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9/4/2024

HLI Solutions, Inc.
710 Hesters Crossing
Round Rock, TX 78681
USA

Dear Justin Foster,

Enclosed is the EMC Wireless test report for compliance testing of the HLI Solutions, Inc. NXOFM2 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

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

Nancy LaBrecque
Documentation Department

Reference: WIRA132106-FCC-IC-BLE_R2

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Bluetooth Low Energy Test Report

for the

HLI Solutions, Inc.
NXOFM2

Tested under
FCC Part 15.247 and RSS-247 Issue 3
For Intentional Radiators



Bryan Taylor, Wireless Team Lead
Electromagnetic Compatibility Lab



Nancy LaBrecque
Documentation Department

Engineering Statement: The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC Rules Part 15.247 under normal use and maintenance.



Matthew Hinojosa
EMC Manager, Austin Electromagnetic Compatibility Lab

Report Status Sheet

Revision	Report Date	Reason for Revision
Ø	6/25/2024	Initial Issue.
1	7/23/2024	Changes requested by client.
2	9/4/2024	Changes requested by reviewer

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List of Terms and Abbreviations

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

I. Executive Summary

A. Purpose of Test

An EMC evaluation was performed to determine compliance of the NXOFM2, with the requirements of FCC Part 15.247 and RSS-247 Issue 3. HLI Solutions, Inc. should retain a copy of this document which should be kept on file for at least two years after the manufacturing of the NXOFM2, 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 HLI Solutions, Inc. purchase order number 4710448434. All tests were conducted using measurement procedures ANSI C63.4-2014 and ANSI C63.10-2013.

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

Table 1. Executive Summary

II. Equipment Configuration

A. Overview

Eurofins MET Labs was contracted by HLI Solutions, Inc. to perform testing on the NXOFM2, under HLI Solutions, Inc.'s purchase order number 4710448434.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the NXOFM2.

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

Product Name:	NXOFM2	
Model(s) Tested:	NXOFM2	
Model(s) Covered:	NXOFM2	
FCCID:	YH9NXOFM2	
ICID:	9044A-NXOFM2	
Serial Number or Sample Number:	Test Sample 1	
EUT Specifications:	Primary Power: 120Vac – 480Vac	
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	10.72dBm
	EUT Frequency Ranges:	2402MHz – 2480MHz
	Antenna Gain ¹ :	2.7dBi
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):	5/28/2024 through 6/17/2024	

Table 2. EUT Summary Table

¹ The antenna gain information was provided by HLI Solutions, Inc. and may affect compliance.

B. References

CFR 47, Part 15, Subpart C	Federal Communication Commission, Code of Federal Regulations, Title 47, Part 15: General Rules and Regulations, Allocation, Assignment, and Use of Radio Frequencies
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.

ISED Lab Info:

CAB Identifier: US0004
Company Number: 2043D

FCC Lab Info:

Designation Number: US1127

D. Measurement Uncertainty

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

Table 4. Uncertainty Calculations Summary

E. Description of Test Sample

The NXFM series On-Fixture Module enables a complete control solution for a single luminaire. The On-Fixture Module incorporates a single pole relay for On/Off control as well as industry standard 0 - 10 volt continuous dimming control. An auxiliary input and auxiliary 12 volt power output are available through the 7-pin interface. The input can be programmed to act as any of the NX input types including occupancy and various switch types. On-board power metering circuitry accurately measures current and voltage. The water tight twist lock package contains the control logic, NX Network radio, Bluetooth®; radio antennas, and 0 - 10 volt dimming driver. The twist lock form factor allows for easy installation and removal of the module on luminaires equipped with a compatible 7-pin twist lock receptacle. Setup and programming is performed using any Android®; or iOS®; smart device with an available App that is free for download.

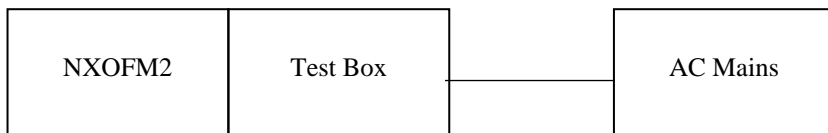


Figure 1. Block Diagram of Test Configuration

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

Ref. ID	Name/Description	Manufacturer	Model Number	Customer Supplied Calibration Data
	Test Box with 250 Ohm Res Load	Current Lighting	N/A	N/A

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
---	AC Input	AC Power Input to Test Box	1	1.5m	---	No	Test Box with 250 Ohm Res Load

Table 6. Ports and Cabling Information

I. Mode of Operation

Special radio software was installed on the test sample such that with every power cycle the sample would switch from transmitting on low to mid and then high channels as outlined below at maximum output power.

The EUT has the capability to operate in BLE and Wirepas modes. Wirepas has similar characteristics and power levels as BLE and uses the same physical layer as BLE. Therefore, test data for BLE mode is reported in this report.

Transmit Band	Modulation	Channel Frequencies Tested	Test Tool Power Setting
2400 – 2483.5MHz	BLE (GFSK)	2402MHz / 2440MHz / 2480MHz	NA

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 HLI Solutions, Inc. upon completion of testing.

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): 6/17/2024

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 μ H/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

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

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

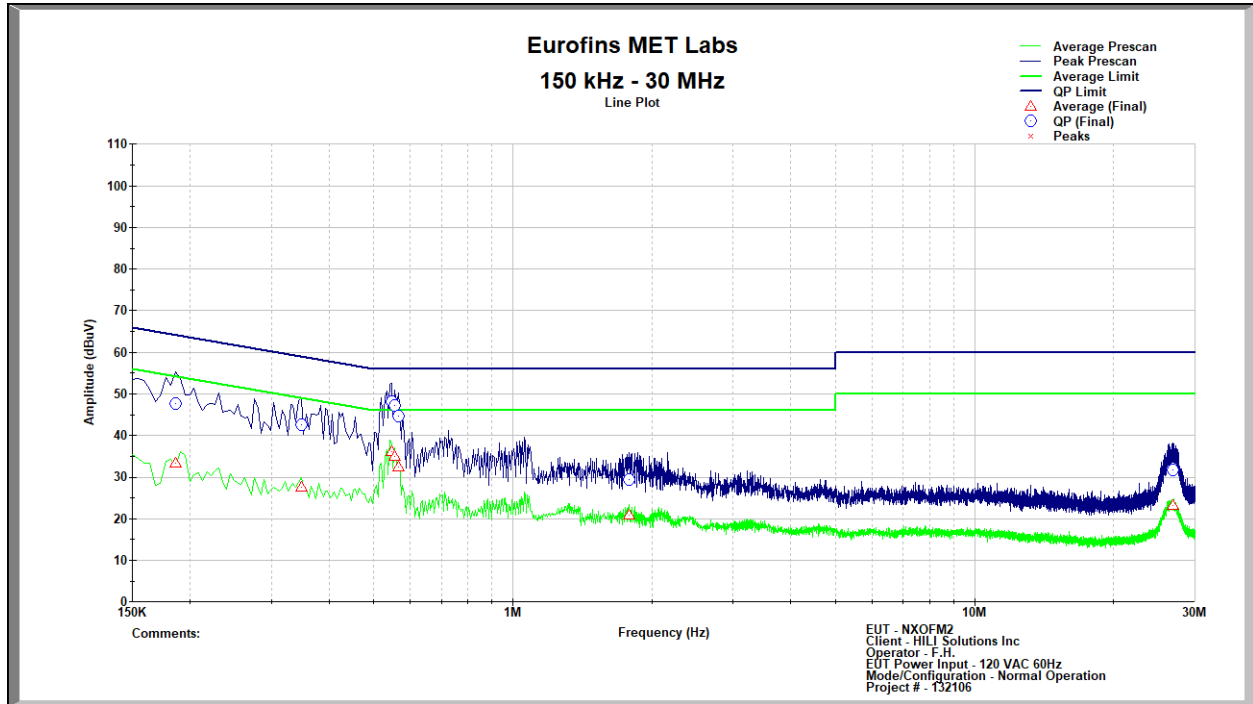
Test Procedure: The EUT was placed on a 0.8 m-high wooden table. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω /50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

Test Results: The EUT was compliant with this requirement. During these tests the NXOFM2 was connected to a D2-PS-120 AC/DC power adapter.

Test Engineer(s): Frank Hernandez

Test Date(s): 5/29/2024

15.207(a) Conducted Emissions Test Results

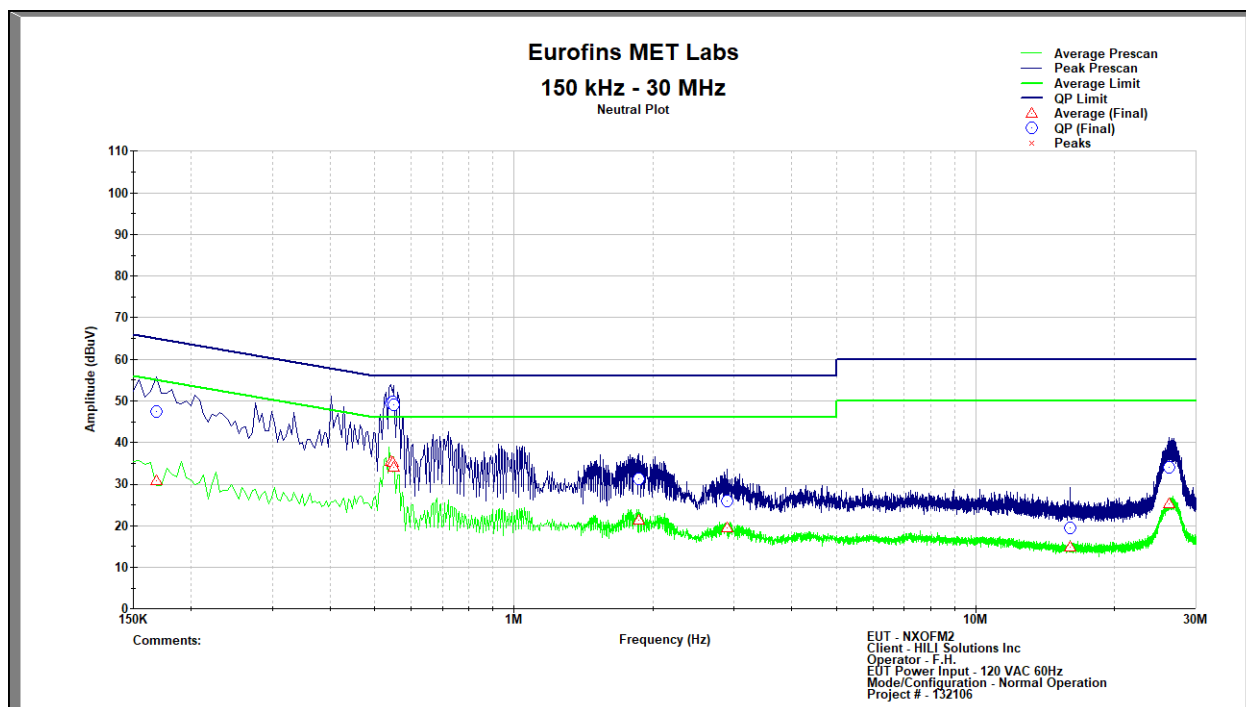


Conducted Emissions, 15.207(a), Phase

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)
0.186	47.583	64.971	17.389	33.349	54.971	21.622
0.348	42.509	60.343	17.834	27.546	50.343	22.797
0.546	48.200	56.000	7.800	36.103	46.000	9.897
0.555	47.145	56.000	8.855	34.874	46.000	11.126
0.564	44.746	56.000	11.254	32.449	46.000	13.551
1.788	29.306	56.000	26.694	20.869	46.000	25.131
26.905	31.801	60.000	28.199	23.265	50.000	26.735

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	47.463	65.486	18.023	30.842	55.486	24.644
0.541	49.563	56.000	6.437	35.508	46.000	10.492
0.546	49.760	56.000	6.240	35.063	46.000	10.937
0.550	49.142	56.000	6.858	34.040	46.000	11.960
1.860	31.350	56.000	24.650	21.286	46.000	24.714
2.890	26.003	56.000	29.997	19.376	46.000	26.624
16.043	19.517	60.000	40.483	14.793	50.000	35.207
26.258	33.943	60.000	26.057	25.254	50.000	24.746

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

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(a)(2) 6 dB Bandwidth

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

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

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

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

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

Test Engineer(s): Bryan Taylor

Test Date(s): 6/17/2024

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 determined from the plots on the following pages.

Test Engineer(s): Bryan Taylor

Test Date(s): 6/17/2024

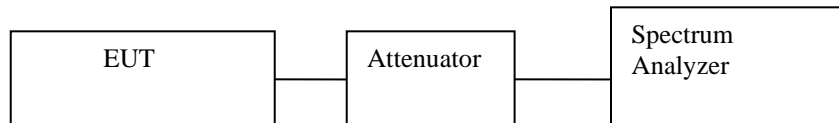


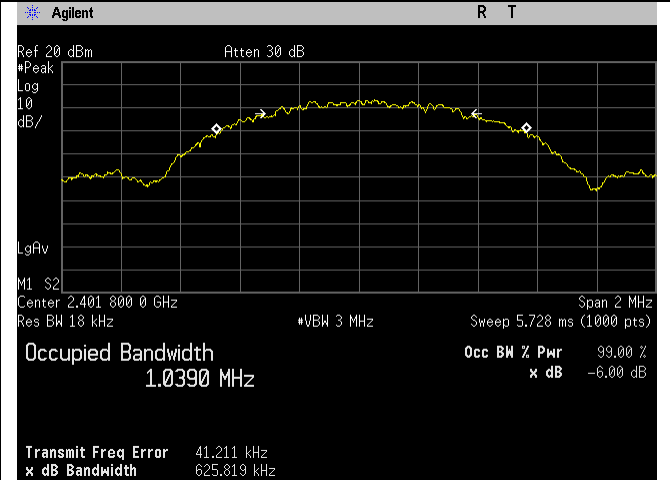
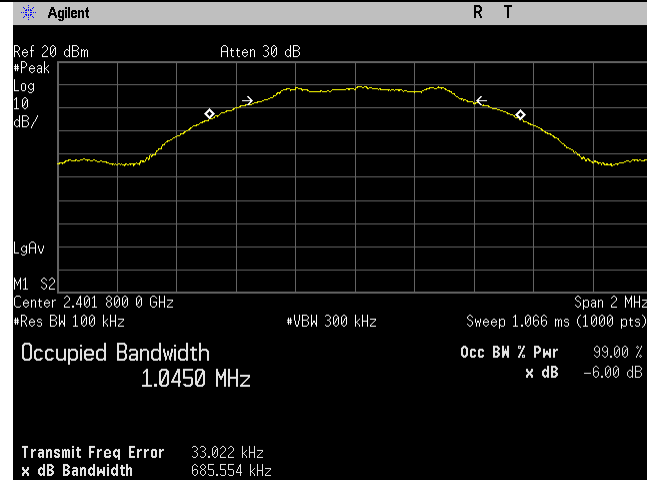
Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Channel	Frequency (MHz)	6dB Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	99% Bandwidth (MHz)	Result
Low	2402MHz	1.045MHz	0.5	1.039MHz	Pass
Middle	2440MHz	1.048MHz	0.5	1.035MHz	Pass
High	2480MHz	1.048MHz	0.5	1.035MHz	Pass

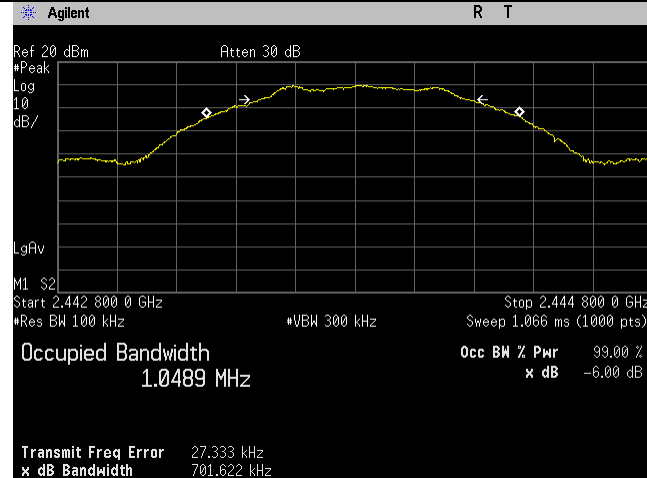
Table 11. 99% and 6 dB Occupied Bandwidth, Test Results

Occupied Bandwidth Test Results

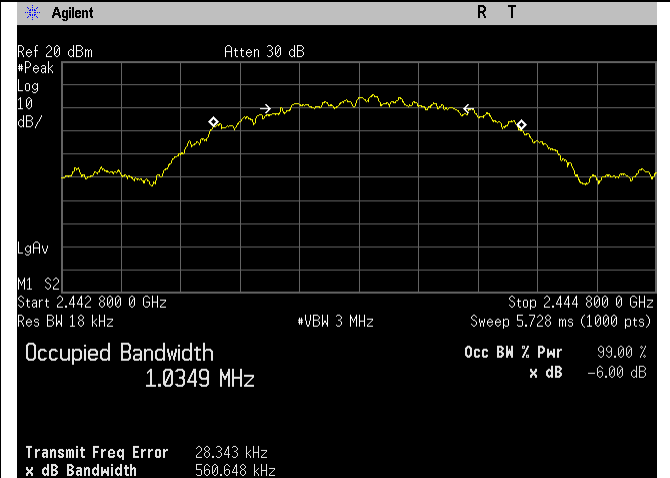
Occupied Bandwidth Plots



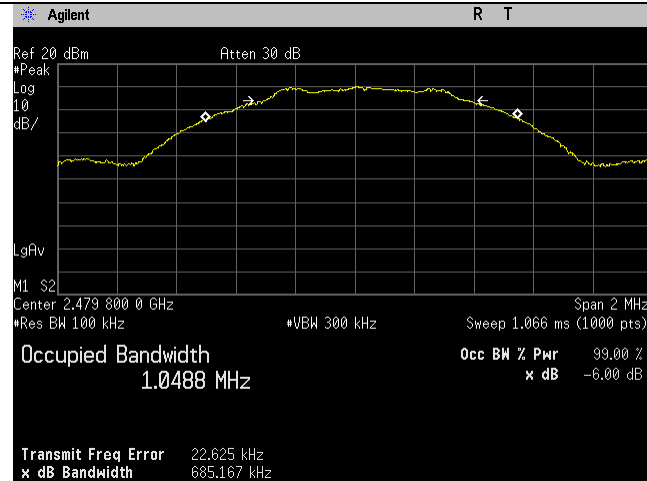
Low Channel 6dB Bandwidth



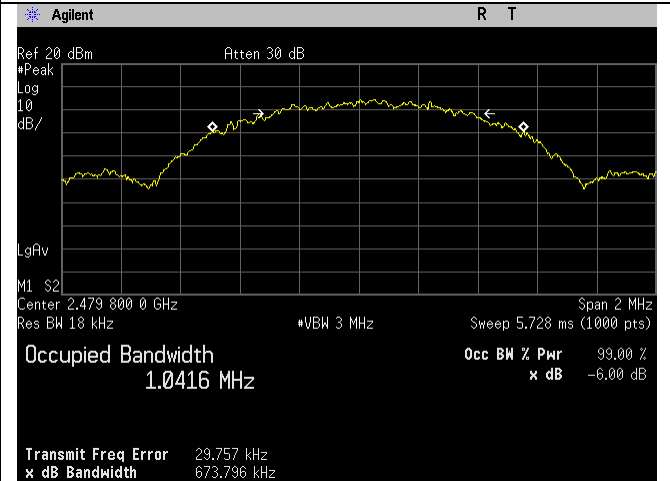
Low Channel 99% Bandwidth



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.

RSS-247 EIRP Limit: For DTSs employing digital modulation techniques operating in the bands 902-928 MHz and 2400-2483.5 MHz, the maximum peak conducted output power shall not exceed 1 W. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

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) and the EIRP limits from RSS-247.

Test Engineer(s): Bryan Taylor

Test Date(s): 6/17/2024

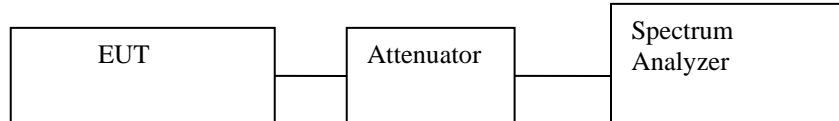


Figure 3. Peak Power Output Test Setup

Peak Power Output Test Results

Channel	Frequency (MHz)	Peak Conducted Power (dBm)	Peak Power Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
Low	2402MHz	9.72dBm	30	2.7	12.42	36	Pass
Middle	2440MHz	10.72dBm	30	2.7	13.42	36	Pass
High	2480MHz	10.59dBm	30	2.7	13.29	36	Pass

Table 13. Peak Power Output and EIRP, Test Results

Electromagnetic Compatibility Criteria for Intentional Radiators

§ 15.247(e) Peak Power Spectral Density

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

Test Procedure: The transmitter was connected directly to a Spectrum Analyzer through 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: 6/17/2024

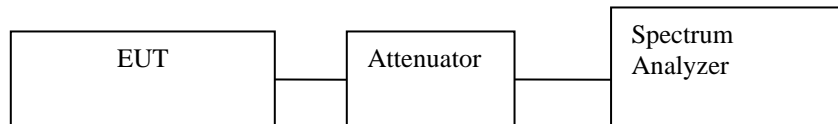
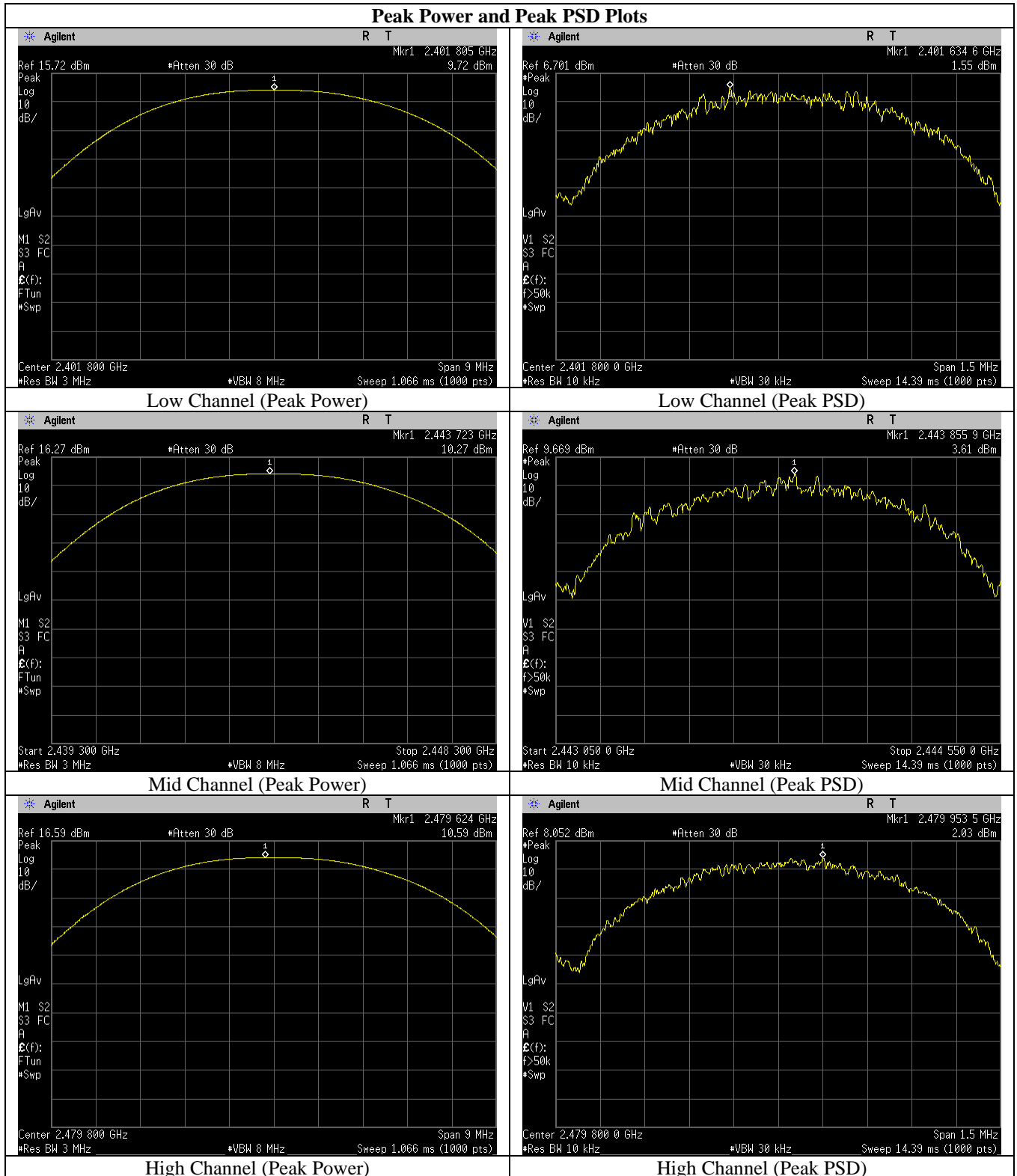


Figure 4. Block Diagram, Peak Power Spectral Density Test Setup

Channel	Frequency (MHz)	Peak Power Spectral Density (dBm/10kHz)	10log (3/10)	Peak Power Spectral Density (dBm/3kHz)	Peak Power Spectral Density Limit (dBm / 3kHz)	Result
Low	2402MHz	1.55	-5.22	-3.67	8	Pass
Middle	2440MHz	3.61	-5.22	-1.61	8	Pass
High	2480MHz	2.03	-5.22	-3.19	8	Pass

Table 14. Peak Power Spectral Density, Test Results



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): 6/17/2024

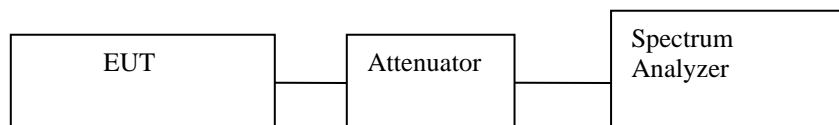


Figure 5. Block Diagram, Conducted Spurious Emissions Test Setup

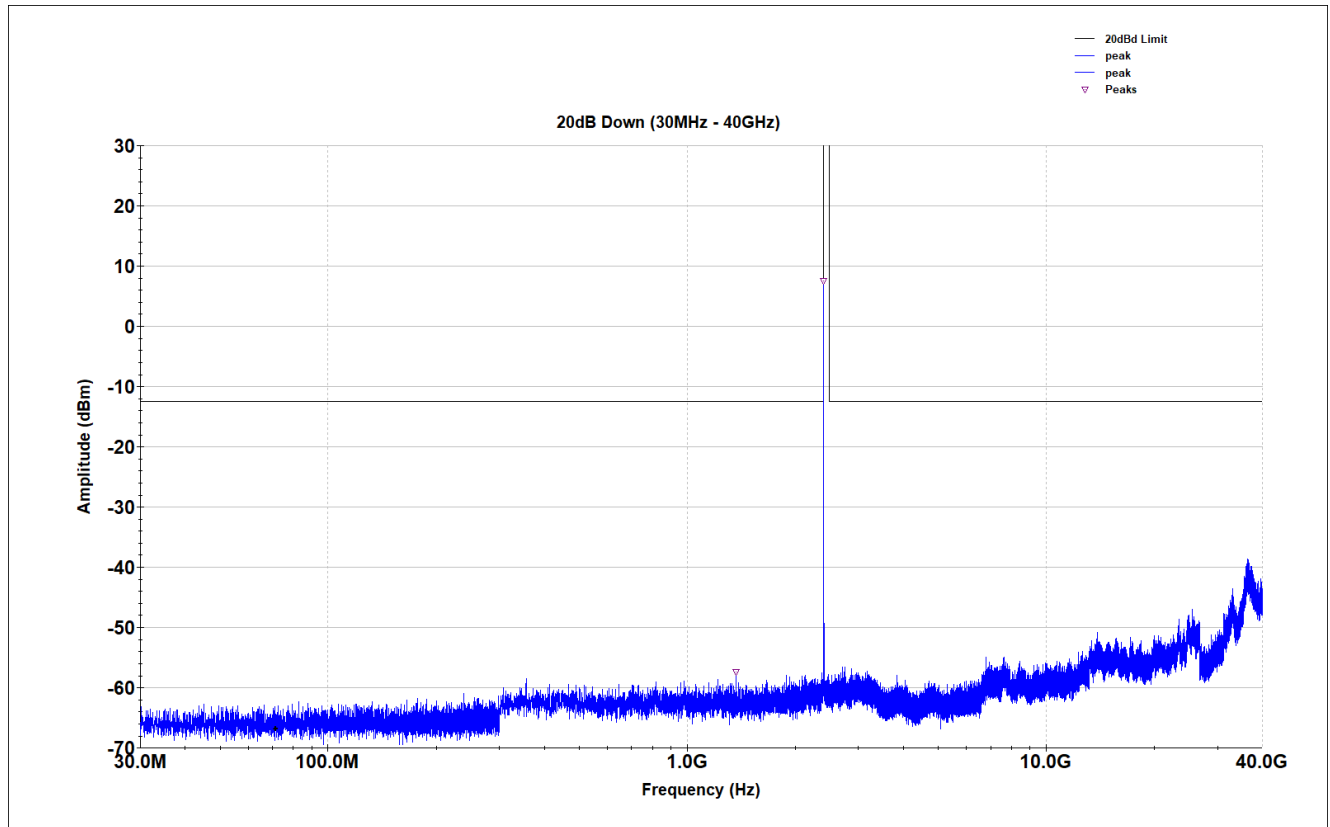


Figure 6. Low Channel, 30MHz – 40GHz Conducted Spurious Emissions

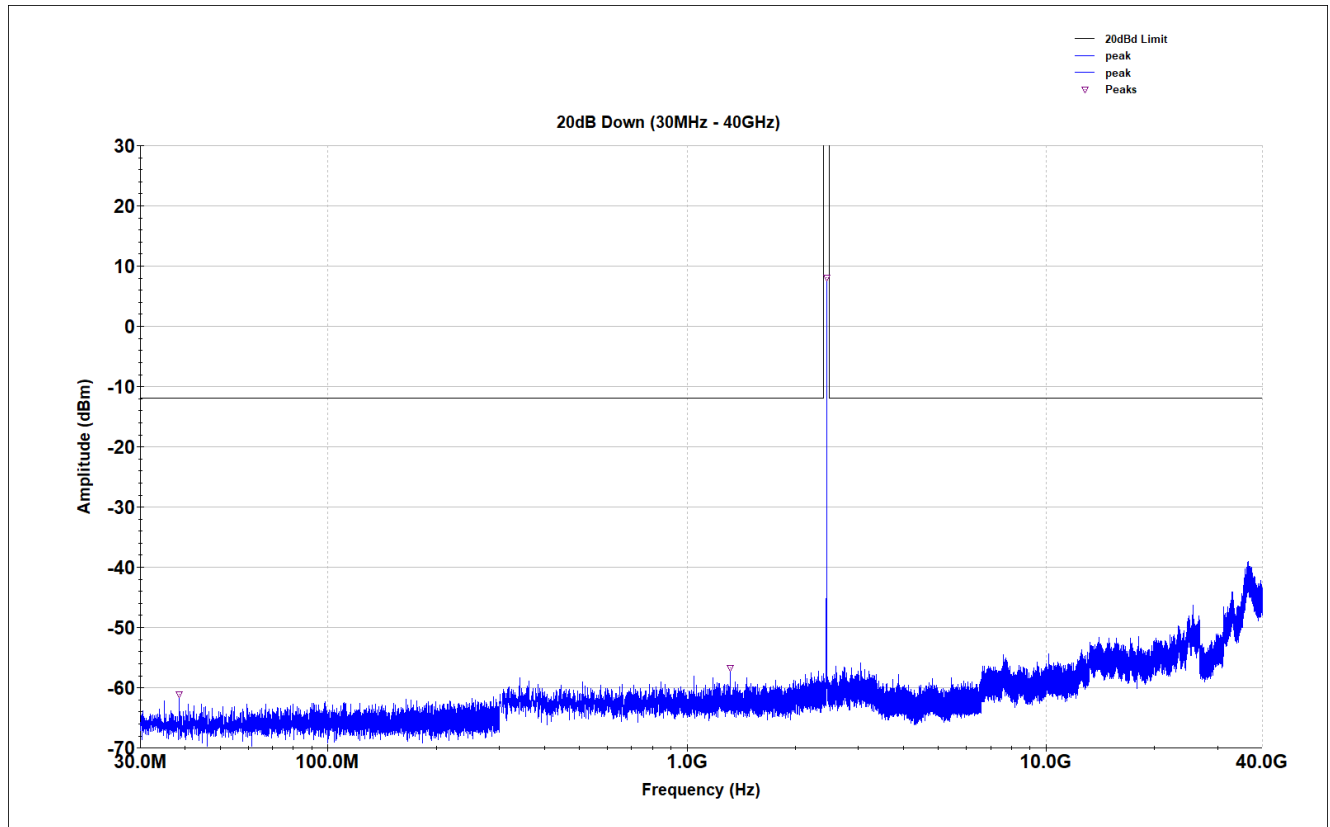


Figure 7. Mid Channel, 30MHz – 40GHz Conducted Spurious Emissions

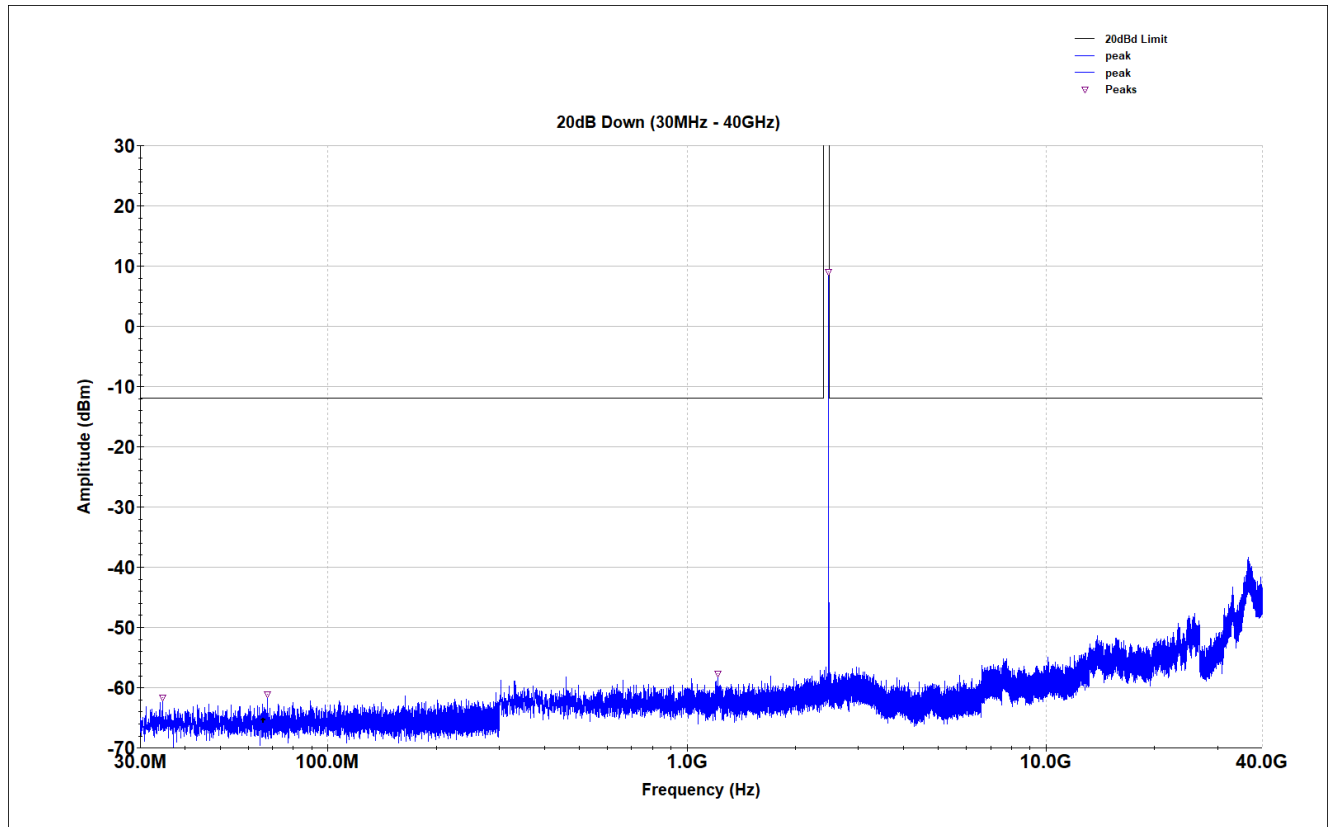
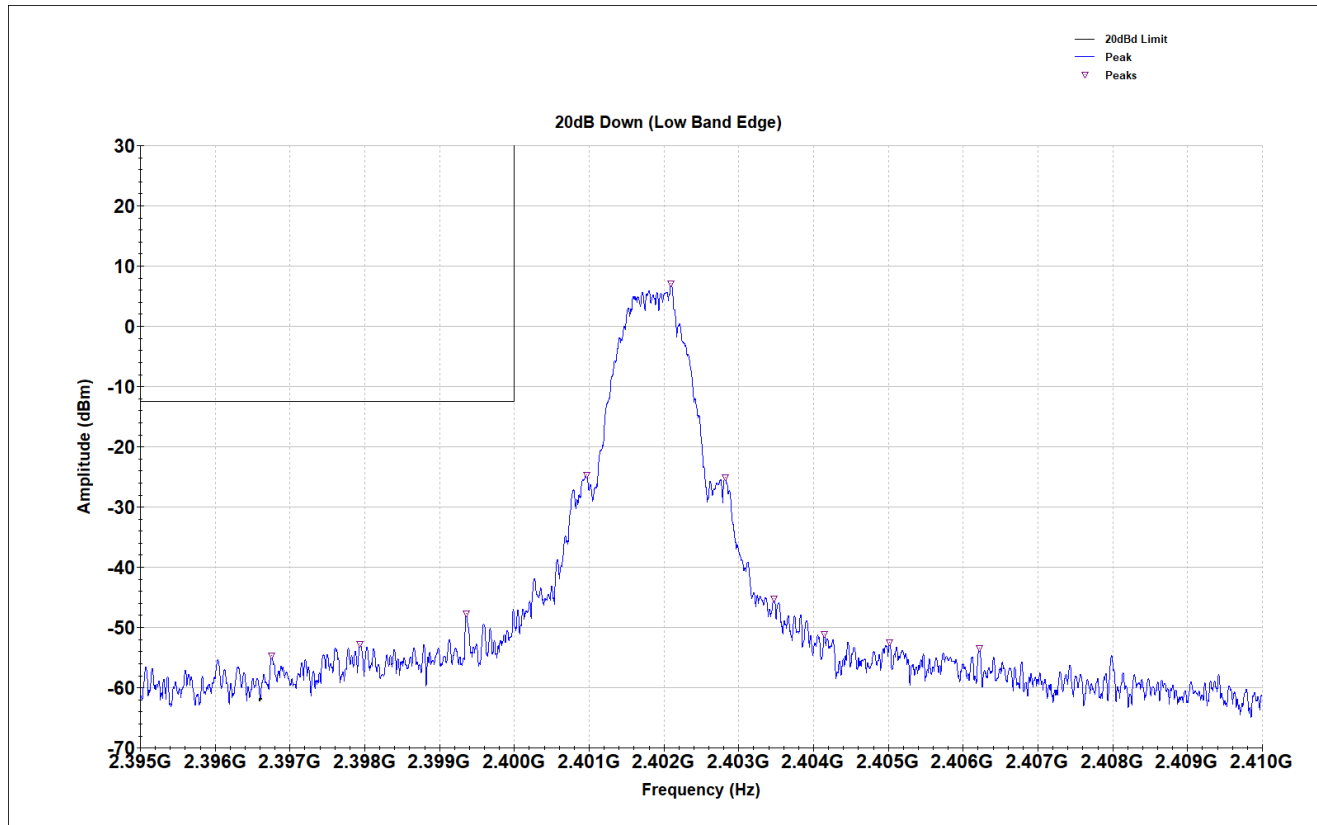
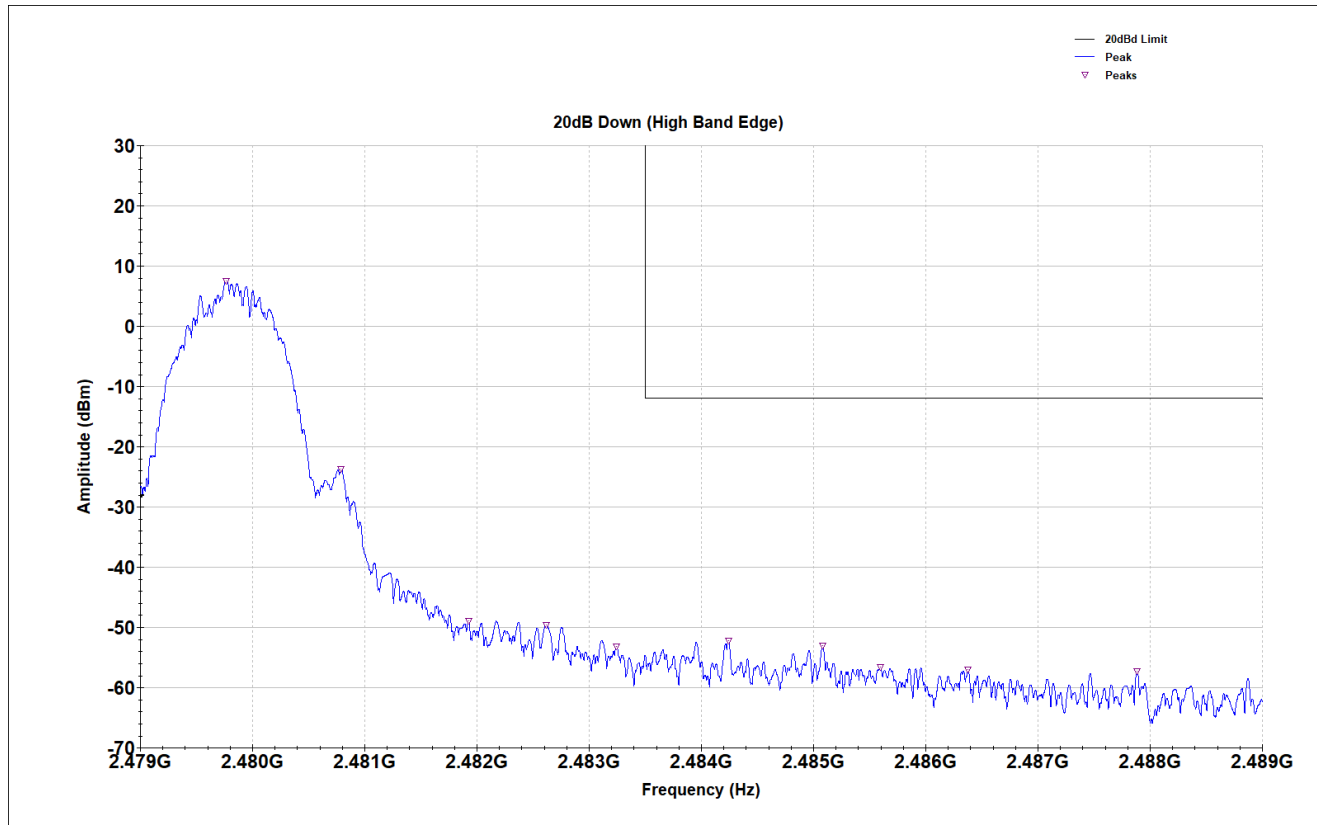


Figure 8. High Channel, 30MHz – 40GHz Conducted Spurious Emissions



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2396.755	-54.67	-12.42	42.25	Pass
2397.94	-52.77	-12.42	40.35	Pass
2399.358	-47.63	-12.42	35.21	Pass

Figure 9. Low Channel, Low Band Edge



Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
2484.24	-52.26	-11.87	40.39	Pass
2485.08	-53.05	-11.87	41.18	Pass
2485.595	-56.55	-11.87	44.68	Pass
2486.378	-57.01	-11.87	45.14	Pass
2487.883	-57.22	-11.87	45.35	Pass

Figure 10. High Channel, Low Band Edge

Electromagnetic Compatibility Criteria for Intentional Radiators

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

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

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

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

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

Table 15. Restricted Bands of Operation

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

² Above 38.6

Test Requirement(s): § 15.209 (a): Except as provided elsewhere in this subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in Table 16.

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

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

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

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): 5/28/2024 - 6/17/2024

Radiated Spurious Emissions Test Results

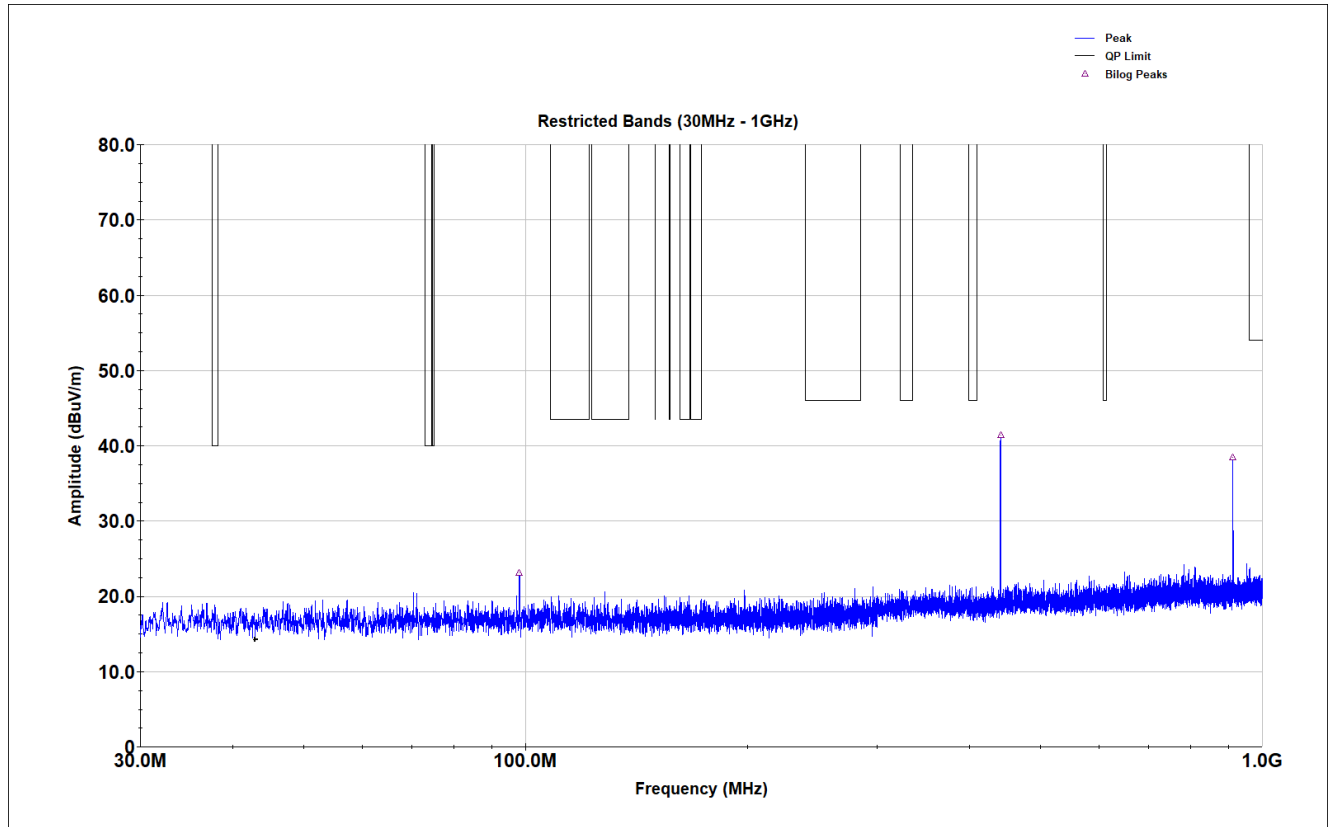


Figure 11. Low Channel, 30MHz – 1GHz Restricted Band Spurious Emissions

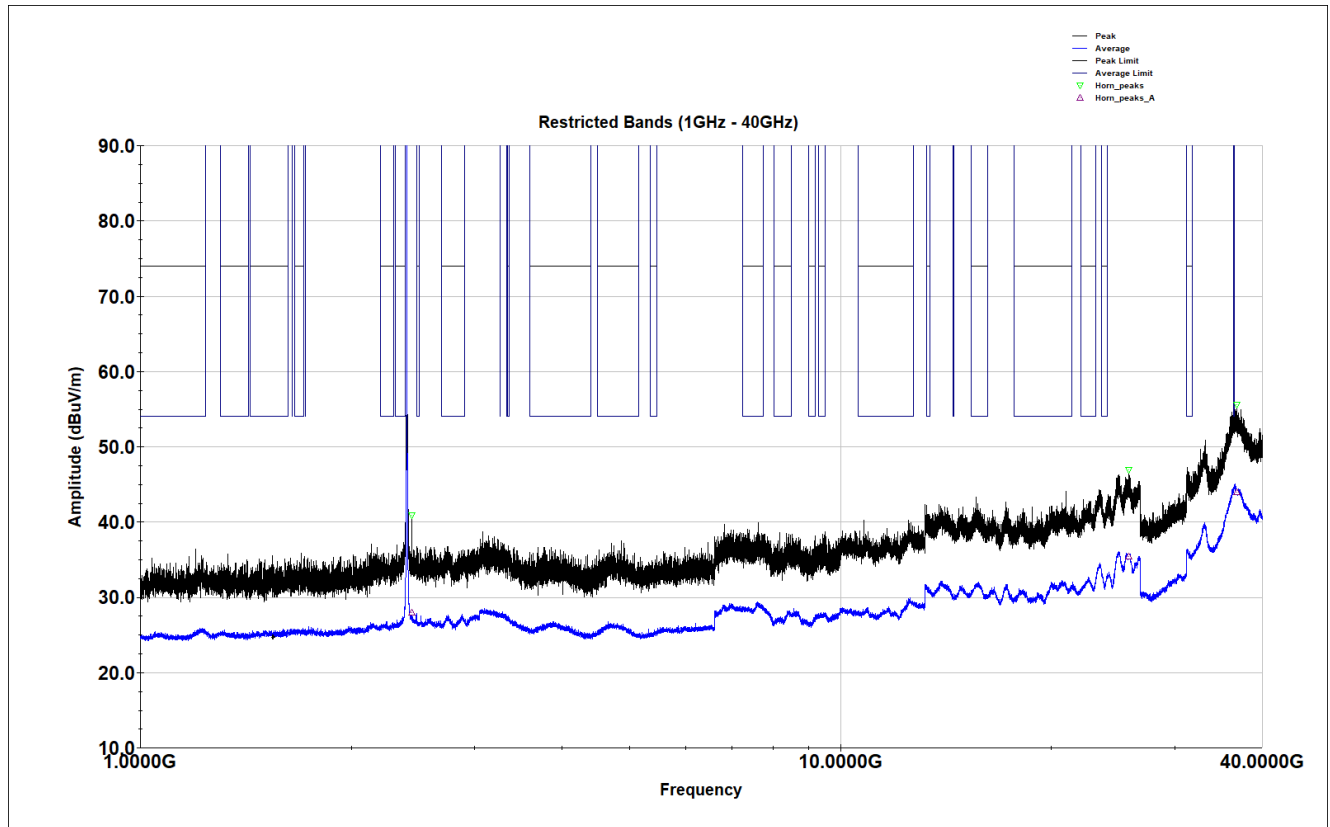


Figure 12. Low Channel, 1GHz – 40GHz Restricted Band Spurious Emissions

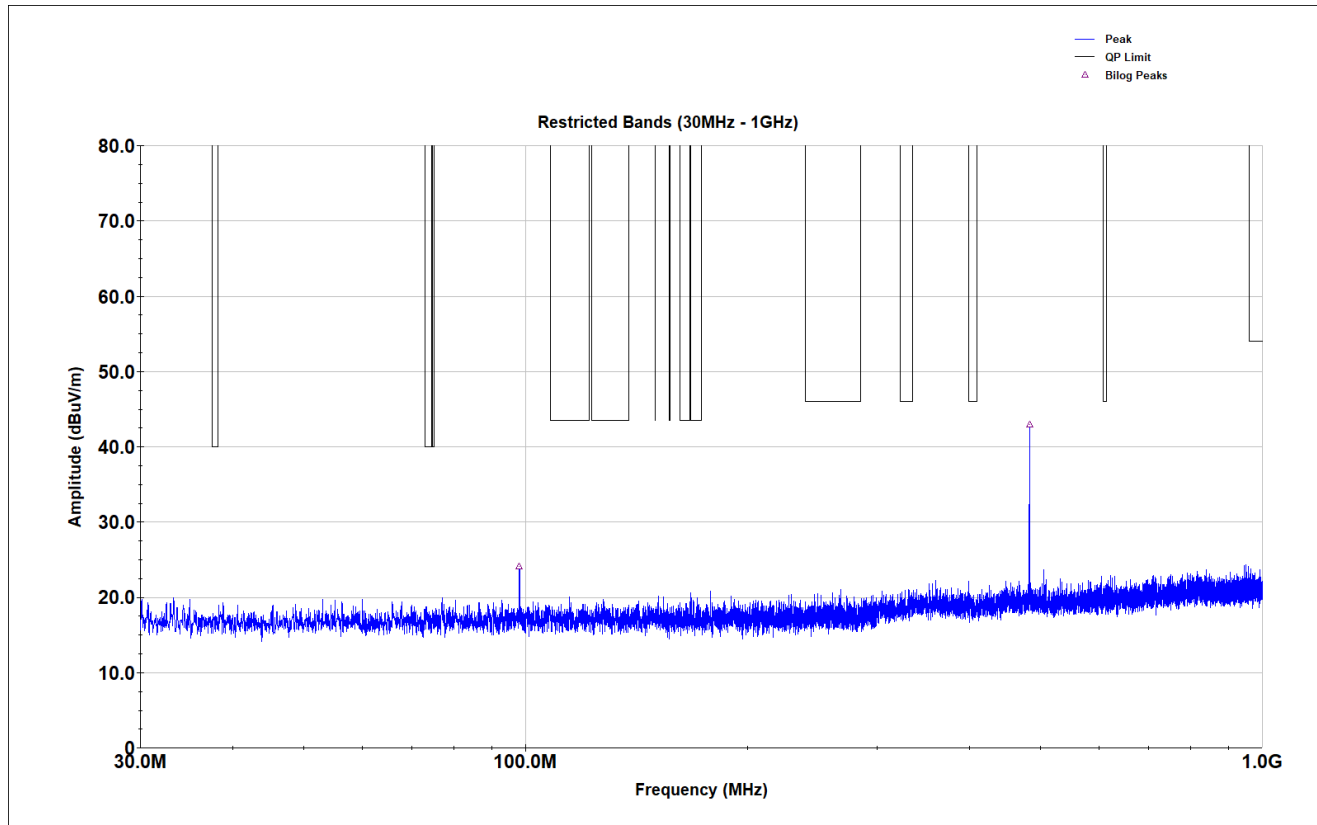


Figure 13. Middle Channel, 30MHz – 1GHz Restricted Band Spurious Emissions

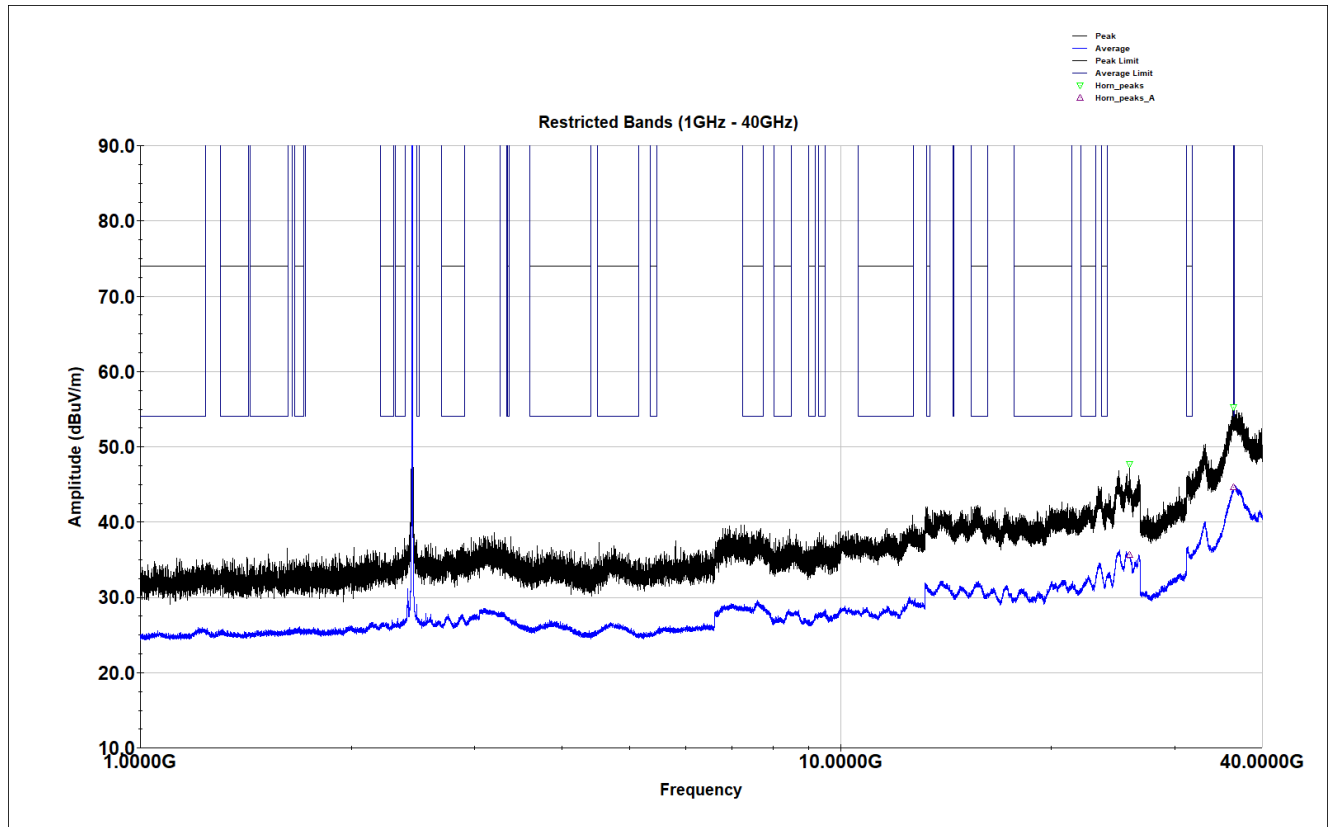


Figure 14. Middle Channel, 1GHz – 40GHz Restricted Band Spurious Emissions

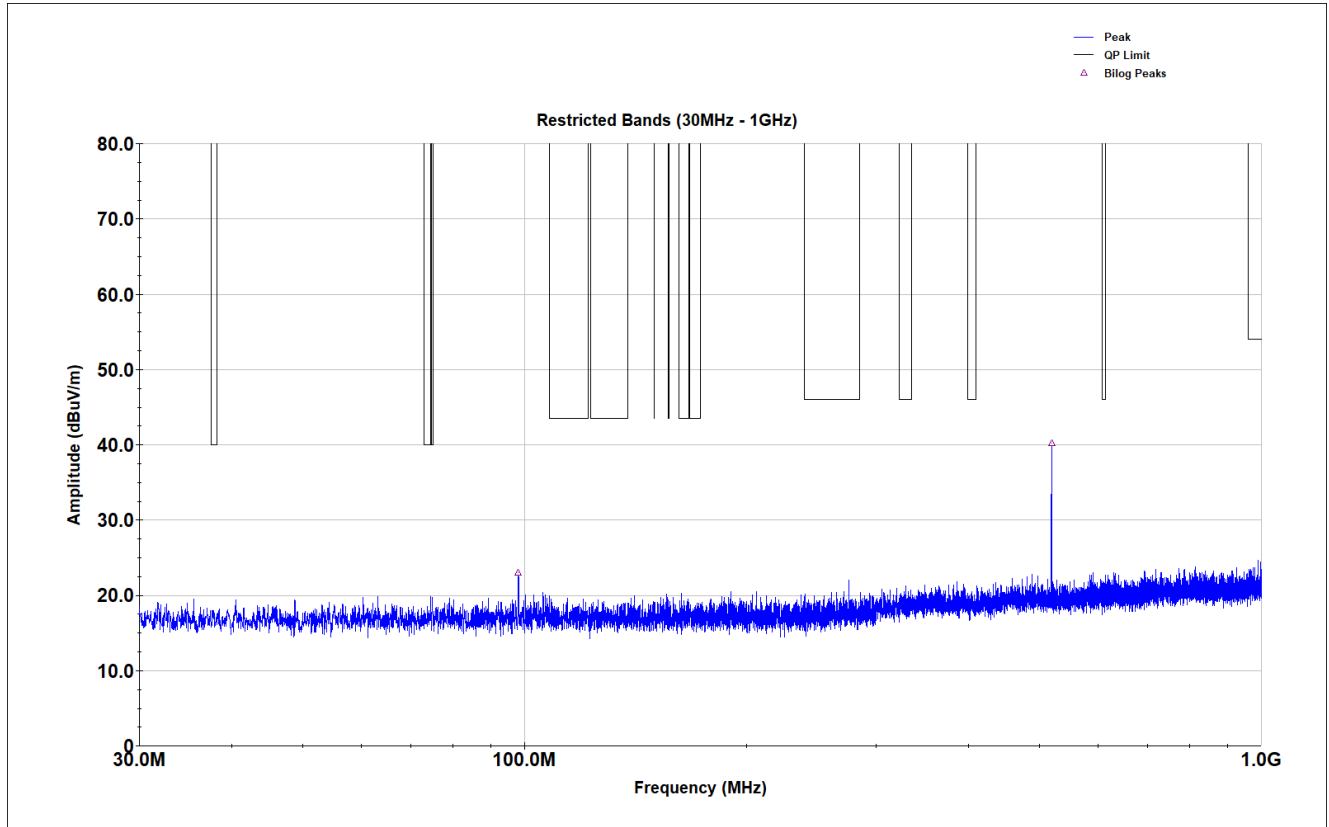
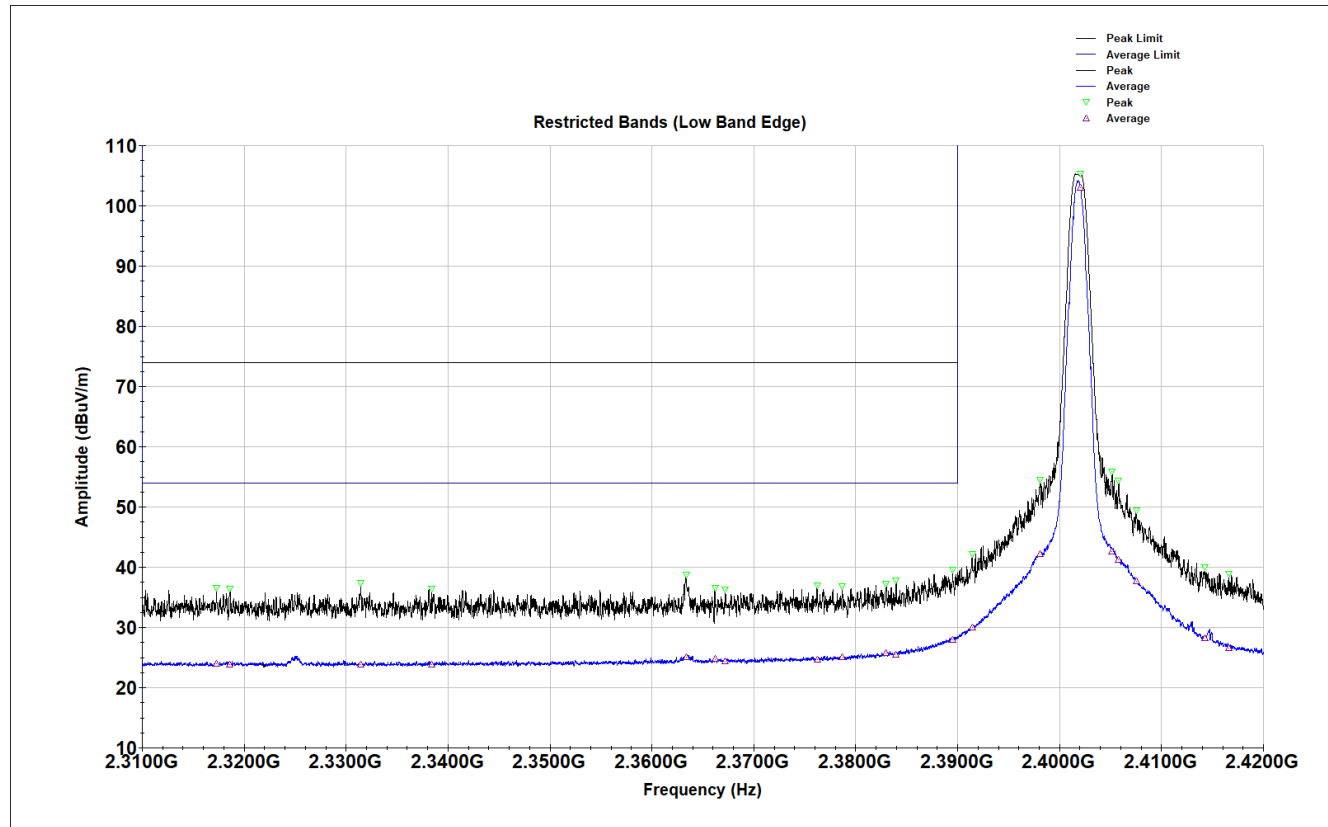
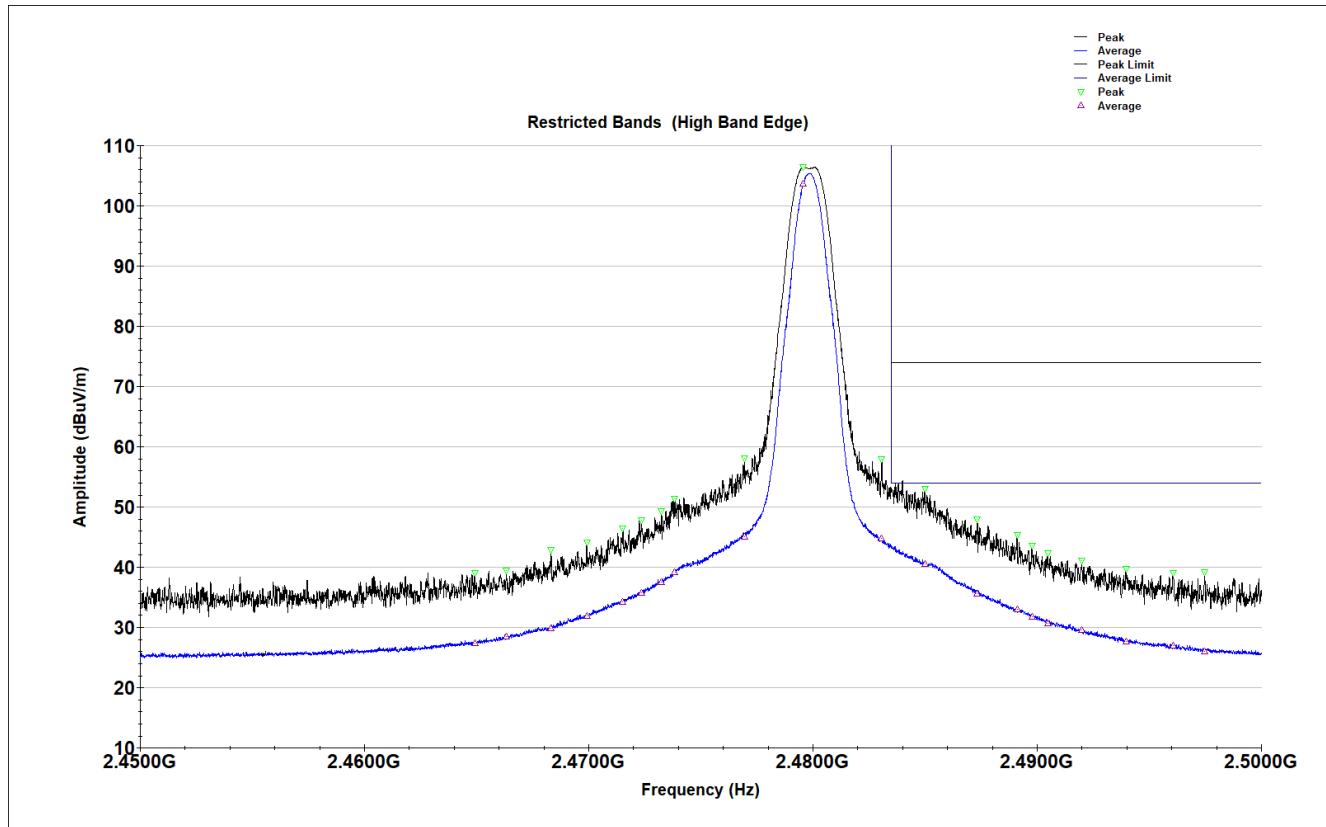


Figure 15. High Channel, 30MHz – 1GHz Restricted Band Spurious Emissions



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
2317.287	36.59	74	37.41	23.94	54	30.06	Pass
2318.58	36.48	74	37.52	23.79	54	30.21	Pass
2331.423	37.38	74	36.62	23.8	54	30.2	Pass
2338.366	36.49	74	37.51	23.88	54	30.12	Pass
2363.364	38.71	74	35.29	25.13	54	28.87	Pass
2366.182	36.62	74	37.38	24.72	54	29.28	Pass
2367.214	36.23	74	37.77	24.37	54	29.63	Pass
2376.22	36.94	74	37.06	24.71	54	29.29	Pass
2378.668	36.81	74	37.19	25.01	54	28.99	Pass
2382.971	37.3	74	36.7	25.7	54	28.3	Pass
2383.948	37.74	74	36.26	25.46	54	28.54	Pass
2389.516	39.58	74	34.42	27.99	54	26.01	Pass

Figure 16. Restricted Band Edge Spurious Emissions (Low Band Edge)



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
2484.994	53	74	21	40.5	54	13.5	Pass
2487.319	47.92	74	26.08	35.62	54	18.38	Pass
2489.1	45.28	74	28.72	33	54	21	Pass
2489.775	43.59	74	30.41	31.85	54	22.15	Pass
2490.475	42.38	74	31.62	30.71	54	23.29	Pass
2491.981	41.12	74	32.88	29.56	54	24.44	Pass
2493.956	39.74	74	34.26	27.73	54	26.27	Pass
2496.056	39.07	74	34.93	26.96	54	27.04	Pass
2497.469	39.17	74	34.83	26.08	54	27.92	Pass

Figure 17. Restricted Band Edge Spurious Emissions (High Band Edge)

Worst Case Cabinet Spurious Emissions

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Meas. BW [kHz]	Result
0.090	41.96	108.52	66.56	11.76	V	87.9	1	0.200	Pass
0.098	39.94	107.79	67.85	11.37	H	248.7	1	0.200	Pass
0.492	45.53	813.24	767.71	11.31	H	78.8	1	9.000	Pass
0.501	45.64	73.69	28.05	11.27	V	1.5	1	9.000	Pass
2.175	32.26	69.54	37.28	11.69	H	334.3	1	9.000	Pass

Figure 18. Worst Case Cabinet Radiation, 9kHz - 30MHz

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
74.340	15.39	40.00	24.61	-12.21	V	303.9	3.65	120.000	Pass
172.890	14.17	43.52	29.35	-8.33	H	282.7	3.5	120.000	Pass
271.590	16.49	46.02	29.53	-5.97	H	301.1	2.65	120.000	Pass
608.700	21.38	46.02	24.64	1.04	H	60.2	3.8	120.000	Pass
608.910	27.23	46.02	18.79	1.35	V	179.8	2.71	120.000	Pass

Figure 19. Worst Case Cabinet Radiation, 30MHz - 1GHz

Frequency [MHz]	PK+ Level [dBμV/m]	PK+ Limit [dBμV/m]	PK+ Margin [dB]	AVG Level [dBμV/m]	AVG Limit [dBμV/m]	AVG Margin [dB]	Correction [dB]	Polarization	Azimuth [deg]	Antenna Height [m]	Result
4,888.000	46.51	74.00	27.49	36.02	54.00	17.98	-3.21	H	46.5	3.5	Pass
4,888.000	43.45	74.00	30.55	31.64	54.00	22.36	-3.21	V	159.6	2.88	Pass
7,332.000	43.50	74.00	30.50	30.29	54.00	23.71	-2.73	V	187.5	1.22	Pass
8,425.500	49.07	74.00	24.93	36.34	54.00	17.66	-3.50	V	142.8	1.5	Pass
12,220.000	45.76	74.00	28.24	32.89	54.00	21.11	-1.95	V	24.6	1.58	Pass
18,877.250	52.71	74.00	21.29	40.50	54.00	13.50	12.70	H	279.9	1.7	Pass
19,520.000	52.09	74.00	21.91	40.44	54.00	13.56	12.35	H	290.6	3.33	Pass
19,520.000	51.51	74.00	22.49	40.35	54.00	13.65	12.35	V	56.5	2.5	Pass
31,586.375	54.10	74.00	19.90	42.83	54.00	11.17	16.86	V	360.4	4	Pass
31,614.563	54.32	74.00	19.68	43.07	54.00	10.93	16.80	H	297.4	1	Pass

Figure 20. Worst Case Cabinet Radiation, Above 1GHz

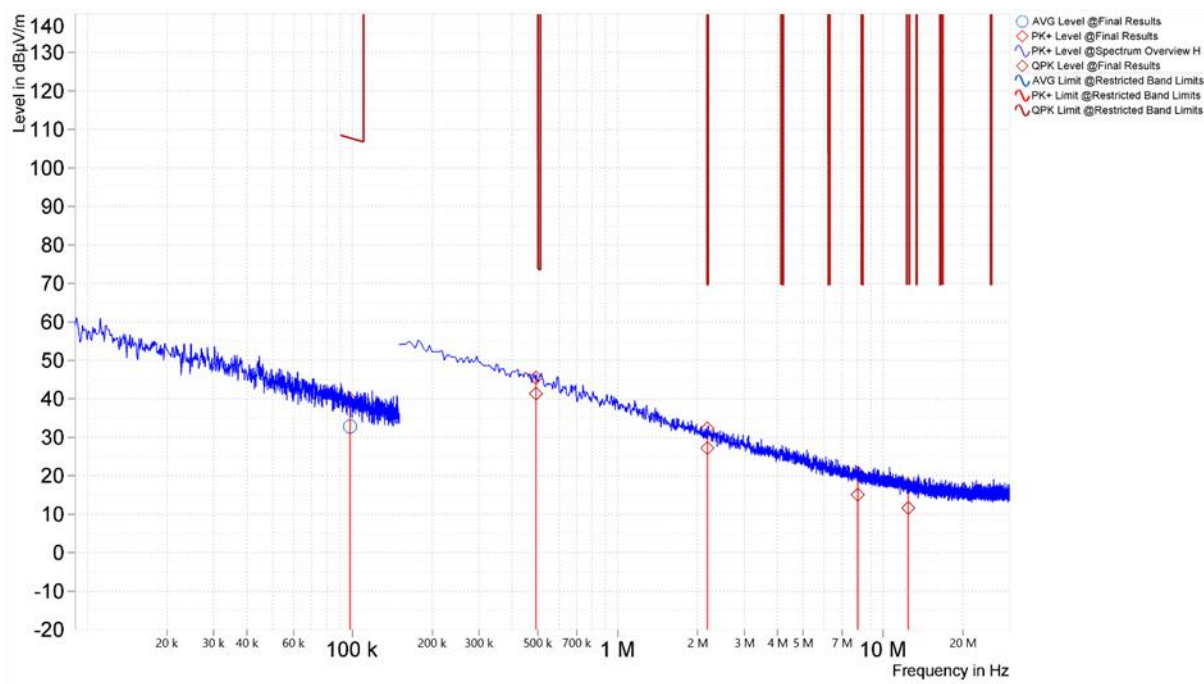


Figure 21. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coaxial Loop

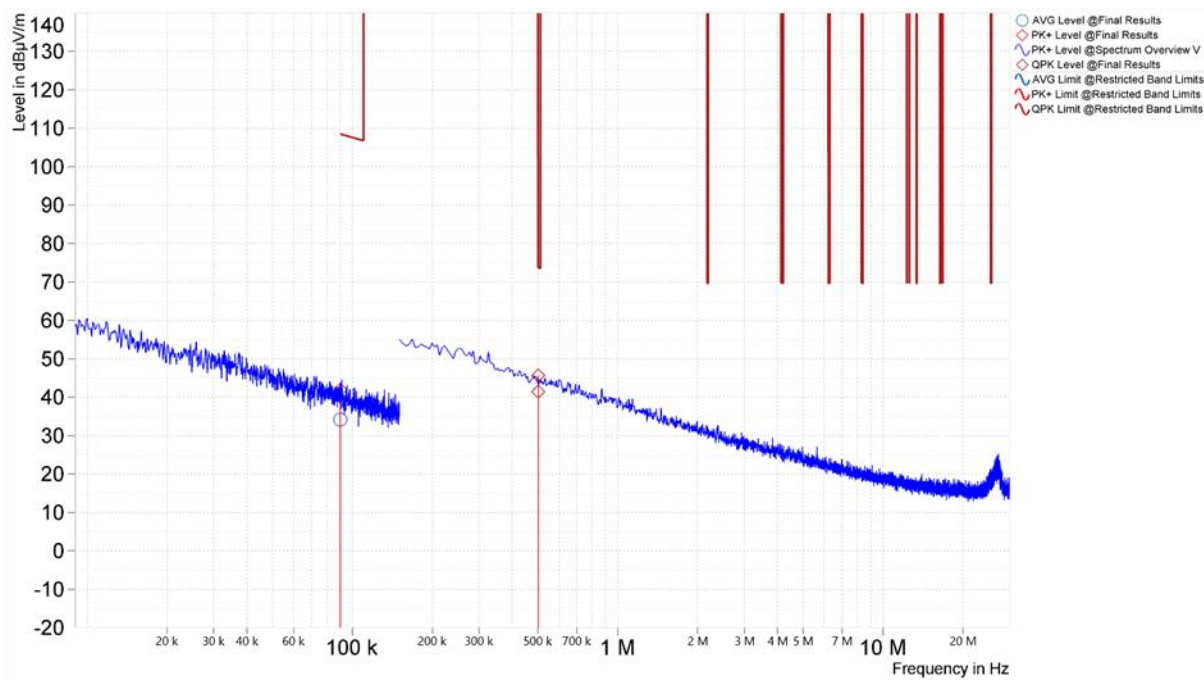


Figure 22. Worst Case Cabinet Radiation, 9kHz – 30MHz, Coplanar Loop

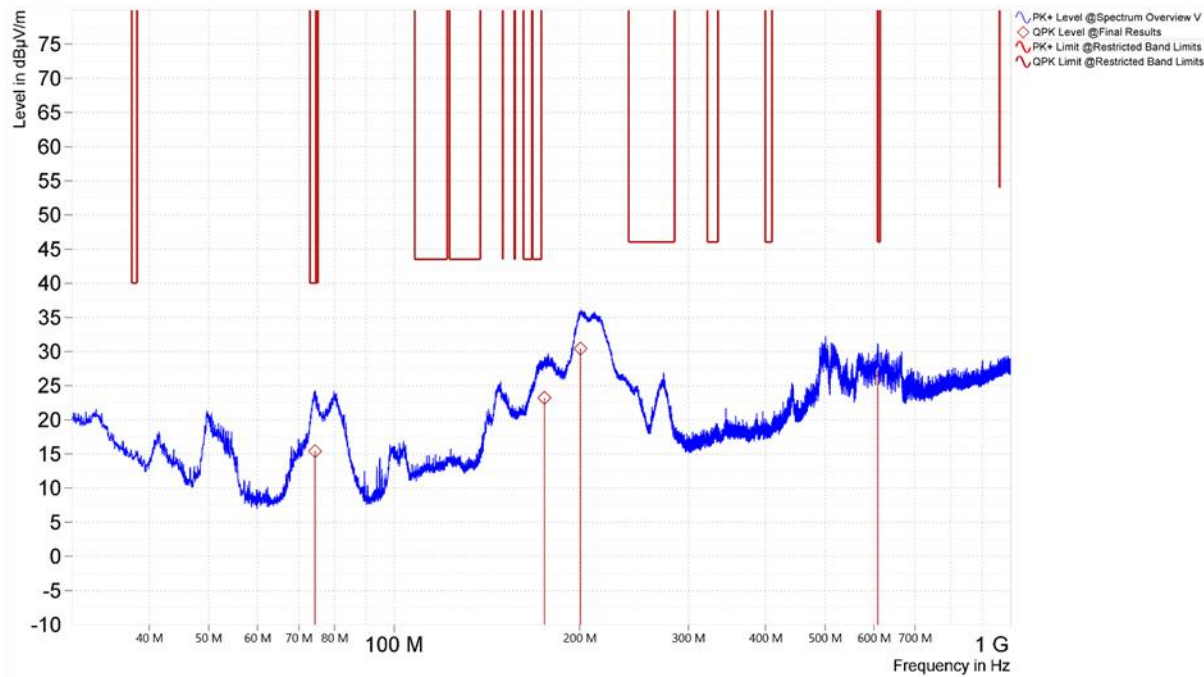


Figure 23. Worst Case Cabinet Radiation, 30MHz – 1GHz, Vertical Polarity

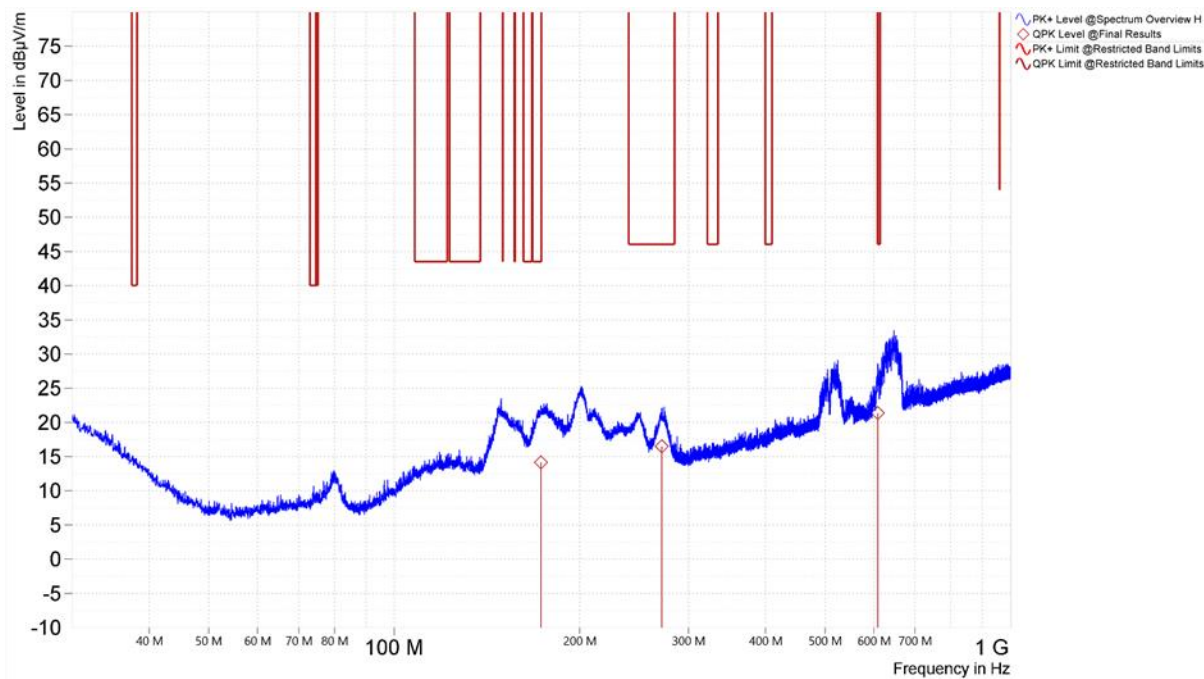


Figure 24. Worst Case Cabinet Radiation, 30MHz – 1GHz, Horizontal Polarity

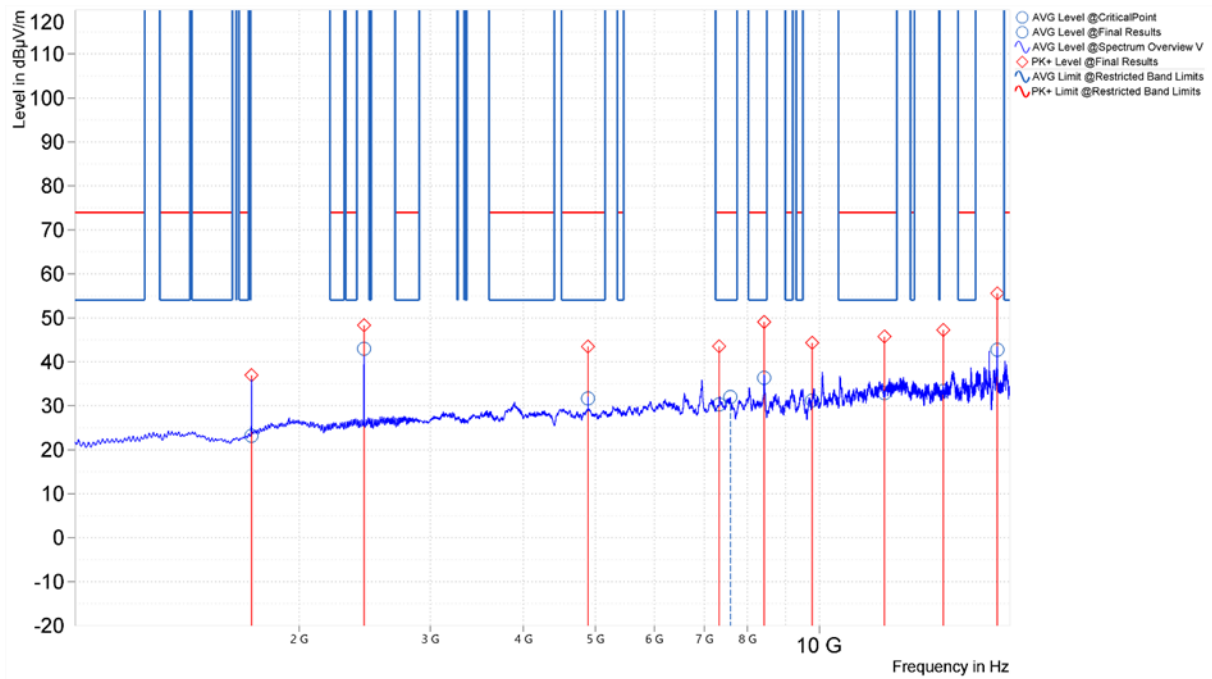


Figure 25. Worst Case Cabinet Radiation, 1GHz – 18GHz, Vertical Polarity

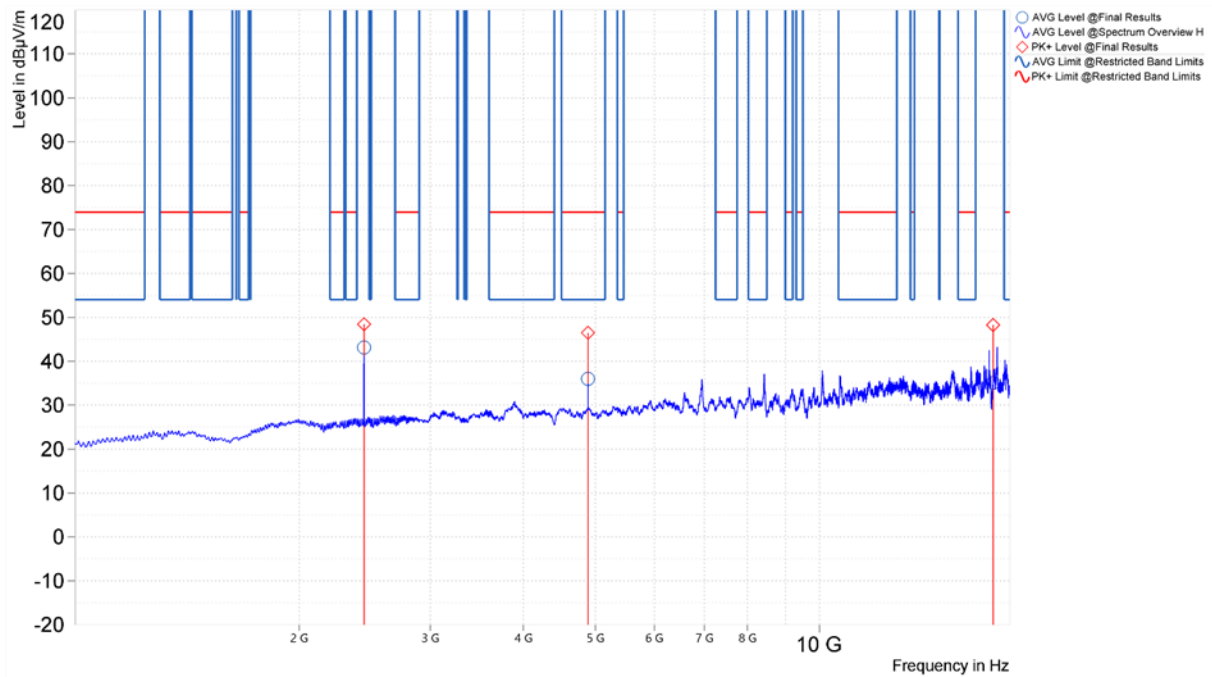


Figure 26. Worst Case Cabinet Radiation, 1GHz – 18GHz, Horizontal Polarity

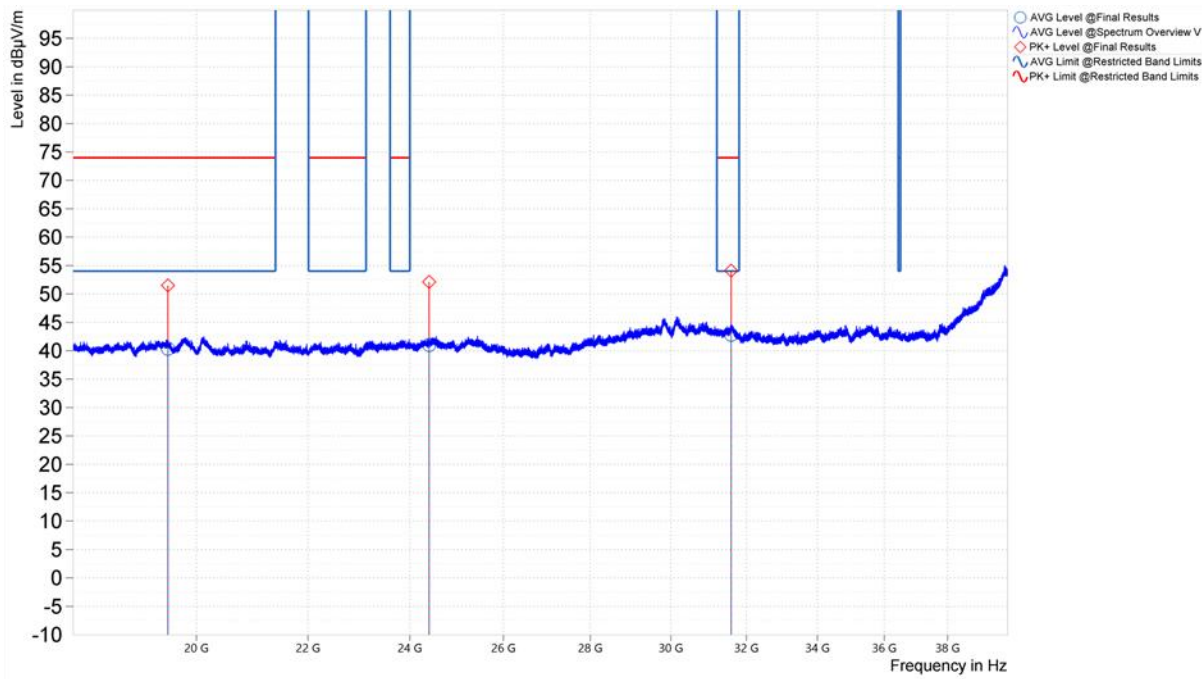


Figure 27. Worst Case Cabinet Radiation, 18GHz – 40GHz, Vertical Polarity

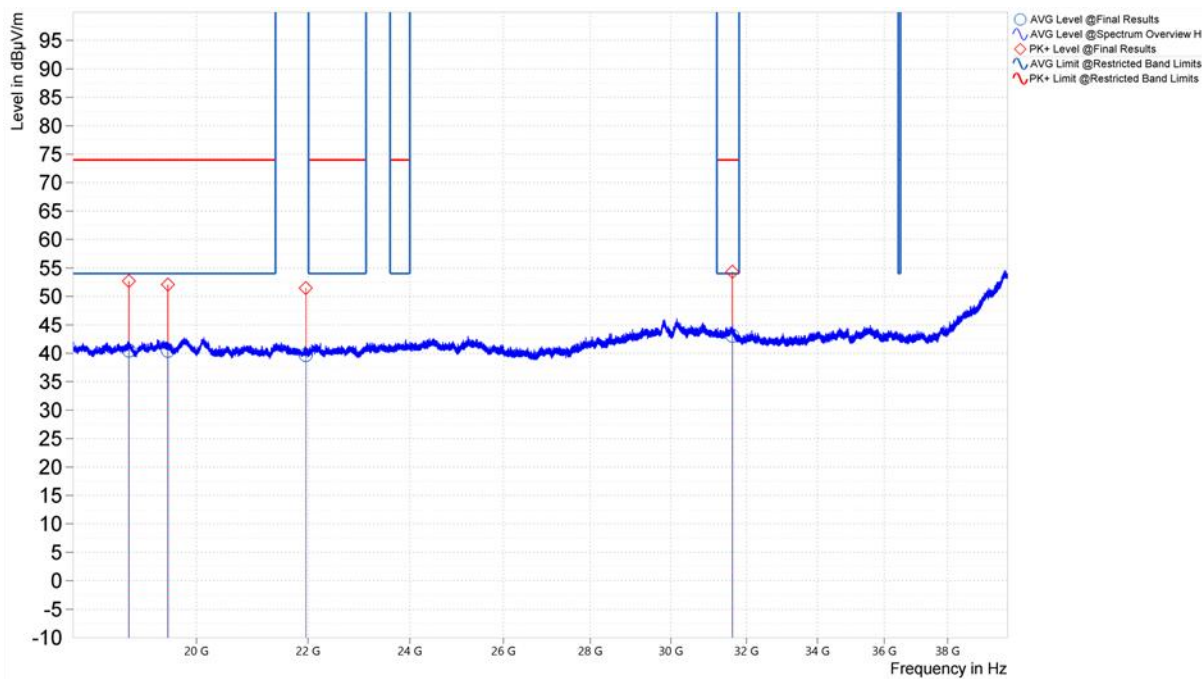


Figure 28. Worst Case Cabinet Radiation, 18GHz – 40GHz, Horizontal Polarity

IV. Test Equipment

Test Equipment

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

MET Asset #	Description	Manufacturer	Model	Last Cal Date	Cal Due Date
MY46180897	Spectrum Analyzer	Keysight	E4448A	7/27/2023	7/27/2024
1A1083	Receiver	Rohde & Schwarz	ESU40	11/20/2023	11/20/2024
1A1176	Active Loop Antenna (9KHz-30MHz)	ETS-Lindgren	6502	7/13/2023	7/13/2024
1A1147	Bi-Log Antenna	Suno Sciences Corp	JB3	04/06/2023	04/06/2025
1A1047	Horn Antenna	ETS - Lindgren	3117	06/16/2022	06/16/2024
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
1A1177	Pulse Limiter	Rohde & Schwarz	ESH3Z2	12/14/2023	12/14/2024
1A1122	LISN	TESEQ	NNB 51	09/21/2023	09/21/2024
1A1123	LISN	TESEQ	NNB 51	12/14/2023	12/14/2024
1A1149	DC Milliohm Meter	GW Instek	GOM-802	9/20/2023	9/20/2024
1A1099	Generator	Com-Power	CGO-51000	See Note	
1A1088	Preamplifier	Rohde & Schwarz	TS-PR1	See Note	
1A1044	Generator	Com-Power	CG-520	See Note	
1A1073	Multi Device Controller	ETS	2090	See Note	
1A1074	System Controller	Panasonic	WV-CU101	See Note	
1A1080	Multi-Device	ETS	2090	See Note	
1A1180	Preamplifier	Miteq	AMF-7D- 01001800-22- 10P	See Note	

Table 17. Test Equipment List

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

End of Report