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FCC RF Test Report

Test Report Number	SUB-24041751-C-FCC-DTS-BLE
FCC ID	2AS4H-BLINC3
Applicant	Subeca, Inc.
Applicant Address	4514 Cole Avenue Suite 600, Dallas, TX 75205
Product Name	Subeca BLINC S2
Model (s)	BLINC S2
Date of Receipt	06/11/2024
Date of Test	06/15/2024- 08/08/2024
Report Issue Date	08/16/2024
Test Standards	47 CFR Part 15.247
Test Result	**PASS**

Issued by:

Vista Compliance Laboratories
1261 Puerta Del Sol, San Clemente, CA 92673 USA
www.vista-compliance.com

Minoush Niknam (Test Engineer)

David Zhang (Technical Manager)

REVISION HISTORY

Report Number	Version	Description	Issued Date
SUB-24041751-C-FCC-DTS-BLE	01	Initial report	08/16/2024

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1 Test Summary

Test Item	Test Requirement	Test Method	Result
Antenna Requirement	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
AC Power Line Conducted Emissions	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Occupied Bandwidth	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
DTS (6 dB) Channel Bandwidth	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Conducted Maximum Output Power	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Power Spectral Density	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Conducted Band-Edge & Unwanted Emissions	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Radiated Emissions & Unwanted Emissions into Restricted Frequency Bands	47 CFR Part 15.247	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass

2 General Information

2.1 Applicant

Applicant	Subeca, Inc.
Applicant address	4514 Cole Avenue Suite 600, Dallas, TX 75205
Manufacturer	Subeca, Inc.
Manufacturer Address	4514 Cole Avenue Suite 600, Dallas, TX 75205

2.2 Product information

Product Name	Subeca BLINC S2
Product Description	Subeca BLINC S2
Model Number	BLINC S2
Family Models	N/A
Serial Number	N/A
Frequency Band	BLE: 2402-2480MHz
Type of modulation	GFSK
Equipment Class	DTS
Antenna Information	P/N: Molex 1461530100 (BLE Balance Flex antenna), peak gain: 3 dBi P/N: Abracon AMCA31-2R450G-S1F-T3 (BLE Chip Antenna), Peak gain: 2.3 dBi
Clock Frequencies	N/A
Input Power	DC 3.6V
Power Adapter Manufacturer/Model	N/A
Power Adapter SN	N/A
Hardware version	N/A
Software version	N/A
Simultaneous Transmission	BLE and 900MHz can transmit simultaneously
Additional Info	EUT supports BLE and 900 MHz LoRA/Sidewalk procotols. The 900MHz LoRA is under DSS equpment class as hopping device; the 900MHz Sidewalk is under DTS equipment class as digital modulation device. EUT is soldered onto a devleopment board for testing purpose.

2.3 Test standard and method

Test standard	47 CFR Part 15.247
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	23.5°C	55.1%	996 mbar
Radiated Emission Testing	23.5°C	55.1%	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
STM32CubeMonitor-RF	Set BLE into DTM mode and RF test mode

5.2 Supporting Equipment

Description	Manufacturer	Model #	Serial #
Development board	Subeca	PROP PLUG	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 two types of antennas connection: one is using on board unique u.FL connector, for connecting to a external BLE balance flex antenna (peak gain: 3 dBi); one is a on board chip antenna (2.3 dBi), which is soldered to the mainboard and considered permantely attached.

Conclusion:

- EUT complies with antenna requirement in § 15.203.

7.2 Conducted Emissions

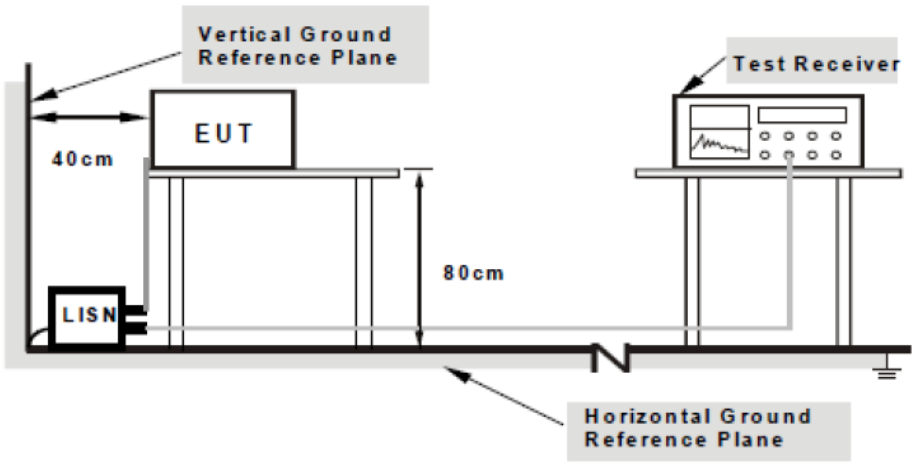
7.2.1 Requirement

Per § 15.207 (a), 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.			

7.2.2 Test setup



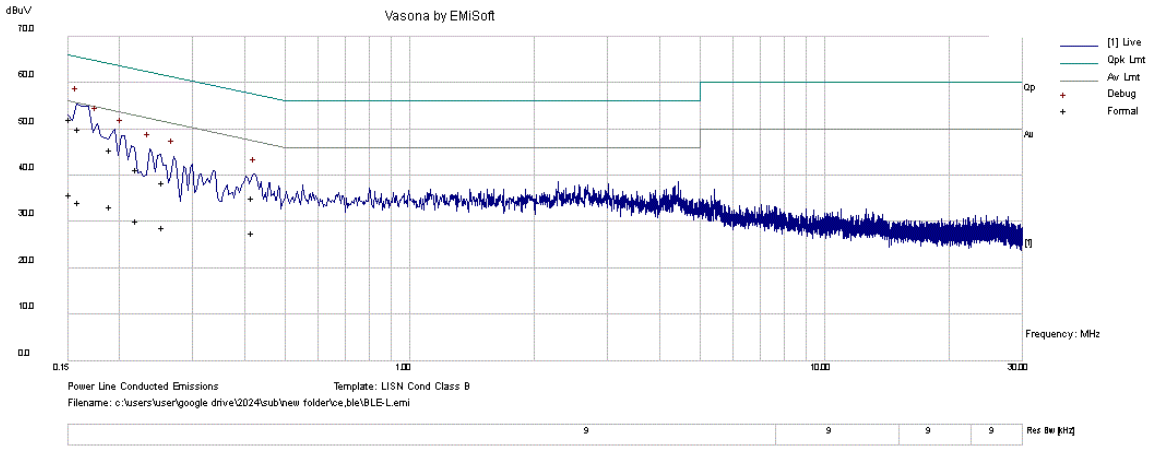
Note: 1.Support units were connected to second LISN.
2.Both of LISNs (AMN) are 80cm from EUT and at least 80cm from other units and other metal planes support units.

7.2.3 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.

7.2.4 Test Result

Test Standard:	Part 15.207	Mode:	TX, Live
Frequency Range:	0.15-30MHz	Test Date:	08/08/2024
Antenna Type/Polarity:	N/A	Test Personnel:	Minoush Niknam
Remark:	Class B, 120VAC, 60Hz	Test Result:	Pass

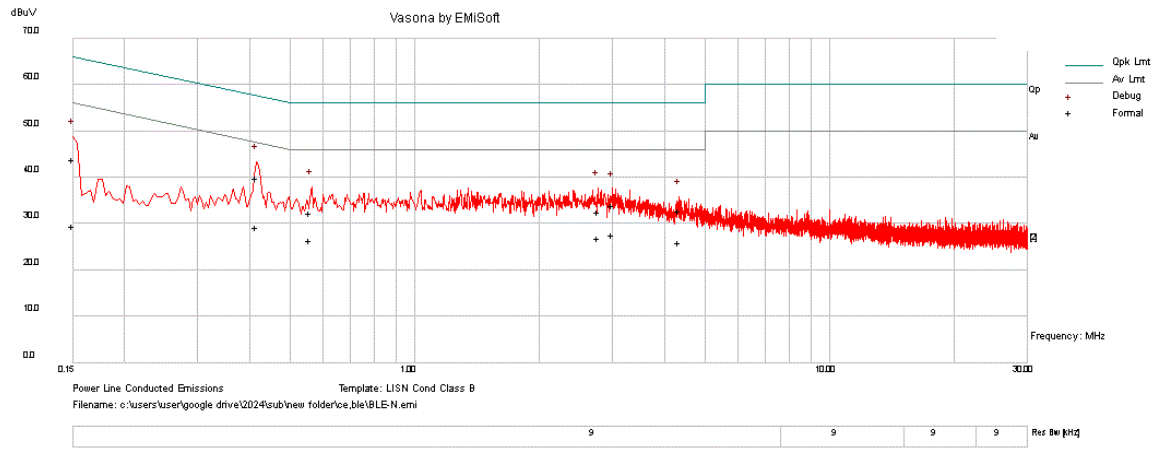


No.	Frequency (MHz)	Raw (dBuV)	Cable Loss (dB)	Factors (dB)	Level (dBuV)	Meas. Type	Line	Limit (dBuV)	Margin (dB)	Pass /Fail
1	0.152	41.8	10	0.2	52.0	Quasi Peak	Live	65.9	13.9	Pass
2	0.159	39.7	10	0.2	49.9	Quasi Peak	Live	65.5	15.6	Pass
3	0.190	35.4	10	0.2	45.6	Quasi Peak	Live	64.0	18.4	Pass
4	0.221	31.2	10	0.2	41.4	Quasi Peak	Live	62.8	21.4	Pass
5	0.254	28.4	10	0.2	38.6	Quasi Peak	Live	61.6	23.0	Pass
6	0.418	25.0	10	0.1	35.1	Quasi Peak	Live	57.5	22.4	Pass
7	0.152	25.7	10	0.2	35.9	Average	Live	55.9	20.0	Pass
8	0.159	23.9	10	0.2	34.1	Average	Live	55.5	21.4	Pass
9	0.190	23.2	10	0.2	33.4	Average	Live	54.0	20.6	Pass
10	0.221	20.2	10	0.2	30.4	Average	Live	52.8	22.4	Pass
11	0.254	18.7	10	0.2	28.9	Average	Live	51.6	22.7	Pass
12	0.418	17.6	10	0.1	27.7	Average	Live	47.5	19.8	Pass

REMARKS:

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

Test Standard:	Part 15.207	Mode:	TX, Neutral
Frequency Range:	0.15-30MHz	Test Date:	08/08/2024
Antenna Type/Polarity:	N/A	Test Personnel:	Minoush Niknam
Remark:	Class B, 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	0.415	29.7	10	0.1	39.8	Quasi Peak	Neutral	57.5	17.7	Pass
2	0.15	33.6	10	0.2	43.8	Quasi Peak	Neutral	66	22.2	Pass
3	0.559	22.3	10	0.1	32.4	Quasi Peak	Neutral	56	23.6	Pass
4	2.771	22.4	10.1	0.1	32.6	Quasi Peak	Neutral	56	23.4	Pass
5	2.993	23.8	10.1	0.1	34	Quasi Peak	Neutral	56	22	Pass
6	4.331	22.6	10.1	0.1	32.8	Quasi Peak	Neutral	56	23.2	Pass
7	0.415	19.1	10	0.1	29.2	Average	Neutral	47.5	18.3	Pass
8	0.15	19.3	10	0.2	29.5	Average	Neutral	56	26.5	Pass
9	0.559	16.4	10	0.1	26.5	Average	Neutral	46	19.5	Pass
10	2.771	16.7	10.1	0.1	26.9	Average	Neutral	46	19.1	Pass
11	2.993	17.5	10.1	0.1	27.7	Average	Neutral	46	18.3	Pass
12	4.331	15.9	10.1	0.1	26.1	Average	Neutral	46	19.9	Pass

REMARKS:

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

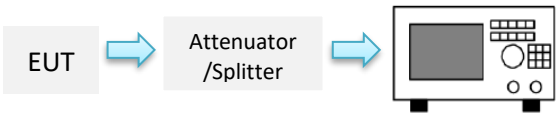
7.3 DTS (6 dB) Bandwidth

7.3.1 Requirement

§ 15.247 (a)(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.

7.3.2 Test Setup



7.3.3 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:

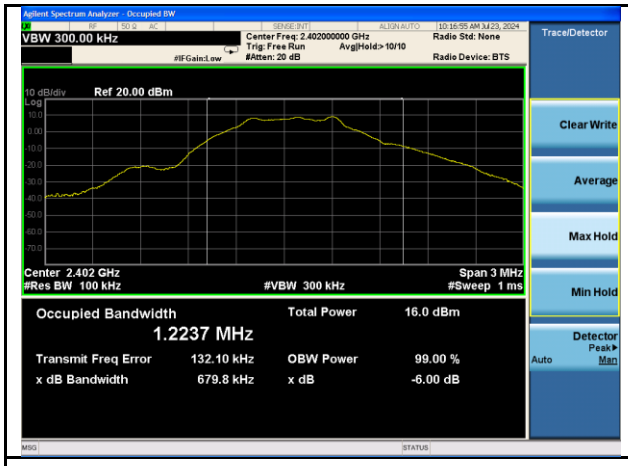
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this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

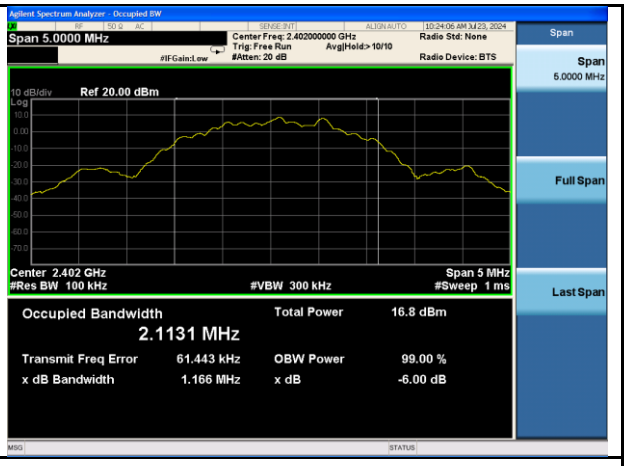
7.3.4 Test Result

Mode/ Bandwidth	Frequency (MHz)	Data rate	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
BLE	2402	1Mbps	679.8	500	Pass
	2440		678.3	500	Pass
	2480		683.4	500	Pass
	2402	2Mbps	1166	500	Pass
	2440		1166	500	Pass
	2480		1162	500	Pass

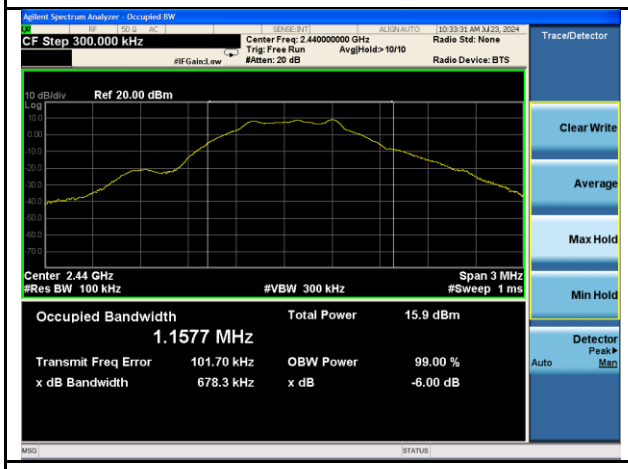
7.3.5 Test Plots



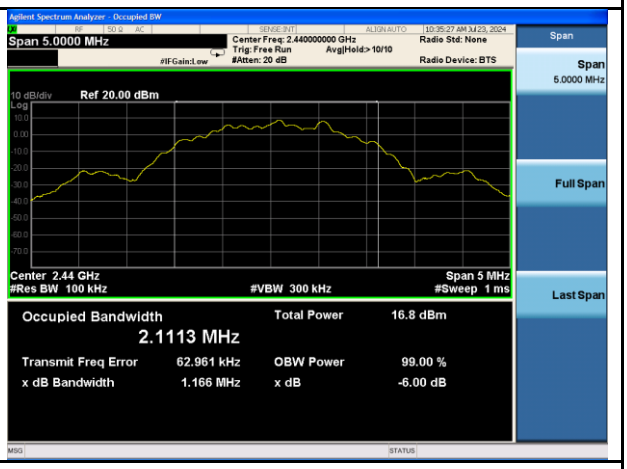
DTS BW-Low-1Mbps



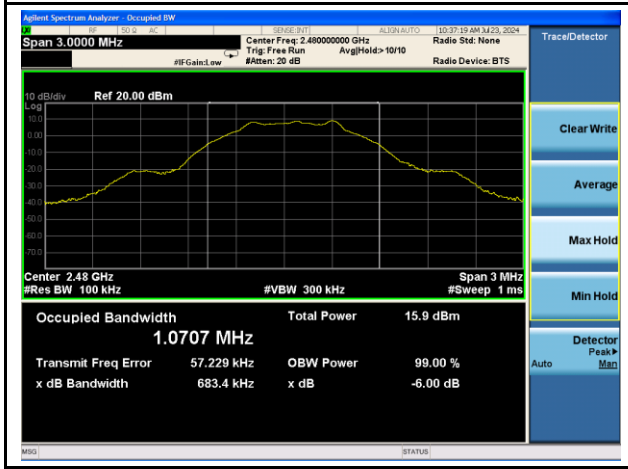
DTS BW-Low-2Mbps



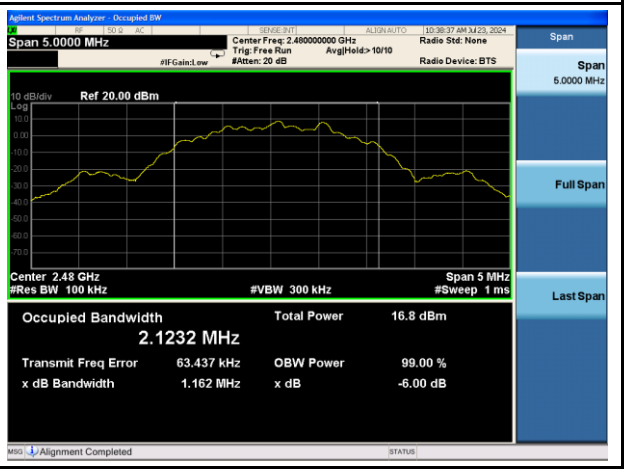
DTS BW-Mid-1Mbps



DTS BW-Mid-2Mbps



DTS BW-High-1Mbps



DTS BW-High-2Mbps

7.4 Maximum Output Power

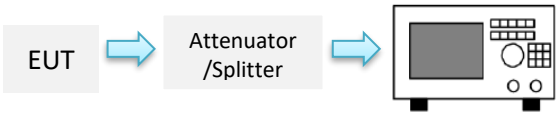
7.4.1 Requirement

§ 15.247 (b)(3),

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

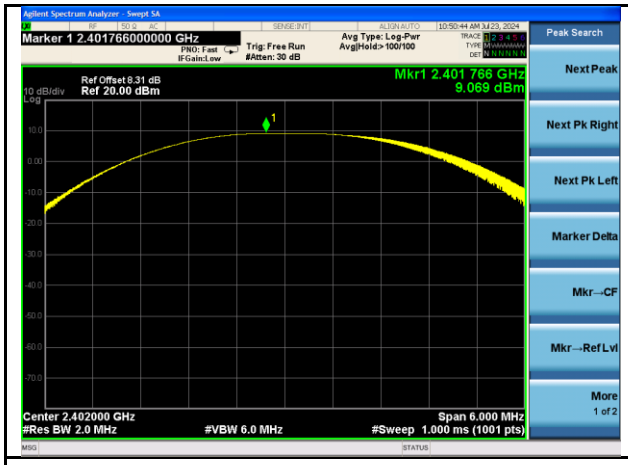
For BLE, power measurement is according to subclause 11.9.1.1 of ANSI C63.10-2013:

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.

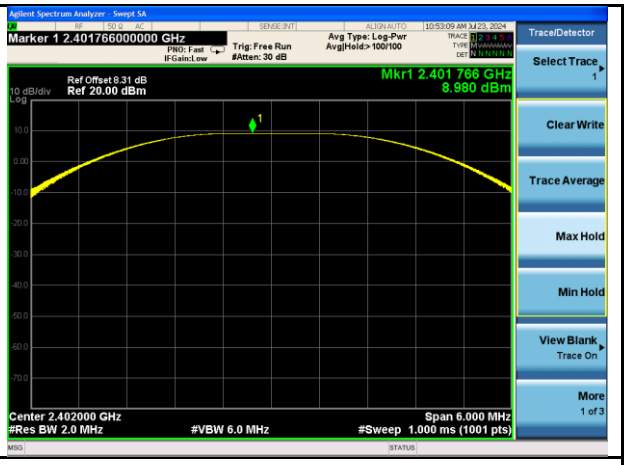
7.4.4 Test Result

Mode/ Bandwidth	Frequency (MHz)	Data rate	Measured Output Power (dBm)	Max Output Power (dBm)	Result
BLE	2402	1Mbps	9.069	30	Pass
	2440		9.131	30	Pass
	2480		8.948	30	Pass
	2402	2Mbps	8.980	30	Pass
	2440		9.103	30	Pass
	2480		9.073	30	Pass

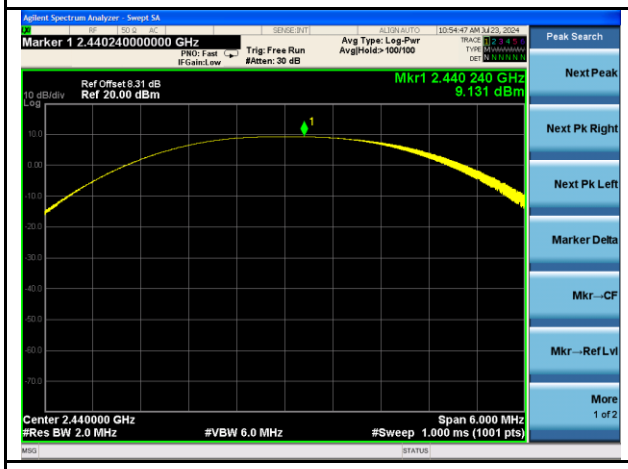
7.4.5 Test Plots



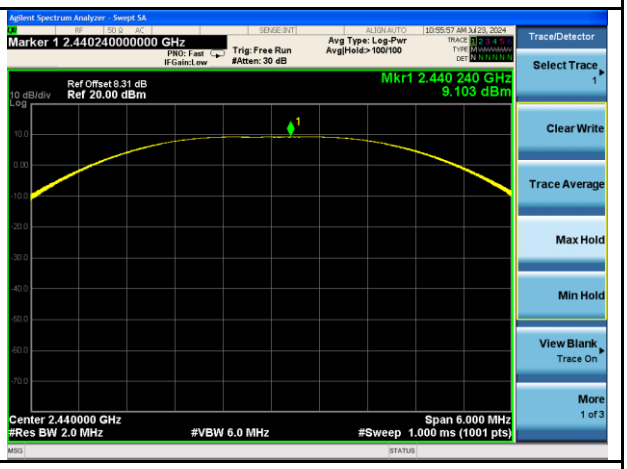
Power-Low-1Mbps



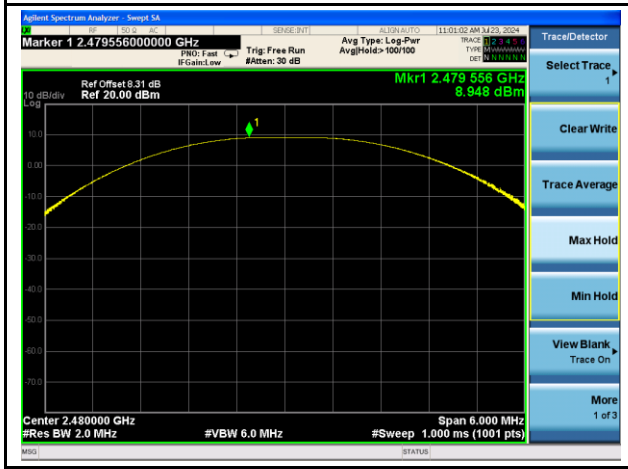
Power-Low-2Mbps



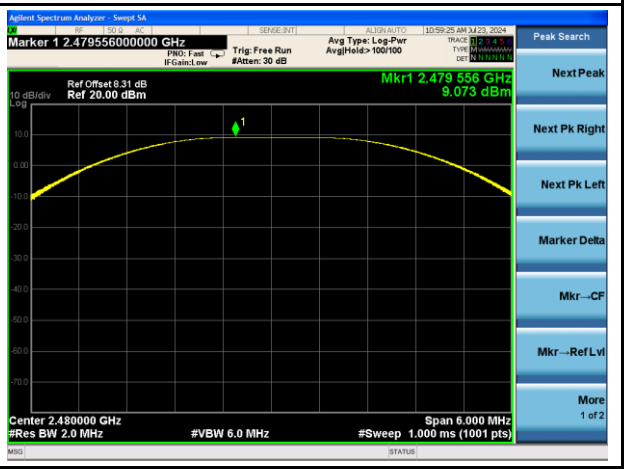
Power-Mid-1Mbps



Power-Mid-2Mbps



Power-High-1Mbps



Power-High-2Mbps

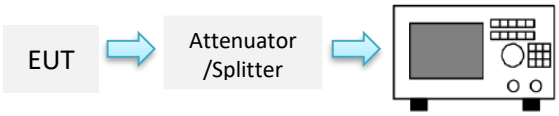
7.5 Power Spectral Density

7.5.1 Requirement

§ 15.247 (e),

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/ Bandwidth	Frequency (MHz)	Data rate	Measured PSD (dBm/3KHz)	Max PSD (dBm/3KHz)	Result
BLE	2402	1Mbps	-7.063	8	Pass
	2440		-6.874	8	Pass
	2480		-6.964	8	Pass
	2402	2Mbps	-9.168	8	Pass
	2440		-9.230	8	Pass
	2480		-9.379	8	Pass

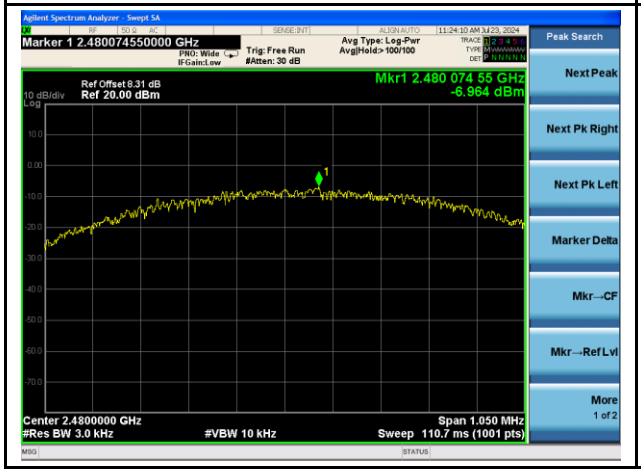
7.5.5 Test Plots

PSD-Low-1Mbps

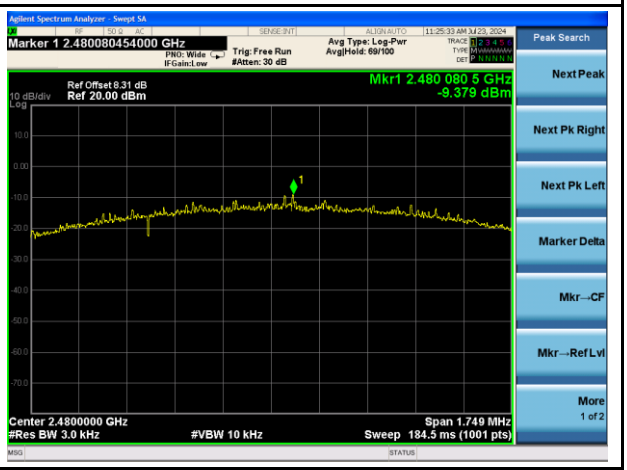
PSD-Low-2Mbps

PSD-Mid-1Mbps

PSD-Mid-2Mbps



PSD-Hig-1Mbps



PSD-High-2Mbps

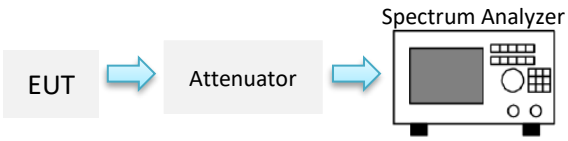
7.6 Conducted Band-Edge & Unwanted Emissions

7.6.1 Requirement

§ 15.247 (d),

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



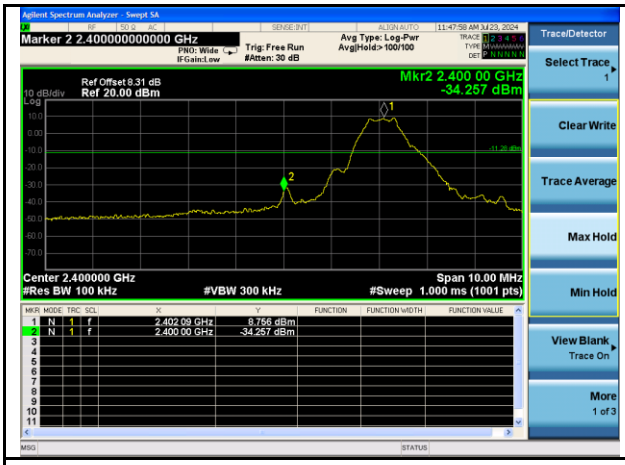
7.6.3 Test Procedure

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



Band Edge-Low CH-1Mbps

Band Edge -High CH -1Mbps

Band Edge-Low CH-2Mbps

Band Edge -High CH -2Mbps

Conducted Spurious emission

CSE-Low-REF-1Mbps

CSE-Low-1Mbps

CSE-Mid-REF-1Mbps

CSE-Mid-1Mbps

CSE-High-REF-1Mbps

CSE-High-1Mbps

CSE-Low-REF-2Mbps

CSE-Low-2Mbps

CSE-Mid-REF-2Mbps

CSE-Mid-2Mbps

CSE-High-REF-2Mbps

CSE-High-2Mbps

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

7.7.1 Requirement

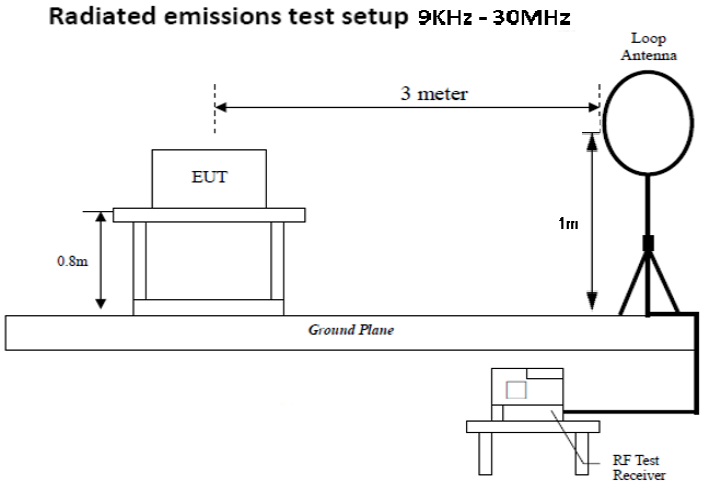
§ 15.247 (d), RSS-247 §5.5

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.

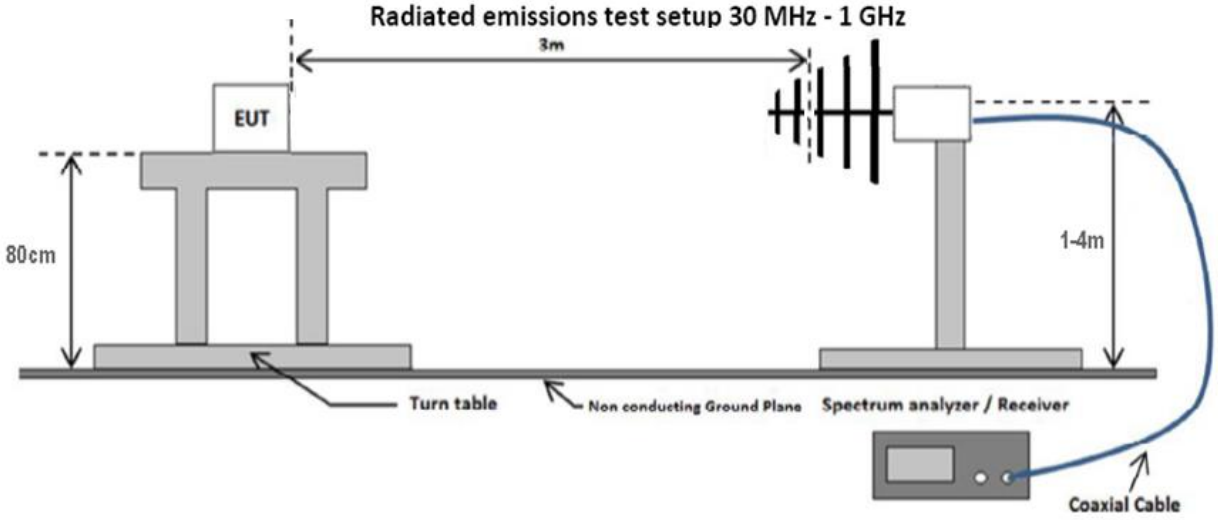
Attenuation below the general limits specified in §15.209(a) and RSS-Gen is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

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

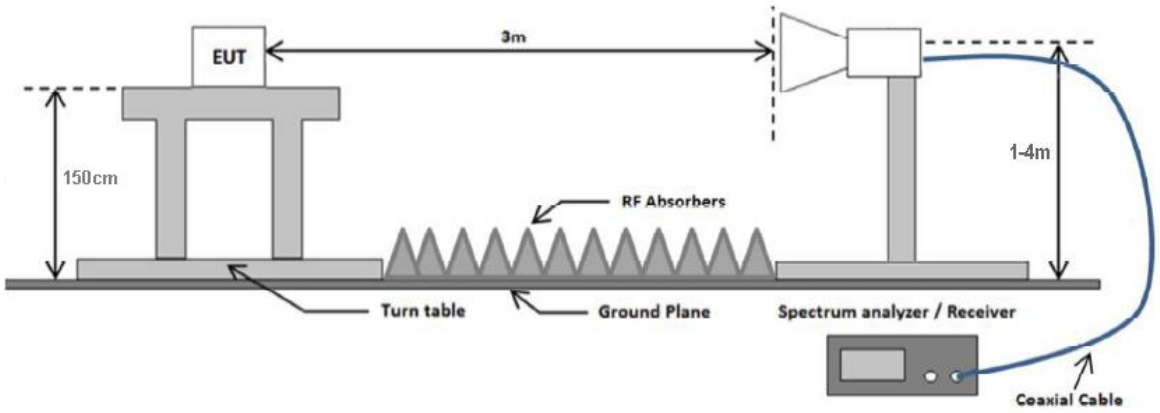
7.7.2 Test Setup



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 C62.10-2013 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.

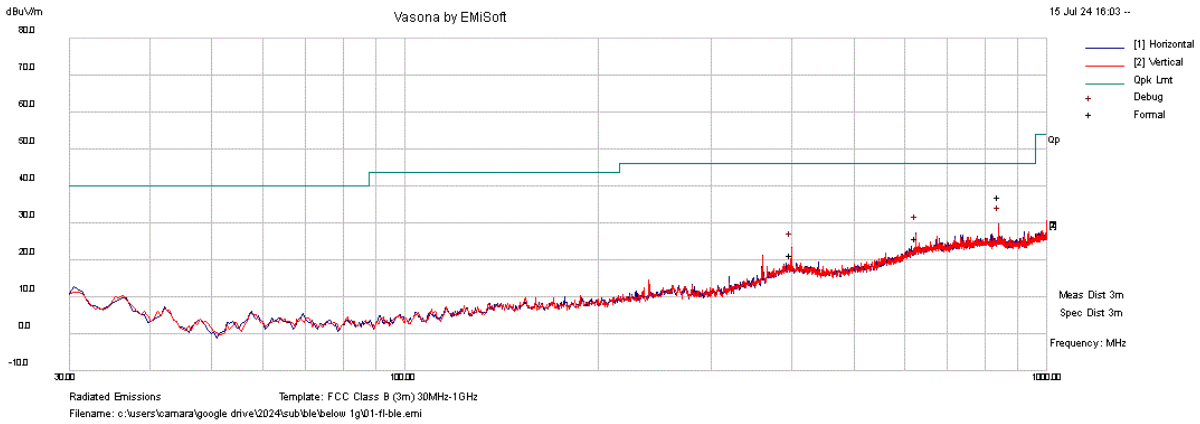
7.7.4 Test Result

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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	30 MHz - 1 GHz	Test Date:	06/15/2024
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE + External Antenna	Test Result:	Pass



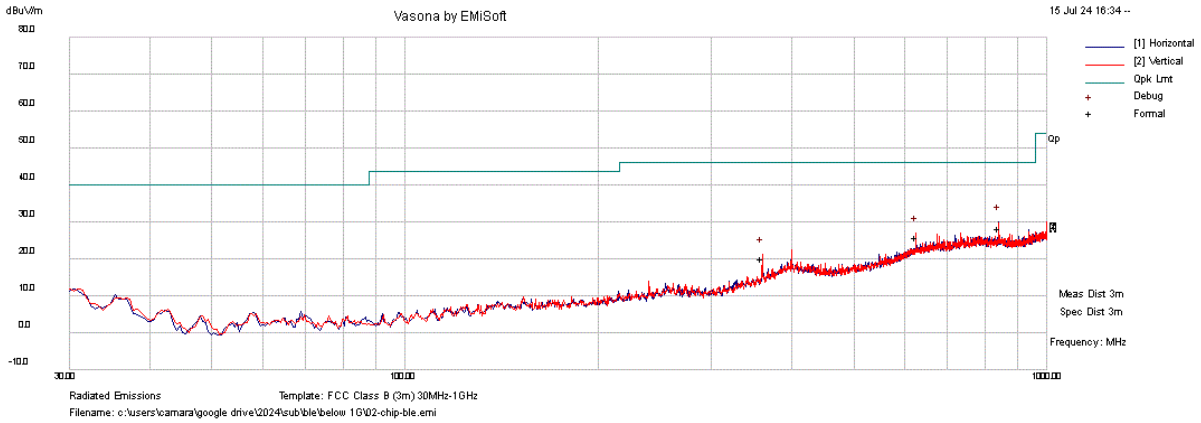
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	840.011	29.2	7.4	0.6	37.2	Quasi Max	H	351	70	46	-8.8	Pass
2	625.081	20.6	7.2	-2	25.8	Quasi Max	H	144	28	46	-20.2	Pass
3	399.722	22.5	6.4	-7.5	21.4	Quasi Max	V	214	277	46	-24.6	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	30 MHz - 1 GHz	Test Date:	06/15/2024
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE + Chip antenna	Test Result:	Pass



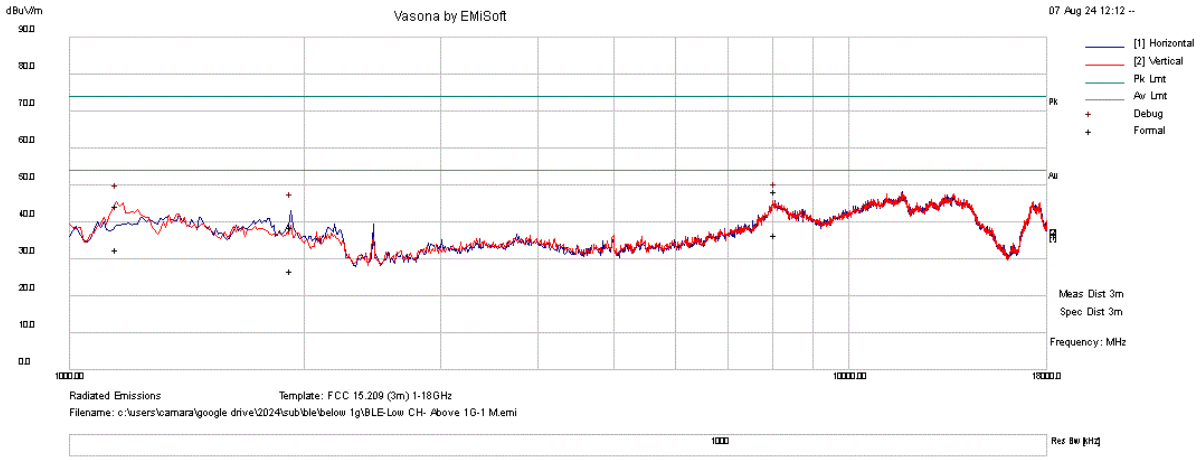
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	840.006	20.2	7.4	0.6	28.2	Quasi Max	H	381	102	46	-17.8	Pass
2	625.052	20.8	7.2	-2	26	Quasi Max	V	143	207	46	-20	Pass
3	359.741	23.8	6.1	-9.8	20.1	Quasi Max	V	173	0	46	-25.9	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2023
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Low Ch- 1Mbps-Ex Antenna	Test Result:	Pass



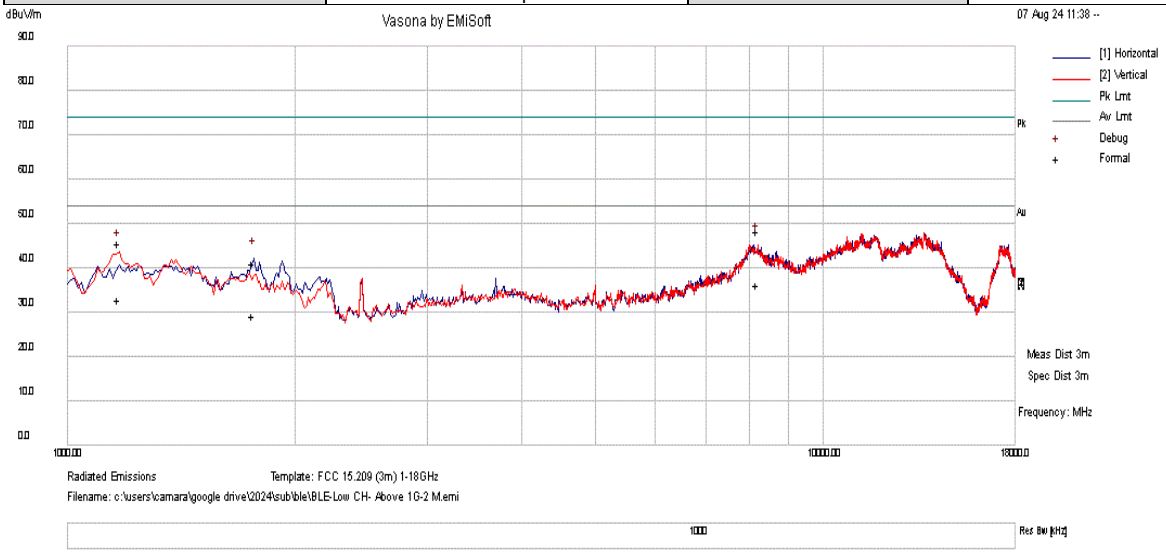
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8055.273	18.18	14.24	15.81	48.24	Peak Max	H	190	72	74.00	-25.76	Pass
2	1149.650	41.48	4.49	-1.56	44.41	Peak Max	V	199	70	74.00	-29.60	Pass
3	1925.728	31.90	6.26	0.31	38.47	Peak Max	H	135	152	74.00	-35.53	Pass
4	8055.273	6.48	14.24	15.81	36.54	Average Max	H	190	72	54.00	-17.46	Pass
5	1149.650	29.70	4.49	-1.56	32.63	Average Max	V	199	70	54.00	-21.37	Pass
6	1925.728	20.22	6.26	0.31	26.79	Average Max	H	135	152	54.00	-27.21	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2023
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Low Ch- 2Mbps-Ex Antenna	Test Result:	Pass



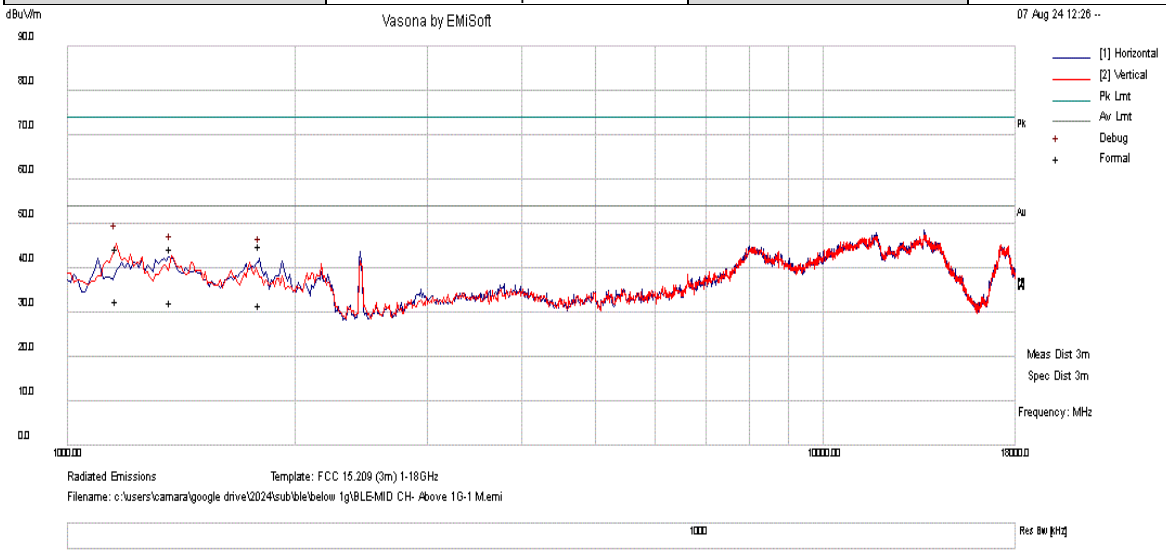
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8204.453	18.38	14.18	15.60	48.16	Peak Max	V	180	52	74.00	-25.84	Pass
2	1169.023	42.44	4.55	-1.41	45.58	Peak Max	V	194	21	74.00	-28.42	Pass
3	1763.354	35.86	6.00	-0.80	41.06	Peak Max	H	117	146	74.00	-32.94	Pass
4	8204.453	6.42	14.18	15.60	36.20	Average Max	V	180	52	54.00	-17.80	Pass
5	1169.023	29.60	4.55	-1.41	32.74	Average Max	V	194	21	54.00	-21.27	Pass
6	1763.345	24.11	6.00	-0.80	29.31	Average Max	H	117	146	54.00	-24.69	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Mid Ch- 1Mbps-Ex Antenna	Test Result:	Pass



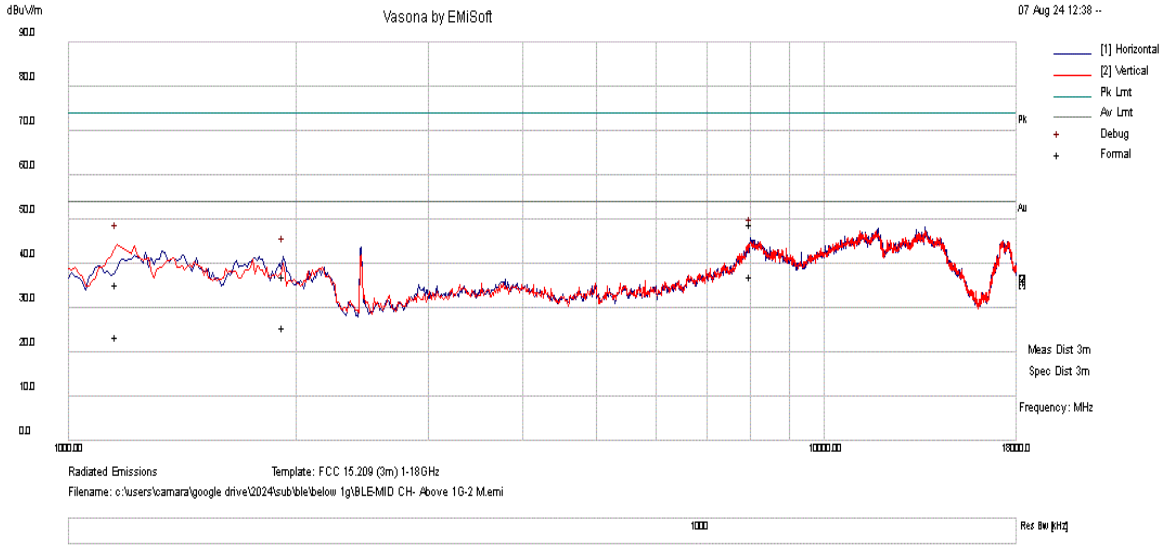
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	1161.275	41.22	4.52	-1.47	44.27	Peak Max	V	195	73	74.00	-29.73	Pass
2	1370.340	40.74	5.01	-1.29	44.46	Peak Max	V	103	0	74.00	-29.54	Pass
3	1795.285	39.19	6.05	-0.36	44.88	Peak Max	H	103	137	74.00	-29.12	Pass
4	1161.275	29.47	4.52	-1.47	32.53	Average Max	V	195	73	54.00	-21.48	Pass
5	1370.340	28.58	5.01	-1.29	32.30	Average Max	V	103	0	54.00	-21.70	Pass
6	1795.285	26.01	6.05	-0.36	31.71	Average Max	H	103	137	54.00	-22.30	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Mid Ch- 2Mbps-Ex Antenna	Test Result:	Pass



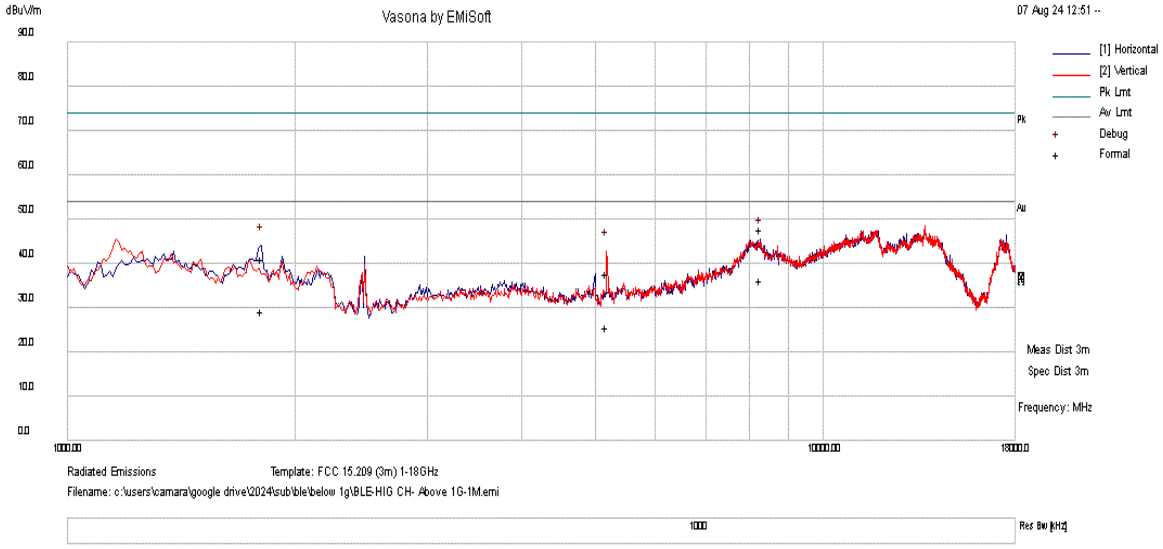
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8001.780	18.71	14.27	15.86	48.84	Peak Max	H	174	0	74.00	-25.16	Pass
2	1157.560	32.21	4.51	-1.50	35.22	Peak Max	V	100	73	74.00	-38.78	Pass
3	1923.916	30.50	6.25	0.32	37.07	Peak Max	H	141	41	74.00	-36.93	Pass
4	8001.780	6.90	14.27	15.86	37.03	Average Max	H	174	0	54.00	-16.97	Pass
5	1157.560	20.52	4.51	-1.50	23.53	Average Max	V	100	73	54.00	-30.47	Pass
6	1923.916	18.86	6.25	0.32	25.43	Average Max	H	141	41	54.00	-28.57	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE High Ch- 1Mbps-Ex Anttena	Test Result:	Pass



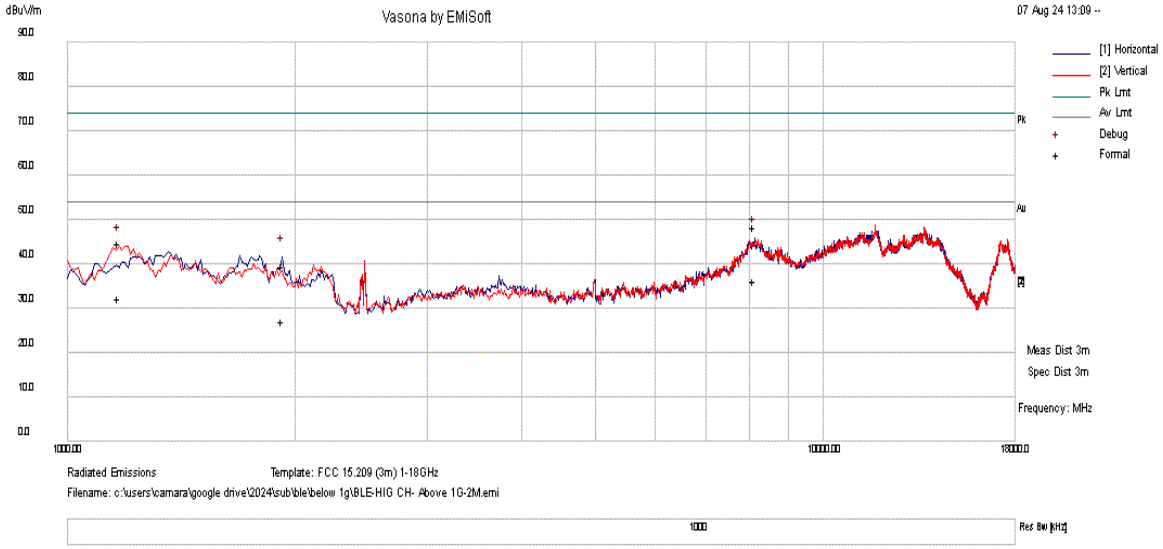
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8277.188	18.26	14.16	15.35	47.77	Peak Max	H	138	180	74.00	-26.23	Pass
2	1807.280	35.08	6.07	-0.19	40.96	Peak Max	H	125	28	74.00	-33.04	Pass
3	5174.315	21.80	9.87	5.98	37.65	Peak Max	V	107	0	74.00	-36.35	Pass
4	8277.188	6.52	14.16	15.35	36.03	Average Max	H	138	180	54.00	-17.97	Pass
5	1807.280	23.27	6.07	-0.19	29.15	Average Max	H	125	28	54.00	-24.85	Pass
6	5174.315	9.77	9.87	5.98	25.62	Average Max	V	107	0	54.00	-28.38	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE High Ch- 2Mbps-Ex Antenna	Test Result:	Pass



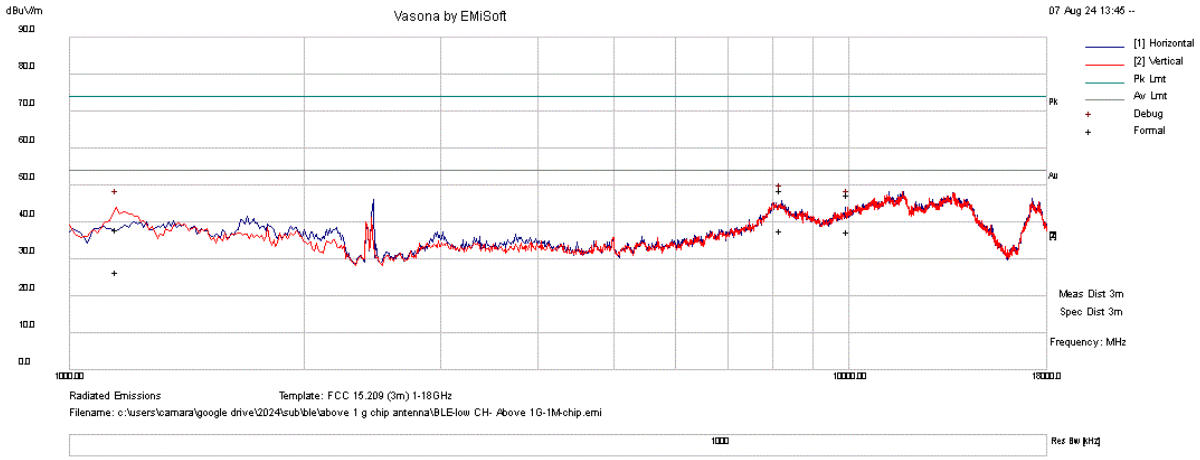
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8116.965	18.33	14.22	15.69	48.24	Peak Max	H	122	106	74.00	-25.77	Pass
2	1168.290	41.38	4.54	-1.41	44.51	Peak Max	V	198	76	74.00	-29.49	Pass
3	1924.945	32.88	6.26	0.31	39.45	Peak Max	H	206	180	74.00	-34.55	Pass
4	8116.965	6.27	14.22	15.69	36.18	Average Max	H	122	106	54.00	-17.82	Pass
5	1168.290	29.18	4.54	-1.41	32.31	Average Max	V	198	76	54.00	-21.69	Pass
6	1924.945	20.44	6.26	0.31	27.01	Average Max	H	206	180	54.00	-26.99	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2023
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Low Ch- 1Mbps-Chip Antenna	Test Result:	Pass



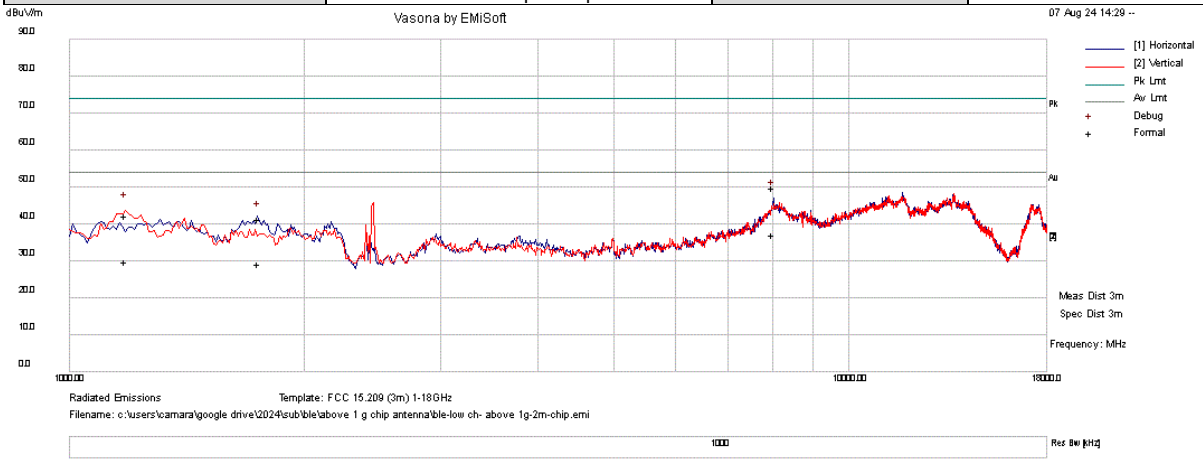
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8203.540	18.8	14.2	15.6	48.6	Peak Max	H	155	140	74	-25.4	Pass
2	1150.040	35.1	4.5	-1.6	38	Peak Max	V	158	75	74	-36	Pass
3	9979.135	18.1	16.7	12.7	47.4	Peak Max	H	145	140	74	-26.6	Pass
4	8203.540	8	14.2	15.6	37.8	Average Max	H	155	140	54	-16.2	Pass
5	1150.040	23.6	4.5	-1.6	26.5	Average Max	V	158	75	54	-27.5	Pass
6	9979.135	8.1	16.7	12.7	37.4	Average Max	H	145	140	54	-16.6	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2023
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Low Ch- 2Mbps-Chip antenna	Test Result:	Pass



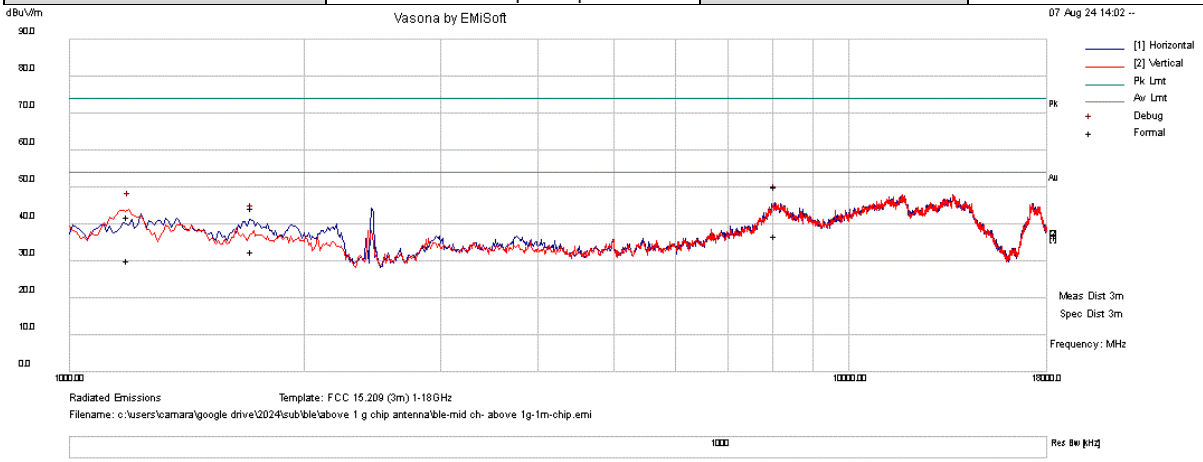
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8012.940	19.6	14.3	15.9	49.7	Peak Max	H	194	125	74	-24.3	Pass
2	1180.858	38.9	4.6	-1.3	42.2	Peak Max	V	156	57	74	-31.8	Pass
3	1748.260	36.3	6	-1	41.2	Peak Max	H	132	163	74	-32.8	Pass
4	8012.940	6.9	14.3	15.9	37.1	Average Max	H	194	125	54	-16.9	Pass
5	1180.858	26.7	4.6	-1.3	29.9	Average Max	V	156	57	54	-24.1	Pass
6	1748.260	24.2	6	-1	29.2	Average Max	H	132	163	54	-24.8	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Mid Ch- 1Mbps-Chip Antenna	Test Result:	Pass



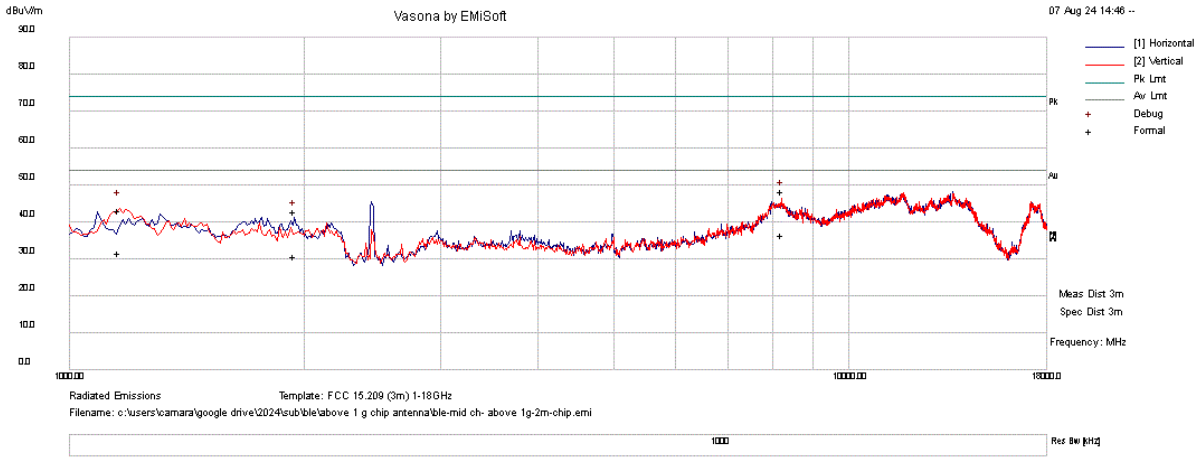
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8055.610	20	14.2	15.8	50	Peak Max	H	152	153	74	-24	Pass
2	1189.920	38.7	4.6	-1.2	42.1	Peak Max	V	195	311	74	-31.9	Pass
3	1715.570	40	5.9	-1.4	44.5	Peak Max	H	138	141	74	-29.5	Pass
4	8055.610	6.6	14.2	15.8	36.7	Average Max	H	152	153	54	-17.3	Pass
5	1189.920	26.8	4.6	-1.2	30.2	Average Max	V	195	311	54	-23.8	Pass
6	1715.570	27.9	5.9	-1.4	32.5	Average Max	H	138	141	54	-21.5	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE Mid Ch- 2Mbps-Chip Antenna	Test Result:	Pass



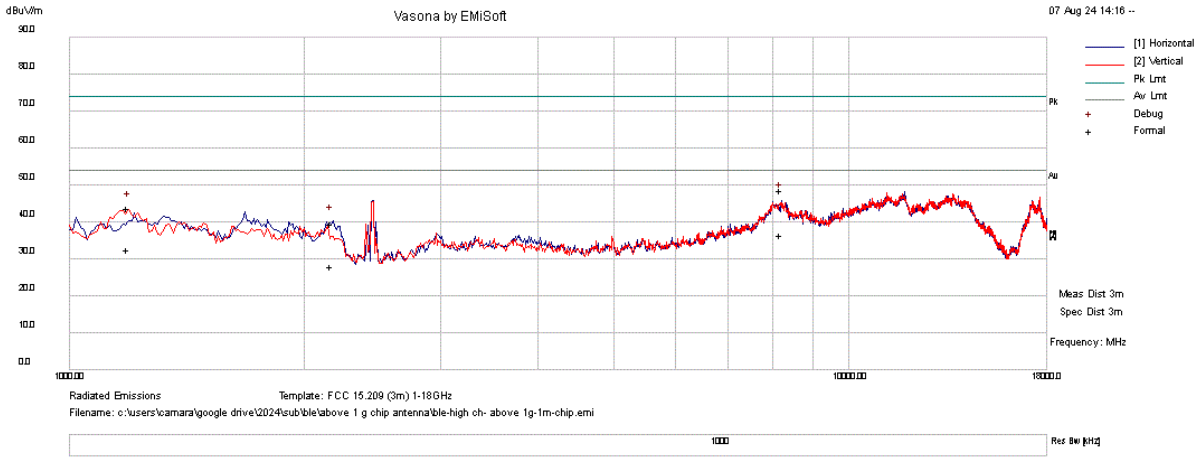
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8223.380	18.4	14.2	15.6	48.2	Peak Max	V	138	132	74	-25.8	Pass
2	1159.703	40.1	4.5	-1.5	43.2	Peak Max	V	197	0	74	-30.8	Pass
3	1943.476	36.2	6.3	0.3	42.8	Peak Max	H	100	180	74	-31.2	Pass
4	8223.380	6.7	14.2	15.6	36.5	Average Max	V	138	132	54	-17.5	Pass
5	1159.703	28.5	4.5	-1.5	31.5	Average Max	V	197	0	54	-22.5	Pass
6	1943.476	24.1	6.3	0.3	30.7	Average Max	H	100	180	54	-23.3	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE High Ch- 1Mbps-Chip Antenna	Test Result:	Pass



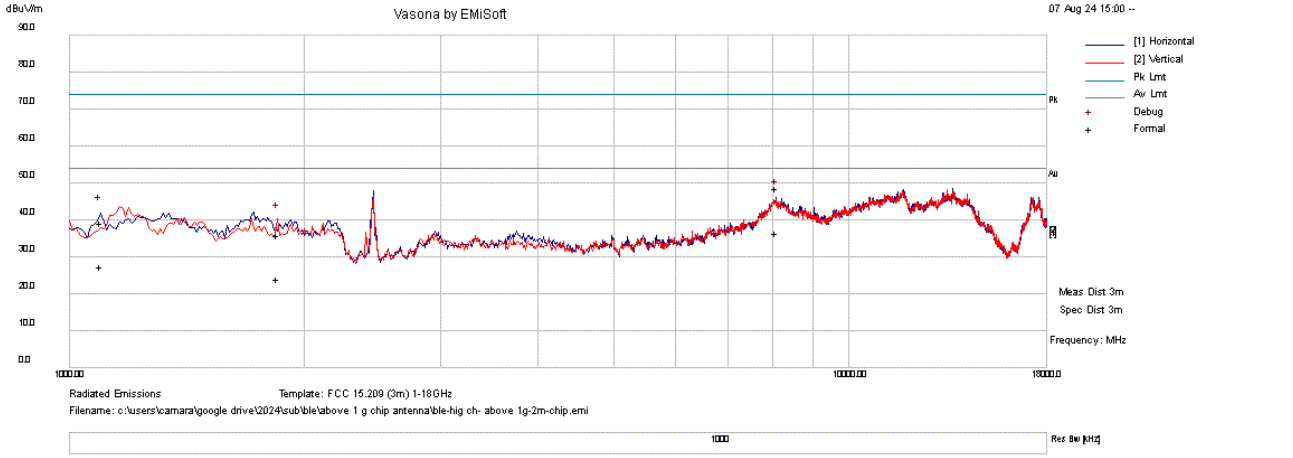
No.	Frequency MHz	Raw dBuV	Cable Loss dB	AF dB/m	Level dBuV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBuV/m	Margin dB	Pass/Fail
1	8204.448	18.9	14.2	15.6	48.7	Peak Max	H	182	180	74	-25.3	Pass
2	1189.305	40.4	4.6	-1.2	43.8	Peak Max	V	198	26	74	-30.2	Pass
3	2172.663	33.1	6.5	0.1	39.6	Peak Max	H	126	29	74	-34.4	Pass
4	8204.448	6.6	14.2	15.6	36.4	Average Max	H	182	180	54	-17.6	Pass
5	1189.305	29.2	4.6	-1.2	32.6	Average Max	V	198	26	54	-21.4	Pass
6	2172.663	21.4	6.5	0.1	28	Average Max	H	126	29	54	-26	Pass

Remarks:

1. Level (dBuV/m) = Raw (dBuV) + Cable loss(dB) + AF (dB/m).
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:	15.247, 15.209	Mode:	BLE Transmit mode
Frequency Range:	1 GHz – 18 GHz	Test Date:	08/07/2024
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Minoush Niknam
Remark:	BLE High Ch- 2Mbps-Chip Antenna	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	8077.493	18.5	14.2	15.8	48.5	Peak Max	H	201	116	74	-25.5	Pass
2	1097.033	36.2	4.3	-1.2	39.3	Peak Max	H	136	146	74	-34.7	Pass
3	1852.045	29.2	6.1	0.4	35.8	Peak Max	V	136	22	74	-38.2	Pass
4	8077.493	6.6	14.2	15.8	36.6	Average Max	H	201	116	54	-17.4	Pass
5	1097.033	24.3	4.3	-1.2	27.4	Average Max	H	136	146	54	-26.6	Pass
6	1852.045	17.4	6.1	0.4	24	Average Max	V	136	22	54	-30	Pass

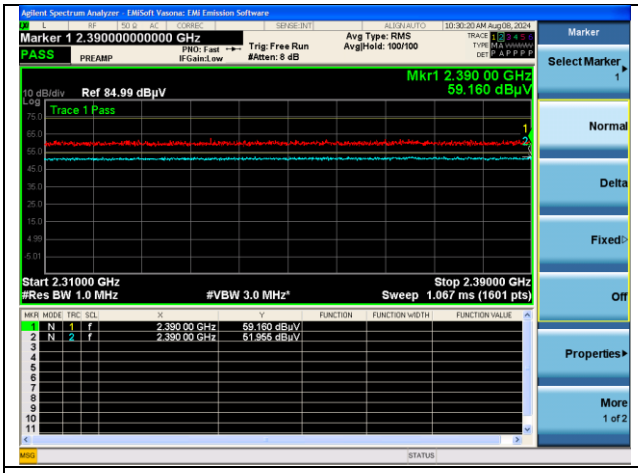
Remarks:

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

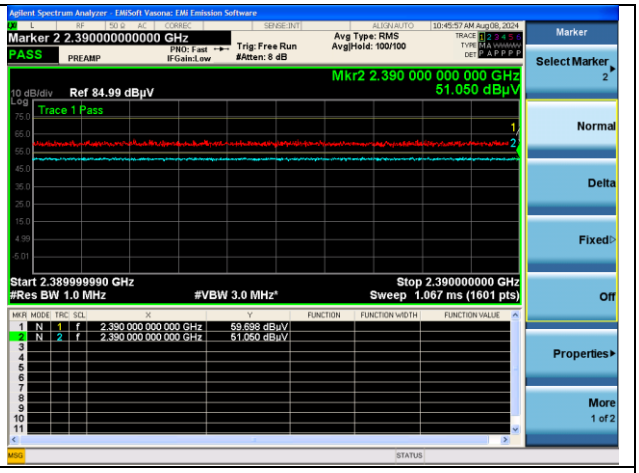
Radiated Emission between 18GHz – 40GHz test result

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

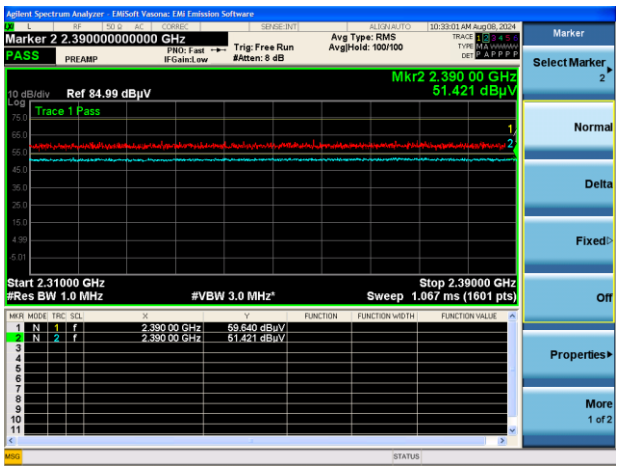
Restricted Band Measurement Result



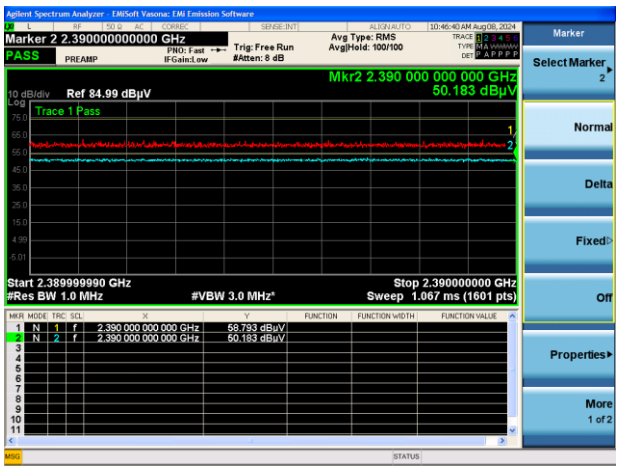
BLE – Low CH-1Mpbs-External antenna



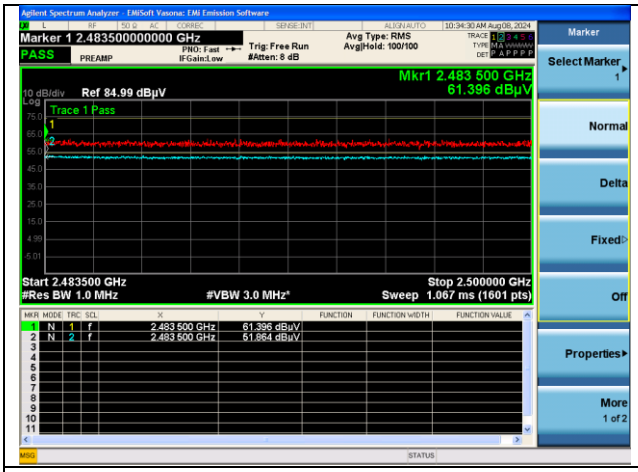
BLE – Low CH-1Mpbs-Chip antenna



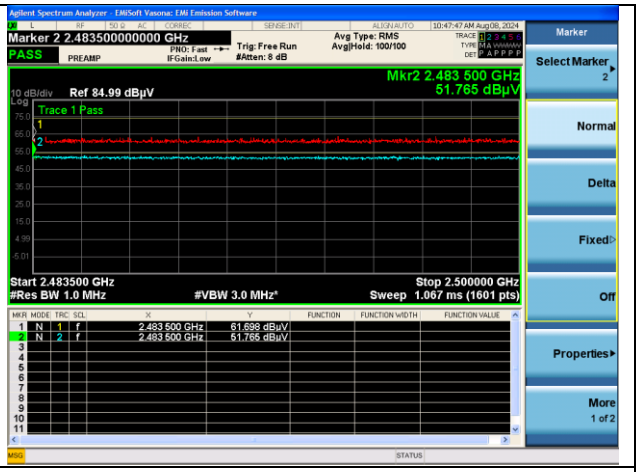
BLE – Low CH-2Mpbs-External antenna



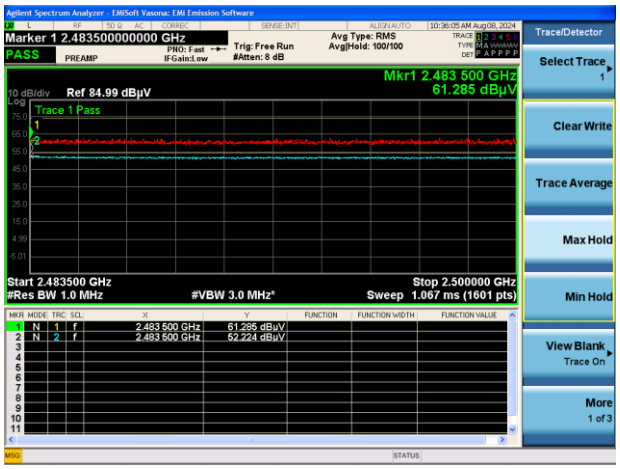
BLE – Low CH-2Mpbs-Chip antenna



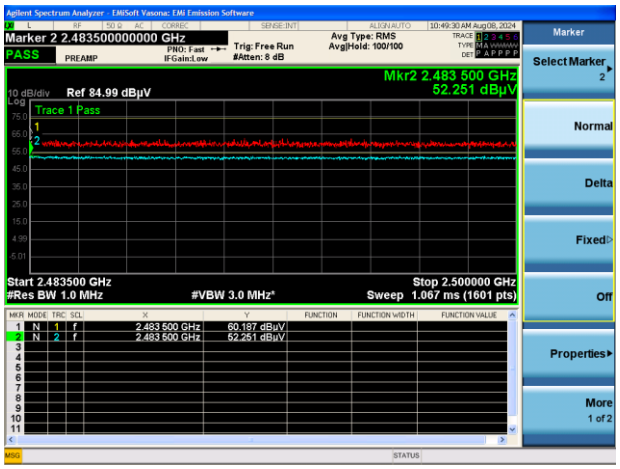
BLE – High CH-1Mpbs-External antenna



BLE – High CH-1Mpbs-Chip antenna



BLE – High CH-2Mpbs-External antenna



BLE – High CH-2Mpbs-Chip antenna

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	10/18/2023	10/18/2024
Shielding Control Room	ETS-Lindgren	Series 81	VL006	N/A1)	N/A1)
Spectrum Analyzer	Keysight	N9020A	MY50110074	06/09/2024	06/09/2025
EMC Test Receiver	R&S	ESL6	100230	06/07/2024	06/07/2025
LISN (9KHz – 30MHz)	EMCO	3816/2	9705-1066	07/12/2024	07/12/2025
Bi-Log Antenna	ETS-Lindgren	3142E	217921	07/19/2024	07/19/2025
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	07/21/2024	07/21/2025
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	07/21/2024	07/21/2025
Preamplifier	RF Bay, Inc.	LPA-10-20	11180621	07/16/2024	07/16/2025
True RMS Multi-meter	UNI-T	UT181A	C173014829	06/07/2024	06/07/2025
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	06/07/2024	06/07/2025
RF Attenuator	Pasternack	PE7005-3	VL061	N/A2)	N/A2)
EM Center Control	ETS-Lindgren	7006-001	160136	N/A1)	N/A1)
Turn Table	ETS-Lindgren	2181-3.03	VL002	N/A1)	N/A1)
Boresight Antenna Tower	ETS-Lindgren	2171B	VL003	N/A1)	N/A1)
Loop Antenna (9k-30MHz)	Com-Power	AL-130	121012	06/09/2024	06/09/2025
RE test cable (below 6GHz)	Vista	RE-6GHz-01	RE-6GHz-01	07/16/2024	07/16/2025
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	07/16/2024	07/16/2025
RE test cable (>18GHz)	Sucoflex	104	344903/4	07/16/2024	07/16/2025
Pulse limiter	Com-Power	LIT-930A	531727	07/16/2024	07/16/2025
CE test cable #1	FIRST RF	FRF-C-1002-001	CE-6GHz-01	07/16/2024	07/16/2025
CE test cable#2	FIRST RF	FRF-C-1002-001	CE-6GHz-02	07/16/2024	07/16/2025

Note:

1) These pieces of equipment are not for measurement purposes and only require functional verification. Calibration is not required.
2) This equipment is part of the test system that is to be calibrated as a system. It's verified together with the test system prior to testing.

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