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7/1/2024
HID Global Corporation (US)
6533 Flying Cloud Drive, Ste. 1000
Eden Prairie, MN 55344
USA

Dear Chris Armstrong,

Enclosed is the EMC Wireless test report for compliance testing of the HID Global Corporation (US) 40T 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 Bluetooth Low Energy (BLE) transmitter onboard which operates in the 2400-2483.5MHz 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: WIRA129255-FCC-IC-BLE_R2

Bluetooth Low Energy
Test Report

for the

HID Global Corporation (US)
Signo Tactile (Model:40T)

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
∅	1/24/2024	Initial Issue.
1	3/21/2024	Corrections requested by HID
2	7/1/2024	Corrections requested by reviewer

Table of Contents

List of Tables

List of Figures

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 40T, with the requirements of FCC Part 15.247 and RSS-247 Issue 3. HID Global Corporation (US) should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the 40T, 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 HID Global Corporation (US) purchase order number HID019245. All tests were conducted using measurement procedures ANSI C63.4-2014 and ANSI C63.10-2013.

FCC Reference 47 CFR Part 15.247	IC Reference RSS-247 Issue 3 RSS-GEN Issue 5	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 HID Global Corporation (US) to perform testing on the 40T, under HID Global Corporation (US)'s purchase order number HID019245.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the 40T.

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

Product Name:	Signo Tactile	
Model(s) Tested:	40T (Terminal)	
Model(s) Covered:	40T (Pigtail and Terminal)	
Serial Number or Sample Number:	Test Sample 1	
EUT Specifications:	Primary Power: 12VDC	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	0.610dBm
	EUT Frequency Ranges:	2402MHz – 2480MHz
	Antenna Gain[1]:	-1.9dBi
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):	10/24/2023 through 12/20/2023	

Table 2. EUT Summary Table

[1] The antenna gain information was provided by HID Global Corporation (US) 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 Signo Tactile (Model: 40T) is a smartcard reader typically installed near doorway as part of physical access system, to control access to that door. A user will approach the door and present a BLE or RFID credentials to the reader with intention of entering the door. The reader will read the credential and send its data to a connected access control panel, which determine whether or not grant the user access to the door. Optionally, a personal identification number (PIN) may also be required, in which case the user will enter the PIN on the reader's keypad.

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	Laptop Computer	Dell	NA	NA
None	12V Battery	Duracell	DURA12-8F2	None
None	12V AC/DC Power Supply	Unknown	Unknown	None

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
DC Power Cable	1	2m	N	12V Battery
Wiring Harness	1	2m	Y	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]
2400 – 2483.5MHz (1MBps)	BLE (GFSK)	2402MHz / 2440MHz / 2480MHz	0dBm
2400 – 2483.5MHz (2Mps)	BLE (GFSK)	2402MHz / 2440MHz / 2480MHz	0dBm

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

An RF connector was soldered into place of the BLE antenna to facilitate conducted antenna port measurements.

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 HID Global Corporation (US) 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 is permanently attached to the unit (criteria a).

Test Engineer(s): Bryan Taylor

Test Date(s): 10/24/2023

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 μH/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 (dBμV)	
	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)

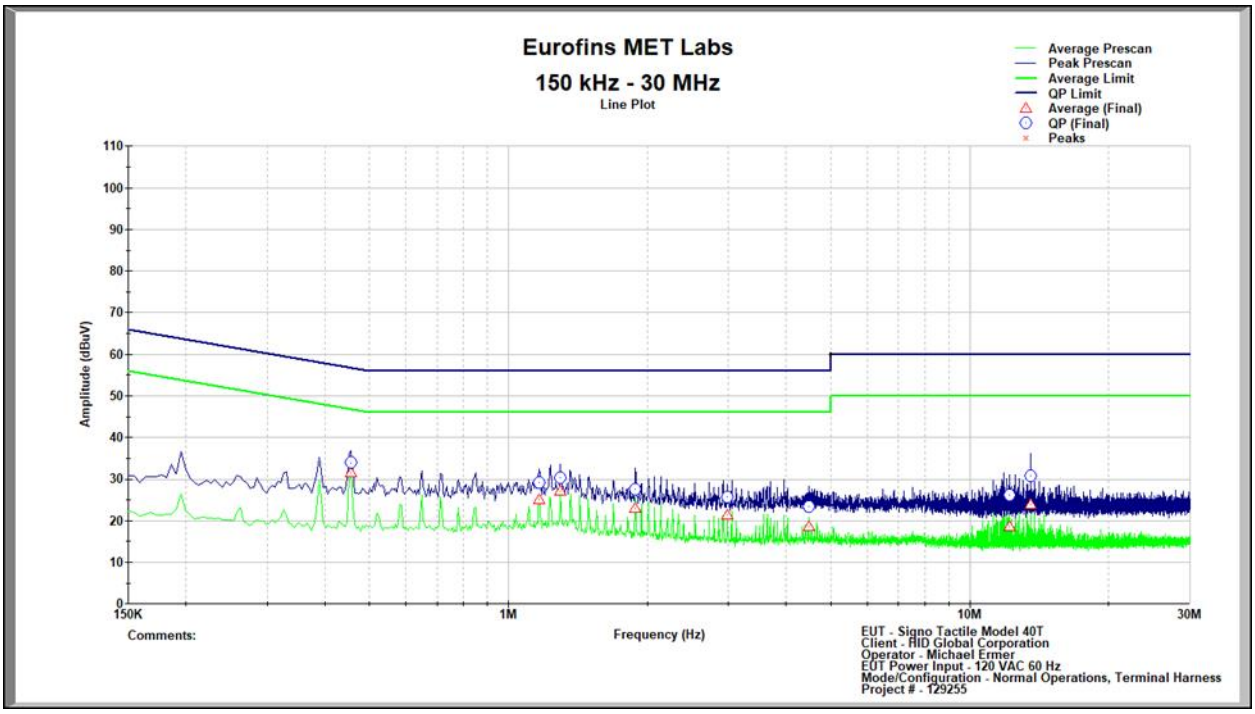
Test Procedure: The EUT was placed on a 0.8 m-high wooden table. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 μH 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 μH 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 Signo Tactile was powered via an external AC/DC Power adapter which was connected to the LISN during the testing.

Test Engineer(s): Michael Ermer

Test Date(s): 10/24/2023

15.207(a) Conducted Emissions Test Results

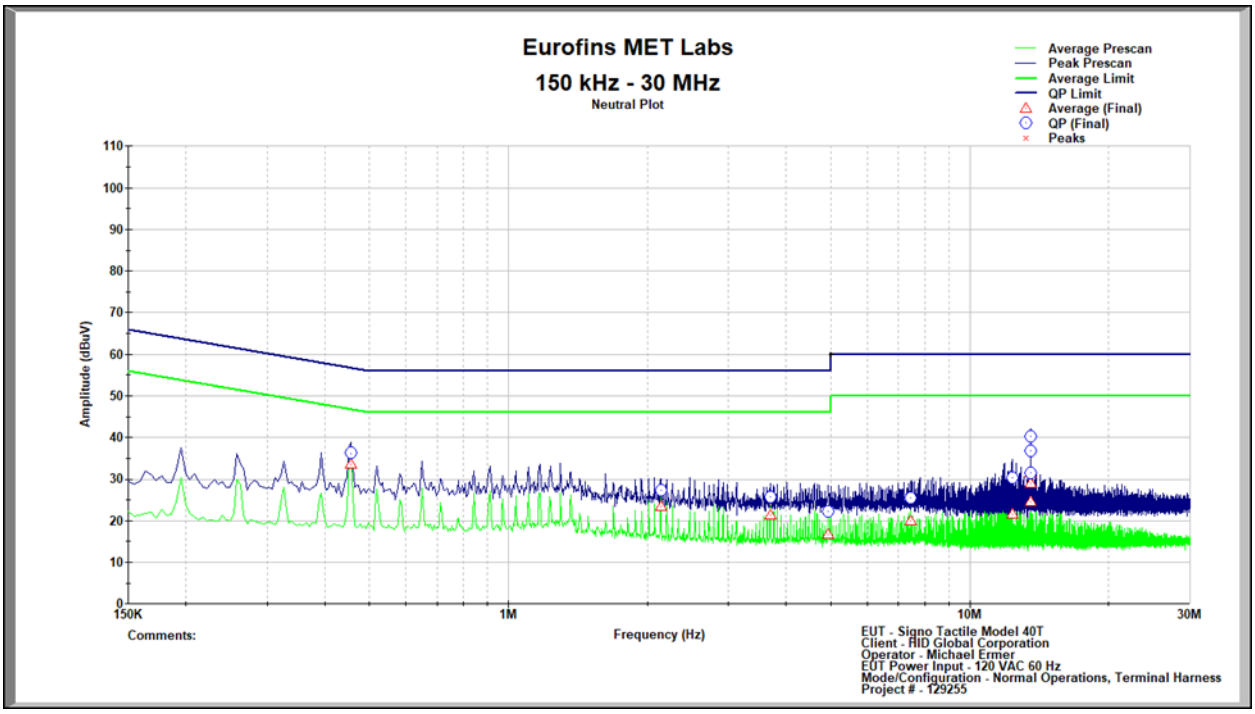


Conducted Emissions, 15.207(a), Phase

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)
0.456	33.920	57.257	23.337	31.491	47.257	15.766
1.167	29.102	56.000	26.898	24.962	46.000	21.038
1.298	30.410	56.000	25.590	27.060	46.000	18.940
1.883	27.475	56.000	28.525	22.837	46.000	23.163
2.981	25.611	56.000	30.389	21.285	46.000	24.715
4.471	23.415	56.000	32.585	18.628	46.000	27.372
12.211	26.248	60.000	33.752	18.458	50.000	31.542
13.566	30.723	60.000	29.277	23.775	50.000	26.225

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)
0.456	36.234	57.257	21.023	33.524	47.257	13.733
2.139	27.426	56.000	28.574	23.377	46.000	22.623
3.693	25.657	56.000	30.343	21.244	46.000	24.756
4.939	22.227	56.000	33.773	16.606	46.000	29.394
7.452	25.463	60.000	34.537	19.901	50.000	30.099
12.342	30.426	60.000	29.574	21.472	50.000	28.528
13.557	36.905	60.000	23.095	28.850	50.000	21.150
13.562	40.181	60.000	19.819	31.488	50.000	18.512
13.566	31.434	60.000	28.566	24.593	50.000	25.407

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 is shown on the plots on the following pages.

Test Engineer(s): Bryan Taylor

Test Date(s): 10/24/2023

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 rang between two points, one above and the other blow 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 is shown on the plots on the following pages.

Test Engineer(s): Bryan Taylor

Test Date(s): 10/23/2023

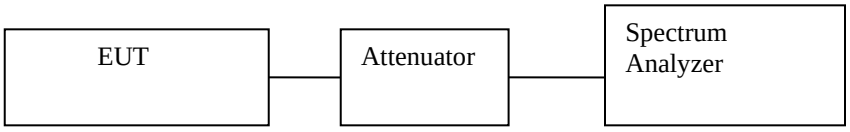
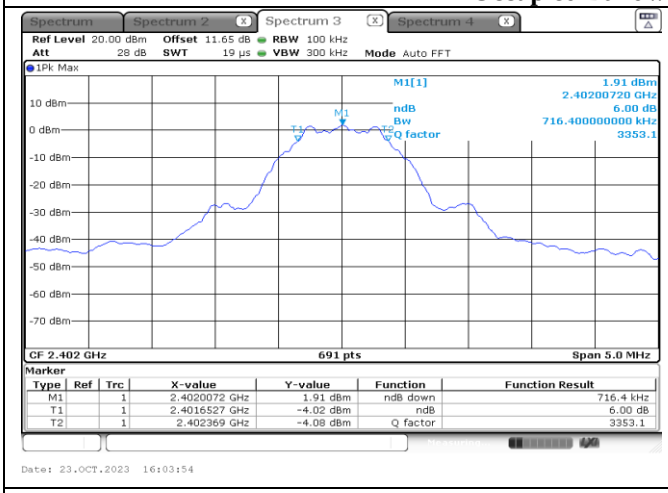
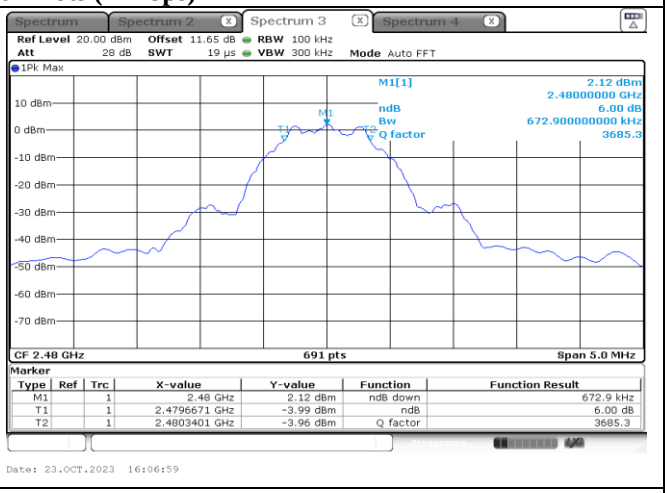
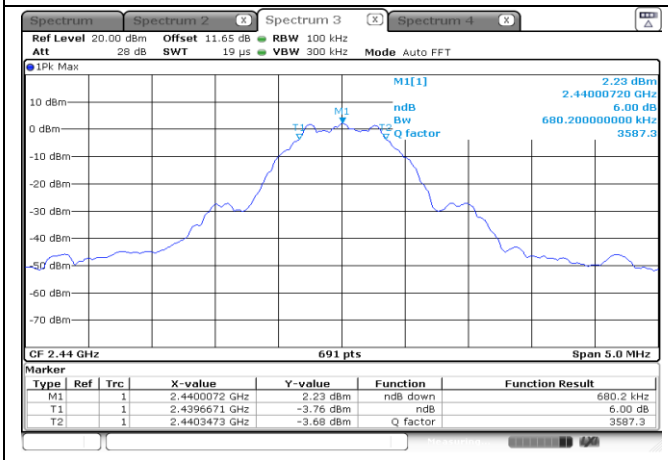
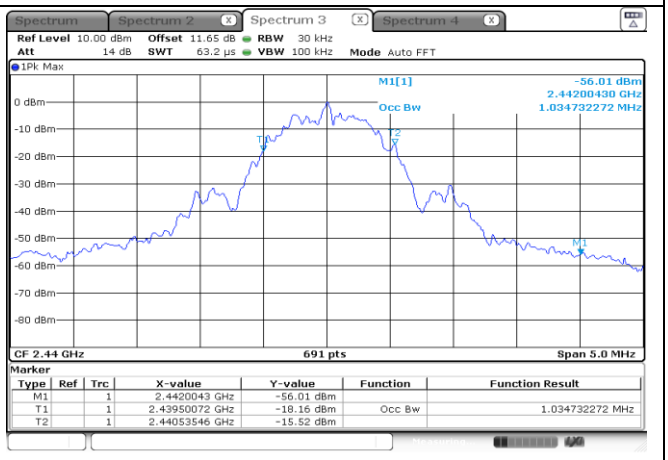
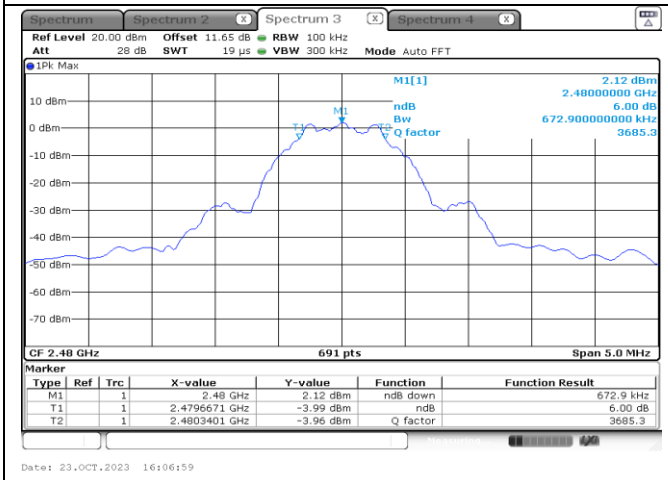
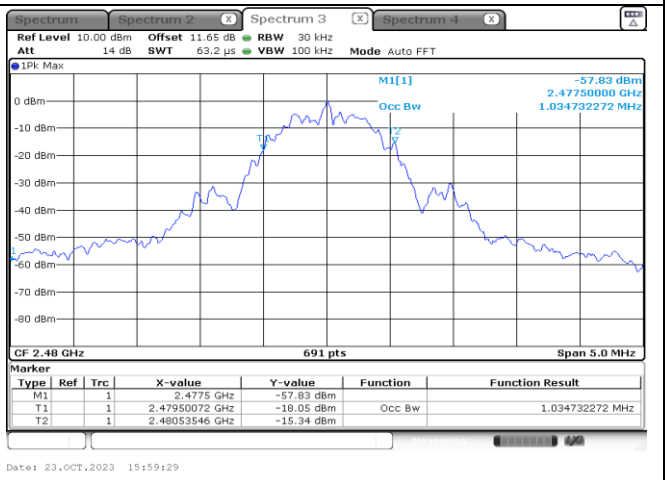


Figure 2. Block Diagram, Occupied Bandwidth Test Setup

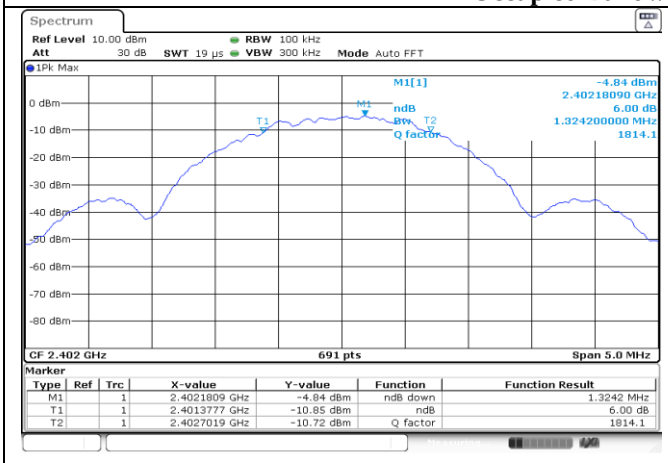
Data Rate	Channel	Frequency (MHz)	6dB Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	99% Bandwidth (MHz)	Result
1MBps	Low	2402MHz	0.716	0.5	1.034	Pass
	Middle	2440MHz	0.680	0.5	1.034	Pass
	High	2480MHz	0.673	0.5	1.034	Pass
2MBps	Low	2402MHz	1.324	0.5	2.055	Pass
	Middle	2440MHz	1.252	0.5	2.066	Pass
	High	2480MHz	1.353	0.5	2.061	Pass

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

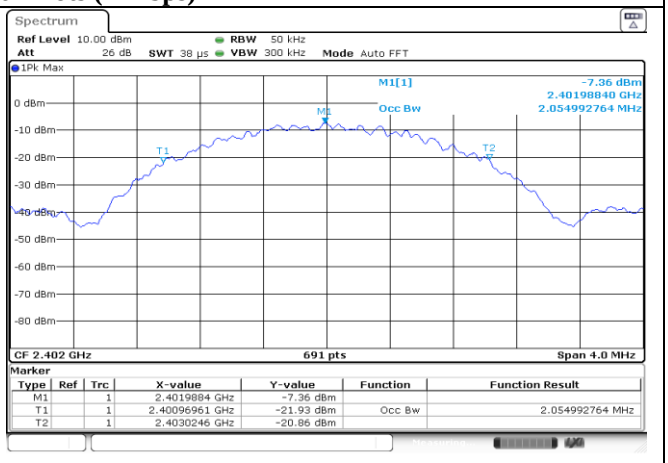
Occupied Bandwidth Test Results

Occupied Bandwidth Plots (1 Mbps)	
	
Low Channel 6dB Bandwidth	Low Channel 99% Bandwidth
	
Mid Channel 6dB Bandwidth	Mid Channel 99% Bandwidth
	
High Channel 6dB Bandwidth	High Channel 99% Bandwidth

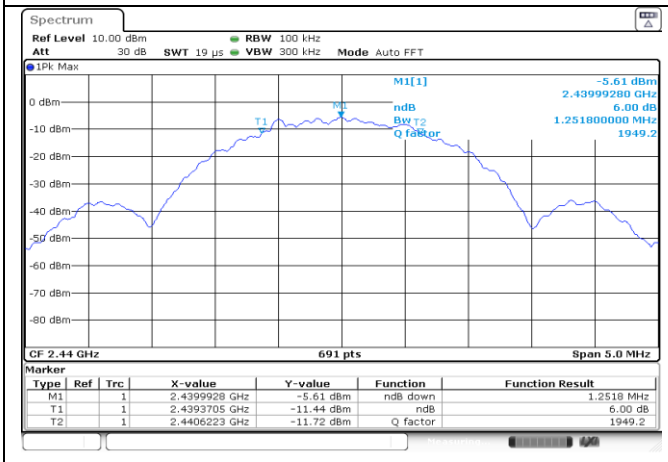
Occupied Bandwidth Plots (2 Mbps)



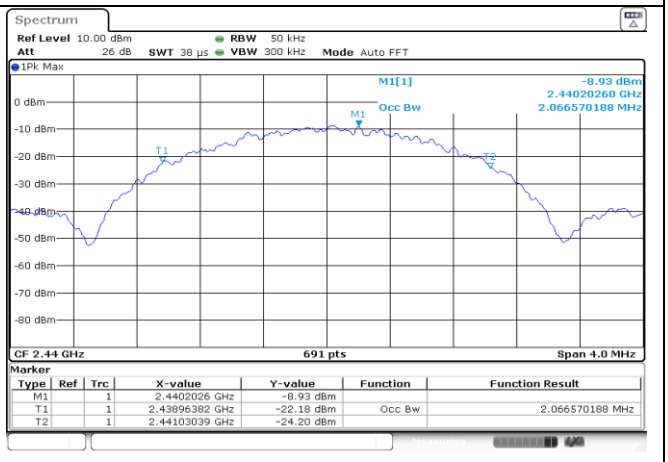
Low Channel 6dB Bandwidth



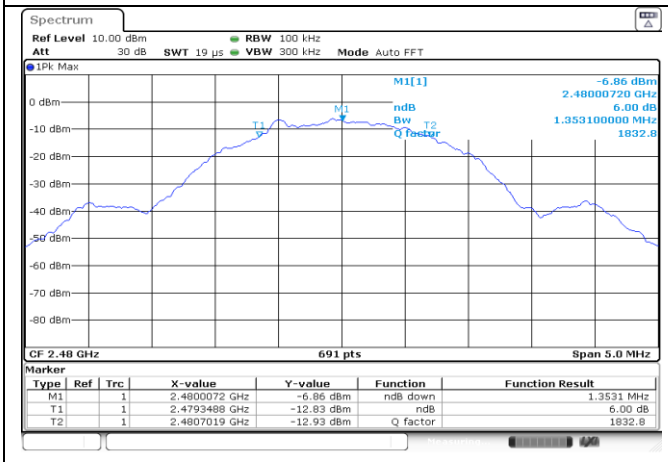
Low Channel 99% Bandwidth



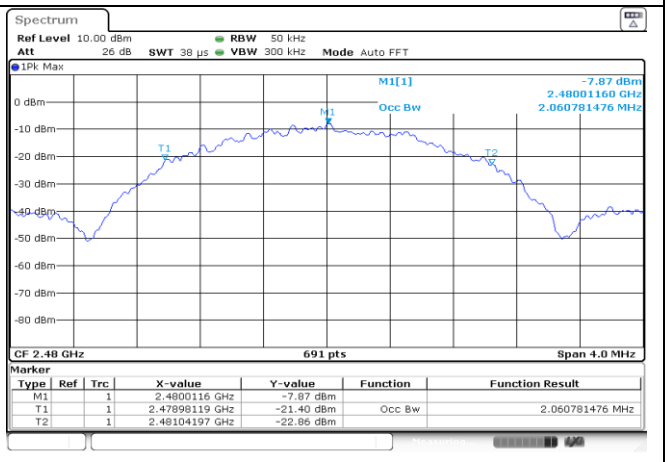
Mid Channel 6dB Bandwidth



Mid Channel 99% Bandwidth



High Channel 6dB Bandwidth



High Channel 99% Bandwidth

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): 10/24/2023

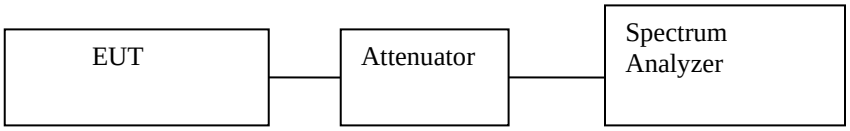


Figure 3. Peak Power Output Test Setup

Peak Power Output Test Results

Data Rate	Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power Limit (dBm)	Result
1MBps	Low	2402MHz	0.610	30	Pass
	Middle	2440MHz	0.260	30	Pass
	High	2480MHz	-0.150	30	Pass
2MBps	Low	2402MHz	0.610	30	Pass
	Middle	2440MHz	0.150	30	Pass
	High	2480MHz	-0.280	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: 10/24/2023

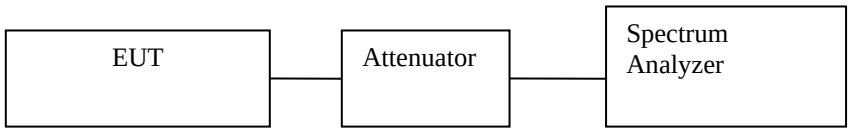
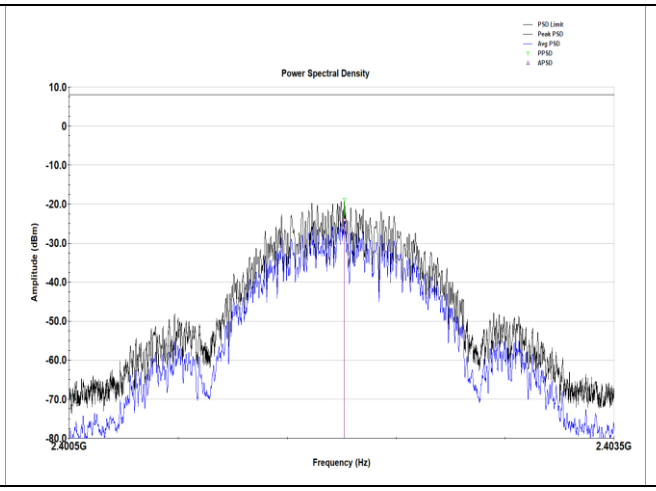
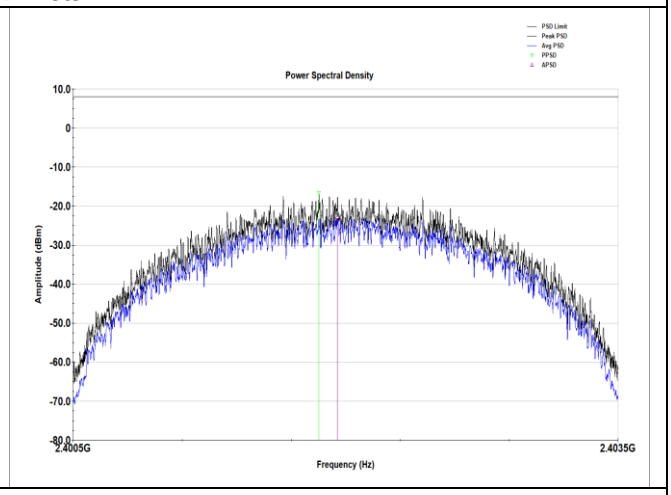
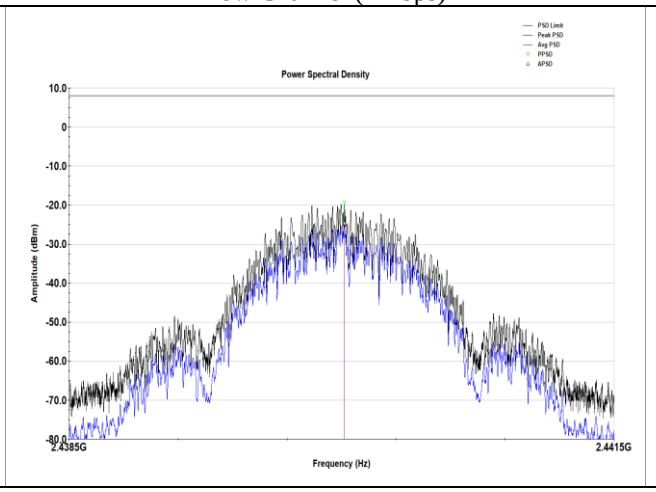
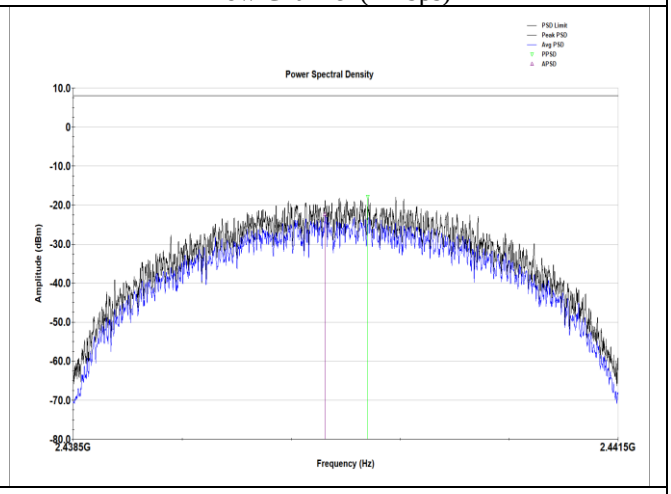
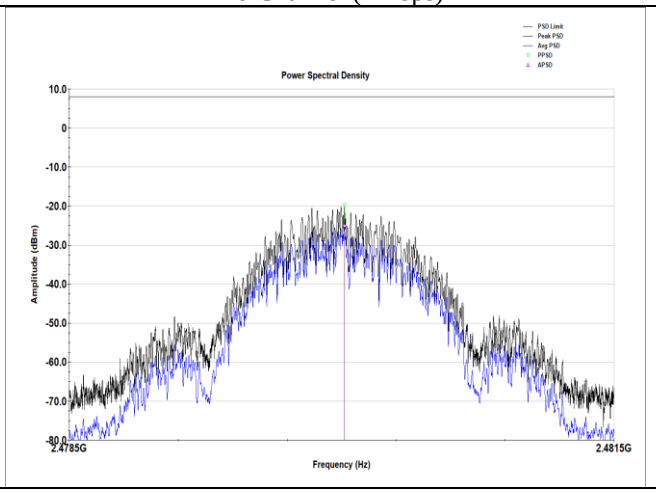
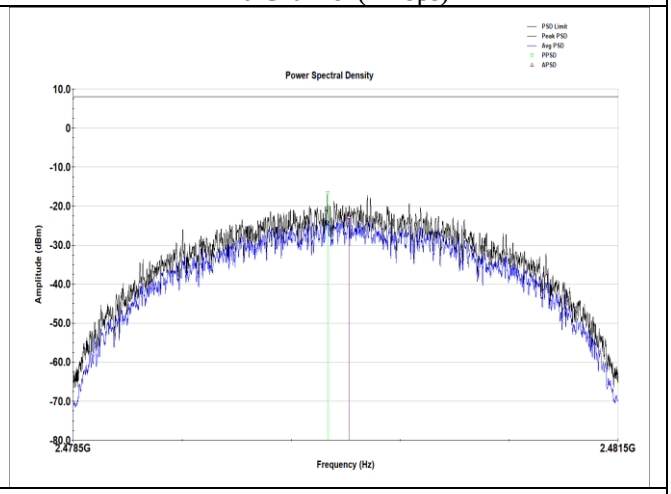


Figure 4. Block Diagram, Peak Power Spectral Density Test Setup

Data Rate	Channel	Frequency (MHz)	Peak Power Spectral Density (dBm / 3kHz)	Peak Power Spectral Density Limit (dBm / 3kHz)	Result
1MBps	Low	2402MHz	-18.90	8	Pass
	Middle	2440MHz	-19.37	8	Pass
	High	2480MHz	-19.77	8	Pass
2Mbps	Low	2402MHz	-16.62	8	Pass
	Middle	2440MHz	-17.85	8	Pass
	High	2480MHz	-16.61	8	Pass

Table 14. Peak Power Spectral Density, Test Results

Peak PSD Plots	
	
Low Channel (1Mbps)	Low Channel (2Mbps)
	
Mid Channel (1Mbps)	Mid Channel (2Mbps)
	
High Channel (1Mbps)	High Channel (2Mbps)

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): 1/24/2023

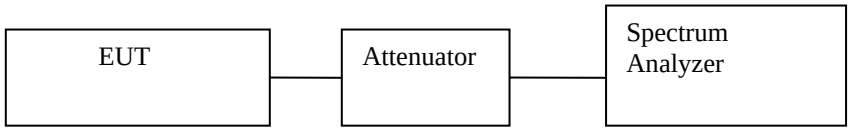


Figure 5. Block Diagram, Conducted Spurious Emissions Test Setup

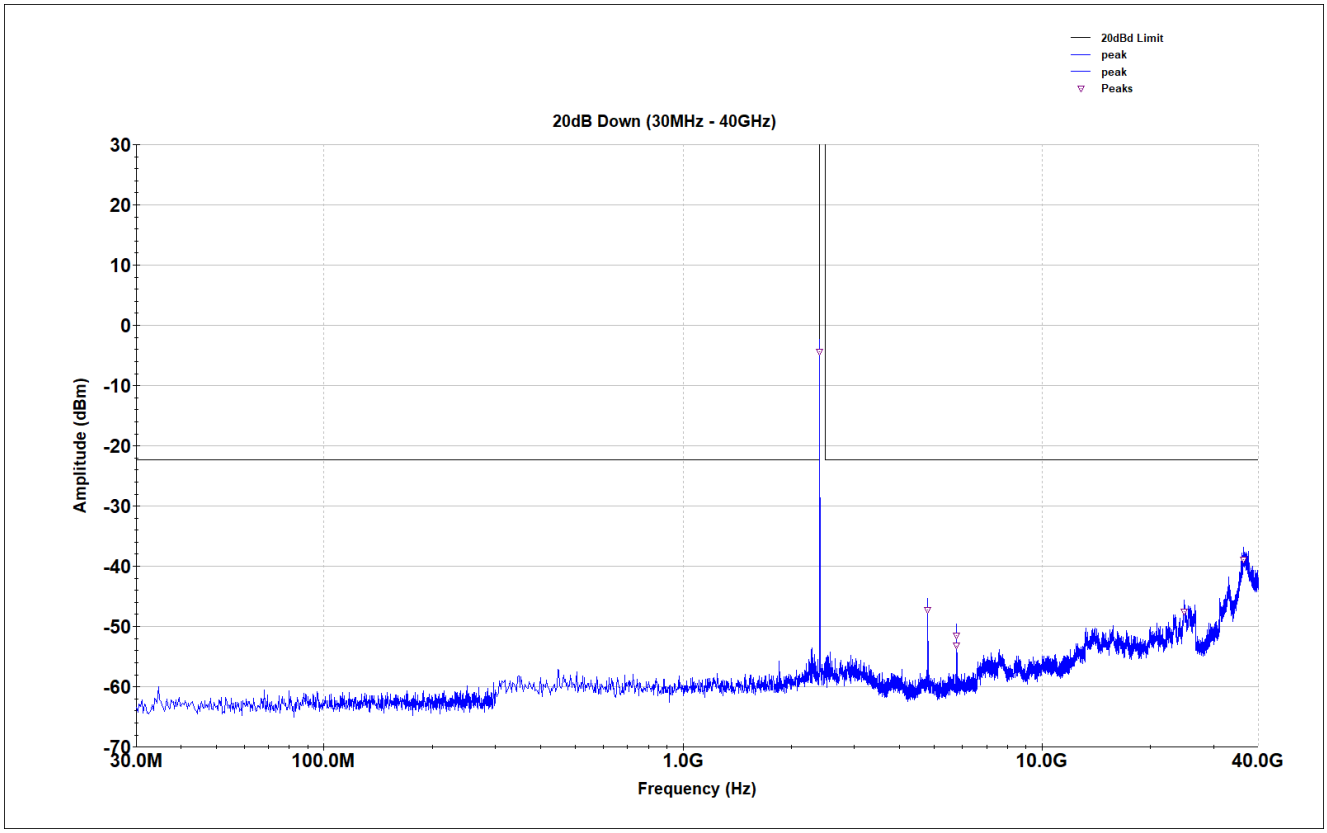


Figure 6. Low Channel, 30MHz – 40GHz Conducted Spurious Emissions (1Mbps)

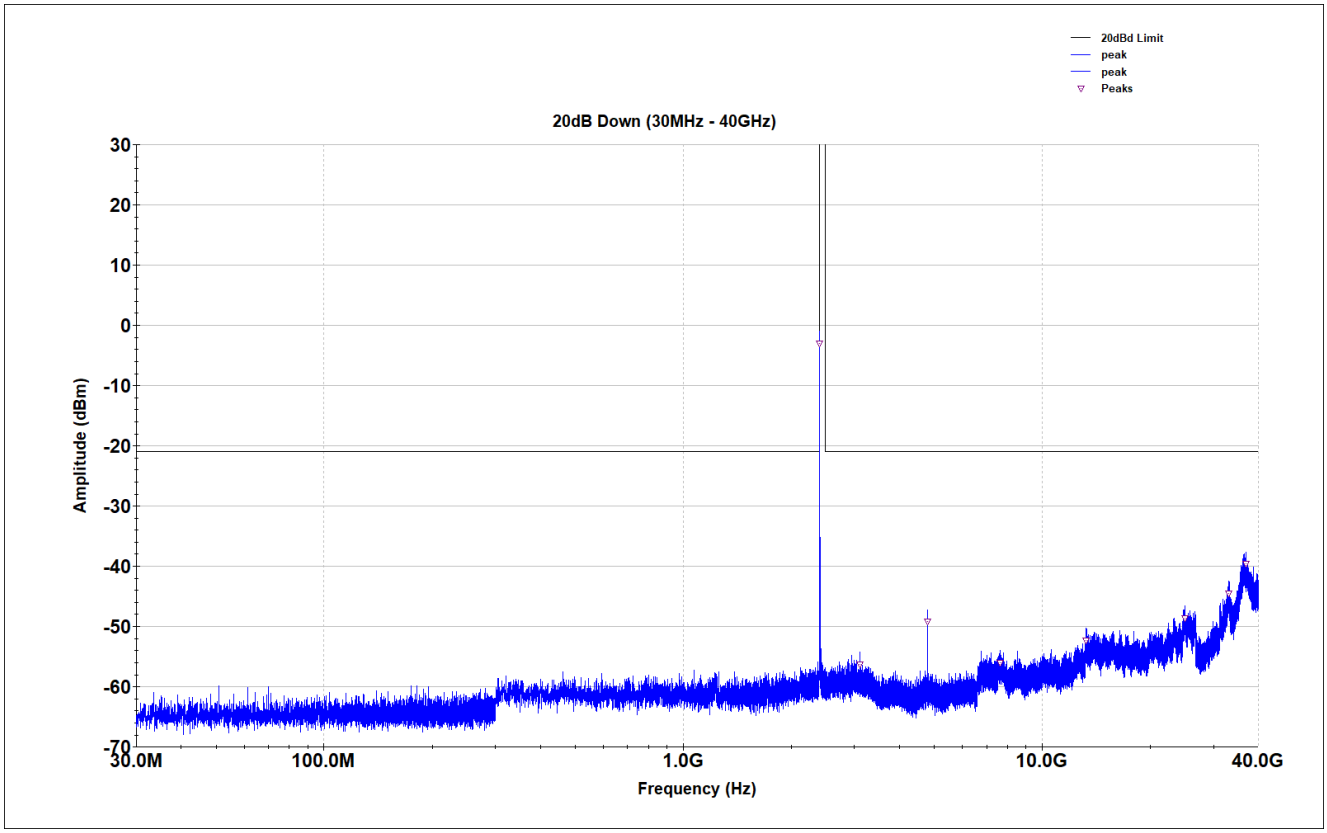


Figure 7. Low Channel, 30MHz – 40GHz Conducted Spurious Emissions (2Mbps)

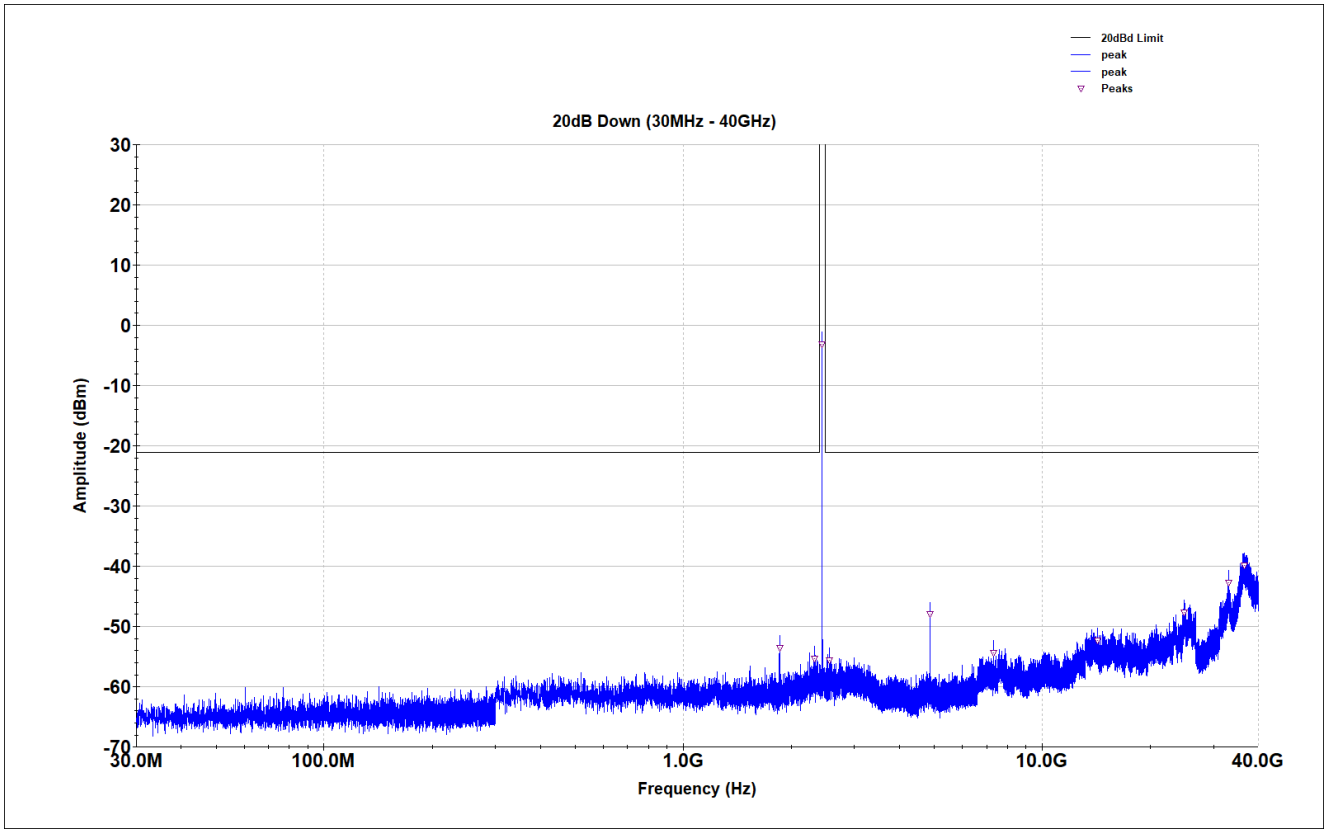


Figure 8. Mid Channel, 30MHz – 40GHz Conducted Spurious Emissions (1Mbps)

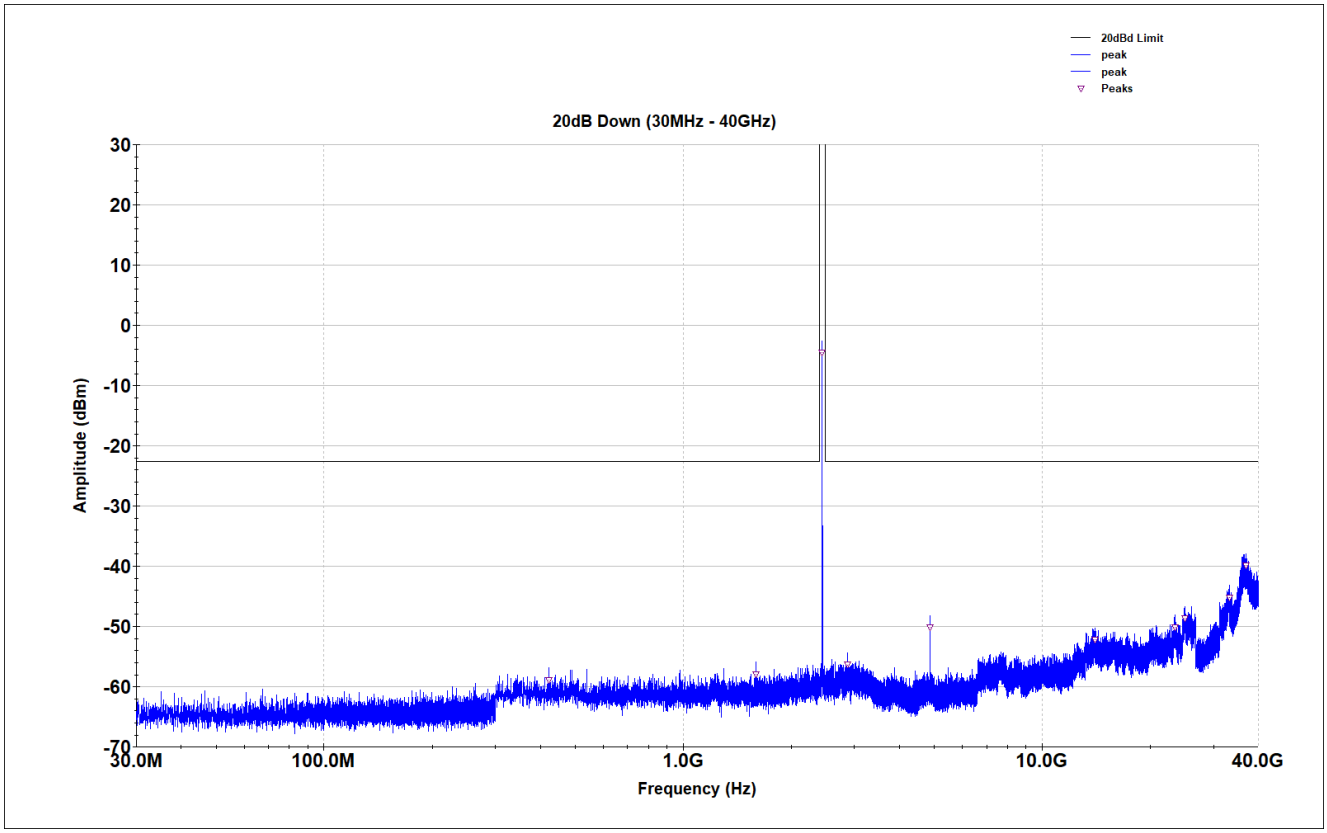


Figure 9. Mid Channel, 30MHz – 40GHz Conducted Spurious Emissions (2Mbps)

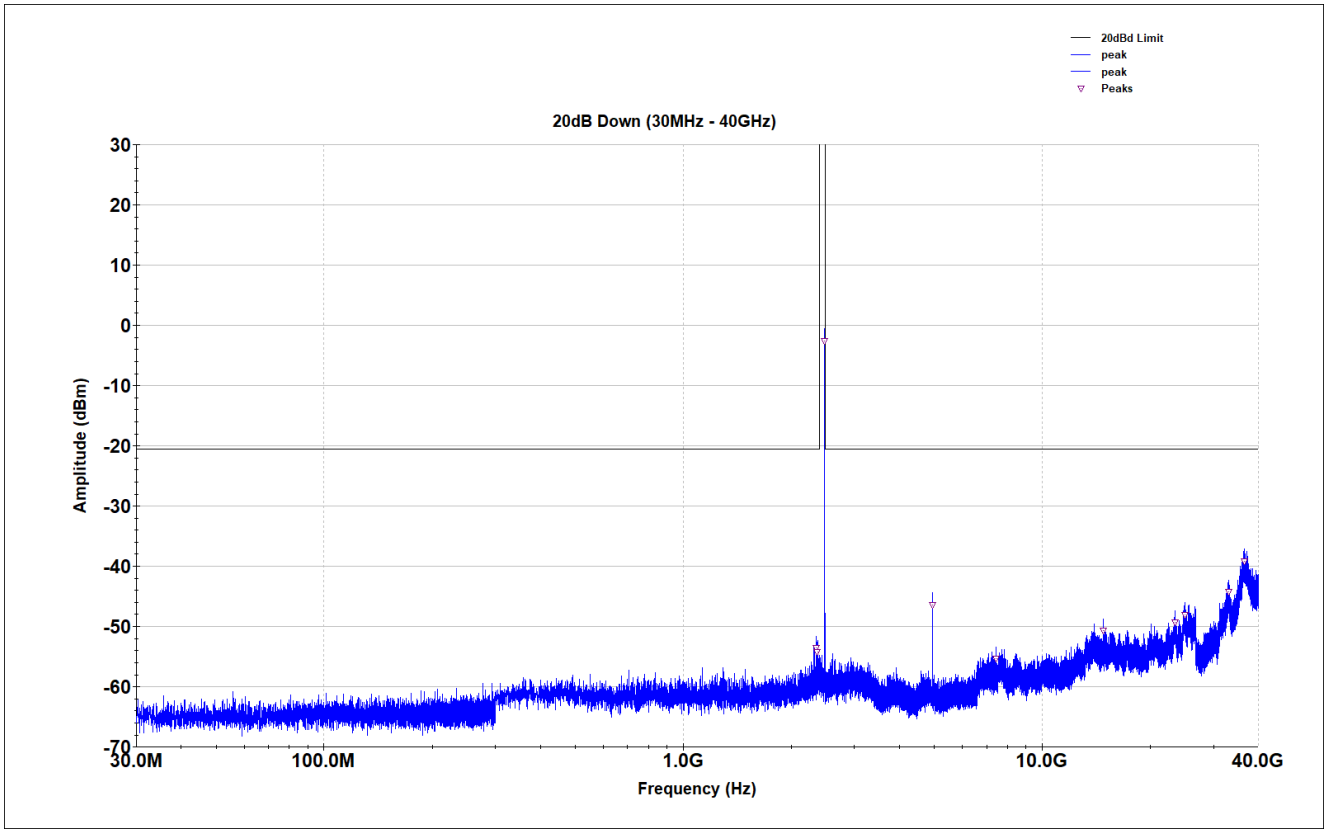


Figure 10. High Channel, 30MHz – 40GHz Conducted Spurious Emissions (1Mbps)

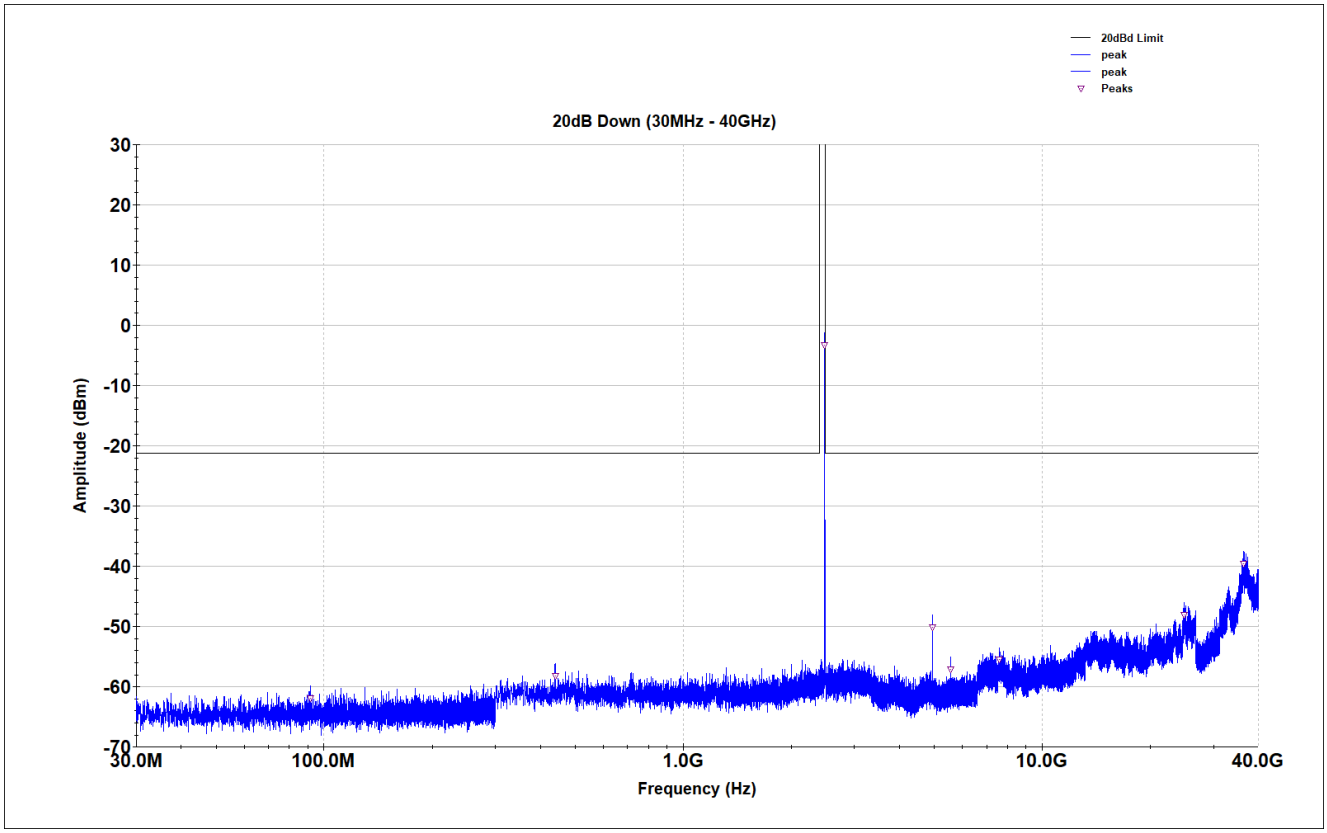
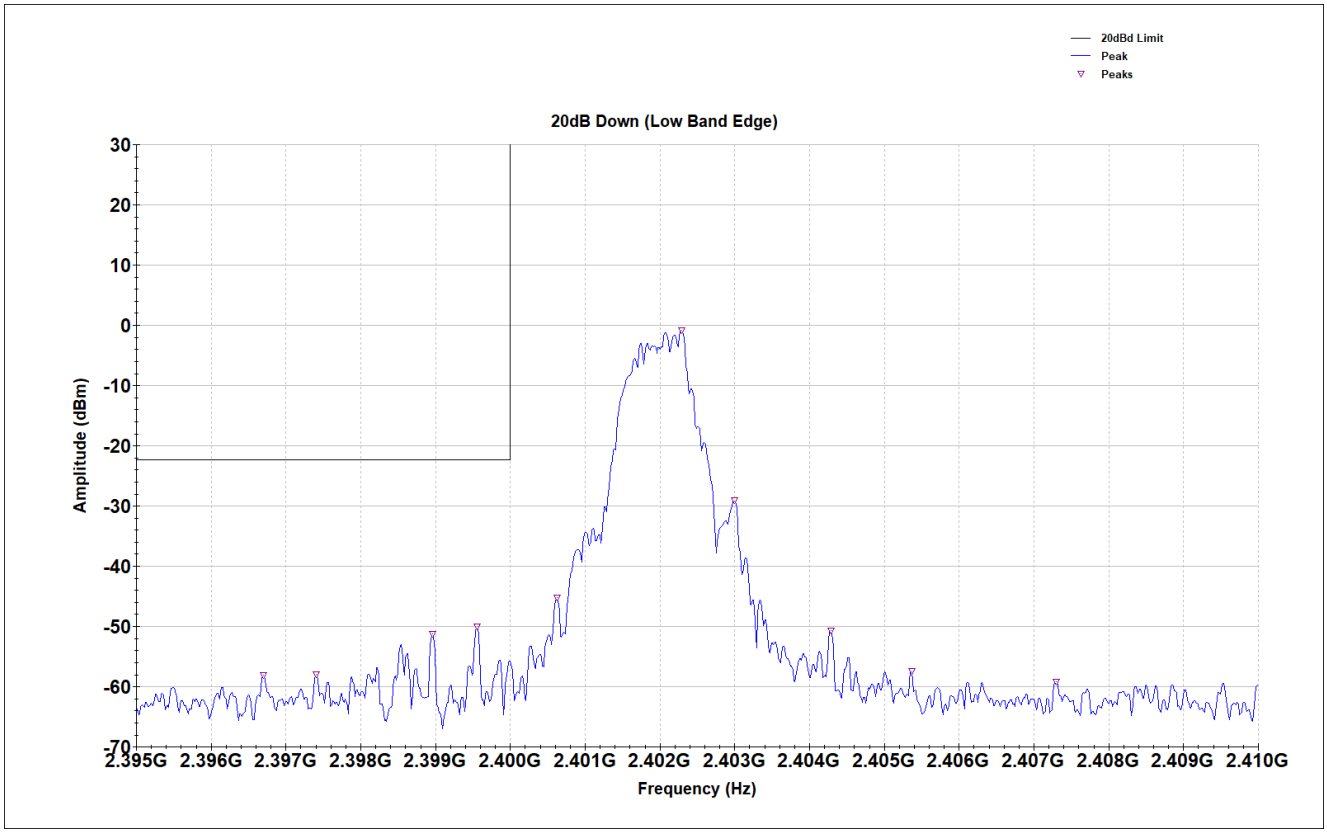
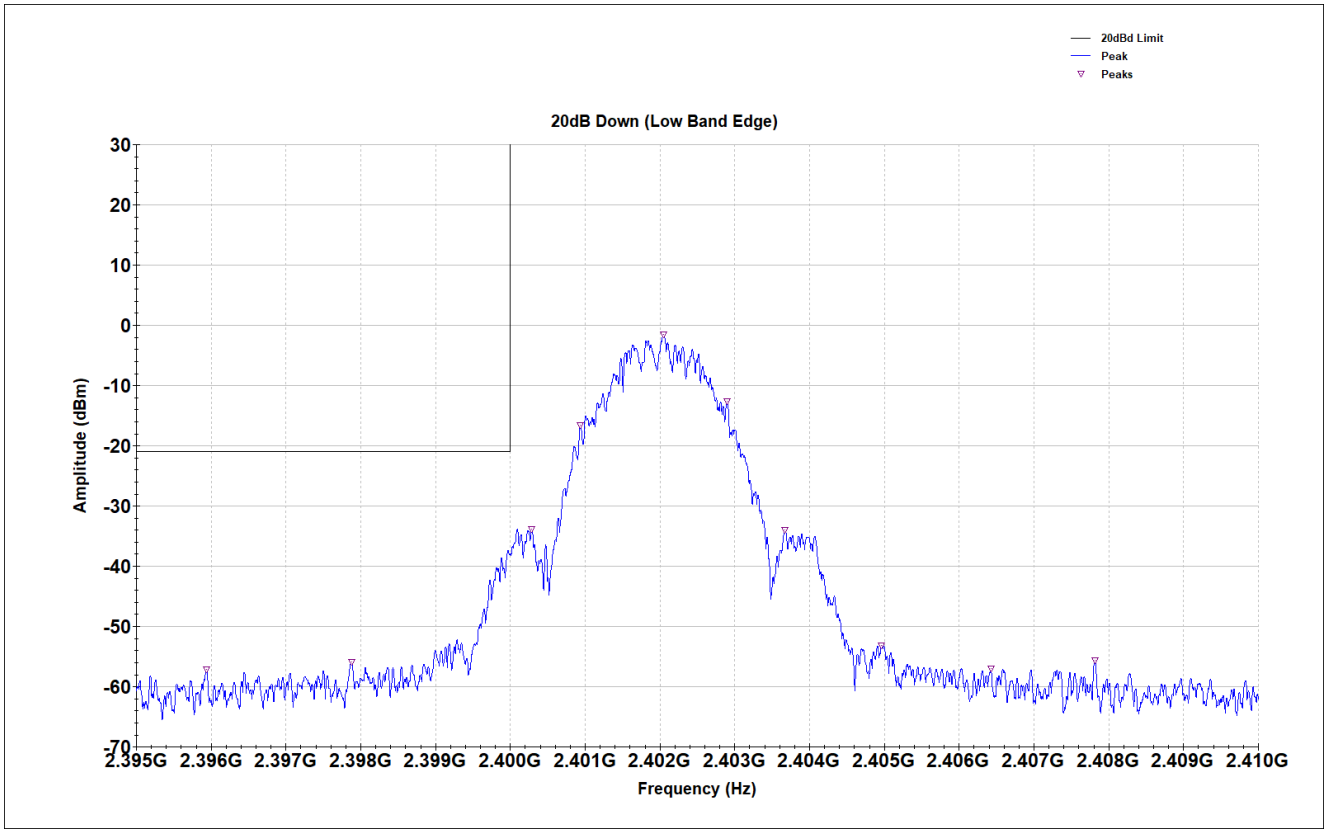


Figure 11. High Channel, 30MHz – 40GHz Conducted Spurious Emissions (2Mbps)



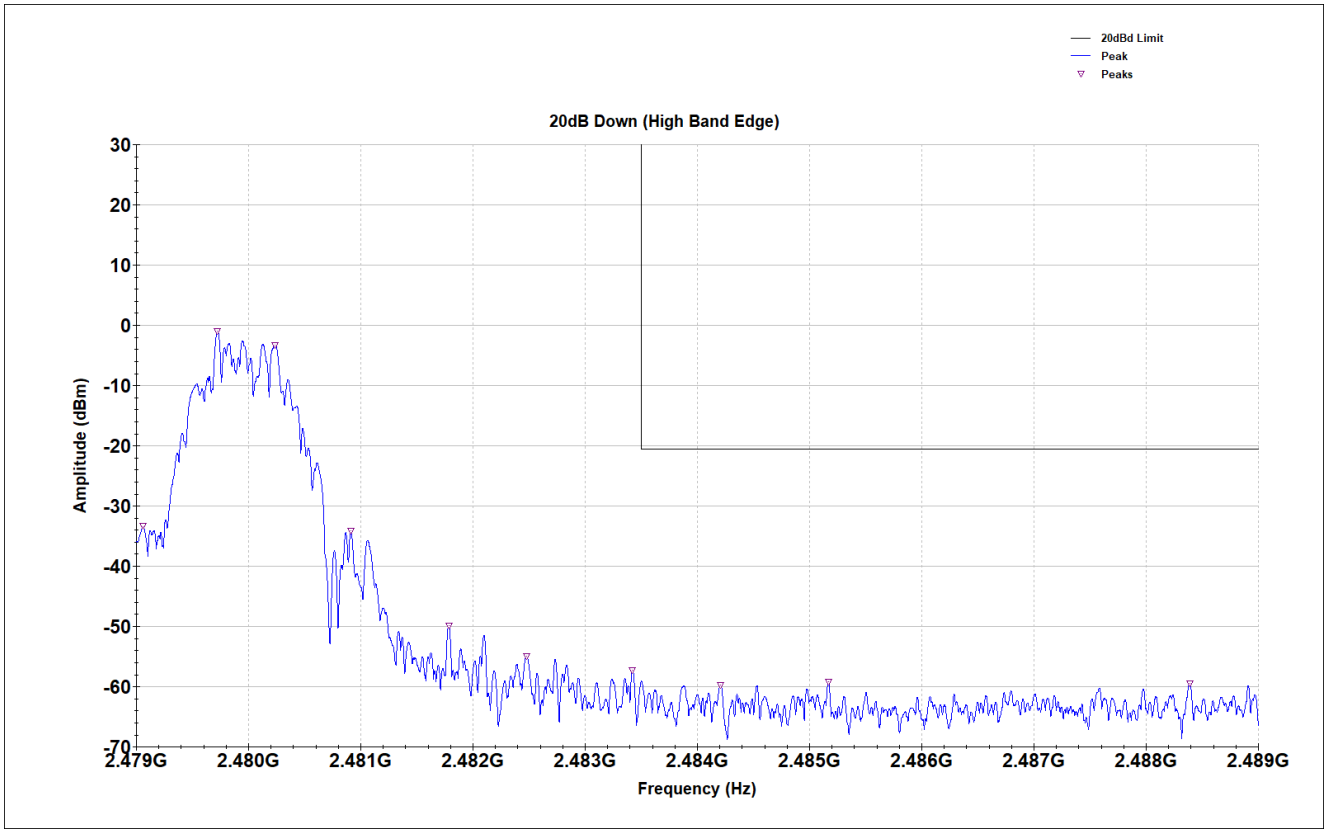
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2396.695	-58.1	-22.36	35.74	Pass
2397.4	-57.97	-22.36	35.61	Pass
2398.96	-51.27	-22.36	28.9	Pass
2399.56	-49.97	-22.36	27.61	Pass

Figure 12. Low Channel, Low Band Edge (1Mbps)



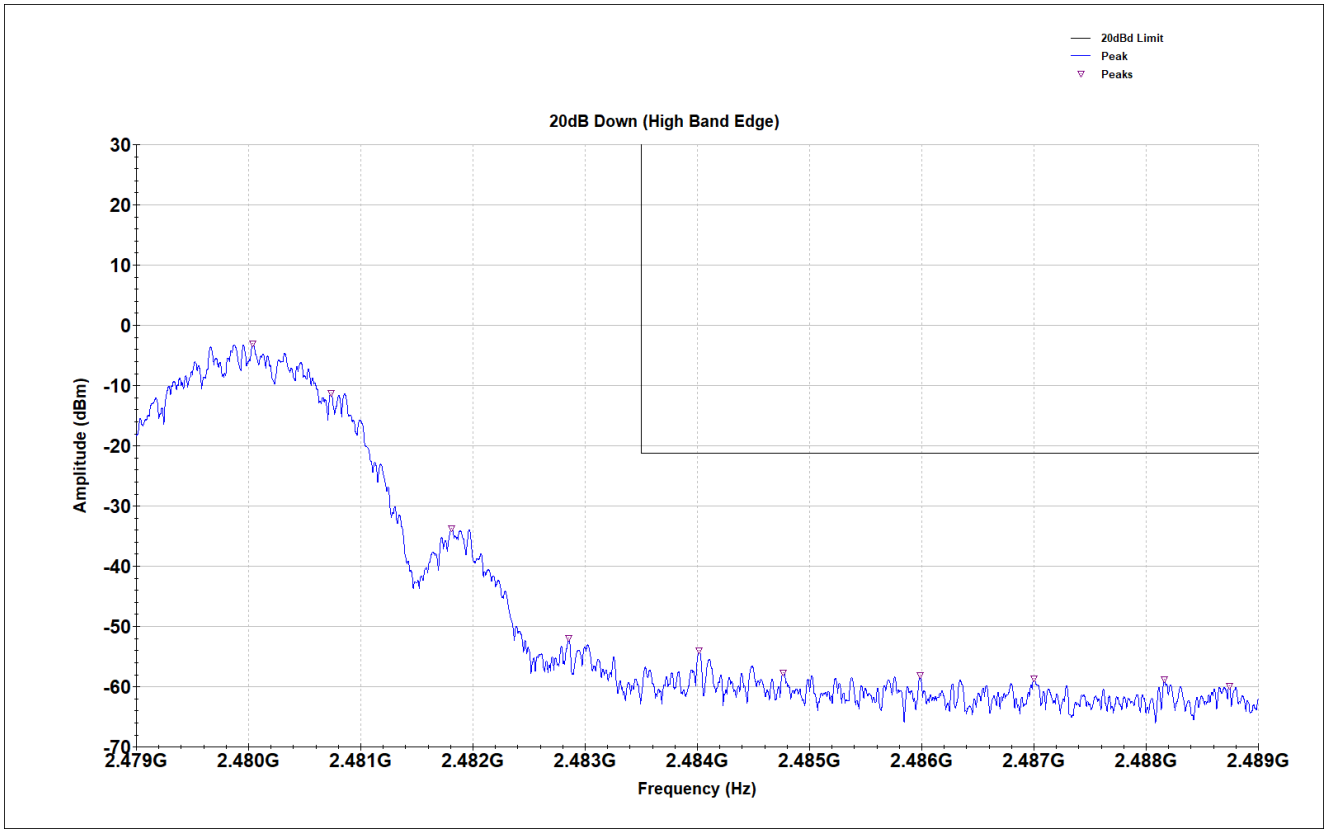
Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2395.936	-57.16	-20.98	36.18	Pass
2397.874	-55.85	-20.98	34.87	Pass

Figure 13. Low Channel, Low Band Edge (2Mbps)



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2484.206	-59.74	-20.57	39.17	Pass
2485.168	-59.23	-20.57	38.66	Pass
2488.387	-59.47	-20.57	38.9	Pass

Figure 14. High Channel, High Band Edge (1Mbps)



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2484.016	-54	-21.29	32.71	Pass
2484.765	-57.65	-21.29	36.36	Pass
2485.985	-58.04	-21.29	36.75	Pass
2486.999	-58.6	-21.29	37.31	Pass
2488.162	-58.76	-21.29	37.47	Pass
2488.74	-59.83	-21.29	38.54	Pass

Figure 15. High Channel, High Band Edge (2Mbps)

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 form 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. Scans from 9kHz – 30MHz were performed with a measurement distance of 3m. Scans from 30MHz – 1GHz were performed with a measurement distance of 10m. Scans from 1GHz – 40GHz were performed with a measurement distance of 3m. Plots shown are corrected for both antenna correction factor and distance and compared to a 3m 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): 10/24/2023 – 12/20/2023

Radiated Spurious Emissions Test Results

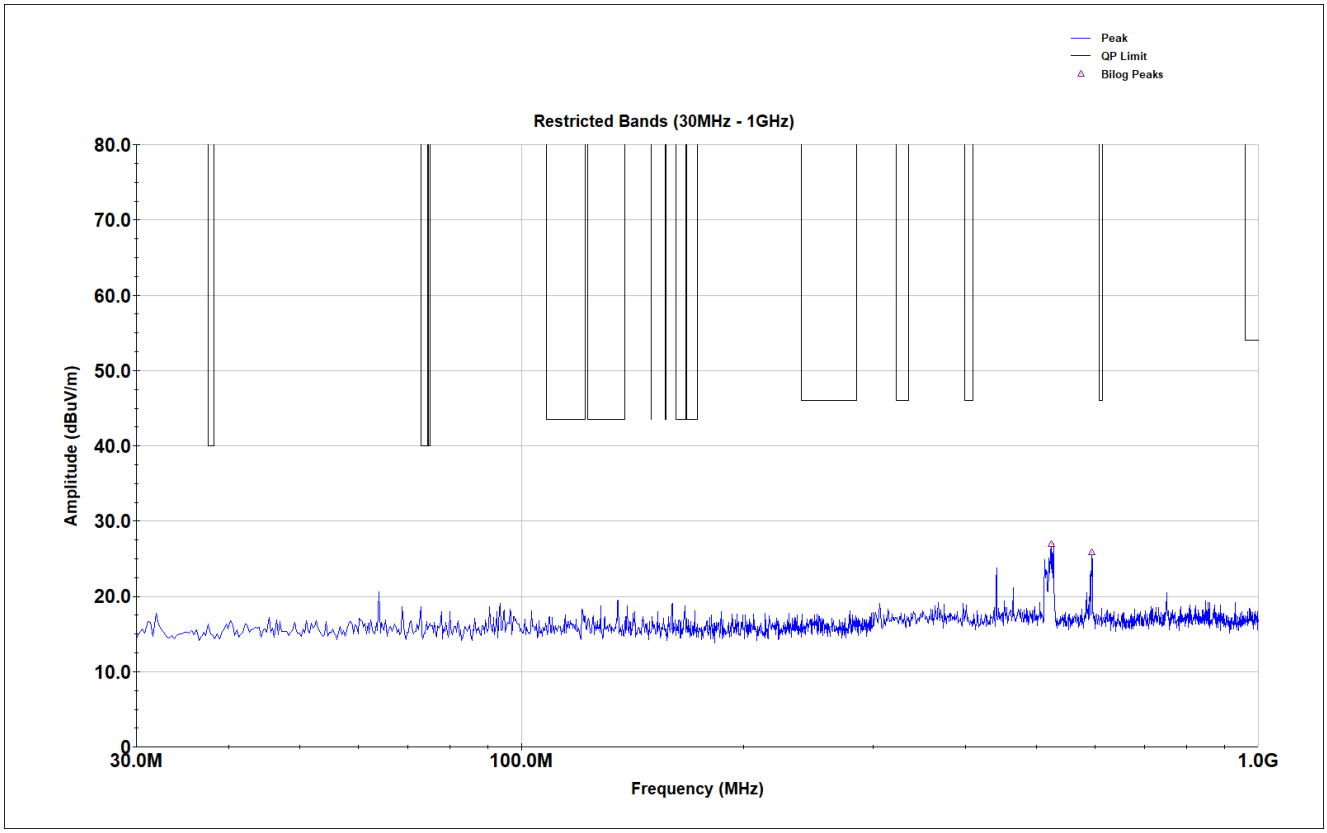


Figure 16. Low Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (1Mbps)

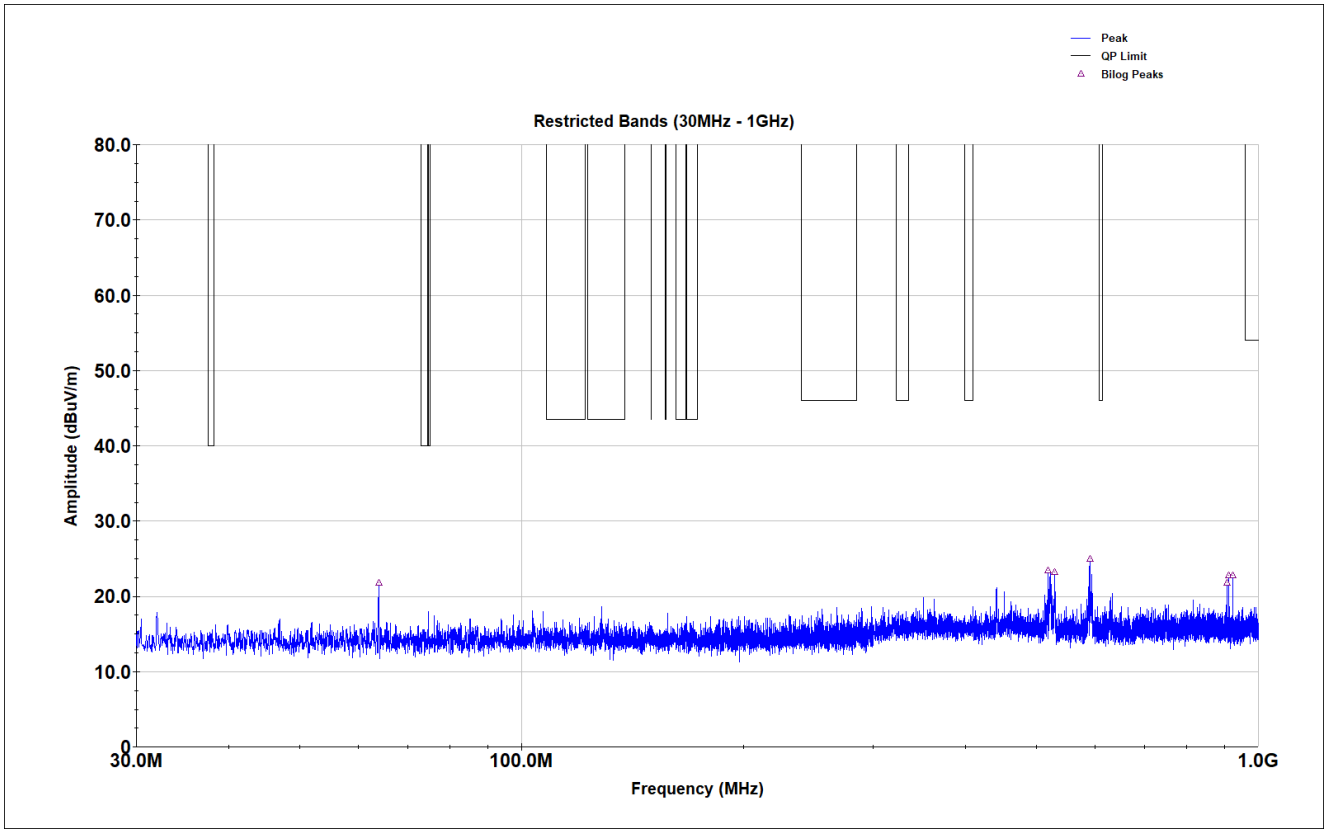


Figure 17. Low Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (2Mbps)

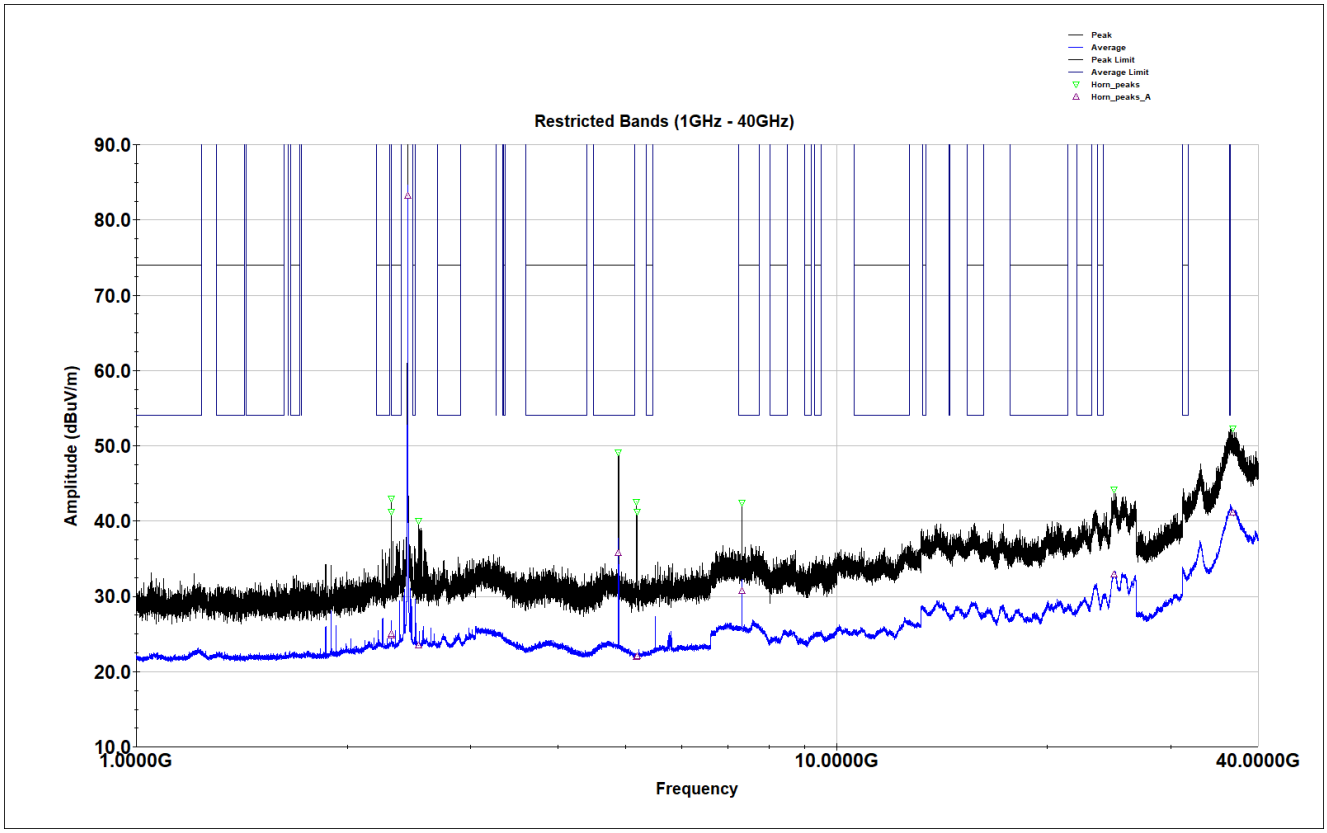


Figure 18. Low Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (1Mbps)

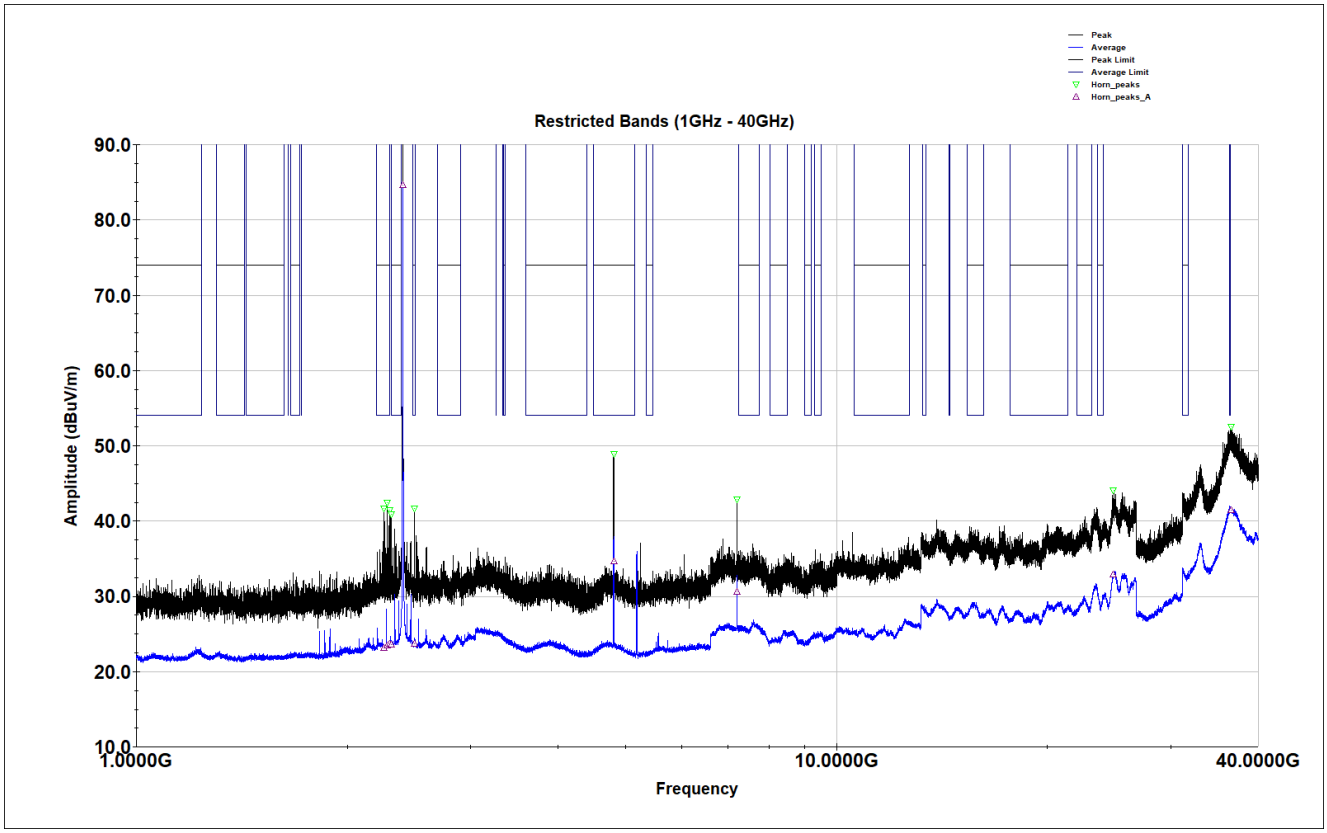


Figure 19. Low Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (2Mbps)

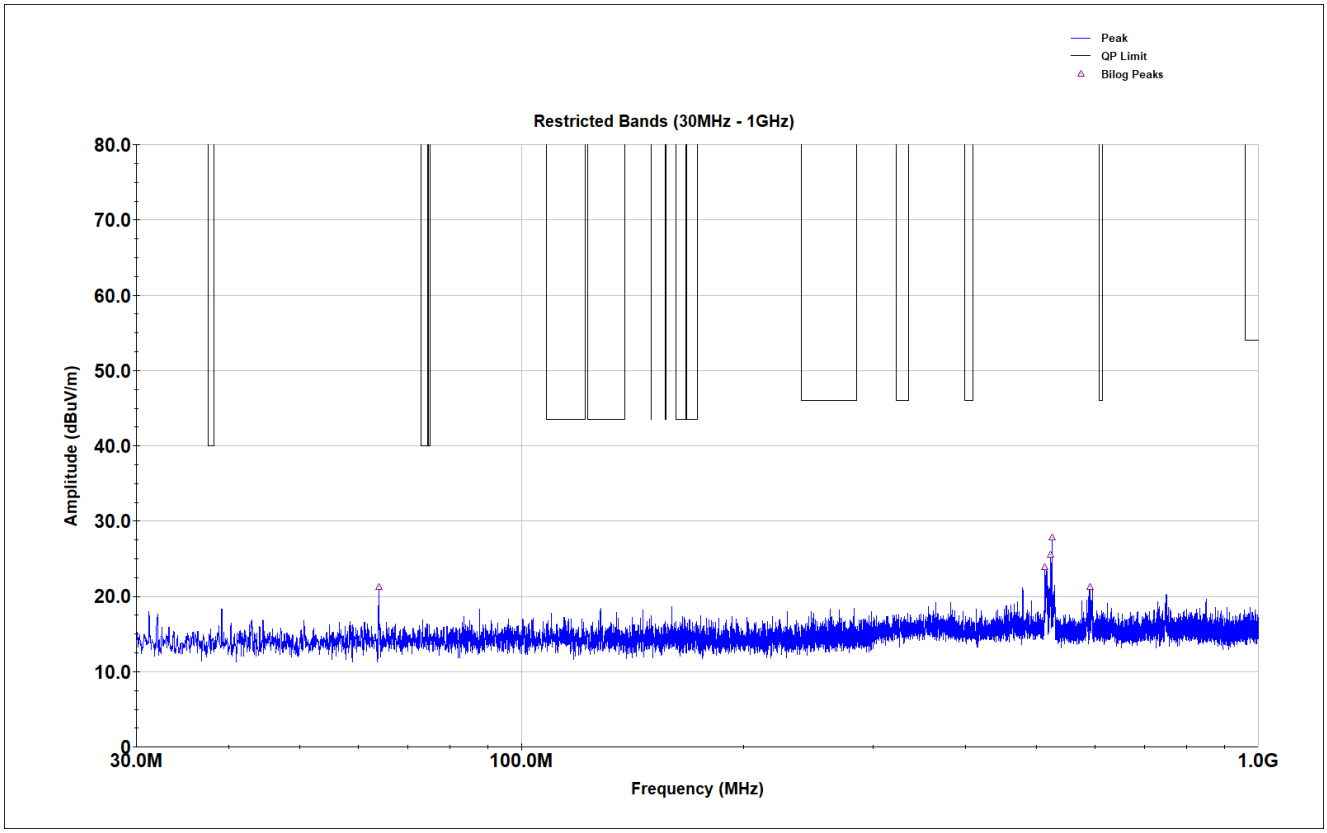


Figure 20. Middle Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (1Mbps)

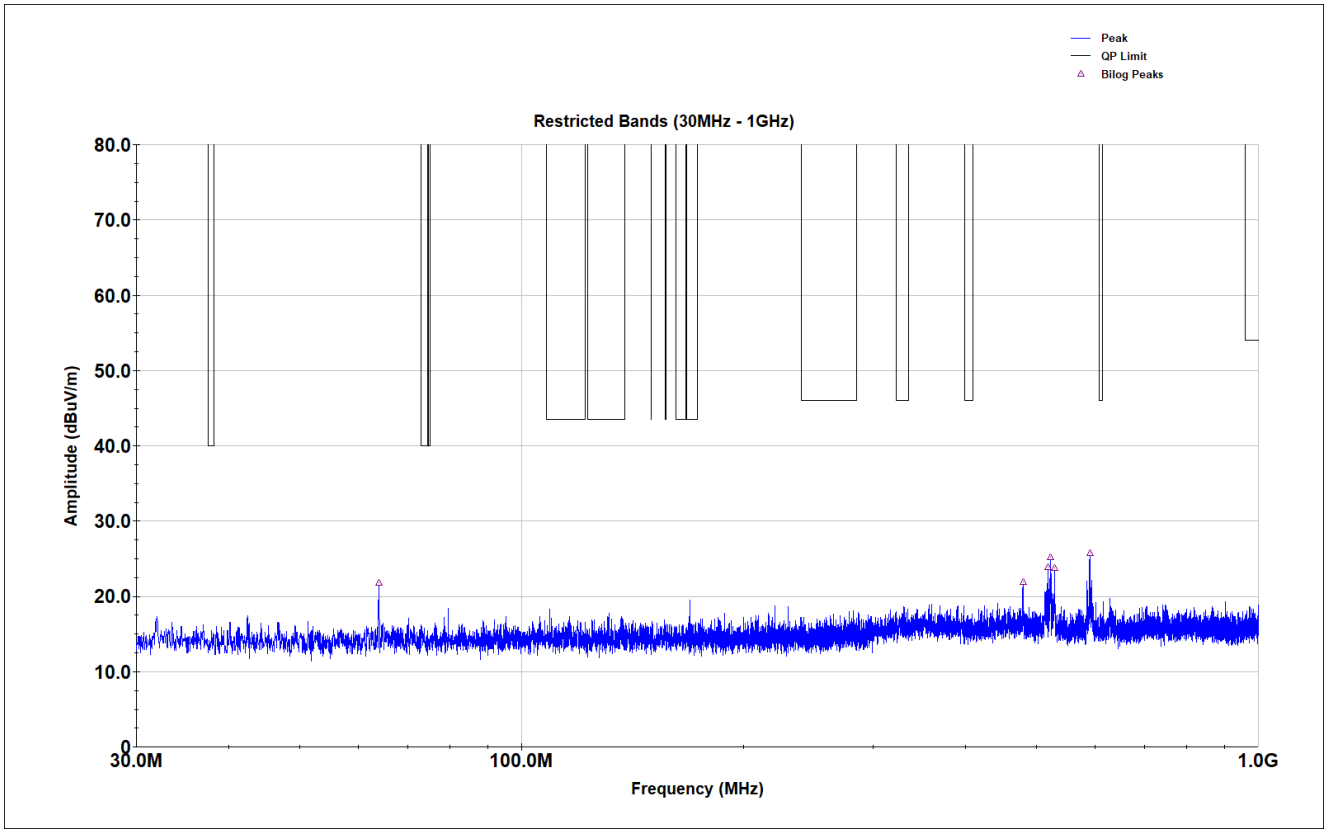


Figure 21. Middle Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (2Mbps)

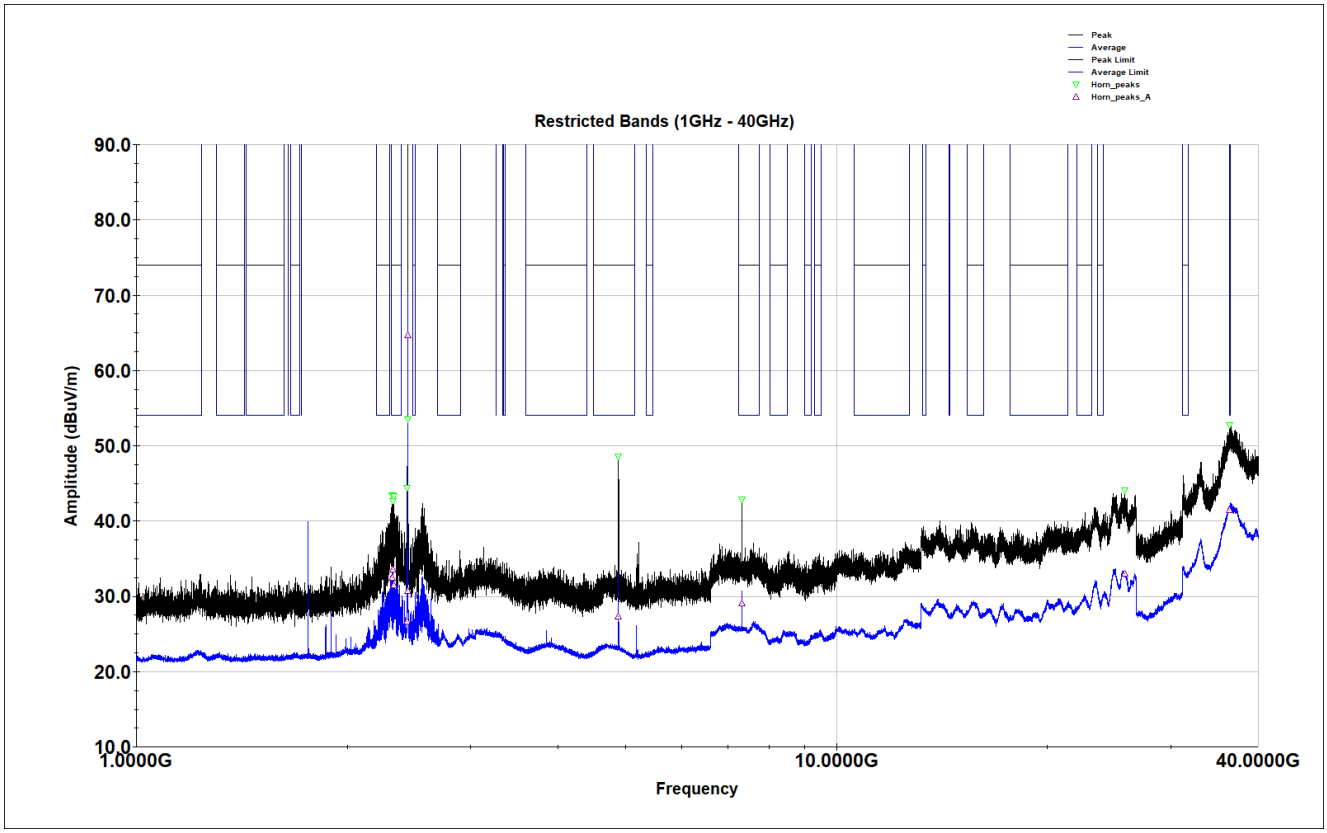


Figure 22. Middle Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (1Mbps)

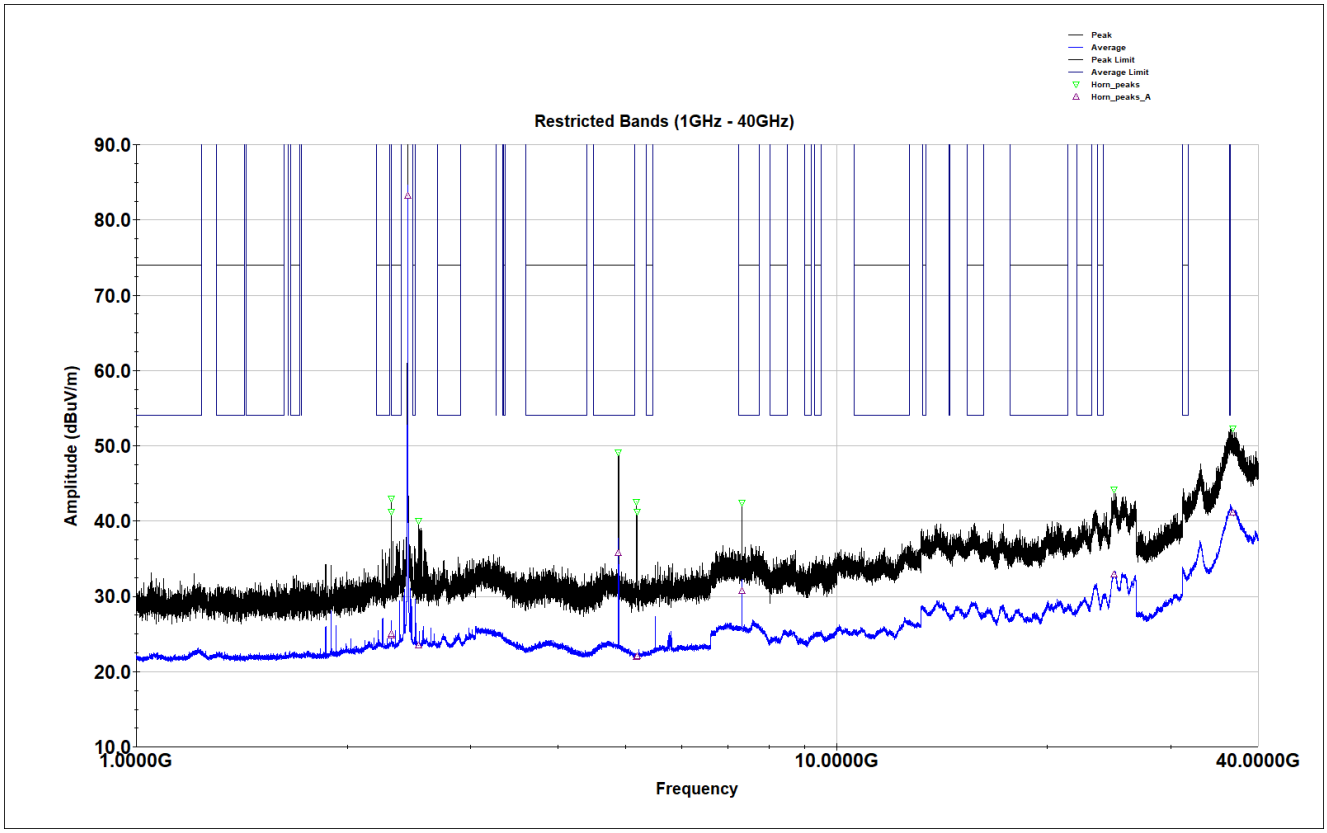


Figure 23. Middle Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (2Mbps)

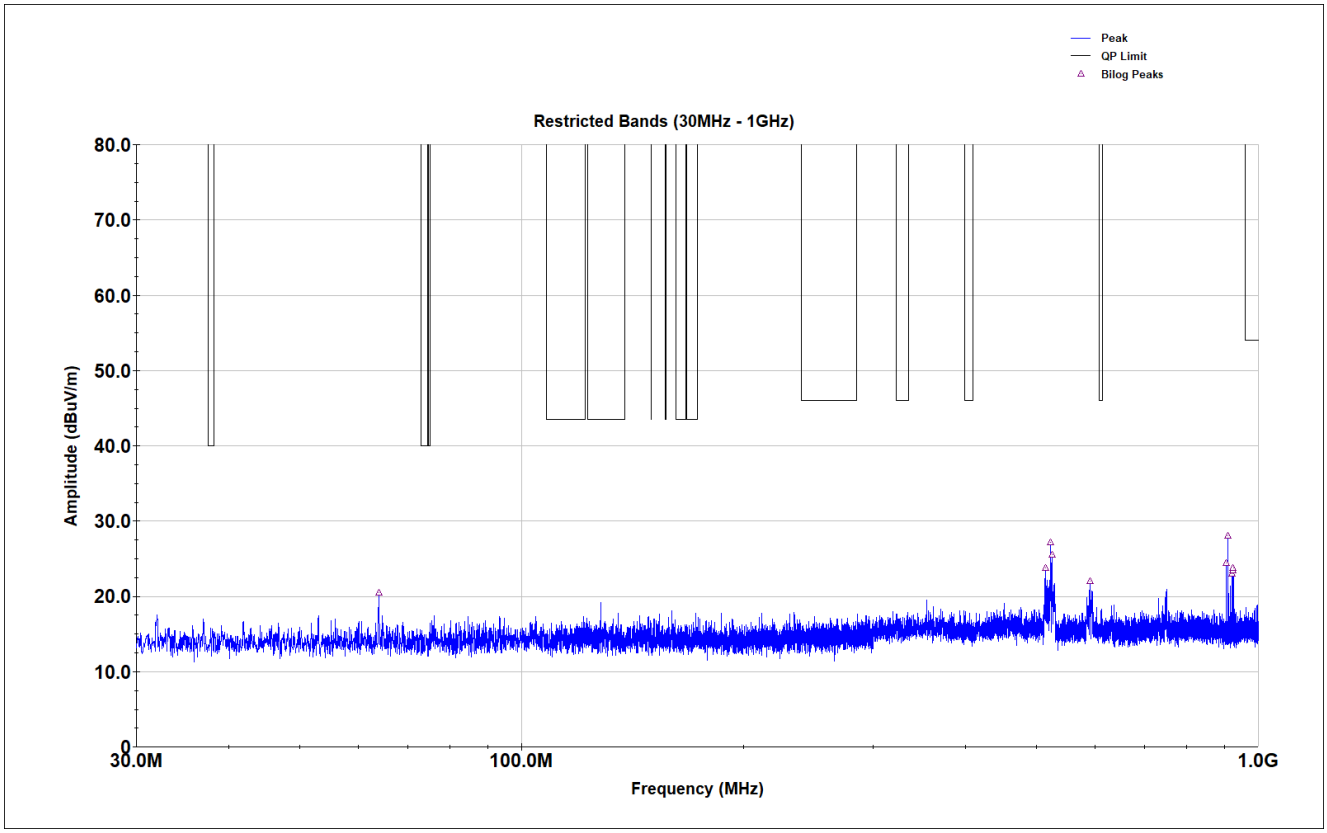


Figure 24. High Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (1Mbps)

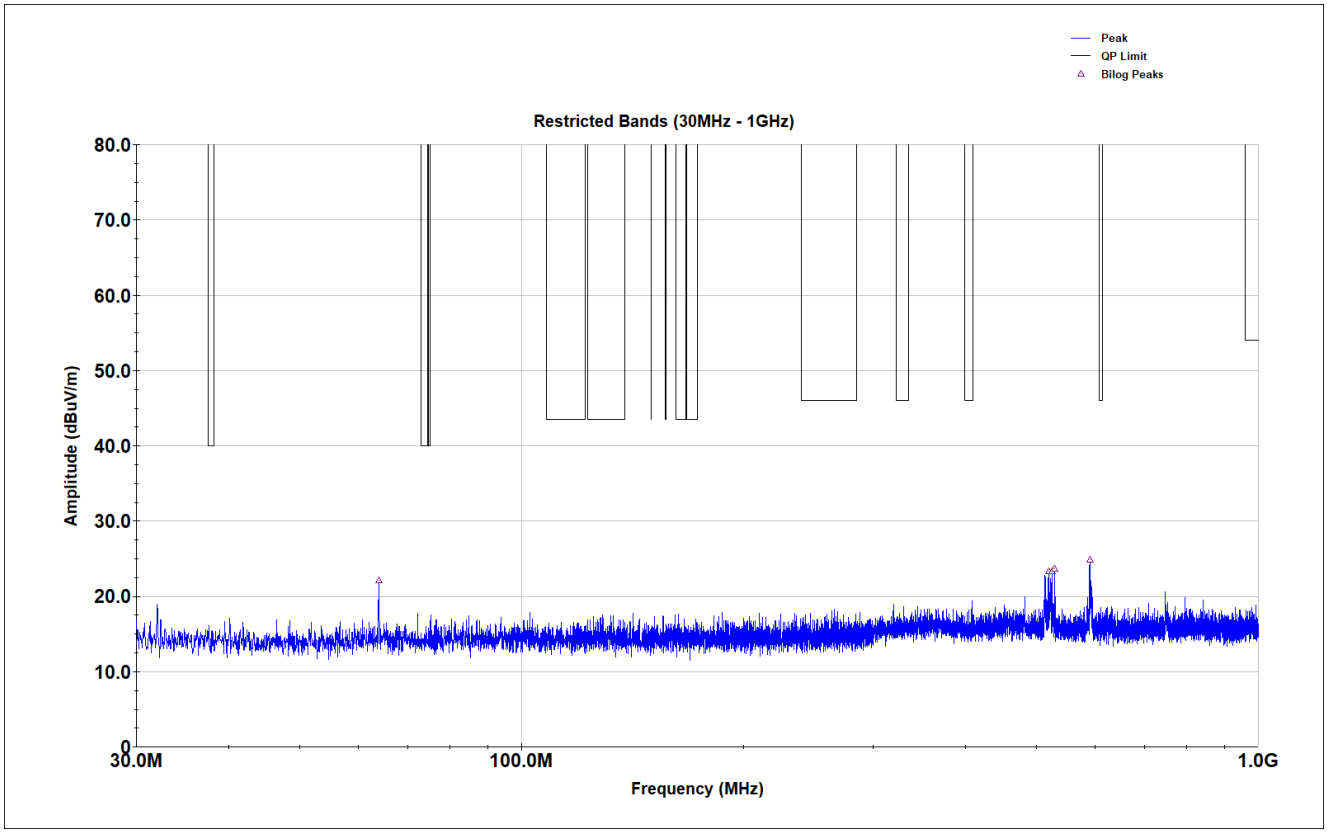


Figure 25. High Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (2Mbps)

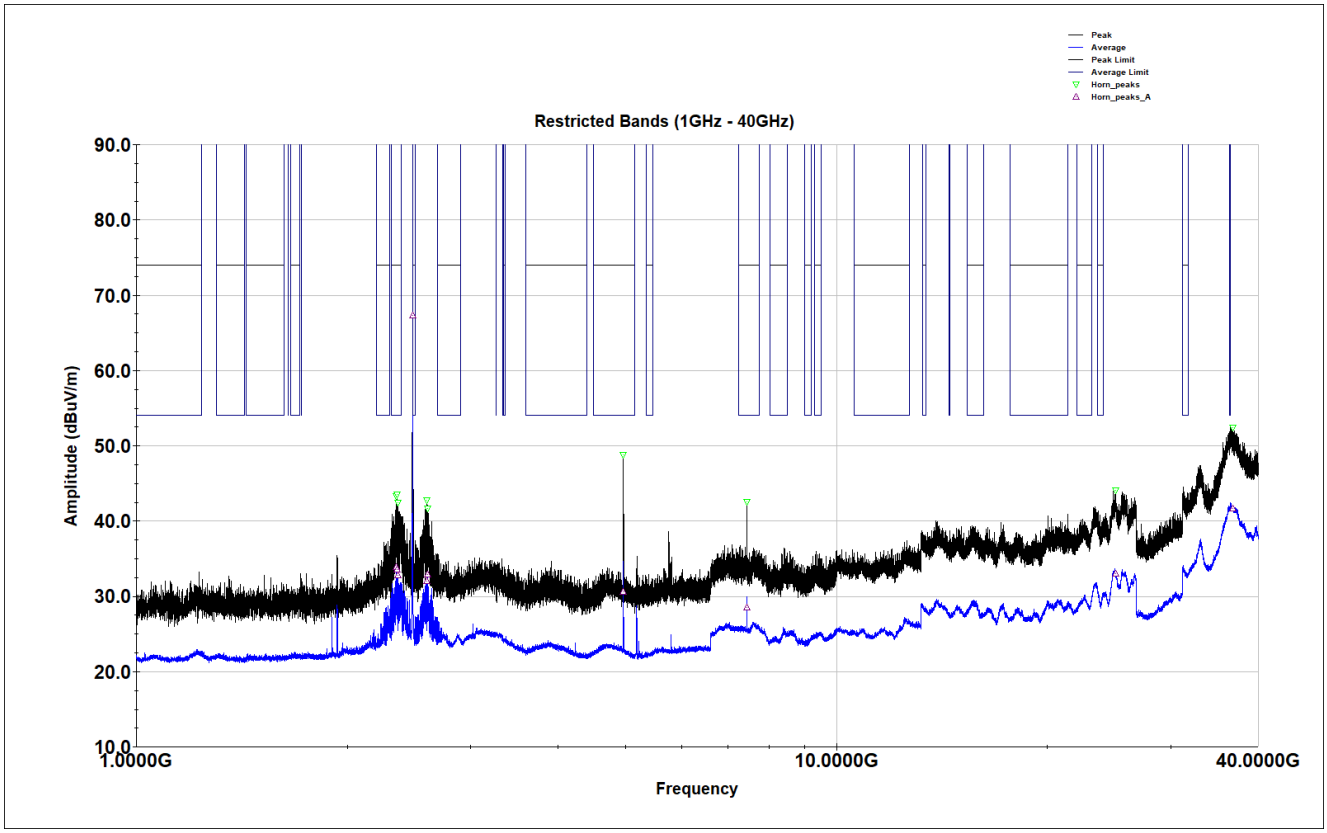


Figure 26. High Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (1Mbps)

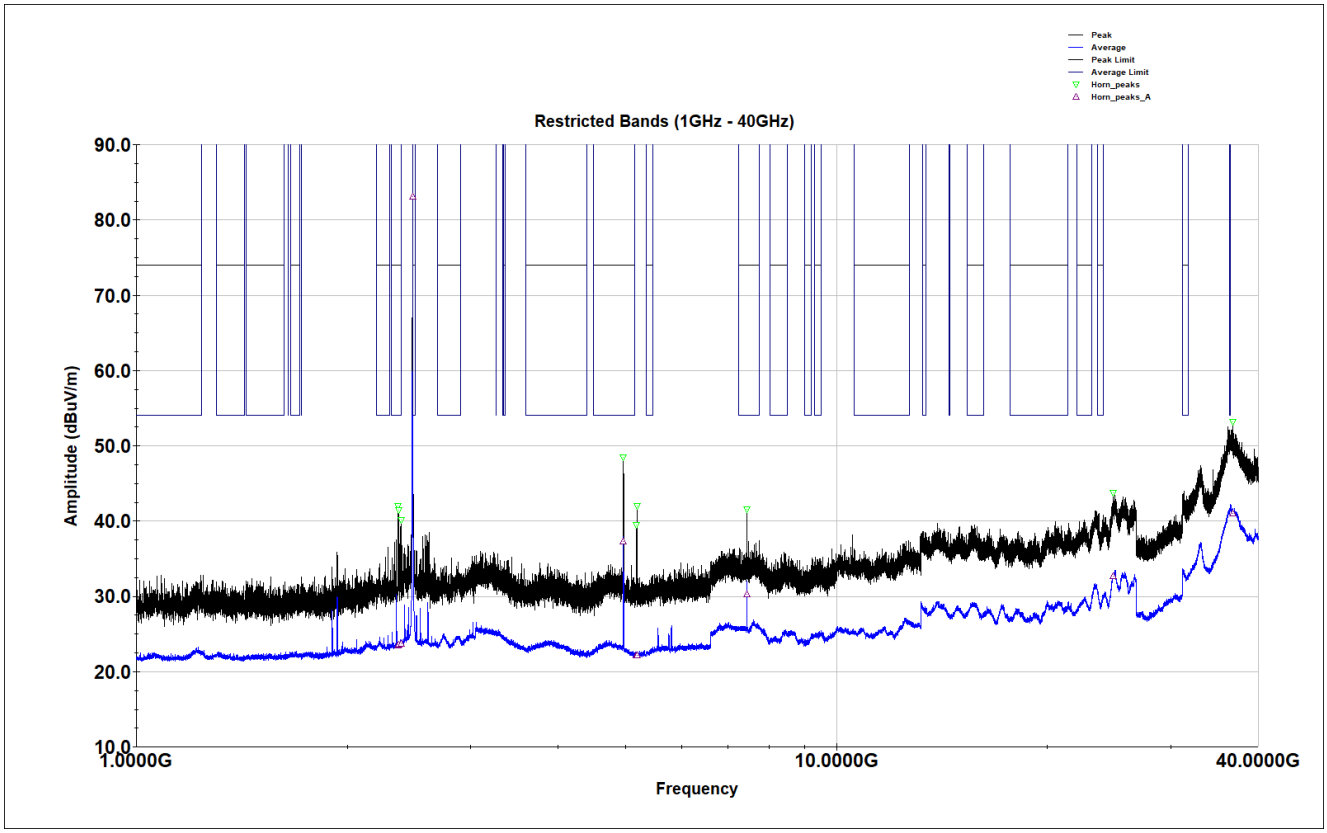
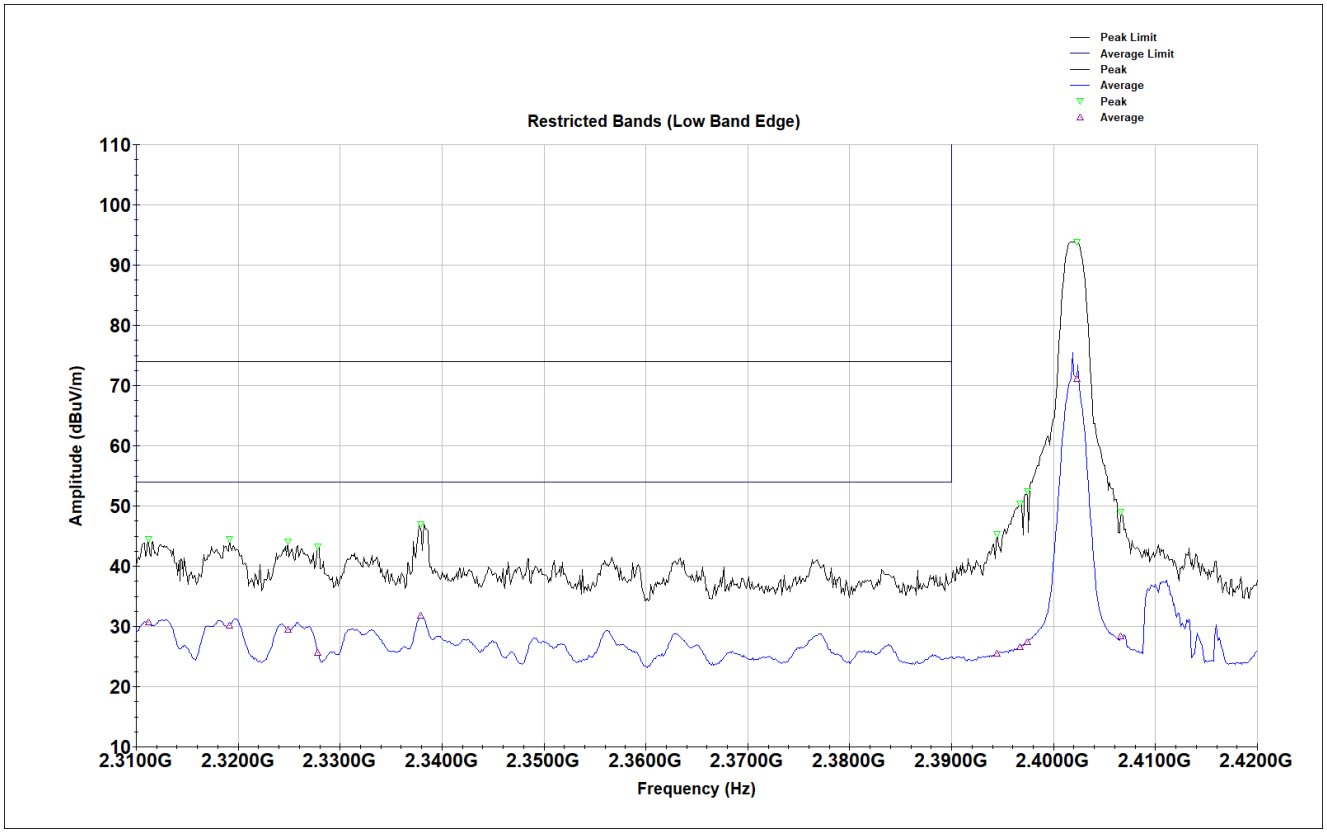
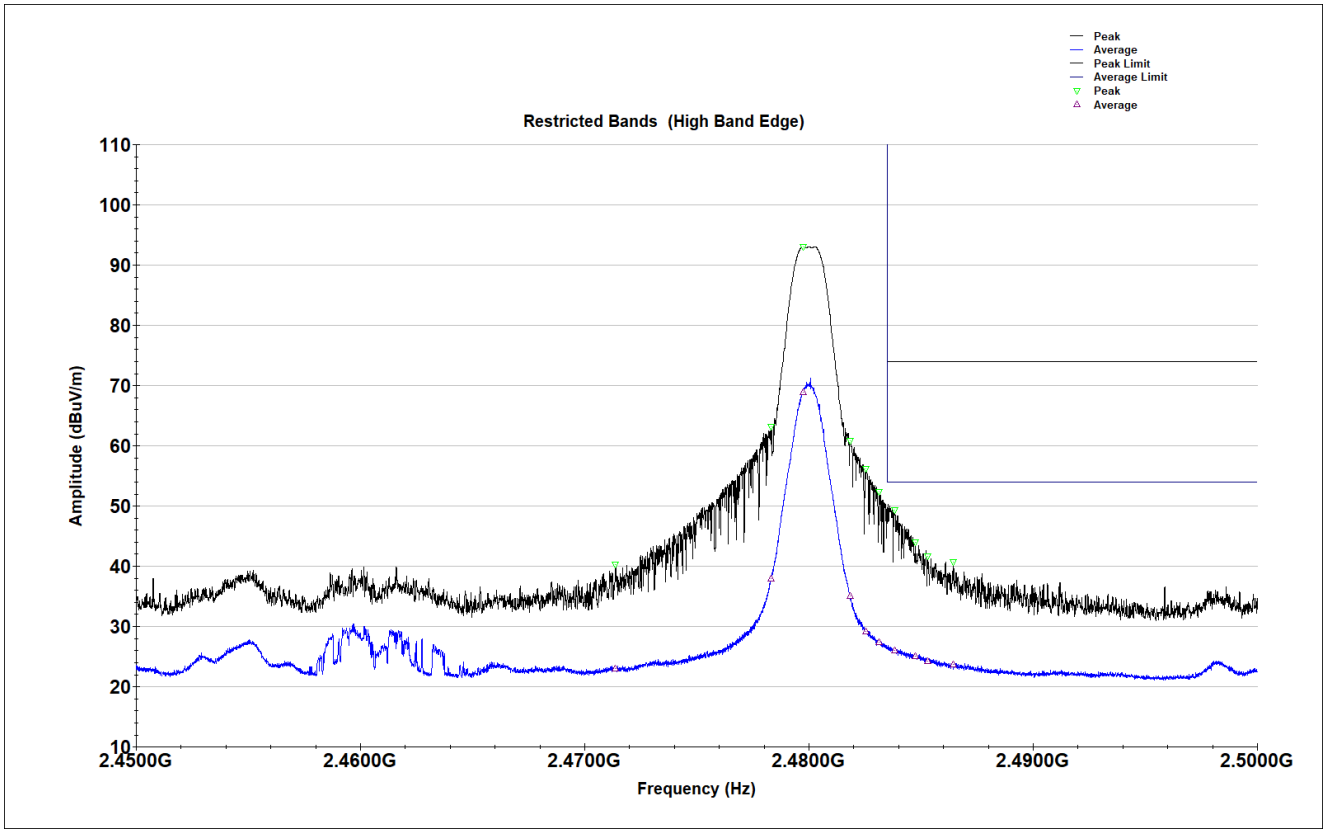


Figure 27. High Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (2Mbps)



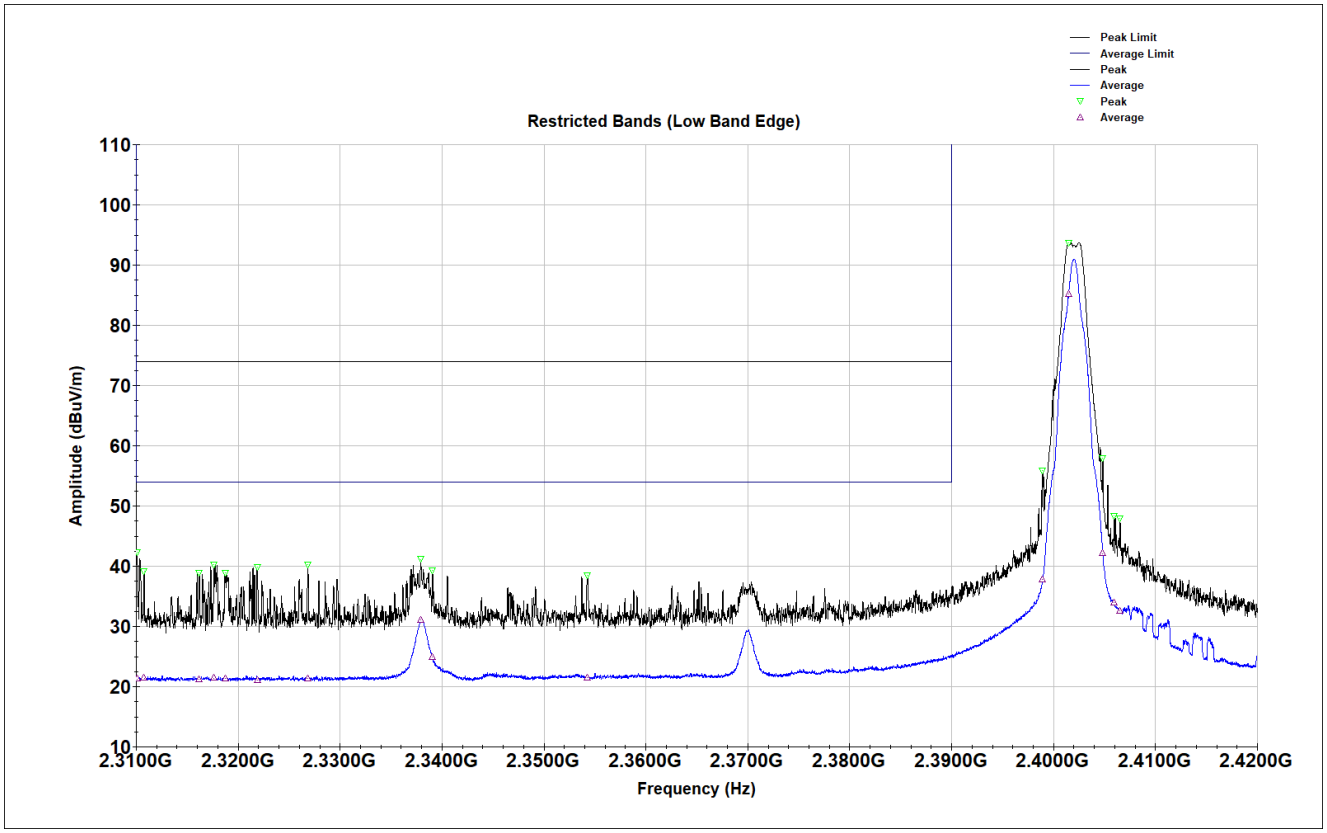
Frequency	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2311.21	44.45	74	29.55	30.66	54	23.34	Pass
2319.13	44.55	74	29.45	30.17	54	23.83	Pass
2324.85	44.05	74	29.95	29.4	54	24.6	Pass
2327.82	43.26	74	30.74	25.62	54	28.38	Pass

Figure 28. Restricted Band Edge Spurious Emissions (Low Channel, 1MBps)



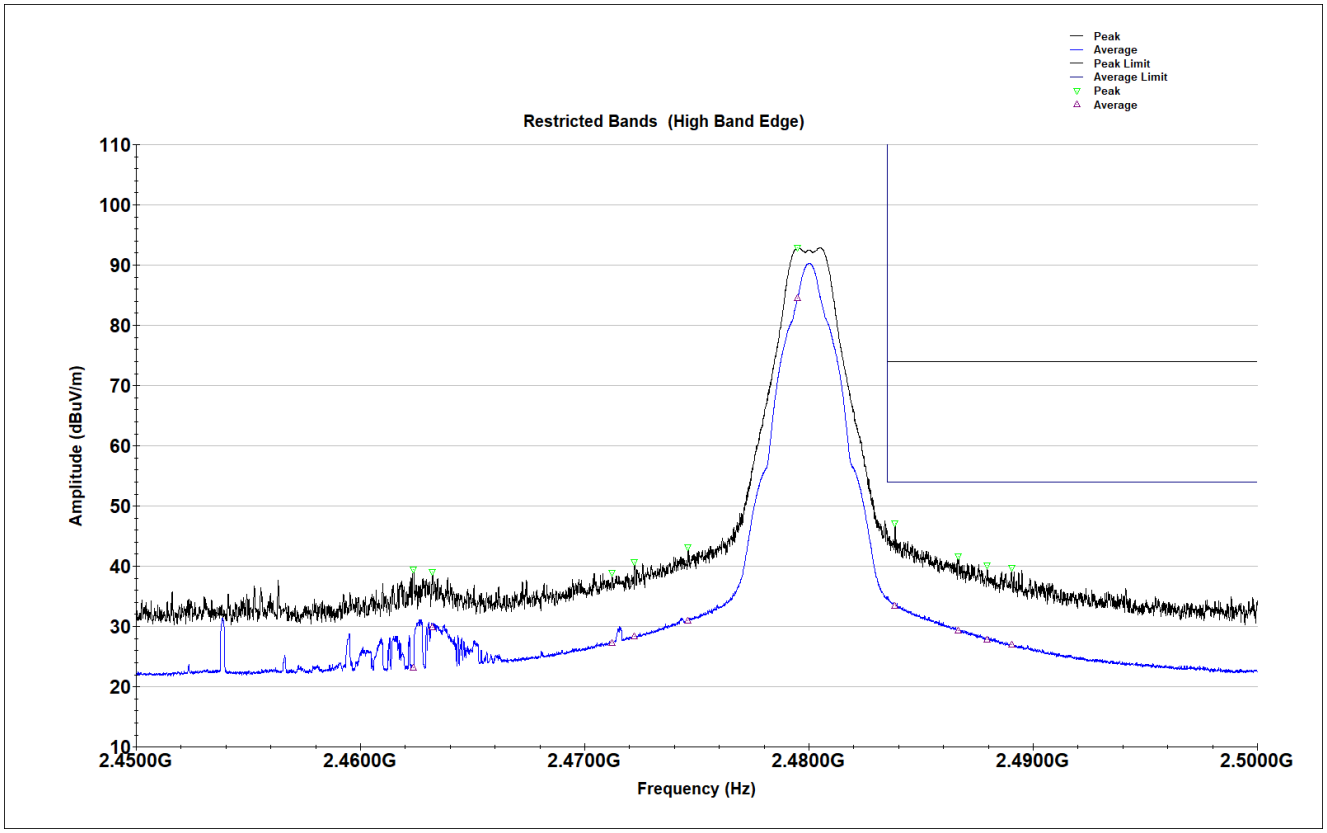
Frequency	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2483.806	49.34	74	24.66	26.09	54	27.91	Pass
2484.738	43.91	74	30.09	25.01	54	28.99	Pass
2485.287	41.6	74	32.4	24.26	54	29.74	Pass
2486.444	40.67	74	33.33	23.64	54	30.36	Pass

Figure 29. Restricted Band Edge Spurious Emissions (High Channel, 1MBps)



Frequency	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2310.055	42.32	74	31.68	21.31	54	32.69	Pass
2310.77	39.15	74	34.85	21.45	54	32.55	Pass
2316.188	38.88	74	35.12	21.22	54	32.78	Pass
2317.645	40.26	74	33.74	21.44	54	32.56	Pass
2318.704	38.92	74	35.08	21.32	54	32.68	Pass
2321.866	39.85	74	34.15	21.07	54	32.93	Pass
2326.83	40.33	74	33.67	21.39	54	32.61	Pass
2337.899	41.16	74	32.84	31.08	54	22.92	Pass
2339.054	39.31	74	34.69	24.96	54	29.04	Pass
2354.261	38.51	74	35.49	21.55	54	32.45	Pass
2310.055	42.32	74	31.68	21.31	54	32.69	Pass

Figure 30. Restricted Band Edge Spurious Emissions (Low Channel, 2MBps)



Frequency	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2483.844	47.15	74	26.85	33.4	54	20.6	Pass
2486.644	41.63	74	32.37	29.38	54	24.62	Pass
2487.944	40.1	74	33.9	27.83	54	26.17	Pass
2489.037	39.71	74	34.29	27.04	54	26.96	Pass

Figure 31. Restricted Band Edge Spurious Emissions (High Channel, 2MBps)

Worst Case Cabinet Spurious Emissions

Frequency [MHz]	QPK Level [dBµV/m] [3]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB] [4]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
244.080	36.50	46.02	9.52	-7.16	H	48.1	3.39	120.000	Pass
244.080	26.65	46.02	19.37	-7.16	V	13.5	2.03	120.000	Pass
257.610	23.12	46.02	22.90	-5.54	V	179.8	2.54	120.000	Pass
271.200	31.13	46.02	14.89	-6.25	H	225.7	3.4	120.000	Pass
284.760	34.61	46.02	11.41	-6.13	H	76.7	3.5	120.000	Pass

Figure 32. Worst Case Cabinet Radiation, Below 1GHz (1Mbps)

Frequency [MHz]	PK+ Level [dBµV/m][3]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m][3]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB][4]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
4,879.500	45.18	74.00	28.82	30.59	54.00	23.41	-3.35	H	161.4	1.91	Pass
4,880.500	45.86	74.00	28.14	31.20	54.00	22.80	-3.34	V	0	2.28	Pass
7,319.500	46.20	74.00	27.80	32.13	54.00	21.87	-2.79	H	128.1	2.5	Pass
7,320.500	50.17	74.00	23.83	35.19	54.00	18.81	-2.79	V	318.1	1.81	Pass
12,222.000	47.01	74.00	26.99	32.76	54.00	21.24	-1.96	H	194.3	2.08	Pass
12,256.000	45.63	74.00	28.37	32.72	54.00	21.28	-2.04	V	31.5	1.19	Pass
19,447.500	50.43	74.00	23.57	37.42	54.00	16.58	12.36	V	122	2.99	Pass
19,501.500	50.60	74.00	23.40	37.12	54.00	16.88	12.38	H	199.8	1.33	Pass

Figure 33. Worst Case Cabinet Radiation, Above 1GHz (1Mbps)

[3] This corrected level includes the factor shown in the "correction" column. The corrected level = Raw Reading + Correction Factor. The raw reading is not shown in the table above.
[4] This correction factor includes cable loss in dB, preamplifier gain in dB, and an electric field antenna factor in (dB/m).

Frequency [MHz]	QPK Level [dBµV/m] [5]	QPK Limit [dBµV/m]	QPK Margin [dB]	Correction [dB] [6]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
119.520	11.59	43.52	31.93	-7.57	V	113.7	3.28	120.000	Pass
127.500	11.48	43.52	32.04	-7.75	H	134.8	3.23	120.000	Pass
258.960	14.60	46.02	31.42	-5.46	V	338	3.71	120.000	Pass
259.140	14.60	46.02	31.42	-5.45	H	73.8	1.83	120.000	Pass

Figure 34. Worst Case Cabinet Radiation, Below 1GHz (2Mbps)

Frequency [MHz]	PK+ Level [dBµV/m][5]	PK+ Limit [dBµV/m]	PK+ Margin [dB]	AVG Level [dBµV/m][5]	AVG Limit [dBµV/m]	AVG Margin [dB]	Correction [dB][6]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
4,879.000	45.17	74.00	28.83	33.26	54.00	20.74	-3.36	H	22	1.5	Pass
4,881.000	46.24	74.00	27.76	35.29	54.00	18.71	-3.33	V	329.7	2.5	Pass
7,318.500	52.83	74.00	21.17	43.00	54.00	11.00	-2.80	V	315.5	1.07	Pass
12,264.500	45.89	74.00	28.11	32.89	54.00	21.11	-2.06	V	269.6	3.55	Pass
12,277.000	45.31	74.00	28.69	32.86	54.00	21.14	-2.10	H	100.7	3.88	Pass
17,875.500	49.44	74.00	24.56	36.73	54.00	17.27	1.51	V	233.5	2.5	Pass
17,880.000	50.56	74.00	23.44	37.65	54.00	16.35	1.50	H	208.8	3.7	Pass
19,520.000	49.75	74.00	24.25	36.57	54.00	17.43	12.33	V	354.4	2.06	Pass

Figure 35. Worst Case Cabinet Radiation, Above 1GHz (2Mbps)

[5] This corrected level includes the factor shown in the "correction" column. The corrected level = Raw Reading + Correction Factor. The raw reading is not shown in the table above.
[6] This correction factor includes cable loss in dB, preamplifier gain in dB, and an electric field antenna factor in (dB/m).

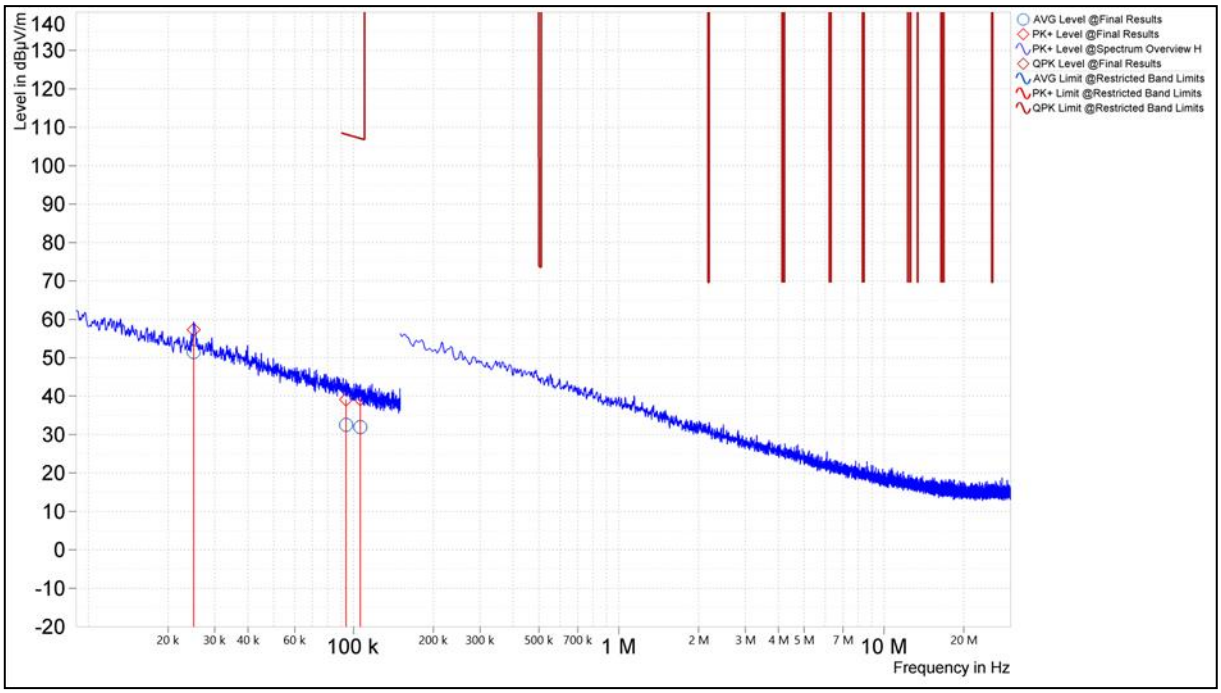


Figure 36. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coaxial Loop (1MBps)

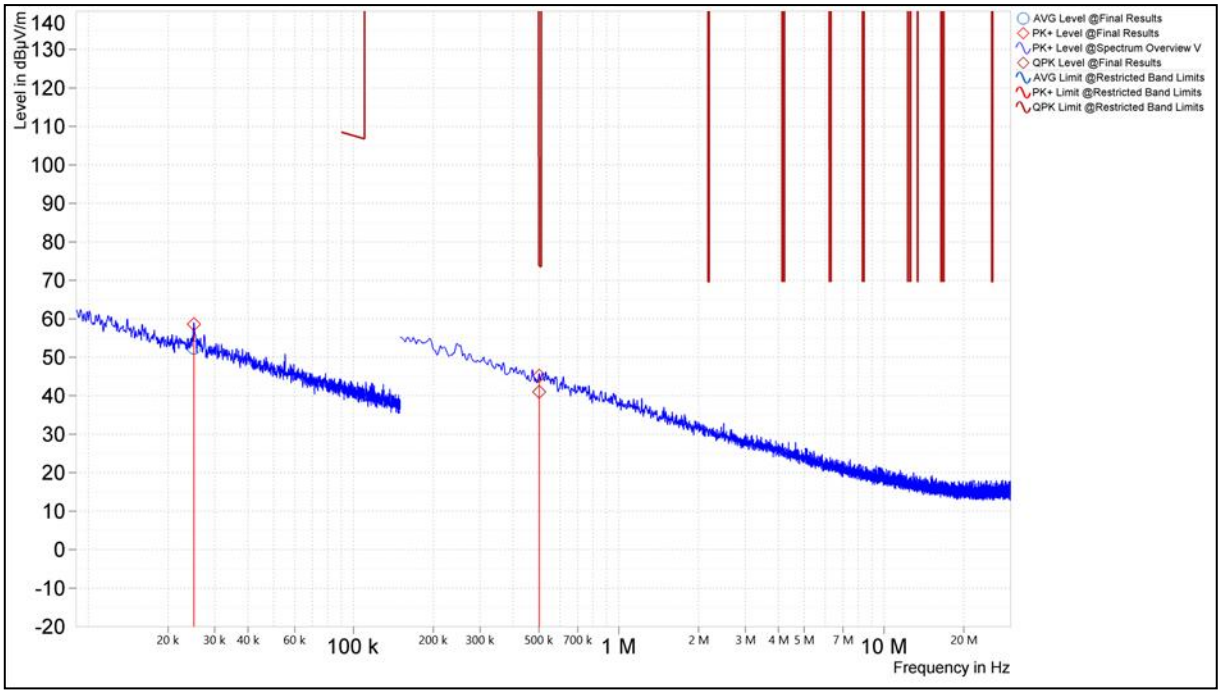


Figure 37. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coplanar Loop (1MBps)

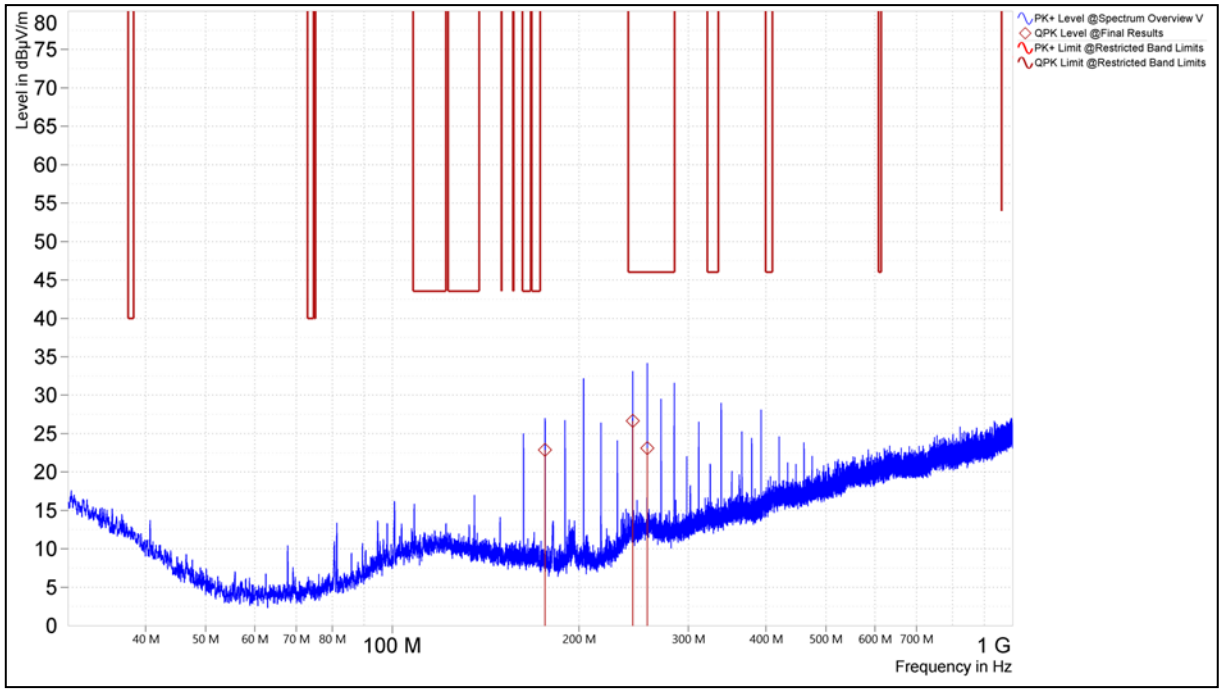


Figure 38. Worst Case Cabinet Radiation, 30MHz – 1GHz, Vertical Polarity (1MBps)

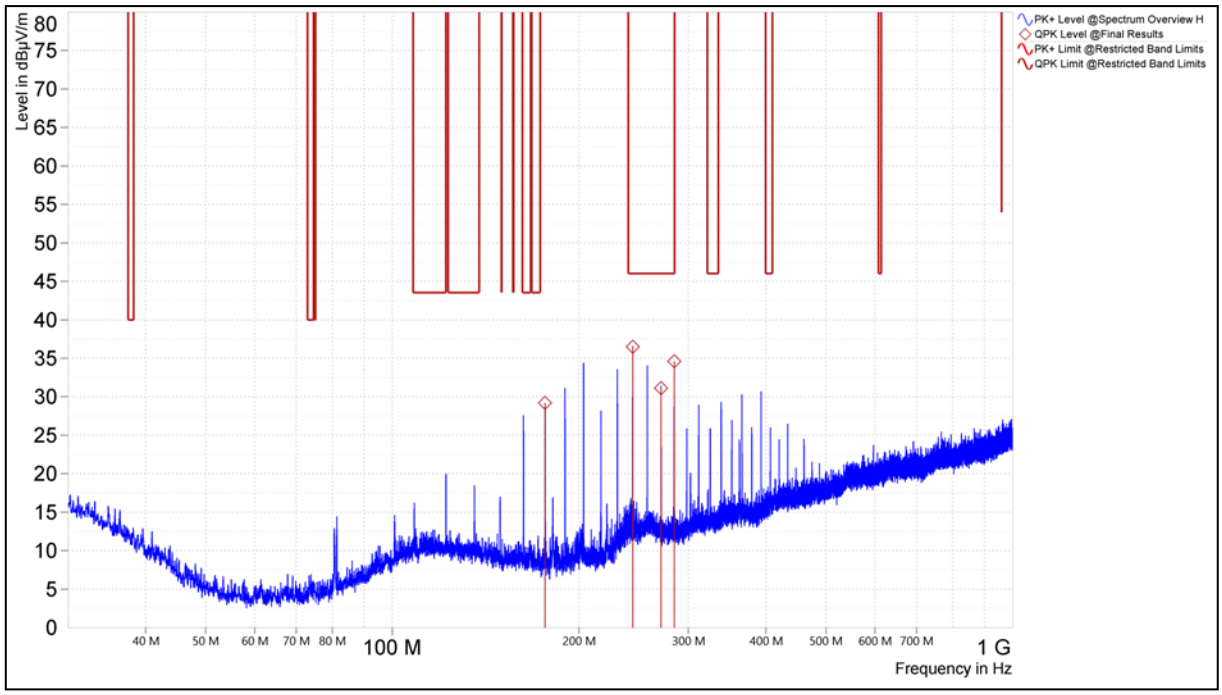


Figure 39. Worst Case Cabinet Radiation, 30MHz – 1GHz, Horizontal Polarity (1MBps)

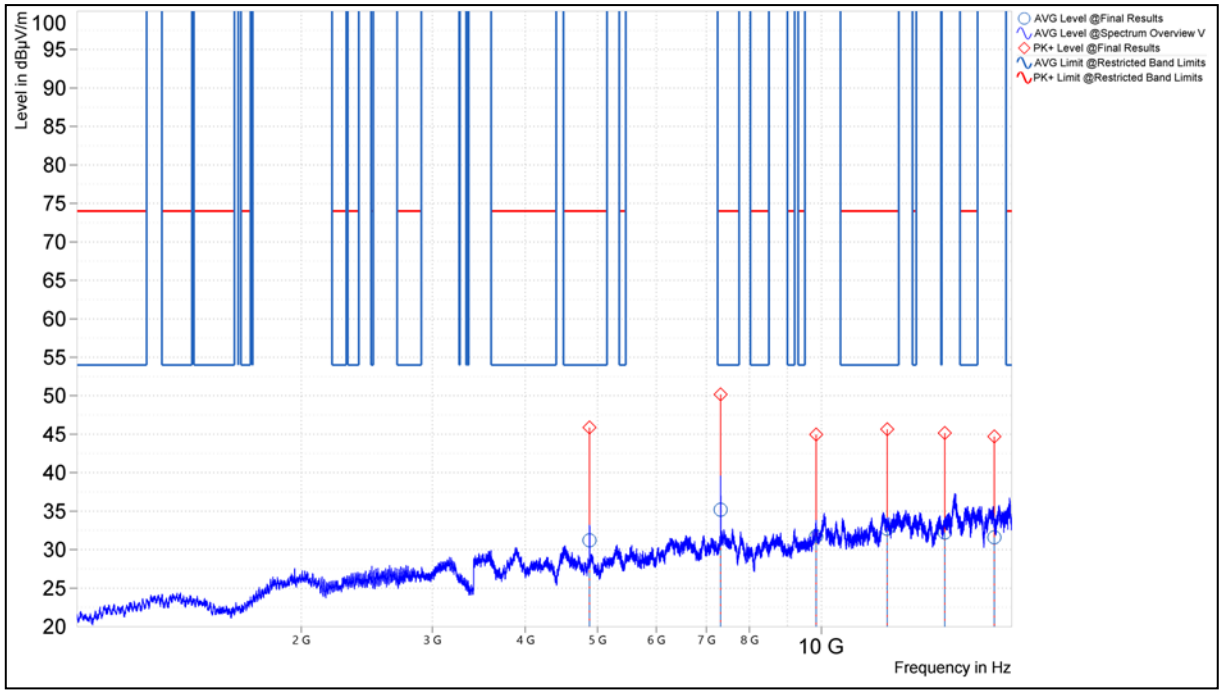


Figure 40. Worst Case Cabinet Radiation, 1GHz – 18GHz, Vertical Polarity (1MBps)

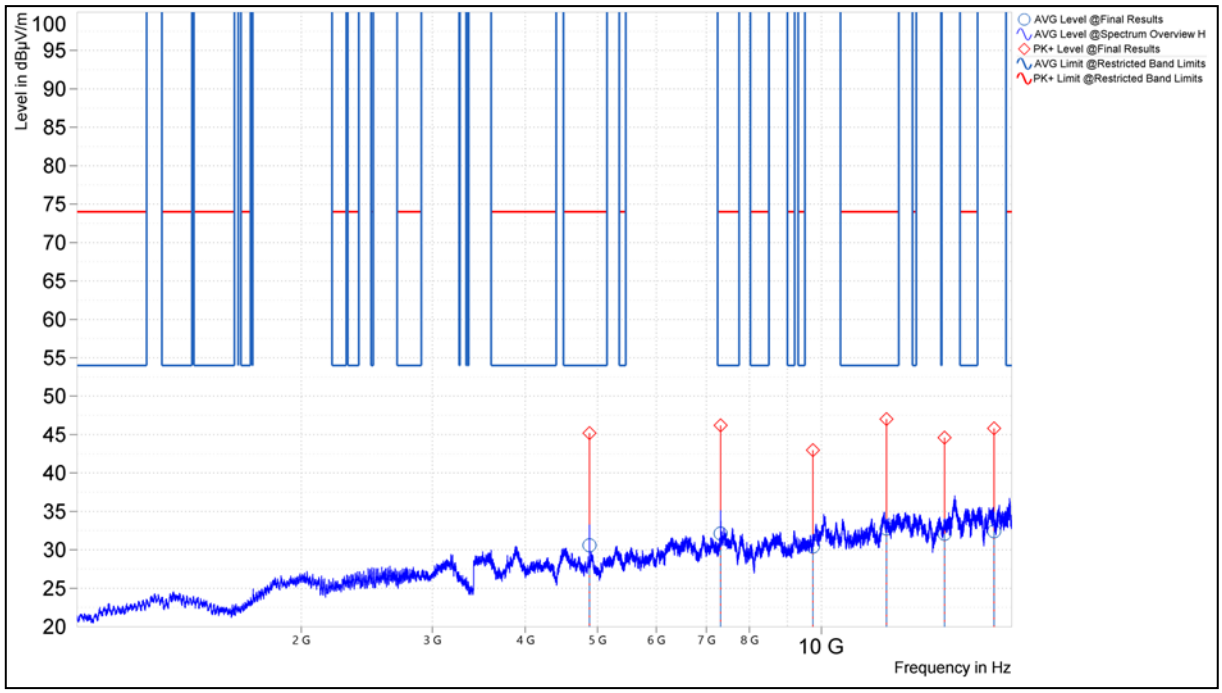


Figure 41. Worst Case Cabinet Radiation, 1GHz – 18GHz, Horizontal Polarity (1MBps)

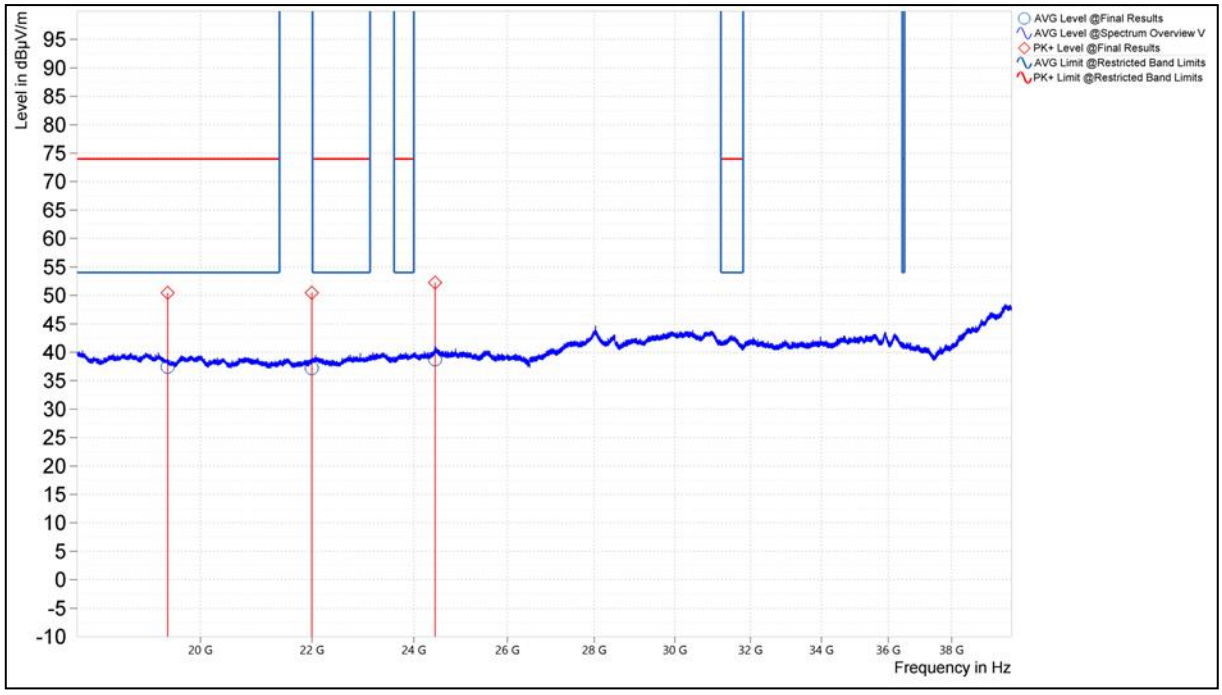


Figure 42. Worst Case Cabinet Radiation, 18GHz – 40GHz, Vertical Polarity (1MBps)

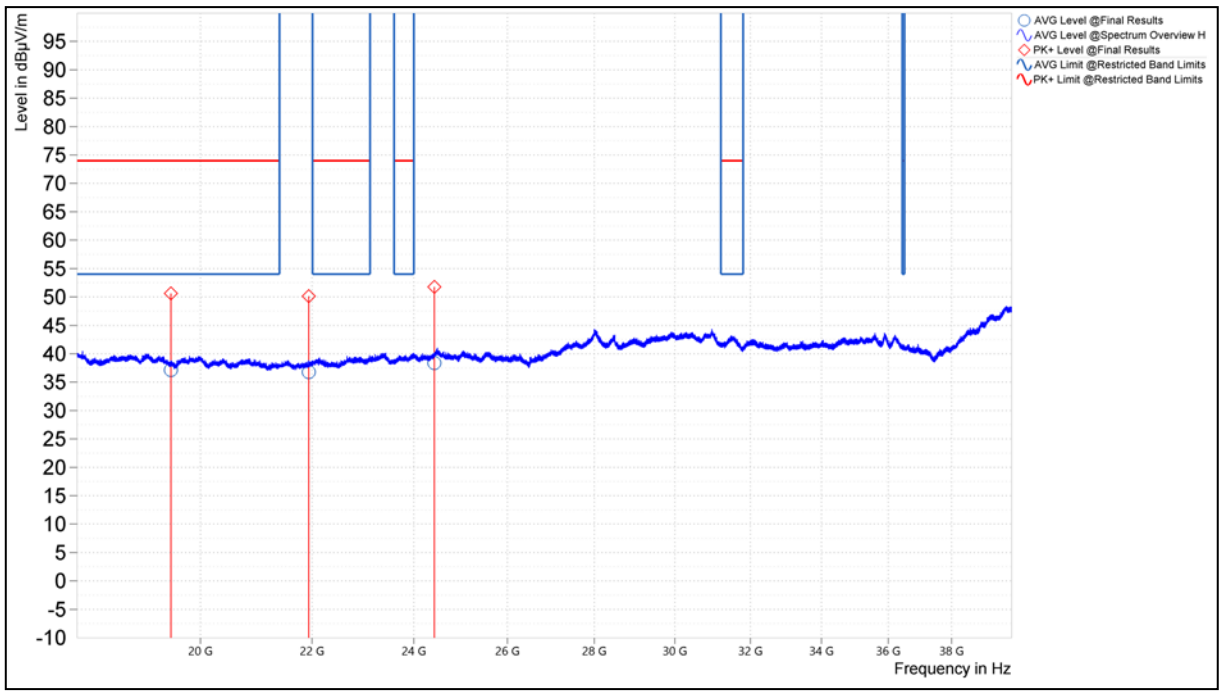


Figure 43. Worst Case Cabinet Radiation, 18GHz – 40GHz, Horizontal Polarity (1MBps)

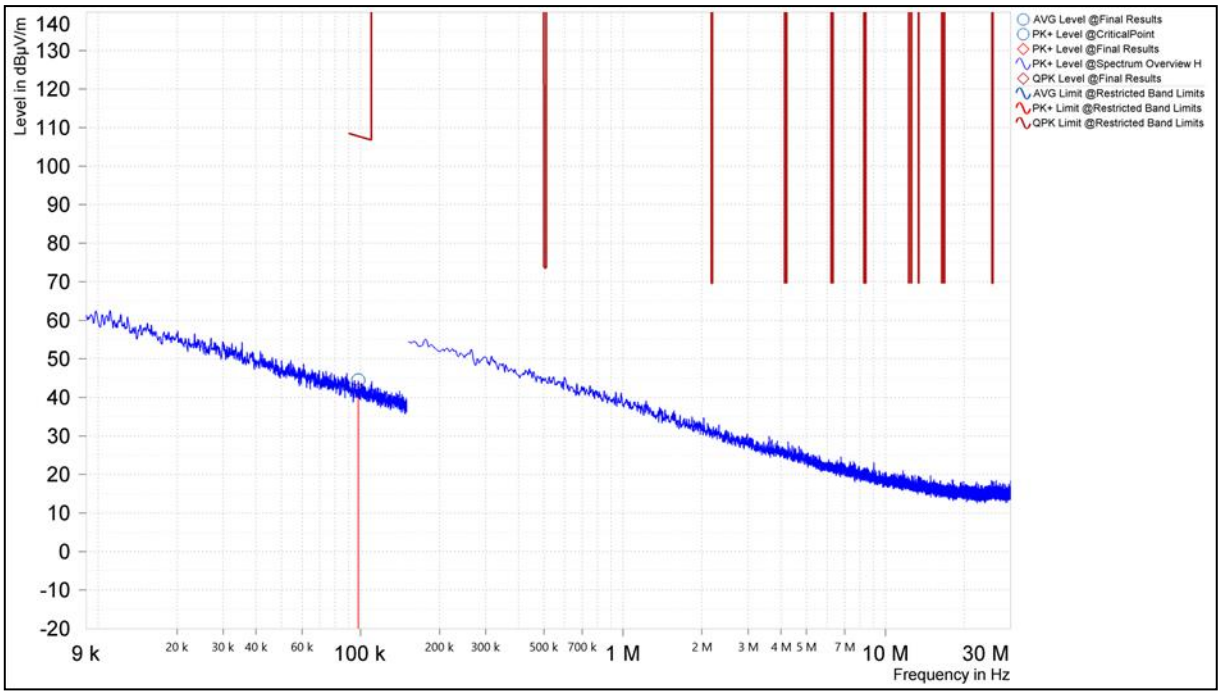


Figure 44. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coaxial Loop (2MBps)

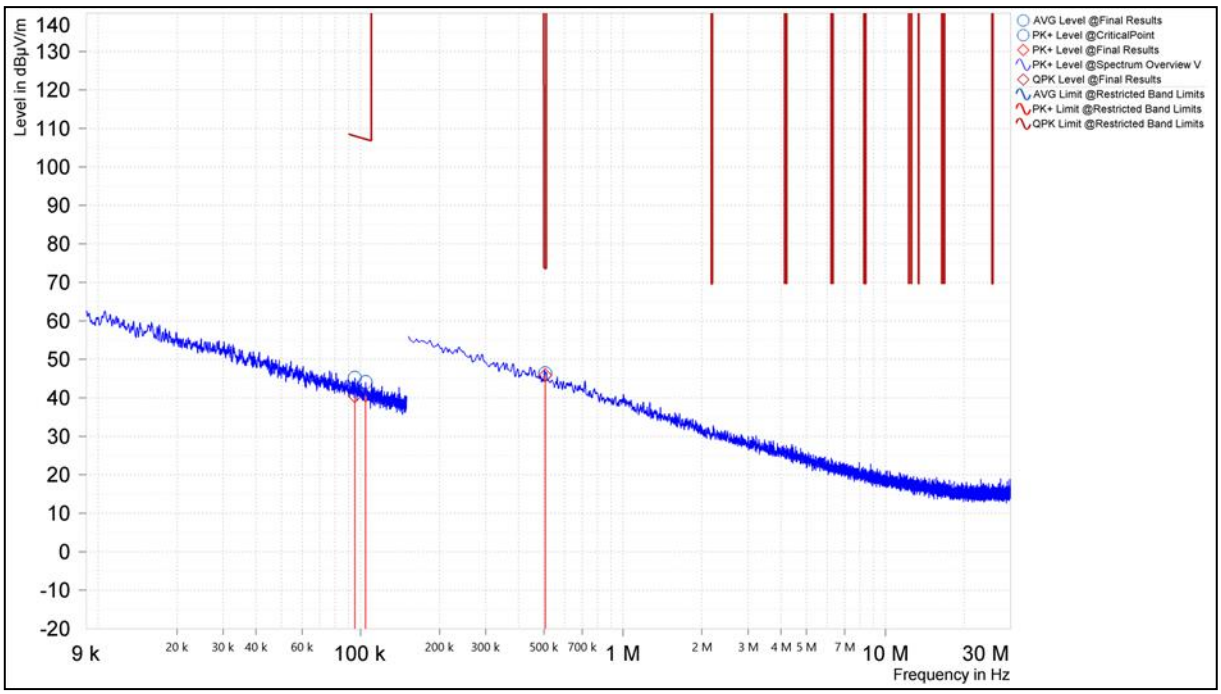


Figure 45. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coplanar Loop (2MBps)

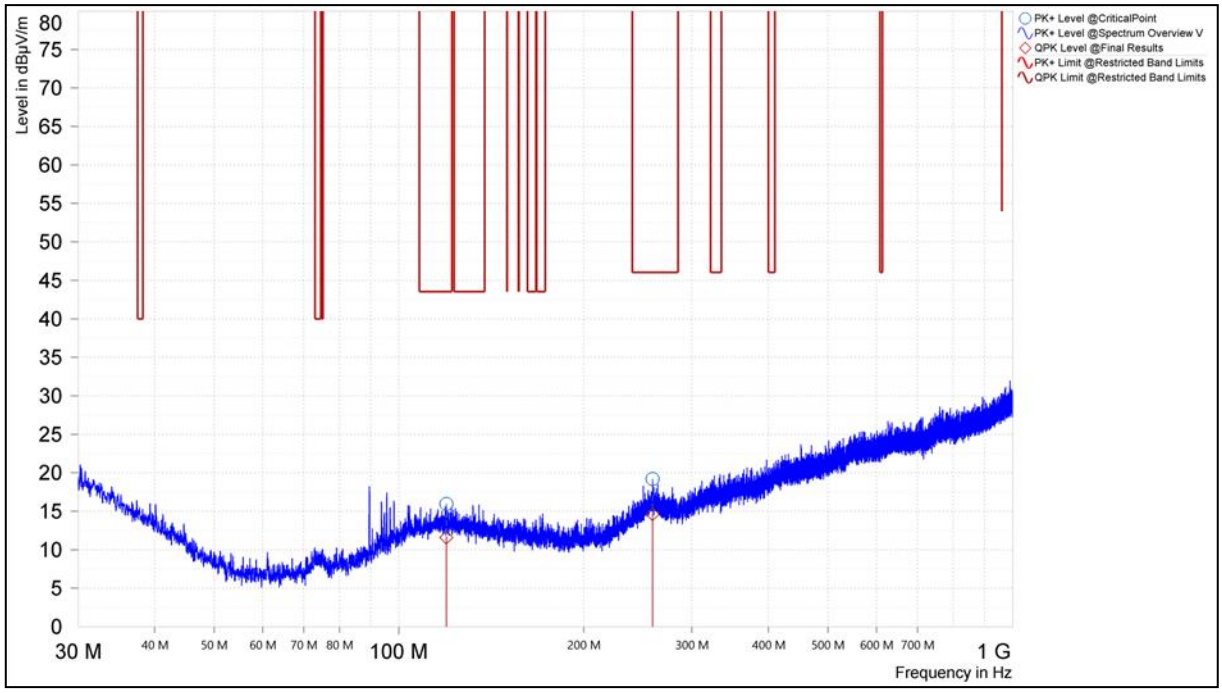


Figure 46. Worst Case Cabinet Radiation, 30MHz – 1GHz, Vertical Polarity (2MBps)

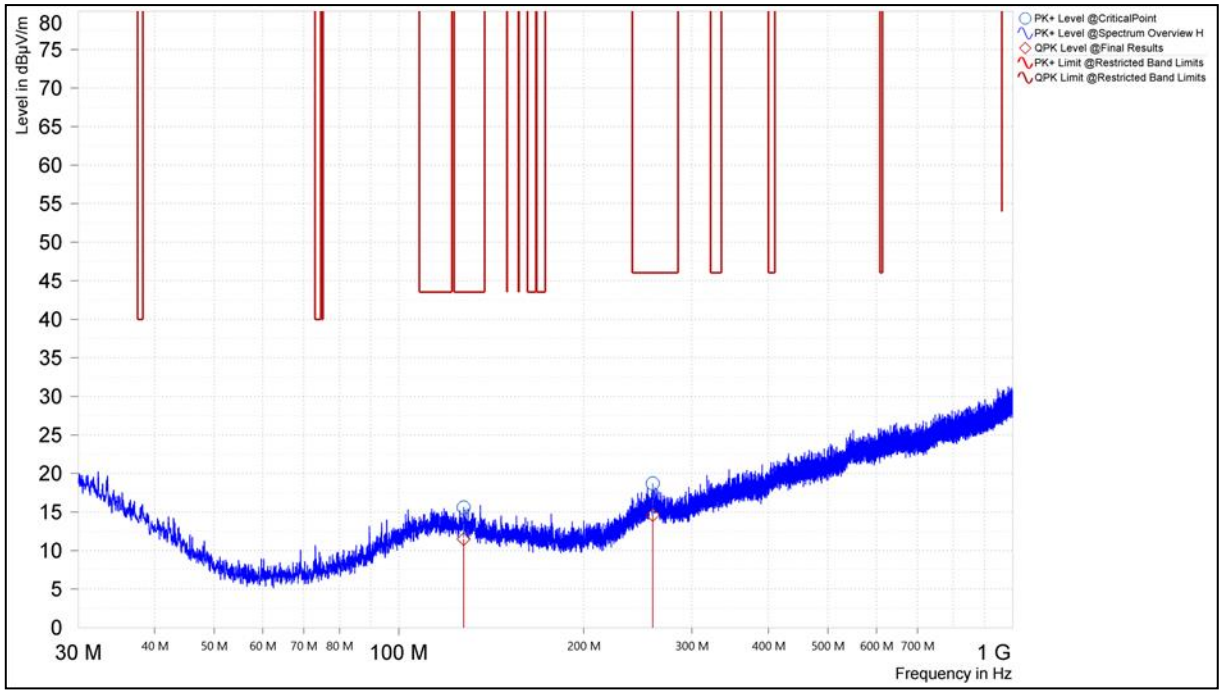


Figure 47. Worst Case Cabinet Radiation, 30MHz – 1GHz, Horizontal Polarity (2MBps)

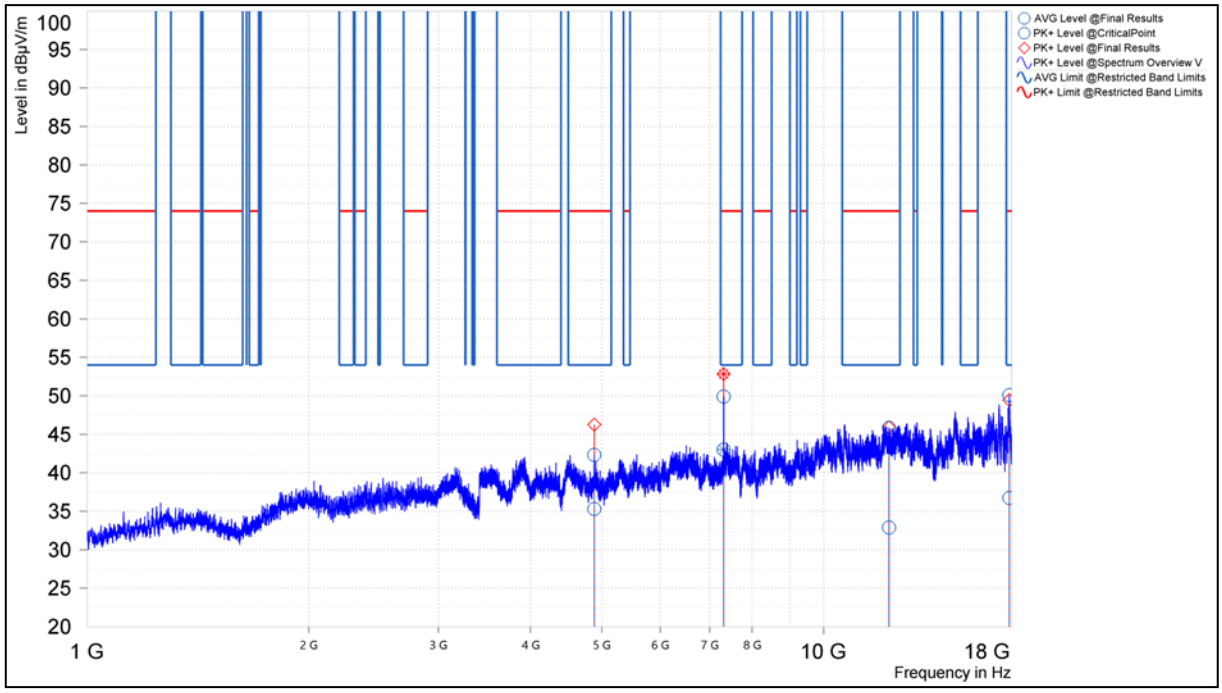


Figure 48. Worst Case Cabinet Radiation, 1GHz – 18GHz, Vertical Polarity (2MBps)

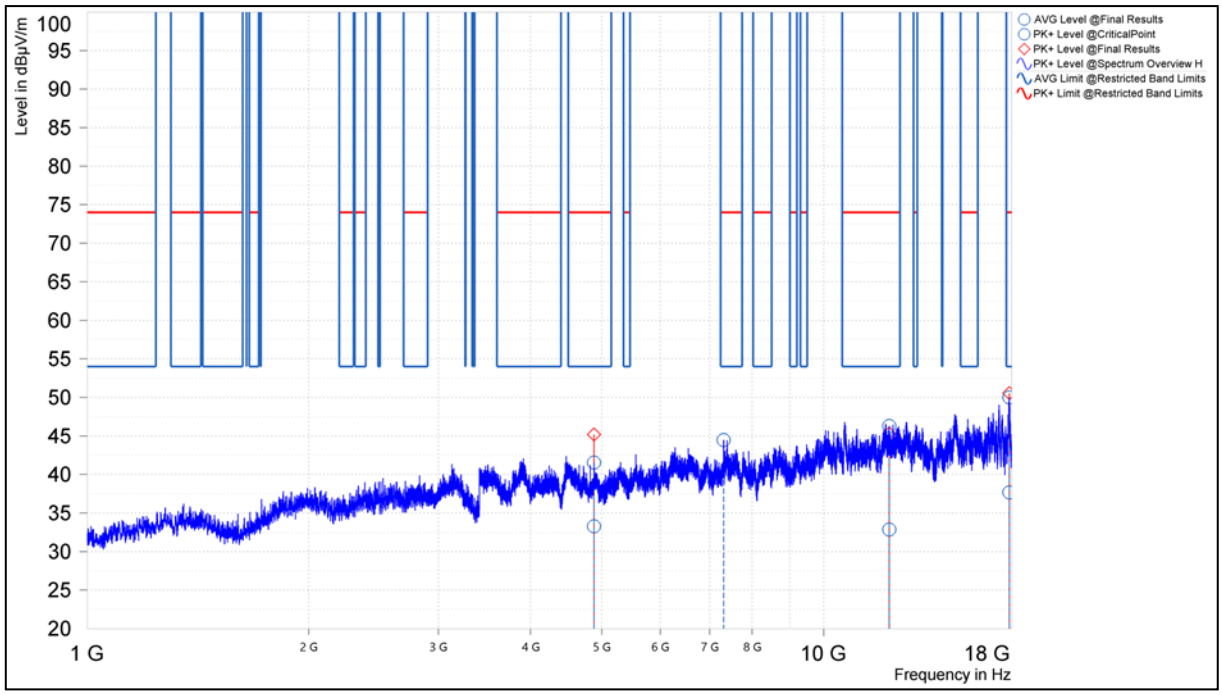


Figure 49. Worst Case Cabinet Radiation, 1GHz – 18GHz, Horizontal Polarity (2MBps)

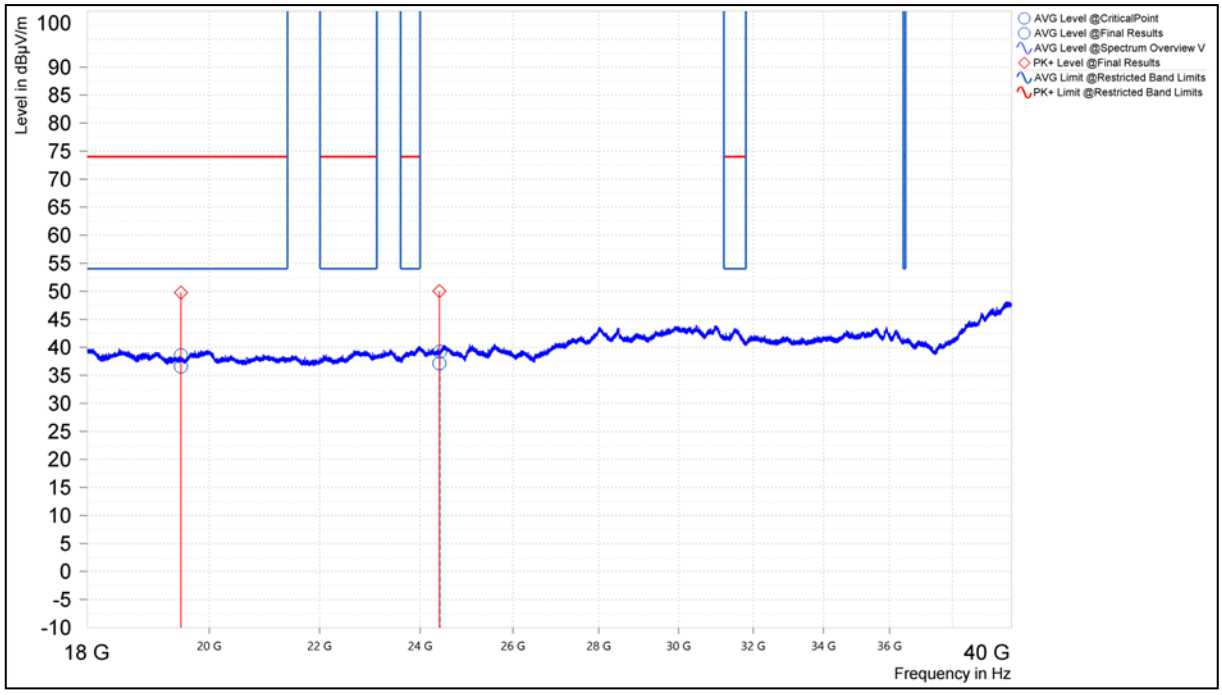


Figure 50. Worst Case Cabinet Radiation, 18GHz – 40GHz, Vertical Polarity (2MBps)

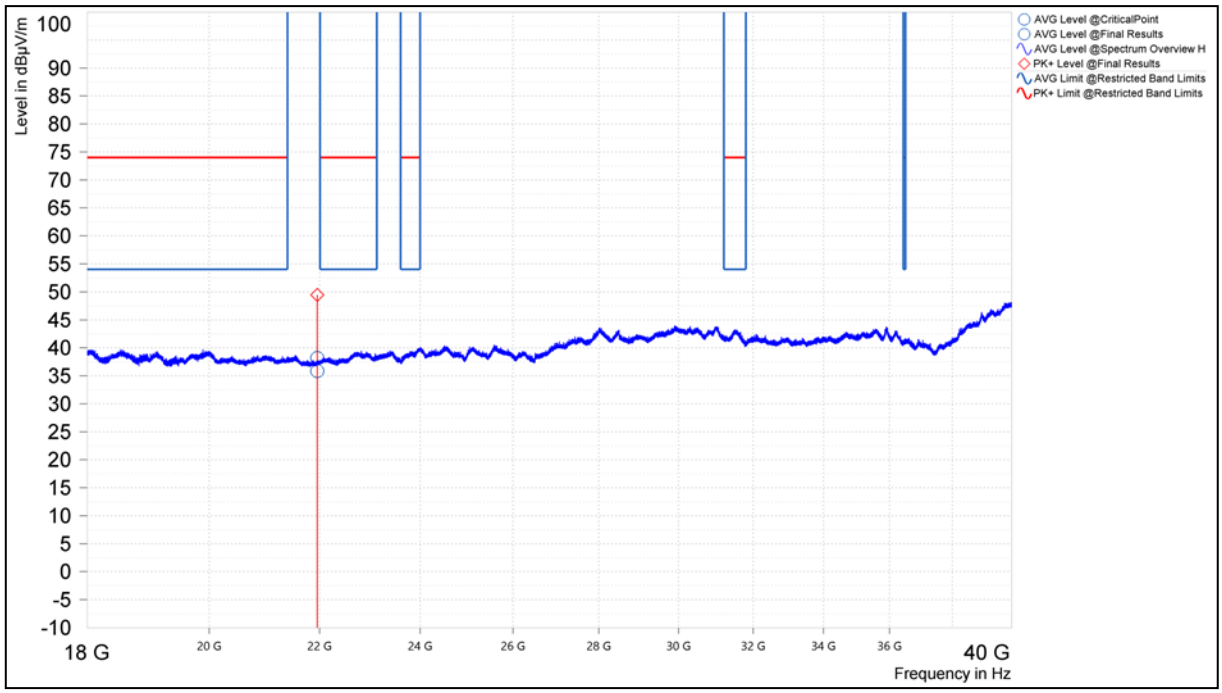


Figure 51. Worst Case Cabinet Radiation, 18GHz – 40GHz, Horizontal Polarity (2MBps)

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[7]	EMI Test Receiver	Rohde & Schwarz	ESW44	05/26/2023	05/26/2024
1A1083[8]	EMI Test 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
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.

[7] This item was used for test dates in October of 2023
[8] This item was used for test dates in December of 2023

End of Report