FCC RADIO TEST REPORT

FCC ID	:	**2A7ZY-M811-TX**
Equipment	:	**Minder 811**
Brand Name	:	**Two-Commas**
Model Name	:	**M811**
Applicant	:	**Two Commas llc** **2576 Barona Street, West Sacramento** **CA 95691**
Manufacturer	:	**Two Commas llc** **2576 Barona Street, West Sacramento** **CA 95691**
Standard	:	**FCC Part 15 Subpart C §15.247**

The product was received on Jul. 08, 2022 and testing was performed from Jul. 19, 2022 to Jul. 27, 2022. We, Sporton International (USA) Inc., would like to declare that the tested sample has been evaluated in accordance with the test procedures and has been in compliance with the applicable technical standards.

The test results in this report apply exclusively to the tested model / sample. Without written approval from Sporton International (USA) Inc., the test report shall not be reproduced except in full.

Neil Kao

Approved by: Neil Kao

Sporton International (USA) Inc.

1175 Montague Expressway, Milpitas, CA 95035

Table of Contents

History of this test report **3**
Summary of Test Result **4**
1 General Description **5**
1.1 Product Feature of Equipment Under Test 5
1.2 Modification of EUT 5
1.3 Testing Location 6
1.4 Applicable Standards 6
2 Test Configuration of Equipment Under Test **7**
2.1 Carrier Frequency Channel 7
2.2 Test Mode 8
2.3 Connection Diagram of Test System 9
2.4 Support Unit used in test configuration and system 9
2.5 EUT Operation Test Setup 10
2.6 Measurement Results Explanation Example 10
3 Test Result **11**
3.1 6dB and 99% Bandwidth Measurement 11
3.2 Output Power Measurement 14
3.3 Power Spectral Density Measurement 15
3.4 Conducted Band Edges and Spurious Emission Measurement 18
3.5 Radiated Band Edges and Spurious Emission Measurement 22
3.6 Antenna Requirements 26
4 List of Measuring Equipment **27**
5 Uncertainty of Evaluation **28**
Appendix A. Conducted Test Results
Appendix B. Radiated Spurious Emission
Appendix C. Radiated Spurious Emission Plots
Appendix D. Duty Cycle Plots
Appendix E. Setup Photographs

History of this test report

Report No.	Version	Description	Issue Date
FR220714005	01	Initial issue of report	Aug. 15, 2022

Summary of Test Result

Report Clause	Ref Std. Clause	Test Items	Result (PASS/FAIL)	Remark
3.1	15.247(a)(2)	6dB Bandwidth	Pass	-
3.1	2.1049	99% Occupied Bandwidth	Reporting only	-
3.2	15.247(b)(3)	Output Power	Pass	-
3.3	15.247(e)	Power Spectral Density	Pass	-
3.4	15.247(d)	Conducted Band Edges and Spurious Emission	Pass	-
3.5	15.247(d)	Radiated Band Edges and Spurious Emission	Pass	7.89 dB under the limit at 7440.000 MHz
-	15.207	AC Conducted Emission	Not Required	See Note 2
3.6	15.203 & 15.247(b)	Antenna Requirement	Pass	-

Note:

1. Not required means after assessing, test items are not necessary to carry out.

2. The EUT is powered by batteries which is deemed DC power source, it does not operate from the AC power lines or contain provisions for operation while connected to the AC power lines, according to 47 CFR §15.207(c), the conducted emission limits are not applicable to the device hence the test is not performed.

Conformity Assessment Condition:
1. The test results (PASS/FAIL) with all measurement uncertainty excluded are presented against the regulation limits or in accordance with the requirements stipulated by the applicant/manufacturer who shall bear all the risks of non-compliance that may potentially occur if measurement uncertainty is taken into account. 2. Please refer to the section ” Uncertainty of Evaluation ” for measurement uncertainty.
Comments and Explanations:
The product specifications of the EUT presented in the report are declared by the manufacturer who shall take full responsibility for the authenticity.

1 General Description

1.1 Product Feature of Equipment Under Test

Bluetooth-LE

Product Feature	
EUT Stage	Identical Prototype
Antenna Type	Bluetooth-LE: Ceramic Antenna

Remark: The EUT's information above is declared by manufacturer. Please refer to Comments and Explanations in report summary.

1.2 Modification of EUT

No modifications made to the EUT during the testing.

1.3 Testing Location

Test Site	Sporton International (USA) Inc.
Test Site Location	1175 Montague Expressway, Milpitas, CA 95035 TEL : 408 9043300
Test Site No.	**Sporton Site No.**
	TH01-CA, 03CH02-CA

Note: The test site complies with ANSI C63.4 2014 requirement.

FCC Designation No.: US 1250

1.4 Applicable Standards

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

- FCC Part 15 Subpart C §15.247
- FCC KDB Publication No. 558074 D01 DTS Meas. Guidance v05r02
- FCC KDB 414788 D01 Radiated Test Site v01r01
- ANSI C63.10-2013

Remark:

1. All the test items were validated and recorded in accordance with the standards without any modification during the testing.
2. This EUT has also been tested and complied with the requirements of FCC Part 15, Subpart B, recorded in a separate test report.

2 Test Configuration of Equipment Under Test

2.1 Carrier Frequency Channel

Frequency Band	Channel	Freq. (MHz)	Channel	Freq. (MHz)
2400-2483.5 MHz	0	2402	21	2444
	1	2404	22	2446
	2	2406	23	2448
	3	2408	24	2450
	4	2410	25	2452
	5	2412	26	2454
	6	2414	27	2456
	7	2416	28	2458
	8	2418	29	2460
	9	2420	30	2462
	10	2422	31	2464
	11	2424	32	2466
	12	2426	33	2468
	13	2428	34	2470
	14	2430	35	2472
	15	2432	36	2474
	16	2434	37	2476
	17	2436	38	2478
	18	2438	39	2480
	19	2440	-	-
	20	2442	-	-

2.2 Test Mode

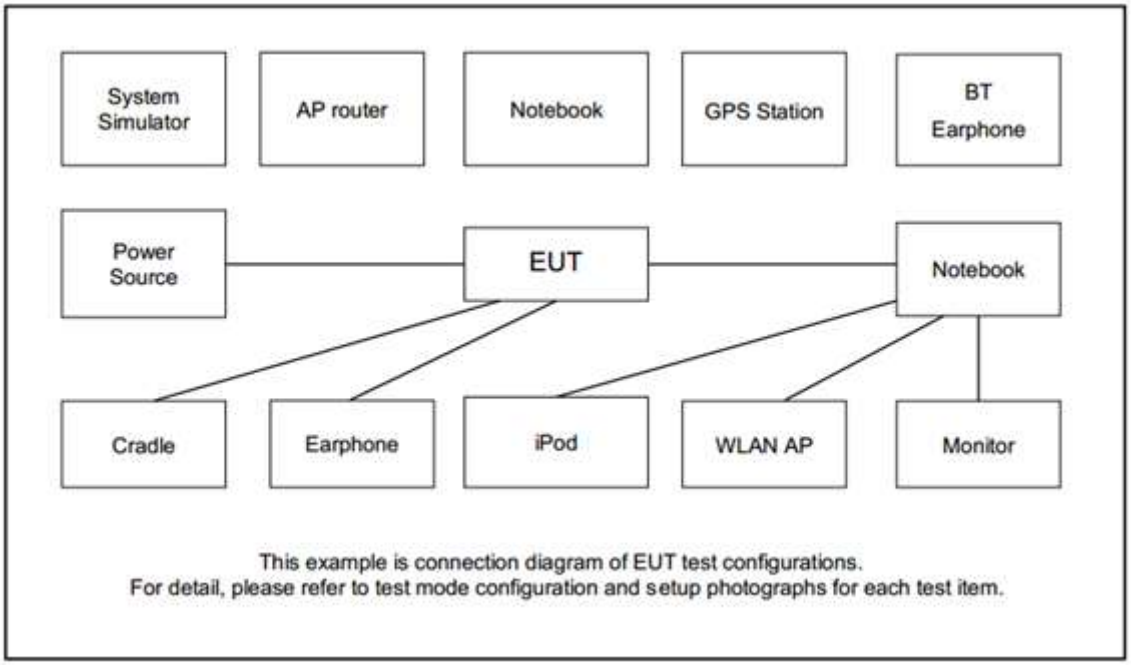
a. The EUT has been associated with peripherals and configuration operated in a manner tended to maximize its emission characteristics in a typical application. Frequency range investigated: radiation emission (9 kHz to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower). For radiated measurement, the measured emission level of the EUT was maximized by rotating the EUT on a turntable, adjusting the orientation of the EUT and EUT antenna in three orthogonal axis (X: flat, Y: portrait, Z: landscape), and adjusting the measurement antenna orientation, following C63.10 exploratory test procedures and find X plane as worst plane.

b. AC power line Conducted Emission was tested under maximum output power.

The following summary table is showing all test modes to demonstrate in compliance with the standard.

Summary table of Test Cases	
Test Item	**Data Rate / Modulation**
Conducted Test Cases	**Bluetooth – LE / GFSK**
	Mode 1: Bluetooth Tx CH00_2402 MHz_1Mbps Mode 2: Bluetooth Tx CH19_2440 MHz_1Mbps Mode 3: Bluetooth Tx CH39_2480 MHz_1Mbps
Radiated Test Cases	Mode 1: Bluetooth Tx CH00_2402 MHz_1Mbps Mode 2: Bluetooth Tx CH19_2440 MHz_1Mbps Mode 3: Bluetooth Tx CH39_2480 MHz_1Mbps

2.3 Connection Diagram of Test System



2.4 Support Unit used in test configuration and system

Item	Equipment	Brand Name	Model Name	FCC ID	Data Cable	Power Cord
1.	Notebook	ACER	Altos PS548-G1	N/A	N/A	AC I/P: Unshielded, 1.2 m DC O/P: Shielded, 1.8 m

2.5 EUT Operation Test Setup

The RF test items, utility “nRF connect for Desktop V3.11.1” was installed in Notebook which was programmed in order to make the EUT get into the engineering modes to provide channel selection, power level, data rate and the application type and for continuous transmitting signals.

2.6 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 4.2 dB and 10 dB attenuator.

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

= 4.2 + 10 = 14.2 (dB)

3 Test Result

3.1 6dB and 99% Bandwidth Measurement

3.1.1 Limit of 6dB and 99% Bandwidth

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

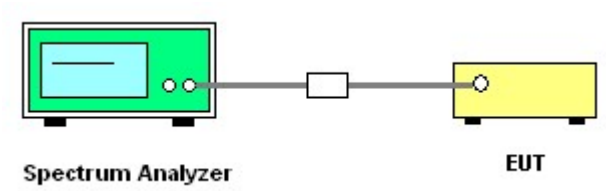
3.1.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.1.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 6.9.3 (OBW) and 11.8.1 (6dB BW).
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to 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 6dB bandwidth must be greater than 500 kHz.
5. For 99% Bandwidth Measurement, the spectrum analyzer's resolution bandwidth (RBW) is set 1-5% of the emission bandwidth and set the Video bandwidth (VBW) ≥ 3 * RBW.
6. Measure and record the results in the test report.

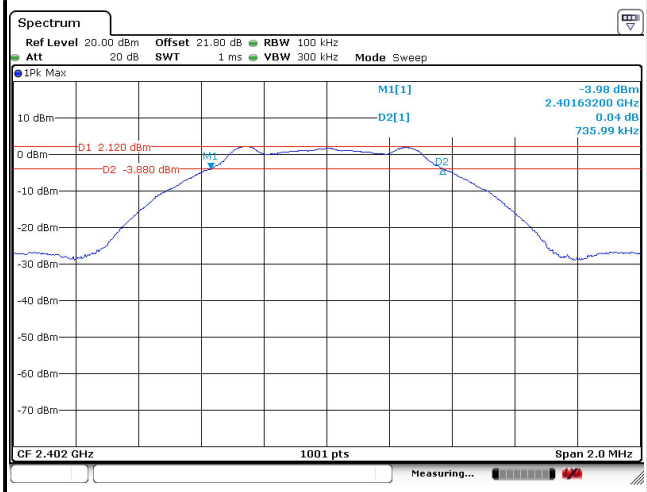
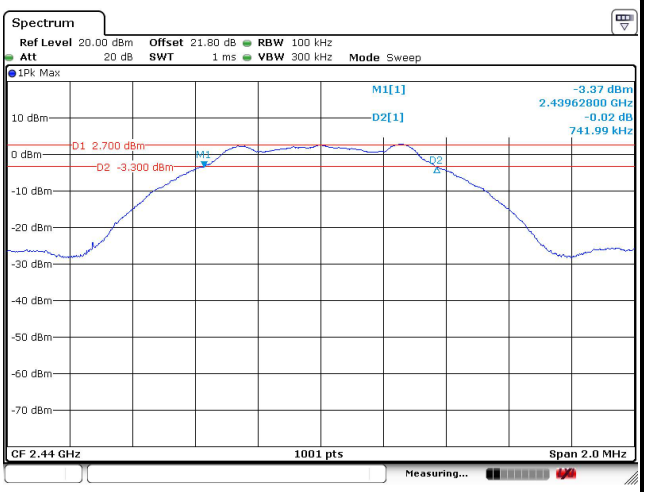
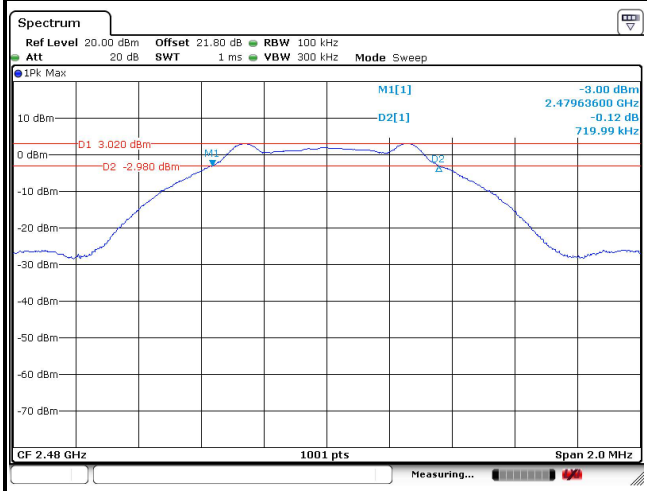
3.1.4 Test Setup



3.1.5 Test Result of 6dB Bandwidth

Please refer to Appendix A.

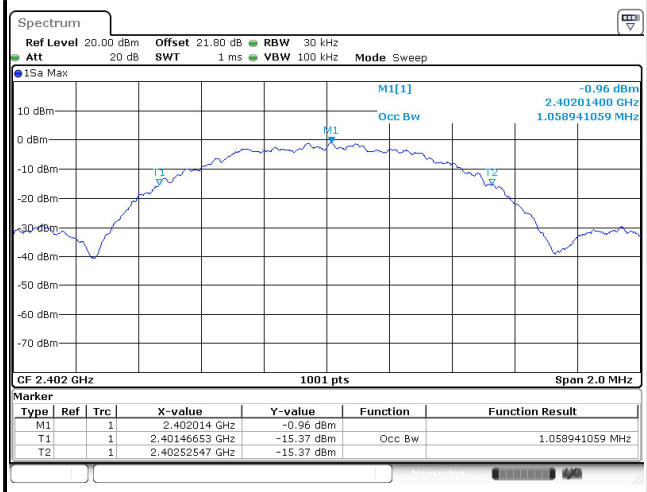
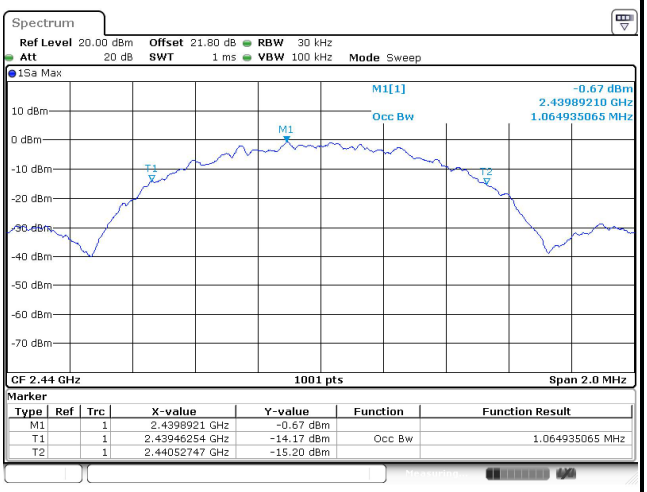
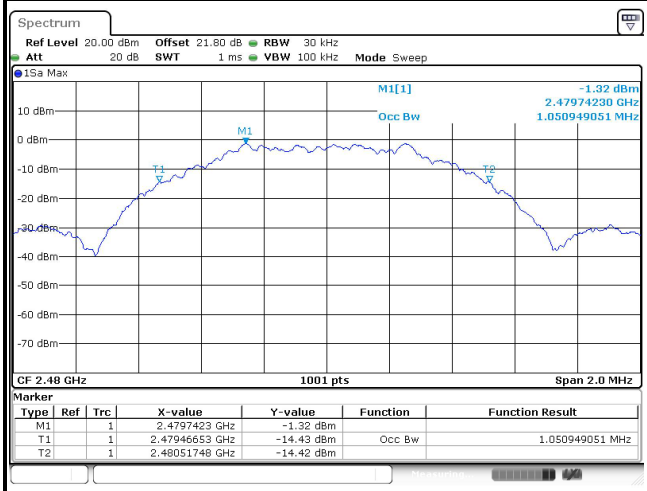
<1Mbps>

6 dB Bandwidth Plot on Channel 00	6 dB Bandwidth Plot on Channel 19
	
6 dB Bandwidth Plot on Channel 39	**N/A**
	

3.1.6 Test Result of 99% Occupied Bandwidth

Please refer to Appendix A.

<1Mbps>

99% Bandwidth Plot on Channel 00	99% Occupied Bandwidth Plot on Channel 19
	
99% Occupied Bandwidth Plot on Channel 39	**N/A**
	

Note: The occupied channel bandwidth is maintained within the band of operation for all of the modulations.

3.2 Output Power Measurement

3.2.1 Limit of Output Power

For systems using digital modulation in the 2400-2483.5 MHz, the limit for output power is 30 dBm. If transmitting antenna of directional gain greater than 6 dBi is used, the peak output power from the intentional radiator shall be reduced below the above stated value by the amount in dB that the directional gain of the antenna exceeds 6 dBi. In case of point-to-point operation, the limit has to be reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

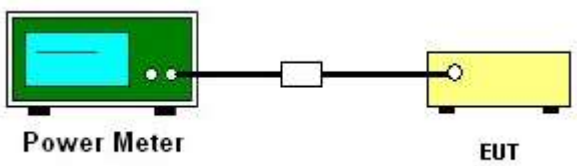
3.2.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.2.3 Test Procedures

1. For Average Power, the testing follows ANSI C63.10 Section 11.9.2.3.2 Method AVGPM-G
2. The RF output of EUT is connected to the power meter by RF cable and attenuator.
3. The path loss is compensated to the results for each measurement.
4. Set the maximum power setting and enable the EUT to transmit continuously.
5. Measure the conducted output power and record the results in the test report.

3.2.4 Test Setup



3.2.5 Test Result of Average Output Power

Please refer to Appendix A.

3.3 Power Spectral Density Measurement

3.3.1 Limit of Power Spectral Density

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

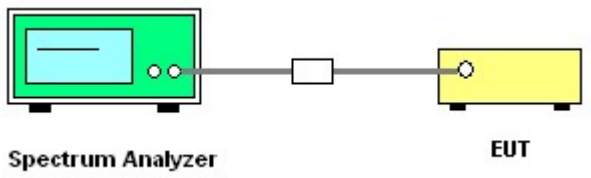
3.3.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.3.3 Test Procedures

1. The testing follows the ANSI C63.10 Section 11.10.2 Method PKPSD.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. 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. (6 dB BW)
5. 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.
6. Measure and record the results in the test report.
7. The Measured power density (dBm)/ 100 kHz is a reference level and is used as 20 dBc down limit line for Conducted Band Edges and Conducted Spurious Emission.

3.3.4 Test Setup

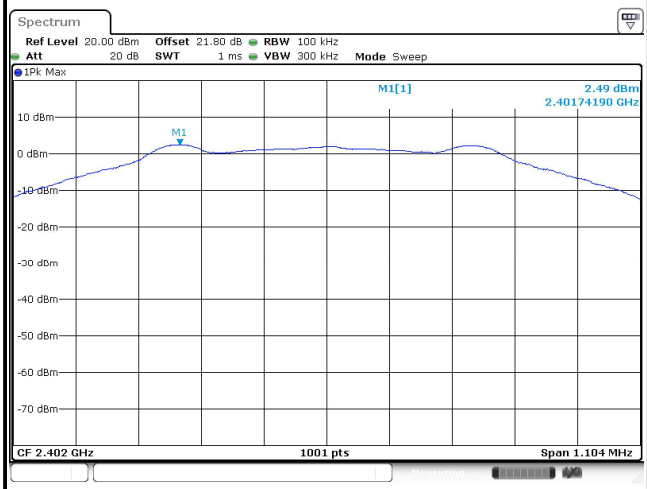
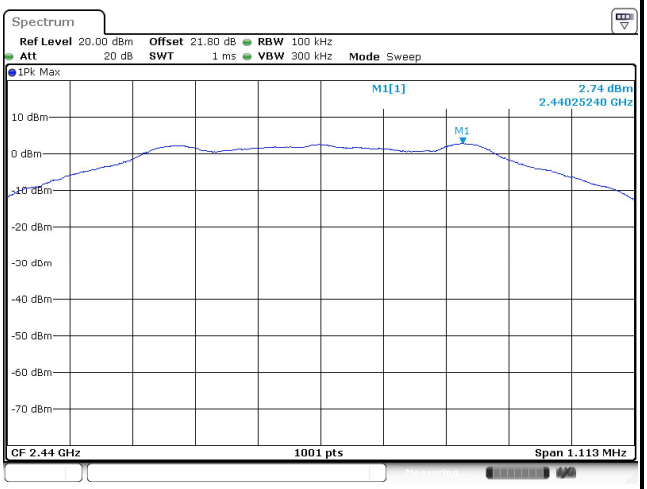
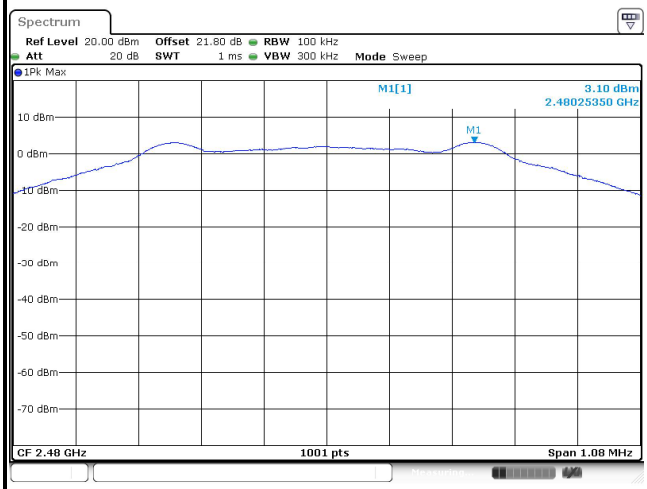


3.3.5 Test Result of Power Spectral Density

Please refer to Appendix A.

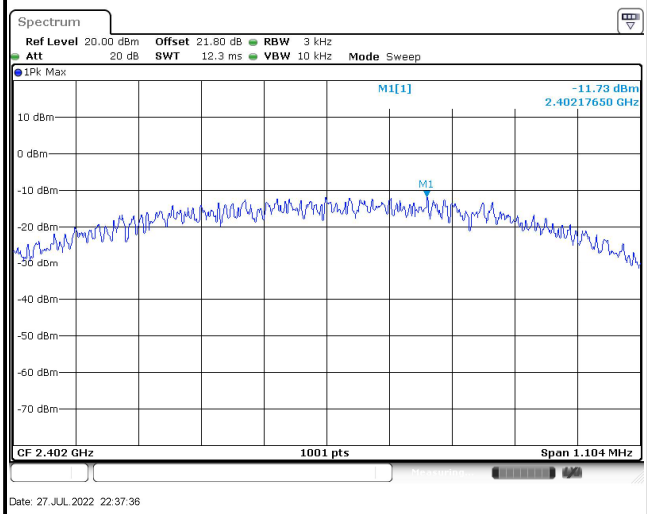
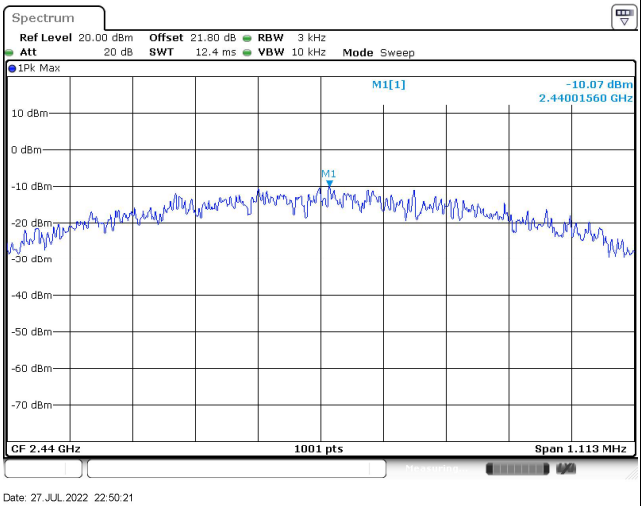
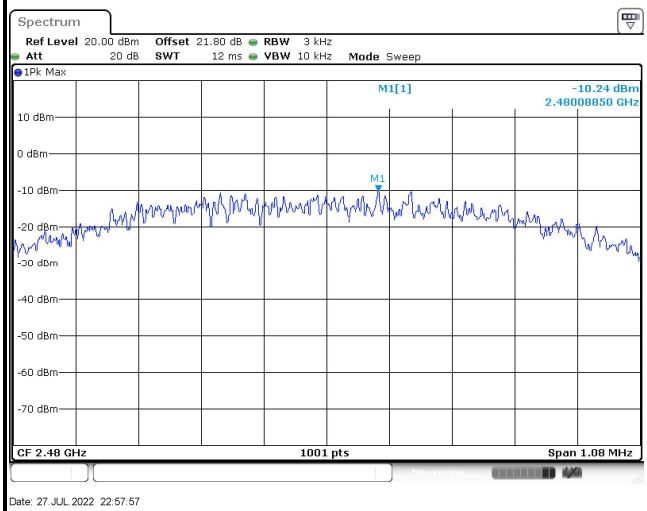
3.3.6 Test Result of Power Spectral Density Plots (100kHz)

<1Mbps>

PSD 100kHz Plot on Channel 00	PSD 100kHz Plot on Channel 19
	
Date: 27.JUL.2022 22:38:20	Date: 27.JUL.2022 22:50:44
PSD 100kHz Plot on Channel 39	**N/A**
	
Date: 27.JUL.2022 22:58:15	

3.3.7 Test Result of Power Spectral Density Plots (3kHz)

<1Mbps>

PSD 3kHz Plot on Channel 00	PSD 3kHz Plot on Channel 19
	
PSD 3kHz Plot on Channel 39	**N/A**
	

3.4 Conducted Band Edges and Spurious Emission Measurement

3.4.1 Limit of Conducted Band Edges and Spurious Emission

All harmonics/spurious must be at least 20 dB down from the highest emission level within the authorized band.

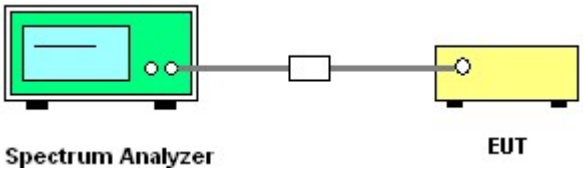
3.4.2 Measuring Instruments

Please refer to the measuring equipment list in this test report.

3.4.3 Test Procedure

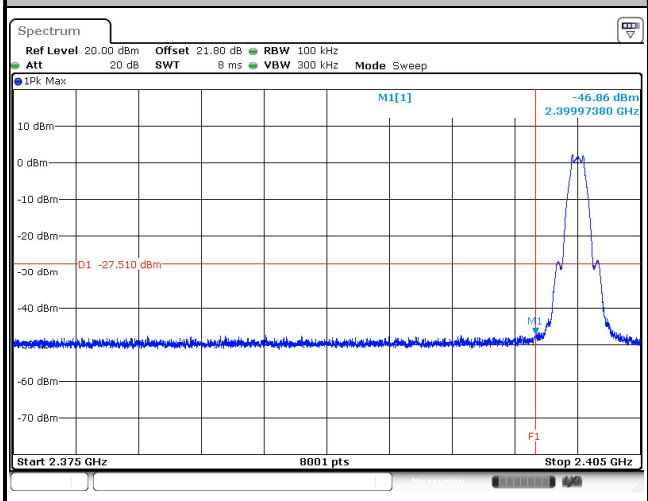
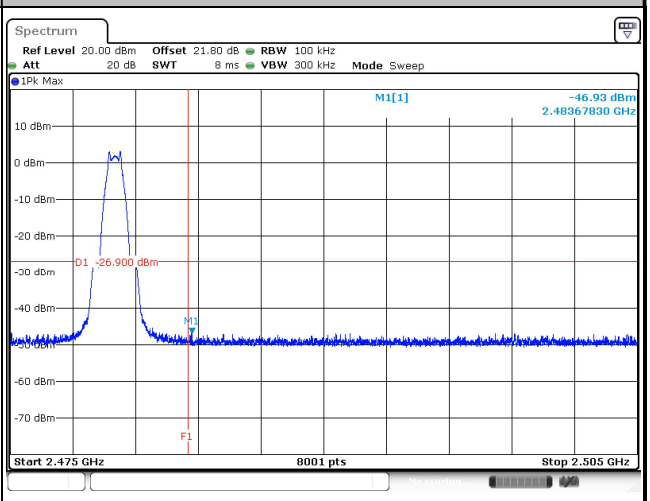
1. The testing follows the ANSI C63.10 Section 11.11.3 Emission level measurement.
2. The RF output of EUT is connected to the spectrum analyzer by RF cable and attenuator. The path loss is compensated to the results for each measurement.
3. Set the maximum power setting and enable the EUT to transmit continuously.
4. 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.
5. Measure and record the results in the test report.
6. The RF fundamental frequency should be excluded against the limit line in the operating frequency band.

3.4.4 Test Setup



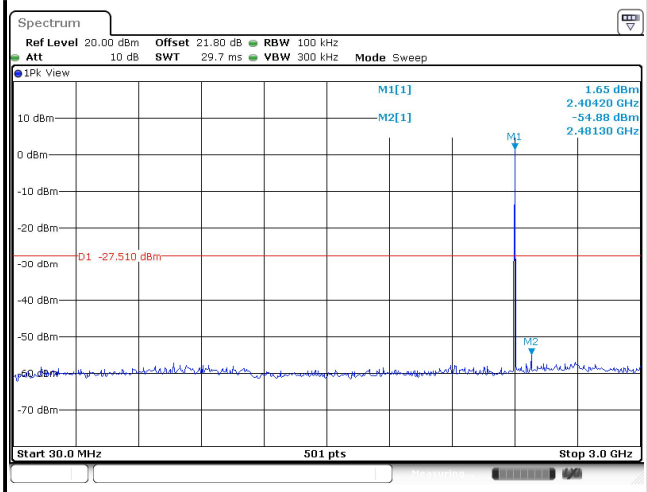
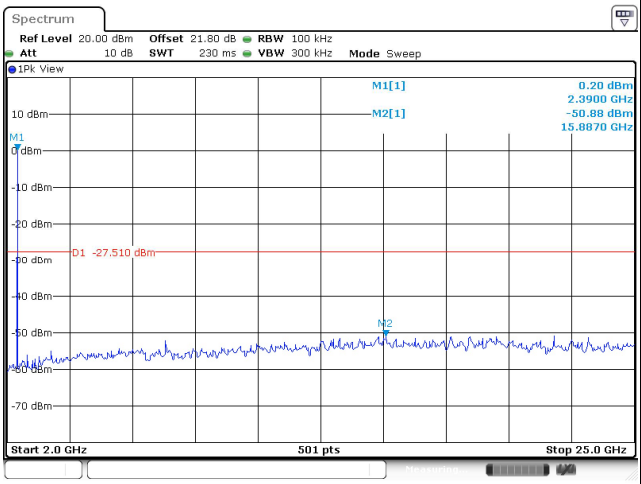
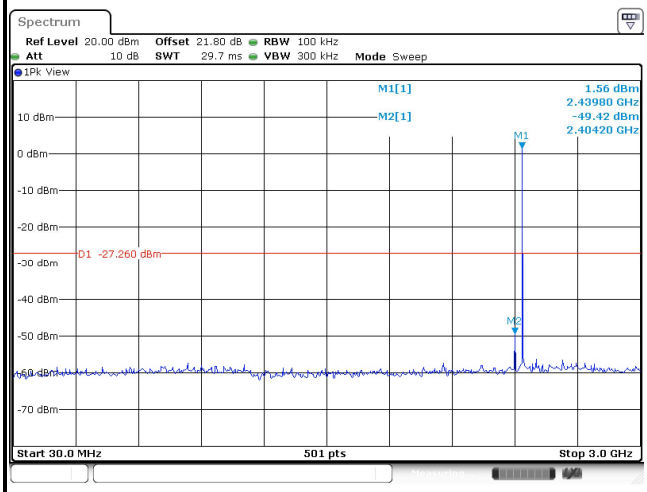
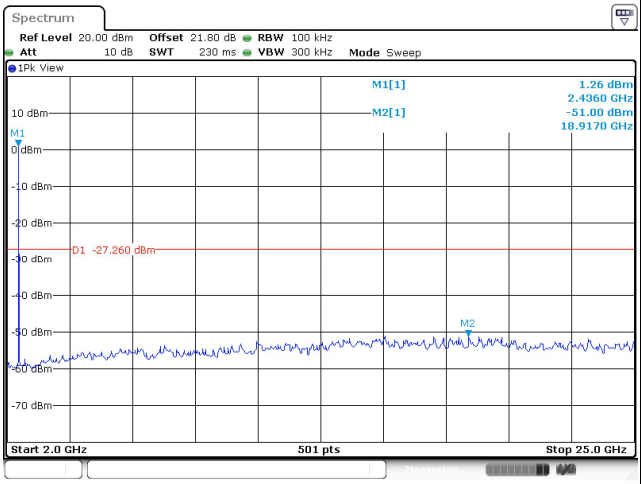
3.4.5 Test Result of Conducted Band Edges Plots

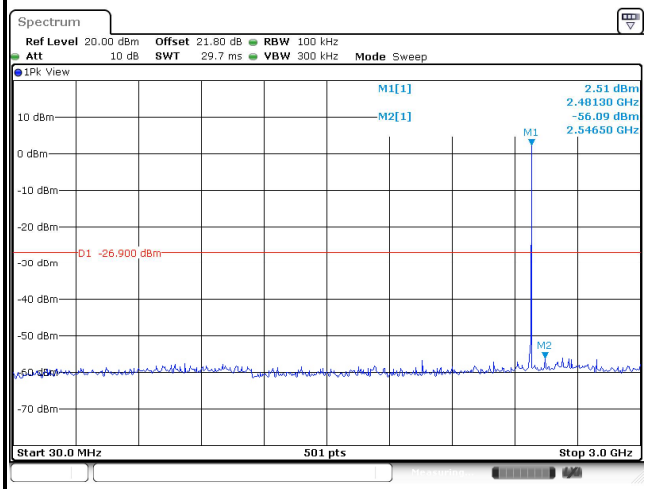
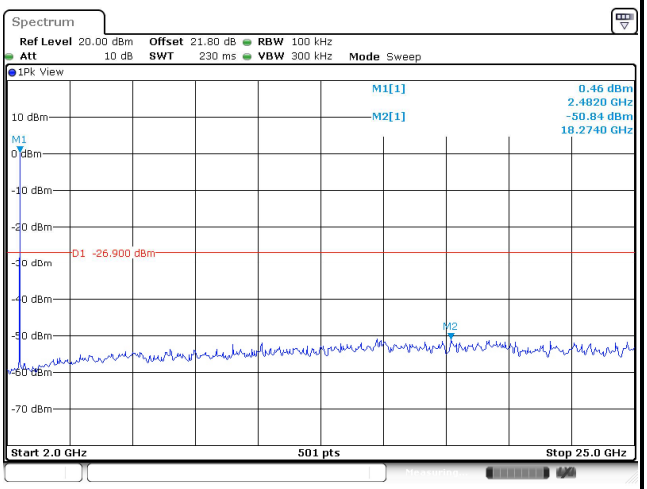
<1Mbps>

Low Band Edge Plot on Channel 00	High Band Edge Plot on Channel 39
	

3.4.6 Test Result of Conducted Spurious Emission Plots

<1Mbps>

Conducted Spurious Emission Plot on Bluetooth LE 1Mbps GFSK Channel 00	Conducted Spurious Emission Plot on Bluetooth LE 1Mbps GFSK Channel 00
	
Conducted Spurious Emission Plot on Bluetooth LE 1Mbps GFSK Channel 19	Conducted Spurious Emission Plot on Bluetooth LE 1Mbps GFSK Channel 19
	

Conducted Spurious Emission Plot on Bluetooth LE 1Mbps GFSK Channel 39	Conducted Spurious Emission Plot on Bluetooth LE 1Mbps GFSK Channel 39
	

3.5 Radiated Band Edges and Spurious Emission Measurement

3.5.1 Limit of Radiated Band Edges and Spurious Emission

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. If the output power of this device is measured by spectrum analyzer, the attenuation under this paragraph shall be 30 dB instead of 20 dB. In addition, radiated emissions which fall in the restricted bands must also comply with the 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

3.5.2 Measuring Instruments

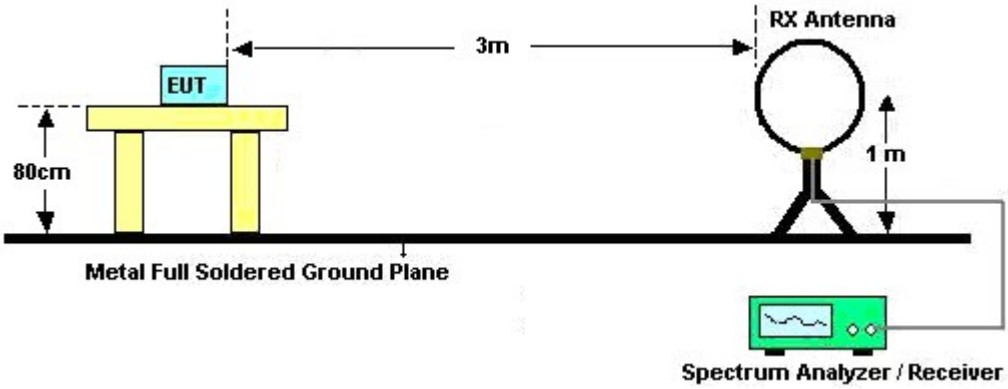
Please refer to the measuring equipment list in this test report.

3.5.3 Test Procedures

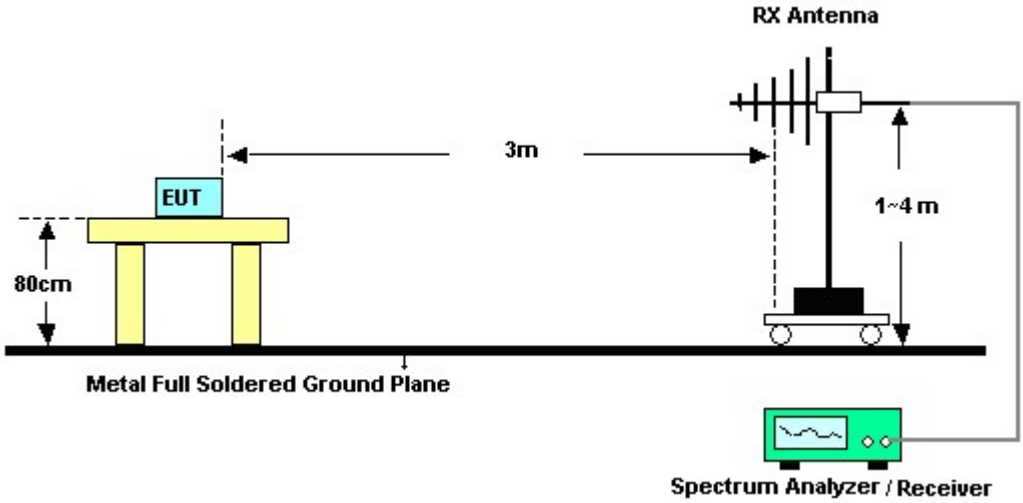
1. The testing follows the ANSI C63.10 Section 11.12.1 Radiated emission measurements.
2. The EUT is arranged to its worst case and then tune the antenna tower (from 1 m to 4 m) and turntable (from 0 degree to 360 degrees) to find the maximum reading. A pre-amp and a high pass filter are used for the test in order to get better signal level.
3. The EUT is placed on a turntable with 0.8 meter for frequency below 1 GHz and 1.5 meter for frequency above 1 GHz respectively above ground.
4. The EUT is set 3 meters away from the receiving antenna, which is mounted on the top of a variable height antenna tower.
5. Corrected Reading: Antenna Factor + Cable Loss + Read Level - Preamp Factor = Level
6. Radiated testing below 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading. When there is no suspected emission found and the emission level is with at least 6 dB margin against QP limit line, the position is marked as "-".
7. Radiated testing above 1 GHz is performed by adjusting the antenna tower from 1 m to 4 m and by rotating the turn table from 0 degree to 360 degrees to find the peak maximum hold reading for scanning all frequencies. When there is no suspected emission found and the harmonic emission level is with at least 6 dB margin against average limit line, the position is marked as "-".
8. 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; VBW ≥ RBW; Sweep = auto; Detector function = peak; Trace = max hold;
   (3) Set RBW = 1 MHz, VBW = 3 MHz for f ≥ 1 GHz for peak measurement.
   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.

3.5.4 Test Setup

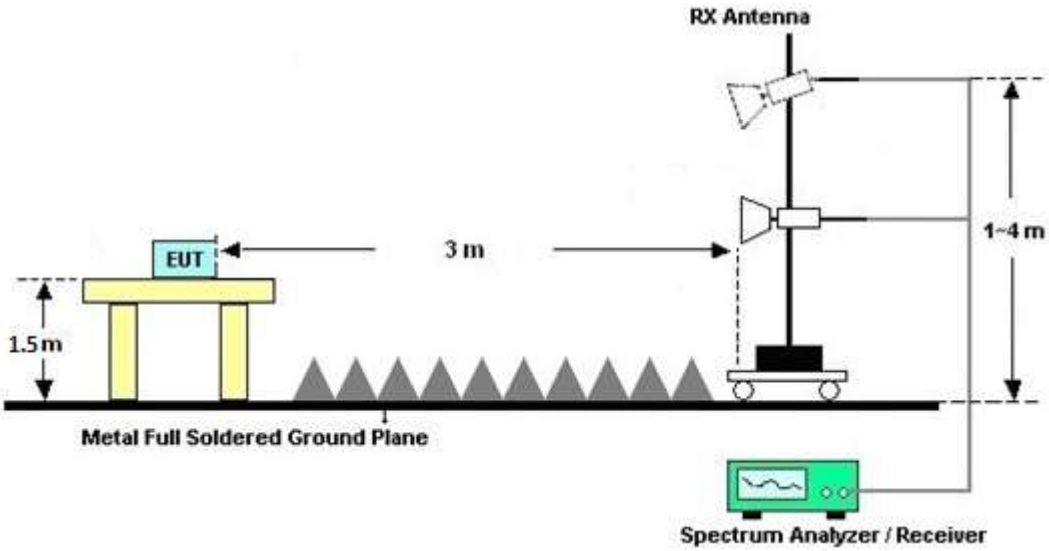
For radiated test below 30MHz



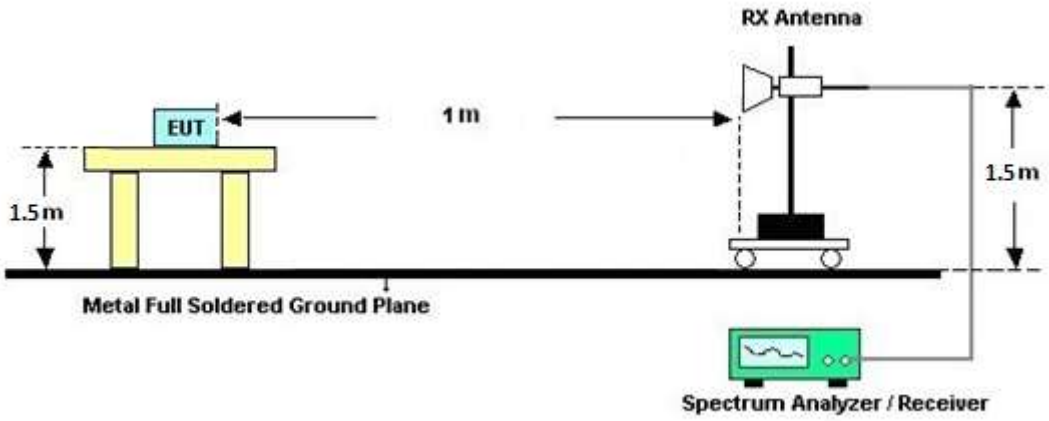
For radiated test from 30MHz to 1GHz



For radiated test from 1GHz to 18GHz



For radiated test above 18GHz



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

The low frequency, which starts from 9 kHz to 30 MHz, is pre-scanned and the result which is 20 dB lower than the limit line is not reported.

There is adequate comparison measurement of both open-field test site and alternative test site - semi-Anechoic chamber according to 414788 D01 Radiated Test Site v01r01, and the result comes out very similar.

3.5.6 Test Result of Radiated Spurious at Band Edges

Please refer to Appendix B and C.

3.5.7 Duty Cycle

Please refer to Appendix D.

3.5.8 Test Result of Radiated Spurious Emission (30 MHz ~ 10th Harmonic)

Please refer to Appendix B and C.

3.6 Antenna Requirements

3.6.1 Standard Applicable

If directional gain of transmitting antennas is greater than 6 dBi, the power shall be reduced by the same level in dB comparing to gain minus 6 dBi. 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 rule.

3.6.2 Antenna Anti-Replacement Construction

An embedded-in antenna design is used.

3.6.3 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.

4 List of Measuring Equipment

Instrument	Brand Name	Model No.	Serial No.	Characteristics	Calibration Date	Test Date	Due Date	Remark
Hygrometer	Testo	608-H1	45142595	N/A	Aug. 30. 2021	Jul. 27, 2022	Aug. 29, 2022	Conducted (TH01-CA)
Power Sensor	DARE!!	RPR3006W	RPR6W-1901026	10MHz-6GHz	May 10, 2022	Jul. 27, 2022	May 09, 2023	Conducted (TH01-CA)
Switch Box& RF Cable	EM Electronics	EMSW26	1090304	N/A	Mar. 30, 2022	Jul. 27, 2022	Mar. 29, 2023	Conducted (TH01-CA)
Spectrum Analyzer	Rohde & Schwarz	FSV40	101089	10Hz-40GHz	Jun. 01, 2022	Jul. 27, 2022	May 31, 2023	Conducted (TH01-CA)
Loop Antenna	Rohde & Schwarz	HFH2-Z2	100315	9kHz~30MHz	Jan. 07, 2022	Jul. 20, 2022~ Jul. 21, 2022	Jan. 06, 2023	Radiation (03CH02-CA)
Bilog Antenna	TESEQ	6111D	54683	30MHz~1GHz	Oct. 15, 2021	Jul. 20, 2022~ Jul. 21, 2022	Oct. 14, 2022	Radiation (03CH02-CA)
Horn Antenna	SCHWARZBECK	BBHA 9120D	01895	1GHz~18GHz	Aug. 25, 2021	Jul. 20, 2022~ Jul. 21, 2022	Aug. 24, 2022	Radiation (03CH02-CA)
Horn Antenna	SCHWARZBECK	BBHA 9170D	00841	18GHz~40GHz	Aug. 26, 2021	Jul. 20, 2022~ Jul. 21, 2022	Aug. 25, 2022	Radiation (03CH02-CA)
Amplifier	SONOMA	310N	372240	N/A	May 10, 2022	Jul. 20, 2022~ Jul. 21, 2022	May 09, 2023	Radiation (03CH02-CA)
Preamplifier	Keysight	83017A	MY53270323	1GHz~26.5GHz	May 11, 2022	Jul. 20, 2022~ Jul. 21, 2022	May 10, 2023	Radiation (03CH02-CA)
Preamplifier	E-instrument	ERA-100M-18G-56-01-A70	EC1900251	1GHz~18GHz	May 10, 2022	Jul. 20, 2022~ Jul. 21, 2022	May 09, 2023	Radiation (03CH02-CA)
Preamplifier	EMEC	EMC18G40G	060725	18GHz-40GHz	May 10, 2022	Jul. 20, 2022~ Jul. 21, 2022	May 09, 2023	Radiation (03CH02-CA)
RF Cable	HUBER+SUHNER	SUCOFLEX 102	8024032/2, 802406/2, 802875/2	N/A	Jun. 22, 2022	Jul. 20, 2022~ Jul. 21, 2022	Jun. 21, 2023	Radiation (03CH02-CA)
Spectrum Analyzer	Keysight	N9010A	MY57420221	10Hz~44GHz	Sep. 22, 2021	Jul. 20, 2022~ Jul. 21, 2022	Sep. 21, 2022	Radiation (03CH02-CA)
Filter	Wainwright	WHKX12-2700-3000-18000-60ST	SN10	3GHz High Pass Filter	Jul. 22, 2021	Jul. 19, 2022~ Jul. 20, 2022	Jul. 21, 2022	Radiation (03CH02-CA)
Filter	Wainwright	WLK12-1200-1272-11000-40SS	SN1	1.2GHz Low Pass Filter	Jul. 22, 2021	Jul. 19, 2022~ Jul. 20, 2022	Jul. 21, 2022	Radiation (03CH02-CA)
Hygrometer	TESEO	608-H1	45142602	N/A	Aug. 04, 2021	Jul. 20, 2022~ Jul. 21, 2022	Aug. 03, 2022	Radiation (03CH02-CA)
Controller	ChainTek	EM-1000	060876	NA	N/A	Jul. 20, 2022~ Jul. 21, 2022	N/A	Radiation (03CH02-CA)
Antenna Mast	ChainTek	MBS-520-1	N/A	1m~4m	N/A	Jul. 20, 2022~ Jul. 21, 2022	N/A	Radiation (03CH02-CA)
Turn Table	ChainTek	T-200-S-1	N/A	0~360 Degree	N/A	Jul. 20, 2022~ Jul. 21, 2022	N/A	Radiation (03CH02-CA)
Software	Audix	E3	N/A	N/A	N/A	Jul. 20, 2022~ Jul. 21, 2022	N/A	Radiation (03CH02-CA)

5 Uncertainty of Evaluation

Uncertainty of Radiated Emission Measurement (30 MHz ~ 1000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	4.7 dB

Uncertainty of Radiated Emission Measurement (1000 MHz ~ 18000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	6.2 dB

Uncertainty of Radiated Emission Measurement (18000 MHz ~ 40000 MHz)

Measuring Uncertainty for a Level of Confidence of 95% (U = 2Uc(y))	6.4 dB

Appendix A. Test Result of Conducted Test Items

Test Engineer:	Venkata Kondepudi	Temperature:	21~24.4	°C
Test Date:	2022/7/27	Relative Humidity:	48.9~50.8	%

TEST RESULTS DATA
6dB and 99% Occupied Bandwidth

Mod.	Data Rate	NTx	CH.	Freq. (MHz)	99% Occupied BW (MHz)	6dB BW (MHz)	6dB BW Limit (MHz)	Pass/Fail
BLE	1Mbps	1	0	2402	1.058	0.736	0.50	Pass
BLE	1Mbps	1	19	2440	1.065	0.742	0.50	Pass
BLE	1Mbps	1	39	2480	1.050	0.720	0.50	Pass

TEST RESULTS DATA
Average Power Table

Mod.	Data Rate	NTx	CH.	Freq. (MHz)	Average Conducted Power (dBm)	Conducted Power Limit (dBm)	DG (dBi)	EIRP Power (dBm)	EIRP Power Limit (dBm)	Pass /Fail
BLE	1Mbps	1	0	2402	3.21	30.00	0.00	3.21	36.00	Pass
BLE	1Mbps	1	19	2440	3.34	30.00	0.00	3.34	36.00	Pass
BLE	1Mbps	1	39	2480	3.23	30.00	0.00	3.23	36.00	Pass

TEST RESULTS DATA
Peak Power Density

Mod.	Data Rate	NTx	CH.	Freq. (MHz)	Peak PSD (dBm /100kHz)	Peak PSD (dBm /3kHz)	DG (dBi)	Peak PSD Limit (dBm /3kHz)	Pass/Fail
BLE	1Mbps	1	0	2402	2.49	-11.73	0.00	8.00	Pass
BLE	1Mbps	1	19	2440	2.74	-10.07	0.00	8.00	Pass
BLE	1Mbps	1	39	2480	3.10	-10.24	0.00	8.00	Pass

Note: PSD (dBm/ 100kHz) is a reference level used for Conducted Band Edges and Conducted Spurious Emission 30dBc limit.

Appendix B. Radiated Spurious Emission

Test Engineer :	Fu Chen	**Temperature :**	20~24°C
		Relative Humidity :	42~49%

2.4GHz 2400~2483.5MHz

BLE (Band Edge @ 3m)

BLE	Note	Frequency	Level	Margin	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
					Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BLE CH 00 2402MHz		2360.715	55.69	-18.31	74	42.09	27.75	17.38	31.53	100	117	P	H
		2338.035	44.4	-9.6	54	30.76	27.84	17.33	31.53	100	117	A	H
	*	2402	100.72	-	-	87.11	27.66	17.44	31.49	100	117	P	H
	*	2402	100.42	-	-	86.81	27.66	17.44	31.49	100	117	A	H
													H
													H
		2337.3	56.13	-17.87	74	42.41	27.92	17.33	31.53	375	51	P	V
		2337.93	43.93	-10.07	54	30.21	27.92	17.33	31.53	375	51	A	V
	*	2402	96.42	-	-	82.73	27.74	17.44	31.49	375	51	P	V
	*	2402	96.06	-	-	82.37	27.74	17.44	31.49	375	51	A	V
													V
													V
BLE CH 19 2440MHz		2383.6	55.28	-18.72	74	41.68	27.7	17.41	31.51	115	115	P	H
		2376.08	44.37	-9.63	54	30.78	27.71	17.4	31.52	115	115	A	H
	*	2440	100.63	-	-	86.94	27.66	17.5	31.47	115	115	P	H
	*	2440	100.31	-	-	86.62	27.66	17.5	31.47	115	115	A	H
		2488	55.5	-18.5	74	41.75	27.62	17.59	31.46	115	115	P	H
		2499.68	43.95	-10.05	54	30.18	27.61	17.61	31.45	115	115	A	H
		2325.04	55.41	-18.59	74	41.71	27.92	17.31	31.53	399	40	P	V
		2376.08	43.92	-10.08	54	30.21	27.83	17.4	31.52	399	40	A	V
	*	2440	95.16	-	-	81.54	27.59	17.5	31.47	399	40	P	V
	*	2440	94.83	-	-	81.21	27.59	17.5	31.47	399	40	A	V
		2494.48	54.54	-19.46	74	40.91	27.49	17.6	31.46	399	40	P	V
		2499.04	43.83	-10.17	54	30.18	27.49	17.61	31.45	399	40	A	V

BLE CH 39 2480MHz	*	2480	99.41	-	-	85.66	27.63	17.58	31.46	104	114	P	H
	*	2480	99.1	-	-	85.35	27.63	17.58	31.46	104	114	A	H
		2485.08	55.52	-18.48	74	41.77	27.62	17.59	31.46	104	114	P	H
		2483.52	44.46	-9.54	54	30.72	27.62	17.58	31.46	104	114	A	H
													H
													H
	*	2480	94.14	-	-	80.51	27.51	17.58	31.46	392	54	P	V
	*	2480	93.78	-	-	80.15	27.51	17.58	31.46	392	54	A	V
		2499.08	56.01	-17.99	74	42.36	27.49	17.61	31.45	392	54	P	V
		2483.52	43.91	-10.09	54	30.28	27.51	17.58	31.46	392	54	A	V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line.												

2.4GHz 2400~2483.5MHz

BLE (Harmonic @ 3m)

BLE	Note	Frequency (MHz)	Level (dBμV/m)	Margin (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BLE CH 00 2402MHz		4804	46.51	-27.49	74	71.44	31.51	11.44	67.88	100	264	P	H
		4804	41.39	-12.61	54	66.32	31.51	11.44	67.88	100	264	A	H
		11325	49.65	-24.35	74	60.49	39.83	17.59	68.26	-	-	P	H
		11325	37.95	-16.05	54	48.79	39.83	17.59	68.26	-	-	A	H
		14490	50.88	-23.12	74	56.72	41.94	20.2	67.98	-	-	P	H
		14490	41.87	-12.13	54	47.71	41.94	20.2	67.98	-	-	A	H
		18000	58.6	-15.4	74	57.59	48.82	21.91	69.72	-	-	P	H
		18000	48.92	-5.08	54	47.91	48.82	21.91	69.72	-	-	A	H
													H
													H
													H
													H
		4804	42.43	-31.57	74	67.33	31.54	11.44	67.88	383	304	P	V
		4804	34.16	-19.84	54	59.06	31.54	11.44	67.88	383	304	A	V
		11400	49.32	-24.68	74	59.8	39.92	17.66	68.06	-	-	P	V
		11400	38.52	-15.48	54	49	39.92	17.66	68.06	-	-	A	V
		14490	51.07	-22.93	74	56.91	41.94	20.2	67.98	-	-	P	V
		14490	41.75	-12.25	54	47.59	41.94	20.2	67.98	-	-	A	V
		17985	58.22	-15.78	74	57.52	48.7	21.9	69.9	-	-	P	V
		17985	48.52	-5.48	54	47.82	48.7	21.9	69.9	-	-	A	V
													V
													V
													V
													V

BLE	Note	Frequency (MHz)	Level (dBμV/m)	Margin (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BLE CH 19 2440MHz		4880	46.58	-27.42	74	71.57	31.45	11.48	67.92	100	270	P	H
		4880	41.03	-12.97	54	66.02	31.45	11.48	67.92	100	270	A	H
		7320	51.28	-22.72	74	68.1	36.33	13.92	67.07	100	273	P	H
		7320	44.59	-9.41	54	61.41	36.33	13.92	67.07	100	273	A	H
		11355	50.02	-23.98	74	60.69	39.91	17.62	68.2	-	-	P	H
		11355	38.3	-15.7	54	48.97	39.91	17.62	68.2	-	-	A	H
		14490	51.69	-22.31	74	57.53	41.94	20.2	67.98	-	-	P	H
		14490	41.77	-12.23	54	47.61	41.94	20.2	67.98	-	-	A	H
		18000	58.57	-15.43	74	57.56	48.82	21.91	69.72	-	-	P	H
		18000	49	-5	54	47.99	48.82	21.91	69.72	-	-	A	H
													H
													H
		4880	43.32	-30.68	74	68.38	31.38	11.48	67.92	399	301	P	V
		4880	35.5	-18.5	54	60.56	31.38	11.48	67.92	399	301	A	V
		7320	48.95	-25.05	74	65.7	36.4	13.92	67.07	101	71	P	V
		7320	39.89	-14.11	54	56.64	36.4	13.92	67.07	101	71	A	V
		11280	49.5	-24.5	74	60.6	39.67	17.55	68.32	-	-	P	V
		11280	37.51	-16.49	54	48.61	39.67	17.55	68.32	-	-	A	V
		14490	50.68	-23.32	74	56.52	41.94	20.2	67.98	-	-	P	V
		14490	41.73	-12.27	54	47.57	41.94	20.2	67.98	-	-	A	V
		18000	58.57	-15.43	74	57.34	49.04	21.91	69.72	-	-	P	V
		18000	49.12	-4.88	54	47.89	49.04	21.91	69.72	-	-	A	V
													V
													V

BLE	Note	Frequency (MHz)	Level (dBμV/m)	Margin (dB)	Limit Line (dBμV/m)	Read Level (dBμV)	Antenna Factor (dB/m)	Path Loss (dB)	Preamp Factor (dB)	Ant Pos (cm)	Table Pos (deg)	Peak Avg. (P/A)	Pol. (H/V)
BLE CH 39 2480MHz		4960	48.13	-25.87	74	73.17	31.51	11.51	68.06	100	298	P	H
		4960	43.9	-10.1	54	68.94	31.51	11.51	68.06	100	298	A	H
		7440	52.43	-21.57	74	69.1	36.49	14.07	67.23	100	300	P	H
		7440	46.11	-7.89	54	62.78	36.49	14.07	67.23	100	300	A	H
		11595	50.58	-23.42	74	60.3	40	17.86	67.58	-	-	P	H
		11595	39.11	-14.89	54	48.83	40	17.86	67.58	-	-	A	H
		14490	50.77	-23.23	74	56.61	41.94	20.2	67.98	-	-	P	H
		14490	41.91	-12.09	54	47.75	41.94	20.2	67.98	-	-	A	H
		17970	58.38	-15.62	74	58.51	48.04	21.9	70.07	-	-	P	H
		17970	47.87	-6.13	54	48	48.04	21.9	70.07	-	-	A	H
													H
													H
		4960	44.33	-29.67	74	69.42	31.46	11.51	68.06	380	324	P	V
		4960	37.46	-16.54	54	62.55	31.46	11.51	68.06	380	324	A	V
		7440	49.17	-24.83	74	65.86	36.47	14.07	67.23	107	297	P	V
		7440	41.22	-12.78	54	57.91	36.47	14.07	67.23	107	297	A	V
		11550	49.57	-24.43	74	59.37	40.04	17.81	67.65	-	-	P	V
		11550	39.17	-14.83	54	48.97	40.04	17.81	67.65	-	-	A	V
		14490	50.89	-23.11	74	56.73	41.94	20.2	67.98	-	-	P	V
		14490	41.85	-12.15	54	47.69	41.94	20.2	67.98	-	-	A	V
		18000	58.54	-15.46	74	57.31	49.04	21.91	69.72	-	-	P	V
		18000	49.11	-4.89	54	47.88	49.04	21.91	69.72	-	-	A	V
													V
													V

Remark

1. No other spurious found.
2. All results are PASS against Peak and Average limit line.
3. The emission position marked as "-" means no suspected emission found with sufficient margin against limit line or noise floor only.
4. The emission level close to 18GHz is checked that the average emission level is noise floor only.

Emission above 18GHz

2.4GHz BLE (SHF)

BT	Note	Frequency	Level	Margin	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
					Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz BLE SHF		23894	39.29	-34.71	74	36.93	38.94	15.24	51.82	-	-	P	H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
													H
		22914	39.58	-34.42	74	38.23	38.77	14.52	51.94	-	-	P	V
													V
													V
													V
													V
													V
													V
													V
													V
													V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. The emission position marked as "-" means no suspected emission found with sufficient margin against limit line or noise floor only.												

Emission below 1GHz

2.4GHz BLE (LF)

BLE	Note	Frequency	Level	Margin	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
					Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
2.4GHz BLE LF		170.65	19.48	-24.02	43.5	34.04	15.73	2.11	32.4	-	-	P	H
		260.86	20.06	-25.94	46	29.64	20.2	2.63	32.41	-	-	P	H
		411.21	23.07	-22.93	46	29.77	22.52	3.29	32.51	-	-	P	H
		636.25	29.83	-16.17	46	31.96	26.45	4.03	32.61	-	-	P	H
		748.77	30.42	-15.58	46	30.26	28.1	4.46	32.4	-	-	P	H
		944.71	34.45	-11.55	46	29.74	30.98	4.99	31.26	-	-	P	H
													H
													H
													H
													H
													H
													H
		173.56	20.32	-23.18	43.5	35.06	15.54	2.13	32.41	-	-	P	V
		260.86	19.79	-26.21	46	29.37	20.2	2.63	32.41	-	-	P	V
		401.51	21.92	-24.08	46	29.01	22.16	3.25	32.5	-	-	P	V
		675.05	27.45	-18.55	46	29.32	26.5	4.19	32.56	-	-	P	V
		753.62	31.88	-14.12	46	31.64	28.17	4.47	32.4	-	-	P	V
		954.41	33.74	-12.26	46	28.5	31.38	5.04	31.18	-	-	P	V
													V
													V
													V
													V
													V
													V
Remark	1. No other spurious found. 2. All results are PASS against Peak and Average limit line. 3. The emission position marked as “-” means no suspected emission found and emission level has at least 6dB margin against limit or noise floor only.												

Note symbol

*	**Fundamental Frequency** which can be ignored. However, the level of any unwanted emissions shall not exceed the level of the fundamental frequency.
!	Test result is **over limit** line.
P/A	**P**eak or **A**verage
H/V	**H**orizontal or **V**ertical

A calculation example for radiated spurious emission is shown as below:

BLE	Note	Frequency	Level	Over	Limit	Read	Antenna	Path	Preamp	Ant	Table	Peak	Pol.
				Limit	Line	Level	Factor	Loss	Factor	Pos	Pos	Avg.	
		(MHz)	(dBμV/m)	(dB)	(dBμV/m)	(dBμV)	(dB/m)	(dB)	(dB)	(cm)	(deg)	(P/A)	(H/V)
BLE CH 00 2402MHz		2390	55.45	-18.55	74	54.51	32.22	4.58	35.86	103	308	P	H
		2390	43.54	-10.46	54	42.6	32.22	4.58	35.86	103	308	A	H

1. Path Loss(dB) = Cable loss(dB) + Filter loss(dB) + Attenuator loss(dB)
2. Level(dBμV/m) =

Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

3. Over Limit(dB) = Level(dBμV/m) – Limit Line(dBμV/m)

For Peak Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 54.51(dBμV) – 35.86 (dB)

= 55.45 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 55.45(dBμV/m) – 74(dBμV/m)

= -18.55(dB)

For Average Limit @ 2390MHz:

1. Level(dBμV/m)

= Antenna Factor(dB/m) + Path Loss(dB) + Read Level(dBμV) - Preamp Factor(dB)

= 32.22(dB/m) + 4.58(dB) + 42.6(dBμV) – 35.86 (dB)

= 43.54 (dBμV/m)

2. Over Limit(dB)

= Level(dBμV/m) – Limit Line(dBμV/m)

= 43.54(dBμV/m) – 54(dBμV/m)

= -10.46(dB)

Both peak and average measured complies with the limit line, so test result is “PASS”.

Appendix C. Radiated Spurious Emission Plots

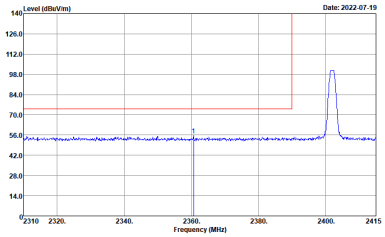
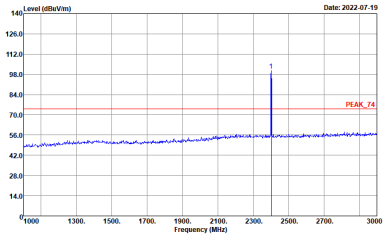
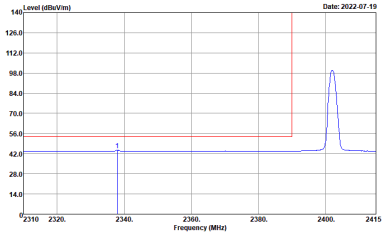
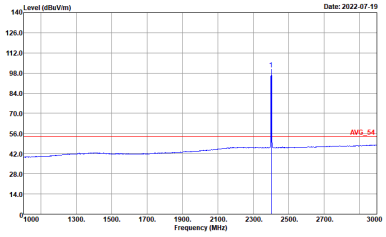
Test Engineer :	Fu Chen	**Temperature :**	20~24°C
		Relative Humidity :	42~49%

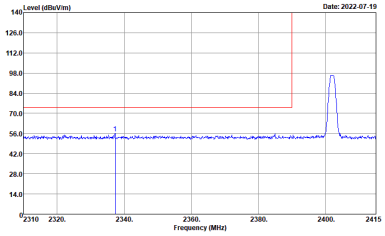
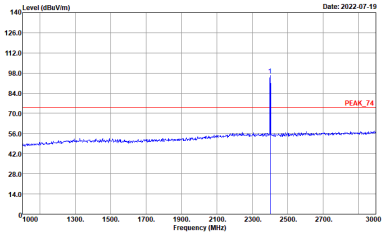
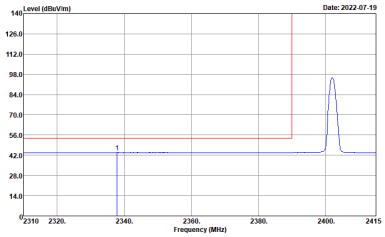
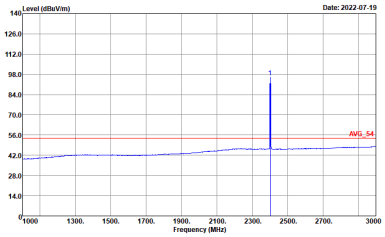
Note symbol

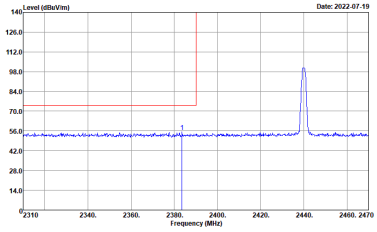
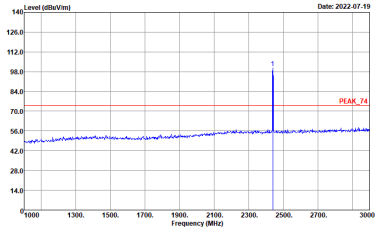
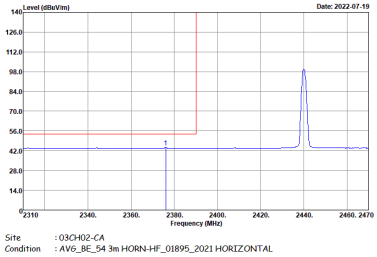
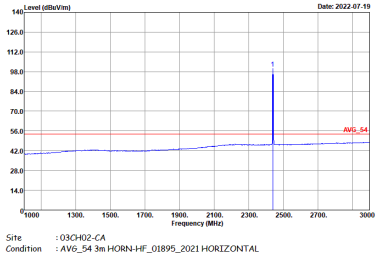
-L	**Low channel location**
-R	**High channel location**

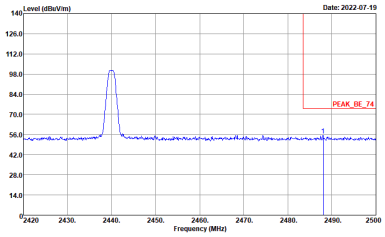
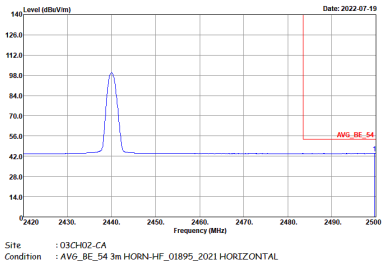
2.4GHz 2400~2483.5MHz

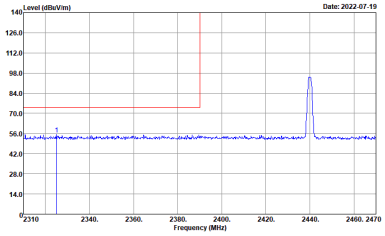
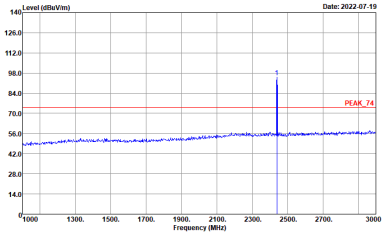
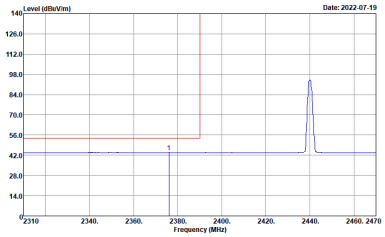
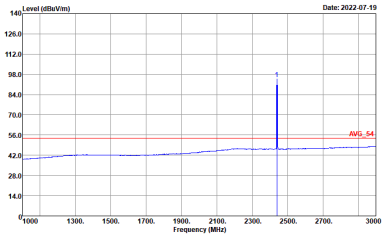
BLE (Band Edge @ 3m)

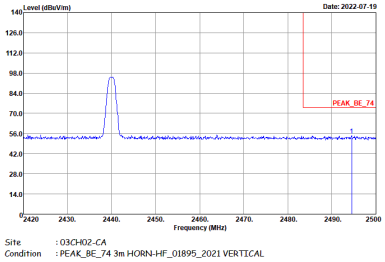
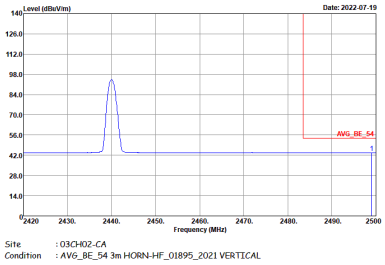
BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH00 2402MHz	
	Horizontal	Fundamental
Peak	 Site : 03CH02-CA Condition : PEAK_BE_74 3m HORN-HF_01895_2021 HORIZONTAL	 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 HORIZONTAL
Avg.	 Site : 03CH02-CA Condition : AVG_BE_54 3m HORN-HF_01895_2021 HORIZONTAL	 Site : 03CH02-CA Condition : AVG_54 3m HORN-HF_01895_2021 HORIZONTAL

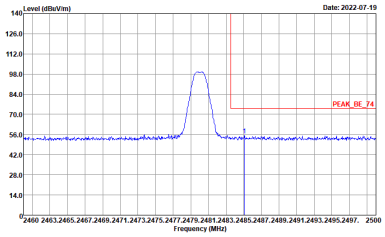
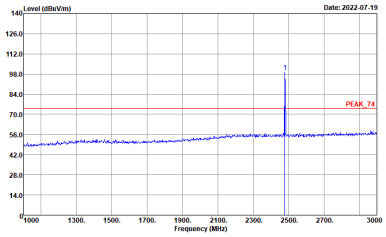
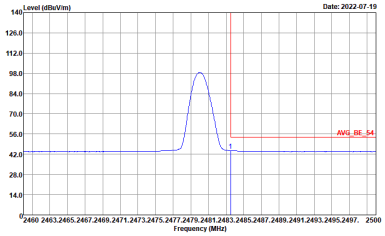
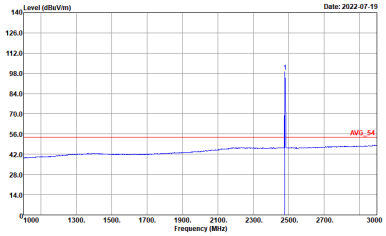
BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH00 2402MHz	
	Vertical	Fundamental
Peak		
Avg		

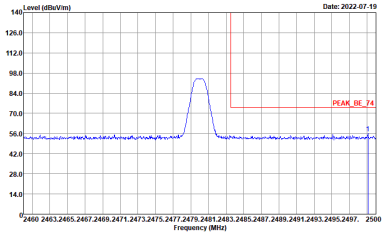
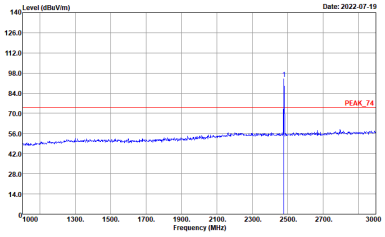
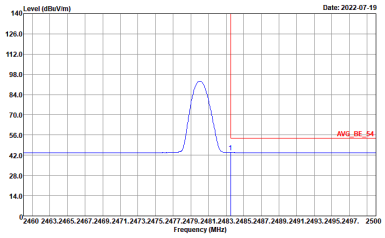
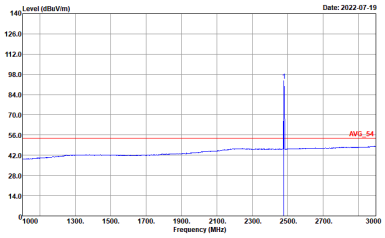
BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH19 2440MHz - L	
	Horizontal	Fundamental
Peak		
Avg.		

BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH19 2440MHz - R	
	Horizontal	Fundamental
Peak		Left blank
Avg.		Left blank

BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH19 2440MHz - L	
	Vertical	Fundamental
Peak		
Avg.		

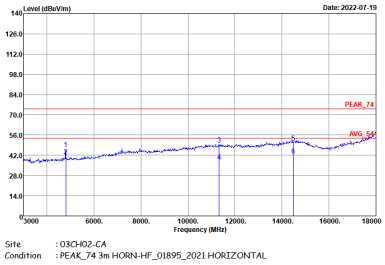
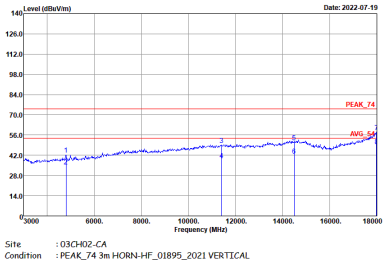
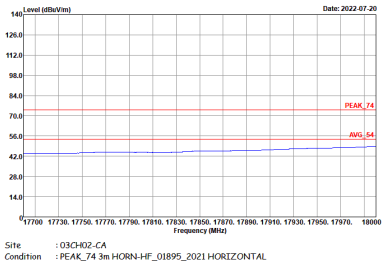
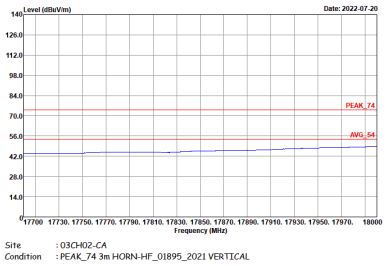
BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH19 2440MHz - R	
	Vertical	Fundamental
Peak		Left blank
Avg.		Left blank

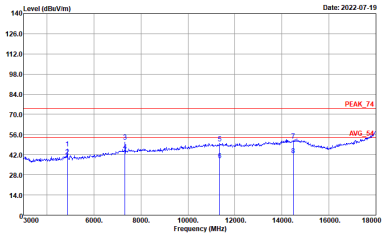
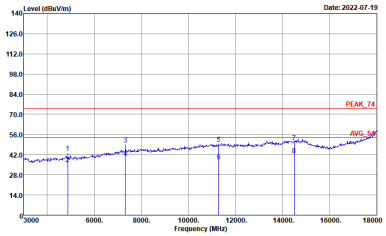
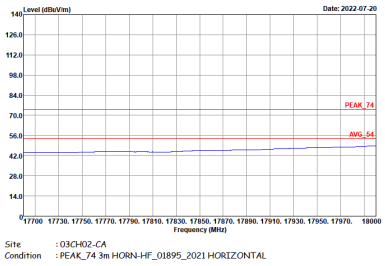
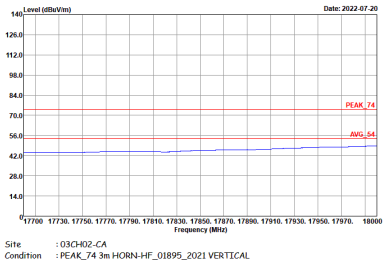
BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH39 2480MHz	
	Horizontal	Fundamental
Peak	 Site : 03CH02-CA Condition : PEAK_BE_74 3m HORN-HF_01895_2021 HORIZONTAL	 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 HORIZONTAL
Avg.	 Site : 03CH02-CA Condition : AVG_BE_54 3m HORN-HF_01895_2021 HORIZONTAL	 Site : 03CH02-CA Condition : AVG_54 3m HORN-HF_01895_2021 HORIZONTAL

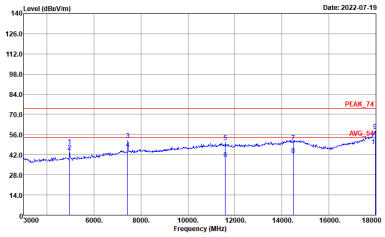
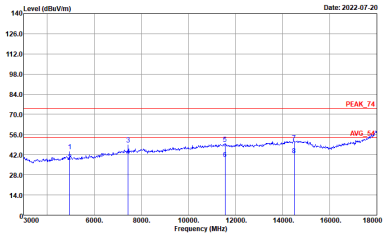
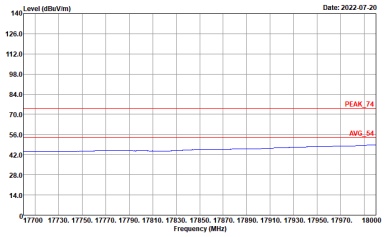
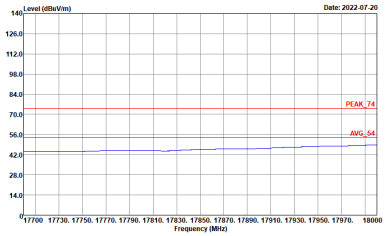
BLE	2.4GHz 2400~2483.5MHz Band Edge @ 3m	
	BLE CH39 2480MHz	
	Vertical	Fundamental
Peak	 Site : 03CH02-CA Condition : PEAK_BE_74 3m HORN-HF_01895_2021 VERTICAL	 Site : 03CH02-CA Condition : PEAK_74 3m HORN-HF_01895_2021 VERTICAL
Avg.	 Site : 03CH02-CA Condition : AVG_BE_54 3m HORN-HF_01895_2021 VERTICAL	 Site : 03CH02-CA Condition : AVG_54 3m HORN-HF_01895_2021 VERTICAL

2.4GHz 2400~2483.5MHz

BLE (Harmonic @ 3m)

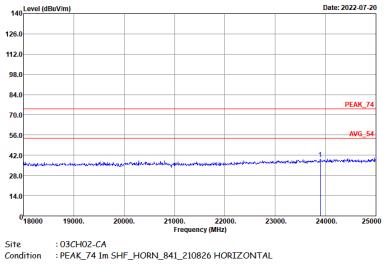
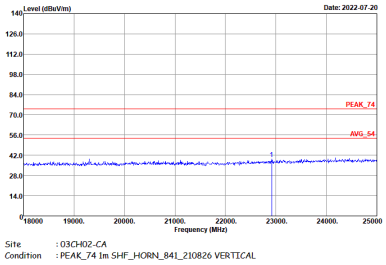
BLE	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BLE CH00 2402MHz	
	Horizontal	Vertical
Peak Avg.		
Avg.		

BLE	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BLE CH19 2440MHz	
	Horizontal	Vertical
Peak Avg.		
Avg.		

BLE	2.4GHz 2400~2483.5MHz Harmonic @ 3m	
	BLE CH39 2480MHz	
	Horizontal	Vertical
Peak Avg.		
Avg.		

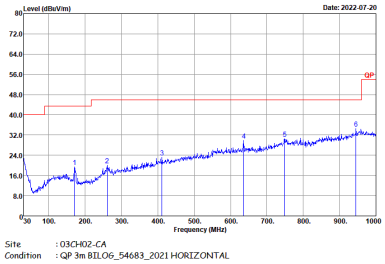
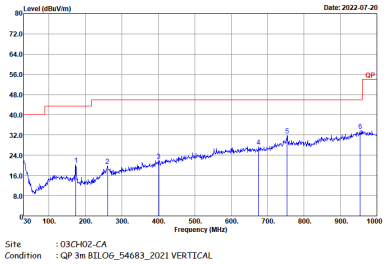
Emission above 18GHz

2.4GHz BLE (SHF @ 1m)

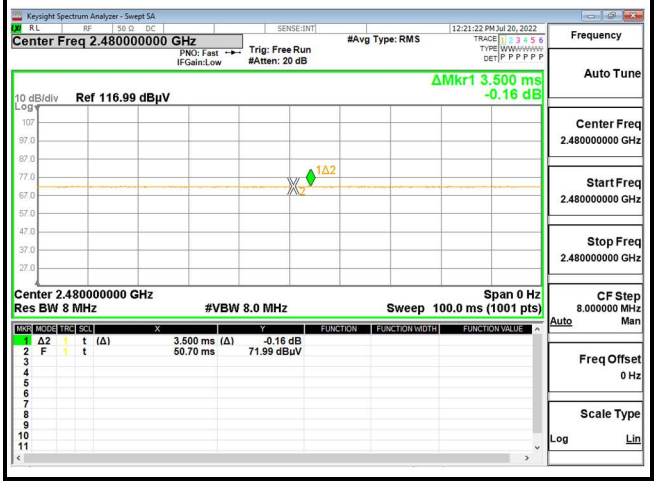
BLE	2.4GHz 2400~2483.5MHz	
	BLE SHF	
	Horizontal	Vertical
Peak Avg.		

Emission below 1GHz

2.4GHz BLE (LF)

BLE	2.4GHz 2400~2483.5MHz	
	BLE LF	
	Horizontal	Vertical
QP / Peak		

Appendix D. Duty Cycle Plots

Band	Duty Cycle(%)	T(us)	1/T(kHz)	VBW Setting
Bluetooth - LE for 1Mbps	100.00	-	-	10Hz

Bluetooth –LE for 1Mbps