INTENTIONAL RADIATOR TEST REPORT

Report Reference Number:	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev2.1
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CERT #3657.02

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Manufacturer:	**Copper Electrical Canada (Eaton)**
Address:	74-1833 Coast Meridian Rd. Port Coquitlam, BC, V3E 6G5, Canada
Equipment Tested:	**XPD2400 Radio Module**
Model Number(s):	XPD2400
FCC ID:	IA9XPD2400A
ISED ID:	1338B-XPD2400A
FVIN:	358401R48543

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REVISION HISTORY

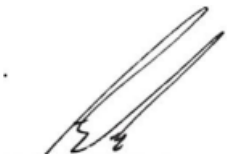
Date	Report Number	Details	Author's Initials
October 24, 2022	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev0.0	Initial draft	AH
October 26, 2022	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev0.1	Update	AH
October 26, 2022	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev0.2	Update	AH
October 26, 2022	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev1.0	Final	AH
November 3, 2022	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev2.0	Updated FVIN, Output Power, Radiated Emissions	AH
November 8, 2022	E10788-2207_CooperElectrical_XPD2400_FCC-ISED_Rev2.1	Updated antenna gains	AH
All previous versions of this report have been superseded by the latest dated revision as listed in the above table. Please dispose of all previous electronic and paper printed revisions accordingly.			

REPORT AUTHORIZATION

The data documented in this report is for the test equipment provided by the manufacturer. The tests were conducted on the sample equipment as requested by the manufacturer for the purpose of demonstrating compliance with the standards outlined in Section I of this report as agreed upon by the Manufacturer under the quote 22RH09233R1.

The Manufacturer is responsible for the tested product configurations, continued product compliance, and for the appropriate auditing of subsequent products as required.

This report may comprise a partial list of tests that are required for FCC and ISED Declaration of Conformity can only be produced by the manufacturer. This is to certify that the following report is true and correct to the best of our knowledge.



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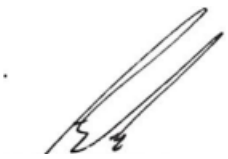
Senior RF/EMC Engineer



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EMC Laboratory Location	FCC Designation (3m SAC)	IC Registration (3m SAC)	A2LA Certificate
Burnaby, BC, Canada	CA9543	9543A	3657.02

EMC Facility Burnaby BC, Canada

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 EXECUTIVE SUMMARY

1.1 Purpose

The purpose of this report is to demonstrate and document the compliance of XPD2400 as per Sections 1.2 and 1.3.

1.2 Scope

The information documented in this report is based on the test methods and levels as per Quote 22RH09233R1:

- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart B – Intentional Radiators 15.109: Radiated emission limits
- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart C – Intentional Radiators 15.203: Antenna Requirement
- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart C – Intentional Radiators 15.205: Restricted bands of operation
- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart C – Intentional Radiators 15.209: Radiated emission limits; general requirements
- **FCC Title 47 Part 15** – Radio Frequency Devices, Subpart C – Intentional Radiators 15.247: Operation in the bands 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz
- **RSS-Gen Issue 5 –** General Requirements for Compliance of Radio Apparatus
- **RSS-102 Issue 5** – Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands)
- **RSS-247 Issue 2 –** Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and License-Exempt Local Area Network (LE-LAN) Devices
- **ICES-003 Issue 7 –** Information Technology Equipment (including Digital Apparatus)

1.3 Summary of Results

The following testing was performed pursuant to FCC Title 47 Part 15 and Industry Canada ICES-003 to demonstrate the testimony to "FCC, IC, & CE" mark Electromagnetic Compatibility testing for the product.

No.	Test	Applicable Standard	Description	Result
1	Antenna Requirement	FCC 47 CFR Part 15.203 RSS-Gen Issue 5 Section 7.1.2	Soldered, non-replaceable antenna	Complies
2	RF Peak Output Power	FCC 47 CFR Part 15.247 (b)(2) RSS-247 Issue 2 (5.1) (b)	Maximum peak conducted output power shall not exceed 1 W for systems employing at least 50 hopping channels.	Complies
3	20 dB Bandwidth	FCC 47 CFR Part 15.247 (a)(1)(iii) RSS-247 Issue 2 (5.1) (c)	Maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz	Complies
4	99% Occupied Bandwidth	RSS-247 Issue 2 RSS-Gen Issue 5	99% of the signal shall fall completely within the frequency range specified by the standard.	Complies
5	Out-of-Band Emmisions (Band Edge)	FCC 47 CFR Part 15.247 (d)	In any 100 kHz bandwidth outside the frequency band in which the device is operating, the RF power shall be at least 20dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power.	Complies
6	Channel Separation	FCC 47 CFR Part 15.247 (a)(1) RSS-247 Issue 2 (5.1) (b)	Frequency hopping systems shall have channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater.	Complies
7	Number of Channels	FCC 47 CFR Part 15.247 (a)(1)(iii) RSS-247 Issue 2 (5.1) (c)	If the 20 dB bandwidth of the hopping channel is <250 kHz, the system shall use at least 50 hopping channels.	Complies
8	Time of Occupancy	FCC 47 CFR Part 15.247 (a)(1)(iii) RSS-247 Issue 2 (5.1) (c)	Average time of occupancy on any frequency shall not be greater than 0.4 s within a 20 s period.	Complies
9	Hopping Requirements	FCC 47 CFR Part 15.247 (a)(1) RSS-247 Issue 2 (5.1) (a)	Each pseudo random hopping frequency must be used equally on the average by each transmitter.	Complies
10	Radiated Spurious Emissions	FCC 47 CFR Part 15.205 (a), 15.209 (a), and 15.247 (d) FCC 47 CFR Part 15.109 RSS-247 Issue 2 (8.9) (8.10)	Radiated emissions requirements as stated in the Standards	Complies
11	Spurious Emissions – Receiver Mode	FCC 47 CFR Part 15.109 ICES-003 Issue 7	Radiated emissions requirements as stated in the Standards	Complies

Table 1: Applicable test standards and descriptions

Note: The gain of the antenna(s) is provided by the client to measure or calculate test results and is not independently measured by QAI.

2 GENERAL INFORMATION

2.1 Product Description

The information provided in this section is for the Equipment Under Test (EUT) and the corresponding Auxiliary Equipment needed to perform the tests as a complete system.

Figure 1: EUT

Equipment Under Test (EUT)

Equipment	XPD2400 Transceiver Radio Module
Description	2.4 GHz Transceiver Module using FHSS modulation
Manufacturer	Cooper Electrical
Model No.	XPD2400
Serial No.	1E065874
Clock frequencies tuned upon within the EUT:	8 MHz, 16 MHz
Highest frequency generated within the EUT:	2479.8 MHz

Equipment Under Test (EUT) – RF Information

RF device type	Frequency Hopping Spread Spectrum Tranceiver
Model No. (HVIN)	TPCB-3499-01
Operating frequency	2403.1 MHz – 2479.8 MHz
Number of available	768 channels from which 64 are used at a time
Channel separation	1200 kHz
Channel bandwidth	24.84 kHz
Output Power/Transmitter	15.47 dBm
Modulation type	2-level FSK
Test Channels (L, M, H)	2403.1 MHz, 2441.4 MHz, 2479.8 MHz
Data Rate	10416 BAUD
Adaptive	No
Geo-location-capable	No
Number of antennas	5
Antenna Type 1	2.4-2.5 GHz, ½ λ Dipole (Gain = 3dBi)
Antenna Type 2	2.4-2.5 Dual Closed Coil Whip (Gain = 5dBi)
Antenna Type 3	2.4-2.5GHz ½ λ Dipole (Gain = 2.5dBi)
Antenna Type 4	2.4-2.5GHz Edge Inverted L (Gain = 2.54dBi)
Antenna Type 5	2.4-2.5GHz SMD Ceramic (Gain = 2.62dBi)

Notes: None.

Equipment Under Test (EUT) – General Information

Tested as	Table-top
Dimensions	5 x 7 x 0.5 cm
Declared operating temperature range:	-40 °C to +85 °C
Input power	6VDC, 1.5W
Grounded	No
Device use	Portable – Used within 20 cm of the human body

Notes: None.

Test Modes

Test	Transmitter State	Power
1	ON – Transmitting Continuously	DC Power Supply
2	OFF – Receiver Mode	DC Power Supply

Auxiliary Manufacturer Supplied Equipment

Equipment	Manufacturer	Product Description	Model No.
Aux 1	Omnex/Eaton	Development board	N/A
Aux 2	Eaton	RS-232 adapter board	N/A

2.2 Environmental Conditions

The equipment under test was operated and tested under the following environmental conditions:

Parameter	Conditions
Location	QAI Burnaby – Indoors
Temperature	22 °C
Relative Humidity	54% RH

2.3 Measurement Uncertainty

Parameter	Uncertainty
Radiated Emissions, 30MHz-1GHz	± 2.40 dB
Radiated Emissions, 1GHz-40GHz	± 2.48 dB
Radio Frequency	±1.5 x 10-5 MHz
Total RF Power Conducted	±1.36 dB
Spurious Emissions, Conducted	±1.36 dB
RF Power Density, Conducted	±1.36 dB
Temperature	±1ºC
Humidity	±5 %
DC and low frequency voltages	±3 %

2.4 Worst Test Case

Worst-case orientation was determined during the preliminary testing. The final radiated emissions were performed in the worst-case orientation.

2.5 Sample Calculations of Emissions Data

Radiated and conducted emissions were performed using EMC32 software developed by Rohde & Schwarz. Transducer factors such as antenna factors, cable losses and amplifier gains were stored in the test templates which are used to perform the emissions measurements. After the test is finished, data is generated from the EMC32 consisting of product details, emission plots and final data tables as shown below.

Frequency (MHz)	Q-Peak (dBµV/m)	Meas. Time (ms)	Bandwidth (kHz)	Ant. Ht. (cm)	Pol	Turntable Position (deg)	Corr. (dB)	Margin (dB)	Limit (dBµV/m)
42.663900	33.0	1000.000	120.000	100.0	H	70.0	13.2	7.5	40.5

Table 2: Sample Quasi-Peak Correction Data - Radiated

Quasi-Peak reading shown in the table above is already corrected by the software using the correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

Corr.(dB) = Antenna factor + Cable loss

Or

Corr.(dB) = Antenna factor + Cable Loss - Amp gain (if pre-amplifier was used)

The final Quasi peak reading shown in the data is calculated by the software using following equation:

Corrected Quasi-Peak (dBµV/m) = Raw Quasi-Peak Reading + Antenna factor + Cable loss

To obtain the final Quasi-Peak or Average reading during power line conducted emissions, transducer factors are included in the final measurement as shown below.

Frequency (MHz)	Q-Peak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	44.3	1000.000	9.000	GND	0.6	21.7	66.0

Table 3: Sample Quasi-Peak Correction Data - Conducted Emissions

Frequency (MHz)	Average (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150	27.2	1000.000	9.000	GND	0.6	28.8	56.0

Table 4: Sample Average Correction Data- Radiated Emissions

Quasi Peak or Average reading shown in above table is already corrected by the software using the correction factor shown in column "Corr." The correction factor listed under "Corr." table calculated as:

Corr.(dB) = Antenna factor + Cable loss

The final Quasi-peak or Average reading shown in the data is calculated by the software using following equation:

Corr. Quasi-Peak/Average Reading (dBµV) = Raw Quasi-Peak/Average Reading + Antenna factor + Cable loss

The allowable margin from the limits, as per the standards, were calculated for both radiated and conducted emissions:

Margin(dB) = Limit – Quasi-Peak or Average reading

3 DATA & TEST RESULTS

3.1 Antenna Requirements

Date Performed: October 3, 2022

Test Standard: FCC CFR 47 Part 15.203
IC RSS-Gen Issue 7 Section 7.1.2

Test Method: ANSI C63.10:2013

Modifications: None

Final Result: Complies

Applicable Regulations:

The purpose of this requirement is to make certain that no other antenna, except for that provided by the responsible party, shall be used with the Equipment-Under-Test (EUT) as defined in Section 1.1.

"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 the user can replace a broken antenna, but the use of a standard antenna jack or electrical connector is prohibited." … "the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in the Part are not exceeded."

Data:

Ant.	Manufacturer	Part Number	Type	Connection	Max Gain (dBi)
1	Laird Technologies	ANXTRA24003NP	Dome	N-Female	3
2	Pulse/Larsen	NMO5E2400B	Collinear	NMOHF	5
3	Wellshow	AR010-2.4G	Rubber Duck	UFL	2
4	Copper Industries (Electrical) Inc	ACAB-2683-07	Wire	Soldered	2.54
5	Yageo	ANT7020LL05R2400A	Chip Antenna	Soldered	2.62

Note: Antenna gain provided by manufacturer

3.2 RF Peak Output Power

Date Performed: November 2, 2022

Test Standard: FCC CFR 47 Part 15.247 (b)(1)
IC RSS-247 Issue 2

Test Method: FCC KDB 558074 D01 DTS Measurement Guidance V04
Span = 1 MHz, RBW = 120 kHz, VBW = 300 kHz
Trace stabilization time: 3.5 minutes

Modifications: None.

Final Result: Complies

Applicable Regulation:

For frequency hopping systems operating in the 2400-2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725-5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 watts.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per FCC KDB 558074 D01 DTS Measurement Guidance V04. The spectrum analyser was set as follows:

Measurement Data and Plots:

Carrier Frequency (MHz)	Raw Peak (dBm)	Correction Factor[1] (dB)	Corrected Peak Conducted Output Power (dBm)	Limit (dBm)	Margin (dB)	Results
2403.10	-4.34	21.55	17.21	20.97	3.76	Complies
2441.40	-3.97	21.60	17.63	20.97	3.34	Complies
2479.80	-3.87	21.45	17.58	20.97	3.39	Complies

[1] Correction factor consists of cable loss, external attenuator, and adapter(s)

Table 5: RF Peak Output Power

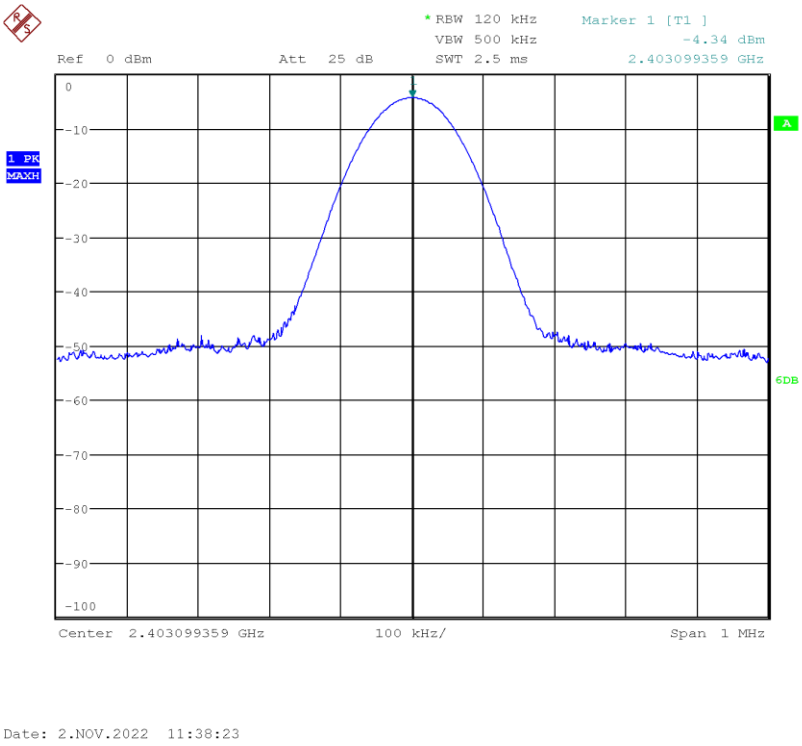

Figure 2: Peak Output Power – Lowest Frequency

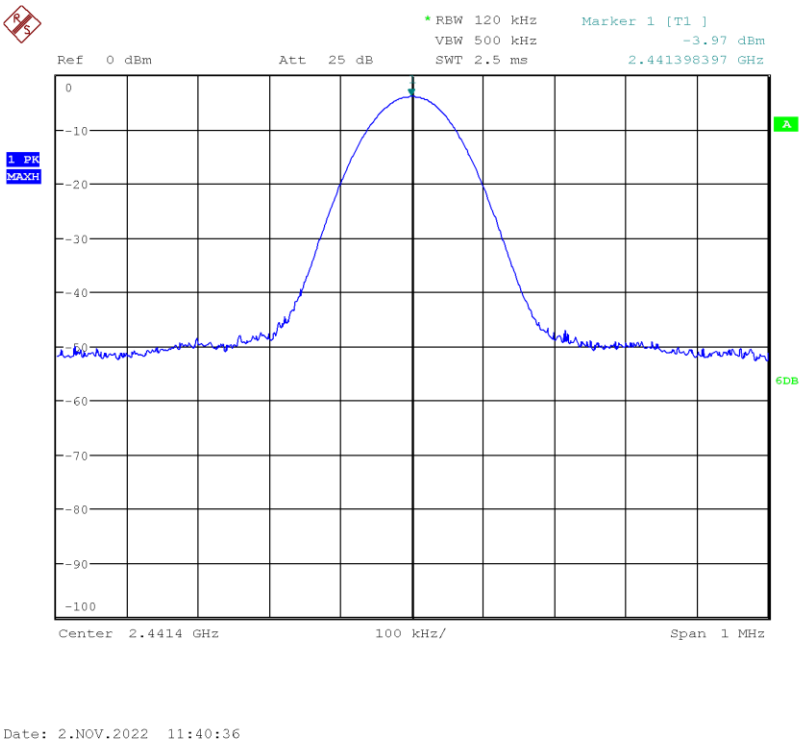

Figure 3: Peak Output Power - Middle Frequency

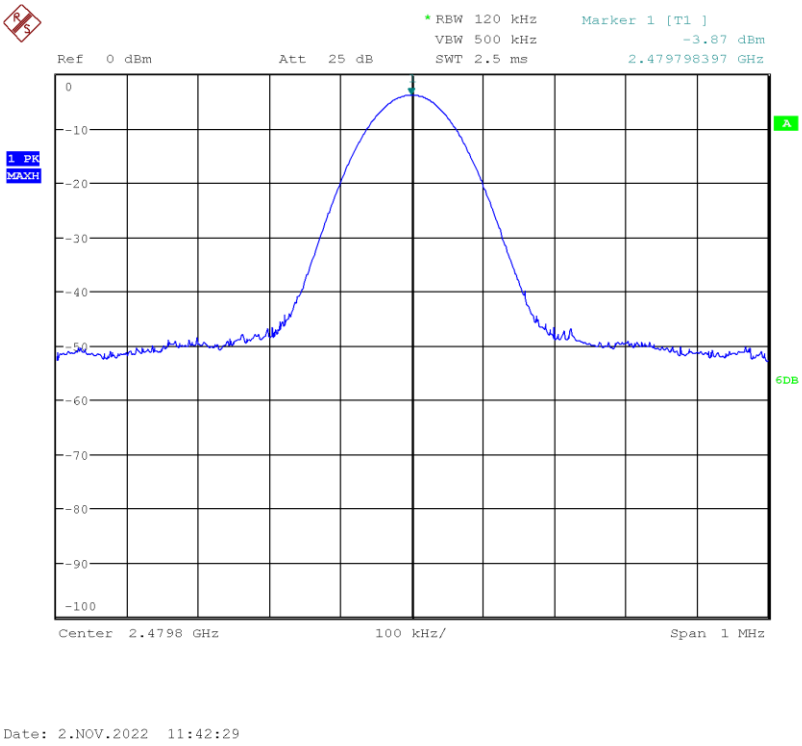

Figure 4: Peak Output Power - Highest Frequency

3.3 20dB Occupied Bandwidth

Date Performed: October 18, 2022

Test Standard: FCC CFR 47 Part 15.247
IC RSS-247 Issue 2
IC RSS-Gen Issue 5

Test Method: ANSI C63.10:2013
Span = 2 to 5 x OBW, RBW = 1 to 5% of OBW, VBW = 3 x RBW
Ref Level > 10log(OBW/RBW) above signal peak
Trace stabilization time: 3.5 minutes

Modifications: None.

Final Result: Complies

Applicable Regulation:

The maximum allowed 20 dB bandwidth of the hopping channel is 500 kHz.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

A spectrum analyzer or other instrument providing a spectral display is recommended for these measurements. When using a spectrum analyzer or other instrument providing a spectral display, the video bandwidth shall be set to a value at least three times greater than the IF bandwidth of the measuring instrument to avoid the introduction of unwanted amplitude smoothing. Video filtering is not used during occupied bandwidth tests.

Measurement Data and Plots:

Channels	Carrier Frequency (MHz)	20dB Bandwidth (kHz)	Limit (kHz)	Result
Low	2403.10	25.00	N/A	Complies
Middle	2441.40	25.16	N/A	Complies
High	2479.80	25.32	N/A	Complies

Table 6: 20 dB Bandwidth Results

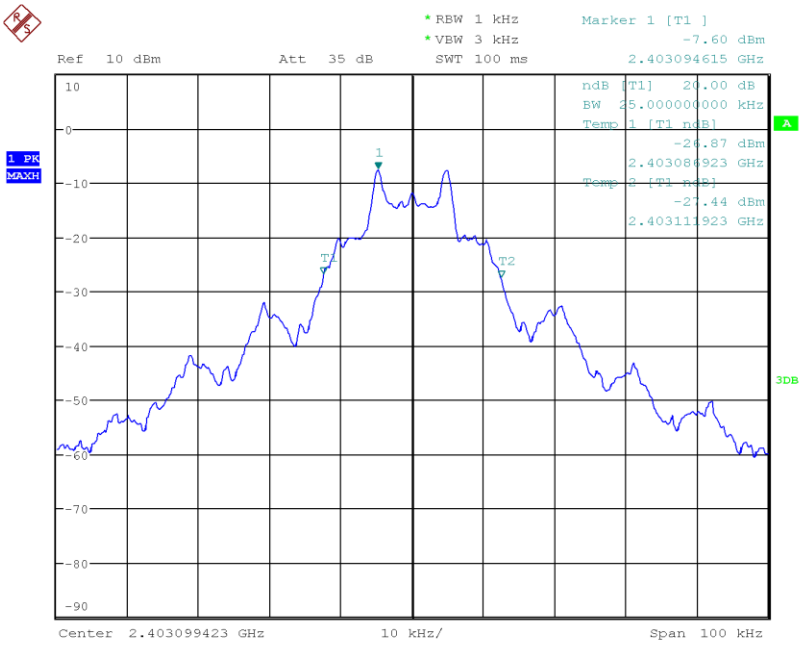

Figure 5: 20 dB Bandwidth - Low Channel

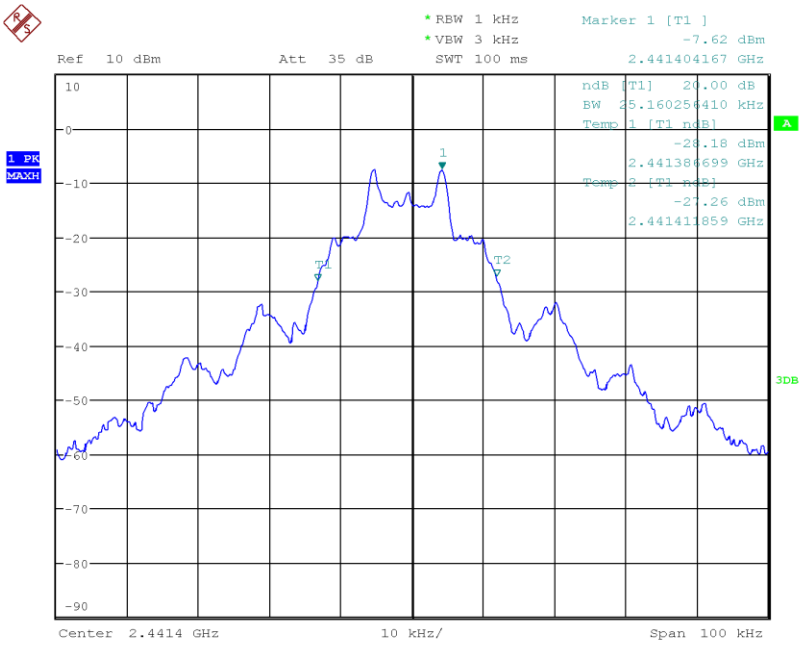

Figure 6: 20 dB Bandwidth - Mid Channel

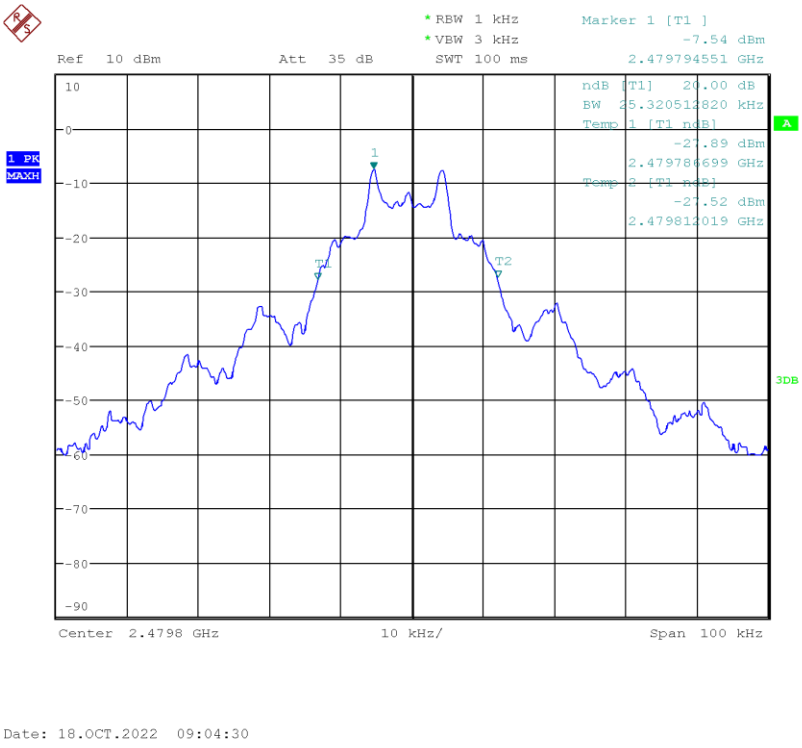

Figure 7: 20 dB Bandwidth - High Channel

3.4 99% Occupied Bandwidth

Date Performed: October 18, 2022

Test Standard: IC RSS-247 Issue 2
IC RSS-Gen Issue 5

Test Method: ANSI C63.10:2013
Span = 1.5 to 5 x OBW, RBW = 1 to 5% of OBW, VBW = 3 x RBW
Ref Level > 10log(OBW/RBW) above signal peak
Trace Detector: Peak, Trace: Max Hold

Modifications: None

Final Result: Complies

Applicable Regulation:

The Occupied Channel Bandwidth is the bandwidth that contains 99% of the signal power. The bandwidth shall fall completely within the range specified by the standard.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

Measurement Data and Plots:

Channel	Carrier Frequency (MHz)	99% Bandwidth (kHz)	Limit (kHz)	Result
Low	2403.09	24.84	500 kHz	Complies
Middle	2441.39	24.84	500 kHz	Complies
High	2479.79	24.84	500 kHz	Complies

Table 7: 99% Occupied Bandwidth Results

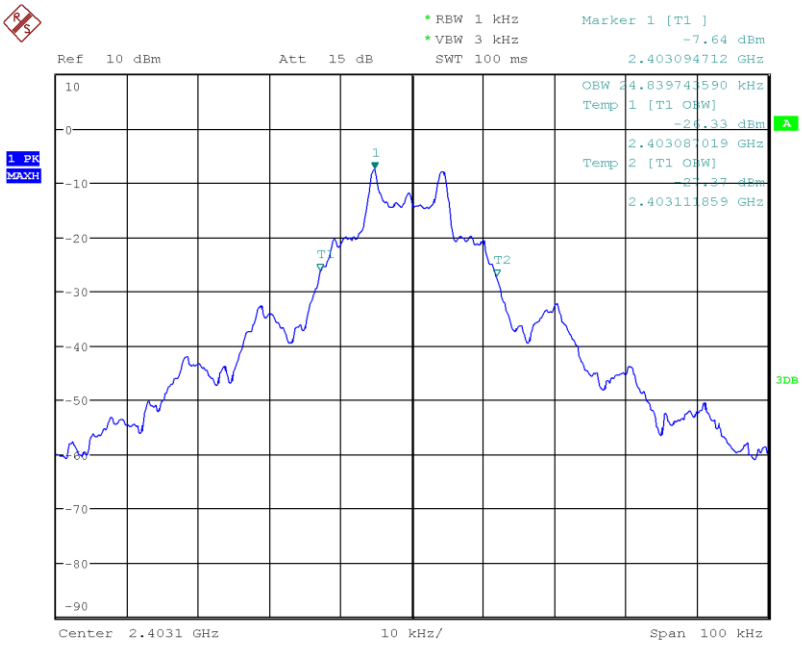

Figure 8: 99% Occupied Bandwidth - Low Channel

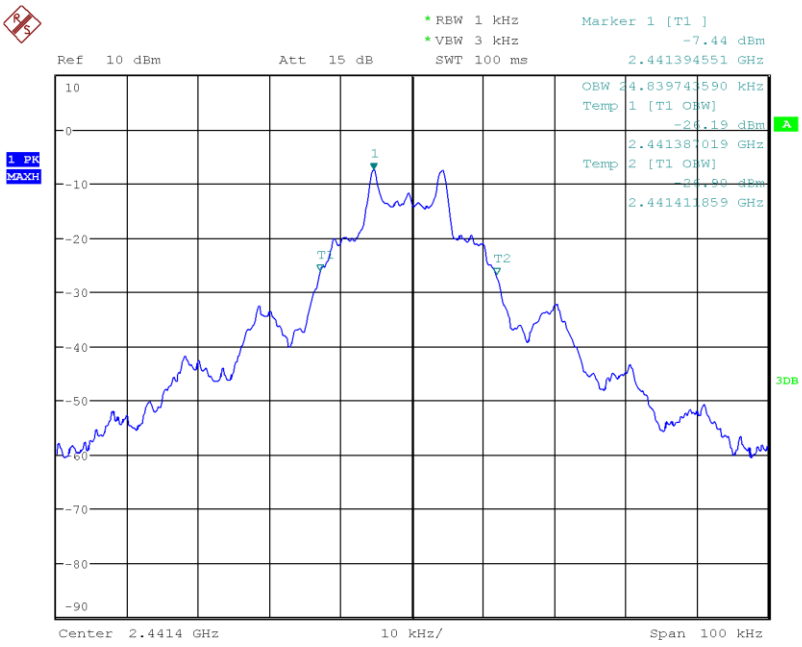

Figure 9: 99% Bandwidth - Mid Channel

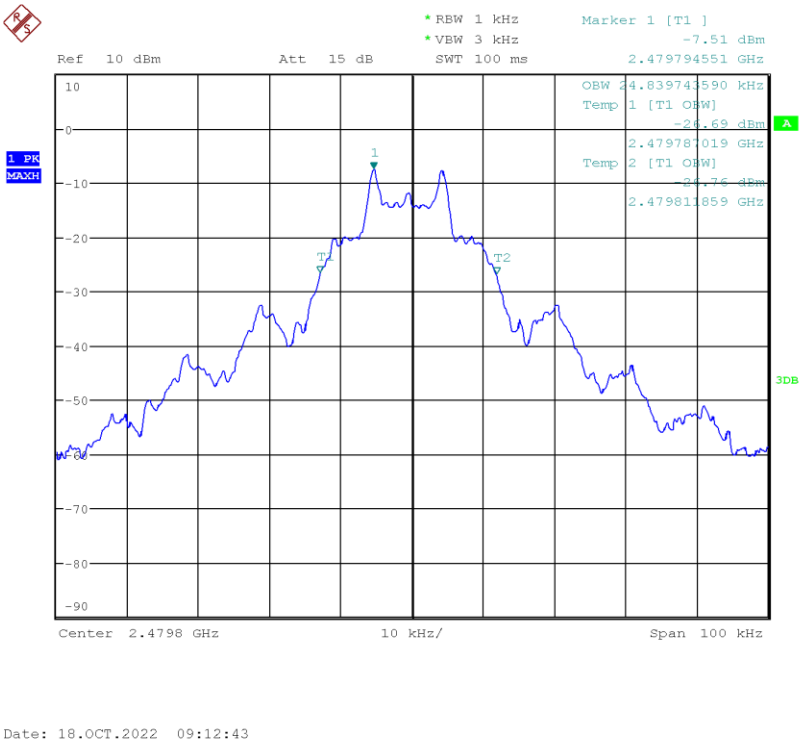

Figure 10: 99% Bandwidth - High Channel

3.5 Out-Of-Band Emissions (Band Edge)

Date Performed: October 24, 2022

Test Standard: FCC CFR 47 Part 15.247 (d)
IC RSS-247 Issue 2

Test Method: ANSI C63.10:2013
Span = Wide enough to capture the peak level of the emission closest to the band edge, as well as any modulation products that fall outside of the band.
Ref Level = High enough to keep the signal from overdriving the input mixer
RBW = 100 kHz, VBW = 300 kHz
Trace Detector: Peak, Trace: Max Hold

Modifications: None

Final Result: Complies

Applicable Regulation:

In any 100kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, shall be at least 20 dB below that in the 100kHz 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 A8.4 (4) of the standard, the attenuation required shall be 30 dB instead of 20dB.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

This test was performed twice: once with the hopping function turned OFF and then repeated with the hopping function turn ON. The purpose of the test with the hopping function turned on is to confirm that the RF power remains OFF while the device is changing frequencies, and that the oscillator stabilizes at the new frequency before RF power is turned back ON. Overshoot of any oscillator, including phase-lock-loop stabilized oscillators, can cause the device to be temporarily tuned to frequencies outside the authorized band, and it is important that no transmissions occur during such temporary periods.

Measurement Data and Plots:

Band Edge	Hopping	Highest Out of Band Emission	Limit	Result
Low	On	-47.23 dB	-20 dB	Complies
High	On	-46.93 dB	-20 dB	Complies
Low	Off	-56.14 dB	-20 dB	Complies
High	Off	-54.35 dB	-20 dB	Complies

Table 8: Band Edge Results

3.5.1 FSK Hopping: ON

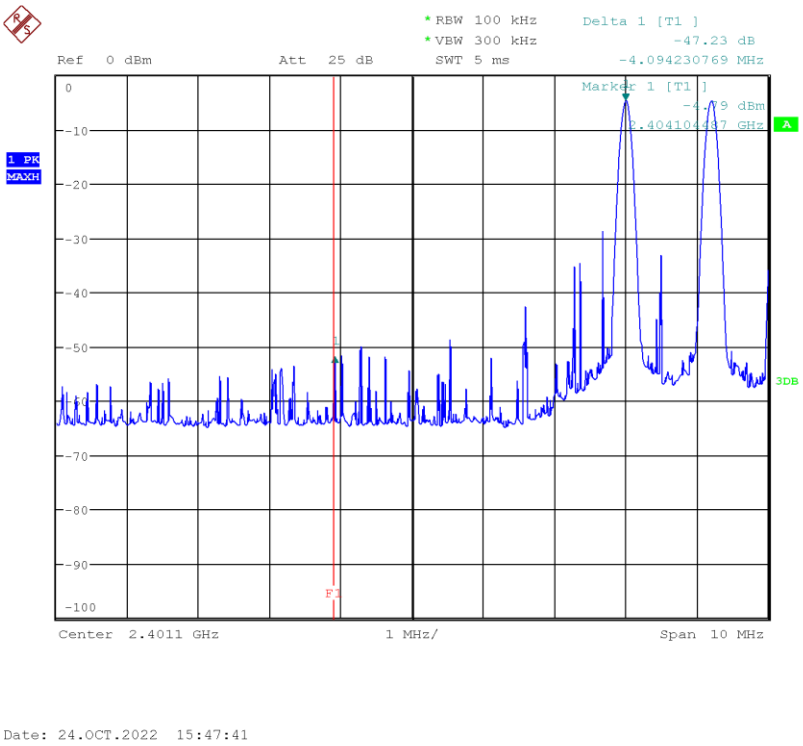

Figure 11: Band Edge, Hopping ON - Low Channel

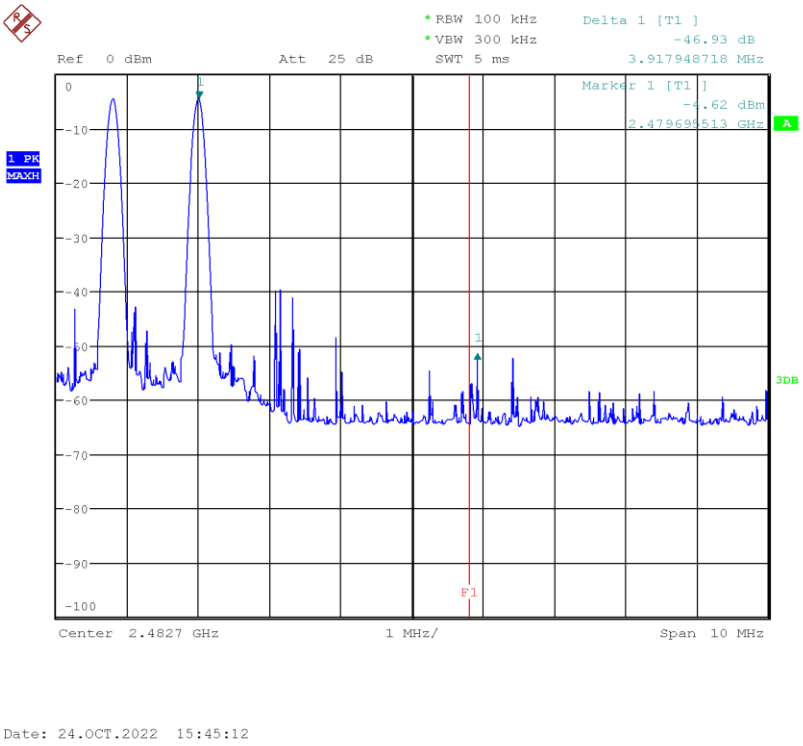

Figure 12: Band Edge, Hopping ON - High Channel

3.5.2 FSK Hopping: OFF

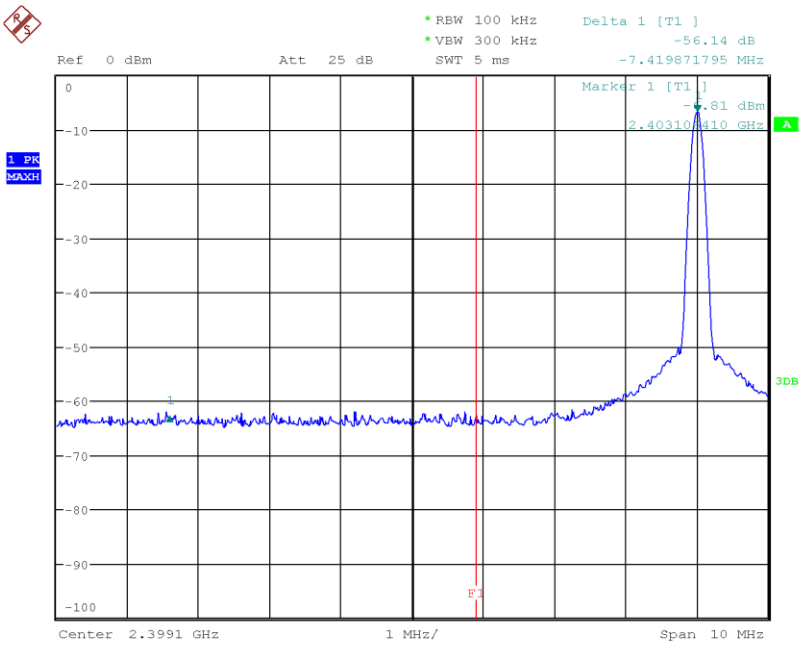

Figure 13: Band Edge, Hopping OFF - Low Channel

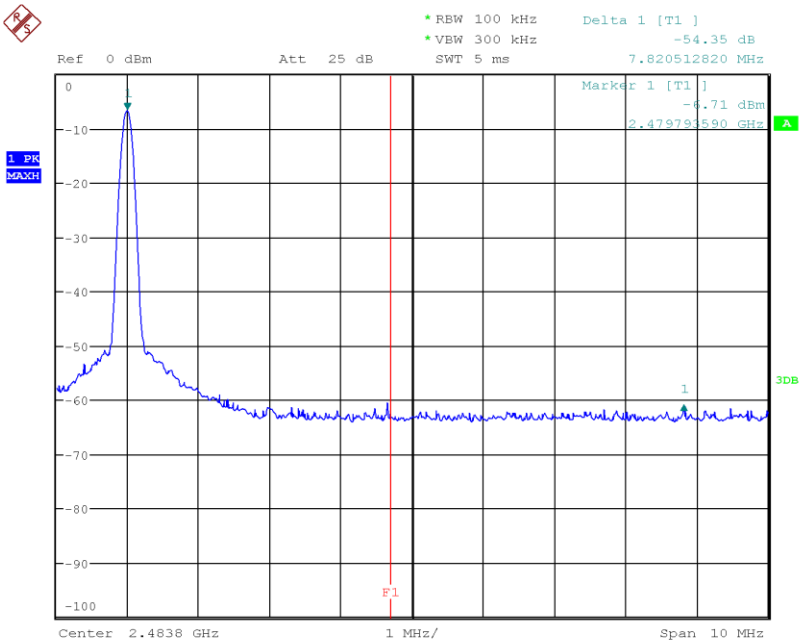

Figure 14: Band Edge, Hopping OFF - High Channel

3.6 Channel Separation

Date Performed: October 18, 2022

Test Standard: FCC CFR 47 Part 15.247 (a)(1)
IC RSS-247 Issue 2 (5.1)(c)

Test Method: ANSI C63.10:2013
Span = Wide enough to capture the peak of two adjacent channels.
Ref Level = High enough to keep the signal from overdriving the input mixer
RBW = Approximately 30% of the channel spacing; adjusted as necessary to identify the center of each individual channel.
VBW ≥ RBW
Trace Detector: Peak, Trace: Max Hold

Modifications: None.

Final Result: Complies

Applicable Standard:

Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

The channel separation measurement was made by connecting the spectrum analyzer to the active antenna port using a 20dB attenuator. Testing was done using the maximum power output with the system configured for normal operation using a pseudorandom hopping pattern.

Measurement Data and Plots:

Modulation	Channel Separation (kHz)	Limit (Maximum of)		Result
		20dB Bandwidth (kHz)	Minimum Limit (kHz)	
FSK	1197.12	25.32	25 kHz	Complies

Table 9: Channel Separation Results

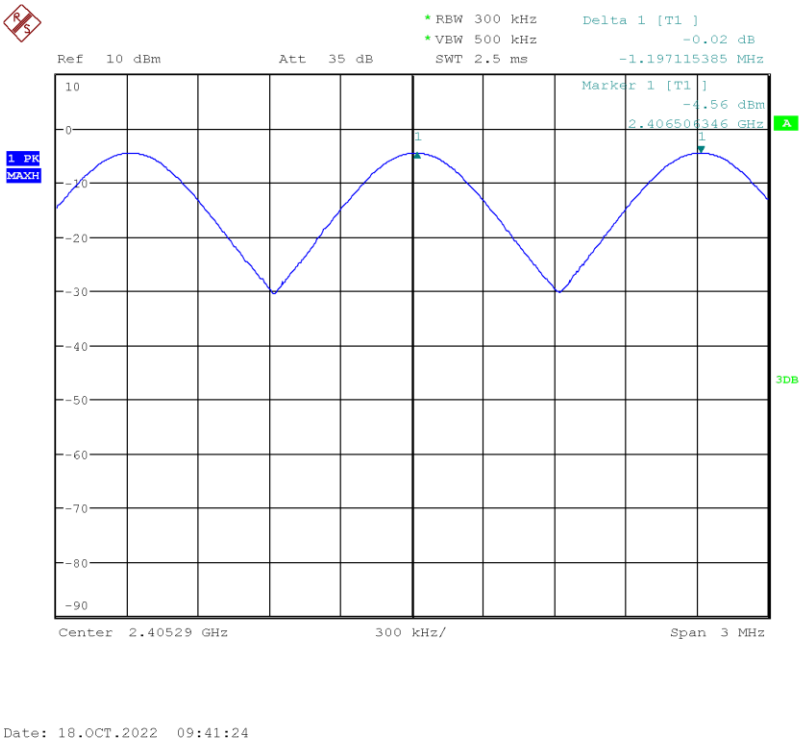

Figure 15: Channel Separation Plot

3.7 Number of Hopping Channels

Date Performed: October 18, 2022

Test Standard: FCC CFR 47 Part 15.247 (a)(1)(iii)
IC RSS-247 Issue 2 (5.1)(c)

Test Method: ANSI C63.10:2013
Span = The frequency band of operation. Depending on the number of channels the device
supports, it may be necessary to divide the frequency range of operation across multiple spans,
to allow the individual channels to be clearly seen.
RBW = 30% of the channel spacing or the 20 dB BW, whichever is smaller.
VBW ≥ RBW
Detector: Peak, **Trace:** Max Hold

Modifications: None

Final Result: Complies

Applicable Standard:

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Setup:

The EUT was tested outside the SAC via output conducted measurements per ANSI C63.10:2013.

The channel separation measurement was made by connecting the spectrum analyzer to the active antenna port using a 20 dB attenuator. Testing was done using the maximum power output with the system configured for normal operation using a pseudorandom hopping pattern.

Modulation	Number of Hopping Channels	Channel Separation (kHz)	Minimum Number of Channels	Result
FSK	63	1197.12	15	Complies

Table 10: Number of Hopping Channels Results

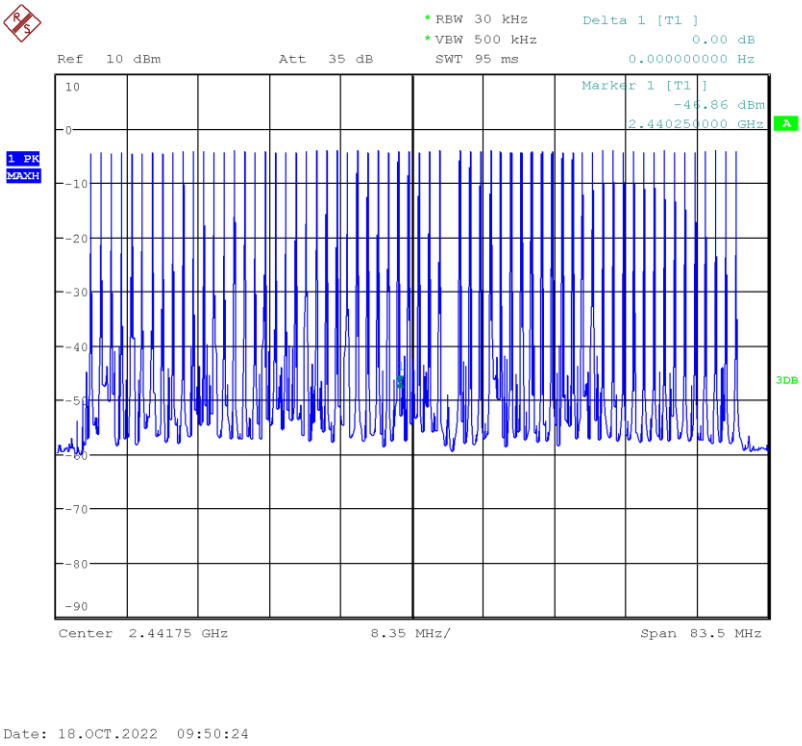

Figure 16: Number of Hopping Channels Plot

3.8 Time of Occupancy (Dwell Time)

Date Performed: October 18, 2022

Test Standard: FCC CFR 47 Part 15.247 (a)(1)(iii)
IC RSS-247 Issue 2 (5.1)(c)

Test Method: ANSI C63.10:2013
Span = Zero span on a hopping channel.
RBW = ≤ Channel spacing and where possible RBW >> 1/*T* where *T* is the expected dwell time.
Detector: Peak, **Trace:** Max Hold

Modifications: None

Final Result: Complies

Applicable Standard:

Frequency hopping systems in the 2400-2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

Test Setup:

Bandwidth and band-edge measurements for frequency-hopping spread spectrum systems are typically made by connecting the spectrum analyzer to the active antenna port using a suitable RF attenuator. These measurements require verification that the antenna port selected is the active one if the system has more than one antenna. Testing shall be done using the maximum power output. The system shall be configured for normal operation using a pseudorandom hopping pattern.

Measurement Data and Plots:

Modulation	Number of Hopping Channels	Transmit Time per Burst (ms)	Number of Bursts	Time of Occupancy (ms)	Maximum Dwell Time (ms)	Result
FSK	63	14.50	10	145.0	400	Complies

Table 11: Time of Occupancy (Dwell Time) Results

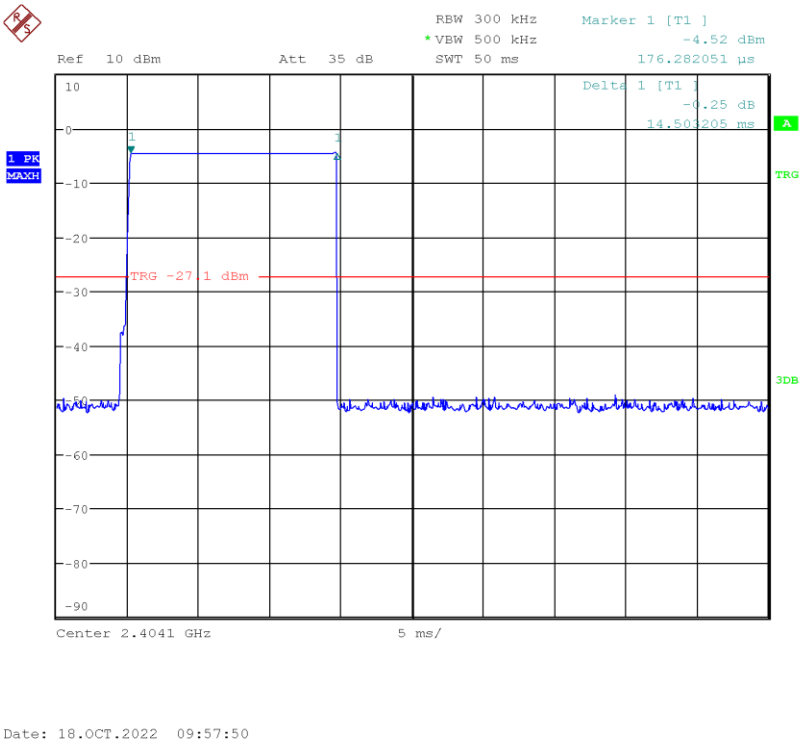

Figure 17: Transmit Time per Hop Plot

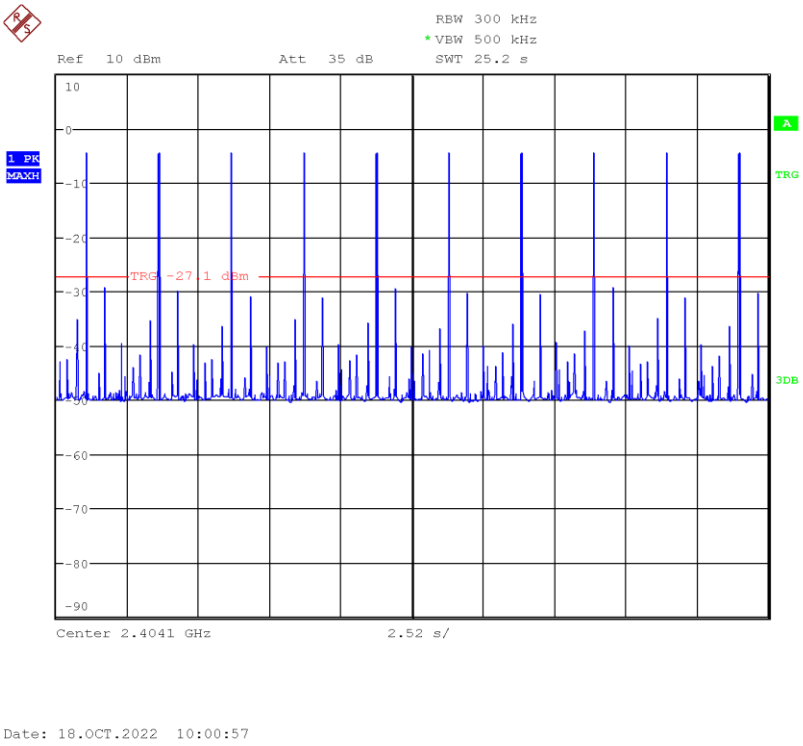

Figure 18: Number of Hops Plot

The average time of occupancy is calculated from the transmit time per hop multiplied by the number of hops in the period specified in the standard.

$$Time\ of\ Occupancy = N_{Bursts} \times T_{Burst}$$

Where,
N_{Bursts} is the number of bursts
T_{Burst} is the transmit time of each burst

The sweep time used to measure the time of occupancy is calculated as:

$$T_{Measurement} = 0.4 \times N_{channels}$$

Where,
$N_{channels}$ is the number of channels used

3.9 Hopping Requirements

Date Performed:	September 30, 2022
Test Standard:	FCC CFR 47 Part 15.247 (a)(1) IC RSS-247 Issue 2 (5.1)(a)
Modifications:	None.
Final Result:	Complies

Applicable Standard:

The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter.

Manufacturers Description of Hopping Algorithm:

The XPD2400 transceiver module can be set to operate on any of 256 frequency channels in the 2403.1 to 2479.8 MHz band. The frequencies are divided into twelve groups of 64 frequencies, each group using every twelfth available frequency. These 64 frequencies in a group are then used equally by the spread spectrum transmitter in a pseudo random sequence. The hop sequence is a sequence of 63 numbers randomly generated with a Reed-Solomon algorithm. The unique serial number of the transmitter is used as a seed to the random number generator. The list of 63 numbers (channels) is used to lookup in the frequency table to determine the next transmit frequency. Here are the first five sequences:

Seq(1): 0 59 54 35 44 7 6 45 24 28 13 50 11 42 26 56 47 34 55 27 25 43 36 9 21 15 20 10 51 33 48 61 30 18 4 23 46 57 53 60 49 14 22 5 8 37 17 31 41 12 29 62 39 3 19 16 38 63 2 40 32 52 58

Seq(2): 59 0 60 55 36 45 8 7 46 25 29 14 51 12 43 27 57 48 35 56 28 26 44 37 10 22 16 21 11 52 34 49 62 31 19 5 24 47 58 54 61 50 15 23 6 9 38 18 32 42 13 30 63 40 4 20 17 39 1 3 41 33 53

Seq(3): 54 60 0 61 56 37 46 9 8 47 26 30 15 52 13 44 28 58 49 36 57 29 27 45 38 11 23 17 22 12 53 35 50 63 32 20 6 25 48 59 55 62 51 16 24 7 10 39 19 33 43 14 31 1 41 5 21 18 40 2 4 42 34

Seq(4): 35 55 61 0 62 57 38 47 10 9 48 27 31 16 53 14 45 29 59 50 37 58 30 28 46 39 12 24 18 23 13 54 36 51 1 33 21 7 26 49 60 56 63 52 17 25 8 11 40 20 34 44 15 32 2 42 6 22 19 41 3 5 43

Seq(5): 44 36 56 62 0 63 58 39 48 11 10 49 28 32 17 54 15 46 30 60 51 38 59 31 29 47 40 13 25 19 24 14 55 37 52 2 34 22 8 27 50 61 57 1 53 18 26 9 12 41 21 35 45 16 33 3 43 7 23 20 42 4 6

After the receiver reaches the last channel, it starts again from the beginning.

3.10 Radiated Spurious Emissions

Date Performed: See Dates Below

Test Standard: FCC CFR 47 Part 15.205, 15.209, 15.247
FCC KDB 558074 D01
IC RSS-247 Issue 2
IC RSS-Gen Issue 5

Test Method: ANSI C63.10:2013

Modifications: None

Final Result: Complies

Applicable Standard:

Test or Measurement	Applicable Standards	Investigated Spectrum
Radiated Emissions	ICES-003 Issue 6 CFR Title 47 FCC Part 15 Subpart B	The radiated emissions are measured in the 30-1000MHz range or **upto** the highest EUT frequency required by the standard.
	RSS-247-Issue 2, RSS-Gen Issue 5 (8.9) & (8.10) FCC Subpart C §15.205(a), 15.209(a) & 15.247(d) and 15.33(a)(1) & (4)	From the lowest radio frequency signal generated in the device, without going below 9 kHz, up to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

Required Limits:

1) Radiated emission limits; general requirements – intentional radiators:

The emissions from an intentional radiator shall not exceed the field strength levels specified in the following table as per §15.209:

Frequency, *f* (MHz)	Maximum Field strength Quasi-peak (dBµV/m at 3 m)
0.009 – 0.490	20*log(2400/F(kHz)) + 40 dB
0.490 – 1.705	20*log(24000/F(kHz)) + 20 dB
1.705 – 30.0	49.5
30 – 88	40.0
88 – 216	43.5
216 – 960	46.0
above 960	54.0

Note 1: The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.

Note 2: The emissions limits shown in the above table are based on measurements employing a CISPR quasi-peak detector except for the frequency bands 9-90 kHz., 110-490 kHz. and above 1000 MHz.

Radiated emission limits in these three bands are based on measurements employing an average detector

2) Restricted bands of operation:

Unwanted emissions that fall into the restricted bands specified on the table below shall comply with the limits specified on the table limits above as per §15.209 and Clause 8.9 of RSS-Gen.

Restricted Bands – RSS Gen Issue 5

MHz	MHz	GHz
0.090 - 0.110	149.9 - 150.05	9.0 - 9.2
0.495 - 0.505	156.52475 - 156.52525	9.3 - 9.5
2.1735 - 2.1905	156.7 - 156.9	10.6 - 12.7
3.020 - 3.026	162.0125 - 167.17	13.25 - 13.4
4.125 - 4.128	167.72 - 173.2	14.47 - 14.5
4.17725 - 4.17775	240 - 285	15.35 - 16.2
4.20725 - 4.20775	322 - 335.4	17.7 - 21.4
5.677 - 5.683	399.9 - 410	22.01 - 23.12
6.215 - 6.218	608 - 614	23.6 - 24.0
6.26775 - 6.26825	960 - 1427	31.2 - 31.8
6.31175 - 6.31225	1435 - 1626.5	36.43 - 36.5
8.291 - 8.294	1645.5 - 1646.5	Above 38.6
8.362 - 8.366	1660 - 1710	Certain frequency bands listed in table 2 and in bands above 38.6 GHz are designated for licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs.
8.37625 - 8.38675	1718.8 - 1722.2	
8.41425 - 8.41475	2200 - 2300	
12.29 - 12.293	2310 - 2390	
12.51975 - 12.52025	2483.5 - 2500	
12.57675 - 12.57725	2655 - 2900	
13.36 - 13.41	3260 - 3267	
16.42 - 16.423	3332 - 3339	
16.69475 - 16.69525	3345.8 - 3358	
16.80425 - 16.80475	3500 - 4400	
25.5 - 25.67	4500 - 5150	
37.5 - 38.25	5350 - 5460	
73 - 74.6	7250 - 7750	
74.8 - 75.2	8025 - 8500	
108 - 138	--	

Restricted Bands – FCC Part 15.205

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.15
0.495-0.505	16.69475-16.69525	608-614	5.35-5.46
2.1735-2.1905	16.80425-16.80475	960-1240	7.25-7.75
4.125-4.128	25.5-25.67	1300-1427	8.025-8.5
4.17725-4.17775	37.5-38.25	1435-1626.5	9.0-9.2
4.20725-4.20775	73-74.6	1645.5-1646.5	9.3-9.5
6.215-6.218	74.8-75.2	1660-1710	10.6-12.7
6.26775-6.26825	108-121.94	1718.8-1722.2	13.25-13.4
6.31175-6.31225	123-138	2200-2300	14.47-14.5
8.291-8.294	149.9-150.05	2310-2390	15.35-16.2
8.362-8.366	156.52475-156.52525	2483.5-2500	17.7-21.4
8.37625-8.38675	156.7-156.9	2690-2900	22.01-23.12
8.41425-8.41475	162.0125-167.17	3260-3267	23.6-24.0
12.29-12.293	167.72-173.2	3332-3339	31.2-31.8
12.51975-12.52025	240-285	3345.8-3358	36.43-36.5
12.57675-12.57725	322-335.4	3600-4400	
13.36-13.41			

FCC Standard §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)).

FCC KDB 558074 D01 15.247 Meas Guidance v05r02 states that the use of a duty cycle correction factor (DCCF) is permitted for calculating average radiated field strength emission levels for an FHSS device in 15.247. This DCCF can be applied when the unwanted emission limit is subject to an average field strength limit. The average radiated field strength is calculated by subtracting the DCCF from the maximum radiated field strength level as determined through measurement.

Duty Cycle Correction Factor Calculation:

Per FCC 47 CFR 15.35 (c) and Ansi C63.10:2013, when the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed, the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 s (100 ms). In cases where the pulse train exceeds 0.1 s, the measured field strength shall be determined during a 0.1 s interval. The average field strength may be found by measuring the peak pulse amplitude (in log equivalent units) and determining the duty cycle correction factor (in dB) associated with the pulse modulation as shown below:

$$\delta(dB) = 20\log(\Delta)$$

Where

δ is the duty cycle correction factor (dB)

Δ is the duty cycle (dimensionless)

This correction factor may then be subtracted from the peak pulse amplitude to find the average value of the emission.

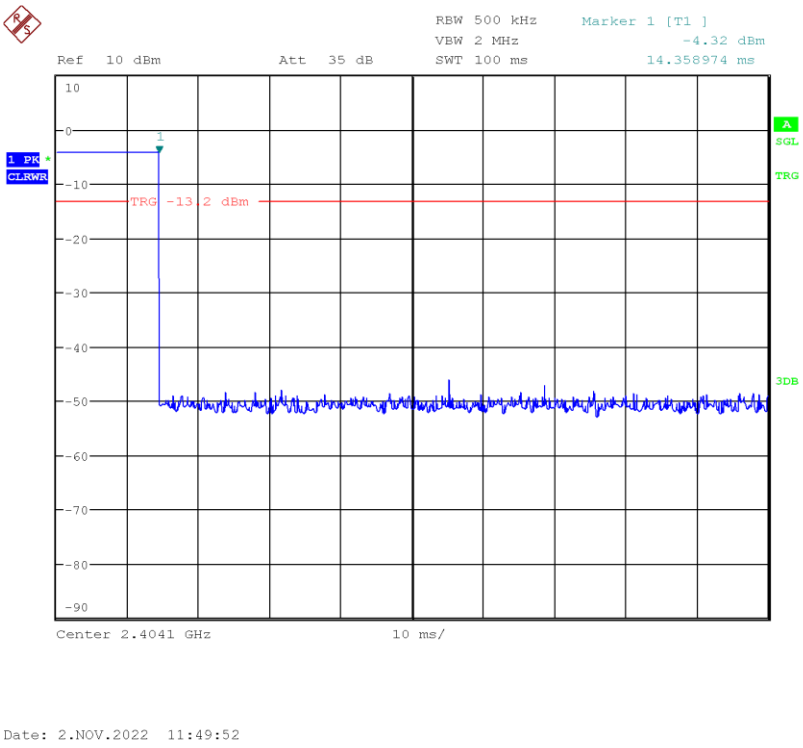

Figure 19: Single Channel Duty Cycle Measured Over 100ms

Using the channel ON time measured in Figure 19, the DCCF was calculated as:

$$\delta(dB) = 20\log\left(\frac{14.35ms}{100ms}\right) = -16.86\ dB$$

Test Setup:

The EUT was tested in our 3 m SAC and was positioned on the front of the turntable. The transmitter was set for continuous transmission. The radiated output of the device was measured for all emissions from 150 kHz up to the 10th harmonic of the highest fundamental frequency. The EUT was pre-scanned in 3 different orthogonal orientations and was found to radiate highest when placed as indicated in the test photos.

The EUT was tested with a total of five (5) different antennas across the full frequency range. The antennas tested are described in Section 3.1: Antenna Requirements.

3.10.1 150kHz to 30 MHz

Antenna 1, Tested October 20, 2022:

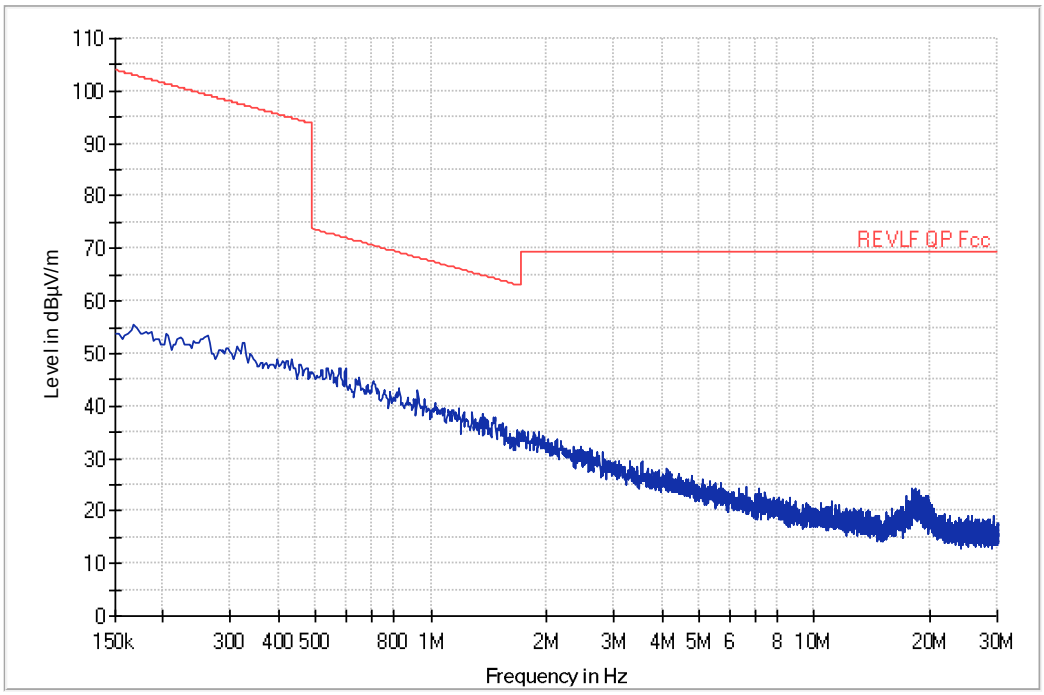

Figure 20: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 1, Horizontally Polarized

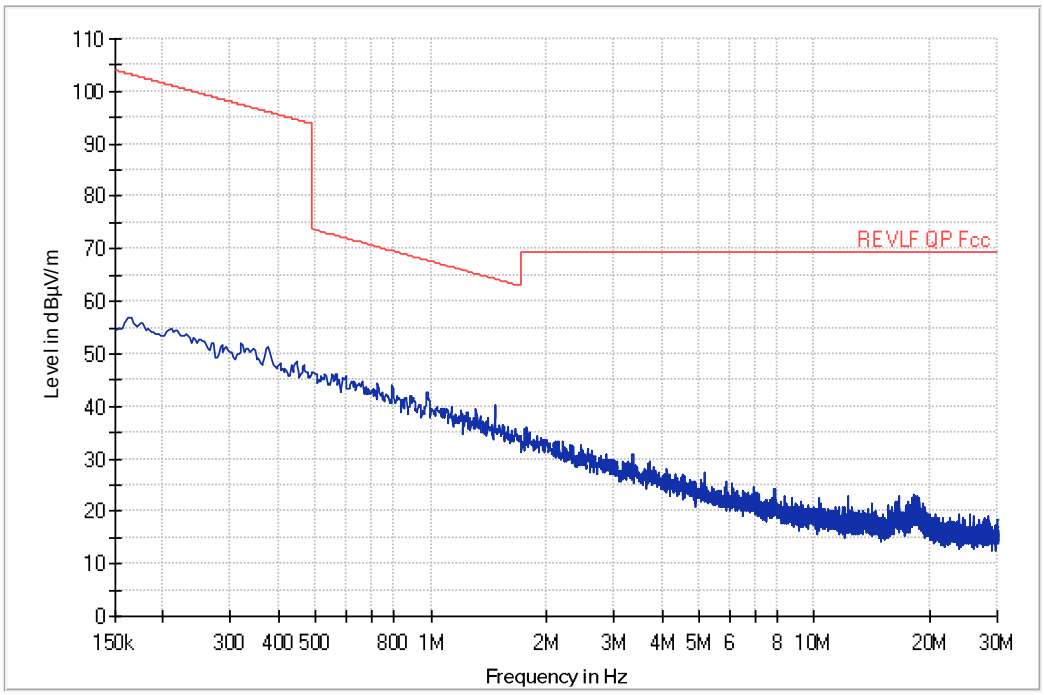

Figure 21: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 1, Vertically Polarized

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 2, Tested October 20, 2022:

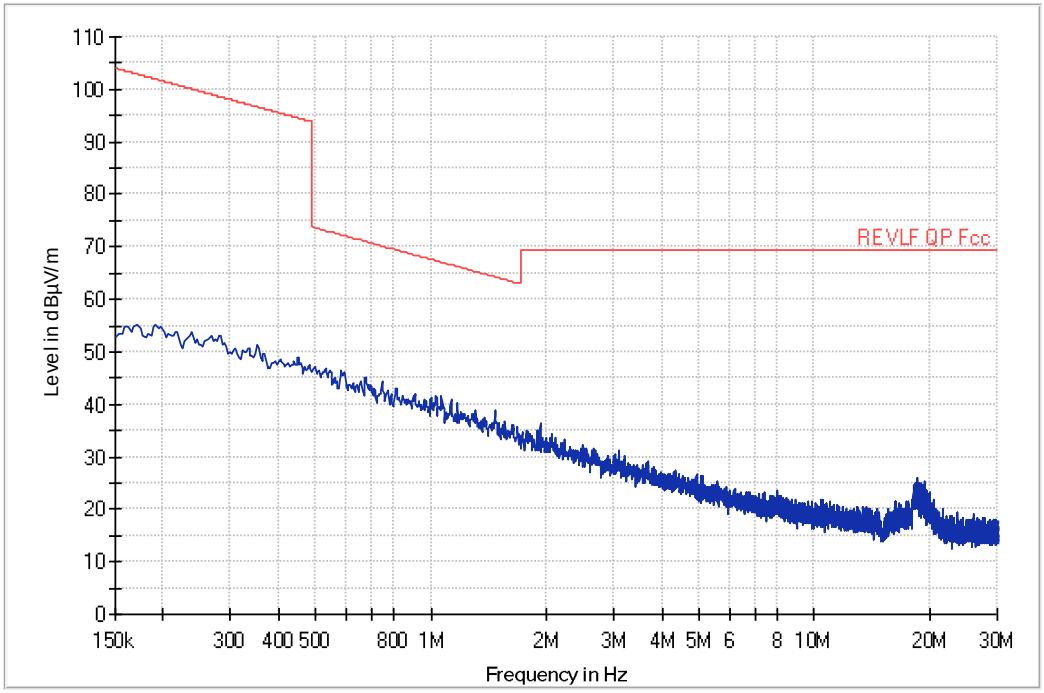

Figure 22: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 2, Horizontally Polarized

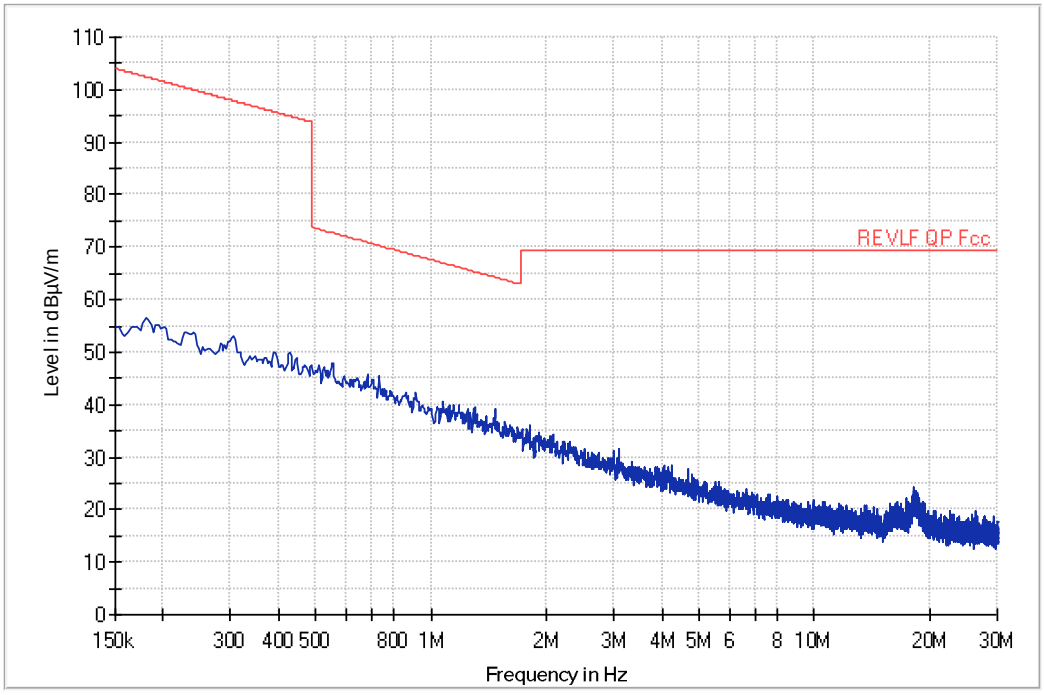

Figure 23: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 2, Vertically Polarized

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 3, Tested October 20, 2022:

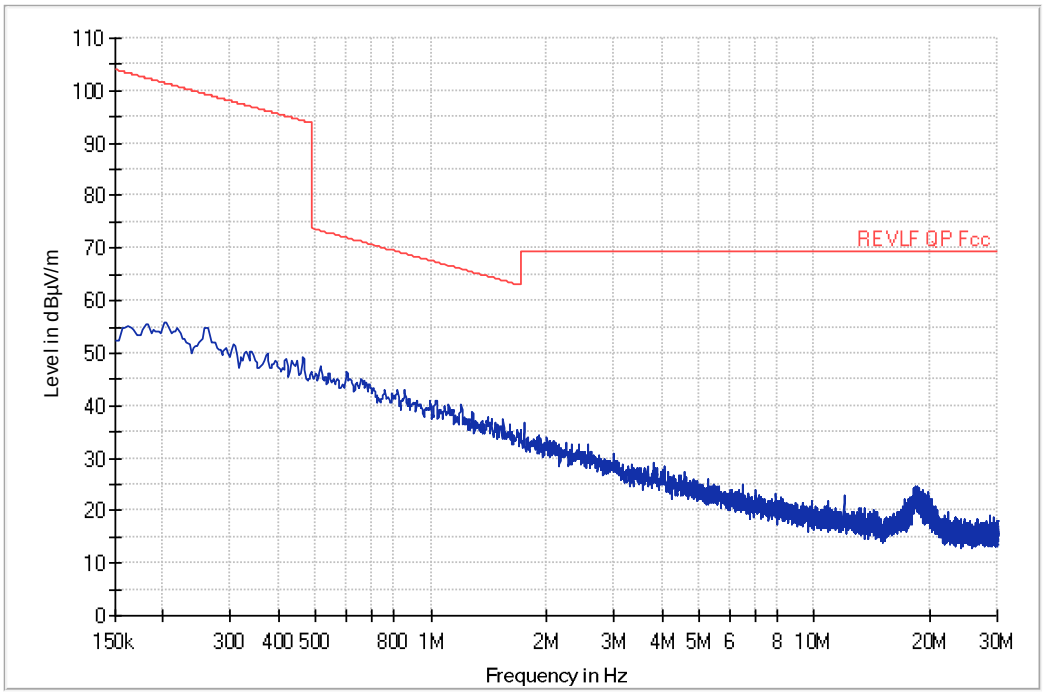

Figure 24: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 3, Horizontally Polarized

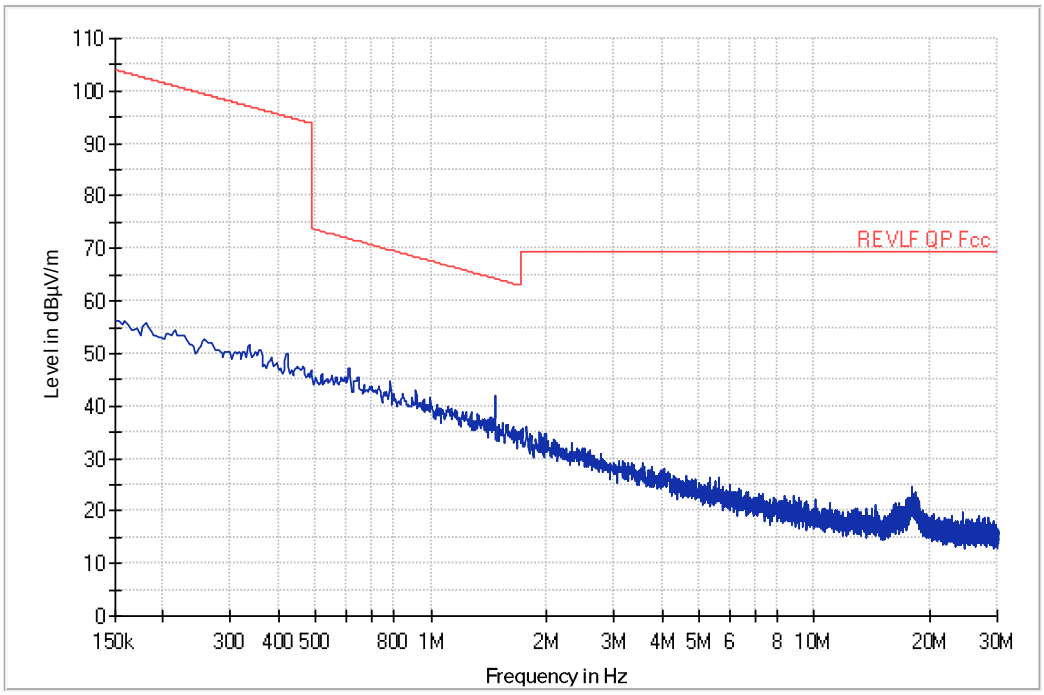

Figure 25: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 3, Vertically Polarized

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 4, Tested October 20, 2022:

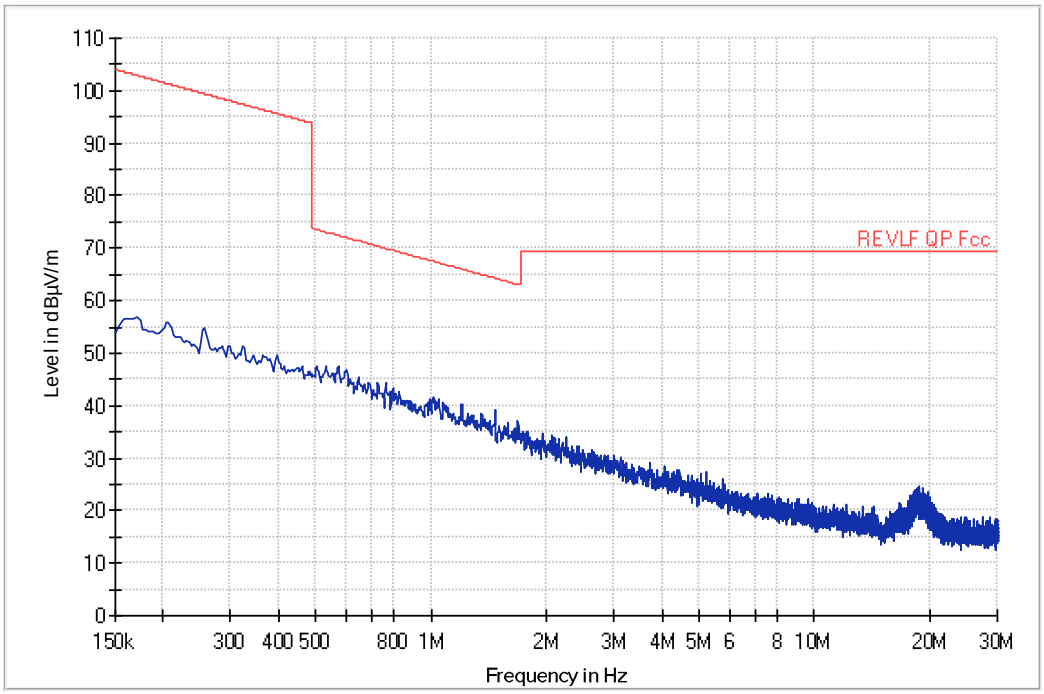

Figure 26: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 4, Horizontally Polarized

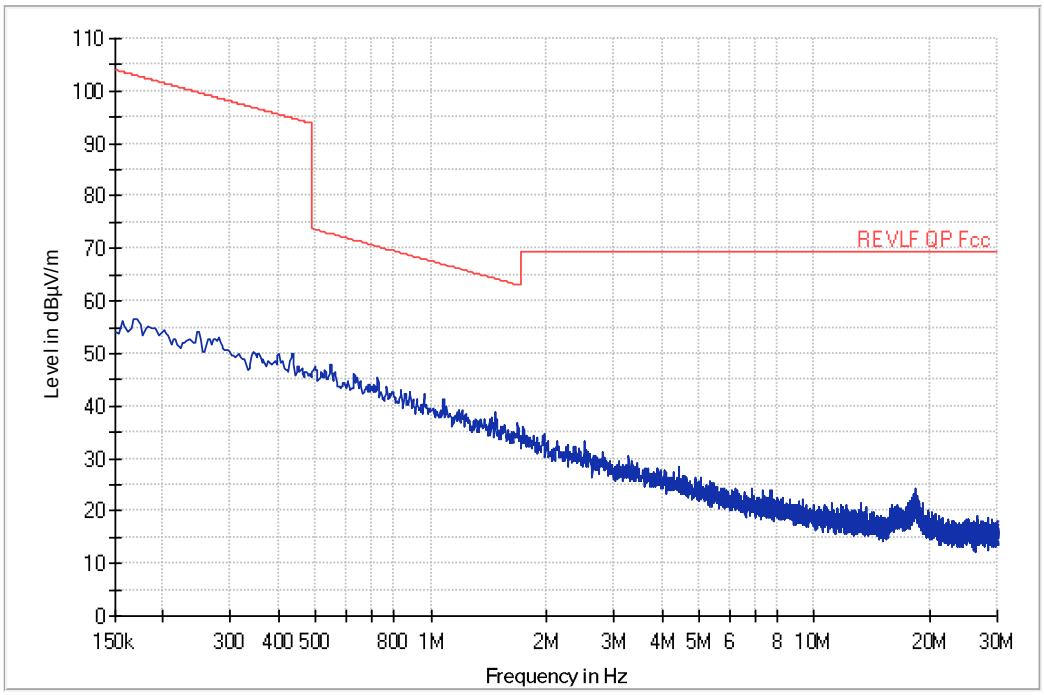

Figure 27: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 4, Vertically Polarized

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 5, Tested October 20, 2022:

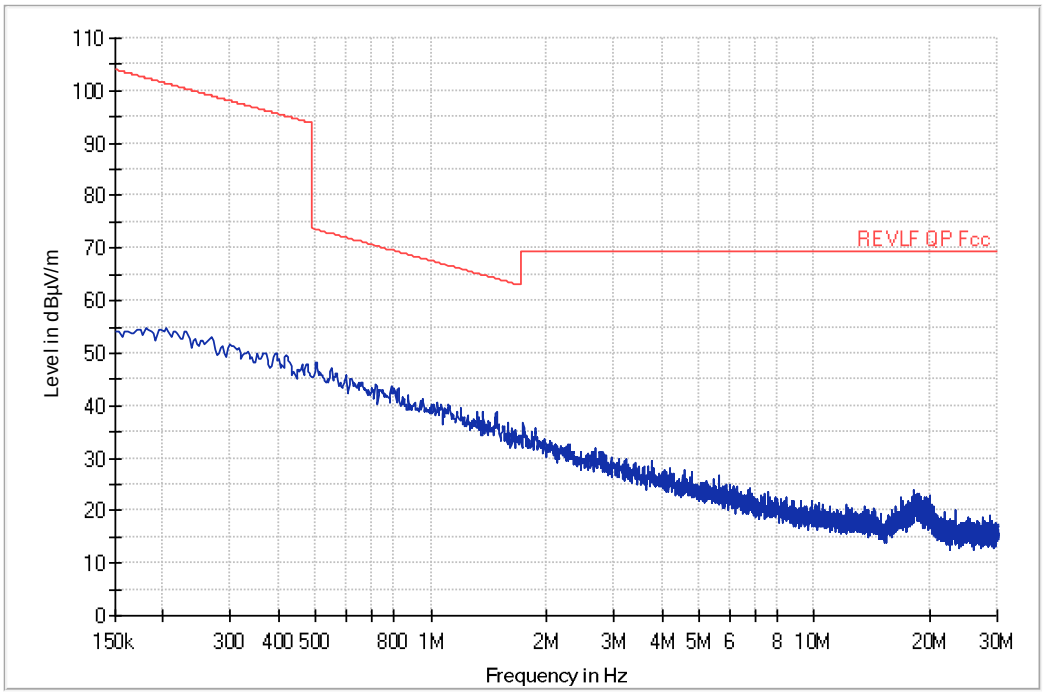

Figure 28: Radiated Emissions From 0.15-30MHz Measured at 3m– Antenna 5, Horizontally Polarized

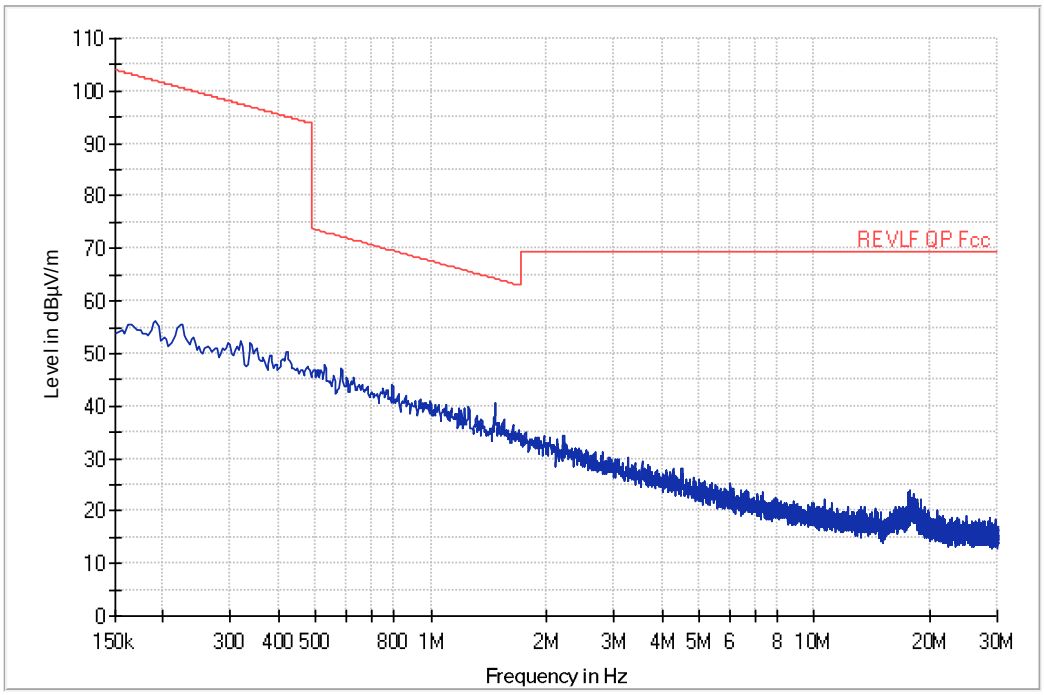

Figure 29: Radiated Emissions From 0.15-30MHz Measured at 3m – Antenna 5, Vertically Polarized

No significant emissions were seen in either vertical or horizontal polarizations.

3.10.2 30 MHz to 1 GHz

Antenna 1, Tested October 19, 2022:

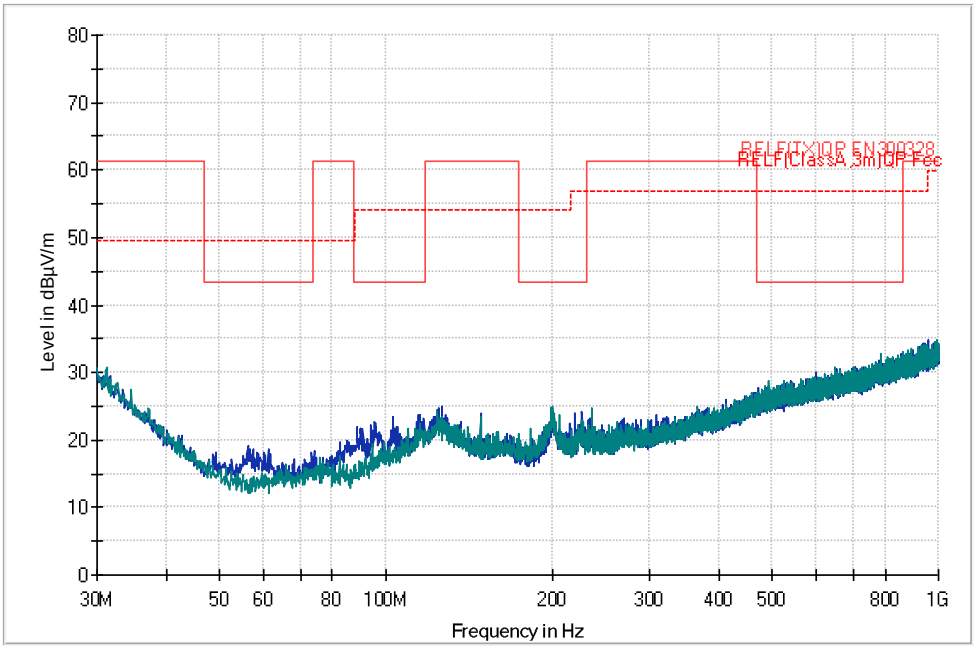

Figure 30: Radiated Emissions From 30-1000MHz Measured at 3m, Class A – Antenna 1

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 2, Tested October 19, 2022:

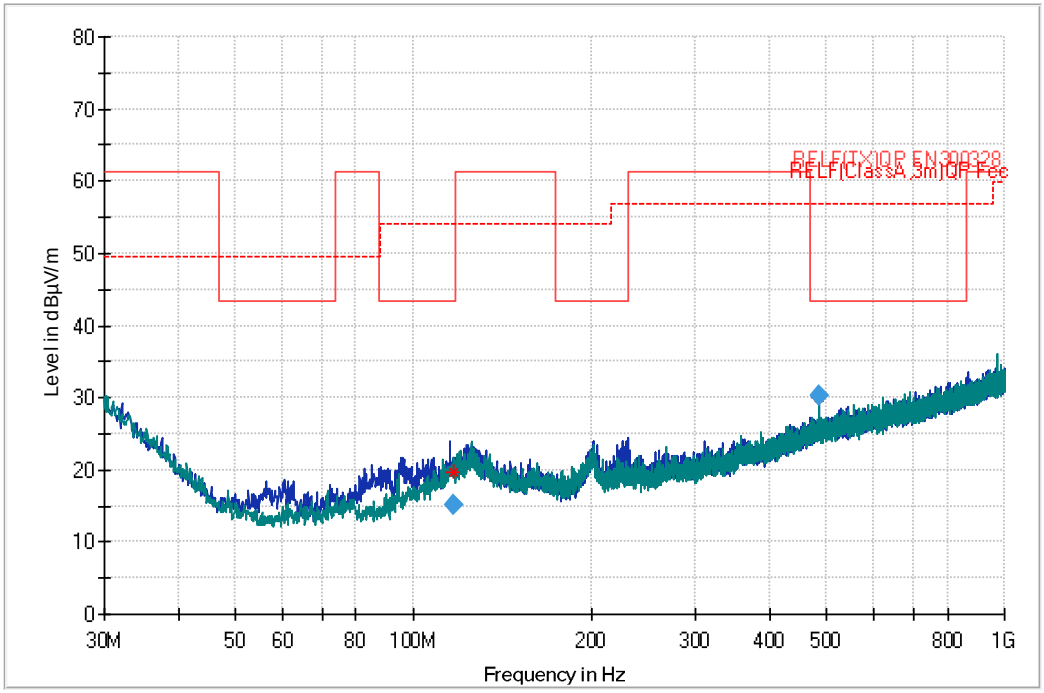

Figure 31: Radiated Emissions From 30-1000MHz scanned at 3m, Class A – Antenna 2

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Height (cm)	Pol	Azimuth (°)	Corr. Factor (dB)
116.8652	15.14	43.40	28.26	367	H	334	18.7
486.0013	30.38	43.40	13.02	114	V	84	23.8

Table 12: Antenna 2 Radiated Emissions (0.15 - 30 MHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 3, Tested October 19, 2022:

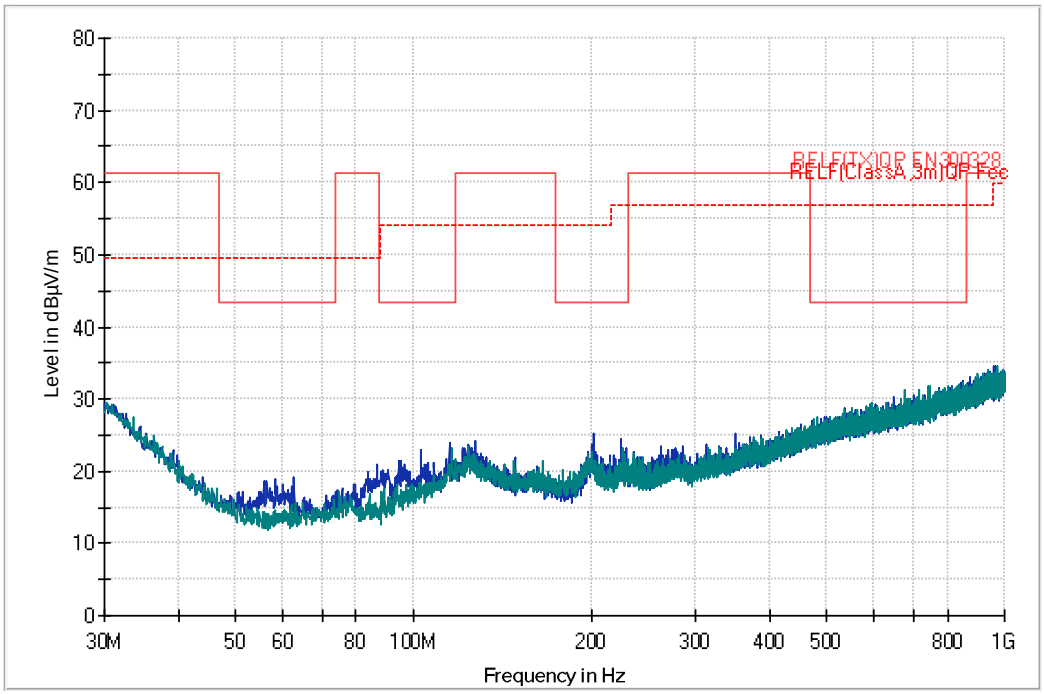

Figure 32: Radiated Emissions From 30-1000MHz Measured at 3m, Class A – Antenna 3

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 4, Tested October 19, 2022:

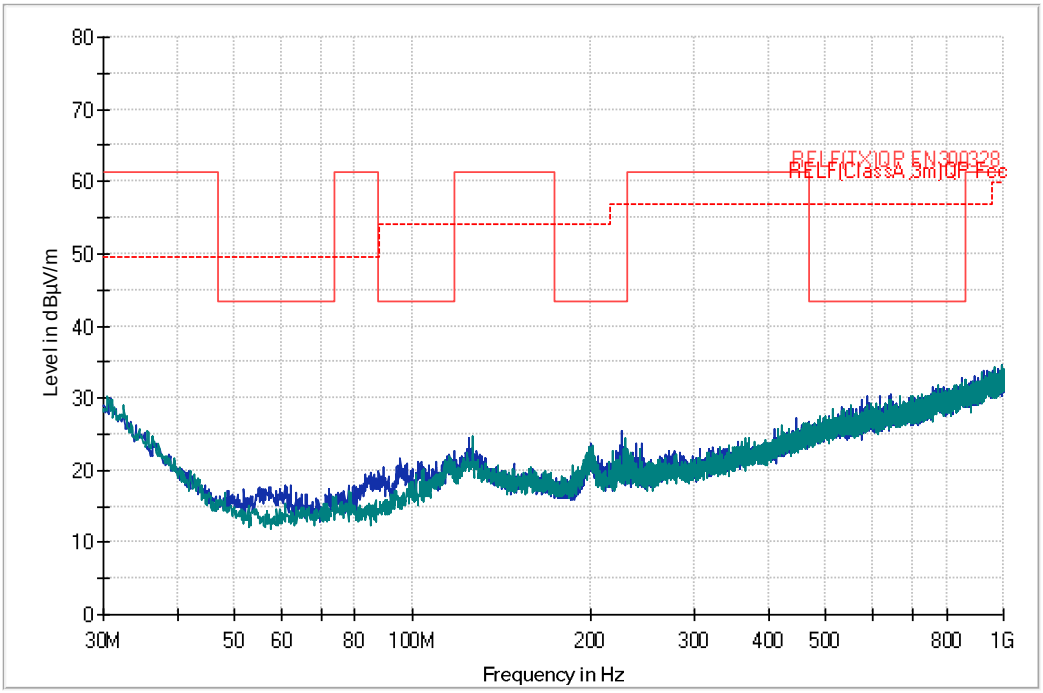

Figure 33: Radiated Emissions From 30-1000MHz Measured at 3m, Class A – Antenna 4

No significant emissions were seen in either vertical or horizontal polarizations.

Antenna 5, Tested October 20, 2022:

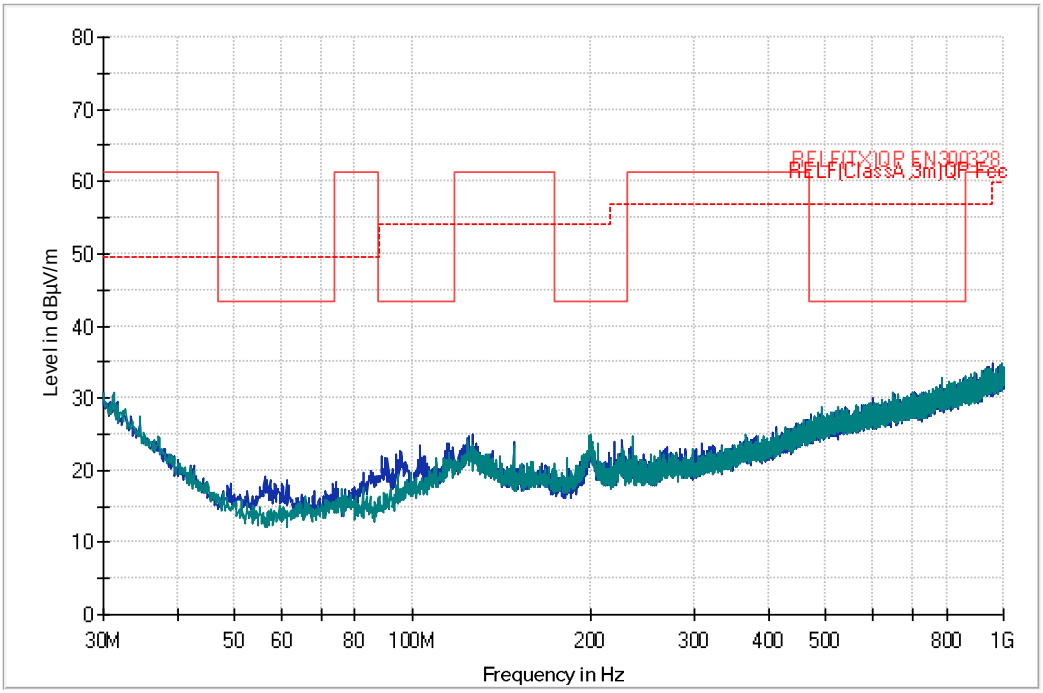

Figure 34: Radiated Emissions From 30-1000MHz Measured at 3m, Class A – Antenna 5

No significant emissions were seen in either vertical or horizontal polarizations.

3.10.3 1 GHz to 6 GHz

Antenna 1, Tested October 6, 2022:

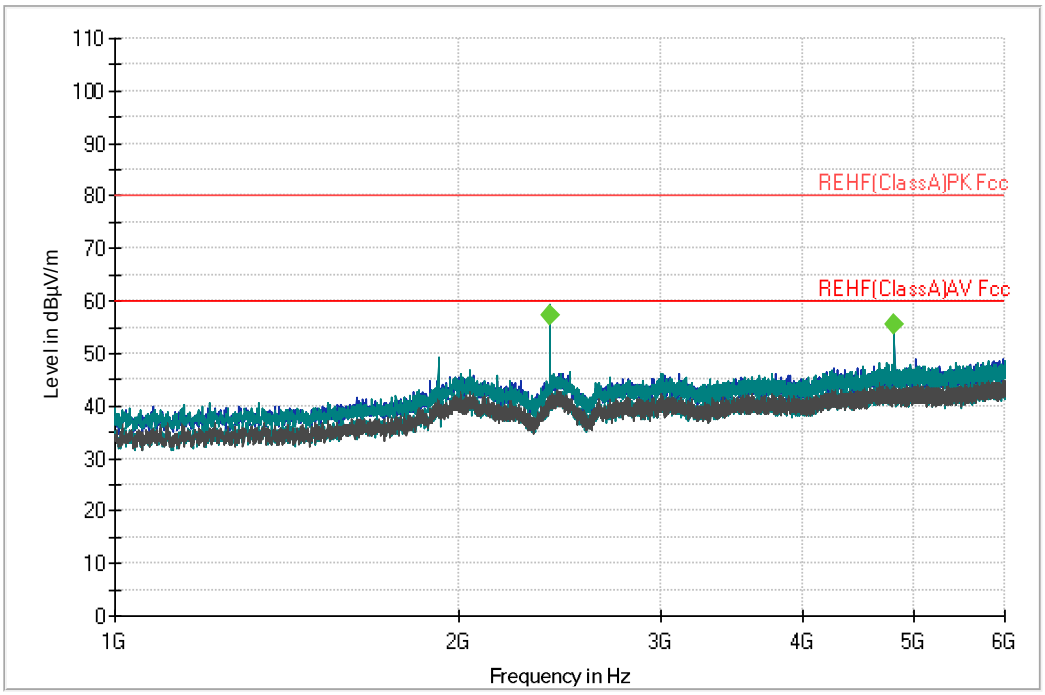

Figure 35: Radiated Emissions From 1-6GHz Measured at 3m, Class A – Antenna 1

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2403.1080	57.41	149.0	V	121	-16.86	40.55	60.00	19.45	Complies
4806.2200	55.37	99.0	H	351	-16.86	38.51	60.00	21.49	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 13: Antenna 1 Radiated Emissions (1 - 6 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 2, Tested October 6, 2022:

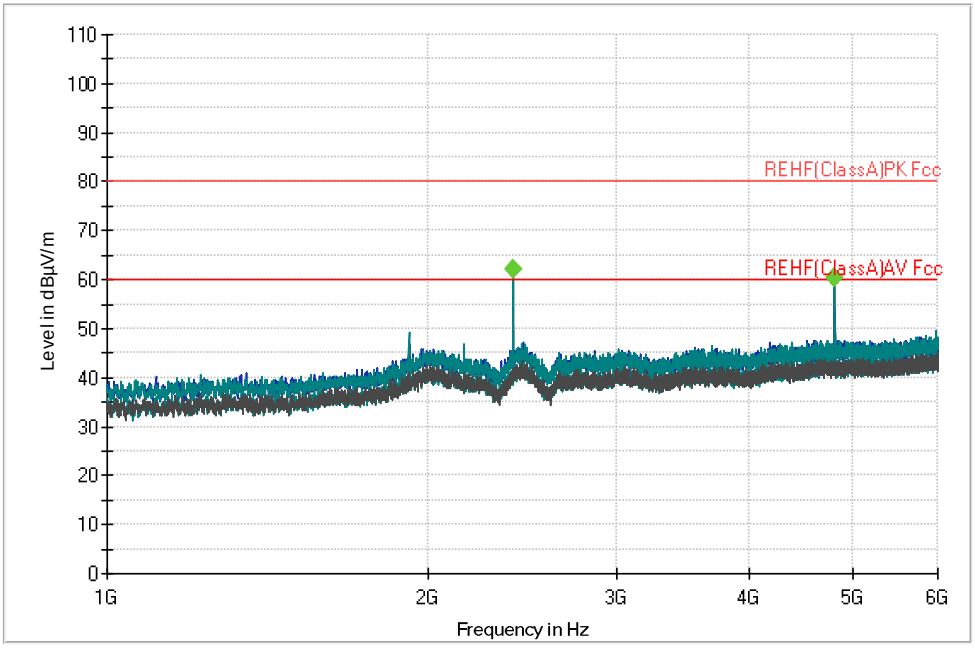

Figure 36: Radiated Emissions From 1-6GHz Measured at 3m, Class A – Antenna 2

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2403.092	62.04	149.0	V	9	-16.86	45.18	60.00	14.82	Complies
4806.2240	60.53	199.0	H	0	-16.86	43.67	60.00	16.33	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 14: Antenna 2 Radiated Emissions (1 - 6 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 3, Tested October 6, 2022:

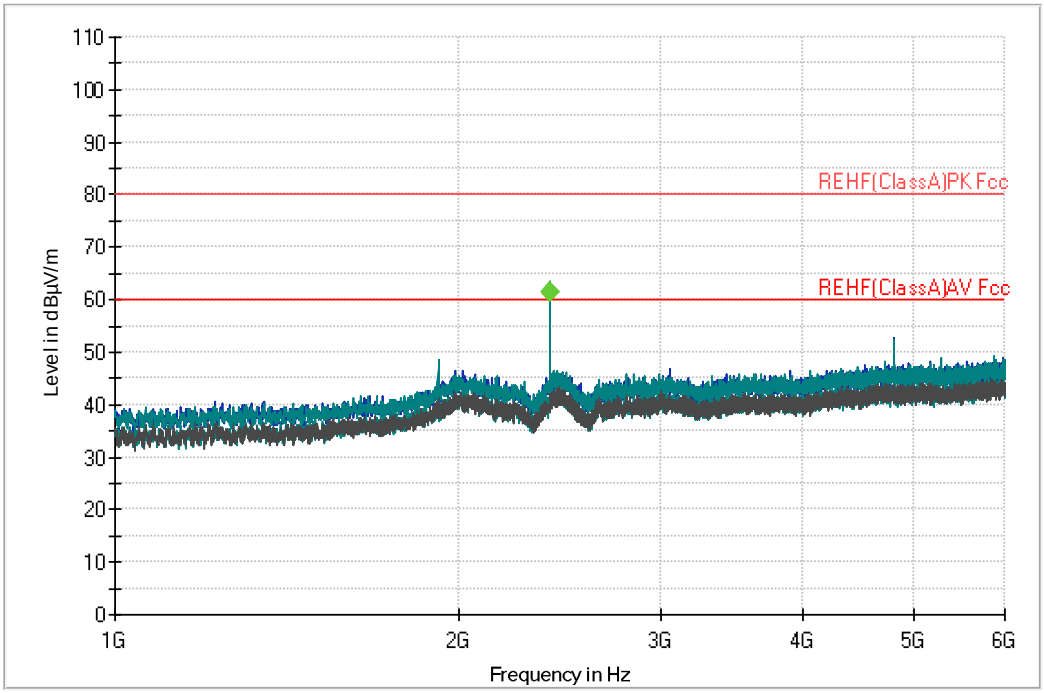

Figure 37: Radiated Emissions From 1-6GHz Measured at 3m, Class A – Antenna 3

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2403.1000	61.26	150.0	V	52	-16.86	44.40	60.00	15.60	Complies
[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above									

Table 15: Antenna 3 Radiated Emissions (1 - 6 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 4, Tested October 6, 2022:

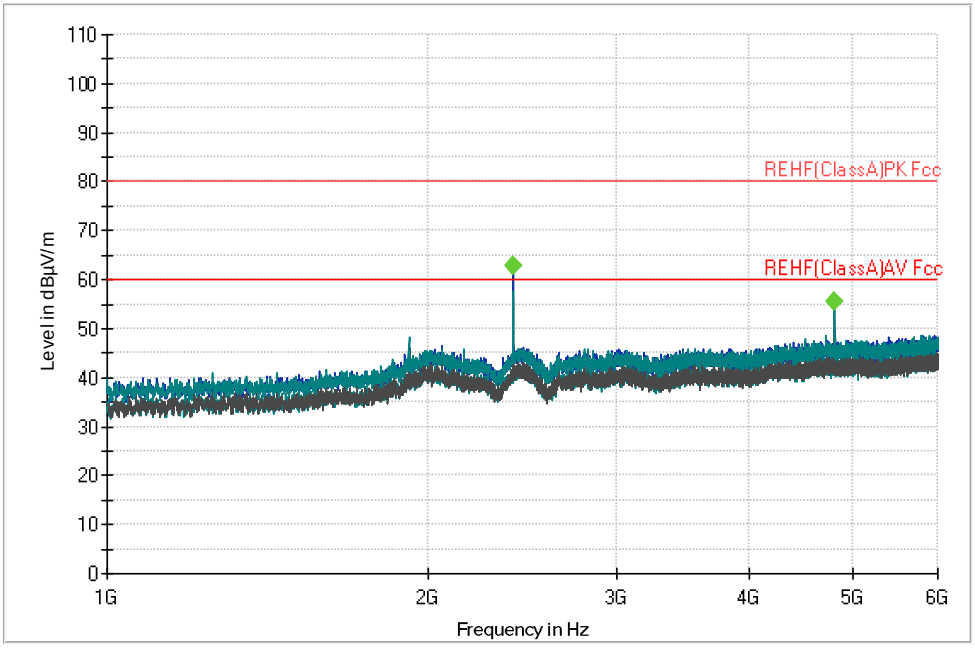

Figure 38: Radiated Emissions From 1-6GHz Measured at 3m, Class A – Antenna 4

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2403.1040	62.69	249.0	H	346	-16.86	45.83	60.00	14.17	Complies
4806.1880	55.62	199.0	H	7	-16.86	38.76	60.00	21.24	Complies
[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above									

Table 16: Antenna 4 Radiated Emissions (1 - 6 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 5, Tested October 6, 2022:

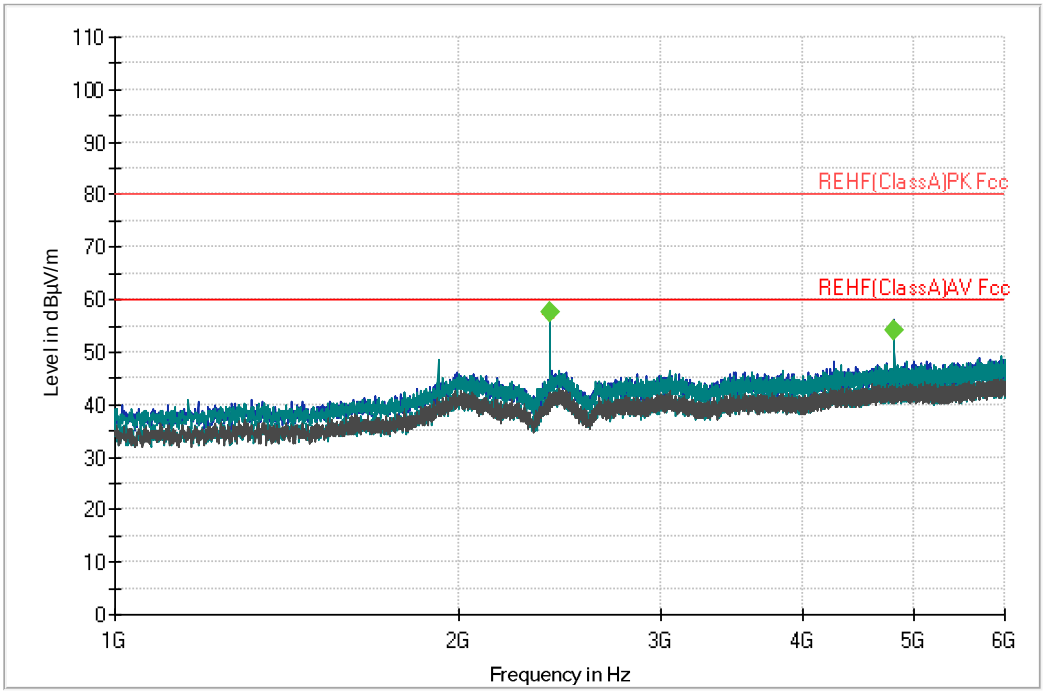

Figure 39: Radiated Emissions From 1-6GHz Measured at 3m, Class A – Antenna 5

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
2403.0920	57.50	299.0	V	93	-16.86	40.64	60.00	19.36	Complies
4806.2040	54.06	199.0	H	0	-16.86	37.20	60.00	22.80	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 17: Antenna 5 Radiated Emissions (1 - 6 GHz) Measured at 3m - FCC/ISED Class A Limit

Note that the signal at 2.4 GHz is the intentional transmitter and was not investigated as a spurious emission.

3.10.4 6 GHz to 18 GHz

Antenna 1, Tested October 6, 2022:

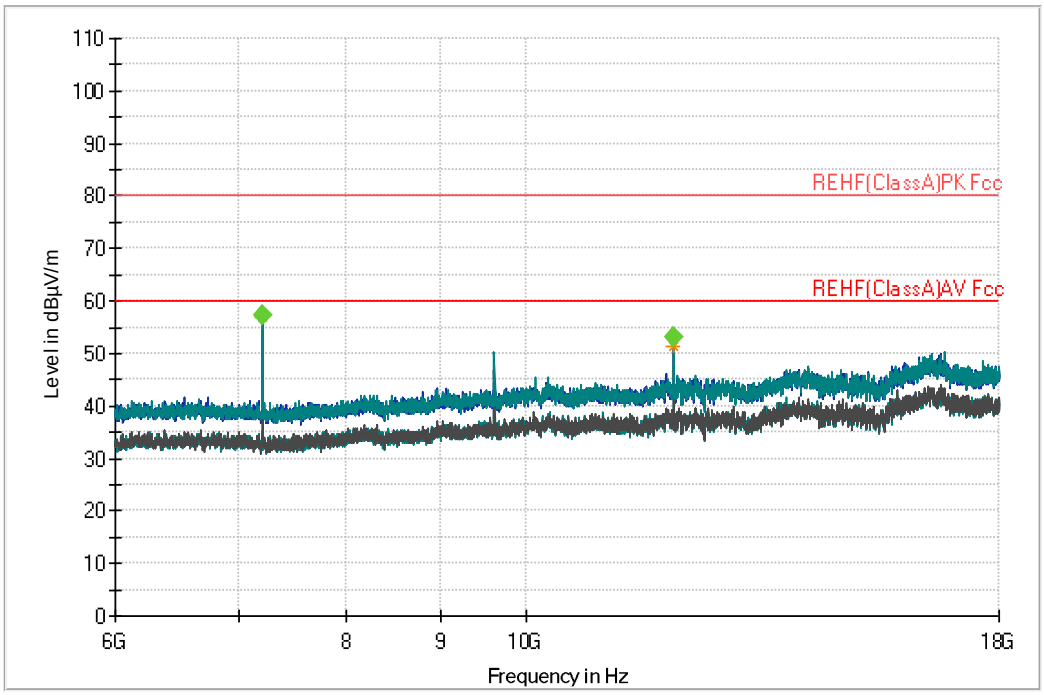

Figure 40: Radiated Emissions From 6-18GHz Measured at 3m, Class A – Antenna 1

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
7209.2760	59.86	202.0	H	17	-16.86	43.00	60.00	17.00	Complies
12015.520	51.24	224.0	H	143	-16.86	34.38	60.00	25.62	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 18: Antenna 1 Radiated Emissions (6 - 18 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 2, Tested October 6, 2022:

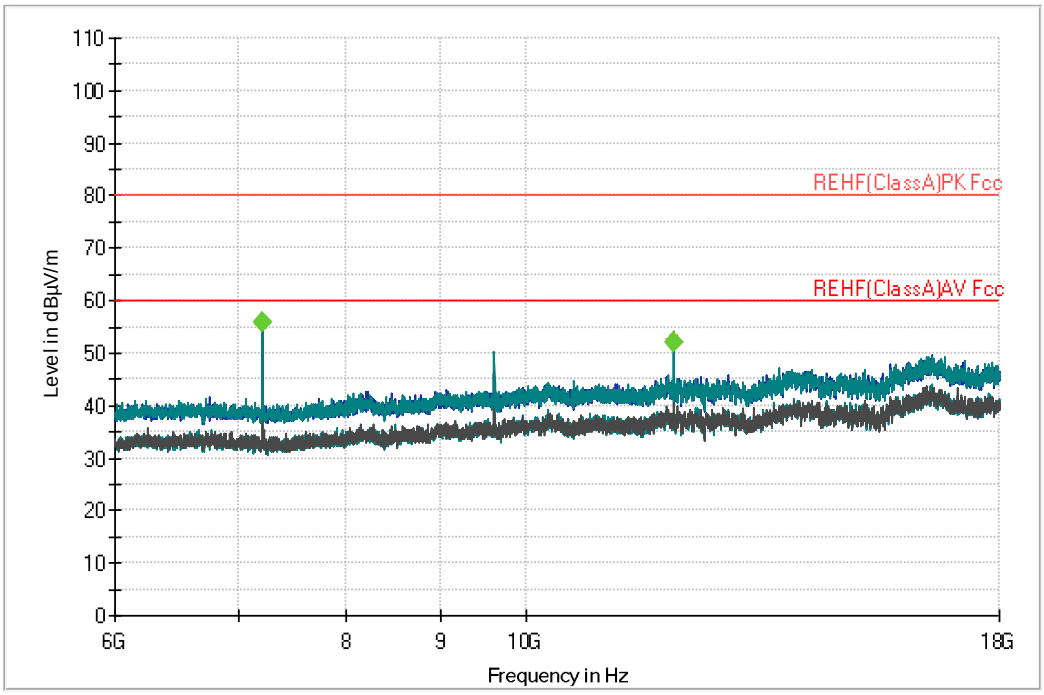

Figure 41: Radiated Emissions From 6-18GHz Measured at 3m, Class A – Antenna 2

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
7209.2920	55.60	201.0	V	15	-16.86	38.74	60.00	21.26	Complies
12015.5200	52.91	194.0	V	337	-16.86	36.05	60.00	23.95	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 19: Antenna 2 Radiated Emissions (6 - 18 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 3 Tested October 5, 2022:

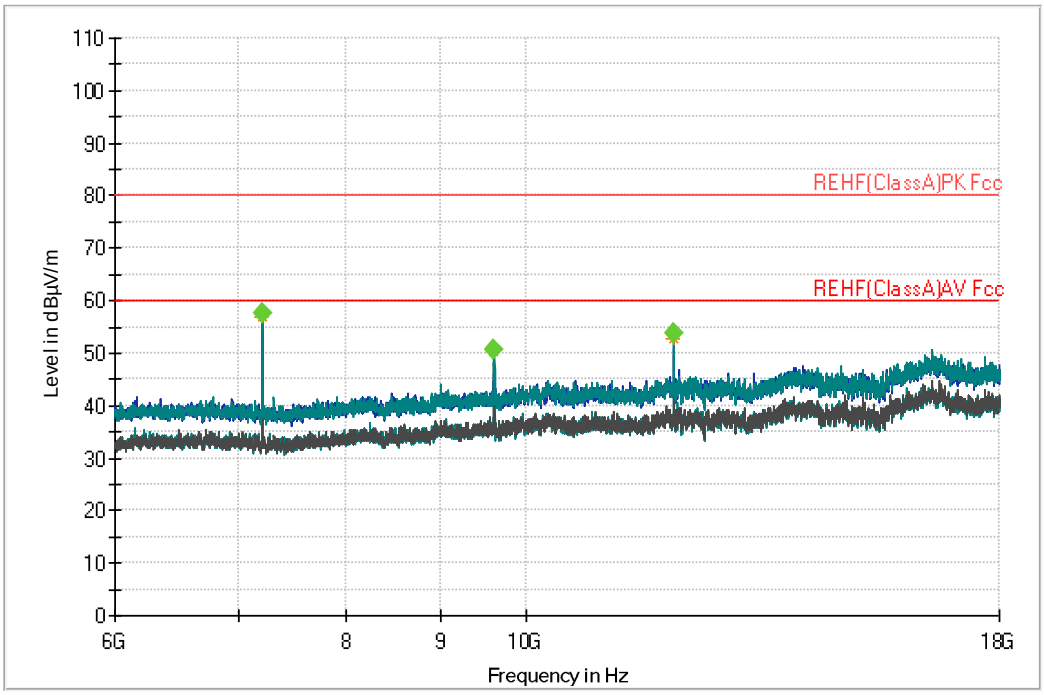

Figure 42: Radiated Emissions From 6-18GHz Measured at 3m, Class A – Antenna 3

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
7209.2960	57.61	205.0	H	298	-16.86	40.75	60.00	19.25	Complies
9612.4120	50.59	194.0	V	324	-16.86	33.78	60.00	26.22	Complies
12015.4800	53.68	188.0	H	136	-16.86	37.05	60.00	22.95	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 20: Antenna 3 Radiated Emissions (6 - 18 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 4 Tested October 7, 2022:

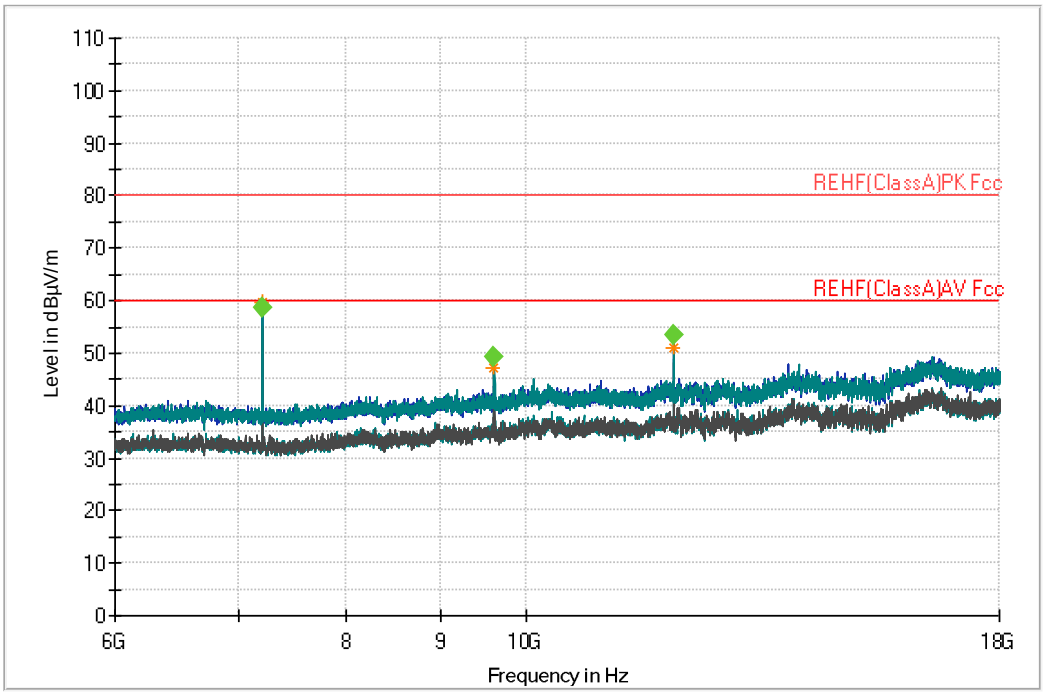

Figure 43: Radiated Emissions From 6-18GHz Measured at 3m, Class A – Antenna 4

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
7209.2800	62.18	228.0	V	6	-16.86	45.32	60.00	14.68	Complies
9612.3680	47.17	228.0	V	20	-16.86	30.31	60.00	29.69	Complies
12015.4880	51.04	194.0	H	320	-16.86	34.18	60.00	25.82	Complies

[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above

Table 21: Antenna 4 Radiated Emissions (6 - 18 GHz) Measured at 3m - FCC/ISED Class A Limit

Antenna 5 Tested October 5, 2022:

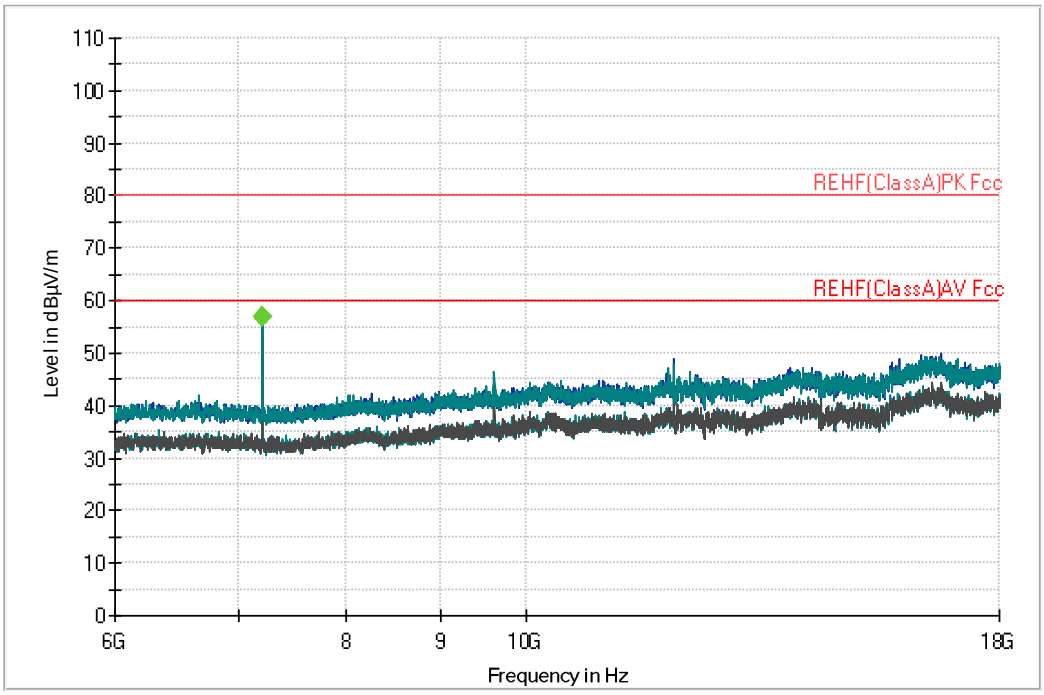

Figure 44: Radiated Emissions From 6-18GHz Measured at 3m, Class A – Antenna 5

Frequency (MHz)	Measured Average (dBµV/m)	Height (cm)	Pol	Azimuth (°)	Corr. Factor[1] (dB)	Average (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Result
7209.2880	60.05	261.0	H	266	-16.86	43.19	60.00	16.81	Complies
[1] Correction factor includes system gains and losses, as well as duty cycle correction factor calculated above									

Table 22: Antenna 5 Radiated Emissions (6 - 18 GHz) Measured at 3m - FCC/ISED Class A Limit

3.10.5 18 GHz to 26 GHz

Antennas 1-5 Tested October 14, 2022:

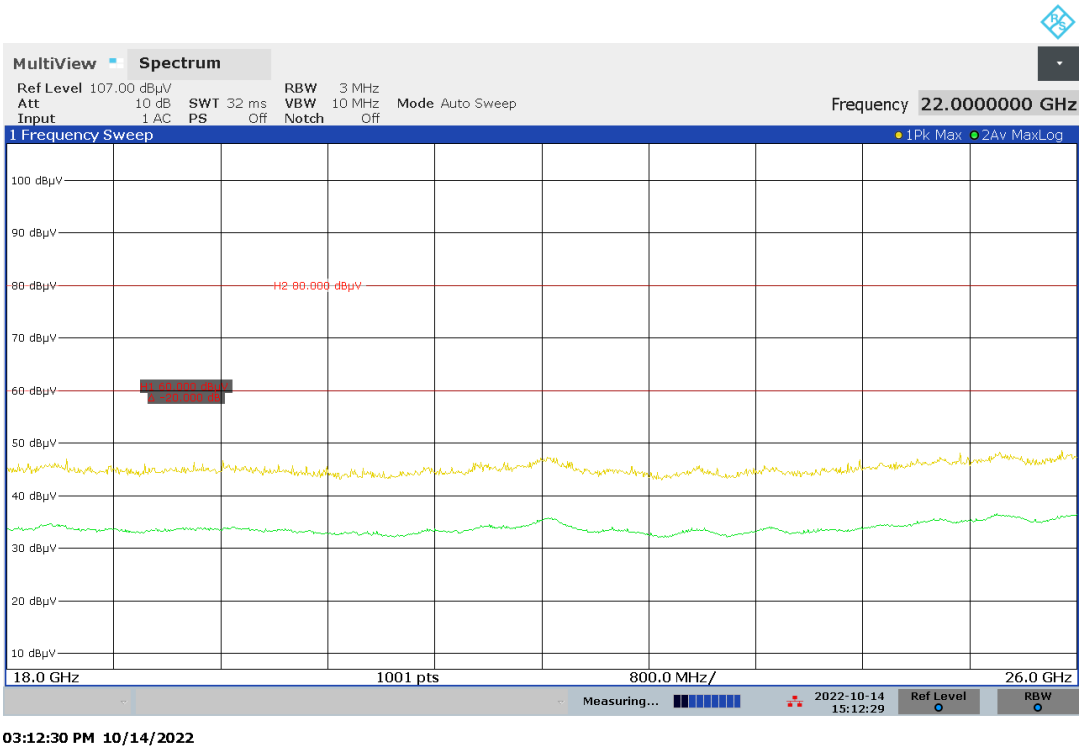

Figure 45: Radiated Emissions From 18-26GHz Measured at 3m, Class A – Antenna 1

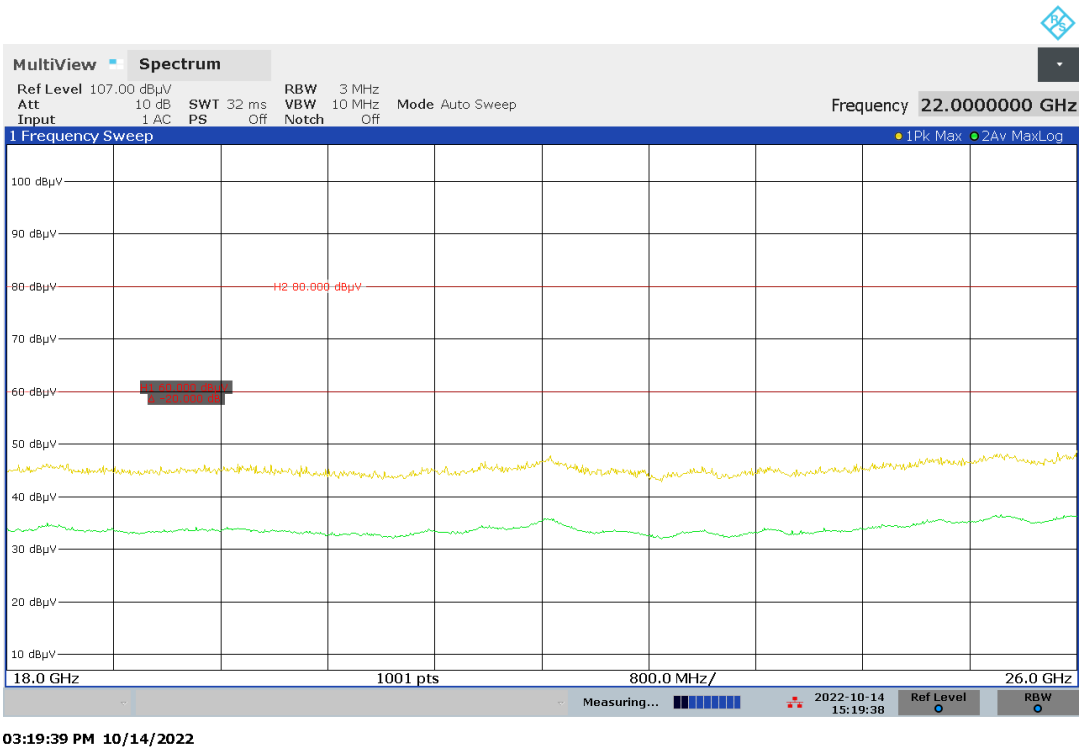

Figure 46: Radiated Emissions From 18-26GHz Measured at 3m, Class A – Antenna 2

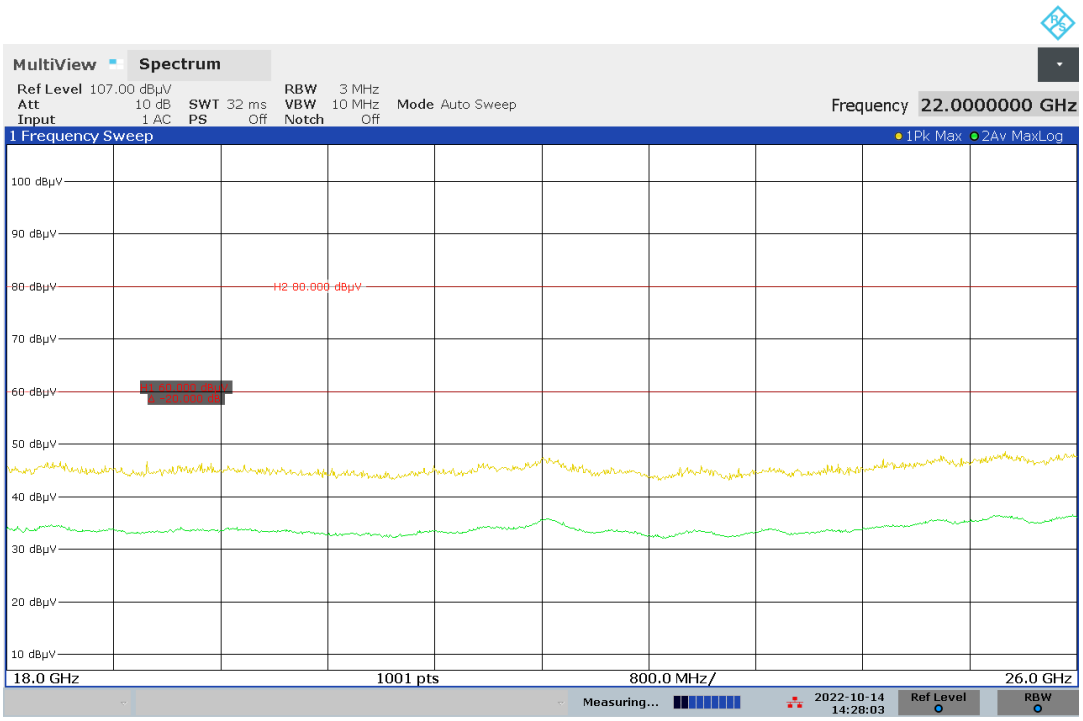

Figure 47: Radiated Emissions From 18-26GHz Measured at 3m, Class A – Antenna 3

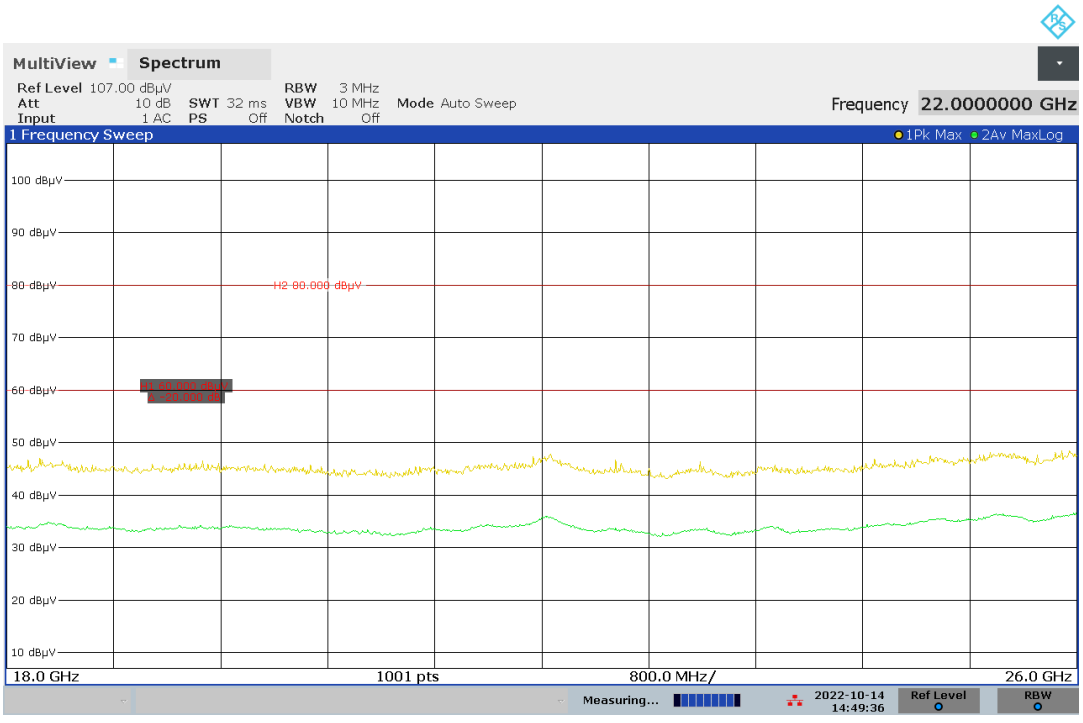

Figure 48: Radiated Emissions From 18-26GHz Measured at 3m, Class A – Antenna 4

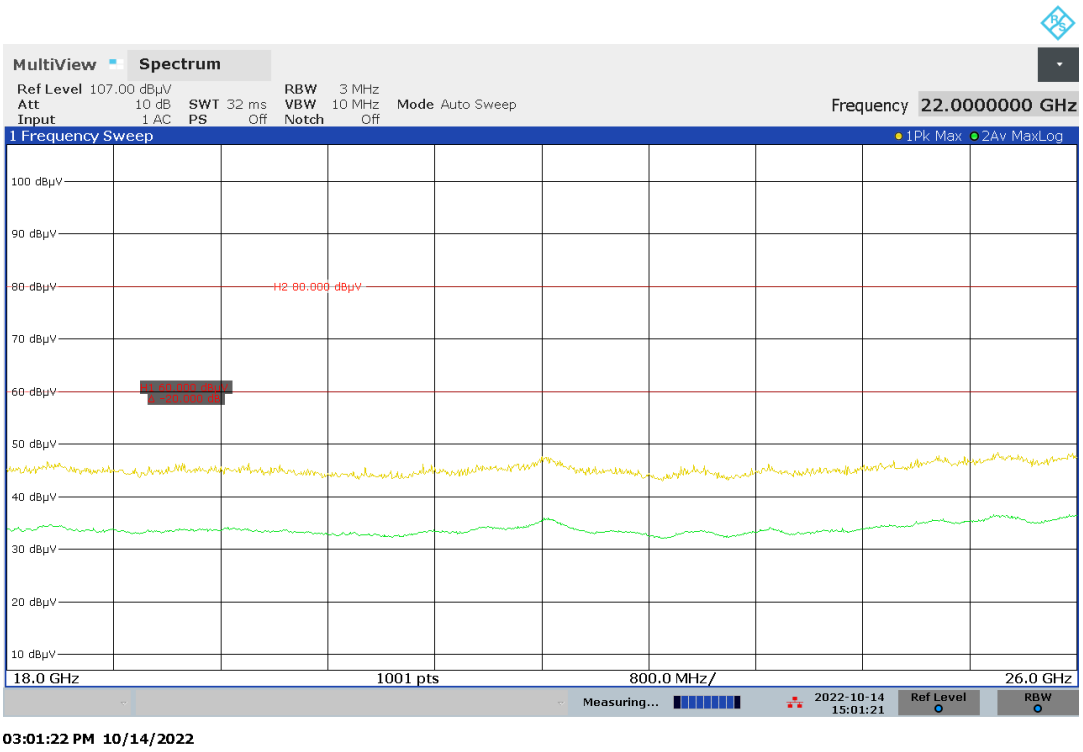

Figure 49: Radiated Emissions From 18-26GHz Measured at 3m, Class A – Antenna 5

No significant spurious emissions were observed with any of the antennas in the 18 - 26 GHz band.

3.11 Spurious Emissions – Receiver Mode

Date Performed: See Dates Below

Test Standard: FCC CFR 47 Part 15.109
ICES-003 Issue 7

Test Method: ANSI C63.10: 2014

Modifications: None

Final Result: Complies

Applicable Standard:

Radiated emission measurements shall be performed with the receiver antenna connected to the receiver antenna ports. The search for spurious emissions shall be from the lowest frequency internally generated or used in the receiver (e.g. local oscillator, intermediate or carrier frequency), or 30 MHz, whichever is higher, to at least five times the highest tunable or local oscillator frequency, whichever is higher, without exceeding 40 GHz.

Test Setup:

The EUT was positioned in the center of the turntable in the SAC. The EUT was then measured for all the radiated emissions in the frequency range of 30 MHz to 1 GHz. Measurements were made using the spectrum analyzer and receiver using the appropriate antennas, amplifiers, attenuators, and filters.

Emissions in both horizontal and vertical polarizations were measured while rotating the EUT on the turntable to maximize signal strength.

All emissions in receive mode were made using the highest gain antenna: antenna 2.

Required Limits:

Frequency, *f* (MHz)	Calculated Maximum Field Strength (dBµV/m at 3 m)
30 – 88	40.0
88 – 216	43.5
216 – 960	46.0
above 960	54.0
Note 1: The above field strength limits are specified at a distance of 3 meters. The tighter limits apply at the band edges.	

Measurement Data and Plots:

Tested October 20, 2022

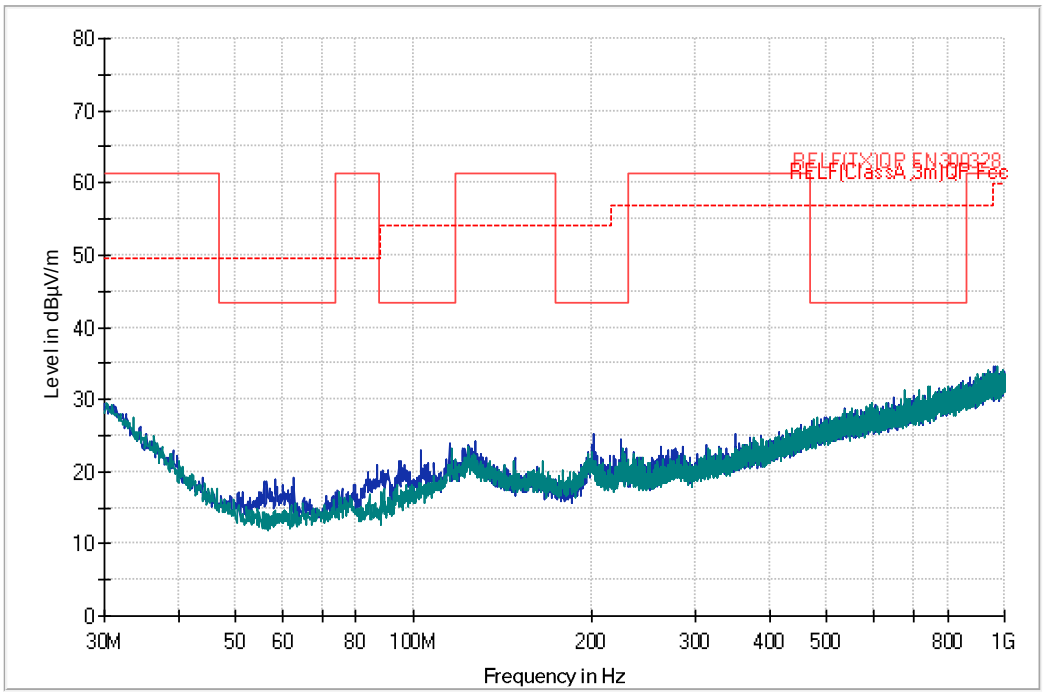

Figure 50: Unintentional Radiated Emissions From 30-1000MHz Measured at 3m

Tested October 19, 2022

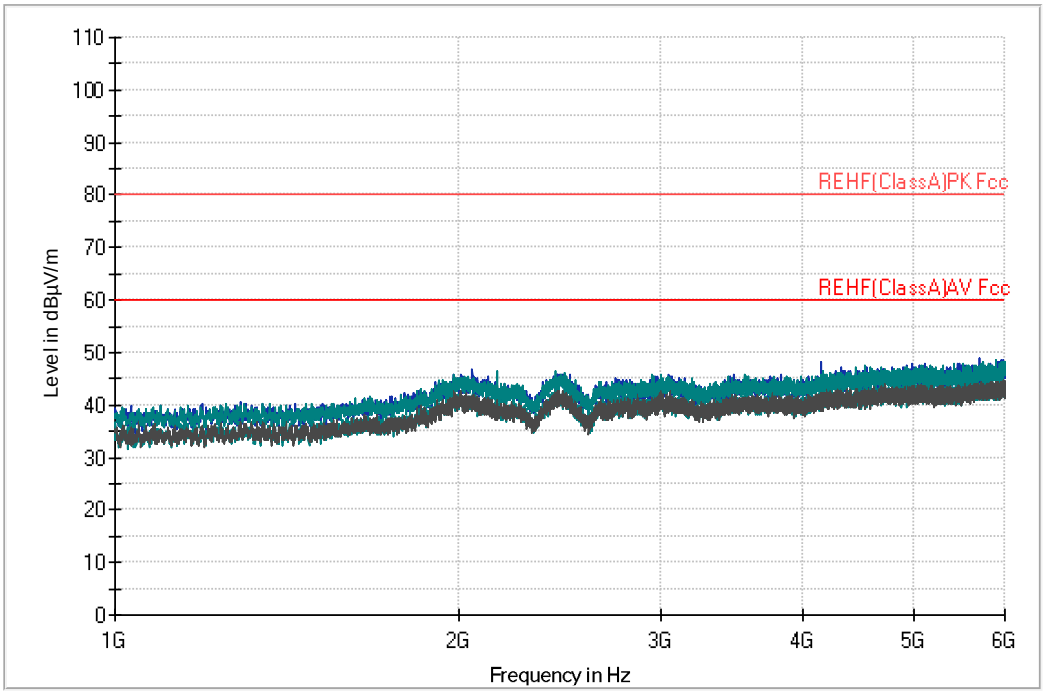

Figure 51: Unintentional Radiated Emissions From 1-6GHz Measured at 3m

Tested October 14, 2022

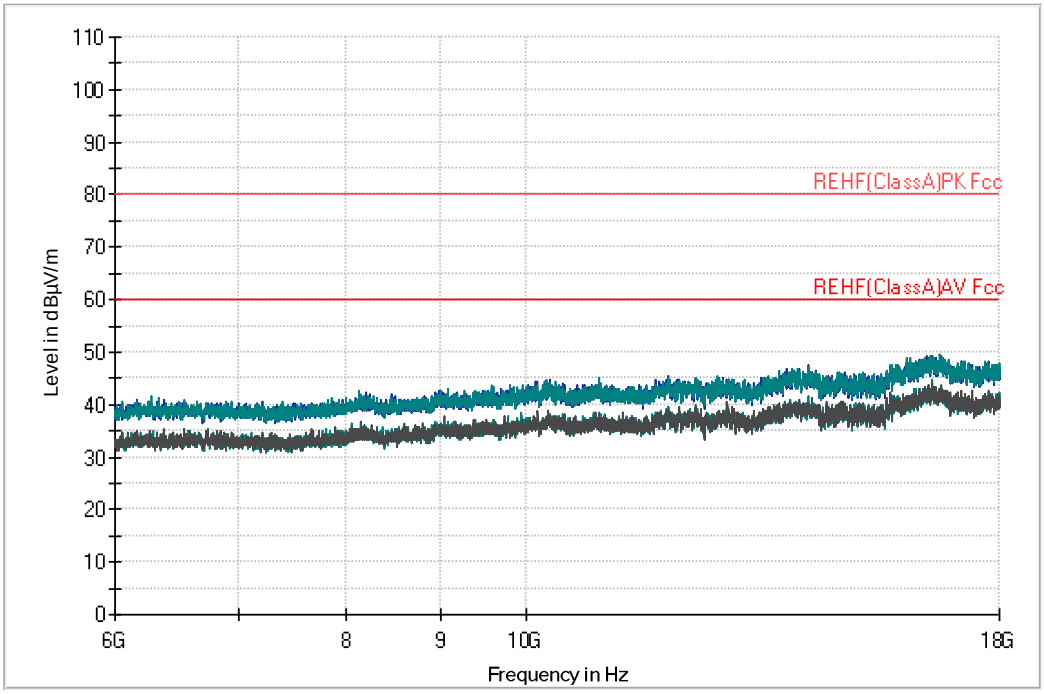

Figure 52: Unintentional Radiated Emissions 6-18GHz Measured at 3m

3.12 RF Exposure Evaluation

Date Performed:	October 24, 2022
Test Standard:	FCC CFR 47 Part 2.1093 FCC CFR 47 Part 1.1310
Test Method:	KDB 447498 RSS-102 Section 2.5.1
Modifications:	None
Final Result:	Complies

Applicable Standard:

FCC – KDB 447498

4.2.3: Extremity exposure conditions:

Devices that are designed or intended for use on extremities, or mainly operated in extremity only exposure conditions, i.e. hands, wrists, feet and ankles, may require extremity SAR evaluation. When the device also operates in close proximity to the user's body, SAR compliance for the body is also required. The 1-g body and 10-g extremity *SAR Test Exclusion Thresholds* in 4.3 should be applied to determine SAR test requirements.

4.3.1 a): Standalone SAR test exclusion considerations: For 100 MHz to 6 GHz and test separation distances ≤ 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following:

$$\frac{max.power\ of\ channel, including\ tuneup\ tolerance\ (mW)}{min.test\ separation\ distance\ (mm)} * \sqrt{f_{GHz}} \ \leq \ 3.0 \qquad \text{for 1g SAR}$$

And

$$\frac{max.power\ of\ channel, including\ tuneup\ tolerance\ (mW)}{min.test\ separation\ distance\ (mm)} * \sqrt{f_{GHz}} \ \leq \ 7.5 \qquad \text{for 10g SAR}$$

- f_{GHz} is the RF channel transmit frequency in GHz
- Power and distance are rounded ot the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison
- The values 3.0 and 7.5 are referred to as *numeric thresholds* in step b) below

The test exclusions are applicable only when the minimum *test separation distance* is ≤ 50 mm, and for transmission frequencies between 100 MHz and 6 GHz. When the minimum *test separation distance* is < 5 mm, a distance of 5mm according to 4.1 f) is applied to dermine SAR test exclusion.

4.3.1 b):

For 100 MHz to 6 GHz and *test separation distances* >50 mm, the 1-g and 10-g *SAR test exclusion thresholds* are determined by the following:

For 100 – 1500 MHz:

$$(Power\ allowed\ at\ numeric\ threshold\ for\ 50\ mm\ in\ step\ a + test\ separation\ distance - 50\ mm) * \frac{f_{MHz}}{150} \quad (mW)$$

For 1500 – 6000 MHz:

$$(Power\ allowed\ at\ numeric\ threshold\ for\ 50\ mm\ in\ step\ a + test\ separation\ distance - 50\ mm) * 10 \quad (mW)$$

ISED – RSS-102

Section 2.5.1 Exemption Limits for Routine Evaluation – SAR Evaluation:

RF Exposure evaluation is required if the separation distance between the user and/or bystander and the antenna and/or radiating element of the device is less than or equal to 20 cm, except when the device operates at or below the applicable output power level (adjusted for tune-up tolerance) for the specified separation distance defined in the following table.

Exemption Limits (mW)					
Frequency (MHz)	**At separation distance of ≤ 5mm**	**At separation distance of 10 mm**	**At separation distance of 15 mm**	**At separation distance of 20 mm**	**At separation distance of 25 mm**
≤ 300	71	101	132	162	193
450	52	70	88	106	123
835	17	30	42	55	67
1900	7	10	18	34	60
2450	4	7	15	30	52
3500	2	6	16	32	55
5800	1	6	15	27	41

Exemption Limits (mW)					
Frequency (MHz)	**At separation distance of 30 mm**	**At separation distance of 35 mm**	**At separation distance of 40 mm**	**At separation distance of 45 mm**	**At separation distance of ≥ 50 mm**
≤ 300	223	254	284	315	345
450	141	159	177	195	213
835	80	92	105	117	130
1900	99	153	225	316	431
2450	83	123	173	235	309
3500	86	124	170	225	290
5800	56	71	85	97	106

Output power level shall be the higher of the maximum conducted or equivalent isotropically radiated power (e.i.r.p.) source-based, time-averaged output power. For controlled use devices where the 8 W/Kg for 1 gram of tissue applies, the exemption limits for routine evaluation in the above table are multiplied by a factor of 5. For limb-worn devices where the 10 gram value applies, the exemption limits for routine evaluation in the above table are multiplied by a factor of 2.5. If the operating frequency of the device is between two frequencies located int eh table, linear interpolation shall be applied for the applicable separation distance. For test separations distance less than 5 mm, the exemption limits for a separation distance of 5 mm can be applied to determine if a routine evaluation is required.

RF Field Strength Limits for Devices Used by the General Public (Uncontrolled Environment)				
Frequency Range (MHz)	**Electric Field (V/m rms)**	**Magnetic Field (A/m rms)**	**Power Density (W/m^2)**	**Reference Period (Minutes)**
0.003 – 10	83	90	-	Instantaneous*
0.1 – 10	-	0.73 / f	-	6**
1.1 – 10	$87 / f^{0.5}$	-	-	6**
10 – 20	27.46	0.0728	2	6
20 – 48	$58.07 / f^{0.25}$	$0.1541 / f^{0.25}$	$8.944 / f^{0.5}$	6
48 – 300	22.06	0.05852	1.291	6
300 – 6000	$3.142 f^{0.3417}$	$0.008335 f^{0.3417}$	$0.02619 f^{0.6834}$	6
6000 – 15000	61.4	0.163	10	6
15000 – 150000	61.4	0.163	10	$616000 / f^{1.2}$
150000 – 300000	$0.158 f^{0.5}$	$4.21 \times 10^{-4} f^{0.5}$	$6.67 \times 10^{-5} f$	$616000 / f^{1.2}$

Note: f is frequency in MHz.

* Based on nerve stimulation (NS).

** Based on specific absorption rate (SAR).

Measurement Data and Plots:

The measurement and calculations data for the RF exposure is contained in a separate report. See report 23-IA9-XPD2400A_RF_Exposure_Report_0.

Appendix A: TEST SETUP PHOTOS

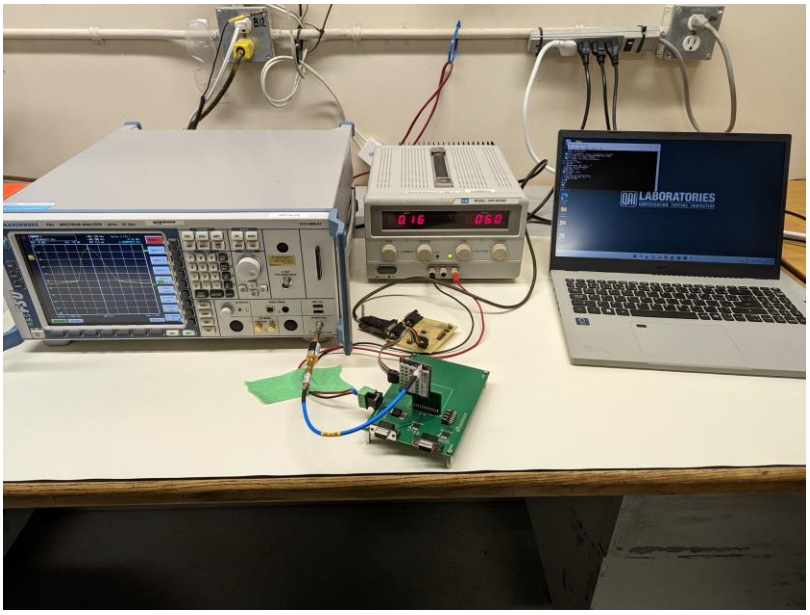

Figure 53: Peak Output Power Measurement Setup

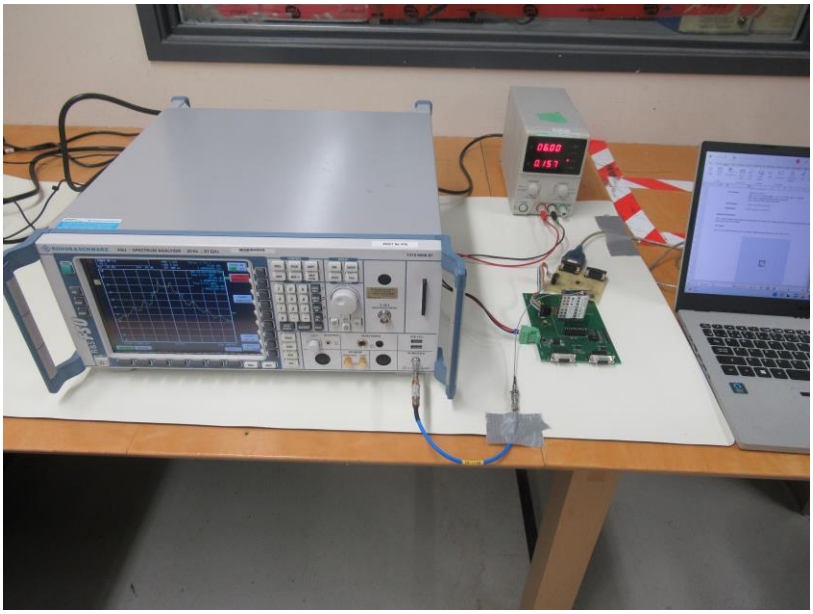

Figure 54: Other Conducted Radio Measurements Setup

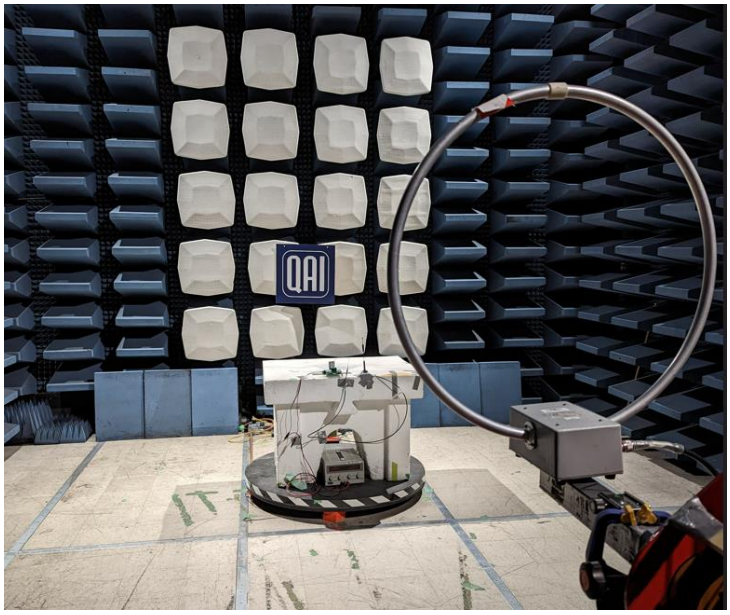

Figure 55: Radiated Emissions From 0.15 MHz - 30 MHz, Measured at 3m Setup

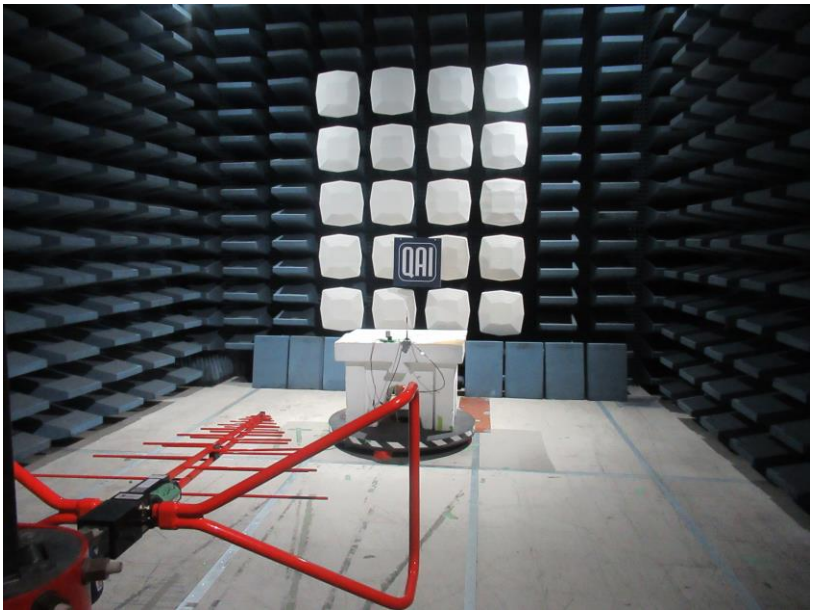

Figure 56: Radiated Emissions: 30 MHz - 1000 MHz, Measured at 3m Setup

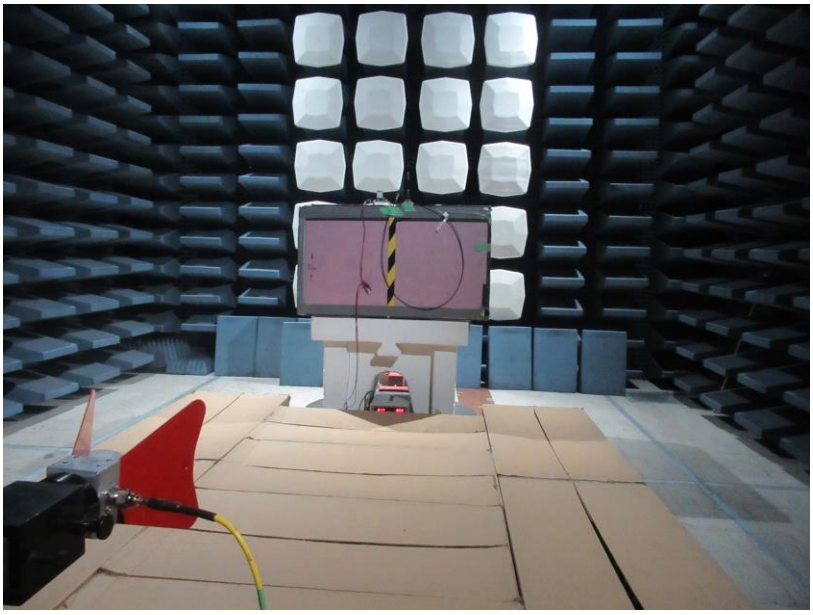

Figure 57: Radiated Emissions above 1 GHz, Measured at 3m Setup

Appendix B: ABBREVIATIONS

Abbreviation	Definition
AC	Alternating Current
AM	Amplitude Modulation
CE	European Conformity
CISPR	Comité International Spécial des Perturbations Radioélectriques (International Special Committee on Radio Interference)
DC	Direct Current
EFT	Electrical Fast Transient
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference
ESD	Electrostatic Discharge
EUT	Equipment Under Test
FCC	Federal Communications Commission
FVIN	Firmware Version Identification Number FVIN
IC	Industry Canada
ICES	Interference Causing Equipment Standard
IEC	International Electrotechnical Commission
LISN	Line Impedance Stabilizing Network
OATS	Open Area Test Site
RF	Radio Frequency
RMS	Root-Mean-Square
SAC	Semi-Anechoic Chamber

END OF REPORT