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1/5/2024
Verge Aero
1705 Robers S Light Blvd
Unit 101
Buda Texas, 78610
USA

Dear Anthony Merlino,

Enclosed is the EMC Wireless test report for compliance testing of the Verge Aero X7 as tested to the requirements of FCC Part 15.247 and RSS-247 Issue 3 for Intentional Radiators. This test report pertains specifically to the LoRa transmitter onboard.

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

A handwritten signature in blue ink that reads "Nancy LaBrecque".

Nancy LaBrecque
Documentation Department

Reference: WIRA130068-FCC-IC-LoRa

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LoRa Test Report

for the

Verge Aero
X7

Tested under

FCC Part 15.247 and RSS-247 Issue 3
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
Ø	1/5/2024	Initial Issue.

Table of Contents

I.	Executive Summary	8
	A. Purpose of Test	9
	B. Executive Summary	9
II.	Equipment Configuration	10
	A. Overview.....	11
	B. References.....	12
	C. Test Site	13
	D. Measurement Uncertainty	13
	E. Description of Test Sample.....	13
	F. Equipment Configuration.....	14
	G. Support Equipment	14
	H. Ports and Cabling Information.....	14
	I. Mode of Operation.....	15
	J. Method of Monitoring EUT Operation	15
	K. Modifications.....	15
	a) Modifications to EUT	15
	b) Modifications to Test Standard.....	15
	L. Disposition of EUT	15
III.	Electromagnetic Compatibility Criteria for Intentional Radiators.....	16
	§ 15.203 Antenna Requirement	17
	§ 15.207(a) Conducted Emissions Limits.....	18
	§ 15.247(a)(a) 6 dB and 99% Bandwidth	21
	RSS-GEN (6.7) 99% Bandwidth	22
	§ 15.247(b) Peak Power Output	24
	§ 15.247(e) Peak Power Spectral Density	26
	§ 15.247(d) RF Conducted Spurious Emissions Requirements and Band Edge.....	30
	§ 15.247(d) Radiated Spurious Emissions Requirements and Band Edge.....	36
IV.	Test Equipment	49

List of Tables

Table 1. Executive Summary	9
Table 2. EUT Summary Table.....	11
Table 3. References	12
Table 4. Uncertainty Calculations Summary.....	13
Table 5. Support Equipment.....	14
Table 6. Ports and Cabling Information	14
Table 7. Test Channels Utilized	15
Table 8. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)	18
Table 9. Conducted Emissions, 15.207(a), Phase, Test Results	19
Table 10. Conducted Emissions, 15.207(a), Neutral, Test Results	20
Table 11. 99% and 6 dB Occupied Bandwidth, Test Results	22
Table 12. Output Power Requirements from §15.247(b)	24
Table 13. Peak Power Output, Test Results	25
Table 14. Peak Power Spectral Density, Test Results	26
Table 15. Restricted Bands of Operation.....	36
Table 16. Radiated Emissions Limits Calculated from FCC Part 15, § 15.209 (a)	37
Table 17. Test Equipment List	50

List of Figures

Figure 1. Block Diagram of Test Configuration.....	14
Figure 2. Block Diagram, Occupied Bandwidth Test Setup.....	22
Figure 3. Peak Power Output Test Setup.....	25
Figure 4. Block Diagram, Peak Power Spectral Density Test Setup	26
Figure 5. Low Channel, Power Spectral Density	27
Figure 6. Mid Channel, Power Spectral Density	28
Figure 7. High Channel, Power Spectral Density	29
Figure 8. Block Diagram, Conducted Spurious Emissions Test Setup.....	30
Figure 9. Low Channel, 30MHz – 40GHz Conducted Spurious Emissions.....	31
Figure 10. Mid Channel, 30MHz – 40GHz Conducted Spurious Emissions	32
Figure 11. High Channel, 30MHz – 40GHz Conducted Spurious Emissions	33
Figure 12. Low Channel, Low Band Edge	34
Figure 13. High Channel, High Band Edge.....	35
Figure 14. Low Channel, 30MHz – 1GHz Restricted Band Spurious Emissions	38
Figure 15. Low Channel, 1GHz – 40GHz Restricted Band Spurious Emissions	39
Figure 16. Middle Channel, 30MHz – 1GHz Restricted Band Spurious Emissions	40
Figure 17. Middle Channel, 1GHz – 40GHz Restricted Band Spurious Emissions	41
Figure 18. High Channel, 30MHz – 1GHz Restricted Band Spurious Emissions.....	42
Figure 19. High Channel, 1GHz – 40GHz Restricted Band Spurious Emissions	43
Figure 20. Worst Case Cabinet Radiation, Below 1GHz	44
Figure 21. Worst Case Cabinet Radiation, Above 1GHz	44
Figure 22. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coaxial Loop.....	45
Figure 23. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coplanar Loop.....	45
Figure 24. Worst Case Cabinet Radiation, 30MHz – 1GHz, Vertical Polarity	46
Figure 25. Worst Case Cabinet Radiation, 30MHz – 1GHz, Horizontal Polarity	46
Figure 26. Worst Case Cabinet Radiation, 1GHz – 18GHz, Vertical Polarity	47
Figure 27. Worst Case Cabinet Radiation, 1GHz – 18GHz, Horizontal Polarity.....	47
Figure 28. Worst Case Cabinet Radiation, 18GHz – 40GHz, Vertical Polarity	48
Figure 29. Worst Case Cabinet Radiation, 18GHz – 40GHz, Horizontal Polarity	48

List of Terms and Abbreviations

AC	Alternating Current
ACF	Antenna Correction Factor
Cal	Calibration
<i>d</i>	Measurement Distance
dB	Decibels
dB μ A	Decibels above one microamp
dB μ V	Decibels above one microvolt
dB μ A/m	Decibels above one microamp per meter
dB μ V/m	Decibels above one microvolt per meter
DC	Direct Current
E	Electric Field
DSL	Digital Subscriber Line
ESD	Electrostatic Discharge
EUT	Equipment Under Test
<i>f</i>	Frequency
FCC	Federal Communications Commission
GRP	Ground Reference Plane
H	Magnetic Field
HCP	Horizontal Coupling Plane
Hz	Hertz
IEC	International Electrotechnical Commission
kHz	kilohertz
kPa	kilopascal
kV	kilovolt
LISN	Line Impedance Stabilization Network
MHz	Megahertz
μ H	microhenry
μ	microfarad
μ s	microseconds
NEBS	Network Equipment-Building System
PRF	Pulse Repetition Frequency
RF	Radio Frequency
RMS	Root-Mean-Square
TWT	Traveling Wave Tube
V/m	Volts per meter
VCP	Vertical Coupling Plane

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the X7, with the requirements of FCC Part 15.247 and RSS-247 Issue 3. Verge Aero should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the X7, 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 and RSS-247 Issue 3, in accordance with Verge Aero purchase order number PO-X212112301. All tests were conducted using measurement procedures ANSI C63.4-2014 and ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247:2005	IC Reference RSS-247 Issue 2: 2017; RSS-GEN Issue 5: 2018	Description	Compliance
Title 47 of the CFR, Part 15 §15.203	---	Antenna Requirement	Compliant
Title 47 of the CFR, Part 15 §15.207(a)	RSS-GEN(8.8)	Conducted Emission Limits	Compliant
Title 47 of the CFR, Part 15 §15.247(a)(2)	RSS-247 (5.2)	6dB Occupied Bandwidth	Compliant
---	RSS-GEN(6.7)	99% Occupied Bandwidth	Compliant
Title 47 of the CFR, Part 15 §15.247(b)	RSS-247(5.4)	Peak Power Output	Compliant
Title 47 of the CFR, Part 15 §15.247(d); §15.209; §15.205	RSS-GEN (6.13), (8.9), & (8.10)	Radiated Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15 §15.247(d)	RSS-247(5.5)	RF Conducted Spurious Emissions Requirements	Compliant
Title 47 of the CFR, Part 15; §15.247(e)	RSS-247(5.2)	Peak Power Spectral Density	Compliant

Table 1. Executive Summary

II. Equipment Configuration

A. Overview

Eurofins MET Labs was contracted by Verge Aero to perform testing on the X7, under Verge Aero's purchase order number PO-X212112301.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the X7.

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

Model(s) Tested:	X7	
Model(s) Covered:	X7	
Serial Number or Sample Number:	24069-12 (radiated tests); 24069-19 (conducted antenna port tests)	
EUT Specifications:	Primary Power: 5-20VDC	
	Type of Modulations:	LoRa Chirp Spread Spectrum
	Equipment Code:	DTS
	Peak RF Output Power:	17.60dBm
	EUT Frequency Ranges:	902.5MHz – 927.5MHz
	Antenna Gain ¹ :	3.9dBi (quarter-wave monopole)
Analysis:	The results obtained relate only to the item(s) tested.	
Environmental Test Conditions:	Temperature: 15-35° C	
	Relative Humidity: 30-60%	
	Barometric Pressure: 860-1060 mbar	
Evaluated by:	Bryan Taylor	
Report Date(s):	12/13/2023 through 1/4/2023	

Table 2. EUT Summary Table

¹ The antenna gain information was provided by Verge Aero 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
RSS-247, Issue 3, August 2023	Digital Transmission Systems (DTSS), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
RSS-GEN, Issue 5, March 2019	General Requirements and Information for the Certification of Radio Apparatus
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.

D. Measurement Uncertainty

Test Method	Typical Expanded Uncertainty	K	Confidence Level
RF Frequencies	±4.52 Hz	2	95%
RF Power Conducted Emissions	±2.97 dB	2	95%
RF Power Radiated Emissions	±2.95 dB	2	95%

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The X7 product is a small quad-rotor UAV, equipped with a smart battery (Li-Ion), and a high-intensity RGBW LED. It is purpose-built for performing synchronized light shows with hundreds to thousands of the drones flying in a synchronized manner.

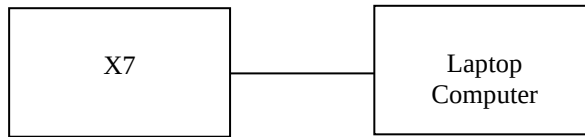


Figure 1. Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 1, Block Diagram of Test Setup. 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	Putty (terminal application)	Simon Tatham	Putty Release 0.77	None

Table 5. Support Equipment

H. Ports and Cabling Information

Ref. Id	Port Name on EUT	Qty	Length as tested	Shielded? (Y/N)	Termination Box ID & Port Name
None	USB-C	1	3 ft	Yes	USB-C Charging Adapter or Laptop

Table 6. Ports and Cabling Information

I. Mode of Operation

The support laptop provided 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 ²
902MHz – 928MHz	LoRa Chirp Spread Spectrum	902.5MHz / 915.1MHz / 927.5MHz	15

Table 7. Test Channels Utilized

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 Verge Aero upon completion of testing.

² 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): 12/16/2023

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.207(a) Conducted Emissions Limits

Test Requirement(s): § 15.207 (a): For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30MHz, shall not exceed the limits in the following table, as measured using a 50 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

Frequency range (MHz)	§ 15.207(a), Conducted Limit (dB μ V)	
	Quasi-Peak	Average
0.15-0.5	66 - 56	56 - 46
0.5-5	56	46
5-30	60	50

Table 8. Conducted Limits for Intentional Radiators from FCC Part 15 § 15.207(a)

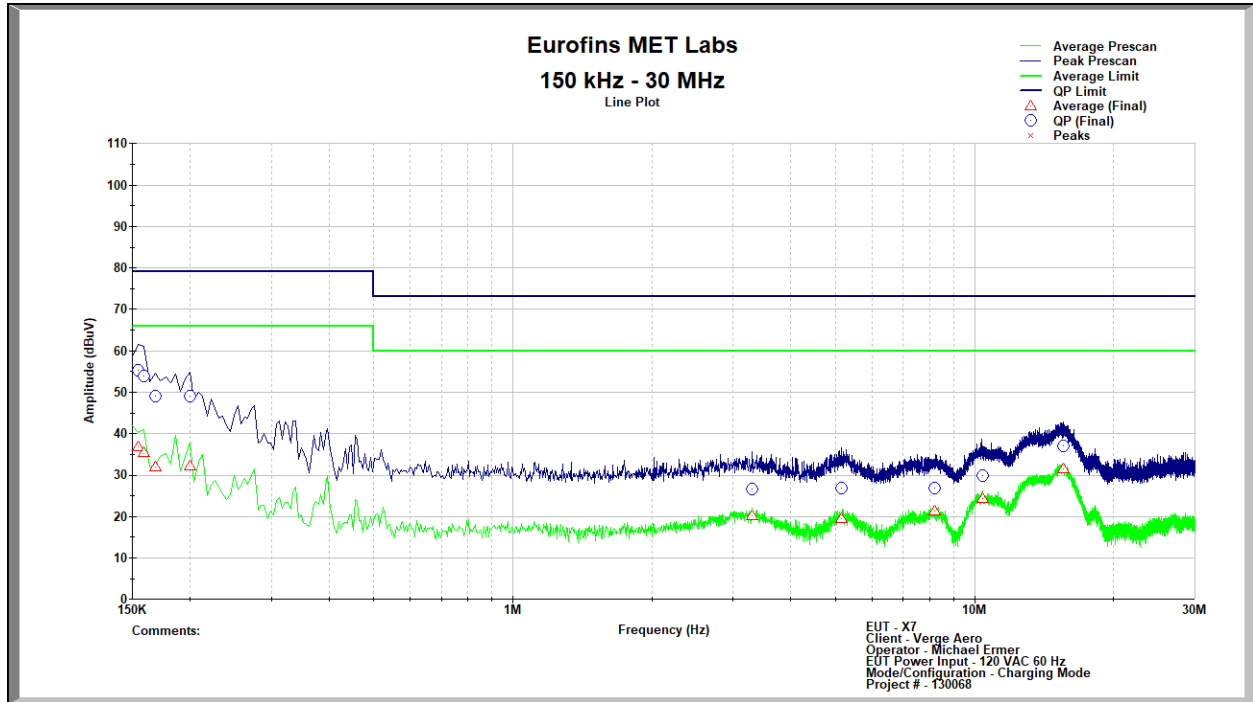
Test Procedure: The EUT was placed on a 0.8 m-high wooden table. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω /50 μ H Line Impedance Stabilization Network (LISN). The EMC receiver scanned the frequency range from 150 kHz to 30 MHz. Conducted Emissions measurements were made in accordance with ANSI C63.4-2014 "Methods and Measurements of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9kHz to 40 GHz". The measurements were performed using a 50 Ω /50 μ H LISN as the input transducer to an EMI receiver. For the purpose of this testing, the transmitter was turned on.

Test Results: The EUT was compliant with this requirement. During these tests the Verge Aero X7 Drone was in charging mode and connected to a USB-C charging adapter.

Test Engineer(s): Michael Ermer

Test Date(s): 12/14/2023

15.207(a) Conducted Emissions Test Results

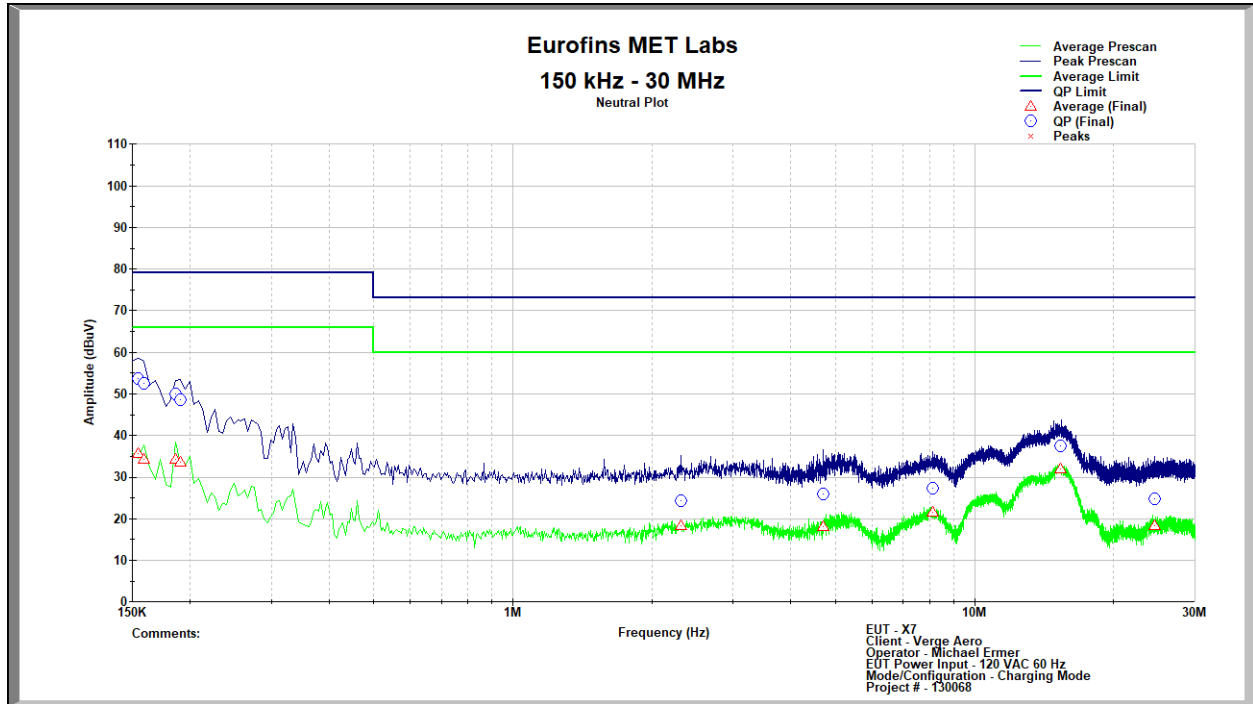


Conducted Emissions, 15.207(a), Phase

Frequency (MHz)	Quasi-Peak (dBμV/m)	Quasi-Peak Limit (dBμV/m)	Quasi-Peak Margin (dB)	Average (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
0.154	55.272	79.000	23.728	36.901	66.000	29.099
0.159	53.812	79.000	25.188	35.293	66.000	30.707
0.168	49.047	79.000	29.953	31.870	66.000	34.130
0.200	49.029	79.000	29.971	32.204	66.000	33.796
3.297	26.518	73.000	46.482	20.168	60.000	39.832
5.138	26.957	73.000	46.043	19.480	60.000	40.520
8.199	26.954	73.000	46.046	21.335	60.000	38.665
10.410	29.780	73.000	43.220	24.302	60.000	35.698
15.606	36.962	73.000	36.038	31.446	60.000	28.554

Table 9. Conducted Emissions, 15.207(a), Phase, Test Results

15.207(a) Conducted Emissions Test Results



Conducted Emissions, 15.207(a), Neutral

Frequency (MHz)	Quasi-Peak (dBμV/m)	Quasi-Peak Limit (dBμV/m)	Quasi-Peak Margin (dB)	Average (dBμV/m)	Average Limit (dBμV/m)	Average Margin (dB)
0.154	53.686	79.000	25.314	35.591	66.000	30.409
0.159	52.441	79.000	26.559	34.249	66.000	31.751
0.186	50.061	79.000	28.939	34.239	66.000	31.761
0.191	48.590	79.000	30.410	33.524	66.000	32.476
2.314	24.402	73.000	48.598	18.266	60.000	41.734
4.697	25.832	73.000	47.168	18.156	60.000	41.844
8.095	27.291	73.000	45.709	21.429	60.000	38.571
15.322	37.453	73.000	35.547	32.017	60.000	27.983
24.498	24.724	73.000	48.276	18.410	60.000	41.590

Table 10. Conducted Emissions, 15.207(a), Neutral, Test Results

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): 1/4/2023

Electromagnetic Compatibility Criteria for Intentional Radiators

RSS-GEN (6.7) 99% Bandwidth

Test Requirements: The occupied bandwidth or the “99% emission bandwidth” is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained. The occupied bandwidth shall be reported for all equipment in addition to the specified bandwidth required in the applicable RSSs.

Test Procedure: The transmitter was connected to the spectrum analyzer through an attenuator. The bandwidth of the fundamental frequency was measured with the spectrum analyzer using a RBW approximately equal to 1% of the total emission bandwidth, and the VBW > RBW. The 99% Bandwidth was measured and recorded.

Test Results The 99% Bandwidth determined from the plots on the following pages.

Test Engineer(s): Bryan Taylor

Test Date(s): 1/4/2023

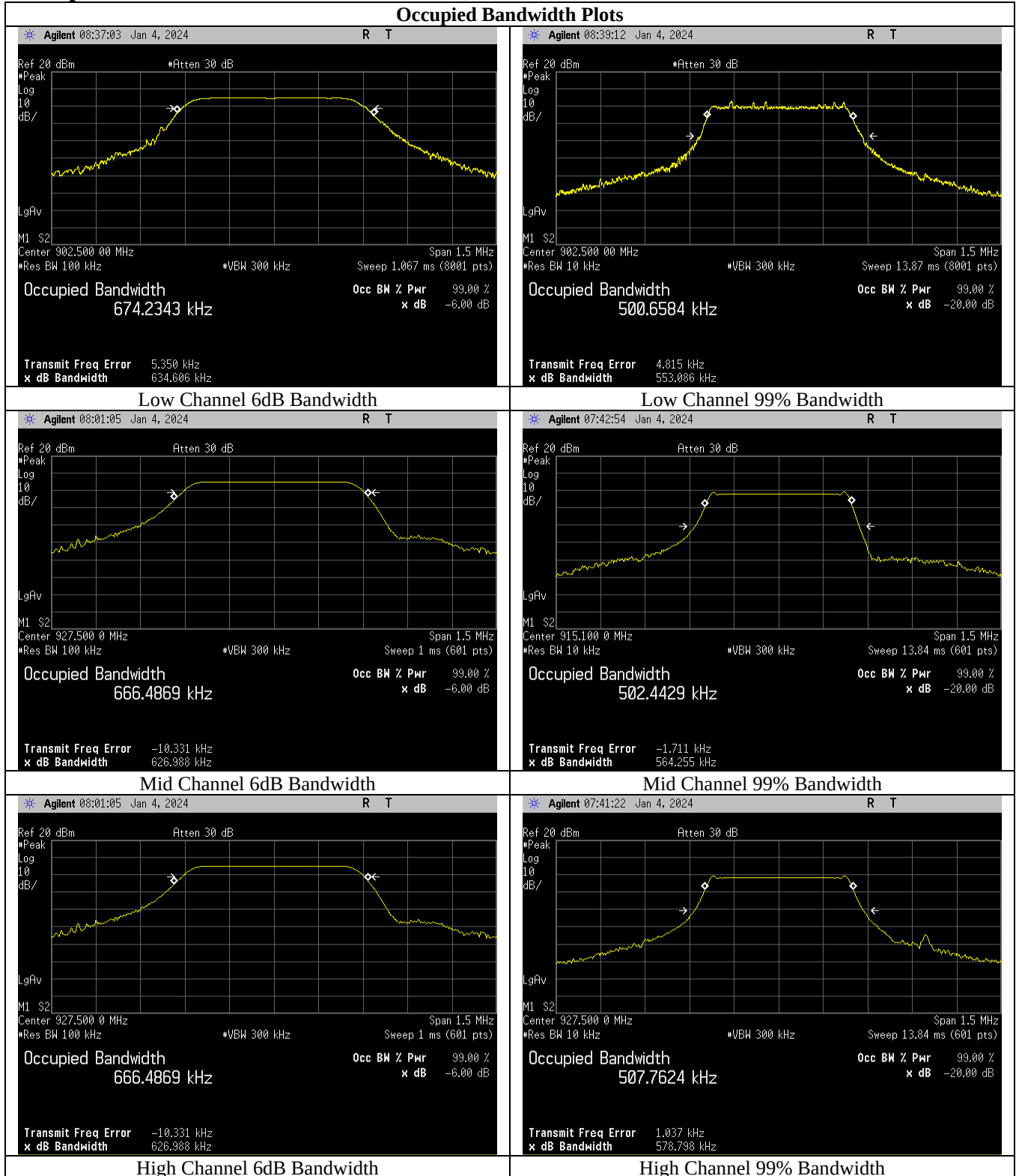


Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	99% Bandwidth (MHz)	Result
Low	902.5MHz	634.6kHz	0.5	553.1kHz	Pass
Middle	915.1MHz	627.3kHz	0.5	564.2kHz	Pass
High	927.5MHz	626.9kHz	0.5	578.7kHz	Pass

Table 11. 99% and 6 dB Occupied Bandwidth, Test Results

Occupied Bandwidth Test Results



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 12. 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 12, 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 Results: The EUT was compliant with the Peak Power Output limits of §15.247(b).

Test Engineer(s): Bryan Taylor

Test Date(s): 1/4/2023



Figure 3. Peak Power Output Test Setup

Peak Power Output Test Results

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power Limit (dBm)	Result
Low	902.5MHz	17.23	30	Pass
Middle	915.1MHz	17.20	30	Pass
High	927.5MHz	17.60	30	Pass

Table 13. Peak Power Output, 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 an attenuator. 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 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).

Test Engineer: Bryan Taylor

Test Date: 1/4/2023

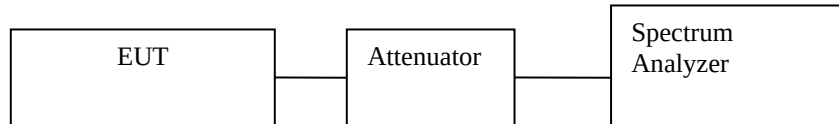


Figure 4. Block Diagram, Peak Power Spectral Density Test Setup

Channel	Frequency (MHz)	Peak Power Spectral Density (dBm / 8kHz)	Peak Power Spectral Density Limit (dBm / 8kHz)	Result
Low	902.5MHz	-0.90	8	Pass
Middle	915.1MHz	-0.90	8	Pass
High	927.5MHz	-0.42	8	Pass

Table 14. Peak Power Spectral Density, Test Results

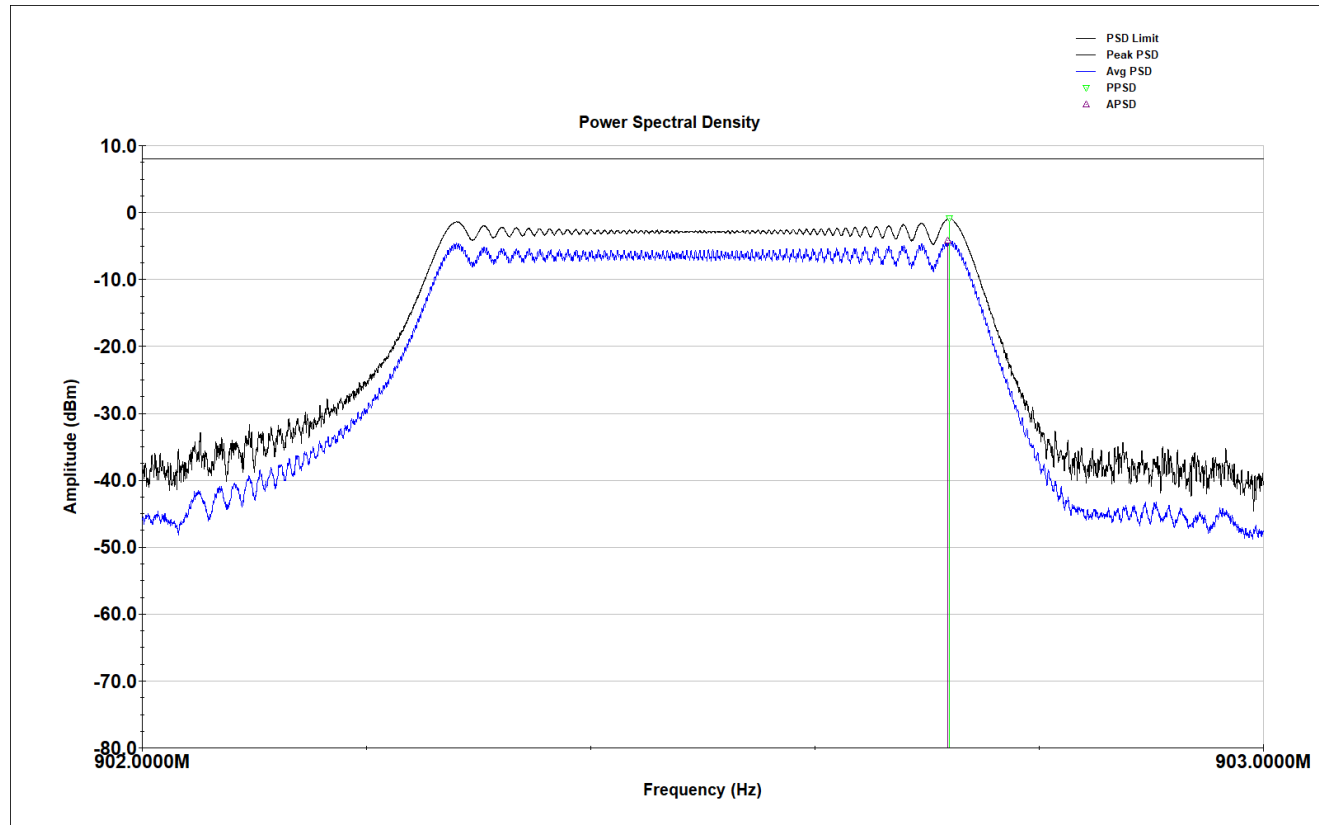


Figure 5. Low Channel, Power Spectral Density

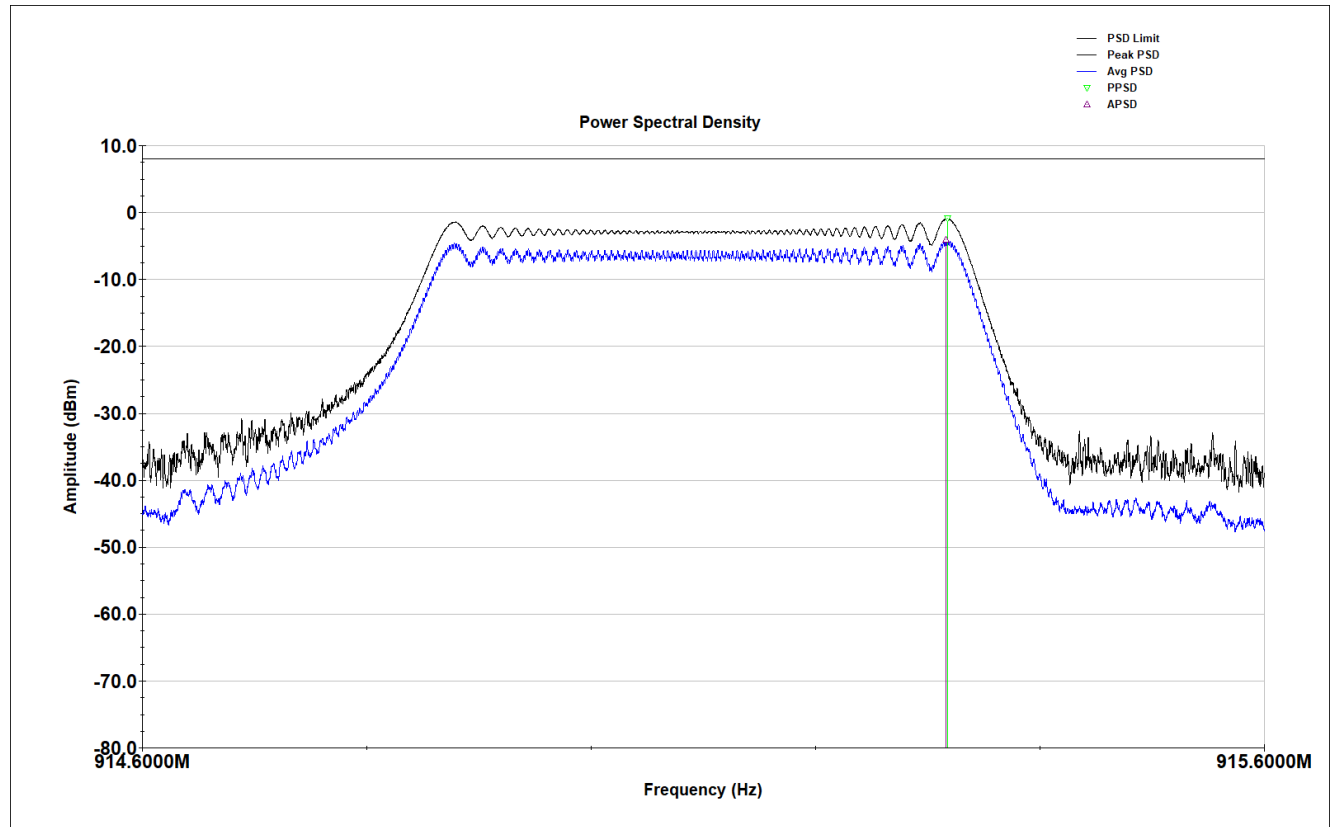


Figure 6. Mid Channel, Power Spectral Density

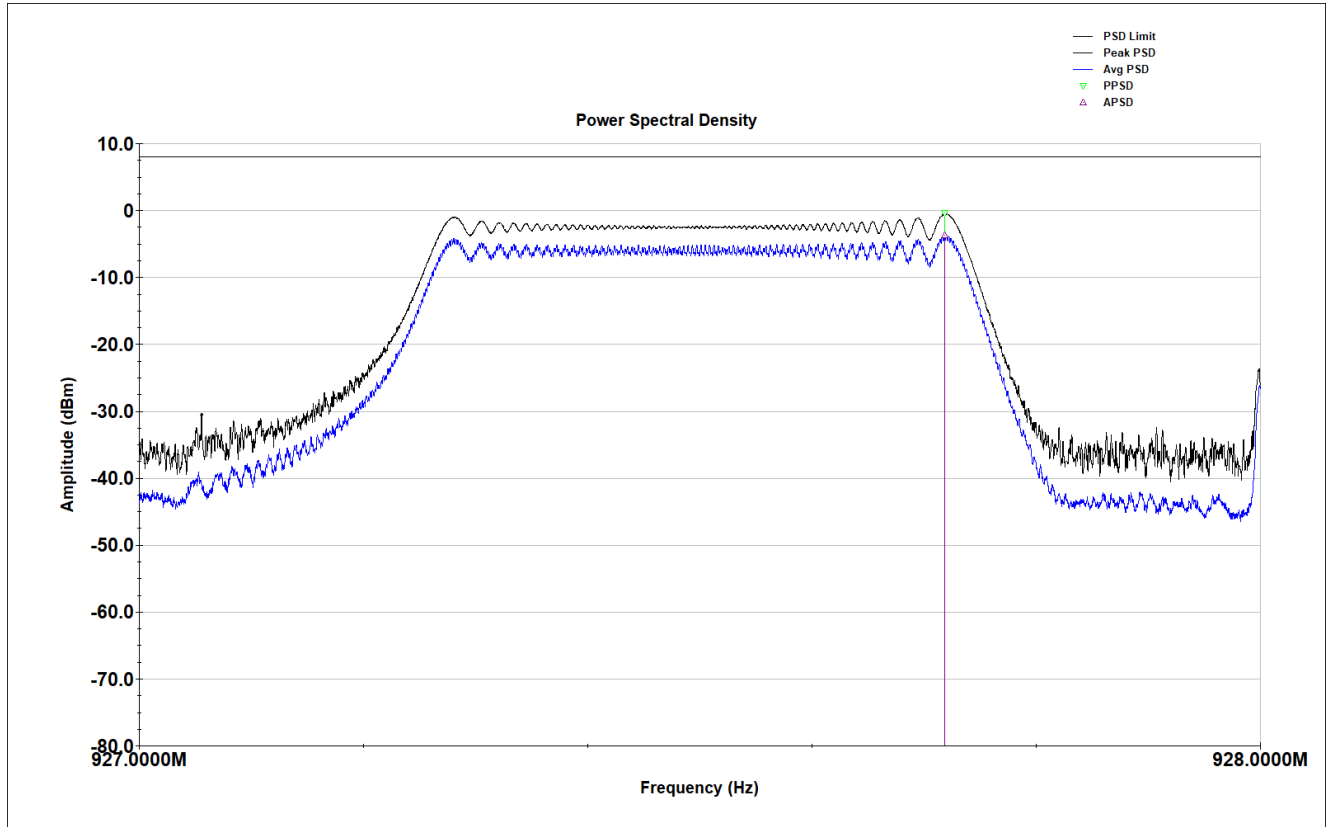


Figure 7. High Channel, Power Spectral Density

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 an attenuator. 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 Results: The EUT was compliant with the Conducted Spurious Emission limits of **§15.247(d)**.

Test Engineer(s): Bryan Taylor

Test Date(s): 1/4/2023



Figure 8. Block Diagram, Conducted Spurious Emissions Test Setup

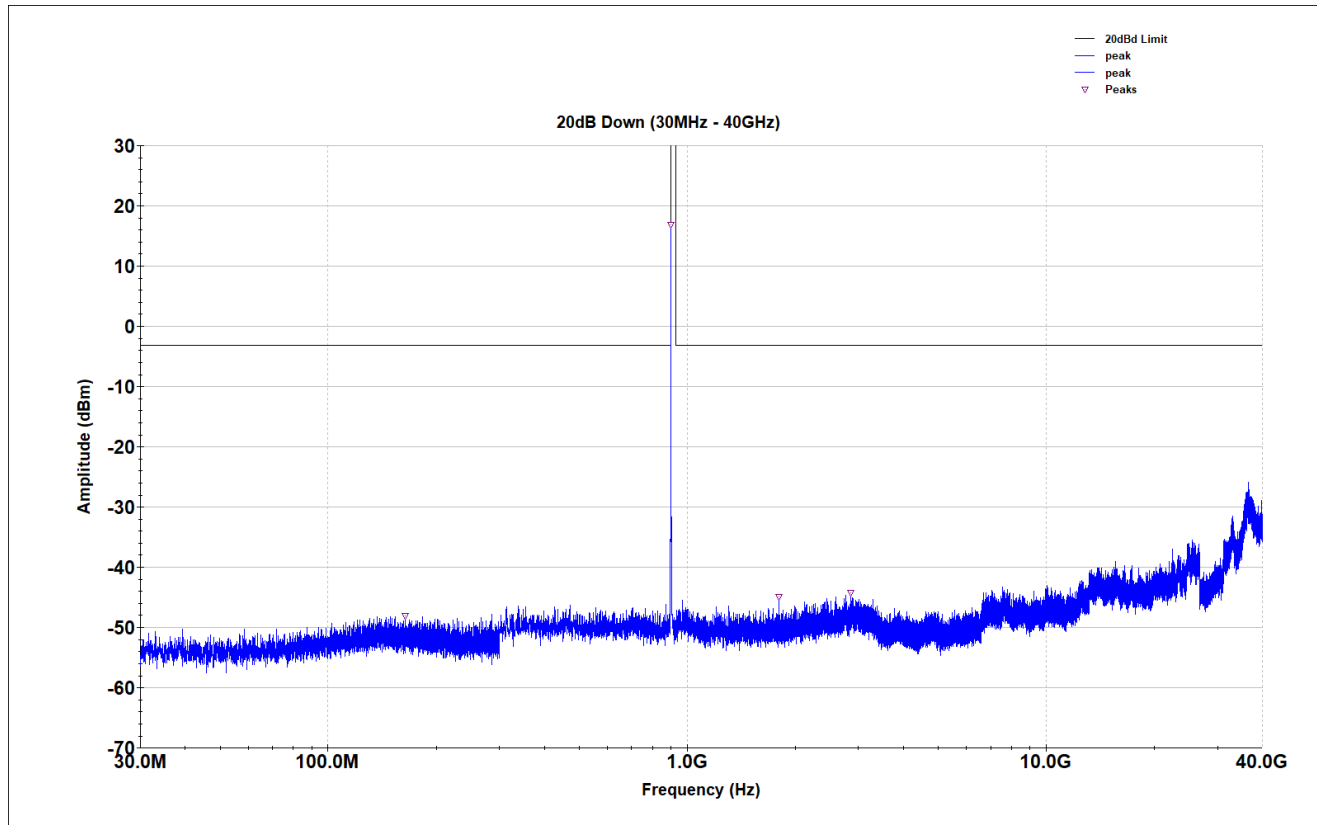


Figure 9. Low Channel, 30MHz – 40GHz Conducted Spurious Emissions

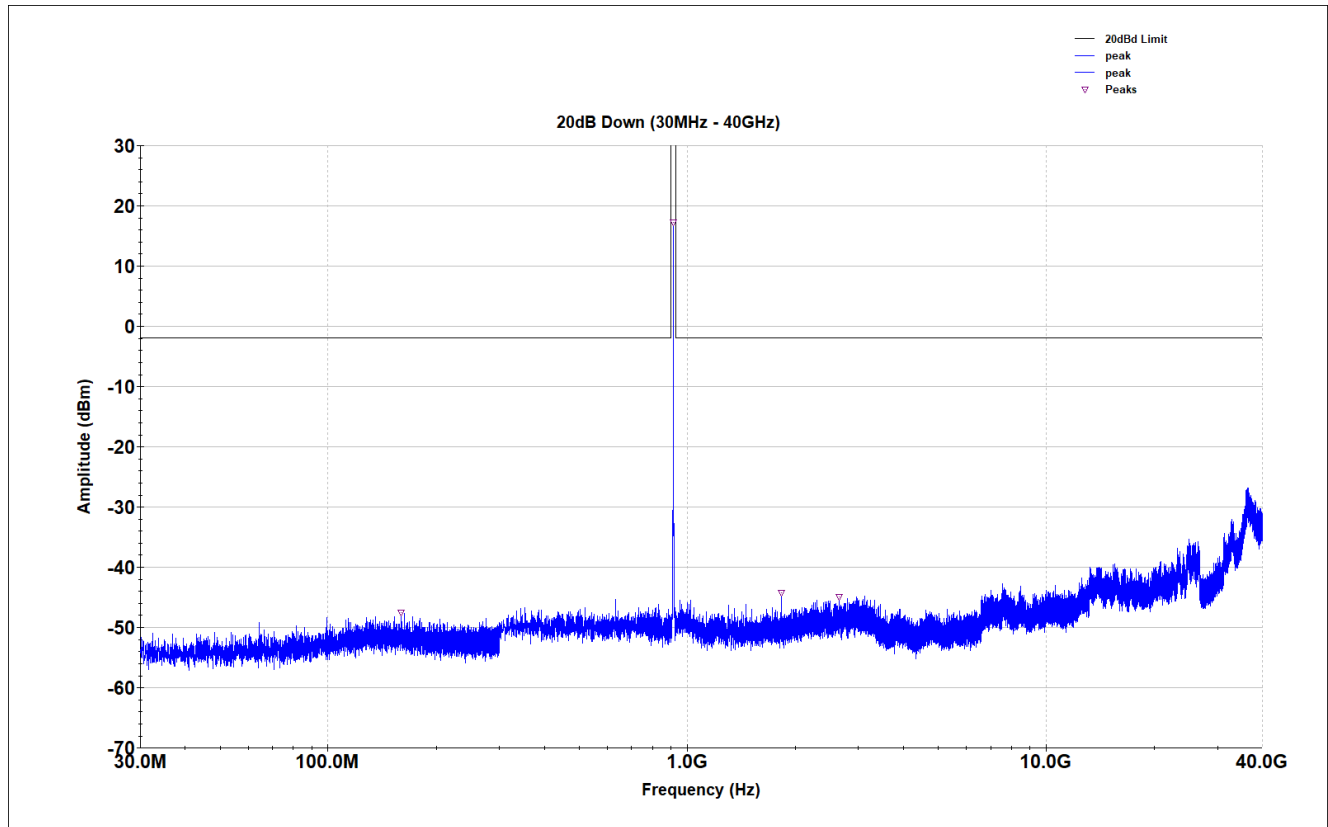


Figure 10. Mid Channel, 30MHz – 40GHz Conducted Spurious Emissions

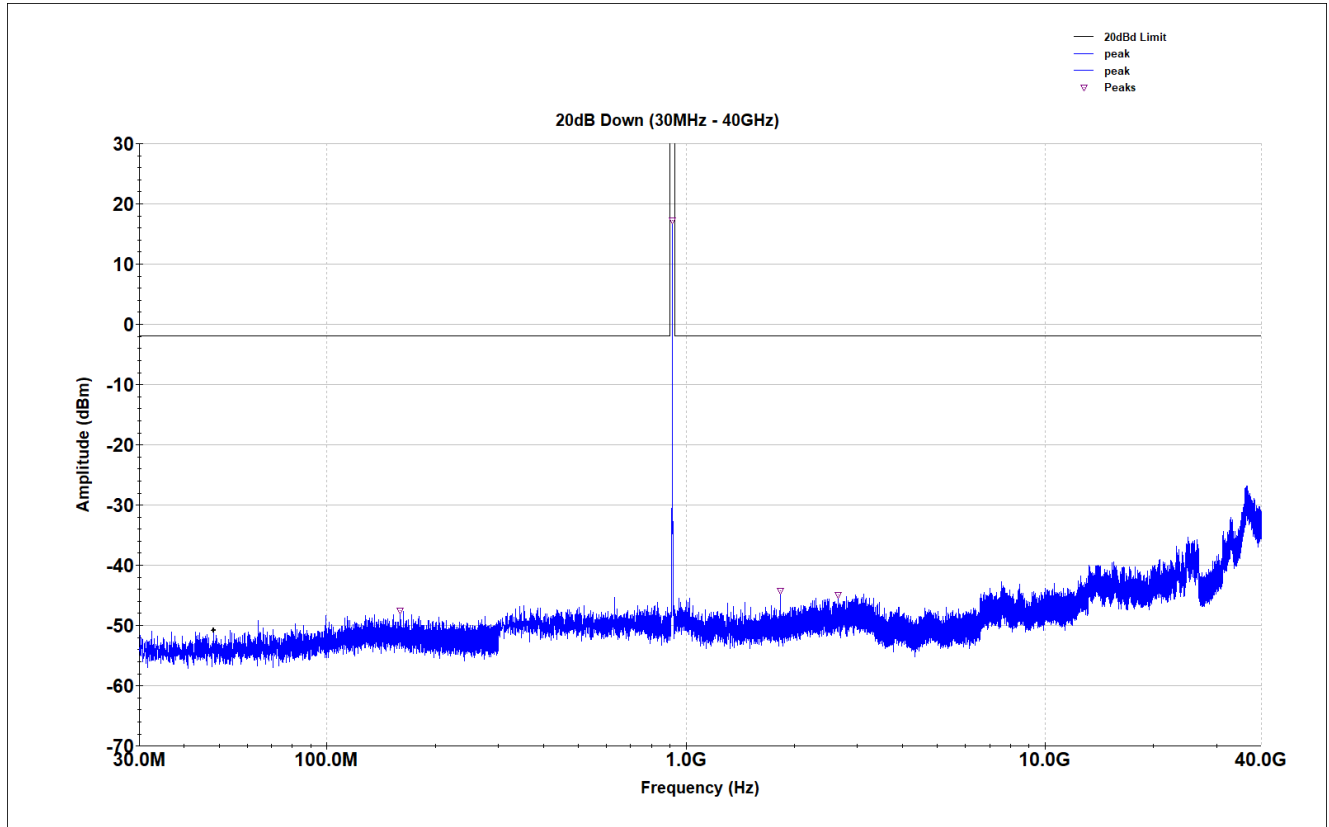
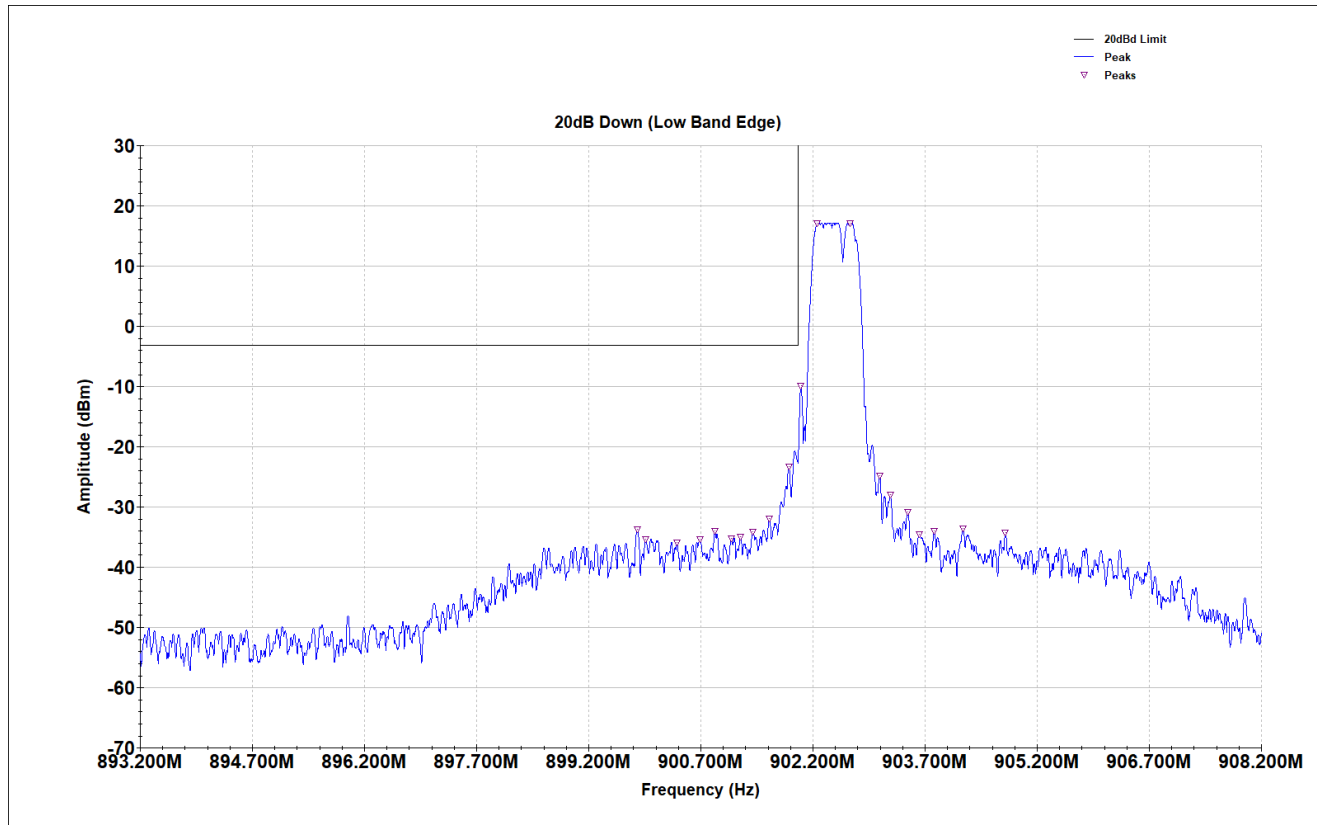
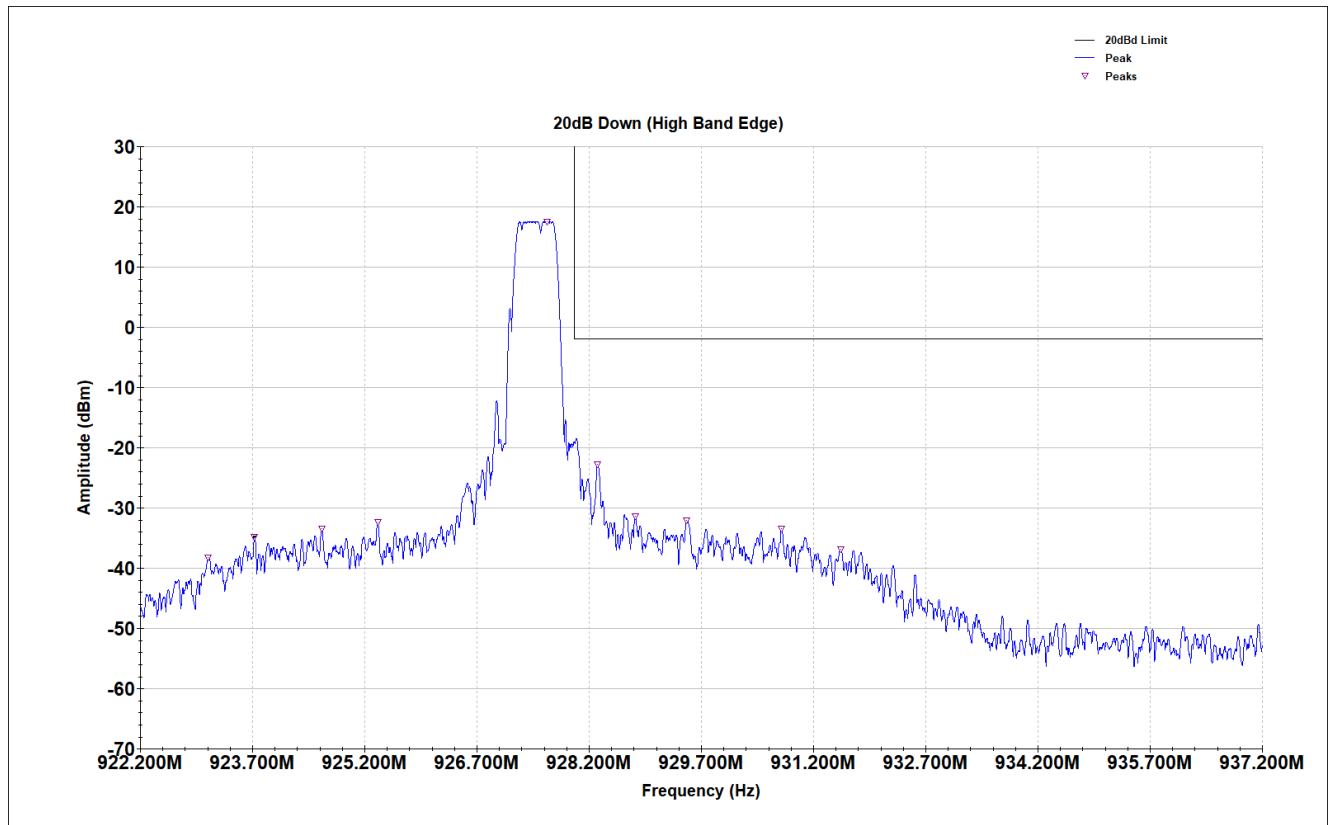


Figure 11. High Channel, 30MHz – 40GHz Conducted Spurious Emissions



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
899.851	-33.73	-3.14	30.59	Pass
899.961	-35.36	-3.14	32.22	Pass
900.378	-35.83	-3.14	32.69	Pass
900.687	-35.3	-3.14	32.16	Pass
900.889	-33.96	-3.14	30.82	Pass
901.109	-35.17	-3.14	32.03	Pass
901.232	-34.99	-3.14	31.85	Pass
901.396	-34.14	-3.14	31	Pass
901.617	-31.87	-3.14	28.73	Pass
901.876	-23.31	-3.14	20.17	Pass

Figure 12. Low Channel, Low Band Edge



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
928.316	-22.68	-1.87	20.81	Pass
928.817	-31.37	-1.87	29.5	Pass
929.507	-32.03	-1.87	30.16	Pass
930.774	-33.39	-1.87	31.52	Pass
931.562	-36.92	-1.87	35.05	Pass

Figure 13. High Channel, High Band Edge

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 15. 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 16.

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

Test Procedures: The antenna-port methodology from ANSI C63.10: 2013 Section 11.12.2 was utilized as an alternative to radiated emissions in the restricted bands.

The transmitter was connected directly to a Spectrum Analyzer through an attenuator. The power level was set to the maximum level. For frequencies below 1GHz, the RBW was set to 100 kHz and the VBW was set to 3x the RBW. For frequencies above 1GHz the RBW was set to 1MHz and the VBW was set to 3x the RBW. The spectrum analyzer was set to an auto sweep time and a peak detector was used. The maximum antenna gain was added to the measurement trace as was the appropriate maximum ground reflection factor as outlined in section 11.12.2 of ANSI C63.10. The resultant EIRP was then converted to an equivalent electric field strength which is shown on the graphical plots which follow. Measurements were carried out at the low, mid and high channels.

In order to assess the cabinet radiated spurious emissions, a radiated scan was performed with the antenna of proper impedance installed. 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).

Test Engineer(s): Bryan Taylor, Sergio Gutierrez

Test Date(s): 12/15/2023 – 1/4/2023

Radiated Spurious Emissions Test Results

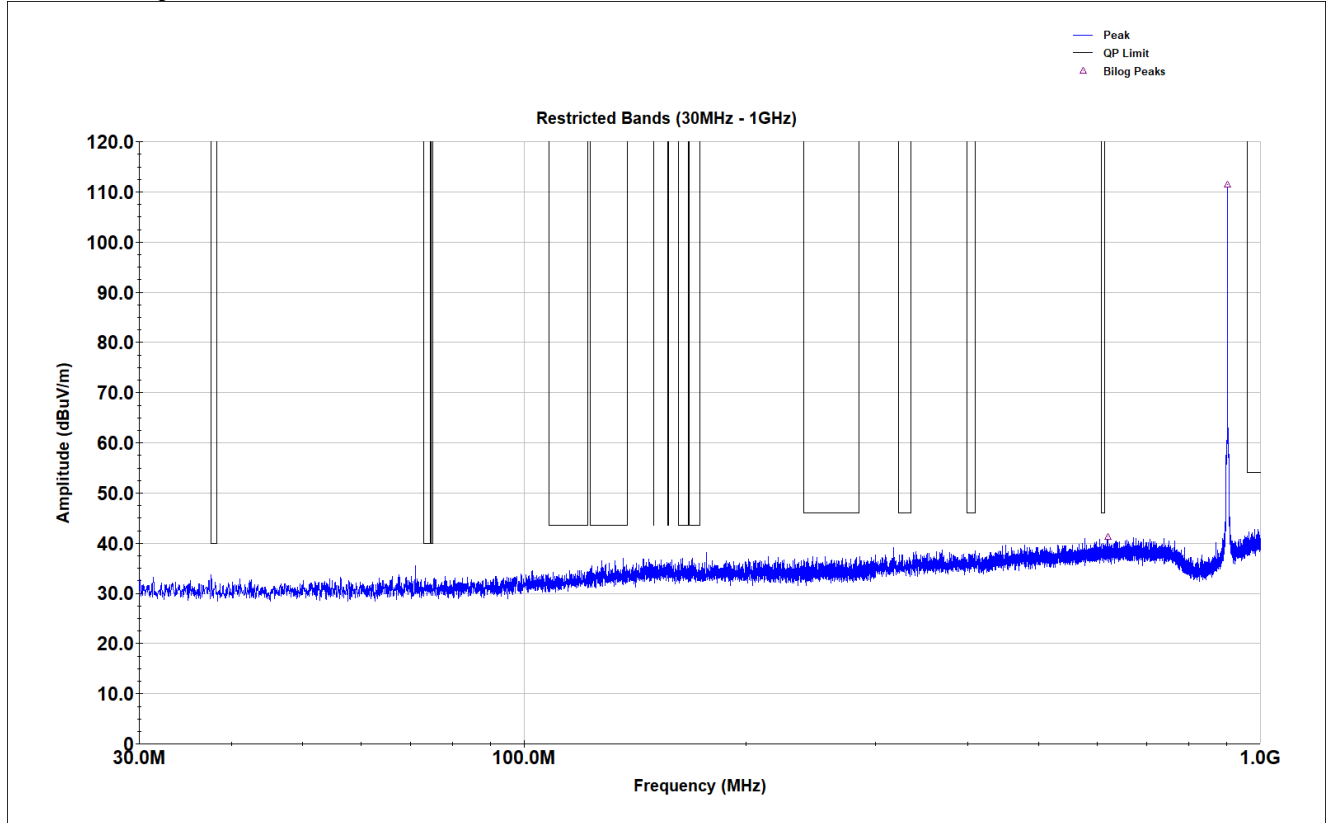


Figure 14. Low Channel, 30MHz – 1GHz Restricted Band Spurious Emissions

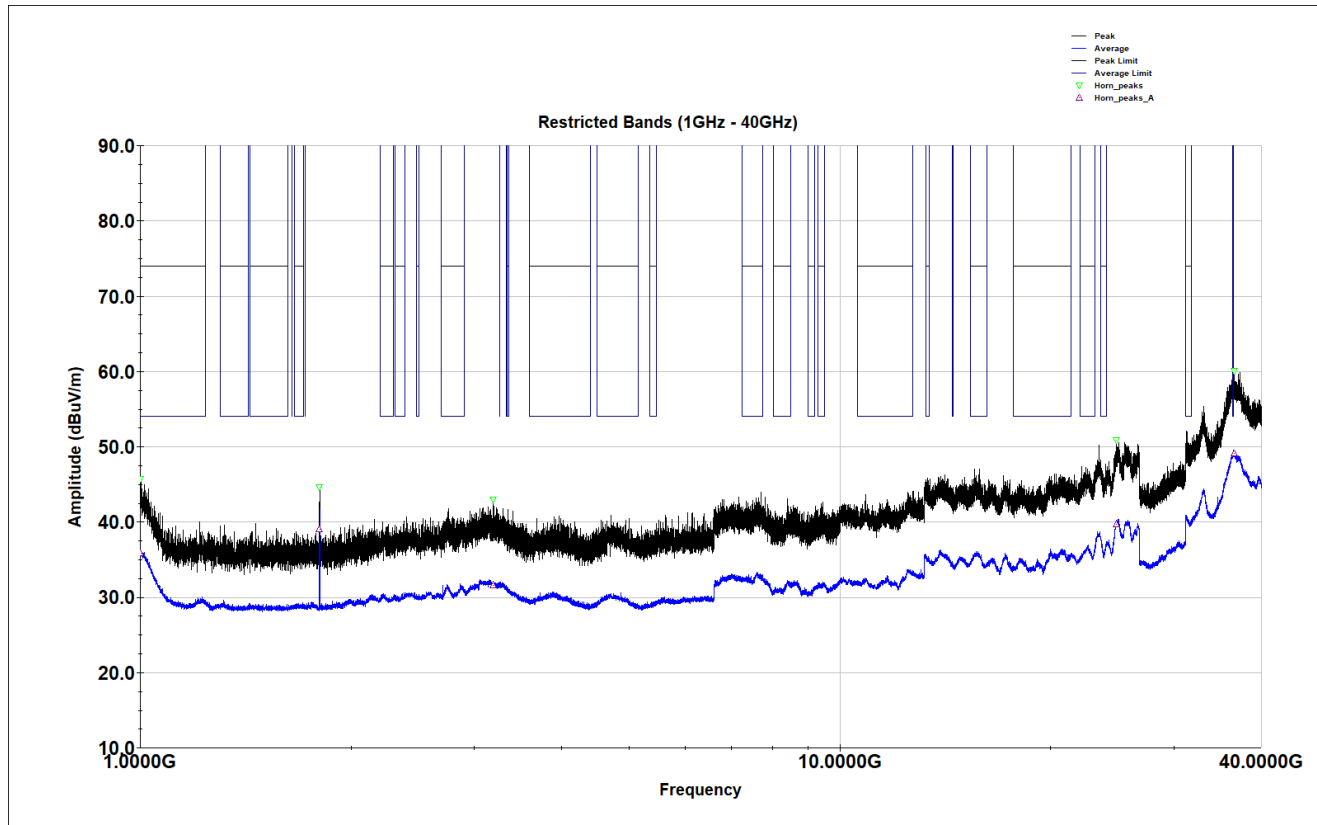


Figure 15. Low Channel, 1GHz – 40GHz Restricted Band Spurious Emissions

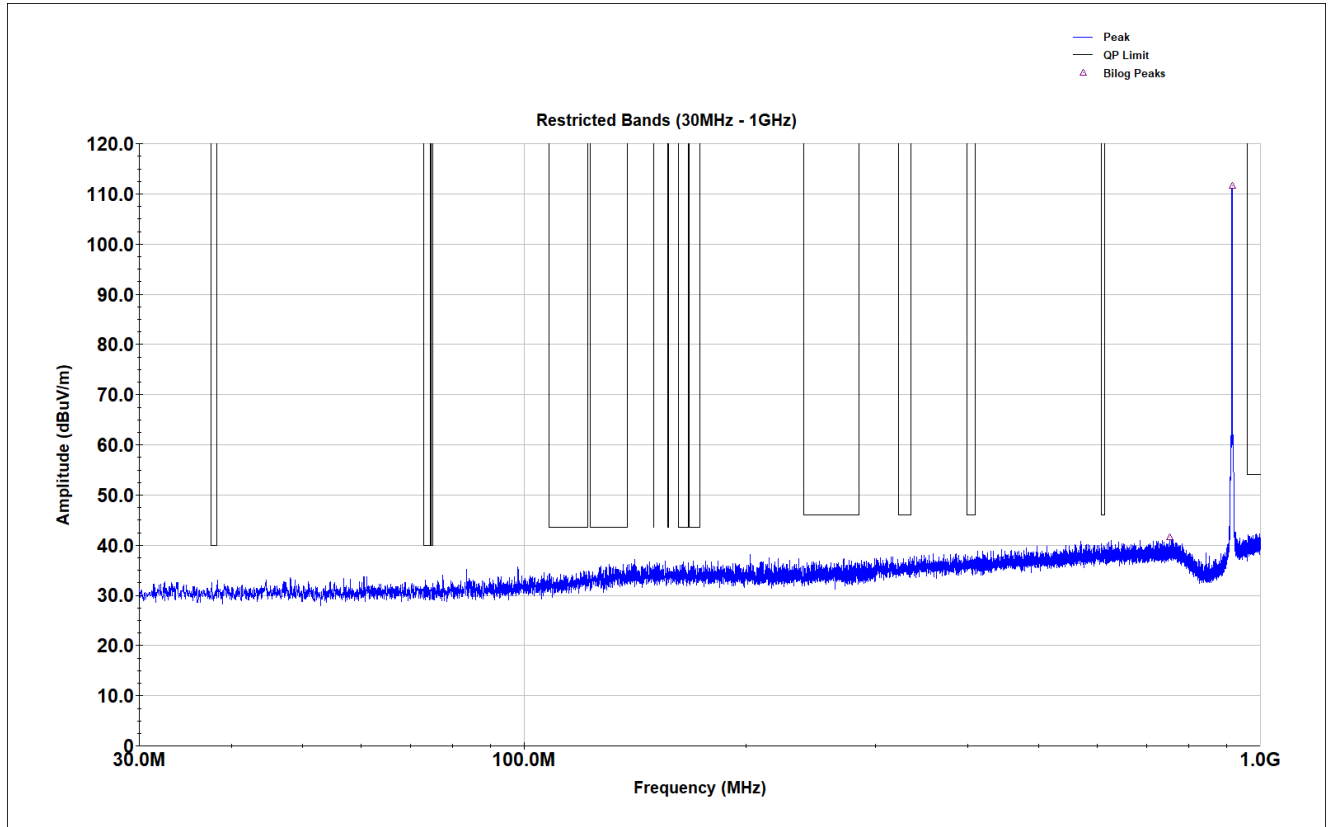


Figure 16. Middle Channel, 30MHz – 1GHz Restricted Band Spurious Emissions

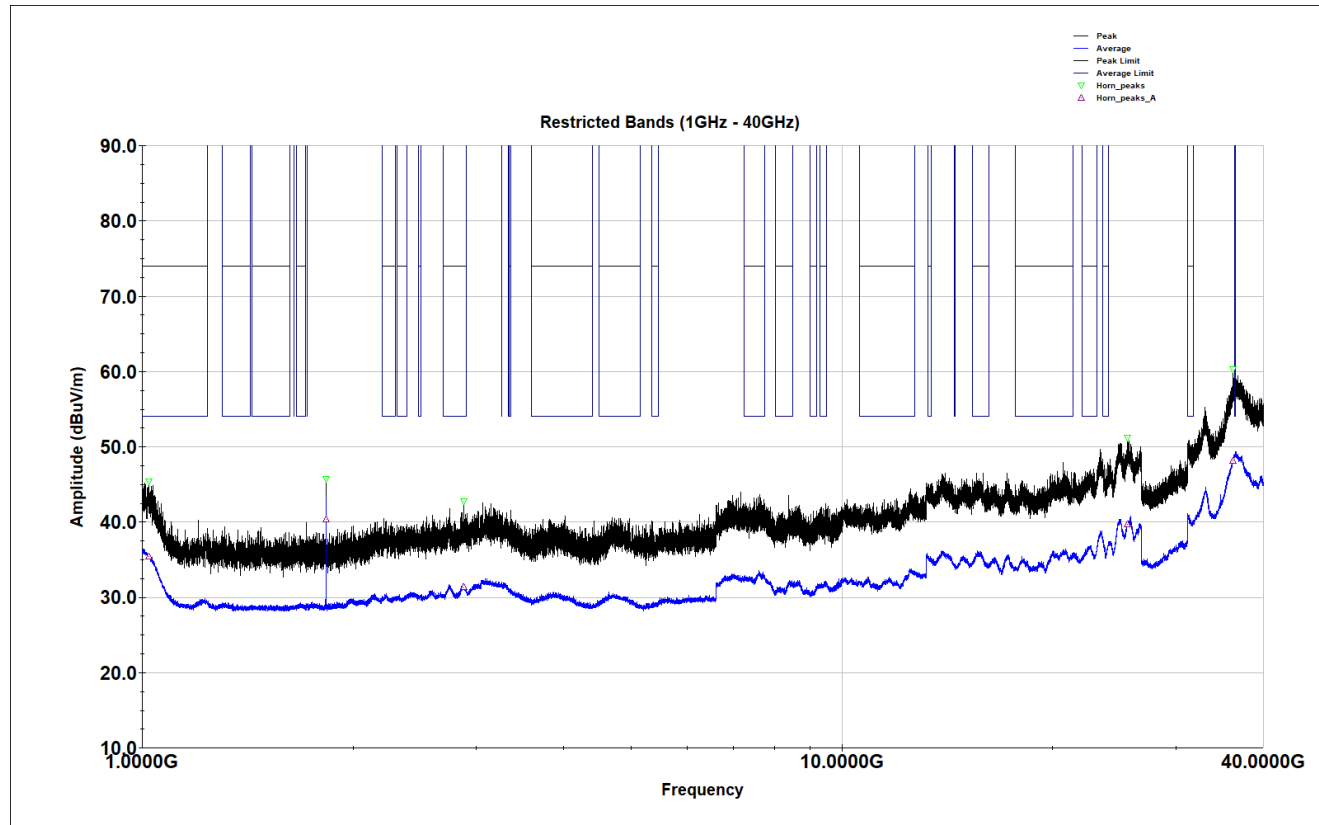


Figure 17. Middle Channel, 1GHz – 40GHz Restricted Band Spurious Emissions

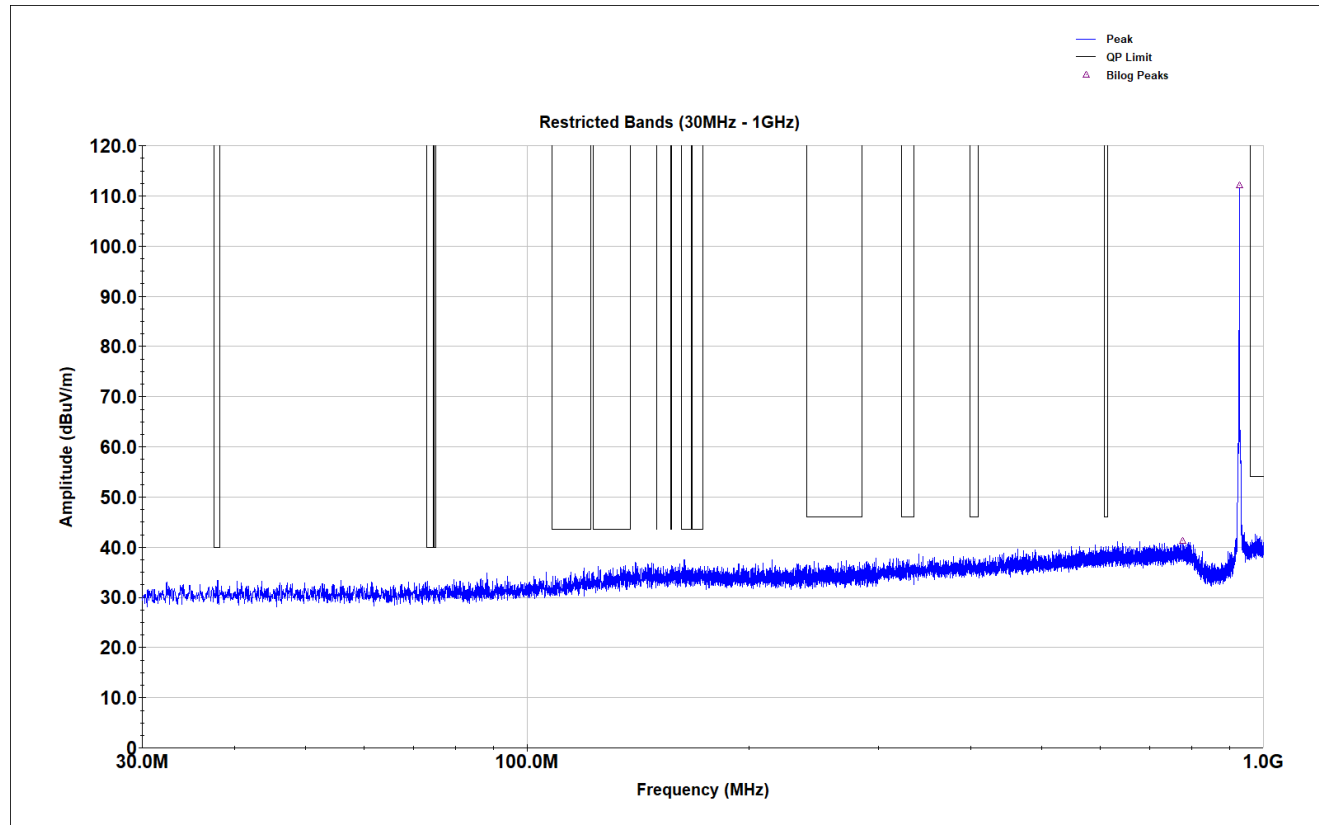


Figure 18. High Channel, 30MHz – 1GHz Restricted Band Spurious Emissions

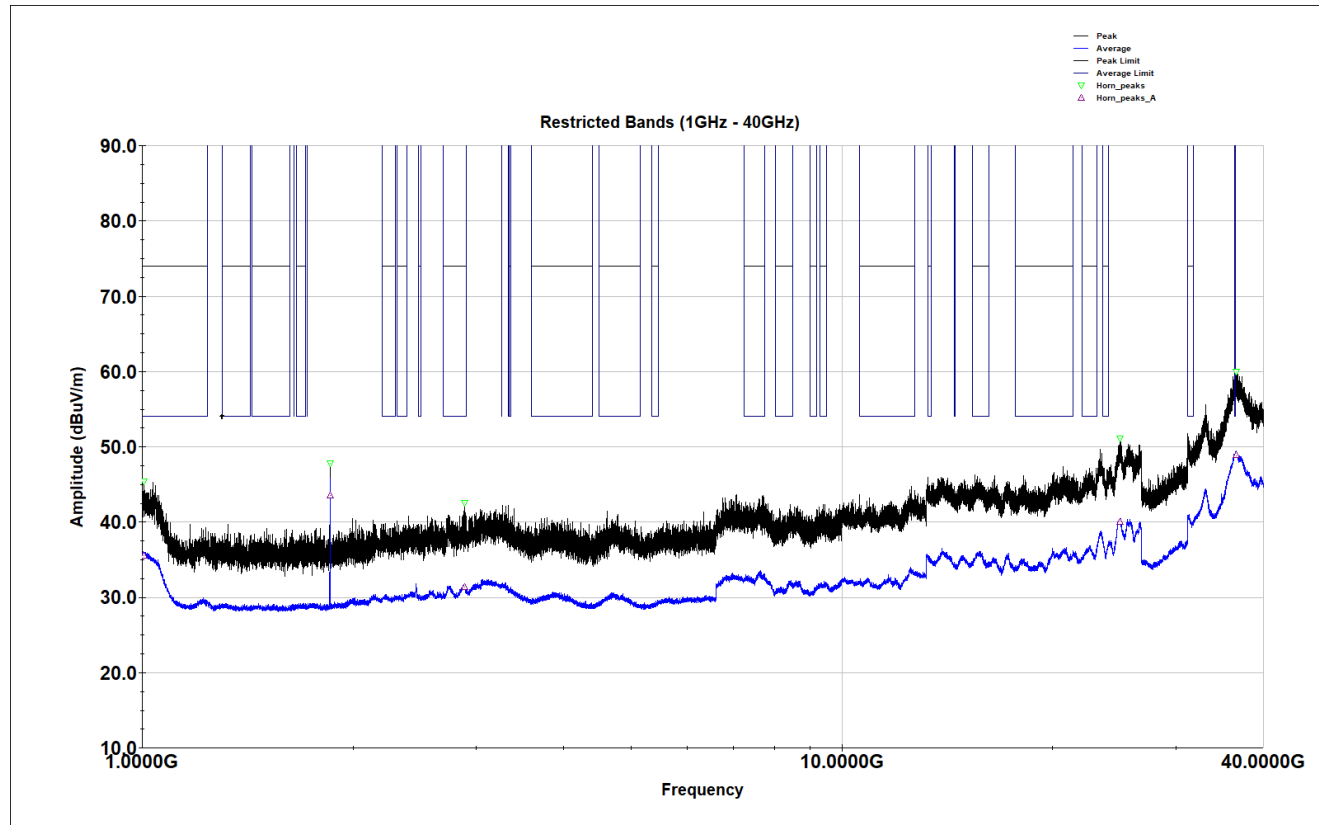


Figure 19. High Channel, 1GHz – 40GHz Restricted Band Spurious Emissions

Worst Case Cabinet Spurious Emissions

Frequency [MHz]	QPK Level [dBμV/m]	QPK Limit [dBμV/m]	QPK Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
112.080	11.61	43.52	31.91	-7.73	H	227.8	3.99	120.000	Pass
122.310	11.73	1,000.00	988.27	-7.56	V	102.4	1.33	120.000	Pass
131.010	11.34	43.52	32.18	-7.93	H	84.2	2.49	120.000	Pass
259.080	14.55	46.02	31.47	-5.45	H	42.2	2.94	120.000	Pass
259.950	14.65	46.02	31.37	-5.37	V	16.9	3.88	120.000	Pass

Figure 20. Worst Case Cabinet Radiation, Below 1GHz

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
1,041.500	46.17	74.00	27.83	33.09	54.00	20.91	-0.62	H	357.7	2.29	Pass
2,745.000	55.80	74.00	18.20	52.80	54.00	1.20	-2.74	H	267.7	2.37	Pass
2,745.500	54.78	74.00	19.22	52.30	54.00	1.70	-2.74	V	56.8	2.37	Pass
10,671.000	47.43	74.00	26.57	34.24	54.00	19.76	-0.92	V	345.6	1.42	Pass
15,718.500	47.52	74.00	26.48	34.92	54.00	19.08	0.96	H	360.2	2.15	Pass
19,828.000	50.74	74.00	23.26	37.79	54.00	16.21	12.65	H	360.3	3.77	Pass
22,627.000	50.49	74.00	23.51	37.49	54.00	16.51	14.20	V	38.4	2.28	Pass

Figure 21. Worst Case Cabinet Radiation, Above 1GHz

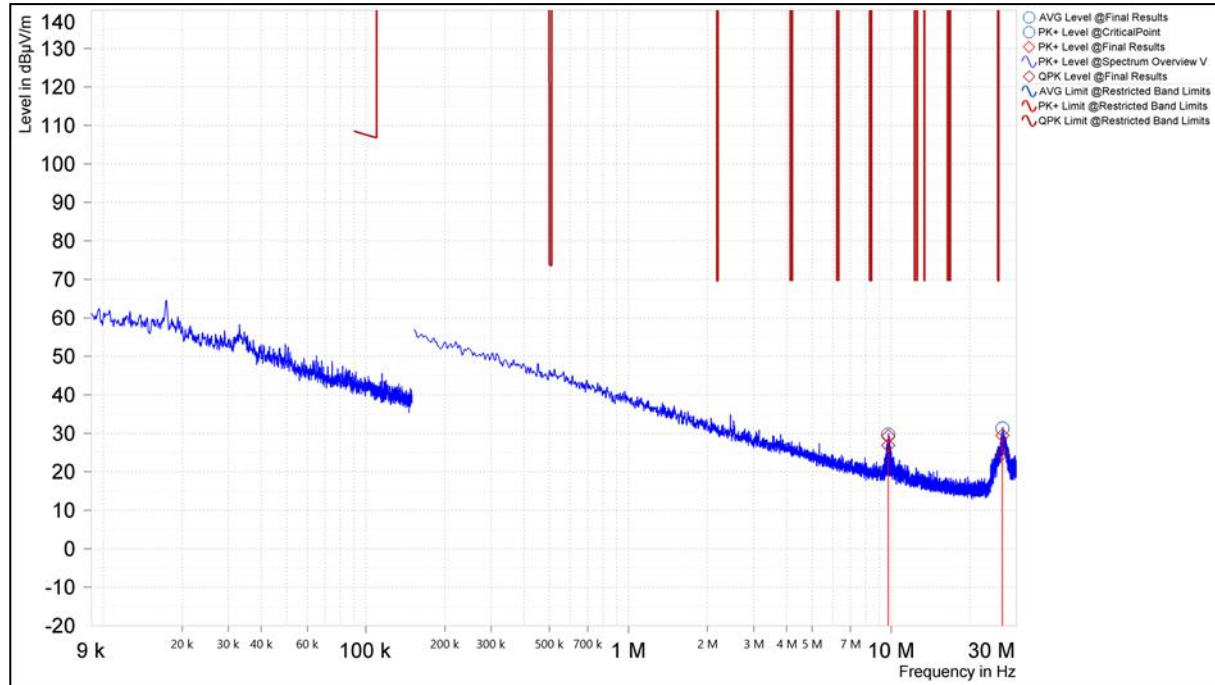


Figure 22. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coaxial Loop

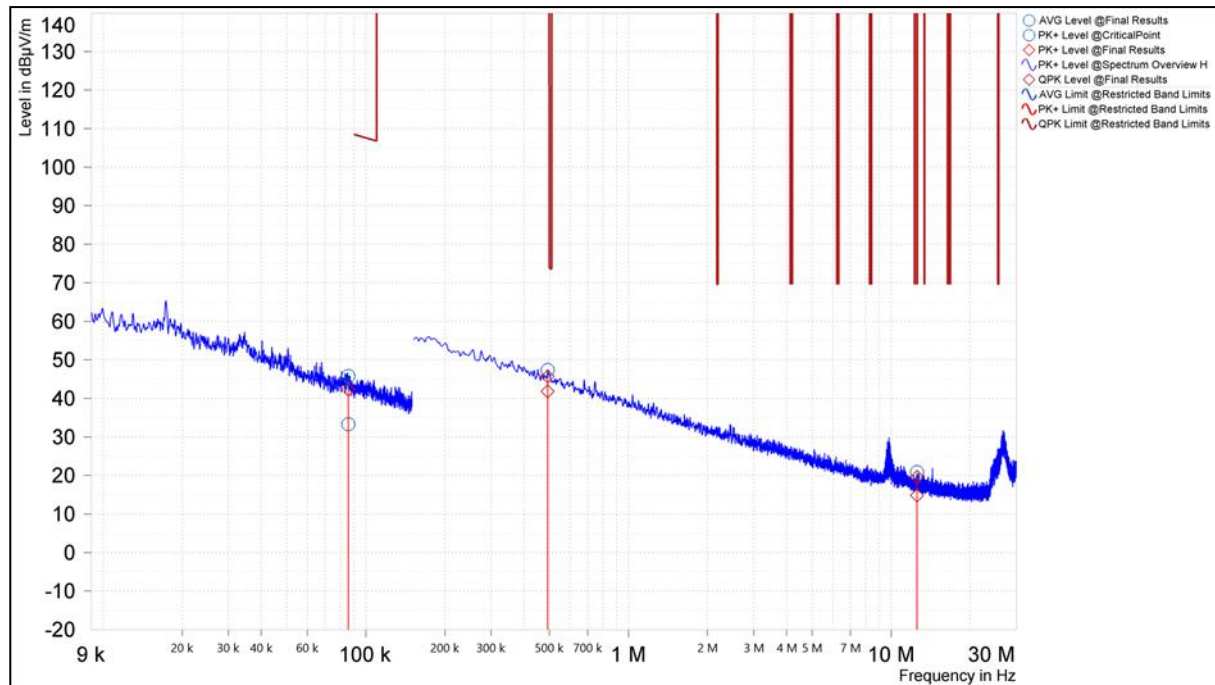


Figure 23. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coplanar Loop

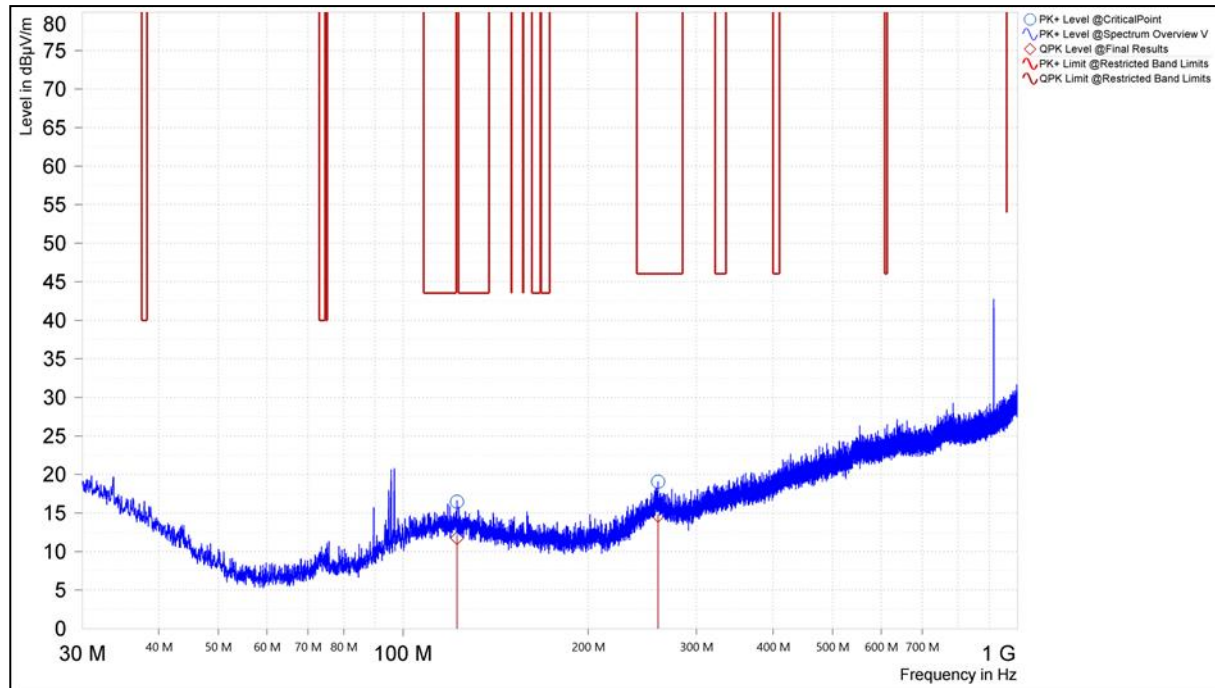


Figure 24. Worst Case Cabinet Radiation, 30MHz – 1GHz, Vertical Polarity

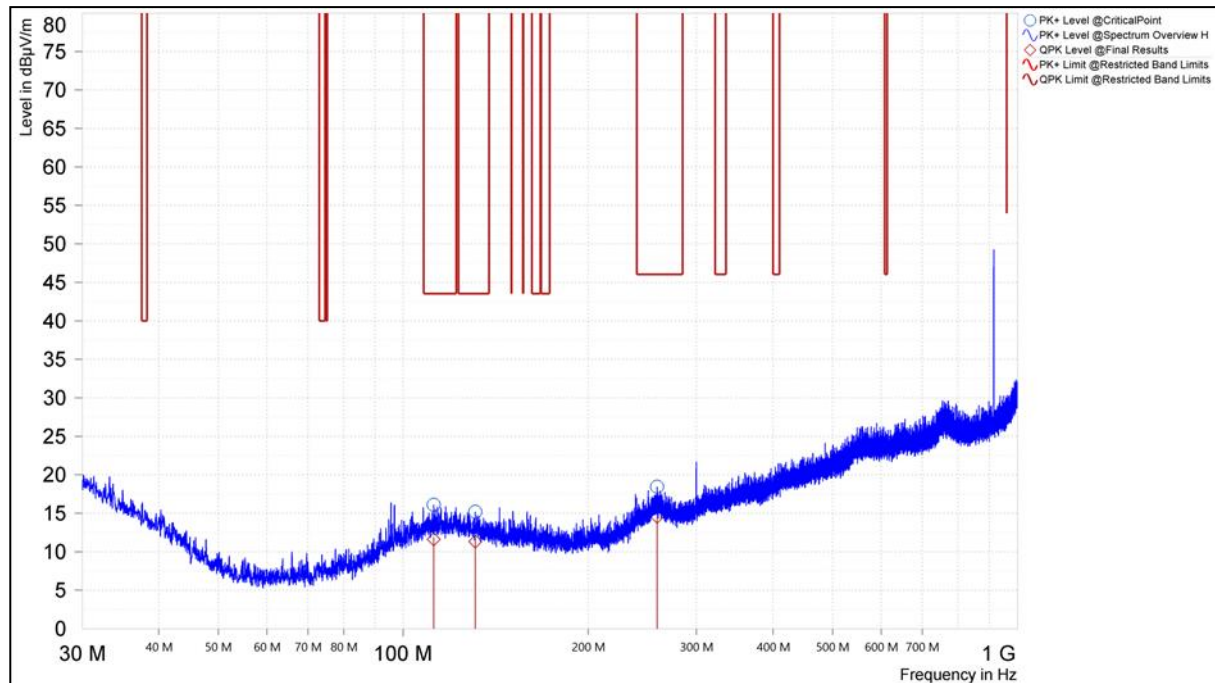


Figure 25. Worst Case Cabinet Radiation, 30MHz – 1GHz, Horizontal Polarity

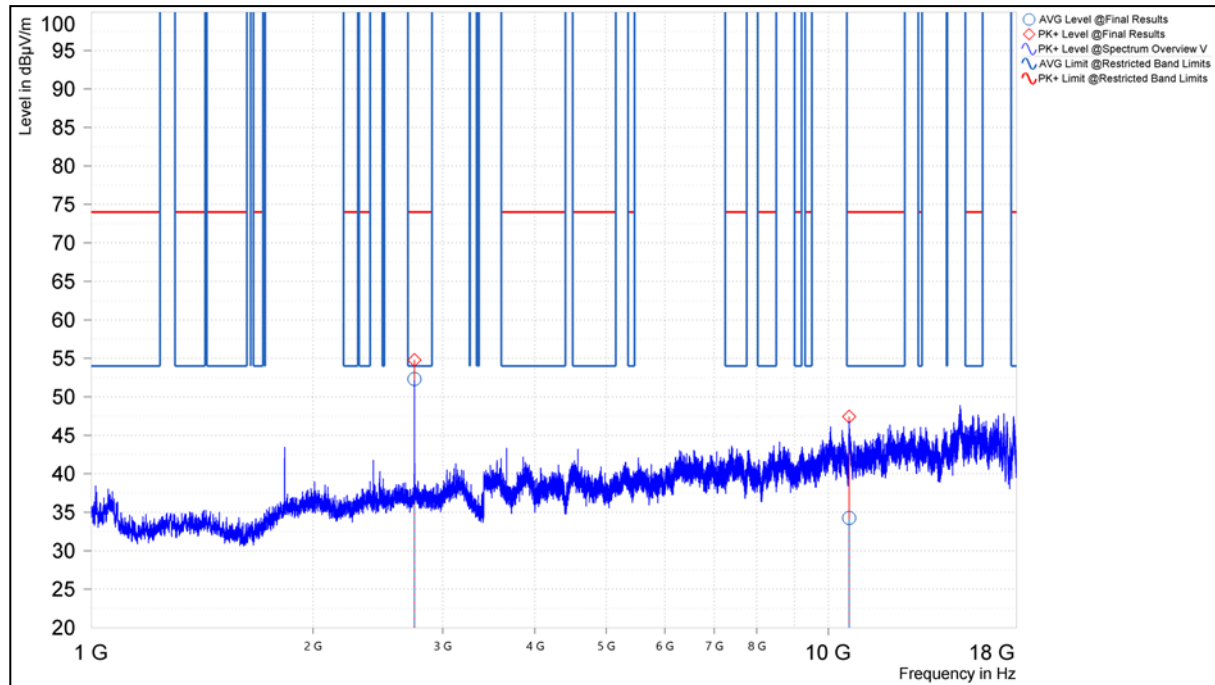


Figure 26. Worst Case Cabinet Radiation, 1GHz – 18GHz, Vertical Polarity

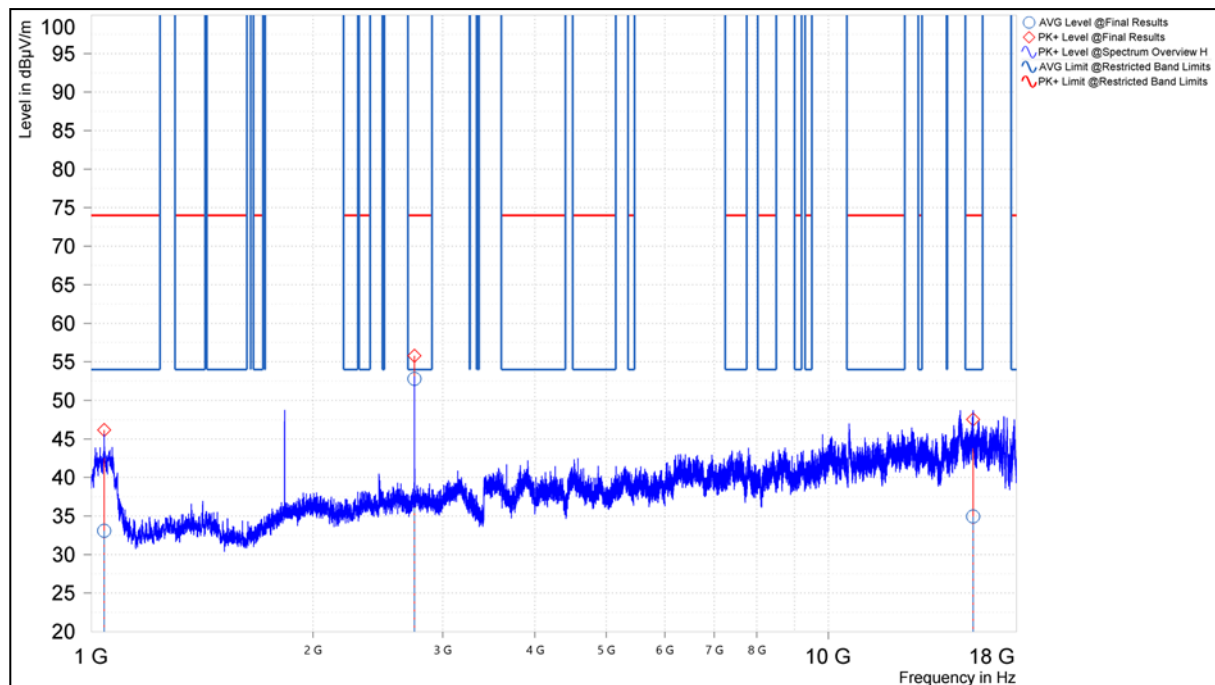


Figure 27. Worst Case Cabinet Radiation, 1GHz – 18GHz, Horizontal Polarity

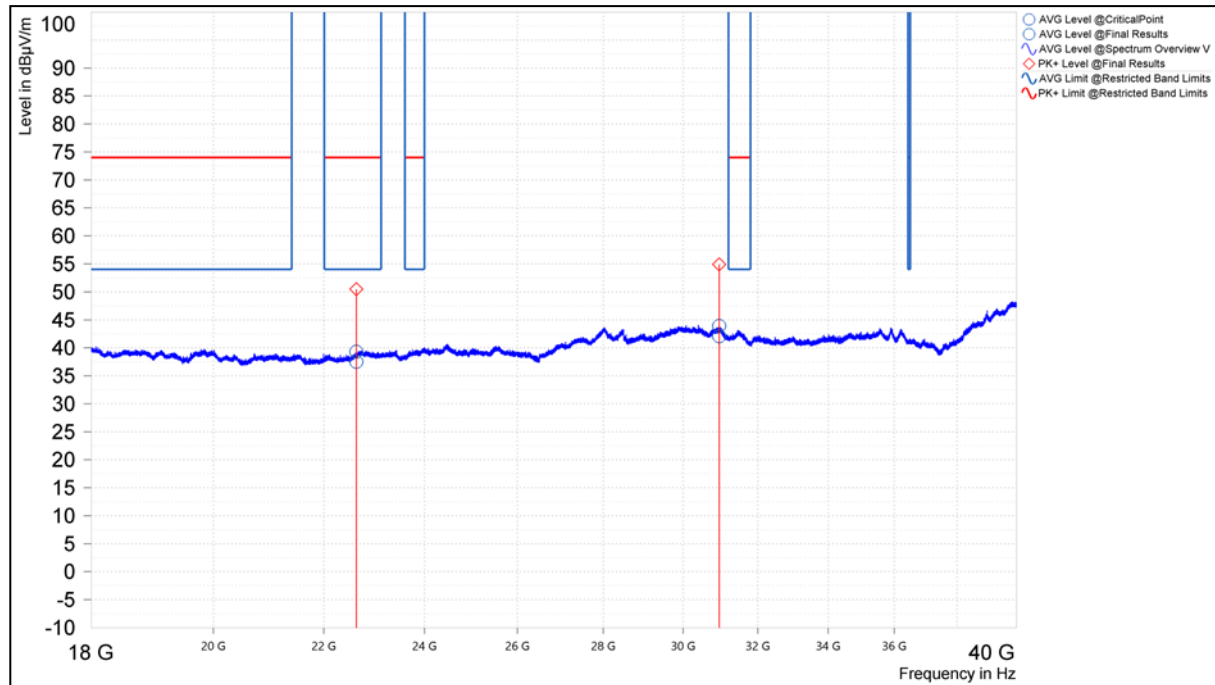


Figure 28. Worst Case Cabinet Radiation, 18GHz – 40GHz, Vertical Polarity

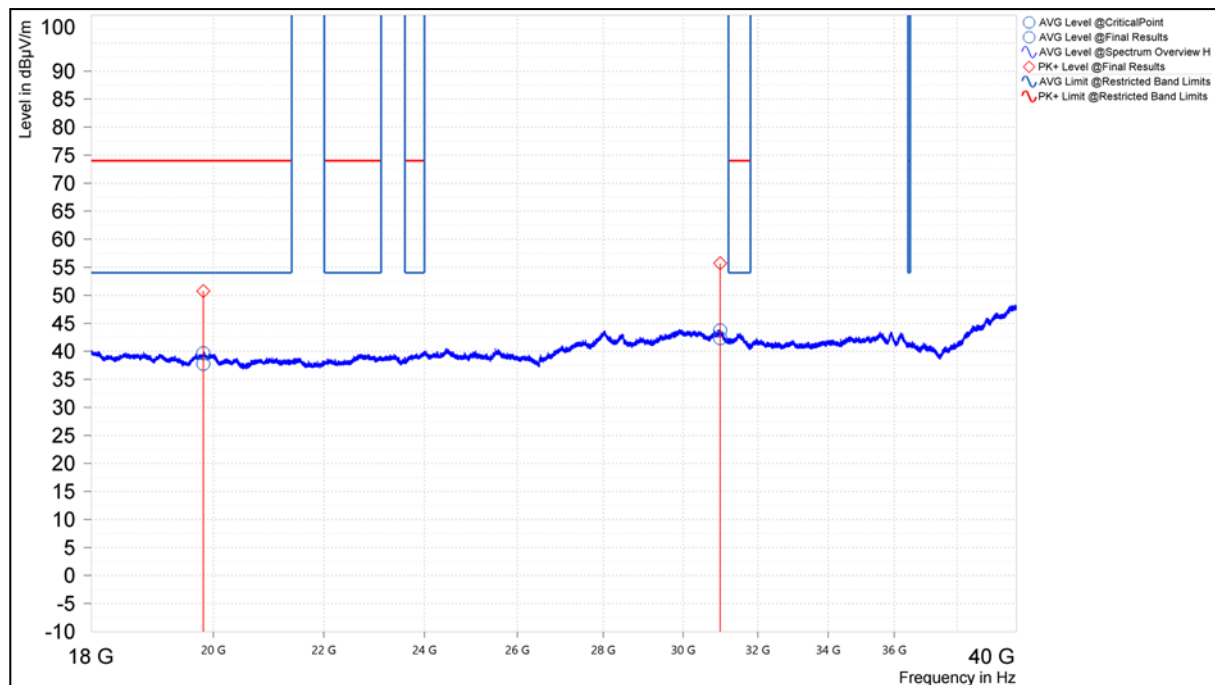


Figure 29. Worst Case Cabinet Radiation, 18GHz – 40GHz, Horizontal Polarity

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
1A1083	Receiver	Rohde & Schwarz	ESU40	11/20/2023	11/20/2024
1A1176	Active Loop Antenna (9KHz-30MHz)	ETS-Lindgren	6502	7/13/2023	7/13/2024
1A1050	Bilog Antenna (30MHz – 1GHz)	Schaffner	CBL 6112D	1/24/2023	1/24/2024
1A1183	Horn Antenna (1GHz – 18GHz)	ETS Lindgren	3117	1/4/2023	1/4/2024
1A1161	Horn Antenna (18GHz – 40GHz)	ETS Lindgren	3116C	7/11/2023	7/11/2024
1A1065	EMI Receiver	Rohde & Schwarz	ESCI	8/4/2023	8/4/2024
1A1087	Pulse Limiter	Rohde & Schwarz	ESH3Z2	12/21/2022	12/21/2023
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 17. Test Equipment List

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

End of Report