Project 18001-15

uAvionix

ping2020

UAT ADS-B Transceiver

Wireless Certification Report

Prepared for:

uAvionix LLC
300 Pine Needle Lane
Big Fork, MT 59911

By

Professional Testing (EMI), Inc.
1601 North A.W. Grimes Blvd., Suite B
Round Rock, Texas 78665

9 May 2016

Reviewed by	Written by
	
Larry Finn	Eric Lifsey
Chief Technical Officer	EMC Engineer

Revision History

Revision Number	Description	Date
00	Initial release for review.	26 Apr 2016
01	Revised with final model designation and antenna gain.	28 Apr 2016
02	Revised antenna gain from 2 to 4 dBi.	9 May 2016

Errata Corrected:

None.

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Certificate of Compliance

Applicant	Device & Test Identification	
uAvionix LLC	Model(s):	ping2020
300 Pine Needle Lane	FCC ID:	2AFFTUAT016
Big Fork, MT 59911	Laboratory Project ID:	18001-15
Certificate Date: 26 Apr 2016		

The EUT model(s) listed above were tested utilizing the following documents and found to be in compliance with the required criteria.

47 CFR, FCC Part 87 and Part 2	
Section	**Description**
87.131; 2.1046	Power and emissions; conducted output power
87.135; 87.137; 2.1049	Bandwidth of emission; type of emission; occupied bandwidth
87.139(l)(1); 2.1047	UAT modulation mask; modulation characteristics
87.139; 2.1051	Emission limitations; Spurious/harmonic emissions at antenna terminals
87.139; 2.1053	Emission limitations; radiated emissions 30 MHz - 10 GHz
87.133; 2.1055(a)(1)	Frequency stability (Radionavigation 960 to 1215 MHz; 20 ppm)
87.143	Transmitter control requirements

I, Eric Lifsey, for Professional Testing (EMI), Inc., being familiar with the above rules and test procedures have reviewed the test setup, measured data, and this report. I believe them to be true and accurate.

Eric Lifsey
EMC Engineer

This report has been reviewed and accepted by the Applicant**.** The undersigned is responsible for ensuring that this device will continue to comply with the requirements listed above.

_____
Representative of Applicant

1.0 Introduction

1.1 Scope

This report describes the extent to which the equipment under test (EUT) conformed to the intentional radiator requirements of the United States.

1.2 EUT Description

Table 1.2.1 Equipment Under Test			
Manufacturer & Description	**Model**	**Serial #**	**Photo**
uAvionix LLC UAT ADS-B Transceiver for 978 MHz	ping2020	123-4567	
Operating Voltage: 12 to 26 VDC nominal.			

Table 1.2.2 EUT Options		
Description	**Gain**	**Notes**
¼ wave SMA whip antenna	4 dBi	For use directly on EUT.

1.3 EUT User Control Requirement

Power is removed at the aircraft operator's position by the user either removing power from the EUT itself or from the vehicle power plug at the end of the power cable. This satisfies control requirements of FCC 87.143.

1.4 EUT Operation

The EUT was exercised in a manner consistent with normal operations. To insure accurate measurement, the EUT was placed into higher than normal duty cycle modes or even briefly in continuous transmit mode. Continuous 100% duty cycle transmit was limited to only a few seconds as the transmitter would otherwise overheat.

1.5 Modifications to EUT

Transmitter output matching network components were adjusted to better suppress harmonic spurious emissions. The top plastic cover was coated with a conductive paint to reduce radiated spurious emissions.

1.6 Test Site

Radiated measurements were made at the PTI semi-anechoic facility designated Site 45 (FCC 459644, IC 3036B-1) in Austin, Texas. The site is registered with the FCC under Section 2.948 and Industry Canada per RS-GEN, and is subsequently confirmed by laboratory accreditation (NVLAP). The test site is located at 11400 Burnet Road, Austin, Texas 78758, while the main office is located at 1601 North A.W. Grimes Boulevard, Suite B, Round Rock, Texas, 78665.

Professional Testing (EMI), Inc., (PTI) follows the guidelines of National Institute of Standards and Technology (NIST) for all uncertainty calculations, estimates, and expressions thereof for electromagnetic compatibility testing.

2.0 Applicable Documents

Table 2.0.1: Applicable Documents	
Document #	**Title/Description**
TIA/EIA 603C 2004	Land Mobile FM or PM Communications Equipment, Measurement and Performance Standards
47 CFR	FCC Part 87 – Subpart D – Technical requirements FCC Part 2 – Subpart J – Equipment authorization procedures

3.0 Conducted Output Power at Antenna Terminal

3.1 Test Procedure

The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. A peak detector was used for the measurement. The transmitter was switched on, and the measurement receiver was tuned to the frequency of the transmitter under test. The loss of the attenuator was compensated by adding an offset to the analyzer amplitude. Power was measured directly with the spectrum analyzer using a resolution bandwidth greater than the occupied bandwidth of the transmitter.

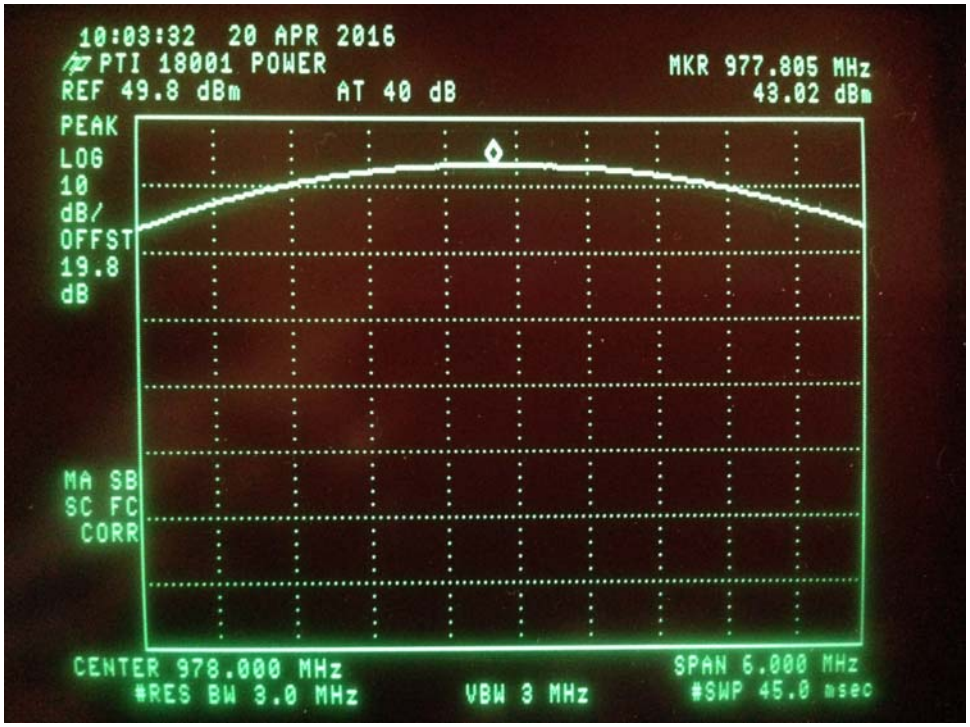
3.2 Test Criteria

Table 3.2.1 Authorized Power, 87.131 (Radionavigation Unspecified), FAA Minimum, 2.1046
Minimum 16 Watts per FAA

3.3 Test Results

Table 3.3.1 Power Measured In 3 MHz RBW/VBW	
Measured Power	43.02 dBm or 20.0 Watts

The EUT satisfied the requirements. Plotted results included below.



4.0 Occupied Bandwidth

4.1 Test Procedure

The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. The spectrum analyzer was tuned to the frequency of the transceiver under test and the EUT activated in continuous transmit mode. Bandwidth is measured relative to the peak power measurement measured separately in full bandwidth.

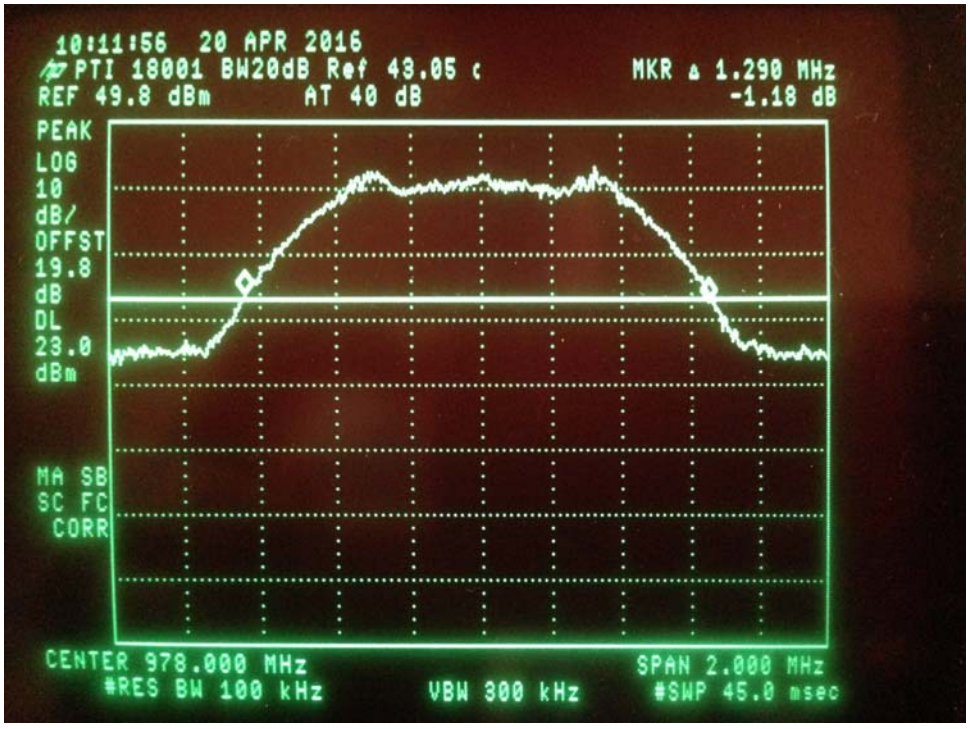
4.2 Test Criteria

Table 4.2.1 Authorized Bandwidth, 87.135; 87.137; 2.1049
1.3 MHz

4.3 Test Results

Table 4.3.1 Bandwidth In 20 dB (100 kHz RBW 300 kHz VBW)	
Reference Power Level (in 3 MHz RBW)	43.05 dBm
Measured Bandwidth	1290 kHz

The EUT satisfied the requirements. Results appear below.



5.0 Modulation Characteristics, UAT Emission Mask

5.1 Test Procedure

The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. The spectrum analyzer was tuned to the frequency of the transceiver under test and the EUT activated in continuous transmit mode. Software is used to operate the spectrum analyzer to produce a measurement is superimposed mask limits.

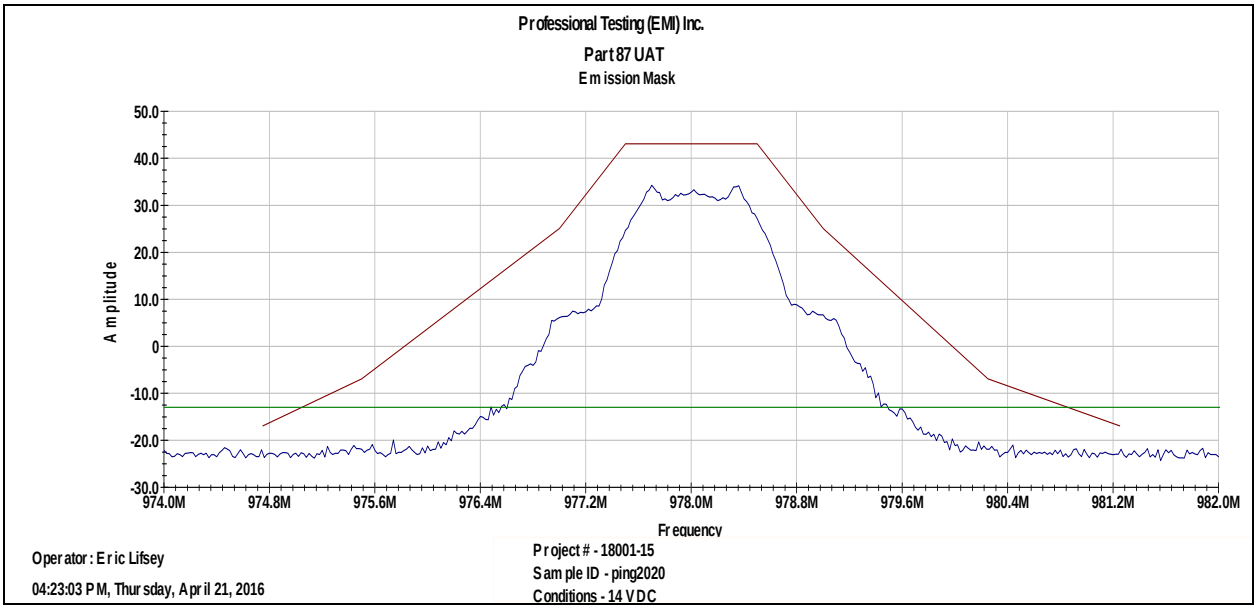
5.2 Test Criteria

Table 5.2.1 Mask Definition, 87.139(l)(1)

UAT Transmit Shape (Measured in 100 kHz RBW.)			Measured Crossing Point in Shape (MHz)	
Table Citation Line	Attenuation (dB)	Frequency Span (MHz)	To Lower Freq Limit	To Upper Freq Limit
1	0	+/- 0.50	0.453	0.463
2	18	+/- 1.00	0.644	0.602
3	50	+/- 2.25	1.890	1.876
4	60	+/- 3.25	2.464	2.394

5.3 Test Results

The EUT satisfied the requirements. Plotted result appears below.



The mask limit appears in red. The -13 dBm limit appears in green.

6.0 Spurious Emissions at Antenna Terminals

6.1 Test Procedure

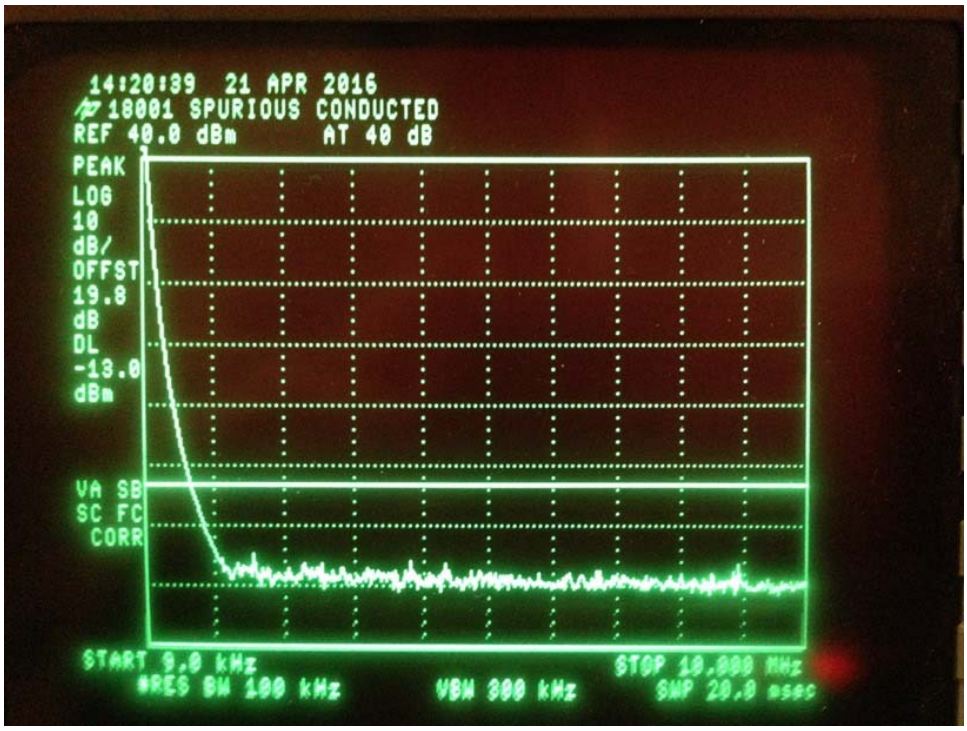
The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. A peak detector was used for the measurement. The transmitter was switched on, and the measurement receiver was tuned to the frequency of the transmitter under test. The loss of the attenuator was compensated by adding an offset to the analyzer amplitude. Spurious power was then measured directly with the spectrum analyzer.

6.2 Test Criteria

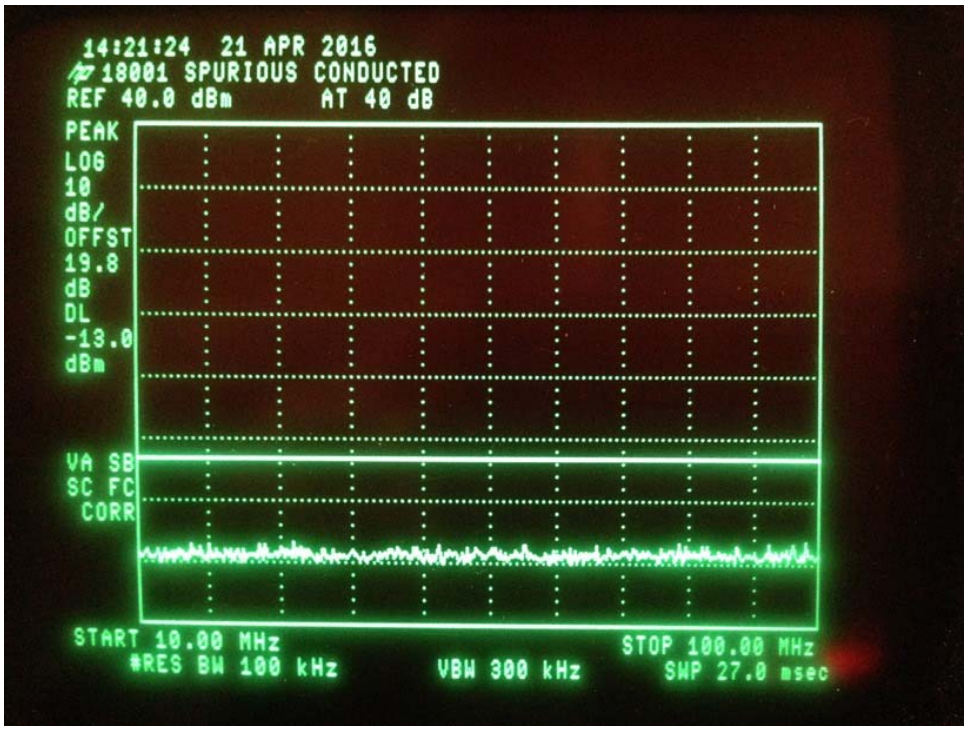
Table 6.2.1 Spurious Limit, 87.139 UAT Transmitter > 5 Watts Power	
Measured Maximum Transmitter Power:	P_t = 43.05 dBm or 20.0 Watts
Method of FCC Part 87.139 for P_t > 5 W:	43 + 10 $\log_{10}$ (P_t) dB
Find Required Attenuation:	43 + 10 $\log_{10}$ (20.0 W) = 56.01 dB
Deduct Attenuation from Measured Power:	43.05 dBm – 56.01 dB = –13 dBm
Spurious Limit for Emissions Beyond 250% of Authorized BW:	-13 dBm

6.3 Test Results

The EUT satisfied the requirements. Plotted measurements appear below.



Range 1 of 6



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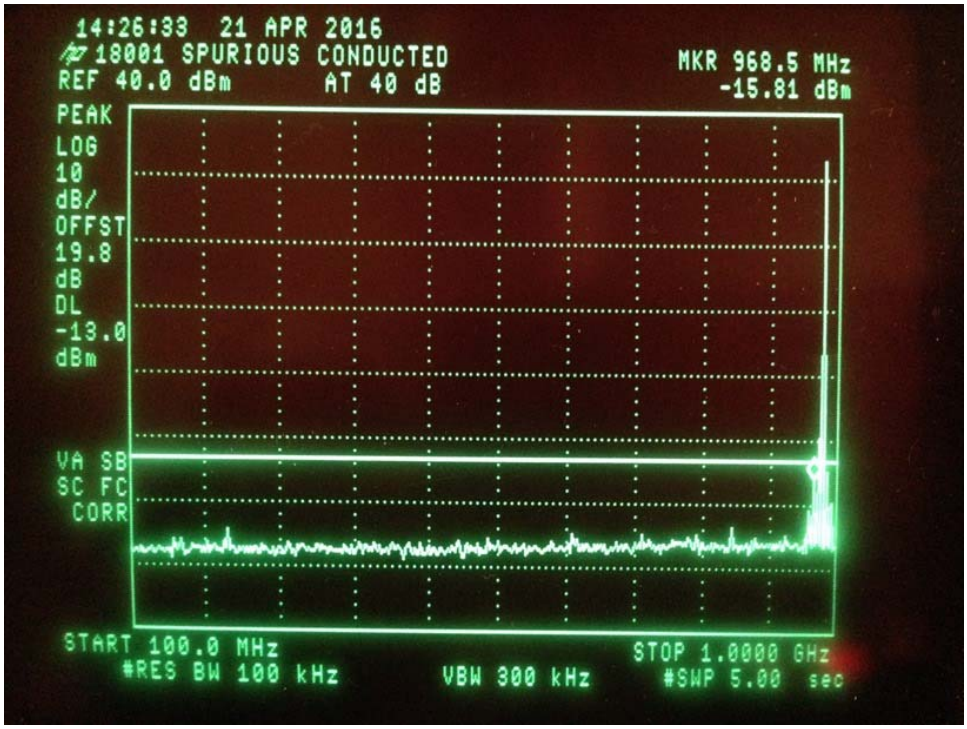

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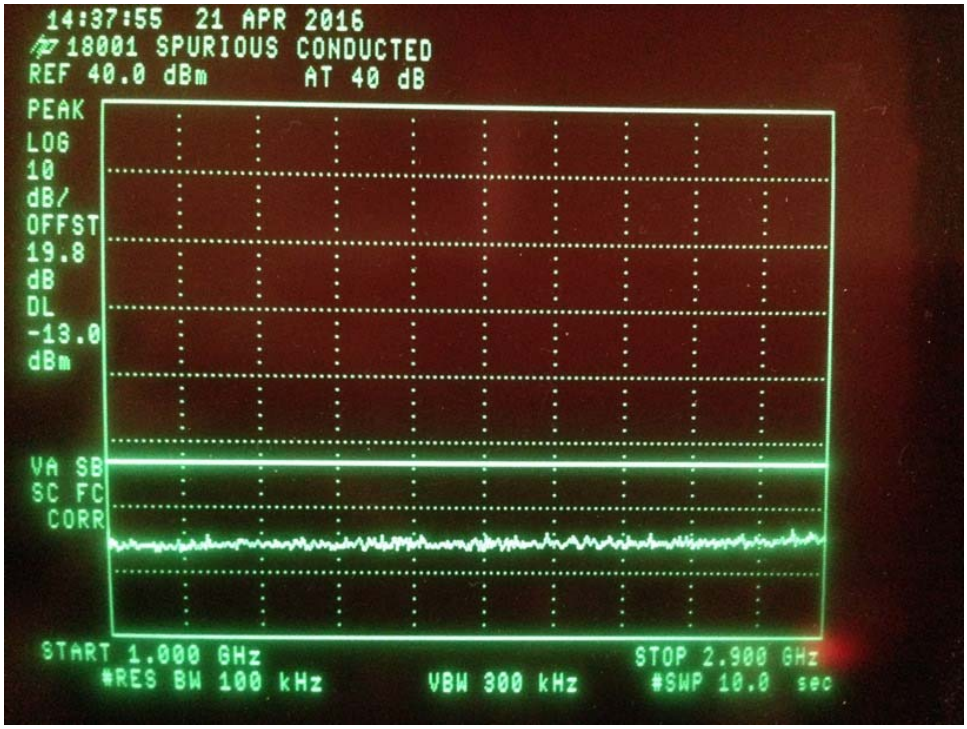
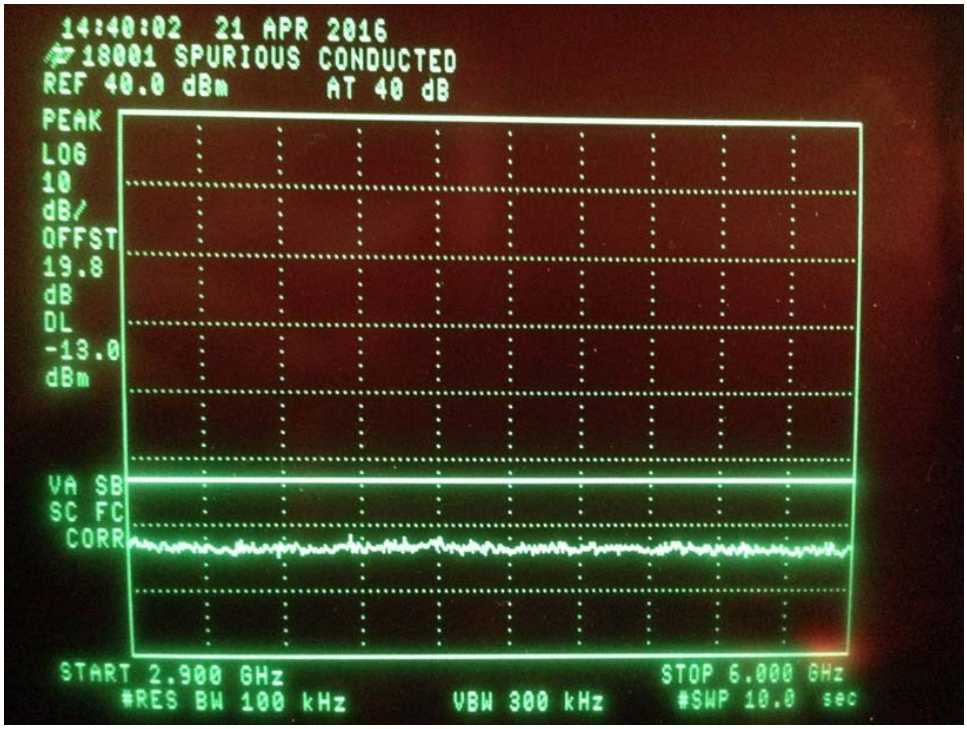
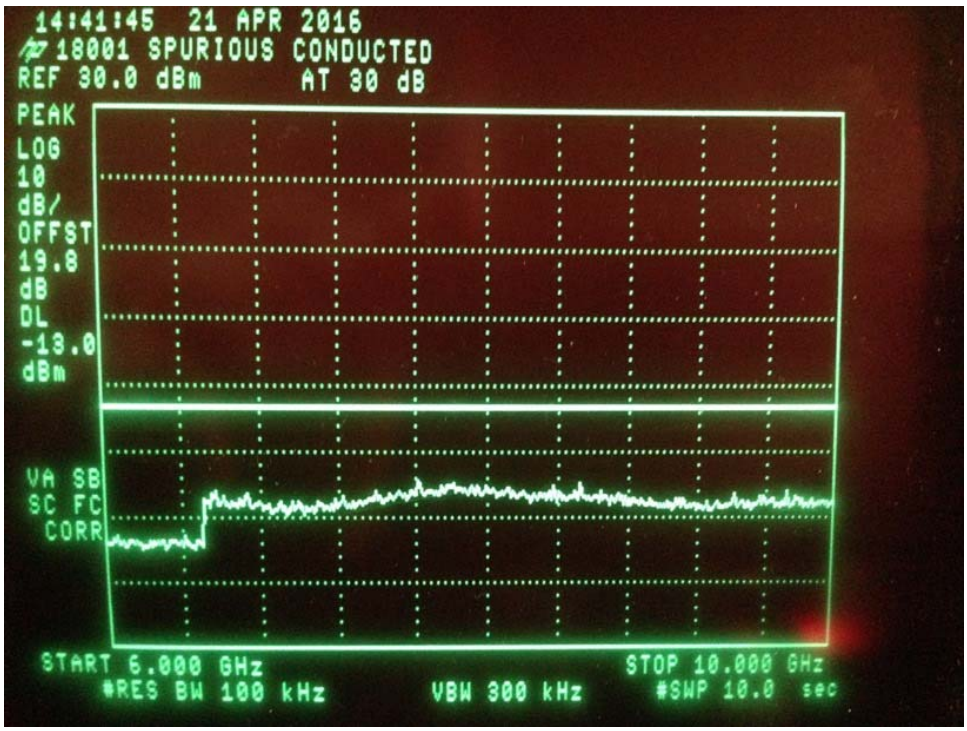


Range 4 of 6



Range 5 of 6

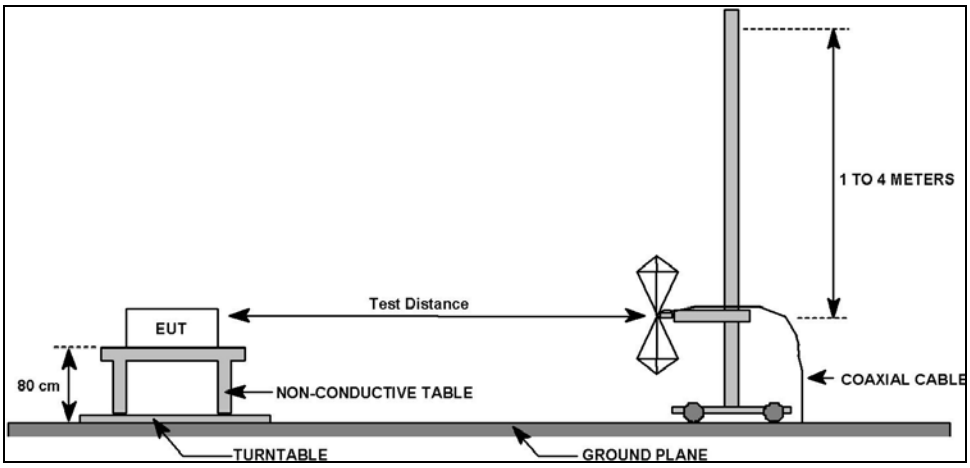


Range 6 of 6

7.0 Field Strength of Spurious Emissions

7.1 Test Procedure

The EUT was placed on a non-conductive table 0.8 meters above the ground plane. The table was centered on a rotating turntable at a distance of 10 meters from the measurement antenna. The EUT was placed into transmit mode with the antenna removed and a resistive terminator substituted.



Field Strength of Radiated Emissions Test Setup

7.2 Test Criteria

Table 7.2.1 Radiated Spurious Limit, 87.139	
Method:	$P_r = P_t + G_t + G_r + 20\log_{10}\left(\frac{\lambda}{4\pi R}\right)$
Path Loss Term:	20 $\log_{10}$ (λ/ 4πR) = 20 $\log_{10}$ (0.30675 / 4π10) = -52.25 dB
Power at *R*:	-13 dBm + 0 dB + 0 dB + [-52.25 dB] = -65.25 dBm
Field Strength Limit Conversion Formula:	$E(dB\mu V/m) = P_{meas}(dBm) - P_{gain}(dB) + 77.2dB + 20\log(f, MHz) - G_{ant}(dB)$
Field Strength Limit Calculation:	[-65.25 dBm] – 0 dB + 77.2 dB + 20 $\log_{10}$ (978 MHz) - 0 dB = 71.5 dBµV/m

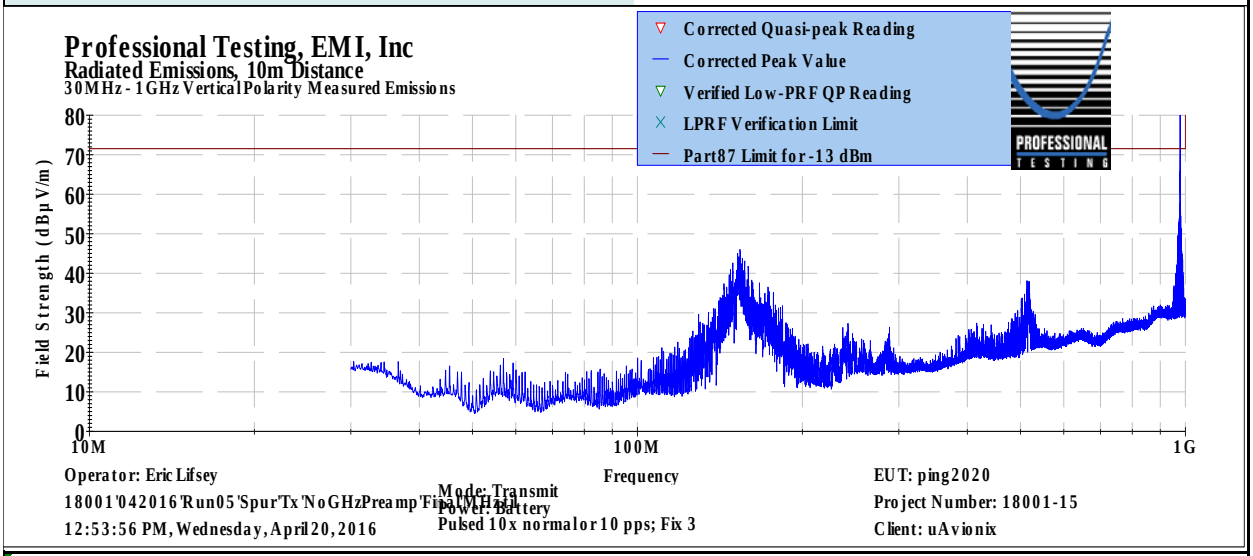
7.3 Test Results

The EUT satisfied the requirements. Plotted measurements appear below.

Table 7.3.1: Radiated Emissions, 30 MHz to 1 GHz, Vertical Polarization

Professional Testing, EMI, Inc.			
Test Method:	47 CFR Part 87		
In accordance with:	FCC Part 87 Emission limitations.		
Section:	Limit 87.139(l)(3) or -13 dBm		
Test Date(s):	4/21/2015	EUT Serial #:	123-4567
Customer:	uAvionix LLC	EUT Part #:	NA
Project Number:	18001-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	ping2020	Witness' Name:	Jeff Walker

Radiated Emissions Test Results Data Sheet			Page: 1 of 1		
EUT Line Voltage:	12	VDC	EUT Power Frequency:	0	N/A
Antenna Orientation:	Vertical		Frequency Range:	30MHz to 1GHz	
EUT Mode of Operation:			Transmit		

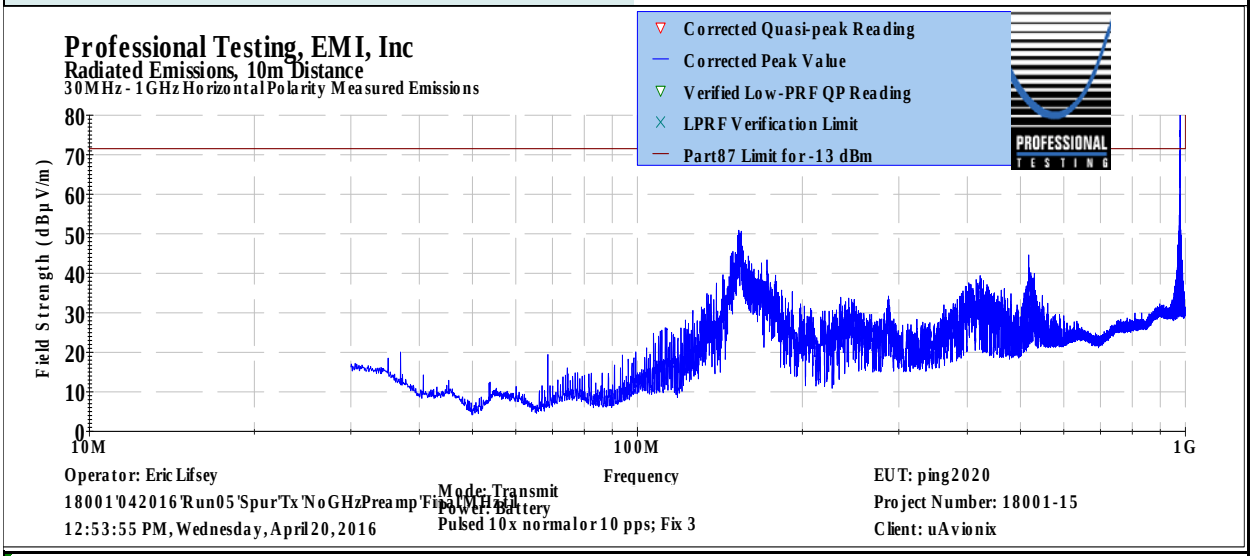


≤ 1GHz Vertical Antenna Polarity Measured Emissions

Table 7.3.2: Radiated Emissions, 30 MHz to 1 GHz, Horizontal Polarization

Professional Testing, EMI, Inc.			
Test Method:	47 CFR Part 87		
In accordance with:	FCC Part 87 Emission limitations.		
Section:	Limit 87.139(l)(3) or -13 dBm		
Test Date(s):	4/21/2015	EUT Serial #:	123-4567
Customer:	uAvionix LLC	EUT Part #:	NA
Project Number:	18001-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	ping2020	Witness' Name:	Jeff Walker

Radiated Emissions Test Results Data Sheet			Page: 1 of 1		
EUT Line Voltage:	12	VDC	EUT Power Frequency:	0	N/A
Antenna Orientation:	Horizontal		Frequency Range:	30MHz to 1GHz	
EUT Mode of Operation:			Transmit		

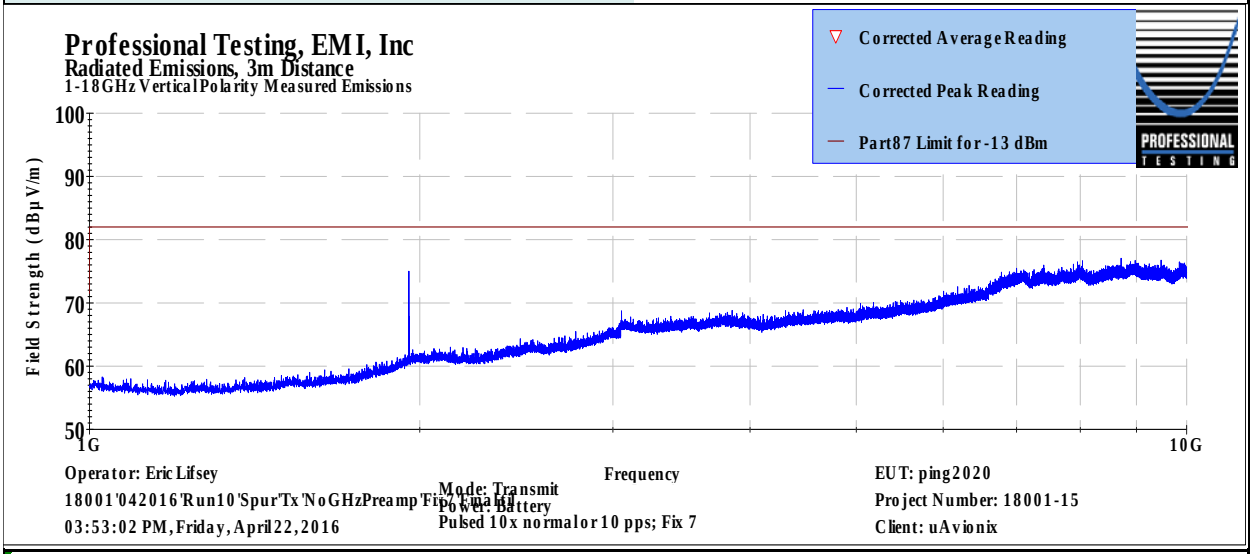


≤ 1GHz Horizontal Antenna Polarity Measured Emissions

Table 7.3.3: Radiated Emissions, 1 to 10 GHz, Vertical Polarization

Professional Testing, EMI, Inc.			
Test Method:	47 CFR Part 87		
In accordance with:	FCC Part 87 Emission limitations.		
Section:	Limit 87.139(l)(3) or -13 dBm		
Test Date(s):	4/21/2015	EUT Serial #:	123-4567
Customer:	uAvionix LLC	EUT Part #:	NA
Project Number:	18001-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	ping2020	Witness' Name:	Jeff Walker

Radiated Emissions Test Results Data Sheet			Page: 1 of 1		
EUT Line Voltage:	12	VDC	EUT Power Frequency:	0	N/A
Antenna Orientation:	Vertical		Frequency Range:	Above 1GHz	
EUT Mode of Operation:			Transmit		

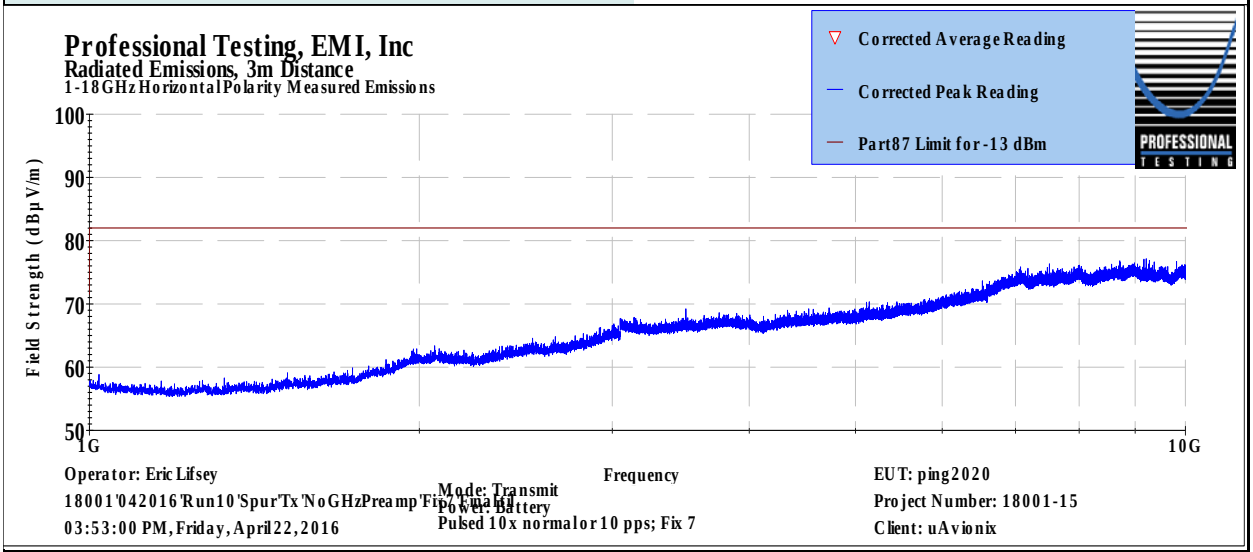


> 1GHz Vertical Antenna Polarity Measured Emissions

Table 7.3.4: Radiated Emissions, 1 to 10 GHz, Horizontal Polarization

Professional Testing, EMI, Inc.			
Test Method:	47 CFR Part 87		
In accordance with:	FCC Part 87 Emission limitations.		
Section:	Limit 87.139(l)(3) or -13 dBm		
Test Date(s):	4/21/2015	EUT Serial #:	123-4567
Customer:	uAvionix LLC	EUT Part #:	NA
Project Number:	18001-15	Test Technician:	Eric Lifsey
Purchase Order #:	NA	Supervisor:	Lisa Arndt
Equip. Under Test:	ping2020	Witness' Name:	Jeff Walker

Radiated Emissions Test Results Data Sheet			Page: 1 of 1		
EUT Line Voltage:	12	VDC	EUT Power Frequency:	0	N/A
Antenna Orientation:	Horizontal		Frequency Range:	Above 1GHz	
EUT Mode of Operation:			Transmit		



> 1GHz Horizontal Antenna Polarity Measured Emissions

8.0 Frequency Stability

8.1 Test Procedure

The EUT is placed into a temperature chamber and connected by cable to a spectrum analyzer; attenuation added if needed. On reaching each set point temperature, the EUT is allowed to soak at least 15 minutes without power applied. After soak time was satisfied, the EUT is powered on in transmit mode and the frequency is observed until it becomes stable; then the measurement of frequency is taken.

Operating voltage stability was also measured for selected extremes based on operating design. This device operates over a wide voltage range greater than the usual requirement.

The EUT is operated in unmodulated mode and continuous transmit.

8.2 Test Criteria

Table 8.2.1 Frequency Stability Criteria, 87.133; 2.1055(a)(1)
Parameter: Frequency Tolerance
20 ppm or ±19,560 Hz for 978 MHz

Table 8.2.2 Test Conditions, Temperatures
-30 C to 50 C and by 10 C steps

Table 8.2.3 Test Conditions, Voltage	
Low Voltage	12 V less 15% = 10.0 VDC
Nominal Voltage	14.0 VDC
High Voltage	24 V plus 15% = 27.6 VDC

8.3 Test Results

The EUT satisfies the requirement. Tabular results appear below.

8.3.1 Temperature

Table 8.3.1.1 Frequency Stability			21-Apr-2016
Condition	**Frequency**		**Deviation**
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	978.000000	978.007630	7630
-20	978.000000	978.006650	6650
-10	978.000000	978.007040	7040
0	978.000000	978.010660	10660
10	978.000000	978.009090	9090
20	978.000000	978.010070	10070
30	978.000000	978.009290	9290
40	978.000000	978.009000	9000
50	978.000000	978.001170	1170
Max Deviation (Hz)			10660
Min Deviation (Hz)			1170

8.3.2 Voltage

Table 8.3.2.1 Frequency Stability				21-Apr-2016
Condition	**Voltage**	**Frequency**		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	10.00	978.000000	978.005280	5280
Nominal	14.00	978.000000	978.010070	10070
High	27.60	978.000000	978.006650	6650

9.0 Equipment Lists

Table 9.1 Equipment List; Power, Bandwidth, and Mask				
Asset #	**Manufacturer**	**Model #**	**Description**	**Calibration Due**
2216	HP	8593E	Spectrum Analyzer	2 Nov 2016
A105	Narda	768A-20	Attenuator, 20 W, 20 dB	5 Nov 2016
0472	Tektronix	THS730A	Scope/DMM	7 Dec 2016
Client Supplied	Rigol	DP832A	Adjustable DC Power Supply	CIU

Table 9.2 Equipment List; Frequency Stability				
Asset #	**Manufacturer**	**Model #**	**Description**	**Calibration Due**
2216	HP	8593E	Spectrum Analyzer	2 Nov 2016
A105	Narda	768A-20	Attenuator, 20 W, 20 dB	5 Nov 2016
2134	Tenny	TPC T2C	Temperature Chamber	13 Oct 2016
C247	Pasternack	RG type	Coaxial Cable, double shielded	CNR
0472	Tektronix	THS730A	Scope/DMM	7 Dec 2016
Client Supplied	Rigol	DP832A	Adjustable DC Power Supply	CIU

Table 9.3 Equipment List; Radiated Emissions

Professional Testing, EMI, Inc.

Test Method:	**47 CFR Part 87**		
In accordance with:	**FCC Part 87 Emission limitations.**		
Section:	**Limit 87.139(l)(3) or -13 dBm**		
Test Date(s):	**4/21/2015**	**EUT Serial #:**	**123-4567**
Customer:	**uAvionix LLC**	**EUT Part #:**	**NA**
Project Number:	**18001-15**	**Test Technician:**	**Eric Lifsey**
Purchase Order #:	**NA**	**Supervisor:**	**Lisa Arndt**
Equip. Under Test:	**ping2020**	**Witness' Name:**	**Jeff Walker**

Radiated Emissions Test Equipment List

Tile! Software Version:	**4.2.A, May 23, 2010, 08:38:52 AM**
Test Profile:	**2015 Rad Emissions_ClassA - LowPRF_072715.til or 2015 Rad Emissions_ClassB - LowPRF_072715.til**

Asset #	Manufacturer	Model	Equipment Nomenclature	Serial Number	Calibration Due Date
1509A	Braden	N/A	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	2/5/2017
1890	HP	8447F	Preamp/Amp, 9kHz-1300MHz, 28/25dB	3313A05298	2/1/2018
1937	Agilent	E4440A	Spectrum Analyzer, 3 Hz - 26.5 GHz, Opt. AYZ	MY44808298	12/15/2016
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	1/25/2017
C027D	none	RG214	Cable Coax, N-N, 25m	none	10/1/2016
1327	EMCO	1050	Controller, Antenna Mast	none	N/A
0942	EMCO	11968D	Turntable, 4ft.	9510-1835	N/A
1969	HP	11713A	Attenuator/Switch Driver	3748A04113	N/A
1509B	Braden	N/A	TDK 10M Chamber, VSWR > 1 GHz	DAC-012915-005	3/14/2017
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/11/2018
C030	none	none	Cable Coax, N-N, 30m	none	10/1/2016
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	2/25/2017

Appendix: Policy, Rationale, and Evaluation of EMC Measurement Uncertainty

All uncertainty calculations, estimates and expressions thereof shall be in accordance with NIST policy. Since PTI operates in accordance with NIST (NVLAP) Handbook 150-11: 2007, all instrumentation having an effect on the accuracy or validity of tests shall be periodically calibrated or verified traceable to national standards by a competent calibration laboratory. The certificates of calibration or verification on this instrumentation shall include estimates of uncertainty as required by NIST Handbook 150-11.

1. Rationale and Summary of Expanded Uncertainty.

Each piece of instrumentation at PTI that is used in making measurements for determining conformance to a standard (or limit), shall be assessed to evaluate its contribution to the overall uncertainty of the measurement in which it is used. The assessment of each item will be based on either a type A evaluation or a type B evaluation. Most of the evaluations will be type B, since they will be based on the manufacturer's statements or specifications of the calibration tolerances, or uncertainty will be stated along with a brief rationale for the type of evaluation and the resulting stated uncertainties.

The individual uncertainties included in the combined standard uncertainty for a specific test result will depend on the configuration in which the item of instrumentation is used. The combination will always be based on the law of propagation of uncertainty. Any systematic effects will be accommodated by including their uncertainties, in the calculation of the combined standard uncertainty; except that if the direction and amount of the systematic effect cannot be determined and separated from its uncertainty, the whole effect will be treated as uncertainty and combined along with the other elements of the test setup.

Type A evaluations of standard uncertainty will usually be based on calculating the standard deviation of the mean of a series of independent observations, but may be based on a least-squares curve fit or the analysis of variance for unusual situations. Type B evaluations of standard uncertainty will usually be based on manufacturer's specifications, data provided in calibration reports, and experience. The type of probability distribution used (normal, rectangular, a priori, or u-shaped) will be stated for each Type B evaluation.

In the evaluation of the uncertainty of each type of measurement, the uncertainty caused by the operator will be estimated. One notable operator contribution to measurement uncertainty is the manipulation of cables to maximize the measured values of radiated emissions. The operator contribution to measurement uncertainty is evaluated by having several operators independently repeat the same test. This results in a Type A evaluation of operator-contributed measurement uncertainty.

A summary of the expanded uncertainties of PTI measurements is shown as Table 1. These are the worst-case uncertainties considering all operative influence factors.

Table 1: Summary of Measurement Uncertainties for Site 45

Type of Measurement	Frequency Range	Meas. Dist.	Expanded Uncertainty U, dB (k=2)
Mains Conducted Emissions	150 kHz to 30 MHz	N/A	2.9
Telecom Conducted Emissions	150 kHz to 30 MHz	N/A	2.8
Radiated Emissions	30 to 1,000 MHz	10 m	4.8
	1 to 18 GHz	3 m	5.7

End of Report

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