

7.4 UNWANTED EMISSIONS IN NON-RESTRICTED FREQUENCY BANDS

7.4.1 Applicable Standard

According to FCC Part 15.247(d) and KDB 558074 D01 15.247 Meas Guidance v05r02

7.4.2 Conformance Limit

According to FCC Part 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.

7.4.3 Test Configuration

Test according to clause 6.1 radio frequency test setup 1

7.4.4 Test Procedure

The transmitter output (antenna port) was connected to the spectrum analyzer

■ Reference level measurement

Establish a reference level by using the following procedure:

Set instrument center frequency to DTS channel center frequency.

Set the span to = 1.5 times the DTS bandwidth.

Set the RBW = 100 kHz.

Set the VBW $\geq 3 \times$ RBW.

Set Detector = peak.

Set Sweep time = auto couple.

Set Trace mode = max hold.

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum PSD level.

Note that the channel found to contain the maximum PSD level can be used to establish the reference level.

■ Emission level measurement

Set the center frequency and span to encompass frequency range to be measured.

Set the RBW = 100 kHz.

Set the VBW = 300 kHz.

Set Detector = peak

Sweep time = auto couple.

Trace mode = max hold.

Allow trace to fully stabilize.

Use the peak marker function to determine the maximum amplitude level.

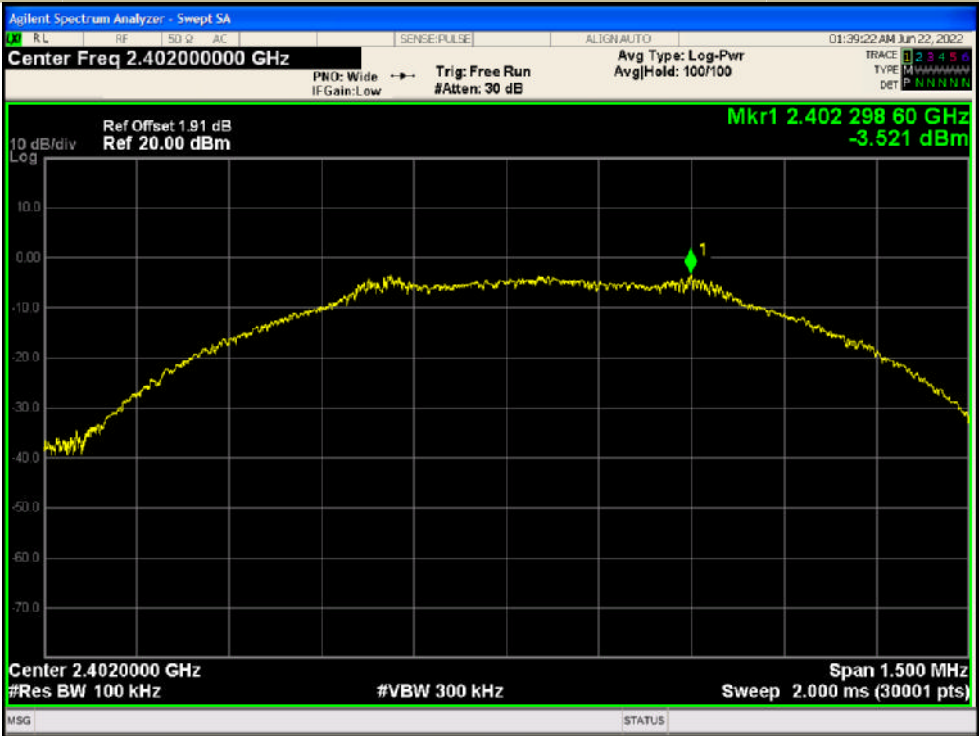
Ensure that the amplitude of all unwanted emissions outside of the authorized frequency band (excluding restricted frequency bands) are attenuated by at least the minimum requirements .

Report the three highest emissions relative to the limit.

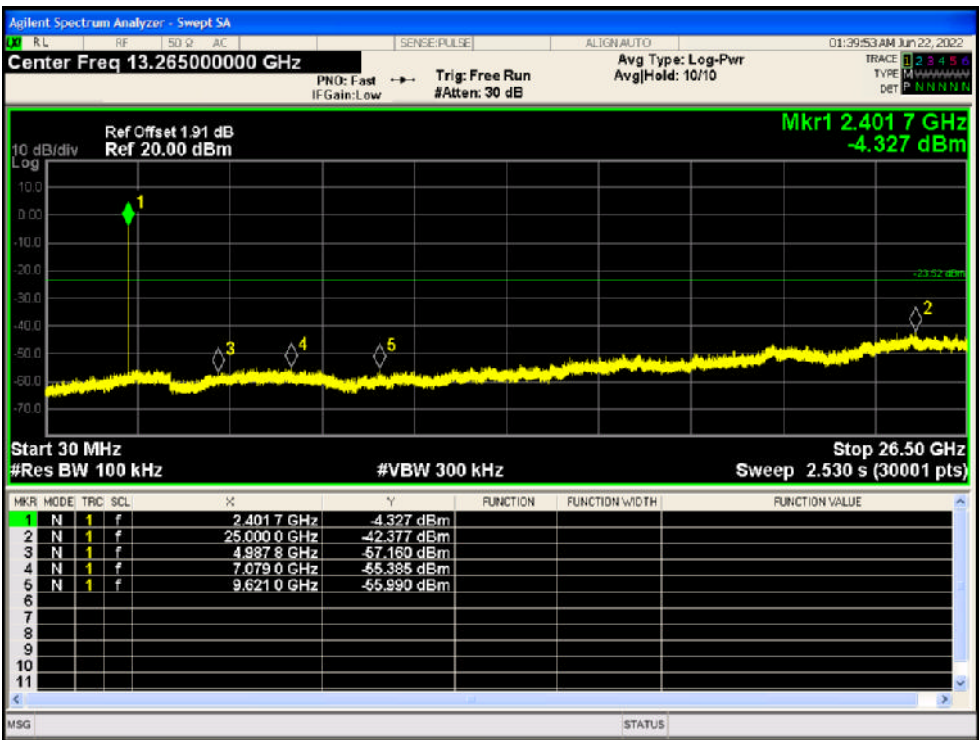
7.4.5 Test Results

Temperature:	26° C
Relative Humidity:	54%
ATM Pressure:	1011 mbar

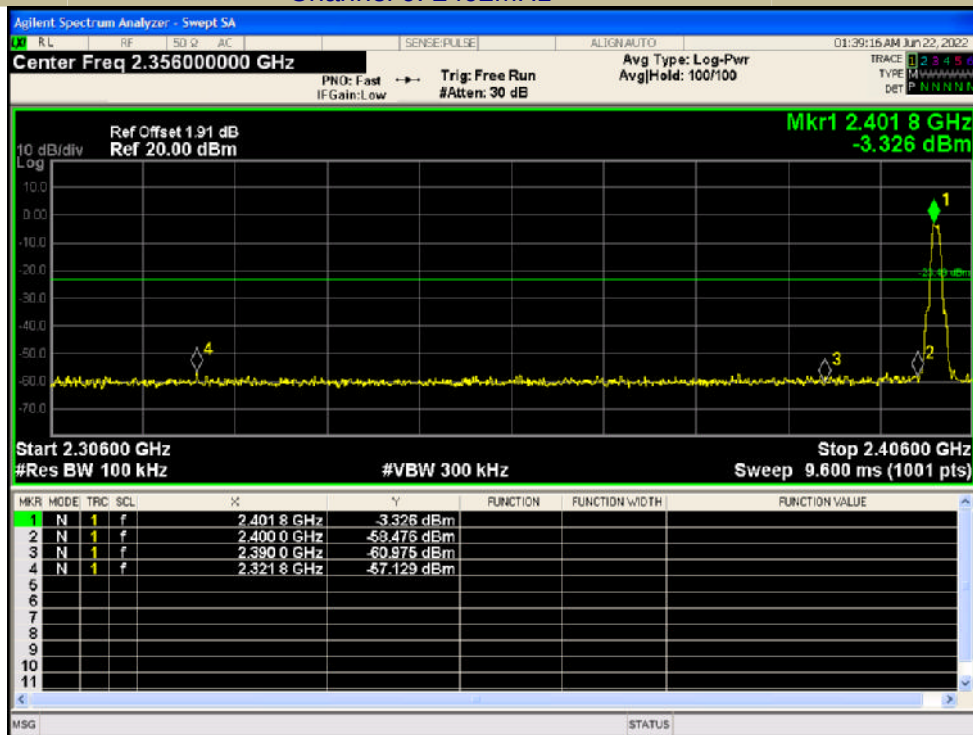
Test Model	PSD(Power Spectral Density) RBW=100kHz
	Bluetooth V5.1 DTS (1Mbps)
	Channel 0: 2402MHz



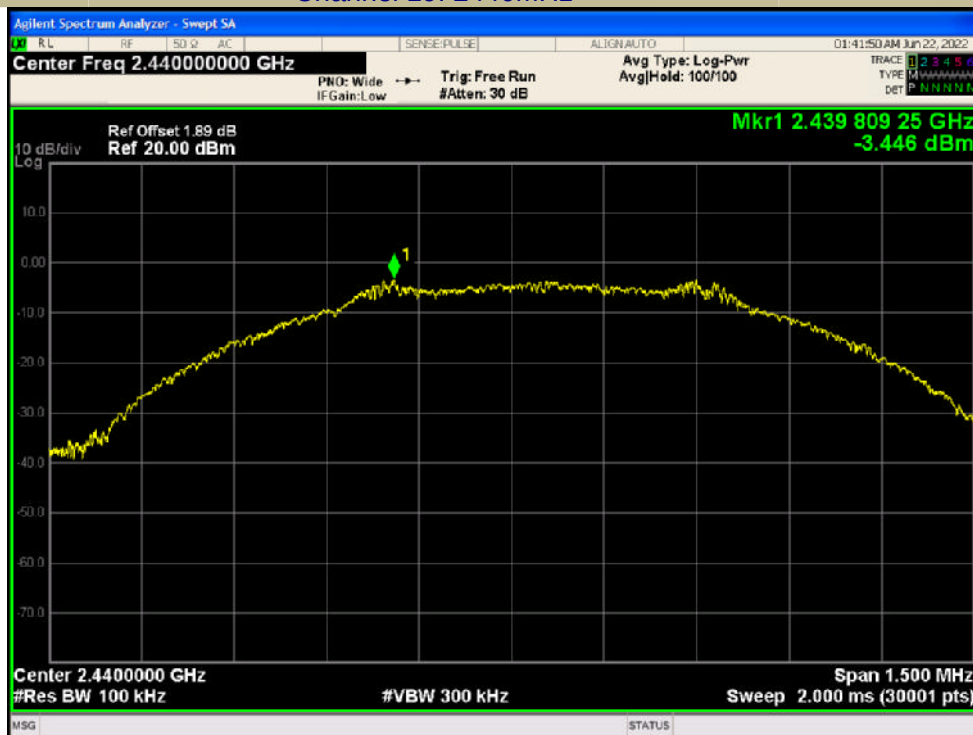
Test Model	Unwanted Emissions in non-restricted frequency bands
	Bluetooth V5.1 DTS (1Mbps)
	Channel 0: 2402MHz



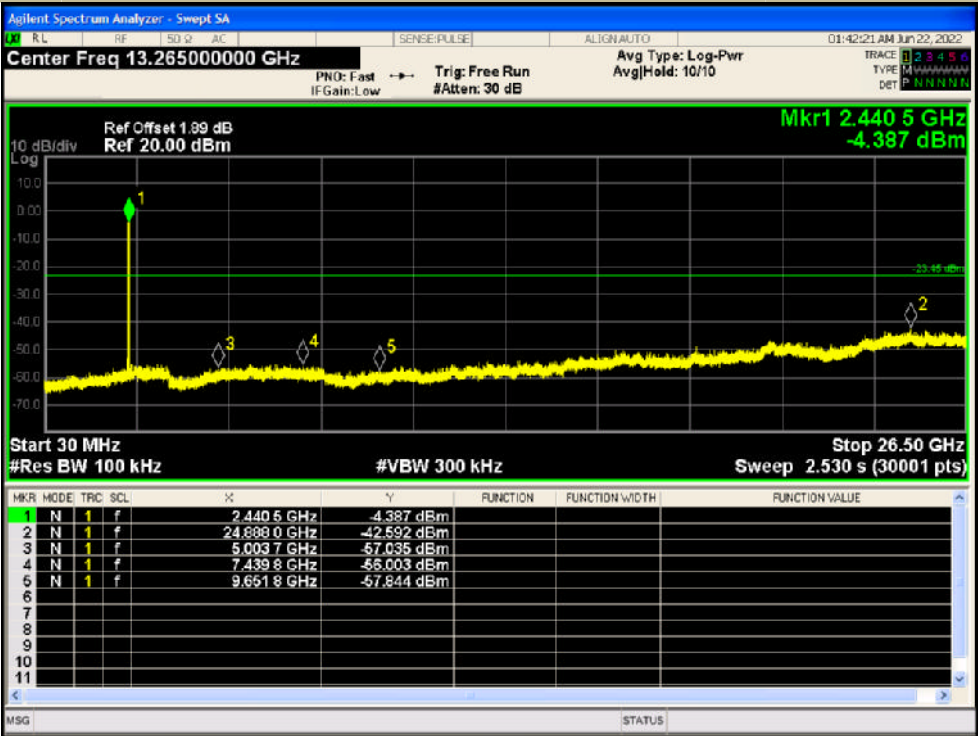
Test Model

 Band edge
 Bluetooth V5.1 DTS (1Mbps)
 Channel 0: 2402MHz


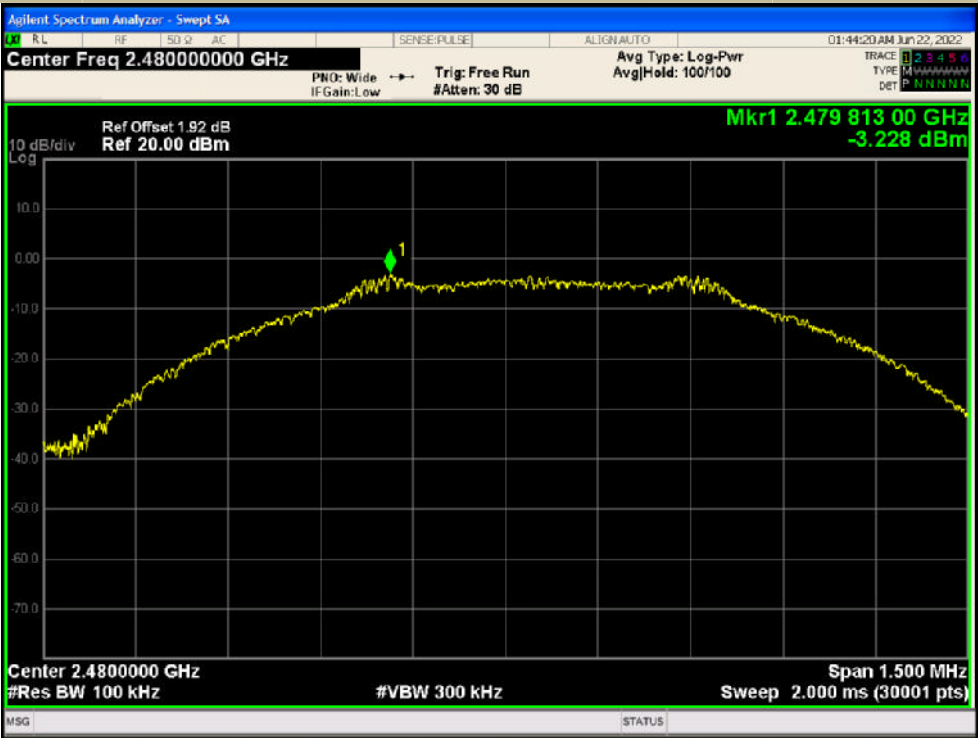
Test Model

 PSD(Power Spectral Density) RBW=100kHz
 Bluetooth V5.1 DTS (1Mbps)
 Channel 19: 2440MHz


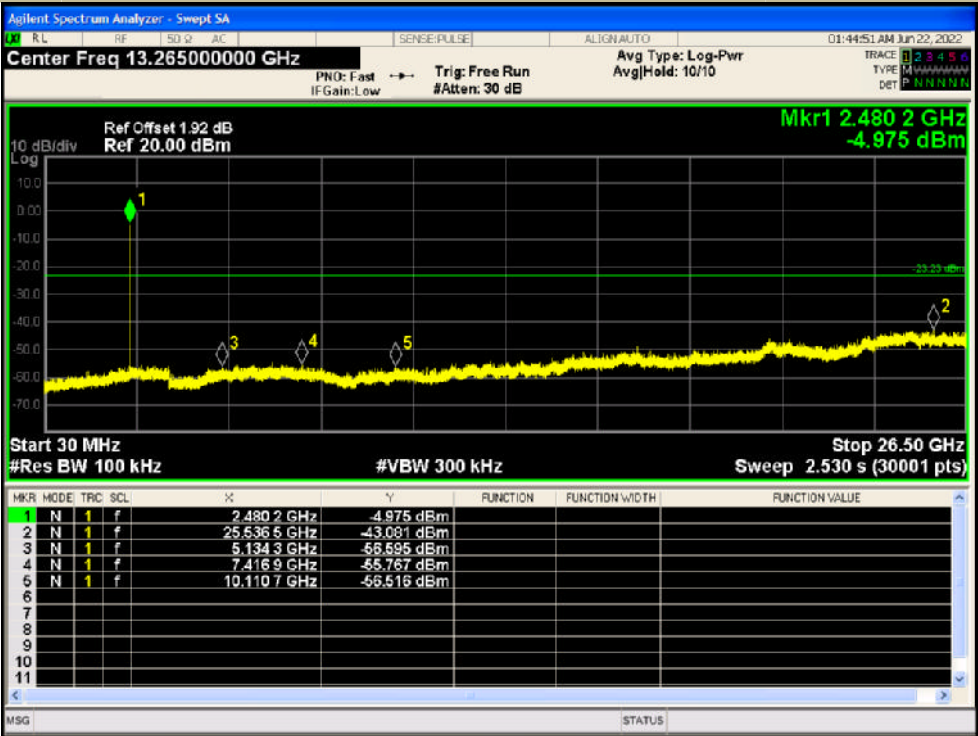
Test Model	Unwanted Emissions In Non-Restricted Frequency Bands
	Bluetooth V5.1 DTS (1Mbps)
Channel 19: 2440MHz	



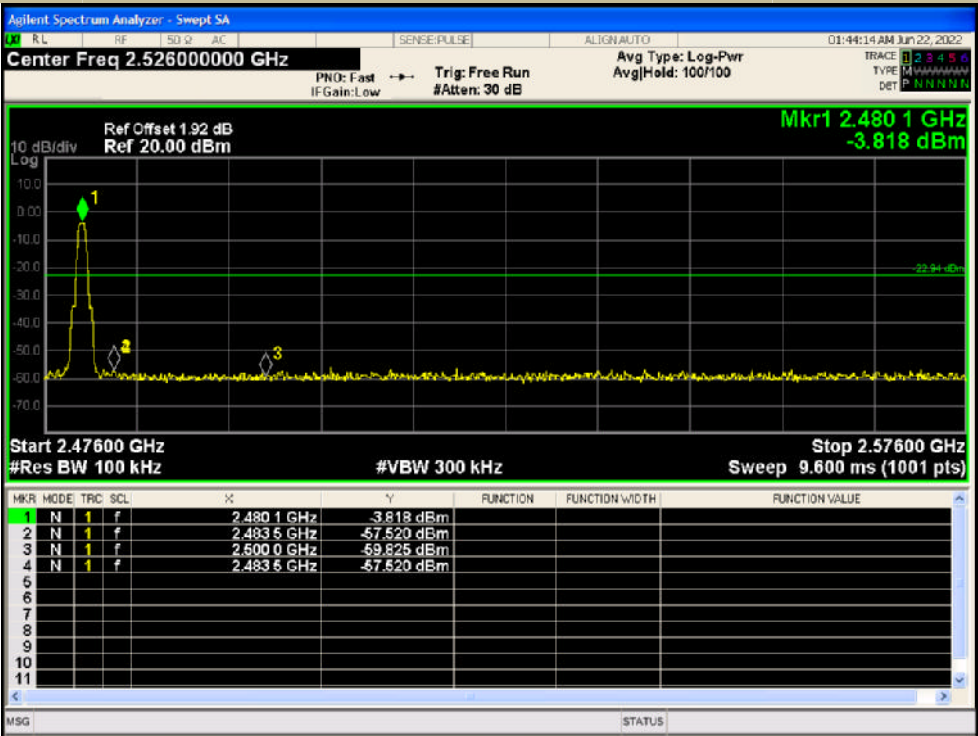
Test Model	PSD(Power Spectral Density) RBW=100kHz
	Bluetooth V5.1 DTS (1Mbps)
Channel 19: 2480MHz	



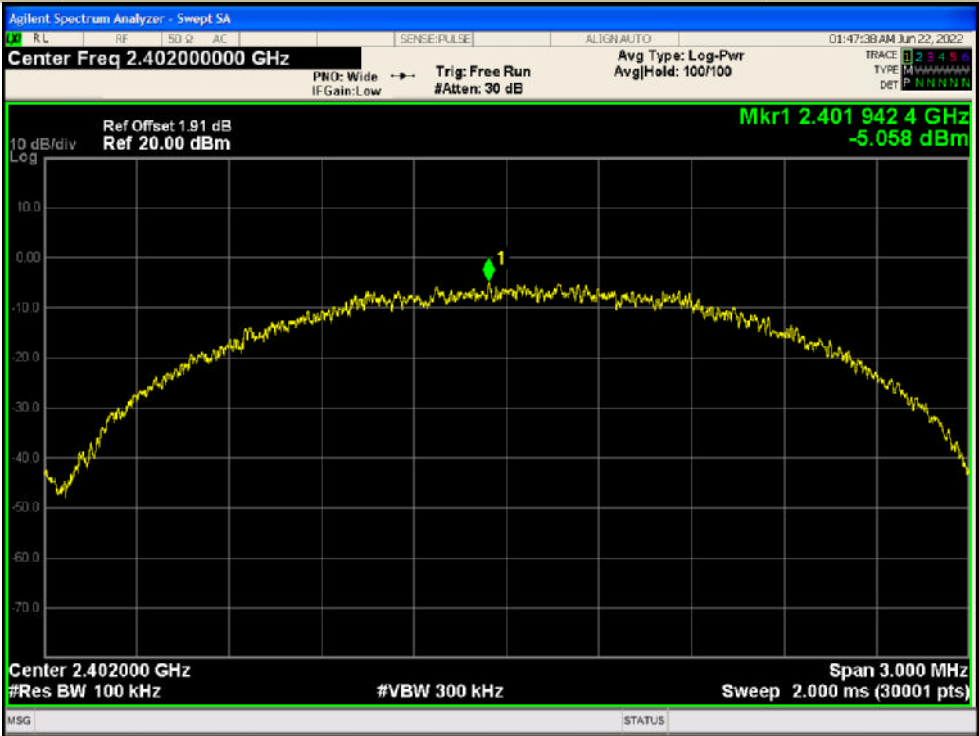
Test Model	Unwanted Emissions In Non-Restricted Frequency Bands
	Bluetooth V5.1 DTS (1Mbps)
	Channel 39: 2480MHz



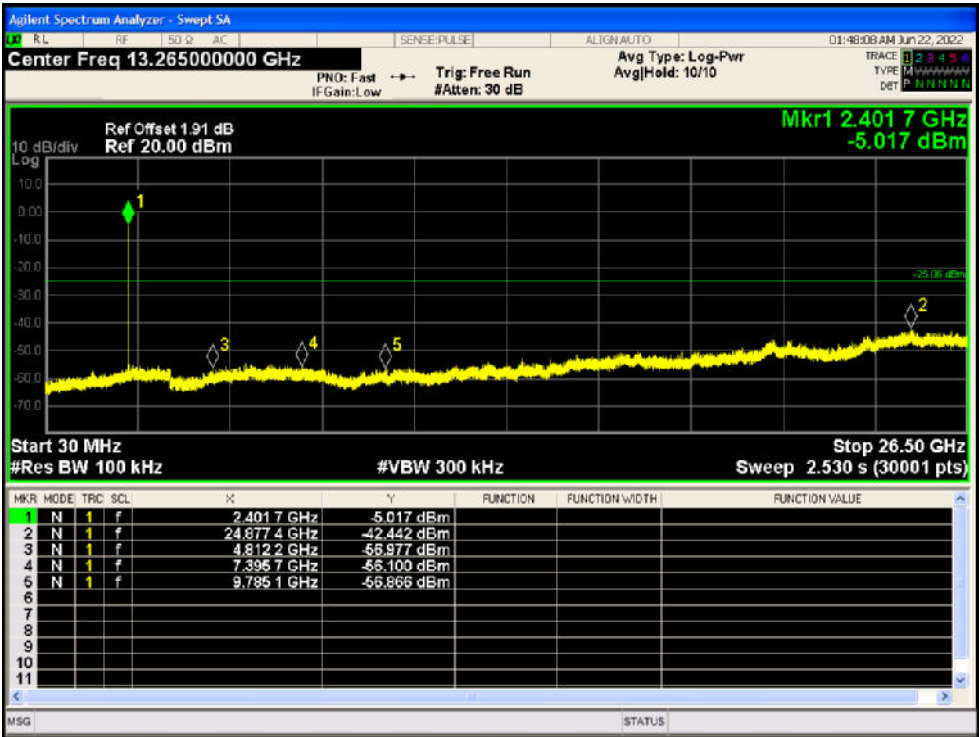
Test Model	Band edge
	Bluetooth V5.1 DTS (1Mbps)
	Channel 39: 2480MHz



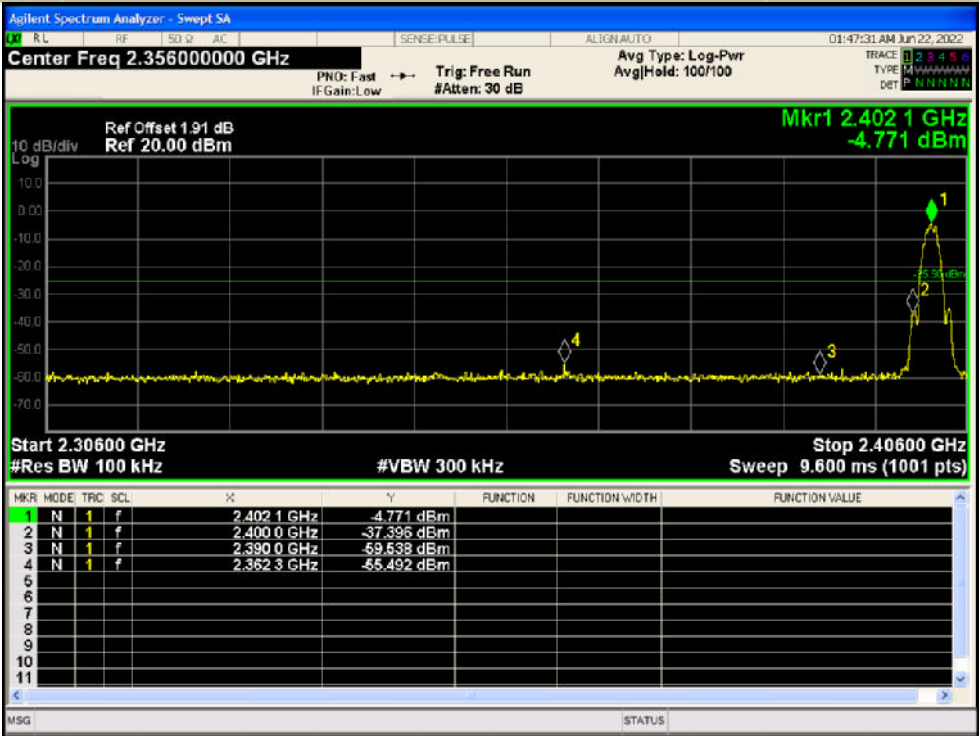
Test Model	PSD(Power Spectral Density) RBW=100kHz
	Bluetooth V5.1 DTS (2Mbps)
Channel 0: 2402MHz	



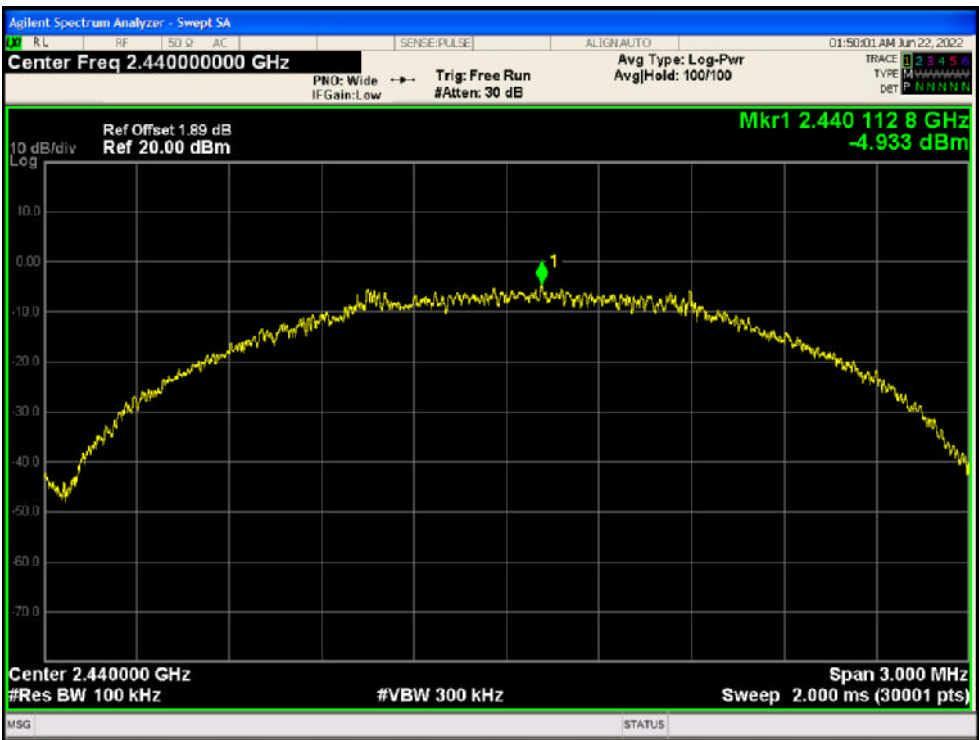
Test Model	Unwanted Emissions in non-restricted frequency bands
	Bluetooth V5.1 DTS (2Mbps)
Channel 0: 2402MHz	



Test Model	PSD(Power Spectral Density) RBW=100kHz
	Bluetooth V5.1 DTS (2Mbps)
	Channel 0: 2402MHz

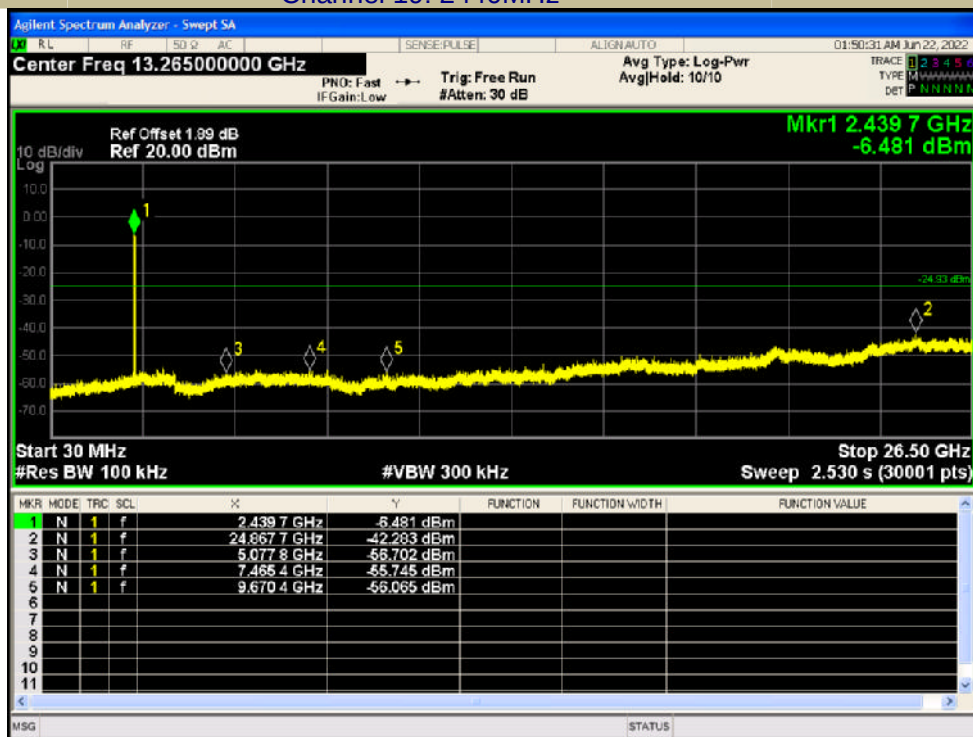


Test Model	Unwanted Emissions in non-restricted frequency bands
	Bluetooth V5.1 DTS (2Mbps)
	Channel 0: 2440MHz



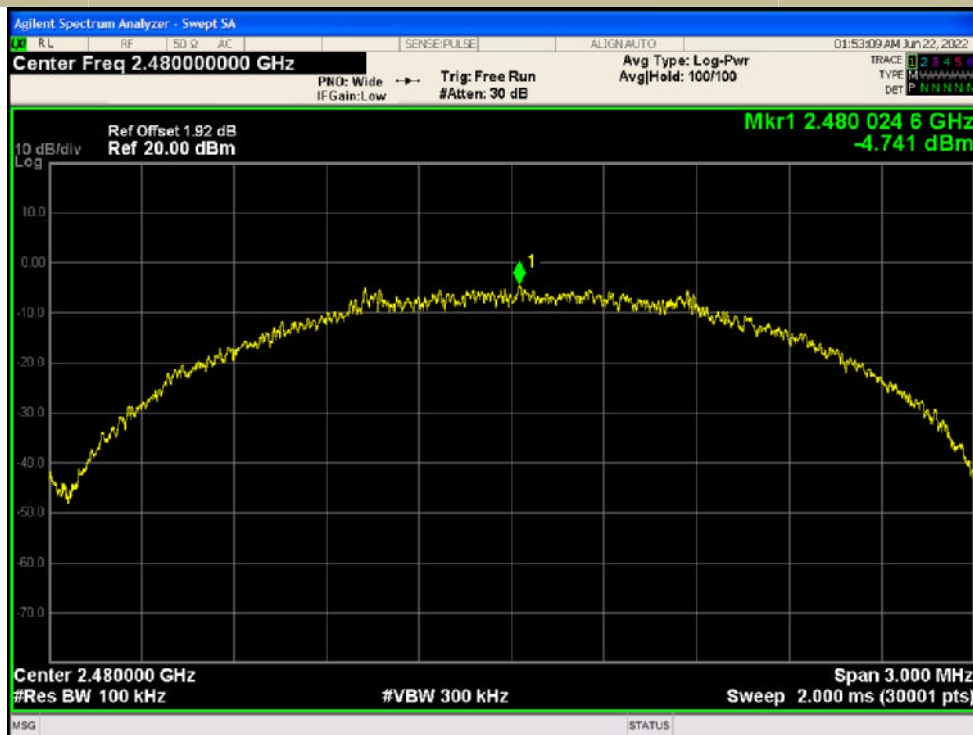
Test Model

Unwanted Emissions In Non-Restricted Frequency Bands
 Bluetooth V5.1 DTS (2Mbps)
 Channel 19: 2440MHz



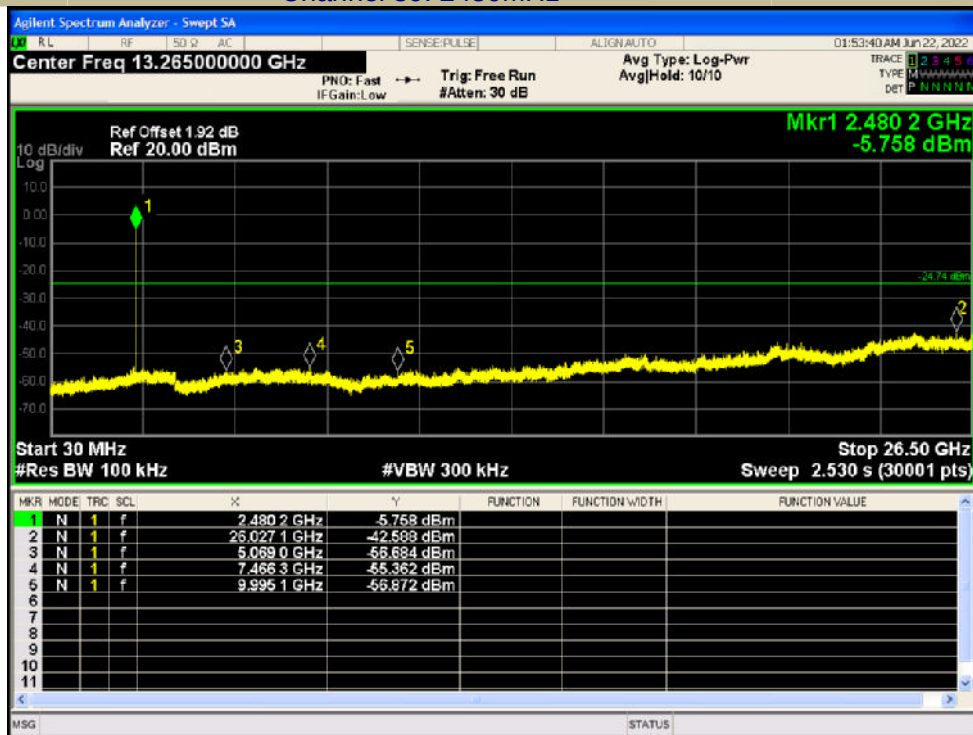
Test Model

PSD(Power Spectral Density) RBW=100kHz
 Bluetooth V5.1 DTS (2Mbps)
 Channel 19: 2480MHz



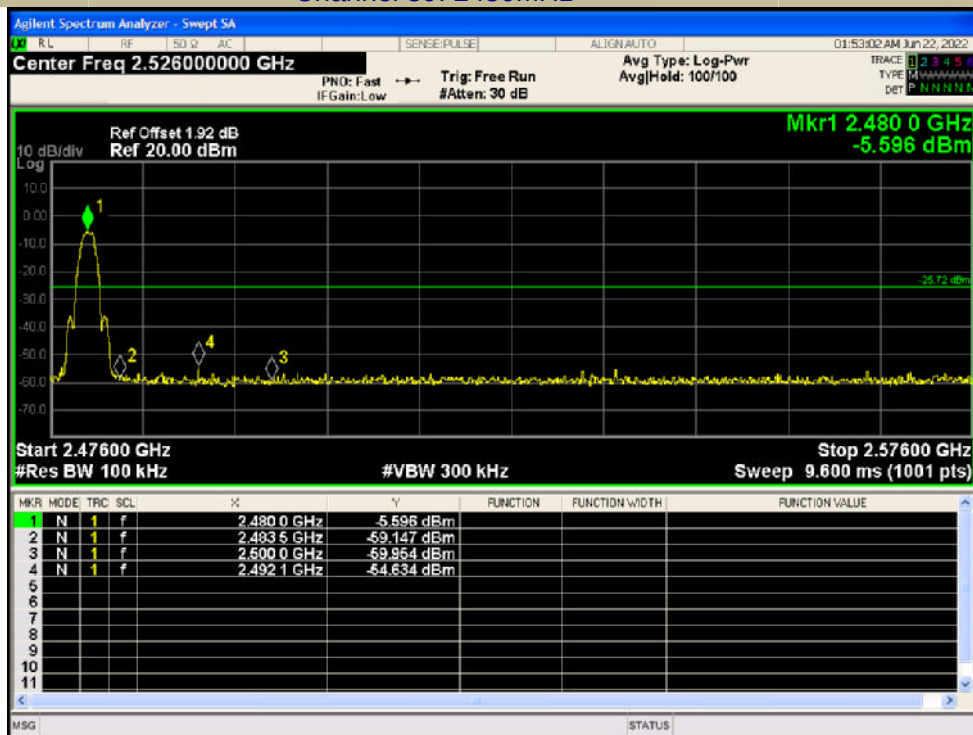
Test Model

Unwanted Emissions In Non-Restricted Frequency Bands
 Bluetooth V5.1 DTS (2Mbps)
 Channel 39: 2480MHz



Test Model

Band edge
 Bluetooth V5.1 DTS (2Mbps)
 Channel 39: 2480MHz



7.5 RADIATED SPURIOUS EMISSION

7.5.1 Applicable Standard

According to FCC Part 15.247(d) and 15.209 and KDB 558074 D01 15.247 Meas Guidance v05r02

7.5.2 Conformance Limit

According to FCC Part 15.247(d): 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)).

According to FCC Part 15.205, Restricted bands

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
10.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	(2)
13.36-13.41			

According to FCC Part 15.205, the level of any transmitter spurious emission in Restricted bands shall not exceed the level of the emission specified in the following table

Restricted Frequency(MHz)	Field Strength (μV/m)	Field Strength (dBμV/m)	Measurement Distance
0.009-0.490	2400/F(KHz)	20 log (uV/m)	300
0.490-1.705	2400/F(KHz)	20 log (uV/m)	30
1.705-30	30	29.5	30
30-88	100	40	3
88-216	150	43.5	3
216-960	200	46	3
Above 960	500	54	3

7.5.3 Test Configuration

Test according to clause 6.2 radio frequency test setup 2

7.5.4 Test Procedure

This test is required for any spurious emission that falls in a Restricted Band, as defined in Section 15.205. It must be performed with the highest gain of each type of antenna proposed for use with the EUT. Use the following spectrum analyzer settings:

The EUT was placed on a turn table which is 0.8m above ground plane.

Maximum procedure was performed on the highest emissions to ensure EUT compliance.

Span = wide enough to fully capture the emission being measured

RBW = 1 MHz for $f \geq 1$ GHz (1GHz to 25GHz), 100 kHz for $f < 1$ GHz (30MHz to 1GHz)

VBW $\geq$ RBW

Sweep = auto

Detector function = peak

Trace = max hold

Follow the guidelines in ANSI C63.10-2013 with respect to maximizing the emission by rotating the EUT, measuring the emission while the EUT is situated in three orthogonal planes (if appropriate), adjusting the measurement antenna height and polarization, etc. A pre-amp and a high pass filter are required for this test, in order to provide the measuring system with sufficient sensitivity. Allow the trace to stabilize. The peak reading of the emission, after being corrected by the antenna factor, cable loss, pre-amp gain, etc., is the peak field strength, which must comply with the limit specified in Section 15.35(b). Submit this data.

Now set the VBW to 10 Hz, while maintaining all of the other instrument settings. This peak level, once corrected, must comply with the limit specified in Section 15.209. If the dwell time per channel of the hopping signal is less than 100 ms, then the reading obtained with the 10 Hz VBW may be further adjusted by a "duty cycle correction factor", derived from $20\log(\text{dwell time}/100 \text{ ms})$, in an effort to demonstrate compliance with the 15.209 limit. Submit this data.

Repeat above procedures until all frequency measured was complete.

7.5.5 Test Results

Temperature:	26° C
Relative Humidity:	54%
ATM Pressure:	1011 mbar

■ Spurious Emission below 30MHz (9KHz to 30MHz)

Freq. (MHz)	Ant.Pol. H/V	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
		PK	AV	PK	AV	PK	AV
--	--	--	--	--	--	--	--

Note: the amplitude of spurious emission that is attenuated by more than 20dB below the permissible

limit has no need to be reported.

Distance extrapolation factor = $40\log(\text{Specific distance}/ \text{test distance})$ (dB);

Limit line=Specific limits(dBuV) + distance extrapolation factor

■ Spurious Emission Above 1GHz (1GHz to 25GHz)

Bluetooth V5.1 DTS mode have been tested, and the worst result was report as below:

Test mode: BLE Frequency: Channel 0: 2402MHz

Freq. (MHz)	Ant.Pol. H/V	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
		PK	AV	PK	AV	PK	AV
4818.21	V	55.05	41.26	74	54	-18.95	-12.74
7191.36	V	61.63	47.82	74	54	-12.37	-6.18
12341.03	V	60.21	46.40	74	54	-13.79	-7.60
4792.96	H	57.52	43.70	74	54	-16.48	-10.30
7217.80	H	59.55	45.76	74	54	-14.45	-8.24
14610.57	H	59.67	45.86	74	54	-14.33	-8.14

Test mode: BLE Frequency: Channel 19: 2440MHz

Freq. (MHz)	Ant.Pol. H/V	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
		PK	AV	PK	AV	PK	AV
4757.48	V	57.08	43.27	74	54	-16.92	-10.73
7242.41	V	59.72	45.89	74	54	-14.28	-8.11
12339.41	V	59.40	45.59	74	54	-14.60	-8.41
4836.10	H	57.22	43.33	74	54	-16.78	-10.67
7221.04	H	59.64	45.82	74	54	-14.36	-8.18
14453.81	H	58.99	45.19	74	54	-15.01	-8.81

Test mode: BLE Frequency: Channel 39: 2480MHz

Freq. (MHz)	Ant.Pol. H/V	Emission Level(dBuV/m)		Limit 3m(dBuV/m)		Over(dB)	
		PK	AV	PK	AV	PK	AV
4777.34	V	58.02	44.22	74	54	-15.98	-9.78
7179.25	V	59.99	46.18	74	54	-14.01	-7.82
12346.12	V	59.96	46.17	74	54	-14.04	-7.83
4813.79	H	56.81	42.02	74	54	-17.19	-11.98
7178.44	H	59.24	44.38	74	54	-14.76	-9.62
14786.40	H	58.41	43.63	74	54	-15.59	-10.37

Note: (1) All Readings are Peak Value (VBW=3MHz) and Peak Value (VBW=10Hz).

(2) Emission Level= Reading Level+Correct Factor +Cable Loss.

(3) Correct Factor= Ant_F + Cab_L - Preamp

(4)Data of measurement within this frequency range shown “ -- ” in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

■ Spurious Emission in Restricted Band 2310-2390MHz and 2483.5-2500MHz

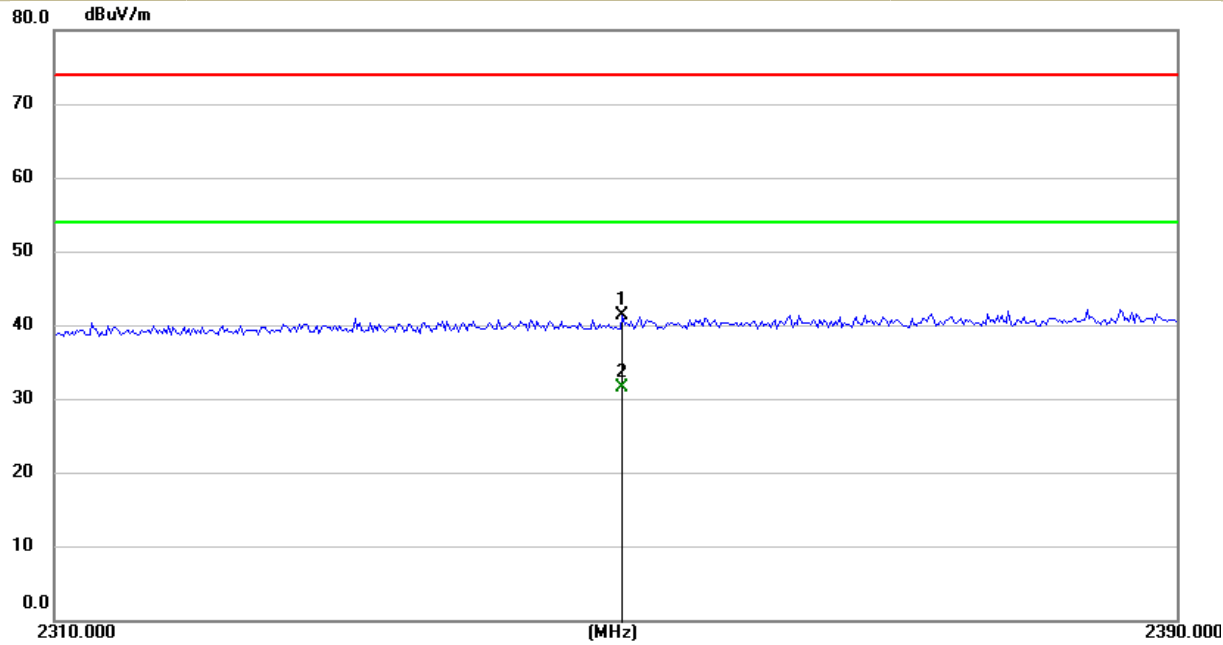
Frequency (MHz)	Polarity	PK(dBuV/m) (VBW=3MHz)	Limit 3m (dBuV/m)	AV(dBuV/m) (VBW=10Hz)	Limit 3m (dBuV/m)
2350.16	H	41.37	74	31.67	54
2367.76	V	43.51	74	34.62	54

Frequency (MHz)	Polarity	PK(dBuV/m) (VBW=3MHz)	Limit 3m (dBuV/m)	AV(dBuV/m) (VBW=10Hz)	Limit 3m (dBuV/m)
2490.13	H	44.61	74	35.36	54
2491.42	V	46.29	74	37.94	54

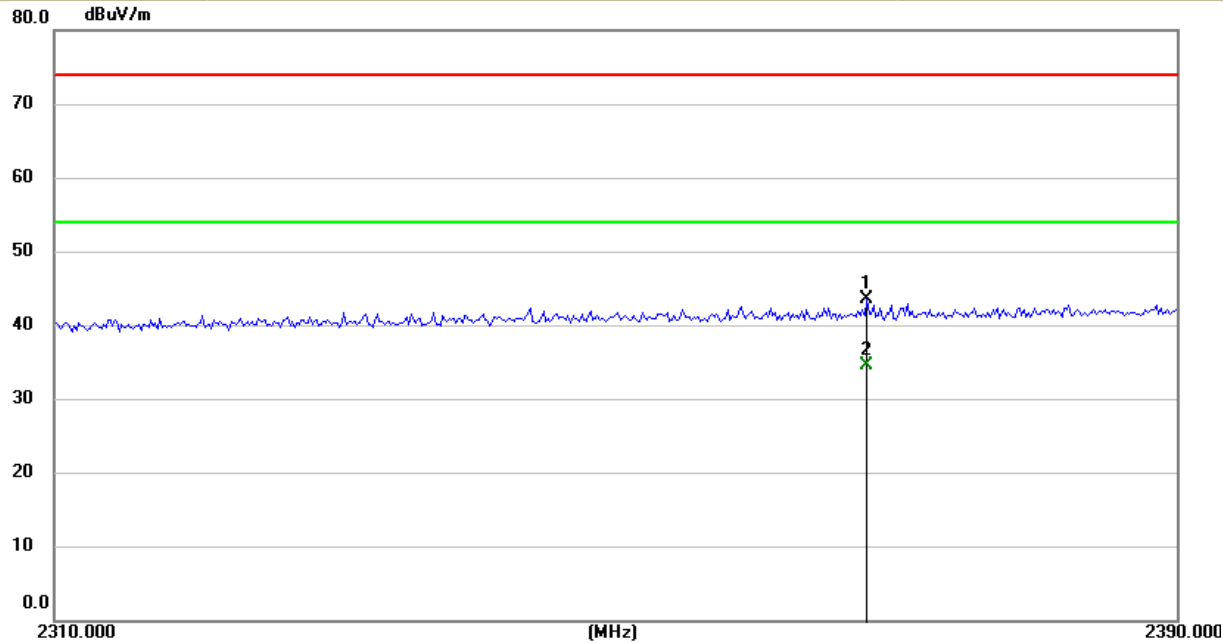
Note: (1) All Readings are Peak Value (VBW=3MHz) and Peak Value (VBW=10Hz).
 (2) Emission Level= Reading Level+Correct Factor +Cable Loss.
 (3) Correct Factor= Ant_F + Cab_L - Preamp
 (4) Data of measurement within this frequency range shown “ -- ” in the table above means the reading of emissions are attenuated more than 20dB below the permissible limits or the field strength is too small to be measured.

All the modulation modes were tested, the data of the worst mode are described in the following table

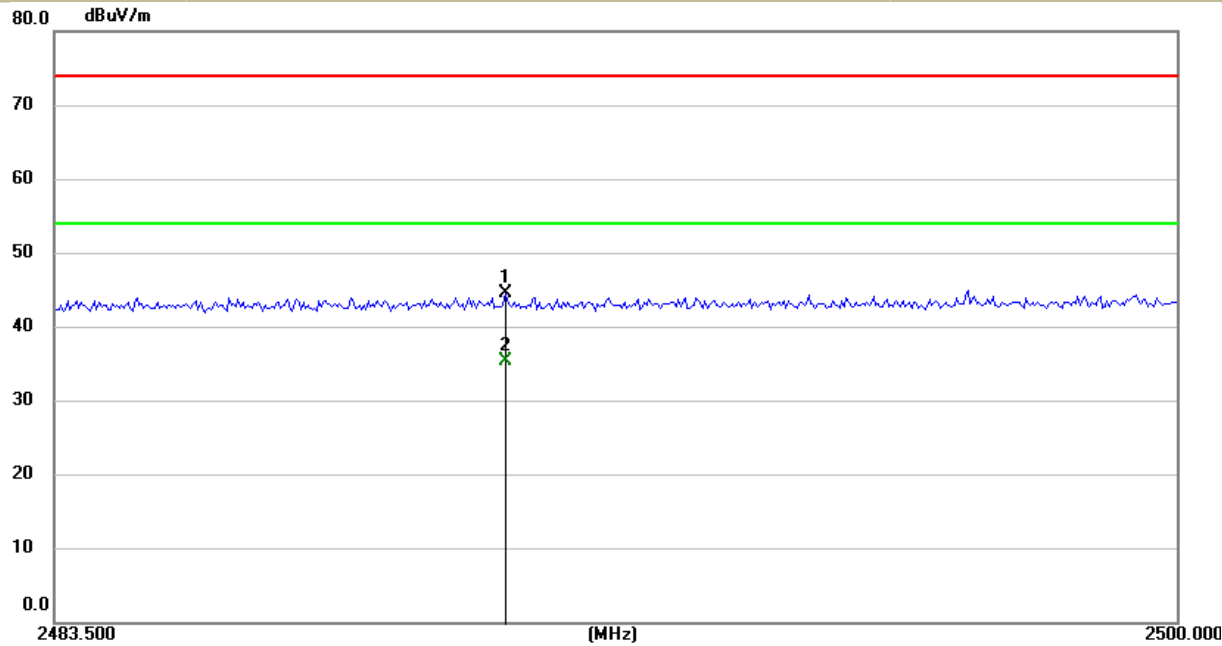
Test Model	Spurious Emission in Restricted Band 2310-2390MHz	
	Bluetooth V5.1 DTS	
	Channel 0: 2402MHz	H



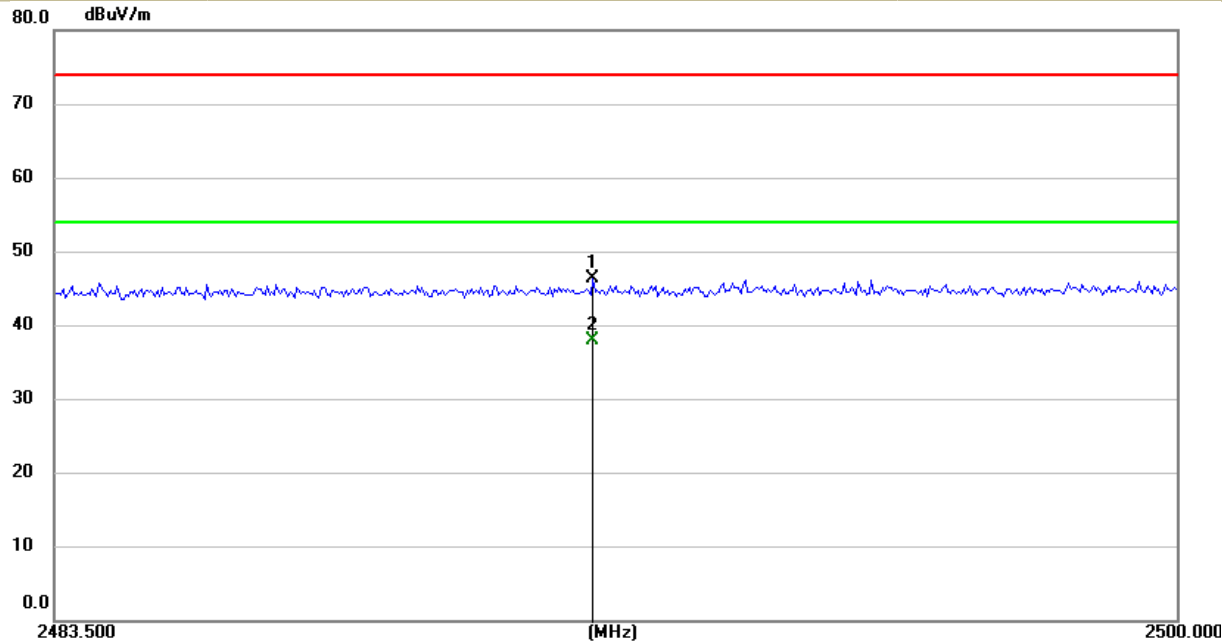
Test Model	Spurious Emission in Restricted Band 2310-2390MHz	
	Bluetooth V5.1 DTS	
	Channel 0: 2402MHz	V



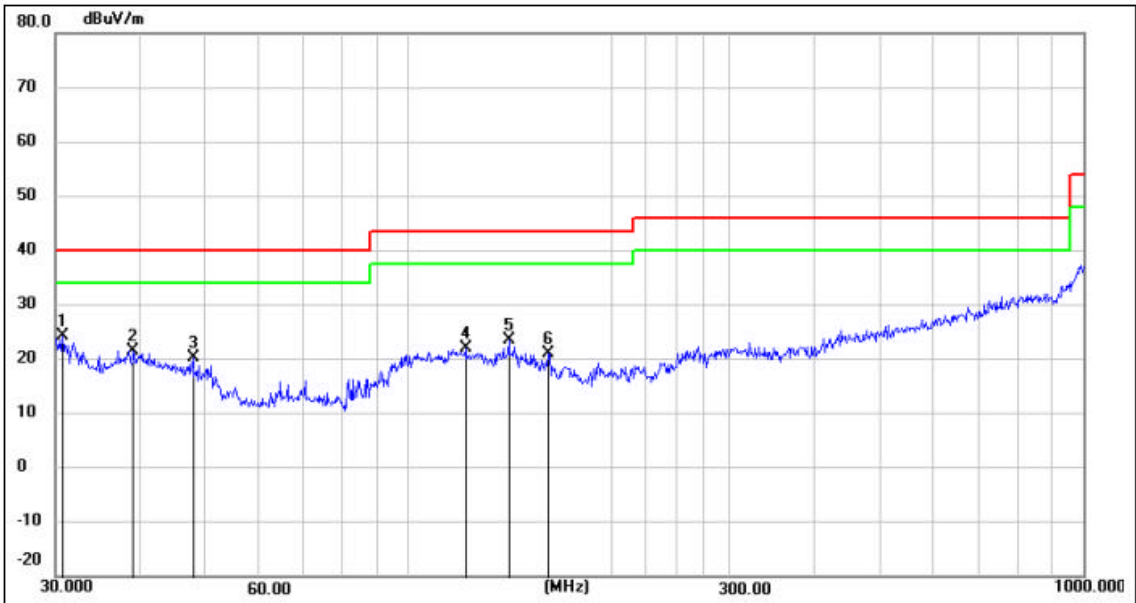
Test Model	Spurious Emission in Restricted Band 2483.5-2500MHz		
	Bluetooth V5.1 DTS		
	Channel 39: 2480MHz	H	



Test Model	Spurious Emission in Restricted Band 2483.5-2500MHz		
	Bluetooth V5.1 DTS		
	Channel 39: 2480MHz	V	

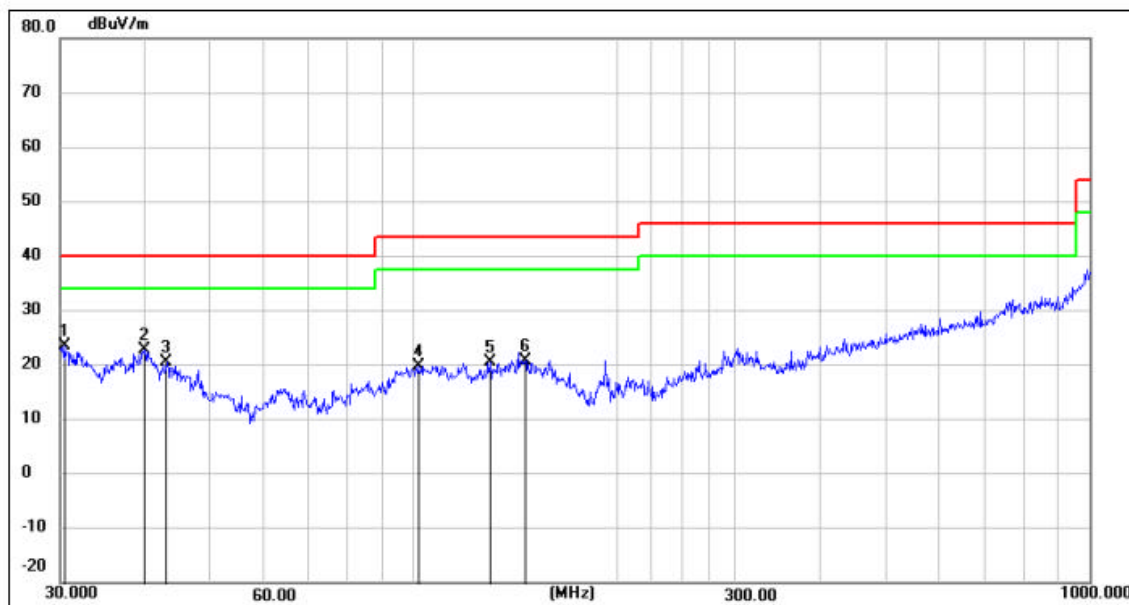


■ Spurious Emission below 1GHz (30MHz to 1GHz)
All modes have been tested, and the worst result recorded was report as below:



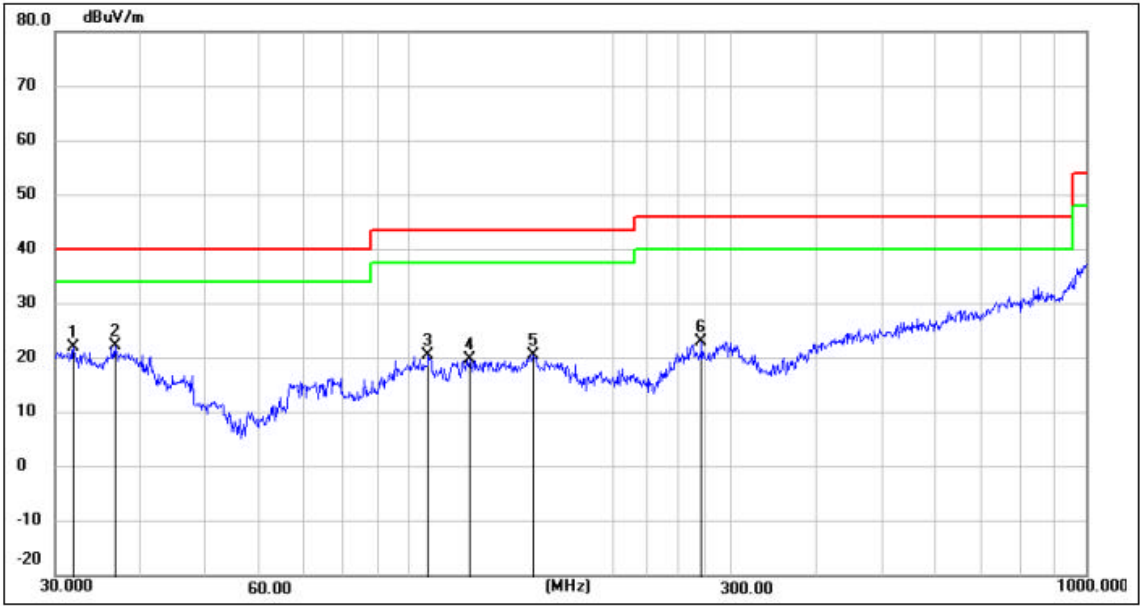
Site:	.	Antenna:Vertical	Temperature(C): 24.5(C)
Limit:	FCC Class15C Radiation(QP)		Humidity(%): 55%RH
Mode:	TX 2402	Test Engineer:	Ken
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	30.745400	24.58	-0.43	24.15	40.00	-15.85	peak
2	39.161300	26.51	-5.03	21.48	40.00	-18.52	peak
3	47.993800	28.88	-8.69	20.19	40.00	-19.81	peak
4	121.548500	25.26	-3.19	22.07	43.50	-21.43	peak
5	140.835000	26.16	-2.64	23.52	43.50	-19.98	peak
6	161.473900	25.63	-4.58	21.05	43.50	-22.45	peak



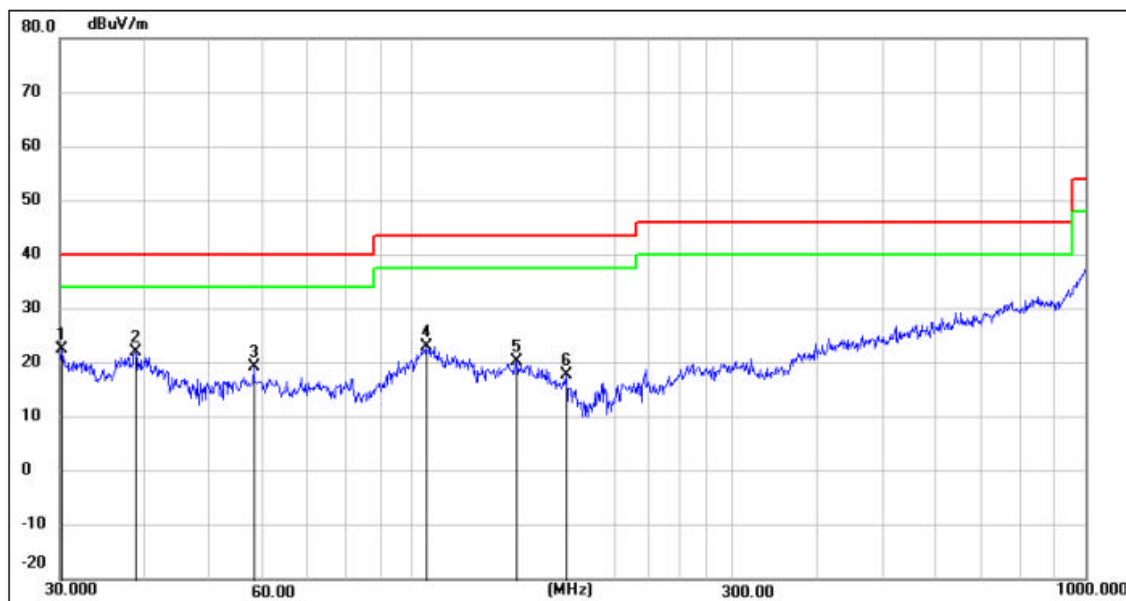
Site:	.	Antenna:Horizontal	Temperature(C): 24.5(C)
Limit:	FCC Class15C Radiation(QP)		Humidity(%): 55%RH
Mode:	TX 2402	Test Engineer:	Ken
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	30.423700	23.69	-0.08	23.61	40.00	-16.39	peak
2	39.994100	27.80	-5.03	22.77	40.00	-17.23	peak
3	43.201400	26.77	-6.27	20.50	40.00	-19.50	peak
4	101.644300	24.55	-4.68	19.87	43.50	-23.63	peak
5	129.922500	23.91	-3.27	20.64	43.50	-22.86	peak
6	146.373400	23.93	-3.14	20.79	43.50	-22.71	peak



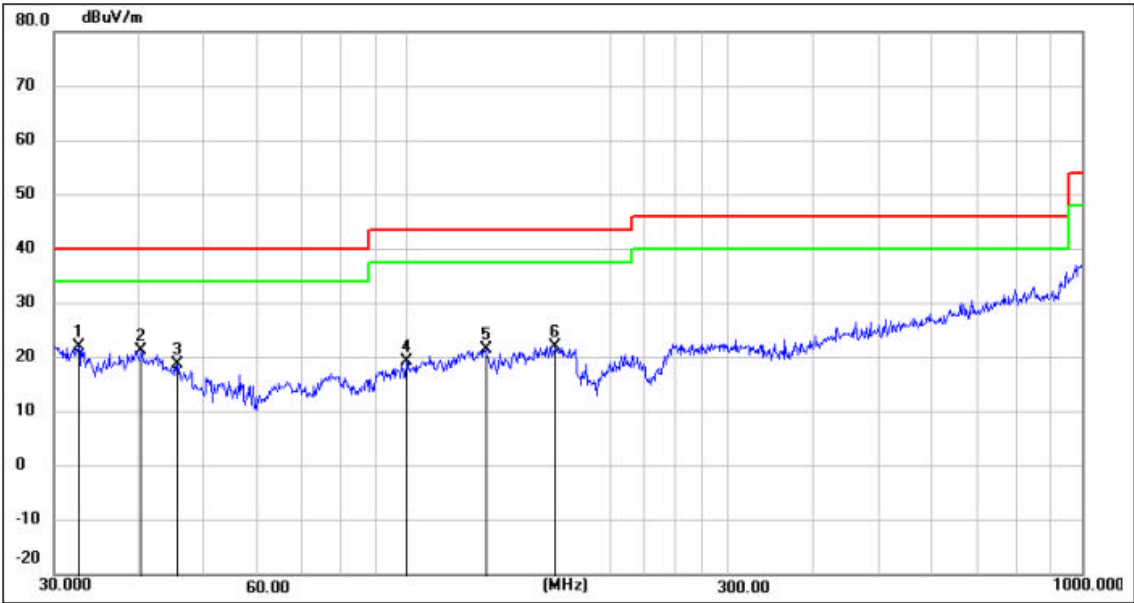
Site:	.	Antenna:Vertical	Temperature(C): 24.5(C)
Limit:	FCC Class15C Radiation(QP)		Humidity(%): 55%RH
Mode:	TX 2440	Test Engineer:	Ken
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	31.954300	23.79	-1.75	22.04	40.00	-17.96	peak
2	36.766100	27.24	-5.06	22.18	40.00	-17.82	peak
3	106.758700	24.77	-4.37	20.40	43.50	-23.10	peak
4	122.833700	23.00	-3.21	19.79	43.50	-23.71	peak
5	152.663900	24.32	-3.74	20.58	43.50	-22.92	peak
6	270.374700	25.83	-2.88	22.95	46.00	-23.05	peak



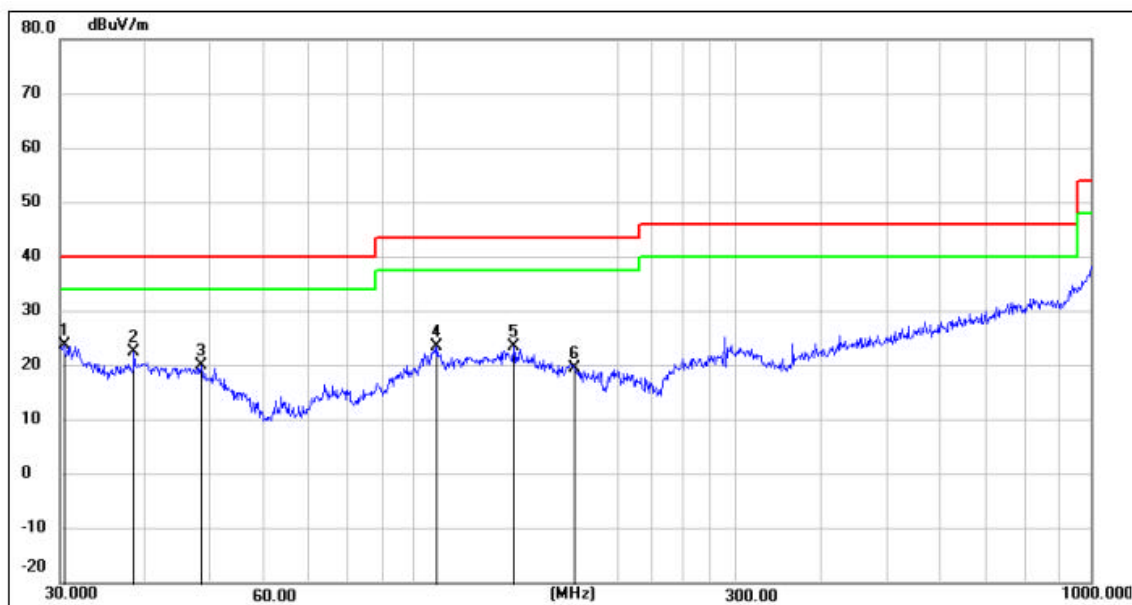
Site:	.	Antenna:Horizontal	Temperature(C): 24.5(C)
Limit:	FCC Class15C Radiation(QP)		Humidity(%): 55%RH
Mode:	TX 2440	Test Engineer:	Ken
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	30.210900	22.47	0.14	22.61	40.00	-17.39	peak
2	38.887700	27.03	-5.04	21.99	40.00	-18.01	peak
3	58.202800	33.26	-13.89	19.37	40.00	-20.63	peak
4	104.903000	27.61	-4.48	23.13	43.50	-20.37	peak
5	143.325800	23.21	-2.87	20.34	43.50	-23.16	peak
6	169.598800	23.06	-5.23	17.83	43.50	-25.67	peak



Site:	.	Antenna:Vertical	Temperature(C): 24.5(C)
Limit:	FCC Class15C Radiation(QP)		Humidity(%): 55%RH
Mode:	TX 2480	Test Engineer:	Ken
Note:			

No.	Frequency	Reading	Correct	Result	Limit	Margin	Remark
	(MHz)	(dBuV)	(dB/m)	(dBuV/m)	(dBuV/m)	(dB)	
1	32.634000	24.58	-2.49	22.09	40.00	-17.91	peak
2	40.417000	26.50	-5.20	21.30	40.00	-18.70	peak
3	45.694600	26.08	-7.37	18.71	40.00	-21.29	peak
4	99.877700	24.05	-4.83	19.22	43.50	-24.28	peak
5	130.836900	24.71	-3.22	21.49	43.50	-22.01	peak
6	166.068000	26.94	-4.95	21.99	43.50	-21.51	peak



Site:	.	Antenna:Horizontal	Temperature(C): 24.5(C)
Limit:	FCC Class15C Radiation(QP)		Humidity(%): 55%RH
Mode:	TX 2480	Test Engineer:	Ken
Note:			

No.	Frequency (MHz)	Reading (dBuV)	Correct (dB/m)	Result (dBuV/m)	Limit (dBuV/m)	Margin (dB)	Remark
1	30.423700	23.87	-0.08	23.79	40.00	-16.21	peak
2	38.616000	27.54	-5.03	22.51	40.00	-17.49	peak
3	48.501500	28.94	-8.97	19.97	40.00	-20.03	peak
4	108.266400	27.87	-4.28	23.59	43.50	-19.91	peak
5	140.342000	26.01	-2.60	23.41	43.50	-20.09	peak
6	172.598700	25.24	-5.71	19.53	43.50	-23.97	peak

7.6 CONDUCTED EMISSIONS TEST

7.6.1 Applicable Standard

According to FCC Part 15.207(a)

7.6.2 Conformance Limit

Frequency(MHz)	Conducted Emission Limit	
	Quasi-peak	Average
0.15-0.5	66-56	56-46
0.5-5.0	56	46
5.0-30.0	60	50

Note: 1. The lower limit shall apply at the transition frequencies
2. The limit decreases in line with the logarithm of the frequency in the range of 0.15 to 0.50MHz.

Remark: Test results were obtained from the following equation:

$$\begin{aligned}\text{Measurement (dB}\mu\text{V)} &= \text{LISN Factor (dB)} + \text{Cable Loss (dB)} + \text{Reading (dB}\mu\text{V)} \\ \text{Over (dB)} &= \text{Measurement (dB}\mu\text{V)} - \text{Limit (dB}\mu\text{V)}\end{aligned}$$

7.6.3 Test Configuration

Test according to clause 6.3 conducted emission test setup

7.6.4 Test Procedure

The EUT was placed on a table which is 0.8m above ground plane.
Maximum procedure was performed on the highest emissions to ensure EUT compliance.
Repeat above procedures until all frequency measured were complete.

7.6.5 Test Results

Not Applicable

7.7 ANTENNA APPLICATION

7.7.1 Antenna Requirement

Standard	Requirement
FCC CRF Part 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. This requirement does not apply to carrier current devices or to devices operated under the provisions of §15.211, §15.213, §15.217, §15.219, or §15.221. Further, this requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

For intentional device, according to FCC 47 CFR Section 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. And according to FCC 47 CFR Section 15.247 (b), if transmitting antennas of directional gain greater than 6dBi are used, the power shall be reduced by the amount in dB that the directional gain of the antenna exceeds 6dBi.

7.7.2 Result

PASS.

The EUT has 1 antenna: a Chip Antenna for BT V5.1 with classic model, the gain is -0.33 dBi;

Note: ☒ Antenna use a permanently attached antenna which is not replaceable.
☐ Not using a standard antenna jack or electrical connector for antenna replacement
☐ The antenna has to be professionally installed (please provide method of installation)

which in accordance to section 15.203, please refer to the internal photos.

----- END OF REPORT -----