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Phone: +1 (949) 393-1123
Web: www.vista-compliance.com
Email: info@vista-compliance.com

FCC RF Test Report

Test Report Number	GLS-21090842-L-FCC-IC-BLE Rev_1.0
FCC ID	MG3-59007000007
IC	2575A-59007000007
Applicant	Universal Electronic Inc.
Applicant Address	201 East Sandpointe Ave., 7th Floor, Santa Ana, CA 92707
Product Name	UE61 Module
Model (s)	UE61V
Date of Receipt	09/08/2021
Date of Test	11/24/2021- 05/17/2022
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
www.vista-compliance.com

Devin Tai (Test Engineer)

David Zhang (Technical Manager)

REVISION HISTORY

Report Number	Version	Description	Issued Date
GLS-21090842-L-FCC-IC-BLE	01	Initial report	05/18/2022
GLS-21090842-L-FCC-IC-BLE Rev_1.0	1.0	Update Applicant's address	10/28/2022

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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	UE61V
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:

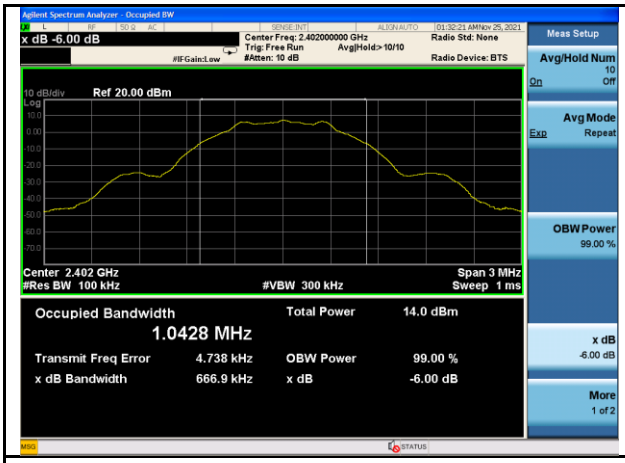
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this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

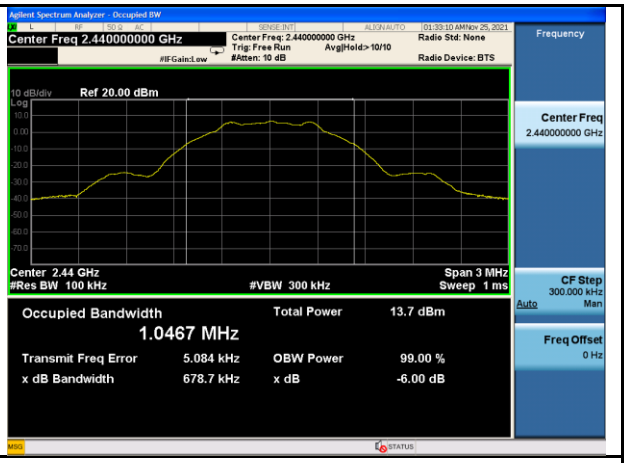
7.2.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
BLE	1Mbps	2402	666.9	500	Pass
		2440	678.7	500	Pass
		2480	666.9	500	Pass
	2Mbps	2402	1175	500	Pass
		2440	1160	500	Pass
		2480	1153	500	Pass

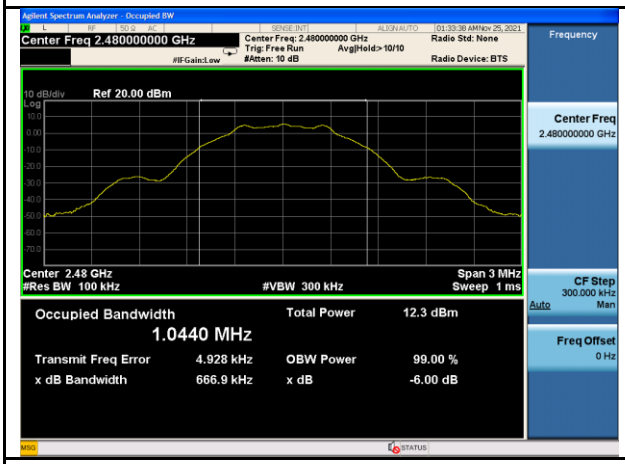
7.2.5 Test Plots



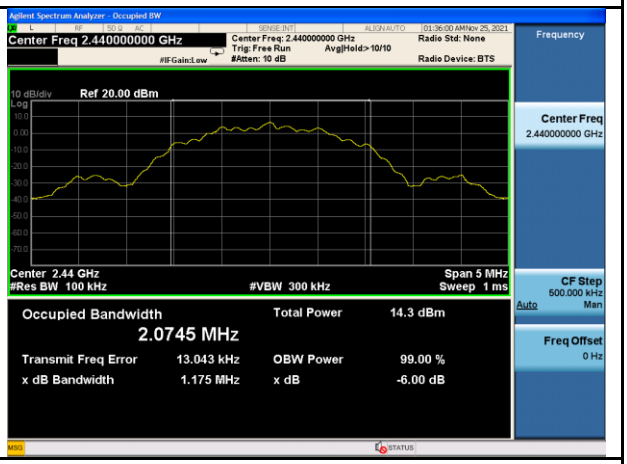
BLE-DTS BW-Low-1Mbps



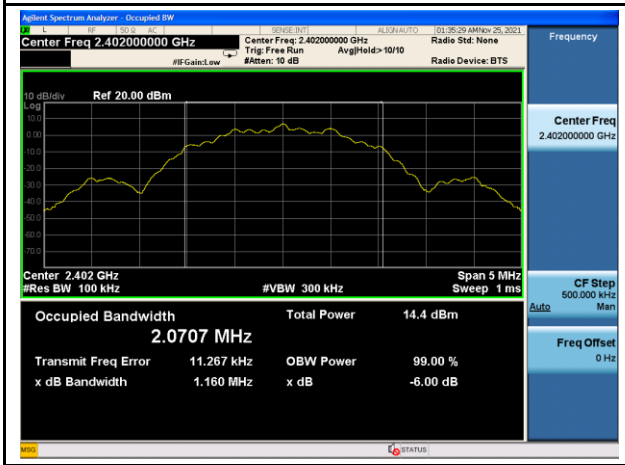
BLE-DTS BW-Mid-1Mbps



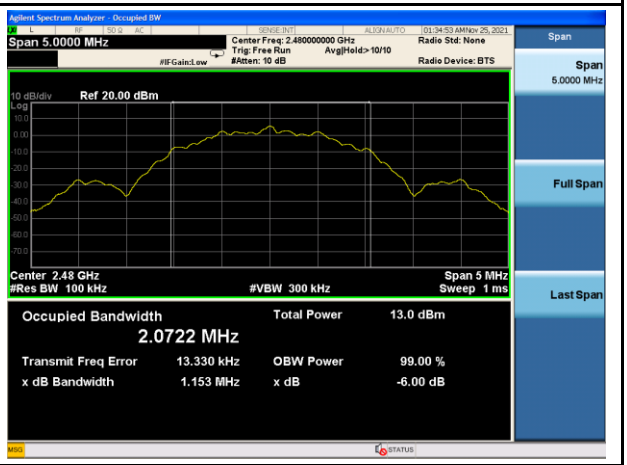
BLE-DTS BW-High-1Mbps



BLE-DTS BW-Low-2Mbps



BLE-DTS BW-Mid-2Mbps



BLE-DTS BW-High-2Mbps

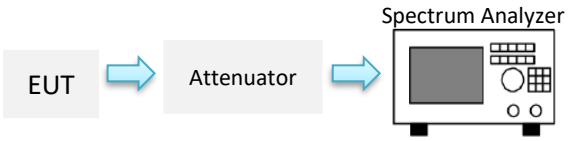
7.3 Occupied Bandwidth (99%)

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

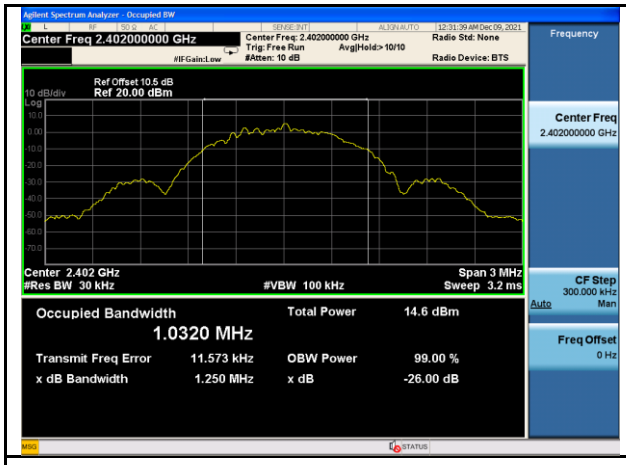
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this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

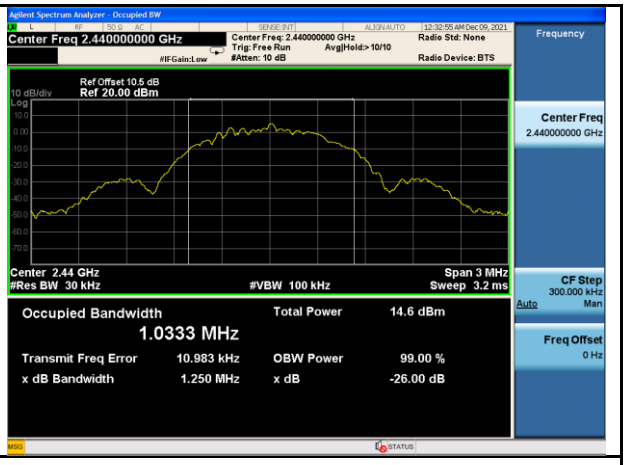
7.3.4 Test Result

Mode	Data rate	Frequency (MHz)	Measured 99% OBW (KHz)	Limit (KHz)	Result
BLE	1Mbps	2402	1032.0	N/A	N/A
		2440	1033.3	N/A	N/A
		2480	1030.4	N/A	N/A
	2Mbps	2402	2074.5	N/A	N/A
		2440	2070.7	N/A	N/A
		2480	2072.2	N/A	N/A

7.3.5 Test Plots

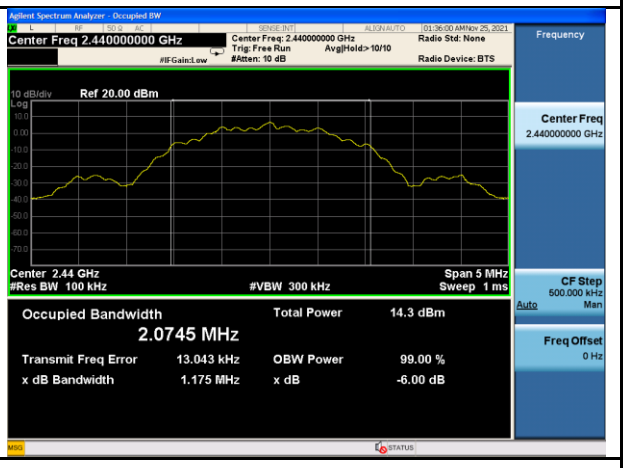


BLE-OBW-Low-1Mpbs

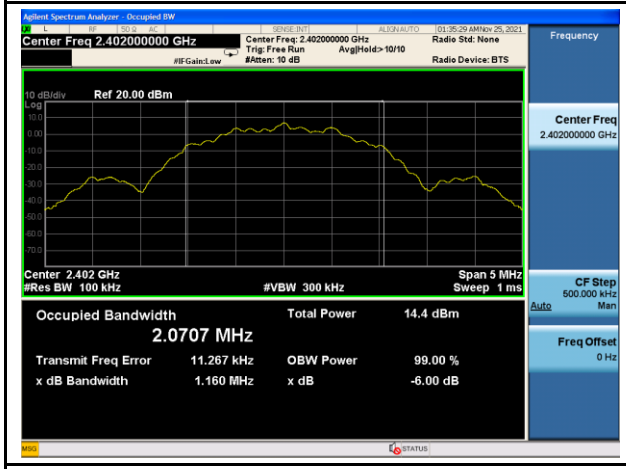


BLE-OBW-Mid-1Mpbs

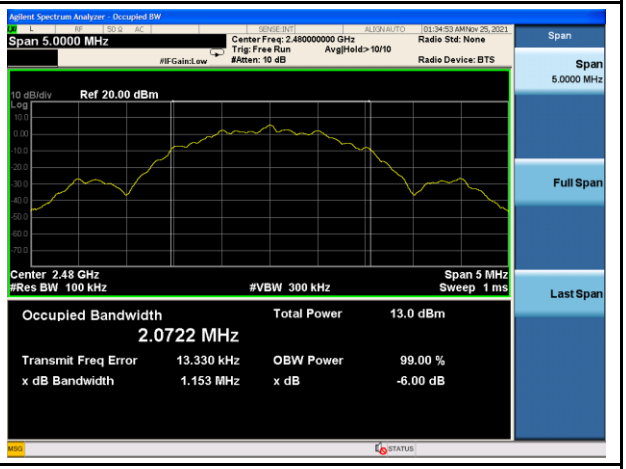
BLE-OBW-Mid-1Mpbs



BLE-OBW-Low-2Mpbs



BLE-OBW-Mid-2Mpbs



BLE-OBW-High-2Mpbs

7.4 Maximum Output Power

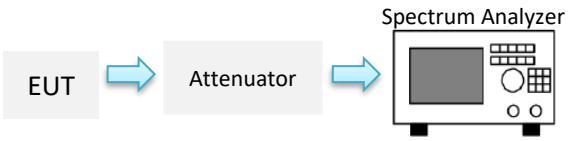
7.4.1 Requirement

§ 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

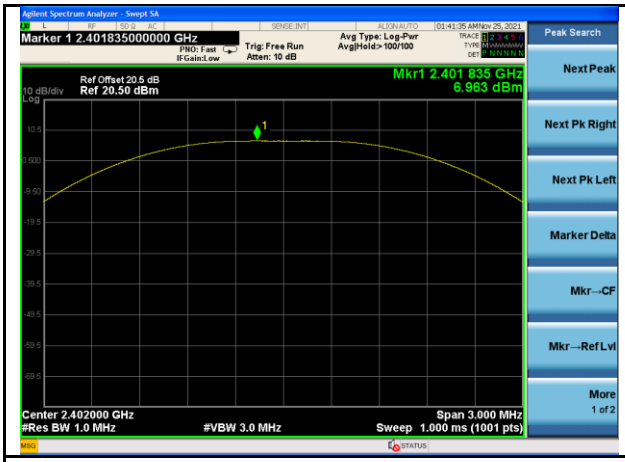
For BLE, power measurement is according to subclause 11.9.1.1 of ANSI C63.10-2013:

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

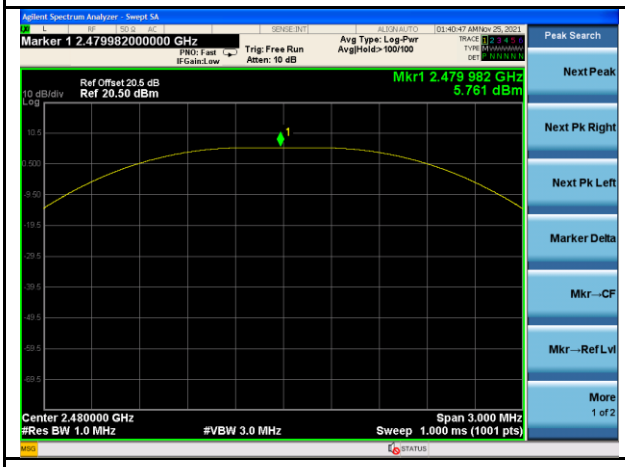
Mode	Data rate	Frequency (MHz)	Measured Output Power (dBm)	Max Output Power (dBm)	Result
BLE	1Mbps	2402	6.963	30	Pass
		2440	7.449	30	Pass
		2480	5.761	30	Pass
	2Mbps	2402	7.055	30	Pass
		2440	7.956	30	Pass
		2480	5.851	30	Pass

7.4.5 Test Plots

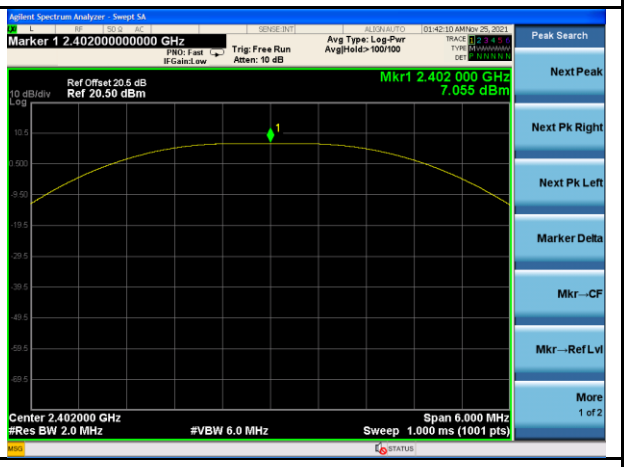


BLE-Power-Low-1Mbps

BLE-Power-Mid-1Mbps

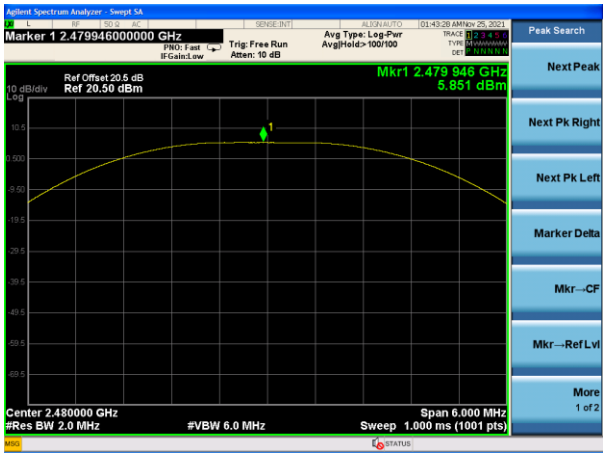


BLE-Power-High-1Mbps



BLE-Power-Low-2Mbps

BLE-Power-Mid-2Mbps



BLE-Power-High-2Mbps

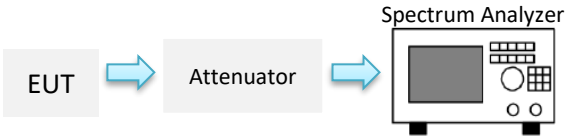
7.5 Power Spectral Density

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	-7.437	8	Pass
		2440	-9.210	8	Pass
		2480	-10.782	8	Pass
	2Mbps	2402	-10.992	8	Pass
		2440	-10.520	8	Pass
		2480	-12.441	8	Pass

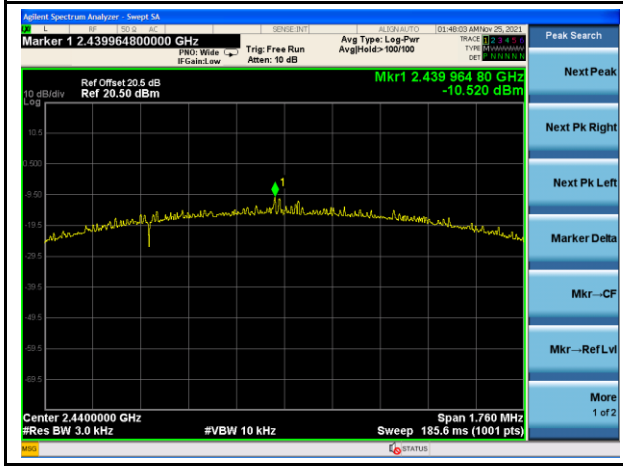
7.5.5 Test Plots

BLE-PSD-Low-1Mbps

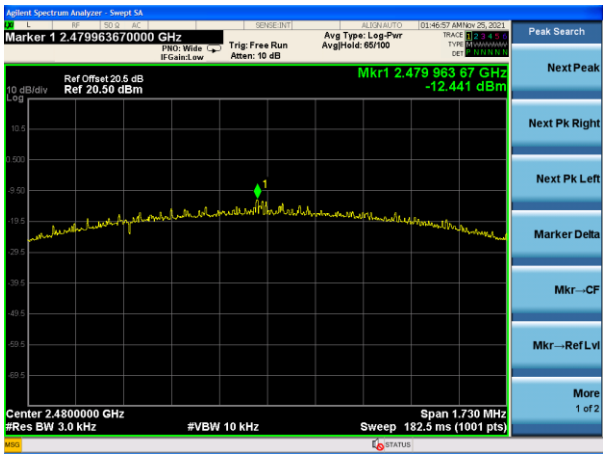
BLE-PSD-Mid-1Mbps

BLE-PSD-High-1Mbps

BLE-PSD-Low-1Mbps



BLE-PSD-Mid-2Mbps



BLE-PSD-High-2Mbps

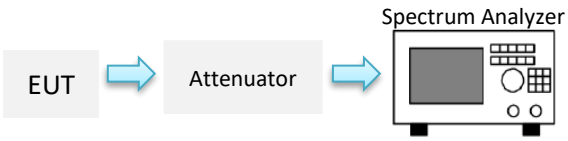
7.6 Conducted Band-Edge & Unwanted Emissions

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



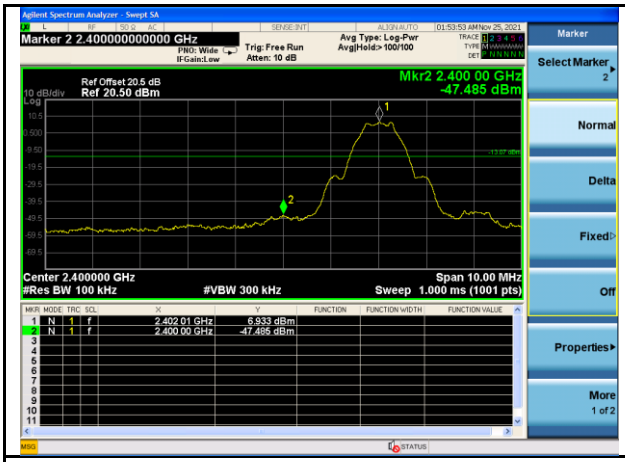
7.6.3 Test Procedure

According to ANSI C63.10-2013 clause 11.13

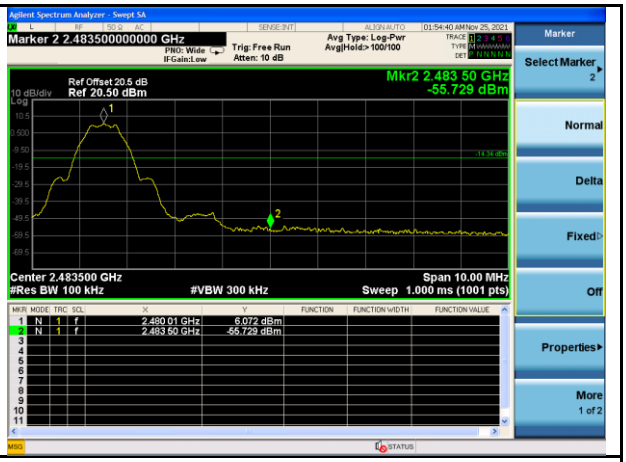
1. The RF output of EUT was connected to the spectrum analyzer by RF cable and attenuator. The path loss was compensated to the results for each measurement.
2. Set to the maximum power setting and enable the EUT transmit continuously.
3. Set RBW=100 KHZ, VBW=300 KHZ, Peak Detector. Unwanted Emissions 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

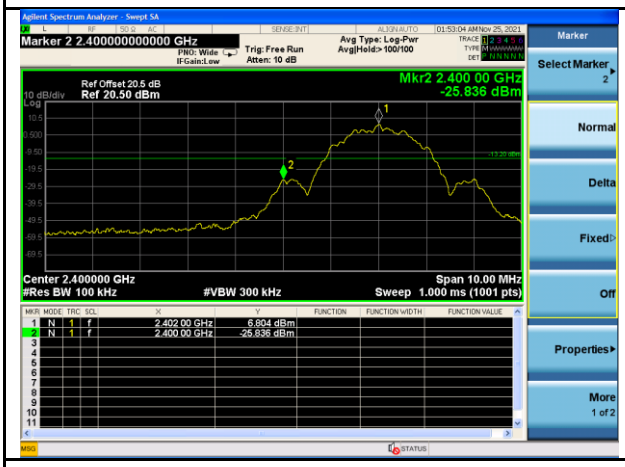
Conducted Band edge



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

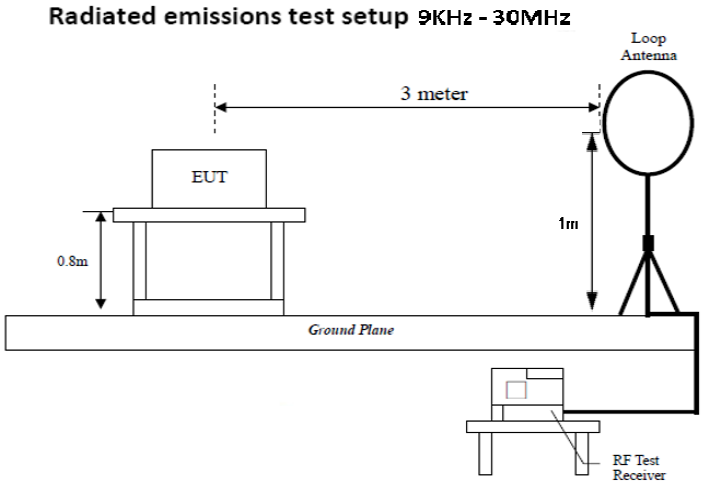
§ 15.247 (d), RSS-247 §5.5

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.

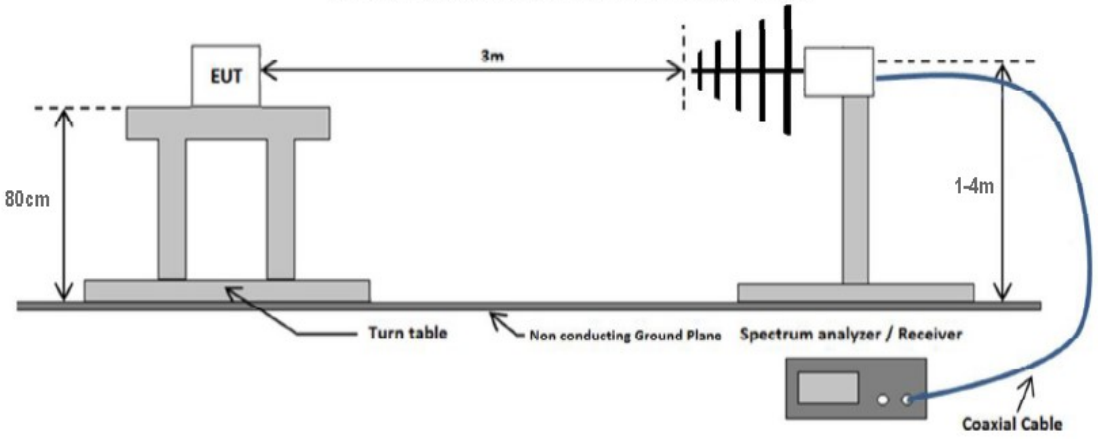
Attenuation below the general limits specified in §15.209(a) and RSS-Gen is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

Frequency Range (MHZ)	Field Strength (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

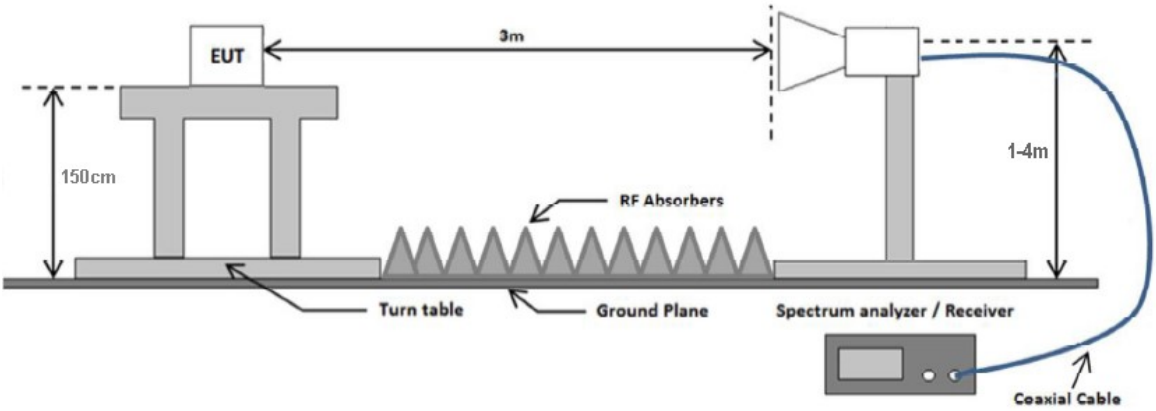
7.7.2 Test Setup



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.

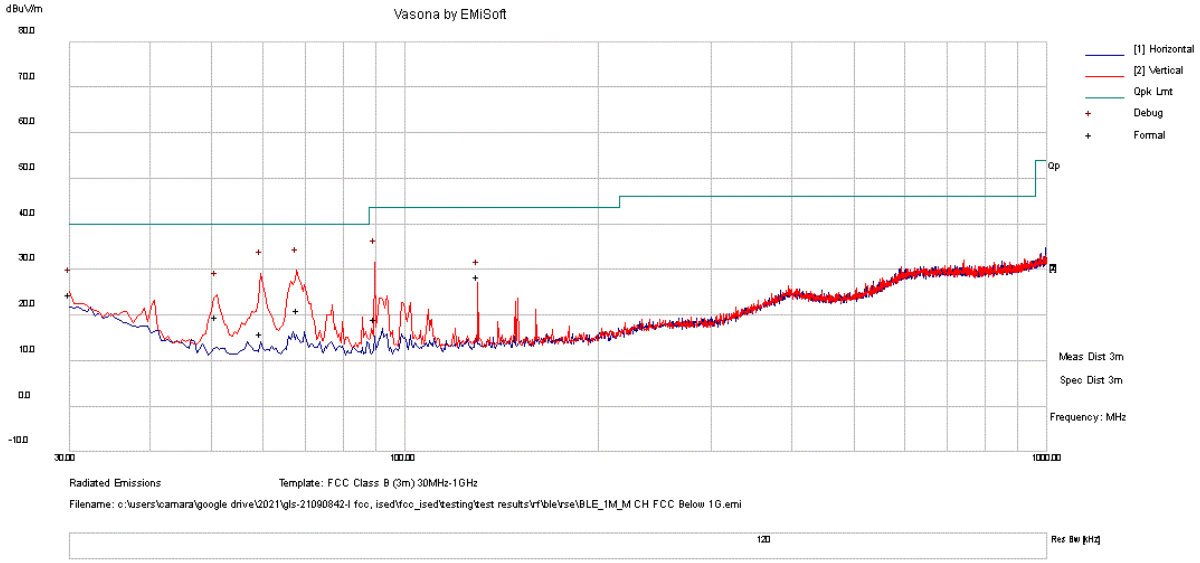
7.7.4 Test Result

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:	12/06/2021
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid channel	Test Result:	Pass



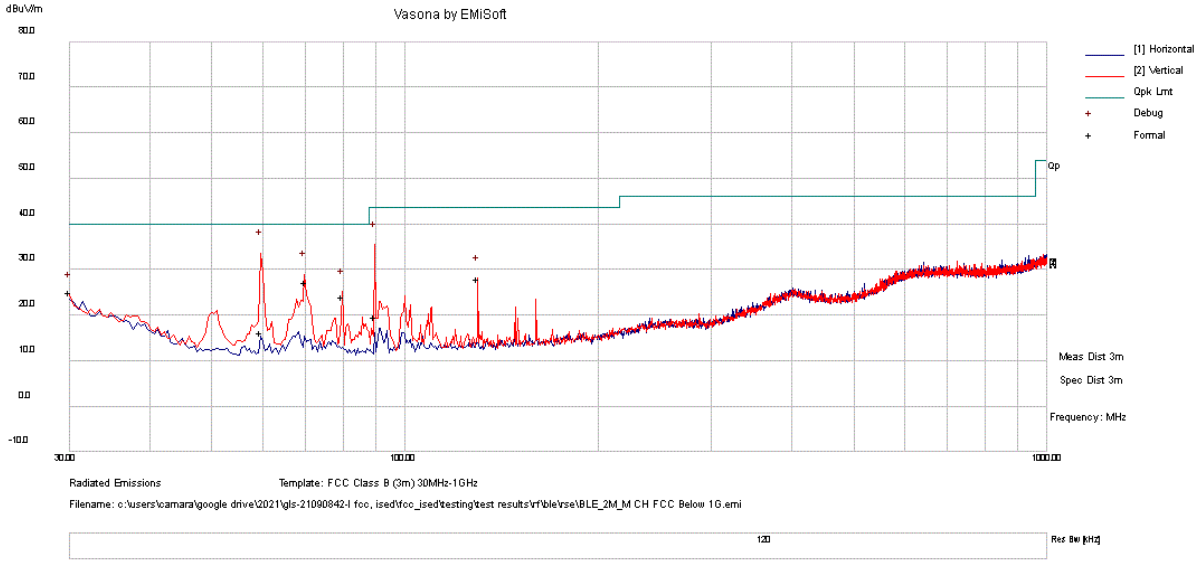
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	
1	68.01	38.2	3.1	-20.2	21.2	Quasi Max	V	130	0	40	-18.8	Pass
2	59.728	33.7	3	-20.7	16	Quasi Max	V	280	239	40	-24	Pass
3	89.904	35.9	3.4	-20.1	19.2	Quasi Max	V	116	252	43.5	-24.3	Pass
4	30.003	33.8	2.2	-11.5	24.5	Quasi Max	V	252	76	40	-15.5	Pass
5	50.803	37.7	2.8	-20.9	19.7	Quasi Max	V	121	0	40	-20.3	Pass
6	130.004	42.7	4	-18.3	28.5	Quasi Max	V	100	193	43.5	-15	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:	12/06/2021
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid channel	Test Result:	Pass



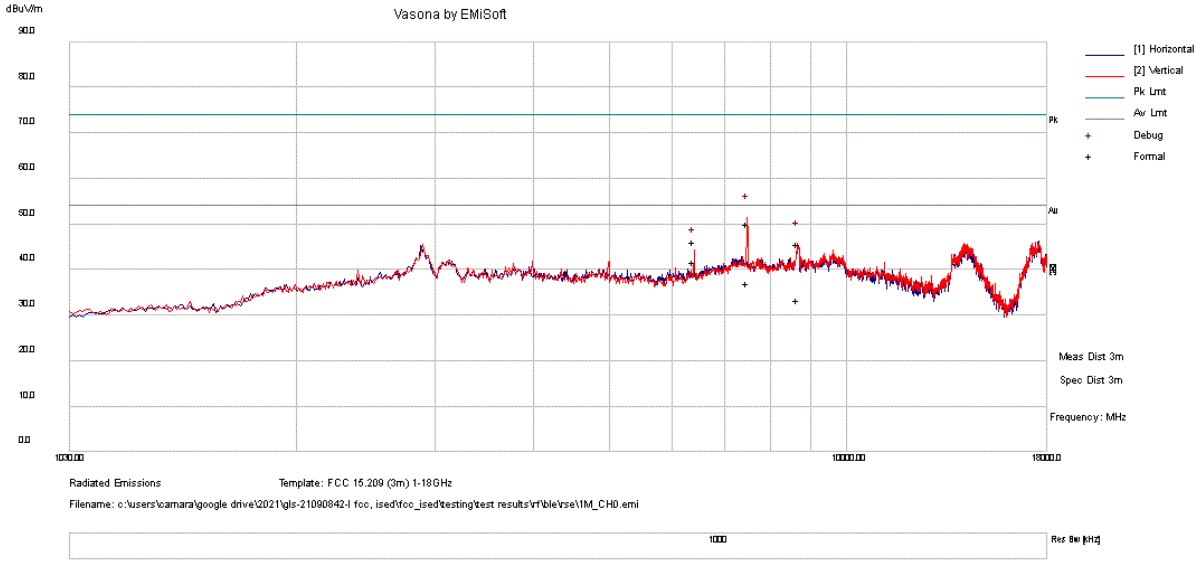
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	59.528	34.1	3	-20.7	16.4	Quasi Max	V	255	34	40	-23.6	Pass
2	89.898	36.4	3.4	-20.1	19.7	Quasi Max	V	115	319	43.5	-23.8	Pass
3	70.006	44.3	3.2	-20.1	27.4	Quasi Max	V	122	342	40	-12.6	Pass
4	79.989	41.2	3.3	-20.3	24.2	Quasi Max	V	100	128	40	-15.8	Pass
5	129.997	42.3	4	-18.3	28.1	Quasi Max	V	101	51	43.5	-15.4	Pass
6	30	34.5	2.2	-11.5	25.2	Quasi Max	V	214	64	40	-14.8	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:	05/16/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Low Channel	Test Result:	Pass



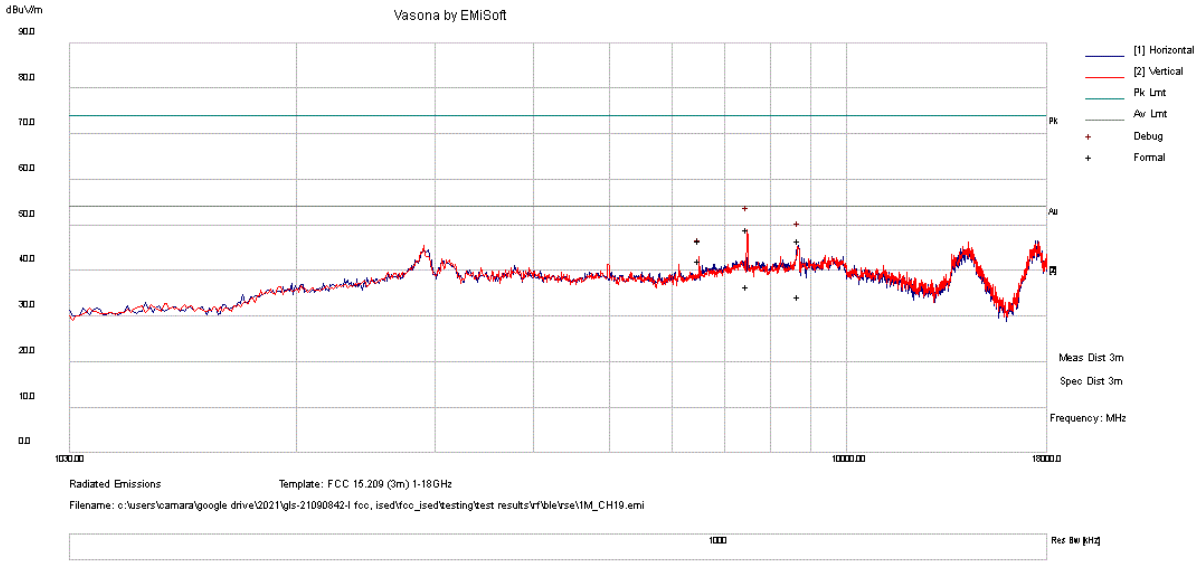
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7479.58	43.9	11.9	-5.7	50.1	Peak Max	V	304	142	74	-23.9	Pass
2	8675.641	34.5	16.9	-5.7	45.6	Peak Max	V	391	159	74	-28.4	Pass
3	6405.276	43.9	10.9	-8.6	46.2	Peak Max	V	208	0	74	-27.8	Pass
4	7479.58	30.8	11.9	-5.7	37	Average Max	V	304	142	54	-17	Pass
5	8675.641	22.1	16.9	-5.7	33.3	Average Max	V	391	159	54	-20.7	Pass
6	6405.276	39.3	10.9	-8.6	41.6	Average Max	V	208	0	54	-12.4	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:	05/16/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid Channel	Test Result:	Pass



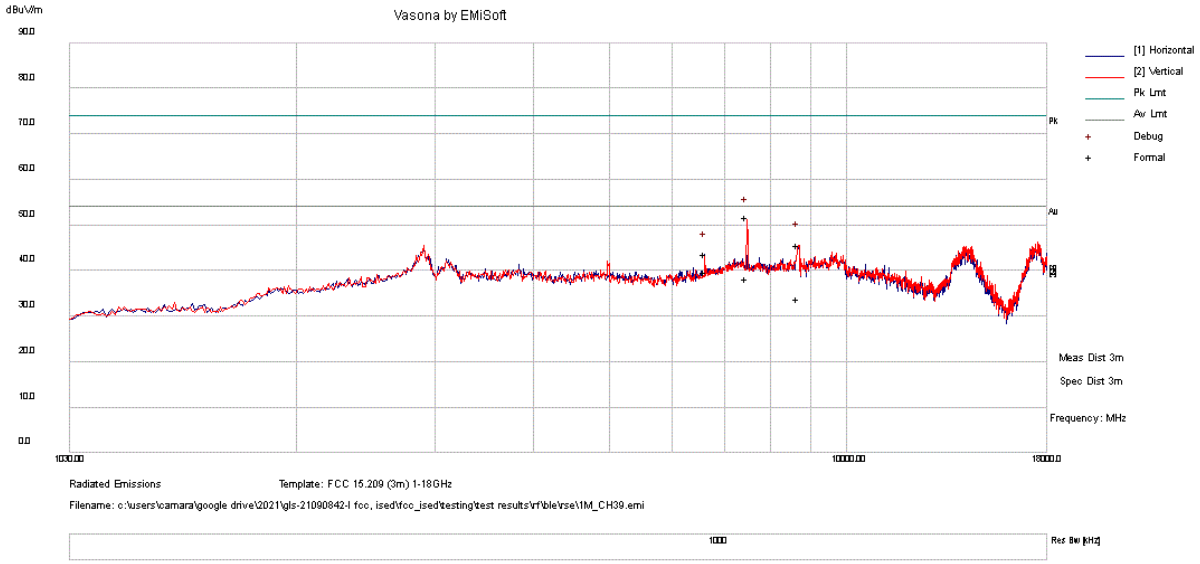
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7479.208	42.9	11.9	-5.7	49.1	Peak Max	V	171	0	74	-24.9	Pass
2	8700.316	34.5	17.9	-5.7	46.7	Peak Max	H	169	145	74	-27.3	Pass
3	6506.732	43.9	10.9	-8.2	46.6	Peak Max	V	111	331	74	-27.4	Pass
4	7479.208	30.5	11.9	-5.7	36.7	Average Max	V	171	0	54	-17.3	Pass
5	8700.316	22.1	17.9	-5.7	34.3	Average Max	H	169	145	54	-19.7	Pass
6	6506.732	39.4	10.9	-8.2	42.2	Average Max	V	111	331	54	-11.8	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 EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_1Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	05/16/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	High Channel	Test Result:	Pass



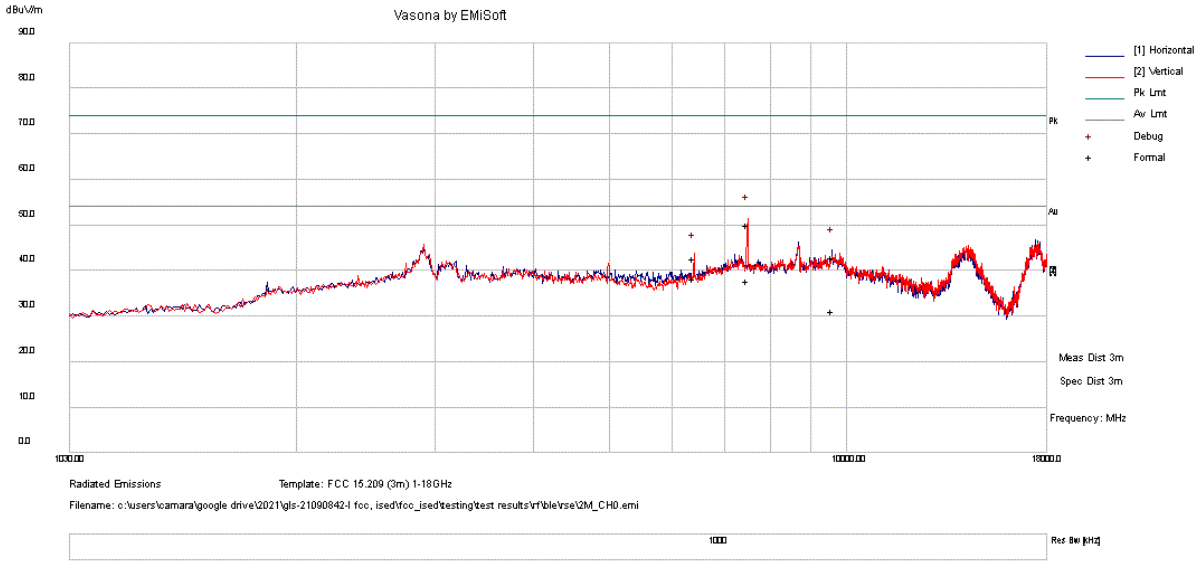
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7467.711	45.5	11.9	-5.7	51.8	Peak Max	V	358	94	74	-22.2	Pass
2	8686.325	34.1	17.3	-5.7	45.8	Peak Max	V	390	178	74	-28.2	Pass
3	6607.208	40	11.2	-7.6	43.6	Peak Max	V	100	248	74	-30.4	Pass
4	7467.711	32.1	11.9	-5.7	38.4	Average Max	V	358	94	54	-15.6	Pass
5	8686.325	22.2	17.3	-5.7	33.8	Average Max	V	390	178	54	-20.2	Pass
6	6607.208	36.1	11.2	-7.6	39.7	Average Max	V	100	248	54	-14.3	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:	05/16/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Low Channel	Test Result:	Pass



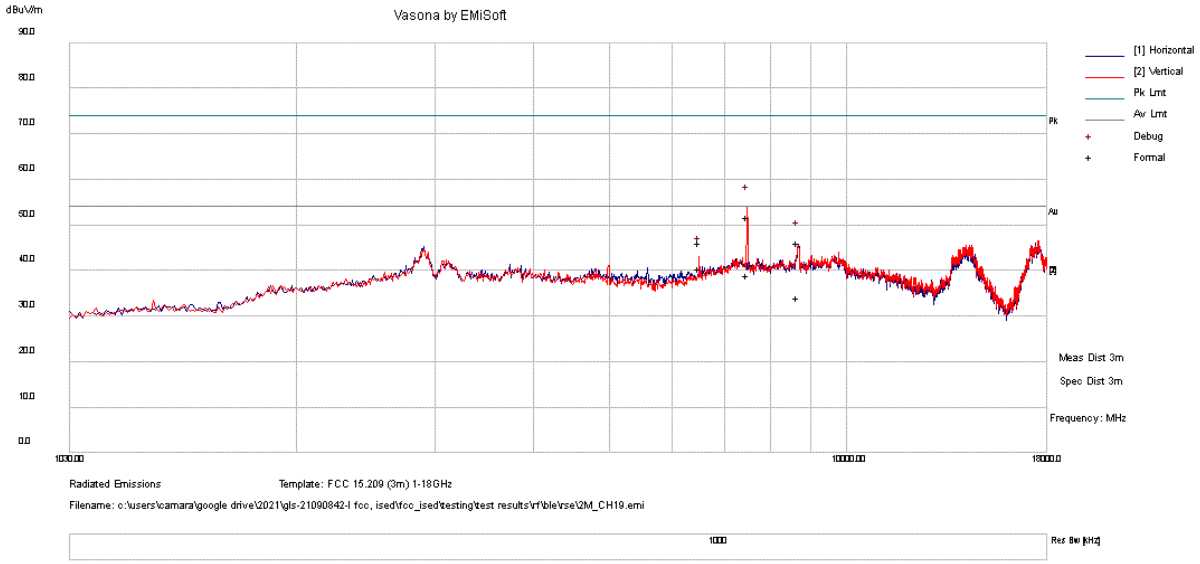
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7499.043	44	11.9	-5.7	50.2	Peak Max	V	330	89	74	-23.8	Pass
2	9588.134	34	14	-5.2	42.9	Peak Max	H	284	0	74	-31.1	Pass
3	6409.978	40.5	10.9	-8.6	42.8	Peak Max	V	255	223	74	-31.2	Pass
4	7499.043	31.7	11.9	-5.7	37.9	Average Max	V	330	89	54	-16.1	Pass
5	9588.134	22.2	14	-5.2	31.1	Average Max	H	284	0	54	-22.9	Pass
6	6409.978	35.9	10.9	-8.6	38.2	Average Max	V	255	223	54	-15.8	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 EMISSIONS 1 - 18 GHZ

Test Standard:	FCC15.247, 15.209, RSS-247	Mode:	BLE_2Mbps
Frequency Range:	1 GHz – 18 GHz	Test Date:	05/16/2022
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	Mid Channel	Test Result:	Pass



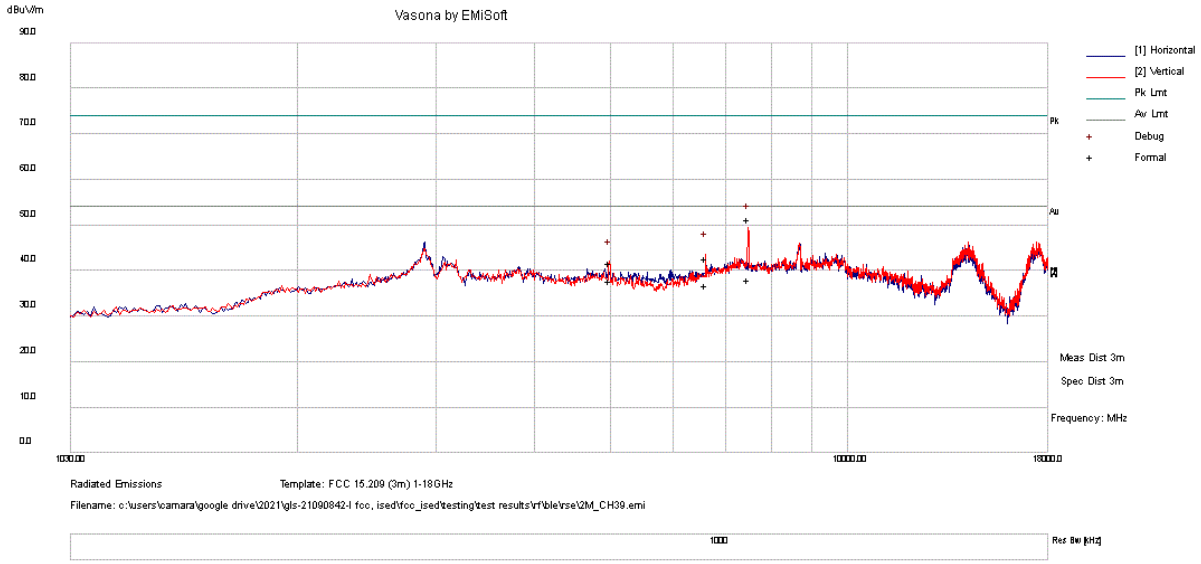
No.	Frequency MHz	Raw dBuV	Cable Loss	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	7489.139	45.6	11.9	-5.7	51.8	Peak Max	V	146	96	74	-22.2	Pass
2	8686.273	34.6	17.3	-5.7	46.2	Peak Max	H	101	156	74	-27.8	Pass
3	6506.5	43.4	10.9	-8.2	46.1	Peak Max	V	157	331	74	-27.9	Pass
4	7489.139	32.9	11.9	-5.7	39.1	Average Max	V	146	96	54	-14.9	Pass
5	8686.273	22.5	17.3	-5.7	34.1	Average Max	H	101	156	54	-19.9	Pass
6	6506.5	37.8	10.9	-8.2	40.6	Average Max	V	157	331	54	-13.4	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:	05/16/2022
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	7477.828	45.2	11.9	-5.7	51.4	Peak Max	V	111	88	74	-22.6	Pass
2	6607.437	36.9	11.2	-7.6	43.2	Peak Max	V	358	246	74	-30.8	Pass
3	4989.906	39.5	9.1	-6.9	42.7	Peak Max	V	100	46	74	-31.3	Pass
4	7477.828	25.5	11.9	-5.7	38.1	Average Max	V	111	88	54	-15.9	Pass
5	6607.437	24.5	11.2	-7.6	37.2	Average Max	V	358	246	54	-16.8	Pass
6	4989.906	25.8	9.1	-6.9	38.5	Average Max	V	100	46	54	-15.5	Pass

Remarks:

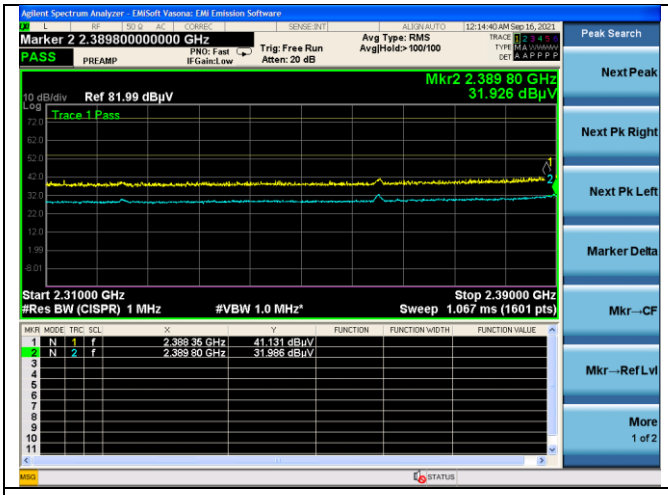
1. Level (dBuV) = Raw (dBuV) + Cable loss(dB) + AF (dB).
2. AF(dB/m) = Antenna Factor (dB) – Preamplifier Gain (dB)
3. Margin = Level (dBuV/m) - Limit value(dBuV/m)

Radiated Emission between 18GHz – 40GHz test result

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

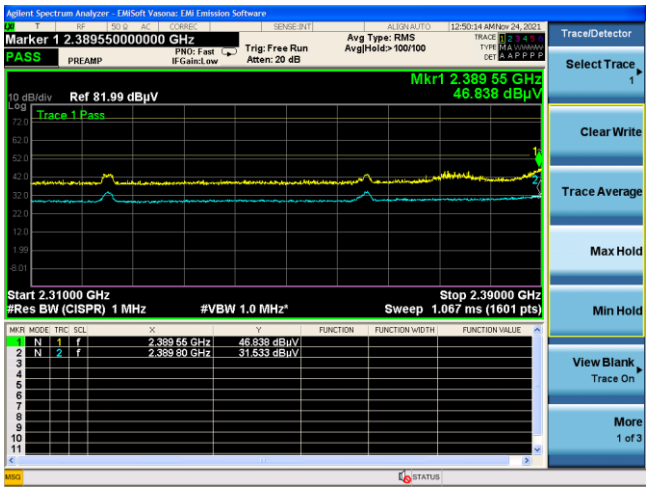
Restricted Band Measurement Result

Mode	TX CH (MHz)	Frequency (MHz)	Emission Level (dBuV/m)	Detector Type	Limit (dBuV/m)	Margin (dB)	Result
BLE_1M	2402	2390	41.13	PK	74	-32.87	Pass
		2390	31.99	AV	54	-22.01	Pass
	2480	2483.5	51.76	PK	74	-22.24	Pass
		2483.5	38.03	AV	54	-15.97	Pass
BLE_2M	2402	2390	46.84	PK	74	-27.16	Pass
		2390	31.53	AV	54	-22.47	Pass
	2480	2483.5	56.28	PK	74	-17.72	Pass
		2483.5	40.35	AV	54	-13.65	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

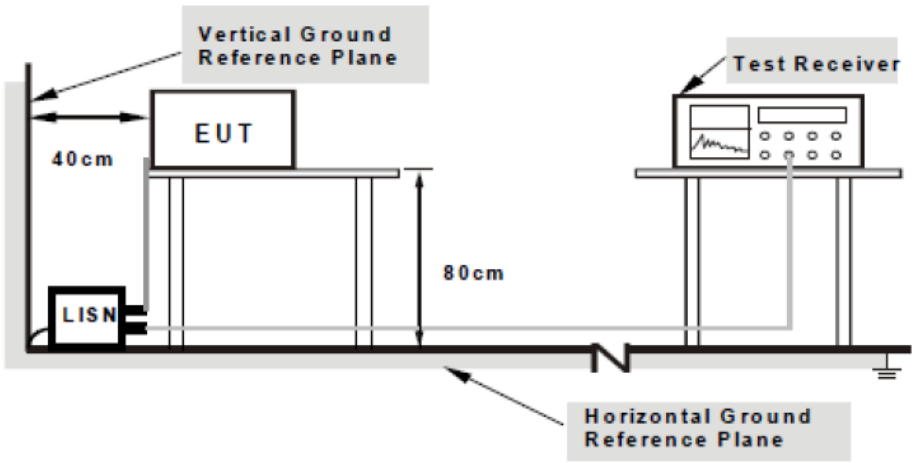
Per § 15.207 (a), RSS Gen 8.8

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



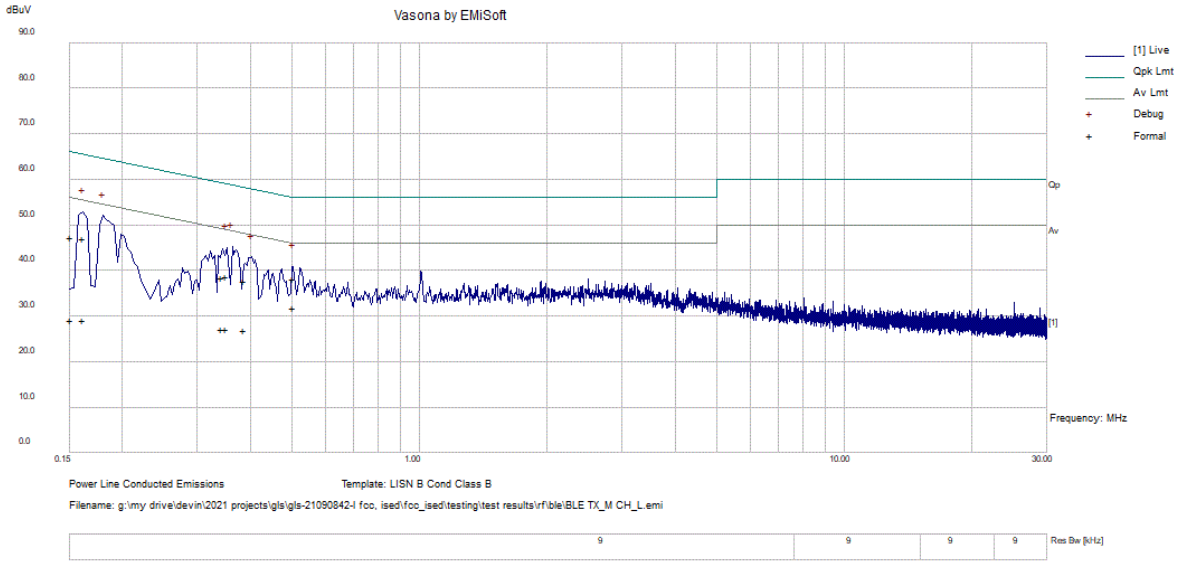
Note: 1.Support units were connected to second LISN.
2.Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

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:	12/06/2021
Antenna Type/Polarity:	N/A	Test Personnel:	Devin Tai
Remark:	Line 120VAC, 60Hz	Test Result:	Pass

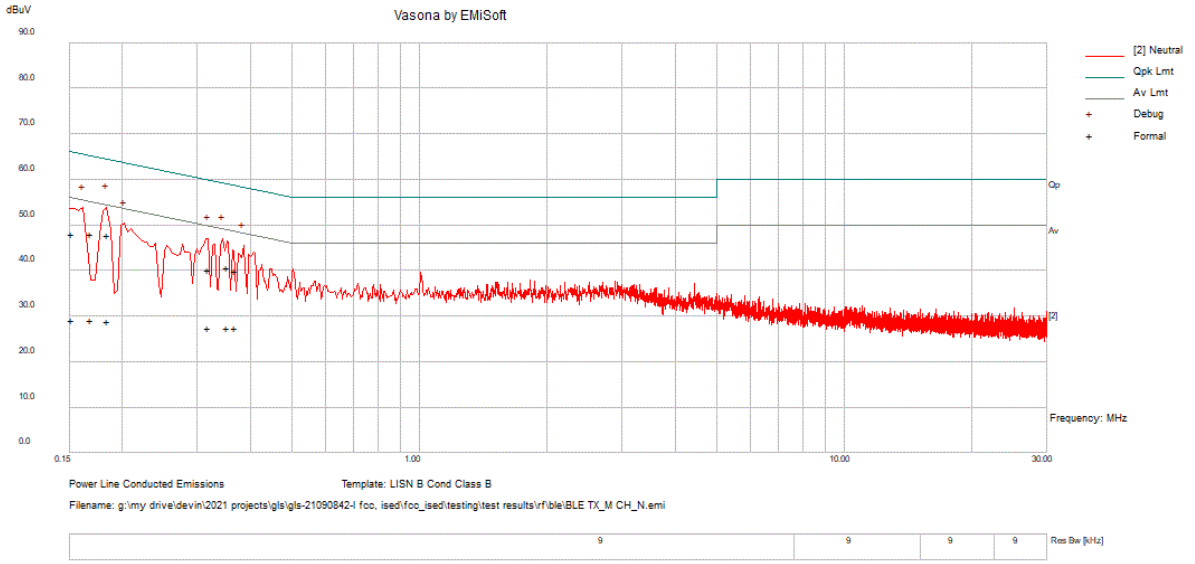


No.	Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Meas. Type	Line	Limit (dBuV)	Margin (dB)	Pass /Fail
1	0.162	36.9	10.1	0.2	47.2	Quasi Peak	Live	65.4	-18.2	Pass
2	0.151	37.2	10.1	0.2	47.5	Quasi Peak	Live	65.9	-18.5	Pass
3	0.351	28.5	10.1	0.1	38.7	Quasi Peak	Live	58.9	-20.3	Pass
4	0.342	28.3	10.1	0.1	38.6	Quasi Peak	Live	59.2	-20.6	Pass
5	0.387	27.6	10.1	0.1	37.8	Quasi Peak	Live	58.1	-20.3	Pass
6	0.506	28.1	10.1	0.1	38.3	Quasi Peak	Live	56	-17.7	Pass
7	0.162	18.9	10.1	0.2	29.2	Average	Live	55.4	-26.2	Pass
8	0.151	18.8	10.1	0.2	29.1	Average	Live	55.9	-26.8	Pass
9	0.351	17	10.1	0.1	27.2	Average	Live	48.9	-21.7	Pass
10	0.342	16.9	10.1	0.1	27.1	Average	Live	49.2	-22	Pass
11	0.387	16.8	10.1	0.1	27	Average	Live	48.1	-21.1	Pass
12	0.506	21.6	10.1	0.1	31.8	Average	Live	46	-14.2	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	0.169	37.9	10.1	0.2	48.2	Quasi Peak	Neutral	65	-16.8	Pass
2	0.152	37.9	10.1	0.2	48.2	Quasi Peak	Neutral	65.9	-17.7	Pass
3	0.353	30.4	10.1	0.1	40.6	Quasi Peak	Neutral	58.9	-18.2	Pass
4	0.318	30.1	10.1	0.1	40.3	Quasi Peak	Neutral	59.8	-19.4	Pass
5	0.369	29.8	10.1	0.1	40	Quasi Peak	Neutral	58.5	-18.5	Pass
6	0.185	37.5	10.1	0.2	47.8	Quasi Peak	Neutral	64.3	-16.5	Pass
7	0.169	19	10.1	0.2	29.3	Average	Neutral	55	-25.7	Pass
8	0.152	19	10.1	0.2	29.3	Average	Neutral	55.9	-26.6	Pass
9	0.353	17.2	10.1	0.1	27.4	Average	Neutral	48.9	-21.5	Pass
10	0.318	17.4	10.1	0.1	27.6	Average	Neutral	49.8	-22.2	Pass
11	0.369	17.2	10.1	0.1	27.4	Average	Neutral	48.5	-21.1	Pass
12	0.185	18.8	10.1	0.2	29.1	Average	Neutral	54.3	-25.2	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	10/18/20	10/18/22
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	05/16/21	05/16/22
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
RF Power Amplifier (80-1000MHz)	Ophir	5226FE	1013/1815	N/A	N/A
RF Power Amplifier (700-6000MHz)	Ophir	5293FE	1063/1815	N/A	N/A
Horn Antenna (1-18GHz)	FT-RF	HA-07M18G-NF	180010HA	N/A	N/A

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