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

For the

Clean Hands Safe Hands, LLC

Model Number: Gen4 Sensor

FCC ID: 2AHQD-SENSOR4

UST Project: 22-0125
Test Dates: May 31, 2022 – June 3, 2022
Issue Date: June 6, 2022

Total Pages: 66

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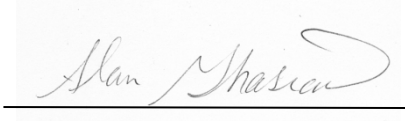
Testing Tomorrow's Technology

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

US Tech (Agent Responsible For Test):

By: 

Name: Alan Ghasiani

Title: Consulting Engineer, President

Date: June 6, 2022

NVLAP TESTING

NVLAP LAB CODE 200162-0

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MEASUREMENT TECHNICAL REPORT

COMPANY NAME: Clean Hands Safe Hands, LLC
MODEL: Gen4 Sensor
FCC ID: 2AHQD-SENSOR4
DATE: June 6, 2022

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

Equipment type: Bluetooth Low Energy transmitter Device

Technical:
BLE
2402 MHz - 2480 MHz (Channels 0-39)
Type of modulation: GFSK
Data/Bit Rate: 1 MBPS
Antenna Gain: +3.3 dBi (Trace Antenna)
Maximum Output Power: +0 dBm
Software used to program EUT: BLE-NCP
EUT firmware number: V3.x
Power setting: Maximum level

Report prepared by:
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3505 Francis Circle
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Table of Contents

List of Figures

Figures **Title** **Page**

List of Tables

List of Attachments

FCC Agency Agreement
FCC 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

1 General Information

1.1 Purpose of this Report

This report is prepared as a means of conveying test results and information concerning the suitability of this exact product for public distribution according to FCC Rules and Regulations Part 15 Subpart C, Section 15.247.

1.2 Characterization of Test Sample

The sample used for testing was received by US Tech on May 31, 2022 in good operating condition.

1.3 Product Description

The Equipment under Test (EUT) is the Clean Hands Safe Hands, LLC Model Gen4 Sensor. The purpose of the Sensor is to monitor for sensory input and scan for Clean Hands Safe Hands Badges (BLE). This data is then transmitted back over Zigbee to a central network coordinator that processes the data and forwards it on to the cloud.

The EUT incorporates both Bluetooth LE technology and 2.4 GHz Zigbee technology. This report is for the Bluetooth LE radio module.

The Bluetooth LE radio details include:

Antenna Gain: +3.3 dBi (Trace Antenna)
Bandwidth: 2 MHz bandwidth modulation
Maximum Output Power: +0 dBm

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.

A list of EUT and Peripherals is 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 also been fully described and submitted to Industry Canada (IC), and has been approved under file number 9900A-1.

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/ Clean Hands Safe Hands, LLC	GEN4 Sensor	N/A	FCC ID: 2AHQD-SENSOR4 (pending)	N/A
Antenna See antenna details	--	--	--	--

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

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 herein.

Table 2. Test Instruments

TEST INSTRUMENT	MANUFACTURER	MODEL NUMBER	SERIAL NUMBER	CALIBRATION DUE DATE
Spectrum Analyzer	Agilent	E4407B	US41442935	9/2/2022 2 yr.
Spectrum Analyzer	Hewlett-Packard	8593E	3205A00124	2/28/2024 2 yr.
RF Preamp 100 kHz To 1.3 GHz	Hewlett-Packard	8447D	1937A02980	6/9/2022
Preamp 1.0 GHz To 26.0 GHz	Hewlett-Packard	8449B	3008A00480	2/11/2023
Biconical Antenna	EMCO	3110B	9307-1431	11/11/2022 2 yr.
Log Periodic Antenna	EMCO	3146	9110-3236	12/13/2023 2 yr.
Horn Antenna	EMCO	SAS-571	605	4/28/2024 2 yr.
High Pass Filter	Microwave Circuits	H3R020G2	001DC9528	7/16/2022
SMA Fixed Attenuator 8 dB 50 Ohm	Mini-Circuits Inc.	VAT-8 15542	3 0519	8/10/2022

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 requirements.

2.3 Number of Measurements for Intentional Radiators (15.31(m))

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

Because the EUT operates over 2.402 GHz to 2.480 GHz, 3 test frequencies will be used.

2.4 Frequency Range of Radiated Measurements (Part 15.33)

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 10th 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)

The radiated and conducted emissions limits shown herein 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 EUT Antenna Requirements (CFR 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. 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	Clean Hands Safe Hands, LLC	PCB Trace	Inverted F type	+3.3	PCB Trace

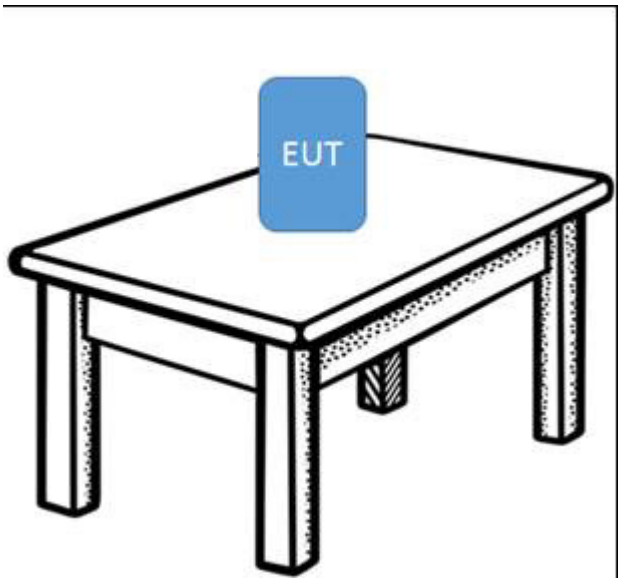


Figure 1. Block Diagram of Test Configuration

2.7 Restricted Bands of Operation (Part 15.205)

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.

2.8 Transmitter Duty Cycle (Part15.35 (c))

The EUT employs pulse transmission however for testing purpose 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.

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

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 generate 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).

All harmonics/spurs must be at least 20 dB down from the highest emission level within the authorized band.

Figure 2. Block Diagram of Conducted Radio Measurement

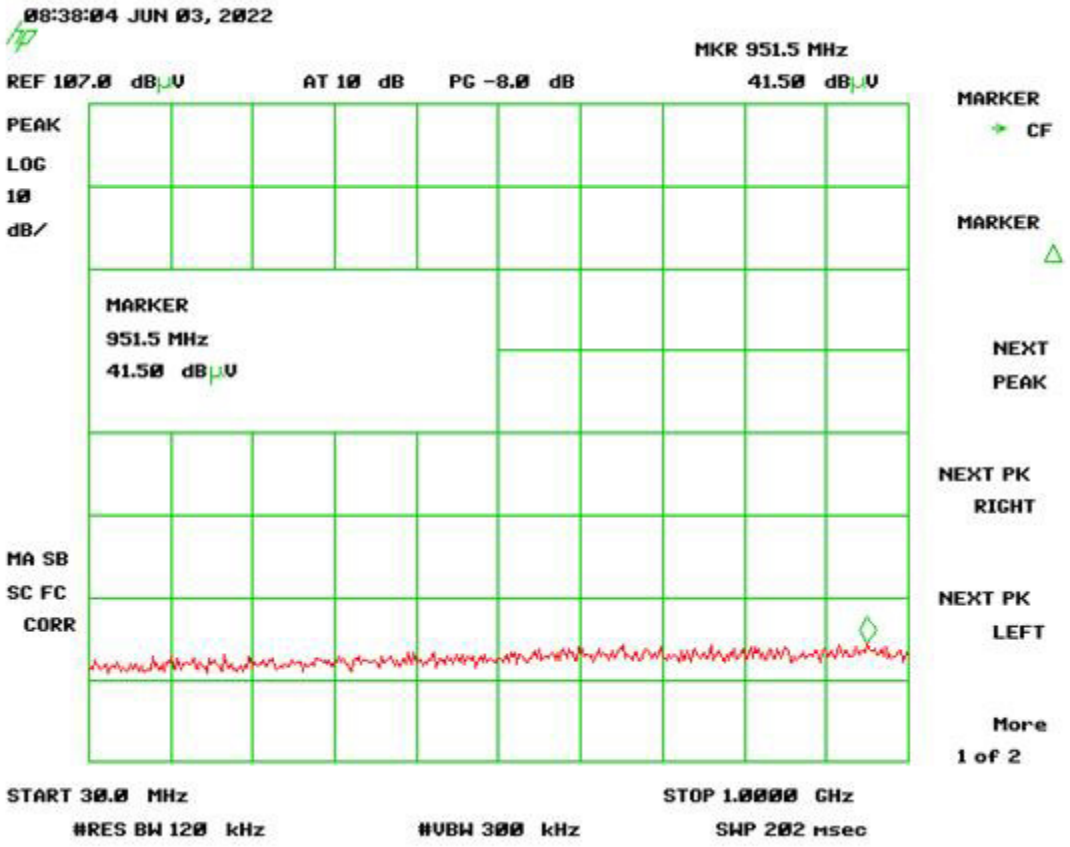


Figure 3. Channel 37, 30 MHz -1 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.407 GHz): 104.81 – 107 = -2.19 dBm
Spur measurement (951.5 MHz): 41.50 – 107 = -65.5 dBm

Fundamental	-2.19	dB
Spur	+(-65.5)	dB
Difference	67.69	dB
Limit	-20.00	dB
Margin	47.69	dB

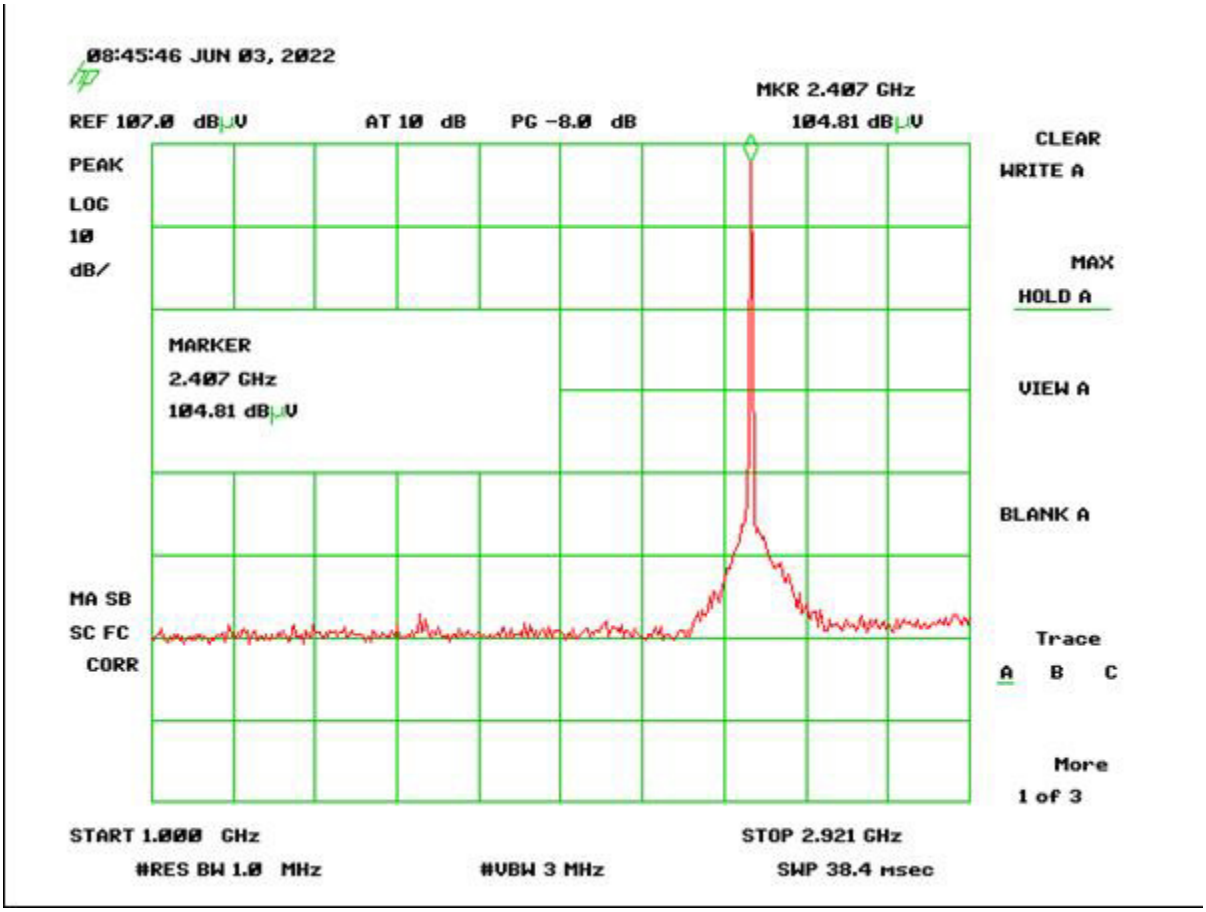


Figure 4. Channel 37, 1 GHz – 2.921 GHz

(Note: Intentional Emission seen for radio operating at 2405 MHz)

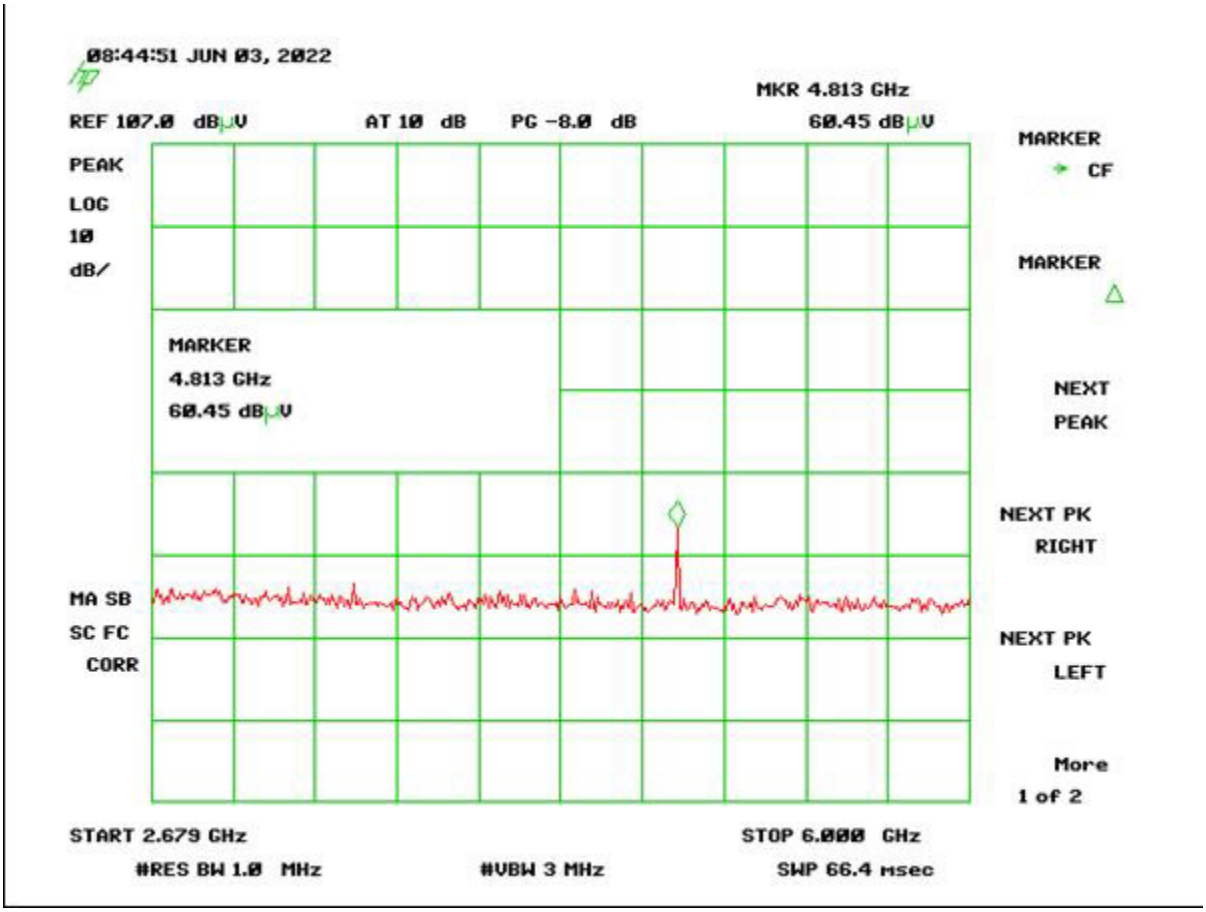


Figure 5. Channel 37, 2.679 - 6 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.407 GHz): 104.81 – 107 = -2.19 dBm
Spur measurement (4.813 GHz): 60.45 – 107 = -46.55 dBm

Fundamental	-2.19	dB
Spur	+(-46.55)	dB
Difference	48.74	dB
Limit	-20.00	dB
Margin	28.74	dB

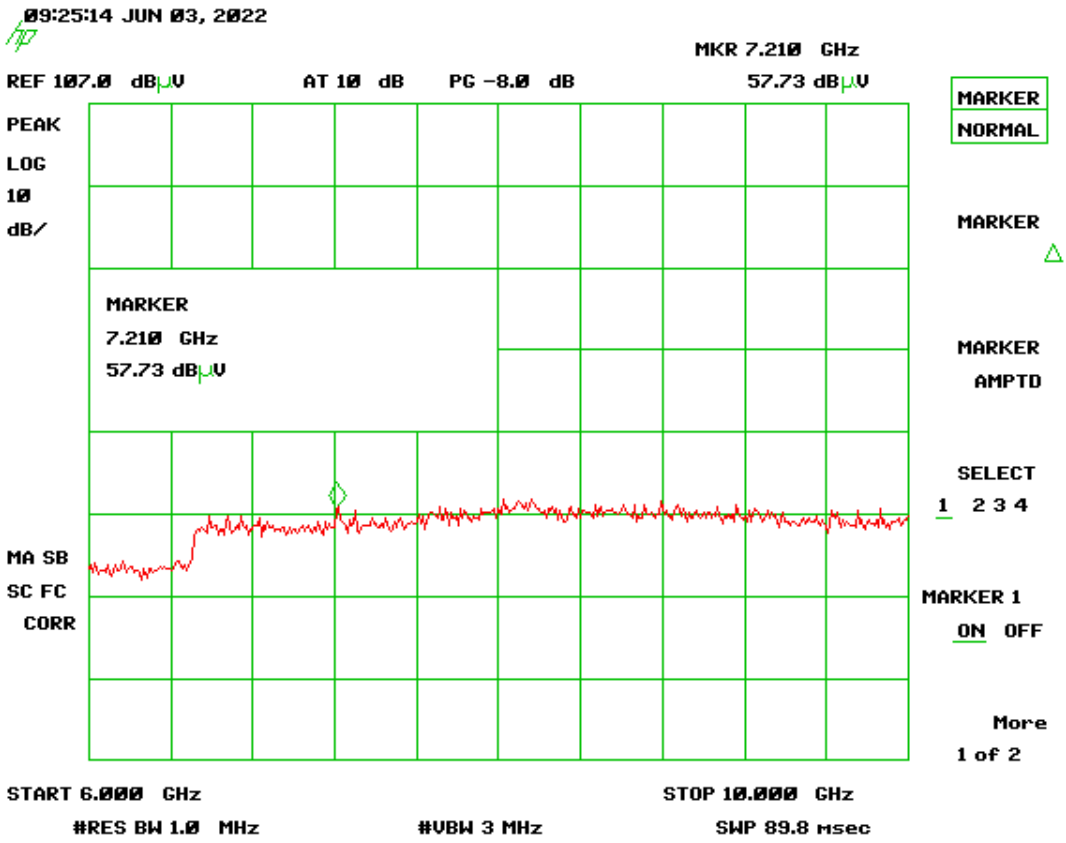


Figure 6. Channel 37, 6 GHz -10 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.407 GHz): 104.81 – 107 = -2.19 dBm
Spur measurement (7.210 GHz): 57.73 – 107 = -49.27 dBm

Fundamental	-2.19	dB
Spur	+(-49.27)	dB
Difference	51.46	dB
Limit	-20.00	dB
Margin	31.46	dB

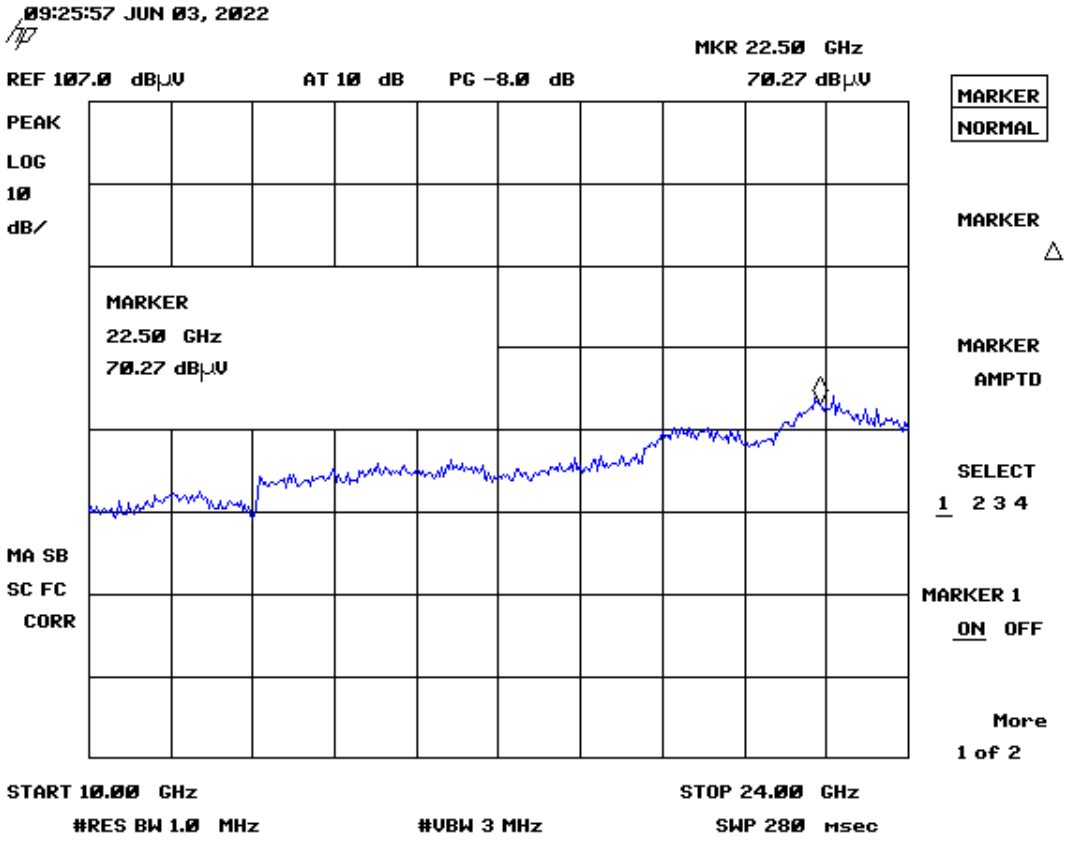


Figure 7. Channel 37, 10GHz -24 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.407 GHz): 104.81 – 107 = -2.19 dBm
Spur measurement (22.50 GHz): 70.27 – 107 = -36.73 dBm

Fundamental	-2.19	dB
Spur	+(-36.73)	dB
Difference	38.92	dB
Limit	-20.00	dB
Margin	18.92	dB

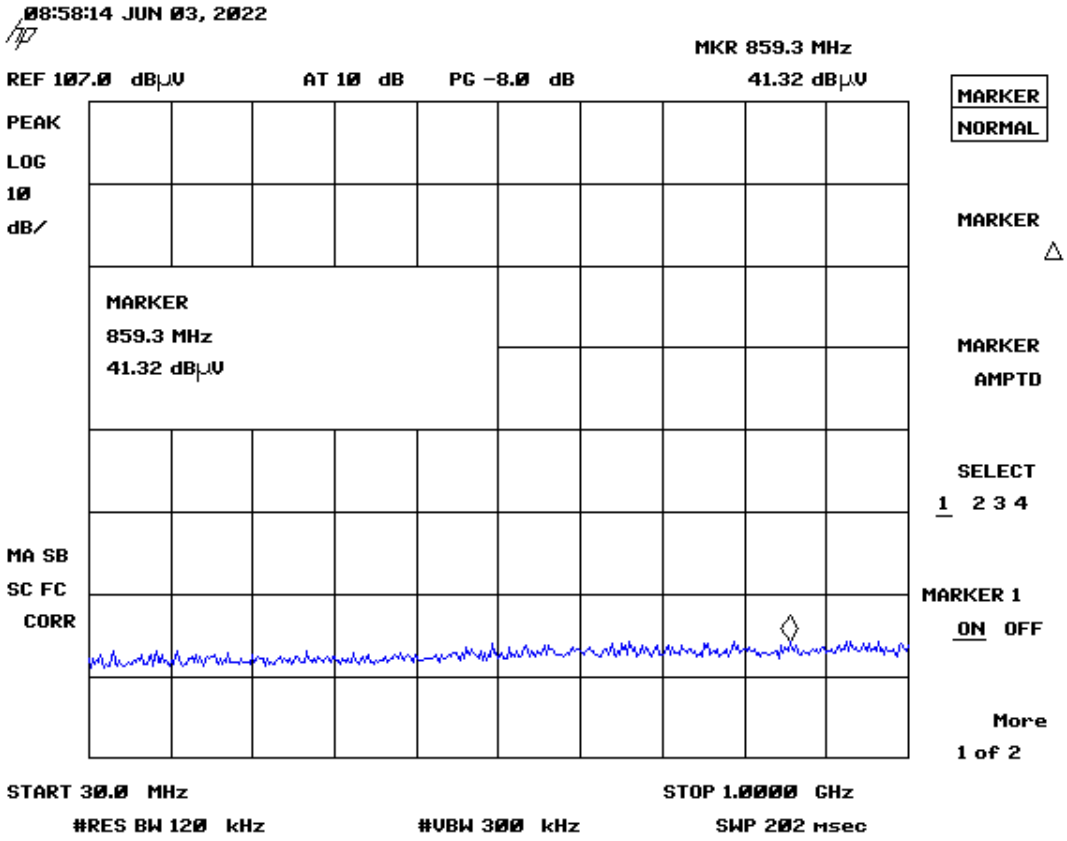


Figure 8. Channel 17, 30 MHz -1 GHz

(Note: Intentional Emission seen for radio operating at 2442 MHz)

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.446 GHz): 104.42 – 107 = -2.58 dBm
Spur measurement (859.3 MHz): 41.32 – 107 = -65.68 dBm

Fundamental	-2.58	dB
Spur	+(-65.68)	dB
Difference	68.26	dB
Limit	-20.00	dB
Margin	48.26	dB

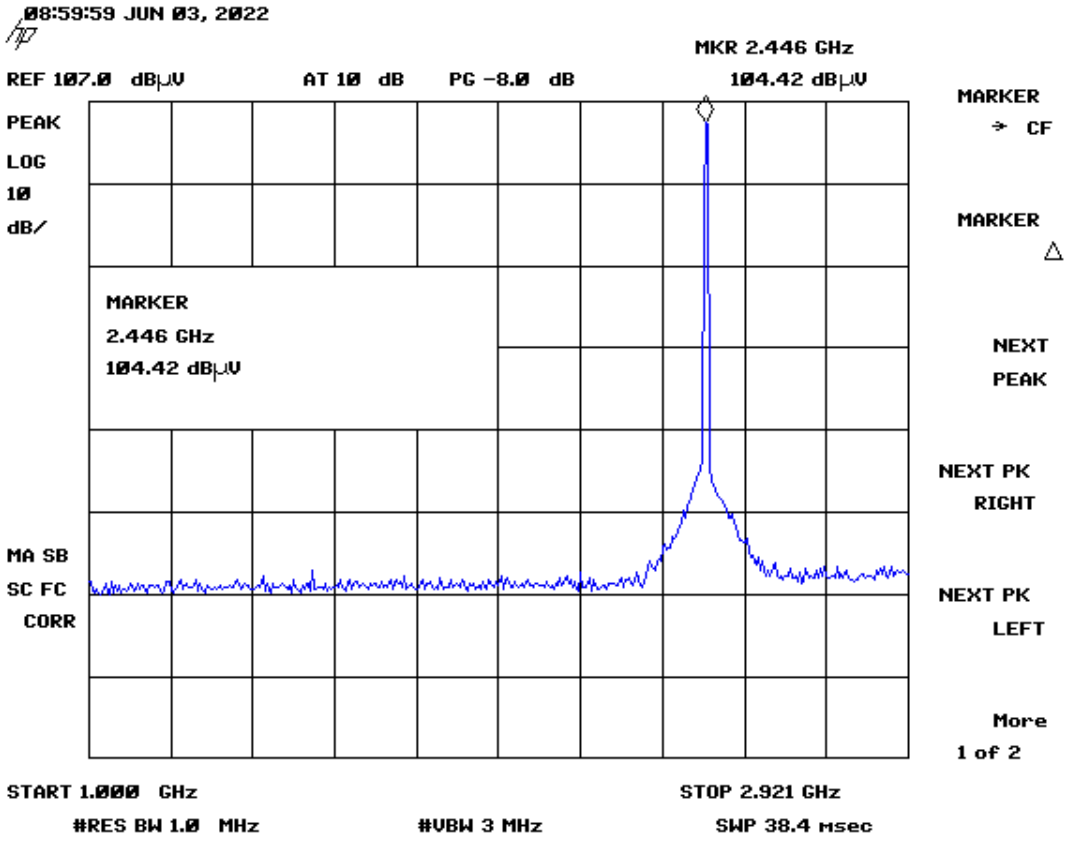


Figure 9. Channel 17, 1-2.921 GHz

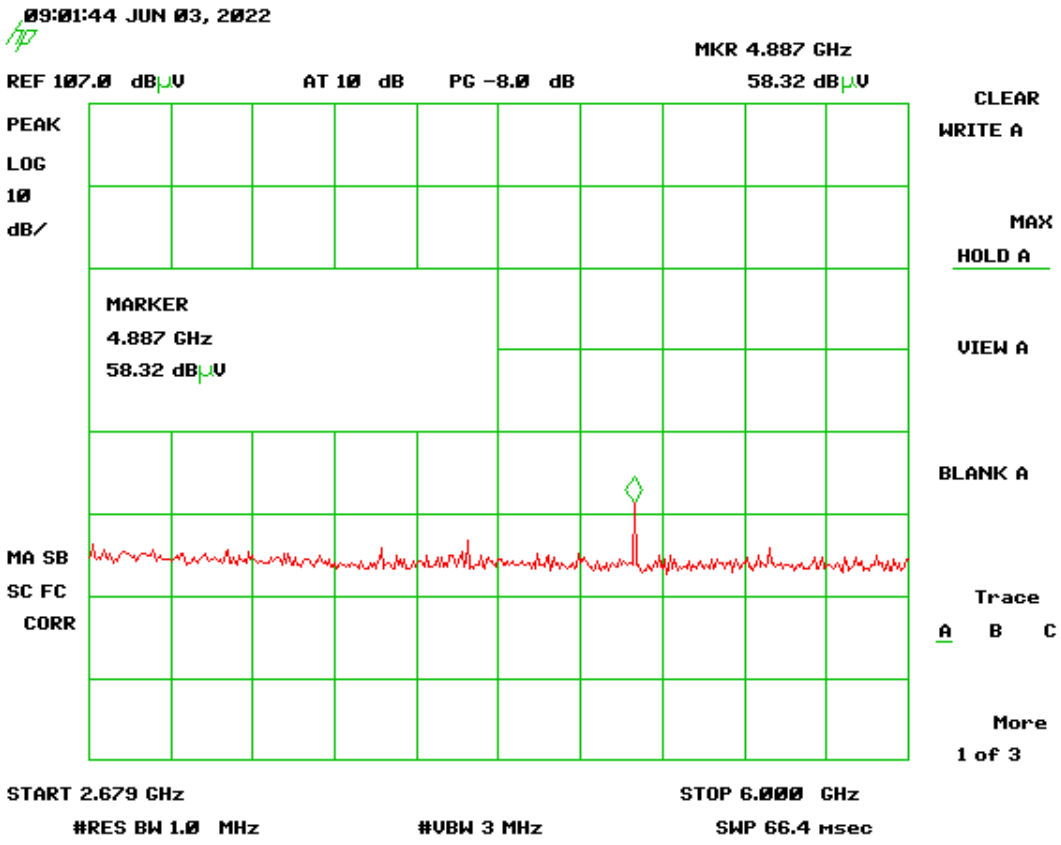


Figure 10. Channel 17, 2.6-6 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.446 GHz): 104.42 – 107 = -2.58 dBm
Spur measurement (4.887 GHz): 58.32 – 107 = -48.68 dBm

Fundamental	-2.58	dB
Spur	+(-48.68)	dB
Difference	51.26	dB
Limit	-20.00	dB
Margin	31.26	dB

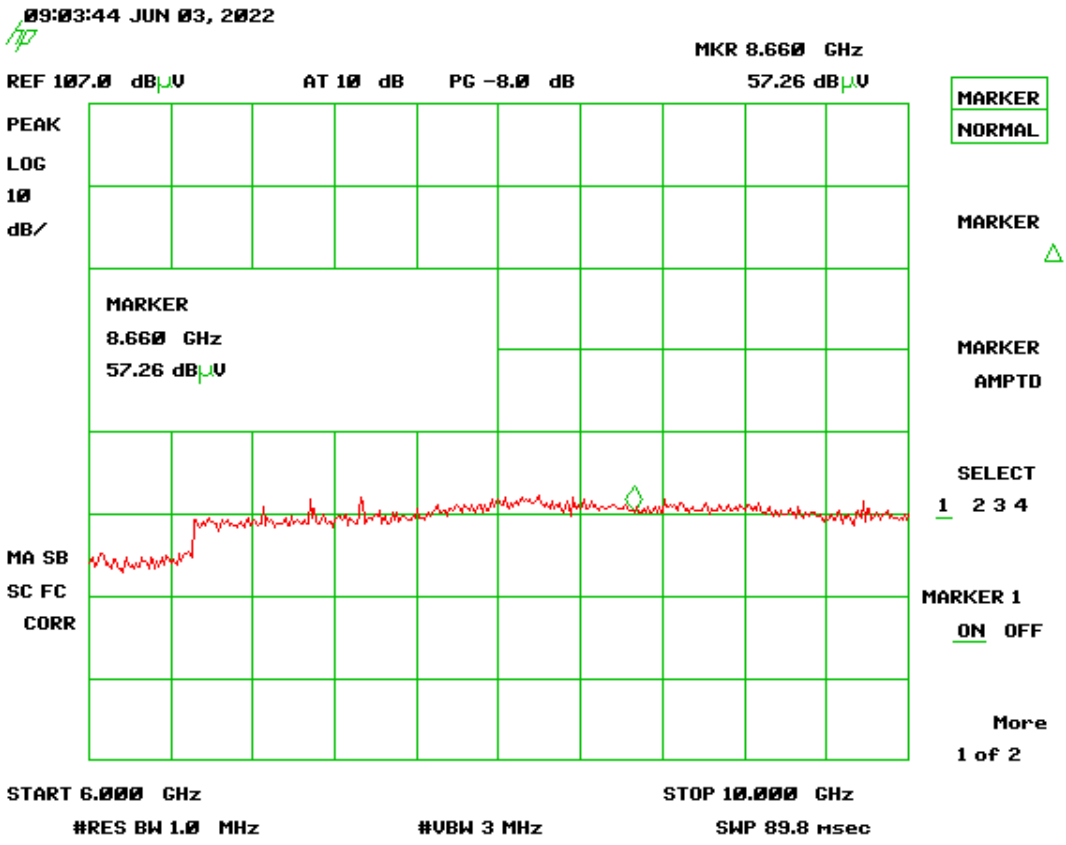


Figure 11. Channel 17, 6 GHz -10 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.446 GHz): 104.42 – 107 = -2.58 dBm
Spur measurement (8.660 GHz): 57.26 – 107 = -49.74 dBm

Fundamental	-2.58	dB
Spur	+(-49.74)	dB
Difference	52.32	dB
Limit	-20.00	dB
Margin	32.32	dB

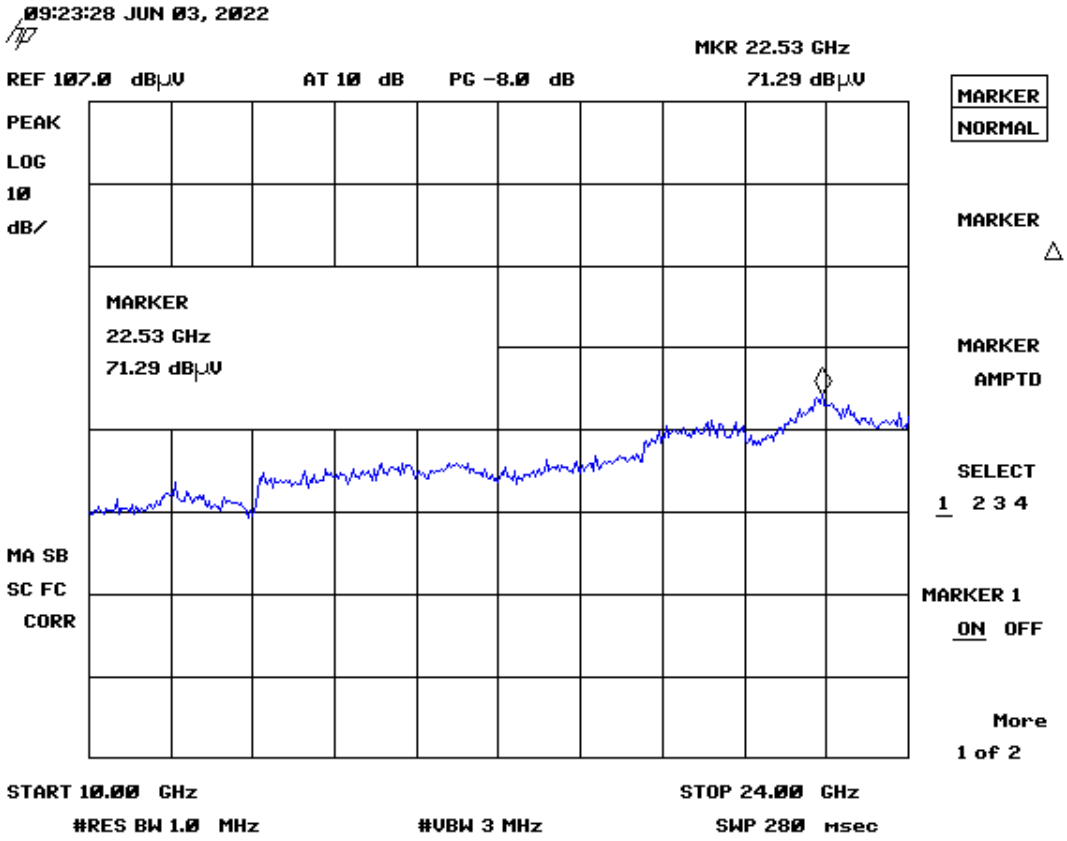


Figure 12. Channel 17, 10GHz -24 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.446 GHz): 104.42 – 107 = -2.58 dBm
Spur measurement (22.53 GHz): 71.29 – 107 = -35.71 dBm

Fundamental	-2.58	dB
Spur	+(-35.71)	dB
Difference	38.29	dB
Limit	-20.00	dB
Margin	18.29	dB

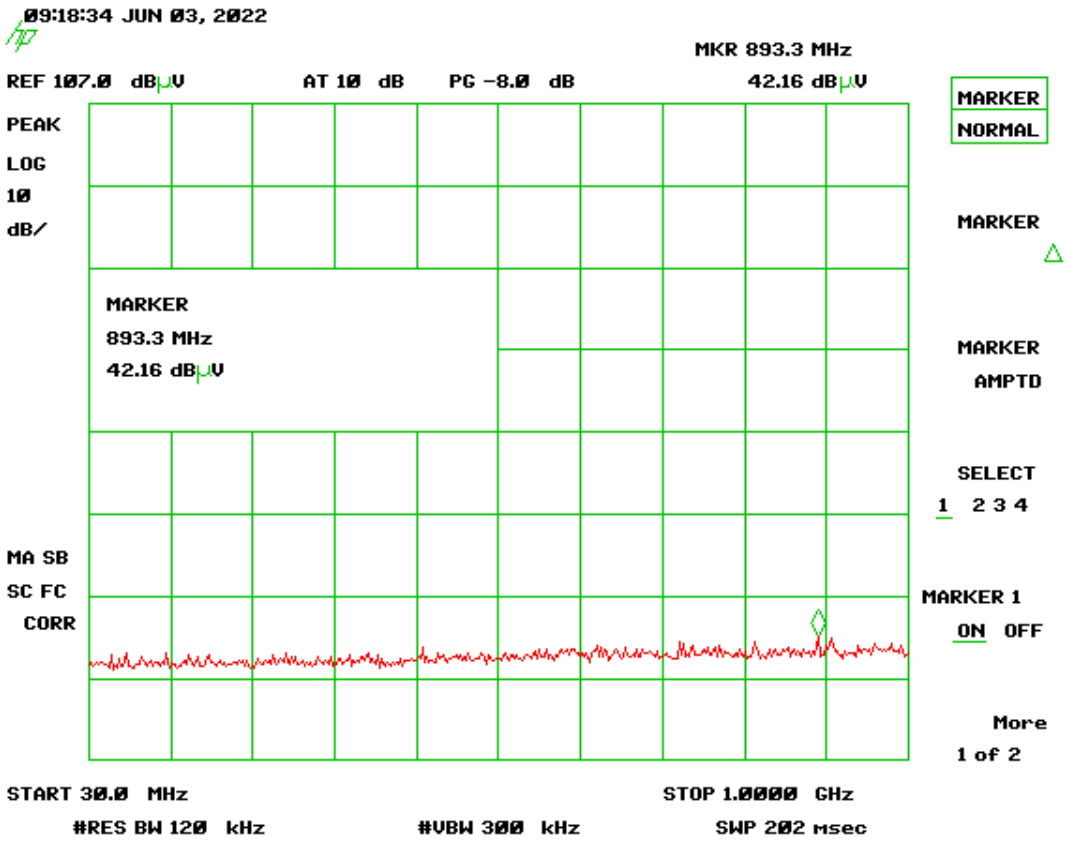


Figure 13. Channel 39, 30 MHz -1 GHz

(Note: Intentional Emission seen for radio operating at 2480 MHz)
Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.484 GHz): 104.12 – 107 = -2.88 dBm
Spur measurement (517.4 MHz): 42.16 – 107 = - 64.84 dBm

Fundamental	-2.88	dB
Spur	+ (- 64.84)	dB
Difference	67.72	dB
Limit	-20.00	dB
Margin	47.72	dB

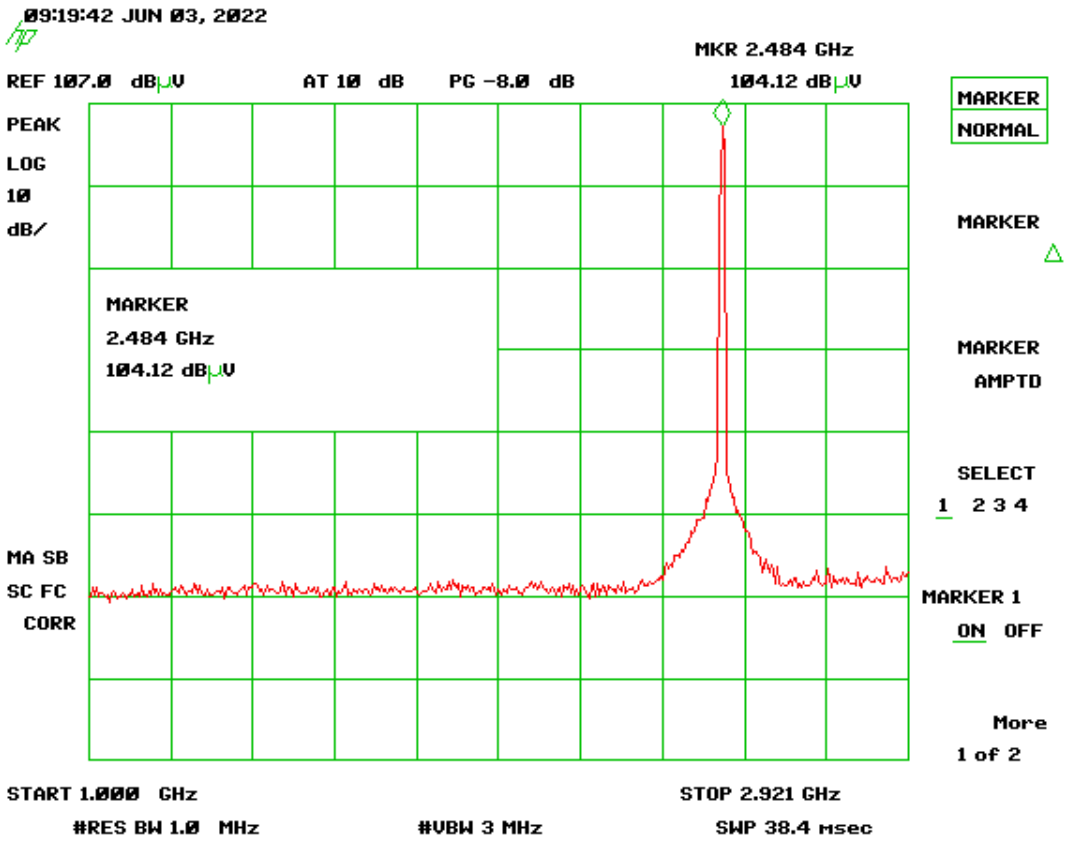


Figure 14. Channel 39, 1 GHz – 2.921 GHz

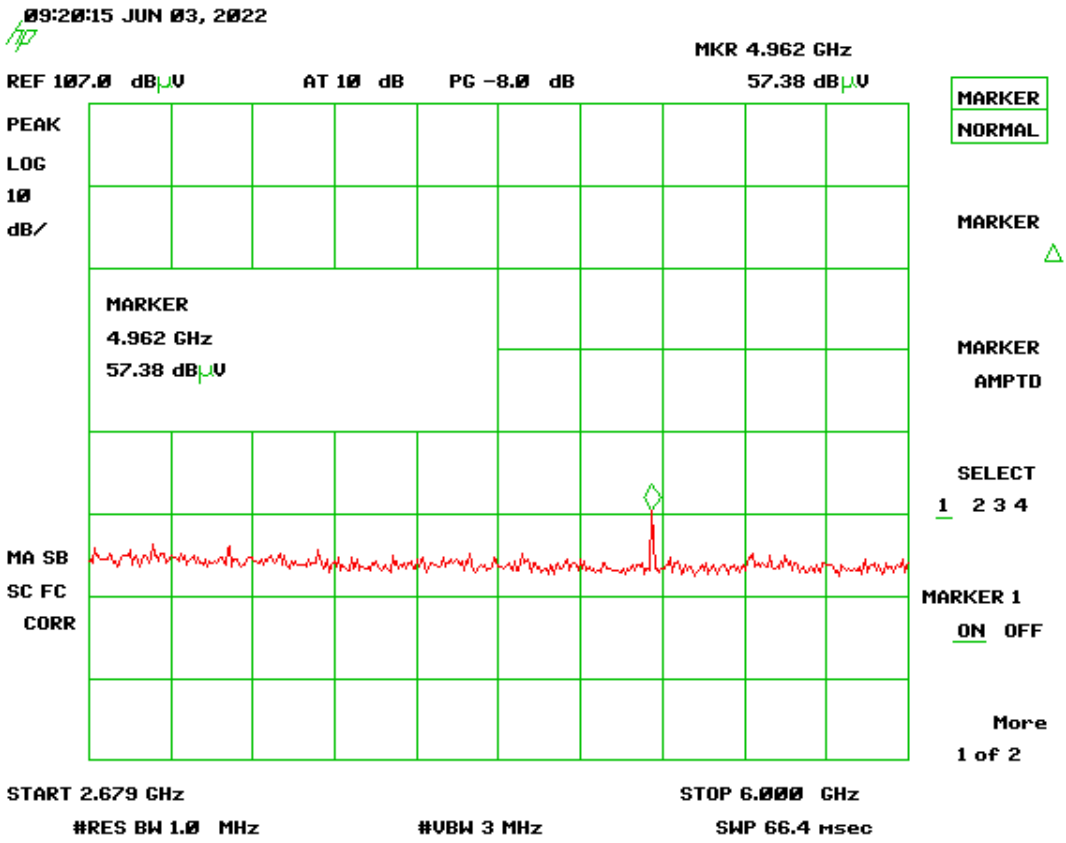


Figure 15. Channel 39 2.679 GHz -6 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.484 GHz): 104.12 – 107 = -2.88 dBm
Spur measurement (4.692 GHz): 57.38 – 107 = - 49.62 dBm

Fundamental	-2.88	dB
Spur	+ (- 49.62)	dB
Difference	52.50	dB
Limit	-20.00	dB
Margin	32.50	dB

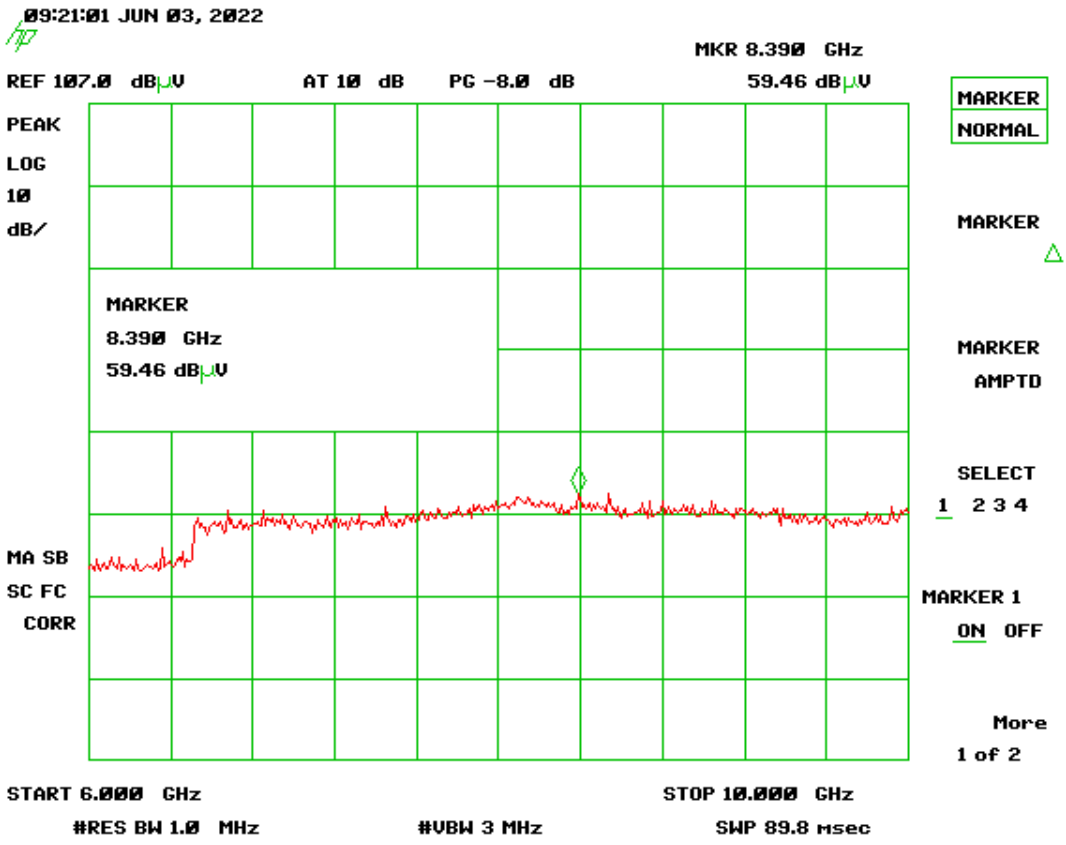


Figure 16. Channel 39, 6 GHz -10 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.484 GHz): 104.12 – 107 = -2.88 dBm
Spur measurement (8.390 GHz): 59.46 – 107 = - 47.54 dBm

Fundamental	-2.88	dB
Spur	+ (- 47.54)	dB
Difference	50.42	dB
Limit	-20.00	dB
Margin	30.42	dB

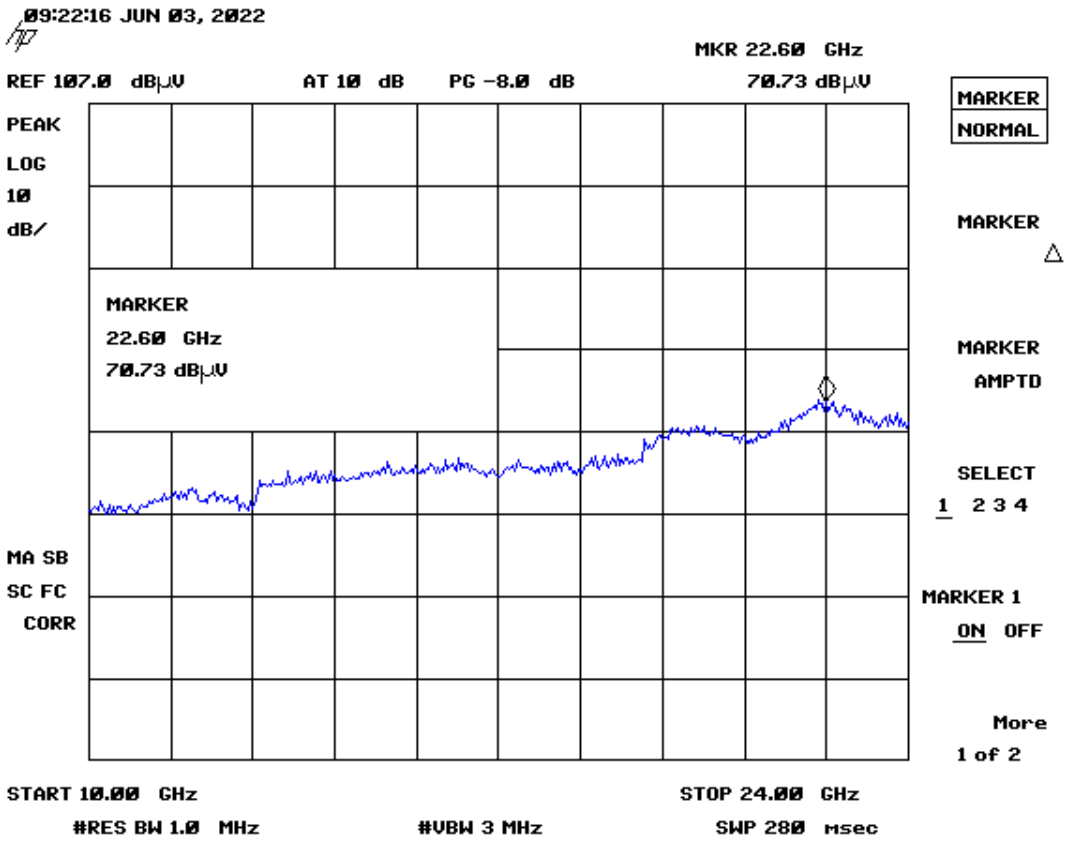


Figure 17. Channel 39, 10 GHz -24 GHz

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
Fundamental conversion (2.484 GHz): 104.12 – 107 = -2.88 dBm
Spur measurement (22.60 GHz): 70.73 – 107 = - 36.27 dBm

Fundamental	-2.88	dB
Spur	+ (- 36.27)	dB
Difference	39.15	dB
Limit	-20.00	dB
Margin	19.15	dB

2.10 Intentional Radiator, Radiated Emissions (CFR 15.209, 15.247(d))

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 > 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. Also, the EUT was rotated about its Y-axis while monitoring the Spectrum Analyzer display for maximum. The EUT azimuth was recorded for reproducibility purposes. The EUT was measured when both maxima were simultaneously satisfied.

For radiated measurements, the EUT was set into a continuous transmission mode. 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 6below.

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.

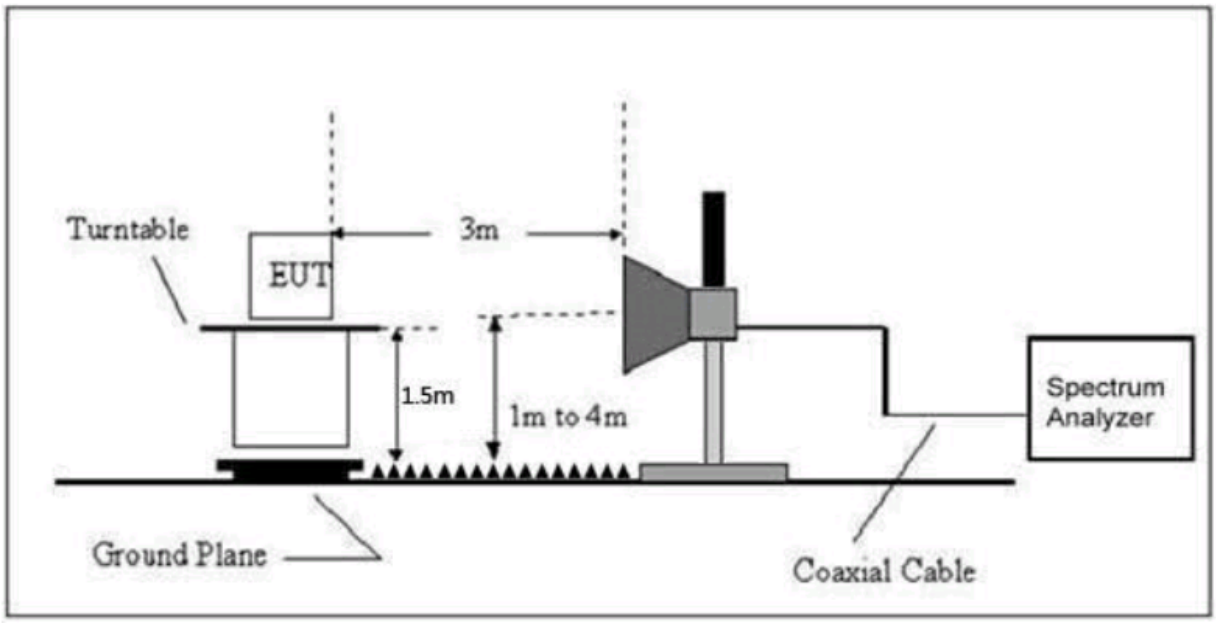


Figure 18. Block Diagram of Radiated Intentional measurements above 1 GHz

Table 5. Radiated Fundamental & Harmonic Emissions

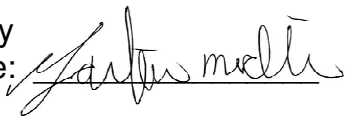
Test: FCC Part 15,247(d)								
Frequency (MHz)	**Test Data (dBuV)**	**Additional Factor**	**AF+CL-PA (dB/m)**	**Corrected Results (dBuV/m)**	**AVG Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**Detector**
Low Channel								
2402.00	96.17	0.00	-7.91	88.26	--	3.0m./VERT	--	**PK**
4799.00	50.87	0.00	-3.33	47.54	54.0	3.0m./VERT	6.5	**PK**
7209.00	50.76	-9.50	3.71	44.97	54.0	1.0m./VERT	9.0	**PK**
Mid Channel								
2441.00	88.98	0.00	-8.04	80.94	--	3.0m./HORZ	--	**PK**
4883.00	49.01	0.00	-3.87	45.14	54.0	3.0m./HORZ	8.9	**PK**
7329.00	50.26	-9.50	3.73	44.49	54.0	1.0m./HORZ	9.5	**PK**
High Channel								
2480.00	85.66	0.00	-7.75	77.91	--	3.0m./HORZ	--	**PK**
4957.00	50.53	0.00	-3.83	46.70	54.0	3.0m./HORZ	7.3	**PK**
7439.00	50.49	-9.50	2.71	43.70	54.0	1.0m./HORZ	10.3	**PK**

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 worst case.
4. Measurement at 1 meters corrected using inverse extrapolation factor of -9.5 dB to correct the value for 3 meter.
5. Peak detected measurements meet AVG limits.

Sample Calculation at 2402.00 MHz:

Magnitude of Measured Frequency	96.17	dBuV
+Additional Factor	0.00	dB
+Antenna Factor + Cable Loss+ Amplifier Gain	-7.91	dB/m
Corrected Result	88.26	dBuV/m

Test Date: June 1, 2022

Tested By
Signature:  Name: Gabriel Medina

2.11 Band Edge and Restricted Band Measurements (CFR 15.247(d))

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 test is 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 antenna is connected to its antenna port during testing. The EUT was set to its highest rated output power level during testing. The results are collected and presented below.

All measurements below were collected using radiated methods.

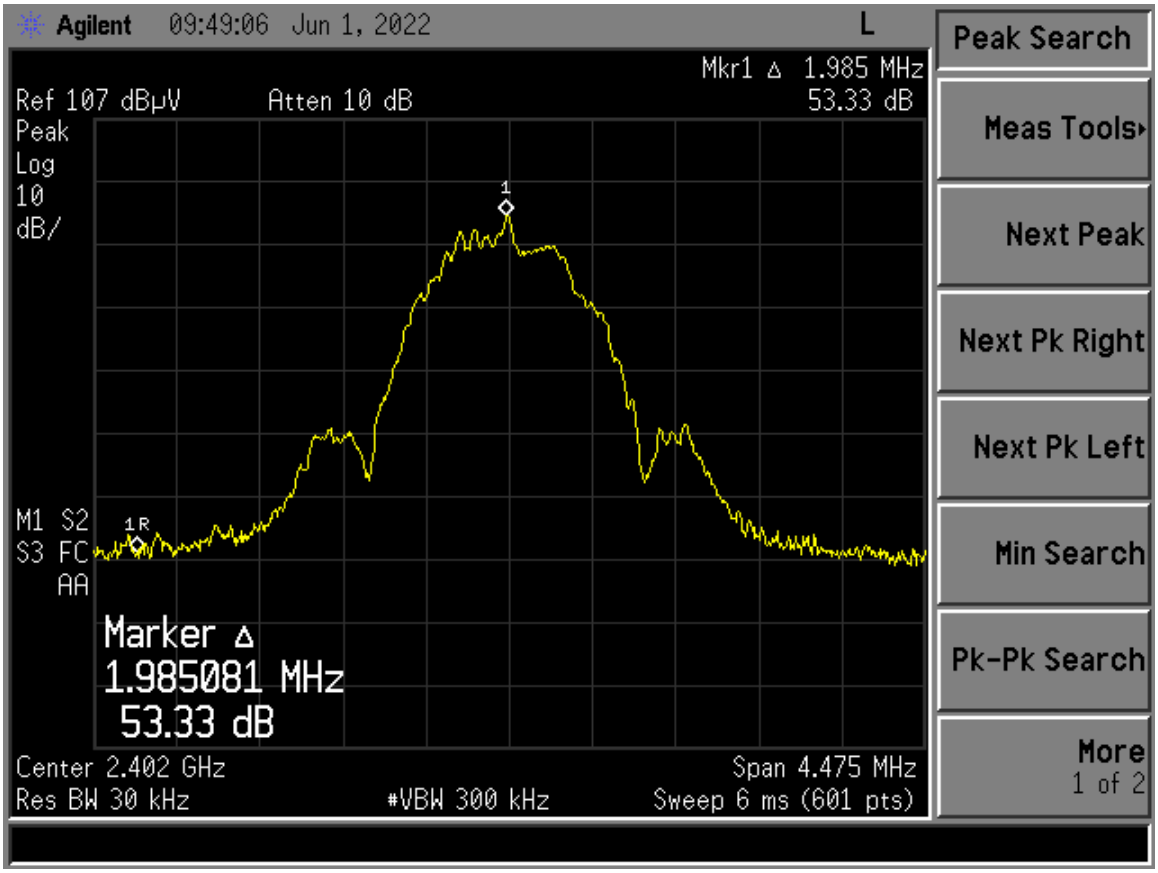


Figure 19. Band Edge Compliance – Low Channel Delta – Peak (Horizontal)

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

Measured Result	53.33	dB
Band Edge Limit	-20.00	dB
Band Edge Margin	33.33	dB

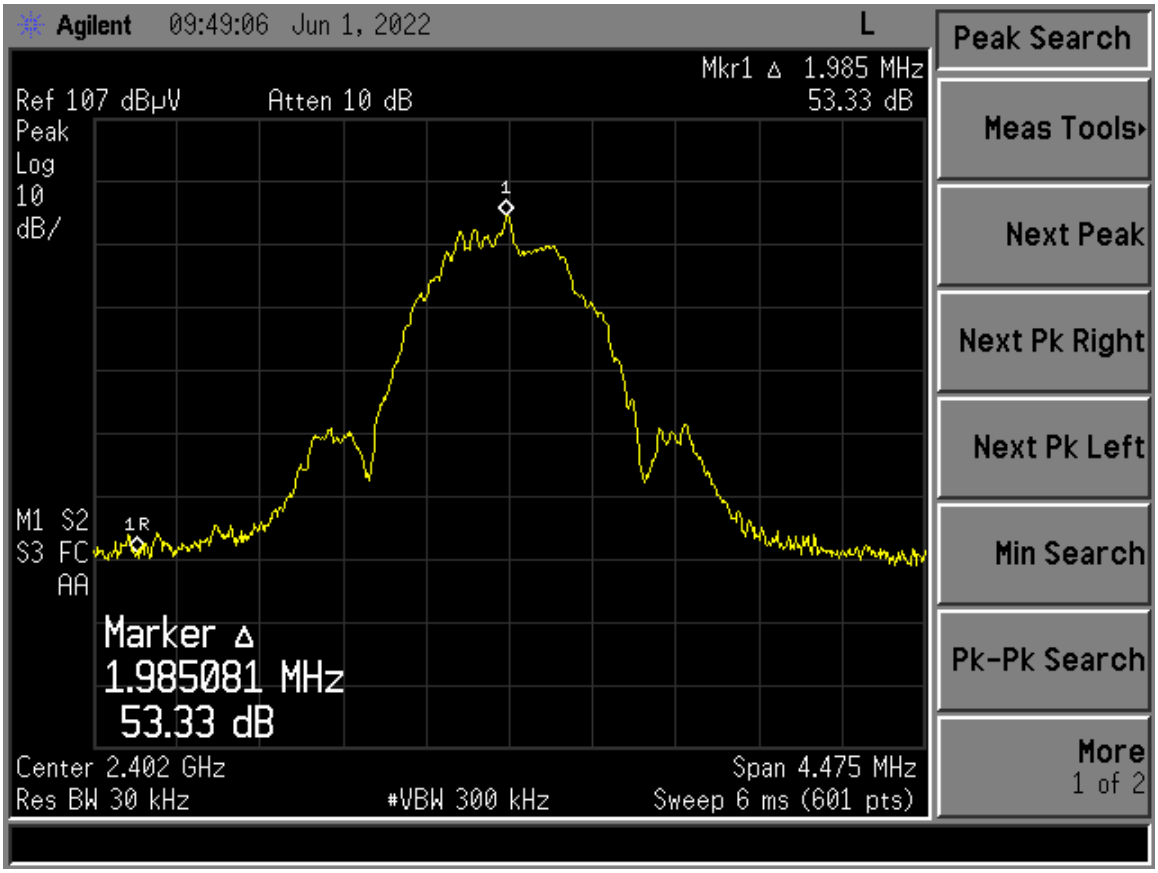


Figure 20. Band Edge Compliance – Low Channel Delta – Peak (Vertical)

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

Measured Result	53.33	dB
Band Edge Limit	-20.00	dB
Band Edge Margin	33.33	dB

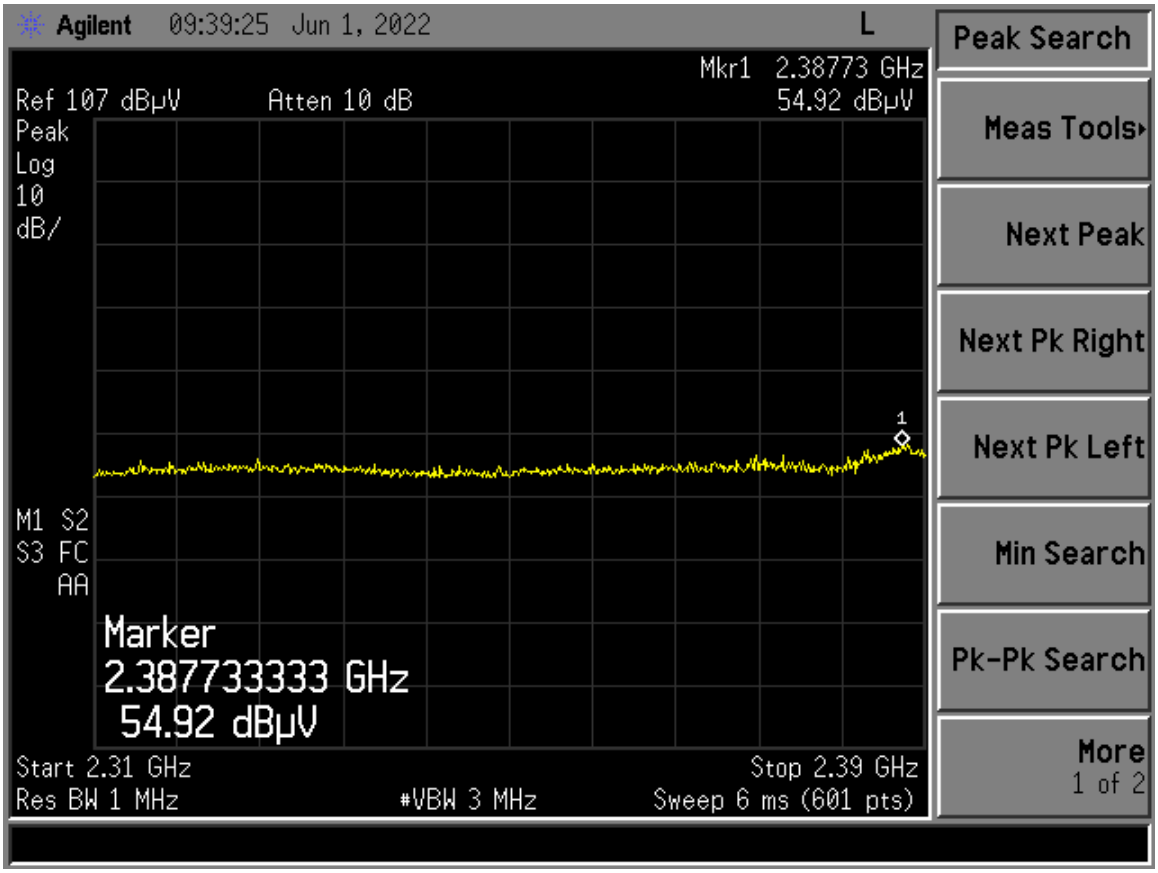


Figure 21. Low Channel Restricted Band – Peak (Horizontal)

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2387.73	54.92	-8.36	46.56	54.0	3.0m./HORZ	7.4	**PK**

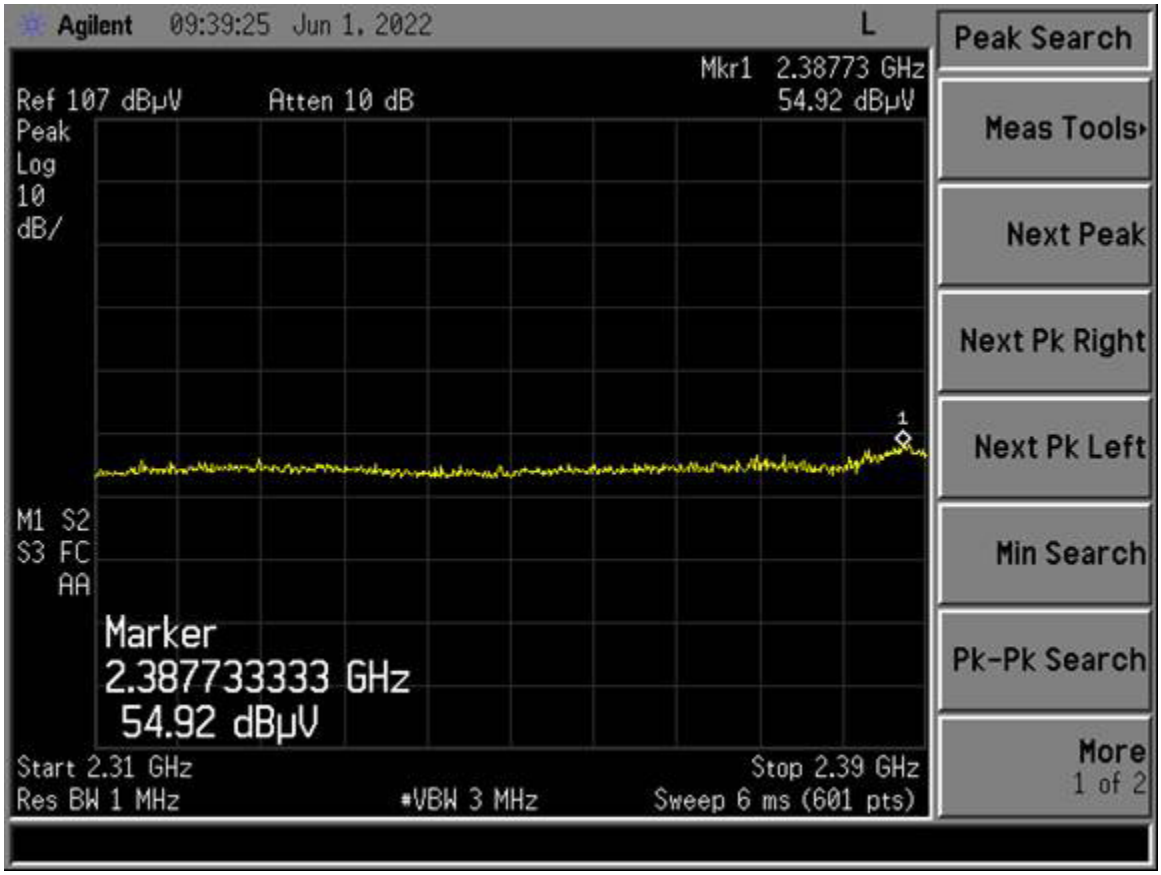


Figure 22. Low Channel Restricted Band – Peak (Vertical)

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2387.73	54.92	-8.23	46.69	54.0	3.0m./VERT	7.3	**PK**

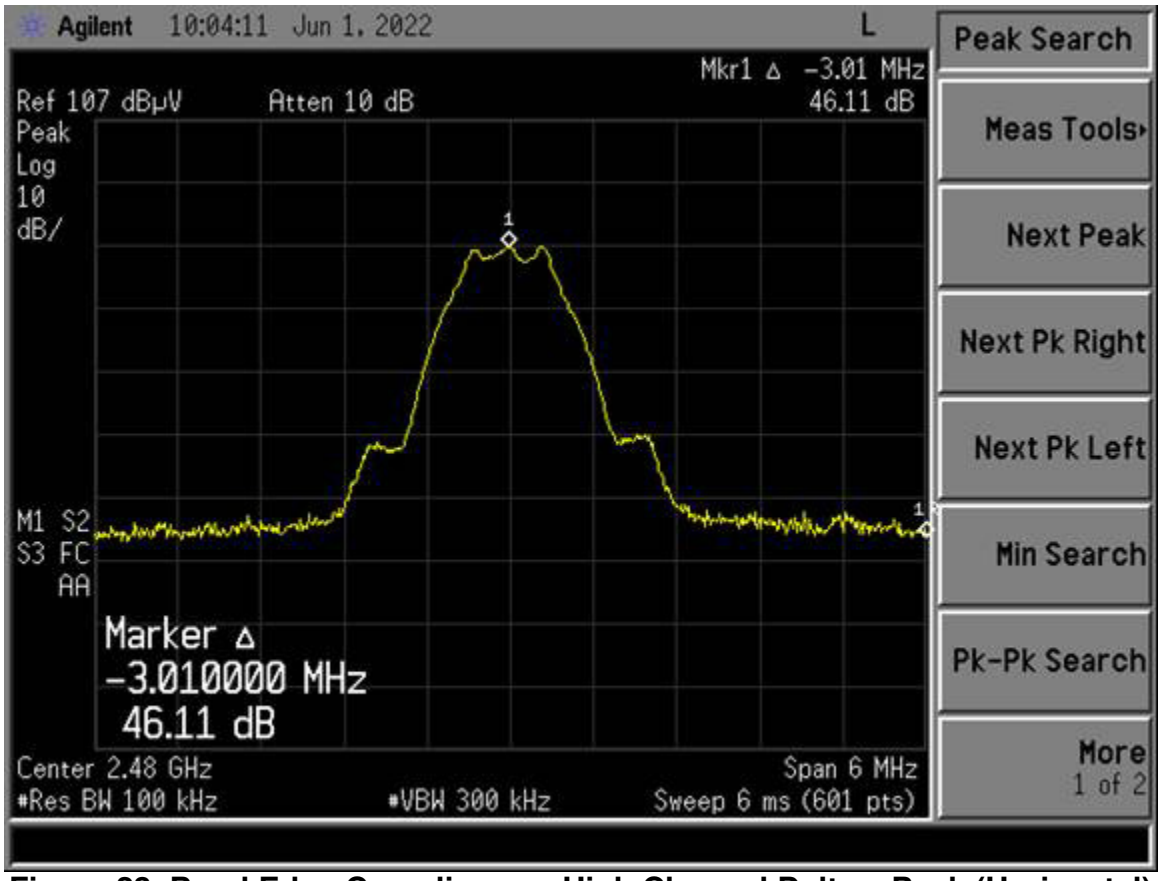


Figure 23. Band Edge Compliance – High Channel Delta – Peak (Horizontal)

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

Measured Result	46.11	dB
Band Edge Limit	-20.00	dB
Band Edge Margin	26.11	dB

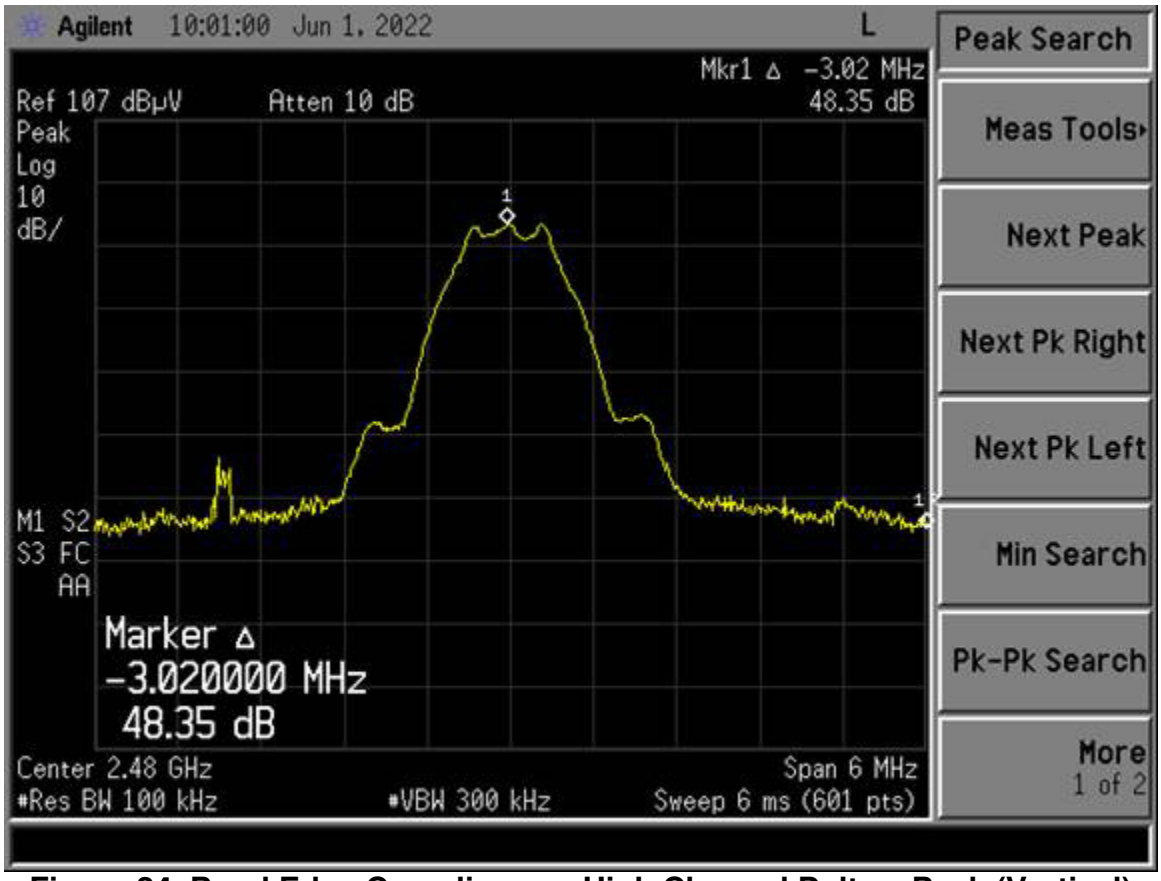


Figure 24. Band Edge Compliance – High Channel Delta – Peak (Vertical)

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

Measured Result	48.35	dB
Band Edge Limit	20.00	dB
Band Edge Margin	28.35	dB

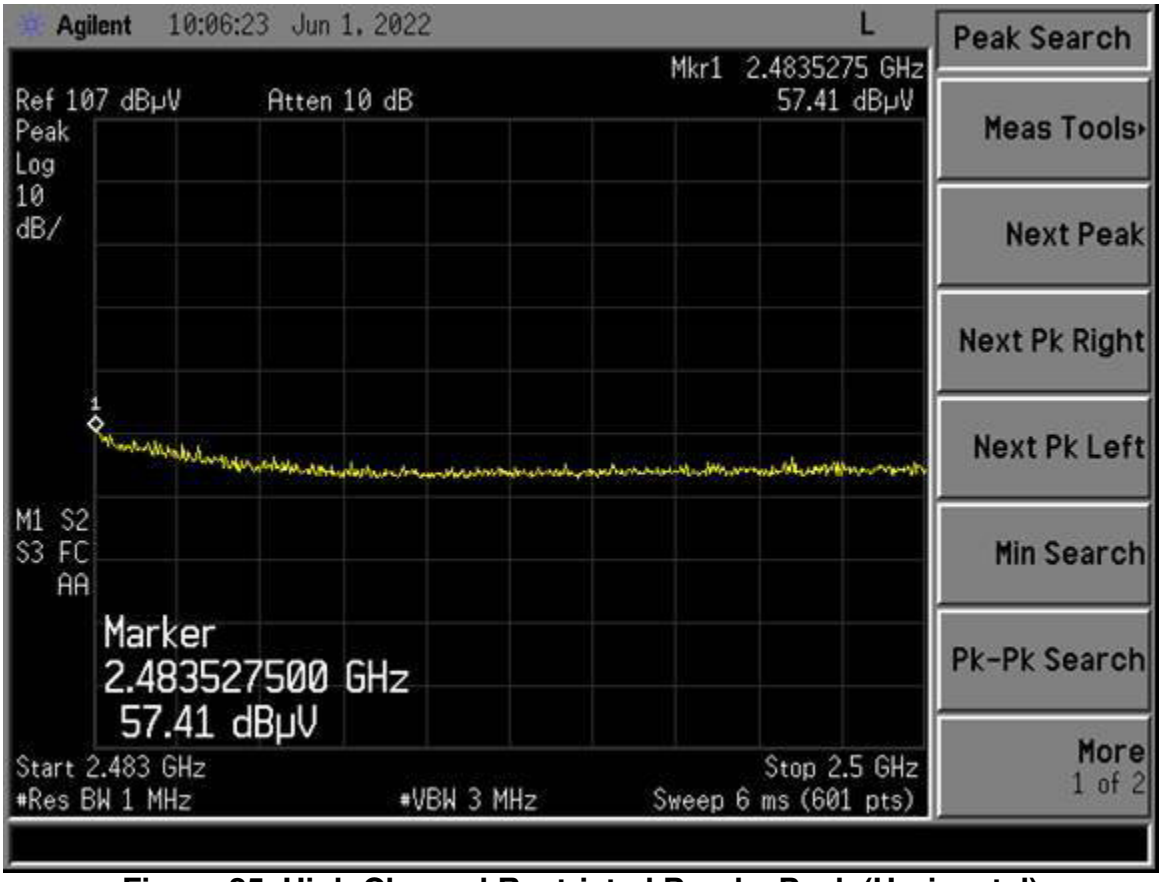


Figure 25. High Channel Restricted Band – Peak (Horizontal)

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2483.52	57.41	-7.75	49.66	54.0	3.0m./HORZ	4.3	**PK**

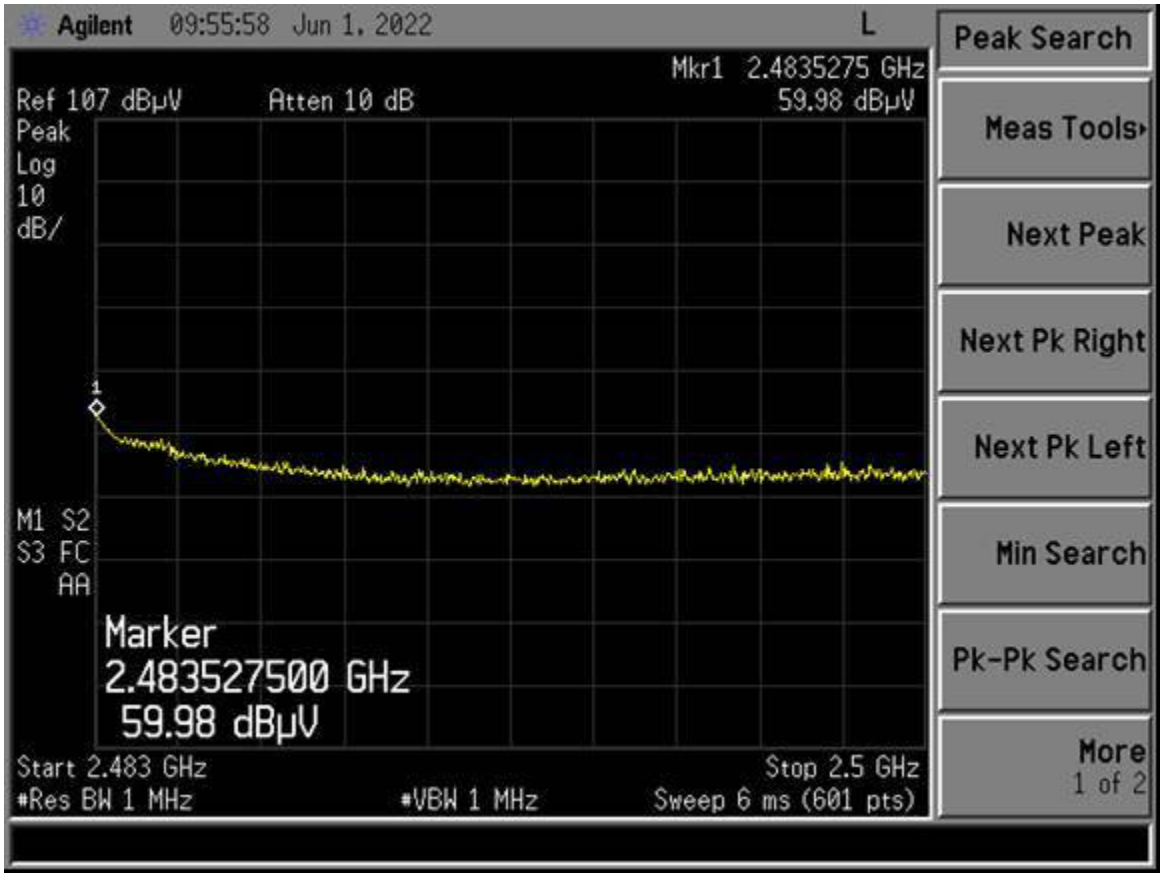


Figure 26. High Channel Restricted Band – Peak (Vertical)

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2483.52	59.98	-7.81	52.17	54.0	3.0m./VERT	1.8	**PK**

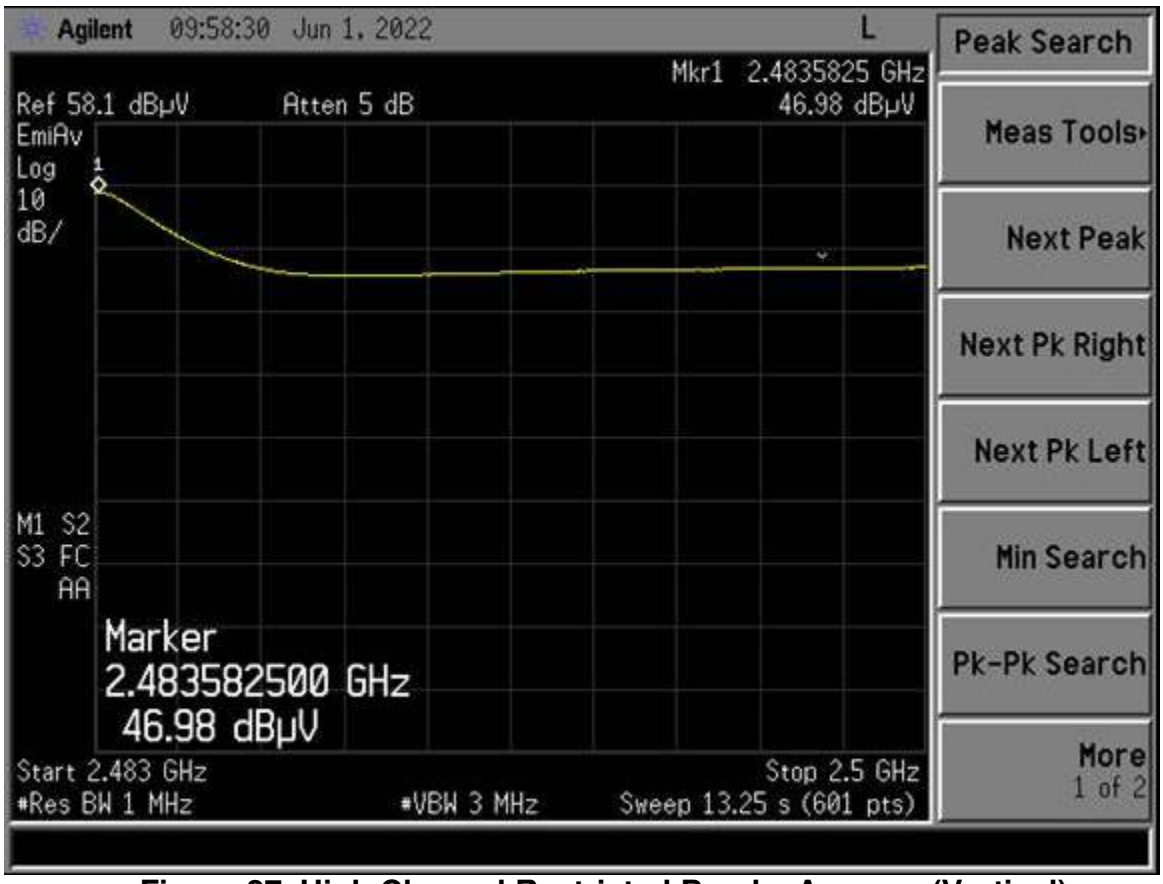


Figure 27. High Channel Restricted Band – Average (Vertical)

Frequency (MHz)	Test Data (dBuV)	AF+CA-AMP+DC (dB/m)	Results (dBuV/m)	Limits (dBuV/m)	Distance / Polarization	Margin (dB)	Detector PK/QP/AVG
2483.58	49.98	-7.81	42.17	54.0	3.0m./VERT	11.8	**AVG**

2.12 Six (6) dB Bandwidth (CFR 15.247(a)(2))

The EUT antenna port was connected to a spectrum analyzer having a 50 Ω 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 below and figures below.

Figure 28. Block Diagram of Conducted Radio Measurement

Table 6. Six (6) dB Bandwidth

Frequency (MHz)	6 dB Bandwidth (MHz)	Minimum FCC Bandwidth (MHz)
2402	0.730	0.5
2442	0.763	0.5
2480	0.738	0.5

Test Date: June 3 2022

Tested By
Signature: Name: Gabriel Medina

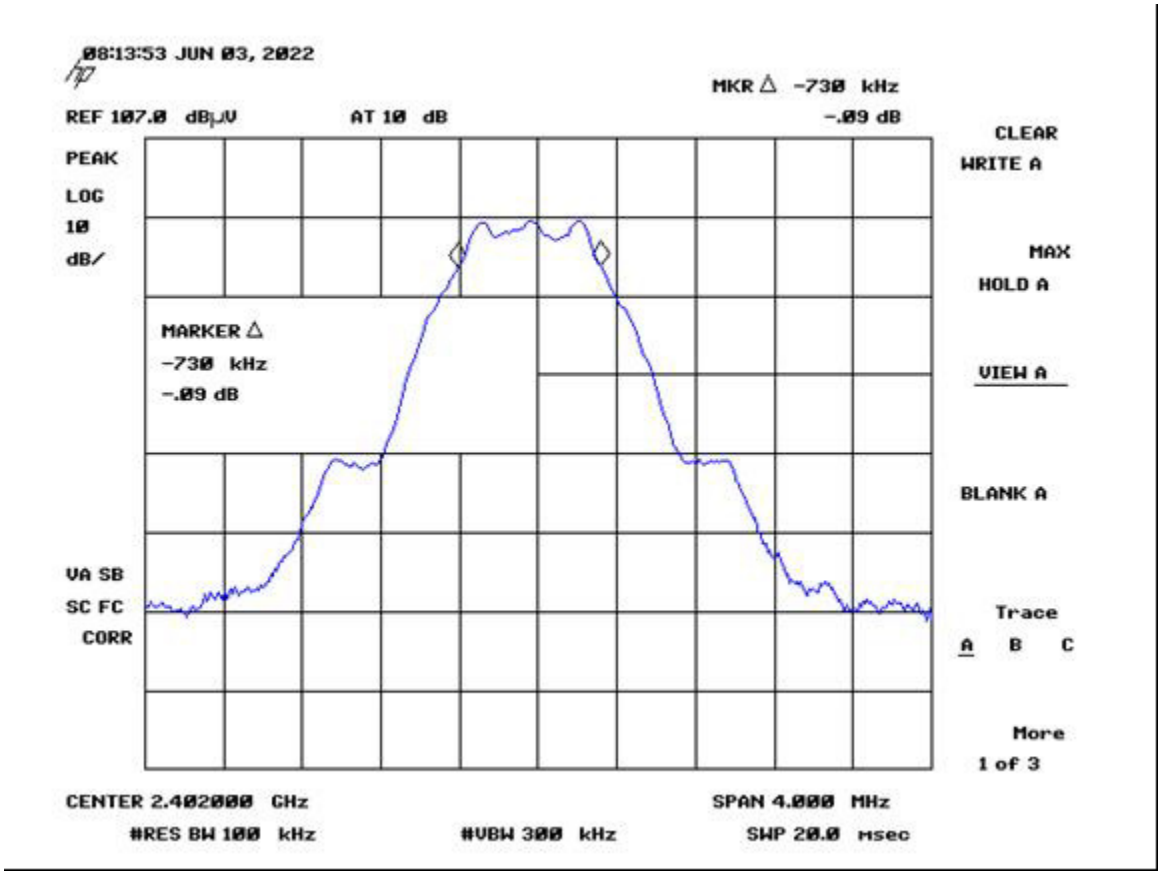


Figure 29. 6 dB Bandwidth Low Channel

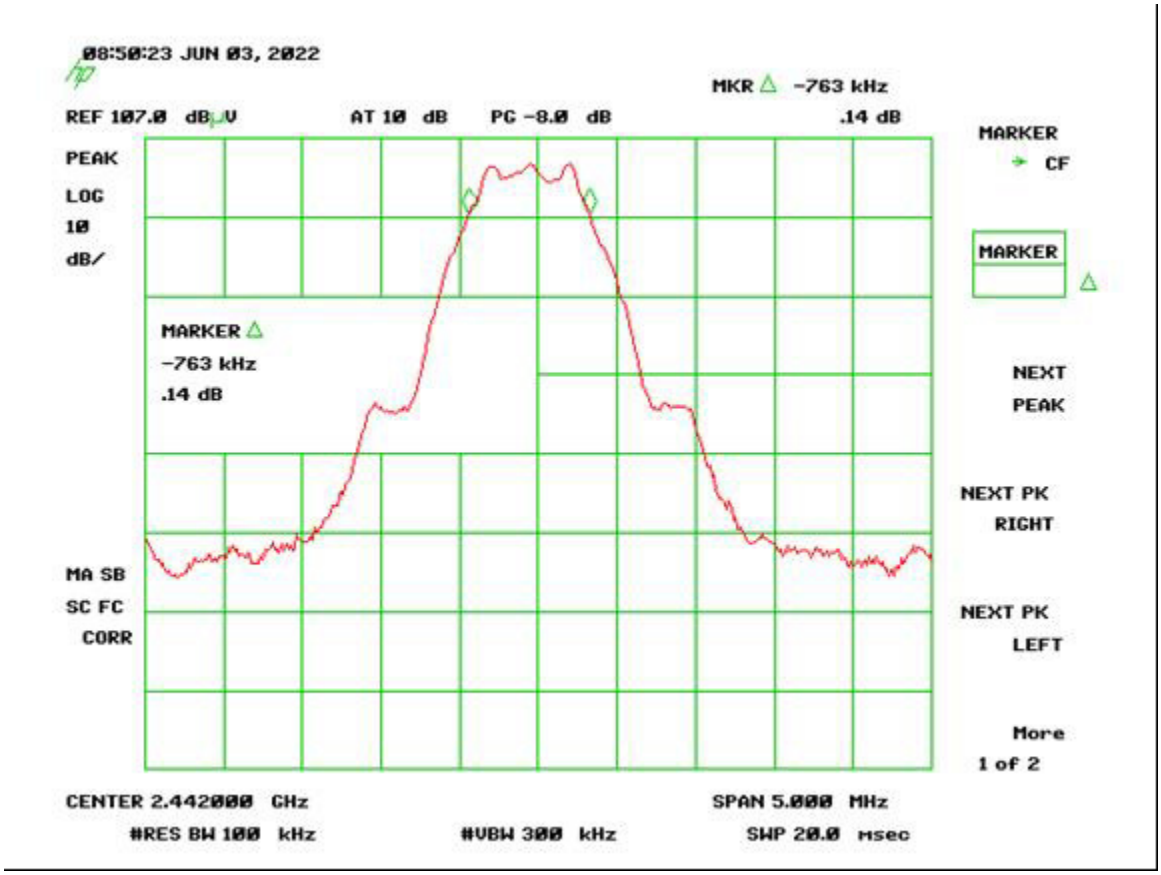


Figure 30. 6 dB Bandwidth Mid Channel

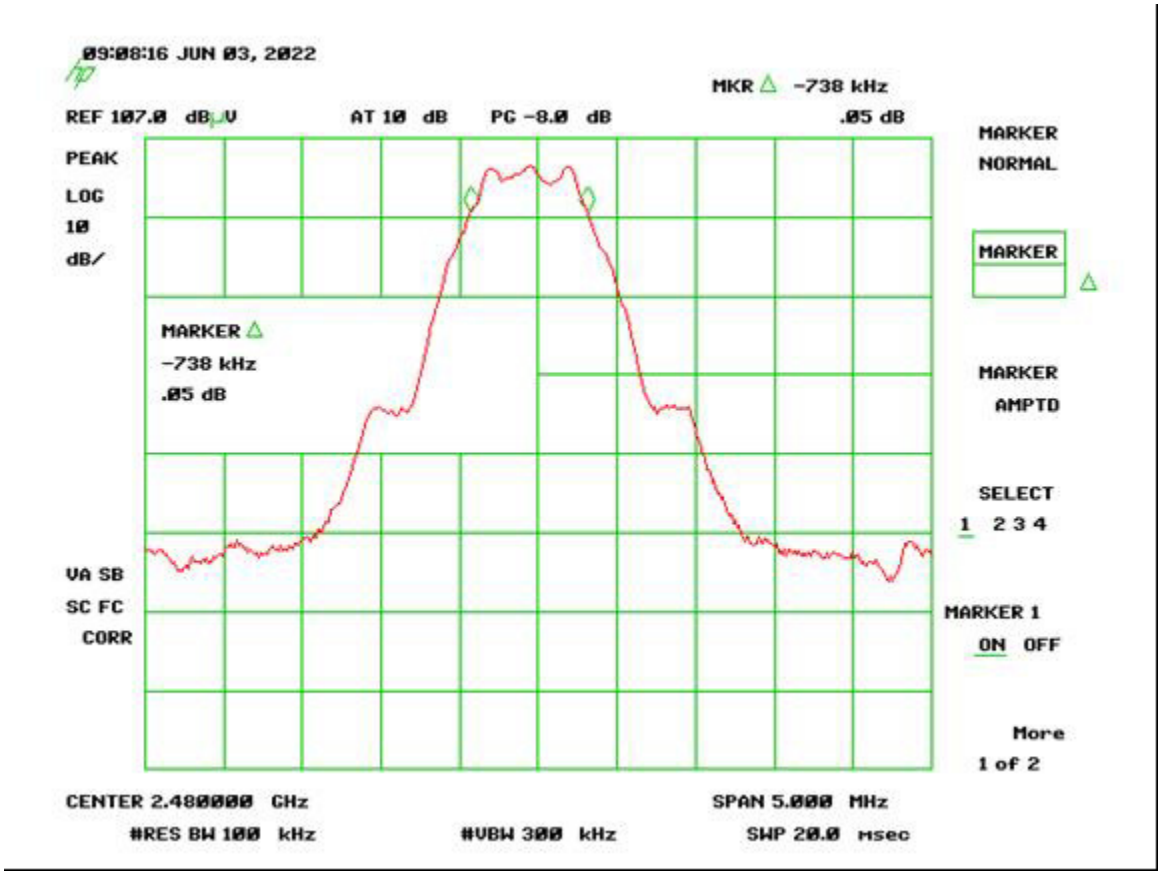


Figure 31. 6 dB Bandwidth High Channel

2.13 Occupied Bandwidth, (99% bandwidth)

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 7 and presented in the figures herein.

Conducted Radio measurement was used to collect this test data.

Table 7. 99% Occupied Bandwidth

Frequency (MHz)	99% Occupied Bandwidth (MHz)
2402	1.035
2442	1.028
2480	1.035

Test Date: June 3 2022

Tested By
Signature:  Name: Gabriel Medina

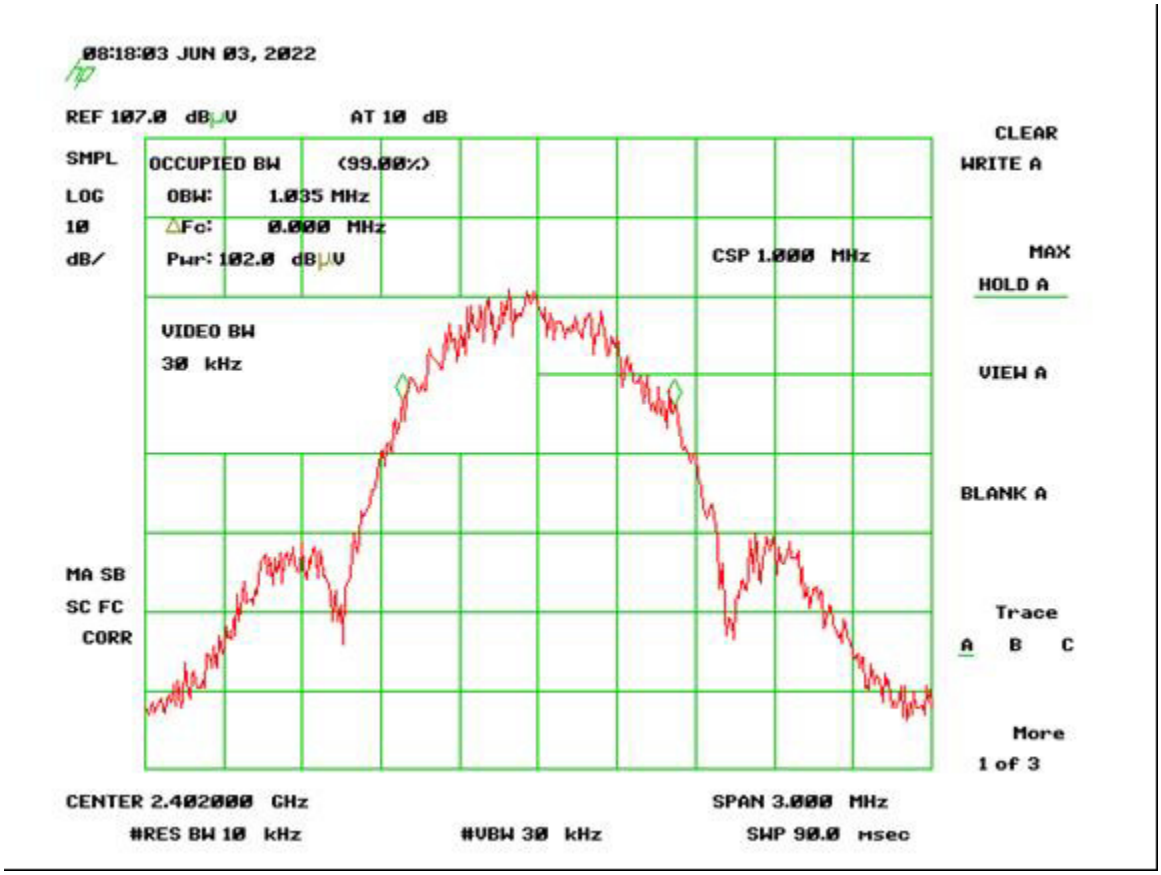


Figure 32. 99% Occupied Bandwidth Low Channel

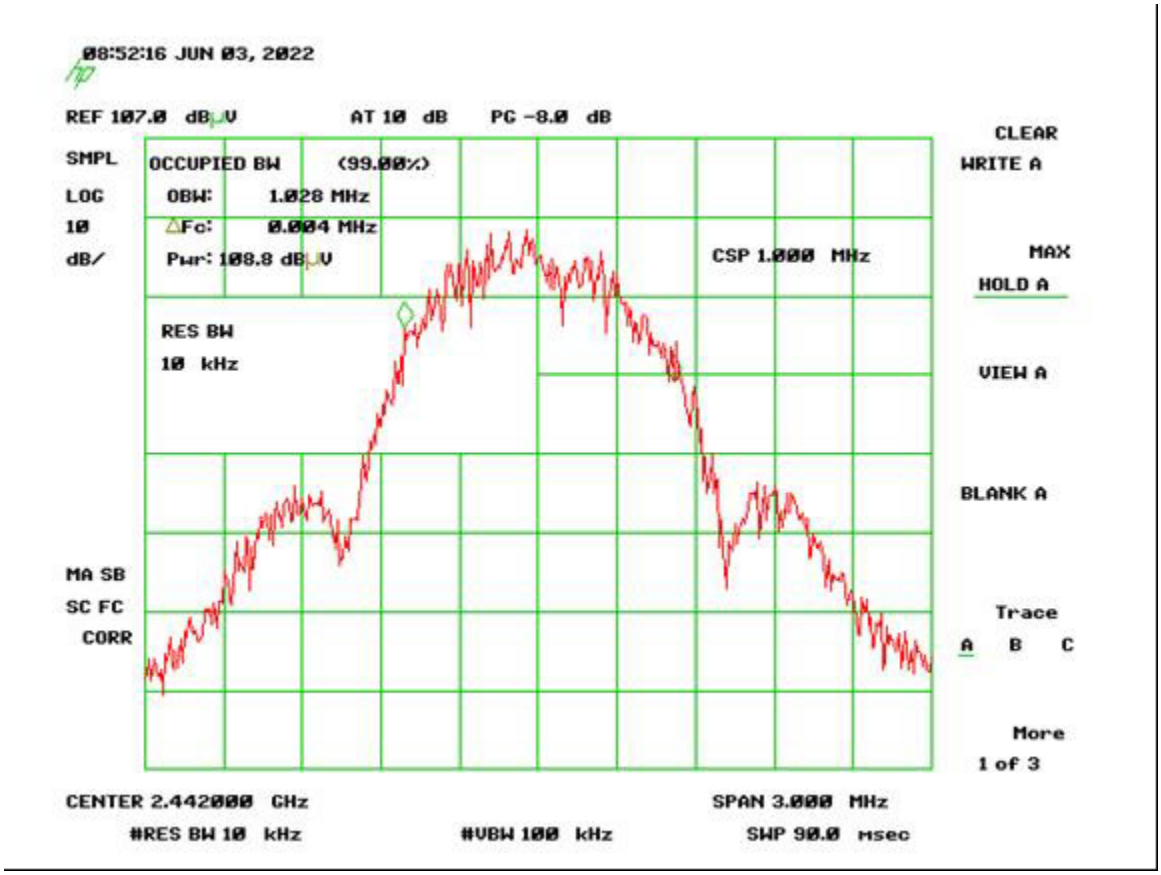


Figure 33. 99% Occupied Bandwidth Mid Channel

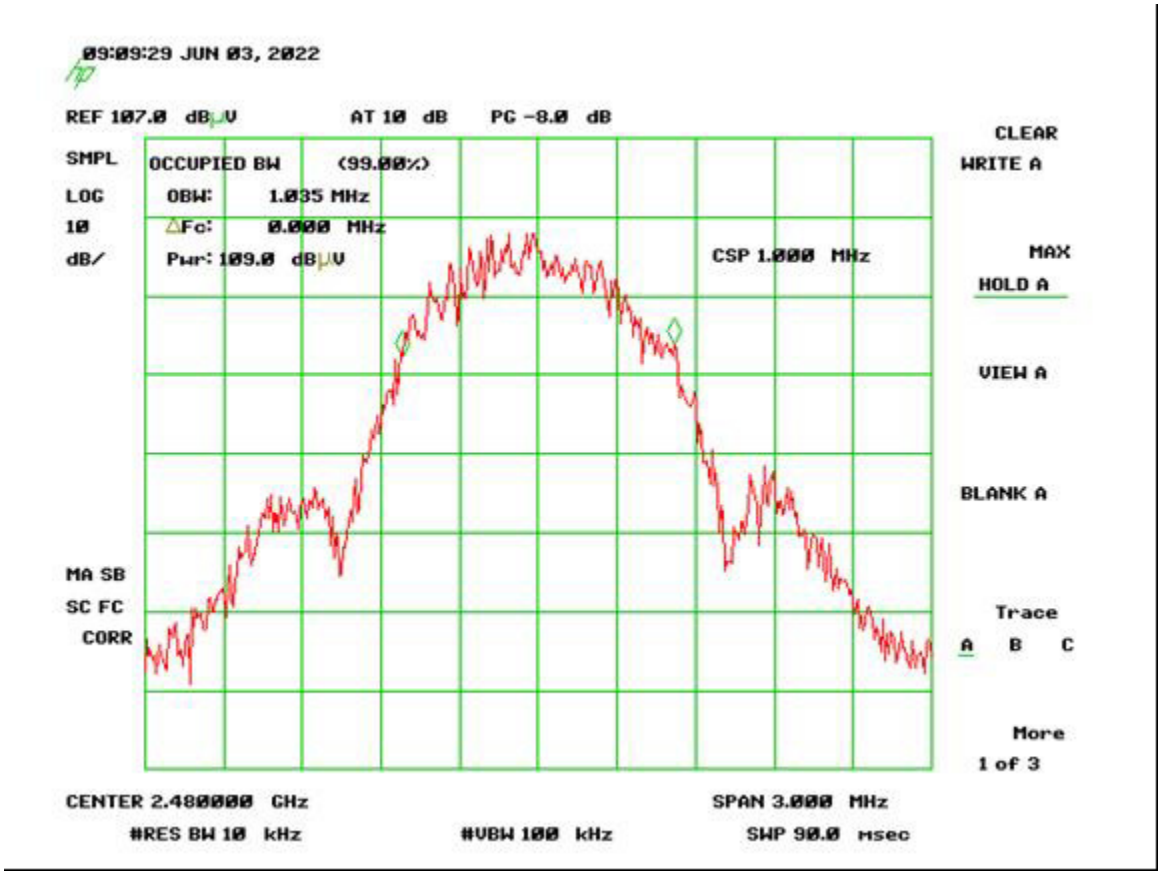


Figure 34. 99% Occupied Bandwidth High Channel

2.14 Maximum Peak Conducted Output Power (CFR 15.247 (b) (3))

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 of 1 MBPS.

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 of1 MHz, and the VBW ≥ RBW. The integration method was used. Peak antenna conducted output power is tabulated in the table below.

Conducted Radio measurement was used to collect this test data.

Table 8. Peak Antenna Conducted Output Power per Part 15.247 (b)(3)

Frequency of Fundamental (MHz)	Raw Test Data dBm	Converted Data (mW)	FCC Limit (mW Maximum)
2402	-1.98	0.633	1000
2442	-2.48	0.564	1000
2480	-2.79	0.526	1000

Test Date: June 3 2022

Tested By
Signature:  Name: Gabriel Medina

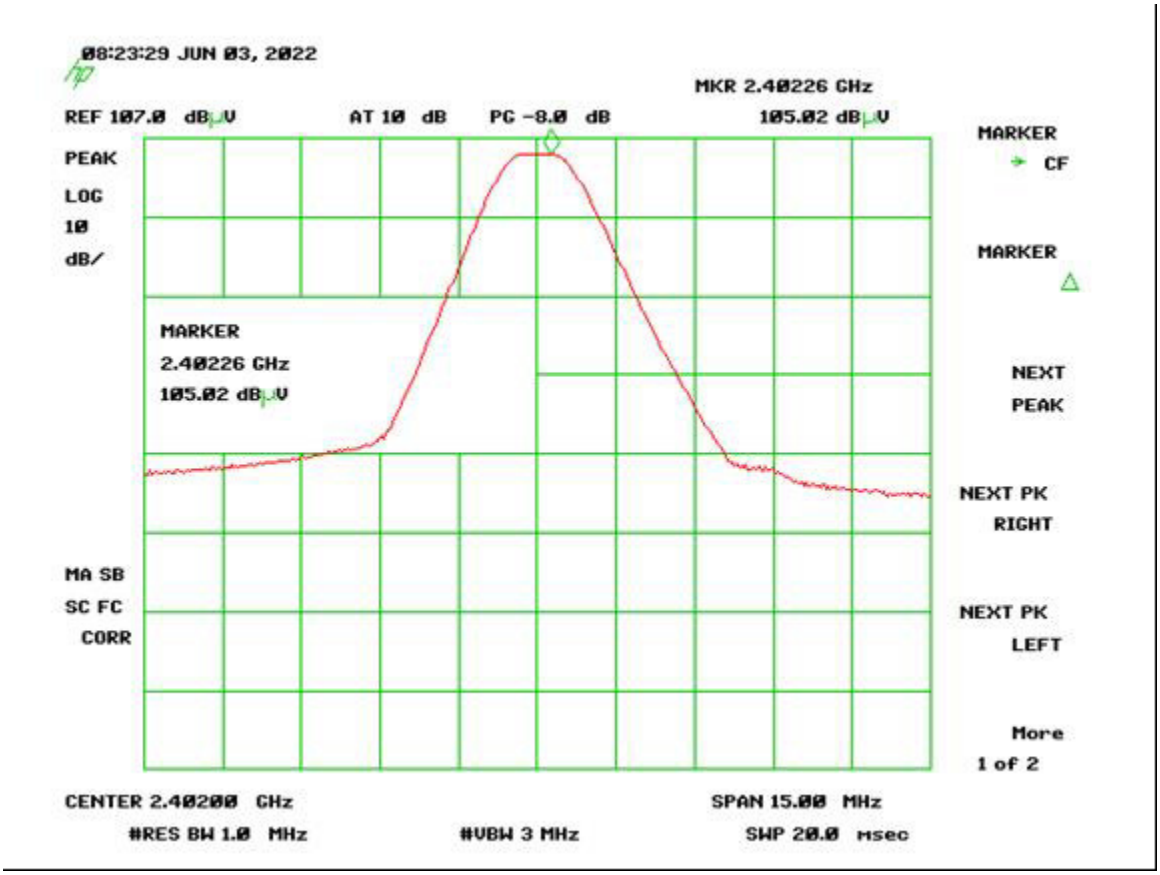


Figure 35. Peak Antenna Conducted Output Power, Low Channel

Sample Calculation
Conversion from dBuV to dBm: dBm = dBuV - 107
105.02 – 107 = -1.98 dBm

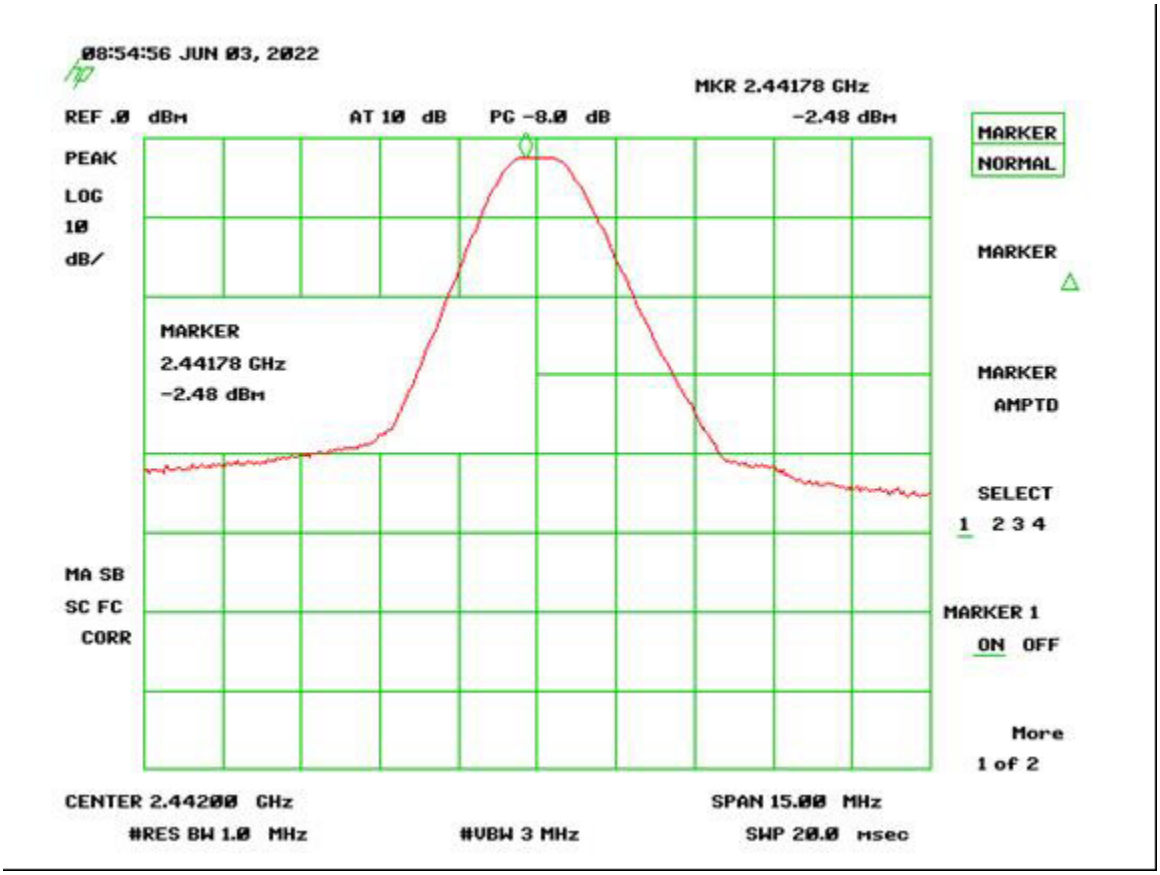


Figure 36. Peak Antenna Conducted Output Power, Mid Channel

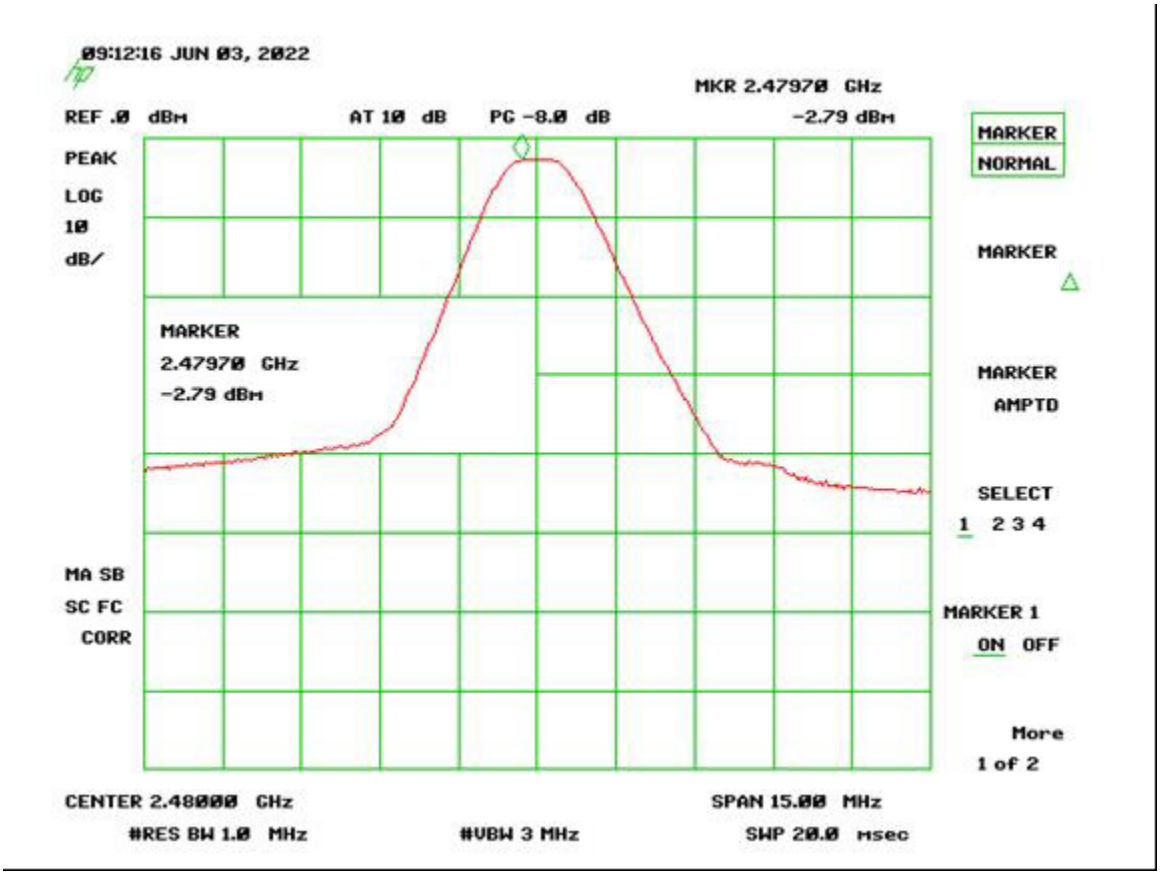


Figure 37. Peak Antenna Conducted Output Power, High Channel

2.15 Power Spectral Density (CFR 15.247(e))

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 100 kHz and the Video Bandwidth was set to ≥ RBW.

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.

Conducted Radio measurement was used to collect this test data.

Table 9. Power Spectral Density for Low, Mid and High Bands

Frequency (MHz)	Measured Result (dBm/100kHz)	Corrected Results (dBm/3kHz)	FCC Limit (dBm/3 kHz)
2402	-2.92	-18.14	+8.0
2442	-3.28	-18.51	+8.0
2480	-3.51	-18.74	+8.0

Note: dBm/Hz correct to dBm/kHz using the following formula, 10 log RBW ref/RBW measured.

Test Date: June 3 2022

Tested By
Signature:  Name: Gabriel Medina

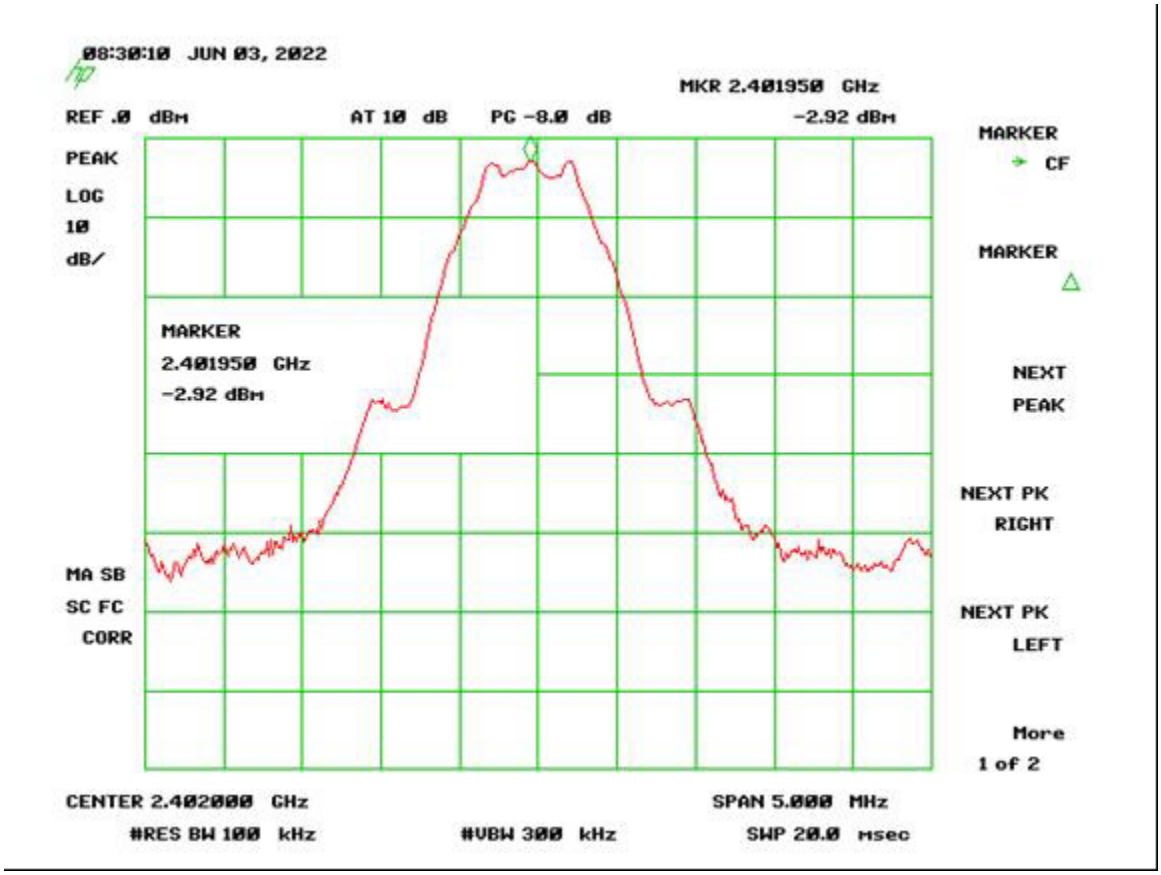


Figure 38. Power Spectral Density, Low Channel

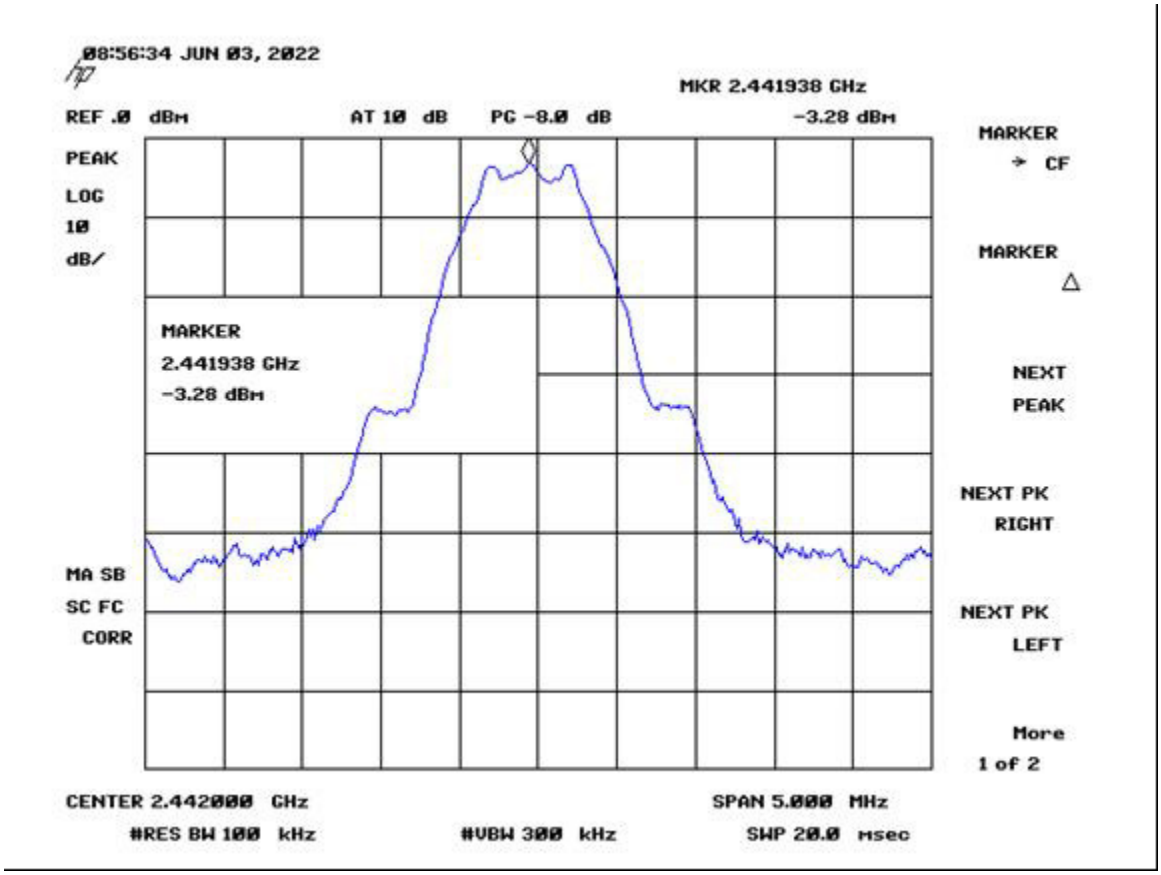


Figure 39. Power Spectral Density, Mid Channel

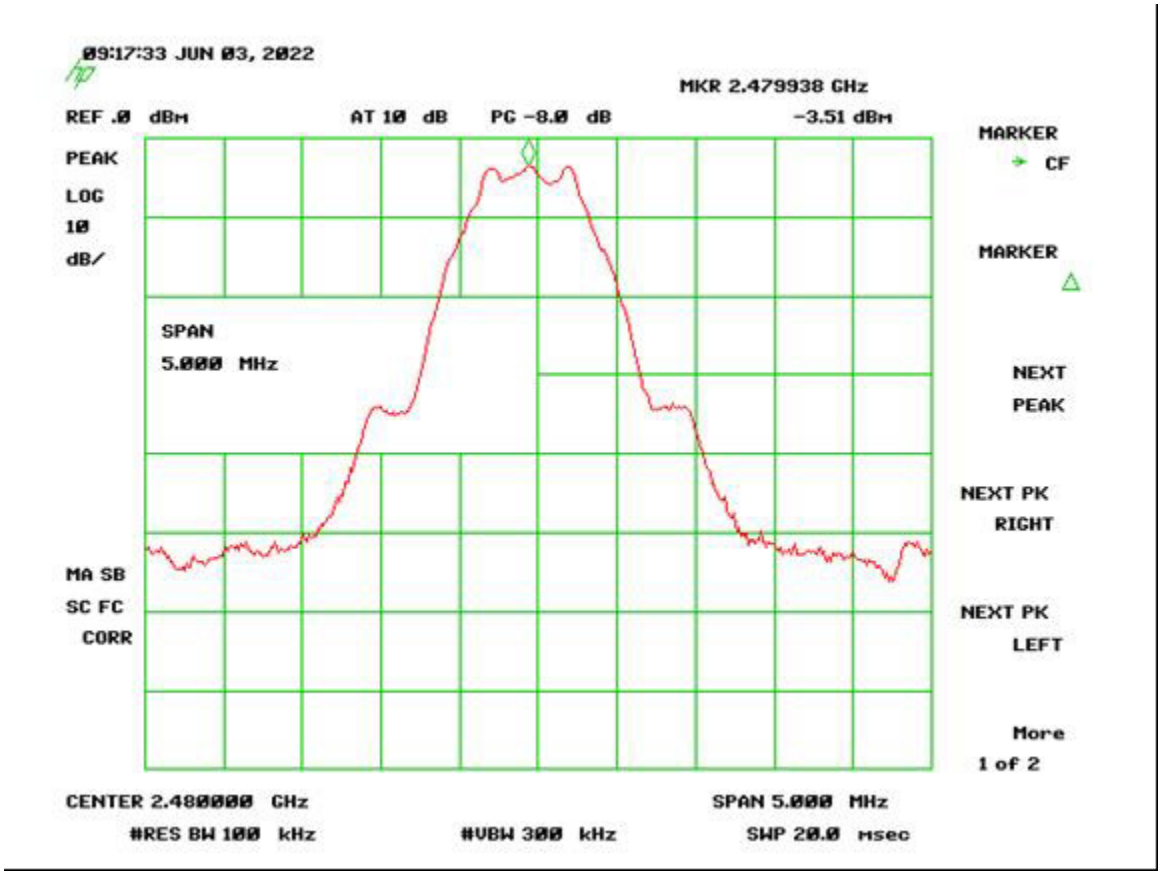


Figure 40. Power Spectral Density, High Channel

2.16 Intentional Radiator Power Lines Conducted Emissions (CFR 15.207)

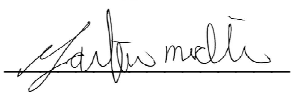
The power line conducted voltage emission measurements have been carried out in accordance with CFR 15.207, per ANSI C63.10:2013, Clause 6.2, with a spectrum analyzer connected to an LISN and the EUT placed into a continuous mode of transmission.

This EUT is Battery operated. Therefor not power line conducted emissions testing needed.

Table 10. Power Line Conducted Emissions

Conducted Emissions 150 kHz to 30 MHz						
Frequency (MHz)	**Test Data (dBuV)**	**LISN+CL (dB)**	**Corrected Results (dBuV)**	**AVG Limits (dBuV)**	**Margin (dB)**	**Detector**
Not Applicable						

Test Date: N/A

Tested By
Signature:  Name: Gabriel Medina

2.17 Intentional Radiator, Radiated Emissions (CFR 15.209)

The test data provided herein is to support the verification requirement for radiated emissions coming for the EUT in a transmitting state per 15.209 and were investigated from 9kHz or the lowest operating clock frequency to 25 GHz and tested as detailed in ANSI C63.10:2013, Clause 6.4-6.6.

Measurements were made with the analyzer's resolution bandwidth set to 120 kHz for measurements made below 1 GHz and 1 MHz for measurements made above 1 GHz. The video bandwidth was set to three times the resolution bandwidth; 1 MHz RBW and 3 MHz VBW. The test data were maximized for magnitude by rotating the turn-table through 360 degrees and raising and lowering the receiving antenna between 1 to 4 meters in height as a part of the measurement procedure.

The worst-case radiated emission was greater than 20.0 dB below the specification limit. The results are shown in the table following. These results are meant to show that this EUT has met the intentional transmitter requirements of CFR Part 15.209.

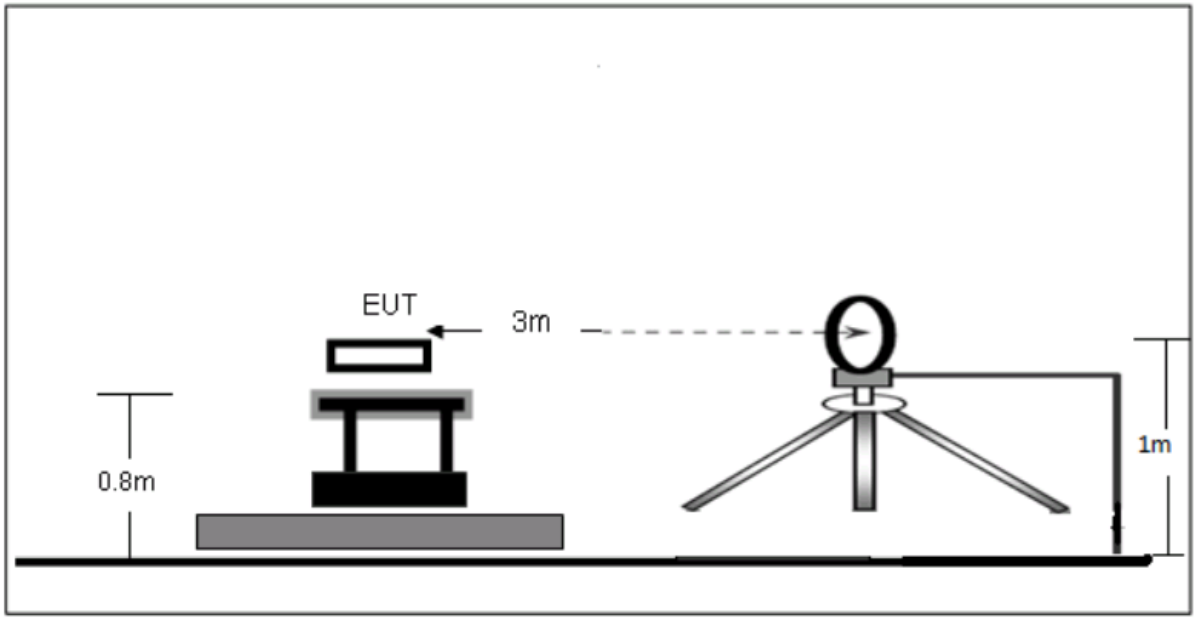


Figure 41. Block Diagram Below 30 MHz Radiated Emissions Test Setup

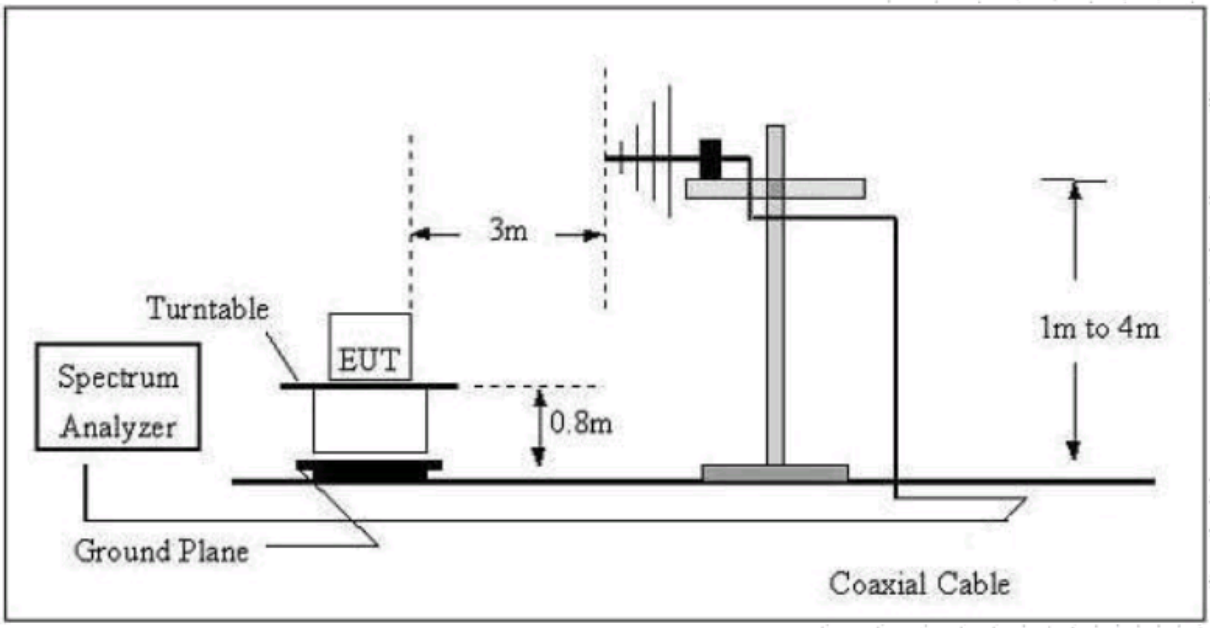


Figure 42. Block Diagram 30- 1000 MHz Radiated Emissions Test Setup

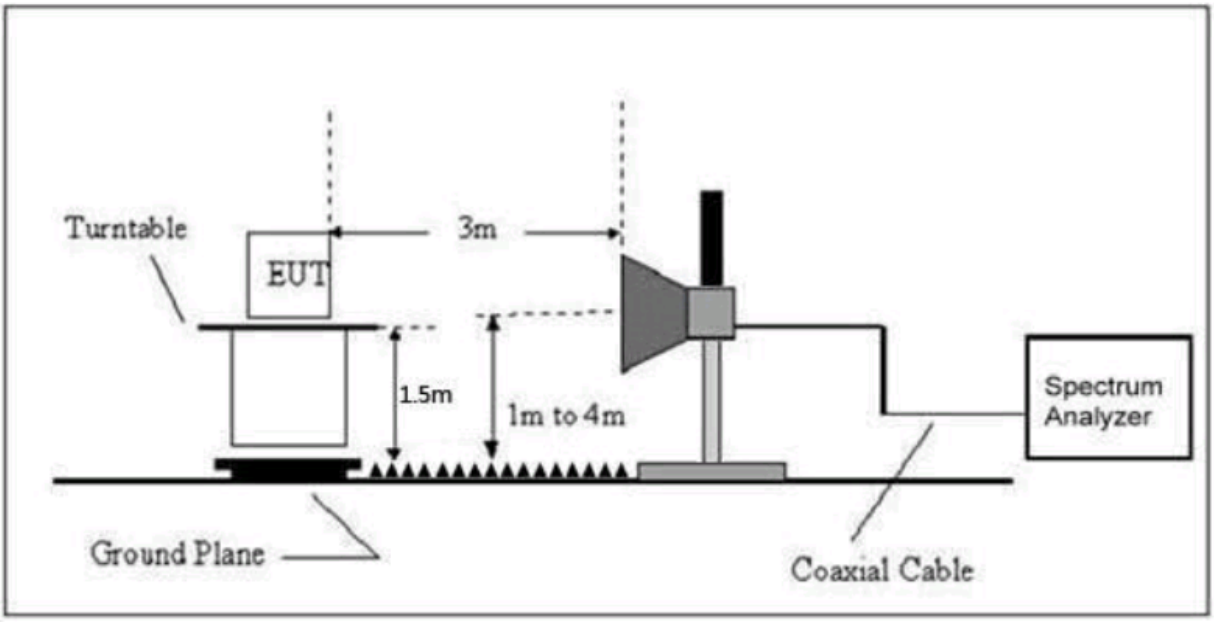


Figure 43. Block Diagram Above 1 GHz Radiated Emissions Test Setup

Table 11. Spurious Radiated Emissions (30 MHz – 1 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
90.54	41.09	-17.97	23.12	43.5	3m./HORZ	20.4	**PK**
181.01	41.20	-13.42	27.78	43.5	3m./HORZ	15.7	**PK**
360.26	41.30	-11.77	29.53	46.0	3m./HORZ	16.5	**PK**
636.32	41.37	-6.06	35.31	46.0	3m./HORZ	10.7	**PK**
848.16	41.56	-3.82	37.74	46.0	3m./HORZ	8.3	**PK**
80.94	41.25	-18.22	23.03	40.0	3m./HORZ	17.0	**PK**
154.72	41.68	-14.87	26.81	43.5	3m./HORZ	16.7	**PK**
417.80	41.36	-11.42	29.94	46.0	3m./VERT	16.1	**PK**
645.02	41.26	-7.26	34.00	46.0	3m./VERT	12.0	**PK**
818.80	41.86	-5.46	36.40	46.0	3m./VERT	9.6	**PK**

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

Sample Calculation at 90.54 MHz:

Magnitude of Measured Frequency	41.09	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-17.97	dB/m
Corrected Result	23.12	dBuV/m

Test Date: June 2 2022

Tested By
Signature:  Name: Gabriel Medina

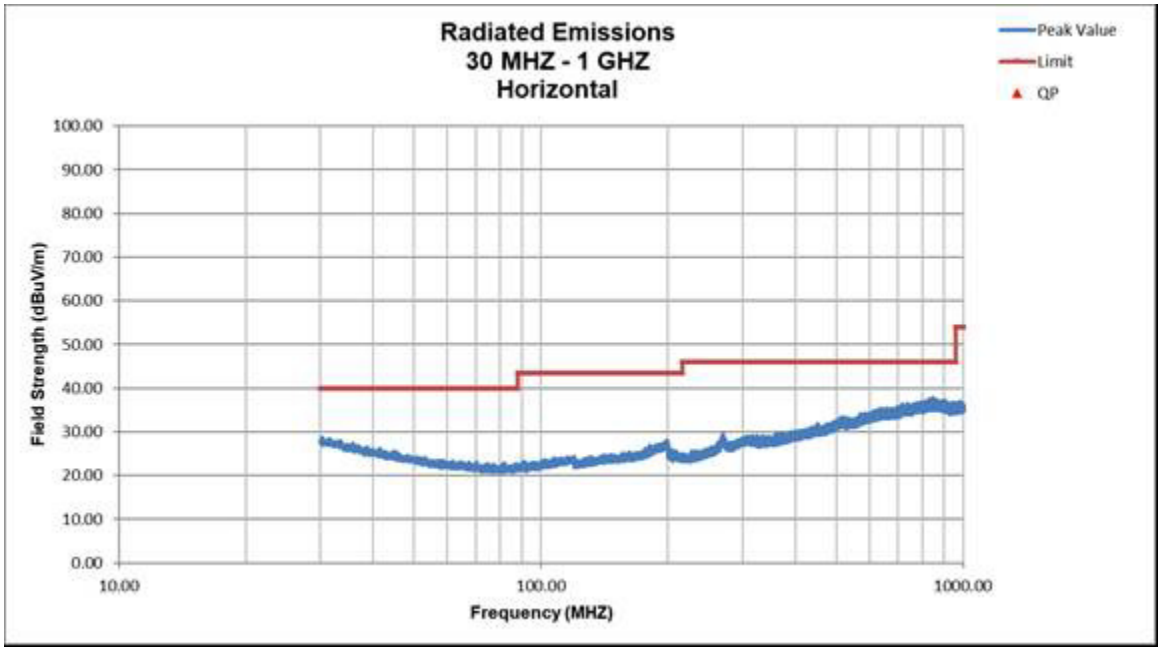


Figure 44. Radiated Emissions, Horizontal 30 MHz – 1 GHz

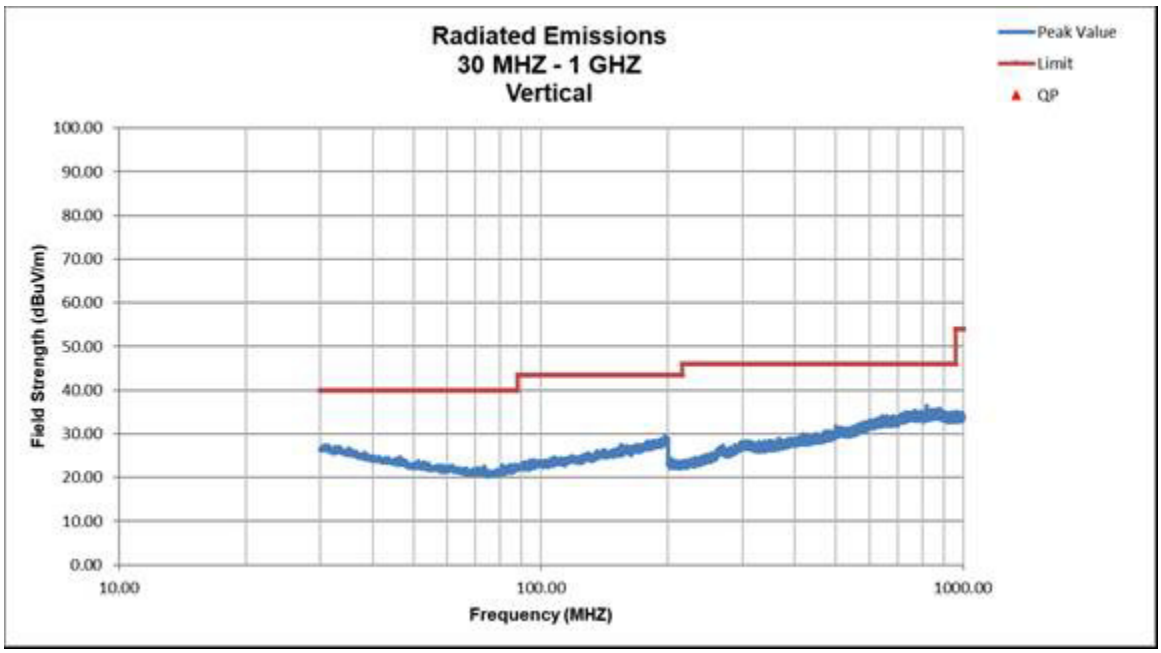


Figure 45. Radiated Emissions, Vertical 30 MHz – 1 GHz

Table 12. Spurious Radiated Emissions (1 GHz – 10 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
5214.00	31.31	-2.17	29.14	54.0	3.0m./HORZ	24.9	**AVG**
5762.00	31.78	-1.06	30.72	54.0	3.0m./HORZ	23.3	**AVG**
8646.00	43.35	2.98	46.33	54.0	1.0m./HORZ	7.7	**PK**
5759.00	31.27	-1.13	30.14	54.0	3.0m./VERT	23.9	**AVG**
8388.00	43.48	2.77	46.25	54.0	1.0m./VERT	7.7	**PK**

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

Sample Calculation at 5214.00 MHz:

Magnitude of Measured Frequency	31.31	dBuV
+Antenna Factor + Cable Loss - Amplifier Gain	-2.17	dB/m
Corrected Result	29.14	dBuV/m

Test Date: June 2 2022

Tested By
Signature:  Name: Gabriel Medina

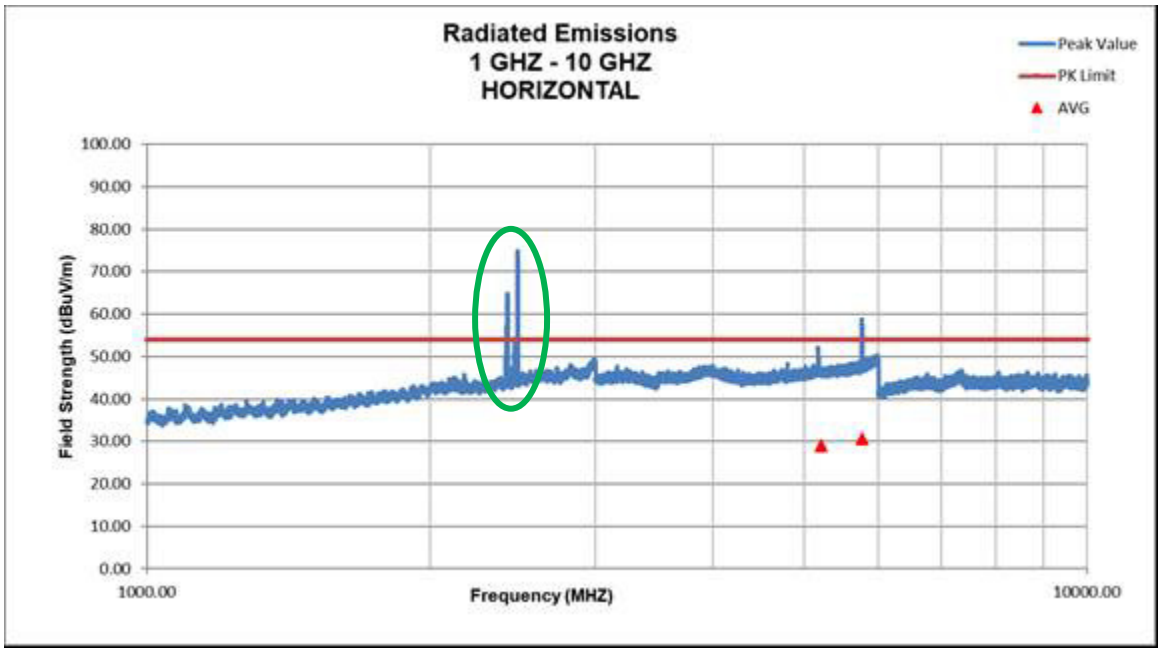


Figure 46. Radiated Emissions, Horizontal 1 GHz – 10 GHz

Note: fundamental emission is encircled in green

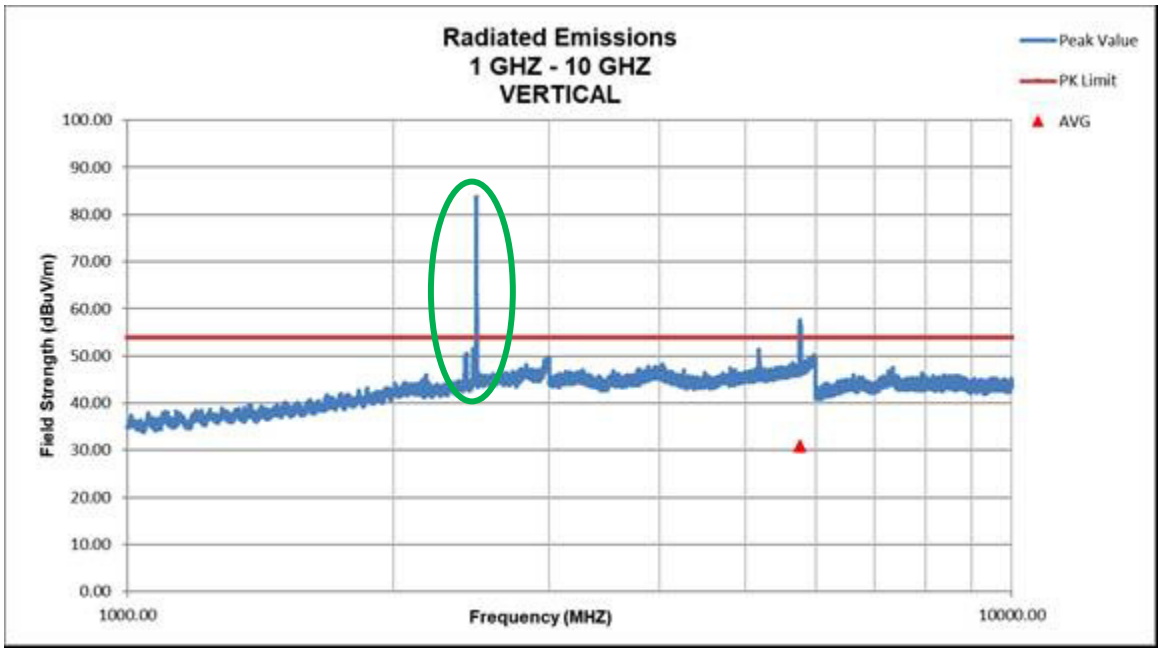


Figure 47. Radiated Emissions, Vertical 1 GHz – 10 GHz

Note: fundamental emission is encircled in green

Table 13. Spurious Radiated Emissions (10 GHz – 25 GHz)

Test: FCC Part 15.209							
Frequency (MHz)	**Test Data (dBuV)**	**AF+CL-PA (dB)**	**Results (dBuV/m)**	**Limits (dBuV/m)**	**Distance / Polarization**	**Margin (dB)**	**DETECTOR PK / QP/AVG**
No emission were greater than 6 dB above the noise floor							

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

Sample Calculation: N/A

Test Date: June 2 2022

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

The EUT is battery powered; therefore, this test is not applicable.

2.18.2 Radiated Emissions Measurement Uncertainty

For a measurement distance of 3 m 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.