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

3/25/2024
HID Global Corporation (US)
6533 Flying Cloud Drive, Ste. 1000
Eden Prairie, MN 55344
USA

Dear Richard Georgerian,

Enclosed is the EMC Wireless test report for compliance testing of the HID Global Corporation (US) OMNIKEY SE Reader Core 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: WIRA125908 – FCC15.247-RSS-247_R1

Bluetooth Low Energy
Test Report

for the

HID Global Corporation (US)
OMNIKEY SE Reader Core (Model:RCL5510)

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
∅	2/26/2024	Initial Issue.
1	3/25/2024	Addressed comments from HID and from TCB reviewer

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List of Terms and Abbreviations

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

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the OMNIKEY SE Reader Core, 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 OMNIKEY SE Reader Core, 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 1110985118. 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 OMNIKEY SE Reader Core, under HID Global Corporation (US)'s purchase order number 1110985118.

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

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

Product Name:	OMNIKEY SE Reader Core	
Model(s) Tested:	RCL5510	
Model(s) Included by Similarity	RCS5510	
FCC Identifiers	JQ6-RCL5510 (for model RCL5510), JQ6-RCS5510 (for model RCS5510)	
ISED Identifiers	2236B-RCL5510 (for model RCL5510), JQ6-RCS5510 (for model RCS5510)	
EUT Specifications:	Primary Power: 3.6 – 6VDC	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	4.78dBm
	EUT Frequency Ranges:	2402MHz – 2480MHz
	Antenna Gain[1]:	4.4dBi
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):	1/8/2024 through 1/16/2024	

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

OMNIKEY SE Reader Core/OMNIKEY SE Reader Core Standard (RCL55100000, SRD Model: RCL5510) OMNIKEY SE Reader Core/OMNIKEY SE Reader Core MINI (RCS55100000, SRD Model: RCS5510) The OMNIKEY SE Reader Core's triple frequency capability allows the use of the high, low, and BLE frequency credentials with the same reader, providing a solution for mixed credential and credential migration applications. It includes more memory, faster performance, expanded connectivity, and Bluetooth Smart (BLE), while still offering a secure and standards-based independent technology and flexible identity data structure.

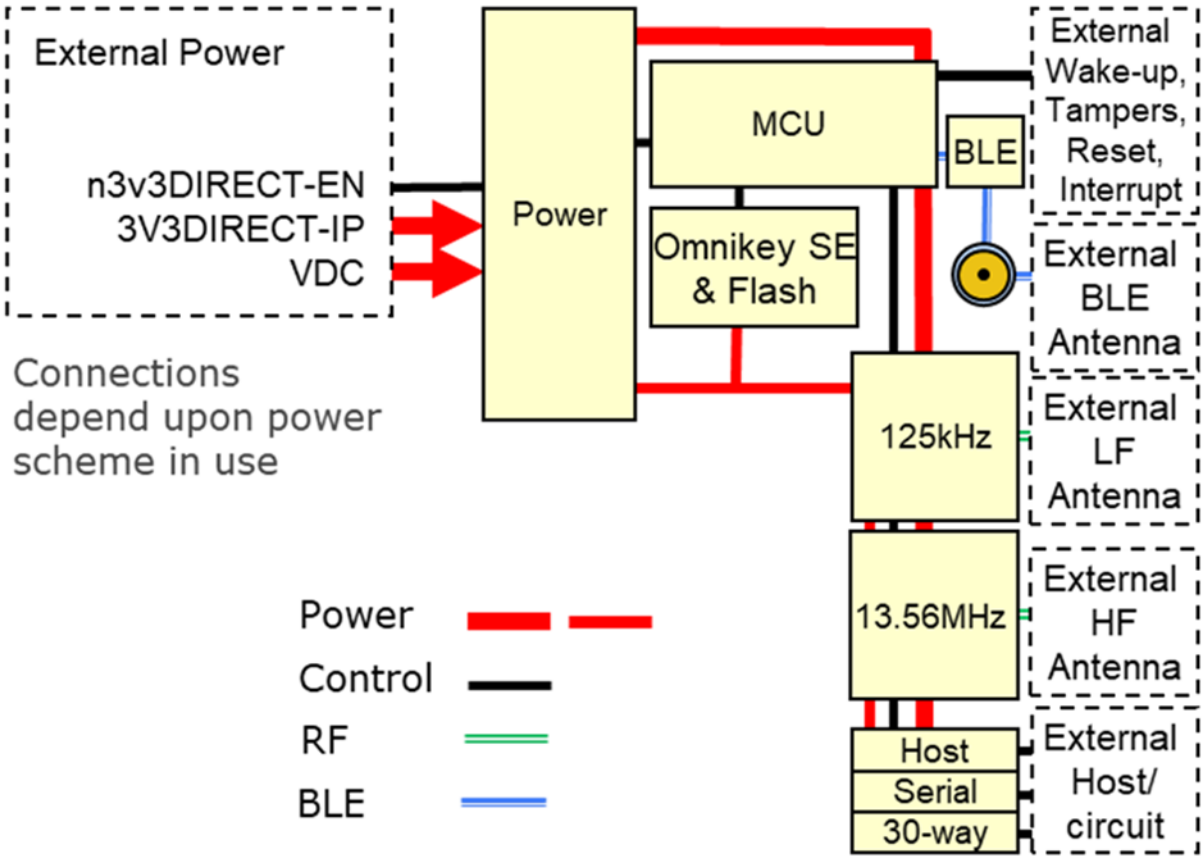


Figure 1. Block Diagram of Test Configuration

F. Equipment Configuration

The EUT was set up as outlined in Figure 1 above. A laptop computer was used to send test commands to force transmission on low, mid, or high channels at the maximum output power as directed by HID Global Corporation (US). According to HID Global Corporation (US), the OMNIKEY SE Reader Core only supported BLE transmissions at 2Mbps data rate.

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
	USB port, host	USB cable	Generic	Not applicable.
	USB to Fibre optic	Fibre optic cable	Generic	Not applicable.
	DELL Laptop	DELL	Latitude 7480	Not applicable.
	USB-UART Convertor	Waveshare	FT232 USB UART Board (Micro)	Not applicable.
	UART-Fibre Optic convertor	AVAGO	AFBR-1629, AFBR-2529	Not applicable.
	Motorola /Android phone	Motorola	YDMW1942401P	Not applicable.
	Battery pack, 4x1.2Vdc, NiMH	Generic	Not applicable.	Not applicable.
	LF credential/Prox	HID Global	Indala FlexISO	Not applicable.
	HF credential/14443A	HID Global	MIFARE Classic 4K SE	Not applicable.
	BLE Antenna	HID Global	A51270031	Not applicable.
	Small HF antenna	HID Global	4090A10	Not applicable.
	Large HF antenna	HID Global	4090A11	Not applicable.
	Combined LF/HF antenna	HID Global	4090A16	Not applicable.

Table 5. Support Equipment

H. Ports and Cabling Information

Ref. Id	Port Name on EUT	Cable Description or reason for no cable	Qty	Length as tested (m)	Max Length (m)	Shielded? (Y/N)	Termination Box ID & Port Name
	Rx-Tx	3-wire twisted		0.2	0.2	No	Not applicable.

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 (2Mbps)	BLE (GFSK)	2402MHz / 2440MHz / 2480MHz	+6dBm

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 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 uses a unique coupling.

Test Engineer(s): Bryan Taylor

Test Date(s): 1/10/2024

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)

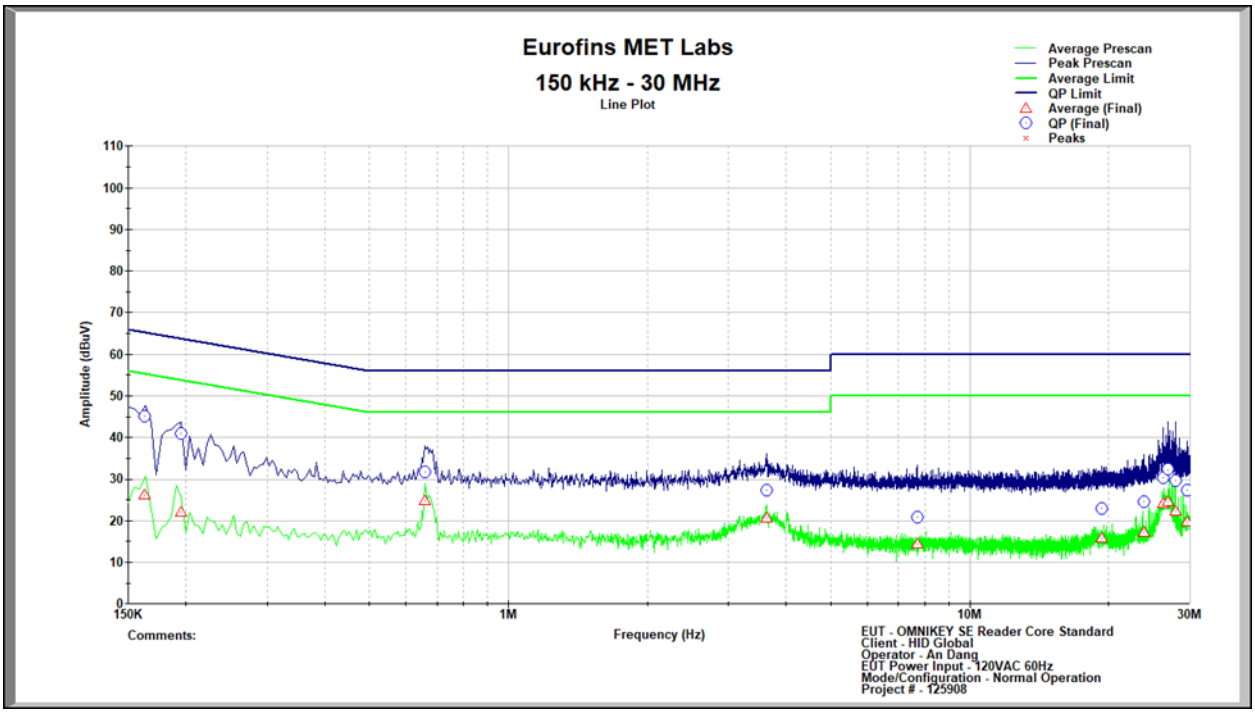
Test Procedure: The EUT was placed on a 0.8 m-high wooden table. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 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 OMNIKEY SE Reader Core was powered via an external AC/DC Power adapter. Both the LF and HF antennas were replaced with 50 ohm load resistors. The resistors were located at the antenna solder locations on the main printed circuit board.

Test Engineer(s): An Dang

Test Date(s): 1/9/2024

15.207(a) Conducted Emissions Test Results

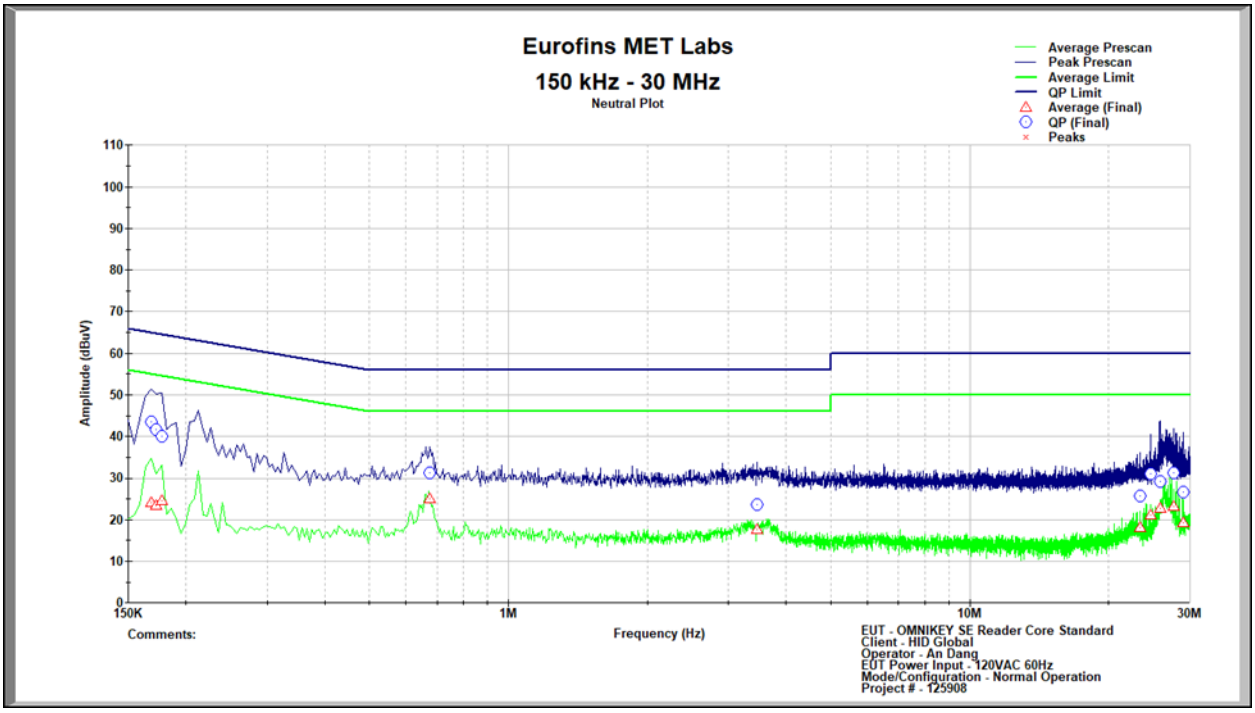


Conducted Emissions, 15.207(a), Phase

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)
0.163	45.158	65.629	20.471	26.151	55.629	29.478
0.195	40.944	64.714	23.770	21.949	54.714	32.765
0.658	31.720	56.000	24.280	24.796	46.000	21.204
3.621	27.253	56.000	28.747	20.667	46.000	25.333
7.686	20.888	60.000	39.112	14.462	50.000	35.538
19.297	22.913	60.000	37.087	15.845	50.000	34.155
23.826	24.610	60.000	35.390	17.184	50.000	32.816
26.271	30.304	60.000	29.696	24.116	50.000	25.884
26.838	32.296	60.000	27.704	24.637	50.000	25.363
27.897	29.623	60.000	30.377	22.290	50.000	27.710
29.611	27.365	60.000	32.635	19.645	50.000	30.355

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)
0.168	43.415	65.486	22.070	24.109	55.486	31.376
0.172	41.643	65.357	23.714	23.334	55.357	32.024
0.177	40.104	65.229	25.124	24.524	55.229	30.705
0.676	31.213	56.000	24.787	24.986	46.000	21.014
3.463	23.685	56.000	32.315	17.534	46.000	28.466
23.363	25.678	60.000	34.322	17.970	50.000	32.030
24.674	31.047	60.000	28.953	21.155	50.000	28.845
25.852	29.224	60.000	30.776	22.716	50.000	27.284
27.645	31.164	60.000	28.836	23.195	50.000	26.805
29.076	26.585	60.000	33.415	19.213	50.000	30.787

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): 1/10/2024

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): 1/10/2024

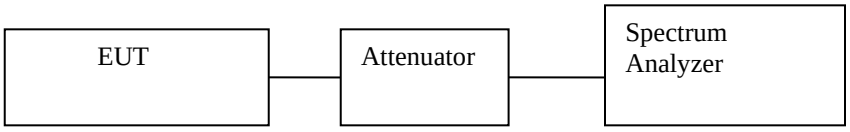


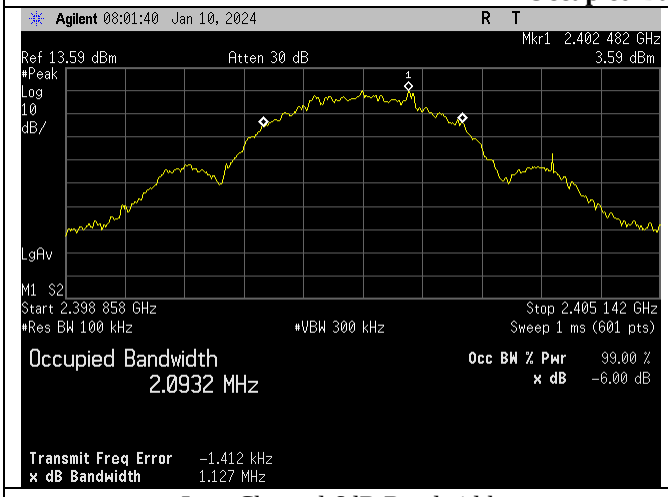
Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Data Rate	Channel	Frequency (MHz)	6dB Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	99% Bandwidth (MHz)	Result
2MBps	Low	2402MHz	1.12MHz	0.5	2.06MHz	Pass
	Middle	2440MHz	1.09MHz	0.5	2.05MHz	Pass
	High	2480MHz	1.13MHz	0.5	2.06MHz	Pass

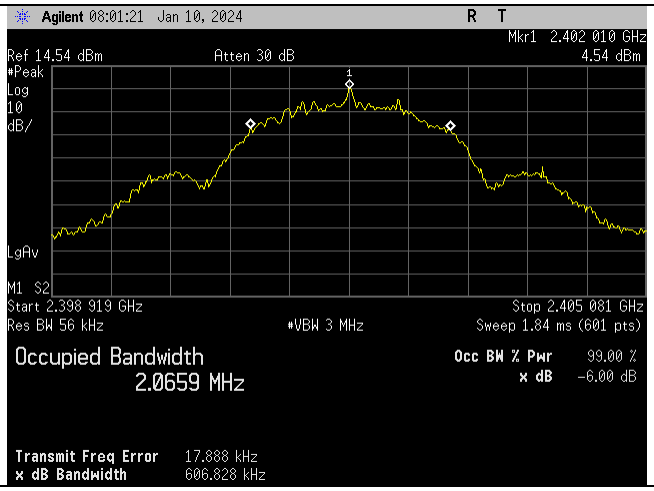
Table 11. 99% and 6 dB Occupied Bandwidth, Test Results

Occupied Bandwidth Test Results

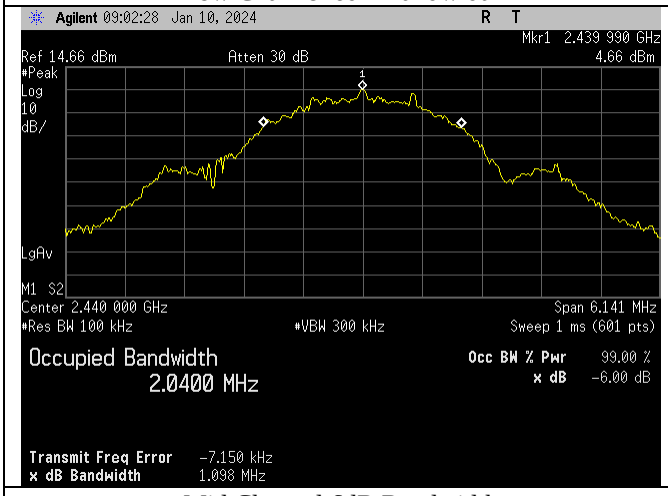
Occupied Bandwidth Plots



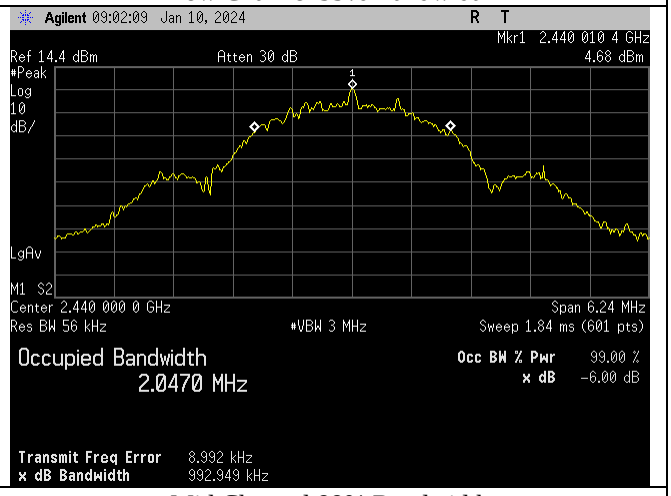
Low Channel 6dB Bandwidth



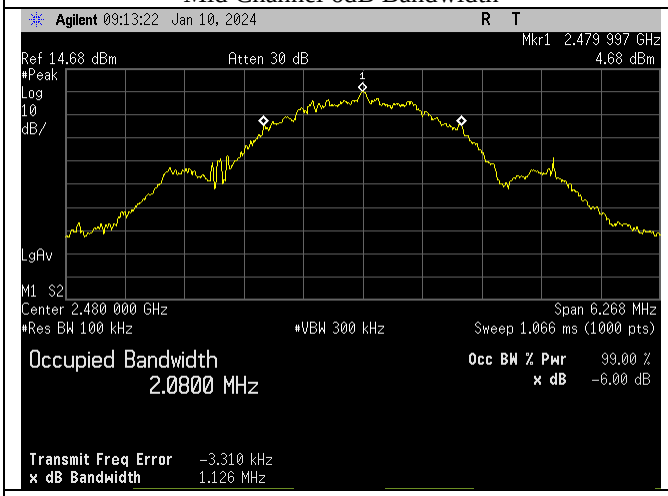
Low Channel 99% Bandwidth



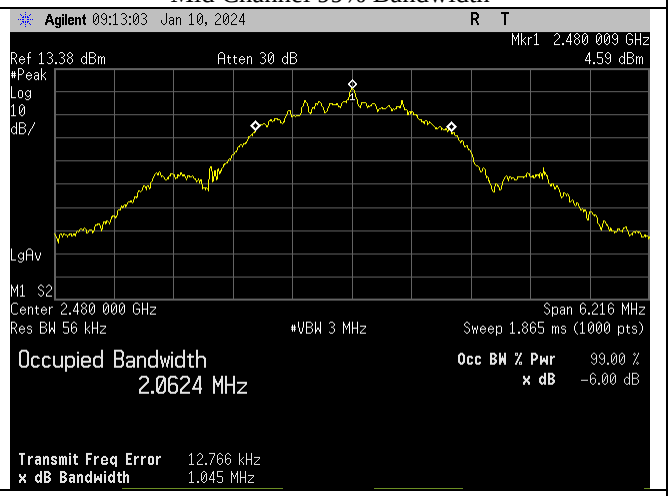
Mid Channel 6dB Bandwidth



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): 1/10/2024

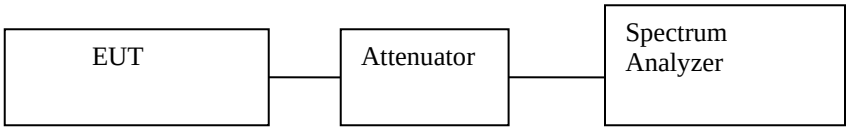


Figure 3. Peak Power Output Test Setup

Peak Power Output Test Results

Data Rate	Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power Limit (dBm)	Result
2MBps	Low	2402MHz	4.78dBm	30	Pass
	Middle	2440MHz	4.69dBm	30	Pass
	High	2480MHz	4.72dBm	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: 1/10/2024

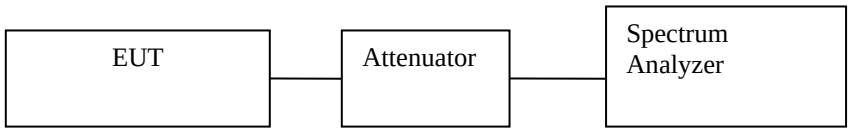
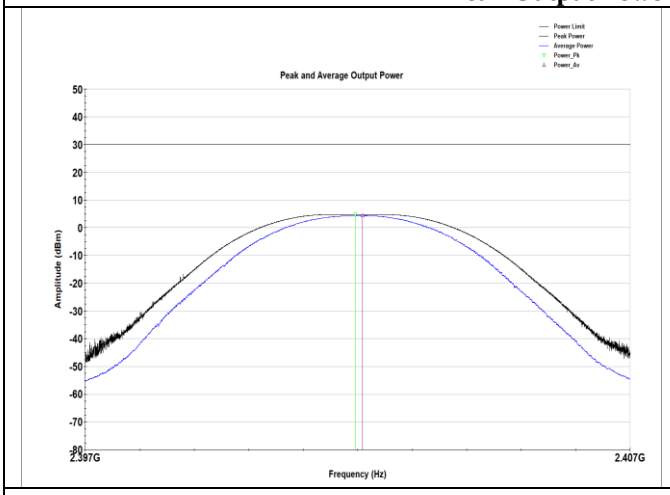
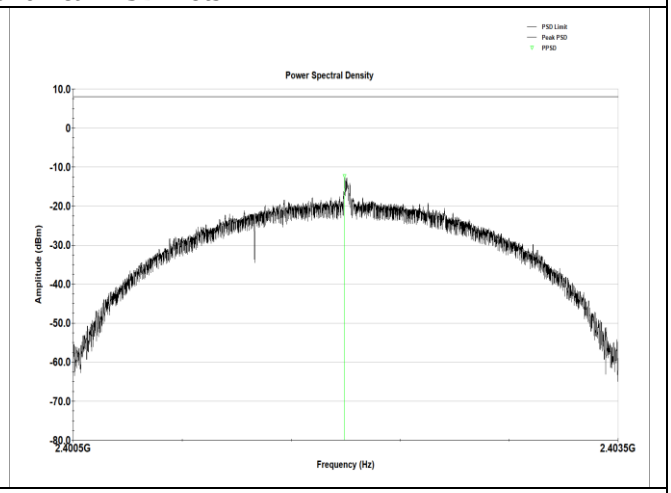
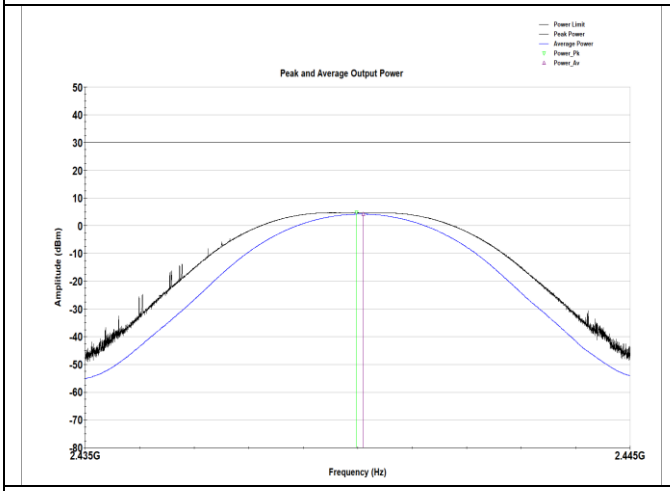
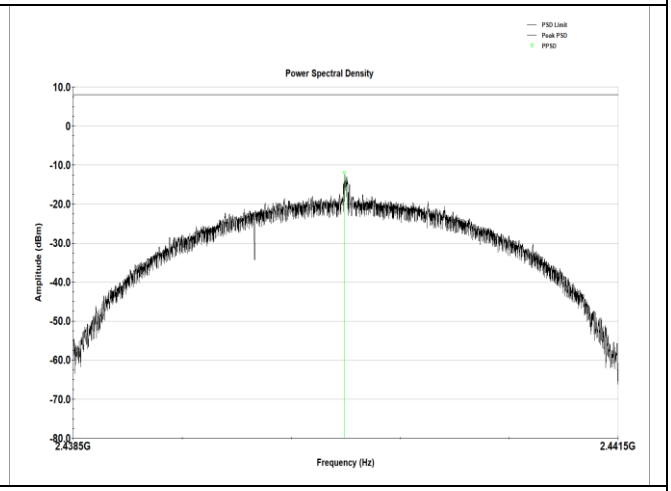
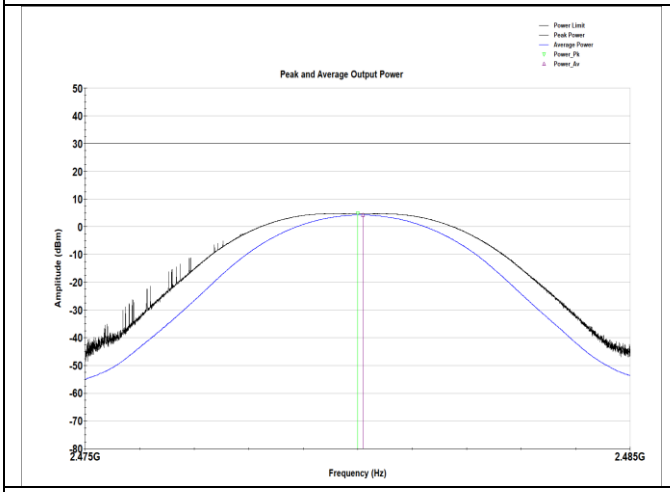
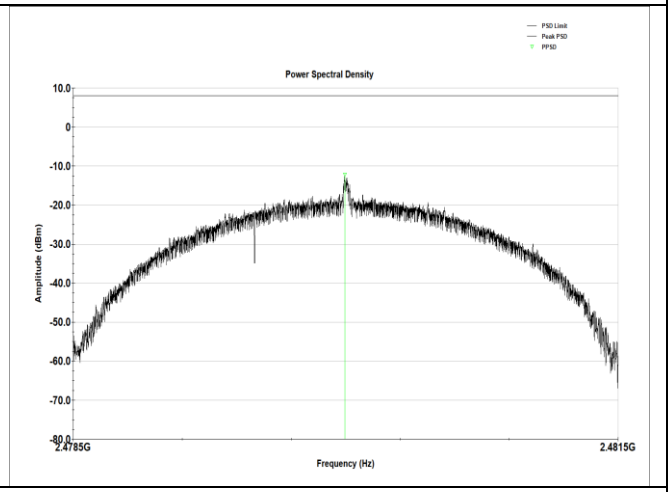


Figure 4. Block Diagram, Peak Power Spectral Density Test Setup

Data Rate	Channel	Frequency (MHz)	Peak Power Spectral Density (dBm / 8kHz)	Peak Power Spectral Density Limit (dBm / 8kHz)	Result
2Mbps	Low	2402MHz	-12.32dBm	8	Pass
	Middle	2440MHz	-12.02dBm	8	Pass
	High	2480MHz	-12.20dBm	8	Pass

Table 14. Peak Power Spectral Density, Test Results

Peak Output Power and Peak PSD Plots	
	
Low Channel Peak Power	Low Channel Peak PSD
	
Mid Channel Peak Power	Mid Channel Peak PSD
	
High Channel Peak Power	High Channel Peak PSD

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): 1/10/2024

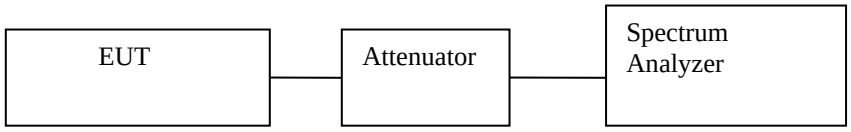


Figure 5. Block Diagram, Conducted Spurious Emissions Test Setup

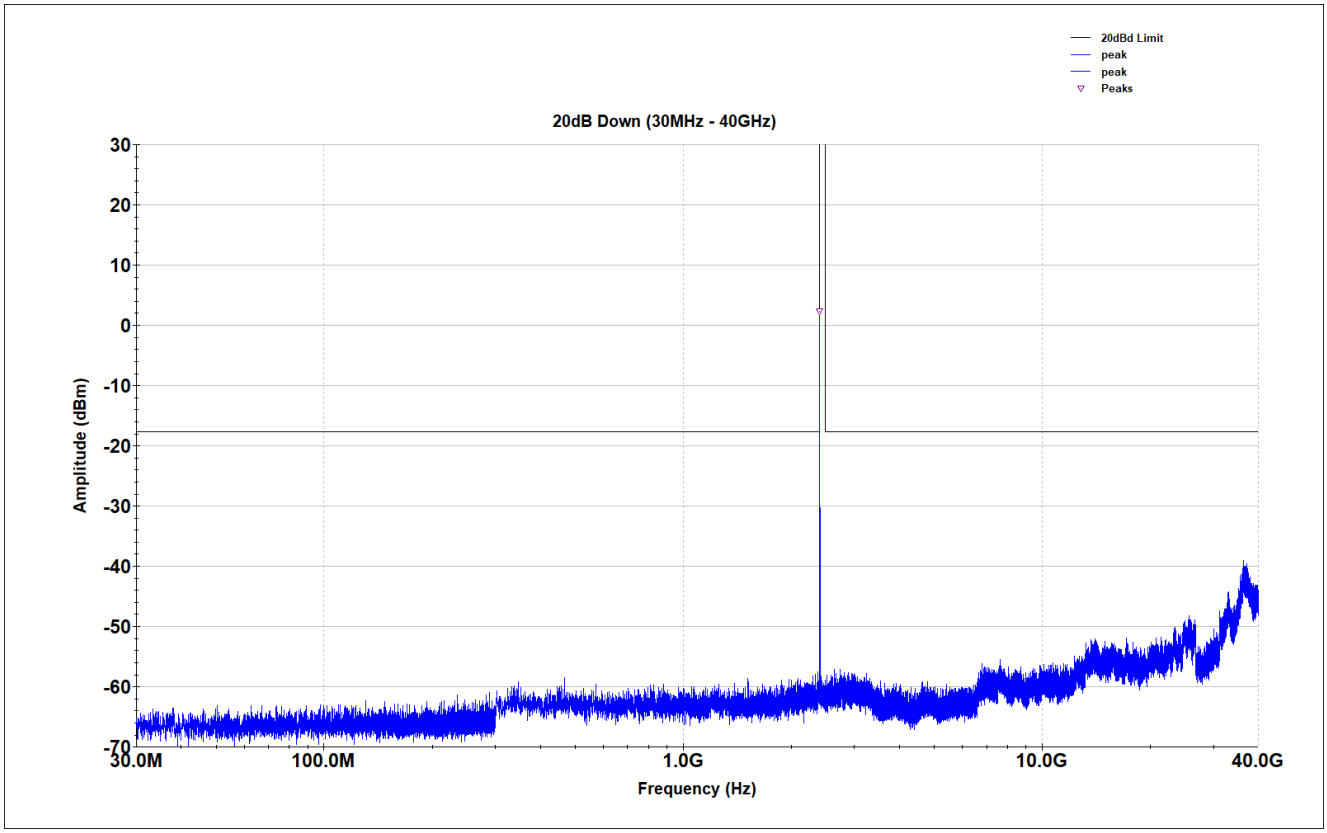


Figure 6. Low Channel, 30MHz – 40GHz Conducted Spurious Emissions (2Mbps)

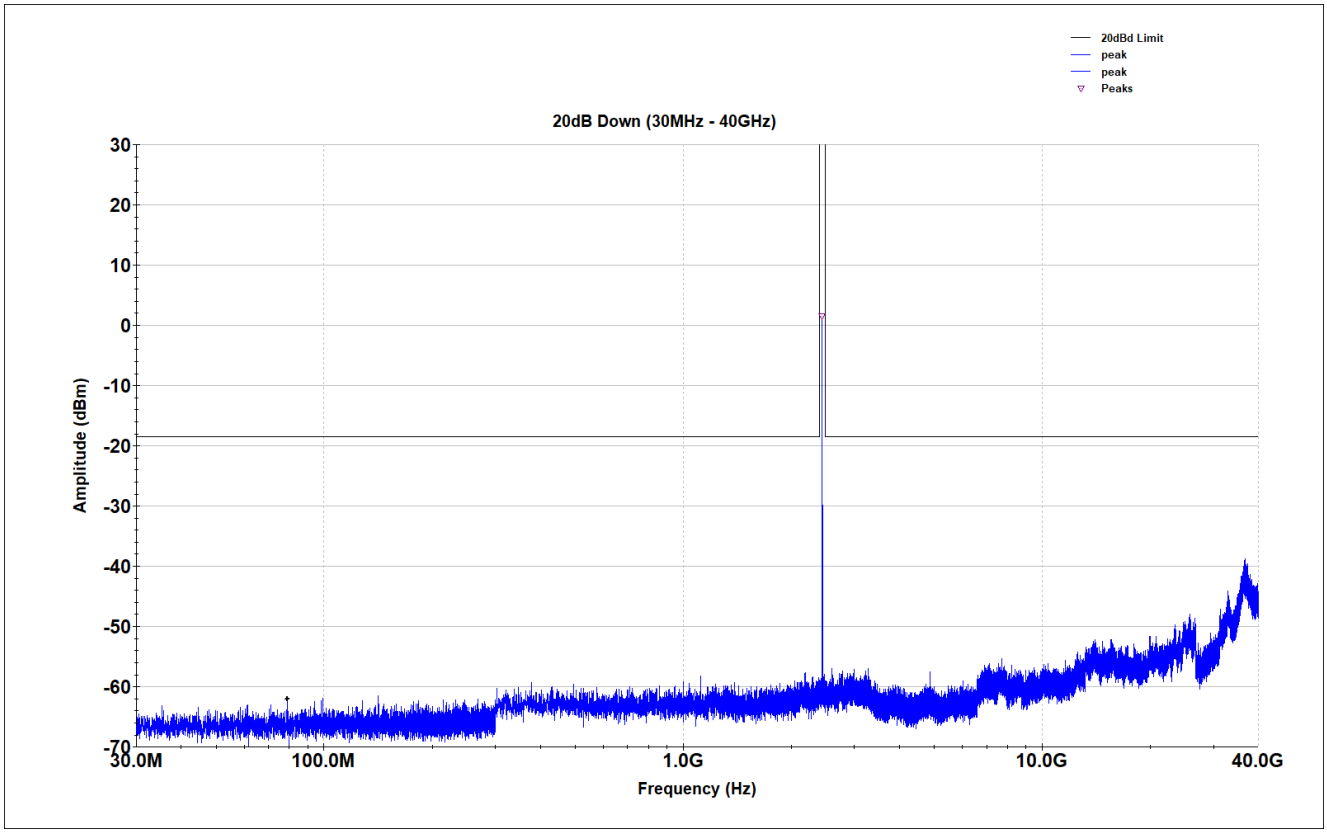


Figure 7. Mid Channel, 30MHz – 40GHz Conducted Spurious Emissions (2Mbps)

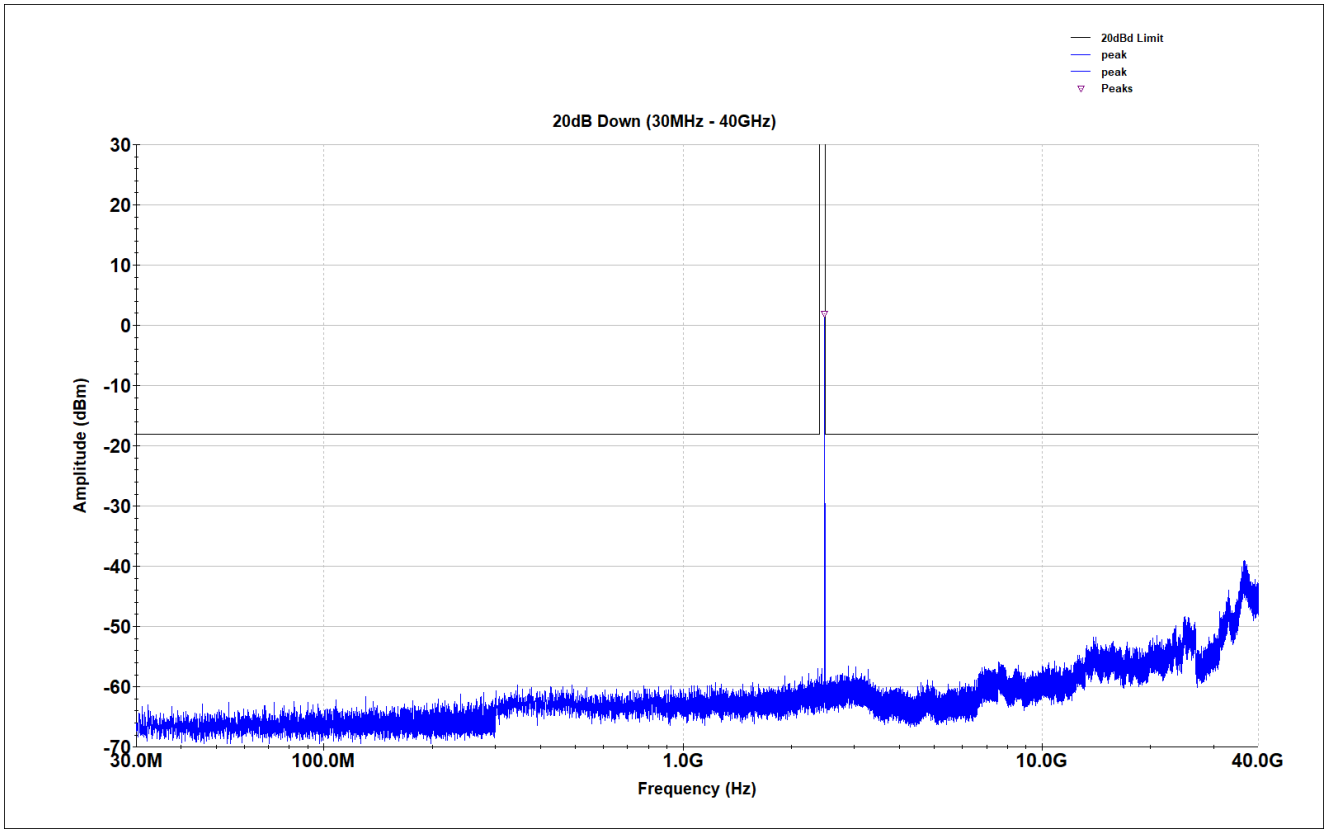
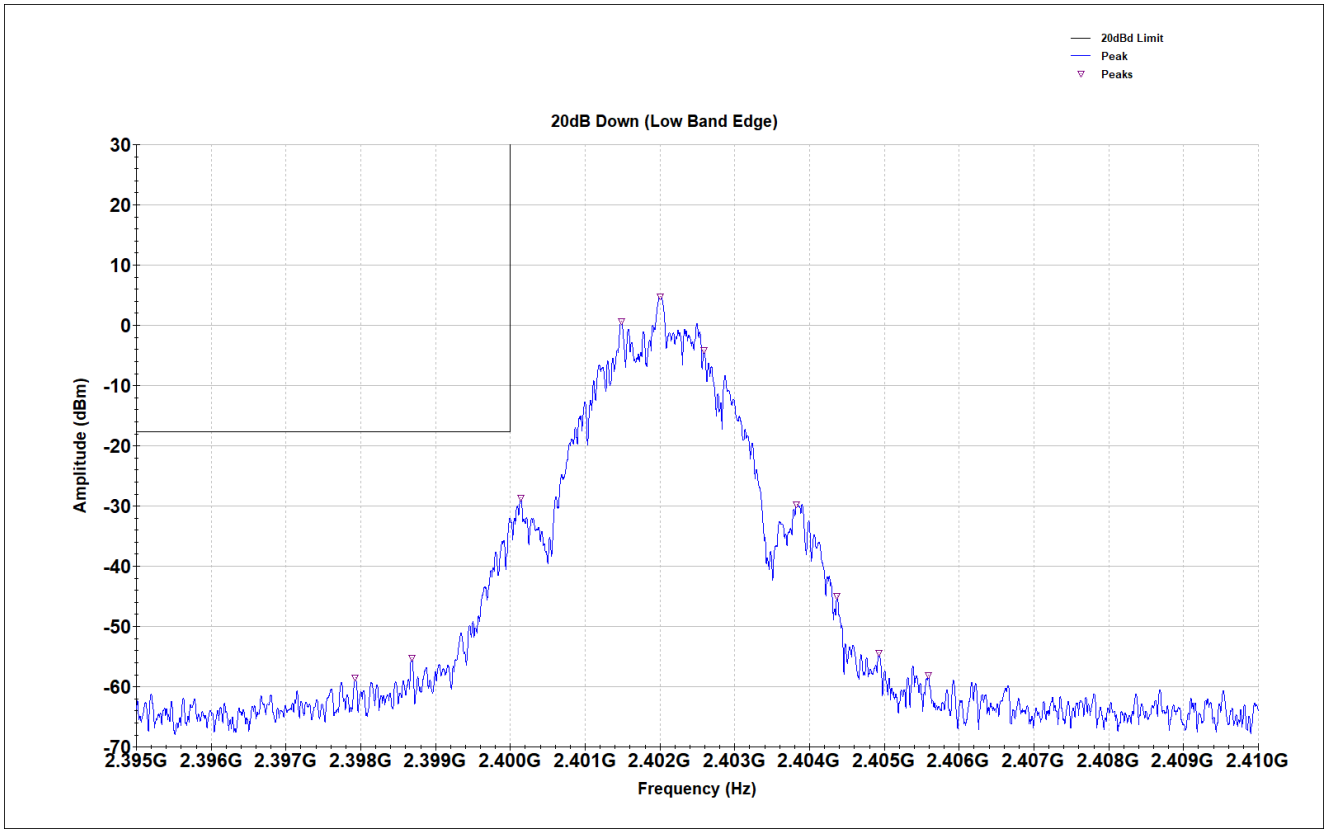
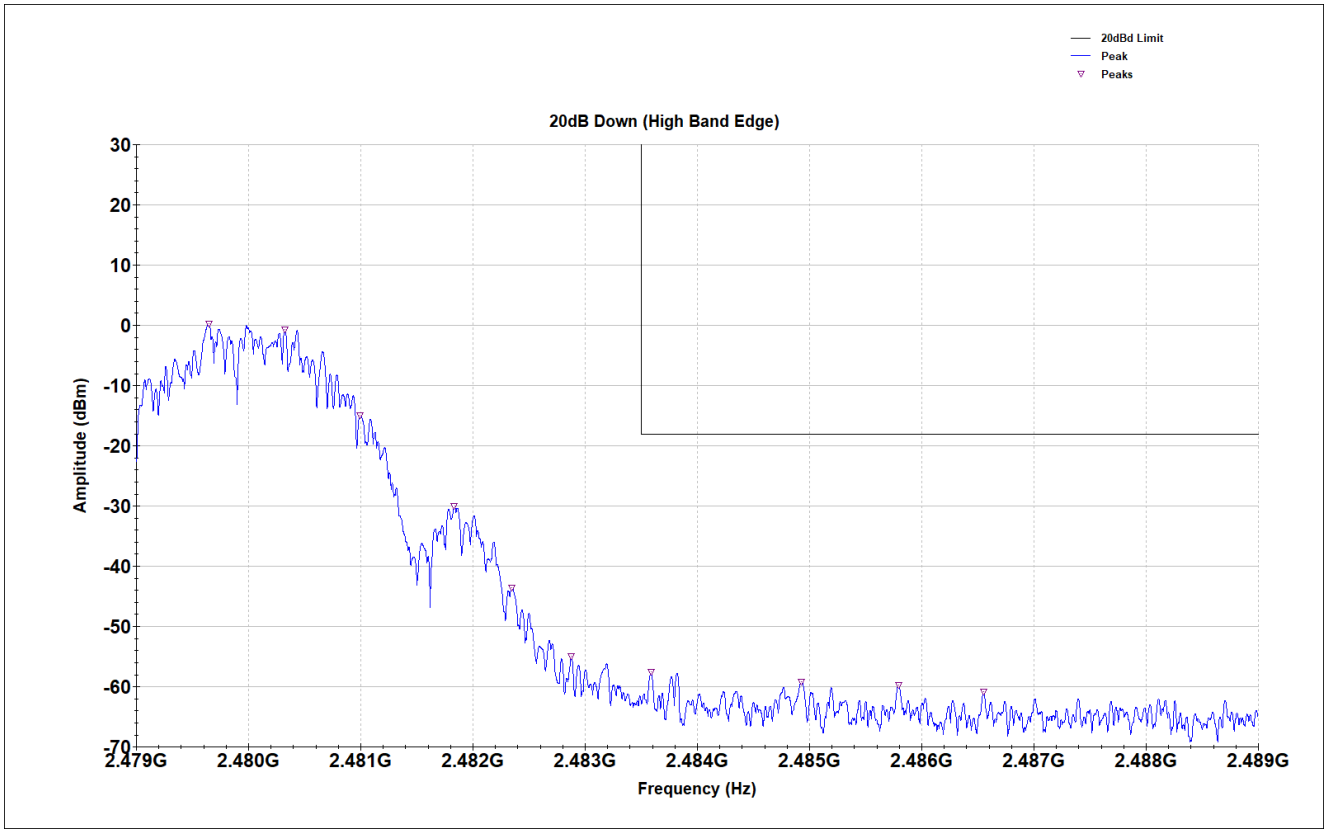


Figure 8. High Channel, 30MHz – 40GHz Conducted Spurious Emissions (2Mbps)



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2397.929	-58.53	-17.65	40.88	Pass
2398.681	-55.14	-17.65	37.49	Pass

Figure 9. Low Channel, Low Band Edge (2Mbps)



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2483.586	-57.59	-18.14	39.45	Pass
2484.927	-59.11	-18.14	40.97	Pass
2485.793	-59.77	-18.14	41.63	Pass
2486.551	-60.79	-18.14	42.65	Pass

Figure 10. 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. 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): 1/10/2024 – 1/16/2024

Radiated Spurious Emissions Test Results

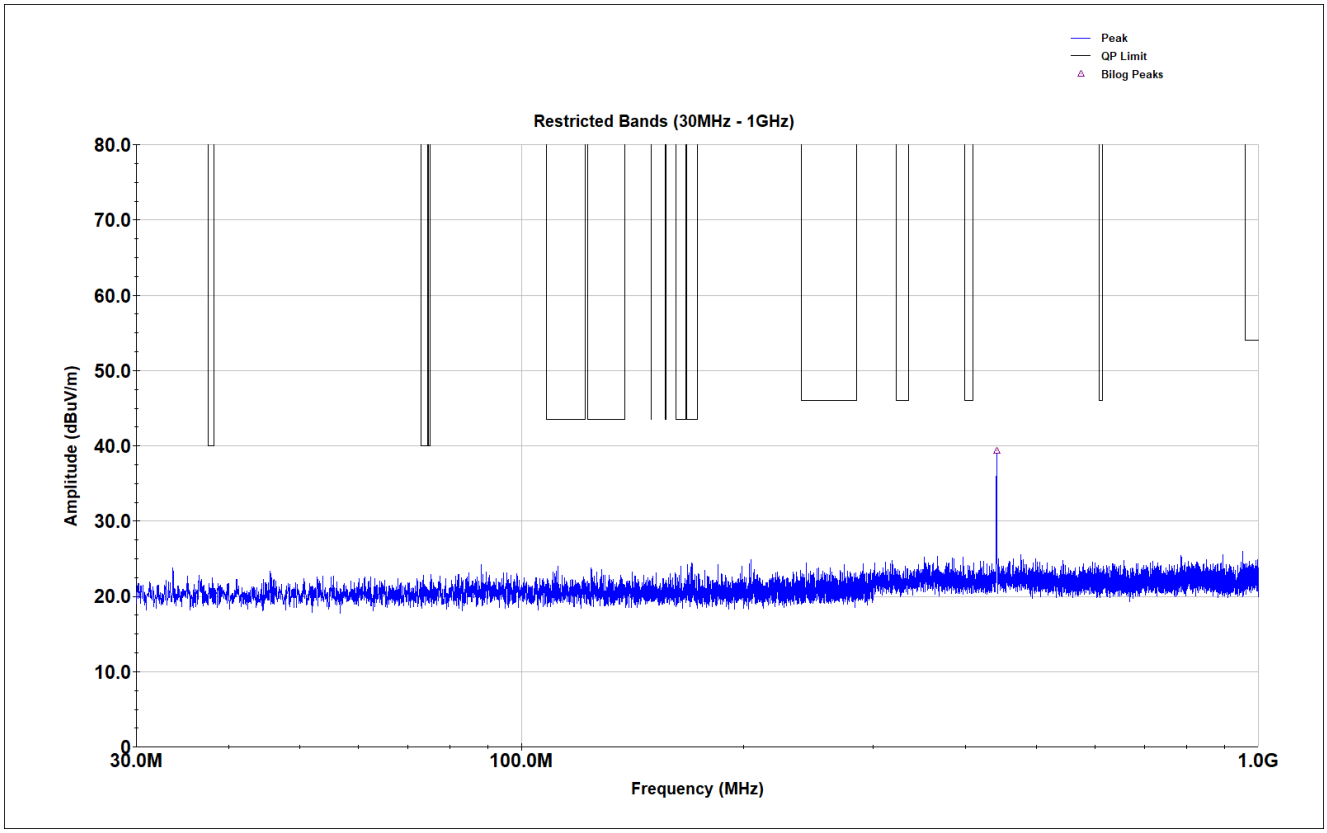


Figure 11. Low Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (2Mbps)

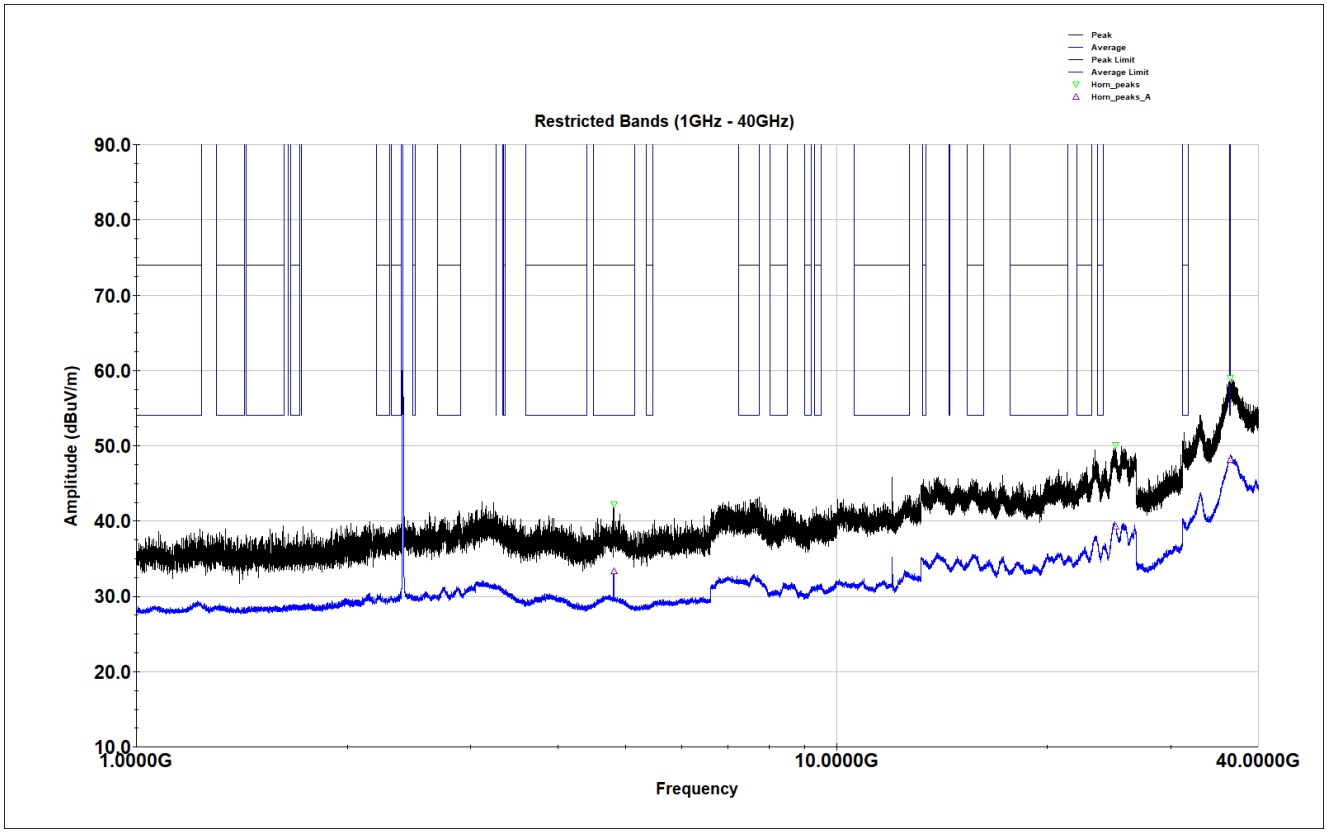


Figure 12. Low Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (2Mbps)

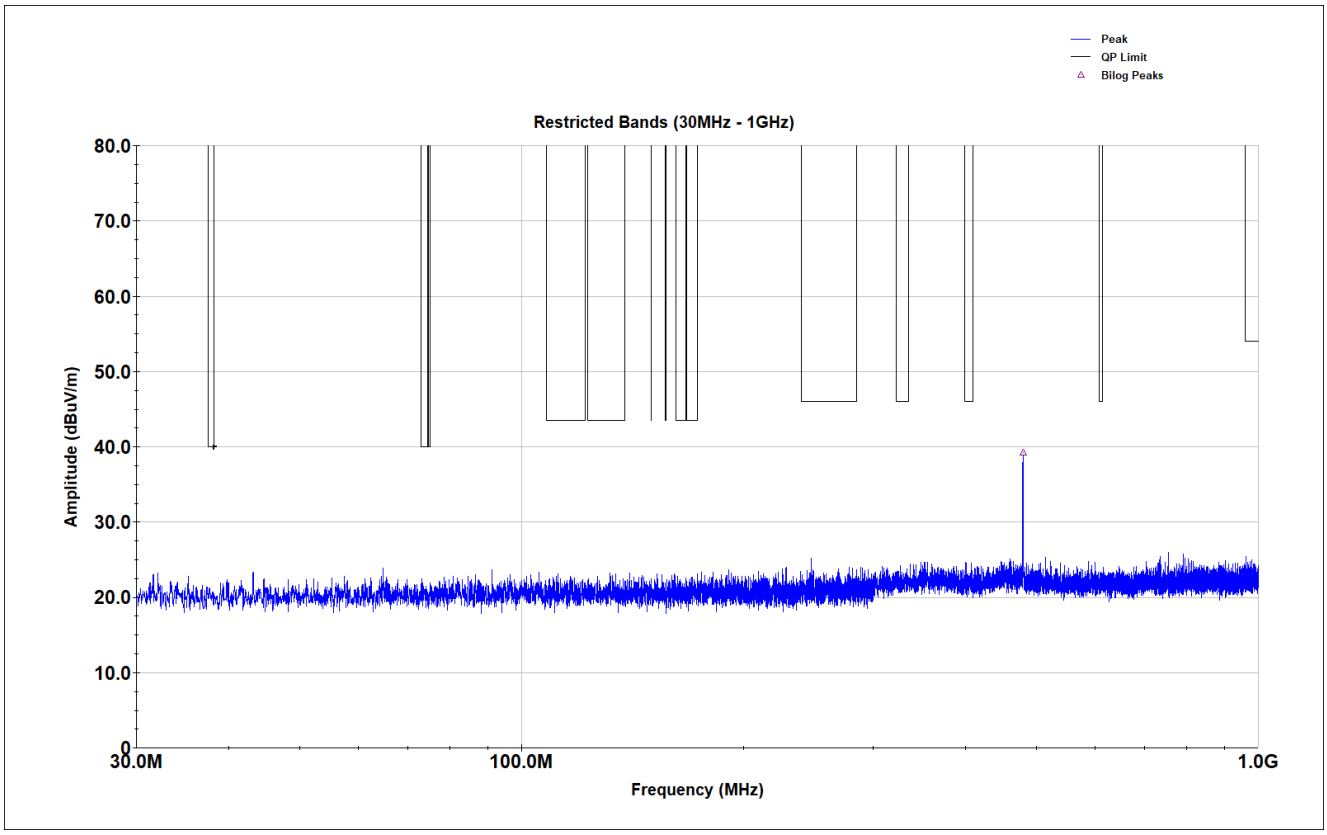


Figure 13. Middle Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (2Mbps)

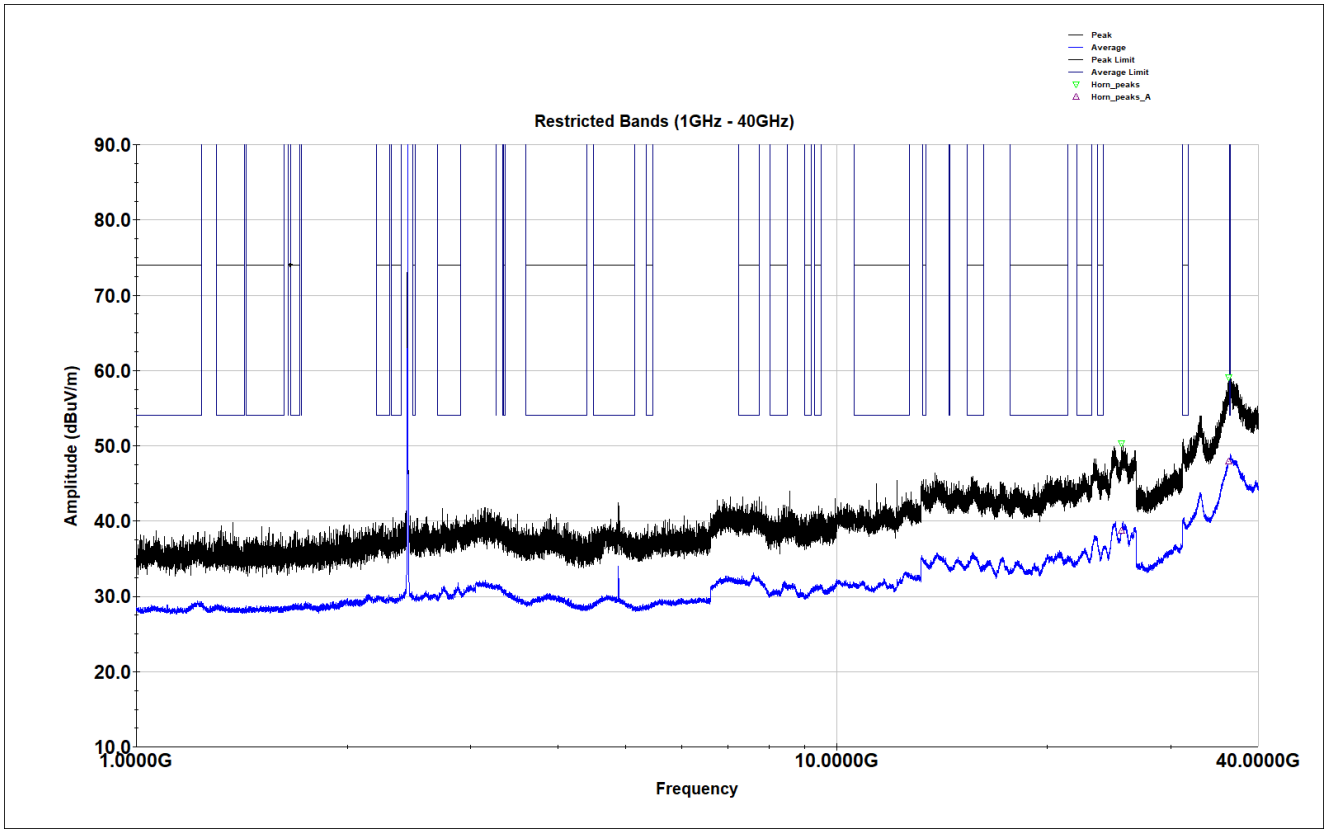


Figure 14. Middle Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (2Mbps)

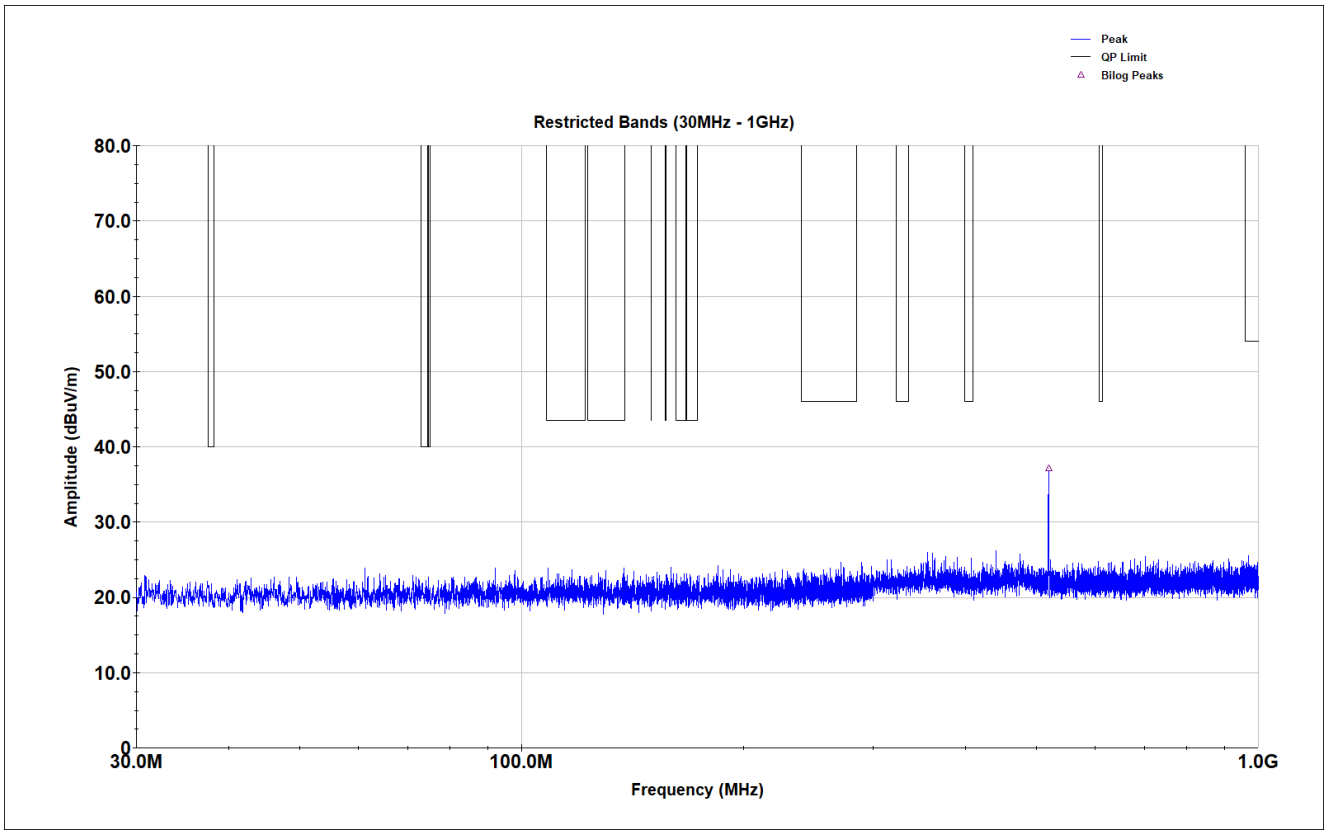


Figure 15. High Channel, 30MHz – 1GHz Restricted Band Spurious Emissions (2Mbps)

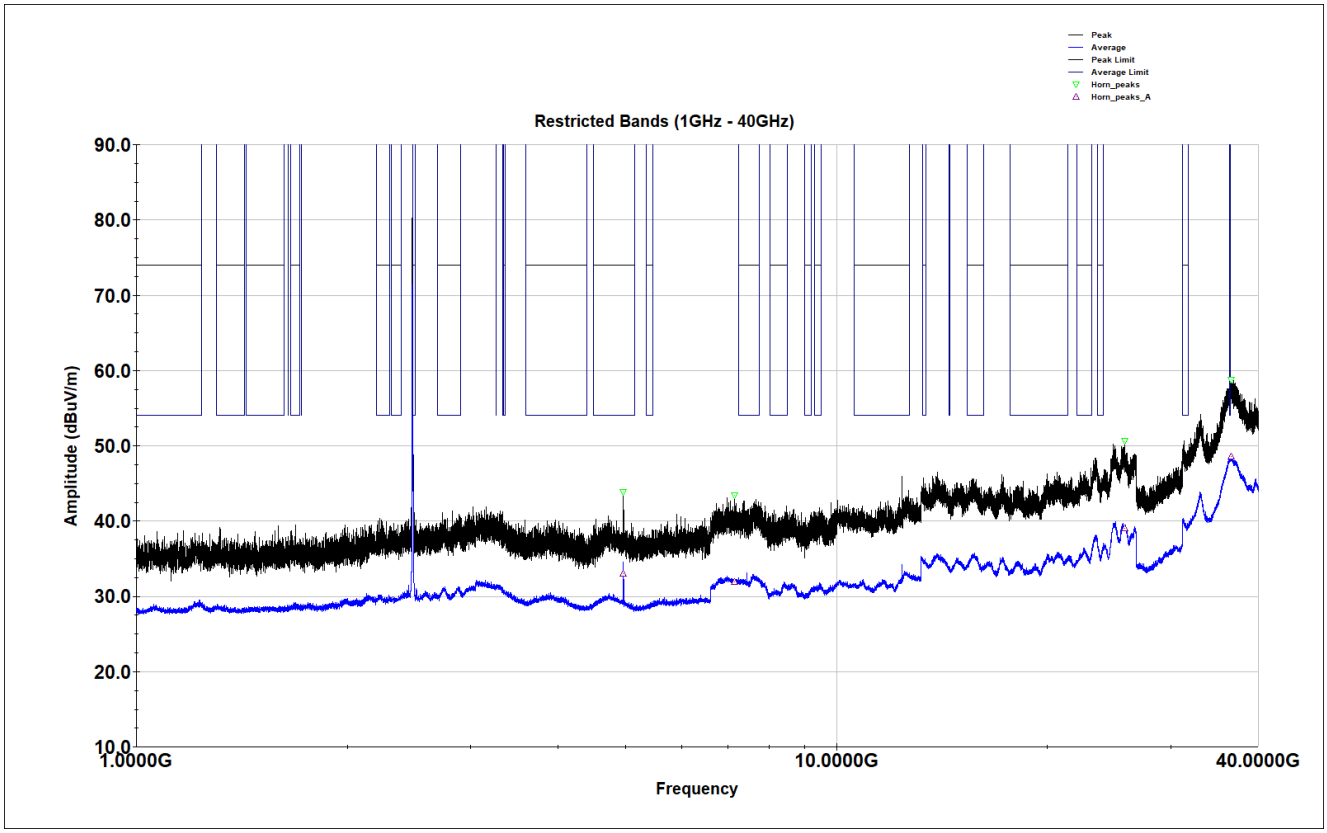
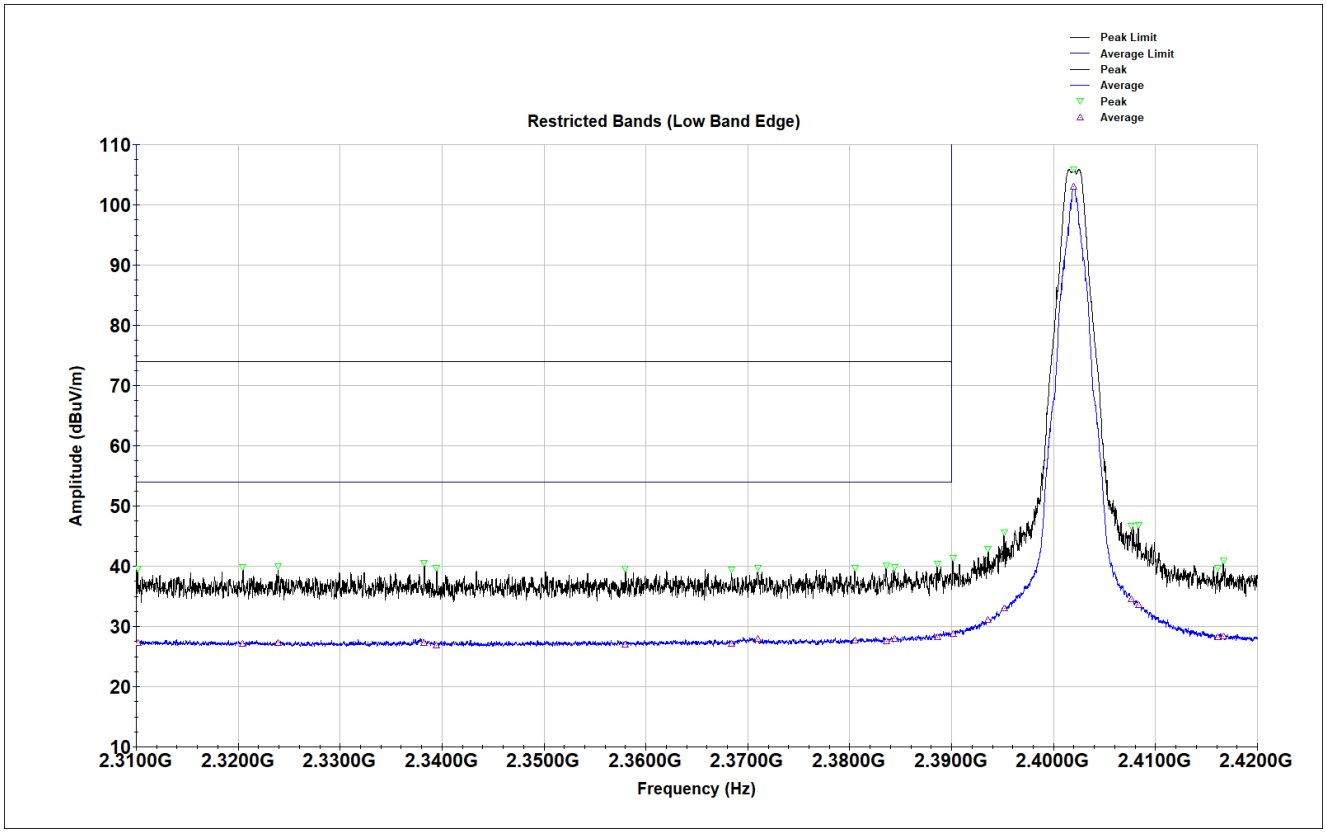
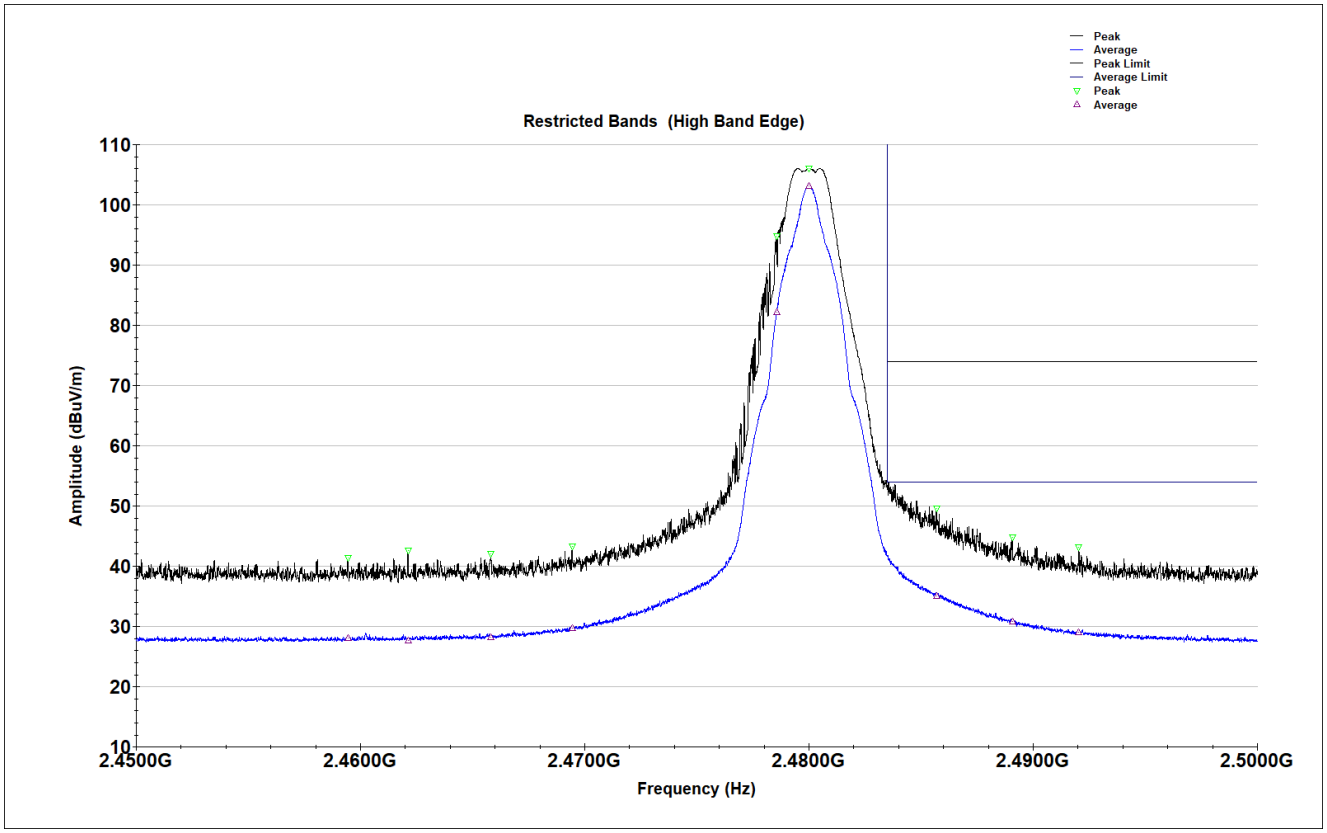


Figure 16. High Channel, 1GHz – 40GHz Restricted Band Spurious Emissions (2Mbps)



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
2310.137	39.54	74	34.46	27.2	54	26.8	Pass
2320.477	39.84	74	34.16	27.07	54	26.93	Pass
2323.929	39.97	74	34.03	27.27	54	26.73	Pass
2338.256	40.61	74	33.39	27.25	54	26.75	Pass
2339.48	39.68	74	34.32	26.85	54	27.15	Pass
2358.001	39.63	74	34.37	26.94	54	27.06	Pass
2368.41	39.46	74	34.54	27.16	54	26.84	Pass
2370.981	39.7	74	34.3	27.87	54	26.13	Pass
2380.51	39.74	74	34.26	27.64	54	26.36	Pass
2383.59	40.12	74	33.88	27.53	54	26.47	Pass
2384.401	39.9	74	34.1	27.93	54	26.07	Pass
2388.609	40.35	74	33.65	28.23	54	25.77	Pass
2310.137	39.54	74	34.46	27.2	54	26.8	Pass
2320.477	39.84	74	34.16	27.07	54	26.93	Pass

Figure 17. 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
2485.688	49.61	74	24.39	35.12	54	18.88	Pass
2489.069	44.76	74	29.24	30.83	54	23.17	Pass
2492.031	43.13	74	30.87	29.06	54	24.94	Pass
2483.500	53.99	74	20.01	41.77	54	12.23	Pass

Figure 18. Restricted Band Edge Spurious Emissions (High Channel, 2MBps)

Worst Case Cabinet Spurious Emissions

Frequency [MHz]	PK Level [dBµV/m]	Limit [dBµV/m]	Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
0.104	41.30	107.25	65.95	11.50	V	324.9	1	0.200	Pass
0.107	39.92	107.02	67.10	11.53	H	255.8	1	0.200	Pass
0.503	46.62	73.65	27.03	11.43	V	269.8	1	9.000	Pass
0.508	45.12	73.58	28.45	11.47	H	30.3	1	9.000	Pass

Figure 19. Worst Case Cabinet Radiation, Below 30MHz (2Mbps)

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
115.380	11.55	43.52	31.97	-7.61	H	11.3	1.13	120.000	Pass
127.950	11.98	43.52	31.54	-7.75	V	193.4	3.19	120.000	Pass
257.910	14.51	46.02	31.51	-5.48	V	43.5	2.02	120.000	Pass
284.820	18.97	46.02	27.05	-6.13	H	51.8	3.45	120.000	Pass

Figure 20. Worst Case Cabinet Radiation, Below 1GHz (2Mbps)

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
4,879.500	42.06	74.00	31.94	28.77	54.00	25.23	-3.35	V	99.1	1.29	Pass
4,897.000	41.90	74.00	32.10	28.44	54.00	25.56	-3.06	H	24.4	2.3	Pass
7,318.500	48.22	74.00	25.78	33.73	54.00	20.27	-2.80	V	219.3	3.42	Pass
7,320.000	43.42	74.00	30.58	29.80	54.00	24.20	-2.79	H	45.1	3.52	Pass
12,222.500	43.94	74.00	30.06	30.74	54.00	23.26	-1.96	H	237	3.04	Pass
12,315.500	44.27	74.00	29.73	31.29	54.00	22.71	-2.24	V	133.9	2.11	Pass
19,527.000	50.33	74.00	23.67	36.70	54.00	17.31	12.33	V	45.2	1.63	Pass
19,527.000	48.68	74.00	25.32	35.47	54.00	18.53	12.33	H	49.3	3.55	Pass
22,667.000	51.01	74.00	22.99	37.47	54.00	16.53	14.33	V	0	1.5	Pass
22,708.500	51.24	74.00	22.76	37.34	54.00	16.66	14.44	H	230.6	3.6	Pass

Figure 21. Worst Case Cabinet Radiation, Above 1GHz (2Mbps)

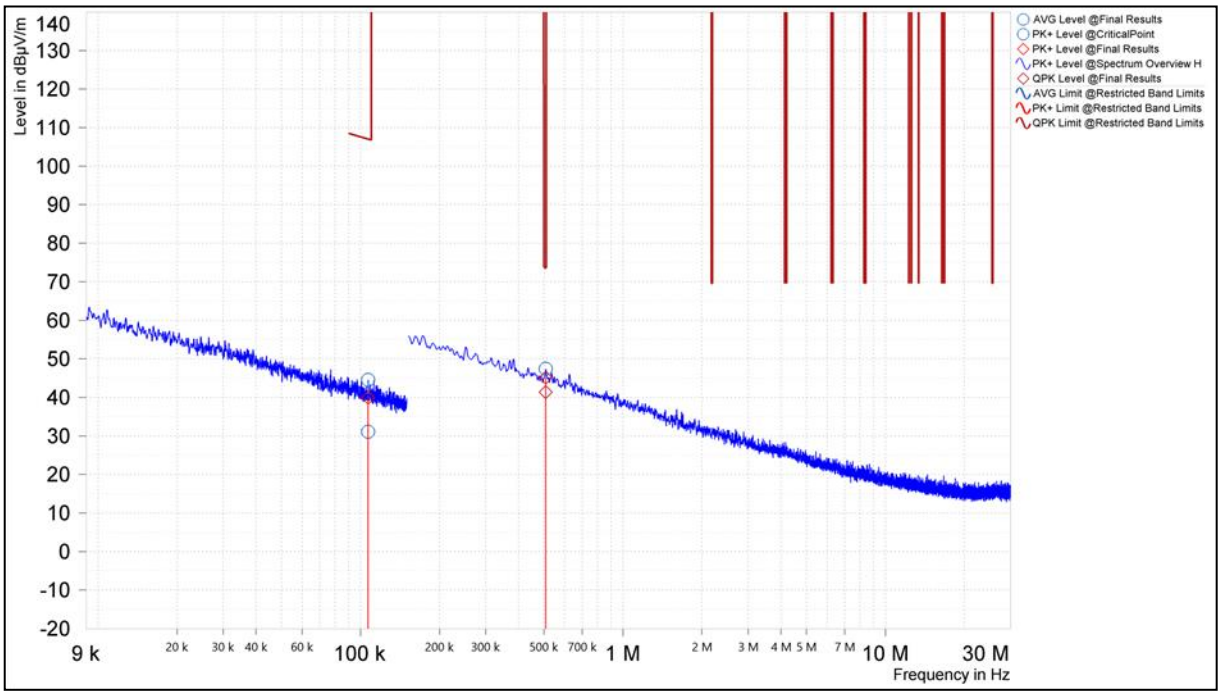


Figure 22. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coaxial Loop (2MBps)

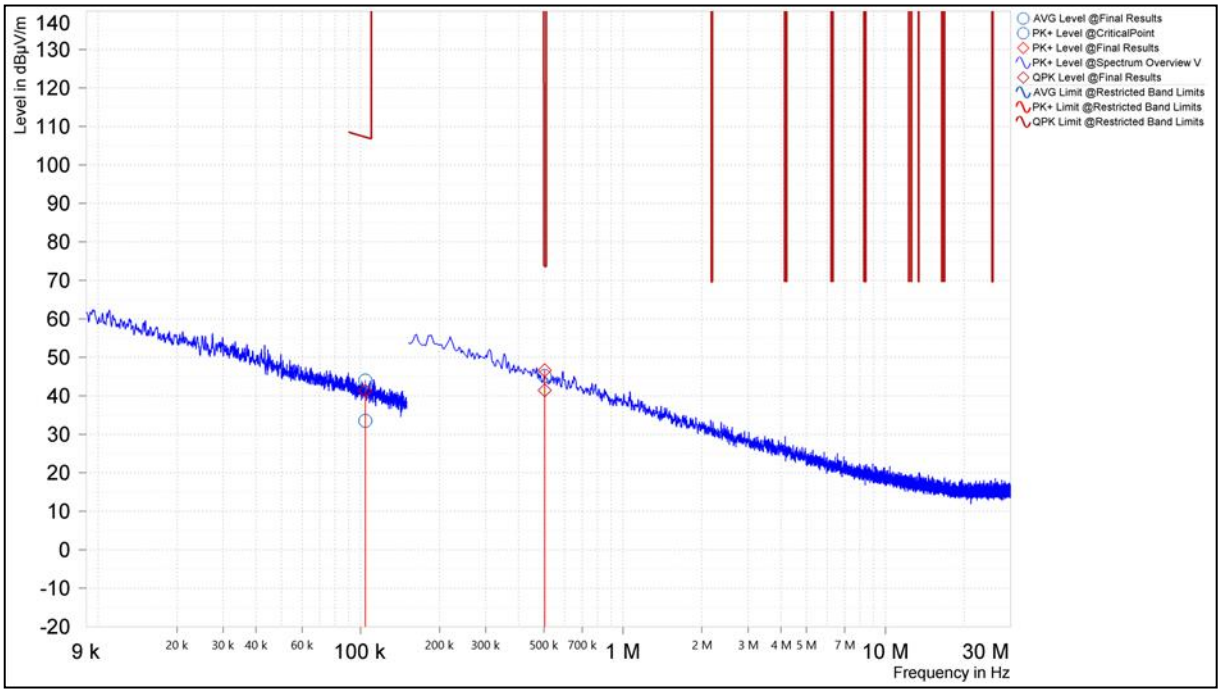


Figure 23. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coplanar Loop (2MBps)

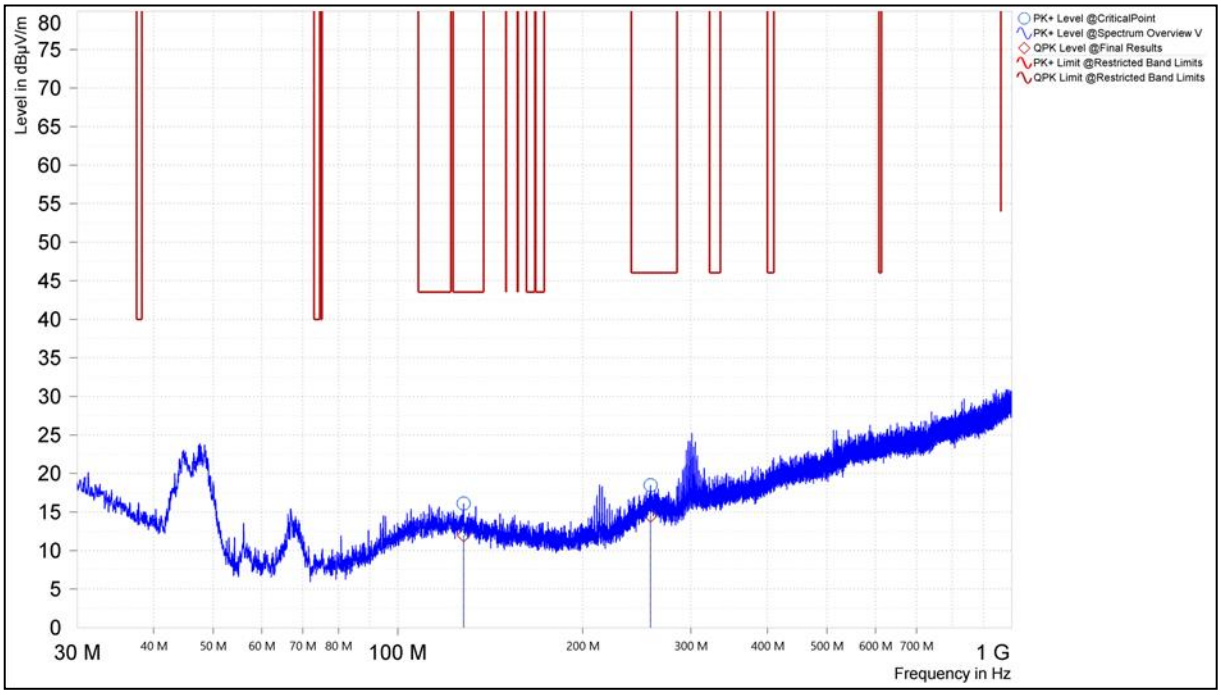


Figure 24. Worst Case Cabinet Radiation, 30MHz – 1GHz, Vertical Polarity (2MBps)

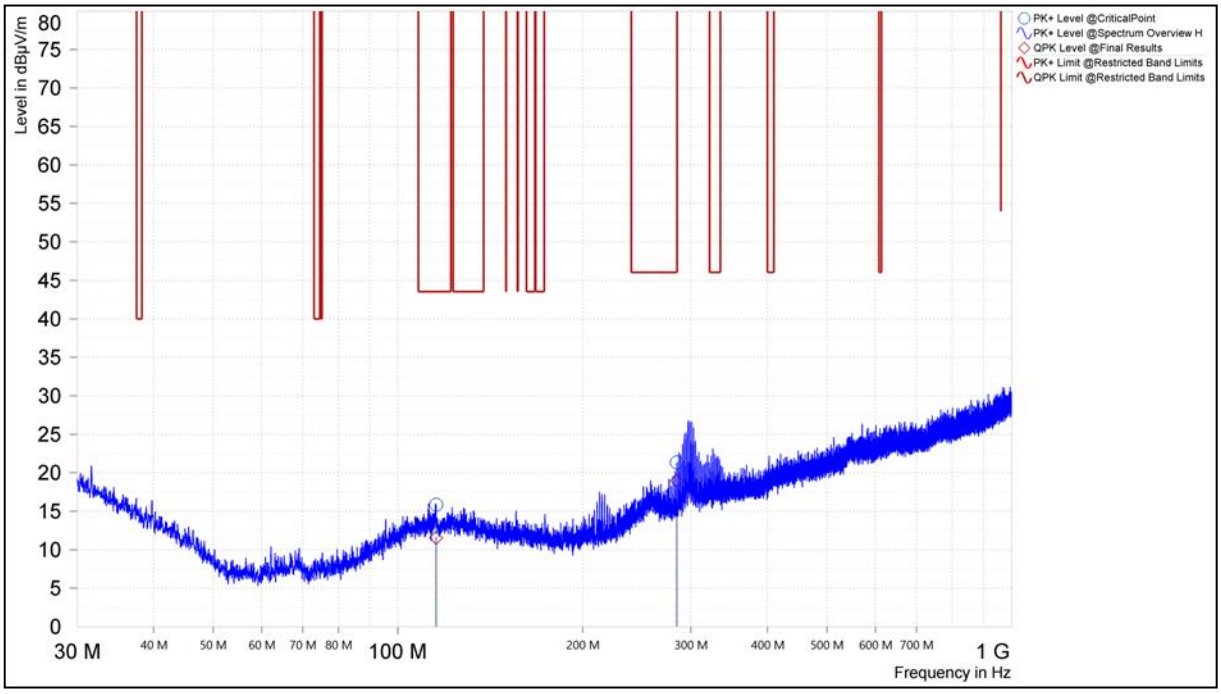


Figure 25. Worst Case Cabinet Radiation, 30MHz – 1GHz, Horizontal Polarity (2MBps)

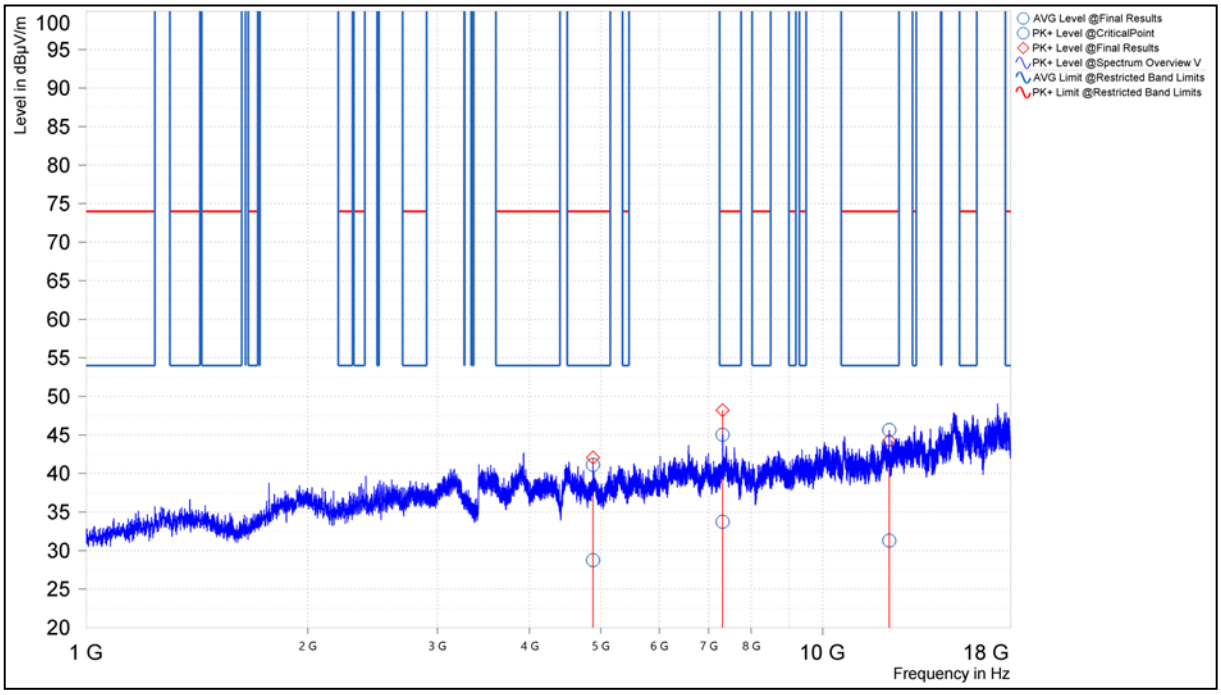


Figure 26. Worst Case Cabinet Radiation, 1GHz – 18GHz, Vertical Polarity (2MBps)

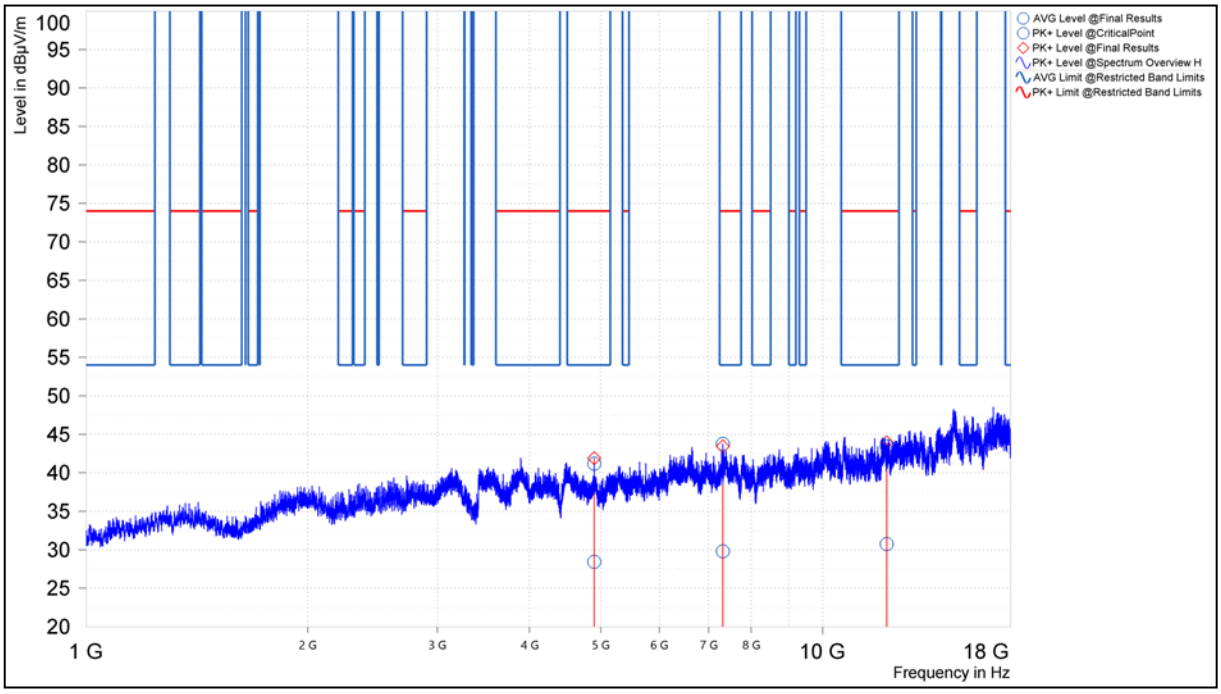


Figure 27. Worst Case Cabinet Radiation, 1GHz – 18GHz, Horizontal Polarity (2MBps)

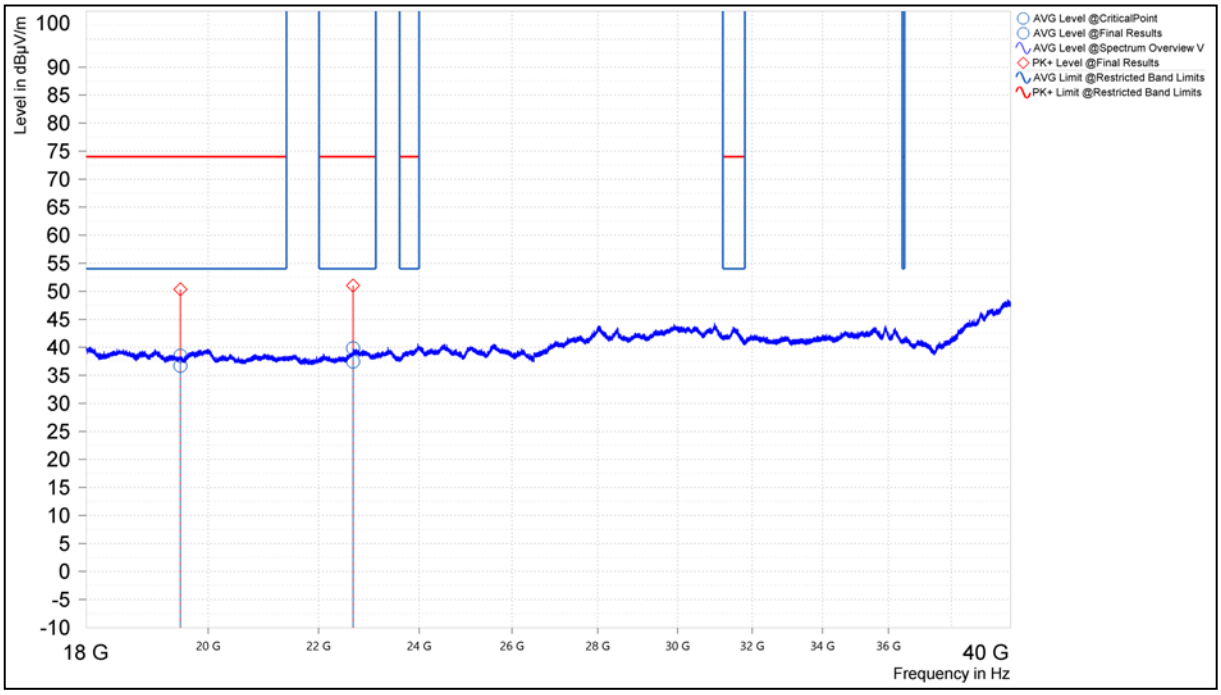


Figure 28. Worst Case Cabinet Radiation, 18GHz – 40GHz, Vertical Polarity (2MBps)

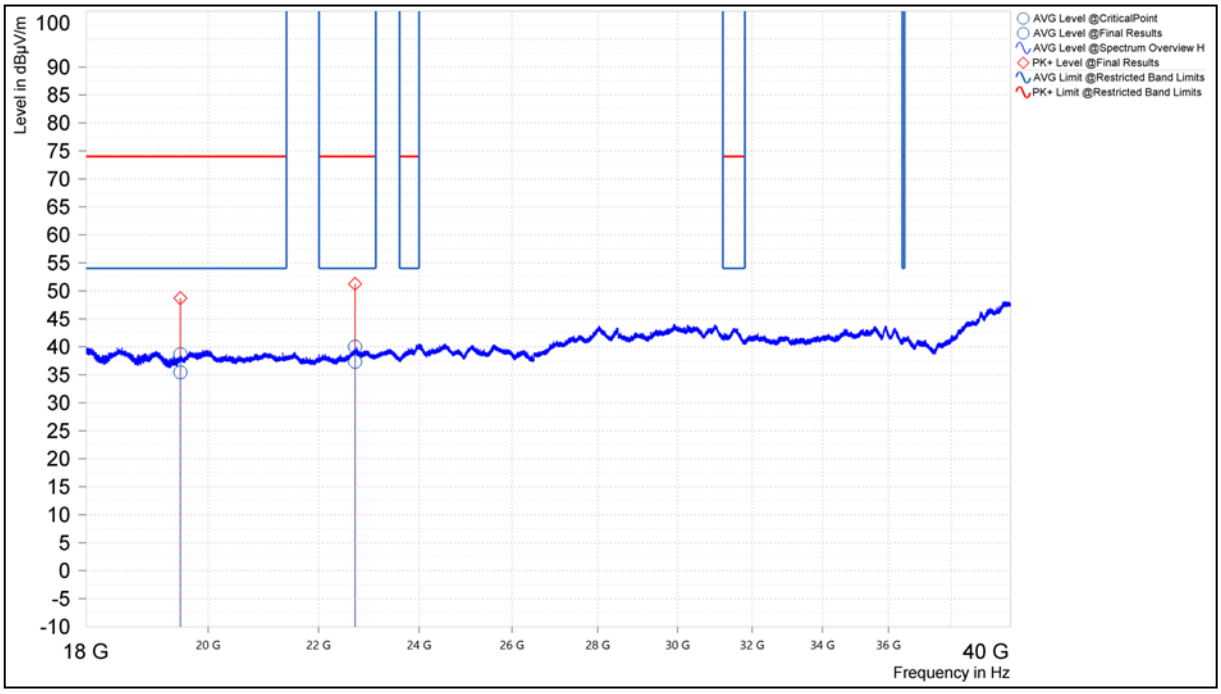


Figure 29. Worst Case Cabinet Radiation, 18GHz – 40GHz, Horizontal Polarity (2MBps)

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
1A1234	FSV Signal Analyzer	Rohde & Schwarz	FSV 40	1/23/2023	1/23/2024
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
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
1A1117	Digital Multimeter	Fluke	87 III	11/6/2023	11/6/2024
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