Testing Tomorrow's Technology

Application
For

Part 2, Subpart J, Paragraph 2.907 Equipment Authorization of Certification for an Intentional Radiator per Part 15, Subpart C, paragraphs 15.207, 15.209 and 15.247

And

Innovation, Science, and Economic Development Canada
Certification Per
RSS-Gen General Requirements for Radio Apparatus (Issue 5) March 2019+A1
And
RSS-247 Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSS) and License-Exempt Local Area Network (LE-LAN) Devices (Issue 3) Aug 2023

For the

Centero LLC

Model Number: CW-24-200

FCC ID: 2ANDP-CW24-200
IC: 23069-CW24200

UST Project: 24-0098
Issue Date: September 24, 2024

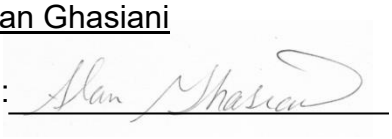
Total Pages: 57

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

I certify that I am authorized to sign for the Test Agency and the statements in this report and in the exhibits attached are true and correct to the best of my knowledge and belief:

US TECH (Agent Responsible For Test):

By: Alan Ghasiani

Name: 

Title: Compliance Engineer – President

Date: September 24, 2024

NVLAP LAB CODE 200162-0

3505 Francis Circle Alpharetta, GA 30004
PH: 770-740-0717 Fax: 770-740-1508
www.ustech-lab.com

MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Centero LLC
ADDRESS: 1775 The Exchange Southeast Suite 180, Atlanta GA 30339
MODEL: CW-24-200
FCC ID: 2ANDP-CW24-200
IC: 23069-CW24200
DATE: September 24, 2024

This report concerns (check one): ☒Original grant □Class II change

Equipment type: 2.4 GHz IEEE 802.15.4 (ZigBee) Transceiver module

Technical:
2405.0 – 2475.0 MHz operating band
Type of modulation: O-QPSK
Data/Bit Rate: 250 kpbs
Software used to program EUT: Hardware Test Firmware
EUT firmware number: version: 200
Antenna Gain: 8.0 dBi (max gain)
Maximum Output Power: +18 dBm & +16 dBm depending antenna gain
Power setting: "20" & "16"

Report prepared by:	Test facility	Test facility
US Tech 3505 Francis Circle Alpharetta, GA 30004 USA	FCC Lab Designation #: US5301	CANADA Lab code: 9900A-1 CAB ID: US0031

Table of Contents

List of Figures

Figures **Title** **Page**

List of Tables

Table **Title** **Page**

List of Attachments

FCC Agency Agreement
IC Agency Agreement
FCC Application Forms
IC Application Forms
Letter of Confidentiality
Equipment Label(s)
Block Diagram(s)
Schematic(s)
Test Configuration Photographs
External Photographs
Internal Photographs
Theory of Operation
RF Exposure
User's Manual
IC Cross Reference
FCC Modular Approval Letter
IC Modular Approval Letter

1 General Information

1.1 Purpose of this Report

This report is prepared to convey test results and information concerning the suitability of this exact product for public distribution according to ISED RSS-Gen (I5) and RSS-247 (I3) and FCC Rules and Regulations Part 15 Subpart C, Part 15.247.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on July 15, 2024 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Centero LLC model CW-24-200. The EUT is a WISA2/WIHART2 wireless module and is an OEM component that will be integrated in customer's products. It exposes an API via a serial interface to allow external processors to interact with the communication stack running on the WISA2/WIHART2 wireless module.

1.4 Configuration of Tested System

The Test Sample was tested per *ANSI C63.10:2013, American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices* for the intentional radiator aspect of the device and *ANSI C63.4:2014, Methods of Measurement of Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz (2014)* for the unintentional radiator aspect of the device as well as FCC subpart B and C of Part 15 and per FCC KDB Publication number 558074 v03r05 for Digital Transmission Systems Operating Under section 15.247.

Digital RF conducted and radiated emissions data below 1 GHz were taken with the measuring receiver (or spectrum analyzer's) resolution bandwidth adjusted to 9 kHz and 120 kHz, respectively. All measurements performed above 1.0 GHz were made with a RBW of 1 MHz. All measurements are peak unless stated otherwise. The video filter associated with the spectrum analyzer was set to 3 times the RBW or as required per the standard throughout the evaluation process.

The EUT and Peripherals are found in Table 1. A block diagram of the tested system is shown in Figure 1. Test configuration photographs for spurious and fundamental emissions are provided in separate appendices.

1.5 Test Facility

Testing was performed at US Tech's measurement facility at 3505 Francis Circle, Alpharetta, GA 30004. This site has been fully described and registered with the FCC. Its designation number is US5301. Additionally, this site has been fully described and submitted to Industry Canada (IC) and has been approved under file number 9900A-1 and CAB ID: US0031.

1.6 Related Submittal(s)/Grant(s)

The EUT is subject to the following FCC Equipment Authorizations:

a) Certification of the transmitter incorporated within the EUT, see test data presented herein.

Table 1. EUT and Peripherals

PERIPHERAL MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	FCC/IC ID	CABLES P/D
EUT/ Centero LLC	CW-24-200	Engineering Sample	FCC ID: 2ANDP-CW24-200 (Pending) IC: 23069-CW24200 (Pending)	PU
Antenna See antenna details	--	--	--	--

S = Shielded, U = Unshielded, P = Power, D = Data

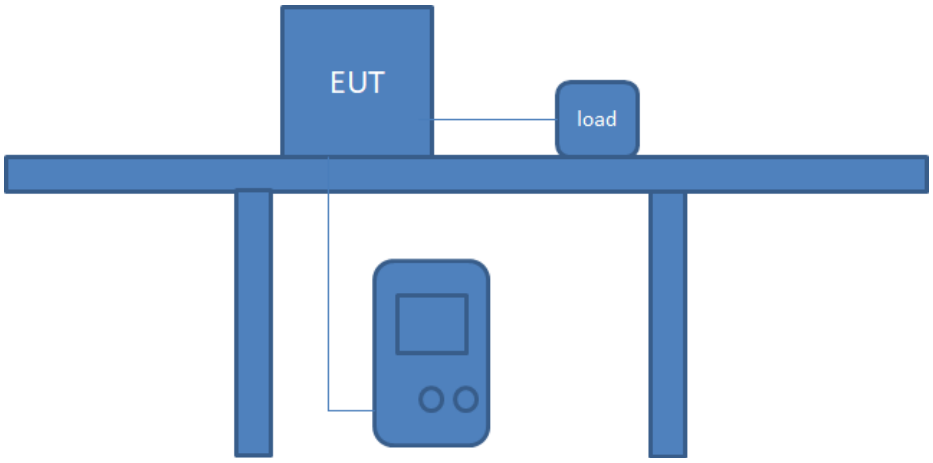


Figure 1. Block Diagram of Test Configuration

Note: PC used to program EUT for intentional spurious emissions. Bench top power supply used to power the EUT.

2 Tests and Measurements

2.1 Test Equipment

The table below lists test equipment used to evaluate this product. Model numbers, serial numbers, and their calibration status are included below.

Table 2. Test Instruments

TEST INSTRUMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DUE DATE
Spectrum Analyzer	Agilent	E4440A	MY45304803	7/21/2025 2 yr.
Spectrum Analyzer	RIGOL	DSA815	DSA8A180300138	2/22/2026 2 yr.
RF Preamp 100 kHz To 1.3 GHz	Hewlett-Packard	8447D	1937A01611	6/17/2025
Preamp 1.0 GHz To 26.0 GHz	Hewlett-Packard	8449B	3008A00480	3/04/2025
Loop Antenna	ETS Lindgren	6502	9810-3246	12/07/2024 2 yr.
Biconical Antenna	EMCO	3110B	9306-1708	01/13/2025 2yr.
Log Periodic Antenna	EMCO	3146	9110-3236	3/13/2026 2 yr.
Horn Antenna	EMCO	3115	9107-3723	3/13/2025 2 yr.
High Pass Filter (2.4 GHz)	Microwave Circuits	H3R020G2	001DC9528	7/02/2025
RF Cable	Bracke MFG	RG188A	None	11/28/2024
RF Cable	Time Microwave Systems	LMR400	19424	3/04/2025
RF Cable	US Tech	RG214 N/N	None	3/05/2025
LISN X 2	Solar Electronics	9247-50-TS-50-N	955824 and 955825	4/28/2025

Note 1: The calibration interval of the above test instruments are 12 months unless stated otherwise and all calibrations are traceable to NIST/USA.

2.2 Modifications to EUT Hardware

No modifications were made by US Tech to bring the EUT into compliance with FCC Part 15.247 or RSS-210 requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m), RSS-Gen 6.9)

Measurements of intentional radiators or receivers shall be performed and reported for each band in which the device can be operated, with the device operating at the number of frequencies in each band specified in Table 3.

Table 3. Number of Test Frequencies for Intentional Radiators

Frequency Range Over Which the Device Operates	Number of Frequencies	Location in the Range of Operation
1 MHz or less	1	Middle
1 to 10 MHz	2	1 near the top 1 near the bottom
Greater than 10 MHz	3	1 near top 1 near middle 1 near bottom

If the frequency range over which the EUT operates is greater than 10 MHz, 3 test frequencies will be used.

2.4 Frequency Range of Unwanted Emissions Measurements (Part 15.33, RSS-Gen 6.13.2)

2.4.1 Intentional Radiator

The spectrum shall be investigated for the intentional radiator from the lowest RF signal generated in the EUT, without going below 9 kHz to the 10^{th} harmonic of the highest fundamental frequency generated or 40 GHz, whichever is the lowest.

2.4.2 Unintentional Radiator

For the digital device, an unintentional radiator, the frequency range shall be 30 MHz to 1000 MHz, or to the range specified in 2.4.1 above, whichever is the higher range of investigation.

2.5 Measurement Detector Function and Bandwidth (CFR 15.35, RSS-Gen 6.10)

The radiated and conducted emissions limits shown are based on the following:

2.5.1 Detector Function and Associated Bandwidth

On frequencies below 1000 MHz, the limits herein are based upon measurement equipment employing a CISPR Quasi-peak detector function and related measurement bandwidths (i.e. 9 kHz from 150 kHz to 30 MHz and 120 kHz from 30 MHz to 1000 MHz). Alternatively, measurements may be made with equipment employing a peak detector function as long as the same bandwidths specified for the Quasi-peak device are used.

2.5.2 Corresponding Peak and Average Requirements

Above 1000 MHz, radiated limits are based on measuring instrumentation employing an average detector function. When average radiated emissions are specified, there is also a corresponding peak requirement, as measured using a peak detector, of 20 dB greater than the average limit. For all measurements above 1000 MHz the Resolution Bandwidth shall be at least 1 MHz.

2.6 Transmitter Duty Cycle (Part15.35 (c), RSS-Gen 6.10)

The EUT employs pulse transmission. However, for testing purposes the EUT was programmed to transmit at a rate >98%. The pulse transmission requirements of this subpart were acknowledged and considered during testing.

When the radiated emissions limit is expressed as an average value, and the transmitter is pulsed, the measured field strength shall be determined by applying a Duty Cycle Correction Factor based upon dividing the total ON time during the first 100 ms period by 100 ms (or by the period if less than 100 ms). The duty cycle may also be expressed logarithmically in dB.

The Manufacturer has declared a Duty Cycle of 41% intended for normal operation: therefore where applicable (when using AVG detection) the duty cycle factor, -7.74 dBm was applied. See the Theory of Operation for details.

DC factor = 20 * Log (41%) = -7.74 dB

2.7 EUT Antenna Requirements (CFR 15.203, RSS-Gen 6.8)

An intentional radiator is 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 is considered sufficient to comply with the provisions of this section. Only the antenna(s) listed in Table 4 will be used with this module.

Table 4. Allowed Antenna(s)

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	TYPE OF CONNECTOR
Antenna 1	Nearson	Dipole	S181AH-2450S	2.0	sma to mmxc pigtail
Antenna 2	Yokogawa	Omni	F9915KW	2.14	N-type to mmxc pigtail
Antenna 3	Huber+Suhner	Dipole	1399.17.0237	2.0	N-type to mmxc pigtail
Antenna 4	Huber+Suhner	Dipole	1324.17.0114	6.0	N-type to mmxc pigtail
Antenna 5	COMROD	Dipole	UHF2458G	4.0	sma to mmxc pigtail
Antenna 6	Data Alliance	Dipole	A2O8Nm-MTL16N	8.0	N-type to mmxc pigtail

Note: All antennas require a short mmcx pigtail cable in order to connect to radio module.

2.8 Restricted Bands of Operation (Part 15.205, RSS-Gen 8.10)

Only spurious emissions can fall in the frequency bands of CFR 15.205. The field strength of these spurious emissions cannot exceed the limits of 15.209. Radiated harmonics and other spurious emissions are examined for this requirement the test results are presented herein.

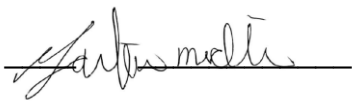
2.9 Antenna Conducted Intentional and Spurious Emissions (CFR 15.209, 15.247(d)) (RSS 247, 5.5))

The EUT was put into a continuous-transmit mode of operation and tested per ANSI C63.10-2013 for conducted out-of-band emissions emanating from the antenna port over the frequency range of 30 MHz to ten times the highest clock frequency generates or used in this case, 25 GHz. A conducted scan was performed on the EUT to identify and record spurious signals that were related to the transmitter. Antenna Conducted Emissions of a significant magnitude that fell within restricted bands were then measured as radiated emissions in the EMC Chamber. The conducted emissions graphs are found in the figures below. The limit for antenna conducted power is 1 Watt (30 dBm) per 15.247 (b)(3).

For Conducted RF antenna tests, the RBW was set to 100 kHz, video bandwidth (VBW)> RBW, scan up through the 10th harmonic of the fundamental frequency. All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band.

Figure 2. Bench Test Setup

Test Date: July 22, 2024

Tested by
Signature:  Name: Gabriel Medina

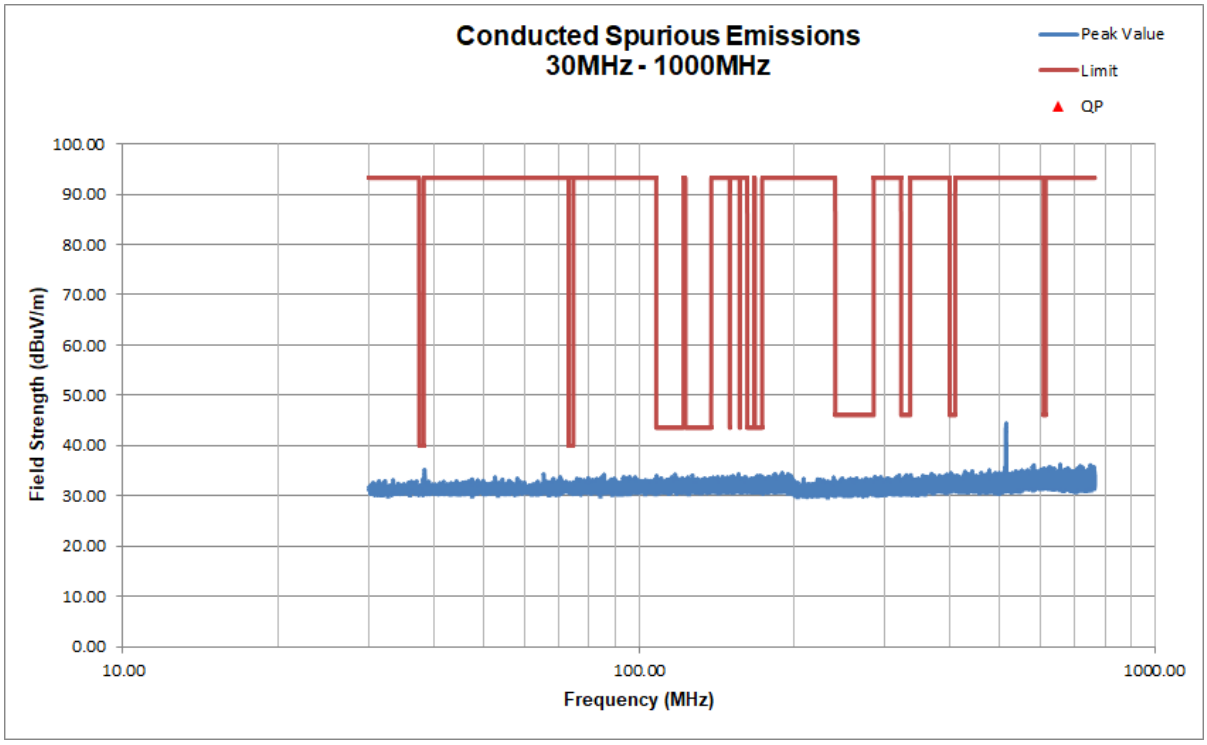


Figure 3. Low Channel, 30 MHz – 1000 MHz

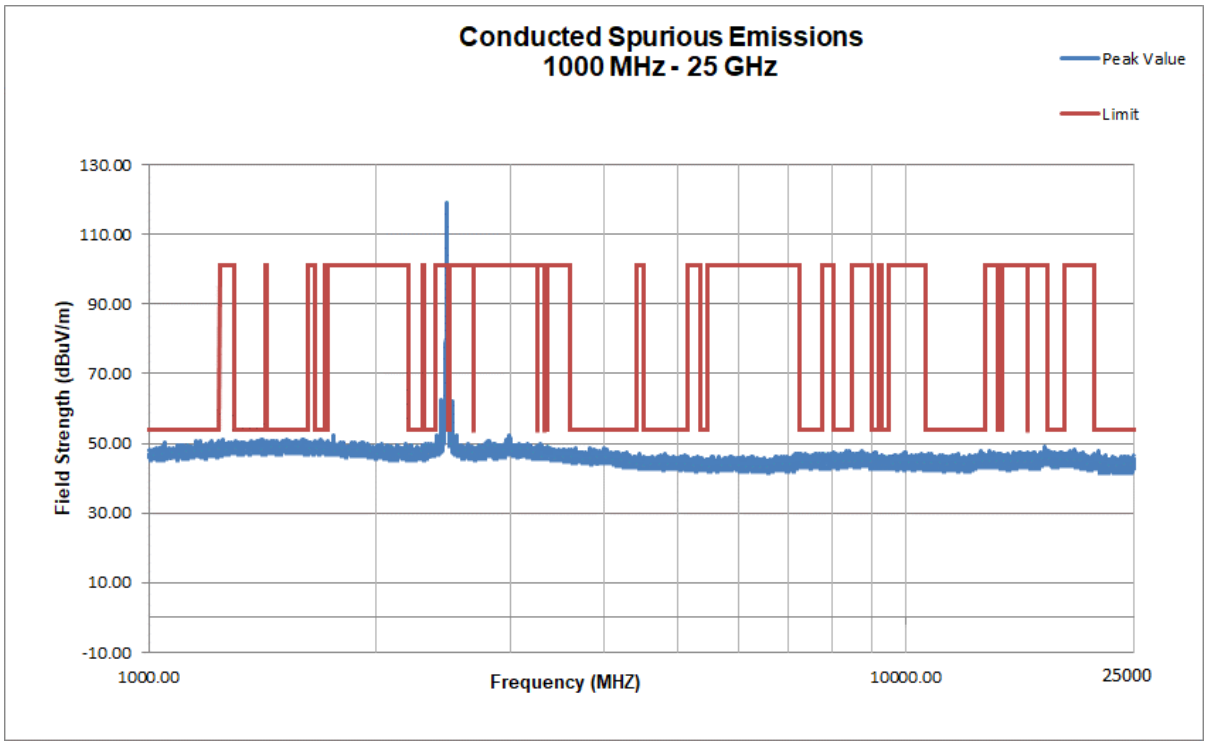


Figure 4. Low Channel, 1 GHz – 25 GHz

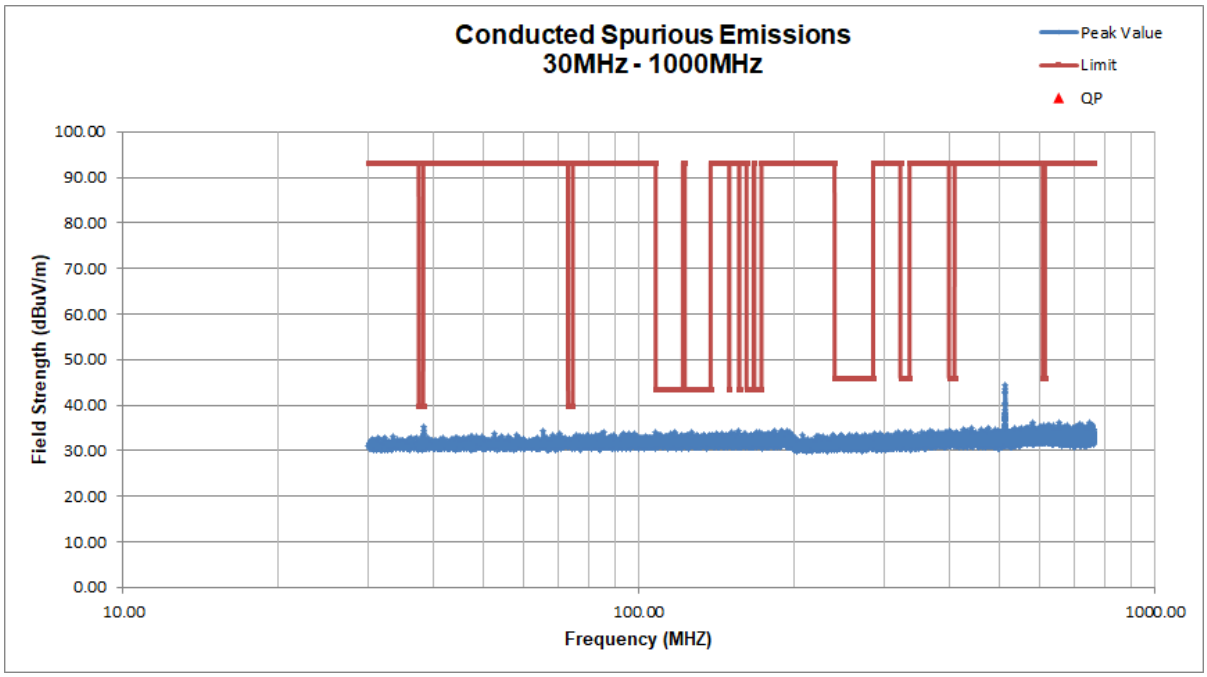


Figure 5. Mid Channel, 30 – 1000 MHz

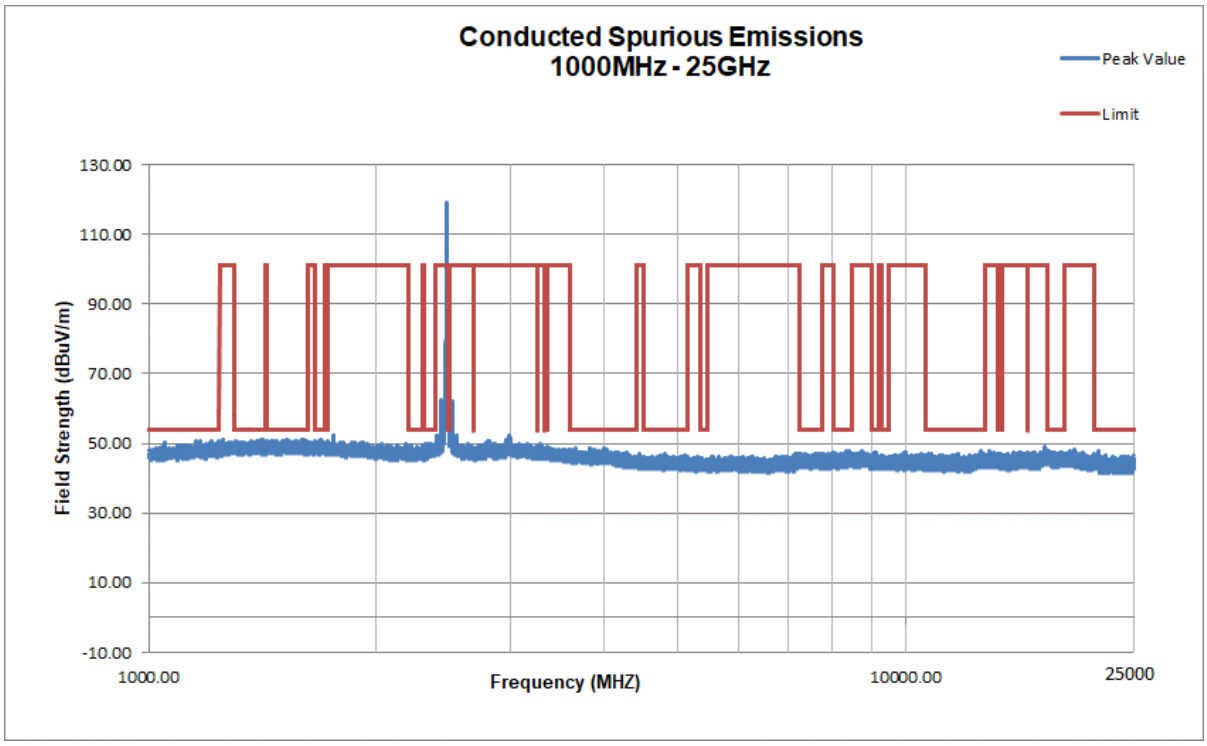


Figure 6. Mid Channel, 1 GHz – 25 GHz

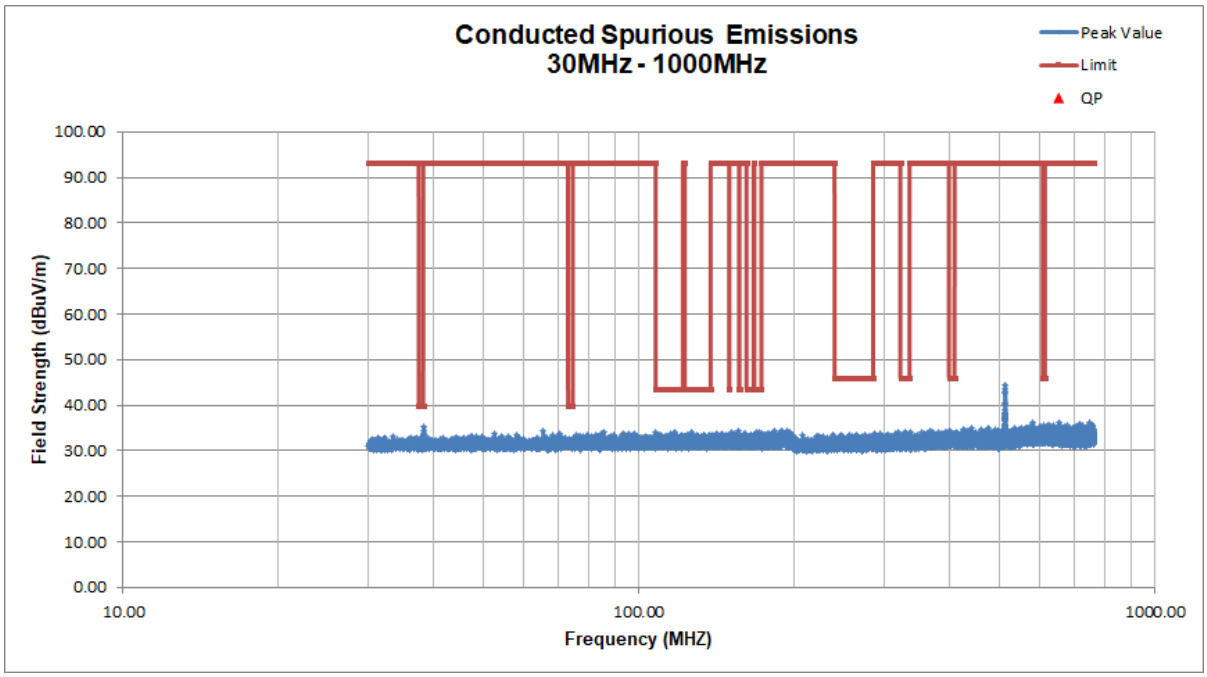


Figure 7. High Channel, 30 – 1000 MHz

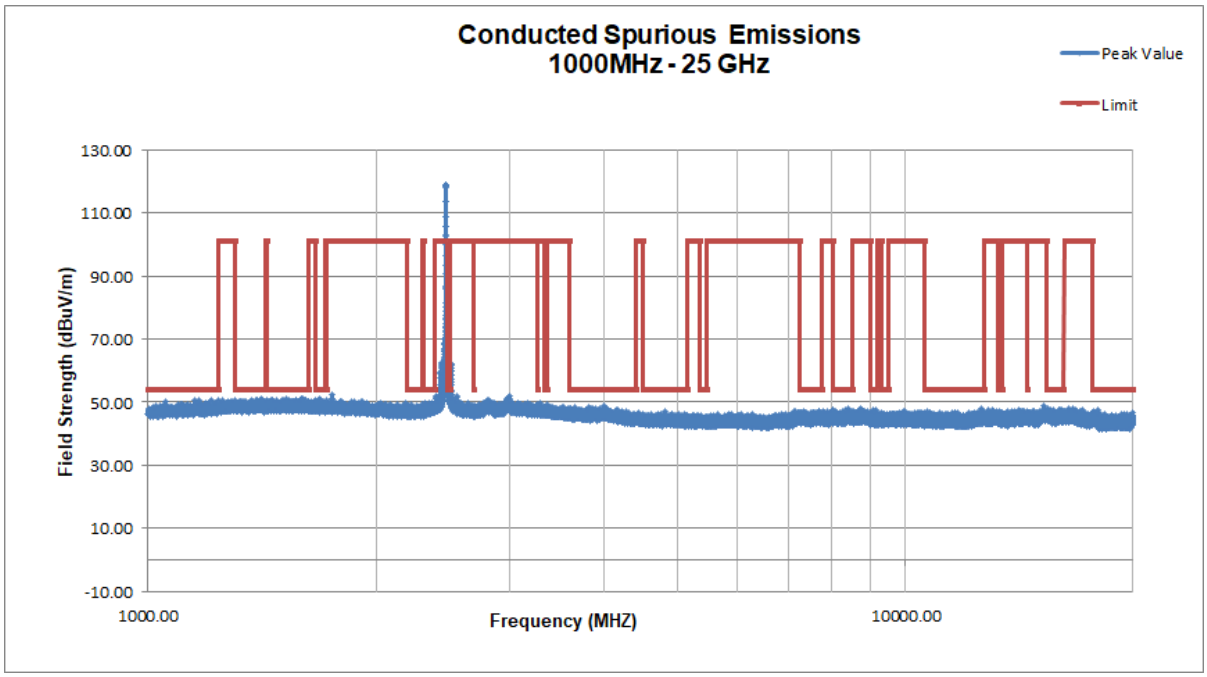


Figure 8. High Channel, 1 GHz – 25 GHz

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d), RSS-247, 5.5)

On the test site, the EUT was placed on top of a non-conductive table, 80 cm above the floor for measurements below 1 GHz and 150 cm above the floor for measurements above 1 GHz. The EUT was also evaluated in three orthogonal positions to determine the worst case position. The front of the EUT faced the measurement antenna located 3 meters away. Each signal measured was maximized by raising and lowering the receive antenna between 1 and 4 meters in height while monitoring the ever-changing spectrum analyzer display (with channel A in the Clear-Write mode and channel B in the Max-Hold mode) for the largest signal visible. That exact antenna height where the signal was maximized was recorded for reproducibility purposes. Additionally, the EUT was rotated about its Y-axis while monitoring the Spectrum Analyzer display for the maximum. The EUT azimuth was recorded for reproducibility purposes. The EUT was measured when both maxima were simultaneously satisfied.

Below 1 GHz, the RBW of the measuring instrument was set equal to 120 kHz. Peak measurements above 1 GHz were measured using a RBW = 1 MHz, with a VBW ≥ RBW. The results of peak radiated spurious emissions falling within restricted bands are given in Table 6 below.

For average measurements above 1 GHz, the emissions were measured using RBW = 1 MHz and VBW = 10 Hz or the duty cycle correction factor was applied to the Peak recorded value.

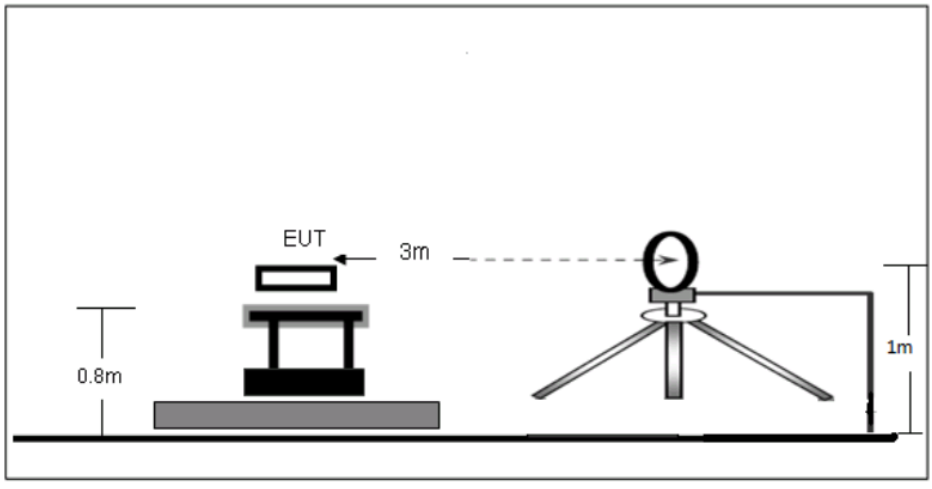


Figure 9. Radiated Emissions, Below 30 MHz

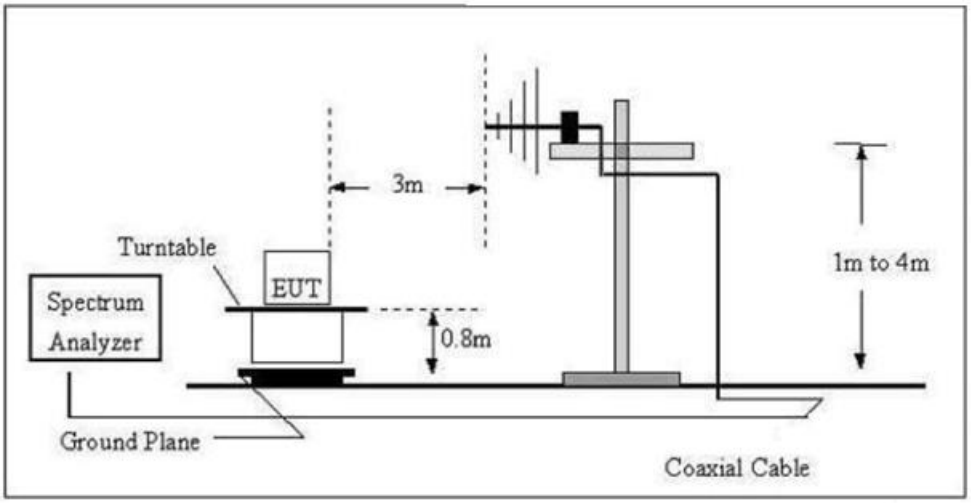


Figure 10. Radiated Emissions, 30 MHz to 1000 MHz

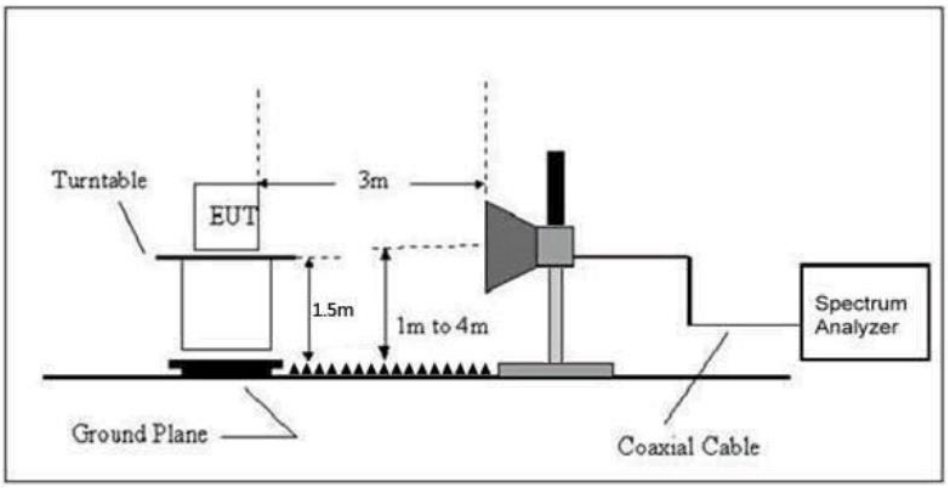


Figure 11. Radiated Emissions, above 1 GHz

For radiated spurious emissions measurements, the EUT was set into a continuous transmission mode. The antenna port was terminated with a 50 ohm load. The power setting was set to the highest level, “20”. This was the configuration used throughout the testing. The results are depicted below.

Table 5. Spurious Radiated Emissions (150 kHz-30MHz)

Test: FCC Part 15.209, 15.247, RSS-Gen 8.9, RSS-247 5.5							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
All other emissions were more than 20 dB below the applicable limit.							

Note(*):Emission is not in restricted Band, sufficiently attenuated below Fundamental
AF = antenna factor.
CL = cable loss.
PA = preamplifier gain.

Sample Calculation: N/A

Test Date: July 18 - 22, 2024

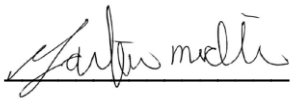
Tested by
Signature:  Name: Gabriel Medina

Table 6. Spurious Radiated Emissions (30 MHz – 1 GHz)

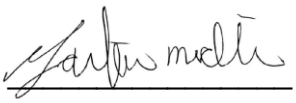
Test: FCC Part 15.209, 15.247, RSS-Gen 8.9, RSS-247 5.5							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
32.20	32.79	-8.83	23.96	40.0	3m./HORZ	16.0	**PK**
98.80	33.18	-14.23	18.95	43.5	3m./HORZ	24.6	**PK**
118.75	32.35	-12.87	19.49	43.5	3m./HORZ	24.0	**PK**
153.95	33.05	-11.26	21.79	43.5	3m./HORZ	21.7	**PK**
740.97	29.61	0.19	29.80	46.0	3m./HORZ	16.2	**PK**
32.05	39.97	-9.97	30.01	40.0	3m./VERT	10.0	**PK**
76.00	39.12	-15.19	23.93	40.0	3m./VERT	16.1	**PK**
84.00	35.72	-14.55	21.17	40.0	3m./VERT	18.8	**PK**
89.50	37.01	-13.85	23.15	43.5	3m./VERT	20.3	**PK**
108.20	38.40	-12.93	25.47	43.5	3m./VERT	18.0	**PK**
884.11	30.14	0.61	30.75	46.0	3m./VERT	15.3	**PK**

AF is antenna factor. CL is cable loss. PA is preamplifier gain.

Sample Calculation At: 32.20 MHz

Magnitude of Measured Frequency	32.79	dBuV
+Antenna Factor + Cable Loss+ Amplifier Gain	-8.83	dB
Corrected Result	23.96	dBuV/m

Test Date: July 18 - 22, 2024

Tested by
Signature: 

Name: Gabriel Medina

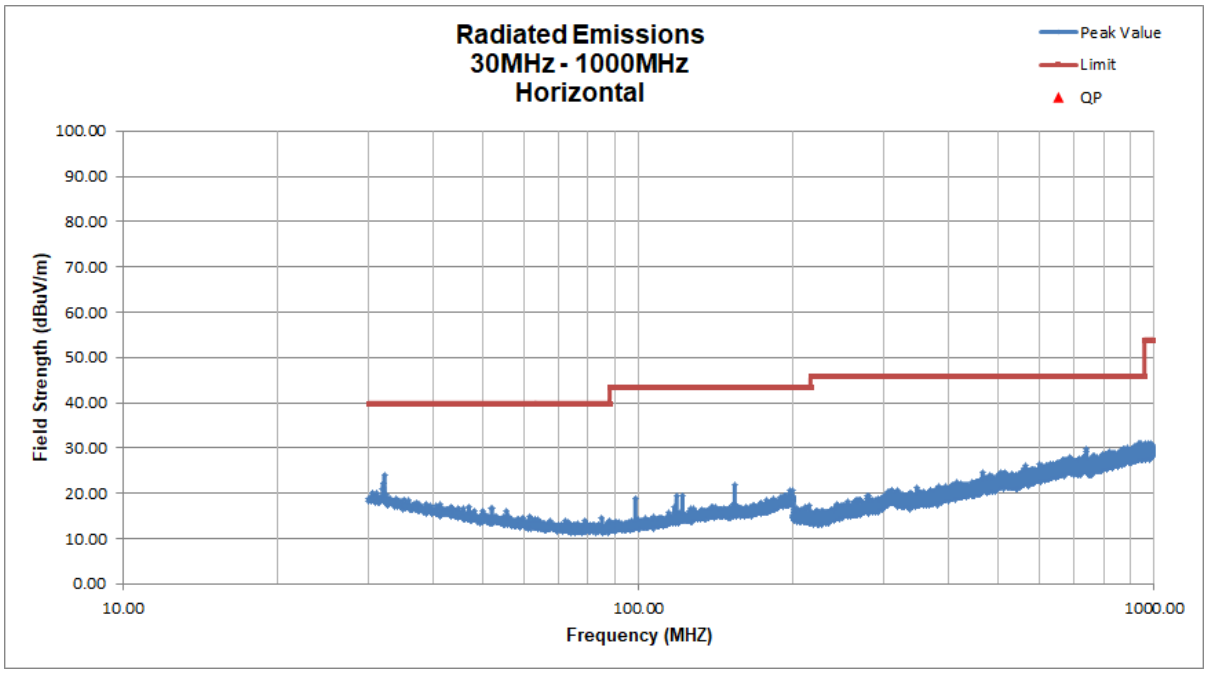


Figure 12. Radiated Emission, 30 MHz - 1000 MHz – Horizontal

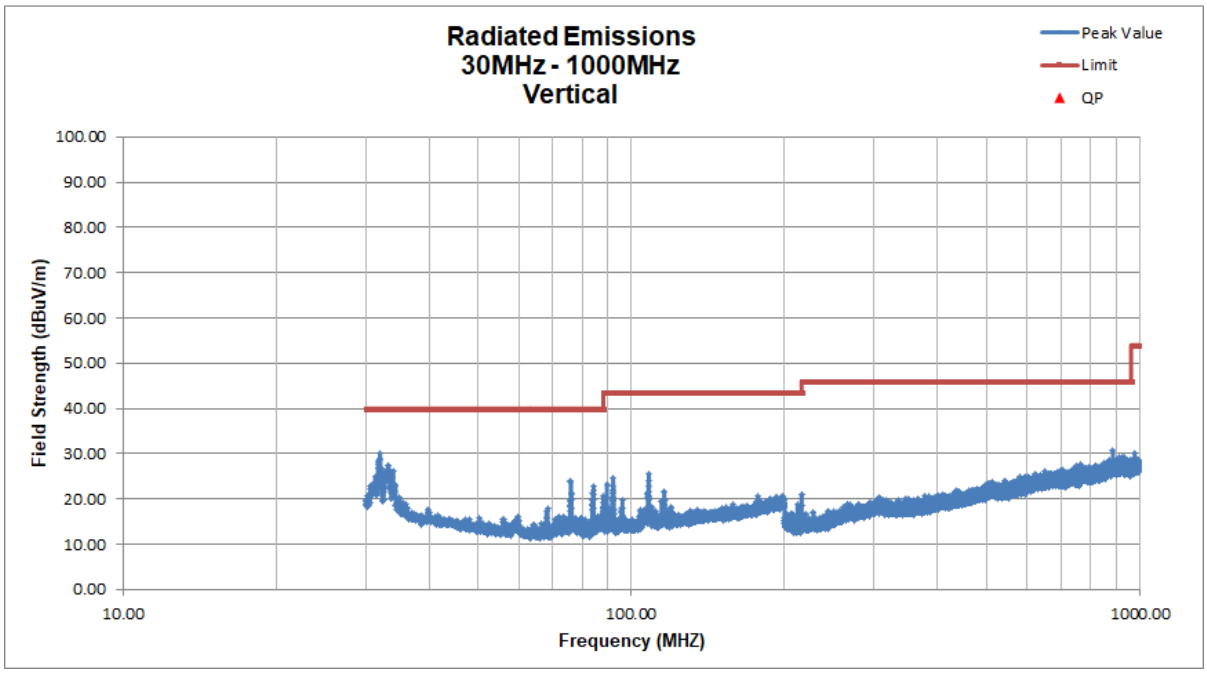


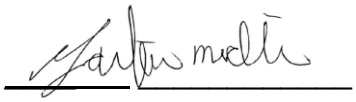
Figure 13. Radiated Emissions, 30 MHz - 1000 MHz – Vertical

Table 7. Radiated Emissions, 1 GHz – 25 GHz

Test: FCC Part 15.209, 15.247, RSS-Gen 8.9, RSS-247 5.5								
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector**
No emissions seen other than fundamental emissions. Emission beyond 14 GHz not reported. Emission beyond 14 GHz are more than 20 dB below the applicable limit.								

1. (*) Falls within the restricted bands of CFR 15.205. Limits based on CFR15.209& 15.247.
2. No other signals detected within 20 dB of specification limit. Harmonics investigated up to the 10th harmonic
3. The EUT was placed in three orthogonal positions, tested while broadcasting from each antenna, and the transmitter was in constant broadcast mode, with a duty cycle of greater than 98%. The emissions were measured with the receive antenna in vertical and horizontal polarizations. The data listed in the above table was the worst case.

Test Date: July 18 - 22, 2024

Tested by
Signature:  Name: Gabriel Medina

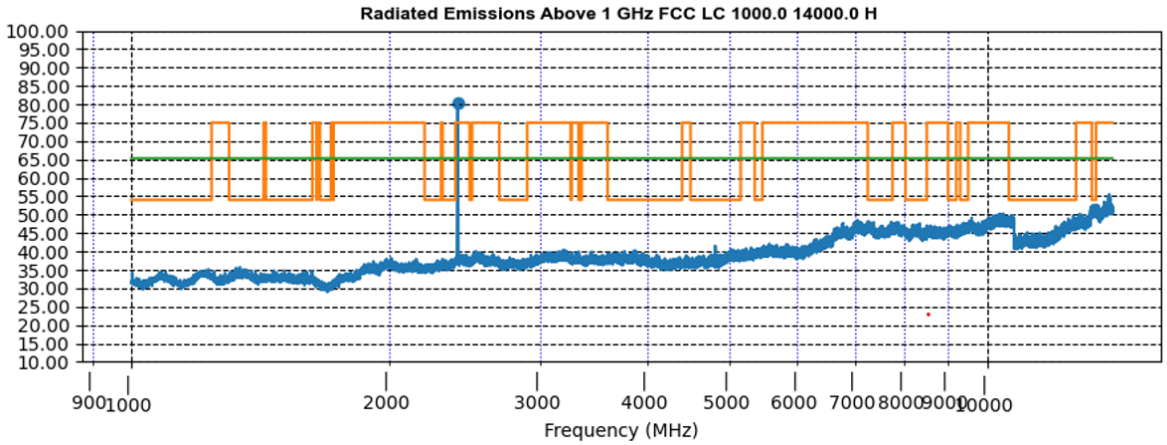


Figure 14. High Frequency Spurious Radiated Emissions, Horizontal

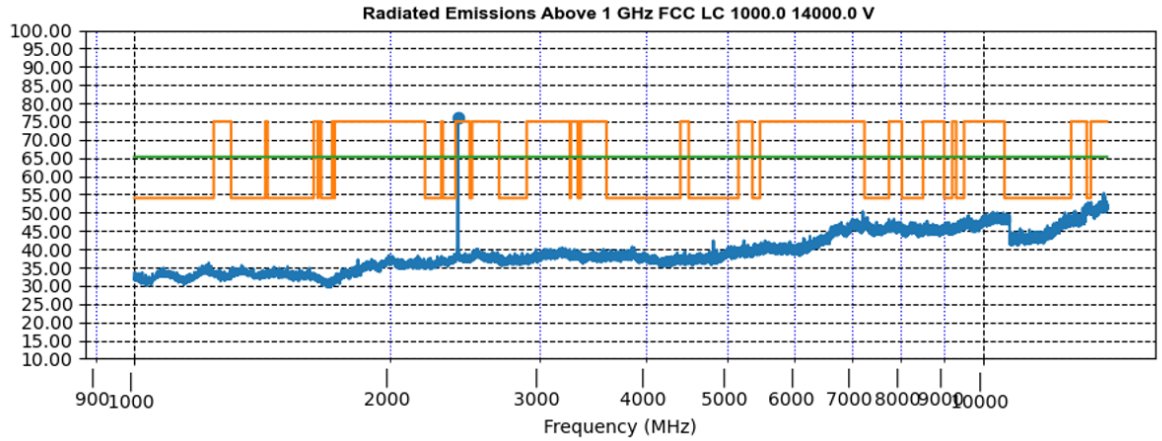


Figure 15. High Frequency Spurious Radiated Emissions, Vertical

2.11 Band Edge and Restricted Band Measurements (CFR 15.247(d), RSS-Gen 8.10, RSS-247, 5.5)

Band Edge measurements are made following the guidelines in ANSI C63.10-2013 Clause 6.10 with the EUT initially operating on the Lowest Channel and then operating on the Highest Channel within its band of operation. Restricted band and band edge tests are performed as radiated measurements. The test instrument used for testing has both Peak and Average detection. In consideration of Clause 5.8 of ANSI C63.10-2013, the EUT was set to its highest rated output power level during testing. The results are collected and presented below.

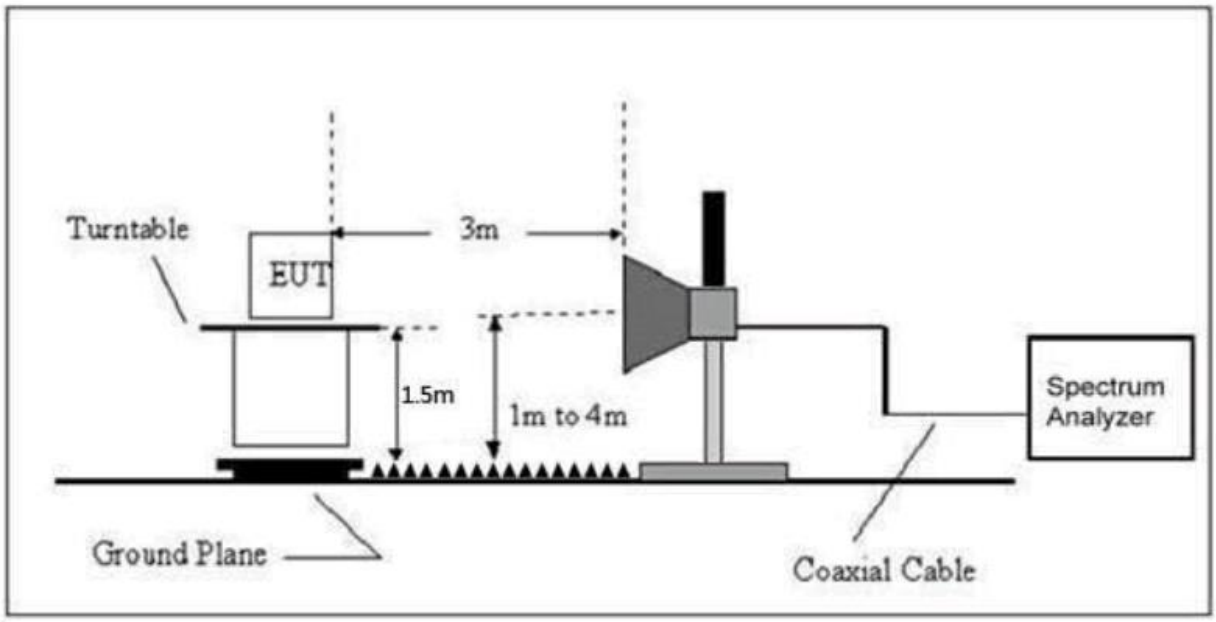


Figure 16. Radiated Emissions Setup

Test Date: September 3, 2024

Tested by
Signature: Name: Gabriel Medina

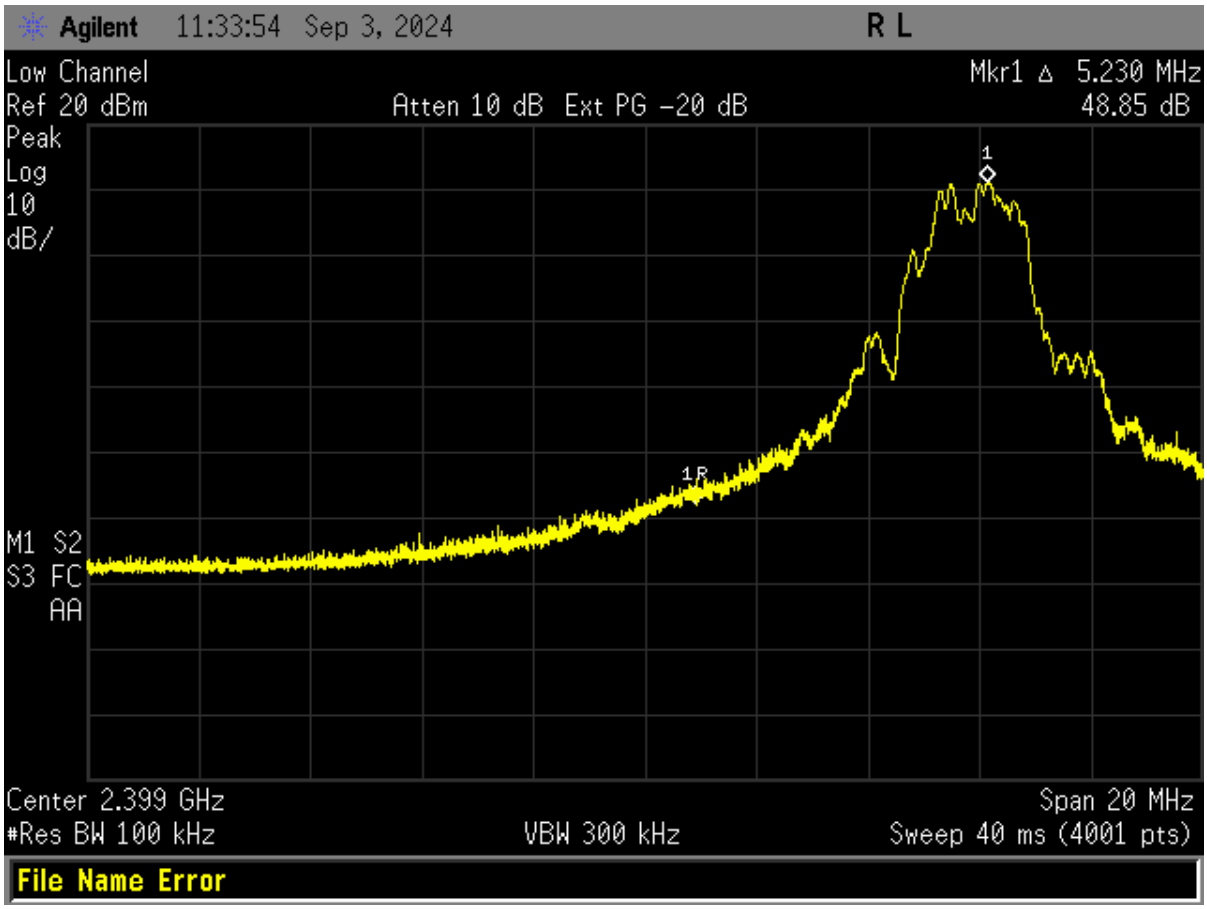


Figure 17. Band Edge Compliance – Radio 1 Low Channel Delta – Peak

Lower band edge must be 20 dB below the fundamental. This requirement is met.

Measured Result	-48.85	dB
Band Edge Limit	-20.00	dB
Band Edge Margin	28.85	dB

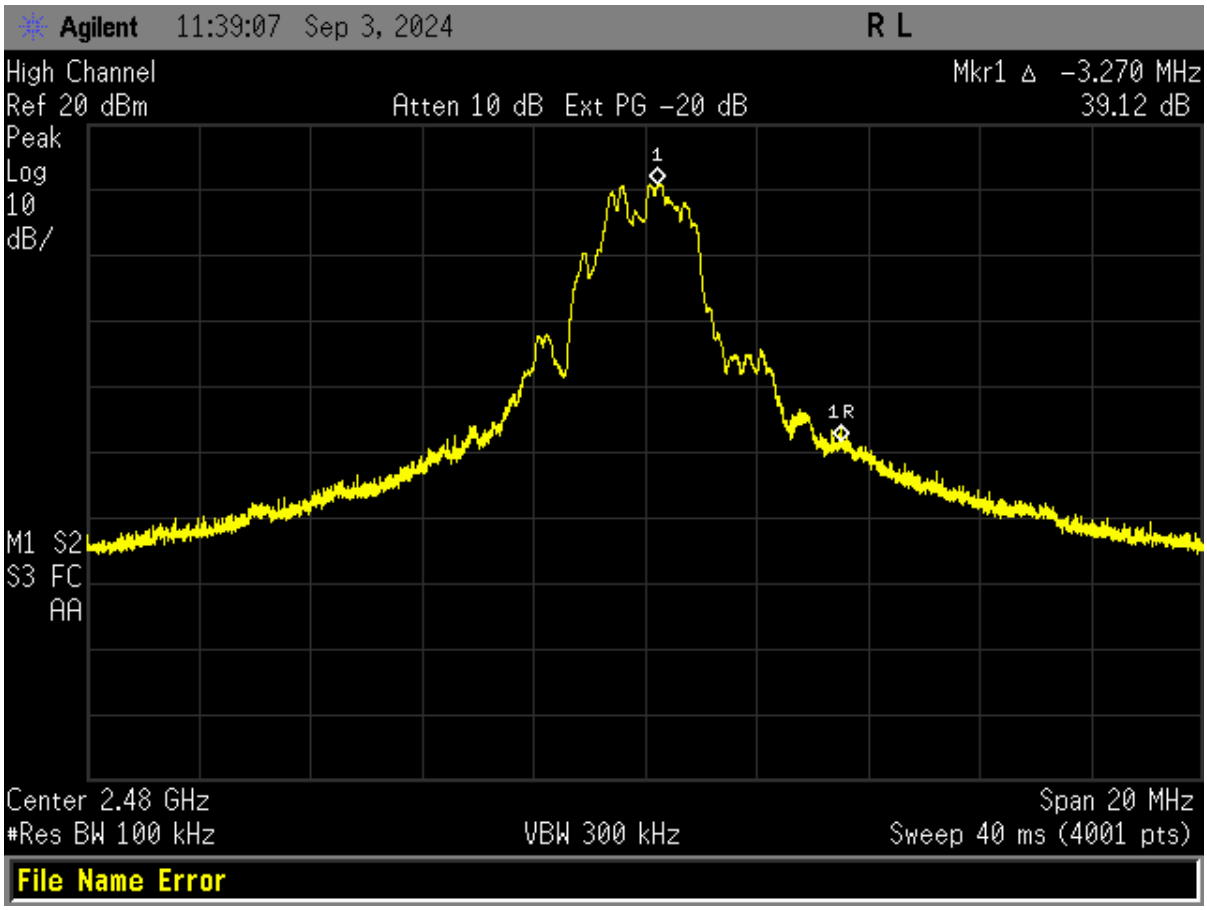


Figure 18. Band Edge Compliance – Radio 1 High Channel Delta – Peak

Higher band edge must be 20 dB below the fundamental. This requirement is met.

Measured Result	-39.12	dB
Band Edge Limit	-20.00	dB
Band Edge Margin	19.12	dB

2.11 Band Edge and Restricted Band Measurements (CFR 15.247(d), RSS-Gen 8.10, RSS-247, 5.5)

The restricted band measurements were collected using radiated methods. The EUT was tested with each of the antenna connected. The data presented below is the worst case data. This data is used as representative test results for all antennas.

The worst case configuration is the radio module with 8 dBi gain antenna set to output power setting “16”. EIRP = 24 dBm.

The Duty Cycle factor of -7.74 dB was applied to the Low Channel measurement.

Test Date: July 22, 2024

Tested by
Signature:  Name: Gabriel Medina

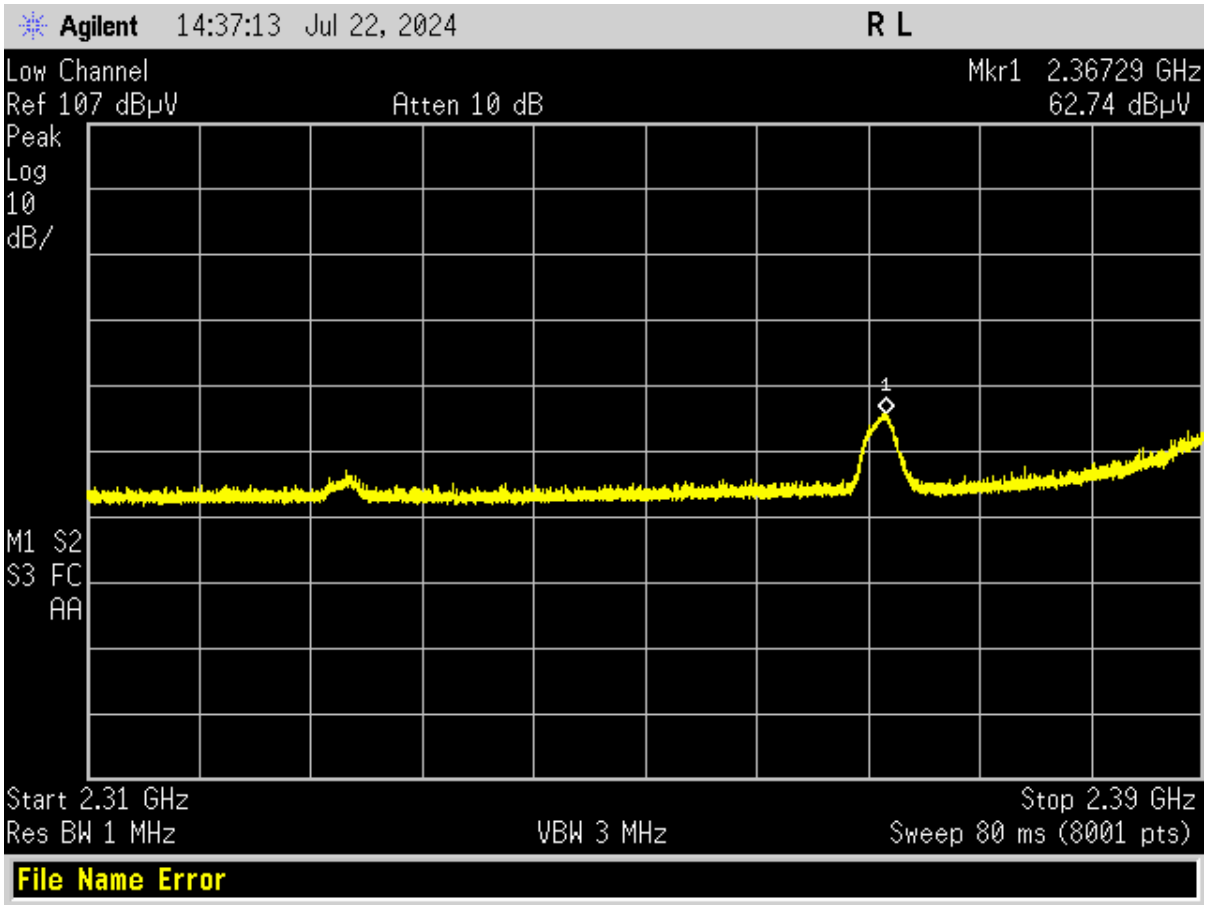


Figure 19. Low Channel Restricted Band

Frequency (MHz)	Test Data (dBuV)	Duty-Cycle Correction	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2367.29	62.74	0.00	-7.09	55.65	74.0	3.0m./VERT	18.4	**PK**
2367.29	62.74	-7.74	-7.09	47.91	54.0	3.0m./VERT	6.1	**AVG**

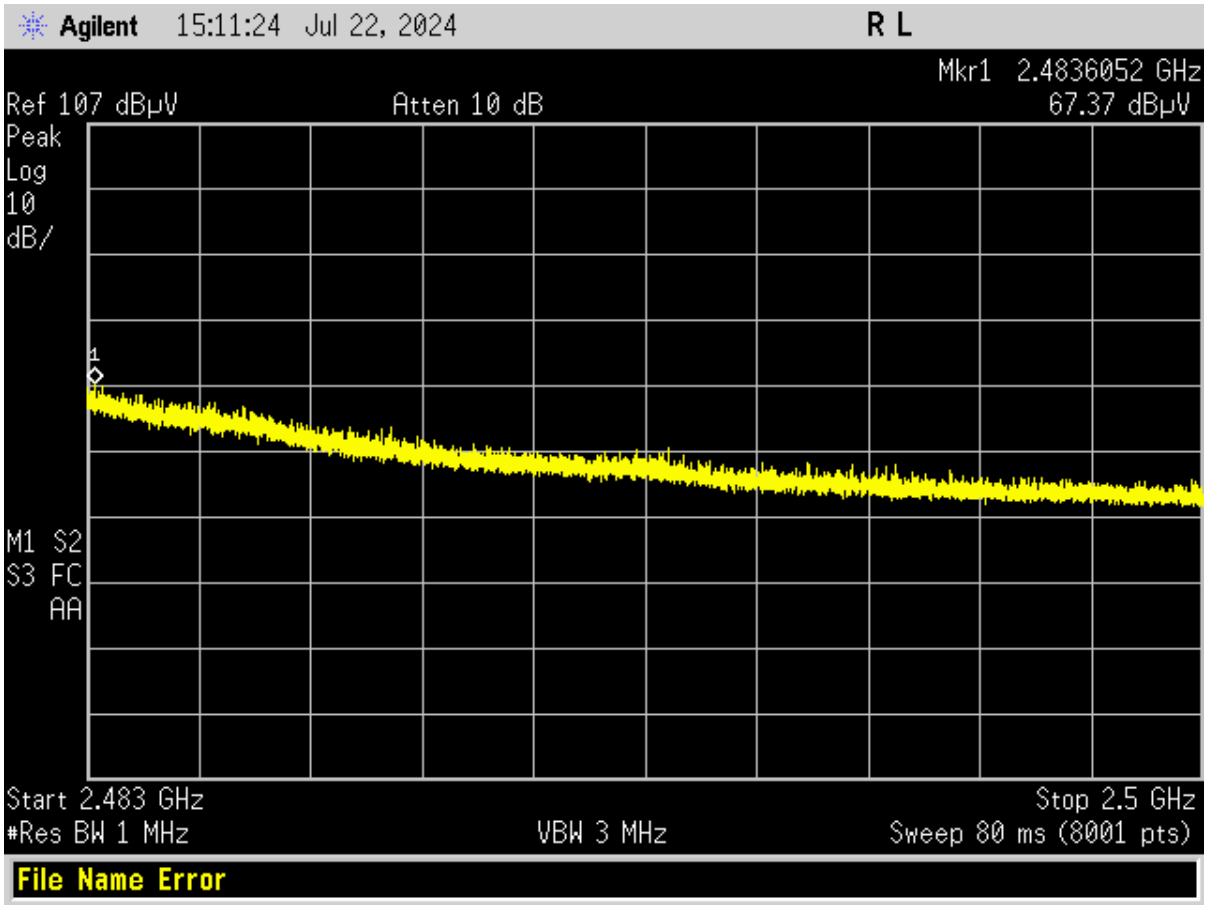


Figure 20. High Channel Restricted Band

Frequency (MHz)	Test Data (dBuV)	Duty-Cycle Correction	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2483.61	67.37	0.00	-6.62	60.75	74.0	3.0m./VERT	13.3	**PK**
2483.61	67.37	-7.74	-6.62	53.01	54.0	3.0m./VERT	0.9	**AVG**

2.12 Six (6) dB Bandwidth (CFR 15.247(a)(2), RSS-Gen 6.7, RSS-247, 5.2(a))

The EUT antenna port was connected to a spectrum analyzer having a 50Ω input impedance. Measurements were performed per ANSI C63.10-2013, clause 11.8. The RBW was set to 100 kHz and the VBW ≥ RBW. The results of this test are given in the table and figures below.

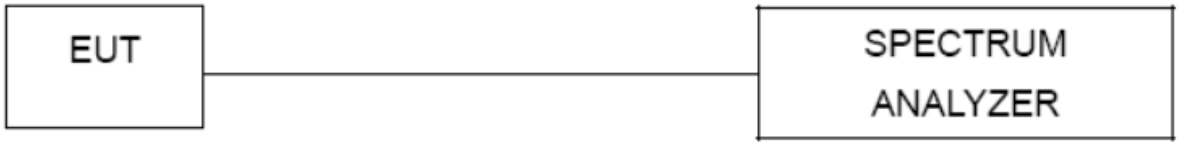


Figure 21. Bench Test Setup

Table 8. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC P15.247 & RSS-247 6 dB Bandwidth Limit (MHz)	Verdict
2405	1.619	0.5	PASS
2440	1.620	0.5	PASS
2475	1.608	0.5	PASS

Test Date: July 22, 2024

Tested by
Signature: Name: Gabriel Medina

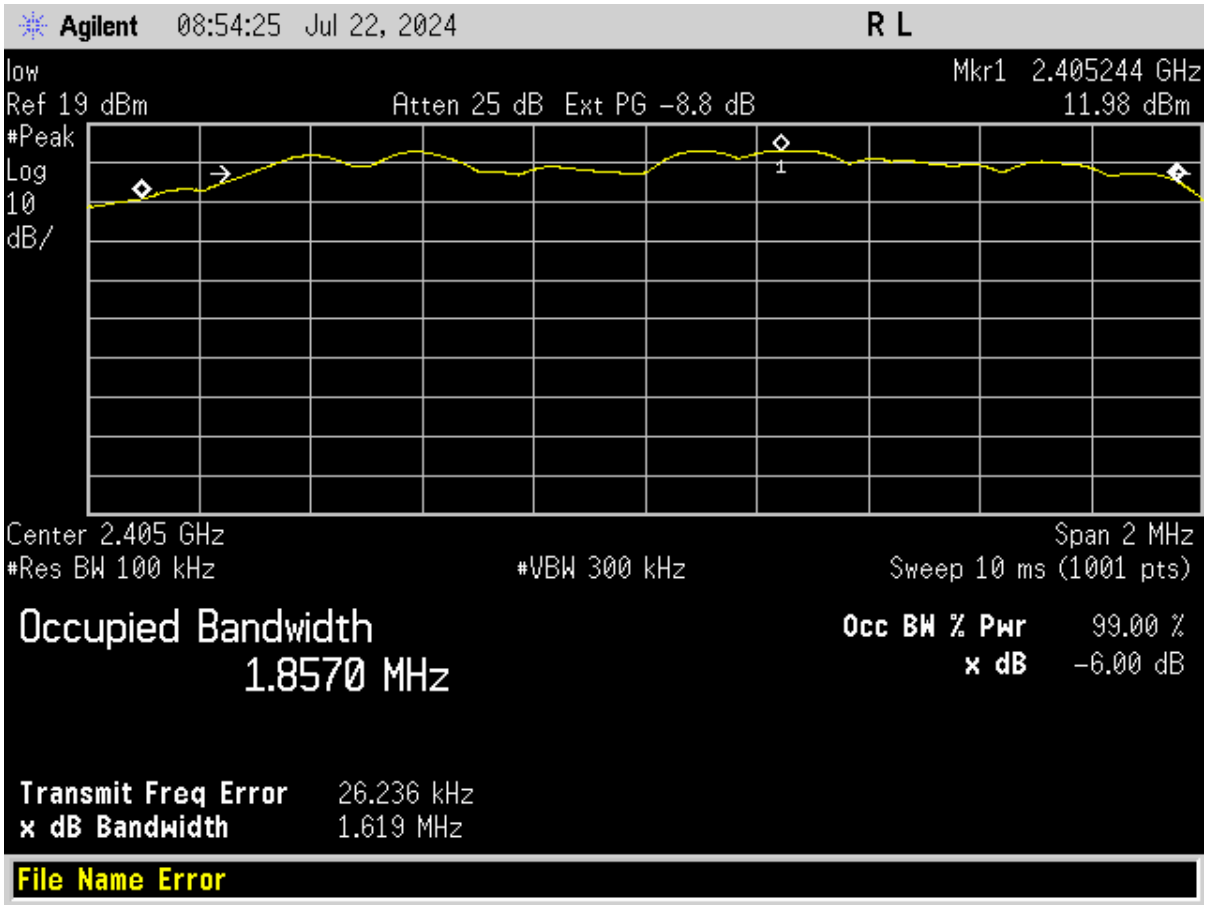


Figure 22. 6 dB Bandwidth Radio 1 Low Channel

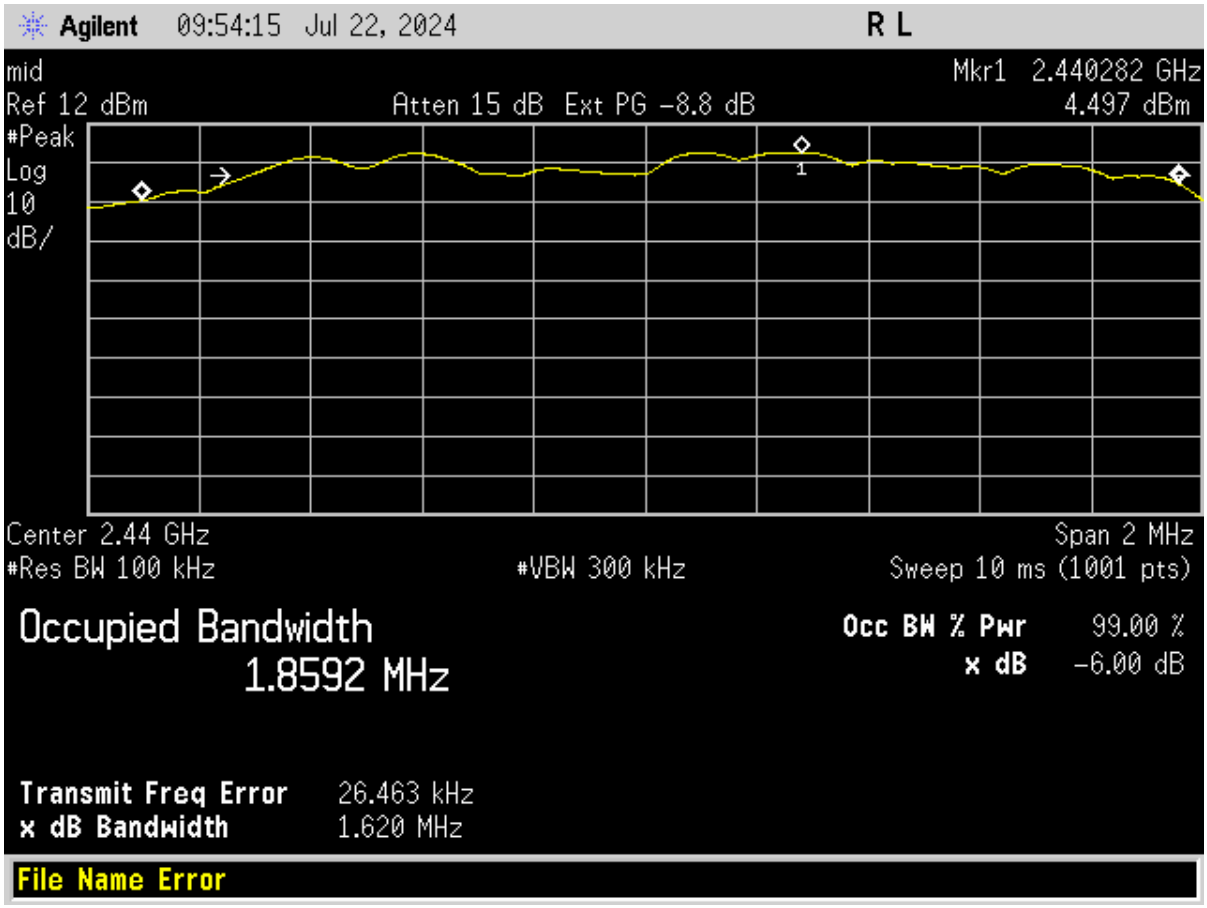


Figure 23. 6 dB Bandwidth Radio 1 Mid Channel

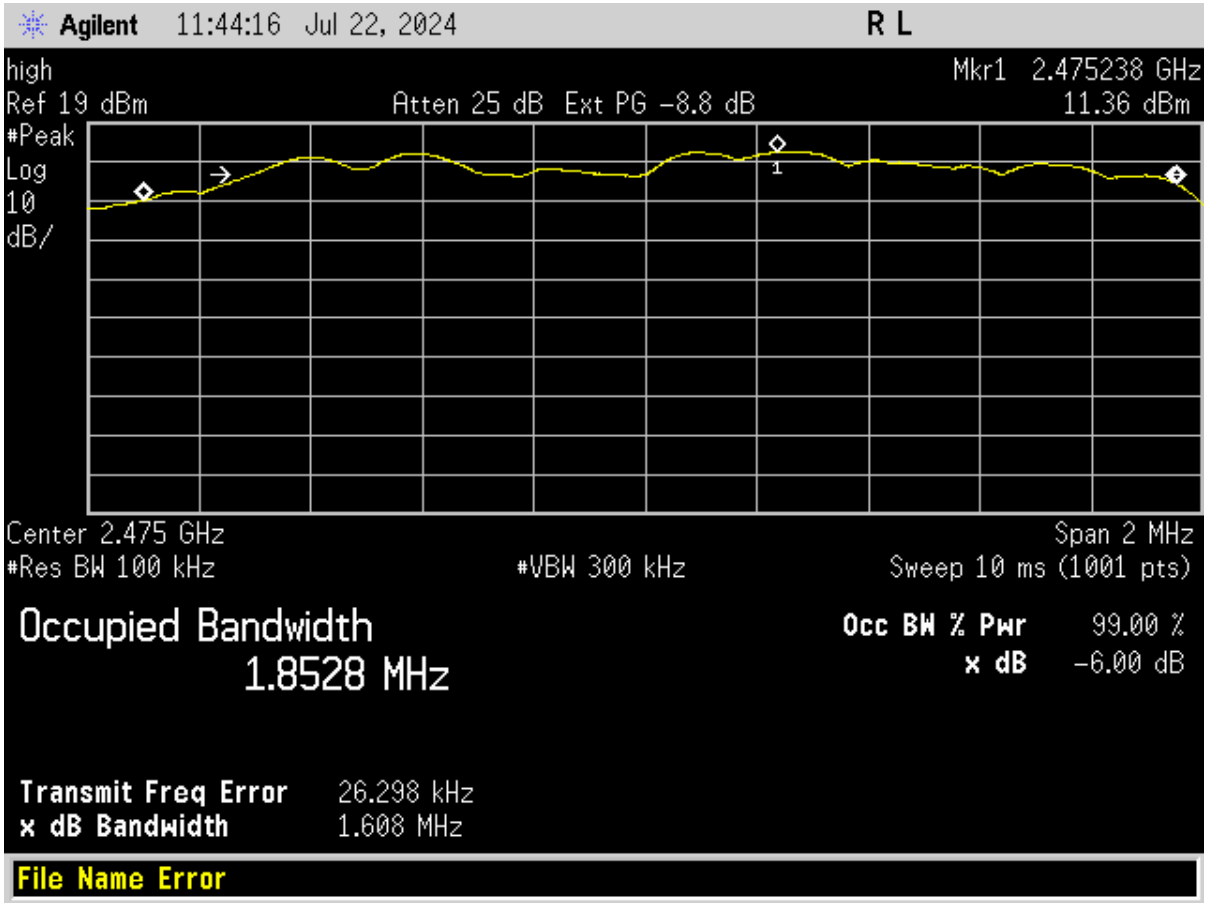


Figure 24. 6 dB Bandwidth Radio 1 High Channel

2.13 Occupied Bandwidth, 99% Bandwidth (RSS-GEN (6.7))

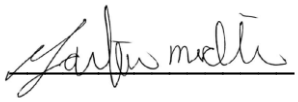
The EUT antenna port was connected to a spectrum analyzer having a 50Ω input impedance. Measurements were performed similar to the method of FCC, KDB Publication No. 558074 v03r05 for a bandwidth of 20 dB. The RBW was set to approximately 1/100 of the manufacturers claimed RBW and with the VBW ≥ RBW. The results of this test are given in Table 17 and presented in the figures in section 2.12 above.

Figure 25. Bench Test Setup

Table 9. 99% Occupied Bandwidth

Frequency (MHz)	99% Occupied Bandwidth (RSS-Gen 6.7) (MHz)
2405	2.181
2440	2.160
2475	2.187

Test Date: July 22, 2024

Tested by
Signature:  Name: Gabriel Medina

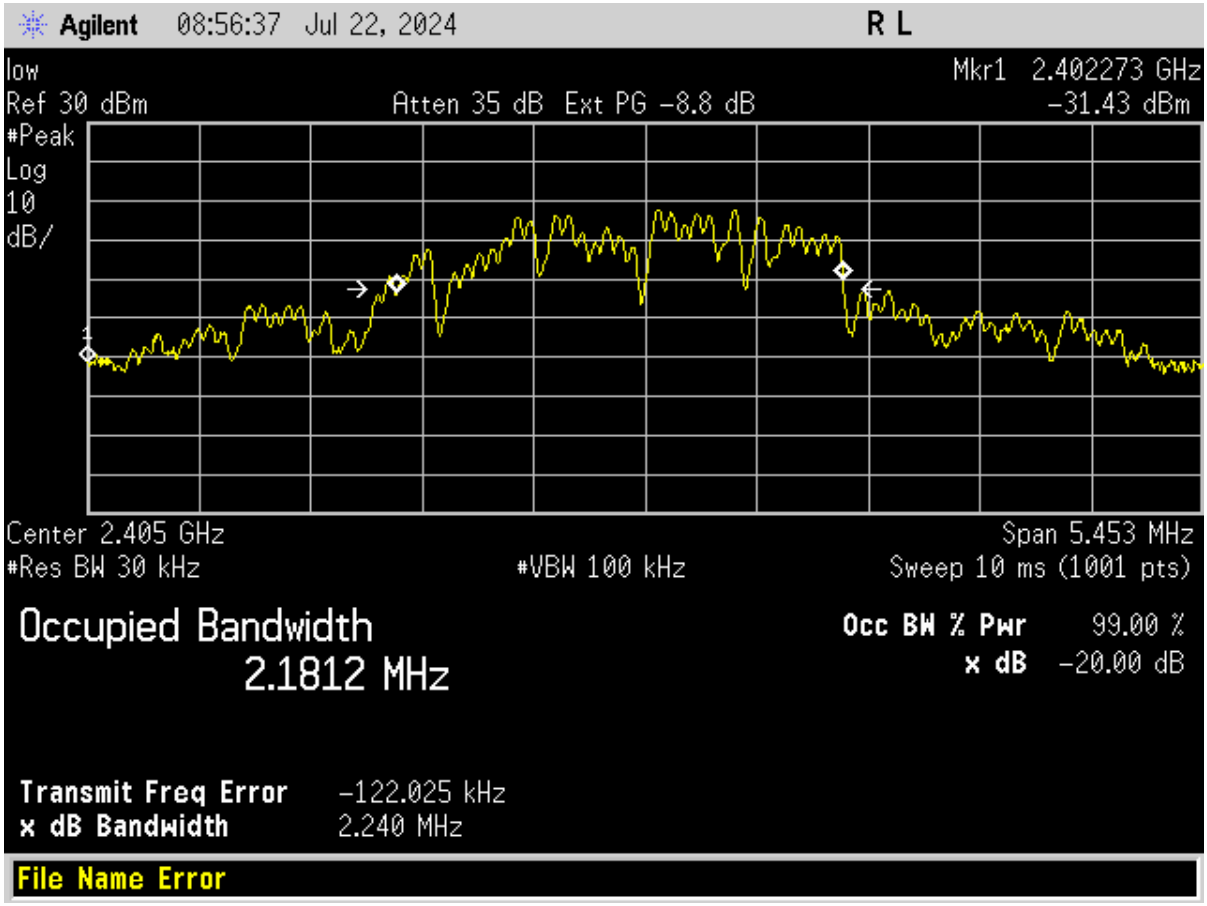


Figure 26. 99% Occupied Bandwidth Radio 1 Low Channel

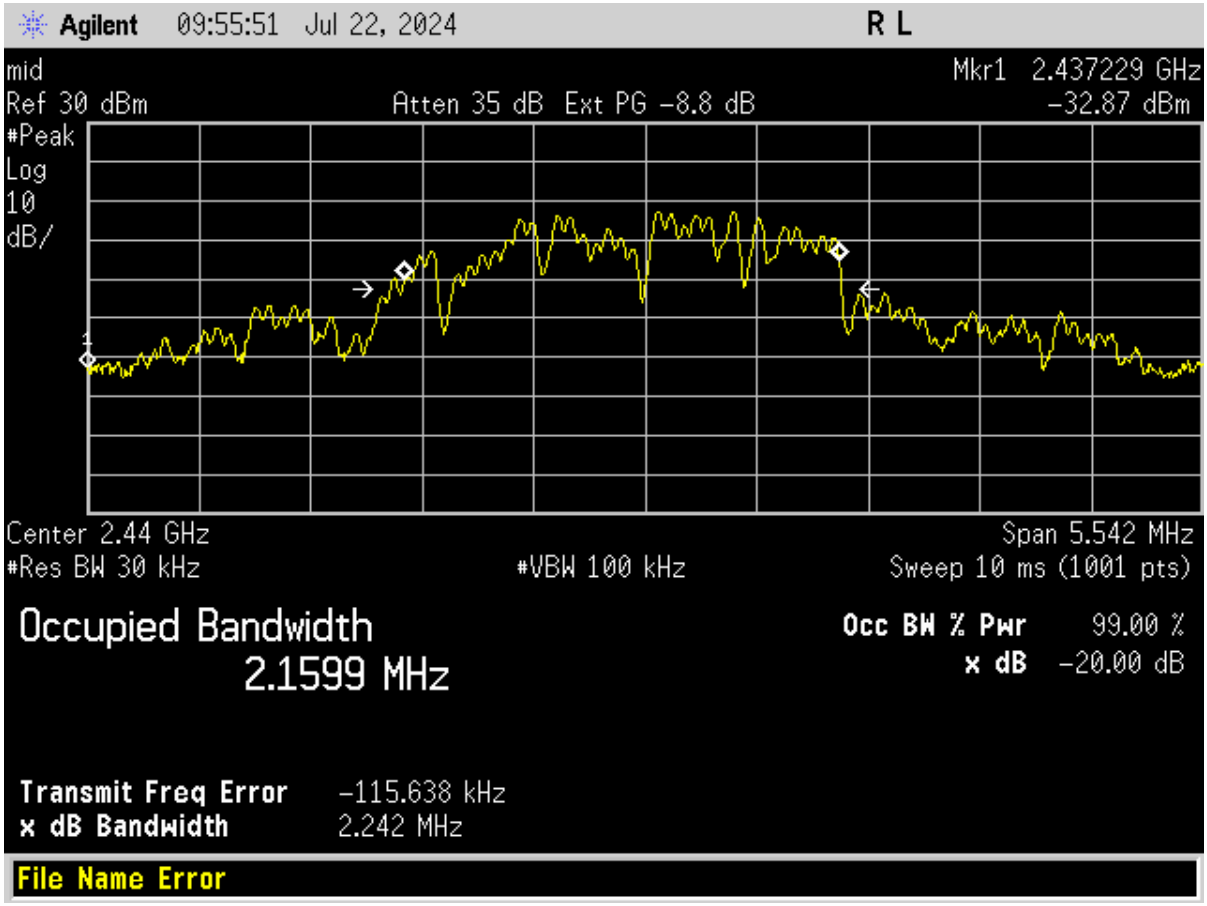


Figure 27. 99% Occupied Bandwidth Radio 1 Mid Channel

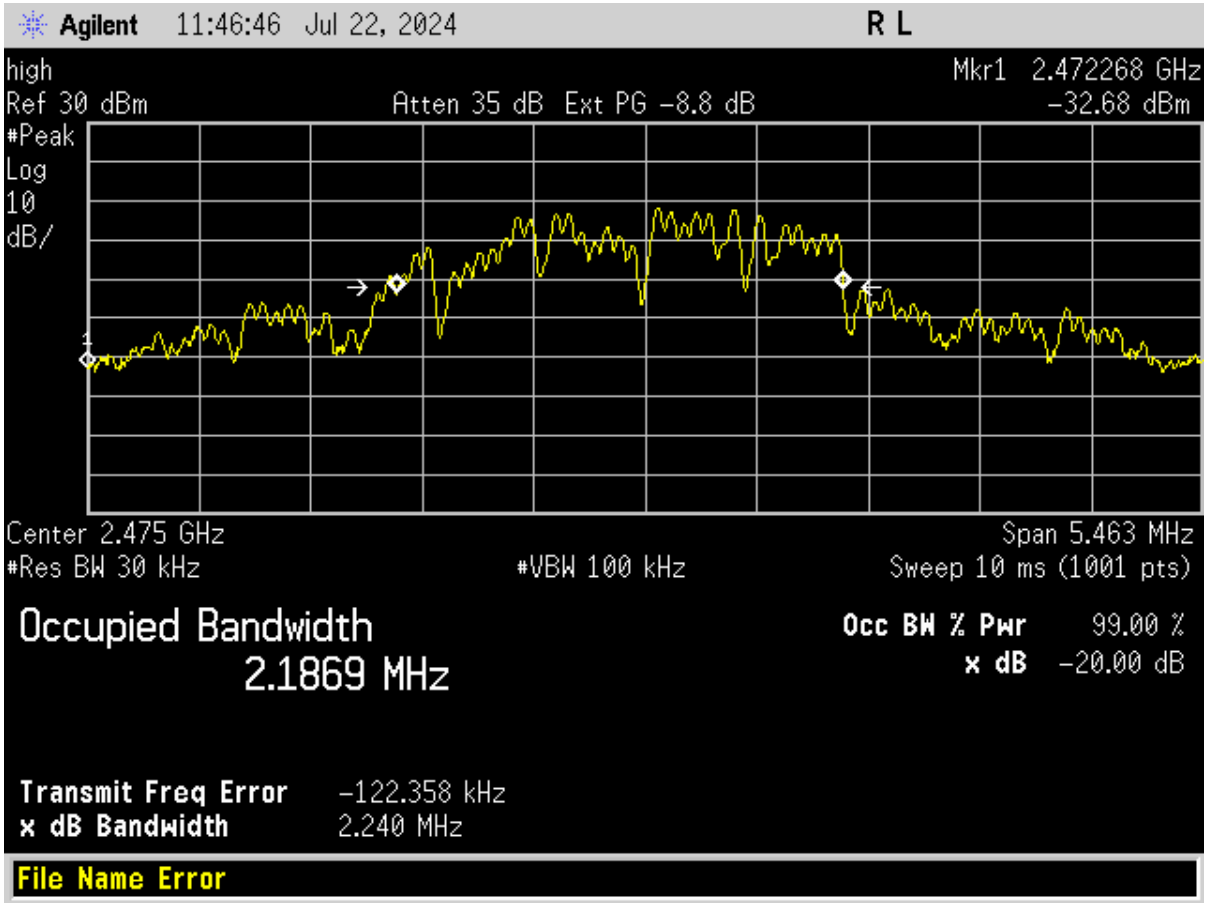


Figure 28. 99% Occupied Bandwidth Radio 1 High Channel

2.14 Transmitter Maximum Peak Conducted Output Power (CFR 15.247(b)(3), RSS-247 5.4(d))

The transmitter was programmed to operate at a maximum output power across the bandwidth. For this test, the output power of the radio was set to the maximum data rate, with 11Mbps for mode B, 54 Mbps for mode G, and MSC-7 for mode N, to meet all test requirements.

Peak power within the band 2400 MHz to 2483.5 MHz was measured per ANSI C63.10-2013 as an Antenna Conducted test with a spectrum analyzer by connecting the spectrum analyzer directly, via a short RF cable, and attenuators to the antenna output terminals on the EUT. The spectrum analyzer was set to a RBW of 1 MHz, and the VBW ≥ RBW. The integration method was used. Peak antenna conducted output power is tabulated in the table below.

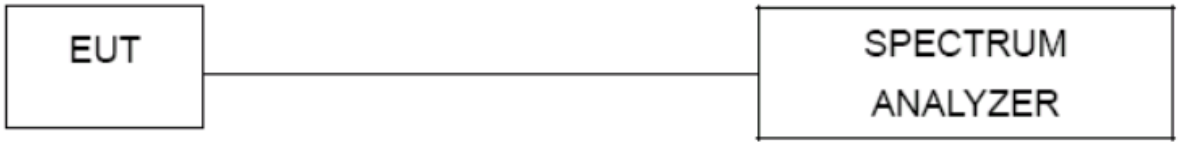
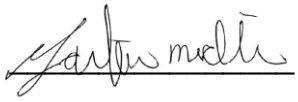


Figure 29. Bench Test Setup

Table 10. Peak Antenna Conducted Output Power per Part 15.247 (b)(3)

Frequency of Fundamental (MHz)	dBm	Converted Data (mW)	P15.247 & RSS-247 Limit (mW Maximum)	Verdict
Power Setting “20”				
2405	18.30	67.6	1000.0	PASS
2440	18.19	65.9	1000.0	PASS
2475	18.15	65.3	1000.0	PASS
Power Setting “16”				
2405	15.58	36.1	1000.0	PASS
2440	15.38	34.5	1000.0	PASS
2475	15.26	33.6	1000.0	PASS

Test Date: July 25, 2024

Tested by
Signature:  Name: Gabriel Medina

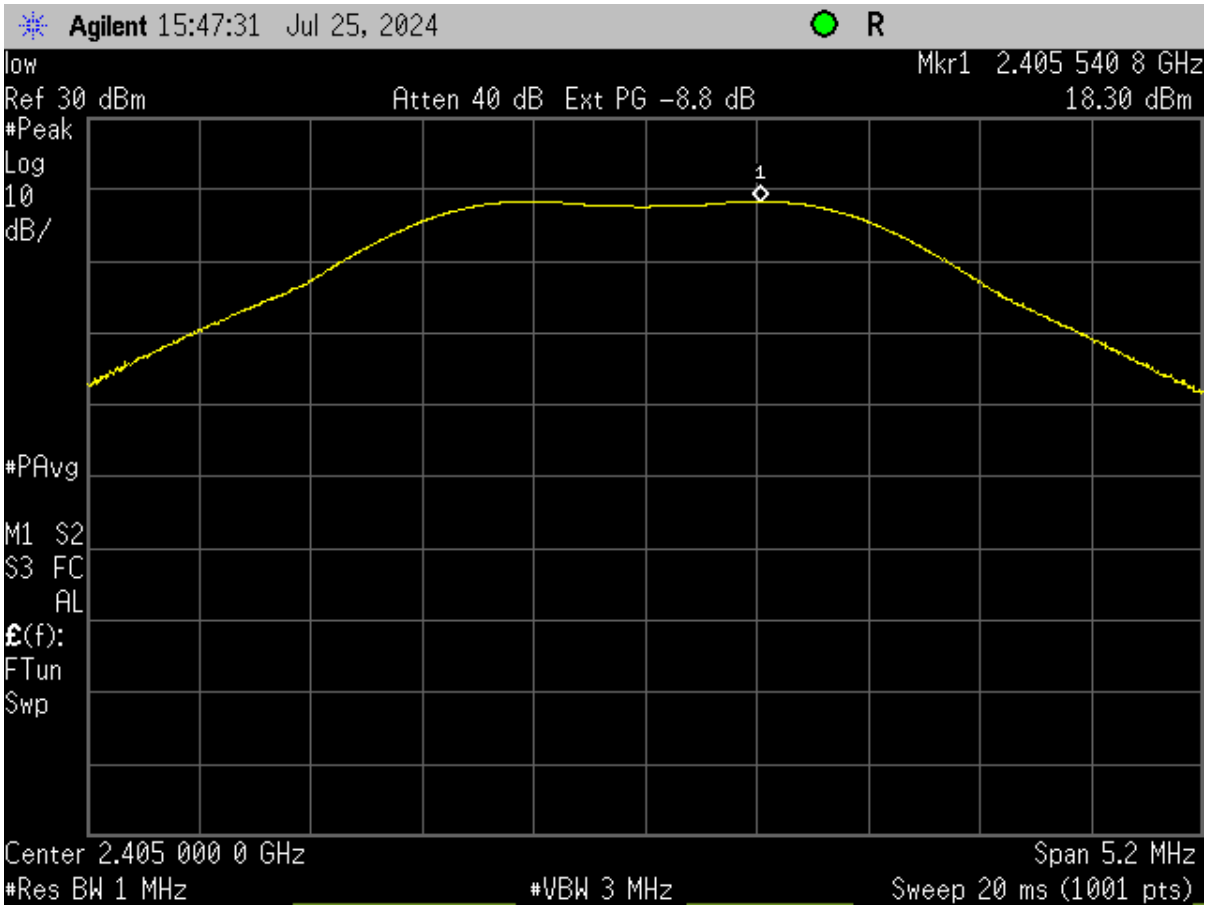


Figure 30. Low Channel, Power Setting "20"

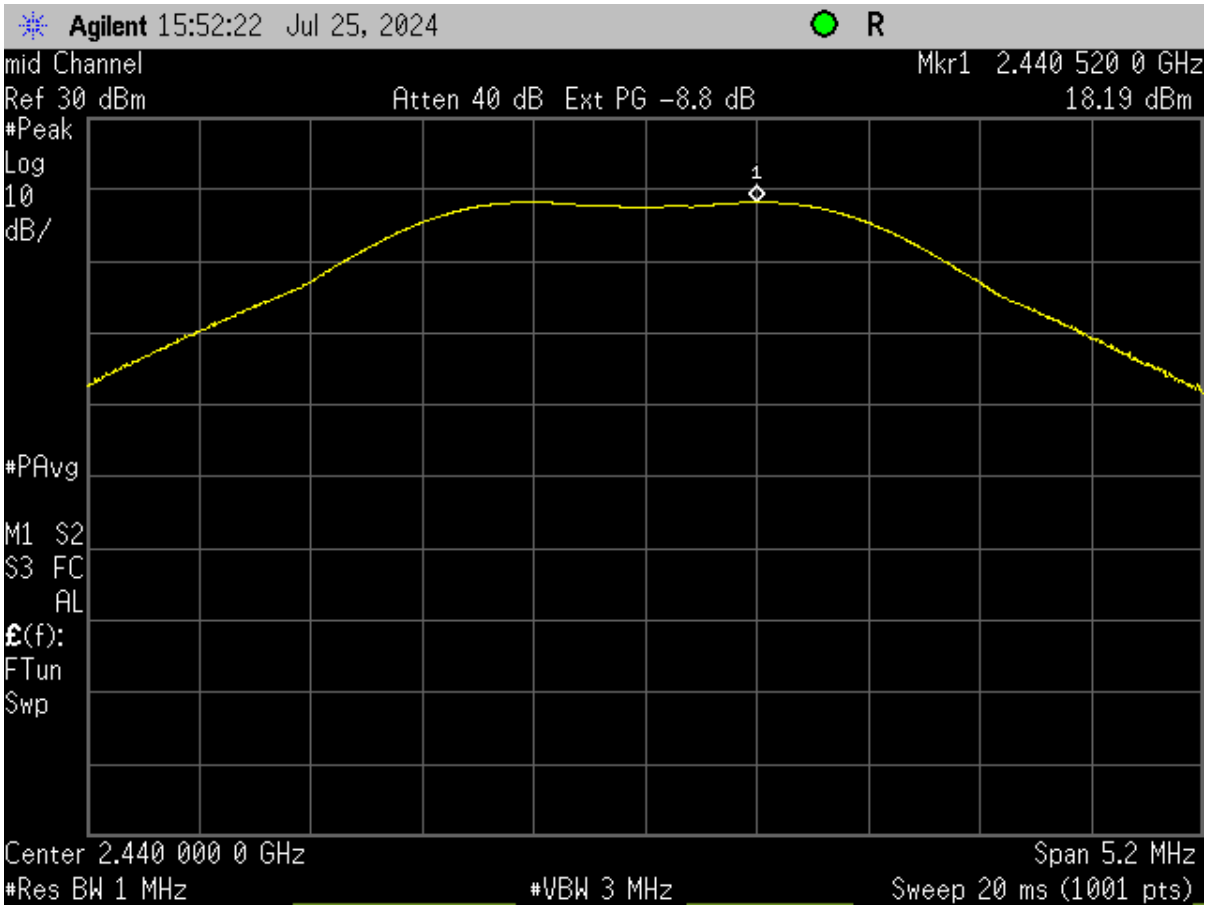


Figure 31. Mid Channel, Power Setting "20"

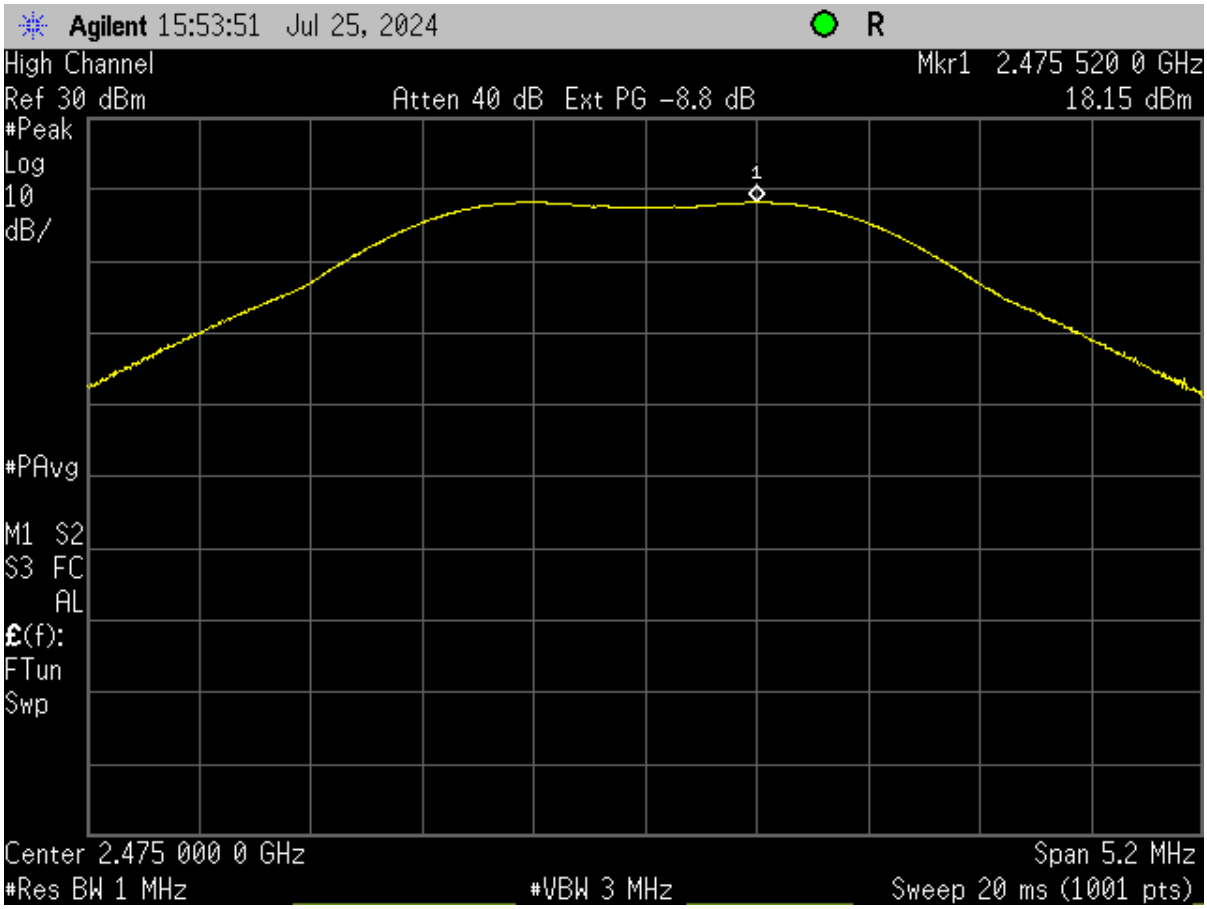


Figure 32. High Channel, Power Setting "20"

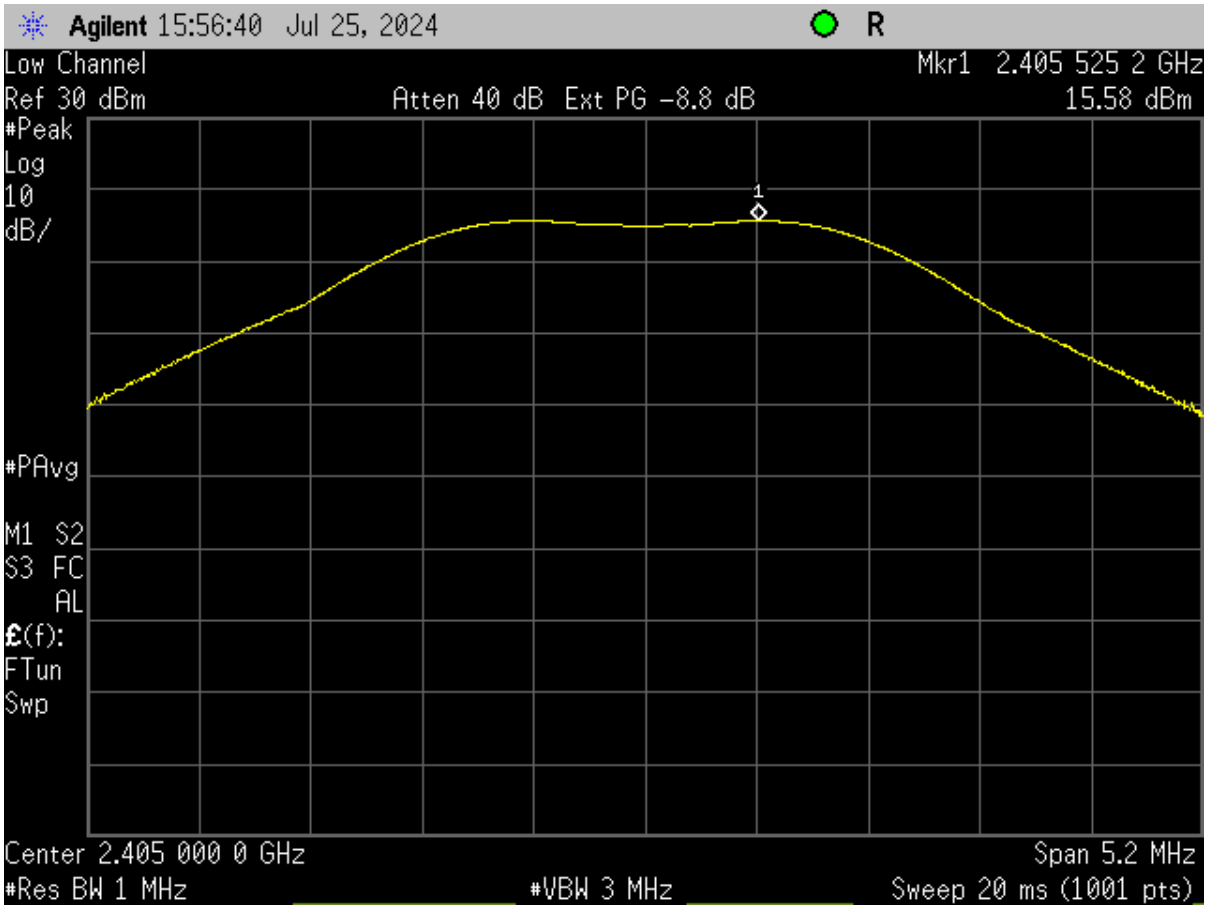


Figure 33. Low Channel, Power Setting "16"

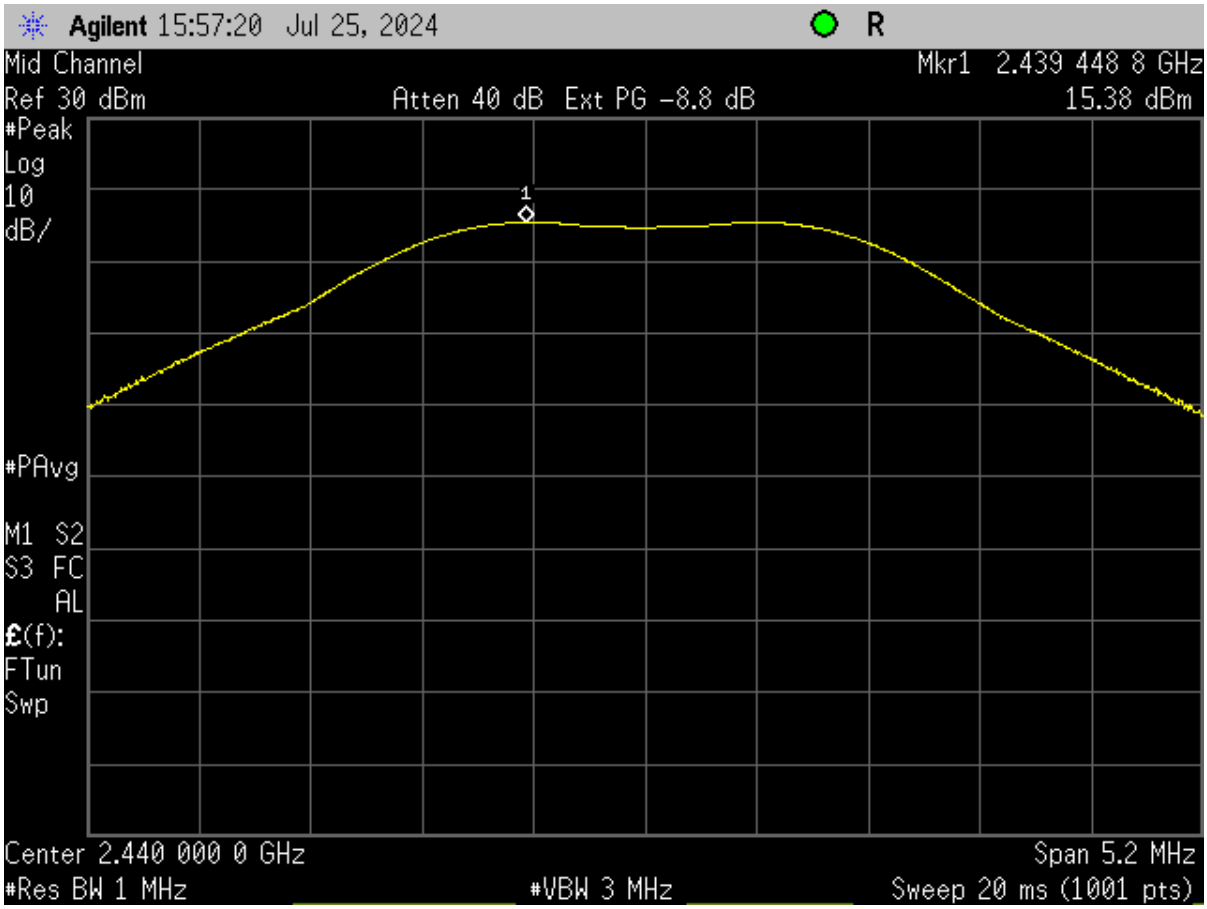


Figure 34. Mid Channel, Power Setting "16"

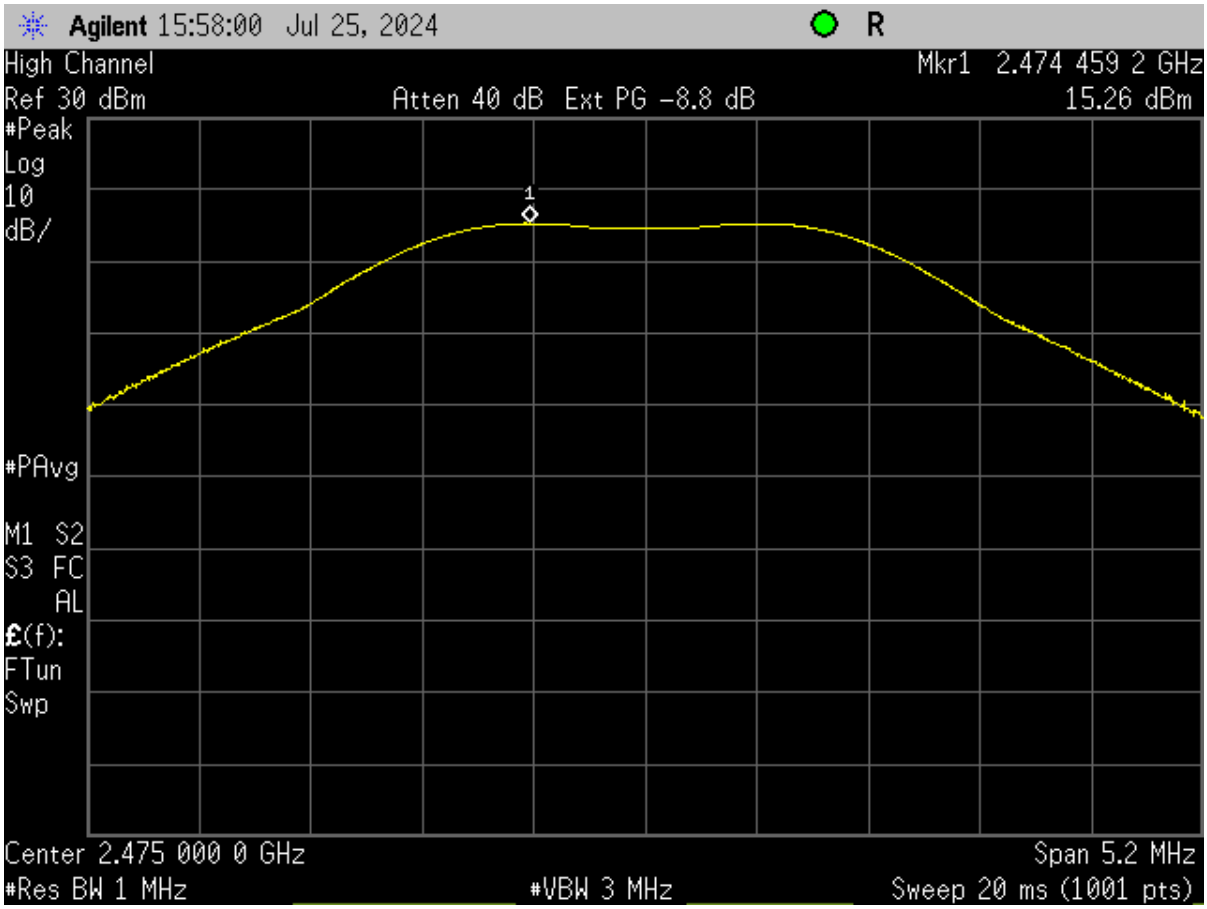


Figure 35. High Channel, Power Setting "16"

2.14.1 Power levels for each antenna

The power levels for each of the antennas listed in Table 4 is presented here. The power setting is either 16 or 20.

Table 11. Power Levels for each Antenna

REPORT REFERENCE	MANUFACTURER	TYPE OF ANTENNA	MODEL	GAIN dB_i	POWER SETTING
Antenna 1	Nearson	Dipole	S181AH-2450S	2.0	20.0
Antenna 2	Yokogawa	Omni	F9915KW	2.14	20.0
Antenna 3	Huber+Suhner	Dipole	1399.17.0237	2.0	18.5
Antenna 4	Huber+Suhner	Dipole	1324.17.0114	6.0	16.0
Antenna 5	COMROD (Mimes)	Dipole	UHF2458G	4.0	20.0
Antenna 6	Data Alliance	Dipole	A2O8Nm-MTL16N	8.0	16.0

2.15 Power Spectral Density (CFR 15.247(e), RSS-247, 5.2(b))

The transmitter was placed into a continuous mode of operation at all applicable frequencies. The measurements were performed per the procedures of ANSI C63.10-2013. The RBW was set to 3 kHz and the Video Bandwidth was set to ≥ RBW. The trace capture time was set to (Span/3 kHz).

In accordance with 15.247 (e), the power spectral density shall be no greater than +8 dBm per any 3 kHz band.

Results are shown in the table below and figures below. All are less than +8 dBm per 3 kHz band. See figures below.

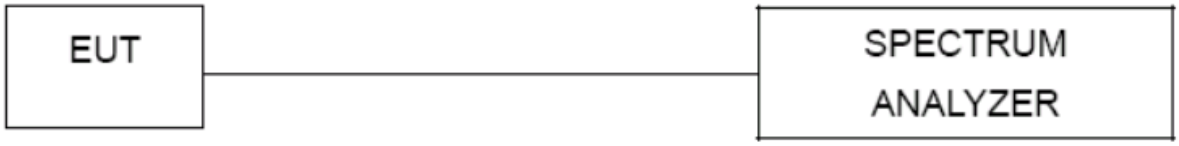


Figure 36. Bench Test Setup

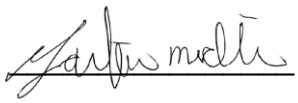
EUT power level set to “20” for all measurements. This is considered the worst case output power setting.

Table 12. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Measured Result (dBm/3kHz)	P15.247 & RSS-247 Limit (dBm/3 kHz)	Verdict
2405	+7.508	+8.0	PASS
2440	+7.251	+8.0	PASS
2475	+7.774	+8.0	PASS

Note 1: dBm/Hz correct to dBm/kHz using the following formula, 10 log RBW ref/RBW measured.
Note 2: Measurements collect at 30kHz.

Test Date: July 22, 2024

Tested by
Signature:  Name: Gabriel Medina

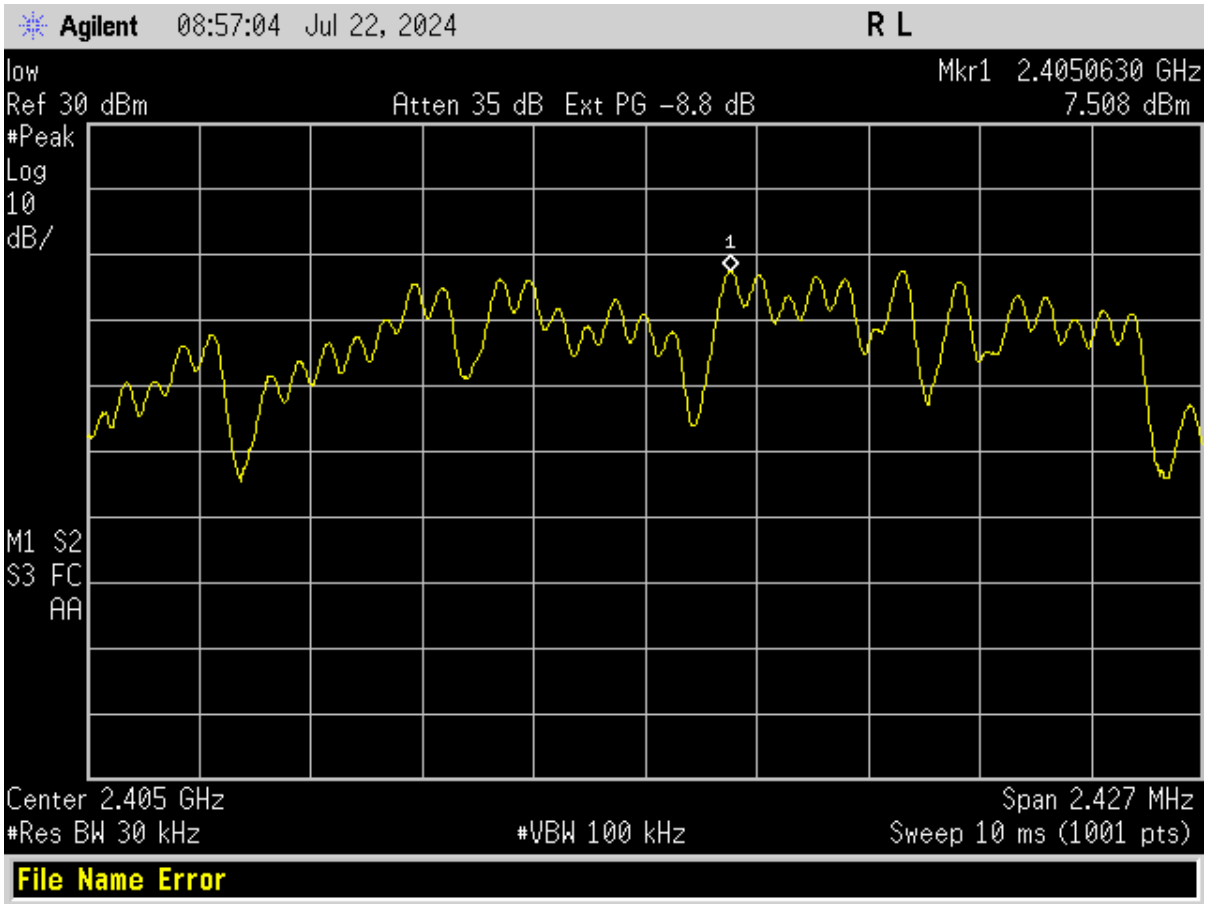


Figure 37. Power Spectral Density, Low Channel

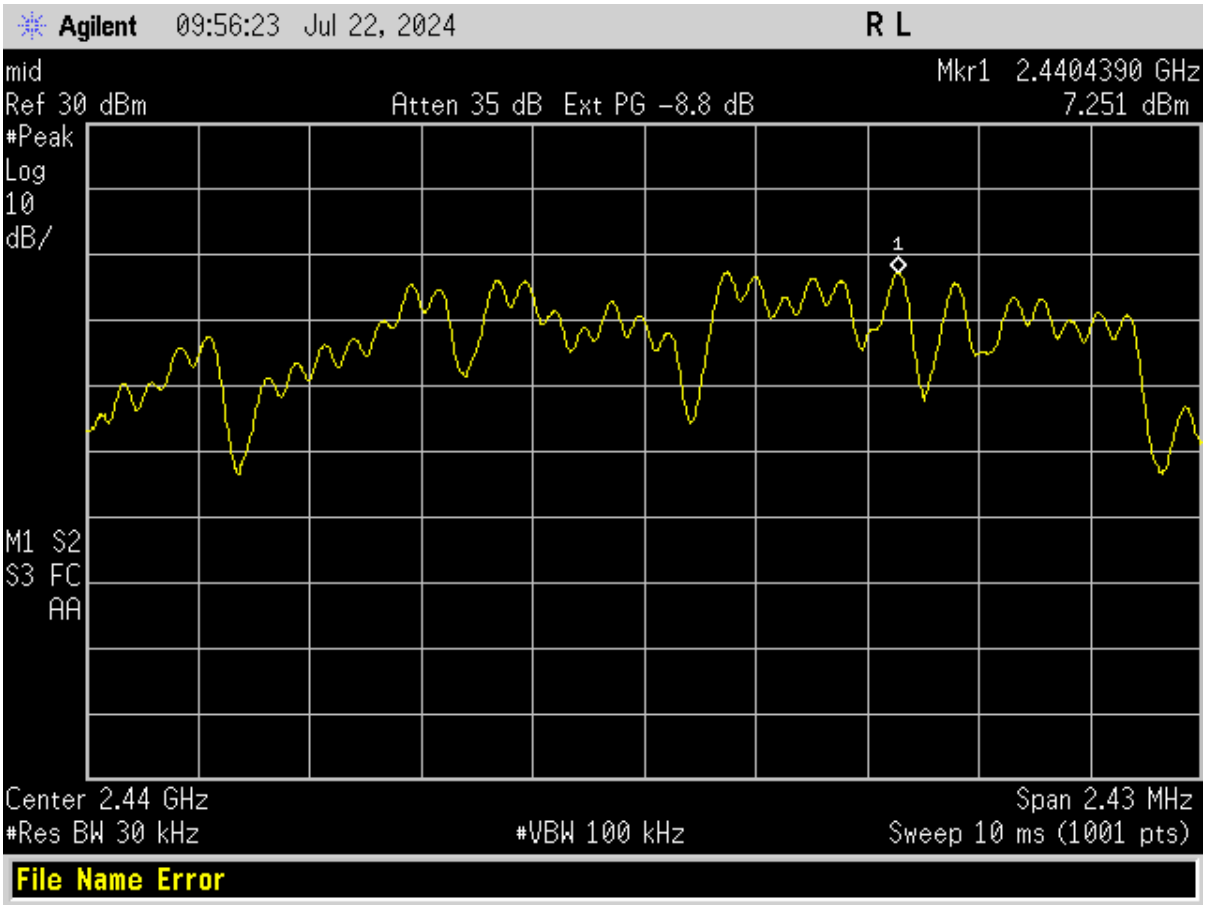


Figure 38. Power Spectral Density, Mid Channel

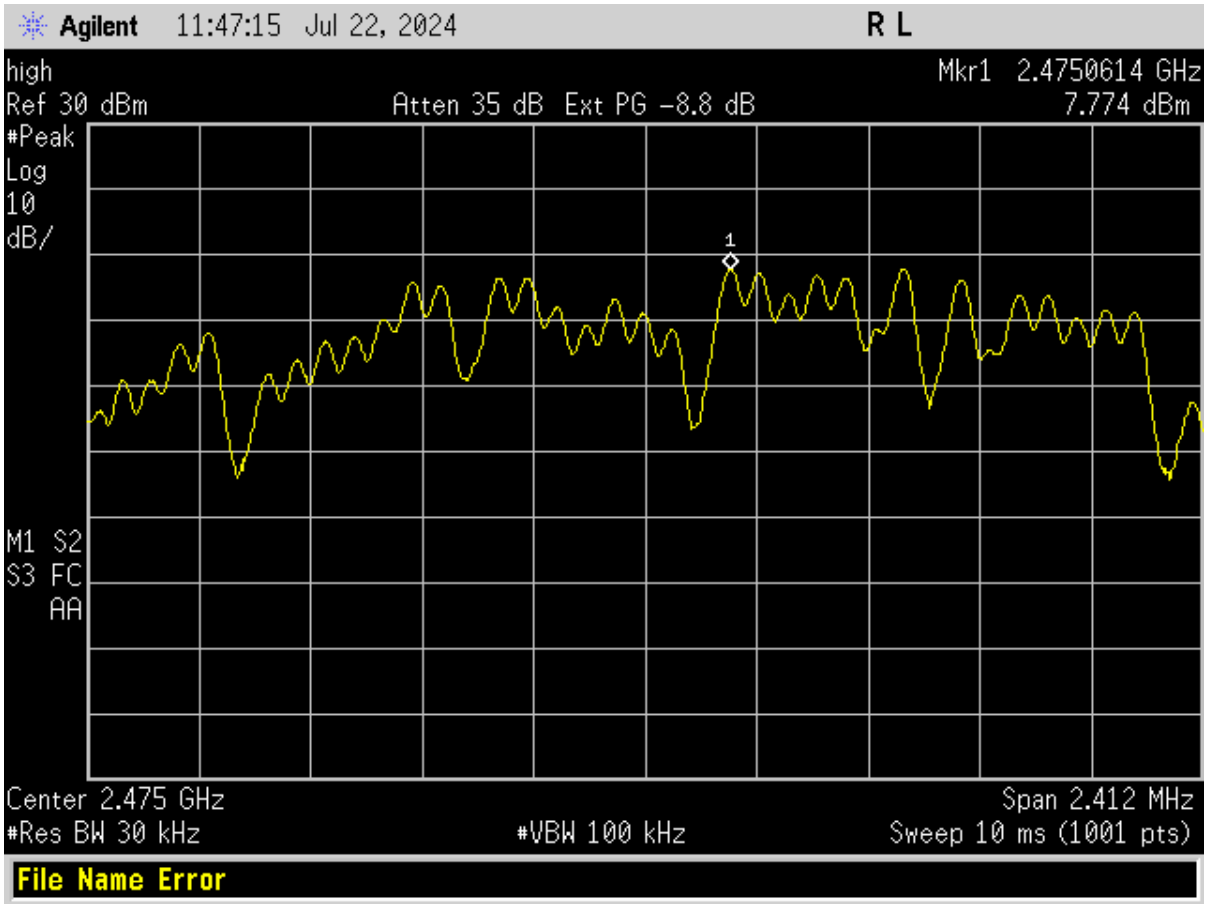


Figure 39. Power Spectral Density, High Channel

2.16 Intentional Radiator Power Lines Conducted Emissions (CFR 15.207, RSS-Gen 8.8)

The power line conducted voltage emission measurements have been carried out in accordance with CFR 15.207, per ANSI C63.10:2013, Clause 6.2, with a spectrum analyzer connected to an LISN and the EUT placed into a continuous mode of transmission.

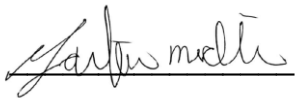
The EUT is a radio module device that has regulated power supply circuitry. The EUT does not connect to the AC mains. The EUT relies of the host device for power source. The host device must be evaluated to the applicable Part 15 Subpart once the EUT has been integrated in the host device.

Table 13. Power Line Conducted Emissions

Test: Part 15.207, RSS-Gen 8.8 Conducted Emissions 150 kHz to 30 MHz						
Frequency (MHz)	**Test Data (dBuV)**	**LISN+CL (dB)**	**Corrected Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector**
The EUT does not connect to AC mains.						

Sample Calculation: N/A

Test Date: July 22, 2024

Tested by
Signature:  Name: Gabriel Medina

2.18 Measurement Uncertainty

The measurement uncertainties given were calculated using the method detailed in CISPR 16-4-2:2011. A coverage factor of k=2 was used to give a level of confidence of approximately 95%.

2.18.1 Conducted Emissions Measurement Uncertainty

Measurement Uncertainty (within a 95% confidence level) for this test is ±2.85 dB.

2.18.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3m, the measurement uncertainty (with a 95% confidence level) for this test using a Biconical Antenna (30 MHz to 200 MHz) is ±5.2 dB. This value includes all elements of measurement.

The measurement uncertainty (with a 95% confidence level) for this test using a Log Periodic Antenna (200 MHz to 1000 MHz) is ±5.2 dB.

The measurement uncertainty (with a 95% confidence level) for this test using a Horn Antenna is ±5.2 dB.

3 Conclusions

The EUT is deemed to have met the requirements of the standards cited within the test report when tested as detailed in the present test report.