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CERTIFICATION TEST REPORT

Manufacturer:	**lushSensor, LLC** **11855 SW Ridgecrest Drive** **Suite 127** **Beaverton, Oregon 97008 USA**
Applicant:	**Same as Above**
Product Name:	**lushSensor Gateway**
Product Description:	Receives data from Sensors and relays it to services in the Cloud using a standard internet connection.
Operating Voltage/Frequency:	6VDC from a 120V Power Supply
Model:	**LS-GW-00-000W-01**
FCC ID:	**2APTWGW0001**
Testing Commenced:	May 28, 2018
Testing Ended:	Aug. 28, 2018
Summary of Test Results:	**In Compliance** The EUT complies with the EMC requirements when manufactured identically as the unit tested in this report, including any required modifications and/or manufacturer's statement. Any changes to the design or build of this unit subsequent to this testing may deem it non-compliant.

Standards:

- **FCC Part 15 Subpart C, Section 15.249**
- **FCC Part 15 Subpart C, Section 15.215(c) – Additional provisions to the general radiated emission limitations**
- **FCC15.207 - Conducted Limits**
- **FCC Part 15 Subpart A, Section 15.31(e) – Measurement Standards**

Evaluation Conducted by:

Julius Chiller, EMC/Wireless Engineer

Report Reviewed by:

Ken Littell, Director of EMC & Wireless Operations

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1 ADMINISTRATIVE INFORMATION

1.1 Measurement Location:

F2 Labs in Middlefield, Ohio. Site description and attenuation data are on file with the FCC's Sampling and Measurement Branch at the FCC Laboratory in Columbia, MD**.**

1.2 Measurement Procedure:

All measurements were performed according to the 2013 version of ANSI C63.10 and recommended FCC procedure of measurement of DXT Low Power Transceiver operating under Section 15.249. A list of the measurement equipment can be found in Section 6.

1.3 Uncertainty Budget:

The uncertainty in EMC measurements arises from several factors which affect the results, some associated with environmental conditions in the measurement room, the test equipment being used, and the measurement techniques adopted.

The measurement uncertainty budgets detailed below are calculated from the test and calibration data and are expressed with a 95% confidence factor using a coverage factor of k=2. The Uncertainty for a laboratory are referred to as *U*lab. For Radiated and Conducted Emissions, the Expanded Uncertainty is compared to the *U*cispr values to determine if a specific margin is required to deem compliance.

*U*lab

Measurement Range	Combined Uncertainly	Expanded Uncertainty
Radiated Emissions <1 GHz @ 3m	2.54	5.07dB
Radiated Emissions <1 GHz @ 10m	2.55	5.09dB
Radiated Emissions 1 GHz to 2.7 GHz	1.81	3.62dB
Radiated Emissions 2.7 GHz to 18 GHz	1.55	3.10dB
AC Power Line Conducted Emissions, 150kHz to 30 MHz	1.38	2.76dB
AC Power Line Conducted Emissions, 9kHz to 150kHz	1.66	3.32dB

*U*cispr

Measurement Range	Expanded Uncertainty
Radiated Emissions <1 GHz @ 3m	5.2dB
Radiated Emissions <1 GHz @ 10m	5.2dB
Radiated Emissions 1 GHz to 2.7 GHz	Under Consideration
Radiated Emissions 2.7 GHz to 18 GHz	Under Consideration
AC Power Line Conducted Emissions, 150kHz to 30 MHz	3.6dB
AC Power Line Conducted Emissions, 9kHz to 150kHz	4.0dB

If *U*lab is less than or equal to *U*cispr, then:
- compliance is deemed to occur if no measured disturbance exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance exceeds the disturbance limit.

If *U*lab is greater than *U*cispr in table 1, then:
- compliance is deemed to occur if no measured disturbance, increased by (*U*lab – *U*cispr), exceeds the disturbance limit;
- non-compliance is deemed to occur if any measured disturbance, increased by (*U*lab – *U*cispr), exceeds the disturbance limit.

Note: Only measurements listed in the tables above that relate to tests included in this Test Report are applicable.

1.4 Document History:

Document Number	Description	Issue Date	Approved By
F2P18768A-01E	First Issue	Aug. 31, 2018	K. Littell

2 SUMMARY OF TEST RESULTS

Test Name	Standard(s)	Results
-20dB Occupied Bandwidth	CFR 47 Part 15.215(c)	Complies
Field Strength of Emissions	CFR 47 Part 15.249(a)(d)	Complies
Conducted Emissions	CFR 47 Part 15.207(a)	Complies
Variation of the Input Power	CFR 47 Part 15.231(e)	Complies*

**Gateway was operated using an AC to DC power supply, so Voltage Variation testing in 15.31(3)(e) was performed at the nominal voltage, and then the 85% and 115% of that voltage was tested also. The output power at the Low, Mid and High channels was measured to verify how much the power and frequency were affected by the variation of the input power. No shift in frequency or increased power was measured at either of the varied voltages on any of the channels.*

Modifications Made to the Equipment
None

3 TABLES OF MEASURED RESULTS

Test	Low Channel 903 MHz	Mid Channel 915 MHz	High Channel 927 MHz
Max Field Strength of Fundamental	80.0 dBµV/m (10.0 mV/m)	81.1 dBµV/m (11.3 mV/m)	80.5 dBµV/m (10.5 mV/m)
Limit for Fundamental	50 millivolts/meter (93.97 dBµV/m)	50 millivolts/meter (93.97 dBµV/m)	50 millivolts/meter (93.97 dBµV/m)
-20dB Occupied Bandwidth (kHz)	78.0	78.0	78.0
Voltage Variations, 85% (dBµV/m)	80.0	78.2	78.0
Voltage Variations, 115% (dBµV/m)	80.0	78.7	78.1

The -20dB bandwidth of the emission shall be contained within the frequency band designated in the rule section under which the equipment is operated.

4 ENGINEERING STATEMENT

This report has been prepared on behalf of lushSensor, LLC to provide documentation for the testing described herein. This equipment has been tested and found to comply with part 15.249 of the FCC Rules using ANSI C63.10 2013 standard. The equipment also complies with Subpart B of CFR 47 FCC parts 15.107 and 15.109 for the unintentional radiator portion. The test results found in this test report relate only to the items tested.

5 EUT INFORMATION AND DATA

5.1 Equipment Under Test:

Product: lushSensor Gateway
Model: LS-GW-00-000W-01
Serial No.: 0100001F
FCC ID: 2APTWGW0001

5.2 Trade Name:

lushSensor, LLC

5.3 Power Supply:

AC/DC Supply Triad model WSU060-3000

5.4 Applicable Rules:

CFR 47, Part 15.249

5.5 Equipment Category:

DXT Low Power Transceiver

5.6 Antenna:

3.3dBi External

5.7 Accessories:

N/A

5.8 Test Item Condition:

The equipment to be tested was received in good condition.

5.9 Testing Algorithm:

EUT was set up in a normal operating mode. EUT was placed on an 80cm and 1.5m high table on the turntable of a semi-anechoic chamber, 3m from the measuring antenna. Radiated emissions were measured of the fundamental (902-928 MHz) and out-of-band spectrums. Measurements were made on three different channels (low, mid and high).

6 LIST OF MEASUREMENT INSTRUMENTATION

Equipment Type	Asset Number	Manufacturer	Model	Serial Number	Calibration Due Date
Shielded Chamber	CL166-E	Albatross Projects	B83117-DF435-T261	US140023	Jan. 9, 2019
Shield Room	0175-3V	Ray Proof	N/A	11645	Feb. 28, 2019
Spectrum Analyzer	CL138	Agilent Technologies	E4407B	US41192779	June 19, 2019
Receiver	CL151	Rohde & Schwarz	ESU40	100319	Nov. 17, 2018
Horn Antenna	CL098	Emco	3115	9809-5580	Dec. 28, 2018
Pre-Amplifier	CL153	Keysight Tech.	83006A	MY39500791	Sept. 20, 2018
Pre-Amplifier	CL136	Hewlett Packard	8447E	A937A01894	Mar. 26, 2019
Active 18” Loop Antenna	CL163-Loop	A.H. Systems, Inc.	EHA-52B	100	June 4, 2019
Antenna, JB3 Combination	CL175	Sunol Sciences	JB3	A030315	Oct.11, 2019
Temp/Hum. Recorder	CL232	Extech	445814	01	Mar. 22, 2019
Transient Limiter	0202	Hewlett Packard	11947A	3107A00729	June 19, 2019
Software:	Tile Version 3.4.B.3.			Software Verified: May 28-Aug. 28, 2018	
Spectrum Analyzer	CL147	Agilent	E7402A	MY45101241	Nov. 16, 2018
LISN	CL181	Com-Power	LI-125A	191226	July 3, 2021
LISN	CL182	Com-Power	LI-125A	191225	July 3, 2021
Software:	EMC 32, Version 8.53.0		Software Verified: May 28-Aug. 28, 2018		

7 OCCUPIED BANDWIDTH

7.1 Requirements:

§15.215 Additional provisions to the general radiated emission limitations.

(a) The regulations in §§15.217 through 15.257 provide alternatives to the general radiated emission limits for intentional radiators operating in specified frequency bands. Unless otherwise stated, there are no restrictions as to the types of operation permitted under these sections.

(b) In most cases, unwanted emissions outside of the frequency bands shown in these alternative provisions must be attenuated to the emission limits shown in §15.209. In no case shall the level of the unwanted emissions from an intentional radiator operating under these additional provisions exceed the field strength of the fundamental emission.

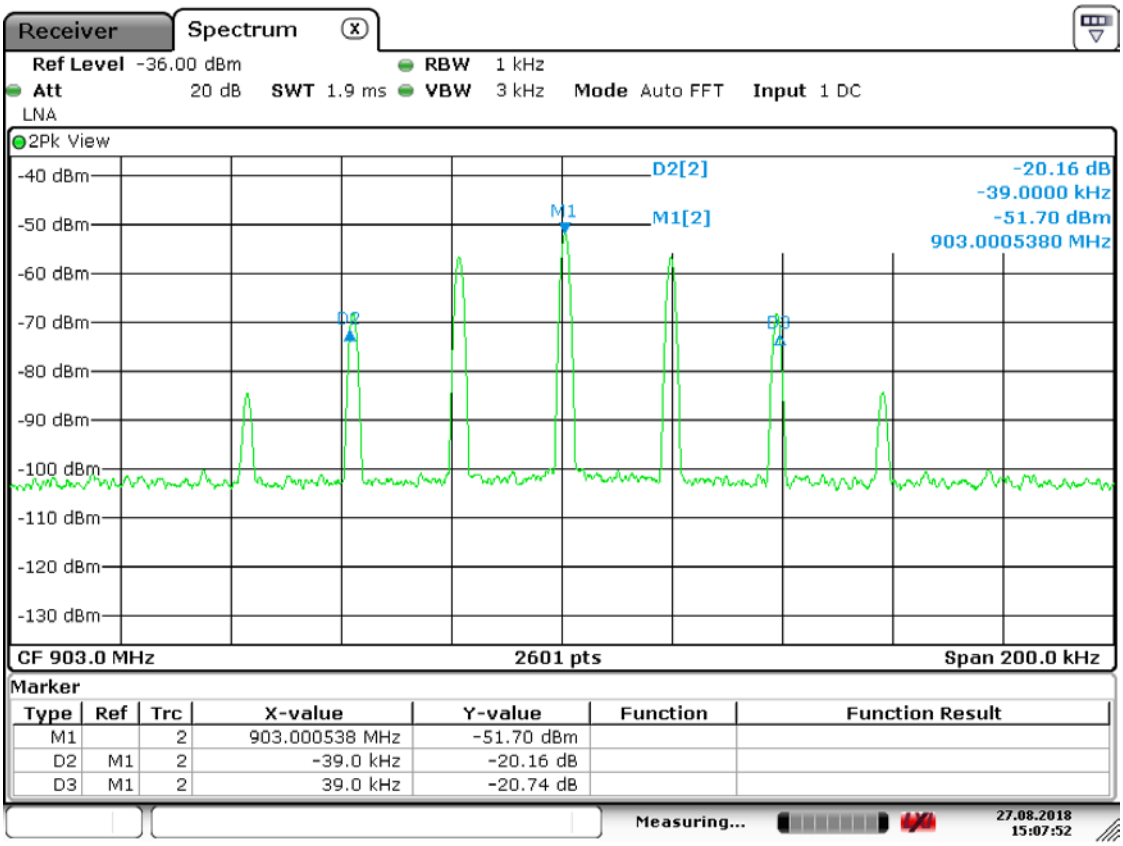
(c) Intentional radiators operating under the alternative provisions to the general emission limits, as contained in §§15.217 through 15.257 and in subpart E of this part, must be designed to ensure that the 20dB bandwidth of the emission, or whatever bandwidth may otherwise be specified in the specific rule section under which the equipment operates, is contained within the frequency band designated in the rule section under which the equipment is operated. In the case of intentional radiators operating under the provisions of subpart E, the emission bandwidth may span across multiple contiguous frequency bands identified in that subpart. The requirement to contain the designated bandwidth of the emission within the specified frequency band includes the effects from frequency sweeping, frequency hopping and other modulation techniques that may be employed as well as the frequency stability of the transmitter over expected variations in temperature and supply voltage. If a frequency stability is not specified in the regulations, it is recommended that the fundamental emission be kept within at least the central 80% of the permitted band in order to minimize the possibility of out-of-band operation.

Bandwidth measurements were made at the low (903), mid (915) and upper (927) frequencies. The bandwidth was measured using the analyzer's marker function.

7.2 Occupied Bandwidth Test Data

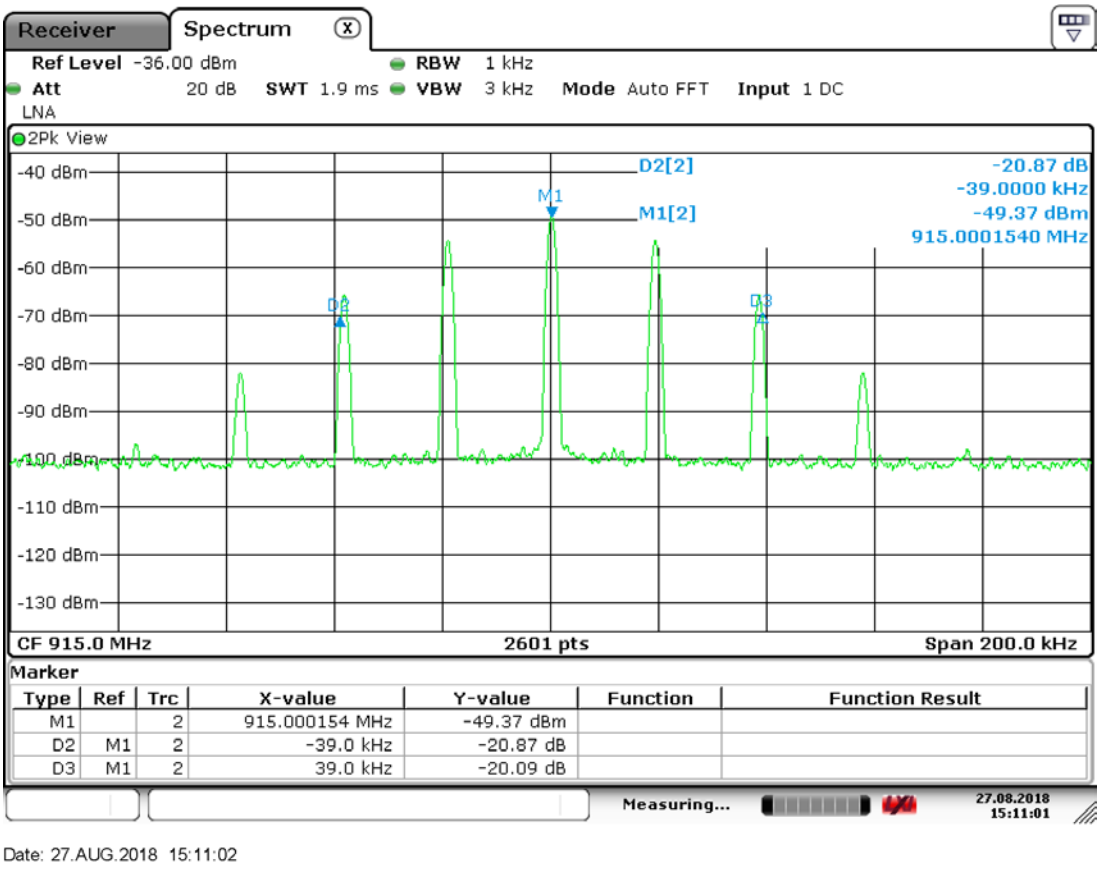
Test Date(s):	Aug. 27, 2018	Test Engineer(s):	J. Chiller
Standards:	CFR 47 Part 15.215(c)	Air Temperature:	22.1ºC
		Relative Humidity:	42%

-20dB, Low Channel



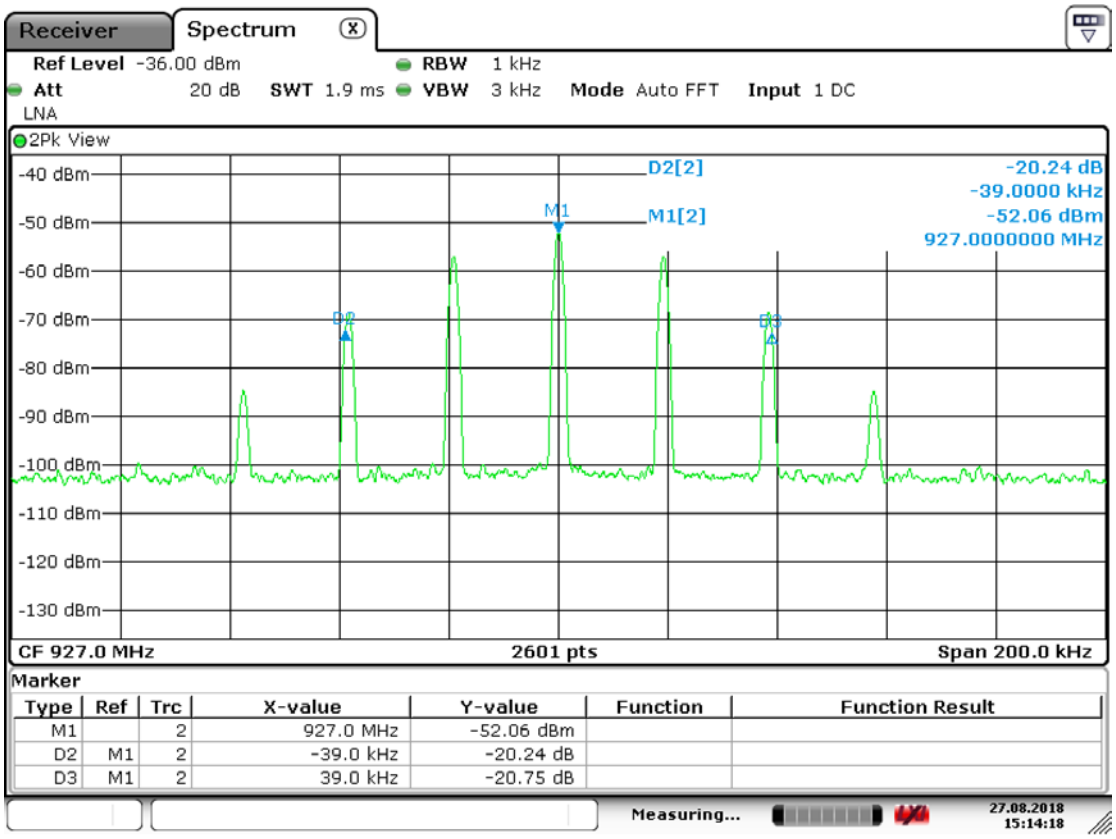
Date: 27.AUG.2018 15:07:51

-20dB, Mid Channel



Date: 27.AUG.2018 15:11:02

-20dB, High Channel



Date: 27.AUG.2018 15:14:18

8 FCC PART 15.249(a)(d) – FIELD STRENGTH OF EMISSIONS FROM INTENTIONAL RADIATORS

(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:

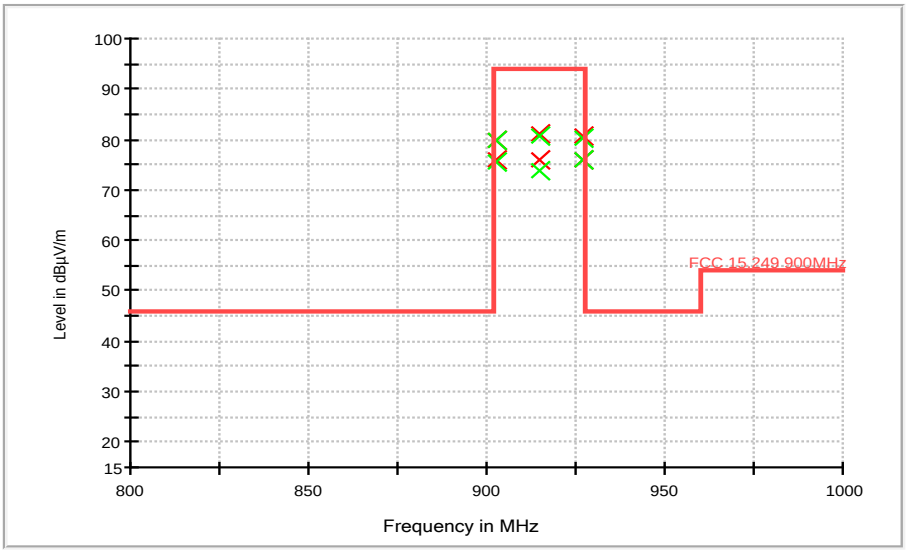
Fundamental frequency	Field strength of fundamental (millivolts/meter)	Field strength of harmonics (microvolts/meter)
902-928 MHz	50	500
2400-2483.5 MHz	50	500
5725-5875 MHz	50	500
24.0-24.25 GHz	250	2500

(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.

NOTE: During the pre-scan evaluation, the EUT was rotated in all three orthogonal positions to find the maximum emissions. The orthogonal position that showed the highest emissions was used. The antenna was raised between 1 and 4 meters and the EUT turntable was rotated 360 degrees to maximize the emissions.

8.1 Test Data - Field Strength of Emissions from Intentional Radiators

Test Date(s):	June 12, 2018	**Test Engineer(s):**	J. Chiller
Standards:	CFR 47 Part 15.249(a)	**Air Temperature:**	21.9ºC
		Relative Humidity:	47%



Max-Peak detector was used and shows the Max-Peak emissions were below the Quasi-Peak limits**.**

Frequency (MHz)	Polarity	Antenna Height (cm)	Azimuth (deg)	Corr. (dB)	MaxPeak (dBµV/m)	Quasi-Peak (dBµV/m) Limit	MaxPeak Margin (dB)	Bandwidth (kHz)
903.000000	H	150.0	45.0	11.5	80.0	94	-14.0	120.000
903.000000	V	150.0	22.0	11.5	75.9	94	-18.1	120.000
915.000000	H	100.0	88.0	11.6	81.1	94	-12.9	120.000
915.040000	V	100.0	220.0	11.6	75.8	94	-18.2	120.000
927.000000	V	153.0	19.0	11.9	76.1	94	-17.9	120.000
927.000000	H	145.0	75.0	11.9	80.5	94	-13.5	120.000

8.2 Test Data – Spurious Emissions

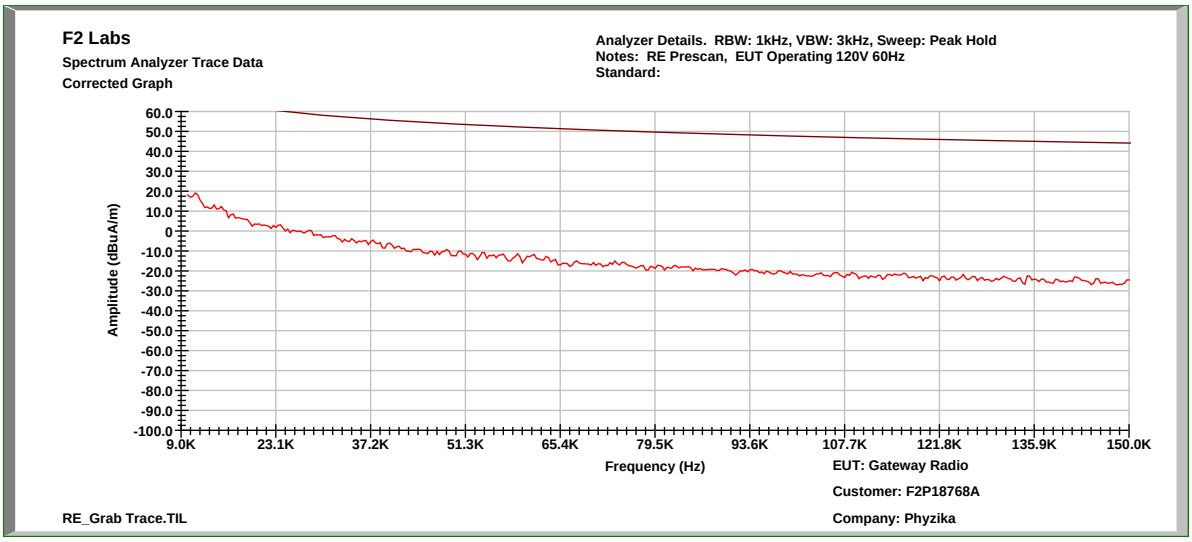
Notes: Plots are peak, max hold pre-scan data included only to determine what frequencies to investigate and measure. During the pre-scan evaluation, the EUT was rotated in all three orthogonal positions to find the maximum emissions. The orthogonal position that showed the highest emissions was used. At some frequencies, no emissions from the EUT were measurable over the ambient noise floor. The readings did not change with EUT on and EUT off.

Where emissions from the EUT were visible within 20dB of the limit, at least 6 of the highest frequencies were measured per ANSI 63.4 in a 3-meter anechoic chamber. Frequencies below 1GHz were measured using a quasi-peak detector. The antenna was raised between 1 and 4 meters and the EUT turntable was rotated 360 degrees to maximize the emissions. Some of the frequencies did not change with the EUT on or off. At those frequencies, the test distance was shortened to 1 meter and still no emissions from the EUT were visible or over the ambient or limit. Frequencies were scanned from 9kHz to 10 GHz and the highest emissions are listed below.

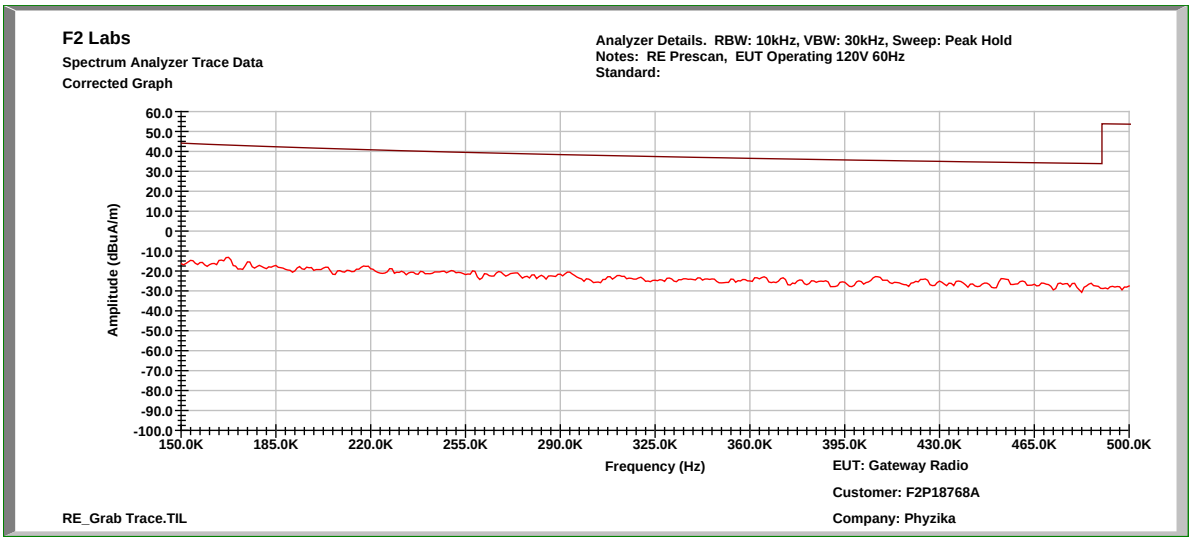
Note: Spurious emissions in these EUTs were tested for all three channels. The results below are from the one that was deemed worst case - 915 MHz (Mid Channel).

Test Date(s):	May 28, 2018	**Test Engineer(s):**	J. Chiller
Standards:	CFR 47 Part 15.249(d) / Part 15.209	**Air Temperature:**	19.4ºC
Results:	Complies	**Relative Humidity:**	47%

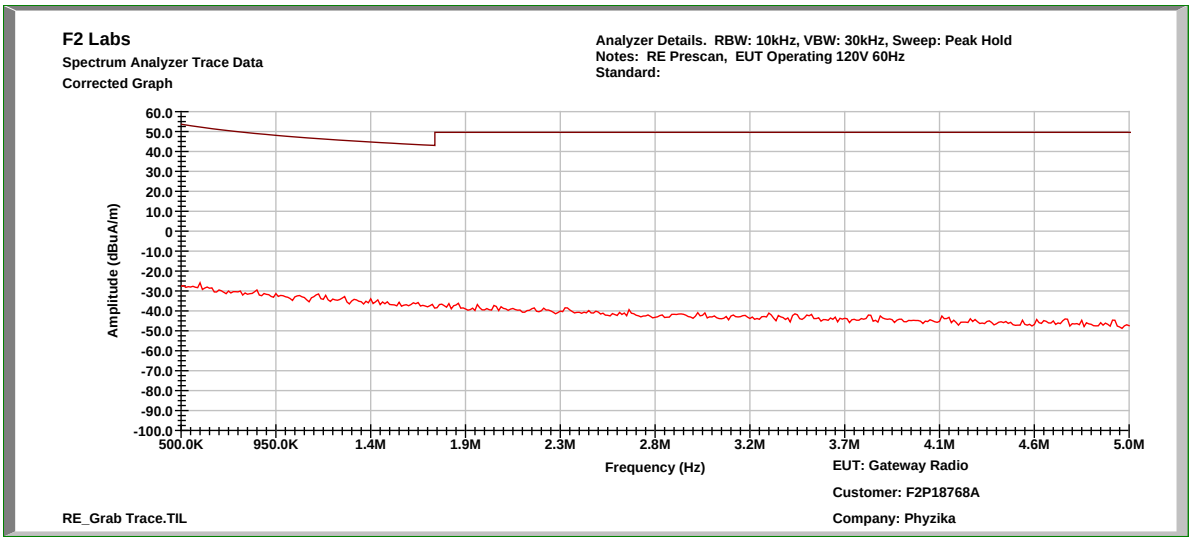
0.009 MHz to 0.15 MHz, Mid Channel



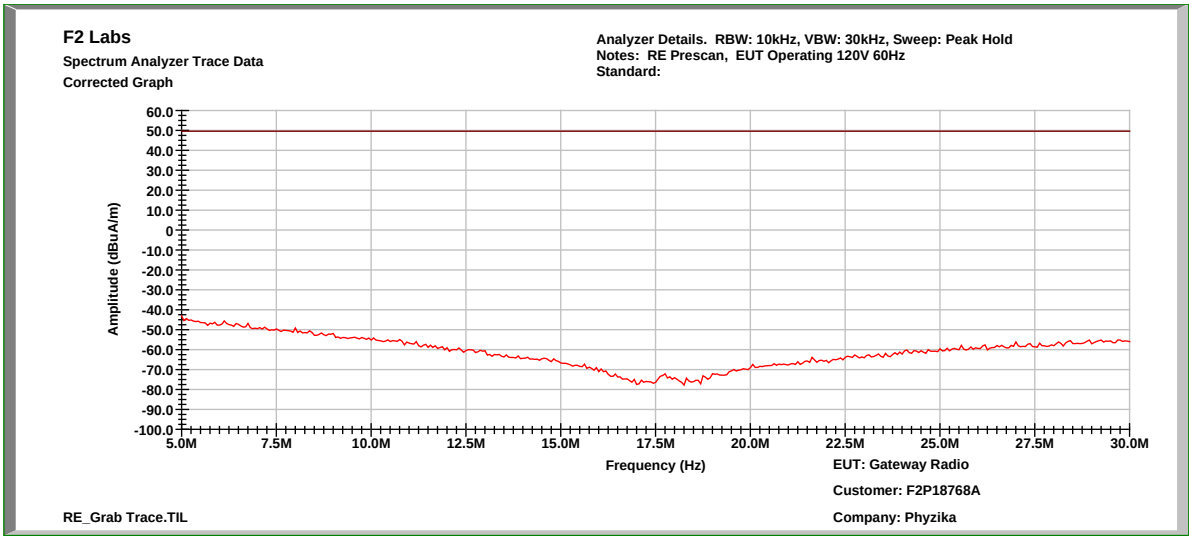
0.15 MHz to 0.5 MHz, Mid Channel



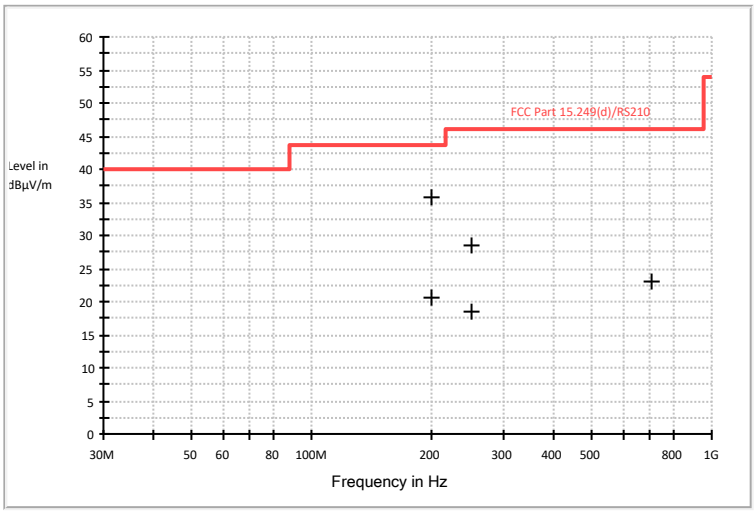
0.5 MHz to 5.0 MHz, Mid Channel



5.0 MHz to 30.0 MHz, Mid Channel



30 MHz to 1000 MHz, Mid Channel

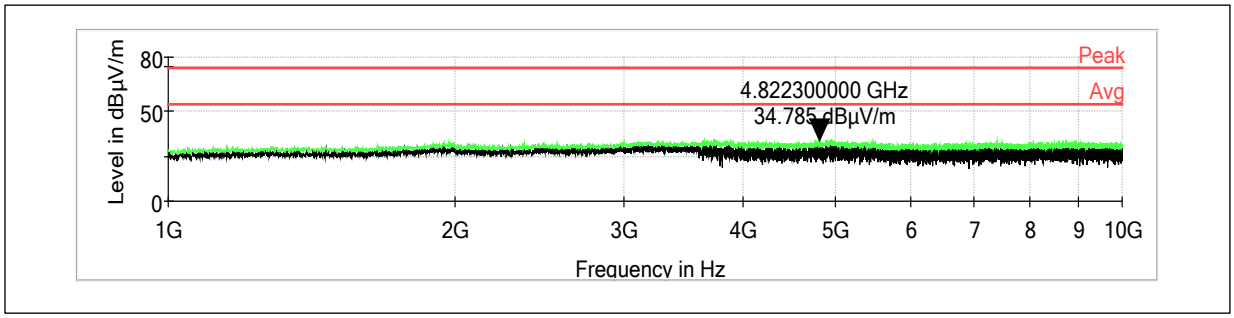


Frequency (MHz)	Antenna Polarization	Antenna Height (cm)	Azimuth (degrees)	Reading (dBµV)	Correction Factors (dB)	Emission (dBµV/m)	Limit (dBµV/m)	Margin (dB)
199.960000	H	150.00	312.00	21.9	-1.4	20.50	43.5	-23.0
199.960000	V	100.00	0.00	37.3	-1.4	35.90	43.5	-7.6
249.940000	V	150.00	359.00	30.7	-2.2	28.50	46.0	-17.5
250.000000	H	150.00	73.00	20.8	-2.2	18.60	46.0	-27.4
708.800000	V	150.00	0.00	14.6	8.4	23.00	46.0	-23.0

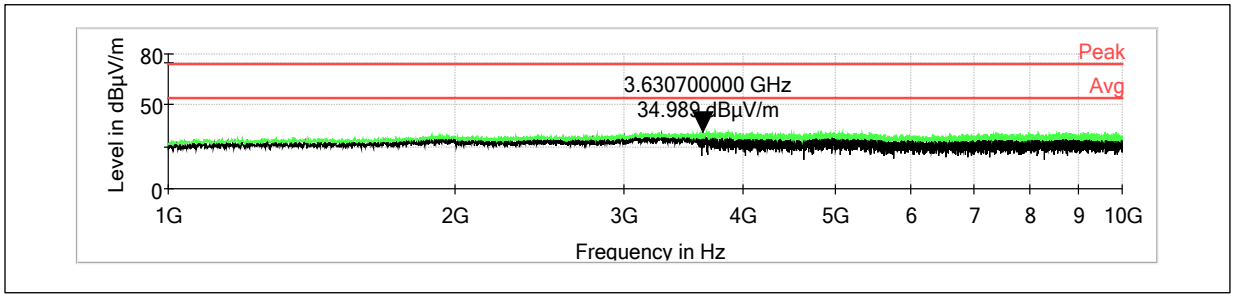
Note: No emissions were within 20dB of the limit.

In the following plots, the green line indicates measurement with a Peak Detector and the black indicates measurement with an Average Detector.

1 GHz to 10 GHz, Vertical, Mid Channel

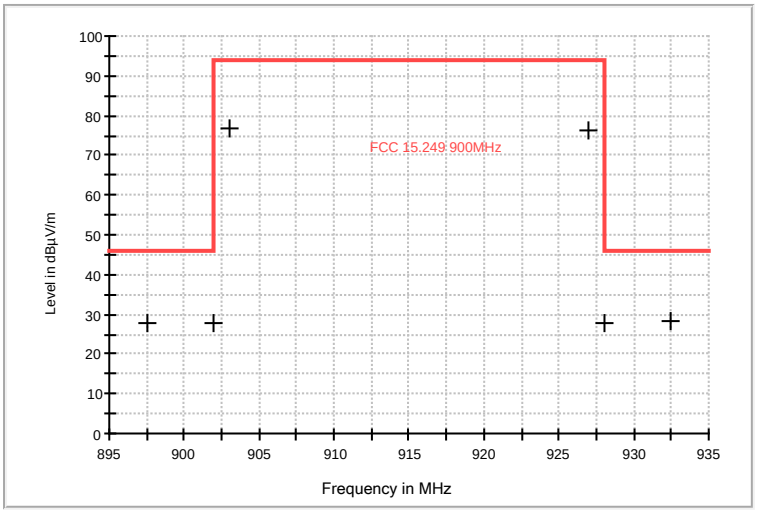


1 GHz to 10 GHz, Horizontal, Mid Channel



Note: No emissions within 20dB of the limit, and no emissions present up to 26 GHz.

Band Edges



Frequency (MHz)	Polarity	Antenna Height (cm)	Azimuth (deg)	Corr. (dB)	QuasiPeak (dBµV/m)	QuasiPeak (dBµV/m) Limit	QuasiPeak Margin (dB)	Bandwidth (kHz)
897.500000	V	155.0	0.0	11.6	27.7	46	-18.3	120.000
902.000000	V	155.0	0.0	11.6	27.7	46	-18.3	120.000
903.020000	V	155.0	0.0	11.5	77.0	94	-17.0	120.000
926.980000	V	155.0	0.0	12.1	76.4	94	-17.6	120.000
928.000000	V	155.0	0.0	12.1	27.9	46	-18.1	120.000
932.000000	V	155.0	0.0	12.1	28.1	46	-17.9	120.000

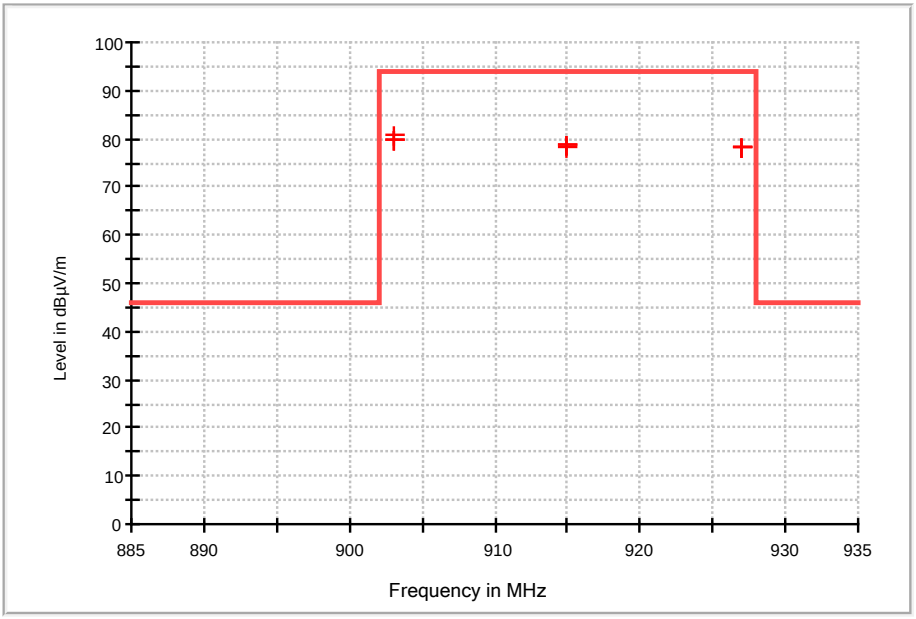
9 VOLTAGE VARIATIONS, 15.31(e)

9.1 Procedure:

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery. A nominal voltage of 120VAC was used and then 100VAC and 138VAC were used as the 85% and 115% variations.

9.2 Voltage Variations Test Data

Test Date(s):	June 13 2018	**Test Engineer:**	J. Chiller
Rule:	FCC PART 15.31(e)	**Air Temperature:**	21.9º C
Test Results:	Complies	**Relative Humidity:**	41%



Frequency (MHz)	Polarity	Antenna Height (cm)	Azimuth (deg)	Corr. (dB)	QuasiPeak (dBµV/m)	Voltage Variance (%)
903.000000	V	100.0	356.0	11.5	80.0	-15
903.000000	V	100.0	357.0	11.5	80.0	15
915.000000	V	100.0	357.0	11.6	78.2	-15
915.000000	V	100.0	341.0	11.6	78.7	15
927.000000	V	100.0	358.0	12.1	78.0	-15
927.000000	V	100.0	358.0	12.1	78.1	15

The results showed that the fundamental frequency did not move outside the frequency band and the field strength did not increase above the limit during the variations.

10 CONDUCTED EMISSIONS

10.1 Requirements

In accordance with FCC CFR 47 Part 15.207(a), “Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 μH/50 ohms line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency of Emission (MHz)	Conducted Limit (dBμV)	
	Quasi-peak	Average
0.15-0.5	66 to 56*	56 to 46*
0.5-5	56	46
5-30	60	50

*Decreases with the logarithm of the frequency.

10.2 Procedure

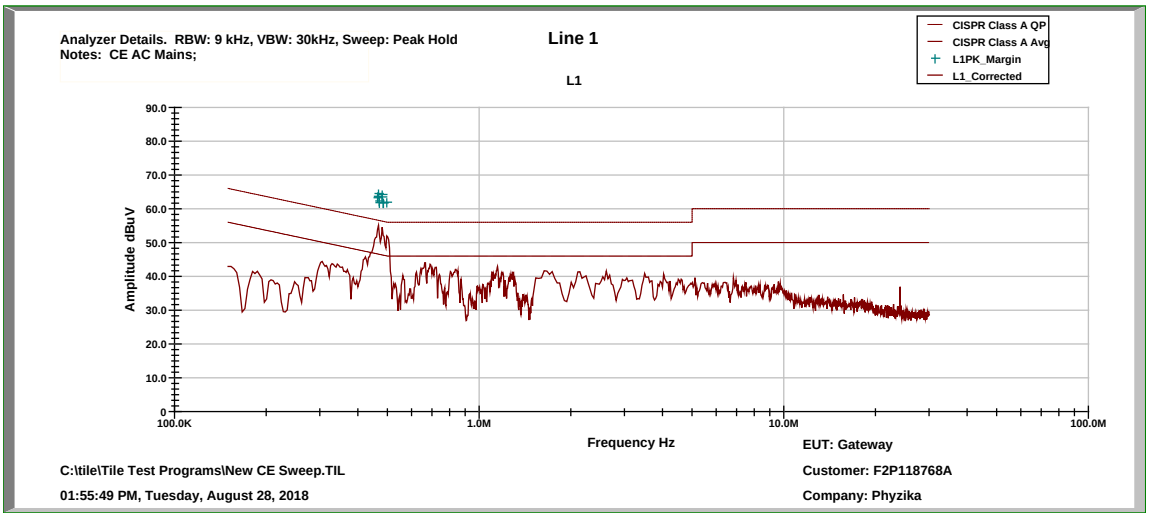
The EUT was placed on a 1.0 x 1.5 meter non-conductive table, 0.8 meter above a horizontal ground plane and 0.4 meter from a vertical ground plane. Power was provided to the EUT through a LISN bonded to a 3 x 2 meter ground plane. The LISN and peripherals were supplied power through a filtered AC power source. The output of the LISN was connected to the input of the receiver via a transient limiter, and emissions in the range 150 kHz to 30 MHz were measured. The measurements were recorded using the quasi-peak and average detectors as directed by the standard, and the resolution bandwidth during testing was 9 kHz. The raw measurements were corrected to allow for attenuation from the LISN, transient limiter and cables.

10.3 Conducted Emissions Test Data

Test Date(s):	Aug. 28, 2018	**Test Engineer:**	J. Chiller
Rule:	15.207	**Air Temperature:**	23.9º C
Test Results:	Complies	**Relative Humidity:**	45%

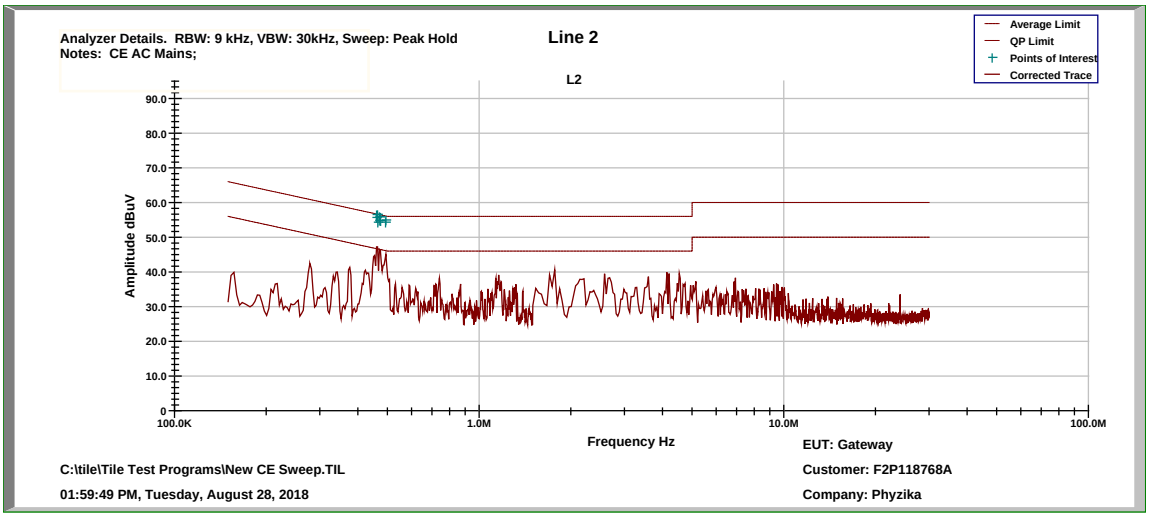
Note: The data below represents 903 MHz channel, determined to be worst case of all three channels.

Conducted Test – Line 1: 0.15 MHz to 30 MHz



Top Discrete Measurements								
No.	**Conductor**	**Frequency (MHz)**	**Detector**	**Level (dBµV)**	**Adjustment (dB)**	**Results (dBµV)**	**Limit (dBµV)**	**Margin (dB)**
1	Line 1	0.463875	Quasi-Peak	40.778	10.430	51.208	56.623	-5.415
			Average	28.036	10.430	38.466	46.623	-8.157
2	Line 1	0.65	Quasi-Peak	41.608	10.429	52.037	56.603	-4.566
			Average	29.379	10.429	39.808	46.603	-6.795
3	Line 1	0.46725	Quasi-Peak	42.267	10.428	52.695	56.563	-3.868
			Average	30.464	10.428	40.892	46.563	-5.671
4	Line 1	0.47	Quasi-Peak	42.988	10.425	53.413	56.514	-3.101
			Average	29.190	10.425	39.615	46.514	-6.899
5	Line 1	0.470625	Quasi-Peak	43.350	10.425	53.775	56.503	-2.73
			Average	31.149	10.425	41.574	46.503	-4.929
6	Line 1	0.48	Quasi-Peak	42.778	10.417	53.195	56.339	-3.144
			Average	31.123	10.417	41.540	46.339	-4.799
7	Line 1	0.48075	Quasi-Peak	42.791	10.417	53.208	56.326	-3.118
			Average	30.299	10.417	40.716	46.326	-5.610
8	Line 1	0.484125	Quasi-Peak	42.005	10.414	52.419	56.268	-3.849
			Average	27.989	10.414	38.403	46.268	-7.865
9	Line 1	0.485	Quasi-Peak	41.814	10.413	52.227	56.253	-4.026
			Average	28.596	10.413	39.009	46.253	-7.244
10	Line 1	0.497625	Quasi-Peak	39.432	10.405	49.837	56.040	-6.203
			Average	25.434	10.405	35.839	46.040	-10.201

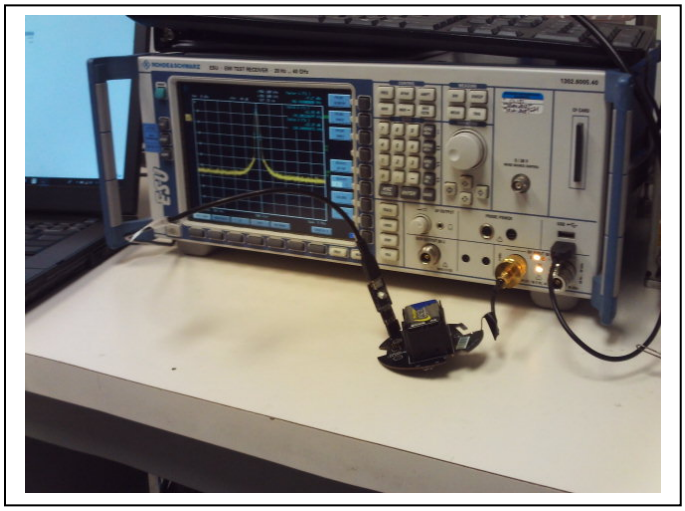
Conducted Test – Line 2: 0.15 MHz to 30.0 MHz



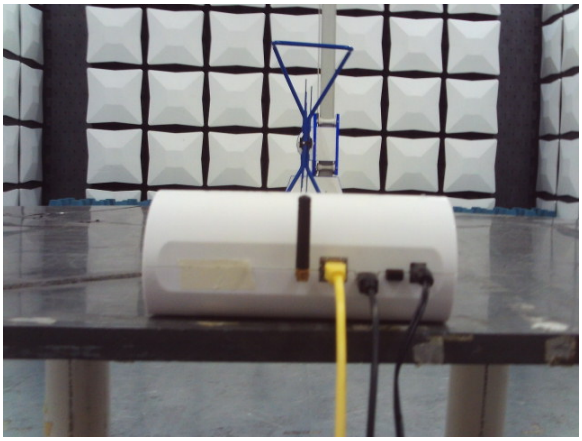
Top Discrete Measurements								
No.	Conductor	Frequency (MHz)	Detector	Level (dBµV)	Adjustment (dB)	Results (dBµV)	Limit (dBµV)	Margin (dB)
1	Line 2	0.46	Quasi-Peak	33.656	10.433	44.089	56.693	-12.604
			Average	20.034	10.433	30.467	46.693	-16.226
2	Line 2	0.4605	Quasi-Peak	33.912	10.433	44.345	56.684	-12.339
			Average	19.896	10.433	30.329	46.684	-16.355
3	Line 2	0.463875	Quasi-Peak	35.460	10.430	45.890	56.623	-10.733
			Average	21.857	10.430	32.287	46.623	-14.336
4	Line 2	0.465	Quasi-Peak	35.043	10.429	45.472	56.603	-11.131
			Average	21.221	10.429	31.650	46.603	-14.953
5	Line 2	0.47	Quasi-Peak	35.637	10.425	46.062	56.514	-10.45
			Average	24.318	10.425	34.743	46.514	-11.771
6	Line 2	0.470625	Quasi-Peak	37.281	10.425	47.706	56.503	-8.797
			Average	24.228	10.425	34.653	46.503	-11.850
7	Line 2	0.474	Quasi-Peak	36.629	10.422	47.051	56.444	-9.393
			Average	23.694	10.422	34.116	46.444	-12.328
8	Line 2	0.475	Quasi-Peak	37.710	10.421	48.131	56.426	-8.295
			Average	21.623	10.421	32.044	46.426	-14.382
9	Line 2	0.492873	Quasi-Peak	33.604	10.407	44.011	56.120	-12.109
			Average	18.741	10.407	29.148	46.120	-16.972
10	Line 2	0.49425	Quasi-Peak	33.160	10.406	43.566	56.097	-12.531
			Average	18.047	10.406	28.453	46.097	-17.644

11 PHOTOGRAPHS

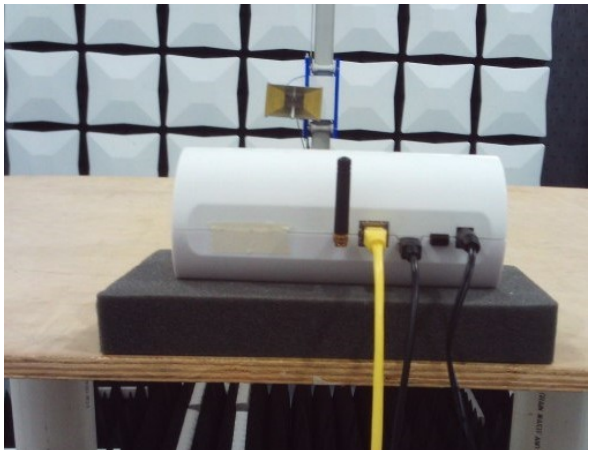
Occupied Bandwidth: Gateway, Black Sensor, Blue Sensor & White Sensor



Radiated Emissions: 30 MHz to 1 GHz



Radiated Emissions: Above 1 GHz



Conducted Emissions