Compliance Testing, LLC
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Test Report

Prepared for: Aerotenna

Model: µLanding™

Description: Microwave Altimeter System for UAV's

Serial Number: N/A

FCC ID: 2AI3E-ULANDINGC1

To

FCC Part 15.249

Date of Issue: August 18, 2017

On the behalf of the applicant:	**Aerotenna** **2029 Becker Drive** **Bioscience & Technology Business Center** **Lawrence, KS 66047**
Attention of:	**Zhenyu Hu** **Ph: (785) 331-9258** **Email: zhu@aerotenna.com**

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Poona Saber
Project Test Engineer

Test Report Revision History

Revision	Date	Revised By	Reason for Revision
1.0	April 3, 2017	Poona Saber	Original Document
2.0	May 31, 2017	Poona Saber	Added 30Mhz-1Ghz spurious emissions plot + setup photo
3.0	June 12, 2017	Poona Saber	Revised page 9 average measurement, page 14 tables and radiated spurious plot for 1-18 GHz. Added Note on page 18
4.0	June 13, 2017	Poona Saber	Added additional informational notes on pages 10 and 13
5.0	July 18, 2017	Poona Saber	Updated device information regarding stopping of the sweep- Added new Power and spurious measurements data and plots- Revised Instrument table Added Annex A
6.0	August 4, 2017	Poona Saber	Revised Annex A by adding the 30Mhz-1GHz Measurements and band edge measurements for low and high channel Revised radiated spurious procedure by adding details on mixers, correction factors and distances on page 15 Updated high Channel peak and bandwidth measurements based on new tuned frequency
7.0	August 18,2017	Poona Saber	Annex A updated with duty cycle and explanation for 12.135 GHz emission on page 4 added duty cycle for 32GHz emissions to Annex A Added Average value for 12.135 GHz with a note on page 16 Changed the 1-18GHz test setup photo on page 18

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ILAC / A2LA

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The tests results contained within this test report all fall within our scope of accreditation, unless noted below.

Please refer to http://www.compliancetesting.com/labscope.html for current scope of accreditation.

Testing Certificate Number: **2152.01**

FCC Site Reg. #349717

IC Site Reg. #2044A-2

Non-accredited tests contained in this report:

N/A

The applicant has been cautioned as to the following

15.21: Information to User

The user's manual or instruction manual for an intentional radiator shall caution the user that changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

15.27(a): Special Accessories

Equipment marketed to a consumer must be capable of complying with the necessary regulations in the configuration in which the equipment is marketed. Where special accessories, such as shielded cables and/or special connectors are required to enable an unintentional or intentional radiator to comply with the emission limits in this part, the equipment must be marketed with, i.e. shipped and sold with, those special accessories. However, in lieu of shipping or packaging the special accessories with the unintentional or intentional radiator the responsible part may employ other methods of ensuring that the special accessories are provided to the consumer, without an additional charge.

Information detailing any alternative method used to supply the special accessories for a grant of equipment authorization or retained in the verification records, as appropriate. The party responsible for the equipment, as detailed in § 2.909 of this chapter, shall ensure that these special accessories are provided with the equipment. The instruction manual for such devices shall include appropriate instructions on the first page of text concerned with the installation of the device that these special accessories must be used with the device. It is the responsibility of the user to use the needed special accessories supplied with the equipment.

Standard Test Conditions Engineering Practices
Except as noted herein, the following conditions and procedures were observed during the testing:

In accordance with ANSI C63.10:2013 and unless otherwise indicated in the specific measurement results, the ambient temperature of the actual EUT was maintained within the range of 10° to 40°C (50° to 104°F) unless the particular equipment requirements specified testing over a different temperature range. Also, unless otherwise indicated, the humidity levels were in the range of 10% to 90% relative humidity.

Measurement results, unless otherwise noted, are worst-case measurements.

Environmental Conditions		
Temperature (°C)	**Humidity (%)**	**Pressure (mbar)**
25.1	36.4	970.6

EUT Description
Model: µLanding™
Description: Microwave Altimeter System for UAV's - This device intended for use as a low power radar system operating in the 24.00 - 24.25GHz. Its microwave altimeter designed to mount on compatible UAV.
Firmware: V4.0
Software: V1.0
Serial Number: N/A
Additional Information:
Antenna gain is 18 dBm and the maximum clock/ processor is 40 MHz. Device is 5V DC power operated. It's using FMCW (frequency modulation with a continuous wave) modulation technique. For testing purposes the sweeping function is stopped and device is put on Low, Mid and High channels. Peak measurements of the signal is made and average is calculated for FMCW to be

EUT Operation during Tests
Normal

Accessories: None

Modifications: None

Cables: None

15.203: Antenna Requirement:

X	The antenna is permanently attached to the EUT
	The antenna uses a unique coupling
	The EUT must be professionally installed
	The antenna requirement does not apply

Test Results Summary

Specification	Test Name	Pass, Fail, N/A	Comments
15.249(a)	Fundamental Field Strength	Pass	
15.249(d)	Out of Band Spurious Emissions	Pass	
RSS-310	Fundamental Field Strength	Pass	
RSS-310	Out of Band Spurious Emissions	Pass	

Fundamental Field Strength

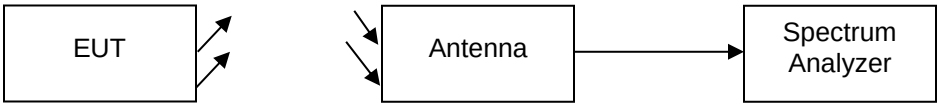
Engineer: Poona Saber

Test Date: 3/24/2017

Test Procedure

The EUT was tested on site in a semi- anechoic chamber at a distance of 1 meter away from the receiving antenna and corrected to the 3 meter limit**.** A spectrum analyzer was used to verify that the EUT meet the requirements for Fundamental Field Strength. The antenna correction and distance correction factors were summed with the peak measurement to ensure correct readings. The following table indicates the highest emission in each of the indicated bands.

Test Setup



Spectrum Analyzer Settings

Detector Settings	RBW	VBW
Peak	1 MHz	3 MHz

Sample Calculations:

Correction Factors include Antenna, preamp and cable insertion loss.

Measured Level includes correction factors that were entered into the spectrum analyzer before recording test data.

Fundamental Field Strength

Channel	Tuned Frequency (GHz)	Peak Measured Level (dBuV/m)	Peak Limit (dBuV/m)	Result
Low	24.04	106.3	127.95	Pass
Mid	24.14	106.39	127.95	Pass
High	24.24	108.2	127.95	Pass

Tuned Frequency (MHz)	Average Measured Level (dBuV/m)	Average Limit (dBuV/m)	Result
24.04	58.7	107.95	Pass
24.14	58.79	107.95	Pass
24.24	60.6	107.95	Pass

Average calculation of the peak measurement is done as following:

Dwell time TD of the sweep frequency signal per MHz of the sweep frequency span:

TD= Ts/ DeltaF

Ts= 1.38 ms = 0.00138 s
DeltaF= 239.25 MHz
TD= 5.8 us

Average factor= TD/ cycle time

Average factor= 1/deltaF= 1/ 240= 0.00417

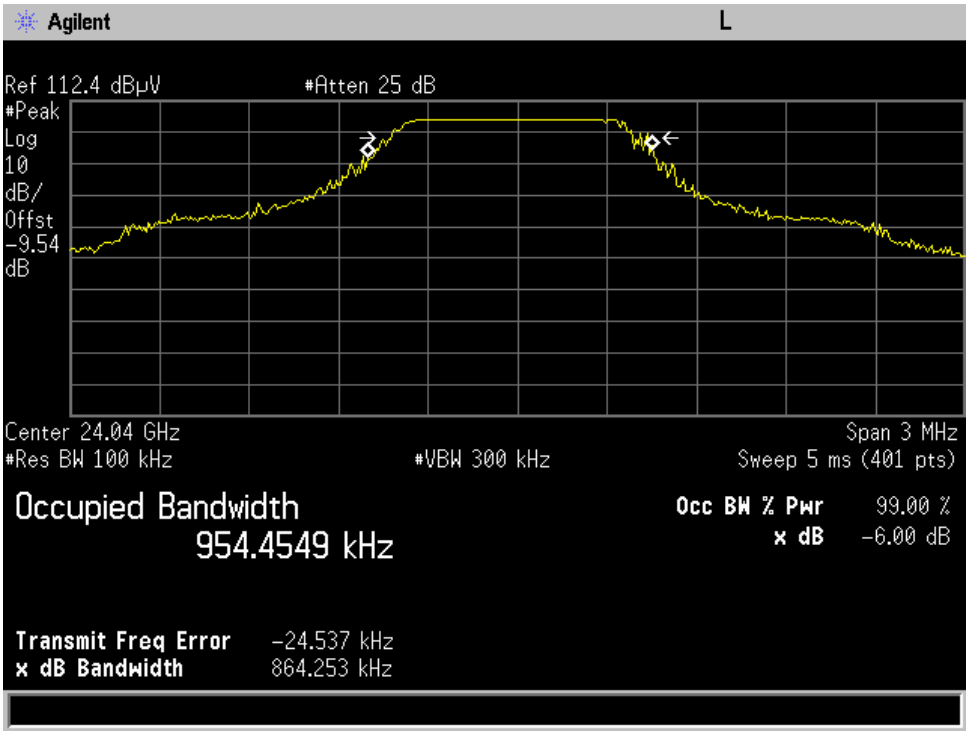
Cycle time= is the total time for a complete cycle of the signal including retrace and any other latency times. In this case since it's a continuous sweep and there is no latency or retrace time the cycle time is equal to signal sweep time

Ts= signal sweep frequency time in seconds

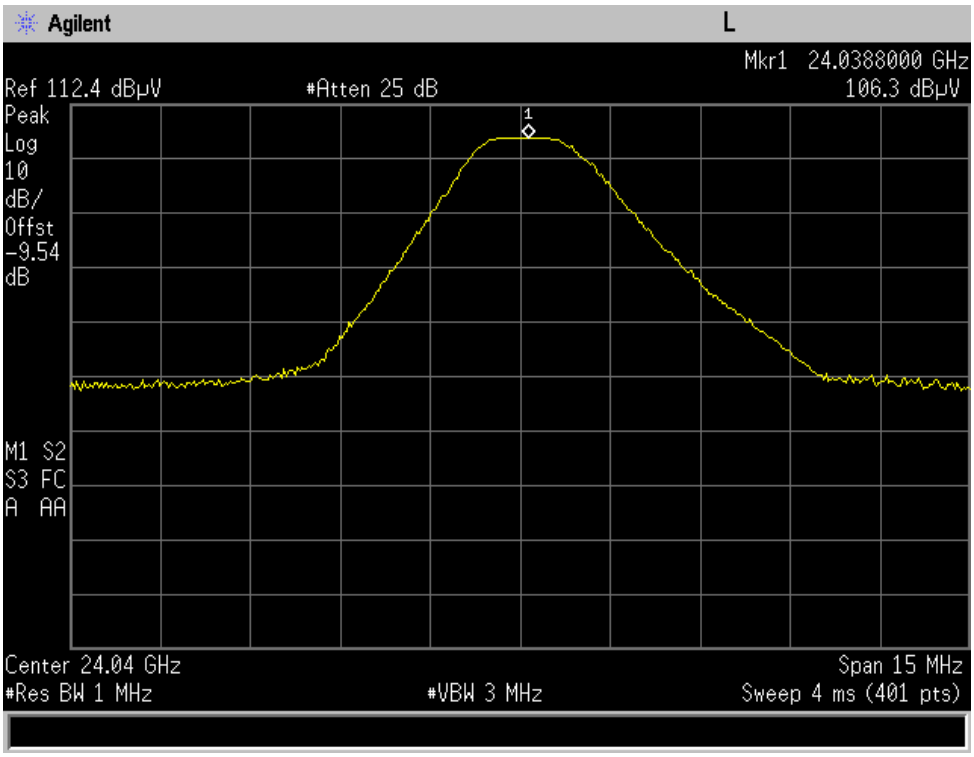
DeltaF= signal sweep frequency span in MHz

After Average factor is derived when peak measured value is converted from logarithmic to linear, multiplied by average factor and convert this value back to logarithmic to derive Average measured level.

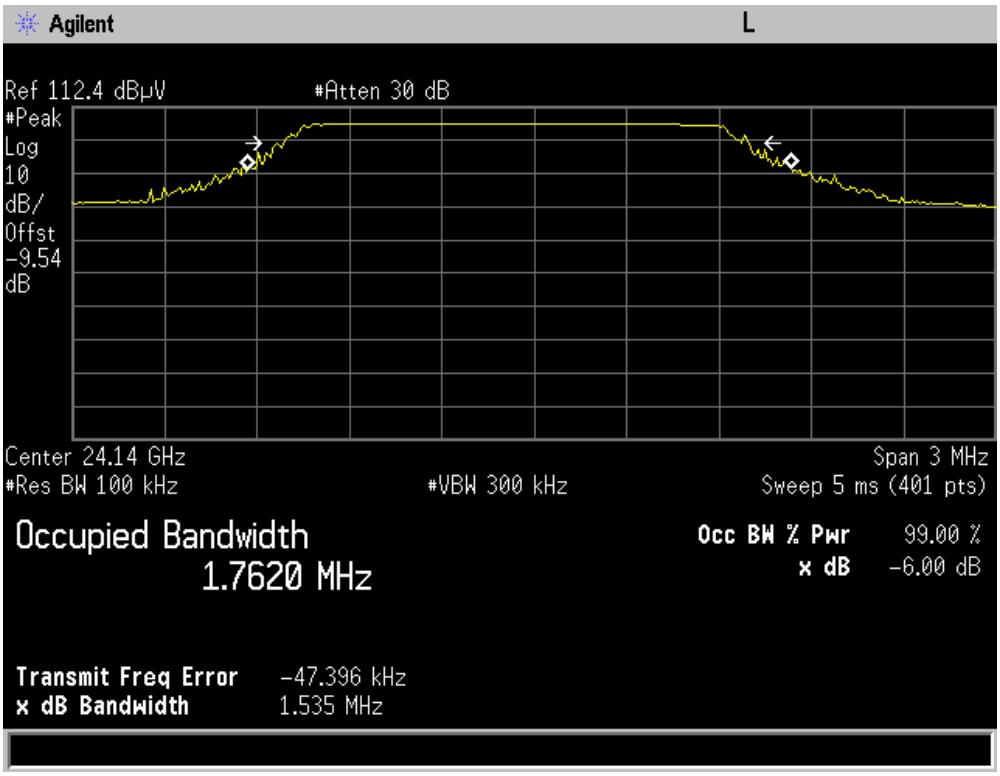
OBW Low channel



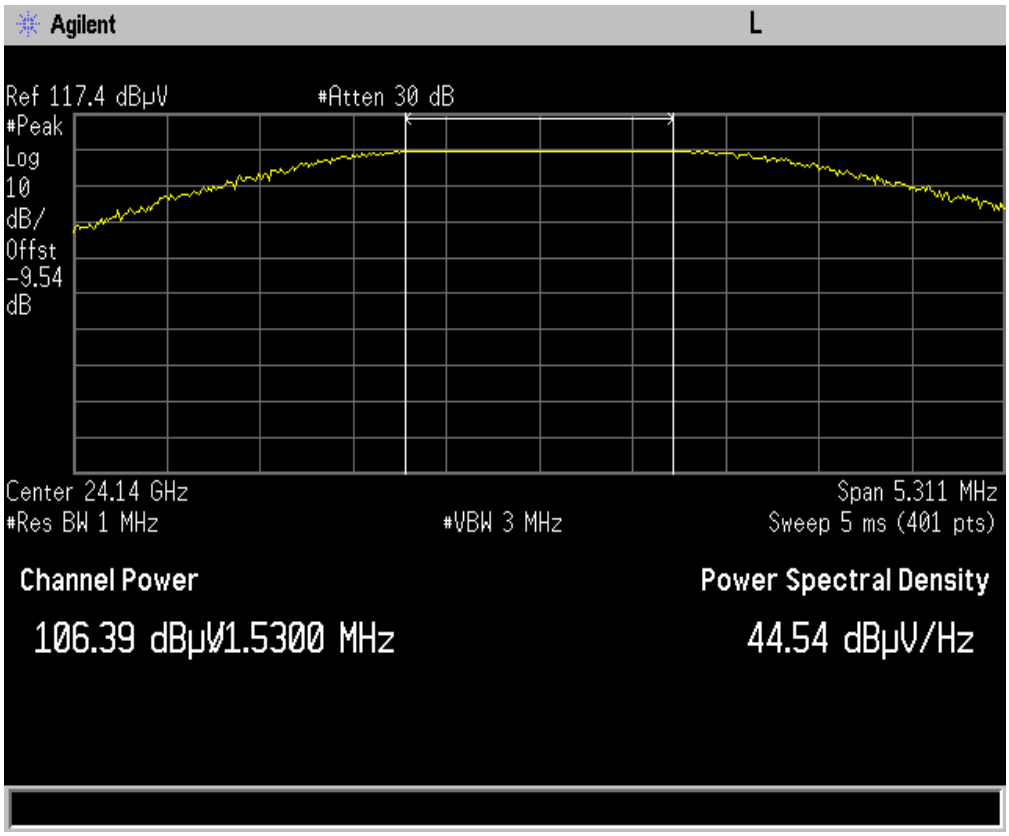
Peak measurement of the fundamental Low channel



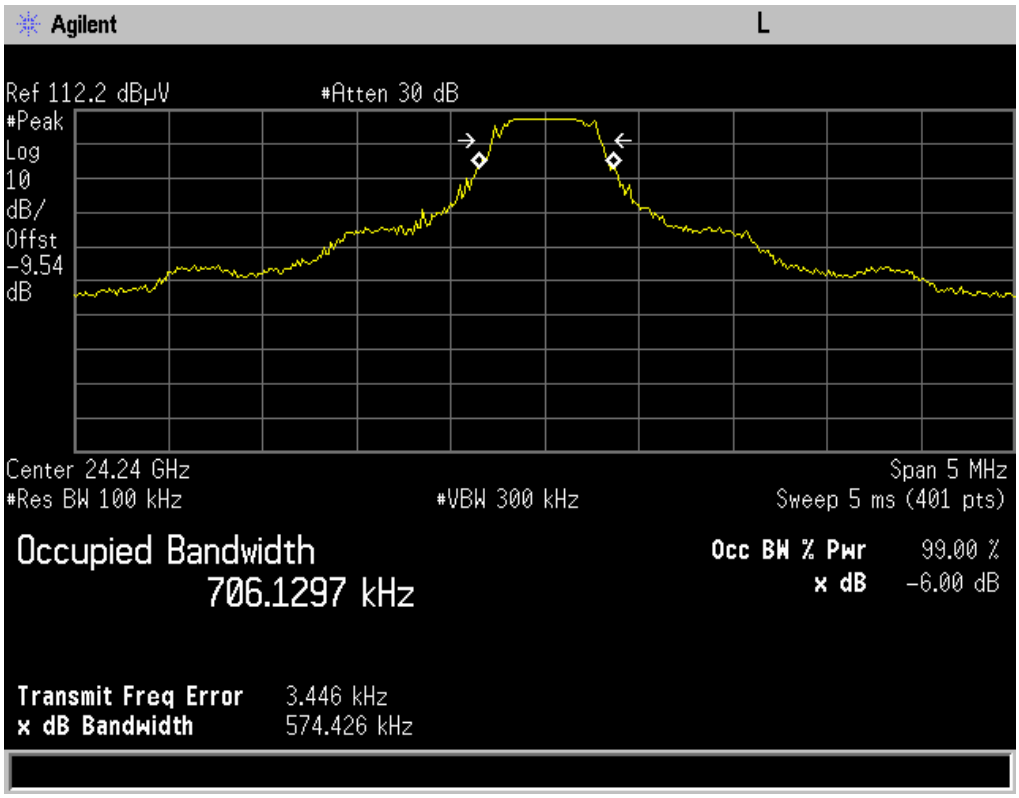
OBW Mid channel



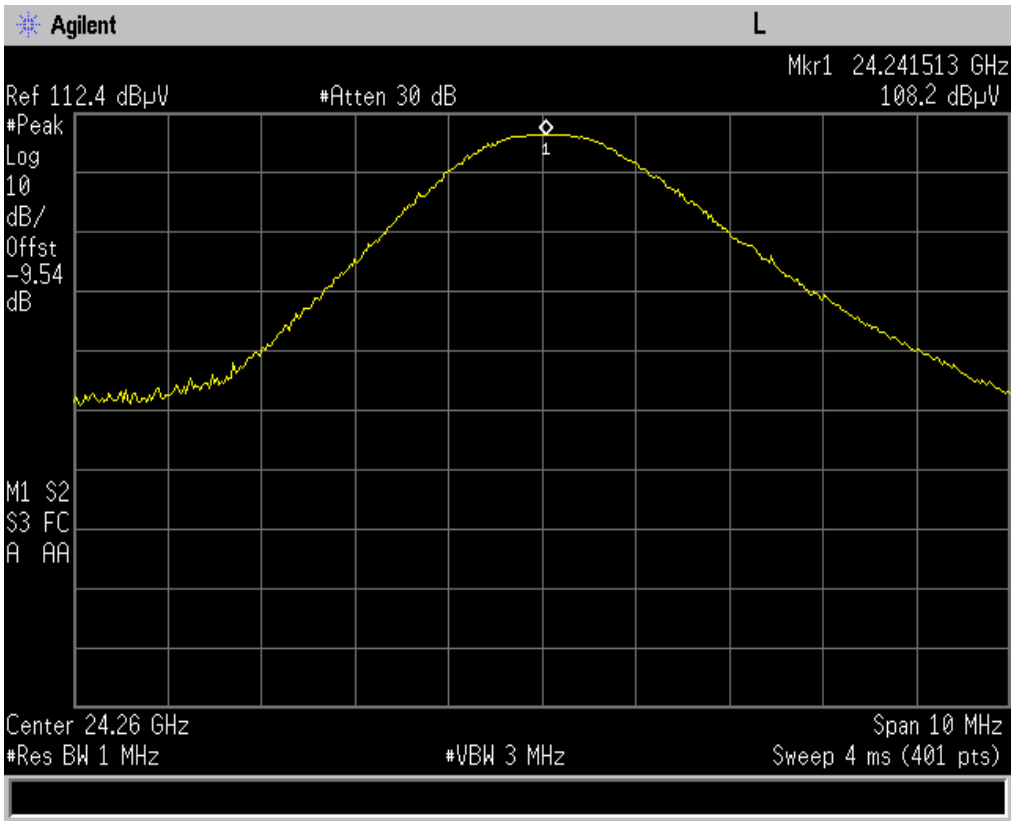
Peak measurement of the fundamental Mid channel



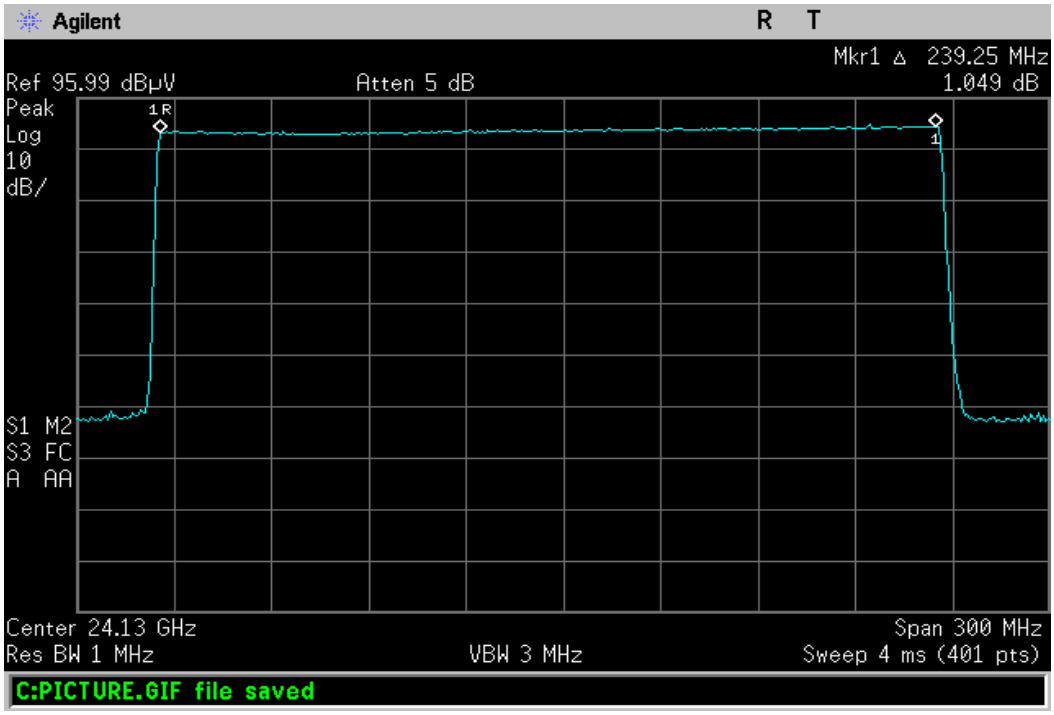
OBW High Channel



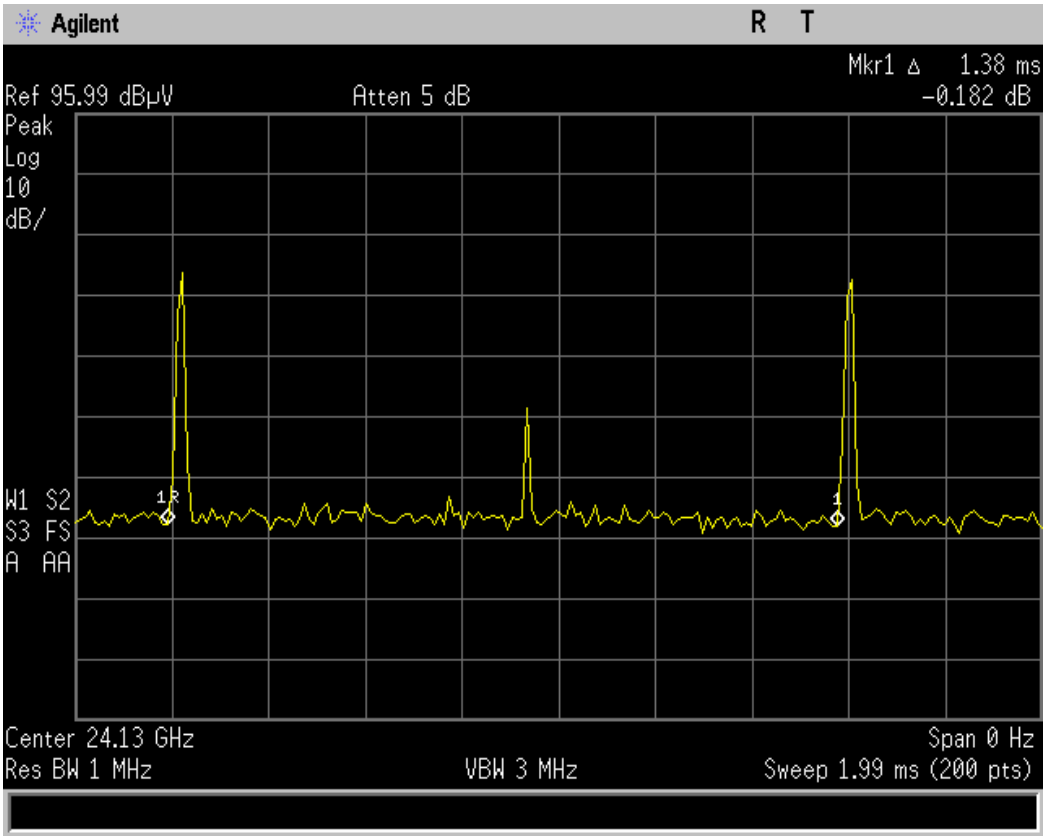
Peak measurement of the fundamental High channel



Sweep frequency Span of the signal



Cycle time of the signal



Radiated Spurious Emissions

Engineer: Poona Saber

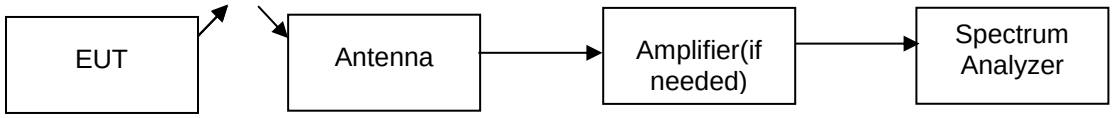
Test Date: 3/24/2017

Test Procedure

The EUT was tested in a semi-anechoic chamber on a 1.5m support for frequencies above 1GHz and 80 cm support for frequencies below 1GHz at mentioned distances from receiving antenna as below. A spectrum analyzer was used to verify that the EUT met the limits for Radiated Spurious Emissions. Harmonic Mixers were used to extend the measurement frequency range of the spectrum analyzer beyond 26.5 GHz and their factors were put into the amplifier before recording data. The same was done for receive antennas, pre-amplifier and cable correction factors.
The spectrum for each channel was examined up to 5th harmonic of the carrier or 100GHz whichever is less.

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. Field strength of harmonics shall be below 67.9 dBuV/m

Test Setup



Analyzer Settings

Detector Settings	RBW	VBW
Peak	1 MHz	3 MHz

Measurement distances:

30 MHz- 18 GHz: 3 meters
18 GHz- 40 GHz: 1 meters
40 GHz- 100 GHz: 40 Centimeters

Sample Calculations:

Correction Factors include Antenna, Harmonic mixers and cable insertion loss correction factors.
Measured Level includes correction factors that were input to the spectrum analyzer before recording test data

Measurement distances that are not taken at 3 meters are corrected to 3 meters by following formula and compensated in spectrum analyzer by an offset.

Distance correction factor = 20 log (distance1/distance2)

Note: for above 26.5 GHz different mixers were used for different frequency bands and correction factors of those mixers were included in spectrum analyzer as well

Radiated Spurious Emissions

Frequency Range (GHz)	Emission Frequency (GHz)	Peak Measured Level (dBuV/m)	Average Factor	Average Measured Level (dBuV/m)	Average Limit (dBuV/m)
1-18 GHz	12.135	62.87	0.00417	15.27	54.0
26.5-40 GHz	32.44	73.26	0.00417	25.66	54.0
26.5-40 GHz	32.16	68.25	0.00417	20.65	54.0
26.5-40 GHz	34.4	68.37	0.00417	20.77	54.0
26.5-40 GHz	32.3	70.31	0.00417	22.71	54.0

Note: All Harmonics emissions have the same characteristic of the fundamental Emission with same duty Cycle, therefore the same Method of calculating the Average power is used with the same Average Factor calculated on page 10 of this report.
Duty Cycle for all these emissions are included in Annex A

Note: No emission beyond noise floor was seen above 40 GHz.

Note: all the spurious emissions (from 26.5-40 GHz) were captured originally with the signal identity capability of the spectrum analyzer off and it was observed that most of them disappear after the signal iden capability is turned on which indicates that those emissions which disappeared were image signal and not real emissions.
Plots that are included in Annex A are with signal iden capability on and peak measurements of highest emission is taken

Please Refer to Annex A for spurious emission plots

Test Equipment Utilized

Description	MFG	Model Number	CT Asset #	Last Cal Date	Cal Due Date
Spectrum Analyzer	Agilent	4407B	i00331	11/19/16	11/19/17
Harmonic mixer 26.5-40 GHz	HP	11970 A	i00193	6/4/15	6/4/18
Waveguide Adapter	HP	R281A	NA	Functional Verificaiton	Functional Verificaiton
Harmonic mixer 33-50 GHz	HP	11970 Q	i00465	6/4/15	6/4/18
Harmonic mixer 50-75 GHz	HP	11970 V	i00463	6/20/15	6/20/18
Harmonic mixer 75-110 GHz	HP	11970 W	i00464	6/4/15	6/4/18
High gain WR22 waveguide Horn Antenna (33-50 GHz)	cmi	HO22R	i00484	NA	NA
High gain WR22 waveguide Horn Antenna (50-75 GHz)	cmi	HO15R	i00477	NA	NA
High gain WR22 waveguide Horn Antenna (75-110 GHz)	cmi	HO10R	i00476	NA	NA
Horn Antenna (18-40 GHz)	EMCO	3116	i00085	2/6/17	2/6/18
Preamp 18-40 GHz	MITEQ	AMF-18004000-29-8P	i00461	Verified on 3/22/16	
Horn Antenna (1-18GHz)	ARA	DRG-118/A	i00271	6/16/16	6/16/18

In addition to the above listed equipment standard RF connectors and cables were utilized in the testing of the described equipment. Prior to testing these components were tested to verify proper operation.

END OF TEST REPORT