Test Report

Date : 2024-11-07
No. : HMD24090007

Applicant	:	Aqua Design Amano Co. LTD 8554-1 Urushiyama,Nishikan-Ku,Niigata 953-0054,Japan
Supplier / Manufacturer	:	Shenzhen Adana Technology Co., Ltd 401, building K, no.45, southwest pinglu, pingxi community, pingdi street, longgang district, shenzhen city
Description of Sample(s)	:	Submitted sample(s) said to be Product: Solar RGB II Brand Name: ADA Model No.: Solar RGB II FCC ID: 2BAVX-2RGB
Date Samples Received	:	2024-09-23
Date Tested	:	2024-09-24 to 2024-11-05
Investigation Requested	:	Perform Electro Magnetic Interference measurement in accordance with FCC 47CFR [Codes of Federal Regulations] Part 15 and ANSI C63.10:2013 for FCC Certification.
Conclusions	:	The submitted product COMPLIED with the requirements of Federal Communications Commission [FCC] Rules and Regulations Part 15. The tests were performed in accordance with the standards described above and on Section 2.2 in this Test Report.
Remarks	:	Bluetooth FHSS (GFSK / π/4-DQPSK/ 8DPSK)
Test by		Susu

Dr.CHAN Kwok Hung, Brian
Authorized Signatory

Test Report

CONTENT:

1.0 General Details

1.1 Test Laboratory

The Hong Kong Standards and Testing Centre Ltd.
EMC Laboratory
10 Dai Wang Street, Taipo Industrial Estate, New Territories, Hong Kong
Telephone: 852 2666 1888
Fax: 852 2664 4353

1.2 Equipment Under Test [EUT]

Description of Sample(s)

Product:	Solar RGB II
Manufacturer:	Shenzhen Adana Technology Co., Ltd 401, building K, no.45, southwest pinglu, pingxi community, pingdi street, longgang district, shenzhen city
Brand Name:	ADA
Model Number:	Solar RGB II
Rating:	36.0Vd.c. by adapter

The AC/DC adaptor was provided by the applicant with following details:
Brand name: Fuyuang, Model no.: FY3605000, Input: 100-240Va.c. 50/60Hz 2.5A, Output: 36Vd.c. 5.0A 180.0W

1.2.1 Description of EUT Operation

The Equipment Under Test (EUT) is a Solar RGB II. The transmission signal is digital modulated with channel frequency range 2402-2480MHz. The R.F. signal was modulated by IC; the type of modulation used was frequency hopping spread spectrum Modulation.

1.3 Date of Order

2024-09-23

1.4 Submitted Sample(s):

1 Sample

1.5 Test Duration

2024-09-24 to 2024-11-05

1.6 Country of Origin

China

1.7 RF Module Details

Module Model Number:	ESP32-WROOM-32E
Module FCC ID:	N/A
Module Transmission Type:	Bluetooth 4.2 BR+EDR+BLE
Modulation:	FHSS (GFSK / π/4-DQPSK/ 8DPSK)
Data Rates:	1MBps: GFSK
	2 MBps: π/4-DQPSK
	3 MBps: 8DPSK
Frequency Range:	2400-2483.5MHz
Carrier Frequencies:	2402MHz – 2480MHz

Module Specification (specification provided by manufacturer)

1.8 Antenna Details

Antenna Type:	PCB antenna
Antenna Gain:	3.76dBi

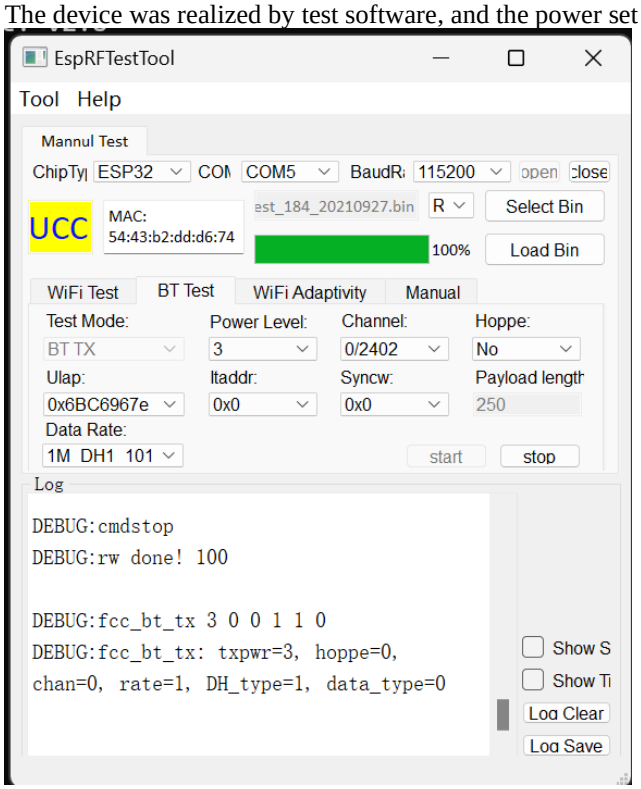
1.9 Channel List

Channel	Frequency (MHz)	Channel	Frequency (MHz)
0	2402	42	2444
1	2403	43	2445
2	2404	44	2446
3	2405	45	2447
4	2406	46	2448
5	2407	47	2449
6	2408	48	2450
7	2409	…	…
8	2410	67	2469
9	2411	68	2470
…	…	69	2471
33	2435	70	2472
34	2436	71	2473
35	2437	72	2474
36	2438	73	2475
37	2439	74	2476
38	2440	75	2477
39	2441	76	2478
40	2442	77	2479
41	2443	78	2480

2.0 Technical Details

2.1 Investigations Requested

Perform Electromagnetic Interference measurements in accordance with FCC 47CFR [Codes of Federal Regulations] Part 15 Regulations and ANSI C63.10:2013for FCC Certification.
The device was realized by test software, and the power set select “3”..



2.2 Test Standards and Results Summary Tables

EMISSION Results Summary						
Test Condition	Test Requirement	Test Method	Class / Severity	Test Result		
				Pass	Failed	N/A
Maximum Peak Conducted Output Power	FCC 47CFR 15.247(b)(1)	ANSI C63.10: 2013	N/A	☒	☐	☐
Radiated Spurious Emissions	FCC 47CFR 15.209, FCC 47CFR 15.205	ANSI C63.10: 2013	N/A	☒	☐	☐
AC Mains Conducted Emissions	FCC 47CFR 15.207	ANSI C63.10: 2013	N/A	☒	☐	☐
Conducted Spurious Emissions	FCC 47CFR 15.247(d)	ANSI C63.10: 2013	N/A	☒	☐	☐
Number of Hopping Frequency	FCC 47CFR 15.247 (b)(1)	ANSI C63.10: 2013	N/A	☒	☐	☐
20dB Bandwidth	FCC 47CFR 15.247(a)(2)	ANSI C63.10: 2013	N/A	☒	☐	☐
Hopping Channel Separation	FCC 47CFR 15.247(a)(1)	ANSI C63.10: 2013	N/A	☒	☐	☐
Band-edge measurement (Radiated)	FCC 47CFR 15.247(d)	ANSI C63.10: 2013	N/A	☒	☐	☐
Pseudorandom Hopping Algorithm	FCC 47CFR 15.247(a)(1)	N/A	N/A	☒	☐	☐
Time of Occupancy (Dwell Time)	FCC 47CFR 15.247(a)(1)(iii)	ANSI C63.10: 2013	N/A	☒	☐	☐
Antenna requirement	FCC 47CFR 15.203	N/A	N/A	☒	☐	☐

Note: N/A - Not Applicable

2.3 Table for Test Modes

Preliminary tests were performed in different data rate to find the worst radiated emission. The data rate in the table below is the worst-case rate with respect to the specific test item.
Investigation has been done on all the possible configurations for searching the worst cases.
The following table is a list of the test modes shown in this test report.

Test Items	Mode	Data Rate
Maximum Peak Conducted Output Power	GFSK / π/4-DQPSK / 8DPSK	1MBps / 2MBps / 3MBps
Hopping Channel Separation	GFSK / π/4-DQPSK / 8DPSK	1MBps / 2MBps / 3MBps
Number of Hopping Frequency	GFSK / π/4-DQPSK / 8DPSK	1MBps / 2MBp / 3MBps
Time of Occupancy (Dwell Time)	8DPSK (3DH1 / 3DH3 / 3DH5)	3MBps
Radiated Spurious Emissions	GFSK / π/4-DQPSK / 8DPSK	1MBps / 2MBps / 3MBps
Band-edge compliance of Conducted Emission	GFSK / π/4-DQPSK / 8DPSK	1MBps / 2MBps / 3MBps

3.0 Test Results

3.1 Emission

3.1.1 Maximum Peak Conducted Output Power

Test Requirement:	FCC 47CFR 15.247(b) (1)
Test Method:	ANSI C63.10: 2013
Test Date:	2024-09-24
Mode of Operation:	Tx mode

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

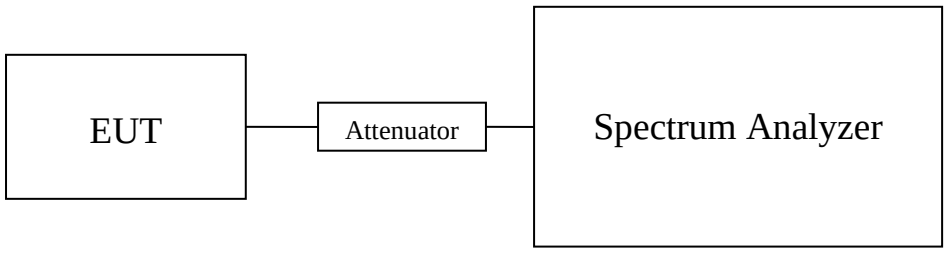
Test Method:

A temporary antenna connector was soldered to the RF output. The RF output of the EUT was connected to the spectrum analyzer. All the attenuation or cable loss will be added to the measured maximum output power. The results are recorded in Watt.

Spectrum Analyzer Setting:

RBW = 3 MHz, VBW= 3MHz, Sweep = Auto, Span: Approximately five times the 20 dB bandwidth
Detector = Peak, Trace = Max. hold

Test Setup:



Note: a temporary antenna connector was soldered to the RF output.

Limits for Maximum Peak Conducted Output Power [FCC 47CFR 15.247]:

The maximum peak output power shall not exceeded the following limits: For frequency hopping systems employing at least 75 hopping channels: 1 Watt For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 Watts For Digital Transmission systems in 2400-2483.5 MHz Band: 1 Watt

Results of Bluetooth Communication mode (GFSK) (Fundamental Power): Pass					
Channel	**Frequency(MHz)**	**Conducted power(dBm)**	**Antenna Gain(dBi)**	**E.I.R.P(dBm)**	**E.I.R.P (Watt)**
0	2402	-3.08	3.76	0.68	0.001169
39	2441	-2.18	3.76	1.58	0.001439
78	2480	-2.13	3.76	1.63	0.001455

Results of Bluetooth Communication mode (π/4-DQPSK) (Fundamental Power): Pass					
Channel	**Frequency(MHz)**	**Conducted power(dBm)**	**Antenna Gain(dBi)**	**E.I.R.P(dBm)**	**E.I.R.P (Watt)**
0	2402	-0.95	3.76	2.81	0.001910
39	2441	-0.02	3.76	3.74	0.002366
78	2480	-0.03	3.76	3.73	0.002360

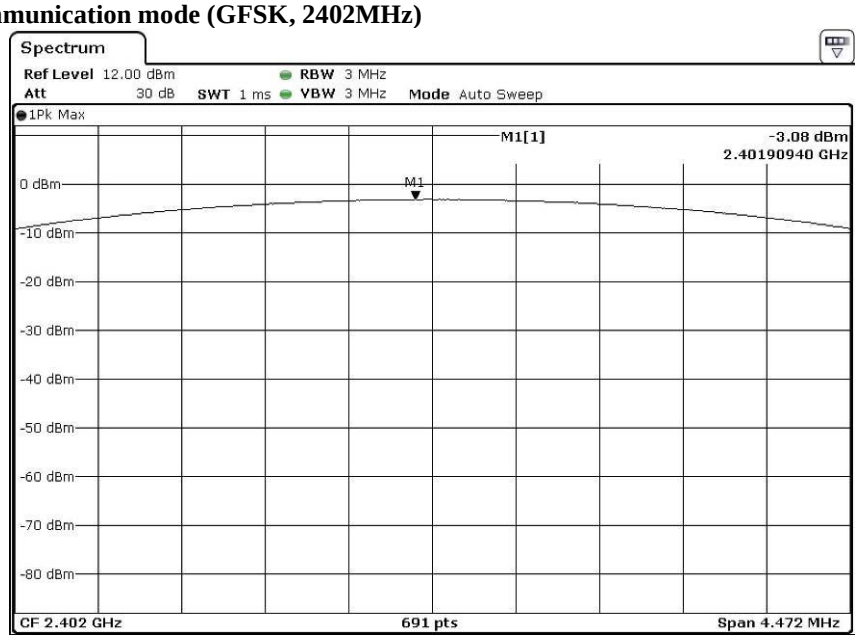
Results of Bluetooth Communication mode (8DPSK) (Fundamental Power): Pass					
Channel	**Frequency(MHz)**	**Conducted power(dBm)**	**Antenna Gain(dBi)**	**E.I.R.P(dBm)**	**E.I.R.P (Watt)**
0	2402	-1.62	3.76	2.14	0.001637
39	2441	-0.48	3.76	3.28	0.002128
78	2480	-0.54	3.76	3.22	0.002099

Calculated measurement uncertainty : 30MHz to 1GHz 1.7dB
1GHz to 18GHz 1.7dB

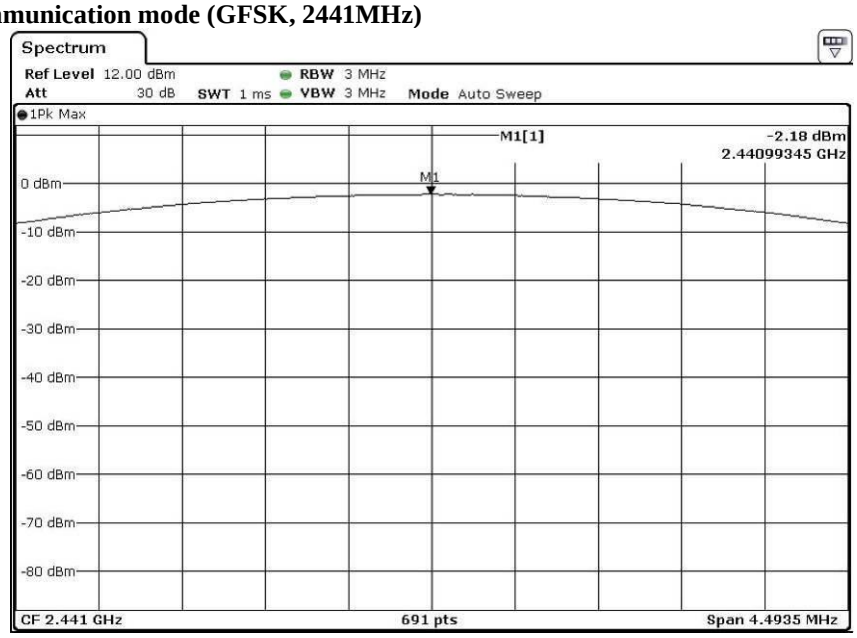
Remark:
1. All test data for each data rate were verified, but only the worst case was reported.
2. The EUT is programmed to transmit signals continuously for all testing.

Test plot of Maximum Peak Conducted Output Power：

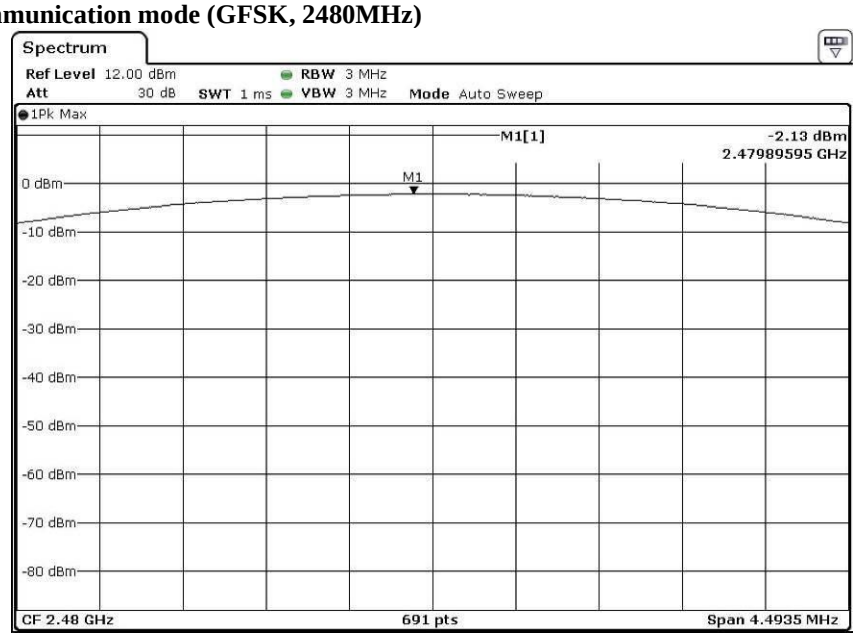
Bluetooth Communication mode (GFSK, 2402MHz)



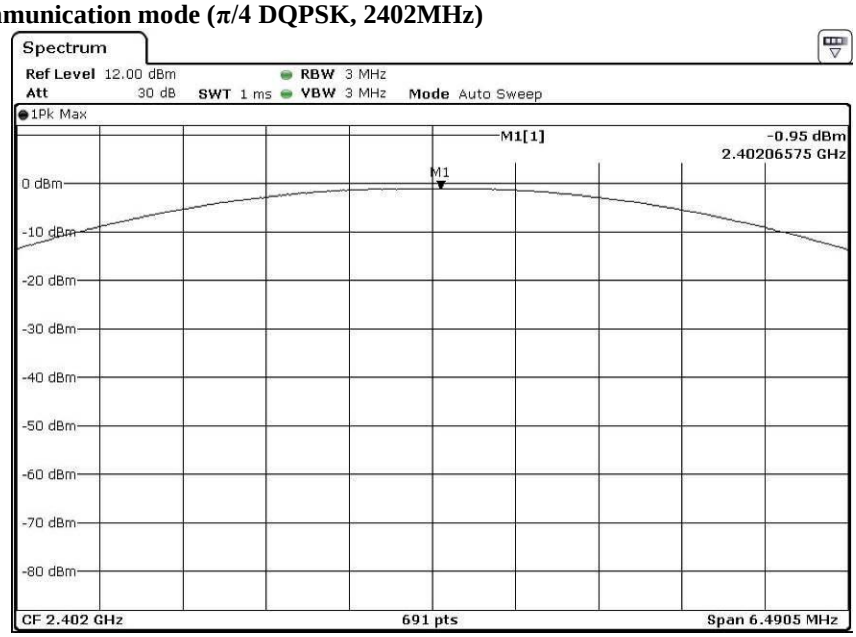
Bluetooth Communication mode (GFSK, 2441MHz)



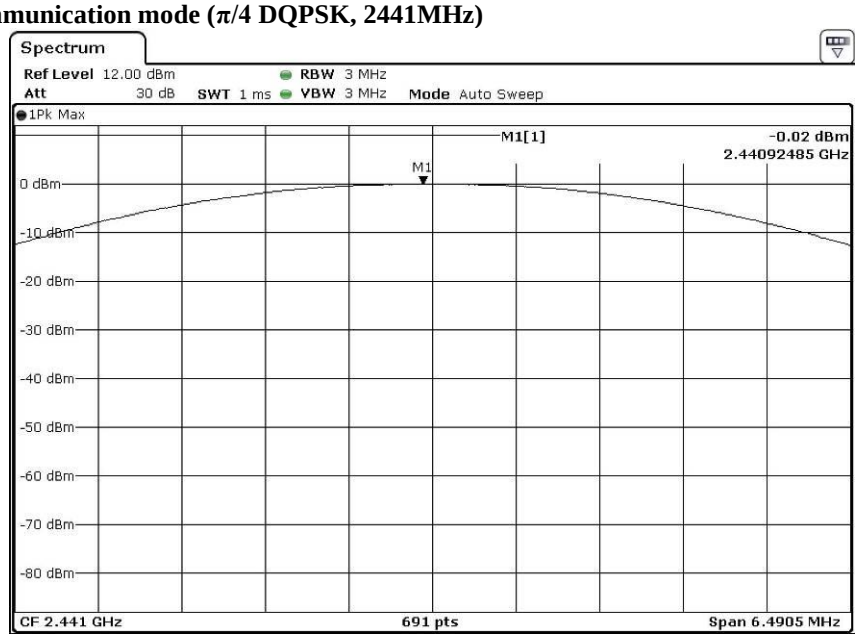
Bluetooth Communication mode (GFSK, 2480MHz)



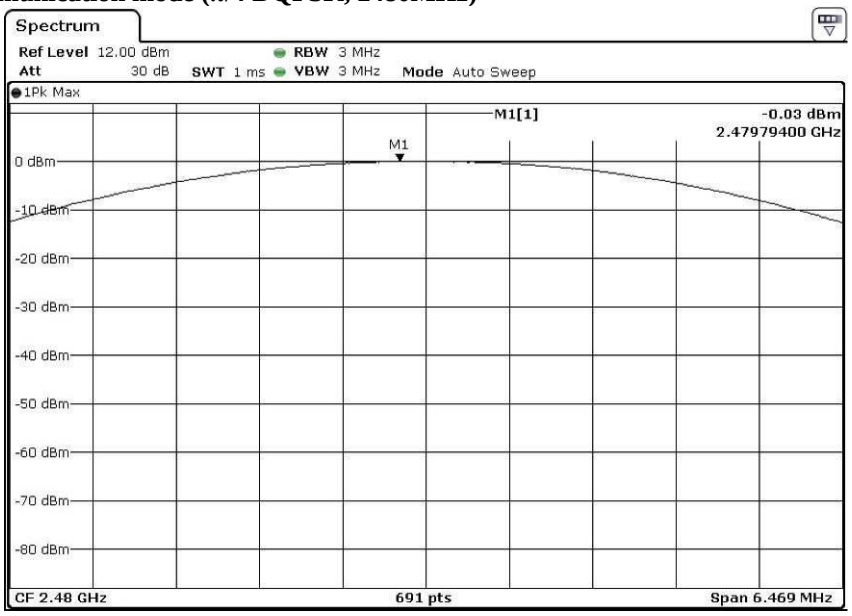
Bluetooth Communication mode (π/4 DQPSK, 2402MHz)



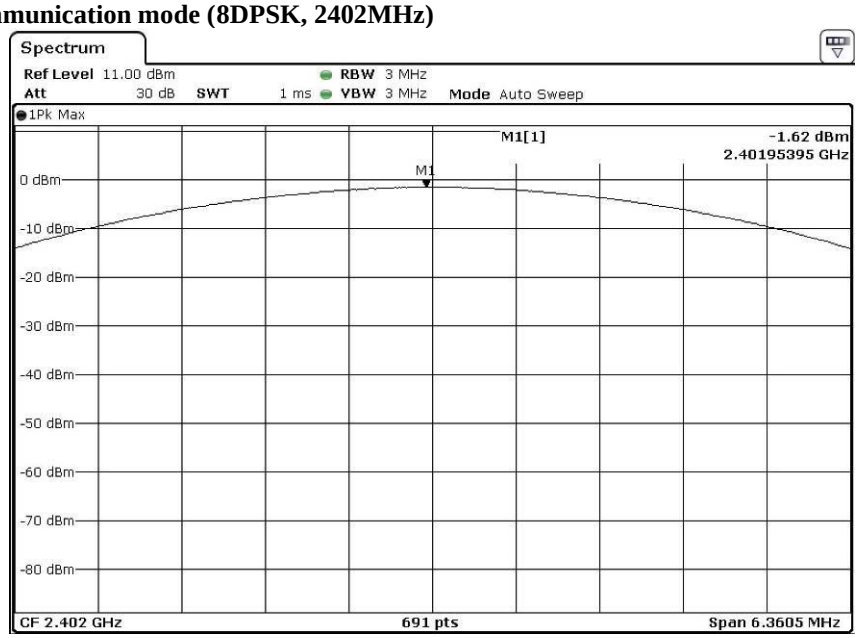
Bluetooth Communication mode (π/4 DQPSK, 2441MHz)



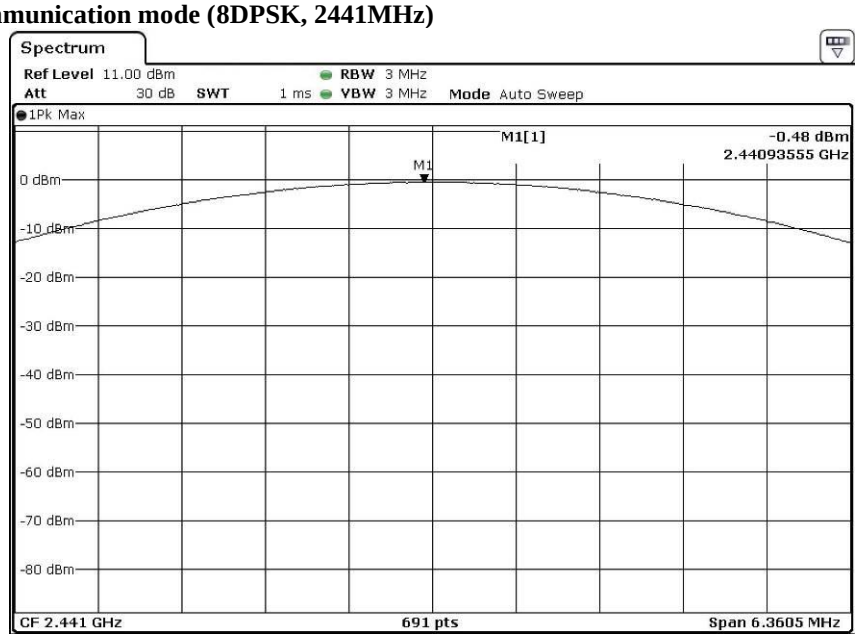
Bluetooth Communication mode (π/4 DQPSK, 2480MHz)



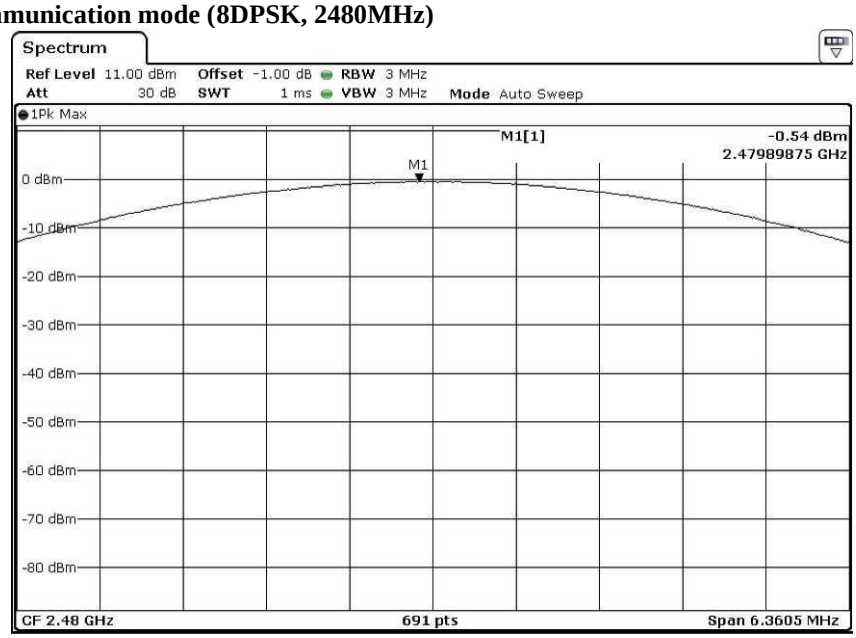
Bluetooth Communication mode (8DPSK, 2402MHz)



Bluetooth Communication mode (8DPSK, 2441MHz)



Bluetooth Communication mode (8DPSK, 2480MHz)



3.1.2 Radiated Spurious Emissions

Test Requirement:	FCC 47CFR 15.209
Test Method:	ANSI C63.10:2013
Test Date:	2024-09-24 to 2024-09-26
Mode of Operation:	Tx mode / Bluetooth play mode (GFSK)

Ambient Temperature: 26.8℃ Relative Humidity: 43.9% Atmospheric Pressure: 100.8 kPa

Test Method:

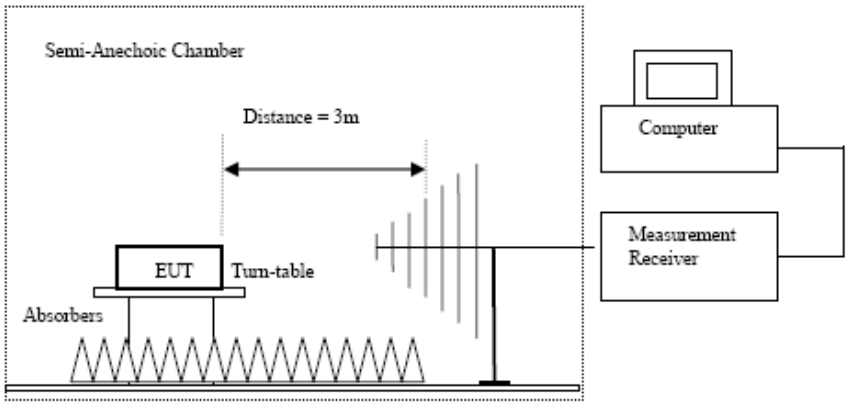
For emission measurements at or below 1 GHz, the sample was placed 0.8m above the ground plane of semi-anechoic Chamber*. For emission measurements above 1 GHz, the sample was placed 1.5m above the ground plane of semi-anechoic Chamber*. Measurements in both horizontal and vertical polarities were performed. 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 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.

* Semi-Anechoic chamber located on the G/F of The Hong Kong Standards and Testing Centre Ltd. with Registration Number: HK0001
Test Firm Registration Number: 367672

Spectrum Analyzer Setting:

9KHz – 30MHz (Pk & AVG)	RBW:	10kHz
	VBW:	30kHz
	Sweep:	Auto
	Span:	Fully capture the emissions being measured
	Trace:	Max. hold
30MHz – 1GHz (QP)	RBW:	120kHz
	VBW:	120kHz
	Sweep:	Auto
	Span:	Fully capture the emissions being measured
	Trace:	Max. hold
Above 1GHz (Pk & AVG)	RBW:	1MHz
	VBW:	1MHz
	Sweep:	Auto
	Span:	Fully capture the emissions being measured
	Trace:	Max. hold

Test Setup:



Ground Plane

- Absorbers placed on top of the ground plane are for measurements above 1000MHz only.
- Measurements between 30MHz to 1000MHz made with Bi-log antennas, above 1000MHz horn antennas are used, 9kHz to 30MHz loop antennas are used.

Limits for Radiated Emissions FCC 47 CFR 15.247 Class B]:

Frequency Range	Quasi-Peak Limits
[MHz]	[μV/m]
0.009-0.490	2400/F (kHz)
0.490-1.705	24000/F (kHz)
1.705-30	30
30-88	100
88-216	150
216-960	200
Above960	500

The emission limits shown in the above table are based on measurement employing a CISPR quasi-peak detector and above 1000MHz are based on measurements employing an average detector.

Result of Tx mode (2402.0 MHz) (GFSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2402.0 MHz) (GFSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBμV	Correction Factor dB/m	Field Strength dBμV/m	Limit @3m dBμV/m	Margin dB	E-Field Polarity
4804.0	57.0	0.8	57.8	74.0	16.2	Vertical
4804.0	57.0	0.5	57.5	74.0	16.5	Horizontal
7206.0	49.8	7.0	56.8	74.0	17.2	Vertical
7206.0	49.7	6.5	56.2	74.0	17.8	Horizontal
9608.0	46.1	8.5	54.6	74.0	19.4	Vertical
9608.0	46.3	8.3	54.6	74.0	19.4	Horizontal
12010.0	45.1	10.9	56.0	74.0	18.0	Vertical
12010.0	45.3	10.8	56.1	74.0	18.0	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4804.0	41.5	0.8	42.3	54.0	11.7	Vertical
4804.0	41.3	0.5	41.8	54.0	12.2	Horizontal
7206.0	35.8	7.0	42.8	54.0	11.2	Vertical
7206.0	33.7	6.5	40.2	54.0	13.8	Horizontal
9608.0	31.7	8.5	40.2	54.0	13.8	Vertical
9608.0	32.0	8.3	40.3	54.0	13.7	Horizontal
12010.0	30.0	10.9	40.9	54.0	13.1	Vertical
12010.0	29.5	10.8	40.3	54.0	13.7	Horizontal

Result of Tx mode (2441.0 MHz) (GFSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2441.0 MHz) (GFSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4882.0	57.7	0.8	58.5	74.0	15.5	Vertical
4882.0	57.1	0.5	57.6	74.0	16.4	Horizontal
7223.0	50.0	7.0	57.0	74.0	17.0	Vertical
7223.0	50.2	6.5	56.7	74.0	17.3	Horizontal
9764.0	48.0	8.5	56.5	74.0	17.5	Vertical
9764.0	47.2	8.3	55.5	74.0	18.5	Horizontal
12205.0	45.1	10.9	56.0	74.0	18.1	Vertical
12205.0	45.4	10.8	56.2	74.0	17.8	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBuV	Correction Factor dB/m	Field Strength dBuV/m	Limit @3m dBuV/m	Margin dB	E-Field Polarity
4882.0	41.8	0.8	42.6	54.0	11.4	Vertical
4882.0	42.3	0.5	42.8	54.0	11.2	Horizontal
7323.0	36.1	7.0	43.1	54.0	10.9	Vertical
7323.0	35.7	6.5	42.2	54.0	11.8	Horizontal
9764.0	33.1	8.5	41.6	54.0	12.4	Vertical
9764.0	32.2	8.3	40.5	54.0	13.5	Horizontal
12205.0	30.5	10.9	41.4	54.0	12.6	Vertical
12205.0	30.1	10.8	40.9	54.0	13.1	Horizontal

Result of Tx mode (2480.0 MHz) (GFSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2480.0 MHz) (GFSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4960.0	57.1	0.8	57.9	74.0	16.1	Vertical
4960.0	57.3	0.5	57.8	74.0	16.2	Horizontal
7440.0	50.4	7.0	57.4	74.0	16.6	Vertical
7440.0	50.5	6.5	57.0	74.0	17.0	Horizontal
9920.0	47.3	8.5	55.8	74.0	18.2	Vertical
9920.0	47.0	8.3	55.3	74.0	18.7	Horizontal
12400.0	45.5	10.9	56.4	74.0	17.6	Vertical
12400.0	45.3	10.8	56.1	74.0	17.9	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4960.0	41.1	0.8	41.9	54.0	12.1	Vertical
4960.0	41.9	0.5	42.4	54.0	11.6	Horizontal
7440.0	35.2	7.0	42.2	54.0	11.8	Vertical
7440.0	35.5	6.5	42.0	54.0	12.0	Horizontal
9920.0	33.5	8.5	42.0	54.0	12.0	Vertical
9920.0	31.8	8.3	40.1	54.0	13.9	Horizontal
12400.0	30.1	10.9	41.0	54.0	13.0	Vertical
12400.0	30.1	10.8	40.9	54.0	13.1	Horizontal

Result of Tx mode (2402.0 MHz) (π/4-DQPSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2402.0 MHz) (π/4-DQPSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4804.0	56.4	0.8	57.2	74.0	16.8	Vertical
4804.0	56.2	0.5	56.7	74.0	17.3	Horizontal
7206.0	50.0	7.0	57.0	74.0	17.0	Vertical
7206.0	50.1	6.5	56.6	74.0	17.4	Horizontal
9608.0	46.8	8.5	55.3	74.0	18.7	Vertical
9608.0	47.8	8.3	56.1	74.0	17.9	Horizontal
12010.0	45.3	10.9	56.2	74.0	17.9	Vertical
12010.0	45.5	10.8	56.3	74.0	17.8	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4804.0	42.0	0.8	42.8	54.0	11.2	Vertical
4804.0	41.2	0.5	41.7	54.0	12.3	Horizontal
7206.0	35.2	7.0	42.2	54.0	11.8	Vertical
7206.0	35.4	6.5	41.9	54.0	12.1	Horizontal
9608.0	32.7	8.5	41.2	54.0	12.8	Vertical
9608.0	33.0	8.3	41.3	54.0	12.7	Horizontal
12010.0	30.7	10.9	41.6	54.0	12.4	Vertical
12010.0	31.1	10.8	41.9	54.0	12.1	Horizontal

Result of Tx mode (2441.0 MHz) (π/4-DQPSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2441.0 MHz) (π/4-DQPSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBuV	Correction Factor dB/m	Field Strength dBuV/m	Limit @3m dBuV/m	Margin dB	E-Field Polarity
4882.0	56.7	0.8	57.5	74.0	16.5	Vertical
4882.0	57.1	0.5	57.6	74.0	16.4	Horizontal
7323.0	50.0	7.0	57.0	74.0	17.0	Vertical
7323.0	50.1	6.5	56.6	74.0	17.4	Horizontal
9764.0	48.2	8.5	56.7	74.0	17.3	Vertical
9764.0	47.9	8.3	56.2	74.0	17.8	Horizontal
12205.0	45.4	10.9	56.3	74.0	17.7	Vertical
12205.0	45.3	10.8	56.1	74.0	18.0	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBuV	Correction Factor dB/m	Field Strength dBuV/m	Limit @3m dBuV/m	Margin dB	E-Field Polarity
4882.0	41.2	0.8	42.0	54.0	12.0	Vertical
4882.0	41.1	0.52	41.6	54.0	12.4	Horizontal
7323.0	35.4	7	42.4	54.0	11.6	Vertical
7323.0	35.7	6.5	42.2	54.0	11.8	Horizontal
9764.0	32.2	8.5	40.7	54.0	13.3	Vertical
9764.0	33.1	8.3	41.4	54.0	12.7	Horizontal
12205.0	31.5	10.9	42.4	54.0	11.6	Vertical
12205.0	30.6	10.8	41.4	54.0	12.6	Horizontal

Result of Tx mode (2480.0 MHz) (π/4-DQPSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2480.0 MHz) (π/4-DQPSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4960.0	56.8	0.8	57.6	74.0	16.4	Vertical
4960.0	57.2	0.5	57.7	74.0	16.3	Horizontal
7440.0	50.0	7.0	57.0	74.0	17.0	Vertical
7440.0	50.1	6.5	56.6	74.0	17.4	Horizontal
9920.0	47.4	8.5	55.9	74.0	18.1	Vertical
9920.0	47.9	8.3	56.2	74.0	17.8	Horizontal
12400.0	45.4	10.9	56.3	74.0	17.7	Vertical
12400.0	45.4	10.8	56.2	74.0	17.8	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4960.0	41.4	0.8	42.2	54.0	11.8	Vertical
4960.0	41.2	0.5	41.7	54.0	12.3	Horizontal
7440.0	34.8	7.0	41.8	54.0	12.2	Vertical
7440.0	35.1	6.5	41.6	54.0	12.4	Horizontal
9920.0	33.2	8.5	41.7	54.0	12.3	Vertical
9920.0	32.8	8.3	41.1	54.0	12.9	Horizontal
12400.0	30.9	10.9	41.8	54.0	12.2	Vertical
12400.0	30.5	10.8	41.3	54.0	12.8	Horizontal

Result of Tx mode (2402.0 MHz) (8DPSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2402.0 MHz) (8DPSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4804.0	56.4	0.8	57.2	74.0	16.8	Vertical
4804.0	56.9	0.5	57.4	74.0	16.6	Horizontal
7206.0	49.5	7.0	56.5	74.0	17.5	Vertical
7206.0	49.7	6.5	56.2	74.0	17.8	Horizontal
9608.0	47.8	8.5	56.3	74.0	17.7	Vertical
9608.0	47.7	8.3	56.0	74.0	18.1	Horizontal
12010.0	45.1	10.9	56.0	74.0	18.0	Vertical
12010.0	45.0	10.8	55.8	74.0	18.2	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4804.0	41.4	0.8	42.2	54.0	11.8	Vertical
4804.0	41.3	0.5	41.8	54.0	12.2	Horizontal
7206.0	35.0	7.0	42.0	54.0	12.0	Vertical
7206.0	35.5	6.5	42.0	54.0	12.0	Horizontal
9608.0	32.1	8.5	40.6	54.0	13.4	Vertical
9608.0	33.2	8.3	41.5	54.0	12.5	Horizontal
12010.0	31.5	10.9	42.4	54.0	11.6	Vertical
12010.0	30.4	10.8	41.2	54.0	12.8	Horizontal

Result of Tx mode (2441.0 MHz) (8DPSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2441.0 MHz) (8DPSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4882.0	57.2	0.8	58.0	74.0	16.0	Vertical
4882.0	57.2	0.5	57.7	74.0	16.3	Horizontal
7223.0	50.1	7.0	57.1	74.0	16.9	Vertical
7223.0	50.8	6.5	57.3	74.0	16.7	Horizontal
9764.0	48.0	8.5	56.5	74.0	17.5	Vertical
9764.0	47.3	8.3	55.6	74.0	18.4	Horizontal
12205.0	45.2	10.9	56.1	74.0	17.9	Vertical
12205.0	45.5	10.8	56.3	74.0	17.7	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBuV	Correction Factor dB/m	Field Strength dBuV/m	Limit @3m dBuV/m	Margin dB	E-Field Polarity
4882.0	41.5	0.8	42.3	54.0	11.7	Vertical
4882.0	41.7	0.5	42.2	54.0	11.8	Horizontal
7323.0	34.6	7.0	41.6	54.0	12.4	Vertical
7323.0	35.5	6.5	42.0	54.0	12.0	Horizontal
9764.0	33.4	8.5	41.9	54.0	12.1	Vertical
9764.0	33.8	8.3	42.1	54.0	11.9	Horizontal
12205.0	30.9	10.9	41.8	54.0	12.2	Vertical
12205.0	30.5	10.8	41.3	54.0	12.7	Horizontal

Result of Tx mode (2480.0 MHz) (8FPSK) (9kHz – 30MHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level dBuV	Correction Factor dB/m	Field Strength dBuV/m	Field Strength uV/m	Limit uV/m	E-Field Polarity
Emissions detected are more than 20 dB below the FCC Limits						

Result of Tx mode (2480.0 MHz) (8DPSK) (Above 1GHz): Pass

Field Strength of Spurious Emissions Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4960.0	57.1	0.8	57.9	74.0	16.1	Vertical
4960.0	57.3	0.5	57.8	74.0	16.2	Horizontal
7440.0	50.0	7.0	57.0	74.0	17.0	Vertical
7440.0	50.8	6.5	57.3	74.0	16.7	Horizontal
9920.0	47.1	8.5	55.6	74.0	18.4	Vertical
9920.0	47.6	8.3	55.9	74.0	18.1	Horizontal
12400.0	45.3	10.9	56.2	74.0	17.8	Vertical
12400.0	45.4	10.8	56.2	74.0	17.8	Horizontal

Field Strength of Spurious Emissions Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
4960.0	41.3	0.8	42.1	54.0	11.9	Vertical
4960.0	41.9	0.5	42.4	54.0	11.6	Horizontal
7440.0	34.6	7.0	41.6	54.0	12.4	Vertical
7440.0	35.5	6.5	42.0	54.0	12.0	Horizontal
9920.0	31.5	8.5	40.0	54.0	14.0	Vertical
9920.0	32.5	8.3	40.8	54.0	13.2	Horizontal
12400.0	31.1	10.9	42.0	54.0	12.0	Vertical
12400.0	30.9	10.8	41.7	54.0	12.3	Horizontal

Remarks:
No additional spurious emissions found between lowest internal used/generated frequency and 30 MHz
* Denotes restricted band of operation.
Measurements were made using a peak detector. Any emission less than 1000MHz and falling within the restricted bands of FCC Rules Part 15 Section 15.205 and the limits of FCC Rules Part 15 Section 15.209 were applied.

Correction Factor included Antenna Factor and Cable Attenuation.

Calculated measurement uncertainty
(9kHz-30MHz): 2.0dB
(30MHz -1GHz): 4.9dB
(1GHz -6GHz): 4.02dB
(6GHz -26.5GHz): 4.03dB

Emissions in the vertical and horizontal polarizations have been investigated and the worst-case test results are recorded in this report.

Radiated Emissions Measurement:

Limit：

In any 100 kHz 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 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in Section 15.205(a), must also comply with the radiated emission limits specified in Section 15.209(a) (see Section 5.205(c)).

Result： RF Radiated Emissions (Lowest)-GFSK

Field Strength of Band-edge Compliance Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
2390.0	48.0	-4.8	43.2	74.0	30.8	Vertical
2390.0	47.0	-4.7	42.3	74.0	31.7	Horizontal

Field Strength of Band-edge Compliance Average Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
2390.0	43.2	-4.8	38.4	54.0	15.6	Vertical
2390.0	42.1	-4.7	37.4	54.0	16.6	Horizontal

Result： RF Radiated Emissions (Highest) -GFSK

Field Strength of Band-edge Compliance Peak Value						
Frequency MHz	Measured Level @3m dBµV	Correction Factor dB/m	Field Strength dBµV/m	Limit @3m dBµV/m	Margin dB	E-Field Polarity
2483.5	55.9	-4.8	51.1	74.0	22.9	Vertical
2483.5	55.1	-4.7	50.4	74.0	23.6	Horizontal

Field Strength of Band-edge Compliance Average Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2483.5	45.3	-4.8	40.5	54.0	13.5	Vertical
2483.5	45.1	-4.7	40.4	54.0	13.6	Horizontal

Result: RF Radiated Emissions (Lowest)- π/4-DQPSK

Field Strength of Band-edge Compliance Peak Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2390.0	48.4	-4.8	43.6	74.0	30.4	Vertical
2390.0	48.6	-4.7	43.9	74.0	30.1	Horizontal

Field Strength of Band-edge Compliance Average Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2390.0	43.1	-4.8	38.3	54.0	15.7	Vertical
2390.0	43.0	-4.7	38.3	54.0	15.7	Horizontal

Result: RF Radiated Emissions (Highest) -π/4-DQPSK

Field Strength of Band-edge Compliance Peak Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2483.5	56.3	-4.8	51.5	74.0	22.5	Vertical
2483.5	56.0	-4.7	51.3	74.0	22.7	Horizontal

Field Strength of Band-edge Compliance Average Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2483.5	45.6	-4.8	40.8	54.0	13.2	Vertical
2483.5	45.1	-4.7	40.4	54.0	13.6	Horizontal

Result: RF Radiated Emissions (Lowest)- 8DPSK

Field Strength of Band-edge Compliance Peak Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2390.0	47.8	-4.8	43.0	74.0	31.0	Vertical
2390.0	48.0	-4.7	43.3	74.0	30.7	Horizontal

Field Strength of Band-edge Compliance Average Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2390.0	44.0	-4.8	39.2	54.0	14.8	Vertical
2390.0	43.5	-4.7	38.8	54.0	15.2	Horizontal

Result: RF Radiated Emissions (Highest) -8DPSK

Field Strength of Band-edge Compliance Peak Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2483.5	56.1	-4.8	51.3	74.0	22.7	Vertical
2483.5	55.9	-4.7	51.2	74.0	22.8	Horizontal

Field Strength of Band-edge Compliance Average Value						
Frequency	Measured Level @3m	Correction Factor	Field Strength	Limit @3m	Margin	E-Field Polarity
MHz	dBµV	dB/m	dBµV/m	dBµV/m	dB	
2483.5	46.3	-4.8	41.5	54.0	12.5	Vertical
2483.5	46.1	-4.7	41.4	54.0	12.6	Horizontal

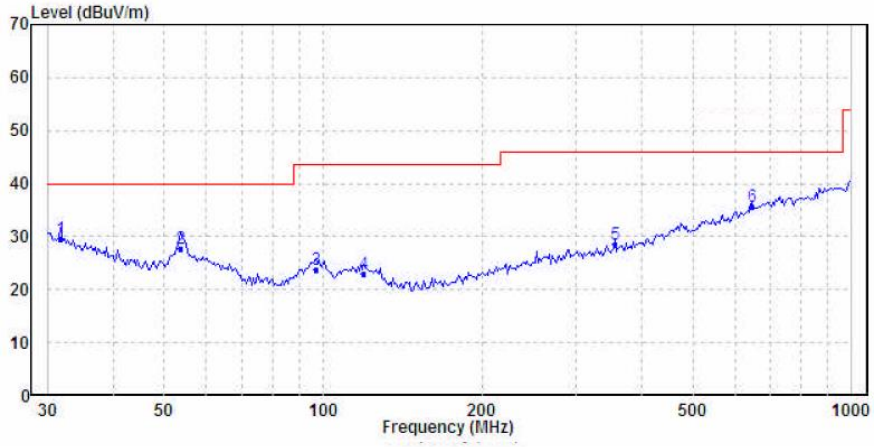
Limits for Radiated Emissions FCC 47 CFR 15.247 Class B]:

Frequency Range	Quasi-Peak Limits
[MHz]	[μV/m]
0.009-0.490	2400/F (kHz)
0.490-1.705	24000/F (kHz)
1.705-30	30
30-88	100
88-216	150
216-960	200
Above960	500

The emission limits shown in the above table are based on measurement employing a CISPR quasi-peak detector and above 1000MHz are based on measurements employing an average detector.

Results of Bluetooth mode (GFSK 2402.0 MHz) (30MHz – 1GHz): Pass

Horizontal



Ambient Temperature: 26.3C
Relative Humidity : 54.7%
Air Pressure : 100.9kPa

	Freq	Level	Limit Line	Over Limit	Remark	Pol/Phase
	MHz	dBuV/m	dBuV/m	dB		
1	31.731	29.68	40.00	-10.32	QP	Horizontal
2	53.693	27.86	40.00	-12.14	QP	Horizontal
3	96.775	23.77	43.50	-19.73	QP	Horizontal
4	119.436	22.91	43.50	-20.59	QP	Horizontal
5	356.676	28.65	46.00	-17.35	QP	Horizontal
6	647.386	35.58	46.00	-10.42	QP	Horizontal

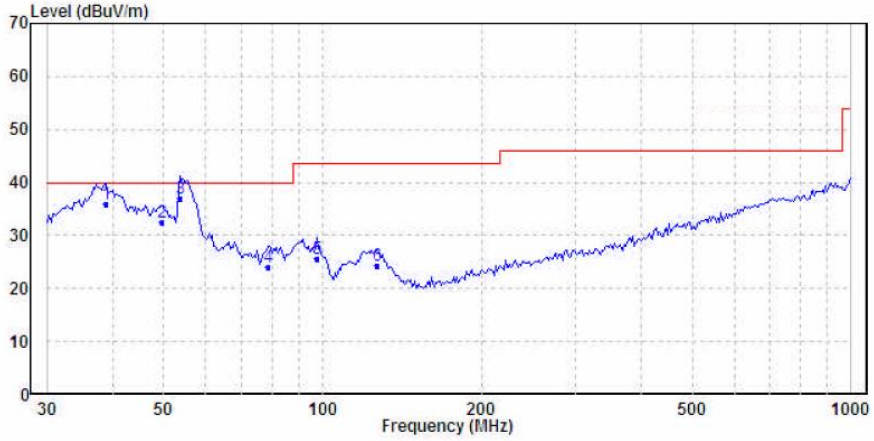
Limits for Radiated Emissions FCC 47 CFR 15.247 Class B]:

Frequency Range	Quasi-Peak Limits
[MHz]	[μV/m]
0.009-0.490	2400/F (kHz)
0.490-1.705	24000/F (kHz)
1.705-30	30
30-88	100
88-216	150
216-960	200
Above960	500

The emission limits shown in the above table are based on measurement employing a CISPR quasi-peak detector and above 1000MHz are based on measurements employing an average detector.

Results of Bluetooth mode (GFSK 2402.0 MHz) (30MHz – 1GHz): Pass

Vertical



Ambient Temperature: 26.3C
Relative Humidity : 54.7%
Air Pressure : 100.9kPa

	Freq	Level	Limit Line	Over Limit	Remark	Pol/Phase
	MHz	dBuV/m	dBuV/m	dB		
1	38.888	35.80	40.00	-4.20	QP	Vertical
2	49.707	32.58	40.00	-7.42	QP	Vertical
3	53.693	37.09	40.00	-2.91	QP	Vertical
4	78.965	23.98	40.00	-16.02	QP	Vertical
5	97.456	25.68	43.50	-17.82	QP	Vertical
6	126.329	24.36	43.50	-19.14	QP	Vertical

Remarks: Calculated measurement uncertainty (30MHz – 1GHz): 4.9dB
Emissions in the vertical and horizontal polarizations have been investigated and the worst-case test results are recorded in this report.

3.1.3 AC Mains Conducted Emissions (0.15MHz to 30MHz)

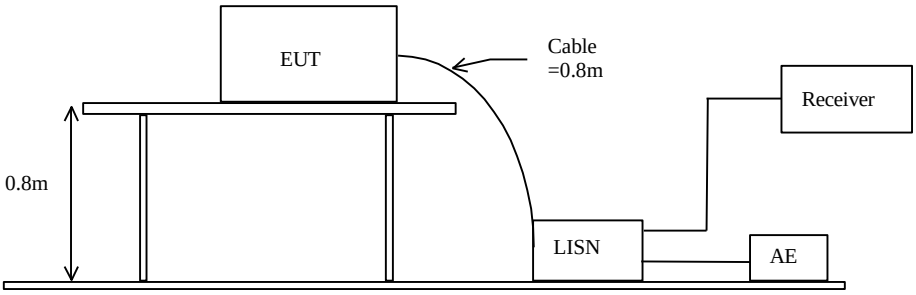
Test Requirement:	FCC 47CFR 15.207
Test Method:	ANSI C63.10:2013
Test Date:	2024-11-05
Mode of Operation:	BT mode
Test Voltage:	120Va.c. 60Hz

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Test Method:
The test was performed in accordance with ANSI ANSI C63.10:2013, with the following: an initial measurement was performed in peak and average detection mode on the live line, any emissions recorded within 30dB of the relevant limit line were re-measured using quasi-peak and average detection on the live and neutral lines with the worst case recorded in the table of results.

Receiver Setting:
Bandw. = 9 kHz, Meas. Time= 10.0 ms, Step Width = 5.0kHz
Detector = MaxPeak and CISPR AV

Test Setup:

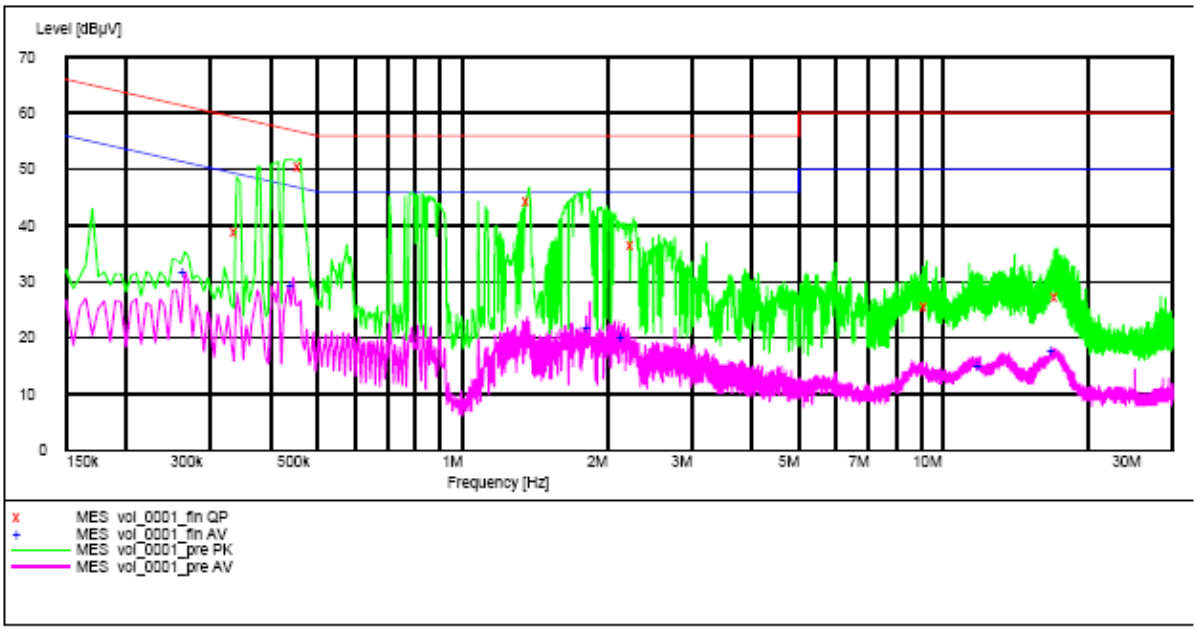


Limits for Conducted Emissions (FCC 47 CFR 15.207):

Frequency Range [MHz]	Quasi-Peak Limits [dBμV]	Average [dBμV]
0.15-0.5	66 to 56*	56 to 46*
0.5-5.0	56	46
5.0-30.0	60	50

* Decreases with the logarithm of the frequency.
Remarks:
Calculated measurement uncertainty (0.15MHz – 30MHz): 3.25dB
-*- Emission(s) that is far below the corresponding limit line.

Results of Bluetooth mode (L): PASS
Please refer to the following diagram for individual results.



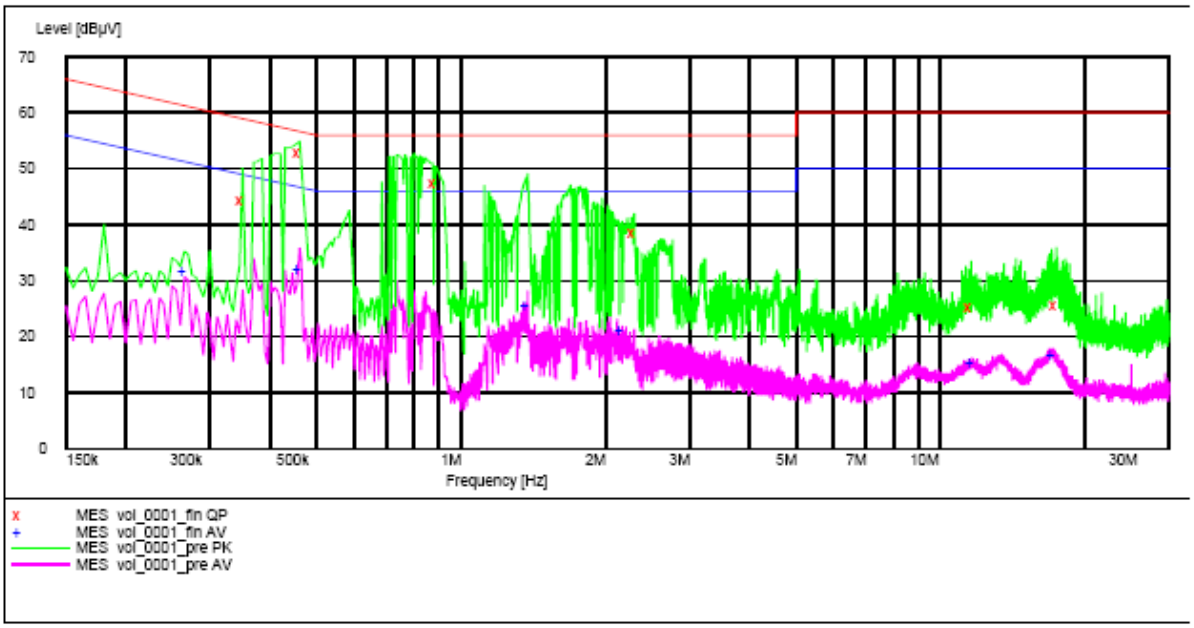
MEASUREMENT RESULT: "vol_0001_fin QP"

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Line	PE
0.340000	38.70	9.6	59.20	20.50	L1	GND
0.460000	50.50	9.6	56.70	6.20	L1	GND
1.380000	44.20	9.6	56.00	11.80	L1	GND
2.265000	36.60	9.6	56.00	19.40	L1	GND
9.245000	25.50	9.7	60.00	34.50	L1	GND
17.335000	27.20	9.8	60.00	32.80	L1	GND

MEASUREMENT RESULT: "vol_0001_fin AV"

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Line	PE
0.265000	31.80	9.6	51.30	19.40	L1	GND
0.445000	29.20	9.6	47.00	17.80	L1	GND
1.840000	21.70	9.6	46.00	24.30	L1	GND
2.165000	20.00	9.6	46.00	26.00	L1	GND
11.950000	14.90	9.8	50.00	35.10	L1	GND
16.965000	17.60	9.8	50.00	32.40	L1	GND

Results of Bluetooth mode (N): PASS
Please refer to the following diagram for individual results.



MEASUREMENT RESULT: "vol_0001_fin QP"

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Line	PE
0.350000	44.50	9.6	59.00	14.50	N	GND
0.460000	52.80	9.6	56.70	3.90	N	GND
0.885000	47.40	9.6	56.00	8.60	N	GND
2.300000	38.50	9.6	56.00	17.50	N	GND
11.585000	25.10	9.8	60.00	34.90	N	GND
17.465000	25.60	9.8	60.00	34.40	N	GND

MEASUREMENT RESULT: "vol_0001_fin AV"

Frequency MHz	Level dBµV	Transd dB	Limit dBµV	Margin dB	Line	PE
0.265000	31.60	9.6	51.30	19.70	N	GND
0.460000	31.90	9.6	46.70	14.80	N	GND
1.380000	25.70	9.6	46.00	20.30	N	GND
2.165000	21.20	9.6	46.00	24.80	N	GND
11.665000	15.20	9.8	50.00	34.80	N	GND
17.220000	16.70	9.8	50.00	33.30	N	GND

3.1.4 Number of Hopping Frequency

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Limit of Number of Hopping Frequency

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

Test Method:

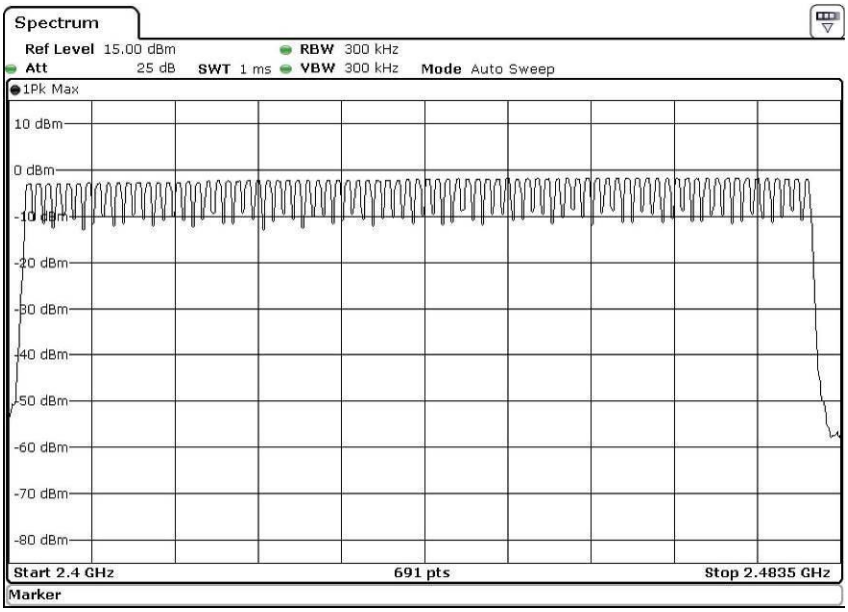
The RF output of the EUT was connected to the spectrum analyzer by a low loss cable.

Spectrum Analyzer Setting:

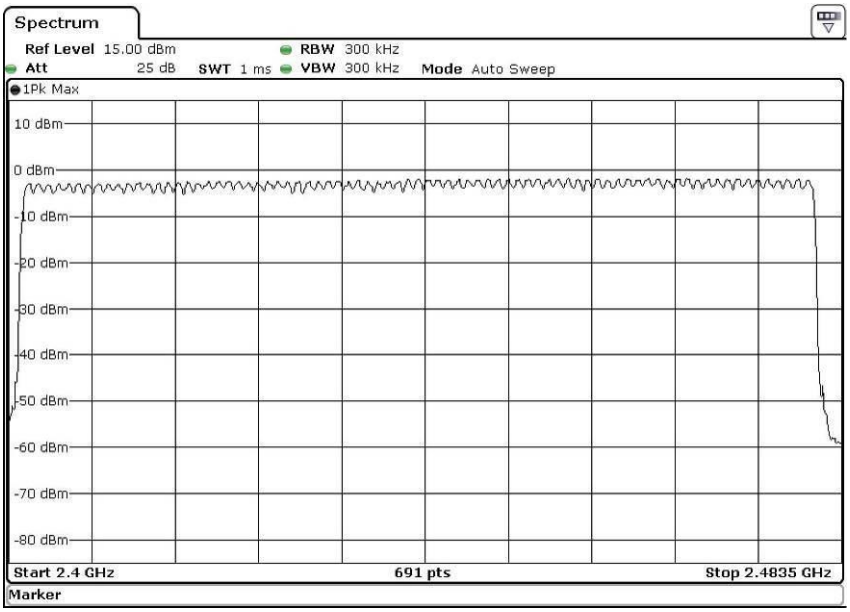
RBW = 300kHz, VBW ≥ RBW, Sweep = Auto, Span = the frequency band of operation
Detector = Peak, Trace = Max. hold

Test Setup:
As Test Setup of clause 3.1.1 in this test report.

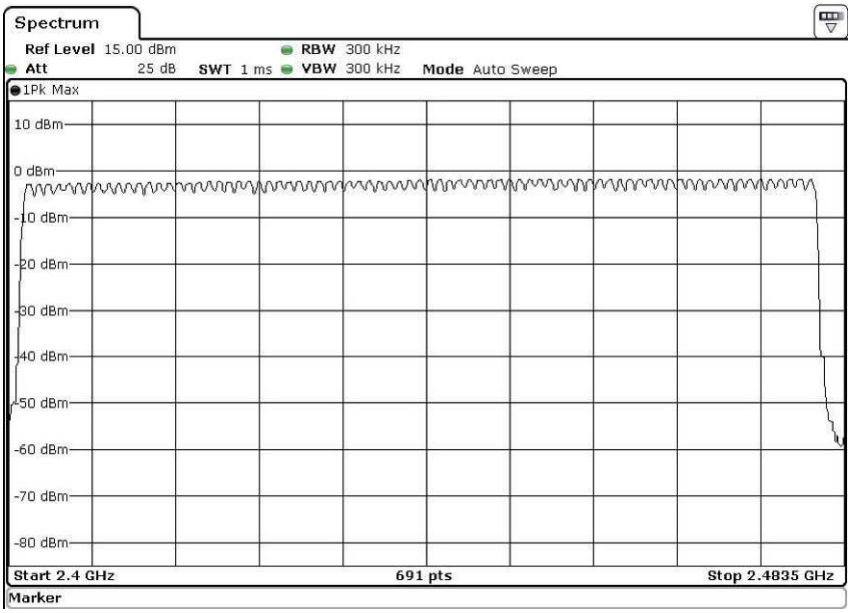
Measurement Data:
GFSK: 79 of 79 Channel



π/4-DQPSK: 79 of 79 Channel



8DPSK: 79 of 79 Channel



3.1.5 20dB Bandwidth

Test Requirement:	FCC 47CFR 15.247(a)(1)
Test Method:	ANSI C63.10:2013
Test Date:	2024-09-27
Mode of Operation:	Tx mode

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Remark:
The result has been done on all the possible configurations for searching the worst cases.

Test Method:

The bandwidth is measured at an amplitude level reduced from the reference level by a specified ratio. The reference level is the level of the highest amplitude signal observed from the transmitter at the fundamental frequency. Once the reference level is established, the equipment is conditioned with typical modulating signal to produce the worst-case (i.e. the widest) bandwidth.

Spectrum Analyzer Setting:

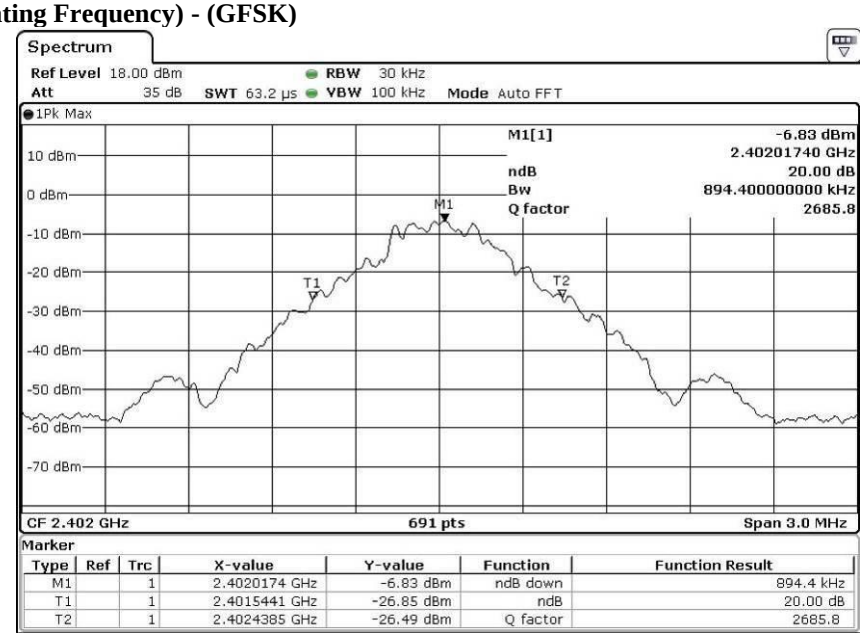
RBW = 30kHz, VBW ≥ RBW, Sweep = Auto, Span = two times and five times the OBW
Detector = Peak, Trace = Max. hold

Test Setup:

As Test Setup of clause 3.1.1 in this test report.

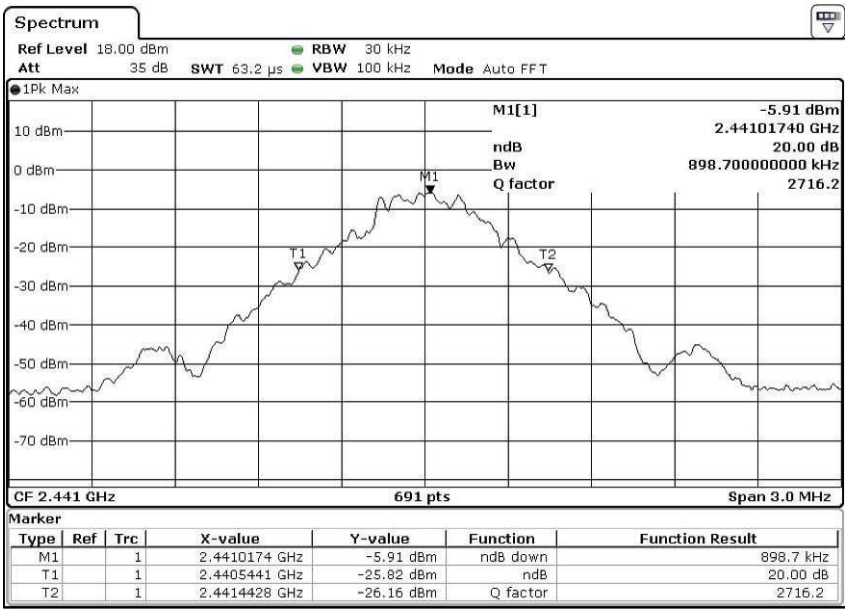
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2402	0.8944	Within 2400-2483.5

(Lowest Operating Frequency) - (GFSK)



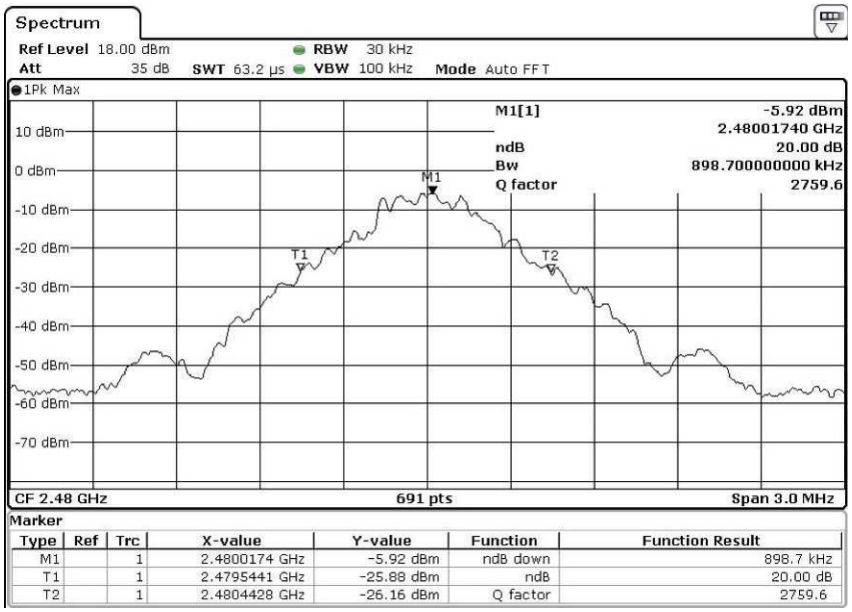
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2441	0.8987	Within 2400-2483.5

(Middle Operating Frequency) - (GFSK)



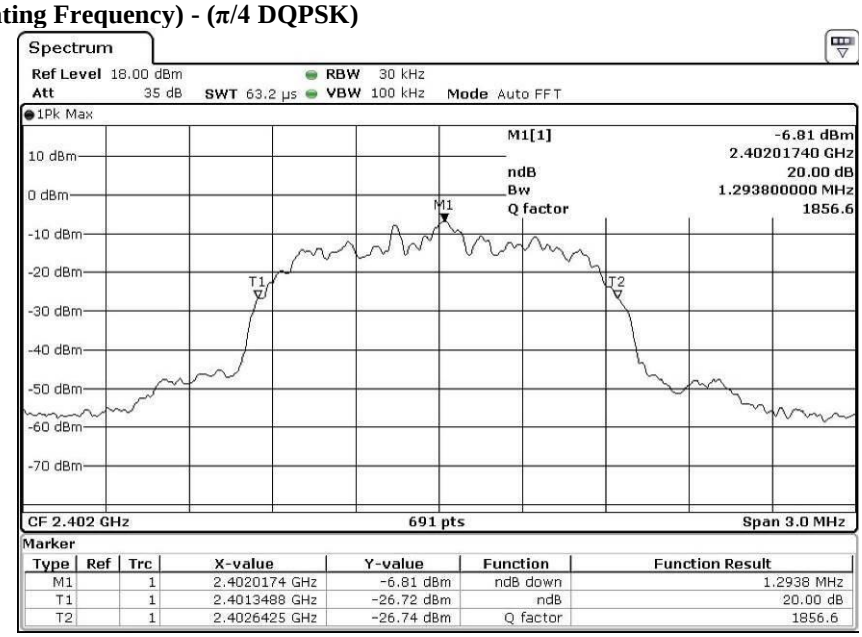
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2480	0.8987	Within 2400-2483.5

(Highest Operating Frequency) - (GFSK)



Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2402	1.2938	Within 2400-2483.5

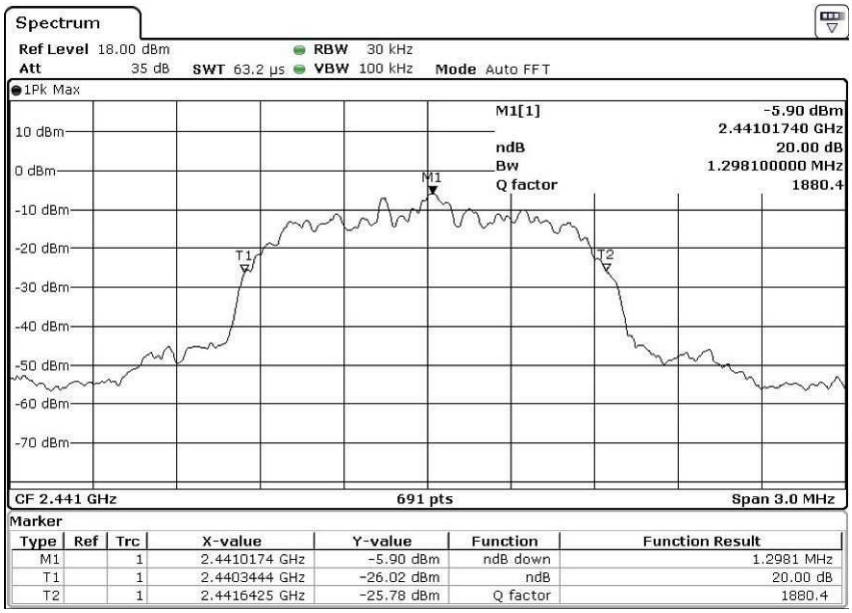
(Lowest Operating Frequency) - (π/4 DQPSK)



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4020174 GHz	-6.81 dBm	ndB down	1.2938 MHz
T1		1	2.4013488 GHz	-26.72 dBm	ndB	20.00 dB
T2		1	2.4026425 GHz	-26.74 dBm	Q factor	1856.6

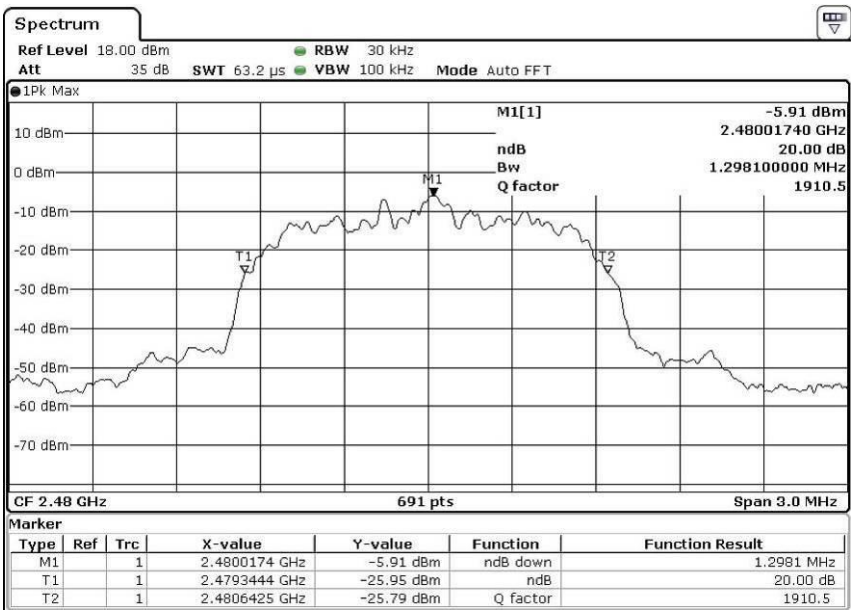
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2441	1.2981	Within 2400-2483.5

(Middle Operating Frequency) - (π/4 DQPSK)



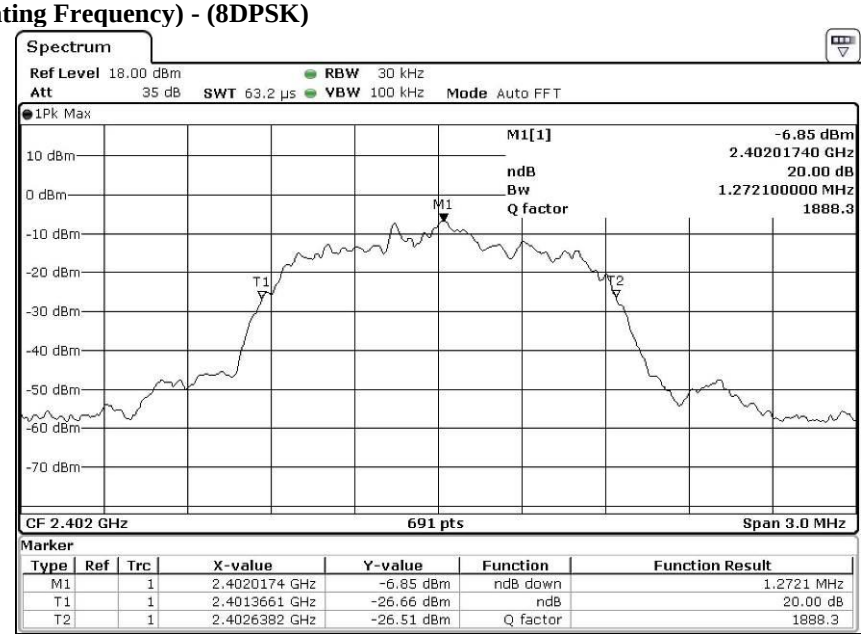
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2480	1.2981	Within 2400-2483.5

(Highest Operating Frequency) - (π/4 DQPSK)



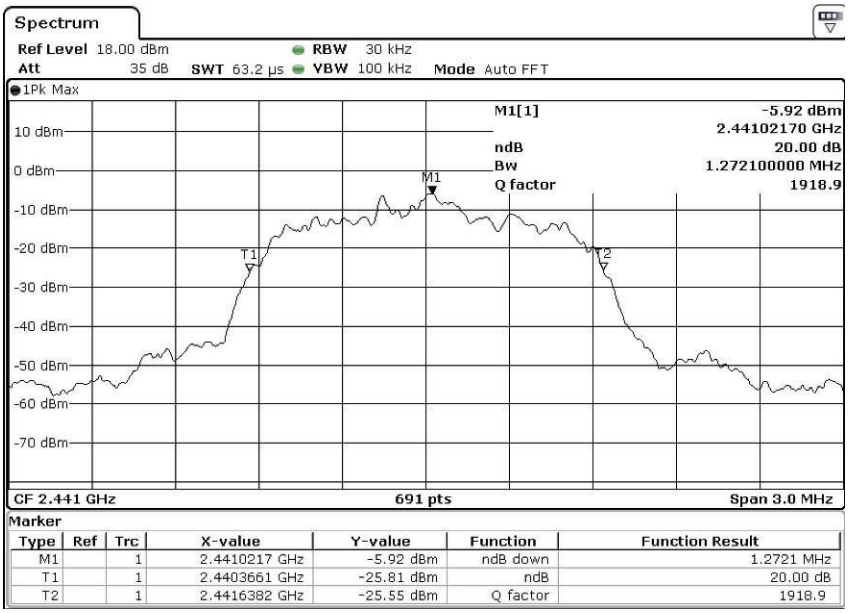
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2402	1.2721	Within 2400-2483.5

(Lowest Operating Frequency) - (8DPSK)



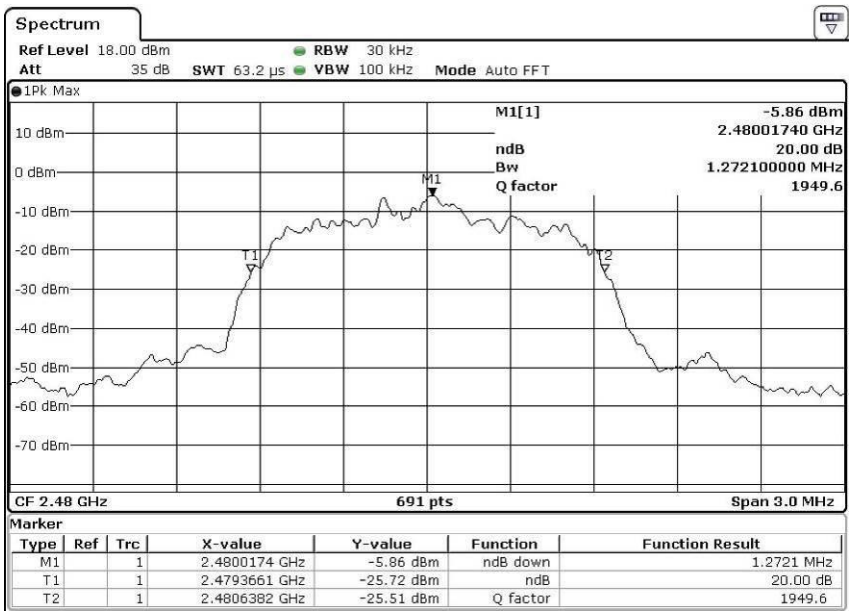
Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2441	1.2721	Within 2400-2483.5

(Middle Operating Frequency) - (8DPSK)



Fundamental Frequency [MHz]	20dB Bandwidth [MHz]	FCC Limits [MHz]
2480	1.2721	Within 2400-2483.5

(Highest Operating Frequency) - (8DPSK)



Type	Ref	Trc	X-value	Y-value	Function	Function Result
M1		1	2.4800174 GHz	-5.86 dBm	ndB down	1.2721 MHz
T1		1	2.4793661 GHz	-25.72 dBm	ndB	20.00 dB
T2		1	2.4806382 GHz	-25.51 dBm	Q factor	1949.6

3.1.6 Hopping Channel Separation

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Requirements:

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.

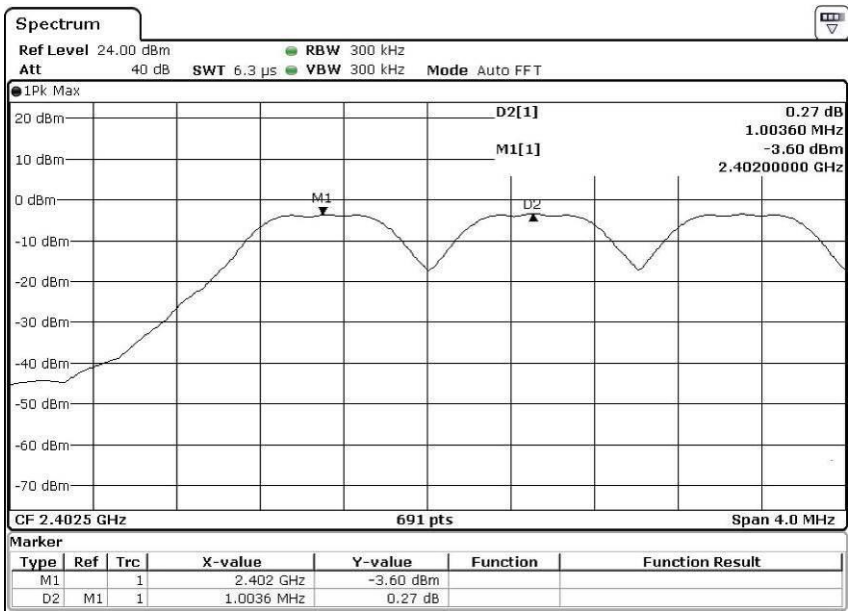
Spectrum Analyzer Setting:

RBW = 300kHz, VBW ≥ RBW, Sweep = Auto,
Span = Wide enough to captur the peaks of two adjacent channels
Detector = Peak, Trace = Max. hold

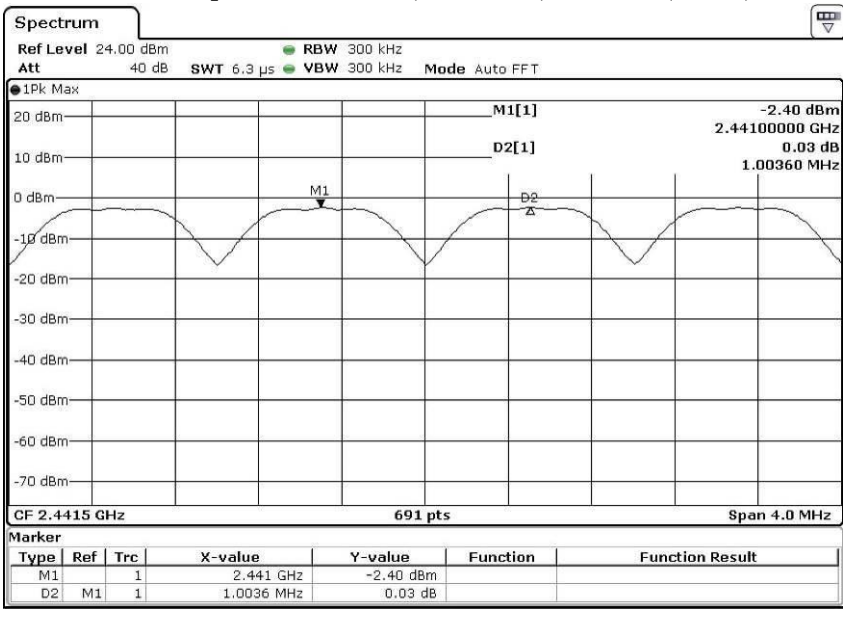
Limit:
The measured maximum bandwidth=1298.1 kHz

The measured maximum bandwidth * 2/3 = 1298.1KHz * 2/3 = 865.4kHz

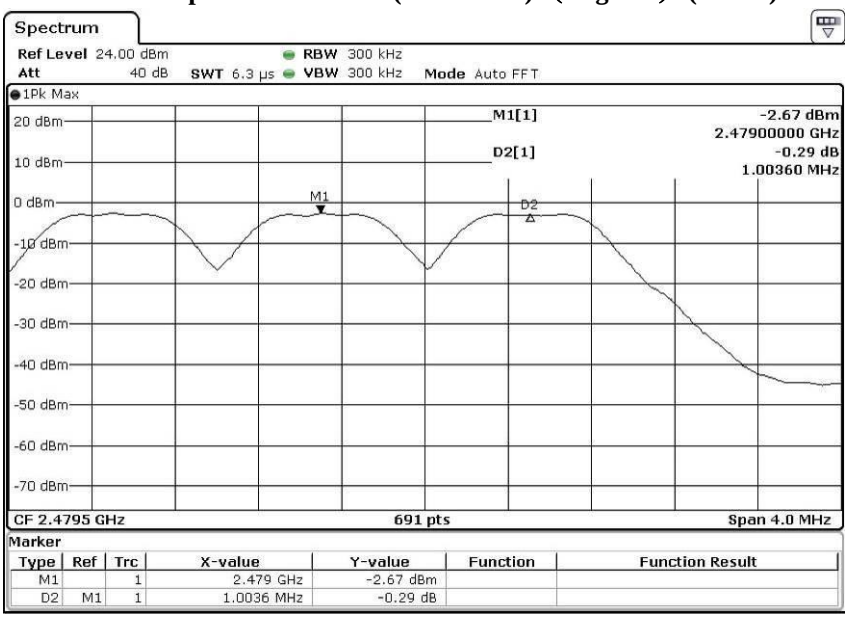
Channel separation = 1MHz (>865.4kHz)（Lowest）(GFSK)



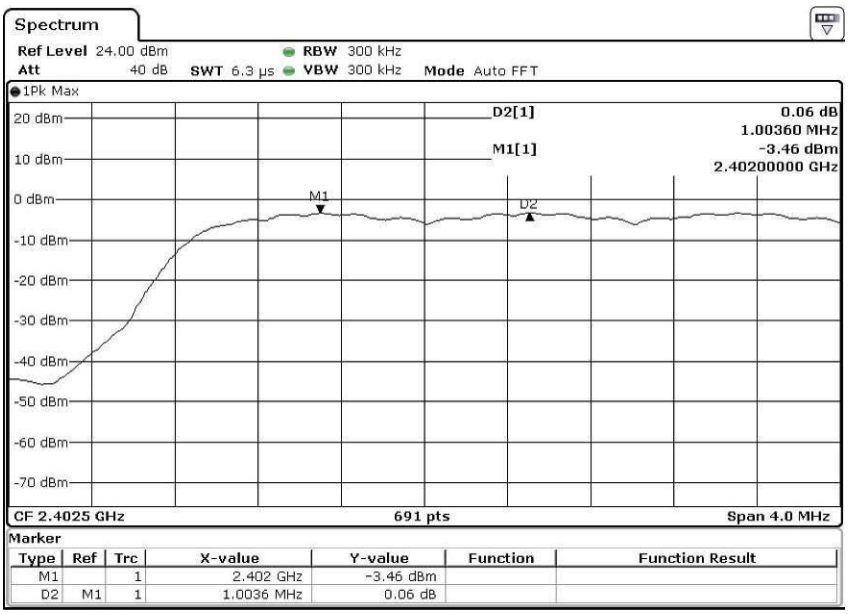
Channel separation = 1MHz(>865.4kHz)（Mid）(GFSK)



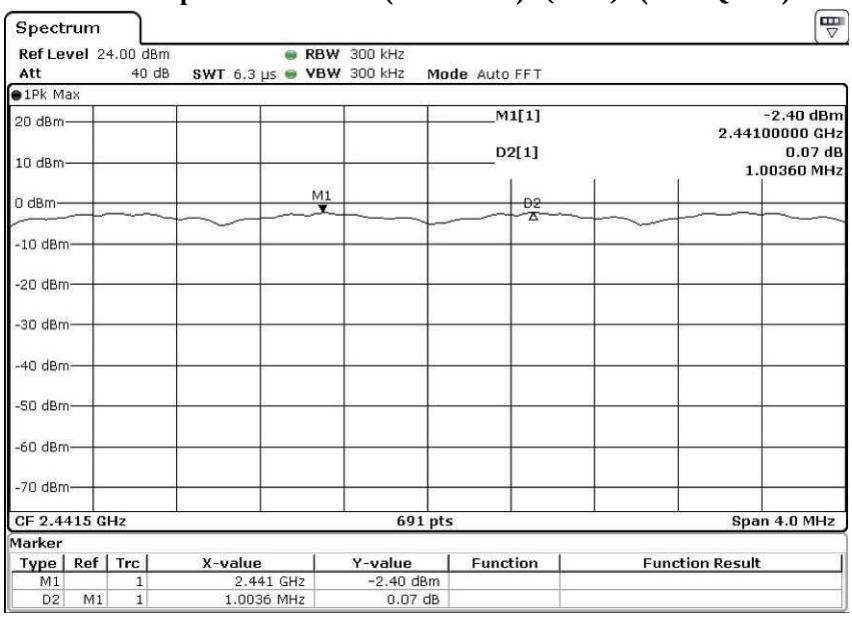
Channel separation = 1MHz (>865.4kHz)（Highest）(GFSK)



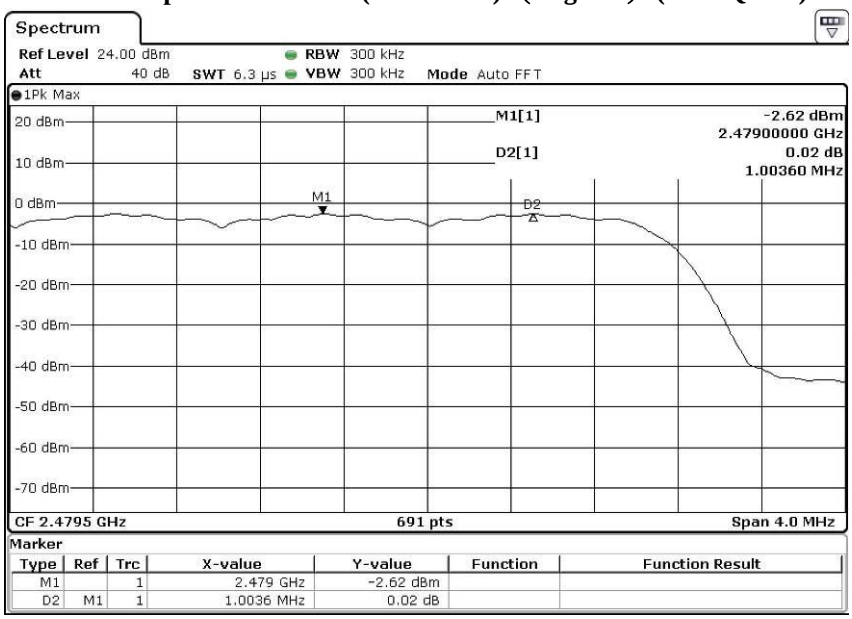
Channel separation = 1MHz (>865.4kHz)（Lowest）(π/4 DQPSK)



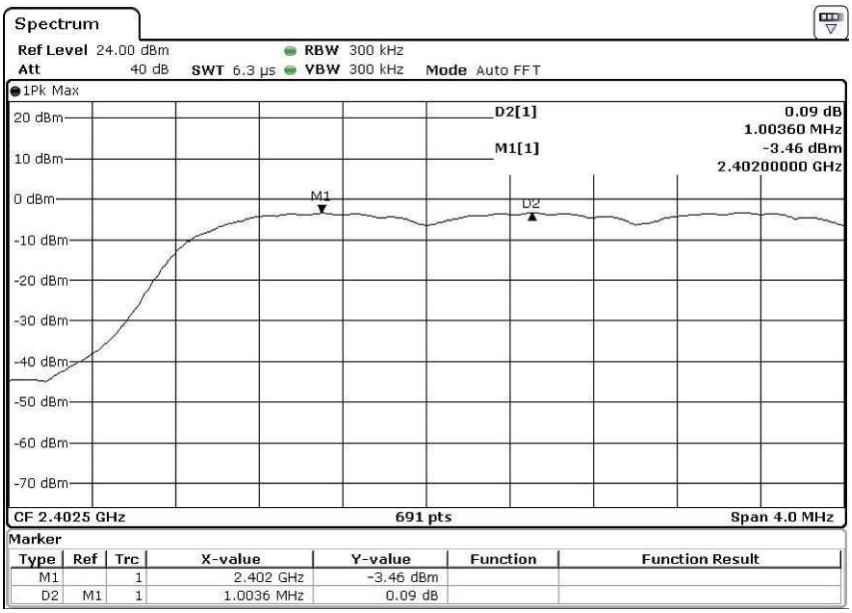
Channel separation = 1MHz (>865.4kHz) （Mid） (π/4 DQPSK)



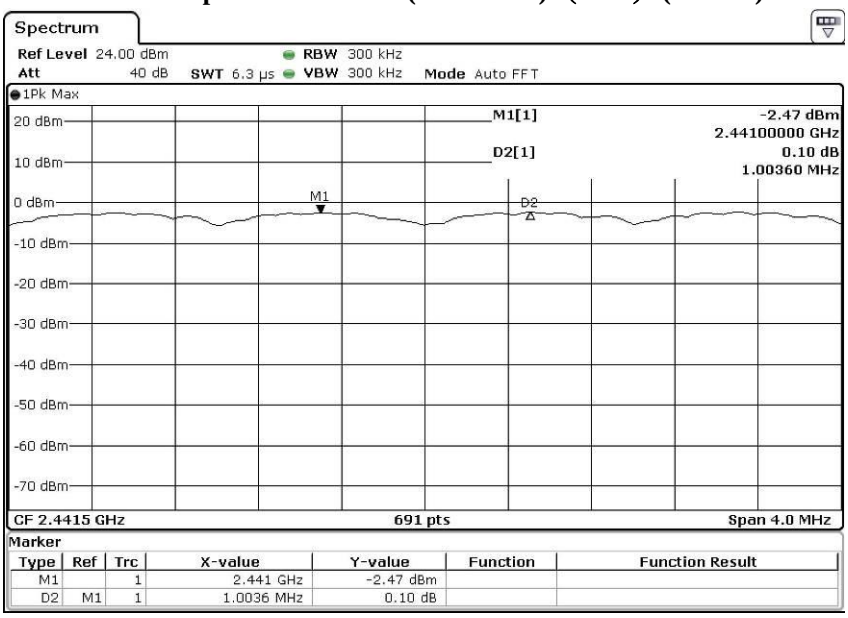
Channel separation = 1MHz(>865.4kHz) （Highest） (π/4 DQPSK)



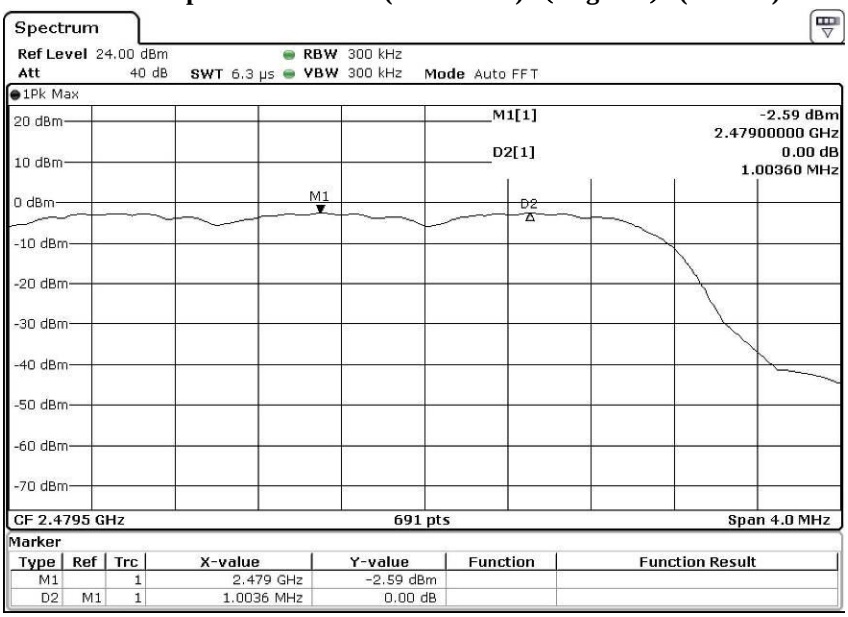
Channel separation = 1MHz (>865.4kHz)（Lowest） (8DPSK)



Channel separation = 1MHz (>865.4kHz) （Mid） (8DPSK)



Channel separation = 1MHz(>865.4kHz) （Highest） (8DPSK)



3.1.7 Band-edge Compliance of RF Conducted Emissions Measurement:

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Limit：
In any 100 kHz 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 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.
According to the test method DA 00-705.

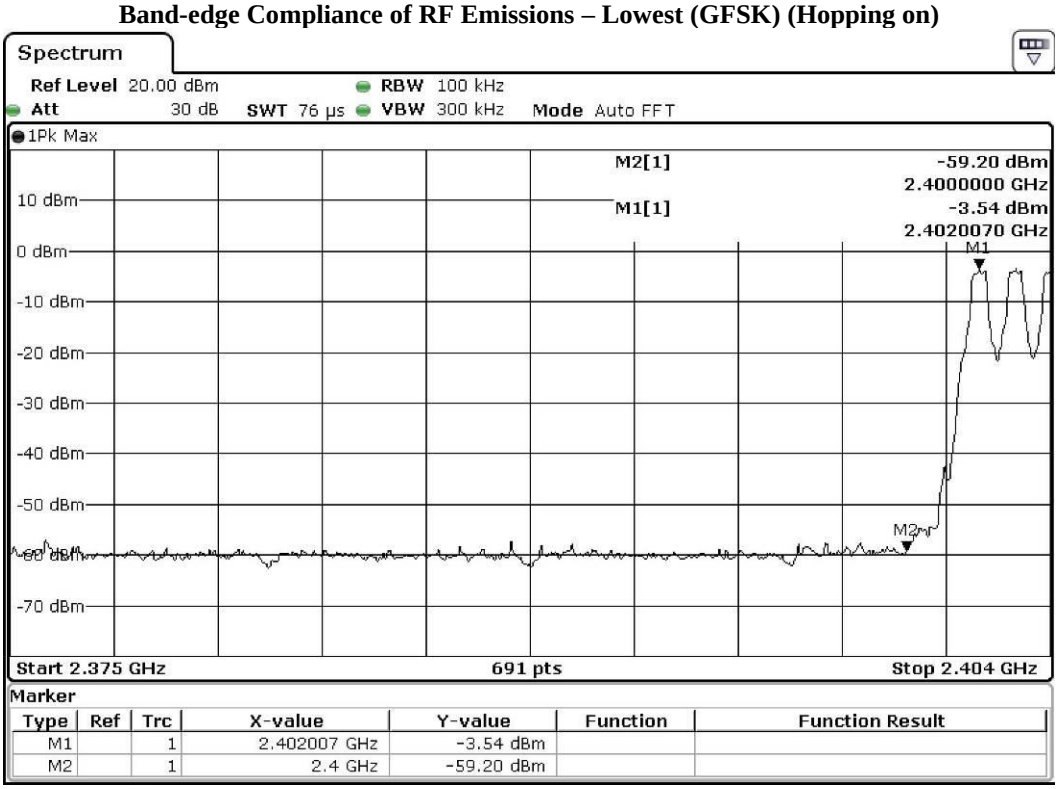
Spectrum Analyzer Setting:
RBW = 100kHz, VBW= 300kHz, Sweep = Coupled,
Span = Wide enough to captur the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products that fall outside of the authorized band of operation.
Detector = Peak, Trace = Max. hold

Remark: Emissions under the fixed frequency mode and hopping mode have been investigated, the worst-case measurement results were recorded in the test report

Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBm]	[dBm]	[dBm]	
2400 – Lowest Fundamental (2402)	-3.54	-23.54	-59.20	PASS

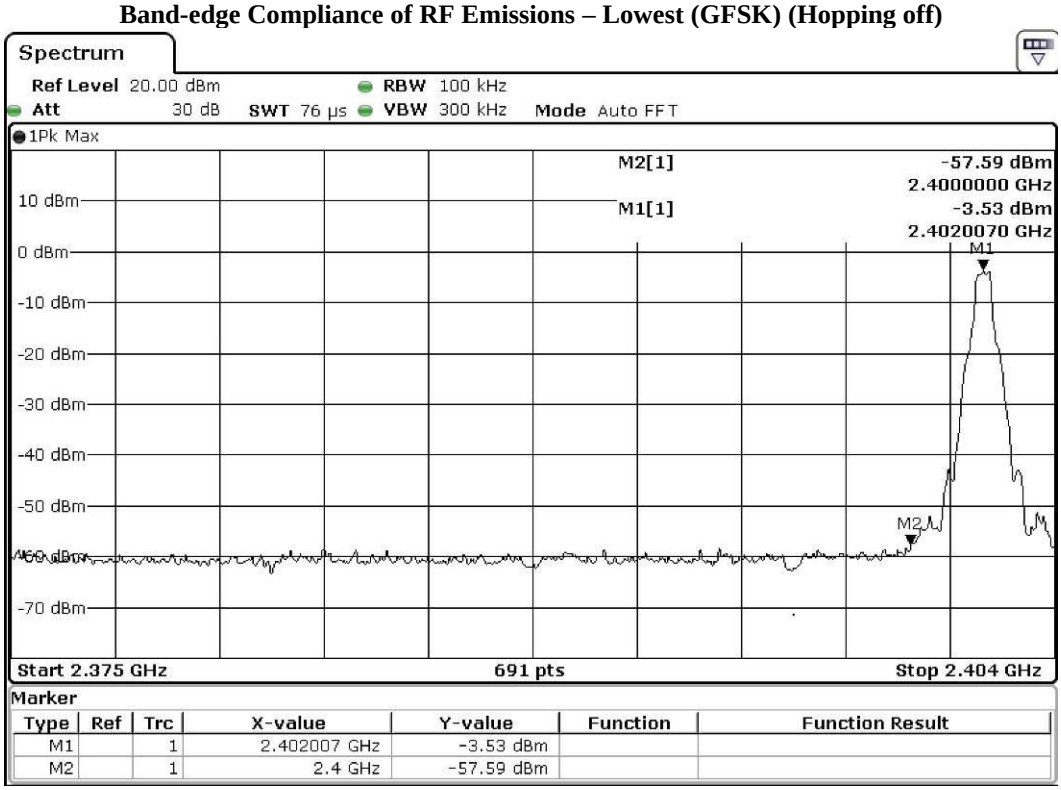
Band-edge Compliance of RF Emissions – Lowest (GFSK) (Hopping on)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2400 – Lowest Fundamental (2402)	-3.53	-23.53	-57.59	PASS

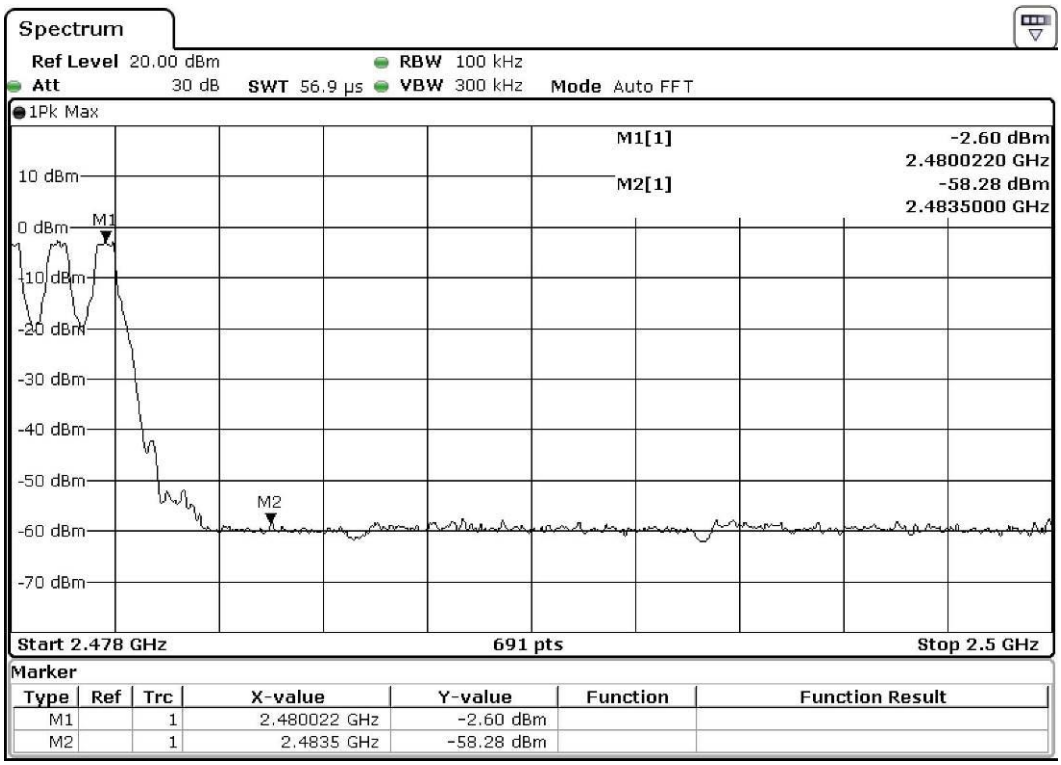
Band-edge Compliance of RF Emissions – Lowest (GFSK) (Hopping off)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2483.5 - Highest Fundamental (2480)	-2.60	-22.60	-58.28	PASS

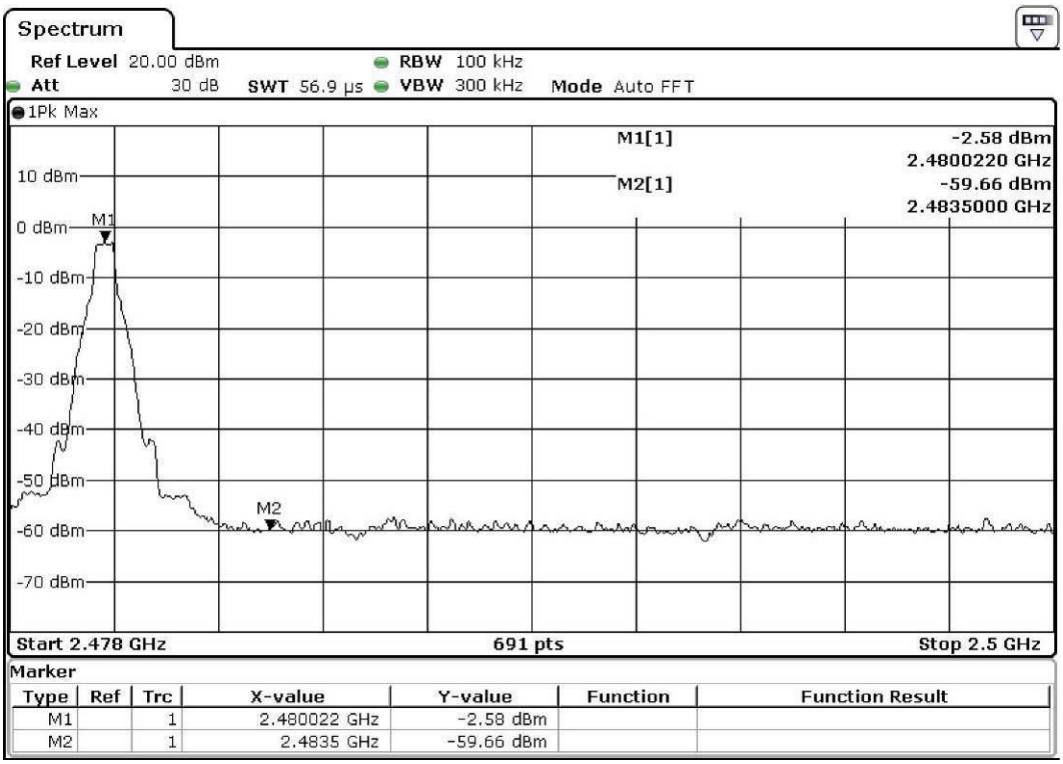
Band-edge Compliance of RF Emissions – Highest (GFSK) (Hopping on)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2483.5 - Highest Fundamental (2480)	-2.58	-22.58	-59.66	PASS

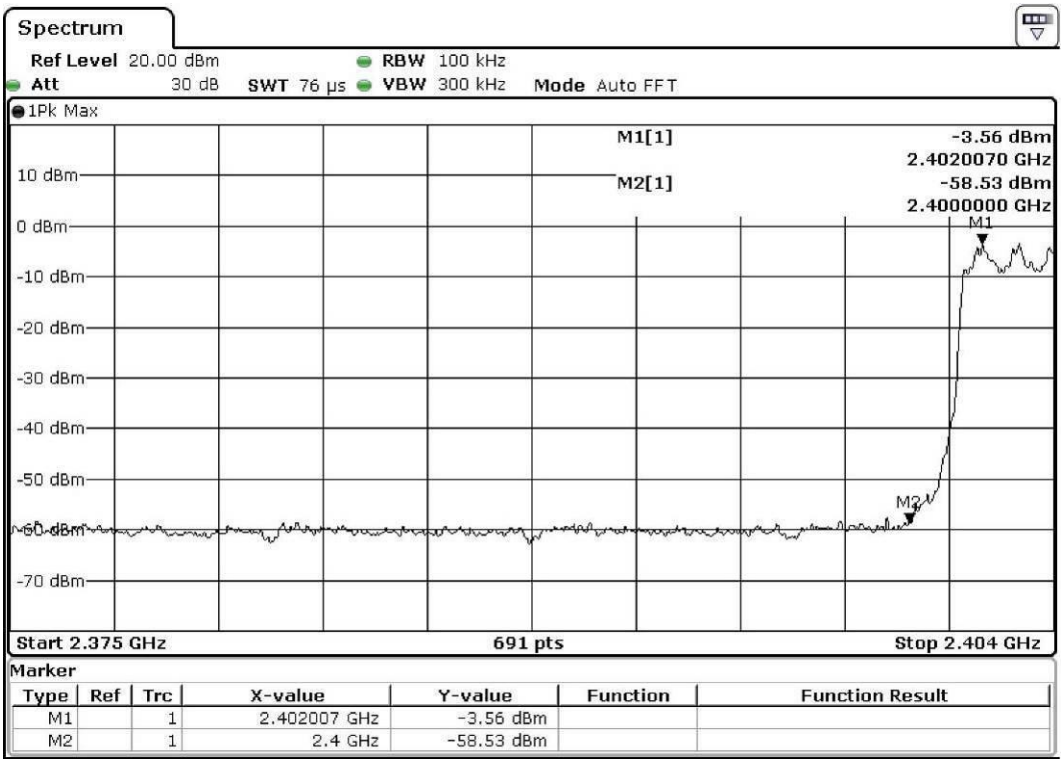
Band-edge Compliance of RF Emissions – Highest (GFSK) (Hopping off)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2400 – Lowest Fundamental (2402)	-3.56	-23.56	-58.53	PASS

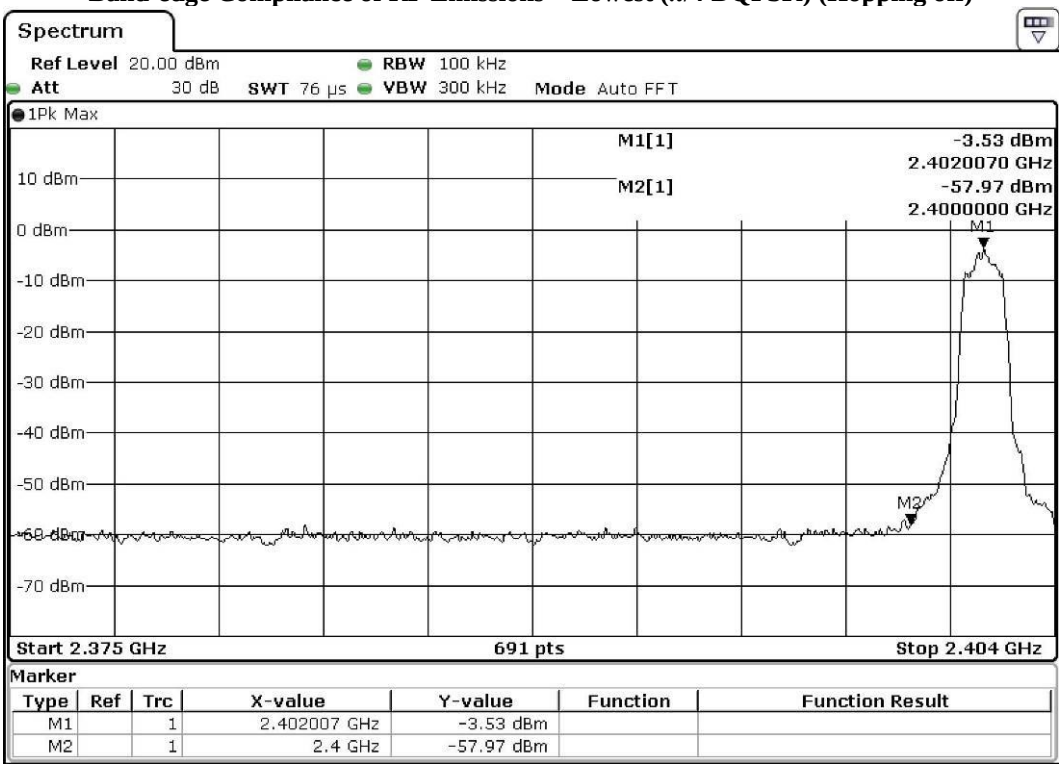
Band-edge Compliance of RF Emissions – Lowest (π/4 DQPSK) (Hopping on)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2400 – Lowest Fundamental (2402)	-3.53	-23.53	-57.97	PASS

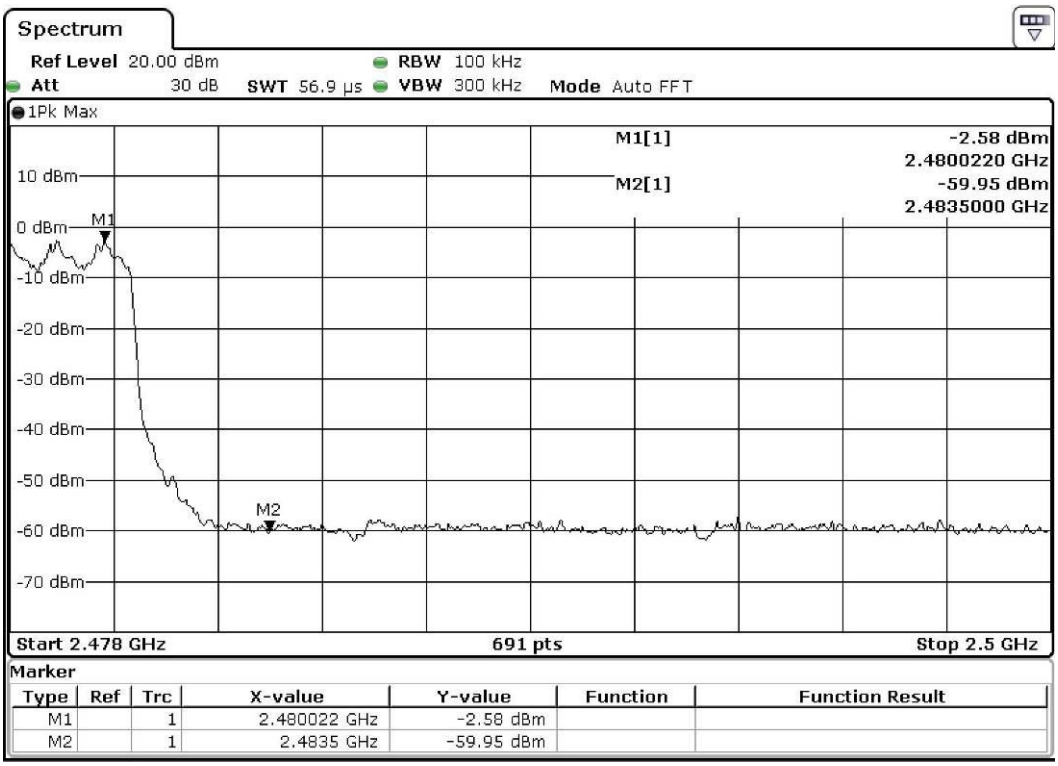
Band-edge Compliance of RF Emissions – Lowest (π/4 DQPSK) (Hopping off)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2483.5 - Highest Fundamental (2480)	-2.58	-22.58	-59.95	PASS

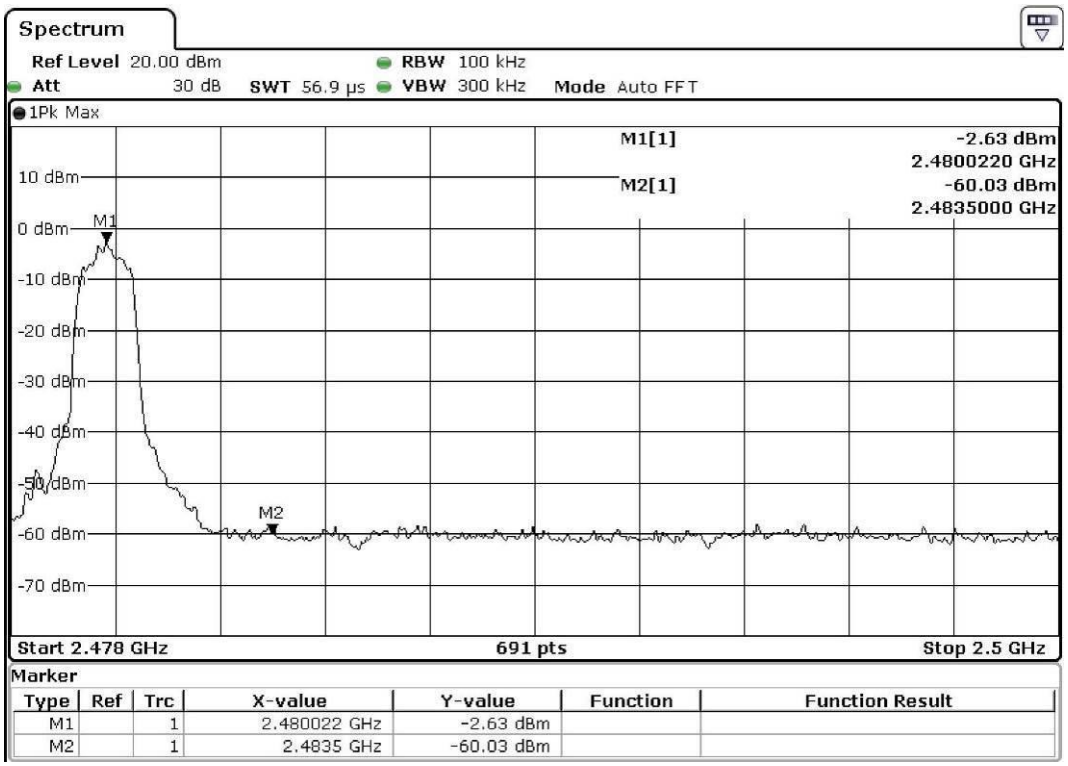
Band-edge Compliance of RF Emissions – Highest (π/4 DQPSK) (Hopping on)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2483.5 - Highest Fundamental (2480)	-2.63	-22.63	-60.03	PASS

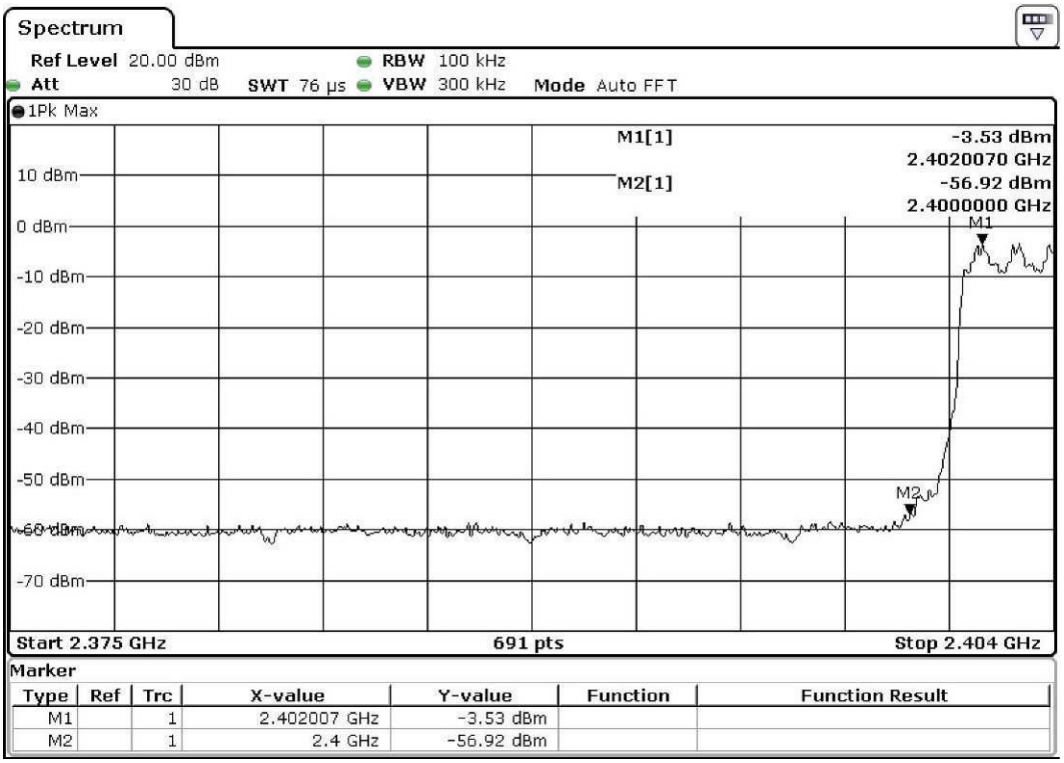
Band-edge Compliance of RF Emissions – Highest (π/4 DQPSK) (Hopping off)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2400 – Lowest Fundamental (2402)	-3.53	-23.53	-56.92	PASS

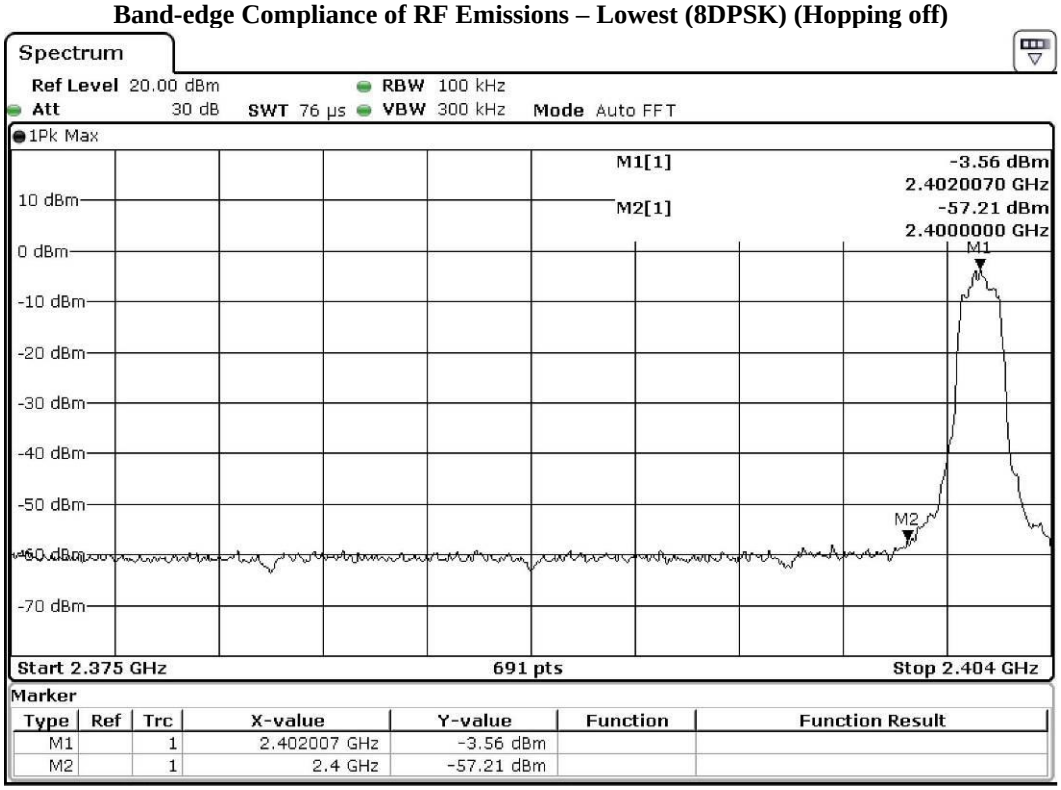
Band-edge Compliance of RF Emissions – Lowest (8DPSK) (Hopping on)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2400 – Lowest Fundamental (2402)	-3.56	-23.56	-57.21	PASS

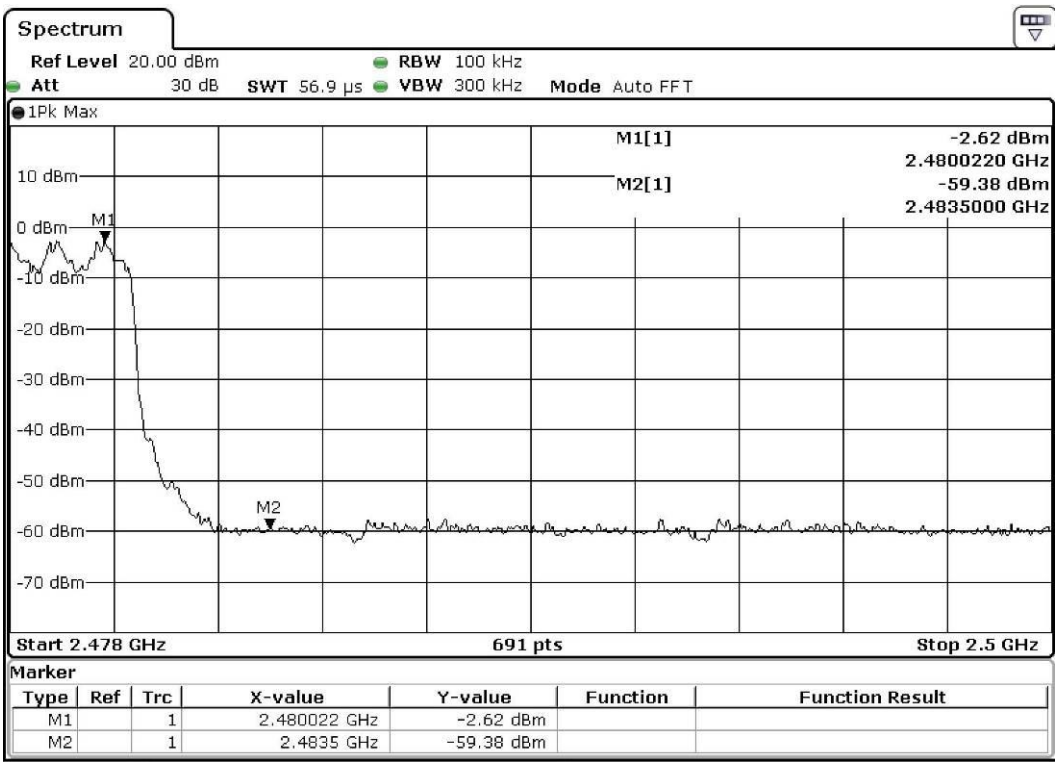
Band-edge Compliance of RF Emissions – Lowest (8DPSK) (Hopping off)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2483.5 - Highest Fundamental (2480)	-2.62	-22.62	-59.38	PASS

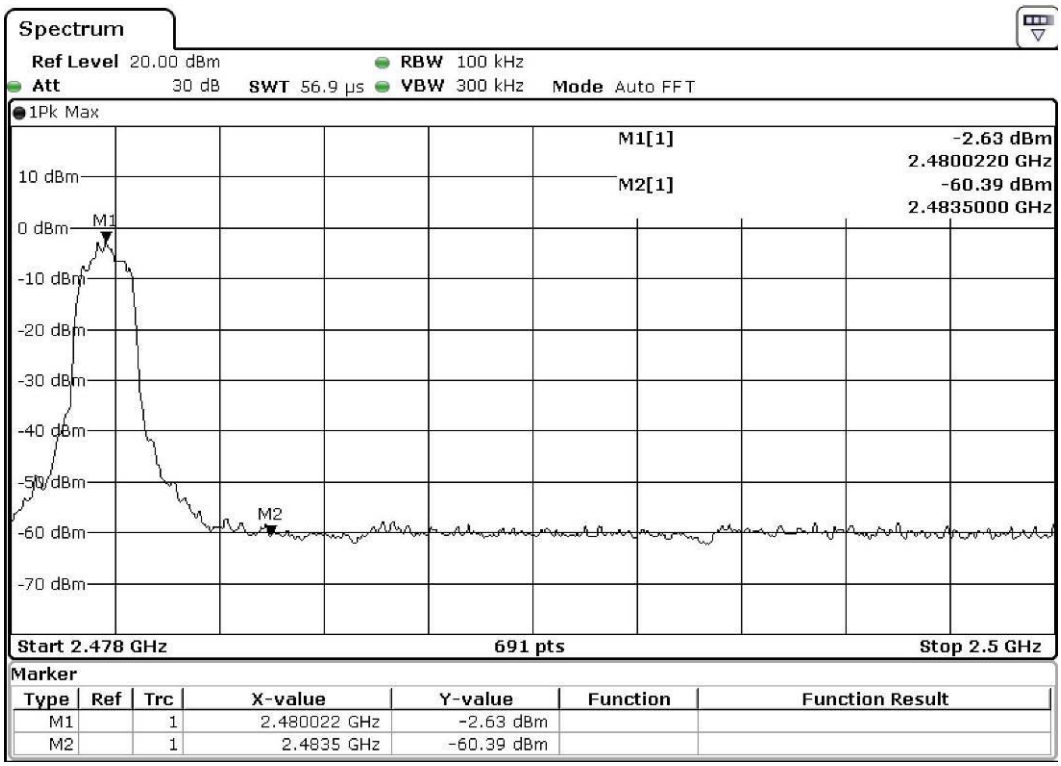
Band-edge Compliance of RF Emissions – Highest (8DPSK) (Hopping on)



Band-edge Compliance of RF Conducted Emissions Measurement:

Frequency Range	Reference level	Limit	The highest conducted band edge emission	Result
[MHz]	[dBµV]	[dBµV]	[dBµV]	
2483.5 - Highest Fundamental (2480)	-2.63	-22.63	-60.39	PASS

Band-edge Compliance of RF Emissions – Highest (8DPSK) (Hopping off)



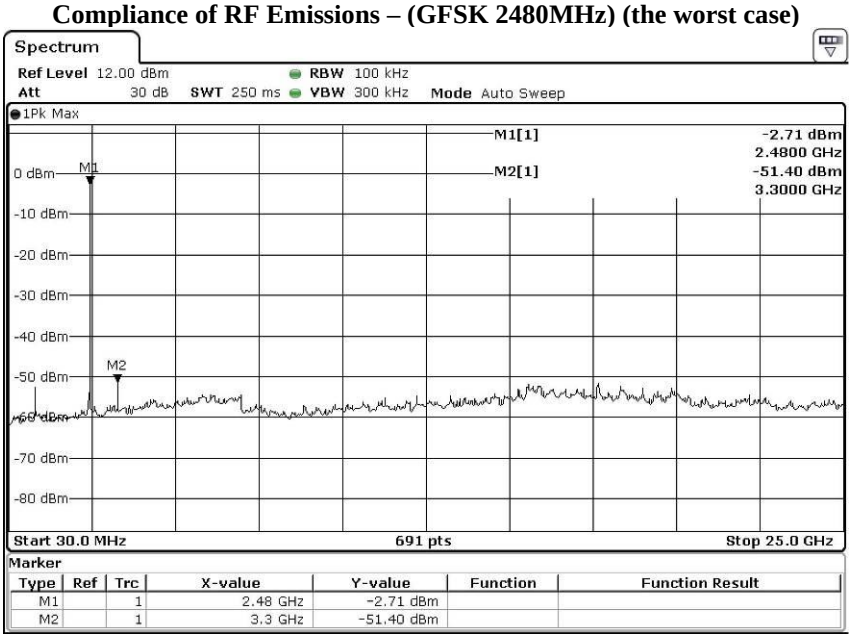
Compliance of RF Conducted Emissions Measurement:

Limit：

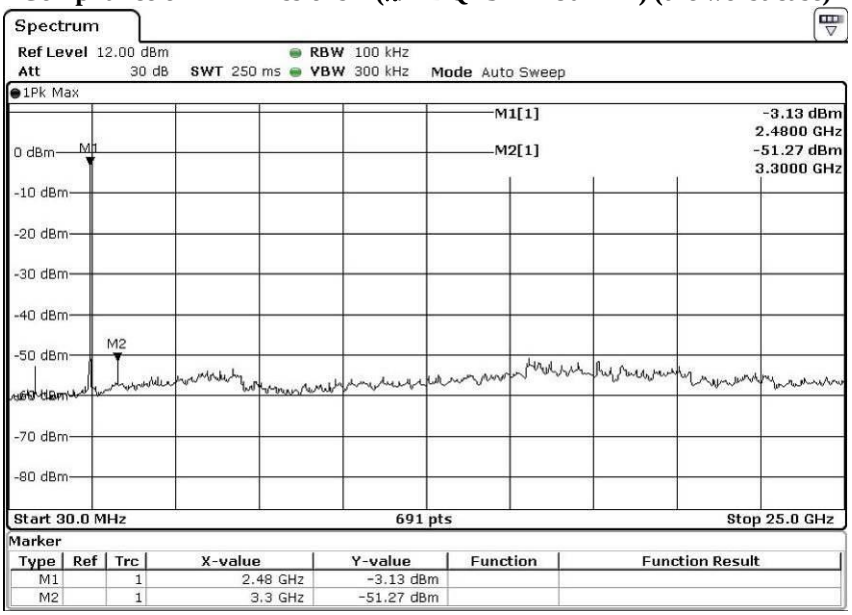
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in Section 15.209(a) is not required.

Remark: Emissions under the fixed frequency mode and hopping mode have been investigated, the worst-case measurement results were recorded in the test report

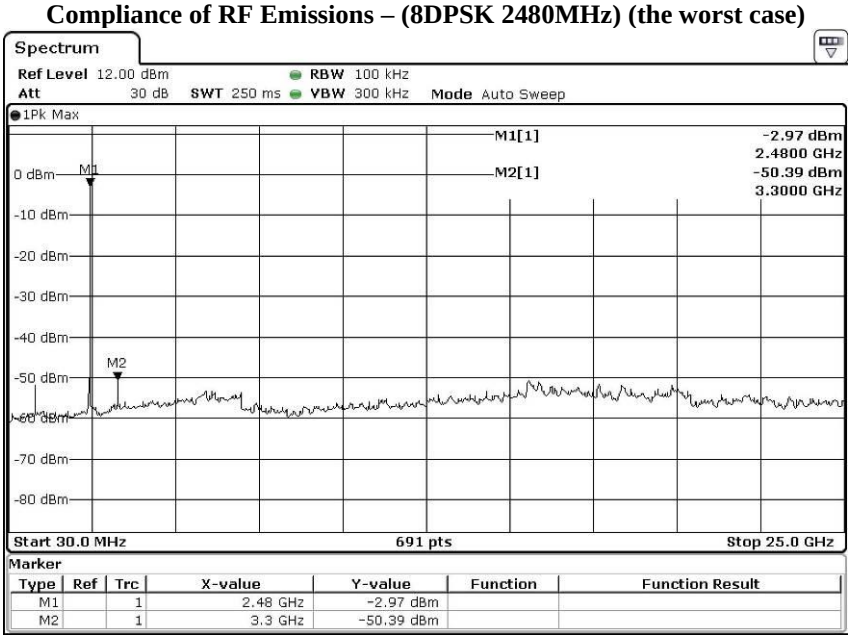
Compliance of RF Emissions – (GFSK 2480MHz) (the worst case)



Compliance of RF Emissions – (π/4-DQPSK 2480MHz) (the worst case)



Compliance of RF Emissions – (8DPSK 2480MHz) (the worst case)



3.1.8 Time of Occupancy (Dwell Time)

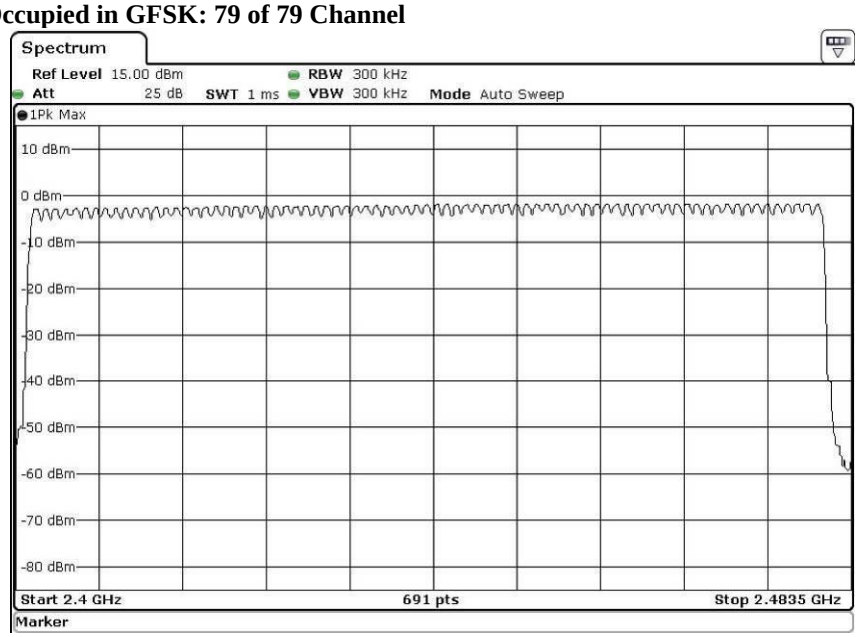
Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Requirements:
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 channel employed.
No requirements for Digital Transmission System.

Spectrum Analyzer Setting:
RBW = 300kHz, VBW≥RBW,
Sweep = A longer sweep time to show two successive hops on a channel,
Span = Zero, Detector = Peak, Trace = Max. hold

Dwell Time = Pulse Duration * hop rate / number of channel * observation duration
Observed duration: 0.4s x 79 = 31.6s

Measurement Data:
Channel Occupied in GFSK: 79 of 79 Channel



3DH5 Packet:

3DH5 Packet permit maximum 1600/79/6 = 3.37 hops per second in each channel (5 time slots RX, 1 time slot TX). The Dwell time is the time duration of the pulse times 3.37 x 31.6 = 106.6 within 31.6 seconds

Fig. A
[Pulse duration of Lowest Channel]

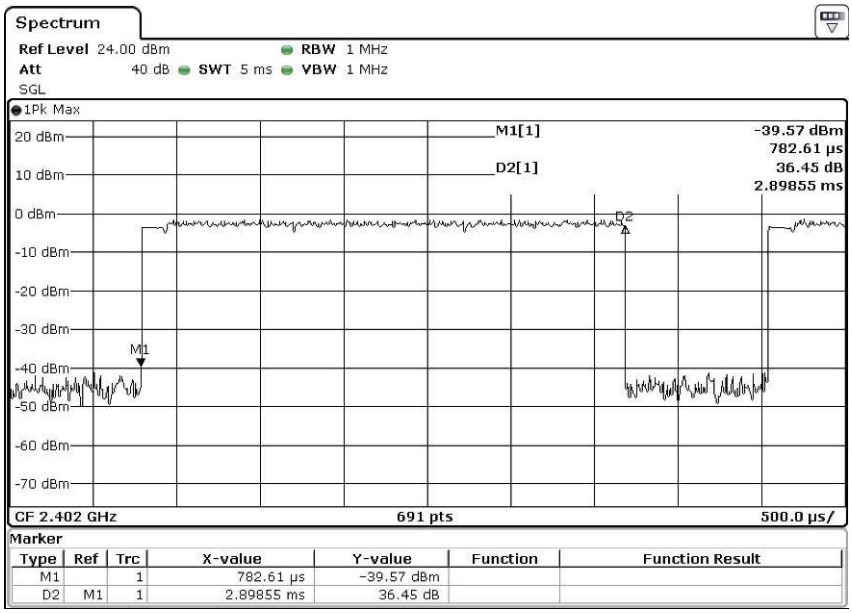


Fig. B
[Pulse duration of Middle Channel]

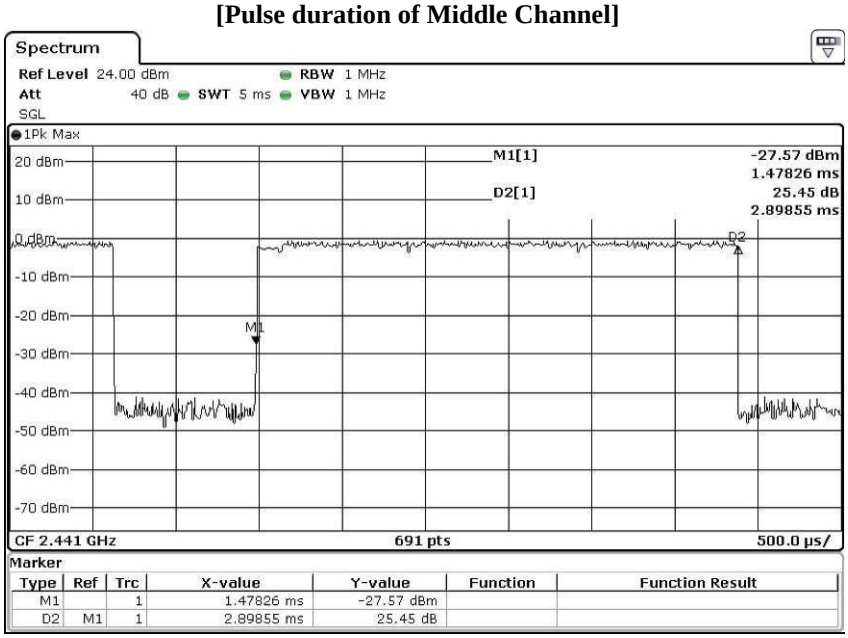
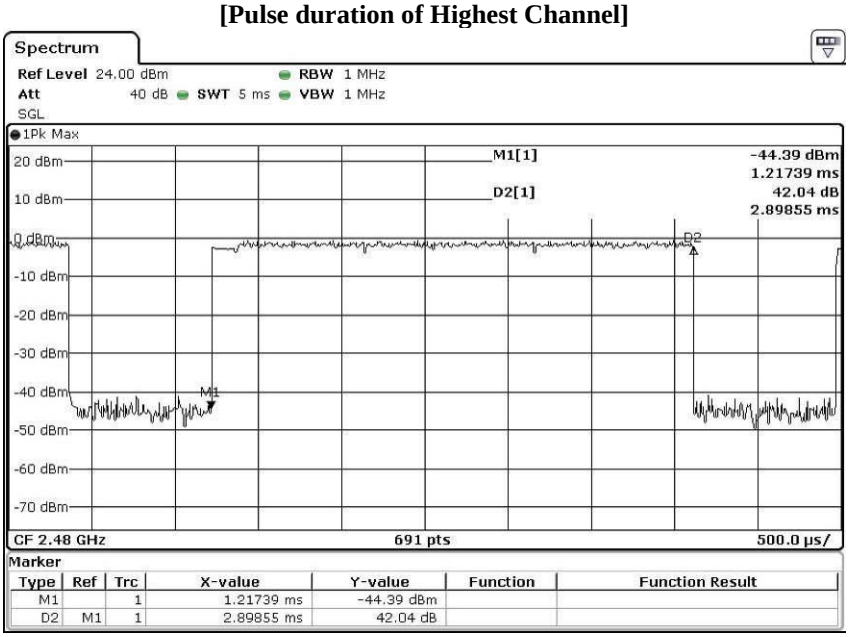


Fig. C
[Pulse duration of Highest Channel]



3DH3 Packet:

3DH3 Packet permit maximum 1600/79/4 = 5.06 hops per second in each channel (3 time slots RX, 1 time slot TX). The Dwell time is the time duration of the pulse times 5.06 x 31.6 = 160 within 31.6 seconds

Fig. D
[Pulse duration of Lowest Channel]

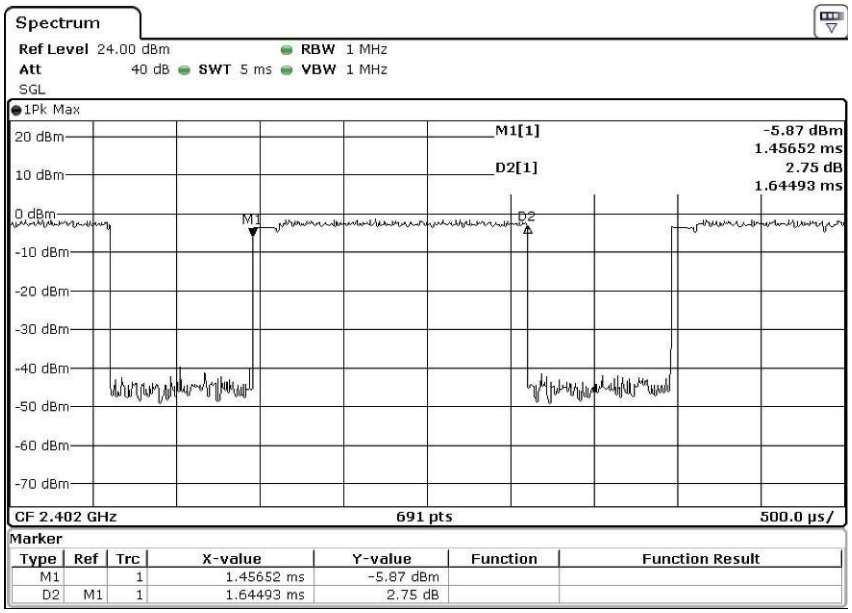


Fig. E
[Pulse duration of Middle Channel]

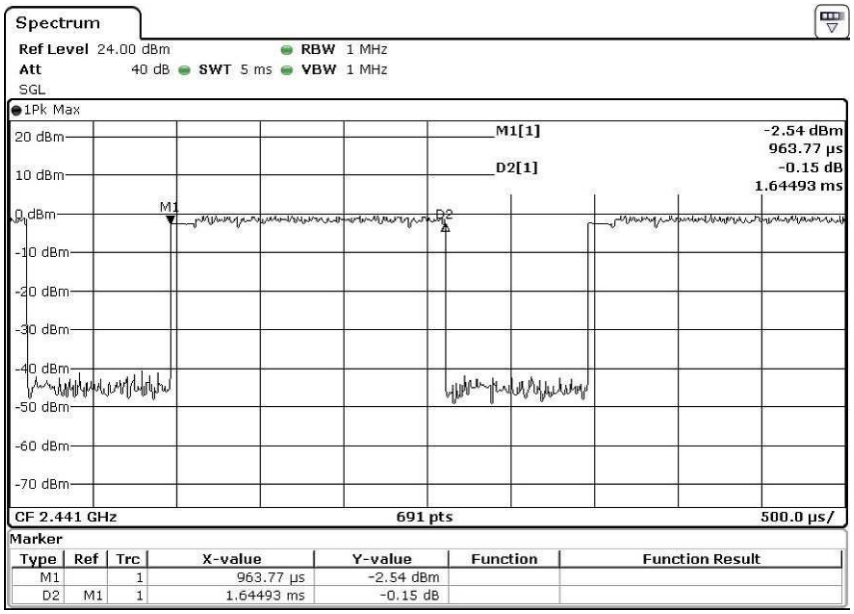
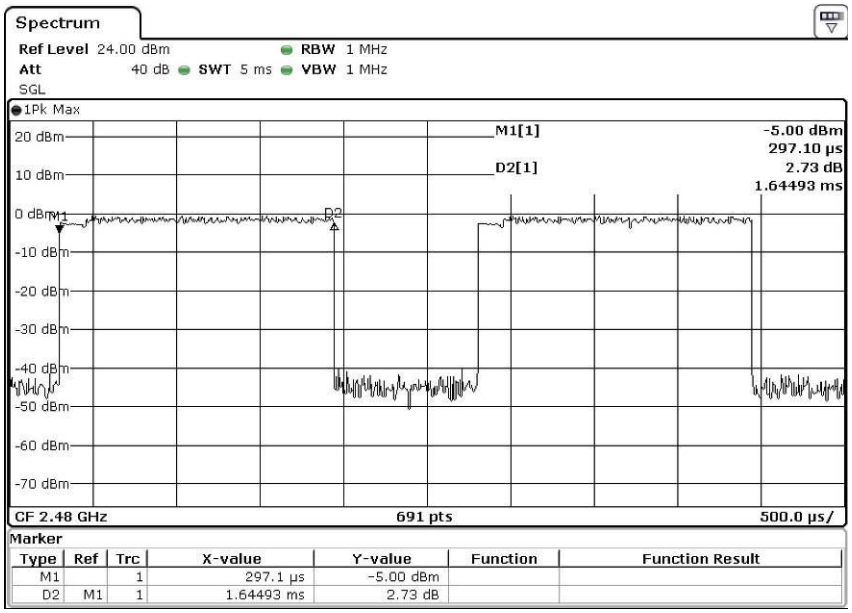


Fig. F
[Pulse duration of Highest Channel]



3DH1 Packet:

3DH1 Packet permit maximum 1600/79/2 = 10.12 hops per second in each channel (3 time slots RX, 1 time slot TX). The Dwell time is the time duration of the pulse times 10.12 x 31.6 = 320 within 31.6 seconds

Fig. G
[Pulse duration of Lowest Channel]

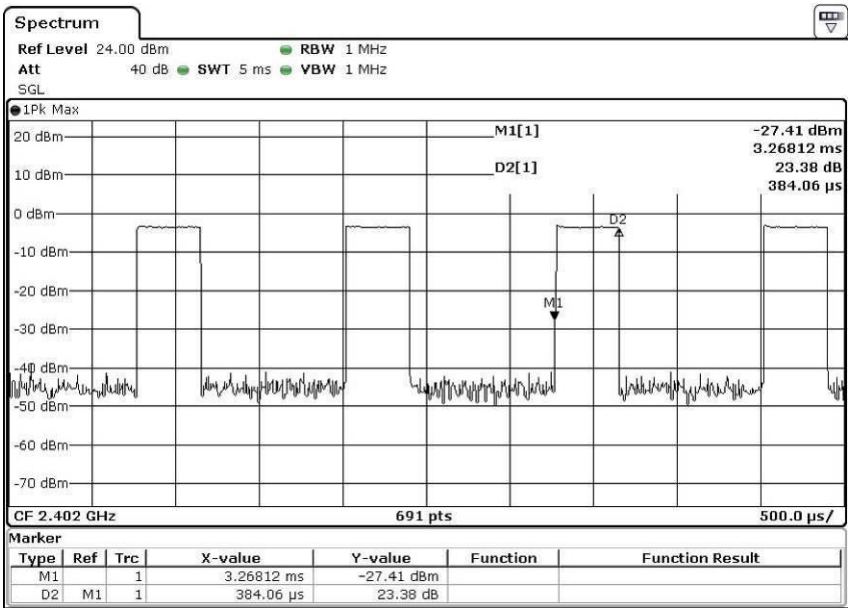


Fig. H
[Pulse duration of Middle Channel]

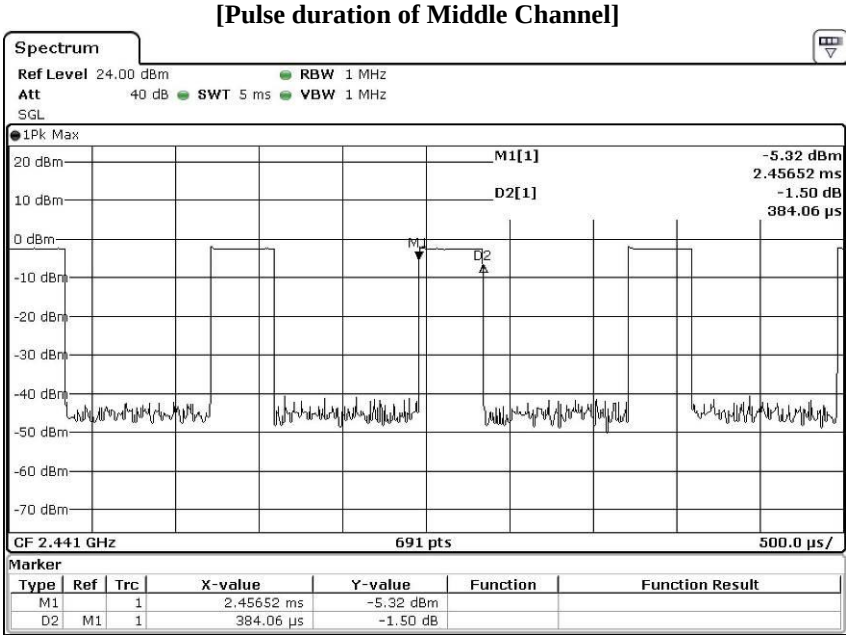
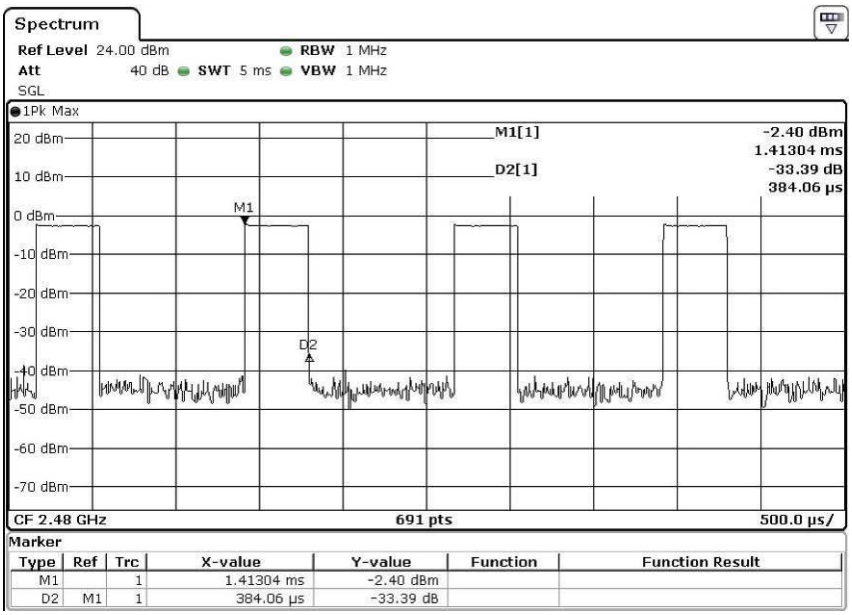


Fig. I
[Pulse duration of Highest Channel]



Time of occupancy (Dwell Time):

Data Packet	Frequency (MHz)	Pulse Duration (ms)	Dwell Time (s)	Limits (s)	Test Results
3DH5	2402	2.89855	0.309	0.400	Complies
3DH5	2441	2.89855	0.309	0.400	Complies
3DH5	2480	2.89855	0.309	0.400	Complies
3DH3	2402	1.64493	0.263	0.400	Complies
3DH3	2441	1.64493	0.263	0.400	Complies
3DH3	2480	1.64493	0.263	0.400	Complies
3DH1	2402	0.38406	0.123	0.400	Complies
3DH1	2441	0.38406	0.123	0.400	Complies
3DH1	2480	0.38406	0.123	0.400	Complies

3.1.9 Channel Centre Frequency

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Requirements:
Frequency hopping system in the 2400-2483.5MHz band shall use at least 79 (Channel 1 to 79) non-overlapping channels.

The EUT operates in according with the Bluetooth system specification within the 2400 - 2483.5 MHz frequency band.
RF channels for Bluetooth systems are spaced 1 MHz and are ordered in channel number k. In order to comply with out-of-band regulations, a lower frequency guard band of 2.0 MHz and a higher frequency guard band of 3.5MHz is used.

The operating frequencies of each channel are as follows:

First RF channel start from 2400MHz + 2MHz guard band = 2402MHz
Frequency of RF Channel = 2402+k MHz, k = 0,…,78 (Channel separation = 1MHz)

3.1.10 Pseudorandom Hopping Algorithm

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Requirements:
The channel frequencies shall be selected from a pseudorandom ordered list of hopping frequencies. Each frequency must be used equally by the transmitter.

EUT Pseudorandom Hopping Algorithm
The EUT is a Bluetooth device, the Pseudo-random hopping pattern; hopping characteristics and algorithm are based on the Bluetooth specification.

3.1.11 Antenna Requirement

Ambient Temperature: 25℃ Relative Humidity: 51% Atmospheric Pressure: 101 kPa

Test Requirements: § 15.203

Test Specification:

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. 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.

Test Results:

This is PCB antenna. There is no external antenna, the antenna gain = 3.76dBi. User is unable to remove or changed the Antenna.

Appendix A

List of Measurement Equipment

Radiated Emission

EQP NO.	DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CAL	DUE CAL
EM215	MULTIDEVICE CONTROLLER	EMCO	2090	00024676	N/A	N/A
EM217	ELECTRIC POWERED TURNTABLE	EMCO	2088	00029144	N/A	N/A
EM218	ANECHOIC CHAMBER	ETS-LINDGREN	FACT-3	--	2024-04-18	2029-04-18
EM356	ANTENNA POSITIONING TOWER	ETS-LINDGREN	2171B	00150346	N/A	N/A
EM293	SPECTRUM ANALYZER	AGILENT TECHNOLOGIES	N9020A	MY50510152	2023-03-21	2025-03-21
EM363	SIGNAL ANALYZER(10HZ-40GHZ)	R & S	FSV40	101231	2024-01-17	2026-01-17
EM299	BROADBAND HORN ANTENNA	ETS-LINDGREN	3115	00114120	2023-01-25	2025-01-25
EM300	PYRAMIDAL STANDARD GAIN HORN ANTENNA	ETS-LINDGREN	3160-09	00130130	2023-01-16	2025-01-16
EM301	PYRAMIDAL STANDARD GAIN HORN ANTENNA	ETS-LINDGREN	3160-10	00130988	2023-02-15	2025-02-15
EM353	LOOP ANTENNA	ETS_LINDGREN	6502	00206533	2022-09-26	2025-09-26
EM355	BICONILOG ANTENNA	ETS-LINDGREN	3143B	00094856	2022-08-26	2025-08-26
EM200	DUAL CHANNEL POWER METER	R & S	NRVD	100592	2023-08-02	2025-08-02

Line Conducted

EQP NO.	DESCRIPTION	MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CAL	DUE CAL
EM232	LISN	SCHAFFNER	NNB41	04/100082	2023-05-30	2025-05-30
EM181	EMI TEST RECEIVER	R & S	ESIB7	100072	2024-04-18	2025-04-18
EM179	IMPULSE LIMITER	R & S	ESH3-Z2	357.8810.52/54	2023-03-17	2025-03-17
EM154	SHIELDING ROOM	SIEMENS MATSUSHITA COMPONENTS	N/A	803-740-057-99A	2022-02-06	2027-02-06
N/A	MEASUREMENT AND EVALUATION SOFTWARE	ROHDE & SCHWARZ	BSIB-K1	V1.20	N/A	N/A

Remarks:-

CM CORRECTIVE MAINTENANCE
N/A NOT APPLICABLE
TBD TO BE DETERMINED

View of the product

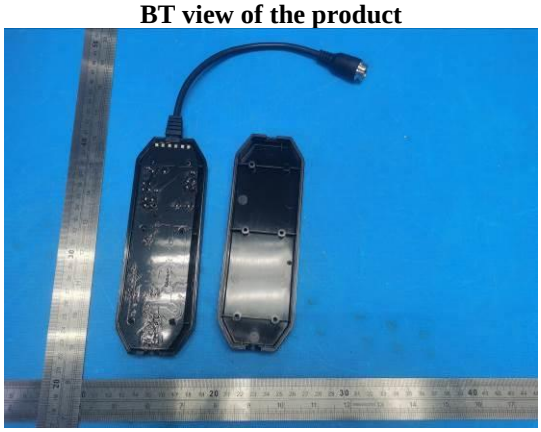
View of the product

View of the product

View of the product

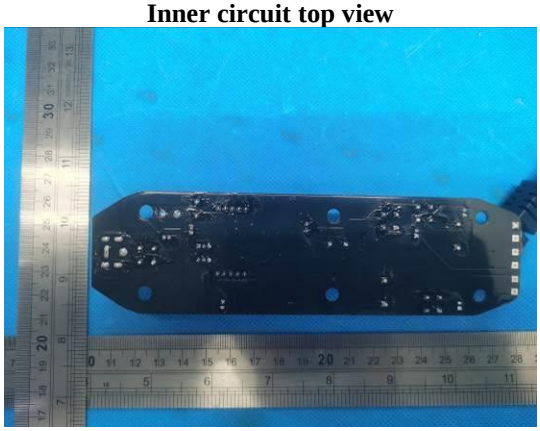
Inside View of the product

BT view of the product

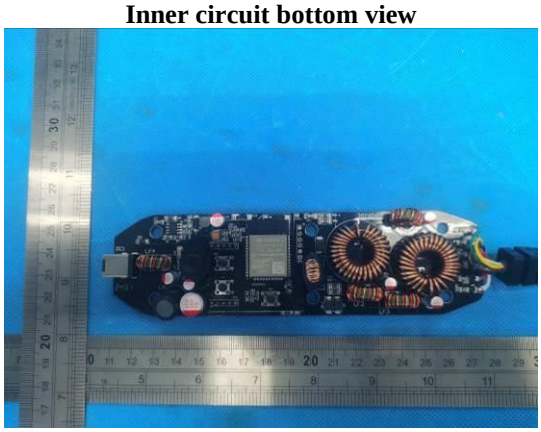


Photographs of EUT

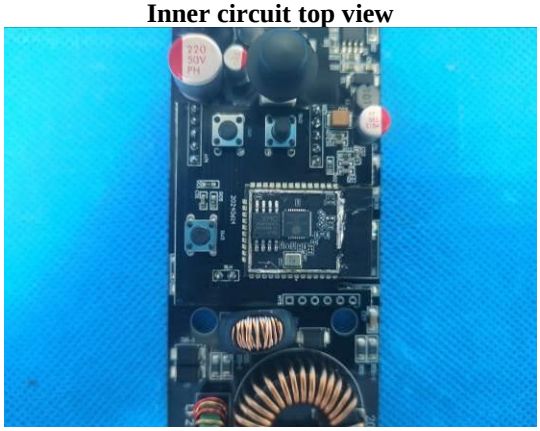
Inner circuit top view



Inner circuit bottom view

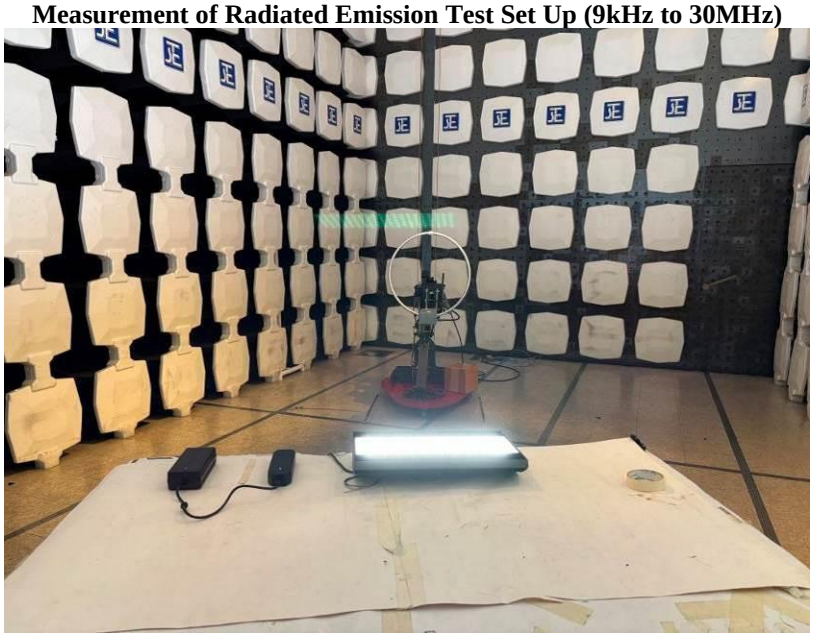


Inner circuit top view

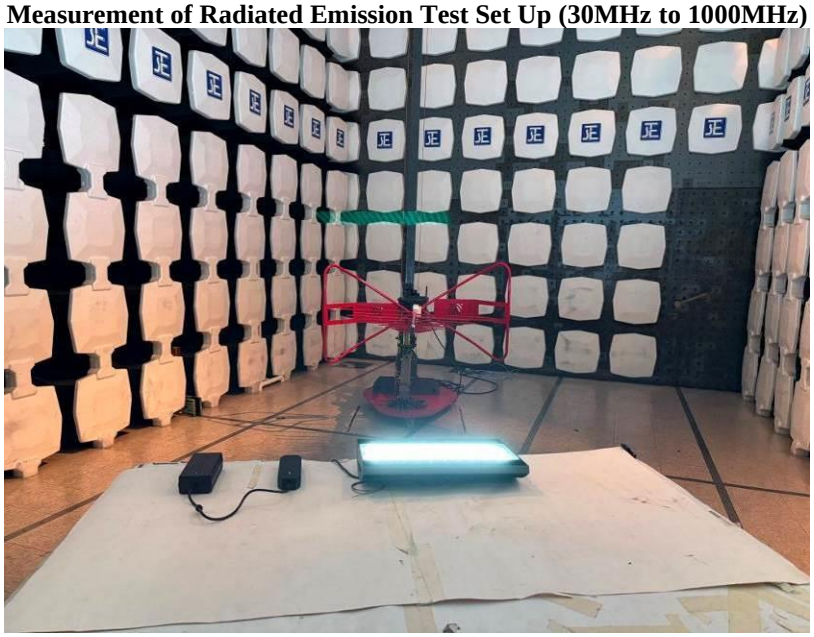


Photographs of EUT

Measurement of Radiated Emission Test Set Up (9kHz to 30MHz)

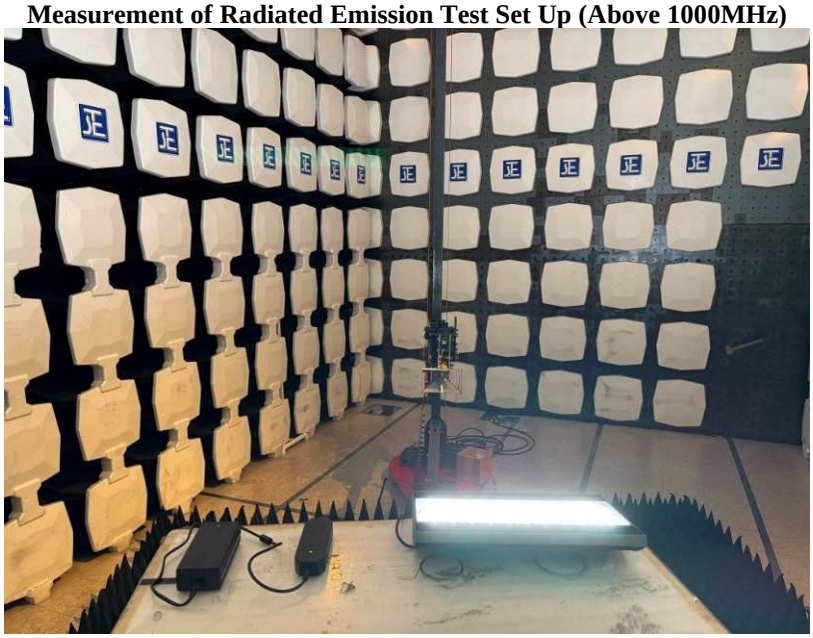


Measurement of Radiated Emission Test Set Up (30MHz to 1000MHz)

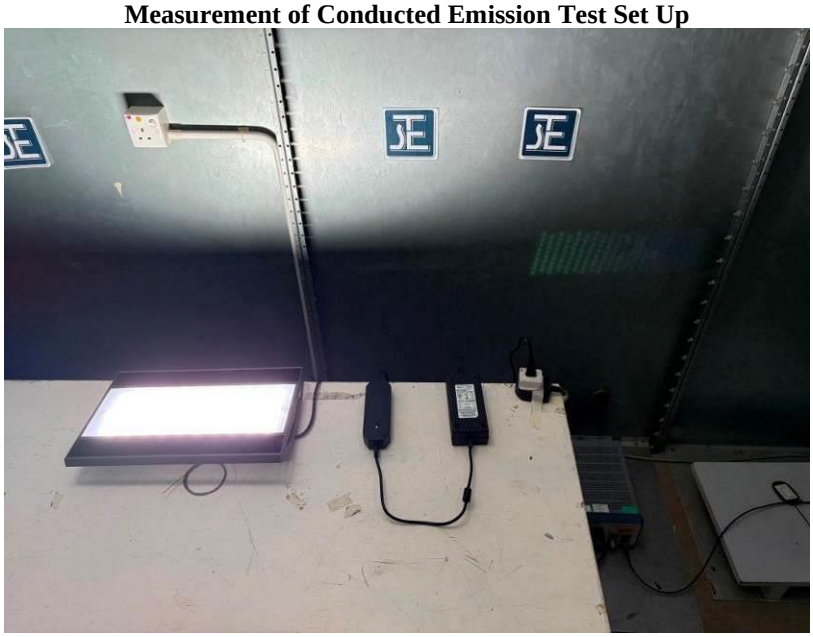


Photographs of EUT

Measurement of Radiated Emission Test Set Up (Above 1000MHz)



Measurement of Conducted Emission Test Set Up



******* End of Test Report *******

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