TEST REPORT

Report Number: 104873202MIN-002
Project Number: G104873202

Testing performed on the
K50RF-8060-LDQ

to
47 CFR, Part 15:2021, §15.107 and §15.109, Class A
ICES-003, Issue 7 Updated 2020

For
Banner Engineering Corporation

Test Performed by:	Test Authorized by:
Intertek Testing Services NA, Inc.	Banner Engineering Corporation
40 51st Way NE, Suite 100	9714 10th Ave N
Fridley, MN 55421 USA	Minneapolis, MN 55441, USA

Prepared by: Richard Blonigen

Reviewed by: Uri Spector

Date of issue: November 29, 2021

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1.0 DESCRIPTION OF THE SAMPLE (EUT)

Model:	K50RF-8060-LDQ
Type of EUT:	Radar sensor
Serial Number:	RD2111023
Company:	Banner Engineering Corporation
Customer:	Dennis Swanson
Address:	9714 10th Ave N Minneapolis, MN 55441, USA
e-mail:	dswanson@bannerengineering.com
Test Standards:	☒ 47 CFR, Part 15:2021, §15.107 and §15.109, Class A, test method: ANSI C63.4-2014 ☒ ICES-003, Issue 7 Updated 2020
Date Sample Submitted:	November 16, 2021
Test Work Started:	November 16, 2021
Test Work Completed:	November 22, 2021
Test Sample Conditions:	☐ Damaged ☐Poor (Usable) ☒ Good ☐ Prototype ☒Production ☐ Used

2.0 TEST SUMMARY

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

TEST STANDARD	TEST	RESULT
Subpart B – 15.107	Conducted Emissions	Pass
Subpart B – 15.109	Radiated Emissions	Pass

2.1 Measurement Uncertainty

Radiated Emissions:

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
Radiated Emissions, 3m	30-1000 MHz	4.9 dB	6.3 dB
Radiated Emissions, 3m	1-6 GHz	4.0 dB	5.2 dB
Radiated Emissions, 3m	6-18 GHz	4.0 dB	5.5 dB

As shown above our radiated emissions Measurement Uncertainty is less than the corresponding reference value U_{cispr} 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.

AC Mains Conducted Emissions:

Measurement	Frequency Range	Expanded Uncertainty (k=2)	Ucispr
AC Line Conducted Emissions	150 kHz - 30 MHz	2.6 dB	3.4 dB

As shown above our conducted emissions Measurement Uncertainty is less than the corresponding reference value *Ucispr* 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.

3.0 EQUIPMENT UNDER TEST

3.1 Power Configuration

Rated voltage:	☒ 12-30VDC powered through DC source
Rated current:	Amp.
Rated frequency:	☐ 50Hz ☐ 60Hz
Number of phases:	☐ 1 Phase ☐ 3 Phases

3.2 EUT Configuration

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

☐ - Standby
☐ - Test program (H - Pattern)
☒ - Continuous Operation
☐ - Specific test program
☐ -

Operating modes of the EUT:

No.	Description
1	SENSE mode

Cables:

No.	Type	Length	Designation	Note
1	4-wire shielded	unspecified	DC power and Output 1 and Output 2	

Support equipment/Services:

No.	Item	Description
1	Sorensen XDL 56-4	DC power supply
2	Banner SN:03	Latchbox

General notes: The EUT was powered at 30VDC through the Sorensen XDL 56-4 DC Power Source for all tests.

3.3 Environmental conditions

During the measurement the environmental conditions were within the required ranges and shown in the test data sections

4.0 TEST CONDITIONS AND RESULTS

4.1 Line Conducted Emissions

Test result: **Pass**

Frequency range: 0.15MHz-30MHz

Max. Emissions margin: 20.4 dB below the limits

Notes: The EUT is DC powered, therefore testing was performed on the AC cable of the DC Power source.

Sample Calculations

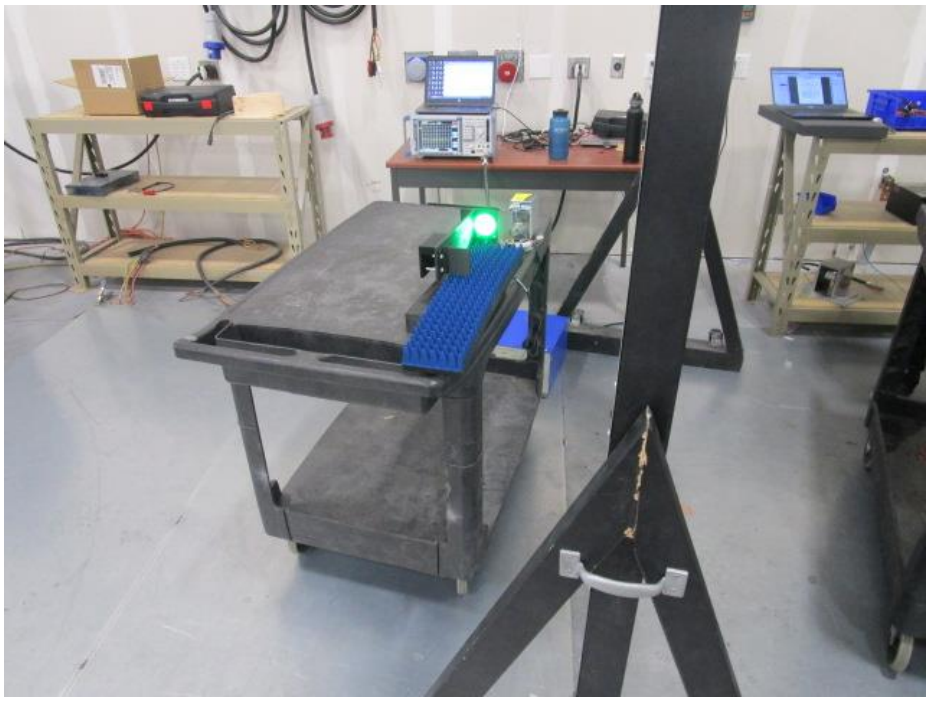
The following is how net line-conducted readings were determined:

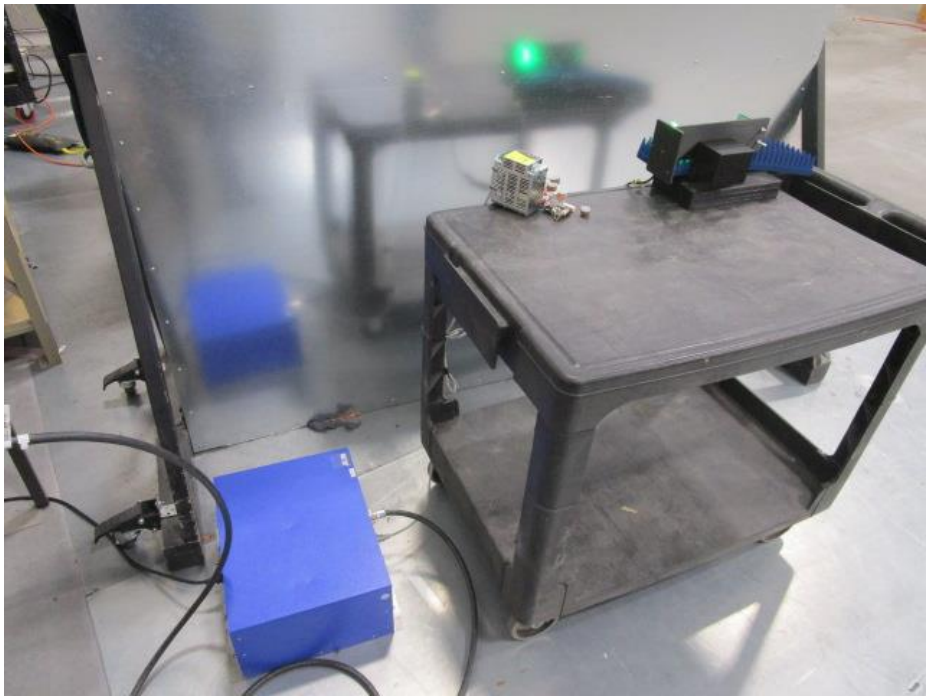
NF = RF + LF + CF + AF

Where NF = Net Reading in dBµV
RF = Reading from receiver in dBµV
LF = LISN or ISN Correction Factor in dB
CF = Cable Correction Factor in dB
AF = Attenuator Loss Factor in dB

Example:

NF = RF + LF + CF + AF = 28.5 + 0.2 + 0.4 + 20.0 = 49.1 dBµV





Test Setup Photos

Date:	November 17, 2021	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC Part 15.107 / ICES-003, Class A	
Test Point:	Line 1 and Line 2	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 41%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

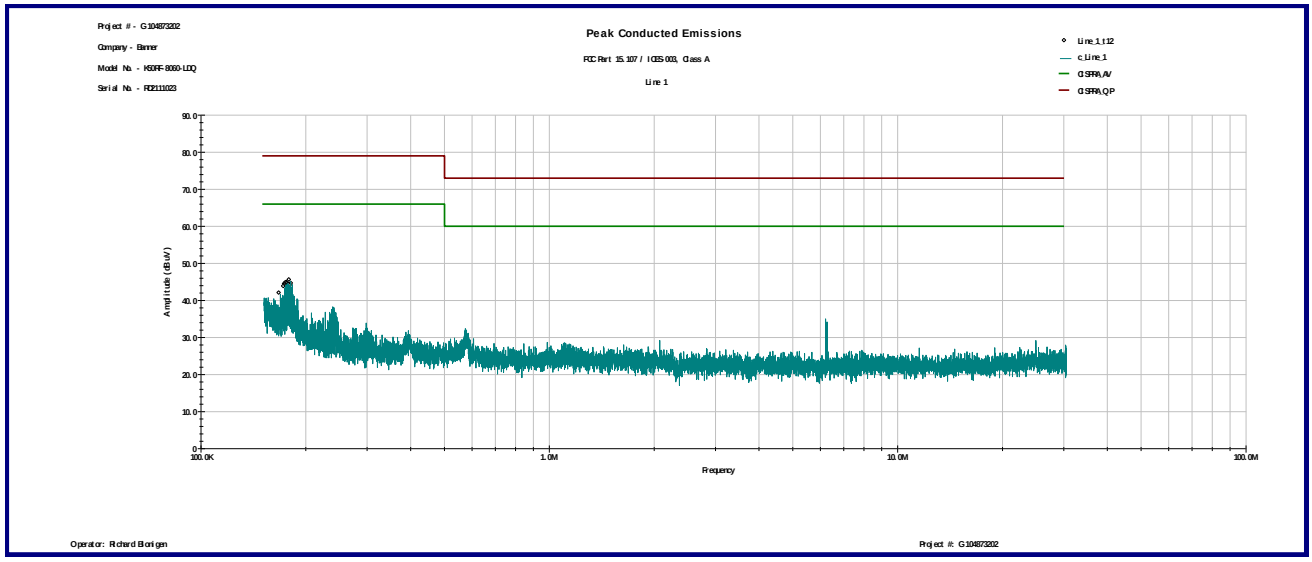
Table 1

Line 1

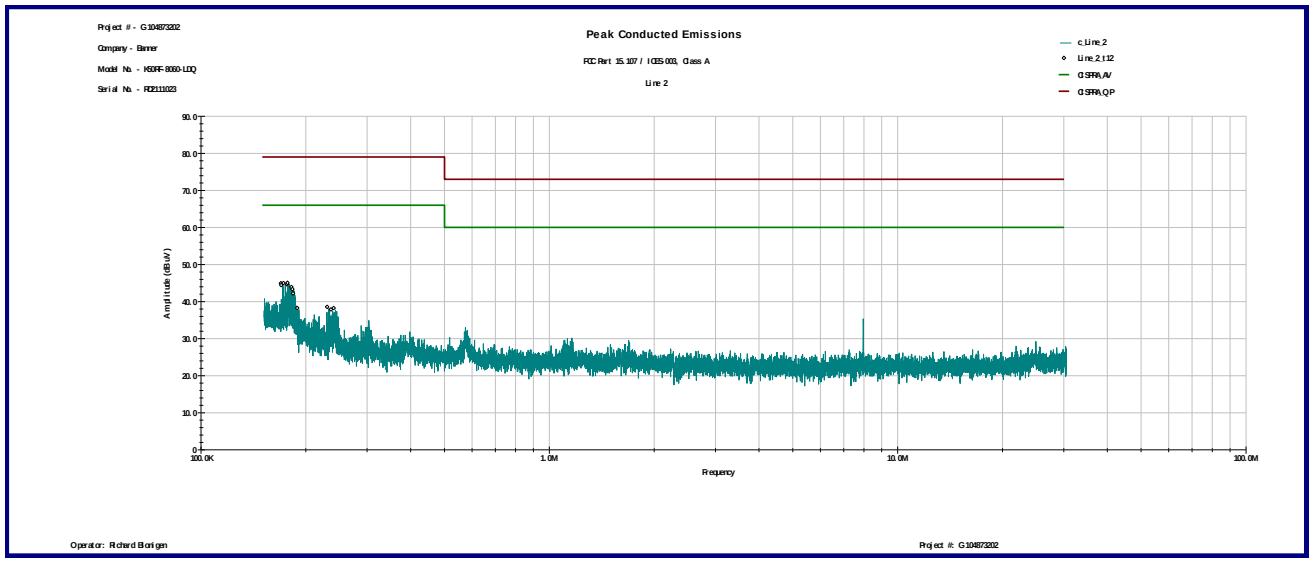
Frequency	Peak	QP Limit	AVG Limit	QP Margin	AVG Margin
	dBµV	dBµV	dBµV	dB	dB
167.09 KHz	42.1	79.0	66.0	-36.9	-23.9
172.22 KHz	43.9	79.0	66.0	-35.1	-22.1
173.15 KHz	44.6	79.0	66.0	-34.5	-21.5
174.47 KHz	44.5	79.0	66.0	-34.5	-21.5
174.78 KHz	44.9	79.0	66.0	-34.1	-21.1
175.71 KHz	45.0	79.0	66.0	-34.1	-21.1
176.18 KHz	44.8	79.0	66.0	-34.2	-21.2
177.42 KHz	44.5	79.0	66.0	-34.5	-21.5
178.35 KHz	44.4	79.0	66.0	-34.6	-21.6
178.66 KHz	45.7	79.0	66.0	-33.4	-20.4
179.6 KHz	44.1	79.0	66.0	-34.9	-21.9
180.99 KHz	44.7	79.0	66.0	-34.3	-21.3

Line 2

Frequency	Peak	QP Limit	AVG Limit	QP Margin	AVG Margin
	dBµV	dBmV	dBmV	dB	dB
169.57 KHz	44.9	79.0	66.0	-34.1	-21.1
169.96 KHz	44.4	79.0	66.0	-34.6	-21.6
172.6 KHz	45.0	79.0	66.0	-34.0	-21.0
176.72 KHz	44.6	79.0	66.0	-34.4	-21.4
177.19 KHz	45.1	79.0	66.0	-34.0	-21.0
181.69 KHz	43.9	79.0	66.0	-35.1	-22.1
182.94 KHz	43.3	79.0	66.0	-35.7	-22.7
183.87 KHz	42.2	79.0	66.0	-36.8	-23.8
188.94 KHz	38.2	79.0	66.0	-40.8	-27.8
230.2 KHz	38.6	79.0	66.0	-40.5	-27.5
236.17 KHz	37.9	79.0	66.0	-41.1	-28.1
240.44 KHz	38.3	79.0	66.0	-40.8	-27.8



Graph 1



Graph 2

4.2 Radiated Emissions

Test location:	☐ OATS	☒ Anechoic Chamber
Test distance:	☐ 10 meters	☒ 3 meters
Test result:	**Pass**	
Frequency range:	30MHz-40GHz	
Max. Emissions margin:	17.2dB below the limits	

Notes: The highest oscillator frequency of the EUT is 61GHz, therefore testing was performed up to 40GHz. No emissions above ambient were detected above 26GHz.

Field Strength Calculation

The field strength is calculated by adding the Antenna Factor and Cable Factor, and subtracting the Amplifier Gain (if any) from the measured emissions reading on the EMI Receiver.
The basic equation with a sample calculation is as follows:
FS = RA + AF + CF - AG

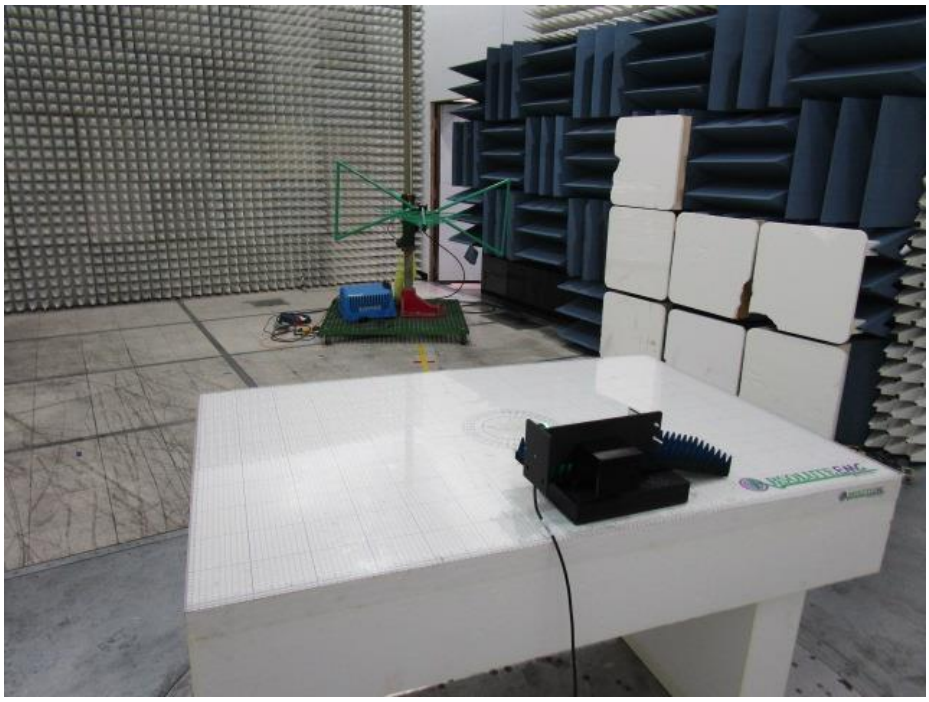
Where: FS = Field Strength in dB(µV/m)
RA = Receiver Amplitude in dB(µV)
CF = Cable Attenuation Factor in dB
AF = Antenna Factor in dB(m^{-1})
AG = Amplifier Gain in dB

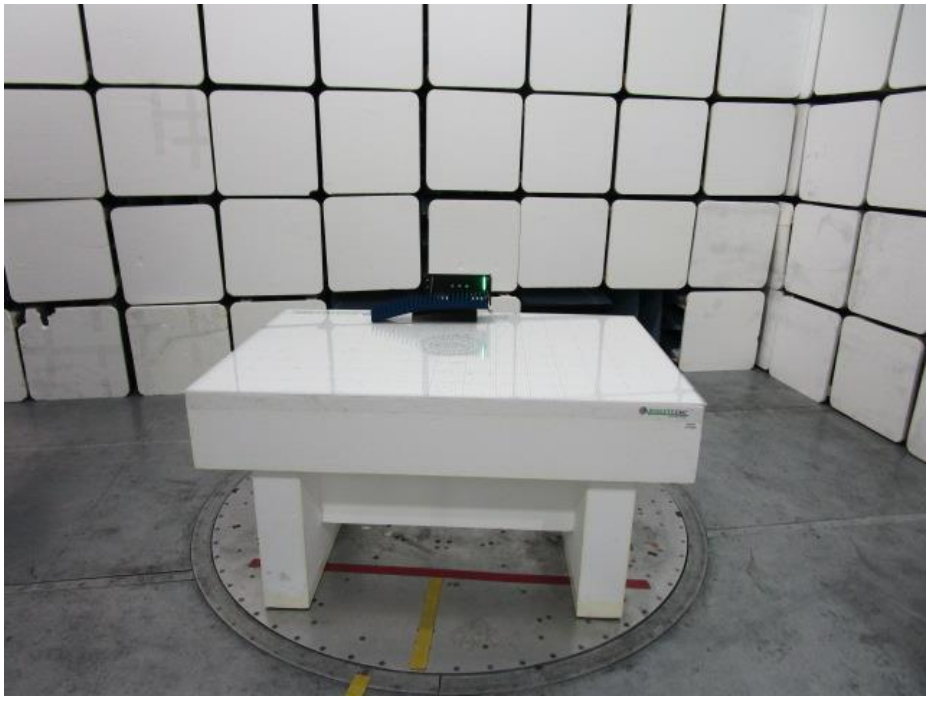
Assume a receiver reading of 52.0 dBµV is obtained. The antenna factor of 7.4 dB and cable factor of 1.6 dB is added. The amplifier gain of 29 dB is subtracted, giving a field strength of 32 dBµV/m. This value in dBµV/m was converted to its corresponding level in µV/m.

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

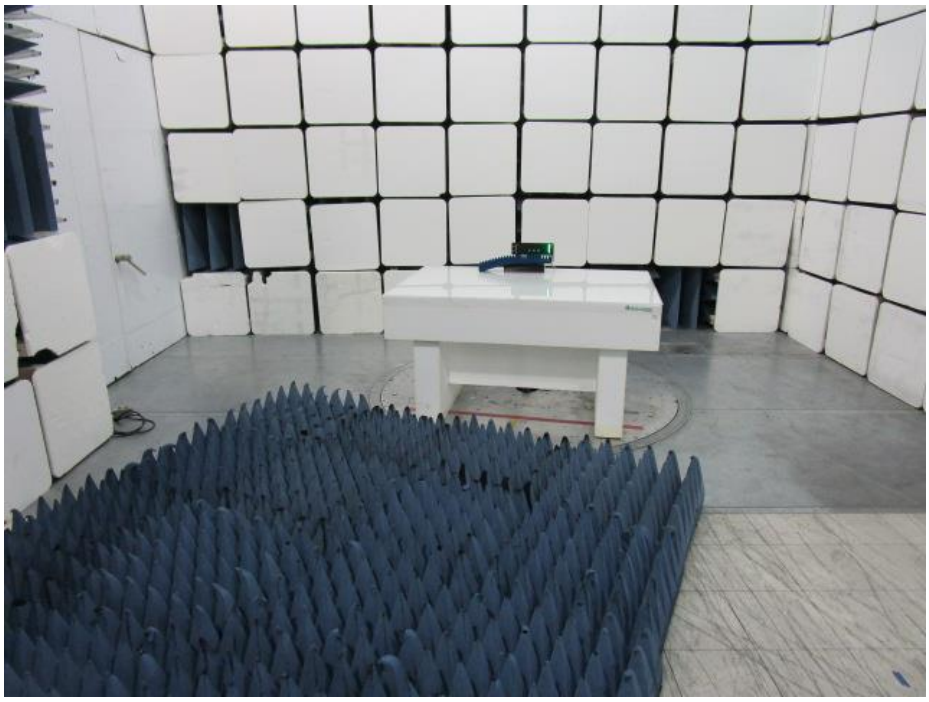
To convert from dBµV to µV or mV the following was used:
UF = $10^{(NF / 20)}$ where UF = Net Reading in µV
NF = Net Reading in dBµV

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



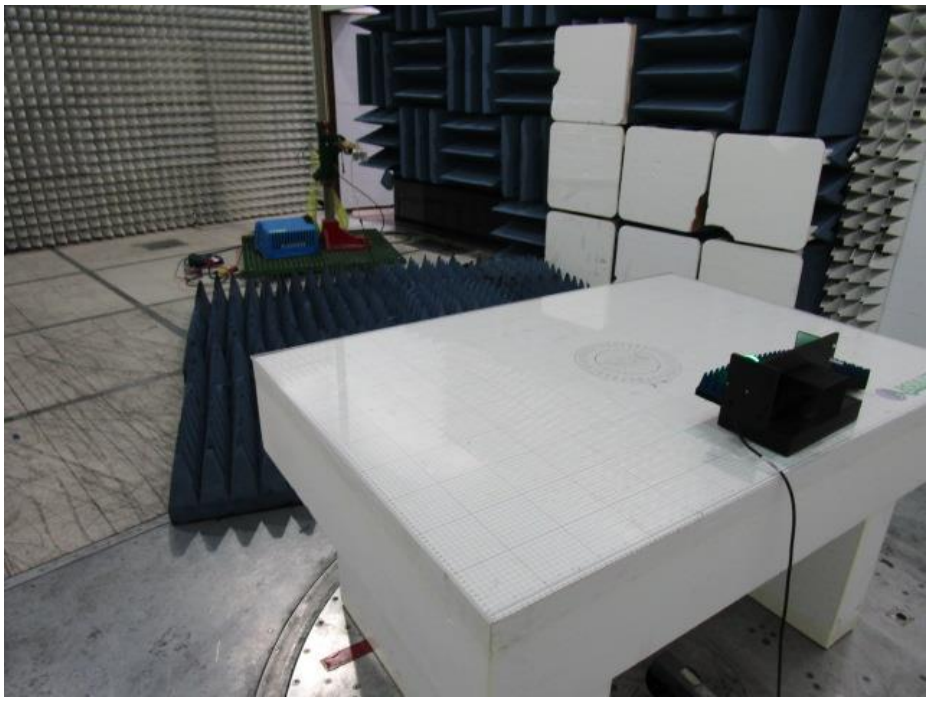


Test Setup Photos





Test Setup Photos



Test Setup Photos

Date:	November 17 & 18, 2021	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC Part 15.109, Class A	
Test Point:	Enclosure	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 41%(RH); 98kPa	
Equipment Verification:	☒	
Note:	Frequency Range: 30MHz – 1GHz	

Table 2

Frequency	Antenna		Ant. CF	Cable loss	Pre-amp	Peak Reading	Total @ 3m	Limit	Margin	Comments
MHz	Polarity	Hts(cm)	dB1/m	dB	Gain (dB)	dBµV	dBµV/m	dBµV/m	dB	
96.28	V	100	14.8	0.8	0.0	13.6	29.2	54.0	-24.8	
99.52	V	100	15.5	0.8	0.0	16.2	32.5	54.0	-21.5	
267.87	V	100	17.8	1.3	0.0	11.2	30.3	56.9	-26.6	
314.94	V	100	18.3	1.5	0.0	13.1	32.9	56.9	-24.0	
97.00	H	100	15.0	0.8	0.0	12.3	28.0	54.0	-26.0	
107.35	H	100	16.4	0.8	0.0	11.0	28.2	54.0	-25.8	
161.29	H	100	14.8	1.0	0.0	12.0	27.8	54.0	-26.1	
273.70	H	100	17.6	1.4	0.0	11.4	30.3	56.9	-26.6	

Date:	November 17 & 18, 2021	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	ICES-003, Class A	
Test Point:	Enclosure	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 41%(RH); 98kPa	
Equipment Verification:	☒	
Note:	Frequency Range: 30MHz – 1GHz	

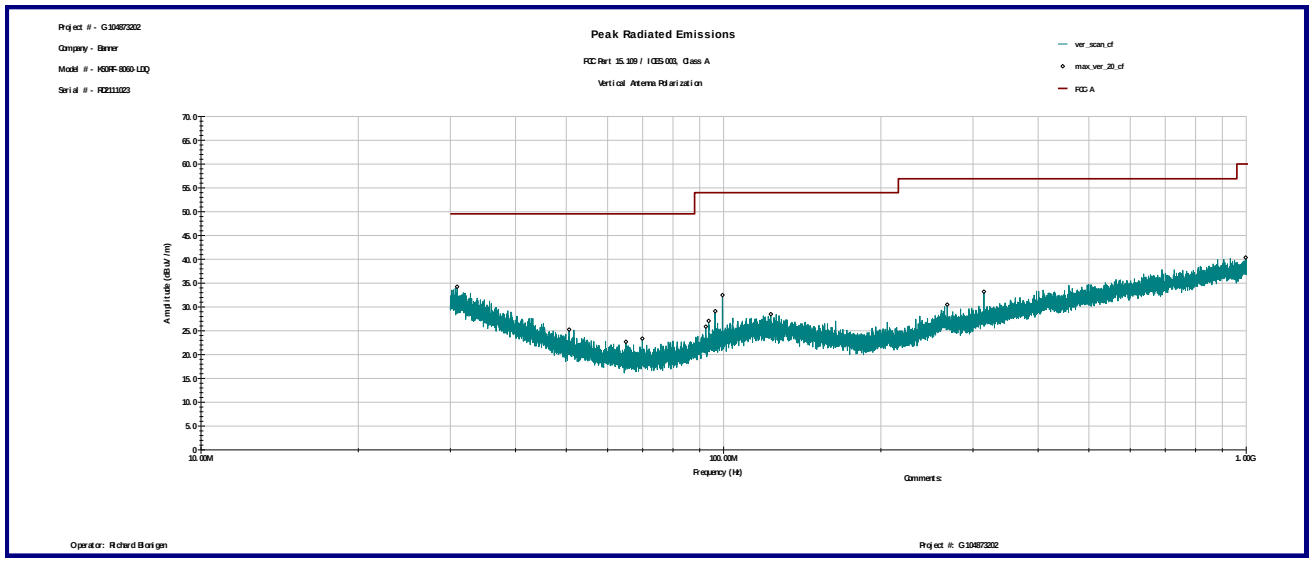
Table 3

Frequency	Antenna		Ant. CF	Cable loss	Pre-amp	Peak Reading	Total @ 3m	Limit	Margin	Comments
MHz	Polarity	Hts(cm)	dB1/m	dB	Gain (dB)	dBµV	dBµV/m	dBµV/m	dB	
96.28	V	100	14.8	0.8	0.0	13.6	29.2	54.0	-24.8	
99.52	V	100	15.5	0.8	0.0	16.2	32.5	54.0	-21.5	
267.87	V	100	17.8	1.3	0.0	11.2	30.3	57.0	-26.7	
314.94	V	100	18.3	1.5	0.0	13.1	32.9	57.0	-24.1	
97.00	H	100	15.0	0.8	0.0	12.3	28.0	54.0	-26.0	
107.35	H	100	16.4	0.8	0.0	11.0	28.2	54.0	-25.8	
161.29	H	100	14.8	1.0	0.0	12.0	27.8	54.0	-26.1	
273.70	H	100	17.6	1.4	0.0	11.4	30.3	57.0	-26.7	

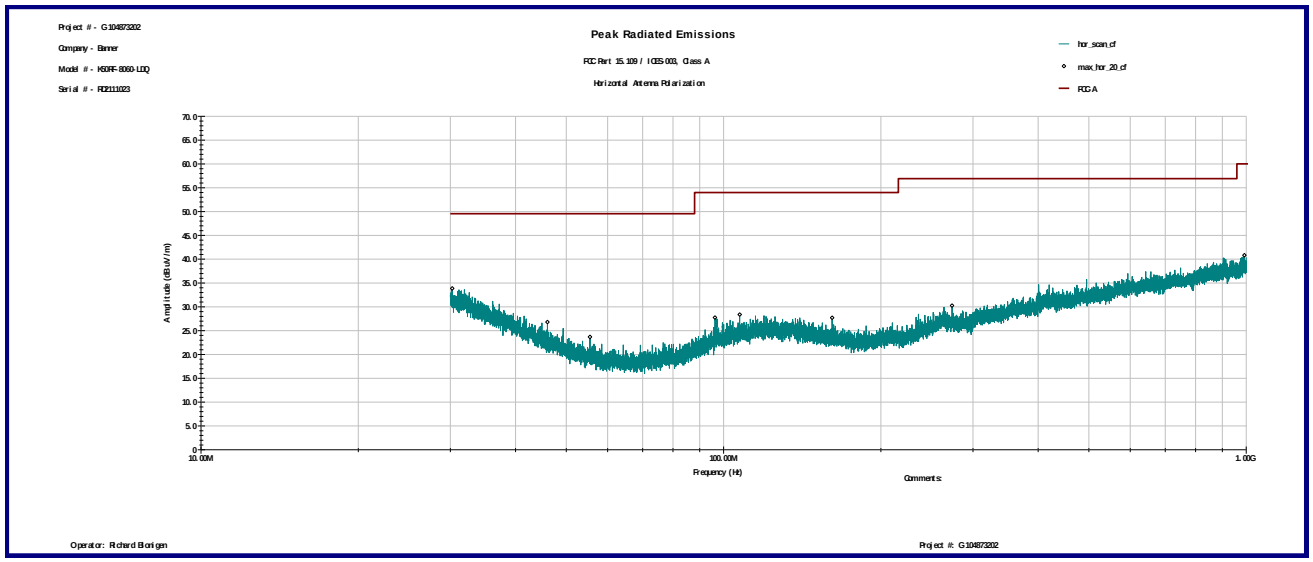
Date:	November 17 & 18, 2021	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC Part 15.109 / ICES-003, Class A	
Test Point:	Enclosure	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 41%(RH); 98kPa	
Equipment Verification:	☒	
Note:	Frequency Range: 1GHz-40GHz	

Table 4

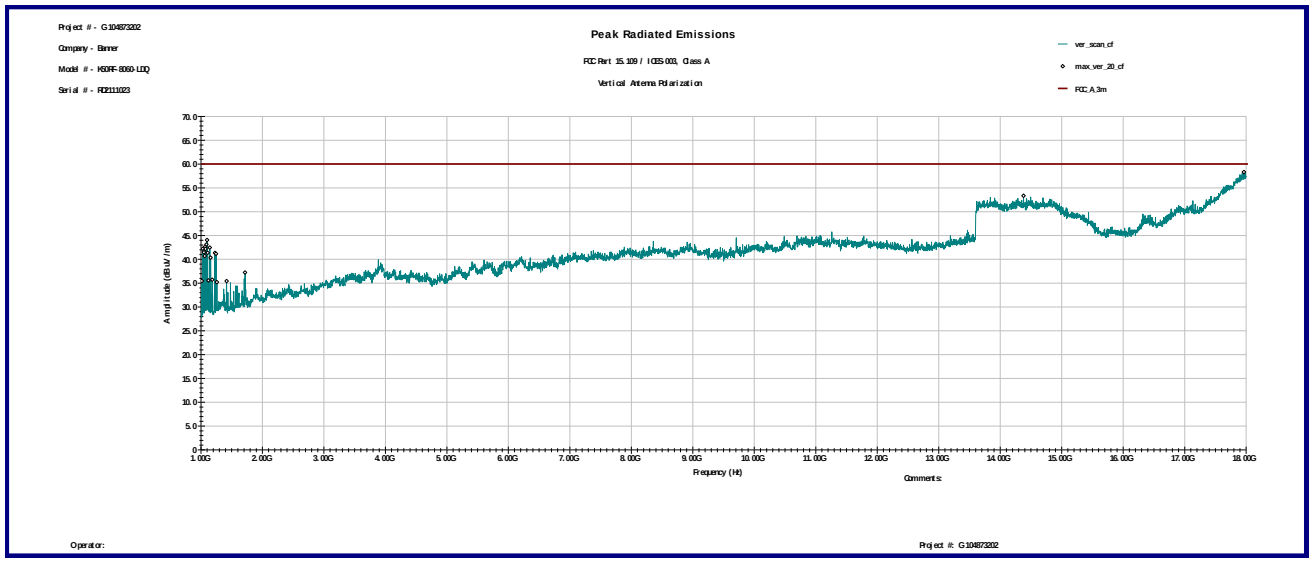
Frequency	Antenna		Ant. CF	Cable loss	Pre-amp	Peak Reading	Total @ 3m	Limit	Margin	Comments
MHz	Polarity	Hts(cm)	dB1/m	dB	Gain (dB)	dBµV	dBµV/m	dBµV/m	dB	
1050.00	V	100	24.2	3.0	42.1	56.1	41.2	60.0	-18.8	
1090.00	V	100	24.3	3.1	42.1	57.5	42.8	60.0	-17.2	
1160.00	V	100	24.4	3.2	42.1	54.5	40.0	60.0	-20.0	
1240.00	V	100	24.6	3.3	42.1	54.9	40.7	60.0	-19.3	
1180.00	H	100	24.5	3.2	42.1	52.8	38.4	60.0	-21.6	
1380.00	H	100	24.9	3.5	42.2	51.4	37.6	60.0	-22.4	
1440.00	H	100	25.1	3.5	42.2	51.6	38.0	60.0	-22.0	
1660.00	H	100	25.8	3.8	42.3	51.1	38.5	60.0	-21.5	



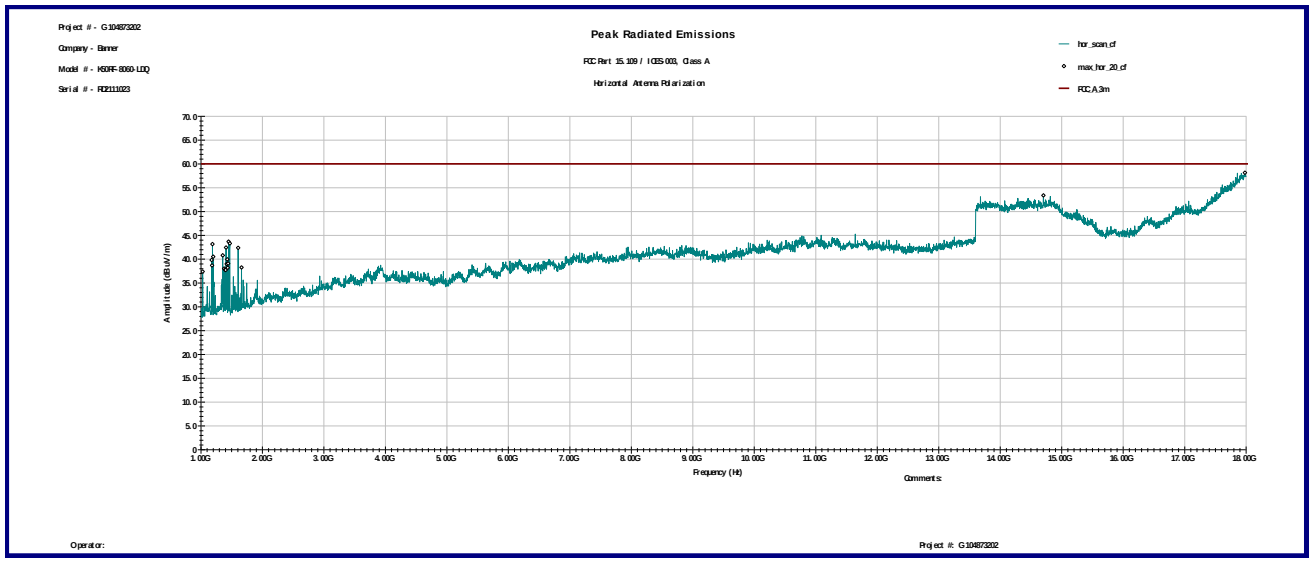
Graph 3



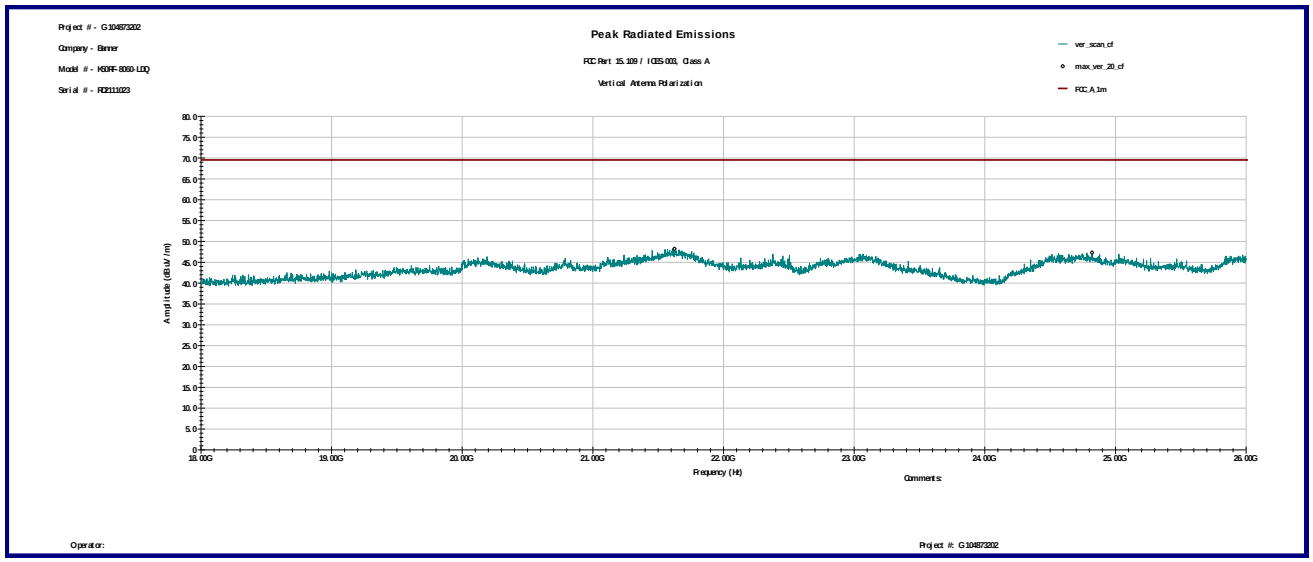
Graph 4



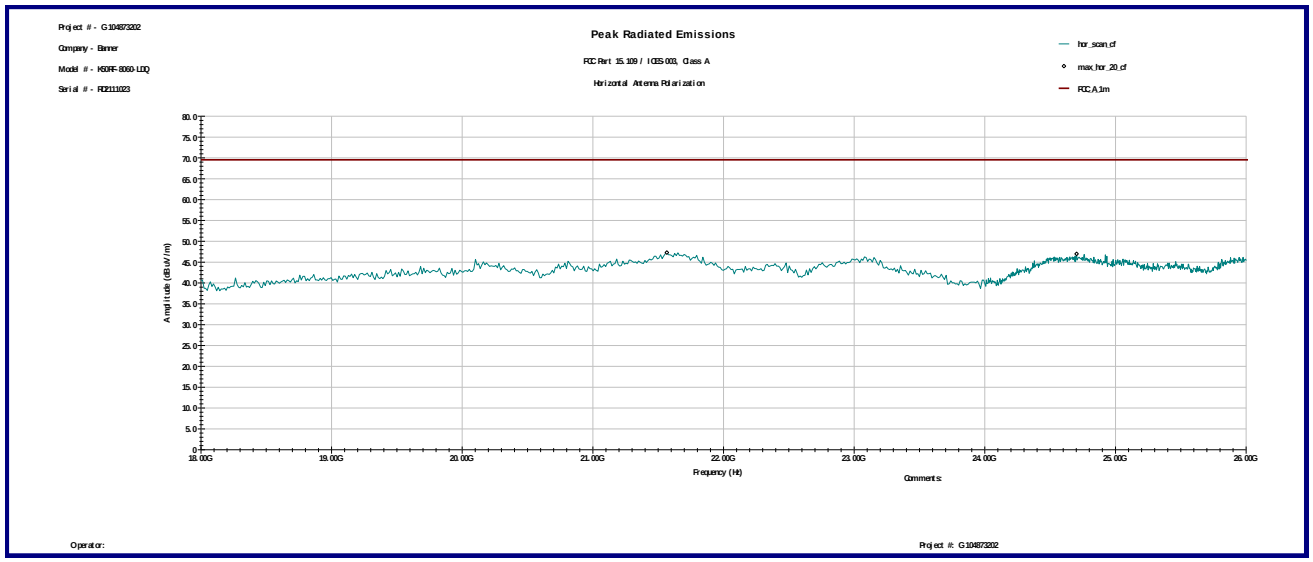
Graph 5



Graph 6



Graph 7



Graph 8

5.0 TEST EQUIPMENT

DESCRIPTION	MANUFACTURER	MODEL	SERIAL NO.	INTERTEK ID	LAST CAL DATE	CAL DUE
Spectrum Analyzer	R & S	FSP 40	100024	12559	02/12/2021	02/12/2022
Spectrum Analyzer	R & S	ESU	100398	25283	07/26/2021	07/26/2022
Spectrum Analyzer	R & S	ESCI	100358	12909	02/10/2021	02/10/2022
Bicono-Log Antenna	Teseq	CBL6112D	32859	25289	05/18/2021	05/18/2022
Chamber HF Cable	Insulated Wire Inc.	KPS-1571-3600-KPS		172516	06/09/2021	06/09/2022
Chamber RE Cable	Coleman	RG214/U M17/164-00001		172505	06/09/2021	06/09/2022
CE Cable	Pasternack Enterprises LLC	RG217/U		172515	06/09/2021	06/09/2022
Horn Antenna	EMCO	3115	9507-4513	9936	08/19/2021	08/19/2022
Waveguide Horn Antenna	EMCO	3116	9904-2423	9705	01/22/2021	01/22/2022
LISN	COM-Power	Li-215A	191970	172315	08/09/2021	08/09/2022
Pre-Amplifier	MITEQ	LNA-40-00101800-35-15P	2108525	172474	06/30/2021	06/30/2022
Pre-Amplifier	MITEQ	AMF-6F-16002600-25-10P	1222383	MIN-0065	01/20/2021	01/20/2022
Pre-Amplifier	MITEQ	AMF-6F-26004000-40-8P	13224444	MIN-0064	01/20/2021	01/20/2022
System	Quantum Change	TILE! Instrument Control	Ver. 3.4.K.29	15259	VBU	VBU

6.0 Revision History

REVISION LEVEL	DATE	REPORT NUMBER	PREPARED	REVIEWED	NOTES
0	11-29-2021	104873202MIN-002	RB	US	Original Issue