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HAE Innovations TEST REPORT

SCOPE OF WORK
EMC TESTING – IOT WEARABLE DEVICE

REPORT NUMBER
104469626LEX-018

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DOCUMENT CONTROL NUMBER
Non-Specific EMC Report Shell Rev. December 2017

EMC TEST REPORT

(FULL COMPLIANCE)

Report Number: 104469626LEX-018
Project Number: G104469626

Report Issue Date: 2/14/2021

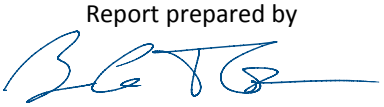
Product Name: IoT Wearable Device
Model(s) Tested: IoT Wearable Device

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:
HAE Innovations
14 Culnen Drive
Branchburg, NJ 08876
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:	HAE Innovations
Address:	14 Culnen Drive Branchburg, NJ 08876 USA
Contact:	Hesham ElHamahmy
Email:	hesham@haeinnovations.com
Manufacturer Information	
Manufacturer Name:	HAE Innovations
Manufacturer Address:	14 Culnen Drive Branchburg, NJ 08876 USA

4 Description of Equipment under Test and Variant Models

Equipment Under Test	
Product Name	IoT Wearable Device
Model Number	IoT Wearable Device
Serial Number	Test Sample 1
Transmit Bands	Bluetooth Low Energy 2402 – 2480MHz
Antenna Info	PCB Trace Antenna Gain: 1.1dBi
Receive Date	12/8/2020
Test Start Date	1/22/2021
Test End Date	1/28/2021
Device Received Condition	Good
Test Sample Type	Production
Ratings	3.7VDC via 400mAh battery
Description of Equipment Under Test (provided by client)	
The IoT Wearable Device was a small wireless device used in contact tracing applications.	

4.1 Variant Models:

There were no variant models covered by this evaluation.

5 System Setup and Method

5.1 Method:

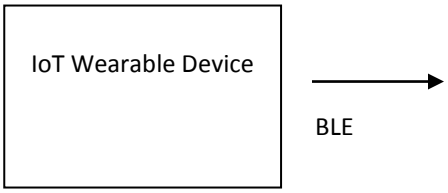
Configuration as required by ANSI C63.4: 2014 and ANSI C63.10:2013

No.	Descriptions of EUT Exercising
1	Test commands were used to force the IoT Wearable Device to transmit a Bluetooth Low Energy (BLE) signal or low, middle, or high channel.
2	Idle, not transmitting.

Cables					
Qty	Description	Length (m)	Shielding	Ferrites	Termination
None					

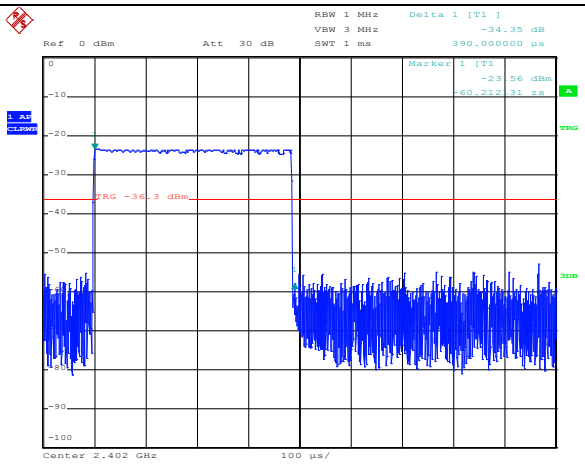
Support Equipment			
Description	Manufacturer	Model Number	Serial Number
None			

5.2 EUT Block Diagram:

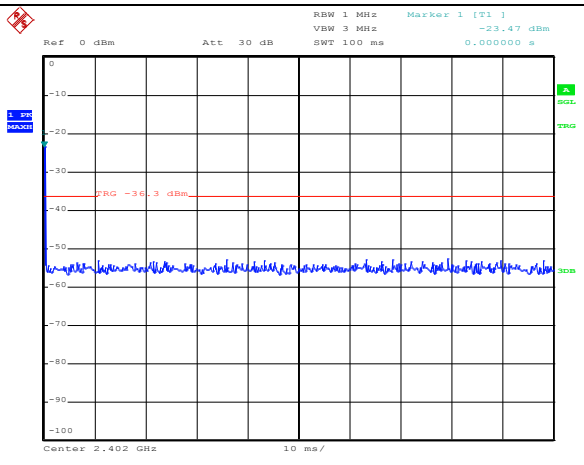


6 Duty Cycle Correction Factor

The BLE transmission was a pulsed type of signal. As such the ANSI C63.10 methodology for using a duty cycle correction factor to obtain the true average value of emissions was utilized (for radiated spurious emissions). Below, the “on time” of one pulse and the number of pulses in 100mS were measured and used to calculate a duty cycle correction factor.



One Hop = 390us



One hop in 100ms

Duty Cycle Correction Factor = 10log(0.390mS/100ms) = -24.08dB

7 Receiver Spurious Emissions

7.1 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)	Ucispr
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.

7.2 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 dBμV/m
RA = Receiver Amplitude (including preamplifier) in dBμV
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 dBμV 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 dBμV/m. This value in dBμV/m was converted to its corresponding level in μV/m.

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

To convert from dBμV to μV or mV the following was used:

$UF = 10^{(NF / 20)}$ where UF = Net Reading in μV
NF = Net Reading in dBμV

Example:

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

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
Bilog Antenna (30MHz-1GHz)	7085	SunAR	JB6	9/4/2020	9/4/2021
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
Coaxial Cable	3339			12/4/2019	12/4/2020
Coaxial Cable	3074			12/4/2019	12/4/2020
3m Cable Preamplifier	3918	Rohde & Schwarz	TS-PR18	12/4/2019	12/4/2020
Coaxial Cable	2588			12/4/2019	12/4/2020
Coaxial Cable	2593			12/4/2019	12/4/2020
Coaxial Cable	2592			12/4/2019	12/4/2020

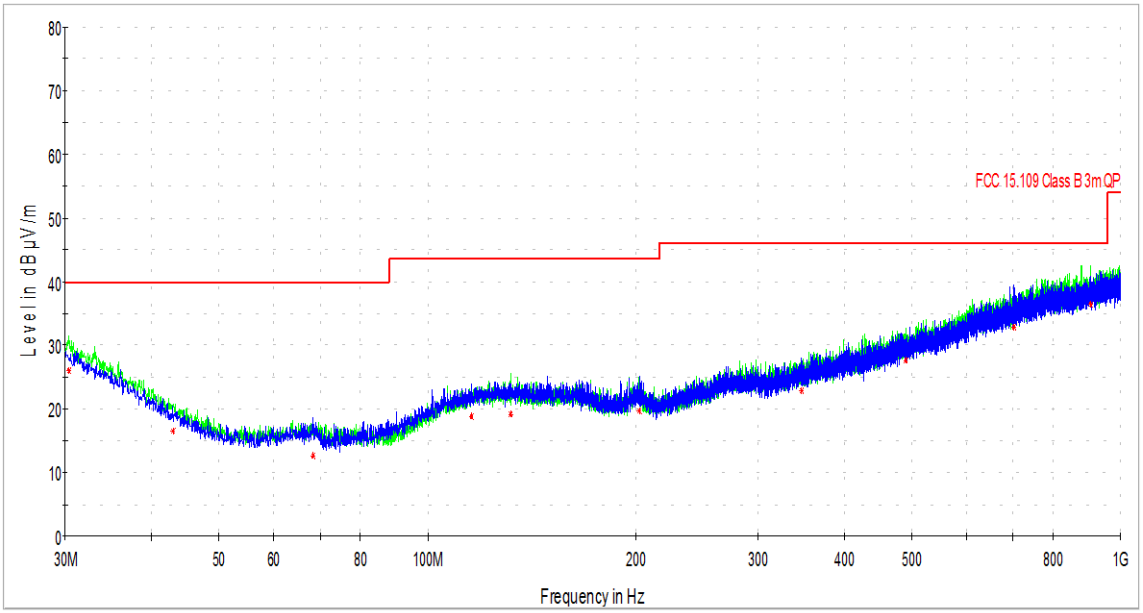
7.4 Software Utilized

Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.02

7.5 Test Results

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

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

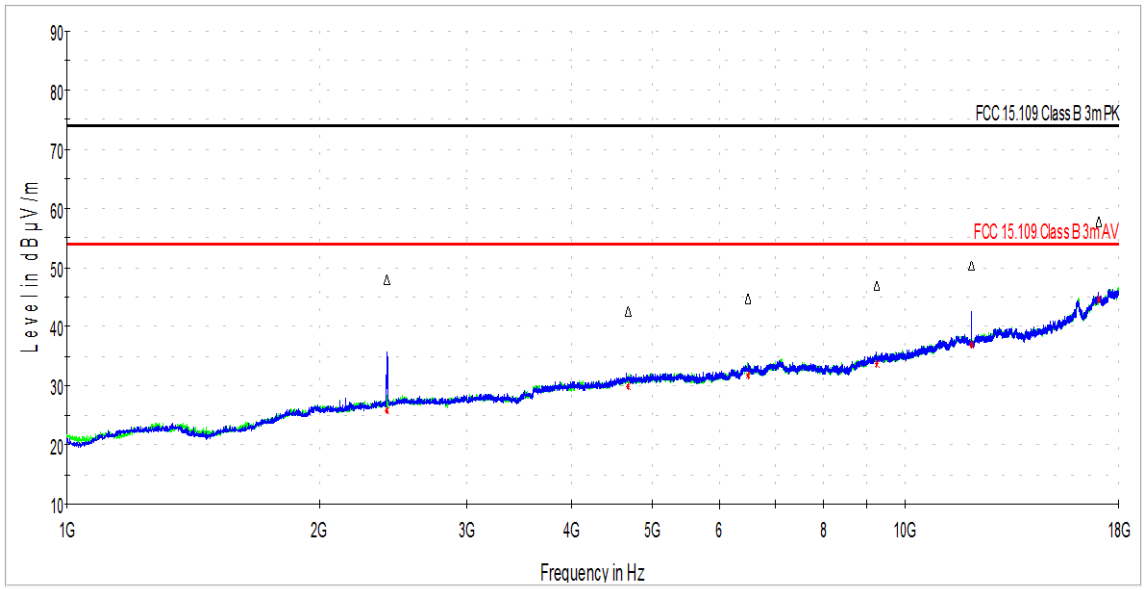


Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
30.377222	26.05	40.00	13.95	120.000	246.3	H	54.0	28.6
42.933333	16.49	40.00	23.51	120.000	379.5	H	144.0	19.5
68.422778	12.61	40.00	27.39	120.000	333.8	V	0.0	15.3
115.737222	18.78	43.52	24.74	120.000	100.2	V	272.0	21.7
131.742222	19.12	43.52	24.40	120.000	118.4	H	343.0	22.1
202.228889	19.73	43.52	23.79	120.000	106.1	V	8.0	22.3
346.920556	22.83	46.02	23.19	120.000	399.9	V	0.0	25.0
489.780000	27.55	46.02	18.47	120.000	142.0	H	182.0	29.5
702.641111	32.80	46.02	13.22	120.000	359.8	V	300.0	33.6
906.017778	36.46	46.02	9.56	120.000	240.4	H	117.0	36.9

Test Personnel:	Ben Coolbear	Test Date:	11/12/2020
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	See Table Above
Product Standard:	FCC Part 15B ICES-003 Issue 6	Ambient Temperature:	23.2 °C
Input Voltage:	3.7 VDC	Relative Humidity:	48.3 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985.4 mbar

Deviations, Additions, or Exclusions: None

7.7 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)
2409.000000	47.92	73.98	26.06	1000.000	178.0	V	13.0	3.7
4670.500000	42.74	73.98	31.24	1000.000	317.0	H	280.0	8.2
6496.500000	44.80	73.98	29.18	1000.000	312.0	V	331.0	11.1
9258.500000	46.82	73.98	27.16	1000.000	100.0	V	302.0	13.8
12011.000000	50.28	73.98	23.70	1000.000	410.0	V	282.0	17.8
17025.000000	57.76	73.98	16.22	1000.000	318.0	V	183.0	25.7

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2409.000000	25.69	53.98	28.29	1000.000	178.0	V	13.0	3.7
4670.500000	29.83	53.98	24.15	1000.000	317.0	H	280.0	8.2
6496.500000	31.77	53.98	22.21	1000.000	312.0	V	331.0	11.1
9258.500000	33.72	53.98	20.26	1000.000	100.0	V	302.0	13.8
12011.000000	36.87	53.98	17.11	1000.000	410.0	V	282.0	17.8
17025.000000	44.66	53.98	9.32	1000.000	318.0	V	183.0	25.7

Test Personnel:	Ben Coolbear	Test Date:	11/12/2020
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	See Table Above
Product Standard:	FCC Part 15B ICES-003 Issue 6	Ambient Temperature:	23.2 °C
Input Voltage:	3.7 VDC	Relative Humidity:	48.3 %
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	985.4 mbar

Deviations, Additions, or Exclusions: None

8 Transmitter Spurious Emissions

8.1 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.

8.2 Test Method

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

8.3 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
Magnetic Loop Antenna	2366	ETS	6502	7/17/2020	7/17/2021
Horn Antenna (18-40GHz)	3779	ETS	3116c	7/23/2020	7/23/2021
Horn Antenna (1-18GHz)	3780	ETS	3117	6/18/2020	6/18/2021
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	12/4/2021
Coaxial Cable (40GHz)	7020			12/21/2020	12/4/2021
Coaxial Cable (40GHz)	7021			12/21/2020	12/4/2021
Coaxial Cable	3074			12/21/2020	12/4/2021
3m Cable Preamplifier	3918	Rohde & Schwarz	TS-PR18	12/21/2020	12/4/2021
Coaxial Cable	2588			12/21/2020	12/4/2021
Coaxial Cable	2593			12/21/2020	12/4/2021
Coaxial Cable	2592			12/21/2020	12/4/2021

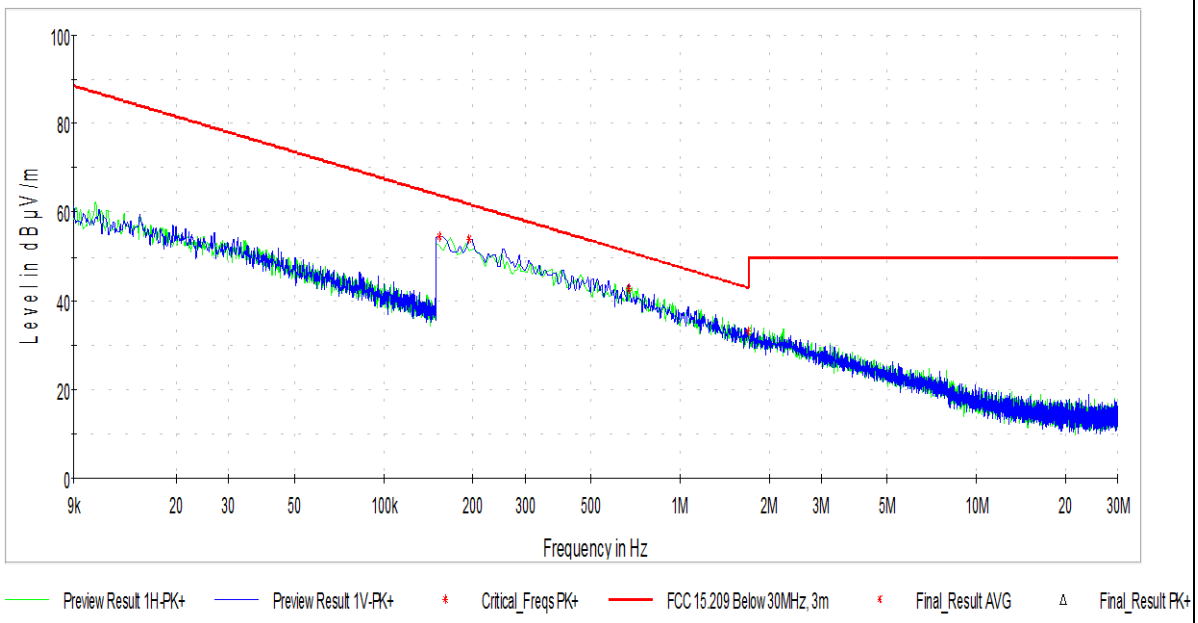
8.4 Software Utilized

Name	Manufacturer	Version
EMC32	Rohde & Schwarz	Version 9.15.02

8.5 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. An investigation was performed from 18GHz – 25GHz and no additional spurious emissions were detected.

8.6 Radiated Spurious Emissions (9kHz – 30MHz)



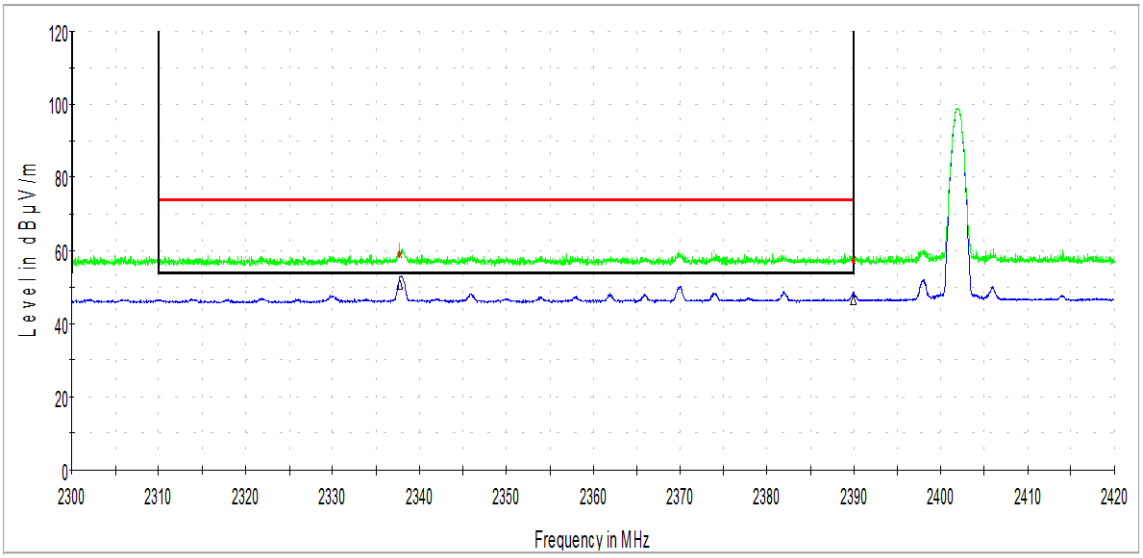
Note: The scan above was performed in a continuous max-hold mode and includes the worst case emissions with the transmitter operating on low, mid, and high channels.

Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Azimuth (deg)	Corr. (dB)
0.154390	54.51	63.83	9.32	9kHz	90.0	12.1
0.193897	54.01	61.85	7.84	9kHz	0.0	12.1
0.672375	42.87	51.05	8.18	9kHz	180.0	11.9
1.690787	33.20	43.04	9.85	9kHz	270.0	11.8

Test Personnel:	Bryan Taylor	Test Date:	1/27/2021
Supervising/Reviewing Engineer: (Where Applicable)	N/A	Limit Applied:	15.209
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7 VDC	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: This data was measured in a semi-anechoic chamber that has been correlated to measurements performed in an open field.

8.7 Radiated Spurious Emissions (BLE, Low Band Edge)



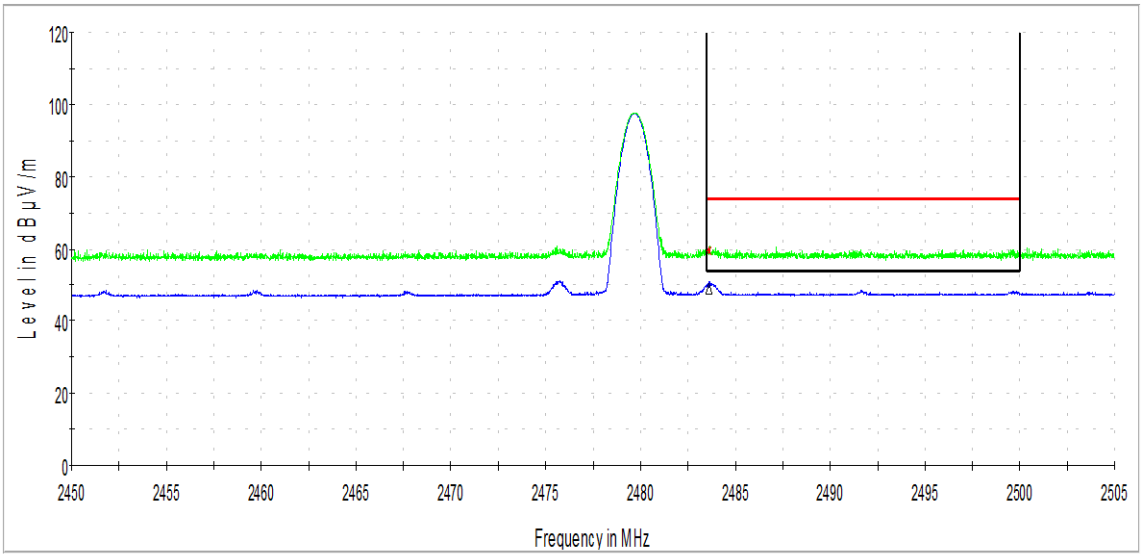
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2337.730769	59.01	73.98	14.97	1000.000	309.0	H	0.0	38.5
2389.976923	57.42	73.98	16.56	1000.000	309.0	H	187.0	38.6

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2337.730769	50.85	53.98	3.13	1000.000	309.0	H	0.0	38.5
2389.976923	46.60	53.98	7.38	1000.000	309.0	H	187.0	38.6

Test Personnel:	Bryan Taylor	Test Date:	1/23/2021
Supervising/Reviewing Engineer: (Where Applicable)	N/A	Limit Applied:	15.205 Restricted Bands
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7VDC (Battery)	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: None

8.8 Radiated Spurious Emissions (BLE, High Band Edge)



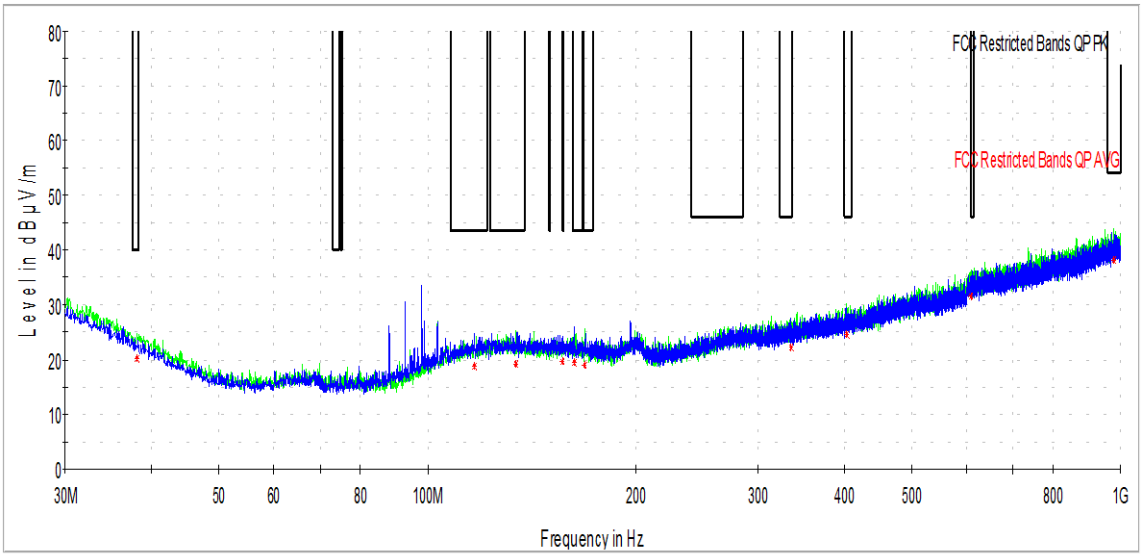
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.592308	59.31	73.98	14.67	1000.000	100.0	H	140.0	39.2

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
2483.592308	48.92	53.98	5.06	1000.000	100.0	H	140.0	39.2

Test Personnel:	Bryan Taylor	Test Date:	1/23/2021
Supervising/Reviewing Engineer: (Where Applicable)	N/A	Limit Applied:	15.205 Restricted Bands
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7VDC (Battery)	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: None

8.9 Radiated Spurious Emissions (30MHz – 1 GHz)



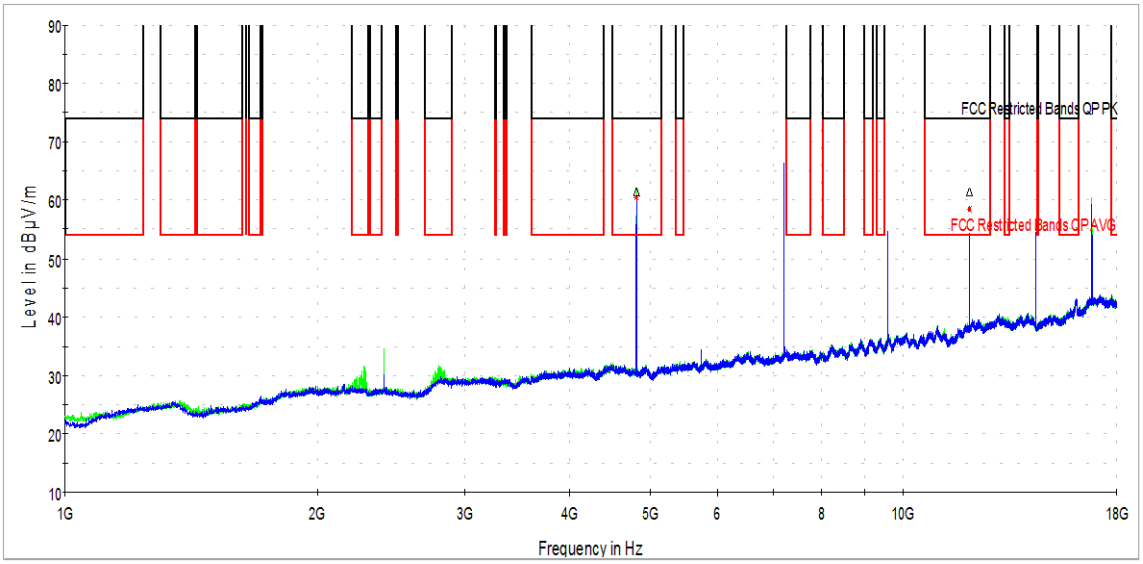
Note, the data above is representative of the worst case from low, mid and high channels.

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
38.083333	20.12	40.00	19.88	120.000	400.1	H	295.0	22.9
116.761111	18.77	43.52	24.75	120.000	202.3	V	300.0	21.8
134.221111	19.09	43.52	24.43	120.000	106.2	H	267.0	21.9
156.746667	19.58	43.52	23.94	120.000	337.2	V	10.0	21.7
162.728333	19.40	43.52	24.12	120.000	285.2	V	230.0	21.6
168.763889	18.97	43.52	24.55	120.000	284.7	H	200.0	21.2
334.795556	22.29	46.02	23.73	120.000	118.1	V	174.0	24.3
402.587778	24.45	46.02	21.57	120.000	219.1	H	137.0	26.7
608.712778	31.58	46.02	14.44	120.000	400.0	H	262.0	31.6
979.037222	38.07	53.98	15.91	120.000	400.1	H	36.0	38.0

Test Personnel:	Bryan Taylor	Test Date:	1/23/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.205 Restricted Bands
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7 VDC	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: None

8.10 Radiated Spurious Emissions (Low Channel, 1GHz – 18GHz)



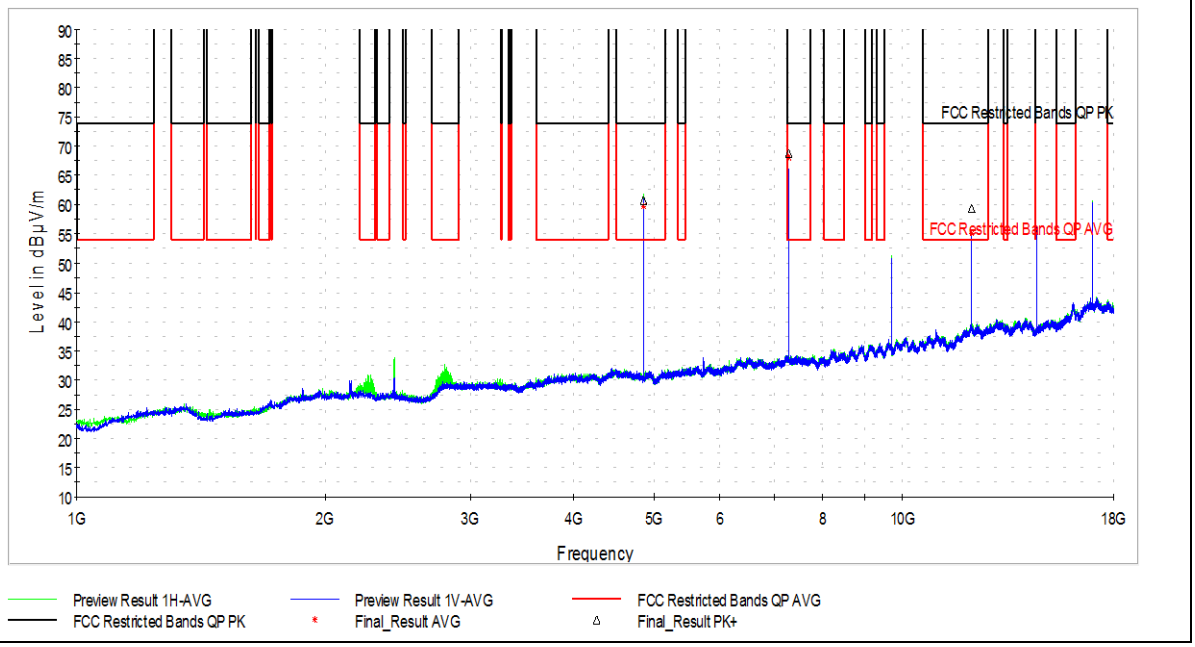
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4804.000000	61.49	73.98	12.49	1000.000	100.0	H	169.0	9.3
12009.500000	61.57	73.98	12.41	1000.000	396.0	V	22.0	19.4

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4804.000000	60.48 (36.4)	53.98	17.58	1000.000	100.0	H	169.0	9.3 (-24.08)
12009.500000	58.43 (34.35)	53.98	19.63	1000.000	396.0	V	22.0	19.4 (-24.08)

Test Personnel:	Bryan Taylor	Test Date:	1/23/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.205 Restricted Bands
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7 VDC	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: The measurements in parentheses had a duty cycle correction factor applied to them prior to comparison to the limit. The amplitude without the duty cycle correction factor appears above each corrected value.

8.11 Radiated Spurious Emissions (Mid Channel, 1GHz – 18GHz)



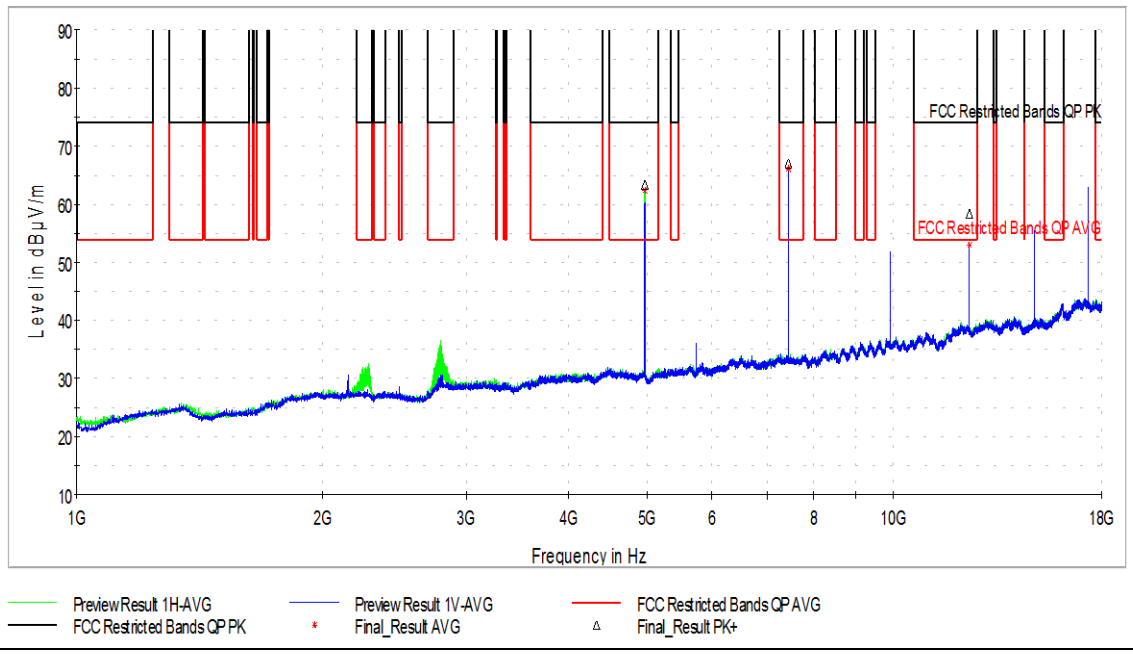
Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4852.000000	60.85	73.98	13.13	1000.000	100.0	H	143.0	9.7
7278.000000	68.85	73.98	5.13	1000.000	367.0	V	18.0	13.5
12129.500000	59.40	73.98	14.58	1000.000	100.0	V	133.0	20.0

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4852.000000	59.76 (35.68)	53.98	18.3	1000.000	100.0	H	143.0	9.7 (-24.08)
7278.000000	68.14 (44.06)	53.98	9.92	1000.000	367.0	V	18.0	13.5 (-24.08)
12129.500000	55.02 (30.94)	53.98	23.04	1000.000	100.0	V	133.0	20.0 (-24.08)

Test Personnel:	Bryan Taylor	Test Date:	1/23/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.205 Restricted Bands
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7 VDC	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: The measurements in parentheses had a duty cycle correction factor applied to them prior to comparison to the limit. The amplitude without the duty cycle correction factor appears above each corrected value.

8.12 Radiated Spurious Emissions (High Channel, 1GHz – 18GHz)



Frequency (MHz)	MaxPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4959.500000	63.36	73.98	10.62	1000.000	100.0	H	191.0	9.8
7439.000000	67.12	73.98	6.86	1000.000	100.0	V	198.0	13.1
12398.500000	58.32	73.98	15.66	1000.000	242.0	V	314.0	20.4

Frequency (MHz)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB)
4959.500000	62.35 (38.27)	53.98	15.71	1000.000	100.0	H	191.0	9.8 (-24.08)
7439.000000	66.14 (42.06)	53.98	11.92	1000.000	100.0	V	198.0	13.1 (-24.08)
12398.500000	52.98 (28.90)	53.98	25.08	1000.000	242.0	V	314.0	20.4 (-24.08)

Test Personnel:	Bryan Taylor	Test Date:	1/23/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	15.205 Restricted Bands
Product Standard:	FCC Part 15C	Ambient Temperature:	24.3°C
Input Voltage:	3.7 VDC	Relative Humidity:	52.8%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	987.3 mbar

Deviations, Additions, or Exclusions: The measurements in parentheses had a duty cycle correction factor applied to them prior to comparison to the limit. The amplitude without the duty cycle correction factor appears above each corrected value.

9 Output Power

9.1 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.

9.2 Test Method

Tests are performed in accordance with ANSI C63.10:2013 § 11.9.1.3 PKPM1

9.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Wideband Power Sensor	4022	Rohde&Schwarz	NRP-Z81	9/22/2020	9/22/2021
Coaxial Cable	6086	Megaphase	SF26-S1S1-40	12/21/2020	12/4/2021

9.4 Test Results

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

9.5 Test Conditions

Test Personnel:	Bryan Taylor	Test Date:	1/22/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	1 Watt (30dBm)
Product Standard:	FCC Part 15.247 RSS-247 Issue 2	Ambient Temperature:	22.6C
Input Voltage:	3.7VDC	Relative Humidity:	41.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	991.2mbar

9.6 Test Data

Channel	Frequency (MHz)	Conducted Power (dBm)	Limit (dBm)	Margin (dB)	Result
37	2402	-3.7	30	33.7	PASS
38	2438	-1.8	30	31.8	PASS
39	2480	-2.3	30	32.3	PASS

Deviations, Additions, or Exclusions: None
Note: Since a power meter was used for these measurements there are no spectral plots available.

10 Occupied Bandwidth

10.1 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.

10.2 Test Method

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

10.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	10/13/2020	10/13/2021
Coaxial Cable	6086	Megaphase	SF26-S1S1-40	12/21/2020	12/4/2021

10.4 Test Results

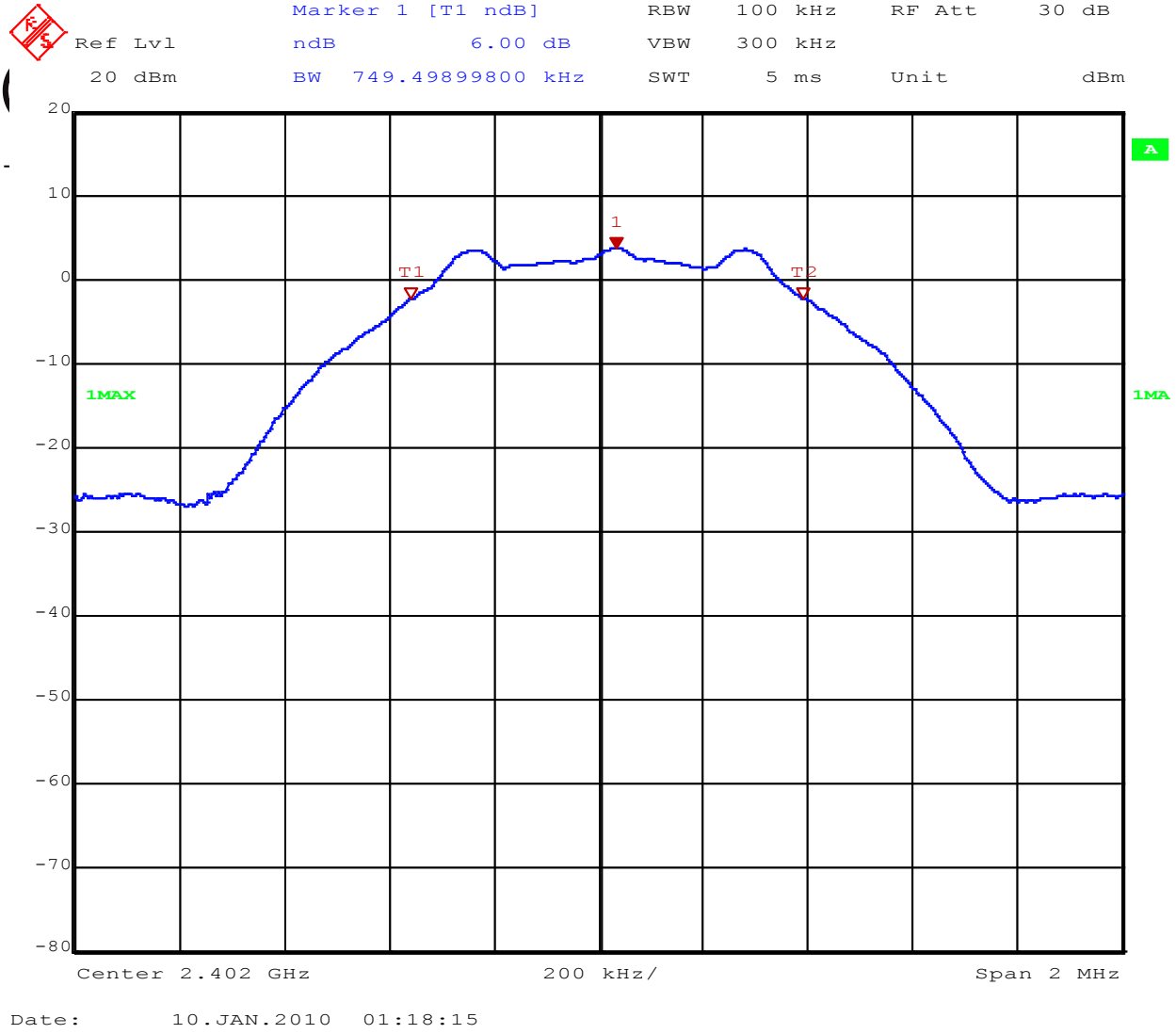
The device was found to be **compliant**. The 6dB bandwidth was at least 500kHz.

10.5 Test Conditions

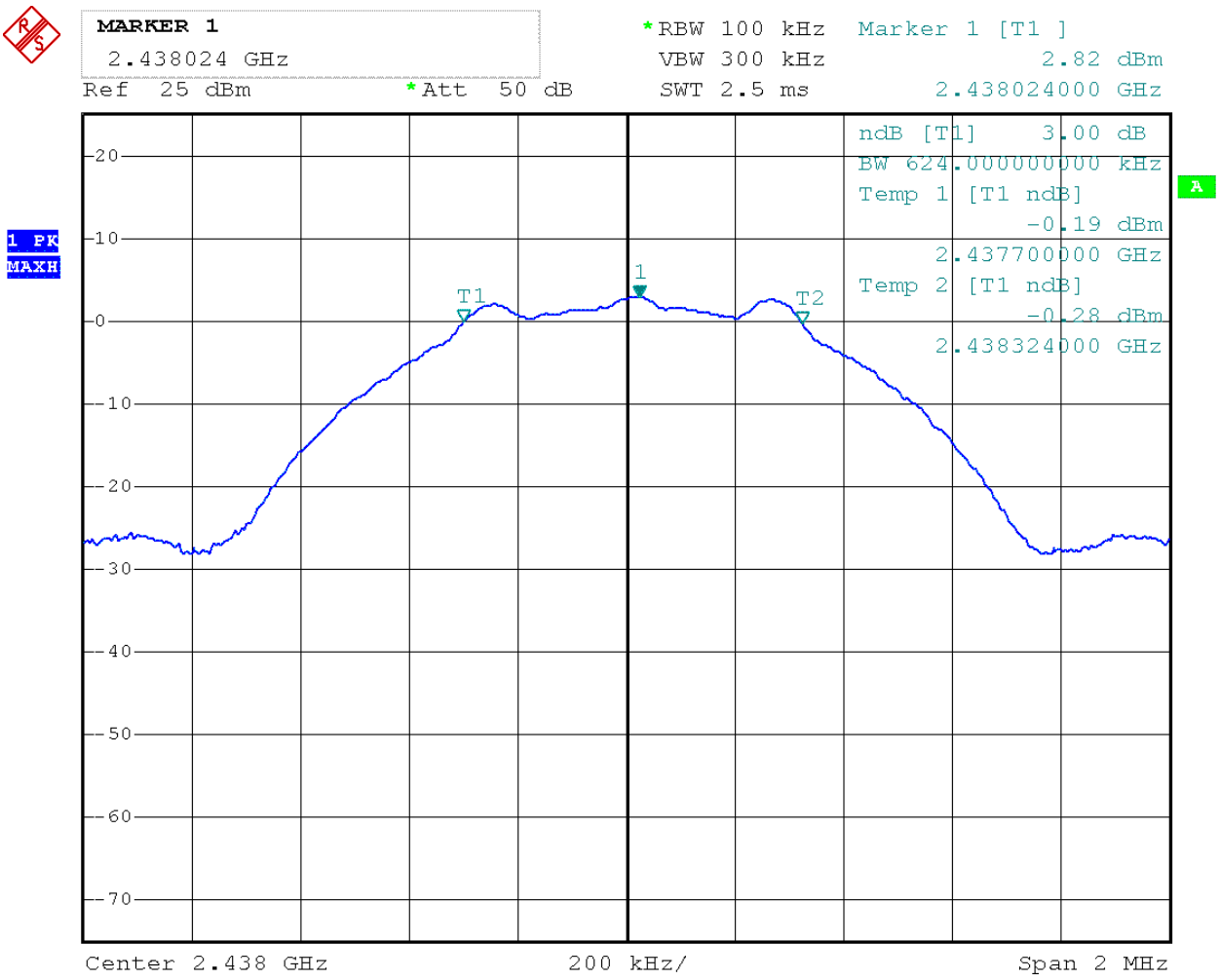
Test Personnel:	Bryan Taylor	Test Date:	1/22/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	500kHz minimum 6dB Bandwidth
Product Standard:	FCC Part 15.247 RSS-247 Issue 2	Ambient Temperature:	22.6C
Input Voltage:	3.7VDC	Relative Humidity:	41.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	991.2mbar

10.6 Test Data

Channel	Frequency (MHz)	DTS BW (kHz)	6dB BW (kHz)	99% BW (kHz)
37	2402	749.5	584	1060
38	2438	624	684	1065
39	2480	628	600	1065

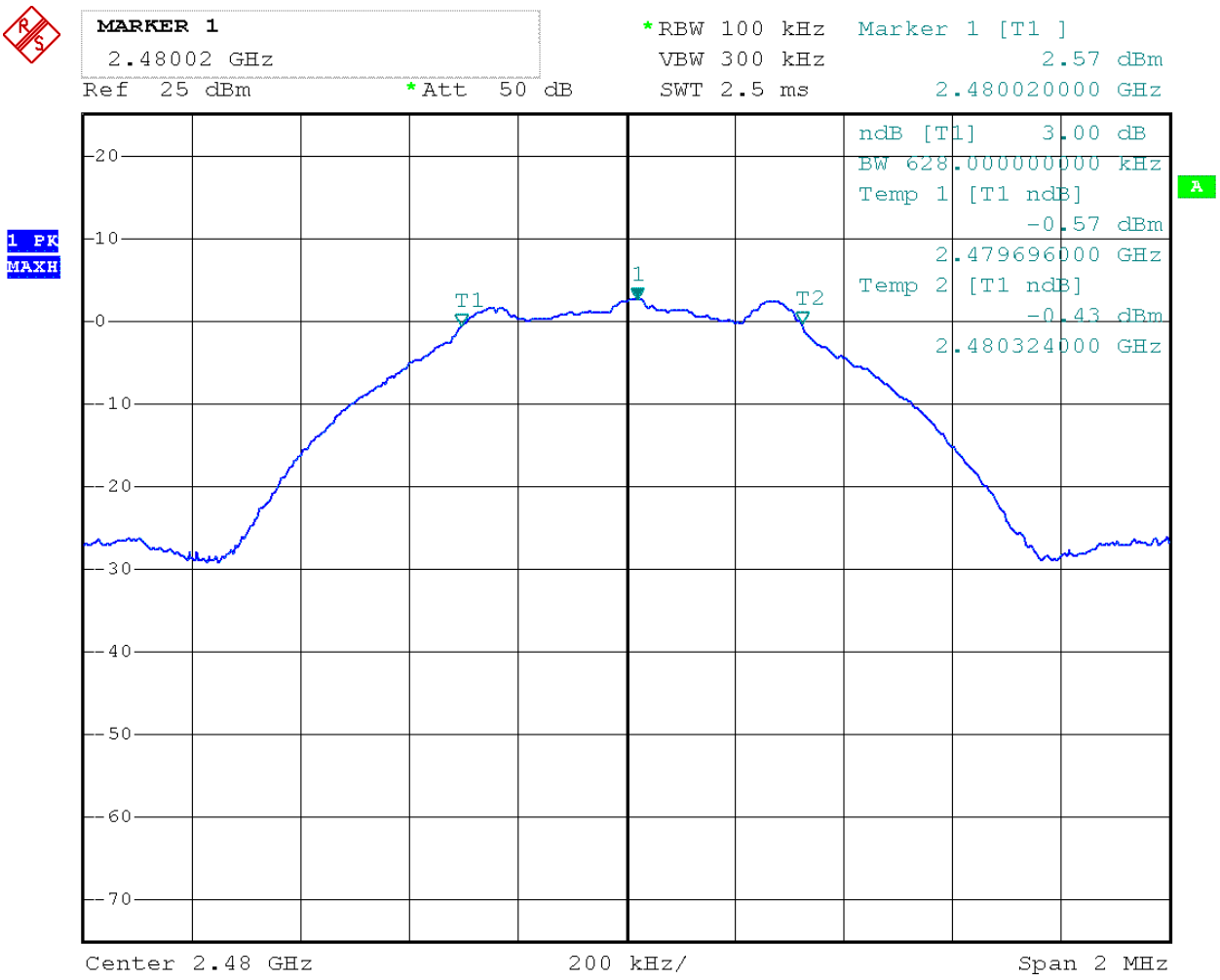


DTS Bandwidth, 2402MHz

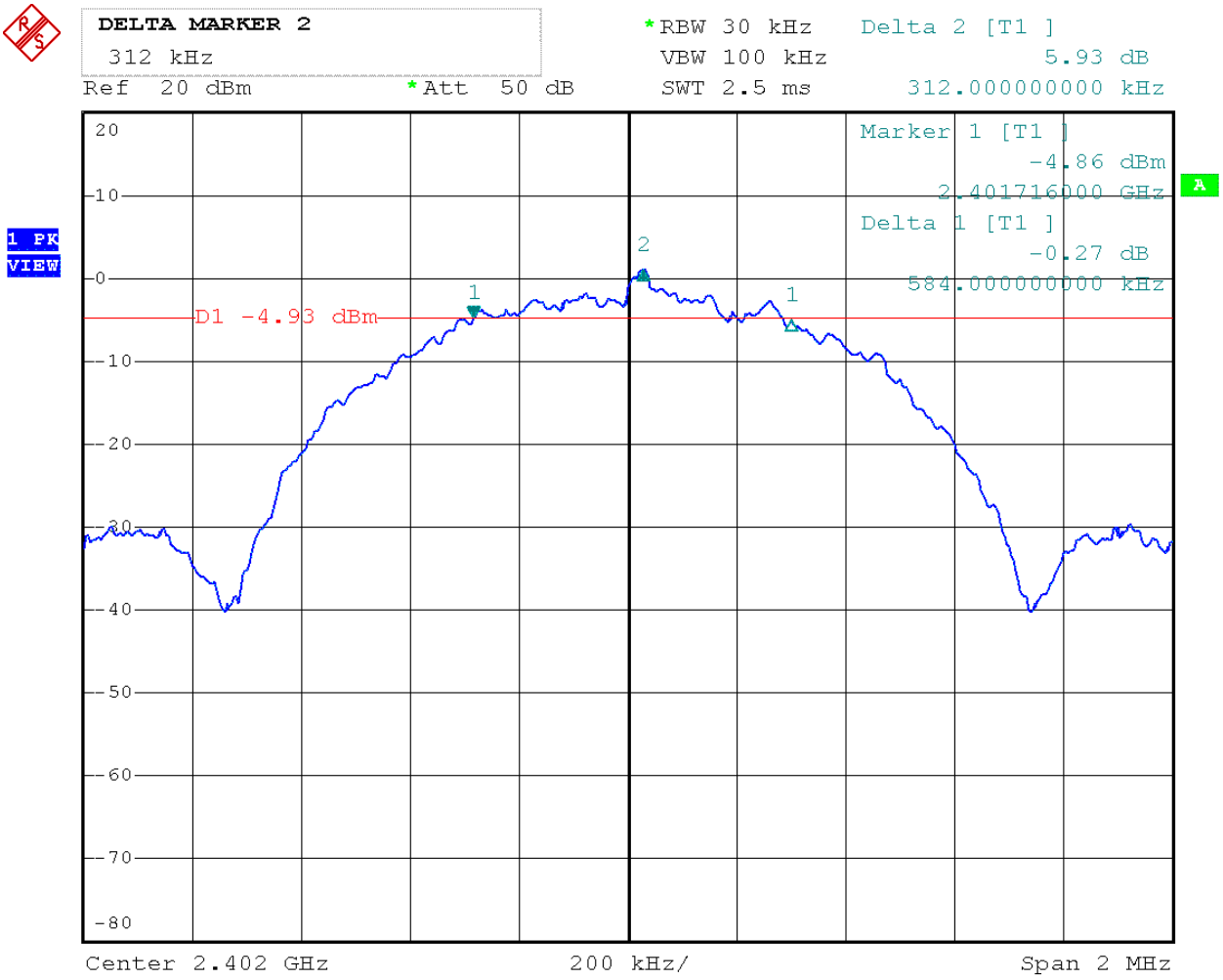


Date: 21.JAN.2021 10:32:58

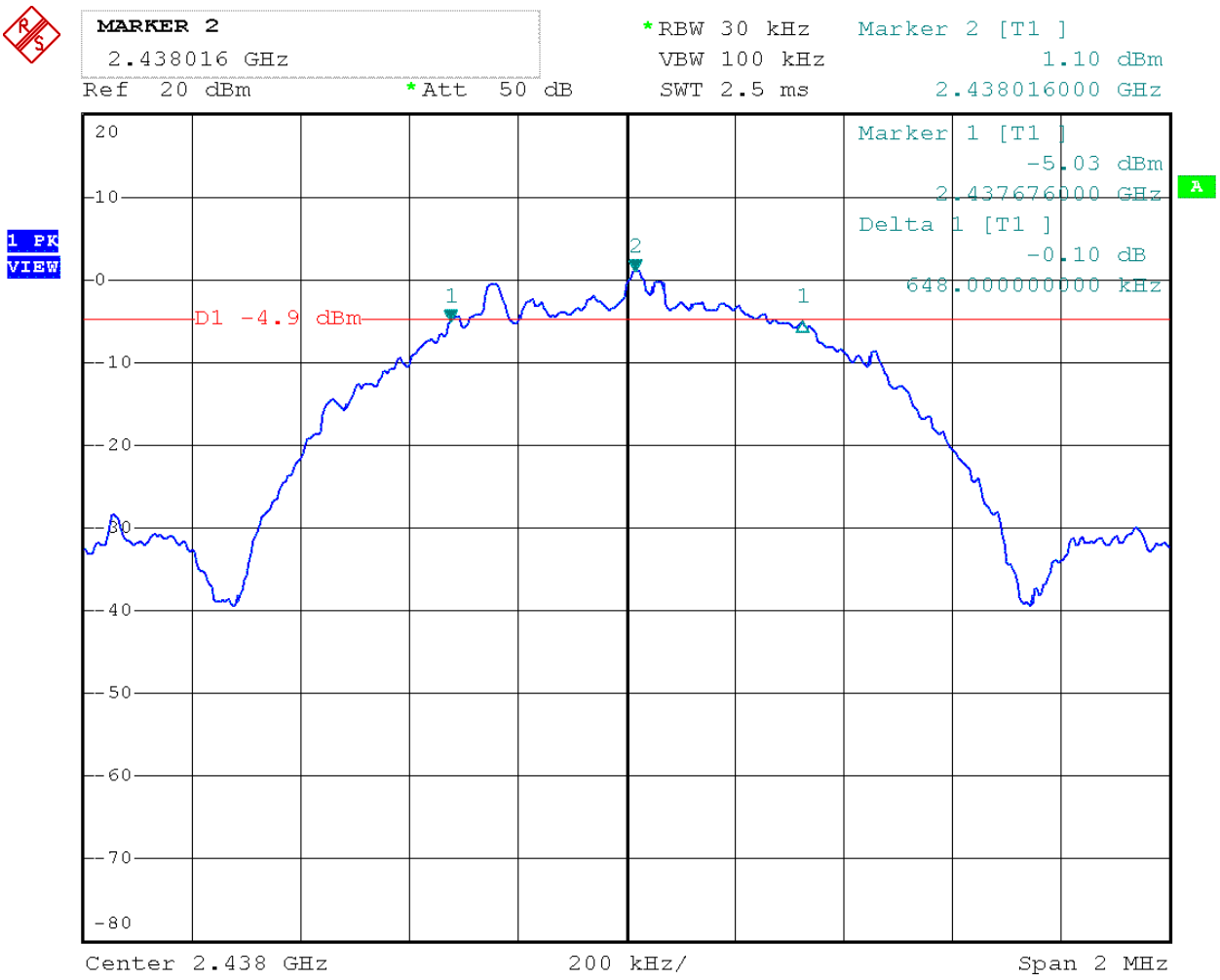
DTS Bandwidth, 2438MHz



DTS Bandwidth, 2480MHz

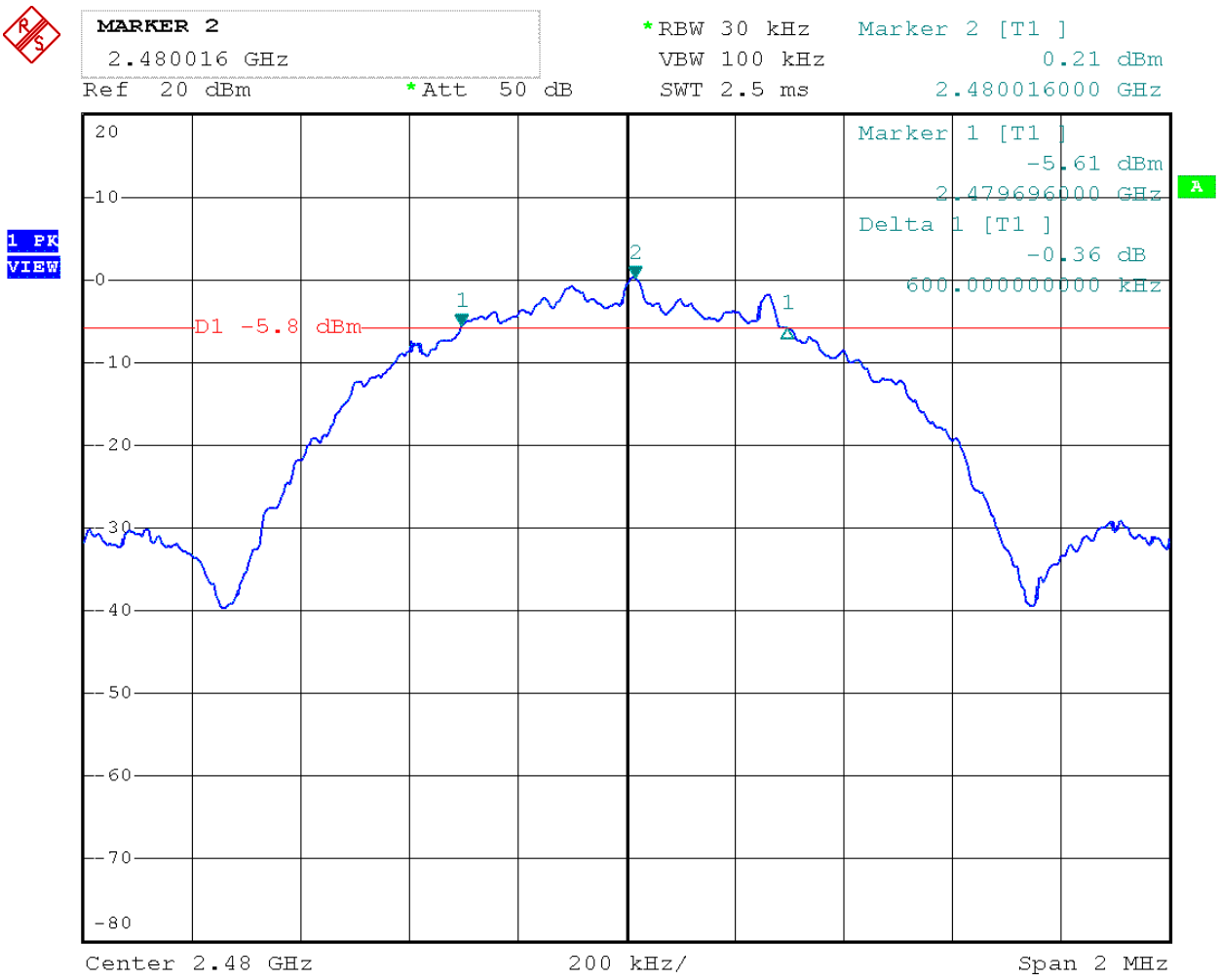


6dB Bandwidth, 2402MHz



Date: 21.JAN.2021 11:29:12

6dB Bandwidth, 2438MHz



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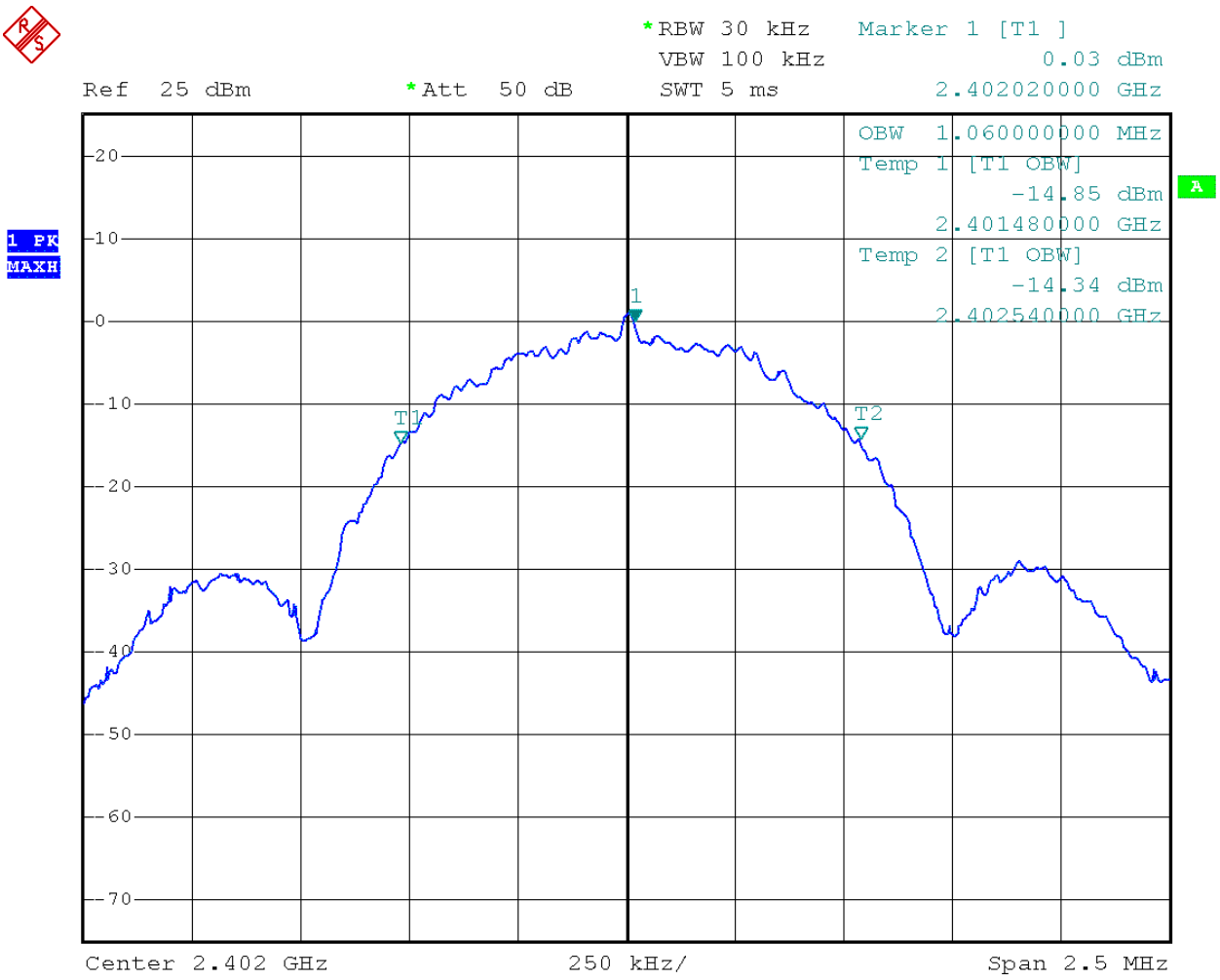
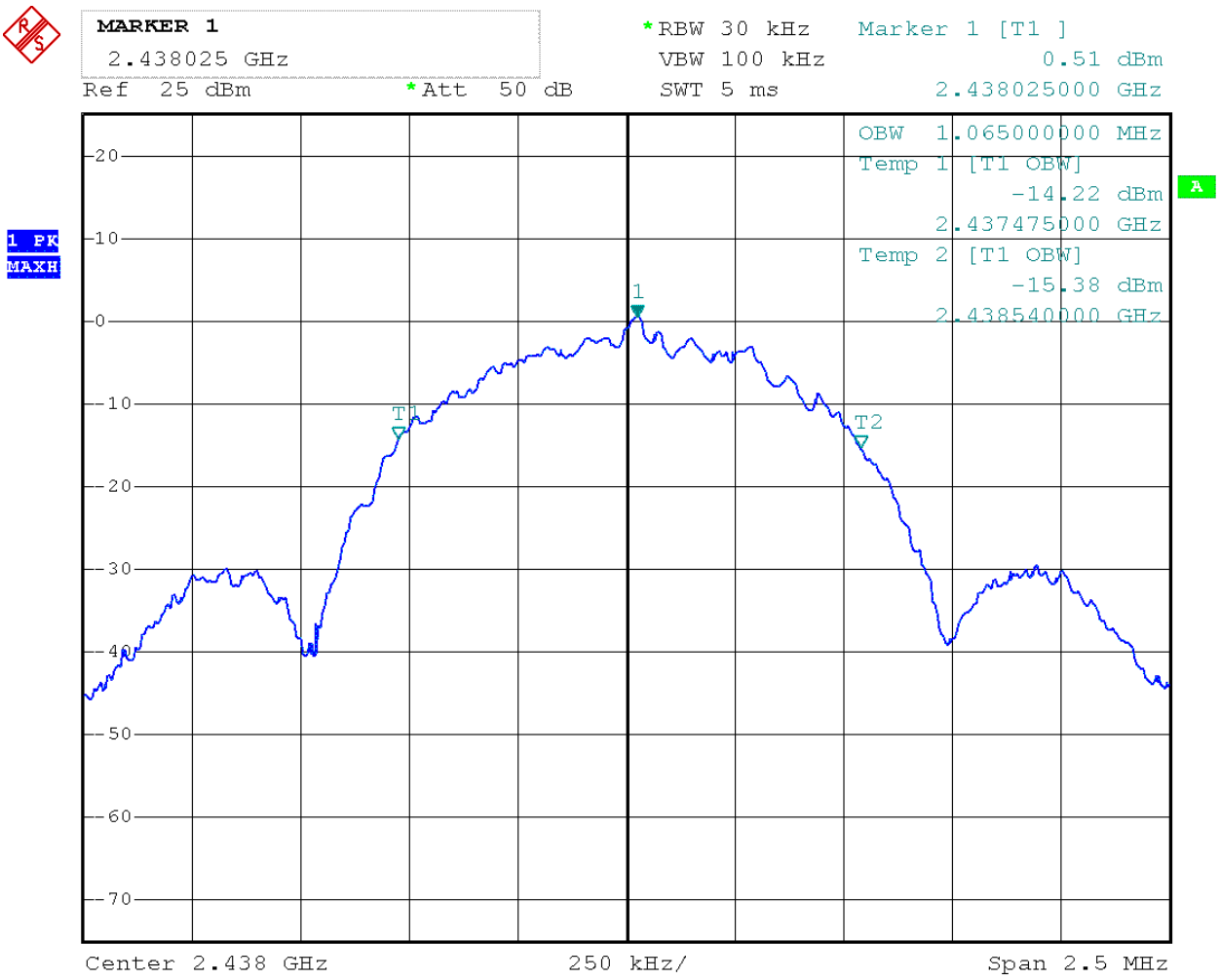
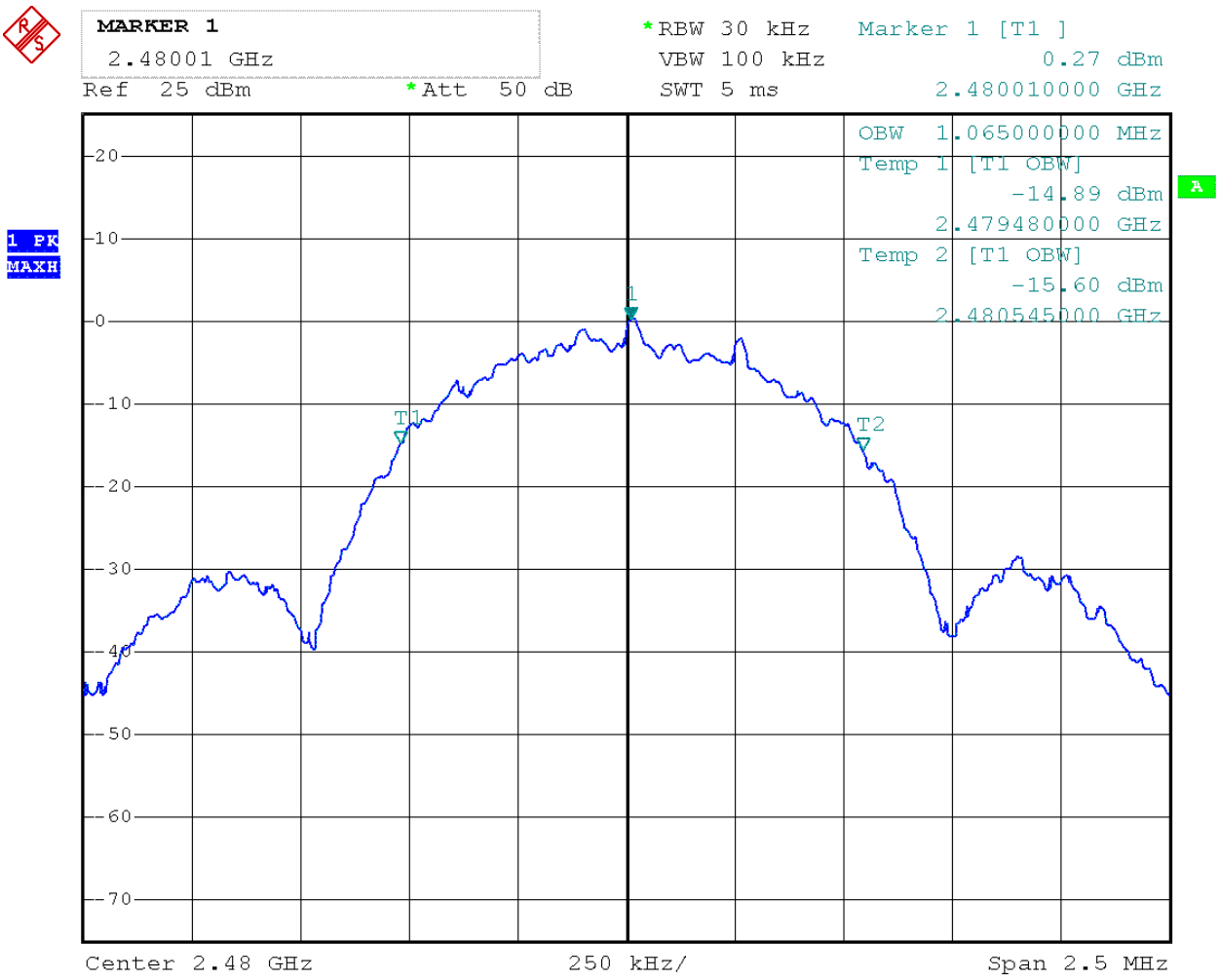
6dB Bandwidth, 2480MHz



99% Bandwidth, 2402MHz



99% Bandwidth, 2438MHz



99% Bandwidth, 2480MHz

11 Power Spectral Density

11.1 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).

11.2 Test Method

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

11.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	10/13/2020	10/13/2021
Coaxial Cable	6086	Megaphase	SF26-S1S1-40	12/21/2020	12/4/2021

11.4 Test Results

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

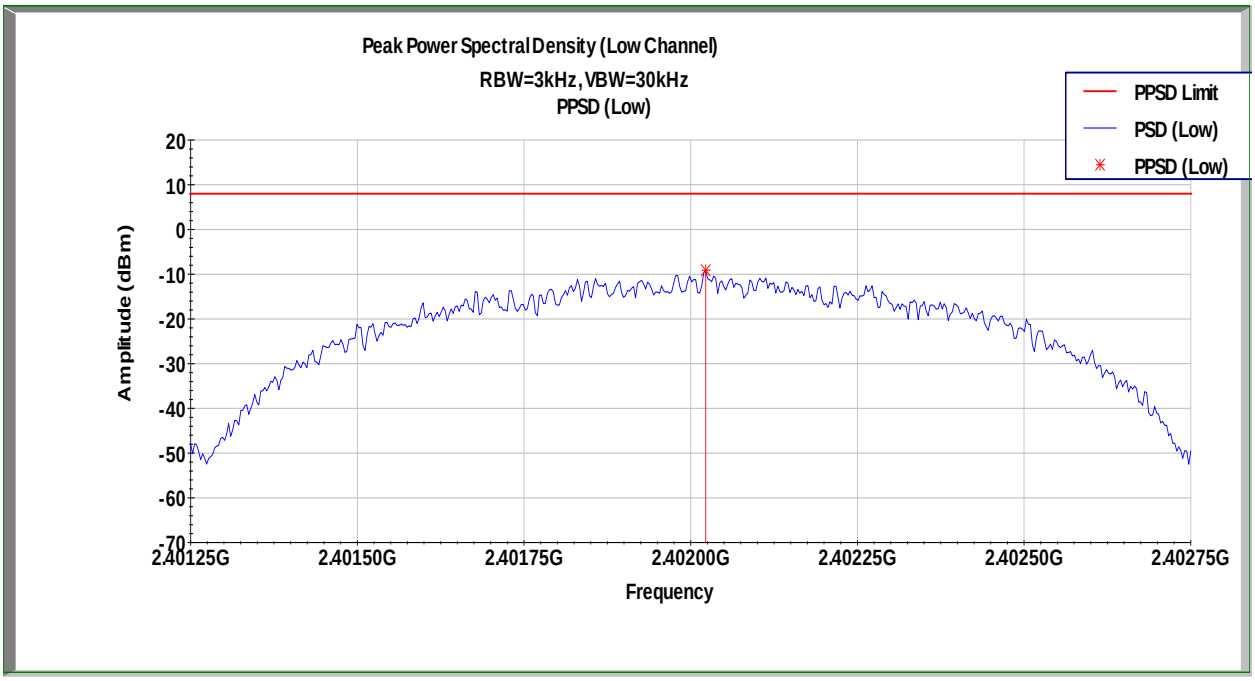
11.5 Test Conditions

Test Personnel:	Bryan Taylor	Test Date:	1/22/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	8dBm / 3kHz
Product Standard:	FCC Part 15.247 RSS-247 Issue 2	Ambient Temperature:	22.6C
Input Voltage:	3.7VDC	Relative Humidity:	41.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	991.2mbar

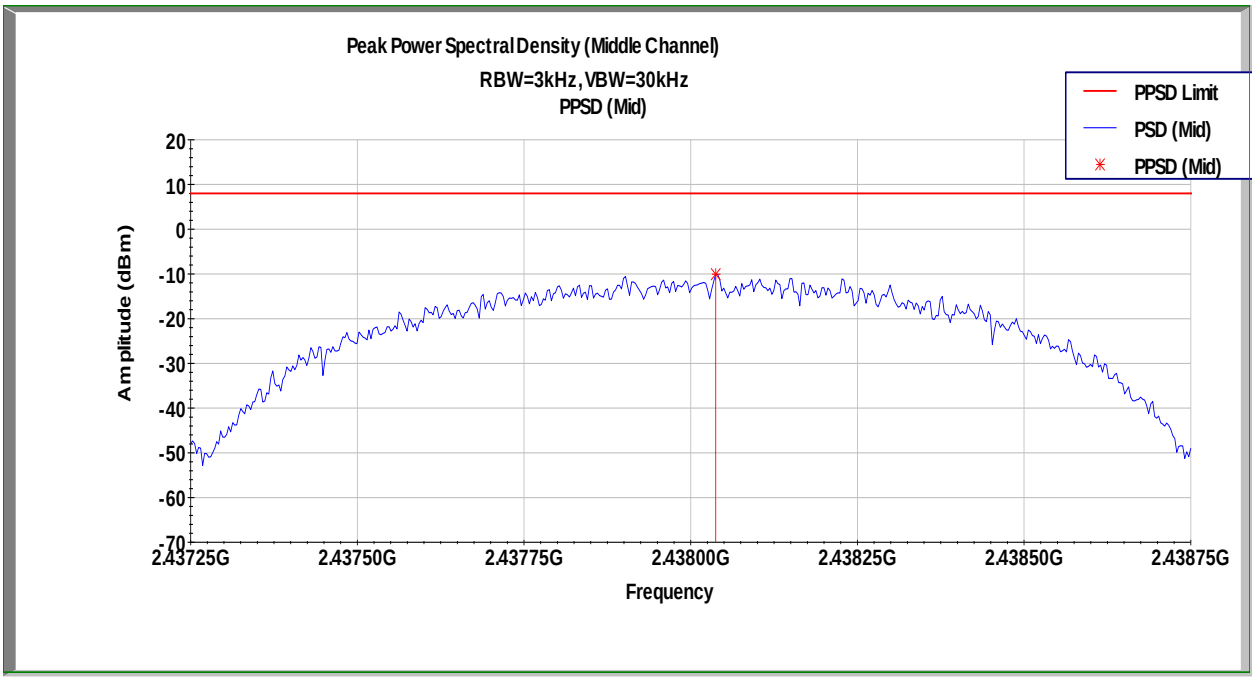
Deviations, Additions, or Exclusions: None.

11.6 Test Data

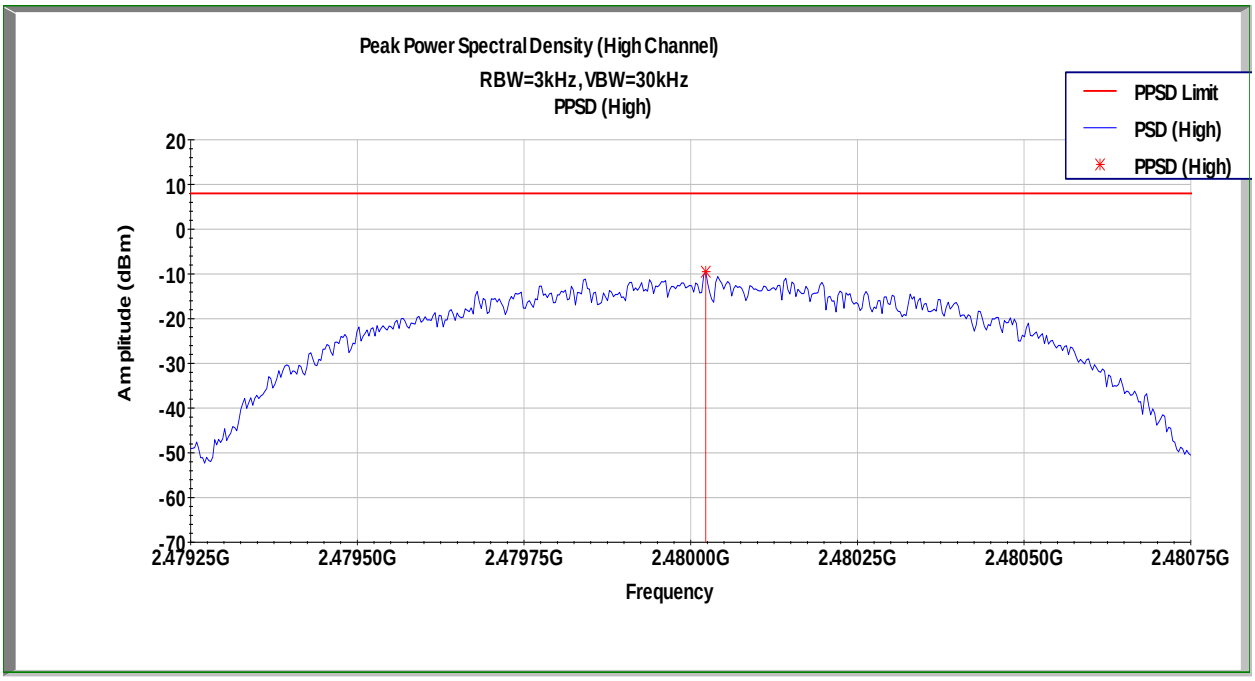
Channel	Frequency (MHz)	PPSD (dBm/3kHz)	Limit (dBm/3kHz)	Margin (dB)	Result
37	2402	-9.15	8	17.15	PASS
38	2438	-10.09	8	18.09	PASS
39	2480	-9.51	8	17.51	PASS



Peak PSD 2402MHz



Peak PSD 2438MHz



Peak PSD 2480MHz

12 Conducted Spurious Emissions

12.1 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.

12.2 Test Method

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

12.3 Test Equipment Used

Description	Asset	Manufacturer	Model	Cal Date	Cal Due
Spectrum Analyzer	3720	Rohde & Schwarz	FSEK30	10/13/2020	10/13/2021
Coaxial Cable	6086	Megaphase	SF26-S1S1-40	12/21/2020	12/4/2021

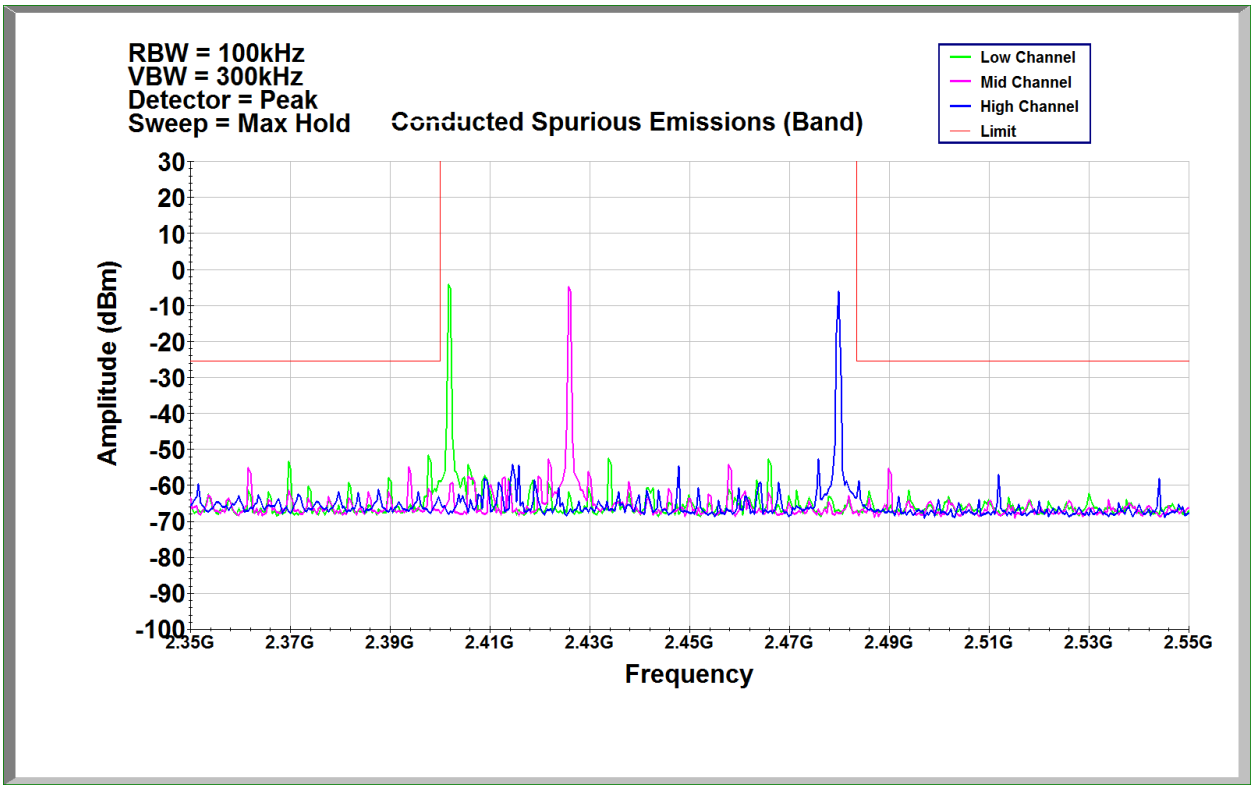
12.4 Test Results

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

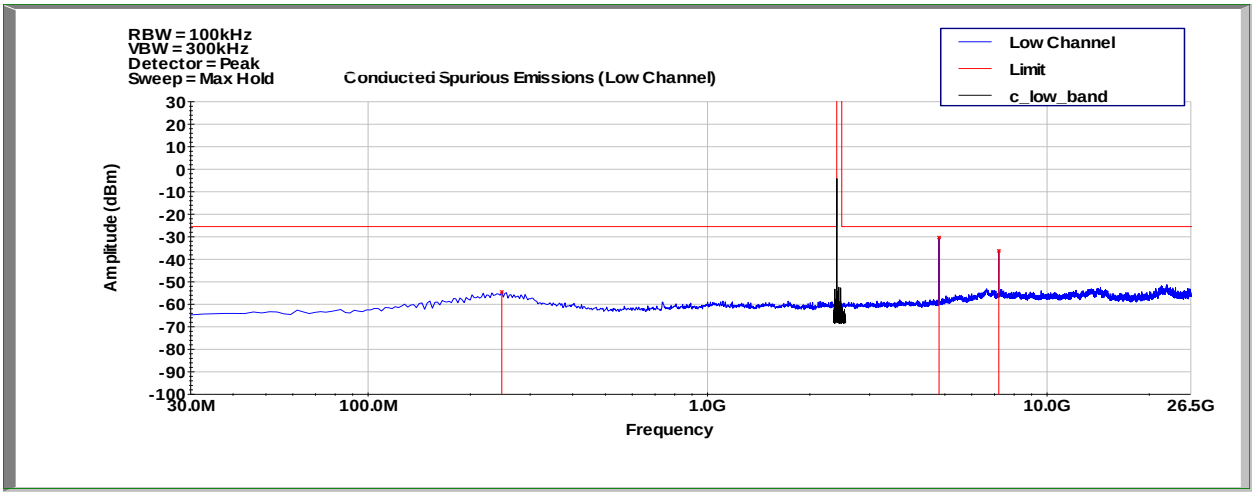
12.5 Test Conditions

Test Personnel:	Bryan Taylor	Test Date:	1/22/2021
Supervising/Reviewing Engineer: (Where Applicable)	NA	Limit Applied:	-20dBc
Product Standard:	FCC Part 15.247 RSS-247 Issue 2	Ambient Temperature:	22.6C
Input Voltage:	3.67VDC	Relative Humidity:	41.2%
Pretest Verification w / Ambient Signals or BB Source:	Yes	Atmospheric Pressure:	991.2mbar

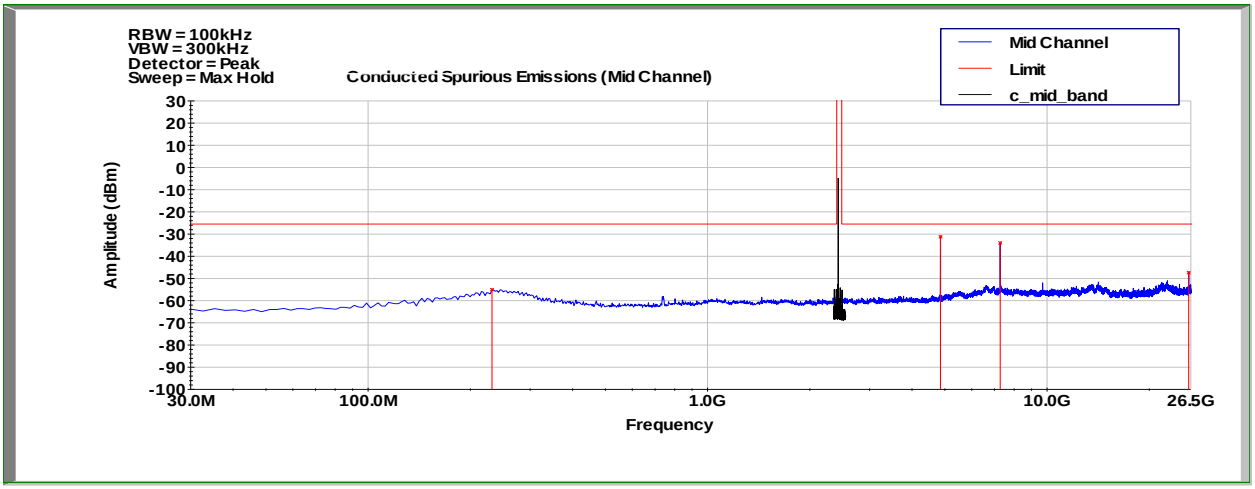
12.6 Test Data



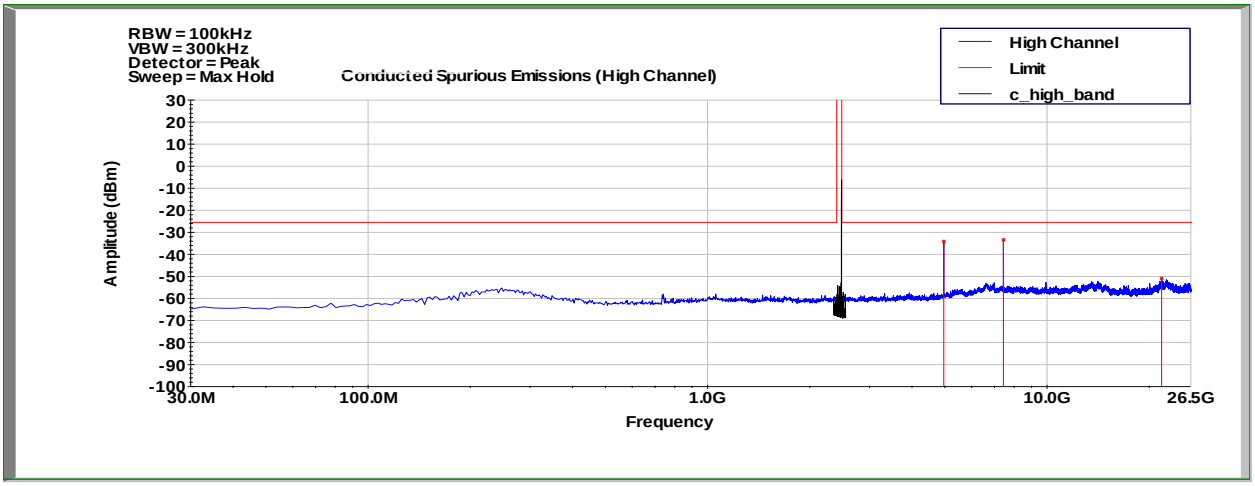
Conducted Spurious Emissions (In-Band)



2402MHz Conducted Spurious Emissions[2]



2438MHz Conducted Spurious Emissions[2]



2480MHz Conducted Spurious Emissions

2 Note, the out of band spurious emissions were performed with a band reject filter in line with the spectrum analyzer.

13 Antenna Requirement

13.1 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).

13.2 Test Results

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

14 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	2/21/2021	104469626LEX-018	BCT	BL	Original Issue