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Amended

FCC/IC Test Report

Prepared for: **Bauer Compressors, Inc.**
1328 Azalea Garden Road
Norfolk, VA 23502

Product: **UNICUS 4i**
SCBA Tank Fil-Station with RF ID reader

Test Report No: **R20161024-20C**

Approved By:

Nic S. Johnson, NCE
Technical Manager
iNARTE Certified EMC Engineer #EMC-003337-NE

DATE: **4 January 2018**

Total Pages: **24**

ilac-MRA A2LA ACCREDITED TESTING LABORATORY CERTIFICATE NO. 1953.01

Revision Page

Rev. No.	Date	Description
Original	20 November 2017	Original – NJohnson
A	15 December 2017	Includes NCEE Labs report R20161024-20 and its amendment in full. Frequency deviation measurement s were repeated with a smaller resolution bandwidth 3m measurements were used with the 40dB/decade rule applied to extrapolate the limits to 3m from 10 – 30MHz. -NJ
B	28 December 2017	Page 13, the limit at the fundamental frequency was corrected to be 124 dBuV/m. Figures 4 – 6 were corrected to show the correct fundamental level -NJ
C	4 January 2018	The 3m limits in Section 4.2.5 were corrected. The F1 and F2 frequencies in Figures 2 and 3 were also corrected. -NJ

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Tables

Figures

1 Summary of Test Results

Table 1 – Test Result Summary

Standard Section(s)	Test Description	Test Limit	Test Condition	Test Result	Report Section
FCC Part 15.215, 15.225	Occupied Bandwidth	N/A	Radiated	PASS	Section 4.1
FCC Part 15.225(a)	In-band Emissions	15,848µV/m at 30m 13.553 – 13.567 MHz 334 µV/m at 30m 13.410 – 13.553 106 µV/m at 30m 13.110 – 13.410 MHz 13.710 – 14.010 MHz	Radiated	PASS	Section 4.2
FCC Part 15.225(d) And 15.209	Out-of-Band Emissions	Emissions outside the specified band (13.110 – 14.010 MHz) must meet the radiated emissions from 15.209	Radiated	PASS	Section 4.3
FCC Part 15.209	AC Conducted Emissions	15.207 Limits	AC Line conducted	PASS	Section 4.4
FCC Part 15.225(e)	Frequency tolerance of the carrier	±0.01% of operating frequency over -20 to 50degC.	Conducted	PASS	Section 4.5

2 EUT Description

The Equipment Under Test (EUT) was a SCBA Tank Fil-Station with RF ID reader.

2.1 EUT Details

Table 2 - Equipment under Test (EUT)

Identification	UNICUS 4i SCBA Tank Fil-Station with RF ID reader
Manufacturer	Bauer Compressors, Inc.
Model Number	CFS-3M55
Serial Number	19J59
EUT Received Date	27 December 2016*
EUT Tested Date	17 July 2017 (spurious emissions, frequency deviation) 20 Nov 2017 (in-band emissions, conducted emissions) 14 Dec 2017 (bandwidth measurement)
Power Supply	CS Power Supply Model No. JYH32-1202000 100-240V, 50/60Hz, 12V, 0.8A

*Final configuration of EUT was tested in July and November 2017. The EUT was modified from its original configuration ion order to meet the requirement. The addition of band pass filters and updated firmware were required.

2.2 EUT Setup

The EUT was powered by 120VAC/60Hz through an AC/DC wall-wart style power adapter. It was connected to a PC via RS-232 connector and the PC was used to initiate a read command that would cause the antennas to transmit.

The antennas to do not have the capability to transmit continuously.

3 Laboratory Description

All testing was performed at the following Facility:

The Nebraska Center for Excellence in Electronics (NCEE Labs)
4740 Discovery Drive
Lincoln, NE 68521

A2LA Certificate Number:	1953.01
FCC Accredited Test Site Designation No:	US1060
Industry Canada Test Site Registration No:	4294A-1
NCC CAB Identification No:	US0177

3.1 Environmental Conditions

Environmental conditions varied slightly throughout the tests:
Relative humidity of 42 ± 4%
Temperature of 23 ± 3° Celsius

3.2 Test technicians and engineers

All testing was performed by
1. Karthik Vepuri
2. Dustin Hoffman
3. Nic Johnson

3.3 Test equipment used

DESCRIPTION AND MANUFACTURER	MODEL NO.	SERIAL NO.	LAST CALIBRATION DATE	CALIBRATION DUE DATE
Rohde & Schwarz Test Receiver	ES126	100037	24 Jan 2017	24 Jan 2018
EMCO Biconilog Antenna	3142B	1647	02 Aug 2017	02 Aug 2018
EMCO Horn Antenna	3115	6416	25 Jan 2016	25 Jan 2018
EMCO Loop Antenna	6512	00024936	25 Jan 2016	25 Jan 2018
Rohde & Schwarz Preamplifier	TS-PR18	3545700803	9 Feb 2017*	9 Feb 2018*
Trilithic High Pass Filter	6HC330	23042	9 Feb 2017*	9 Feb 2018*
Rohde & Schwarz LISN	ESH3-Z5	100023	23 Jan 2017	23 Jan 2018
RF Cable (preamplifier to antenna)	MFR-57500	01-07-002	09 Feb 2017*	09 Feb 2018*
RF Cable (antenna to 10m chamber bulkhead)	FSCM 64639	01E3872	09 Feb 2017*	09 Feb 2018*
RF Cable (10m chamber bulkhead to control room bulkhead)	FSCM 64639	01E3874	09 Feb 2017*	09 Feb 2018*
RF Cable (Control room bulkhead to RF switch)	FSCM 64639	01E3871	09 Feb 2017*	09 Feb 2018*
RF Cable (RF switch to test receiver)	FSCM 64639	01F1206	09 Feb 2017*	09 Feb 2018*
RF switch – Rohde and Schwarz	TS-RSP	1113.5503.14	09 Feb 2017*	09 Feb 2018*
N connector bulkhead (10m chamber)	PE9128	NCEEBH1	09 Feb 2017*	09 Feb 2018*
N connector bulkhead (control room)	PE9128	NCEEBH2	09 Feb 2017*	09 Feb 2018*
Russells Temp Chamber	ECMD-2-10	01013187	26 Jul 2017	26 Jul 2018

*Internal Characterization

4 Test Results

4.1 Bandwidth

Test:	CFR 47; FCC Part 15.215, 15.225		
Test Method:	ANSI C63.10:2013, Section 6.9.2		
Test Result:	Complies	**Date:**	7/17/2017

4.1.1 Test Description

Bandwidth measurements were made at a distance 3m inside a semi-anechoic chamber. The EUT was rotated 360^{o}, the antenna height varied from 1 – 4 meters and both the vertical and horizontal antenna polarizations examined to find the height and angle of the maximum emissions.

4.1.2 Test Results

The 20 dB Bandwidth was measured to be 116.23 kHz

4.1.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 42 ± 5%
Temperature of 25 ±2^{o} C

4.1.4 Test Setup

See Section 2.3 for further details.

4.1.5 Test Data

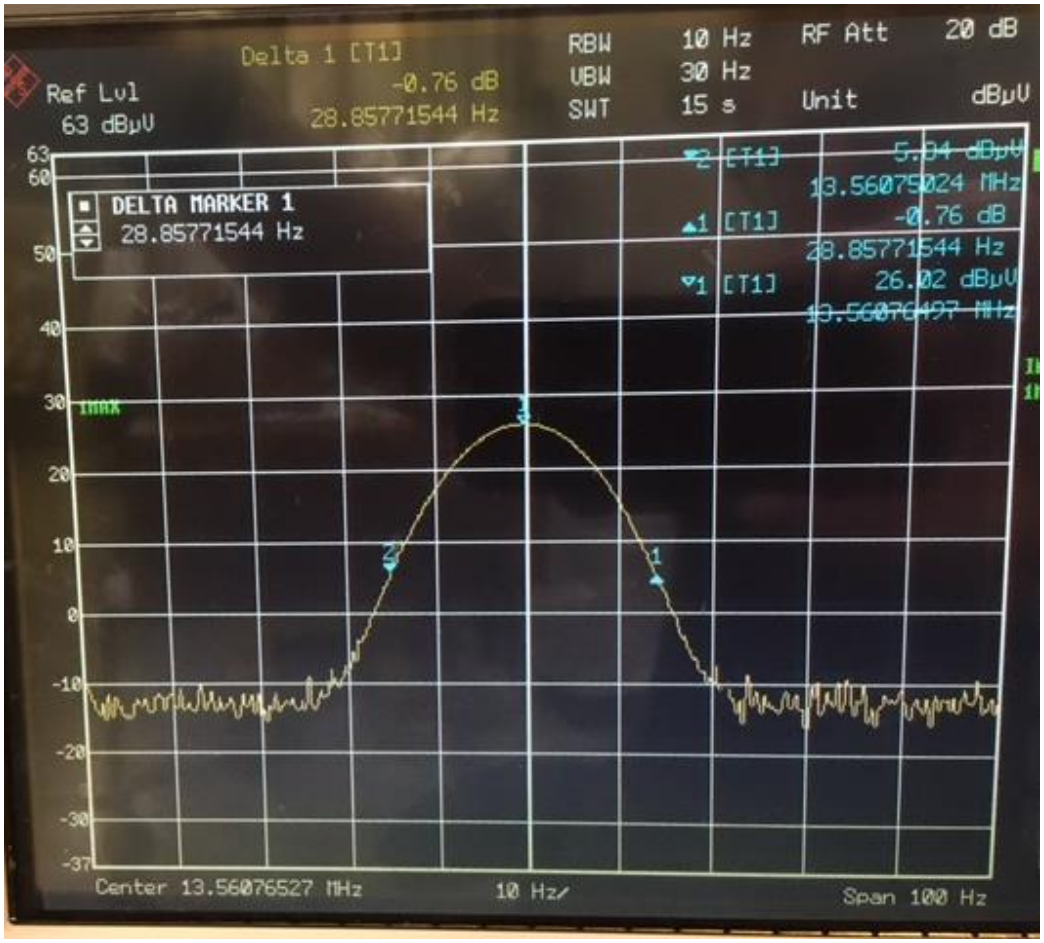


Figure 1 - 20 dB Bandwidth Plot

20 dB bandwidth = 28.86 Hz. This falls within the 13.110 to 14.010 MHz band.

4.2 In-Band Emissions

Test:	CFR 47; FCC Part 15.225(a)(b)(c) using ANSI C63.10:2013		
Test Method:	ANSI C63.10:2013		
Test Result:	Complies	**Date:**	7/17/2017

4.2.1 Test Description

Radiated emissions measurements were made from 30MHz to 25 GHz at a distance 3m inside a semi-anechoic chamber. The EUT was rotated 360°, the antenna height varied from 1 – 4 meters and both the vertical and horizontal antenna polarizations examined. The results were compared against the limits. Measurements were made by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

10MHz – 30MHz: 9kHz IF bandwidth, 5kHz steps

§15.225 Operation within the band 13.110-14.010 MHz.

(a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.

(b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

(c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

(d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

4.2.2 Test Results

No radiated emissions measurements were found in excess of the limits.

4.2.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 42 ± 5%
Temperature of 25 ±2° C

4.2.4 Test Setup

See Section 2.3 for further details.

The EUT was tested at a height of 13cm. This was intended to match the actual height the EUT would be in a field installation.

4.2.5 Test Data

Frequency	FS H	FS V	Limit at 3m*	Margin	Antenna
MHz	dBµV/m	dBµV/m	dBµV/m		
13.56	69.01	75.54	124.00	48.46	1
13.56	75.81	68.99	124.00	48.19	2
13.56	69.01	75.54	124.00	48.46	3

The maximum EIRP is calculated from the field strength measurements at 3m:

EIRP = 110.52 – 95.23 = 15.29 dB = **33.81 mW**

EIRP is used instead of conducted measurements because the antenna gain for the custom-built loop antennas is unknown.

Note: For measurements from 10 to 30MHz, the limit was calculated at 3m by using the 40dB/decade extrapolation factor from FCC Part 15.31, Section (f)(2). This was a deviation from ANSI C63.10, Section 6.4.3 because it is specified in FCC Part 15.31 and the regulatory requirements take precedence over the test method.

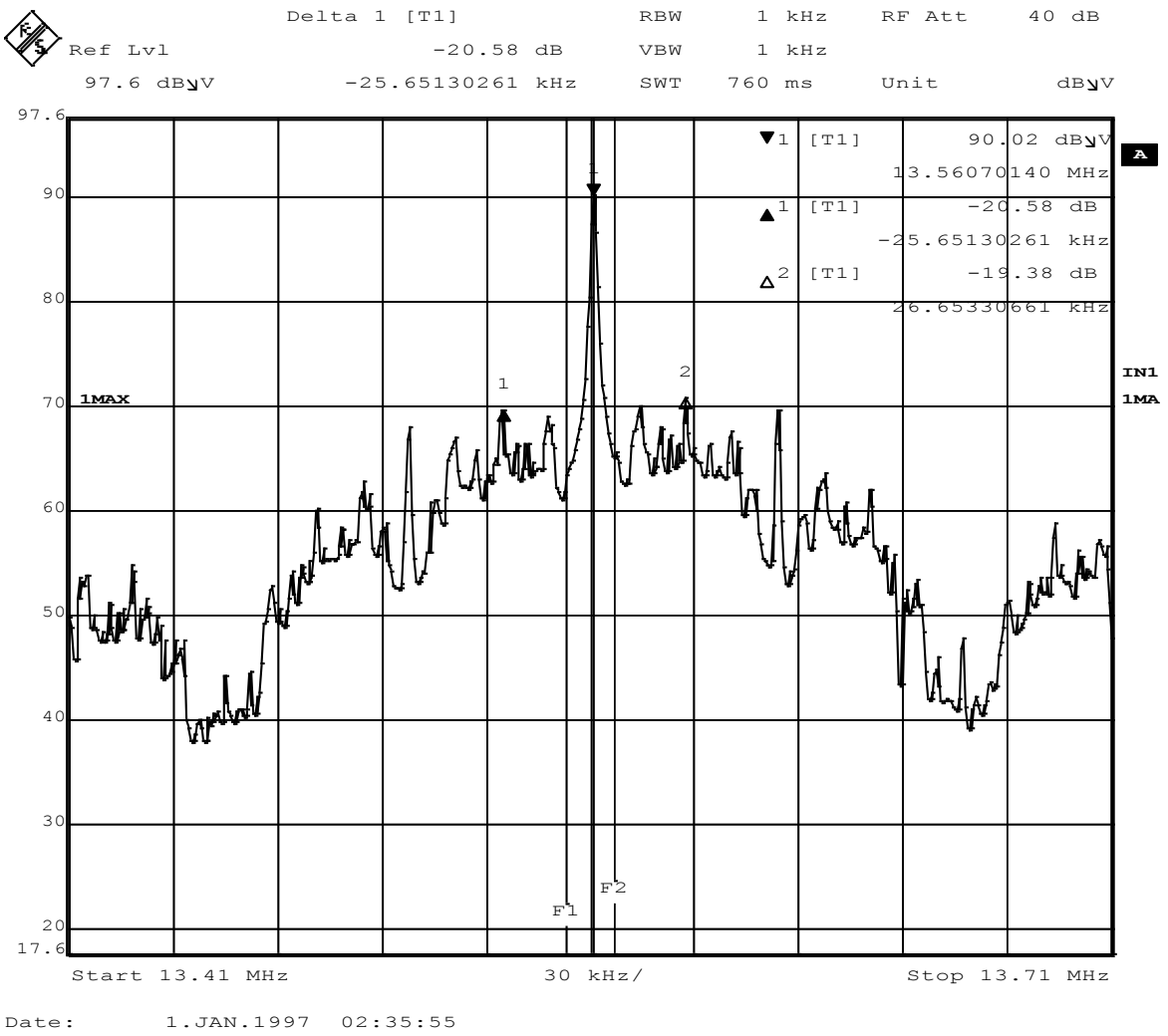


Figure 2 – In-band emissions, 13.410-13.553 and 13.567–13.710 MHz Band, Conducted

F1 = 13.553

F2 = 13.567

Fundamental with 9 kHz rBW = 75.81 dBµV/m

Highest emissions is 25.65 dB below the fundamental

75.81 dBµV/m at 3m – 25.65 = **50.16 dBµV/m at 3m**

Limit = 50.47 dBµV/m at 30m = 90.5 dBµV/m at 3m

Margin = 90.5 – 50.16 dBµV/m = 40.34 dB

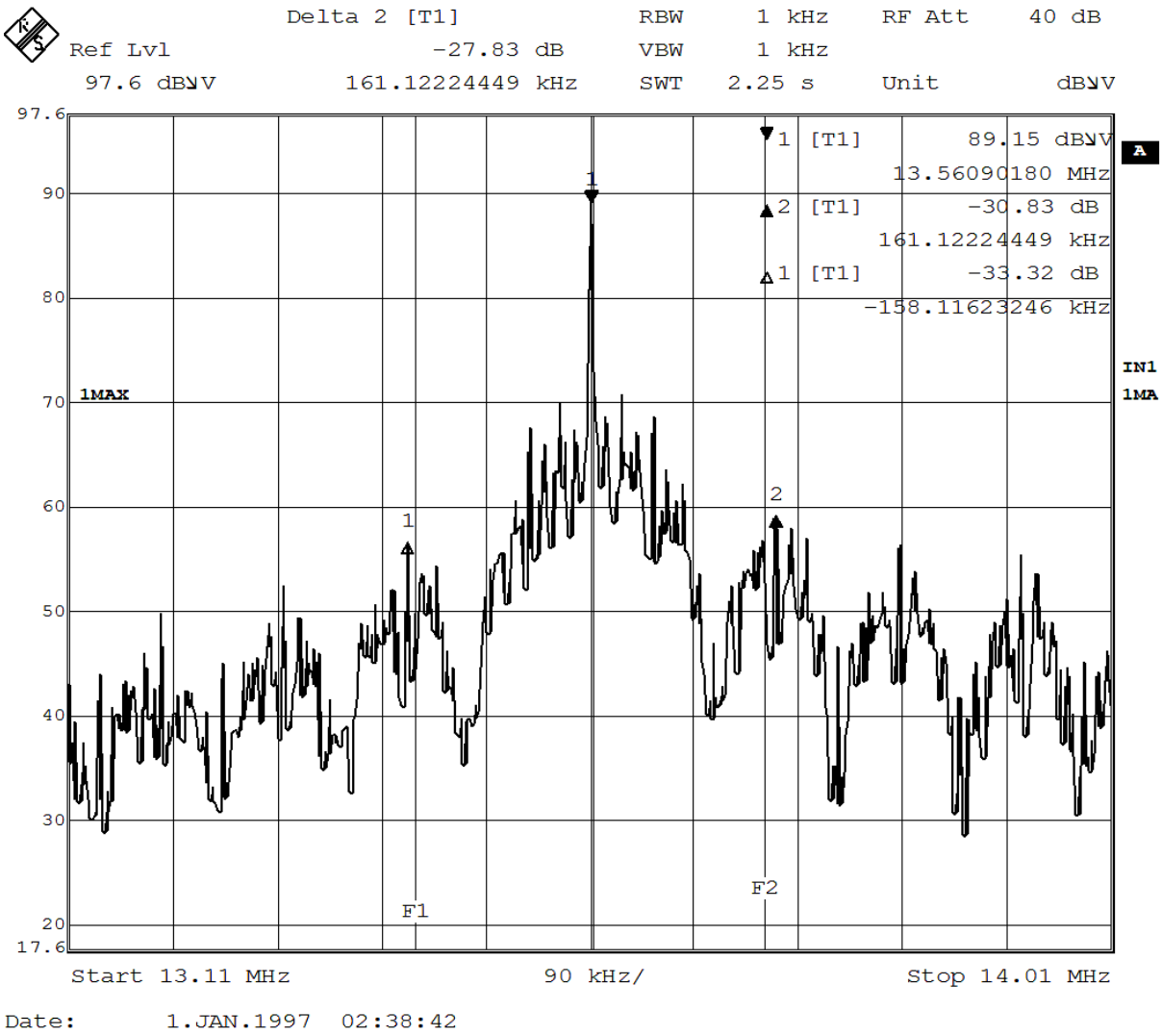


Figure 3 – In-band emissions, 13.110 – 13.410 and 13.710 – 14.010 MHz, Conducted

F1 = 13.410

F2 = 13.710

Fundamental with 9 kHz rBW = 75.81 dBµV/m

Highest emission in these bands is 30.83 dB below the fundamental

75.81 dBµV/m at 3m – 30.83 = **44.98 dBµV/m at 3m**

Limit = 50.51 dBµV/m at 30m = 80.5 dBµV/m at 3m

Margin = 80.5 – 44.98 dBµV/m = 35.52 dB

4.3 Out-of-Band Emissions

Test:	CFR 47; FCC Part 15.209		
Test Method:	ANSI C63.10:2013		
Test Result:	Complies	**Date:**	7/17/2017

4.3.1 Test Description

Radiated emissions measurements were made from 30MHz to 25 GHz at a distance 3m inside a semi-anechoic chamber. The EUT was rotated 360°, the antenna height varied from 1 – 4 meters and both the vertical and horizontal antenna polarizations examined. The results were compared against the limits. Measurements were made by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

10MHz – 30MHz: 9kHz IF bandwidth, 5kHz steps

Note: For measurements from 10 to 30MHz, the limit was calculated at 3m by using the 40dB/decade extrapolation factor from FCC Part 15.31, Section (f)(2). This was a deviation from ANSI C63.10, Section 6.4.3 because it is specified in FCC Part 15.31 and the regulatory requirements take precedence over the test method.

30MHz – 1GHz: 120kHz IF bandwidth, 60kHz steps

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

4.3.2 Test Results

No radiated emissions measurements were found in excess of the limits.

Test Environment

Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 42 ± 5%
Temperature of 25 ±2° C

4.3.3 Test Setup

See Section 2.3 for further details.

The EUT was tested at a height of 13cm. This was intended to match the actual height the EUT would be in a field installation.

4.3.4 Test Data

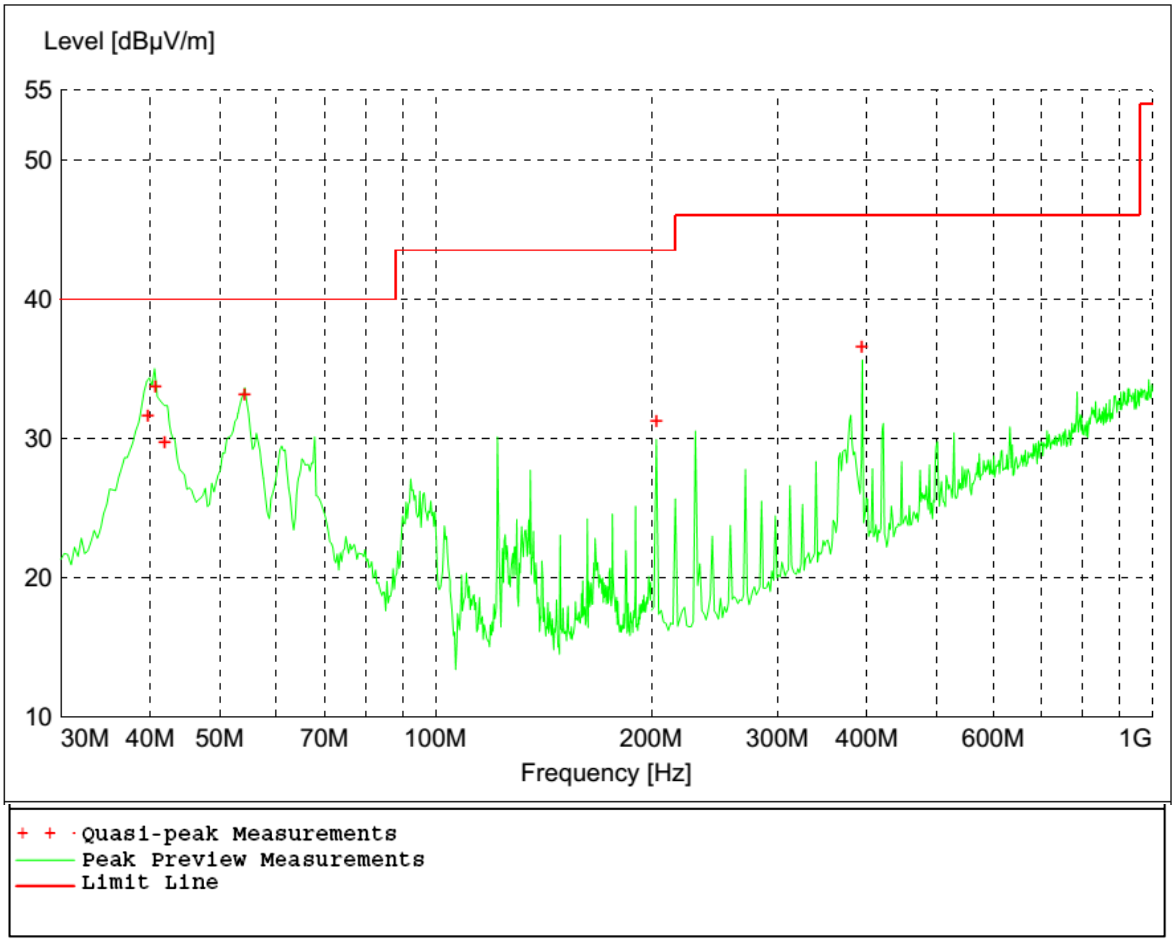


Figure - Out-of-band emissions, 30MHz – 1GHz, worse-case, Radiated

Note: All 3 antennas were tested. The worse-case was Antenna 2 and the results are shown

Table 3 - Radiated Emissions Quasi-Peak Data

Frequency MHz	Level dBµV/m	Measured dBµV	Transd dB	Cables dB	Limit dBµV/m	Margin dB	Height cm	Angle deg	Pol.
39.720000	31.64	17.31	13.0	-1.3	40.0	8.4	99.0	24	VERT
40.680000	33.66	19.80	12.6	-1.3	40.0	6.3	100.0	0	VERT
41.940000	29.68	16.35	12.0	-1.3	40.0	10.3	101.0	29	VERT
54.240000	33.10	23.00	8.8	-1.3	40.0	6.9	100.0	38	VERT
203.400000	31.17	17.80	10.9	-2.5	43.5	12.3	100.0	82	VERT
393.240000	36.59	16.73	16.7	-3.2	46.0	9.4	100.0	94	VERT

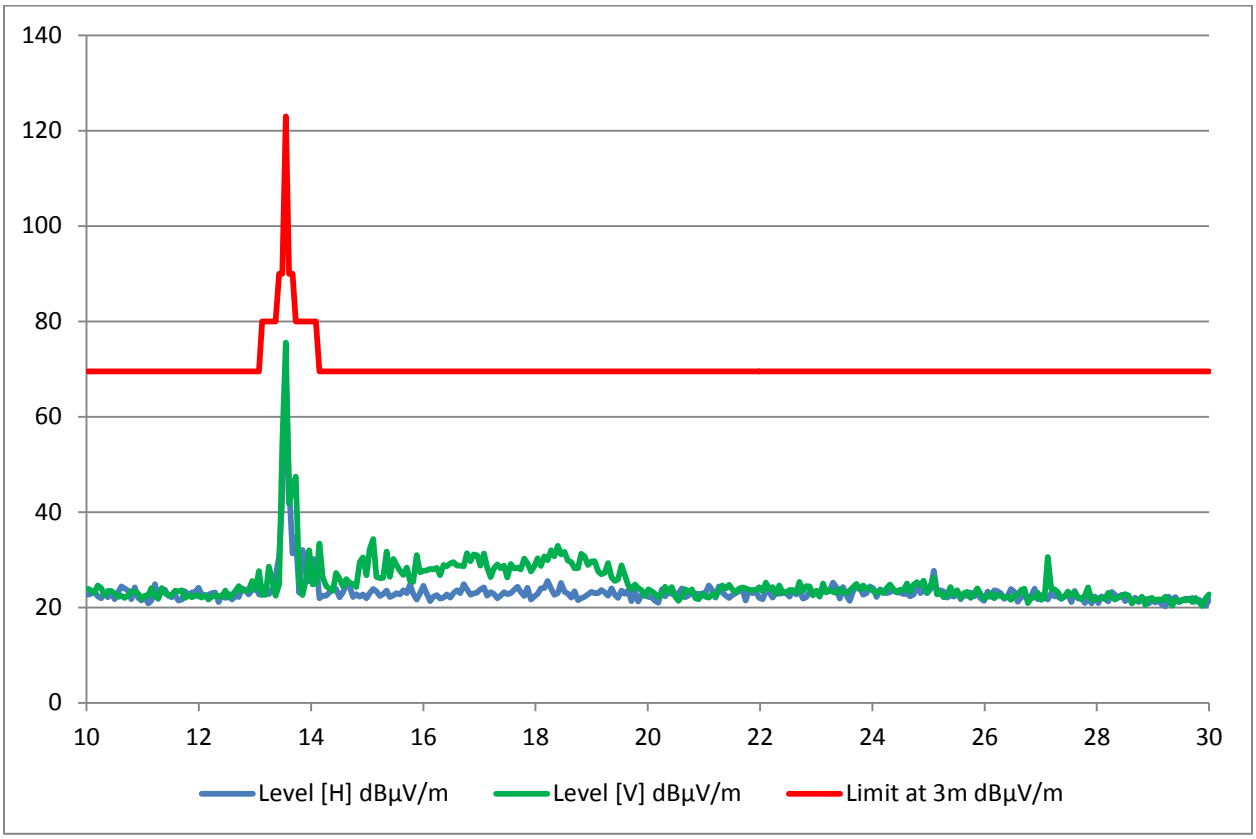


Figure 4 - Out-of-band Emissions, Antenna 1, Radiated

All measurements were found to be at least 10 dB below the limit, except within the 13.41 to 13.71 MHz band, which is covered in Section 4.3 of this report.

Table 4 - 6 Highest Emissions with respect to limit, Antenna 1
Outside of 13.41 to 13.71 MHz band

Frequency	FS H	FS V	Limit at 3m	Margin
MHz	dBµV/m	dBµV/m	dBµV/m	dB
14.147796	21.91	33.42	69.54	36.12
15.104910	23.91	34.38	69.54	35.16
15.045090	23.04	32.21	69.54	37.33
10.199699	22.36	24.64	69.54	44.90
15.344188	23.54	31.72	69.54	37.82
10.020240	22.69	23.98	69.54	45.56

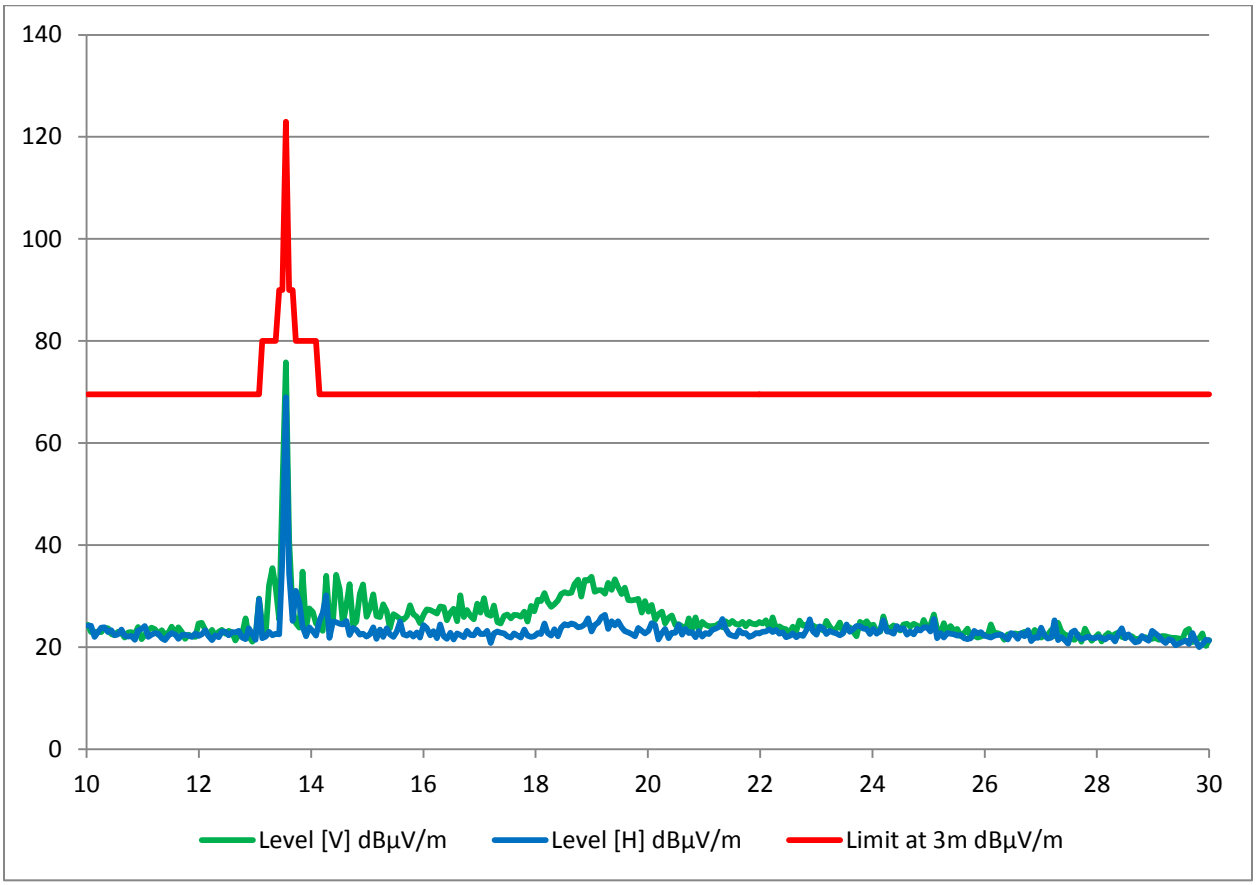


Figure 5 - Out-of-band emissions, Antenna 2, Radiated

All measurements were found to be at least 10 dB below the limit, except within the 13.41 to 13.71 MHz band, which is covered in Section 4.3 of this report.

Table 5 - 6 Highest Emissions with respect to limit, Antenna 2
Outside of 13.41 to 13.71 MHz band

Frequency	FSH	FSV	Limit at 3m	Margin
MHz	dBµV/m	dBµV/m	dBµV/m	
14.267435	33.99	30.20	69.54	35.55
14.446894	34.18	24.88	69.54	35.36
14.686172	32.39	22.39	69.54	37.15
14.925451	32.30	22.65	69.54	37.24
13.071042	29.54	29.39	69.54	40.00
14.506713	31.35	24.60	69.54	38.19

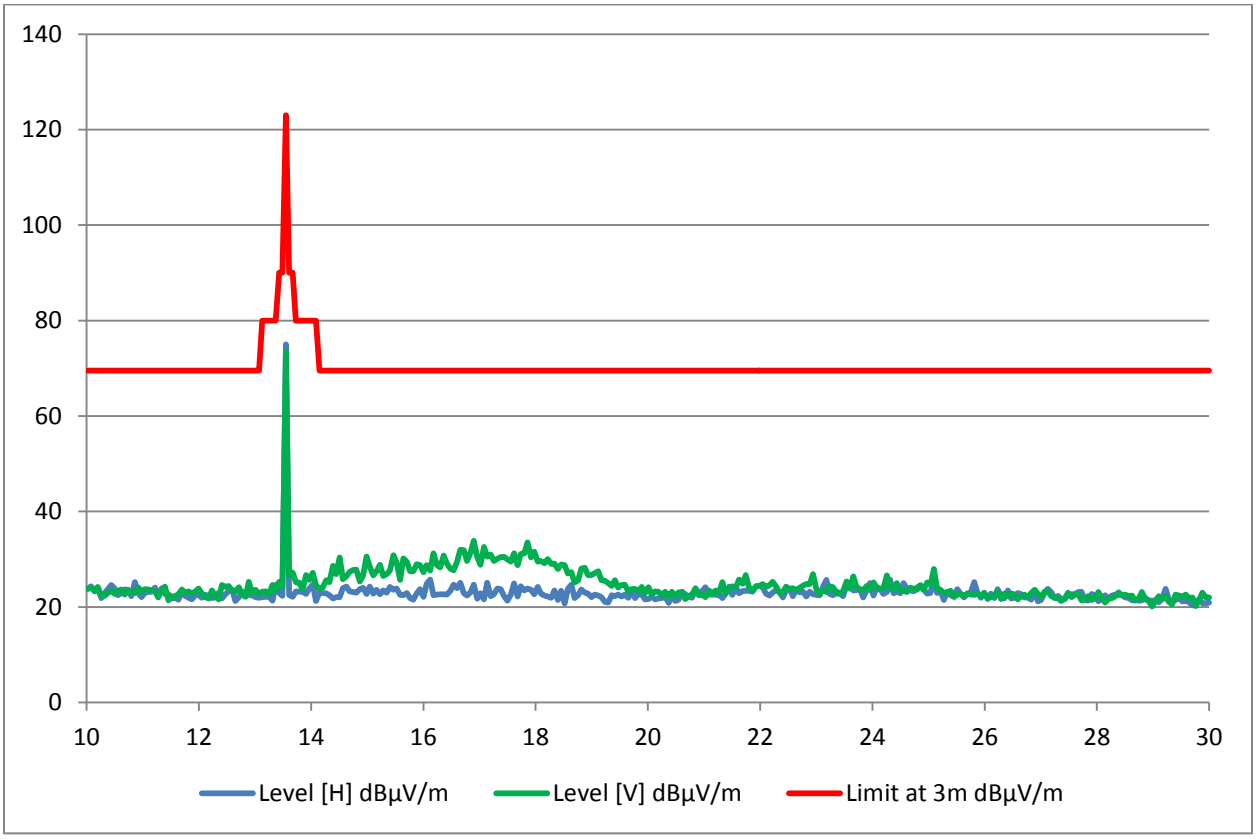


Figure 6 - Out-of-band Emissions, Antenna 3, Radiated

All measurements were found to be at least 10 dB below the limit, except within the 13.41 to 13.71 MHz band, which is covered in Section 4.3 of this report.

Table 6 - 6 Highest Emissions with respect to limit, Antenna 3
Outside of 13.41 to 13.71 MHz band

Frequency	FS H	FS V	Limit at 3m	Margin
MHz	dBµV/m	dBµV/m	dBµV/m	
16.899499	24.69	33.82	69.54	35.72
10.080060	24.31	23.98	69.54	45.23
10.199699	23.90	24.23	69.54	45.31
10.438978	24.63	23.44	69.54	44.91
14.506713	22.03	30.34	69.54	39.20
10.857715	25.21	22.92	69.54	44.33

4.4 Conducted Emissions

Test:	CFR 47; FCC Part 15.207		
Test Method:	ANSI C63.10:2013		
Test Result:	Complies	**Date:**	7/17/2017

4.4.1 Test Description

Conducted emissions measurements were made from 150kHz to 30MHz via a 50µH Line Impedance Stabilization Network (LISN). The results were compared against the limits. Measurements were made on both the line and neutral conductors by first using a spectrum analyzer to acquire the signal spectrum; individual frequencies were then measured using a CISPR 16.1 compliant receiver with the following bandwidth setting:

150kHz – 30MHz: 9kHz IF bandwidth, 5kHz steps

4.4.2 Test Results

No results were found to be in excess of the limits. All the peak values and average values were at least 10dB below the limit so tabular data was not provided for one of the plot. A plot of the results can be seen below.

4.4.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility on the conducted emissions ground plane. Laboratory environmental conditions varied slightly throughout the test:

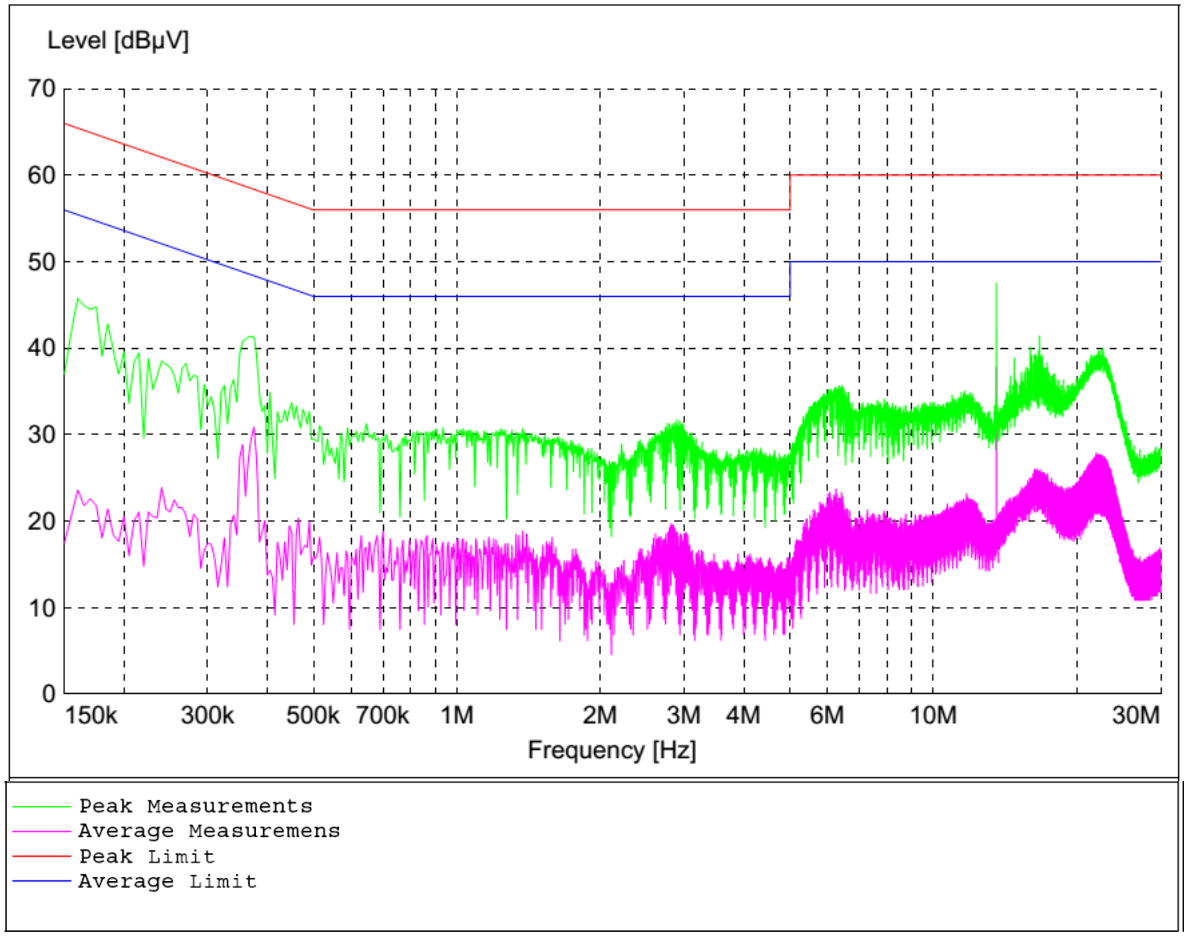
Relative humidity of 40 ± 5%
Temperature of 25 ±2^{o} C

4.4.4 Test Setup

Conducted emissions tests on the AC mains were performed 120VAC/60Hz. The EUT passed the conducted emissions test after removing the conduit on power cable. See Section 2.3 for further details.

The EUT was tested at a height of 13cm. This was intended to match the actual height the EUT would be in a field installation.

4.4.5 Test Data



All measurements were found to be at least 10 dB below the applicable limit

4.5 Frequency Error

Test:	CFR 47, FCC Part 15.225(e)		
Test Result:	Complies	**Date:**	12/15/2017

4.5.1 Test Description

Radiated power was measured on a spectrum analyzer with resolution bandwidth and video bandwidth set to 10 Hz and 30 Hz respectively. The center frequency was found by measuring the frequency of the signal 10dB below the peak on the high and low end of the signal. The frequency half way in between these frequencies was recorded as the center frequency. The temperature was varied from -20°C to 50°C.

4.5.2 Test Results

No radiated emissions measurements were found in excess of the limits. Test result data can be seen below.

4.5.3 Test Environment

Testing was performed at the NCEE Labs Lincoln facility in the 10m semi-anechoic chamber. Laboratory environmental conditions varied slightly throughout the test:

Relative humidity of 45 ± 5%
Temperature of 25 ±2^{o} C

4.5.4 Test Setup

The EUT was placed inside of a thermal chamber. It was set to continuously transmit.

Test results

Table 7 - Frequency Range Measurements

Temperature (°C)	Voltage (VDC)	Channel (MHz) Nom = 13.5600	Min MHz	Max MHz	Result
-20°C	5	13.5607	13.5586	13.5614	PASS
-10°C	5	13.5603	13.5586	13.5614	PASS
0°C	5	13.5607	13.5586	13.5614	PASS
10°C	5	13.5607	13.5586	13.5614	PASS
20°C	5	13.5603	13.5586	13.5614	PASS
30°C	5	13.5603	13.5586	13.5614	PASS
40°C	5	13.5603	13.5586	13.5614	PASS
50°C	5	13.5607	13.5586	13.5614	PASS

Annex A – Measurement Uncertainty

Where relevant, the following measurement uncertainty levels have been for tests performed in this test report:

Test	Frequency Range	Uncertainty Value (dB)
Radiated Emissions, 3m	30MHz - 1GHz	3.82
Radiated Emissions, 3m	1GHz - 18GHz	4.44

Expanded uncertainty values are calculated to a confidence level of 95%.

CISPR 16-4-2:2011 was used to calculate the above values.

Annex B - Sample Calculation

Radiated Emissions

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) + AV

where FS = Field Strength

RA = Receiver Amplitude

AF = Antenna Factor

CF = Cable Attenuation Factor

AG = Amplifier Gain

AV = Averaging Factor (if applicable)

Assume a receiver reading of 55 dBμV is obtained. The Antenna Factor of 12 and a Cable Factor of 1.1 is added. The Amplifier Gain of 20 dB is subtracted, giving a field strength of 48.1 dBμV/m.

FS = 55 + 12 – (-1.1 + 20) + 0 = 48.1 dBμV/m

The 48.1 dBμV/m value can be mathematically converted to its corresponding level in μV/m.

Level in μV/m = Common Antilogarithm [(48.1 dBμV/m)/20]= 254.1 μV/m

REPORT END