TEST REPORT

Report Number: 104218940MIN-008
Project Number: G104218940

Date of issue: March 4, 2020
Date of revision: July 30, 2021

Testing performed on the
SmartShelf

to
47 CFR, Part 15.225:2020
RSS- 210, Issue 10, 2019
RSS-Gen, Issue 5, 2019, Amendment 1
47 CFR, Part 15:2020, §15.107 and §15.109, Class / ICES-003, Issue 6 Update 2017

For
Bibliotheca LLC

Test Performed by:
Intertek Testing Services NA, Inc.
40 51st Way NE, Suite 100
Fridley, MN 55421 USA

Test Authorized by:
Bibliotheca LLC
403 Hayward Avenue North
Oakdale, MN 55128, USA

Prepared by: Richard Blonigen

Reviewed by: Uri Spector

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1.0 GENERAL DESCRIPTION

Model:	SmartShelf
Type of EUT:	RFID Library reader
Intertek Sample ID:	N/A
Related Submittal(s) Grants:	None
Company:	Bibliotheca
Customer:	John McManus
Address:	403 Hayward Avenue North Oakdale, MN 55128, USA
Phone:	+44 (0) 161-498-1140
e-mail:	j.mcmanus@bibliotheca.com
Test Standards:	☒ 47 CFR, Part 15:2020, §15.225 ☒ RSS- 210, Issue 10, 2019 ☒ RSS-Gen, Issue 5, 2019, Amendment 1 ☒ 47 CFR, Part 15:2020, §15.107 and §15.109, Class B, test method: ANSI C63.4-2014 ☒ ICES-003, Issue 6 Update 2017
Type of radio:	☐ Stand -alone ☐ Module ☐ Hybrid
Date Sample Submitted:	January 21, 2020
Test Work Started:	January 21, 2020
Test Work Completed:	January 27, 2020
Test Sample Conditions:	☐ Damaged ☐Poor (Usable) ☒ Good

1.1 Product Description; Test Facility

Product Description:	RFID Library Reader
Operating Frequency	13.56MHz
Antenna(s) Info:	Integral
Antenna Installation:	☐ User ☐ Professional ☐ Factory
Transmitter Power Configuration:	☐ Internal battery ☒ External power source ☒ 100-240VAC Amp. ☒ 50-60Hz
Special Test Arrangement:	None
Test Facility Accreditation:	A2LA (Certificate No. 1427.01)
Test Methodology:	Measurements performed according to the procedures in ANSI C63.10-2013

1.2 EUT Configuration

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

☒ - Standby
☒ - Continuous
☐ - Continuous un-modulated
☐ - Test program (customer specific)

Operating modes of the EUT:

No.	Description
1	The EUT was controlled using Bibliotheca software from remote PC to transmit continuously using one multiplex port. The software allowed to use modulated or unmodulated signal.
2	Standby mode

Cables:

No.	Type	Length	Designation	Note
1	Unshielded	>3m	Ethernet	
2	BNC	>3m	Reader to multiplex port	

Support equipment/Services:

No.	Item	Description
1	Remote PC	
2	Keyboard	
3	Mouse	

1.3 Environmental conditions

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

☒ **Normal**

Temperature: 15-35°C

Humidity: 30-60%

Atmospheric pressure: 86-106kPa

☒ **Extreme**

Temperature: -20 to +50°C

Primary Supply Voltage: ± 15%

1.4 Measurement uncertainty

The expanded uncertainty (k = 2) for radiated emissions from 30 to 1000 MHz has been determined to be: ±4 dB at 10m and ±4.8 dB at 3m

The expanded uncertainty (k = 2) for radiated emissions above 1GHz has been determined to be: ±5.9 dB at 3m

The expanded uncertainty (k = 2) for conducted emissions from 150 kHz to 30 MHz has been determined to be: ±2.6 dB

1.5 Field Strength Calculation

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

Where: FS = Field Strength in dB(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 48.1 dB(µV) is obtained. The antenna factor of 7.4 dB(m^{-1}) and cable factor of 1.6 dB is added and amplifier gain of 16.0 dB is subtracted giving field strength of 41.1 dB(µV/m).

RA = 48.1 dB(µV)
AF = 7.4 dB(m^{-1})
CF = 1.6 dB
AG = 16.0 dB
FS = RA + AF + CF - AG
FS = 48.1 + 7.4 + 1.6 – 16.0
FS = 41.1 dB(µV/m)

General notes: None

2.0 TEST SUMMARY

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

TEST SPECIFICATION	TEST PARAMETERS	RESULT
15.225(a)(b)(c) / RSS-210 A2.6(a)(b)(c)	Field strength within the band of operation	Pass
15.225(d) / RSS-210 A2.6(d)	Out of band emissions	Pass
15.215(c) / RSS- Gen 4.6.1	Bandwidth of the emission	Pass
15.225(e) / RSS-210 A2.6	Frequency tolerance	Pass
15.207/RSS-Gen 7.2.2	Transmitter Power Line conducted emissions	Pass
15.109/ICES-003	Receiver/digital device radiated emissions	Pass
15.107/ ICES-003	Digital device conducted emissions	Pass

Note1: A larger RBW was used due to the nature of the design that modulation spectrum starts 20 dB below the carrier.

Note 2: Radiated emissions are taken at three meters unless specified otherwise. If necessary, a pre-amplifier is used. Radiated emission measurements were performed from 9 kHz to 1 GHz, with the following resolution bandwidths:

200Hz for 9kHz to 150kHz
9 kHz for 150kHz to 30 MHz
120 kHz for 30MHz to 1000 MHz

3.0 TEST CONDITIONS AND RESULTS

3.1 Field strength within the band of operation

Test location: ☒ OATS ☒ Anechoic Chamber ☐ Other

Test distance: ☒ 10 meters ☒ 3 meters

Test result: **Pass**

Max. Emissions margin: 3.5 dB below the limits

Notes: None

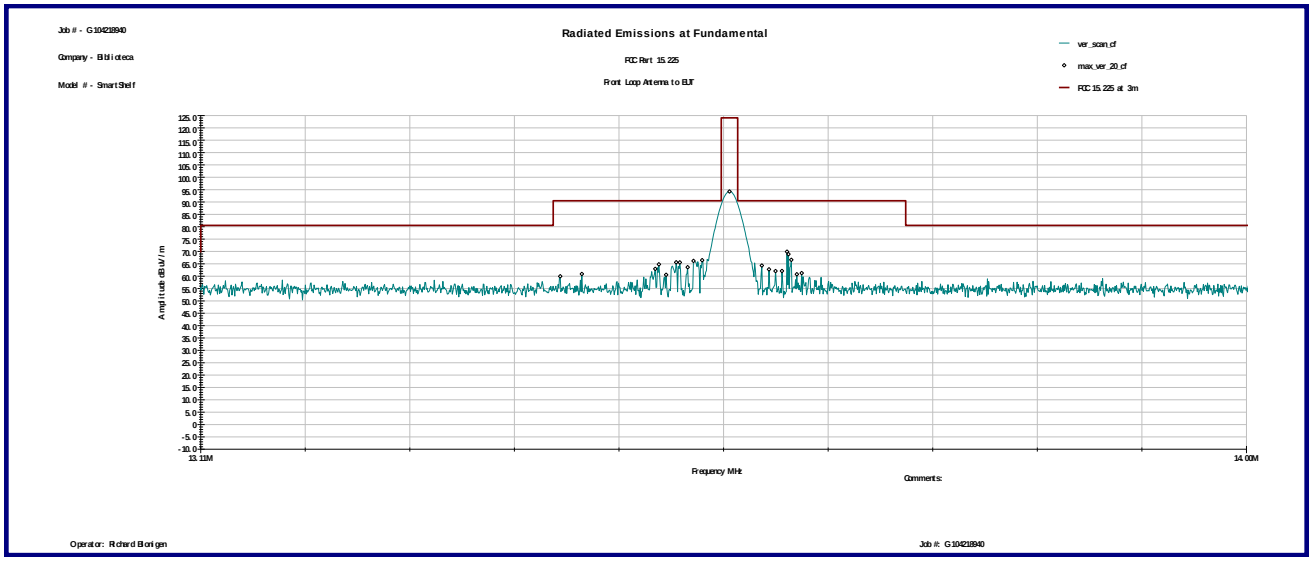
Date:	January 22, 2020	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC 15.225(a)(b)(c) / RSS-210 A2.6(a)(b)(c)	
Test Point:	Enclosure with antenna	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 42%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

Table 3.1.1

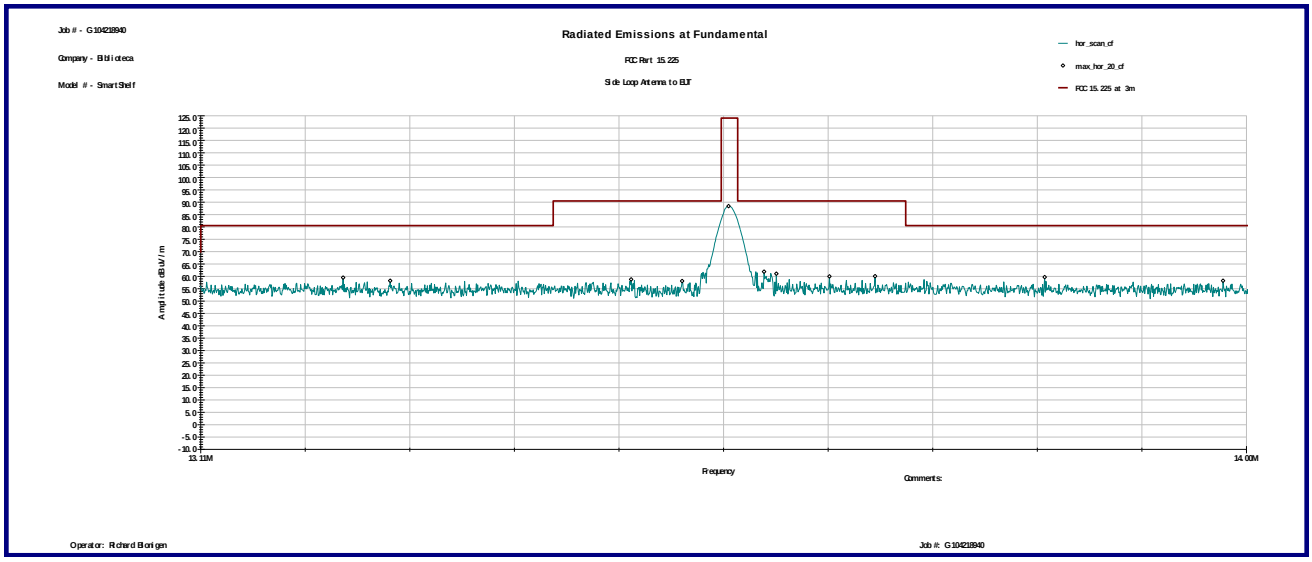
Frequency MHz	Antenna Orient.	Ant. CF dB1/m	Cable loss dB	Pre-amp Gain (dB)	Reading dBµV	Total @ 10m dBµV/m	15.209 Limit dBµV/m	Margin dB	Comments
13.110	Front	35.0	0.2	0.0	13.1	48.3	59.6	-11.3	
13.410	Front	35.0	0.2	0.0	15.3	50.5	59.6	-9.1	
13.553	Front	35.0	0.2	0.0	30.3	65.4	69.6	-4.2	
13.560	Front	35.0	0.2	0.0	62.6	97.7	103.1	-5.4	
13.567	Front	35.0	0.2	0.0	31.0	66.1	69.6	-3.5	
13.710	Front	35.0	0.2	0.0	15.1	50.2	59.6	-9.4	
14.010	Front	34.9	0.2	0.0	12.9	48.0	59.6	-11.6	
13.110	Side	35.0	0.2	0.0	13.3	48.5	59.6	-11.1	
13.410	Side	35.0	0.2	0.0	15.7	50.9	59.6	-8.7	
13.553	Side	35.0	0.2	0.0	30.6	65.7	69.6	-3.9	
13.560	Side	35.0	0.2	0.0	62.5	97.6	103.1	-5.5	
13.567	Side	35.0	0.2	0.0	30.4	65.5	69.6	-4.1	
13.710	Side	35.0	0.2	0.0	14.1	49.2	59.6	-10.4	
14.010	Side	34.9	0.2	0.0	12.8	47.9	59.6	-11.7	

Graph 3.1.1

Front antenna orientation



Side antenna orientation



3.2 Field strength outside of the band of operation

Test location: ☒ OATS ☒ Anechoic Chamber ☐ Other

Test distance: ☒ 10 meters ☒ 3 meters

Frequency range of measurements: 0.15MHz-1000MHz

Test result: **Pass**

Max. margin of spurious emissions: 4.9 dB below the limits

Notes:
1. No Emissions below 30MHz were detected other than Fundamental.
2. Fundamental frequency was omitted from Table.

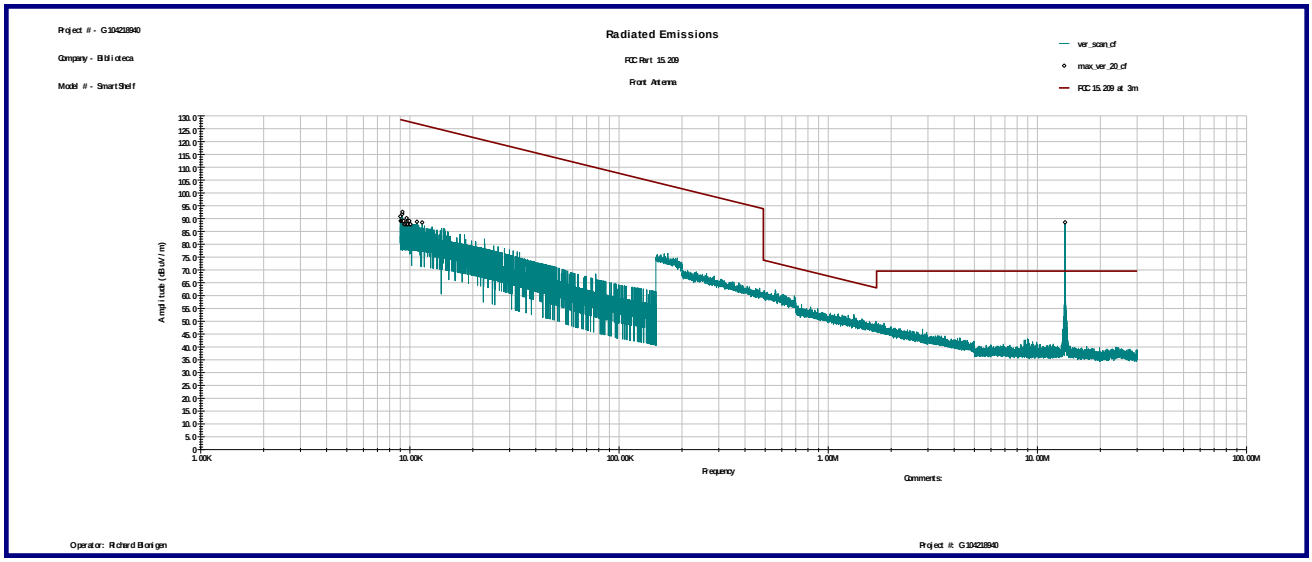
Date:	February 27, 2020	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC 15.225(d) / RSS-210 A2.6(d)	
Test Point:	Enclosure with antenna	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 40%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

Table 3.2.1

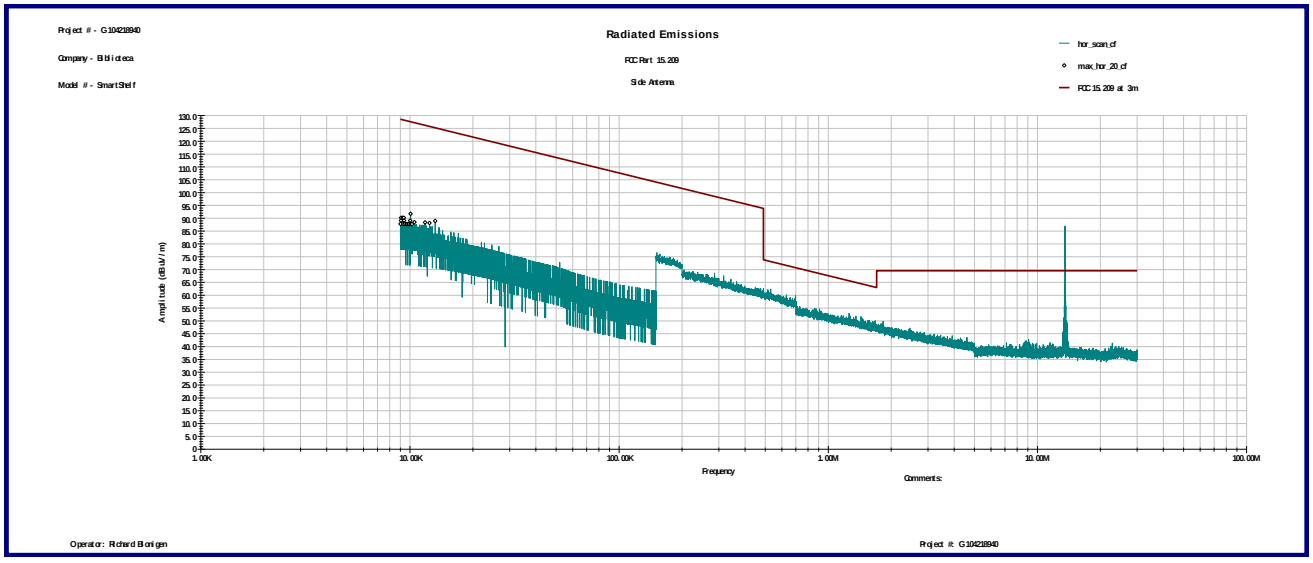
Frequency	Antenna		Ant. CF	Cable loss	Pre-amp	QP Reading	Total @ 3m	Limit	Margin	Comments
MHz	Polarity	Hts(cm)	dB1/m	dB	Gain (dB)	dBµV	dBµV/m	dBµV/m	dB	
31.20	V	100	23.4	0.4	0.0	11.3	35.1	40.0	-4.9	
35.30	V	100	21.0	0.4	0.0	12.9	34.3	40.0	-5.7	
35.60	V	100	20.9	0.4	0.0	11.3	32.6	40.0	-7.4	
94.40	V	100	14.4	0.7	0.0	15.6	30.7	40.0	-9.3	
109.00	V	100	16.6	0.8	0.0	12.2	29.6	40.0	-10.4	
314.91	V	100	18.3	1.4	0.0	10.8	30.5	47.0	-16.5	
77.30	H	100	11.4	0.7	0.0	12.4	24.4	40.0	-15.6	
94.40	H	100	14.4	0.7	0.0	13.0	28.1	40.0	-11.9	
109.00	H	100	16.6	0.8	0.0	11.0	28.4	40.0	-11.6	
115.30	H	100	16.9	0.8	0.0	10.9	28.6	40.0	-11.4	
187.80	H	100	13.9	1.1	0.0	10.7	25.7	40.0	-14.3	

Graph 3.2.1

Front antenna orientation

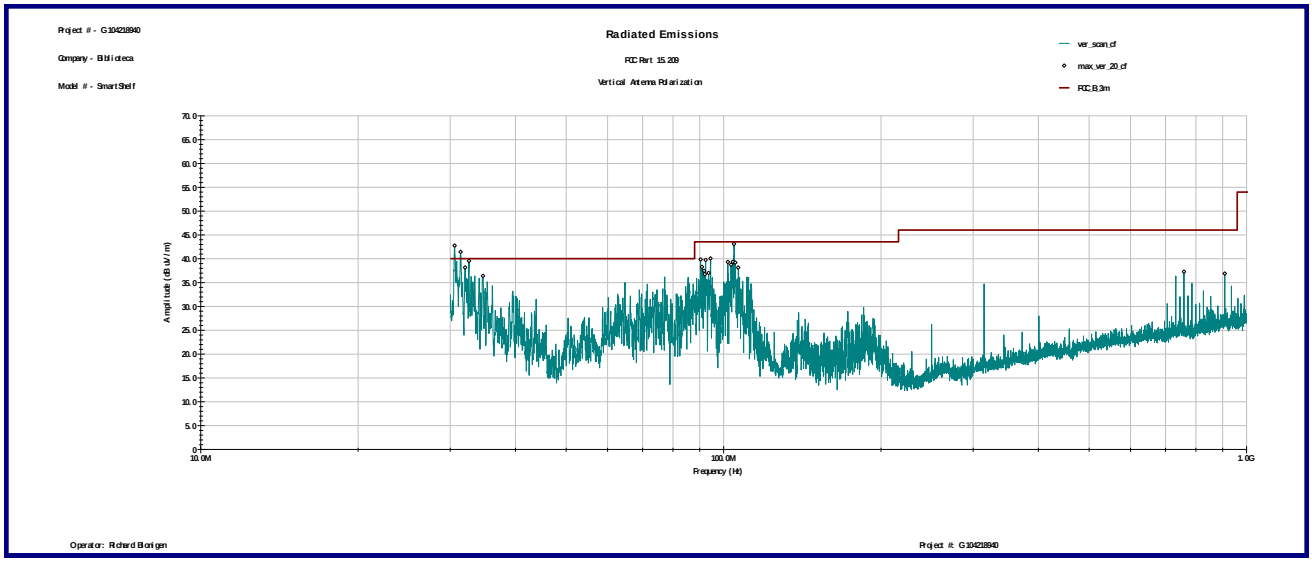


Side antenna orientation

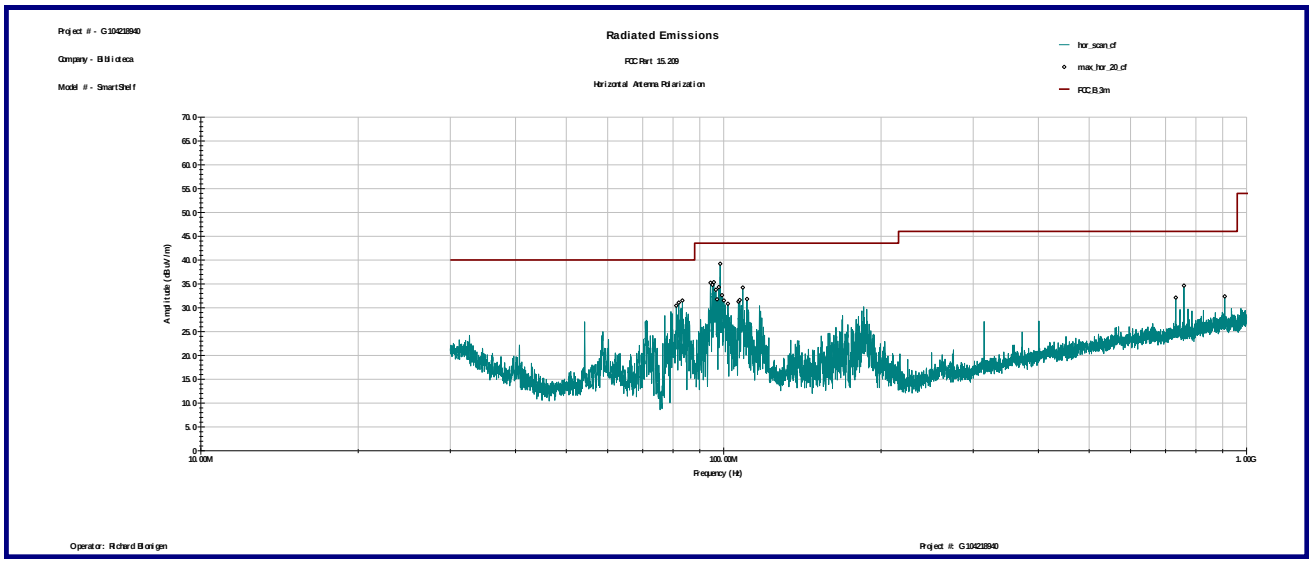


Graph 3.2.2

Vertical antenna polarization



Horizontal antenna polarization



3.3 Frequency Tolerance

Test location: ☐ OATS ☐ Anechoic Chamber ☐ Other

Test date: January 27, 2020

Tested by: Richard Blonigen

Test result: **Pass**

Test Parameter		Measured Deviation (Hz)	Maximum Allowed Deviation (Hz)	Margin
Temperature °C	Voltage V			
-20	120	-10.9	1356	**Pass**
-10		-10.7	1356	**Pass**
0		-9.6	1356	**Pass**
10		-9.6	1356	**Pass**
20		0	1356	**Pass**
30		-10.0	1356	**Pass**
40		-8.9	1356	**Pass**
50		-10.3	1356	**Pass**
20	102	0	1356	**Pass**
	108	0	1356	**Pass**
	114	0	1356	**Pass**
	120	0	1356	**Pass**
	126	0	1356	**Pass**
	132	0	1356	**Pass**
	138	0	1356	**Pass**

Notes: None

3.4 Bandwidth of Emissions

Test location: ☐ OATS ☒ Anechoic Chamber ☐ Other

Test distance: ☐ 10 meters ☒ 3 meters

Test result: **Pass**

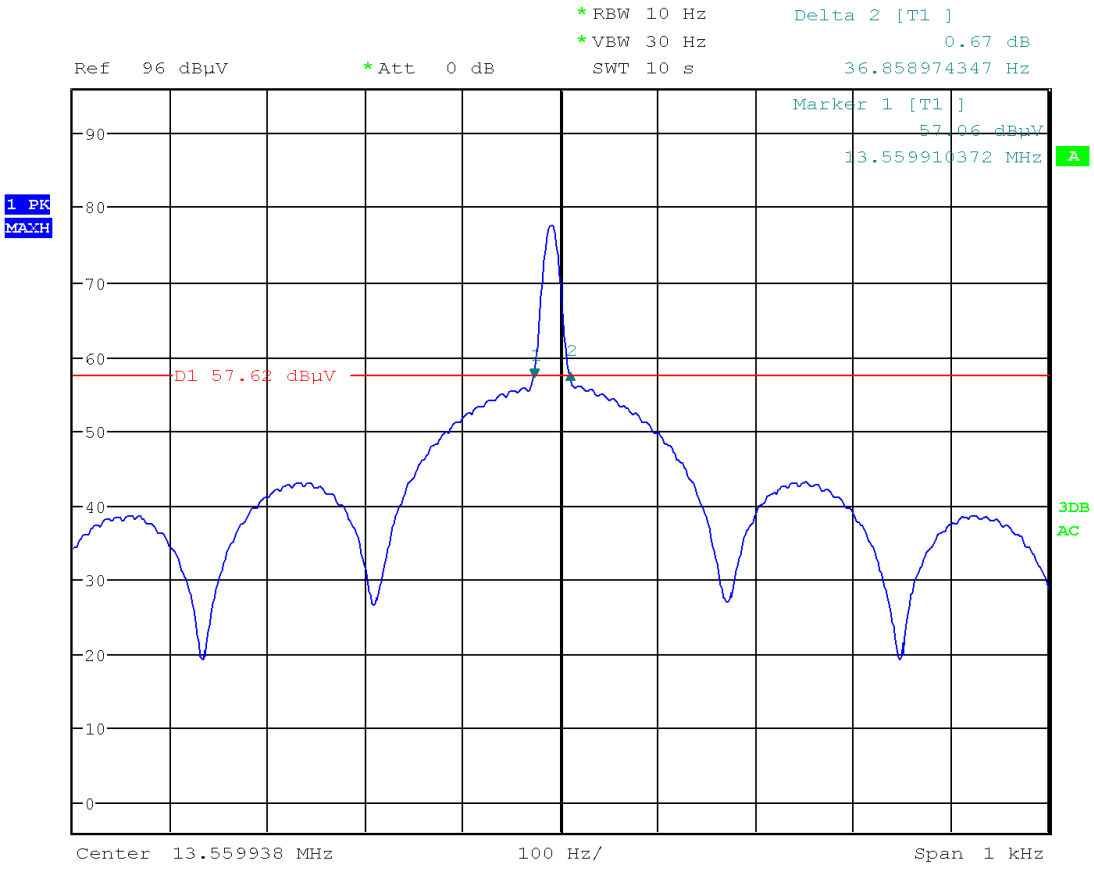
Center Frequency of operation MHz	Measured 20dB bandwidth Hz	Measured 99% bandwidth Hz
13.56	36.85	207

Graphs 3-4-1 and 3-4-2 show bandwidth of emissions

Notes: A larger RBW was used due to the nature of the design that modulation spectrum starts 20 dB below the carrier.

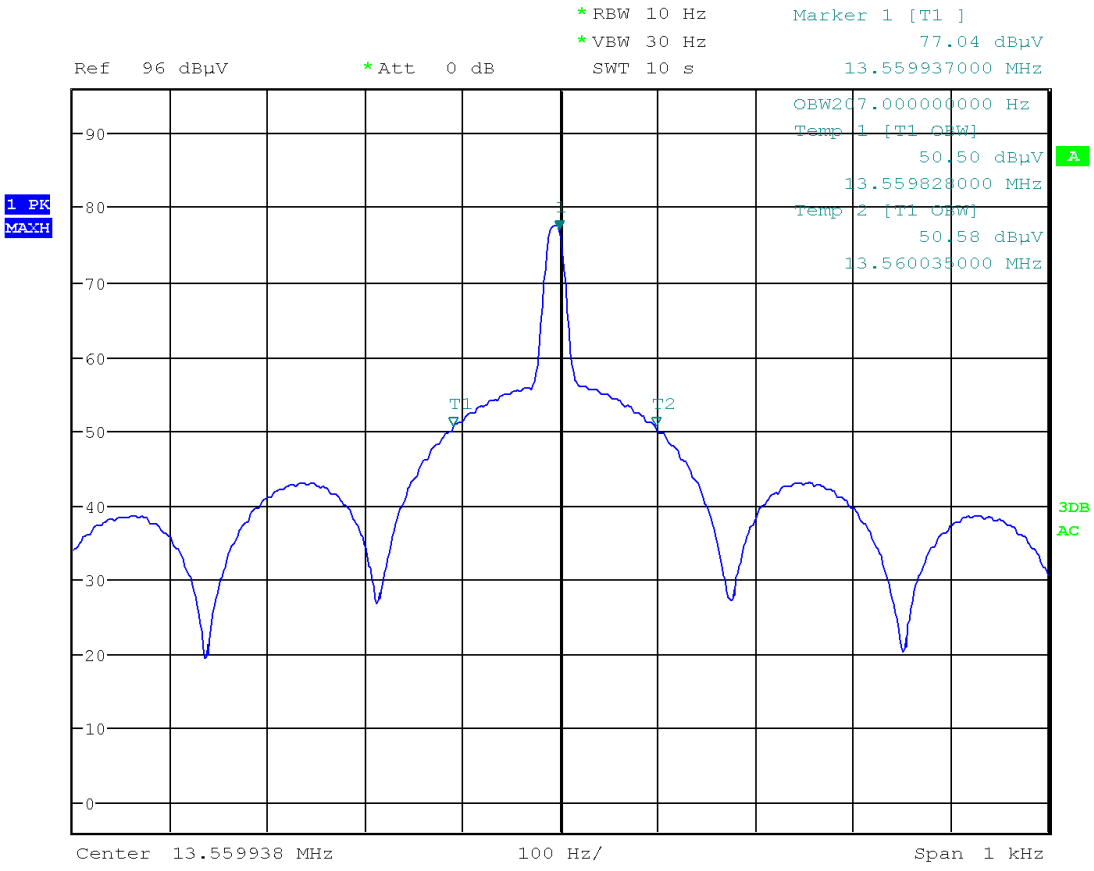
Field strength outside of the band of operation comply with the limits of §15.209 (see Page 11. Table 3.2.1 and Graphs 3.2.1 and 3.2.2.

Graph 3.3.1



Date: 29.JUN.2021 15:35:54

Graph 3.3.2



Date: 29.JUN.2021 15:17:11

3.5 Transmitter power line conducted emissions

Test location: ☐ OATS ☐ Anechoic Chamber ☐ Other

Test result: **Pass**

Frequency range: 0.15MHz-30MHz

Max. Emissions margin: 1.5 dB below the limits

Notes: A 50ohm terminator was placed on antenna output during the test.

Date:	January 22, 2020	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC Part 15.207	
Test Point:	Power Line	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 42%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

Table 3.5.1

Line 1

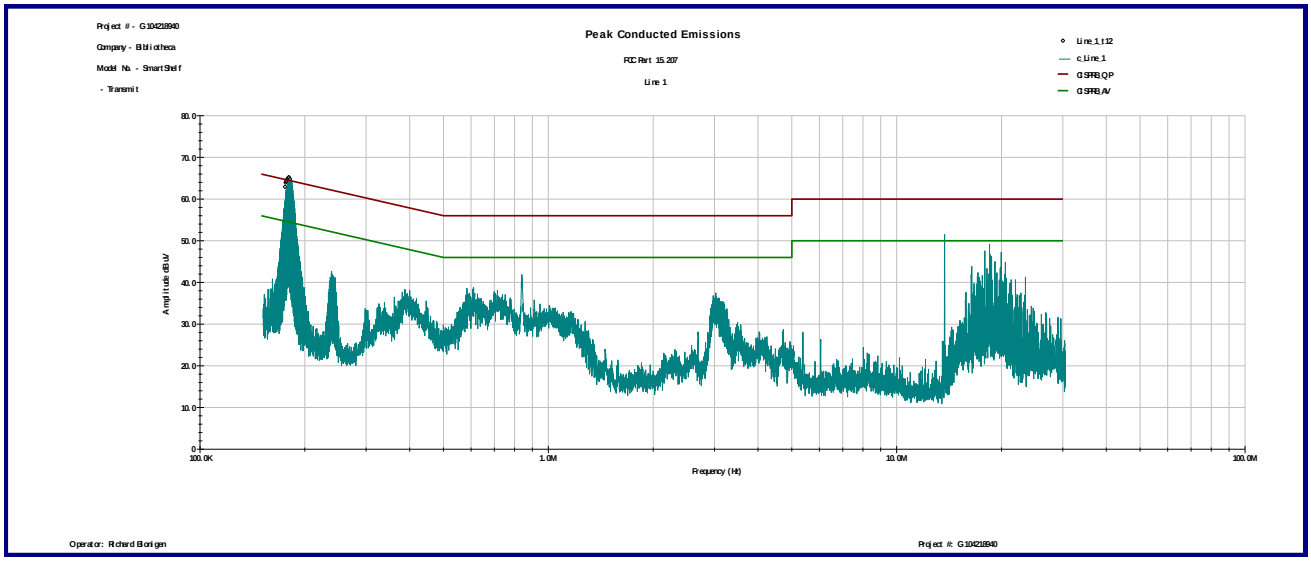
Frequency	QP dBµV	AVG dBµV	QP Limit dBµV	AVG Limit dBµV	QP Margin dB	AVG Margin dB
177.58 KHz	62.1	49.9	64.6	54.6	-2.5	-4.7
179.27 KHz	62.6	49.4	64.5	54.5	-2.0	-5.2
179.84 KHz	62.3	48.8	64.5	54.5	-2.2	-5.7
180.05 KHz	62.2	48.6	64.5	54.5	-2.3	-5.9
234.6 KHz	39.6	27.7	62.3	52.3	-22.7	-24.5
13.56 MHz	50.2	48.3	60.0	50.0	-9.8	-1.7

Line 2

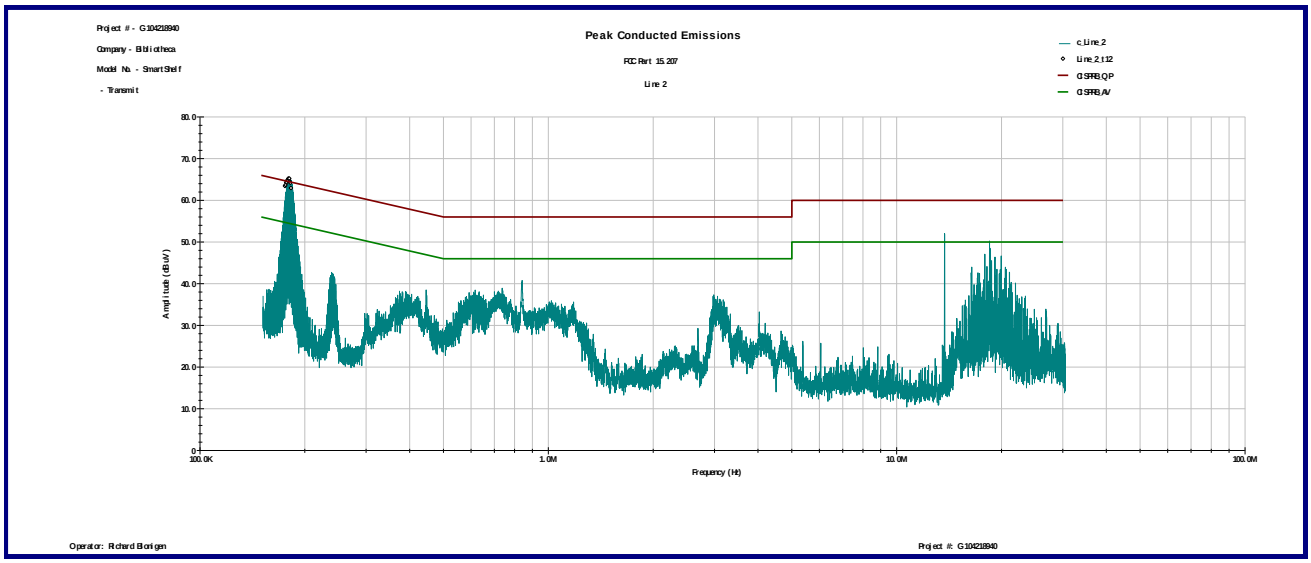
Frequency	QP dBµV	AVG dBµV	QP Limit dBµV	AVG Limit dBµV	QP Margin dB	AVG Margin dB
177.36 KHz	61.7	49.7	64.6	54.6	-2.9	-4.9
179.17 KHz	62.3	49.3	64.5	54.5	-2.2	-5.2
179.83 KHz	62.1	48.7	64.5	54.5	-2.4	-5.8
232.8 KHz	37.7	25.0	62.4	52.4	-24.7	-27.4
13.56 MHz	50.3	48.5	60.0	50.0	-9.7	-1.5
19.712 MHz	37.7	32.8	60.0	50.0	-22.3	-17.2

Graph 3.5.1

Line 1



Line 2



3.6 Receiver/digital device radiated emissions

Test location: ☐ OATS ☒ Anechoic Chamber

Test distance: ☐ 10 meters ☒ 3 meters

Test result: **Pass**

Frequency range: 30MHz-1000MHz

Max. Emissions margin: 4.2 dB below the limits

Notes: The Radiated Emissions test was performed in the Anechoic chamber at 3m measurement distance (see Table 3.6.1 and Graph 3.6.1)

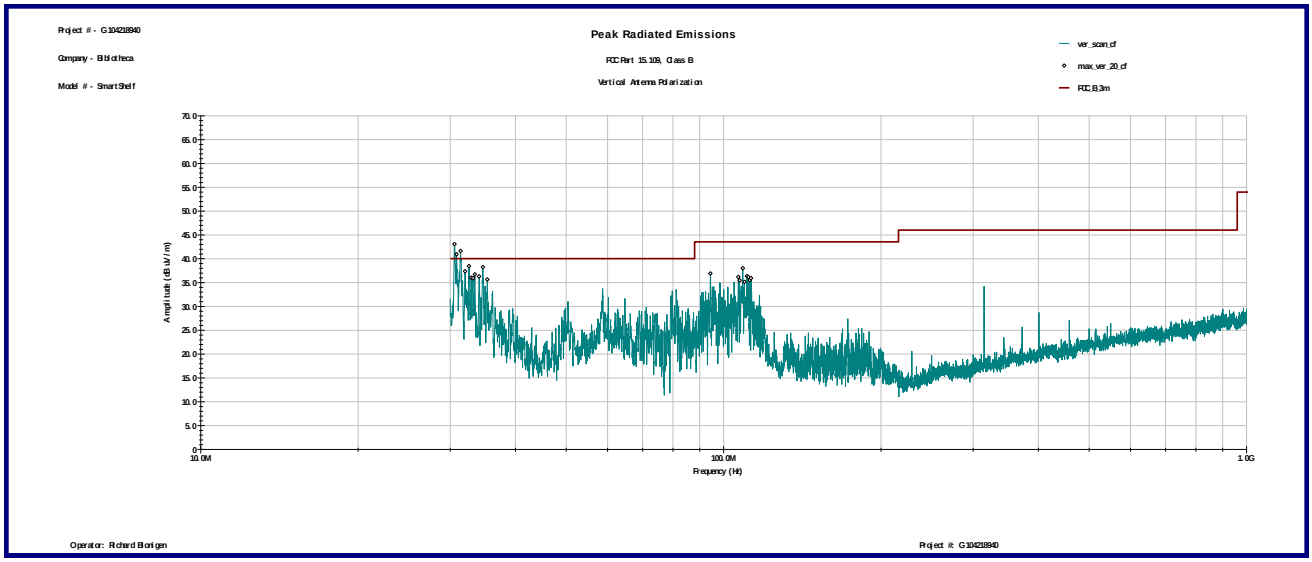
Date:	January 22, 2020	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC Part 15.109, Class B	
Test Point:	Enclosure	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 41%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

Table 3.6.1

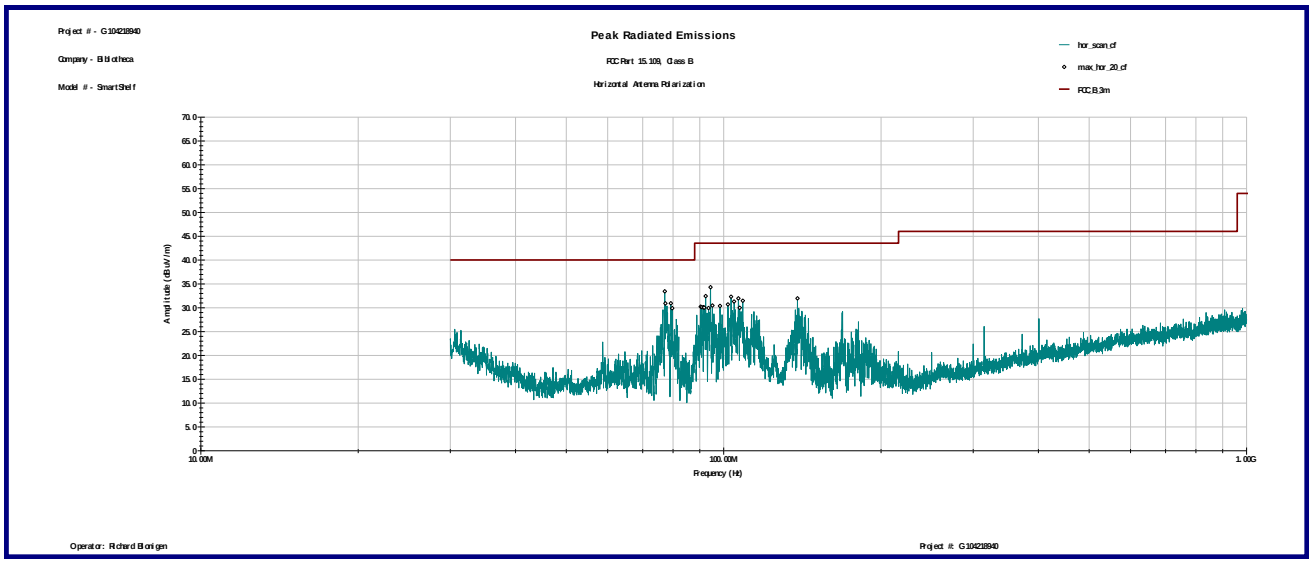
Frequency	Antenna		Ant. CF	Cable loss	Pre-amp	QP Reading	Total @ 3m	Limit	Margin	Comments
MHz	Polarity	Hts(cm)	dB1/m	dB	Gain (dB)	dBµV	dBµV/m	dBµV/m	dB	
31.40	V	100	23.3	0.4	0.0	12.1	35.8	40.0	-4.2	
34.65	V	100	21.4	0.4	0.0	13.2	35.0	40.0	-5.0	
35.33	V	100	21.0	0.4	0.0	11.1	32.5	40.0	-7.5	
94.35	V	100	14.4	0.7	0.0	15.5	30.6	40.0	-9.4	
108.80	V	100	16.6	0.8	0.0	12.6	29.9	40.0	-10.1	
314.91	V	100	18.3	1.4	0.0	10.2	29.9	47.0	-17.1	
77.16	H	100	11.4	0.7	0.0	12.3	24.3	40.0	-15.7	
94.35	H	100	14.4	0.7	0.0	13.1	28.2	40.0	-11.8	
106.69	H	100	16.3	0.8	0.0	11.1	28.2	40.0	-11.8	
114.23	H	100	16.8	0.8	0.0	10.6	28.2	40.0	-11.8	
138.43	H	100	16.3	0.8	0.0	10.9	28.1	40.0	-11.9	

Graph 3.6.1

Vertical antenna polarization



Horizontal antenna polarization



3.7 Digital device conducted emissions

Test location: ☐ OATS ☒ Anechoic Chamber ☐ Other

Test result: **Pass**

Frequency range: 0.15MHz-30MHz

Max. Emissions margin: 9.5 dB below the limits

Notes: None

Date:	January 22, 2020	**Result: Pass**
Tested by:	Richard Blonigen	
Standard:	FCC Part 15.107, Class B	
Test Point:	Line 1 and Line 2	
Operation mode:	See page 5	
Environmental Conditions:	22°C; 41%(RH); 98kPa	
Equipment Verification:	☒	
Note:	None	

Table 3.7.1

Line 1

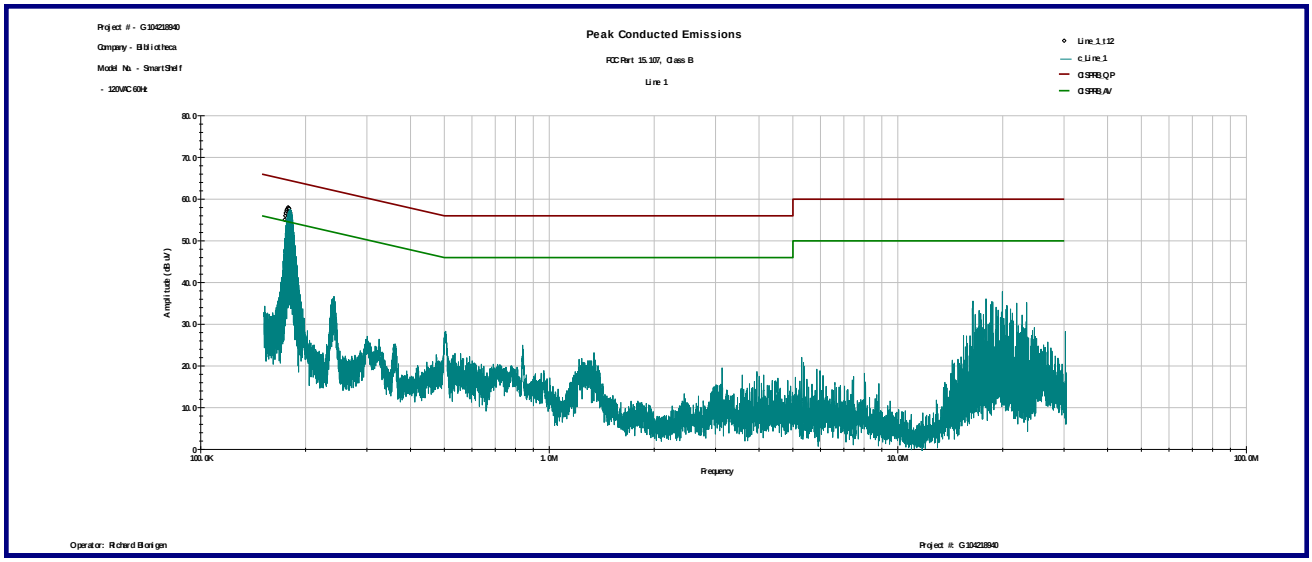
Frequency	QP dBµV	AVG dBµV	QP Limit dBµV	AVG Limit dBµV	QP Margin dB	AVG Margin dB
176.54 KHz	55.9	44.6	64.7	54.7	-8.7	-10.0
177.07 KHz	56.4	45.0	64.6	54.6	-8.2	-9.7
179.27 KHz	56.4	44.6	64.5	54.5	-8.1	-10.0
179.44 KHz	56.3	44.4	64.5	54.5	-8.2	-10.1
236.33 KHz	34.7	26.9	62.2	52.2	-27.6	-25.3
19.712 MHz	36.3	34.4	60.0	50.0	-23.8	-15.7

Line 2

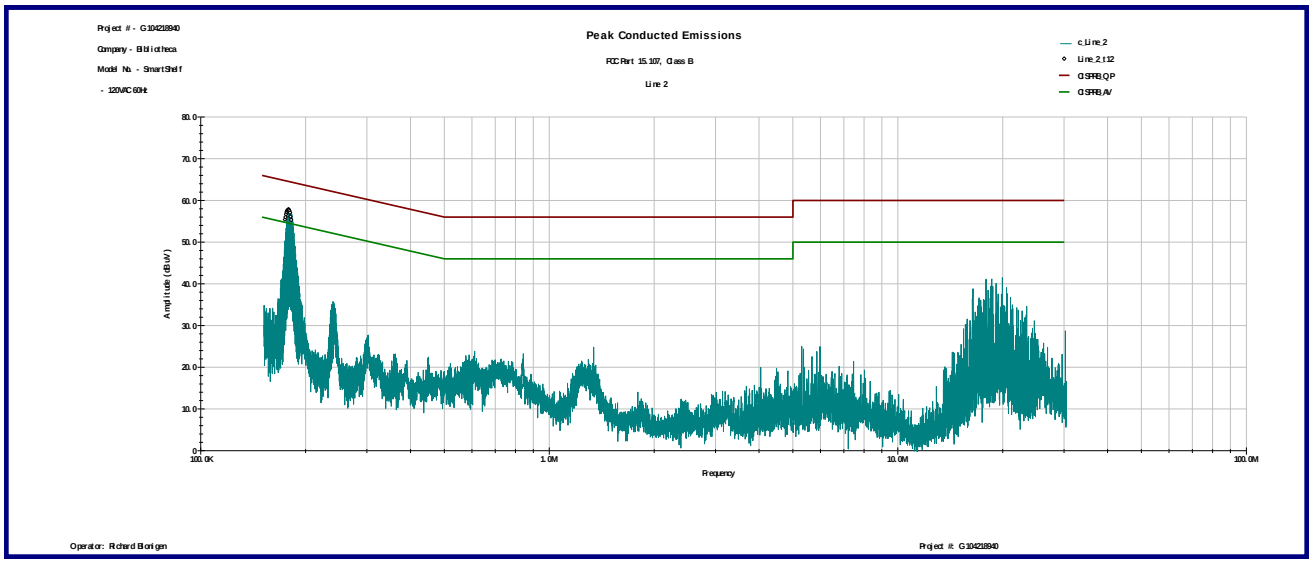
Frequency	QP dBµV	AVG dBµV	QP Limit dBµV	AVG Limit dBµV	QP Margin dB	AVG Margin dB
176.35 KHz	55.7	44.3	64.7	54.7	-9.0	-10.3
177.61 KHz	56.6	45.1	64.6	54.6	-8.0	-9.5
179.76 KHz	56.2	44.3	64.5	54.5	-8.3	-10.2
180.42 KHz	55.6	43.5	64.5	54.5	-8.9	-10.9
17.691 MHz	35.8	35.8	60.0	50.0	-24.2	-14.2
19.712 MHz	34.3	30.7	60.0	50.0	-25.7	-19.3

Graph 3.7.1

Line 1



Line 2



3.8 SAR Test Exclusion Calculation

RF Exposure requirements are described in FCC KDB 447498 D01 v05r02, Mobile and Portable Devices RF Exposure Procedures and Equipment Authorization Policies.

Annex C of this document set SAR Test Exclusions for devices operated in frequency range below 100MHz, which are based on the power at the EUT output RF power according to the Table below

MHz	< 50	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	mm
100	237	474	481	487	494	501	507	514	521	527	534	541	547	554	561	567	
50	308	617	625	634	643	651	660	669	677	686	695	703	712	721	729	738	
10	474	948	961	975	988	1001	1015	1028	1041	1055	1068	1081	1095	1108	1121	1135	
1	711	1422	1442	1462	1482	1502	1522	1542	1562	1582	1602	1622	1642	1662	1682	1702	mW
0.1	948	1896	1923	1949	1976	2003	2029	2056	2083	2109	2136	2163	2189	2216	2243	2269	
0.05	1019	2039	2067	2096	2125	2153	2182	2211	2239	2268	2297	2325	2354	2383	2411	2440	
0.01	1185	2370	2403	2437	2470	2503	2537	2570	2603	2637	2670	2703	2737	2770	2803	2837	

The EUT Output Power (W) can be calculated using the formula:

$P = (E \times d)^2/30G$, where

E – field strength in V/m,
D – field strength measurement distance in m,
G – numerical value of antenna gain.

The EUT Output Power can be calculated based on technical characterization and operation of the EUT.

The power calculation is P = (0.08 V/m x 10m)2 / (30 x 1) = 21.333mW

The Minimum SAR Test Exclusion Threshold power for frequency range 10-50MHz per the Table above is 308mW.
The EUT calculated power of 21.33mW is below the Minimum SAR Test Exclusion Threshold power of 308mW, and also below the Minimum Exemption Limits for SAR Routine Evaluation of RSS-102 (section 2.5) is 345mW.

Therefore, the transmitter is exempt from SAR testing.

4.0 TEST EQUIPMENT

DESCRIPTION	MANUFACTURER	MODEL	SERIAL NO.	INTERTEK ID	LAST CAL DATE	CAL DUE	USED
Spectrum Analyzer	R & S	ESU	100398	25283	07/17/2019	07/17/2020	☒
Spectrum Analyzer	R & S	ESCI	100358	12909	05/13/2019	05/13/2020	☒
Bicono-Log Antenna	Teseq	CBL6112D	32859	25289	05/23/2019	05/23/2020	☒
Loop Antenna	ETS	6512	00060486	19942	02/12/2020	02/12/2021	☒
System	Quantum Change	TILE! Instrument Control	Ver. 3.4.K.29	15259	VBU	VBU	☒
LISN	COM-Power	Li-215A	191970	172315	07/25/2019	07/25/2020	☒
LISN	COM-Power	Li-215A	191971	172316	04/04/2019	04/04/2020	☒

Equipment used for 20dB and 99% OBW retest

DESCRIPTION	MANUFACTURER	MODEL	SERIAL NO.	INTERTEK ID	LAST CAL DATE	CAL DUE	USED
Spectrum Analyzer	R & S	ESCI	100358	12909	02/10/2021	02/10/2022	☒

5.0 Revision History

REVISION LEVEL	DATE	REPORT NUMBER	PREPARED	REVIEWED	NOTES
0	03-04-2020	104218940MIN-008	RB	US	Original Issue
1	07-30-2021	104218940MIN-008	RB 	US 	Retested 20dB and 99% OBW. Additional notes were added on page 7 and 16.