

FCC Part 15C

Measurement and Test Report

For

Underwater Audio LLC

FCC ID: 2ANUWUKU01

FCC Rule(s):	<u>FCC Part 15.249</u>
Product Description:	<u>Uku</u>
Tested Model:	<u>Uku01</u>
Report No.:	<u>BSL1801850200005Y-ER-3</u>
Tested Date:	<u>Jan. 21-24, 2018</u>
Issued Date:	<u>Jan. 24, 2018</u>
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1. GENERAL INFORMATION

1.1 Product Description for Equipment Under Test (EUT)

Client Information

Applicant: Underwater Audio LLC
Address of applicant: 215 SW 4th St. Suite 210 Corvallis OR, 97333
United States

Manufacturer: Underwater Audio LLC
Address of manufacturer: 215 SW 4th St. Suite 210 Corvallis OR, 97333
United States

General Description of EUT	
Product Name:	Uku
Trade Name:	Uku
Model No.:	Uku01
Adding Model(s):	N/A
Rated Voltage:	DC 3.7V from battery
Power Adapter Model:	N/A
<i>Note: The test data is gathered from a production sample, provided by the manufacturer.</i>	

Technical Characteristics of EUT	
Frequency Range:	2402-2480MHz
Max. Field Strength:	93.36 dBuV/m@1.5m
Data Rate:	1Mbps, 2Mbps, 3Mbps
Modulation:	GFSK, Pi/4 QDPSK, 8DPSK
Quantity of Channels:	79
Channel Separation:	1MHz
Antenna Type:	PCB
Antenna Gain:	1dBi
Lowest Internal Frequency of EUT:	26MHz

1.2 Test Standards

The following report is prepared on behalf of the Underwater Audio LLC in accordance with FCC Part 15, Subpart B, Subpart C, and section 15.107, 15.203, 15.205, 15.207, 15.209 and 15.249 of the Federal Communication Commissions rules.

The objective is to determine compliance with FCC Part 15, Subpart C, and section 15.107,15.203, 15.205, 15.207, 15.209 and 15.249 of the Federal Communication Commissions rules.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product, which results in lowering the emission, should be checked to ensure compliance has been maintained.

1.3 Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard for Testing Unlicensed Wireless Devices, and ANSI C63.4-2014, American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the range of 9 kHz to 40 GHz.

1.4 Test Facility

BSL Testing Co.,LTD.

NO. 24, ZH Park, Nantou, Shenzhen, 518000 China

Designation Number : CN1217

Test Firm Registration Number: 866035

Tel: 86- 755-26508703

Fax: 86- 755-26508703

1.5 EUT Setup and Test Mode

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. All testing shall be performed under maximum output power condition, and to measure its highest possible emissions level, more detailed description as follows:

Test Mode List		
Test Mode	Description	Remark
TM1	Low Channel	2402MHz
TM2	Middle Channel	2441MHz
TM3	High Channel	2480MHz
TM4	Hopping	2402-2480MHz

Modulation Configure			
Modulation	Packet	Packet Type	Packet Size
GFSK	DH1	4	27
	DH3	11	183
	DH5	15	339
Pi/4 DQPSK	2DH1	20	54
	2DH3	26	367
	2DH5	30	679
8DPSK	3DH1	24	83
	3DH3	27	552
	3DH5	31	1021
Normal mode: the Bluetooth has been tested on the modulation of GFSK, (Pi/4)DQPSK and 8DPSK, compliance test and record the worst case.			

Special Cable List and Details			
Cable Description	Length (m)	Shielded/Unshielded	With / Without Ferrite
/	/	/	/

Auxiliary Equipment List and Details			
Description	Manufacturer	Model	Serial Number
Notebook	Lenovo	E23	EB12648265
USB	ESR	S01	19682904994

1.6 Measurement Uncertainty

Measurement uncertainty		
Parameter	Conditions	Uncertainty
RF Output Power	Conducted	$\pm 0.42\text{dB}$
Occupied Bandwidth	Conducted	$\pm 1.5\%$
Conducted Spurious Emission	Conducted	$\pm 2.17\text{dB}$
Conducted Emissions	Conducted	$\pm 2.88\text{dB}$
Transmitter Spurious Emissions	Radiated	$\pm 5.1\text{dB}$

1.7 Test Equipment List and Details

Description	Manufacturer	Model	Serial No.	Cal Date	Due. Date
Communication Tester	Rohde & Schwarz	CMW500	100358	2017-10-21	2018-10-20
Spectrum Analyzer	R&S	FSP40	100550	2017-10-21	2018-10-20
Test Receiver	R&S	ESCI7	US47140102	2017-10-21	2018-10-20
Signal Generator	HP	83630B	3844A01028	2017-10-22	2018-10-21
Test Receiver	R&S	ESPI-3	100180	2017-10-21	2018-10-20
Amplifier	Agilent	8449B	4035A00116	2017-10-22	2018-10-21
Amplifier	HP	8447E	2945A02770	2017-10-22	2018-10-21
Signal Generator	IFR	2023A	202307/242	2017-10-22	2018-10-21
Broadband Antenna	SCHAFFNER	2774	2774	2017-10-17	2018-10-16
Biconical and log periodic antennas	ELECTRO-METRIC	EM-6917B-1	171	2017-10-17	2018-10-16
Horn Antenna	R&S	HF906	100253	2017-10-17	2018-10-16
Horn Antenna	EM	EM-6961	6462	2017-10-17	2018-10-16
LISN	R&S	ESH3-Z5	100196	2017-10-17	2018-10-16
LISN	COM-POWER	LI-115	02027	2017-10-17	2018-10-16
3m Semi-Anechoic Chamber	Chengyu Electron	9 (L)*6 (W)* 6 (H)	BSL086	2017-10-21	2018-10-20
Horn Antenna	A-INFOMW	LB-180400KF	BSL088	2017-10-21	2018-10-20

2. SUMMARY OF TEST RESULTS

FCC Rules	Description of Test Item	Result
§ 15.203	Antenna Requirement	PASS
§15.205	Restricted Band of Operation	PASS
§ 15.207(a)	Conducted Emission	N/A
§ 15.209(a)(f)	Radiated Spurious Emissions	PASS
§15.249(a)	Field Strength of Emissions	PASS
§15.249(d)	Out of Band Emission	PASS
§15.215 (c)	Emission Bandwidth	PASS

Note: PASS: applicable, N/A: not applicable.

3. Antenna Requirements

3.1 Standard Applicable

According to FCC Part 15.203, 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 shall be considered sufficient to comply with the provisions of this section.

3.2 Test Result

This product has a PCB antenna, fulfill the requirement of this section.

4. Radiated Emissions

4.1 Standard Applicable

According to §15.249(a), the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following:

Fundamental Frequency	Field strength of fundamental (milli-volts/meter)	Field strength of Harmonics (micro-volts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

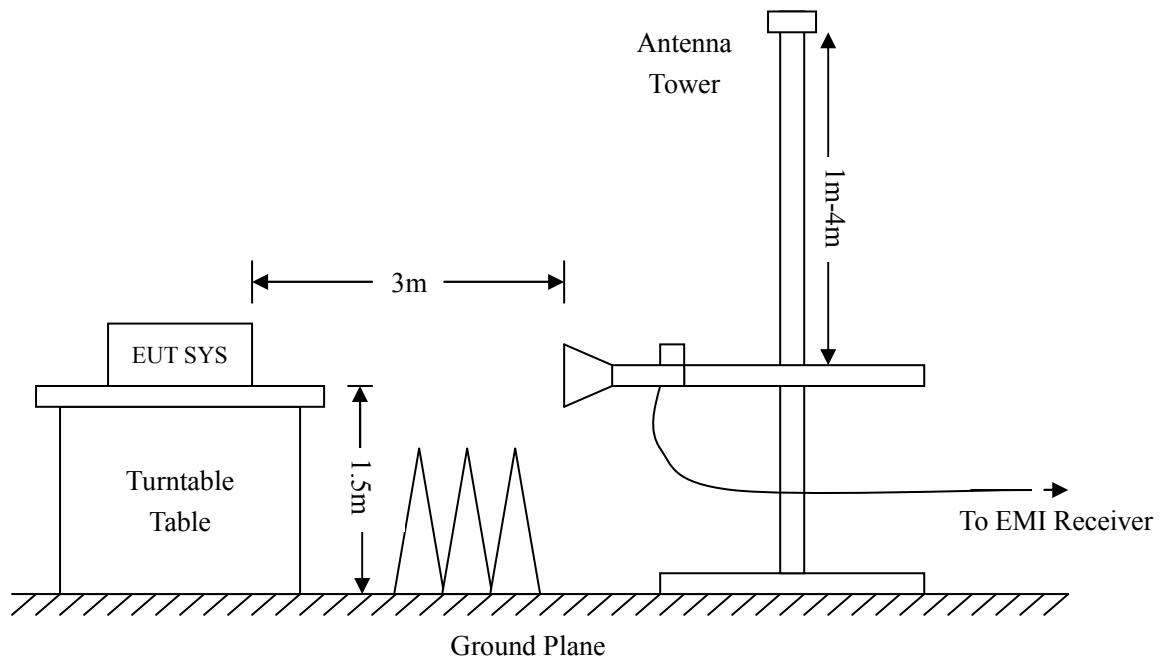
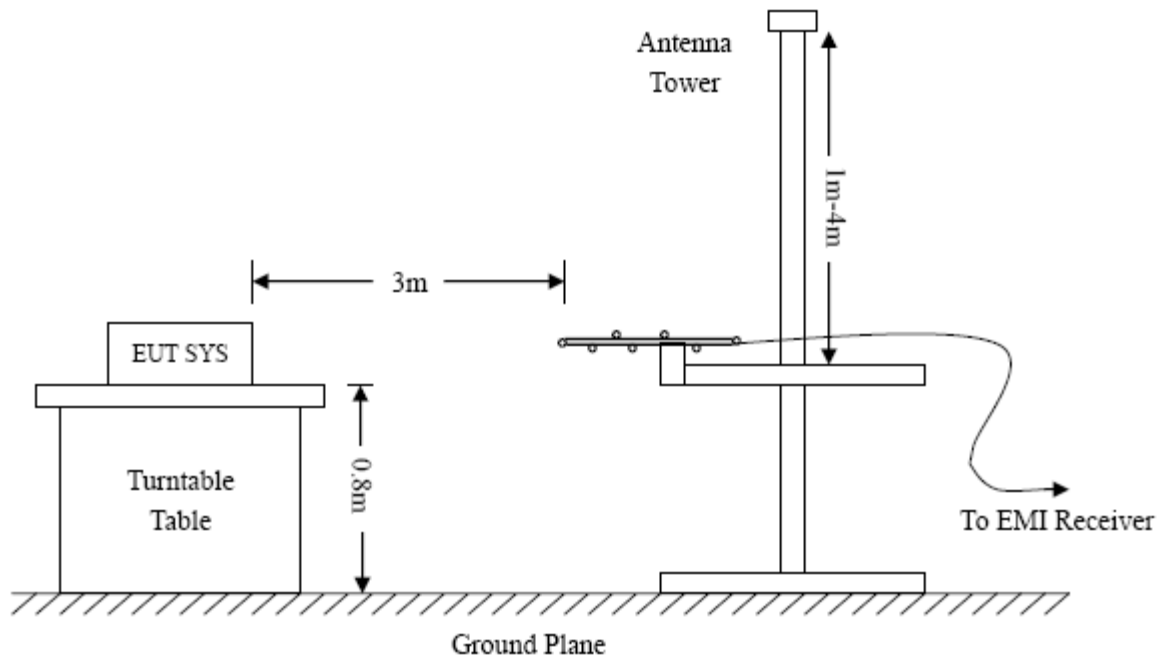
The emission limit in this paragraph is based on measurement instrumentation employing an average detector. The provisions in §15.35 for limiting peak emissions apply. Spurious Radiated Emissions measurements starting below or at the lowest crystal frequency.

4.2 Test Procedure

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.205 15.249(a) and FCC Part 15.209 Limit.

The external I/O cables were draped along the test table and formed a bundle 30 to 40 cm long in the middle.

The spacing between the peripherals was 10 cm.



Frequency :9kHz-30MHz
 RBW=10KHz,
 VBW =30KHz
 Sweep time= Auto
 Trace = max hold
 Detector function = peak

Frequency :30MHz-1GHz
 RBW=120KHz,
 VBW=300KHz
 Sweep time= Auto
 Trace = max hold
 Detector function = peak, QP

Frequency :Above 1GHz
 RBW=1MHz,
 VBW=3MHz(Peak), 10Hz(AV)
 Sweep time= Auto
 Trace = max hold
 Detector function = peak, AV

4.3 Corrected Amplitude & Margin Calculation

The Corrected Amplitude is calculated by adding the Antenna Factor and the Cable Factor, and subtracting the Amplifier Gain from the Amplitude reading. The basic equation is as follows:

$$\text{Corr. Ampl.} = \text{Indicated Reading} + \text{Ant. Factor} + \text{Cable Loss} - \text{Ampl. Gain}$$

The “**Margin**” column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of -6dB μ V means the emission is 6dB μ V below the maximum limit. The equation for margin calculation is as follows:

$$\text{Margin} = \text{Corr. Ampl.} - \text{FCC Part 15C Limit}$$

4.4 Environmental Conditions

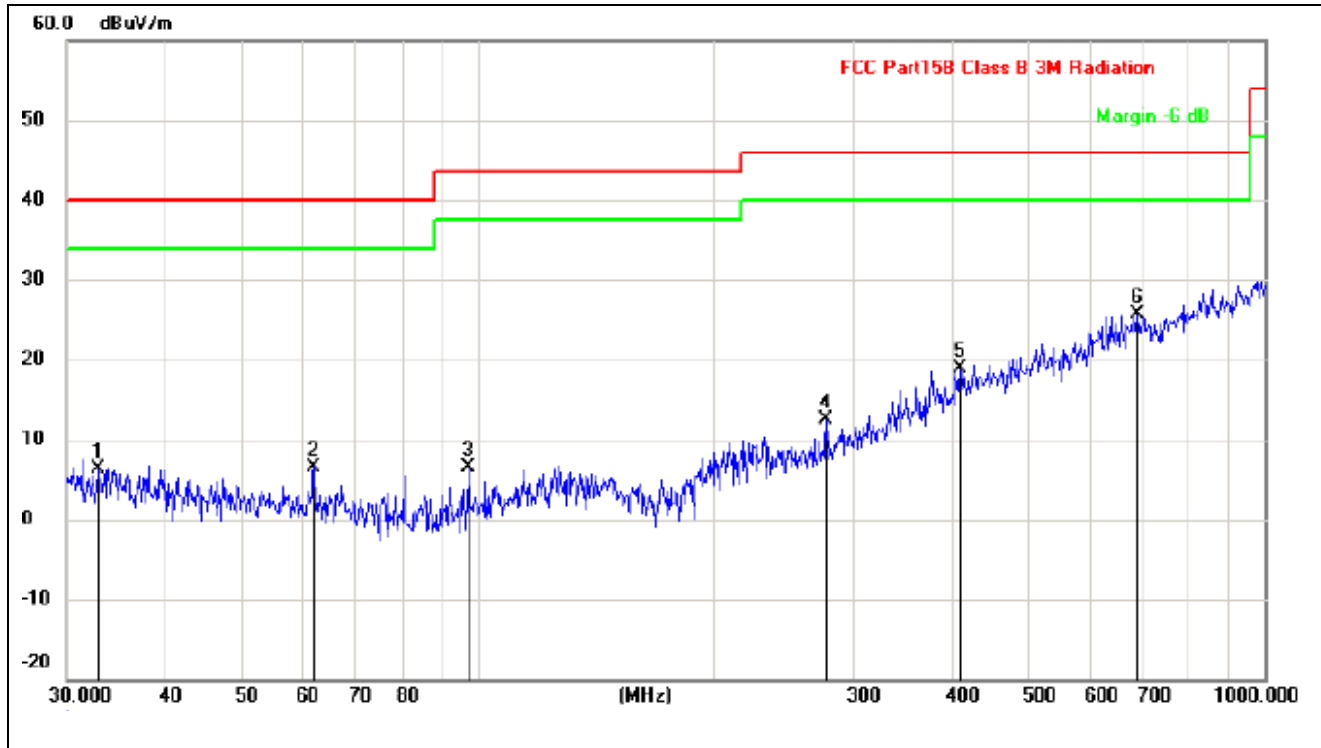
Temperature:	24 °C
Relative Humidity:	60 %
ATM Pressure:	1012 mbar

4.5 Summary of Test Results/Plots

According to the data below, the FCC Part 15.205, 15.209 and 15.249 standards, and had the worst cases.

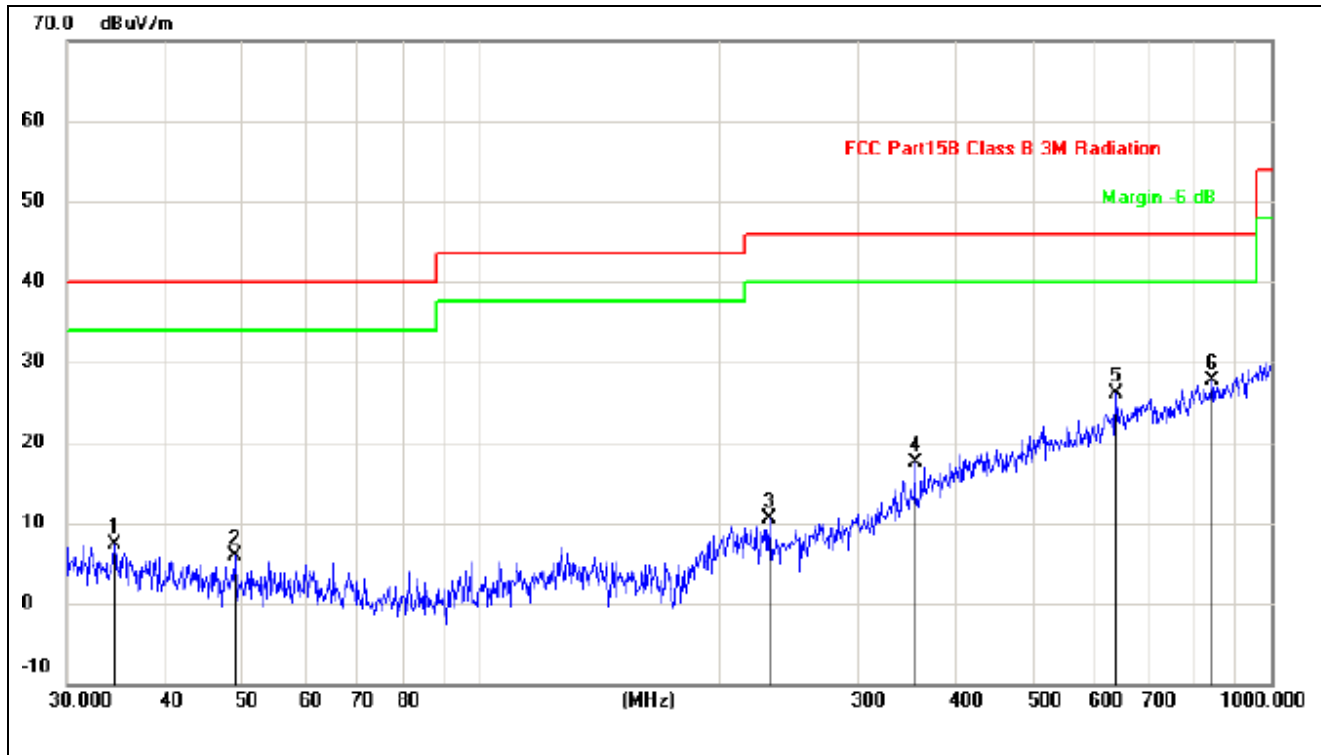
Note:

- 1. Worst-case radiated emission below 1GHz is GFSK (CH Low) mode.*
- 2. Worst-case radiated emission above 1GHz is (Pi/4)DQPSK (CH Low, Middle, High) mode.*

Plot of Radiated Emissions Test Data (30MHz to 1GHz): GFSK (CH Low) mode:*Test Specification: Horizontal*

No.	Mk.	Freq. MHz	Reading Level dBuV	Correct Factor dBuV/m	Measure- ment dBuV/m	Limit dBuV/m	Over dB	Detector	Antenna Height cm	Table Degree degree	Comment
1		32.8637	12.96	-6.61	6.35	40.00	-33.65	QP			
2		61.7781	16.72	-10.12	6.60	40.00	-33.40	QP			
3		97.1148	16.46	-10.04	6.42	43.50	-37.08	QP			
4		277.0935	15.05	-2.58	12.47	46.00	-33.53	QP			
5		410.3825	14.17	4.83	19.00	46.00	-27.00	QP			
6	*	689.5644	14.07	11.62	25.69	46.00	-20.31	QP			

Test Specification: Vertical



No.	Mk.	Freq.	Reading Level	Correct Factor	Measure-ment	Limit	Over	Antenna Height	Table Degree	
		MHz	dBuV	dBuV/m	dBuV/m	dBuV/m	dB	cm	degree	Comment
1		34.3964	14.10	-6.79	7.31	40.00	-32.69	QP		
2		48.8429	14.89	-8.96	5.93	40.00	-34.07	QP		
3		231.7179	14.37	-3.96	10.41	46.00	-35.59	QP		
4		354.1831	15.47	1.99	17.46	46.00	-28.54	QP		
5		636.1340	15.76	10.29	26.05	46.00	-19.95	QP		
6	*	842.1296	14.52	13.23	27.75	46.00	-18.25	QP		

Spurious Emissions Above 1GHz :(Pi/4)DQPSK (CH Low, Middle, High) mode.

Frequency	Reading	Correct	Result	Limit	Margin	Polar	Detector
(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	H/V	
Low Channel-2402MHz							
2402	93.36	-2.27	95.63	114	-18.37	H	PK
2402	80.37	-2.27	82.64	94	-11.36	H	AV
4804	61.68	-3.71	57.97	74	-16.03	H	PK
4804	50.48	-3.71	46.77	54	-7.23	H	AV
7206	59.51	-0.64	58.87	74	-15.13	H	PK
7206	44.5	-0.64	43.86	54	-10.14	H	AV
2402	92.3	-2.27	94.57	114	-19.43	V	PK
2402	79.36	-2.27	81.63	94	-12.37	V	AV
4804	59.41	-3.71	55.7	74	-18.3	V	PK
4804	48.38	-3.71	44.67	54	-9.33	V	AV
7206	60.36	-0.64	59.72	74	-14.28	V	PK
7206	44.4	-0.64	43.76	54	-10.24	V	AV
Middle Channel-2441MHz							
2441	91.93	-2.27	94.2	114	-19.8	H	PK
2441	77.99	-2.27	80.26	94	-13.74	H	AV
4882	58.5	-3.61	54.89	74	-19.11	H	PK
4882	47.4	-3.61	43.79	54	-10.21	H	AV
7323	58.51	-0.59	57.92	74	-16.08	H	PK
7323	43.4	-0.59	42.81	54	-11.19	H	AV
2441	92.03	-2.27	94.3	114	-19.7	V	PK
2441	78.01	-2.27	80.28	94	-13.72	V	AV
4882	60.5	-3.61	56.89	74	-17.11	V	PK
4882	49.39	-3.61	45.78	54	-8.22	V	AV
7323	60.38	-0.59	59.79	74	-14.21	V	PK
7323	45.41	-0.59	44.82	54	-9.18	V	AV

Frequency	Reading	Correct	Result	Limit	Margin	Polar	Detector
(MHz)	(dBuV/m)	dB/m	(dBuV/m)	(dBuV/m)	(dB)	H/V	
Low Channel-2480MHz							
2480	91.72	-2.27	93.99	114	-20.01	H	PK
2480	79.2	-2.27	81.47	94	-12.53	H	AV
4960	64.53	-3.53	61	74	-13	H	PK
4960	49.81	-3.53	46.28	54	-7.72	H	AV
7440	53.71	-0.54	53.17	74	-20.83	H	PK
7440	44.42	-0.54	43.88	54	-10.12	H	AV
2480	90.04	-2.27	92.31	114	-21.69	V	PK
2480	76.98	-2.27	79.25	94	-14.75	V	AV
4960	57.94	-3.53	54.41	74	-19.59	V	PK
4960	44.78	-3.53	41.25	54	-12.75	V	AV
7440	59.37	-0.54	58.83	74	-15.17	V	PK
7440	44.2	-0.54	43.66	54	-10.34	V	AV

Note: Testing is carried out with frequency rang 9kHz to the tenth harmonics, which above 5th Harmonics are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

The measurements greater than 20dB below the limit from 9kHz to 30MHz..

5. Out of Band Emissions

5.1 Standard Applicable

Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

5.2 Test Procedure

As the radiation test, set the Lowest and Highest Transmitting Channel, observed the outside band of 2400MHz to 2483.5MHz, than mark the higher-level emission for comparing with the FCC rules.

5.3 Environmental Conditions

Temperature:	24 °C
Relative Humidity:	60 %
ATM Pressure:	1012 mbar

5.4 Summary of Test Results/Plots

Note: We pre-scan all mode, the worst data is DH1, 2DH1, 3DH1.

Worst mode: GFSK (DH1)

Channel	Freq.(MHz)	Level(dBuV)	Limit(dBuV)	Margin(dB)	Detector
	2400	51.06	74	-22.94	Peak
LOW	2400	34.9	54	-19.1	Average
	2483.5	47.95	74	-26.05	Peak
HIGH	2483.5	34.03	54	-19.97	Average

Worst mode: Pi/4 QDPSK (2DH1)

Channel	Freq.(MHz)	Level(dBuV)	Limit(dBuV)	Margin(dB)	Detector
	2400	50.84	74	-23.16	Peak
LOW	2400	34.68	54	-19.32	Average
	2483.5	47.73	74	-26.27	Peak
HIGH	2483.5	33.81	54	-20.19	Average

Worst mode: 8DPSK (3DH1)

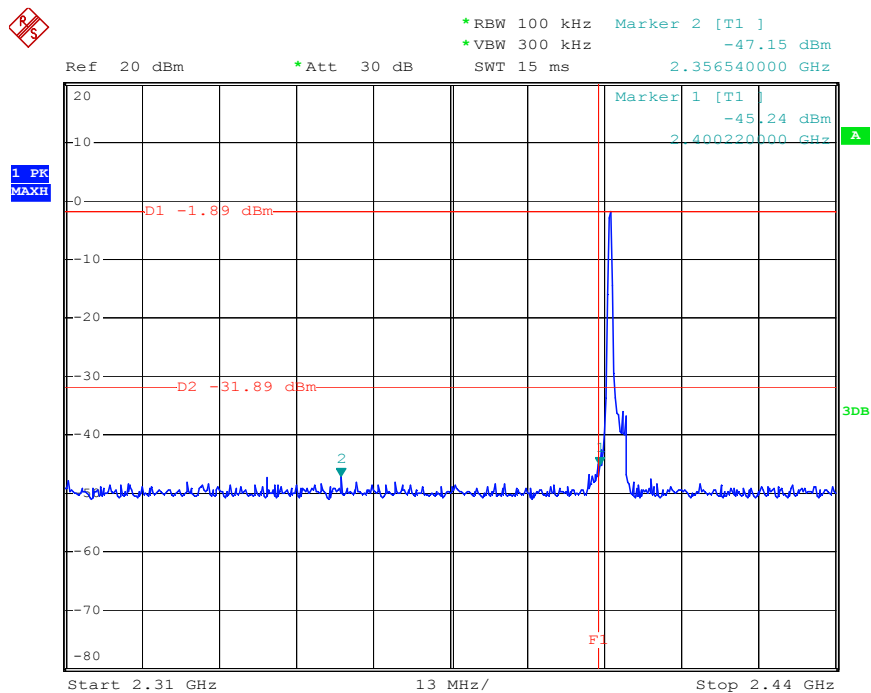
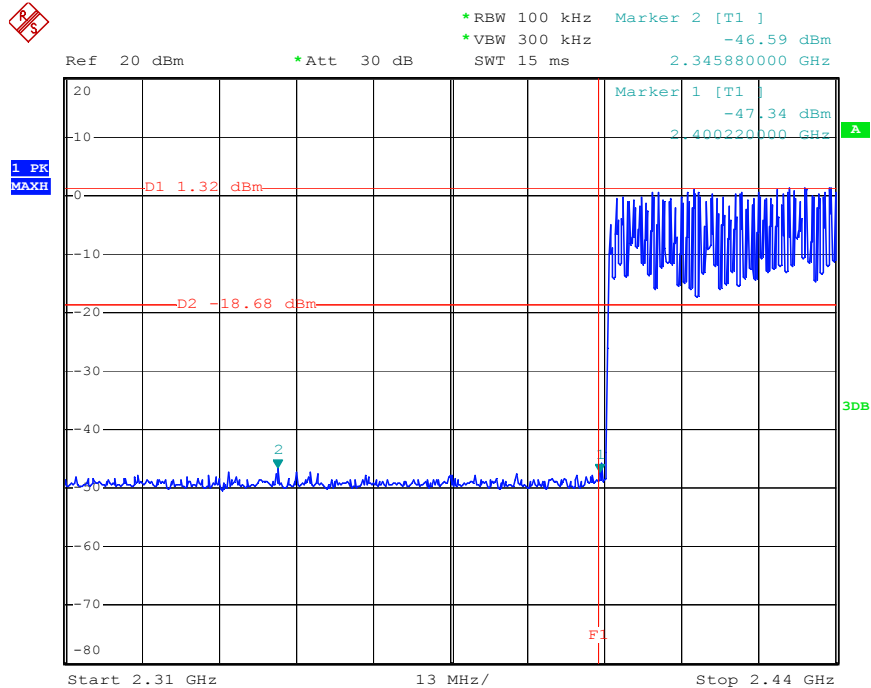
Channel	Freq.(MHz)	Level(dBuV)	Limit(dBuV)	Margin(dB)	Detector
	2400	51.15	74	-22.85	Peak
LOW	2400	34.21	54	-19.79	Average
	2483.5	47.84	74	-26.16	Peak
HIGH	2483.5	35.61	54	-18.39	Average

The edge emissions are below the FCC 15.209 Limits or complies with the 15.249 requirements.

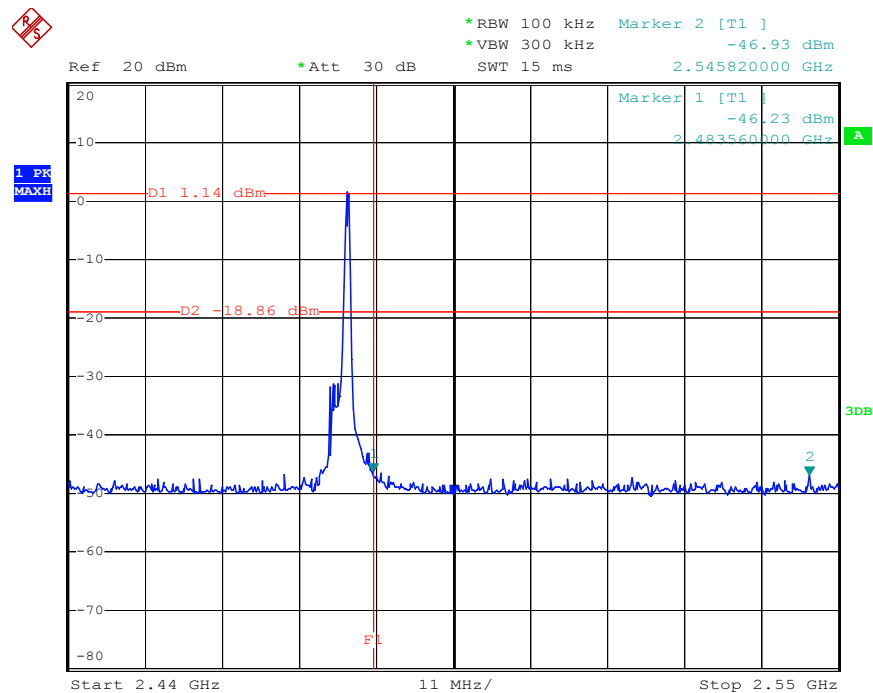
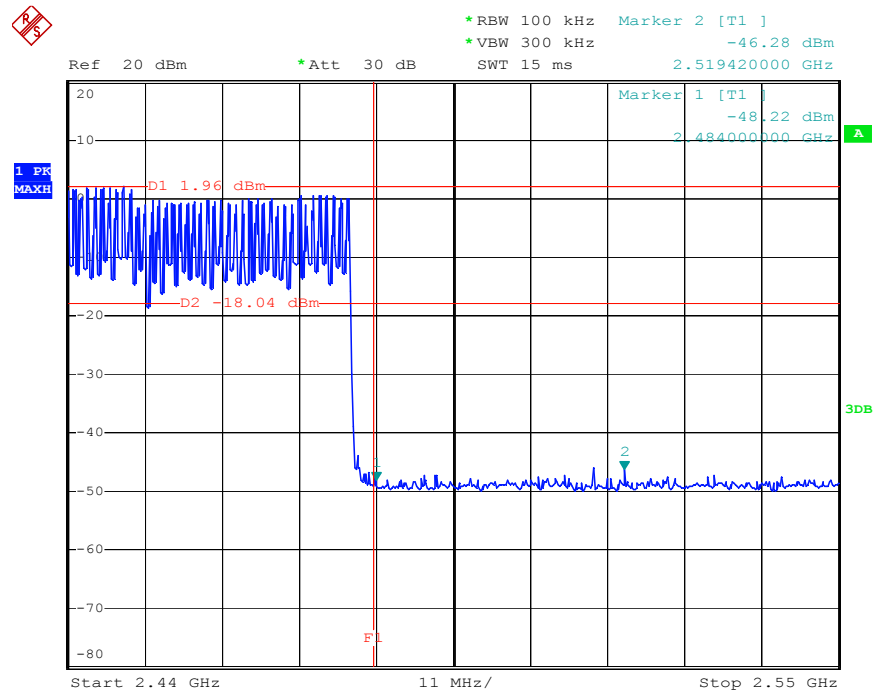
Please refer to the test plots as below.

Worst mode: GFSK (DH1)

Lowest:

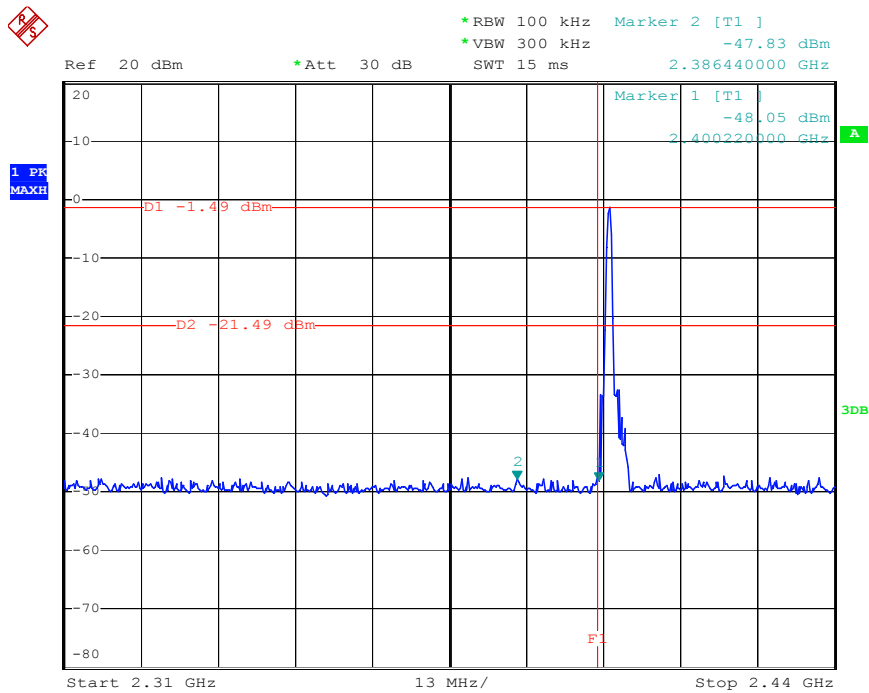
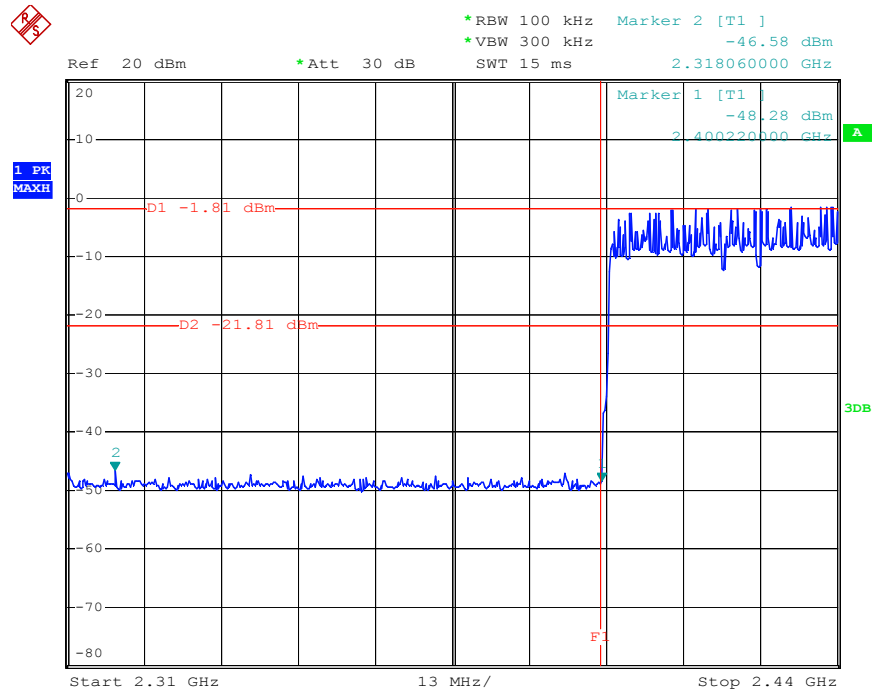


Highest:

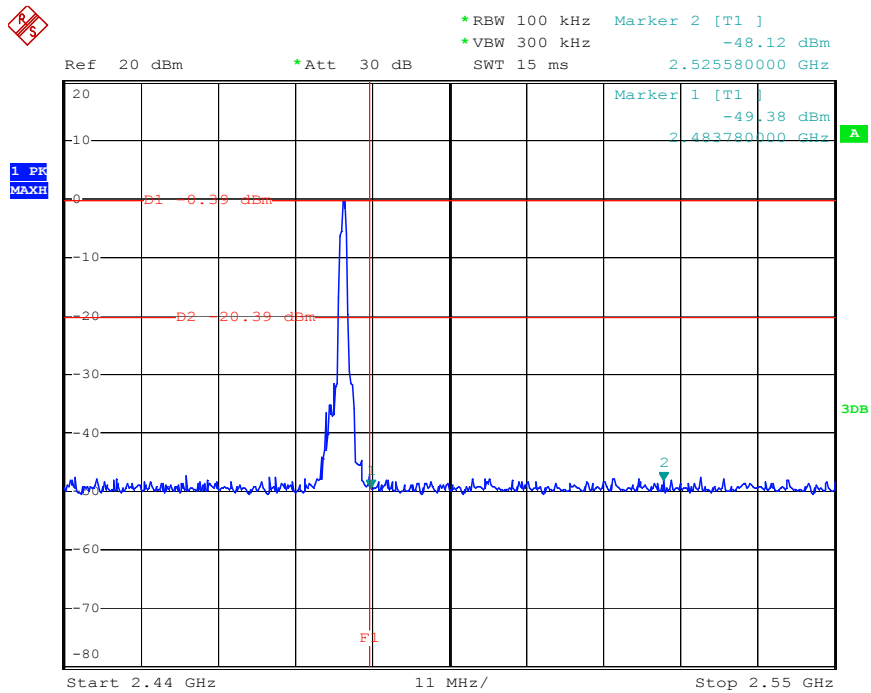
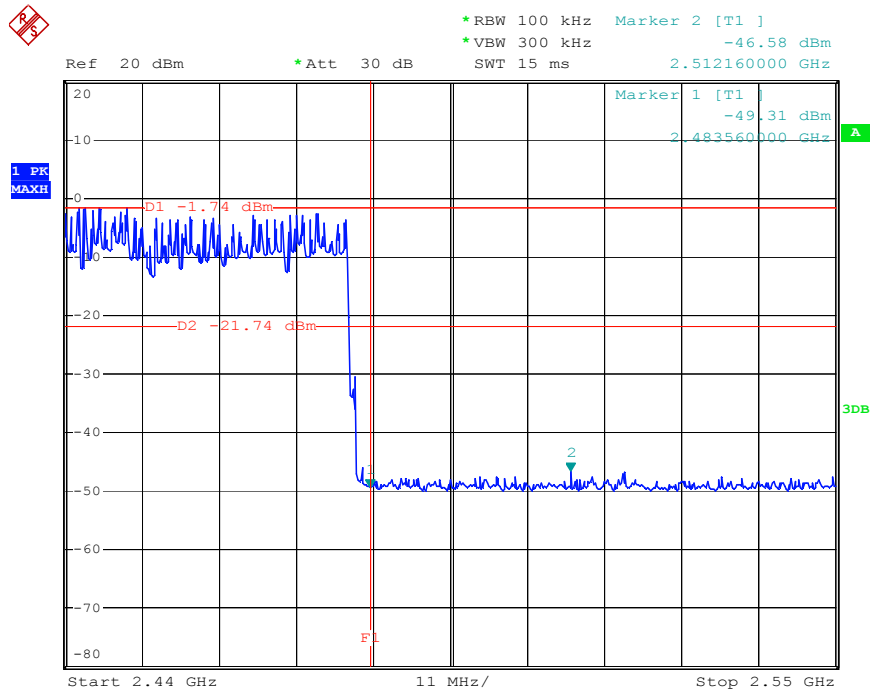


Worst mode: Pi/4 QDPSK (2DH1)

Lowest:

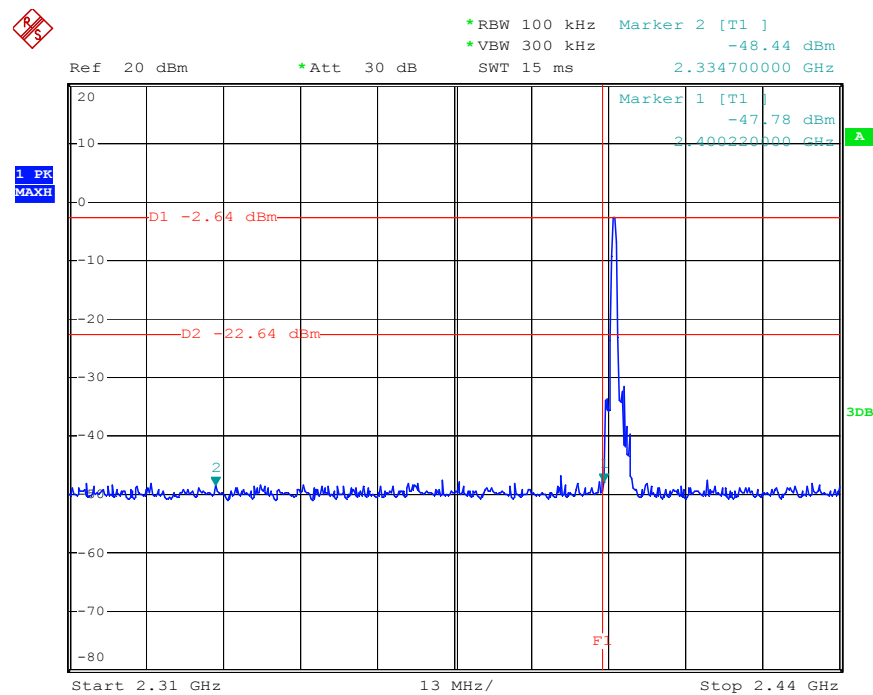
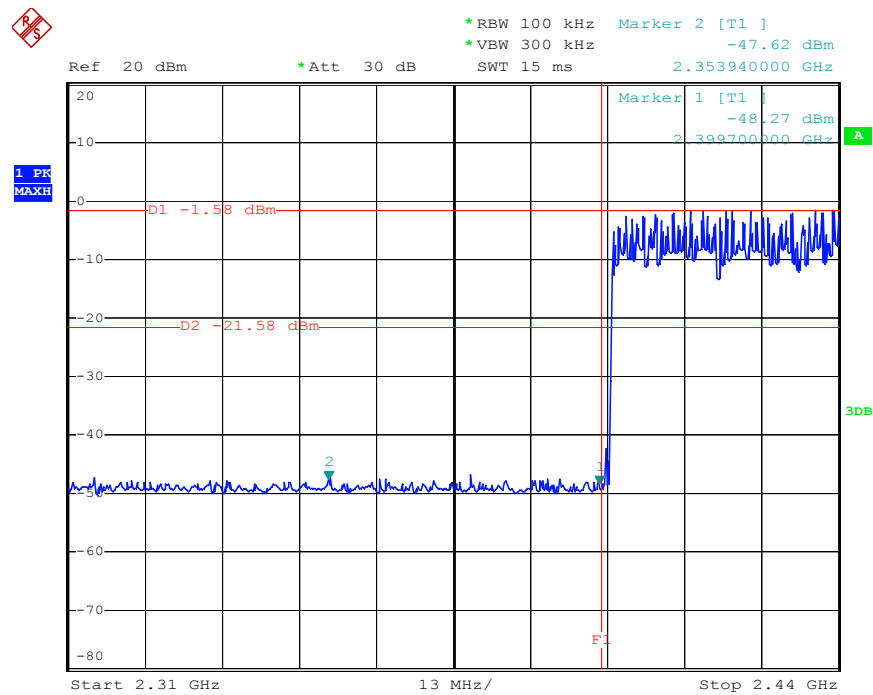


Highest:

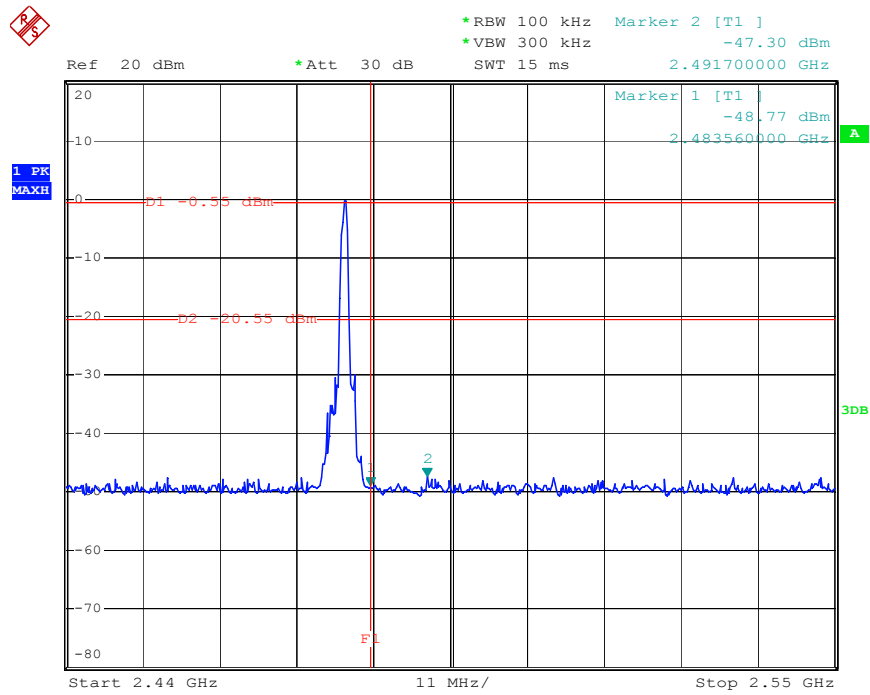
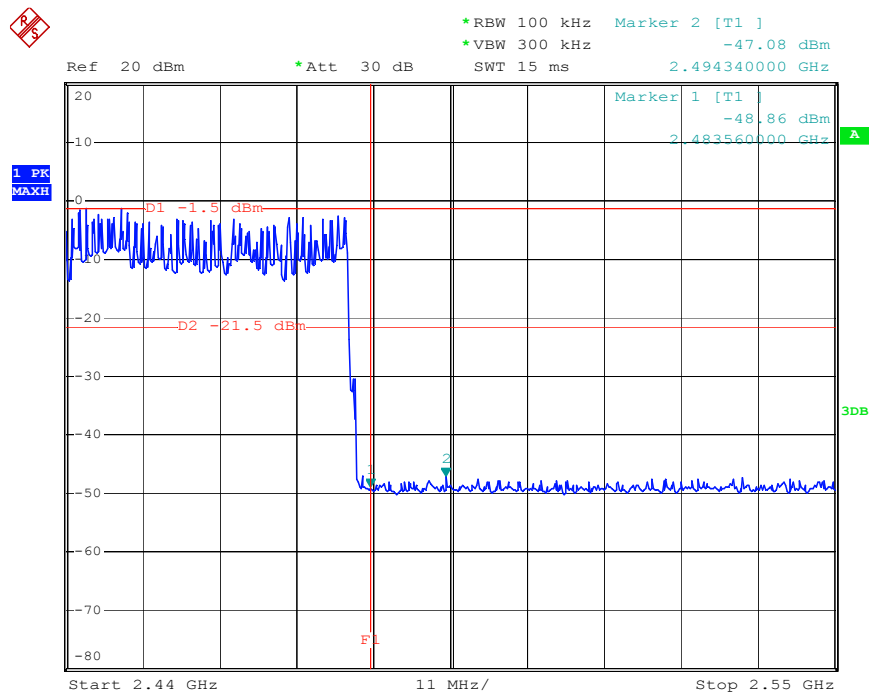


Worst mode: 8DPSK (3DH1)

Lowest:



Highest:



6. Emission Bandwidth

6.1 Standard Applicable

According to 15.215 (c), intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in Subpart E of this part, must be designed to ensure that the 20 dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

6.2 Test Procedure

According to the ANSI 63.10-2013, the emission bandwidth test method as follows.

Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to the spectrum analyzer.

Set span = 1MHz, centered on a transmitting channel

RBW $\geq$ 1% 20dB Bandwidth, VBW $\geq$ RBW

Sweep = auto

Detector function = peak

Trace = max hold

All the trace to stabilize, use the marker-to-peak function to set the marker to the peak of the emission, use the marker-delta function to measure and record the 20dB down and 99% bandwidth of the emission.

6.3 Environmental Conditions

Temperature:	25 °C
Relative Humidity:	53%
ATM Pressure:	1018 mbar

6.4 Summary of Test Results/Plots

Worst mode: GFSK (DH1)

Channel	Frequency MHz	20dB Bandwidth kHz	99% Bandwidth kHz
Low Channel	2402	912	1044.7
Middle Channel	2441	888	1056.3
High Channel	2480	864	1069.9

Worst mode: Pi/4 QDPSK (2DH1)

Channel	Frequency MHz	20dB Bandwidth kHz	99% Bandwidth kHz
Low Channel	2402	1224	1044.7
Middle Channel	2441	1224	1056.3
High Channel	2480	1230	1069.9

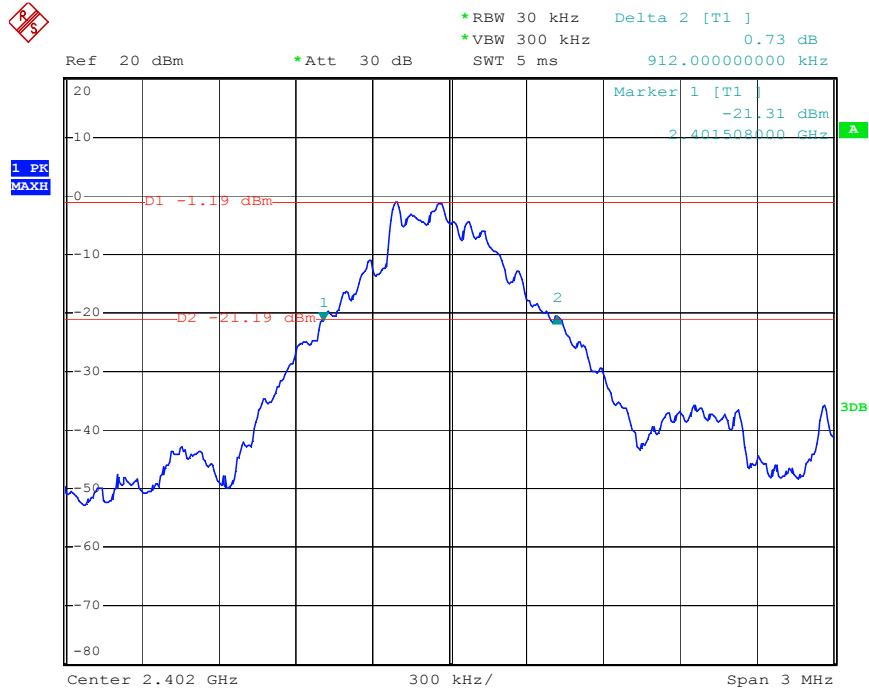
Worst mode: 8DPSK (3DH1)

Channel	Frequency MHz	20dB Bandwidth kHz	99% Bandwidth kHz
Low Channel	2402	1212	1044.7
Middle Channel	2441	1224	1056.3
High Channel	2480	1230	1069.9

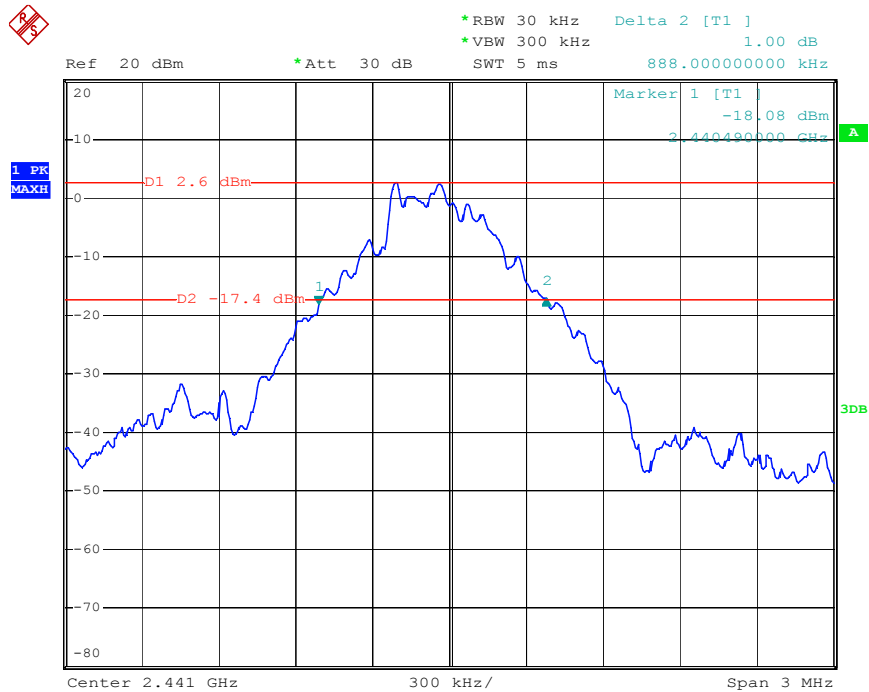
Please refer to the following test plots

Worst mode: GFSK (DH1)

Low Channel:



Middle Channel:

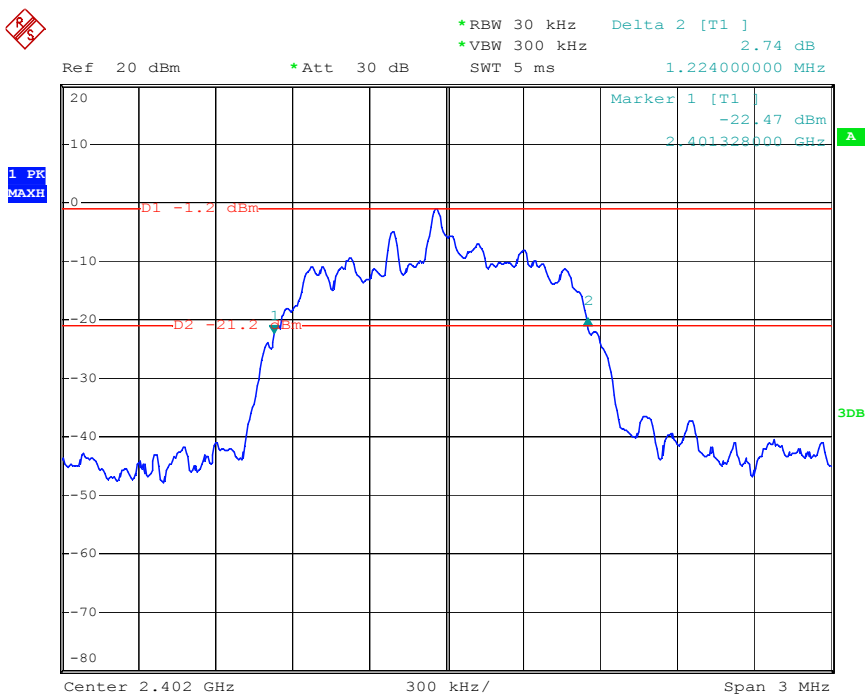


High Channel:

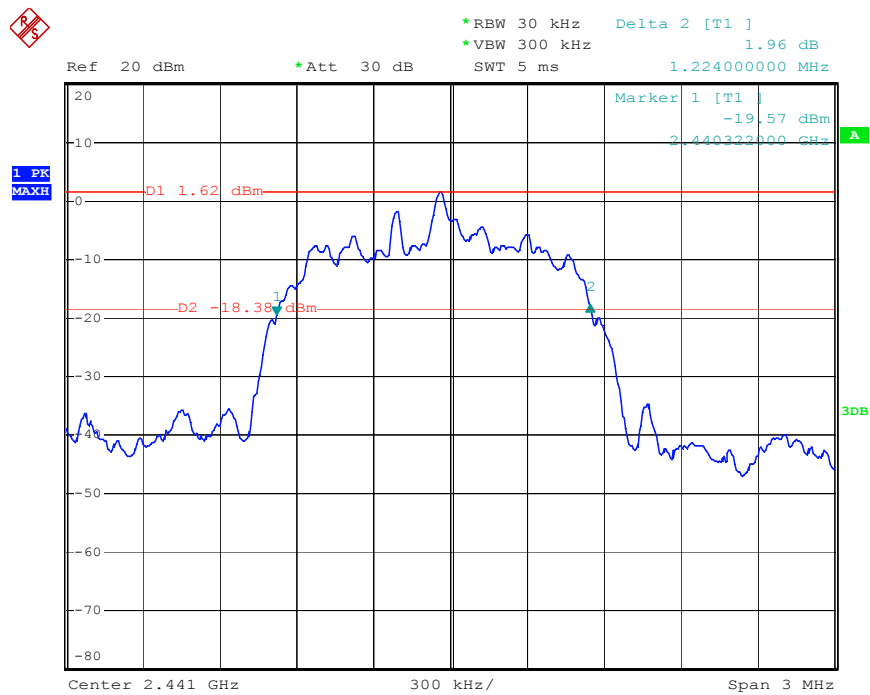


Worst mode: Pi/4 QDPSK (2DH1)

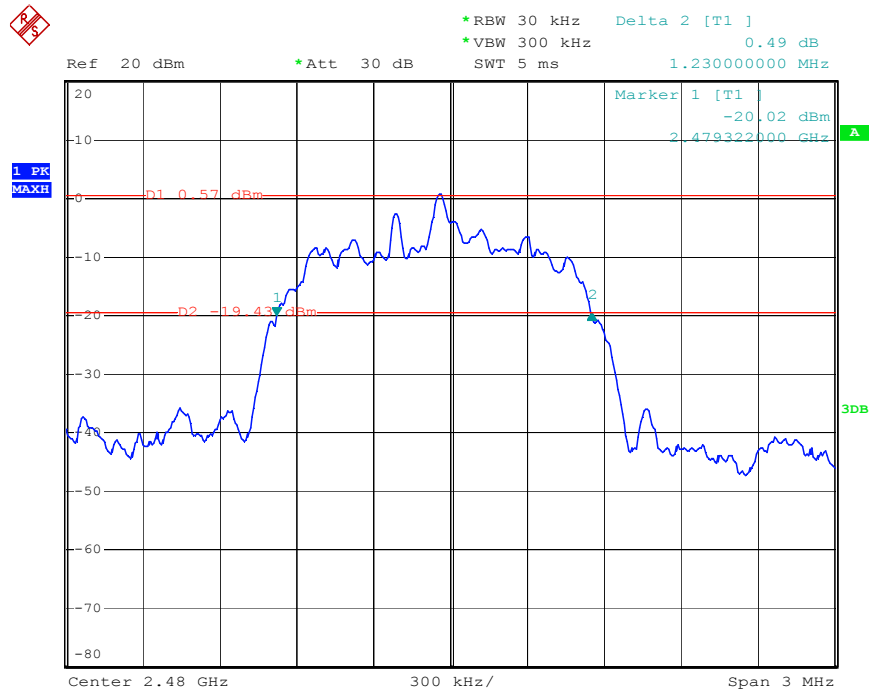
Low Channel:



Middle Channel:

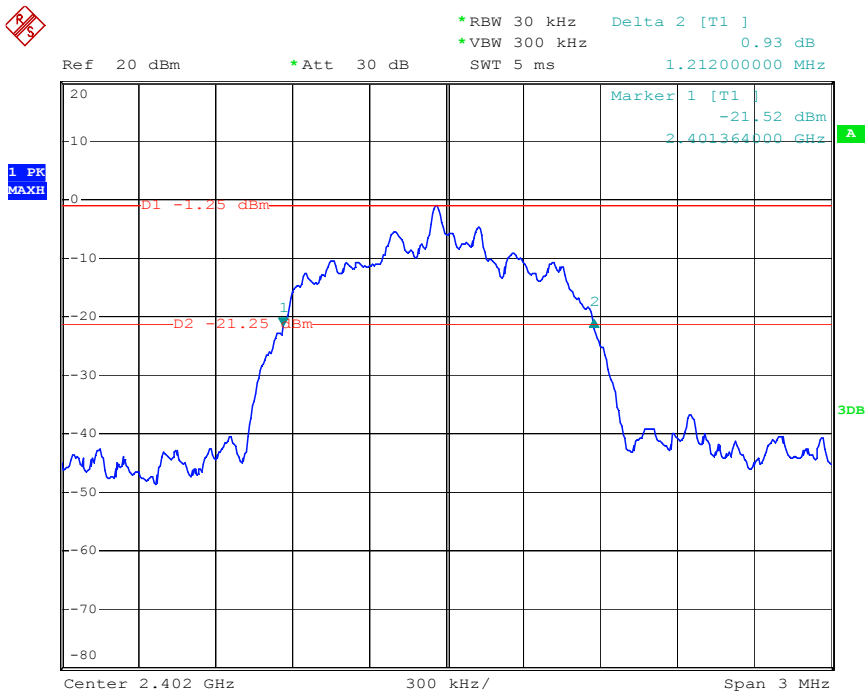


High Channel:

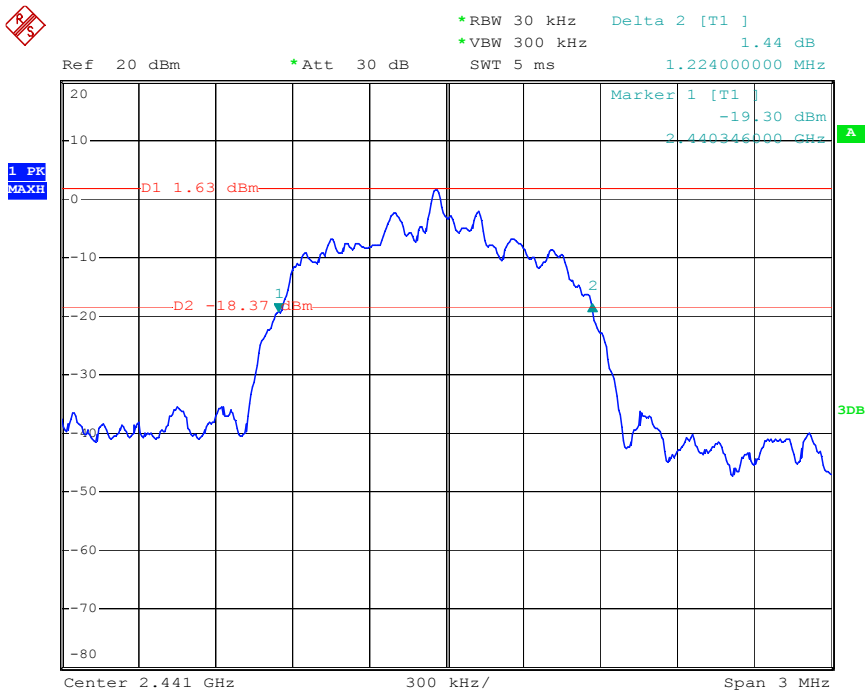


Worst mode: 8DPSK (3DH1)

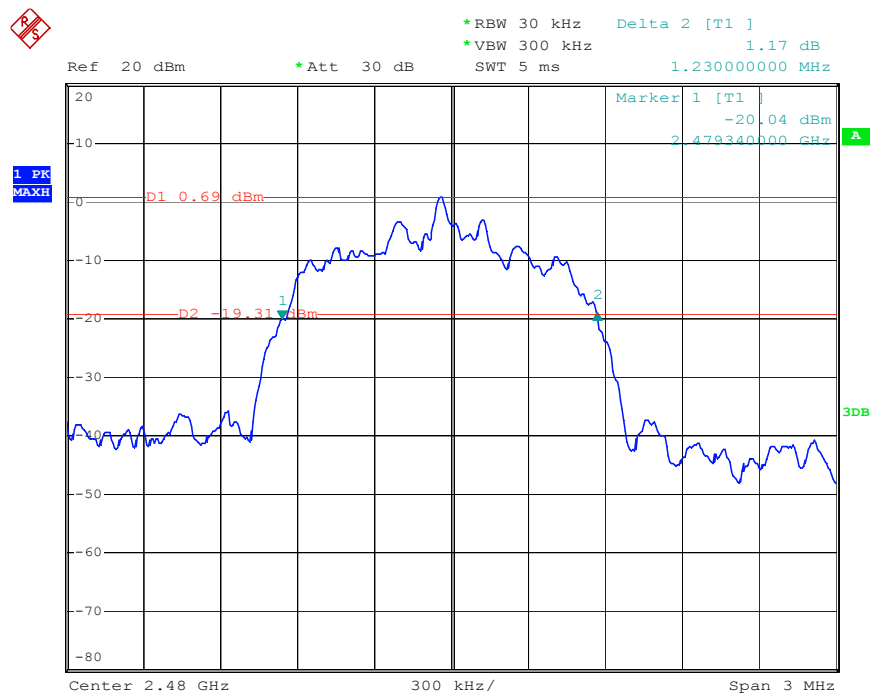
Low Channel:



Middle Channel:



High Channel:



7. Conducted Emissions

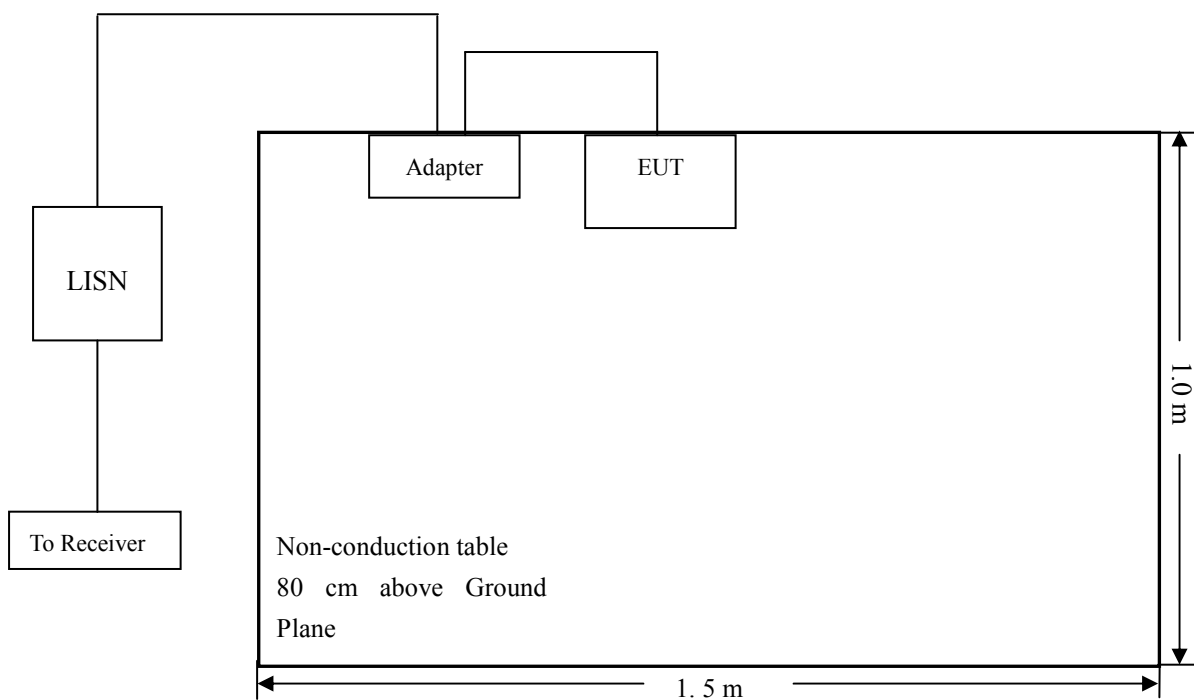
7.1 Test Procedure

The setup of EUT is according with per ANSI C63.4-2014 measurement procedure. The specification used was with the FCC Part 15.207 Limit.

The external I/O cables were draped along the test table and formed a bundle 30 to 40 cm long in the middle.

The spacing between the peripherals was 10 cm.

7.2 Basic Test Setup Block Diagram



7.3 Environmental Conditions

Temperature:	25 °C
Relative Humidity:	52%
ATM Pressure:	1012 mbar

7.4 Test Receiver Setup

During the conducted emission test, the test receiver was set with the following configurations:

Start Frequency	150 kHz
Stop Frequency.....	30 MHz
Sweep Speed	Auto
IF Bandwidth.....	10 kHz
Quasi-Peak Adapter Bandwidth	9 kHz
Quasi-Peak Adapter Mode	Normal

7.5 Summary of Test Results/Plots

According to the data in section 7.7, the EUT complied with the FCC Part 15.207 Conducted margin for this device.

7.6 Conducted Emissions Test Data

Note: The EUT is supplied by the battery. So it is not applicable.

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