RF Test Report

For

Hankyul Marketing Co, LTD

Test Standards:	Part 15C Subpart C §15.247
Product Name:	Wireless Keyboard
Tested Model:	ENK100A
FCC ID:	2BA8D-ENK100A
Classification	(DTS) Digital Transmission System
Report No.:	EC2305033RF04
Tested Date:	2023-05-17 to 2023-06-13
Issued Date:	2023-06-13
Prepared By:	Jack Liu / Engineer
Approved By:	Tiny Yang / RF Manager

Hunan Ecloud Testing Technology Co., Ltd.

Building A1, Changsha E Center, No. 18 Xiangtai Avenue, Liuyang Economic and Technological Development Zone, Hunan, P.R.C

Tel.: +86-731-89634887 Fax.: +86-731-89634887

www.hn-ecloud.com

Report Revise Record

Report Version	Revise Time	Issued Date	Valid Version	Notes
V1.0	/	2023.06.13	Valid	Original Report

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Summary of Test RESULT

FCC Rule	Description	Limit	Result	Remark
15.247(a)(2)	6dB Bandwidth	≥ 0.5MHz	Pass	Test Engineer: Luo Xiang
-	99% Bandwidth	-	Pass	Test Engineer: Luo Xiang
15.247(b)(3)	Peak Output Power	≤ 30dBm	Pass	Test Engineer: Luo Xiang
15.247(e)	Power Spectral Density	≤ 8dBm/3kHz	Pass	Test Engineer: Luo Xiang
15.247(d)	Conducted Band Edges and Spurious Emission	≤ 20dBc	Pass	Test Engineer: Luo Xiang
15.247(d)	Radiated Band Edges and Spurious Emission	15.209(a) & 15.247(d)	Pass	Under limit 3.59 dB at 7440 MHz
15.207	AC Conducted Emission	Not Required	-	-
15.203 & 15.247(b)	Antenna Requirement	15.203 & 15.247(b)	Pass	-

1. Test Laboratory

1.1 Test facility

CNAS (accreditation number:L11138)

Hunan Ecloud Testing Technology Co., Ltd. has obtained the accreditation of China National Accreditation Service for Conformity Assessment (CNAS).

FCC (Designation number:CN1244 , Test Firm Registration Number:793308)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the US Federal Communications Commission list of test facilities recognized to perform electromagnetic emissions measurements.

ISED(CAB identifier: CN0012, ISED# :24347)

Hunan Ecloud Testing Technology Co., Ltd. has been listed on the Wireless Device Testing Laboratories list of innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements.

A2LA (Certificate Number:4895.01)

Hunan Ecloud Testing Technology Co., Ltd. has been listed by American Association for Laboratory Accreditation to perform electromagnetic emission measurement.

2. General Description

2.1 Applicant

Hankyul Marketing Co, LTD
9-5 bamgogaero27gil, gangnamgu, seoul, south korea

2.2 Manufacturer

Dongguan Lingjie Electronics & Technology Co., Ltd
Building 3, No.23 Zhenxing North Road, Xiegang Town, Dongguan City, Guangdong Province, China

2.3 General Description Of EUT

Product	Wireless Keyboard
Model No.	ENK100A
Additional No.	N/A
Difference Description	N/A
FCC ID	2BA8D-ENK100A
Power Supply	3.0Vdc (dry battery)
Modulation Technology	BLE
Modulation Type	GFSK
Operating Frequency	2402MHz~2480MHz
Number Of Channel	40
Max. Output Power	-1.8 dBm (0.0007 W)
Antenna Type	PCB Antenna type with 2.34dBi gain
HW Version	V1.0
SW Version	V1.0
Sample no.	2305033R-1/2~2/2
Sample Received Date	2023/05/17
I/O Ports	Refer to user's manual

NOTE:

1. The above EUT information is declared by manufacturer. The laboratory is not responsible for the information provided by the manufacturer.
2. For a more detailed features description, please refer to the manufacturer's specifications or the user's manual.
3. For the test results, the EUT had been tested with all conditions. But only the worst case was shown in

test report.

2.4 Modification of EUT

No modifications are made to the EUT during all test items.

2.5 Applicable Standards

According to the specifications of the manufacturer, the EUT must comply with the requirements of the following standards:

- FCC Part 15 Subpart C §15.247
- ANSI C63.10-2013
- KDB 558074 D01 15.247 Meas Guidance v05r02

Remark:

1. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

3. Test Configuration of Equipment Under Test

3.1 Descriptions of Test Mode

The transmitter has a maximum peak conducted output power as follows:

Channel	Frequency	Mode	Bluetooth RF Output Power(dBm)
Ch00	2402MHz	GFSK	-1.8 dBm
Ch19	2440MHz	GFSK	-2.0 dBm
Ch39	2480MHz	GFSK	-1.97 dBm

a. Radiated emission and power line conducted emission were performed with the EUT set to transmit at the channel with highest output power as worst-case scenario.

3.2 Test Mode

3.2.1 Antenna Port Conducted Measurement

Summary table of Test Cases	
Test Item	Data Rate / Modulation
	Bluetooth 5.0 – LE GFSK
Conducted Test Cases	Mode 1: CH00_2402 MHz Mode 2: CH19_2440 MHz Mode 3: CH39_2480 MHz

3.2.2 Radiated Emission Test (Below 1GHz)

Radiated Test Cases	Bluetooth 5.0 – LE GFSK
	Mode 1: CH39_2480 MHz

Note : 1. Pre-Scan has been conducted to determine the worst-case mode from all possible combinations between available modulations, XYZ axis, antenna ports (if EUT with antenna diversity architecture) and packet type. Z orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Z orientation.

2. Following channel(s) was (were) selected for the final test as listed above

3.2.3 Radiated Emission Test (Above 1GHz)

Radiated Test Cases	Bluetooth 5.0 – LE GFSK
	Mode 1: CH00_2402 MHz Mode 2: CH19_2440 MHz

	Mode 3: CH39_2480 MHz

Note : 1. The fundamental of the EUT was investigated in three orthogonal orientations X, Y and Z it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in Z orientation.

2. Following channel(s) was (were) selected for the final test as listed above

3. For frequency above 18GHz, the measured value is much lower than the limit, therefore, it is not reflected in the report.

3.2.4 Power Line Conducted Emission Test:

Not Required

3.3 Support Equipment

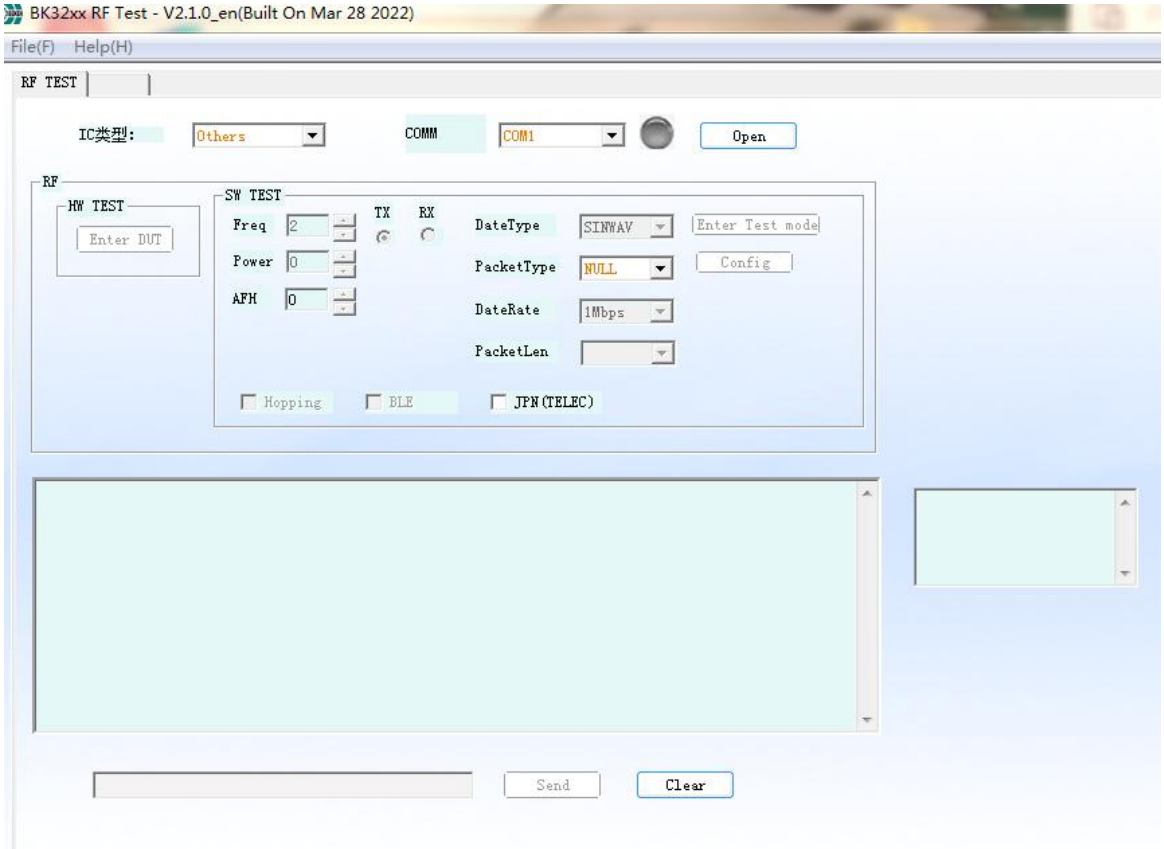
Manufacturer	Description	Model	Serial Number	Certificate
Lenovo	Notebook	E470C	N/A	FCC sDoC

3.4 Test Setup

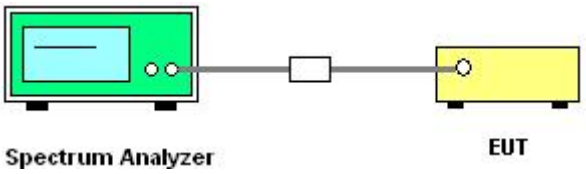
The EUT is continuously communicating to the Bluetooth tester during the tests.

EUT was set in the Hidden menu mode to enable BT communications.

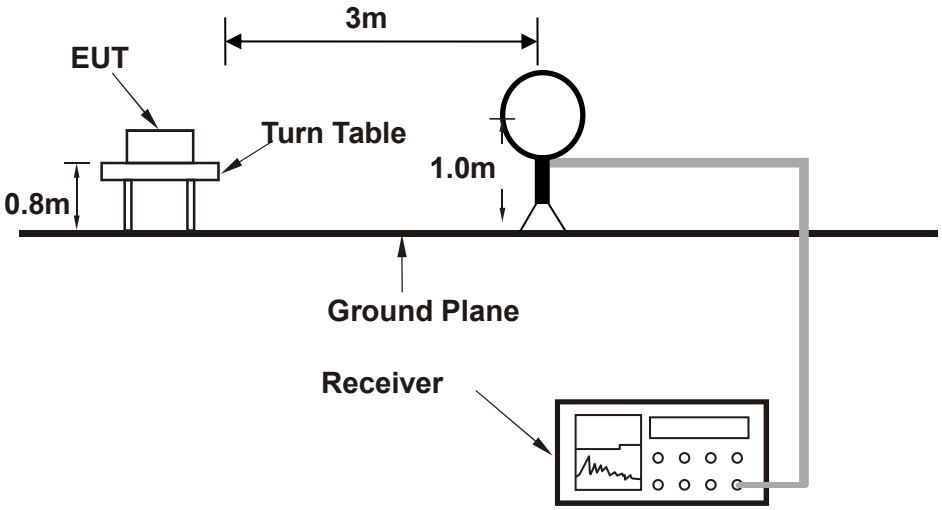
The following picture is a screenshot of the test software



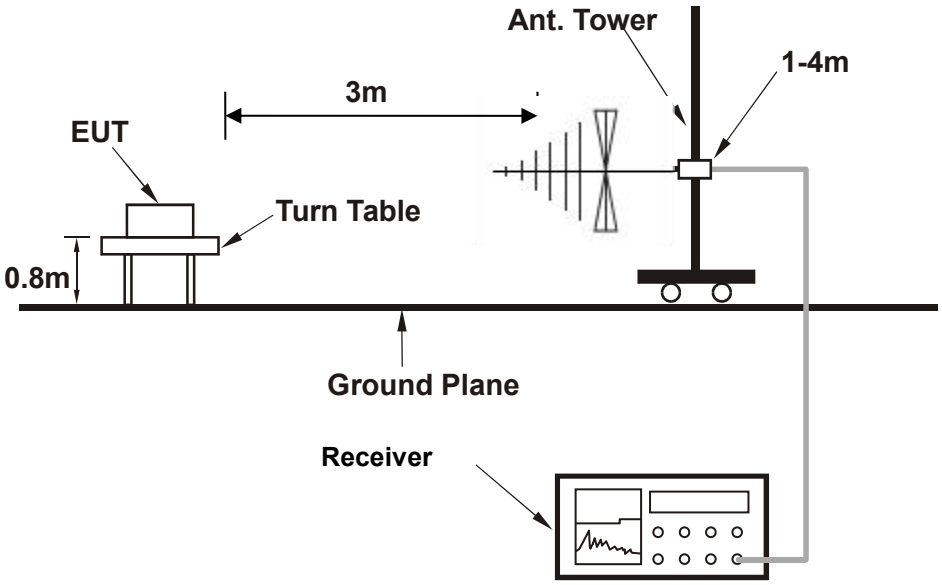
Setup diagram for Conducted Test



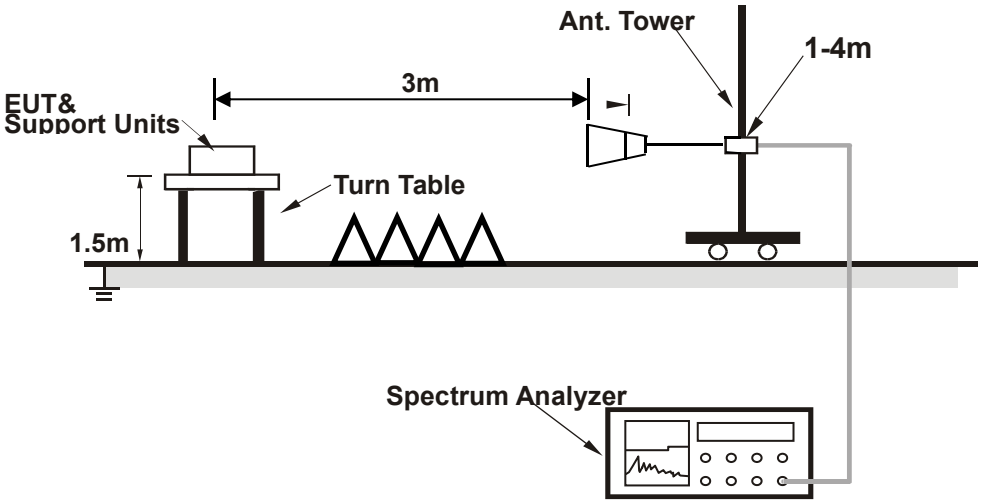
Setup diagram for Radiation(9KHz~30MHz) Test



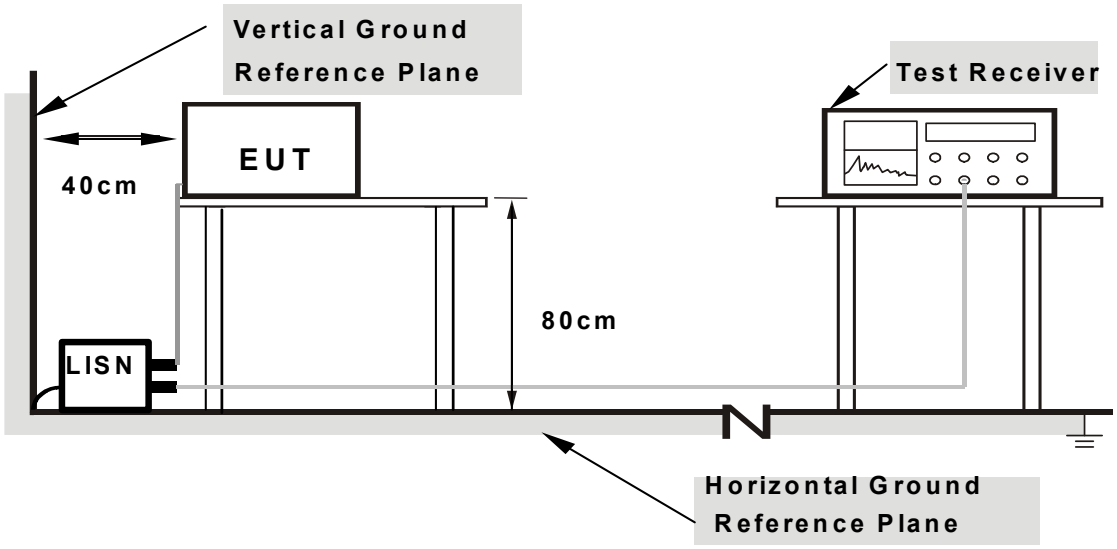
Setup diagram for Radiation(Below 1G) Test



Setup diagram for Radiation (Above1G) Test



Setup diagram for AC Conducted Emission Test



Note: 1.Support units were connected to second LISN.

2.Both of LISNs (AMN) are 80 cm from EUT and at least 80 from other units and other metal planes

3.5 Measurement Results Explanation Example

For all conducted test items:

The offset level is set in the spectrum analyzer to compensate the RF cable loss and attenuator factor between EUT conducted output port and spectrum analyzer. With the offset compensation, the spectrum analyzer reading level is exactly the EUT RF output level.

Example:

The spectrum analyzer offset is derived from RF cable loss and attenuator factor.

Offset = RF cable loss + attenuator factor.

Following shows an offset computation example with cable loss 5 dB and 10dB attenuator.

Offset(dB) = RF cable loss(dB) + attenuator factor(dB).

= 5 + 10 = 15 (dB)

For all radiated test items:

Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level

Over Limit (dB μ V/m) = Level(dB μ V/m) - Limit Level (dB μ V/m)

4. Test Result

4.1 6dB and 99% Bandwidth Measurement

4.1.1 Limit of 6dB and 99% Bandwidth

FCC §15.247 (a) (2)

The minimum 6 dB bandwidth shall be at least 500 kHz.

4.1.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Set to the maximum power setting and enable the EUT transmit continuously
4. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 100 kHz. Set the Video bandwidth (VBW) = 300 kHz. In order to make an accurate measurement. The 6 dB bandwidth must be greater than 500 kHz.
5. For 99% Bandwidth Measurement, the spectrum analyzer's resolution bandwidth (RBW) is set 43kHz and set the Video bandwidth (VBW) = 130kHz.

4.1.3 Test Result of 6dB Bandwidth

Refer to Appendix A of this test report.

4.1.4 Test Result of 99% Bandwidth

Refer to Appendix B of this test report.

4.2 Peak Output Power Measurement

4.2.1 Limit of Peak Output Power

FCC §15.247 (b)(3)

For systems using digital modulation in the 2400-2483.5 MHz bands: 30dBm.

4.2.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to spectrum analyzer.
3. Set to the maximum power setting and enable the EUT transmit continuously
4. Set the RBW≥DTS Bandwidth,VBW≥3*RBW,Span≥1.5*DTS Bandwidth,Detector=Peak,Sweep time=auto couple,Trace mode=max holde.
5. Allow trace to fully stabilize, Use peak marker function to determine the peak amplitude level.
6. Measure the conducted output power

4.2.3 Test Result of Peak Output Power

Refer to Appendix C of this test report.

4.3 Power Spectral Density Measurement

4.3.1 Limits of Power Spectral Density

FCC§15.247(e)

The peak power spectral density shall not be greater than 8dBm in any 3kHz band at any time interval of continuous transmission.

4.3.2 Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Make the measurement with the spectrum analyzer's resolution bandwidth (RBW) = 3 kHz. Video bandwidth VBW = 10 kHz In order to make an accurate measurement, set the span to 1.5 times DTS Channel Bandwidth. (6dB BW)
4. Detector = peak, Sweep time = auto couple, Trace mode = max hold, Allow trace to fully stabilize. Use the peak marker function to determine the maximum power level.
5. Measure and record the results in the test report.
6. The Measured power density (dBm)/ 100kHz is a reference level and used as 20dBc down limit line for Conducted Band Edges and Conducted Spurious Emission.

4.3.3 Test Result of Power Spectral Density

Refer to Appendix D of this test report.

4.4 Conducted Band Edges and Spurious Emission Measurement

4.4.1 Limit of Conducted Band Edges and Spurious Emission

FCC §15.247 (d)

Maximum conducted (average) output power was used to determine compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz (i.e., 20 dBc).

4.4.2 Test Procedures

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Turn on the EUT and connect it to measurement instrument.
3. Set RBW = 100 kHz, VBW=300 kHz, Peak Detector. Unwanted Emissions measured in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 dB instead of 20 dB per 15.247(d).
4. Measure and record the results in the test report.
5. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

4.4.3 Test Result of Conducted Band Edges

Refer to Appendix E of this test report.

4.4.4 Test Result of Conducted Spurious Emission

Refer to Appendix F of this test report.

4.5 Radiated Band Edges and Spurious Emission Measurement

4.5.1 Limit of Radiated Band Edges and Spurious Emission

FCC §15.247 (d)

In any 100 kHz bandwidth outside the intentional radiator frequency band, all harmonics/spurious must be at least 20 dB below the highest emission level within the authorized band. In addition, radiated emissions which fall in the restricted bands must also comply with the FCC section 15.209 limits as below.

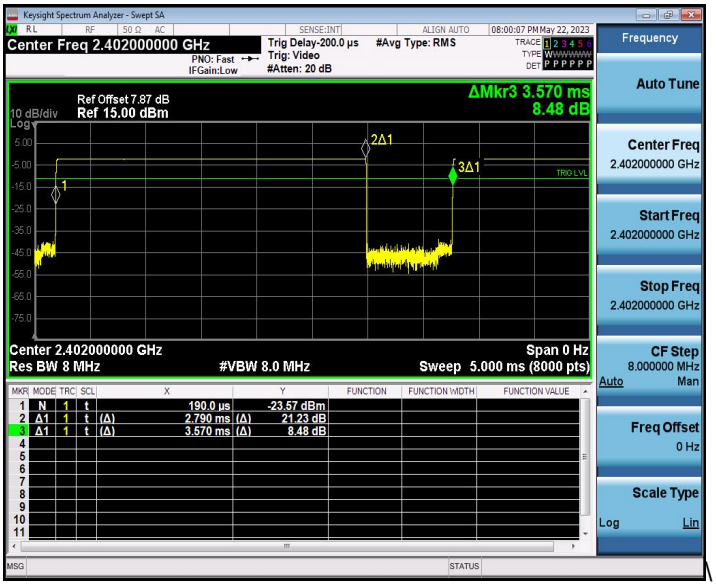
Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30.0	30	30
30 – 88	100	3
88 – 216	150	3
216 - 960	200	3
Above 960	500	3

4.5.2 Test Procedures

1. The EUT was placed on a turntable with 0.8 meter for frequency below 1GHz and 1.5 meter for frequency above 1GHz respectively above ground.
2. The measurement distance is 3 meter.
3. For each suspected emission, 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 to comply with the guidelines.
4. Set to the maximum power setting and enable the EUT transmit continuously.
5. 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:
   VBW = 10 Hz, when duty cycle is no less than 98 percent.
   VBW ≥ 1/T, when duty cycle is less than 98 percent where T is the minimum transmission duration over which the transmitter is on and is transmitting at its maximum power control

level for the tested mode of operation.

Band	Duty Cycle(%)	T(ms)	1/T(kHz)	VBW Setting
Bluetooth 5.0 - LE	78.15	2.79	0.36	1KHz



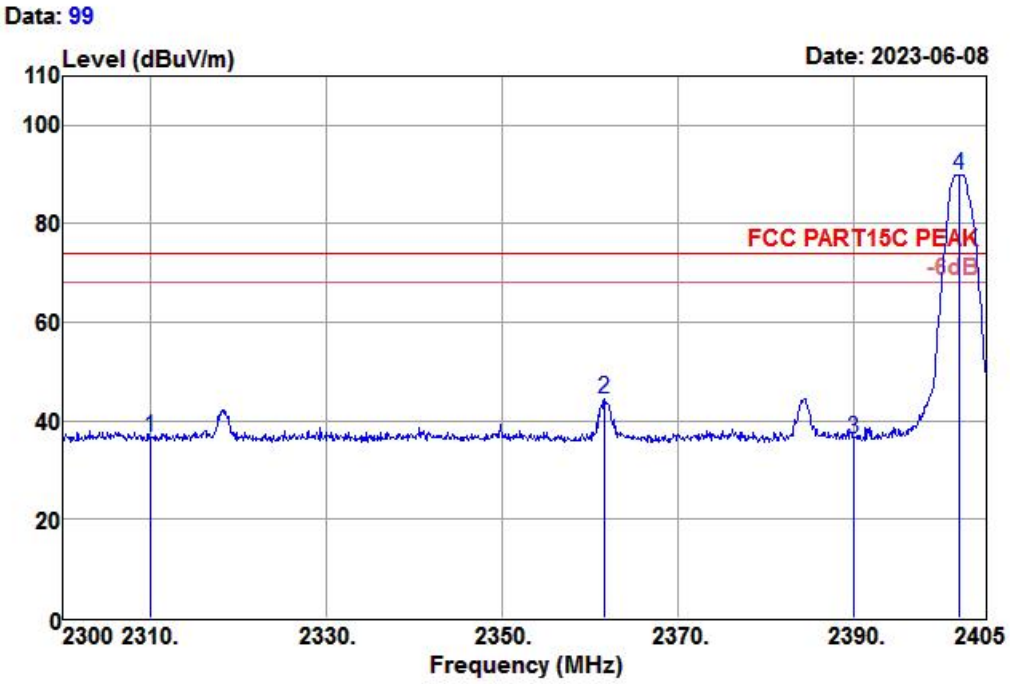
Note: Emission was scanned up to 26GHz; No emissions were detected above the noise floor which was at least 20dB below the specification limit.

4.5.3 Test Results of Radiated Spurious Emissions (9 kHz ~ 30 MHz)

The low frequency, which started from 9 kHz to 30MHz, was pre-scanned and the result which was 20dB lower than the limit line per 15.31(o) was not reported.

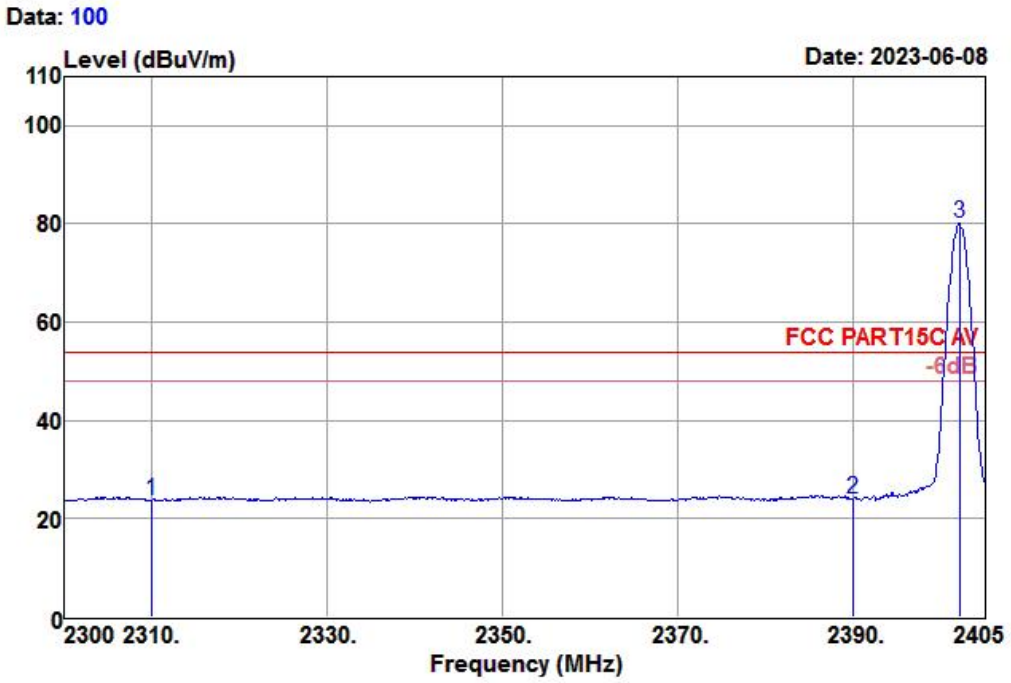
4.5.4 Test Result of Radiated Spurious at Band Edges

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.3GHz~2.405GHz	Polarization :	Horizontal



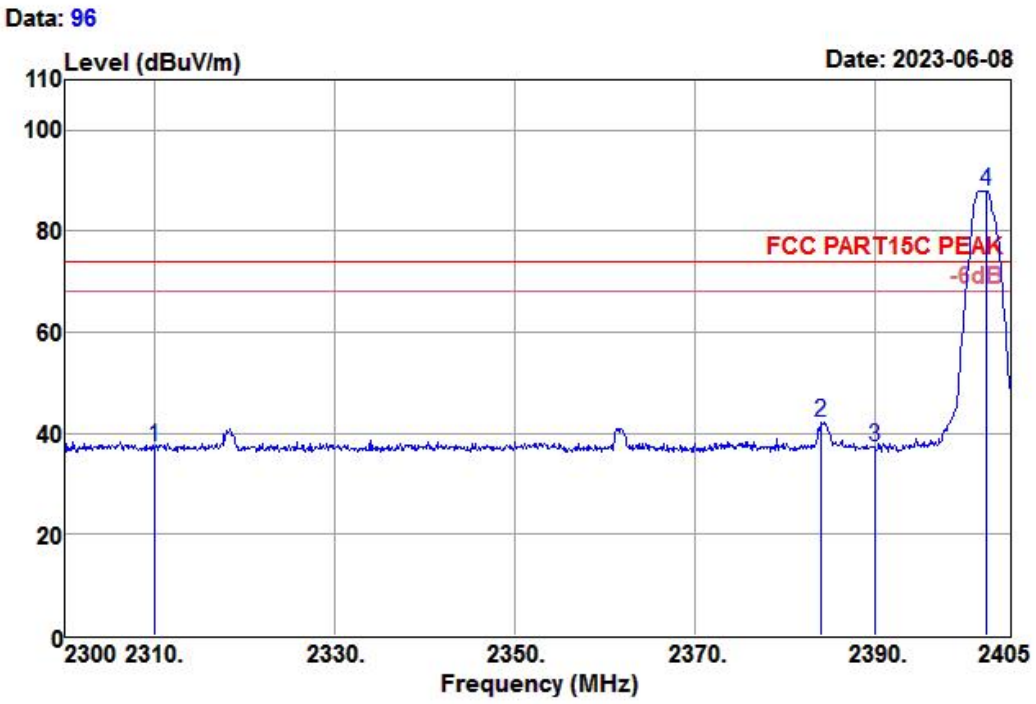
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
2310.000	41.25	27.12	4.15	35.70	36.82	74.00	-37.18	Peak
2361.530	48.85	27.22	4.35	35.85	44.57	74.00	-29.43	Peak
2390.000	40.67	27.28	4.46	35.93	36.48	74.00	-37.52	Peak
2401.850	94.10	27.30	4.51	35.97	89.94	74.00	15.94	Peak

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.3GHz~2.405GHz	Polarization :	Horizontal



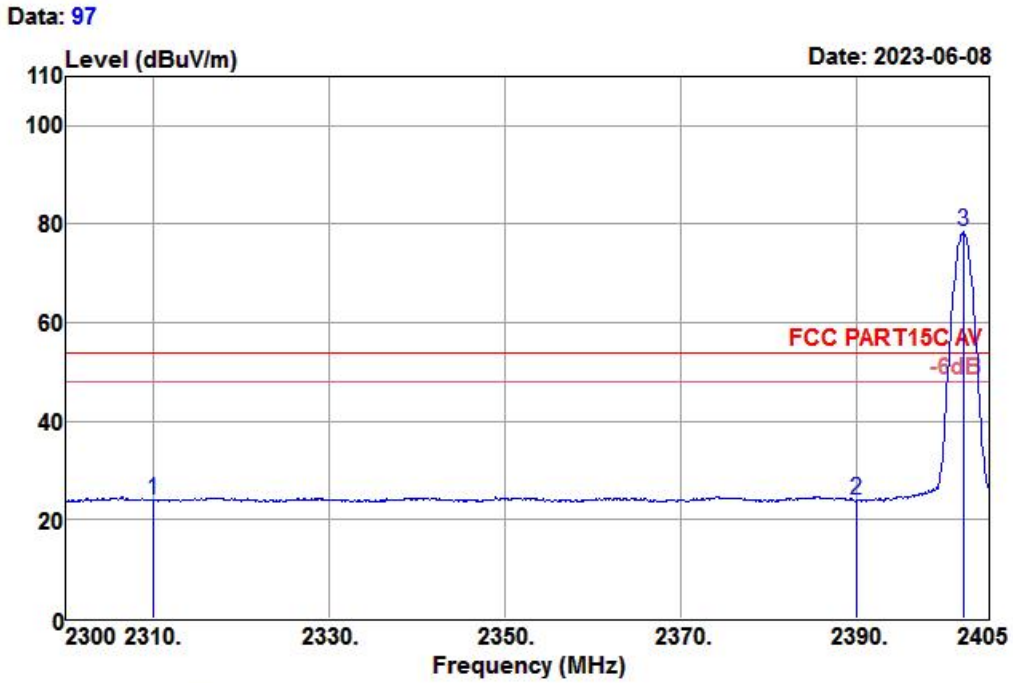
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2310.000	28.25	27.12	4.15	35.70	23.82	54.00	-30.18	Average
2390.000	28.24	27.28	4.46	35.93	24.05	54.00	-29.95	Average
2402.060	84.21	27.30	4.51	35.97	80.05	54.00	26.05	Average

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.3GHz~2.405GHz	Polarization :	Vertical



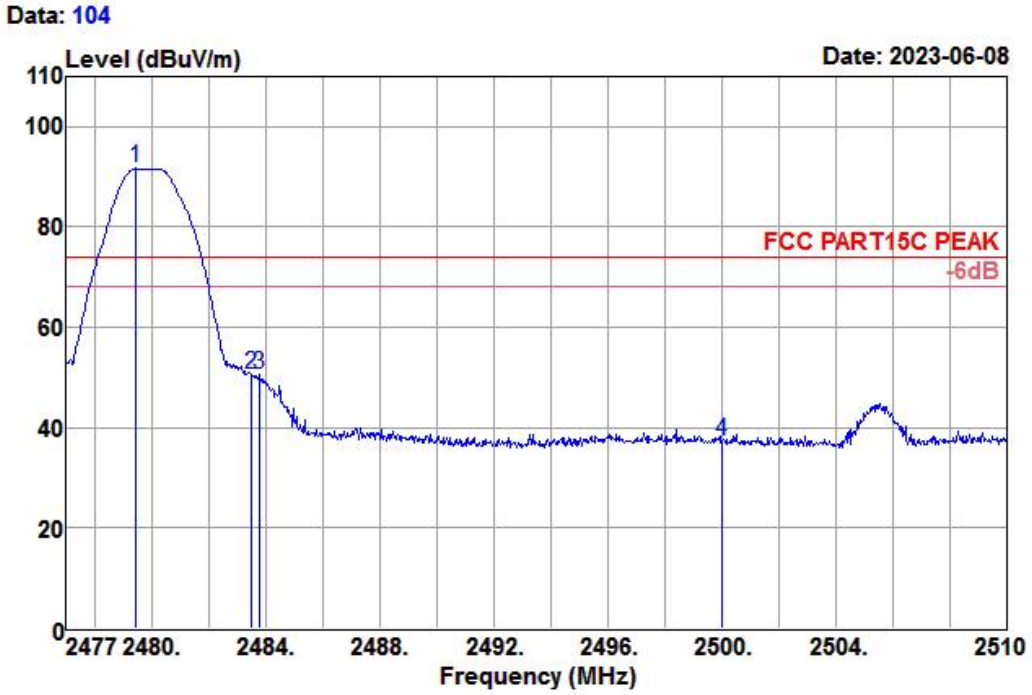
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
2310.000	41.84	27.12	4.15	35.70	37.41	74.00	-36.59	Peak
2384.000	46.39	27.27	4.44	35.91	42.19	74.00	-31.81	Peak
2390.000	41.42	27.28	4.46	35.93	37.23	74.00	-36.77	Peak
2402.270	92.14	27.30	4.51	35.97	87.98	74.00	13.98	Peak

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.3GHz~2.405GHz	Polarization :	Vertical



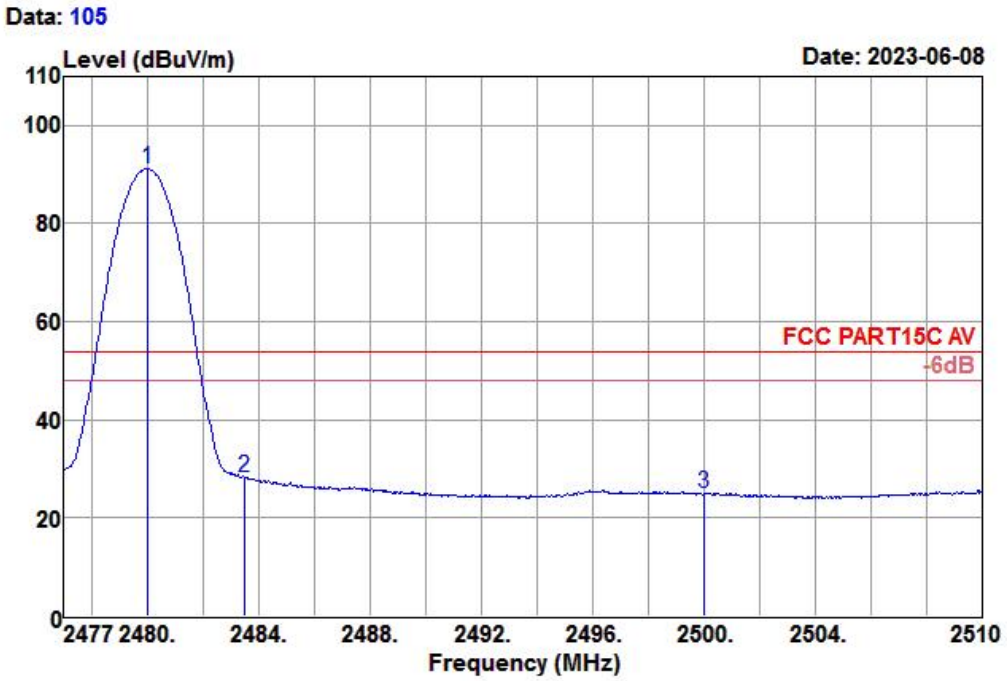
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
2310.000	28.30	27.12	4.15	35.70	23.87	54.00	-30.13	Average
2390.000	28.12	27.28	4.46	35.93	23.93	54.00	-30.07	Average
2402.060	82.71	27.30	4.51	35.97	78.55	54.00	24.55	Average

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.477GHz~2.51GHz	Polarization :	Horizontal



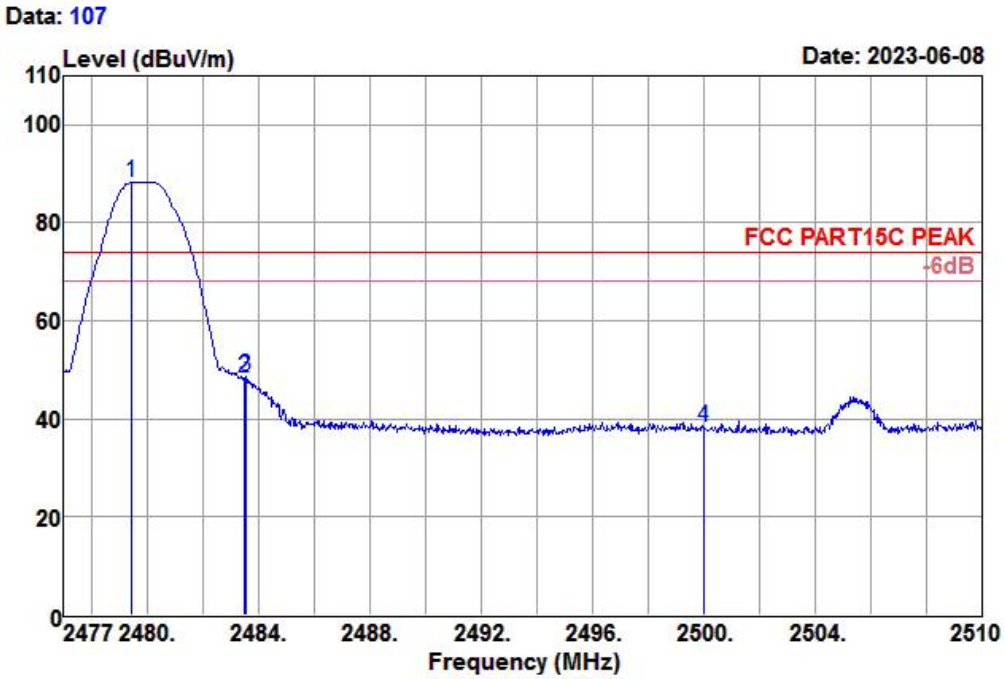
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
2479.475	95.68	27.46	4.74	36.19	91.69	74.00	17.69	Peak
2483.500	54.67	27.47	4.75	36.20	50.69	74.00	-23.31	Peak
2483.798	54.44	27.47	4.76	36.20	50.47	74.00	-23.53	Peak
2500.000	41.42	27.50	4.81	36.25	37.48	74.00	-36.52	Peak

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.477GHz~2.51GHz	Polarization :	Horizontal



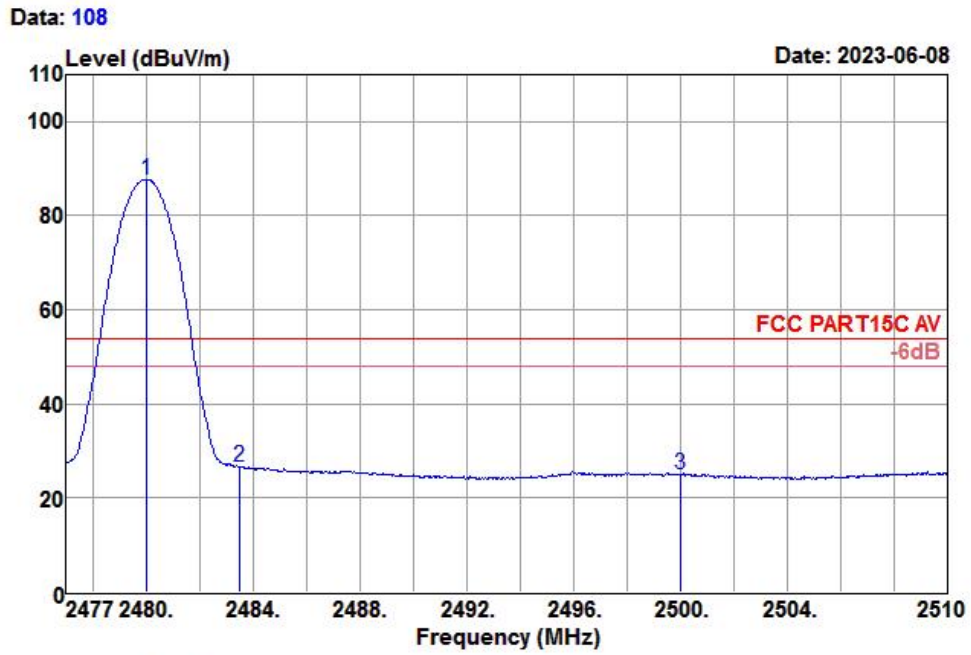
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2480.003	95.15	27.46	4.74	36.19	91.16	54.00	37.16	Average
2483.500	32.31	27.47	4.75	36.20	28.33	54.00	-25.67	Average
2500.000	28.82	27.50	4.81	36.25	24.88	54.00	-29.12	Average

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.477GHz~2.51GHz	Polarization :	Vertical



Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
2479.475	92.28	27.46	4.74	36.19	88.29	74.00	14.29	Peak
2483.500	52.37	27.47	4.75	36.20	48.39	74.00	-25.61	Peak
2483.567	52.76	27.47	4.75	36.20	48.78	74.00	-25.22	Peak
2500.000	42.21	27.50	4.81	36.25	38.27	74.00	-35.73	Peak

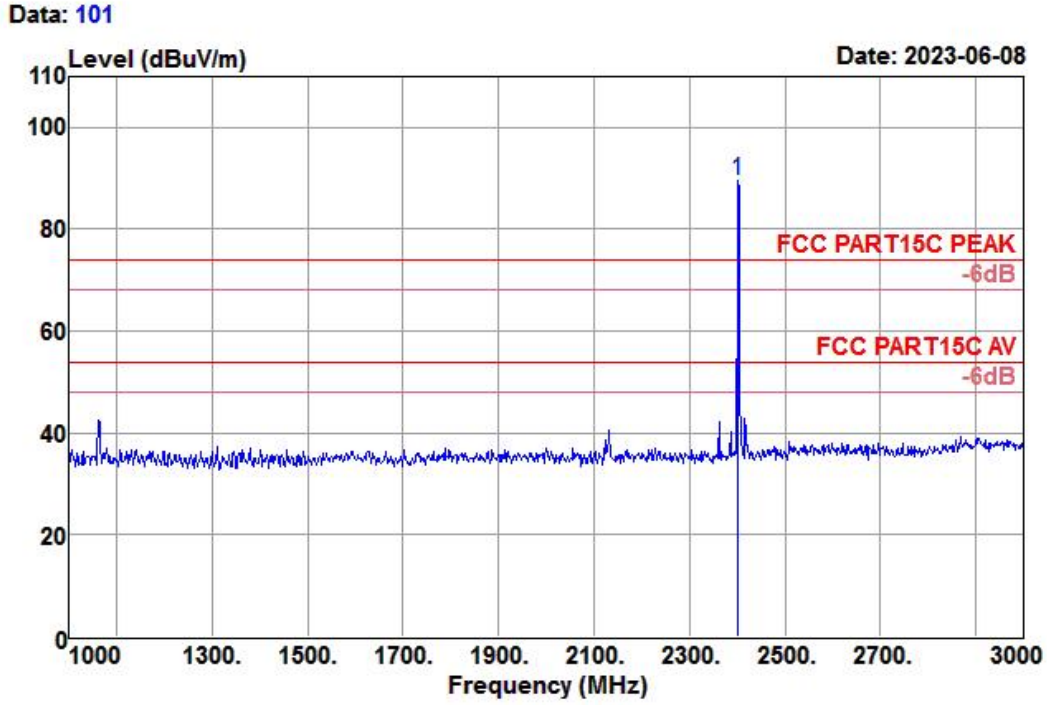
Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	2.477GHz~2.51GHz	Polarization :	Vertical



Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2480.003	91.76	27.46	4.74	36.19	87.77	54.00	33.77	Average
2483.500	30.68	27.47	4.75	36.20	26.70	54.00	-27.30	Average
2500.000	28.86	27.50	4.81	36.25	24.92	54.00	-29.08	Average

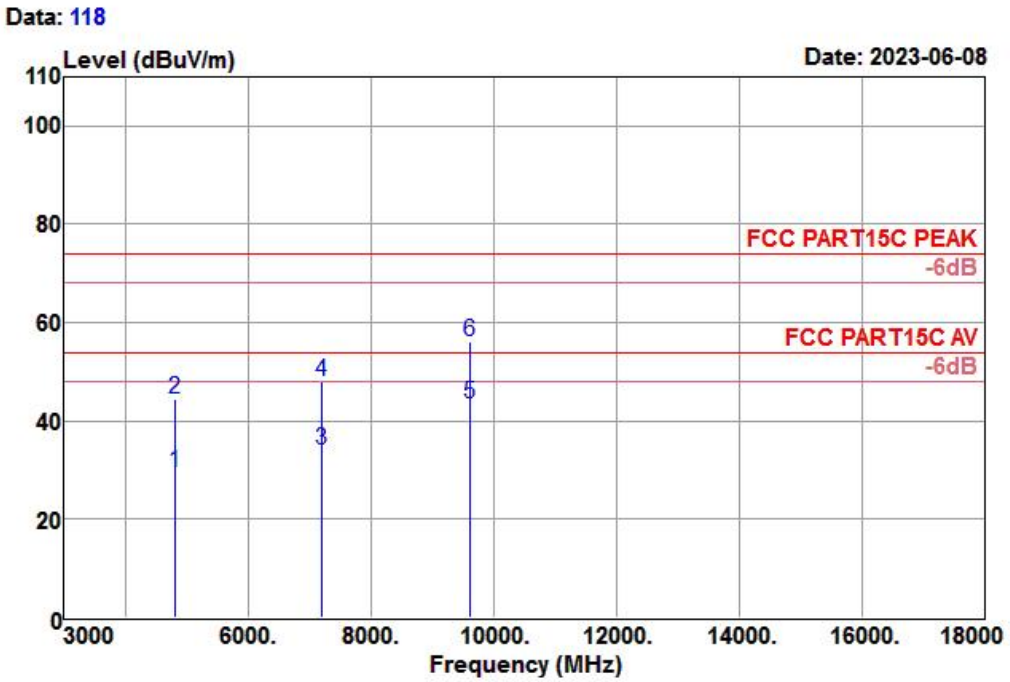
4.5.5 Test Result of Radiated Spurious Emission (1GHz ~ 10th Harmonic)

Test Mode :	BLE CH00 (2402 MHz)	**Temperature :**	21~23℃
Test Engineer :	Jack Liu	**Relative Humidity :**	63~65%
Frequencey Range	1GHz~3GHz	**Polarization :**	Horizontal



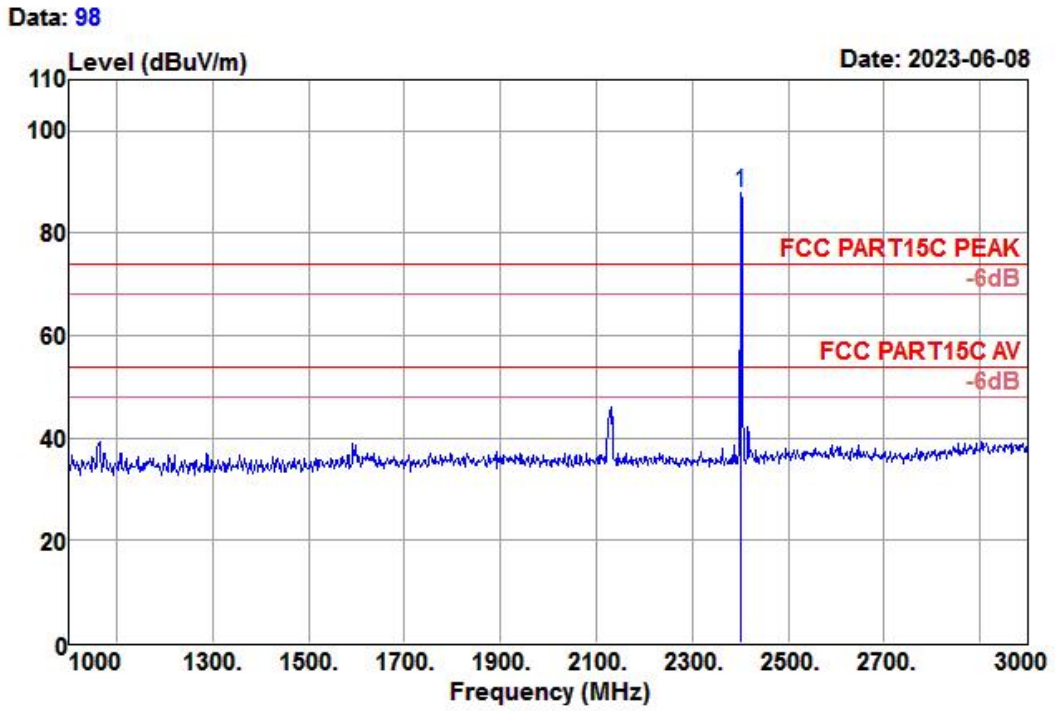
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2402.000	93.76	27.30	4.51	35.97	89.60	74.00	15.60	Peak

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	3GHz~18GHz	Polarization :	Horizontal



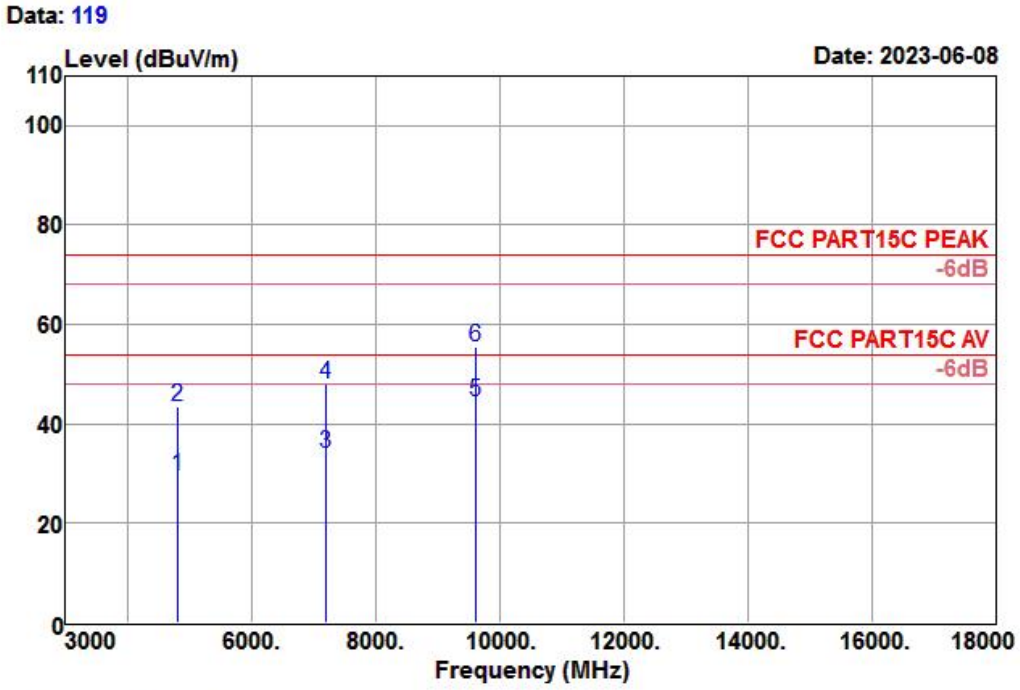
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
4804.000	26.39	30.93	6.44	34.12	29.64	54.00	-24.36	Average
4804.000	41.18	30.93	6.44	34.12	44.43	74.00	-29.57	Peak
7206.000	24.58	35.39	8.61	34.39	34.19	54.00	-19.81	Average
7206.000	38.40	35.39	8.61	34.39	48.01	74.00	-25.99	Peak
9608.000	27.52	38.39	11.69	34.14	43.46	54.00	-10.54	Average
9608.000	40.37	38.39	11.69	34.14	56.31	74.00	-17.69	Peak

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	1GHz~3GHz	Polarization :	Vertical



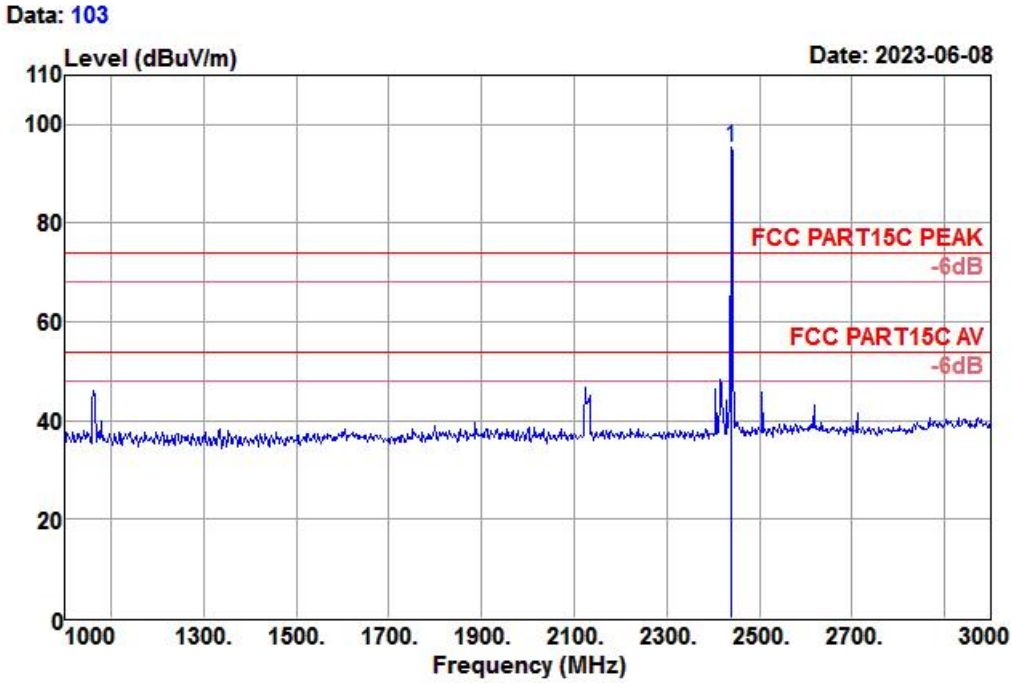
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2402.000	92.06	27.30	4.51	35.97	87.90	74.00	13.90	Peak

Test Mode :	BLE CH00 (2402 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	3GHz~18GHz	Polarization :	Vertical



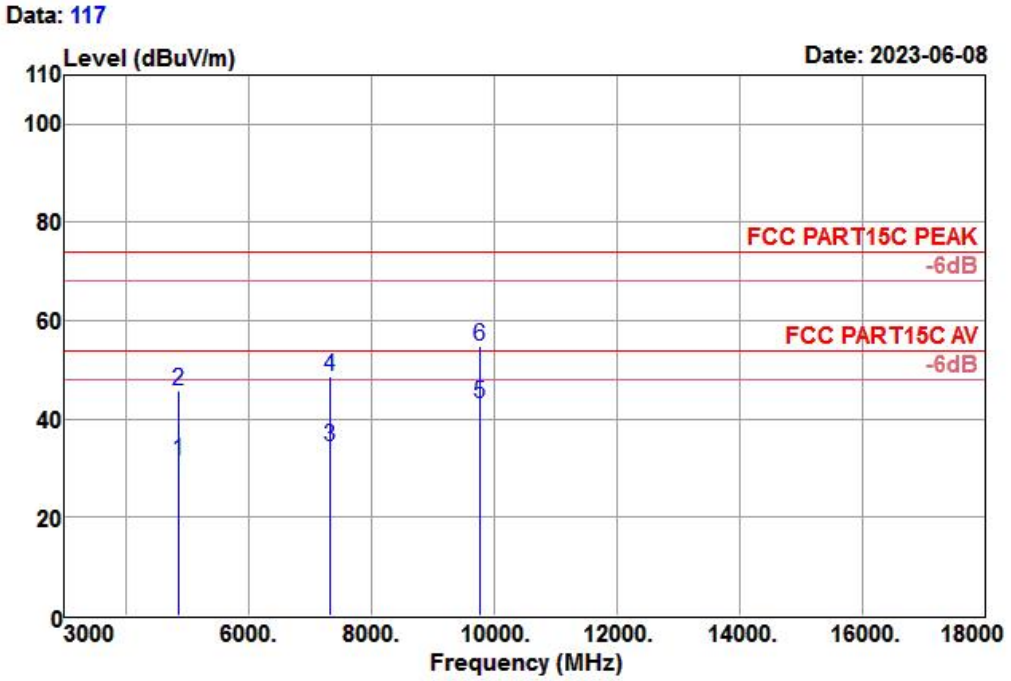
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
4804.000	26.34	30.93	6.44	34.12	29.59	54.00	-24.41	Average
4804.000	40.22	30.93	6.44	34.12	43.47	74.00	-30.53	Peak
7206.000	24.63	35.39	8.61	34.39	34.24	54.00	-19.76	Average
7206.000	38.52	35.39	8.61	34.39	48.13	74.00	-25.87	Peak
9608.000	28.63	38.39	11.69	34.14	44.57	54.00	-9.43	Average
9608.000	39.57	38.39	11.69	34.14	55.51	74.00	-18.49	Peak

Test Mode :	BLE CH19 (2440 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	1GHz~3GHz	Polarization :	Horizontal



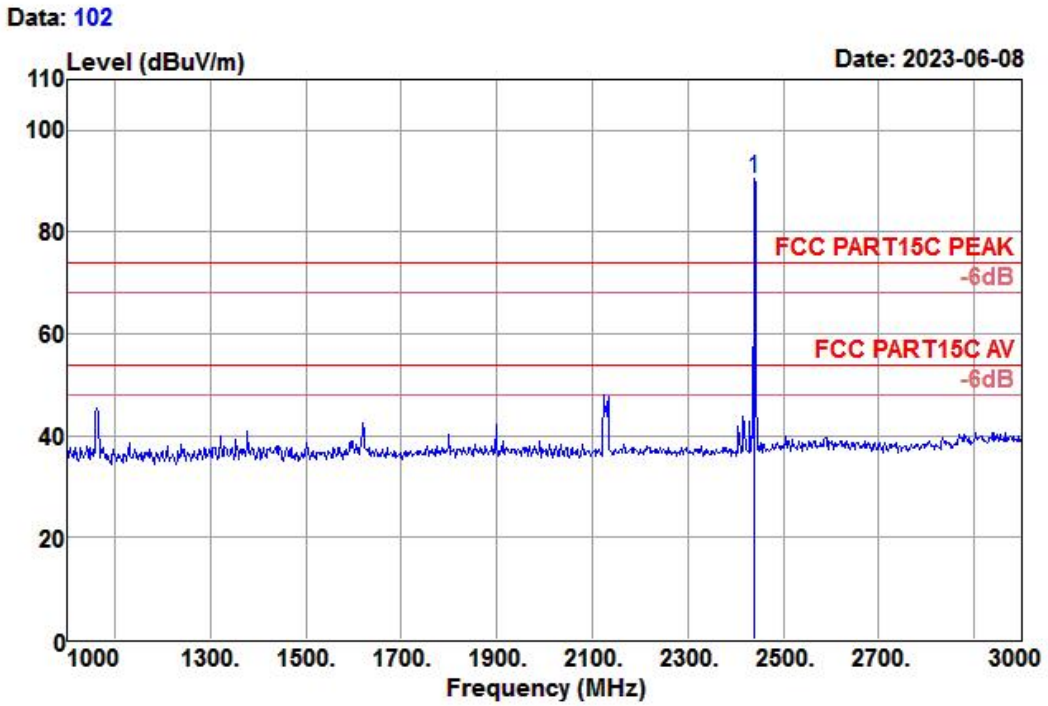
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2440.000	99.51	27.38	4.62	36.08	95.43	74.00	21.43	Peak

Test Mode :	BLE CH19 (2440 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	3GHz~18GHz	Polarization :	Horizontal



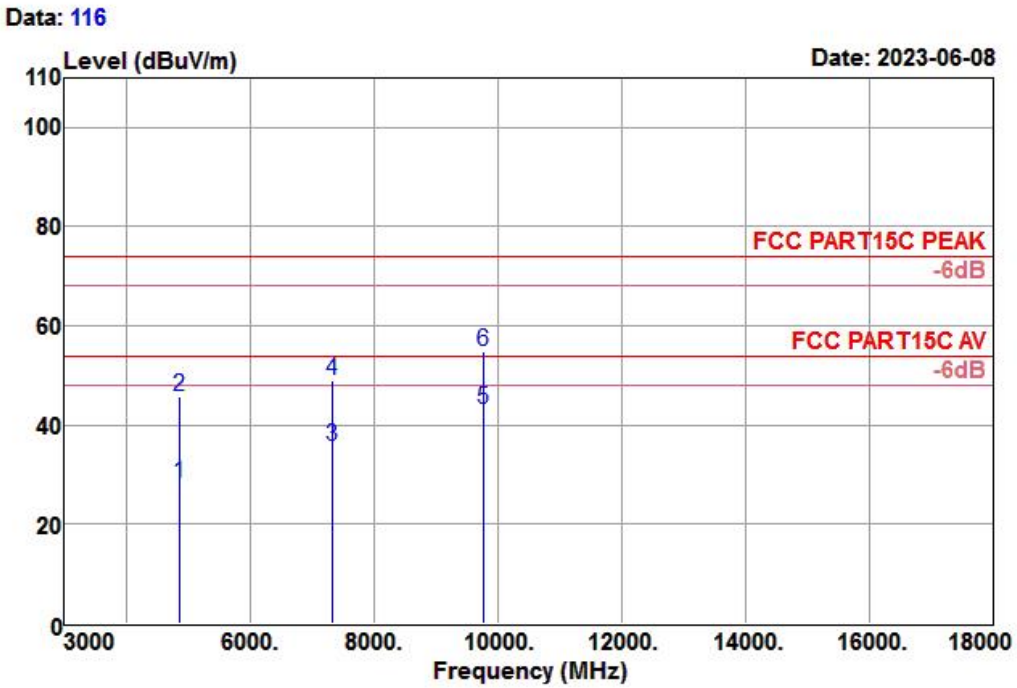
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
4880.000	27.58	31.03	7.01	34.03	31.59	54.00	-22.41	Average
4880.000	41.61	31.03	7.01	34.03	45.62	74.00	-28.38	Peak
7320.000	24.36	35.67	8.97	34.49	34.51	54.00	-19.49	Average
7320.000	38.41	35.67	8.97	34.49	48.56	74.00	-25.44	Peak
9760.000	27.62	38.51	11.16	34.20	43.09	54.00	-10.91	Average
9760.000	39.40	38.51	11.16	34.20	54.87	74.00	-19.13	Peak

Test Mode :	BLE CH19 (2440 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	1GHz~3GHz	Polarization :	Vertical



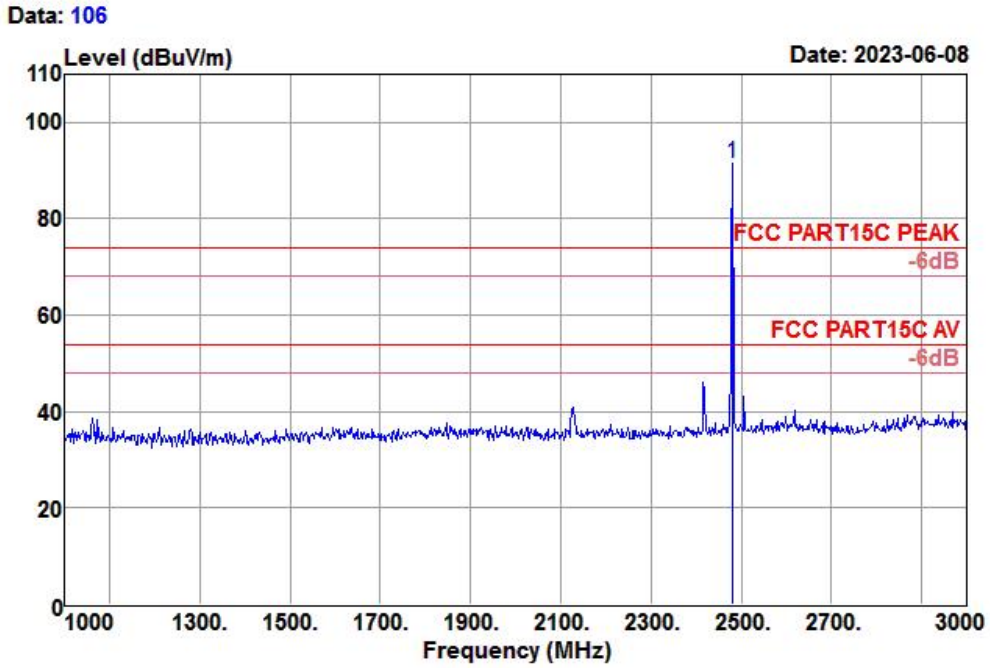
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
2440.000	94.76	27.38	4.62	36.08	90.68	74.00	16.68	Peak

Test Mode :	BLE CH19 (2440 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	3GHz~18GHz	Polarization :	Vertical



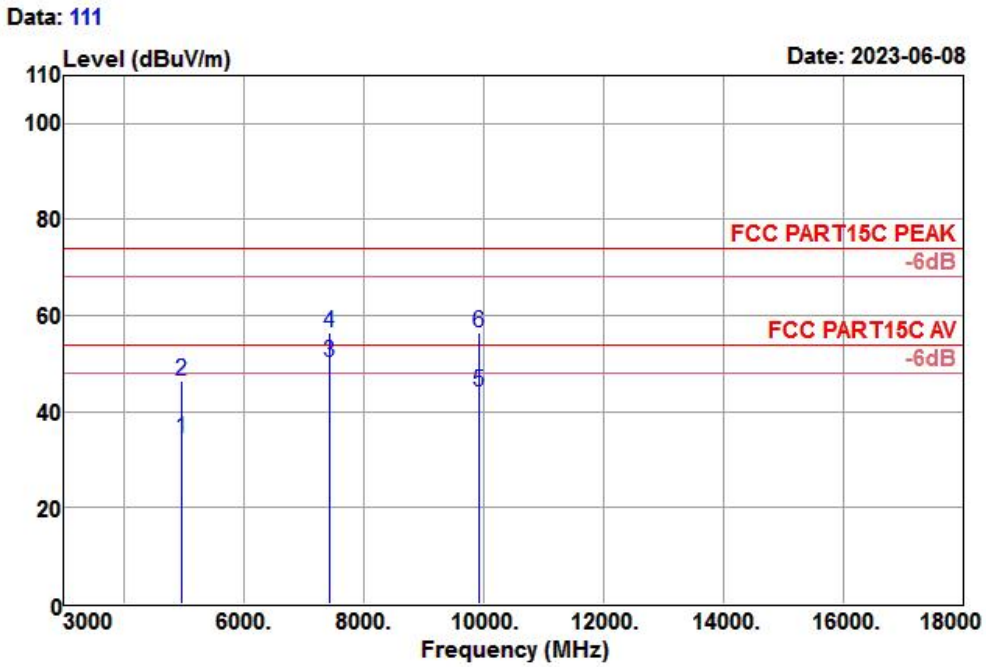
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
4880.000	24.38	31.03	7.01	34.03	28.39	54.00	-25.61	Average
4880.000	41.85	31.03	7.01	34.03	45.86	74.00	-28.14	Peak
7320.000	25.43	35.67	8.97	34.49	35.58	54.00	-18.42	Average
7320.000	38.87	35.67	8.97	34.49	49.02	74.00	-24.98	Peak
9760.000	27.68	38.51	11.16	34.20	43.15	54.00	-10.85	Average
9760.000	39.37	38.51	11.16	34.20	54.84	74.00	-19.16	Peak

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	1GHz~3GHz	Polarization :	Horizontal



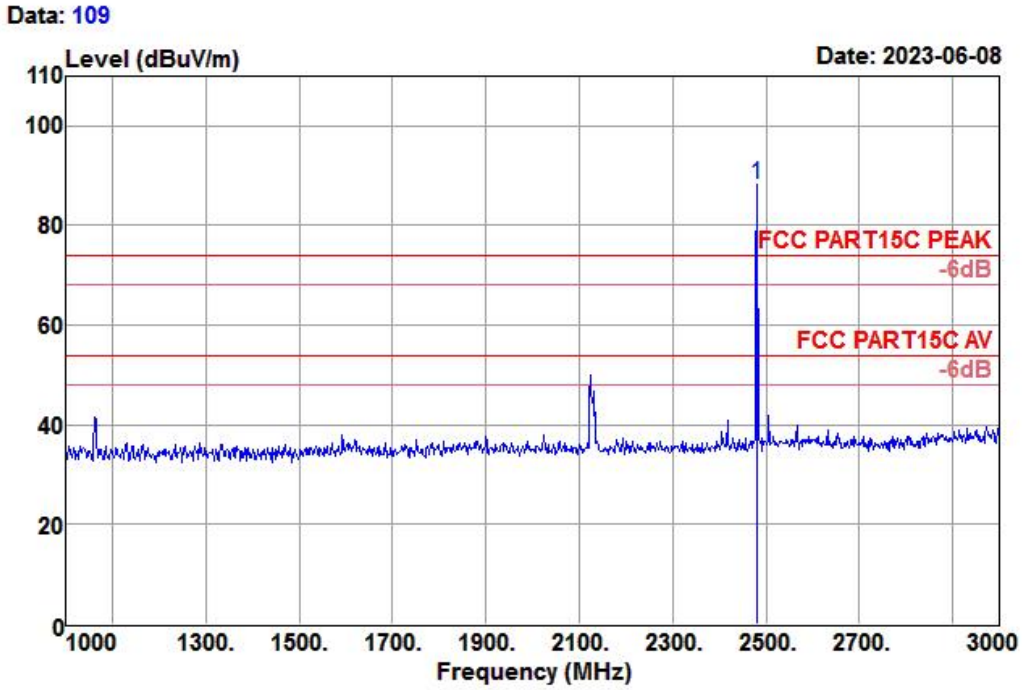
Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2480.000	95.59	27.46	4.74	36.19	91.60	74.00	17.60	Peak

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	3GHz~18GHz	Polarization :	Horizontal



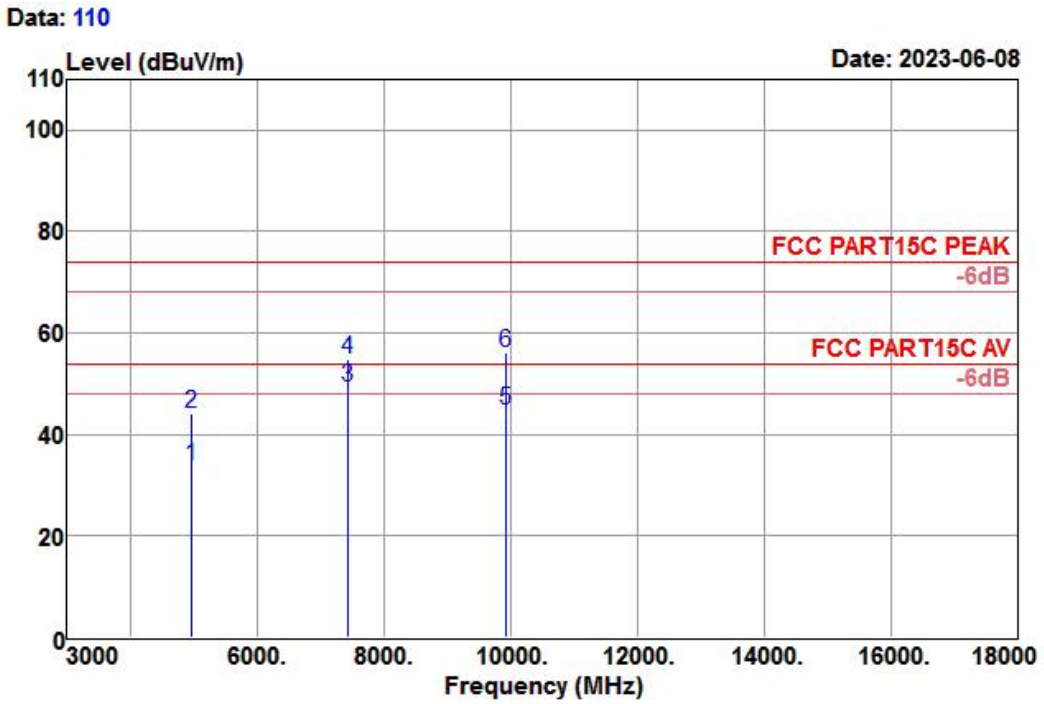
Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
4960.000	30.86	31.43	7.56	35.50	34.35	54.00	-19.65	Average
4960.000	42.98	31.43	7.56	35.50	46.47	74.00	-27.53	Peak
7440.000	38.22	36.07	8.97	32.85	50.41	54.00	-3.59	Average
7440.000	44.39	36.07	8.97	32.85	56.58	74.00	-17.42	Peak
9920.000	27.90	38.57	11.98	34.16	44.29	54.00	-9.71	Average
9920.000	39.98	38.57	11.98	34.16	56.37	74.00	-17.63	Peak

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	1GHz~3GHz	Polarization :	Vertical



Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
2480.000	92.23	27.46	4.74	36.19	88.24	74.00	14.24	Peak

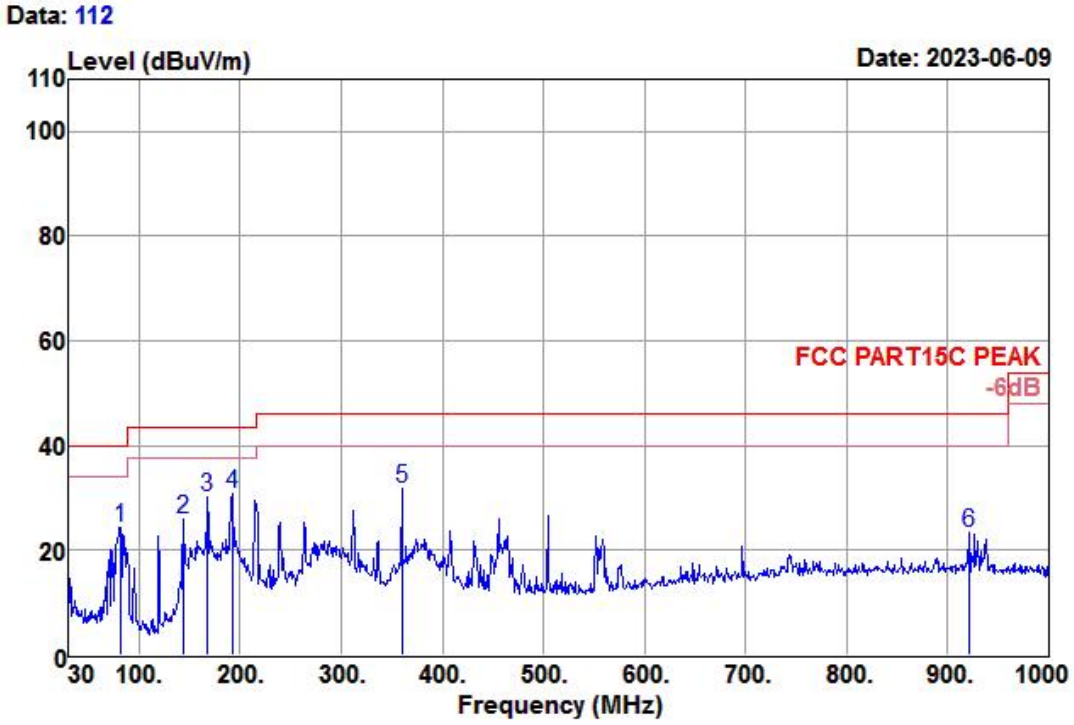
Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	3GHz~18GHz	Polarization :	Vertical



Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
4960.000	30.13	31.43	7.56	35.50	33.62	54.00	-20.38	Average
4960.000	40.73	31.43	7.56	35.50	44.22	74.00	-29.78	Peak
7440.000	37.15	36.07	8.97	32.85	49.34	54.00	-4.66	Average
7440.000	42.79	36.07	8.97	32.85	54.98	74.00	-19.02	Peak
9920.000	28.55	38.57	11.98	34.16	44.94	54.00	-9.06	Average
9920.000	39.75	38.57	11.98	34.16	56.14	74.00	-17.86	Peak

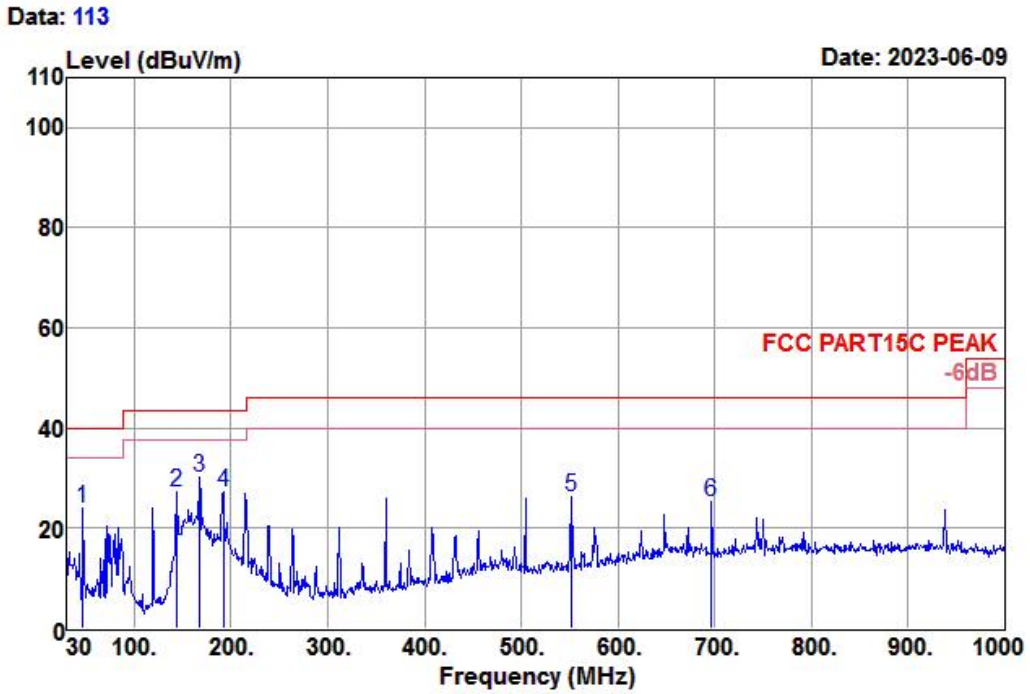
4.5.6 Test Result of Radiated Spurious Emission (30MHz ~ 1GHz)

Test Mode :	BLE CH39 (2480 MHz)	**Temperature :**	21~23℃
Test Engineer :	Jack Liu	**Relative Humidity :**	63~65%
Frequencey Range	30MHz~1GHz	**Polarization :**	Horizontal



Freq	Reading level	Antenna factor	Cable loss	Preamp factor	level	Limit level	Over limit	Remark
MHz	dBuV	dB/m	dB	dB	dBuV/m	dBuV/m	dB	
81.410	46.21	8.98	1.69	32.46	24.42	40.00	-15.58	QP
143.490	42.20	14.02	2.27	32.50	25.99	43.50	-17.51	QP
167.740	46.62	13.61	2.49	32.50	30.22	43.50	-13.28	QP
191.990	49.77	10.96	2.66	32.50	30.89	43.50	-12.61	QP
359.800	46.24	14.35	3.67	32.58	31.68	46.00	-14.32	QP
921.430	27.89	22.33	6.28	33.12	23.38	46.00	-22.62	QP

Test Mode :	BLE CH39 (2480 MHz)	Temperature :	21~23℃
Test Engineer :	Jack Liu	Relative Humidity :	63~65%
Frequencey Range	30MHz~1GHz	Polarization :	Vertical



Freq MHz	Reading level dBuV	Antenna factor dB/m	Cable loss dB	Preamp factor dB	level dBuV/m	Limit level dBuV/m	Over limit dB	Remark
47.460	40.23	14.91	1.26	32.40	24.00	40.00	-16.00	QP
143.490	43.32	14.02	2.27	32.50	27.11	43.50	-16.39	QP
167.740	46.70	13.61	2.49	32.50	30.30	43.50	-13.20	QP
191.990	46.22	10.96	2.66	32.50	27.34	43.50	-16.16	QP
551.860	36.40	17.68	4.69	32.51	26.26	46.00	-19.74	QP
696.390	32.58	19.81	5.29	32.31	25.37	46.00	-20.63	QP

4.6 AC Conducted Emission Measurement

4.6.1 Limit of AC Conducted Emission

FCC §15.207

For equipment that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz shall not exceed the limits in the following table.

Frequency of emission (MHz)	Conducted limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

4.6.2 Test Procedures

1. The EUT was placed 0.4 meter from the conducting wall of the shielding room was kept at least 80 centimeters from any other grounded conducting surface.
2. Connect EUT to the power mains through a line impedance stabilization network (LISN).
3. All the support units are connecting to the other LISN.
4. The LISN provides 50 ohm coupling impedance for the measuring instrument.
5. The FCC states that a 50 ohm, 50 microhenry LISN should be used.
6. Both sides of AC line were checked for maximum conducted interference.
7. The frequency range from 150 kHz to 30 MHz was searched.
8. Set the test-receiver system to Peak Detect Function and specified bandwidth (IF Bandwidth = 9kHz) with Maximum Hold Mode. Then measurement is also conducted by Average Detector and Quasi-Peak Detector Function respectively.

4.6.3 Test Result of AC Conducted Emission

Not Required

4.7 Antenna Requirements

4.7.1 Standard Applicable

According to antenna requirement of §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. The manufacturer may design the unit so that a broken antenna can be re-placed by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to carrier current devices or to devices operated under the provisions of Sections 15.211, 15.213, 15.217, 15.219, or 15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with Section 15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this Part are not exceeded..

And according to §15.247(4)(1), system operating in the 2400-2483.5MHz bands that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6dBi.

4.7.2 Antenna Connected Construction

An PCB antenna design is used.

4.7.3 Antenna Gain

The antenna peak gain of EUT is less than 6 dBi. Therefore, it is not necessary to reduce maximum peak output power limit.

5. List of Measuring Equipment

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
Spectrum Analyzer	Keysight	N9010A	MY56070788	2022-12-26	2023-12-25	Conducted
Power Sensor	Keysight	U2021XA	MY56510025	2022-12-27	2023-12-26	Conducted
Power Sensor	Keysight	U2021XA	MY57030005	2022-12-27	2023-12-26	Conducted
Power Sensor	Keysight	U2021XA	MY56510018	2022-12-27	2023-12-26	Conducted
Power Sensor	Keysight	U2021XA	MY56480002	2022-12-27	2023-12-26	Conducted
Thermal Chamber	Howkin	UHL-34	19111801	2022-12-23	2023-12-22	Conducted
Base Station	R&S	CMW 270	101231	2022-12-26	2023-12-25	Conducted
Signal Generator (Interferer)	Keysight	N5182B	MY56200384	2022-12-26	2023-12-25	Conducted
Signal Generator (Blocker)	Keysight	N5171B	MY56200661	2022-12-26	2023-12-25	Conducted

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
Spectrum Analyzer	R&S	FSV 40	101433	2022-12-26	2023-12-25	Radiation
Amplifier	Sonoma	310	363917	2022-12-26	2023-12-25	Radiation
Amplifier	Schwarzbeck	BBV 9718	327	2022-12-27	2023-12-26	Radiation
Amplifier	Narda	TTA1840-35-HG	2034380	2023-01-04	2024-01-03	Radiation
Loop Antenna	Schwarzbeck	FMZB 1519B	1519B-051	2023-02-12	2026-02-11	Radiation
Broadband Antenna	Schwarzbeck	VULB 9168	9168-757	2020-09-27	2023-09-26	Radiation
Horn Antenna	Schwarzbeck	BBHA 9120 D	1677	2023-02-12	2026-02-11	Radiation
Horn Antenna	COM-POWER	AH-1840	101117	2021-06-05	2024-06-04	Radiation
Test Software	Audix	E3	6.111221a	N/A	N/A	Radiation
Filter	Micro-Tronics	BRM 50702	G266	N/A	N/A	Radiation

Instrument	Manufacturer	Model No.	Serial No.	Calibration Date	Due Date	Remark
LISN	R&S	ENV216	102125	2022-12-19	2023-12-20	Conducted
LISN	R&S	ENV432	101327	2022-12-19	2023-12-20	Conducted
EMI Test Receiver	R&S	ESR3	102143	2022-12-19	2023-12-20	Conducted
EMI Test Software	Audix	E3	N/A	N/A	N/A	Conducted

N/A: No Calibration Required

6. Uncertainty of Evaluation

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the EUT as specified in CISPR 16-4-2:

MEASUREMENT	FREQUENCY	UNCERTAINTY
Conducted emissions	9kHz~30MHz	2.00 dB
Radiated emission	30MHz ~ 1GMHz	5.28 dB
	1GHz ~ 18GHz	5.12 dB
	18GHz ~ 40GHz	5.27 dB

MEASUREMENT	UNCERTAINTY
Occupied Channel Bandwidth	±71.333Hz
RF output power, conducted	±0.78 dB
Power density, conducted	±2.02dB
Emissions, conducted	±2.00dB

This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=2.

Appendix A: DTS Bandwidth

Test Result

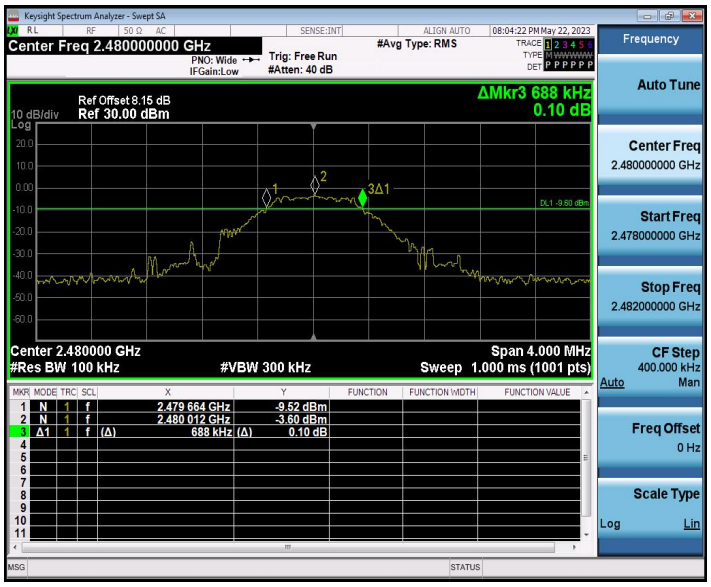
TestMode	Antenna	Channel	DTS BW [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	0.716	2401.648	2402.364	0.5	PASS
		2440	0.668	2439.672	2440.340	0.5	PASS
		2480	0.688	2479.664	2480.352	0.5	PASS

Test Graphs

BLE_1M_Ant1_2402

BLE_1M_Ant1_2440

BLE_1M_Ant1_2480


Keysight Spectrum Analyzer - Swept SA
Center Freq 2.480000000 GHz
PNO: Wide
IFGain:Low
Trig: Free Run
#Atten: 40 dB
#Avg Type: RMS
08:04:22 PM May 22, 2023
Frequency
Auto Tune
Ref Offset 8.15 dB
10 dB/div
Ref 30.00 dBm
ΔMkr3 688 kHz
0.10 dB
Center Freq
2.480000000 GHz
Start Freq
2.478000000 GHz
Stop Freq
2.482000000 GHz
Center 2.480000 GHz
#Res BW 100 kHz
#VBW 300 kHz
Span 4.000 MHz
Sweep 1.000 ms (1001 pts)
CF Step
400.000 kHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin
1 N 1 f 2.479 664 GHz -9.52 dBm
2 N 1 f 2.480 012 GHz -3.60 dBm
3 Δ1 1 f (Δ) 688 kHz (Δ) 0.10 dB

Appendix B: Occupied Channel Bandwidth

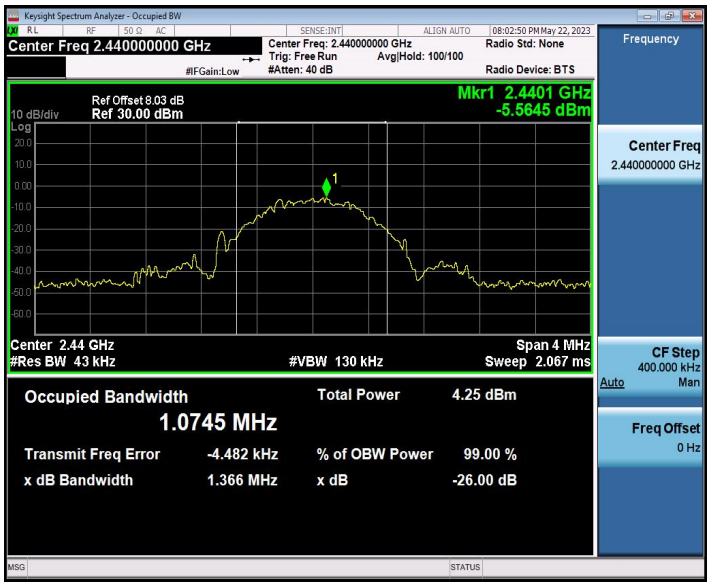
Test Result

TestMode	Antenna	Channel	OCB [MHz]	FL[MHz]	FH[MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	1.0487	2401.4873	2402.5360	---	PASS
		2440	1.0745	2439.4583	2440.5328	---	PASS
		2480	1.0464	2479.4894	2480.5358	---	PASS

Test Graphs

BLE_1M_Ant1_2402

BLE_1M_Ant1_2440



BLE_1M_Ant1_2480


Keysight Spectrum Analyzer - Occupied BW
Center Freq 2.480000000 GHz
Center Freq: 2.480000000 GHz
Trig: Free Run
Avg|Hold: 100/100
#IFGain:Low
#Atten: 40 dB
Radio Std: None
Radio Device: BTS
Frequency
Ref Offset 8.15 dB
10 dB/div
Ref 30.00 dBm
Log
Mkr1 2.479996 GHz
-5.8072 dBm
Center Freq
2.480000000 GHz
Center 2.48 GHz
#Res BW 43 kHz
#VBW 130 kHz
Span 4 MHz
Sweep 2.067 ms
CF Step
400.000 kHz
Auto
Man
Freq Offset
0 Hz
Occupied Bandwidth
1.0464 MHz
Total Power
4.17 dBm
Transmit Freq Error
12.639 kHz
% of OBW Power
99.00 %
x dB Bandwidth
1.440 MHz
x dB
-26.00 dB
MSG
STATUS

Appendix C: Maximum conducted output power

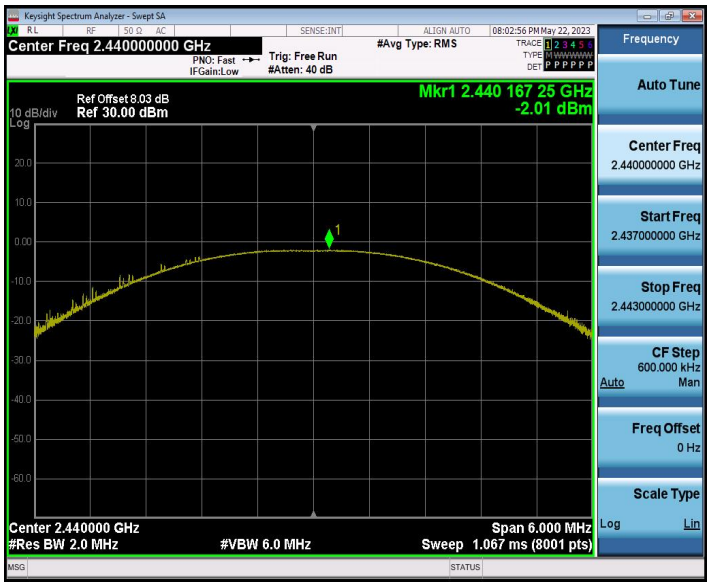
Test Result

TestMode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	2402	-1.8	≤30	PASS
		2440	-2.01	≤30	PASS
		2480	-1.97	≤30	PASS

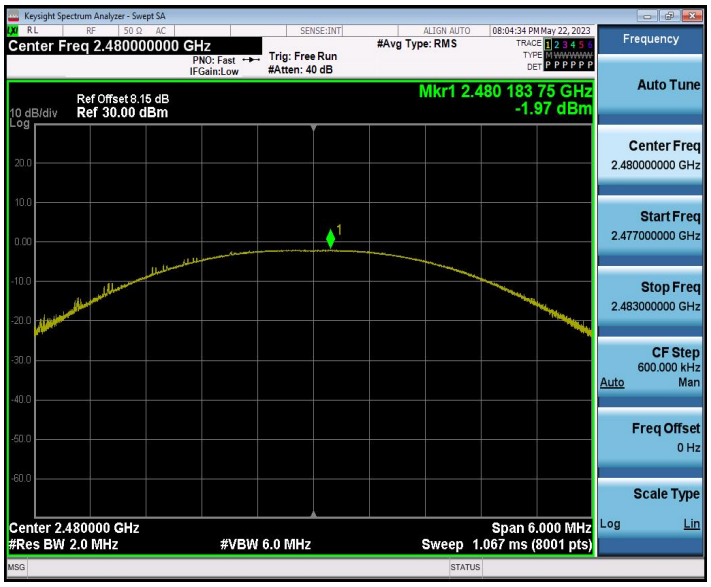
Test Graphs

BLE_1M_Ant1_2402

BLE_1M_Ant1_2440



BLE_1M_Ant1_2480


Keysight Spectrum Analyzer - Swept SA
Center Freq 2.480000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 40 dB
#Avg Type: RMS
08:04:34 PM May 22, 2023
Frequency
Auto Tune
Ref Offset 8.15 dB
10 dB/div
Ref 30.00 dBm
Log
Mkr1 2.480 183 75 GHz
-1.97 dBm
Center Freq
2.480000000 GHz
Start Freq
2.477000000 GHz
Stop Freq
2.483000000 GHz
CF Step
600.000 kHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin
Center 2.480000 GHz
#Res BW 2.0 MHz
#VBW 6.0 MHz
Span 6.000 MHz
Sweep 1.067 ms (8001 pts)
MSG
STATUS

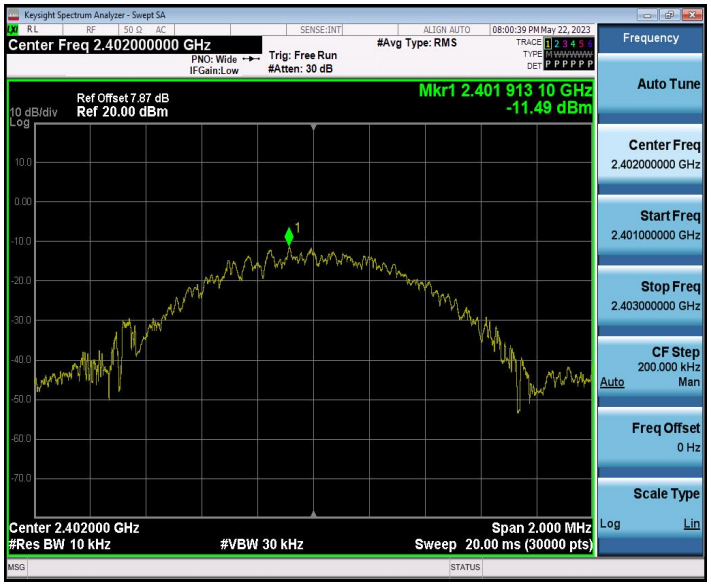
Appendix D: Maximum power spectral density

Test Result

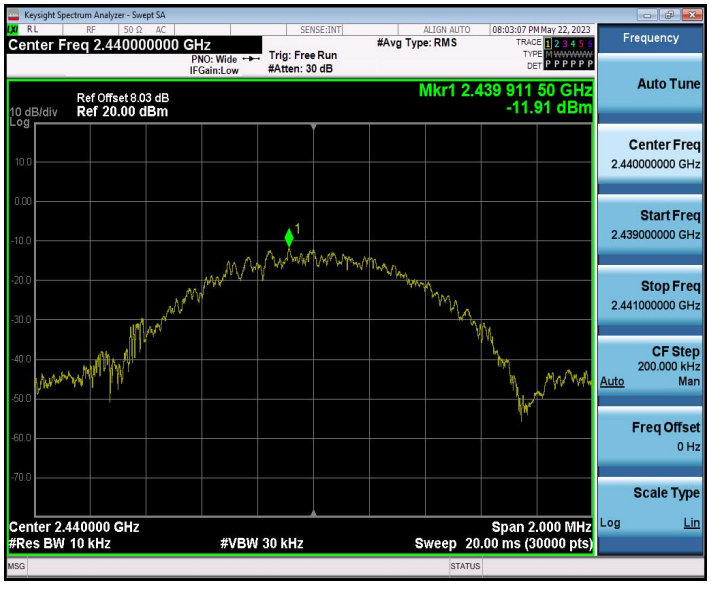
TestMode	Antenna	Channel	Result [dBm/10kHz]	Result [dBm/3kHz]	Limit[dBm/3kHz]	Verdict
BLE_1M	Ant1	2402	-11.49	-16.72	≤8.00	PASS
		2440	-11.91	-17.14	≤8.00	PASS
		2480	-11.61	-16.84	≤8.00	PASS

Test Graphs

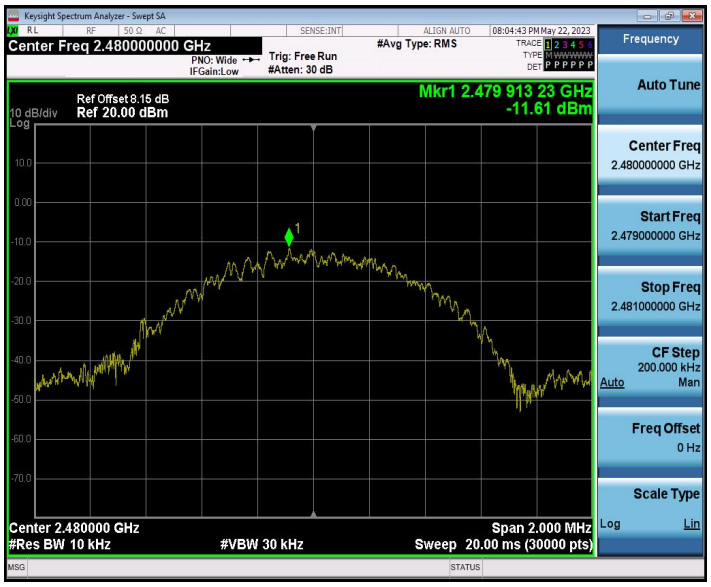
BLE_1M_Ant1_2402



BLE_1M_Ant1_2440



BLE_1M_Ant1_2480


Keysight Spectrum Analyzer - Swept SA
Center Freq 2.480000000 GHz
PNO: Wide
IFGain:Low
Trig: Free Run
#Atten: 30 dB
#Avg Type: RMS
08:04:43 PM May 22, 2023
Frequency
Auto Tune
Ref Offset 8.15 dB
10 dB/div
Ref 20.00 dBm
Log
Mkr1 2.479 913 23 GHz
-11.61 dBm
Center Freq
2.480000000 GHz
Start Freq
2.479000000 GHz
Stop Freq
2.481000000 GHz
CF Step
200.000 kHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin
Center 2.480000 GHz
#Res BW 10 kHz
#VBW 30 kHz
Span 2.000 MHz
Sweep 20.00 ms (30000 pts)
MSG
STATUS

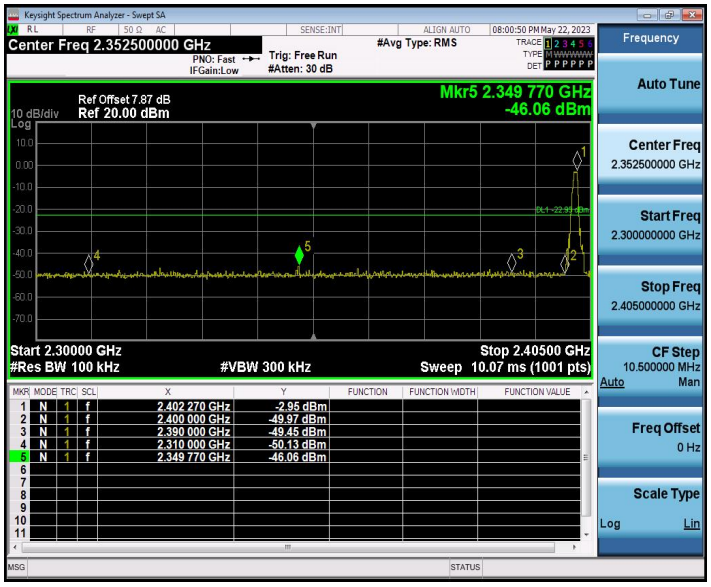
Appendix E: Band edge measurements

Test Result

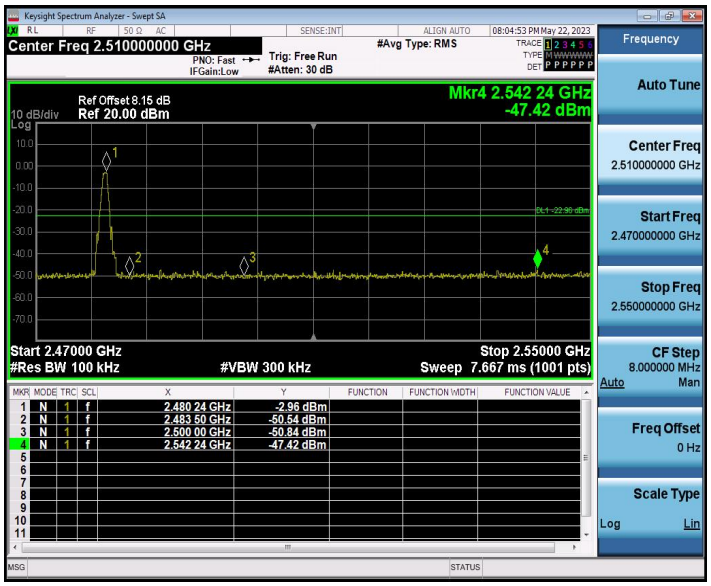
TestMode	Antenna	ChName	Channel	RefLevel[dBm]	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	Low	2402	-2.95	-46.06	≤-22.95	PASS
		High	2480	-2.96	-47.42	≤-22.96	PASS

Test Graphs

BLE_1M_Ant1_Low_2402



BLE_1M_Ant1_High_2480



Appendix F: Conducted Spurious Emission

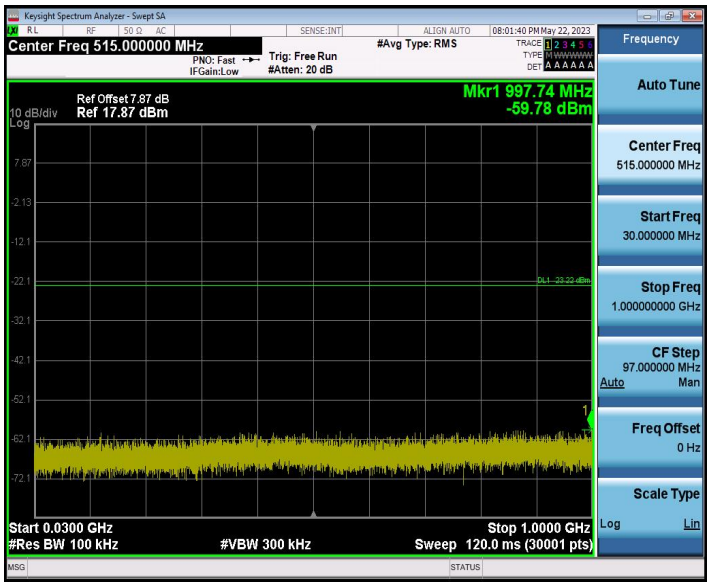
Test Result

TestMode	Antenna	Channel	FreqRange [MHz]	RefLevel [dBm]	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	2402	Reference	-3.22	-3.22	---	PASS
			30~1000	-3.22	-59.78	≤-23.22	PASS
			1000~26500	-3.22	-39.23	≤-23.22	PASS
		2440	Reference	-3.94	-3.94	---	PASS
			30~1000	-3.94	-59.19	≤-23.94	PASS
			1000~26500	-3.94	-38.71	≤-23.94	PASS
		2480	Reference	-4.22	-4.22	---	PASS
			30~1000	-4.22	-59.04	≤-24.22	PASS
			1000~26500	-4.22	-37.92	≤-24.22	PASS

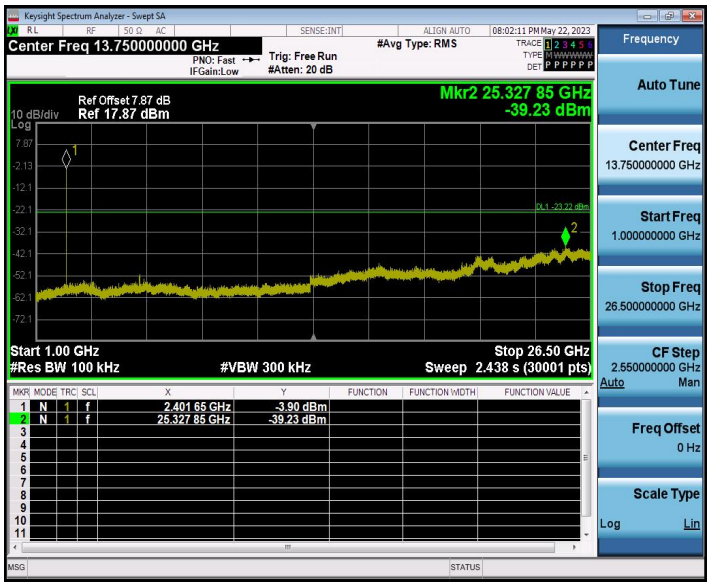
Test Graphs

BLE_1M_Ant1_2402_0~Reference

BLE_1M_Ant1_2402_30~1000

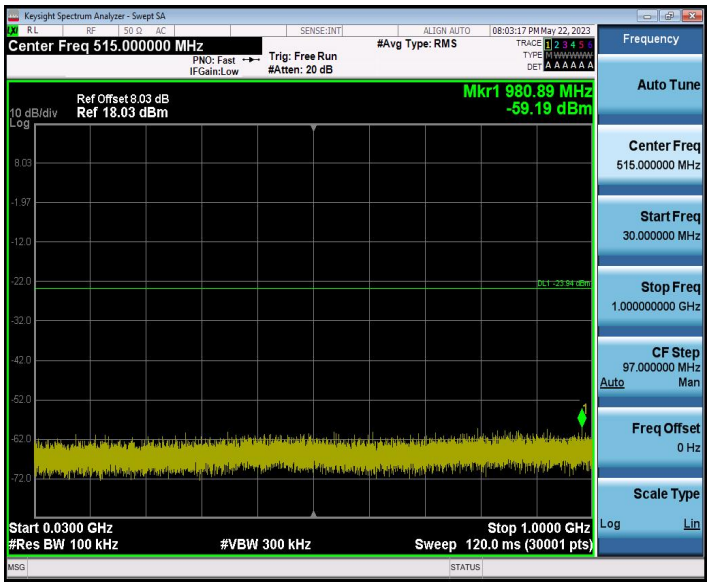


BLE_1M_Ant1_2402_1000~26500

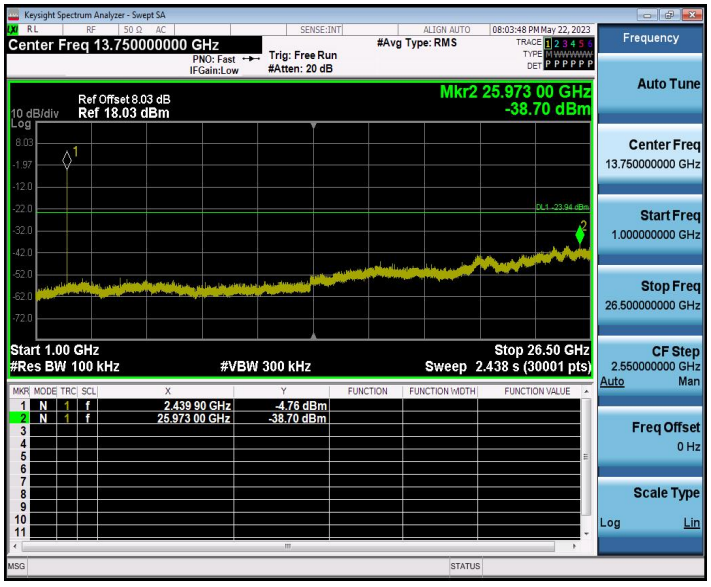


BLE_1M_Ant1_2440_0~Reference

BLE_1M_Ant1_2440_30~1000

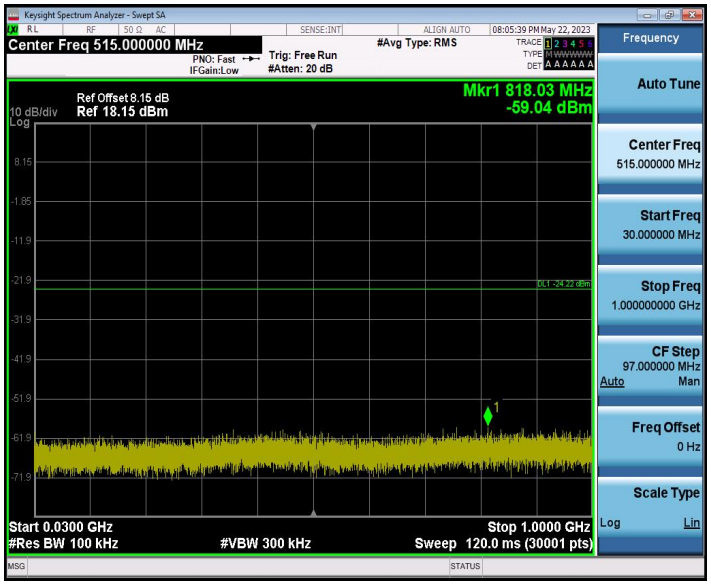


BLE_1M_Ant1_2440_1000~26500

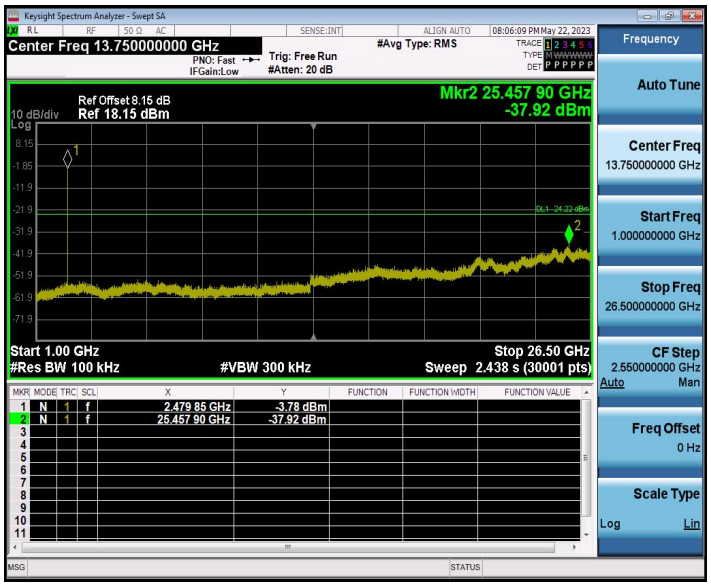


BLE_1M_Ant1_2480_0~Reference

BLE_1M_Ant1_2480_30~1000



BLE_1M_Ant1_2480_1000~26500


Keysight Spectrum Analyzer - Swept SA
Center Freq 13.750000000 GHz
PNO: Fast
IFGain:Low
Trig: Free Run
#Atten: 20 dB
#Avg Type: RMS
08:06:09 PM May 22, 2023
Ref Offset 8.15 dB
10 dB/div
Ref 18.15 dBm
Mkr2 25.457 90 GHz
-37.92 dBm
Start 1.00 GHz
#Res BW 100 kHz
#VBW 300 kHz
Stop 26.50 GHz
Sweep 2.438 s (30001 pts)
1 N 1 f 2.479 85 GHz -3.78 dBm
2 N 1 f 25.457 90 GHz -37.92 dBm
Frequency
Auto Tune
Center Freq
13.750000000 GHz
Start Freq
1.000000000 GHz
Stop Freq
26.500000000 GHz
CF Step
2.550000000 GHz
Auto
Man
Freq Offset
0 Hz
Scale Type
Log
Lin