

ROBE LIGHTING S.R.O.

TEST REPORT

SCOPE OF WORK

EMISSIONS TESTING – DMX/RDM MODULE, TYPE RW 001

REPORT NUMBER

105040075ATL-001d

ISSUE DATE

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EMISSIONS TEST REPORT (FULL COMPLIANCE)

Report Number: 105040075ATL-001d

Project Number: G105040075

Report Issue Date: September 6, 2022

Report Revision Date: January 27, 2023

Model(s) Tested: DMX/RDM MODULE, TYPE RW
001

Standards: CFR47 FCC Part 15.247 Subpart C: 2022,
CFR47 FCC Part 15 Subpart B: 2022,
RSS-247 Issue 2 February 2017,
ICES-003 Issue 6 Published: 2020,
RSS-Gen Issue 5 April 2018, +A1:2019 +A2:2021

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Client:
ROBE Lighting s.r.o.
Hazovice 2090
Roznov pad Radhostem
Czeck Republic

Report prepared by Dan Alvarez



Dan Alvarez / EMC Engineer

Report reviewed by Kouma Sinn



Kouma Sinn / EMC Engineering Supervisor

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1 Introduction and Conclusion

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

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

2 Test Summary

Section	Test full name	Result
3	Client Information	--
4	Description of Equipment Under Test and Variant Models	--
5	System Setup and Method	---
6	Maximum Peak Output CFR47 FCC Part 15 Subpart B:2022, Section 15.247 (b)(1)(4) RSS-247 Issue 2 February 2017	Pass
7	20 dB Bandwidth and Occupied Bandwidth CFR47 FCC Part 15 Subpart C:2022, Section 15.247 (a)(2) RSS-247 Issue 2 February 2017	Pass
8	Carrier frequency separation CFR47 FCC Part 15 Subpart C:2022, Section 15.247(a), (b)(1) RSS-247 Issue 2 February 2017	Pass
9	Number of hopping frequencies CFR47 FCC Part 15 Subpart C:2022, Section 15.247 (a), (b)(1) RSS-247 Issue 2: 02/2017)	Pass
10	Time of occupancy (dwell time) CFR47 FCC Part 15 Subpart C:2022, Section 15.247 (a), (b)(1) RSS-247 Issue 2: 02/2017)	Pass
11	Band Edge Compliance CFR47 FCC Part 15 Subpart C:2022, Section 15.247 (d) RSS-247 Issue 2: 02/2017)	Pass
12	Transmitter spurious emissions CFR47 FCC Part 15 Subpart C:2022, Section 15.247 (d) RSS-247 Issue 2 February 2017	Pass
13	AC Mains Conducted Emissions CFR47 FCC Part 15 Subpart C:2022, Section 15.247 (d) RSS-247 Issue 2 February 2017	Pass
14	Revision History	--

Notes: The EUT is powered by 5 VDC Adapter.

3 Client Information

This EUT was tested at the request of:

Client: ROBE Lighting s.r.o.
Hazovice 2090
Roznov pod Radhostem
Czech Republic

Contact: Libor Blinka
Telephone: +420 (5) 7166-9272
Email: libor.blinka@robe.cz

4 Description of Equipment Under Test and Variant Models

Manufacturer: ROBE Lighting s.r.o.
Hazovice 2090
Roznov pod Radhostem
Czech Republic

Equipment Under Test			
Description	Manufacturer	Model Number	Serial Number
DMX/RDM MODULE, TYPE RW 001 (VCP-03B-USB REV.4)	ROBE Lighting s.r.o.	DMX/RDM Module, Type RW001	201217
External AC Adapter	Sunny Computer Technology Europe S.R.O	SYS1421-0605-W2E	None
DMX/RDM MODULE, TYPE RW 001 VCP-03B-USB REV.5	ROBE Lighting s.r.o.	DMX/RDM Module, Type RW001	143424

Receive Date:	06/06/2022
Received Condition:	Good
Type:	Production

Description of Equipment Under Test (provided by client)

ROBE wireless DMX/RDM module has full support for wireless communication protocols at entertainment market. Modul is based on well known LumenRadio RF technology, with implemented wire interface for connection with Robe products. RF output for MCX interface antenna as standard output.

Equipment Under Test Power Configuration			
Rated Voltage	Rated Current	Rated Frequency	Number of Phases
100-240 VAC	0.5 Amps	50/60 Hz	Single

Note: Output is +5 VDC at 1.2 Amps

Operating modes of the EUT:

No.	Descriptions of EUT Exercising
1	Continuously transmitting on low, mid, and high channels.

Software used by the EUT:

No.	Descriptions of EUT Exercising
1	None

Radio/Receiver Characteristics		
Frequency Band(s)	2402-2480 MHz	
Modulation Type(s)	GFSK	
Data Rates	250 kbps	
Power Setting During Test	1 Power setting down from Max	
Maximum Output Power	Low Channel (2401.988): +22.07 dBm (Conducted) Mid Channel (2440.018 MHz): +21.579 dBm (Conducted) High Channel (2480.042 MHz): +20.623 dBm (Conducted)	
Test Channels	Low Channel (2402 MHz) Mid Channel (2440 MHz) High Channel (2480 MHz)	
Occupied Bandwidth	Low Channel (2402.1 MHz):	858.95 kHz
	Mid Channel (2440 MHz):	855.68 kHz
	High Channel (2480 MHz):	852.75 kHz
20 dB Bandwidth	Low Channel (2402.1 MHz):	852.85 kHz
	Mid Channel (2440 MHz):	853.56 kHz
	High Channel (2480 MHz):	857.76 kHz
Frequency Hopper: Number of Hopping Channels	75 hopping channels	
Frequency Hopper: Channel Dwell Time	225 ms	
Frequency Hopper: Max interval between two instances of use of the same channel	50.5 ms	
MIMO Information (# of Transmit and Receive antenna ports)	N/A	
Equipment Type	Standalone	
Antenna Type and Gain	PCB (Johanson Technology: P/N 2450AT18A100), 0.5 dBi External (Sectron: AW-A24G-2M260), 0 dBi External, (TopBlue: TP-928) +2.0 +/- 0.5 dBi	

Antenna Requirement – FCC: Section 15.203

The PCB antenna is a mounted antenna and the antenna is permanently attached to the board. The board also provides an MCX connection for external antenna. This satisfies the requirements of Section 15.203.

Variant Models:

The following variant models were not tested as part of this evaluation, but have been identified by the manufacturer as being electrically identical models, depopulated models, or with reasonable similarity to the model(s) tested. Intertek does not make any claims of compliance for samples or variants which were not tested.

None

Lowest Clock Frequency: 16 MHz

Highest Clock Frequency: 2480 MHz

5 System Setup and Method

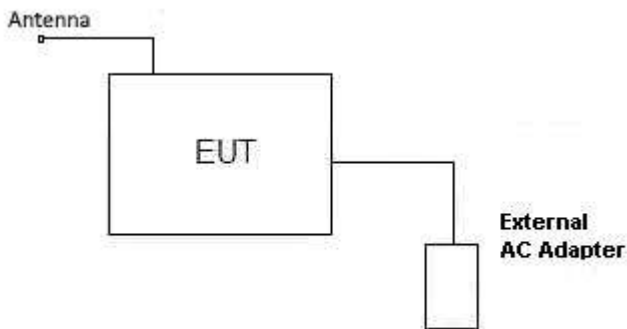
Cables					
ID	Description	Length (m)	Shielding	Ferrites	Termination
1	AC Mains cable	1.9	N	Y	Mains
2	Antenna Cable	40cm	Y	N	Antenna

Support Equipment			
Description	Manufacturer	Model Number	Serial Number
None	N/A	N/A	N/A

5.1 Method:

Configuration as required by Configuration as required by FCC Part 15 Subpart C 15.247:2022; FCC Part 15 Subpart B:2022; RSS 247 Issue 2: 02/2017; ICES 003 Issue 7:2020; RSS-Gen Issue 5 April 2018, +A1:2019 +A2:2021; ANSI C 63.10: 2013; ANSI C 63.4: 2014; and KBD 558074 D01 15.247 Meas Guidance v05r02:2019.

5.2 EUT Block Diagram:



6 Maximum Peak Output Power

6.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02.

TEST SITE: EMC Lab

The EMC Lab has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

6.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
232944'	EMI Receiver 10Hz-26.5GHz	Agilent	MXE-9038A	MY51210135	10/12/2022	10/12/2023
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023
213370'	Attenuator N M/F 18Ghz -10db	Centric RF	C18N5W-10	C18N5W-10-2	02/08/2022	02/08/2023

Note: Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz.

Software Utilized:

Name	Manufacturer	Version
None	N/A	N/A

6.3 Results:

The sample tested was found to Comply.

Limits – FCC Part §15.247 (b) (3) For systems using digital modulation in the 902-928 MHz, 2400-2483.5 MHz, and 5725-5850 MHz bands: 1 Watt or + 30 dBm.

Note: The conducted output power limit is based on the use of antennas with directional gains that do not exceed 6 dBi.

6.4 Setup Photograph:



6.5 Plots/Data:

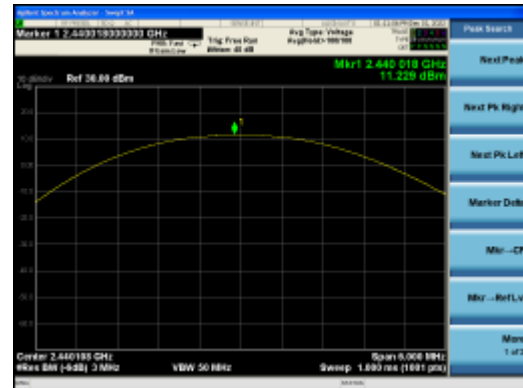
Frequency (MHz)	Conducted Power (dBm)
2401.988	$11.720 + 9.95 + 0.4 = 22.070$
2440.018	$11.229 + 9.95 + 0.4 = 21.579$
2480.042	$10.273 + 9.95 + 0.4 = 20.623$

Note: 9.95 dB attenuator was used during measurement. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz.

Low Channel Conducted Power



Mid Channel Conducted Power



High Channel Conducted Power



Note: Calibrated 9.95 dB attenuator used during measurement. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on plots does not take into account the attenuator and cable loss.

Test Personnel: Troy Ihle TJI
 Supervising/Reviewing Engineer: Dan Alvarez DA
 (Where Applicable) CFR47 FCC Part 15.247, RSS-247
 Product Standard: 120VAC, 60Hz
 Input Voltage: N/A
 Pretest Verification w/ Ambient Signals or BB Source: N/A

Test Date: 12/01/2022

Limit Applied: See report section 6.3

Ambient Temperature: 23.3 °C

Relative Humidity: 22.6 %

Atmospheric Pressure: 996.1 mbars

Deviations, Additions, or Exclusions: None

7 20 dB Bandwidth and Occupied Bandwidth

7.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02.

TEST SITE: EMC Lab

The EMC Lab has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

7.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
232944'	EMI Receiver 10Hz-26.5GHz	Agilent	MXE-9038A	MY51210135	10/12/2021	10/12/2022
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Notes: A 20 dB attenuator was used while performing measurements. Attenuator was verified before use and characterized with 20.362 dB of loss at 2.4 GHz to 2.480 GHz. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on plots does not take into account the attenuator and cable loss.

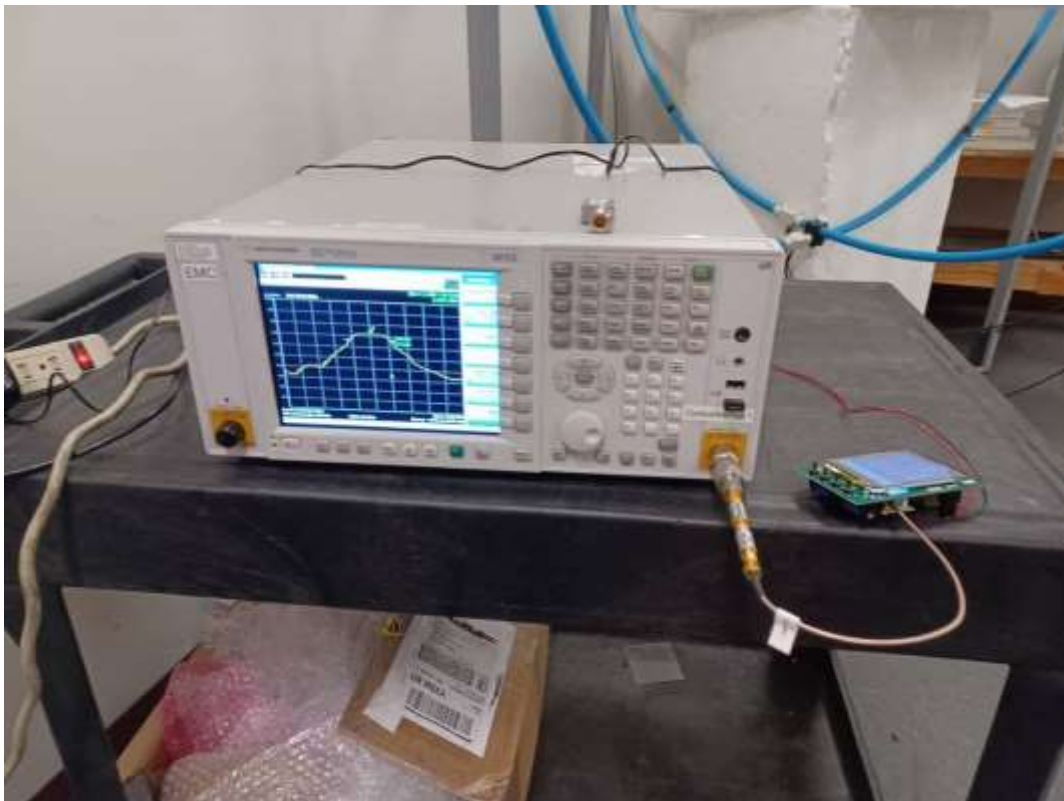
Software Utilized:

Name	Manufacturer	Version
None	N/A	N/A

7.3 Results:

The sample tested was found to Comply.

7.4 Setup Photograph:



7.5 Plots/Data:

Occupied Bandwidths

Frequency	99% Occupied Bandwidth	Bandwidth Limit	Result
2402.1 MHz	858.95 kHz	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Pass
2440 MHz	855.68 kHz	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Pass
2480 MHz	852.75 kHz	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Pass

Notes: Measurement was performed using conducted method. A 20 dB attenuator used while performing measurements. Attenuator was verified before use and characterized with 20.362 dB of loss at 2.4 GHz to 2.480 GHz. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on the plots do not take into account the 0.4 dB cable loss.

Low Channel 99% Power Occupied Bandwidth



Mid Channel 99% Power Occupied Bandwidth



High Channel 99% Power Occupied Bandwidth



20 dB Bandwidths

Frequency	20 dB Bandwidth	Bandwidth Limit	Result
2402.1 MHz	852.85 kHz	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Pass
2440 MHz	853.56 kHz	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Pass
2480 MHz	857.76 kHz	Upper and Lower Edges of OBW within 2400-2483.5 MHz	Pass

Notes: Measurement was performed using conducted method. A 20 dB attenuator used while performing measurements. Attenuator was verified before use and characterized with 20.362 dB of loss at 2.4 GHz to 2.480 GHz. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on the plots do not take into account the 0.4 dB cable loss.

Low Channel 20 dB Bandwidth



Mid Channel 20 dB Bandwidth



High Channel 20 dB Bandwidth



Test Personnel: Dan Alvarez
Supervising/Reviewing
Engineer:
(Where Applicable) N/A
Product Standard: CFR47 FCC Part 15.247,
Input Voltage: RSS-247
120VAC, 60Hz
Pretest Verification w/
Ambient Signals or
BB Source: N/A

Test Date: 06/10/2022

Limit Applied: See report section 7.3

Ambient Temperature: 23 °C

Relative Humidity: 43 %

Atmospheric Pressure: 980 mbars

Deviations, Additions, or Exclusions: None

8 Carrier frequency separation

8.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02.

TEST SITE: EMC Lab

The EMC Lab has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

8.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
232944'	EMI Receiver 10Hz-26.5GHz	Agilent	MXE-9038A	MY51210135	10/12/2021	10/12/2022
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Notes: A 20 dB attenuator was used while performing measurements. Attenuator was verified before use and characterized with 20.362 dB of loss at 2.4 GHz to 2.480 GHz. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on the plots do not take into account the 0.4 dB cable loss.

2.2 FHSS equipment

The following table provides a shorthand summary of the FHSS power limits and other basic requirements, per Sections 15.247(a), 15.247(b)(1), and 15.247(b)(2).

902-928 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 250 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 20 \text{ s}$	$P_{\text{max-pk}} \leq 0.25 \text{ W}$ $25 \leq N_{\text{ch}} < 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $250 \text{ kHz} < BW_{20\text{dB}} \leq 500 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 10 \text{ s}$
2400-2483.5 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$	$P_{\text{max-pk}} \leq 0.125 \text{ W}$ $N_{\text{ch}} \geq 15$ $\Delta f \geq [\text{MAX} \{ 25 \text{ kHz}, 0.67 \cdot BW_{20\text{dB}} \}$ $\text{OR MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}]$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$
5725-5850 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 1 \text{ MHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 30 \text{ s}$	

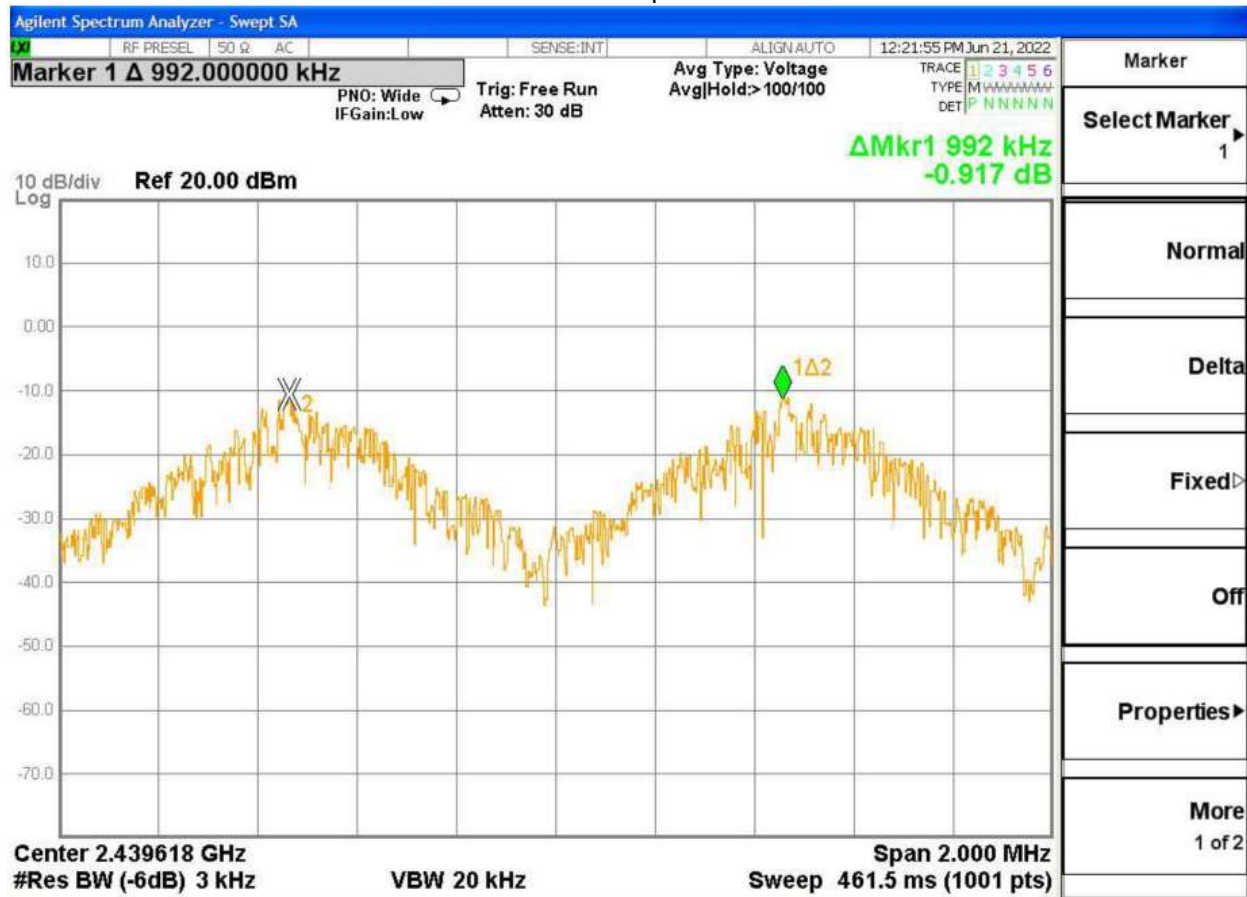
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies;
 BW = bandwidth; Δf = hopping channel carrier frequency separation

Requirement: $\geq 25 \text{ kHz}$, $BW_{20\text{dB}}$

Measured: 992 kHz

Result: Compliant

Channel Separation



9 Number of hopping frequencies

9.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02.

TEST SITE: EMC Lab

The EMC Lab has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

9.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
232944'	EMI Receiver 10Hz-26.5GHz	Agilent	MXE-9038A	MY51210135	10/12/2021	10/12/2022
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Notes: A 20 dB attenuator used while performing measurements. Attenuator was verified before use and characterized with 20.362 dB of loss at 2.4 GHz to 2.480 GHz. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on the plots do not take into account the 0.4 dB cable loss.

2.2 FHSS equipment

The following table provides a shorthand summary of the FHSS power limits and other basic requirements, per Sections 15.247(a), 15.247(b)(1), and 15.247(b)(2).

902-928 MHz	$P_{\max\text{-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 250 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 20 \text{ s}$	$P_{\max\text{-pk}} \leq 0.25 \text{ W}$ $25 \leq N_{\text{ch}} < 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $250 \text{ kHz} < BW_{20\text{dB}} \leq 500 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 10 \text{ s}$
2400-2483.5 MHz	$P_{\max\text{-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$	$P_{\max\text{-pk}} \leq 0.125 \text{ W}$ $N_{\text{ch}} \geq 15$ $\Delta f \geq [\text{MAX} \{ 25 \text{ kHz}, 0.67 \cdot BW_{20\text{dB}} \}$ $\text{OR MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}]$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$
5725-5850 MHz	$P_{\max\text{-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 1 \text{ MHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 30 \text{ s}$	

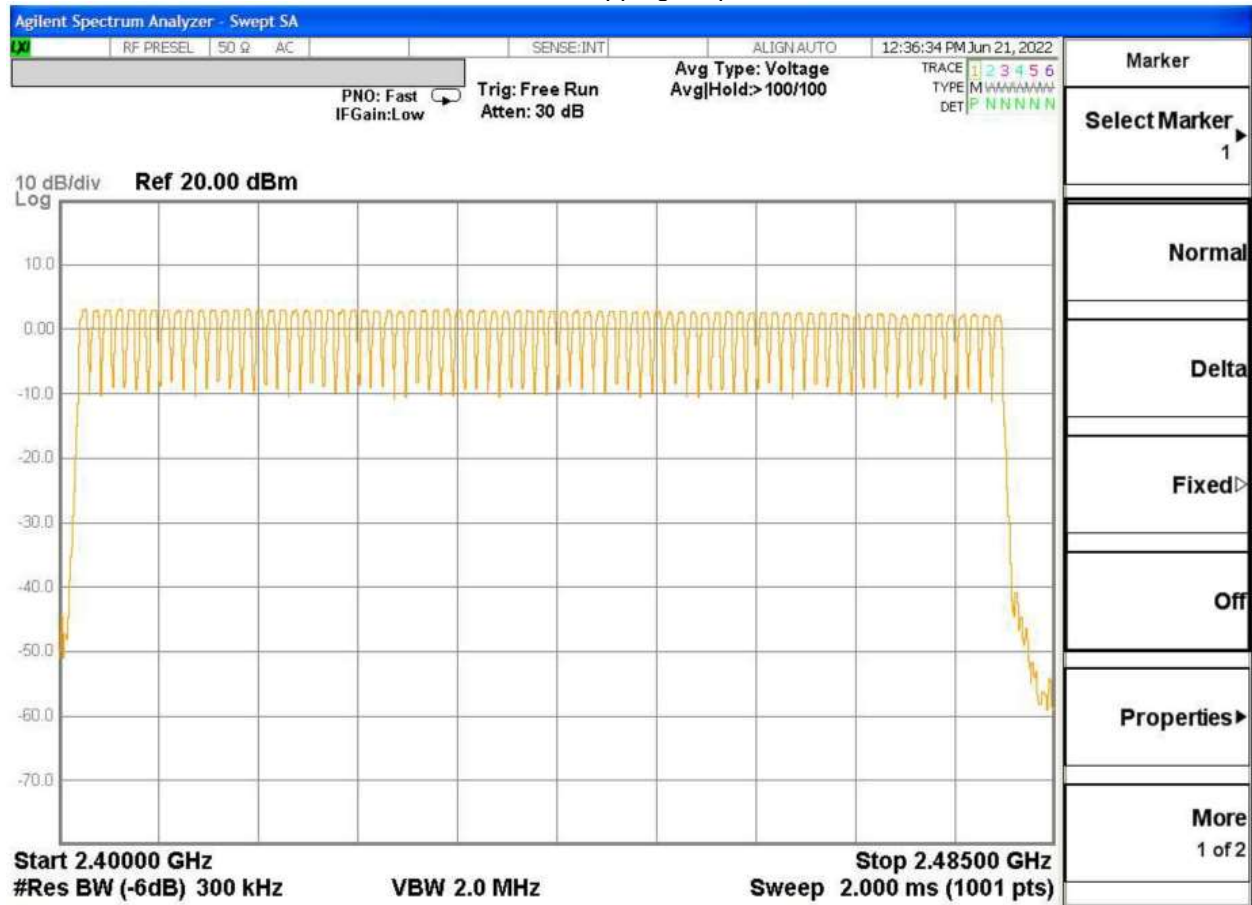
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies;
 BW = bandwidth; Δf = hopping channel carrier frequency separation

Requirement: ≥ 75 channels

Measured: 75 channels

Result: Compliant

Number of hopping frequencies



10 Time of occupancy (dwell time)

10.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.247, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02.

TEST SITE: EMC Lab

The EMC Lab has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

10.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
232944'	EMI Receiver 10Hz-26.5GHz	Agilent	MXE-9038A	MY51210135	10/12/2021	10/12/2022
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Notes: A 20 dB attenuator used while performing measurements. Attenuator was verified before use and characterized with 20.362 dB of loss at 2.4 GHz to 2.480 GHz. Cable loss was measured at 0.4 dB loss from 2400 MHz to 2480 MHz. The reading on the plots do not take into account the 0.4 dB cable loss.

2.2 FHSS equipment

The following table provides a shorthand summary of the FHSS power limits and other basic requirements, per Sections 15.247(a), 15.247(b)(1), and 15.247(b)(2).

902-928 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 250 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 20 \text{ s}$	$P_{\text{max-pk}} \leq 0.25 \text{ W}$ $25 \leq N_{\text{ch}} < 50$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $250 \text{ kHz} < BW_{20\text{dB}} \leq 500 \text{ kHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 10 \text{ s}$
2400-2483.5 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$	$P_{\text{max-pk}} \leq 0.125 \text{ W}$ $N_{\text{ch}} \geq 15$ $\Delta f \geq [\text{MAX} \{ 25 \text{ kHz}, 0.67 \cdot BW_{20\text{dB}} \}$ $\text{OR MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}]$ $\text{max. } BW_{20\text{dB}} \text{ not specified}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 0.4 \cdot N_{\text{ch}}$
5725-5850 MHz	$P_{\text{max-pk}} \leq 1 \text{ W}$ $N_{\text{ch}} \geq 75$ $\Delta f \geq \text{MAX} \{ 25 \text{ kHz}, BW_{20\text{dB}} \}$ $BW_{20\text{dB}} \leq 1 \text{ MHz}$ $t_{\text{ch}} \leq 0.4 \text{ s for } T = 30 \text{ s}$	

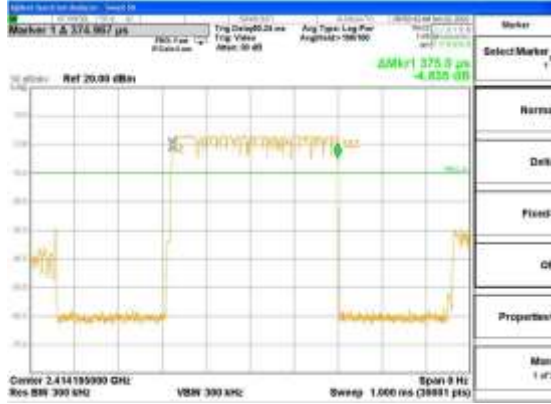
t_{ch} = average time of occupancy; T = period; N_{ch} = # hopping frequencies;
 BW = bandwidth; Δf = hopping channel carrier frequency separation

Requirement: $\leq 0.4 \text{ s}$ in 0.4 s period

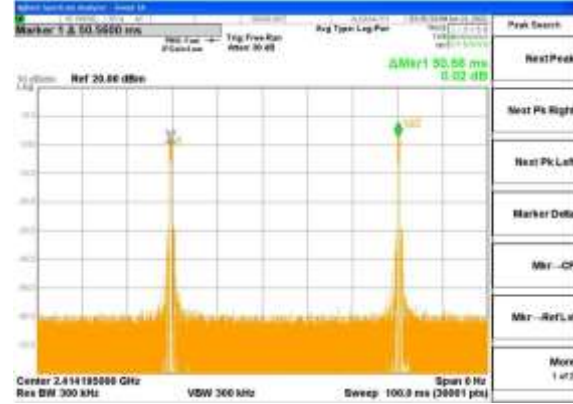
Measured: Transmission duration: $375 \mu\text{s} \times 8 \text{ transmissions in } 400 \text{ ms period} \times 75 \text{ channels} = 225 \text{ ms total time of occupancy}$

Result: Compliant

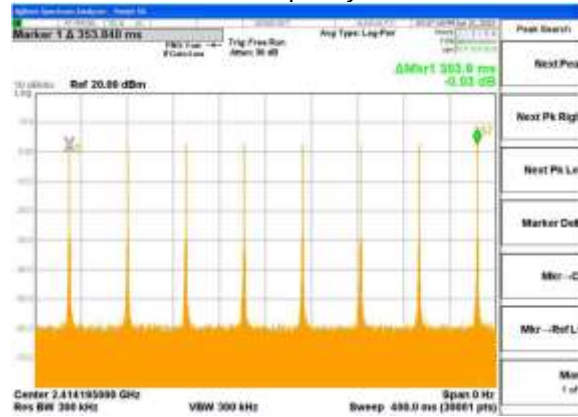
Time of Occupancy – One Hop



Time of Occupancy – Two Successive Hops



Time of Occupancy – 400ms



11 Band Edge Compliance

11.1 Method

Tests are performed in accordance with FCC Part 15 Subpart C 15.247 RSS 247, ANSI C 63.10, and ANSI C 63.4.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. The turntable is located on one end of the chamber and the antennas are mounted 3 and 10 meters away at the other end of the chamber on the adjustable an Antenna Mast. The antenna mast is a non-conductive bore sighted type with remote control of antenna height and polarization. The Antenna Mast and the turntable can be remotely controlled through the controller located in the adjacent Control room. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 10m	30-1000 MHz	4.9 dB	6.3 dB
Radiated Emissions, 3m	30-1000 MHz	4.6 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.6 dB	5.2 dB
Radiated Emissions, 3m	6-15 GHz	5.8 dB	5.5 dB
Radiated Emissions, 3m	15-18 GHz	4.7 dB	5.5 dB
Radiated Emissions, 3m	18-40 GHz	4.9 dB	6.3 dB

As shown in the table above our radiated emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample Calculation

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

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

Where

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

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

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

in dB μ V/m was converted to its corresponding level in μ V/m.

RA = 52.0 dB μ V

AF = 7.4 dB/m

CF = 1.6 dB

AG = 29.0 dB

FS = 32 dB μ V/m

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

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

NF = Net Reading in dB μ V

Example:

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

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

11.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
200003	Attenuator, 03 dB, <18GHz	Weinschel Corp	2	BK7899	03/30/2022	03/30/2023
213451	(20Mhz step5GHz) Omni -directional Comb Generator	Com-Power	CGO-520	281266	VBV	Verified
200162	EMI Receiver (20Hz-40GHz)	Rohde & Schwarz	ESU 40	100314	10/13/2021	10/13/2022
MM1	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM36	161471	09/09/2021	09/09/2022
212165	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023
213453	Preamplifier 500MHz-18GHz	Com-Power	PAM-118A	18040030	10/13/2021	10/13/2022
213058a	Antenna, Horn, <18 GHz	A.H. Systems	SAS-200/571	246	02/08/2022	02/08/2023
MM8	RF Coax Cable 9KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/13/2021	10/13/2022

Test Equipment Used: 11/10/2022

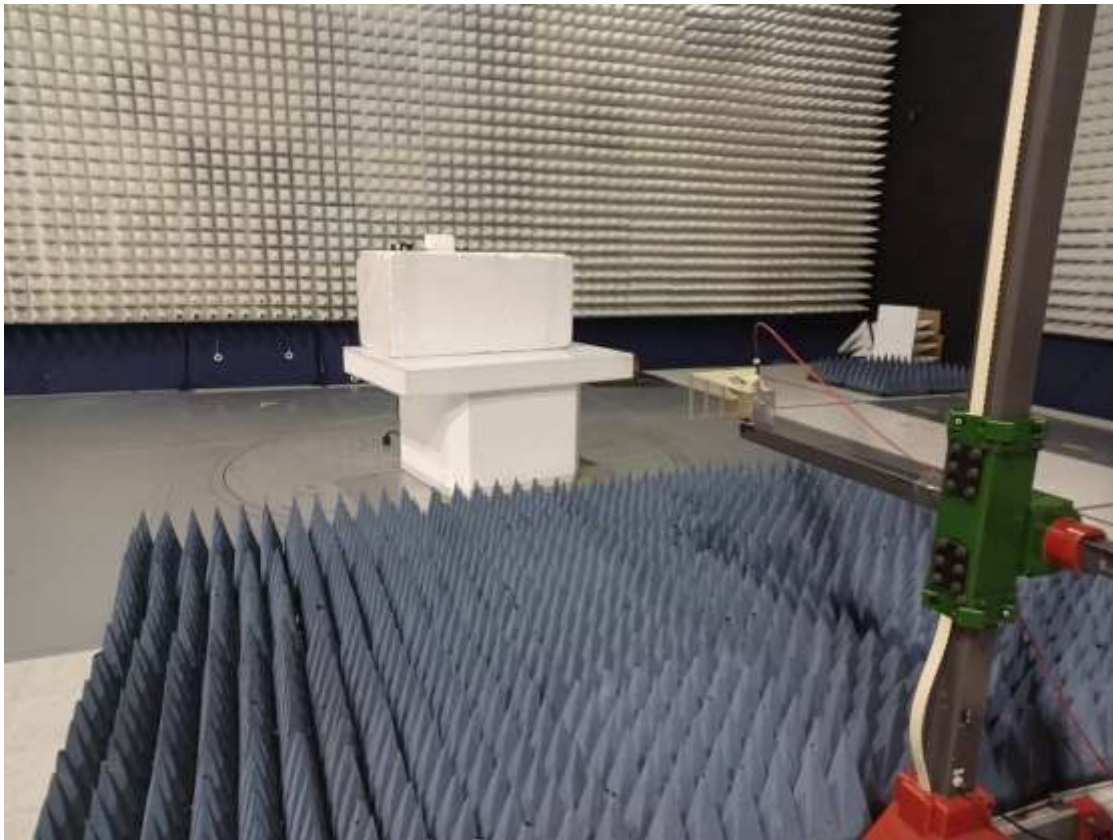
Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
200003	Attenuator, 03 dB, <18GHz	Weinschel Corp	2	BK7899	03/30/2022	03/30/2023
213451	(20Mhz step5GHz) Omni -directional Comb Generator	Com-Power	CGO-520	281266	VBV	Verified
200162	EMI Receiver (20Hz-40GHz)	Rohde & Schwarz	ESU 40	100314	10/11/2022	10/11/2023
MM3	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM36	769548	06/08/2022	06/08/2023
212165	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023
213453	Preamplifier 500MHz-18GHz	Com-Power	PAM-118A	18040030	10/12/2022	10/12/2023
213058a	Antenna, Horn, <18 GHz	A.H. Systems	SAS-200/571	246	02/08/2022	02/08/2023
MM8	RF Coax Cable 9KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/11/2022	10/11/2023

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.19.1.18

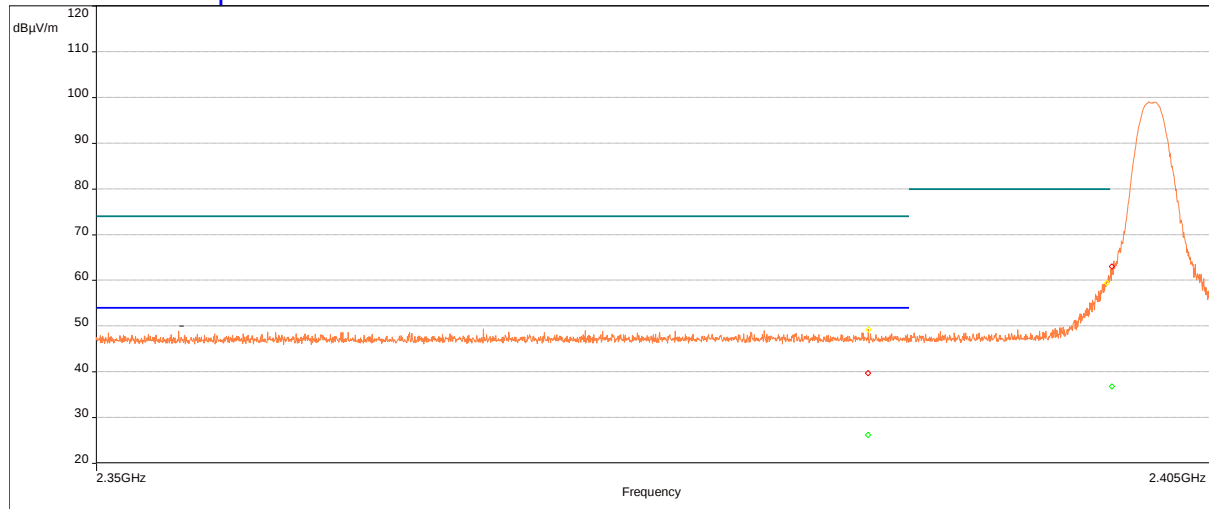
11.3 Results:

The sample tested was found to Comply.

11.4 Setup Photograph:

11.5 Plots/Data:

Lower Band Edge – Restricted Band, 2.35GHz-2.405GHz (X-axis)
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna

Emissions Graph:

FCC Part 15 Transmitters/Restricted Band
11/10/2022 2:08:40 PM

Data Results:**Avg (PASS) (2)**

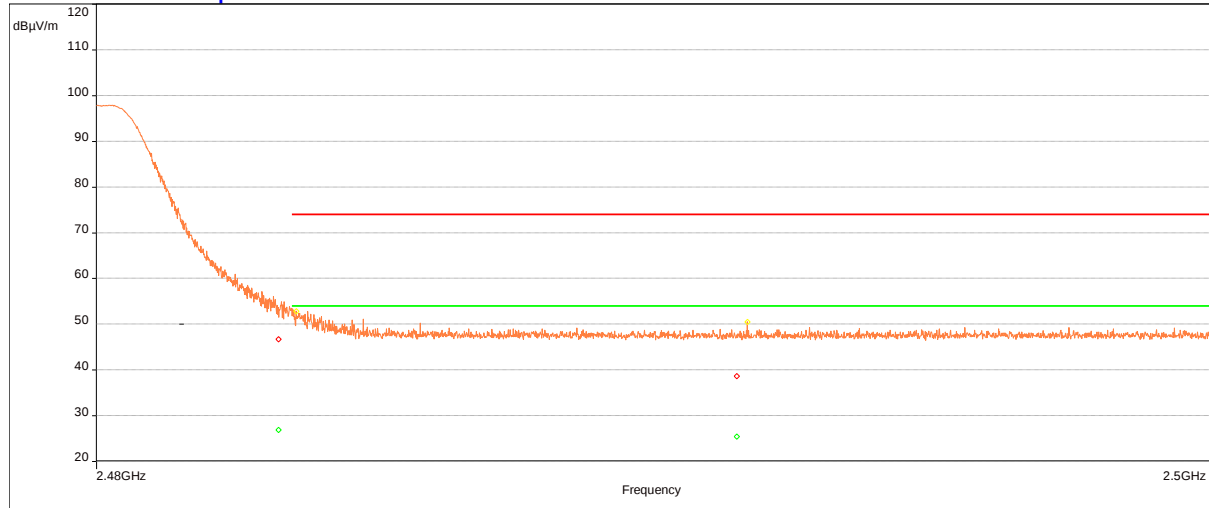
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2387.972672	26.25	54.00	-27.75	162.00	1.91	Horizontal	1.00	-5.05
2400.097213	36.78	80.00	-23.22	141.00	1.37	Horizontal	1.00	-5.06

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2387.972672	39.76	74.00	-34.24	162.00	1.91	Horizontal	1.00	-5.05
2400.097213	63.01	80.00	-16.99	141.00	1.37	Horizontal	1.00	-5.06

Upper Band Edge – Restricted Band, 2.48GHz-2.5GHz (X-axis)
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
11/10/2022 2:11:07 PM

Data Results:

Avg (PASS) (2)

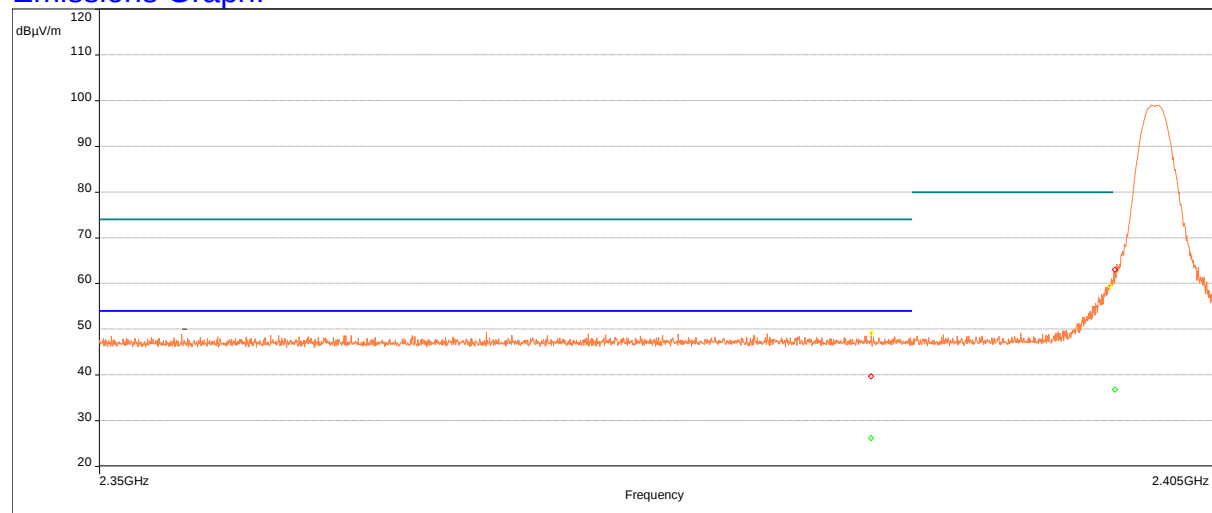
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.255885	26.96	54.00	-27.04	276.00	1.13	Horizontal	1.00	-5.20
2491.482803	25.42	54.00	-28.58	270.00	2.82	Vertical	1.00	-5.20

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.255885	46.69	74.00	-27.31	276.00	1.13	Horizontal	1.00	-5.20
2491.482803	38.69	74.00	-35.31	270.00	2.82	Vertical	1.00	-5.20

Lower Band Edge – Restricted Band, 2.35GHz-2.405GHz (Y-axis)
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
11/10/2022 12:39:07 PM

Data Results:

Avg (PASS) (2)

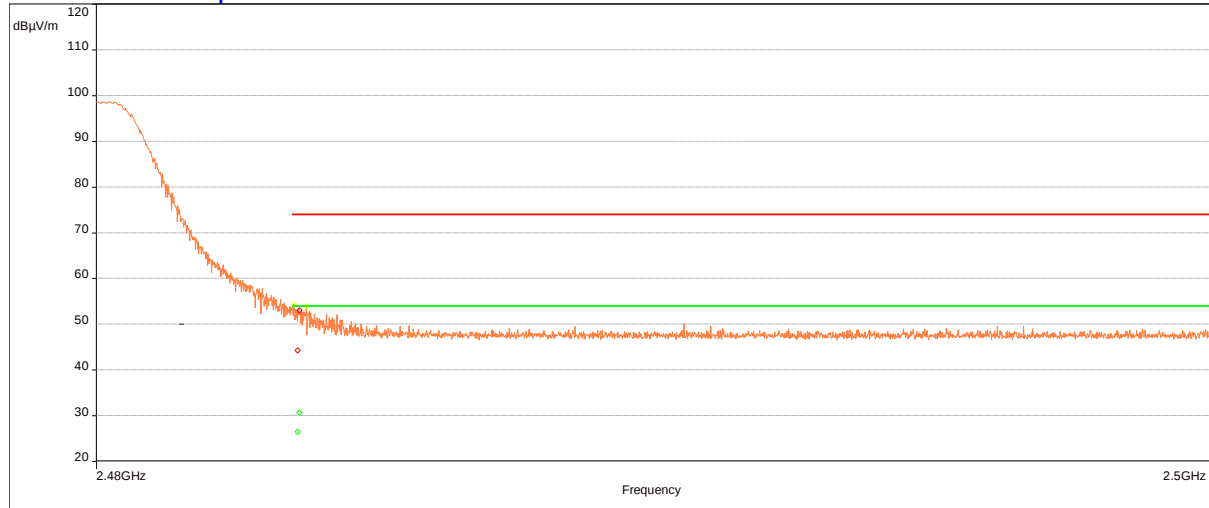
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2389.216346	36.09	54.00	-17.91	192.00	3.31	Vertical	1.00	4.83
2400.097687	37.62	80.00	-42.38	152.00	1.59	Vertical	1.00	4.81

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2389.216346	50.05	74.00	-23.95	192.00	3.31	Vertical	1.00	4.83
2400.097687	63.77	80.00	-16.23	152.00	1.59	Vertical	1.00	4.81

Upper Band Edge – Restricted Band, 2.48GHz-2.5GHz (Y-axis)
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
11/10/2022 12:35:27 PM

Data Results:

Avg (PASS) (2)

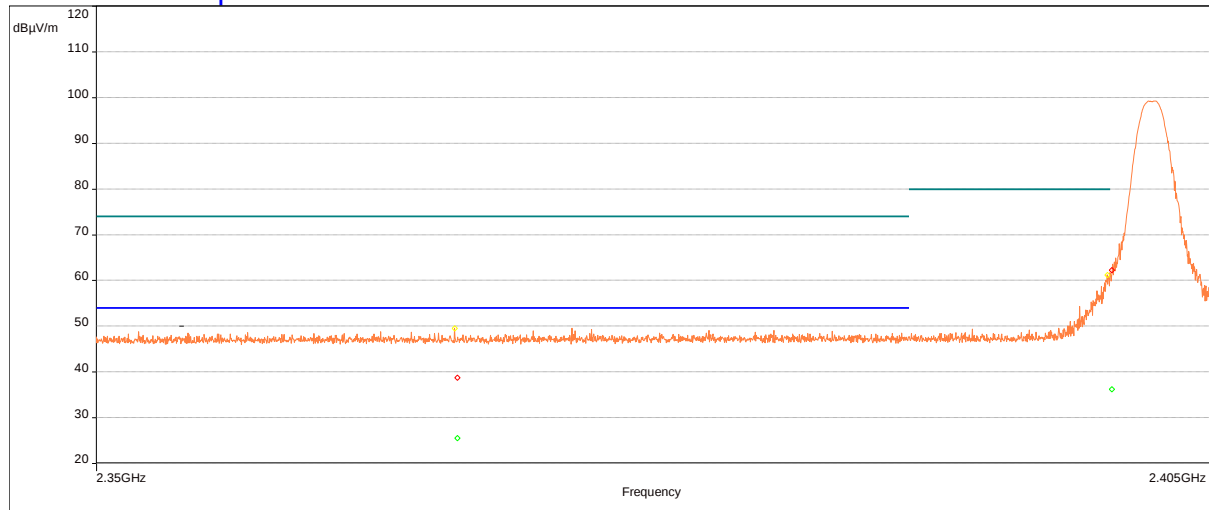
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.600103	26.51	54.00	-27.49	46.00	1.72	Vertical	1.00	-5.20
2483.6337	30.72	54.00	-23.28	152.00	3.69	Vertical	1.00	-5.20

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.600103	44.27	74.00	-29.73	46.00	1.72	Vertical	1.00	-5.20
2483.6337	53.02	74.00	-20.98	152.00	3.69	Vertical	1.00	-5.20

Lower Band Edge – Restricted Band, 2.35GHz-2.405GHz (Z-axis)
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
11/10/2022 3:02:50 PM

Data Results:

Avg (PASS) (2)

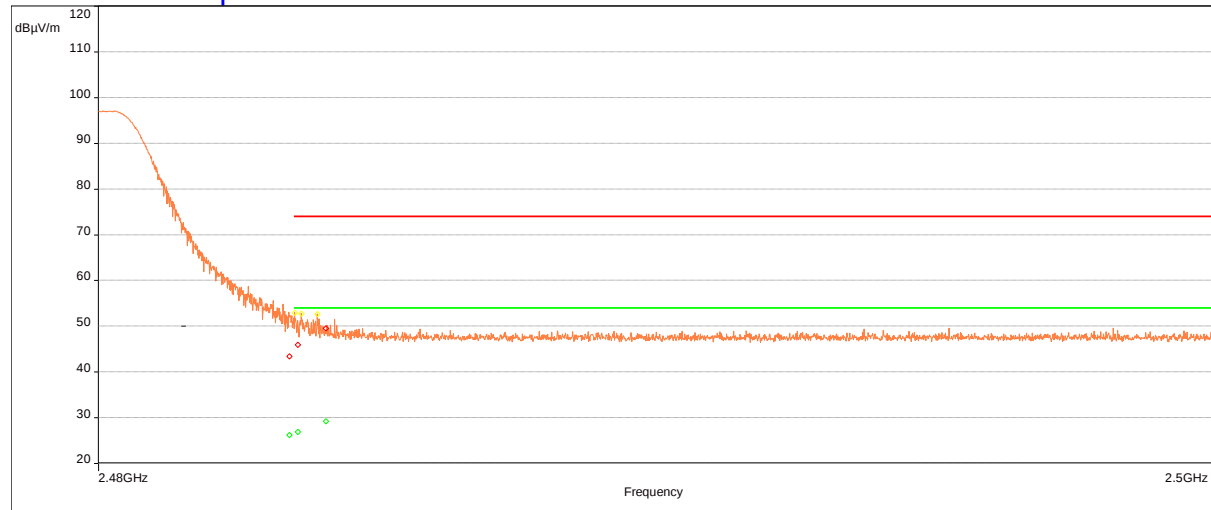
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2367.688123	25.53	54.00	-28.47	244.00	2.34	Vertical	1.00	-5.10
2400.094659	36.21	80.00	-43.79	85.00	2.38	Horizontal	1.00	-5.06

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2367.688123	38.72	74.00	-35.28	244.00	2.34	Vertical	1.00	-5.10
2400.094659	62.27	80.00	-17.73	85.00	2.38	Horizontal	1.00	-5.06

Upper Band Edge – Restricted Band, 2.48GHz-2.5GHz (Z-axis)
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna

Emissions Graph:



Data Results:

Avg (PASS) (3)

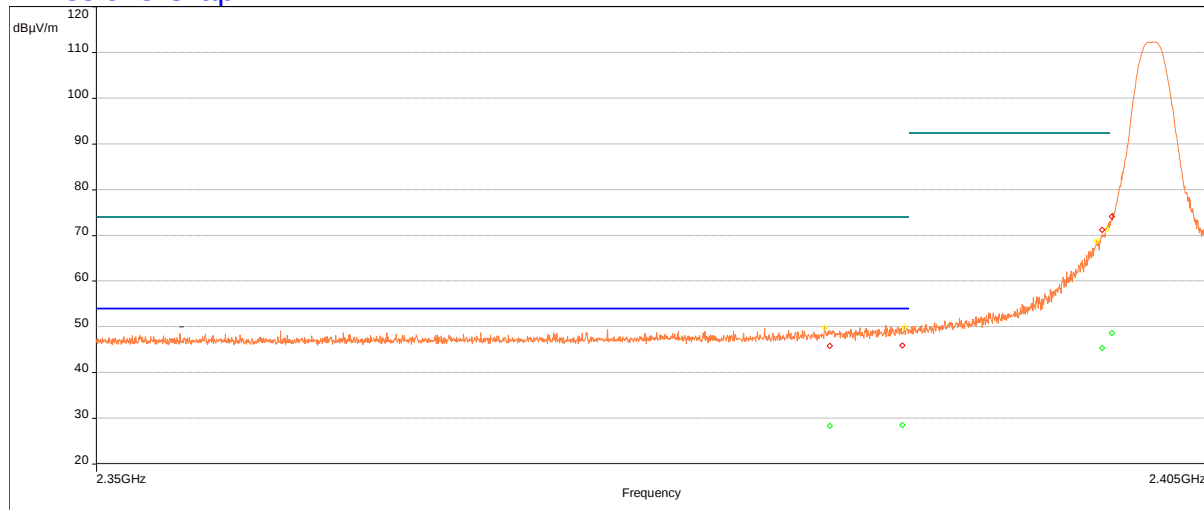
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.415146	26.20	54.00	-27.80	302.00	3.82	Horizontal	1.00	-5.20
2483.564597	26.95	54.00	-27.05	167.00	3.34	Horizontal	1.00	-5.20
2484.073544	29.20	54.00	-24.80	95.00	2.79	Horizontal	1.00	-5.20

Peak (PASS) (3)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.415146	43.38	74.00	-30.62	302.00	3.82	Horizontal	1.00	-5.20
2483.564597	45.95	74.00	-28.05	167.00	3.34	Horizontal	1.00	-5.20
2484.073544	49.52	74.00	-24.48	95.00	2.79	Horizontal	1.00	-5.20

Lower Band Edge – Restricted Band, 2.35GHz-2.405GHz and 20 dBc (X-axis)
RW 001 W-MODEL VCP-03B-USB REV.4_TB-928 Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
9/6/2022 8:48:55 AM

Data Results:

Avg (PASS) (4)

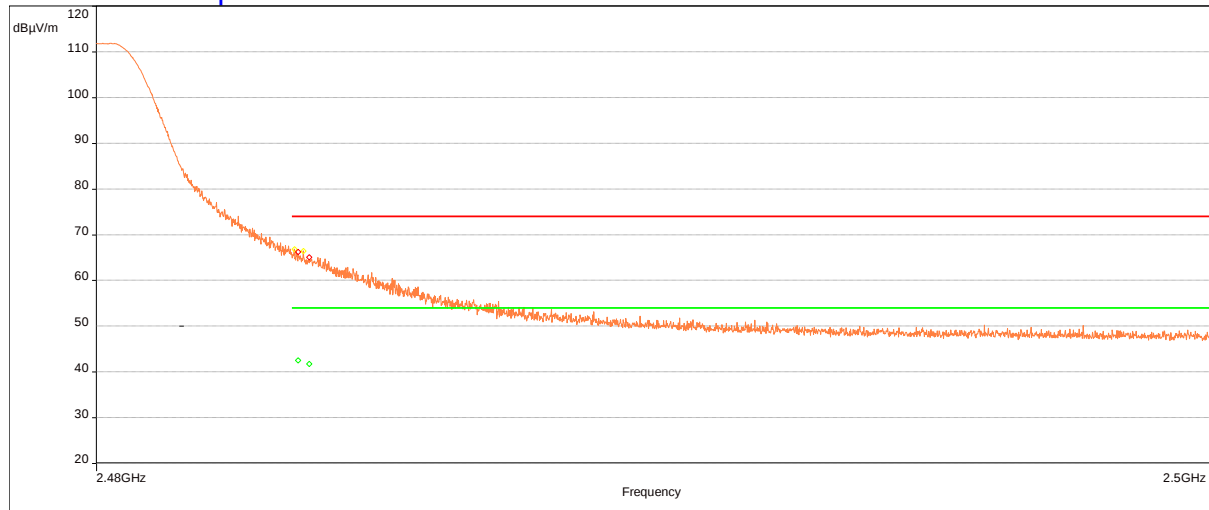
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2386.077	28.34	54.00	-25.66	21.00	1.45	Vertical	1.00	-5.22
2389.66111	28.57	54.00	-25.43	220.00	1.39	Vertical	1.00	-5.23
2399.602431	45.40	92.5	-47.1	144.00	2.47	Vertical	1.00	-5.24
2400.098044	48.71	92.5	-43.79	302.00	3.28	Vertical	1.00	-5.24

Peak (PASS) (4)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2386.077	45.89	74.00	-28.11	21.00	1.45	Vertical	1.00	-5.22
2389.66111	45.92	74.00	-28.08	220.00	1.39	Vertical	1.00	-5.23
2399.602431	71.20	92.5	-21.3	144.00	2.47	Vertical	1.00	-5.24
2400.098044	74.12	92.5	-18.38	302.00	3.28	Vertical	1.00	-5.24

Upper Band Edge – Restricted Band, 2.48GHz-2.5GHz (X-axis)
RW 001 W-MODEL VCP-03B-USB REV.4_TB-928 Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
9/6/2022 9:48:12 AM

Data Results:

Avg (PASS) (2)

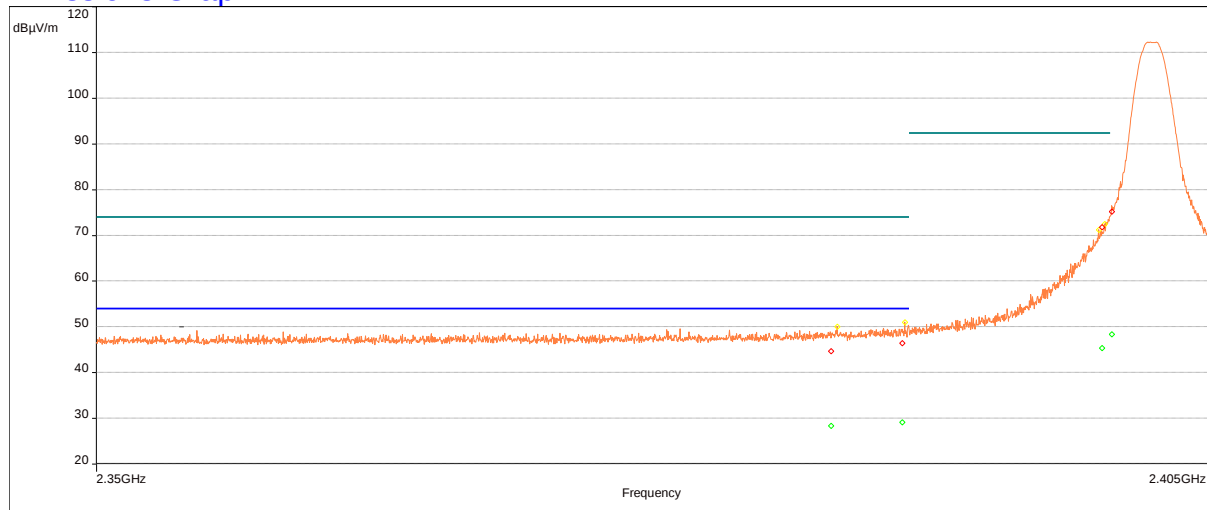
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.604803	42.52	54.00	-11.48	11.00	1.61	Vertical	1.00	-5.38
2483.805769	41.81	54.00	-12.19	191.00	3.49	Vertical	1.00	-5.38

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.604803	66.25	74.00	-7.75	11.00	1.61	Vertical	1.00	-5.38
2483.805769	65.08	74.00	-8.92	191.00	3.49	Vertical	1.00	-5.38

Lower Band Edge – Restricted Band, 2.35GHz-2.405GHz and 20 dBc (Y-axis)
RW 001 W-MODEL VCP-03B-USB REV.4_TB-928 Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
9/6/2022 10:50:49 AM

Data Results:

Avg (PASS) (4)

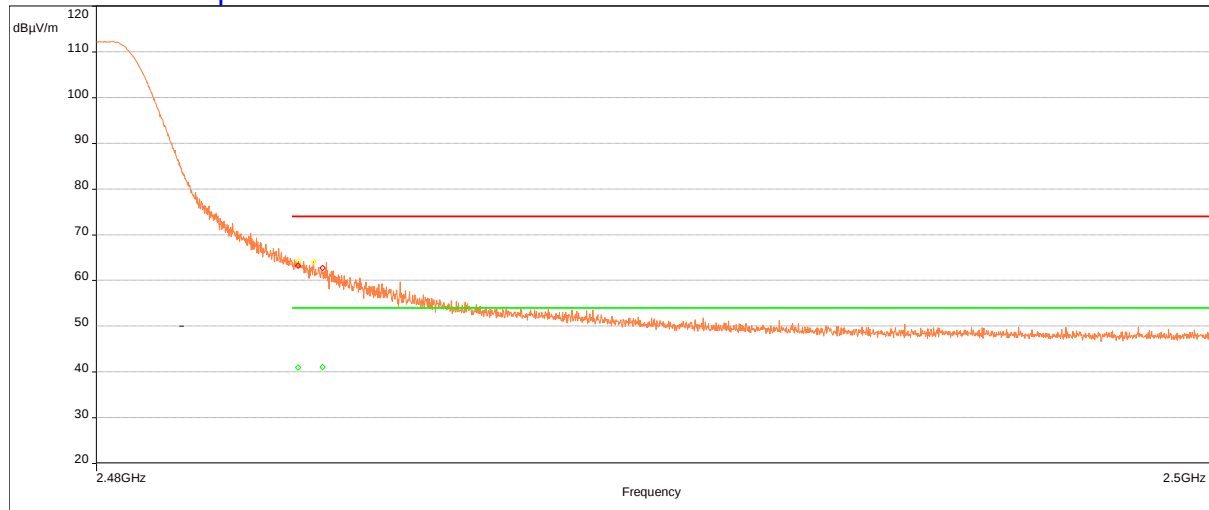
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2386.14611	28.32	54.00	-25.68	351.00	3.60	Horizontal	1.00	-5.23
2389.665679	29.18	54.00	-24.82	181.00	3.70	Horizontal	1.00	-5.23
2399.605533	45.33	92.5	-47.17	164.00	3.23	Horizontal	1.00	-5.24
2400.100777	48.37	92.5	-44.13	112.00	1.77	Horizontal	1.00	-5.24

Peak (PASS) (4)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2386.14611	44.71	74.00	-29.29	351.00	3.60	Horizontal	1.00	-5.23
2389.665679	46.48	74.00	-27.52	181.00	3.70	Horizontal	1.00	-5.23
2399.605533	71.79	92.5	-20.71	164.00	3.23	Horizontal	1.00	-5.24
2400.100777	75.22	92.5	-17.28	112.00	1.77	Horizontal	1.00	-5.24

Upper Band Edge – Restricted Band, 2.48GHz-2.5GHz (Y-axis)
RW 001 W-MODEL VCP-03B-USB REV.4_TB-928 Antenna

Emissions Graph:



Data Results:

Avg (PASS) (2)

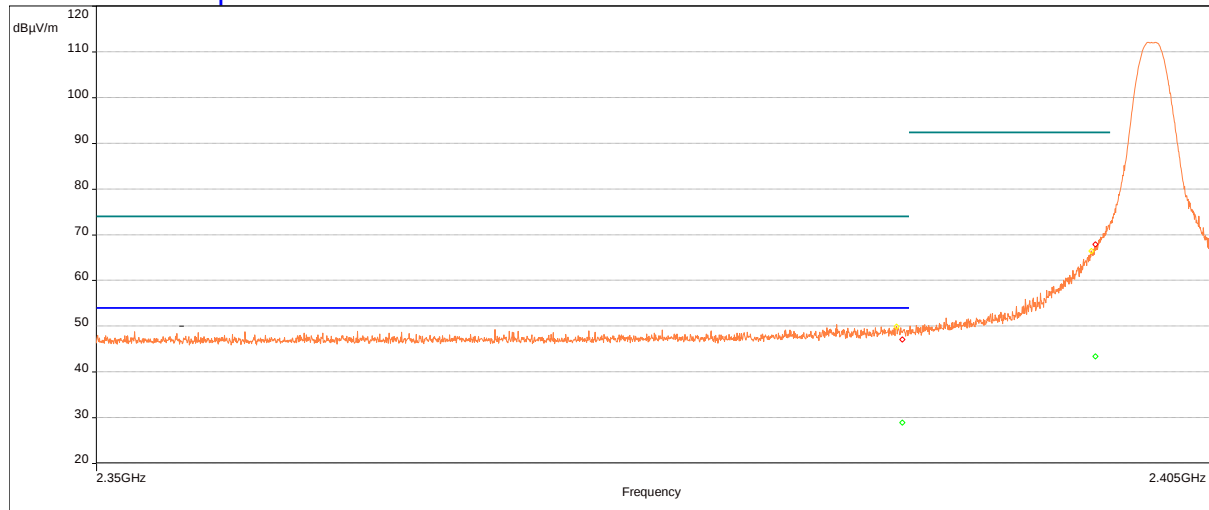
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.607482	40.95	54.00	-13.05	217.00	3.35	Horizontal	1.00	-5.38
2484.046256	41.08	54.00	-12.92	87.00	2.44	Horizontal	1.00	-5.38

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.607482	63.26	74.00	-10.74	217.00	3.35	Horizontal	1.00	-5.38
2484.046256	62.74	74.00	-11.26	87.00	2.44	Horizontal	1.00	-5.38

Lower Band Edge – Restricted Band, 2.35GHz-2.405GHz and 20 dBc (Z-axis)
RW 001 W-MODEL VCP-03B-USB REV.4_TB-928 Antenna

Emissions Graph:



FCC Part 15 Transmitters/Restricted Band
9/2/2022 3:49:09 PM

Data Results:

Avg (PASS) (2)

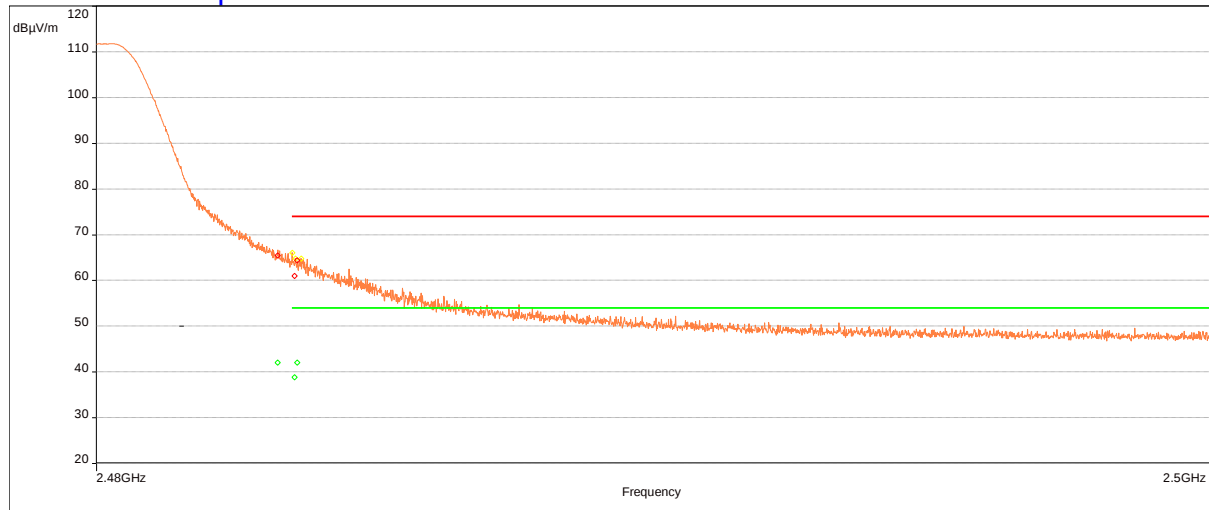
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2389.662744	28.99	54.00	-25.01	223.00	1.41	Vertical	1.00	-5.23
2399.264197	43.46	92.5	-49.04	1.00	1.27	Vertical	1.00	-5.24

Peak (PASS) (2)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2389.662744	47.11	74.00	-26.89	223.00	1.41	Vertical	1.00	-5.23
2399.264197	67.88	92.5	-24.62	1.00	1.27	Vertical	1.00	-5.24

Upper Band Edge – Restricted Band, 2.48GHz-2.5GHz (Z-axis)
RW 001 W-MODEL VCP-03B-USB REV.4_TB-928 Antenna

Emissions Graph:



Data Results:

Avg (PASS) (3)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.241185	42.03	54.00	-11.97	361.00	2.13	Vertical	1.00	-5.38
2483.541162	38.91	54.00	-15.09	57.00	1.52	Vertical	1.00	-5.38
2483.595185	42.06	54.00	-11.94	278.00	1.16	Vertical	1.00	-5.38

Peak (PASS) (3)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
2483.241185	65.48	74.00	-9.66	361.00	2.13	Vertical	1.00	-5.38
2483.541162	61.02	74.00	-12.98	57.00	1.52	Vertical	1.00	-5.38
2483.595185	64.41	74.00	-9.59	278.00	1.16	Vertical	1.00	-5.38

Test Personnel:	<u>Dan Alvarez</u>	Test Date:	<u>09/02/2022;09/06/2022; 11/10/2022</u>
Supervising/Reviewing Engineer:			
(Where Applicable)	<u>N/A</u>		
Product Standard:	<u>CFR47 FCC Part 15.247, RSS-247</u>	Limit Applied:	<u>See report section 9.3</u>
Input Voltage:	<u>Battery Powered</u>		
Pretest Verification w/ Ambient Signals or BB Source:	<u>BB Source</u>	Ambient Temperature:	<u>24 °C; 23 °C</u>
		Relative Humidity:	<u>40 %, 44 %</u>
		Atmospheric Pressure:	<u>981 mbars, 986 mbars</u>

Deviations, Additions, or Exclusions: None

12 Transmitter spurious emissions

Tests are performed in accordance with CFR47 FCC Part 15.247, 15.209, RSS-247, ANSI C63.10, and 558074 D01 15.247 Meas Guidance v05r02.

TEST SITE: EMC Lab

The EMC Lab has one Semi-anechoic Chamber and one Shielded Chamber. AC Mains Power is available at 120, 230, and 277 Single Phase; 208, 400, and 480 3-Phase. Large reference ground-planes are installed in the general lab area to facilitate EMC work not requiring a shielded environment.

12.1 Test Equipment Used:

Test Equipment Used For Conducted Emissions Test

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
232944'	EMI Receiver 10Hz-26.5GHz	Agilent	MXE-9038A	MY51210135	10/12/2022	10/12/2023
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Software Utilized:

Name	Manufacturer	Version
None	N/A	N/A

Test Equipment Used For Radiated Emissions Test

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
200003'	Attenuator, 03 dB, <18GHz	Weinschel Corp	2	BK7899	03/30/2022	03/30/2023
213451'	(20Mhz step5GHz) Omni -directional Comb Generator	Com-Power	CGO-520	281266	VBV	Verified
200162'	EMI Receiver (20Hz-40GHz)	Rohde & Schwarz	ESU 40	100314	10/13/2021	10/13/2022
MM1'	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM36	161471	09/09/2021	09/09/2022
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023
213453'	Preamplifier 500MHz-18GHz	Com-Power	PAM-118A	18040030	10/13/2021	10/13/2022
213058a'	Antenna, Horn, <18 GHz	A.H. Systems	SAS-200/571	246	02/08/2022	02/08/2023
MM8'	RF Coax Cable 9KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/13/2021	10/13/2022
E402'	Cable E402, 40 GHz, 2.9, 9"	Megaphase	TM40 K1K1 9	E402	10/13/2021	10/13/2022
E405'	Cable E405, 40 GHz, 2.9, 2m	Megaphase	TM40 K1K1 80	E405	10/13/2021	10/13/2022
213023'	Antenna, Horn, 18-40 GHz	EMCO	3116	9310-2222	03/30/2022	03/30/2023
200080'	Preamplifier, 18-40GHz, 29 dB Gain	Miteq	JS41800400-30-5P-S	818197	10/12/2021	10/12/2022
213462'	Band reject Filter 2.4-2.5GHz	Micro Tronics	BRM50702	G357	02/07/2022	02/07/2023

Test Equipment Used From 11/08/22 to 1/27/23

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
200003	Attenuator, 03 dB, <18GHz	Weinschel Corp	2	BK7899	03/30/2022	03/30/2023
MM8	RF Coax Cable 9KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/11/2022	10/11/2023
TW4 211413	RF Low loss cable 9KHz-18GHz	Fairview Microwave	FMCA1282-472	TW4	06/08/2022	06/08/2023
200074	Preamplifier, 10 MHz to 2000 MHz, 37 dB gain	Mini-Circuits	ZKL-2	D052005	08/23/2022	08/23/2023
211386'	Antenna, BiLog, 20-2000MHz	Chase	CBL6112B	2622	05/26/2022	05/26/2023
213451	(20Mhz step5GHz) Omni -directional Comb Generator	Com-Power	CGO-520	281266	VBV	Verified
200162	EMI Receiver (20Hz-40GHz)	Rohde & Schwarz	ESU 40	100314	10/11/2022	10/11/2023
MM5	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM-118	163203	02/07/2022	02/07/2023
MM1	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM36	161471	10/11/2022	10/11/2023
212165	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023
213023	Antenna, Horn, 18-40 GHz	EMCO	3116	9310-2222	03/30/2022	03/30/2023
213462	Band reject Filter 2.4-2.5GHz	Micro Tronics	BRM50702	G357	02/07/2022	02/07/2023
213453	Preamplifier 500MHz-18GHz	Com-Power	PAM-118A	18040030	10/12/2022	10/12/2023
213058a	Antenna, Horn, <18 GHz	A.H. Systems	SAS-200/571	246	02/08/2022	02/08/2023
MM3	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM36	769548	06/08/2022	06/08/2023
213057	Antenna, Monopole, Active (10kHz to 60MHz)	A.H. Systems	SAS-200/550-1	694	05/17/2022	05/17/2023
MM8	RF Coax Cable 10KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/11/2022	10/11/2023

Name	Manufacturer	Version
BAT-EMC	Nexio	3.19.1.18

12.2 Results:

The sample tested was found to Comply with the following modification:

- Fair-Rite model 0461178181 on the input power cable with 2 turns.

Found that with the transmitter set to receive and not transmitting, the board produced disturbances that were above the FCC Part B Class B limit. The ferrite added helped to reduce those unintentional

disturbances to a compliant level.

Testing for non-restricted band emissions was performed using the Conducted Method. Low channel, Mid, and High Channels were tested. Testing for spurious restricted band was performed using Radiated Emissions method.

On graphs that state a power setting, this number represents how many levels down from max power the power setting was adjusted to achieve compliance. Example: Power 1 represents that the power setting was reduce by 1 level; Full Power is with the transmitter set at maximum power; Power 3 represents that the power setting was reduced by 3 levels.

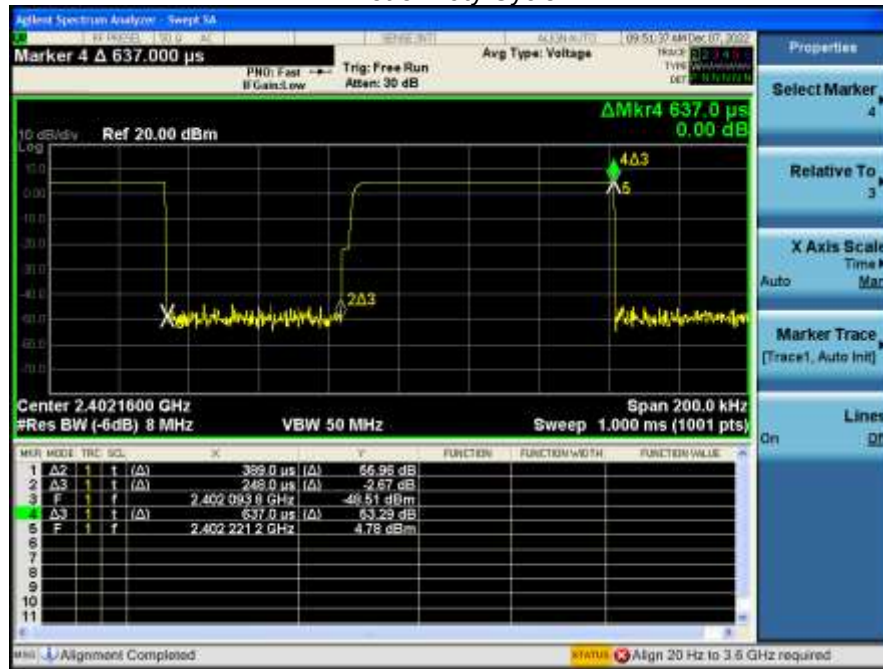
Testing was performed in X-Axis (With sample upright on table), Y-Axis (With sample standing up on side of board), and Z-Axis (With sample flat on table).

Testing was performed in X, Y, and Z axis in FHSS mode to determine the worst-case azimuth orientation of the transmitter. Low, Mid, and High Channel was then performed in worst case azimuth orientation.

Duty Cycle correction factor (DCCF) of -4.28 dB was used to take into account duty cycle of transmitter module of 637us total time.

Duty cycle was measured to be 61%. Duty Cycle correction factor (DCCF) = $20 \cdot \log(0.61) = -4.28$ This factor was added to harmonics of the fundamental to provide the correct calculated measurement to compare against the limit.

Plot of Duty Cycle



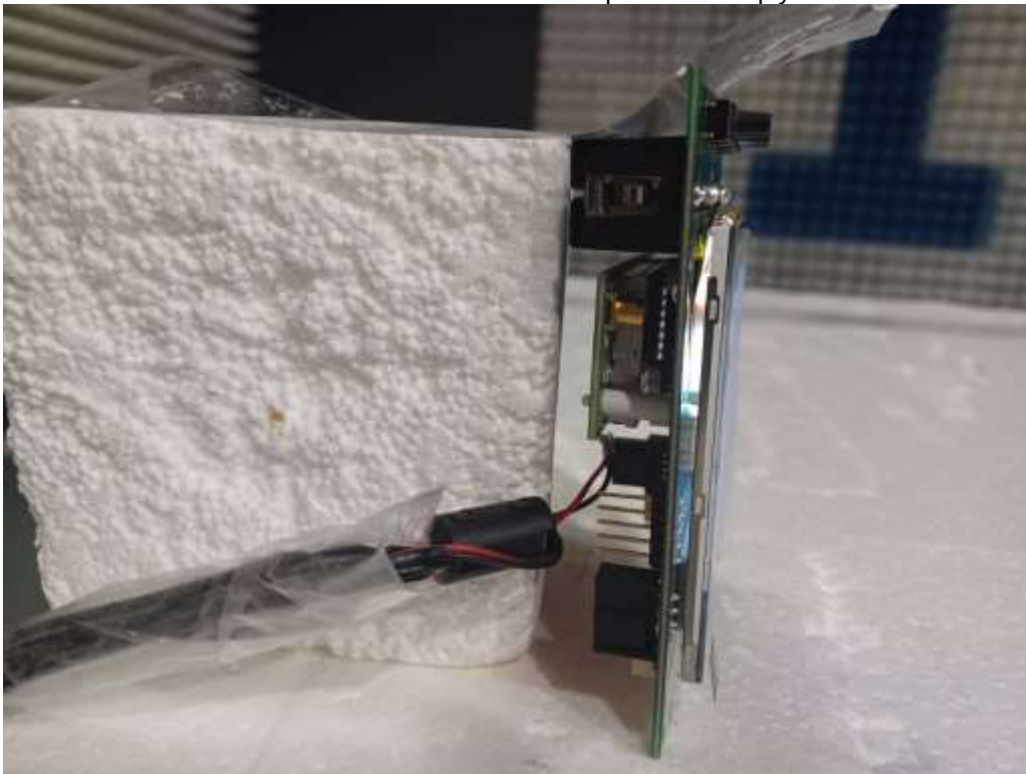
389us on time
248us off time
637us total time

12.3 Setup Photograph:

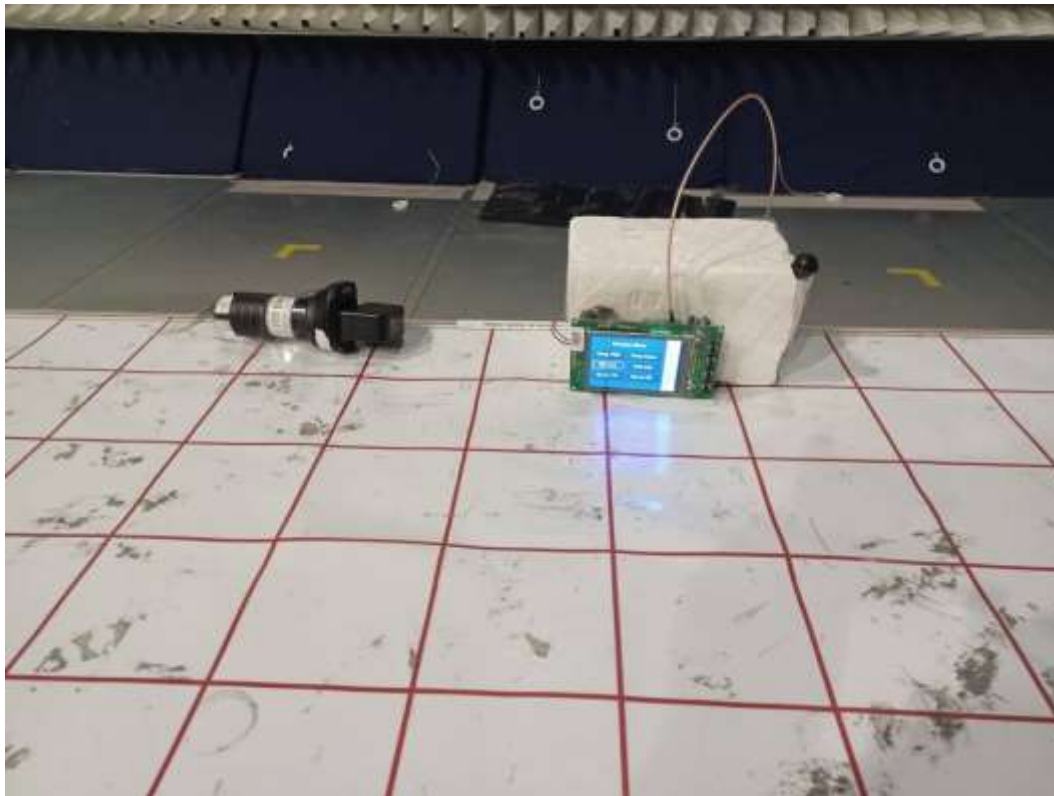
Conducted spurious emissions



Photo of ferrite modification required to comply.



X-Axis Orientation with TB-928 antenna



Y-Axis Orientation with TB-928 antenna



Z-Axis Orientation with TB-928 antenna



30 MHz to 1 GHz with TB-928 antenna (X-Axis)



30 MHz to 1 GHz with 2450AT18A100 Chipset antenna (Y-Axis)



Above 1 GHz TB-928 antenna (Z-Axis)



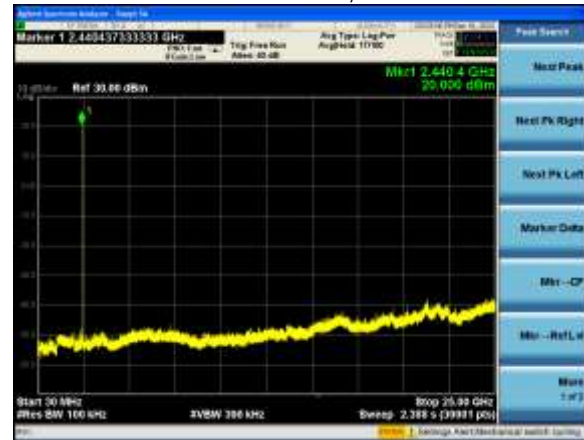
12.4 Plots/Data:

Conducted spurious emissions

Low Channel, 30 MHz-25 GHz



Mid Channel, 30 MHz-25 GHz



High Channel, 30 MHz-25 GHz



Note: When configured at one setting below max power.

Test Personnel: Troy Ihle TJI
 Supervising/Reviewing Engineer: _____
 (Where Applicable)
 Product Standard: FCC Part 15 Subpart C, ICES-003
 Input Voltage: 5 VDC via Ext. Power Supply
 Pretest Verification w/ Ambient Signals or BB Source: N/A

Test Date: 12/01/2022

Limit Applied: FCC Part 15.209, FCC Part 15.205

Ambient Temperature: 23.3 °C

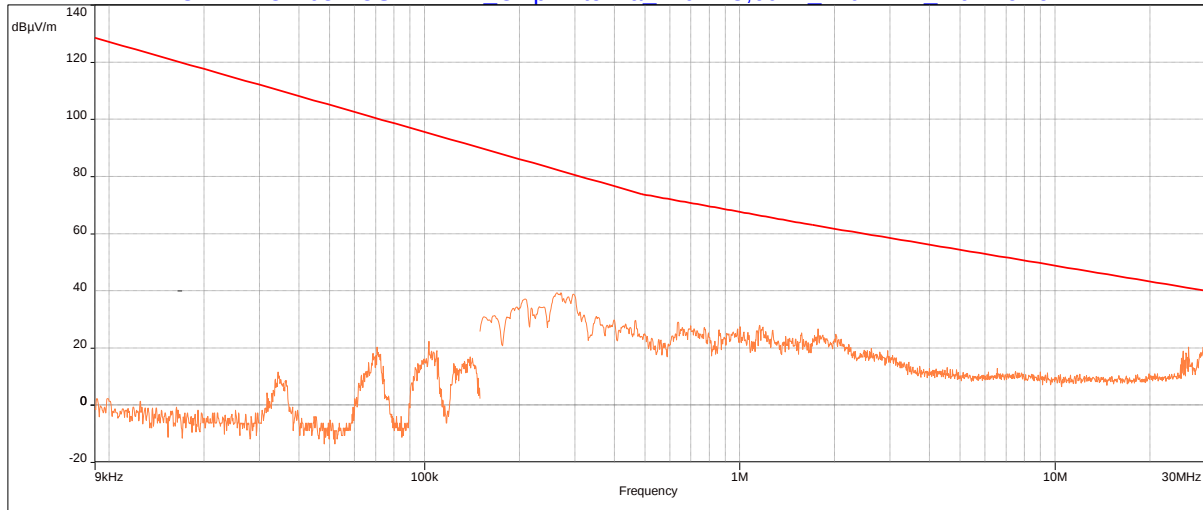
Relative Humidity: 22.6 %

Atmospheric Pressure: 996.1 mbars

Deviations, Additions, or Exclusions: None

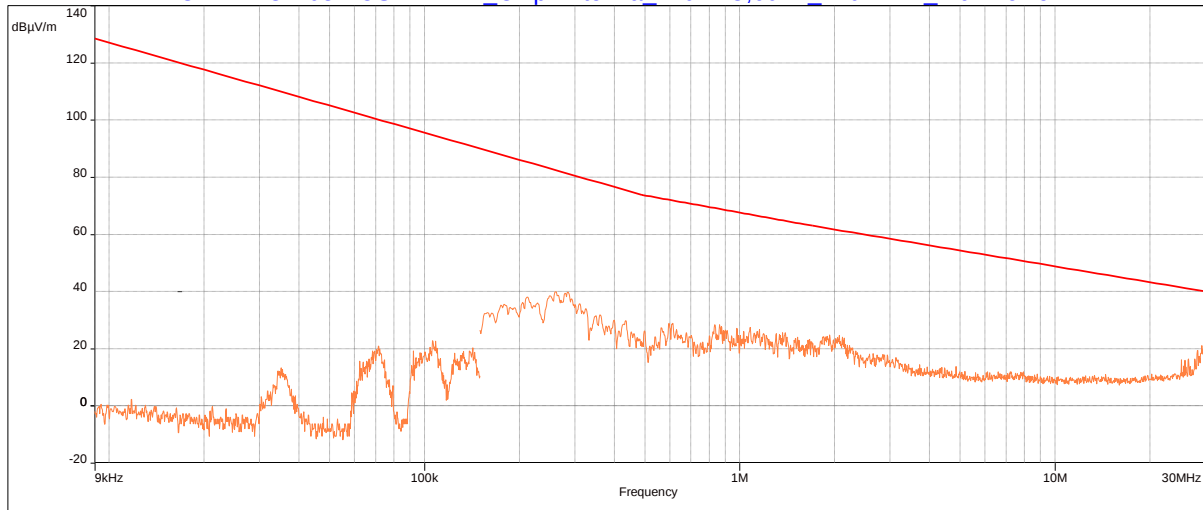
Note: Radiated emissions tests from 9kHz to 30MHz were performed for each channel in each azimuth. The worst-case results are shown below:

FCC 15.209_9kHz-30MHz- Class 9kHz-30MHz. (Low Channel, X-Axis), Chip Antenna RW 001 W-MODEL VCP-03B-USB REV.4 Chip Antenna 120VAC,60Hz 2402MHz Full Power



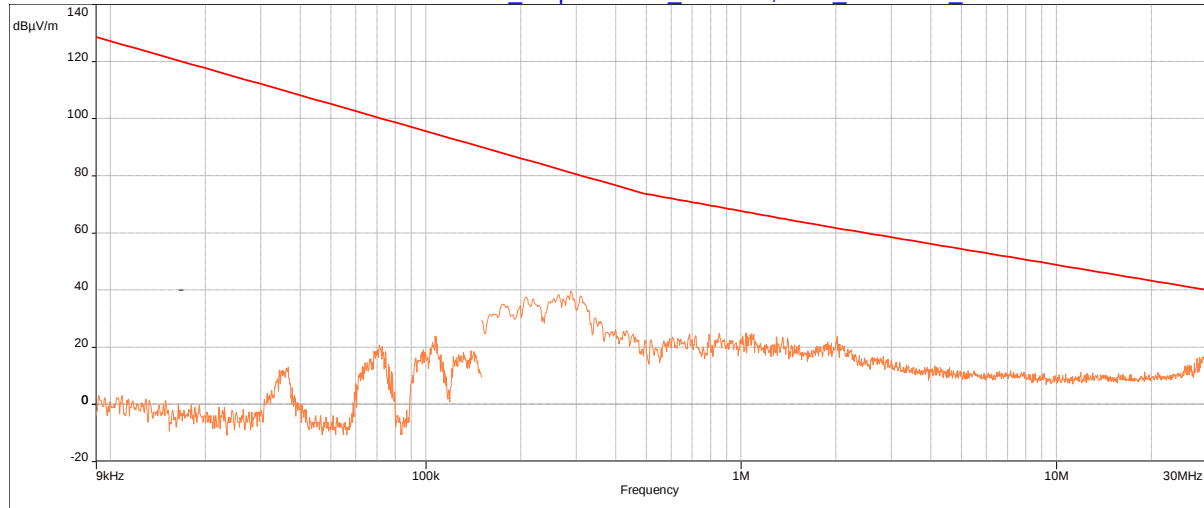
FCC Part 15/FCC 15.209_9kHz-30MHz

FCC 15.209_9kHz-30MHz- Class 9kHz-30MHz. (Low Channel, Y-Axis), Chip Antenna RW 001 W-MODEL VCP-03B-USB REV.4 Chip Antenna 120VAC,60Hz 2402MHz Full Power



FCC Part 15/FCC 15.209_9kHz-30MHz

FCC 15.209_9kHz-30MHz- Class 9kHz-30MHz. (Low Channel, Z-Axis), Chip Antenna RW 001 W-
MODEL VCP-03B-USB REV.4_Chip Antenna_120VAC,60Hz_2402MHz_Full Power

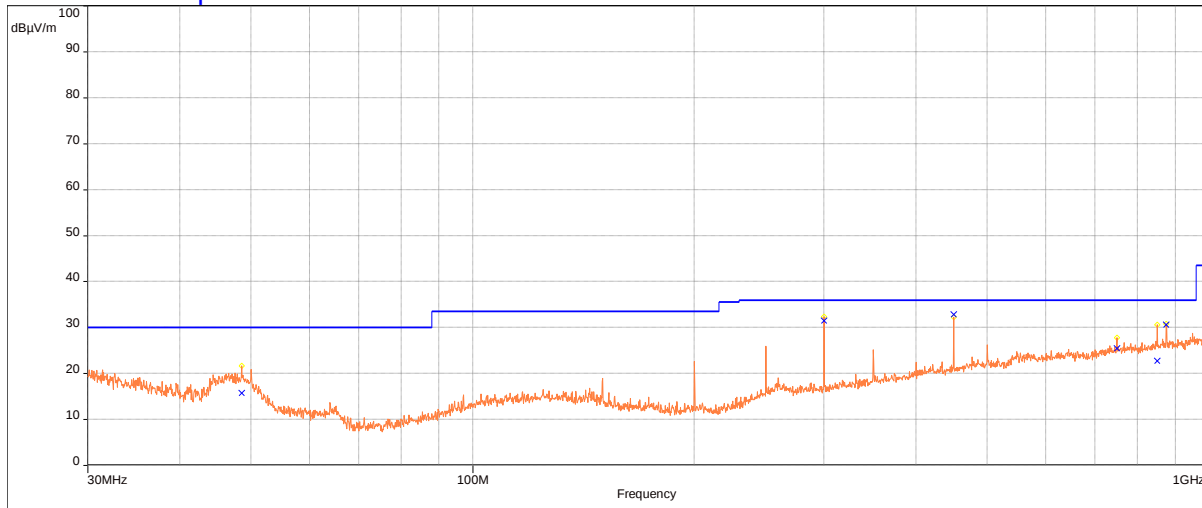


FCC Part 15/FCC 15.209_9kHz-30MHz
1/27/2023 8:20:12 AM

Note: Y-Axis was worst case azimuth for 30MHz to 1 GHz.

FCC Part 15 & ICES-003 Class B, 30MHz-1GHz (Low Channel, Y-Axis), Chip Antenna
RW 001 W-MODEL VCP-03B-USB REV.4_Chip Antenna_120VAC,60Hz_2402MHz_
Full Power_Y-Axis_standing on table_RE 30MHz-1GHz

Emissions Graph:



FCC Part 15/FCC Part 15 ICESB
11/8/2022 11:14:28 AM

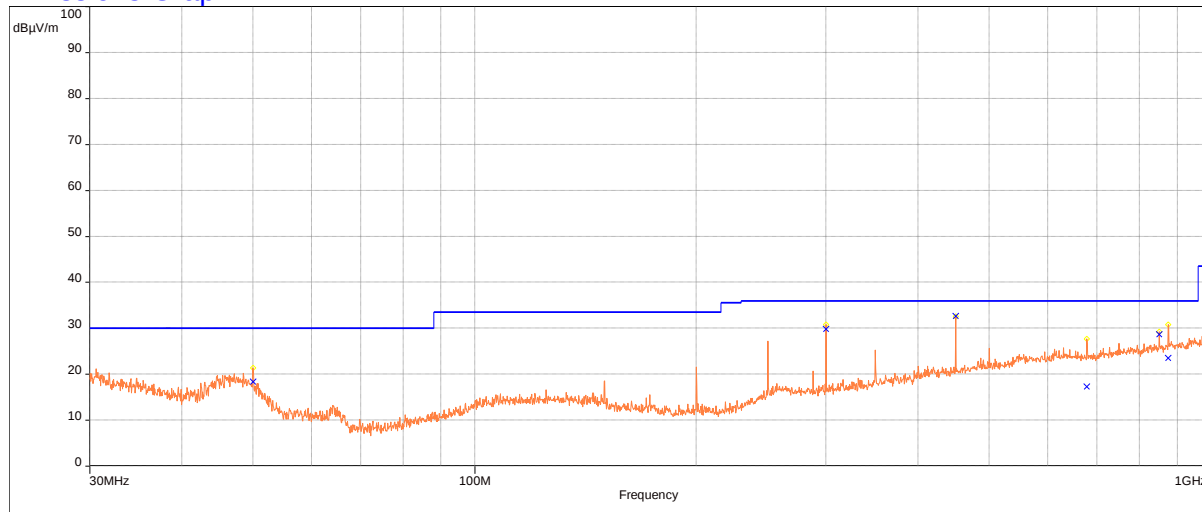
Data Results:

QuasiPeak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (kHz)	Correction (dB)
48.56141633	15.77	30.00	-14.23	13.00	2.37	Vertical	120.00	-21.70
300.0081379	31.46	36.00	-4.54	264.00	1.02	Vertical	120.00	-15.69
450.0122436	32.84	36.00	-3.16	325.00	2.14	Horizontal	120.00	-11.45
750.0204649	25.46	36.00	-10.54	299.00	1.00	Horizontal	120.00	-7.33
850.0232146	22.72	36.00	-13.28	191.00	3.62	Vertical	120.00	-6.46
875.0236572	30.64	36.00	-5.36	352.00	1.01	Horizontal	120.00	-6.31

FCC Part 15 & ICES-003 Class B, 30MHz-1GHz (Mid Channel, Y-Axis), Chip Antenna
 RW 001 W-MODEL VCP-03B-USB REV.4_Chip Antenna_120VAC,60Hz_2440MHz_Full
 Power_Y-Axis_standing on table_RE 30MHz-1GHz

Emissions Graph:



FCC Part 15/FCC Part 15 JCESB
 11/8/2022 12:27:37 PM

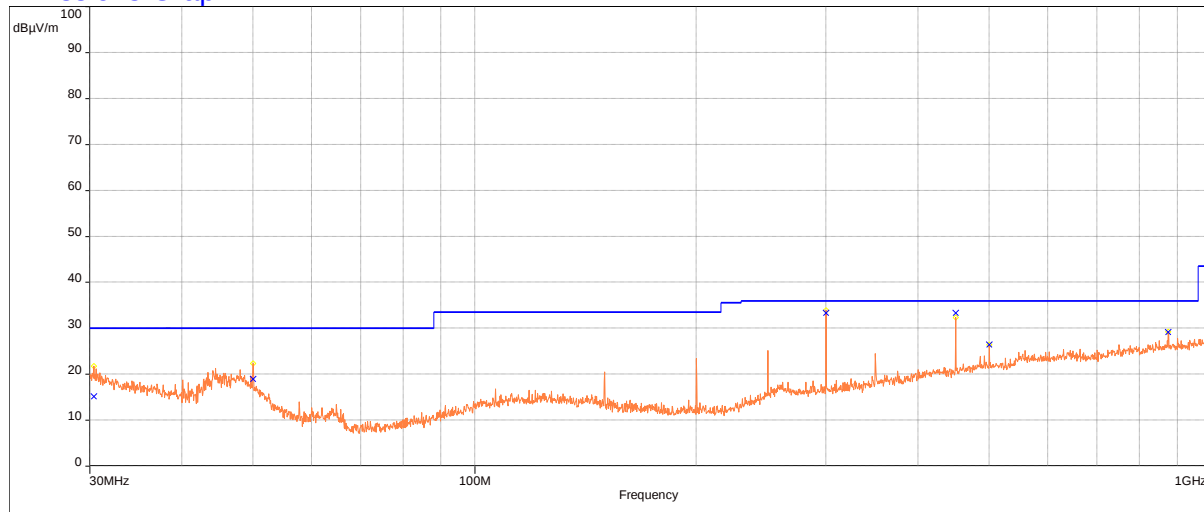
Data Results:

QuasiPeak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (kHz)	Correction (dB)
50.00123077	18.36	30.00	-11.64	180.00	1.72	Vertical	120.00	-22.36
300.0081379	29.87	36.00	-6.13	262.00	1.00	Vertical	120.00	-15.69
450.0122436	32.66	36.00	-3.34	323.00	2.36	Horizontal	120.00	-11.45
678.2831379	17.27	36.00	-18.73	290.00	2.35	Vertical	120.00	-8.38
850.0230962	28.63	36.00	-7.37	328.00	1.96	Vertical	120.00	-6.46
875.0239777	23.57	36.00	-12.43	35.00	2.02	Horizontal	120.00	-6.31

FCC Part 15 & ICES-003 Class B, 30MHz-1GHz (High Channel, Y-Axis), Chip Antenna
RW 001 W-MODEL VCP-03B-USB REV.4_Chip Antenna_120VAC,60Hz_2480MHz_Full
Power_Y-Axis_standing on table_RE 30MHz-1GHz

Emissions Graph:



Data Results:

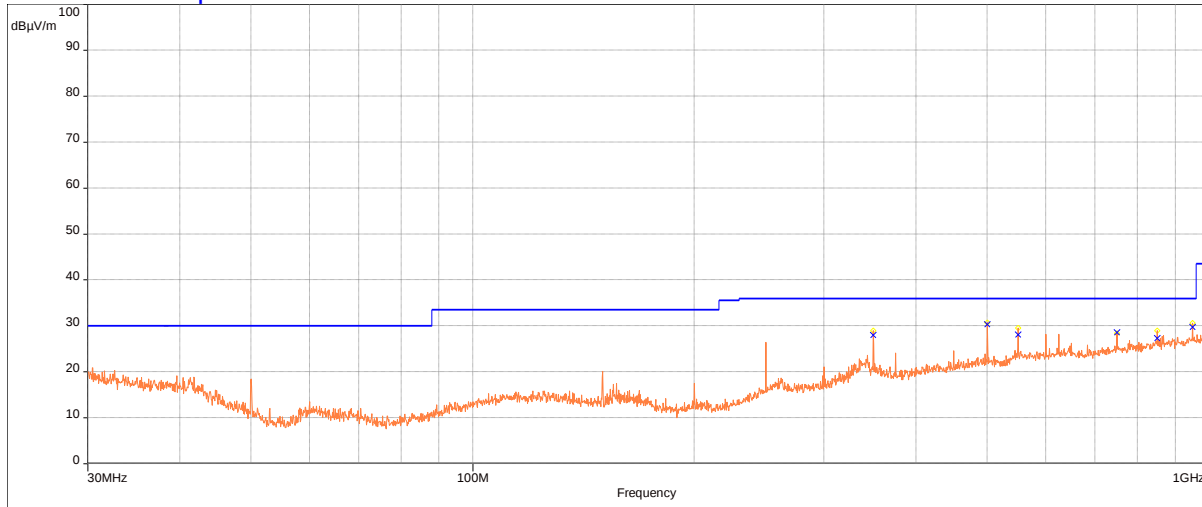
QuasiPeak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (kHz)	Correction (dB)
30.37485897	15.15	30.00	-14.85	358.00	1.88	Vertical	120.00	-12.92
50.00139103	18.92	30.00	-11.08	293.00	2.33	Vertical	120.00	-22.36
300.0082982	33.33	36.00	-2.67	271.00	1.00	Vertical	120.00	-15.69
450.0124038	33.37	36.00	-2.63	322.00	2.19	Horizontal	120.00	-11.45
500.0136444	26.47	36.00	-9.53	313.00	2.22	Horizontal	120.00	-10.39
875.0239777	29.18	36.00	-6.82	133.00	2.03	Vertical	120.00	-6.31

Note: Z-Axis was worst case azimuth for 30MHz to 1 GHz.

FCC Part 15 & ICES-003 Class B, 30MHz-1GHz (Low Channel, Z-Axis), TB-928 antenna
RW 001 W-MODEL VCP-03B-USB REV.5_120VAC,60Hz_2402 MHz_Z-Axis_flat on table_RE
30MHz-1GHz_TB-928 antenna

Emissions Graph:



FCC Part 15/FCC Part 15 JCESB
11/9/2022 11:04:10 AM

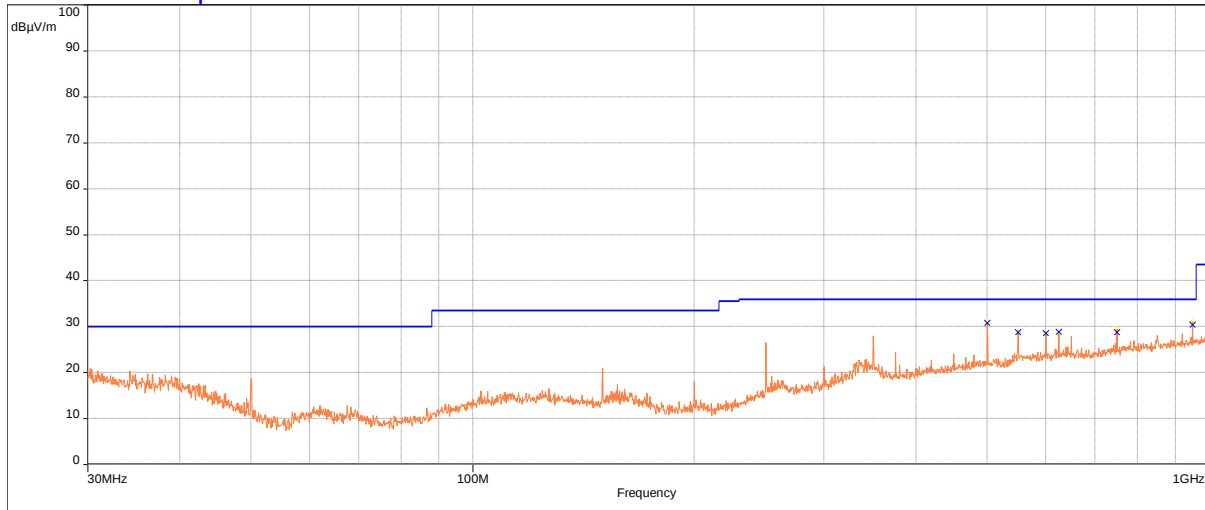
Data Results:

QuasiPeak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (kHz)	Correction (dB)
350.0102115	27.96	36.00	-8.04	358.00	2.10	Horizontal	120.00	-14.12
500.0142854	30.37	36.00	-5.63	155.00	1.42	Horizontal	120.00	-10.39
550.0158782	28.05	36.00	-7.95	325.00	1.05	Horizontal	120.00	-8.82
750.0215449	28.54	36.00	-7.46	166.00	1.01	Horizontal	120.00	-7.33
850.0243782	27.34	36.00	-8.66	28.00	3.31	Horizontal	120.00	-6.46
950.0273718	29.78	36.00	-6.22	172.00	2.72	Horizontal	120.00	-5.66

FCC Part 15 & ICES-003 Class B, 30MHz-1GHz (Mid Channel, Z-Axis), TB-928 antenna
 RW 001 W-MODEL VCP-03B-USB REV.5_120VAC,60Hz_2440 MHz_Z-Axis_flat on table_RE
 30MHz-1GHz_TB-928 antenna

Emissions Graph:



FCC Part 15/FCC Part 15_JCESB
 11/9/2022 9:19:26 AM

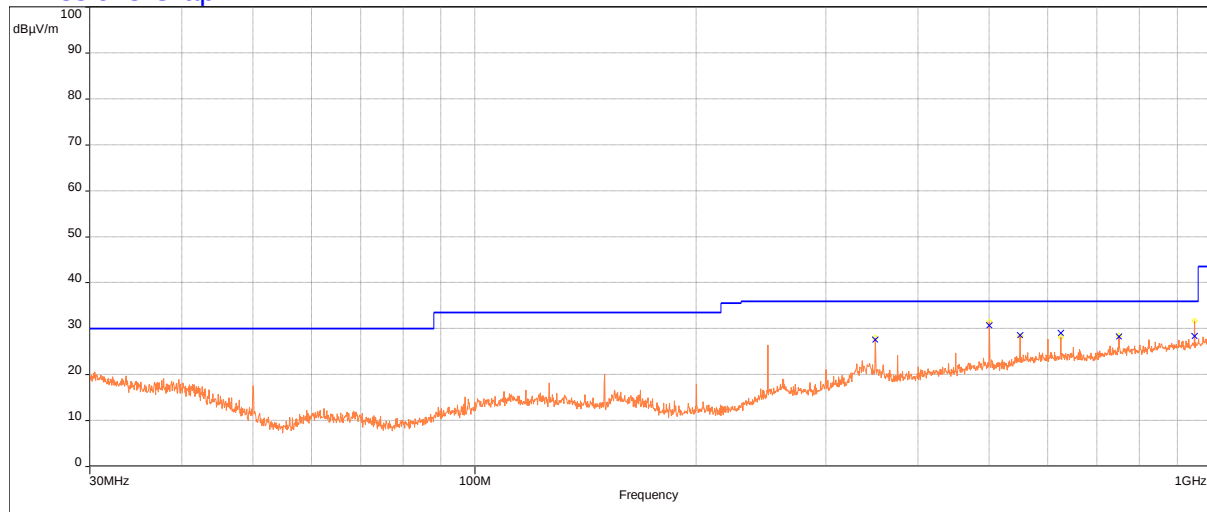
Data Results:

QuasiPeak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (kHz)	Correction (dB)
500.0142854	30.79	36.00	-5.21	159.00	1.51	Horizontal	120.00	-10.39
550.0157179	28.77	36.00	-7.23	330.00	1.72	Horizontal	120.00	-8.82
600.0171187	28.60	36.00	-7.40	16.00	1.16	Horizontal	120.00	-8.75
625.0177982	28.88	36.00	-7.12	185.00	1.51	Horizontal	120.00	-8.37
750.0213846	28.78	36.00	-7.22	166.00	1.17	Horizontal	120.00	-7.33
950.0270513	30.40	36.00	-5.60	163.00	2.80	Horizontal	120.00	-5.66

FCC Part 15 & ICES-003 Class B, 30MHz-1GHz (High Channel, Z-Axis), TB-928 antenna
 RW 001 W-MODEL VCP-03B-USB REV.5_120VAC,60Hz_2480 MHz_Z-Axis_flat on table_RE
 30MHz-1GHz_TB-928 antenna

Emissions Graph:



FCC Part 15/FCC Part 15_JCESB
 11/9/2022 10:22:26 AM

Data Results:

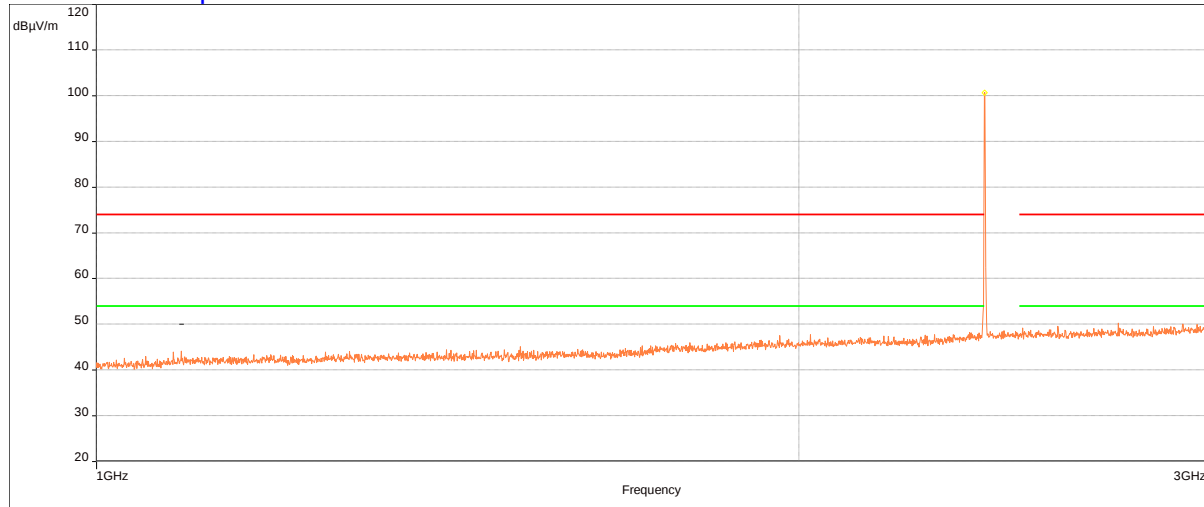
QuasiPeak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (kHz)	Correction (dB)
350.0100931	27.59	36.00	-8.41	7.00	2.61	Horizontal	120.00	-14.12
500.0143172	30.69	36.00	-5.31	157.00	1.44	Horizontal	120.00	-10.39
550.0157179	28.59	36.00	-7.41	332.00	1.76	Horizontal	120.00	-8.82
625.0177982	29.02	36.00	-6.98	181.00	1.10	Horizontal	120.00	-8.37
750.0213846	28.27	36.00	-7.73	164.00	1.00	Horizontal	120.00	-7.33
950.0272115	28.43	36.00	-7.57	152.00	1.10	Horizontal	120.00	-5.66

Note: Y-Axis was worst case azimuth for 1-3 GHz.

FCC Part 15.205 and 15.209, 1-3 GHz (Low Channel, Y-Axis), Chip antenna
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna_Y-Axis_2402 MHz_RE_1GHz-3GHz

Emissions Graph:

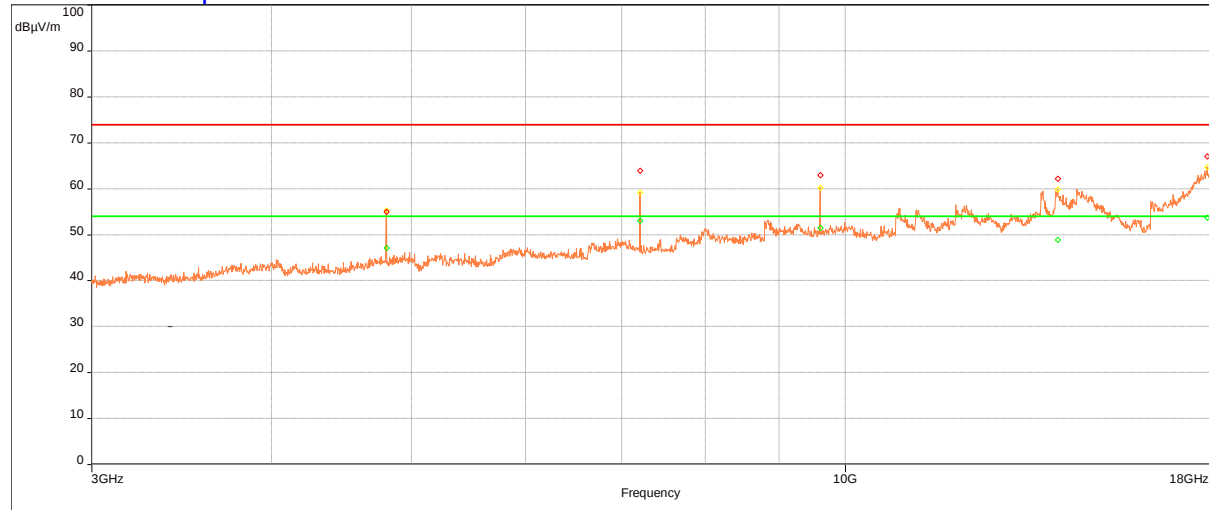


FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
11/9/2022 1:54:16 PM

Data Results: No emission was detected.

**FCC Part 15.205 and 15.209, 3-18 GHz (Low Channel, Y-Axis), Chip antenna
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna_Y-Axis_2402 MHz_Band Reject
Filter_2.4G_Power 1_RE_3GHz-18GHz**

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB

11/9/2022 3:07:14 PM

*Note: Frequency at 17833.64263 MHz was high due to noise floor. This point was manually re-measured at 1 meter distance and found to comply.

Data Results:

Corrected Average Values

Frequency (MHz)	Level (dBμV/m)	DCCF	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
4804.299679	47.15	-4.28	54.00	-11.13	172.00	1.13	Vertical	1.00	0.97

Avg (PASS)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m) 1 meter	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
17833.64263	53.78	64.00	-10.22	200.00	3.04	Vertical	1.00	24.19

Avg (The following frequencies do not fall within the restricted band frequencies and were compared to the 20dB)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7206.782051	53.09	80.00	-26.91	214.00	1.21	Horizontal	1.00	6.28
9608.913462	51.50	80.00	-28.50	198.00	1.13	Horizontal	1.00	10.32
14044.68269	48.92	80.00	-31.08	34.00	1.62	Vertical	1.00	17.78

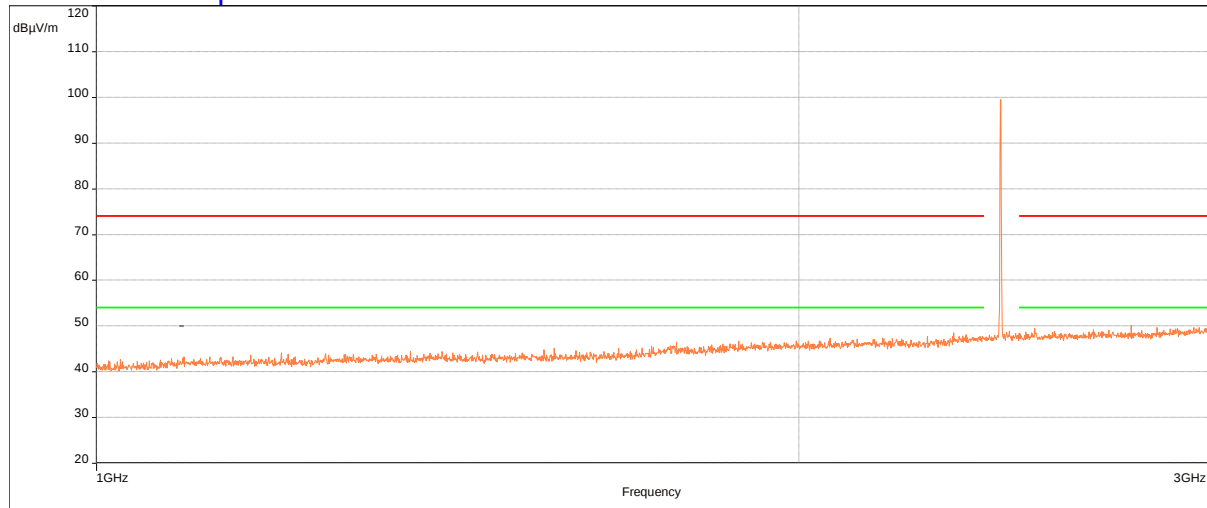
Peak (PASS) (5)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
4804.299679	55.05	74.00	-18.95	172.00	1.13	Vertical	1.00	0.97
7206.782051	63.93	74.00	-10.07	214.00	1.21	Horizontal	1.00	6.28
9608.913462	62.96	74.00	-11.04	198.00	1.13	Horizontal	1.00	10.32
14044.68269	62.18	74.00	-11.82	34.00	1.62	Vertical	1.00	17.78
17833.64263	67.03	74.00	-6.97	200.00	3.04	Vertical	1.00	24.19

Hand scanned to 25 GHz. No discernable emissions detected above 18 GHz.

FCC Part 15.205 and 15.209, 1-3 GHz (Mid Channel, Y-Axis), Chip antenna
 FCC Part 15.205, 15.209_RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna_Y-
 Axis_2440 MHz_Power 1_RE_1GHz-3GHz

Emissions Graph:

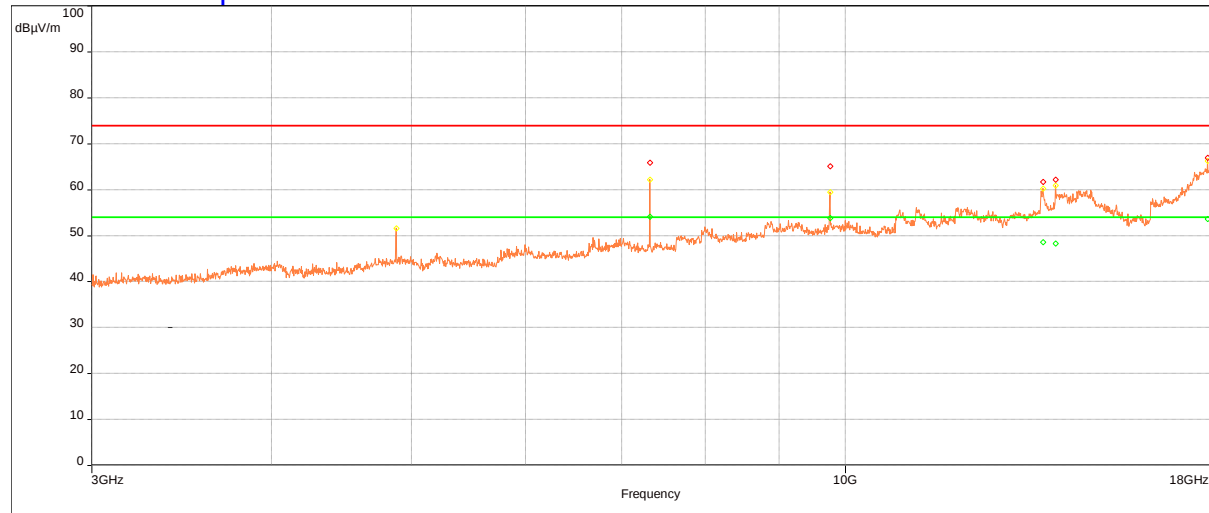


FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
 11/10/2022 10:21:29 AM

Data Results: No emission was detected.

**FCC Part 15.205 and 15.209, 3-18 GHz (Mid Channel, Y-Axis), Chip antenna
RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna_Y-Axis_2440 MHz_Band
Reject Filter_2.4G_Power 1_RE_3GHz-18GHz**

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB

11/10/2022 11:25:19 AM

*Note: Frequency at 17842.94872 MHz was high due to noise floor. This point was manually re-measured at 1 meter distance and found to comply.

Data Results:

Corrected Average Values

Frequency (MHz)	Level (dBμV/m)	DCCF	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7319.764423	54.18	-4.28	54.00	-4.01	124.00	1.11	Horizontal	1.00	6.81

Avg (PASS) (4)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m) 1 meter	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
17842.94872	53.69	64.00	-10.31	76.00	2.07	Vertical	1.00	24.22

Avg (The following frequencies do not fall within the restricted band frequencies and were compared to the 20dB)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
9760.391026	53.87	80.00	-26.13	183.00	3.22	Vertical	1.00	10.37
13719.12981	48.58	80.00	-31.42	162.00	2.86	Vertical	1.00	16.86
14000.53846	48.33	80.00	-31.67	327.00	3.11	Vertical	1.00	17.65

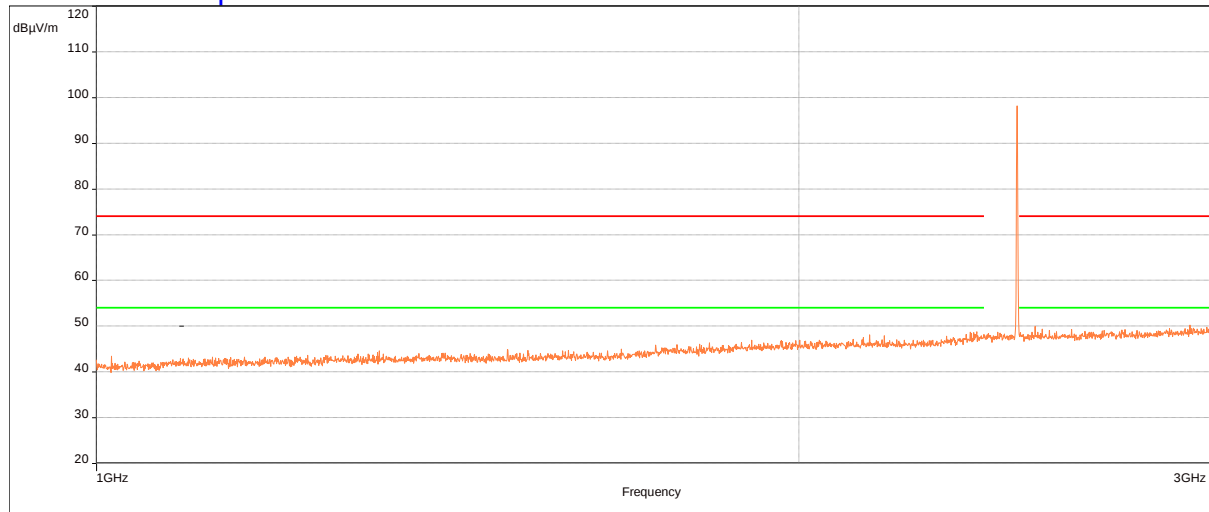
Peak (PASS) (5)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7319.764423	65.93	74.00	-8.07	124.00	1.11	Horizontal	1.00	6.81
9760.391026	65.11	74.00	-8.89	183.00	3.22	Vertical	1.00	10.37
13719.12981	61.68	74.00	-12.32	162.00	2.86	Vertical	1.00	16.86
14000.53846	62.16	74.00	-11.84	327.00	3.11	Vertical	1.00	17.65
17842.94872	66.98	74.00	-7.02	76.00	2.07	Vertical	1.00	24.22

Hand scanned to 25 GHz. No discernable emissions detected above 18 GHz.

FCC Part 15.205 and 15.209, 1-3 GHz (High Channel, Y-Axis), Chip antenna.
 RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna_Y-Axis_2480 MHz_Power
 1_RE_1GHz-3GHz

Emissions Graph:

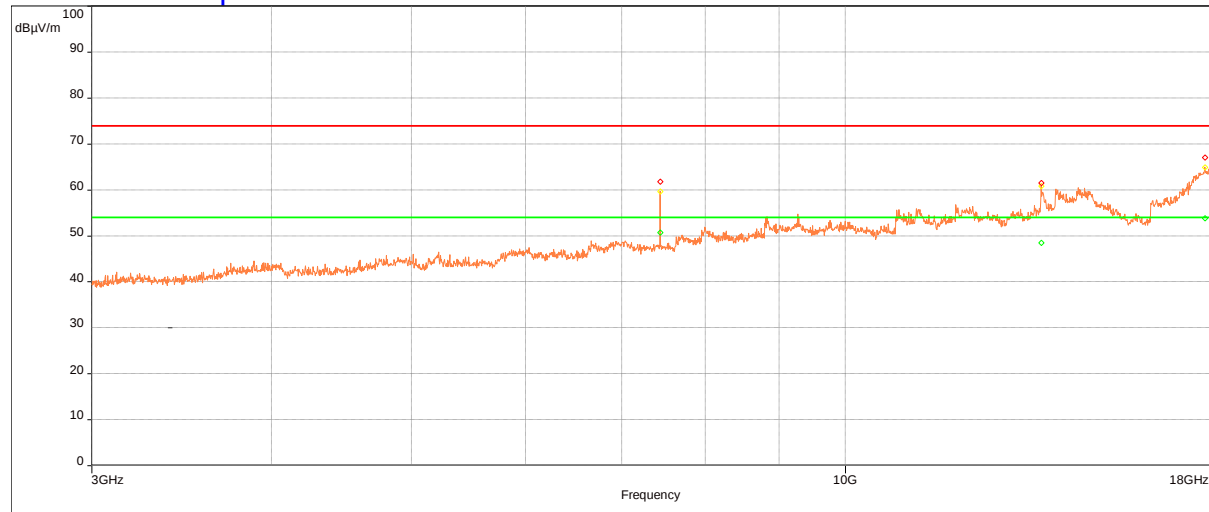


FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
 11/10/2022 11:28:57 AM

Data Results: No emission was detected.

FCC Part 15.205 and 15.209, 3-18 GHz (High Channel, Y-Axis), Chip antenna.
 RW 001 W-MODEL VCP-03B-USB REV.5_Chip Antenna_Y-Axis_2480 MHz_Band
 Reject Filter_2.4G_Power 1_RE_3GHz-18GHz

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
 11/10/2022 11:37:00 AM

*Note: Frequency at 17766.41827 MHz was high due to noise floor. This point was manually re-measured at 1 meter distance and found to comply.

Data Results:

Corrected Average Values

Frequency (MHz)	Level (dBμV/m)	DCCF	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7440.786859	50.74	-4.28	54.00	-7.54	117.00	1.12	Horizontal	1.00	7.05

Avg (PASS)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m) 1 meter	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
17766.41827	53.81	64.00	-10.19	224.00	3.30	Vertical	1.00	23.84

Avg (The following frequencies do not fall within the restricted band frequencies and were compared to the 20dB)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
13678.74519	48.49	80.00	-31.51	137.00	1.38	Vertical	1.00	16.82

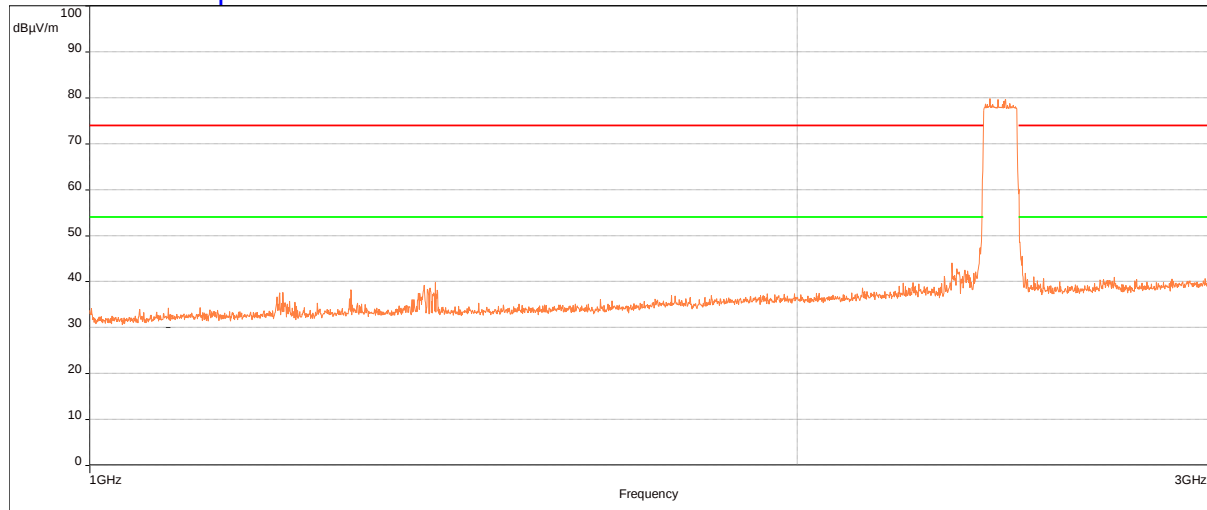
Peak (PASS) (3)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7440.786859	61.84	74.00	-12.16	117.00	1.12	Horizontal	1.00	7.05
13678.74519	61.57	74.00	-12.43	137.00	1.38	Vertical	1.00	16.82
17766.41827	67.04	74.00	-6.96	224.00	3.30	Vertical	1.00	23.84

Hand scanned to 25 GHz. No discernable emissions detected above 18 GHz.

FCC Part 15.205 and 15.209, 1-3 GHz (Mid-Channel, X-Axis), TB-928 Antenna.
FCC Part 15.205, 15.209, 30MHz-18GHz- Class B 1GHz-3GHz.
RW 001 W-MODEL VCP-03B-USB REV.4_X-Axis_Hopping_TB-928
antenna_RE_1GHz-3GHz

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
9/8/2022 9:03:00 AM

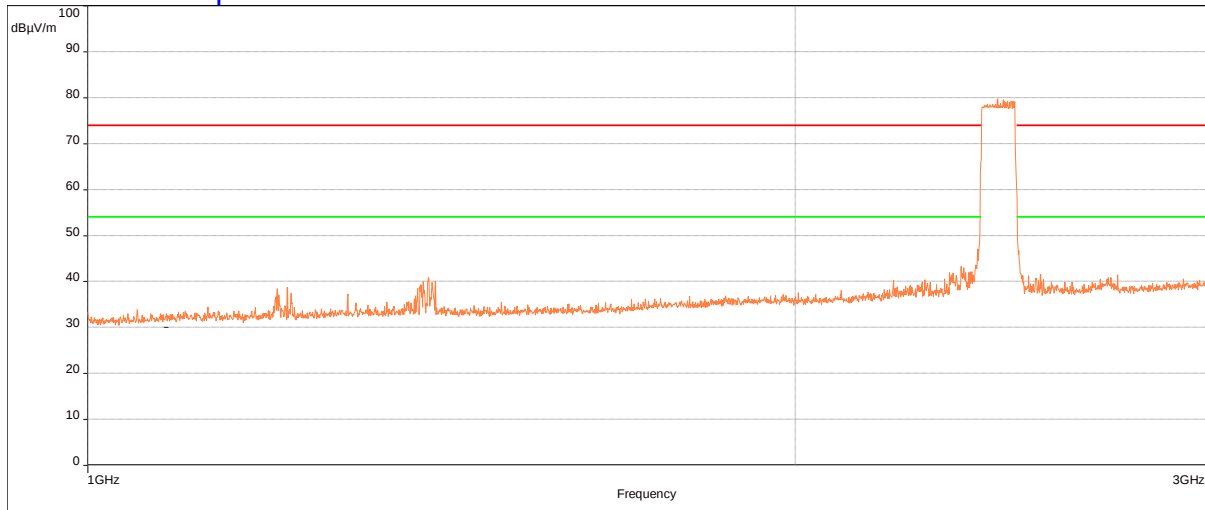
Data Results: No emission was detected.

FCC Part 15.205 and 15.209, 1-3 GHz (Mid-Channel, Y-Axis), TB-928 Antenna.

FCC Part 15.205, 15.209, 30MHz-18GHz- Class B 1GHz-3GHz.

RW 001 W-MODEL VCP-03B-USB REV.4_Y-Axis_Hopping_RE_1GHz-3GHz_TB-928 antenna

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB

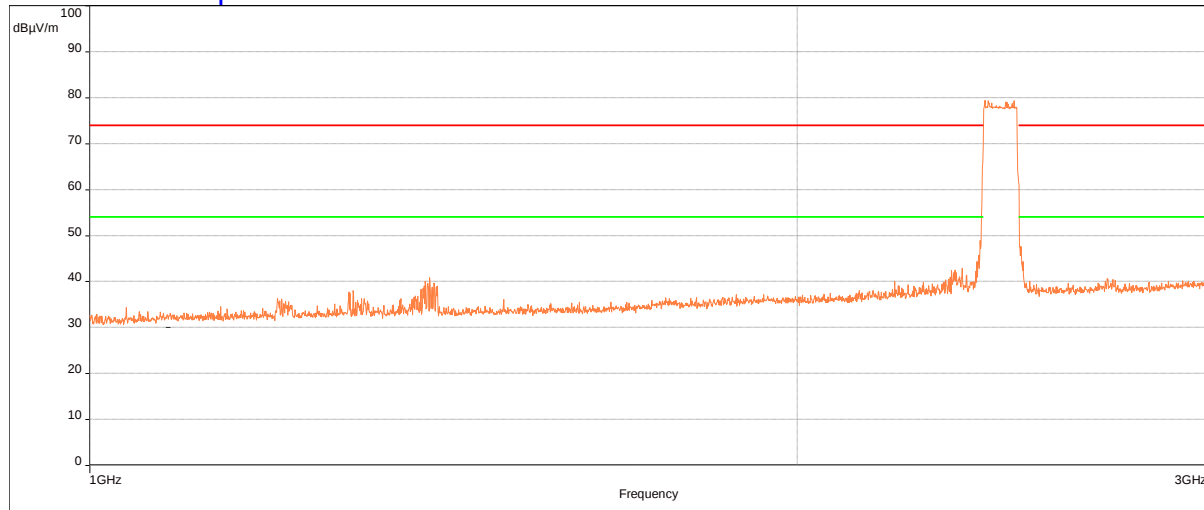
9/6/2022 12:08:11 PM

Data Results: No emission was detected.

FCC Part 15.205 and 15.209, 1-3 GHz (Mid-Channel, Z-Axis), TB-928 Antenna.

FCC Part 15.205, 15.209, 30MHz-18GHz- Class B 1GHz-3GHz.

RW 001 W-MODEL VCP-03B-USB REV.4_Z-Axis_Hopping_RE_1GHz-3GHz_TB-928 antenna
Emissions Graph:



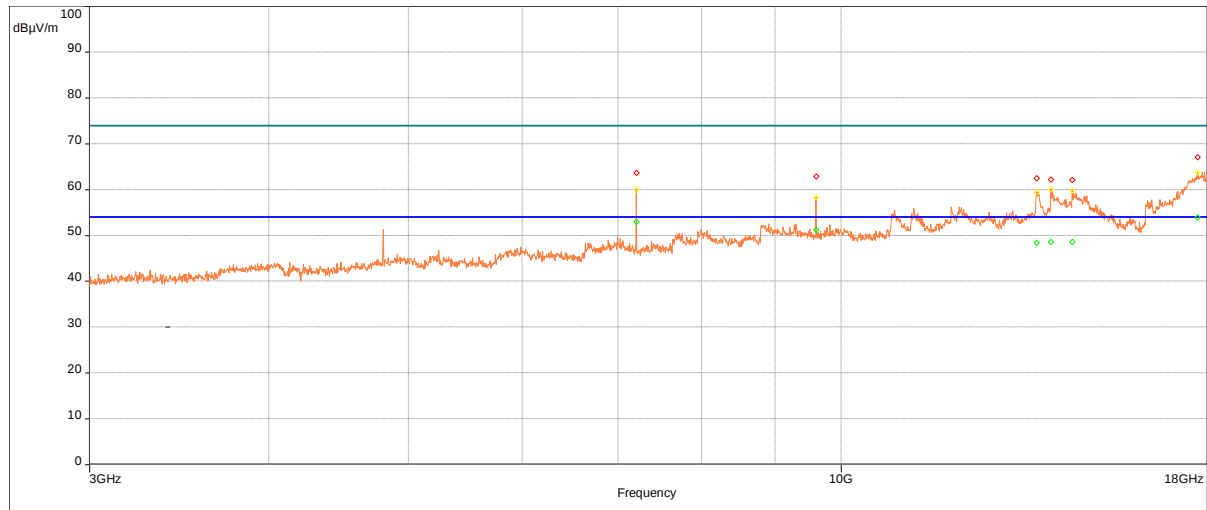
FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
9/8/2022 9:25:10 AM

Data Results: No emission was detected.

Note: X-Axis was worst case azimuth.

FCC Part 15.205 and 15.209, 3-18 GHz (Low Channel, X-Axis), TB-928 Antenna.

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
11/30/2022 1:21:59 PM

Data Results:

Avg (PASS) (6)

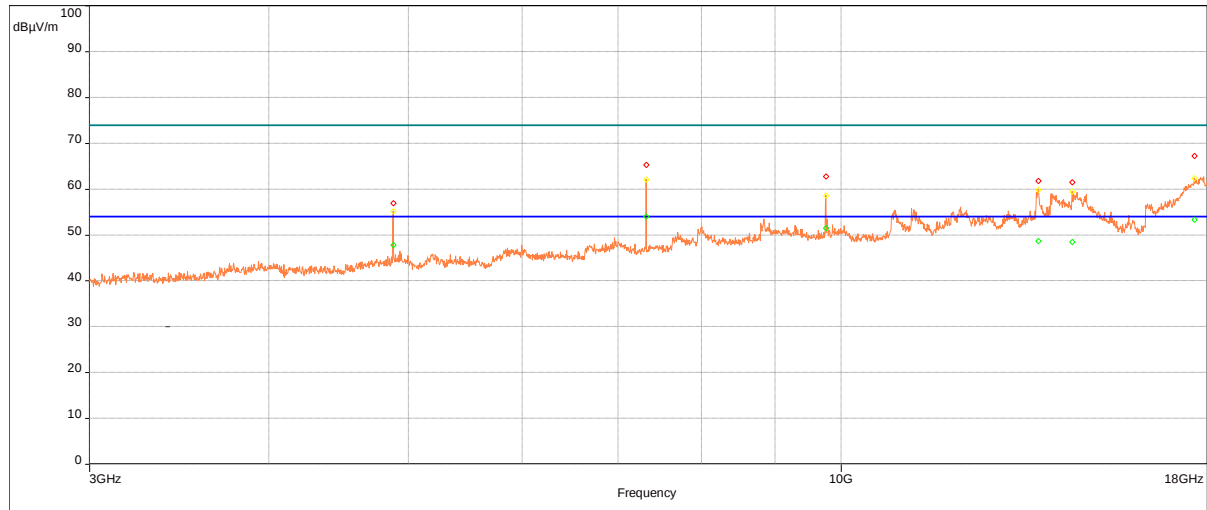
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7206.774038	53.00	54.00	-1.00	195.00	1.03	Horizontal	1.00	6.28
9608.963141	51.25	54.00	-2.75	242.00	1.79	Horizontal	1.00	10.32
13682.71635	48.43	54.00	-5.57	5.00	3.14	Horizontal	1.00	16.83
14001.03686	48.62	54.00	-5.38	138.00	1.38	Horizontal	1.00	17.66
14488.16827	48.62	54.00	-5.38	188.00	3.57	Vertical	1.00	18.03
17705.28045	53.96	54.00	-0.04	142.00	1.12	Horizontal	1.00	23.34

Peak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7206.774038	63.61	74.00	-10.39	195.00	1.03	Horizontal	1.00	6.28
9608.963141	62.85	74.00	-11.15	242.00	1.79	Horizontal	1.00	10.32
13682.71635	62.50	74.00	-11.50	5.00	3.14	Horizontal	1.00	16.83
14001.03686	62.20	74.00	-11.80	138.00	1.38	Horizontal	1.00	17.66
14488.16827	62.11	74.00	-11.89	188.00	3.57	Vertical	1.00	18.03
17705.28045	67.04	74.00	-6.96	142.00	1.12	Horizontal	1.00	23.34

FCC Part 15.205 and 15.209, 3-18 GHz (Mid Channel, X-Axis), TB-928 Antenna.

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
11/30/2022 2:15:47 PM

Data Results:

Avg (With the addition of Duty Cycle Factor)

Frequency (MHz)	Level (dBμV/m)	Duty Cycle Factor	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
7319.810	54.05	-4.28	54.00	-4.23	200.00	1.04	Horizontal	1.00	6.81

Avg (PASS) (5)

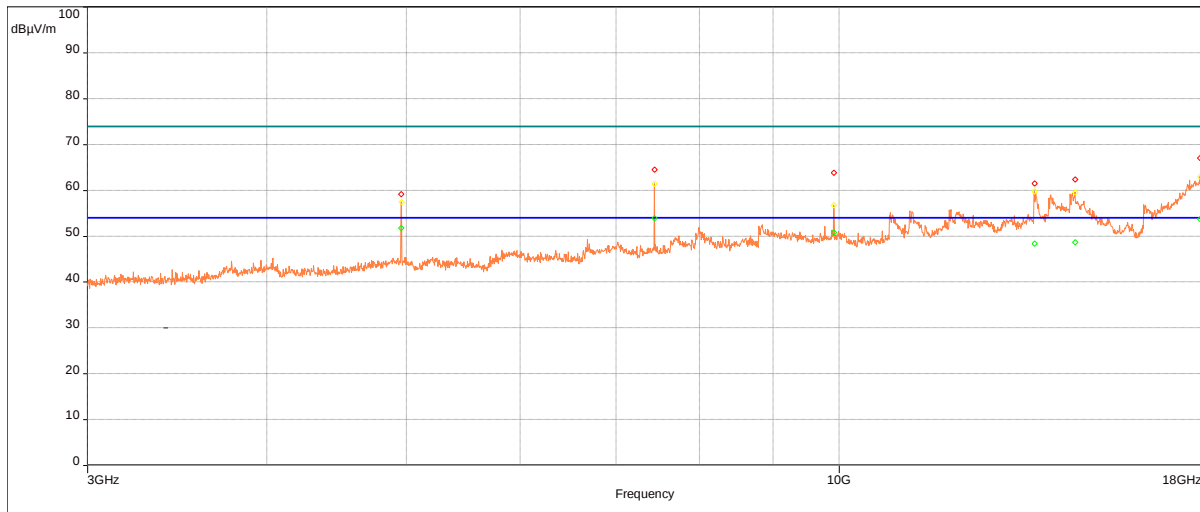
Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
4879.923077	47.79	54.00	-6.21	181.00	1.44	Horizontal	1.00	1.27
9760.794872	51.49	54.00	-2.51	238.00	1.49	Horizontal	1.00	10.38
13721.61859	48.65	54.00	-5.35	215.00	3.77	Horizontal	1.00	16.86
14484.92628	48.50	54.00	-5.50	206.00	2.72	Vertical	1.00	18.03
17622.15385	53.37	54.00	-0.63	95.00	1.29	Vertical	1.00	22.70

Peak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
4879.923077	56.94	74.00	-17.06	181.00	1.44	Horizontal	1.00	1.27
7319.810897	65.35	74.00	-8.65	200.00	1.04	Horizontal	1.00	6.81
9760.794872	62.81	74.00	-11.19	238.00	1.49	Horizontal	1.00	10.38
13721.61859	61.78	74.00	-12.22	215.00	3.77	Horizontal	1.00	16.86
14484.92628	61.53	74.00	-12.47	206.00	2.72	Vertical	1.00	18.03
17622.15385	67.30	74.00	-6.70	95.00	1.29	Vertical	1.00	22.70

FCC Part 15.205 and 15.209, 3-18 GHz (High Channel, X-Axis), TB-928 Antenna.

Emissions Graph:



FCC Part 15 Transmitters/FCC Part 15.205, 15.209, 30MHz-18GHzB
11/30/2022 3:14:13 PM

Data Results:

Avg (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
4960.190705	51.78	54.00	-2.22	177.00	1.26	Horizontal	1.00	1.37
7440.777244	53.98	54.00	-0.02	235.00	1.27	Horizontal	1.00	7.05
9921.11859	50.86	54.00	-3.14	210.00	1.10	Horizontal	1.00	10.82
13675.77564	48.44	54.00	-5.56	23.00	1.89	Vertical	1.00	16.82
14601.99199	48.71	54.00	-5.29	80.00	3.13	Vertical	1.00	17.98
17834.1859	53.79	54.00	-0.21	11.00	2.53	Horizontal	1.00	24.19

Peak (PASS) (6)

Frequency (MHz)	Level (dBμV/m)	Limit (dBμV/m)	Margin (dB)	Azimuth (°)	Height (m)	Pol.	(RBW) (MHz)	Correction (dB)
4960.190705	59.20	74.00	-14.80	177.00	1.26	Horizontal	1.00	1.37
7440.777244	64.50	74.00	-9.50	235.00	1.27	Horizontal	1.00	7.05
9921.11859	63.89	74.00	-10.11	210.00	1.10	Horizontal	1.00	10.82
13675.77564	61.48	74.00	-12.52	23.00	1.89	Vertical	1.00	16.82
14601.99199	62.43	74.00	-11.57	80.00	3.13	Vertical	1.00	17.98
17834.1859	67.11	74.00	-6.89	11.00	2.53	Horizontal	1.00	24.19

Test Personnel: Dan Alvarez
Supervising/Reviewing
Engineer:
(Where Applicable) N/A
Product Standard: FCC Part 15 Subpart C,
ICES-003
Input Voltage: 5 VDC via Ext. Power
Supply
Pretest Verification w/
Ambient Signals or
BB Source: Yes

Test Date: 06/22/2022; 09/07/2022;
11/10/2022; 11/30/2022

Limit Applied: FCC Part 15.209,
FCC Part 15.205

Ambient Temperature: 23 °C

Relative Humidity: 40 %

Atmospheric Pressure: 981 mbars

Deviations, Additions, or Exclusions: None

13 AC Mains Conducted Emissions

13.1 Method

Tests are performed in accordance with CFR47 FCC Part 15.209 and ANSI C63.4.

TEST SITE: 10m ALSE

The 10m ALSE is 13m (Length) x 21m (Depth) x 10m (Height) with the effective size in terms of space from the tips of the absorber is 12m (Length) x 20m (Depth) x 8.5m (Height). This chamber achieves broadband performance using a unique arrangement of hybrid and ferrite tile absorber. This chamber has a built in 3m diameter turntable (Embedded type). The metal structure of the table makes electrical connection around the entire circumference of the turntable to the ground plane with a metal brush type connection. A Styrofoam table 80 cm high is used for table-top equipment.

Measurement Uncertainty

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucisp
AC Line Conducted Emissions	150 kHz - 30 MHz	2.8 dB	3.4dB
Telco Port Emissions	150 kHz - 30 MHz	2.8 dB	5.0dB

As shown in the table above our conducted emissions U_{lab} is less than the corresponding U_{CISPR} reference value in CISPR 16-4-2 Table 1, hence the compliance of the product is only based on the measured value, and no measurement uncertainty correction is required, based on CISPR 22 and CISPR 11 (for 2006 and later revisions) Clause 11.

Sample Calculations

The following is how net line-conducted readings were determined:

$$NF = RF + LF + CF + AF$$

Where NF = Net Reading in dB μ V

RF = Reading from receiver in dB μ V

LF = LISN or ISN Correction Factor in dB

CF = Cable Correction Factor in dB

AF = Attenuator Loss Factor in dB

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 = Net Reading in dB μ V

Example:

$$NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 \text{ dB}\mu\text{V}$$

$$UF = 10^{(49.1 \text{ dB}\mu\text{V} / 20)} = 285.1 \mu\text{V/m}$$

13.2 Test Equipment Used:

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
MP4'	RF Coax Cable 9KHz-18GHz	Fairview Microwave	FMCA1282-394	MP4	09/09/2021	09/09/2022
E212'	RF Coax Cable	Megaphase	TM18-N1N1-120	15055601002	09/09/2021	09/09/2022
213052'	Line Impedance Stabilization Network (LISN) - Rated 9kHz to 30 Mhz, 15 Amps.	Com-Power	LI-215A	191958	07/22/2021	07/22/2022
213152'	Transient Limiter	HEWLETT PACKARD	11947A	3107A01318	02/08/2022	02/08/2023
200076'	Conducted Emissions Site Source	Com-Power	CGC-255	311024	VBV	Verified
200162'	EMI Receiver (20Hz-40GHz)	Rohde & Schwarz	ESU 40	100314	10/13/2021	10/13/2022
MM8'	RF Coax Cable 9KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/13/2021	10/13/2022
AID2426'	Digital Milliohm Meter	Amprobe	MO-100	1609002	05/13/2022	05/13/2023
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Test Equipment Used 11/10/2022

Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due
213149'	Line Input Stabilization Network (LISN)	Com-Power	LI-215A	191966	06/07/2022	06/07/2023
213152'	Transient Limiter	HEWLETT PACKARD	11947A	3107A01318	02/08/2022	02/08/2023
200076'	Conducted Emissions Site Source	Com-Power	CGC-255	311024	VBV	Verified
200162'	EMI Receiver (20Hz-40GHz)	Rohde & Schwarz	ESU 40	100314	10/11/2022	10/11/2023
MM8'	RF Coax Cable 9KHz-18GHz	Maury Microwave	UC-N-MM-267	1635289	10/11/2022	10/11/2023
AID2426'	Digital Milliohm Meter	Amprobe	MO-100	1609002	05/13/2022	05/13/2023
212165'	Barometric Pressure/Humidity Datalogger	Extech	SD700	110344	04/08/2022	04/08/2023

Software Utilized:

Name	Manufacturer	Version
BAT-EMC	Nexio	3.19.1.18

13.3 Results:

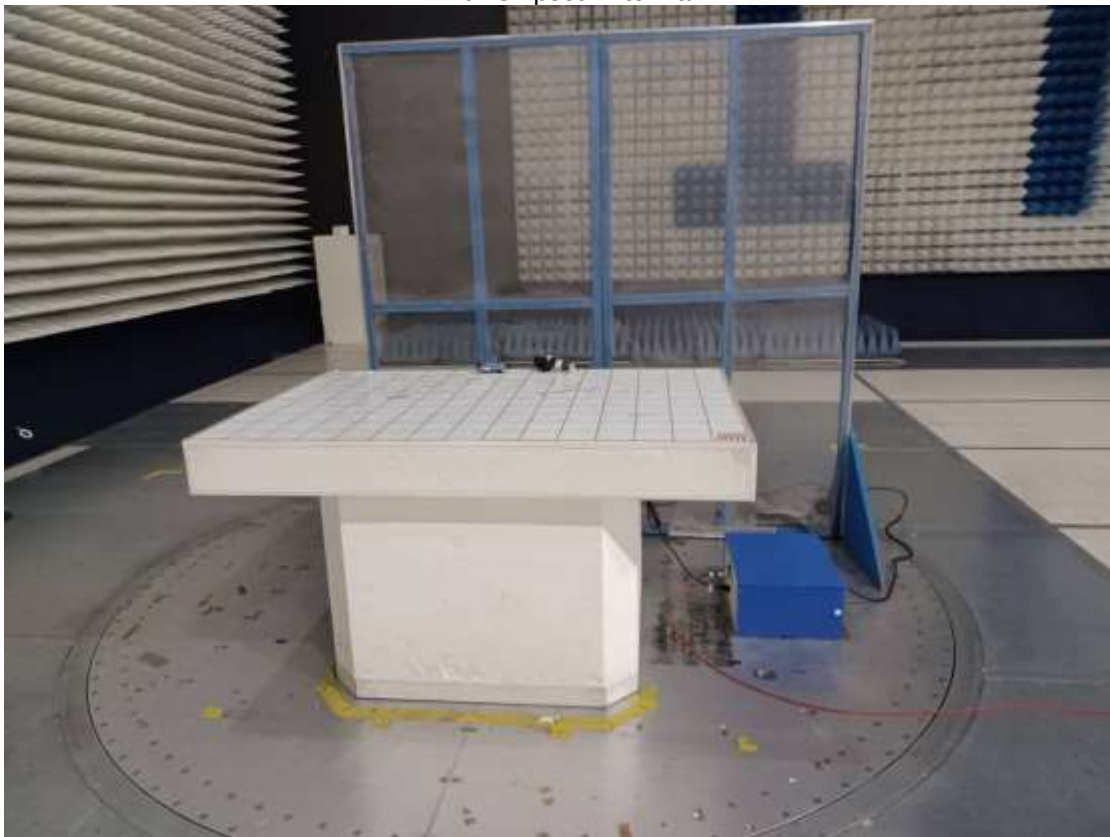
The sample tested was found to Comply.

13.4 Setup Photographs:

With TB-928 antenna

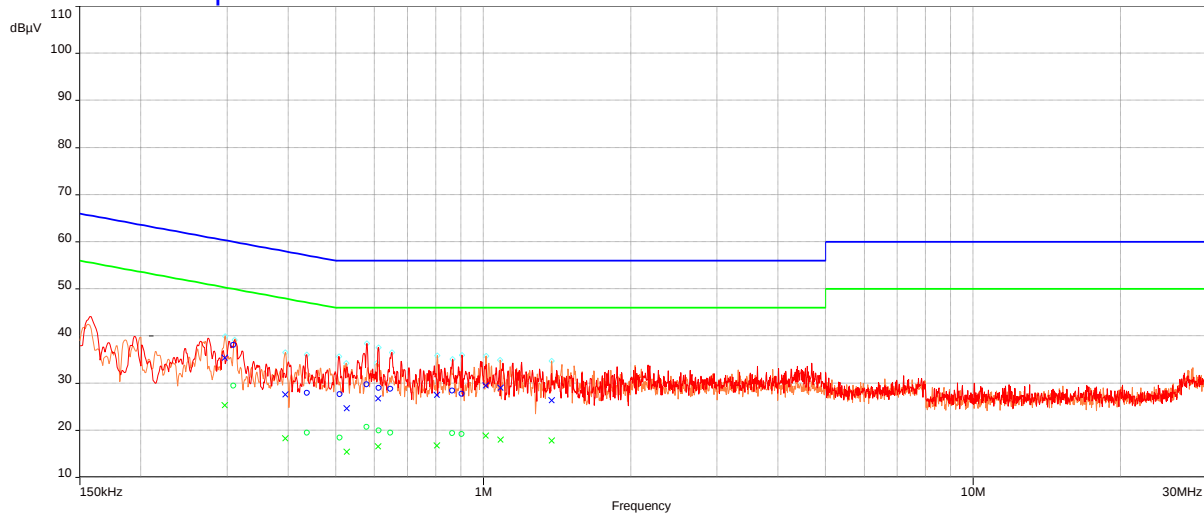


With Chipset Antenna



13.5 Plots/Data:

FCC Part 15.207– Class B,150kHz-30MHz, 120VAC 60Hz_TB-928 antenna

Emissions Graph:

6/23/2022 11:41:51 AM

Data Results:

Final QP and AVG (16)

Frequency (MHz)	AVG Level (dBμV)	QP Level (dBμV)	AVG Limit (dBμV)	QP Limit (dBμV)	AVG Margin (dB)	QPeak Margin (dB)	Position	Correction (dB)
0.3087046154	29.39	38.09	49.99	59.99	-20.60	-21.90	Phase 1	10.04
0.436590641	19.45	27.84	47.13	57.13	-27.68	-29.29	Phase 1	10.05
0.5095447436	18.40	27.59	46.00	56.00	-27.60	-28.41	Phase 1	10.05
0.5776576923	20.66	29.64	46.00	56.00	-25.34	-26.36	Phase 1	10.05
0.6130728205	19.94	28.91	46.00	56.00	-26.06	-27.09	Phase 1	10.05
0.6461580769	19.40	28.70	46.00	56.00	-26.60	-27.30	Phase 1	10.05
0.8646357692	19.34	28.33	46.00	56.00	-26.66	-27.67	Phase 1	10.05
0.9037292308	19.11	27.71	46.00	56.00	-26.89	-28.29	Phase 1	10.05
0.2963465385	25.32	35.38	50.35	60.35	-25.03	-24.97	Phase 2	10.03
0.3934544872	18.31	27.57	47.98	57.98	-29.67	-30.42	Phase 2	10.04
0.5260444872	15.46	24.64	46.00	56.00	-30.54	-31.36	Phase 2	10.04
0.6097324359	16.59	26.74	46.00	56.00	-29.41	-29.26	Phase 2	10.04
0.8038460256	16.77	27.49	46.00	56.00	-29.23	-28.51	Phase 2	10.04
1.011206667	18.84	29.45	46.00	56.00	-27.16	-26.55	Phase 2	10.05
1.083228462	18.03	29.05	46.00	56.00	-27.97	-26.95	Phase 2	10.05
1.379145513	17.83	26.39	46.00	56.00	-28.17	-29.61	Phase 2	10.05

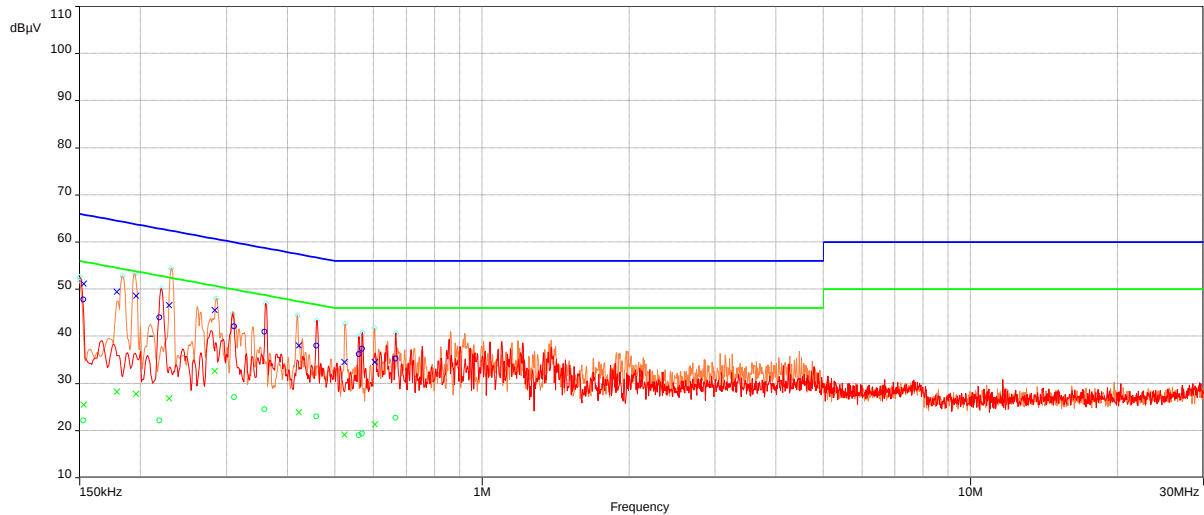
Test Personnel: Dan Alvarez
 Supervising/Reviewing
 Engineer:
 (Where Applicable)
 Product Standard: FCC 15.209
 Input Voltage: 120VAC,60Hz
 Pretest Verification w/
 Ambient Signals or
 BB Source: Yes

Test Date: 06/23/2022Limit Applied: FCC 15.209Ambient Temperature: 24 °CRelative Humidity: 40 %Atmospheric Pressure: 978 mbars

Deviations, Additions, or Exclusions: None

FCC Part 15.207– Class B,150kHz-30MHz, 120VAC 60Hz_Chip Antenna
 FCC Part 15.207– Class B 150kHz-30MHz.
 Model VCP-03B-USB Rev.5_Chip Antenna_Frequency
 Hopping_120VAC,60Hz_CE_150KHz-30MHz

Emissions Graph:



11/10/2022 3:52:17 PM

Data Results:

Final QP and AVG (16)

Frequency (MHz)	AVG Level (dBμV)	QP Level (dBμV)	AVG Limit (dBμV)	QP Limit (dBμV)	AVG Margin (dB)	QPeak Margin (dB)	Position	Correction (dB)
0.1532371795	22.04	47.77	55.84	65.84	-33.80	-18.07	Phase 1	10.12
0.2190584615	22.03	43.92	52.87	62.87	-30.84	-18.95	Phase 1	10.05
0.3109614103	27.01	42.07	49.94	59.94	-22.93	-17.87	Phase 1	10.05
0.3589047436	24.46	40.93	48.75	58.75	-24.29	-17.82	Phase 1	10.05
0.4583378205	22.94	37.92	46.72	56.72	-23.78	-18.80	Phase 1	10.06
0.5595539744	18.94	36.18	46.00	56.00	-27.06	-19.82	Phase 1	10.06
0.5690232051	19.31	37.24	46.00	56.00	-26.69	-18.76	Phase 1	10.06
0.6656503846	22.64	35.24	46.00	56.00	-23.36	-20.76	Phase 1	10.06
0.1528846154	25.52	51.15	55.84	65.84	-30.32	-14.68	Phase 2	10.12
0.1789261538	28.21	49.49	54.54	64.54	-26.33	-15.04	Phase 2	10.06
0.1961371795	27.77	48.57	53.79	63.79	-26.02	-15.22	Phase 2	10.04
0.2284155128	26.84	46.58	52.50	62.50	-25.66	-15.92	Phase 2	10.04
0.2836853846	32.65	45.59	50.72	60.72	-18.07	-15.12	Phase 2	10.04
0.4216147436	23.89	38.09	47.42	57.42	-23.52	-19.32	Phase 2	10.05
0.5233026923	19.14	34.56	46.00	56.00	-26.86	-21.44	Phase 2	10.05
0.602355	21.30	34.56	46.00	56.00	-24.70	-21.44	Phase 2	10.05

Test Personnel: Dan Alvarez
 Supervising/Reviewing Engineer:
 (Where Applicable)
 Product Standard: FCC 15.209
 Input Voltage: 120VAC,60Hz
 Pretest Verification w/ Ambient Signals or BB Source: Yes

Test Date: 11/10/2022Limit Applied: FCC 15.209Ambient Temperature: 23 °CRelative Humidity: 41 %Atmospheric Pressure: 979 mbars

Deviations, Additions, or Exclusions: None

14 Revision History

Revision Level	Date	Report Number	Prepared By	Reviewed By	Notes
0	09/06/2022	105040075ATL-001	DA	KPS/KPS	Original Issue
1	09/30/2022	105040075ATL-001a	DA		Address correction on page 2
2	11/10/2022	105040075ATL-001b	DA	KPS/KPS	TCB Corrections
3	12/07/2022	105040075ATL-001d	DA		Additional TCB Corrections
4	1/27/2023	105040075ATL-001d	Jeff H.	KPS/KPS	Additional TCB Corrections