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Verizon Connect, Inc. TEST REPORT

SCOPE OF WORK

EMC TESTING – MERIDIAN PRIME AND ZENITH

REPORT NUMBER

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EMC TEST REPORT
(FULL COMPLIANCE)

Report Number: 104473451LEX-002.1

Project Number: G104473451

Report Issue Date: 2/1/2021

Model(s) Tested: Meridian Prime and Zenith

Standards: Title 47 CFR Part 15.247
RSS-247 Issue 2
RSS-Gen Issue 5

Tested by:
Intertek Testing Services NA, Inc.
731 Enterprise Dr.
Lexington, KY 40510
USA

Client:
Verizon Connect, Inc.
5055 North Point Parkway
Alpharetta, GA
USA

Report prepared by



Bryan Taylor, Team Leader

Report reviewed by



Brian Lackey, Staff Engineer

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1 Introduction and Conclusion

The tests indicated in section 2.0 were performed on the product constructed as described in section 4.0. The remaining test sections are the verbatim text from the actual data sheets used during the investigation. These test sections include the test name, the specified test Method, a list of the actual Test Equipment Used, documentation Photos, Results and raw Data. No additions, deviations, or exclusions have been made from the standard(s) unless specifically noted.

Based on the results of our investigation, we have concluded the product tested **complies** with the requirements of the standard(s) indicated. The results obtained in this test report pertain only to the item(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

2 Test Summary

Section	Test full name	Result
6	Receiver Spurious Emissions (ANSI C63.4: 2014)	Pass
7	Transmitter Spurious Emissions (FCC Part 15.247(d), RSS-247 Issue 2 § 5.5)	Pass
8	Output Power (FCC Part 15.247(b)(3), RSS-247 Issue 2 § 5.4(d))	Pass
9	Occupied Bandwidth (FCC Part 15.247, RSS-247 Issue 2 § 5.2(a))	Pass
10	Power Spectral Density (FCC Part 15.247(e), RSS-247 Issue 2 § 5.2(b))	Pass
11	Conducted Spurious Emissions (FCC Part 15.247(d), RSS-247 Issue 2 § 5.5)	Pass
12	Antenna Requirement (FCC Part 15.203, RSS-Gen Issue 5 § 6.8)	Pass
---	Conducted Emissions (ANSI C63.4: 2014)	N/A ¹

1 Not applicable since this device is battery powered and does not connect to the AC mains.



3 Client Information

This product was tested at the request of the following:

Client Information	
Client Name:	Verizon Connect, Inc.
Address:	5055 North Point Parkway Alpharetta, GA USA
Contact:	Keith Wright
Email:	Keith.wright@verizonconnect.com
Manufacturer Information	
Manufacturer Name:	Verizon Connect, Inc.
Manufacturer Address:	5055 North Point Parkway Alpharetta, GA USA



4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	Meridian Prime and Zenith
Model Number	AI-110
Serial Number	42400000267
Supported Transmitters	LTE, GSM, Bluetooth Low Energy
Embedded Module	BG95-M3
Receive Date	12/17/2020
Test Start Date	12/16/2020
Test End Date	12/21/2020
Device Received Condition	Good
Test Sample Type	Production
Rated Voltage	4.5VDC
Low Voltage	3.6VDC
High Voltage	5.4VDC
Description of Equipment Under Test (provided by client)	
<p>The Meridian Prime and Zenith devices are wireless enabled asset trackers. Meridian Zenith is a battery-only device for use as an asset tracker. The Meridian Prime includes a wiring harness for external power. Both models include the BG95-M3 cellular module and Bluetooth Low Energy transmitter.</p>	

4.1 Variant Models:

There were no variant models covered by this evaluation.



5 System Setup and Method

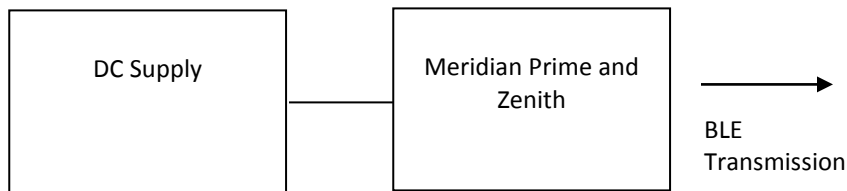
5.1 Method:

Configuration as required by ANSI C63.4: 2014 and ANSI C63.10:2013

No.	Descriptions of EUT Exercising
1	Special test code allowed the tamper button to be used to cycle through low, mid, and high channels.
2	Idle, not transmitting.

Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
1	DC power cable	0.5	none	none	DC power supply
2	USB Cables	1	none	none	USB Plug

5.2 EUT Block Diagram:





6 Receiver Spurious Emissions

6.1 Test Method

Tests are performed in accordance with ANSI C63.4: 2014

TEST SITE: 10m ALSE

Site Designation: 10m Chamber

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucisp
Radiated Emissions, 10m	30-1000 MHz	3.9dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.0dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.7dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.7dB	5.5 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required.



6.2 Sample Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured reading. The basic equation with a sample calculation is as follows:

$$FS = RA + AF + CF - AG$$

Where

- FS = Field Strength in dB μ V/m
- RA = Receiver Amplitude (including preamplifier) in dB μ V
- CF = Cable Attenuation Factor in dB
- AF = Antenna Factor in dB
- AG = Amplifier Gain in dB

In the following table(s), the reading shown on the data table reflects the preamplifier gain. An example for the calculations in the following table is as follows.

Assume a receiver reading of 52.0 dB μ V is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dB μ V/m. This value in dB μ V/m was converted to its corresponding level in μ V/m.

RA = 52.0 dB μ V
AF = 7.4 dB/m
CF = 1.6 dB
AG = 29.0 dB
FS = 32 dB μ V/m

To convert from dB μ V to μ V or mV the following was used:

$$UF = 10^{(NF / 20)} \text{ where } UF = \text{Net Reading in } \mu\text{V}$$
$$NF = \text{Net Reading in dB}\mu\text{V}$$

Example:

$$FS = RA + AF + CF - AG = 52.0 + 7.4 + 1.6 - 29.0 = 32.0$$
$$UF = 10^{(32 \text{ dB}\mu\text{V} / 20)} = 39.8 \mu\text{V/m}$$



6.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3900	Rohde & Schwarz	ESU40	10/5/2020	10/5/2021
Bilog Antenna (30MHz-1GHz)	7085	SunAR	JB6	9/4/2020	9/4/2021
Horn Antenna (18-40GHz)	3779	ETS	3116c	7/23/2020	7/23/2021
Horn Antenna	4001	ETS	3117	1/16/2020	1/16/2021
System Controller	4096	ETS Lindgren	2090	Verify at Time of Use	Verify at Time of Use
System Controller	3957	Sunol Sciences	SC99V	Verify at Time of Use	Verify at Time of Use
Preamplifier (18-40GHz)	3921	Rohde & Schwarz	TS-PR40	12/21/2020	12/21/2021
Coaxial Cable (40GHz)	7020			12/21/2020	12/21/2021
Coaxial Cable (40GHz)	7021			12/21/2020	12/21/2021
3m Cable Antenna→Preamp	3074			12/21/2020	12/21/2021
3m Cable Preamplifier	3918	Rohde & Schwarz	TS-PR18	12/21/2020	12/21/2021
3m Cable Preamp→Chamber	2588			12/21/2020	12/21/2021
3m Cable Chamber→Control Room	2593			12/21/2020	12/21/2021
3m Cable Control Room→Receiver	2592			12/21/2020	12/21/2021

6.4 Software Utilized

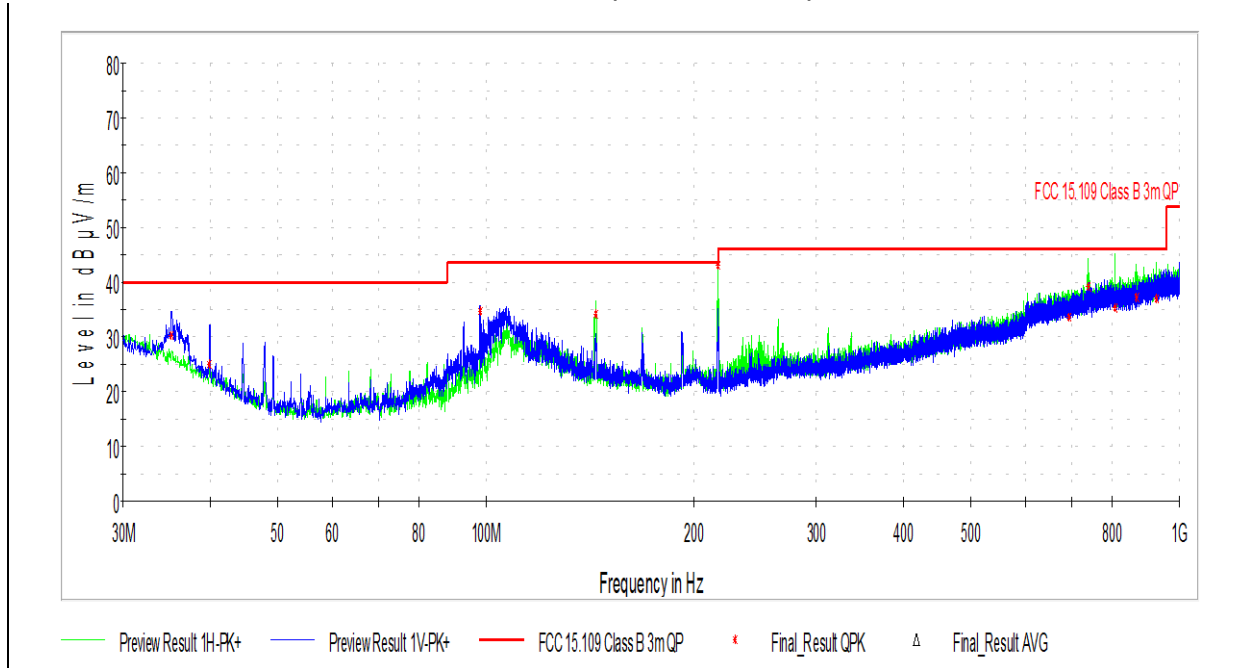
Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.02

6.5 Test Results

The sample tested was found to be **compliant**.



6.6 Plots/Data: Radiated Emissions, 30MHz – 1GHz (Transmitters Idle)



Frequency (MHz)	QuasiPeak (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
35.227222	30.32	40.00	9.68	120.000	101.0	V	1.0	23.7
39.915556	25.03	40.00	14.97	120.000	105.1	V	305.0	20.4
98.061667	34.81	43.52	8.71	120.000	284.0	V	179.0	18.9
143.975000	34.09	43.52	9.43	120.000	202.9	H	19.0	21.6
215.970556	42.95	43.52	0.57	120.000	101.1	H	49.0	20.5
692.833333	33.62	46.02	12.40	120.000	400.0	H	82.0	33.9
738.854444	39.20	46.02	6.82	120.000	104.3	H	6.0	34.5
806.754444	35.36	46.02	10.66	120.000	285.6	H	138.0	35.6
866.786667	37.32	46.02	8.70	120.000	240.3	H	0.0	36.2
927.088333	36.81	46.02	9.21	120.000	400.0	H	132.0	36.9

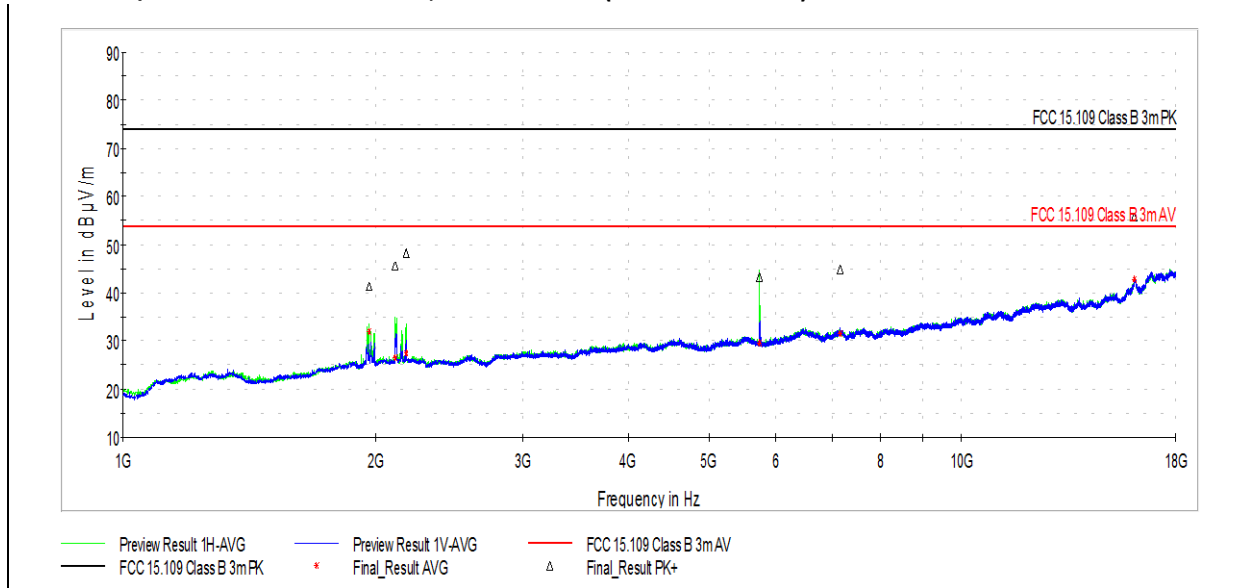
Test Personnel: Michael Carlson
 Supervising/Reviewing Engineer: _____
 (Where Applicable) NA
 FCC Part 15B
 Product Standard: ICES-003 Issue 6
 Input Voltage: 4.5 VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: Class B
 Ambient Temperature: 21.5 °C
 Relative Humidity: 40.2 %
 Atmospheric Pressure: 988.8 mbar

Deviations, Additions, or Exclusions: None



6.7 Plots/Data: Radiated Emissions, 1GHz – 18GHz (Transmitters Idle)



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1966.000000	41.27	73.98	32.71	1000.000	100.0	H	0.0	2.7
2110.500000	45.56	73.98	28.42	1000.000	150.0	H	0.0	2.4
2176.500000	48.25	73.98	25.73	1000.000	346.0	H	243.0	2.8
5740.000000	43.19	73.98	30.79	1000.000	355.0	H	347.0	9.6
7170.000000	44.85	73.98	29.13	1000.000	410.0	V	207.0	11.7
16078.000000	55.87	73.98	18.11	1000.000	410.0	H	159.0	25.2

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1966.000000	32.05	53.98	21.93	1000.000	100.0	H	0.0	2.7
2110.500000	26.49	53.98	27.49	1000.000	150.0	H	0.0	2.4
2176.500000	27.57	53.98	26.41	1000.000	346.0	H	243.0	2.8
5740.000000	29.50	53.98	24.48	1000.000	355.0	H	347.0	9.6
7170.000000	31.39	53.98	22.59	1000.000	410.0	V	207.0	11.7
16078.000000	42.80	53.98	11.18	1000.000	410.0	H	159.0	25.2

Test Personnel: Ben Coolbear
 Supervising/Reviewing Engineer: NA
 (Where Applicable) FCC Part 15B
 Product Standard: ICES-003 Issue 6
 Input Voltage: 4.5 VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: Class B
 Ambient Temperature: 21.5 °C
 Relative Humidity: 40.2 %
 Atmospheric Pressure: 988.8 mbar

Deviations, Additions, or Exclusions: None



7 Transmitter Spurious Emissions

7.1 Test Limits

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. Attenuation below the general limits specified in §15.209(a) 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)).

RSS-247 Issue 2 § 5.5:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

7.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013 § 11.12.1 Radiated emission measurements.



7.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3900	Rohde & Schwarz	ESU40	10/5/2020	10/5/2021
Magnetic Loop Antenna	2366	ETS	6502	7/17/2020	7/17/2021
Bilog Antenna (30MHz-1GHz)	7085	SunAR	JB6	9/4/2020	9/4/2021
Horn Antenna (18-40GHz)	3779	ETS	3116c	7/23/2020	7/23/2021
Horn Antenna	4001	ETS	3117	1/16/2020	1/16/2021
System Controller	4096	ETS Lindgren	2090	Verify at Time of Use	Verify at Time of Use
System Controller	3957	Sunol Sciences	SC99V	Verify at Time of Use	Verify at Time of Use
Preamplifier (18-40GHz)	3921	Rohde & Schwarz	TS-PR40	12/21/2020	12/21/2021
Coaxial Cable (40GHz)	7020			12/21/2020	12/21/2021
Coaxial Cable (40GHz)	7021			12/21/2020	12/21/2021
3m Cable Antenna→Preamp	3074			12/21/2020	12/21/2021
3m Cable Preamplifier	3918	Rohde & Schwarz	TS-PR18	12/21/2020	12/21/2021
3m Cable Preamp→Chamber	2588			12/21/2020	12/21/2021
3m Cable Chamber→Control Room	2593			12/21/2020	12/21/2021
3m Cable Control Room→Receiver	2592			12/21/2020	12/21/2021

7.4 Software Utilized

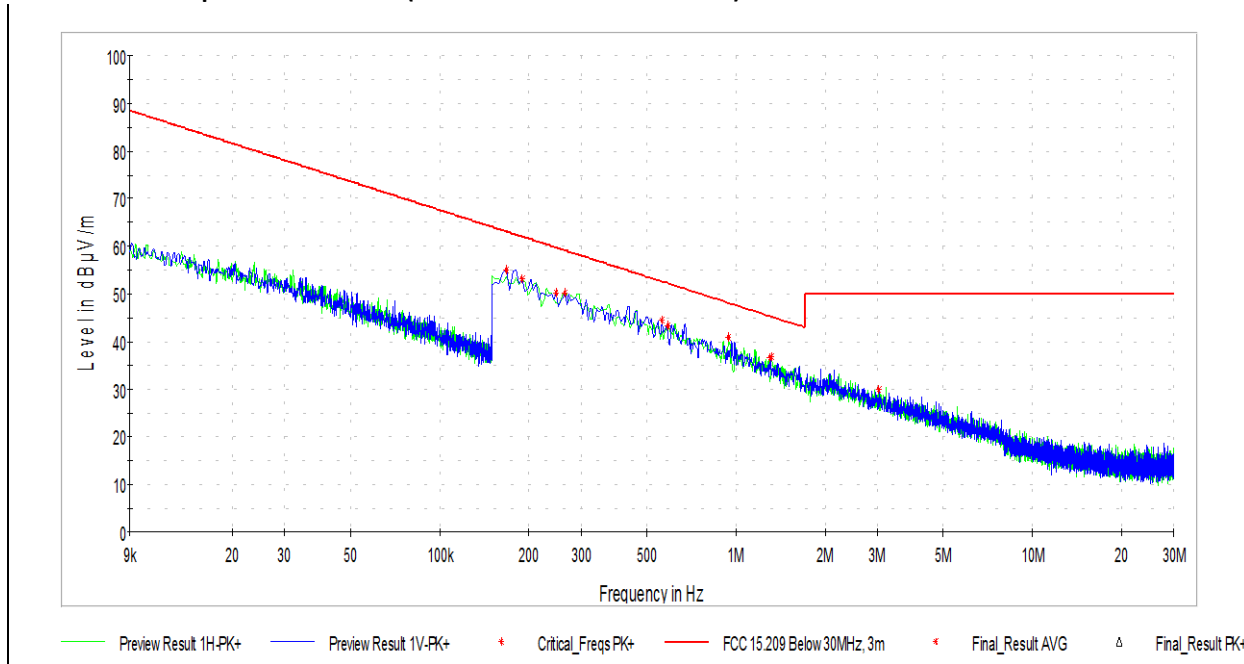
Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.02

7.5 Test Results

The sample tested was found to be **compliant**. The data presented represents the worst case emissions with the device positioned in three orthogonal positions. All observed emissions outside of the band of operation were attenuated by at least 20dB.



7.1 Radiated Spurious Emissions (Bluetooth BLE 9kHz – 30MHz)



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
0.562632	44.40	52.60	8.20	9.00	0.0	12.0
1.317662	36.76	45.21	8.45	9.00	90.0	11.9
3.020868	30.01	50.00	19.99	9.00	90.0	11.6
0.167559	55.13	63.12	7.99	9.00	90.0	12.1
0.246574	50.18	59.77	9.58	9.00	90.0	12.0
0.944537	40.90	48.10	7.20	9.00	180.0	11.9
0.264132	50.14	59.17	9.03	9.00	180.0	11.9
1.300103	36.51	45.32	8.81	9.00	180.0	11.9
0.588971	43.23	52.20	8.97	9.00	270.0	12.0
0.189507	53.17	62.05	8.88	9.00	270.0	12.1

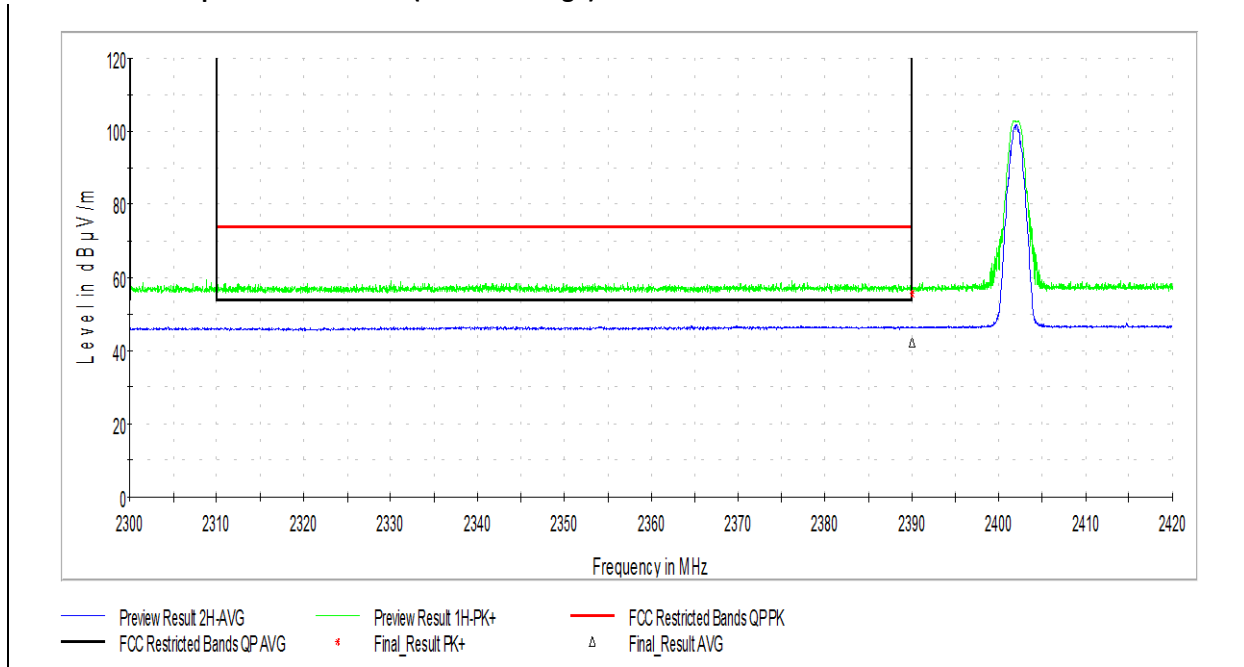
Test Personnel: Bryan Taylor
 Supervising/Reviewing Engineer: N/A
 (Where Applicable) FCC Part 15.247
 Product Standard: RSS-247 Issue 2
 Input Voltage: 4.5VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: 15.205 Restricted Bands
 Ambient Temperature: 24.3°C
 Relative Humidity: 52.8%
 Atmospheric Pressure: 987.3 mbar

Deviations, Additions, or Exclusions: Test results above are the worst case from low, mid, and high transmit channels. The test site used for these measurements was correlated to an open area test site.



7.2 Radiated Spurious Emissions (Low Band Edge)



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	55.49	73.98	18.49	1000.000	157.0	H	92.0	38.6

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2390.000000	42.35	53.98	11.63	1000.000	157.0	H	92.0	38.6

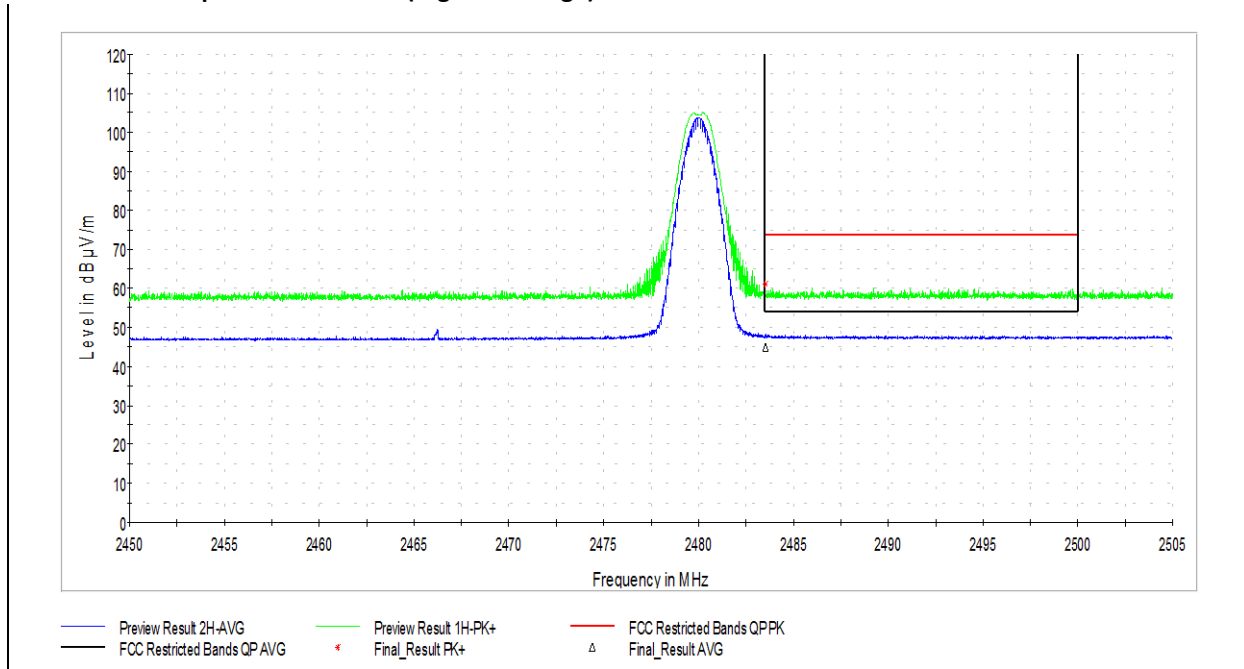
Test Personnel: Bryan Taylor
 Supervising/Reviewing Engineer: N/A
 (Where Applicable) FCC Part 15.247
 Product Standard: RSS-247 Issue 2
 Input Voltage: 4.5VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: 15.205 Restricted Bands
 Ambient Temperature: 24.3°C
 Relative Humidity: 52.8%
 Atmospheric Pressure: 987.3 mbar

Deviations, Additions, or Exclusions: None



7.3 Radiated Spurious Emissions (High Band Edge)



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.518269	61.11	73.98	12.87	1000.000	100.0	H	225.0	39.2

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.518269	44.80	53.98	9.18	1000.000	100.0	H	225.0	39.2

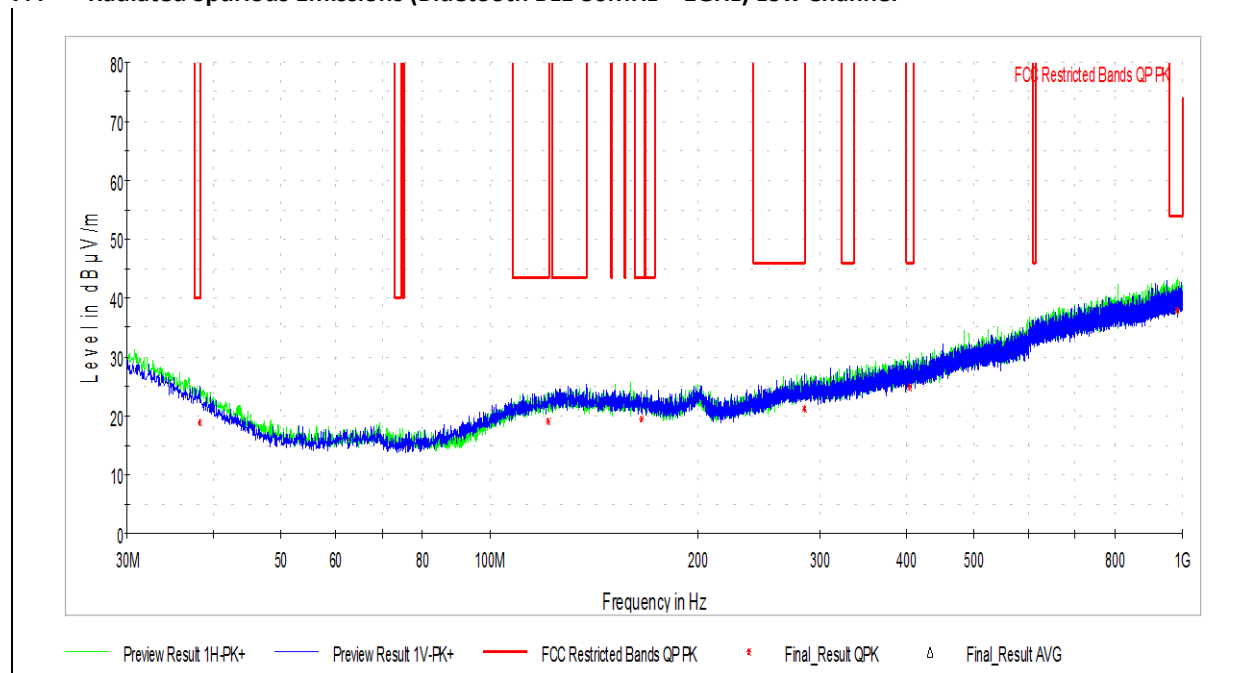
Test Personnel: Bryan Taylor
 Supervising/Reviewing Engineer: N/A
 (Where Applicable)
 Product Standard: FCC Part 15.247
RSS-247 Issue 2
 Input Voltage: 4.5VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: 15.205 Restricted Bands
 Ambient Temperature: 24.3°C
 Relative Humidity: 52.8%
 Atmospheric Pressure: 987.3 mbar

Deviations, Additions, or Exclusions: None



7.4 Radiated Spurious Emissions (Bluetooth BLE 30MHz – 1GHz) Low Channel



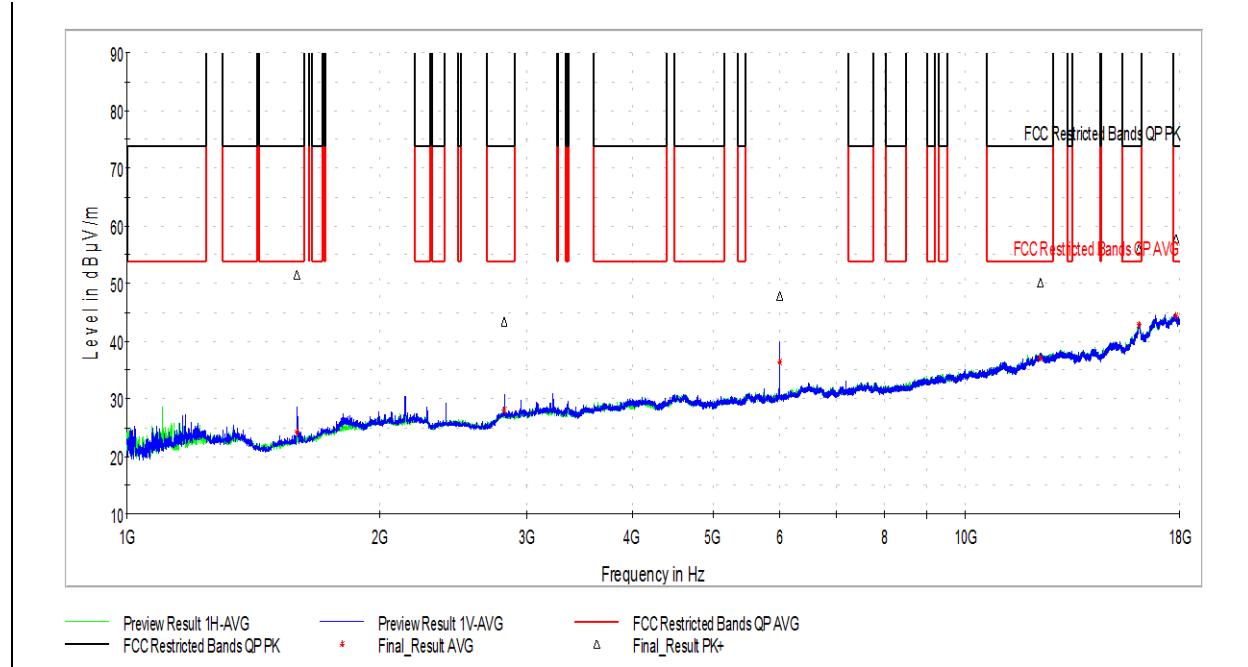
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
38.137222	18.84	40.00	21.16	120.000	99.9	V	108.0	21.7
121.503333	18.95	43.52	24.57	120.000	106.4	H	182.0	21.9
165.530556	19.42	43.52	24.10	120.000	249.4	V	36.0	21.7
284.786667	21.22	46.02	24.80	120.000	360.9	V	128.0	23.5
403.234445	24.76	46.02	21.26	120.000	210.2	H	259.0	27.0
983.779444	37.92	53.98	16.06	120.000	167.7	H	74.0	37.7

Test Personnel:	<u>Michael Carlson</u>	Test Date:	<u>12/21/2020</u>
Supervising/Reviewing Engineer:	<u>(Where Applicable) NA</u>	Limit Applied:	<u>FCC Part 15.205 Restricted Band Limit</u>
Product Standard:	<u>RSS-247 Issue 2</u>	Ambient Temperature:	<u>21.5 °C</u>
Input Voltage:	<u>4.5 VDC</u>	Relative Humidity:	<u>40.2 %</u>
Pretest Verification w / Ambient Signals or BB Source:	<u>Yes</u>	Atmospheric Pressure:	<u>988.8 mbar</u>

Deviations, Additions, or Exclusions: None



7.5 Radiated Spurious Emissions (Bluetooth BLE 1GHz – 18GHz) Low Channel



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1594.000000	51.61	73.98	22.37	1000.000	389.0	V	231.0	-1.3
2817.000000	43.35	73.98	30.63	1000.000	298.0	V	255.0	4.6
12269.500000	50.22	73.98	23.76	1000.000	100.0	V	328.0	18.5
16080.000000	55.98	73.98	18.00	1000.000	343.0	H	218.0	25.2
17813.500000	57.86	73.98	16.12	1000.000	100.0	H	302.0	26.6

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1594.000000	24.08	53.98	29.90	1000.000	389.0	V	231.0	-1.3
2817.000000	28.14	53.98	25.84	1000.000	298.0	V	255.0	4.6
12269.500000	36.99	53.98	16.99	1000.000	100.0	V	328.0	18.5
16080.000000	42.85	53.98	11.13	1000.000	343.0	H	218.0	25.2
17813.500000	44.29	53.98	9.69	1000.000	100.0	H	302.0	26.6

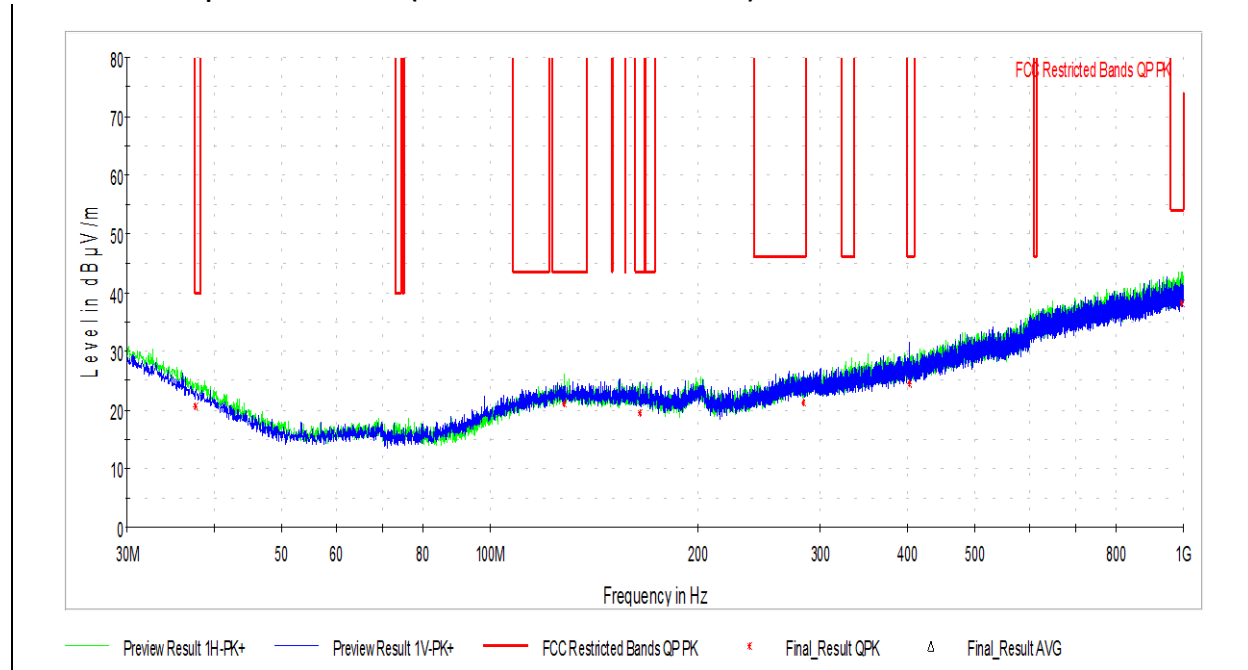
Test Personnel: Michael Carlson
 Supervising/Reviewing Engineer: NA
 (Where Applicable) FCC Part 15.247
 Product Standard: RSS-247 Issue 2
 Input Voltage: 4.5 VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: FCC Part 15.205 Restricted Band Limit
 Ambient Temperature: 21.5 °C
 Relative Humidity: 40.2 %
 Atmospheric Pressure: 988.8 mbar

Deviations, Additions, or Exclusions: None



7.6 Radiated Spurious Emissions (Bluetooth BLE 30MHz – 1 GHz) Mid Channel



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
37.652222	20.51	40.00	19.49	120.000	105.0	H	54.0	23.2
128.023889	21.10	43.52	22.42	120.000	242.5	H	319.0	22.1
164.398889	19.42	43.52	24.10	120.000	231.0	V	94.0	21.8
282.900556	21.22	46.02	24.80	120.000	204.2	V	141.0	23.5
402.965000	24.48	46.02	21.54	120.000	260.6	V	0.0	26.7
994.880556	38.08	53.98	15.90	120.000	177.5	H	9.0	37.9

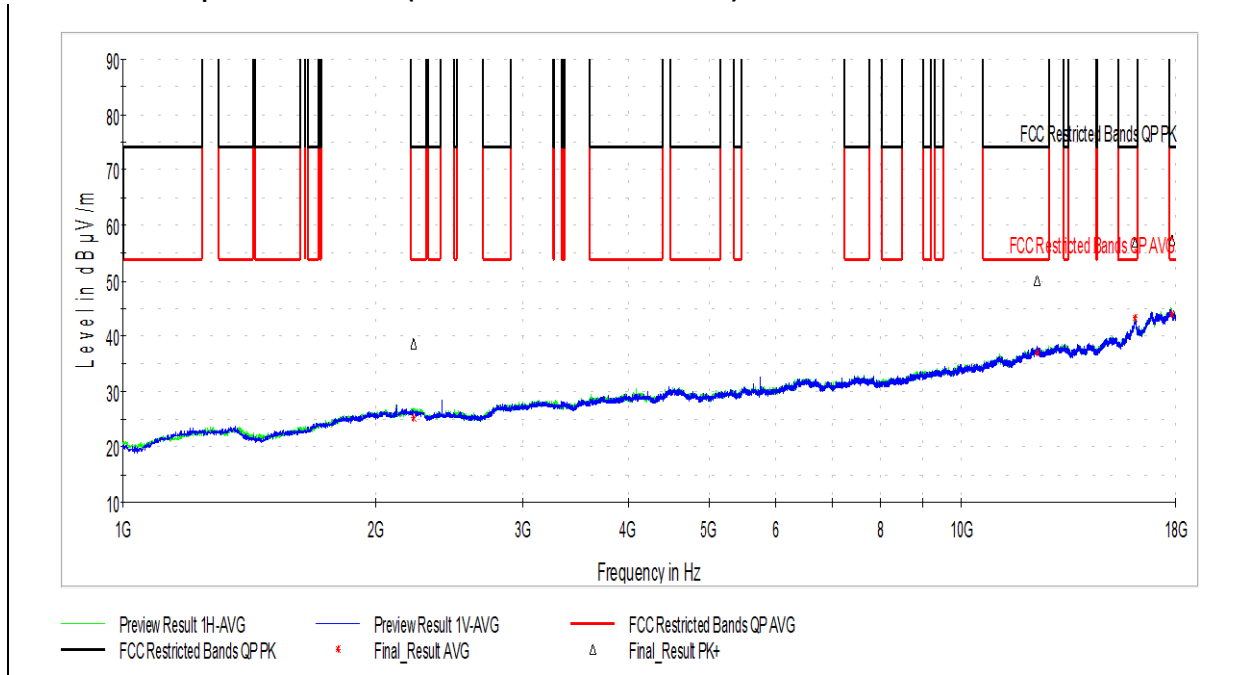
Test Personnel: Ben Coolbear
 Supervising/Reviewing Engineer: NA
 (Where Applicable)
 FCC Part 15.247
 Product Standard: RSS-247 Issue 2
 Input Voltage: 4.5 VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: FCC Part 15.205 Restricted Band Limit
 Ambient Temperature: 21.5 °C
 Relative Humidity: 40.2 %
 Atmospheric Pressure: 988.8 mbar

Deviations, Additions, or Exclusions: None



7.7 Radiated Spurious Emissions (Bluetooth BLE 1GHz – 18GHz) Mid Channel



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2218.500000	38.55	73.98	35.43	1000.000	116.0	H	292.0	3.4
12314.000000	50.20	73.98	23.78	1000.000	100.0	V	334.0	18.5
16102.500000	56.92	73.98	17.06	1000.000	100.0	H	150.0	25.6
17828.500000	57.34	73.98	16.64	1000.000	100.0	H	244.0	26.5

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2218.500000	25.17	53.98	28.81	1000.000	116.0	H	292.0	3.4
12314.000000	36.97	53.98	17.01	1000.000	100.0	V	334.0	18.5
16102.500000	43.24	53.98	10.74	1000.000	100.0	H	150.0	25.6
17828.500000	44.11	53.98	9.87	1000.000	100.0	H	244.0	26.5

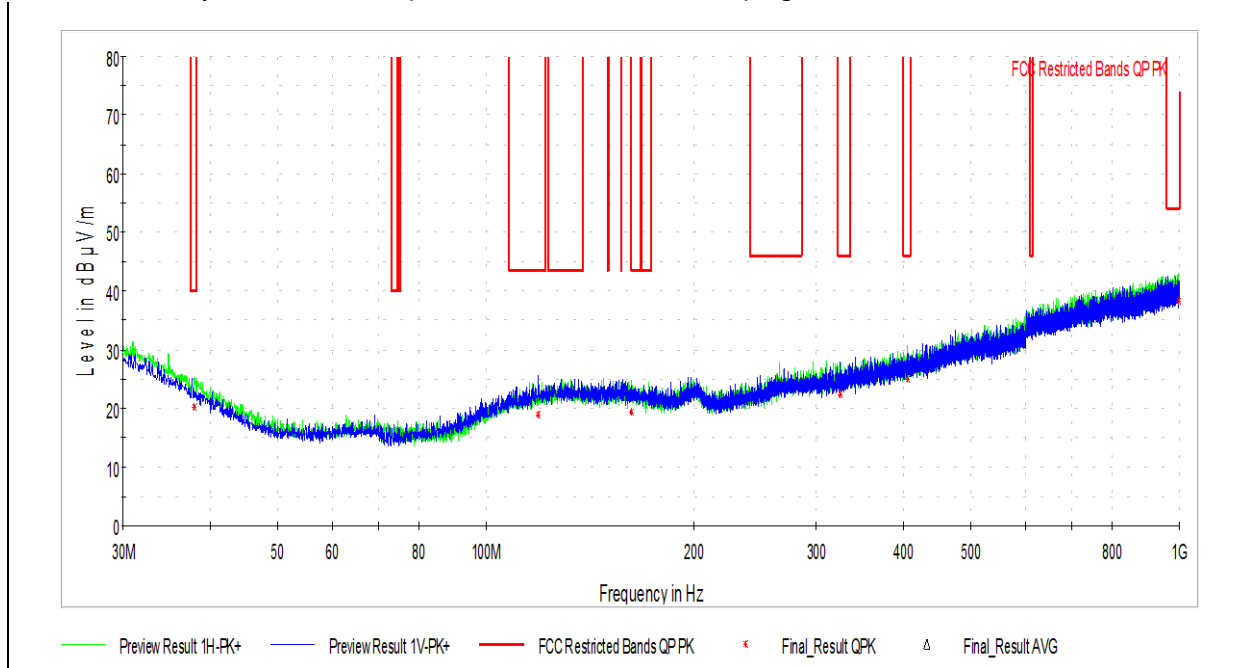
Test Personnel: Ben Coolbear
 Supervising/Reviewing Engineer: (Where Applicable) NA
 Product Standard: RSS-247 Issue 2
 Input Voltage: 4.5 VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: FCC Part 15.205 Restricted Band Limit
 Ambient Temperature: 21.5 °C
 Relative Humidity: 40.2 %
 Atmospheric Pressure: 988.8 mbar

Deviations, Additions, or Exclusions: None



7.8 Radiated Spurious Emissions (Bluetooth BLE 30MHz – 1 GHz) High Channel



Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
38.029445	20.13	40.00	19.87	120.000	99.9	H	174.0	22.9
118.970556	19.02	43.52	24.50	120.000	400.1	V	145.0	21.9
162.027778	19.42	43.52	24.10	120.000	251.0	H	0.0	21.7
324.179445	22.26	46.02	23.76	120.000	129.3	V	108.0	24.3
405.336111	24.86	46.02	21.16	120.000	332.0	H	8.0	27.1
997.844444	38.20	53.98	15.78	120.000	142.2	H	327.0	38.0

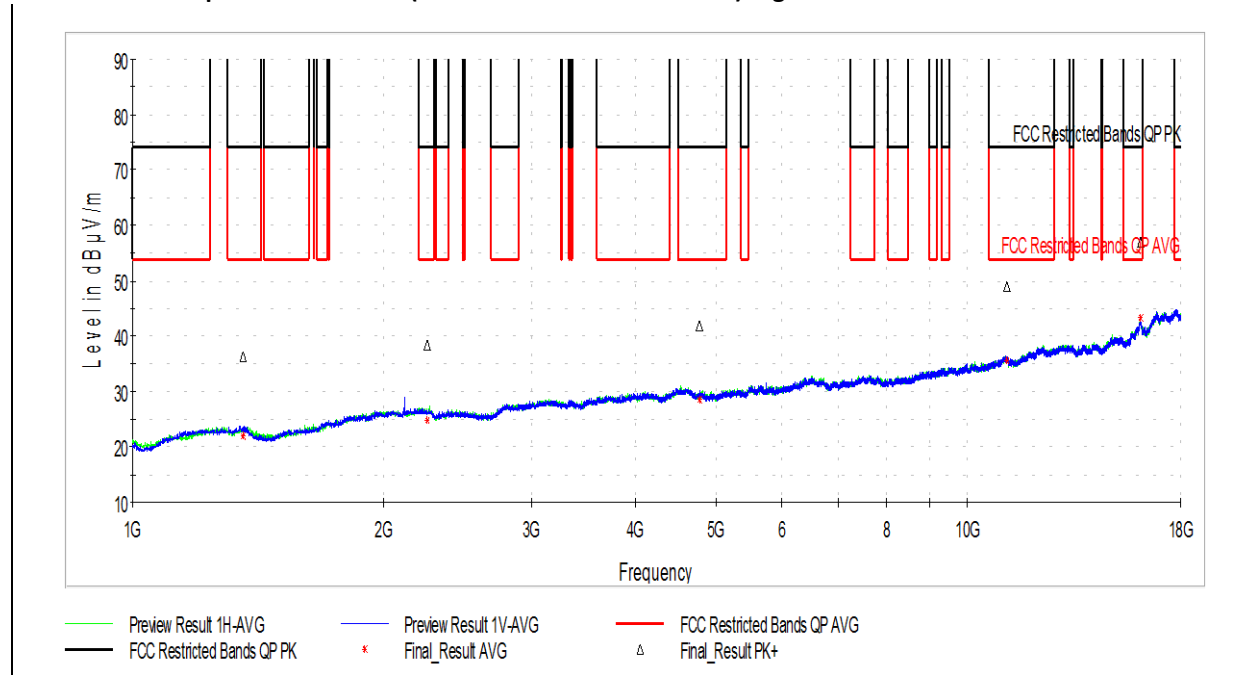
Test Personnel: Ben Coolbear
 Supervising/Reviewing Engineer: NA
 (Where Applicable)
 Product Standard: FCC Part 15.247
RSS-247 Issue 2
 Input Voltage: 4.5 VDC
 Pretest Verification w / Ambient Signals or BB Source: Yes

Test Date: 12/21/2020
 Limit Applied: FCC Part 15.205 Restricted Band Limit
 Ambient Temperature: 21.5 °C
 Relative Humidity: 40.2 %
 Atmospheric Pressure: 988.8 mbar

Deviations, Additions, or Exclusions: None



7.9 Radiated Spurious Emissions (Bluetooth BLE 1GHz – 18GHz) High Channel



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1356.500000	36.29	73.98	37.69	1000.000	100.0	H	252.0	-0.6
2253.000000	38.31	73.98	35.67	1000.000	100.0	H	336.0	3.3
4773.000000	42.00	73.98	31.98	1000.000	100.0	V	339.0	8.0
11152.000000	48.97	73.98	25.01	1000.000	262.0	V	14.0	17.2
16103.000000	56.89	73.98	17.09	1000.000	322.0	V	269.0	25.6

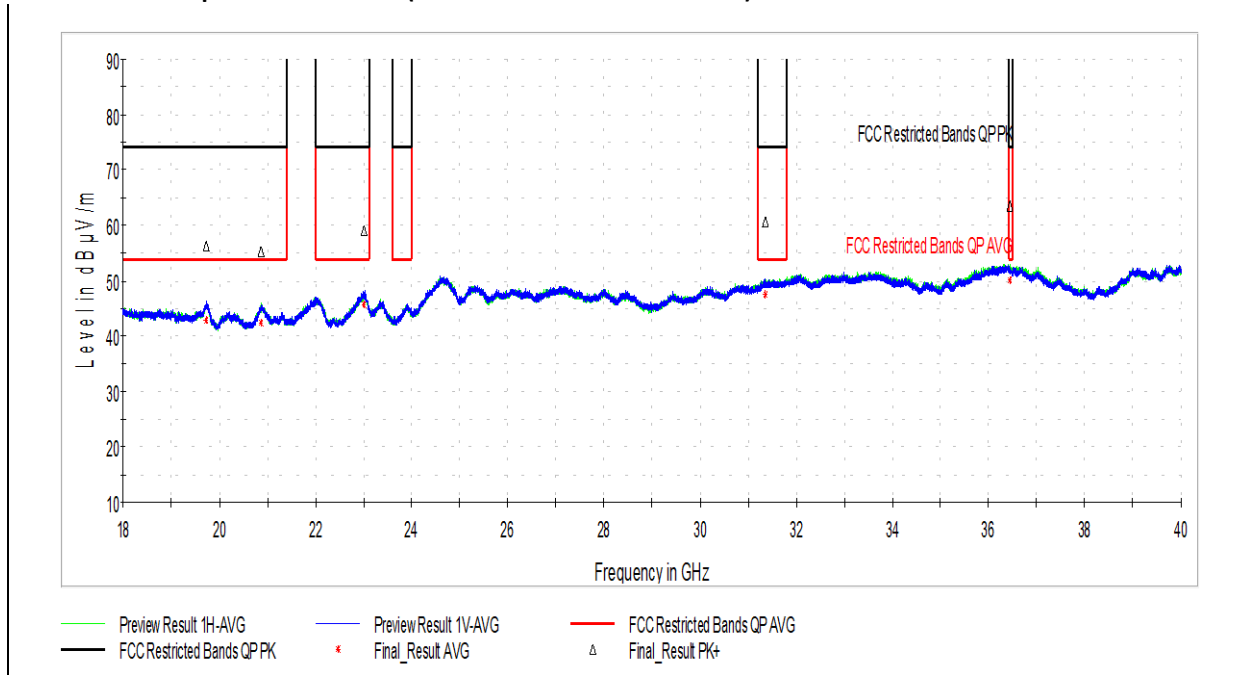
Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
1356.500000	21.85	53.98	32.13	1000.000	100.0	H	252.0	-0.6
2253.000000	24.88	53.98	29.10	1000.000	100.0	H	336.0	3.3
4773.000000	28.53	53.98	25.45	1000.000	100.0	V	339.0	8.0
11152.000000	35.49	53.98	18.49	1000.000	262.0	V	14.0	17.2
16103.000000	43.20	53.98	10.78	1000.000	322.0	V	269.0	25.6

Test Personnel:	<u>Ben Coolbear</u>	Test Date:	<u>12/21/2020</u>
Supervising/Reviewing Engineer:	<u>NA</u>	Limit Applied:	<u>FCC Part 15.205 Restricted Band Limit</u>
(Where Applicable)	<u>FCC Part 15.247</u>	Ambient Temperature:	<u>21.5 °C</u>
Product Standard:	<u>RSS-247 Issue 2</u>	Relative Humidity:	<u>40.2 %</u>
Input Voltage:	<u>4.5 VDC</u>	Atmospheric Pressure:	<u>988.8 mbar</u>
Pretest Verification w / Ambient Signals or BB Source:	<u>Yes</u>		

Deviations, Additions, or Exclusions: None



7.10 Radiated Spurious Emissions (Bluetooth BLE 18GHz – 40GHz)



Frequency	MaxPeak	Limit	Margin	Bandwidth	Height	Pol	Azimuth	Corr.
19725.500000	56.12	73.98	17.86	1000.000	100.0	H	1.0	16.0
20871.500000	55.31	73.98	18.67	1000.000	234.0	H	152.0	13.0
23005.000000	58.94	73.98	15.04	1000.000	227.0	V	216.0	10.6
31363.500000	60.66	73.98	13.32	1000.000	100.0	V	160.0	16.7
36441.000000	63.52	73.98	10.46	1000.000	100.0	H	0.0	19.4

Frequency	Average	Limit	Margin	Bandwidth	Height	Pol	Azimuth	Corr.
19725.500000	42.96	53.98	11.02	1000.000	100.0	H	1.0	16.0
20871.500000	42.29	53.98	11.69	1000.000	234.0	H	152.0	13.0
23005.000000	45.72	53.98	8.26	1000.000	227.0	V	216.0	10.6
31363.500000	47.50	53.98	6.48	1000.000	100.0	V	160.0	16.7
36441.000000	50.05	53.98	3.93	1000.000	100.0	H	0.0	19.4

Test Personnel:	<u>Ben Coolbear</u>	Test Date:	<u>12/21/2020</u>
Supervising/Reviewing Engineer:	<u>(Where Applicable) NA</u>	Limit Applied:	<u>FCC Part 15.205 Restricted Band Limit</u>
Product Standard:	<u>FCC Part 15.247</u>	Ambient Temperature:	<u>21.5 °C</u>
Input Voltage:	<u>RSS-247 Issue 2</u>	Relative Humidity:	<u>40.2 %</u>
Pretest Verification w / Ambient Signals or BB Source:	<u>Yes</u>	Atmospheric Pressure:	<u>988.8 mbar</u>

Deviations, Additions, or Exclusions: Test results above are the worst case from low, mid, and high transmit channels.



8 Output Power

8.1 Test Limits

FCC Part 15.247(b)(3):

For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt. As an alternative to a peak power measurement, compliance with the one Watt limit can be based on a measurement of the maximum conducted output power. Maximum Conducted Output Power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or is transmitting at a reduced power level. If multiple modes of operation are possible (e.g., alternative modulation methods), the maximum conducted output power is the highest total transmit power occurring in any mode.

RSS-247 Issue 2 § 5.4(d):

For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

As an alternative to a peak power measurement, compliance can be based on a measurement of the maximum conducted output power. The maximum conducted output power is the total transmit power delivered to all antennas and antenna elements, averaged across all symbols in the signalling alphabet when the transmitter is operating at its maximum power control level. Power must be summed across all antennas and antenna elements. The average must not include any time intervals during which the transmitter is off or transmitting at a reduced power level. If multiple modes of operation are implemented, the maximum conducted output power is the highest total transmit power occurring in any mode.



8.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013 § 11.9.1.3

8.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Wideband RF Power Meter	4022	Rohde & Schwarz	NRP-Z81	9/22/2020	9/22/2021

8.4 Test Results

The device was found to be **compliant**. The peak output power was less than 1W.

8.5 Test Conditions

Test Personnel:	<u>Bryan Taylor</u>	Test Date:	<u>12/19/2020</u>
Supervising/Reviewing Engineer: (Where Applicable)	<u>NA</u>	Limit Applied:	<u>See Above</u>
	<u>FCC Part 15.247</u>		
Product Standard:	<u>RSS-247 Issue 2</u>	Ambient Temperature:	<u>22.6C</u>
Input Voltage:	<u>4.5VDC</u>	Relative Humidity:	<u>41.2%</u>
Pretest Verification w / Ambient Signals or BB Source:	<u>Yes</u>	Atmospheric Pressure:	<u>991.2mbar</u>

Deviations, Additions, or Exclusions: None

8.6 Test Data (Peak Power)

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
0	2402	3.73	30	26.27	PASS
39	2440	3.59	30	26.41	PASS
79	2480	3.33	30	26.67	PASS



9 Occupied Bandwidth

9.1 Test Limits

FCC Part 15.247(a)(2):

Systems using digital modulation techniques may operate in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

RSS-247 Issue 2 § 5.2(a):

The minimum 6 dB bandwidth shall be 500 kHz.

9.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013 § 11.8.1.

9.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3720	Rohde & Schwarz	FSEK30	10/13/2020	10/13/2021

9.4 Test Results

The device was found to be **compliant**. The 6dB bandwidth was at least 500kHz.

9.5 Test Conditions

Test Personnel:	<u>Bryan Taylor</u>	Test Date:	<u>12/19/2020</u>
Supervising/Reviewing Engineer:	<u>NA</u>	Limit Applied:	<u>See Above</u>
(Where Applicable)	<u>FCC Part 15.247</u>	Ambient Temperature:	<u>22.6C</u>
Product Standard:	<u>RSS-247 Issue 2</u>	Relative Humidity:	<u>41.2%</u>
Input Voltage:	<u>4.5VDC</u>	Atmospheric Pressure:	<u>991.2mbar</u>
Pretest Verification w / Ambient Signals or BB Source:	<u>Yes</u>		

Deviations, Additions, or Exclusions: None



9.6 Test Data

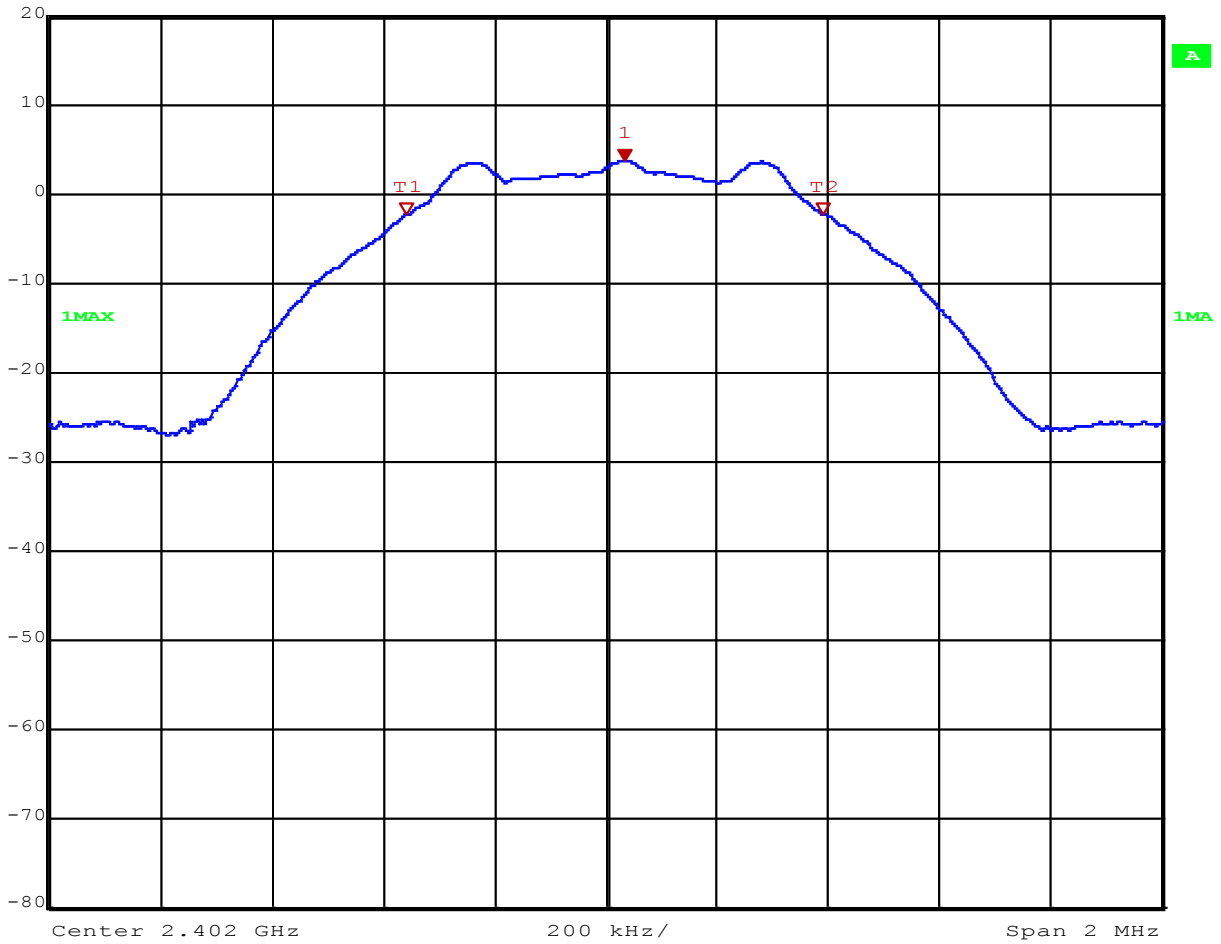
Channel	Frequency (MHz)	DTS BW (kHz)	6dB BW (kHz)	99% BW (kHz)
0	2402	749.5	645.3	1050
39	2440	733.5	673.3	1062
79	2480	733.5	633.3	1066



9.7 DTS Bandwidth Plots



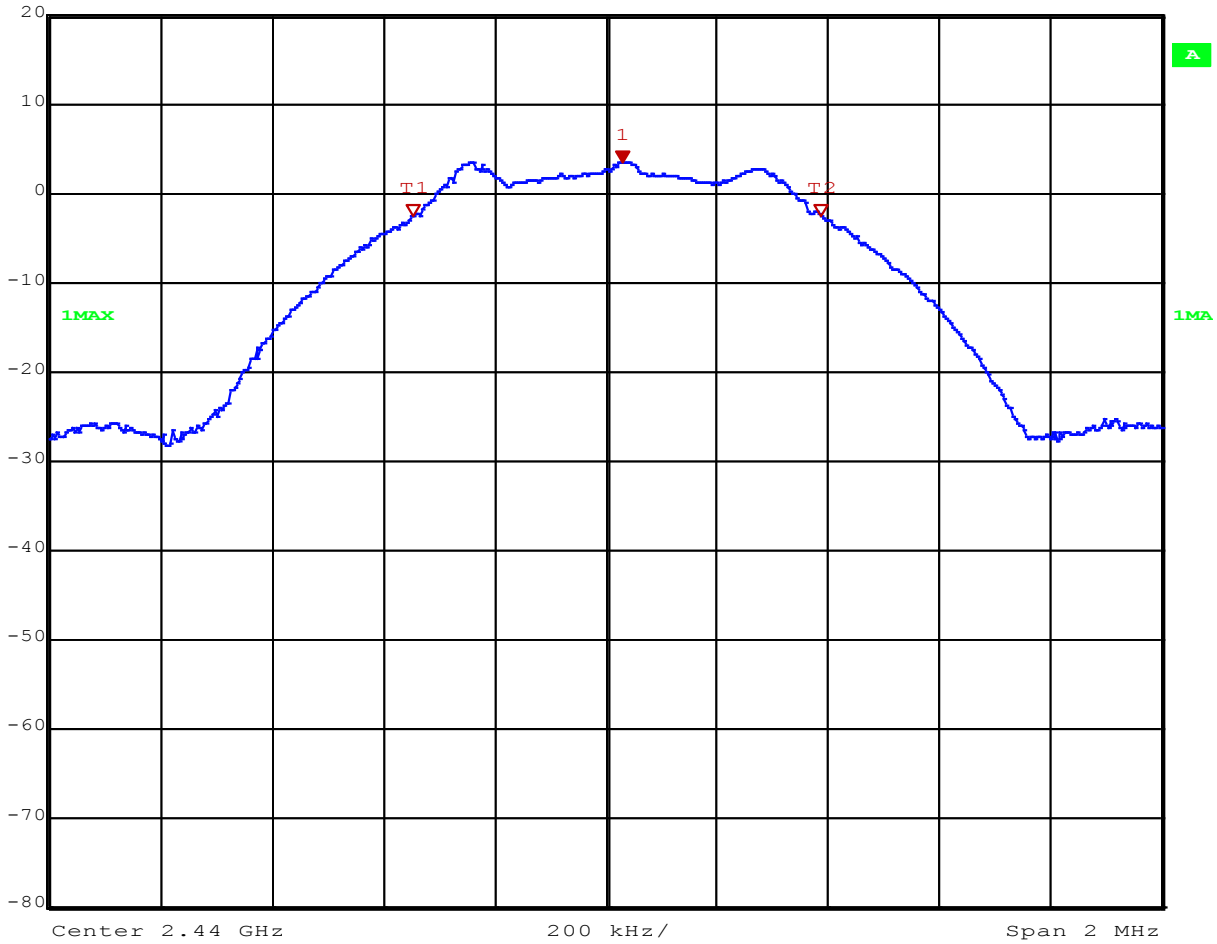
Marker 1 [T1 ndB]	RBW	100 kHz	RF Att	30 dB
Ref Lvl	ndB	6.00 dB	VBW	300 kHz
20 dBm	BW	749.49899800 kHz	SWT	5 ms
			Unit	dBm



DTS Bandwidth, 2402MHz



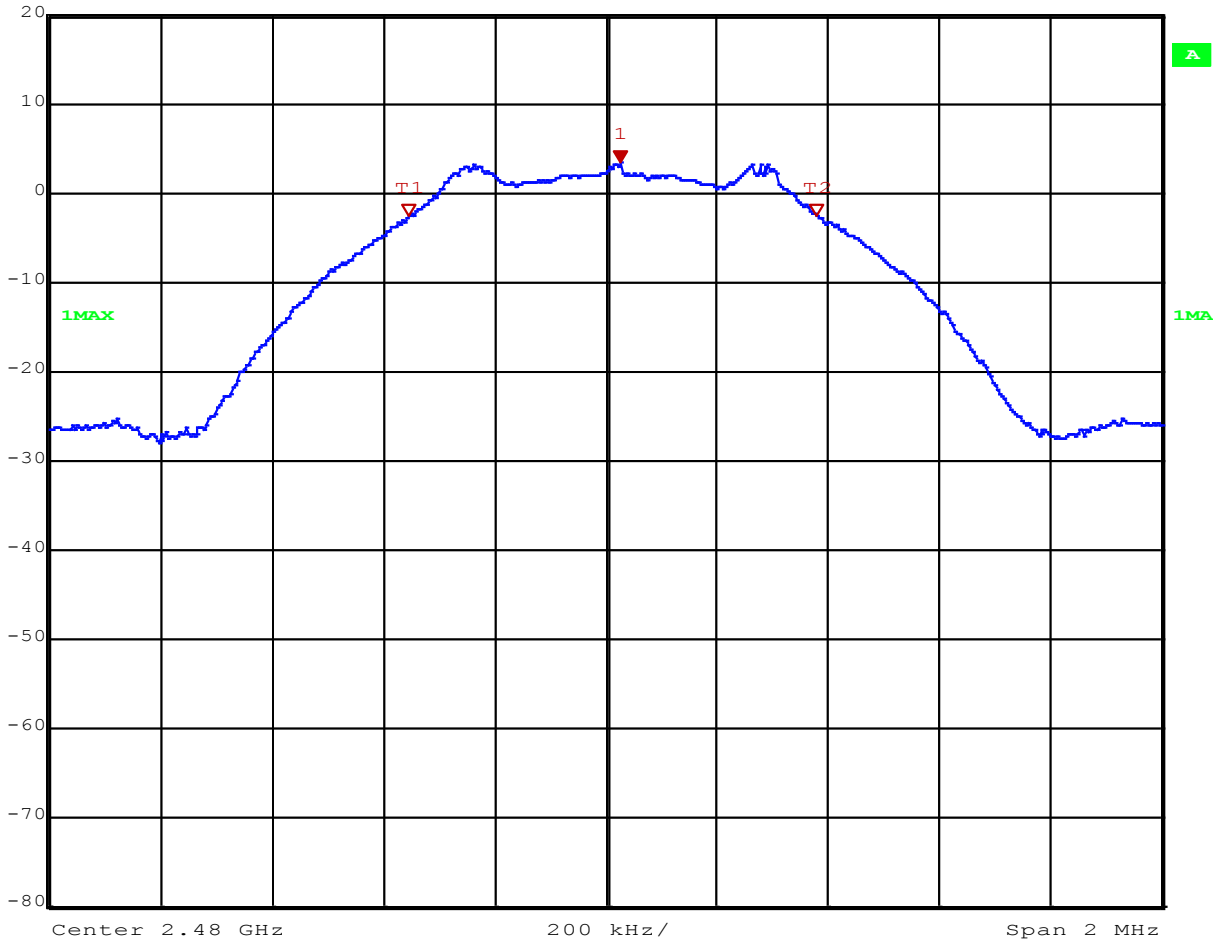
Ref Lvl	Marker 1 [T1 ndB]	RBW	100 kHz	RF Att	30 dB
20 dBm	ndB 6.00 dB	VBW	300 kHz		
	BW 733.46693387 kHz	SWT	5 ms	Unit	dBm



DTS Bandwidth, 2440MHz



Ref Lvl	Marker 1 [T1 ndB]	RBW	100 kHz	RF Att	30 dB
20 dBm	ndB 6.00 dB	VBW	300 kHz		
	BW 733.46693387 kHz	SWT	5 ms	Unit	dBm

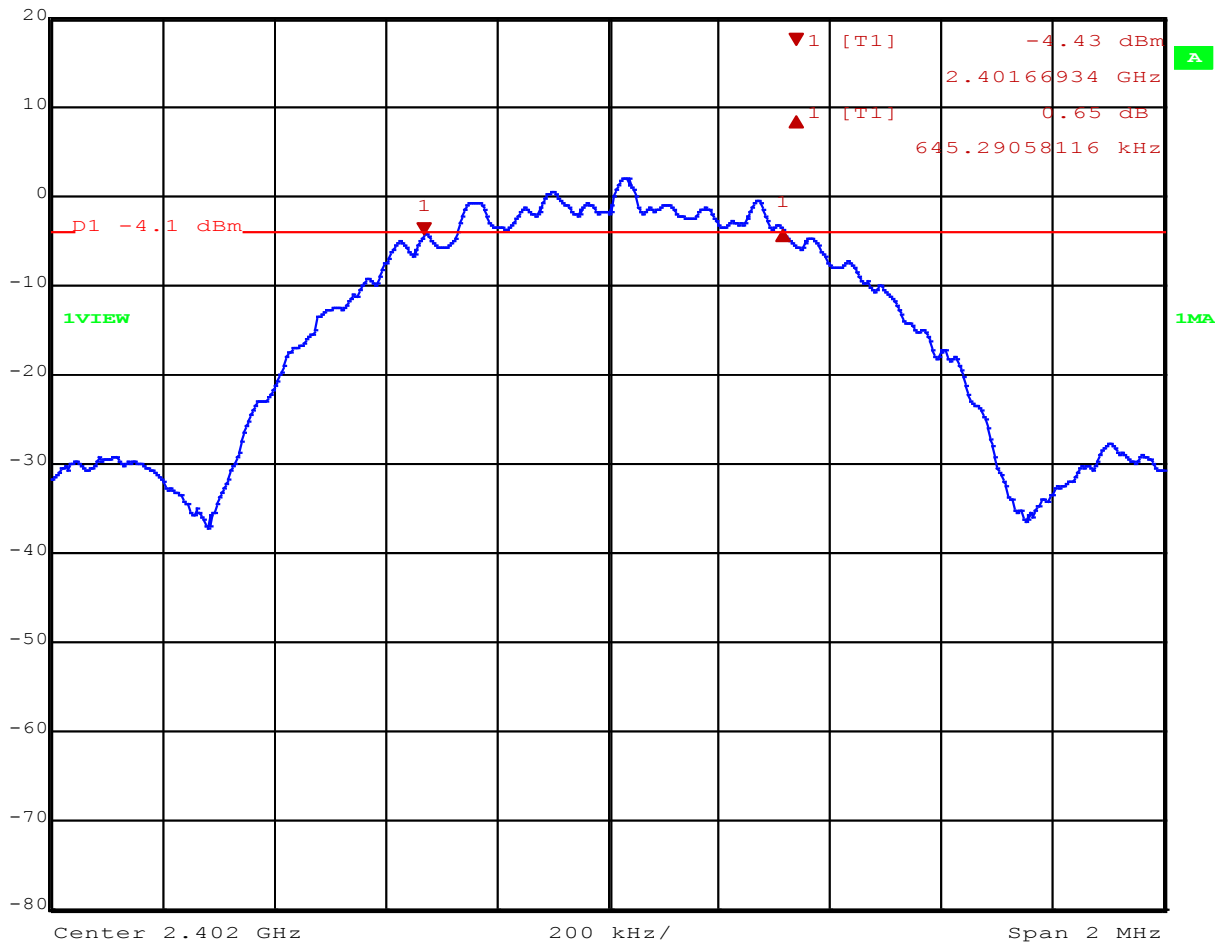


DTS Bandwidth, 2480MHz



9.8 6dB Bandwidth Plots (Antenna Path 1)

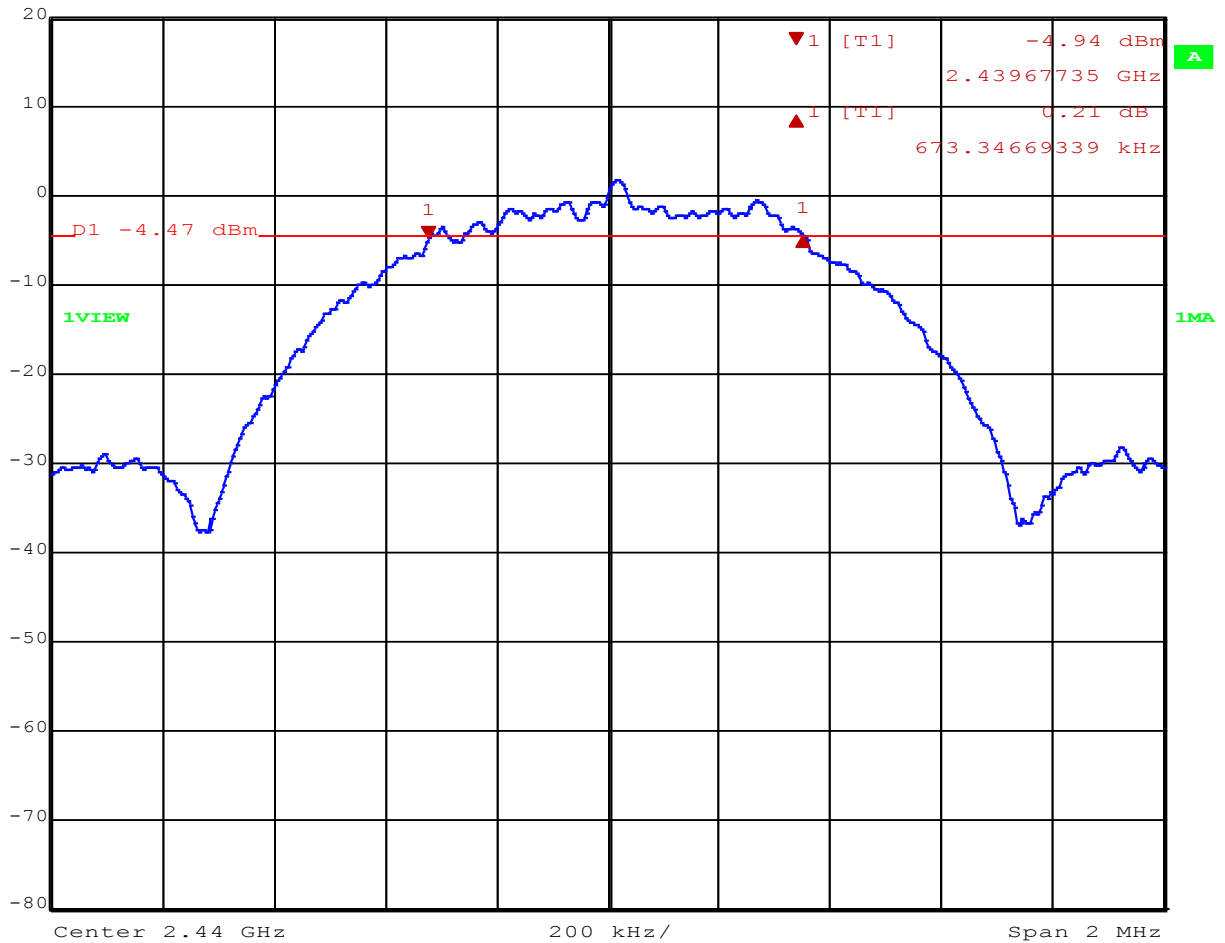
	Delta 1 [T1]	RBW	30 kHz	RF Att	30 dB
Ref Lvl	0.65 dB	VBW	300 kHz		
20 dBm	645.29058116 kHz	SWT	6 ms	Unit	dBm



6dB Bandwidth, 2402MHz



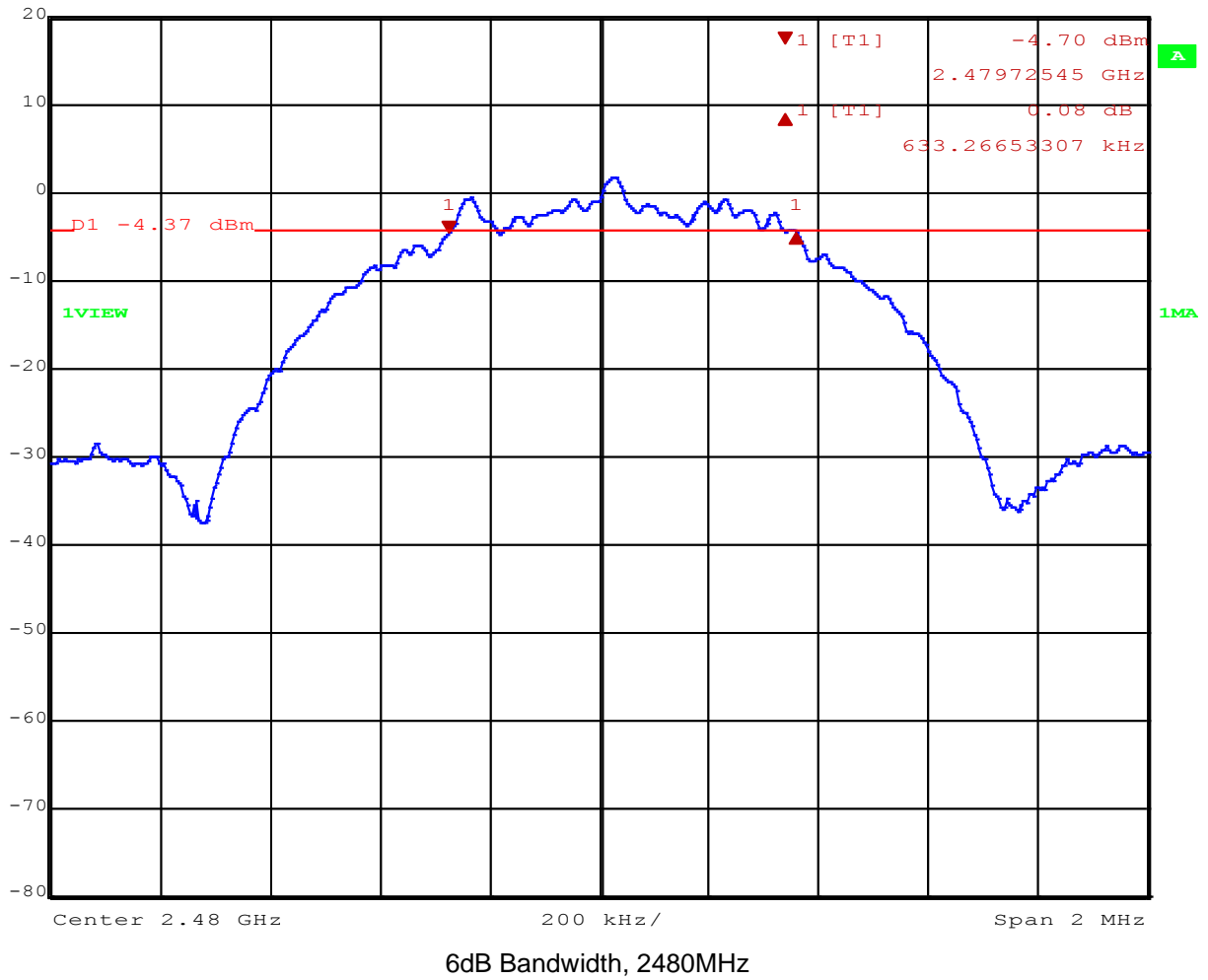
Delta 1 [T1] RBW 30 kHz RF Att 30 dB
Ref Lvl 0.21 dB VBW 300 kHz
20 dBm 673.34669339 kHz SWT 6 ms Unit dBm



6dB Bandwidth, 2440MHz



Delta 1 [T1] RBW 30 kHz RF Att 30 dB
Ref Lvl 0.08 dB VBW 300 kHz
20 dBm 633.26653307 kHz SWT 6 ms Unit dBm

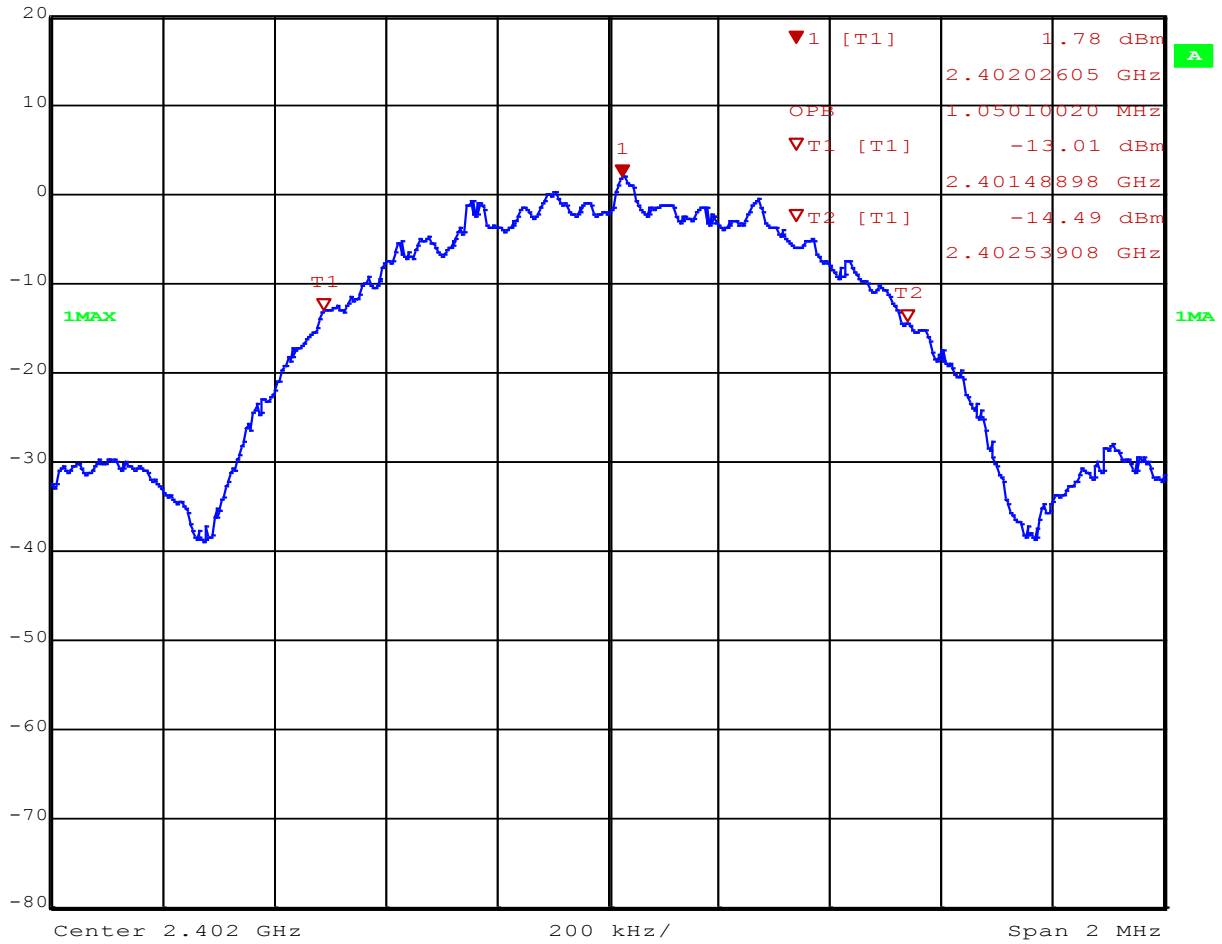




9.9 99% Bandwidth Plots



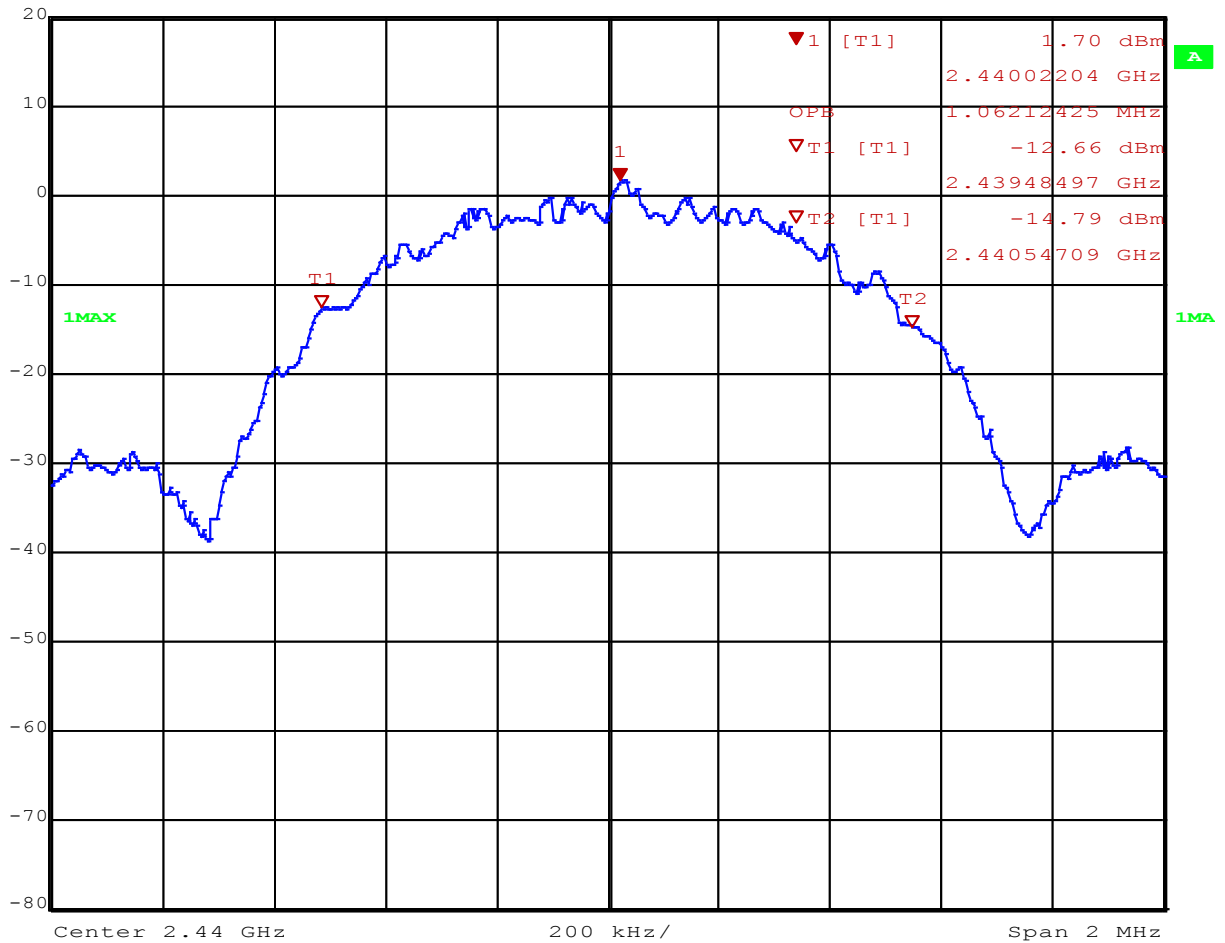
Marker 1 [T1] RBW 30 kHz RF Att 30 dB
Ref Lvl 1.78 dBm VBW 300 kHz
20 dBm 2.40202605 GHz SWT 6 ms Unit dBm



99% Bandwidth, 2402MHz



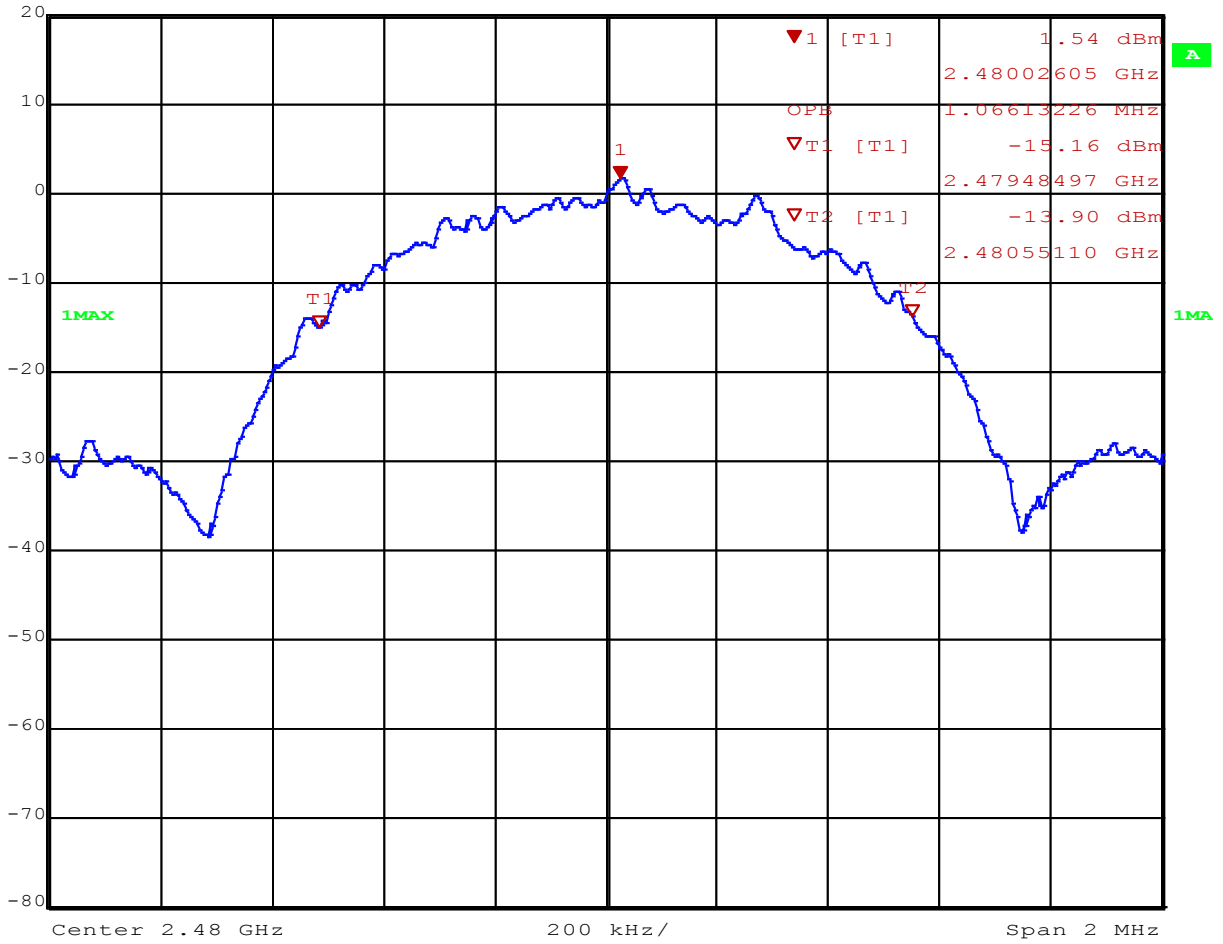
Marker 1 [T1] RBW 30 kHz RF Att 30 dB
Ref Lvl 1.70 dBm VBW 300 kHz
20 dBm 2.44002204 GHz SWT 6 ms Unit dBm



99% Bandwidth, 2440MHz



Ref Lvl	Marker 1 [T1]	RBW	30 kHz	RF Att	30 dB
20 dBm	1.54 dBm	VBW	300 kHz		
	2.48002605 GHz	SWT	6 ms	Unit	dBm



99% Bandwidth, 2480MHz



10 Power Spectral Density

10.1 Test Limits

FCC Part 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 shall be used to determine the power spectral density.

RSS-247 Issue 2 § 5.2(b):

The transmitter power spectral density conducted from the transmitter 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 section 5.4(d), (i.e. the power spectral density shall be determined using the same method as is used to determine the conducted output power).

10.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013 § 11.10.2 Method PKPSD (peak PSD).

10.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3720	Rohde & Schwarz	FSEK30	10/13/2020	10/13/2021

10.4 Test Results

The device was found to be **compliant**. The peak power spectral density was less than 8dBm.

10.5 Test Conditions

Test Personnel:	<u>Bryan Taylor</u>	Test Date:	<u>12/19/2020</u>
Supervising/Reviewing Engineer:	<u>NA</u>	Limit Applied:	<u>See Above</u>
(Where Applicable)	<u>FCC Part 15.247</u>	Ambient Temperature:	<u>22.6C</u>
Product Standard:	<u>RSS-247 Issue 2</u>	Relative Humidity:	<u>41.2%</u>
Input Voltage:	<u>4.5VDC</u>	Atmospheric Pressure:	<u>991.2mbar</u>
Pretest Verification w / Ambient			
Signals or BB Source:	<u>Yes</u>		

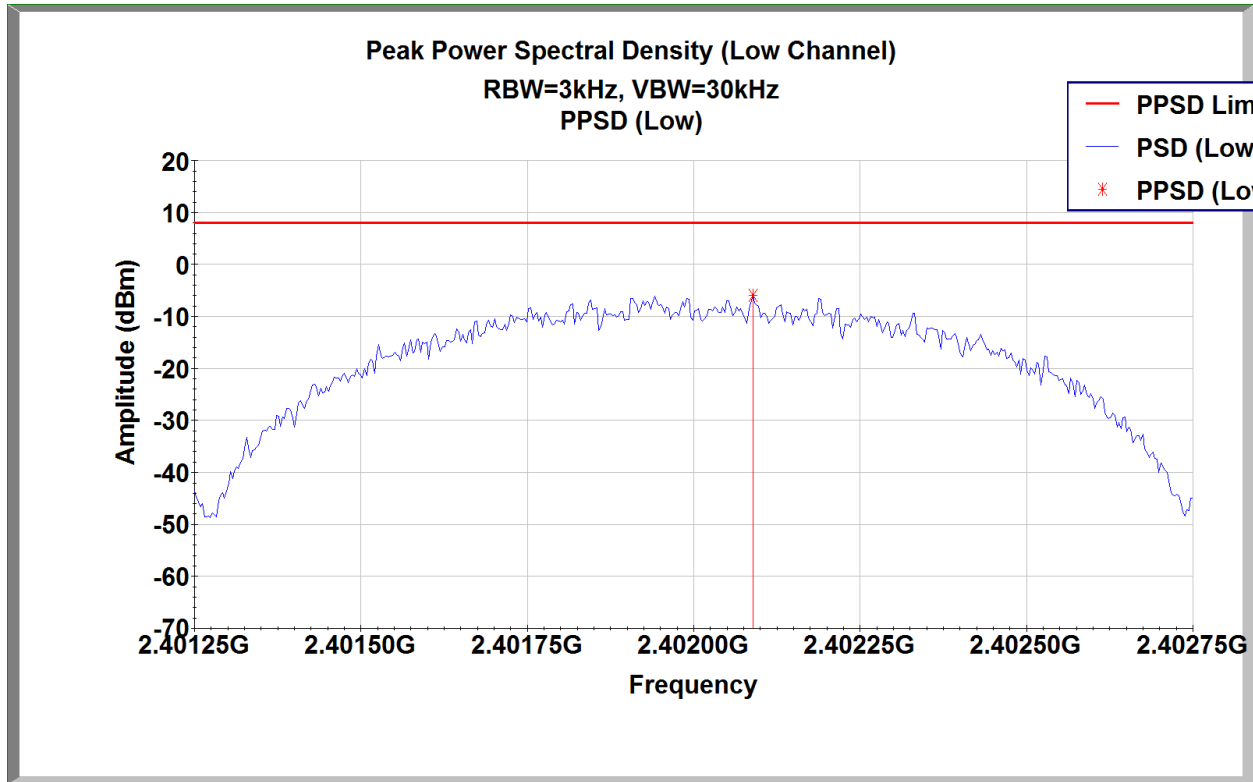
Deviations, Additions, or Exclusions: None

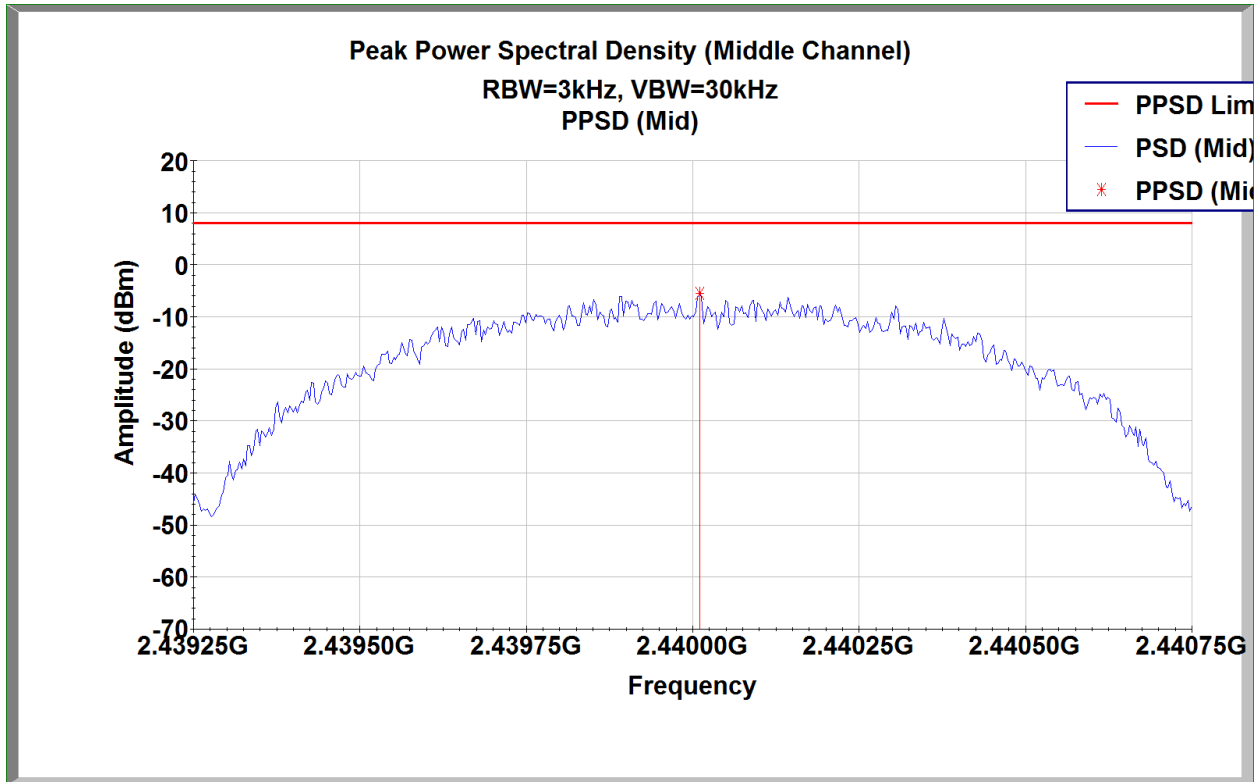


10.6 Test Data

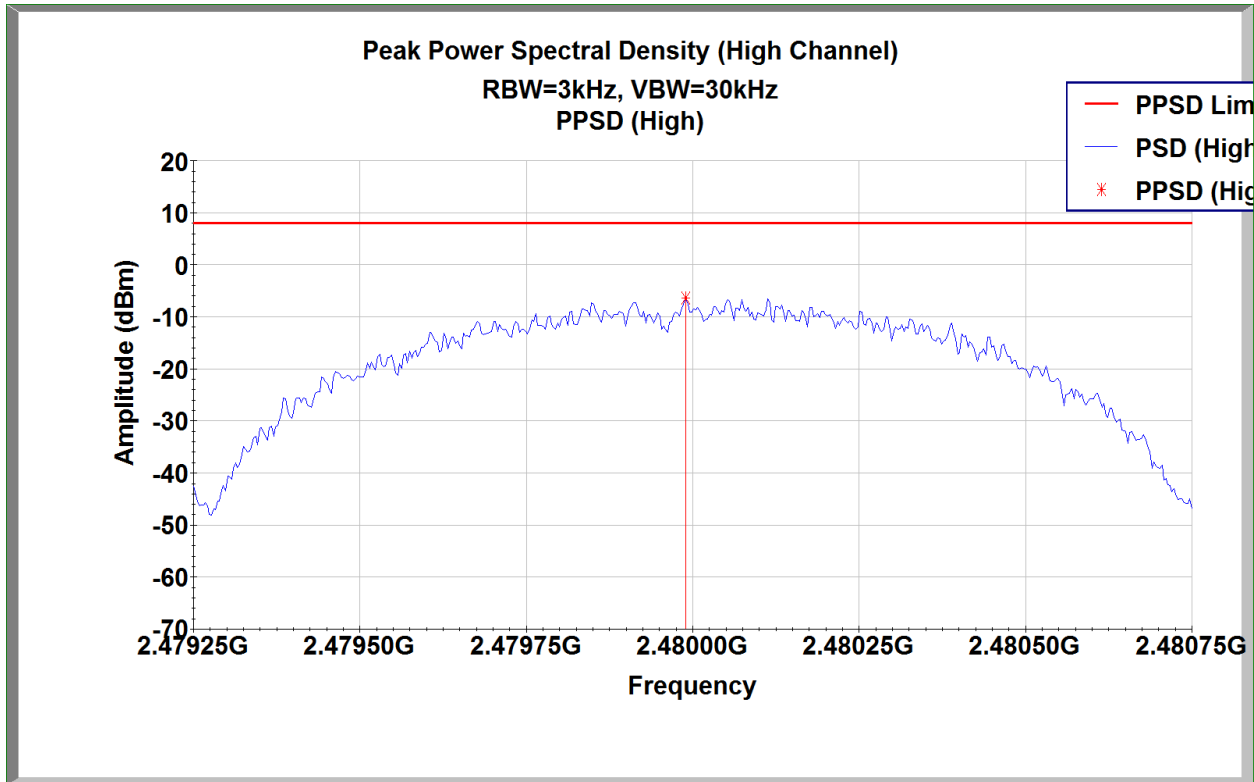
Channel	Frequency (MHz)	PPSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)	Result
0	2402	-5.97	8	13.97	PASS
39	2440	-5.53	8	13.53	PASS
79	2480	-6.32	8	14.32	PASS

10.7 PPSD Plots





Peak Power Spectral Density (2440MHz)



Peak Power Spectral Density (2480MHz)



11 Conducted Spurious Emissions

11.1 Test Limits

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. Attenuation below the general limits specified in §15.209(a) 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)).

RSS-247 Issue 2 § 5.5:

In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced 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 that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under section 5.4(d), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

11.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013 § 11.11 Emissions in nonrestricted frequency bands.

11.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
EMI Test Receiver	3720	Rohde & Schwarz	FSEK30	10/13/2020	10/13/2021

11.4 Test Results

The device was found to be **compliant**. All spurious emissions were found to be attenuated more than 20dB below the level of the fundamental.

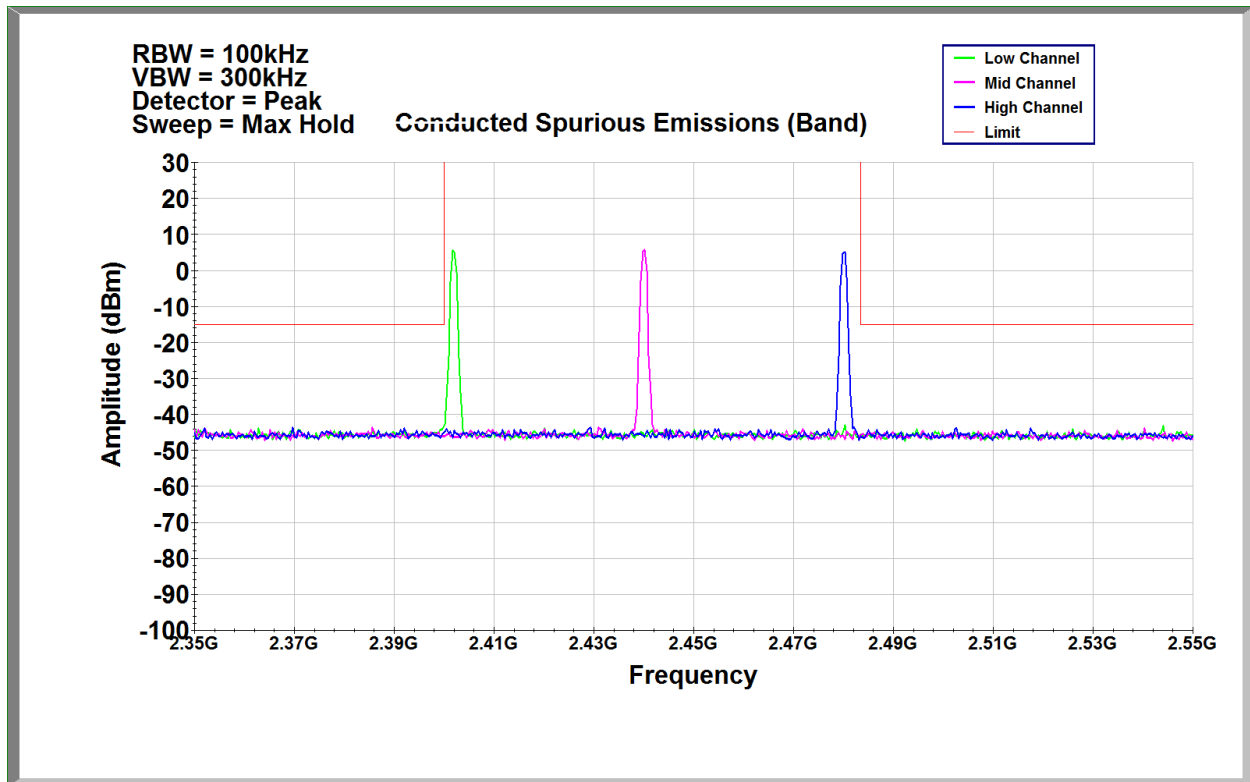


11.5 Test Conditions

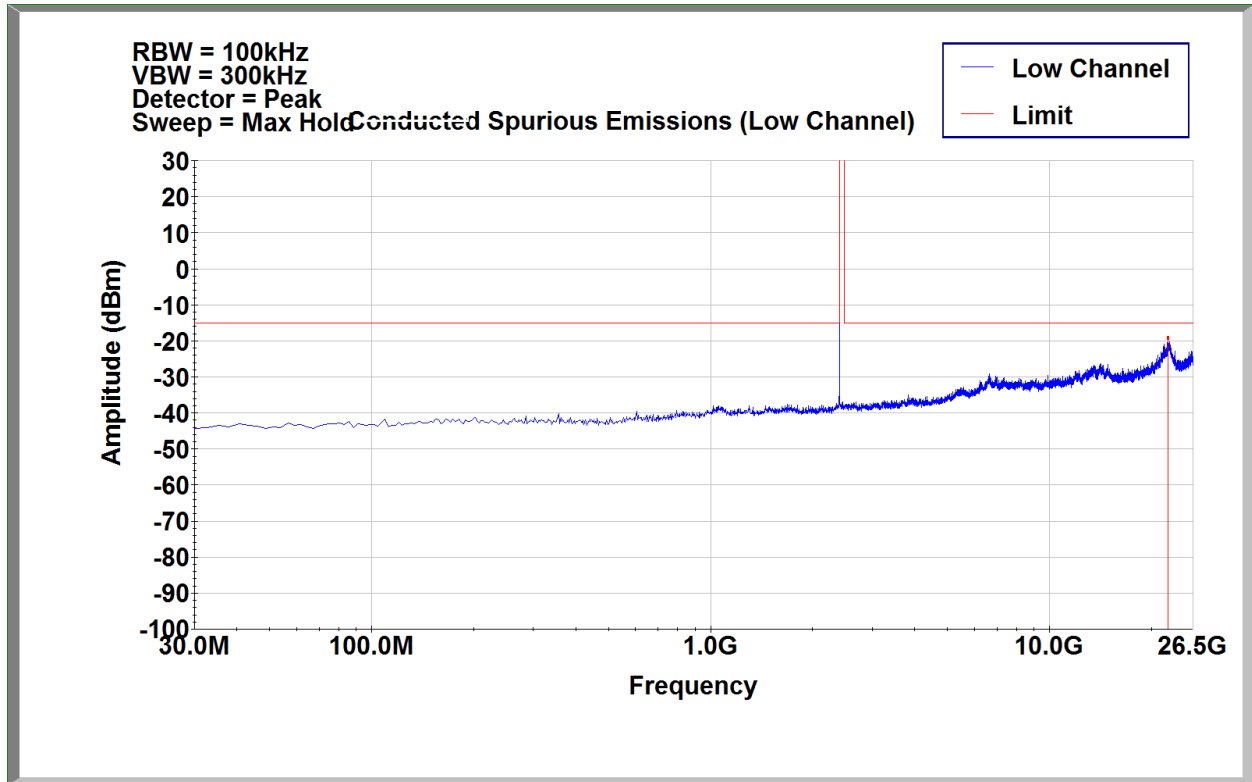
Test Personnel:	<u>Bryan Taylor</u>	Test Date:	<u>12/18/2020</u>
Supervising/Reviewing Engineer:	<u>NA</u>	Limit Applied:	<u>See Above</u>
(Where Applicable)	<u>FCC Part 15.247</u>		
Product Standard:	<u>RSS-247 Issue 2</u>	Ambient Temperature:	<u>22.6C</u>
Input Voltage:	<u>4.5VDC</u>	Relative Humidity:	<u>41.2%</u>
Pretest Verification w / Ambient		Atmospheric Pressure:	<u>991.2mbar</u>
Signals or BB Source:	<u>Yes</u>		

Deviations, Additions, or Exclusions: None

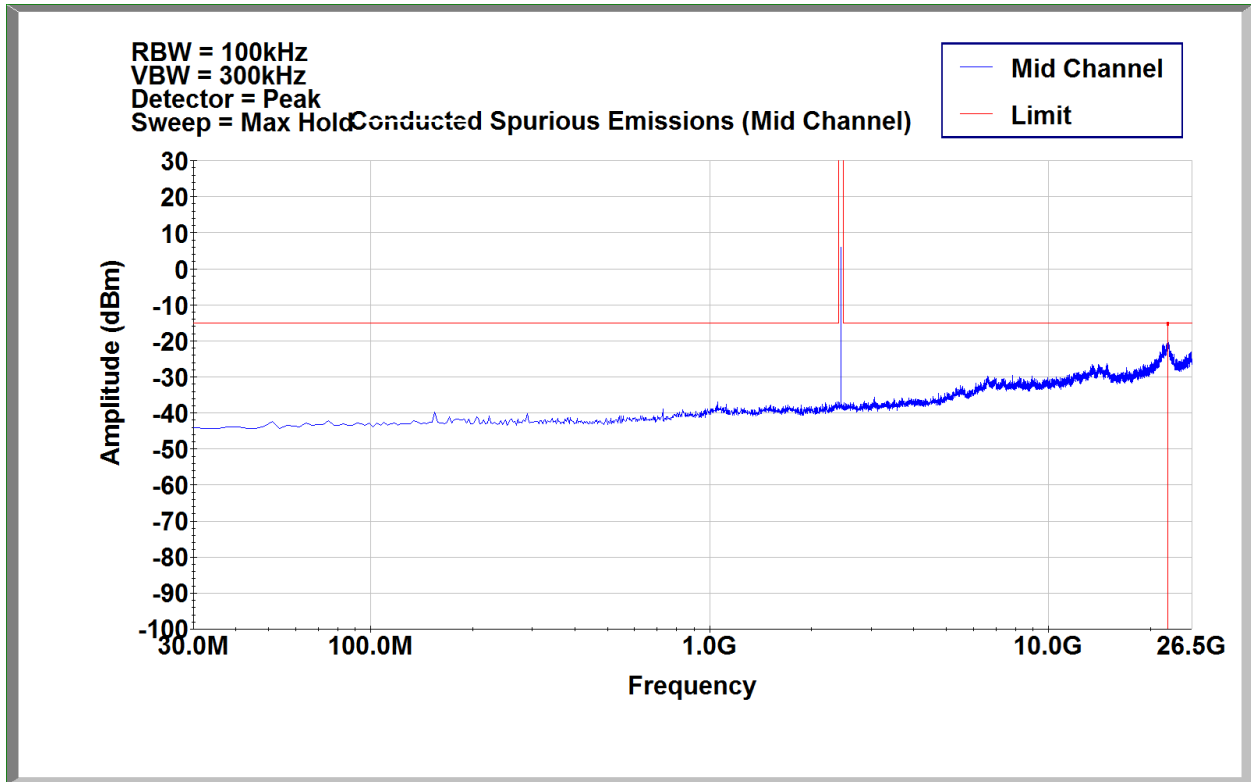
11.6 Test Data



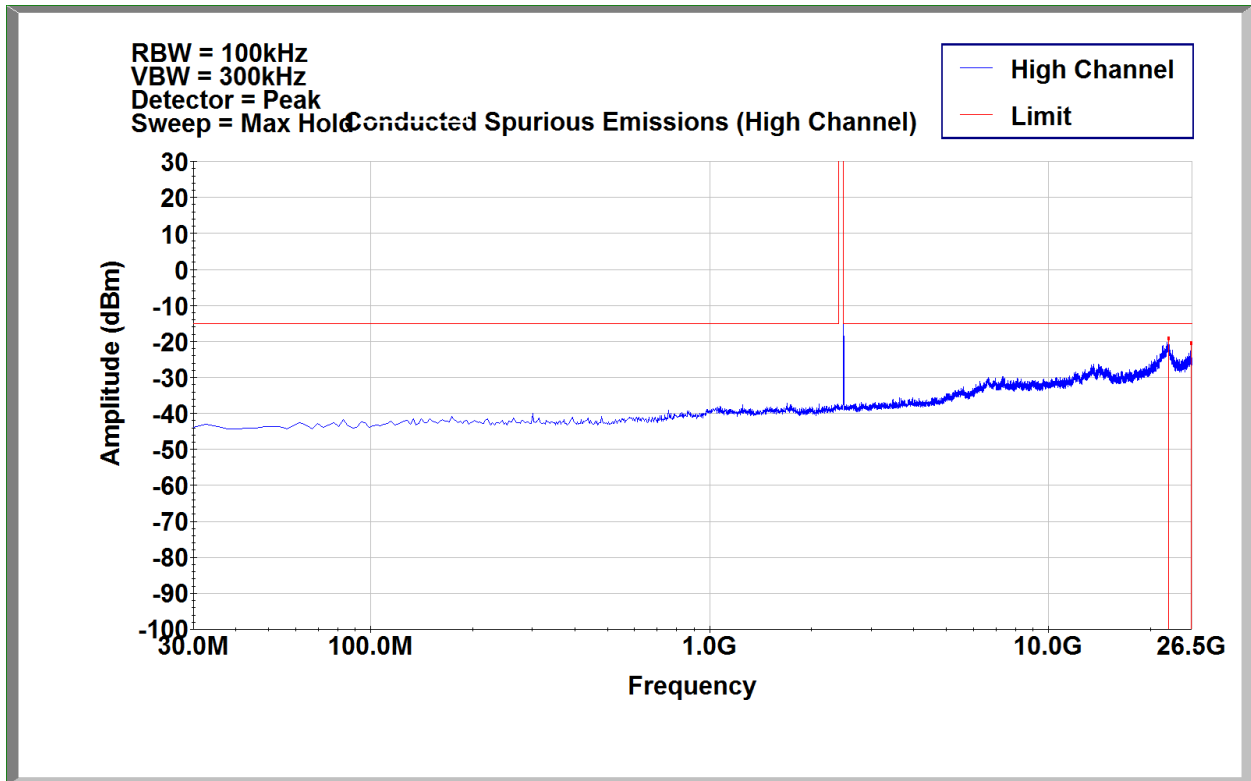
Conducted Spurious Emissions (Band Edge)



Conducted Spurious Emissions (2402MHz)



Conducted Spurious Emissions (2440MHz)



Conducted Spurious Emissions (2480MHz)



12 Antenna Requirement

12.1 Test Limits

FCC 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, 15.221, or §15.236. 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.

RSS-Gen Issue 5 § 6.8:

The applicant for equipment certification, as per RSP-100, must provide a list of all antenna types that may be used with the licence-exempt transmitter, indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna.

Licence-exempt transmitters that have received equipment certification may operate with different types of antennas. However, it is not permissible to exceed the maximum equivalent isotropically radiated power (e.i.r.p.) limits specified in the applicable standard (RSS) for the licence-exempt apparatus.

Testing shall be performed using the highest gain antenna of each combination of licence-exempt transmitter and antenna type, with the transmitter output power set at the maximum level. When a measurement at the antenna connector is used to determine RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna manufacturer.

User manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:

This radio transmitter (identify the device by certification number) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Immediately following the above notice, the manufacturer shall provide a list of all antenna types approved for use with the transmitter, indicating the maximum permissible antenna gain (in dBi).

12.2 Test Results

The device was found to be **compliant**. The device has an internal, permanently affixed antenna.



13 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	2/1/2021	104473451LEX-002.1	BCT	BZ	Original Issue