

FCC & IC RADIO TEST REPORT

The device described below is tested by Dongguan Nore Testing Center Co., Ltd. to determine the maximum emission levels emanating from the device, the severe levels which the device can endure and E.U.T.'s performance criterion. The test results, data evaluation, test procedures, and equipment of configurations shown in this report were made in accordance with the procedures in ANSI C63.10(2013).

Applicant : Banana Phone LLC
Address : 9 Swallow Lane Orchard Park, New York, United States, 14127
Manufacturer / Factory : Shenzhen Tenking Technology Co., Ltd
Address : Floor 8, Building C3, Hengfeng Industry Park, Zhoushi Road, Xixiang, Baoan, Shenzhen
E.U.T. : Banana Phone
Model No. : 002
Brand Name : Banana Phone
FCC ID : 2ANCU-002
IC : 23535-00002
HVIN : 002
Measurement Standard : FCC Part 15 Subpart C Section 15.247
ANSI C63.10: 2013
RSS-247 Issue 2 February 2017
RSS-Gen Issue 5 April 2018
Date of Receiver : September 19, 2019
Date of Test : September 20, 2019 to September 30, 2019
Date of Report : October 11, 2019

This Test Report is Issued Under the Authority of :

Prepared by



Evan Yang / Engineer

Approved & Authorized Signer



NTC
Nore
Testing Center

Iori Fan / Authorized Signatory

This test report is for the customer shown above and their specific product only. This report applies to above tested sample only and shall not be reproduced in part without written approval of Dongguan Nore Testing Center Co., Ltd.

Table of Contents

1. GENERAL INFORMATION	5
1.1 PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST	5
1.2 RELATED SUBMITTAL(S) / GRANT (S)	7
1.3 TEST METHODOLOGY	7
1.4 EQUIPMENT MODIFICATIONS	7
1.5 SUPPORT DEVICE	7
1.6 TEST FACILITY AND LOCATION	8
1.7 SUMMARY OF TEST RESULTS	9
2. SYSTEM TEST CONFIGURATION	10
2.1 EUT CONFIGURATION	10
2.2 SPECIAL ACCESSORIES	10
2.3 DESCRIPTION OF TEST MODES	10
2.4 EUT EXERCISE	10
3. AC POWER LINE CONDUCTED EMISSIONS	11
3.1 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	11
3.2 TEST CONDITION	11
3.3 MEASUREMENT RESULTS	11
4. RADIATED EMISSION	14
4.1 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	14
4.2 MEASUREMENT PROCEDURE	15
4.3 LIMIT	16
4.4 MEASUREMENT RESULTS	16
5. CHANNEL SEPARATION	20
5.1 MEASUREMENT PROCEDURE	20
5.2 LIMIT	20
5.3 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	20
5.4 MEASUREMENT RESULTS	20
6. 20DB BANDWIDTH AND 99% OCCUPIED BANDWIDTH	25
6.1 MEASUREMENT PROCEDURE	25
6.2 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	25
6.3 MEASUREMENT RESULTS	25
7. HOPPING CHANNEL NUMBER	29
7.1 MEASUREMENT PROCEDURE	29
7.2 LIMIT	29
7.3 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	29

7.4 MEASUREMENT RESULTS	29
8. TIME OF OCCUPANCY (DWELL TIME)	31
8.1 MEASUREMENT PROCEDURE	31
8.2 LIMIT	31
8.3 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	31
8.4 MEASUREMENT RESULTS	31
9. MAXIMUM PEAK OUTPUT POWER.....	36
9.1 MEASUREMENT PROCEDURE	36
9.2 LIMIT	36
9.3 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	36
9.4 MEASUREMENT RESULTS	36
10. BAND EDGE	40
10.1 MEASUREMENT PROCEDURE	40
10.2 LIMIT	40
10.3 MEASUREMENT RESULTS	40
11. ANTENNA APPLICATION.....	49
11.1 ANTENNA REQUIREMENT	49
11.2 MEASUREMENT RESULTS	49
12. CONDUCTED SPURIOUS EMISSIONS	50
12.1 MEASUREMENT PROCEDURE	50
12.2 LIMIT	50
12.3 TEST SET-UP (BLOCK DIAGRAM OF CONFIGURATION)	50
12.4 MEASUREMENT RESULTS	50
13. TEST EQUIPMENT LIST	54

Revision History of This Test Report

Report Number	Description	Issued Date
NTC1909234FV00	Initial Issue	2019-10-11

1. GENERAL INFORMATION

1.1 Product Description for Equipment under Test

Product Name : Banana Phone

Model Name : 002

E.U.T. Type : Class B

Rating : DC 5V from USB Port
DC 3.7V from built-in battery

Technical Specification:

BT Function
Version : V5.0+EDR

Frequency Range : 2402-2480MHz

Modulation Type : GFSK, $\pi/4$ -DQPSK

Number of Channel : 79

Channel Space : 1MHz

Antenna Type : PCB antenna

Antenna Gain : -0.58dBi

Bluetooth Channel List

Channel	Frequency MHz	Channel	Frequency MHz	Channel	Frequency MHz	Channel	Frequency MHz
1	2402	21	2422	41	2442	61	2462
2	2403	22	2423	42	2443	62	2463
3	2404	23	2424	43	2444	63	2464
4	2405	24	2425	44	2445	64	2465
5	2406	25	2426	45	2446	65	2466
6	2407	26	2427	46	2447	66	2467
7	2408	27	2428	47	2448	67	2468
8	2409	28	2429	48	2449	68	2469
9	2410	29	2430	49	2450	69	2470
10	2411	30	2431	50	2451	70	2471
11	2412	31	2432	51	2452	71	2472
12	2413	32	2433	52	2453	72	2473
13	2414	33	2434	53	2454	73	2474
14	2415	34	2435	54	2455	74	2475
15	2416	35	2436	55	2456	75	2476
16	2417	36	2437	56	2457	76	2477
17	2418	37	2438	57	2458	77	2478
18	2419	38	2439	58	2459	78	2479
19	2420	39	2440	59	2460	79	2480
20	2421	40	2441	60	2461		

Note: According to section 15.31(m), regards to the operating frequency range over 10MHz, the Lowest, middle, and the Highest frequency of channel were selected to perform the test. The selected frequency and test software see below:

Channel	Frequency (MHz)
1	2402
40	2441
79	2480

1.2 Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended for **FCC ID: 2ANCU-002** filing to comply with Section 15.247 of the FCC Part 15, Subpart C Rule.

This submittal(s) (test report) is intended for **IC: 23535-00002** filing to comply with RSS-247 Rule.

1.3 Test Methodology

Both AC mains line-conducted and radiated emission measurements were performed according to the procedures in ANSI C63.10 (2013). Radiated emission measurement was performed in semi-anechoic chamber and conducted emission measurement was performed in shield room. For radiated emission measurement, preliminary scans were performed in the semi-anechoic chamber only to determine the worst case modes. All radiated tests were performed at an antenna to EUT distance of 3 meters.

1.4 Equipment Modifications

Not available for this EUT intended for grant.

1.5 Support Device

Description	Manufacturer	Model	S/N
AC/DC Adapter	SAMSUNG	ETA-U90CBC	RT4F629wS/B-E

Note: The adapter is used for conducted emission tests

1.6 Test Facility and Location

Site Description

EMC Lab	: Listed by CNAS, August 13, 2018 The certificate is valid until August 13, 2024 The Laboratory has been assessed and proved to be in compliance with CNAS/CL01 The Certificate Registration Number is L5795. Listed by A2LA, November 01, 2017 The certificate is valid until December 31, 2019 The Laboratory has been assessed and proved to be in compliance with ISO17025 The Certificate Registration Number is 4429.01 Listed by FCC, November 06, 2017 The Designation Number is CN1214 Test Firm Registration Number: 907417 Listed by Industry Canada, June 08, 2017 The Certificate Registration Number. Is 46405-9743
Name of Firm	: Dongguan Nore Testing Center Co., Ltd. (Dongguan NTC Co., Ltd.)
Site Location	: Building D, Gaosheng Science and Technology Park, Hongtu Road, Nancheng District, Dongguan City, Guangdong Province, China

1.7 Summary of Test Results

FCC & IC Rules	Description Of Test	Uncertainty	Result
FCC Section 15.207 RSS-Gen Section 8.8	AC Power Line Conducted Emission	$\pm 1.06\text{dB}$	Compliant
FCC Section 15.247(d) FCC Section 15.209 FCC Section 15.205 RSS-247 Section 5.5 RSS-Gen Section 6.13 RSS-Gen Section 8.9	Radiated Emission	$\pm 3.70\text{dB}$	Compliant
FCC Section 15.247(a)(1) RSS-247 Section 5.1(b)	Channel Separation	$\pm 1.42 \times 10^{-4}\%$	Compliant
FCC Section 15.247(a)(1) RSS-247 Section 5.1(a)	20dB Bandwidth	$\pm 1.42 \times 10^{-4}\%$	Compliant
RSS-Gen Section 6.7	99% Occupied Bandwidth	$\pm 1.42 \times 10^{-4}\%$	Compliant
FCC Section 15.247(a)(1)(iii) RSS-247 Section 5.1(d)	Hopping Channel Number	$\pm 1.42 \times 10^{-4}\%$	Compliant
FCC Section 15.247(a)(1)(iii) RSS-247 Section 5.1(d)	Time of Occupancy (Dwell Time)	$\pm 5\%$	Compliant
FCC Section 15.247(b)(1) RSS-247 Section 5.4(b)	Max Peak Output Power	$\pm 1.06\text{dB}$	Compliant
FCC Section 15.247(d) RSS-247 Section 5.5 RSS-Gen 8.9 RSS-Gen Section 8.10	Band Edge	$\pm 1.70\text{dB}$	Compliant
FCC Section 15.203 RSS-Gen Section 6.8	Antenna Requirement	N/A	Compliant
FCC Section 15.247(d) RSS-247 Section 5.5	Conducted Spurious Emission	$\pm 1.70\text{dB}$	Compliant

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 Special Accessories

Not available for this EUT intended for grant.

2.3 Description of test modes

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and normal mode is programmed. The Lowest, middle and highest channel were chosen for testing, and all packets DH1, DH3, DH5, 2-DH1, 2-DH3, 2-DH5 mode in all modulation type GFSK and $\pi/4$ -DQPSK were tested.

Test Item	Software	Description
Conducted RF Testing and Radiated testing	FCC_Assist_1.0.0.2	Set the EUT to different modulation and channel

Output power setting table:

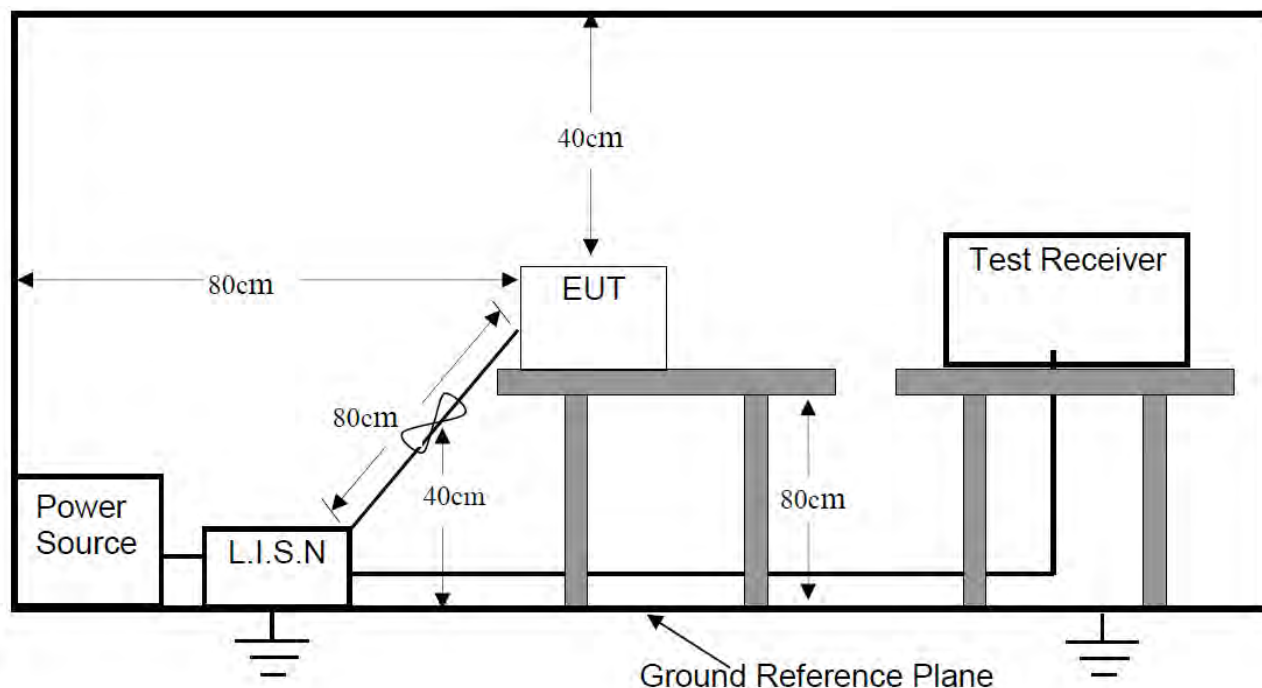
Test Mode	Set Tx Output Power	Data rate
GFSK	-1.0dBm	DH1
$\pi/4$ -DQPSK	-2.0dBm	2-DH1

2.4 EUT Exercise

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements.

3. AC POWER LINE CONDUCTED EMISSIONS

3.1 Test SET-UP (Block Diagram of Configuration)



3.2 Test Condition

Test Requirement: FCC Part 15.207 & RSS-Gen Section 8.8

Frequency Range: 150KHz ~ 30MHz

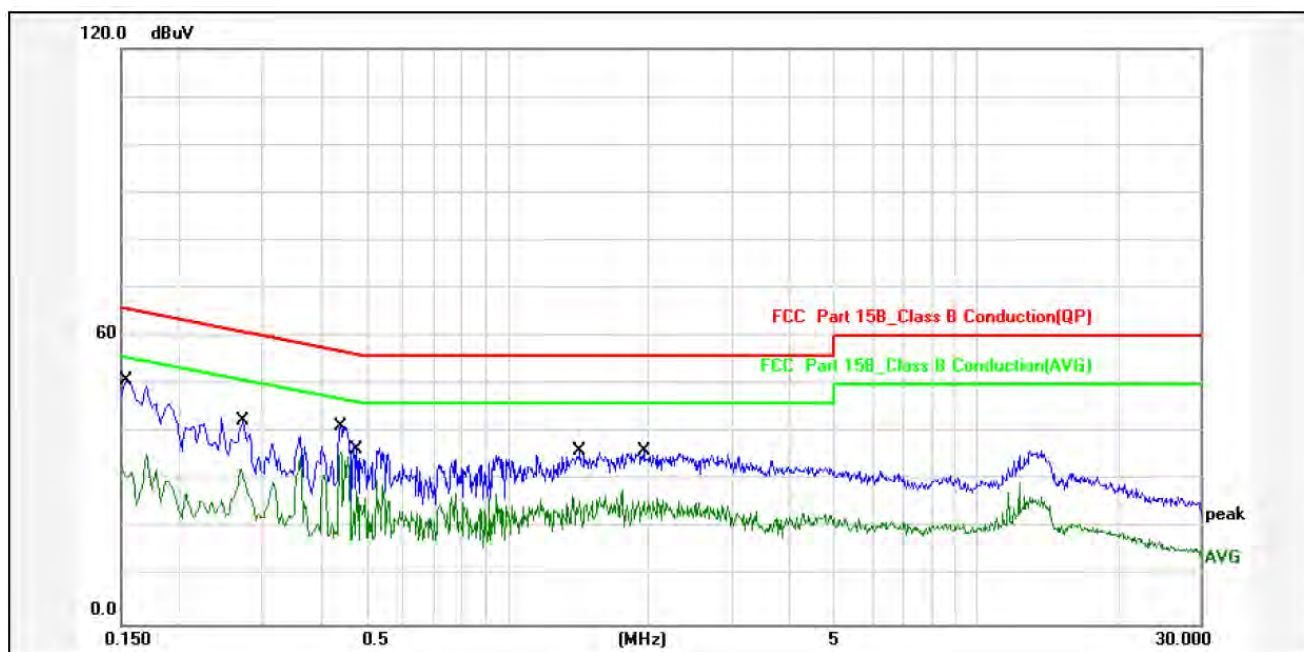
Detector: RBW 9KHz, VBW 30KHz

Operation Mode: BT Communication

3.3 Measurement Results

PASS

Please refer to the following pages of the worst case



Report No.: NTC1909234FV00

Test Standard: FCC Part 15B_Class B Conduction(QP)

Test item: Conducted Emission

Phase: N

Applicant: Banana Phone LLC

Temp.(C)/Hum.(%): 27(°C) / 55.5 %

Product: Banana Phone

Power Rating: AC 120V/60Hz

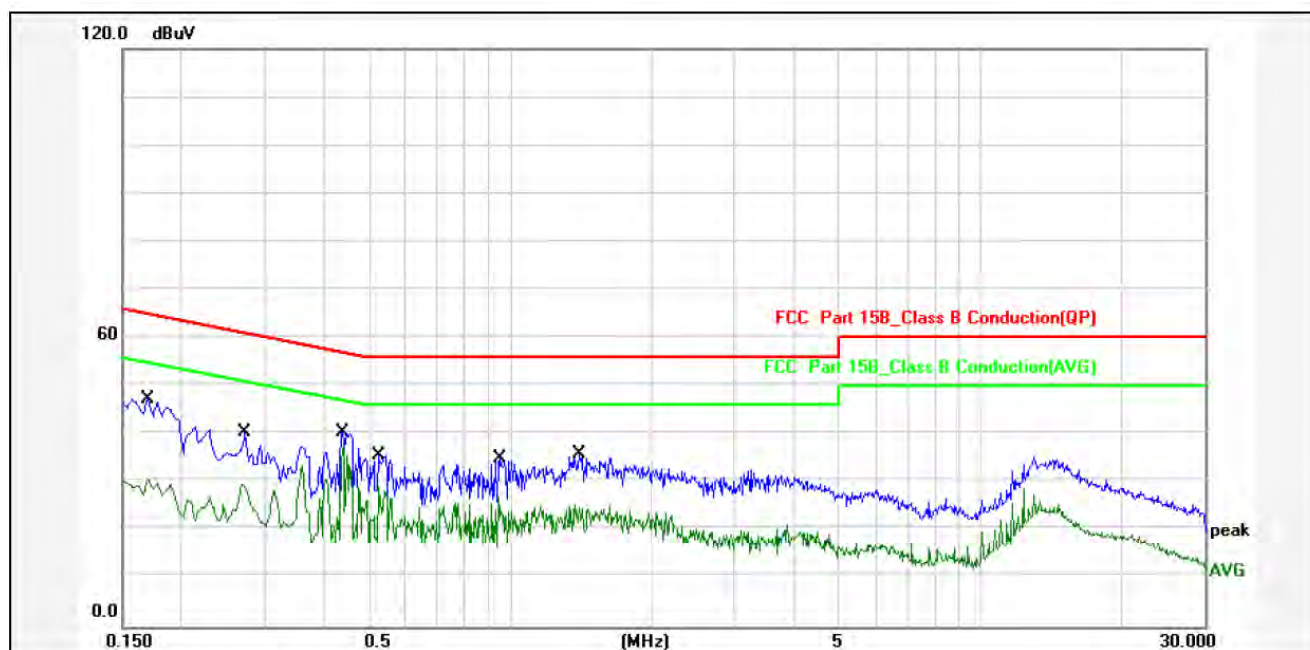
Model No.: 002

Test Engineer: Talon

Test Mode: BT Communication

Remark:

No.	Frequency (MHz)	Factor (dB)	Reading (dBuV)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1539	6.64	44.08	50.72	65.78	-15.06	QP	P	
2	0.1539	6.64	25.26	31.90	55.78	-23.88	AVG	P	
3	0.2740	6.48	36.00	42.48	60.99	-18.51	QP	P	
4	0.2740	6.48	25.78	32.26	50.99	-18.73	AVG	P	
5	0.4420	6.51	34.88	41.39	57.02	-15.63	QP	P	
6	0.4420	6.51	29.39	35.90	47.02	-11.12	AVG	P	
7	0.4780	6.53	31.22	37.75	56.37	-18.62	QP	P	
8	0.4780	6.53	21.25	27.78	46.37	-18.59	AVG	P	
9	1.4260	6.50	29.62	36.12	56.00	-19.88	QP	P	
10	1.4260	6.50	19.02	25.52	46.00	-20.48	AVG	P	
11	1.9580	6.54	29.74	36.28	56.00	-19.72	QP	P	
12	1.9580	6.54	19.09	25.63	46.00	-20.37	AVG	P	



Report No.: NTC1909234FV00

Test Standard: FCC Part 15B Class B Conduction(QP)

Test item: Conducted Emission

Phase: L1

Applicant: Banana Phone LLC

Temp.(C)/Hum.(%): 27(C) / 55.5 %

Product: Banana Phone

Power Rating: AC 120V/60Hz

Model No.: 002

Test Engineer: Talon

Test Mode: BT Communication

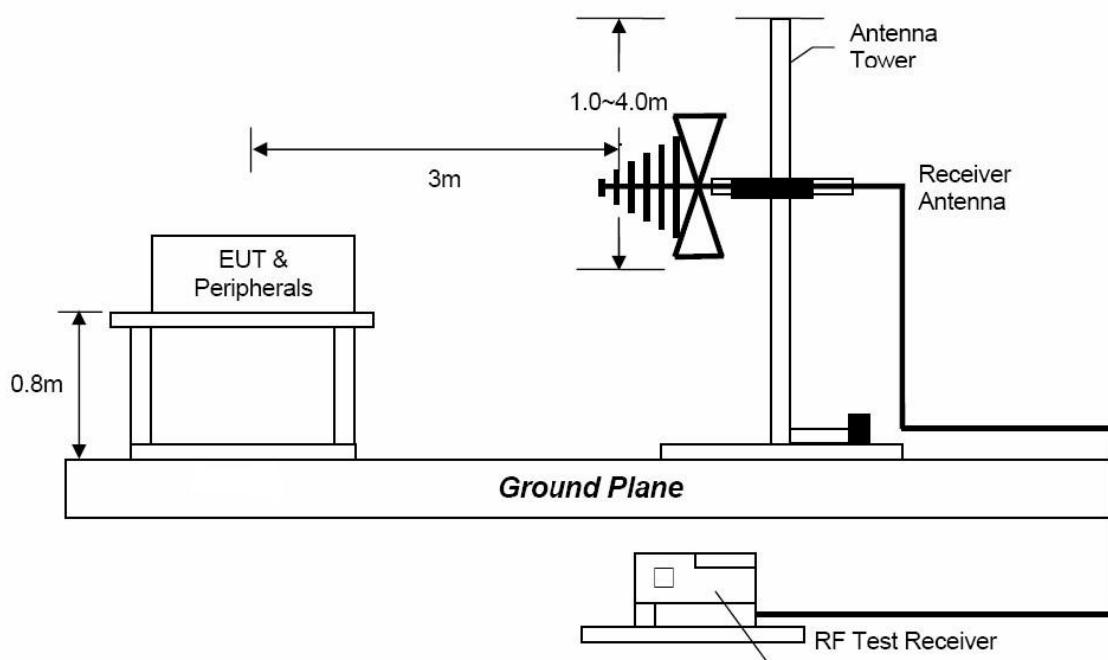
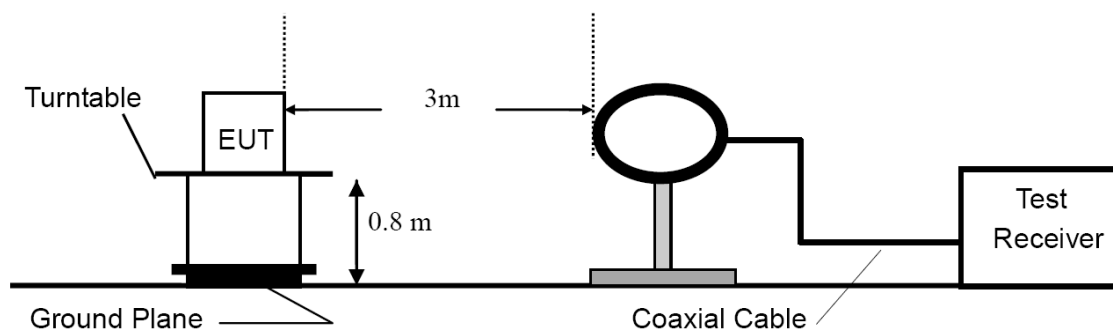
Remark:

No.	Frequency (MHz)	Factor (dB)	Reading (dBuV)	Level (dBuV)	Limit (dBuV)	Margin (dB)	Detector	P/F	Remark
1	0.1700	6.60	40.78	47.38	64.96	-17.58	QP	P	
2	0.1700	6.60	24.10	30.70	54.96	-24.26	AVG	P	
3	0.2740	6.48	33.76	40.24	60.99	-20.75	QP	P	
4	0.2740	6.48	23.02	29.50	50.99	-21.49	AVG	P	
5	0.4420	6.51	33.94	40.45	57.02	-16.57	QP	P	
6	0.4420	6.51	30.64	37.15	47.02	-9.87	AVG	P	
7	0.5260	6.53	29.04	35.57	56.00	-20.43	QP	P	
8	0.5260	6.53	22.43	28.96	46.00	-17.04	AVG	P	
9	0.9460	6.47	28.42	34.89	56.00	-21.11	QP	P	
10	0.9460	6.47	20.37	26.84	46.00	-19.16	AVG	P	
11	1.4100	6.50	29.45	35.95	56.00	-20.05	QP	P	
12	1.4100	6.50	18.73	25.23	46.00	-20.77	AVG	P	

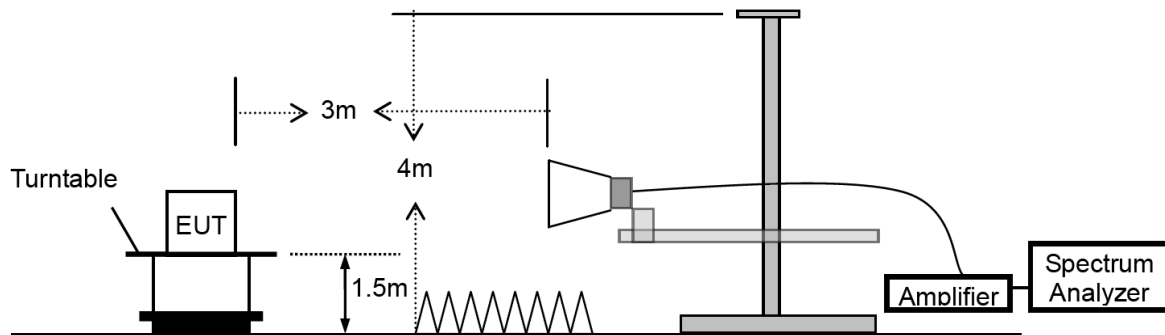
4. RADIATED EMISSION

4.1 Test SET-UP (Block Diagram of Configuration)

4.1.1 Radiated Emission Test Set-Up, Frequency below 30MHz



4.1.2 Radiated Emission Test Set-Up, Frequency above 1GHz



4.2 Measurement Procedure

- Blow 1GHz, the EUT was placed on the top of a rotating table 0.8 meters above the ground at a 3 meter semi- anechoic chamber room.
- For the radiated emission test above 1GHz:
The EUT was placed on the top of a rotating table 1.5 meters above the ground at a 3 meter full anechoic chamber room. The table was rotated 360 degrees to determine the position of the highest radiation. Place the measurement antenna away from each area of the EUT determined to be a source of emissions at the specified measurement distance, while keeping the measurement antenna aimed at the source of emissions at each frequency of significant emissions, with polarization oriented for maximum response. The measurement antenna may have to be higher or lower than the EUT, depending on the radiation pattern of the emission and staying aimed at the emission source for receiving the maximum signal. The final measurement antenna elevation shall be that which maximizes the emissions. The measurement antenna elevation for maximum emissions shall be restricted to a range of heights of from 1 m to 4 m above the ground or reference ground plane.
- The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- The height of antenna is varied from one meter to four meters above the ground to determine the maximum value of the field strength. Both horizontal and vertical polarizations of the antenna are set to make the measurement.
- For each suspected emission, the EUT was arranged to its worst case and then the antenna was tuned to heights from 1 meter to 4 meters and the rotatable table was turned from 0 degrees to 360 degrees to find the maximum reading. The test-receiver system was set to peak detect function and specified bandwidth with maximum hold mode.
- A Quasi-peak measurement was then made for that frequency point for below 1GHz test. PK and AV for above 1GHz emission test.

During the radiated emission test, the spectrum analyzer was set with the following configurations:

Frequency Band (MHz)	Level	Resolution Bandwidth	Video Bandwidth
30 to 1000	QP	120 kHz	300 kHz
Above 1000	Peak	1 MHz	3 MHz
	Average	1 MHz	10 Hz

4.3 Limit

Frequency range MHz	Distance Meters	Field Strengths Limit
		$\mu\text{V/m}$
0.009 ~ 0.490	300	$2400/F(\text{kHz})$
0.490 ~ 1.705	30	$24000/F(\text{kHz})$
1.705 ~ 30	30	30
30 ~ 88	3	100
88 ~ 216	3	150
216 ~ 960	3	200
Above 960	3	500

- Remark : (1) Emission level $(\text{dB})\mu\text{V} = 20 \log \text{Emission level } \mu\text{V/m}$
(2) The smaller limit shall apply at the cross point between two frequency bands.
(3) As shown in 15.35(b), for frequencies above 1000MHz, the field strength limits are based on average detector, however, the peak field strength of any emission shall not exceed the maximum permitted average limits, specified above by more than 20dB under any condition of modulation.
(4) The frequency range scanned is from the lowest radio frequency signal generated in the device which is greater than 9 kHz to the tenth harmonic of the highest fundamental frequency or 40 GHz, whichever is lower.

4.4 Measurement Results

Please refer to following plots of the worst case: $\pi/4$ -DQPSK Low channel.

Note: Below 30MHz, the emissions are lower than 20dB below the allowable limit. Therefore, 9kHz-30MHz data were not recorded.

Test Time: 2019/10/11 14:31:08



Report No.: NTC1909234FV00

Test Standard: FCC Part 15B 3M Radiation

Test item: Radiation Emission

Applicant: Banana Phone LLC

Product: Banana Phone

Model No.: 002

Test Distance:

Ant. Polarization: Horizontal

Temp.(C)/Hum.(%): 28.9(°C) / 47 %

Power Rating: DC 3.7V

Test Engineer: SLY

Test Mode: TX 2402MHz

Remark:

No.	Frequency (MHz)	Factor (dB/m)	Reading (dBuV)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	36.0007	-7.69	24.50	16.81	40.00	-23.19	QP	200	201	P	
2	117.7725	-8.15	29.76	21.61	43.50	-21.89	QP	200	89	P	
3	133.6188	-7.96	31.28	23.32	43.50	-20.18	QP	200	111	P	
4	301.4223	-6.98	36.10	29.12	46.00	-16.88	QP	200	149	P	
5	459.1144	-4.26	32.04	27.78	46.00	-18.22	QP	200	197	P	
6	845.0877	1.47	25.13	26.60	46.00	-19.40	QP	200	124	P	

Test Time: 2019/10/11 14:32:40



Report No.: NTC1909234FV00

Test Standard: FCC Part 15B 3M Radiation

Test item: Radiation Emission

Applicant: Banana Phone LLC

Product: Banana Phone

Model No.: 002

Test Distance:

Ant. Polarization: Vertical

Temp.(C)/Hum.(%): 28.9(C) / 47 %

Power Rating: DC 3.7V

Test Engineer: SLY

Test Mode: TX 2402MHz

Remark:

No.	Frequency (MHz)	Factor (dB/m)	Reading (dBuV)	Level (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Azimuth (deg.)	P/F	Remark
1	43.2017	-13.50	30.12	16.62	40.00	-23.38	QP	100	132	P	
2	57.5939	-18.14	35.11	16.97	40.00	-23.03	QP	100	169	P	
3	112.1305	-8.32	29.43	21.11	43.50	-22.39	QP	100	212	P	
4	132.2206	-7.88	29.56	21.68	43.50	-21.82	QP	100	354	P	
5	440.1963	-4.66	26.82	22.16	46.00	-23.84	QP	100	271	P	
6	752.7432	-0.11	27.46	27.35	46.00	-18.65	QP	100	188	P	

Modulation:	$\pi/4$ -DQPSK (the worst case)		
Frequency Range:	1-25GHz	Test Date:	September 27, 2019
Measured Distance:	3m	Temperature:	25 °C
Test By:	Sance	Humidity:	64 %
Test Result:	PASS		

Freq. (MHz)	Ant.Pol. (H/V)	Reading Level(dBuV)		Factor (dB/m)	Result Level (dBuV/m)		Limit @3m (dBuV/m)		Margin (dB)	
		PK	AV		PK	AV	PK	AV	PK	AV
Operation Mode: TX Mode (Low)										
4804	H	47.36	36.11	4.07	51.43	40.18	74.00	54.00	-22.57	-13.82
7206	H	46.67	33.23	10.27	56.94	43.50	74.00	54.00	-17.06	-10.50

4804	V	46.53	32.48	4.07	50.60	36.55	74.00	54.00	-23.40	-17.45
7206	V	45.38	31.09	10.27	55.65	41.36	74.00	54.00	-18.35	-12.64

Operation Mode: TX Mode (Mid)										
4882	H	45.61	34.13	4.57	50.18	38.70	74.00	54.00	-23.82	-15.30
7323	H	46.36	31.34	10.05	56.41	41.39	74.00	54.00	-17.59	-12.61

4882	V	46.43	31.51	4.57	51.00	36.08	74.00	54.00	-23.00	-17.92
7323	V	46.14	31.43	10.05	56.19	41.48	74.00	54.00	-17.81	-12.52

Operation Mode: TX Mode (High)										
4960	H	46.00	32.83	5.05	51.05	37.88	74.00	54.00	-22.95	-16.12
7440	H	49.78	32.82	9.76	59.54	42.58	74.00	54.00	-14.46	-11.42

4960	V	46.19	31.00	5.05	51.24	36.05	74.00	54.00	-22.76	-17.95
7440	V	46.27	31.26	9.76	56.03	41.02	74.00	54.00	-17.97	-12.98

Other harmonics emissions are lower than 10dB below the allowable limit.

- Note:**
- (1) All Readings are Peak Value and AV.
 - (2) Result Level = Reading Level + Factor
 - (3) Factor= Antenna Gain + Cable Loss – Amplifier Gain
 - (4) Data of measurement within this frequency range shown “---” in the table above means the reading of emissions are attenuated more than 10dB below the permissible limits.
 - (5) Measurement uncertainty: ± 3.7 dB.
 - (6) Horn antenna used for the emission over 1000MHz.

5. CHANNEL SEPARATION

5.1 Measurement Procedure

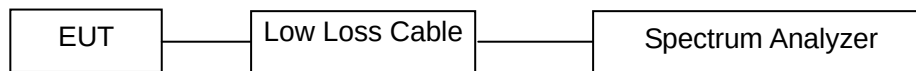
Minimum Hopping Channel Carrier Frequency Separation, FCC Rule 15.247(a)(1) & RSS-247 Section 5.1(b):

Connect EUT antenna terminal to the spectrum analyzer with a low loss cable, and using the Marker and Max-Hold function to record the separation of two adjacent channels.

5.2 Limit

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

5.3 Test SET-UP (Block Diagram of Configuration)



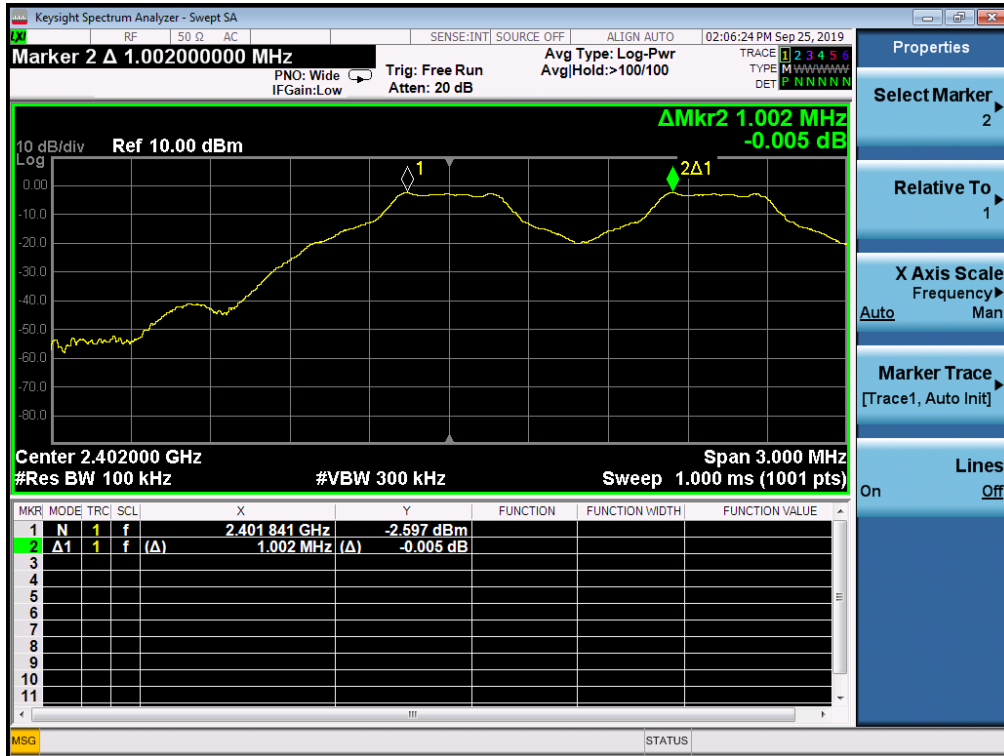
5.4 Measurement Results

Refer to attached data chart.

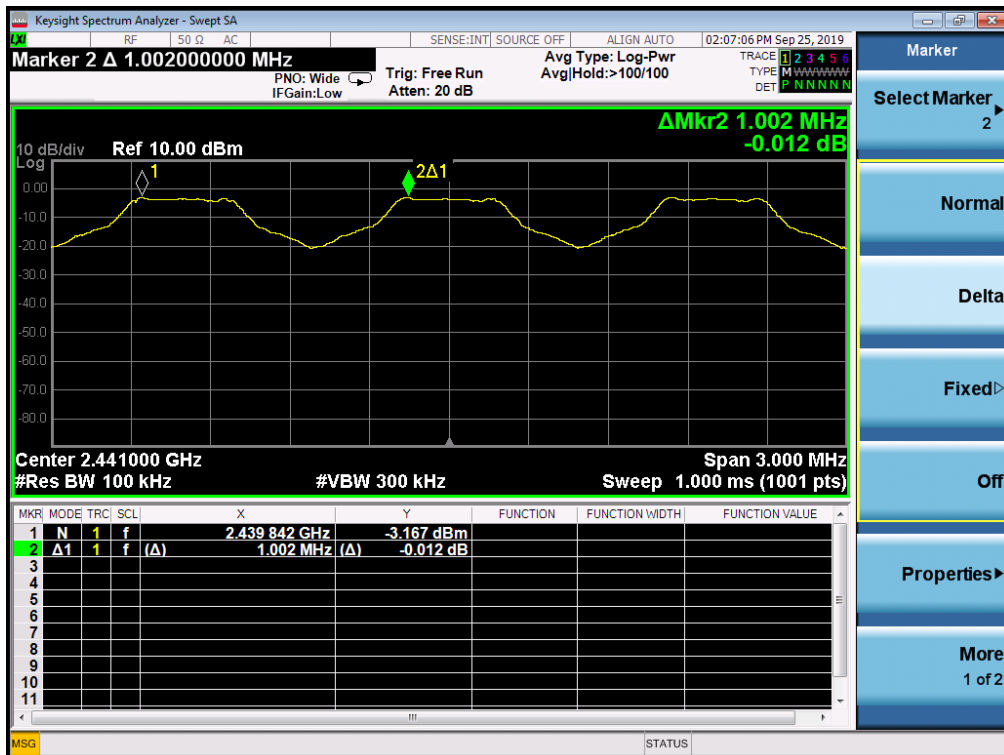
Modulation:	GFSK, $\pi/4$ -DQPSK		
RBW:	100kHz	VBW:	300kHz
Packet:	DH1, 2DH1 (Worst case)	Spectrum Detector:	PK
Test By:	Sance	Test Date:	Sep. 25, 2019
Temperature:	24 °C	Humidity:	50 %
Test Result:	PASS		

Channel	Test Frequency (MHz)	Separation Read Value (kHz)	Separation Limit 2/3 20dB Bandwidth (kHz)
GFSK			
Lowest	2402	1002	>632.3
Middle	2441	1002	>631.9
Highest	2480	1002	>631.5
$\pi/4$ -DQPSK			
Lowest	2402	1002	>872.0
Middle	2441	1002	>872.0
Highest	2480	1002	>873.0

GFSK Lowest Channel



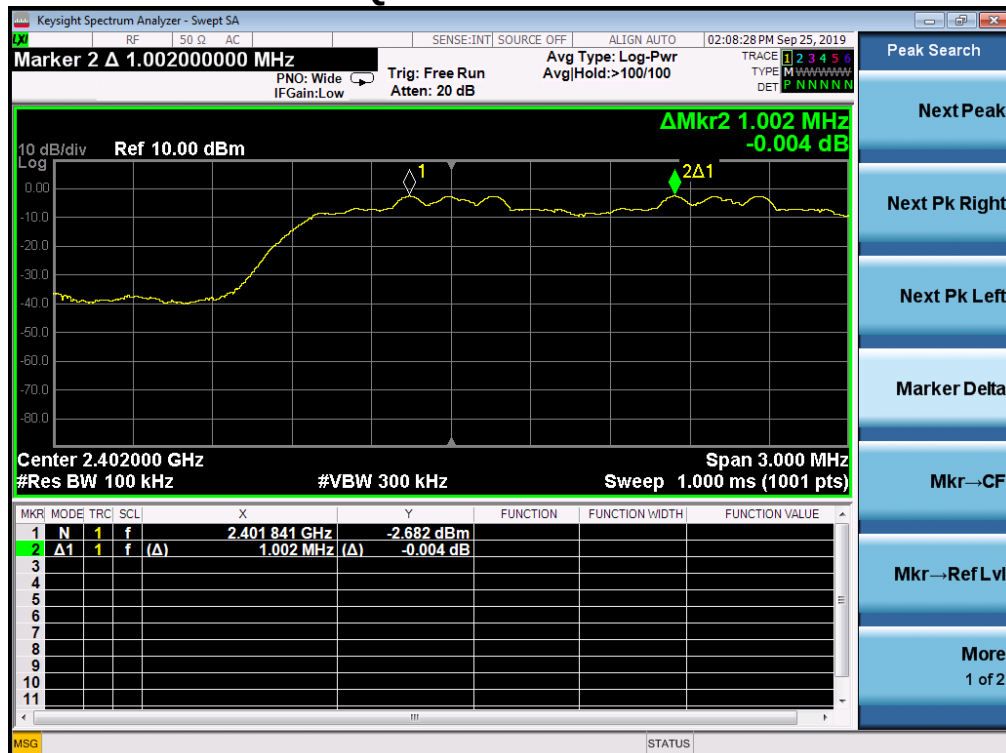
GFSK Middle Channel



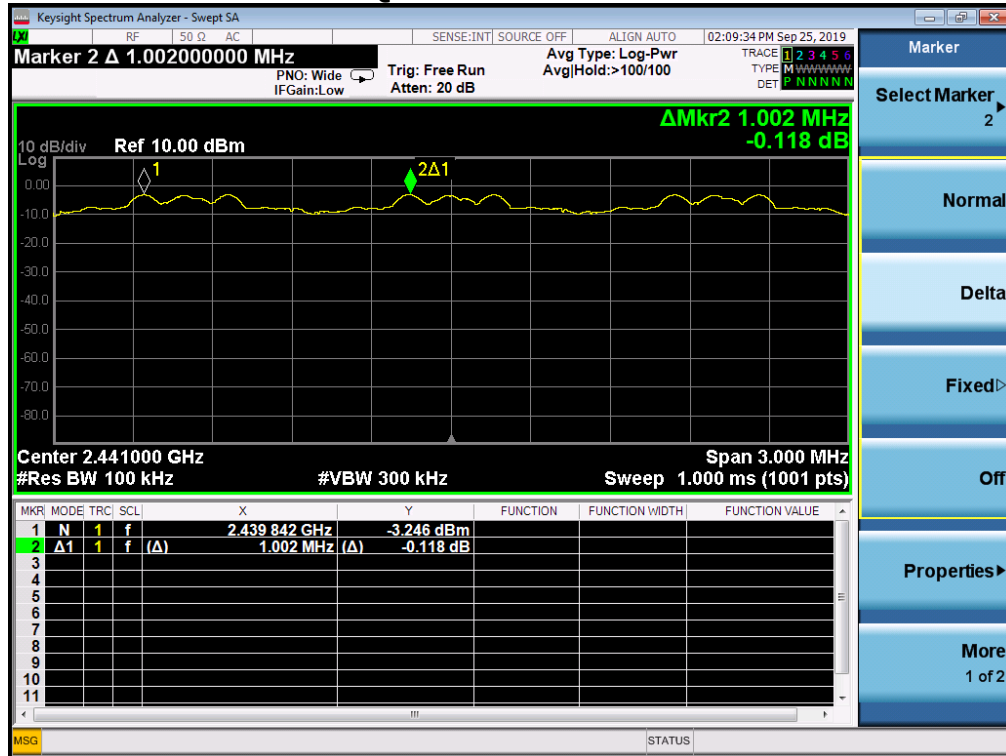
GFSK Highest Channel



$\pi/4$ -DQPSK Lowest Channel



$\pi/4$ -DQPSK Middle Channel



$\pi/4$ -DQPSK Highest Channel



6. 20DB BANDWIDTH AND 99% OCCUPIED BANDWIDTH

6.1 Measurement Procedure

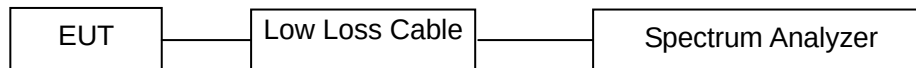
Maximum 20dB RF Bandwidth, FCC Rule 15.247(a)(1) & RSS-247 Section 5.1(a):

The antenna port of the EUT was connected to the input of a spectrum analyzer. Analyzer RBW was chosen so that the display was a result of the hopping channel modulation. For each RF output channel investigated, the spectrum analyzer center frequency was set to the channel carrier. Use the spectrum 20dB down delta function to measure the bandwidth.

99% Occupied Bandwidth, RSS-Gen Clause 6.7:

The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.

6.2 Test SET-UP (Block Diagram of Configuration)

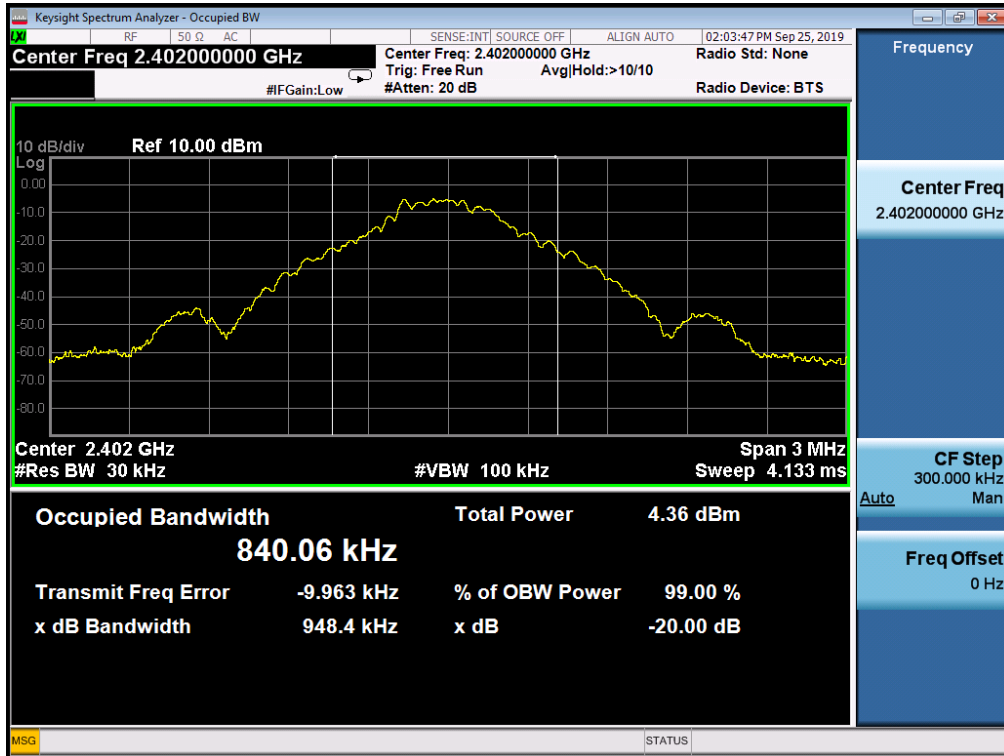


6.3 Measurement Results

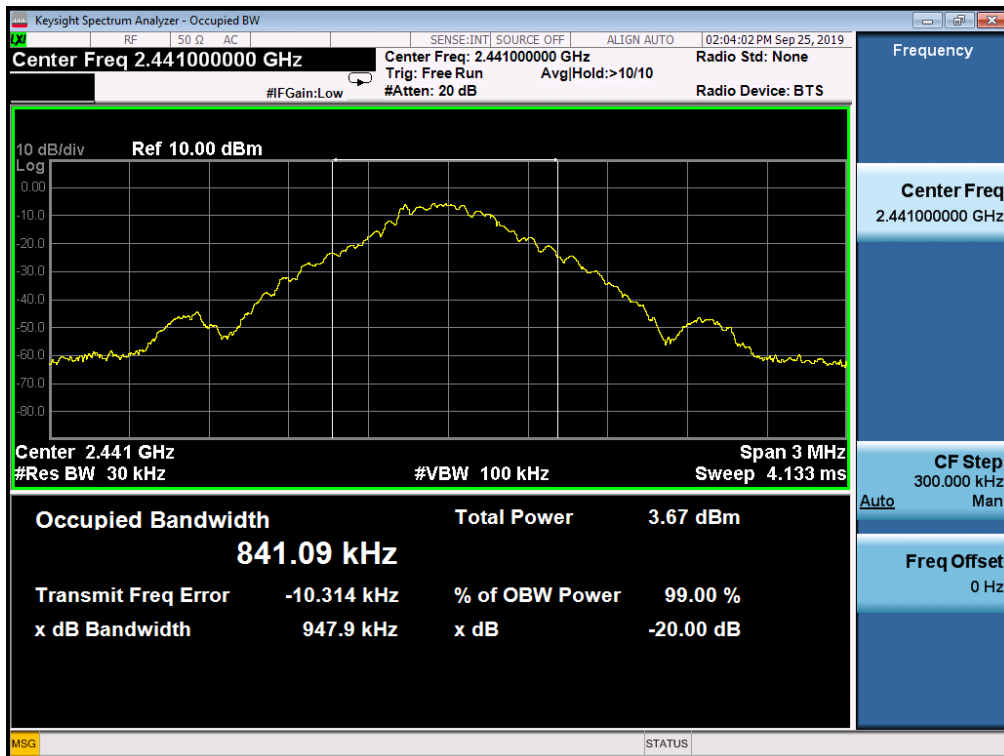
Modulation:	GFSK, $\pi/4$ -DQPSK		
RBW:	30kHz	VBW:	100kHz
Packet:	DH1, 2DH1(Worst case)	Spectrum Detector:	PK
Test By:	Sance	Test Date:	Sep. 25, 2019
Temperature:	24 °C	Humidity:	50 %

Channel	Test Frequency (MHz)	20dB Bandwidth (kHz)	99% Occupied Bandwidth (kHz)
GFSK			
Lowest	2402	948.4	840.06
Middle	2441	947.9	841.09
Highest	2480	947.3	842.48
$\pi/4$ -DQPSK			
Lowest	2402	1308.0	1175.6
Middle	2441	1308.0	1176.8
Highest	2480	1310.0	1177.4

GFSK Lowest Channel



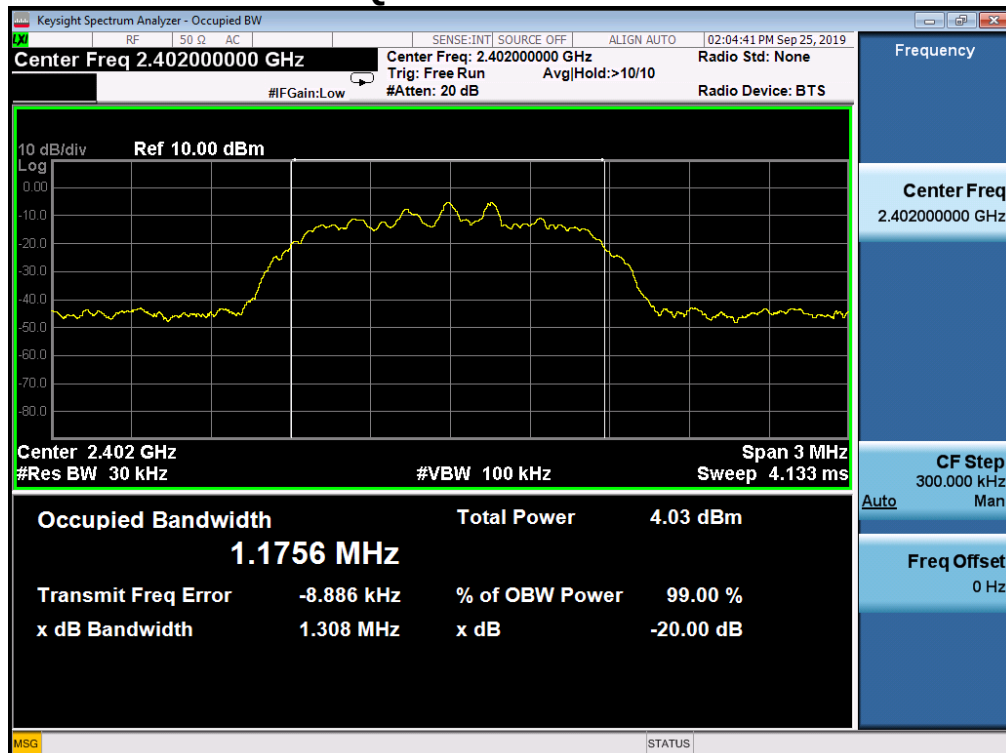
GFSK Middle Channel



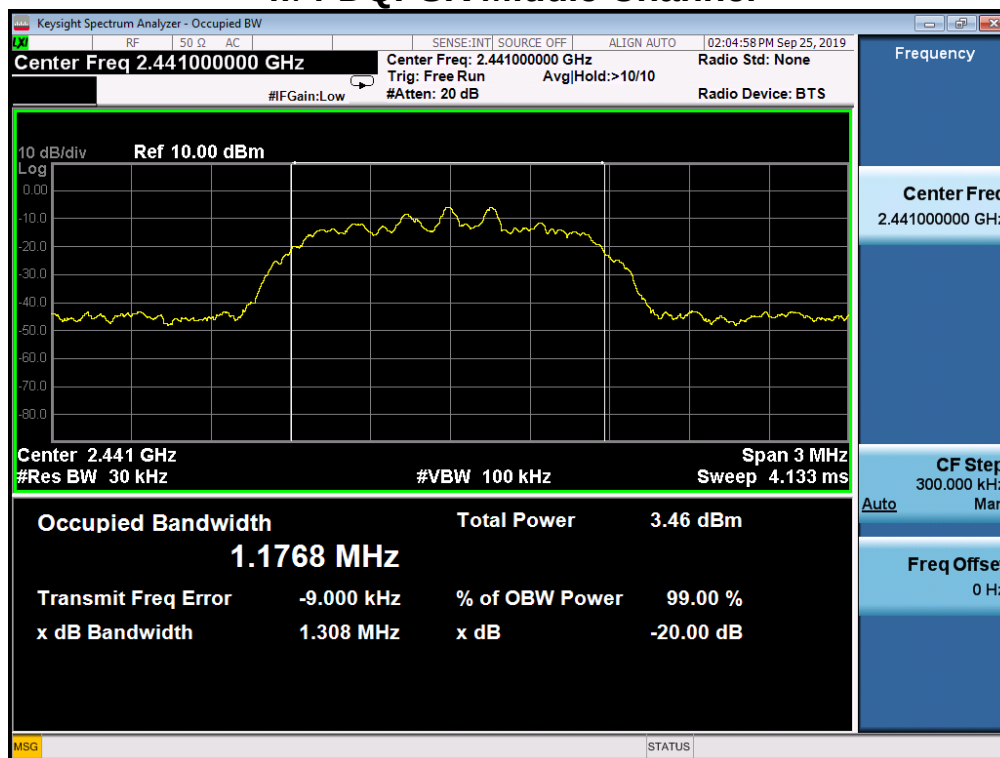
GFSK Highest Channel



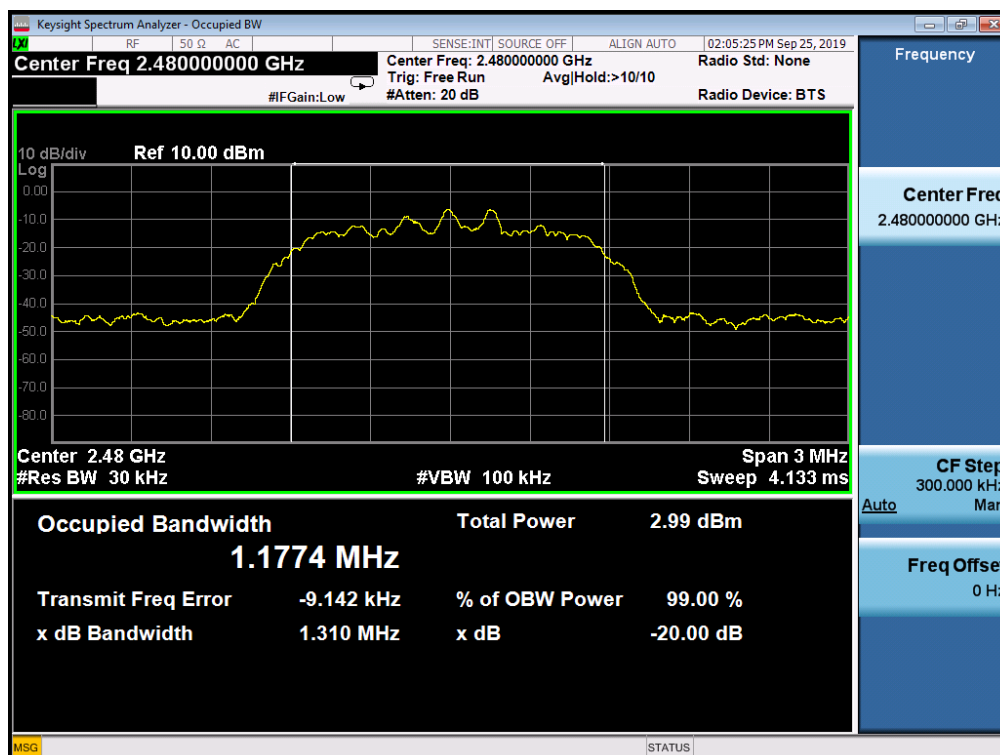
$\pi/4$ -DQPSK Lowest Channel



$\pi/4$ -DQPSK Middle Channel



$\pi/4$ -DQPSK Highest Channel



7. HOPPING CHANNEL NUMBER

7.1 Measurement Procedure

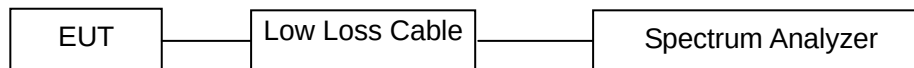
Minimum Number of Hopping Frequencies, FCC Rule 15.247(a)(1)(iii) & RSS-247 Section 5.1(d):

Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum, and the spectrum analyzer set to MAX HOLD readings were taken for 3-5 minutes. The channel peaks so recorded were added together, and the total number compared to the minimum number of channels required in the regulation.

7.2 Limit

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

7.3 Test SET-UP (Block Diagram of Configuration)

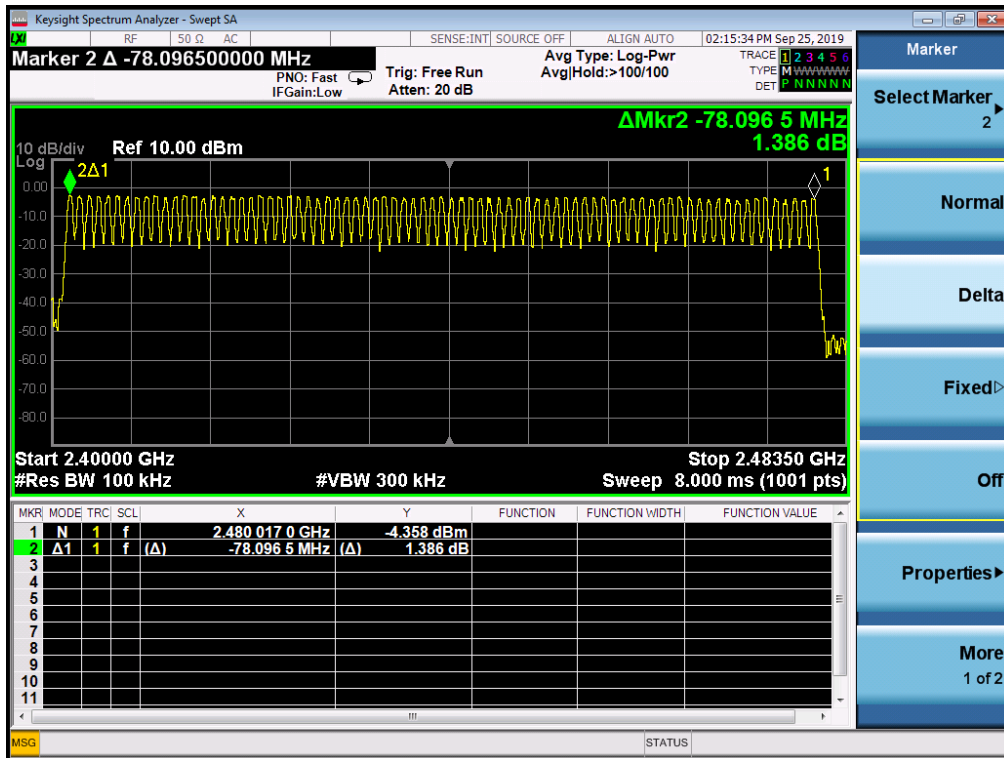


7.4 Measurement Results

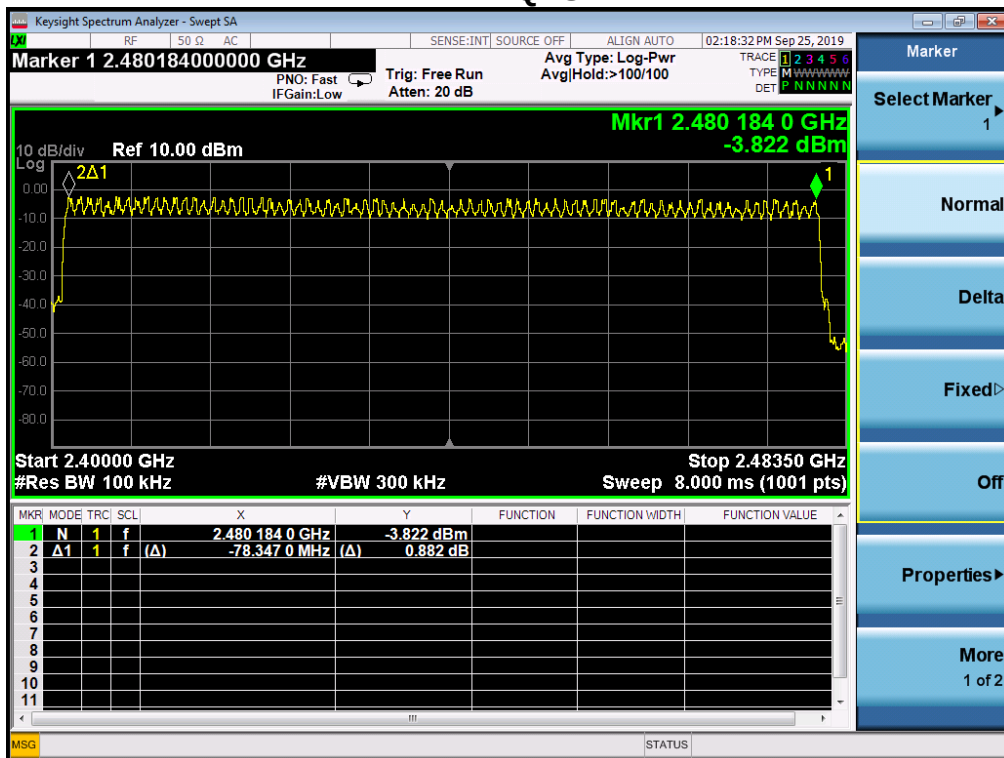
Modulation:	GFSK, $\pi/4$ -DQPSK		
RBW:	100kHz	VBW:	300kHz
Packet:	DH1, 2DH1(Worst case)	Spectrum Detector:	PK
Test By:	Sance	Test Date:	Sep. 25, 2019
Temperature:	24 °C	Humidity:	50 %
Test Result:	PASS		

Hopping Channel Frequency Range	Number of Hopping Channels	Limit
2400-2483.5	79	≥15

GFSK



$\pi/4$ -DQPSK



8. TIME OF OCCUPANCY (DWELL TIME)

8.1 Measurement Procedure

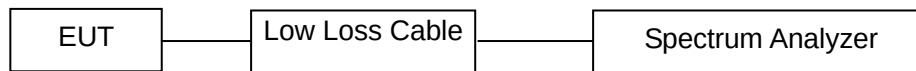
Average Channel Occupancy Time, FCC Ref: 15.247(a)(1)(iii) & RSS-247 Section 5.1(d):

Connect EUT antenna terminal to the spectrum analyzer with a low loss cable. The spectrum analyzer center frequency was set to one of the known hopping channels. The Sweep was set to 10 ms, the SPAN was set to Zero SPAN. The time duration of the transmissions so captured was measured with the Marker Delta function

8.2 Limit

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

8.3 Test SET-UP (Block Diagram of Configuration)



8.4 Measurement Results

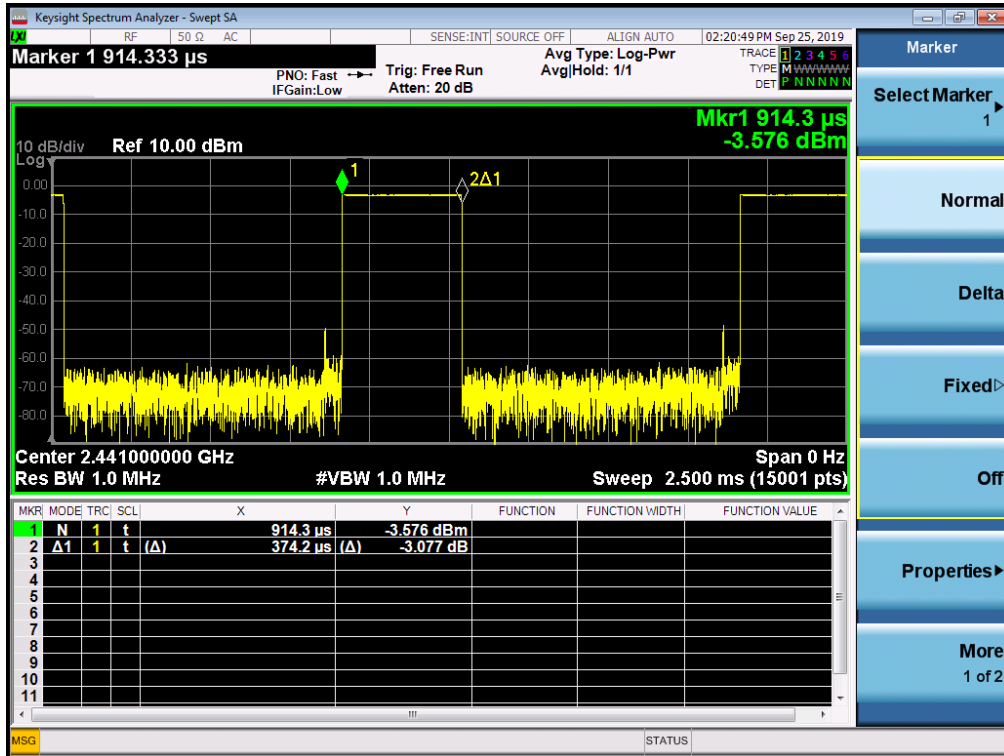
Refer to attached data chart.

The maximum number of hopping channels in 31.6s (0.4s/Channel x 79 Channel)

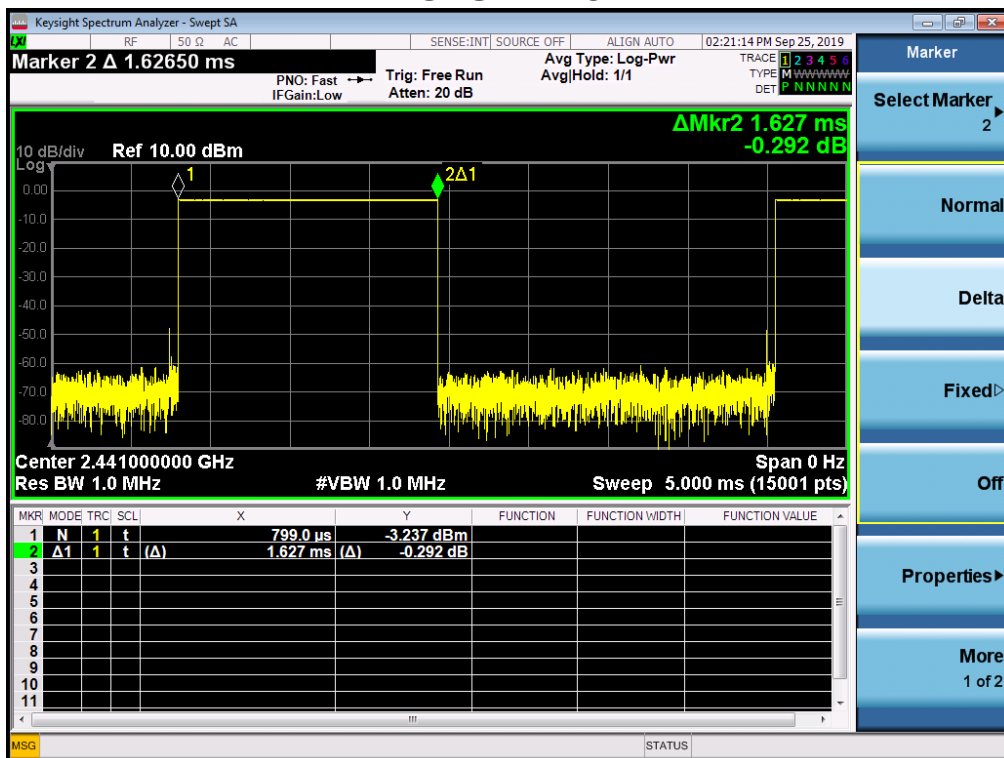
Modulation:	GFSK, $\pi/4$ -DQPSK		
RBW:	1MHz	VBW:	1MHz
Spectrum Detector:	PK	Test By:	Sance
Temperature:	24 °C	Humidity:	50 %
Test Result:	PASS	Test Date:	Sep. 25, 2019

Packet	Frequency (MHz)	Result (msec)			Limit (msec)
GFSK					
DH1	2441	0.374	(ms)*(1600/(2*79))*31.6=	119.68	400
DH3	2441	1.627	(ms)*(1600/(4*79))*31.6=	260.32	400
DH5	2441	2.875	(ms)*(1600/(6*79))*31.6=	306.67	400
π/4-DQPSK					
2-DH1	2441	0.385	(ms)*(1600/(2*79))*31.6=	123.20	400
2-DH3	2441	1.638	(ms)*(1600/(4*79))*31.6=	262.08	400
2-DH5	2441	2.887	(ms)*(1600/(6*79))*31.6=	307.95	400

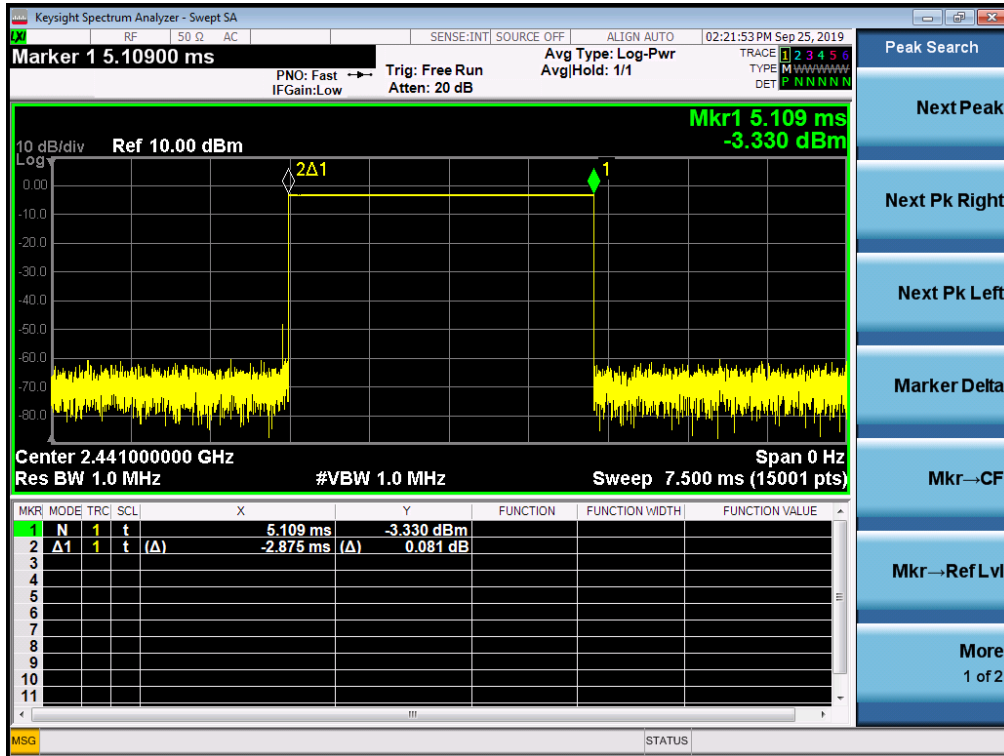
GFSK DH1



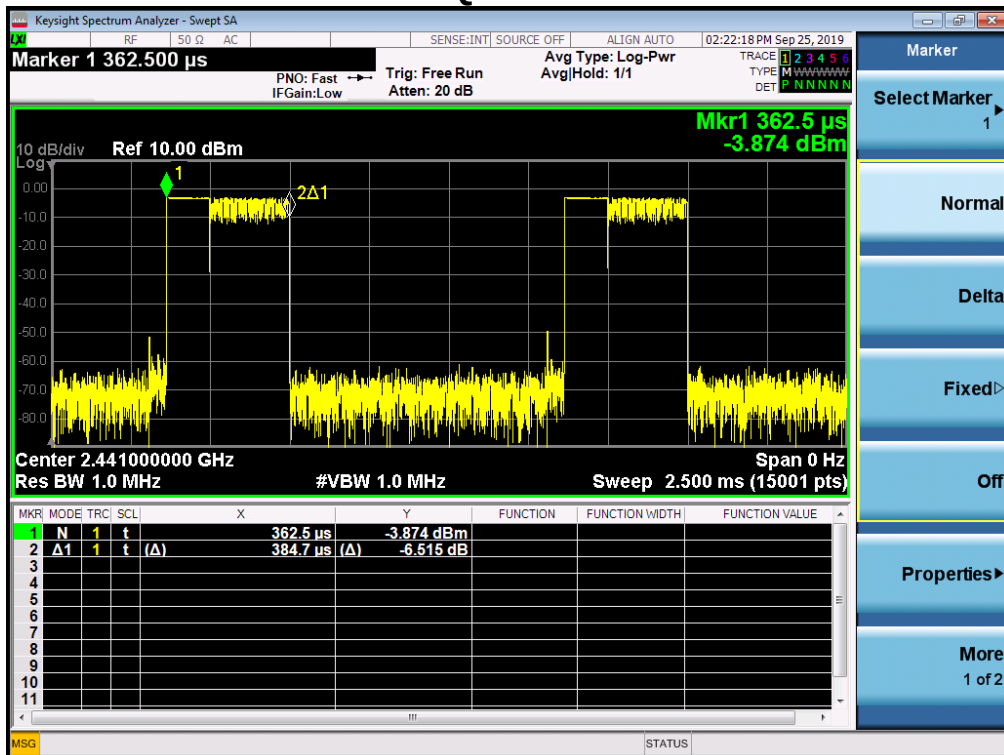
GFSK DH3



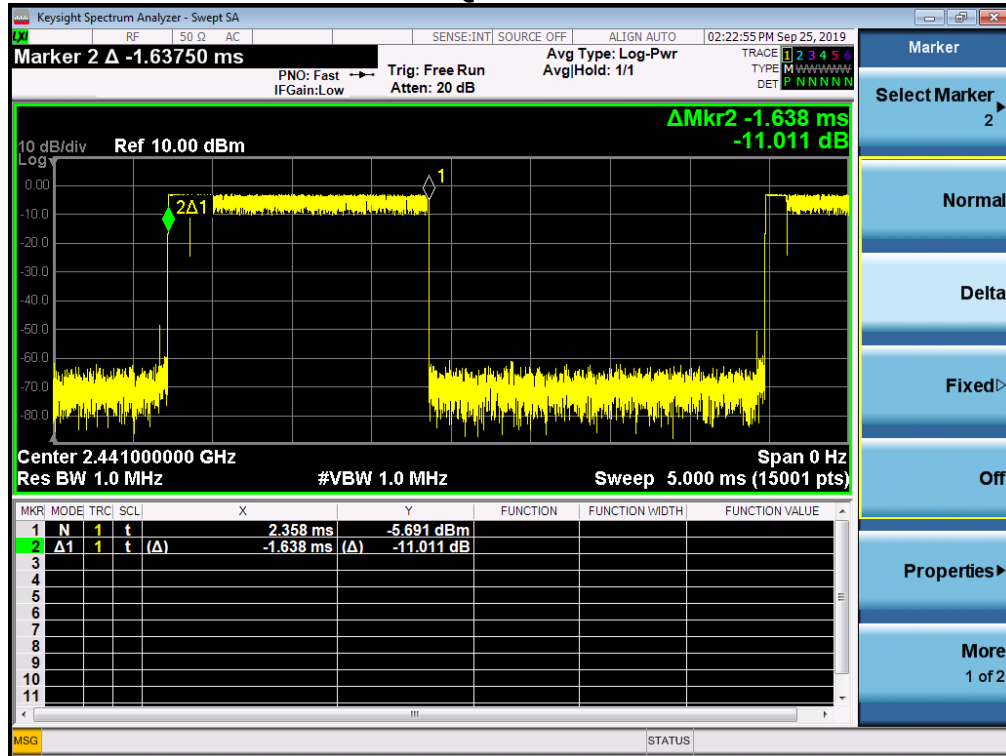
GFSK DH5



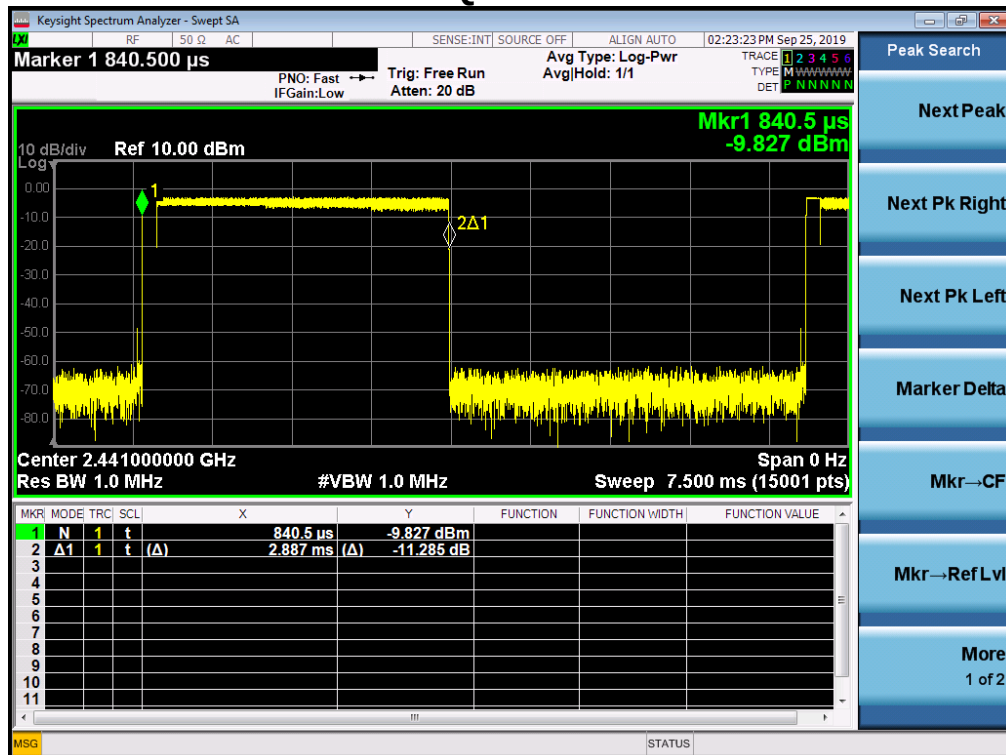
$\pi/4$ -DQPSK 2-DH1



$\pi/4$ -DQPSK 2-DH3



$\pi/4$ -DQPSK 2-DH5



9. MAXIMUM PEAK OUTPUT POWER

9.1 Measurement Procedure

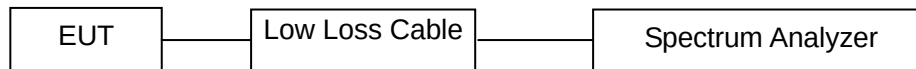
Maximum Conducted Output Power at Antenna Terminals, FCC Rules 15.247(b)(1) & RSS-247 Section 5.4(b):

Remove the antenna from the EUT and then connect a low RF cable from the antenna port to the spectrum. The analyzer was set for RBW > 20dB bandwidth and power was read directly in dBm. Cable loss was considered during this measurement.

9.2 Limit

For all other frequency hopping systems in the 2400-2483.5MHz band: 0.125 watts, The e.i.r.p. shall not exceed 4 W.

9.3 Test SET-UP (Block Diagram of Configuration)



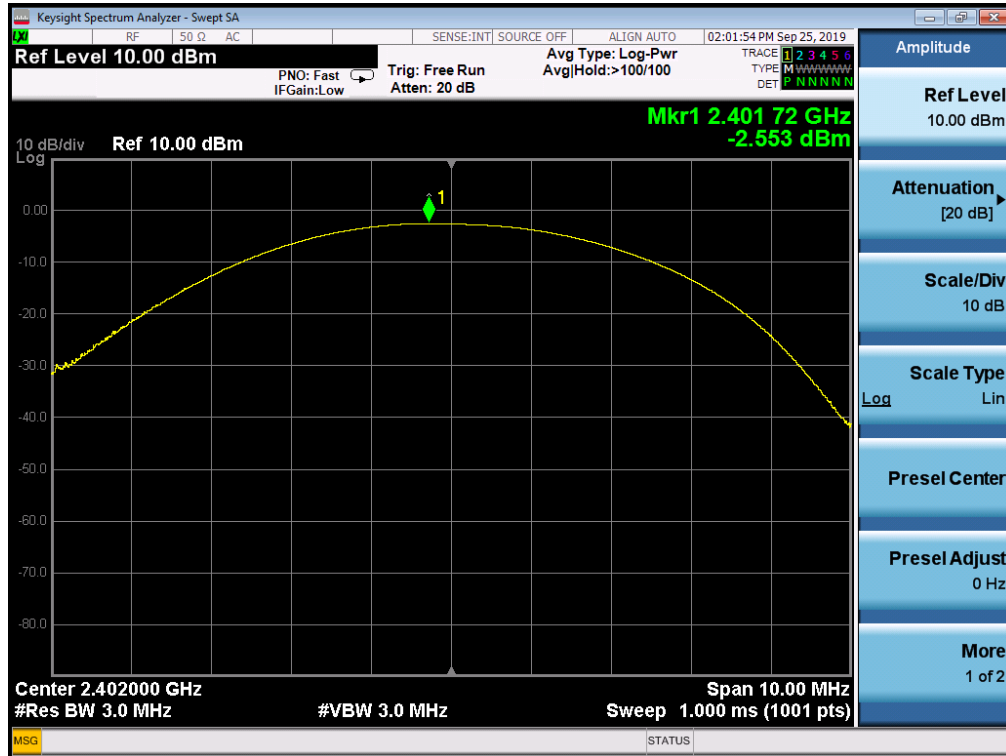
9.4 Measurement Results

RBW:	3MHz	VBW:	3MHz
Packet:	DH1, 2DH1 (Worst case)	Spectrum Detector:	PK
Test By:	Sance	Test Date:	Sep. 25, 2019
Temperature:	24 °C	Humidity:	50 %

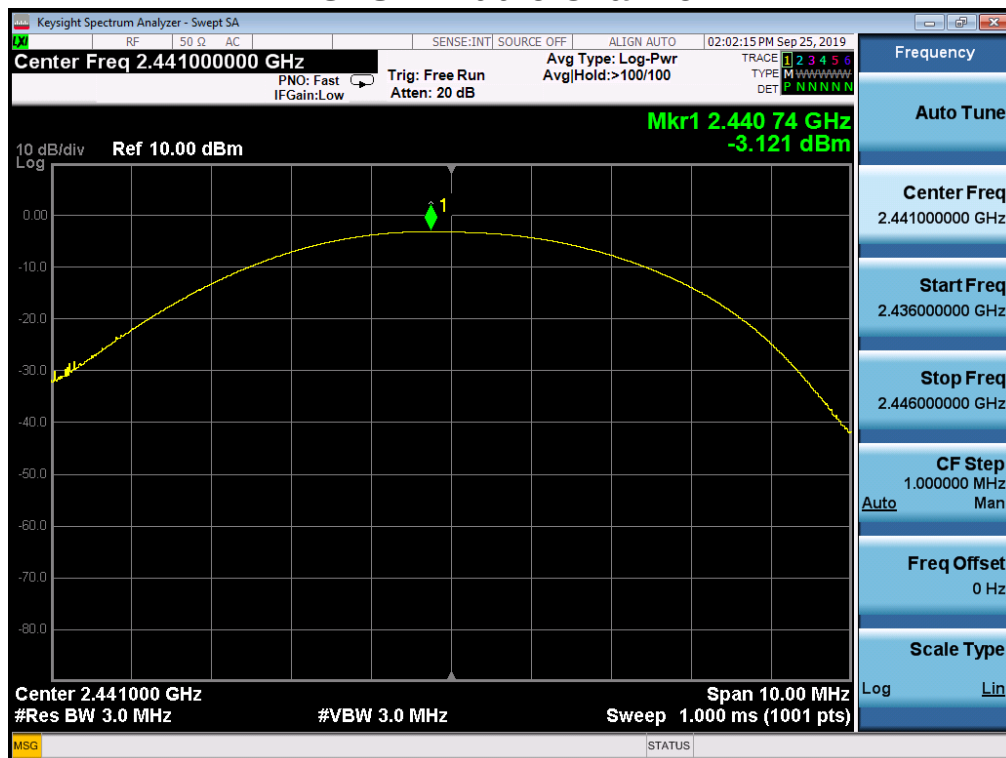
Channel Frequency (MHz)	Peak Power output (dBm/W)	e.i.r.p. (dBm/W)	Peak Power Limit (dBm/W)	e.i.r.p. Limit (dBm/W)	Results
GFSK					
2402.00	-2.553/0.0006	-3.133/0.0005	21 / 0.125	36 / 4	PASS
2441.00	-3.121/0.0005	-3.701/0.0004	21 / 0.125	36 / 4	PASS
2480.00	-3.634/0.0004	-4.214/0.0004	21 / 0.125	36 / 4	PASS
$\pi/4$-DQPSK					
2402.00	-1.780/0.0007	-2.360/0.0006	21 / 0.125	36 / 4	PASS
2441.00	-2.378/0.0006	-2.958/0.0005	21 / 0.125	36 / 4	PASS
2480.00	-2.899/0.0005	-3.479/0.0004	21 / 0.125	36 / 4	PASS

e.i.r.p. = Power output + Antenna Gain

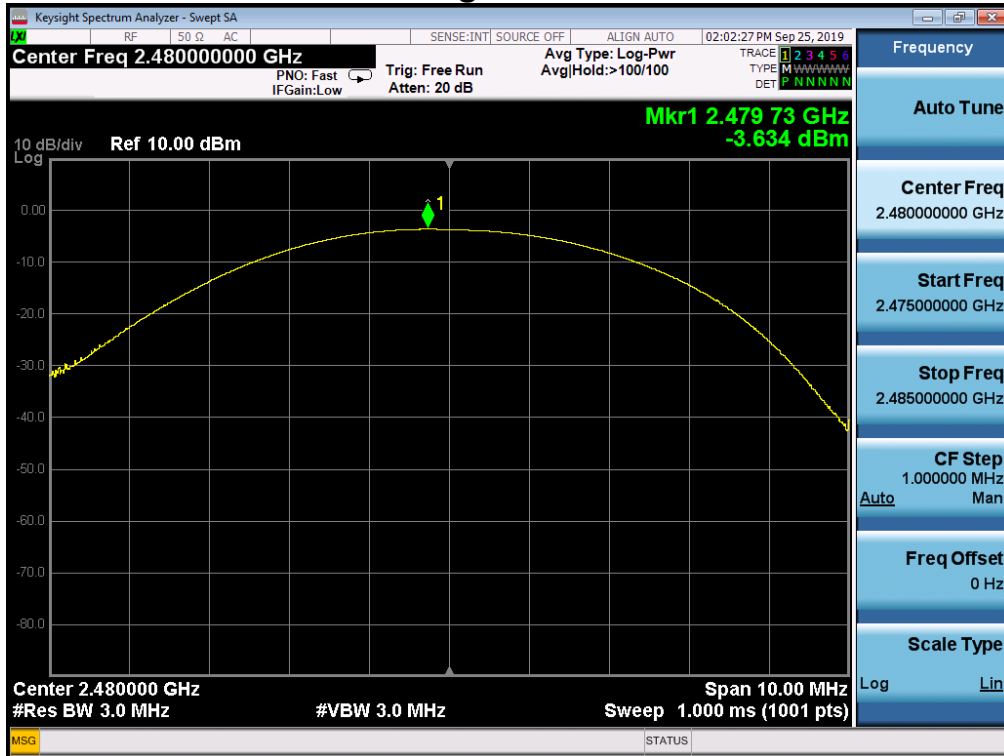
GFSK Lowest Channel



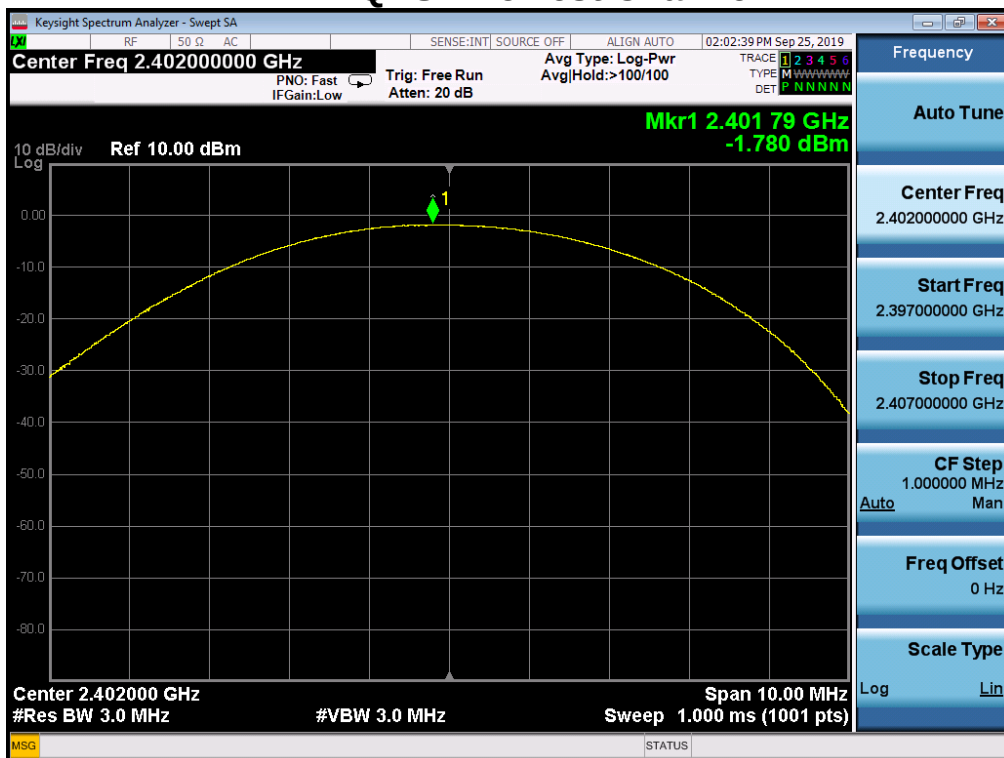
GFSK Middle Channel



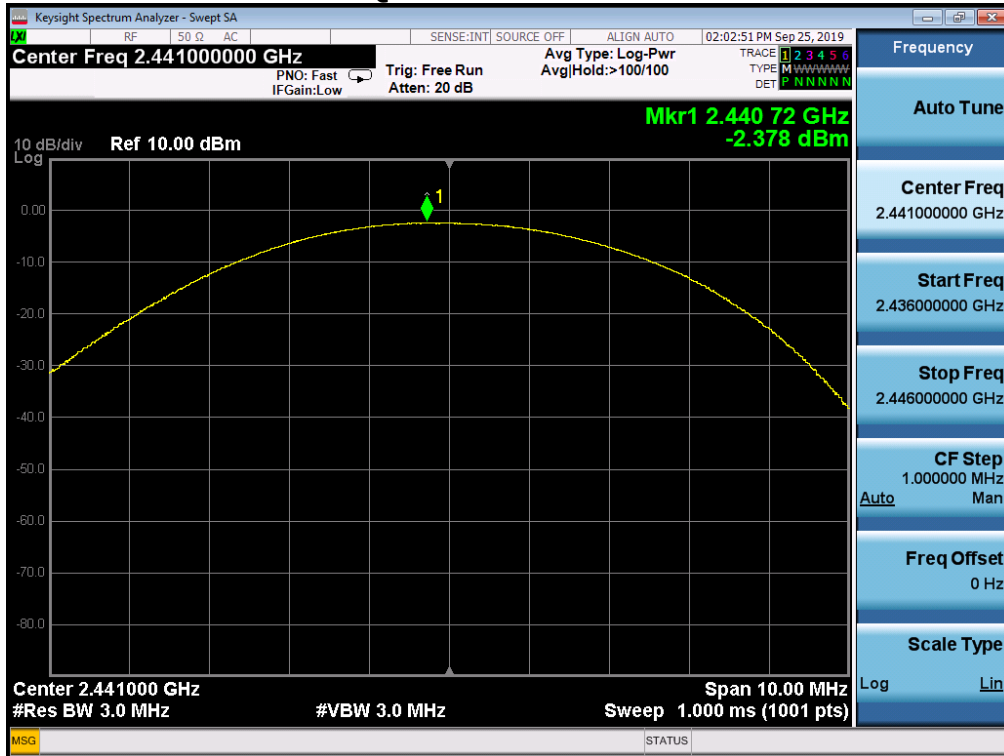
GFSK Highest Channel



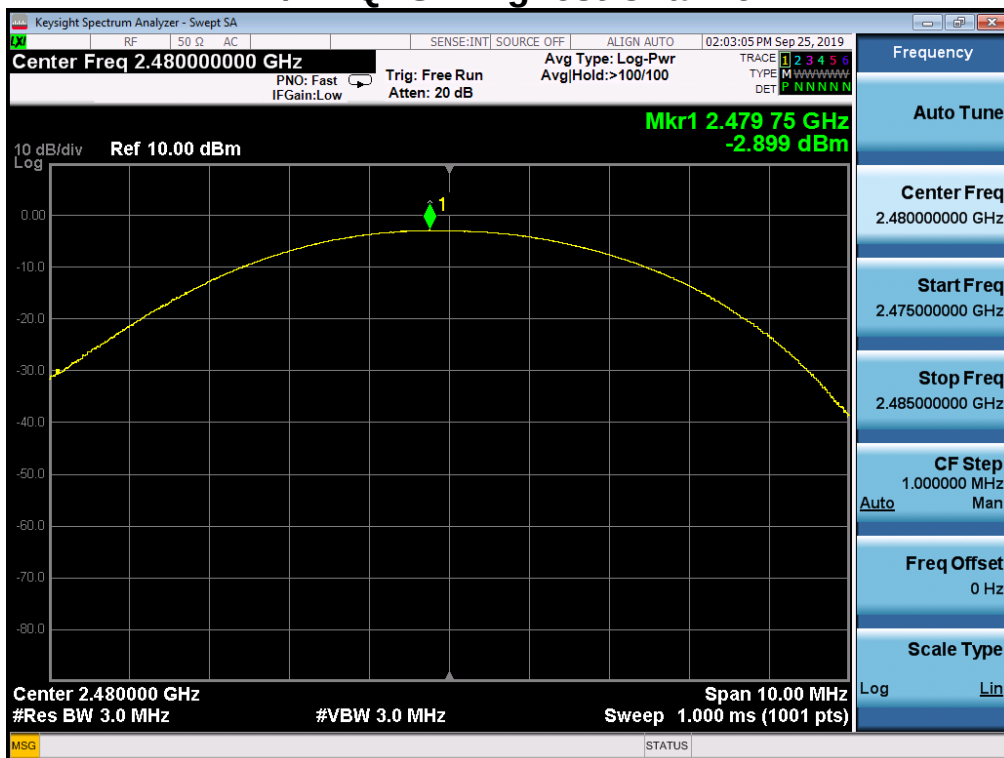
$\pi/4$ -DQPSK Lowest Channel



$\pi/4$ -DQPSK Middle Channel



$\pi/4$ -DQPSK Highest Channel



10. BAND EDGE

10.1 Measurement Procedure

Out of Band Conducted Emissions, FCC Rule 15.247(d) & RSS-247 Section 5.5:

The transmitter output is connected to spectrum analyzer. The resolution bandwidth is set to 100kHz, and the video bandwidth set to 300kHz.

10.2 Limit

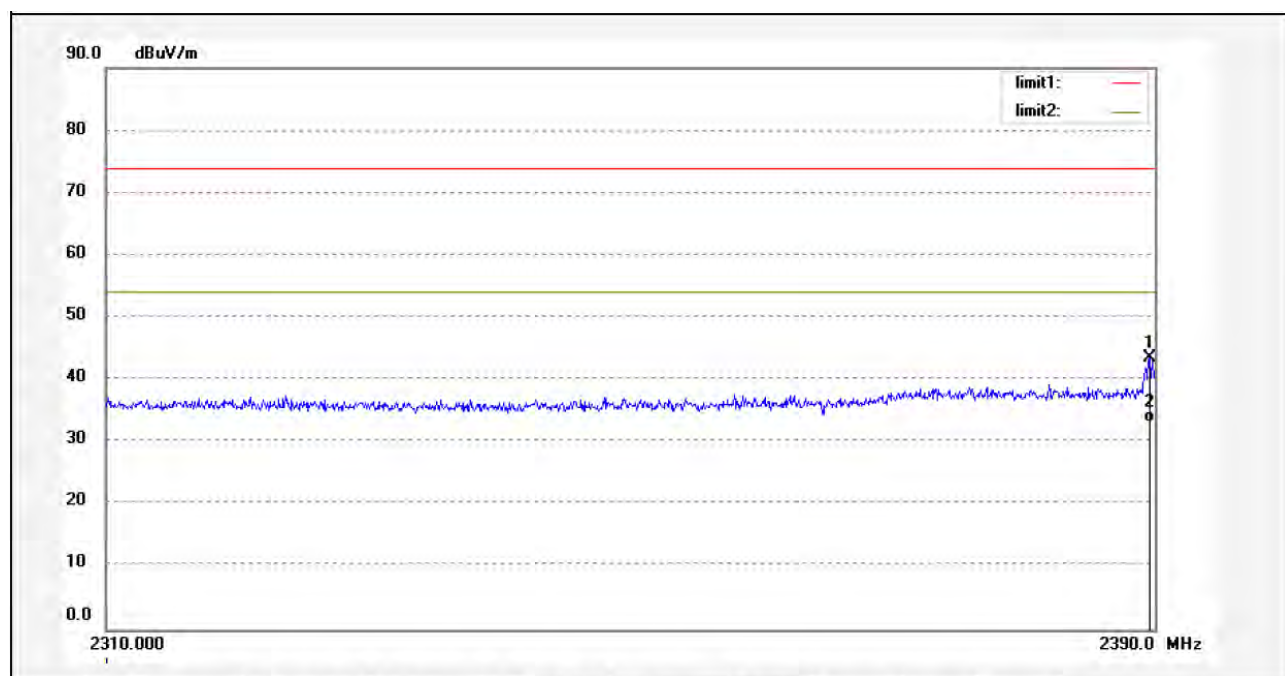
In any 100KHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100KHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

10.3 Measurement Results

Please see below test table and plots.

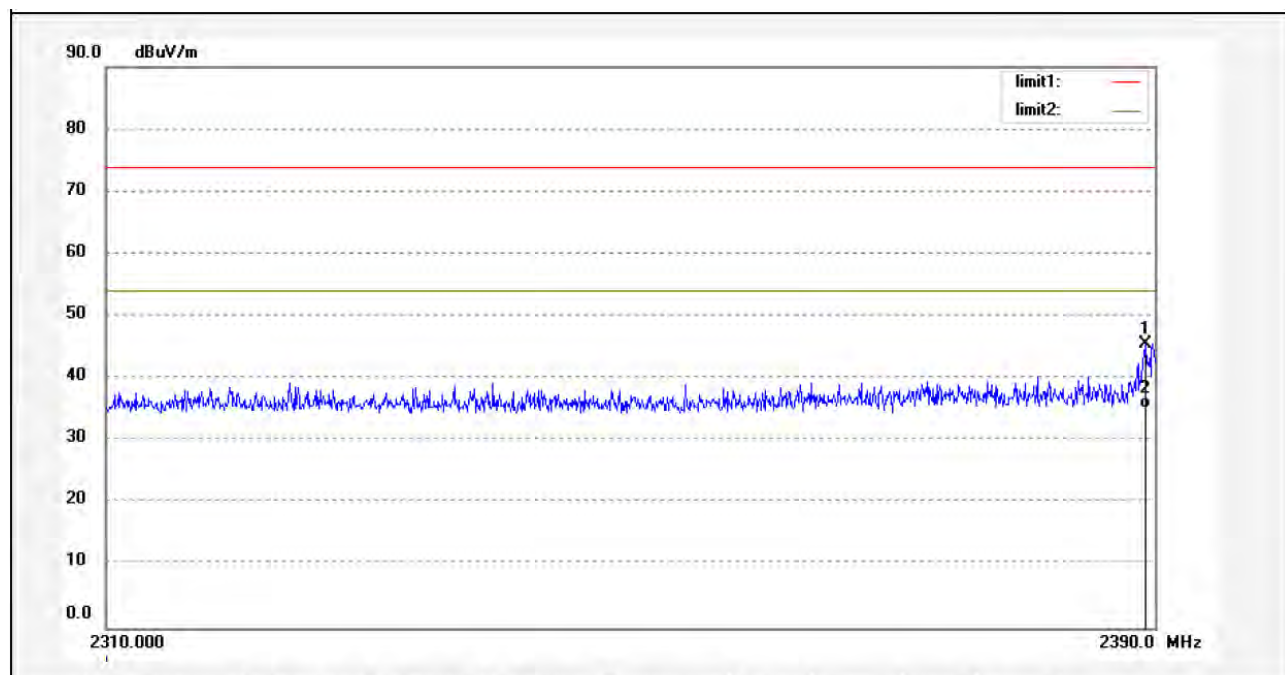
For Radiated restricted band: (The worst case: $\pi/4$ -DQPSK)

Temperature:	25 °C	Humidity:	64 %
Test By:	Sance	Test Date:	September 27, 2019
Measured Distance:	3m	Test Result:	PASS
Test Mode:	TX 2402MHz ($\pi/4$ -DQPSK)	Ant. Polarization:	Horizontal



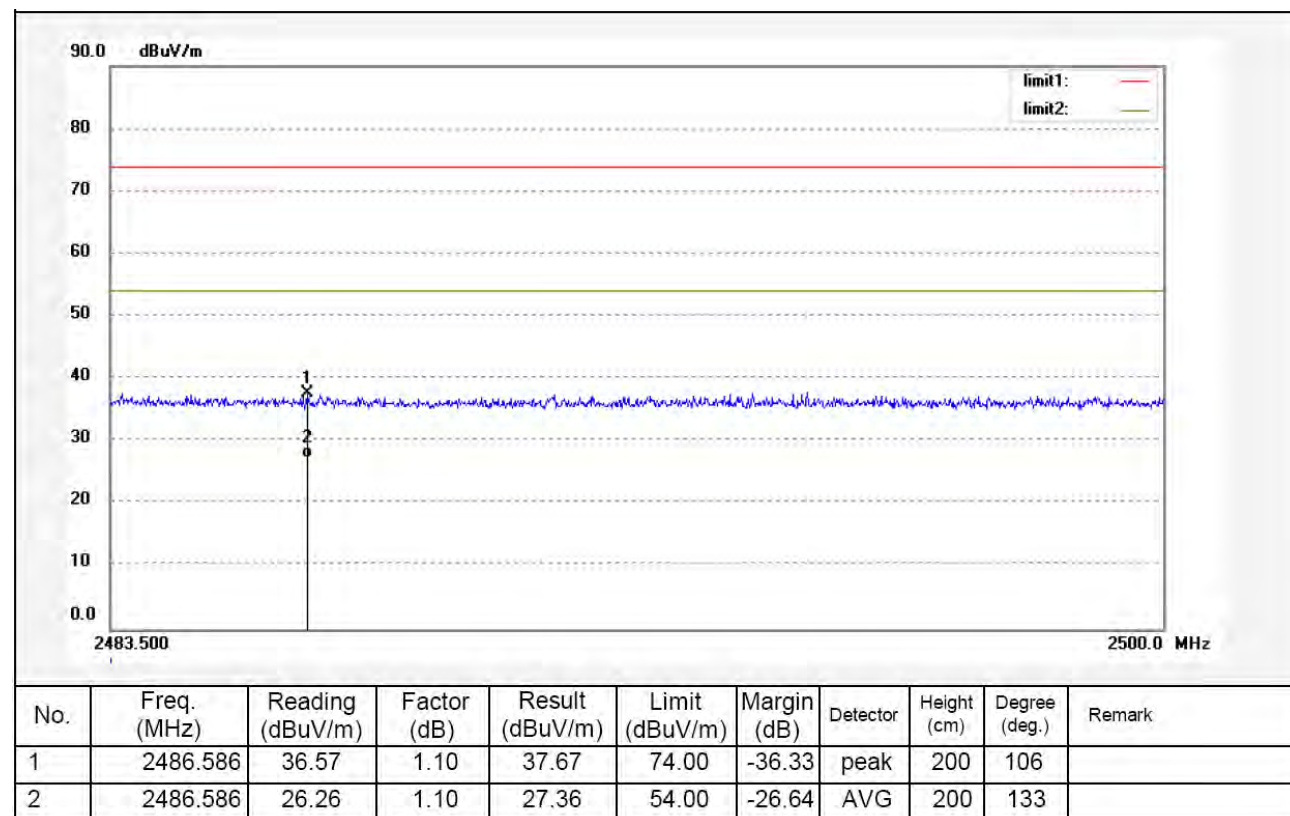
No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	2389.600	42.74	0.79	43.53	74.00	-30.47	peak	200	247	
2	2389.600	32.45	0.79	33.24	54.00	-20.76	AVG	200	264	

Temperature:	25 °C	Humidity:	64 %
Test By:	Sance	Test Date:	September 27, 2019
Measured Distance:	3m	Test Result:	PASS
Test Mode:	TX 2402MHz ($\pi/4$ -DQPSK)	Ant. Polarization:	Vertical

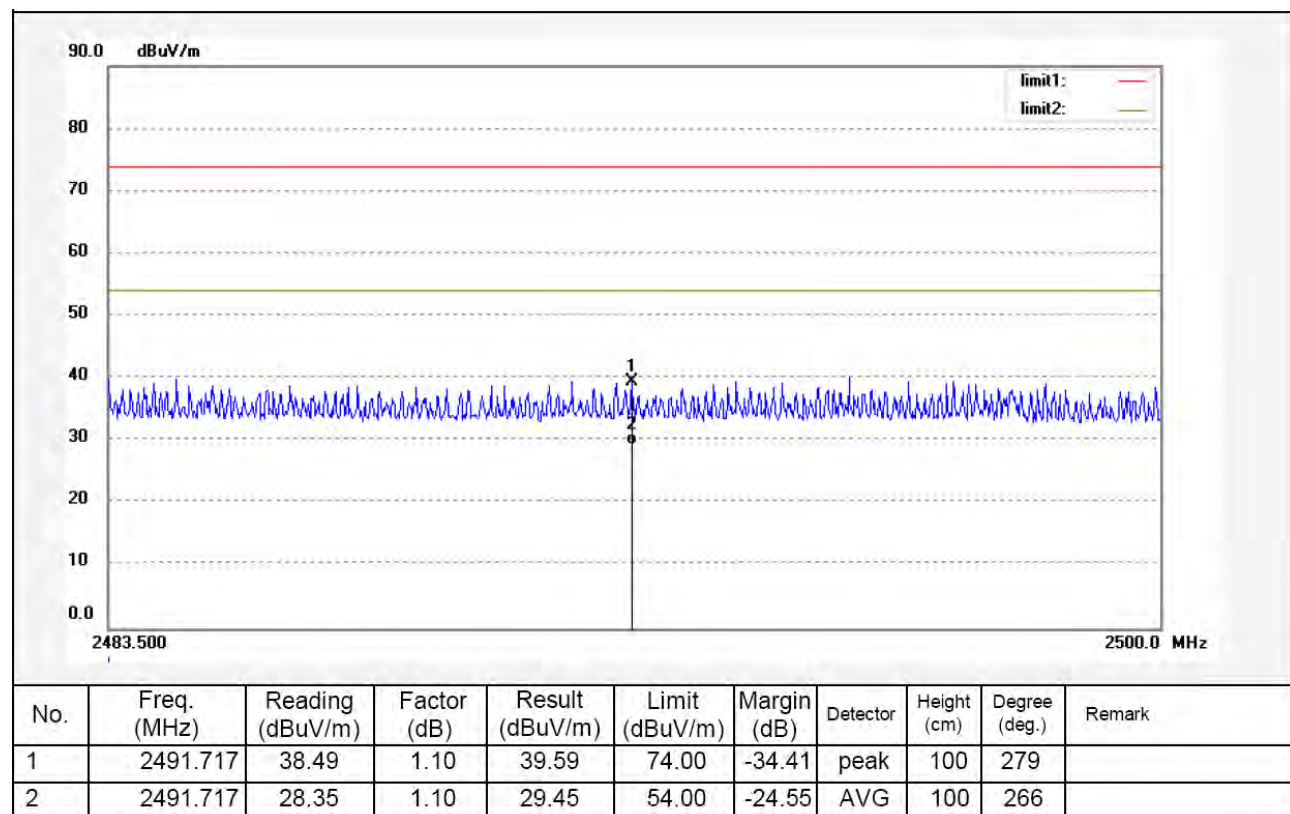


No.	Freq. (MHz)	Reading (dBuV/m)	Factor (dB)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Detector	Height (cm)	Degree (deg.)	Remark
1	2389.280	44.73	0.79	45.52	74.00	-28.48	peak	100	181	
2	2389.280	34.45	0.79	35.24	54.00	-18.76	AVG	100	199	

Temperature:	25 °C	Humidity:	64 %
Test By:	Sance	Test Date:	September 27, 2019
Measured Distance:	3m	Test Result:	PASS
Test Mode:	TX 2480MHz ($\pi/4$ -DQPSK)	Ant. Polarization:	Horizontal



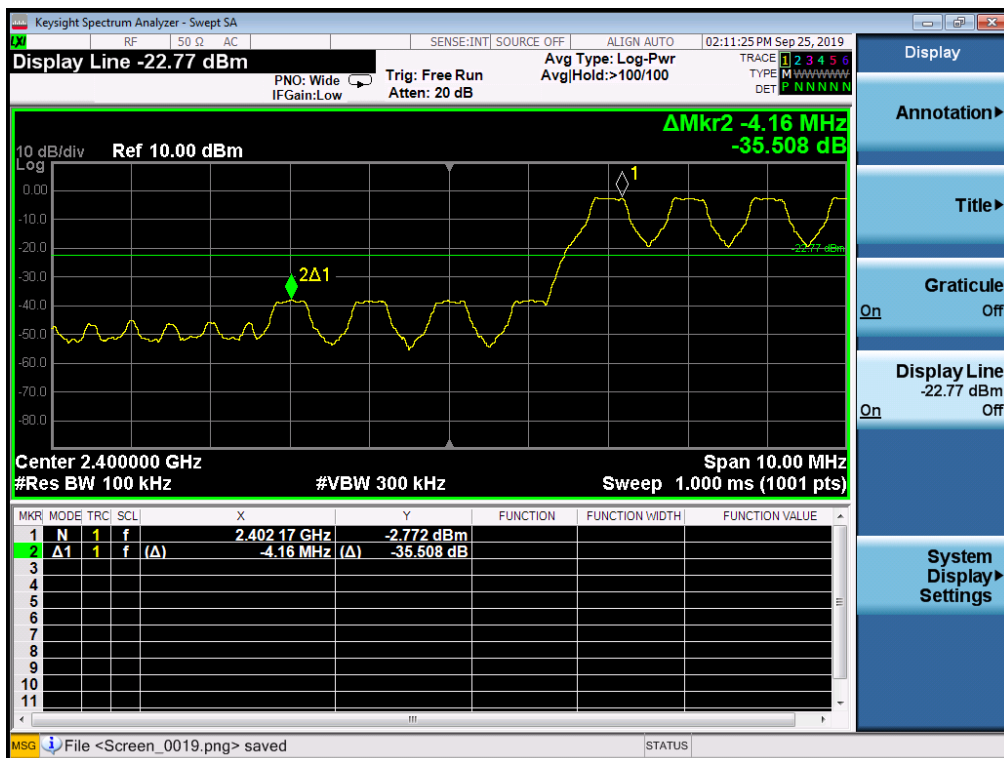
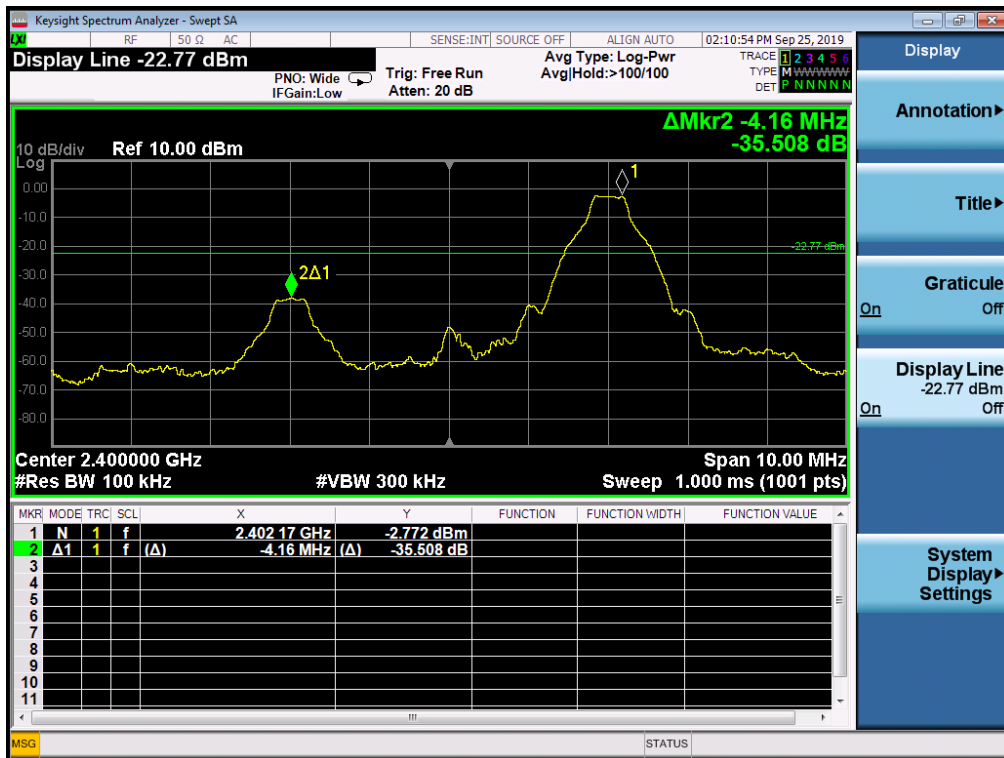
Temperature:	25 °C	Humidity:	64 %
Test By:	Sance	Test Date:	September 27, 2019
Measured Distance:	3m	Test Result:	PASS
Test Mode:	TX 2480MHz (π/4-DQPSK)	Ant. Polarization:	Vertical



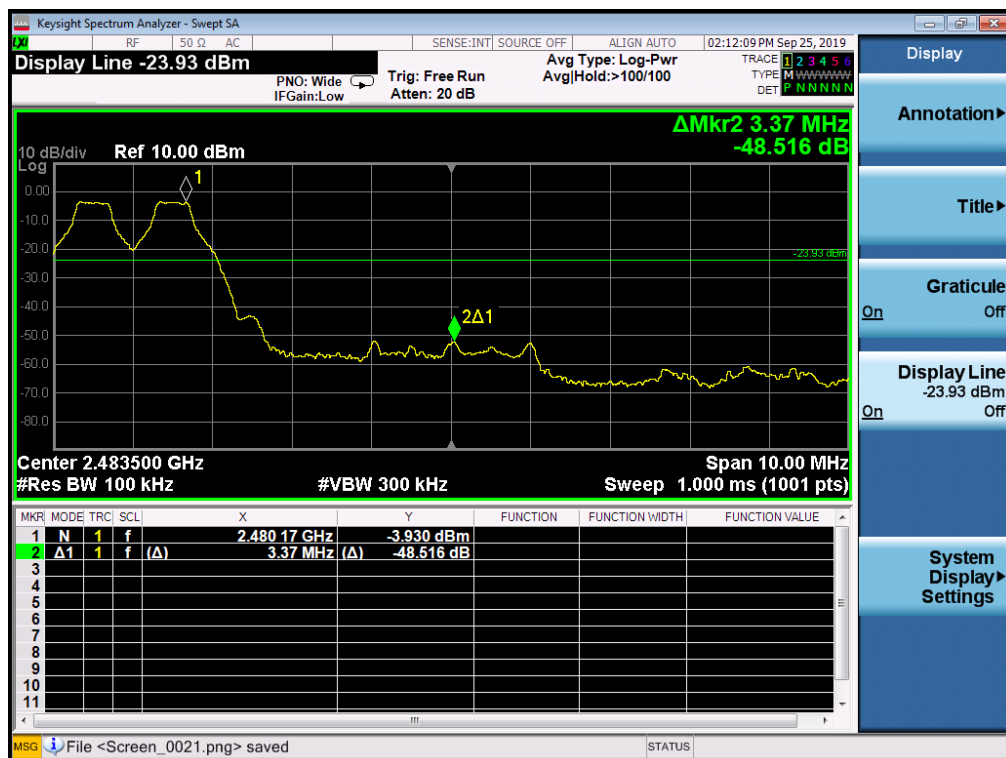
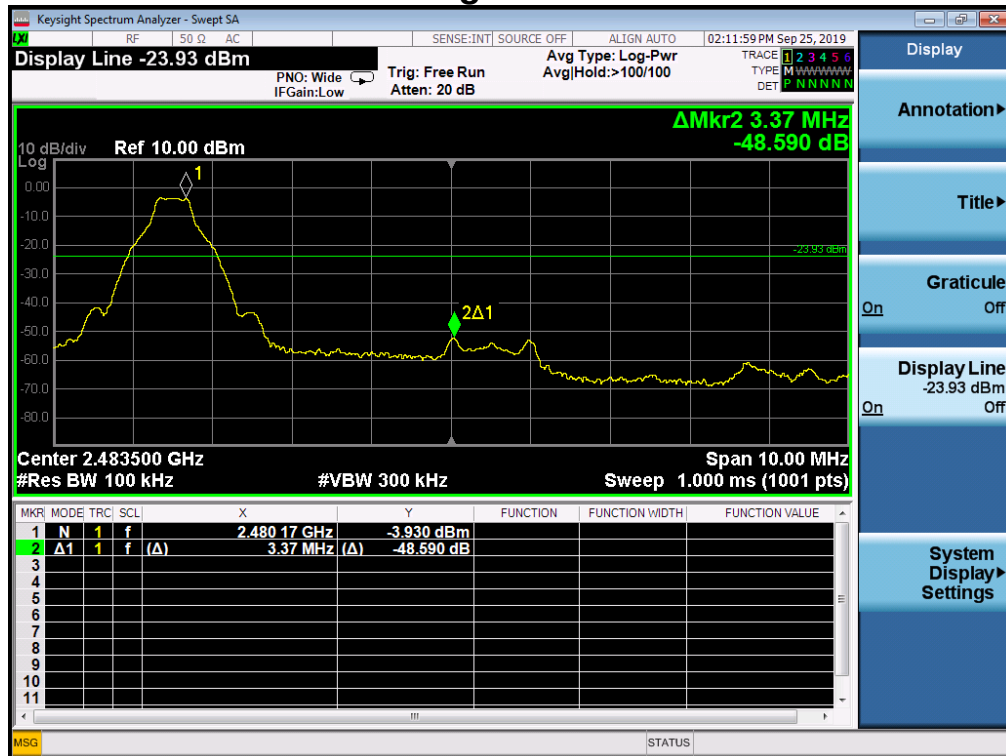
Note: (1) Result= Reading + Factor
 (2) Factor= Antenna Gain + Cable Loss – Amplifier Gain
 (3) Horn antenna used for the emission over 1000MHz.

For RF Conducted restricted band:

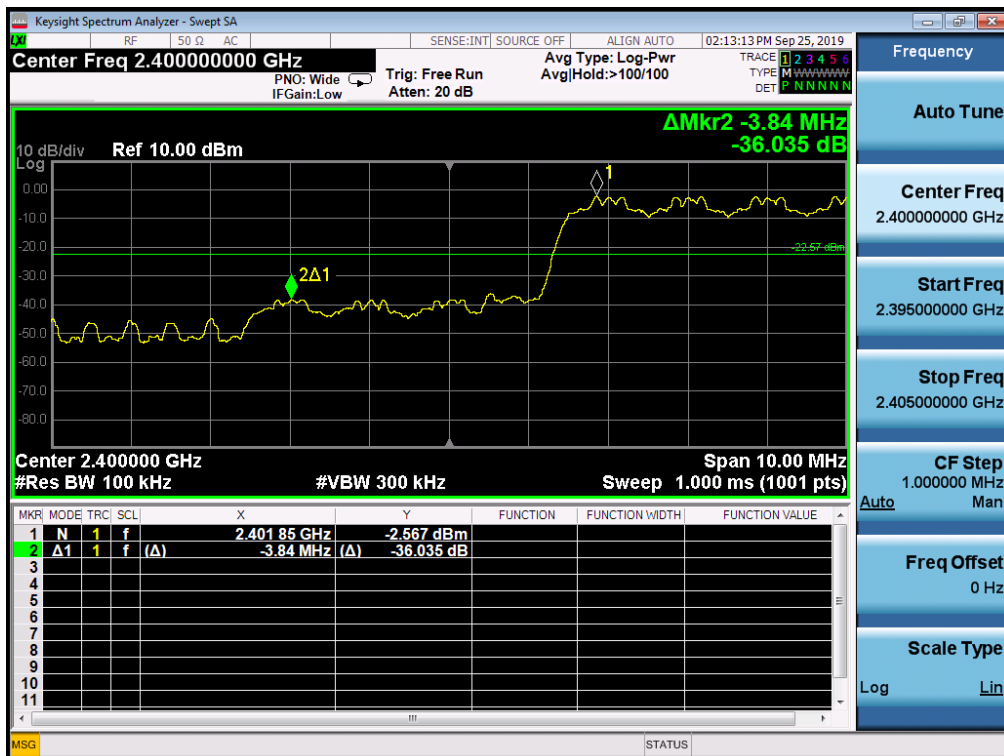
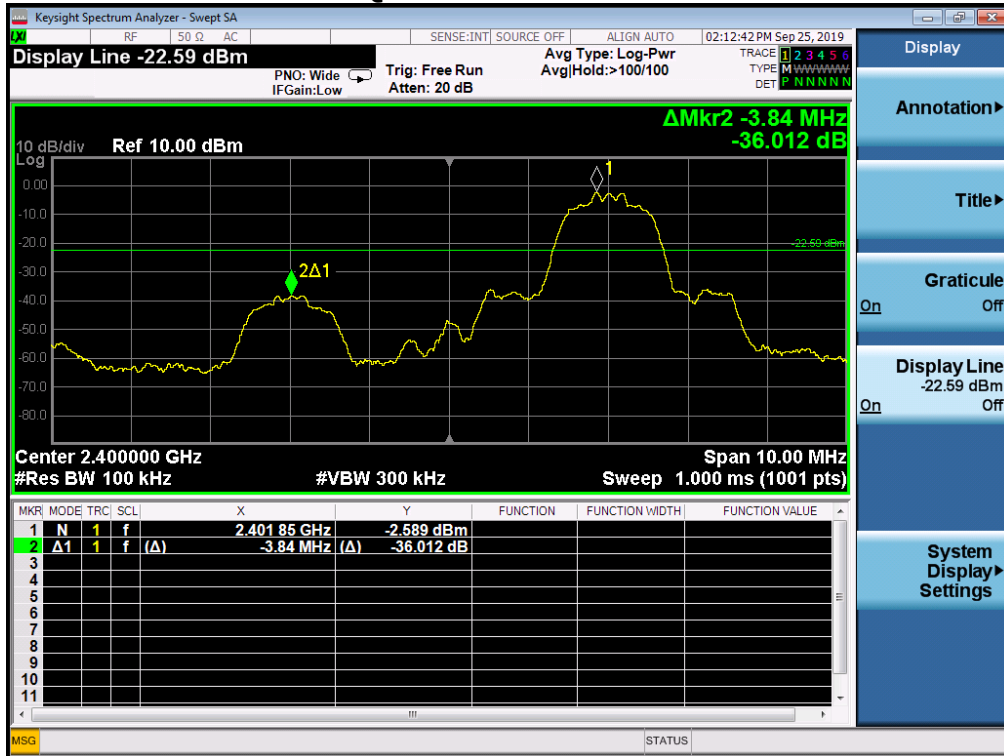
GFSK Lowest Channel



GFSK Highest Channel



$\pi/4$ -DQPSK Lowest Channel



$\pi/4$ -DQPSK Highest Channel



11. ANTENNA APPLICATION

11.1 Antenna requirement

According to of FCC part 15C section 15.203 and RSS GEN 6.8:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator, the manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

Systems operating in the 2400-2483.5MHz 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.

11.2 Measurement Results

The antenna is PCB antenna and no consideration of replacement, and the best case gain of the antenna is -0.58dBi. Therefore, the antenna is consider meet the requirement.

12. CONDUCTED SPURIOUS EMISSIONS

12.1 Measurement Procedure

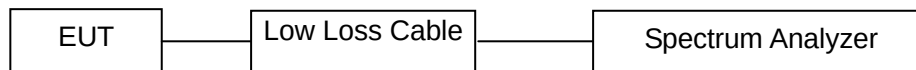
Out of Band Conducted Spurious Emissions, FCC Rule 15.247(d) & RSS-247 section 5.5:

The transmitter output is connected to spectrum analyzer. All spurious emission and up to the tenth harmonic was measured and they were found to be at least 20dB below the highest level of the desired power in the passband.

12.2 Limit

In any 100KHz bandwidth outside the frequency band in which the spread spectrum intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20dB below that in the 100KHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement.

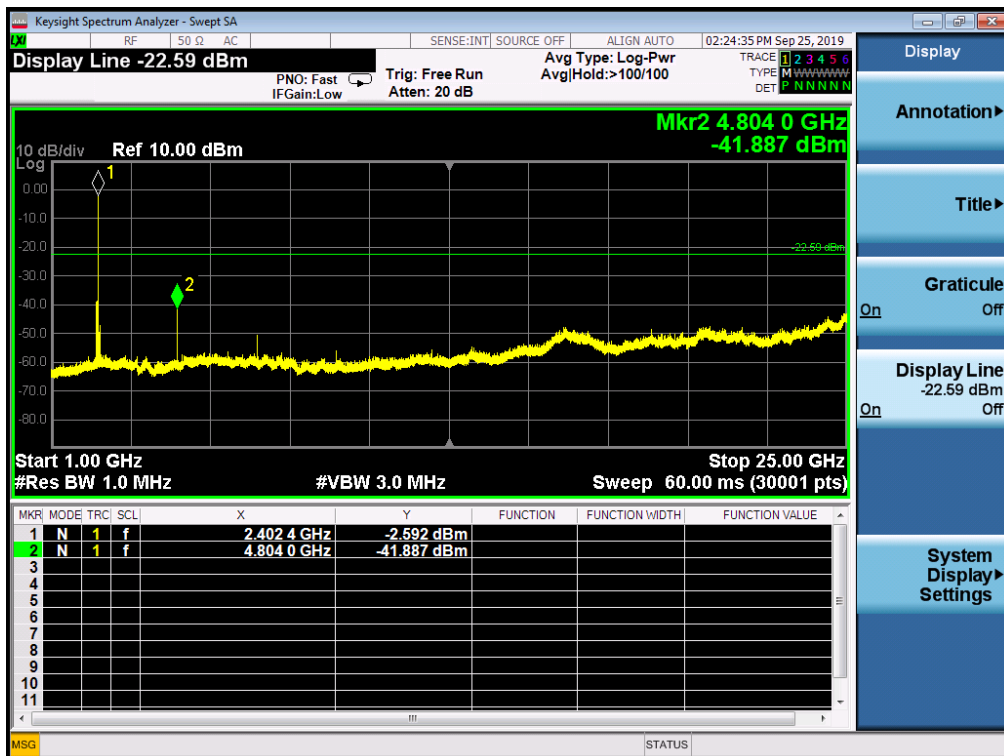
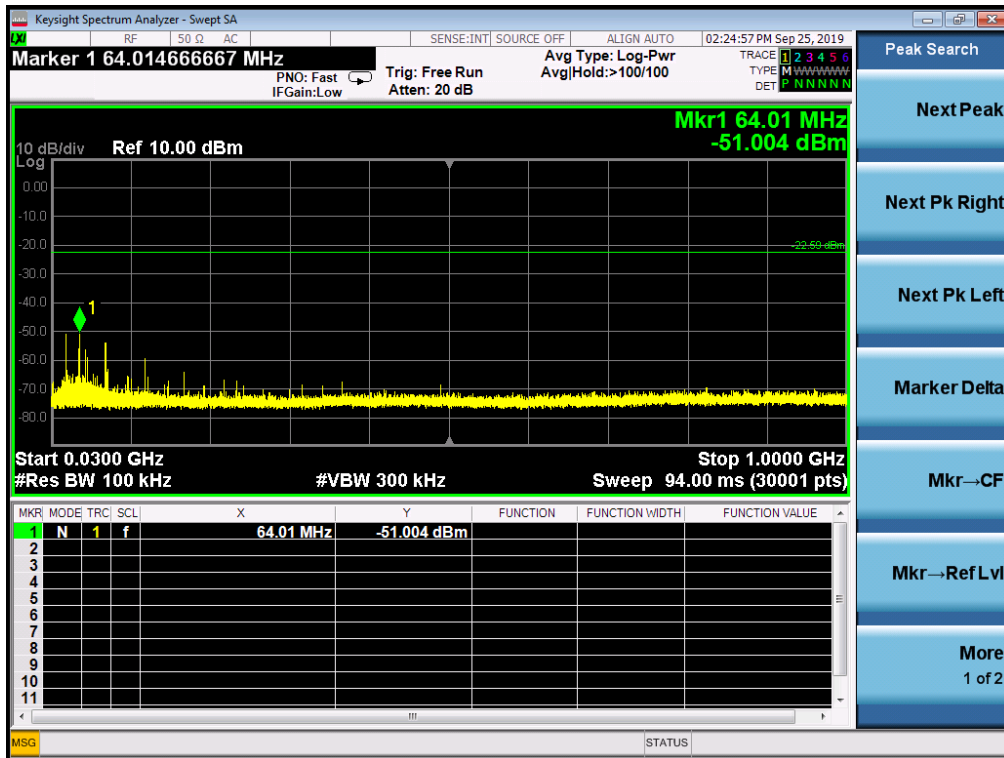
12.3 Test SET-UP (Block Diagram of Configuration)



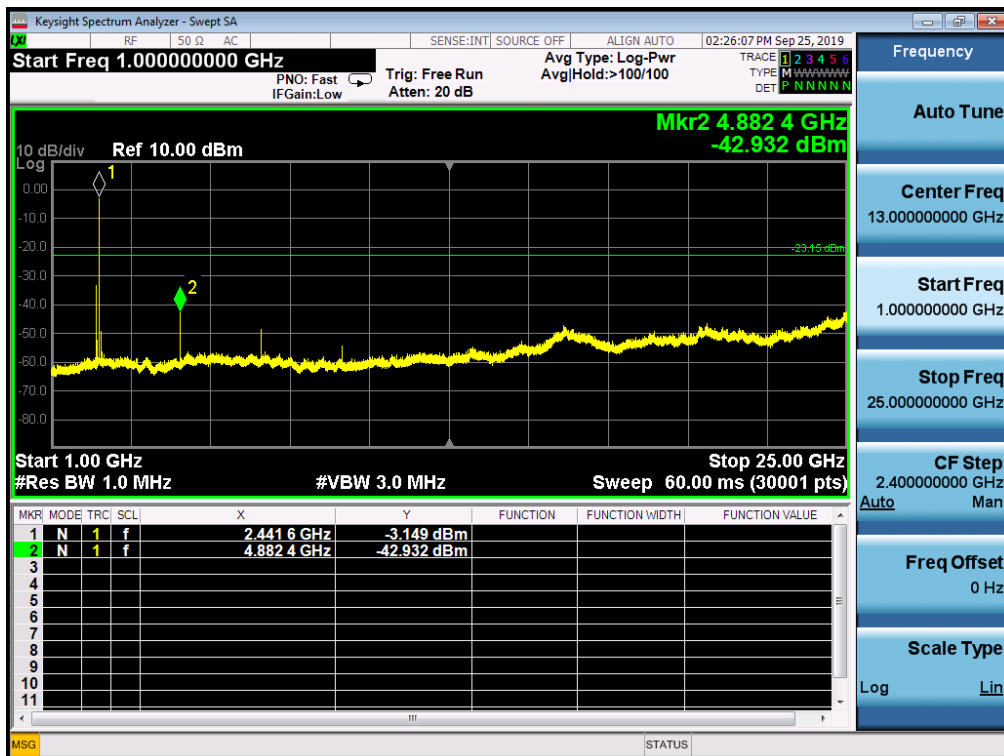
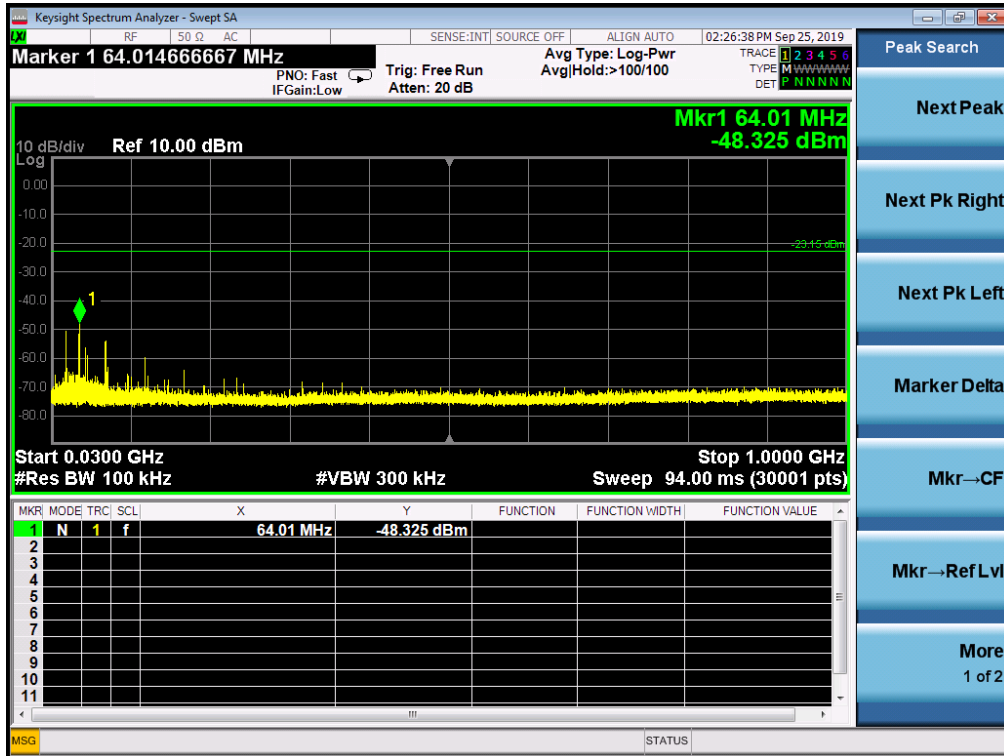
12.4 Measurement Results

Please refer to following plots, the worst case ($\pi/4$ -DQPSK) was shown.

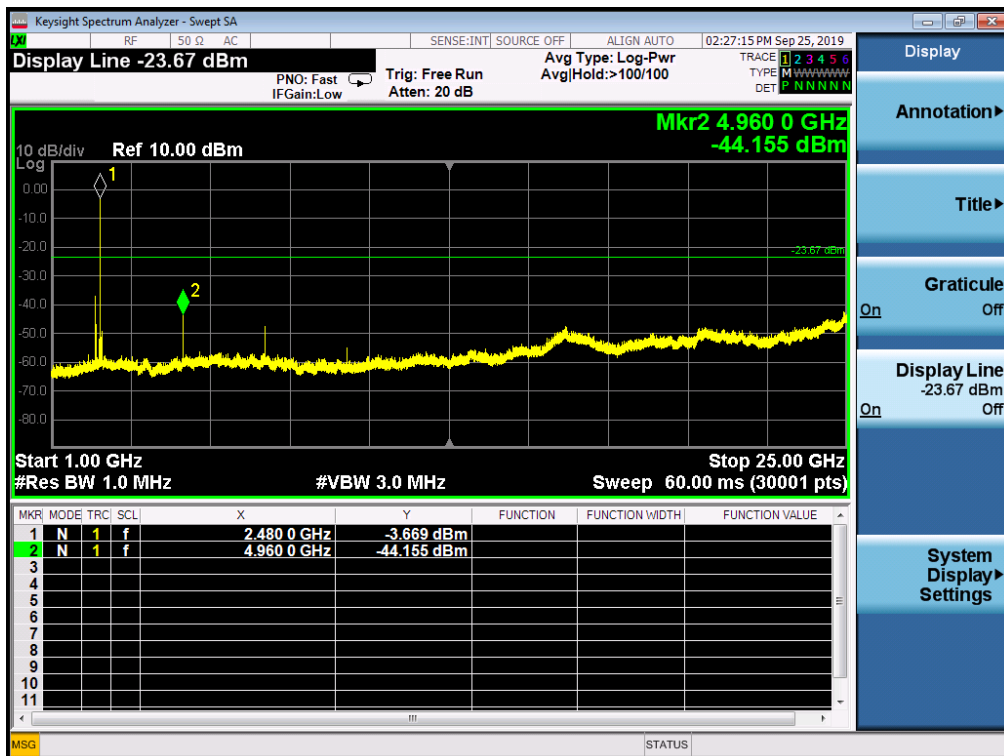
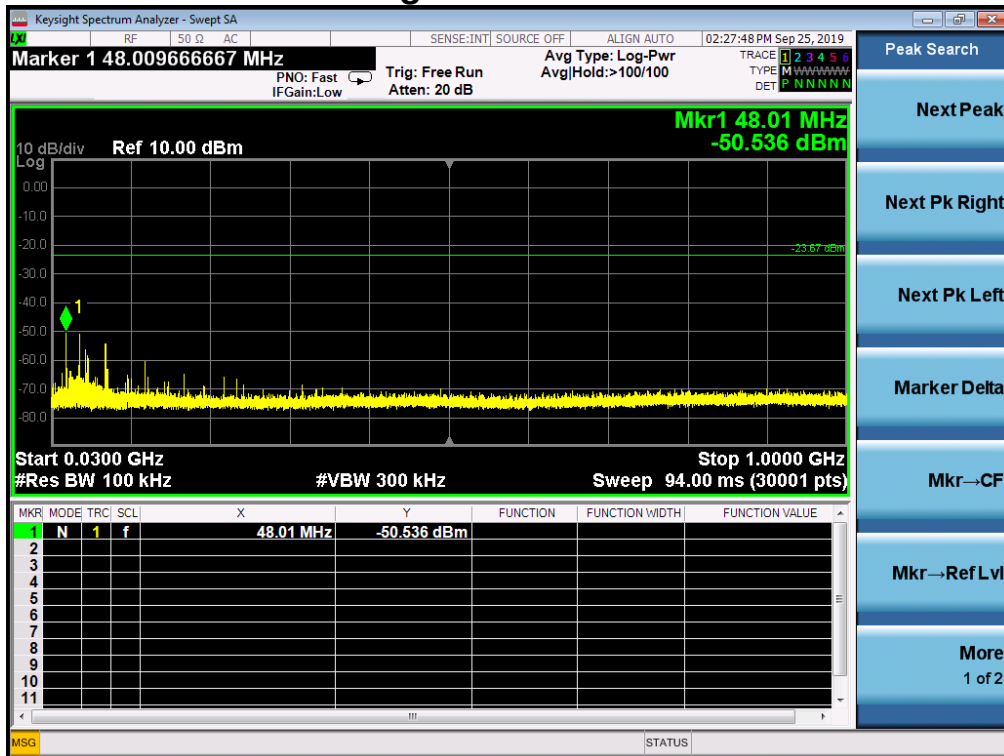
Lowest Channel



Middle Channel



Highest Channel



Note: Sweep points=30001pts

13. TEST EQUIPMENT LIST

Description	Manufacturer	Model Number	Serial Number	Characteristics	Calibration Date	Calibration Due Date
Test Receiver	Rohde & Schwarz	ESCI7	100837	9KHz~7GHz	Mar. 14, 2019	1 year
Antenna	Schwarzbeck	VULB9162	9162-010	30MHz~7GHz	Mar. 23, 2019	1 year
Spectrum Analyzer	Rohde & Schwarz	FSU26	200409/026	20Hz~26.5GHz	Mar. 14, 2019	1 year
Spectrum Analyzer	Keysight	N9020A	MY54200831	20Hz~26.5GHz	Apr. 24, 2019	1 year
Spectrum Analyzer	Rohde & Schwarz	FSV40	101003	10Hz~40GHz	Apr. 24, 2019	1 year
Horn Antenna	Schwarzbeck	BBHA9170	9170-372	15GHz~40GHz	Mar. 23, 2019	1 year
Pre-Amplifier	EMCI	EMC 184045	980102	18GHz~40GHz	Apr. 24, 2019	1 year
Power Sensor	DARE	RPR3006W	15100041SN O64	100MHz~6GHz	Mar. 14, 2019	1 year
Communication Tester	Rohde & Schwarz	CMW500	149004	70MHz~6GHz	Mar. 14, 2019	1 year
Horn Antenna	COM-Power	AH-118	071078	500MHz~18GHz	Mar. 23, 2019	1 year
Pre-Amplifier	HP	HP 8449B	3008A00964	1GHz~26.5GHz	Mar. 14, 2019	1 year
Pre-Amplifier	HP	HP 8447D	1145A00203	100KHz~1.3GHz	Mar. 14, 2019	1 year
Loop Antenna	Schwarzbeck	FMZB 1513	1513-272	9KHz~30MHz	Apr. 24, 2019	1 year
Temperature & Humidity Chamber	REMAFEE	SYHR225L	N/A	-40~150℃	Apr. 24, 2019	1 year
DC Source	MY	MY8811	N/A	0~30V	N/A	N/A
Temporary antenna connector	TESCOM	SS402	N/A	9KHz~25GHz	N/A	N/A
Power Meter	Anritsu	ML2495A	1139001	100k-65GHz	Apr. 24, 2019	1 year
Power Sensor	Anritsu	MA2411B	100345	300M-40GHz	Apr. 24, 2019	1 year
Test Software	EZ	EZ_EMC	N/A	N/A	N/A	N/A

Note: 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.

---END---