TCT 通测检测 TESTING CENTRE TECHNOLOGY

TEST REPORT

FCC ID: 2ALW3PE-MH

Product: Electric Ukulele

Model No.: 22SPEMH

Additional Model No.: 22TCJSU, 22TCJMH, 22TMSLT, 22BLSPT, 22BBCPT, 21CBAEA, 21CBABK, 21CMHEC, 21OSREC

Trade Mark: EleUke

Report No.: TCT170320E004

Issued Date: Mar. 31, 2017

Issued for:

Grantec international

Room 2002, Building 3, Xinglin Bay Operation Center, Jimei District, Xiamen, China

Issued By:

Shenzhen Tongce Testing Lab.

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Hotline: 400-6611-140 Tel: 86-755-27673339 Fax: 86-755-27673332 http://www.tct-lab.com

1. Test Certification

Product:	Electric Ukulele
Model No.:	22SPEMH
Additional Model:	22TCJSU, 22TCJMH, 22TMSLT, 22BLSPT, 22BBCPT, 21CBAEA, 21CBABK, 21CMHEC, 21OSREC
Applicant:	Grantec international
Address:	Room 2002, Building 3, Xinglin Bay Operation Center, Jimei District, Xiamen, China
Manufacturer:	Xiamen Weiyou Intelligent Technology Co., Ltd
Address:	NO.215, Tian Feng Road, Jimei North Industrial Zone, Xiamen.
Date of Test:	Mar. 21 – Mar. 29, 2017
Applicable Standards:	FCC CFR Title 47 Part 15 Subpart C Section 15.247

The above equipment has been tested by Shenzhen Tongce Testing Lab. and found compliance with the requirements set forth in the technical standards mentioned above. The results of testing in this report apply only to the product/system, which was tested. Other similar equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Tested By: Jin Wang ***Date:*** ***Mar. 29, 2017***

Jin Wang

Reviewed By: ***Date:*** ***Mar. 31, 2017***

Joe Zhou

Approved By: Tomsin ***Date:*** ***Mar. 31, 2017***

Tomsin

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2. Test Result Summary

Requirement	CFR 47 Section	Result
Antenna Requirement	§15.203/§15.247 (c)	PASS
AC Power Line Conducted Emission	§15.207	PASS
Conducted Peak Output Power	§15.247 (b)(1) §2.1046	PASS
20dB Occupied Bandwidth	§15.247 (a)(1) §2.1049	PASS
Carrier Frequencies Separation	§15.247 (a)(1)	PASS
Hopping Channel Number	§15.247 (a)(1)	PASS
Dwell Time	§15.247 (a)(1)	PASS
Radiated Emission	§15.205/§15.209 §2.1053, §2.1057	PASS
Band Edge	§15.247(d) §2.1051, §2.1057	PASS

Note:

1. PASS: Test item meets the requirement.

2. Fail: Test item does not meet the requirement.

3. N/A: Test case does not apply to the test object.

4. The test result judgment is decided by the limit of test standard.

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3. EUT Description

Product Name:	Electric Ukulele
Model :	22SPEMH
Additional Model:	22TCJSU, 22TCJMH, 22TMSLT, 22BLSPT, 22BBCPT, 21CBAEA, 21CBABK, 21CMHEC, 21OSREC
Trade Mark:	**EleUke**
Bluetooth version：	2.1 + EDR
Operation Frequency:	2402MHz~2480MHz
Transfer Rate:	1/2 Mbits/s
Number of Channel:	79
Modulation Type:	GFSK, π/4-DQPSK
Modulation Technology:	FHSS
Antenna Type:	PCB Antenna
Antenna Gain:	-0.68dBi
Power Supply:	Rechargeable Li-ion Battery DC3.7V
Remark:	All models above are identical in interior structure, electrical circuits and components, just model names and appearance are different for the marketing requirement.

Operation Frequency each of channel for GFSK, π/4-DQPSK

Channel	Frequency	Channel	Frequency	Channel	Frequency	Channel	Frequency
0	2402MHz	20	2422MHz	40	2442MHz	60	2462MHz
1	2403MHz	21	2423MHz	41	2443MHz	61	2463MHz
…	…	…	…	…	…	…	…
10	2412MHz	30	2432MHz	50	2452MHz	70	2472MHz
11	2413MHz	31	2433MHz	51	2453MHz	71	2473MHz
…	…	…	…	…	…	…	…
18	2420MHz	38	2440MHz	58	2460MHz	78	2480MHz
19	2421MHz	39	2441MHz	59	2461MHz	-	
Remark: Channel 0, 39 &78 have been tested for GFSK, π/4-DQPSK modulation mode.							

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4. Genera Information

4.1. Test environment and mode

Operating Environment:	
Temperature:	25.0 °C
Humidity:	56 % RH
Atmospheric Pressure:	1010 mbar
Test Mode:	
Engineering mode:	Keep the EUT in continuous transmitting by select channel and modulations with Fully-charged battery
The sample was placed 0.8m & 1.5m for the measurement below & above 1GHz above the ground plane of 3m chamber. Measurements in both horizontal and vertical polarities were performed. During the test, each emission was maximized by: having the EUT continuously working, investigated all operating modes, rotated about all 3 axis (X, Y & Z) and considered typical configuration to obtain worst position, manipulating interconnecting cables, rotating the turntable, varying antenna height from 1m to 4m in both horizontal and vertical polarizations. The emissions worst-case are shown in Test Results of the following pages.	

4.2. Description of Support Units

The EUT has been tested as an independent unit together with other necessary accessories or support units. The following support units or accessories were used to form a representative test configuration during the tests.

Equipment	Model No.	Serial No.	FCC ID	Trade Name
Adapter	XC-0501000-06-B	/	/	ADAPTER

Note:

1. All the equipment/cables were placed in the worst-case configuration to maximize the emission during the test.

2. Grounding was established in accordance with the manufacturer's requirements and conditions for the intended use.

3. For conducted measurements (Output Power, 20dB Occupied Bandwidth, Carrier Frequencies Separation, Hopping Channel Number, Dwell Time, Spurious Emissions), the antenna of EUT is connected to the test equipment via temporary antenna connector, the antenna connector is soldered on the antenna port of EUT, and the temporary antenna connector is listed in the Test Instruments.

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5. Facilities and Accreditations

5.1. Facilities

The test facility is recognized, certified, or accredited by the following organizations:

- FCC - Registration No.: 572331

  Shenzhen Tongce Testing Lab

  The 3m Semi-anechoic chamber has been registered and fully described in a report with the (FCC) Federal Communications Commission. The acceptance letter from the FCC is maintained in our files.

- IC - Registration No.: 10668A-1

  The 3m Semi-anechoic chamber of Shenzhen TCT Testing Technology Co., Ltd. has been registered by Certification and Engineering Bureau of Industry Canada for radio equipment testing

- CNAS - Registration No.: CNAS L6165

  Shenzhen TCT Testing Technology Co., Ltd. is accredited to ISO/IEC 17025:2005 General Requirements for the Competence of Testing and Calibration laboratories for the competence of testing. The Registration No. is CNAS L6165.

5.2. Location

Shenzhen Tongce Testing Lab
Address: 1F, Leinuo Watch Building, Fuyong Town, Baoan Dist, Shenzhen, China
Tel: 86-755-36638142

5.3. Measurement Uncertainty

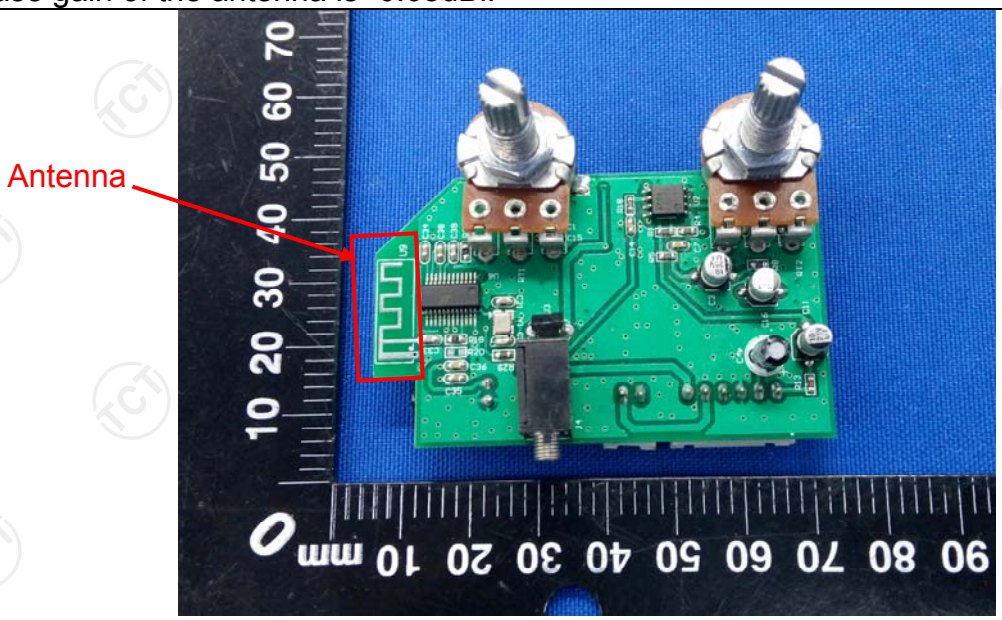
The reported uncertainty of measurement y ± U, where expended uncertainty U is based on a standard uncertainty multiplied by a coverage factor of k=2, providing a level of confidence of approximately 95 %.

No.	Item	MU
1	Conducted Emission	±2.56dB
2	RF power, conducted	±0.12dB
3	Spurious emissions, conducted	±0.11dB
4	All emissions, radiated(<1G)	±3.92dB
5	All emissions, radiated(>1G)	±4.28dB
6	Temperature	±0.1°C
7	Humidity	±1.0%

6. Test Results and Measurement Data

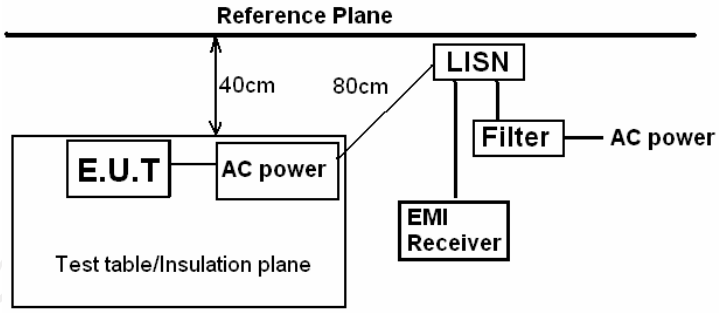
6.1. Antenna requirement

Standard requirement:	FCC Part15 C Section 15.203 /247(c)
15.203 requirement: 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. 15.247(c) (1)(i) requirement: (i) Systems operating in the 2400-2483.5 MHz band that is used exclusively for fixed. Point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum conducted output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.	
E.U.T Antenna:	
The Bluetooth antenna is a PCB antenna which permanently attached, and the best case gain of the antenna is -0.68dBi.	



6.2. Conducted Emission

6.2.1. Test Specification

<table>
<tr><td>Test Requirement:</td><td>FCC Part15 C Section 15.207</td></tr>
<tr><td>Test Method:</td><td>ANSI C63.10:2013</td></tr>
<tr><td>Frequency Range:</td><td>150 kHz to 30 MHz</td></tr>
<tr><td>Receiver setup:</td><td>RBW=9 kHz, VBW=30 kHz, Sweep time=auto</td></tr>
<tr><td>Limits:</td><td>
<table>
<tr><td rowspan="2">Frequency range (MHz)</td><td colspan="2">Limit (dBuV)</td></tr>
<tr><td>Quasi-peak</td><td>Average</td></tr>
<tr><td>0.15-0.5</td><td>66 to 56*</td><td>56 to 46*</td></tr>
<tr><td>0.5-5</td><td>56</td><td>46</td></tr>
<tr><td>5-30</td><td>60</td><td>50</td></tr>
</table>
</td></tr>
<tr><td>Test Setup:</td><td> 

Remark:
E.U.T: Equipment Under Test
LISN: Line Impedence Stabilization Network
Test table height=0.8m</td></tr>
<tr><td>Test Mode:</td><td>Refer to item 4.1</td></tr>
<tr><td>Test Procedure:</td><td>1. The E.U.T is connected to an adapter through a line impedance stabilization network (L.I.S.N.). This provides a 50ohm/50uH coupling impedance for the measuring equipment.
2. The peripheral devices are also connected to the main power through a LISN that provides a 50ohm/50uH coupling impedance with 50ohm termination. (Please refer to the block diagram of the test setup and photographs).
3. Both sides of A.C. line are checked for maximum conducted interference. In order to find the maximum emission, the relative positions of equipment and all of the interface cables must be changed according to ANSI C63.10:2013 on conducted measurement.</td></tr>
<tr><td>Test Result:</td><td>PASS</td></tr>
</table>

6.2.2. Test Instruments

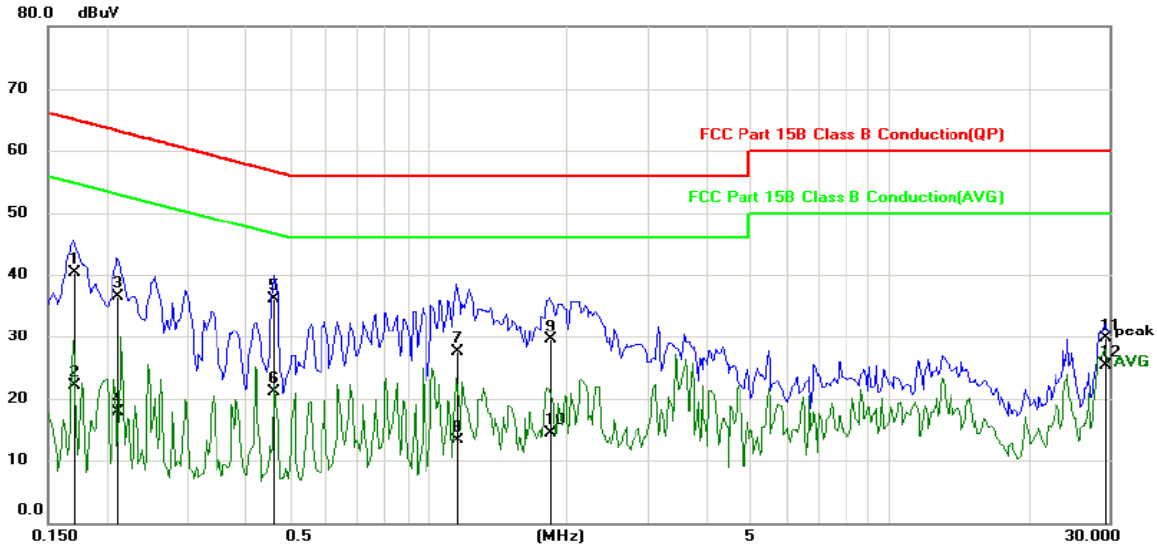
Conducted Emission Shielding Room Test Site (843)				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
EMI Test Receiver	R&S	ESCS30	Aug. 10, 2016	Aug. 11, 2017
LISN	Schwarzbeck	NSLK 8126	Aug. 15, 2016	Aug. 16, 2017
Coax cable (9KHz-40GHz)	TCT	CE-05	Aug. 10, 2016	Aug. 11, 2017
EMI Test Software	Shurple Technology	EZ-EMC	N/A	N/A

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.2.3. Test data

Please refer to following diagram for individual

Conducted Emission on Line Terminal of the power line (150 kHz to 30MHz)



Site

Limit: FCC Part 15B Class B Conduction(QP)

Phase: *L1*

Power: AC 120V/60Hz

Temperature: 26

Humidity: 60 %

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		
		MHz	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1		0.1695	28.85	11.49	40.34	64.98	-24.64	QP	
2		0.1695	10.71	11.49	22.20	54.98	-32.78	AVG	
3		0.2125	24.96	11.46	36.42	63.11	-26.69	QP	
4		0.2125	6.47	11.46	17.93	53.11	-35.18	AVG	
5	*	0.4625	24.72	11.33	36.05	56.65	-20.60	QP	
6		0.4625	9.74	11.33	21.07	46.65	-25.58	AVG	
7		1.1539	16.32	11.28	27.60	56.00	-28.40	QP	
8		1.1539	2.06	11.28	13.34	46.00	-32.66	AVG	
9		1.8414	17.83	11.63	29.46	56.00	-26.54	QP	
10		1.8414	2.85	11.63	14.48	46.00	-31.52	AVG	
11		29.3594	18.97	10.70	29.67	60.00	-30.33	QP	
12		29.3594	14.55	10.70	25.25	50.00	-24.75	AVG	

Note:

Freq. = Emission frequency in MHz

Reading level (dBμV) = Receiver reading

Corr. Factor (dB) = Antenna factor + Cable loss

Measurement (dBμV) = Reading level (dBμV) + Corr. Factor (dB)

Limit (dBμV) = Limit stated in standard

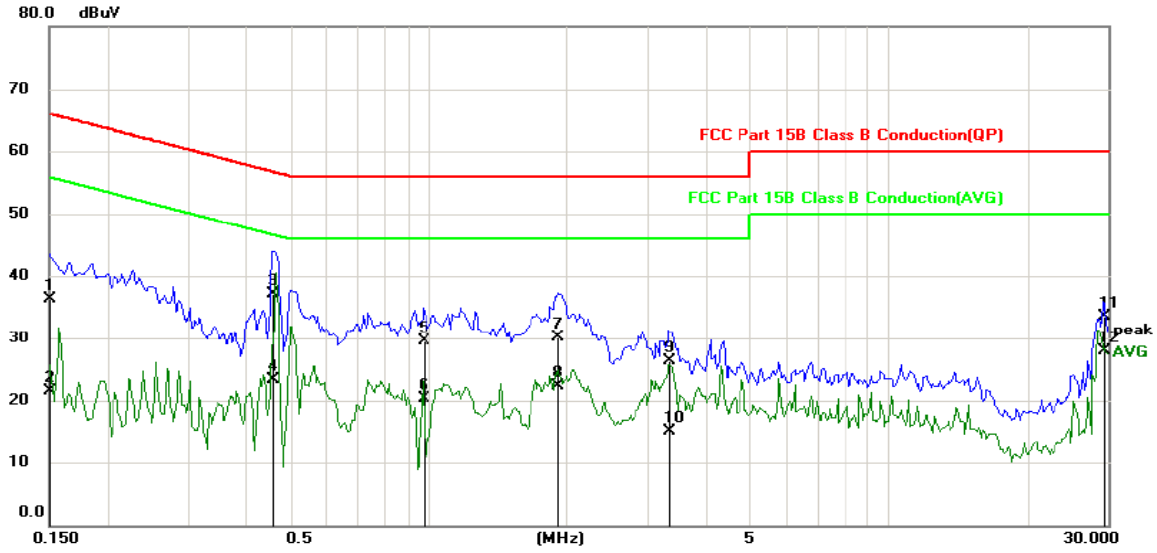
Margin (dB) = Measurement (dBμV) – Limits (dBμV)

Q.P. =Quasi-Peak

AVG =average

** is meaning the worst frequency has been tested in the frequency range 150 kHz to 30MHz*

Conducted Emission on Neutral Terminal of the power line (150 kHz to 30MHz)



Site

Limit: FCC Part 15B Class B Conduction(QP)

Phase: N

Power: AC 120V/60Hz

Temperature: 26

Humidity: 60 %

No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over		
		MHz	dBuV	dB	dBuV	dBuV	dB	Detector	Comment
1		0.1500	24.78	11.50	36.28	66.00	-29.72	QP	
2		0.1500	10.06	11.50	21.56	56.00	-34.44	AVG	
3	*	0.4586	25.76	11.33	37.09	56.72	-19.63	QP	
4		0.4586	11.95	11.33	23.28	46.72	-23.44	AVG	
5		0.9742	18.30	11.21	29.51	56.00	-26.49	QP	
6		0.9742	9.04	11.21	20.25	46.00	-25.75	AVG	
7		1.9117	18.51	11.65	30.16	56.00	-25.84	QP	
8		1.9117	10.66	11.65	22.31	46.00	-23.69	AVG	
9		3.3359	15.10	11.22	26.32	56.00	-29.68	QP	
10		3.3359	3.86	11.22	15.08	46.00	-30.92	AVG	
11		29.3594	22.72	10.70	33.42	60.00	-26.58	QP	
12		29.3594	17.27	10.70	27.97	50.00	-22.03	AVG	

Note1:

Freq. = Emission frequency in MHz

Reading level (dBμV) = Receiver reading

Corr. Factor (dB) = Antenna factor + Cable loss

Measurement (dBμV) = Reading level (dBμV) + Corr. Factor (dB)

Limit (dBμV) = Limit stated in standard

Margin (dB) = Measurement (dBμV) – Limits (dBμV)

Q.P. =Quasi-Peak AVG =average

** is meaning the worst frequency has been tested in the frequency range 150 kHz to 30MHz.*

Note2:

Measurements were conducted in all three channels (high, middle, low) and three modulation (GFSK, Pi/4 DQPSK), and the worst case Mode (Lowest channel and Pi/4 DQPSK) was submitted only.

6.3. Conducted Output Power

6.3.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (b)(3)
Test Method:	ANSI C63.10:2013
Limit:	Section 15.247 (b) The maximum peak conducted output power of the intentional radiator shall not exceed the following: (1) For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band 0.125 watts.
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	Use the following spectrum analyzer settings: Span = approximately 5 times the 20 dB bandwidth, centered on a hopping channel RBW > the 20 dB bandwidth of the emission being measured VBW ≥ RBW Sweep = auto Detector function = peak Trace = max hold Allow the trace to stabilize. Use the marker-to-peak function to set the marker to the peak of the emission.
Test Result:	PASS

6.3.2. Test Instruments

Equipment	Manufacturer	Model	Calibration Date	Calibration Due
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.3.3. Test Data

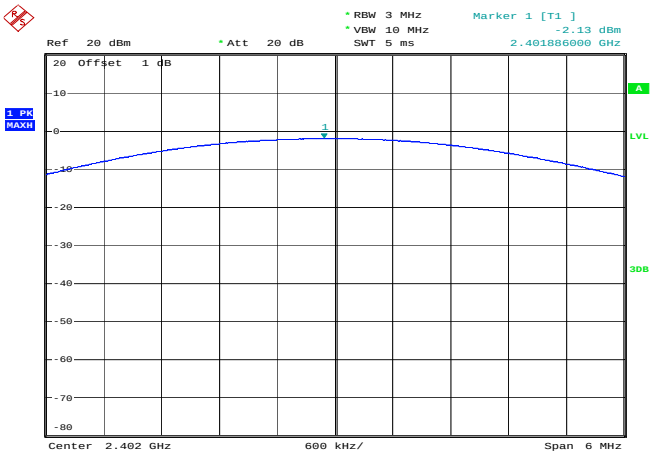
GFSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	-2.13	21.00	PASS
Middle	-2.90	21.00	PASS
Highest	-4.22	21.00	PASS

Pi/4DQPSK mode			
Test channel	Peak Output Power (dBm)	Limit (dBm)	Result
Lowest	-1.00	21.00	PASS
Middle	-1.78	21.00	PASS
Highest	-3.10	21.00	PASS

Test plots as follows:

GFSK Modulation

Lowest channel



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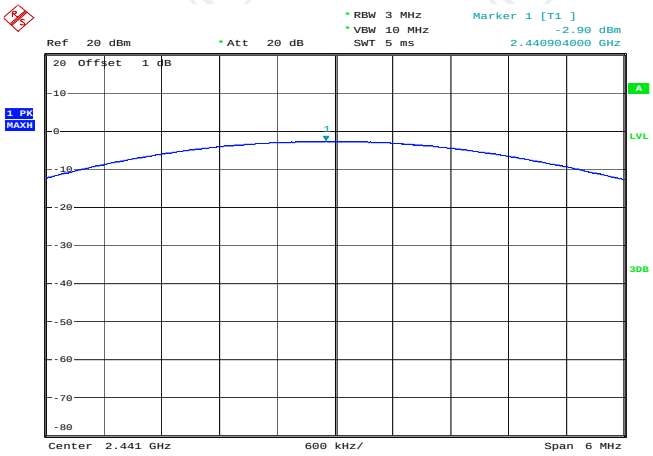
Middle channel



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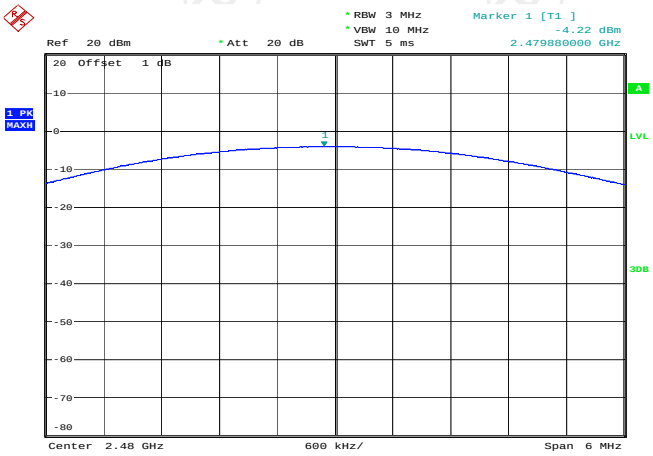
Highest channel



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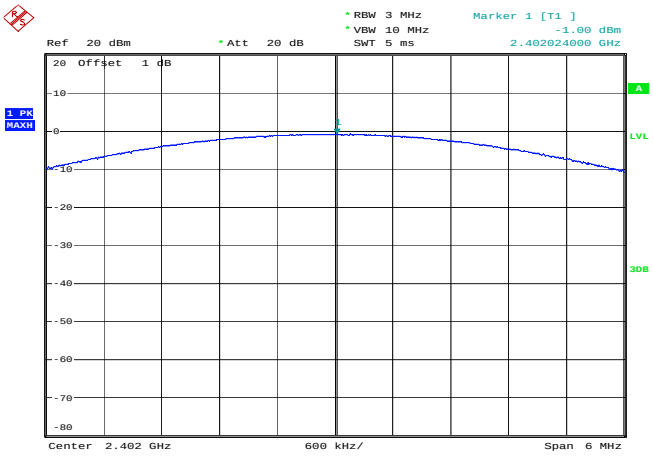
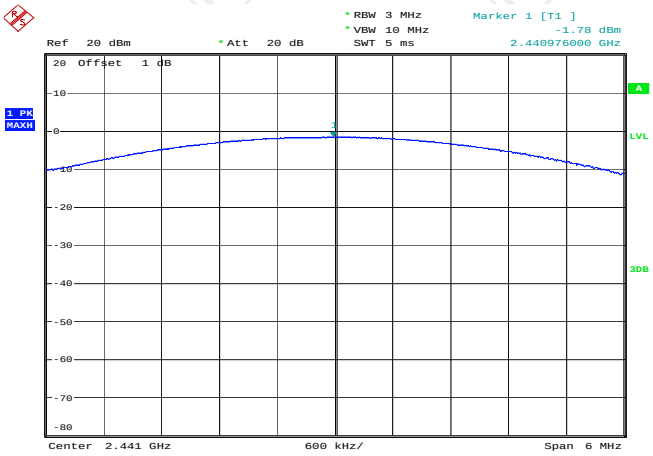
Pi/4DQPSK Modulation

Lowest channel



Date: 28.MAR.2017 11:27:11

Middle channel



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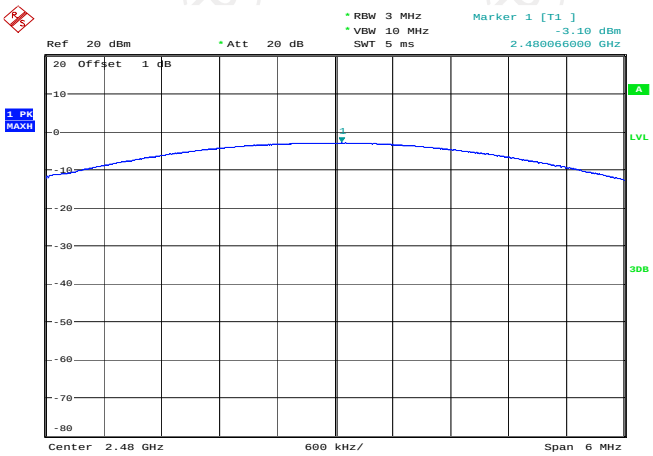
Highest channel



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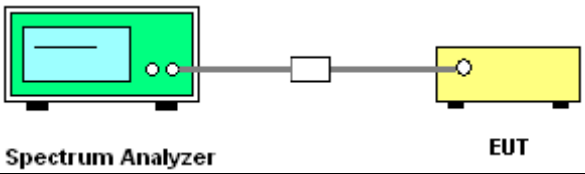
6.4. 20dB Occupy Bandwidth

6.4.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Limit:	N/A
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows ANSI C63.10:2013 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Use the following spectrum analyzer settings for 20dB Bandwidth measurement. Span = approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel; 1%≤ RBW≤5% of the 20 dB bandwidth; VBW≥3RBW; Sweep = auto; Detector function = peak; Trace = max hold. 5. Measure and record the results in the test report.
Test Result:	PASS

6.4.2. Test Instruments

RF Test Room				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

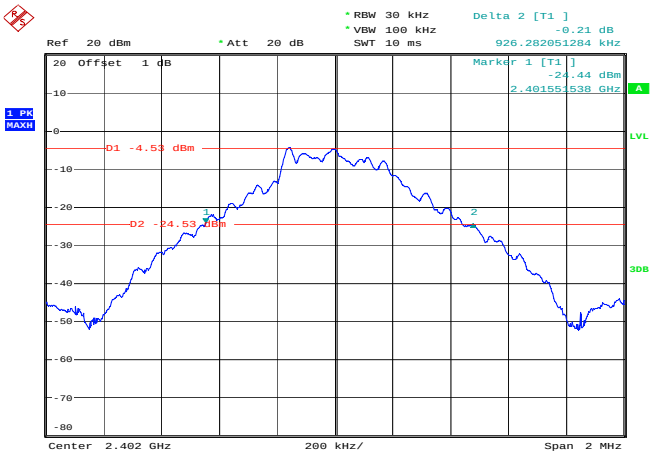
6.4.3. Test data

Test channel	20dB Occupy Bandwidth (kHz)		
	GFSK	π/4-DQPSK	Conclusion
Lowest	926.28	1262.82	PASS
Middle	923.08	1262.82	PASS
Highest	923.08	1262.82	PASS

Test plots as follows:

GFSK Modulation

Lowest channel



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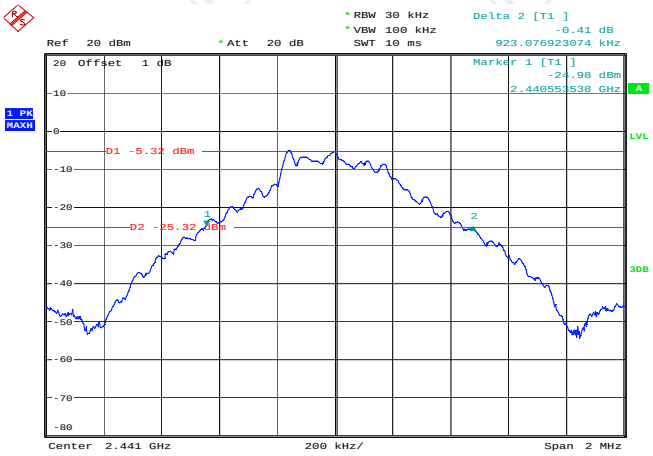
Middle channel



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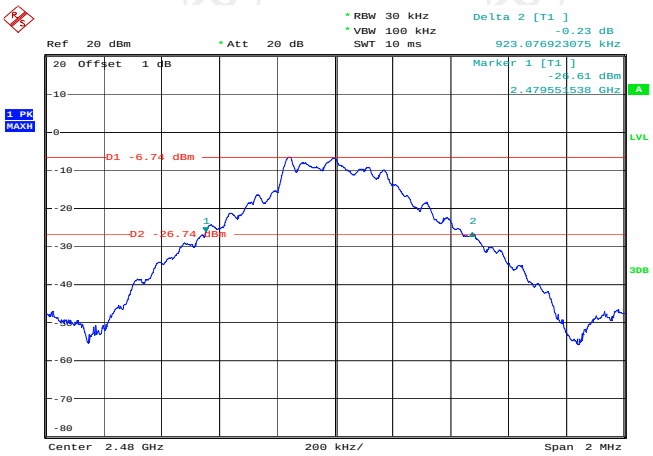
Highest channel



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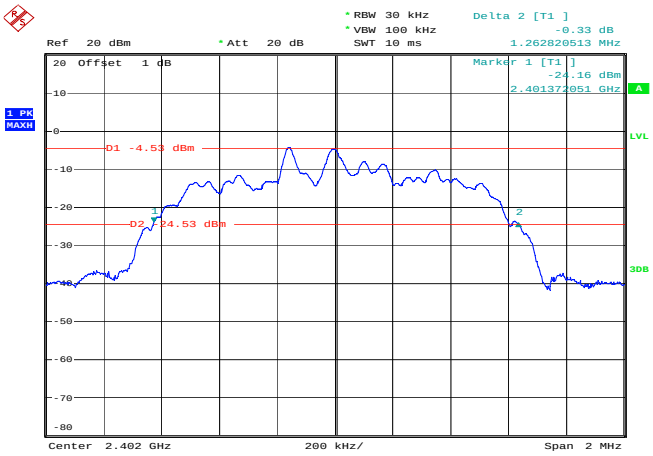
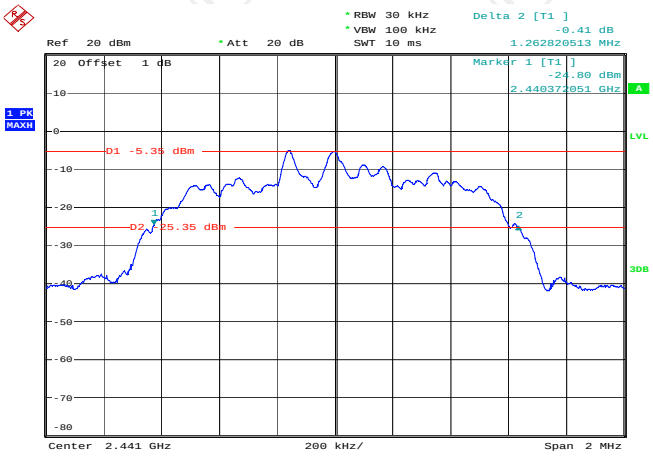
Pi/4DQPSK Modulation

Lowest channel



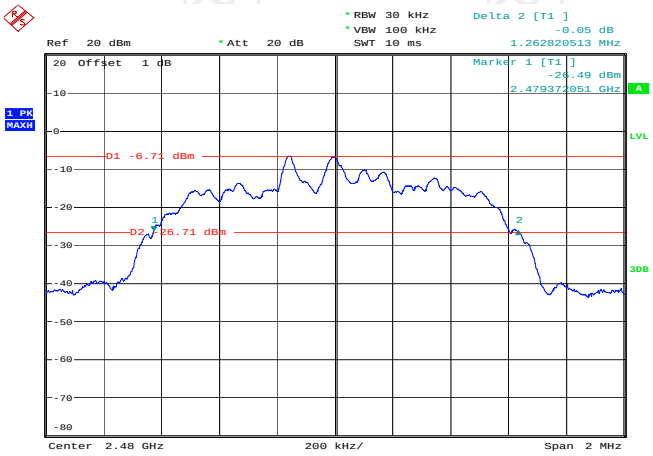
Date: 28.MAR.2017 11:21:11

Middle channel



Date: 28.MAR.2017 11:19:27

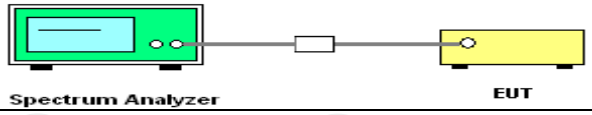
Highest channel



Date: 28.MAR.2017 11:18:11

6.5. Carrier Frequencies Separation

6.5.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Limit:	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.
Test Setup:	
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2013 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = wide enough to capture the peaks of two adjacent channels; RBW is set to approximately 30% of the channel spacing, adjust as necessary to best identify the center of each individual channel; VBW≥RBW; Sweep = auto; Detector function = peak; Trace = max hold. 6. Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Record the value in report.
Test Result:	PASS

6.5.2. Test Instruments

RF Test Room				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.5.3. Test data

GFSK mode			
Test channel	Carrier Frequencies Separation (kHz)	Limit (kHz)	Result
Lowest	1004.00	*617.52*	PASS
Middle	998.00	*617.52*	PASS
Highest	1001.21	*617.52*	PASS

Pi/4 DQPSK mode			
Test channel	Carrier Frequencies Separation (kHz)	Limit (kHz)	Result
Lowest	1000.00	*841.88*	PASS
Middle	1000.00	*841.88*	PASS
Highest	1003.53	*841.88*	PASS

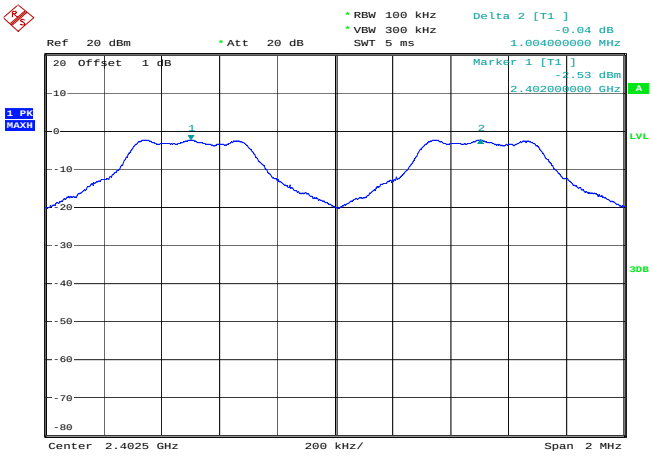
Note: According to section 6.4

Mode	*20dB bandwidth (kHz) (worse case)*	*Limit (kHz) (Carrier Frequencies Separation)*
GFSK	*926.28*	*617.52*
π/4-DQPSK	*1262.82*	*841.88*

Test plots as follows:

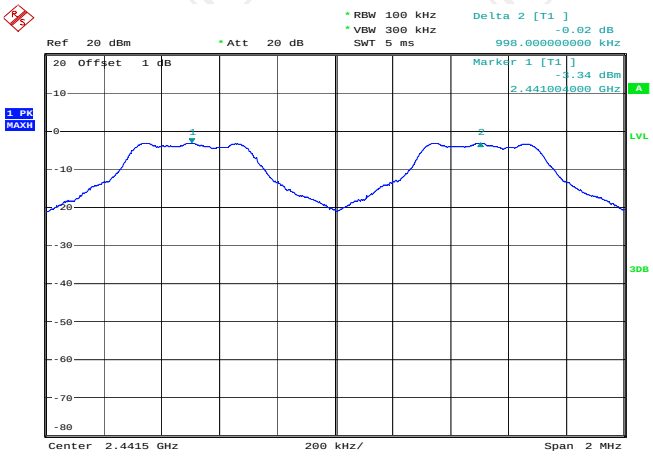
GFSK Modulation

Lowest channel



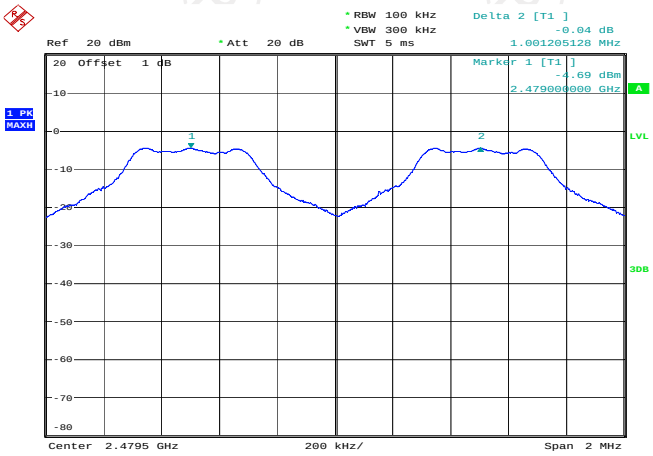
Date: 28.MAR.2017 11:30:18

Middle channel



Date: 28.MAR.2017 11:32:47

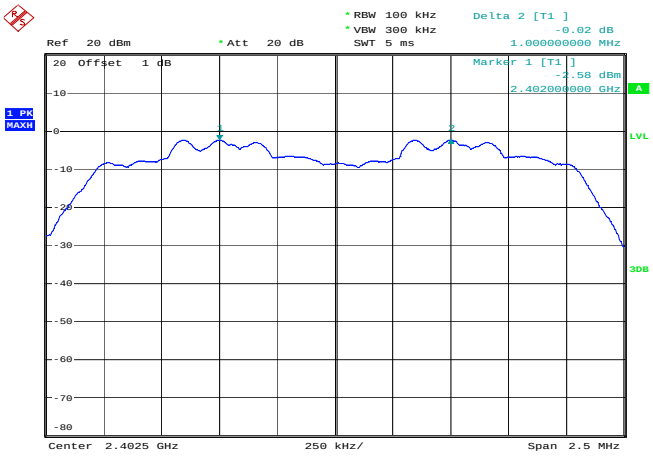
Highest channel



Date: 28.MAR.2017 11:34:24

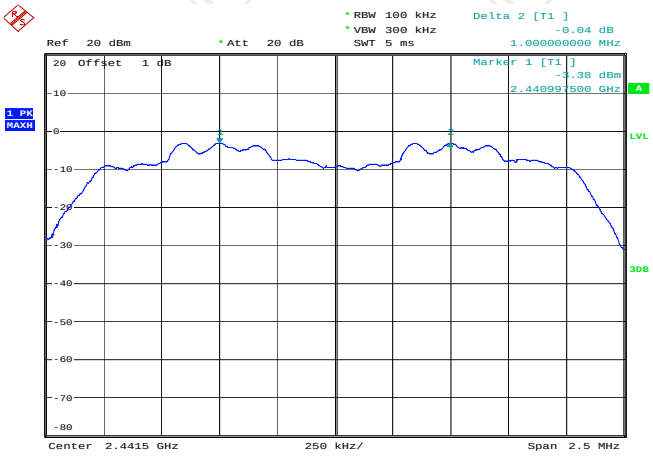
Pi/4DQPSK Modulation

Lowest channel



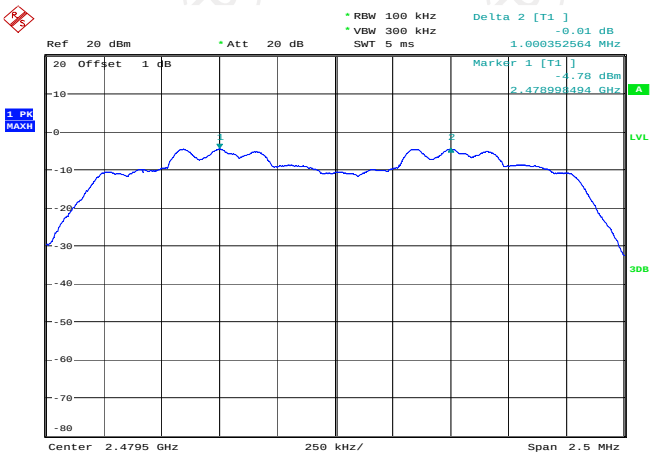
Date: 28.MAR.2017 11:36:32

Middle channel



Date: 28.MAR.2017 11:46:13

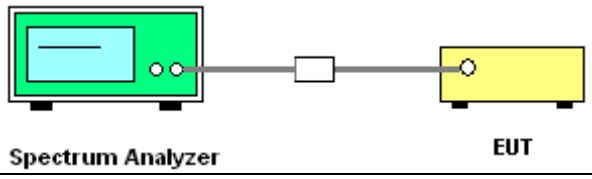
Highest channel



Date: 28.MAR.2017 11:51:05

6.6. Hopping Channel Number

6.6.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
Limit:	Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels.
Test Setup:	
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2013 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = the frequency band of operation; set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller; VBW≥RBW; Sweep = auto; Detector function = peak; Trace = max hold. 6. The number of hopping frequency used is defined as the number of total channel. 7. Record the measurement data in report.
Test Result:	PASS

6.6.2. Test Instruments

RF Test Room				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

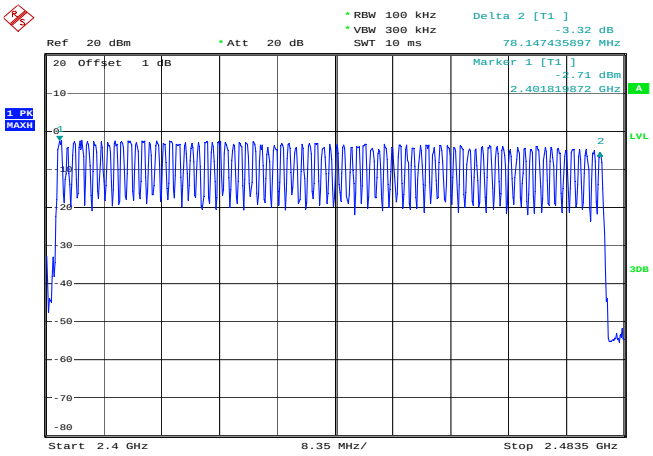
Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.6.3. Test data

Mode	Hopping channel numbers	Limit	Result
GFSK, P/4-DQPSK	79	15	PASS

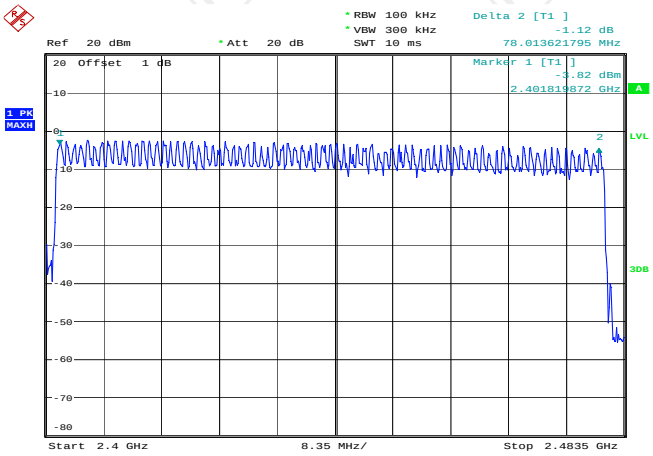
Test plots as follows:

GFSK



Date: 28.MAR.2017 12:05:00

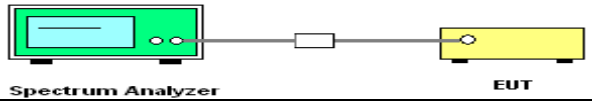
Pi/4DQPSK



Date: 28.MAR.2017 12:07:26

6.7. Dwell Time

6.7.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (a)(1)
Test Method:	ANSI C63.10:2013
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.
Test Setup:	
Test Mode:	Hopping mode
Test Procedure:	1. The testing follows ANSI C63.10:2013 Measurement Guidelines. 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Enable the EUT hopping function. 5. Use the following spectrum analyzer settings: Span = zero span, centered on a hopping channel; RBW shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel; VBW≥RBW; Sweep = as necessary to capture the entire dwell time per hopping channel; Detector function = peak; Trace = max hold. 6. Measure and record the results in the test report.
Test Result:	PASS

6.7.2. Test Instruments

RF Test Room				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.7.3. Test Data

Mode	Packet	Hops Over Occupancy Time (hops)	Package Transfer Time (ms)	Dwell time (second)	Limit (second)	Result
GFSK	DH1	320	0.470	0.150	0.4	PASS
GFSK	DH3	160	1.745	0.279	0.4	PASS
GFSK	DH5	106.67	3.000	0.320	0.4	PASS
Pi/4 DQPSK	2-DH1	320	0.482	0.154	0.4	PASS
Pi/4 DQPSK	2-DH3	160	1.750	0.280	0.4	PASS
Pi/4 DQPSK	2-DH5	106.67	3.006	0.321	0.4	PASS

Note: *1. In normal mode, hopping rate is 1600 hops/s with 6 slots in 79 hopping channels.*

For DH1, With channel hopping rate (1600 / 2 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 2 / 79) x (0.4 x 79) = 320 hops

For DH3, With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 4 / 79) x (0.4 x 79) = 160 hops

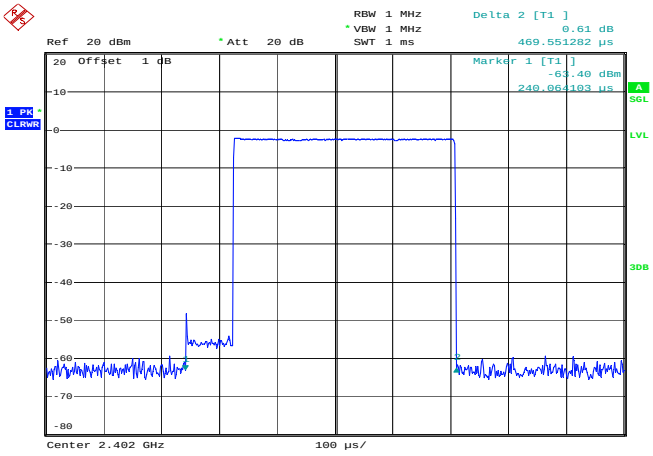
For DH5, With channel hopping rate (1600 / 6 / 79) in Occupancy Time Limit (0.4 x 79) (s), Hops Over Occupancy Time comes to (1600 / 6 / 79) x (0.4 x 79) = 106.67 hops

2. Dwell Time(s) = Hops Over Occupancy Time (hops) x Package Transfer Time

Test plots as follows:

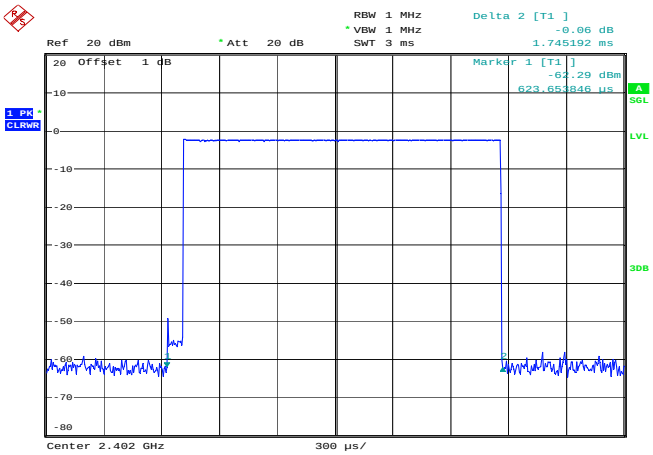
GFSK

DH1



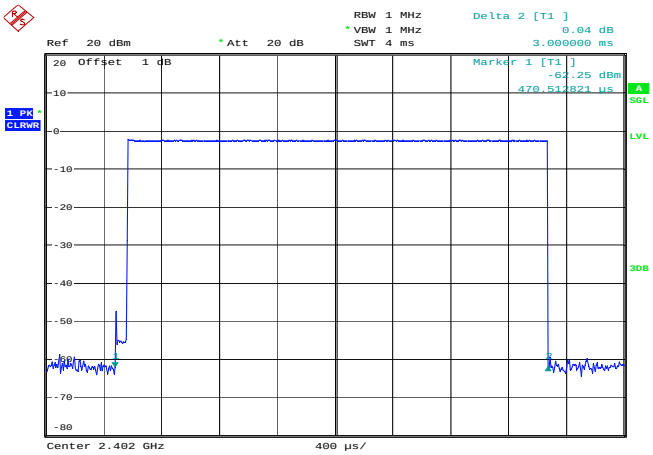
Date: 28.MAR.2017 12:00:00

DH3



Date: 28.MAR.2017 11:58:40

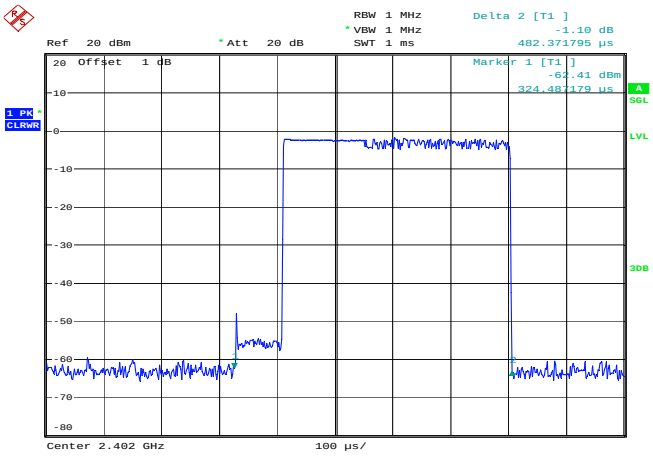
DH5



Date: 28.MAR.2017 11:59:31

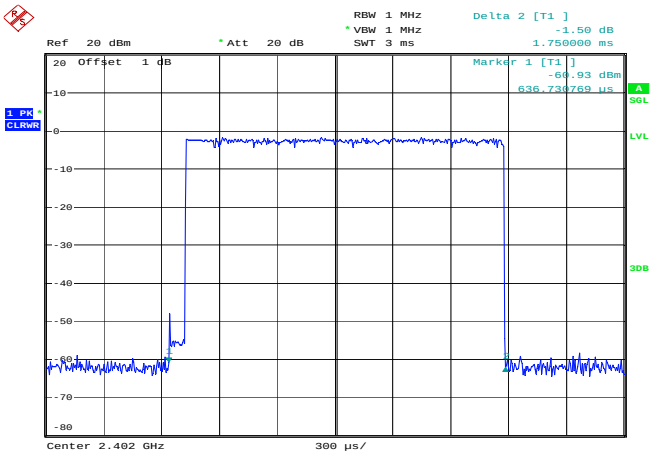
Pi/4DQPSK

2-DH1



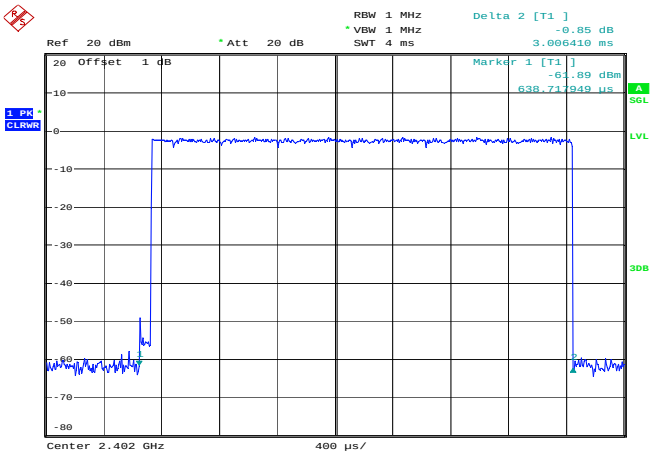
Date: 28.MAR.2017 12:00:28

2-DH3



Date: 28.MAR.2017 12:01:10

2-DH5



Date: 28.MAR.2017 12:01:42

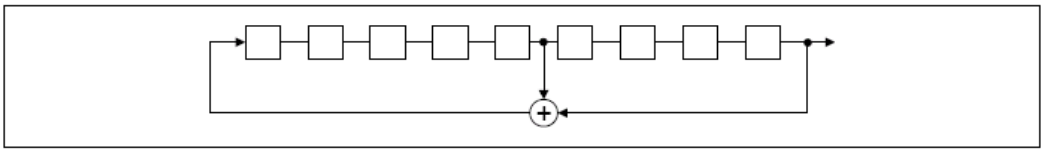
6.8. Pseudorandom Frequency Hopping Sequence

Test Requirement:	FCC Part15 C Section 15.247 (a)(1) requirement:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.
Alternatively. Frequency hopping systems operating in the 2400-2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a Pseudorandom ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

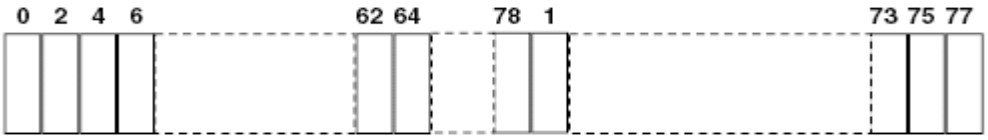
EUT Pseudorandom Frequency Hopping Sequence

The pseudorandom sequence may be generated in a nine-stage shift register whose 5th and 9th stage outputs are added in a modulo-two addition stage. And the result is fed back to the input of the first stage. The sequence begins with the first one of 9 consecutive ones; i.e. the shift register is initialized with nine ones.
• Number of shift register stages: 9
• Length of pseudo-random sequence: 2^9 -1 = 511 bits
• Longest sequence of zeros: 8 (non-inverted signal)



Linear Feedback Shift Register for Generation of the PRBS sequence

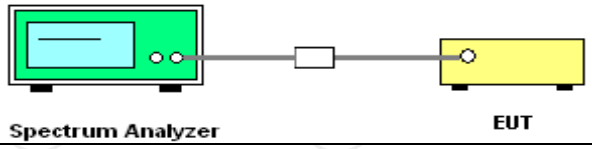
An example of Pseudorandom Frequency Hopping Sequence as follow:



Each frequency used equally on the average by each transmitter.
The system receivers have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shift frequencies in synchronization with the transmitted signals.

6.9. Conducted Band Edge Measurement

6.9.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2013
Limit:	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Band-edge Compliance of RF Conducted Emissions of ANSI C63.10:2013 Measurement Guidelines. 2. Set to the maximum power setting and enable the EUT transmit continuously. 3. Set RBW = 100 kHz (≥1% span=10MHz), VBW = 300 kHz (≥RBW). Band edge emissions must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100kHz RBW. The attenuation shall be 30 dB instead of 20 dB when RMS conducted output power procedure is used. 4. Enable hopping function of the EUT and then repeat step 2 and 3. 5. Measure and record the results in the test report.
Test Result:	PASS

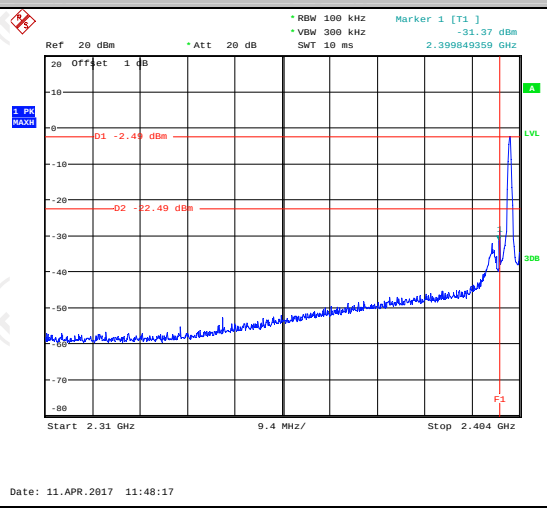
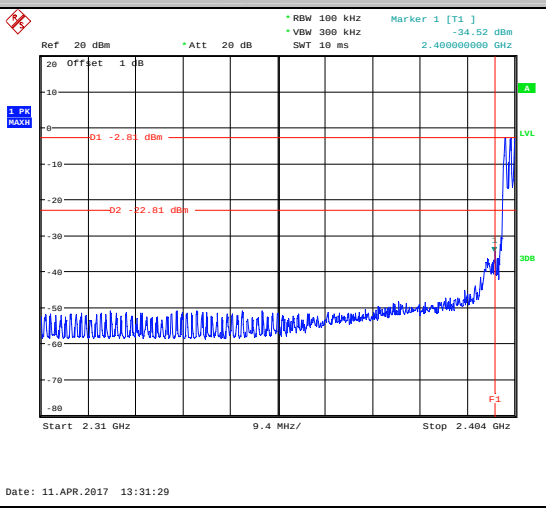
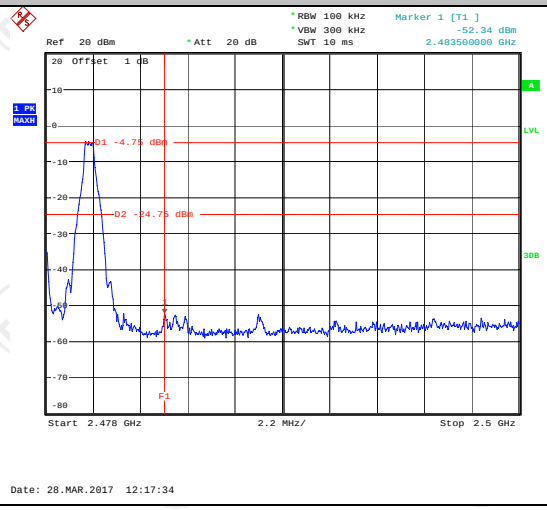
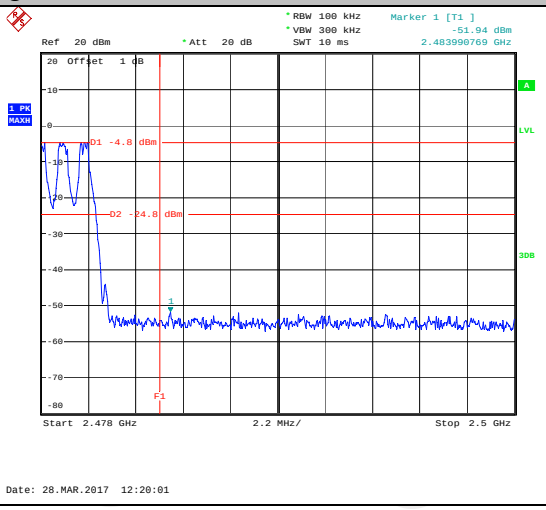
6.9.2. Test Instruments

RF Test Room				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

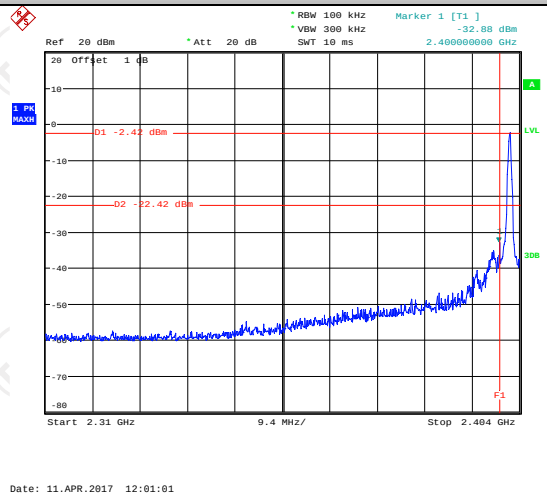
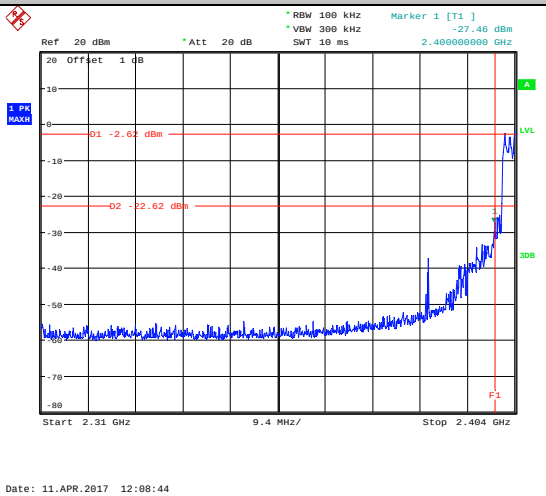
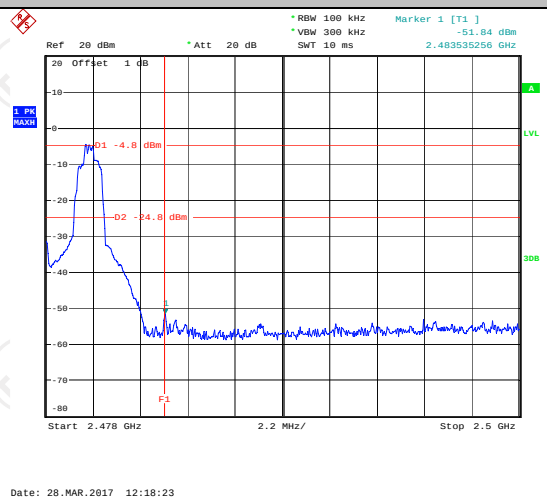
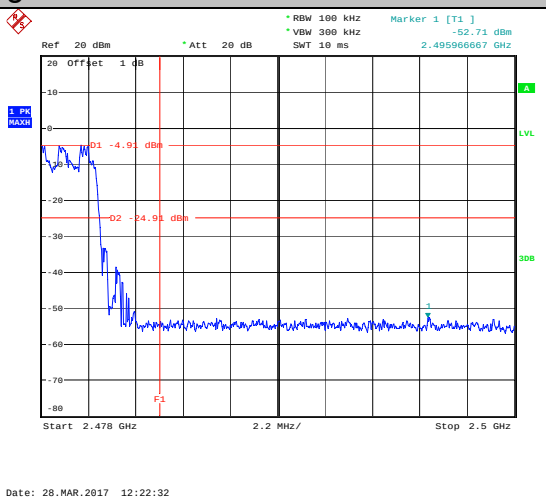
Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.9.3. Test Data

GFSK Modulation

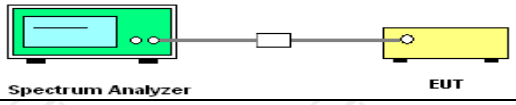
Test channel:	Lowest channel
	
No-hopping mode	Hopping mode
Test channel:	Highest channel
	
No-hopping mode	Hopping mode

Pi/4DQPSK Modulation

Test channel:	Lowest channel
	
No-hopping mode	Hopping mode
Test channel:	**Highest channel**
	
No-hopping mode	Hopping mode

6.10. Conducted Spurious Emission Measurement

6.10.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.247 (d)
Test Method:	ANSI C63.10:2013
Limit:	In any 100 kHz bandwidth outside the intentional radiation frequency band, the radio frequency power shall be at least 20 dB below the highest level of the radiated power. In addition, radiated emissions which fall in the restricted bands must also comply with the radiated emission limits.
Test Setup:	
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Spurious RF Conducted Emissions of ANSI C63.10:2013 Measurement Guidelines 2. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Set RBW = 100 kHz, VBW = 300kHz, scan up through 10th harmonic. All harmonics / spurs must be at least 20 dB down from the highest emission level within the authorized band as measured with a 100 kHz RBW. 5. Measure and record the results in the test report. 6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.
Test Result:	PASS

6.10.2. Test Instruments

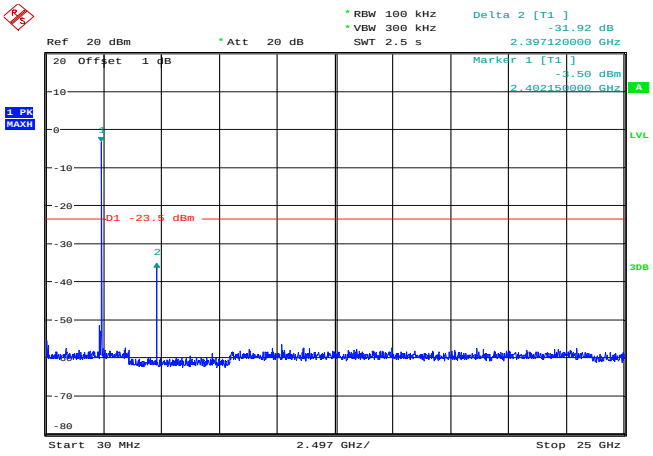
RF Test Room				
Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
Spectrum Analyzer	R&S	FSU	Aug. 10, 2016	Aug. 11, 2017
RF Cable (9KHz-40GHz)	TCT	RE-06	Aug. 11, 2016	Aug. 12, 2017
Antenna Connector	TCT	RFC-01	Aug. 11, 2016	Aug. 12, 2017

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

6.10.3. Test Data

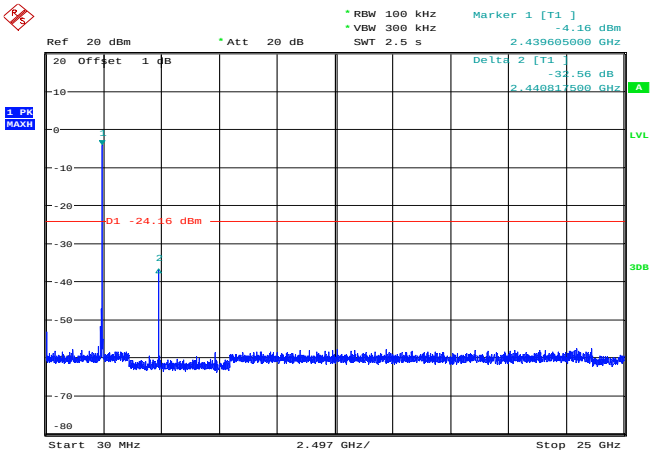
GFSK mode

Lowest Channel



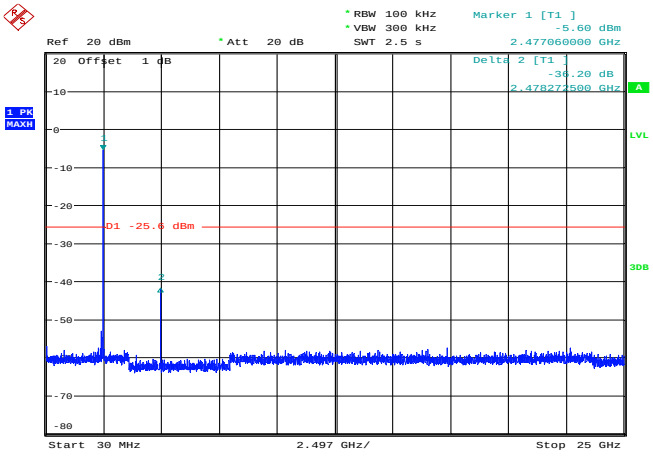
Date: 14.JAN.2003 00:37:22

Middle Channel



Date: 14.JAN.2003 00:41:00

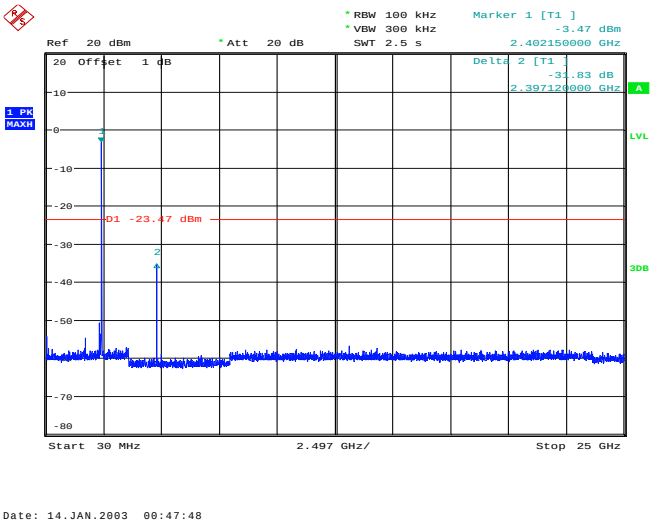
Highest Channel



Date: 14.JAN.2003 00:43:44

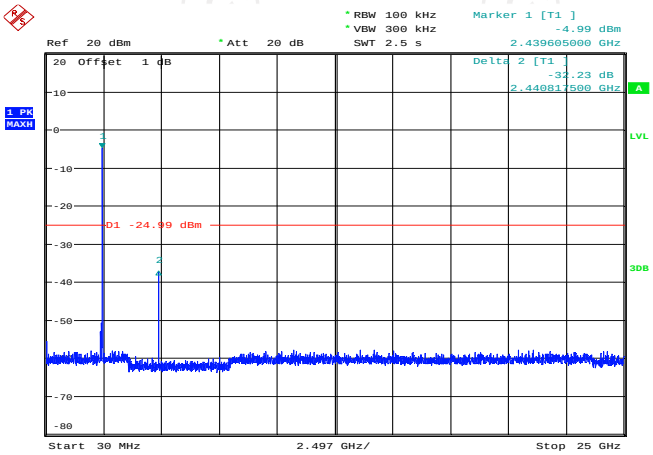
Pi/4DQPSK mode

Lowest Channel



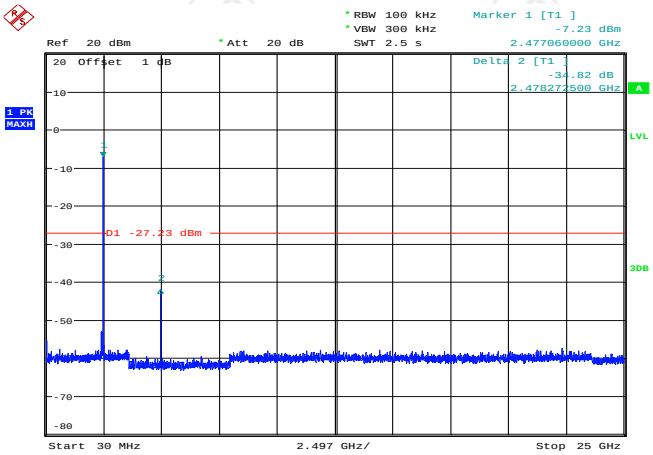
Date: 14.JAN.2003 00:47:48

Middle Channel



Date: 14.JAN.2003 00:52:15

Highest Channel



Date: 14.JAN.2003 00:54:48

6.11. Radiated Spurious Emission Measurement

6.11.1. Test Specification

Test Requirement:	FCC Part15 C Section 15.209
Test Method:	ANSI C63.10:2013
Frequency Range:	9 kHz to 25 GHz
Measurement Distance:	3 m
Antenna Polarization:	Horizontal & Vertical

Receiver Setup:

Frequency	Detector	RBW	VBW	Remark
9kHz- 150kHz	Quasi-peak	200Hz	1kHz	Quasi-peak Value
150kHz-30MHz	Quasi-peak	9kHz	30kHz	Quasi-peak Value
30MHz-1GHz	Quasi-peak	100KHz	300KHz	Quasi-peak Value
Above 1GHz	Peak	1MHz	3MHz	Peak Value
	Peak	1MHz	10Hz	Average Value

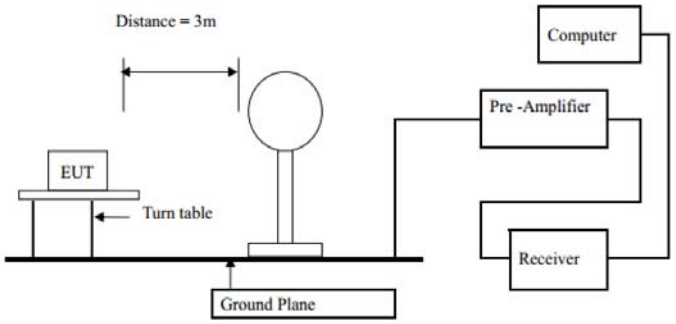
Limit:

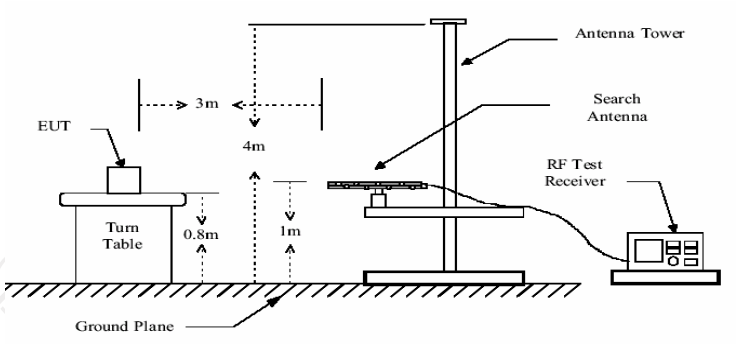
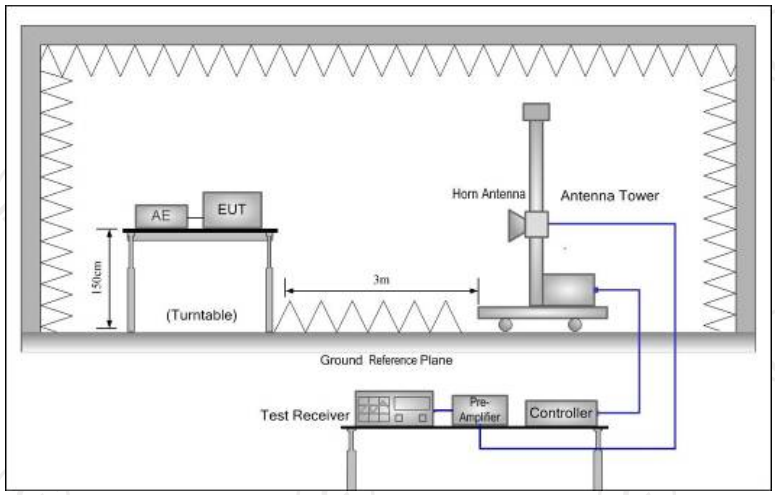
Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009-0.490	2400/F(KHz)	300
0.490-1.705	24000/F(KHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Frequency	Field Strength (microvolts/meter)	Measurement Distance (meters)	Detector
Above 1GHz	500	3	Average
	5000	3	Peak

Test setup:

For radiated emissions below 30MHz



	30MHz to 1GHz  Above 1GHz 
Test Mode:	Transmitting mode with modulation
Test Procedure:	1. The testing follows the guidelines in Spurious Radiated Emissions of ANSI C63.10:2013 Measurement Guidelines. 2. For the radiated emission test below 1GHz: The EUT was placed on a turntable with 0.8 meter above ground. The EUT was set 3 meters from the interference receiving antenna, which was mounted on the top of a variable height antenna tower. The EUT was arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) 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. For the radiated emission test above 1GHz: Place the measurement antenna on a turntable with 1.5 meter above ground, which is 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. 3. Set to the maximum power setting and enable the EUT transmit continuously. 4. Use the following spectrum analyzer settings: (1) Span shall wide enough to fully capture the emission being measured; (2) Set RBW=100 kHz for f < 1 GHz, RBW=1MHz for f>1GHz ; VBW≥RBW; Sweep = auto; Detector function = peak; Trace = max hold for peak (3) For average measurement: use duty cycle correction factor method per 15.35(c). Duty cycle = On time/100 milliseconds On time =N1*L1+N2*L2+...+Nn-1*LNn-1+Nn*Ln Where N1 is number of type 1 pulses, L1 is length of type 1 pulses, etc. Average Emission Level = Peak Emission Level + 20*log(Duty cycle) Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
Test results:	PASS

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6.11.2. Test Instruments

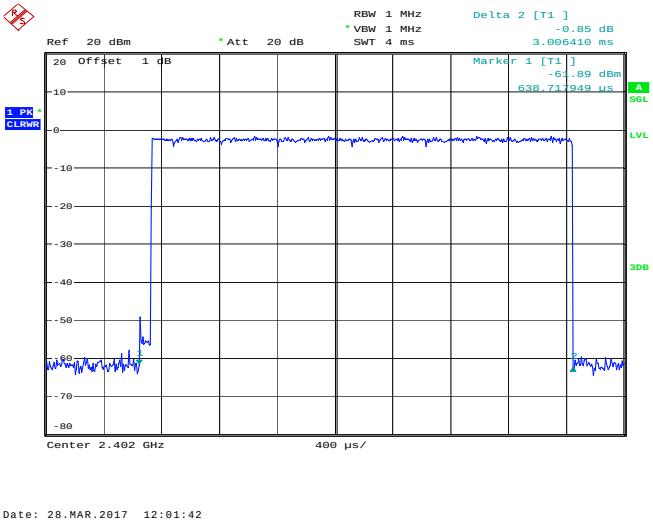
Radiated Emission Test Site (966)				
Name of Equipment	**Manufacturer**	**Model**	**Calibration Date**	**Calibration Due**
ESPI Test Receiver	ROHDE&SCHWARZ	ESVD	Aug. 10, 2016	Aug. 11, 2017
Spectrum Analyzer	ROHDE&SCHWARZ	FSEM	Aug. 10, 2016	Aug. 11, 2017
Spectrum Analyzer	Agilent	N9020A	Aug. 11, 2016	Aug. 12, 2017
Pre-amplifier	EM Electronics Corporation CO.,LTD	EM30265	Aug. 10, 2016	Aug. 11, 2017
Pre-amplifier	HP	8447D	Aug. 10, 2016	Aug. 11, 2017
Loop antenna	ZHINAN	ZN30900A	Aug. 12, 2016	Aug. 13, 2017
Broadband Antenna	Schwarzbeck	VULB9163	Aug. 12, 2016	Aug. 13, 2017
Horn Antenna	Schwarzbeck	BBHA 9120D	Aug. 12, 2016	Aug. 13, 2017
Horn Antenna	Schwarzbeck	BBHA 9170	Aug. 12, 2016	Aug. 13, 2017
Antenna Mast	CCS	CC-A-4M	N/A	N/A
Coax cable (9KHz-40GHz)	TCT	RE-low-01	Aug. 10, 2016	Aug. 11, 2017
Coax cable (9KHz-40GHz)	TCT	RE-high-02	Aug. 10, 2016	Aug. 11, 2017
Coax cable (9KHz-40GHz)	TCT	RE-low-03	Aug. 10, 2016	Aug. 11, 2017
Coax cable (9KHz-40GHz)	TCT	RE-high-04	Aug. 10, 2016	Aug. 11, 2017
EMI Test Software	Shurple Technology	EZ-EMC	N/A	N/A

Note: *The calibration interval of the above test instruments is 12 months and the calibrations are traceable to international system unit (SI).*

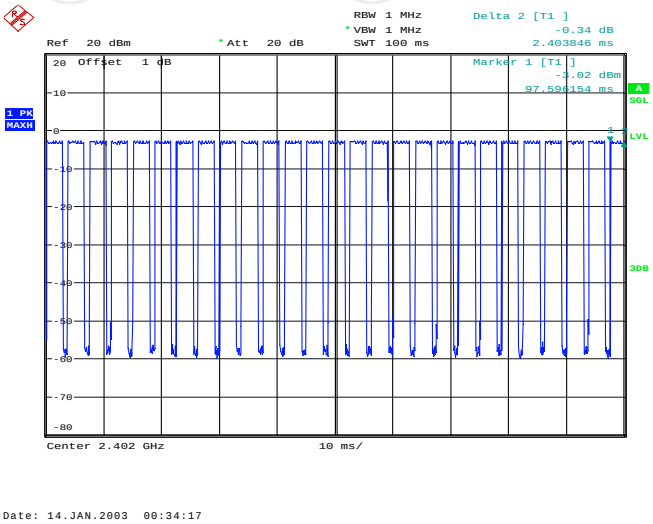
6.11.3. Test Data

Duty cycle correction factor for average measurement

2DH5 on time (One Pulse) Plot on Channel 00



2DH5 on time (Count Pulses) Plot on Channel 00



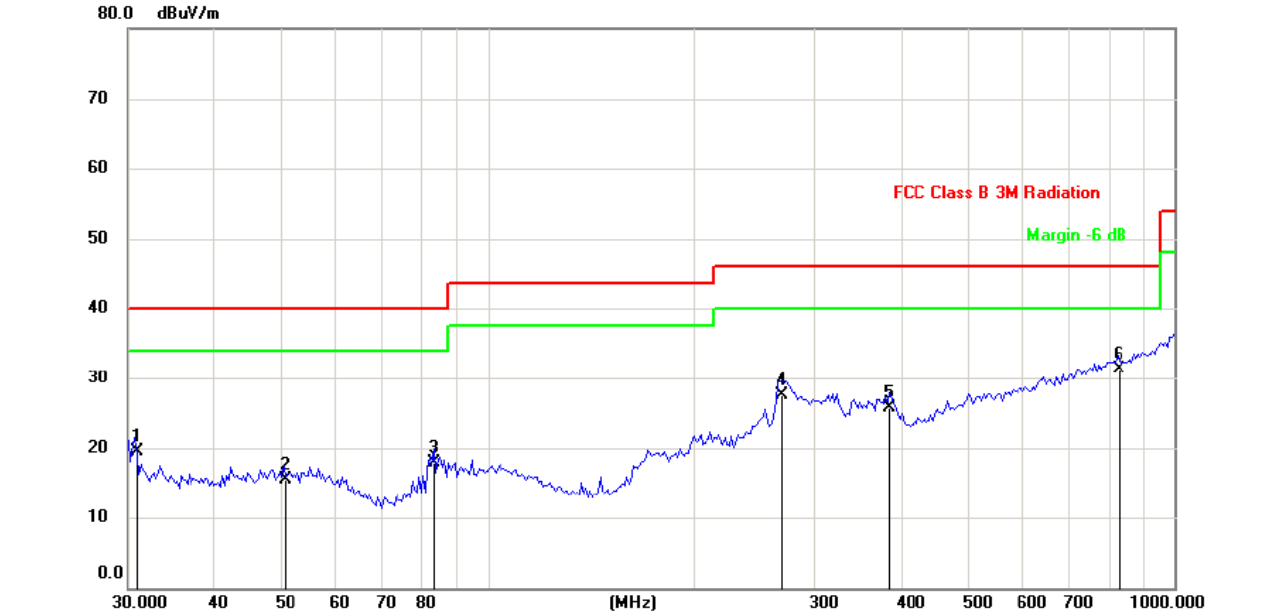
Note:

1. *Worst case Duty cycle = on time/100 milliseconds = (3.006*26+2.404)/100= 0.8056*
2. *Worst case Duty cycle correction factor = 20*log (Duty cycle) = -1.88dB*
3. *2DH5 has the highest duty cycle worst case and is reported.*
4. *The average levels were calculated from the peak level corrected with duty cycle correction factor (-1.88dB) derived from 20log (dwell time/100ms). This correction is only for signals that hop with the fundamental signal, such as band-edge and harmonic. Other spurious signals that are independent of the hopping signal would not use this correction.*

Please refer to following diagram for individual

Below 1GHz

Horizontal:



Site

Limit: FCC Class B 3M Radiation

Polarization: *Horizontal*

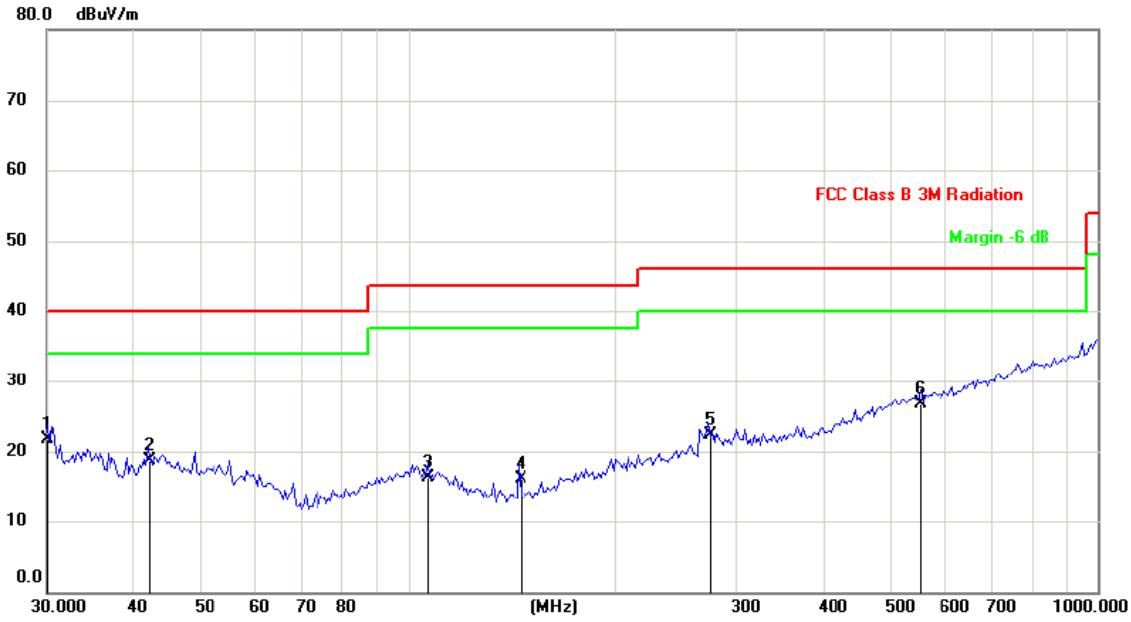
Power: DC 3.7V

Temperature: 25

Humidity: 60 %

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		30.6392	33.10	-13.64	19.46	40.00	-20.54	QP			
2		50.4614	27.50	-12.07	15.43	40.00	-24.57	QP			
3		83.6937	33.00	-15.10	17.90	40.00	-22.10	QP			
4		268.7212	36.90	-9.32	27.58	46.00	-18.42	QP			
5		384.5447	32.30	-6.51	25.79	46.00	-20.21	QP			
6	*	827.1795	29.60	1.79	31.39	46.00	-14.61	QP			

Vertical:



Site

Limit: FCC Class B 3M Radiation

Polarization: *Vertical*

Power: DC 3.7V

Temperature: 25

Humidity: 60 %

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	35.50	-13.72	21.78	40.00	-18.22	QP			
2		42.0350	31.10	-12.39	18.71	40.00	-21.29	QP			
3		107.0306	28.20	-11.83	16.37	43.50	-27.13	QP			
4		144.7899	31.30	-15.28	16.02	43.50	-27.48	QP			
5		272.5246	31.40	-9.18	22.22	46.00	-23.78	QP			
6		554.1708	29.20	-2.41	26.79	46.00	-19.21	QP			

Note: *1.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*

2. Measurements were conducted in all three channels (high, middle, low) and three modulation (GFSK, Pi/4 DQPSK) and the worst case Mode (Lowest channel and Pi/4 DQPSK) was submitted only.

Above 1GHz

Modulation Type: Pi/4 DQPSK									
Low channel: 2402 MHz									
Frequency (MHz)	Ant. Pol. H/V	Peak reading (dBμV)	AV reading (dBuV)	Correction Factor (dB/m)	Emission Level Peak (dBμV/m)	Emission Level AV (dBμV/m)	Peak limit (dBμV/m)	AV limit (dBμV/m)	Margin (dB)
2390	H	49.37	---	-8.23	41.14	---	74	54	-12.86
4804	H	39.19	---	6.59	45.78	---	74	54	-8.22
7206	H	35.53	---	12.87	48.40	---	74	54	-5.60
---	H	---	---	---	---	---	---	---	---
2390	V	48.41	---	-8.23	40.18	---	74	54	-13.82
4804	V	38.68	---	6.59	45.27	---	74	54	-8.73
7206	V	35.84	---	12.87	48.71	---	74	54	-5.29
---	V	---	---	---	---	---	---	---	---

Middle channel: 2441 MHz									
Frequency (MHz)	Ant. Pol. H/V	Peak reading (dBμV)	AV reading (dBμV)	Correction Factor (dB/m)	Emission Level Peak (dBμV/m)	Emission Level AV (dBμV/m)	Peak limit (dBμV/m)	AV limit (dBμV/m)	Margin (dB)
4882	H	37.90	---	7.01	44.91	---	74	54	-9.09
7323	H	36.06	---	13.21	49.27	---	74	54	-4.73
---	H	---	---	---	---	---	---	---	---
4882	V	38.98	---	7.01	45.99	---	74	54	-8.01
7323	V	35.98	---	13.21	49.19	---	74	54	-4.81
---	V	---	---	---	---	----	---	---	---

High channel: 2480 MHz									
Frequency (MHz)	Ant. Pol. H/V	Peak reading (dBμV)	AV reading (dBμV)	Correction Factor (dB/m)	Emission Level Peak (dBμV/m)	Emission Level AV (dBμV/m)	Peak limit (dBμV/m)	AV limit (dBμV/m)	Margin (dB)
2483.5	H	50.03	---	-7.52	42.51	---	74	54	-11.49
4960	H	41.03	---	7.44	48.47	---	74	54	-5.53
7440	H	36.02	---	13.54	49.56	---	74	54	-4.44
---	H	---	---	---	---	---	---	---	---
2483.5	V	49.87	---	-7.52	42.35	---	74	54	-11.65
4960	V	40.59	---	7.44	48.03	---	74	54	-5.97
7440	V	36.30	---	13.54	49.84	---	74	54	-4.16
---	V	---	---	---	---	---	---	---	---

Note:

1. *Emission Level=Peak Reading + Correction Factor; Correction Factor= Antenna Factor + Cable loss – Pre-amplifier*
2. *Margin (dB) = Emission Level (Peak) (dBμV/m)-Average limit (dBμV/m)*
3. *The emission levels of other frequencies are very lower than the limit and not show in test report.*
4. *Measurements were conducted from 1 GHz to the 10th harmonic of highest fundamental frequency.*
5. *Data of measurement shown "---"in the above table mean that the reading of emissions is attenuated more than 20 dB below the limits or the field strength is too small to be measured.*
6. *Measurements were conducted in all three modulation (GFSK, Pi/4 DQPSK), and the worst case Mode (Pi/4 DQPSK) was submitted only.*

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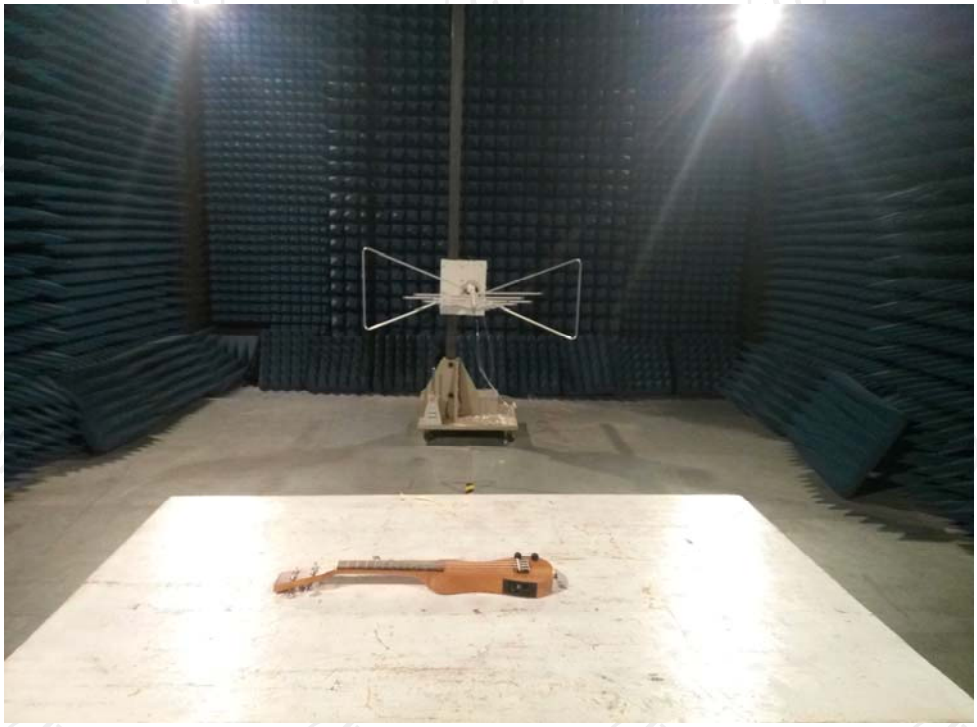
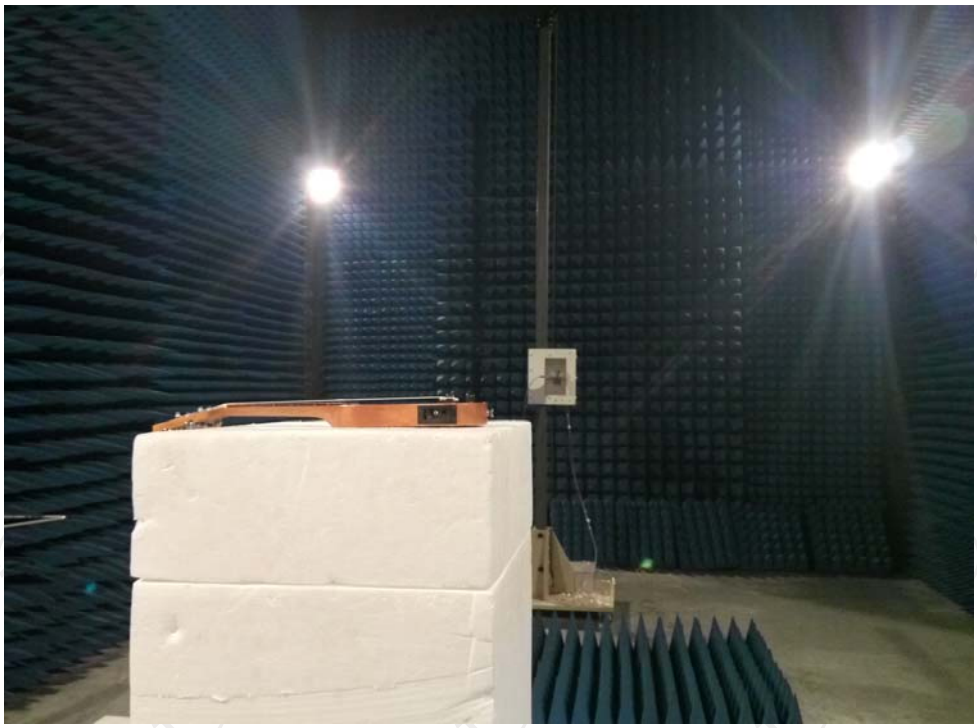
Appendix A: Photographs of Test Setup

Product: Electric Ukulele
Model: 22SPEMH
Radiated Emission





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Conducted Emission

Appendix B: Photographs of EUT

Product: Electric Ukulele
Model: 22SPEMH
External Photos

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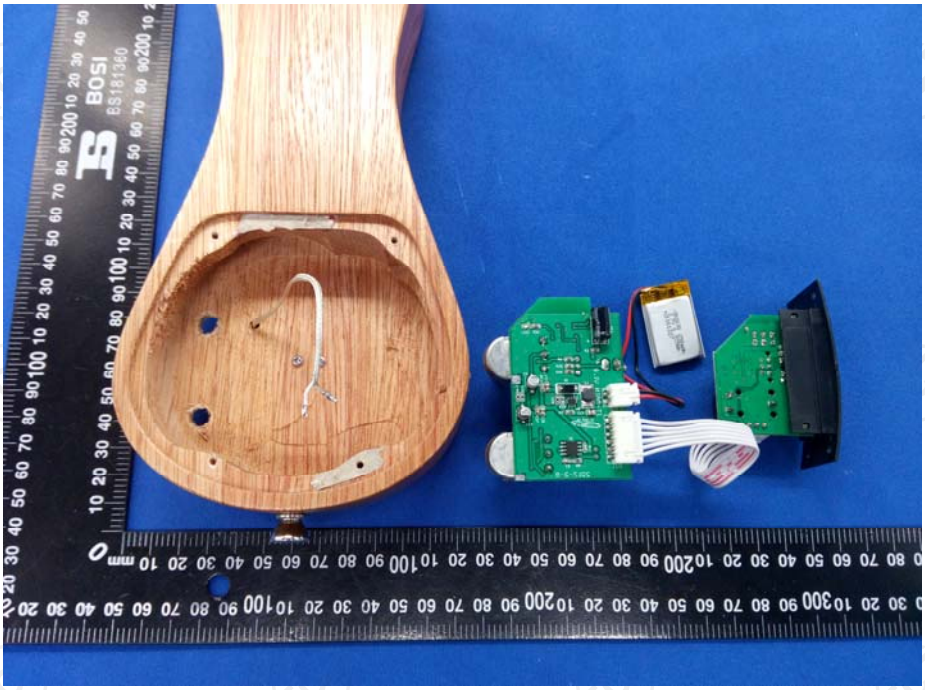
BOSI
BS181360

Model: 22SPEMH
Internal Photos



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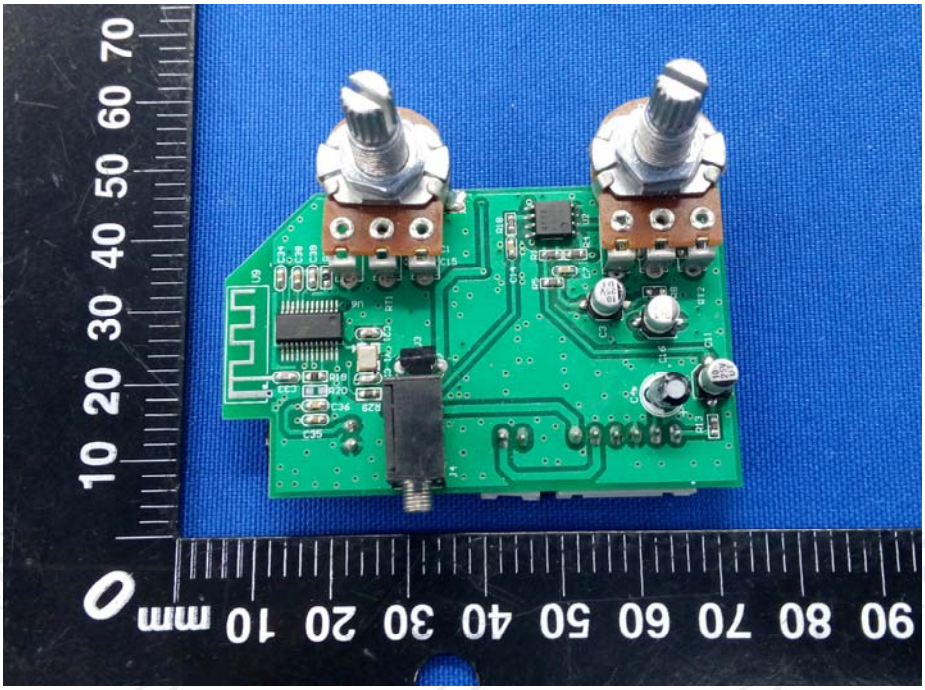

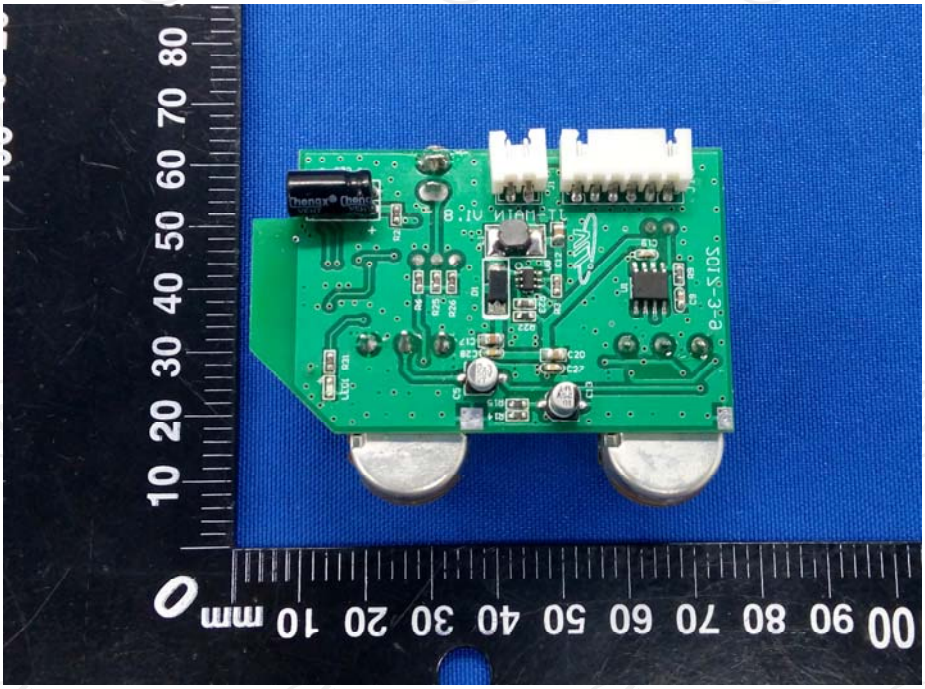

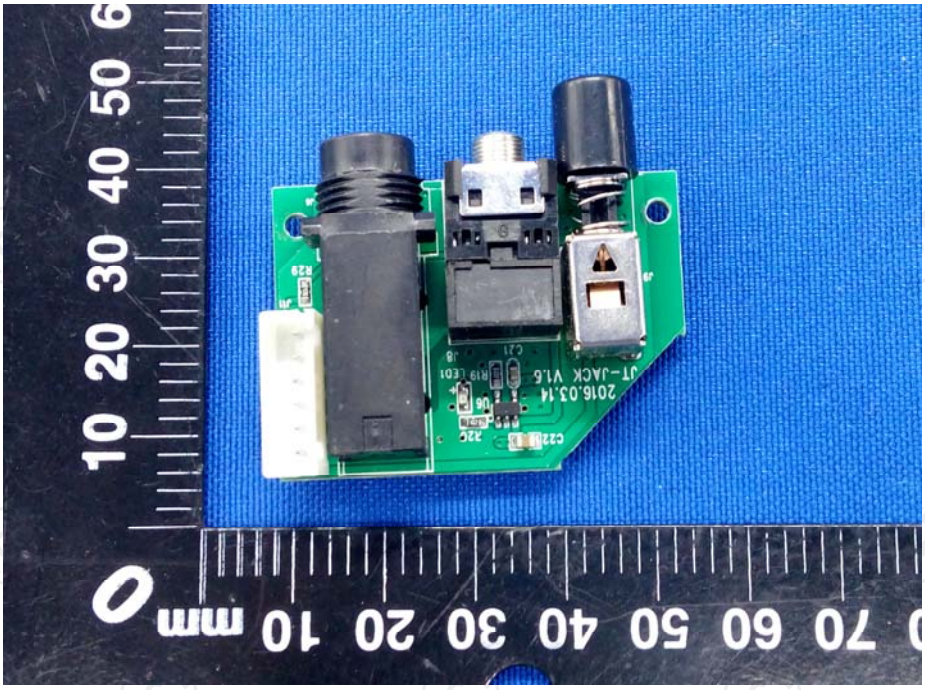
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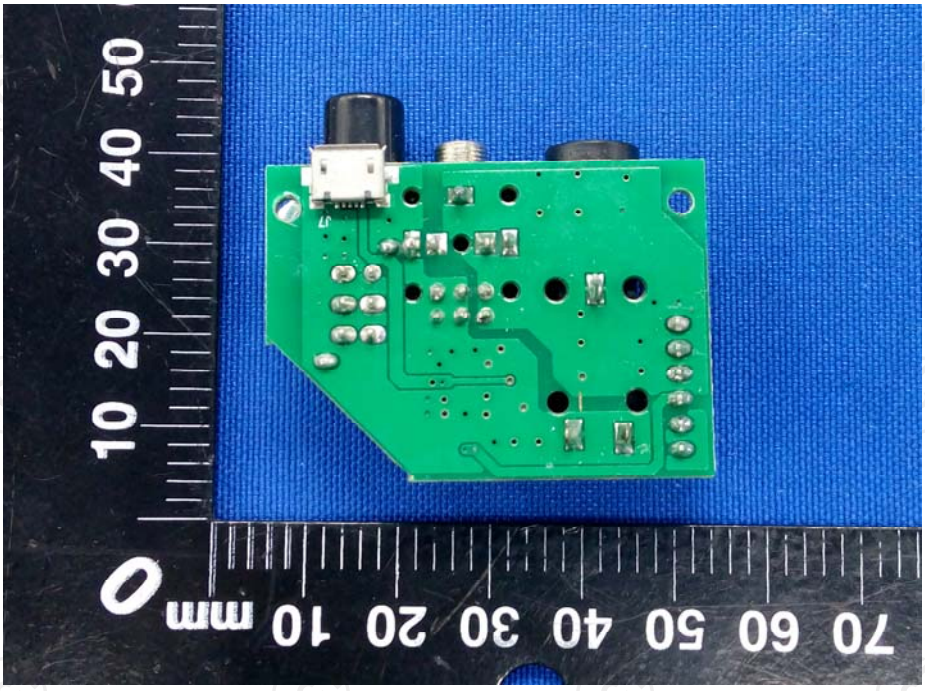
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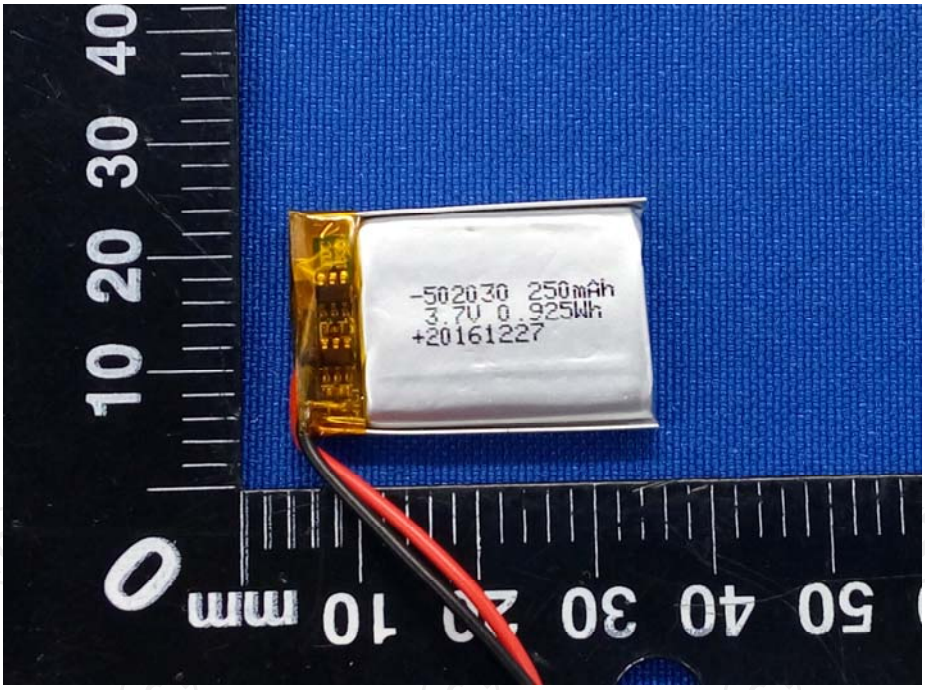

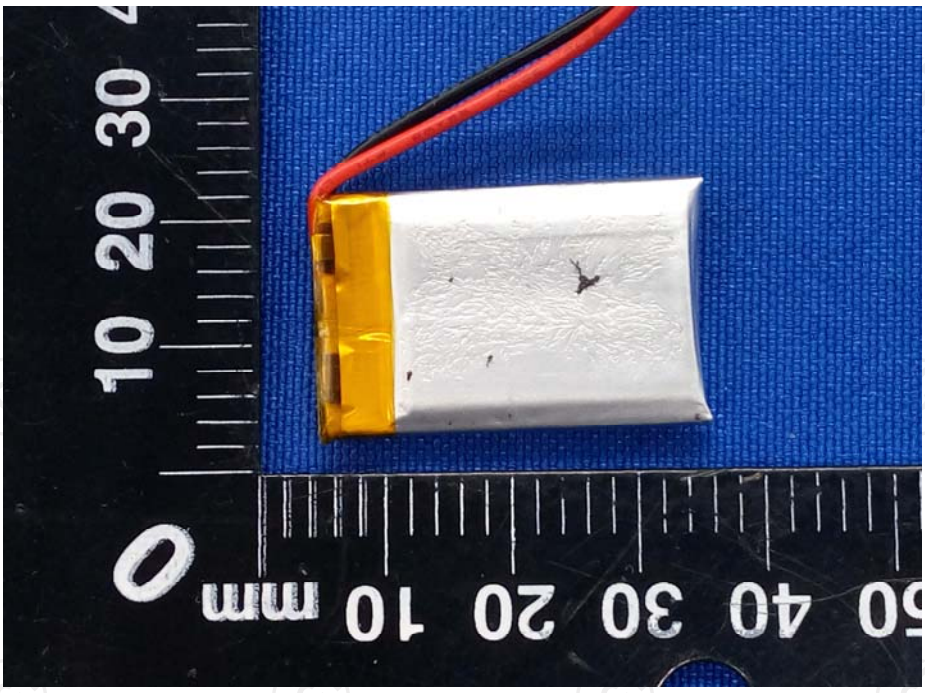

*****END OF REPORT*****