

CLIENT: VotingWorks

PROJECT: VXScan

DOCUMENT NUMBER: VWX-002-D003

DOCUMENT TITLE: 3.1 Emissions Test Report

REVISION: X01

DATE: 8/2/2024

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024


TABLE OF CONTENTS

1.0 PURPOSE AND SCOPE.....	3
2.0 REFERENCES.....	3
2.1 Internal References.....	3
2.2 External References	3
3.0 ACRONYMS AND TERMS DEFINED	3
4.0 ITEMS UNDER TEST, MATERIALS, EQUIPMENT, AND CONDITIONS	3
4.1 Items Under Test.....	3
4.2 Materials	4
4.3 Conditions	4
5.0 PROCEDURE	4
6.0 ACCEPTANCE CRITERIA.....	4
7.0 DATA ANALYSIS	4
8.0 DATA	5
9.0 RESULTS.....	5
10.0 CONCLUSION	5
APPENDIX 1: DATA	6
REVISION HISTORY AND APPROVALS	12

CONFIDENTIAL

This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

Page
2 of 12

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

1.0 PURPOSE AND SCOPE

The purpose of this test is to verify that the unintentional electromagnetic emissions from the VXScan do not exceed the limits for FCC Class B devices.

2.0 REFERENCES

2.1 Internal References

Document Number	Document Title
N/A	VxScan Electromagnetic Compatibility (EMC), Environmental, and Vibration Testing RFP, 5/1/2024 Version
N/A	VxScan v3.1 and v4.0 Tests of Normal Function, 5/20/2024 Version

2.2 External References

Document Number	Document Title
47 CFR 15	FCC Part 15 Class B, Unintentional Radiators

3.0 ACRONYMS AND TERMS DEFINED

Acronym	Definition
EUT	Equipment Under Test
EMC	Electromagnetic Compatibility
NRTL	Nationally Recognized Testing Laboratory


Term	Definition
Shoeshine Mode	A mode in which the machine repeatedly scans the same ballot without user intervention

4.0 ITEMS UNDER TEST, MATERIALS, EQUIPMENT, AND CONDITIONS

The VXScan device is placed in a shielded room and its emissions are monitored during operation using antennas and an RF spectrum analyzer.

4.1 Items Under Test

Item	Item #	Rev	Lot #	Sample Size
EUT	VXScan	3.1	n/a	1

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

4.2 Materials

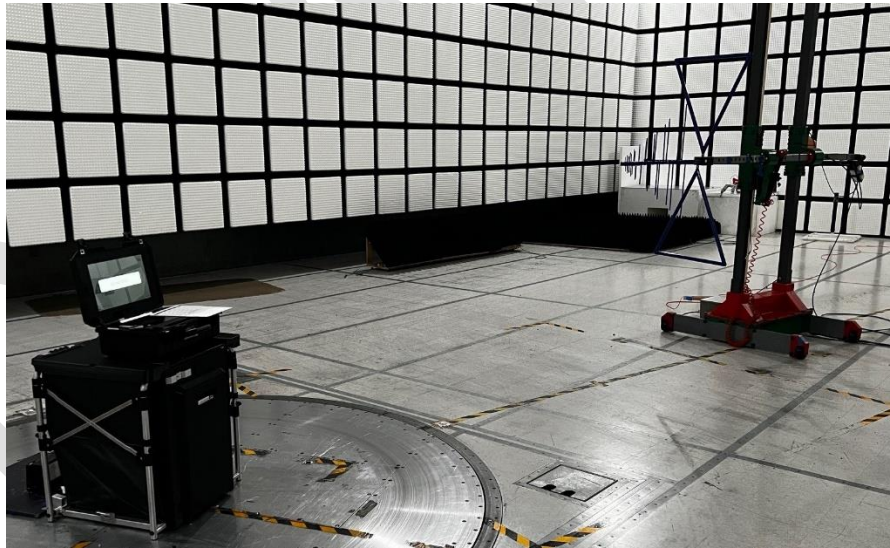
Item	Item#	Lot #	Sample Size
Sample Ballots			

4.3 Conditions

The test is performed in an electromagnetically shielded room at a NRTL (Nemko USA).

5.0 PROCEDURE

The EUT is placed in a shielded room and its emissions are monitored during operation using antennas and an RF spectrum analyzer. The EUT is operated in shoeshine mode during the test to ensure as many of the internal components are active as possible and normal operation is simulated. During the test, the EUT is rotated, the antenna height is varied, and the antenna is oriented horizontally and vertically to ensure a thorough measurement of emissions from all angles and directions. Detailed scans of the emissions from the EUT are recorded at many frequencies, heights, angles and polarizations. The frequencies cover the range from 30MHz to 18GHz in two bands: 30MHz – 1GHz and 1GHz – 18GHz due to antenna limitations.



6.0 ACCEPTANCE CRITERIA

The magnitude of the emissions must be below the specified limit line on the graph.


7.0 DATA ANALYSIS

The NRTL provides graphs and tables to summarize the test. The graphs show an overview of the emissions over the full frequency band. The table gives a list of frequencies that are either over the limit or close to it.

CONFIDENTIAL

This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

Page
4 of 12

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

8.0 DATA

The graphs and tables are included in the appendix.

9.0 RESULTS

These were preliminary scans and not the final test, so there is no pass or fail. However, the unit is likely to pass the formal test when it is performed.

10.0 CONCLUSION & RECOMMENDATIONS


The VXScan device scans look good and have no emissions above the limit. To get to this point, a fully functional HDMI cable and some extra grounding was all that was needed. See the data section for details.

DRAFT

CONFIDENTIAL

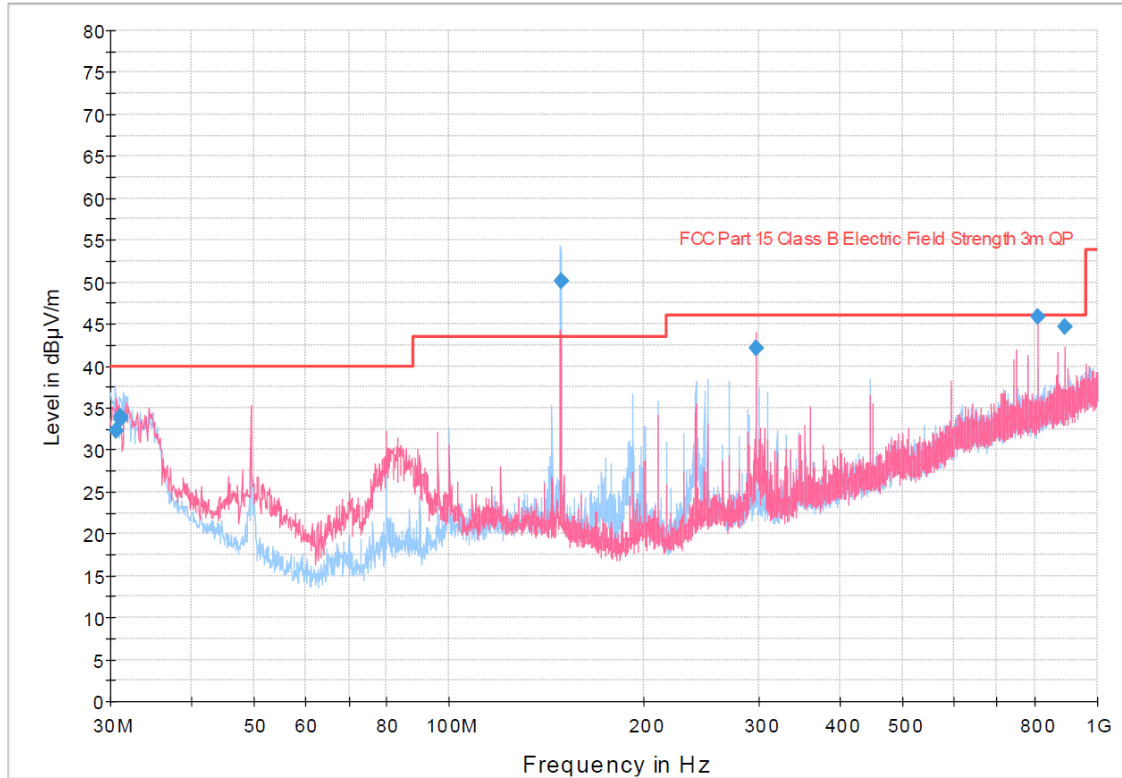
This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

Page
5 of 12

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

APPENDIX 1: DATA

This is the baseline scan of the range from 30MHz to 1GHz. 148.497MHz is well over the limit and 810.014MHz and 891.009MHz are below, but close to the limit.




Final Result

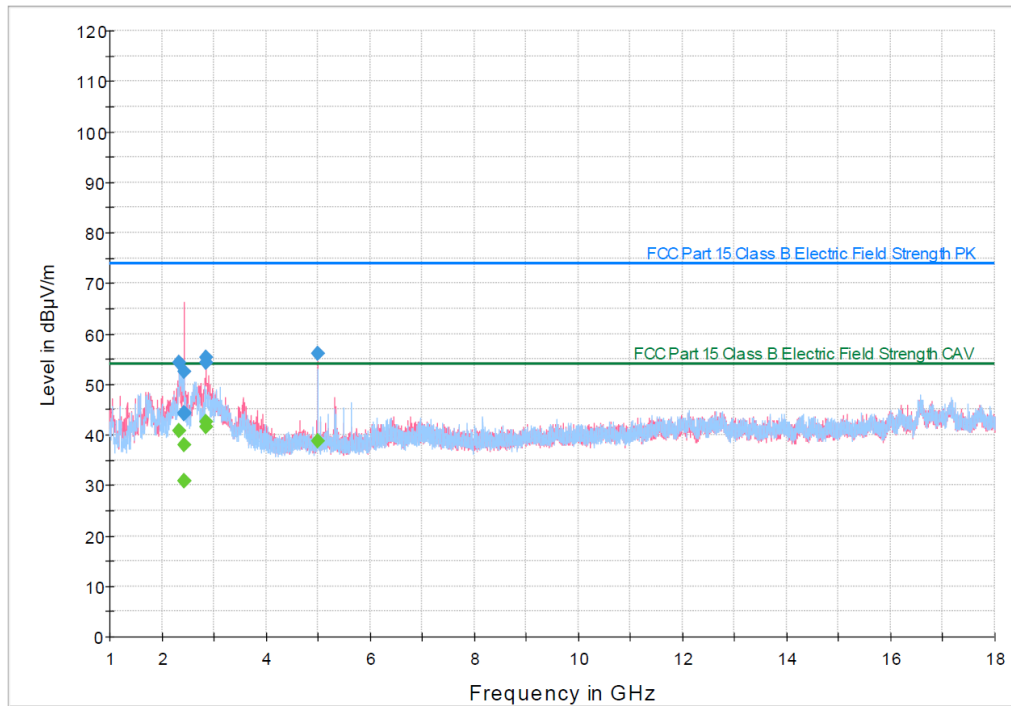
Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
30.660000	32.32	40.00	7.68	5000.0	120.000	102.0	H	137.0	26.2
31.020000	34.00	40.00	6.00	5000.0	120.000	102.0	H	206.0	26.0
31.020000	33.58	40.00	6.42	5000.0	120.000	102.0	H	206.0	26.0
148.497000	50.14	43.50	-6.64	5000.0	120.000	121.0	H	138.0	19.1
297.004000	42.13	46.00	3.87	5000.0	120.000	102.0	V	302.0	21.6
810.014000	45.86	46.00	0.14	5000.0	120.000	102.0	V	165.0	31.4
891.009000	44.64	46.00	1.36	5000.0	120.000	114.0	V	306.0	32.7

CONFIDENTIAL

This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

This is the baseline scan of the range from 1GHz to 18GHz. There are no frequencies of concern in this range. All are well below the limit.



Final Result

Frequency (MHz)	MaxPeak (dBµV/m)	CAverage (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
2336.100000	54.19	---	73.90	19.72	5000.0	1000.000	202.0	H	190.0	-10.1
2336.100000	---	40.87	53.90	13.03	5000.0	1000.000	202.0	H	190.0	-10.1
2420.900000	---	37.84	53.90	16.06	5000.0	1000.000	181.0	V	12.0	-9.6
2420.900000	52.50	---	73.90	21.40	5000.0	1000.000	181.0	V	12.0	-9.6
2424.150000	---	30.93	53.90	22.97	5000.0	1000.000	398.0	H	276.0	-9.6
2424.150000	---	30.95	53.90	22.95	5000.0	1000.000	398.0	H	276.0	-9.6
2424.150000	44.33	---	73.90	29.57	5000.0	1000.000	398.0	H	276.0	-9.6
2424.150000	43.98	---	73.90	29.92	5000.0	1000.000	398.0	H	276.0	-9.6
2841.400000	---	42.45	53.90	11.45	5000.0	1000.000	133.0	V	75.0	-8.9
2841.400000	55.38	---	73.90	18.52	5000.0	1000.000	133.0	V	75.0	-8.9
2856.200000	---	41.45	53.90	12.45	5000.0	1000.000	152.0	V	75.0	-8.9
2856.200000	54.34	---	73.90	19.56	5000.0	1000.000	152.0	V	75.0	-8.9
4996.500000	56.06	---	73.90	17.84	5000.0	1000.000	122.0	V	22.0	-3.0
4996.500000	---	38.70	53.90	15.20	5000.0	1000.000	122.0	V	22.0	-3.0

CONFIDENTIAL

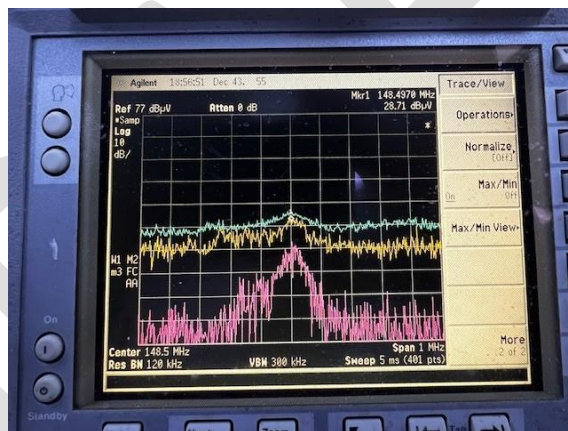
This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

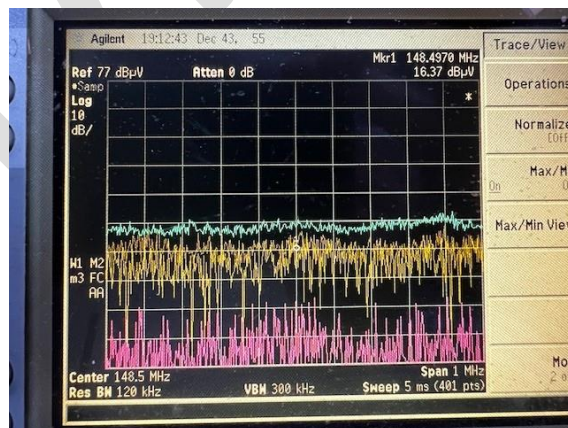
Next, testing was performed in Novo's lab. An RF spectrum analyzer, a near field probe and a biconical antenna were set up. The antenna is used to pick up signals radiated at a distance and the near field probe is used to localize the signals to very small areas within the device under test.



148.497MHz appeared to be coming from the display. With the display operating, the antenna picks up this signal:




With the display cable unplugged from the computer, we see this:



CONFIDENTIAL

This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

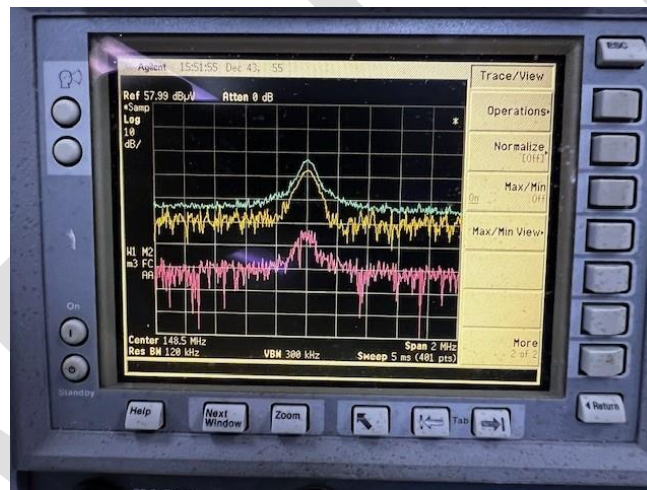
	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

The cyan lines in the screen captures above are the upper limits of the received signals and the magenta lines are the lower limits. With the display connected, the lower limit line is significantly elevated and there is a peak in the upper limit line. With the HDMI cable unplugged from the computer, the upper and lower limit lines are fairly flat with no obvious peak at 148.497MHz. The clock frequency of HDMI when driving a 1080P display is 148.5MHz and this appears to be the source of this failure.

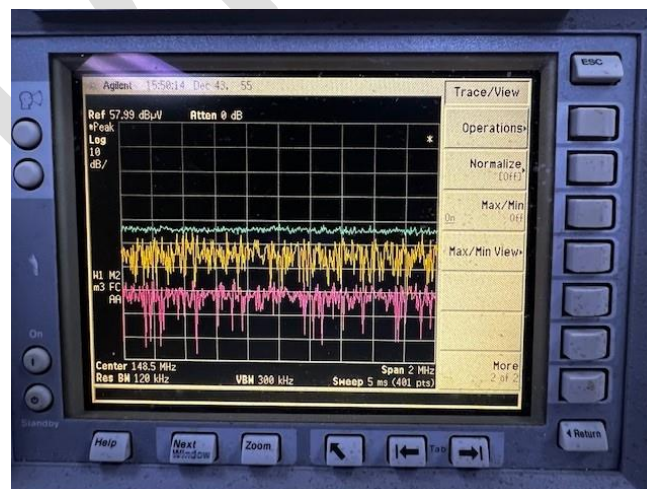
The next frequency of interest is 891.009MHz. This signal is difficult to see in the noise from the signal received by the antenna. However, with the near field probe, this frequency can be detected at the HDMI connector by the computer. This frequency is almost exactly six times the HDMI clock frequency and is probably directly related.

The last frequency is 810.014MHz. This was not detectable with either the antenna or the probe.

The display assembly was removed from the top of the case and a near field probe used on the HDMI cable. There were significant emissions coming from everywhere along the cable in the upper half of the case.




Installing a new HDMI cable resulted in no detectable emissions.



CONFIDENTIAL

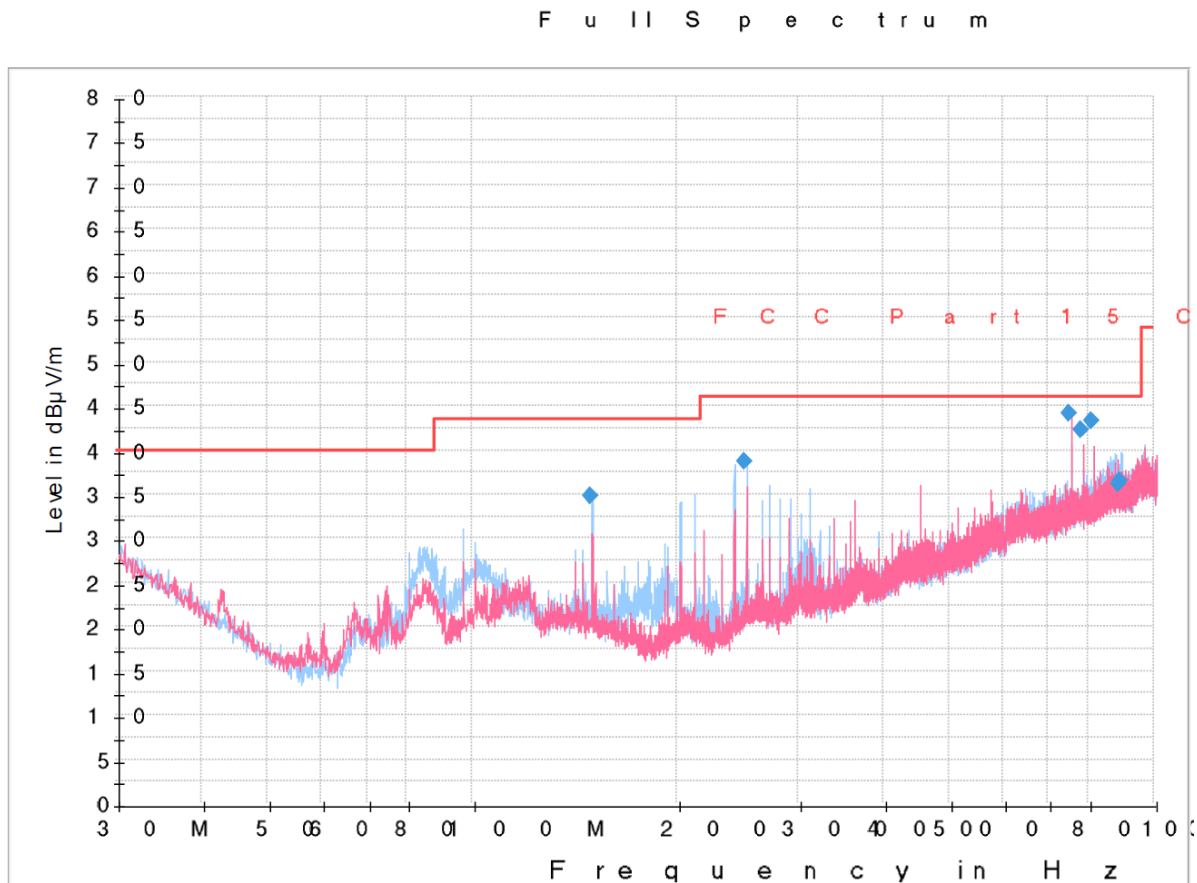
This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

To prepare for another testing session at Nemko, a new HDMI cable was installed, the internal frame in lower half of case was grounded to the power entry module and the display in the upper half of the case was grounded with a dedicated wire connected to the lower half.

148.5MHZ dropped significantly and is no longer a concern. 297MHz is gone. 810 and 891 are significantly reduced. All detected emissions are under the limit for FCC B. 750 and 810MHz have less than 3dB of margin, however, 3dB is no longer required to pass but is still a desirable “rule of thumb” goal.

VxScan V3.1 baseline




Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
148.497000	34.87	43.50	8.63	5000.0	120.000	203.0	H	162.0	19.1
250.016000	38.68	46.00	7.32	5000.0	120.000	101.0	H	354.0	20.7
750.011000	44.17	46.00	1.83	5000.0	120.000	166.0	V	0.0	31.0
780.041000	42.22	46.00	3.78	5000.0	120.000	165.0	V	356.0	31.1
810.014000	43.38	46.00	2.62	5000.0	120.000	141.0	V	343.0	31.4
884.990000	36.24	46.00	9.76	5000.0	120.000	112.0	H	244.0	32.4
889.000000	36.53	46.00	9.47	5000.0	120.000	101.0	H	253.0	32.6

CONFIDENTIAL

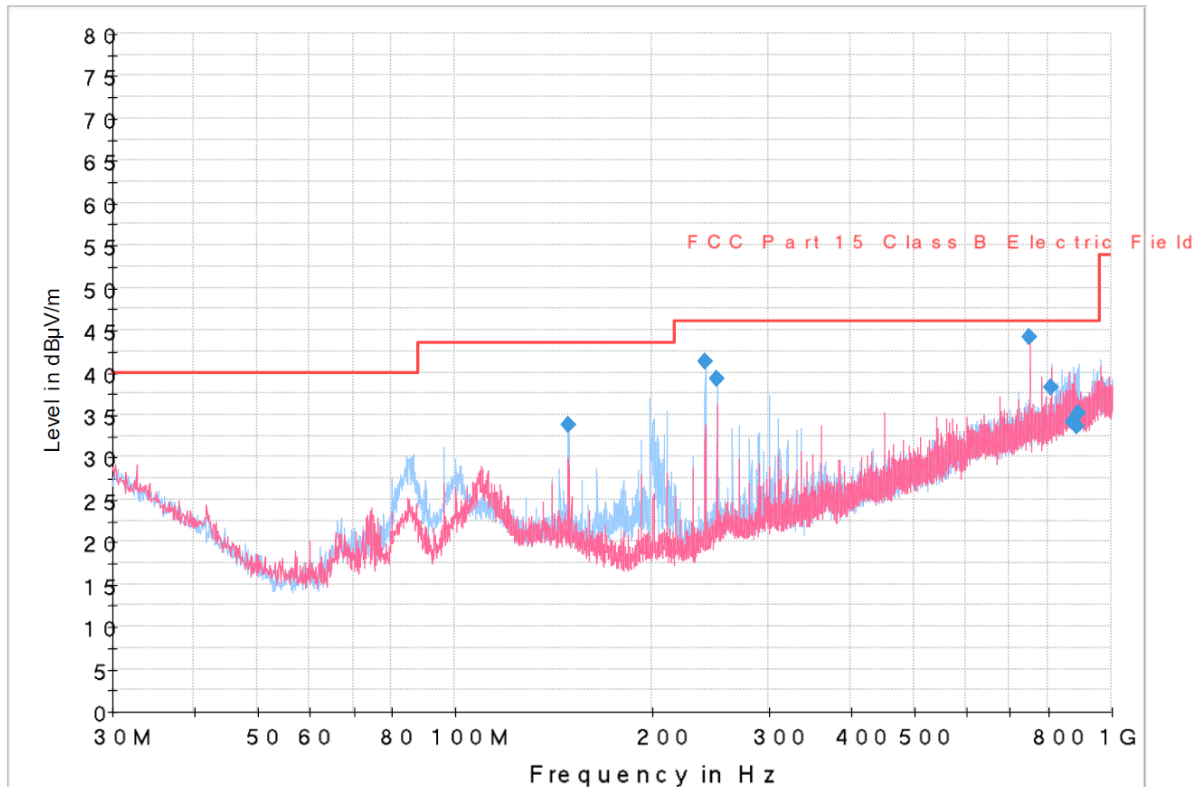
This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

By grounding the access door, most frequencies dropped even more. Only 750MHz has less than 3dB of margin with this configuration.

VxScan V3.1 Door Grounded

Full Spectrum




Final Result

Frequency (MHz)	QuasiPeak (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Meas. Time (ms)	Bandwidth (kHz)	Height (cm)	Pol	Azimuth (deg)	Corr. (dB/m)
148.497000	33.85	43.50	9.65	5000.0	120.000	165.0	H	171.0	19.1
239.985000	41.26	46.00	4.74	5000.0	120.000	101.0	H	102.0	19.6
250.016000	39.16	46.00	6.84	5000.0	120.000	112.0	H	90.0	20.7
750.011000	44.08	46.00	1.92	5000.0	120.000	166.0	V	343.0	31.0
810.014000	38.20	46.00	7.80	5000.0	120.000	194.0	H	0.0	31.4
871.769000	34.17	46.00	11.83	5000.0	120.000	284.0	H	242.0	32.5
885.880000	33.58	46.00	12.42	5000.0	120.000	296.0	H	242.0	32.4
891.711000	35.21	46.00	10.79	5000.0	120.000	101.0	H	293.0	32.7

CONFIDENTIAL

This document contains information that is confidential and proprietary to NOVO Engineering and its Client. It may not be reproduced or distributed, in whole or in part, without prior written permission from NOVO Engineering or its Client.

	Client: VotingWorks	Doc. no.: VWX-002-D008
	Project: VXScan	Revision: X01
	Doc. Title: 3.1 Emissions Test Report	Date: 8/2/2024

REVISION HISTORY AND APPROVALS

Rev	Description	CR#	Date	Submitted By
X01	Submitted to Client	N/A	8/2/2024	D. Dull

DRAFT