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TEST REPORT

For

MOST Tech Sweden AB

Kevinge Strand 20 182 57 Danderyd, Sweden

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Original Report	M2 Asset Tracker

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Reviewed By: Jacob Kong, RF Engineer

Prepared By: Bay Area Compliant Laboratories Corp. (Shenzhen)
5F(B-West) ,6F,7F,the 3rd Phase of Wan Li Industrial Building D,Shihua Rd, FuTian Free Trade Zone, Shenzhen, China
Tel: +86-755-33320018
Fax: +86-755-33320008
www.baclcorp.com.cn

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TABLE OF CONTENTS

GENERAL INFORMATION **4**
PRODUCT DESCRIPTION FOR EQUIPMENT UNDER TEST (EUT) 4
OBJECTIVE 4
TEST METHODOLOGY 4
MEASUREMENT UNCERTAINTY 5
SYSTEM TEST CONFIGURATION **6**
DESCRIPTION OF TEST CONFIGURATION 6
EQUIPMENT MODIFICATIONS 6
EUT EXERCISE SOFTWARE 6
DUTY CYCLE 7
SUPPORT EQUIPMENT LIST AND DETAILS 7
EXTERNAL I/O CABLE 7
BLOCK DIAGRAM OF TEST SETUP 7
SUMMARY OF TEST RESULTS **8**
TEST EQUIPMENT LIST **9**
FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE) **10**
APPLICABLE STANDARD 10
RESULT 10
RSS-102 § 4 –EXPOSURE LIMITS **12**
APPLICABLE STANDARD 12
§15.203 & RSS-Gen §6.8 ANTENNA REQUIREMENT **14**
APPLICABLE STANDARD 14
ANTENNA CONNECTOR CONSTRUCTION 15
§15.207 (a) & RSS-GEN §8.8 AC LINE CONDUCTED EMISSIONS **16**
APPLICABLE STANDARD 16
EUT SETUP 17
EMI TEST RECEIVER SETUP 17
TEST PROCEDURE 17
CORRECTED FACTOR & MARGIN CALCULATION 18
TEST DATA 18
§15.205, §15.209, §15.247(d) & RSS-GEN § 8.10 & RSS-247 § 5.5 SPURIOUS EMISSIONS **21**
APPLICABLE STANDARD 21
EUT SETUP 21
EMI TEST RECEIVER & SPECTRUM ANALYZER SETUP 22
TEST PROCEDURE 22
CORRECTED AMPLITUDE & MARGIN CALCULATION 23
TEST DATA 23
§15.247 (a)(2) & RSS-Gen§6.7 RSS-247 § 5.2 (a) 99% OCCUPIED BANDWIDTH & 6 dB EMISSION BANDWIDTH **31**
APPLICABLE STANDARD 31
TEST PROCEDURE 31
TEST DATA 32

§15.247(b)(3) & RSS-247 § 5.4(d) MAXIMUM CONDUCTED OUTPUT POWER.....33
APPLICABLE STANDARD 33
TEST PROCEDURE 33
TEST DATA 34
§15.247(d) & RSS-247 § 5.5 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE.....35
APPLICABLE STANDARD 35
TEST PROCEDURE 35
TEST DATA 35
§15.247(e) & RSS-247 § 5.2 (b) POWER SPECTRAL DENSITY 36
APPLICABLE STANDARD 36
TEST PROCEDURE 36
TEST DATA 37
APPENDIX BLE.....38
APPENDIX A: DTS BANDWIDTH 38
APPENDIX B: OCCUPIED CHANNEL BANDWIDTH 41
APPENDIX C: MAXIMUM CONDUCTED PEAK OUTPUT POWER 44
APPENDIX D: MAXIMUM POWER SPECTRAL DENSITY.....44
APPENDIX E: BAND EDGE MEASUREMENTS.....47
APPENDIX F: DUTY CYCLE 49

GENERAL INFORMATION

Product Description for Equipment under Test (EUT)

Product	M2 Asset Tracker
Tested Model	M2
HVIN	M2
Frequency Range	BLE 1M/2M: 2402-2480MHz
Maximum Conducted Peak Output Power	BLE 1M/2M: 0.85dBm
Modulation Technique	BLE: GFSK
Antenna Specification*	2.0dBi (It is provided by the applicant)
Voltage Range	DC3.6V from battery
Date of Test	2021-05-17 to 2021-06-03
Sample number	SZ6210428-14459E-RF-S_4AA (Assigned by BACL, Shenzhen)
Received date	2021-04-28
Sample/EUT Status	Good condition

Objective

This report is in accordance with Part 2-Subpart J, Part 15-Subparts A and C of the Federal Communication Commission's rules and RSS-GEN Issue 5, February 2021 Amendment 2 and RSS-247, Issue 2, February 2017 of the Innovation, Science and Economic Development Canada rules.

The tests were performed in order to determine compliance with FCC Part 15, Subpart C, and section 15.203, 15.205, 15.207, 15.209, 15.247 rules, RSS-GEN Issue 5, February 2021 Amendment 2 and RSS-247, Issue 2, February 2017.

Test Methodology

All measurements contained in this report were conducted with ANSI C63.10-2013, American National Standard of Procedures for Compliant Testing of Unlicensed Wireless Devices and RSS-GEN Issue 5, February 2021 Amendment 2 and RSS-247, Issue 2, February 2017.

And KDB 558074 D01 15.247 Meas Guidance v05r02.

All emissions measurement was performed at Bay Area Compliant Laboratories Corp. (Shenzhen). The radiated testing was performed at an antenna-to-EUT distance of 3 meters.
Each test item follows test standards and with no deviation.

Measurement Uncertainty

Parameter		Uncertainty
Occupied Channel Bandwidth		±5%
RF Output Power with Power meter		±0.73dB
RF conducted test with spectrum		±1.6dB
AC Power Lines Conducted Emissions		±1.95dB
Emissions, Radiated	Below 1GHz	±4.75dB
	Above 1GHz	±4.88dB
Temperature		±1℃
Humidity		±6%
Supply voltages		±0.4%

Note: The extended uncertainty given in this report is obtained by combining the standard uncertainty times the coverage factor K with the 95% confidence interval. Otherwise required by the applicant or Product Regulations, Decision Rule in this report did not consider the uncertainty.

Test Facility

The test site used by Bay Area Compliant Laboratories Corp. (Shenzhen) to collect test data is located on the 5F(B-West) ,6F,7F,the 3rd Phase of Wan Li Industrial Building D,Shihua Rd, FuTian Free Trade Zone, Shenzhen, China.

The test site has been approved by the FCC under the KDB 974614 D01 and is listed in the FCC Public Access Link (PAL) database, FCC Registration No.: 342867, the FCC Designation No.: CN1221.

The lab has been recognized by Innovation, Science and Economic Development Canada to test to Canadian radio equipment requirements, the CAB identifier : CN0023.

SYSTEM TEST CONFIGURATION

Description of Test Configuration

For LE 1M&LE 2M mode, 40 channels are provided to testing:

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

EUT was tested with Channel 0, 19 and 39.

Equipment Modifications

No modification was made to the EUT tested.

EUT Exercise Software

"CMD command*" was used.

The device was tested with the worst case was performed as below:

Mode	Data rate	Power level*		
		Low channel	Middle channel	High channel
BLE	1Mbps	Default	Default	Default
	2Mbps	Default	Default	Default

Note: the software and power level was provided by the applicant.

Duty cycle

Test Result: Pass. Please refer to the Appendix.

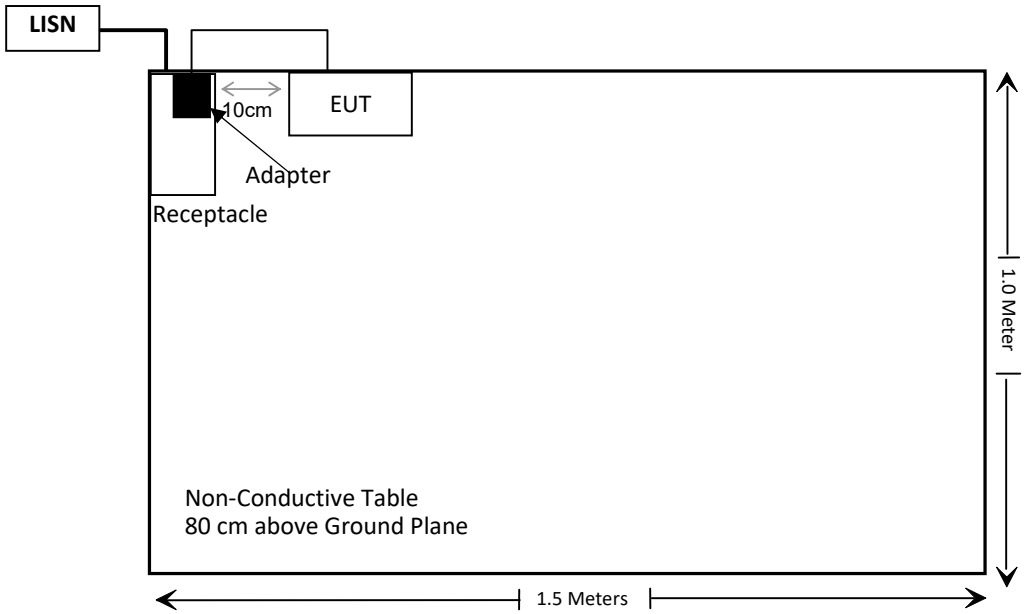
Support Equipment List and Details

Manufacturer	Description	Model	Serial Number
ZTE	Adapter	STC-A51A	Unknown

External I/O Cable

Cable Description	Length (m)	From Port	To
Un-shielding Detachable DC Cable	1.0	EUT	Adapter

Block Diagram of Test Setup



SUMMARY OF TEST RESULTS

FCC Rules	RSS-247 & RSS-Gen Rules	Description of Test	Result
§15.247 (i) & §2.1091	RSS-102 §4	Maximum Permissible Exposure(MPE)& RF Exposure Limit	Compliant
§15.203	RSS-Gen §6.8	Antenna Requirement	Compliant
§15.207 (a)	RSS-Gen §8.8	AC Line Conducted Emissions	Compliant
§15.205, §15.209, §15.247(d)	RSS-GEN § 8.10 & RSS-247 § 5.5	Spurious Emissions	Compliant
§15.247 (a)(2)	RSS- Gen§6.7 RSS-247 § 5.2 (a)	99% Occupied Bandwidth & 6 dB Emission Bandwidth	Compliant
§15.247(b)(3)	RSS-247 § 5.4(d)	Maximum Conducted Output Power	Compliant
§15.247(d)	RSS-247 § 5.5	100 kHz Bandwidth of Frequency Band Edge	Compliant
§15.247(e)	RSS-247 § 5.2 (b)	Power Spectral Density	Compliant

TEST EQUIPMENT LIST

Manufacturer	Description	Model	Serial Number	Calibration Date	Calibration Due Date
Conducted Emissions Test					
Rohde & Schwarz	EMI Test Receiver	ESCI	101120	2020/08/04	2021/08/03
Rohde & Schwarz	LISN	ENV216	101613	2020/08/04	2021/08/03
Rohde & Schwarz	Transient Limitor	ESH3Z2	DE25985	2020/11/29	2021/11/28
Unknown	CE Cable	CE Cable	UF A210B-1-0720-504504	2020/11/29	2021/11/28
Rohde & Schwarz	CE Test software	EMC 32	V8.53.0	NCR	NCR
Radiated Emission Test					
R&S	EMI Test Receiver	ESR3	102455	2020/08/04	2021/08/03
Sonoma instrument	Pre-amplifier	310 N	186238	2020/08/04	2021/08/03
Sunol Sciences	Broadband Antenna	JB1	A040904-2	2020/12/22	2023/12/21
Unknown	Cable	Chamber Cable 1	F-03-EM236	2020/11/29	2021/11/28
Unknown	Cable	Chamber Cable 4	EC-007	2020/11/29	2021/11/28
Rohde & Schwarz	Auto test software	EMC 32	V9.10	NCR	NCR
Rohde & Schwarz	Spectrum Analyzer	FSV40-N	102259	2020/08/04	2021/08/03
COM-POWER	Pre-amplifier	PA-122	181919	2020/11/29	2021/11/28
Quinstar	Amplifier	QLW-18405536-J0	15964001002	2020/11/29	2021/11/28
Sunol Sciences	Horn Antenna	3115	9107-3694	2021/01/15	2024/01/14
Insulted Wire Inc.	RF Cable	SPS-2503-3150	02222010	2020/11/29	2021/11/28
Unknown	RF Cable	W1101-EQ1 OUT	F-19-EM005	2020/11/29	2021/11/28
MICRO-TRONICS	Passband filter	HPM50111	F-19-EM006	2021/04/20	2022/04/20
Ducommun Technolagies	Horn antenna	ARH-4223-02	1007726-02 1304	2020/12/06	2023/12/05
RF Conducted Test					
Tonscend Corporation	RF control Unit	JS0806-2	19D8060154	2020/08/04	2021/08/03
Rohde & Schwarz	Signal and Spectrum Analyzer	FSV40	101473	2020/08/04	2021/08/03
Unknown	RF Cable	Unknown	2301 276	2020/11/29	2021/11/28

*** Statement of Traceability:** Bay Area Compliant Laboratories Corp. (Shenzhen) attests that all calibrations have been performed in accordance to requirements that traceable to National Primary Standards and International System of Units (SI).

FCC §15.247 (i) & §2.1091- MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Applicable Standard

According to subpart 15.247 (i) and subpart 2.1091 systems operating under the provisions of this section shall be operated in a manner that ensures the public is not exposed to RF energy level in excess of the communication guidelines.

Limits for General Population/Uncontrolled Exposure

Limits for General Population/Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (V/m)**	**Magnetic Field Strength (A/m)**	**Power Density (mW/cm^2)**	**Averaging Time (Minutes)**
0.3-1.34	614	1.63	*(100)	30
1.34-30	824/f	2.19/f	*($180/f^2$)	30
30-300	27.5	0.073	0.2	30
300-1500	/	/	f/1500	30
1500-100,000	/	/	1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density

Result

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW).
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

Mode	Frequency (MHz)	Antenna Gain		Max Tune Up Conducted Power		Evaluation Distance (cm)	Power Density (mW/cm^2)	MPE Limit (mW/cm^2)
		(dBi)	(numeric)	(dBm)	(mW)			
BLE	2402-2480	2.0	1.58	1.0	1.26	20	0.0004	1.0
GSM850	824-849	-1.1	0.78	23.31	214.29	20	0.0333	0.55
GSM1900	1850-1910	-1.53	0.70	20.81	120.50	20	0.0168	1.0
LTE NB1 Band 2	1850-1910	-1.53	0.70	21.0	125.89	20	0.0175	1.0
LTE NB1 Band 4	1710-1755	-2.62	0.55	21.0	125.89	20	0.0138	1.0
LTE NB1 Band 5	824-849	-1.1	0.78	21.0	125.89	20	0.0195	0.55
LTE NB1 Band 12	699-716	-4.1	0.39	21.0	125.89	20	0.0098	0.466
LTE NB1 Band 13	777-787	-4.1	0.39	21.0	125.89	20	0.0098	0.518
LTE NB1 Band 25	1850-1915	-1.53	0.70	21.0	125.89	20	0.0175	1.0
LTE NB1 Band 26 (Part 90)	814-823.9	-1.1	0.78	21.0	125.89	20	0.0195	0.543
LTE NB1 Band 26 (Part 22H)	824-849	-1.1	0.78	21.0	125.89	20	0.0195	0.55
LTE NB1 Band 66	1710-1780	-2.62	0.55	21.0	125.89	20	0.0138	1.0
LTE NB1 Band 71	663-698	-4.1	0.39	21.0	125.89	20	0.0098	0.442
LTE NB1 Band 85	698-716	-4.1	0.39	21.0	125.89	20	0.0098	0.465
LTE CatM1 Band 2	1850-1910	-1.53	0.70	22.0	158.49	20	0.0221	1.0
LTE CatM1 Band 4	1710-1755	-2.62	0.55	22.0	158.49	20	0.0173	1.0
LTE CatM1 Band 5	824-849	-1.1	0.78	22.0	158.49	20	0.0246	0.55
LTE CATM1 Band 12	699-716	-4.1	0.39	22.0	158.49	20	0.0123	0.466
LTE CATM1 Band 13	777-787	-4.1	0.39	22.0	158.49	20	0.0123	0.518
LTE CATM1 Band 14	788-798	-4.1	0.39	22.0	158.49	20	0.0123	0.525
LTE CATM1 Band 25	1850-1915	-1.53	0.70	22.0	158.49	20	0.0221	1.0
LTE CATM1 Band 26 (Part 90)	814-824	-1.1	0.78	22.0	158.49	20	0.0246	0.543
LTE CATM1 Band 26 (Part 22H)	824-849	-1.1	0.78	22.0	158.49	20	0.0246	0.55
LTE CATM1 Band 66	1710-1780	-2.62	0.55	22.0	158.49	20	0.0173	1.0
LTE CATM1 Band 85	698-716	-4.1	0.39	22.0	158.49	20	0.0123	0.465

Note: 1. The antenna gain was provided by the applicant.
2. The BLE function can transmit at the same time with the GSM/NB-IoT/eMTC.
3. Please refer to the MPE report of the FCC ID: ZMOMA510GL grant on 2019-11-07 for the GSM/LTE output power.

So the worst simultaneous transmitting consideration:

The ratio=MPE_{BLE}/limit + MPE_{wwan}/limit=0.0004/1.0+0.0333/0.55=0.061＜1.0

To maintain compliance with the FCC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Compliance

RSS-102 § 4 –EXPOSURE LIMITS

Applicable Standard

According to RSS-102 §4:

Table 4: RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)

Frequency Range (MHz)	Electric Field (V/m rms)	Magnetic Field (A/m rms)	Power Density (W/m²)	Reference Period (minutes)
0.003-10[21]	83	90	-	Instantaneous*
0.1-10	-	0.73/ ƒ	-	6**
1.1-10	87/ $f^{0.5}$	-	-	6**
10-20	27.46	0.0728	2	6
20-48	58.07/ $f^{0.25}$	0.1540/ $f^{0.25}$	8.944/ $f^{0.5}$	6
48-300	22.06	0.05852	1.291	6
300-6000	3.142 $f^{0.3417}$	0.008335 $f^{0.3417}$	0.02619 $f^{0.6834}$	6
6000-15000	61.4	0.163	10	6
15000-150000	61.4	0.163	10	616000/ $f^{1.2}$
150000-300000	0.158 $f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	616000/ $f^{1.2}$

Note: ƒ is frequency in MHz.
* Based on nerve stimulation (NS).
** Based on specific absorption rate (SAR).

Calculated Formulary:

Predication of MPE limit at a given distance

$$S = \frac{PG}{4\pi R^2}$$

S = power density (in appropriate units, e.g. mW/cm^2)
P = power input to the antenna (in appropriate units, e.g., mW).
G = power gain of the antenna in the direction of interest relative to an isotropic radiator, the power gain factor, is normally numeric gain.
R = distance to the center of radiation of the antenna (appropriate units, e.g., cm)

For simultaneously transmit system, the calculated power density should comply with:

$$\sum_i \frac{S_i}{S_{Limit,i}} \leq 1$$

Mode	Frequency (MHz)	Antenna Gain		Turn up Power		Evaluation Distance (m)	Power Density (W/m^2)	MPE Limit (W/m^2)
		(dBi)	(numeric)	(dBm)	(W)			
BLE	2402-2480	2.0	1.58	1.0	0.0013	0.2	0.0041	5.35
GSM850	824-849	-1.1	0.78	23.31	0.214	0.2	0.332	2.58
GSM1900	1850-1910	-1.53	0.70	20.81	0.121	0.2	0.169	4.48
LTE NB1 Band 2	1850-1910	-1.53	0.70	21.0	0.126	0.2	0.175	4.48
LTE NB1 Band 4	1710-1755	-2.62	0.55	21.0	0.126	0.2	0.138	4.24
LTE NB1 Band 5	824-849	-1.1	0.78	21.0	0.126	0.2	0.196	2.58
LTE NB1 Band 12	699-716	-4.1	0.39	21.0	0.126	0.2	0.098	2.30
LTE NB1 Band 13	777-787	-4.1	0.39	21.0	0.126	0.2	0.098	2.47
LTE NB1 Band 25	1850-1915	-1.53	0.70	21.0	0.126	0.2	0.175	4.48
LTE NB1 Band 26	824-849	-1.1	0.78	21.0	0.126	0.2	0.196	2.58
LTE NB1 Band 66	1710-1780	-2.62	0.55	21.0	0.126	0.2	0.138	4.24
LTE NB1 Band 71	663-698	-4.1	0.39	21.0	0.126	0.2	0.098	2.22
LTE NB1 Band 85	698-716	-4.1	0.39	21.0	0.126	0.2	0.098	2.30
LTE CatM1 Band 2	1850-1910	-1.53	0.70	22.0	0.158	0.2	0.220	4.48
LTE CatM1 Band 4	1710-1755	-2.62	0.55	22.0	0.158	0.2	0.173	4.24
LTE CatM1 Band 5	824-849	-1.1	0.78	22.0	0.158	0.2	0.245	2.58
LTE CATM1 Band 12	699-716	-4.1	0.39	22.0	0.158	0.2	0.123	2.30
LTE CATM1 Band 13	777-787	-4.1	0.39	22.0	0.158	0.2	0.123	2.47
LTE CATM1 Band 14	788-798	-4.1	0.39	22.0	0.158	0.2	0.123	2.50
LTE CATM1 Band 25	1850-1915	-1.53	0.70	22.0	0.158	0.2	0.220	4.48
LTE CATM1 Band 26	824-849	-1.1	0.78	22.0	0.158	0.2	0.245	2.58
LTE CATM1 Band 66	1710-1780	-2.62	0.55	22.0	0.158	0.2	0.173	4.24
LTE CATM1 Band 85	698-716	-4.1	0.39	22.0	0.158	0.2	0.123	2.30

Note: 1. The antenna gain was provided by the applicant.
2. The BLE function can transmit at the same time with the GSM/NB-IoT/eMTC.
3. Please refer to the MPE report of the IC: 21374-MA510GL for the GSM/LTE output power.

Simultaneous transmitting consideration (worst case):

The ratio=MPE_{BLE}/limit+MPE_{WWAN}/limit=0.0041/5.35+0.332/2.58=0.129＜1.0

To maintain compliance with the ISEDC's RF exposure guidelines, place the equipment at least 20cm from nearby persons.

Result: Pass

§15.203 & RSS-Gen §6.8 ANTENNA REQUIREMENT

Applicable Standard

According to § 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 replaced by the user, but the user of a standard antenna jack or electrical connector is prohibited. The structure and application of the EUT were analyzed to determine compliance with section §15.203 of the rules. §15.203 state that the subject device must meet the following criteria:

a. Antenna must be permanently attached to the unit.
b. Antenna must use a unique type of connector to attach to the EUT.

Unit must be professionally installed, and installer shall be responsible for verifying that the correct antenna is employed with the unit.
And according to FCC 47 CFR section 15.247 (b), if the transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested.

For licence-exempt equipment with detachable antennas, the user manual shall also contain the following notice in a conspicuous location:

This radio transmitter [enter the device's ISED certification number] has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any type listed are strictly prohibited for use with this device.
Immediately following the above notice, the manufacturer shall provide a list of all antenna types which can be used with the transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna type.

Antenna Connector Construction

The EUT has an integral antenna arrangement for BLE which was permanently attached and the antenna gain is 2.0dBi, fulfill the requirement of this section. Please refer to the EUT photos.

Type	Antenna Gain	Impedance
PCB	2.0dBi	50 Ω

Result: Compliant

§ 15.207 (a) & RSS-GEN §8.8 AC LINE CONDUCTED EMISSIONS

Applicable Standard

FCC§15.207

Unless stated otherwise in the applicable RSS, for radio apparatus that are designed to be connected to the public utility AC power network, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies within the range 150 kHz to 30 MHz shall not exceed the limits in table 4, as measured using a 50 µH / 50 Ω line impedance stabilization network. This requirement applies for the radio frequency voltage measured between each power line and the ground terminal of each AC power-line mains cable of the EUT.

For an EUT that connects to the AC power lines indirectly, through another device, the requirement for compliance with the limits in table 4 shall apply at the terminals of the AC power-line mains cable of a representative support device, while it provides power to the EUT. The lower limit applies at the boundary between the frequency ranges. The device used to power the EUT shall be representative of typical applications.

Table 4 - AC Power Lines Conducted Emission Limits		
Frequency range (MHz)	Conducted limit (dBµV)	
	Quasi-Peak	Average
0.15 – 0.5	66 to 56[1]	56 to 46[1]
0.5 – 5	56	46
5 – 30	60	50

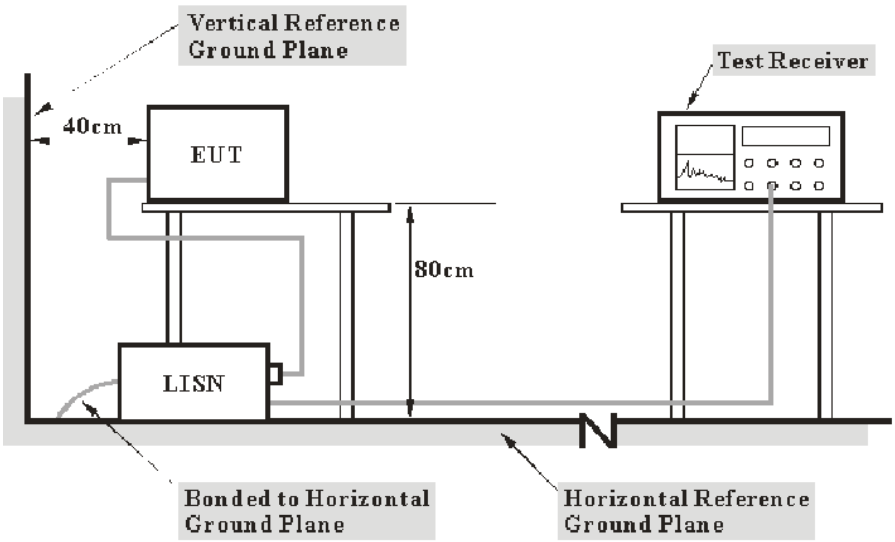
Note 1: The level decreases linearly with the logarithm of the frequency.

For an EUT with a permanent or detachable antenna operating between 150 kHz and 30 MHz, the AC power-line conducted emissions must be measured using the following configurations:

(a) Perform the AC power-line conducted emissions test with the antenna connected to determine compliance with the limits of table 4 outside the transmitter's fundamental emission band.

(b) Retest with a dummy load instead of the antenna to determine compliance with the limits of table 4 within the transmitter's fundamental emission band. For a detachable antenna, remove the antenna and connect a suitable dummy load to the antenna connector. For a permanent antenna, remove the antenna and terminate the RF output with a dummy load or network that simulates the antenna in the fundamental frequency band.

EUT Setup



Note: 1. Support units were connected to second LISN.
2. Both of LISNs (AMN) 80 cm from EUT and at the least 80 cm from other units and other metal planes support units.

The setup of EUT is according with per ANSI C63.10-2013 measurement procedure. The specification used was with the FCC Part 15.207 & RSS-247/RSS-Gen limits.

The spacing between the peripherals was 10 cm.

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

EMI Test Receiver Setup

The EMI test receiver was set to investigate the spectrum from 150 kHz to 30 MHz.

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

Frequency Range	IF B/W
150 kHz – 30 MHz	9 kHz

Test Procedure

During the conducted emission test, the adapter was connected to the outlet of the LISN.

Maximizing procedure was performed on the six (6) highest emissions of the EUT.

All final data was recorded in the Quasi-peak and average detection mode.

Corrected Factor & Margin Calculation

The Corrected factor is calculated by adding LISN VDF (Voltage Division Factor), Cable Loss and Transient Limiter Attenuation. The basic equation is as follows:

Correction Factor = LISN VDF + Cable Loss + Transient Limiter Attenuation

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7 dB means the emission is 7 dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Data

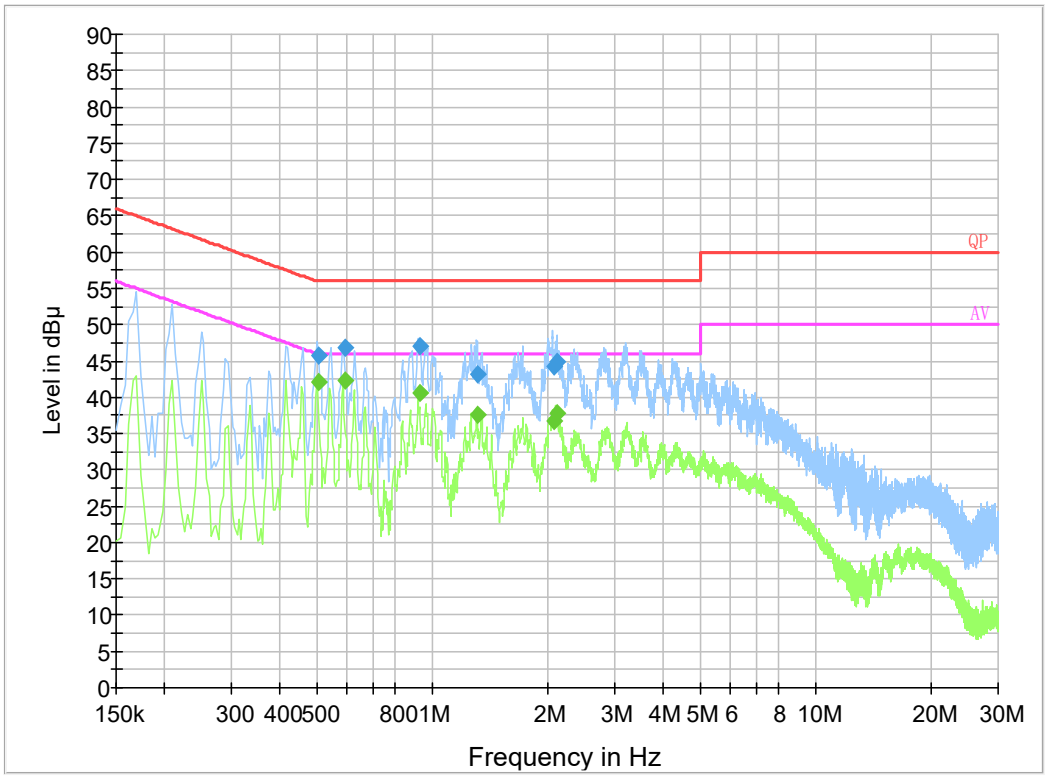
Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	65 %
ATM Pressure:	101.0 kPa

The testing was performed by Haiguo Li on 2021-05-18.

EUT operation mode: Transmitting

AC 120V/60 Hz, Line



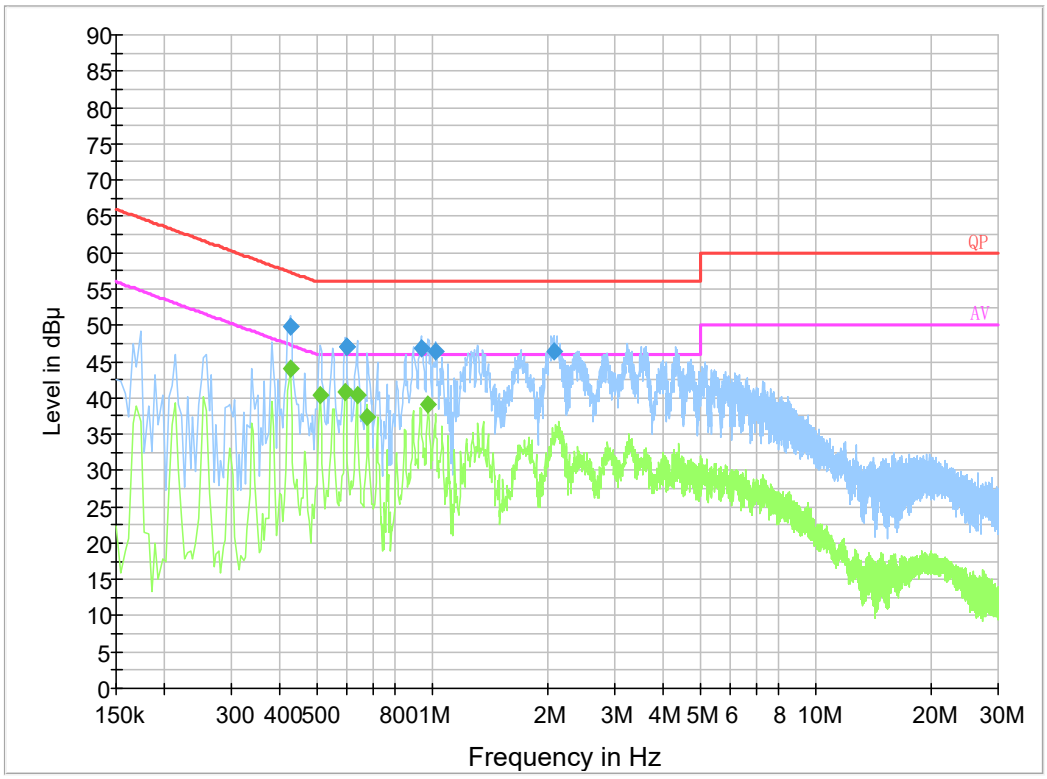
Final Result 1

Frequency (MHz)	QuasiPeak (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.506470	45.7	9.000	L1	19.8	10.3	56.0
0.593210	46.9	9.000	L1	19.8	9.1	56.0
0.931770	47.0	9.000	L1	19.8	9.0	56.0
1.318410	43.2	9.000	L1	19.8	12.8	56.0
2.083130	44.2	9.000	L1	19.9	11.8	56.0
2.130170	44.8	9.000	L1	19.9	11.2	56.0

Final Result 2

Frequency (MHz)	Average (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.506470	42.1	9.000	L1	19.8	3.9	46.0
0.593210	42.3	9.000	L1	19.8	3.7	46.0
0.931770	40.6	9.000	L1	19.8	5.4	46.0
1.318410	37.5	9.000	L1	19.8	8.5	46.0
2.083130	36.7	9.000	L1	19.9	9.3	46.0
2.130170	37.8	9.000	L1	19.9	8.2	46.0

AC 120V/60 Hz, Neutral



Final Result 1

Frequency (MHz)	QuasiPeak (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.427610	49.8	9.000	N	19.8	7.5	57.3
0.597030	47.1	9.000	N	19.8	8.9	56.0
0.597090	47.1	9.000	N	19.8	8.9	56.0
0.939930	46.9	9.000	N	19.8	9.1	56.0
1.022670	46.5	9.000	N	19.8	9.5	56.0
2.080750	46.5	9.000	N	19.9	9.5	56.0

Final Result 2

Frequency (MHz)	Average (dB µ V)	Bandwidth (kHz)	Line	Corr. (dB)	Margin (dB)	Limit (dB µ V)
0.426000	44.1	9.000	N	19.8	3.2	47.3
0.510000	40.3	9.000	N	19.8	5.7	46.0
0.594000	40.9	9.000	N	19.8	5.1	46.0
0.638000	40.5	9.000	N	19.8	5.5	46.0
0.678000	37.3	9.000	N	19.8	8.7	46.0
0.978000	39.1	9.000	N	19.8	6.9	46.0

§15.205, §15.209, §15.247(d) & RSS-GEN § 8.10 & RSS-247 § 5.5 SPURIOUS EMISSIONS

Applicable Standard

FCC §15.247 (d); §15.209; §15.205;

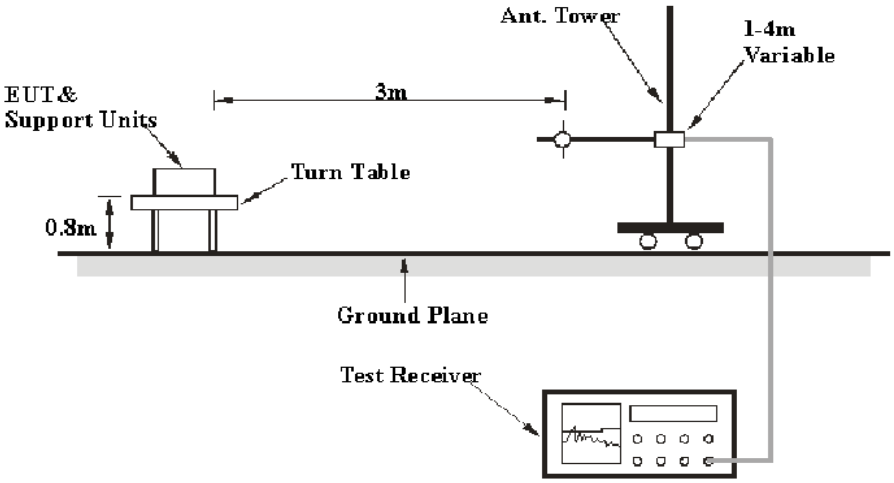
According to RSS-GEN § 8.10 & RSS-247 § 5.5

Restricted frequency bands, identified in table 7, are designated primarily for safety-of-life services (distress calling and certain aeronautical activities), certain satellite downlinks, radio astronomy and some government uses. Except where otherwise indicated, the following conditions related to the restricted frequency bands apply:(a) The transmit frequency, including fundamental components of modulation, of licence-exempt radio apparatus shall not fall within the restricted frequency bands listed in table 7 except for apparatus compliant with RSS-287, Emergency Position Indicating Radio Beacons (EPIRB), Emergency Locator Transmitters (ELT), Personal Locator Beacons (PLB), and Maritime Survivor Locator Devices (MSLD).(b) Unwanted emissions that fall into restricted frequency bands listed in table 7 shall comply with the limits specified in table 5 and table 6.(c) Unwanted emissions that do not fall within the restricted frequency bands listed in table 7 shall comply either with the limits specified in the applicable RSS or with those specified in table 5 and table 6.

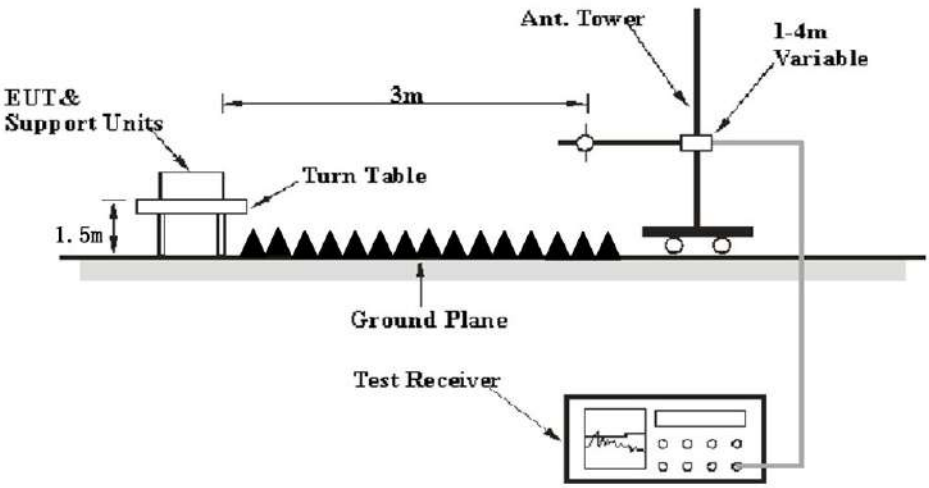
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

EUT Setup

Below 1 GHz:



Above 1GHz:



The radiated emission tests were performed in the 3 meters test site, using the setup accordance with the ANSI C63.10-2013 & RSS-Gen. The specification used was the FCC 15.209, and FCC 15.247 & RSS-Gen limits.

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

EMI Test Receiver & Spectrum Analyzer Setup

The system was investigated from 30 MHz to 25 GHz.

During the radiated emission test, the EMI test receiver & Spectrum Analyzer Setup were set with the following configurations:

Frequency Range	RBW	Video B/W	IF B/W	Measurement
30 MHz – 1000 MHz	100 kHz	300 kHz	120 kHz	QP
Above 1 GHz	1MHz	3 MHz	/	PK
	1MHz	10 Hz Note 1	/	Average
	1MHz	＞1/T Note 2	/	Average

Note 1: when duty cycle is no less than 98%
Note 2: when duty cycle is less than 98%

Test Procedure

Maximizing procedure was performed on the highest emissions to ensure that the EUT complied with all installation combinations.

Data was recorded in Quasi-peak detection mode for frequency range of 30 MHz-1 GHz, peak and Average detection modes for frequencies above 1 GHz.

Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.

Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.

Repeat above procedures until all measured frequencies were complete.

Corrected Amplitude & Margin Calculation

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

Corrected Amplitude = Meter Reading + Antenna Factor + Cable Loss - Amplifier Gain

The "**Margin**" column of the following data tables indicates the degree of compliance with the applicable limit. For example, a margin of 7dB means the emission is 7dB below the limit. The equation for margin calculation is as follows:

Margin = Limit – Corrected Amplitude

Test Data

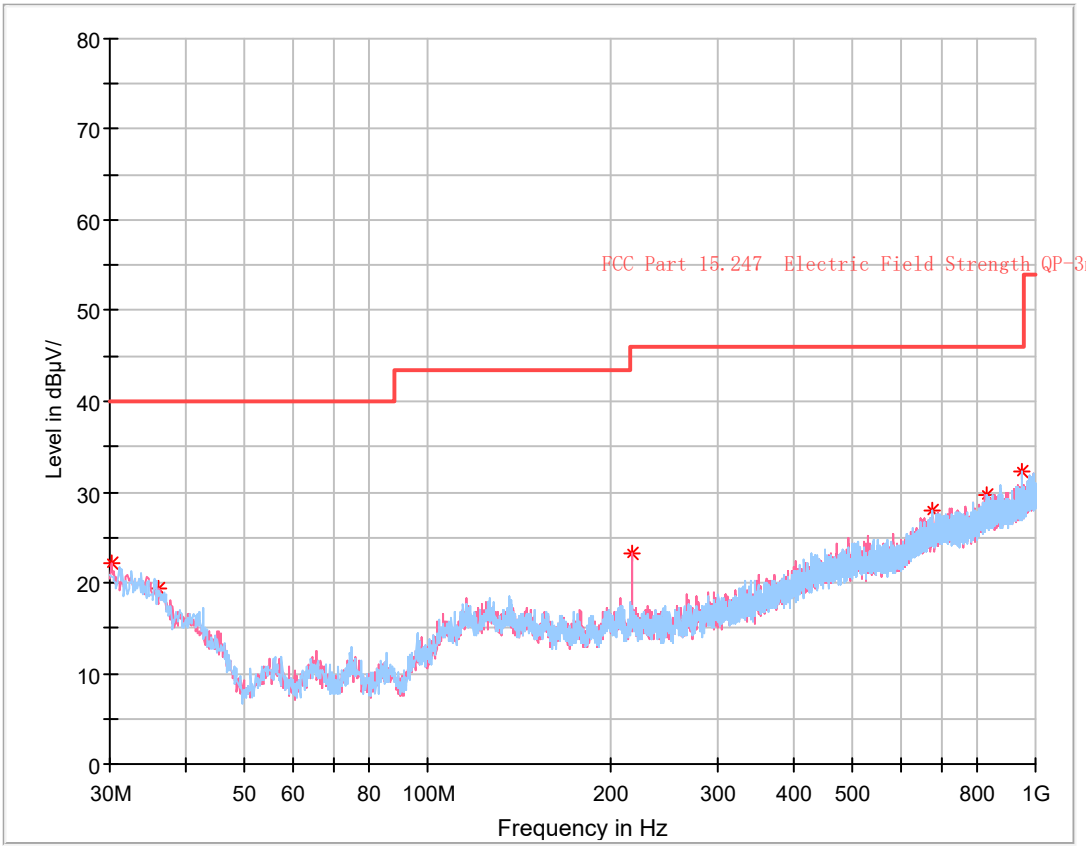
Environmental Conditions

Temperature:	25.8~28℃
Relative Humidity:	51~60 %
ATM Pressure:	101.0kPa

The testing was performed by Zero Yan on 2021-05-17 for below 1GHz and by Alan He on 2021-05-21 for above 1GHz

EUT operation mode: Transmitting

30 MHz~1 GHz: *(worst case at BLE 1M low channel)*



Critical_Freqs

Frequency (MHz)	MaxPeak (dB µ V/m)	Limit (dB µ V/m)	Margin (dB)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.121250	22.15	40.00	17.85	100.0	V	0.0	-3.6
36.183750	19.40	40.00	20.60	100.0	V	128.0	-8.1
216.967500	23.20	46.00	22.80	200.0	V	353.0	-11.3
674.322500	28.03	46.00	17.97	200.0	H	0.0	-2.0
829.037500	29.74	46.00	16.26	100.0	H	0.0	-0.1
947.620000	32.36	46.00	13.64	200.0	H	105.0	1.6

1 GHz-25 GHz:

BLE 1M Mode:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2320.25	28.61	PK	150	1.6	H	31.64	60.25	74	13.75
2320.25	15.67	Ave.	150	1.6	H	31.64	47.31	54	6.69
2483.92	29.2	PK	264	1.3	H	32.13	61.33	74	12.67
2483.92	16.72	Ave.	264	1.3	H	32.13	48.85	54	5.15
4804.00	51.65	PK	359	1.0	H	6.28	57.93	74	16.07
4804.00	46.51	Ave.	20	1.8	H	6.28	52.79	54	1.21
Middle Channel (2440 MHz)									
4880.00	50.65	PK	278	1.4	H	6.76	57.41	74	16.59
4880.00	46.15	Ave.	278	1.4	H	6.76	52.91	54	1.09
High Channel (2480 MHz)									
2346.18	29.6	PK	270	1.9	H	31.64	61.24	70	8.76
2346.18	15.39	Ave.	270	1.9	H	31.64	47.03	50	2.97
2498.08	29.45	PK	110	1.4	H	32.13	61.58	70	8.42
2498.08	16.29	Ave.	110	1.4	H	32.13	48.42	50	1.58
4960.00	49.8	PK	27	2.0	H	6.80	56.60	74	17.40
4960.00	44.73	Ave.	27	2.0	H	6.80	51.53	54	2.47

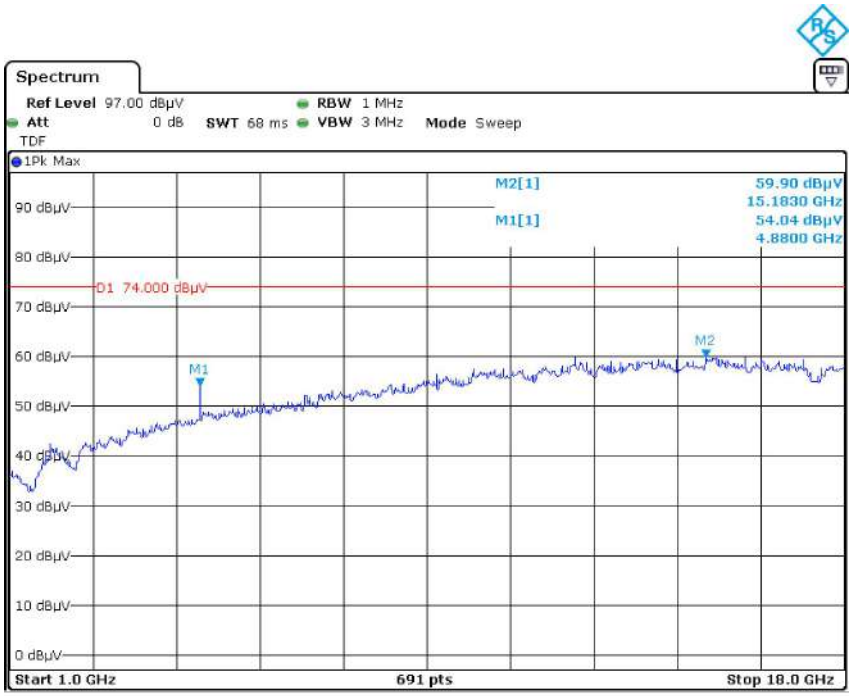
BLE 2M Mode:

Frequency (MHz)	Receiver		Turntable Degree	Rx Antenna		Corrected Factor (dB/m)	Corrected Amplitude (dBμV/m)	Limit (dBμV/m)	Margin (dB)
	Reading (dBμV)	PK/QP/Ave.		Height (m)	Polar (H/V)				
Low Channel (2402 MHz)									
2340.51	28.16	PK	52	1.1	H	31.64	59.80	74	14.20
2340.51	14.47	Ave.	52	1.1	H	31.64	46.11	54	7.89
2484.37	29.4	PK	114	1.2	H	32.13	61.53	74	12.47
2484.37	19.45	Ave.	114	1.2	H	32.13	51.58	54	2.42
4804.00	51.71	PK	268	1.4	H	6.28	57.99	74	16.01
4804.00	46.55	Ave.	268	1.4	H	6.28	52.83	54	1.17
Middle Channel (2440 MHz)									
4880.00	50.36	PK	166	1.2	H	6.76	57.12	74	16.88
4880.00	46.12	Ave.	215	2.5	H	6.76	52.88	54	1.12
High Channel (2480 MHz)									
2354.40	28.63	PK	306	1.0	H	31.77	60.40	74	13.60
2354.40	14.91	Ave.	306	1.0	H	31.77	46.68	54	7.32
2498.39	29.15	PK	66	1.4	H	32.13	61.28	74	12.72
2498.39	16.5	Ave.	66	1.4	H	32.13	48.63	54	5.37
4960.00	49.46	PK	56	1.7	H	6.80	56.26	74	17.74
4960.00	44.19	Ave.	56	1.7	H	6.80	50.99	54	3.01

Note:
Corrected Factor = Antenna factor (RX) + Cable Loss – Amplifier Factor
Corrected Amplitude = Corrected Factor + Reading
Margin = Limit - Corrected. Amplitude
The other spurious emission which is 20dB to the limit was not recorded.

Pre-scan with middle channel in BLE 1M mode Peak

Horizontal



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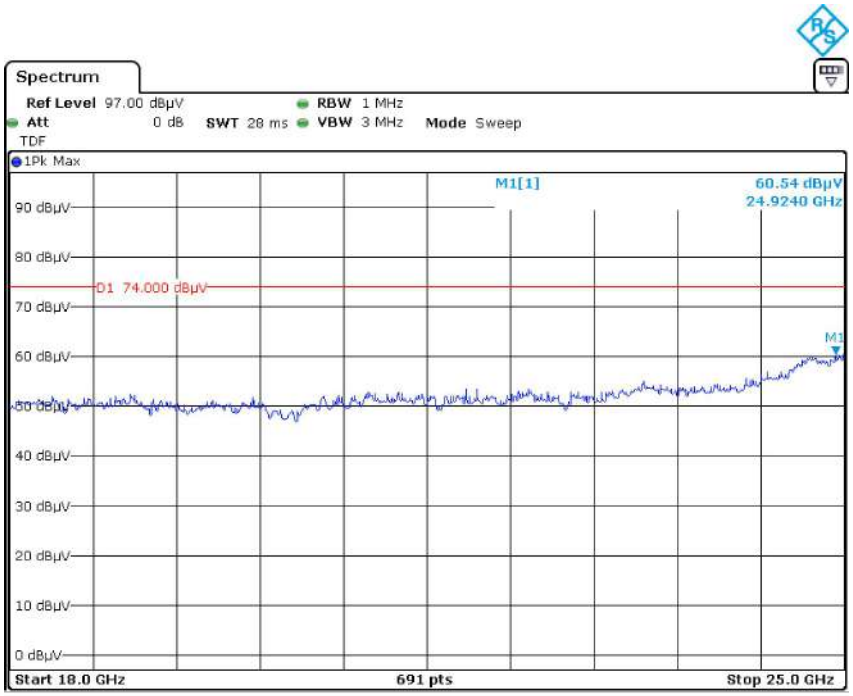

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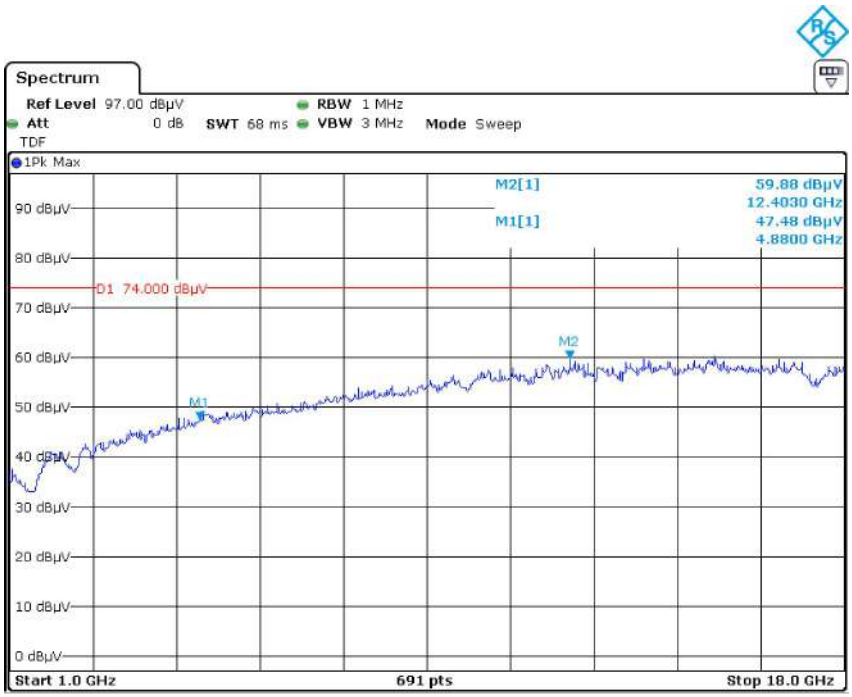
Vertical



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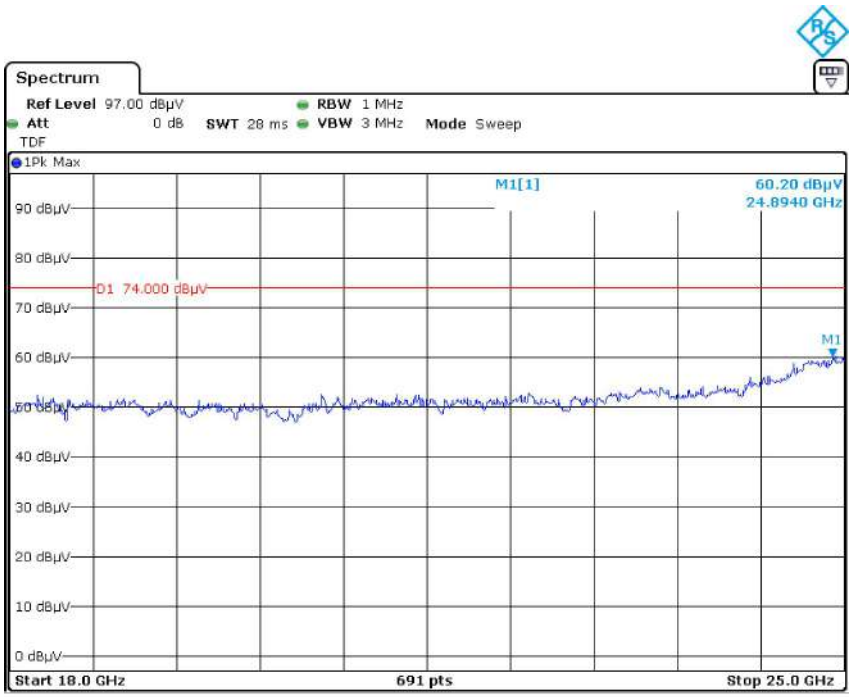

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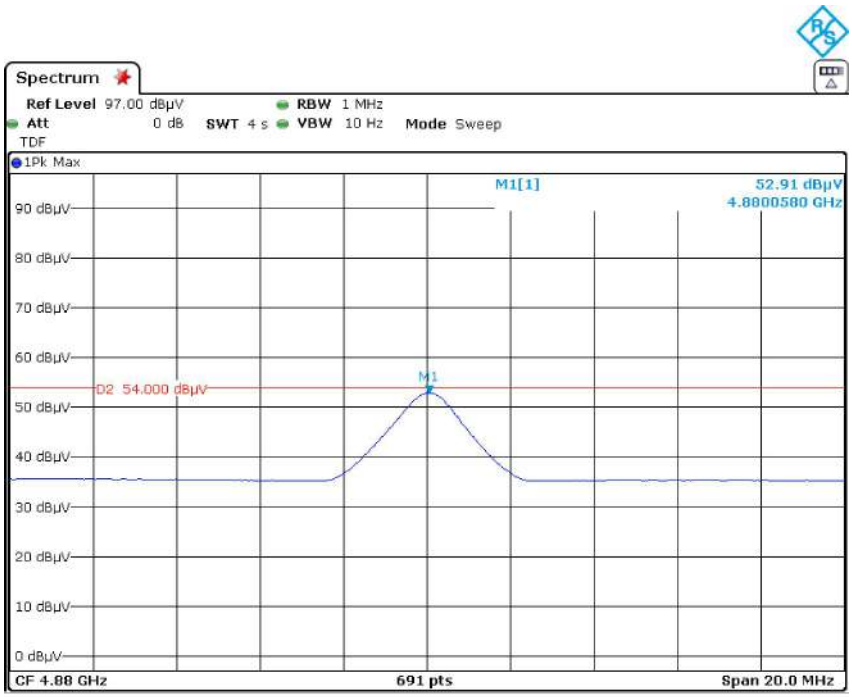
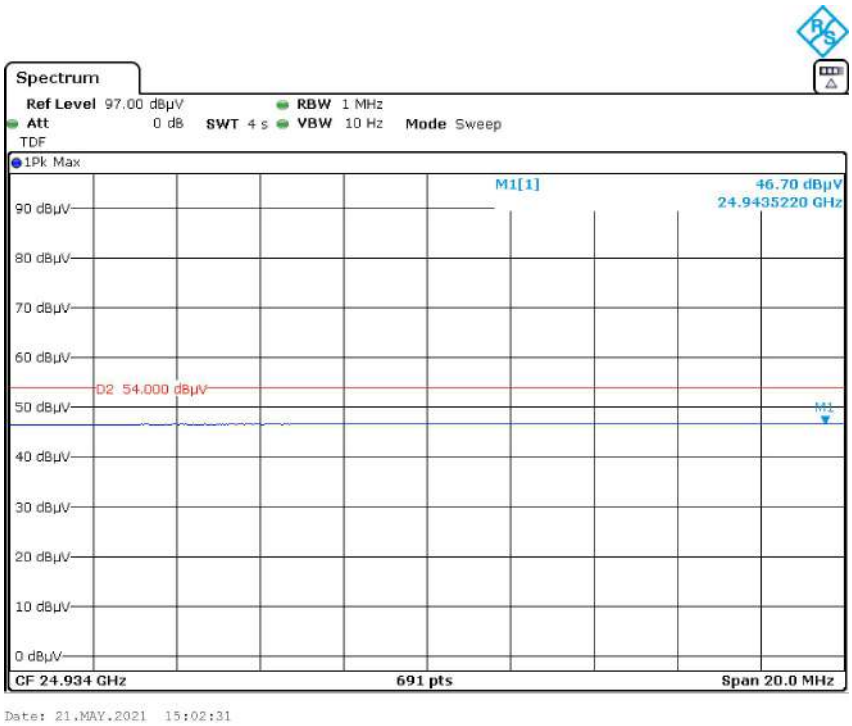
Average
Horizontal





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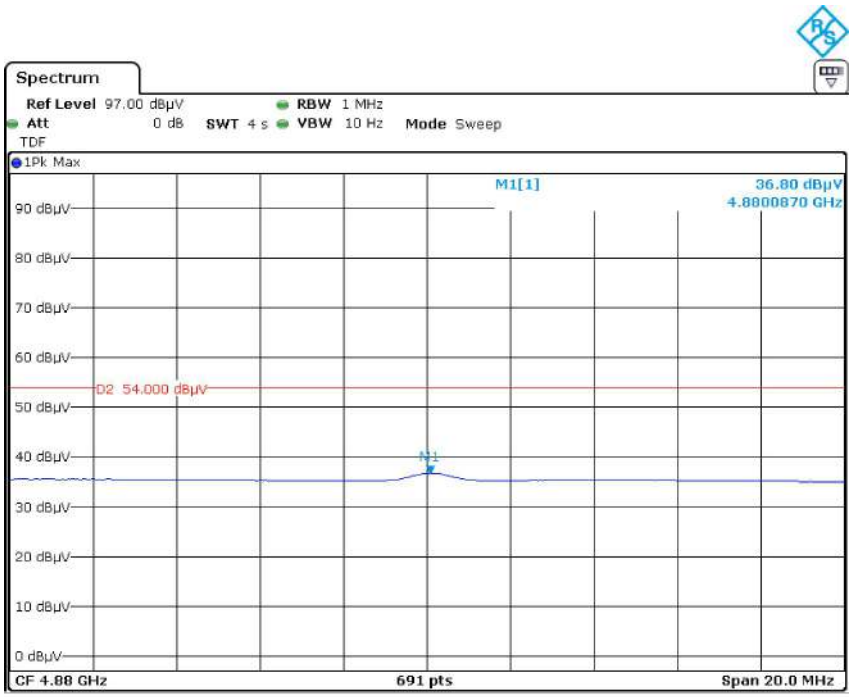

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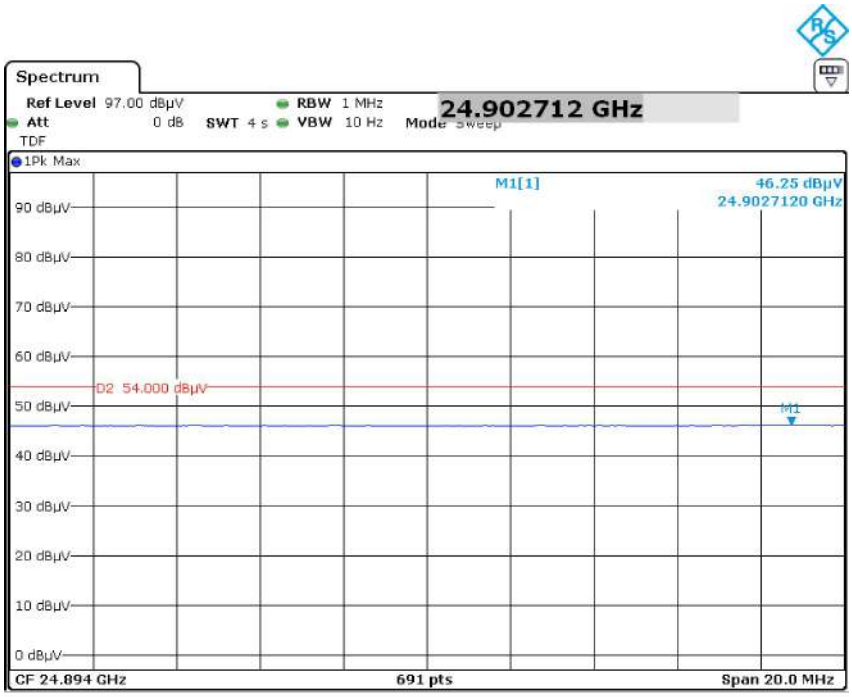

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§15.247 (a)(2) & RSS-Gen§6.7 RSS-247 § 5.2 (a) 99% OCCUPIED BANDWIDTH & 6 dB EMISSION BANDWIDTH

Applicable Standard

Systems using digital modulation techniques may operate in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

The occupied bandwidth or the "99% emission bandwidth" is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

In some cases, the "6 dB bandwidth" is required, which is defined as the frequency range between two points, one at the lowest frequency below and one at the highest frequency above the carrier frequency, at which the maximum power level of the transmitted emission is attenuated 6 dB below the maximum in-band power level of the modulated signal, where the two points are on the outskirts of the in-band emission.

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect it to measurement instrument. Then set it to any one convenient frequency within its operating range. Set a reference level on the measuring instrument equal to the highest peak value.
3. Measure the frequency difference of two frequencies that were attenuated 6 dB from the reference level. Record the frequency difference as the emission bandwidth.
4. Repeat above procedures until all frequencies measured were complete.

The following conditions shall be observed for measuring the occupied bandwidth and 6 dB bandwidth:

• The transmitter shall be operated at its maximum carrier power measured under normal test conditions.

• The span of the spectrum analyzer shall be set large enough to capture all products of the modulation process, including the emission skirts, around the carrier frequency, but small enough to avoid having other emissions (e.g. on adjacent channels) within the span.

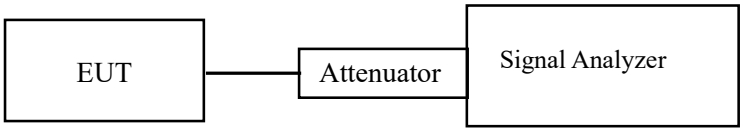
• The detector of the spectrum analyzer shall be set to "Sample". However, a peak, or peak hold, may be used in place of the sampling detector since this usually produces a wider bandwidth than the actual bandwidth (worst-case measurement). Use of a peak hold (or "Max Hold") may be necessary to determine the occupied / 6 dB bandwidth if the device is not transmitting continuously.

• The resolution bandwidth (RBW) shall be in the range of 1% to 5% of the actual occupied / 6 dB bandwidth and the video bandwidth (VBW) shall not be smaller than three times the RBW value. Video averaging is not permitted.

Note: It may be necessary to repeat the measurement a few times until the RBW and VBW are in compliance with the above requirement.

For the 99% emission bandwidth, the trace data points are recovered and directly summed in linear power level terms. The recovered amplitude data points, beginning at the lowest frequency, are placed

in a running sum until 0.5% of the total is reached, and that frequency recorded. The process is repeated for the highest frequency data points (starting at the highest frequency, at the right side of the span, and going down in frequency). This frequency is then recorded. The difference between the two recorded frequencies is the occupied bandwidth (or the 99% emission bandwidth).



Test Data

Environmental Conditions

Temperature:	25 ℃
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-05-18.

EUT operation mode: Transmitting

Test Result: Pass

Please refer to the Appendix.

§15.247(b)(3) & RSS-247 § 5.4(d) MAXIMUM CONDUCTED OUTPUT POWER

Applicable Standard

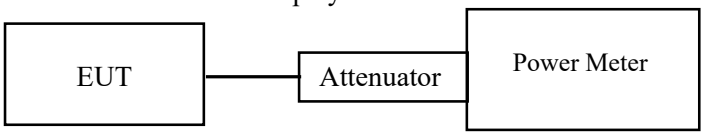
According to FCC §15.247(b) (3), for systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.

Test Procedure

1. Place the EUT on a bench and set it in transmitting mode.
2. Remove the antenna from the EUT and then connect a low loss RF cable from the antenna port to one test equipment.
3. Add a correction factor to the display.



Test Data

Environmental Conditions

Temperature:	25 °C
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-05-18.

EUT operation mode: Transmitting

Test Result: Pass

Please refer to the Appendix.

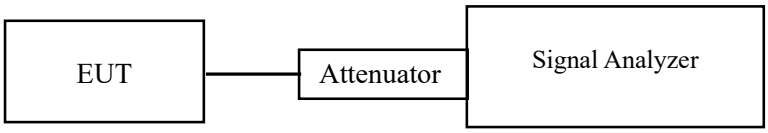
§ 15.247(d) & RSS-247 § 5.5 100 kHz BANDWIDTH OF FREQUENCY BAND EDGE

Applicable Standard

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Test Procedure

1. Check the calibration of the measuring instrument using either an internal calibrator or a known signal from an external generator.
2. Position the EUT without connection to measurement instrument. Turn on the EUT and connect its antenna terminal to measurement instrument via a low loss cable. Then set it to any one measured frequency within its operating range, and make sure the instrument is operated in its linear range.
3. Set RBW to 100 kHz and VBW of spectrum analyzer to 300 kHz with a convenient frequency span including 100 kHz bandwidth from band edge.
4. Measure the highest amplitude appearing on spectral display and set it as a reference level. Plot the graph with marking the highest point and edge frequency.
5. Repeat above procedures until all measured frequencies were complete.



Test Data

Environmental Conditions

Temperature:	25 °C
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-05-18.

EUT operation mode: Transmitting

Test Result: Pass

Please refer to the Appendix.

§15.247(e) & RSS-247 § 5.2 (b) POWER SPECTRAL DENSITY

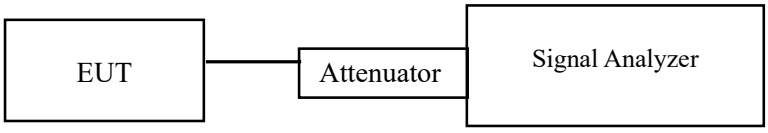
Applicable Standard

For digitally modulated systems, the power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of paragraph (b) of this section. The same method of determining the conducted output power shall be used to determine the power spectral density.

The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than8 dBm in any 3 kHz band during any time interval of continuous transmission. This power spectral density shall be determined in accordance with the provisions of section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

Test Procedure

1. Use this procedure when the maximum peak conducted output power in the fundamental emission is used to demonstrate compliance.
2. Set the RBW to: 3kHz≤ RBW≤100 kHz.
3. Set the VBW ≥ 3×RBW.
4. Set the span to 1.5 times the DTS bandwidth.
5. Detector = peak.
6. Sweep time = auto couple.
7. Trace mode = max hold.
8. Allow trace to fully stabilize.
9. Use the peak marker function to determine the maximum amplitude level within the RBW.
10. If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.



Test Data

Environmental Conditions

Temperature:	25 °C
Relative Humidity:	56 %
ATM Pressure:	101.0 kPa

The testing was performed by Bravos Zhao on 2021-05-18.

EUT operation mode: Transmitting

Test Result: Pass

Please refer to the Appendix.

APPENDIX BLE

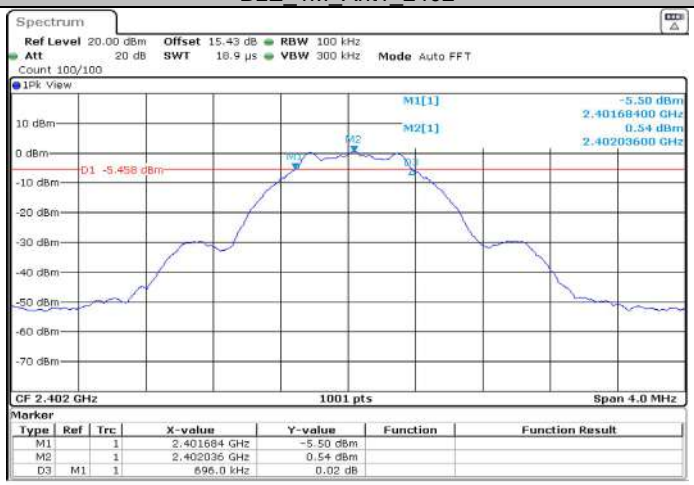
Appendix A: DTS Bandwidth

Test Result

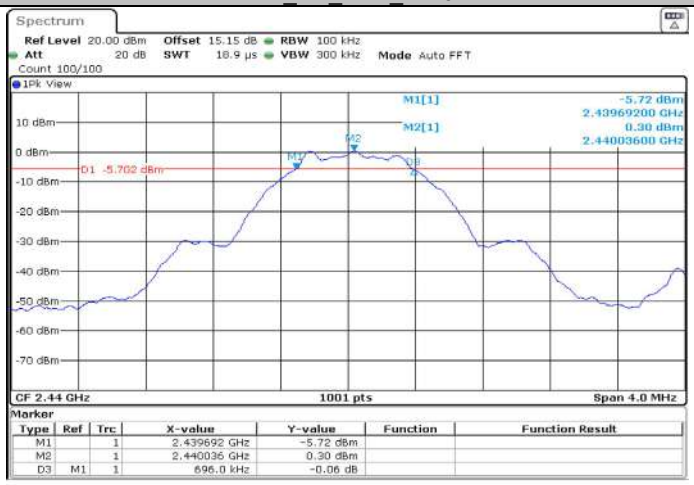
TestMode	Antenna	Channel	DTS BW [MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	0.696	0.5	PASS
		2440	0.696	0.5	PASS
		2480	0.700	0.5	PASS
BLE_2M	Ant1	2402	1.100	0.5	PASS
		2440	1.116	0.5	PASS
		2480	1.184	0.5	PASS

Test Graphs

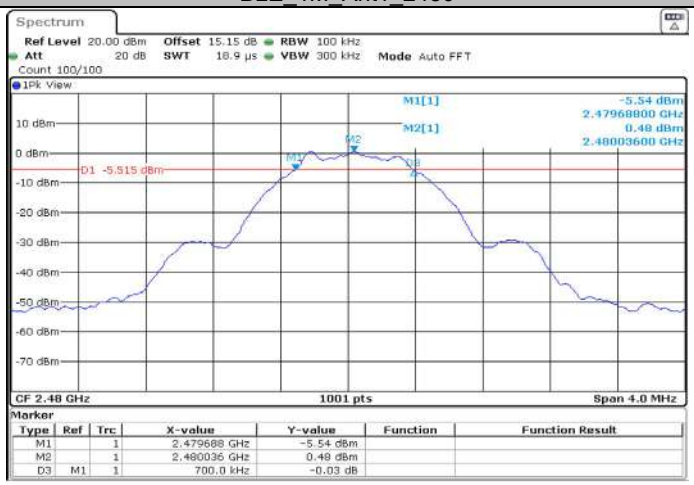
BLE_1M_Ant1_2402



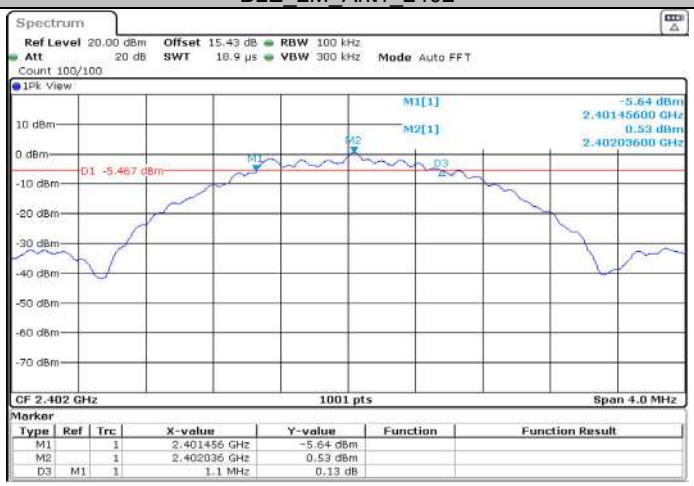
BLE_1M_Ant1_2440



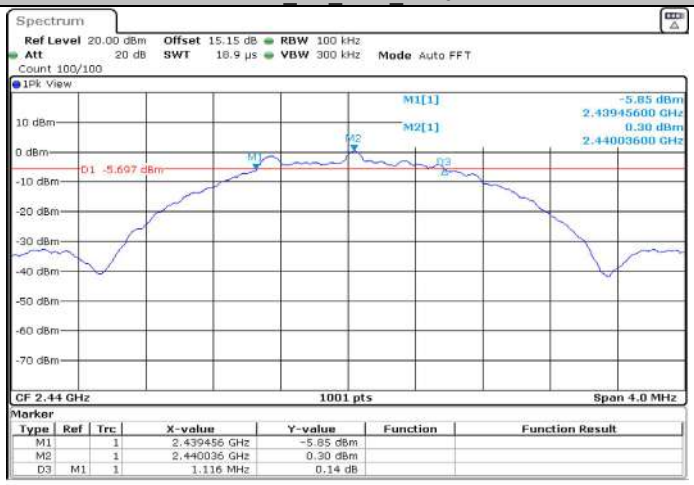
BLE_1M_Ant1_2480



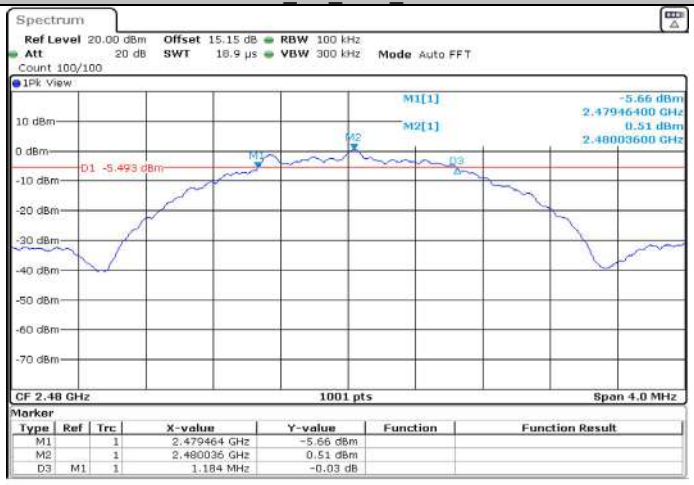
BLE_2M_Ant1_2402



BLE_2M_Ant1_2440



BLE_2M_Ant1_2480



Appendix B: Occupied Channel Bandwidth

Test Result

TestMode	Antenna	Channel	OCB [MHz]	Limit[MHz]	Verdict
BLE_1M	Ant1	2402	1.035	---	PASS
		2440	1.051	---	PASS
		2480	1.043	---	PASS
BLE_2M	Ant1	2402	2.042	---	PASS
		2440	2.062	---	PASS
		2480	2.058	---	PASS

Test Graphs

BLE_1M_Ant1_2402

BLE_1M_Ant1_2440

BLE_1M_Ant1_2480

BLE_2M_Ant1_2402

BLE_2M_Ant1_2440

BLE_2M_Ant1_2480

Appendix C: Maximum conducted Peak output power

Test Result

TestMode	Antenna	Channel	Result[dBm]	Limit[dBm]	Verdict
BLE_1M	Ant1	2402	0.76	<=30	PASS
		2440	0.60	<=30	PASS
		2480	0.85	<=30	PASS
BLE_2M	Ant1	2402	0.74	<=30	PASS
		2440	0.68	<=30	PASS
		2480	0.85	<=30	PASS

Note: the antenna gain is 2dBi, the maximum EIRP=0.85dBm+2dBi=2.85dBm<36dBm, so it compliance with ISEDC EIRP limit.

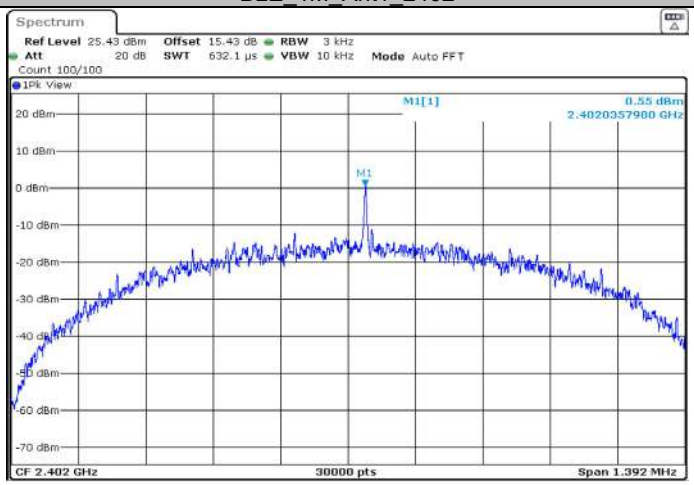
Appendix D: Maximum power spectral density

Test Result

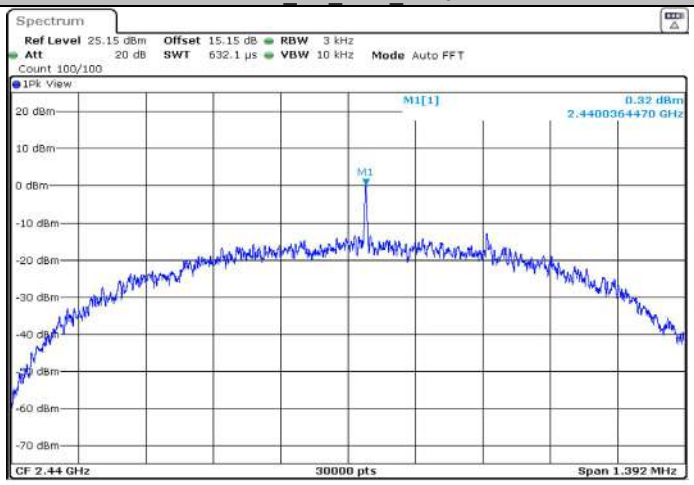
TestMode	Antenna	Channel	Result[dBm/3kHz]	Limit[dBm/3kHz]	Verdict
BLE_1M	Ant1	2402	0.55	<=8	PASS
		2440	0.32	<=8	PASS
		2480	0.52	<=8	PASS
BLE_2M	Ant1	2402	0.53	<=8	PASS
		2440	0.33	<=8	PASS
		2480	0.54	<=8	PASS

Test Graphs

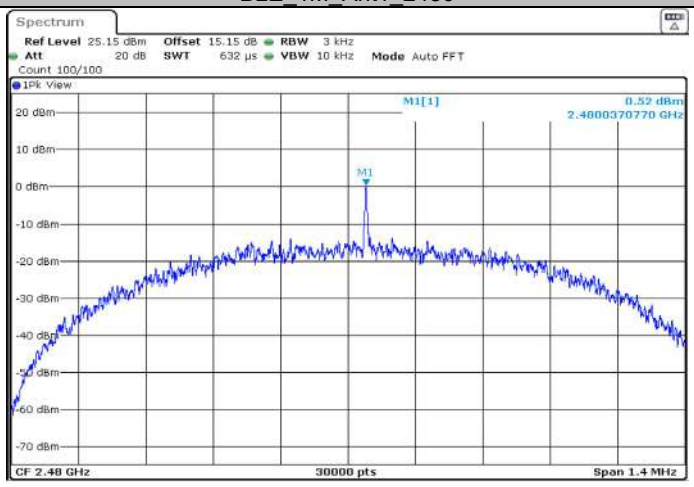
BLE_1M_Ant1_2402



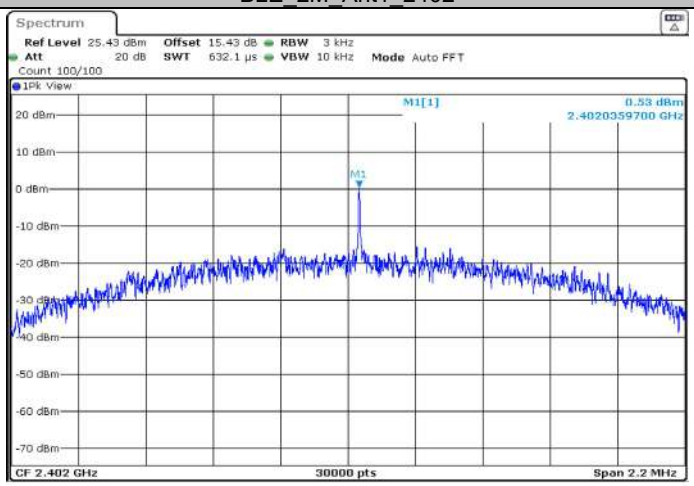
BLE_1M_Ant1_2440



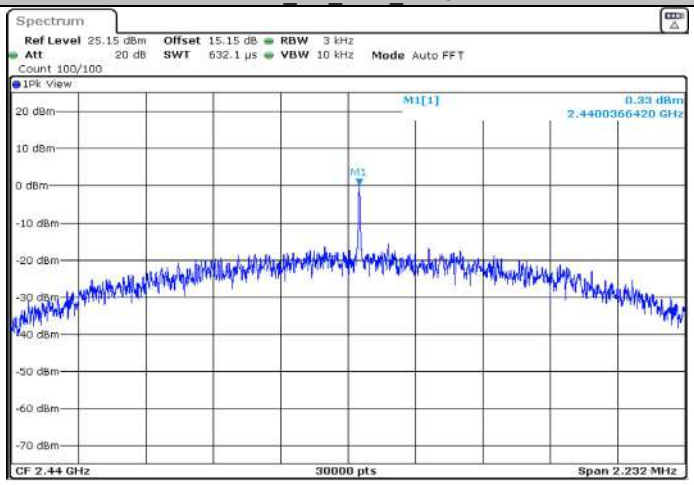
BLE_1M_Ant1_2480



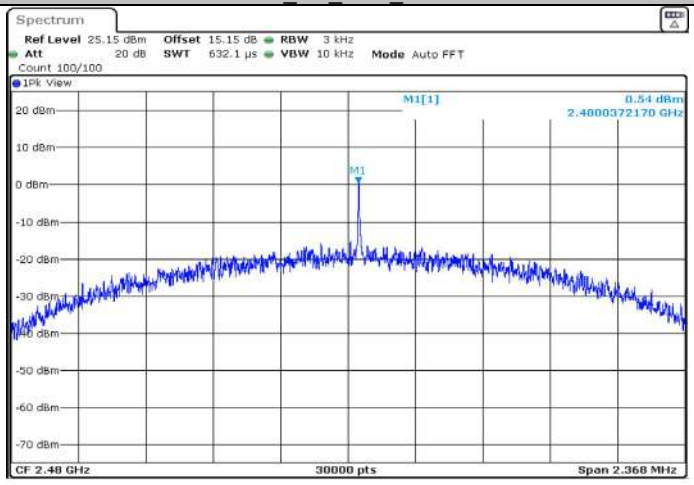
BLE_2M_Ant1_2402



BLE_2M_Ant1_2440



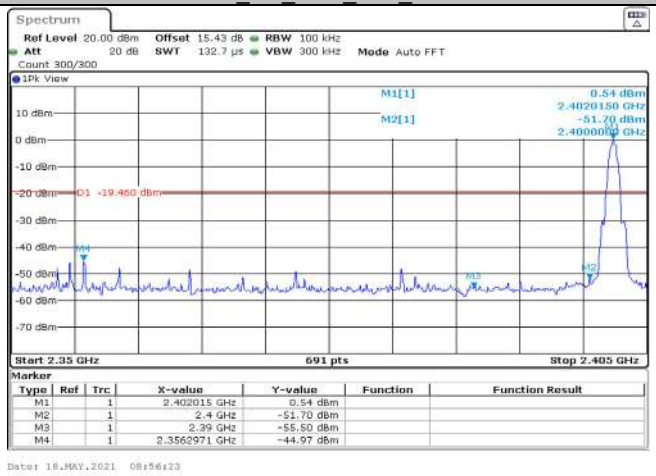
BLE_2M_Ant1_2480



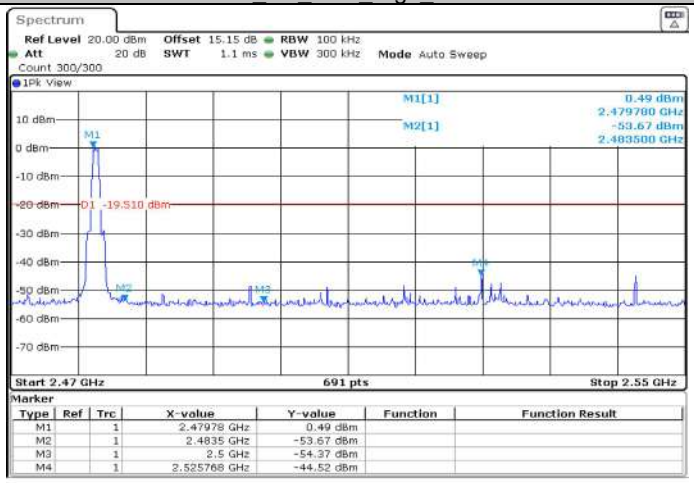
Appendix E: Band edge measurements

Test Graphs

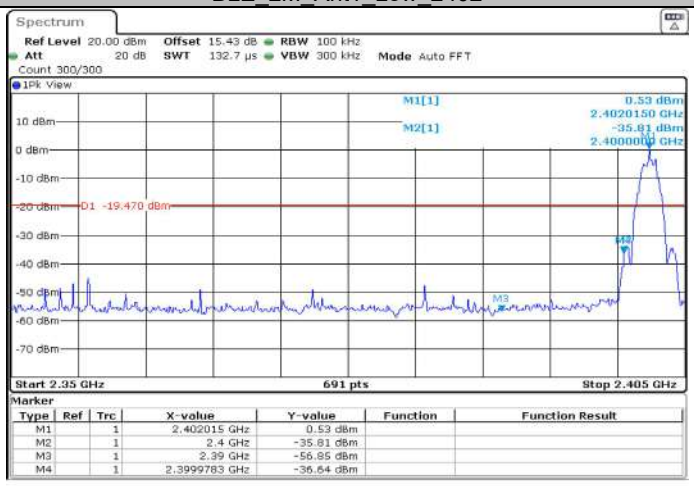
BLE_1M_Ant1_Low_2402



BLE_1M_Ant1_High_2480



BLE_2M_Ant1_Low_2402



BLE_2M_Ant1_High_2480

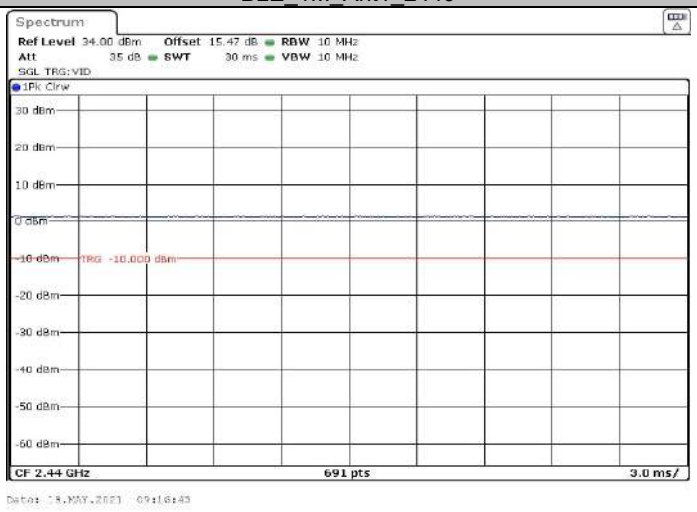
Appendix F: Duty Cycle

Test Result

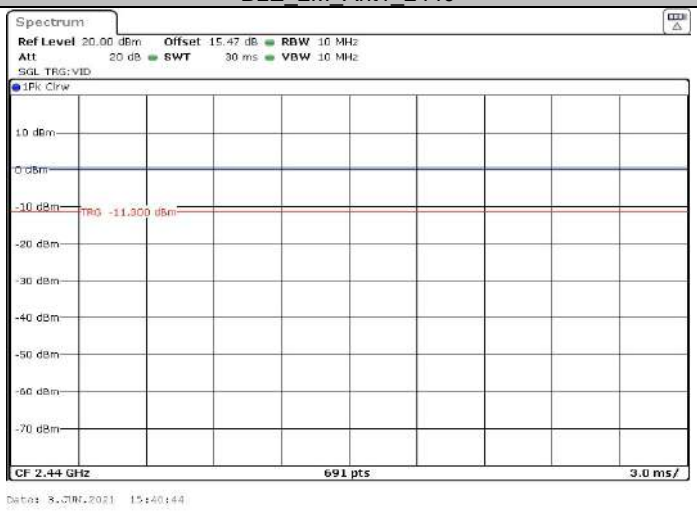
TestMode	Antenna	Channel	Transmission Duration [ms]	Transmission Period [ms]	Duty Cycle [%]
BLE_1M	Ant1	2440	30	30	100%
BLE_2M	Ant1	2440	30	30	100%

Test Graphs

BLE_1M_Ant1_2440



BLE_2M_Ant1_2440



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