FCC CERTIFICATION TEST REPORT

PART §90F, LICENSED TRANSMITTER

for the

RECON ROBOTICS

THROWBOT 2

FCC ID: UYXRSK2022-01

WLL REPORT# 18428-01- REV 2

Prepared for:

RECON ROBOTICS
5251 W 73rd Street,
Suite A Edina, Minnesota 55439

Prepared By:

Washington Laboratories, Ltd.
4840 Winchester Boulevard
Frederick, Maryland 21703

Testing Certificate AT-1448

FCC Certification Test Report

Part §90F, Licensed Transmitter

for the

RECON ROBOTICS

THROWBOT 2

(FCC ID: UYXRSK2022-01)

January 16, 2024

WLL Report# 18428-01-01 Rev 2

Prepared by:

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EMC Test Engineer

Reviewed by:

Steven D. Koster
President

Abstract

This report has been prepared on behalf of Recon Robotics Inc. to support the waiver DA10-291 released Feb 23, 2010, of the FCC rules.

The test report was constructed with guidance from Part 90 Subpart I--Private Land Mobile Radio Services general technical requirements section of the FCC Rules and Regulations (10/2015).

This testing was submitted to support the requested waiver DA10-291 released Feb 23, 2010, and Order of Reconsideration DA 11-675.

Testing was performed at Washington Laboratories, Ltd, 4840 Winchester Blvd. Frederick, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

These tests are accredited and meet the requirements of ISO/IEC 17025:2005 as verified by the ANSI-ASQ National Accreditation Board/ANAB. Refer to certificate and scope of accreditation AT1448.

Revision History	Description of Change	Date
Rev 0	Initial Release	January 16, 2024
Rev 1	ACB Comments	April 5, 2024
Rev 2	ACB Comments	May 9, 2024

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1 Introduction

1.1 Compliance Statement

The RECON ROBOTICS THROWBOT 2 complies with the requirements for an intentional radiator, licensed device under FCC Part §90F.

1.2 Test Scope

Tests for radiated and emissions and frequency stability were performed. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	RECON ROBOTICS.
Purchase Order Number:	10769
Quotation Number:	74329A

1.4 Test and Support Personnel

Washington Laboratories, LTD	Richard Quarcoo
Customer Representative	Steve Gigl

1.5 Test Dates

The Throwbot 2 was tested from 6/7/2023 to 4/1/2024.

2 Equipment Under Test

2.1 EUT Identification & Description

Table 1: Device Summary

EUT Specifications:	
Manufacturer:	Recon Robotics, Inc
FCC ID:	UYXRSK2022-01
FCC Rule Parts:	FCC Part 90
Industry Canada RSS#:	N/A
TX Frequency Range:	430-448 MHz (Primary carrier frequency)
Number of In-Band Channels:	3
Maximum Output Power:	24dBm average, 30dBm peak
Modulation type(s):	AM (Video Carrier) – FM (Audio carrier)
Occupied Channel Bandwidth:	5M75C3F, 250KF3E
Keying:	Always on
Pulse Transmitter	No
Duty Cycle	Always on
Type of Information:	NTSC Video / Audio
Number of Data Channels:	One transmit channel per device, 3 available channels: 430-436 MHz, 436-442 MHz, 442-448 MHz (per waiver)
Antenna Connector:	Not applicable
Antenna Manufacturer, Type, and Maximum Gain:	Fixed 1/4 wave monopole whip
Interface Cables:	Not applicable
Power Source & Voltage: (as tested)	Battery, 11.1V nominal, 12.6V max
Receiver LO:	75.905-77.755 MHz depending on Rx channel
Software / Firmware Version:	2.2.2035

The Throwbot® 2 robot is a surveillance robotic device meant to be deployed into settings where useful real time remote information can be transmitted from hazardous locations thereby improving the safety of personnel. The Throwbot® 2 robot under test transmits analog audio and video information. In low light conditions the unit is capable of illuminating the surrounding area with near infrared light to aid the vision capabilities of the camera. The frequencies used for transmission occur in 6MHz bands centered at 433, 439, and 445MHz. The band is preset at time of manufacture and cannot be changed in the field. The Throwbot 2 robot broadcasts video at a preset power level which is referenced in Paragraph 7 of the FCC waiver DA 10-291, is not to exceed 0.25 W average or 1 W peak. The emission designator is C3F. The transmitter, as a whole, draws approximately 0.13 A at battery voltage (nominally 11.1V). This is

used to power one 5V DC-DC switching regulator and two 3V3 LDO regulators. The final amplifier stage of this system driving a 50 Ohm load uses the 5V switching supply at 0.11 to 0.17 A.

The Throwbot® 2 robot receives commands over a 75MHz radio receiver. The robotic platform maintains mobility through the use of two electric motors that drive each of its wheels independently. Power is supplied from a lithium polymer battery, through a smart battery safety circuit and various voltage regulators. Various sensors aid in physical navigation of the device. Onboard processing, sensor integration, auxiliary systems control, and command receiver monitoring is accomplished through the use of microcontrollers. The chassis of the system and the external metal components are all grounded with respect to the onboard circuitry. The ground system plays an important role in antenna performance and EMI immunity. The video broadcast antenna is an approximately ¼ wave antenna constructed so as to be extremely robust to physical impacts, and yet not interfere with the mobility of the mechanical propulsion systems. The command receive antenna is similar in mechanical construction to the video broadcast antenna but is tuned to use in receiving the 75MHz command signals the platform utilizes.

2.2 Testing Algorithm

The THROWBOT 2 was configured on each test site that produced the worst-case emissions, while facing the testing receive antennas. During each test, the transmitter was controlled by the applicant, via a LAN based interface which allowed for the tuning of each in-band frequencies. The transmitter was set to output the Pulsed-FM signal in a continuous mode, only halting upon user command. All of the transmitter emissions provided throughout this report, are the worst-case emission levels.

2.3 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Site description and site attenuation data have been placed on file with the FCC's Sampling and Measurements Branch at the FCC laboratory in Columbia, MD. The ISED Canada OATS number is 3035A-1 for Washington Laboratories, Ltd.

Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

2.4 Test Configuration

The THROWBOT 2 was configured to transmit at Ch. A Video 443.25MHz & SSB Audio 447.75MHz, Ch. B Video 431.25MHz & SSB Audio 435.75MHz and Ch. C Video 437.25MHz & SSB Audio 441.75MHz

Table 2: System Configuration List

Name / Description	Model Number	Part Number	Serial Number	Rev. #
Channel A.2 – 442-448 MHz Video Carrier - 443.25 MHz Audio Carrier – 447.75 MHz	Throwbot 2 – Channel A.2	RS-TB2-A	0621AE0013	2022-01
Channel B.2 – 430-436 MHz Video Carrier – 431.25 MHz Audio Carrier – 435.75 MHz	Throwbot 2 – Channel B.2	RS-TB2-B	0621AE0010	2022-01
Channel C.2 – 436-442 MHz Video Carrier 437.25 MHz Audio Carrier – 441.75 MHz	Throwbot 2 – Channel C.2	RS-TB2-C	0621AE0007	2022-01

Table 3: Support Equipment

Name / Description	Manufacturer	Model Number	Calibration Data
USB Type C Charger	Anker	N/A	N/A
Custom Power Cable for Modified Throwbot 2	Recon Robotics	N/A	N/A
Printed still video images	Recon Robotics	N/A	N/A
Plastic robot/test image fixture	Recon Robotics	N/A	N/A

Table 4: Cable Configuration

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty.	Length (m)	Shielded?	Termination Box ID & Port ID
1	USB-C Jack	USB Type C Charge Cable - Only needed to recharge robot	1	1.8	Yes	Port 1
2	Non-USB-C Power Jack	Custom Power Cable for Modified Throwbot 2	1	1.8	No	Port 2

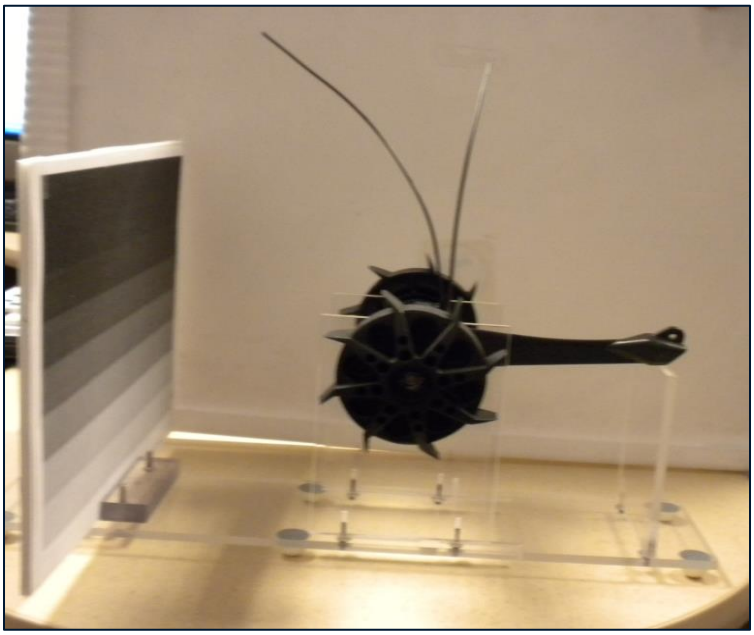


Figure 1: EUT Test Configuration

2.5 EUT Modifications

There were no modifications necessary for the EUT to comply with the requirements.

2.6 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Frederick, MD. Washington Laboratories, Ltd. has been accepted by the FCC and approved by ANAB under Testing Certificate AT-1448 as an independent FCC test laboratory.

2.7 Measurements

2.7.1 References

ANSI C63.2 (Jan-2016) Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 (Jan 2014) American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz

ANSI C63.26 (Dec 2015) American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

2.8 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 (R2002) with a type B evaluation of the standard uncertainty. Elements contributing to the standard uncertainty are combined using the method described in Equation 1 to arrive at the total standard uncertainty. The standard uncertainty is multiplied by the coverage factor to determine the expanded uncertainty which is generally accepted for use in commercial, industrial, and regulatory applications and when health and safety are concerned (see Equation 2). A coverage factor was selected to yield a 95% confidence in the uncertainty estimation.

Equation 1: Standard Uncertainty

$$u_c = \pm\sqrt{\frac{a^2}{div_a{}^2} + \frac{b^2}{div_b{}^2} + \frac{c^2}{div_c{}^2} + ...}$$

Where uc = standard uncertainty
a, b, c,.. = individual uncertainty elements
Diva, b, c = the individual uncertainty element divisor based on the probability distribution
Divisor = 1.732 for rectangular distribution
Divisor = 2 for normal distribution
Divisor = 1.414 for trapezoid distribution

Equation 2: Expanded Uncertainty

$$U = ku_c$$

Where:
U = expanded uncertainty
k = coverage factor
k ≤ 2 for 95% coverage (ANSI/NCSL Z540-2 Annex G)
uc = standard uncertainty

The measurement uncertainty complies with the maximum allowed uncertainty from CISPR 16-4-2. Measurement uncertainty is not used to adjust the measurements to determine compliance. The expanded uncertainty values for the various scopes in the WLL accreditation are provided in Table 5 below.

Table 5: Expanded Uncertainty List

Scope	Standard(s)	Expanded Uncertainty
Conducted Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	± 2.63 dB
Radiated Emissions	CISPR11, CISPR22, CISPR32, CISPR14, FCC Part 15	± 4.55 dB

3 Test Equipment

Table 6 shows a list of the test equipment used for measurements along with the calibration information.

Table 6: Test Equipment List

Test Name:	**Radiated Emissions**	Test Date:	**6/7/2023**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00993	KEYSIGHT N9020B	MXA SIGNAL ANALYZER	12/5/2024
00644	SUNOL SCIENCES CORPORATION JB1 925-833-9936	BICONALOG ANTENNA	11/7/2024
00626	ARA DRG-118/A	ANTENNA HORN	8/20/2023
00065	HP 8447D	RF PRE-AMPLIFIER	5/9/2024
00627	AGILENT 8449B	AMPLIFIER 1-26GHZ	10/11/2023
00595	EAGLE TNF-200 TNF-200	NOTCH FILTER	Cal before Use

Test Name:	**Frequency Deviation (Temperature)**	Test Date:	**11/13/2023**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00974	THERMOTRON SM-16-8200	TEMPERATURE AND HUMIDITY CHAMBER	12/14/2023
00942	AGILENT MXA-N9020A	SPECTRUM ANALYZER	12/19/2024

Test Name:	**Conducted Emissions**	Test Date(s):	**12/18/2023**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00823	AGILENT N9010A	EXA SPECTRUM ANALYZER	6/7/2024
00053	HP 11947A	LIMITER TRANSIENT	2/14/2024
00125	SOLAR 8028-50-TS-24-BNC	LISN	5/25/2024
00126	SOLAR 8028-50-TS-24-BNC	LISN	5/25/2024

Test Name:	**OBW**	Test Date:	**04/01/2024**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
00993	KEYSIGHT N9020B	MXA SIGNAL ANALYZER	11/6/2025
00179	EMCO 7405	PROBE NEAR FIELD KIT	CNR

4 Rule Declarations from Manufacturer

Application of the Waiver DA 10-291 to part 90 of The Commission's Rules is declared by the manufacturer and the Order of Reconsideration DA 11-675

5 Test Results

5.1 Total Power [FCC Waiver DA 10-291 Paragraph 7]

5.1.1 Test Method

ANSI C63.26, Section 5.2.7 d) Radiated Power Measurements

The Field Strength to EIRP Conversion is:

EIRP (dBm) Power = dBuV/m + 20LOG(D_m) – 104.8 *(where D_m = 3.0m)*

5.1.2 Test Limit

FCC Waiver DA 10-291 Paragraph 7 states an operating power not to exceed 250mW (23.98dBm) average power and a 1W (30dBm) peak power.

5.1.3 Test Results

The final (corrected) power levels are provided in

Table 7 through Table 12: RF Peak Power @ 437.25 MHz (Video Carrier), Channel A.

5.1.4 Test Summary

The EIRP Total power complies with the requirements as per FCC Waiver DA 10-291 Paragraph 7.

Table 7: RF Peak Power @ 431.25MHz (Video Carrier), Channel B

Frequency (MHz)	Detector	Corrected Level (dBuV/m)	EIRP (dBm)	EIRP Limit (dBm)	Delta (dB)	Turn Table (deg)	Antenna (cm)	Orientation
431.25	Peak	111.6	16.4	30.0	-13.6	90	Vert, 120	X
	Avg	107.4	12.2	24.0	-11.8	90	Vert, 120	X
	Peak	122.7	27.5	30.0	-2.5	90	Vert, 120	Y
	Avg	118.2	23.0	24.0	-1.0	270	Vert, 120	Y
	Peak	116.6	21.4	30.0	-8.6	90	Horiz,120	Z
	Avg	112.7	17.5	24.0	-6.5	0	Vert, 120	Z

Table 8: RF Peak Power @ 435.75MHz (Audio Carrier), Channel B

Frequency (MHz)	Detector	Corrected Level (dBuV/m)	EIRP (dBm)	EIRP Limit (dBm)	Delta (dB)	Turn Table (deg)	Antenna (cm)	Orientation
435.75	Peak	106.6	11.4	30.0	-18.6	0	Vert, 120	X
	Avg	106.1	10.9	24.0	-13.2	0	Vert, 120	X
	Peak	106.1	10.9	30.0	-19.1	90	Vert, 120	Y
	Avg	105.8	10.6	24.0	-13.4	90	Vert, 120	Y
	Peak	102.7	7.5	30.0	-22.5	180	Vert, 120	Z
	Avg	102.1	6.9	24.0	-17.1	180	Vert, 120	Z

Table 9: RF Peak Power @ 437.25 MHz (Video Carrier), Channel C

Frequency (MHz)	Detector	Corrected Level (dBuV/m)	EIRP (dBm)	EIRP Limit (dBm)	Delta (dB)	Turn Table (deg)	Antenna (cm)	Orientation
437.25	Peak	120.1	24.9	30.0	-5.1	0	Vert, 120	X
	Avg	115.5	20.3	24.0	-3.7	0	Vert, 120	X
	Peak	113.7	18.5	30.0	-11.5	180	Vert, 120	Y
	Avg	109.5	14.3	24.0	-9.7	180	Vert, 120	Y
	Peak	121.4	26.2	30.0	-3.9	180	Vert, 120	Z
	Avg	117.1	21.9	24.0	-8.2	180	Vert, 120	Z

Table 10: RF Peak Power @ 441.75 MHz (Audio Carrier), Channel C

Frequency (MHz)	Detector	Corrected Level (dBuV/m)	EIRP (dBm)	EIRP Limit (dBm)	Delta (dB)	Turn Table (deg)	Antenna (cm)	Orientation
441.75	Peak	104.9	9.7	30.0	-20.3	0	Vert, 120	X
	Avg	104.1	8.9	24.0	-15.1	0	Vert, 120	X
	Peak	100.1	4.9	30.0	-25.1	90	Vert, 120	Y
	Avg	97.8	2.6	24.0	-21.4	90	Vert, 120	Y
	Peak	103.8	8.6	30.0	-21.4	180	Vert, 120	Z
	Avg	103.0	7.8	24.0	-16.2	180	Vert, 120	Z

Table 11: RF Peak Power @ 437.25 MHz (Video Carrier), Channel A

Frequency (MHz)	Detector	Corrected Level (dBuV/m)	EIRP (dBm)	EIRP Limit (dBm)	Delta (dB)	Turn Table (deg)	Antenna (cm)	Orientation
443.25	Peak	118.5	23.3	30.0	-6.7	0	Vert, 120	X
	Avg	115.1	19.9	24.0	-4.1	0	Vert, 120	X
	Peak	121.5	26.3	30.0	-3.7	270	Vert, 120	Y
	Avg	116.7	21.5	24.0	-2.5	270	Vert, 120	Y
	Peak	119.0	23.8	30.0	-6.2	90	Horiz, 120	Z
	Avg	113.9	18.7	24.0	-5.3	90	Horiz, 120	Z

Table 12: RF Peak Power @ 437.25 MHz (Video Carrier), Channel A

Frequency (MHz)	Detector	Corrected Level (dBuV/m)	EIRP (dBm)	EIRP Limit (dBm)	Delta (dB)	Turn Table (deg)	Antenna (cm)	Orientation
447.75	Peak	103.8	8.6	30.0	-21.4	0	Vert, 120	X
	Avg	103.1	7.9	24.0	-16.1	0	Vert, 121	X
	Peak	101.4	6.2	30.0	-23.8	90	Vert, 122	Y
	Avg	100.7	5.5	24.0	-18.5	90	Vert, 123	Y
	Peak	103.0	7.8	30.0	-22.2	180	Vert, 124	Z
	Avg	102.3	7.1	24.0	-16.9	180	Vert, 125	Z

5.2 Emission Bandwidth [FCC Waiver DA 10-291 Paragraph 7]

5.2.1 Test Method

ANSI C63.26, Section 5.4.3 Occupied Bandwidth-Relative measurement procedure.

5.2.2 Test Limit

As per FCC Waiver DA10-291, the emissions bandwidth must not exceed 6MHz.

5.2.3 Test Results

Figure 2 through Figure 4 provide the test results.

5.2.4 Test Summary

Below shows the maximum measured bandwidths for the video & audio signals as well as the combined bandwidth (less than 4.7MHz) This data was investigative to determine which standardized pattern produced worst case operating conditions.

Table 13: Occupied Bandwidth Test Data, Both Audio & Video Carrier

Channel	Frequency (MHz)	20dB OBW
Channel B	Video 431.25MHz& SSB Audio 435.75MHz	4.532 MHz
Channel C	Video 437.25MHz & SSB Audio 441.75MHz	4.597 MHz
Channel A	Video 443.25MHz & SSB Audio-447.75MHz	4.629 MHz

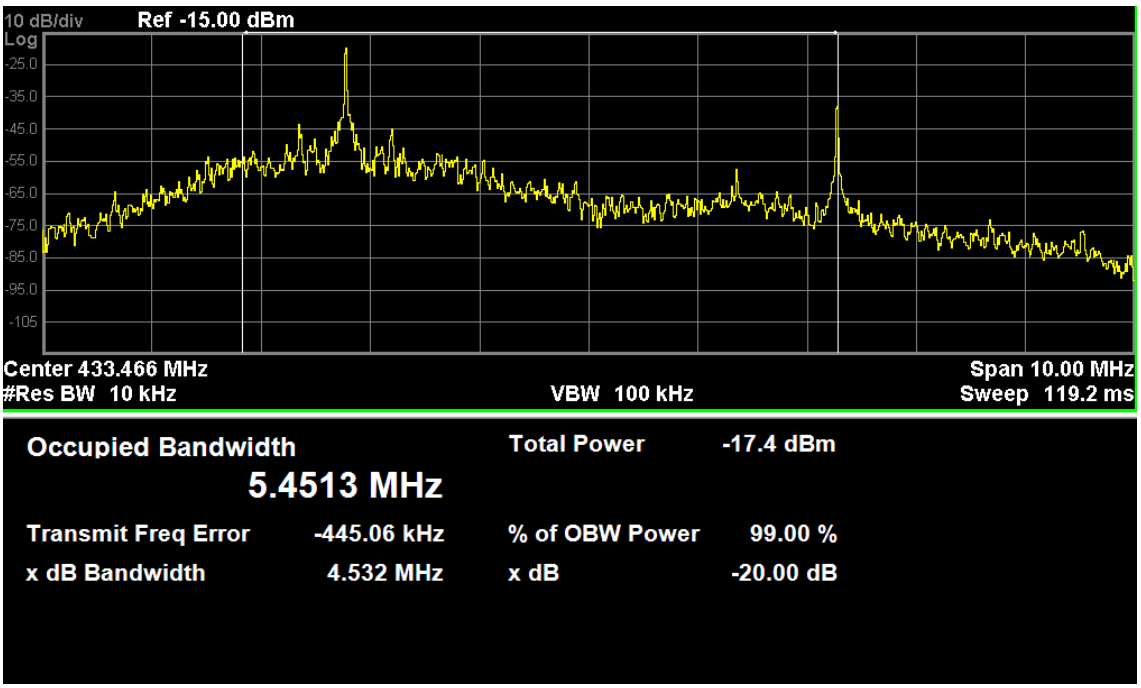


Figure 2: Occupied Bandwidth – Channel B, Video & SSB Audio

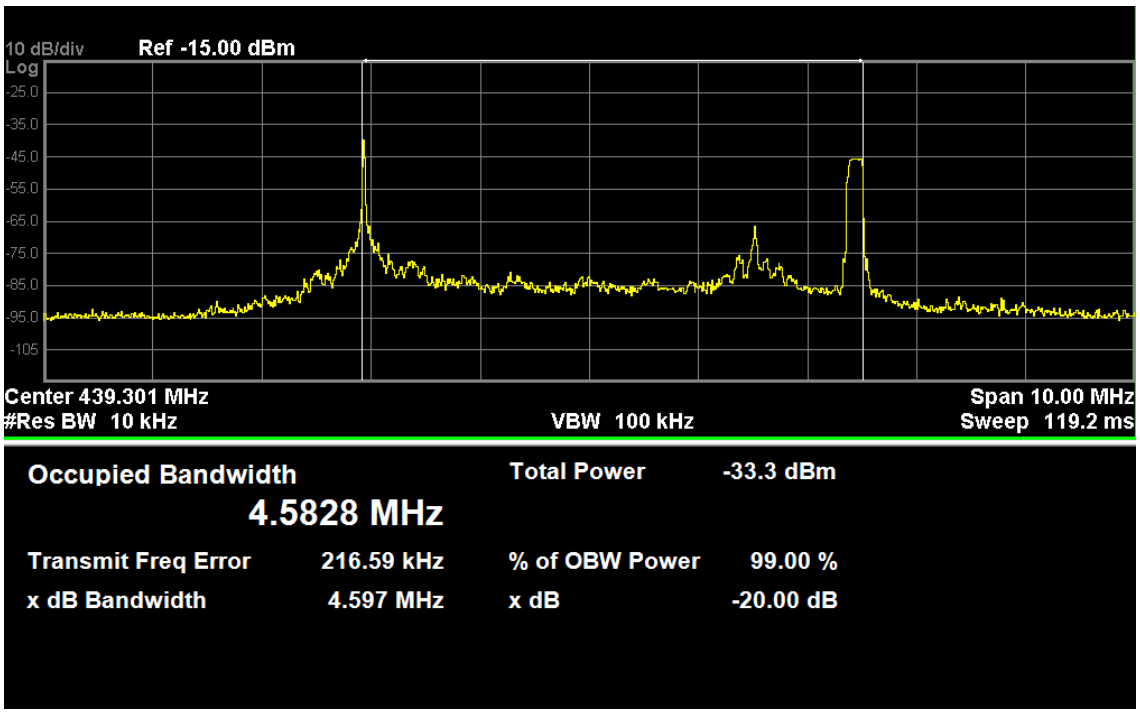


Figure 3: Occupied Bandwidth – Channel C, Video & SSB Audio

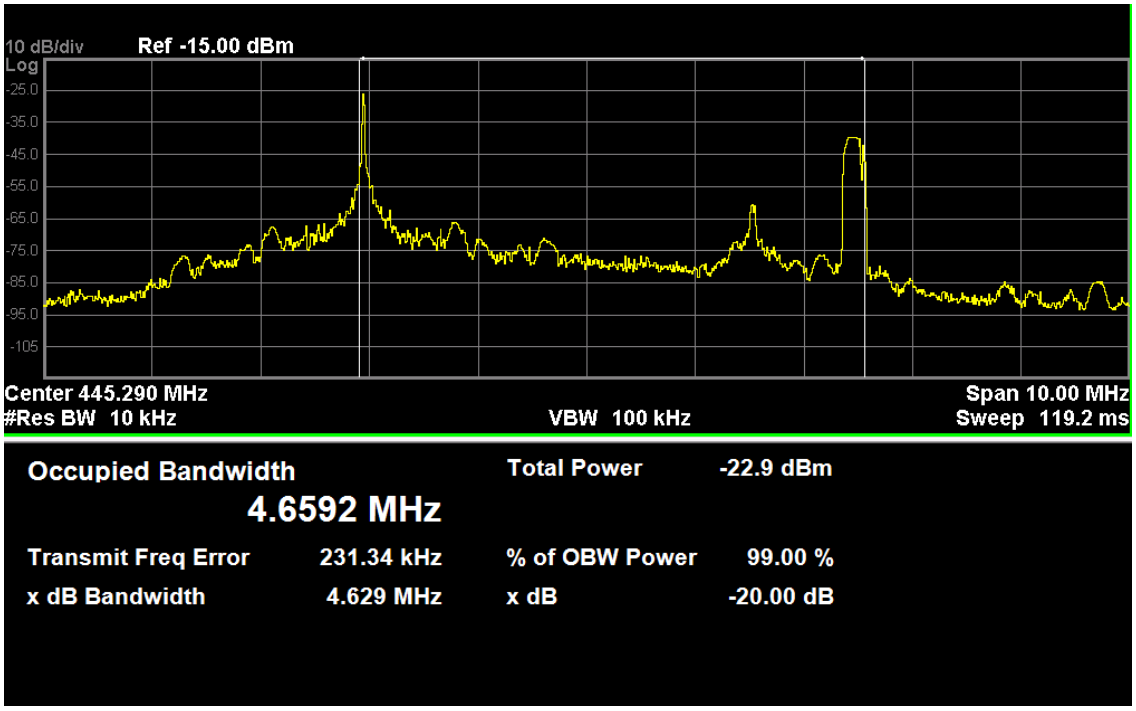


Figure 4: Occupied Bandwidth – Channel A, Video & SSB Audio

Table 14: Occupied Bandwidth Test Data, Audio Carrier 1kHz Test Tone

Channel	Frequency (MHz)	20dB OBW
Channel B	Video 431.25MHz& SSB Audio 435.75MHz	256.95 kHz
Channel C	Video 437.25MHz & SSB Audio 441.75MHz	208.01 kHz
Channel A	Video 443.25MHz & SSB Audio-447.75MHz	175.08 kHz

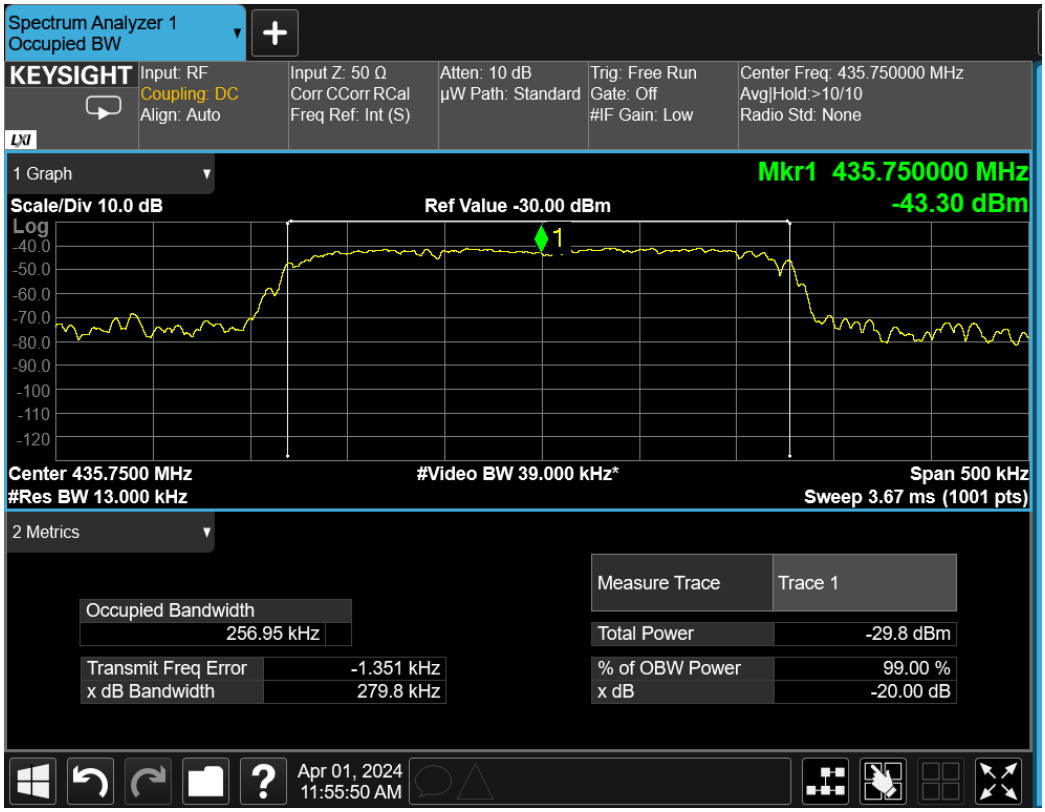


Figure 5: Occupied Bandwidth – Channel B, Audio OBW, With 1kHz Tone

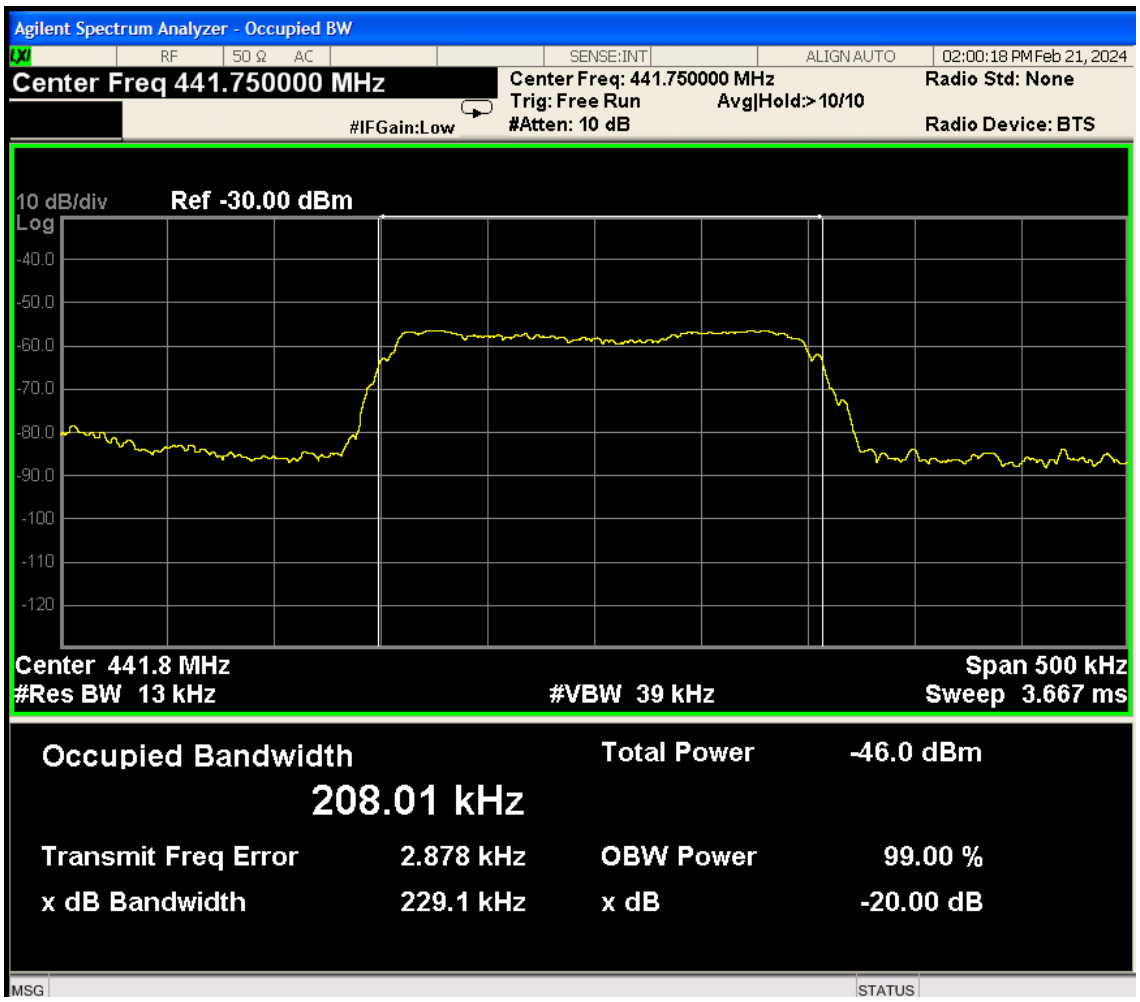


Figure 6: Occupied Bandwidth – Channel C, Audio OBW, With 1kHz Tone

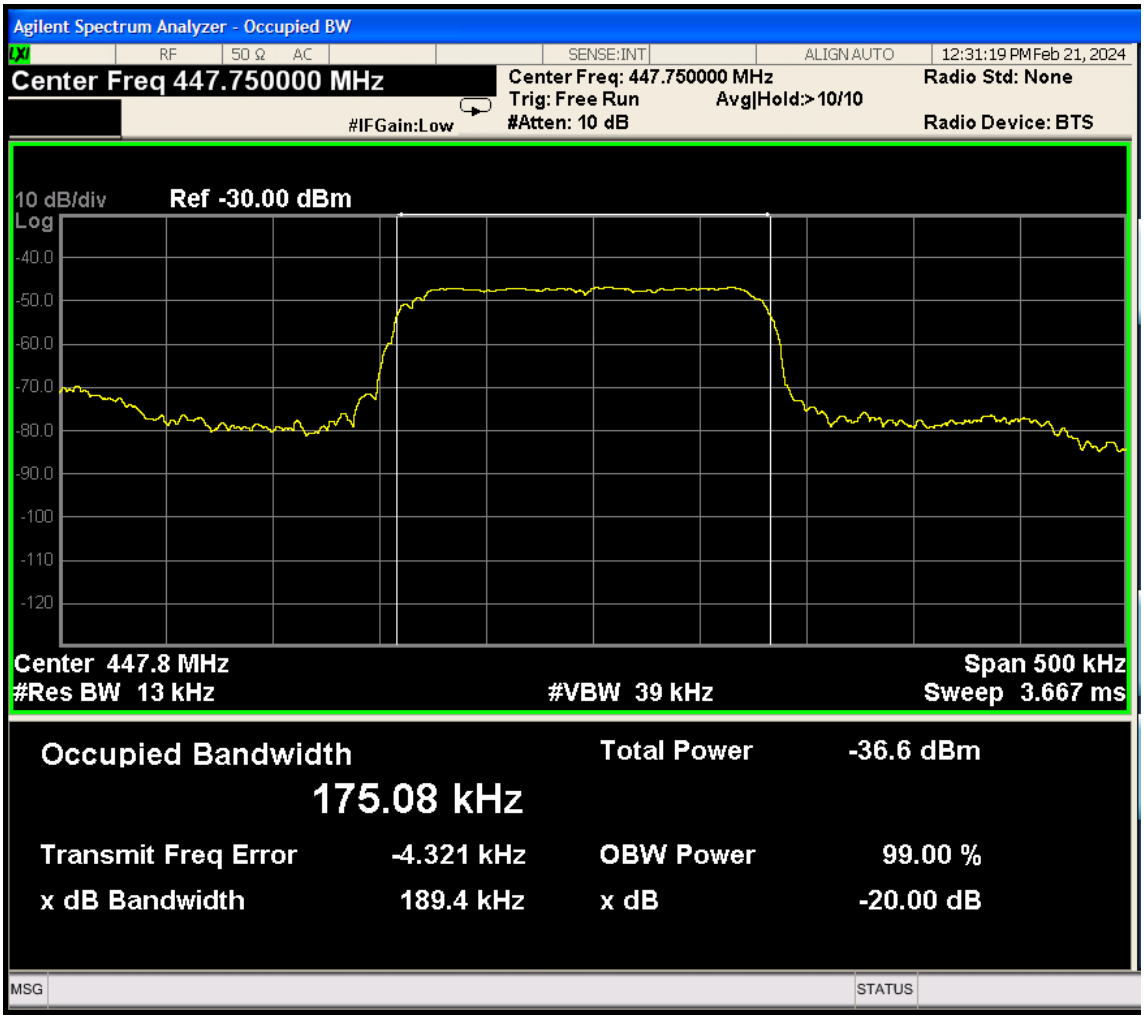


Figure 7: Occupied Bandwidth – Channel A, Audio OBW, With 1kHz Tone

Table 15: Occupied Bandwidth Test Data, Video Carrier

Channel	Frequency (MHz)	20dB OBW
Channel B	Video 431.25MHz& SSB Audio 435.75MHz	644.8 kHz
Channel C	Video 437.25MHz & SSB Audio 441.75MHz	637.2 kHz
Channel A	Video 443.25MHz & SSB Audio-447.75MHz	1.413 MHz

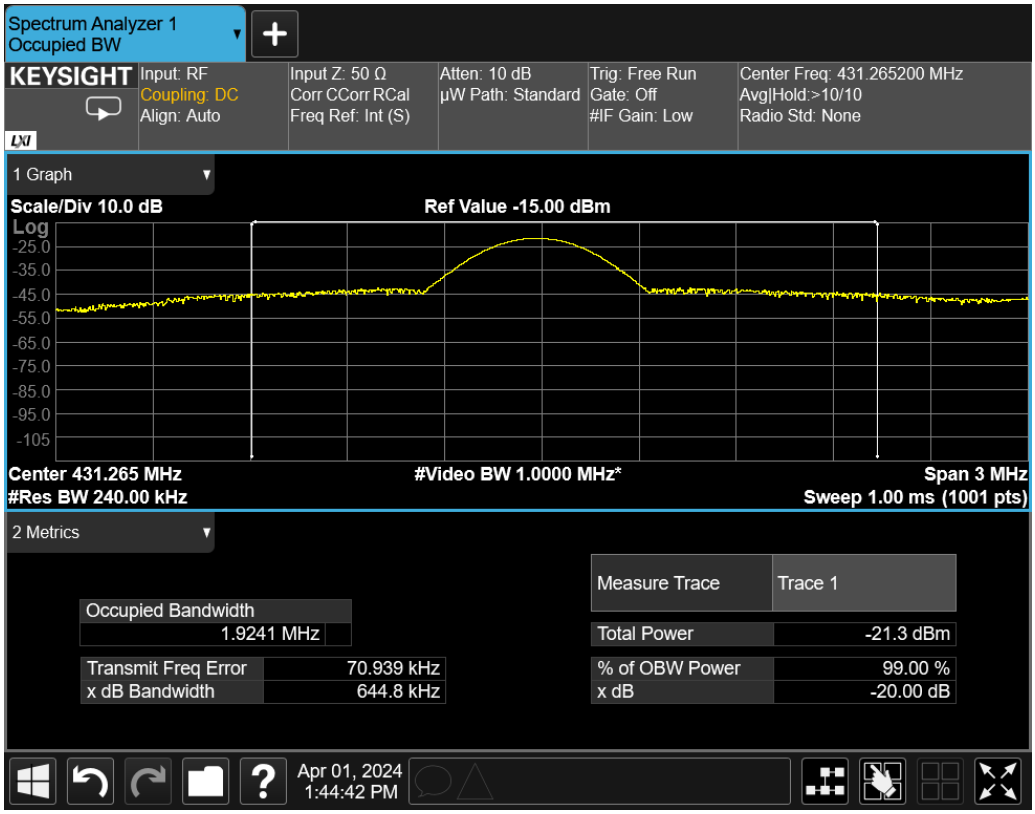


Figure 8: Occupied Bandwidth – Channel B, Video OBW

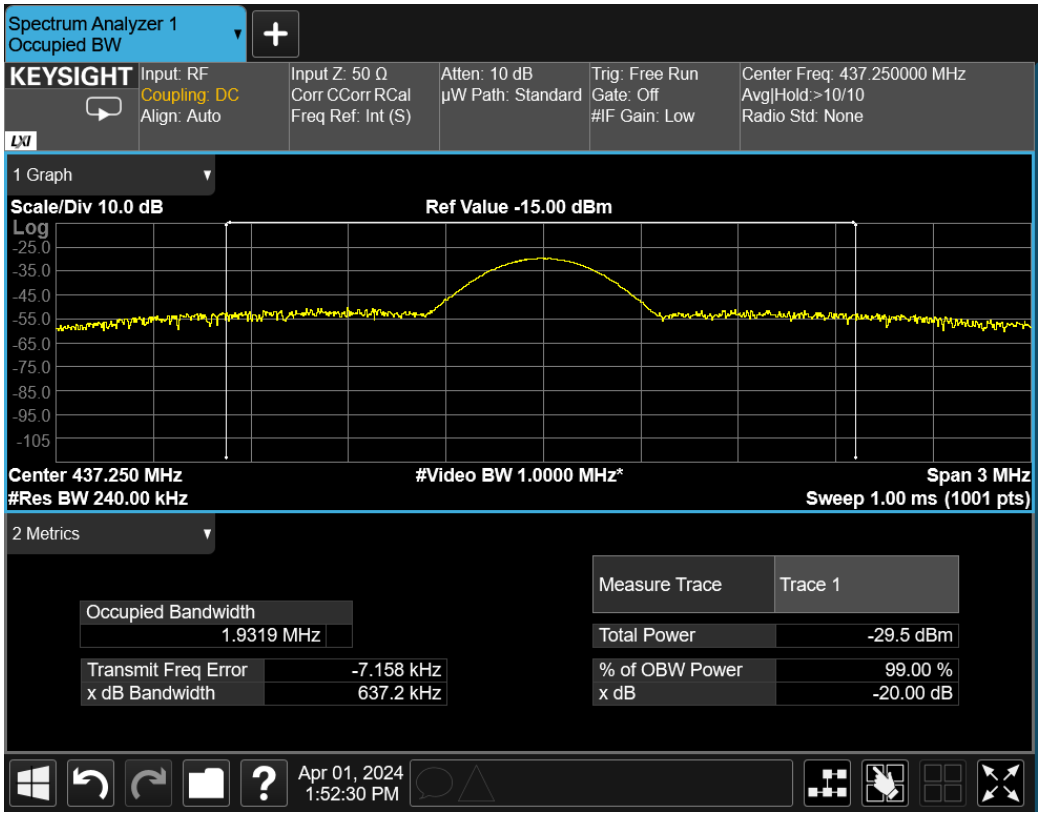


Figure 9: Occupied Bandwidth – Channel C, Video OBW

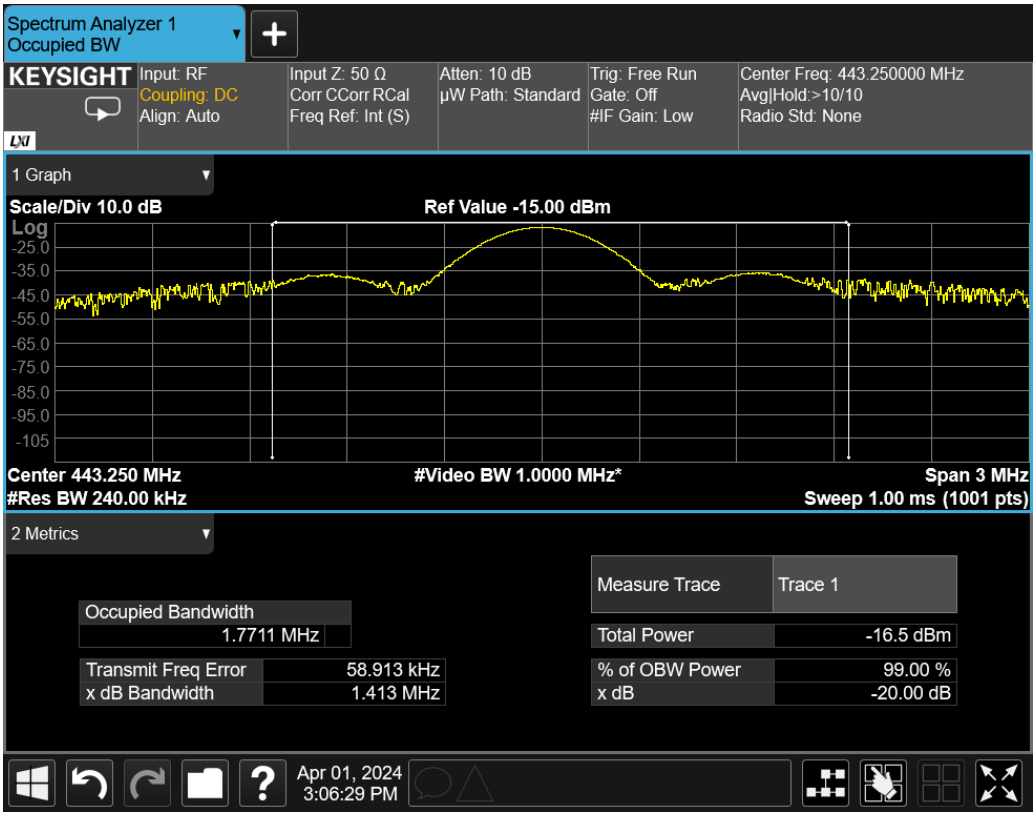


Figure 10: Occupied Bandwidth – Channel A, Video OBW

5.3 Unwanted Radiation [FCC Part 90.210 (b)(1)(2)(3)]

5.3.1 Test Method

ANSI C63.26, Section 5.2.7 d) Radiated Power Measurements

The Field Strength to EIRP Conversion is:

EIRP (dBm) Power = dBuV/m + 20LOG(D_m) – 104.8 *(where D_m = 3.0m)*

5.3.2 Test Results

The reference emissions measurements are shown in Figure 11 thru Figure 13.

5.3.3 Test Summary

The EUT complied with the requirements of FCC Part [90.210 b (1) (2) (3)]. The EUT additionally complied with the requirements of a typical NTSC signal. 6 MHz was used as the authorized bandwidth from the assigned frequency. The plots per emissions Mask B (used to demonstrate the emission characteristics since no masks seemed appropriate to this type of transmitter) indicate compliance to the -13dBm spurious limit at the band edges. The 3 units tested had assigned center frequencies of 445, 433, and 439MHz.

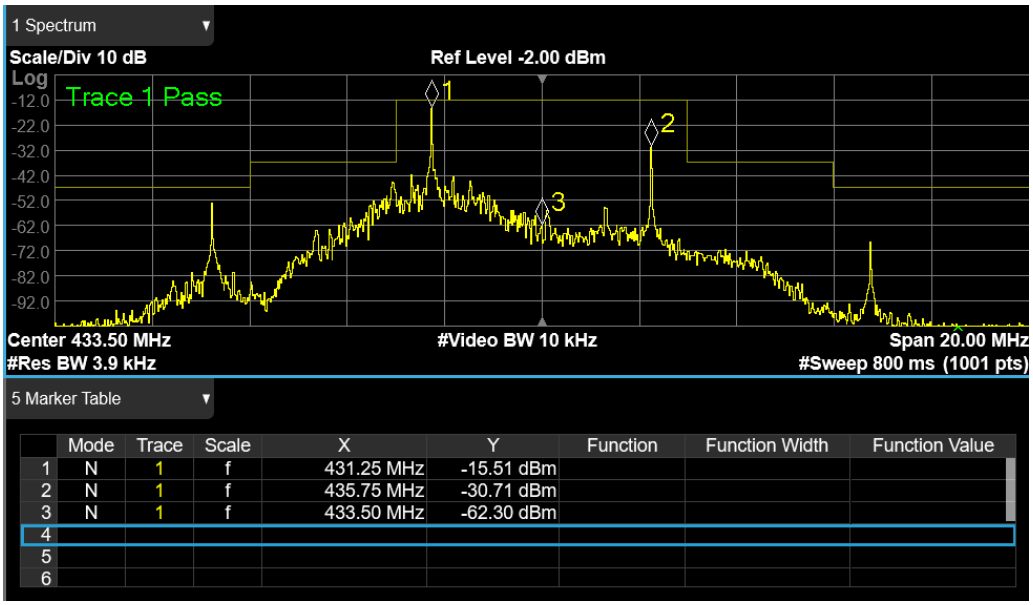


Figure 11: Emissions Mask, Video 431.25MHz & SSB Audio 435.75MHz

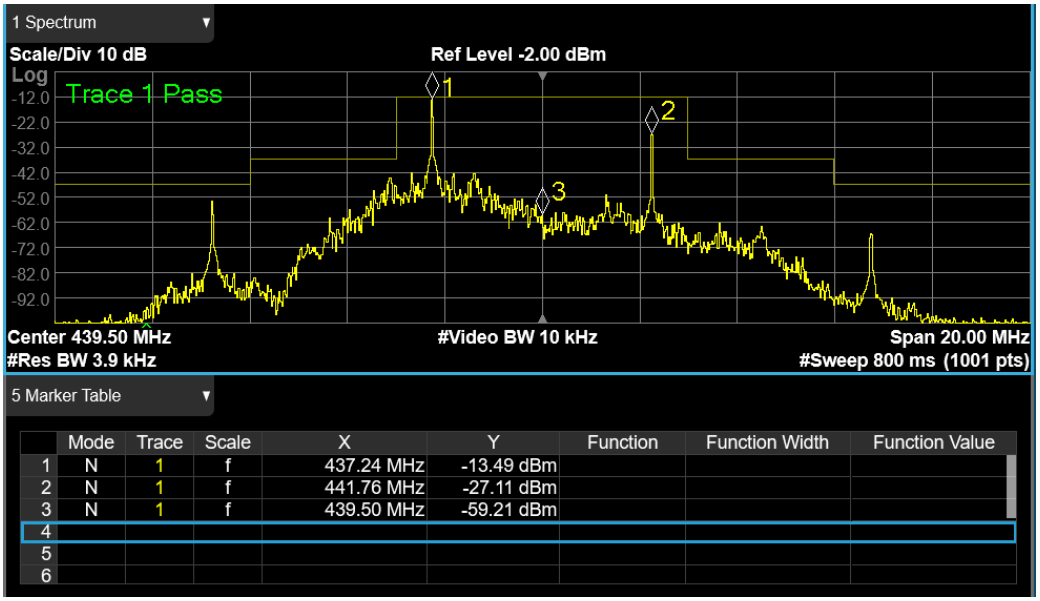


Figure 12: Emissions Mask, Video 437.25MHz & SSB Audio 441.75MHz

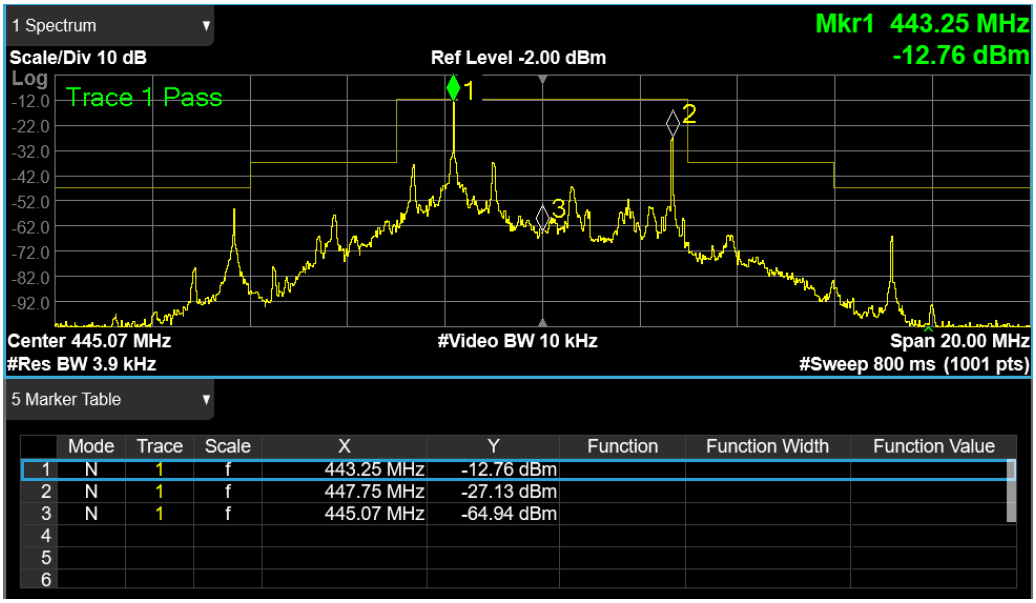


Figure 13: Emissions Mask, Video 443.25MHz & SSB Audio-447.75MHz

5.4 Transmitter Limitations/Case Radiated, §90.210(b)

5.4.1 Test Method: ANSI C63.26, Section 5.2.7 c) Radiated Power Measurements

The requirements of this section shall follow the rules outlined in FCC Part §90.210(b). This section shall focus on the case-radiated unwanted emissions, that are detectable in the frequency range of frequencies which are removed from the assigned frequency by more than 250 percent of the authorized bandwidth. That is, traditionally recognized as 30 MHz to the tenth harmonic of the highest fundamental frequency, or to 40 GHz (whichever is lower); in accordance with FCC Part §2.1057(3).

5.4.2 Requirements

The limits for radiated spurious emissions that are detected in a band that is more than 250% removed from the authorized bandwidth, containing the assigned fundamental frequency, is calculated from the following formula, which is based on the EUT power measurement from Section 4.1 of this report:

$\text{Limit}_{(dBm)} = \text{Peak Power}_{(dBm)} - (43 + 10 * \text{LOG (Peak Power}_{[Watts]})$

Limit = 30 – (43 + 10LOG (1))

Limit = –13.0 dBm

5.4.3 Radiated Data Reduction and Reporting

To convert the raw spectrum analyzer radiated data into a form that can be compared with the FCC limits, it is necessary to account for various calibration factors that are supplied with the antennas and other measurement accessories. These factors are included into the antenna factor (AF) column of the table and in the cable factor (CF) column of the table. The AF (in dB/m) and the CF (in dB) is algebraically added to the raw Spectrum Analyzer Voltage in dBµV to obtain the Radiated Electric Field in dBµV/m. This logarithm amplitude is converted to a linear amplitude, then compared to the FCC limit.

Example:

Spectrum Analyzer Voltage:	VdBµV
Antenna Correction Factor:	AFdB/m
Cable Correction Factor:	CFdB
Pre-Amplifier Gain (if applicable):	GdB
Electric Field: EdBµV/m =	V dBµV + AFdB/m + CFdB - GdB
Convert to linear units of measure:	EdBµV/m/20 Inv log

The measured field strength values, of radiated emission shall be compared to the calculated EIRP limit as shown below.

E (dBμV/m) = EIRP (dBm) − 20log(D) + 104.8; where D is the measurement distance

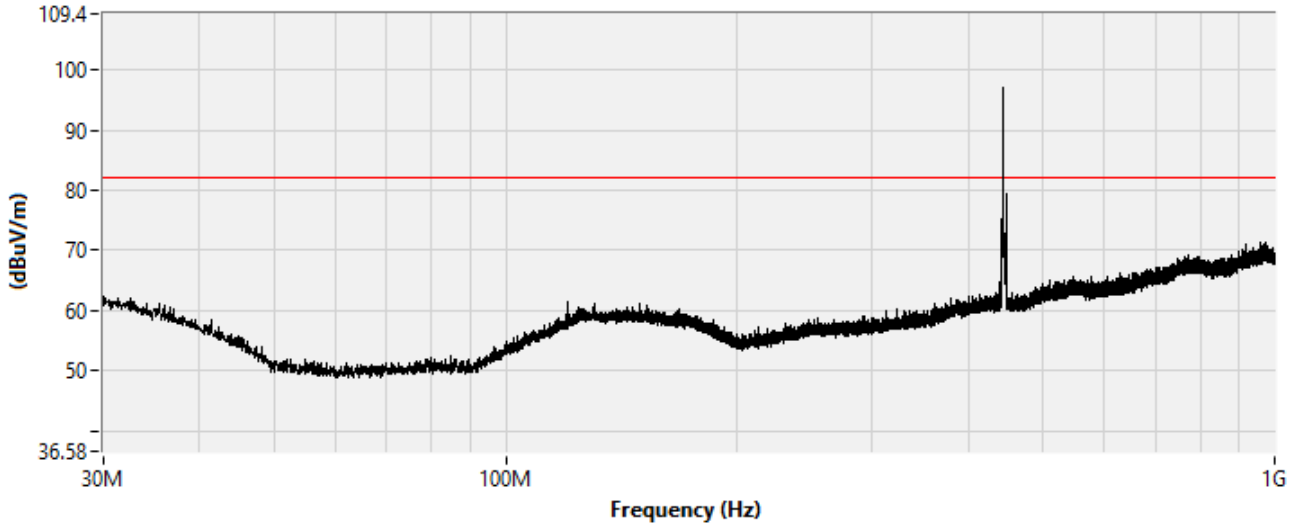
Limit:-13dBm -20Log(3m)+104.8= 82.25dBuV @ 3meters

5.4.4 Test Results

The EUT complies with the emission requirements of this section. Figure 14 Thru Figure 19 provide radiated Emissions test results.

For Radiated Emissions testing, the EUT was set to transmit at the center channel for 30 MHz-1000MHz and for 1000MHz -6 GHz.

Vertical



Horizontal

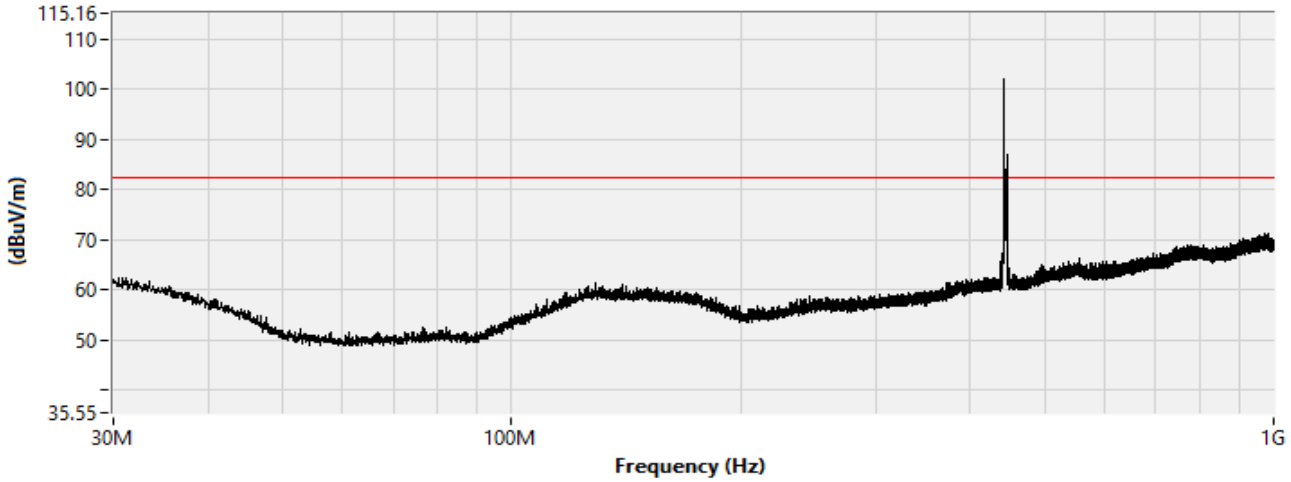
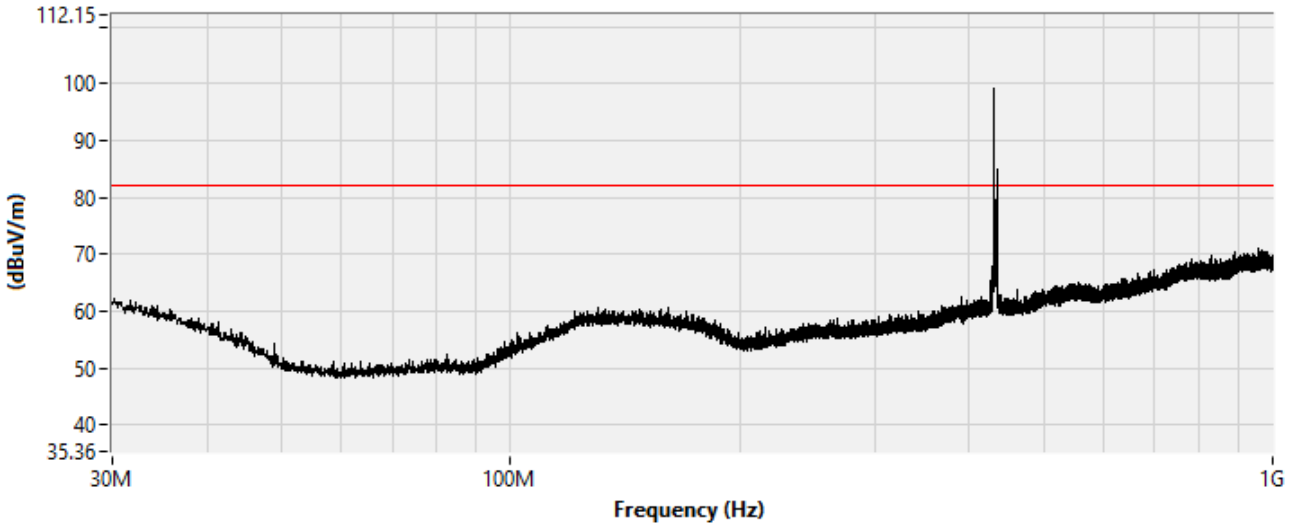


Figure 14: Case Radiated Emissions Test Data, 30 MHz – 1 GHz (EUT A2)

Vertical



Horizontal

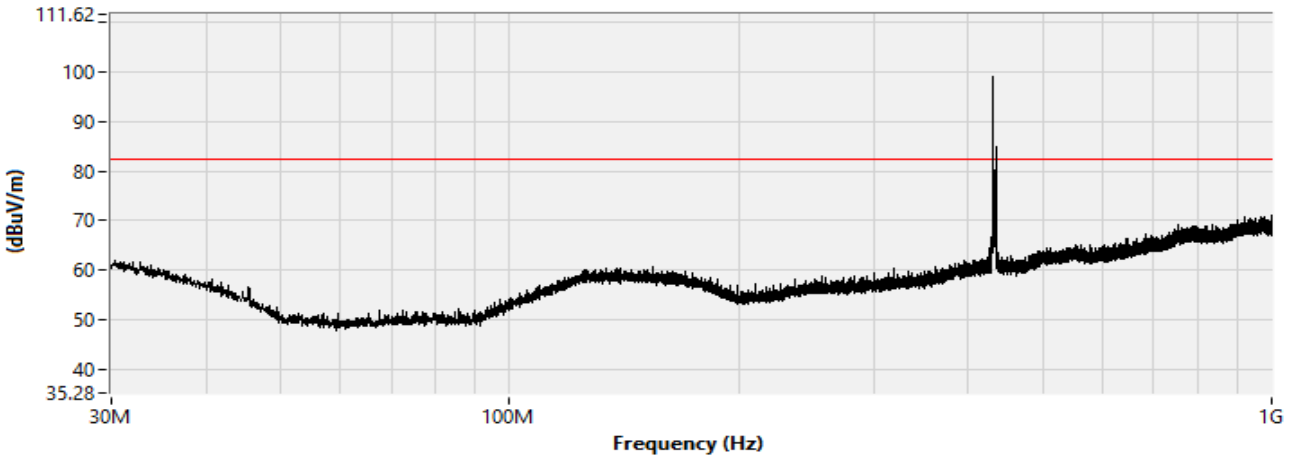
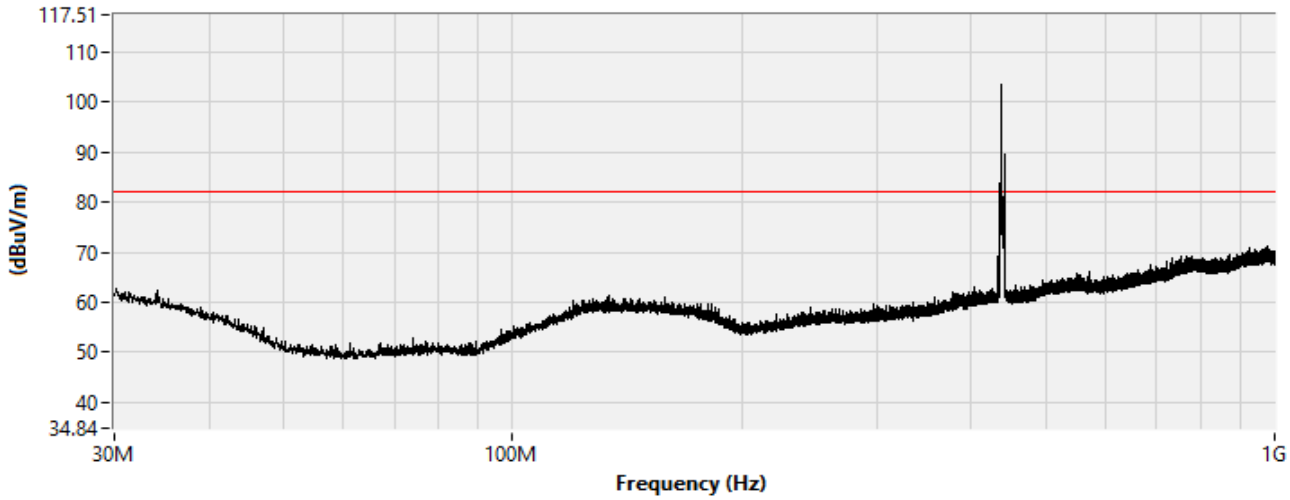


Figure 15: Case Radiated Emissions Test Data, 30 MHz – 1 GHz (EUT B2)

Vertical



Horizontal

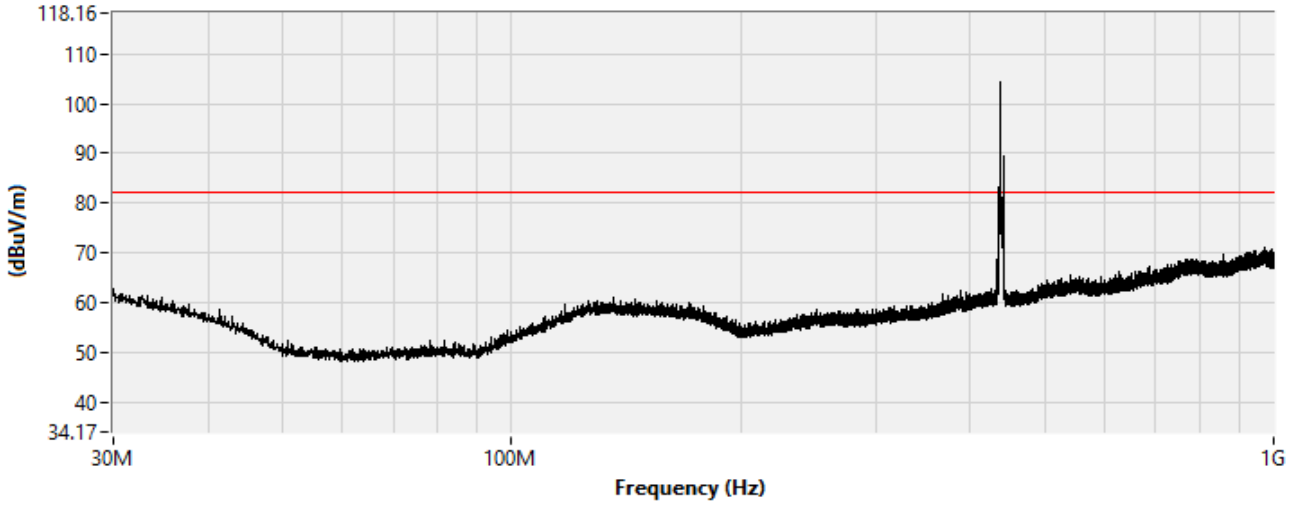
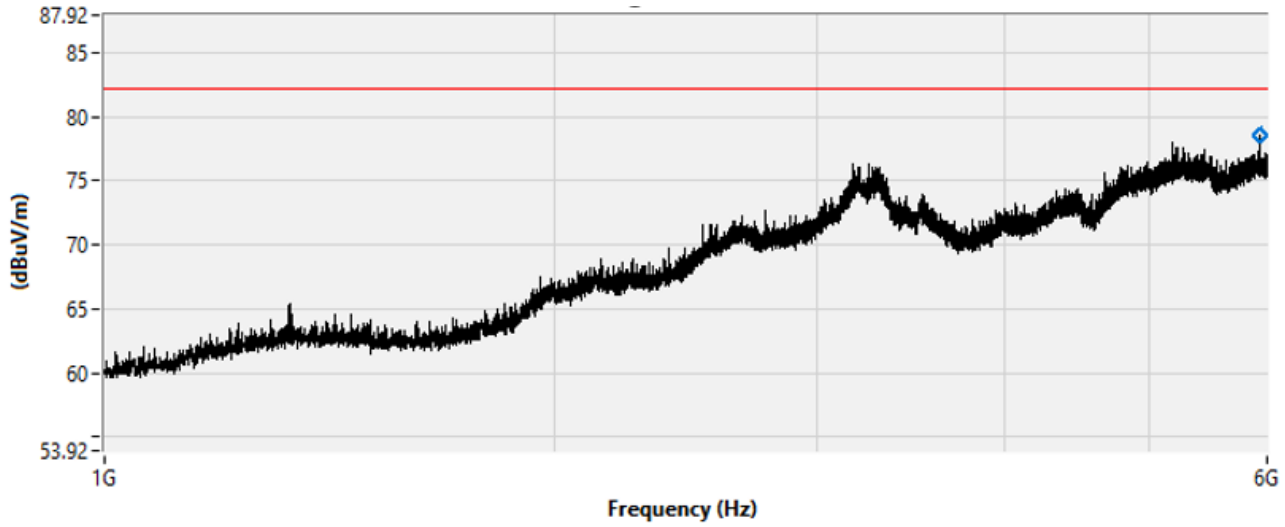


Figure 16: Case Radiated Emissions Test Data, 30 MHz – 1 GHz (EUT C2)

Vertical



Horizontal

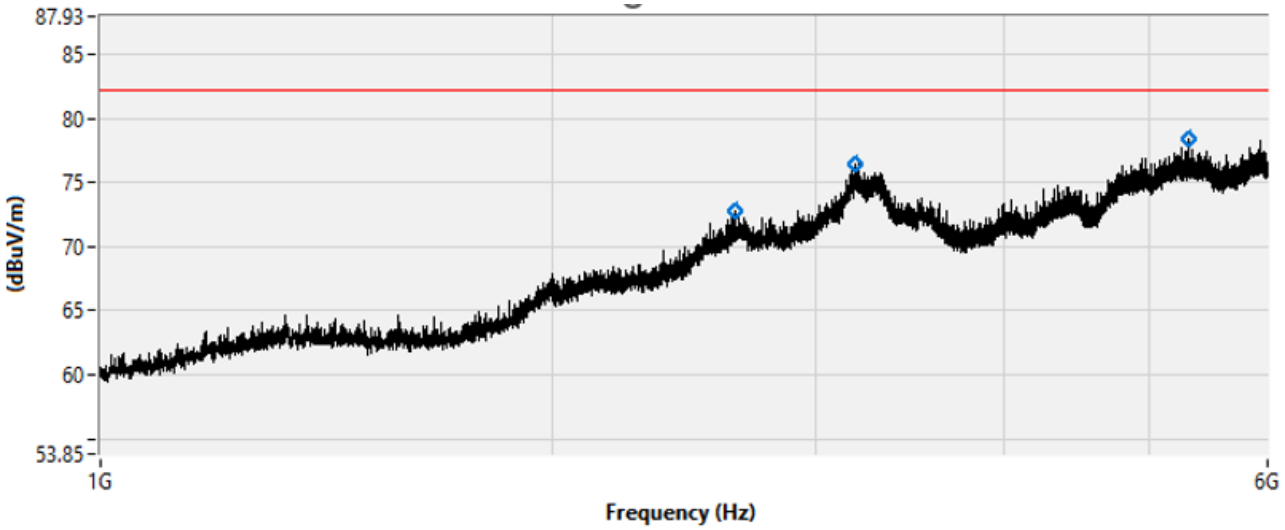
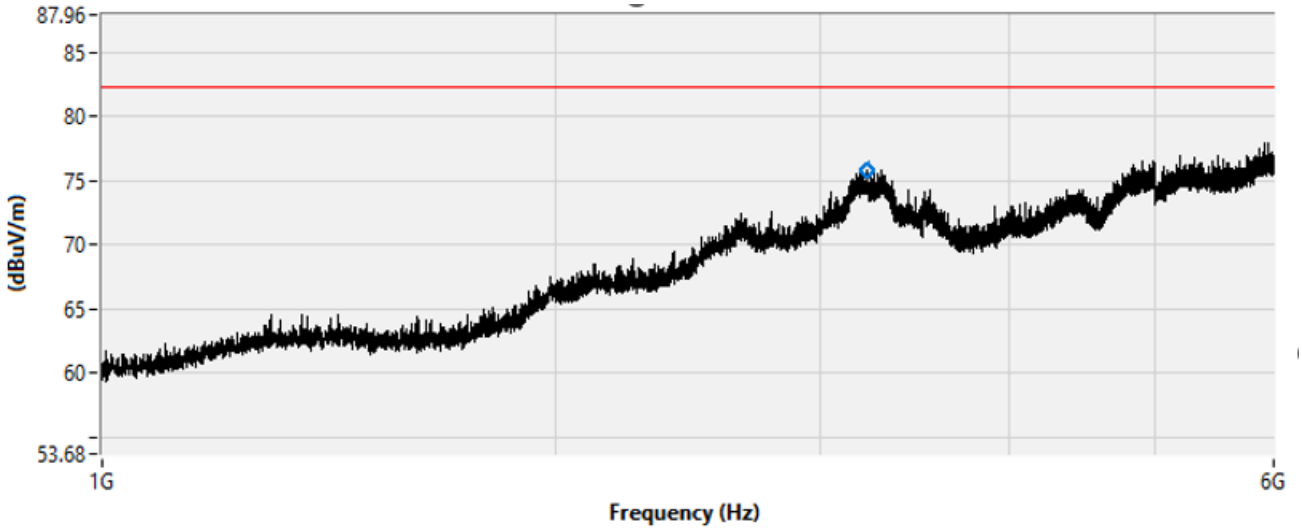


Figure 17: Case Radiated Emissions Test Data, 1 GHz -6 GHz (EUT A2)

Vertical



Horizontal

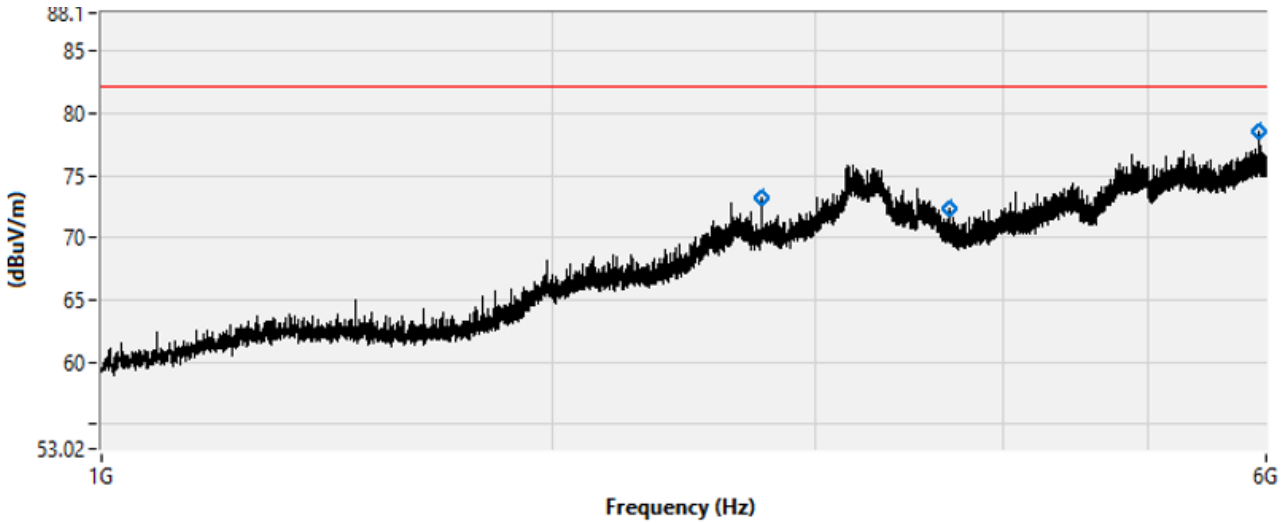
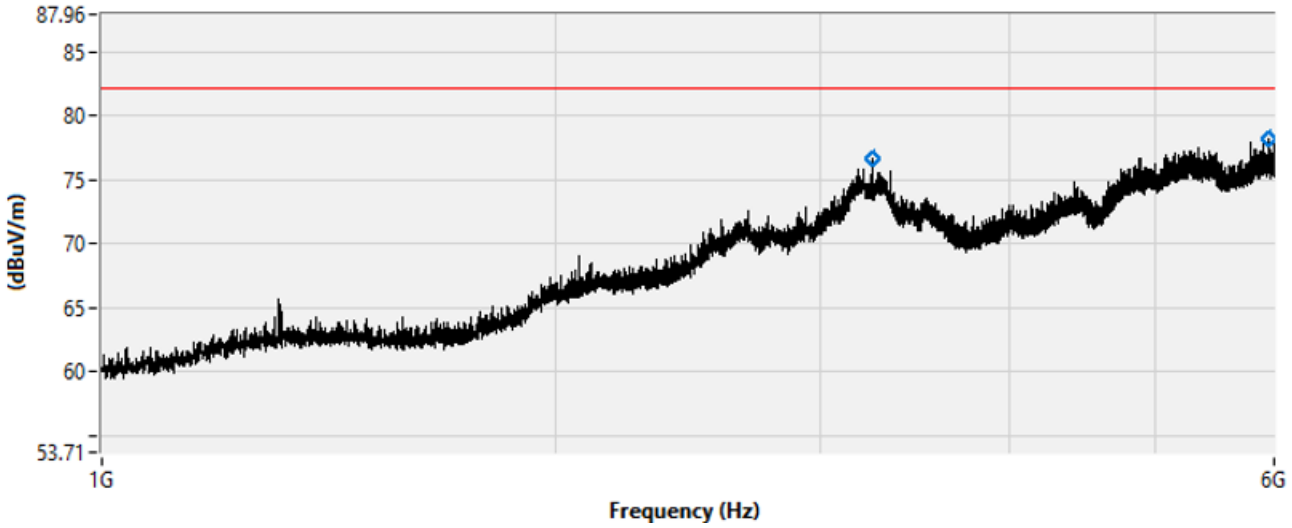


Figure 18: Case Radiated Emissions Test Data, 1 GHz -6 GHz (EUT B2)

Vertical



Horizontal

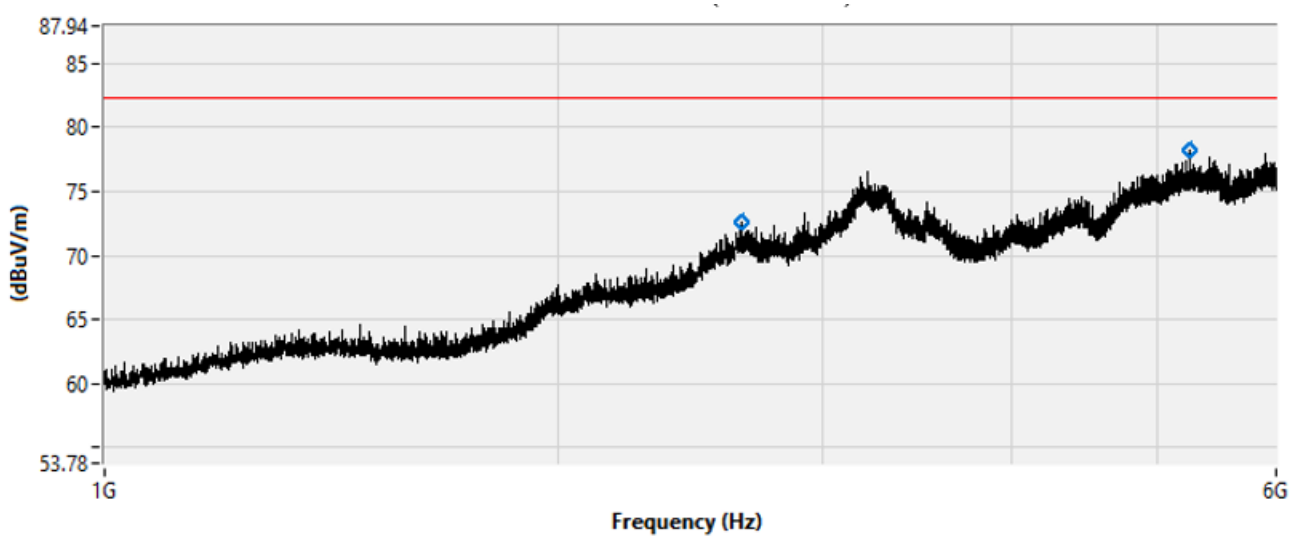


Figure 19: Case Radiated Emissions Test Data, 1 GHz -6 GHz (EUT C2)

5.5 Frequency Stability – FCC Part §90.213(a)

The minimum frequency stability for transmitters that operate above 5925 MHz is not defined.

5.5.1 Test Method

The EUT was placed in a calibrated temperature chamber. A receive antenna was placed in the temperature chamber with the device connected to a frequency counter outside the chamber. All three units were tested in accordance with Part 90. Discussion below provides an example of one configuration.

The EUT was turned on at preconfigured transmit frequency and the frequency recorded at ambient temperature. For example, at ambient temperature, EUT TROWBOT A2 transmit frequency reading on the spectrum analyzer was 443.249518 MHz at (23°C).

The EUT was turned off and the temperature chamber set to -30 Celsius after 1 hour at this temperature the unit was turned on, allowed to settle and a frequency reading was taken. The unit was turned back off and the temperature changed to -20 C. This process was repeated in 10 degree increments up to 50 Degrees Celsius allowing the unit to stabilize for 1 hour at each level before turning on the unit and recording the frequency. At each level the frequency recorded was compared to the ambient reading with the amount of deviation in Hz compared to the part 90 limit.

5.5.2 Test Limit

Part 90.213(a) states that transmitters with 2 watts or less must have a frequency tolerance of not more than 0.0005%.

5.5.3 Test Results

The test results are stated below, and complies with the temperature frequency requirements.

5.5.4 Test Results

Table 16 through Table 19 provide Frequency Stability results.

5.5.5

Table 16: Frequency Stability Test @ 443.25MHz

TROWBOT A2			
Temperature	Frequency	Difference	Deviation
Degrees C	MHz	Hz	(%)
Ambient (23)	443.249518	0	0
-30	443.249448	-70	0.000016
-20	443.249738	220	0.000050
-10	443.249693	175	0.000039
0	443.249708	190	0.000043
10	443.249648	130	0.000029
20	443.249653	135	0.000030
30	443.249388	-130	0.000029
40	443.248973	-545	0.000123
50	443.248963	-555	0.000125

Table 17:Frequency Stability Test @ 431 MHz

TROWBOT B2			
Temperature	Frequency	Difference	Deviation
Degrees C	MHz	Hz	(%)
Ambient (23)	430.997712	0	0
-30	430.99724	-472	0.000110
-20	430.99765	-62	0.000014
-10	430.997982	270	0.000063
0	430.997937	225	0.000052
10	430.997877	165	0.000038
20	430.997420	-292	0.000068
30	430.997442	-270	0.000063
40	430.997182	-530	0.000123
50	430.997182	-530	0.000123

Table 18:Frequency Stability Test @ 437MHz

TROWBOT C2			
Temperature	Frequency	Difference	Deviation
Degrees C (23)	MHz	Hz	(%)
Ambient	437.327785	0.0	0
-30	437.327930	145.0	0.000033
-20	437.328190	405.0	0.000093
-10	437.328275	490.0	0.000112
0	437.328225	440.0	0.000101
10	437.328155	370.0	0.000085
20	437.327960	175.0	0.000040
30	437.327675	-110.0	0.000025
40	437.327540	-245.0	0.000056
50	437.327530	-255.0	0.000058

Table 19: Frequency Tolerance vs. Battery Voltage (C2)

Voltage	Frequency	Difference	Deviation	Voltage
Volts	MHz	Hz	(%)	Volts
At rated 11.1	437.246780	0	0.0	11.10
85% VDC	437.246850	-70	0.000016	9.45
115 %VDC	437.246790	-10	0.000002	12.80