

FCC IC RF Test Report

Test Report Number BTP-21110942-LC-FCC-IC-RF

FCC ID 2A4DM-0001

Applicant Bexar, Inc.

Applicant Address 4680 S Downing St Englewood, CO 80113

Product Name Wavee Touchless Switch

Model (s) 001-0001-01

Date of Receipt 12/16/2021

Date of Test 12/17/2021- 01/24/2022

Report Issue Date 02/16/2022

Test Standards 47 CFR Part 15.247

RSS 247 Issue2, February 2017

Test Result PASS



Issued by:

Vista Compliance Laboratories

1261 Puerta Del Sol, San Clemente, CA 92673 USA

www.vista-compliance.com

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REVISION HISTORY

Report Number	Version	Description	Issued Date
BTP-21110942-LC-FCC-IC-RF	01	Initial report	02/16/2022

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1 Test Summary

Test Item	Test Requirement	Test Method	Result
Antenna Requirement	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass
DTS (6 dB) Channel Bandwidth	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass
Occupied Bandwidth	RSS-Gen Issue 5, Feb 2021	RSS-Gen Issue 5, Feb 2021	Pass
Conducted Maximum Output Power	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass
Power Spectral Density	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass
Conducted Band-Edge & Unwanted Emissions	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass
Radiated Emissions & Unwanted Emissions into Restricted Frequency Bands	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass
AC Power Line Conducted Emissions	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017	ANSI C63.10 (2013)	Pass

2 General Information

2.1 Applicant

Applicant	Bexar, Inc.
Applicant address	4680 S Downing St Englewood, CO 80113
Manufacturer	Bexar, Inc.
Manufacturer Address	4680 S Downing St Englewood, CO 80113

2.2 Product information

Product Name	WAVEE Touchless Switch
Model Number	001-0001-01
Family Models	N/A
Serial Number	20111733
Frequency Band	BLE: 2402-2480MHz
Type of modulation	BLE: GFSK
Equipment Class	DTS
Antenna Information	PCB Trace Antenna Antenna Gain: 0.73dBi (max)
Clock Frequencies	N/A
Input Power	DC 5.0V
Power Adapter Manufacturer/Model	N/A
Power Adapter SN	N/A
Hardware version	N/A
Software version	N/A
Additional Info	N/A

2.3 Test standard and method

Test standard	47 CFR Part 15.247 RSS-247 Issue 2, Feb 2017
Test method	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02

3 Test Site Information

Lab performing tests	Vista Laboratories, Inc.
Lab Address	1261 Puerta Del Sol, San Clemente, CA 92673 USA
Phone Number	+1 (949) 393-1123
Website	www.vista-compliance.com

Test Condition	Temperature	Humidity	Atmospheric Pressure
RF Testing	23.2°C	57.5%	996 mbar
Radiated Emission Testing	23.2°C	57.5%	996 mbar

4 Modification of EUT / Deviations from Standards

The EUT is an engineering test sample loaded with RF testing firmware specifically designed to support the RF TX/RX measurement in different aspects.

5 Test Configuration and Operation

5.1 EUT Test Configuration

EUT is powered by 5Vdc, EUT was set to continuous transmission mode during TX testing.

The following software was used for testing and to monitor EUT performance

Software	Description
EMISoft Vasona	EMC/RF Spurious emission test software used during testing
Putty	Set the EUT to work in different mode, channel, bandwidth, etc.
Wavee Configurator	Communicate with EUT, set the EUT work at normal condition

Power setting as below

BLE_1M		BLE_2M	
Channel	Power Setting	Channel	Power Setting
00	pos4dBm	00	pos4dBm
19	pos4dBm	19	pos4dBm
39	pos4dBm	39	pos4dBm

5.2 EUT transmission duty cycle and correction factor

§ 15.35 (c) allows that when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value.

EUT's BLE application is to support secured 2-way BLE communications with mobile devices for the purposes of software and configuration updates. The primary data transfer is from the mobile device to the Wavee device. The Wavee device simply responds with an acknowledgement and a status. Most responses are just 3 or 4 bytes long. The Nordic softdevice which implements the Bluetooth interface in software forces a hard limit of 247 bytes.

The EUT actual duty cycle was measured with a published app on the iOS and Android app stores, under both of the advertisement mode and normal operation mode (data transfer). All the available commands in the published app were tried to look for the worst-case duty cycle scenario, which was found to be when sending the command of "Read Device ID"

- **Worst case duty cycle under normal operation mode (sending "Read device ID" command)**

Pulse number in 100ms: 3

Single pulse time: 0.31 ms

Duty Cycle = $(0.31 \times 3) / 100 \times 100\% = 0.93\%$

Duty cycle factor = $20 \times \log(\text{Duty cycle}) = -40.63 \text{ dB}$

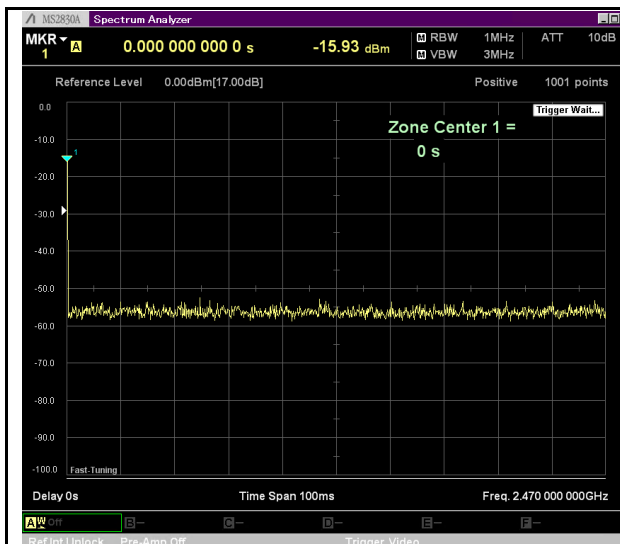
- **Advertisement Mode:**

Pulse number in 100ms: 2

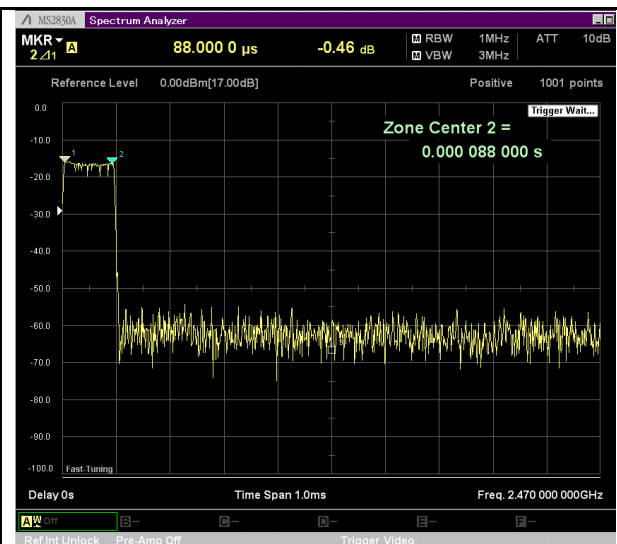
Single pulse time: 0.31 ms

Duty Cycle = $(0.088 \times 1) / 100 \times 100\% = 0.088\%$

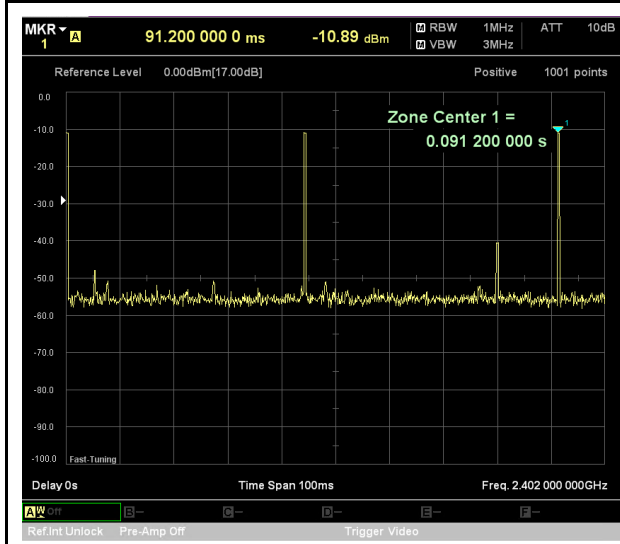
Duty cycle factor = $20 \times \log(\text{Duty cycle}) = -81.11 \text{ dB}$



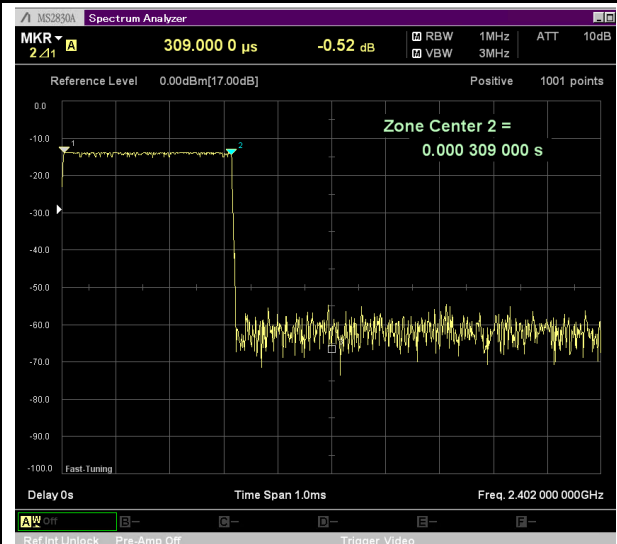
Pulse numbers in 100ms_Normal operation mode
(Read device ID command)



Single pulse _ Normal operation mode
(Read device ID command)



Pulse numbers in 100ms_ Advertisement Mode



Single pulse _ Advertisement Mode

5.3 Supporting Equipment

Description	Manufacturer	Model #	Serial #
DC Power supply	RIGOL	DP712	DP7B194900487
AC/DC adapter	Keyuantai	KYTW40P01	N/A

6 Uncertainty of Measurement

Test item	Measurement Uncertainty (dB)
RF Output Power (Conducted)	±1.2 dB
Power Spectral Density	±0.9 dB
Unwanted Emission (conducted)	±2.6 dB
Occupied Channel Bandwidth	±5 %
Radiated Emission (9KHz-30MHz)	±3.5 dB
Radiated Emission (30MHz-1GHz)	±4.6 dB
Radiated Emission (1-18GHz)	±4.9 dB
Radiated Emission (18-40GHz)	±3.5 dB

7 Test Results

7.1 Antenna Requirement

7.1.1 Requirement

Per § 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 use of a standard antenna jack or electrical connector is prohibited.

7.1.2 Result

Analysis:

- EUT has a PCB trace antenna which is integrated to the main board. And the antenna gain is 0.73dBi maximum.

Conclusion:

- EUT complies with antenna requirement in § 15.203.

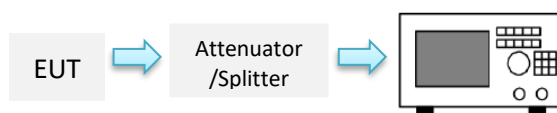
7.2 DTS (6 dB) Bandwidth

7.2.1 Requirement

§ 15.247 (a)(2), RSS-247 §5.2

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

7.2.2 Test Setup



7.2.3 Test Procedure

According to section 8.2, option 2, in KDB 558074 D01 DTS Meas Guidance v05r02 and subclause 11.8 of ANSI C63.10-2013:

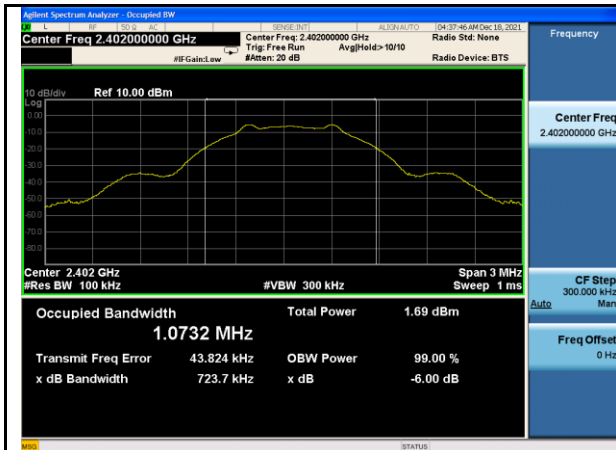
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW $\geq 3 \times$ RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

1. Set RBW = 100 kHz.
2. Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Allow the trace to stabilize.
7. Use automatic bandwidth measurement capability on instrument to obtain BW result.

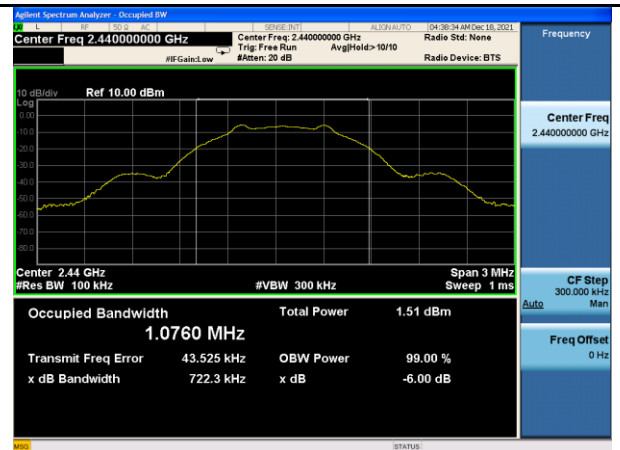
7.2.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
BLE	1Mbps	2402	723.7	500	Pass
		2440	722.3	500	Pass
		2480	733.0	500	Pass
	2Mbps	2402	1332	500	Pass
		2440	1382	500	Pass
		2480	1335	500	Pass

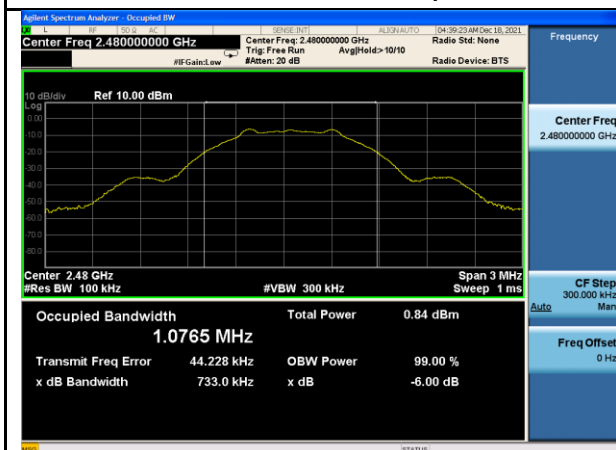
7.2.5 Test Plots



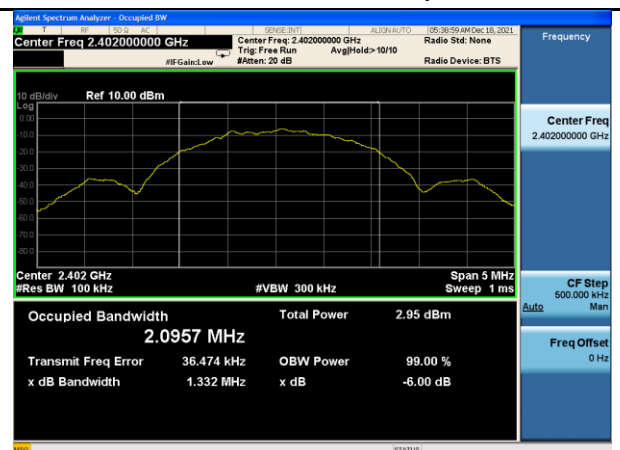
BLE-DTS BW-Low-1Mbps



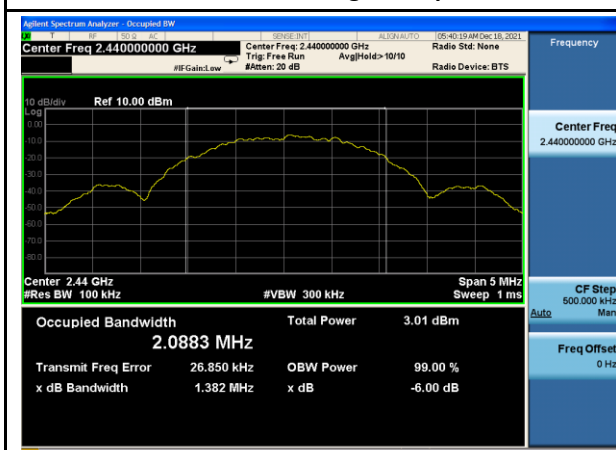
BLE-DTS BW-Mid-1Mbps



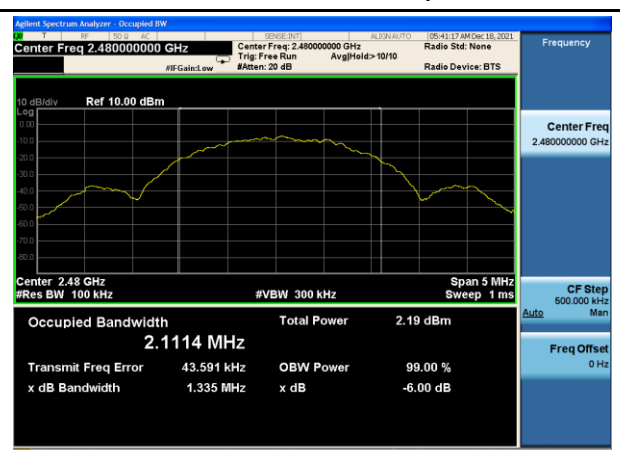
BLE-DTS BW-High-1Mbps



BLE-DTS BW-Low-2Mbps



BLE-DTS BW-Mid-2Mbps



BLE-DTS BW-High-2Mbps

7.3 Occupied Bandwidth (99%)

7.3.1 Requirement

RSS-Gen §6.7

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.

7.3.2 Test Setup



7.3.3 Test Procedure

According to section RSS-Gen §6.7

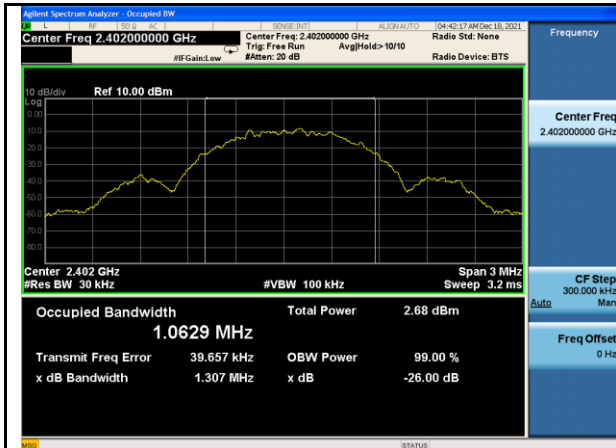
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW $\geq 3 \times$ RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this capability, care shall be taken so that the bandwidth measurement is not influenced by any intermediate power nulls in the fundamental emission that might be ≥ 6 dB.

1. Set RBW = 1% to 5% of the actual occupied BW.
2. Set the video bandwidth (VBW) $\geq 3 \times$ RBW.
3. Detector = Peak.
4. Trace mode = max hold.
5. Sweep = auto couple.
6. Span = large enough to capture all products of the modulation process
7. Allow the trace to stabilize.
8. Use automatic bandwidth measurement capability on instrument to obtain BW result.

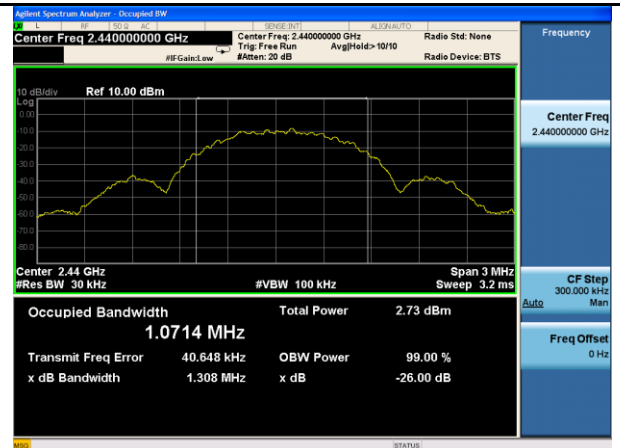
7.3.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured 99% OBW (KHz)	Limit (KHz)	Result
BLE	1Mbps	2402	1062.9	N/A	N/A
		2440	1071.4	N/A	N/A
		2480	1069.4	N/A	N/A
	2Mbps	2402	2108.2	N/A	N/A
		2440	2104.9	N/A	N/A
		2480	2125.6	N/A	N/A

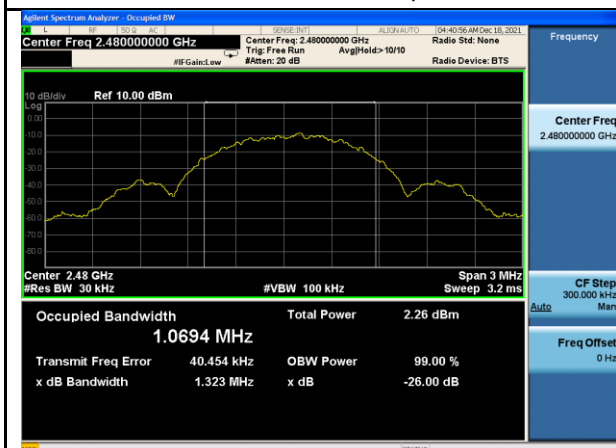
7.3.5 Test Plots



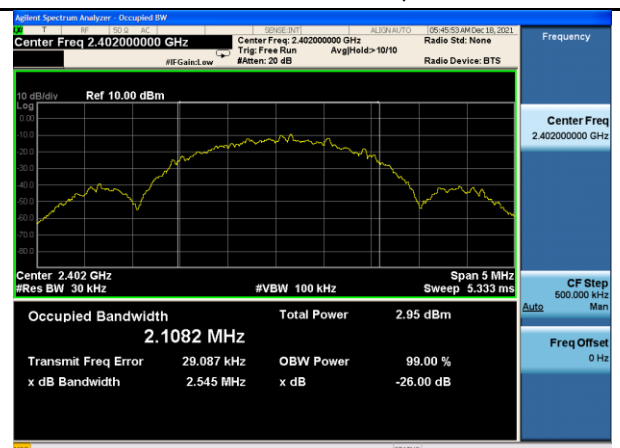
BLE-OBW-Low-1Mbps



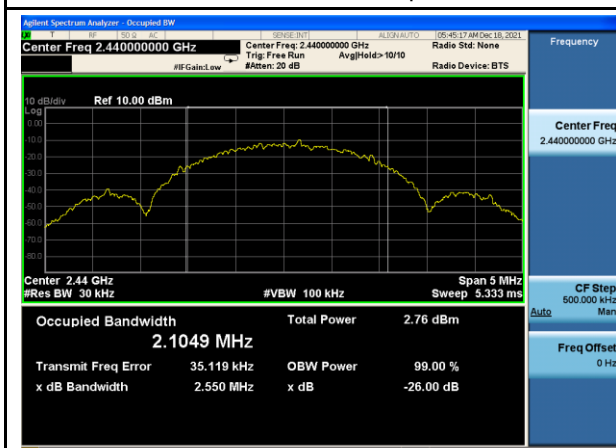
BLE-OBW-Mid-1Mbps



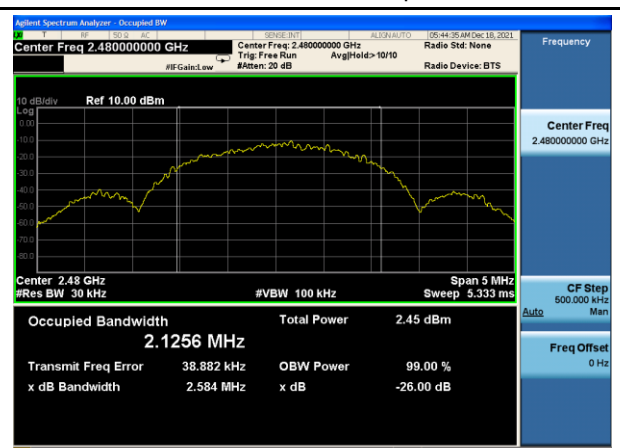
BLE-OBW-Mid-1Mbps



BLE-OBW-Low-2Mbps



BLE-OBW-Mid-2Mbps



BLE-OBW-High-2Mbps

7.4 Maximum Output Power

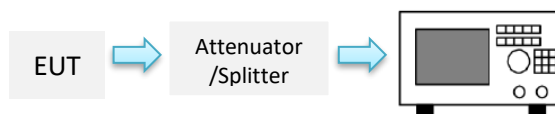
7.4.1 Requirement

§ 15.247 (b)(3), RSS-247 §5.4

or systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: the maximum output power is 1 Watt.

If transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

7.4.2 Test Setup



7.4.3 Test Procedure

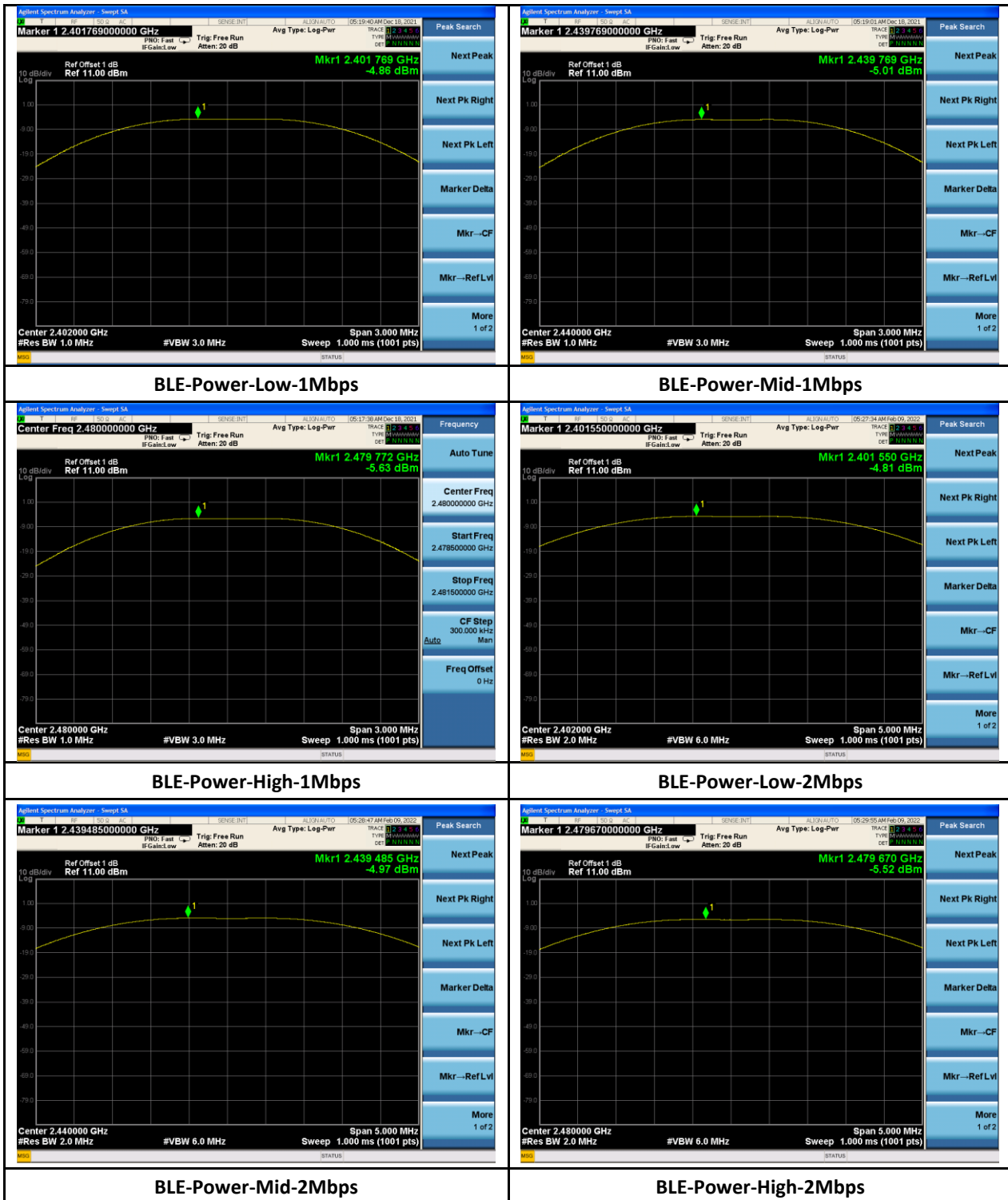
For BLE, power measurement is according to subclause 11.9.1.1 of ANSI C63.10-2013:

1. Set the RBW $\geq$ DTS bandwidth
2. Set VBW $\geq 3 \times$ RBW.
2. Set SPAN $\geq 3 \times$ RBW.
3. Sweep time = auto couple.
4. Detector = peak.
5. Trace mode = max hold
6. Allow trace to fully stabilize.
7. Use peak marker function to determine the peak amplitude level.

7.4.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured Output Power (dBm)	Max Output Power (dBm)	Result
BLE	1Mbps	2402	-4.86	30	Pass
		2440	-5.01	30	Pass
		2480	-5.63	30	Pass
	2Mbps	2402	-4.81	30	Pass
		2440	-4.97	30	Pass
		2480	-5.52	30	Pass

7.4.5 Test Plots



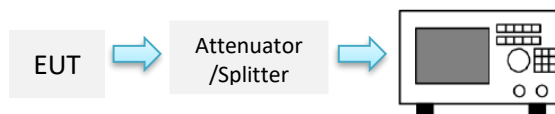
7.5 Power Spectral Density

7.5.1 Requirement

§ 15.247 (e), RSS-247 §5.2

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 is used to determine the power spectral density.

7.5.2 Test Setup



7.5.3 Test Procedure

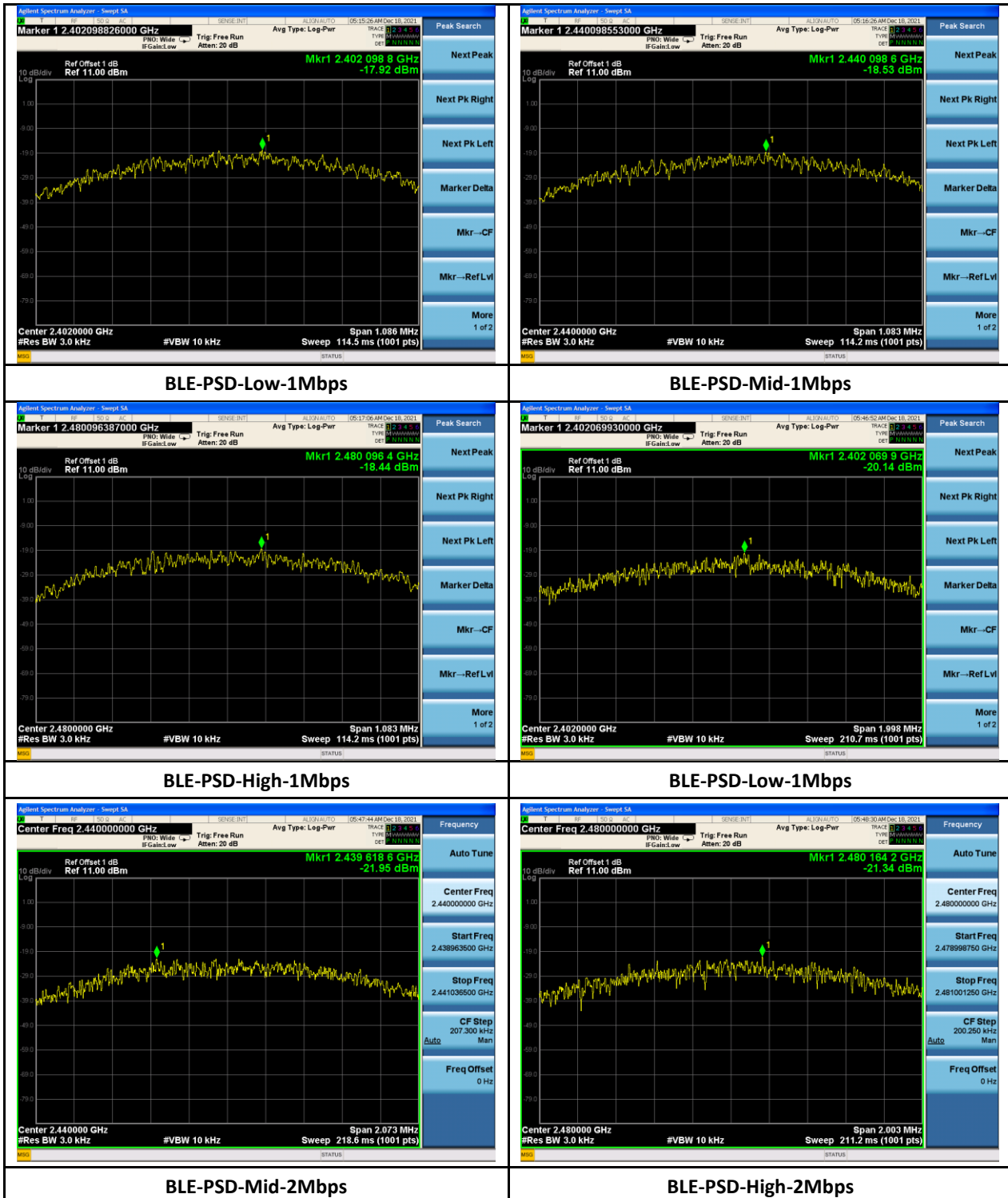
According to section 8.4 in KDB 558074 D01 DTS Meas Guidance v05r02 and subclause 11.10.2 PKPSD of ANSI C63.10-2013:

1. Set analyser centre frequency to DTS channel centre frequency.
2. Set the span to 1.5 X DTS bandwidth.
3. Set the RBW to: $3 \text{ kHz} \leq \text{RBW} \leq 100 \text{ kHz}$.
4. Set the VBW $\geq 3 \times \text{RBW}$.
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.

7.5.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured PSD (dBm/3KHz)	Max PSD (dBm/3KHz)	Result
BLE	1Mbps	2402	-17.92	8	Pass
		2440	-18.53	8	Pass
		2480	-18.44	8	Pass
	2Mbps	2402	-20.14	8	Pass
		2440	-21.95	8	Pass
		2480	-21.34	8	Pass

7.5.5 Test Plots



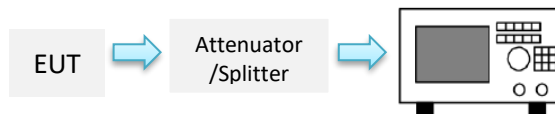
7.6 Conducted Band-Edge & Unwanted Emissions

7.6.1 Requirement

§ 15.247 (d), RSS-247 §5.5

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.

7.6.2 Test Setup



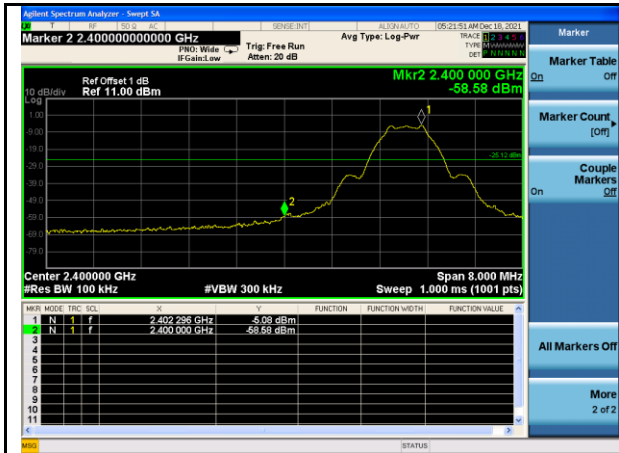
7.6.3 Test Procedure

According to ANSI C63.10-2013 clause 11.13

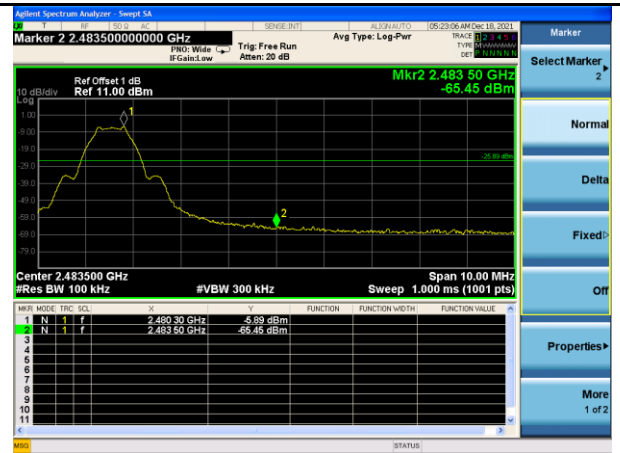
1. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Set RBW=100 KHZ, VBW=300 KHZ, Peak Detector. Unwanted Emissions measured in any 100 khz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 db relative to the maximum in-band peak PSD level in 100 KHZ when maximum peak conducted output power procedure is used. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, the attenuation required under this paragraph shall be 30 db instead of 20 db per 15.247(d).
4. Measure 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 and record the results in the test report.

7.6.4 Test Result

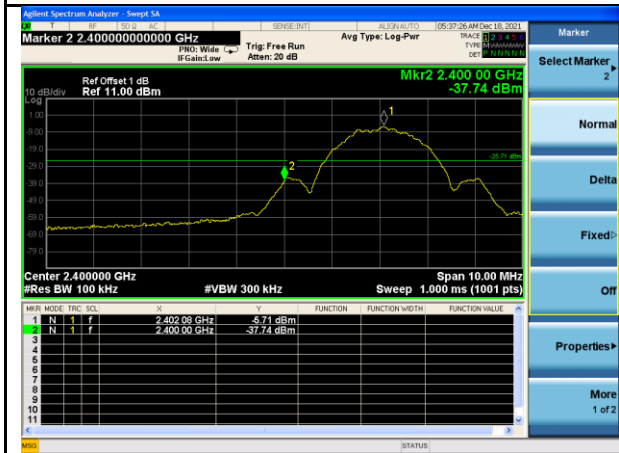
Conducted Band edge



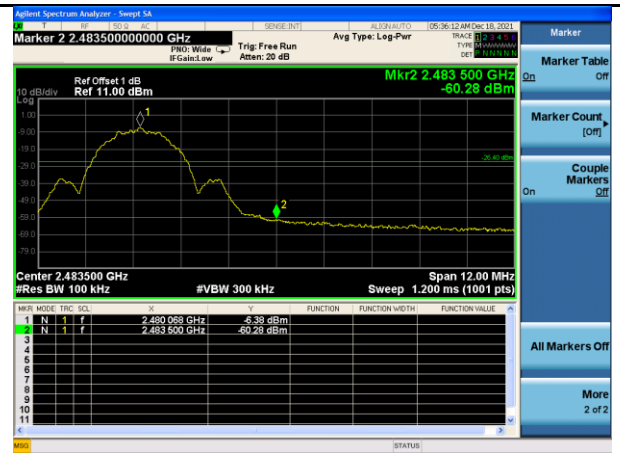
BLE-Band Edge-Low CH-1Mbps



BLE-Band Edge -High CH -1Mbps



BLE-Band Edge-Low CH-2Mbps

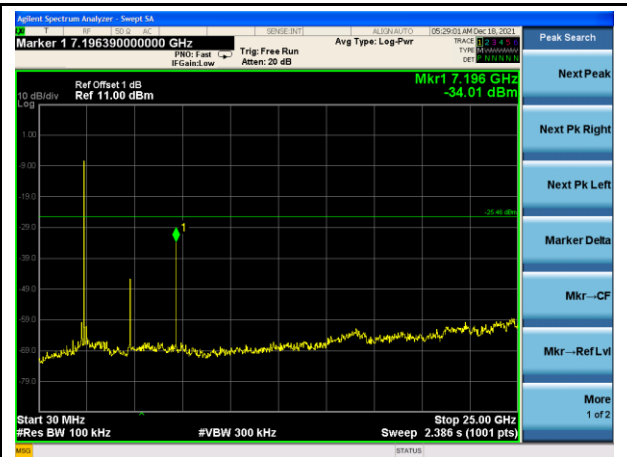


BLE-Band Edge -High CH-2Mbps

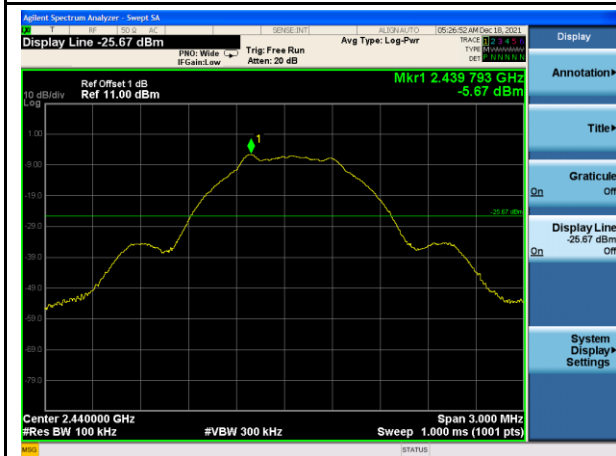
Conducted Spurious emission



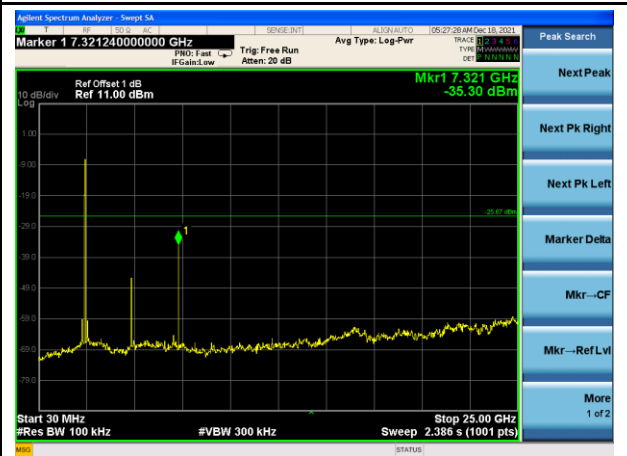
BLE-CSE-Low-REF-1Mbps



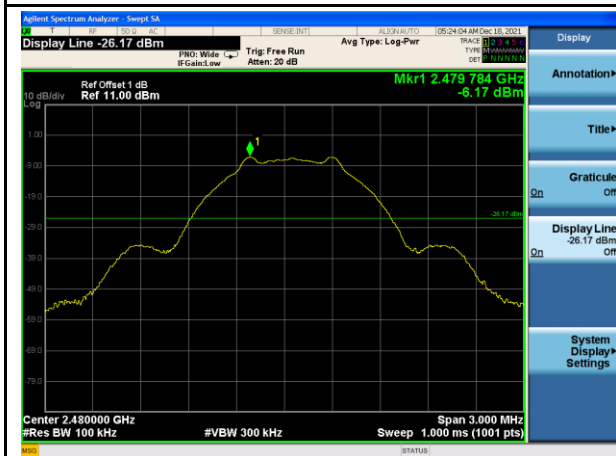
BLE-CSE-Low-1Mbps



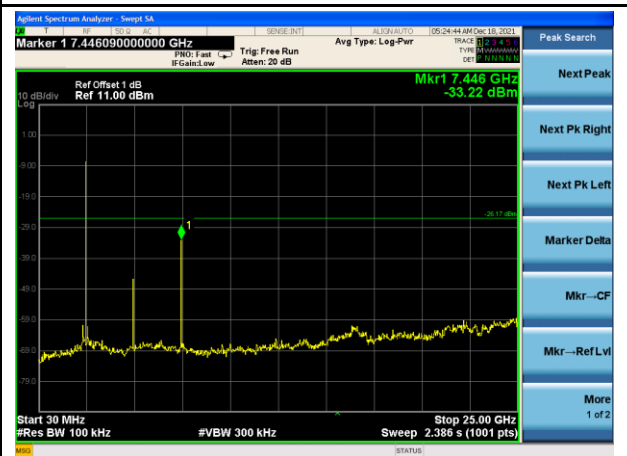
BLE-CSE-Mid-REF-1Mbps



BLE-CSE-Mid-1Mbps



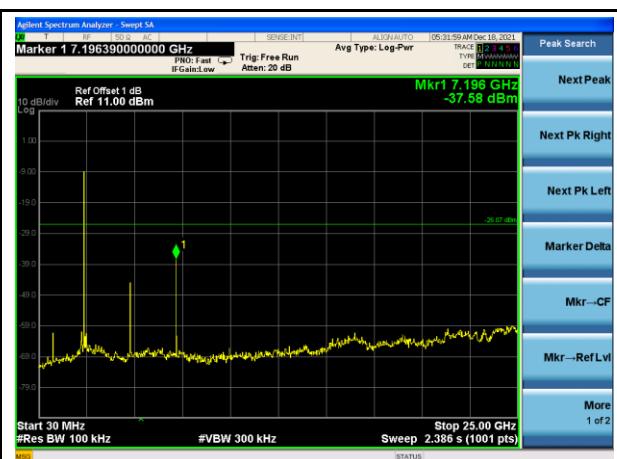
BLE-CSE-High-REF-1Mbps



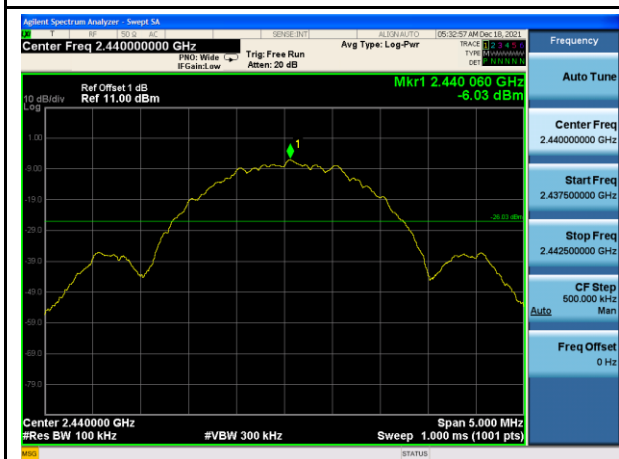
BLE-CSE-High-1Mbps



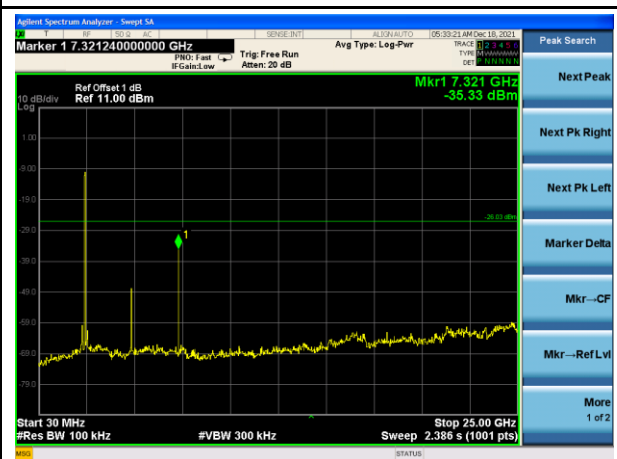
BLE-CSE-Low-REF-2Mbps



BLE-CSE-Low-2Mbps



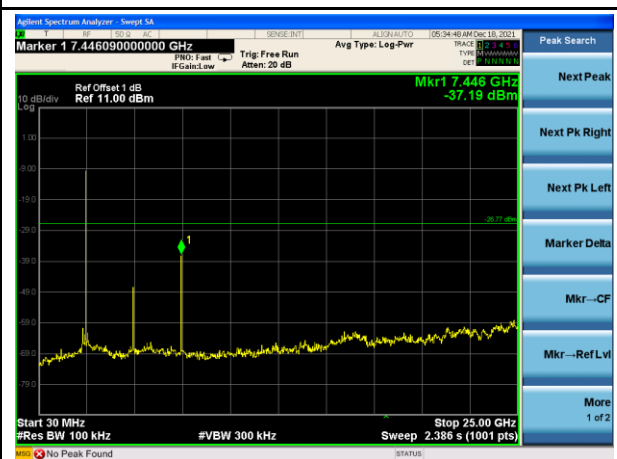
BLE-CSE-Mid-REF-2Mbps



BLE-CSE-Mid-2Mbps



BLE-CSE-High-REF-2Mbps



BLE-CSE-High-2Mbps

7.7 Radiated Band-Edge & Spurious Emissions into Restricted Frequency Bands

7.7.1 Requirement

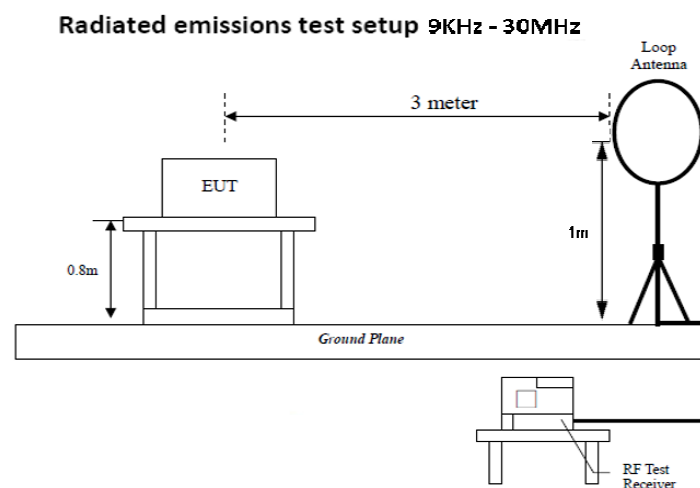
§ 15.247 (d), RSS-247 §5.5

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, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

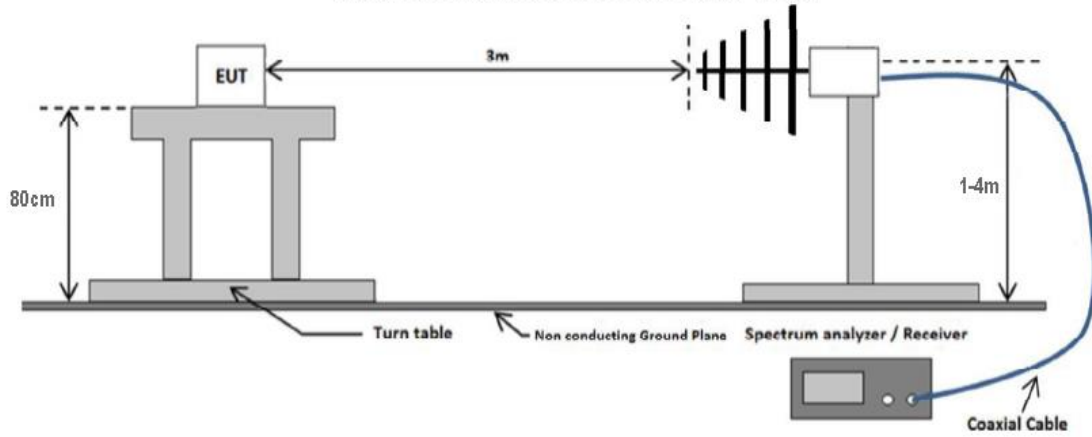
Attenuation below the general limits specified in §15.209(a) and RSS-Gen is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency Range (MHZ)	Field Strength ($\mu\text{V/m}$)
0.009~0.490	2400/F(KHz)
0.490~1.705	24000/F(KHz)
1.705~30.0	30
30 – 88	100
88 – 216	150
216 960	200
Above 960	500

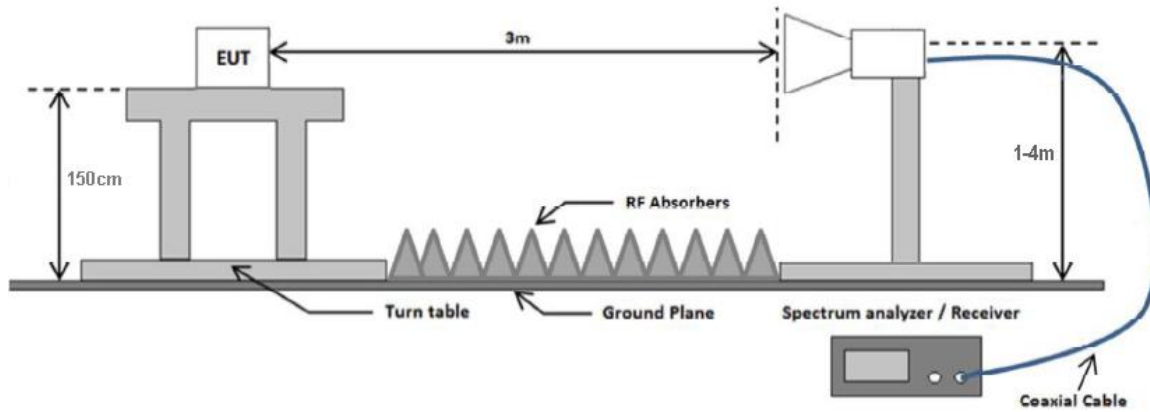
7.7.2 Test Setup



Radiated emissions test setup 30 MHz - 1 GHz



Radiated emissions test setup above 1 GHz



7.7.3 Test Procedure

According to section 8.6 in KDB 558074 D01 DTS Meas Guidance v05r02 and subclause 11.12.2.7 Radiated spurious emission measurements in ANSI C63.10-2013 as well as the procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 was followed. Boresight antenna mast was used during the scanning to point to EUT to maximize the emission. The process will be repeated in 3 EUT orientations.

1. The EUT was switched on and allowed to warm up to its normal operating condition.
2. The test was carried out at the selected frequency points obtained from the EUT characterization. Maximization of the emissions, was carried out by rotating the EUT, changing the antenna polarization, and adjusting the antenna height in the following manner:
 - a. Vertical or horizontal polarization (whichever gave the higher emission level over a full rotation of the EUT) was chosen.
 - b. The EUT was then rotated to the direction that gave the maximum emission.
 - c. Finally, the antenna height was adjusted to the height that gave the maximum emission.
3. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 300 Hz for frequency below 150KHz.
4. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 10 kHz for frequency between 150KHz – 30MHz.
5. The resolution bandwidth and video bandwidth of test receiver/spectrum analyzer is 120 kHz for Quasi-Peak detection at frequency between 30MHz - 1GHz.
6. The resolution bandwidth of test receiver/spectrum analyzer is 1MHz and video bandwidth is 3MHz with Peak detection for Peak and average measurement at frequency above 1GHz.
7. Steps 2 and 3 were repeated for the next frequency point, until all selected frequency points were measured.
8. Per part 15.35 (c), the EUT average emission level could be determined by peak emission level applying duty cycle correction factor, to represent averaging over the whole pulse train.
The average level is derived from the peak level corrected with “duty cycle correction factor”
$$\text{Average Emission Level (dBuV/m)} = \text{Peak Emission level (dBuV/m)} + \text{Duty cycle correction factor (dB)}$$

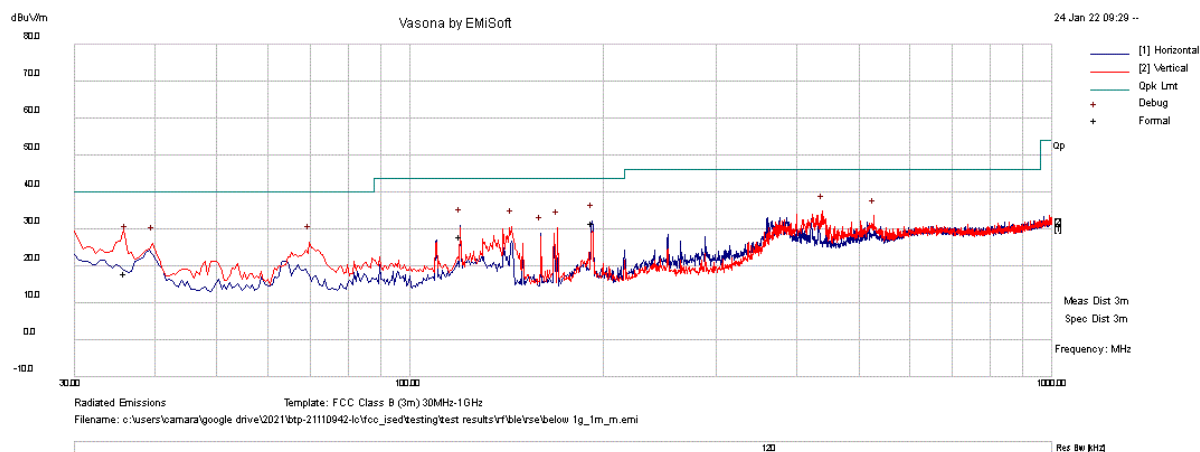
7.7.4 Test Result

Radiated Emission between 9KHz – 30MHz test result

Note: no substantial emission is found other than the noise floor. Different modes have been verified.

RADIATED EMISSIONS BELOW 1 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_1Mbps
Frequency Range:	30 MHz - 1 GHz	Test Date:	01/24/2022
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid channel	Test Result:	Pass



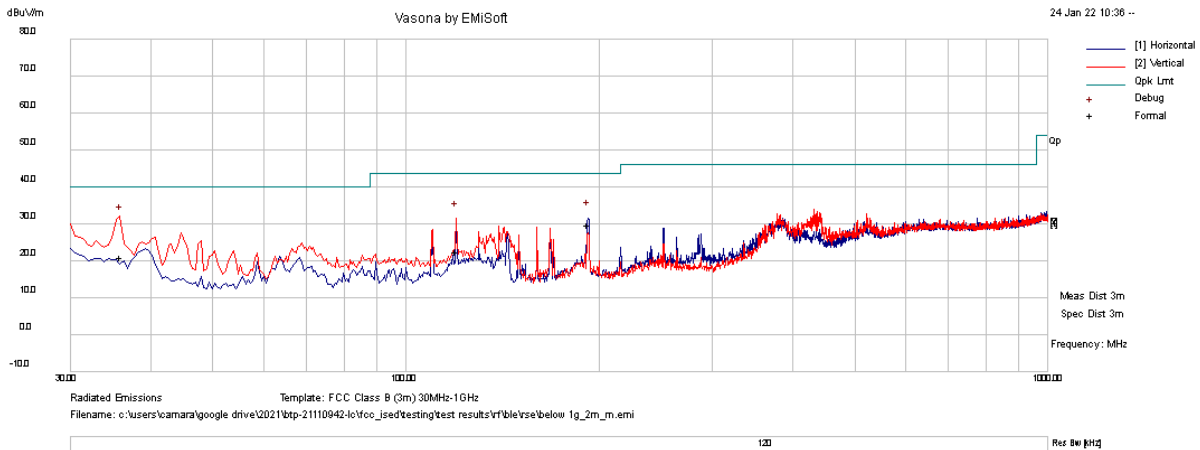
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	
1	191.998	44.2	4.7	-17.1	31.7	Quasi Max	H	169	102	43.5	-11.8	Pass
2	119.973	42.8	3.9	-18.5	28.1	Quasi Max	H	202	273	43.5	-15.4	Pass
3	35.949	30.4	2.4	-14.8	18	Quasi Max	H	278	176	40	-22	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

RADIATED EMISSIONS BELOW 1 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_2Mbps
Frequency Range:	30 MHz - 1 GHz	Test Date:	01/24/2022
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid channel	Test Result:	Pass



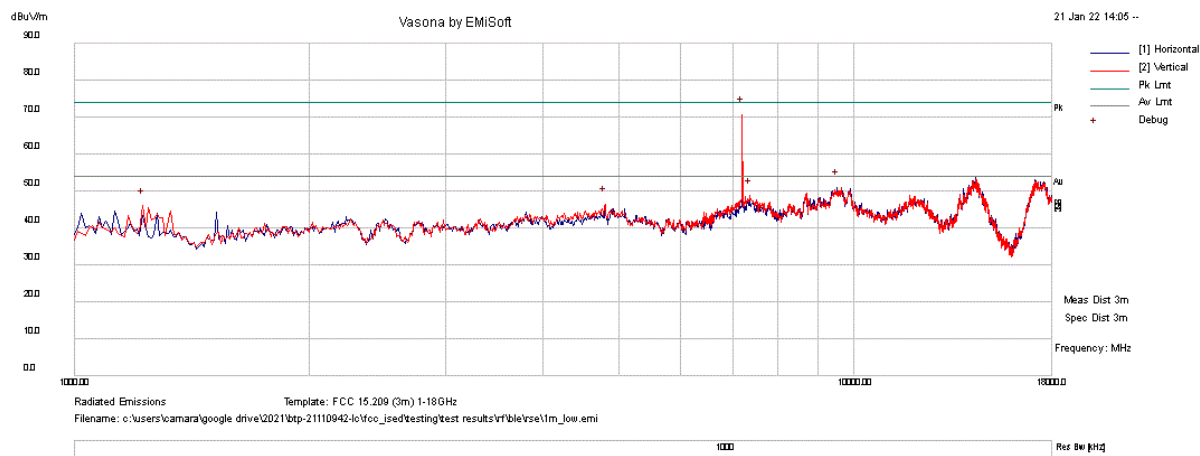
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	36.05238	33.45	2.43	-14.88	21	Quasi Max	V	265	160	40	-19	Pass
2	192.1737	42.17	4.66	-17.11	29.73	Quasi Max	H	218	2	43.5	-13.77	Pass
3	119.8017	37.14	3.87	-18.52	22.49	Quasi Max	V	100	360	43.5	-21.01	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) - Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

RADIATED EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_1Mbps
Frequency Range:	1 GHz - 18 GHz	Test Date:	01/21/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Low Channel	Test Result:	Pass



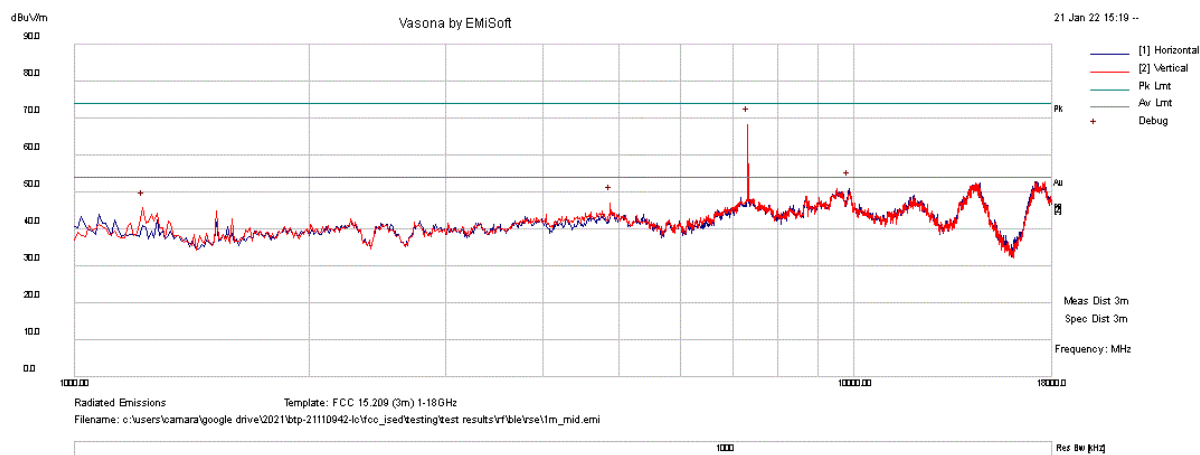
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7205	53.8	11.7	5.1	70.6	Peak Max	V	167	245	74	-3.4	Pass
2	9531.875	29.8	13.9	7.2	51	Peak Max	H	290	321	74	-23	Pass
3	7375	31	11.9	5.6	48.6	Peak Max	V	391	287	74	-25.4	Pass
4	4803.75	34.7	9.1	2.5	46.3	Peak Max	H	167	245	74	-27.7	Pass
5	1223.125	47.2	4.5	-5.8	45.8	Peak Max	V	290	321	74	-28.2	Pass
6	7205	-	-	-	29.97	Average Max	V	-	-	54	-24.03	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) - Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)
4. Average Level = Peak Level + Duty cycle correction factor = Peak level - 40.63 (dB)
5. Only 3rd harmonics average record since the others were 20dB lower than the limit per FCC 15.31(o).

RADIATED EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_1Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	01/21/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid Channel	Test Result:	Pass



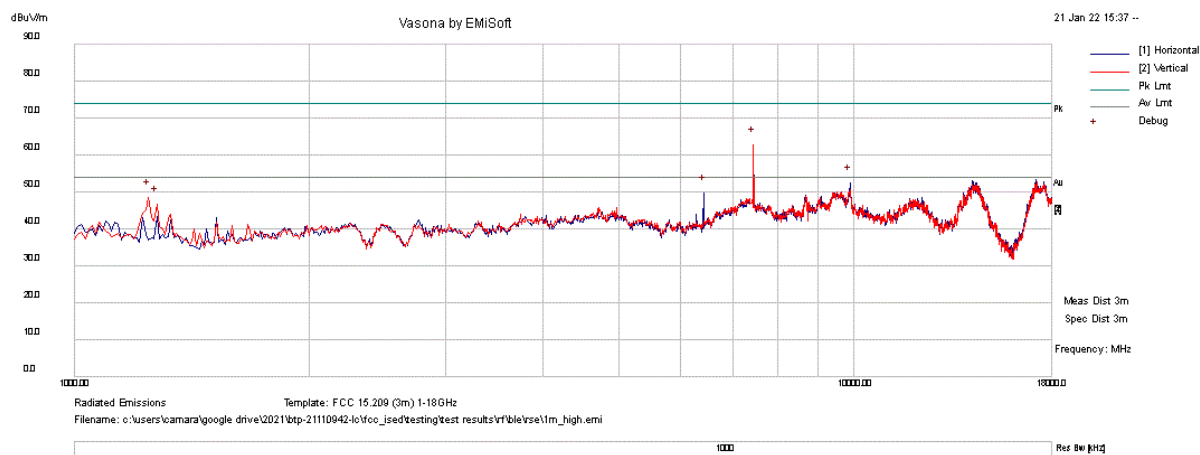
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7321.875	51.1	11.9	5.2	68.2	Peak Max	V	106	359	74	-5.8	Pass
2	9871.875	29.3	14.4	7.1	50.8	Peak Max	H	162	202	74	-23.2	Pass
3	4878.125	34.7	9.1	3.2	47	Peak Max	V	400	188	74	-27	Pass
4	1223.125	47	4.5	-5.8	45.6	Peak Max	V	106	122	74	-28.4	Pass
5	7321.875	-	-	-	27.57	Average Max	V	-	-	54	-26.43	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)
4. Average Level = Peak Level + Duty cycle correction factor = Peak level – 40.63 (dB)
5. Only 3rd harmonics average record since the others were 20dB lower than the limit per FCC 15.31(o).

RADIATED EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_1Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	01/21/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	High Channel	Test Result:	Pass



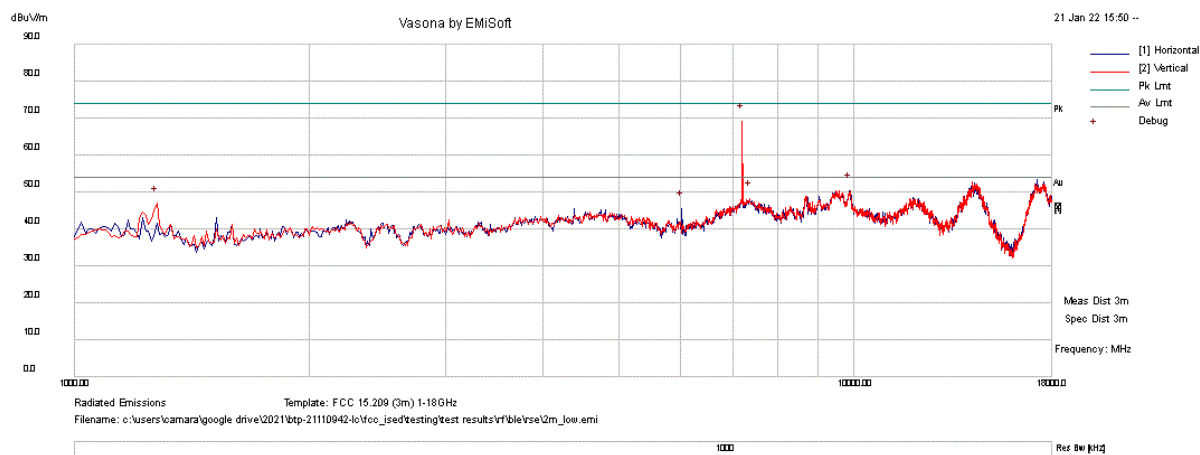
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7438.75	45.4	11.9	5.2	62.6	Peak Max	V	135	276	54	-11.4	Pass
2	9903.75	30.1	14.5	7.7	52.3	Peak Max	H	105	0	54	-21.7	Pass
3	6429.375	34.1	10.9	4.5	49.6	Peak Max	H	226	161	54	-24.4	Pass
4	1244.375	49.9	4.5	-5.9	48.5	Peak Max	V	135	276	54	-25.5	Pass
5	1276.25	48.1	4.5	-6	46.6	Peak Max	V	105	230	54	-27.4	Pass
6	7438.75	-	-	-	21.97	Average Max	V	-	-	54	-32.03	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)
4. Average Level = Peak Level + Duty cycle correction factor = Peak level – 40.63 (dB)
5. Only 3rd harmonics average record since the others were 20dB lower than the limit per FCC 15.31(o).

RADIATED EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	01/21/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Low Channel	Test Result:	Pass



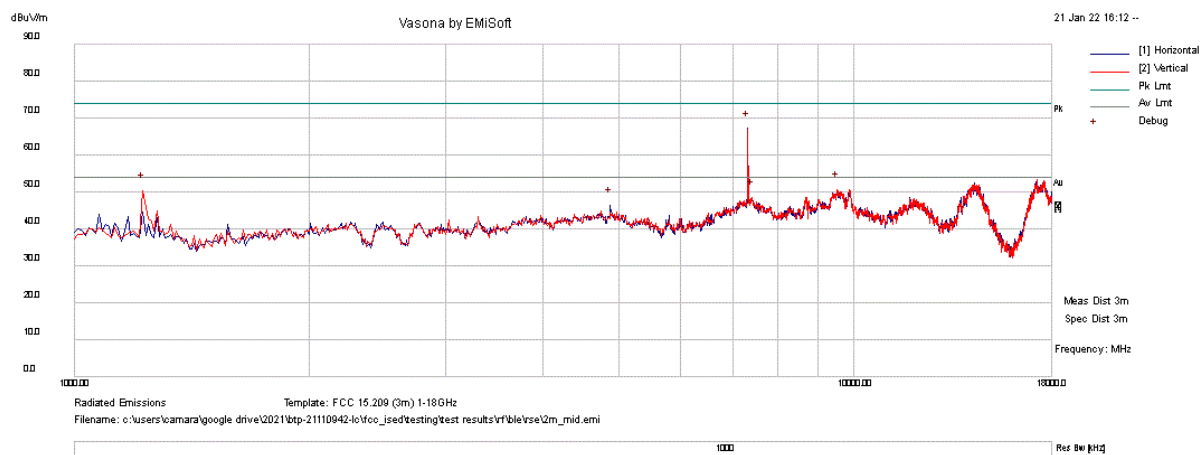
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7205	52.2	11.7	5.1	69	Peak Max	H	131	254	74	-5	Pass
2	9893.125	28.2	14.5	7.6	50.4	Peak Max	H	100	19	74	-23.6	Pass
3	7375	30.6	11.9	5.6	48.1	Peak Max	H	121	202	74	-25.9	Pass
4	1276.25	48.3	4.5	-6	46.8	Peak Max	V	170	26	74	-27.2	Pass
5	6025.625	29.5	10.9	5	45.5	Peak Max	H	131	254	74	-28.5	Pass
6	7205	-	-	-	28.37	Average Max	H	-	-	54	-25.63	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)
4. Average Level = Peak Level + Duty cycle correction factor = Peak level – 40.63 (dB)
5. Only 3rd harmonics average record since the others were 20dB lower than the limit per FCC 15.31(o).

RADIATED EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	01/21/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid Channel	Test Result:	Pass



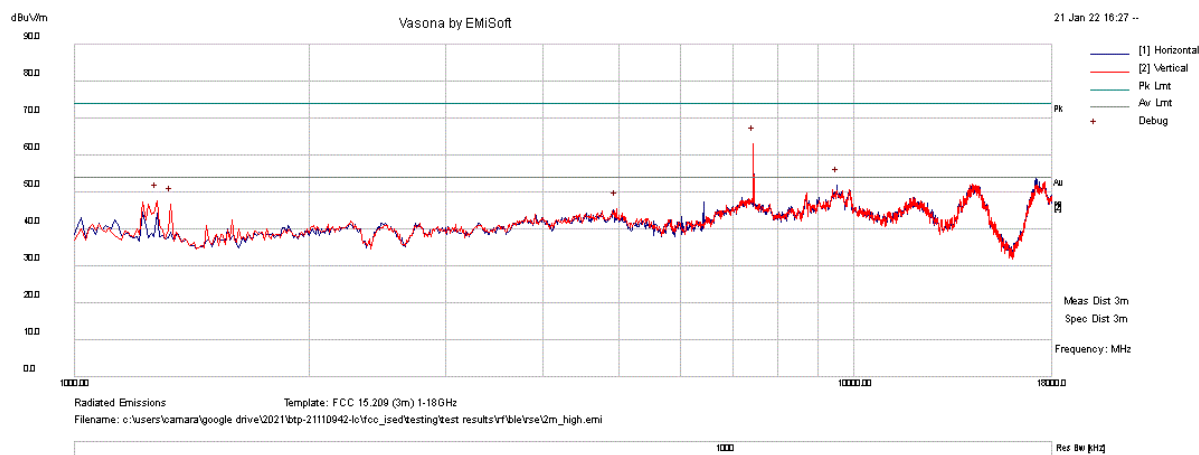
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7321.875	50	11.9	5.2	67.1	Peak Max	H	108	83	74	-6.9	Pass
2	9531.875	29.5	13.9	7.2	50.6	Peak Max	V	220	19	74	-23.4	Pass
3	1223.125	51.6	4.5	-5.8	50.3	Peak Max	V	151	216	74	-23.7	Pass
4	7417.5	31	12	5.5	48.4	Peak Max	V	230	182	74	-25.6	Pass
5	4878.125	34.1	9.1	3.2	46.4	Peak Max	H	313	205	74	-27.6	Pass
6	7321.875	-	-	-	26.47	Average Max	H	-	-	54	-27.53	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)
4. Average Level = Peak Level + Duty cycle correction factor = Peak level – 40.63 (dB)
5. Only 3rd harmonics average record since the others were 20dB lower than the limit per FCC 15.31(o).

RADIATED EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	01/21/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	High Channel	Test Result:	Pass



No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7438.75	45.4	11.9	5.2	62.6	Peak Max	V	100	26	74	-10.9	Pass
2	9903.75	30.1	14.5	7.7	52.3	Peak Max	H	321	214	74	-22.2	Pass
3	6429.375	34.1	10.9	4.5	49.6	Peak Max	H	102	140	74	-26.5	Pass
4	1244.375	49.9	4.5	-5.9	48.5	Peak Max	V	210	261	74	-27.4	Pass
5	1276.25	48.1	4.5	-6	46.6	Peak Max	V	113	90	74	-28.6	Pass
6	7438.75	-	-	-	21.97	Average Max	V	-	-	54	-32.03	Pass

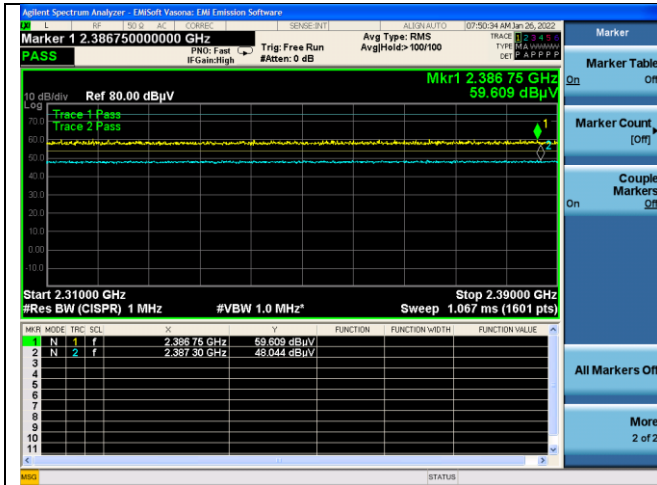
Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)
4. Average Level = Peak Level + Duty cycle correction factor = Peak level – 40.63 (dB)
5. Only 3rd harmonics average record since the others were 20dB lower than the limit per FCC 15.31(o).

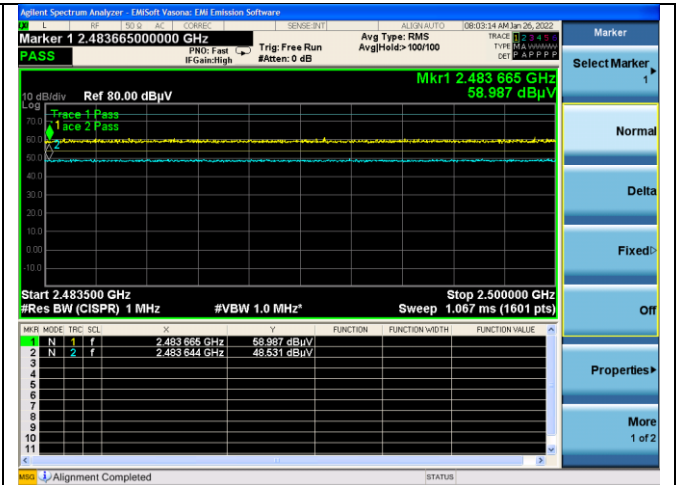
Radiated Emission between 18GHz – 40GHz test result

Note: no substantial emission is found other than the noise floor. Different modes have been verified.

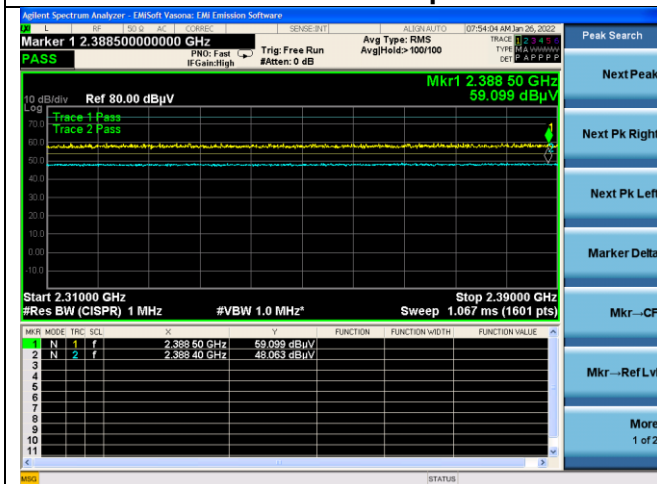
Restricted Band Measurement Result



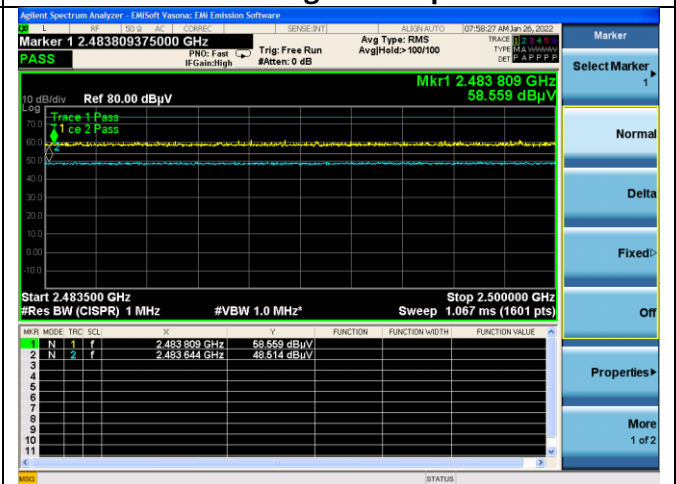
BLE - Low CH-1Mbps



BLE - High CH-1Mbps



BLE - Low CH-2Mbps



BLE - High CH-2Mbps

7.8 Conducted Emissions

7.8.1 Requirement

Per § 15.207 (a), RSS Gen 8.8

An intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 ohms line impedance stabilization network (LISN).

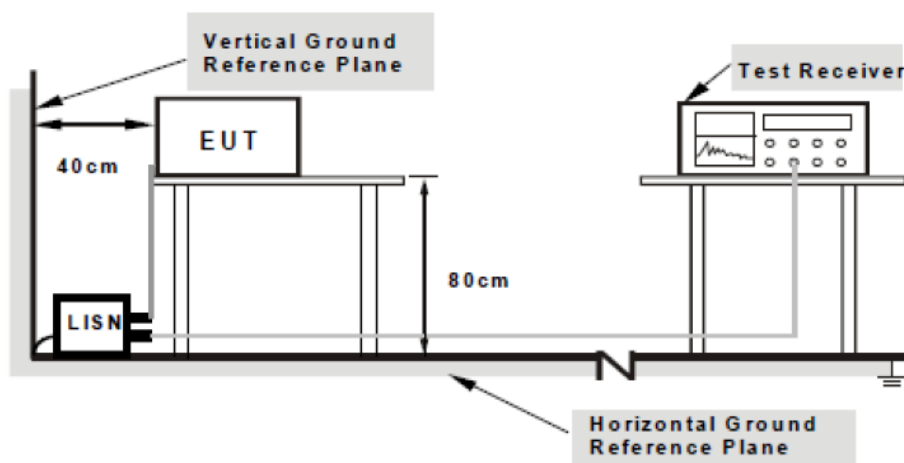
Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Limits for Conducted Emissions at the Mains Ports

Section	Frequency ranges (MHz)	Limit (dBuV)	
		QP	Average
Class B devices	0.15 – 0.5	66 – 56	56 – 46
	0.5 – 5	56	46
	5 – 30	60	50

NOTE 1 The lower limit shall apply at the transition frequencies.

7.8.2 Test setup



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

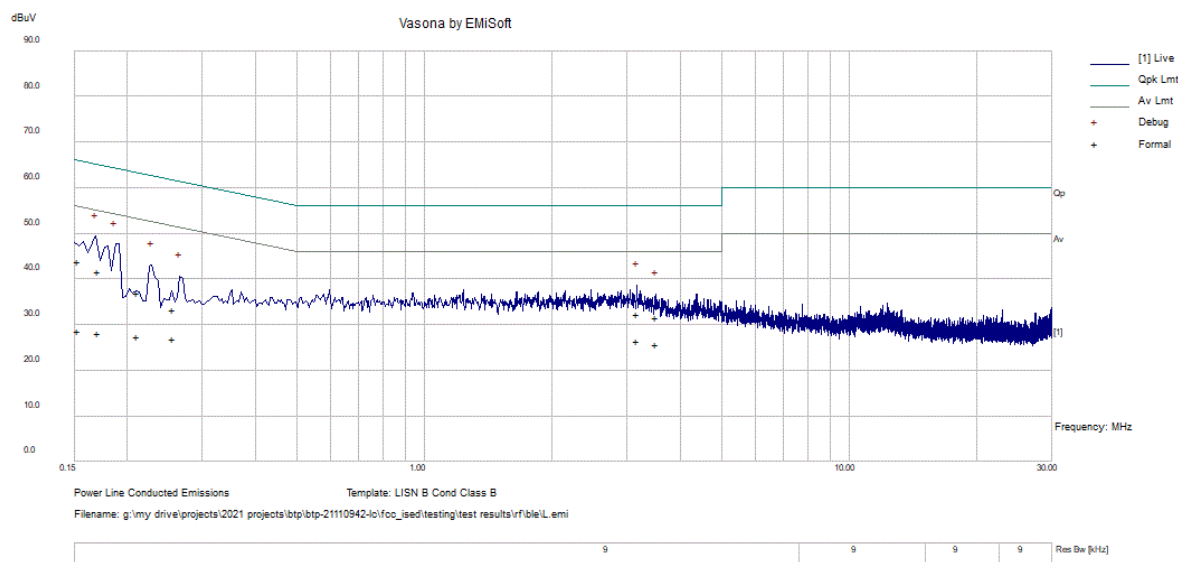
2.Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

7.8.3 Test Procedure

1. The EUT and supporting equipment were set up in accordance with the requirements of the standard on top of a 1.5m x 1m x 0.8m high, non-metallic table.
2. The power supply for the EUT was fed through a 50 Ω /50 μ H EUT LISN, connected to filtered mains.
3. The RF OUT of the EUT LISN was connected to the EMI test receiver via a low-loss coaxial cable.
4. All other supporting equipment was powered separately from another main supply.
5. The EUT was switched on and allowed to warm up to its normal operating condition.
6. A scan was made on the NEUTRAL line (for AC mains) or Earth line (for DC power) over the required frequency range using an EMI test receiver.
7. High peaks, relative to the limit line, were then selected.
8. The EMI test receiver was then tuned to the selected frequencies and the necessary measurements made with a receiver bandwidth setting of 10 kHz. For FCC tests, only Quasi-peak measurements were made; while for CISPR/EN tests, both Quasi-peak and Average measurements were made
9. All possible modes of operation were investigated. Only the worst case emissions were measured and reported. All other emissions were relatively insignificant.

7.8.4 Test Result

Test Standard:	Part 15.207 RSS Gen 8.8	Mode:	BLE_1M_Mid CH
Frequency Range:	0.15-30MHz	Test Date:	01/24/2022
Antenna Type/Polarity:	N/A	Test Personnel:	Devin Tai
Remark:	Line 120VAC, 60Hz	Test Result:	Pass

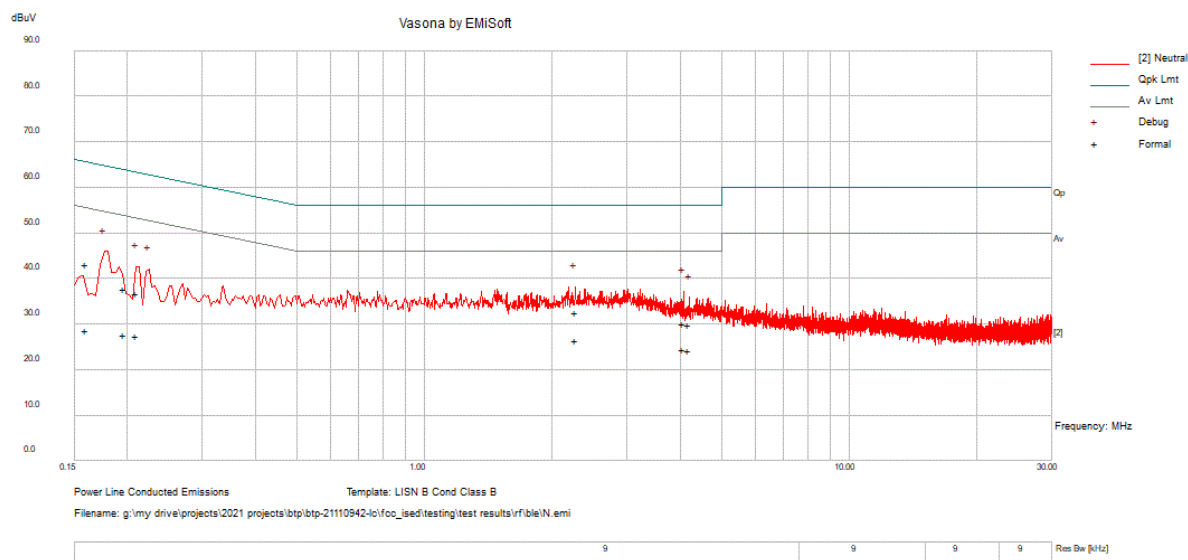


No.	Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Meas. Type	Line	Limit (dBuV)	Margin (dB)	Pass /Fail
1	0.153	33.5	10.1	0.2	43.9	Quasi Peak	Live	65.8	-22	Pass
2	0.17	31.5	10.1	0.2	41.8	Quasi Peak	Live	64.9	-23.1	Pass
3	3.162	22.1	10.3	0.1	32.5	Quasi Peak	Live	56	-23.5	Pass
4	3.512	21.2	10.3	0.1	31.7	Quasi Peak	Live	56	-24.3	Pass
5	0.211	26.9	10.1	0.2	37.1	Quasi Peak	Live	63.2	-26	Pass
6	0.257	23.3	10.1	0.1	33.5	Quasi Peak	Live	61.5	-28	Pass
7	0.153	18.4	10.1	0.2	28.7	Average	Live	55.8	-27.1	Pass
8	0.17	18	10.1	0.2	28.3	Average	Live	54.9	-26.7	Pass
9	3.162	16.2	10.3	0.1	26.6	Average	Live	46	-19.4	Pass
10	3.512	15.3	10.3	0.1	25.7	Average	Live	46	-20.3	Pass
11	0.211	17.3	10.1	0.2	27.6	Average	Live	53.2	-25.6	Pass
12	0.257	16.9	10.1	0.1	27.1	Average	Live	51.5	-24.4	Pass

REMARKS:

1. The emission levels of other frequencies were very low against the limit.
2. Margin value = Emission level - Limit value
3. Emission Level = Raw Value + Cable loss + Factors Value.

Test Standard:	Part 15.207 RSS Gen 8.8	Mode:	BLE_1M_Mid CH
Frequency Range:	0.15-30MHz	Test Date:	01/24/2022
Antenna Type/Polarity:	N/A	Test Personnel:	Devin Tai
Remark:	Neutral 120VAC, 60Hz	Test Result:	Pass



No.	Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Meas. Type	Line	Limit (dBuV)	Margin (dB)	Pass /Fail
1	2.266	22.2	10.2	0.1	32.6	Quasi Peak	Neutral	56	-23.4	Pass
2	0.159	33	10.1	0.2	43.3	Quasi Peak	Neutral	65.5	-22.2	Pass
3	4.061	19.8	10.3	0.1	30.3	Quasi Peak	Neutral	56	-25.7	Pass
4	4.196	19.5	10.3	0.1	30	Quasi Peak	Neutral	56	-26	Pass
5	0.21	26.6	10.1	0.2	36.9	Quasi Peak	Neutral	63.2	-26.3	Pass
6	0.196	27.5	10.1	0.2	37.8	Quasi Peak	Neutral	63.8	-26	Pass
7	2.266	16.3	10.2	0.1	26.6	Average	Neutral	46	-19.4	Pass
8	0.159	18.4	10.1	0.2	28.7	Average	Neutral	55.5	-26.8	Pass
9	4.061	14	10.3	0.1	24.4	Average	Neutral	46	-21.6	Pass
10	4.196	13.7	10.3	0.1	24.2	Average	Neutral	46	-21.8	Pass
11	0.21	17.3	10.1	0.2	27.6	Average	Neutral	53.2	-25.6	Pass
12	0.196	17.5	10.1	0.2	27.7	Average	Neutral	53.8	-26	Pass

REMARKS:

1. The emission levels of other frequencies were very low against the limit.
2. Margin value = Emission level - Limit value
3. Emission Level = Raw Value + Cable loss + Factors Value.

8 EUT and Test Setup Photos

See FCC exhibits

9 Test Instrument List

Equipment	Manufacturer	Model	Instrument Number	Cal. Date	Cal. Due
Semi-Anechoic Chamber	ETS-Lindgren	10M	VL001	10/18/2021	10/18/2022
Shielding Control Room	ETS-Lindgren	Series 81	VL006	N/A	N/A
Spectrum Analyzer	Keysight	N9020A	MY50110074	06/17/2021	06/17/2022
EMC Test Receiver	R&S	ESL6	100230	06/14/2021	06/14/2022
LISN (9KHz – 30MHz)	EMCO	3816/2	9705-1066	05/04/2021	05/04/2022
LISN (9KHz – 30MHz)	Com-Power	LI-550C	20140050	01/29/2021	01/29/2022
LISN (9KHz – 30MHz)	Com-Power	LI-550C	20140051	01/29/2021	01/29/2022
Bi-Log Antenna	ETS-Lindgren	3142E	217921	11/15/2021	11/15/2022
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	05/14/2021	05/14/2022
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	06/24/2021	06/24/2022
Preamplifier	RF Bay, Inc.	LPA-10-20	11180621	07/16/2021	07/16/2022
True RMS Multi-meter	UNI-T	UT181A	C173014829	05/05/2021	05/05/2022
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	05/15/2021	05/15/2022
RF Attenuator	Pasternack	PE7005-3	VL061	07/16/2021	07/16/2022
Preamplifier 100KHz - 40GHz	Aeroflex	33711-392-77150-11	064	07/16/2021	07/16/2022
EM Center Control	ETS-Lindgren	7006-001	160136	N/A	N/A
Turn Table	ETS-Lindgren	2181-3.03	VL002	N/A	N/A
Boresight Antenna Tower	ETS-Lindgren	2171B	VL003	N/A	N/A
Loop Antenna (9k-30MHz)	Com-Power	AL-130	121012	05/16/2021	05/16/2022
RE test cable(below 6GHz)	Vista	RE-6GHz-01	RE-6GHz-01	07/16/2021	07/16/2022
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	07/16/2021	07/16/2022
RE test cable (>18GHz)	Sucoflex	104	344903/4	07/16/2021	07/16/2022
Pulse limiter	Com-Power	LIT-930A	531727	07/16/2021	07/16/2022
CE test cable #1	FIRST RF	FRF-C-1002-001	CE-6GHz-01	07/16/2021	07/16/2022
CE test cable#2	FIRST RF	FRF-C-1002-001	CE-6GHz-02	07/16/2021	07/16/2022
Vector Signal Generator	Keysight	N5182A	US47080548	06/17/2021	06/17/2022
USB RF Power Sensor	ETS-Lindgren	7002-006	SN 00151268	05/15/2019	05/15/2022

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