MET Laboratories, Inc. *Safety Certification - EMI - Telecom Environmental Simulation*

914 WEST PATAPSCO AVENUE ● BALTIMORE, MARYLAND 21230-3432 ● PHONE (410) 354-3300 ● FAX (410) 354-3313
33439 WESTERN AVENUE ● UNION CITY, CALIFORNIA 94587 ● PHONE (510) 489-6300 ● FAX (510) 489-6372
3162 BELICK STREET ● SANTA CLARA, CALIFORNIA 95054 ● PHONE (408) 748-3585 ● FAX (510) 489-6372
13301 MCCALLEN PASS ● AUSTIN, TX 78753 ● PHONE (512) 287-2500 ● FAX (512) 287-2513

September 4, 2018

Full Spectrum
687 N. Pastoria Avenue
Sunnyvale, CA 94085

Dear Mr. Shahar,

Enclosed is the EMC Wireless test report for compliance testing of the Full Spectrum, Venus, tested to the requirements of Title 47 of the Code of Federal Regulations (CFR), Part 95 Subpart F for Land Mobile Radio Services.

Thank you for using the services of MET Laboratories, Inc. If you have any questions regarding these results or if MET can be of further service to you, please feel free to contact me.

Sincerely yours,
MET LABORATORIES, INC.

Joel Huna
Documentation Department

Reference: (\Full Spectrum\EMCS98836-FCC95F Rev. 2)

ACCREDITED
TESTING CERT #0591.02

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Electromagnetic Compatibility Criteria Test Report

For the

Full Spectrum
Venus

Tested under

The FCC Verification Rules
Contained in Title 47 of the CFR, Part 95, Subpart F
for Private Land Mobile Radio Services

MET Report: EMCS98836-FCC95F Rev. 2

September 4, 2018

Prepared For:
Full Spectrum
687 N. Pastoria Avenue
Sunnyvale, CA 94085

Prepared By:
MET Laboratories, Inc.
3162 Belick St.,
Santa Clara, CA 95054

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James Borrott, Project Engineer
Electromagnetic Compatibility Lab

Joel Huna
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of Part 95, Subpart F of the FCC Rules under normal use and maintenance.

John Mason,
Director, Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
0	July 26, 2018	Initial issue.
1	August 29, 2018	Engineer corrections.
2	September 4, 2018	TCB Corrections.

Table of Contents

All references to section numbers are taken directly from the standard/specification used. Only sections requiring testing or evaluation are included.

List of Tables

List of Figures

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List of Terms and Abbreviations

AC	**A**lternating **C**urrent
ACF	**A**ntenna **C**orrection **F**actor
Cal	**Cal**ibration
d	**M**easurement **D**istance
dB	**D**eci**b**els
dBµA	**D**eci**b**els above one **micro**amp
dBµV	**D**eci**b**els above one **micro**volt
dBµA/m	**D**eci**b**els above one **micro**amp **per m**eter
dBµV/m	**D**eci**b**els above one **micro**volt **per m**eter
DC	**D**irect **C**urrent
E	**E**lectric Field
DSL	**D**igital **S**ubscriber **L**ine
ESD	**E**lectro**s**tatic **D**ischarge
EUT	**E**quipment **U**nder **T**est
f	**F**requency
FCC	**F**ederal **C**ommunications **C**ommission
GRP	**G**round **R**eference **P**lane
H	Magnetic Field
HCP	**H**orizontal **C**oupling **P**lane
Hz	**H**ert**z**
IEC	**I**nternational **E**lectrotechnical **C**ommission
kHz	**k**ilo**h**ert**z**
kPa	**k**ilo**pa**scal
kV	**k**ilo**v**olt
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
MHz	**M**ega**h**ertz
µH	**microh**enry
µ	**microf**arad
µs	**micros**econds
NEBS	**N**etwork **E**quipment-**B**uilding **S**ystem
PRF	**P**ulse **R**epetition **F**requency
RF	**R**adio **F**requency
RMS	**R**oot-**M**ean-**S**quare
TWT	**T**raveling **W**ave **T**ube
V/m	**V**olts **per m**eter
VCP	**V**ertical **C**oupling **P**lane

Executive Summary

1. Testing Summary

These tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with Part 95, Subpart F. All tests were conducted using measurement procedure ANSI TIA/EIA-603-A-2004.

Title 47 of the CFR, Part 95, Subpart F Reference and Test Description	Compliance / Comments
95.1955 Transmitter Effective Radiated Power Limitation	Compliant
95.1957(b) Spurious Emissions at Antenna Terminals	Compliant
95.1957(b) Radiated Spurious Emissions	Compliant
2.1047 Modulation	Compliant
2.1049 Occupied Bandwidth (Emission Mask)	Compliant
2.1055(a)(2), (d)(2) Frequency Stability	Compliant
2.1091 RF Exposure	Compliant

Equipment Configuration

2. Equipment Configuration

2.1. Overview

MET Laboratories, Inc. was contracted by Full Spectrum to perform testing on the Venus under purchase order number 05042018-0001.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the Full Spectrum, Venus.

An EMC evaluation to determine compliance of the Venus with the requirements of Part 95, Subpart F, was conducted. (All references are to the most current version of Title 47 of the Code of Federal Regulations in effect). In accordance with §2.1033, the following data is presented in support of the Certification of the Venus. Full Spectrum should retain a copy of this document and it should be kept on file for at least five years after the manufacturing of the EUT has been **permanently** discontinued. The results obtained relate only to the item(s) tested.

Model(s) Tested:	Venus	
Model(s) Covered:	Venus	
EUT Specifications:	Primary Power Source: 18 - 60 VDC 50 Hz	
	FCC ID: X27-FS-V200	
	Type of Modulations:	OFDMA with 128 FFT
	Max Peak and Output Power:	33.04 dBm
	Equipment Code:	TNB
	EUT Frequency Ranges:	218-219 MHz
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature (15-35º C):	
	Relative Humidity (30-60%):	
	Barometric Pressure (860-1060 mbar):	
Evaluated by:	James Borrott	
Report Date(s):	September 4, 2018	

2.2. Test Site

All testing was performed at MET Laboratories, Inc., 3162 Belick St., Santa Clara, CA 95054. All equipment used in making physical determinations is accurate and bears recent traceability to the National Institute of Standards and Technology.

Radiated Emissions measurements were performed in a semi-anechoic chamber (equivalent to an Open Area Test Site). In accordance with §2.948(a)(3), a complete site description is contained at MET Laboratories.

2.3. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.32 dB	2	95%
RF Power Conducted Spurious Emissions	±2.25 dB	2	95%
RF Power Radiated Emissions	±3.01 dB	2	95%

Table 1. Uncertainty Calculations Summary

2.4. Description of Test Sample

The Full Spectrum Venus, Equipment Under Test (EUT), is a Point to Multipoint broadband wireless radio platform designed to operate in the frequency range 218 MHz to 219 MHz. The Venus platform can run both base station and remote station application layer software. It is running 500 KHz wide channel and Time Division Duplex (TDD) mode of operation for communication in both directions over the same frequency.

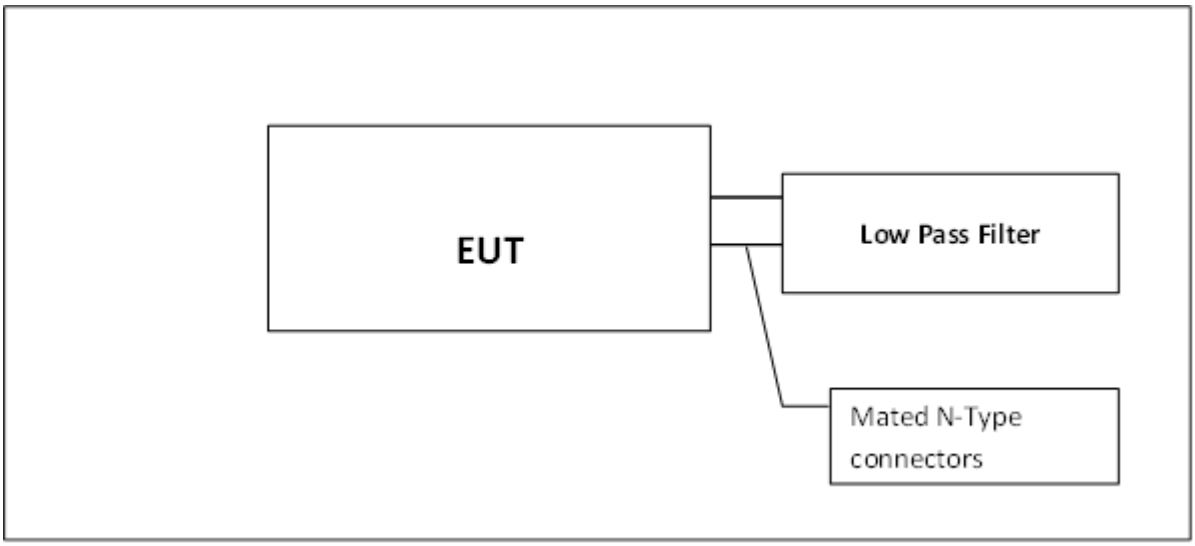


Figure 1. Block Diagram of Test Configuration 1

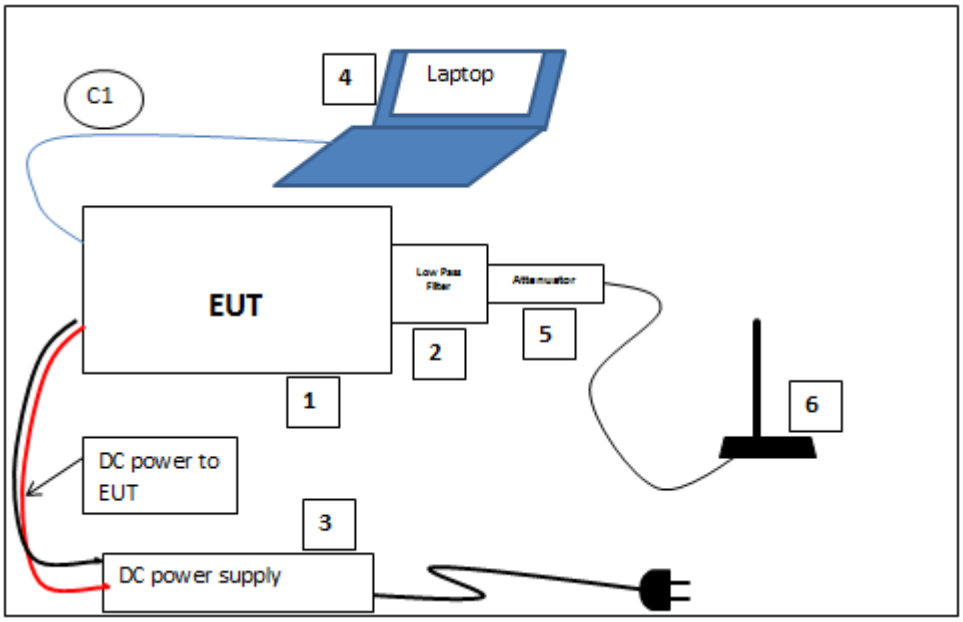


Figure 2. Block Diagram of Test Configuration 2

2.5. Equipment Configuration

The EUT was set up as outlined in Figure 1 and Figure 2. All cards, racks, etc., incorporated as part of the EUT is included in the following list.

Ref. ID	Slot #	Name / Description	Model Number	Part Number	Serial Number	Rev. #
1	-	**Venus radio platform**	VN-500	-	100038	-
2	-	**Low pass filter**	TBA 218.5-10-3EF1	LDC 1441	14130-31	-

Table 2. Equipment Configuration

2.6. Support Equipment

Full Spectrum supplied support equipment necessary for the operation and testing of the Venus. All support equipment supplied is listed in the following Support Equipment List.

Ref. ID	Name / Description	Manufacturer	Model Number	* Customer Supplied Calibration Data
3	**AC/DC Power supply**	Meanwell	RS-150-24	-
4	**Laptop**	Dell	-	-
C1	**Cable connecting laptop to EUT**	-	USB to DB-9	-
5	**Attenuator**	MCE/Weinschel	34-20-34	-
6	**~~Yagi~~ antenna**	Laird Technology	-	-
The 'Customer Supplied Calibration Data' column will be marked as either not applicable, not available, or will contain the calibration date supplied by the customer.				

Table 3. Support Equipment

2.7. Ports and Cabling Information

Ref. ID	Port Name on EUT	Cable Description	Qty.	Length (m)	Max Length	Shielded (Y/N)	Termination Point
1	**Console**	**~~RJ45~~ USB to DB-9**	**1**	**.6**	**For testing only; not normally connected to EUT.**	**No**	Dell Laptop
2	**DC Input**	**2 conductors**	**1**	**.5**	**Varies by installation**	**No**	Meanwell power supply.
3	**RF**	**LMR400**	**1**	**.5**	**Varies by installation**	**Yes**	Laird antenna

Table 4. Ports and Cabling Information

2.8. Mode of Operation

The EUT will employ a special test mode that will force it to transmit in every TDD downlink sub-frame. The transmission will employ 64QAM. The following parameters will be modified during the tests:

1. Center frequency: the test will be done in the following center frequencies:
    a. Center of the band: 218.50 MHz
    b. Left edge of the band: 218.25 MHz
    c. Right edge of the band: 218.75 MHz
2. Transmission Power level: As needed not to exceed the allowed power

2.9. Method of Monitoring EUT Operation

1. A spectrum analyzer will be used to monitor the transmission from the EUT.
2. Proper operation of the EUT will also be monitored from a console connected to the EUT during the tests.

2.10. Modifications

2.10.1. Modifications to EUT

No modifications were made to the EUT.

2.10.2. Modifications to Test Standard

No modifications were made to the test standard.

2.11. Disposition of EUT

The test sample including all support equipment submitted to the Electro-Magnetic Compatibility Lab for testing was returned to Full Spectrum upon completion of testing.

III. Transmitter Effective Radiated Power Limitation

3. Electromagnetic Compatibility RF Power Limitations

3.1. Transmitter Effective Radiated Power Limitation

Test Requirement(s): **§95.1955 Transmitter effective radiated power limitation**

The effective radiated power (ERP) of each cell transmitter stations (CTS) and response transmitter unit (RTU) shall be limited to the minimum necessary for successful communications. No CTS or fixed RTU may transmit with an ERP exceeding 20 Watts. No mobile RTU may transmit with an ERP exceeding 4 Watts.

Test Procedures: As required by 47 CFR 2.1046, *RF power output measurements* were made at the RF output terminals using a Spectrum Analyzer. Procedure 5.2.4.4.3 from ANSI C63.26-2015 was used to perform the measurements.

A laptop was connected to EUT to control the RF power output and frequency channel. The EUT was connected to a Spectrum Analyzer via an attenuator to measure the Peak power. The EUT power was adjusted enough to produce maximum output power as specified in the owner's manual. The output power was then recorded with as an average reading. Measurements were made at the low, mid and high channels.

Test Results: Equipment is compliant with 47CFR 95.1955. Max transmission power of EUT does not exceed fixed EUT limit of 20W, nor the mobile limit of 4W, therefore it is compliant.

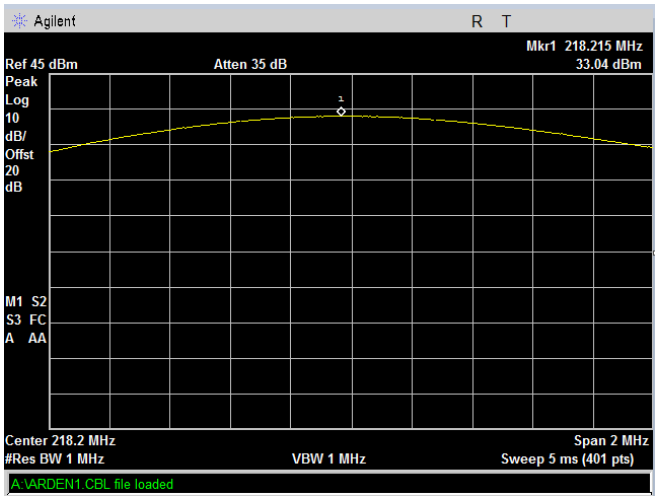
Test Engineer(s): James Borrott

Test Date(s): June 15, 2018

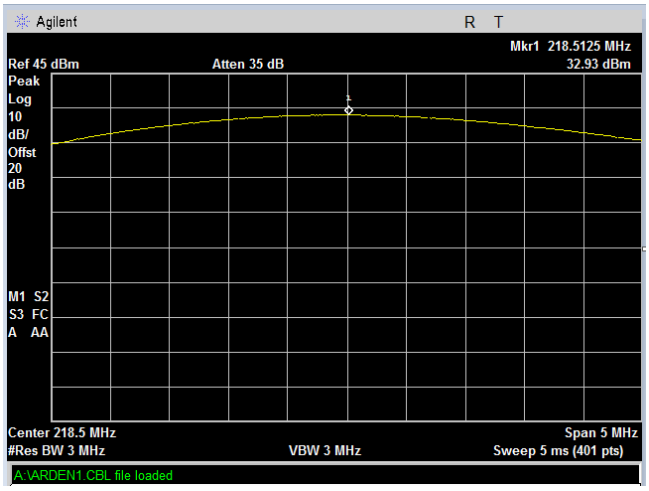
Frequency (MHz)	Measured Conducted Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	ERP (dBm)	ERP Limit (dBm)
218.25	33.04	3	36.04	33.89	43
218.5	32.93	3	35.93	33.78	43
218.75	32.9	3	35.9	33.75	43

Table 5. RF Power Output, Test Results

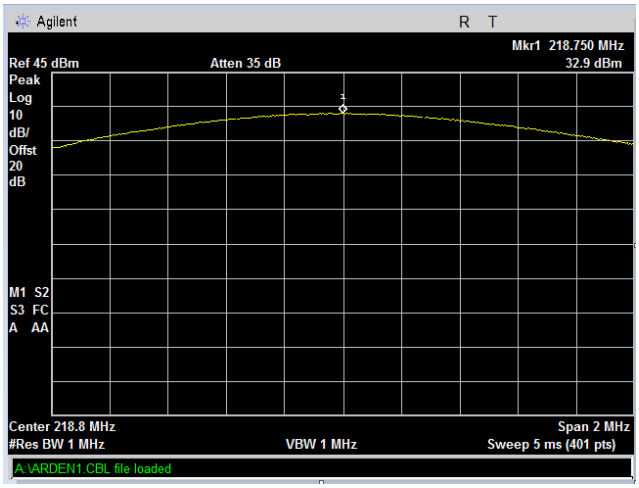
Maximum Transmitter Power,



Plot 1. Maximum Transmitter Power, Channel 218.25M, mode 64QAM, BW 500 kHz



Plot 2. Maximum Transmitter Power, Channel 218.5M, mode 64QAM, BW 1 MHz



Plot 3. Maximum Transmitter Power, mid channel, Channel 218. 75M, mode 64QAM, BW 500 kHz

IV. §95.1957 Emission Standards Section

4. §95.1957 Emission Standards

The following standards apply to the proceeding tests in this section.

(a) All transmissions by each CTS and by each RTU shall use an emission type that complies with the following standard for unnecessary radiation.

(b) All spurious and out-of-band emissions shall be attenuated:

(1) Zero dB on any frequency within the authorized frequency segment.
(2) At least 28 dB on any frequency removed from the midpoint of the assigned frequency segment by more than 250 kHz up to and including 750 kHz;
(3) At least 35 dB on any frequency removed from the midpoint of the assigned frequency segment by more than 750 kHz up to and including 1250 kHz;
(4) At least 43 plus 10 log (base 10) (mean power in Watts) dB on any frequency removed from the midpoint of the assigned frequency segment by more than 1250 kHz.

(c) When testing for certification, all measurements of unnecessary radiation are performed using a carrier frequency as close to the edge of the authorized frequency segment as the transmitter is designed to be capable of operating.

(d) The reference bandwidth of the instrumentation used to measure the emission power shall be 100 Hz for measuring emissions up to and including 250 kHz from the edge of the authorized frequency segment, and 10 kHz for measuring emissions more than 250 kHz from the edge of the authorized frequency segment. If a video filter is used, its bandwidth shall not be less than the reference bandwidth. The power level of the highest emission within the frequency segment, to which the attenuation is referenced, shall be remeasured for each change in reference bandwidth.

4.1. Spurious Emissions at Antenna Terminals

Test Requirement(s):

§95.1957(b)

All spurious and out-of-band emissions shall be attenuated:

(1) Zero dB on any frequency within the authorized frequency segment.

(2) At least 28 dB on any frequency removed from the midpoint of the assigned frequency segment by more than 250 kHz up to and including 750 kHz;

(3) At least 35 dB on any frequency removed from the midpoint of the assigned frequency segment by more than 750 kHz up to and including 1250 kHz;

(4) At least 43 plus 10 log (base 10) (mean power in Watts) dB on any frequency removed from the midpoint of the assigned frequency segment by more than 1250 kHz.

Test Procedures: As required by 47 CFR 2.1051, *spurious emissions at antenna terminal measurements* were made at the RF output terminals using a Spectrum Analyzer. Testing procedures were taken from ANSI/TIA-603-D-2010, clause 3.2.13.

A laptop was connected to EUT to control the RF power output and frequency channel. The EUT was connected to a Spectrum Analyzer and a Power Meter to monitor the output power level. The Spectrum Analyzer was set to sweep 30 MHz and up to 10th harmonic of the fundamental or 40GHz whichever is the lesser. Measurements were made at the low, mid and high channels.

The Conducted Spurious Emissions *Limit* is obtained by the following plots. Note: only noise floor was measurable above 26GHz.

Test Results: Equipment is compliant with Section 95.1957(b).

Test Engineer(s): Jun Qi

Test Date(s): May 18, 2018

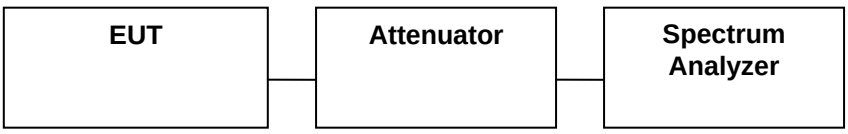
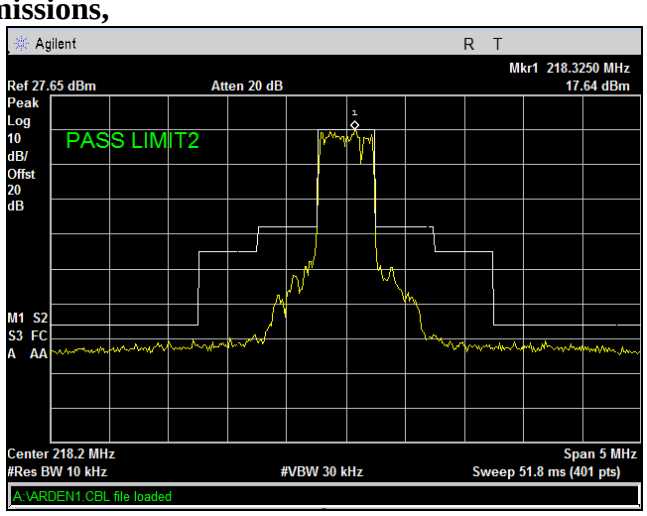
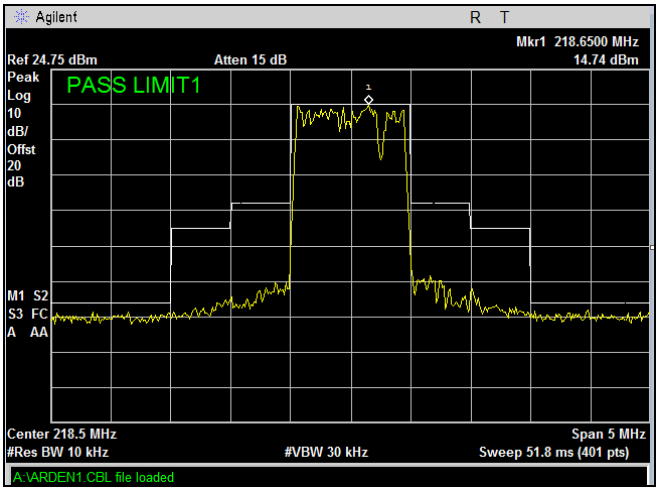


Figure 3. Spurious Emissions at Antenna Terminals Test Setup

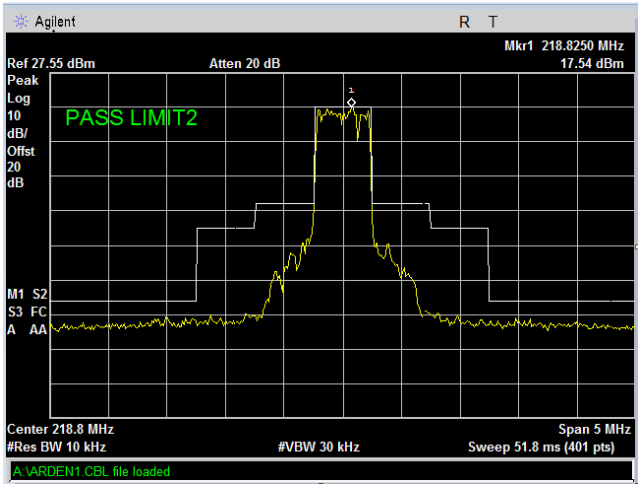
Conducted Spurious Emissions,



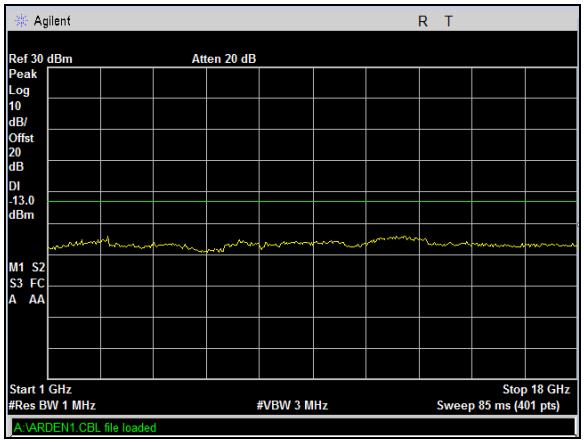
Plot 4. Emission Mask, Channel 218.25M, mode 64QAM, BW 500 kHz



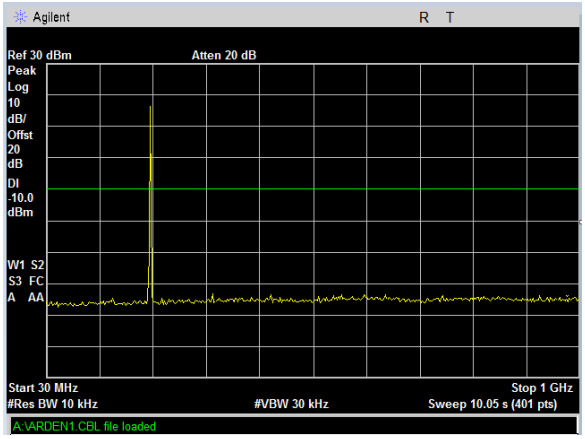
Plot 5. Emission Mask, Channel 218.5M, mode 64QAM, BW 1 MHz



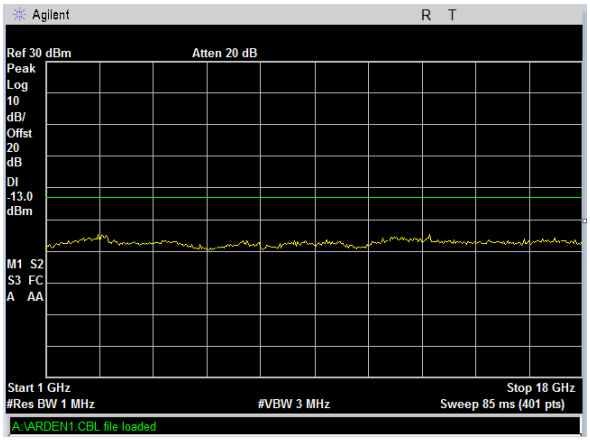
Plot 6. Emission Mask, Channel 218.75M, mode 64QAM, BW 500 kHz



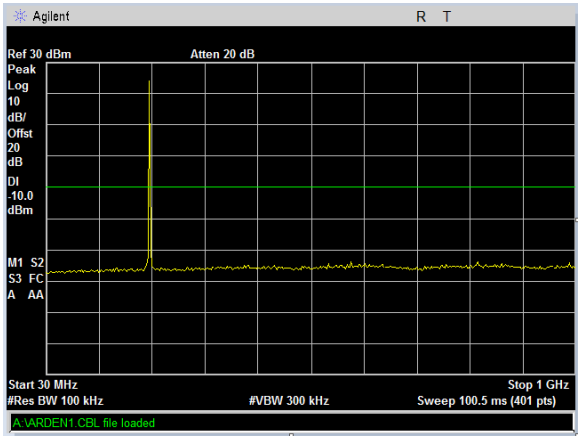
Plot 7. Transmitter Conducted Unwanted Emissions, Channel 218.25M, mode 64QAM, BW 500 kHz, 1 GHz to 18 GHz



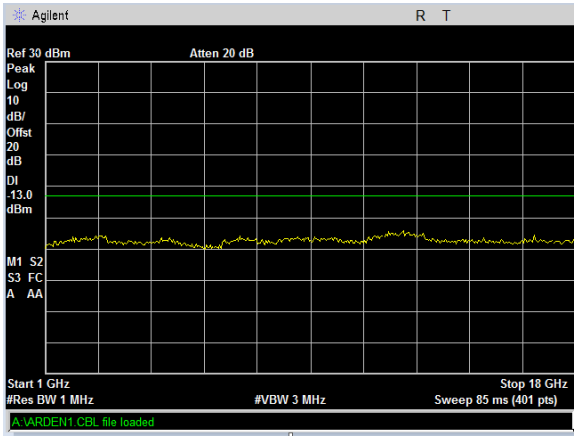
Plot 8. Transmitter Conducted Unwanted Emissions, Channel 218.25M, mode 64QAM, BW 500 kHz, 30 MHz to 1 GHz



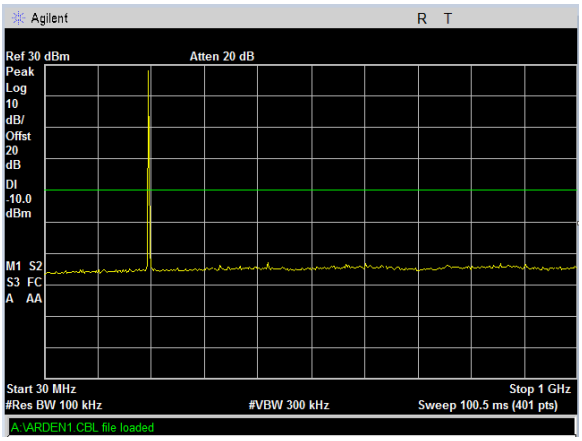
Plot 9. Transmitter Conducted Unwanted Emissions, Channel 218.5M, mode 64QAM, BW 1 MHz, 1 GHz to 18 GHz



Plot 10. Transmitter Conducted Unwanted Emissions, Channel 218.5M, mode 64QAM, BW 1 MHz, 30 MHz to 1 GHz



Plot 11. Transmitter Conducted Unwanted Emissions, Channel 218.75M, mode 64QAM, BW 500 kHz, 1 GHz to 18 GHz



Plot 12. Transmitter Conducted Unwanted Emissions, Channel 218.75M, mode 64QAM, BW 500 kHz, 30 MHz to 1 GHz

4.2. Radiated Emissions

Test Requirement(s): **§95.1957(b)(4)**

(b) All spurious and out-of-band emissions shall be attenuated:
(4) At least 43 plus 10 log (base 10) (mean power in Watts) dB on any frequency removed from the midpoint of the assigned frequency segment by more than 1250 kHz.

Test Procedures: As required by 47 CFR 2.1053, *field strength of radiated spurious measurements* were made in accordance with the procedures of TIA/EIA-603-A-2001 "Land Mobile FM or PM Communications Equipment Measurement and Performance Standards". Test procedures were taken from ANSI/TIA-603-D-2010. Clause 3.2.12.

Radiated emission measurements were performed inside a 5 meter semi-anechoic chamber. The EUT was set at a distance of 3m from the receiving antenna. The EUT's RF ports were terminated to 50ohm load. The EUT was set to transmit at the low, mid and high channels of the transmitter frequency range at its maximum power level. The EUT was rotated about 360^0 and the receiving antenna scanned from 1-4m in order to capture the maximum emission. A calibrated antenna source was positioned in place of the EUT and the previously recorded signal was duplicated. The maximum EIRP of the emission was calculated by adding the forward power to the calibrated source plus its appropriate gain value. These steps were carried out with the receiving antenna in both vertical and horizontal polarization. Harmonic emissions up to the 10^{th} or 40GHz, which ever was the lesser, were investigated.

No peaks were found above 18 GHz.

Note: Signal substitution was not performed due to the fact that only noise floor was detected from 30 MHz – 40 GHz.

Note: only noise floor was measurable above 18GHz.

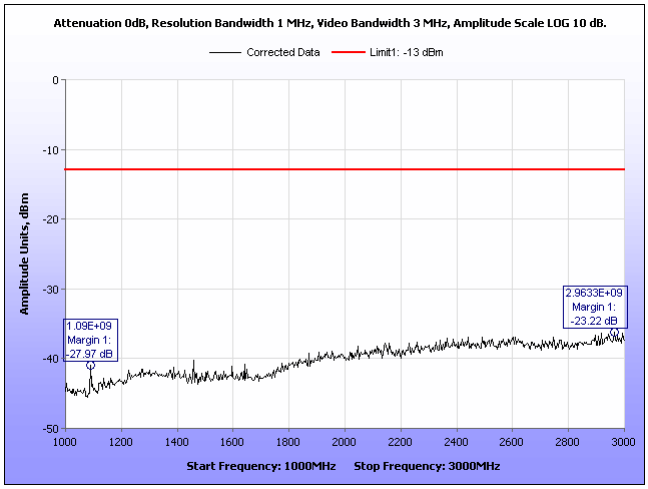
Test Results: Limits for emissions should be at least 43 plus 10 log (base 10) (mean power in Watts) dB on any frequency removed from the midpoint of the assigned frequency segment by more than 1250 kHz. This equals -13dBm in this case.

Equipment is compliant with Section 95.1957(b).

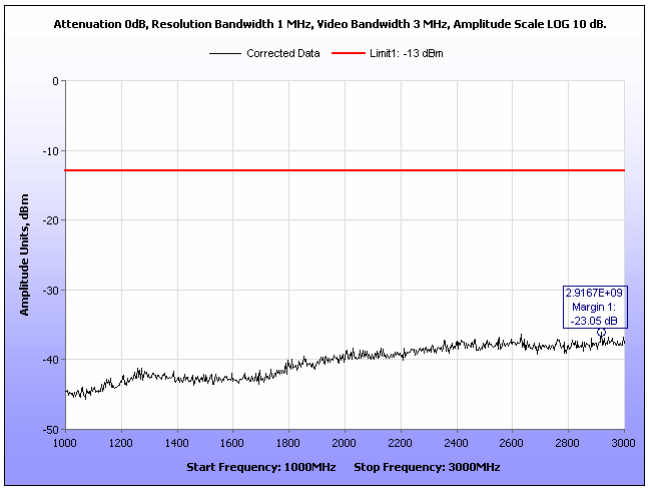
Test Engineer(s): James Borrott

Test Date(s): June 15, 2018

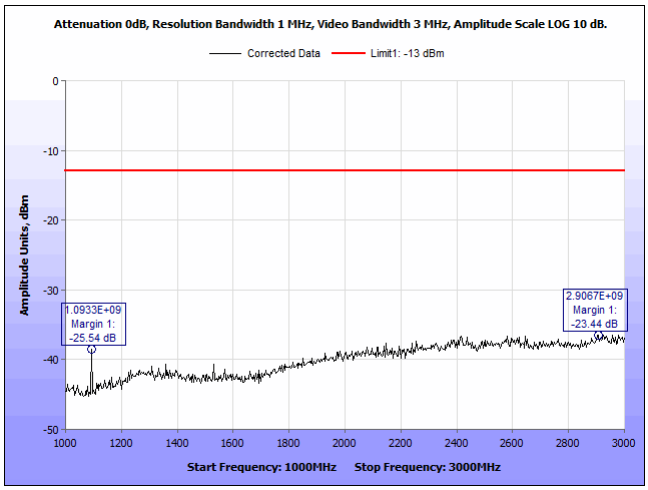
Radiated Spurious Emissions



Plot 13. Transmitter Radiated Unwanted Emissions, 218.25 MHz, Scan 1-3 GHz



Plot 14. Transmitter Radiated Unwanted Emissions, 218.5 MHz, Scan 1-3 GHz



Plot 15. Transmitter Radiated Unwanted Emissions, 218.75 MHz, 1-3GHz

Channel: 218.25		Scan				Substitution Ant. Method					
Freq (MHz)	Table Azimuth	Height	Polar (H/V)	Measured	dBuV	S.G. Reading (dBm)	Ant gain	Cable loss	Final	Limit	Margin
437.42	180	200	V	-56.3932	38.8068	-34.2	6.4	1.92	-29.72	-13	-16.72
437.42	90	100	H	-56.2632	38.9368	-24.5	6	1.92	-20.42	-13	-7.42
656.113	180	200	V	-57.99	37.21	-28.2	7	2.34	-23.54	-13	-10.54
656.113	280	200	H	-57.15	38.05	-33	6.4	2.34	-28.94	-13	-15.94
873.48	0	100	V	-64.4988	30.7012	-35.8	7.2	2.75	-31.35	-13	-18.35
873.48	0	200	H	-63.2488	31.9512	-33.6	6.6	2.75	-29.75	-13	-16.75

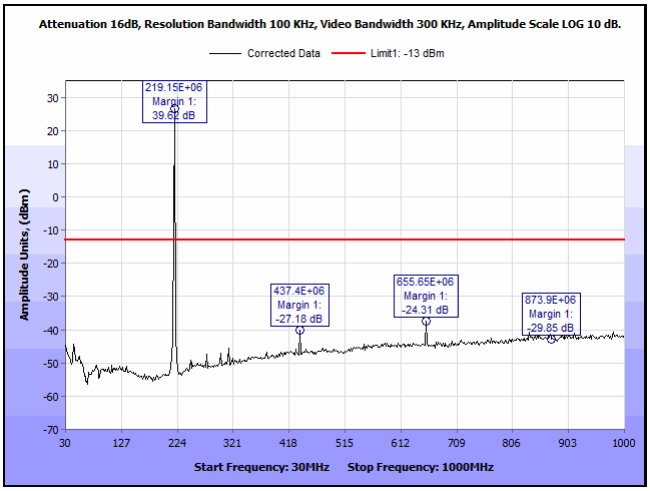
Table 6. Transmitter Radiated Unwanted Emissions, 218.25 MHz, Test Results

Channel: 218.5		Scan				Substitution Ant. Method					
Freq (MHz)	Table Azimuth	Height	Polar (H/V)	Measured	dBuV	S.G. Reading (dBm)	Ant gain	Cable loss	Final	Limit	Margin
437.407	180	200	V	-56.75372	38.4462	-34.5	6.4	1.92	-30.02	-13	-17.02
437.407	270	200	H	-55.94372	39.2562	-24	6	1.92	-19.92	-13	-6.92
656.127	180	200	V	-56.55	38.65	-26.9	7	2.34	-22.24	-13	-9.24
656.127	270	200	H	-56.95	38.25	-32.8	6.4	2.34	-28.74	-13	-15.74
874	0	100	V	-65.29	29.91	-36.6	7.2	2.75	-32.15	-13	-19.15
874	0	200	H	-64.59	30.61	-34.5	6.6	2.75	-38.35	-13	-25.35

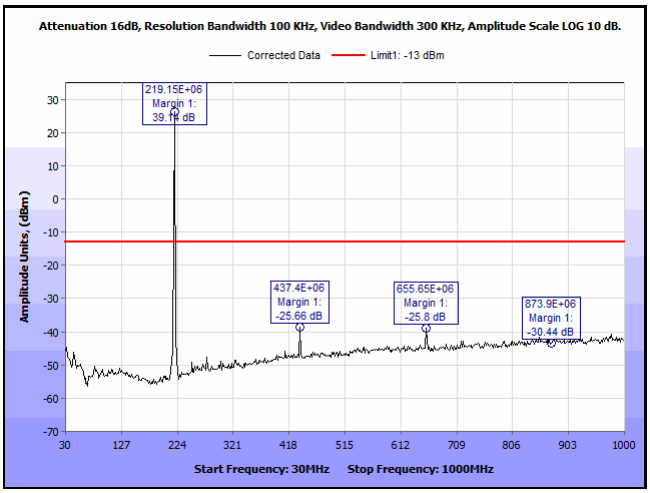
Table 7. Transmitter Radiated Unwanted Emissions, 218.5 MHz, Test Results

Channel: 218.75		Scan				Substitution Ant. Method					
Freq (MHz)	Table Azimuth	Height	Polar (H/V)	Measured	dBuV	S.G. Reading (dBm)	Ant gain	Cable loss	Final	Limit	Margin
437.418	270	200	V	-55.9908	39.2092	-33.8	6.4	1.92	-29.32	-13	-16.32
437.418	270	200	H	-55.8608	39.3392	-23.9	6	1.92	-19.82	-13	-6.82
656.18	180	200	V	-57.7	37.5	-28	7	2.34	-23.34	-13	-10.34
656.18	270	200	H	-56.45	38.75	-32.3	6.4	2.34	-28.24	-13	-15.24
875	0	100	V	-64.66	30.54	-35	7.2	2.75	-30.55	-13	-17.55
875	0	200	H	-64.6	30.6	-35.4	6.6	2.75	-39.25	-13	-26.25

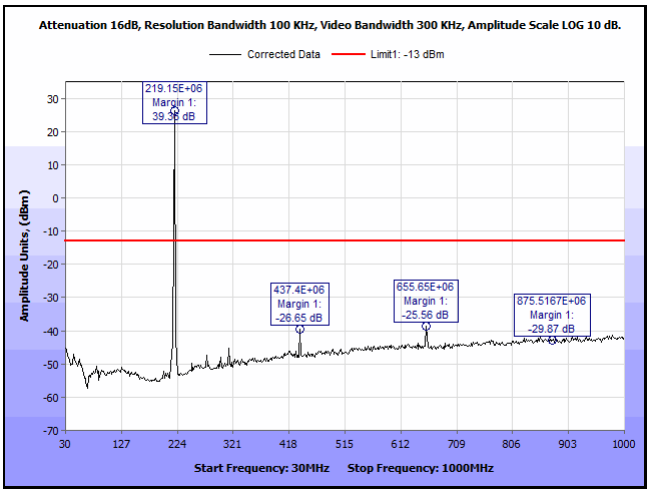
Table 8. Transmitter Radiated Unwanted Emissions, 218.75 MHz, Test Results



Plot 16. Transmitter Radiated Unwanted Emissions, 218.25 MHz, 30 MHz -1 GHz



Plot 17. Transmitter Radiated Unwanted Emissions, 218.5 MHz, 30 MHz – 1 GHz



Plot 18. Transmitter Radiated Unwanted Emissions, 218.75 MHz, 30 MHz – 1 GHz

4.3. Modulation

Test Requirement(s): **§2.1047 Modulation Characteristics**

(d) *Other types of equipment.* A curve or equivalent data which shows that the equipment will meet the modulation requirements of the rules under which the equipment is to be licensed.

Test Results: Equipment is compliant with 47 CFR 2.1047.

Test Engineer(s): Jun Qi

Test Date(s): May 18, 2018

4.4. Occupied Bandwidth (Emission Mask)

Test Requirement(s): **§2.1049**

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:

(i) Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

Test Procedures: As required by 47 CFR 2.1049, *occupied bandwidth measurements* were made at the RF output terminals using a Spectrum Analyzer. The procedures of ANSI C63.26 - 2015 Section 5.4.3 and 5.4.4 were used.

A laptop was connected to EUT to control the RF power output and frequency channel. The EUT was connected to a Spectrum Analyzer via attenuator. The measured highest Average Power was set relative to zero dB reference. The RBW of the Spectrum Analyzer was set to at least 1% of the channel bandwidth. The EUT power was adjusted at the maximum output power level. Measurements were carried out at the low, mid and high channels of the TX band.

Test Results: Equipment is compliant with Section 2.1049.

Test Engineer(s): Jun Qi

Test Date(s): May 18, 2018

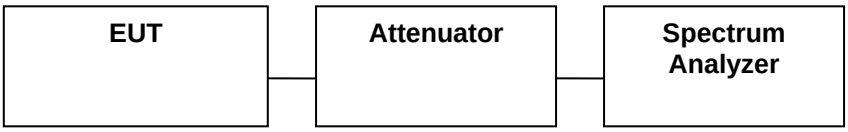
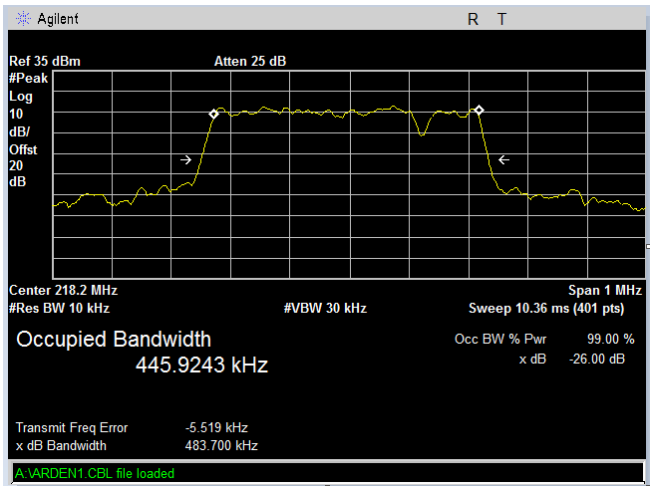
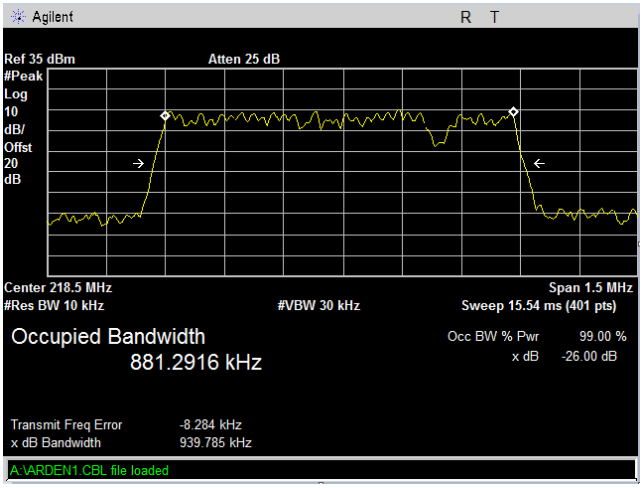


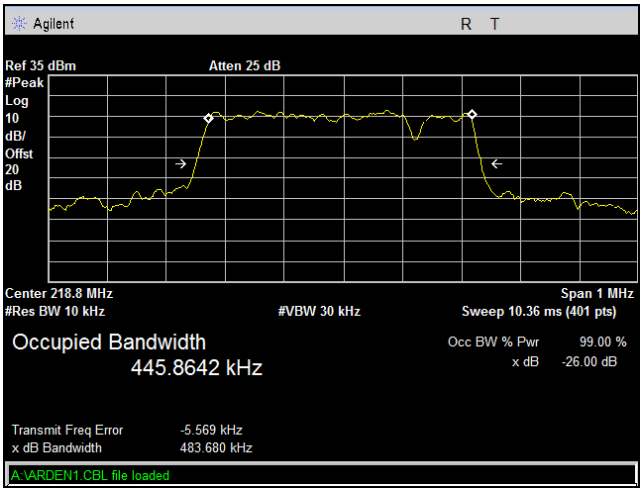
Figure 4. Occupied Bandwidth Test Setup



Plot 19. Emissions Bandwidth, Channel 218.25M, mode 64QAM, BW 500 kHz



Plot 20. Emissions Bandwidth, Channel 218.5M, mode 64QAM, BW 1 MHz



Plot 21. Emissions Bandwidth, Channel 218.75M, mode 64QAM, BW 500 kHz

V. Electromagnetic Compatibility Requirements

5. Electromagnetic Compatibility Requirements

5.1. Frequency Stability

Test Requirement(s): **§2.1055(a)(2), (d)(2)**

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

(2) From −20° to + 50° centigrade for equipment to be licensed for use in the Maritime Services under part 80 of this chapter, except for Class A, B, and S Emergency Position Indicating Radiobeacons (EPIRBS), and equipment to be licensed for use above 952 MHz at operational fixed stations in all services, stations in the Local Television Transmission Service and Point-to-Point Microwave Radio Service under part 21 of this chapter, equipment licensed for use aboard aircraft in the Aviation Services under part 87 of this chapter, and equipment authorized for use in the Family Radio Service under part 95 of this chapter.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

Test Procedures: As required by 47 CFR 2.1055, *Frequency Stability measurements* were made at the RF output terminals using a Directional Coupler through a Spectrum Analyzer and Power Meter. Test procedures were taken from ANSI/TIA 603-D: 2010 clause 3.2.2.

The EUT was placed in the Environmental Chamber and support equipment are outside the chamber on a table. The EUT was set to transmit a CW signal corresponding to the low, mid and high Channels for 10MHz Bandwidths. The frequency counter option on the Spectrum Analyzer was used to measure frequency deviations. The frequency drift was investigated for every 10^{C} increment until the unit is stabilized then recorded the reading in tabular format with the temperature range of -30 to 50^{C}.

Voltage supplied to EUT is 120 VAC reference temperature was done at 20 ^{C}. The voltage was varied by ± 15 % of nominal.

Test Results: Equipment is compliant with Section §2.1055(a)(2), (d)(2).

Test Engineer(s): Jun Qi

Test Date(s): May 22, 2018

(218.25MHz)				
Reference Frequency	**Voltage (DC)**	**Temperature (C)**	**Frequency (MHz)**	**PPM**
218.250000	55.20	50	218.250000	0.000
	48.00		218.249875	0.573
	40.80		218.250000	0.000
	55.20	40	218.250000	0.000
	48.00		218.250000	0.000
	40.80		218.249875	0.573
	55.20	30	218.250000	0.000
	48.00		218.250000	0.000
	40.80		218.249875	0.573
	55.20	20	218.249875	0.573
	48.00		218.250000	0.000
	40.80		218.249875	0.573
	55.20	10	218.250125	0.573
	48.00		218.249875	0.573
	40.80		218.249875	0.573
	55.20	0	218.249875	0.573
	48.00		218.249875	0.573
	40.80		218.250000	0.000
	55.20	-10	218.249750	1.145
	48.00		218.250000	0.000
	40.80		218.250000	0.000
	55.20	-20	218.250000	0.000
	48.00		218.249875	0.573
	40.80		218.250000	0.000

Table 9. Frequency Stability, 48 VDC, 218.25 MHz, Test Results

(218.5MHz)				
Reference Frequency	**Voltage (DC)**	**Temperature (C)**	**Frequency (MHz)**	**PPM**
218.500000	55.20	50	218.500000	0.000
	48.00		218.499875	0.572
	40.80		218.499875	0.572
	55.20	40	218.500000	0.000
	48.00		218.499875	0.572
	40.80		218.499750	1.144
	55.20	30	218.499875	0.572
	48.00		218.500000	0.000
	40.80		218.500000	0.000
	55.20	20	218.500000	0.000
	48.00		218.500000	0.000
	40.80		218.500000	0.000
	55.20	10	218.500000	0.000
	48.00		218.500000	0.000
	40.80		218.499875	0.572
	55.20	0	218.500125	0.572
	48.00		218.499875	0.572
	40.80		218.499875	0.572
	55.20	-10	218.500000	0.000
	48.00		218.500000	0.000
	40.80		218.500000	0.000
	55.20	-20	218.499875	0.572
	48.00		218.500000	0.000
	40.80		218.499875	0.572

Table 10. Frequency Stability, 48 VDC, 218.5 MHz, Test Results

(218.75MHz)				
Reference Frequency	**Voltage (DC)**	**Temperature (C)**	**Frequency (MHz)**	**PPM**
218.750000	55.20	50	218.749875	0.571
	48.00		218.749875	0.571
	40.80		218.749875	0.571
	55.20	40	218.750000	0.000
	48.00		218.749875	0.571
	40.80		218.749875	0.571
	55.20	30	218.750125	0.571
	48.00		218.750000	0.000
	40.80		218.750000	0.000
	55.20	20	218.749875	0.571
	48.00		218.750000	0.000
	40.80		218.749875	0.571
	55.20	10	218.750000	0.000
	48.00		218.750000	0.000
	40.80		218.749875	0.571
	55.20	0	218.750250	1.143
	48.00		218.749750	1.143
	40.80		218.749875	0.571
	55.20	-10	218.750125	0.571
	48.00		218.750000	0.000
	40.80		218.749875	0.571
	55.20	-20	218.750000	0.000
	48.00		218.750000	0.000
	40.80		218.750125	0.571

Table 11. Frequency Stability, 48 VDC, 218.75 MHz, Test Results

(218.25MHz)				
Reference Frequency	**Voltage (DC)**	**Temperature (C)**	**Frequency (MHz)**	**PPM**
218.250000	27.60	50	218.249875	0.573
	24.00		218.249750	1.145
	20.40		218.249875	0.573
	27.60	40	218.250000	0.000
	24.00		218.250000	0.000
	20.40		218.249875	0.573
	27.60	30	218.250000	0.000
	24.00		218.250000	0.000
	20.40		218.249750	1.145
	27.60	20	218.249875	0.573
	24.00		218.250000	0.000
	20.40		218.249750	1.145
	27.60	10	218.250000	0.000
	24.00		218.250000	0.000
	20.40		218.250000	0.000
	27.60	0	218.250125	0.573
	24.00		218.249875	0.573
	20.40		218.249750	1.145
	27.60	-10	218.250125	0.573
	24.00		218.249875	0.573
	20.40		218.249875	0.573
	27.60	-20	218.250000	0.000
	24.00		218.249875	0.573
	20.40		218.250000	0.000

Table 12. Frequency Stability, 24 VDC, 218.25 MHz, Test Results

(218.5MHzl)				
Reference Frequency	**Voltage (DC)**	**Temperature (C)**	**Frequency (MHz)**	**PPM**
218.500000	27.60	50	218.499875	0.572
	24.00		218.500000	0.000
	20.40		218.500000	0.000
	27.60	40	218.500000	0.000
	24.00		218.499875	0.572
	20.40		218.499750	1.144
	27.60	30	218.500000	0.000
	24.00		218.500000	0.000
	20.40		218.499750	1.144
	27.60	20	218.499875	0.572
	24.00		218.500000	0.000
	20.40		218.499875	0.572
	27.60	10	218.500000	0.000
	24.00		218.499875	0.572
	20.40		218.499875	0.572
	27.60	0	218.499875	0.572
	24.00		218.499875	0.572
	20.40		218.500000	0.000
	27.60	-10	218.499750	1.144
	24.00		218.499875	0.572
	20.40		218.500000	0.000
	27.60	-20	218.500125	0.572
	24.00		218.500125	0.572
	20.40		218.500125	0.572

Table 13. Frequency Stability, 24 VDC, 218.5 MHz, Test Results

(218.75MHz)				
Reference Frequency	**Voltage (DC)**	**Temperature (C)**	**Frequency (MHz)**	**PPM**
218.750000	27.60	50	218.749875	0.571
	24.00		218.750000	0.000
	20.40		218.749875	0.571
	27.60	40	218.749875	0.571
	24.00		218.749875	0.571
	20.40		218.749875	0.571
	27.60	30	218.750125	0.571
	24.00		218.750000	0.000
	20.40		218.750000	0.000
	27.60	20	218.750000	0.000
	24.00		218.750000	0.000
	20.40		218.750000	0.000
	27.60	10	218.750000	0.000
	24.00		218.750000	0.000
	20.40		218.750000	0.000
	27.60	0	218.749875	0.571
	24.00		218.750125	0.571
	20.40		218.749875	0.571
	27.60	-10	218.750000	0.000
	24.00		218.749875	0.571
	20.40		218.750000	0.000
	27.60	-20	218.750000	0.000
	24.00		218.750000	0.000
	20.40		218.750000	0.000

Table 14. Frequency Stability, 24 VDC, 218.75 MHz, Test Results

5.2. Antennas

Test Requirement(s): **§95.1959**

(a) The overall height from ground to topmost tip of the CTS antenna shall not exceed the height necessary to assure adequate service. Certain CTS antennas must be individually licensed to the 218-219 MHz System licensee (see §95.1911(b) of this part). CTS antennas must also meet the requirements in §95.317 regarding menaces to air navigation. See 47 CFR 95.317 and consult part 17 of the FCC's Rules for more information (47 CFR part 17).

(b) [Reserved]

(c) The RTU may be connected to an external antenna not more than 6.1 m (20 feet) above ground or above an existing man-made structure (other than an antenna structure). Connectors that are used to connect RTUs to an external antenna shall not be of the types generally known as “F-type” or “BNC type.” Use of an external antenna is subject to §95.1961.

Test Procedures: The manufacturer shall provide a declaration.

Test Results: Equipment is compliant with Section 95.1959.

Test Engineer(s): James Borrott

Test Date(s): June 11, 2018

6. RF Exposure Requirements

RF Exposure Requirements:

§2.1091: Systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines.

(a) Requirements of this section are a consequence of Commission responsibilities under the National Environmental Policy Act to evaluate the environmental significance of its actions. See subpart I of part 1 of this chapter, in particular §1.1307(b).

(c)(1) Mobile devices that operate in the Commercial Mobile Radio Services pursuant to part 20 of this chapter; the Cellular Radiotelephone Service pursuant to part 22 of this chapter; the Personal Communications Services pursuant to part 24 of this chapter; the Satellite Communications Services pursuant to part 25 of this chapter; the Miscellaneous Wireless Communications Services pursuant to part 27 of this chapter; the Upper Microwave Flexible Use Service pursuant to part 30 of this chapter; the Maritime Services (ship earth station devices only) pursuant to part 80 of this chapter; the Specialized Mobile Radio Service, and the 3650 MHz Wireless Broadband Service pursuant to part 90 of this chapter; the 76-81 GHz Band Radar Service pursuant to part 95 of this chapter; and the Citizens Broadband Radio Service pursuant to part 96 of this chapter are subject to routine environmental evaluation for RF exposure prior to equipment authorization or use if:

(i) They operate at frequencies of 1.5 GHz or below and their effective radiated power (ERP) is 1.5 watts or more, or

(ii) They operate at frequencies above 1.5 GHz and their ERP is 3 watts or more.

RF Radiation Exposure Limit:

§2.1091: As specified in this section, the Maximum Permissible Exposure (MPE) Limit shall be used to evaluate the environmental impact of human exposure to radiofrequency (RF) radiation as specified in Sec. 1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of Sec. 2.1093 of this chapter.

Frequency (MHz)	Con. Pwr. (dBm)	Con. Pwr. (mW)	Ant. Gain (dBi)	Ant. Gain Numeric	Pwr. Density (mW/cm^2)	Limit (mW/cm^2)	Margin	Distance (cm)
218.25	33.04	2013.72	3	1.995	0.2	0.2	0	39.98

7. Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2005.

Asset	Equipment	Manufacturer	Model	Calibration Date	Calibration Due Date
1S3908	Spectrum Analyzer	Agilent Technologies	E4402B	04/30/2018	04/30/2019
1S2482A	5 Meter Chamber (FCC)	Panashield	5 Meter Semi-Anechoic Chamber	See Note	
1S2600	Bilog Antenna	Teseq	CBL6112D	11/28/2016	11/28/2018
1S2603	Double Ridged Waveguide Horn	ETS-Lindgren	3117	08/09/2016	08/09/2018
1S2583	Spectrum Analyzer	Agilent/Hewlett Packard	E4447A	11/10/2017	11/10/2018
1S2229	Temperature Chamber	Tenny Engineering	T63C	05/11/2018	11/11/2019
1S2746	Bilog Antenna	Sunol Science	JB3	10/19/2016	10/19/2018

Note: Functionally tested equipment is verified using calibrated instrumentation at the time of testing.

Certification & User's Manual Information

8. Certification Label & User's Manual Information

8.1. Certification Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart I — Marketing of Radio frequency devices:

§ 2.801 Radio-frequency device defined.

As used in this part, a radio-frequency device is any device which in its operation is capable of Emitting radio-frequency energy by radiation, conduction, or other means. Radio- frequency devices include, but are not limited to:

(a) The various types of radio communication transmitting devices described throughout this chapter.

(b) The incidental, unintentional and intentional radiators defined in Part 15 of this chapter.

(c) The industrial, scientific, and medical equipment described in Part 18 of this chapter.

(d) Any part or component thereof which in use emits radio-frequency energy by radiation, conduction, or other means.

§ 2.803 Marketing of radio frequency devices prior to equipment authorization.

(a) Except as provided elsewhere in this chapter, no person shall sell or lease, or offer for sale or lease (including advertising for sale or lease), or import, ship or distribute for the purpose of selling or leasing or offering for sale or lease, any radio frequency device unless:

(1) In the case of a device subject to certification, such device has been authorized by the Commission in accordance with the rules in this chapter and is properly identified and labeled as required by §2.925 and other relevant sections in this chapter; or

(2) In the case of a device that is not required to have a grant of equipment authorization issued by the Commission, but which must comply with the specified technical standards prior to use, such device also complies with all applicable administrative (including verification of the equipment or authorization under a Declaration of Conformity, where required), technical, labeling and identification requirements specified in this chapter.

(d) Notwithstanding the provisions of paragraph (a) of this section, the offer for sale solely to business, commercial, industrial, scientific or medical users (but not an offer for sale to other parties or to end users located in a residential environment) of a radio frequency device that is in the conceptual, developmental, design or pre-production stage is permitted prior to equipment authorization or, for devices not subject to the equipment authorization requirements, prior to a determination of compliance with the applicable technical requirements *provided* that the prospective buyer is advised in writing at the time of the offer for sale that the equipment is subject to the FCC rules and that the equipment will comply with the appropriate rules before delivery to the buyer or to centers of distribution.

(e)(1) Notwithstanding the provisions of paragraph (a) of this section, prior to equipment authorization or determination of compliance with the applicable technical requirements any radio frequency device may be operated, but not marketed, for the following purposes and under the following conditions:

(i) Compliance testing;

(ii) Demonstrations at a trade show provided the notice contained in paragraph (c) of this section is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iii) Demonstrations at an exhibition conducted at a business, commercial, industrial, scientific or medical location, but excluding locations in a residential environment, provided the notice contained in paragraphs (c) or (d) of this section, as appropriate, is displayed in a conspicuous location on, or immediately adjacent to, the device;

(iv) Evaluation of product performance and determination of customer acceptability, provided such operation takes place at the manufacturer's facilities during developmental, design or pre-production states; or

(v) Evaluation of product performance and determination of customer acceptability where customer acceptability of a radio frequency device cannot be determined at the manufacturer's facilities because of size or unique capability of the device, provided the device is operated at a business, commercial, industrial, scientific or medical user's site, but not at a residential site, during the development, design or pre-production stages.

(e)(2) For the purpose of paragraphs (e)(1)(iv) and (e)(1)(v) of this section, the term *manufacturer's facilities* includes the facilities of the party responsible for compliance with the regulations and the manufacturer's premises, as well as the facilities of other entities working under the authorization of the responsible party in connection with the development and manufacture, but not the marketing, of the equipment.

(f) For radio frequency devices subject to verification and sold solely to business, commercial, industrial, scientific and medical users (excluding products sold to other parties or for operation in a residential environment), parties responsible for verification of the devices shall have the option of ensuring compliance with the applicable technical specifications of this chapter at each end user's location after installation, provided that the purchase or lease agreement includes a provision that such a determination of compliance be made and is the responsibility of the party responsible for verification of the equipment.

The following is extracted from Title 47 of the Code of Federal Regulations, Part 2, Subpart Y — Equipment Authorization Procedures:

§ 2.901 Basis and Purpose

(a) In order to carry out its responsibilities under the Communications Act and the various treaties and international regulations, and in order to promote efficient use of the radio spectrum, the Commission has developed technical standards for radio frequency equipment and parts or components thereof. The technical standards applicable to individual types of equipment are found in that part of the rules governing the service wherein the equipment is to be operated.[1] *In addition to the technical standards provided, the rules governing the service may require that such equipment be verified by the manufacturer or importer*, be authorized under a Declaration of Conformity, or receive an equipment authorization from the Commission by one of the following procedures: certification or registration.

(b) The following sections describe the verification procedure, the procedure for a Declaration of Conformity, and the procedures to be followed in obtaining certification from the Commission and the conditions attendant to such a grant, whichever is applicable.

§ 2.902 Certification.

(a) Certification is an equipment authorization issued by the Commission, based on representation and test data submitted by the applicant.

(b) Certification attaches to all units subsequently marketed by the grantee which are identical (see Section 2.908) to the sample tested except for permissive changes or other variations authorized by the Commission pursuant to Section 2.1043.

[1] In this case, the equipment is subject to the rules of Part 15. More specifically, the equipment falls under Subpart B (of Part 15), which deals with unintentional radiators.

§ 2.948 Description of measurement facilities.

(a) Each party making measurements of equipment that is subject to an equipment authorization under Part 15 or Part 18 of this chapter, regardless of whether the measurements are filed with the Commission or kept on file by the party responsible for compliance of equipment marketed within the U.S. or its possessions, shall compile a description of the measurement facilities employed.

(1) If the measured equipment is subject to the verification procedure, the description of the measurement facilities shall be retained by the party responsible for verification of the equipment.

(i) If the equipment is verified through measurements performed by an independent laboratory, it is acceptable for the party responsible for verification of the equipment to rely upon the description of the measurement facilities retained by or placed on file with the Commission by that laboratory. In this situation, the party responsible for the verification of the equipment is not required to retain a duplicate copy of the description of the measurement facilities.

(ii) If the equipment is verified based on measurements performed at the installation site of the equipment, no specific site calibration data is required. It is acceptable to retain the description of the measurement facilities at the site at which the measurements were performed.

(2) If the equipment is to be authorized by the Commission under the certification procedure, the description of the measurement facilities shall be filed with the Commission's Laboratory in Columbia, Maryland. The data describing the measurement facilities need only be filed once but must be updated as changes are made to the measurement facilities or as otherwise described in this section. At least every three years, the organization responsible for filing the data with the Commission shall certify that the data on file is current.

8.2. Label and User's Manual Information

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart A — General:

§ 15.19 Labeling requirements.

(a) In addition to the requirements in Part 2 of this chapter, a device subject to certification or verification shall be labeled as follows:

(1) Receivers associated with the operation of a licensed radio service, e.g., FM broadcast under Part 73 of this chapter, land mobile operation under Part 90, etc., shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the condition that this device does not cause harmful interference.

(2) A stand-alone cable input selector switch, shall bear the following statement in a conspicuous location on the device:

This device is verified to comply with Part 15 of the FCC Rules for use with cable television service.

(3) All other devices shall bear the following statement in a conspicuous location on the device:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

(4) Where a device is constructed in two or more sections connected by wires and marketed together, the statement specified under paragraph (a) of this section is required to be affixed only to the main control unit.

(5) When the device is so small or for such use that it is not practicable to place the statement specified under paragraph (a) of this section on it, the information required by this paragraph shall be placed in a prominent location in the instruction manual or pamphlet supplied to the user or, alternatively, shall be placed on the container in which the device is marketed. However, the FCC identifier or the unique identifier, as appropriate, must be displayed on the device.

§ 15.21 Information to user.

The users manual or instruction manual for an intentional or unintentional 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.

The following is extracted from Title 47 of the Code of Federal Regulations, Part 15, Subpart B — Unintentional Radiators:

§ 15.105 Information to the user.

(a) For a Class B digital device or peripheral, the instructions furnished the user shall include the following or similar statement, placed in a prominent location in the text of the manual:

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a residential environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

– Reorient or relocate the receiving antenna.
– Increase the separation between the equipment and receiver.
– Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
– Consult the dealer or an experienced radio/TV technician for help.

End of Report

