Project 19421-15

uAvionix

UAT016R

UAT 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

19 Sep 2017

Reviewed by

Larry Finn
Chief Technical Officer

Written by

Eric Lifsey
EMC Engineer

Revision History

Revision Number	Description	Date
DRAFT 01	Initial release for review.	18 Sep 2017
Final 01		19 Sep 2017

Errata Corrected:

None.

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Certificate of Compliance

Applicant	Device & Test Identification	
uAvionix LLC	Model(s):	UAT016R
300 Pine Needle Lane	FCC ID:	2AFFT-UAT016
Big Fork, MT 59911	Laboratory Project ID:	19421-15
Certificate Date: 19 Sep 2017		

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 #**
uAvionix LLC UAT Transceiver for 978 MHz	UAT016R	None
Operating Voltage: 11 to 31 VDC		

Table 1.2.2 EUT Options		
Description	**Gain**	**Notes**
1/2 wave printed circuit antenna	2.15 dBi	End-loaded dipole.

1.3 EUT User Control Requirement

Power is removed at the aircraft operator's position by disconnection of the associated circuit breaker. 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 high duty cycle transmit was limited to only a few seconds as the transmitter would otherwise overheat.

1.5 Modifications to EUT

None.

1.6 Measurement Correction Methods

Table 1.6 1 Measurement Corrections	
Parameter	**From Sums Of**
Radiated Field Strength	Raw Measured Level + Antenna Factor + Cable Losses – Amplifier Gain
Conducted Antenna Port	Raw Measured Level + Attenuator Factor + Cable Losses
Conducted Mains Port	Raw Measured Level + LISN Factor + Cable/Filter/Limiter Losses

Additionally, measurement distance extrapolation factors (such as 1/d above 30 MHz) are applied and documented where used.

1.7 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 200026-0). 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 603 D	Land Mobile FM or PM Communications Equipment, Measurement and Performance Standards
ANSI C63.26-2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
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

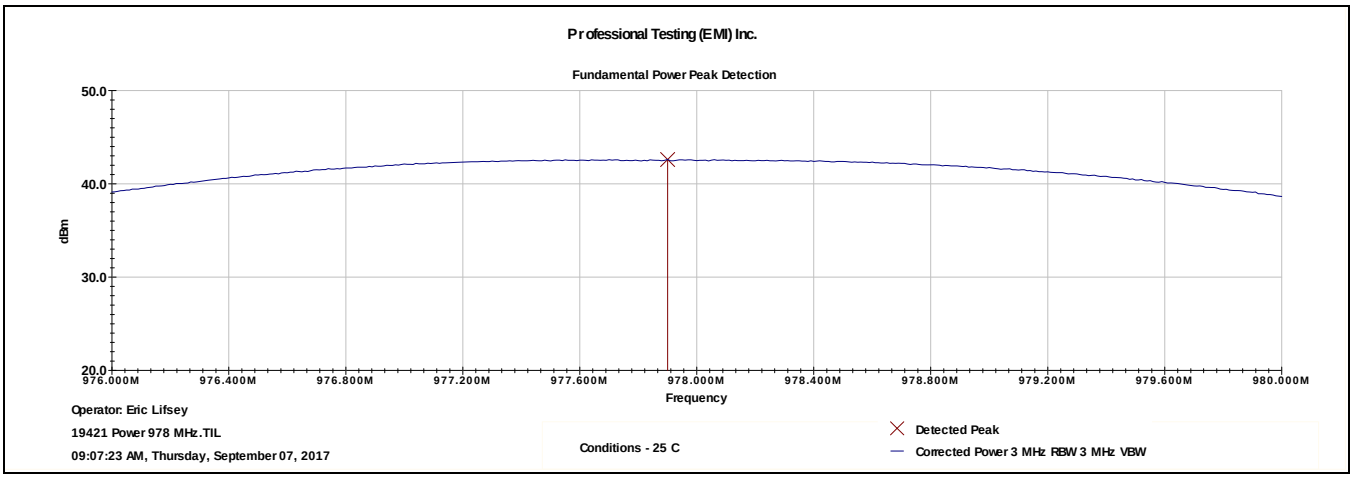
3.3 Test Results

Table 3.3.1 Power Measured In 3 MHz RBW/VBW	
Measured Power (Peak)	42.6 dBm or 18.2 Watts

Table 3.3.2 Calculated Duty Cycle and Average Power	
Measured Power (peak)	42.6 dBm or 18.2 Watts
Transmit Period (ms)*	200 ms
Total Transmit Time (ms)*	0.44 ms
Maximum Duty Cycle	0.44 / 200 = 0.22 %
Averaging Factor	$10\log_{10}(0.22\ \%) = -26.6$ dB
Average Power	$P_{peak} + Factor_{avg} = 42.6 - 26.6 = 16$ dBm or 39.8 mW

*See supporting document 19421 15 FCC_DutyCycleJustification.pdf for details.

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.

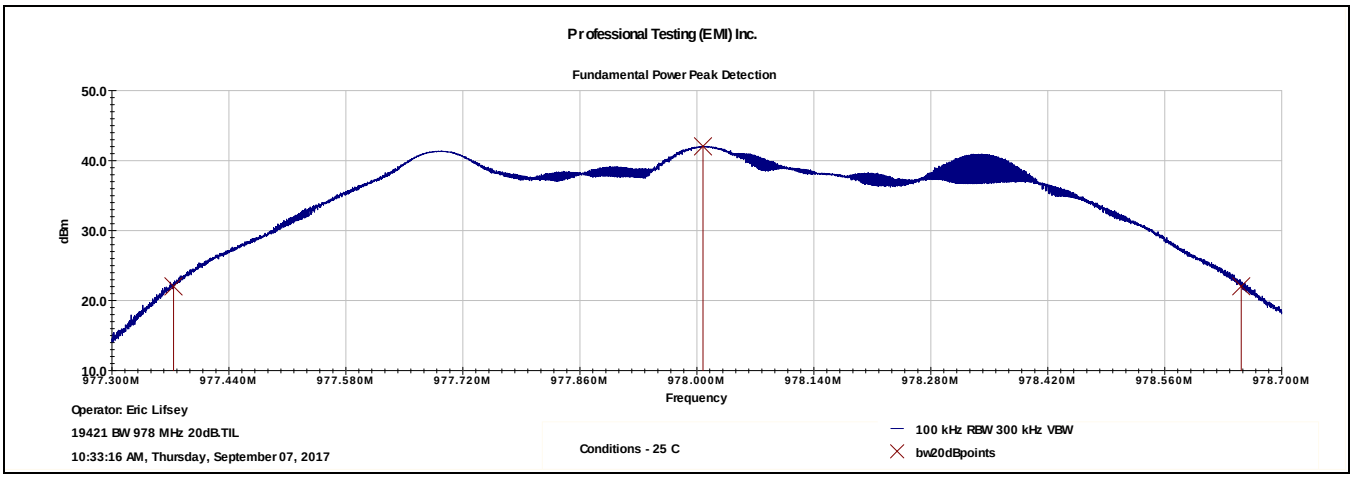
4.2 Test Criteria

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)	
Measured Bandwidth	1278 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.

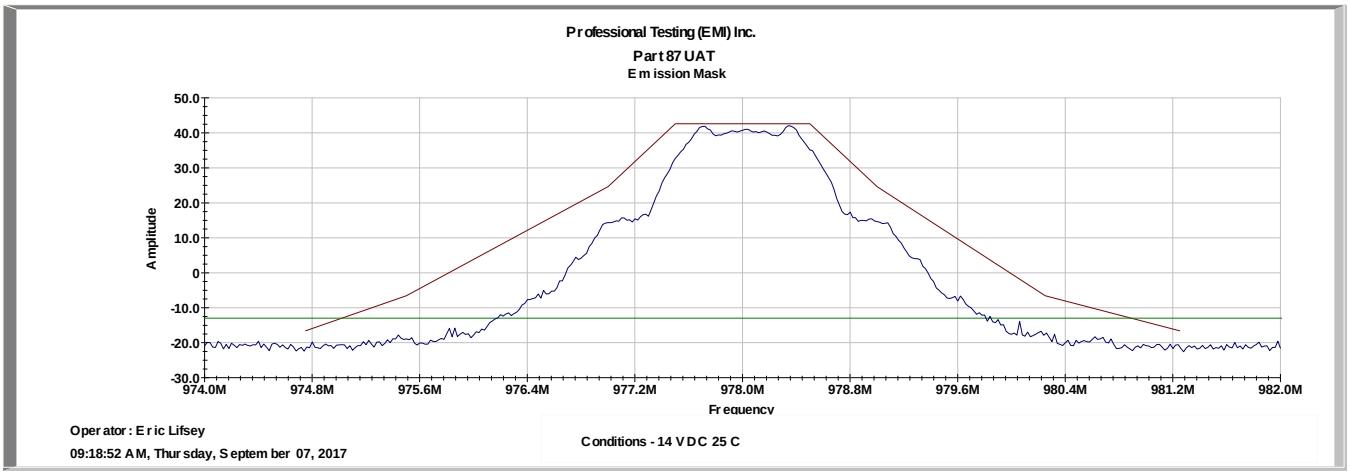
5.2 Test Criteria

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

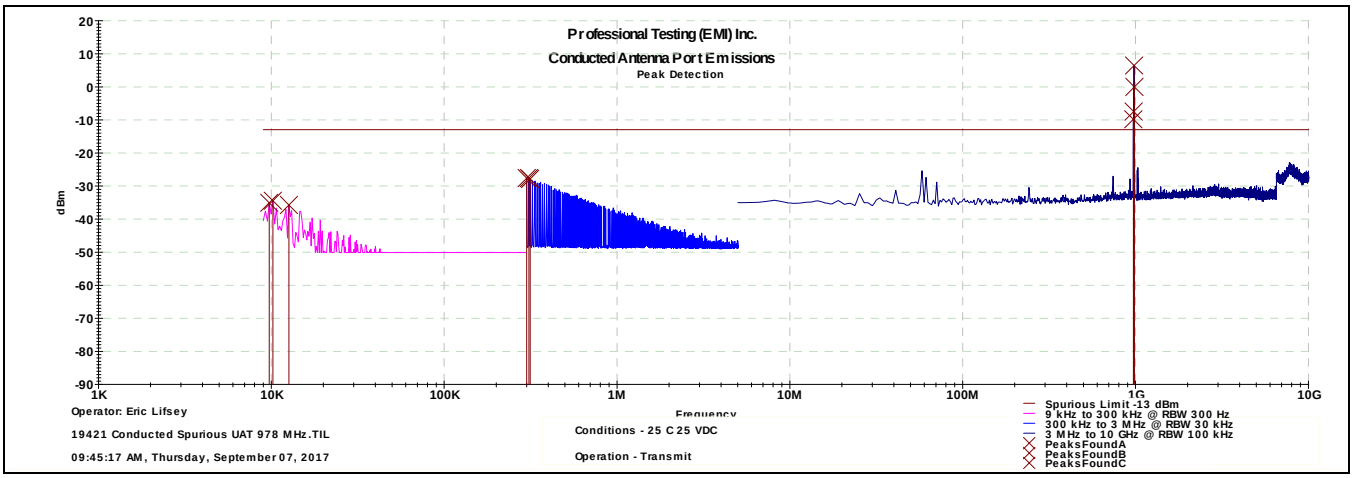
The output of the EUT was connected directly to an attenuator and then to the spectrum analyzer. A peak detector was used for the measurement. The transmitter was switched on, and the measurement receiver was tuned to the frequency of the transmitter under test. The loss of the attenuator was compensated 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 = 16.0 dBm or 39.8 mW
Method of FCC Part 87.139 for P_t > 5 W:	43 + 10 $\log_{10}$ (P_t) dB
Find Required Attenuation:	43 + 10 $\log_{10}$ (0.0398 W) = 29.0 dB
Deduct Attenuation from Measured Peak Power:	16.0 dBm – 29.0 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.



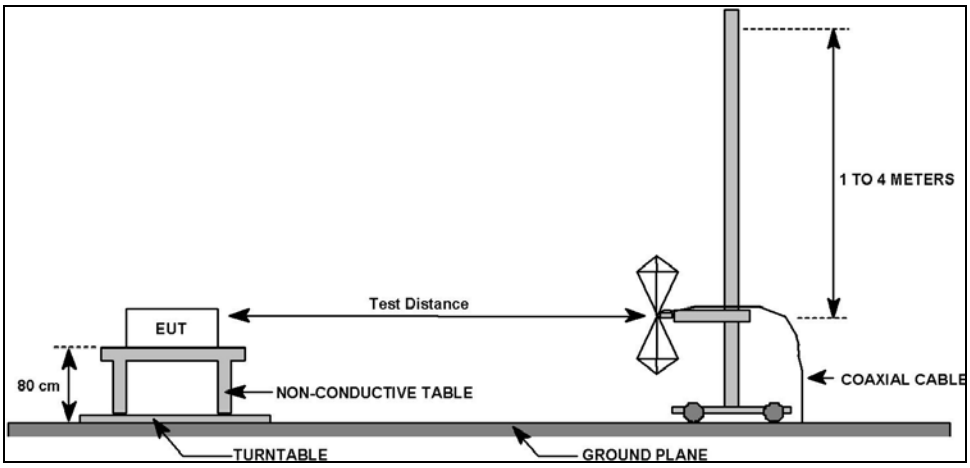
Frequency	Corrected Level
kHz	dBm
9727.5	-35.1
10212.5	-34.5
12637.5	-35.7
300000	-27.6
309400	-27.6
314100	-27.9

Note that the markers on fundamental do not apply.

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

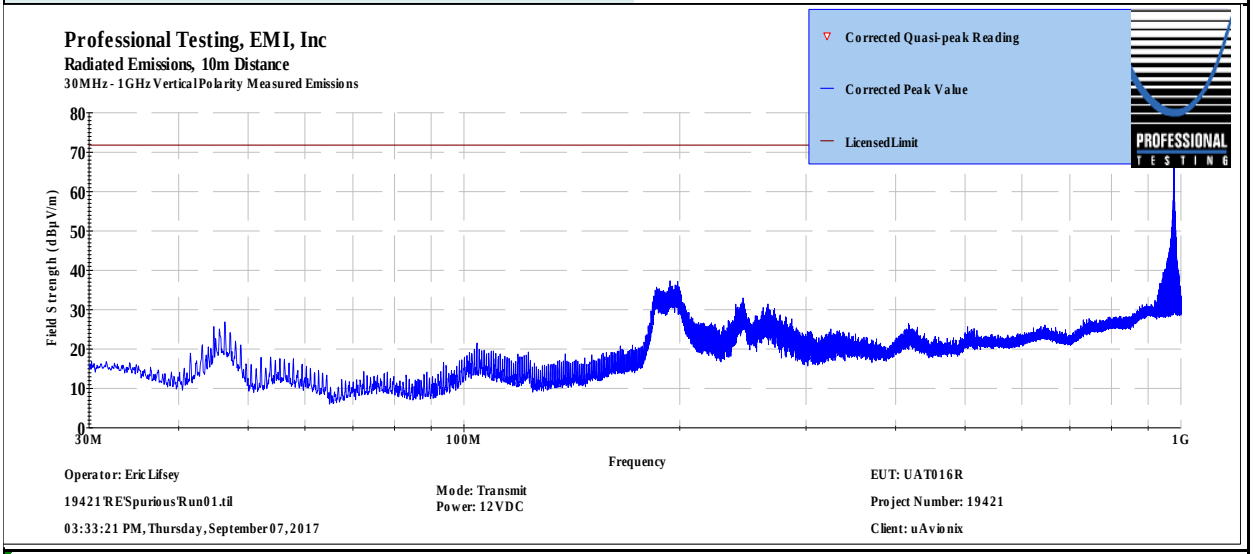
The EUT satisfied the requirements. Plotted measurements of peak emissions appear below.

Note that the averaging factor previous determined is -26.6 dB and can be applied to the peak measurements. The average levels are on the order of ~20 dB below the limit.

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

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Radiated Spurious Emissions		
Test Date(s):	9/7/2017	EUT Serial #:	None
Customer:	uAvionix	EUT Part #:	UAV-1001274-001
Project Number:	19421-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	UAT016R	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		

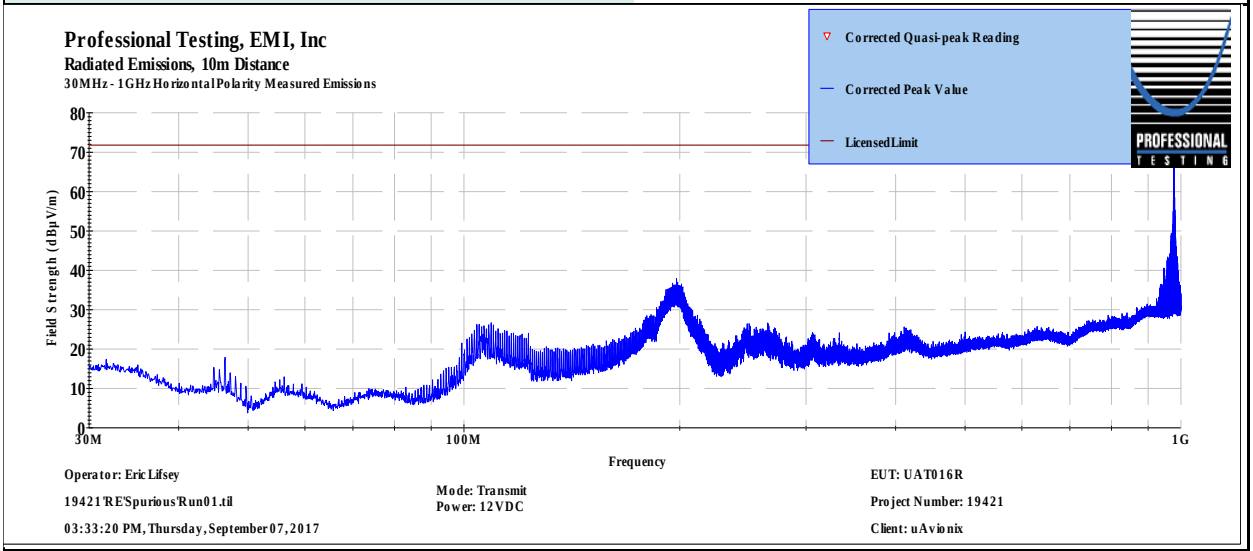


≤ 1GHz Vertical Antenna Polarity Measured Emissions

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

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Radiated Spurious Emissions		
Test Date(s):	9/7/2017	EUT Serial #:	None
Customer:	uAvionix	EUT Part #:	UAV-1001274-001
Project Number:	19421-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	UAT016R	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	

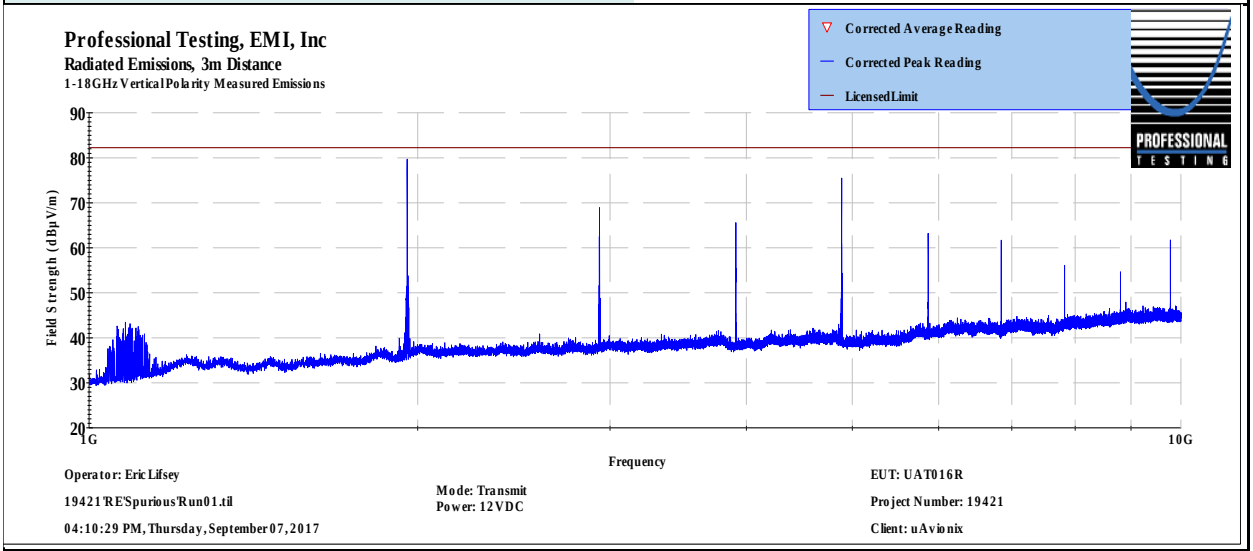


≤ 1GHz Horizontal Antenna Polarity Measured Emissions

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

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Radiated Spurious Emissions		
Test Date(s):	9/7/2017	EUT Serial #:	None
Customer:	uAvionix	EUT Part #:	UAV-1001274-001
Project Number:	19421-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	UAT016R	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		

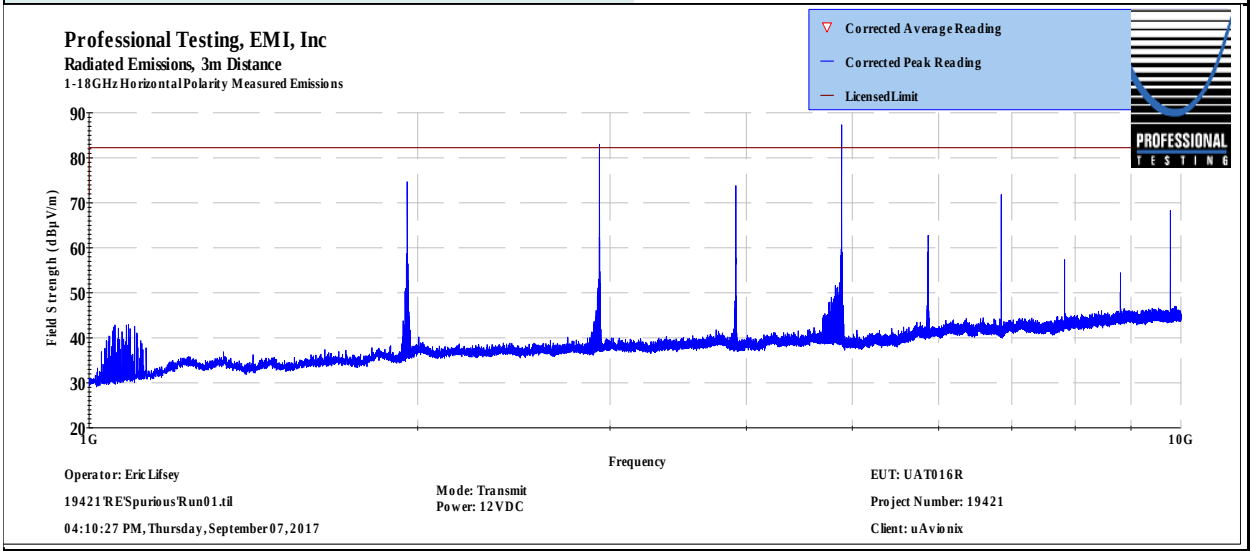


> 1GHz Vertical Antenna Polarity Measured Emissions

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

Professional Testing, EMI, Inc.			
Test Method:	FCC Part 87		
In accordance with:	FCC Part 87		
Section:	Radiated Spurious Emissions		
Test Date(s):	9/7/2017	EUT Serial #:	None
Customer:	uAvionix	EUT Part #:	UAV-1001274-001
Project Number:	19421-15	Test Technician:	Eric Lifsey
Purchase Order #:	0	Supervisor:	Lisa Arndt
Equip. Under Test:	UAT016R	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	13 V less 15% = 11 VDC
Nominal Voltage	13 to 14 VDC
High Voltage	27 V plus 15% = 31 VDC

8.3 Test Results

The EUT satisfies the requirement. Tabular results appear below.

8.3.1 Temperature

Condition	Frequency		Deviation
Temperature (C)	Reference Center Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
-30	978.000000	978.016720	16720
-20	978.000000	978.018090	18090
-10	978.000000	978.017410	17410
0	978.000000	978.015000	15000
10	978.000000	978.011870	11870
20	978.000000	978.008120	8120
30	978.000000	978.005080	5080
40	978.000000	978.002540	2540
50	978.000000	978.001270	1270
Max Deviation (Hz)			18090
Min Deviation (Hz)			1270

8.3.2 Voltage

Condition	Voltage	Frequency		
Voltage Extreme	Voltage (V DC)	Reference Frequency (MHz)	Measured Frequency (MHz)	Calculated Deviation (Hz)
Low	10.00	978.000000	978.007870	7870
Nominal	14.00	978.000000	978.008000	8000
High	27.60	978.000000	978.004620	4620

9.0 Equipment Lists

Table 9.1 Equipment List; Power, Bandwidth, and Mask				
Asset #	**Manufacturer**	**Model #**	**Description**	**Calibration Due**
2216	HP	8593E	Spectrum Analyzer	18 Jan 2018
A105	Narda	768A-20	Attenuator, 20 W, 20 dB	3 Oct 2018
1831	HP	6622A	DC Power Supply	CIU

Table 9.2 Equipment List; Frequency Stability				
Asset #	**Manufacturer**	**Model #**	**Description**	**Calibration Due**
2216	HP	8593E	Spectrum Analyzer	18 Jan 2018
A105	Narda	768A-20	Attenuator, 20 W, 20 dB	3 Oct 2018
2134	Tenny	TPC T2C	Temperature Chamber	12 Oct 2017
C247	Pasternack	RG type	Coaxial Cable, double shielded	CNR
1831	HP	6622A	DC Power Supply	CIU

Table 9.3 Equipment List; Radiated Emissions

Radiated Emissions Test Equipment List					
Tile! Software Version:			**4.2.A, May 23, 2010, 08:38:52 AM**		
Test Profile:			**2016 RE_ClassA - Boresite+Mast_LowPRF_030617.til or 2016 RE_ClassB - Boresite+Mast_LowPRF_030617.til**		
Asset #	**Manufacturer**	**Model**	**Equipment Nomenclature**	**Serial Number**	**Calibration Due Date**
1509A	Braden	TDK 10M	TDK 10M Chamber, NSA < 1 GHz	DAC-012915-005	7/10/2019
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	11/15/2017
1926	ETS-Lindgren	3142D	Antenna, Biconilog, 26 MHz - 6 GHz	135454	3/7/2019
C027D	PTI	None	Relay	none	N/A
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	TDK 10M	TDK 10M Chamber, VSWR > 1 GHz	DAC-012915-005	6/23/2019
2004	Miteq	AFS44-00101800-2S-10P-44	Amplifier, 40dB, .1-18GHz	0	1/11/2018
C030	none	none	Cable Coax, N-N, 30m	none	10/1/2017
1325	EMCO	1050	Controller, Antenna Mast	9003-1461	N/A
1780	ETS-Lindgren	3117	Antenna, Double Ridged Guide Horn, 1 - 18 GHz	110313	3/15/2019

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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