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

12/18/2024

HID Global Corporation (US)
611 Center Ridge Drive
Austin Texas, 78753
USA

Dear Nic Holmes,

Enclosed is the EMC Wireless test report for compliance testing of the HID Global Corporation (US) HID Signo PIV Contact Reader 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: WIRA133283_FCC_IC_BLE_R2

Bluetooth Low Energy
Test Report

for the

HID Global Corporation (US)
HID Signo PIV Contact Reader (Model: 40TC)

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
∅	9/13/2024	Initial Issue.
1	10/21/2024	Customer Requested Changes.
2	12/18/2024	Reviewer Requested Changes.

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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 HID Signo PIV Contact Reader, 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 HID Signo PIV Contact Reader, 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 HID022810. 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 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 HID Signo PIV Contact Reader, under HID Global Corporation (US)'s purchase order number HID022810.

This document describes the test setups, test methods, required test equipment, and the test limit criteria used to perform compliance testing of the HID Signo PIV Contact Reader.

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

Product Name:	HID Signo PIV Contact Reader	
Model(s) Tested:	40TC	
FCCID:	JQ6-SIGNO40TC	
ICID:	2236B-SIGNO40TC	
Sample Number:	24775-17	
Equipment Specifications:	Primary Power:	12VDC
	Type of Modulations:	GFSK
	Equipment Code:	DTS
	Peak RF Output Power:	4.97dBm (0.003W)
	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, Sergio Gutierrez	
Report Date(s):	8/26/2024 through 8/31/2024	

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.

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

HID Signo PIV Contact Reader is a Access Control credential reader that is equipped with LF, HF, BLE and Contact card read ability.

The intended use of the product is for gaining secure access into building, sites or places via the use of a secure credential in the form of a LF credential card, HF credential card, NFC enabled smart phone, BLE Mobile credential or Contact chip credential.

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
None	Laptop Computer	Lenovo	ThinkPad	None

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
---	Serial Port to USB Debug Cable	Serial Port to USB Debug Cable	1	1m	---	No	Laptop Computer
---	DC Input	DC Input	1	1m	---	No	12V DC Power Source

Table 6. Ports and Cabling Information

I. Mode of Operation

The Nordic nRF Connect software (Direct Test Mode v2.4.1) was used to interface with the test sample and force it to transmit on low, mid, and high channels at maximum output power.

Transmit Band	Modulation	Channel Frequencies Tested	Test Tool Power Setting
2400 – 2483.5MHz	BLE (GFSK)	2402MHz / 2440MHz / 2480MHz	8

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.

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 permanently attached to the unit and is not accessible by the end user.

Test Engineer(s): Bryan Taylor

Test Date(s): 8/26/2024

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)

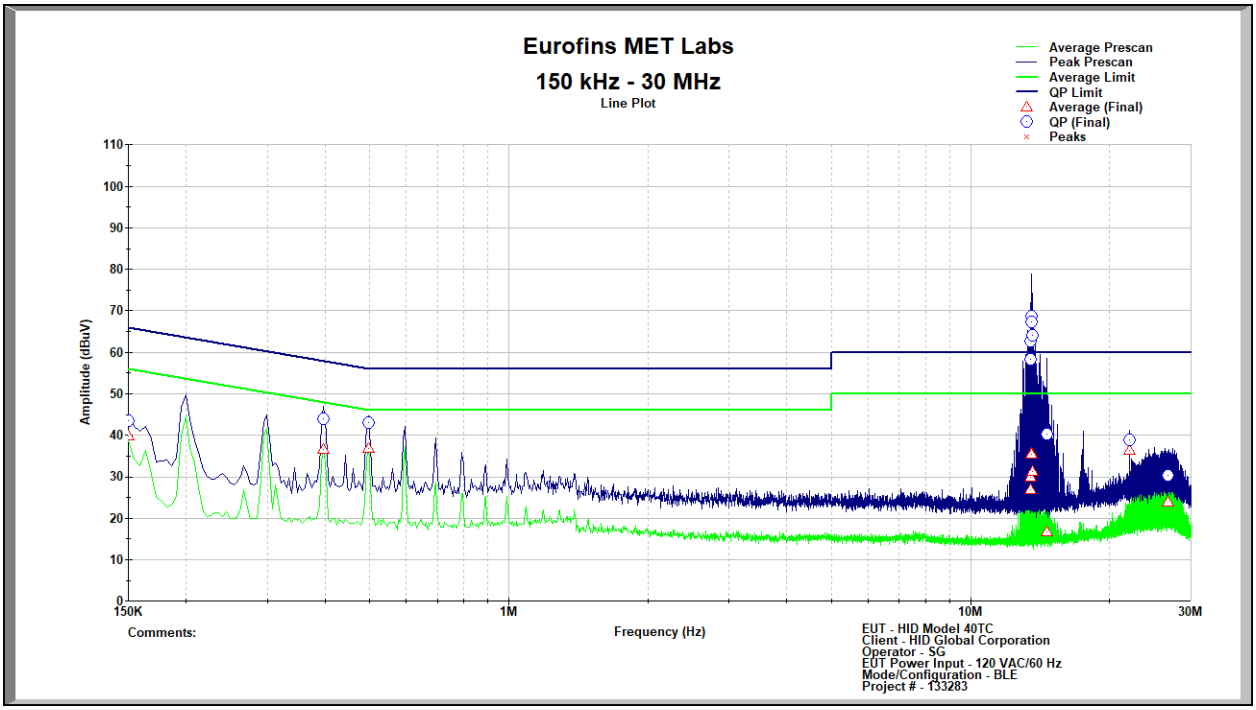
Test Procedure: The EUT was placed on a 0.8 m-high wooden table. The EUT was situated such that the back of the EUT was 0.4 m from one wall of the vertical ground plane, and the remaining sides of the EUT were no closer than 0.8 m from any other conductive surface. The EUT was powered from a 50 Ω/50 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..

Test Engineer(s): Sergio Gutierrez

Test Date(s): 8/28/2024

15.207(a) Conducted Emissions Test Results



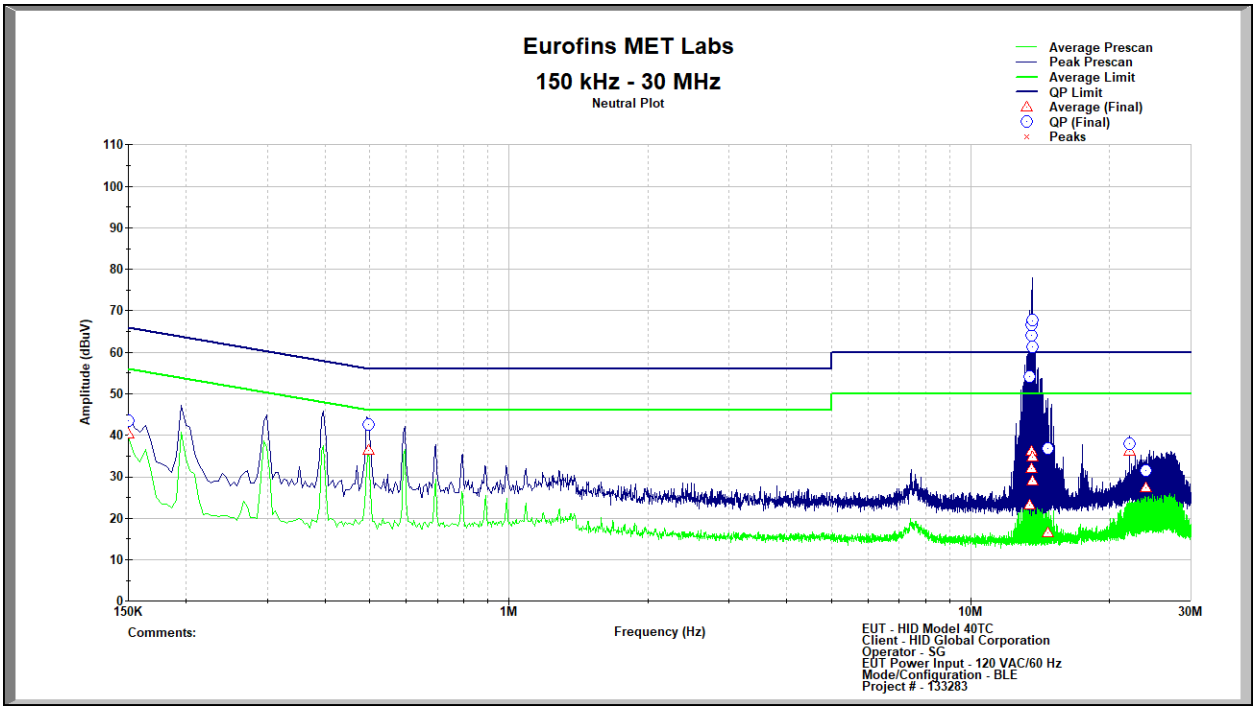
Conducted Emissions, 15.207(a), Phase[2]

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)
0.150	43.463	66.000	22.537	39.905	56.000	16.095
0.398	44.065	58.929	14.864	36.564	48.929	12.364
0.496	43.133	56.100	12.967	36.749	46.100	9.351
13.485	58.421	60.000	1.579	26.904	50.000	23.096
14.619	40.335	60.000	19.665	16.744	50.000	33.256
22.125	38.812	60.000	21.188	36.288	50.000	13.712

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

[2]The large signal at 13.56MHz is from the RFID reader onboard that operates at that frequency.

15.207(a) Conducted Emissions Test Results



Conducted Emissions, 15.207(a), Neutral[3]

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)
0.150	43.602	66.000	22.398	40.191	56.000	15.809
0.496	42.620	56.100	13.480	36.408	46.100	9.692
13.422	54.065	60.000	5.935	23.255	50.000	26.745
14.700	36.749	60.000	23.251	16.420	50.000	33.580
22.125	37.895	60.000	22.105	36.046	50.000	13.954
23.956	31.504	60.000	28.496	27.406	50.000	22.594

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

[3]The large signal at 13.56MHz is from the RFID reader onboard that operates at that frequency.

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): 8/27/2024

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 between 1% and 5% 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): 8/27/2024

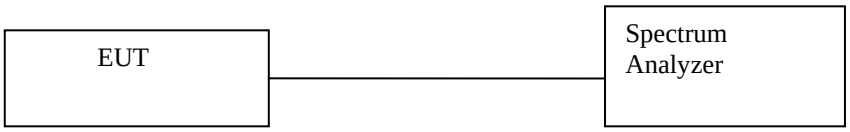


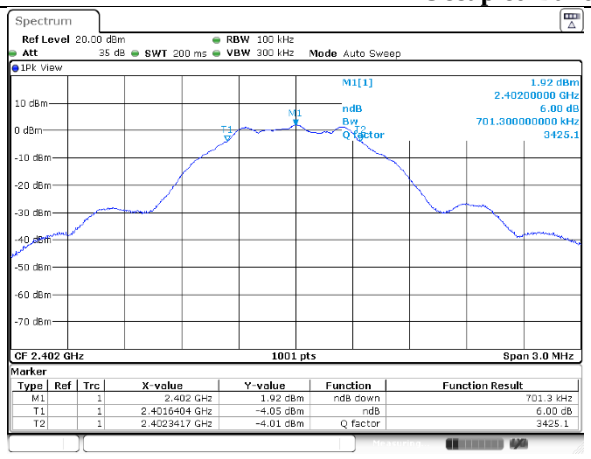
Figure 2. Block Diagram, Occupied Bandwidth Test Setup

Data Rate	Channel	Frequency (MHz)	6dB Bandwidth (MHz)	6dB Bandwidth Limit (MHz)	99% Bandwidth (MHz)	Result
1Mbps	Low	2402	0.5	0.701	1.039	Pass
	Middle	2440	0.5	0.701	1.045	Pass
	High	2480	0.5	0.710	1.048	Pass
2Mbps	Low	2402	0.5	1.163	2.027	Pass
	Middle	2440	0.5	1.178	2.037	Pass
	High	2480	0.5	1.178	2.042	Pass

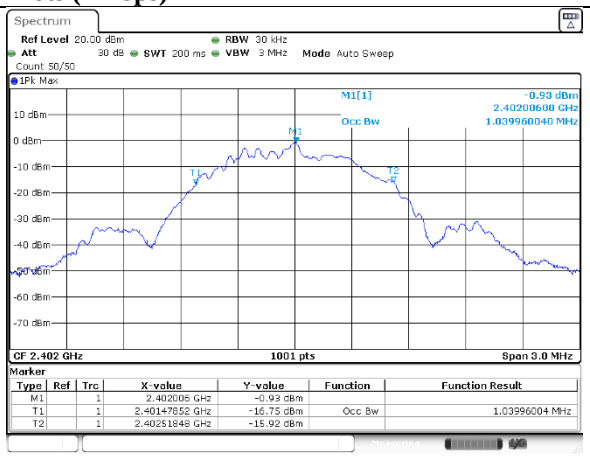
Table 11. 99% and 6 dB Occupied Bandwidth, Test Results

Occupied Bandwidth Test Results

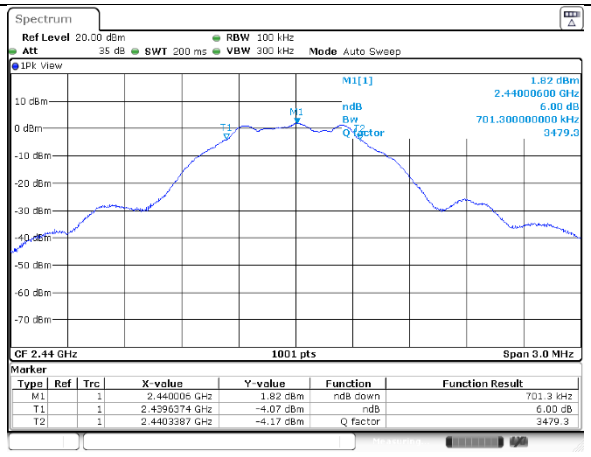
Occupied Bandwidth Plots (1Mbps)



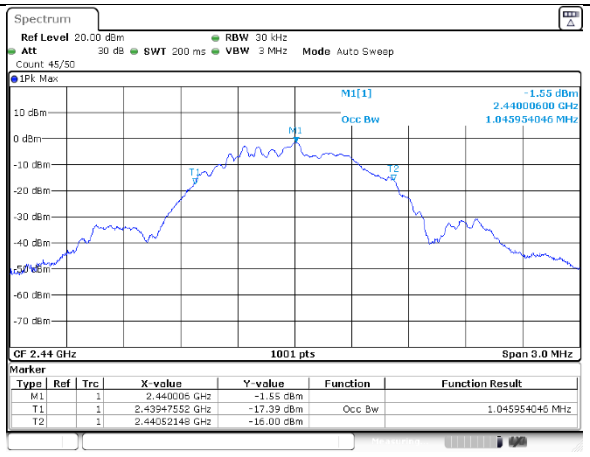
Low Channel 6dB Bandwidth



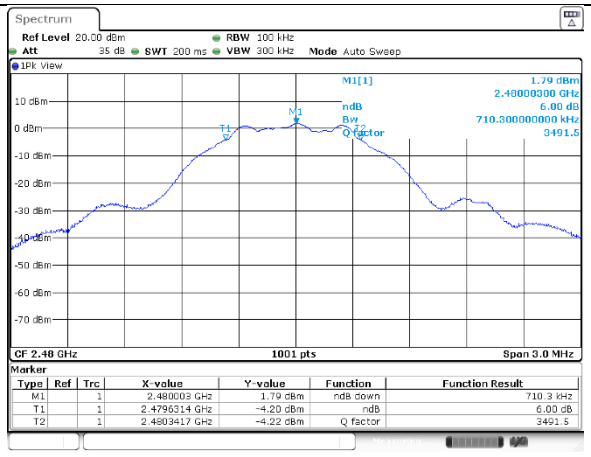
Low Channel 99% Bandwidth



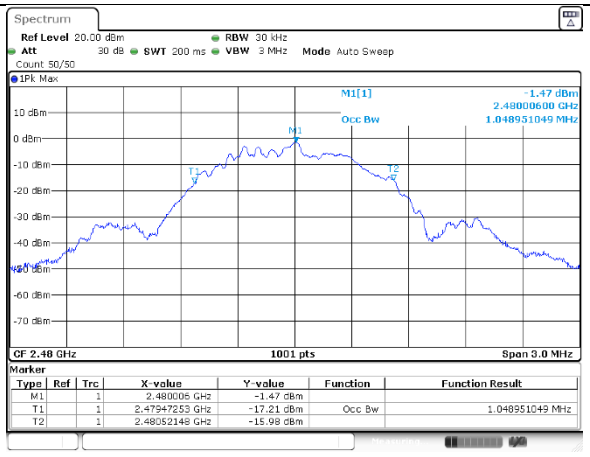
Mid Channel 6dB Bandwidth



Mid Channel 99% Bandwidth

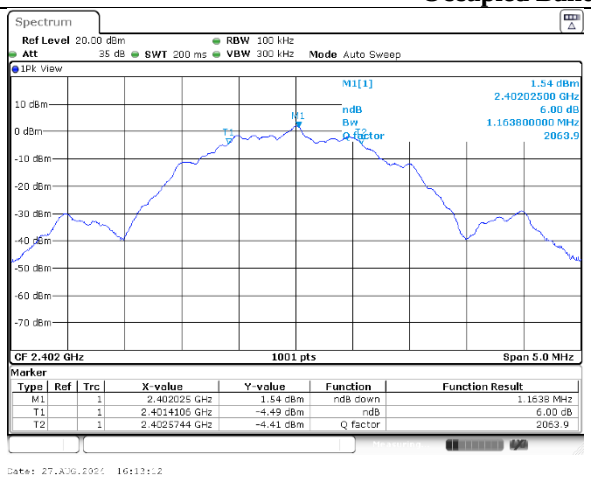


High Channel 6dB Bandwidth

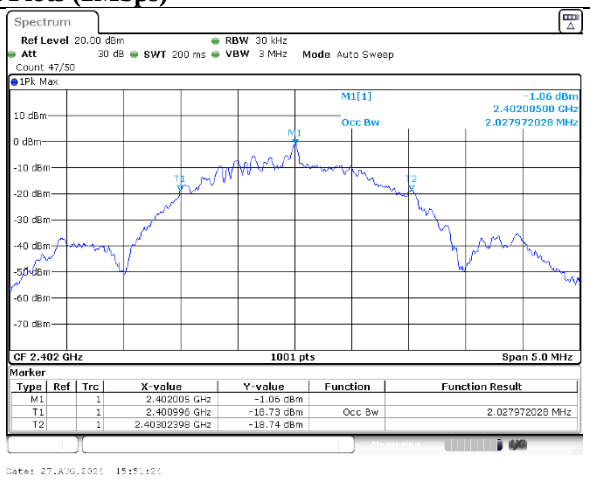


High Channel 99% Bandwidth

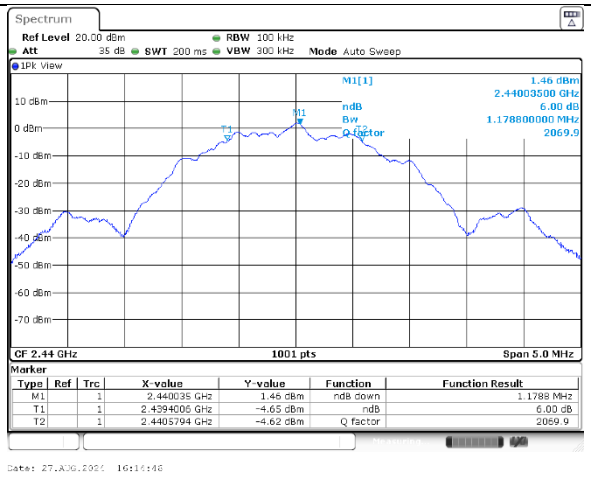
Occupied Bandwidth Plots (2Mbps)



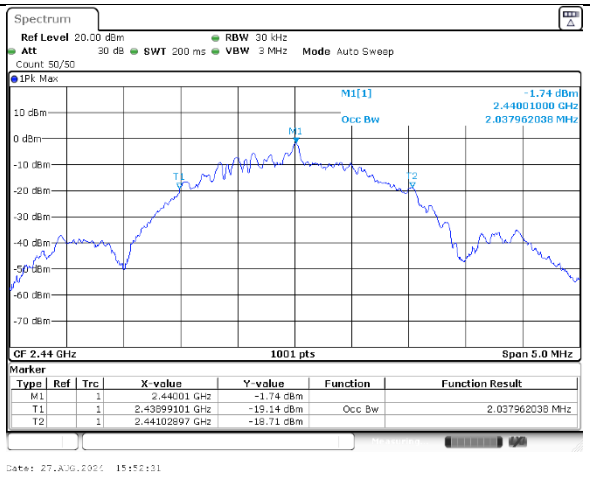
Low Channel 6dB Bandwidth



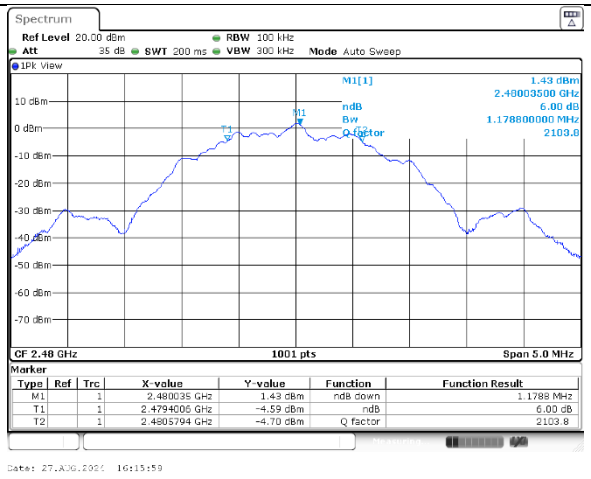
Low Channel 99% Bandwidth



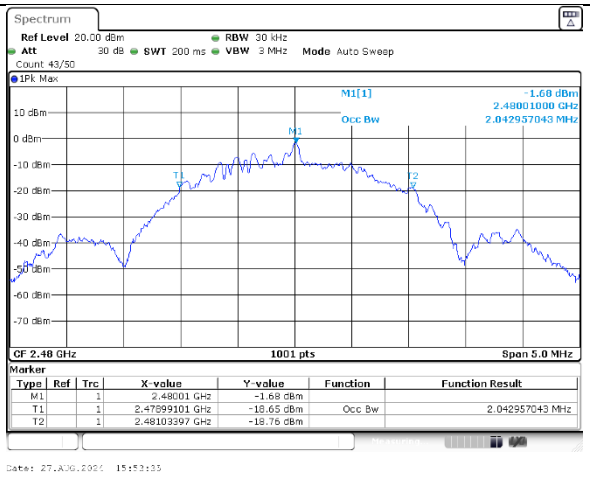
Mid Channel 6dB Bandwidth



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. The antenna gain provided by the manufacturer was added to the measured conducted power to arrive at the EIRP.

The analyzer settings are shown in the following table:

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

Figure 3. Analyzer Settings During Measurement

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

Test Results: The EUT was compliant with the Peak Power Output limits of **§15.247(b)** and the EIRP limits from RSS-247.

Test Engineer(s): Bryan Taylor

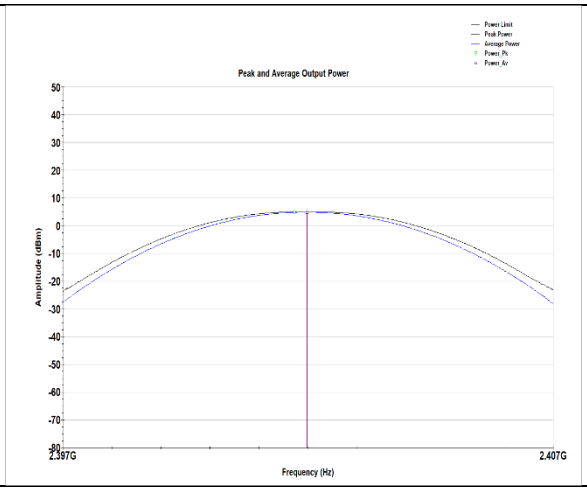
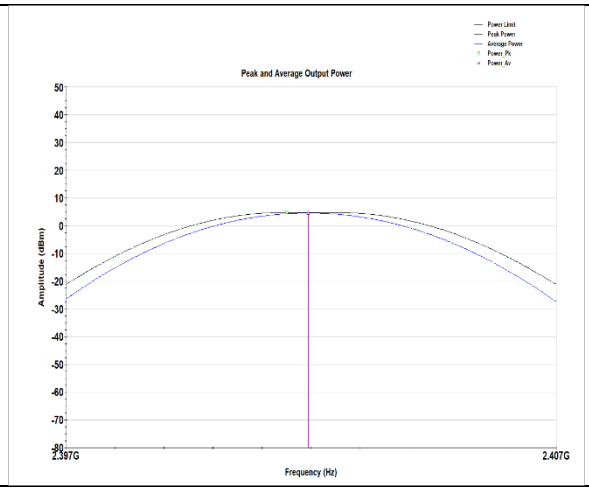
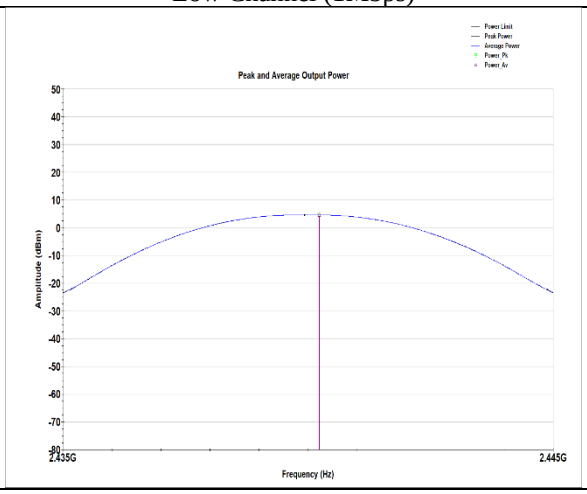
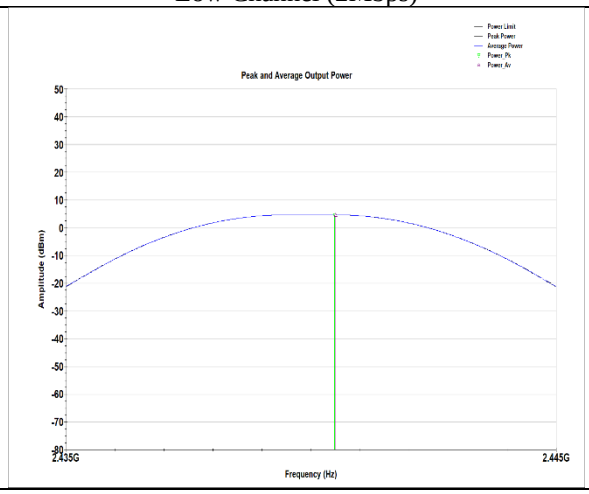
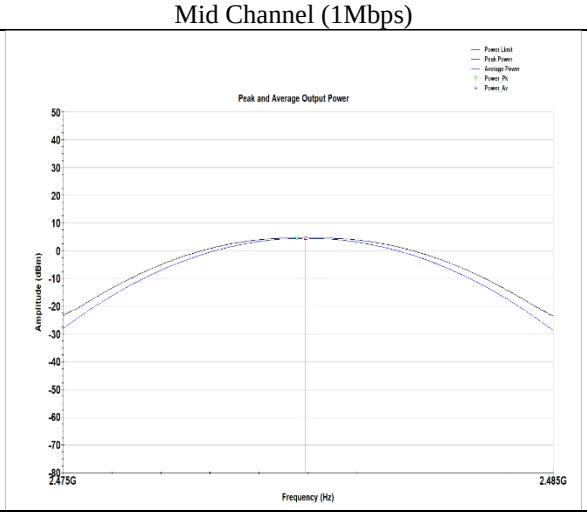
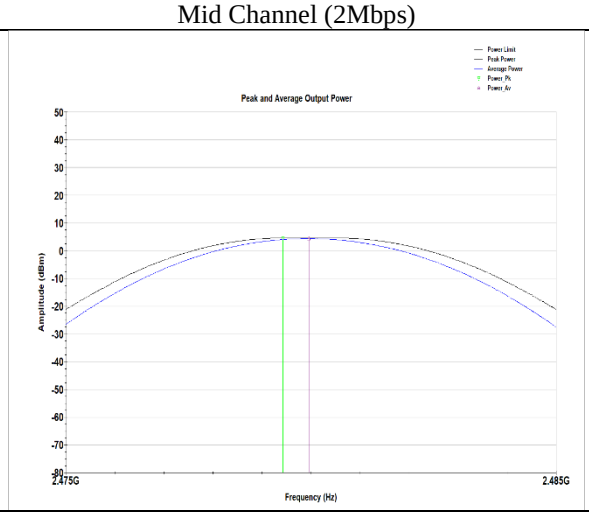
Test Date(s): 8/27/2024

Figure 4. Peak Power Output Test Setup

Peak Power Output Test Results

Data Rate	Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power Limit (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP Limit (dBm)	Result
1Mbps	Low	2402MHz	4.97	30	-1.9	3.07	36	Pass
	Middle	2440MHz	4.57	30	-1.9	2.67	36	Pass
	High	2480MHz	4.61	30	-1.9	2.71	36	Pass
2Mbps	Low	2402MHz	4.81	30	-1.9	2.91	36	Pass
	Middle	2440MHz	4.63	30	-1.9	2.73	36	Pass
	High	2480MHz	4.62	30	-1.9	2.72	36	Pass

Table 13. Peak Power and EIRP, Test Results

Peak Power 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(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 at least 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.

The analyzer settings are shown in the following table:

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

Figure 5. Analyzer Settings During Measurement

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

Test Results: The EUT was compliant with the peak power spectral density limits of **§ 15.247 (e)**.

Test Engineer: Bryan Taylor

Test Date: 8/27/2024

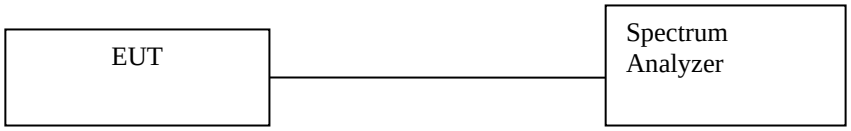
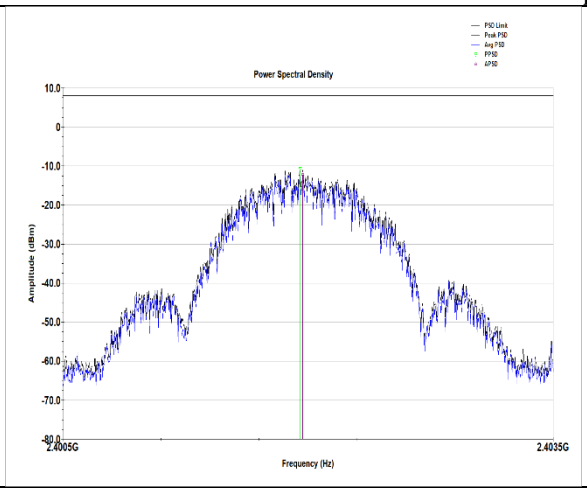
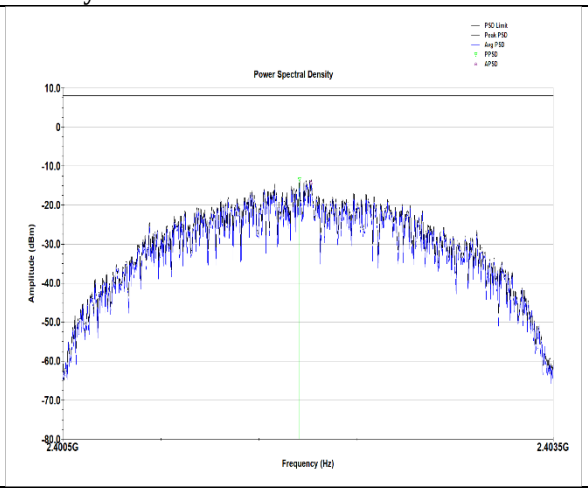
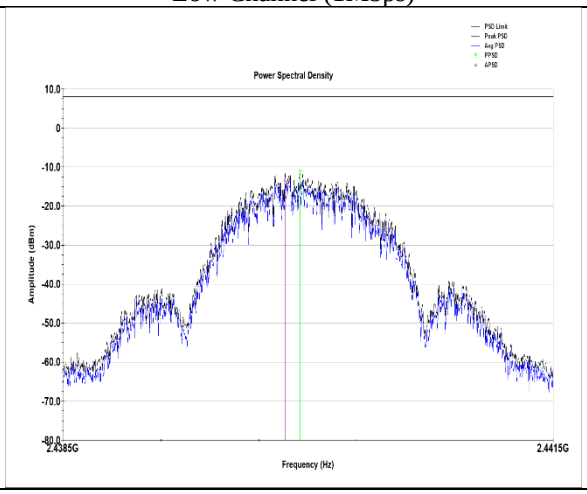
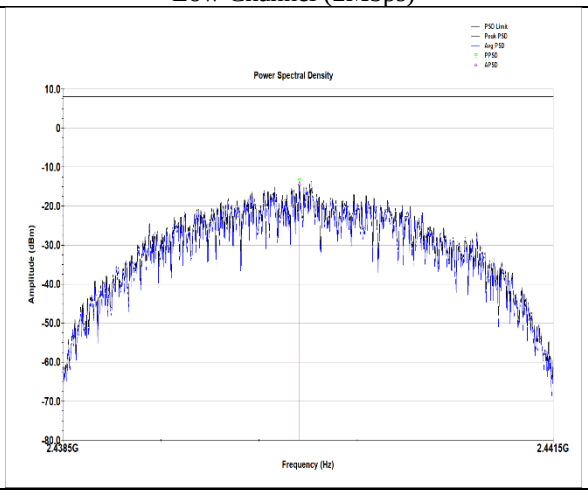
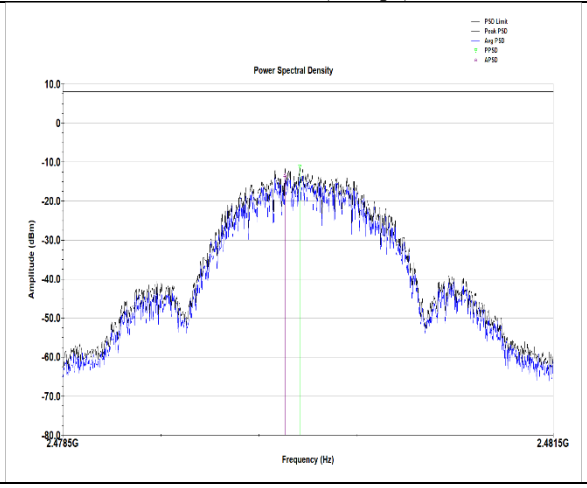
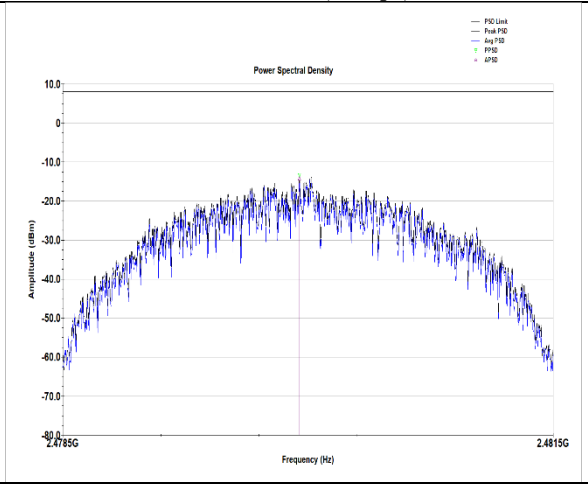


Figure 6. Block Diagram, Peak Power Spectral Density Test Setup

Data Rate	Channel	Frequency (MHz)	Peak Power Spectral Density (dBm / 3kHz)	Peak Power Spectral Density Limit (dBm / 3kHz)	Result
1Mbps	Low	2402MHz	-10.75	8	Pass
	Middle	2440MHz	-11.09	8	Pass
	High	2480MHz	-11.19	8	Pass
2Mbps	Low	2402MHz	-13.41	8	Pass
	Middle	2440MHz	-13.38	8	Pass
	High	2480MHz	-13.35	8	Pass

Table 14. Peak Power Spectral Density, Test Results

Peak Power Spectral Density 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.

The analyzer settings are shown in the following table:

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

Figure 7. Analyzer Settings During Measurement

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

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

Test Engineer(s): Bryan Taylor

Test Date(s): 8/27/2024

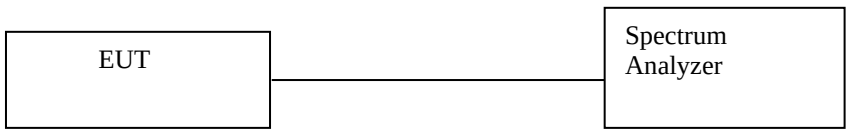


Figure 8. Block Diagram, Conducted Spurious Emissions Test Setup

Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
4804.381	-27.77	-15.44	12.33	Pass
7201.989	-43.95	-15.44	28.51	Pass
39890.0	-41.49	-15.44	26.05	Pass
2396.515	-55.05	-15.44	39.61	Pass
2397.265	-54.71	-15.44	39.27	Pass
2398.585	-52.53	-15.44	37.09	Pass

Figure 9. -20dB Down Spurious Emissions (Low Channel, 1Mbps)

Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
4880.574	-31.55	-17.37	14.18	Pass
7313.911	-41.66	-17.37	24.29	Pass
39,890.0,	-42.49	-17.37	25.12	Pass

Figure 10. -20dB Down Spurious Emissions (Mid Channel, 1Mbps)

Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
4960.23	-36.59	-17.04	19.55	Pass
7433.294	-48.09	-17.04	31.05	Pass
39,880.0	-42.8	-17.04	25.76	Pass
2485.19	-54.36	-17.04	37.32	Pass
2486.19	-55.26	-17.04	38.22	Pass
2488.54	-55.39	-17.04	38.35	Pass

Figure 11. -20dB Down Spurious Emissions (High Channel, 1Mbps)

Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
4804.381	-33.48	-15.86	17.62	Pass
7201.989	-40.3	-15.86	24.44	Pass
39,091.0	-41.81	-15.86	25.95	Pass
2397.43	-52.28	-15.86	36.42	Pass
2398.06	-51.92	-15.86	36.06	Pass
2399.98	-27.45	-15.86	11.59	Pass

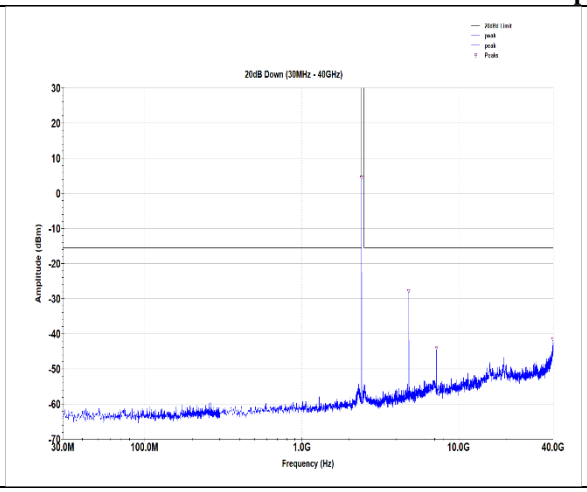
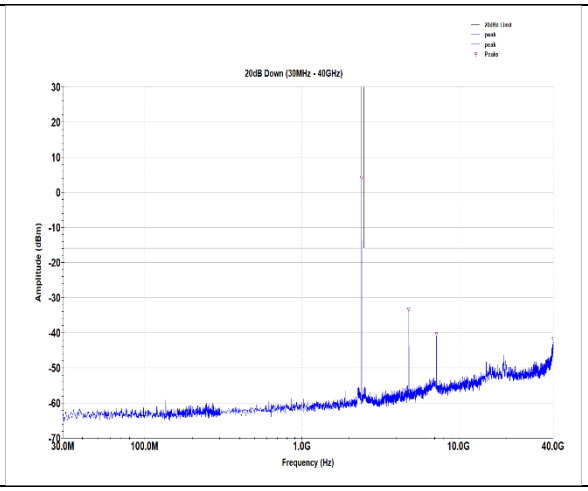
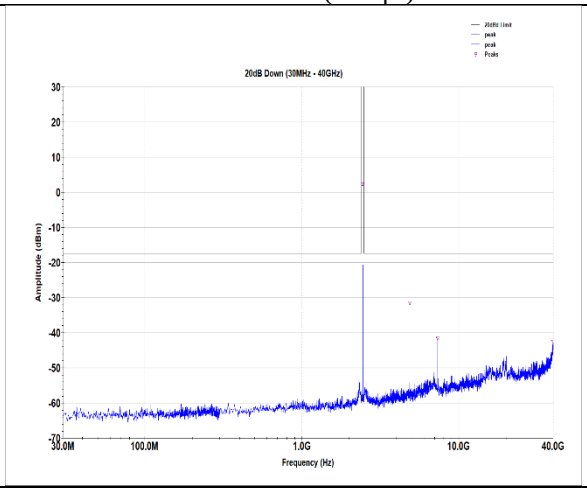
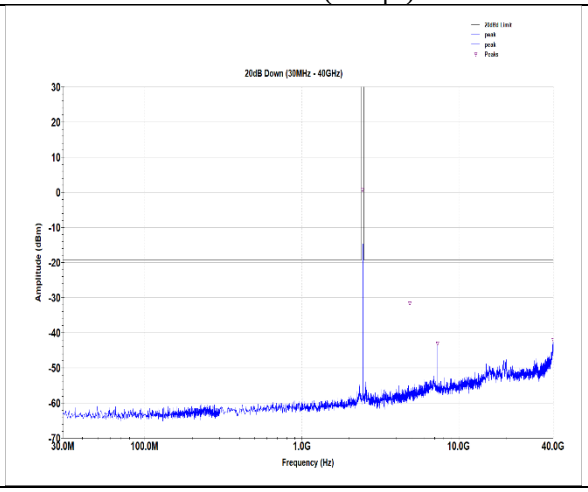
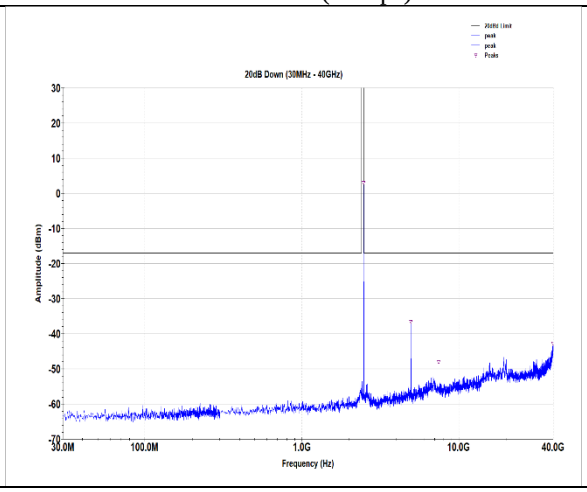
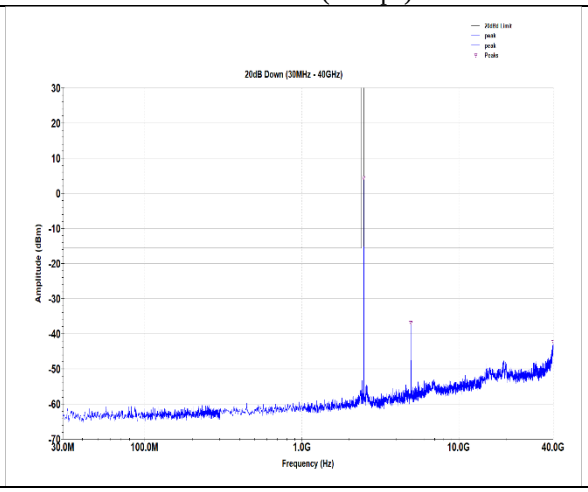
Figure 12. -20dB Down Spurious Emissions (Low Channel, 2Mbps)

Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
4880.574	-31.59	-19.35	12.23	Pass
7313.911	-42.96	-19.35	23.6	Pass
39,920.0	-42.02	-19.35	22.67	Pass

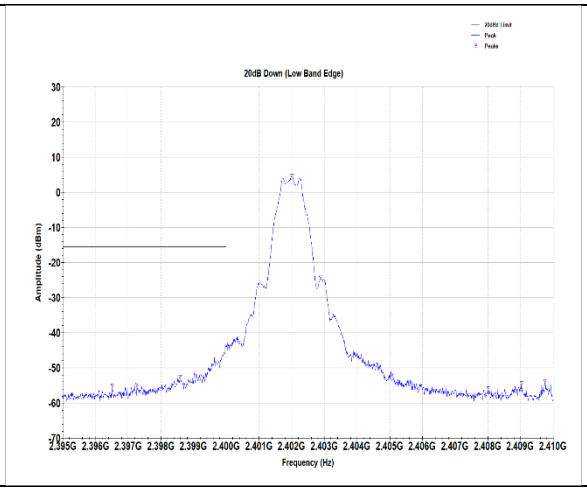
Figure 13. -20dB Down Spurious Emissions (Mid Channel, 2Mbps)

Spurious Frequency (MHz)	Peak Amplitude (dBm)	-20dBd Limit (dBm)	Margin (dB)	Result
4960.23	-36.84	-15.66	21.18	Pass
39,930.0	-42.30	-15.66	26.64	Pass
2484.24	-51.48	-15.66	35.82	Pass
2484.86	-52.53	-15.66	36.87	Pass
2486.29	-53.26	-15.66	37.6	Pass
2487.23	-53.23	-15.66	37.57	Pass
2487.96	-54.01	-15.66	38.35	Pass
2488.57	-55.02	-15.66	39.36	Pass

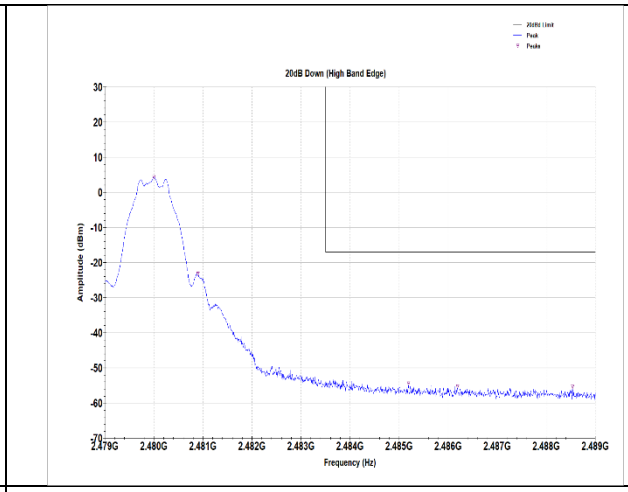
Figure 14. -20dB Down Spurious Emissions (High Channel, 2Mbps)

-20dB Down Spurious Emission Plots	
	
Low Channel (1Mbps)	Low Channel (2Mbps)
	
Mid Channel (1Mbps)	Mid Channel (2Mbps)
	
High Channel (1Mbps)	High Channel (2Mbps)

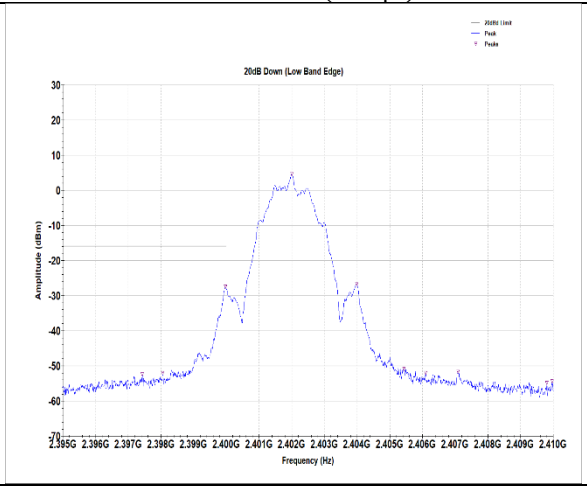
Low and High Band Edge Plots



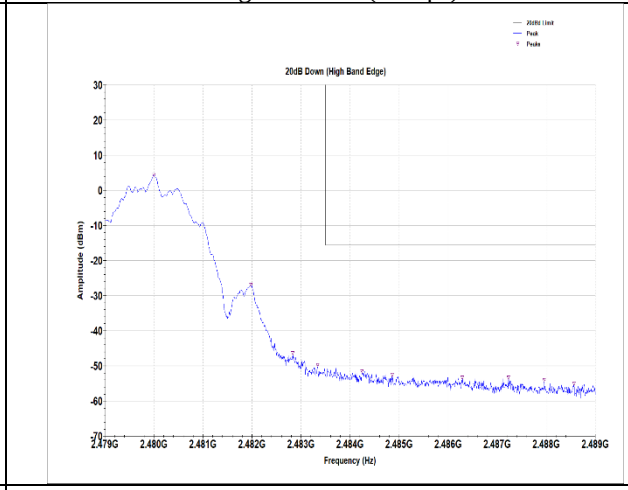
Low Channel (1Mbps)



High Channel (1Mbps)



Low Channel (2Mbps)



High Channel (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 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.

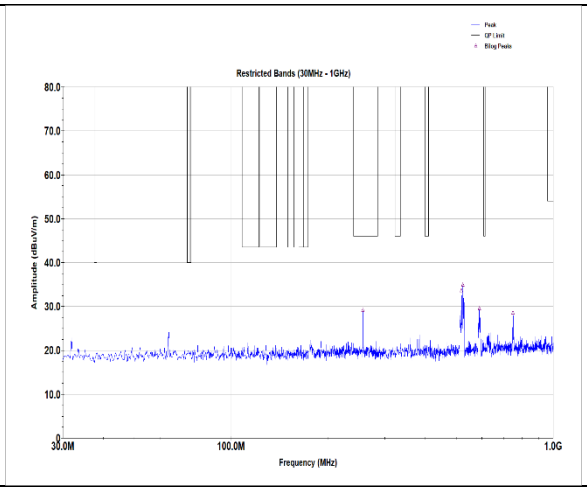
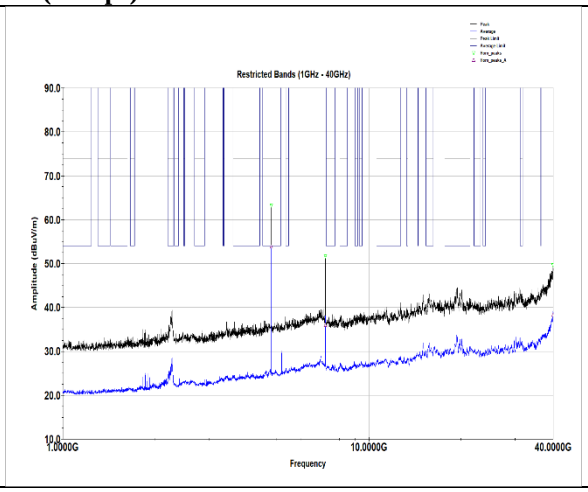
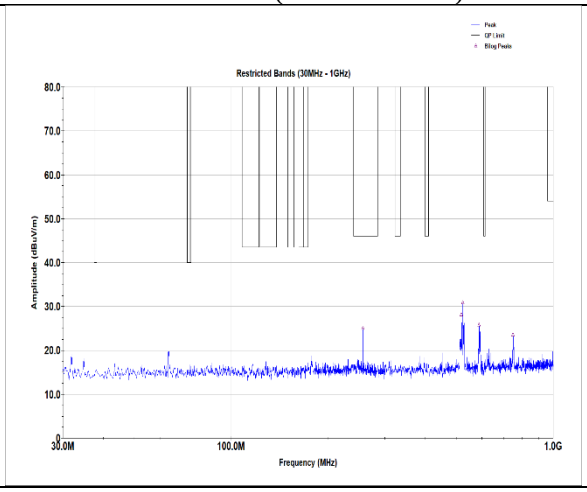
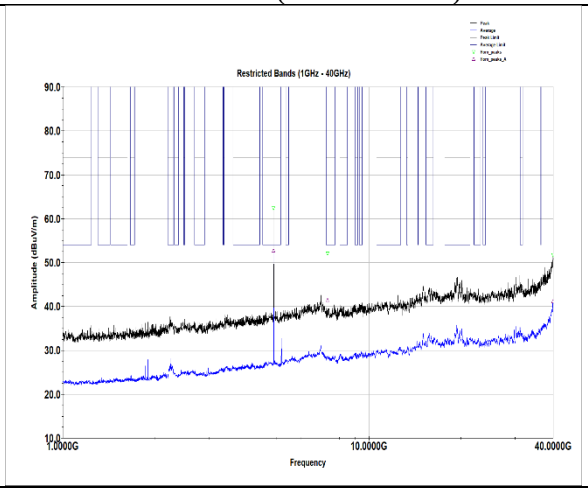
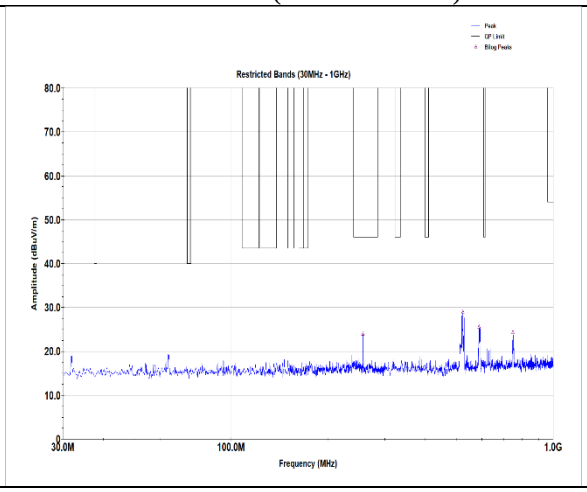
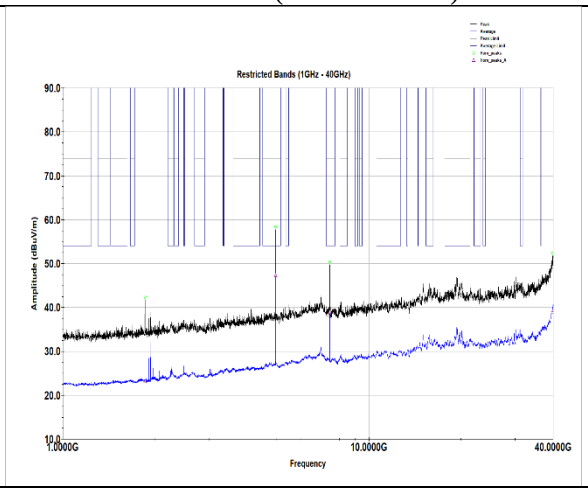
Radiated measurements below 30MHz were performed in a semi-anechoic chamber that has been correlated to an open area site.

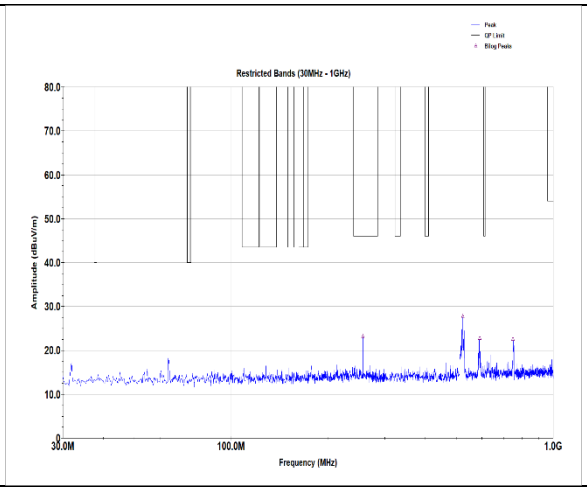
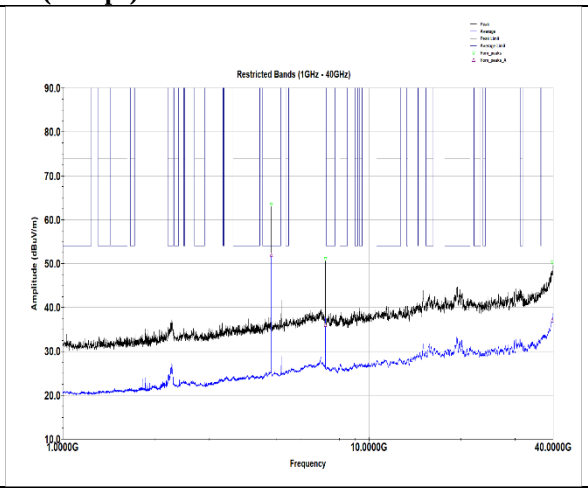
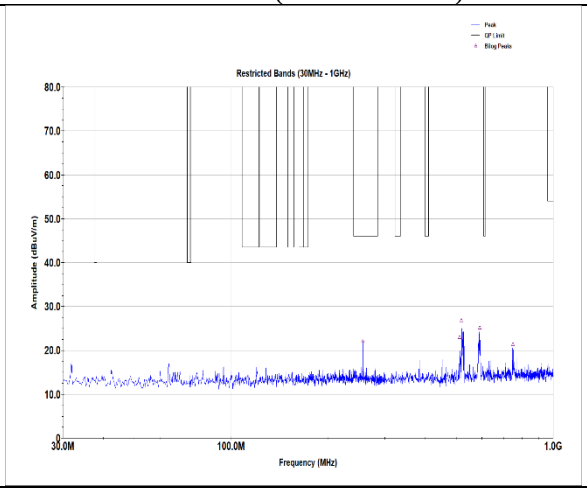
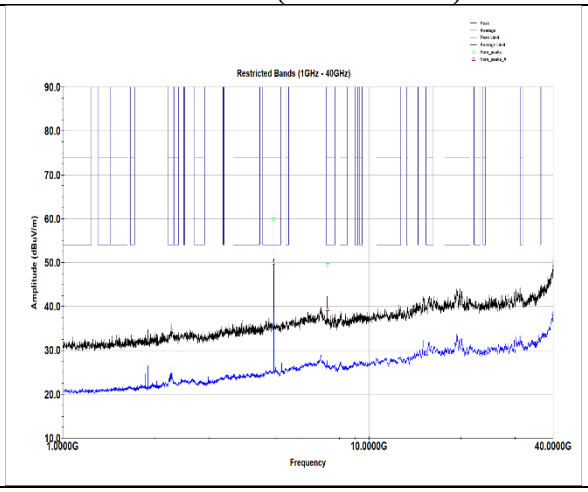
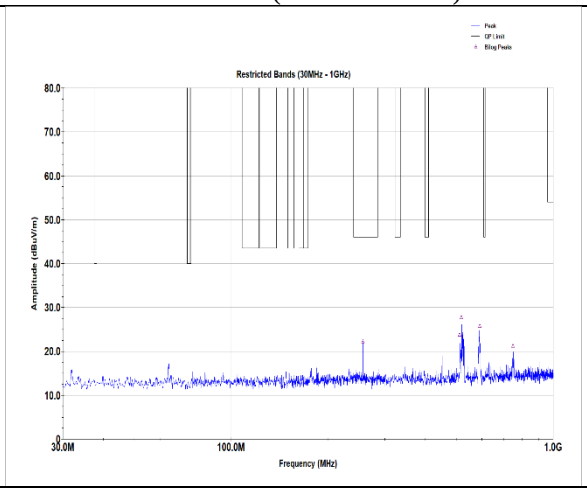
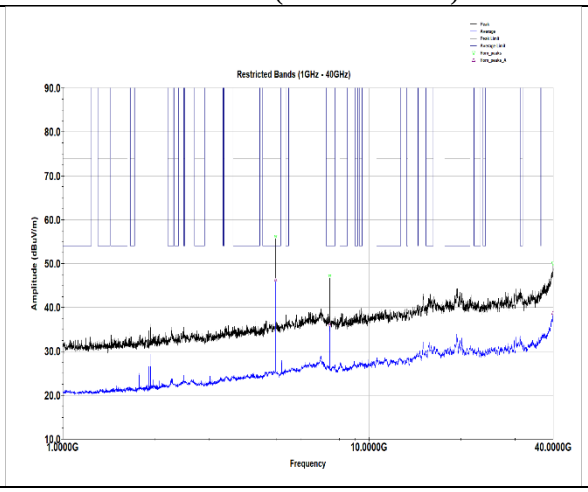
Test Software: TILE Version 7.4.2.5 (Manufactured by ETS Lindgren) and ELEKTRA Version 4.61 (Manufactured by Rohde&Schwarz) was utilized to perform these measurements.

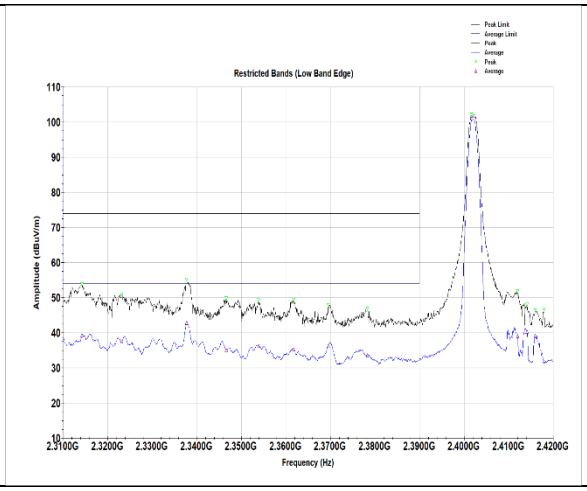
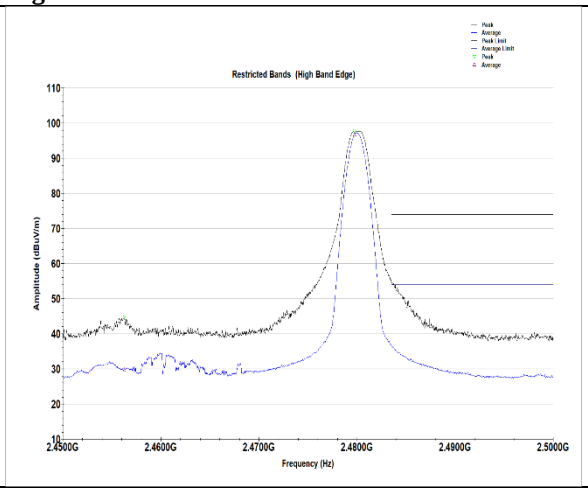
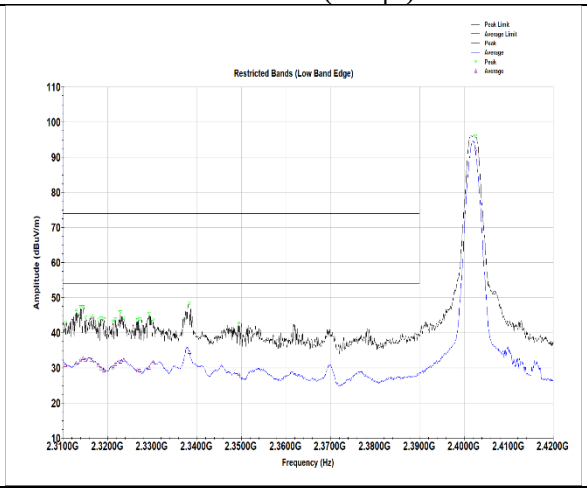
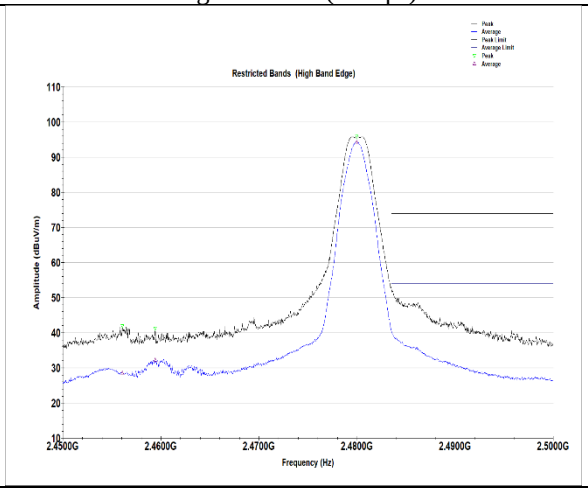
Test Results: The EUT was compliant with the Radiated Spurious Emission limits of **§ 15.247(d)**.

Test Engineer(s): Bryan Taylor, Sergio Gutierrez

Test Date(s): 8/27/2024 – 8/30/2024

Restricted Band Plots (1Mbps)	
	
Low Channel (30MHz – 1GHz)	Low Channel (1GHz – 40GHz)
	
Mid Channel (30MHz – 1GHz)	Mid Channel (1GHz – 40GHz)
	
High Channel (30MHz – 1GHz)	High Channel (1GHz – 40GHz)

Restricted Band Plots (2Mbps)	
	
Low Channel (30MHz – 1GHz)	Low Channel (1GHz – 40GHz)
	
Mid Channel (30MHz – 1GHz)	Mid Channel (1GHz – 40GHz)
	
High Channel (30MHz – 1GHz)	High Channel (1GHz – 40GHz)

Restricted Band Edge Plots	
	
Low Channel (1Mbps)	High Channel (1Mbps)
	
Low Channel (2Mbps)	High Channel (2Mbps)

Frequency (MHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2314.29	53.81	74	20.19	39.19	54	14.81	Pass
2323.2	50.9	74	23.1	37.46	54	16.54	Pass
2337.72	55.17	74	18.83	42.71	54	11.29	Pass
2346.63	49.85	74	24.15	34.99	54	19.01	Pass
2353.89	49.25	74	24.75	36.14	54	17.86	Pass
2361.81	49.41	74	24.59	35.25	54	18.75	Pass
2369.51	47.96	74	26.04	36.19	54	17.81	Pass
2378.31	46.84	74	27.16	33.54	54	20.46	Pass
4802.00	63.22	74	10.78	53.83	54	0.17	Pass

Figure 15. Restricted Band Edge Spurious Emissions (Low Channel, 1Mbps)

Frequency (MHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2310.55	43.05	74	30.95	30.88	54	23.12	Pass
2312.97	46.34	74	27.66	31.35	54	22.65	Pass
2313.96	47.36	74	26.64	32.23	54	21.77	Pass
2314.51	47.37	74	26.63	32.69	54	21.31	Pass
2315.06	44.49	74	29.51	32.37	54	21.63	Pass
2316.49	44.76	74	29.24	32.31	54	21.69	Pass
2318.03	43.55	74	30.45	30.67	54	23.33	Pass
2318.58	44.12	74	29.88	29.8	54	24.2	Pass
2319.24	44.03	74	29.97	29.26	54	24.74	Pass
2321.22	43.3	74	30.7	30.14	54	23.86	Pass
2321.77	43.92	74	30.08	30.91	54	23.09	Pass
2322.87	45.9	74	28.1	31.71	54	22.29	Pass
2323.64	44.26	74	29.74	32.18	54	21.82	Pass
2326.72	43.68	74	30.32	29.5	54	24.5	Pass
2327.27	44.02	74	29.98	29.38	54	24.62	Pass
2329.36	45.31	74	28.69	30.03	54	23.97	Pass
2330.24	43.62	74	30.38	31.62	54	22.38	Pass
2338.38	48.49	74	25.51	34.58	54	19.42	Pass
2349.49	42.65	74	31.35	28.17	54	25.83	Pass
4802.00	63.46	74	10.54	51.94	54	2.06	Pass

Figure 16. Restricted Band Edge Spurious Emissions (Low Channel, 2Mbps)

Frequency (MHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
4877.00	62.33	74	11.67	52.71	54	1.29	Pass
7321.00	52.05	74	21.95	41.48	54	12.52	Pass

Figure 17. Restricted Band Edge Spurious Emissions (Mid Channel, 1Mbps)

Frequency (MHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
4877.00	59.88	74	14.12	50.00	54	4.00	Pass
7321.00	49.47	74	24.53	39.39	54	14.61	Pass

Figure 18. Restricted Band Edge Spurious Emissions (Mid Channel, 2Mbps)

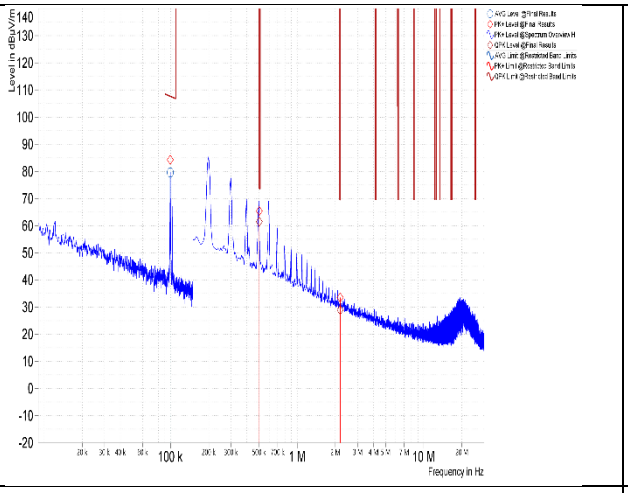
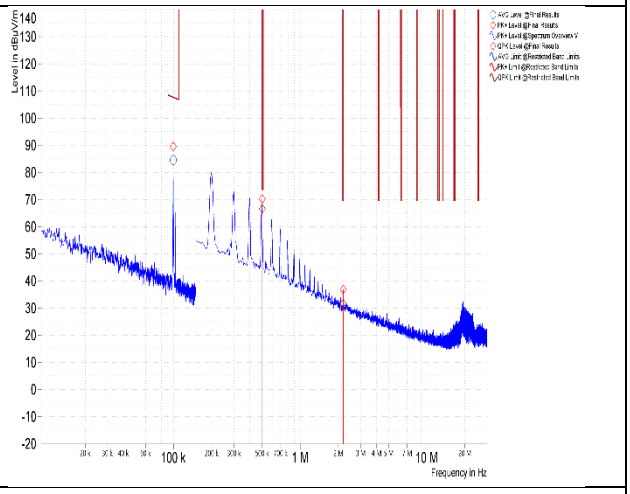
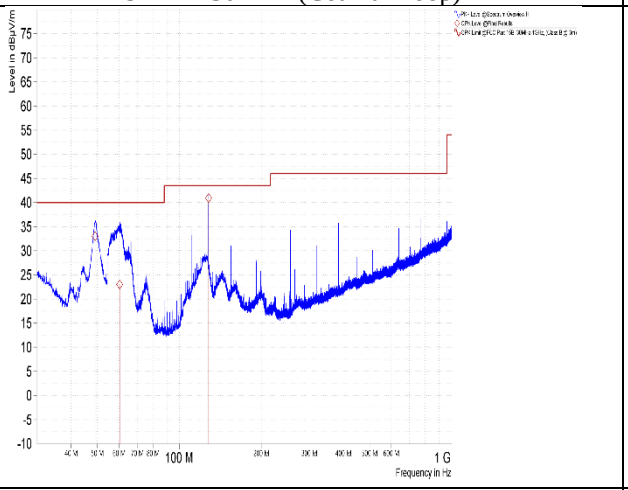
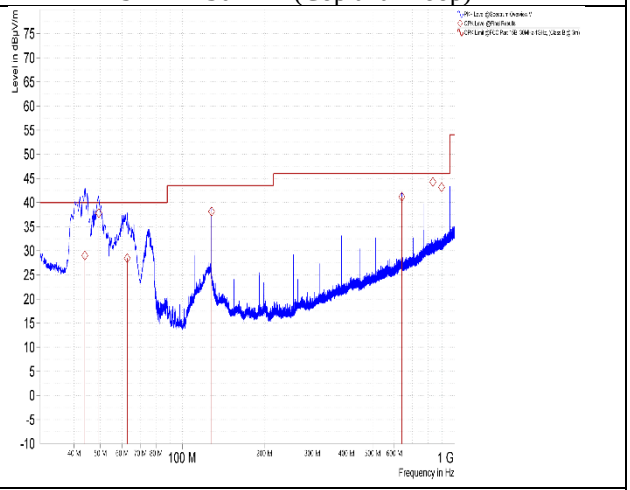
Frequency (MHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2483.50	54.65	74	19.35	37.09	54	16.91	Pass
2484.10	53.34	74	20.66	35.12	54	18.88	Pass
4958.00	58.18	74	15.82	47.34	54	6.66	Pass
7439.00	50.21	74	23.79	38.92	54	15.08	Pass

Figure 19. Restricted Band Edge Spurious Emissions (High Channel, 1Mbps)

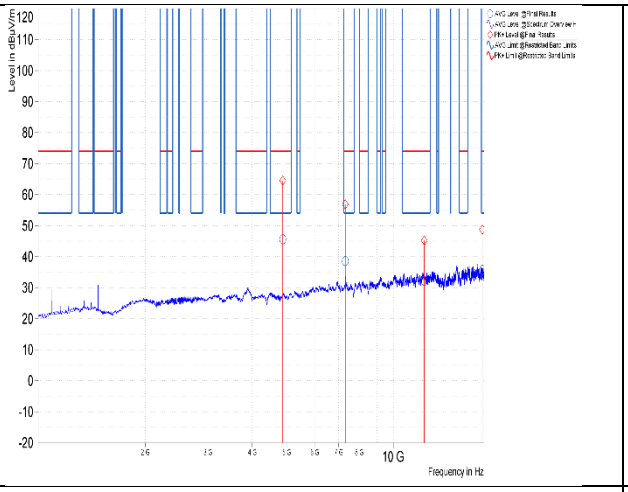
Frequency (MHz)	Peak Reading (dBuV/m)	Peak Limit (dBuV/m)	Peak Margin (dB)	Avg Reading (dBuV/m)	Avg Limit (dBuV/m)	Avg Margin (dBuV/m)	Result
2483.50	52.41	74	21.59	39.51	54	14.49	Pass
2486.20	48.51	74	25.49	35.87	54	18.13	Pass
4958.00	56.19	74	17.81	46.31	54	7.69	Pass
7439.00	47.19	74	26.81	36.13	54	17.87	Pass

Figure 20. Restricted Band Edge Spurious Emissions (High Channel, 2Mbps)

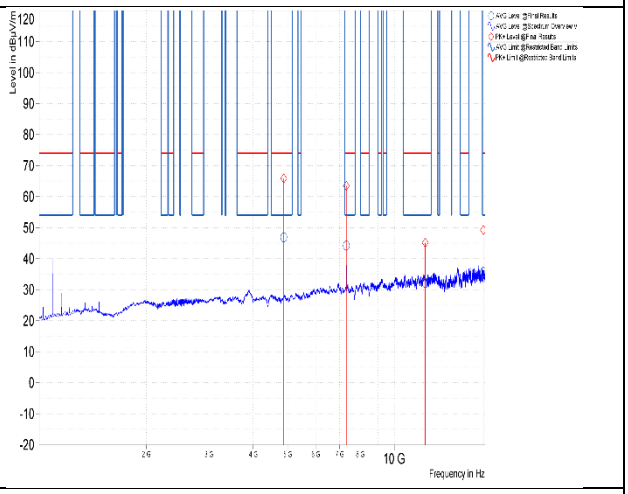
Worst Case Cabinet Spurious Emissions

Worst Case Cabinet Radiation Plots	
	
9kHz – 30MHz (Coaxial Loop)	9kHz – 30MHz (Coplanar Loop)
	
30MHz – 1GHz (Vertical Polarity)	30MHz – 1GHz (Horizontal Polarity)

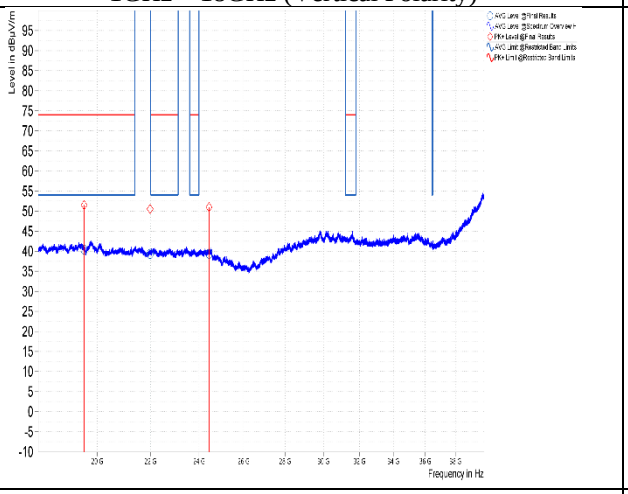
Worst Case Cabinet Radiation Plots



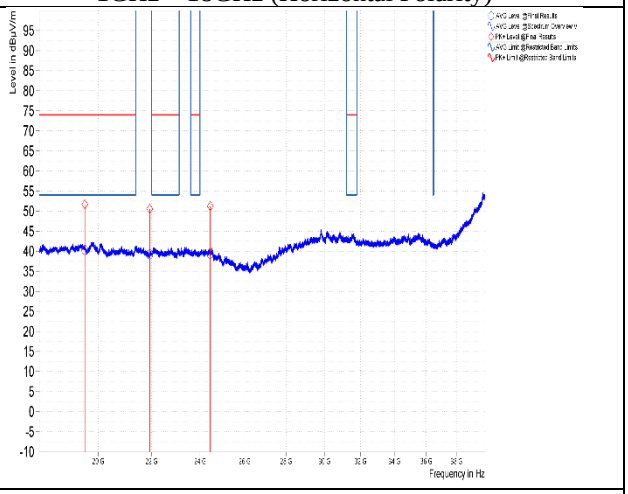
1GHz – 18GHz (Vertical Polarity)



1GHz – 18GHz (Horizontal Polarity)



18GHz – 40GHz (Vertical Polarity)



18GHz – 40GHz (Horizontal Polarity)

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
0.099	84.30	107.68	23.37	11.31	H	262	1	0.200	Pass
0.099	89.55	107.68	18.12	11.31	V	297.4	1	0.200	Pass
0.501	65.35	73.69	8.34	11.27	H	264.4	1	9.000	Pass
0.501	70.22	73.69	3.47	11.27	V	310.8	1	9.000	Pass
2.184	33.50	69.54	36.04	11.69	H	268	1	9.000	Pass
2.184	36.86	69.54	32.68	11.69	V	279.1	1	9.000	Pass
0.099	84.30	107.68	23.37	11.31	H	262	1	0.200	Pass

Figure 21. 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
43.830	28.99	40.00	11.01	-10.74	V	180.8	1.47	120.000	Pass
49.020	33.00	40.00	7.00	-12.85	H	208.4	2.68	120.000	Pass
49.320	37.80	40.00	2.20	-12.81	V	83.6	1.1	120.000	Pass
60.390	22.99	40.00	17.01	-13.46	H	255.4	2.85	120.000	Pass
62.730	28.44	40.00	11.56	-13.10	V	293.8	1.22	120.000	Pass
127.980	40.93	43.50	2.57	-6.34	H	287.4	2.42	120.000	Pass
128.010	38.14	43.50	5.36	-6.75	V	37.2	0.99	120.000	Pass
639.990	41.16	46.00	4.84	2.58	V	179	0.99	120.000	Pass
831.990	44.26	46.00	1.74	5.43	V	16.7	1.06	120.000	Pass
896.010	43.17	46.00	2.83	6.61	V	6	0.99	120.000	Pass

Figure 22. 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
4,880.000	65.37	74.00	8.63	41.11	54.00	12.89	-3.35	H	96	2.98	Pass
4,880.000	62.38	74.00	11.62	38.79	54.00	15.21	-3.35	V	277.7	1.19	Pass
7,318.500	58.56	74.00	15.44	35.08	54.00	18.92	-2.80	H	0.1	2.77	Pass
7,320.000	64.19	74.00	9.81	39.47	54.00	14.53	-2.79	V	332	1.49	Pass
12,219.000	45.23	74.00	28.77	32.28	54.00	21.72	-1.95	V	300.9	2.84	Pass
12,222.000	45.23	74.00	28.77	32.41	54.00	21.59	-1.96	H	187.2	1.02	Pass
19,526.938	51.67	74.00	22.33	40.30	54.00	13.70	12.34	V	319.6	1.48	Pass
19,534.500	51.50	74.00	22.50	40.41	54.00	13.59	12.32	H	178.8	4	Pass

Figure 23. Worst Case Cabinet Radiation, Above 1GHz

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
1A1065	Receiver	Rohde & Schwarz	ESCI	08/20/2024	08/20/2025
1A1250	Receiver	Rohde & Schwarz	ESW44	04/08/2024	04/08/2025
1A1234	Signal Analyzer	Rohde & Schwarz	FSV40	01/23/2023	01/23/2025
1A1176	Active Loop Antenna (9KHz-30MHz)	ETS-Lindgren	6502	8/22/2024	8/22/2026
1A1147	Bi-Log Antenna	Suno Sciences Corp	JB3	04/06/2023	04/06/2025
1A1047	Horn Antenna (1GHz – 18GHz)	ETS - Lindgren	3117	06/26/2024	06/26/2025
1A1161	Horn Antenna (18GHz – 40GHz)	ETS Lindgren	3116C	08/01/2024	08/01/2026
1A1177	Pulse Limiter	Rohde & Schwarz	ESH3Z2	12/14/2023	12/14/2024
1A1122	LISN	TESEQ	NNB 51	09/21/2023	09/21/2024
1A1149	DC Milliohm Meter	GW Instek	GOM-802	09/20/2023	09/20/2024
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