HEADQUARTERS: 914 WEST PATAPSCO AVENUE • BALTIMORE, MARYLAND 21230 • PHONE (410) 354-3300 • FAX (410) 354-3313

9/13/2024
Tractian Technologies Inc.
1389 Peachtree St NE
Atlanta, GA 30309
USA

Dear Jorge Sousa,

Enclosed is the EMC Wireless test report for compliance testing of the Tractian Technologies Inc. Uni Trac as tested to the requirements of FCC Part 15.247 for Intentional Radiators. This test report pertains specifically to the 915MHz ISM transmitter onboard which operates in the 902MHz – 928MHz band.

Thank you for using the services of Eurofins MET Labs. 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,
EUROFINS MET LABS

Nancy LaBrecque
Documentation Department

Reference: WIRA132292- FCC15.247_R1

915MHz ISM Test Report

for the

Tractian Technologies Inc.
Uni Trac

Tested under
FCC Part 15.247
For Intentional Radiators

Bryan Taylor, Wireless Team Lead
Electromagnetic Compatibility Lab

Nancy LaBrecque
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 the FCC Rules Part 15.247 under normal use and maintenance.

Matthew Hinojosa
EMC Manager, Austin Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
∅	9/3/2024	Initial Issue.
1	9/13/2024	Updates requested by TCB reviewer

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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

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the Uni Trac, with the requirements of FCC Part 15.247. Tractian Technologies Inc. should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the Uni Trac, has been **permanently** discontinued.

B. Executive Summary

The following tests were conducted on a sample of the equipment for the purpose of demonstrating compliance with FCC Part 15.247, in accordance with Tractian Technologies Inc. purchase order number 1TRA2105. All tests were conducted using measurement procedures ANSI C63.4-2014 and ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	Antenna Requirement	**Compliant**
Title 47 of the CFR, Part 15 §15.207(a)	Conducted Emission Limits	**Not Applicable**[1]
Title 47 of the CFR, Part 15 §15.247(a)(2)	6dB Occupied Bandwidth	**Compliant**
---	99% Occupied Bandwidth	**Compliant**
Title 47 of the CFR, Part 15 §15.247(b)	Peak Power Output	**Compliant**
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	Radiated Spurious Emissions Requirements	**Compliant**
Title 47 of the CFR, Part 15 §15.247(d)	RF Conducted Spurious Emissions Requirements	**Compliant**
Title 47 of the CFR, Part 15; §15.247(e)	Peak Power Spectral Density	**Compliant**

Table 1. Executive Summary

[1] The Uni Trac is exclusively DC powered and has no connections to the AC mains.

II. Equipment Configuration

A. Overview

Eurofins MET Labs was contracted by Tractian Technologies Inc. to perform testing on the Uni Trac, under Tractian Technologies Inc.'s purchase order number 1TRA2105.

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

The results obtained relate only to the item(s) tested.

Product Name:	Uni Trac	
Model(s) Tested:	Uni Trac	
Serial Number or Sample Number:	Conducted Sample: A008CER Radiated Sample: A010CER	
FCCID:	2BCIS-UNITRAC	
Primary Power:	5 – 24VDC	
EUT Specifications:	Type of Modulations:	O-QPSK
	Equipment Code:	DTS
	Peak RF Output Power:	18.15dBm
	EUT Frequency Ranges:	902MHz – 928MHz
	Antenna Gain[2]:	2.1dBi
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:	Bryan Taylor and Sergio Gutierrez	
Report Date(s):	7/3/2024 through 7/16/2024	

Table 2. EUT Summary Table

[2] The antenna gain information was provided by Tractian Technologies Inc. and may affect compliance.

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
ANSI C63.4:2014	Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical And Electronic Equipment in the Range of 9 kHz to 40 GHz
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories
ANSI C63.10-2013	American National Standard for Testing Unlicensed Wireless Devices

Table 3. References

C. Test Site

All testing was performed at Eurofins MET Labs, 13501 McCallen Pass, Austin, TX 78753. 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 10 meter 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.

FCC Lab Info:
Designation Number: US1127

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
Occupied Bandwidth Measurements	±4.52 Hz	2	95%
Conducted Power Measurements	±2.74 dB	2	95%
Power Spectral Density Measurements	±2.74 dB	2	95%
Conducted Spurious Emissions	±2.80 dB	2	95%
Conducted Emissions (Mains)	±2.97 dB	2	95%
Radiated Spurious Emissions (9kHz – 1GHz)	±2.95 dB	2	95%
Radiated Spurious Emissions (1GHz - 40GHz)	±3.54 dB	2	95%

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The Uni Trac is a smart data collector for industrial assets

Figure 1. Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 1 above. The laptop computer was used to send test commands to force the transmitters to operate in the appropriate test mode.

G. Support Equipment

Support equipment necessary for the operation and testing of the EUT is included in the following list.

Ref. ID	Name / Description	Manufacturer	Model Number	Customer Supplied Calibration Data
None	Laptop Computer	Lenovo	ThinkPad	None
None	Serial-USB FTDI Converter	NA	NA	NA

Table 5. Support Equipment

H. Ports and Cabling Information

Port Name on EUT	Qty	Length as tested (m)	Shielded? (Y/N)	Termination Box ID & Port Name
Serial Cable	1	1m	Yes	Serial FTDI Converter
Power Cable	1	1m	No	DC Power Supply

Table 6. Ports and Cabling Information

I. Mode of Operation

The terminal program "CoolTerm V2.1.0" was used to send test commands to the EUT to achieve 100% duty cycle during EMC testing on low, mid, and high channels and provide a direct means of controlling transmitter parameters. Unless otherwise stated or shown, all tests were performed at worst-case modulation and data rates on the following channels.

Transmit Band	Modulation	Channel Frequencies Tested	Test Tool Power Setting[3]
902 – 928MHz	O-QPSK	903MHz / 915MHz / 925MHz	Product Default (20dBm)

Table 7. Test Channels Utilized

Ch#	Center
0	903
1	905
2	907
3	909
4	911
5	913
6	915
7	917
8	919
9	921
10	923
11	925

Table 8. List of All Possible Channels and Center Frequencies

J. Method of Monitoring EUT Operation

A spectrum analyzer was used to confirm proper transmitter operation.

K. Modifications

a) Modifications to EUT

No modifications were made to the EUT.

b) Modifications to Test Standard

No modifications were made to the test standard.

L. Disposition of EUT

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

[3] Note, the test tool power setting does not necessarily correspond to a power in dBm or Watts.

III. Electromagnetic Compatibility Criteria for Intentional Radiators

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.203 Antenna Requirement

Test Requirement: **§ 15.203:** An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited.

The structure and application of the EUT were analyzed to determine compliance with Section 15.203 of the Rules. Section 15.203 states that the subject device must meet at least one of the following criteria:

a.) Antenna must be permanently attached to the unit.

b.) Antenna must use a unique type of connector to attach to the EUT.

c.) Unit must be professionally installed. Installer shall be responsible for verifying that the correct antenna is employed with the unit.

Results: The EUT as tested is compliant the criteria of §15.203. The TX antenna is not accessible by the end user and it uses a unique coupling.

Test Engineer(s): Bryan Taylor

Test Date(s): 7/15/2024

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

Test Requirements: **§ 15.247(a)(2):** Operation under the provisions of this section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

For systems using digital modulation techniques, the EUT may operate in the 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz bands. The minimum 6dB bandwidth shall be at least 500 kHz.

Test Procedure: The transmitter was on and transmitting at the highest output power. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately 1% of the total emission bandwidth, and the VBW > RBW. The 6 dB Bandwidth was measured and recorded. The measurements were performed on the low, mid and high channels.

Test Results The EUT was compliant with § 15.247 (a)(2).

The 6 dB Bandwidth was determined from the plots on the following pages.

Test Engineer(s): Bryan Taylor

Test Date(s): 7/16/2024

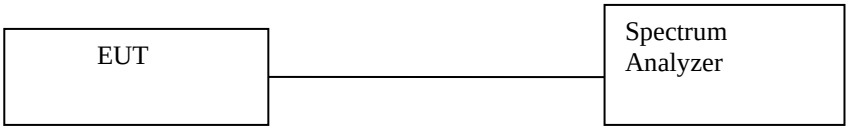
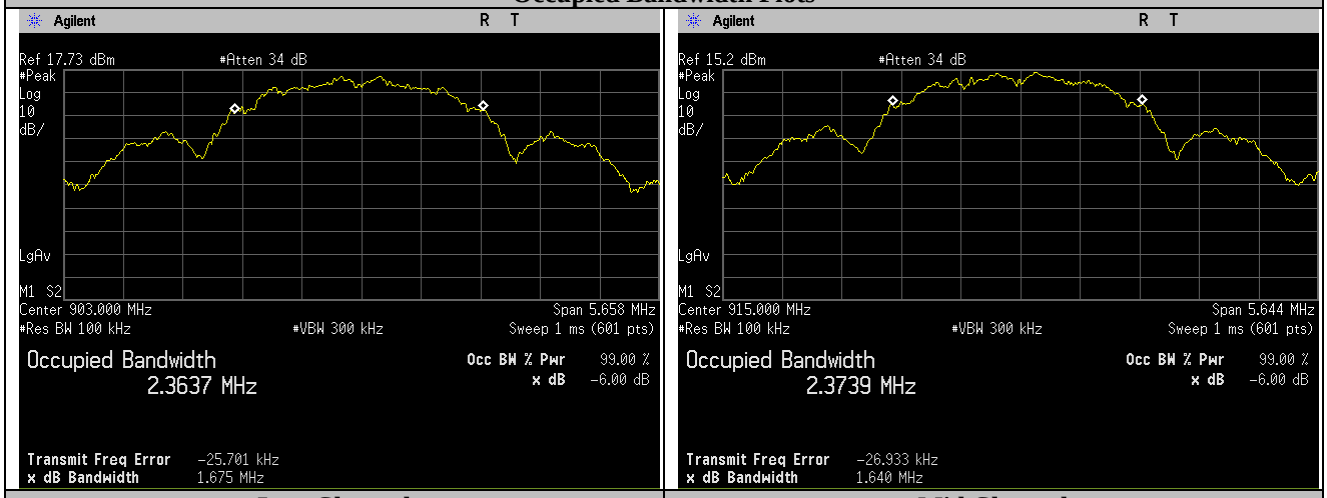


Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	99% Bandwidth (MHz)	Result
Low	903MHz	1.675MHz	0.5MHz	2.363MHz	Pass
Middle	915MHz	1.640MHz	0.5MHz	2.373MHz	Pass
High	925MHz	1.683MHz	0.5MHz	2.385MHz	Pass

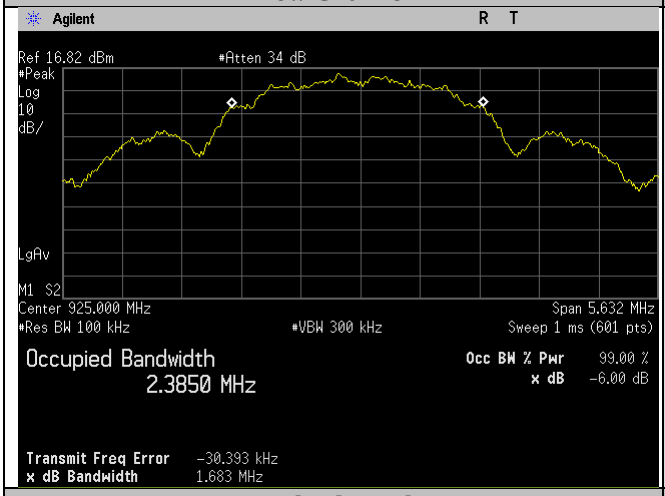
Table 9. 99% and 6 dB Occupied Bandwidth, Test Results

Occupied Bandwidth Plots



Low Channel

Mid Channel



High Channel

Intentionally Blank

Figure 3. 6dB and 99% Bandwidth Plots

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(b) Peak Power Output

Test Requirements: **§15.247(b):** The maximum peak output power of the intentional radiator shall not exceed the following:

Digital Transmission Systems (MHz)	Output Limit (Watts)
902-928	1.000
2400–2483.5	1.000
5725– 5850	1.000

Table 10. Output Power Requirements from §15.247(b)

§15.247(c): if transmitting antennas of directional gain greater than 6 dBi are used the peak output power from the intentional radiator shall be reduced below the stated values in the Table 10, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 2400 – 2483.5 MHz band and using a point to point application may employ transmitting antennas with directional gain greater than 6 dBi provided the maximum peak output power of the intentional radiator is reduced by 1 dB for every 3 dB that the directional gain of the antenna exceeds 6 dBi.

Systems operating in the 5725 – 5850 MHz band that are used exclusively for fixed, point-to-point operations may employ transmitting antennas with directional gain greater than 6 dBi without any corresponding reduction in transmitter peak output power.

Fixed, point-to-point operation excludes the use of point-to-multipoint systems, Omni-directional applications, and multiple co-located intentional radiators transmitting the same information. The operator of the spread spectrum intentional radiator or, if the equipment is professionally installed, the installer is responsible for ensuring that the system is used exclusively for fixed, point-to-point operations. The instruction manual furnished with the intentional radiator shall contain language in the installation instructions informing the operator and the installer of this responsibility.

Test Procedure: The transmitter was connected to a calibrated spectrum analyzer. The analyzer reference level was offset by cable loss connecting to the test sample. The peak power was measured at the low, mid and high channels of each band at the maximum power level.

Test Software: TILE Version 7.4.2.5 (Manufactured by ETS Lindgren) was utilized to perform these measurements.

Test Results: The EUT was compliant with the Peak Power Output limits. The spectrum analyzer settings used during the measurement are shown in the table below.

RBW:	3MHz	Detector:	Peak	Reference Level:	30dBm
VBW:	10MHz	Sweep Time:	Auto	Internal Attenuation:	30dB

Figure 4. Analyzer Settings During Measurement

Test Engineer(s): Bryan Taylor

Test Date(s): 7/15/2024

Figure 5. Peak Power Output Test Setup

Peak Power Output Test Results

Channel	Frequency (MHz)	Peak Conducted Power (dBm)	Peak Power Limit (dBm)	Result
Low	903MHz	18.15dBm	30	Pass
Middle	915MHz	17.23dBm	30	Pass
High	925MHz	17.07dBm	30	Pass

Table 11. Peak Power Output, Test Results

Channel	Frequency (MHz)	Peak Conducted Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	Peak Power Limit (dBm)	Result
Low	903MHz	18.15dBm	2.1	20.25	36	Pass
Middle	915MHz	17.23dBm	2.1	19.33	36	Pass
High	925MHz	17.07dBm	2.1	19.17	36	Pass

Table 12. EIRP, Test Results

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak Power Spectral Density

Test Requirements: **§15.247(e):** For digitally modulated systems, the peak power spectral density conducted from the intentional radiator to the antenna shall not be greater than 8dBm in any 3 kHz band during any time interval of continuous transmission.

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through a coaxial cable. The power level was set to the maximum level. The RBW was set between 3kHz and 100 kHz. The VBW was set to 3x the RBW. The spectrum analyzer was set to an auto sweep time and a peak detector was used. Measurements were carried out at the low, mid and high channels.

Test Software: TILE Version 7.4.2.5 (Manufactured by ETS Lindgren) was utilized to perform these measurements.

Test Results: The EUT was compliant with the peak power spectral density limits of § 15.247 (e). The peak power spectral density was determined from plots on the following page(s). The spectrum analyzer settings used during the measurement are shown in the table below.

RBW:	3kHz	Detector:	Peak	Reference Level:	10dBm
VBW:	30kHz	Sweep Time:	Auto	Internal Attenuation:	20dB

Figure 6. Analyzer Settings During Measurement

Test Engineer: Bryan Taylor

Test Date: 7/15/2024

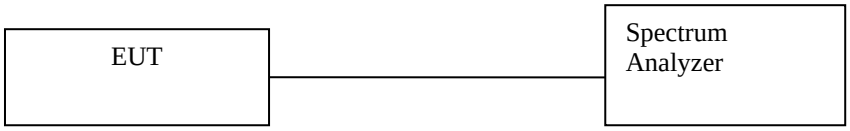


Figure 7. Block Diagram, Peak Power Spectral Density Test Setup

Channel	Frequency (MHz)	Peak Power Spectral Density (dBm / 3kHz)	Peak Power Spectral Density Limit (dBm / 3kHz)	Result
Low	903MHz	0.42	8	Pass
Middle	915MHz	-0.15	8	Pass
High	925MHz	0.37	8	Pass

Table 13. Peak Power Spectral Density, Test Results

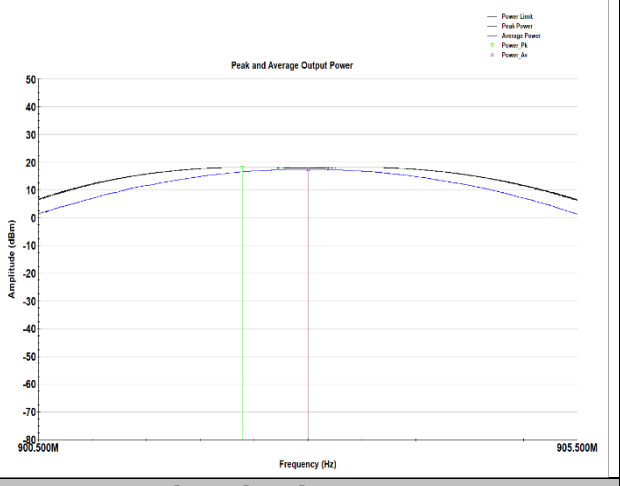
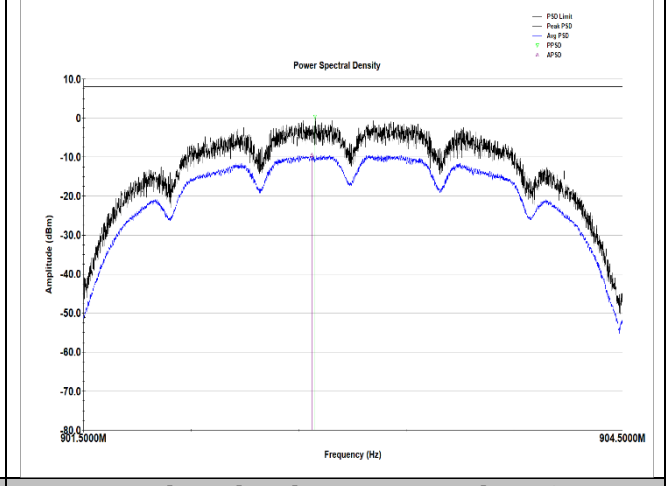
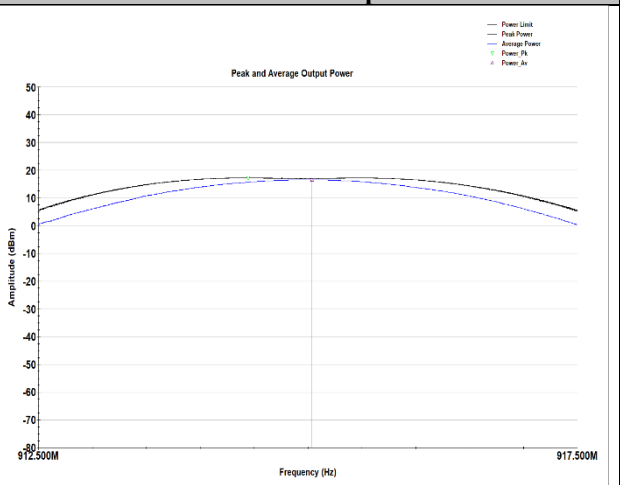
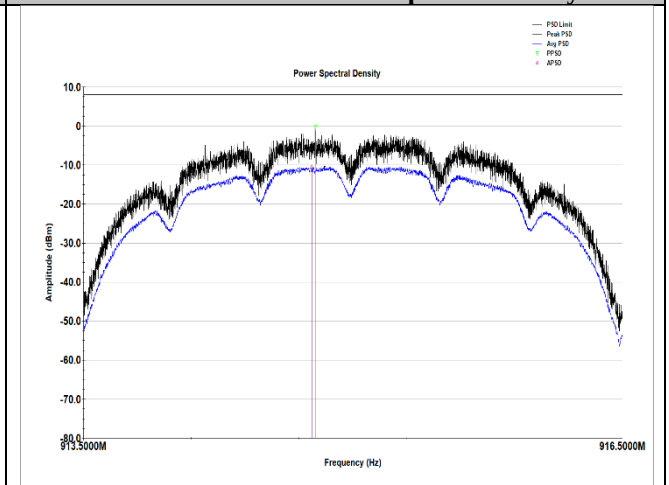
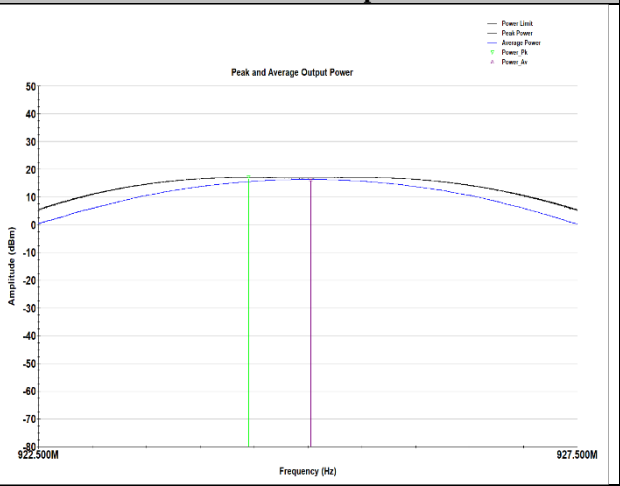
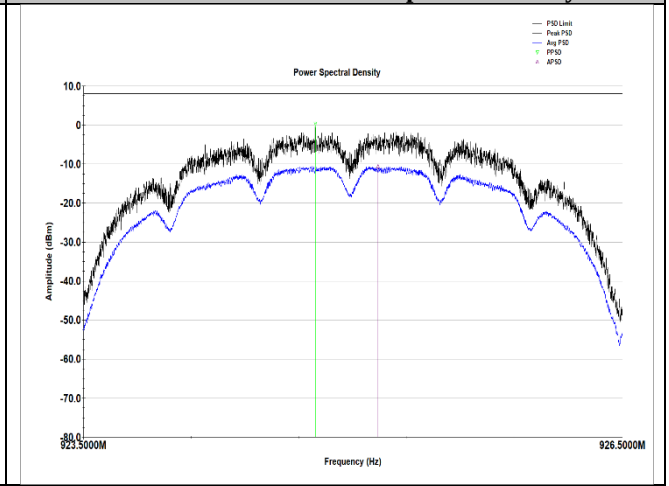
Peak Power and Power Spectral Density Plots	
	
Low Channel Peak Output Power	**Low Channel Peak Power Spectral Density**
	
Mid Channel Peak Output Power	**Mid Channel Peak Power Spectral Density**
	
High Channel Peak Output Power	**High Channel Peak Power Spectral Density**

Figure 8. Peak Power and Power Spectral Density Plots

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) RF Conducted Spurious Emissions Requirements

Test Requirement: **15.247(d)** In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB.

Test Procedure: For intentional radiators with a digital device portion which operates below 10 GHz, the spectrum was investigated as per §15.33(a)(1) and §15.33(a)(4); i.e., the lowest RF signal generated or used in the device up to the 10th harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

The transmitter was connected directly to a Spectrum Analyzer through a coaxial cable. The power level was set to the maximum level. The RBW was set to 100 kHz. The VBW was set to 3x the RBW. The spectrum analyzer was set to an auto sweep time and a peak detector was used. Measurements were carried out at the low, mid and high channels.

See following pages for detailed test results with RF Conducted Spurious Emissions.

Test Software: TILE Version 7.4.2.5 (Manufactured by ETS Lindgren) was utilized to perform these measurements.

Test Results: The EUT was compliant with the Conducted Spurious Emission limits of §15.247(d). The spectrum analyzer settings used during the measurement are shown in the table below.

RBW:	100kHz	Detector:	Peak	Reference Level:	30dBm
VBW:	300kHz	Sweep Time:	Auto	Internal Attenuation:	30dB

Figure 9. Analyzer Settings During Measurement

Test Engineer(s): Bryan Taylor

Test Date(s): 7/15/2024

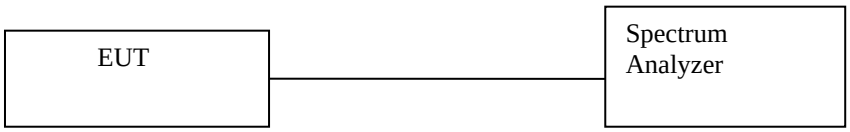


Figure 10. Block Diagram, Conducted Spurious Emissions Test Setup

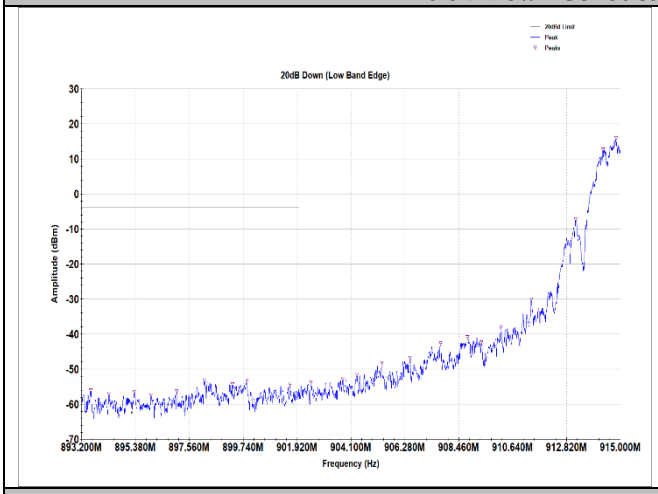
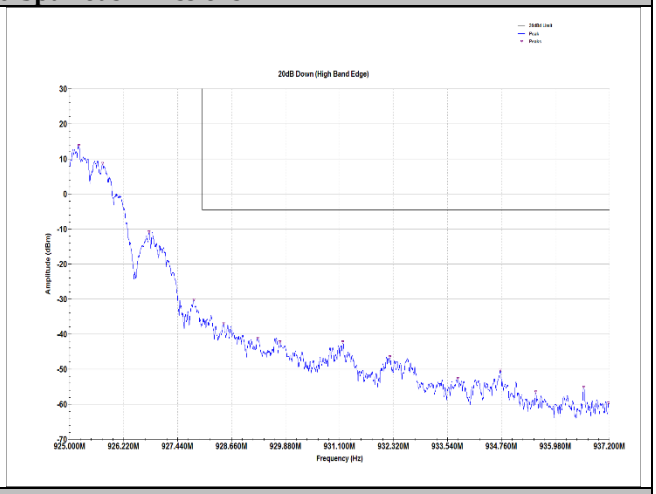
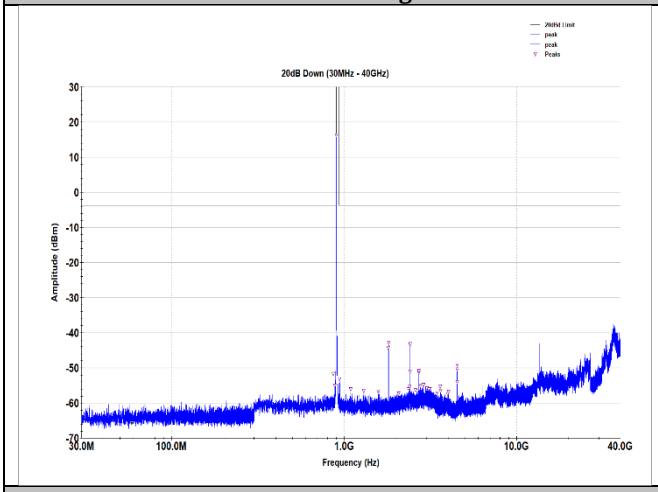
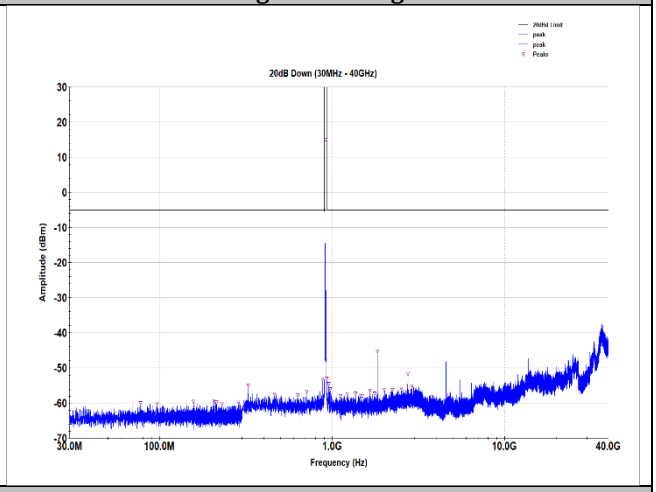
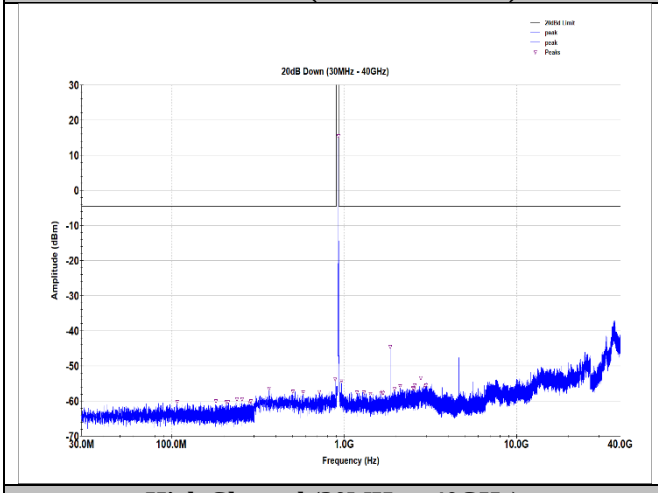
20 dB Down Conducted Spurious Emissions	
	
Low Band Edge	High Band Edge
	
Low Channel (30MHz – 40GHz)	Mid Channel (30MHz – 40GHz)
	
High Channel (30MHz – 40GHz)	Intentionally Blank

Figure 11. 20dB Down Conducted Spurious Emissions

Pk Reference Level:	16.34dBm			
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
893.565	-55.97	-3.66	54.38	Pass
894.306	-57.11	-3.66	55.52	Pass
895.336	-56.58	-3.66	54.99	Pass
896.007	-57.44	-3.66	55.85	Pass
897.053	-56.36	-3.66	54.77	Pass
898.17	-53.15	-3.66	51.56	Pass
899.312	-54.21	-3.66	52.62	Pass
899.884	-53.11	-3.66	51.52	Pass
901.626	-54.37	-3.66	52.78	Pass

Figure 12. Low Channel 20dB Down Emissions, Low Band Edge

Pk Reference Level:	15.48dBm			
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
928.48	-36.88	-4.52	32.36	Pass
929.252	-41.15	-4.52	36.63	Pass
929.753	-42.18	-4.52	37.66	Pass
931.173	-42.18	-4.52	37.66	Pass
932.242	-46.49	-4.52	41.97	Pass
933.773	-52.58	-4.52	48.06	Pass
934.736	-50.34	-4.52	45.82	Pass
935.533	-56.51	-4.52	51.99	Pass
936.62	-55.08	-4.52	50.56	Pass
937.185	-59.57	-4.52	55.05	Pass

Figure 13. High Channel 20dB Down Emissions, High Band Edge

Pk Reference Level:	16.34dBm			
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
864.975	-51.6	-3.66	47.94	Pass
880.837	-55.09	-3.66	51.43	Pass
941.25	-53.19	-3.66	49.53	Pass
1091.1	-56.06	-3.66	52.4	Pass
1294.275	-56.56	-3.66	52.9	Pass
1577.1	-56.87	-3.66	53.21	Pass
1804.912	-44.41	-3.66	40.75	Pass
1806.938	-42.84	-3.66	39.18	Pass
2069.85	-57.23	-3.66	53.57	Pass
2373.262	-56	-3.66	52.34	Pass
2394.863	-55.17	-3.66	51.51	Pass
2411.4	-43.18	-3.66	39.52	Pass
2412.75	-43.4	-3.66	39.74	Pass
2415.45	-50.96	-3.66	47.3	Pass
2591.287	-56.36	-3.66	52.7	Pass
2707.387	-51.24	-3.66	47.58	Pass
2710.425	-50.79	-3.66	47.13	Pass
2762.063	-54.96	-3.66	51.3	Pass
2884.575	-54.83	-3.66	51.17	Pass
3003.509	-55.75	-3.66	52.09	Pass
3143.884	-56.01	-3.66	52.35	Pass
3453.365	-57.06	-3.66	53.4	Pass
3609.97	-55.18	-3.66	51.52	Pass
3613.919	-56.41	-3.66	52.75	Pass
3986.349	-57.46	-3.66	53.8	Pass
4016.179	-56.7	-3.66	53.04	Pass
4512.753	-50.4	-3.66	46.74	Pass
4514.727	-53.96	-3.66	50.3	Pass
4517.578	-49.11	-3.66	45.45	Pass

Figure 14. Low Channel 20 dB Down Emissions

Pk Reference Level:	14.94dBm			
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
77.419	-60.04	-5.06	54.98	Pass
96.589	-60.09	-5.06	55.03	Pass
156.731	-59.63	-5.06	54.57	Pass
205.939	-59.63	-5.06	54.57	Pass
210.056	-59.77	-5.06	54.71	Pass
213.127	-59.7	-5.06	54.64	Pass
230.509	-60.11	-5.06	55.05	Pass
285.791	-59.9	-5.06	54.84	Pass
325.65	-55.08	-5.06	50.02	Pass
463.35	-57.4	-5.06	52.34	Pass
632.775	-57.85	-5.06	52.79	Pass
710.063	-56.83	-5.06	51.77	Pass
876.45	-53.14	-5.06	48.08	Pass
930.45	-53.01	-5.06	47.95	Pass
953.063	-54.51	-5.06	49.45	Pass
976.688	-56.03	-5.06	50.97	Pass
1118.438	-58	-5.06	52.94	Pass
1224.75	-57.45	-5.06	52.39	Pass
1370.55	-57.32	-5.06	52.26	Pass
1466.737	-58.01	-5.06	52.95	Pass
1496.1	-57.92	-5.06	52.86	Pass
1653.713	-56.58	-5.06	51.52	Pass
1763.737	-57.3	-5.06	52.24	Pass
1830.9	-45.24	-5.06	40.18	Pass
2002.688	-56.11	-5.06	51.05	Pass
2242.988	-56.24	-5.06	51.18	Pass
2509.95	-55.83	-5.06	50.77	Pass
2746.2	-51.65	-5.06	46.59	Pass
2897.4	-55.38	-5.06	50.32	Pass

Figure 15. Mid Channel 20 dB Down Emissions

Pk Reference Level:	15.48dBm			
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
107.22	-60.28	-4.52	55.76	Pass
180.221	-60.03	-4.52	55.51	Pass
207.154	-60.29	-4.52	55.77	Pass
212.284	-60.26	-4.52	55.74	Pass
239.183	-59.45	-4.52	54.93	Pass
255.248	-59.41	-4.52	54.89	Pass
282.011	-60.38	-4.52	55.86	Pass
288.053	-59.99	-4.52	55.47	Pass
367.5	-56.51	-4.52	51.99	Pass
504.525	-57.28	-4.52	52.76	Pass
578.438	-57.6	-4.52	53.08	Pass
718.837	-57.39	-4.52	52.87	Pass
886.575	-53.89	-4.52	49.37	Pass
964.875	-54.34	-4.52	49.82	Pass
1188.3	-57.58	-4.52	53.06	Pass
1308.112	-57.54	-4.52	53.02	Pass
1418.475	-57.89	-4.52	53.37	Pass
1635.15	-57.74	-4.52	53.22	Pass
1662.15	-57.43	-4.52	52.91	Pass
1680.037	-57.65	-4.52	53.13	Pass
1849.125	-44.56	-4.52	40.04	Pass
1959.15	-56.53	-4.52	52.01	Pass
2115.412	-55.78	-4.52	51.26	Pass
2499.488	-56.28	-4.52	51.76	Pass
2540.662	-56.54	-4.52	52.02	Pass
2567.325	-55.47	-4.52	50.95	Pass
2773.2	-53.36	-4.52	48.84	Pass
2937.225	-55.9	-4.52	51.38	Pass
2981.1	-55.45	-4.52	50.93	Pass

Figure 16. High Channel 20 dB Down Emissions

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(d) Radiated Spurious Emissions Requirements and Band Edge

Test Requirements: **§15.247(d); §15.205:** Emissions outside the frequency band.

§15.247(d): In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement. Attenuation below the general limits specified in § 15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in § 15.205(a), must also comply with the radiated emission limits specified in § 15.209(a).

§15.205(a): Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090–0.110----------	16.42–16.423	399.9–410	4.5–5.15
[1] 0.495–0.505----------	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905----------	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128----------	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775----------	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775----------	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218----------	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825----------	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225----------	123–138	2200–2300	14.47–14.5
8.291–8.294----------	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366----------	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675----------	156.7–156.9	2655–2900	22.01–23.12
8.41425–8.41475----------	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293----------	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025----------	240–285	3345.8–3358 36.	43–36.5
12.57675–12.57725----------	322–335.4	3600–4400	([2])

Table 14. Restricted Bands of Operation

[1] Until February 1, 1999, this restricted band shall be 0.490 – 0.510 MHz.

[2] Above 38.6

Test Requirement(s): **§ 15.209 (a):** Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 15.

Frequency (MHz)	§ 15.209(a),Radiated Emission Limits (dBµV) @ 3m
30 - 88	40.00
88 - 216	43.50
216 - 960	46.00
Above 960	54.00

Table 15. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)

Test Procedures: The conducted methodology referenced in ANSI C63.10: 2013 Section 11.12.1 was utilized in order to assess the unwanted emissions in the restricted bands.

Additionally, in order to assess the emissions emanating from the cabinet, a radiated scan was performed with the antenna of proper impedance installed per ANSI C63.10 Section 11.12.2.7. The transmitter was turned on. Measurements were performed of the low, mid and high Channels. The EUT was rotated orthogonally through all three axes if multiple mounting orientations are supported. Plots shown are corrected for both antenna correction factor and distance and compared to a 3 m limit line.

Radiated measurements below 30MHz were performed in a semi-anechoic chamber that has been correlated to an open area site.

Test Results: The EUT was compliant with the Radiated Spurious Emission limits of § 15.247(d) and the restricted band limits.

Test Engineer(s): Bryan Taylor, Sergio Gutierrez

Test Date(s): 7/3/2024 - 7/16/2024

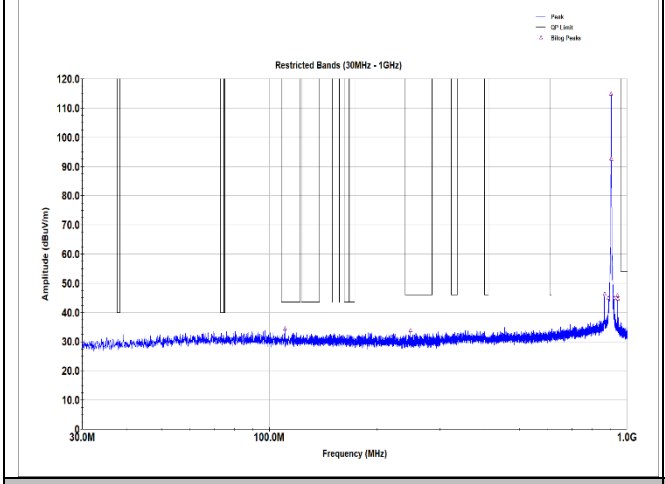
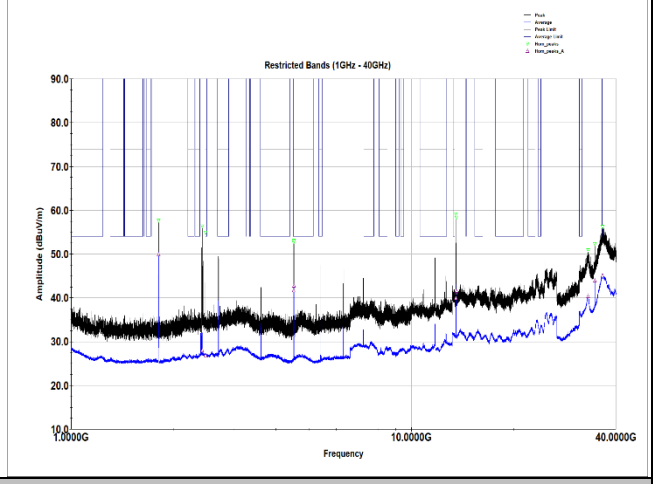
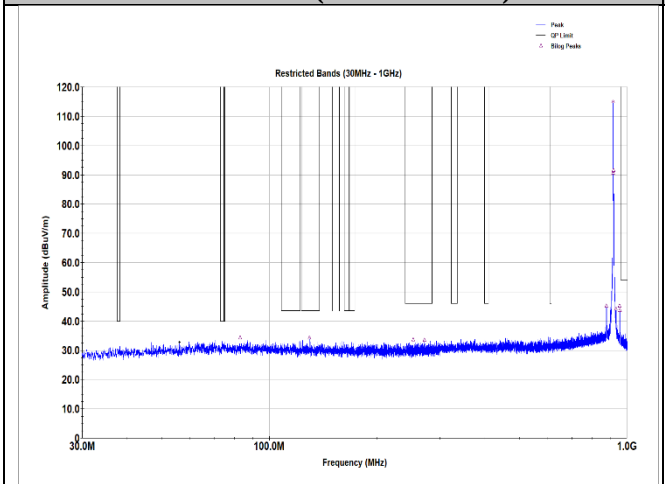
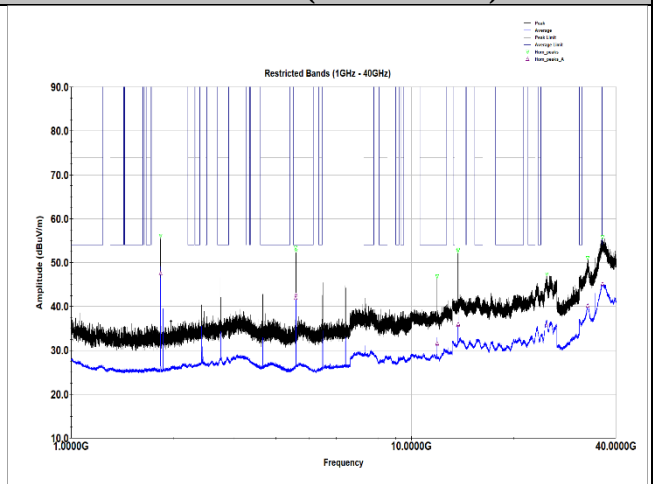
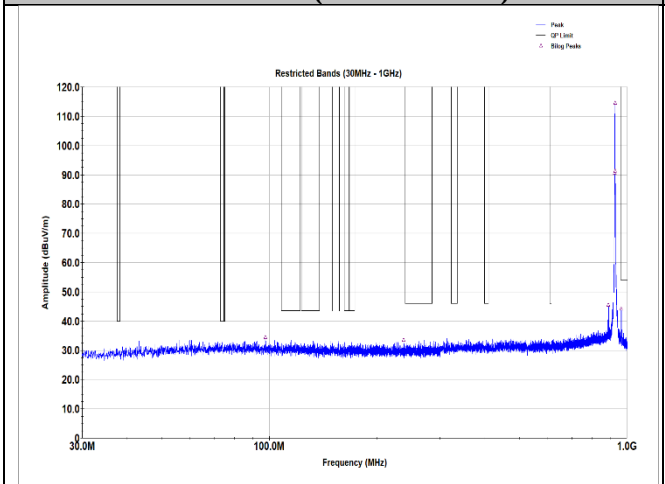
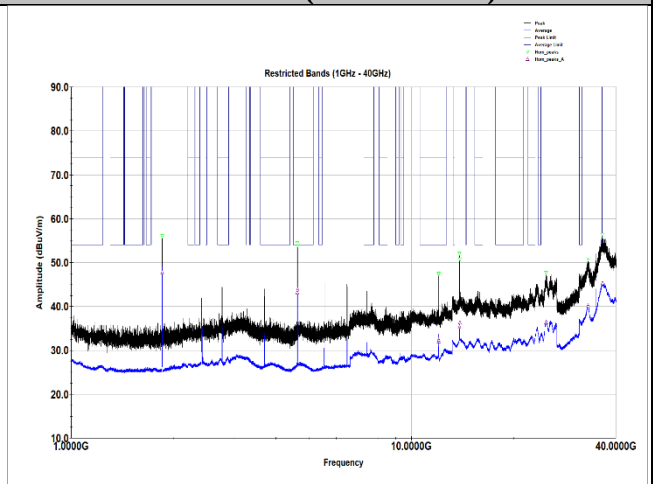
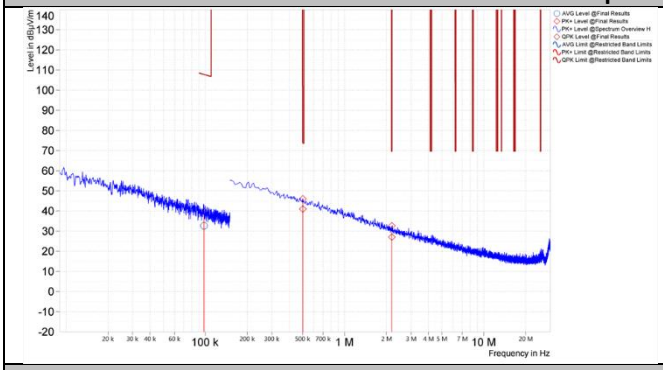
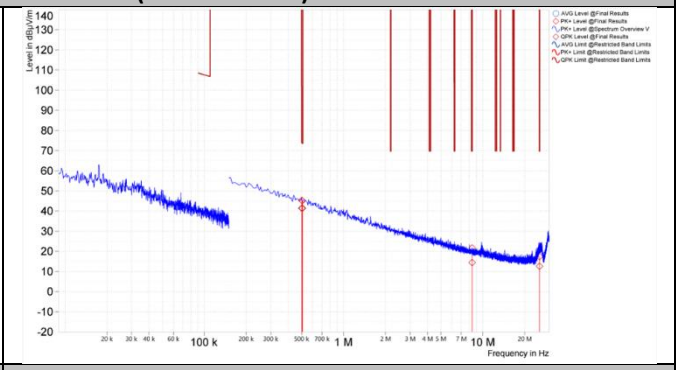
Restricted Band Spurious Emissions	
	
Low Channel (30MHz – 1GHz)	Low Channel (1GHz – 40GHz)
	
Mid Channel (30MHz – 1GHz)	Mid Channel (1GHz – 40GHz)
	
High Channel (30MHz – 1GHz)	High Channel (1GHz – 40GHz)

Figure 17. 30MHz – 40GHz Restricted Band Spurious Emissions

Transmit Channel	Frequency (GHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
Low	4.512	52.71	74	21.29	41.64	54	12.36	Pass
	4.518	53.07	74	20.93	42.75	54	11.25	Pass
	36.473	56.24	74	17.76	45.05	54	8.95	Pass
Mid	4.572	53.41	74	20.59	41.89	54	12.11	Pass
	4.578	52.7	74	21.3	42.69	54	11.31	Pass
	11.888	46.76	74	27.24	31.46	54	22.54	Pass
	11.902	46.96	74	27.04	31.64	54	22.36	Pass
	36.496	55.83	74	18.17	45.12	54	8.88	Pass
High	4.622	54.48	74	19.52	43.25	54	10.75	Pass
	4.628	53.96	74	20.04	43.85	54	10.15	Pass
	12.017	47.34	74	26.66	32.02	54	21.98	Pass
	12.032	47.47	74	26.53	32.48	54	21.52	Pass
	36.463	56.38	74	17.62	45.27	54	8.73	Pass

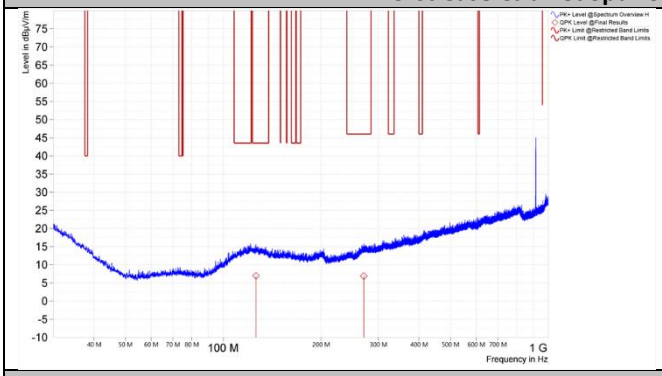
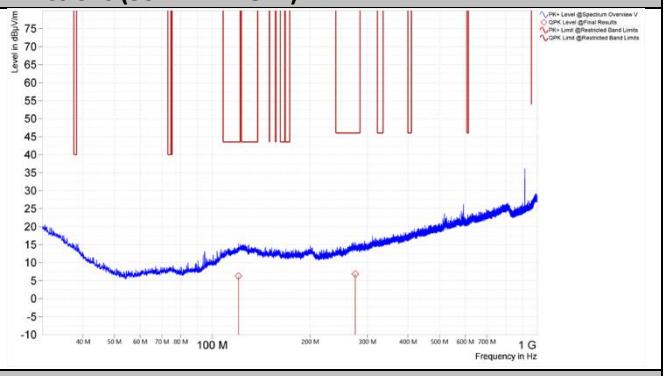
Figure 18. Worst Case Restricted Band Spurious Emissions

Worst Case Cabinet Spurious Emissions

Worst Case Cabinet Spurious Emissions (9kHz – 30MHz)	
	
9kHz – 30MHz (Horizontal)	9kHz – 30MHz (Vertical)

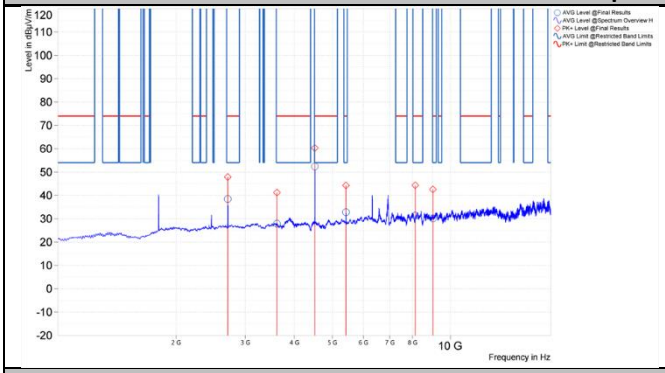
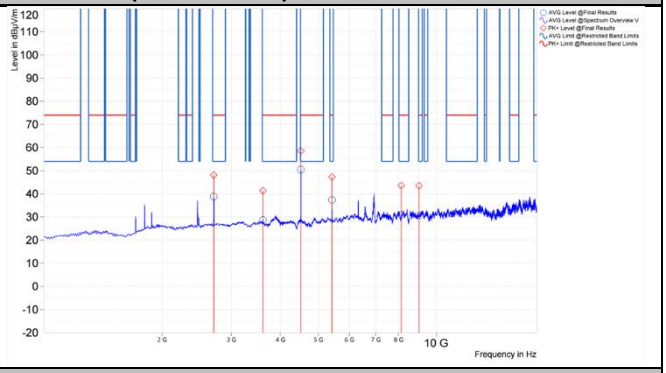
Fequency [MHz]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Detector	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
0.098	39.97	107.82	67.85	Pk	11.39	H	96.2	1	0.200	Pass
0.501	46.03	73.69	27.66	Pk	11.27	H	66.2	1	9.000	Pass
0.501	45.28	73.69	28.41	Pk	11.27	V	121.1	1	9.000	Pass
0.506	45.14	73.62	28.48	Pk	11.31	V	104.8	1	9.000	Pass
2.184	32.67	69.54	36.87	Pk	11.69	H	122.8	1	9.000	Pass
8.385	21.66	69.54	47.88	Pk	10.84	V	204.3	1	9.000	Pass
25.571	17.40	69.54	52.14	Pk	9.40	V	127.8	1	9.000	Pass

Figure 19. Worst Case Cabinet Radiation, Below 30MHz (representative of low, mid, and high channels)

Worst Case Cabinet Spurious Emissions (30MHz – 1GHz)	
	
30MHz – 1GHz (Horizontal)	30MHz – 1GHz (Vertical)

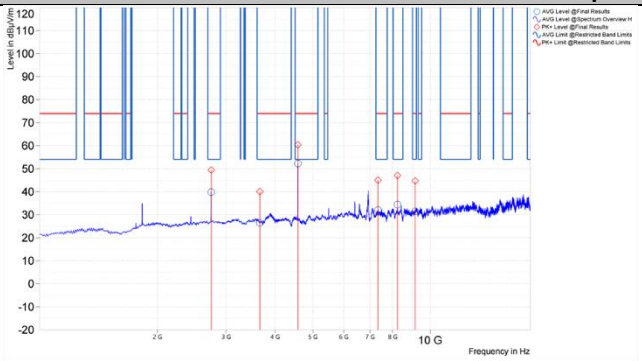
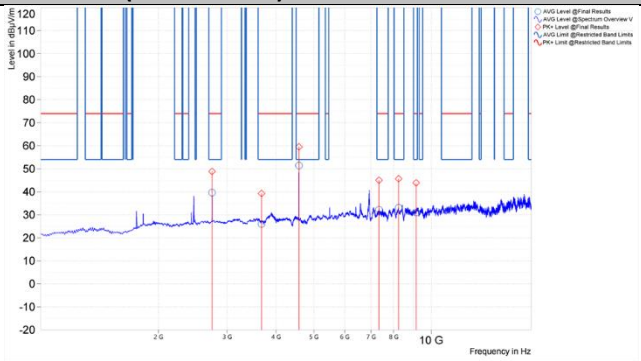
Frequency [MHz]	Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Detector	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
120.360	6.28	43.52	37.24	-6.73	V	290.5	1.37	120.000	120.360	Pass
126.120	6.97	43.52	36.55	-6.25	H	149.3	1.07	120.000	126.120	Pass
270.660	6.92	46.02	39.10	-5.97	H	301.8	1.12	120.000	270.660	Pass
275.520	6.87	46.02	39.15	-5.90	V	329.3	4	120.000	275.520	Pass

Figure 20. Worst Case Cabinet Radiation, 30MHz – 1GHz (representative of low, mid, and high channels)

Worst Case Cabinet Spurious Emissions (1GHz -18GHz)	
	
1GHz – 18GHz (Horizontal)	1GHz – 18GHz (Vertical)

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
2,707.500	47.85	74.00	26.15	38.44	54.00	15.56	-2.71	H	319.2	2.38	Pass
2,707.500	48.11	74.00	25.89	38.79	54.00	15.21	-2.71	V	21.1	2.99	Pass
3,614.000	41.39	74.00	32.61	28.70	54.00	25.30	-2.52	V	355.3	3.45	Pass
3,614.500	41.19	74.00	32.81	27.92	54.00	26.08	-2.53	H	249.4	1.28	Pass
4,512.500	60.30	74.00	13.70	52.40	54.00	1.60	-3.14	H	32	3.16	Pass
4,512.500	58.51	74.00	15.49	50.49	54.00	3.51	-3.14	V	355.7	2.93	Pass
5,415.000	44.29	74.00	29.71	32.79	54.00	21.21	-4.27	H	341	1.39	Pass
5,415.000	47.25	74.00	26.75	37.37	54.00	16.63	-4.27	V	103.3	3.3	Pass
8,131.500	44.33	74.00	29.67	31.41	54.00	22.59	-4.05	H	93.5	3.18	Pass
8,131.500	43.57	74.00	30.43	30.90	54.00	23.10	-4.05	V	264.5	2.99	Pass
9,019.000	42.53	74.00	31.47	30.16	54.00	23.84	-4.65	H	66.1	1.38	Pass
9,024.500	43.48	74.00	30.52	30.62	54.00	23.38	-4.64	V	155.4	1.18	Pass

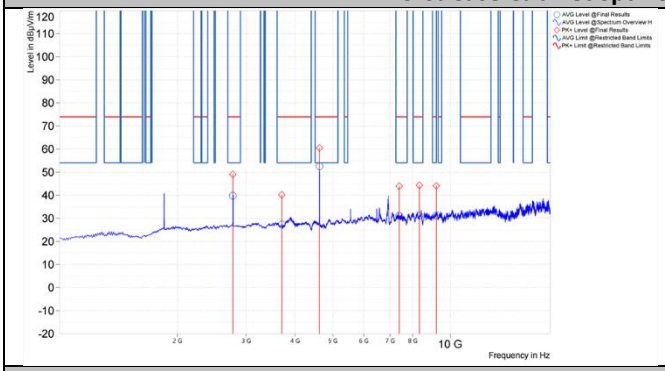
Figure 21. Worst Case Cabinet Radiation, Above 1GHz (Low Channel)

Worst Case Cabinet Spurious Emissions (1GHz -18GHz)	
	
1GHz – 18GHz (Horizontal)	1GHz – 18GHz (Vertical)

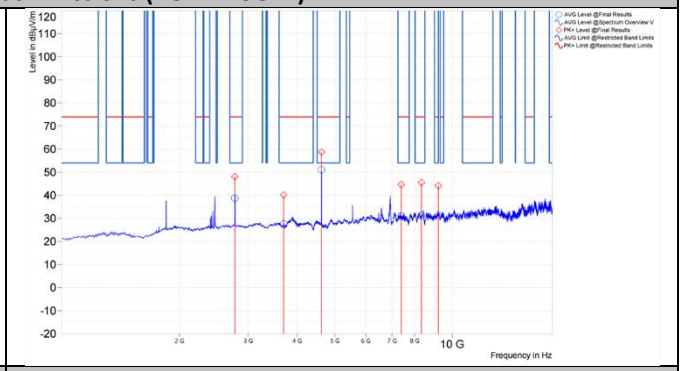
Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
2,743.500	48.83	74.00	25.17	39.60	54.00	14.40	-2.74	V	33	2.97	Pass
2,746.500	49.48	74.00	24.52	39.82	54.00	14.18	-2.74	H	201.3	2.96	Pass
3,658.000	40.05	74.00	33.95	26.46	54.00	27.54	-3.64	H	88.6	3.48	Pass
3,671.500	39.23	74.00	34.77	26.01	54.00	27.99	-3.82	V	213.1	1.06	Pass
4,577.500	60.39	74.00	13.61	52.26	54.00	1.74	-3.82	H	344.6	2.85	Pass
4,577.500	59.50	74.00	14.50	51.41	54.00	2.59	-3.82	V	39.4	3.5	Pass
7,342.000	45.00	74.00	29.00	32.07	54.00	21.93	-2.68	H	162	1.26	Pass
7,343.000	45.00	74.00	29.00	32.16	54.00	21.84	-2.68	V	15.8	1.46	Pass
8,230.000	47.05	74.00	26.95	34.43	54.00	19.57	-3.10	H	271.4	1.5	Pass
8,239.500	45.62	74.00	28.38	33.03	54.00	20.97	-3.21	V	291.2	3.2	Pass
9,140.000	44.71	74.00	29.29	31.48	54.00	22.52	-4.00	H	68.8	3.5	Pass
9,140.000	43.89	74.00	30.11	30.97	54.00	23.03	-4.00	V	61.7	1.85	Pass

Figure 22. Worst Case Cabinet Radiation, Above 1GHz (Mid Channel)

Worst Case Cabinet Spurious Emissions (1GHz -18GHz)



1GHz – 18GHz (Horizontal)



1GHz – 18GHz (Vertical)

Frequency [MHz]	PK+ Level [dBµV/m]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
2,773.500	49.03	74.00	24.97	39.84	54.00	14.16	-2.78	H	353.4	3.24	Pass
2,773.500	48.09	74.00	25.91	38.74	54.00	15.26	-2.78	V	133.5	2.74	Pass
3,698.000	40.11	74.00	33.89	27.57	54.00	26.43	-4.17	V	10.8	3.17	Pass
3,702.000	40.24	74.00	33.76	27.36	54.00	26.64	-4.16	H	179.6	3.18	Pass
4,622.000	58.77	74.00	15.23	51.05	54.00	2.95	-4.22	V	27.6	3.37	Pass
4,622.500	60.51	74.00	13.49	52.54	54.00	1.46	-4.22	H	31.4	2.62	Pass
7,390.500	44.60	74.00	29.40	31.09	54.00	22.91	-2.50	V	298.5	1.01	Pass
7,391.500	43.92	74.00	30.08	31.13	54.00	22.87	-2.50	H	275.4	2.89	Pass
8,329.500	44.33	74.00	29.67	31.26	54.00	22.74	-3.81	H	152.7	3.11	Pass
8,329.500	45.54	74.00	28.46	31.31	54.00	22.69	-3.81	V	19.3	3.3	Pass
9,200.000	44.11	74.00	29.89	31.36	54.00	22.64	-3.44	H	340.4	1.75	Pass
9,200.000	44.17	74.00	29.83	31.42	54.00	22.58	-3.44	V	94.7	2.62	Pass

Figure 23. Worst Case Cabinet Radiation, Above 1GHz (High Channel)

IV. Test Equipment

Test Equipment

Calibrated test equipment utilized during testing was maintained in a current state of calibration per the requirements of ISO/IEC 17025:2017.

MET Asset #	Description	Manufacturer	Model	Last Cal Date	Cal Due Date
MY46180897	Spectrum Analyzer	Keysight	E4448A	7/27/2023	7/27/2024
1A1250	EMI Test Receiver	Rohde & Schwarz	ESW44	04/08/2024	04/08/2025
1A1176	Active Loop Antenna (9KHz-30MHz)	ETS-Lindgren	6502	7/13/2023	7/13/2025
1A1147	Bi-Log Antenna	Suno Sciences Corp	JB3	04/06/2023	4/06/2025
1A1183	Double Ridged Waveguide Antenna	ETS Lindgren	3117	02/20/2024	02/20/2026
1A1065	EMI Receiver	Rohde & Schwarz	ESCI	8/4/2023	8/4/2024
1A1122	LISN	Teseq	NNB 51	9/19/2023	9/19/2024
1A1123	LISN	Teseq	NNB 51	12/20/2023	12/20/2024
1A1149	DC Milliohm Meter	GW Instek	GOM-802	9/20/2023	9/20/2024
1A1099	Generator	Com-Power	CGO-51000	See Note	
1A1088	Preamplifier	Rohde & Schwarz	TS-PR1	See Note	
1A1044	Generator	Com-Power	CG-520	See Note	
1A1073	Multi Device Controller	ETS	2090	See Note	
1A1074	System Controller	Panasonic	WV-CU101	See Note	
1A1080	Multi-Device	ETS	2090	See Note	
1A1180	Preamplifier	Miteq	AMF-7D-01001800-22-10P	See Note	

Table 16. Test Equipment List

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

End of Report