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FCC RF Test Report

Test Report Number	GLS-21120342-LC-FCC IC-BLE Rev_1.0
FCC ID	MG3-59007000006
IC	2575A-59007000006
Applicant	Universal Electronic Inc.
Applicant Address	201 East Sandpointe Ave., 7th Floor, Santa Ana, CA 92707
Product Name	UE61 Module
Model (s)	UE61S
Date of Receipt	05/25/2022
Date of Test	05/27/2022- 06/08/2022
Report Issue Date	10/28/2022
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
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Devin Tai (Test Engineer)

David Zhang (Technical Manager)

REVISION HISTORY

Report Number	Version	Description	Issued Date
GLS-21120342-LC-FCC IC-BLE	01	Initial report	06/10/2022
GLS-21120342-LC-FCC IC-BLE Rev_1.0	1.0	Update Applicant's address	10/28/2022

TABLE OF CONTENTS

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, Mar 2019	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	Universal Electronic Inc.
Applicant address	201 East Sandpointe Ave., 7th Floor, Santa Ana, CA 92707
Manufacturer	Universal Electronic Inc.
Manufacturer Address	201 East Sandpointe Ave., 7th Floor, Santa Ana, CA 92707

2.2 Product information

Product Name	UE61 Module
Product Description	UE61S
Model Number	N/A
Family Models	N/A
Serial Number	N/A
Frequency Band	BLE: 2402-2480MHz WLAN: 2412-2462MHz
Type of modulation	BLE: GFSK WLAN_2.4G: CCK, DQPSK, DBPSK for DSSS 64QAM, 16QAM, QPSK, BPSK for OFDM
Equipment Class	DTS
Antenna Information	PCB Antenna Antenna Gain: 1.5dBi ±0.5dB
Clock Frequencies	N/A
Input Power	DC 3.3V
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

The EUT is mounted onto a development board to support testing. EUT is set to different transmission mode in terms of radio mode bandwidth, power level, test channel, etc.

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
Tera Term	Set the module work at BLE mode
RTLBTAPP	Realtek Bluetooth tool, Set the module at different mode, channel, bandwidth, etc.

Power setting as below

BLE_1M		BLE_2M	
Channel	Power Setting	Channel	Power Setting
00	0x23	00	0x23
19	0x23	19	0x23
39	0x23	39	0x23

5.2 Supporting Equipment

Description	Manufacturer	Model #	Serial #
DC Power supply	RIGOL	DP712	DP7B194900487
USB to TTL Serial Converter Adapter	Songhe	FT232RL	JESSE210825

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 1.5±0.5dBi.

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:

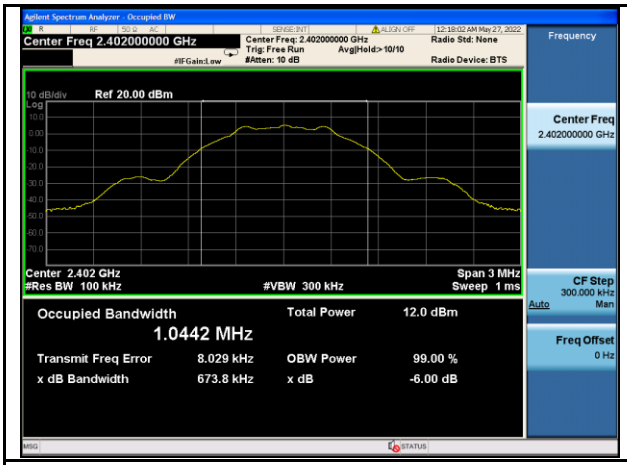
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this 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) ≥ 3 x 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.

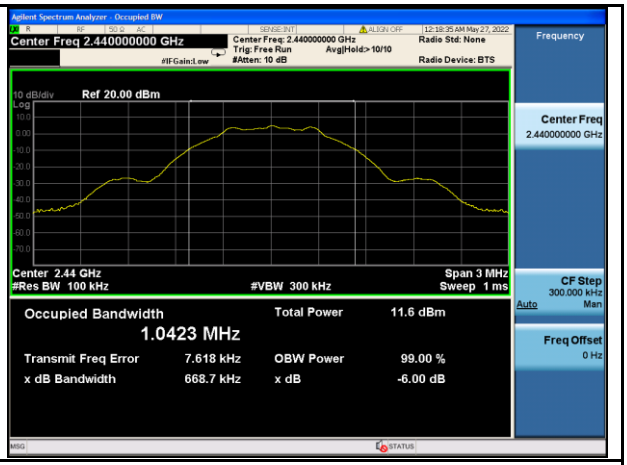
7.2.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
BLE	1Mbps	2402	673.8	500	Pass
		2440	668.7	500	Pass
		2480	665.0	500	Pass
	2Mbps	2402	1154	500	Pass
		2440	1155	500	Pass
		2480	1154	500	Pass

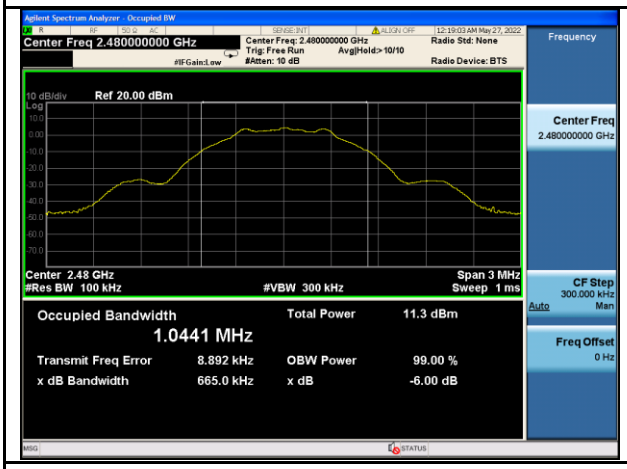
7.2.5 Test Plots



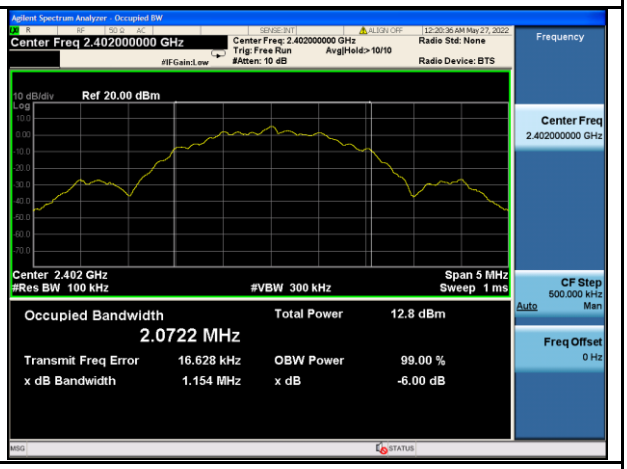
BLE-DTS BW-Low-1Mbps



BLE-DTS BW-Mid-1Mbps

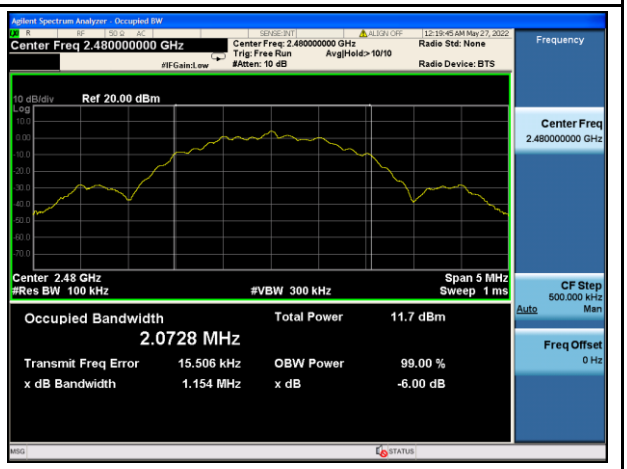


BLE-DTS BW-High-1Mbps



BLE-DTS BW-Low-2Mbps

BLE-DTS BW-Mid-2Mbps



BLE-DTS BW-High-2Mbps

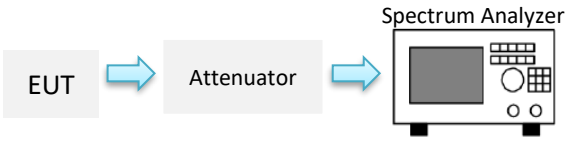
7.3 Occupied Bandwidth (99%)

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

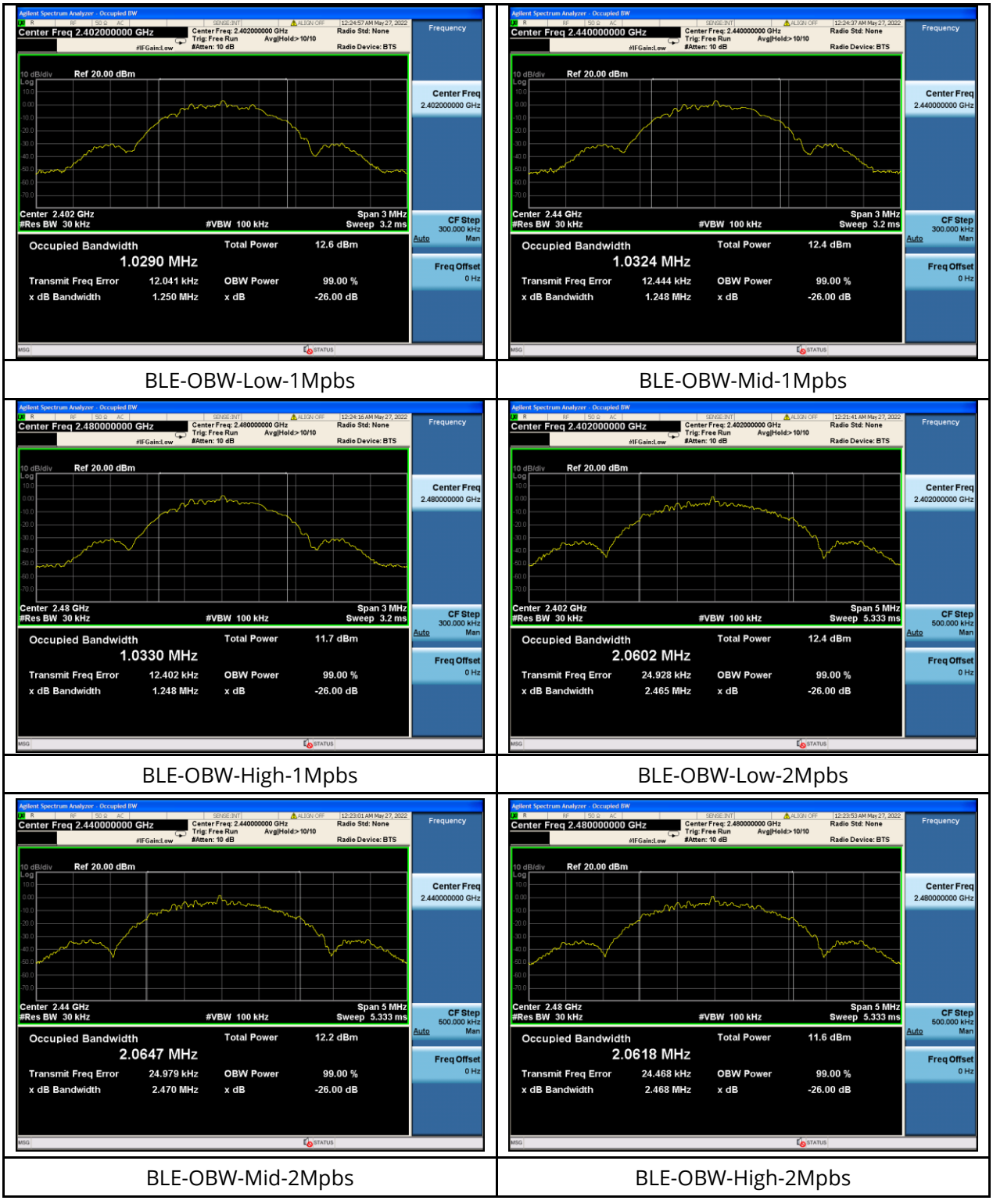
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this 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) ≥ 3 x 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	1029	N/A	N/A
		2440	1032	N/A	N/A
		2480	1033	N/A	N/A
	2Mbps	2402	2060	N/A	N/A
		2440	2065	N/A	N/A
		2480	2062	N/A	N/A

7.3.5 Test Plots



BLE-OBW-Low-1Mpbs	BLE-OBW-Mid-1Mpbs
BLE-OBW-High-1Mpbs	BLE-OBW-Low-2Mpbs
BLE-OBW-Mid-2Mpbs	BLE-OBW-High-2Mpbs

7.4 Maximum Output Power

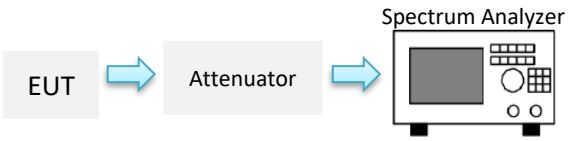
7.4.1 Requirement

§ 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

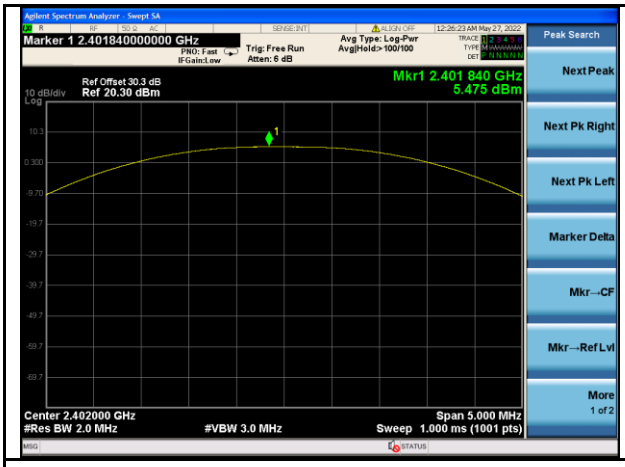
For BLE, power measurement is according to subclause 11.9.1.1 of ANSI C63.10-2013:

1. Set the RBW ≥ DTS bandwidth
2. Set VBW ≥ 3 X RBW.
2. Set SPAN ≥ 3 X 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.

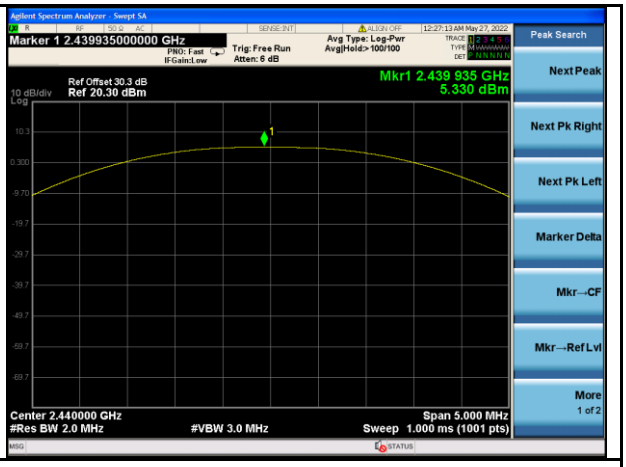
7.4.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured Output Power (dBm)	Max Output Power (dBm)	Result
BLE	1Mbps	2402	5.475	30	Pass
		2440	5.330	30	Pass
		2480	4.694	30	Pass
	2Mbps	2402	4.733	30	Pass
		2440	5.381	30	Pass
		2480	4.733	30	Pass

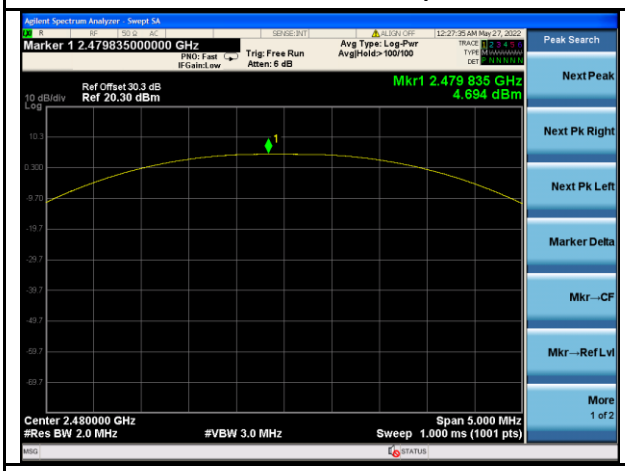
7.4.5 Test Plots



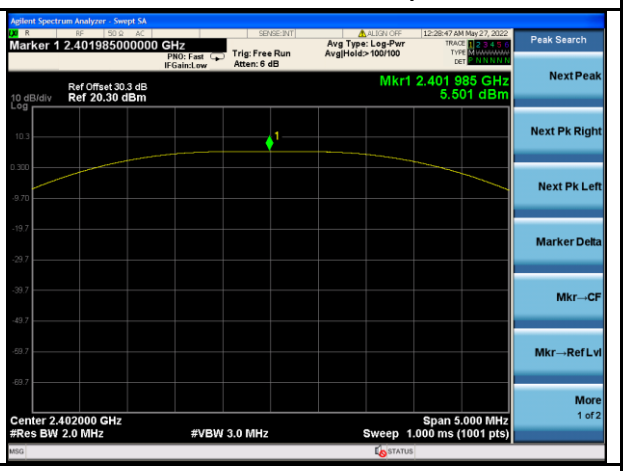
BLE-Power-Low-1Mbps



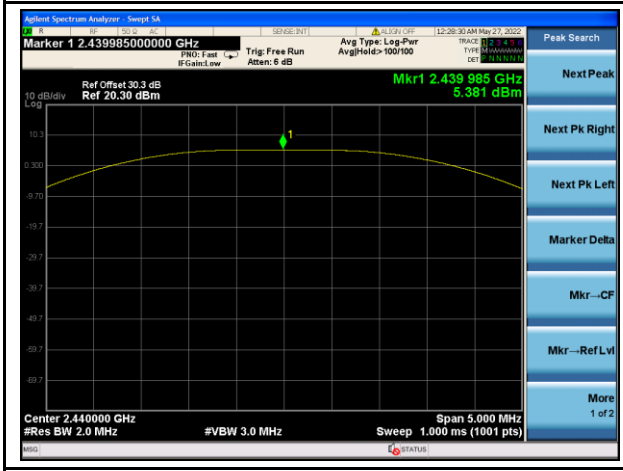
BLE-Power-Mid-1Mbps



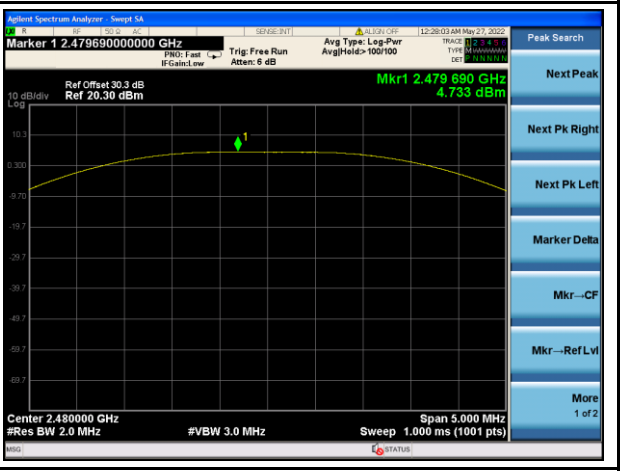
BLE-Power-High-1Mbps



BLE-Power-Low-2Mbps



BLE-Power-Mid-2Mbps



BLE-Power-High-2Mbps

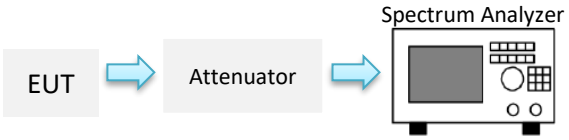
7.5 Power Spectral Density

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

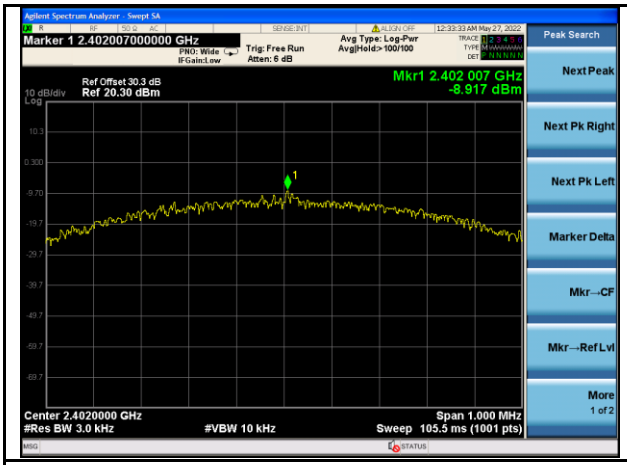
According to section 8.4 in KDB 558074 D01 DTS Meas Guidance v05r02 and subclause 11.10.2 PKPSD of ANSI C63.10-2013:

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 kHz ≤ RBW ≤ 100 kHz.
4. Set the VBW ≥ 3 x 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.

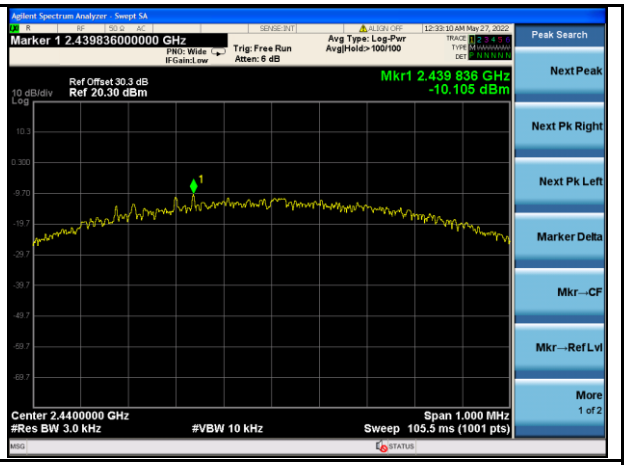
7.5.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured PSD (dBm/3KHz)	Max PSD (dBm/3KHz)	Result
BLE	1Mbps	2402	-8.917	8	Pass
		2440	-10.105	8	Pass
		2480	-11.657	8	Pass
	2Mbps	2402	-12.642	8	Pass
		2440	-13.399	8	Pass
		2480	-12.376	8	Pass

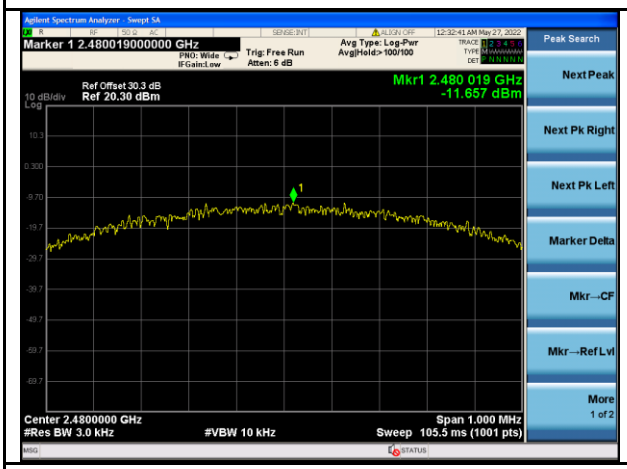
7.5.5 Test Plots



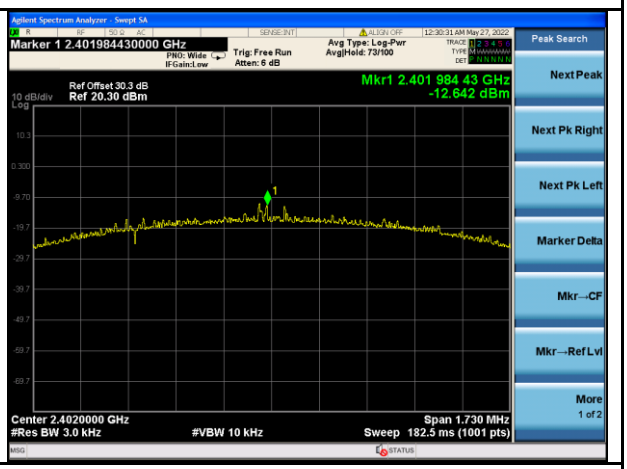
BLE-PSD-Low-1Mbps



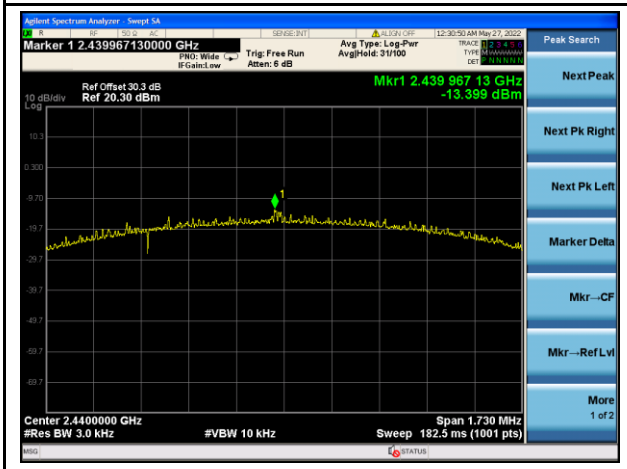
BLE-PSD-Mid-1Mbps



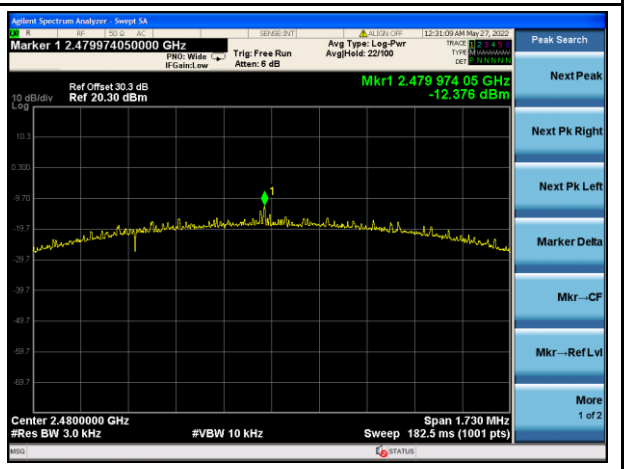
BLE-PSD-High-1Mbps



BLE-PSD-Low-2Mbps



BLE-PSD-Mid-2Mbps



BLE-PSD-High-2Mbps

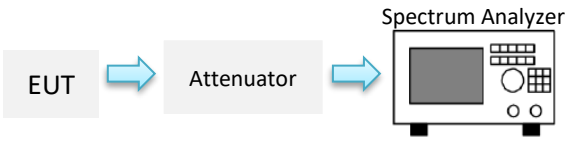
7.6 Conducted Band-Edge & Unwanted Emissions

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

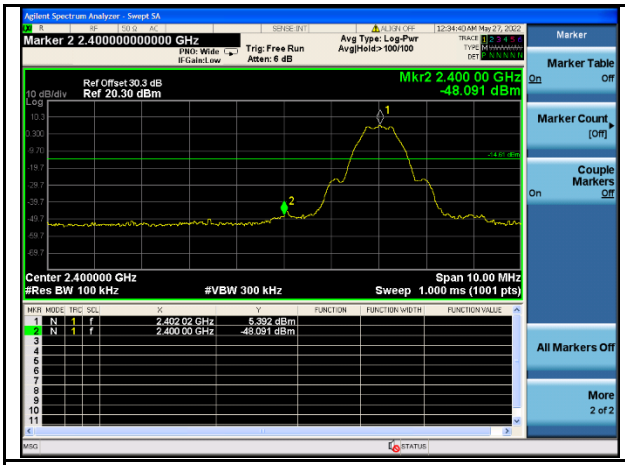
According to ANSI C63.10-2013 clause 11.13

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.

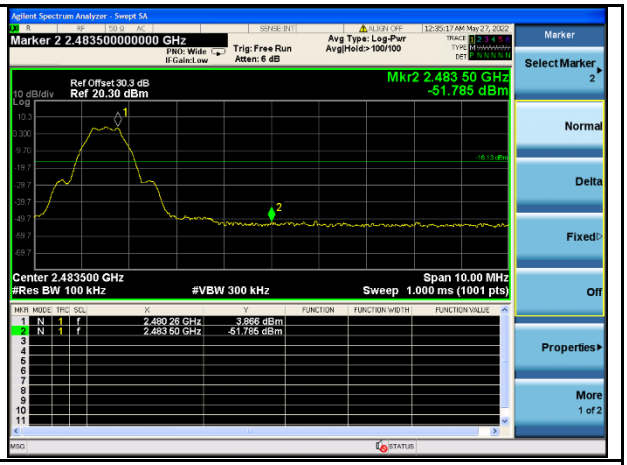
7.6.4 Test Result

Conducted Band edge

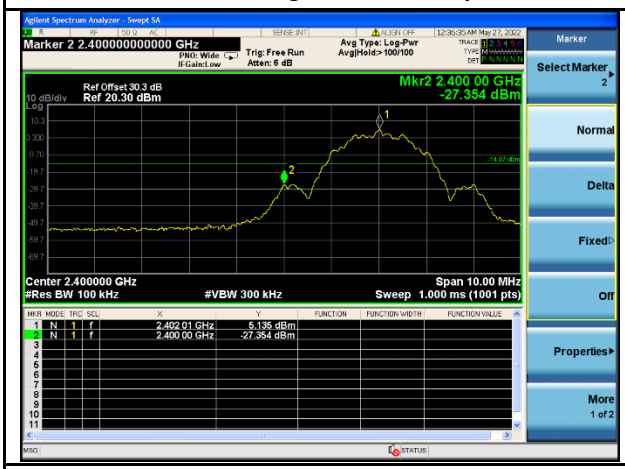
Mode	Data rate	Test Frequency (MHz)	Ref level (dBm)	Emission Level (dBm)	Limit (dBm) Δ-20dBc	Margin (dB)	Result
BLE	1Mbps	2402	5.392	-48.091	-14.608	-33.483	Pass
		2480	3.866	-51.785	-16.134	-35.651	Pass
	2Mbps	2402	5.135	-27.354	-14.865	-12.489	Pass
		2480	4.456	-51.035	-15.544	-35.491	Pass



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

Mode	Data rate	Test Frequency (MHz)	Ref level (dBm)	Emission Frequency (MHz)	Emission Level (dBm)	Limit (dBm) Δ-20dBc	Result
BLE	1Mbps	2402	5.207	16547	-45.143	-14.793	Pass
		2440	5.107	16521	-45.485	-14.893	Pass
		2480	4.483	16599	-46.752	-15.517	Pass

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

Mode	Data rate	Test Frequency (MHz)	Ref level (dBm)	Emission Frequency (MHz)	Emission Level (dBm)	Limit (dBm) Δ-20dBc	Result
BLE	2Mbps	2402	5.074	16547	-45.450	-14.926	Pass
		2440	5.104	6964	-50.351	-14.896	Pass
		2480	4.406	4990	-49.845	-15.594	Pass

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

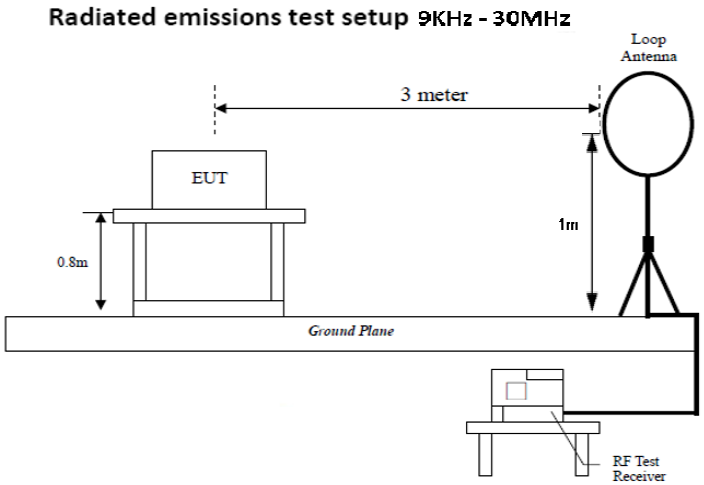
§ 15.247 (d), RSS-247 §5.5

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.

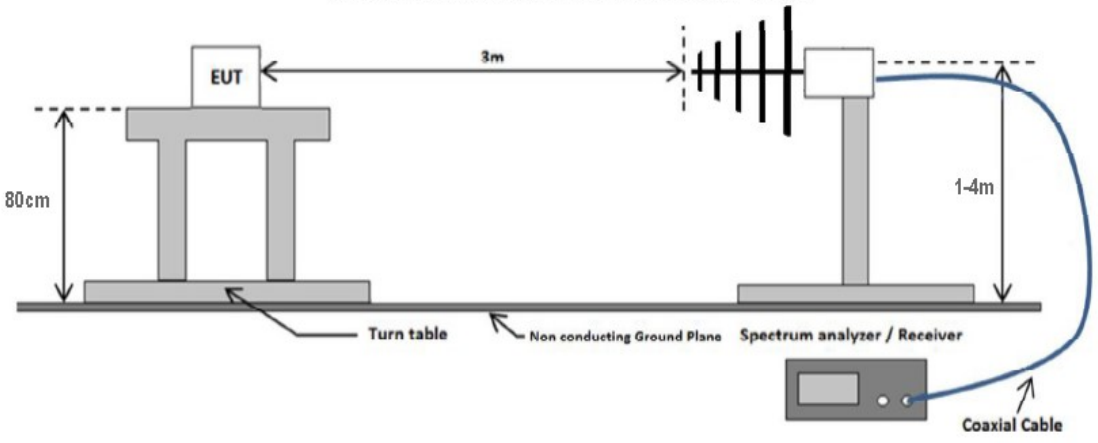
Attenuation below the general limits specified in §15.209(a) and RSS-Gen is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency Range (MHZ)	Field Strength (μV/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

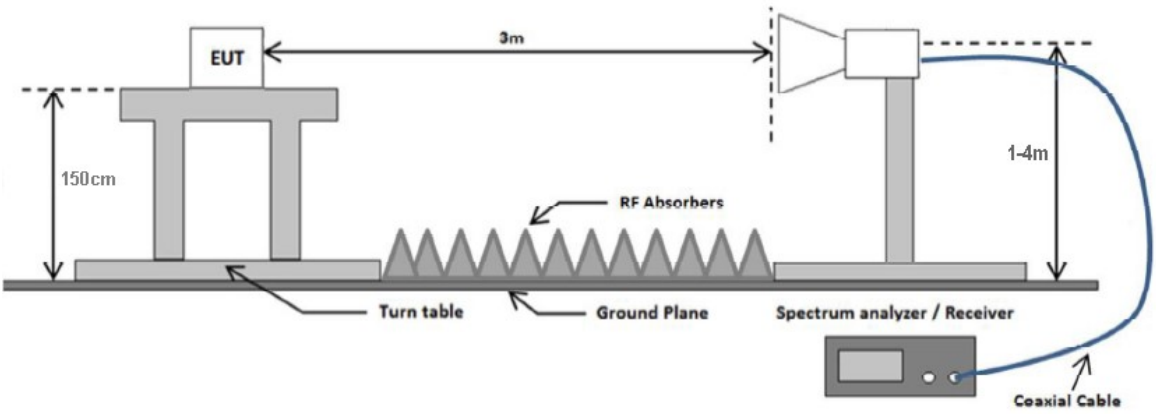
7.7.2 Test Setup



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.

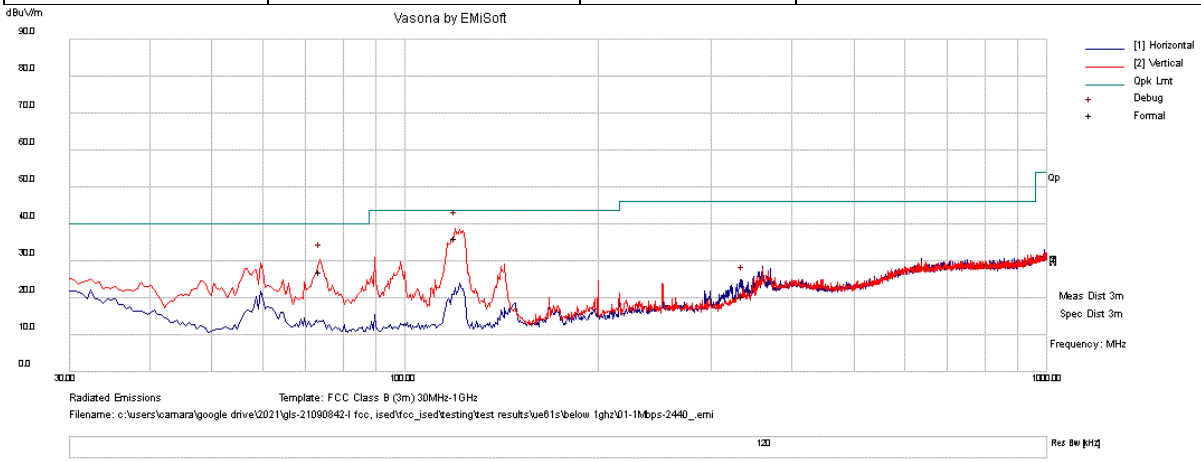
7.7.4 Test Result

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:	06/02/2022
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid channel	Test Result:	Pass



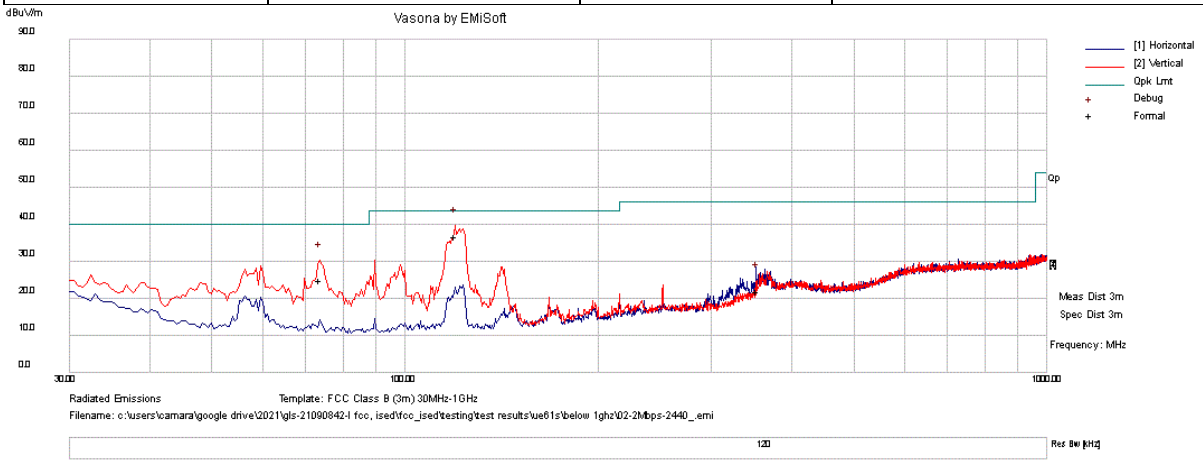
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	119.968	50.9	3.9	-18.5	36.2	Quasi Max	V	145	67	43.5	-7.3	Pass
2	73.853	43.9	3.2	-20.2	27	Quasi Max	V	223	204	40	-13	Pass
3	335.426	26.4	5.9	-11.9	20.4	Quasi Max	H	259	248	46	-25.6	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = 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:	06/02/2022
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid channel	Test Result:	Pass



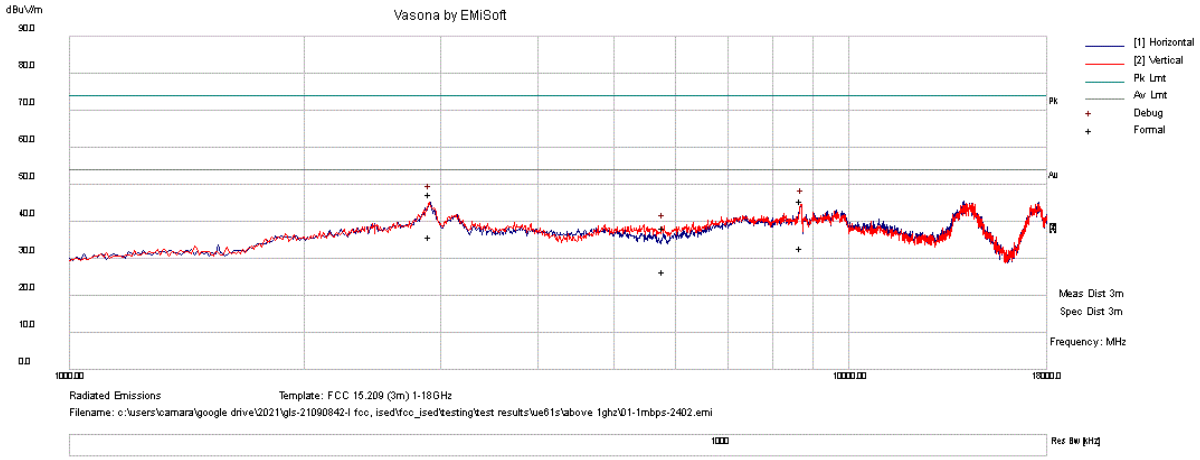
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	119.963	51.4	3.9	-18.5	36.7	Quasi Max	V	100	268	43.5	-6.8	Pass
2	73.891	42	3.2	-20.2	25	Quasi Max	V	114	156	40	-15	Pass
3	353.503	26.7	6.1	-10.8	21.9	Quasi Max	H	132	148	46	-24.1	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB) = Antenna Factor (dB/m) – 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:	06/03/2022-06/06/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Low Channel	Test Result:	Pass



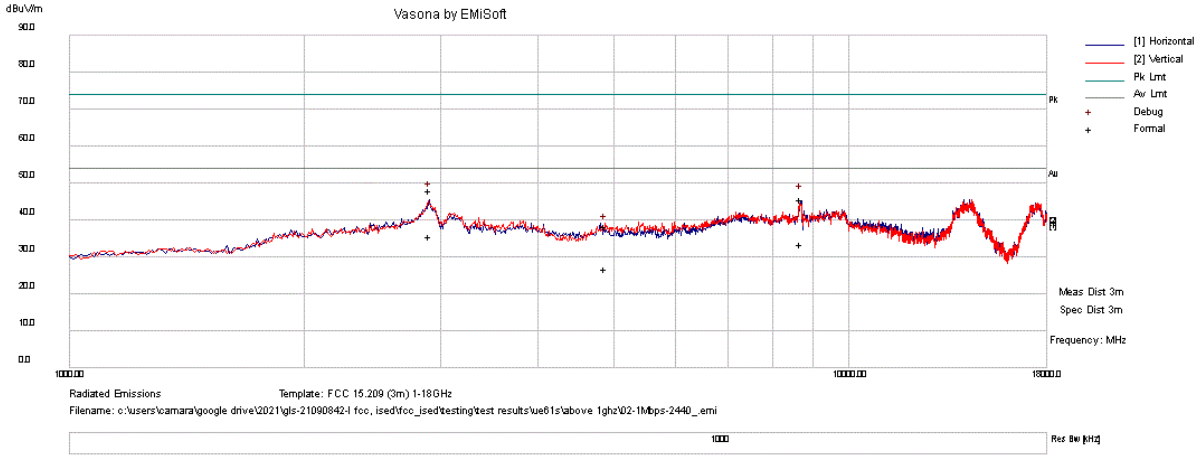
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	2901.643	22	21.6	3.8	47.5	Peak Max	V	130	80	74	-26.5	Pass
2	8711.664	33.8	17.4	-5.7	45.5	Peak Max	V	217	2	74	-28.5	Pass
3	5794.003	38.3	10.3	-10.3	38.3	Peak Max	V	100	110	74	-35.7	Pass
4	2901.643	10.4	21.6	3.8	35.8	Average Max	V	130	80	54	-18.2	Pass
5	8711.664	21	17.4	-5.7	32.7	Average Max	V	217	2	54	-21.3	Pass
6	5794.003	26.6	10.3	-10.3	26.5	Average Max	V	100	110	54	-27.5	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = 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:	06/03/2022-06/06/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid Channel	Test Result:	Pass



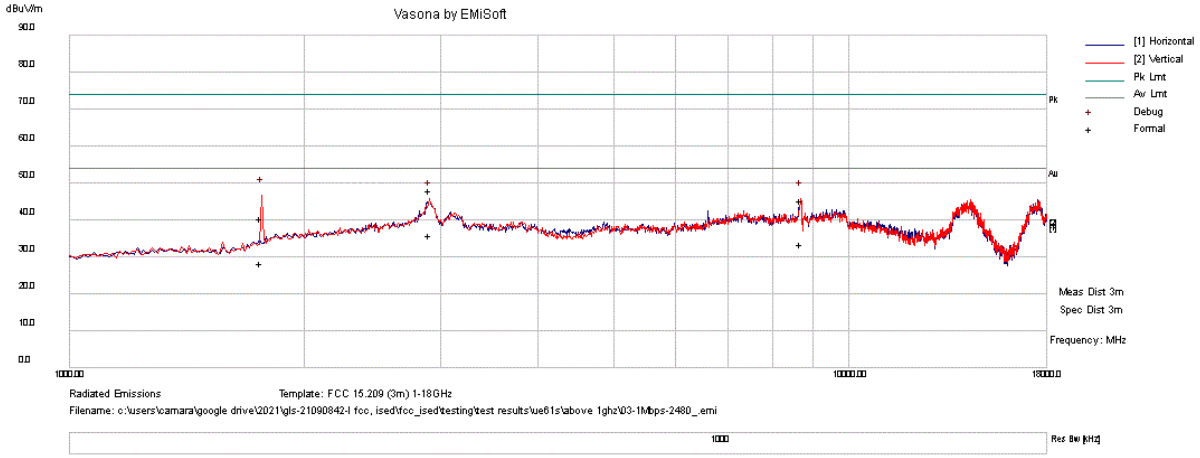
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	2900.955	22.5	21.7	3.8	48.1	Peak Max	H	382	214	74	-25.9	Pass
2	8703.098	33.6	17.8	-5.7	45.7	Peak Max	H	111	154	74	-28.3	Pass
3	4879.177	34.7	9.1	-5.5	38.4	Peak Max	V	300	76	74	-35.6	Pass
4	2900.955	10.2	21.7	3.8	35.7	Average Max	H	382	214	54	-18.3	Pass
5	8703.098	21.3	17.8	-5.7	33.4	Average Max	H	111	154	54	-20.6	Pass
6	4879.177	23.2	9.1	-5.5	26.8	Average Max	V	300	76	54	-27.2	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = 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:	06/03/2022-06/06/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	High Channel	Test Result:	Pass



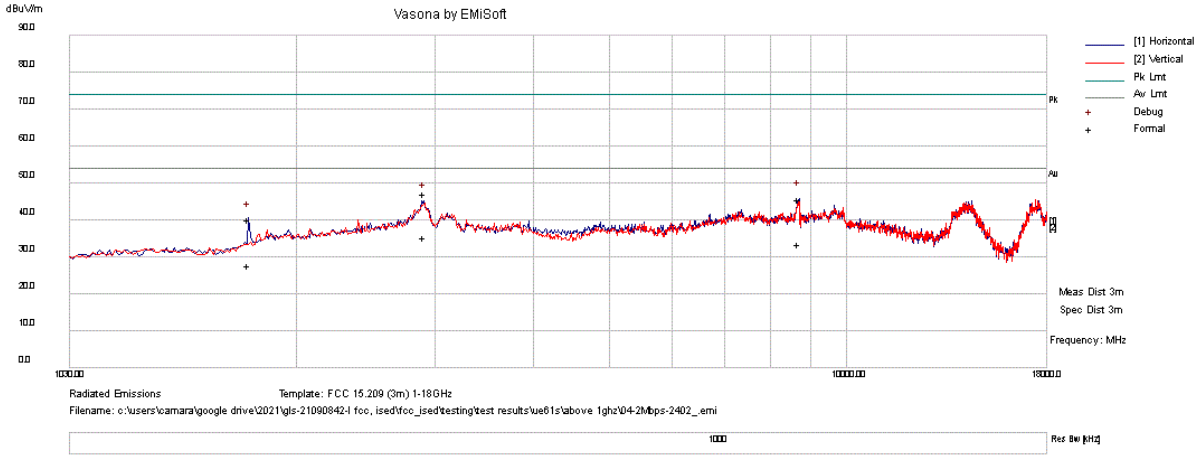
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	1764.59	19	20.4	1	40.5	Peak Max	V	218	64	74	-33.5	Pass
2	2903.038	22.7	21.4	3.9	47.9	Peak Max	V	274	268	74	-26.1	Pass
3	8690.508	33.5	17.5	-5.7	45.4	Peak Max	H	386	227	74	-28.7	Pass
4	1764.59	6.7	20.4	1	28.2	Average Max	V	218	64	54	-25.8	Pass
5	2903.038	10.5	21.4	3.9	35.8	Average Max	V	274	268	54	-18.2	Pass
6	8690.508	21.6	17.5	-5.7	33.4	Average Max	H	386	227	54	-20.6	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = 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_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	06/03/2022-06/06/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Low Channel	Test Result:	Pass



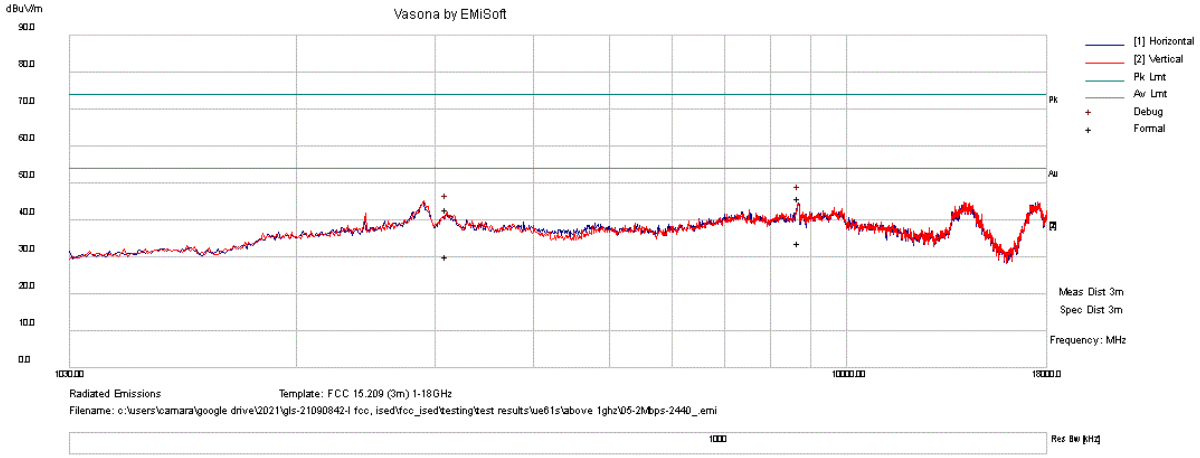
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8708.723	33.6	17.6	-5.7	45.5	Peak Max	H	308	28	74	-28.5	Pass
2	2906.701	22.2	20.9	3.9	46.9	Peak Max	H	221	155	74	-27.1	Pass
3	1740.994	18.9	20.4	0.7	40	Peak Max	H	199	20	74	-34	Pass
4	8708.723	21.4	17.6	-5.7	33.3	Average Max	H	308	28	54	-20.7	Pass
5	2906.701	10.6	20.9	3.9	35.3	Average Max	H	221	155	54	-18.7	Pass
6	1740.994	6.6	20.4	0.7	27.7	Average Max	H	199	20	54	-26.3	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = 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_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	06/03/2022-06/06/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid Channel	Test Result:	Pass



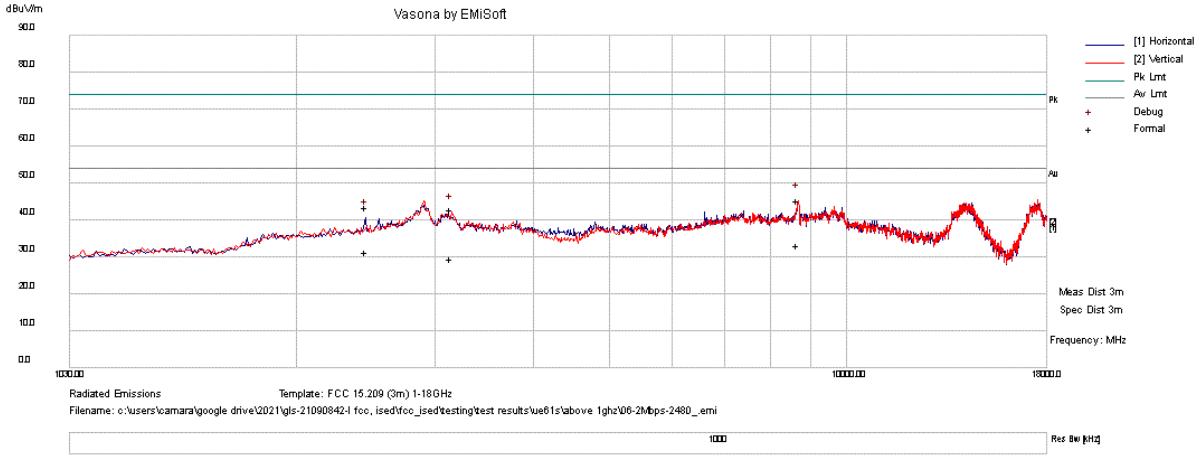
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8700.069	33.7	17.9	-5.7	45.9	Peak Max	H	370	0	74	-28.1	Pass
2	3108.858	37	7.1	-1.2	42.9	Peak Max	V	298	298	74	-31.1	Pass
3	8700.069	21.6	17.9	-5.7	33.9	Average Max	H	370	0	54	-20.2	Pass
4	3108.858	24.2	7.1	-1.2	30.1	Average Max	V	298	298	54	-23.9	Pass

Remarks:

1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = 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_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	06/03/2022-06/06/2022
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/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8687.378	33.6	17.4	-5.7	45.2	Peak Max	V	317	264	74	-28.8	Pass
2	3149.633	39	7.1	-3.3	42.8	Peak Max	V	356	341	74	-31.2	Pass
3	2452.454	19.7	21.3	2.4	43.3	Peak Max	H	220	102	74	-30.7	Pass
4	8687.378	21.6	17.4	-5.7	33.3	Average Max	V	317	264	54	-20.7	Pass
5	3149.633	25.9	7.1	-3.3	29.6	Average Max	V	356	341	54	-24.4	Pass
6	2452.454	7.5	21.3	2.4	31.2	Average Max	H	220	102	54	-22.8	Pass

Remarks:

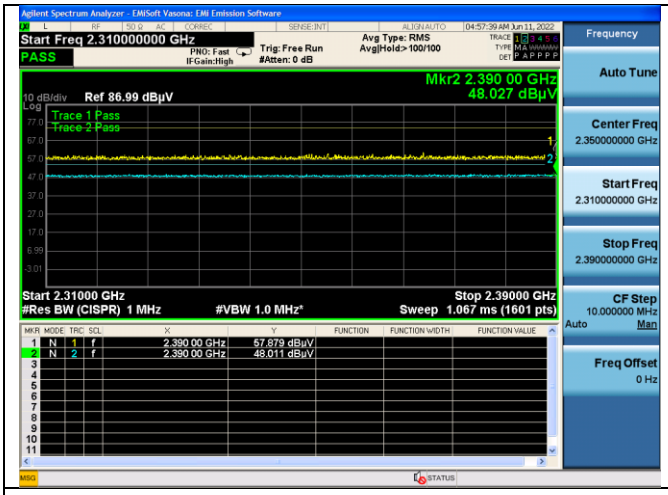
1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Radiated Emission between 18GHz – 40GHz test result

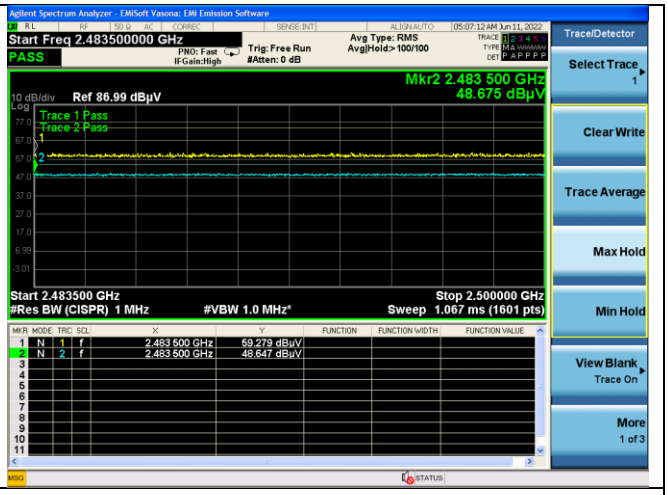
Note: no substantial emission is found other than the noise floor. Different modes have been verified.

Restricted Band Measurement Result

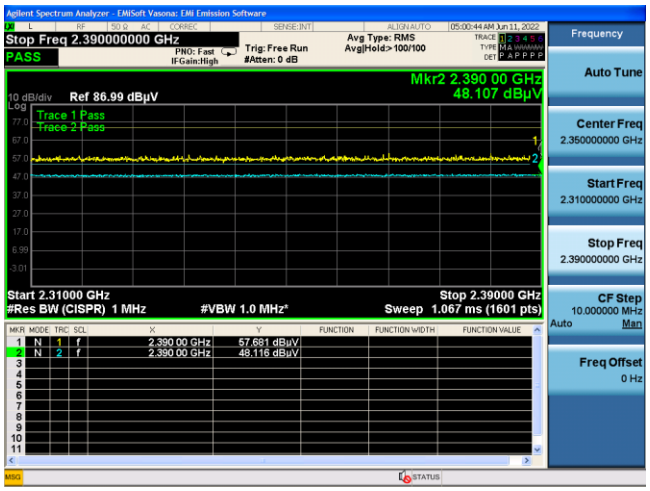
Mode	TX CH (MHz)	Frequency (MHz)	Emission Level (dBuV/m)	Detector Type	Limit (dBuV/m)	Margin (dB)	Result
BLE_1M	2402	2390	57.879	PK	74	-16.121	Pass
		2390	48.011	AV	54	-5.989	Pass
	2480	2483.5	59.279	PK	74	-14.721	Pass
		2483.5	48.647	AV	54	-5.353	Pass
BLE_2M	2402	2390	57.681	PK	74	-16.319	Pass
		2390	48.116	AV	54	-5.884	Pass
	2480	2483.5	58.845	PK	74	-15.155	Pass
		2483.5	48.275	AV	54	-5.725	Pass



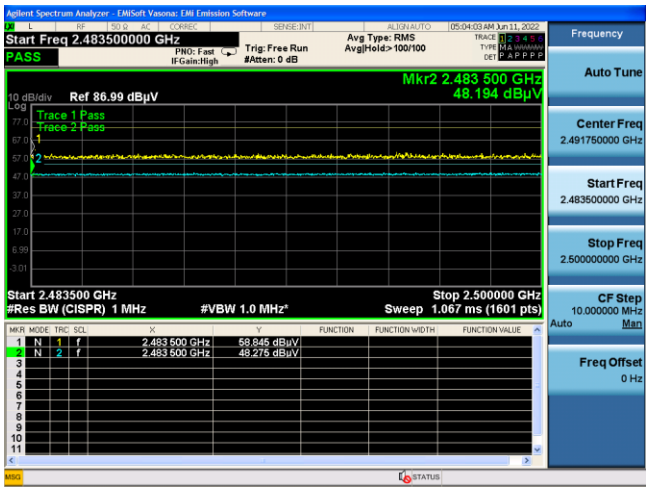
BLE – Low CH-1Mpbs



BLE – High CH-1Mpbs



BLE – Low CH-2Mpbs



BLE – High CH-2Mpbs

7.8 Conducted Emissions

7.8.1 Requirement

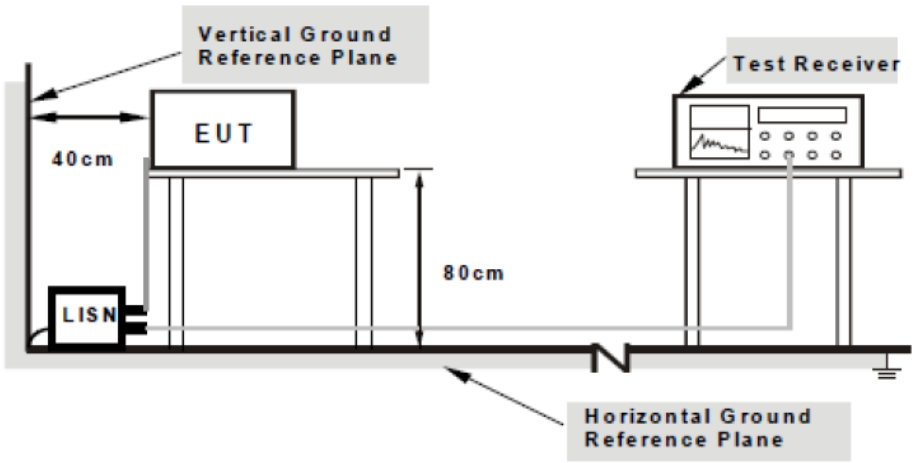
Per § 15.207 (a), RSS Gen 8.8

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 μH/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



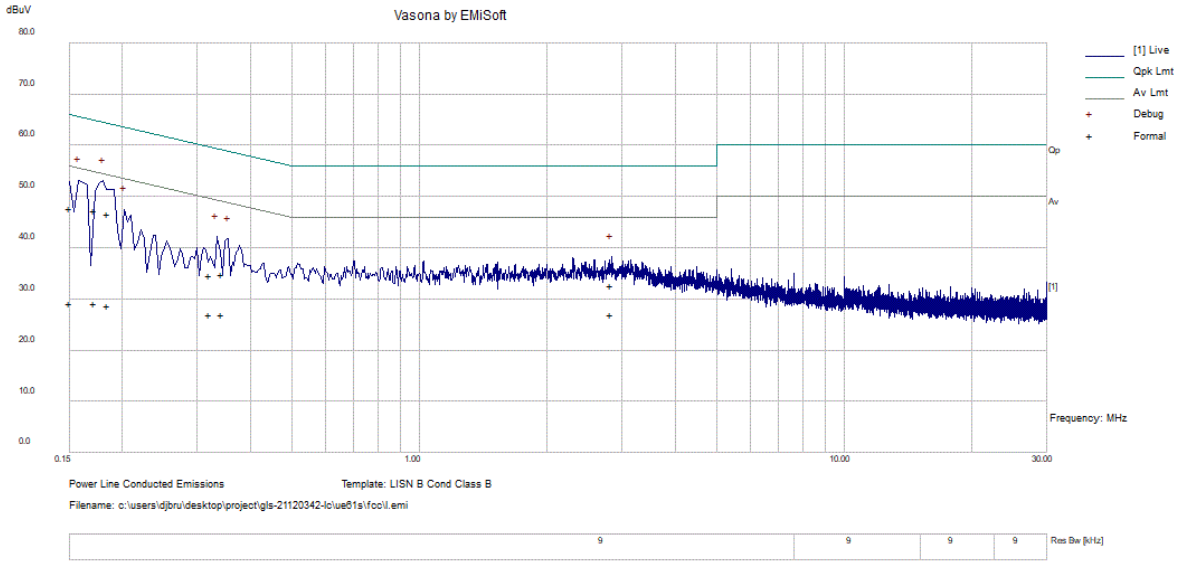
Note: 1.Support units were connected to second LISN.
2.Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

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 50Ω/50µH 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:	06/10/2022
Antenna Type/Polarity:	N/A	Test Personnel:	Devin Tai
Remark:	Line 120VAC, 60Hz	Test Result:	Pass

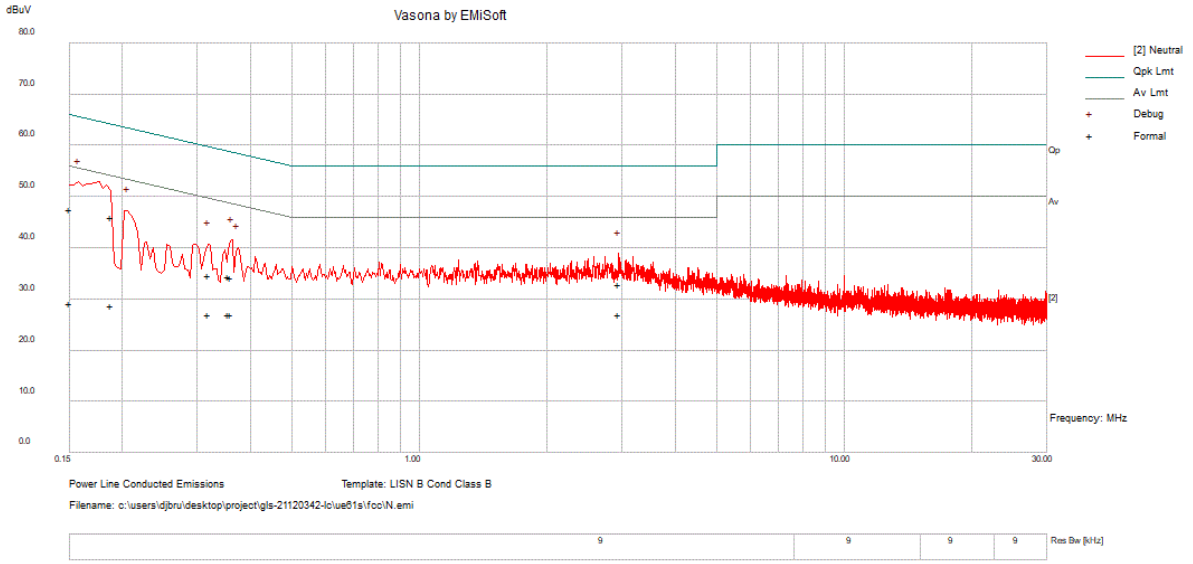


No.	Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Meas. Type	Line	Limit (dBuV)	Margin (dB)	Pass /Fail
1	0.172	37.1	10.1	0.2	47.4	Quasi Peak	Live	64.9	-17.5	Pass
2	0.15	37.4	10.1	0.2	47.8	Quasi Peak	Live	66	-18.2	Pass
3	0.185	36.4	10.1	0.2	46.7	Quasi Peak	Live	64.3	-17.6	Pass
4	0.344	24.6	10.1	0.1	34.8	Quasi Peak	Live	59.1	-24.3	Pass
5	0.321	24.5	10.1	0.1	34.7	Quasi Peak	Live	59.7	-24.9	Pass
6	2.83	22.5	10.3	0.1	32.8	Quasi Peak	Live	56	-23.2	Pass
7	0.172	18.9	10.1	0.2	29.2	Average	Live	54.9	-25.7	Pass
8	0.15	19	10.1	0.2	29.3	Average	Live	56	-26.7	Pass
9	0.185	18.6	10.1	0.2	28.9	Average	Live	54.3	-25.4	Pass
10	0.344	16.8	10.1	0.1	27.1	Average	Live	49.1	-22.1	Pass
11	0.321	16.9	10.1	0.1	27.1	Average	Live	49.7	-22.6	Pass
12	2.83	16.7	10.3	0.1	27.1	Average	Live	46	-18.9	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:	12/06/2021
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	0.15	37.2	10.1	0.2	47.5	Quasi Peak	Neutral	66	-18.5	Pass
2	0.188	35.7	10.1	0.2	46	Quasi Peak	Neutral	64.1	-18.1	Pass
3	2.949	22.7	10.3	0.1	33	Quasi Peak	Neutral	56	-23	Pass
4	0.356	24.2	10.1	0.1	34.4	Quasi Peak	Neutral	58.8	-24.4	Pass
5	0.359	24	10.1	0.1	34.3	Quasi Peak	Neutral	58.7	-24.5	Pass
6	0.318	24.4	10.1	0.1	34.6	Quasi Peak	Neutral	59.3	-24.7	Pass
7	0.15	19	10.1	0.2	29.3	Average	Neutral	56	-26.7	Pass
8	0.188	18.5	10.1	0.2	28.8	Average	Neutral	54.1	-25.3	Pass
9	2.949	16.7	10.3	0.1	27.1	Average	Neutral	46	-18.9	Pass
10	0.356	16.8	10.1	0.1	27	Average	Neutral	48.8	-21.8	Pass
11	0.359	16.8	10.1	0.1	27	Average	Neutral	48.7	-21.8	Pass
12	0.318	16.9	10.1	0.1	27.1	Average	Neutral	49.8	-22.7	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	10/18/2020	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	05/04/2022	05/04/2023
Bi-Log Antenna	ETS-Lindgren	3142E	217921	11/15/2021	11/15/2022
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	05/14/2022	05/14/2023
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
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	05/15/2022	05/15/2023
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	05/16/2022	05/16/2023
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
Agilent Signal Generator	MXG N5182A	N5182A	US47080548	06/17/2021	06/17/2022
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL052	N/A	N/A
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL053	N/A	N/A
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL054	N/A	N/A
Power Splitter/Combiner	Mini-Circuits	ZFSC-2-9G+	VL055	N/A	N/A

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