

FCC 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/ Manufacturer	Shenzhen KingBoard Technology Co., Ltd.				
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Factory	: Shenzhen KingBoard Technology Co., Ltd.				
Address	: Bldg. A, Dakanglong Industry Zone Dabuxiang, Guanlan, Shenzhen, China				
E.U.T.	: BLUETOOTH SPEAKER				
Brand Name	: N/A				
Model No.	: KTS-994, SP585, BTS-01, BTS-02, BTS-03, BTS-04, BTS-05, BTS-06, BTS-07 (For model difference refer to section 2.1)				
FCC ID	: SXX-KTS994				
Measurement Standard	: FCC PART 15.247				
Date of Receiver	: June 11, 2019				
Date of Test	: June 11, 2019 to July 14, 2019				
Date of Report	: July 14, 2019				
This Test Report is Issue	ed Under the Authority of :				
Prepared by Sundiy jiang / Engineer 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.					
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Revision History of This Test Report

Report Number	Description	Issued Date
NTC1906112FV00	Initial Issue	2019-07-14



1. GENERAL INFORMATION

1.1 Product Description for Equipment under Test

Product Name	:	BLUETOOTH SPEAKER
Main Model Name	:	KTS-994
Additional Model Name	:	SP585, BTS-01, BTS-02, BTS-03, BTS-04, BTS-05, BTS-06, BTS-07
Model difference	:	These models have the same circuit schematic, construction, PCB Layout and critical components. The difference is model number only due to trading purpose.
Brand Name	:	N/A
Rating	:	DC 5V (form micro USB port) or DC 3.7V (From built-in battery)
Adapter	:	N/A
Test voltage	:	AC 120V 60Hz (Adapter input), DC 3.7V (Only the worst case was recorded in this report)
Cable	:	N/A
Hardware version	:	V1.0
Software version	:	V1.0
Note	:	According to the model difference, all tests were performed on model KTS-994.
Remark	:	The USB ports without data transfer function.



Technical parameters

Bluetooth Version :	V4.2 (BDR+EDR)
Frequency Range :	2402-2480MHz
Modulation :	GFSK, π/4-DQPSK
Number of Channel :	79
Channel space :	1MHz
Date Rate :	1Mbps for GFSK
_	2Mbps for π/4-DQPSK
51	PCB antenna
Antenna Gain :	-0.68 dBi (Declaration by manufacturer)



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

Test SW version FCC Assist_1.5



1.2 Related Submittal(s) / Grant (s)

This submittal(s) (test report) is intended for **FCC ID: SXX-KTS994** filing to comply with Section 15.247 of the FCC Part 15, Subpart C 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

Notebook :	Manufacturer: IBM
	Model: 1834
	P/N: 13N5615
Adapter :	Manufacturer: Huntkey
(For Notebook)	Model: HKA09019047-6D
	I/P: AC 100-240V 50-60Hz, 1.5A
	O/P: DC 19V 4.74A
Adapter :	Manufacturer: HUWEI
	Model No.: HW-050200C01
	Input: AC100-240V 50/60Hz, 0.5A
	Output: DC5V 2A



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
Name of Firm	:	Listed by Industry Canada, June 08, 2017 The Certificate Registration Number. Is 46405-9743 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 Rules	Description Of Test	Uncertainty	Result
§15.247(a)(1)	Channel Separation test	±1.42 x10 ⁻⁴ %	Compliant
§15.247(a)(1)	20dB Bandwidth	±1.42 x10 ⁻⁴ %	Compliant
§15.247(a)(1)(iii)	Hopping Channel Number	±1.42 x10 ⁻⁴ %	Compliant
§15.247(a)(1)(iii)	Time of Occupancy (Dwell Time)	±5%	Compliant
§15.247(b)	Max Peak output Power test	±1.06dB	Compliant
§15.247(d)	Band edge test	±1.70dB	Compliant
§15.207 (a)	AC Power Conducted Emission	±1.06dB	Compliant
§15.247(d),§15.209, §15.205	Radiated Emission	±3.70dB	Compliant
§15.203	Antenna Requirement	N/A	Compliant
§15.247(d)	Conducted Spurious Emission	±1.70dB	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 and 2-DH5 mode in all modulation type GFSK, π /4-DQPSK were tested.

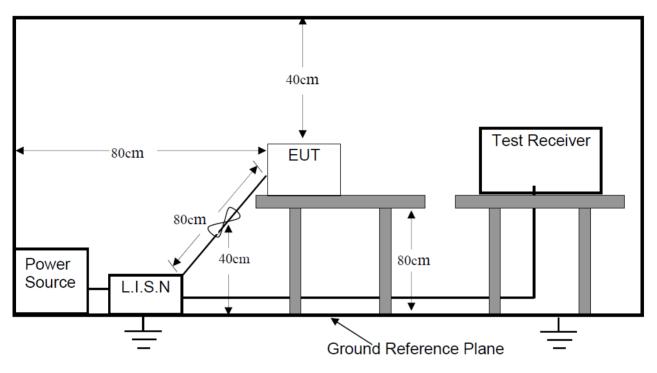
2.4 EUT Exercise

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



3. Conducted Emissions Test





3.2 Test Condition

Test Requirement: FCC Part 15.207

Frequency Range: 150KHz ~ 30MHz

Detector: RBW 9KHz, VBW 30KHz

Operation Mode: TX, TX+ Charging

3.3 Measurement Results

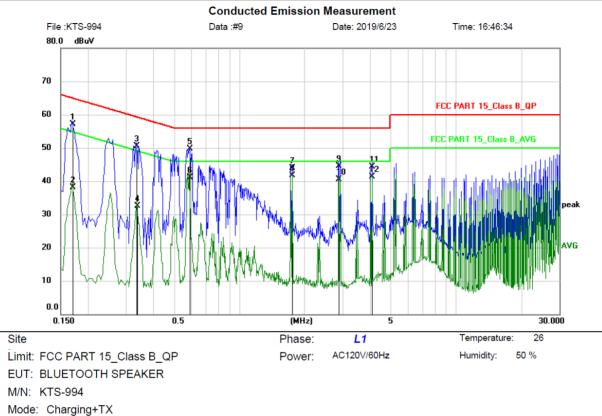
PASS

Please refer to the following pages of the worst case: TX+ Charging (π /4-DQPSK Low Channel)





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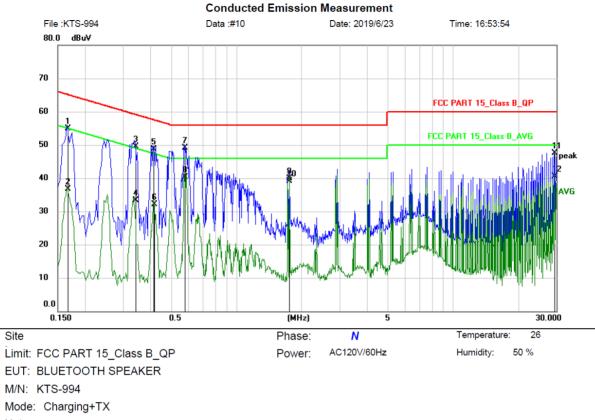
Note:

No. Mk.	Freq.	Reading Level	Correct Factor	Measure- ment	Limit	Over		
	MHz	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1	0.1700	46.49	10.61	57.10	64.96	-7.86	QP	
2	0.1700	27.59	10.61	38.20	54.96	-16.76	AVG	
3	0.3339	39.99	10.61	50.60	59.35	-8.75	QP	
4	0.3379	21.89	10.61	32.50	49.25	-16.75	AVG	
5	0.5899	39.07	10.63	49.70	56.00	-6.30	QP	
6	0.5899	30.57	10.63	41.20	46.00	-4.80	AVG	
7	1.7620	33.25	10.65	43.90	56.00	-12.10	QP	
8 *	1.7620	31.15	10.65	41.80	46.00	-4.20	AVG	
9	2.8820	33.85	10.65	44.50	56.00	-11.50	QP	
10	2.8820	29.85	10.65	40.50	46.00	-5.50	AVG	
11	4.1100	33.74	10.66	44.40	56.00	-11.60	QP	
12	4.1100	30.64	10.66	41.30	46.00	-4.70	AVG	





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Note:

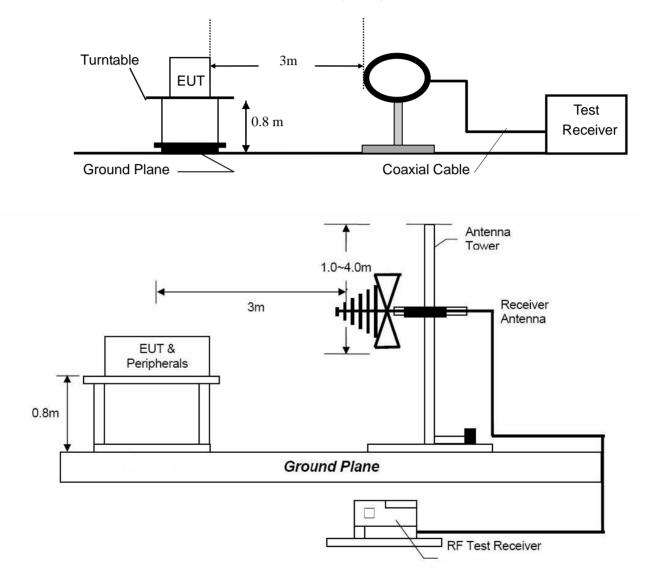
No. Mk.	Freq.	Reading Level	Correct Factor	Measure- ment	Limit	Over		
	MHz	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1	0.1660	44.39	10.61	55.00	65.16	-10.16	peak	
2	0.1660	26.09	10.61	36.70	55.16	-18.46	AVG	
3	0.3420	38.89	10.61	49.50	59.15	-9.65	peak	
4	0.3420	22.69	10.61	33.30	49.15	-15.85	AVG	
5	0.4140	38.18	10.62	48.80	57.57	-8.77	peak	
6	0.4180	21.48	10.62	32.10	47.49	-15.39	AVG	
7	0.5780	38.57	10.63	49.20	56.00	-6.80	peak	
8 *	0.5780	29.67	10.63	40.30	46.00	-5.70	AVG	
9	1.7620	29.35	10.65	40.00	56.00	-16.00	peak	
10	1.7620	28.45	10.65	39.10	46.00	-6.90	AVG	
11	29.3620	36.82	10.68	47.50	60.00	-12.50	peak	
12	29.3620	29.82	10.68	40.50	50.00	-9.50	AVG	



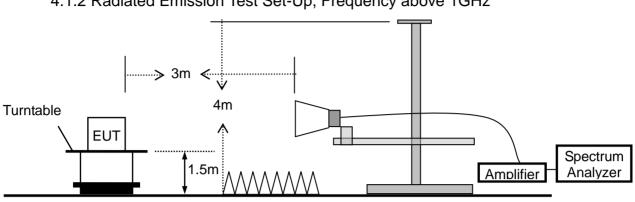
4. Radiated Emission Test

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

- a. 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.
- b. 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.

- c. The EUT was set 3 meters away from the interference-receiving antenna, which was mounted on the top of a variable-height antenna tower.
- d. 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.
- e. 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.
- f. 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	Distance Meters	Field Strengths Limit (15.209)
MHz		μV/m
0.009 ~ 0.490	300	2400/F(kHz)
0.490 ~ 1.705	30	24000/F(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 (dB) μ V = 20 log Emission level μ 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

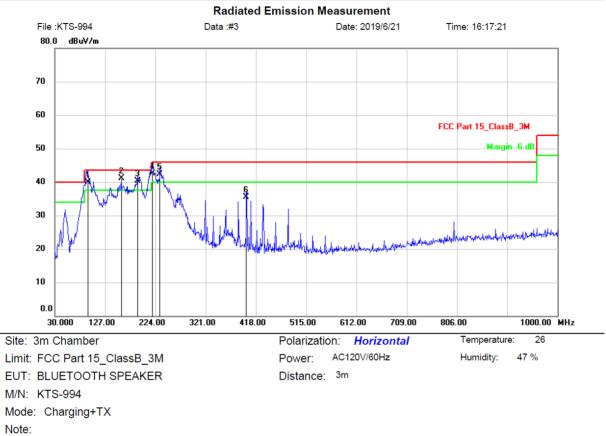
PASS

Please refer to following plots of the worst case: TX+ Charging (π /4-DQPSK Low channel)





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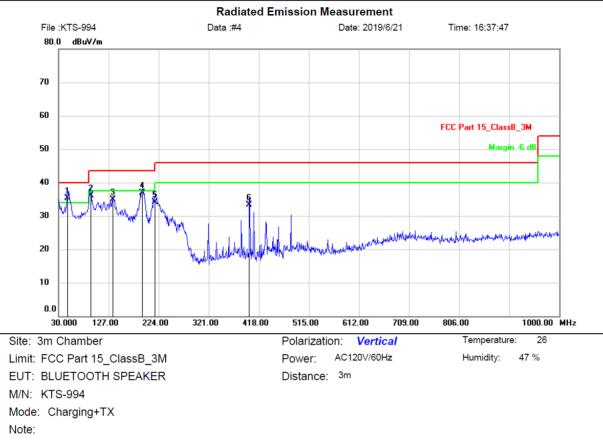


No.	Mk.	Freq.	Reading Level	Correct Factor	Measure- ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	İ	94.0199	53.01	-13.01	40.00	43.50	-3.50	QP			
2	*	158.0399	56.33	-15.23	41.10	43.50	-2.40	QP			
3	İ	190.0500	53.96	-13.57	40.39	43.50	-3.11	QP			
4	İ	218.1800	55.61	-13.02	42.59	46.00	-3.41	QP			
5	ļ	232.7300	54.63	-12.33	42.30	46.00	-3.70	QP			
6		399.5700	44.61	-9.11	35.50	46.00	-10.50	QP			





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No.	Mk.	Freq.	Reading Level	Correct Factor	Measure- ment	Limit	Over		Antenna Height	Table Degree	
		MHz	dBuV	dB/m	dBuV/m	dBuV/m	dB	Detector	cm	degree	Comment
1	*	47.4600	48.80	-13.50	35.30	40.00	-4.70	QP			
2		93.0500	52.42	-16.22	36.20	43.50	-7.30	QP			
3		135.7300	53.40	-18.40	35.00	43.50	-8.50	QP			
4		191.9900	53.41	-16.51	36.90	43.50	-6.60	QP			
5		216.2400	50.28	-16.08	34.20	46.00	-11.80	QP			
6		399.5700	44.41	-11.11	33.30	46.00	-12.70	QP			



Modulation:	Modulation: $\pi/4$ -DQPSK (the worst case)					
Frequency Range:	1-25GHz	Test Date :	June 21, 2019			
Test Result:	PASS	Temperature :	24 °C			
Measured Distance: Test By:	3m Sance	Humidity :	47 %			

		Rea	dina		Emissio		Limi	t 3m	Ma	rgin
Freq. Ant.Pol.		Level(-	Factor	(dBi			V/m)		B)
(MHz)	(H/V)		,	(dB/m)		/	· ·	,		,
. ,	· · /	PK	AV	· · · ·	PK AV PK AV PK AV					
			Oper	ration Mo	ode: TX M	lode (Lo	w)			
4804	V	52.23	37.63	6.30	58.53	43.93	74.00	54.00	-15.47	-10.07
7206	V	45.98	30.70	10.44	56.42	41.14	74.00	54.00	-17.58	-12.86
4804	Н	54.31	41.05	6.30	60.61	47.35	74.00	54.00	-13.39	-6.65
7206	Н	48.00	32.44	10.44	58.44	42.88	74.00	54.00	-15.56	-11.12
Operation Mode: TX Mode (Mid)										
4882	V	53.08	39.47	6.60	59.68	46.07	74.00	54.00	-14.32	-7.93
7323	V	47.37	33.55	10.55	57.92	44.10	74.00	54.00	-16.08	-9.90
4882	Н	54.28	40.45	6.60	60.88	47.05	74.00	54.00	-13.12	-6.95
7323	Н	48.72	33.30	10.55	59.27	43.85	74.00	54.00	-14.73	-10.15
			Oper	ation Mo	de: TX M	ode (Hig	jh)			
4960	V	49.30	36.85	6.89	56.19	43.74	74.00	54.00	-17.81	-10.26
7440	V	45.84	32.23	10.60	56.44	42.83	74.00	54.00	-17.56	-11.17
4960	Н	51.01	36.26	6.89	57.90	43.15	74.00	54.00	-16.10	-10.85
7440	Н	46.63	32.33	10.60	57.23	42.93	74.00	54.00	-16.77	-11.07

Note: (1) All Readings are Peak Value and AV.

- (2) Emission 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 : ±3.7dB.
- (6) Horn antenna used for the emission over 1000MHz.



5. Channel Separation test

5.1 Measurement Procedure

Minimum Hopping Channel Carrier Frequency Separation, FCC Rule 15.247(a)(1):

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 Test SET-UP (Block Diagram of Configuration)

EUT Spectrum Analyzer

5.3 Measurement Results

Modulation:	GFSK, π/4-DQPSK					
RBW:	100KHz	VBW:	300KHz			
Packet:	DH5, 2-DH5	Spectrum Detector:	PK			
Test By:	Lee	Test Date :	June 22, 2019			
Temperature :	22 °C	Humidity :	53 %			
Test Result:	PASS					

Channel number	Channel	Separation Read	Separation Limit					
	frequency (MHz)	Value (KHz)	2/3 20dB Bandwidth					
			(KHz)					
GFSK								
Lowest	2402	1002	>631.47					
Middle	2441	1002	>632.00					
Highest	2480	1002	>630.07					
	π/	4-DQPSK						
Lowest	2402	1002	>871.33					
Middle	2441	1002	>872.00					
Highest	2480	1002	>872.00					





GFSK Lowest Channel

GFSK Middle Channel

Keysight Spectrum Analyzer - Swept SA				
RF 50 Ω AC Marker 1 2.43980600000 Marker 1 Δ	0 GHz	NT SOURCE OFF ALIGN AUTO Avg Type: Log-Pwr	05:07:00 PM Jun 22, 2019 TRACE 1 2 3 4 5 6	Peak Search
10 dB/div Ref 10.00 dBm	PNO: Wide C Trig: Free Ru IFGain:Low Atten: 20 dB		2.439 806 GHz -0.167 dBm	Next Peak
	<u>ζ2Δ1</u>			Next Pk Righ
-30.0				Next Pk Lef
-60.0 -70.0 -80.0				Marker Delta
Center 2.441000 GHz #Res BW 100 kHz MKR MODE TRC SCL X	#VBW 300 kHz	Sweep 1	Span 3.000 MHz .000 ms (1001 pts)	Mkr→C
1 N 1 f 2.43 2 Δ1 1 f (Δ) 3 - - - 4 - - - 5 - - - 6 - - - -	39 806 GHz0.167 dBm 1.002 MHz (Δ) 0.028 dB		E	Mkr→RefLv
7 8 9 10 11 11			÷	Mon 1 of:
MSG		STATUS	;	



GFSK Highest Channel



π/4-DQPSK Lowest Channel

Keysight Spectrum Analyzer - Swept SA			- 7
Marker 2 Δ 1.002000000 N	MHz PNO: Wide	Avg Type: Log-Pwr TRACE 12345 (Avg/Hold > 100/100 TYPE M	
10 dB/div Ref 10.00 dBm	IFGain:Low Atten: 20 dB	ΔMkr2 1.002 MHz -0.026 dB	NextPea
Log		2Δ1	Next Pk Righ
30.0 40.0 50.0			Next Pk Le
60.0 70.0 80.0			Marker Del
Center 2.402000 GHz Res BW 100 kHz IKR MODE TRC SCL		Span 3.000 MHz Sweep 1.000 ms (1001 pts)	Mkr→C
	1 811 GHz 0.052 dBm 1.002 MHz (Δ) -0.026 dB		Mkr→RefL
7 8 9 9 10 10 10 10 10 10 10 10 10 10 10 10 10			Mo 1 of
sg	III	STATUS	





π/4-DQPSK Middle Channel

π /4-DQPSK Highest Channel

Keysight Spectrum Analyzer - Swept SA				
Marker 1 2.479130000000	GHz	T SOURCE OFF ALIGN AUTO Avg Type: Log-Pwr	05:10:05 PM Jun 22, 2019 TRACE 1 2 3 4 5 6	Peak Search
	PNO: Wide Trig: Free Run IFGain:Low Atten: 20 dB	Avg Hold:>100/100	DET P N N N N N	
		Mkr1	2.479 130 GHz	NextPeak
10 dB/div Ref 10.00 dBm	_	0.44	-1.161 dBm	
		2∆1		
-10.0				Next Pk Righ
-20.0				
-30.0				
-40.0				Next Pk Lef
-50.0				
-60.0				
-70.0				Marker Delta
-80.0				
Center 2.480000 GHz			Span 3.000 MHz	
#Res BW 100 kHz	#VBW 300 kHz	-	.000 ms (1001 pts)	Mkr→Ci
MKR MODE TRC SCL X	130 GHz -1.161 dBm	FUNCTION FUNCTION WIDTH	FUNCTION VALUE	
	.002 MHz (Δ) 0.099 dB			
4			_	Mkr→RefLv
6				
7				Mor
9				1 of:
11 <u> </u>				
ISG		STATU	s	



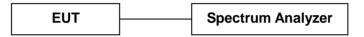
6. 20dB Bandwidth

6.1 Measurement Procedure

Maximum 20dB RF Bandwidth, FCC Rule 15.247(a)(1):

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.

6.2 Test SET-UP (Block Diagram of Configuration)



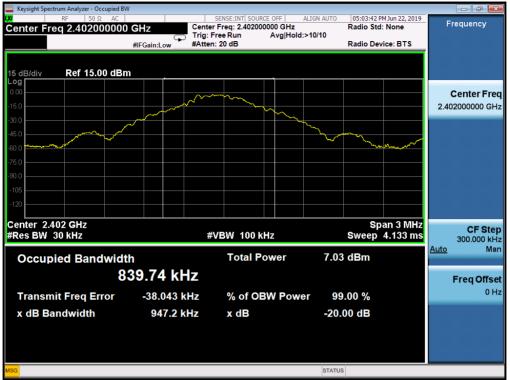
6.3 Measurement Results

Refer to attached data chart.

Modulation:	GFSK, π/4-DQPSK					
RBW:	30KHz	VBW:	100KHz			
Packet:	DH5, 2-DH5	Spectrum Detector:	PK			
Test By:	Lee	Test Date :	June 22, 2019			
Temperature :	22 °C	Humidity :	53 %			
Test Result:	PASS					

Channel frequency (MHz)	20dB Down BW(kHz)		
GF	SK		
2402	947.2		
2441	948.0		
2480	945.1		
π/4-D	QPSK		
2402	1307.0		
2441	1308.0		
2480	1308.0		





GFSK Lowest Channel

GFSK Middle Channel

Keysight Spectrum Analyzer - Occupi	ed BW			
Center Freq 2.441000	000 GHz	SENSE:INT SOURCE OFF Center Freq: 2.441000000 GHz	Radio Std:	None Frequency
		Trig: Free Run Avg Hol #Atten: 20 dB	d:>10/10 Radio Devi	ce: BTS
15 dB/div Ref 15.00 d	1Bm			
Log 0.00		A = 200 A		Center Freq
-15.0				2.441000000 GHz
-30.0			where a second sec	
-45.0			- m	mm
-60.0			~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	- And a second s
-75.0				
-105				
-120				
Center 2.441 GHz #Res BW 30 kHz		#VBW 100 kHz		an 3 MHz CF Step 4.133 ms 300.000 kHz
		T-4-1 D	C 74 JD	Auto Man
Occupied Bandw		Total Power	6.71 dBm	
	841.97 kH	Ζ		Freq Offset
Transmit Freq Error	-38.333 kł	Iz % of OBW Pow	ver 99.00 %	0 Hz
x dB Bandwidth	948.0 k⊦	lz xdB	-20.00 dB	
MSG			STATUS	



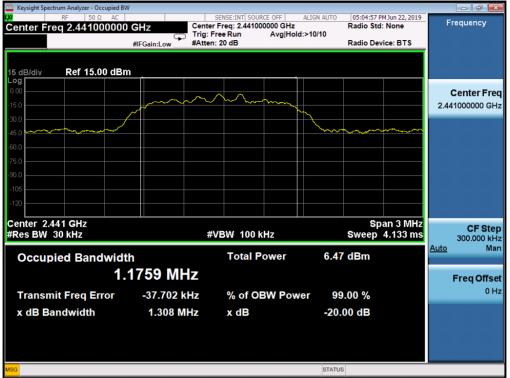
GFSK Highest Channel



π/4-DQPSK Lowest Channel







π/4-DQPSK Middle Channel

π /4-DQPSK Highest Channel

Keysight Spectrum Analyzer - Occupied B	W				
Center Freq 2.48000000	GHz Cer	SENSE:INT SOURCE OFF	ALIGN AUTO	05:05:18 PM Jun 22, 2019 Radio Std: None	Frequency
	Trig	g:FreeRun Avg∣H tten:20 dB	lold:>10/10	Radio Device: BTS	
	#IFGaIn:Low #A	tten. 20 db		Radio Device. D13	T
15 dB/div Ref 15.00 dBr	n				
Log 0.00					Center Freq
-15.0		$\sim\sim\sim\sim\sim$			2.48000000 GHz
-30.0					
-45.0			have	~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~	
-60.0					
-75.0					
-90.0					
-105					
-120					
Center 2.48 GHz				Span 3 MH;	
#Res BW 30 kHz		#VBW 100 kHz		Sweep 4.133 m	
Occupied Bandwidt	th	Total Power	5.53	dBm	<u>Auto</u> Man
	1760 MHz				
					Freq Offset
Transmit Freq Error	-38.416 kHz	% of OBW Po	ower 99	.00 %	0 Hz
x dB Bandwidth	1.308 MHz	x dB	-20.	00 dB	
MSG			STATUS	3	



7. Hopping Channel Number

7.1 Measurement Procedure

Minimum Number of Hopping Frequencies, FCC Rule 15.247(a)(1)(iii):

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 Test SET-UP (Block Diagram of Configuration)



7.3 Measurement Results

Modulation	GFSK, π/4-DQPSK		
RBW:	100KHz	VBW:	300KHz
Packet:	DH5, 2-DH5	Spectrum Detector:	PK
Test By:	Lee	Test Date :	June 22, 2019
Temperature :	22 °C	Humidity :	53 %
Test Result:	PASS		

Hopping Channel Frequency Range	Number of Hopping Channels	Limit
2402-2480	79	≥15



GFSK

Keysight Spectrum Analyzer - Swept SA						67 _
RF 50 Ω AC Marker 1 2.480070500000	GHz			ALIGN AUTO	05:16:44 PM Jun 22, 2019 TRACE 1 2 3 4 5	6 Marker
	PNO: Fast 🖵 IFGain:Low	Trig: Free Run Atten: 20 dB	Avg Hol	id:>100/100		
10 dB/div Ref 10.00 dBm				Mkr1 2	.480 070 5 GHz -2.080 dBm	1
ο og ζ2Δ1 0.00 10.00 20.0						Norma
30.0 4 40.0 4 50.0 8						Delt
60.0 70.0 80.0						Fixed
Start 2.40000 GHz #Res BW 100 kHz	#VBW	300 kHz	FUNCTION F	Sweep 8	Stop 2.48350 GHz .000 ms (1001 pts	0
1 N 1 f 2.480 0	70 5 GHz 33 5 MHz (Δ)	-2.080 dBm 0.730 dB	PONCTION	ONC HON WIDTH		Properties
7 8 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9						Mor 1 of
SG		III		STATUS	5	

π/4-DQPSK

	:18:40 PM Jun 22, 2019	05-19	LIGN AUTO	-	DURCE OF		SEI	1			nalyzer - Sw	trum A RF	ht Spect	Keysi
Marker	TRACE 1 2 3 4 5 6 TYPE MWWWW DET P N N N N N		Log-Pwr 100/100	g Type	A		Trig: Free		MHz PNO: Fa		8.1500		er 2 /	arko
Select Marke	8.150 0 MHz 1.856 dB	2 -78.					Atten: 20		IFGain:L	dBm	10.00	Ref	liv	dB/
Norm		Www	MANAN	᠕᠕᠕	ly <mark>l</mark> vil	~~~\/\	ᠰᢣᢋᡘ᠕	\	M M	JULY WY	MAAAAA		2∆1 ₩₩	
De														.0 .0 .0
Fixe														.0 - .0 -
c	p 2.48350 GHz ms (1001 pts)	8.000 n	weep 8		UNCTION		300 kHz	VBW	#	X		100	2.400 BW 1	les
Properties					one non	m	- <u>2.204 dE</u> 1.856	z z (Δ)	70 5 GH: 50 0 MH:	2.480 0	<u>(Δ)</u>	f	1	N
Мо 1 о														
							III							



8. Time of Occupancy (Dwell Time)

8.1 Measurement Procedure

Average Channel Occupancy Time, FCC Ref:15.247(a)(1)(iii):

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 Measurement Results

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

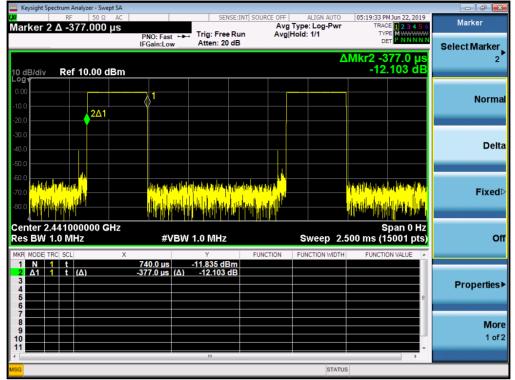
Refer to attached data chart.

Modulation :	GFSK, π/4-DQPSK		
RBW :	1MHz	VBW :	1MHz
Spectrum Detector:	PK	Test By:	Lee
Test Date :	June 18, 2019	Temperature :	22 °C
Test Result:	PASS	Humidity :	53 %

Packet	Frequency		Result		Limit		
	(MHz)		(msec)		(msec)		
	GFSK						
DH1	2441	0.3770	(ms)*(1600/(2*79))*31.6=	120.640	400		
DH3	2441	1.6330	(ms)*(1600/(4*79))*31.6=	261.280	400		
DH5	2441	2.8740	(ms)*(1600/(6*79))*31.6=	306.560	400		
			π/4-DQPSK				
2-DH1	2441	0.3858	(ms)*(1600/(2*79))*31.6=	123.456	400		
2-DH3	2441	1.6390	(ms)*(1600/(4*79))*31.6=	262.240	400		
2-DH5	2441	2.8830	(ms)*(1600/(6*79))*31.6=	307.520	400		



GFSK DH1

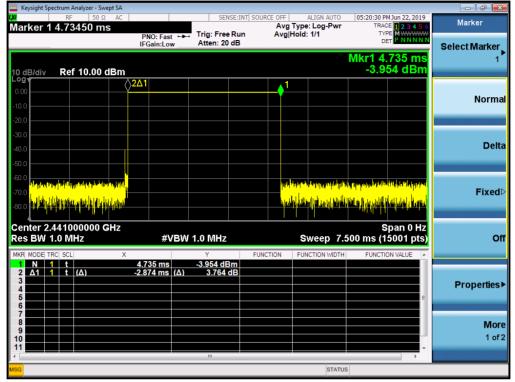


GFSK DH3

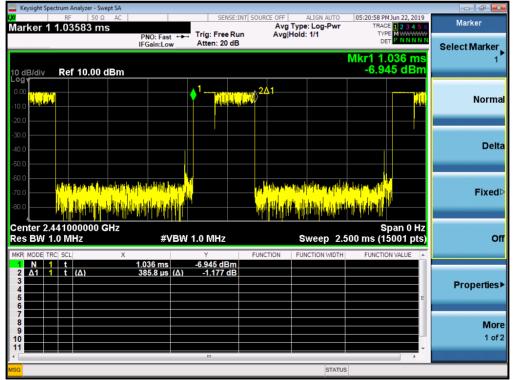
Keysight Spectrum Analyzer - Swept SA				
Marker 2 Δ -1.63300 ms	PNO: Fast +++ Trig: Free Run	Avg Type: Log-Pwr Avg Hold: 1/1	05:20:04 PM Jun 22, 2019 TRACE 1 2 3 4 5 6 TYPE MWWWWW	Marker
10 dB/div Ref 10.00 dBm	IFGain:Low Atten: 20 dB	Δ	DET P NNNNN Mkr2 -1.633 ms -4.277 dB	Select Marker 2
Log 0.00 -10.0 -20.0	1			Norma
-30.0				Delta
-60.0	and being an even of a second strain of the second			Fixed
Center 2.441000000 GHz Res BW 1.0 MHz	#VBW 1.0 MHz	Sweep 5.0	Span 0 Hz 000 ms (15001 pts)	Of
1 N 1 t	2.028 ms -11.462 dBm -1.633 ms (Δ) -4.277 dB			Properties
/ 8 9 10 11 4	m			Mor 1 of:
<mark>ISG</mark>		STATUS	3	



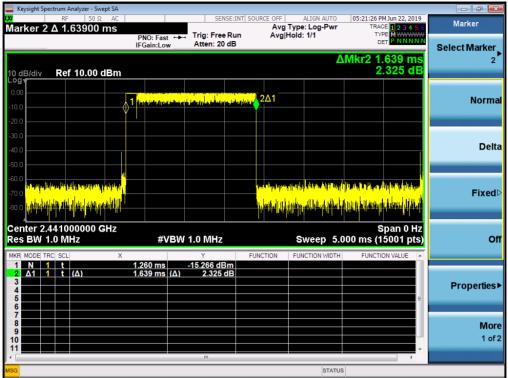
GFSK DH5



π/4-DQPSK 2-DH1







π/4-DQPSK 2-DH3

π/4-DQPSK 2-DH5

🤤 Keysight Spectrum Analyzer - Swept SA			
₩ RF 50 Ω AC Marker 2 Δ 2.88317 ms		SOURCE OFF ALIGN AUTO 05:21:59 PM Jun 22, 2019 Avg Type: Log-Pwr TRACE 1 2 3 4 5	Marker
10 dB/div Ref 10.00 dBm	PNO: Fast ↔ Trig: Free Run IFGain:Low Atten: 20 dB	Avg]Hoid: 1/1	Select Marker
0.00 -10.0		2Δ1	Normal
-30.0			Delta
		an start weed weed we denote the short of the short of the source of the start of the source of	Fixed⊳
Center 2.441000000 GHz Res BW 1.0 MHz	#VBW 1.0 MHz	Span 0 Hz Sweep 7.500 ms (15001 pts FUNCTION FUNCTION VIDTH FUNCTION VALUE	Off
	2.629 ms -0.199 dBm 2.883 ms (Δ) -9.572 dB		Properties►
7 8 9 10 11			More 1 of 2
MSG		STATUS	



9. MAXIMUM PEAK OUTPUT POWER

9.1 Measurement Procedure

Maximum Conducted Output Power at Antenna Terminals, FCC Rules 15.247(b)(1):

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.

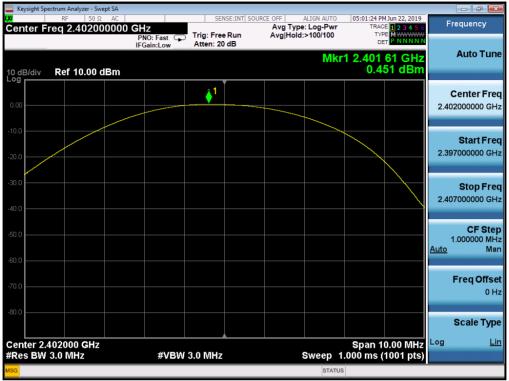
9.2 Measurement Results

Refer to attached data chart.

Modulation :	GFSK, π/4-DQPSK		
RBW :	3MHz	VBW :	3MHz
Spectrum Detector:	PK	Test Date :	June 18, 2019
Test By:	Lee	Temperature :	22 °C
Test Result:	PASS	Humidity :	53 %

Channel Frequency	Peak Power	Peak Power	Peak Power	Pass/Fail	
(MHz)	output(dBm)	output(mW)	Limit(dBm)		
GFSK					
2402.00	0.451	1.10943	21	PASS	
2441.00	0.192	1.04520	21	PASS	
2480.00	-0.705	0.85016	21	PASS	
π/4-DQPSK					
2402.00	1.164	1.30737	21	PASS	
2441.00	0.902	1.23084	21	PASS	
2480.00	0.012	1.00277	21	PASS	



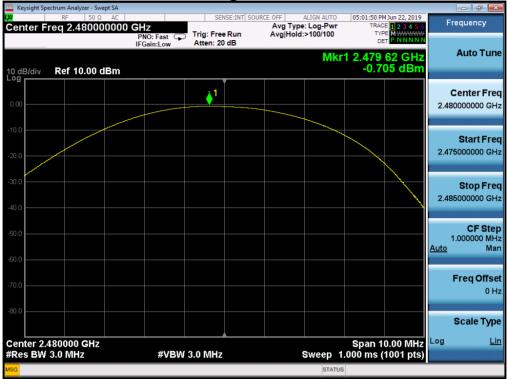


GFSK Lowest Channel

GFSK Middle Channel

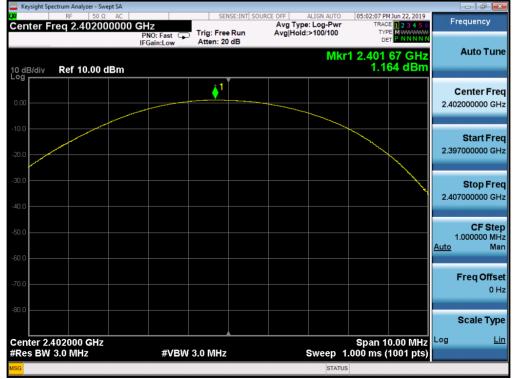
Keysight Spectrum Analyzer - Swept SA					
₩ RF 50 Ω AC Center Freq 2.441000000	GHz	Avg Type	E: Log-Pwr TRA	PM Jun 22, 2019 CE 1 2 3 4 5 6 (PE M WWWWWW	Frequency
10 dB/div Ref 10.00 dBm	PNO: Fast Trig: Free IFGain:Low Atten: 20		Mkr1 2.440	PNNNN	Auto Tune
0.00	<u> </u>				Center Freq 2.441000000 GHz
-10.0					Start Freq 2.436000000 GHz
-30.0					Stop Freq 2.446000000 GHz
-60.0				Ē	CF Step 1.000000 MHz Auto Mar
-70.0					Freq Offse 0 H;
-80.0					Scale Type
Center 2.441000 GHz #Res BW 3.0 MHz	#VBW 3.0 MHz		Span ′ Sweep 1.000 ms	10.00 191112	_og <u>Lin</u>
MSG			STATUS		



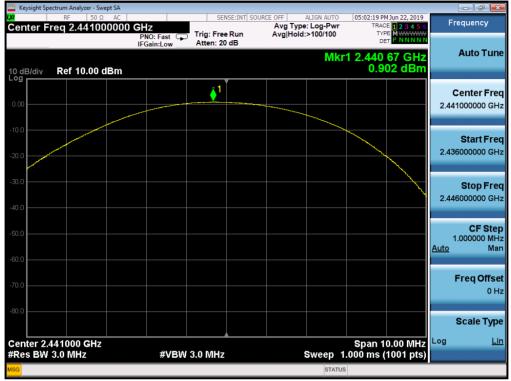


GFSK Highest Channel

π/4-DQPSK Lowest Channel







π/4-DQPSK Middle Channel

π/4-DQPSK Highest Channel





10. Band Edge

10.1 Measurement Procedure

Out of Band Conducted Emissions, FCC Rule 15.247(d):

The transmitter output is connected to spectrum analyzer. The resolution bandwidth is set to100KHz, and the video bandwidth set to 300KHz.

10.2 Limit

15.247(d)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 Emission The worst case: $\pi/4$ -DQPSK

Hopping-on mode

Freq. (MHz)	Ant.Pol. (H/V)	Reading Level(dBuV)		Factor	Emission Level (dBuV)		Limit 3m (dBuV/m)		Margin (dB)	
		PK	AV	(dB/m)	PK	AV	PK	AV	PK	AV
2390.000	Н	54.26	34.02	0.09	54.35	34.11	74.00	54.00	-19.65	-19.89
2390.000	V	50.99	34.65	0.09	51.08	34.74	74.00	54.00	-22.92	-19.26
2483.500	Н	63.26	44.26	0.35	63.61	44.61	74.00	54.00	-10.39	-9.39
2483.500	V	59.22	42.13	0.35	59.57	42.48	74.00	54.00	-14.43	-11.52

Note: (1) Emission Level= Reading Level + Factor

(2) Factor= Antenna Gain + Cable Loss - Amplifier Gain

(3) Horn antenna used for the emission over 1000MHz.



For RF Conducted

aht Spectrum Analyzer - Swept SA Kev 10:48:54 AM Jul 10, 2019 Avg Type: Log-Pwr Avg|Hold:>100/100 Display Display Line -25.15 dBm TRACE 1 2 3 4 1 TYPE MWWW DET P NNN Trig: Free Run Atten: 30 dB PNO: Wide **Annotation**► Mkr2 2.399 78 GHz -49.081 dBm 10 dB/div Log Ref 20.00 dBm Title► Graticule On Off Display Line -25.15 dBm As_A Off <u> 0n</u> Center 2.400000 GHz #Res BW 100 kHz Span 10.00 MHz Sweep 1.000 ms (1001 pts) #VBW 300 kHz FUNCTION FUNCTION WIDTH FUNCTION ' VALUE 2.401 60 GHz 2.399 78 GHz -5.153 dBm -49.081 dBm N 1 f System Display► Settings STATUS abt Spectrum Analyzer - Swept SA Key 10:49:59 AM Jul 10, 2019 GN AU Display Avg Type: Log-Pwr Avg|Hold:>100/100 Display Line -25.15 dBm TRACE 1 2 3 4 5 Trig: Free Run Atten: 30 dB TYP PNO: Wide 😱 IFGain:Low **Annotation** Mkr2 2.399 78 GHz -49.081 dBm Ref 20.00 dBm 10 dB/div Log Title► Graticule Off <u> On</u> Display Line -25.15 dBm <u>On</u> Off Center 2.400000 GHz #Res BW 100 kHz Span 10.00 MHz Sweep 1.000 ms (1001 pts) #VBW 300 kHz EUNCTION EUNCTION EUNCTIO 2.401 60 GHz 2.399 78 GHz -5.153 dBr -49.081 dBr N 1 f N 1 f System Display► Settings File <Screen_0010.png> saved STATUS

GFSK Lowest Channel



GFSK Highest Channel







π/4-DQPSK Lowest Channel



π/4-DQPSK Highest Channel





11.Antenna Application

11.1 Antenna requirement

According to of FCC part 15C section 15.203 and 15.240:

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 -0.68dBi. 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):

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

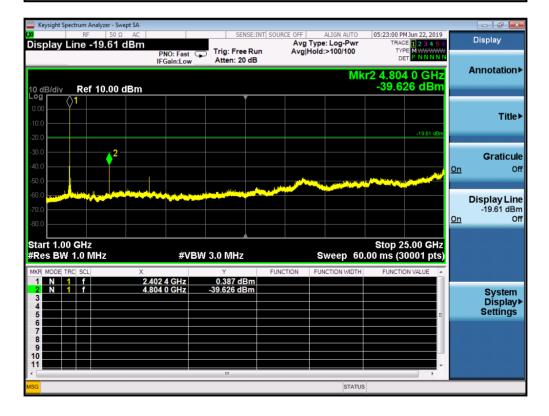
12.2. Measurement Results

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



Lowest Channel

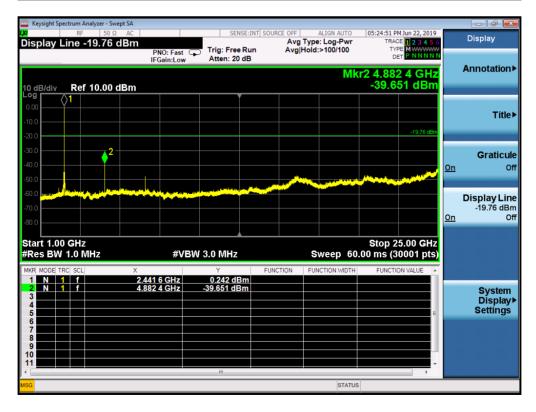
Keysight Spectrum Analyzer - Swept SA				
RF 50Ω AC Marker 1 576.013000000 M	MHz PNO: Fast Trig: Free F			Peak Search
I0 dB/div Ref 10.00 dBm	IFGain:Low Atten: 20 d	-	/kr1 576.01 MHz -69.073 dBm	Next Pea
• • • • • • • • • • • • • • • • • • •			-19.61 dBin	Next Pk Rig
40.0				Next Pk Le
60.0			an an ing see yak na pana in ang an ang ang ang ang ang ang ang ang	Marker De
itart 0.0300 GHz Res BW 100 kHz	Mkr→C			
	76.01 MHz -69.073 dBn	FUNCTION FUNCTION WIDT	H FUNCTION VALUE	Mkr→RefL
6 7 7 8 8 9 9 10 10 10 10 10 10 10 10 10 10 10 10 10				Мо 1 о
sg	III	STAT	US	





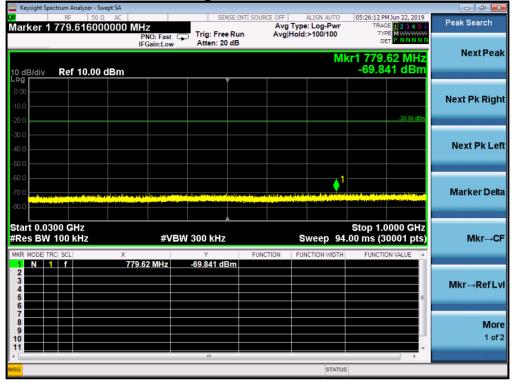
Middle Channel

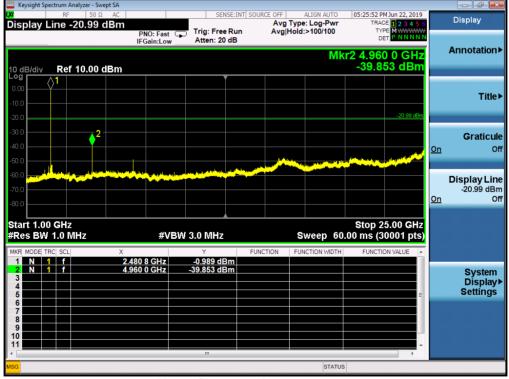
🔤 Keysight Spectrum Analyzer - Swept SA 👘					
x RF 50 Ω AC Marker 1 944.2573333333 I	MHz PNO: Fast 🕟 Tri		ALIGN AUTO g Type: Log-Pwr g Hold:>100/100	05:25:11 PM Jun 22, 2019 TRACE 1 2 3 4 5 6 TYPE MWWWW DET P N N N N N	Peak Search
10 dB/div Ref 10.00 dBm	IFGain:Low At	ten: 20 dB	Mk	r1 944.26 MHz -68.624 dBm	Next Peak
Log 0.00 				-19.76 dBm	Next Pk Right
-30.0					Next Pk Left
-60.0 -70.0 -80.0	an Josef and State and Sta	Hand Background State Responses for the state State And Background State State on the state state of the state State And Background State State State State State State State State State State State State State State State State	eng banggan jin sebya ing ng ku dun dun ku ki k mang bang gang pangan saka ku duk dun se pangan saka		Marker Delta
Start 0.0300 GHz #Res BW 100 KHz	#VBW 300) KHZ	Sweep 94.	Stop 1.0000 GHz 00 ms (30001 pts)	Mkr→CF
1 N 1 f 9/ 2 -	44.26 MHz _68.	624 dBm		=	Mkr→RefLv
7 8 9 10					More 1 of 2
	-	m	STATUS	b.	





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	15I00041SN 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.