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FCC IC RF Test Report

Test Report Number	MIP-21051242-LC-FCC-IC-DTS
FCC ID	2A3CM-MIP-1000
Applicant	Millstone Innovative Products, LLC
Applicant Address	2823 Saybrooke Blvd, Stow, OH 44266
Product Name	Wireless Tailgate Sensor
Model (s)	Tailgate Sensor
Date of Receipt	07/01/2021
Date of Test	07/21/2021- 07/22/2021
Report Issue Date	10/12/2021
Test Standards	47 CFR Part 15.247 RSS-247 Issue 2 Feb 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
MIP-21051242-LC-FCC-IC-DTS	01	Initial report	10/12/2021

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1 Test Summary

Test Item	Test Requirement	Test Method	Result
Antenna Requirement	47 CFR Part 15.247 RSS-Gen Issue 5 April 2018	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
AC Power Line Conducted Emissions	47 CFR Part 15.247 RSS-Gen Issue 5 April 2018	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	N/A
Occupied Bandwidth	RSS-247 Issue 2 Feb 2017	RSS-Gen Issue 5 April 2018	Pass
DTS (6 dB) Channel Bandwidth	47 CFR Part 15.247 RSS-247 Issue 2 Feb 2017	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Conducted Maximum Output Power	47 CFR Part 15.247 RSS-247 Issue 2 Feb 2017	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Power Spectral Density	47 CFR Part 15.247 RSS-247 Issue 2 Feb 2017	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass
Conducted out of band emission	47 CFR Part 15.247 RSS-247 Issue 2 Feb 2017	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 RSS-247 Issue 2 Feb 2017	ANSI C63.10-2013 558074 D01 15.247 Meas Guidance v05r02	Pass

Note: This item is not applicable since EUT is only powered by internal battery.

2 General Information

2.1 Applicant

Applicant	Millstone Innovative Products, LLC
Applicant address	2823 Saybrooke Blvd, Stow, OH 44266
Manufacturer	Millstone Innovative Products, LLC
Manufacturer Address	2823 Saybrooke Blvd, Stow, OH 44266

2.2 Product information

Product Name	Wireless Tailgate Sensor
Product Description	Tailgate Sensor
Model Number	Tailgate Sensor
Family Models	N/A
Serial Number	N/A
Frequency Band	BLE: 2402-2480MHz
Type of modulation	GFSK
Data Rate	1Mbps/2Mbps
Equipment Class	DTS
Antenna Information	PCB Trace Antenna peak gain: 0 dBi
Clock Frequencies	N/A
Input Power	DC 3.0V (battery)
Power Adapter Manufacturer/Model	N/A
Power Adapter SN	N/A
Hardware version	N/A
Software version	N/A
Simultaneous Transmission	N/A
Additional Info	EUT works with the BLE receiver (Charging Unit) as a pair and acts as a transmitter (Tailgate Sensor). It transmits BLE radio signal.

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 RSS-Gen Issue 5 April 2018

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

5.2 Supporting Equipment

Description	Manufacturer	Model #	Serial #
-	-	-	-

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 one PCB trace antenna which permanently attached PCB board. No standard RF connector is used.

Conclusion:

- EUT complies with antenna requirement in § 15.203.

7.2 Conducted Emissions

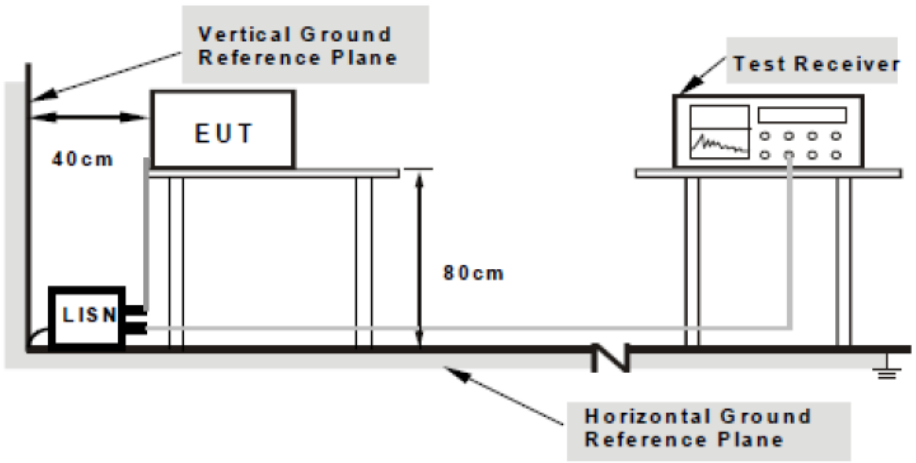
7.2.1 Requirement

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

Note: This item is not applicable since EUT is only powered by internal battery.

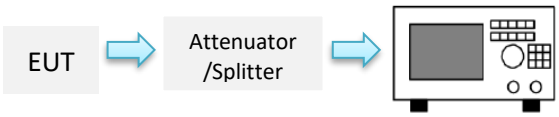
7.3 DTS (6 dB) Bandwidth

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:

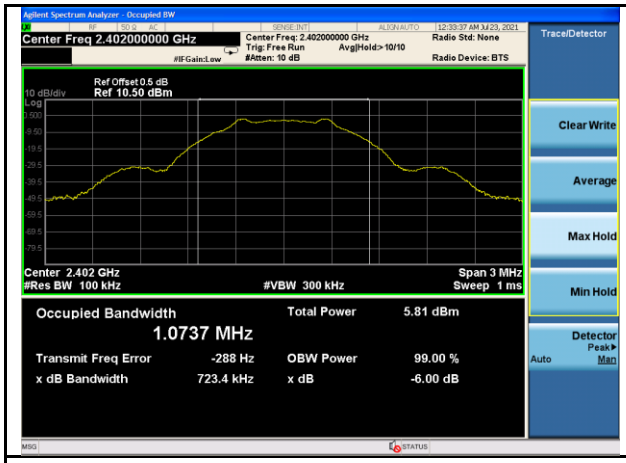
The automatic bandwidth measurement capability of an instrument may be employed using the X dB bandwidth mode with X set to 6 dB, if the functionality described above (i.e., RBW = 100 kHz, VBW ≥ 3 × RBW, peak detector with maximum hold) is implemented by the instrumentation function. When using this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

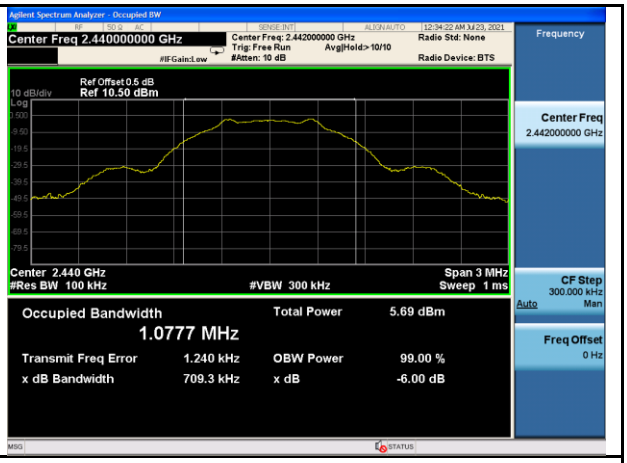
7.3.4 Test Result

Mode/ Bandwidth	Frequency (MHz)	Data rate	Measured Bandwidth (KHz)	Minimum Bandwidth (KHz)	Result
BLE	2402	1Mbps	723.4	500	Pass
BLE	2440	1Mbps	709.3	500	Pass
BLE	2480	1Mbps	718.6	500	Pass
BLE	2402	2Mbps	1332	500	Pass
BLE	2440	2Mbps	1190	500	Pass
BLE	2480	2Mbps	1395	500	Pass

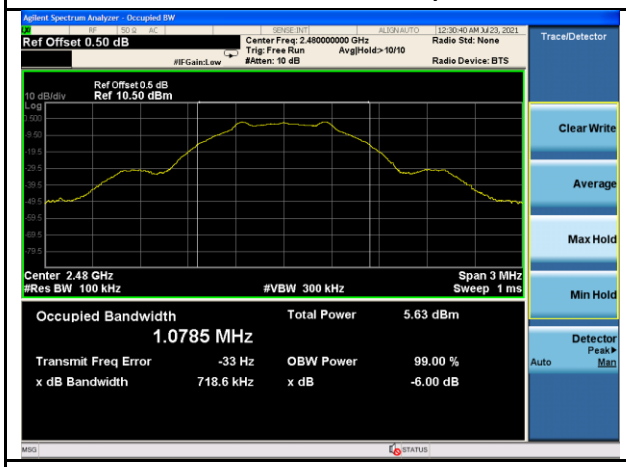
7.3.5 Test Plots



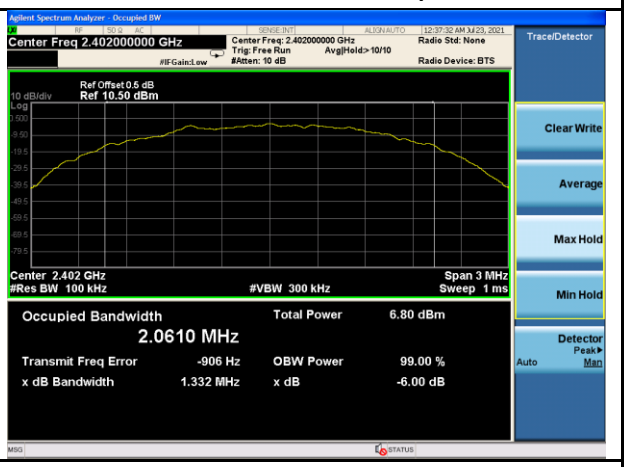
BLE-DTS BW-Low-1Mbps



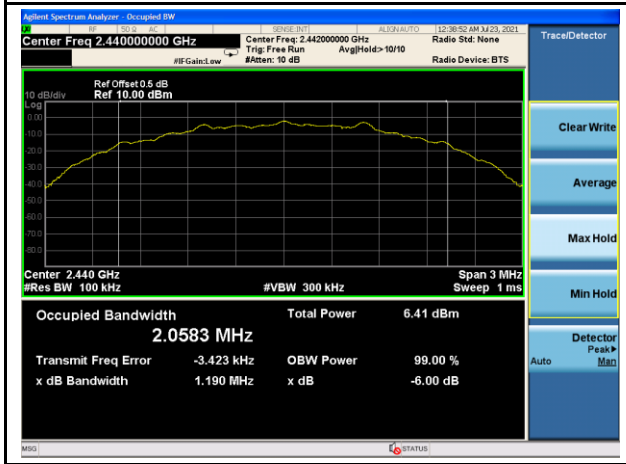
BLE-DTS BW-Mid-1Mbps



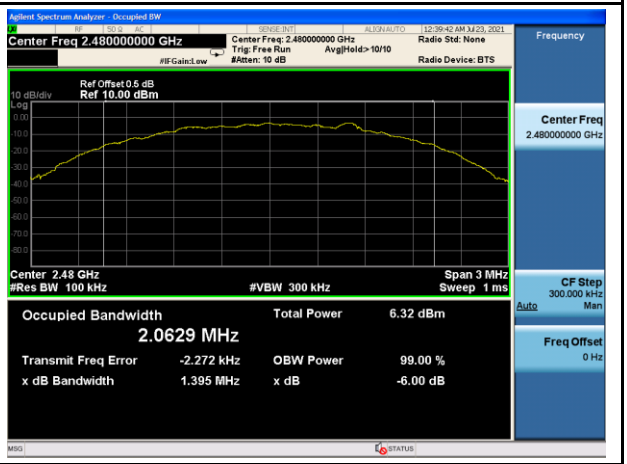
BLE-DTS BW-High-1Mbps



BLE-DTS BW-Low-2Mbps



BLE-DTS BW-Mid-2Mbps



BLE-DTS BW-High-2Mbps

7.4 Maximum Output Power

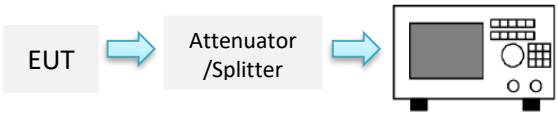
7.4.1 Requirement

§ 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

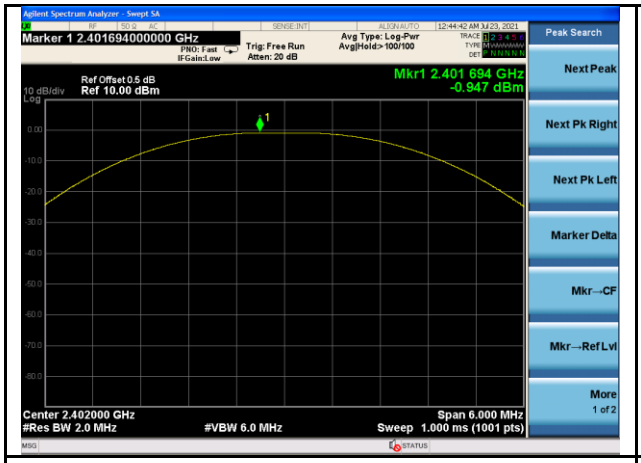
For BLE, power measurement is according to subclause 11.9.1.1 of ANSI C63.10-2013:

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.

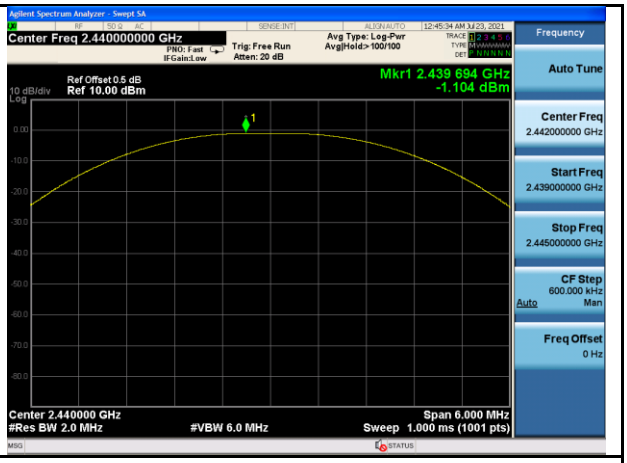
7.4.4 Test Result

Mode/ Bandwidth	Frequency (MHz)	Data rate	Measured Output Power (dBm)	Max Output Power (dBm)	Result
BLE	2402	1Mbps	-0.947	30	Pass
BLE	2440	1Mbps	-1.104	30	Pass
BLE	2480	1Mbps	-1.310	30	Pass
BLE	2402	2Mbps	-0.939	30	Pass
BLE	2440	2Mbps	-1.108	30	Pass
BLE	2480	2Mbps	-1.324	30	Pass

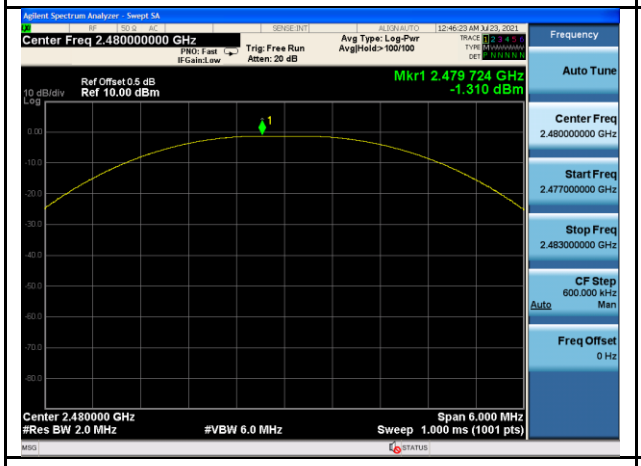
7.4.5 Test Plots



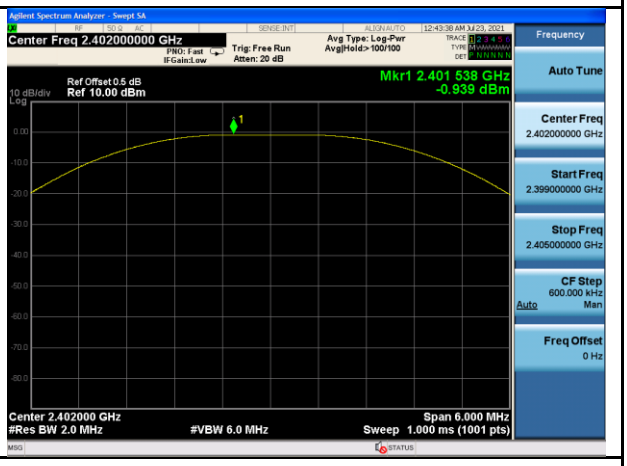
BLE-Power-Low-1Mbps



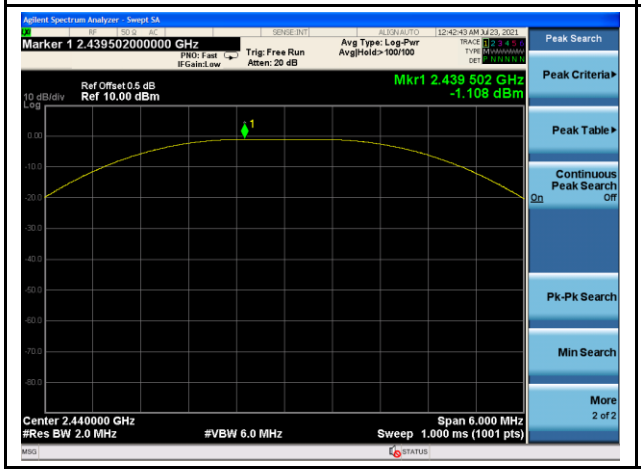
BLE-Power-Mid-1Mbps



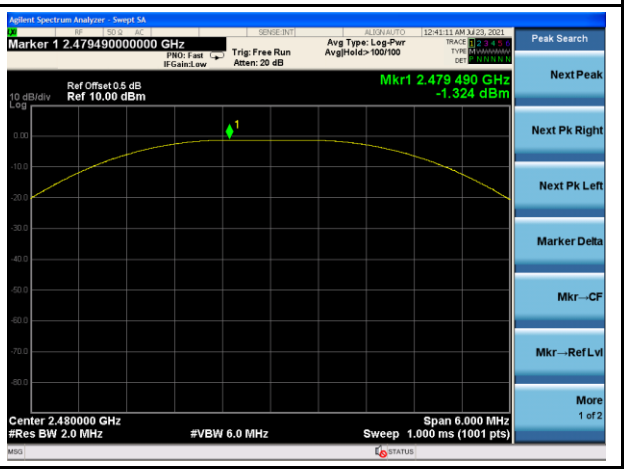
BLE-Power-High-1Mbps



BLE-Power-Low-2Mbps



BLE-Power-Mid-2Mbps



BLE-Power-High-2Mbps

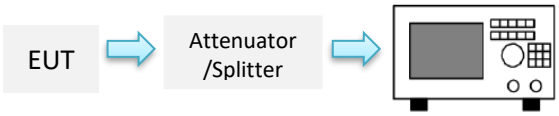
7.5 Power Spectral Density

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

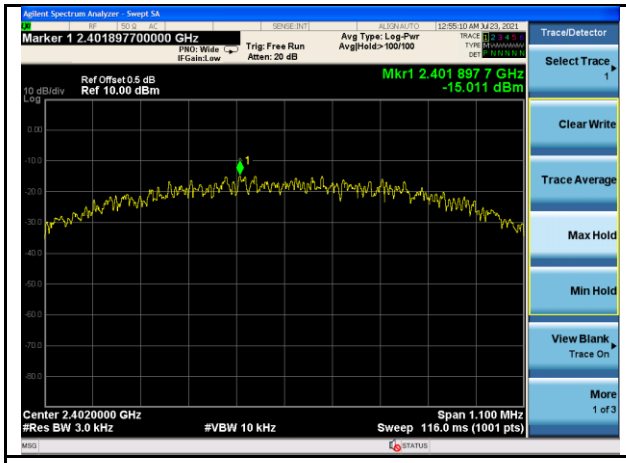
According to section 8.4 in KDB 558074 D01 DTS Meas Guidance v05r02 and subclause 11.10.2 PKPSD of ANSI C63.10-2013:

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.

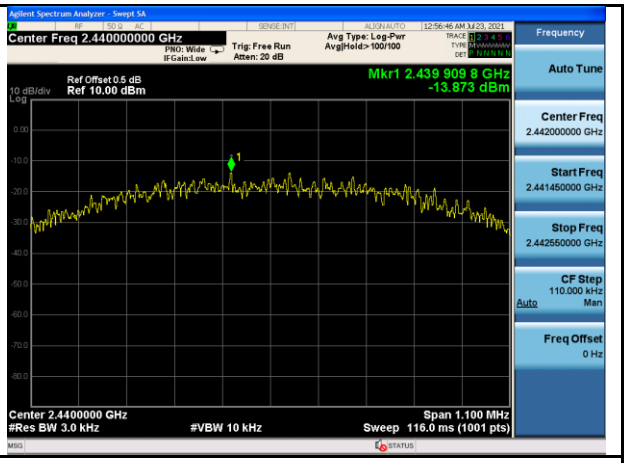
7.5.4 Test Result

Mode/ Bandwidth	Frequency (MHz)	Data rate	Measured PSD (dBm/3KHz)	Max PSD (dBm/3KHz)	Result
BLE	2402	1Mbps	-15.011	8	Pass
BLE	2440	1Mbps	-13.873	8	Pass
BLE	2480	1Mbps	-14.339	8	Pass
BLE	2402	2Mbps	-15.922	8	Pass
BLE	2440	2Mbps	-18.063	8	Pass
BLE	2480	2Mbps	-16.900	8	Pass

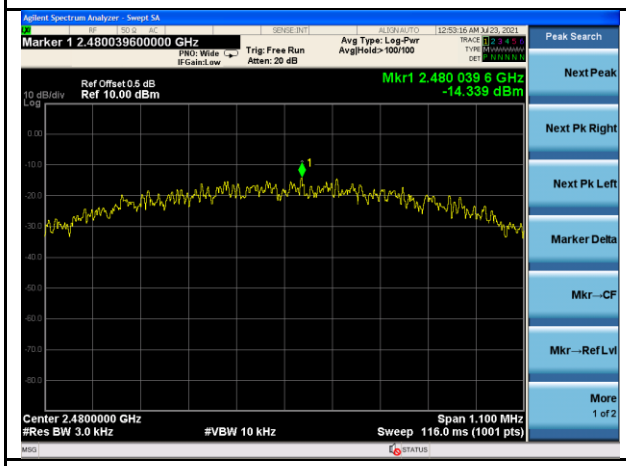
7.5.5 Test Plots



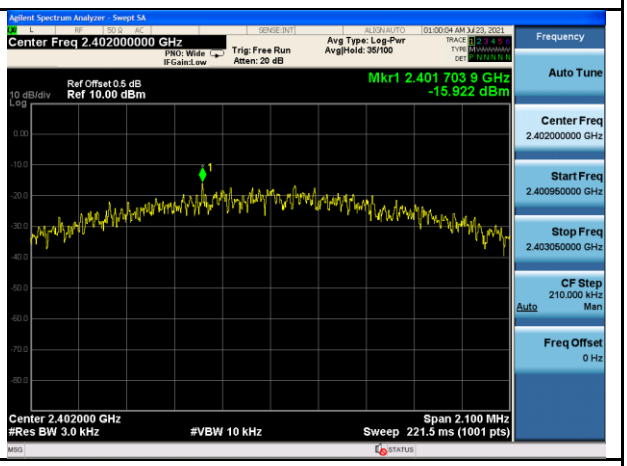
BLE-PSD-Low-1Mbps



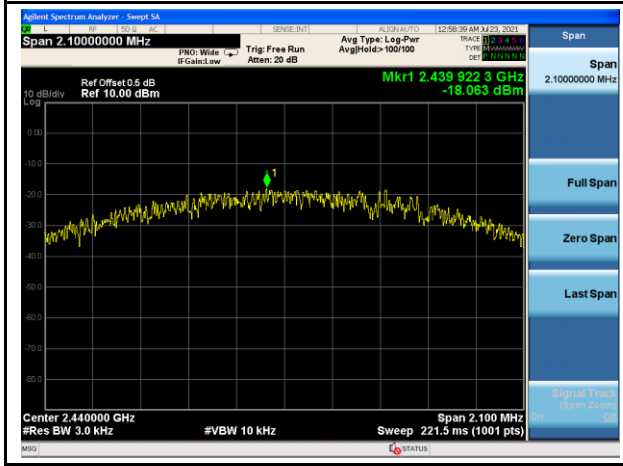
BLE-PSD-Mid-1Mbps



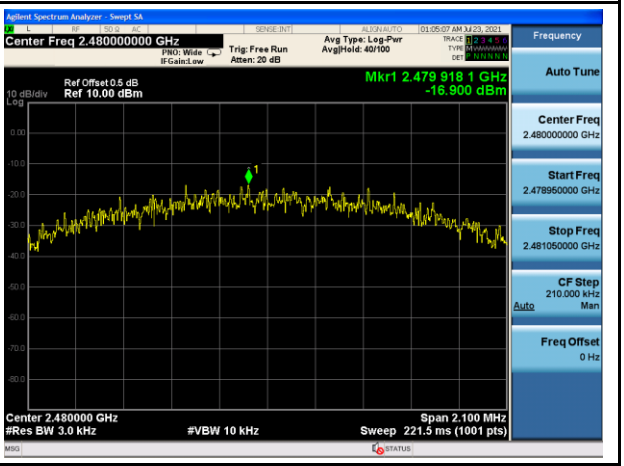
BLE-PSD-High-1Mbps



BLE-PSD-Low-2Mbps



BLE-PSD-Mid-2Mbps



BLE-PSD-High-2Mbps

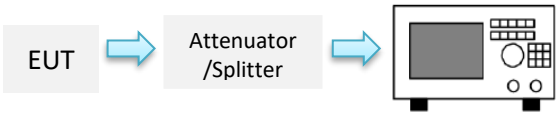
7.6 Conducted Out of Band Emission Measurement

7.6.1 Requirement

§ 15.247 (d), RSS-247 §5.5

Below 20dB of the highest emission level of operating band (in 100 kHz Resolution Bandwidth).

7.6.2 Test Setup



7.6.3 Test Procedure

MEASUREMENT PROCEDURE REF

1. Set the RBW = 100 kHz.
2. Set the VBW ⩾ 300 kHz.
3. Detector = peak.
4. Sweep time = auto couple.
5. Trace mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum power level in any 100 kHz band segment within the fundamental EBW.

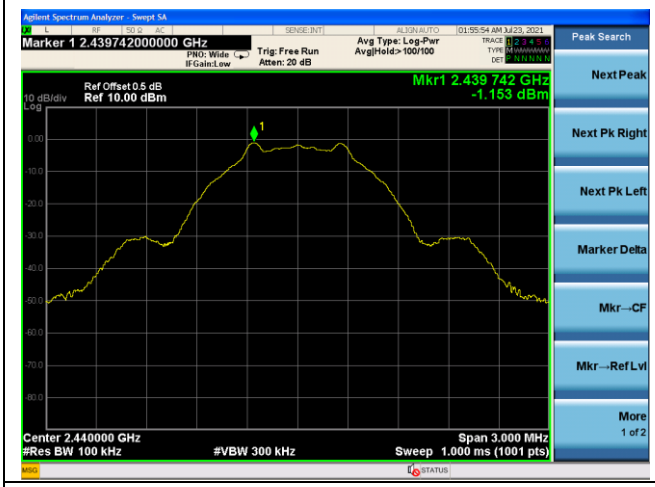
MEASUREMENT PROCEDURE OOBE

1. Set RBW = 100 kHz.
2. Set VBW ⩾ 300 kHz.
3. Detector = peak.
4. Sweep = auto couple.
5. Trace Mode = max hold.
6. Allow trace to fully stabilize.
7. Use the peak marker function to determine the maximum amplitude level.

7.6.4 Test Result

BLE-Low-Ref-1Mbps

BLE-CSE-Low-1Mbps



BLE-Mid-Ref-1Mbps

BLE-CSE-Mid-1Mbps

BLE-High-Ref-1Mbps

BLE-CSE-High-1Mbps

BLE-Low-Ref-2Mbps

BLE-CSE-Low-2Mbps

BLE-Mid-Ref-2Mbps

BLE-CSE-Mid-2Mbps

BLE-High-Ref-2Mbps

BLE-CSE-High-2Mbps

BLE-Band edge-Low-1Mbps

BLE-Band edge-High-1Mbps

BLE-Band edge-Low-2Mbps

BLE-Band edge-High-2Mbps

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

7.7.1 Requirement

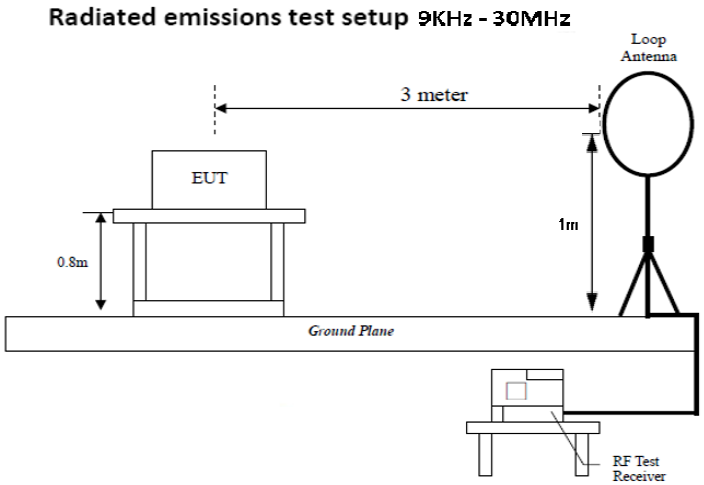
§ 15.247 (d), RSS-247 §5.5

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.

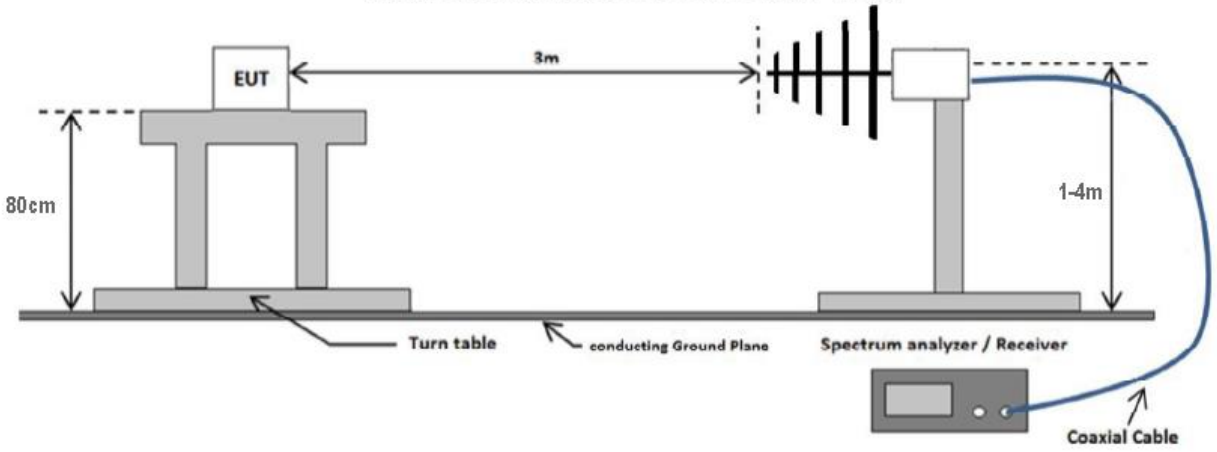
Attenuation below the general limits specified in §15.209(a) and RSS-Gen is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

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

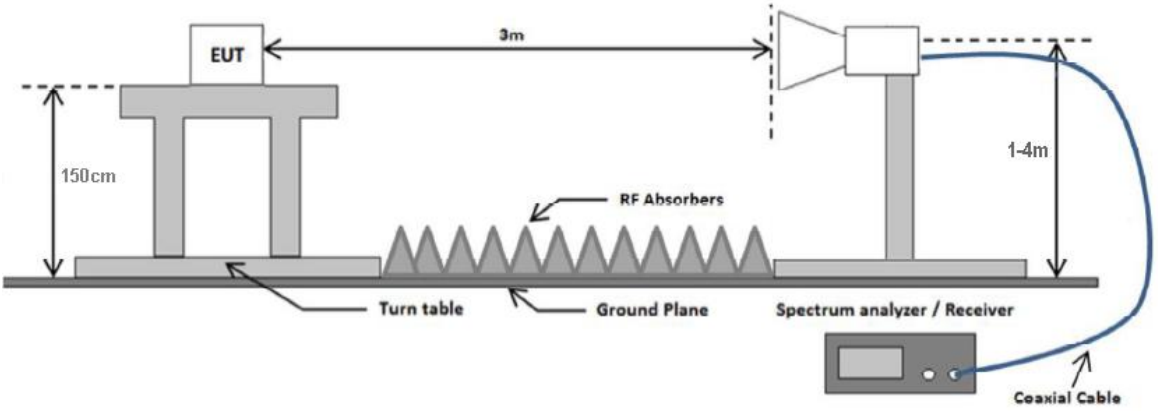
7.7.2 Test Setup



Radiated emissions test setup 30 MHz - 1 GHz



Radiated emissions test setup above 1 GHz



7.7.3 Test Procedure

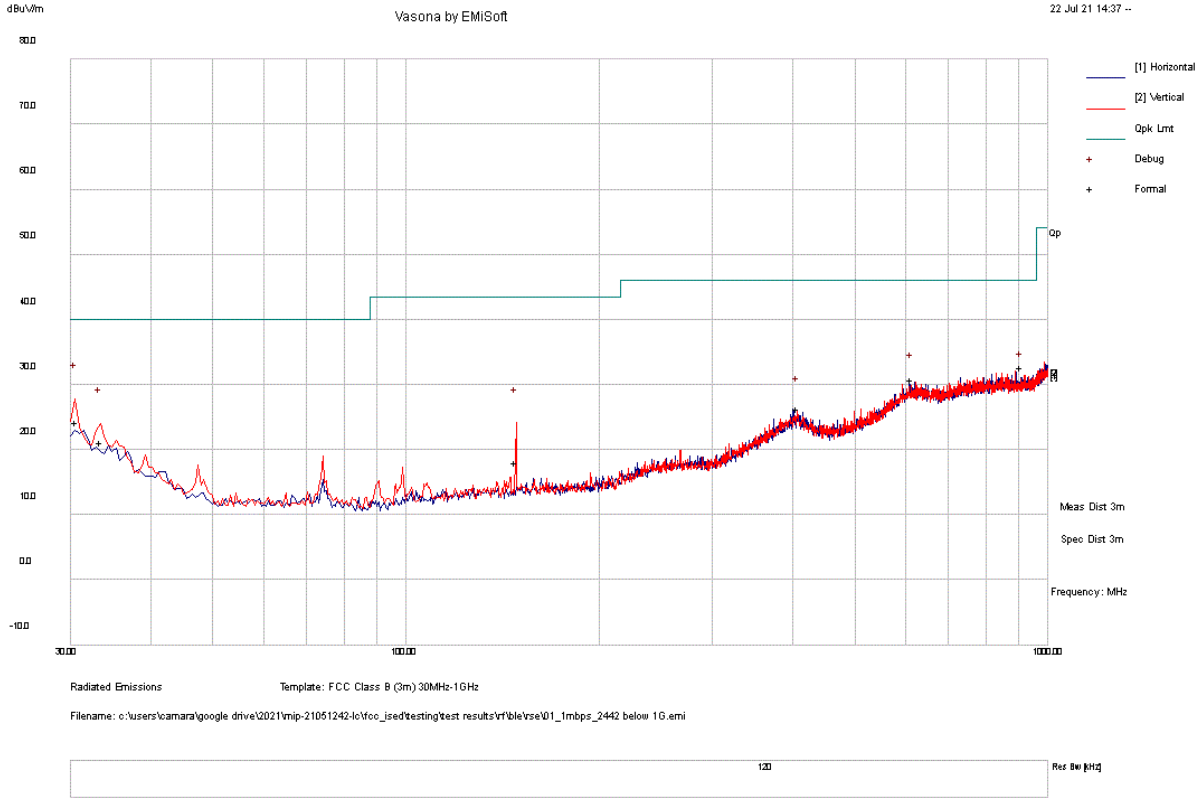
According to section 8.6 in KDB 558074 D01 DTS Meas Guidance v05r02 and subclause 11.12.2.7 Radiated spurious emission measurements in ANSI C62.10-2013 as well as the procedures for maximizing and measuring radiated emissions that are described in ANSI C63.10 was followed. Boresight antenna mast was 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 EMISSIONS BELOW 1 GHZ

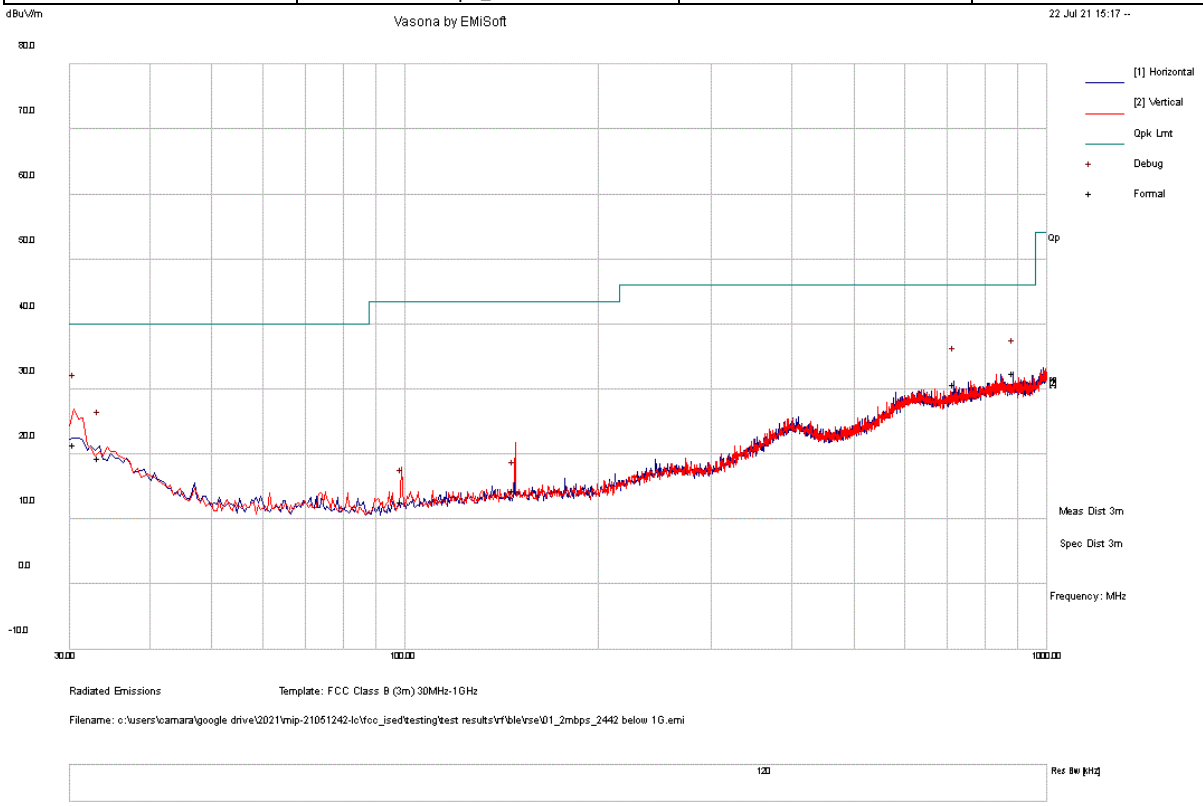
Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	30 MHz - 1 GHz	Test Date:	07/16/2021
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	1Mbps_Mid CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	30.659	33.9	2.2	-11.9	24.3	Quasi Max	V	396	172	40.0	-15.7	Pass
2	33.471	32.3	2.3	-13.4	21.2	Quasi Max	V	129	243	40.0	-18.8	Pass
3	906.430	28.7	7.6	-3.6	32.8	Quasi Max	H	400	162	46.0	-13.2	Pass
4	614.111	28.7	7.2	-5.0	30.9	Quasi Max	H	100	305	46.0	-15.1	Pass
5	148.359	31.6	4.2	-17.8	18.0	Quasi Max	V	368	164	43.5	-25.5	Pass
6	406.862	28.0	6.3	-8.1	26.3	Quasi Max	H	240	0	46.0	-19.7	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	30 MHz - 1 GHz	Test Date:	07/22/2021
Antenna Type/Polarity:	Bi-Log/Hor & Ver	Test Personnel:	Devin Tai
Remark:	2Mbps_Mid CH	Test Result:	Pass

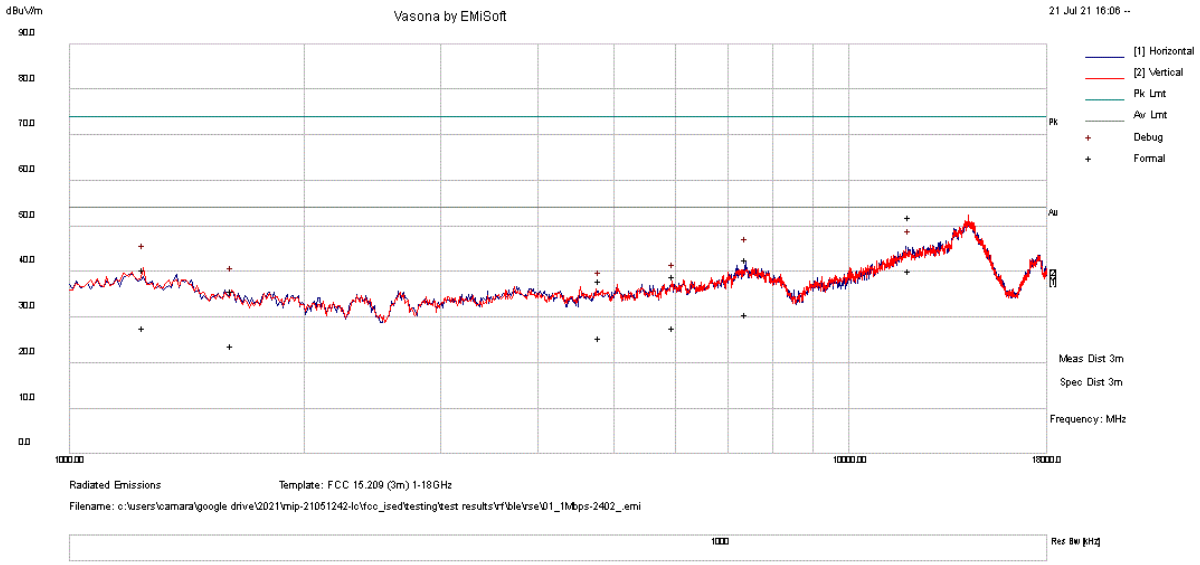


No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	30.520	31.0	2.2	-11.8	21.5	Quasi Max	V	260	221	40.0	-18.5	Pass
2	885.101	28.8	7.6	-3.8	32.6	Quasi Max	H	256	84	46.0	-13.4	Pass
3	715.666	28.7	7.3	-5.2	30.8	Quasi Max	H	400	303	46.0	-15.2	Pass
4	33.283	30.4	2.3	-13.3	19.4	Quasi Max	H	400	182	40.0	-20.6	Pass
5	147.407	28.1	4.2	-17.9	14.4	Quasi Max	V	237	253	43.5	-29.1	Pass
6	98.900	28.4	3.6	-19.2	12.8	Quasi Max	V	172	218	43.5	-30.7	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

RADIATED EMISSIONS 1 - 18 GHZ

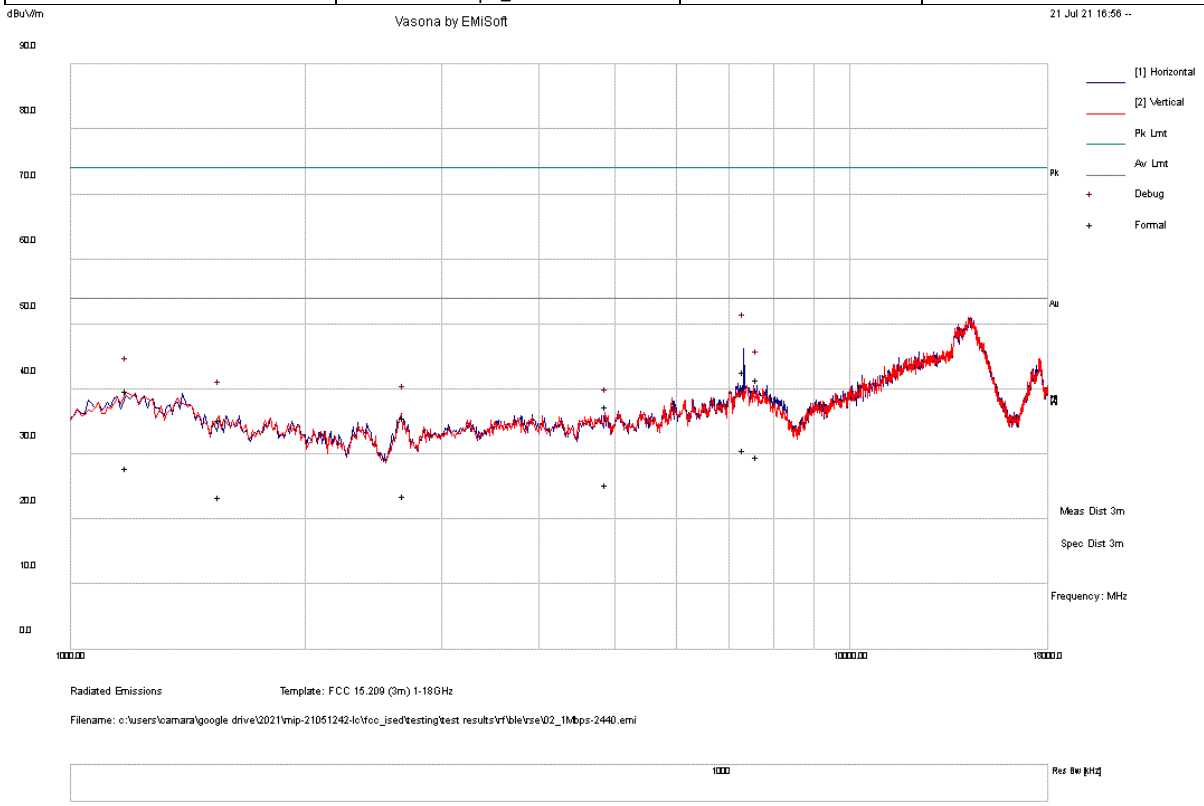
Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	1 GHz – 18 GHz	Test Date:	07/16/2021
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	1Mbps_Low CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	11974.381	22.4	25.6	4.1	52.0	Peak Max	V	234	0	74.0	-22.0	Pass
2	7396.198	20.9	20.8	1.1	42.8	Peak Max	H	340	256	74.0	-31.2	Pass
3	1243.560	31.7	14.4	-5.7	40.4	Peak Max	V	339	280	74.0	-33.6	Pass
4	5975.227	19.6	18.8	.7	39.1	Peak Max	V	248	0	74.0	-34.9	Pass
5	1614.768	30.4	14.7	-9.1	36.0	Peak Max	V	284	91	74.0	-38.0	Pass
6	4802.454	23.1	17.4	-2.3	38.2	Peak Max	V	151	0	74.0	-35.8	Pass
7	11974.381	10.5	25.6	4.1	40.2	Average Max	V	234	0	54.0	-13.8	Pass
8	7396.198	8.8	20.8	1.1	30.7	Average Max	H	340	256	54.0	-23.3	Pass
9	1243.560	19.1	14.4	-5.7	27.8	Average Max	V	339	280	54.0	-26.2	Pass
10	5975.227	8.2	18.8	.7	27.6	Average Max	V	248	0	54.0	-26.4	Pass
11	1614.768	18.4	14.7	-9.1	23.9	Average Max	V	284	91	54.0	-30.1	Pass
12	4802.454	10.4	17.4	-2.3	25.5	Average Max	V	151	0	54.0	-28.5	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

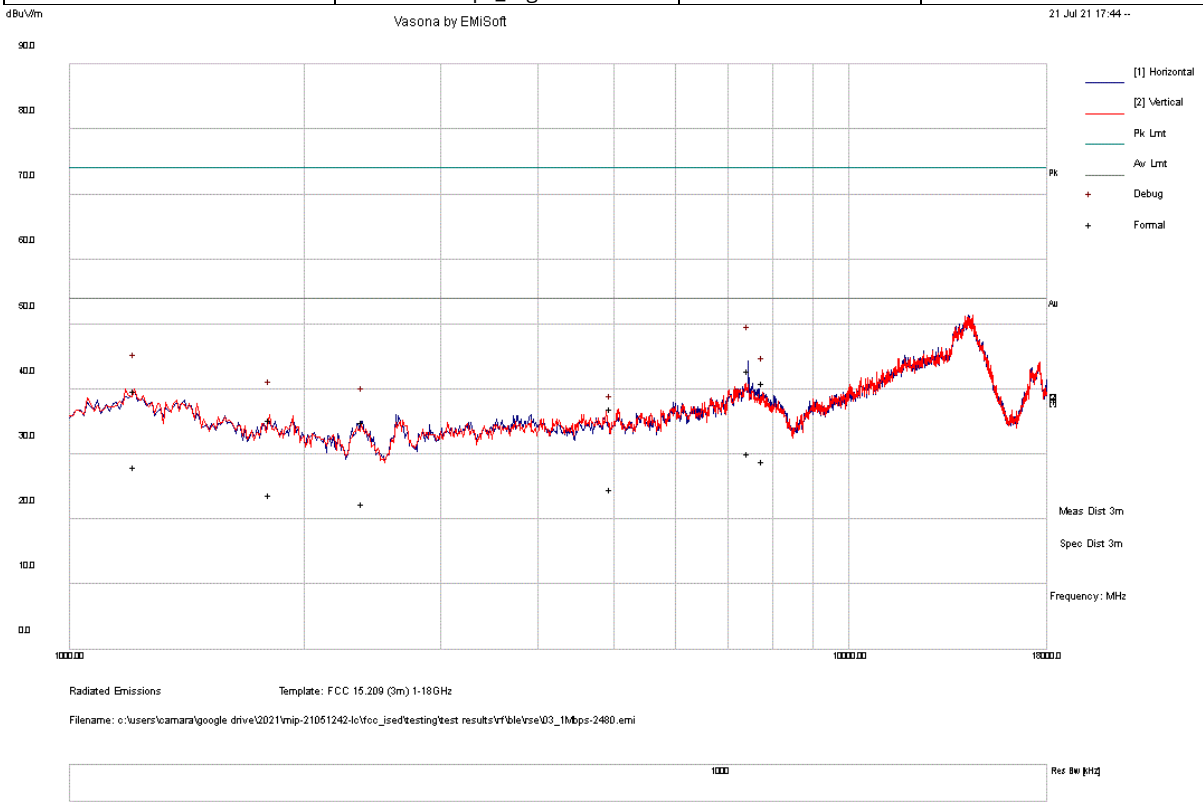
Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	1 GHz – 18 GHz	Test Date:	07/16/2021
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	1Mbps_Mid CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	7323.680	20.9	20.7	1.2	42.7	Peak Max	H	374	262	74.0	-31.3	Pass
2	7609.973	20.0	21.1	.5	41.6	Peak Max	H	285	254	74.0	-32.4	Pass
3	1179.923	30.7	14.3	-5.2	39.8	Peak Max	V	279	343	74.0	-34.2	Pass
4	1551.650	29.4	14.8	-8.8	35.3	Peak Max	V	316	106	74.0	-38.7	Pass
5	2678.307	29.3	15.0	-8.5	35.8	Peak Max	V	400	24	74.0	-38.2	Pass
6	4880.686	22.1	17.4	-2.2	37.3	Peak Max	V	181	45	74.0	-36.7	Pass
7	7323.680	8.8	20.7	1.2	30.7	Average Max	H	374	262	54.0	-23.3	Pass
8	7609.973	8.1	21.1	.5	29.7	Average Max	H	285	254	54.0	-24.3	Pass
9	1179.923	18.8	14.3	-5.2	27.9	Average Max	V	279	343	54.0	-26.1	Pass
10	1551.650	17.5	14.8	-8.8	23.5	Average Max	V	316	106	54.0	-30.5	Pass
11	2678.307	17.2	15.0	-8.5	23.7	Average Max	V	400	24	54.0	-30.3	Pass
12	4880.686	10.1	17.4	-2.2	25.3	Average Max	V	181	45	54.0	-28.7	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

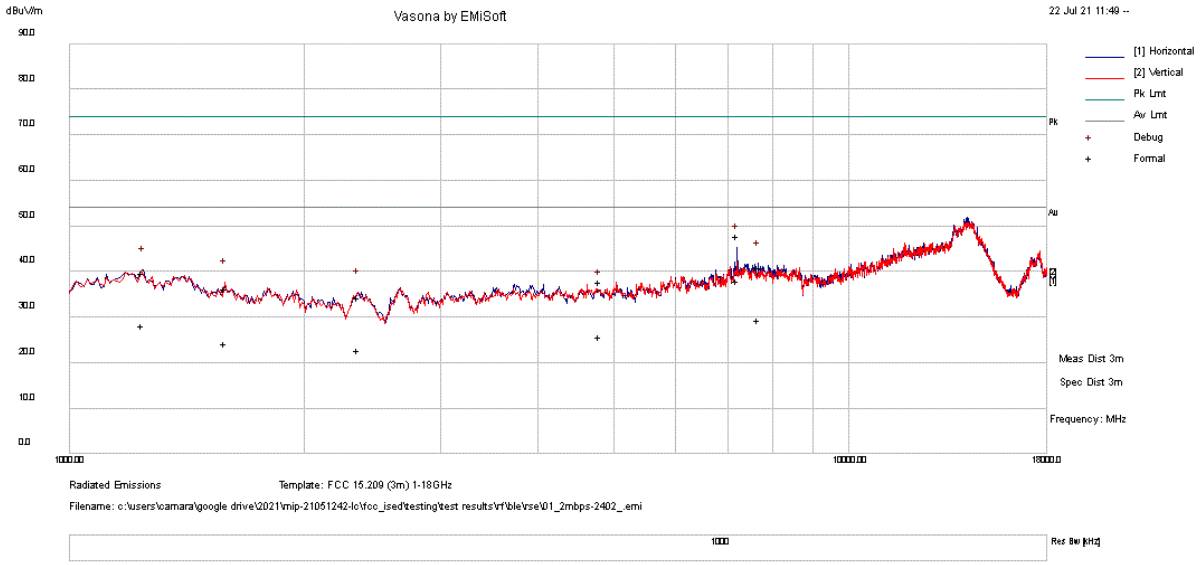
Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	1 GHz – 18 GHz	Test Date:	07/16/2021
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	1Mbps_High CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	7439.003	21.1	20.9	1.0	43.0	Peak Max	H	244	46	74.0	-31.0	Pass
2	1213.178	30.8	14.3	-5.4	39.8	Peak Max	H	167	106	74.0	-34.2	Pass
3	7769.618	19.5	21.1	.3	40.9	Peak Max	V	109	174	74.0	-33.1	Pass
4	1809.388	29.9	14.5	-9.0	35.4	Peak Max	V	383	291	74.0	-38.6	Pass
5	2380.255	29.8	14.7	-9.5	35.0	Peak Max	H	226	355	74.0	-39.0	Pass
6	4964.573	21.9	17.4	-2.2	37.1	Peak Max	V	282	0	74.0	-36.9	Pass
7	7439.003	8.2	20.9	1.0	30.1	Average Max	H	244	46	54.0	-23.9	Pass
8	1213.178	19.1	14.3	-5.4	28.1	Average Max	H	167	106	54.0	-25.9	Pass
9	7769.618	7.5	21.1	.3	29.0	Average Max	V	109	174	54.0	-25.0	Pass
10	1809.388	18.4	14.5	-9.0	23.9	Average Max	V	383	291	54.0	-30.1	Pass
11	2380.255	17.2	14.7	-9.5	22.4	Average Max	H	226	355	54.0	-31.6	Pass
12	4964.573	9.5	17.4	-2.2	24.7	Average Max	V	282	0	54.0	-29.3	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

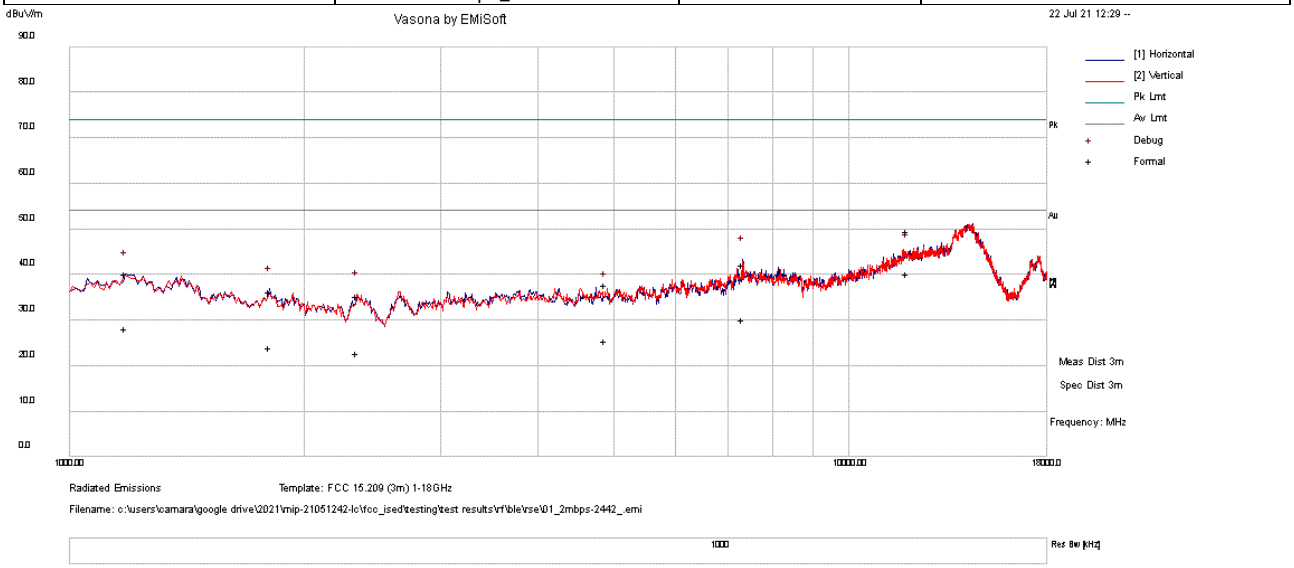
Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	1 GHz – 18 GHz	Test Date:	07/22/2021
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	2Mbps_Low CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	7204.725	26.3	20.5	1.2	47.9	Peak Max	H	100	58	74.0	-26.1	Pass
2	7663.743	19.5	21.1	.4	41.0	Peak Max	H	224	2	74.0	-33.0	Pass
3	1242.853	31.1	14.4	-5.6	39.8	Peak Max	H	340	118	74.0	-34.2	Pass
4	1584.138	30.6	14.7	-9.0	36.4	Peak Max	V	165	0	74.0	-37.6	Pass
5	2348.078	29.2	14.7	-9.5	34.3	Peak Max	V	400	188	74.0	-39.7	Pass
6	4803.090	22.8	17.4	-2.2	37.9	Peak Max	V	400	300	74.0	-36.1	Pass
7	7204.725	16.3	20.5	1.2	38.0	Average Max	H	100	58	54.0	-16.0	Pass
8	7663.743	7.9	21.1	.4	29.5	Average Max	H	224	2	54.0	-24.5	Pass
9	1242.853	19.4	14.4	-5.6	28.1	Average Max	H	340	118	54.0	-25.9	Pass
10	1584.138	18.5	14.7	-9.0	24.3	Average Max	V	165	0	54.0	-29.7	Pass
11	2348.078	17.7	14.7	-9.5	22.8	Average Max	V	400	188	54.0	-31.2	Pass
12	4803.090	10.6	17.4	-2.2	25.7	Average Max	V	400	300	54.0	-28.3	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

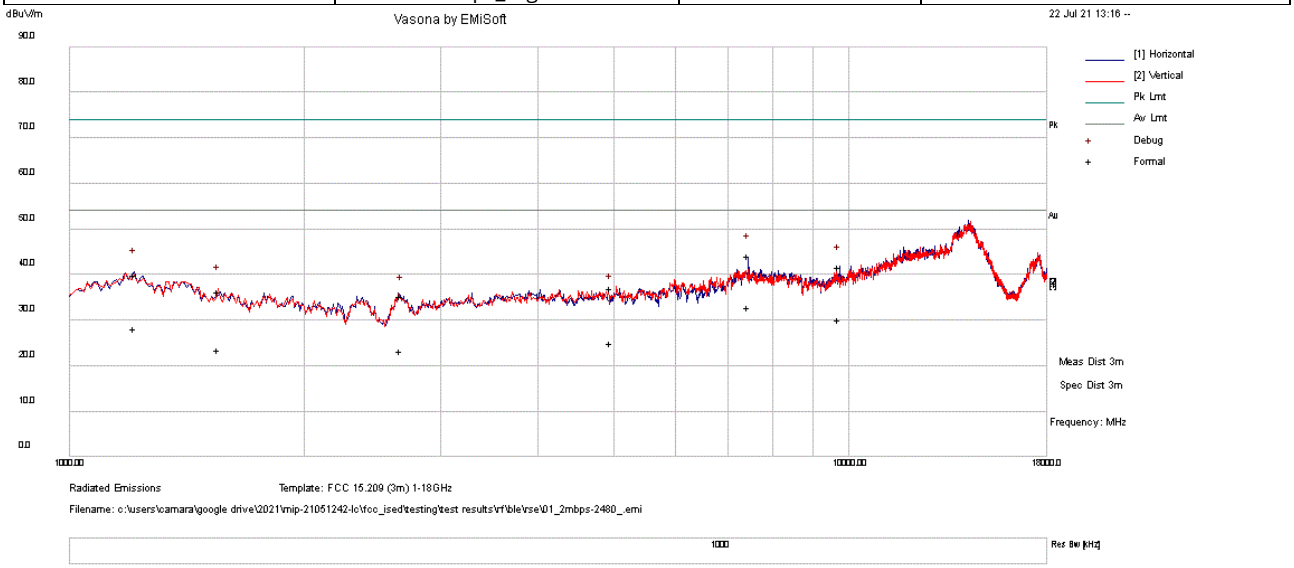
Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	1 GHz – 18 GHz	Test Date:	07/22/2021
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	2Mbps_Mid CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	11887.319	20.2	25.4	4.1	49.7	Peak Max	V	209	236	74.0	-24.3	Pass
2	7320.060	20.4	20.7	1.2	42.3	Peak Max	H	301	0	74.0	-31.7	Pass
3	1179.433	31.3	14.3	-5.2	40.4	Peak Max	H	392	272	74.0	-33.6	Pass
4	1808.880	30.9	14.5	-9.0	36.4	Peak Max	H	148	52	74.0	-37.6	Pass
5	2338.978	30.2	14.6	-9.5	35.4	Peak Max	V	247	331	74.0	-38.6	Pass
6	4883.743	22.6	17.4	-2.2	37.8	Peak Max	V	104	118	74.0	-36.2	Pass
7	11887.319	10.8	25.4	4.1	40.4	Average Max	V	209	236	54.0	-13.6	Pass
8	7320.060	8.4	20.7	1.2	30.3	Average Max	H	301	0	54.0	-23.7	Pass
9	1179.433	19.2	14.3	-5.2	28.3	Average Max	H	392	272	54.0	-25.7	Pass
10	1808.880	18.5	14.5	-9.0	24.0	Average Max	H	148	52	54.0	-30.0	Pass
11	2338.978	17.8	14.6	-9.5	23.0	Average Max	V	247	331	54.0	-31.0	Pass
12	4883.743	10.2	17.4	-2.2	25.4	Average Max	V	104	118	54.0	-28.6	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

Test Standard:	15.247, 15.209	Mode:	BLE Transmit
Frequency Range:	1 GHz – 18 GHz	Test Date:	07/22/2021
Antenna Type/Polarity:	Horn/Hor & Ver	Test Personnel:	Devin Tai
Remark:	2Mbps_High CH	Test Result:	Pass



No.	Frequency MHz	Raw dBµV	Cable Loss	AF dB	Level dBµV/m	Measurement Type	Pol	Hgt cm	Azt Deg	Limit dBµV/m	Margin dB	Pass/Fail
1	7438.438	22.4	20.9	1.0	44.3	Peak Max	H	137	52	74.0	-29.7	Pass
2	9744.619	19.0	22.1	.7	41.8	Peak Max	V	282	110	74.0	-32.2	Pass
3	1212.693	31.1	14.3	-5.4	40.1	Peak Max	H	348	53	74.0	-33.9	Pass
4	1552.963	30.3	14.8	-8.9	36.2	Peak Max	V	223	231	74.0	-37.8	Pass
5	4960.980	21.8	17.4	-2.2	37.0	Peak Max	V	169	342	74.0	-37.0	Pass
6	2666.827	28.9	15.0	-8.5	35.3	Peak Max	V	368	314	74.0	-38.7	Pass
7	7438.438	11.0	20.9	1.0	32.9	Average Max	H	137	52	54.0	-21.1	Pass
8	9744.619	7.4	22.1	.7	30.2	Average Max	V	282	110	54.0	-23.8	Pass
9	1212.693	19.4	14.3	-5.4	28.4	Average Max	H	348	53	54.0	-25.6	Pass
10	1552.963	17.8	14.8	-8.9	23.7	Average Max	V	223	231	54.0	-30.3	Pass
11	4960.980	10.0	17.4	-2.2	25.1	Average Max	V	169	342	54.0	-28.9	Pass
12	2666.827	16.8	15.0	-8.5	23.2	Average Max	V	368	314	54.0	-30.8	Pass

Note: Emission Level = Raw value (dBµV) + Cable Loss (dB) + AF (dB)
AF (dB) = Antenna Factor (dB/m) – Pre-amplifier factor (dB)
Margin Value = Emission Level (dBµV/m) – Limit (dBµV/m)

Radiated Emission between 9KHz – 30MHz test result

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

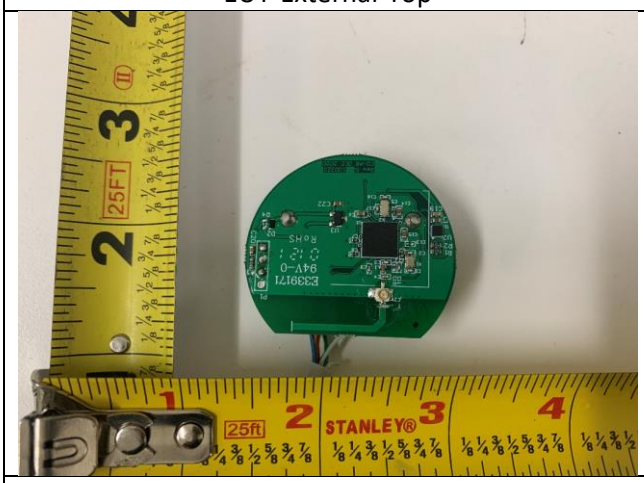
Radiated Emission between 18GHz – 40GHz test result

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

8 EUT and Test Setup Photos

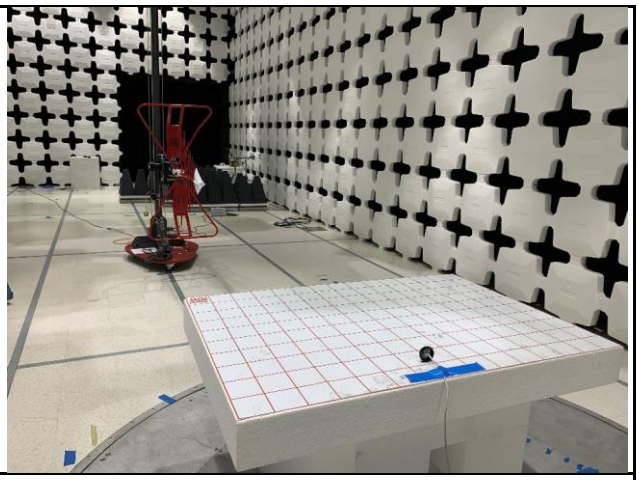
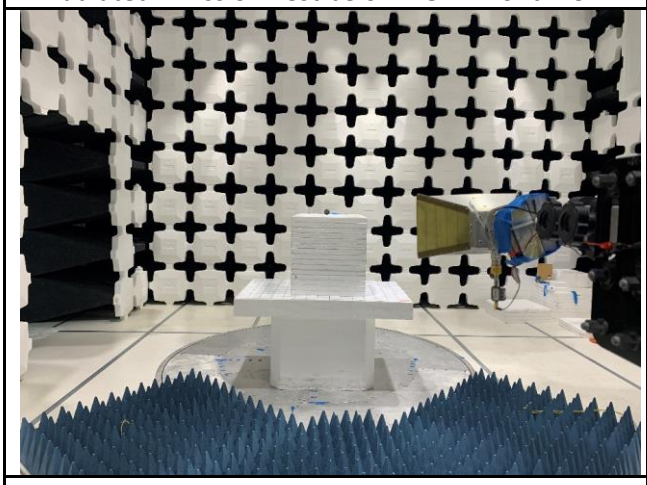
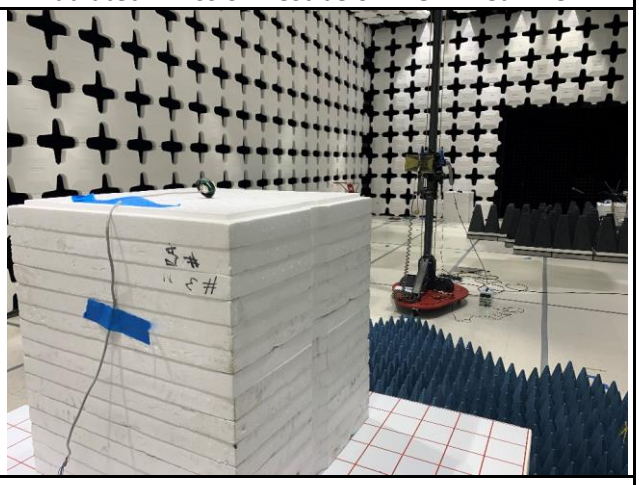
EUT-External-Top

EUT-External-Bottom



EUT-Internal-Top

EUT-Internal-Bottom

	
Radiated Emission Test below 1GHz Front View	Radiated Emission Test below 1GHz Rear View
	
Radiated Emission Test Above1GHz Front View	Radiated Emission Test Abov1GHz Rear View

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	6/17/2021	6/17/2022
EMC Test Receiver	R&S	ESL6	100230	6/14/2021	6/14/2022
LISN (9KHz – 30MHz)	EMCO	3816/2	9705-1066	5/4/2021	5/4/2022
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	11/15/2020	11/15/2021
Horn Antenna (1-18GHz)	Electro-Metrics	EM-6961	6292	5/14/2021	5/14/2022
Horn Antenna (18-40GHz)	Com-Power	AH-840	101109	6/24/2021	6/24/2022
Preamplifier	RF Bay, Inc.	LPA-10-20	11180621	7/16/2021	7/16/2022
True RMS Multi-meter	UNI-T	UT181A	C173014829	5/5/2021	5/5/2022
Temp / Humidity / Pressure Meter	PCE Instruments	PCE-THB 40	R062028	5/15/2021	5/15/2022
RF Attenuator	Pasternack	PE7005-3	VL061	7/16/2021	7/16/2022
Preamplifier 100KHz - 40GHz	Aeroflex	33711-392-77150-11	064	7/16/2021	7/16/2022
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	5/16/2021	5/16/2022
RE test cable(below 6GHz)	Vista	RE-6GHz-01	RE-6GHz-01	7/16/2021	7/16/2022
RE test cable (1-18GHz)	PhaseTrack	II-240	RE-18GHz-01	7/16/2021	7/16/2022
RE test cable (>18GHz)	Sucoflex	104	344903/4	7/16/2021	7/16/2022
Pulse limiter	Com-Power	LIT-930A	531727	7/16/2021	7/16/2022
CE test cable #1	FIRST RF	FRF-C-1002-001	CE-6GHz-01	7/16/2021	7/16/2022
CE test cable#2	FIRST RF	FRF-C-1002-001	CE-6GHz-02	7/16/2021	7/16/2022
Vector Signal Generator	Keysight	N5182A	US47080548	6/17/2021	6/17/2022
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