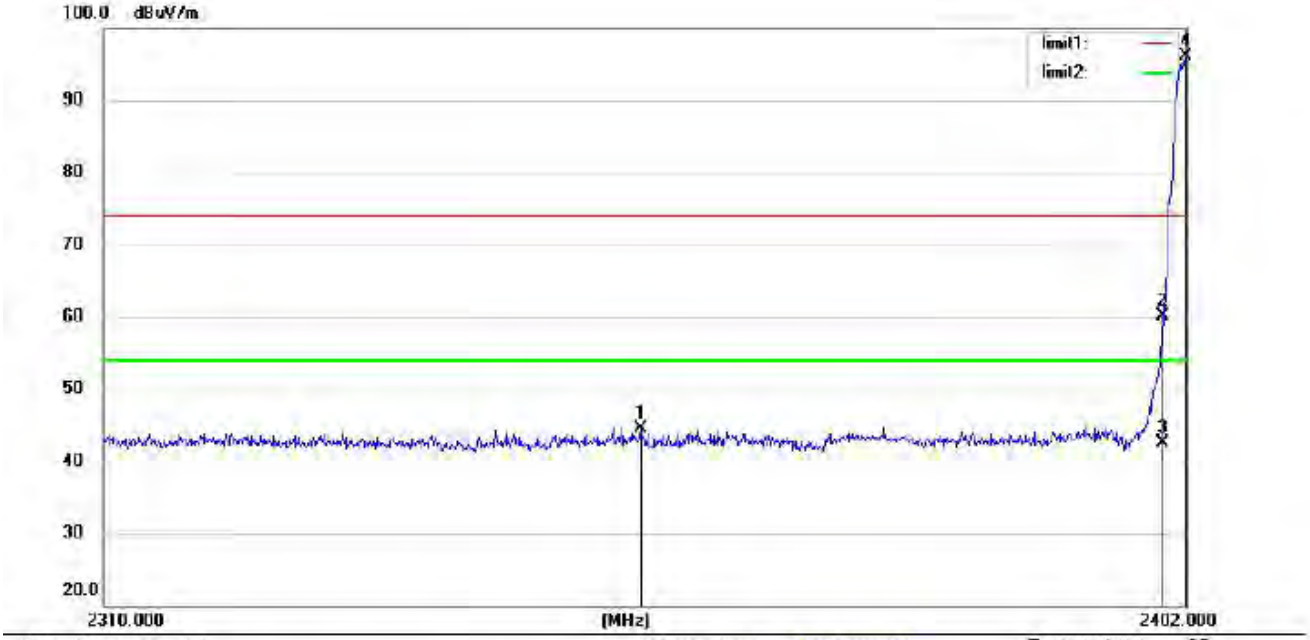
Limit: (RE)FCC PART 15.247 PK Power: DC 3.7V Humidity: 55 %

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	*	2480.120	107.50	-11.45	96.05	74.00	22.05	peak			
2		2483.500	54.44	-11.46	42.98	74.00	-31.02	peak			
3		2493.760	58.72	-11.42	47.30	74.00	-26.70	peak			

For Hopping Mode:



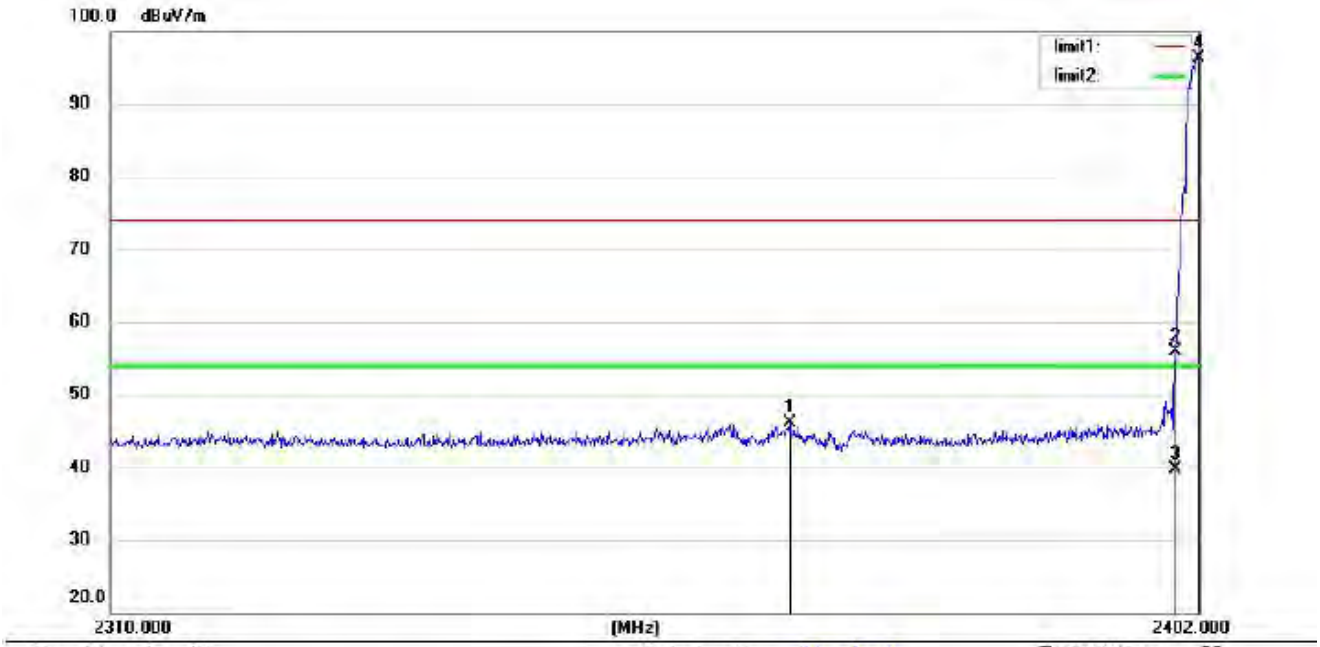
Site Chamber #1 Polarization: *Horizontal* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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		2355.264	56.21	-11.73	44.48	74.00	-29.52	peak			
2		2400.000	71.69	-11.63	60.06	74.00	-13.94	peak			
3		2400.000	54.20	-11.63	42.57	54.00	-11.43	AVG			
4	*	2402.000	107.73	-11.63	96.10	74.00	22.10	peak			



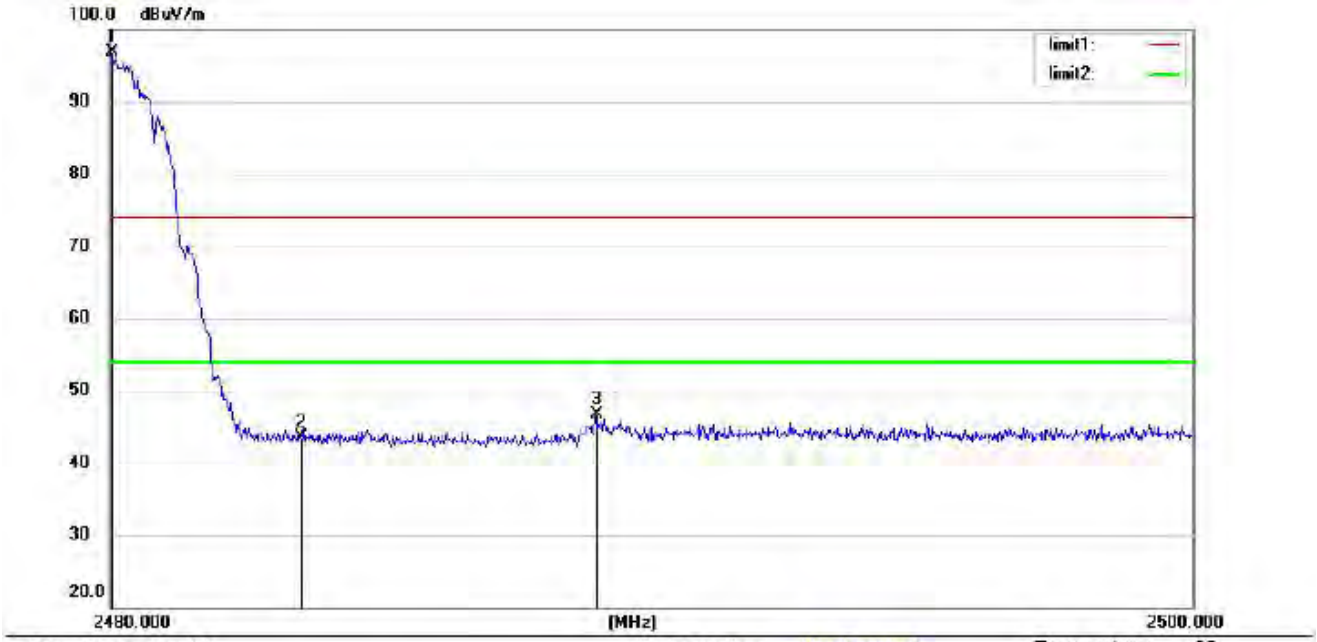
Site Chamber #1 Polarization: *Vertical* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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		2367.040	56.66	-10.65	46.01	74.00	-27.99	peak			
2		2400.000	66.45	-10.47	55.98	74.00	-18.02	peak			
3		2400.000	50.12	-10.47	39.65	54.00	-14.35	AVG			
4	*	2401.908	106.70	-10.46	96.24	74.00	22.24	peak			



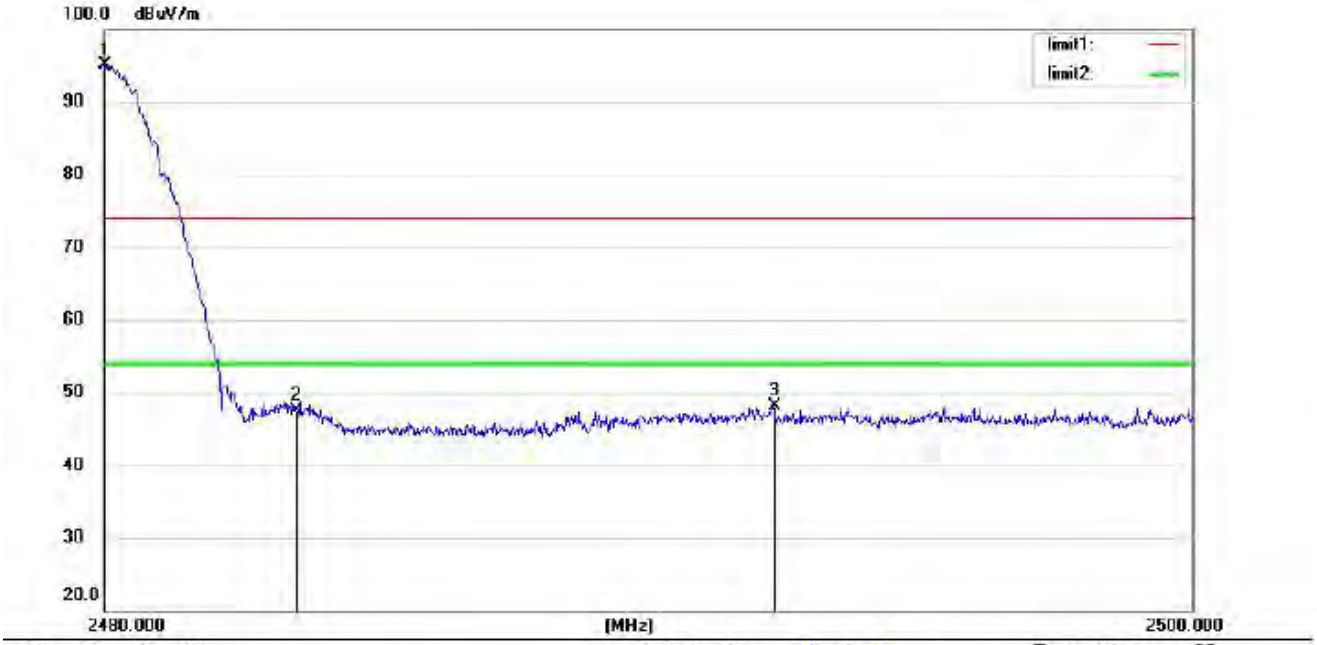
Site Chamber #1 Polarization: *Horizontal* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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	*	2480.020	108.36	-11.45	96.91	74.00	22.91	peak			
2		2483.500	54.89	-11.46	43.43	74.00	-30.57	peak			
3		2488.980	58.11	-11.44	46.67	74.00	-27.33	peak			



Site Chamber #1 Polarization: *Vertical* Temperature: 25

Limit: (RE)FCC PART 15.247 PK Power: DC 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	*	2480.000	105.07	-10.02	95.05	74.00	21.05	peak			
2		2483.500	57.49	-10.01	47.48	74.00	-26.52	peak			
3		2492.300	57.96	-9.95	48.01	74.00	-25.99	peak			

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 0 Bi and meets the requirement.

15. Photos of EUT

Please refer to external photos and internal photos.

*** End of Report ***

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