

TEST REPORT

Report Number: 104862485MIN-006

Project Number: G104862485

Testing performed on the
NeoCoil PurePath Module

to
47 CFR, Part 15. 247:2022
RSS- 247, Issue 2, 2017
RSS-Gen, Issue 5, 2019, Amendment 2

For
NeoCoil, LLC

Test Performed by:
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Test Authorized by:
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Date of issue: January 18, 2022

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1.0 GENERAL DESCRIPTION

Model:	NeoCoil PurePath Module
Type of EUT:	Wireless RF Module
Part Number:	NC00E262
Serial Number:	001
Related Submittal(s) Grants:	None
Company:	NeoCoil, LLC
Customer:	Jon Herkowski
Address:	N27 W23910A Paul Rd Pewaukee, WI 53072, USA
Phone:	(262) 347-1250
e-mail:	Jon.herkowski@neocoil.com
Test Standards:	☒ 47 CFR, Part 15:2022, §15.247 ☒ RSS-247, Issue 2, 2017 ☒ RSS-Gen, Issue 5, 2019, Amendment 2
Type of radio:	☐ Stand -alone ☒ Module ☐ Hybrid
Date Sample Submitted:	December 9, 2021
Test Work Started:	December 13, 2021
Test Work Completed:	December 29, 2021
Test Sample Conditions:	☐ Damaged ☐ Poor (Usable) ☒ Good

1.1 Product Description; Test Facility

Product Description:	2.4GHz radio
Transmitter Type:	☐ FHSS ☒ Digital Modulation ☐ WiFi ☐ Blue Tooth
Permitted Band of Operation	2400 to 2483.5MHz
Operating Frequency Range(s):	2406 to 2474MHz
Number of Channels:	18
Antenna(s) Info:	External Gain:3.2dBi
Antenna Installation:	☐ User ☐ Professional ☒ Factory
Transmitter power configuration:	☐ Internal battery ☐ External power source ☒ 12 VDC new battery
Special Test Arrangement:	The Radio as RF Module was tested for Radiated Emissions in three orthogonal axes
Test Facility Accreditation:	A2LA (Certificate No. 1427.01)
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013 and FCC 558074 D01 DTS Measurement Guidance

1.2 EUT Configuration

The equipment under test was operated during the measurement under the following conditions:

- ☐ - Standby
- ☒ - Continuous transmissions (modulated signal)
- ☒ - Continuous transmissions (un-modulated signal) separately
- ☐ - Continuous receiving

Operating modes of the EUT:

No.	Description
1	Test Mode – The EUT transmitted continuously and per client was configured to transmit with >98% duty cycle. Software used for testing: PurePath Wireless Command software.
2	Test was performed at Ch.1 (2406MHz), Ch.19 (2438MHz), and Ch.39 (2474MHz)
3	Data Rate: 1Mbps. Channels Output Power Setting (Test Software setting) per client request was set to +5 dB for all channels.

Cables:

No.	Type	Length	Designation	Note
1	2-wire unshielded	<3m	DC Power	

Support equipment/Services:

No.	Item	Description
1	Dell Latitude E6420	Laptop computer
2	CC Debugger	PCB board programmer

1.3 Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

☒ **Normal**

Temperature:	+15 to +35 ° C
Humidity:	20-75 %
Atmospheric pressure:	86-106 kPa

☐ **Extreme**

☐ Temperature:	-20 to +50 ° C
☐ Supply voltage:	85% to +115%

1.4 Measurement uncertainty

Radiated Emissions:

Measurement	Frequency Range	Expanded Uncertainty (k=2)
Radiated Emissions, 3m	9 kHz-30 MHz	3.2 dB
Radiated Emissions, 3m	30-1000 MHz	4.5 dB
Radiated Emissions, 3m	1-6 GHz	4.6 dB
Radiated Emissions, 3m	6-18 GHz	4.6 dB
Radiated Emissions, 3m	18-26 GHz	4.8 dB

AC Mains Conducted Emissions:

Measurement	Frequency Range	Expanded Uncertainty (k=2)
AC Line Conducted Emissions	150 kHz - 30 MHz	2.6 dB

Conducted Spurious RF Emissions:

The expanded uncertainty (k = 2) for Conducted Spurious Emissions has been determined to be: ± 1.5 dB

1.5 Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured emissions reading on the EMI Receiver.

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 in dB(μ V)

CF = Cable Attenuation Factor in dB

AF = Antenna Factor in dB(m^{-1})

AG = Amplifier Gain in dB

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.

$$RA = 52.0 \text{ dB}\mu\text{V}$$

$$AF = 7.4 \text{ dB/m}$$

$$CF = 1.6 \text{ dB}$$

$$AG = 29.0 \text{ dB}$$

$$FS = 32 \text{ dB}\mu\text{V/m}$$

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:

$$FS = RA + AF + CF - AG = 52.0 + 7.4 + 1.6 - 29.0 = 32.0$$

$$UF = 10^{(32 \text{ dB}\mu\text{V} / 20)} = 39.8 \mu\text{V/m}$$

2.0 TEST SUMMARY

Referring to the performance criteria and the operating mode during the tests specified in this report, the equipment complies with the requirements according to the following standards.

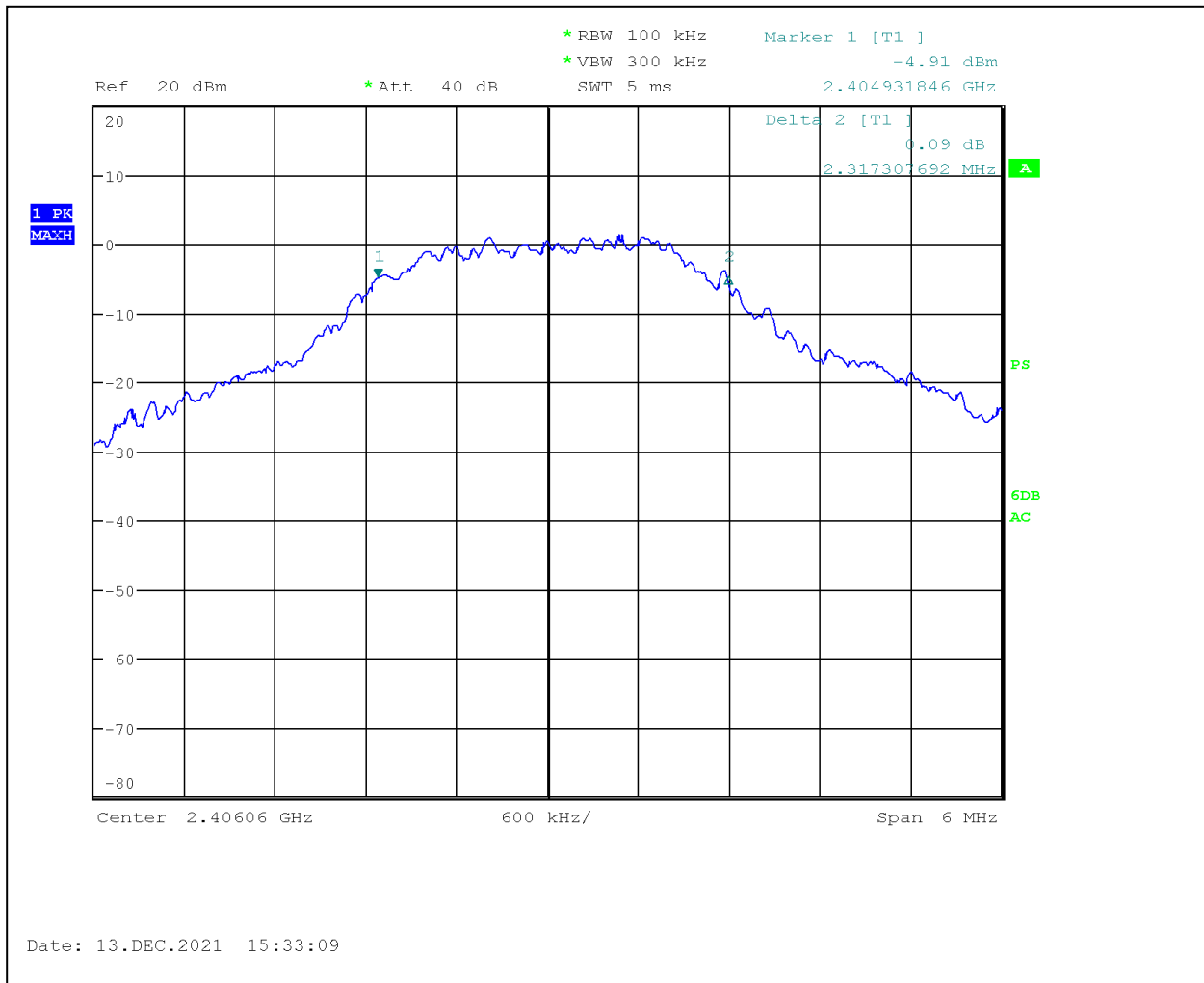
TEST SPECIFICATION	TEST PARAMETERS	RESULT
15.247(a) / RSS-247 5.2	6dB emissions bandwidth of a DTS Transmission	Pass
15.247(b), (c) / RSS-247 5.4	Maximum peak output power	Pass
15.247/(e) / RSS-247 5.2	Power spectral density	Pass
15.247(d) / RSS-247 5.5	Antenna conducted spurious emissions	Pass
15.247(d) / RSS-247 5.5	Radiated spurious emissions	Pass
15.247(i) / RSS- Gen 5.5	RF Exposure Compliance	Pass
15.207 / RSS-Gen 7.2.2	Transmitter Power Line conducted emissions	N/A

3.0 TEST CONDITIONS AND RESULTS

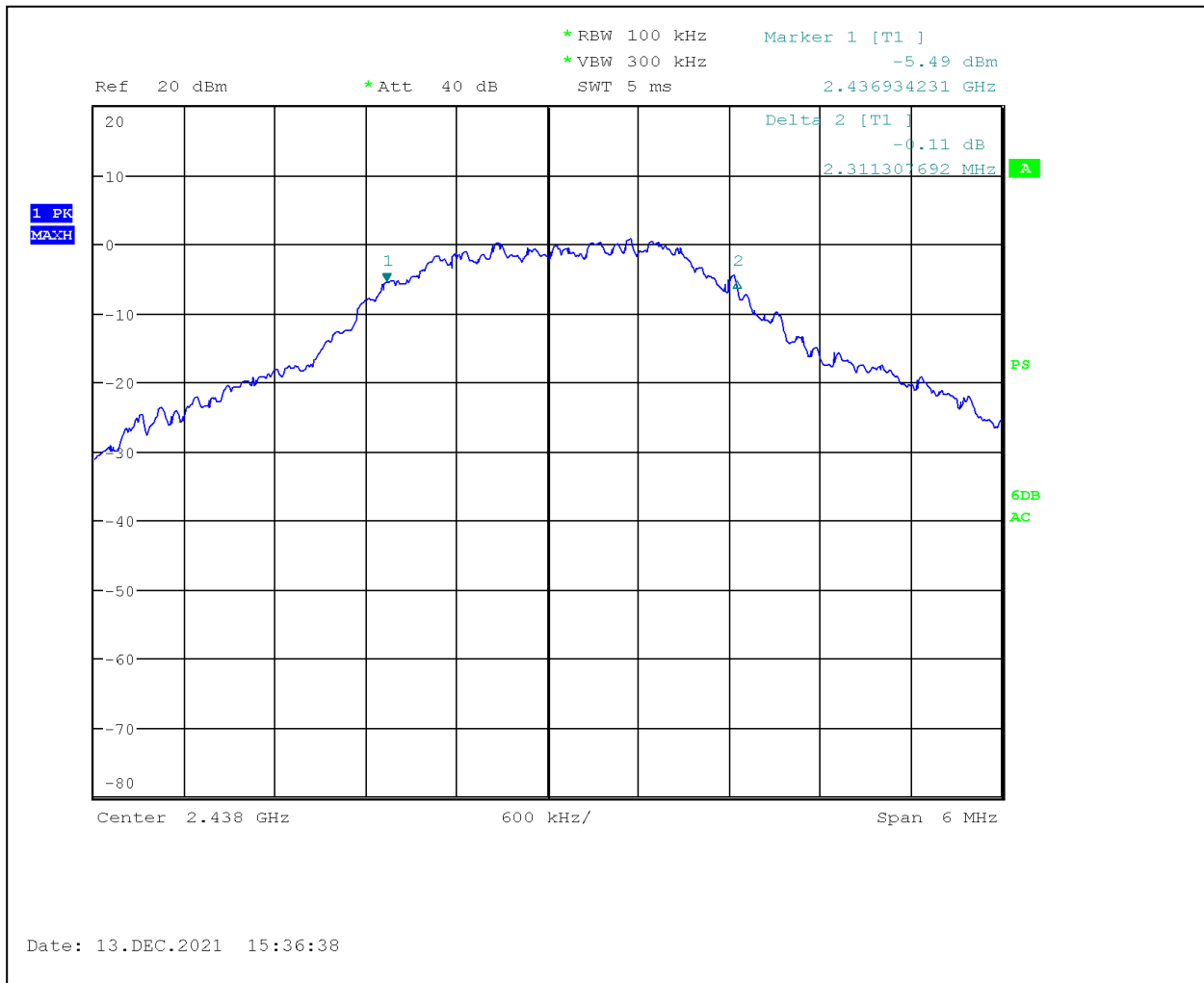
3.1 6dB Emission bandwidth (EBW) a DTS Transmission

Low Frequency Channel kHz	Middle Frequency Channel kHz	Upper Frequency Channel kHz	Minimum Bandwidth kHz	Result
2317	2311	2327	500	Pass
RBW: VBW:	☒ 100kHz ☒ 300kHz			

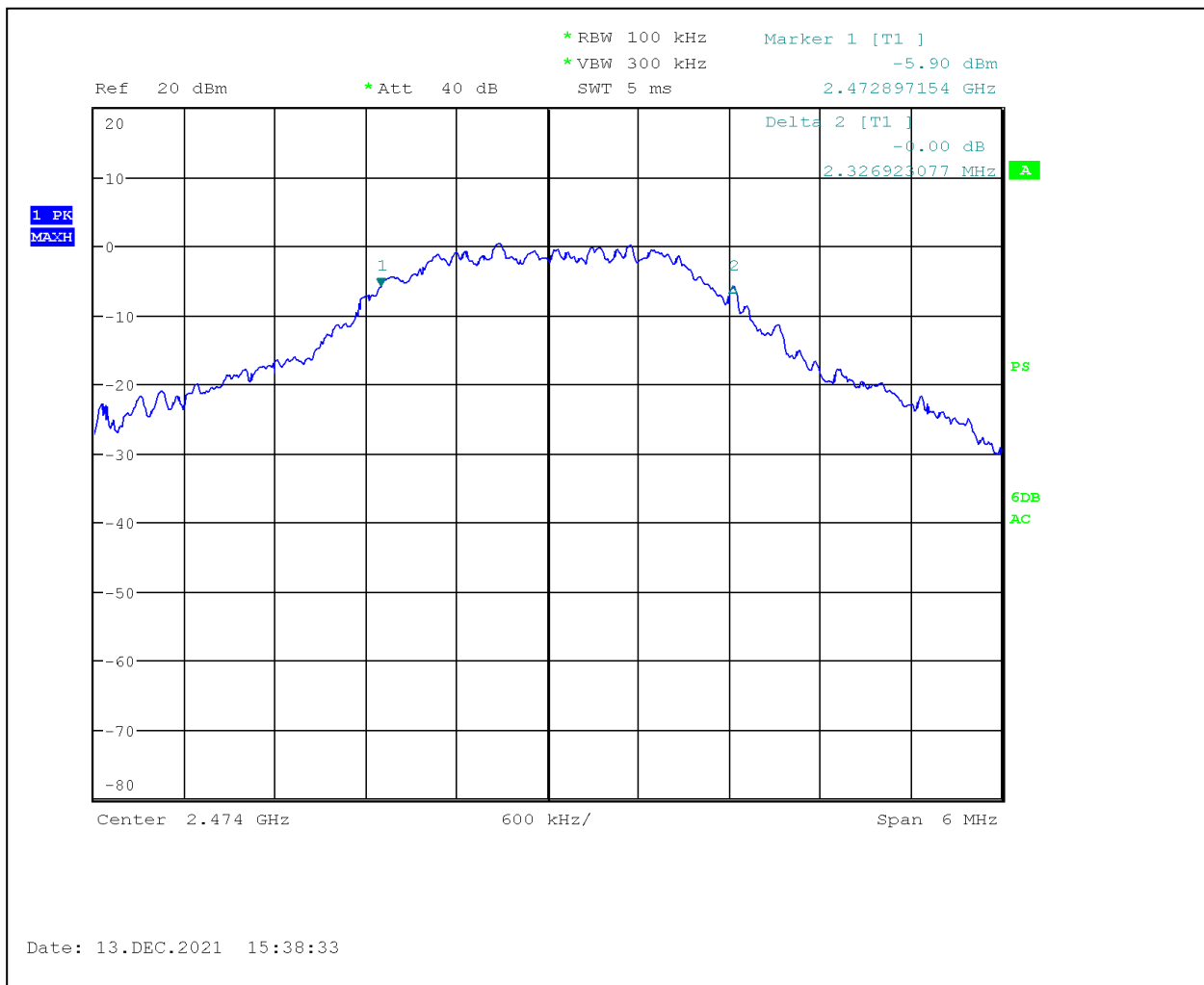
Notes:



Graph 3.1.1



Graph 3.1.2

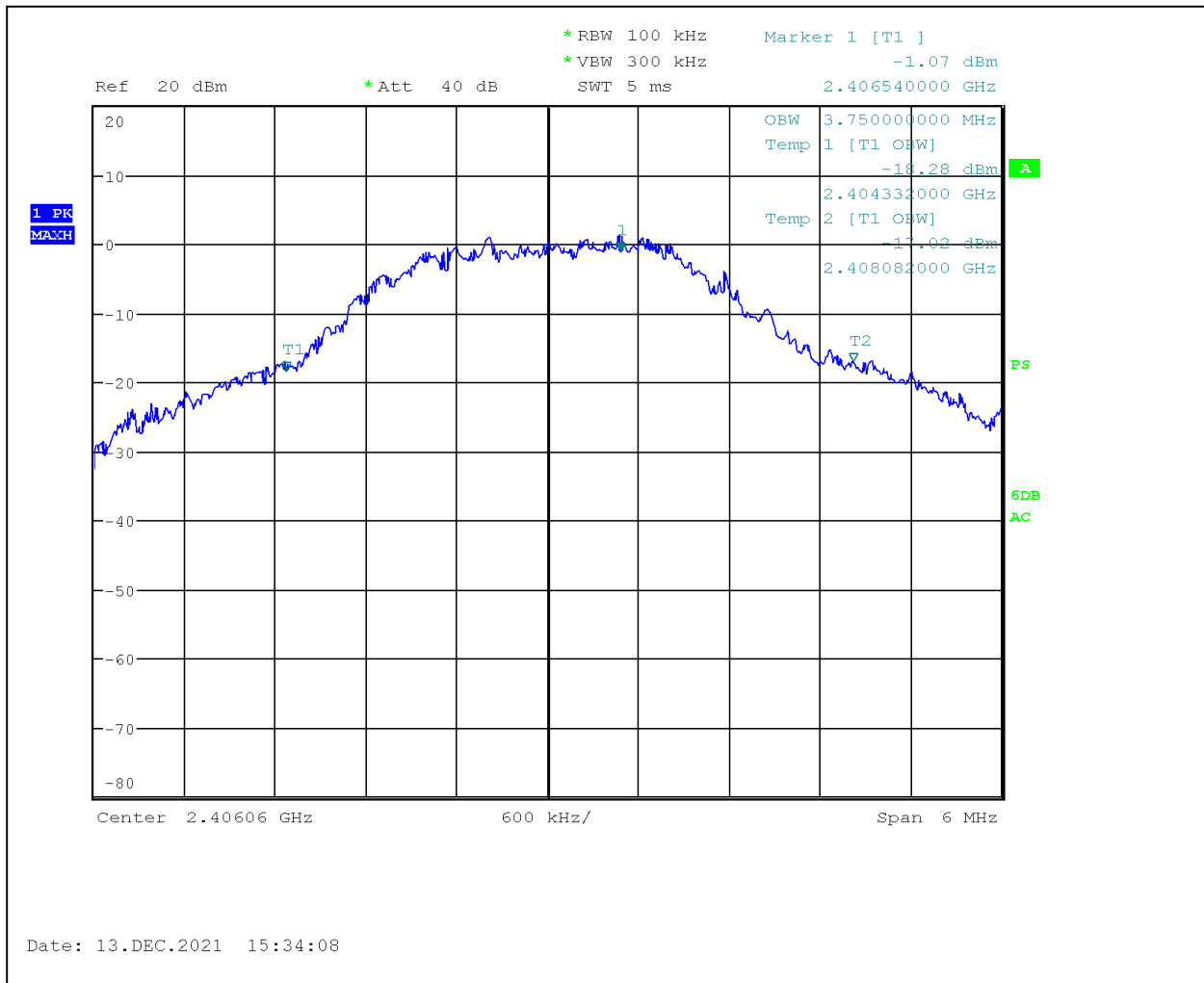


Graph 3.1.3

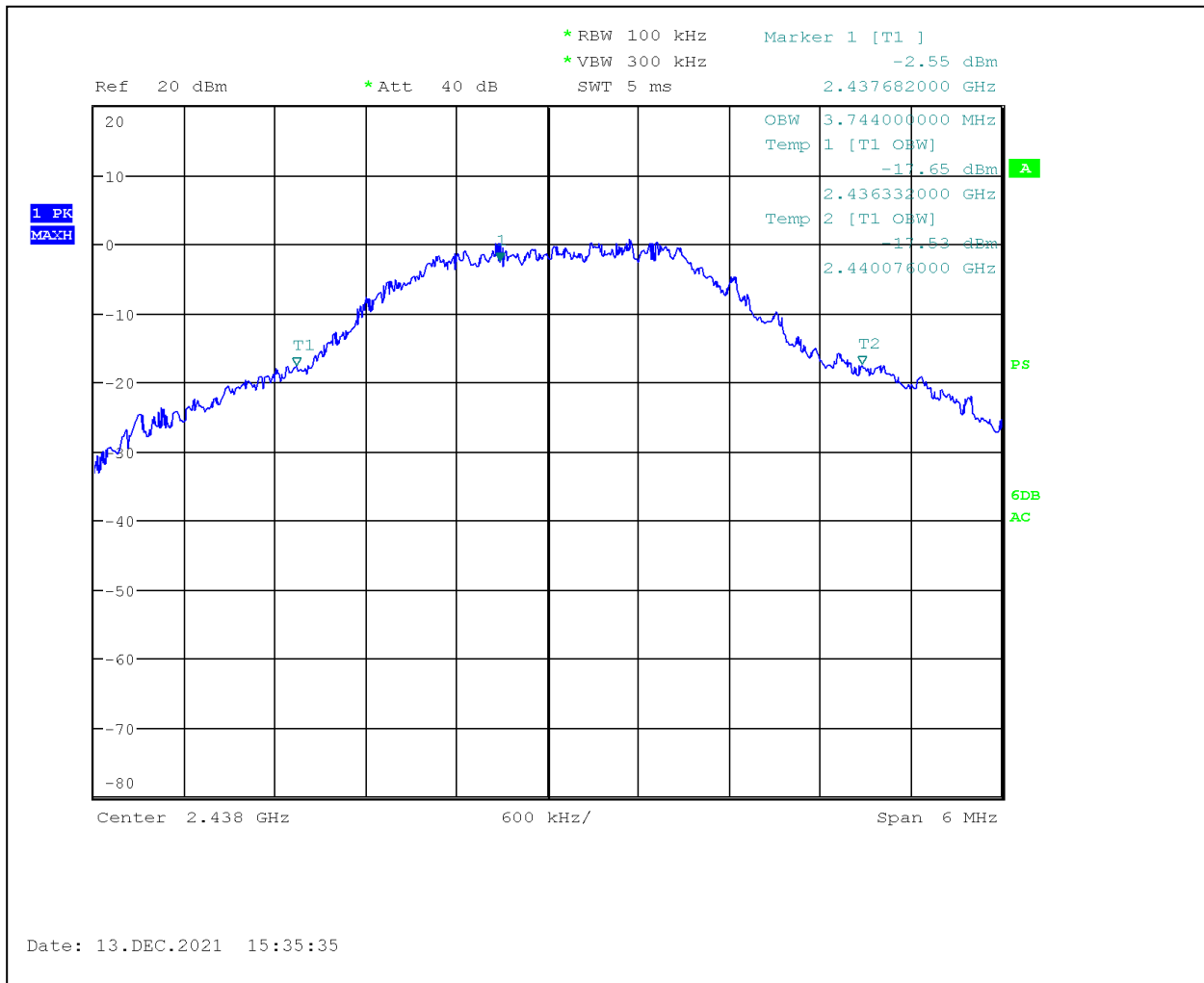
3.2 Occupied bandwidth (OBW) (99%)

Low Frequency Channel kHz	Middle Frequency Channel kHz	Upper Frequency Channel kHz
3750	3744	3756
RBW: VBW:	☒ 100kHz ☒ 300kHz	

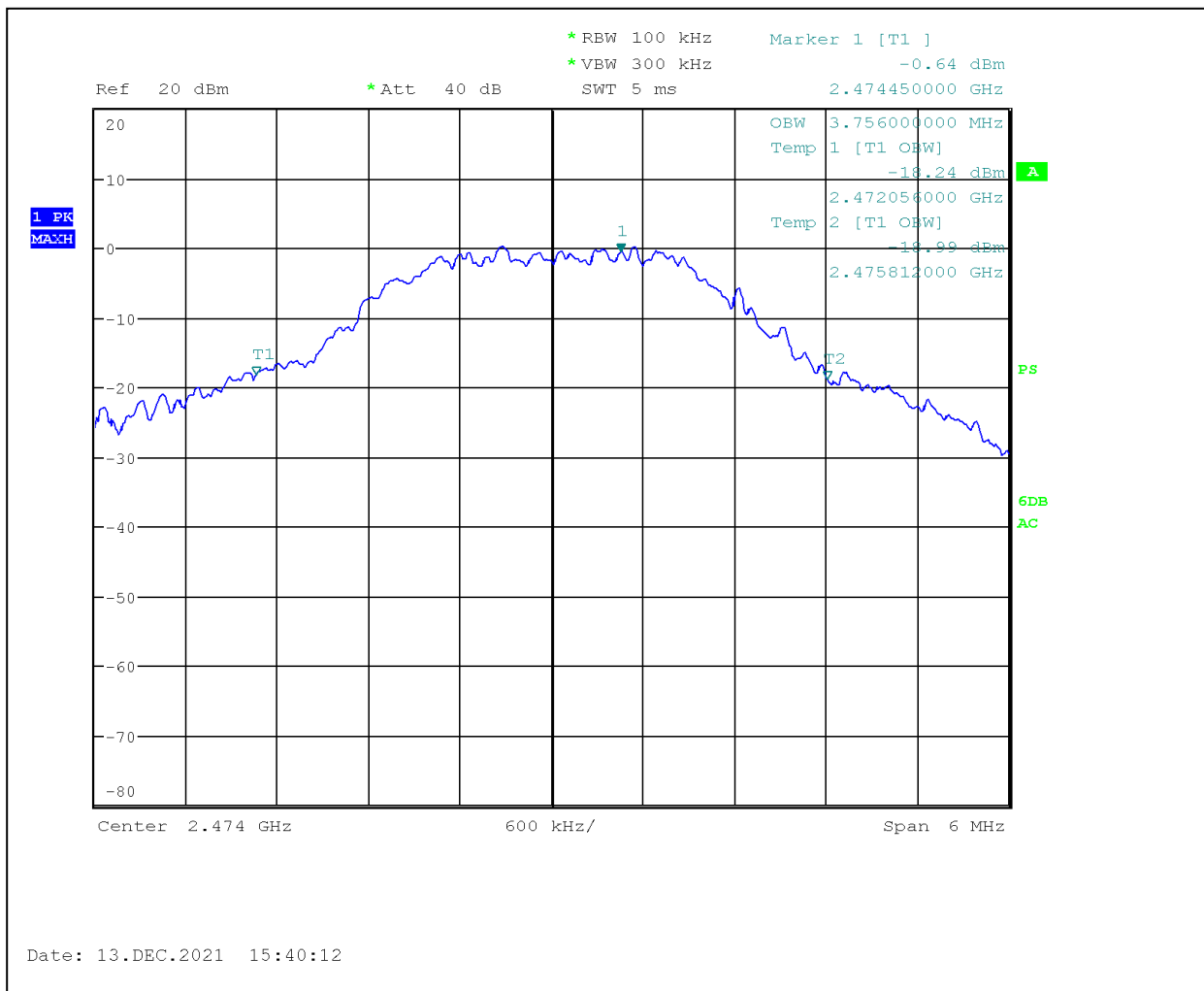
Notes:



Graph 3.2.1



Graph 3.2.2



Graph 3.2.3

3.3 Maximum peak output power

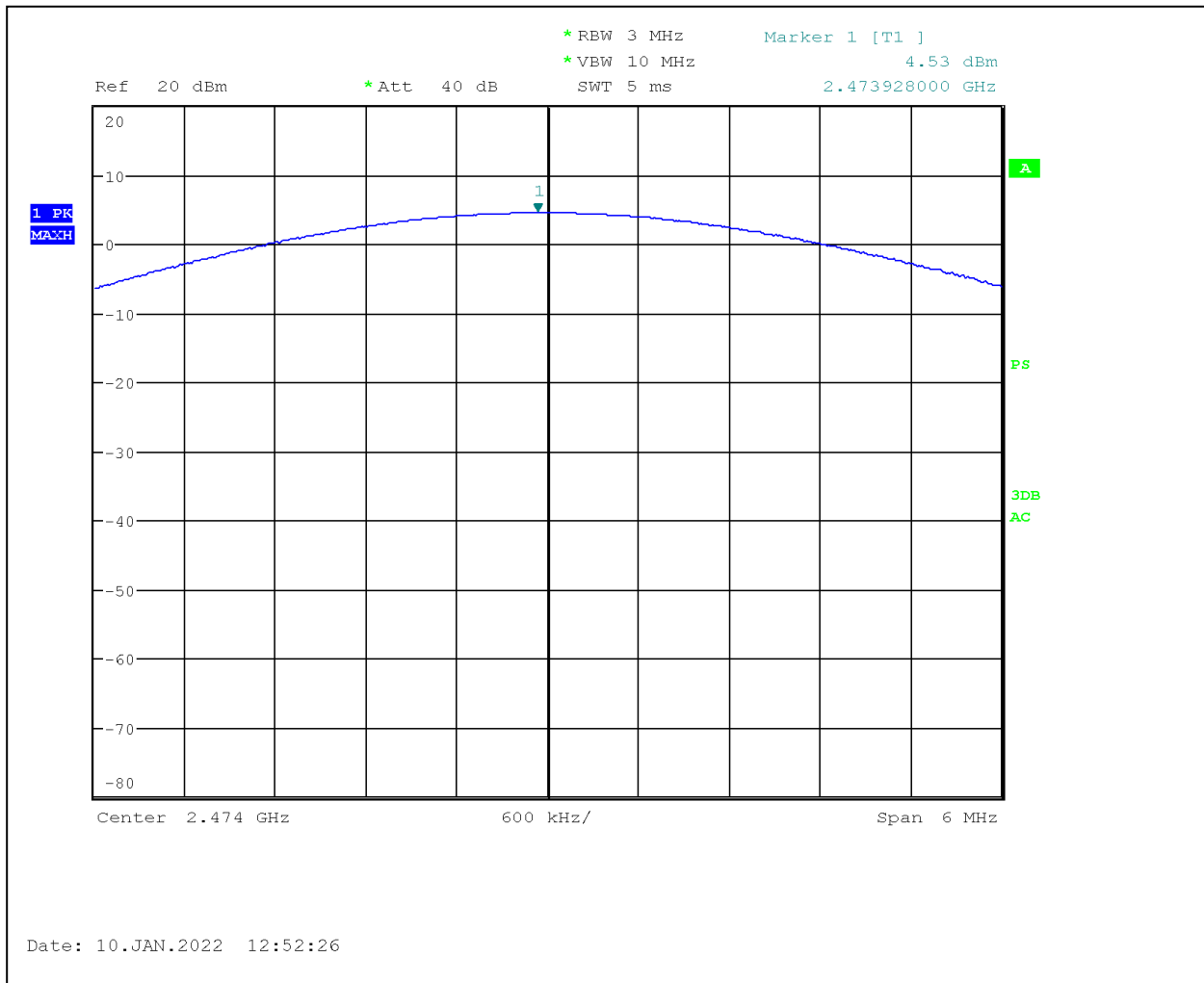
Test result: Pass

Maximum Power: 6.8dBm (4.786mW / 0.00479W) Margin: 23.2dB below the limits

Power Output:	Conducted					
Frequency Range:	☐ 902-928MHz ☒ 2400-2483.5MHz ☐ 5725-5850MHz					
Low Frequency MHz	Measured power dBm	Attenuation dB	Power at Antenna dBm	Limit dBm	Limit Reduction dB	Margin dB
2406	5.3	1.5	6.8	30	0	-23.2
Middle Frequency MHz						
2438	5.3	1.5	6.8	30	0	-23.2
Upper Frequency MHz						
2474	4.5	1.5	6.0	30	0	-24.0
RBW:	☐ 1MHz ☒ 3MHz ☐ 10MHz					
VBW:	☐ 1MHz ☐ 3MHz ☒ 10MHz					
Antenna Gain:	☒ < 6dBi ☐ >6dBi and = dBi, Output power reduction = dB					

Notes: The procedure described in ANSI C63.10-2013 was used. Specifically, Section 11.9.1.1 RBW ≥ DTS bandwidth was utilized as the spectrum analyser's resolution bandwidth was greater than the DTS bandwidth.

The maximum peak conducted output power limit is 1 W, or 30dBm.
Graphs 3.3.1, 3.3.2, 3.3.3 show the conducted peak output power.

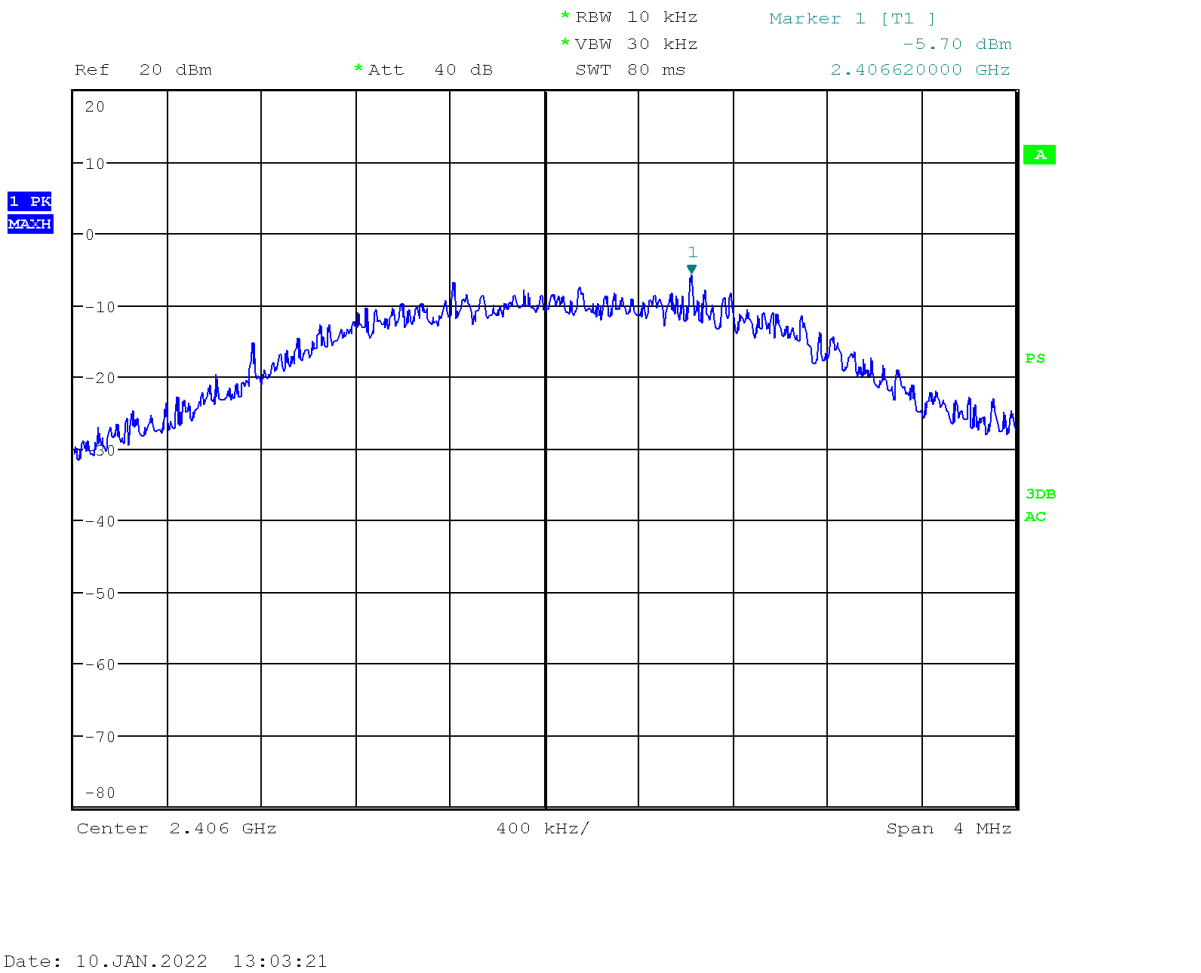


Graph 3.3.3

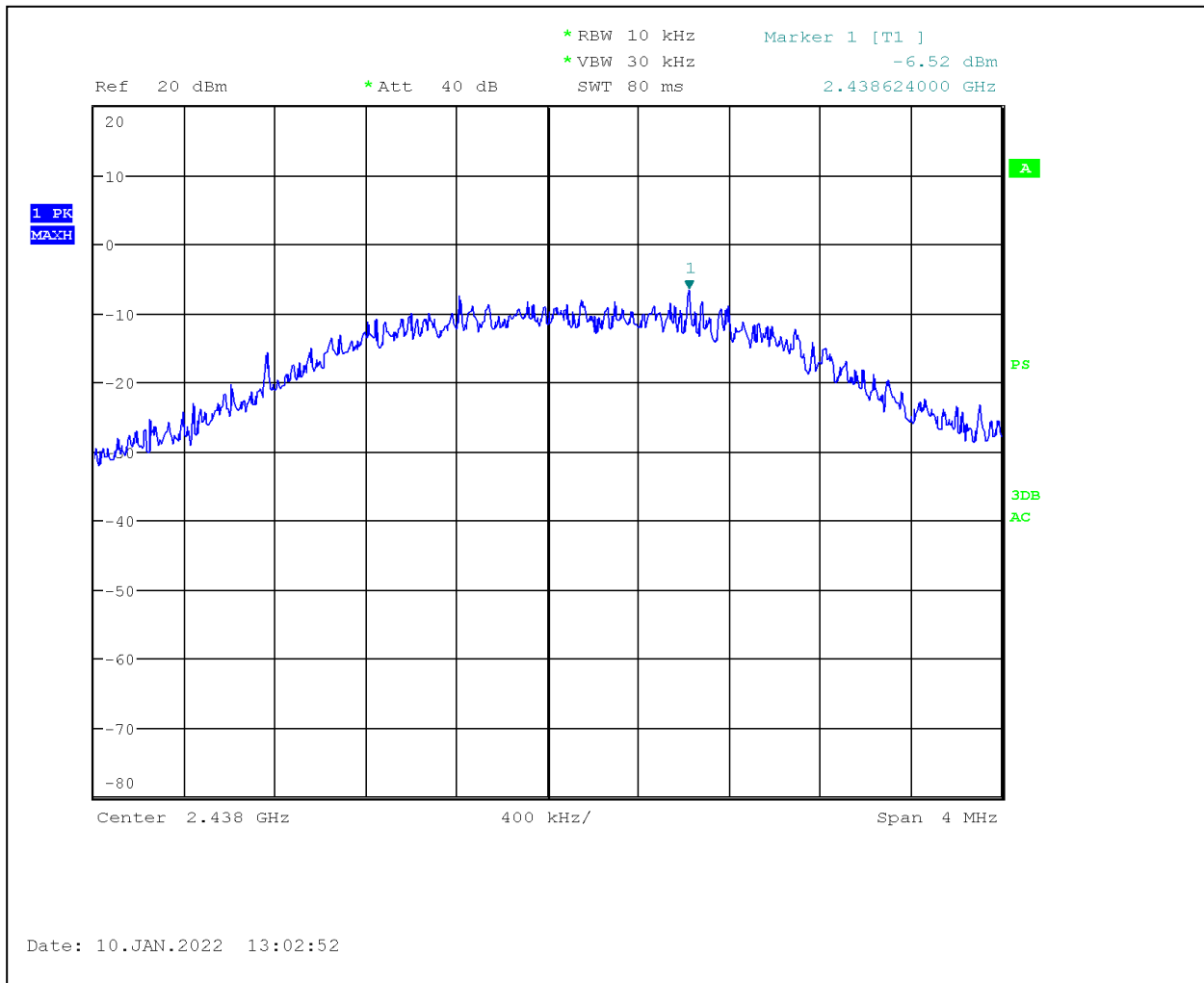
3.4 Power spectral density

Power Output:	☒ Conducted ☐ Radiated			
	Measured Density dBm	Power Density at Antenna dBm	Limit dBm	Margin dB
Low Frequency Channel	-5.7	-4.2	8	-12.2
Middle Frequency Channel	-6.5	-5.0	8	-13.0
Upper Frequency Channel	-6.9	-5.4	8	-13.4
Analyzer Settings:	☒ RBW=10KHz ☒ VBW=30KHz ☒ Span=3.5MHz ☒ Sweep=Auto			
Antenna Gain:	☒ < 6dBi and = 5 dBi ☐ >6dBi and = dBi, limit reduction = dB			

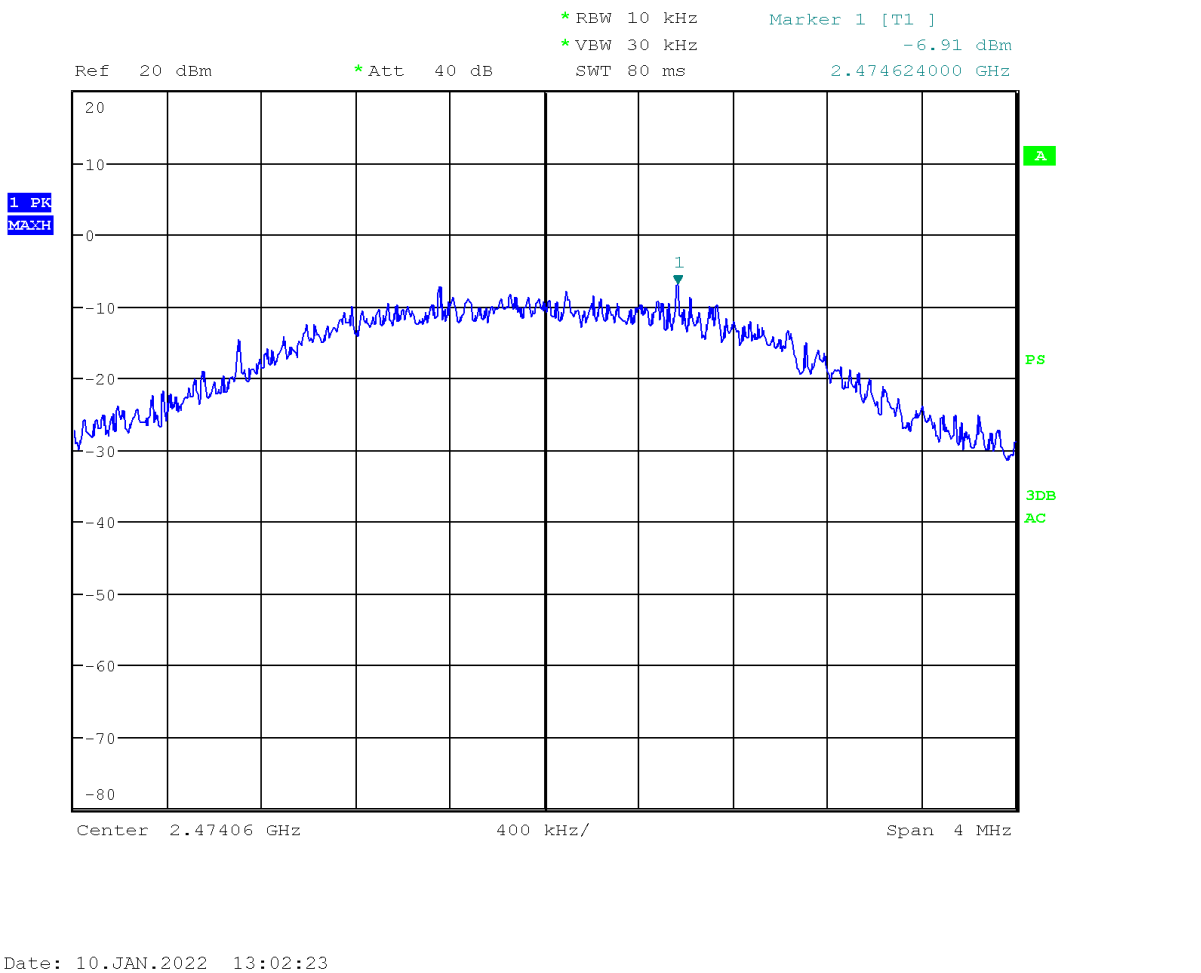
Notes: The Power Spectral Density at Antenna was calculated adding the cable loss of 1.5dB from the measured density value.



Graph 3.4.1



Graph 3.4.2

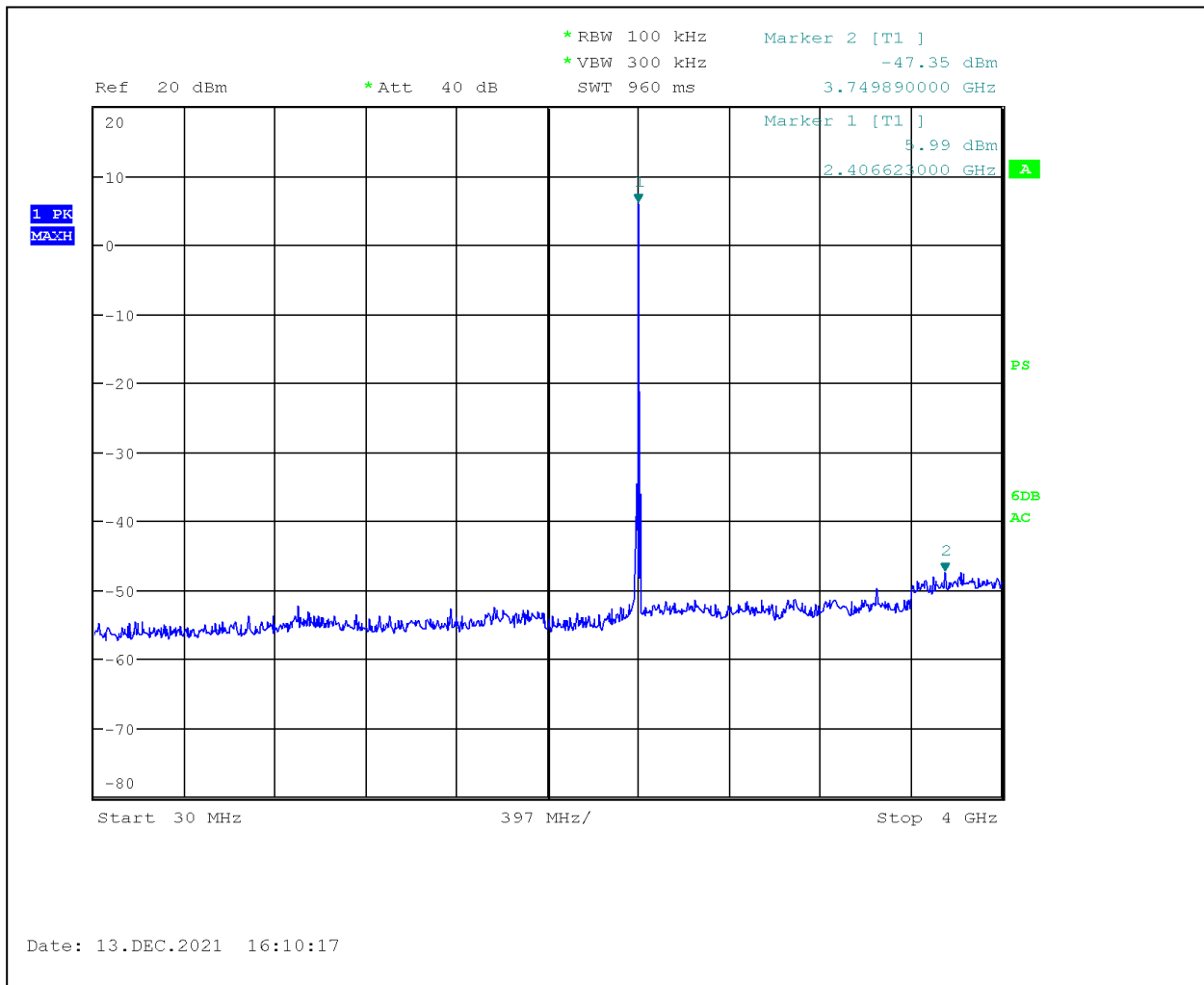


Graph 3.4.3

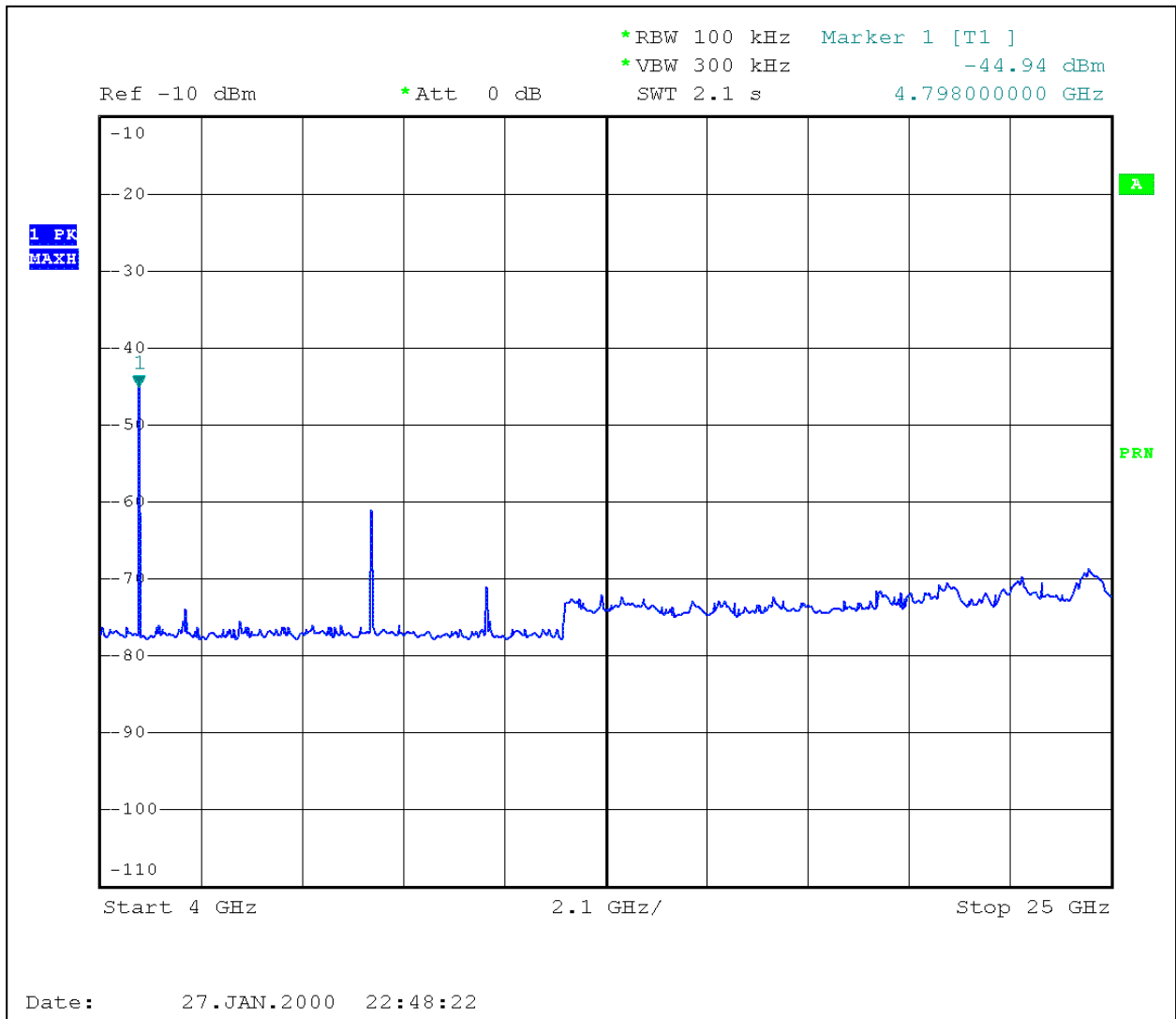
3.5 Antenna conducted spurious emissions

	Minimum Measured Attenuation dB	Minimum Allowed Attenuation dB	Margin dB
Low Frequency Channel	-50.9	-20	-30.9
Middle Frequency Channel	-52.6	-20	-32.6
Upper Frequency Channel	-53.1	-20	-33.1
Analyzer Settings:	☒ RBW=100KHz		
Minimum Allowed Attenuation:	☒ 20dB ☐ 30dB (for digital systems with conducted power measured using RMS averaging over a time interval)		

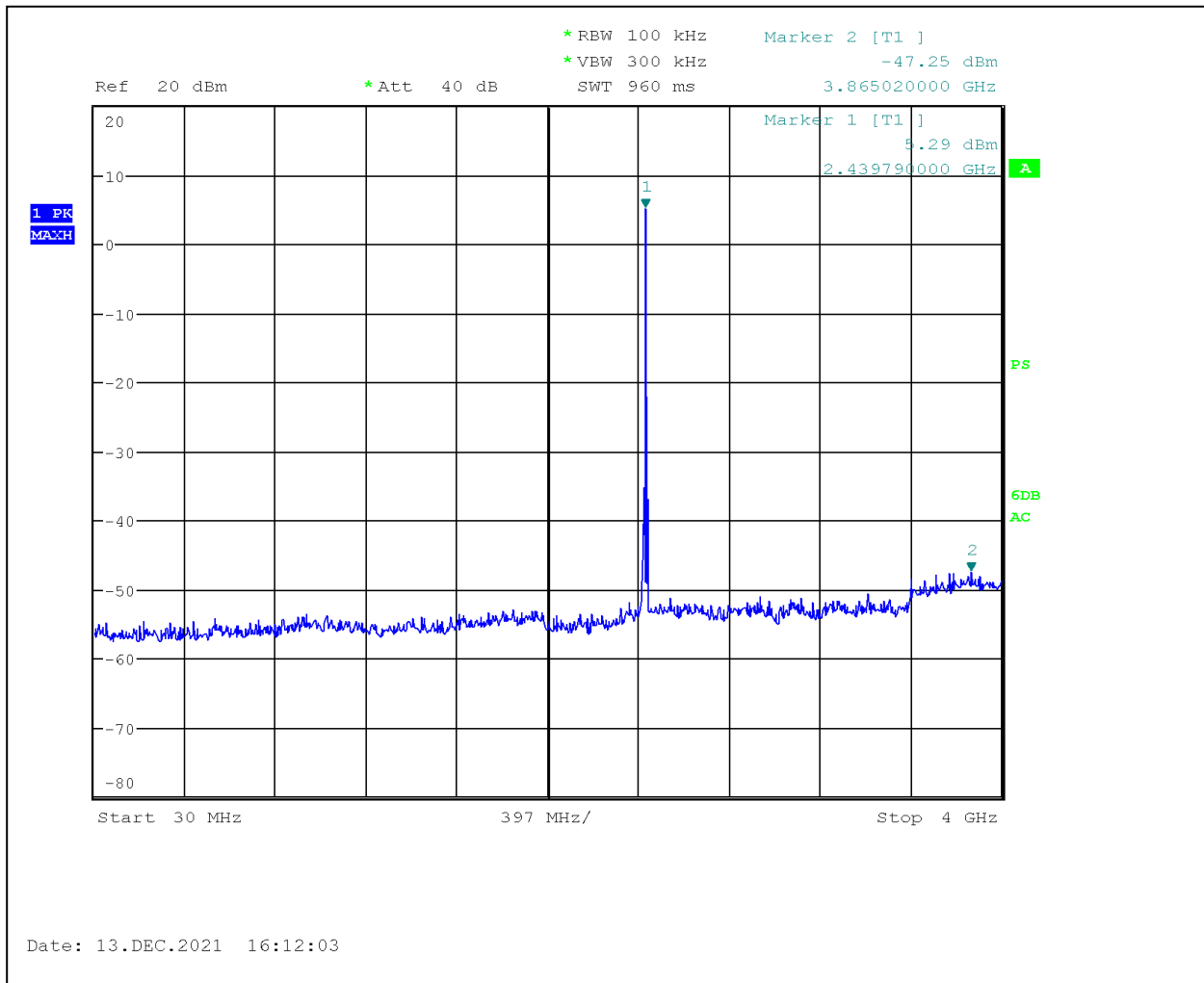
Notes: Graphs 3.5.1 - 3.5.6 show antenna conducted spurious emissions.
 Graphs 3.5.7 - 3.5.8 show band edge compliance.



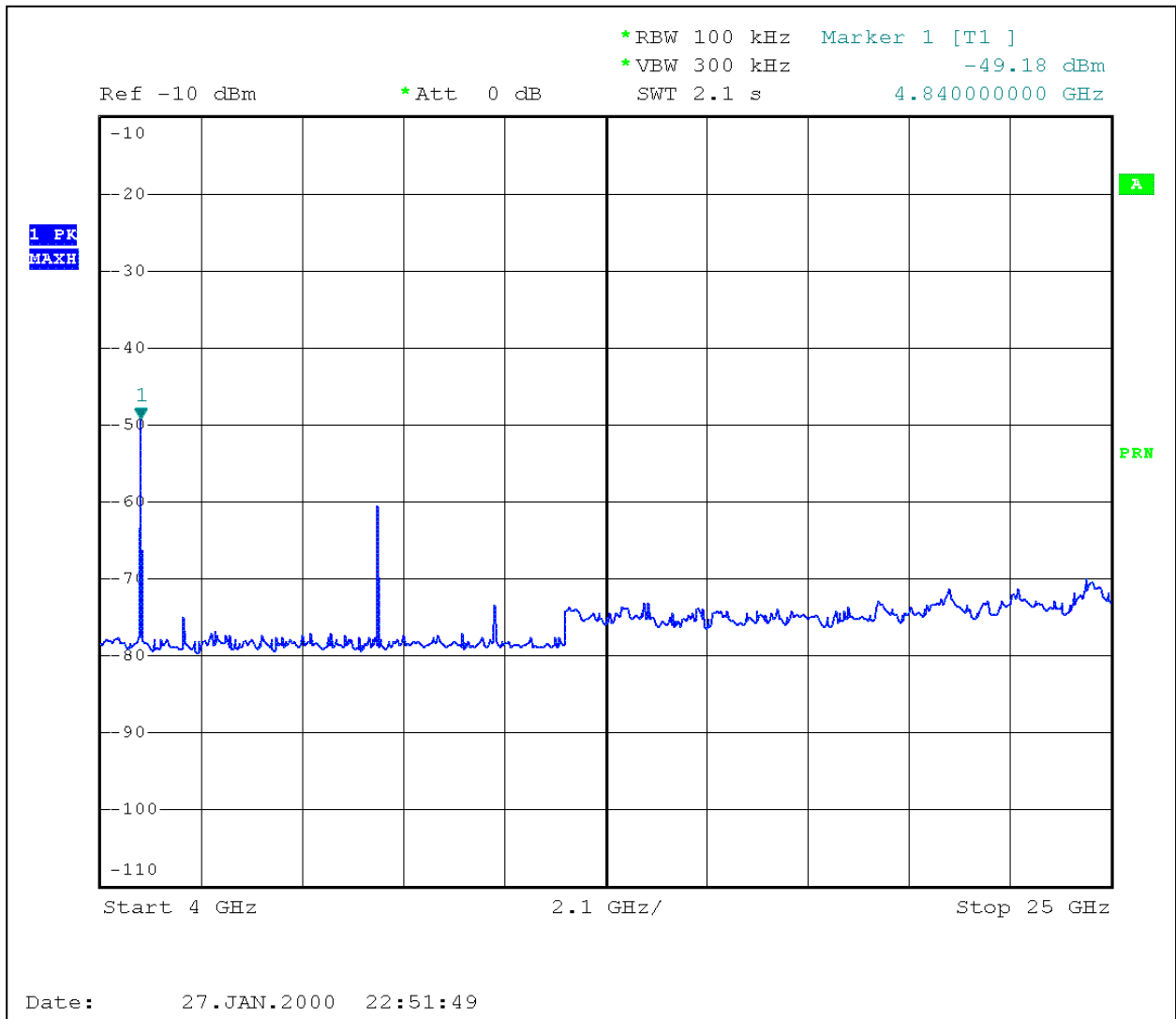
Graph 3.5.1



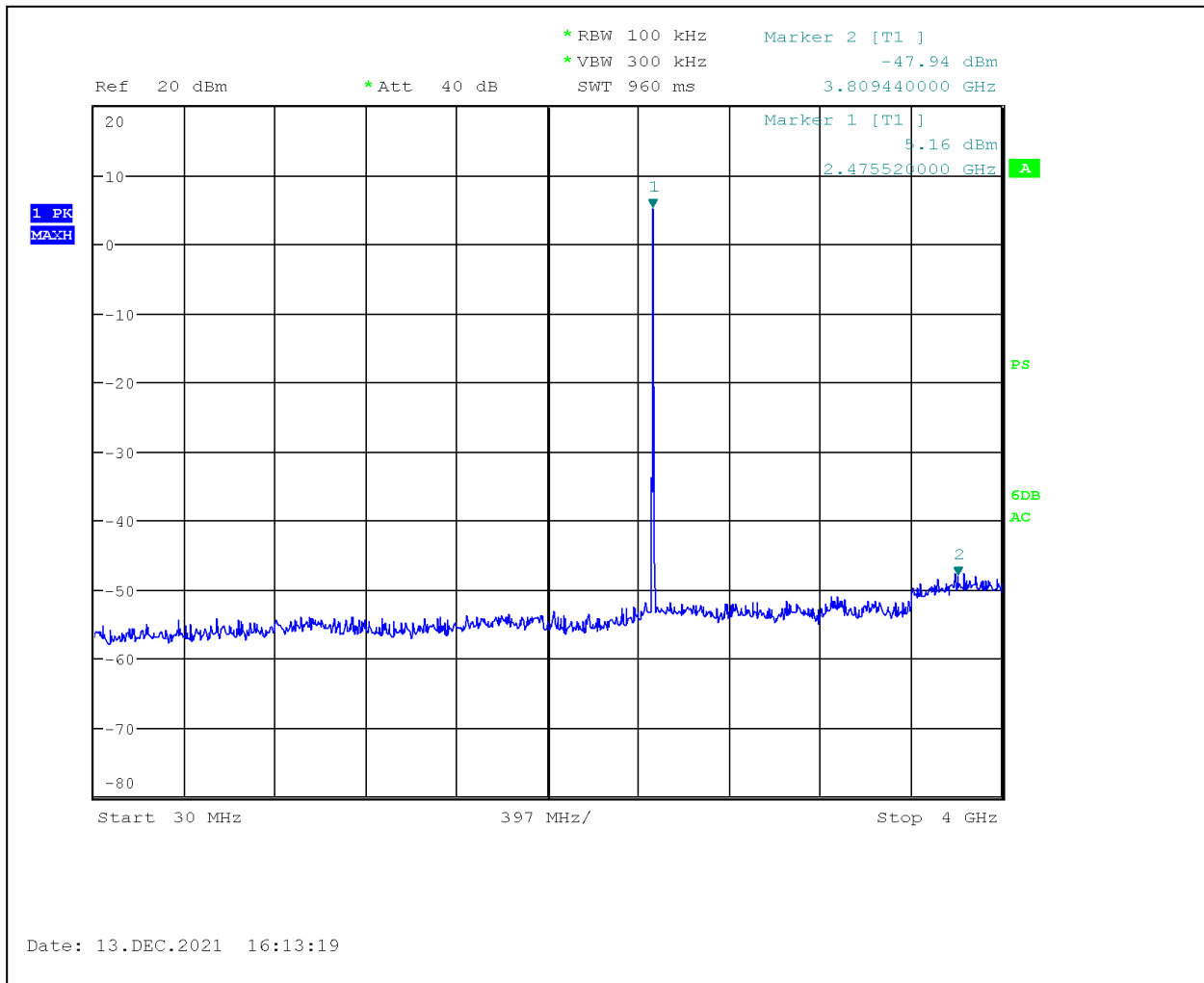
Graph 3.5.2



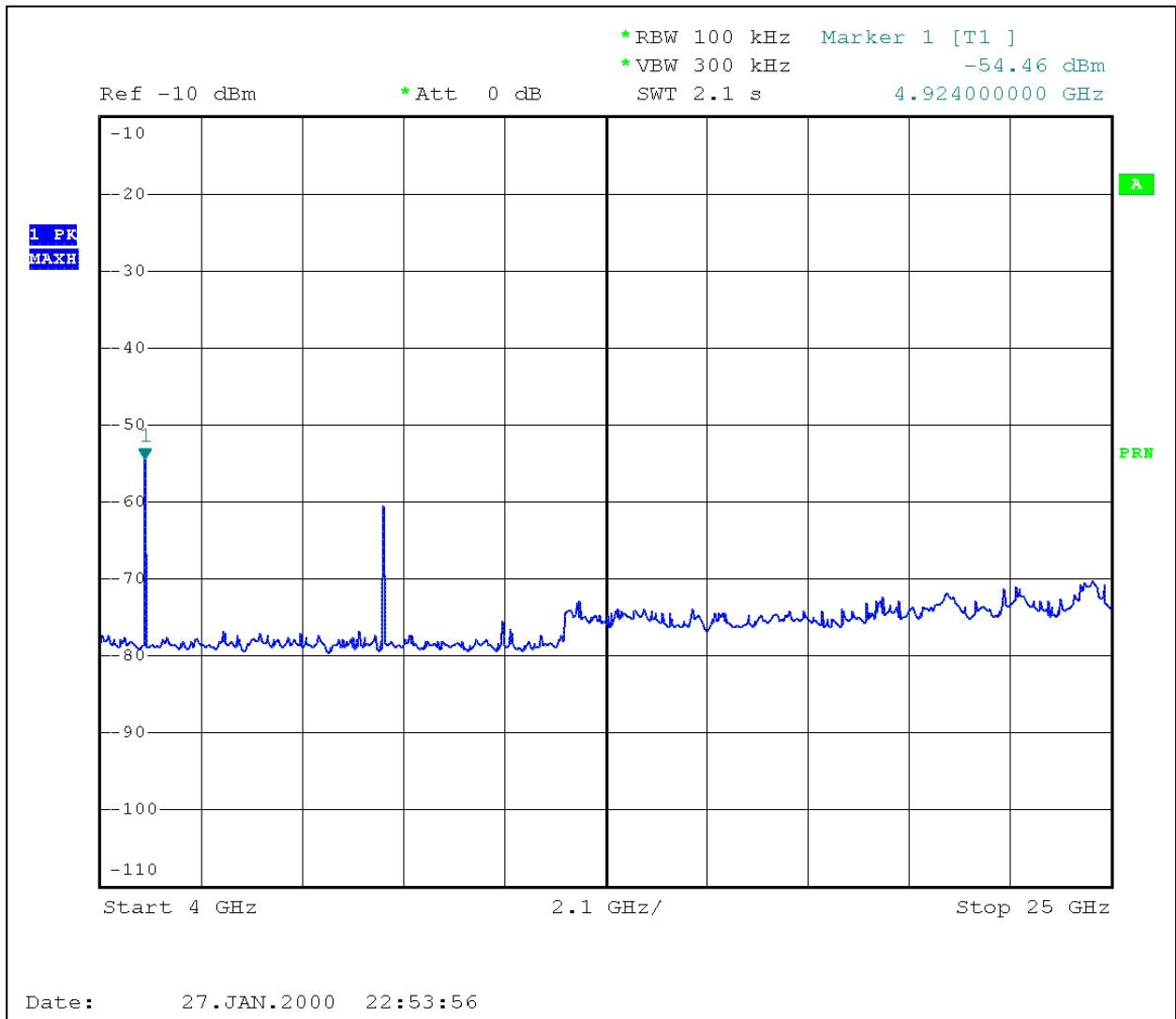
Graph 3.5.3



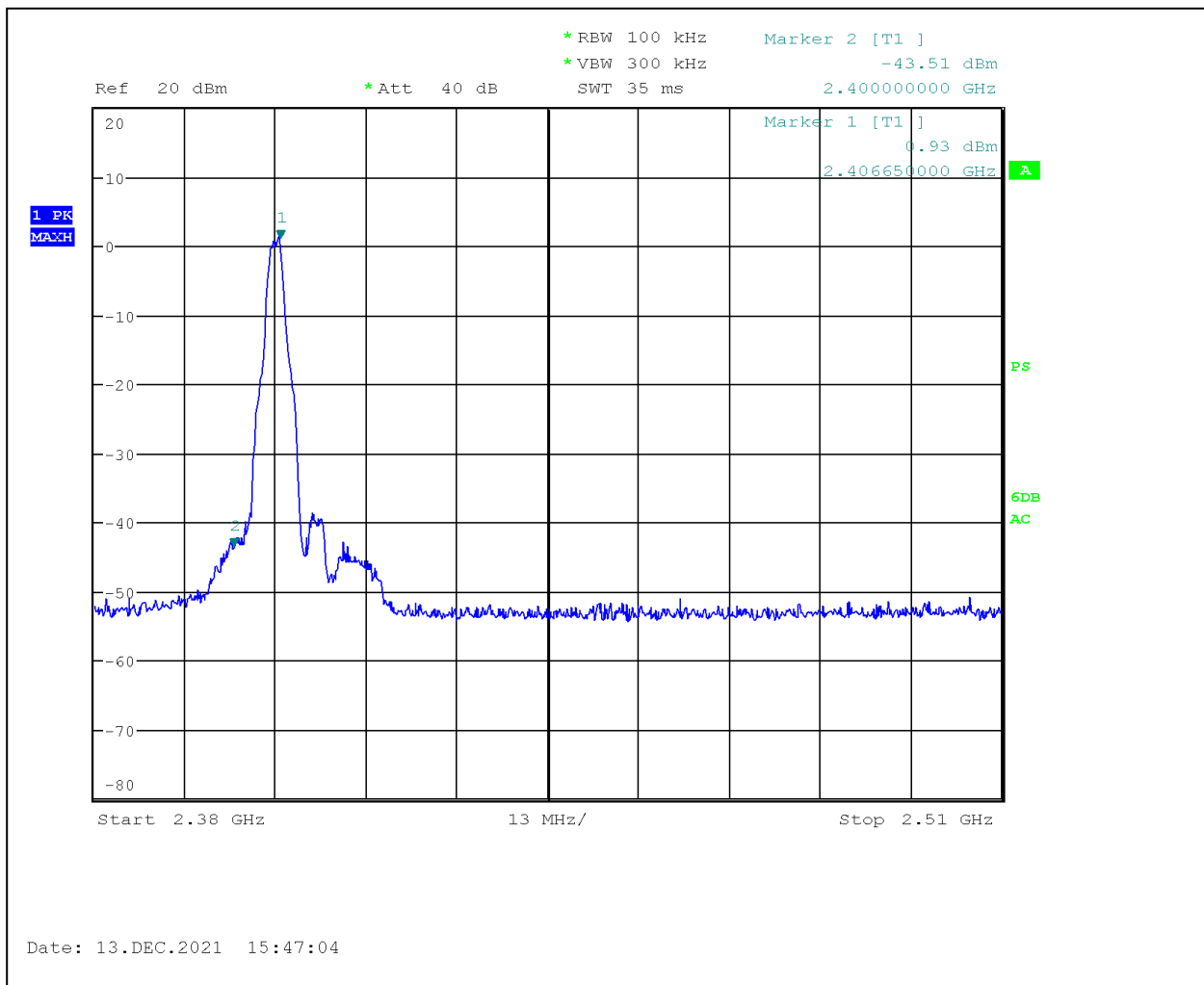
Graph 3.5.4



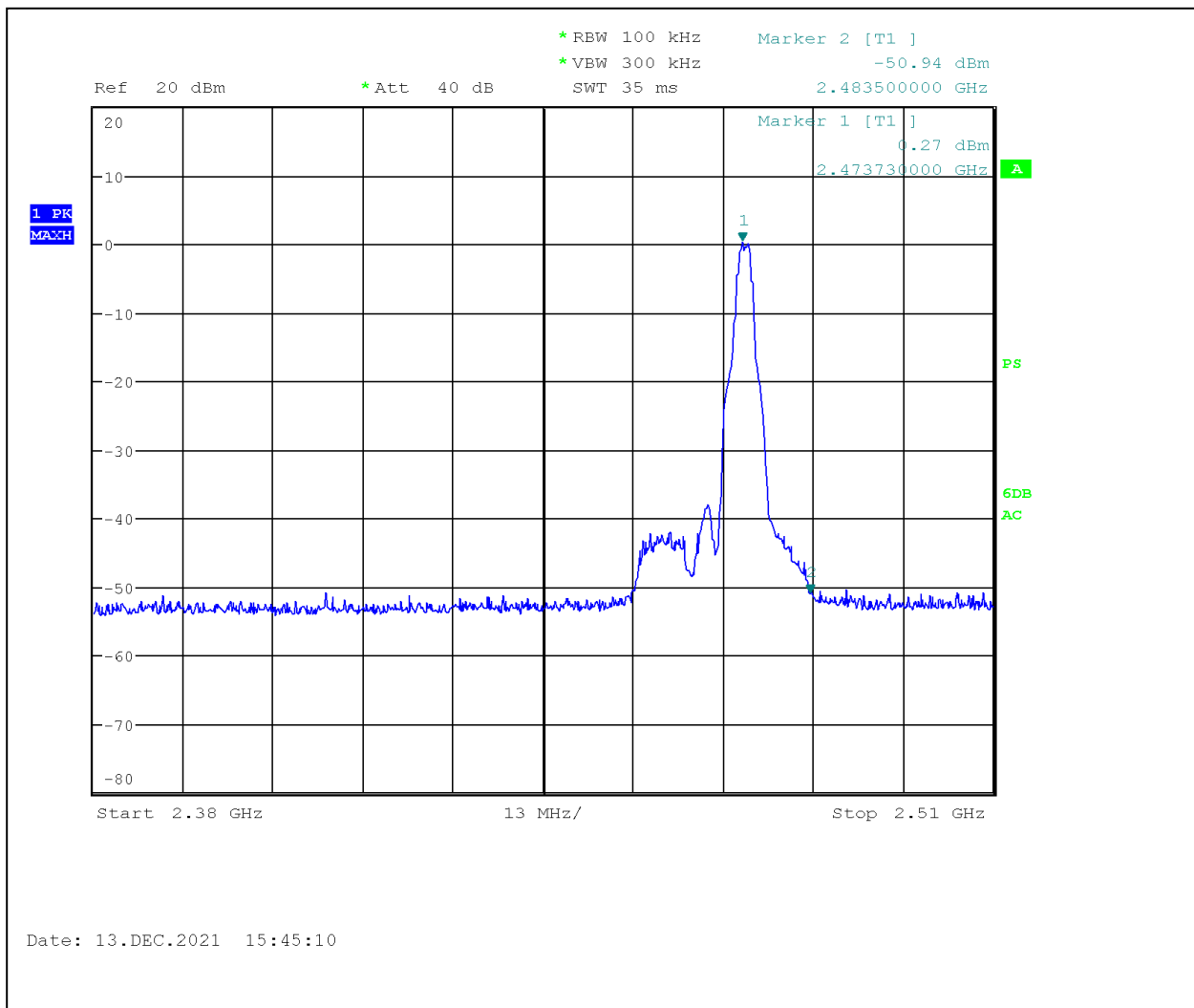
Graph 3.5.5



Graph 3.5.6



Graph 3.5.7



Graph 3.5.8

3.6 Radiated spurious emissions

Test location: ☐ OATS ☒ Anechoic Chamber ☐ Other

Test result: **Pass**

Max. Margin Spurious: 8.1 dB below the limits

Max. Margin Bandedge: 11.7 dB below the limits

EUT was configured to transmit continuously. Radiated emission measurements were performed from 9 kHz to 25 GHz according to the procedure described in ANSI C63.10.

Spectrum analyzer resolution bandwidth is 200 Hz for frequencies 9 kHz to 150 kHz and 9kHz for frequencies 150kHz to 30MHz. Resolution bandwidth is 120 kHz for frequencies 30 MHz to 1000 MHz and 1 MHz for frequencies above 1 GHz. Above 1 GHz, both Peak and Average measurements were performed. The Peak level of radiated emissions was measured with a peak detector. The Average level of radiated emissions was measured with an AVG detector.

The EUT is placed on a non-conductive turntable that is 80 cm in height for frequencies 30 MHz to 1000 MHz, 1.5 meters for frequency above 1000 MHz. If the EUT attaches to peripherals, they are connected and operational (as typical as possible). During testing, all cables were manipulated to produce worst-case emissions. The signal is maximized through rotation. The antenna height and polarization are varied during the search for maximum signal level. The antenna height is varied from 1 to 4 meters.

Data included is representative of the worst-case configuration (the configuration which resulted in the highest emission levels). Data provided is corrected for distance, cables, preamp, filters and antenna factors then compared to the limits

Note:

1. No Radiated and Spurious emissions were detected in the frequency range 9 kHz to 30MHz. No Radiated and Spurious emissions related with transmitter operation were detected in the frequency range 30MHz to 1GHz. No Radiated and Spurious emissions were detected above 2nd harmonic in the frequency range 1GHz to 25GHz.

2. The EUT was tested in three orthogonal orientations. The worse Radiated Emissions were detected in the vertical EUT orientation and shown in the Tables and Graphs below in this Section 3.6

Date:	December 14-23, 2021	Result: Pass
Tested by:	Richard Blonigen	
Standard:	FCC part 15.247(d)	
Test Point:	Enclosure	
Operation mode:	See page 5	
Environmental Conditions:	21°C; 38%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

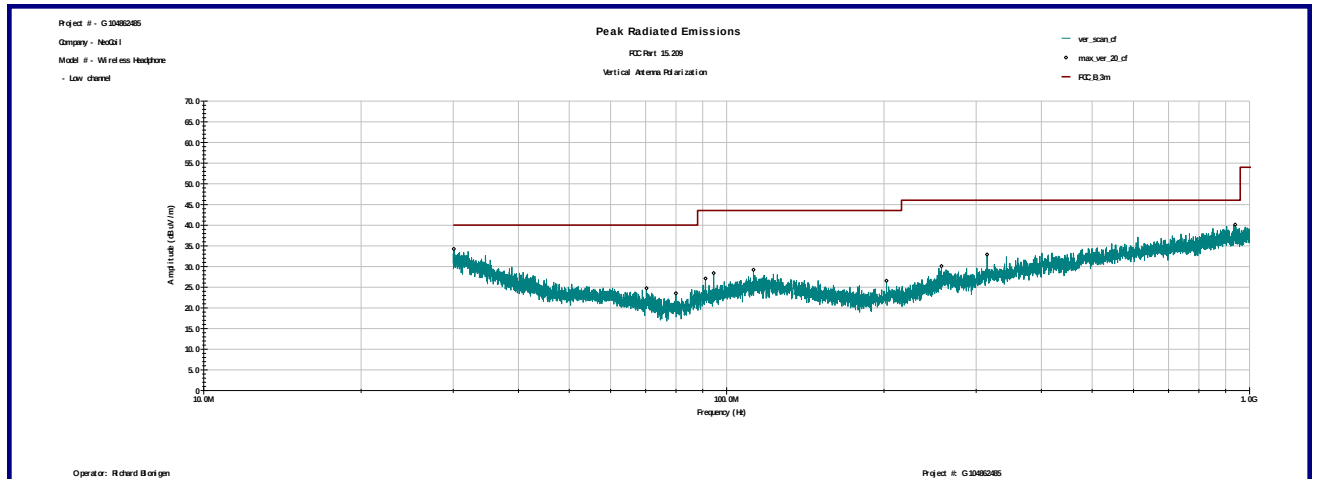
Table 3.6.1

Frequency MHz	Antenna		Ant. CF dB1/m	Cable loss dB	Pre-amp Gain (dB)	Peak Reading dBμV	Total @ 3m dBμV/m	Limit dBμV/m	Margin dB	Comments
	Polarity	Hts(cm)								
Low Channel										
94.50	V	135	14.4	0.5	0.0	13.1	28.0	43.5	-15.5	
112.56	V	143	16.8	0.5	0.0	11.4	28.7	43.5	-14.8	
4812.00	V	151	32.9	2.7	43.2	50.8	43.2	54.0	-10.8	
21626.00	V	160	46.9	4.7	47.9	47.7	51.4	54.0	-2.6	
24588.00	V	167	45.7	4.7	49.2	48.4	49.6	54.0	-4.4	
4812.00	H	189	32.9	2.7	43.2	50.5	42.9	54.0	-11.1	
Mid Channel										
314.90	V	138	18.3	1.0	0.0	14.4	33.6	46.0	-12.4	
742.16	V	146	24.2	1.6	0.0	12.0	37.8	46.0	-8.2	
4876.00	V	152	33.0	2.7	43.2	53.5	45.9	54.0	-8.1	
21640.00	V	177	46.9	4.7	47.9	46.6	50.3	54.0	-3.7	
24620.00	V	139	45.9	4.7	50.0	48.6	49.2	54.0	-4.8	
4876.00	H	191	33.0	2.7	43.2	49.5	42.0	54.0	-12.0	
High Channel										
317.00	V	142	18.3	1.0	0.0	13.2	32.5	46.0	-13.5	
400.90	V	139	20.6	1.1	0.0	12.1	33.8	46.0	-12.2	
4876.00	V	152	33.0	2.7	43.2	53.5	45.9	54.0	-8.1	
21630.00	V	176	46.9	4.7	47.9	46.3	50.0	54.0	-4.0	
24610.00	V	188	45.9	4.7	49.2	48.2	49.6	54.0	-4.4	
4948.00	H	193	33.1	2.7	43.3	48.9	41.4	54.0	-12.6	

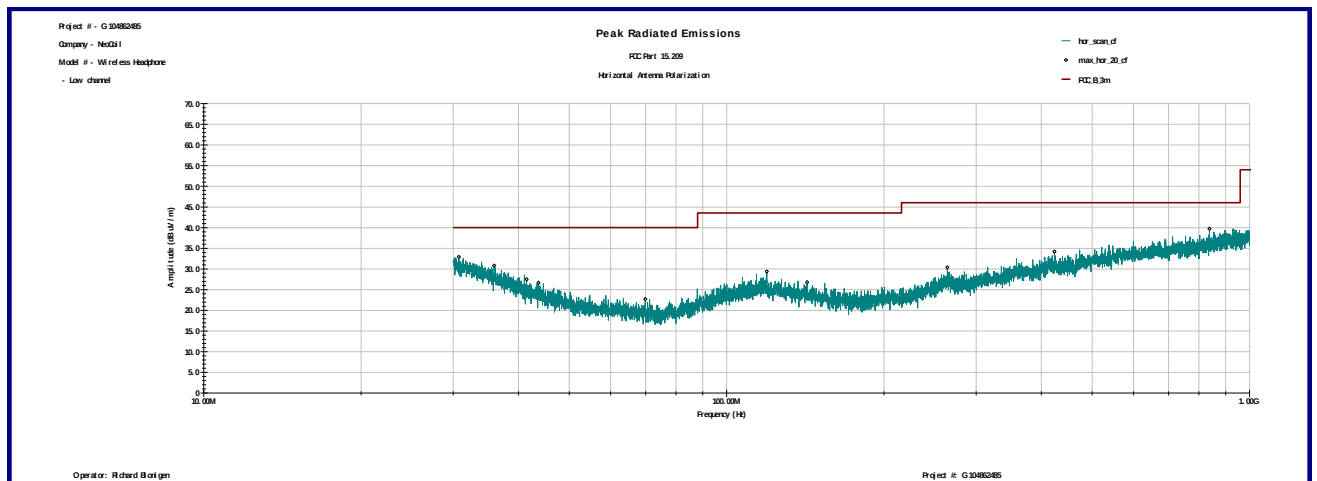
Date:	December 14-23, 2021	Result: Pass
Tested by:	Richard Blonigen	
Standard:	FCC part 15.247(d)	
Test Point:	Enclosure	
Operation mode:	See page 5	
Environmental Conditions:	21°C; 38%(RH); 98kPa	
Equipment Verification:	☒	
Note:	Bandedge Compliance	

Table 3.6.2

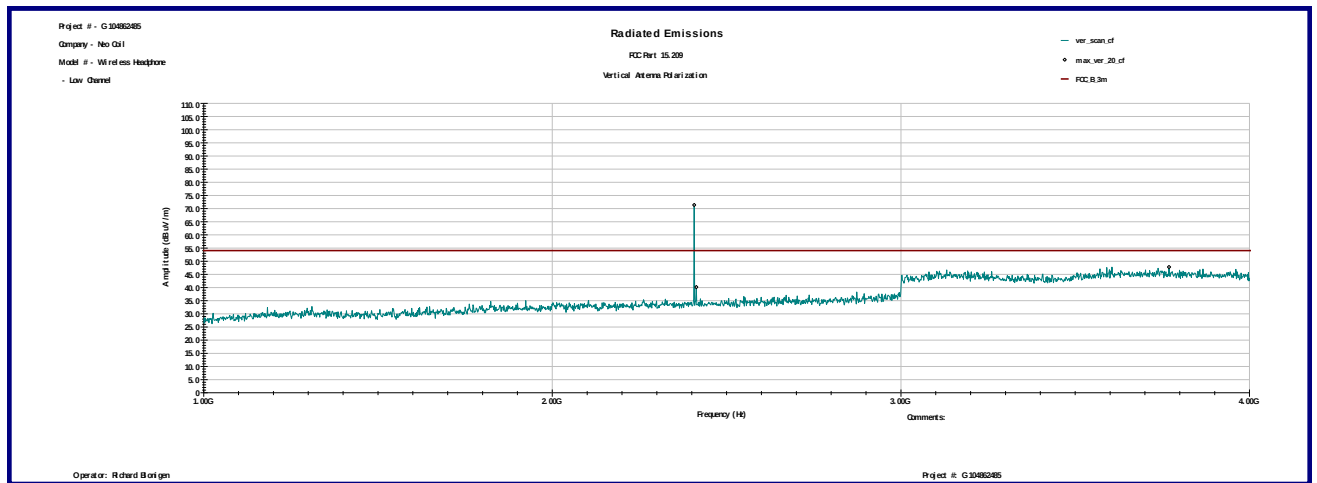
Frequency	Antenna		Ant. CF	Cable loss	Pre-amp	Peak Reading	Total @ 3m	Limit	Margin	Comments
MHz	Polarity	Hts(cm)	dB1/m	dB	Gain (dB)	dBμV	dBμV/m	dBμV/m	dB	Power
2390.00	V	100	28.1	1.9	0.0	11.3	41.3	54.0	-12.7	
2390.00	H	100	28.1	1.9	0.0	11.5	41.5	54.0	-12.5	
2483.50	V	100	28.4	1.9	0.0	12.0	42.3	54.0	-11.7	
2483.50	H	100	28.4	1.9	0.0	11.8	42.1	54.0	-11.9	



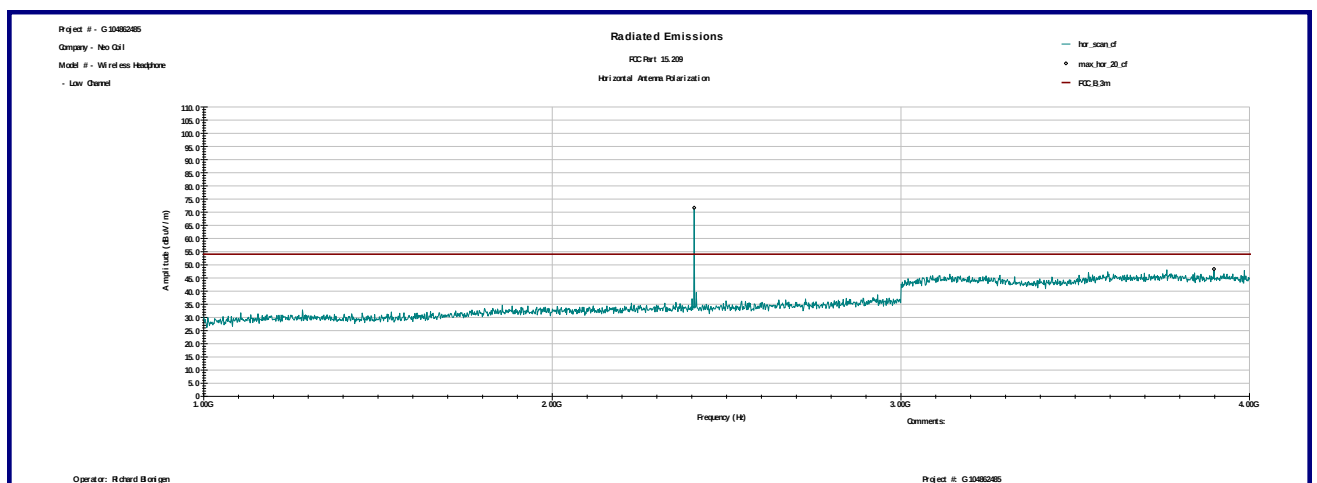
Graph 3.6.1



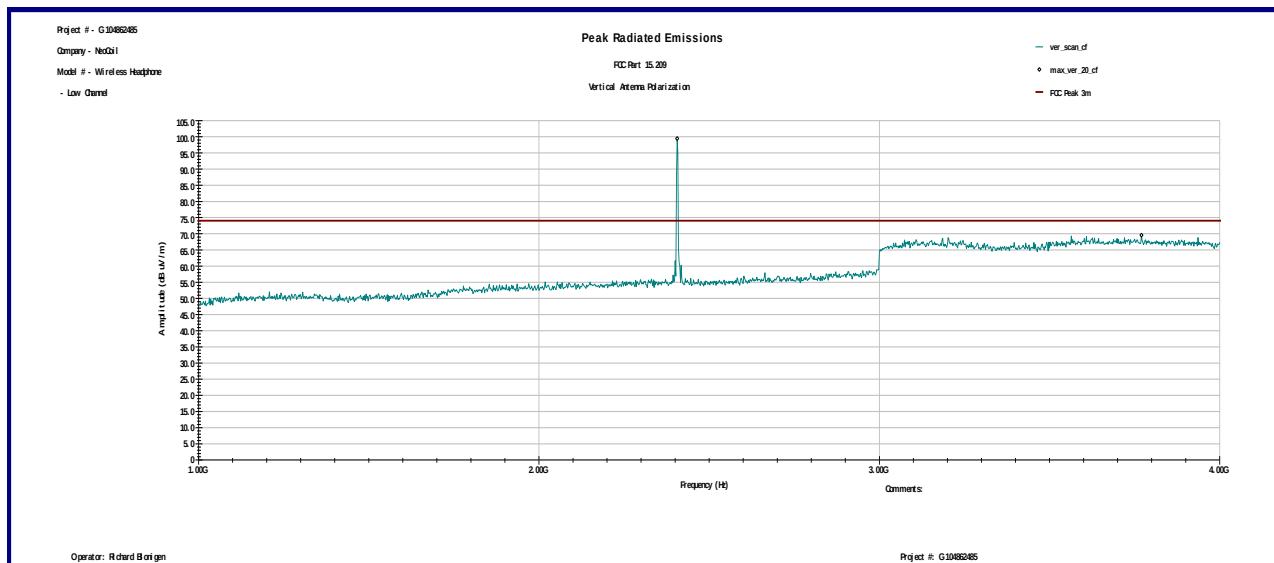
Graph 3.6.2



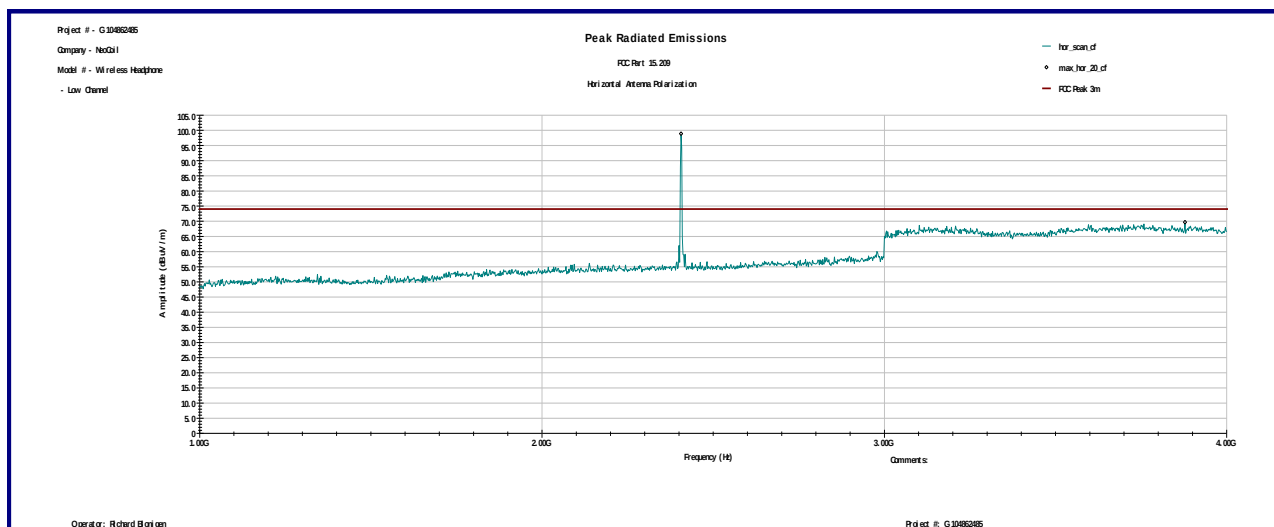
Graph 3.6.3 (Average Scan)



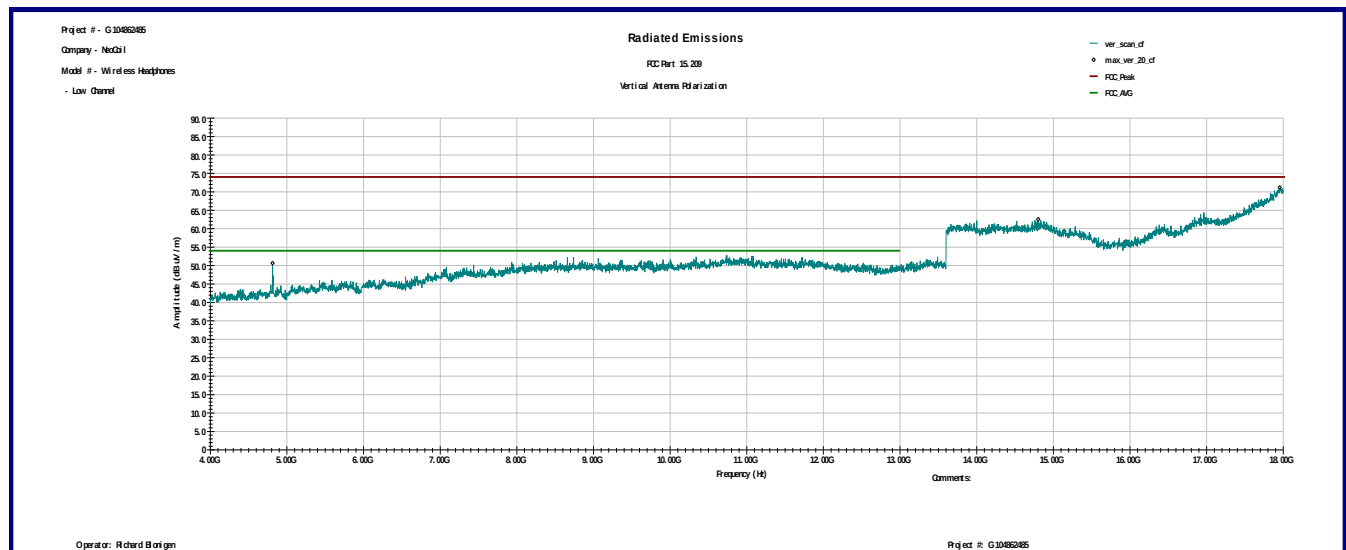
Graph 3.6.4 (Average Scan)



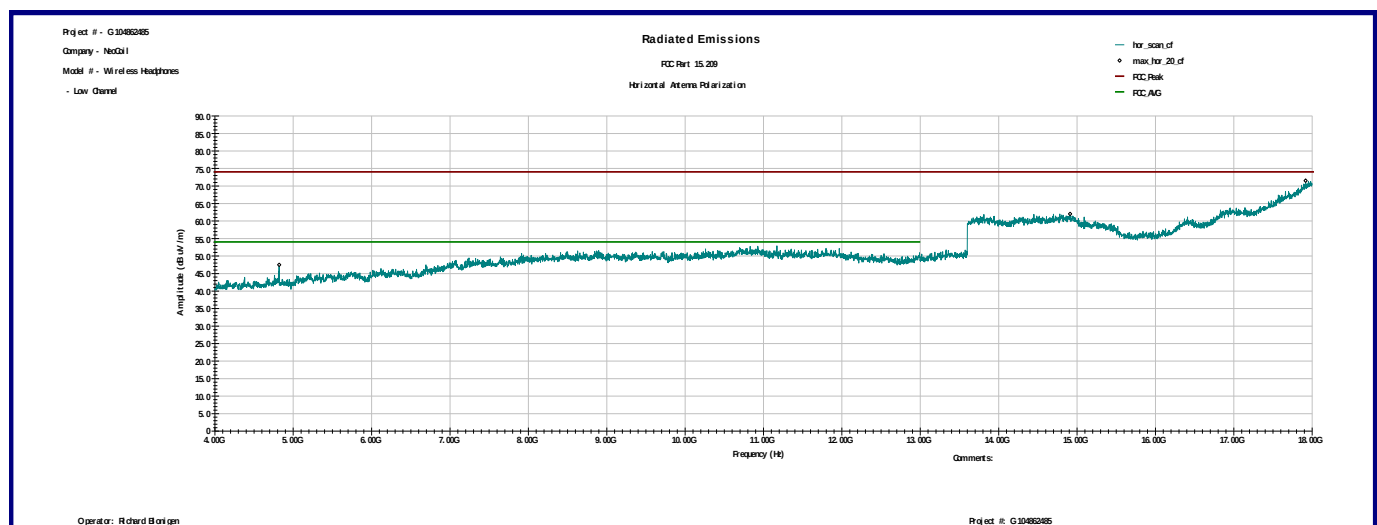
Graph 3.6.5 (Peak Scan)



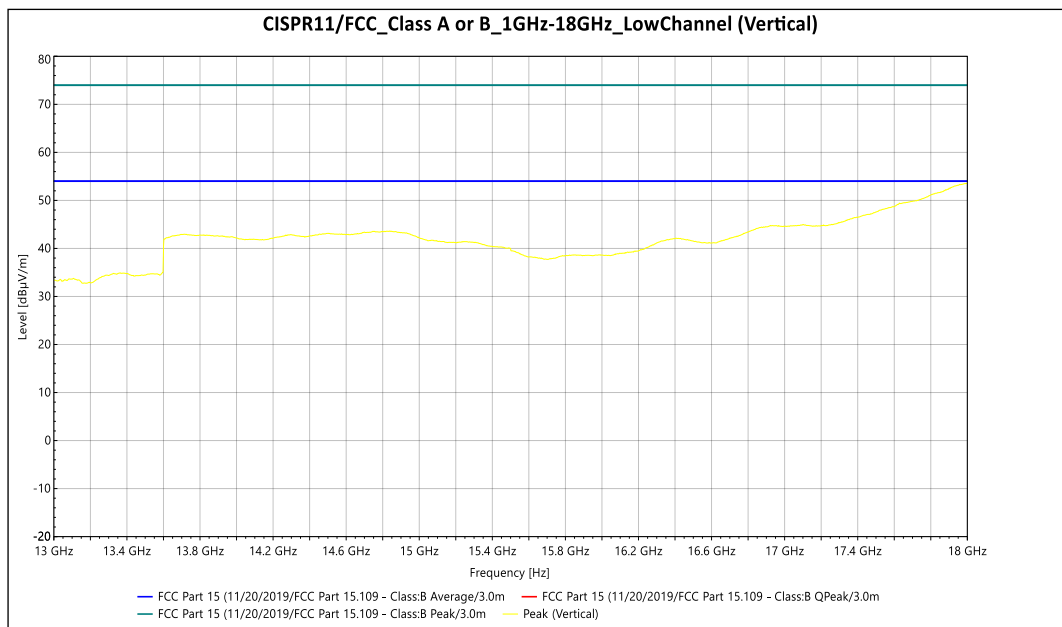
Graph 3.6.6 (Peak Scan)



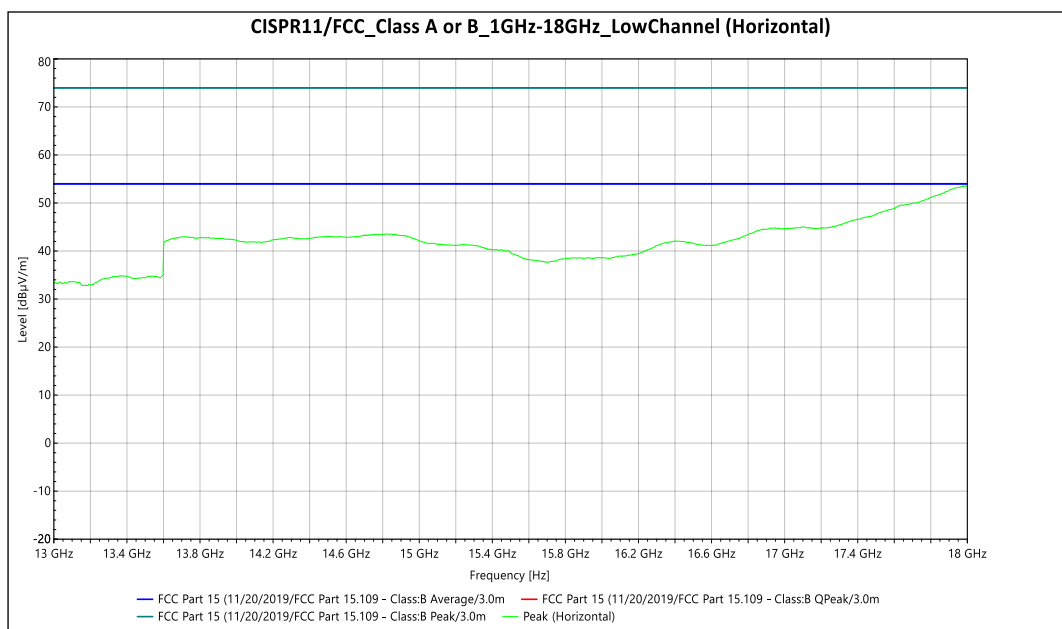
Graph 3.6.7 (Peak Scan)



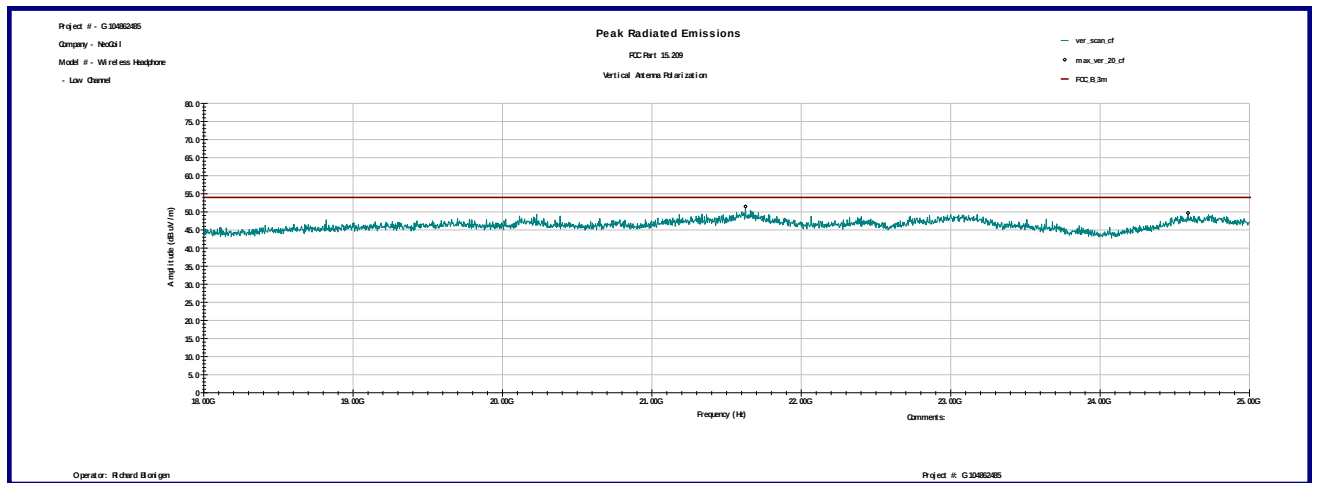
Graph 3.6.8 (Peak Scan)



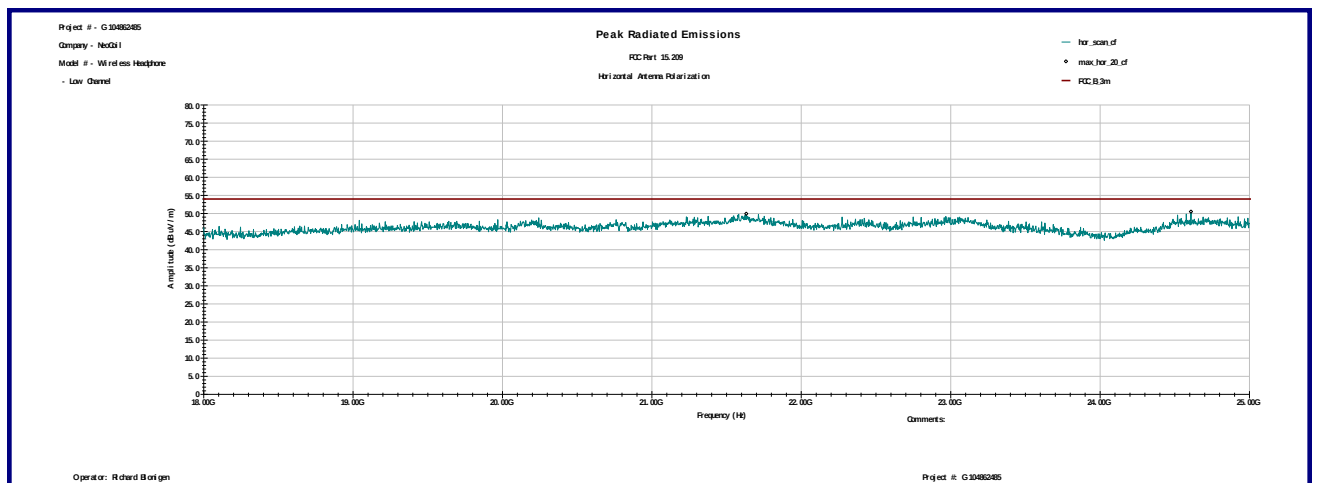
Graph 3.6.9 (AVG Scan)



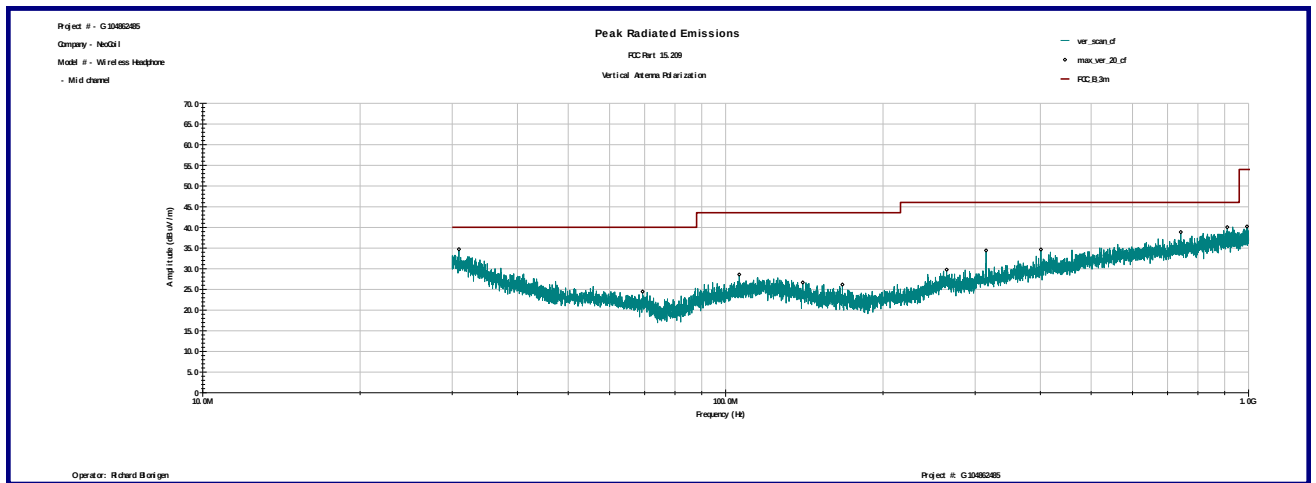
Graph 3.6.10 (AVG Scan)



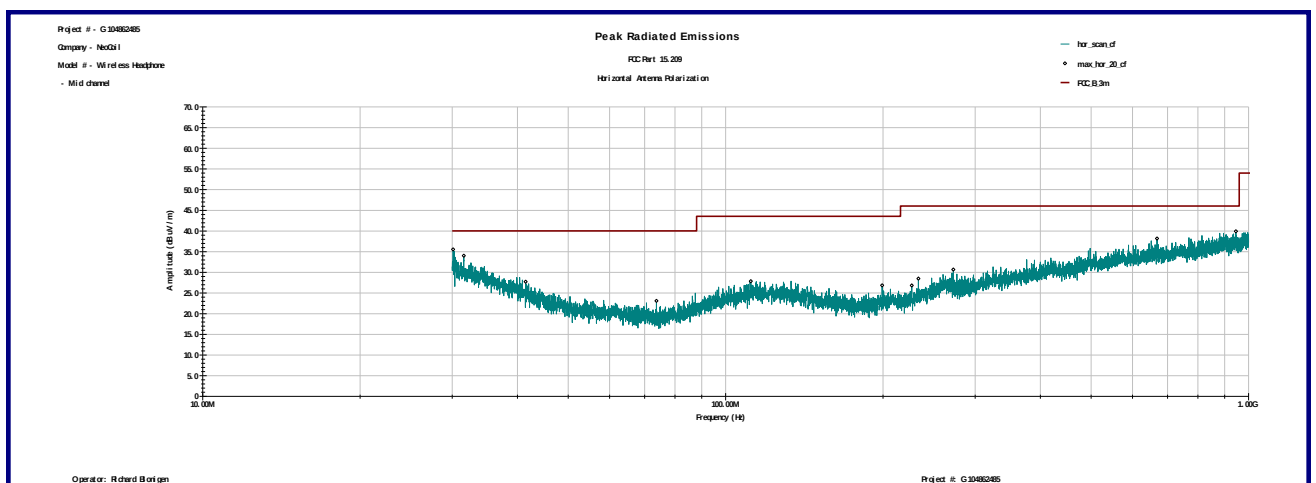
Graph 3.6.11 (Peak Scan)



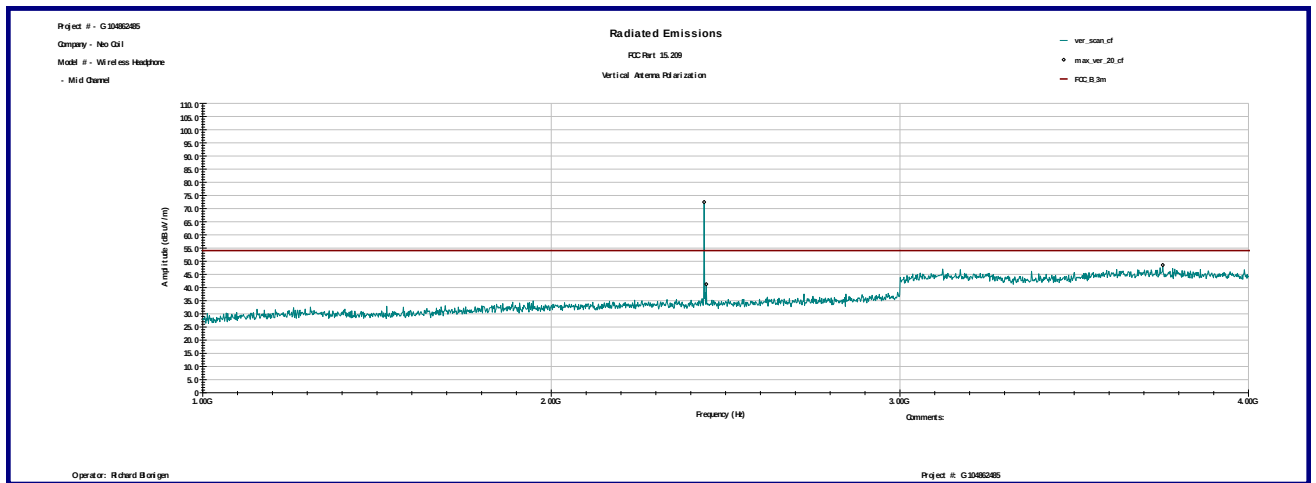
Graph 3.6.12 (Peak Scan)



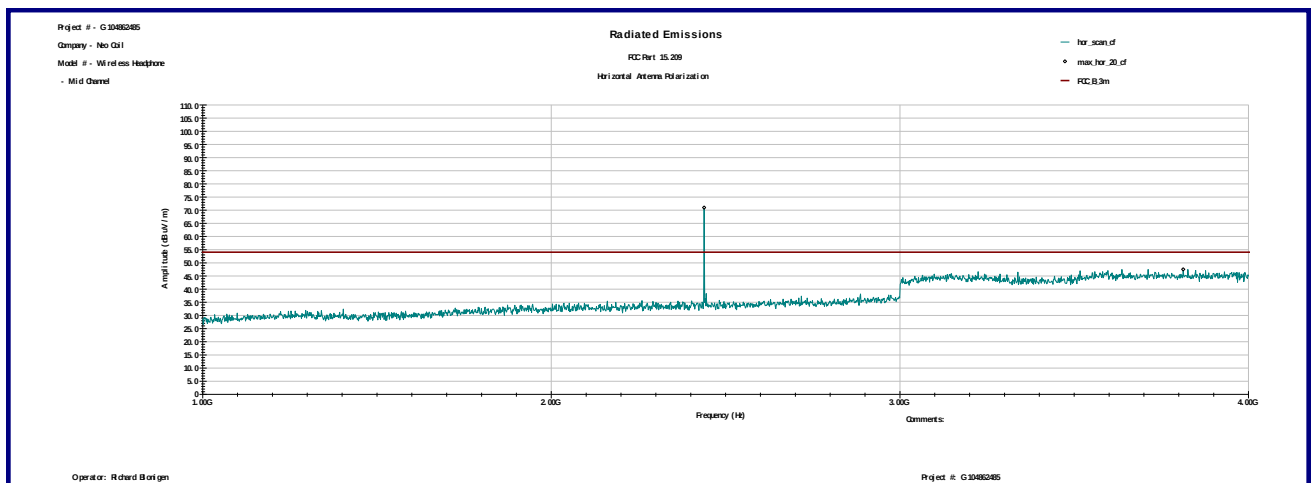
Graph 3.6.13



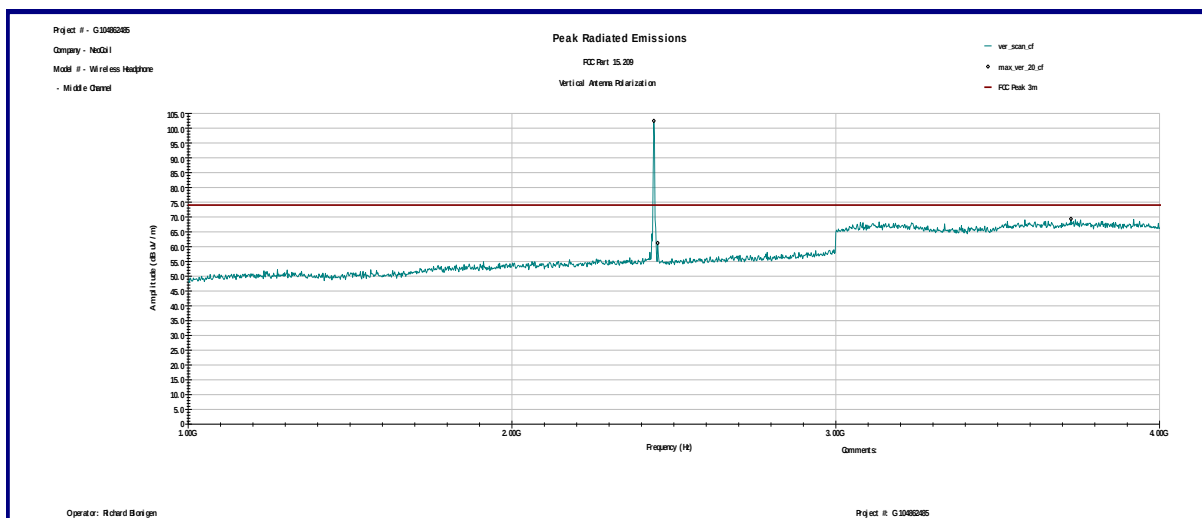
Graph 3.6.15



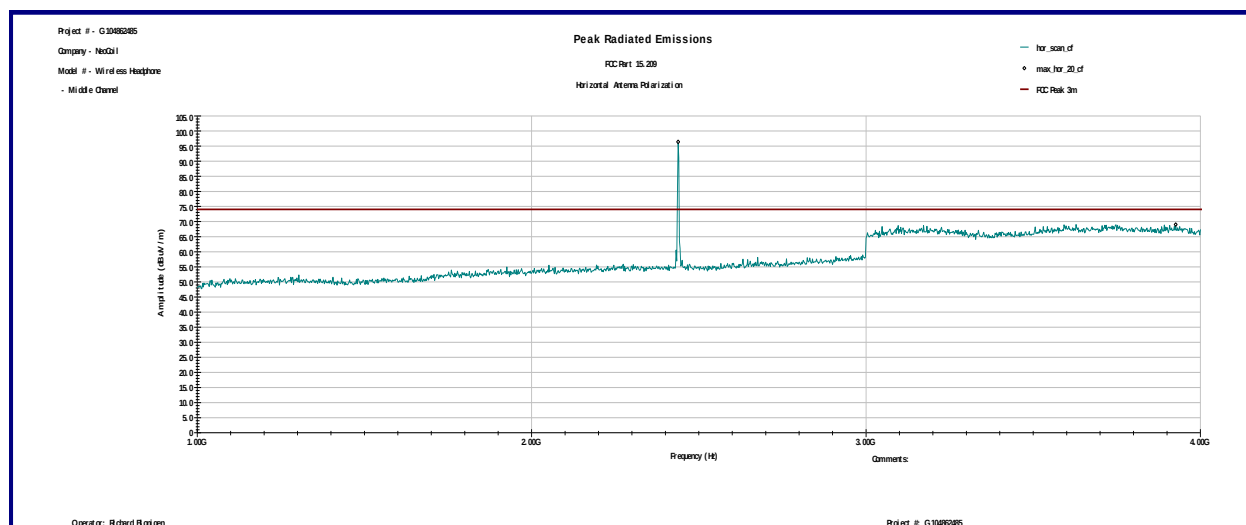
Graph 3.6.16 (Average Scan)



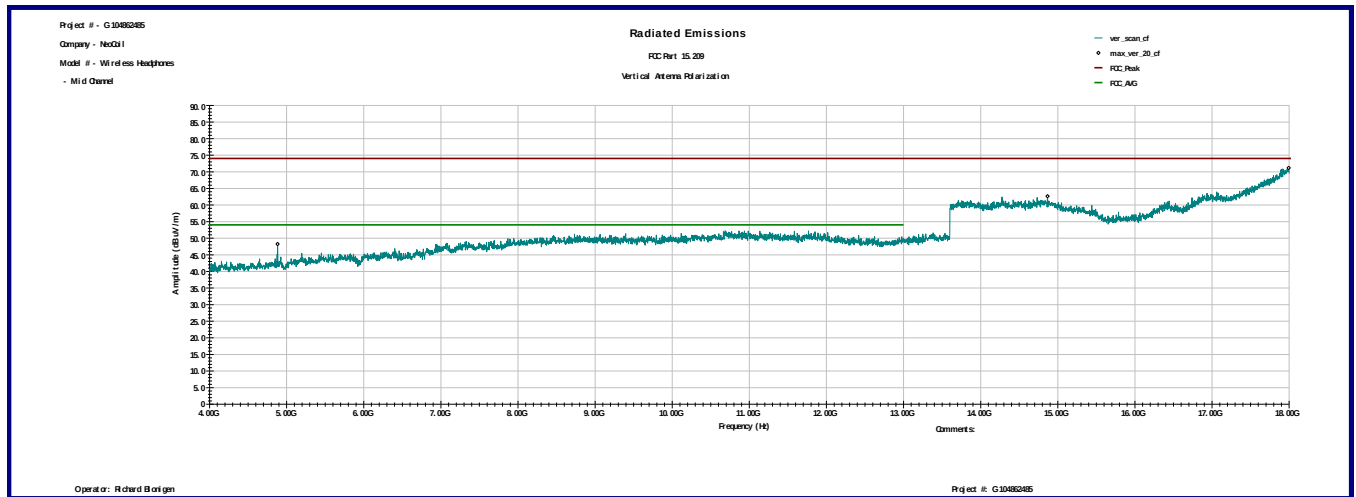
Graph 3.6.17 (Average Scan)



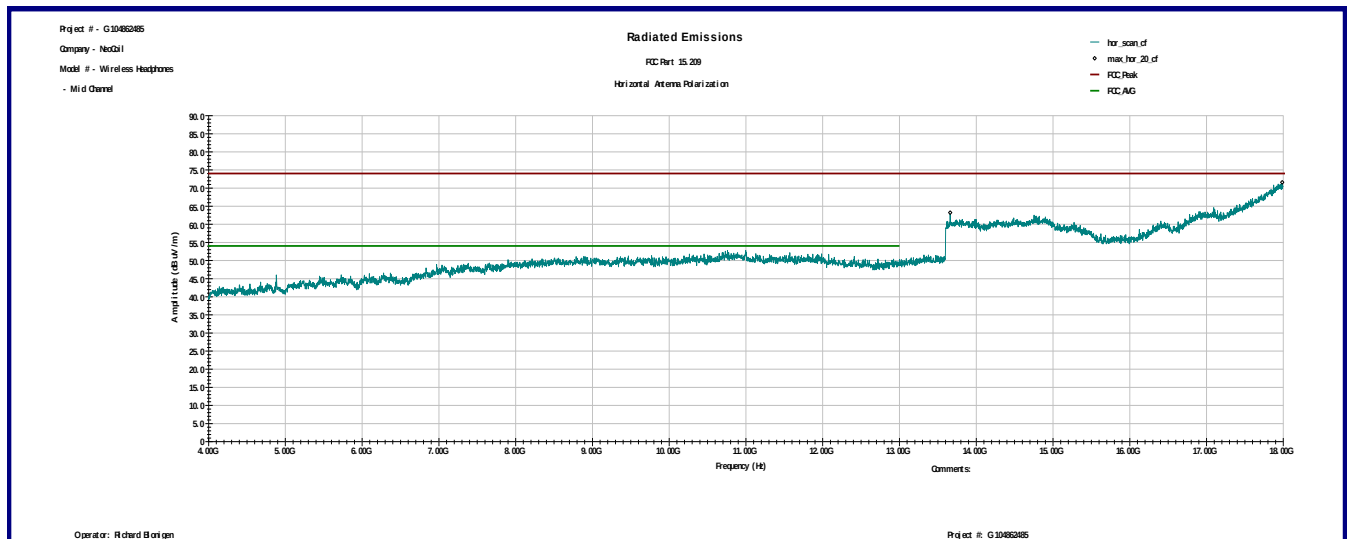
Graph 3.6.18 (Peak Scan)



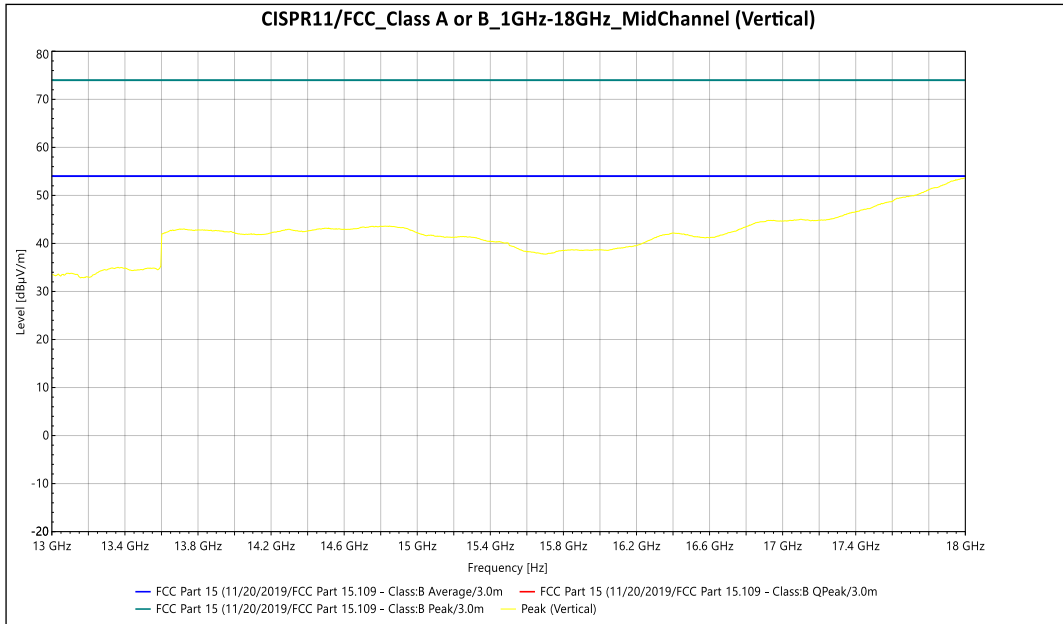
Graph 3.6.19 (Peak Scan)



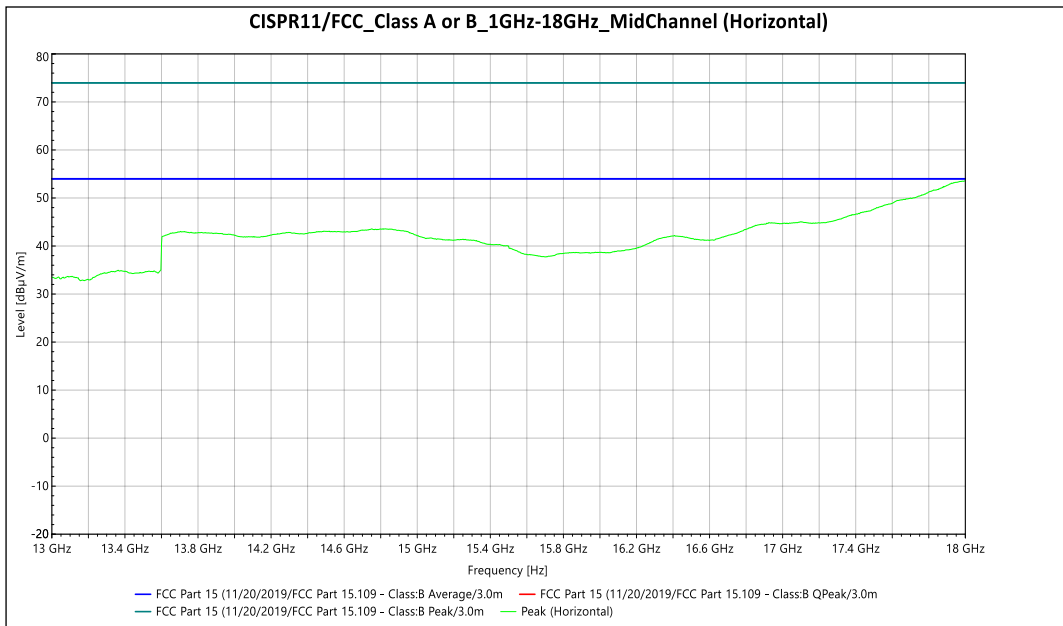
Graph 3.6.20 (Peak Scan)



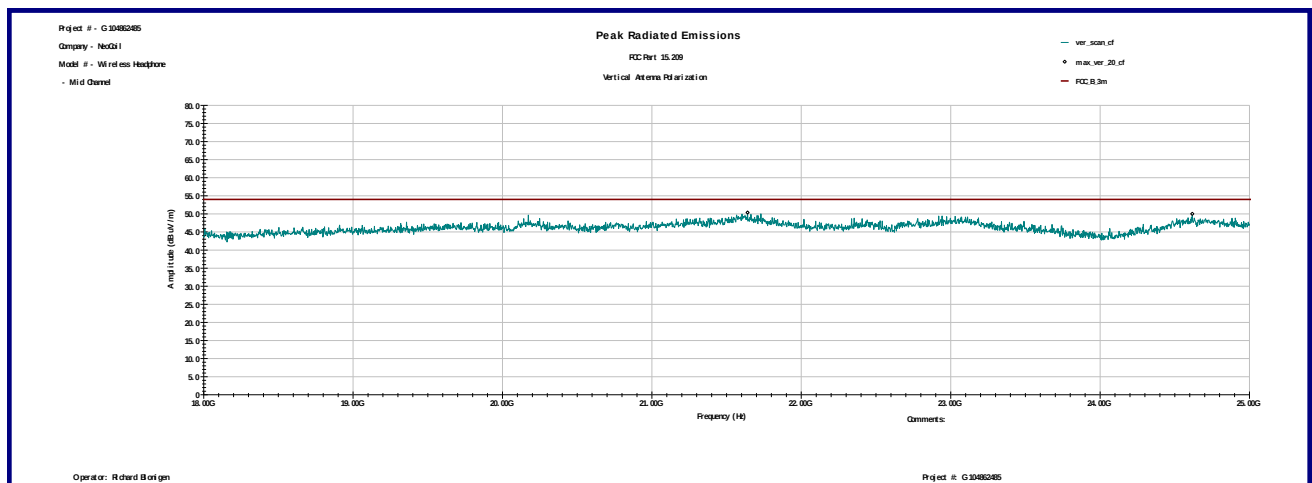
Graph 3.6.21 (Peak Scan)



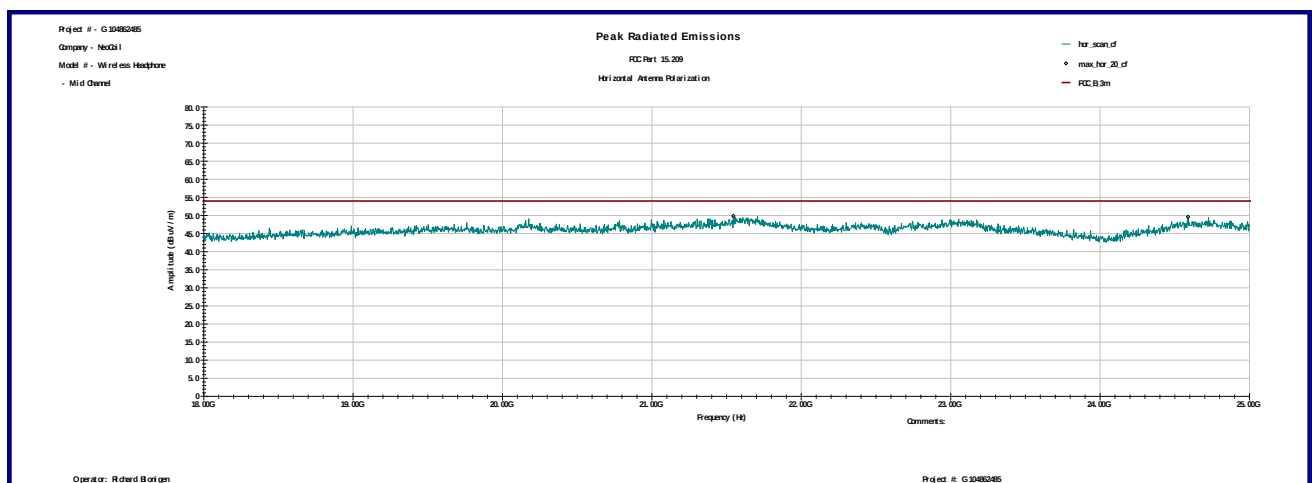
Graph 3.6.22 (AVG Scan)



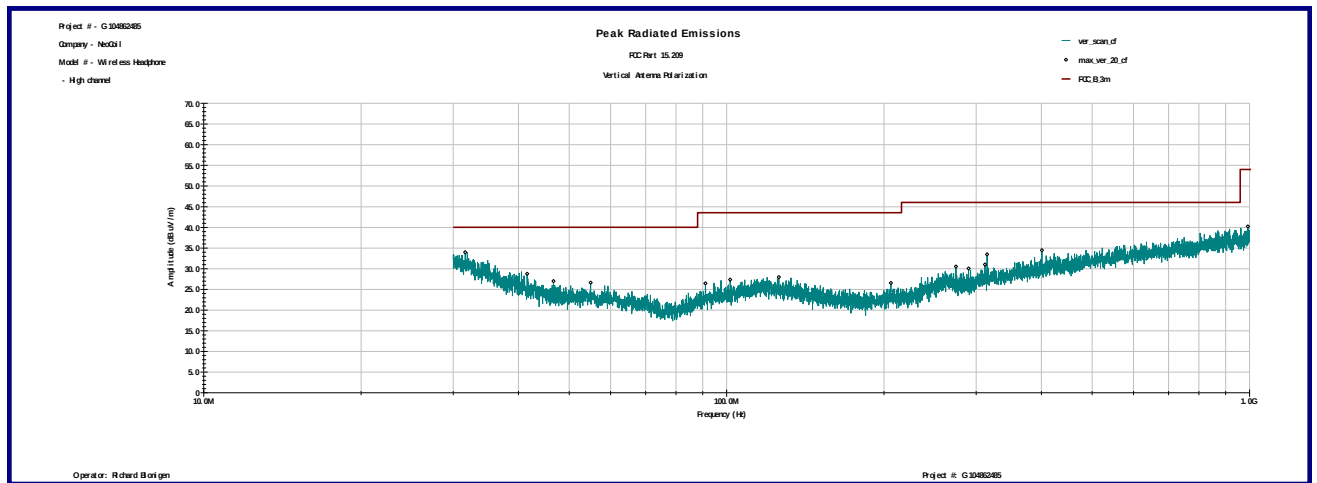
Graph 3.6.23 (AVG Scan)



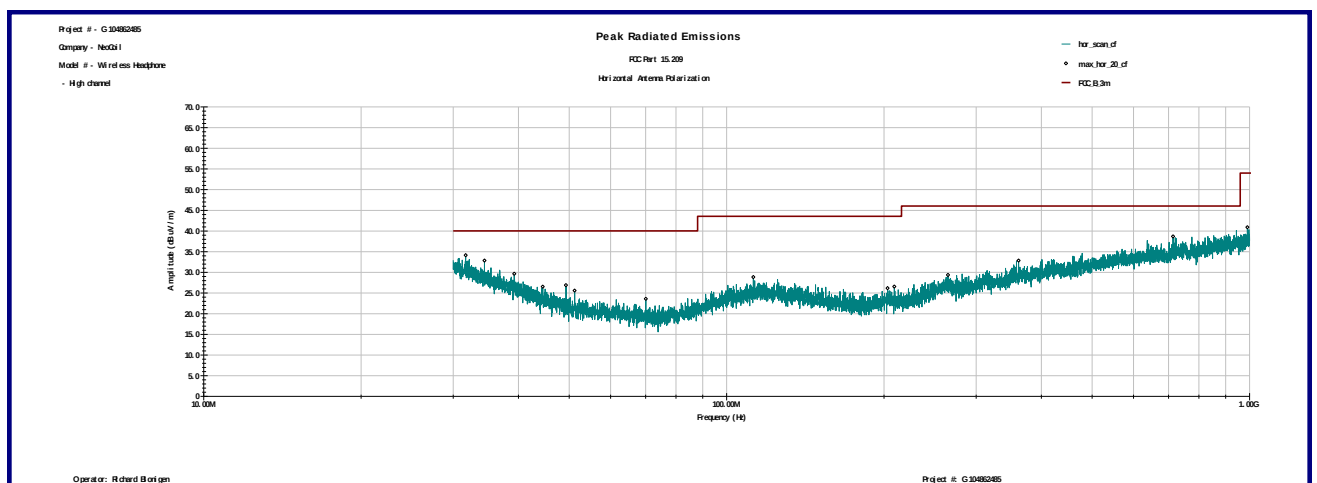
Graph 3.6.24 (Peak Scan)



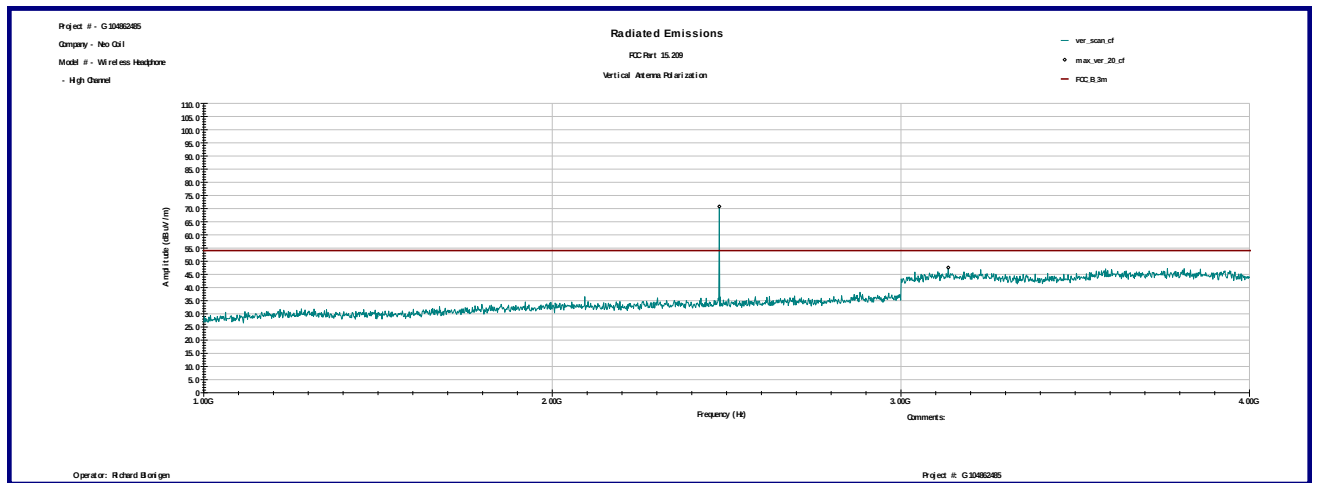
Graph 3.6.25 (Peak Scan)



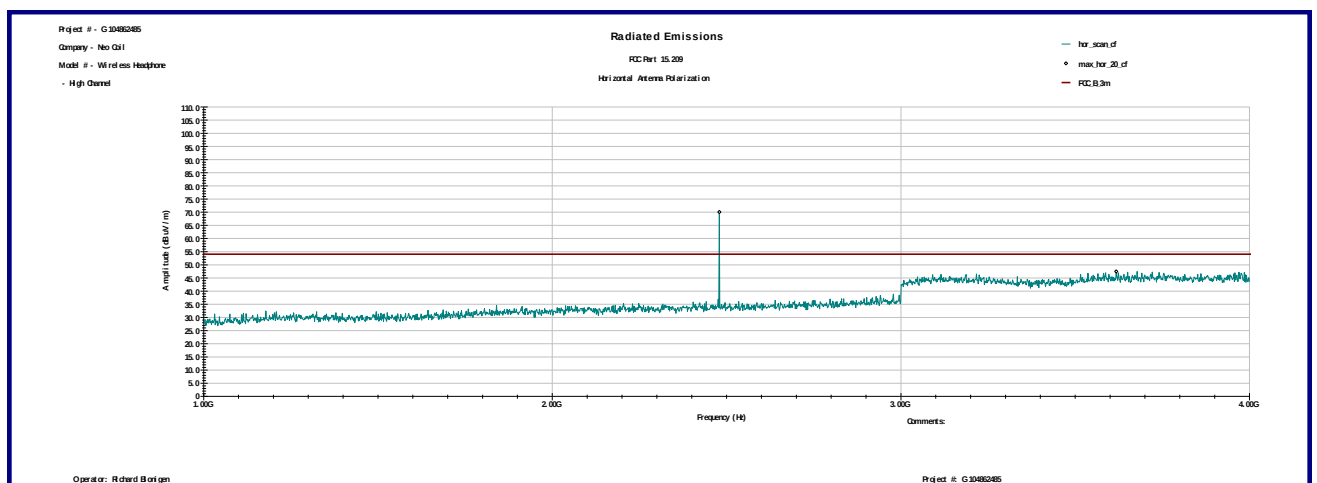
Graph 3.6.26



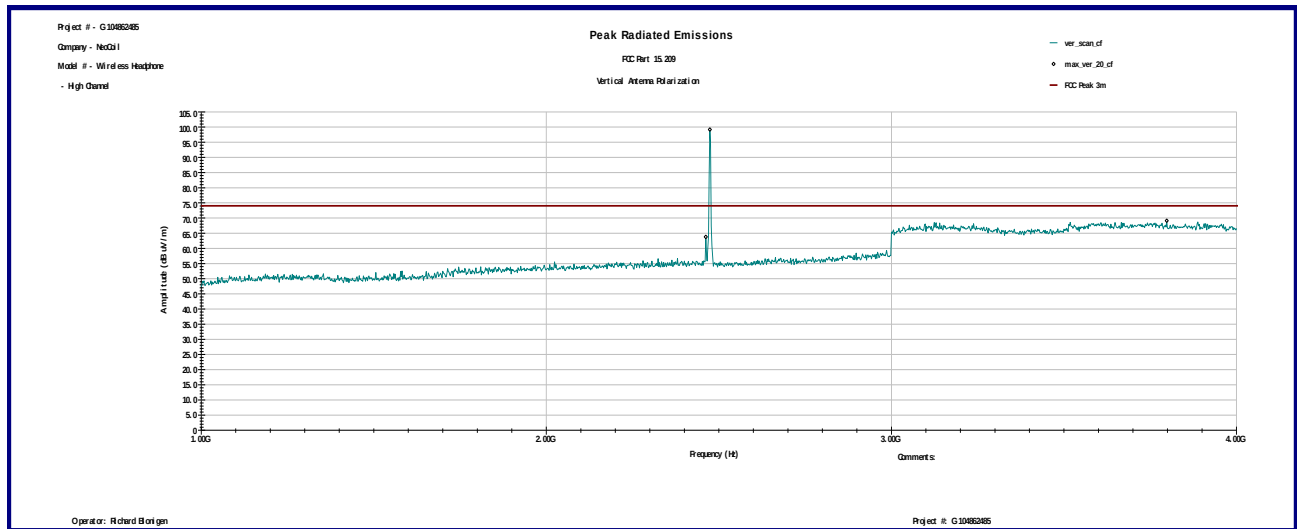
Graph 3.6.27



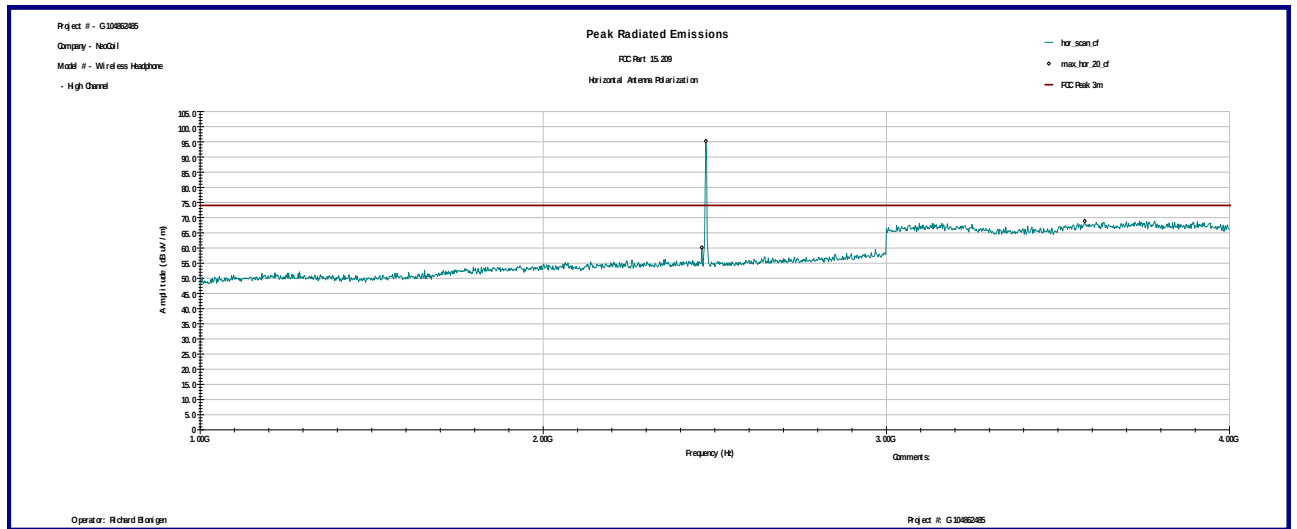
Graph 3.6.28 (Average Scan)



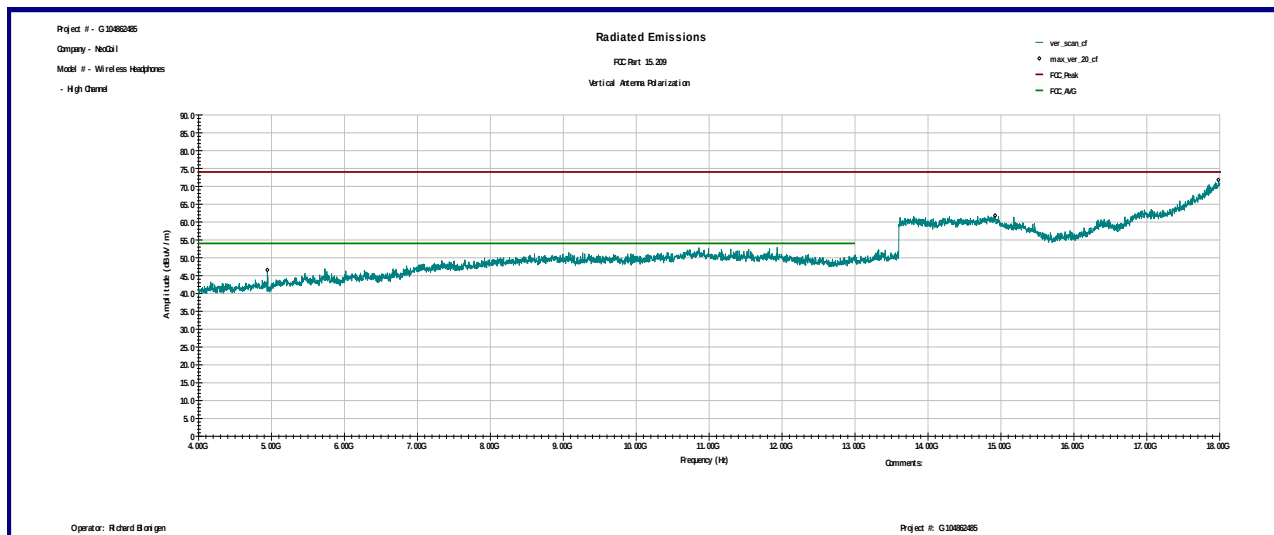
Graph 3.6.29 (Average Scan)



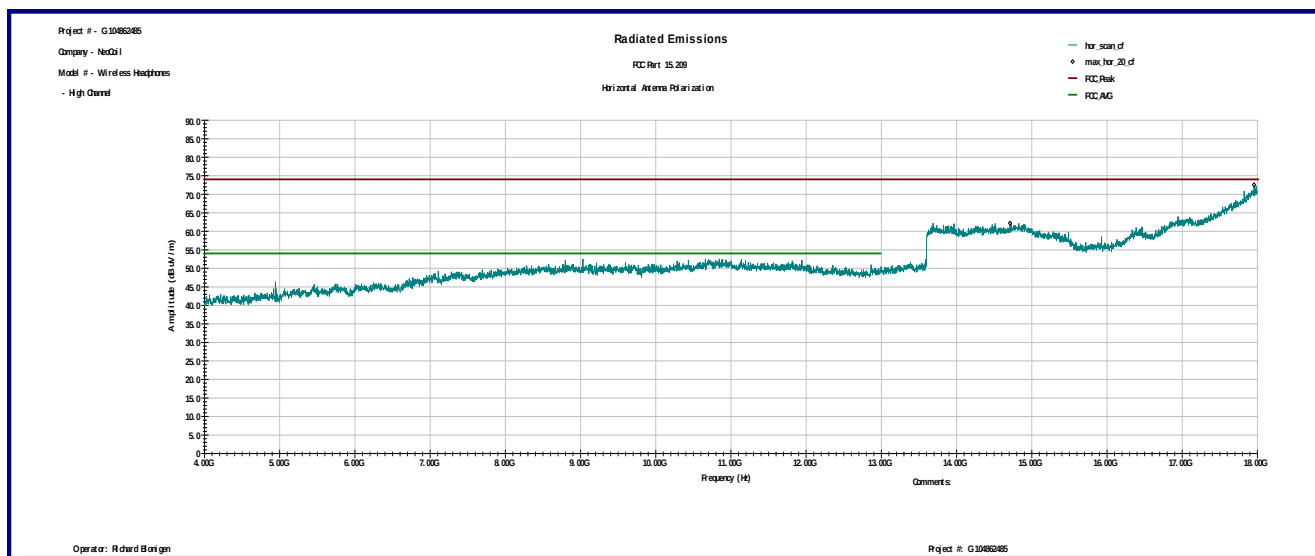
Graph 3.6.30 (Peak Scan)



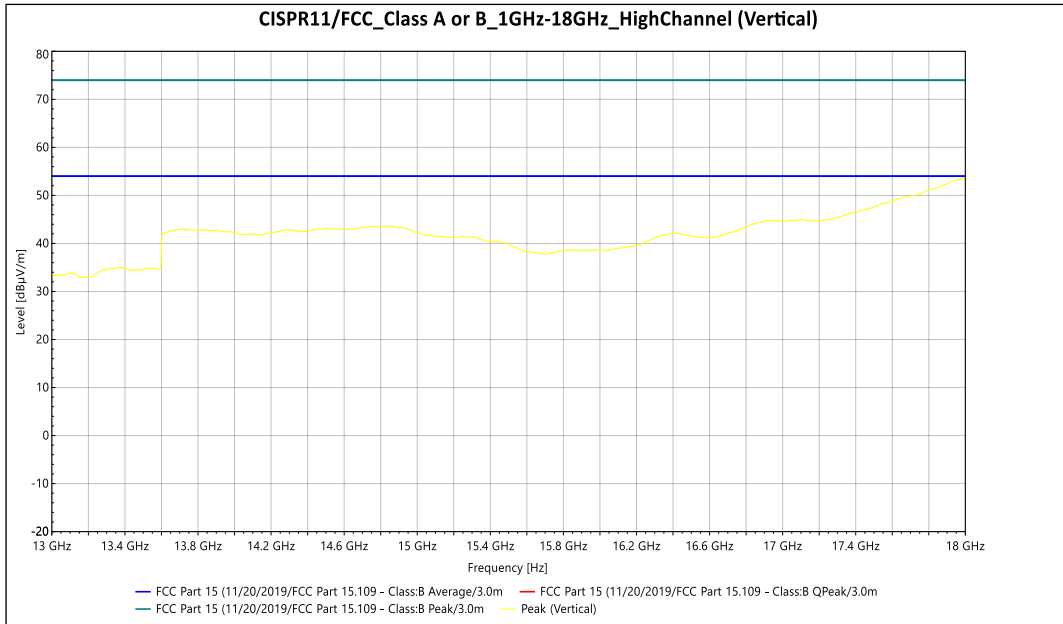
Graph 3.6.31 (Peak Scan)



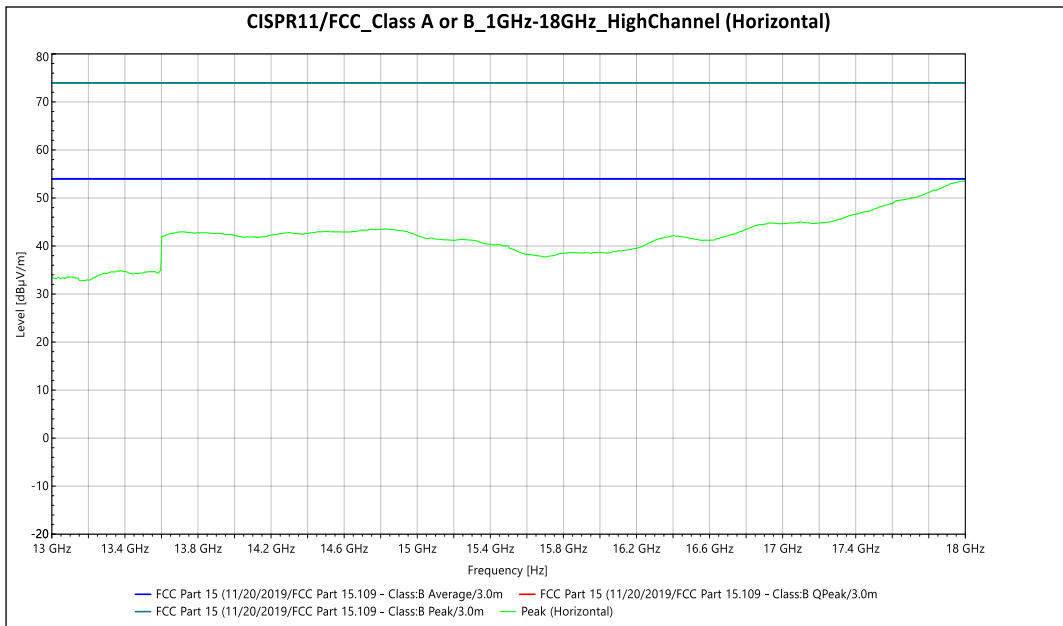
Graph 3.6.32 (Peak Scan)



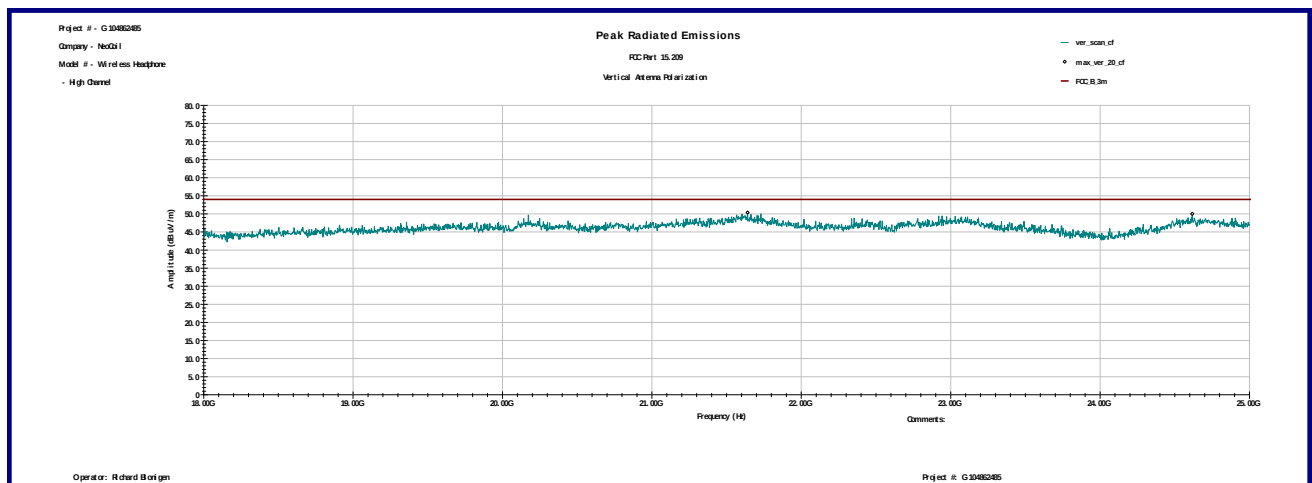
Graph 3.6.33 (Peak Scan)



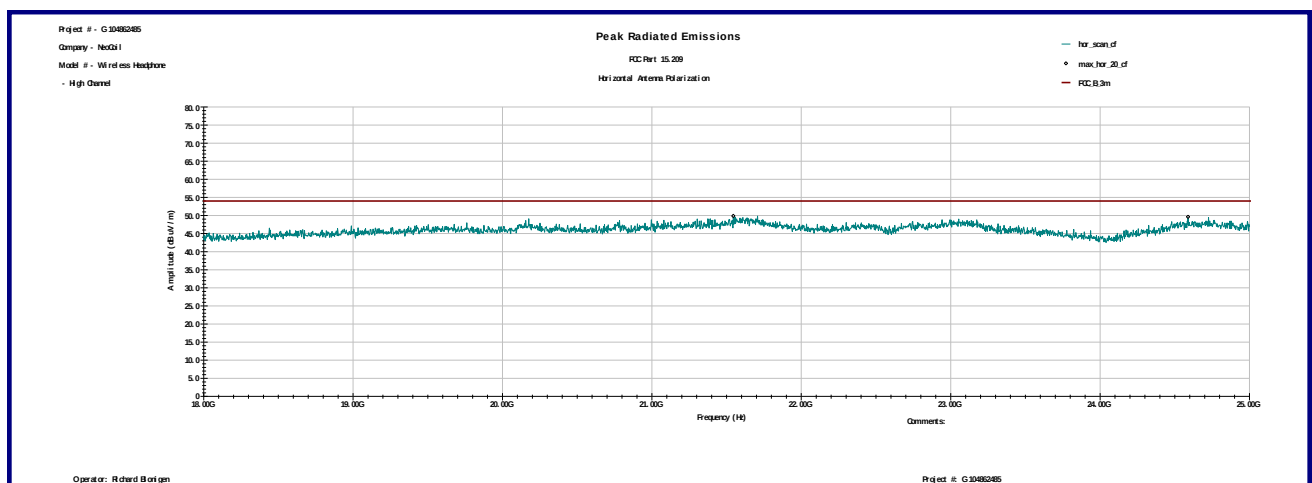
Graph 3.6.34 (AVG Scan)



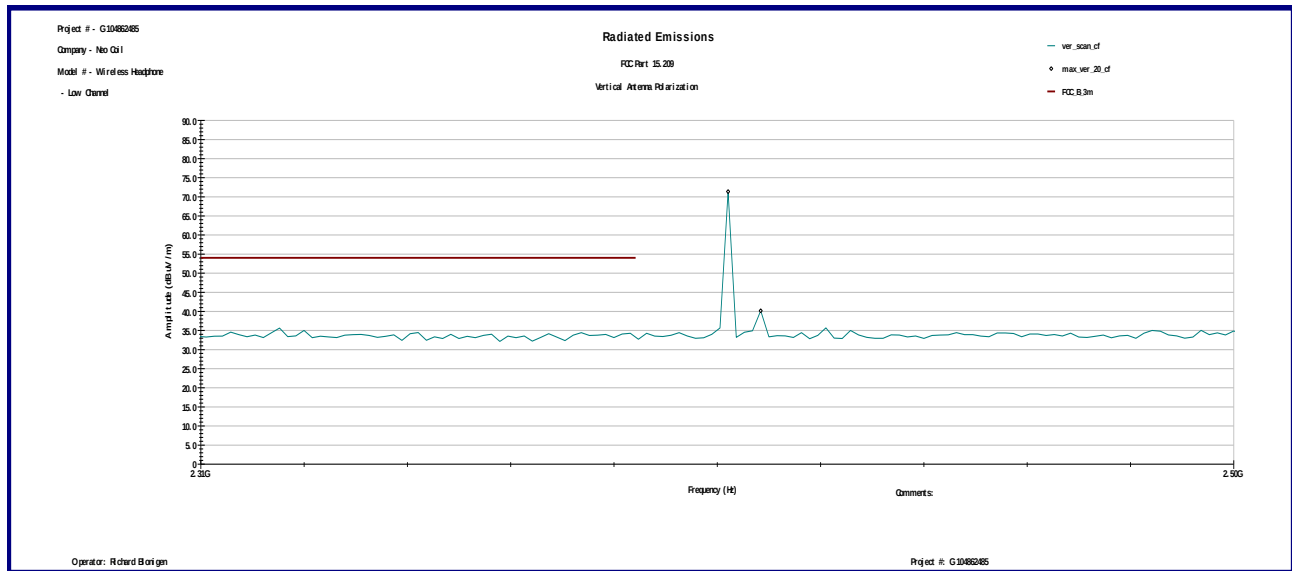
Graph 3.6.35 (AVG Scan)



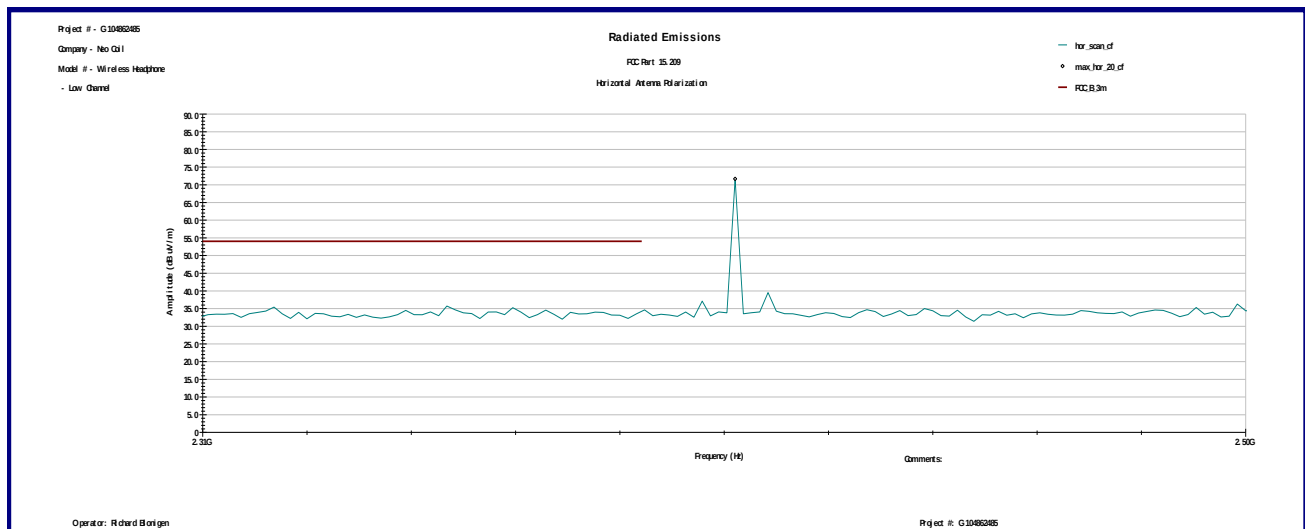
Graph 3.6.36 (Peak Scan)



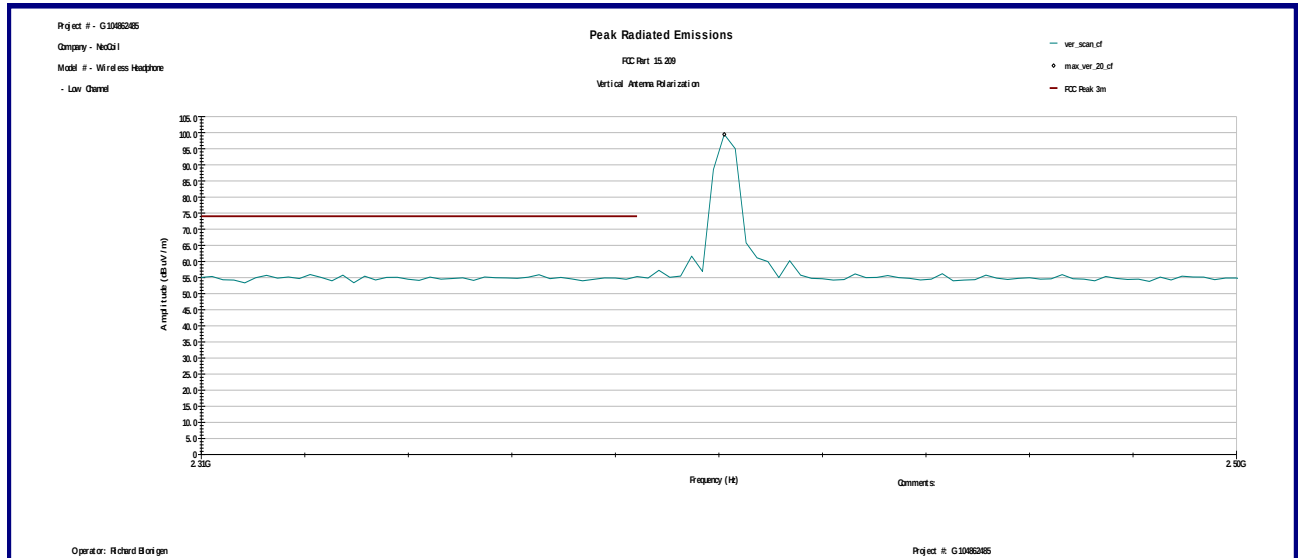
Graph 3.6.37 (Peak Scan)



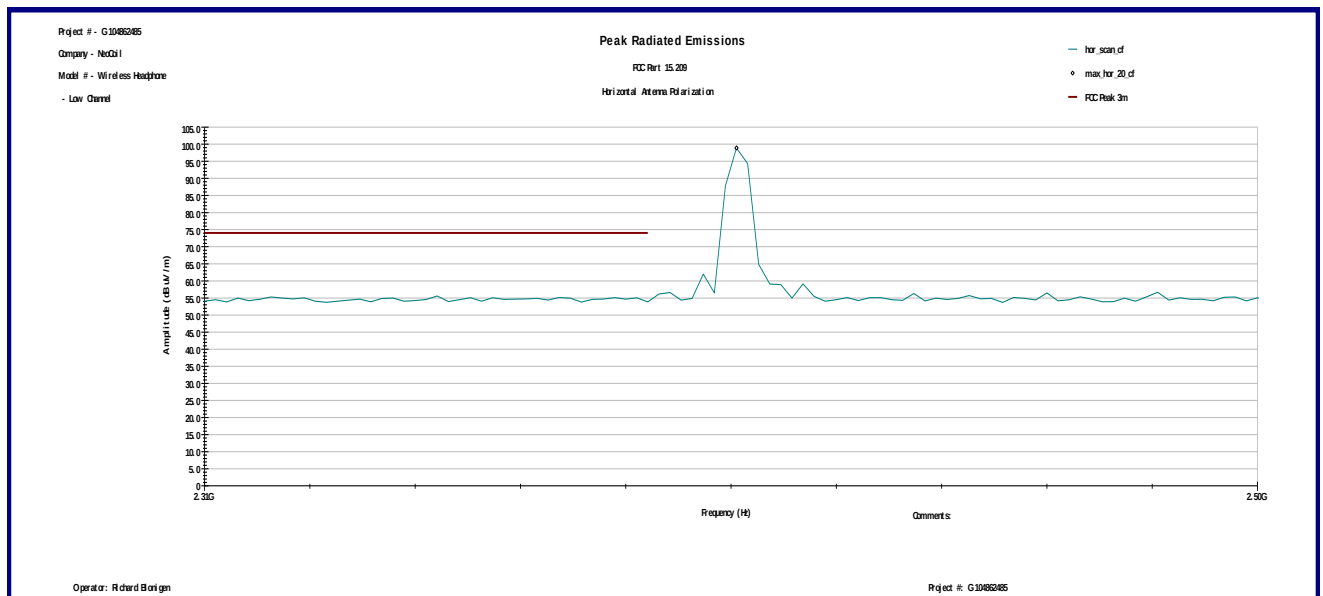
Graph 3.6.38 (Bandedge Low Channel AVG scan)
Note: Limit line is from 2310MHz – 2390MHz



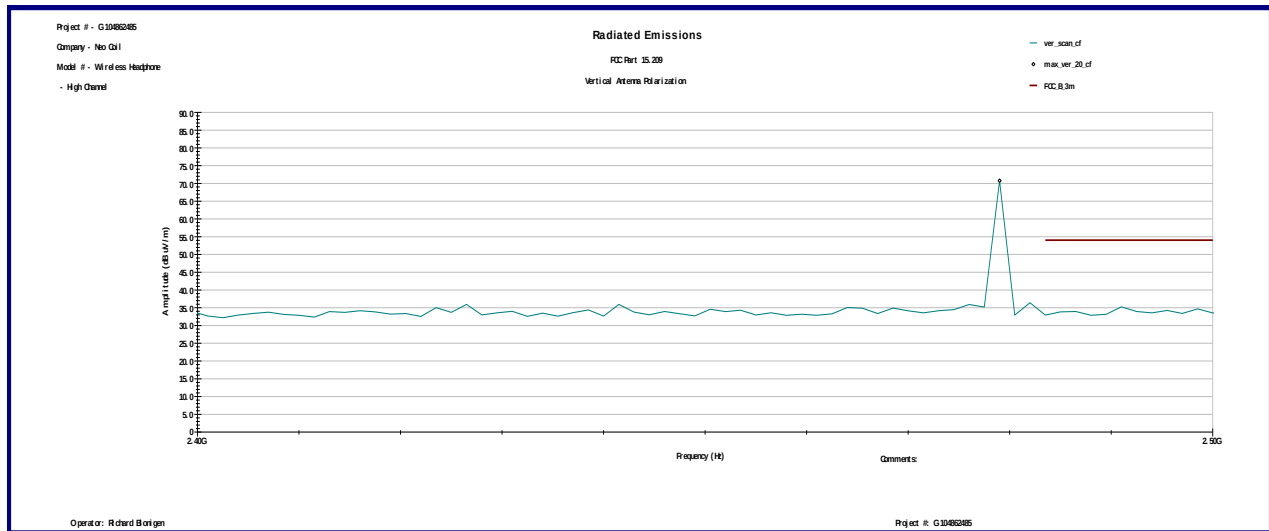
Graph 3.6.39 (Bandedge Low Channel AVG scan)
Note: Limit line is from 2310MHz – 2390MHz



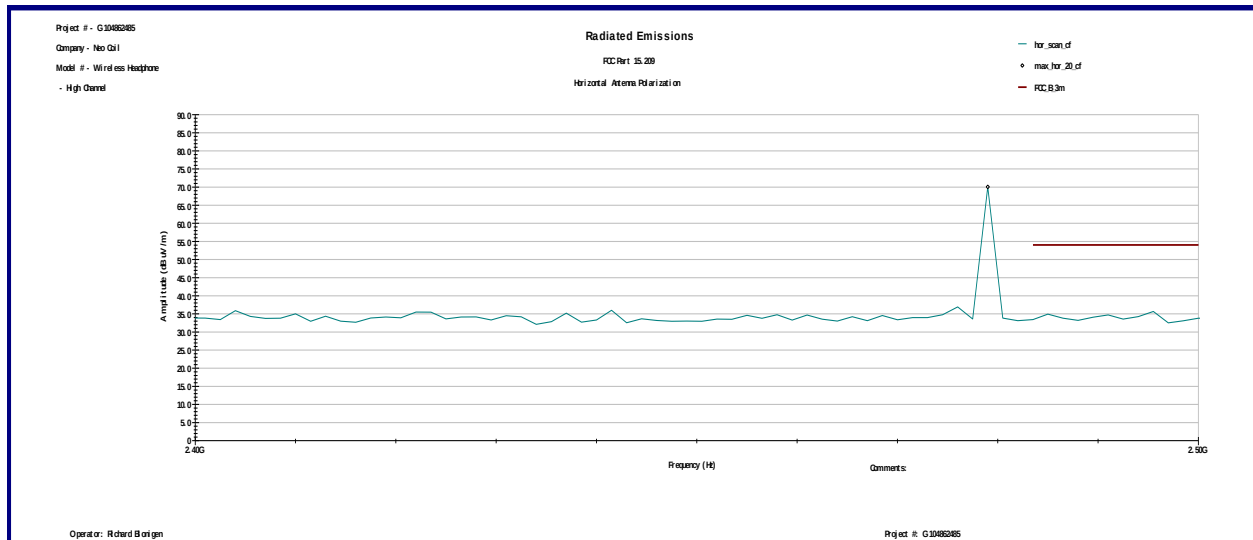
Graph 3.6.38 (Bandedge Low Channel Peak Scan)
Note: Limit line is from 2310MHz – 2390MHz



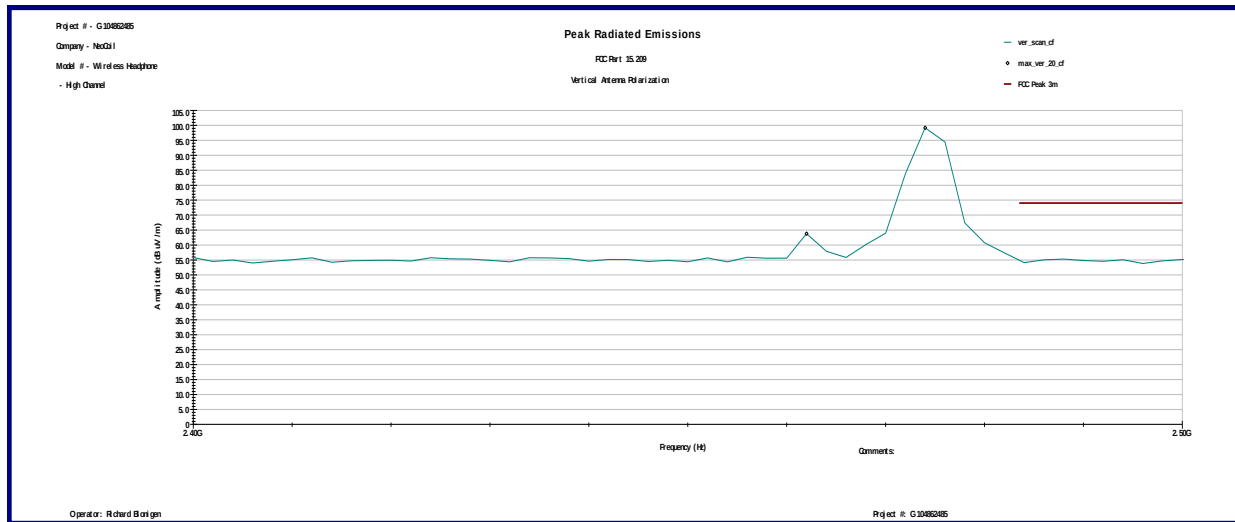
Graph 3.6.39 (Bandedge Low Channel Peak Scan)
Note: Limit line is from 2310MHz – 2390MHz



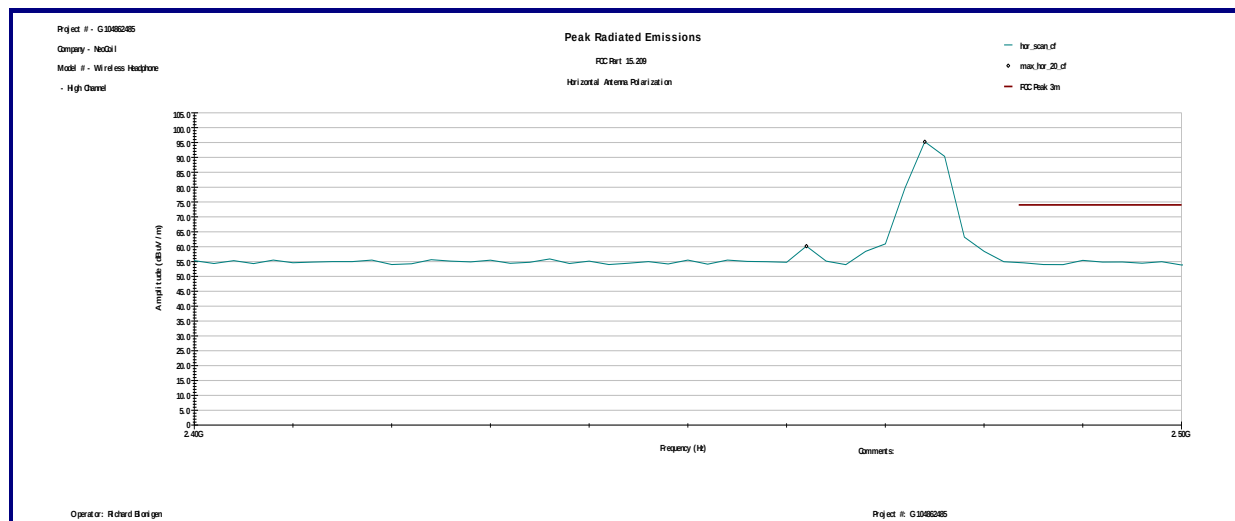
Graph 3.6.40 (Bandedge High Channel AVG scan)
Note: Limit line is from 2483.5MHz – 2500MHz



Graph 3.6.41 (Bandedge High Channel AVG scan)
Note: Limit line is from 2483.5MHz – 2500MHz



Graph 3.6.40 (Bandedge High Channel Peak scan)
Note: Limit line is from 2483.5MHz – 2500MHz



Graph 3.6.41 (Bandedge High Channel Peak scan)
Note: Limit line is from 2483.5MHz – 2500MHz

3.7 Transmitter power line conducted emissions

Test location: ☐ OATS ☐ Anechoic Chamber ☐ Other

Test result: N/A

Frequency range: 0.15MHz-30MHz

Max. Emissions margin: dB below the limits

Note 1: Test not applicable as EUT battery powered device

4.0 TEST EQUIPMENT

DESCRIPTION	MANUFACTURER	MODEL	SERIAL NO.	INTERTEK ID	LAST CAL DATE	CAL DUE
Spectrum Analyzer	R & S	FSP 40	100024	12559	02/12/2021	02/12/2022
Spectrum Analyzer	R & S	ESU	100398	25283	07/26/2021	07/26/2022
Spectrum Analyzer	R & S	ESCI	100358	12909	02/10/2021	02/10/2022
Bicono-Log Antenna	Teseq	CBL6112D	32859	25289	05/18/2021	05/18/2022
Chamber HF Cable	Insulated Wire Inc.	SPS-2303-3600-SPRX		12670	06/09/2021	06/09/2022
Chamber HF Cable	Insulated Wire Inc.	SPS-2301-3600-SPS		172517	06/09/2021	06/09/2022
Chamber RE Cable	Coleman	RG214/U M17/164-00001		172505	06/09/2021	06/09/2022
Horn Antenna	EMCO	3115	9504-4504	172463	08/03/2021	08/03/2022
Waveguide Horn Antenna	EMCO	3116	9904-2423	9705	01/22/2021	01/22/2022
Loop Antenna	ETS	6512	00060486	19942	02/22/2021	02/22/2022
Pre-Amplifier	MITEQ	LNA-40-00101800-35-15P	2108525	172474	06/30/2021	06/30/2022
Pre-Amplifier	MITEQ	AMF-6F-16002600-25-10P	1222383	MIN-0065	01/20/2021	01/20/2022
High Pass Filter	Reactel	9HS-4G/24-S12	20-01		04/08/2021	04/08/2022
System	Quantum Change	TILE! Instrument Control	Ver. 3.4.K.29	15259	VBU	VBU

5.0 Revision History

REVISION LEVEL	DATE	REPORT NUMBER	PREPARED	REVIEWED	NOTES
0	1-18-22	104862485MIN-006	RB	US	Original Issue
1	3-14-22	104862485MIN-006	RB <i>Richard Blay</i>	US <i>M. Spedden</i>	Added Peak and AVG scans where missing, removed BLE, updated Radiated Spurious data, corrected EBW middle channel on page 8, added Bandedge plots