



**FCC 47 CFR PART 15 SUBPART C
ISED CANADA RSS-210 ISSUE 9**

CERTIFICATION TEST REPORT

FOR

ASSET MONITORING DEVICE

MODEL NUMBER: AH100

FCC ID: 2ASD7-AH100-0

REPORT NUMBER: R12694756-E1

ISSUE DATE: 2019-04-11

Prepared for
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Revision History

<u>Ver.</u>	<u>Issue Date</u>	<u>Revisions</u>	<u>Revised By</u>
1	2019-01-31	Initial Issue	Brian T. Kiewra
2	2019-03-29	Corrected FCC ID	Lariah Ijames
3	2019-04-11	Updated 9 kHz – 30 MHz radiated emissions data and OFS and chamber correlation information	Niklas Haydon

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1. ATTESTATION OF TEST RESULTS

COMPANY NAME: CubeWorks Inc.
1600 Huron Parkway OFC520-2364,
Ann Arbor, MI 48109
United States

EUT DESCRIPTION: Asset Monitoring Device

MODEL: AH100

SERIAL NUMBER: Non-Serialized

DATE TESTED: 2019-01-29

APPLICABLE STANDARDS	
STANDARD	TEST RESULTS
CFR 47 Part 15 Subpart C	Complies
ISED CANADA RSS-210 Issue 9	Complies
ISED CANADA RSS-GEN Issue 5	Complies

UL LLC tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. It is the manufacturer's responsibility to assure that additional production units of this model are manufactured with identical electrical and mechanical components. All samples tested were in good operating condition throughout the entire test program. Measurement Uncertainties are published for informational purposes only and were not taken into account unless noted otherwise.

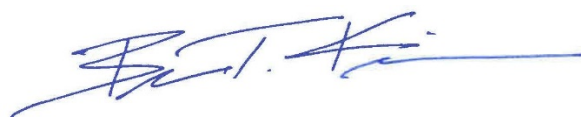
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Approved & Released
For UL LLC By:



Jeffrey Moser
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UL – Consumer Technology Division

Prepared By:



Brian T. Kiewra
Project Engineer
UL – Consumer Technology Division

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.10-2013, FCC CFR 47 Part 2, FCC CFR 47 Part 15, RSS-GEN Issue 5, and RSS-210 Issue 9.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 12 Laboratory Drive, Research Triangle Park, North Carolina 27709, USA and 2800 Perimeter Park Dr., Suite B, Morrisville, North Carolina 27560, USA. The following table identifies which facilities were utilized for radiated emission measurements documented in this report. Specific facilities are also identified in the test results sections.

12 Laboratory Dr.	2800 Perimeter Park Dr.
<input type="checkbox"/> Chamber A (ISED:2180C-1)	<input type="checkbox"/> Chamber North (ISED:2180C-3)
<input type="checkbox"/> Chamber C (ISED:2180C-2)	<input checked="" type="checkbox"/> Chamber South (ISED:2180C-4)

UL LLC (RTP) is accredited by NVLAP, Laboratory Code 200246-0.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. SAMPLE CALCULATION

RADIATED EMISSIONS

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Field Strength (dBuV/m)} &= \text{Measured Voltage (dBuV)} + \text{Antenna Factor (dB/m)} + \text{Cable} \\ &\text{Loss (dB)} - \text{Preamp Gain (dB)} \\ 36.5 \text{ dBuV} + 18.7 \text{ dB/m} + 0.6 \text{ dB} - 26.9 \text{ dB} &= 28.9 \text{ dBuV/m} \end{aligned}$$

MAINS CONDUCTED EMISSIONS

Where relevant, the following sample calculation is provided:

$$\begin{aligned} \text{Final Voltage (dBuV)} &= \text{Measured Voltage (dBuV)} + \text{Cable Loss (dB)} + \text{Limiter Factor} \\ &\text{(dB)} + \text{LISN Insertion Loss.} \\ 36.5 \text{ dBuV} + 0 \text{ dB} + 10.1 \text{ dB} + 0 \text{ dB} &= 46.6 \text{ dBuV} \end{aligned}$$

4.3. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Occupied Channel Bandwidth	2.00%
RF output power, radiated (SAC)	4.52 dB
All emissions, radiated	4.88 dB
Time	3.39%

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is an asset monitoring device with a 915MHz radio.

5.2. MAXIMUM OUTPUT E-FIELD STRENGTH

The transmitter has a maximum output peak E-field as follows:

Frequency Range (MHz)	Output PK E-field Strength (dBuV/m)
915.1	71.03

5.3. DESCRIPTION OF AVAILABLE ANTENNAS

The radio utilizes a magnetic dipole antenna, with a maximum gain of -23 dBi.

5.4. SOFTWARE AND FIRMWARE

The firmware installed in the EUT during testing was AHstack_ondemand, rev. 1.18.

The EUT driver software installed during testing was AHstack_ondemand, rev. 1.18.

The test utility software used during testing was cwgateway, rev. 0.

5.5. WORST-CASE CONFIGURATION AND MODE

The fundamental of the EUT was investigated in three orthogonal orientations X,Y,Z, it was determined that X orientation was worst-case orientation; therefore, all final radiated testing was performed with the EUT in X orientation.

EUT only operates at a frequency of 915.1MHz.

5.6. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

Support Equipment List				
Description	Manufacturer	Model	Serial Number	FCC ID
None				

I/O CABLES

I/O Cable List						
Cable No.	Port	# of Identical Ports	Connector Type	Cable Type	Cable Length (m)	Remarks
None						

TEST SETUP

The EUT is configured as a standalone device

SETUP DIAGRAM FOR TESTS

Please refer to R12694759-EP1 for setup diagrams.

6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

Test Equipment Used - Radiated Disturbance Emissions Test Equipment (Morrisville - South Chamber)

Equip. ID	Description	Manufacturer	Model Number	Last Cal.	Next Cal.
AT0079	Active Loop Antenna	ETS-Lindgren	6502	2019-01-24	2020-01-31
AT0074	Hybrid Broadband Antenna	Sunol Sciences Corp.	JB3	2018-07-24	2019-07-24
AT0069	Double-Ridged Waveguide Horn Antenna, 1 to 18 GHz	ETS Lindgren	3117	2018-04-30	2019-04-30
S-SAC01	Gain-loss string: 0.009-30MHz	Various	Various	2018-09-06	2019-09-06
S-SAC02	Gain-loss string: 25-1000MHz	Various	Various	2018-05-20	2019-05-20
S-SAC03	Gain-loss string: 1-18GHz	Various	Various	2018-03-20	2019-03-20
SA0026	Spectrum Analyzer	Agilent	N9030A	2018-03-20	2019-03-20
SOFTEMI	EMI Software	UL	Version 9.5	NA	NA
s/n 181474409	Environmental Meter	Fisher Scientific	15-077-963	2018-07-27	2020-07-27
HPF009	1GHz high-pass filter, 2W, F _{high} =10GHz	Micro-Tronics	HPM17672	2018-03-13	2019-03-03

7. TEST RESULTS

7.1. ON TIME

LIMITS

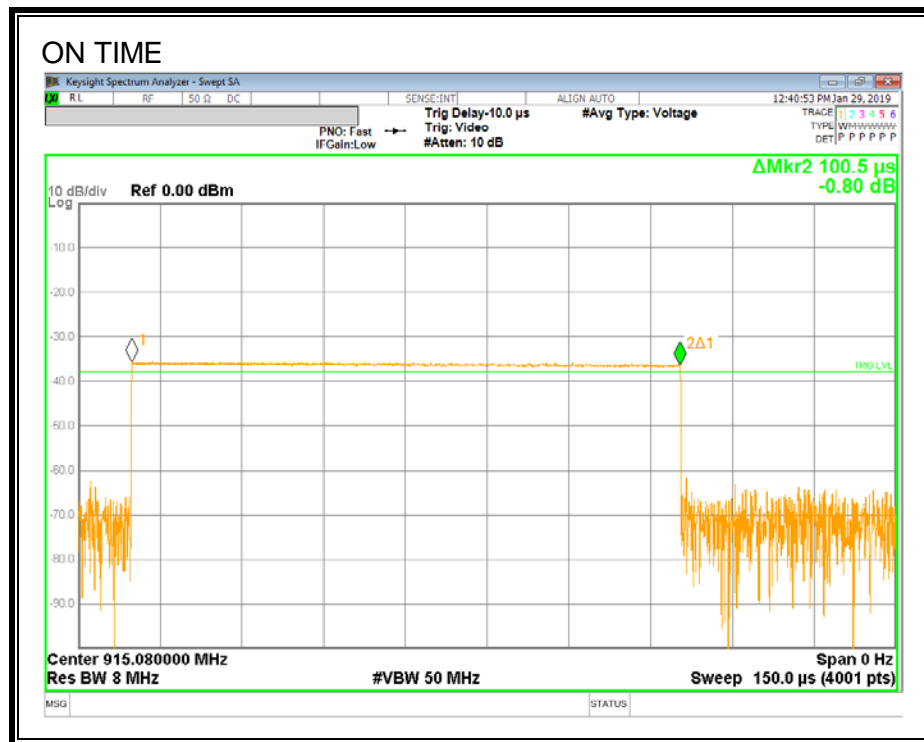
None; for reporting purposes only.

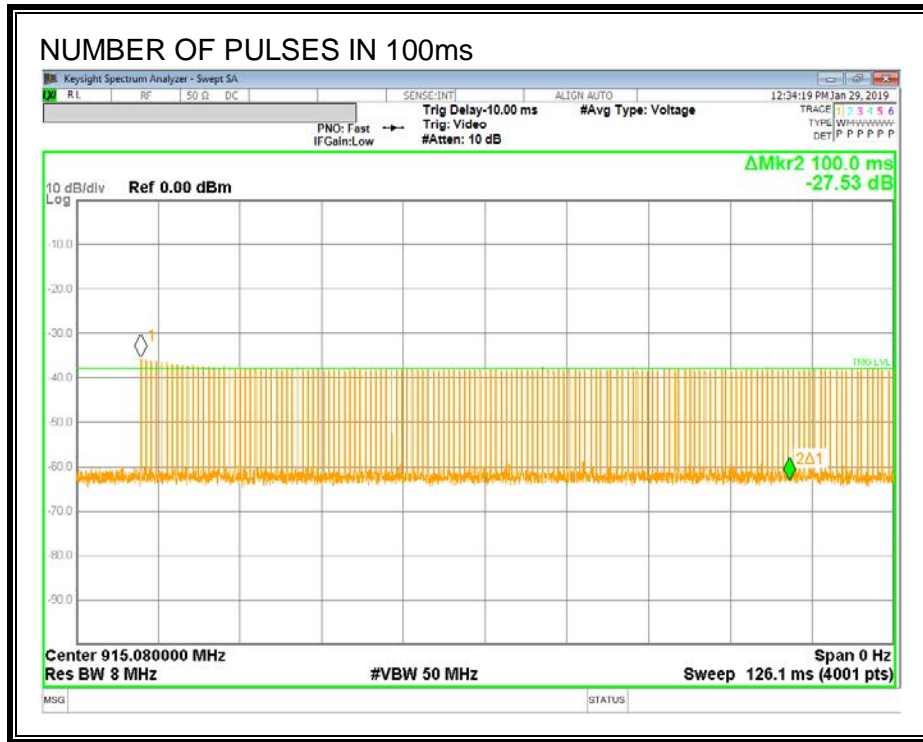
PROCEDURE

ANSI C63.10-2013, section 11.6 (Zero-span spectrum analyzer method.)

ON TIME AND DUTY CYCLE RESULTS

Mode	ON Time T (msec)	Number of pulses in 100ms	Duty Cycle (%)	1/T Minimum VBW (kHz)
915MHz	0.1005	142	14.271	9.950





7.1.1. 99% AND 20dB BANDWIDTH

LIMITS

None; for reporting purposes only.

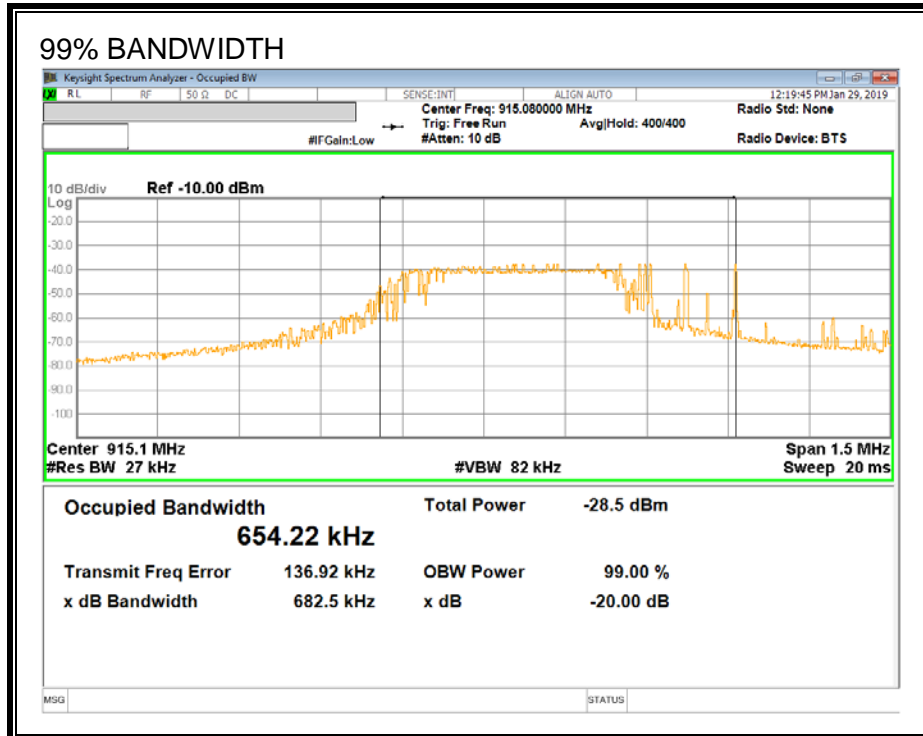
TEST PROCEDURE

The transmitter output is connected to the spectrum analyzer. The RBW is set to 1% to 3% of the 99 % bandwidth. The VBW is set to 3 times the RBW. The sweep time is coupled. The spectrum analyzer internal 99% bandwidth function is utilized.

RESULTS

Frequency (MHz)	20dB Bandwidth (MHz)	99% Bandwidth (MHz)
915.1	0.6825	0.65422

99% BANDWIDTH



7.2. RADIATED EMISSIONS

LIMITS

FCC 15.205(a), 15.209 (a), FCC 15.249 (a)(d)(e)
 IC RSS-210, B.10
 IC RSS-GEN Clause 8.9 (Transmitter)

Operation within the bands 902–928 MHz, 2400–2483.5 MHz, 5725–5875 MHz, and 24.0–24.25 GHz.

(a) Except as provided in paragraph (b) of this section, the field strength of emissions from intentional radiators operated within these frequency bands shall comply with the following @ 3 meter:

Fundamental frequency	Field strength of fundamental at 3 m		Field strength of harmonics at 3 m	
	mV/m	dBuV/m	uV/m	dBuV/m
902-928 MHz	50	94	500	54
2400-2483.5 MHz	50	94	500	54
5725-5875 MHz	50	94	500	54
24.0-24.25 GHz	250	107.95	2500	67.95

(d) Emissions radiated outside of the specified frequency bands, except for harmonics, shall be attenuated by at least 50 dB below the level of the fundamental or to the general radiated emission limits in §15.209, whichever is the lesser attenuation.

Frequency Range (MHz)	Field Strength Limit (uV/m) at 3 m	Field Strength Limit (dBuV/m) at 3 m
0.009-0.490	2400/F(kHz) @ 300m	-
0.490-1.705	24000/F(kHz) @ 30m	-
1.705-30.0	30 @ 30m	-
30 - 88	100**	40**
88 - 216	150**	43.5**
216 - 960	200**	46**
Above 960	500**	54**

**Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this part, e.g., §§15.231 and 15.241.

TEST PROCEDURE

The EUT is placed on a non-conducting table 80 cm above the ground plane for measurement below 1GHz; 1.5 m above the ground plane for measurement above 1GHz. The antenna to EUT distance is 3 meters. The EUT is configured in accordance with ANSI C63.10. The EUT is set to transmit in a continuous mode.

For measurements below 1 GHz the resolution bandwidth is set to 120 kHz for peak and/or quasi-peak detection measurements in the 30-1000MHz range, 9kHz for peak and/or quasi-peak detection measurements in the 0.15-30MHz range and 200Hz for peak and/or quasi-peak detection measurements in the 9 to 150kHz range. Peak detection is used unless otherwise noted as quasi-peak.

For pre-scans above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 30 KHz for peak measurements.

For final measurements above 1 GHz the resolution bandwidth is set to 1 MHz; the video bandwidth is set to 3 MHz for peak measurements. For average measurements above 1GHz, the resolution bandwidth and video bandwidth are set as described in ANSI C63.10:2013 for the applicable measurement. The particular averaging method used for this test program was RMS.

The frequency range of interest is monitored at a fixed antenna height and EUT azimuth. The EUT is rotated through 360 degrees to maximize emissions received. The antenna is scanned from 1 to 4 meters above the ground plane to further maximize the emission. Measurements are made with the antenna polarized in both the vertical and the horizontal positions.

KDB 414788 Open Field Site(OFS) and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

FUNDAMENTAL FREQUENCY RADIATED EMISSION

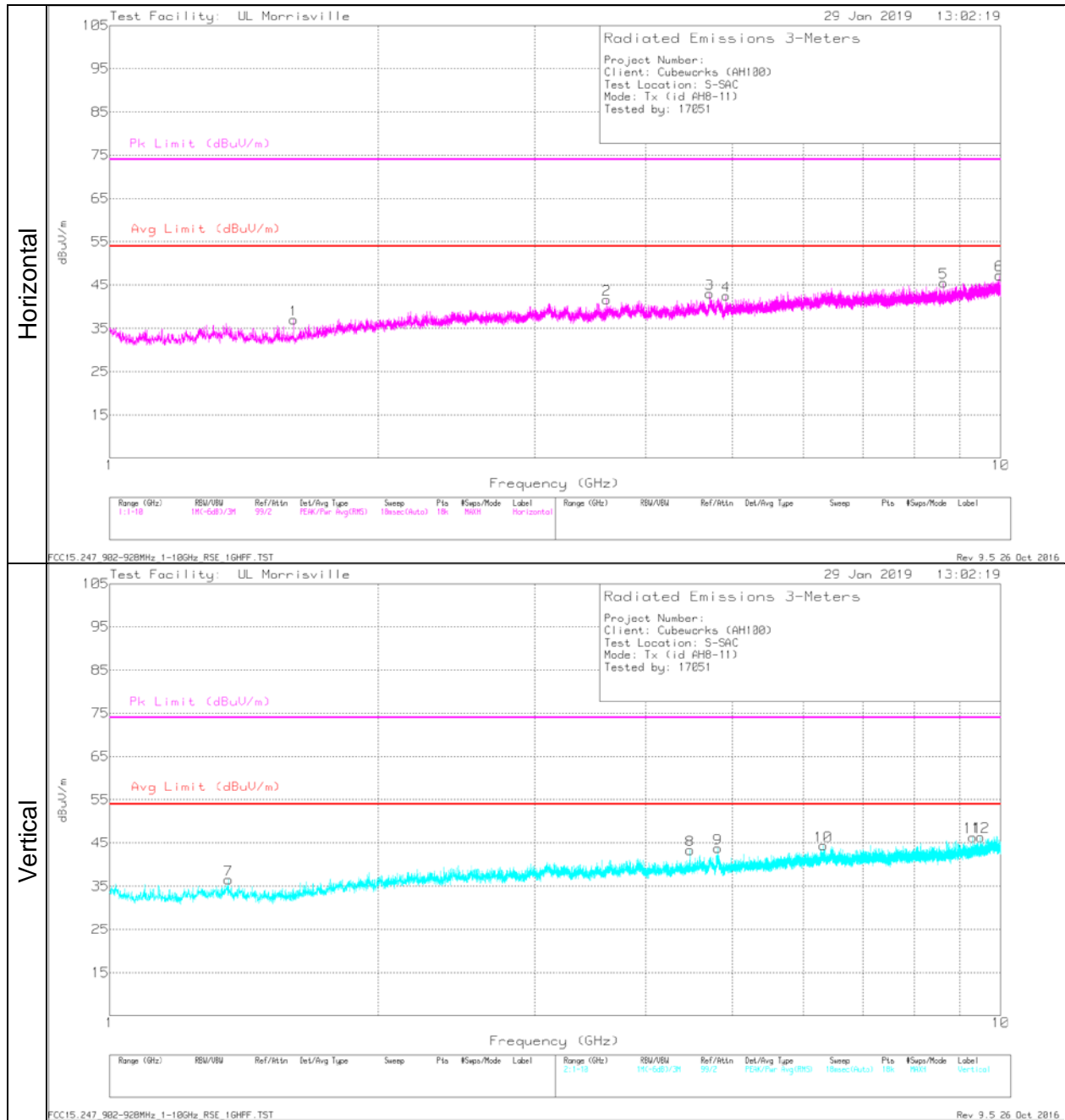
Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 AF (dB/m)	Cbl/Amp	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity	Notes
915.423	71.13	Pk	26.9	-27	71.03	93.98	-22.95	92	100	H	1
915.197	67.63	Qp	26.9	-27	67.53	93.98	-26.45	92	100	H	1
915.383	54.9	Pk	26.9	-27	54.8	93.98	-39.18	179	169	V	1
915.175	51.36	Qp	26.9	-27	51.26	93.98	-42.72	179	169	V	1

Pk - Peak detector

Qp - Quasi-Peak detector

Notes: 1 - RBW = 1MHz

7.2.1. HARMONICS AND SPURIOUS EMISSIONS ABOVE 1GHz



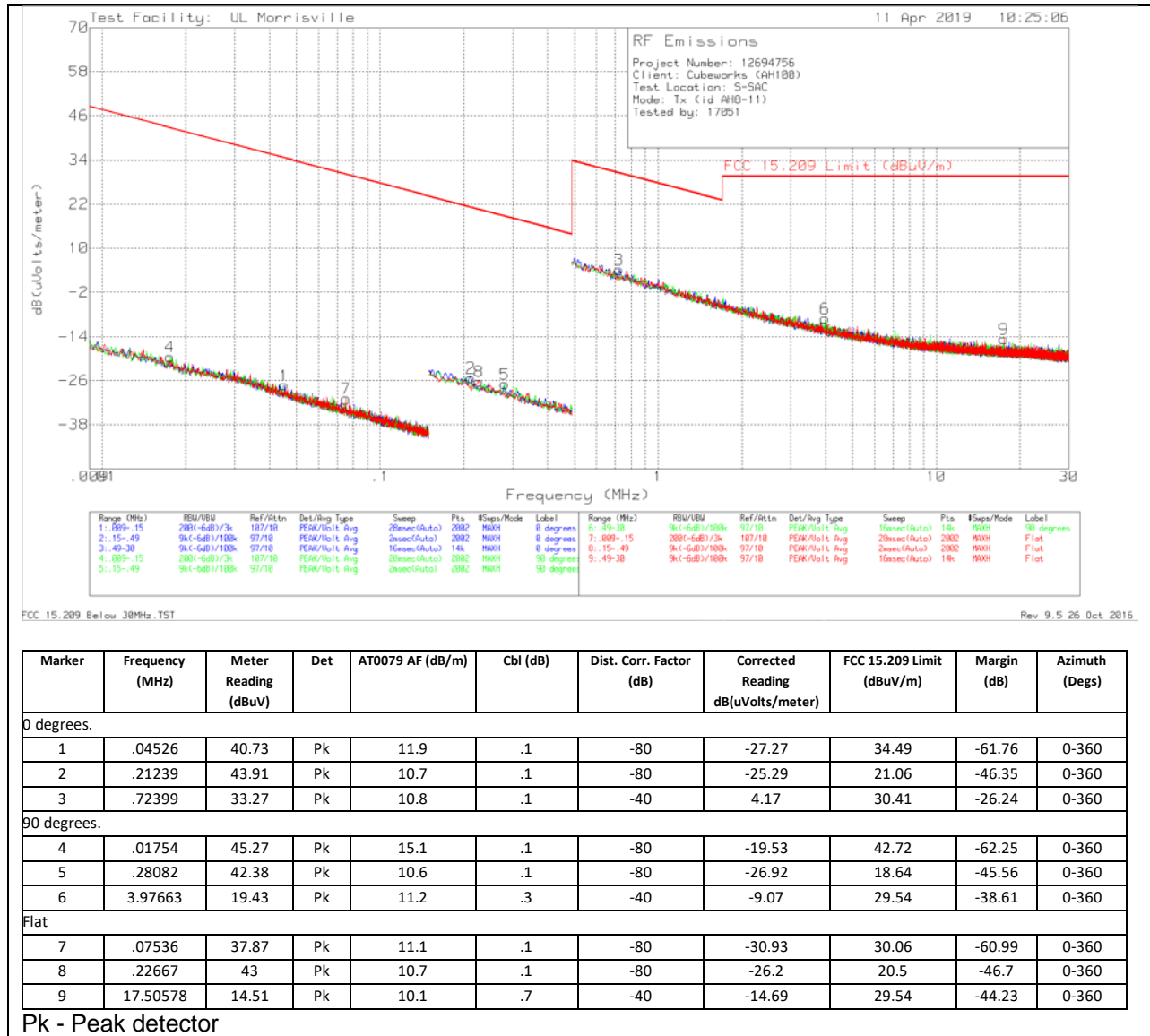
Marker	Frequency (GHz)	Meter Reading (dBuV)	Det	AT0069 AF (dB/m)	Amp/Cbl/Fitr/Pad (dB)	Filter (dB)	Corrected Reading dBuV/m	Avg Limit (dBuV/m)	Margin (dB)	Pk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	1.608	43.1	Pk	28.2	-34.8	.5	37	54	-17	74	-37	0-360	199	H
2	3.613	41.46	Pk	33	-33.3	.5	41.66	54	-12.34	74	-32.34	0-360	299	H
3	4.717	40.62	Pk	34	-31.9	.3	43.02	54	-10.98	74	-30.98	0-360	102	H
4	4.919	39.62	Pk	34	-31.4	.3	42.52	54	-11.48	74	-31.48	0-360	399	H
5	8.625	36.73	Pk	35.9	-27.6	.5	45.53	54	-8.47	74	-28.47	0-360	299	H
6	9.972	35.85	Pk	37	-26.1	.5	47.25	54	-6.75	74	-26.75	0-360	199	H
7	1.359	41.7	Pk	29.4	-35.1	.5	36.5	54	-17.5	74	-37.5	0-360	201	V
8	4.481	41.72	Pk	33.7	-32.4	.3	43.32	54	-10.68	74	-30.68	0-360	301	V
9	4.811	41.25	Pk	34	-31.8	.3	43.75	54	-10.25	74	-30.25	0-360	101	V
10	6.325	38.03	Pk	35.4	-29.5	.4	44.33	54	-9.67	74	-29.67	0-360	201	V
11	9.309	36.17	Pk	36.5	-26.7	.4	46.37	54	-7.63	74	-27.63	0-360	201	V
12	9.495	35.89	Pk	36.7	-26.6	.4	46.39	54	-7.61	74	-27.61	0-360	301	V

Pk - Peak detector

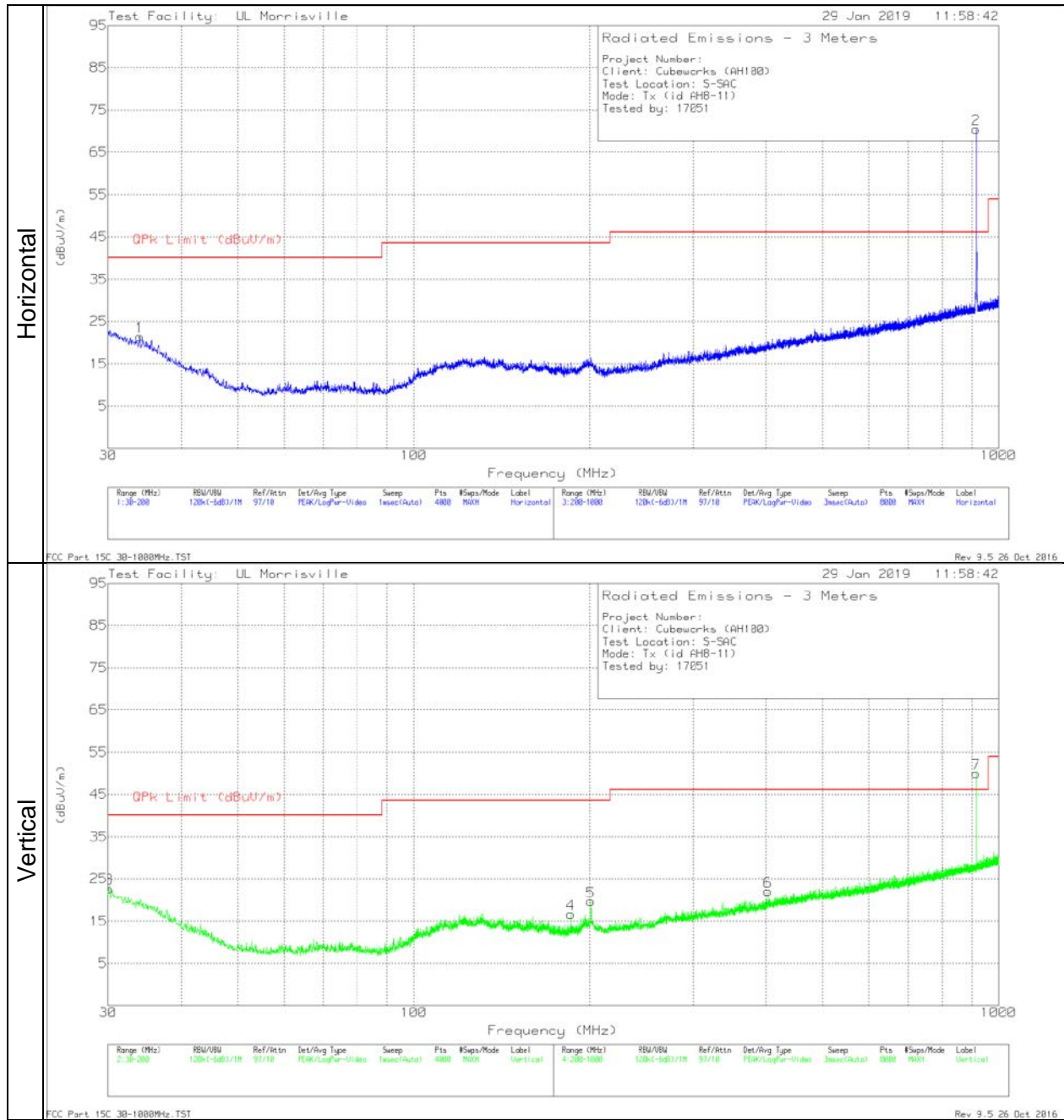
7.2.2. BELOW 1 GHz

SPURIOUS EMISSIONS 0.009 to 30 MHz

Note: All measurements were made at a test distance of 3 m. The measured data was extrapolated from the test distance (3m) to the specification distance (300 m from 9-490 kHz and 30 m from 490 kHz – 30 MHz) to clearly show the relative levels of fundamental and spurious emissions and demonstrate compliance with the requirement that the level of any spurious emissions be below the level of the intentionally transmitted signal. The extrapolation factor for the limits were 40*Log (test distance / specification distance).



SPURIOUS EMISSIONS 30 TO 1000 MHz (HORIZONTAL)



Marker	Frequency (MHz)	Meter Reading (dBuV)	Det	AT0074 AF (dB/m)	Cbl/Amp	Corrected Reading (dBuV/m)	QPk Limit (dBuV/m)	Margin (dB)	Azimuth (Degs)	Height (cm)	Polarity
1	33.996	30.07	Pk	23.1	-31.7	21.47	40	-18.53	0-360	198	H
2	915.197	67.63	Qp	26.9	-27	67.53	93.98	-26.45	92	100	H
3	30.085	28.25	Pk	26.3	-31.8	22.75	40	-17.25	0-360	101	V
4	185.4202	31.29	Pk	15.8	-30.4	16.69	43.52	-26.83	0-360	101	V
5	200.9001	32.26	Pk	17.6	-30.2	19.66	43.52	-23.86	0-360	199	V
6	403.2264	30.76	Pk	20.4	-29.1	22.06	46.02	-23.96	0-360	102	V
7	915.175	51.36	Qp	26.9	-27	51.26	93.98	-42.72	179	169	V

Pk - Peak detector

8. SETUP PHOTOS

Please refer to R12694759-EP1 for setup photos.

END OF TEST REPORT