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FCC Certification Test Report

For the

RECONROBOTICS INC.

THROWBOT XT

FCC ID: UYXRSK2012-01

WLL REPORT# **12431-01 Rev 4**
March 14, 2012

Re-issued May 22, 2012

Prepared for:

ReconRobotics Inc.
7620 W. 78th Street
Edina, MN 55439

Prepared By:
Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

ACCREDITED TESTING

Testing Certificate AT-1448

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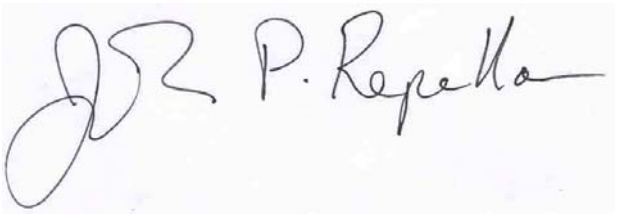


John Repella
EMC Compliance Engineer

Reviewed by:

Steven D. Koster
VP, EMC & Wireless

Abstract

This report has been prepared on behalf of ReconRobotics 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 (10/2010).

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, 7560 Lindbergh Drive, Gaithersburg, MD 20879.

Washington Laboratories, Ltd. has been accepted by the FCC and approved by ACLASS under 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/ACLASS. Refer to certificate and scope of accreditation AT-1448.

Revision History	Reason	Date
Rev 0	Initial Release	March 14, 2012
Rev 1	This revision addresses ACB comments	March 30, 2012
Rev 2	This revision addresses additional ACB comments	May 15, 2012
Rev 3	This revision incorporated the changes to the Emissions designator	May 21, 2012
Rev 4	This revision incorporated the changes to the Emissions designator	May 22, 2012

Table of Contents

List of Tables

List of Figures

1 Introduction

1.1 Compliance Statement

The ReconRobotics Inc. Throwbot XT was tested to the FCC Waiver DA-10-291of the requirements of Part 90 Private Land Mobile Radio Services Subpart I--Private Land Mobile Radio Services general technical requirements section of the FCC Rules and Regulations (10/2010).

1.2 Test Scope Summary

The following tests were performed using the applicable parts of the FCC rules as guidance:

Total Power	FCC Part 90.101
Emission Bandwidth	FCC Part 90.209(b)
Unwanted Radiation	FCC Part 90.210
Frequency Tolerance	FCC Part 90.213(a)
Transient Frequency Behavior	FCC Part 90.214

All measurements were performed in a radiated fashion.

1.3 Contract Information

Customer:	ReconRobotics Inc. 7620 W. 78th Street Edina, MN 55439
Purchase Order Number:	Check #6114
Quotation Number:	66537

1.4 Test Dates

Testing was performed on the following date(s):	02/29/2012 to 04/30/2012, 5/14/2012

1.5 Test and Support Personnel

Washington Laboratories, Ltd.	John P. Repella
Customer Representative	Andrew Drenner

1.6 Abbreviations

A	**A**mpere
ac	**a**lternating **c**urrent
AM	Amplitude Modulation
Amps	**Amp**ere**s**
b/s	**b**its per **s**econd
BW	**B**and**W**idth
CE	**C**onducted **E**mission
cm	**c**enti**m**eter
CW	**C**ontinuous **W**ave
dB	**d**eci**B**el
dc	**d**irect **c**urrent
EMI	**E**lectro**m**agnetic **I**nterference
EUT	**E**quipment **U**nder **T**est
FM	**F**requency **M**odulation
G	**g**iga - prefix for 10^9 multiplier
Hz	**H**ertz
IF	**I**ntermediate **F**requency
k	**k**ilo - prefix for 10^3 multiplier
LISN	**L**ine **I**mpedance **S**tabilization **N**etwork
M	**M**ega - prefix for 10^6 multiplier
m	**m**eter
µ	**m**icro - prefix for 10^{-6} multiplier
NB	**N**arrow**b**and
QP	**Q**uasi-**P**eak
RE	**R**adiated **E**missions
RF	**R**adio **F**requency
rms	**r**oot-**m**ean-**s**quare
SN	**S**erial **N**umber
S/A	**S**pectrum **A**nalyzer
V	**V**olt

2 Equipment Under Test

2.1 EUT Identification

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

Table 1: Overview of Throwbot XT, Equipment Under Test

ITEM	DESCRIPTION
Manufacturer:	ReconRobotics Inc.
EUT Name	Throwbot
FCC ID:	UYXRSK2012-01
Model:	XT
FCC Rule Parts:	Part 90
Frequency Range:	(3) 6 MHz Bands: 430-436MHz, 436-442MHz, 442-448MHz Per FCC Waver DA 10-291 and DA 11-675
Measured Output Power:	5.7dBm
Modulation:	AM Video & FM Audio
Emission Bandwidth:	4.67MHz (6MHz authorized)
Keying:	Automatic
Type of Information:	NTSC Video and Audio
Number of Channels:	3 channels available- units fixed at factory for single channel
Antenna Connector	Internal mmcx (not user accessible)
Antenna Type	¼ wave whip permanently attached to chassis
Antenna Gain	N/A
Frequency Tolerance:	0.0005%
Emission Designator:	Video - 5M753CF / Audio 250KF3E
Interface Cables:	None
Power Source & Voltage:	Rechargeable Battery, 11.3V nominal, 12.6Vmax

2.2 EUT Description

The Recon Scout 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 Recon Scout 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 Recon Scout 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 5M75C3F. The transmitter, as a whole, draws approximately 0.11 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 Recon Scout robot receives commands over a 75MHz R/C 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

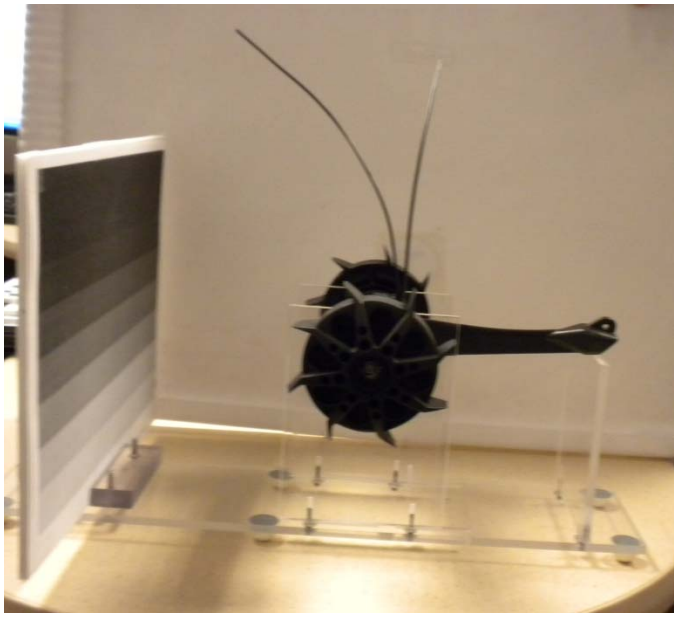
system plays an important role in antenna performance and EMI immunity. The video broadcast antenna is an approximately ¼ wave antenna constructed so as to be extremely robust to physical impacts, and yet not interfere with the mobility of the mechanical propulsion systems. The command receive antenna is similar in mechanical construction to the video broadcast antenna, but is tuned to use in receiving the 75MHz command signals the platform utilizes.

2.3 Test Configuration

The ReconRobotics Inc. Recon Scout (Throwbot XT), Equipment Under Test (EUT), was operated from a DC power supply. The devices are pre-configured with the transmit frequency (not user changeable). Three separate units were provided each unit configured to operate in one of the three 6 MHz channels, Unit A@ 442-448MHz, Unit B @ 430-436MHz, and Unit C@ 436-442MHz. The unit is intended to operate in one orientation only.

When the Throwbot XT is introduced into its intended environment it rights itself operationally, for this reason, it was tested in only one orthogonal, its intended operational position. Worst case investigations were performed on various video photographs; the worst case results were obtained using the 0.125 inch horizontal color bars. A 1 kHz tone was introduced for the audio portion of the EUT.

Note: The figure below depicts a representative test setup sample.



2.4 Equipment Configuration

The EUT was comprised of the following equipment. (All Modules, PCBs, etc. listed were considered as part of the EUT, as tested.)

Table 2: Equipment Configuration

Name / Description	Model Number	Part Number	Serial Number	Revision
Recon Scout/Throwbot	XT	0511H918-Robot	N/A	A (445MHz)
Recon Scout/Throwbot	XT	0511H1224-Robot	N/A	B (433MHz)
Recon Scout/Throwbot	XT	0511H919-Robot	N/A	C (439MHz)

2.5 Support Equipment

The following support equipment was used during testing:

Table 3: Support Equipment

Item	Model/Part Number	Serial Number
Programmable DC Power Supply	HQ Power/PS5005U	#00641

2.6 Interface Cables

Table 4: Interface Cables

Ref. ID	Port name on EUT	Cable Description or reason for no cable	Qty.	Length (m)	Shielded?	Termination Box ID & Port ID
1	DC IN (from Power Supply)	Red/black cable with banana jacks on one end, various DC jacks on other	1	1	No	Port 1

2.7 EUT Modifications

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

2.8 Test Location

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

2.9 Measurement Uncertainty

All results reported herein relate only to the equipment tested. The basis for uncertainty calculation uses ANSI/NCSL Z540-2-1997 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 u_c = standard uncertainty

a, b, c,.. = individual uncertainty elements

$Div_{a, b, c}$ = 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

$k \leq 2$ for 95% coverage (ANSI/NCSL Z540-2 Annex G)

u_c = 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
Radiated Emissions	FCC Part 15	4.55 dB

3 Test Equipment

Test Name: **Temperature Stability**		Test Date:	**3/03/2012**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
528	AGILENT E4446	ANALYZER SPECTRUM	8/30/2012
641	HQ Power PS5005U	DC Power Supply	NA
776	Tenney	Temperature chamber	1/04/2013

Test Name: **Radiated Emissions**		Test Date:	**4/30/2012**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
69	HP - 85650A	ADAPTER QP	6/28/2012
71	HP - 85685A	PRESELECTOR RF	6/26/2012
73	HP - 8568B	ANALYZER SPECTRUM	6/26/2012
478	RHODE & SCHWARZ SMT-06	GENERATOR RF SIGNAL	5/11/2012
382	SUNOL SCIENCES CORPORATION - JB1	ANTENNA BICONLOG	12/27/2012
28	EMCO - 3146	ANTENNA LOG PERIODIC	12/21/2012
7	ARA - LPB-2520	ANTENNA BICONILOG ANTENNA	10/11/2012
1	A.H. SYSTEMS - SAS-200/518	ANTENNA LP 1-18GHZ	5/10/2013

Test Name:	**Transient Frequency Behavior/Modulation Tests**	Test Date:	**05/14/2012**
Asset #	**Manufacturer/Model**	**Description**	**Cal. Due**
734	HEWLET PACKARD - 8647A	SIGNAL GENERATOR - 250KHZ - 1GHZ OPT 1E5 -HIGH STABILITY TIMEBASE	4/28/2014
461	TEKTRONIX - TDS-5104	OSCILLOSCOPE 1GHZ 4 CH DPO	11/8/2012
480	HP - 8495B/8494B	ATTENUATOR SET	Cal before use
558	HP - 8648C	GENERATOR RF SIGNAL	3/16/2012
475	WILTRON - WILTRON 75N50 DETECTOR	RF DETECTOR	N/A
29	EMCO - 3146A	ANTENNA LOG PERIODIC	1/12/2013
N/A	Mini Circuits/15542 ZFSC 4-1	Combiner	N/A
N/A	Mini Circuits/15542 ZFDC 4-1	Combiner	N/A

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

The EUT was tested in band for radiated emissions on an open air test site (OATS) using the substitution method specified in TIA-603-C section 2.2.12 Unwanted Emissions with the following 2 exceptions:
1) Instead of replacing the EUT antenna with a non-reacting load the EUT antenna was left in place. This produces a worst case reading (combined case and antenna).

2) A resolution bandwidth of 8MHz and a video bandwidth of 50MHz were used for measurements conducted on this device. This was done to fully encompass the entire NTSC signal. Each of the three EUT's was the set to transmit at its preconfigured transmit frequency. This level was recorded for the EIRP power.

A sample from the substitution tables is provided below to clarify them.

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	ERP Level (dBm)	ERP Limit (dBm)	Margin (dB)
(a)	(b1)	(b2)	(b3)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)

Column Key:

a) Frequency of detected emission
b (1-3)) Position of EUT and height/ polarization of receive antenna at maximum emission level
c) Maximum field strength level of EUT emission on receiver without any corrections
d) Level of Signal Generator attached to a substitution antenna (replacing EUT) that produced a field strength identical to the EUT emission.
e) Signal Generator level at Substitution antenna (d minus any cable/connector losses
f) Antenna Factor of substitution antenna used to get Antenna Gain
g) Substitution Antenna Gain
h) EIRP level of emission per TIA-603-C (column e plus column g) Note : numbers may have fractional differences due to rounding of numbers
i) ERP level , as The part 95 limit is stated in ERP vice EIRP a correction was used. (ERP= EIRP-2.15dB)
j) ERP limit as specified in FCC part 95.
k) Level of EUT ERP (column i) compared to ERP limit (Column j). Minus numbers indicate level below limit.

5.1.2 Test Limit

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

5.1.3 Test Results

The test results are shown in Table 6.

5.1.4 Test Summary

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

Table 6: EIRP Power

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
Unit Upright											
445.50	V	90.0	1.1	108.72	-0.3	-6.7	16.7	6.5	**-0.2**	30	-30.2
433.43	V	90.0	1.1	107.70	0.7	-5.6	15.9	7.0	**1.4**	30	-28.6
439.45	V	90.0	1.1	108.20	0.3	-6.1	16.4	6.7	**0.6**	30	-29.4
Unit on wheel	V										
445.50	V	90.0	1.3	106.14	-2.7	-9.1	16.7	6.5	-2.6	30	-32.6
433.43	V	90.0	1.3	104.50	-2.5	-8.8	15.9	7.0	-1.8	30	-31.8
439.60	V	90.0	1.3	104.65	-3.2	-9.6	16.4	6.7	-2.9	30	-32.9
Tail vertical	V										
445.50	V	180.0	1.3	108.30	-0.5	-6.9	16.7	6.5	-0.4	30	-30.4
433.43	V	180.0	1.3	107.50	0.5	-5.8	15.9	7.0	1.2	30	-28.8
439.45	V	180.0	1.3	107.30	-0.6	-7.0	16.4	6.7	-0.3	30	-30.3
Unit Upright											
445.50	H	180.0	1.0	113.07	5.1	-1.3	16.7	6.5	**5.2**	30	-24.8
433.43	H	180.0	1.0	110.51	5.0	-1.3	15.9	7.0	**5.7**	30	-24.3
439.45	H	180.0	1.0	111.60	4.7	-1.7	16.4	6.7	**5.0**	30	-25.0
Unit on wheel	H										
445.50	H	180.0	1.0	112.27	4.3	-2.1	16.7	6.5	4.4	30	-25.6
433.43	H	180.0	1.0	106.97	1.6	-4.7	15.9	7.0	2.3	30	-27.7
439.45	H	180.0	1.0	110.19	4.1	-2.3	16.4	6.7	4.4	30	-25.6
Tail vertical	H										
445.50	H	90.0	1.0	110.26	2.4	-4.0	16.7	6.5	2.5	30	-27.5
433.43	H	90.0	1.0	107.61	2.3	-4.0	15.9	7.0	3.0	30	-27.0
439.45	H	90.0	1.0	111.17	4.3	-2.1	16.4	6.7	4.6	30	-25.4

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

5.2.1 Test Method

The emission bandwidth test was performed as an occupied bandwidth measurement. A spectrum analyzer was tuned to the center of the transmit frequency. The span of the analyzer was the reduced to approximately 2 to 3 times the span of the Tx signal. The resolution bandwidth of the device was lowered to approximately 1% of the estimated occupied bandwidth. The span between points on each side of the Tx signal corresponding to 20dB below the peak were then recorded as the emission bandwidth.

5.2.2 Test Limit

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

5.2.3 Test Results

Figure 1 shows the plot of the occupied bandwidth. The recorded level is 4.670MHz. Figure 2 shows a sample of the occupied bandwidth of the video signal alone. Table 7 summarizes the measured bandwidths of the video signal under different test patterns.

5.2.4 Test Summary

Table 7 below shows the maximum measured emissions bandwidths used to determine worst case operating conditions.

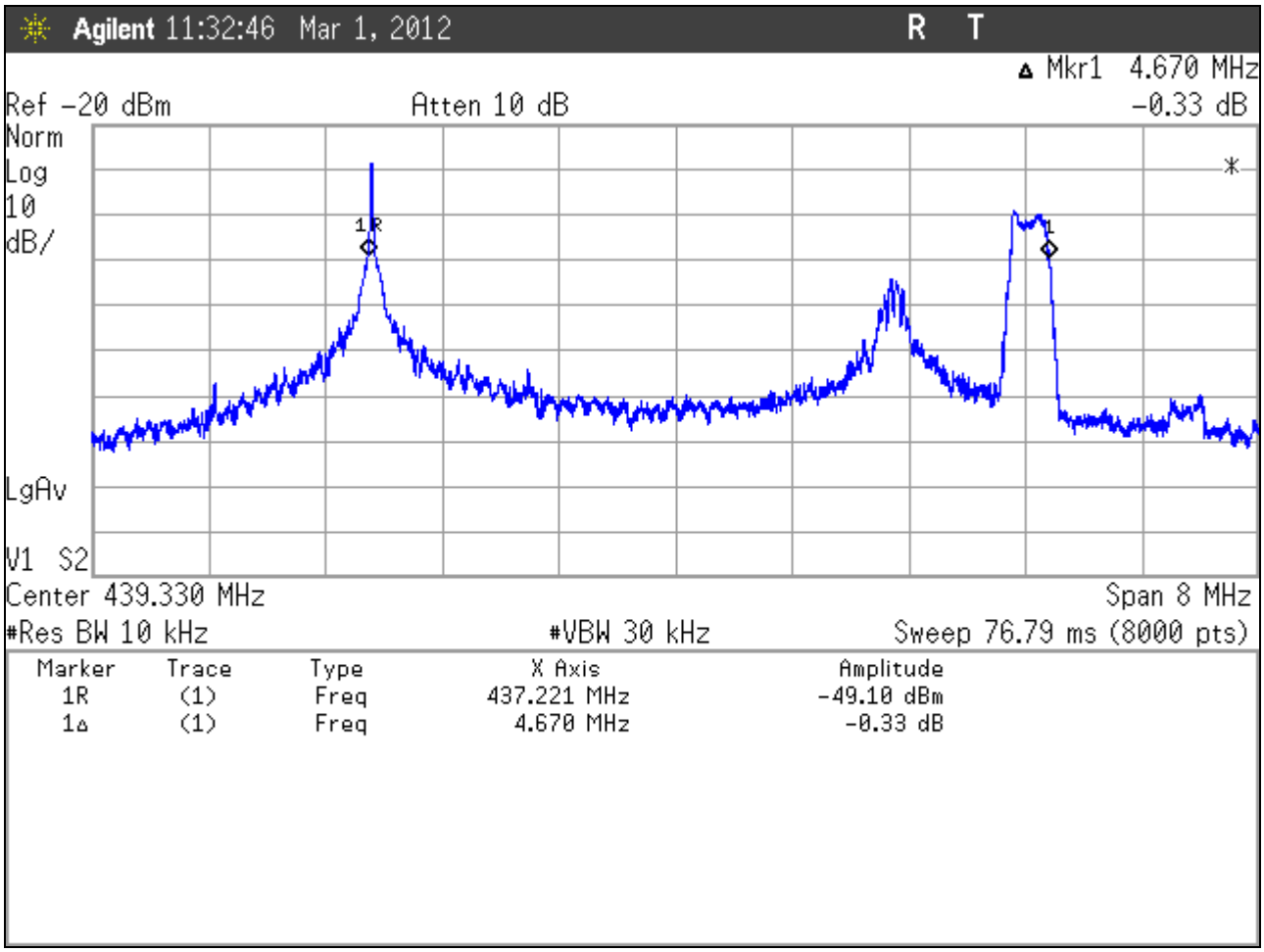


Figure 1: 20dB Occupied bandwidth

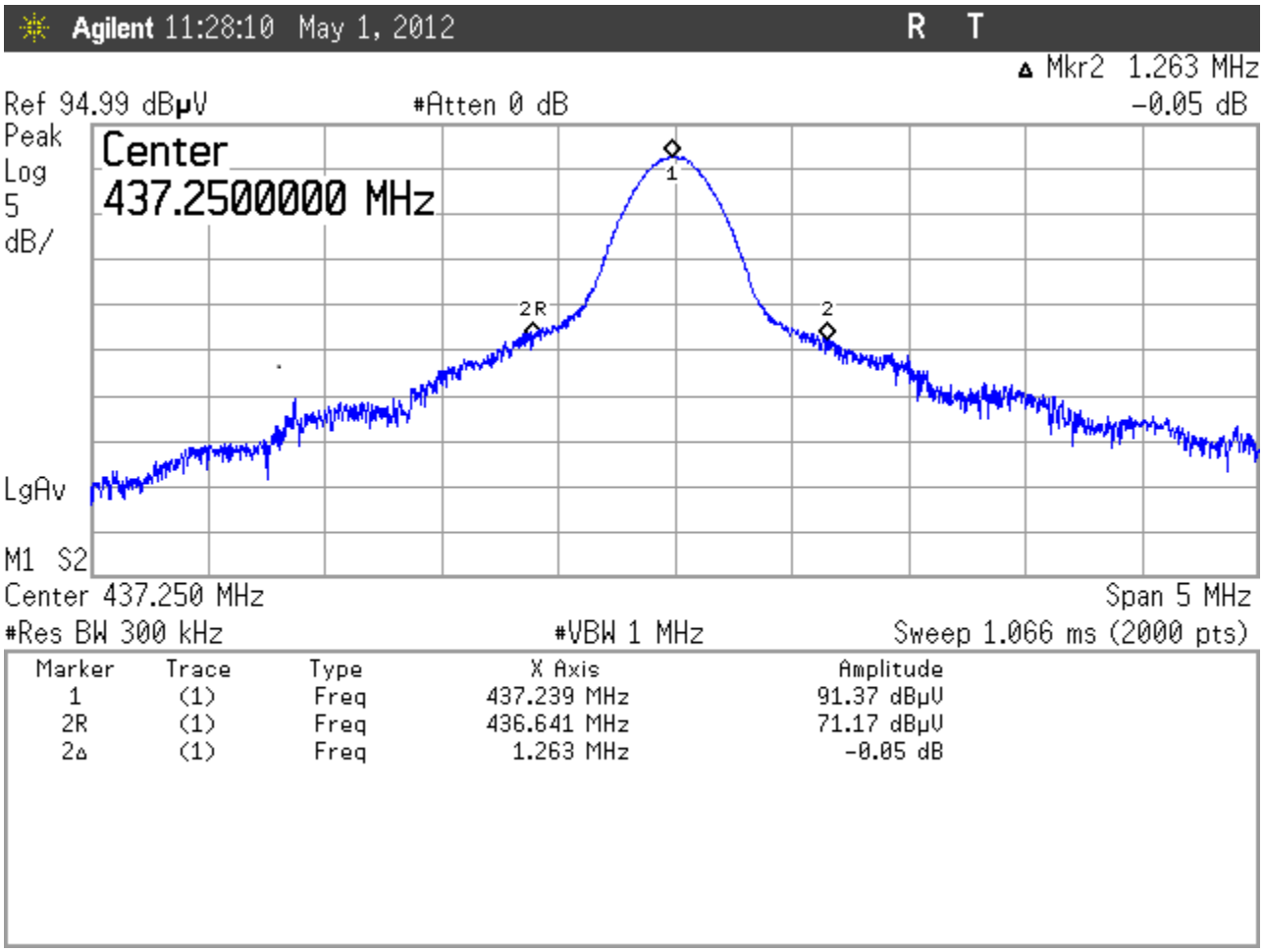


Figure 2: 20dB Occupied bandwidth (Video only)

Table 7: Video Signal Bandwidth Summary

Video Pattern	20dB BW
0.5" Checker Board	840kHz
0.25" Checker Board	830kHz
1.0" Checker Board	850kHz
0.0625" Horizontal Bars	1.236MHz
0.125" Horizontal Bars	1.263MHz
0.25" Horizontal Bars	848kHz
0.5" Horizontal Bars	838kHz
0.125" Vertical Bars	803kHz
0.25" Vertical Bars	818kHz
0.5" Vertical Bars	900kHz
Vertical Gradation	975kHz
Horizontal Gradation	910kHz

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

5.3.1 Test Method

In addition the EUT was tested out of band (>250 % of authorized bandwidth) for radiated emissions on an open air test site (OATS) using a substitution method The EUT was placed on motorized turntable for radiated testing on a 3-meter open field test site. The emissions from the EUT were measured continuously at every azimuth by rotating the turntable. Receiving antennas were mounted on an antenna mast to determine the height of maximum emissions. The EUT was tested in 3 orthogonal positions for compliance and the worst case emissions are presented here. A resolution bandwidth of 100 kHz was used for radiated measurements. The EUT antenna was in place for these readings.

5.3.2 Test Limit

At least 43 + 10 log10 (P) dB (-13dBm) on any frequency removed from the center of the authorized bandwidth by more than 250%.

5.3.3 Test Results

The reference emissions measurements are shown in Figure 3 thru 11 which depict the various NTSC signal parameters and a summary list is stated in table 8. Radiated results and band edge measurements are shown in Table 9, Table 10 and Table 11 respectively. The data listed in tables 7 and 8 correspond to the center channel of the three units (Unit C) which operates in the following band 436-442MHz. These emissions represent the worst case as measured with 0.125inch horizontal bars and a 1kHz tone.

5.3.4 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.

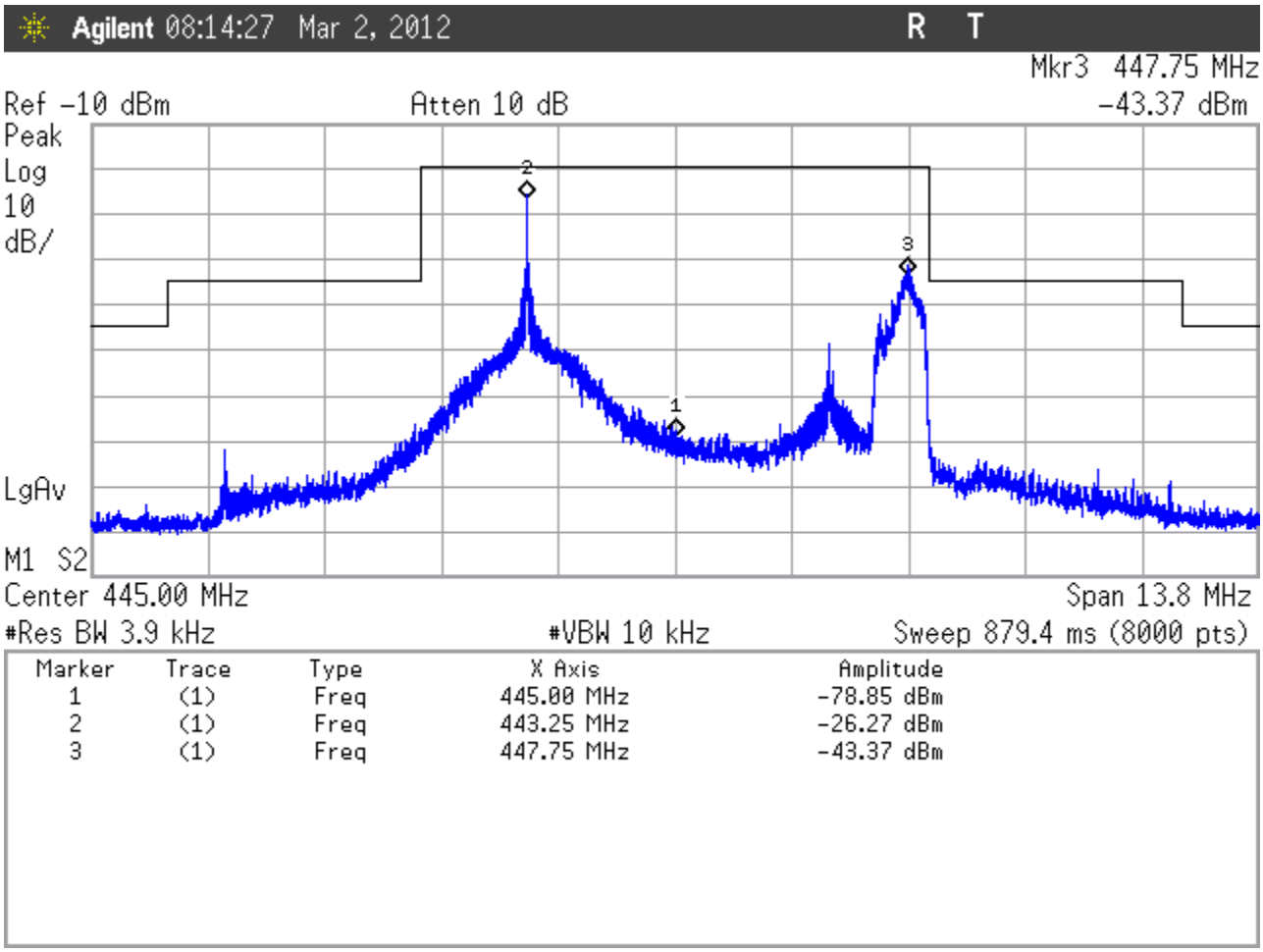


Figure 3: In-Band Emissions Mask, Unit A

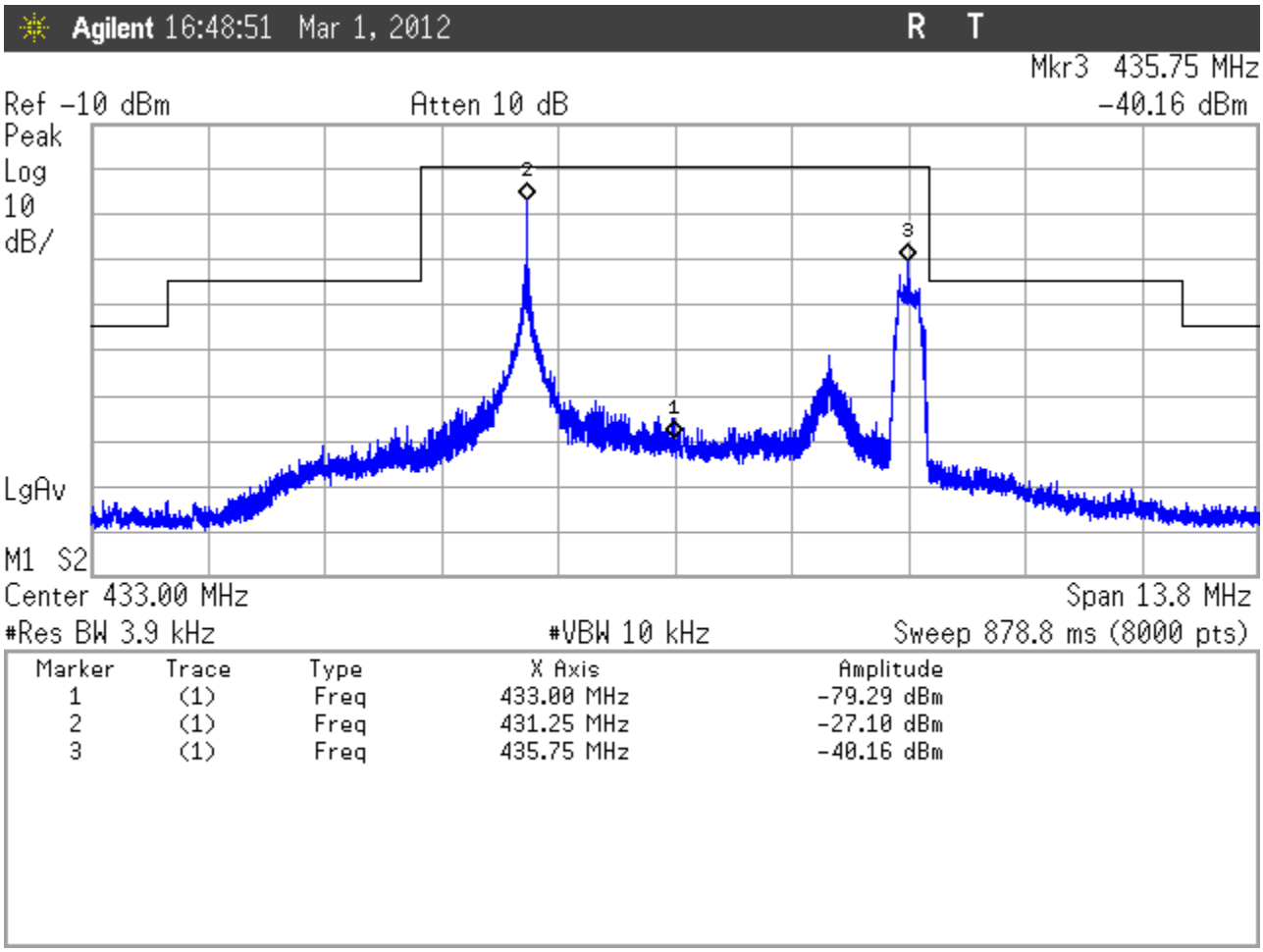


Figure 4: In-Band Emissions Mask, Unit B

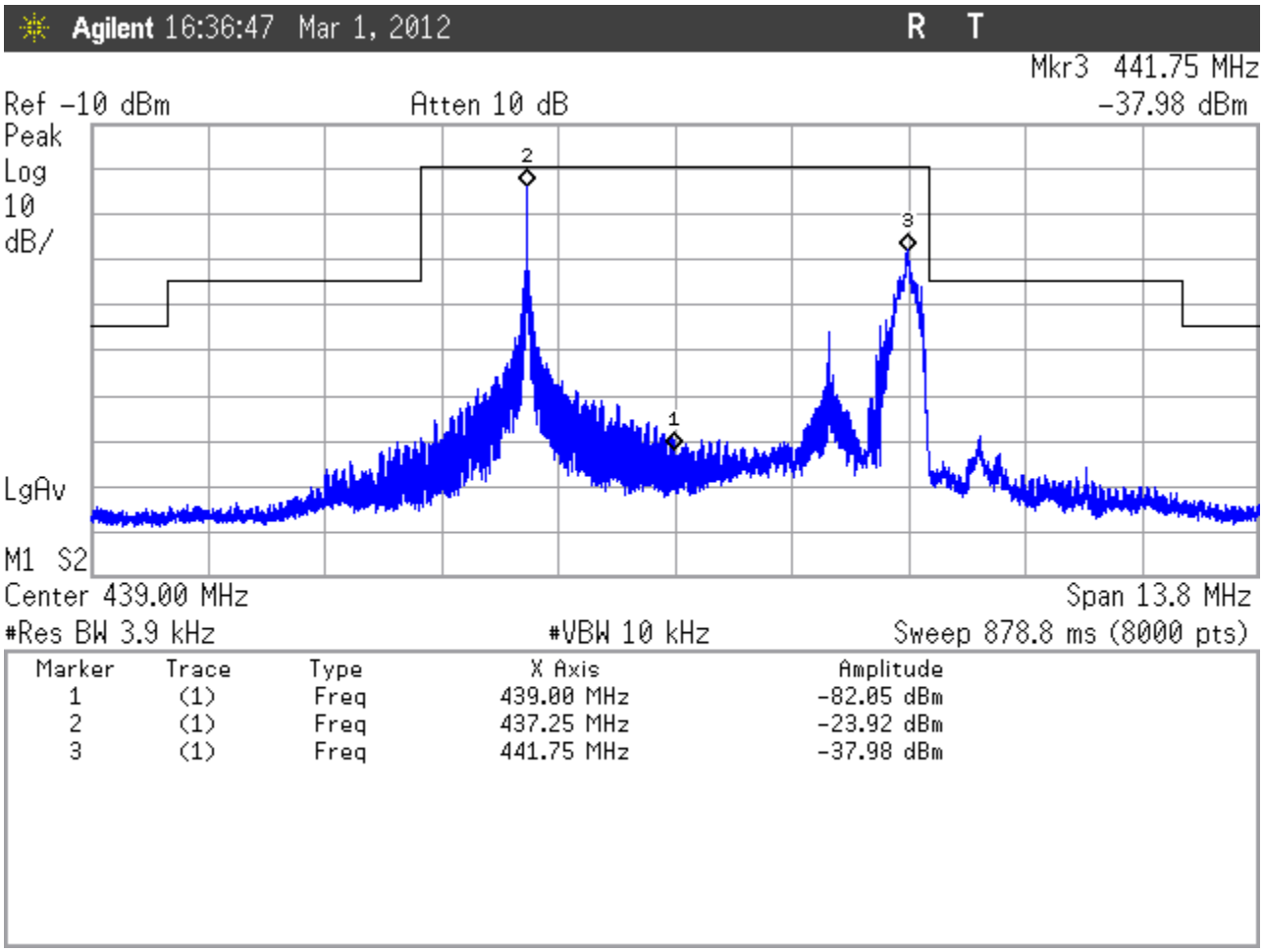


Figure 5: In-Band Emissions Mask, Unit C

Table 8: NTSC Signal Characteristics Summary

	Center of Channel (MHz)	Video Carrier Δ from Lower Bound (MHz)	Video Carrier Δ from Color Carrier (MHz)	Audio Carrier Δ from Upper Bound (MHz)	Video Carrier Δ from Audio Carrier (MHz)
Unit A	445	1.25	3.58	0.25	4.5
Unit B	433	1.25	3.58	0.25	4.5
Unit C	439	1.25	3.58	0.25	4.5

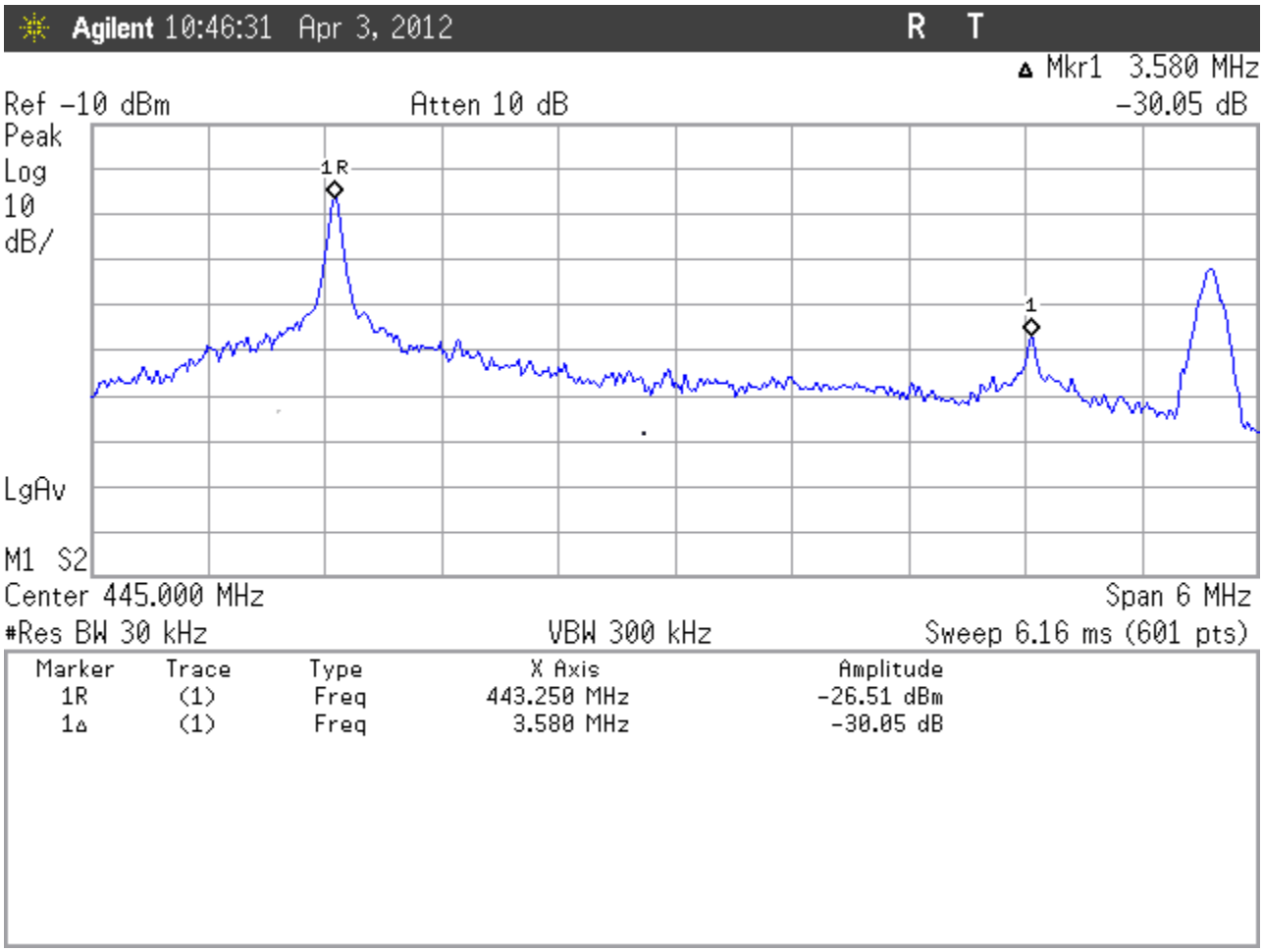


Figure 6: NTSC Signal Parameters, Unit A

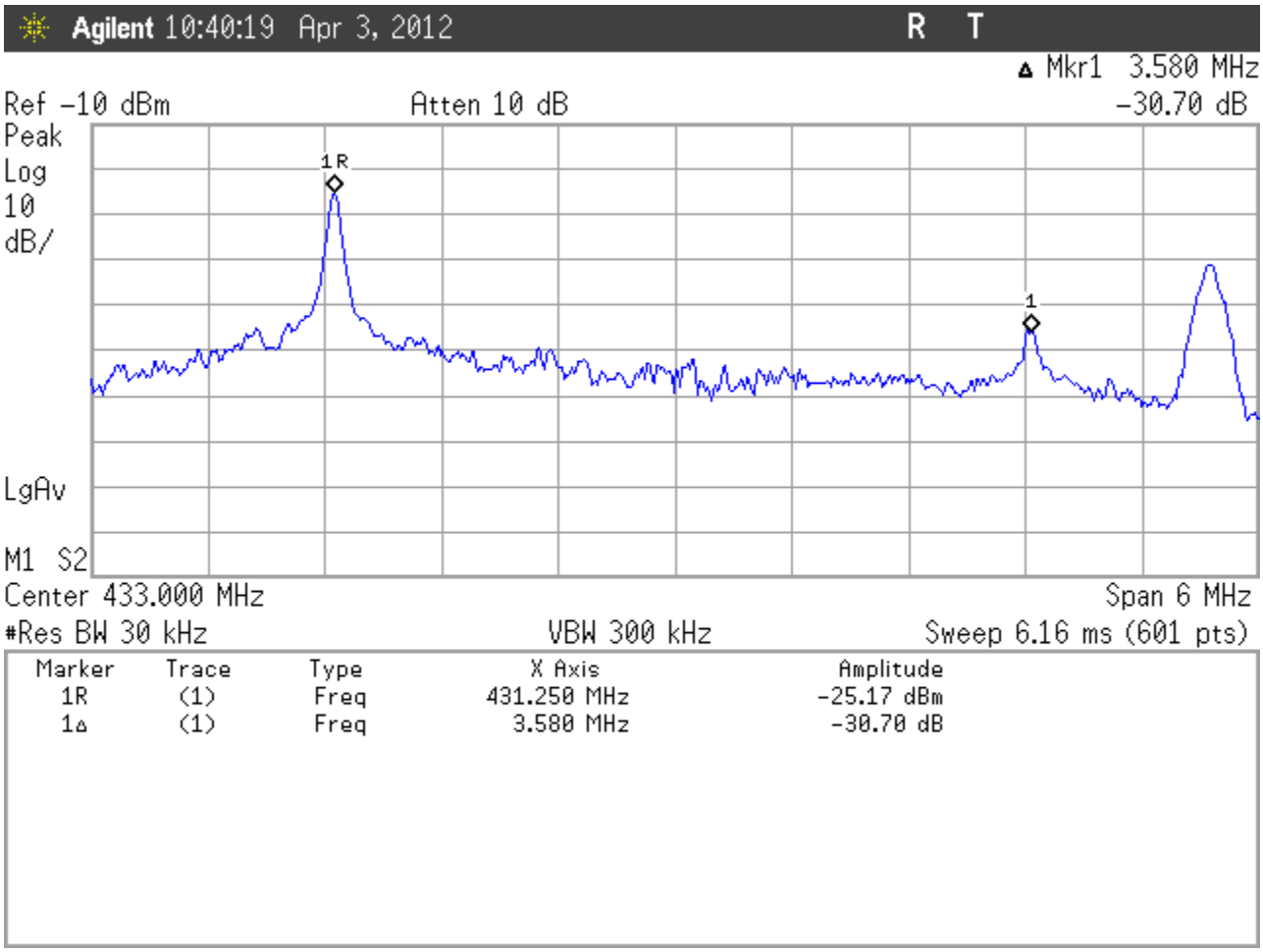


Figure 7: NTSC Signal Parameters, Unit B

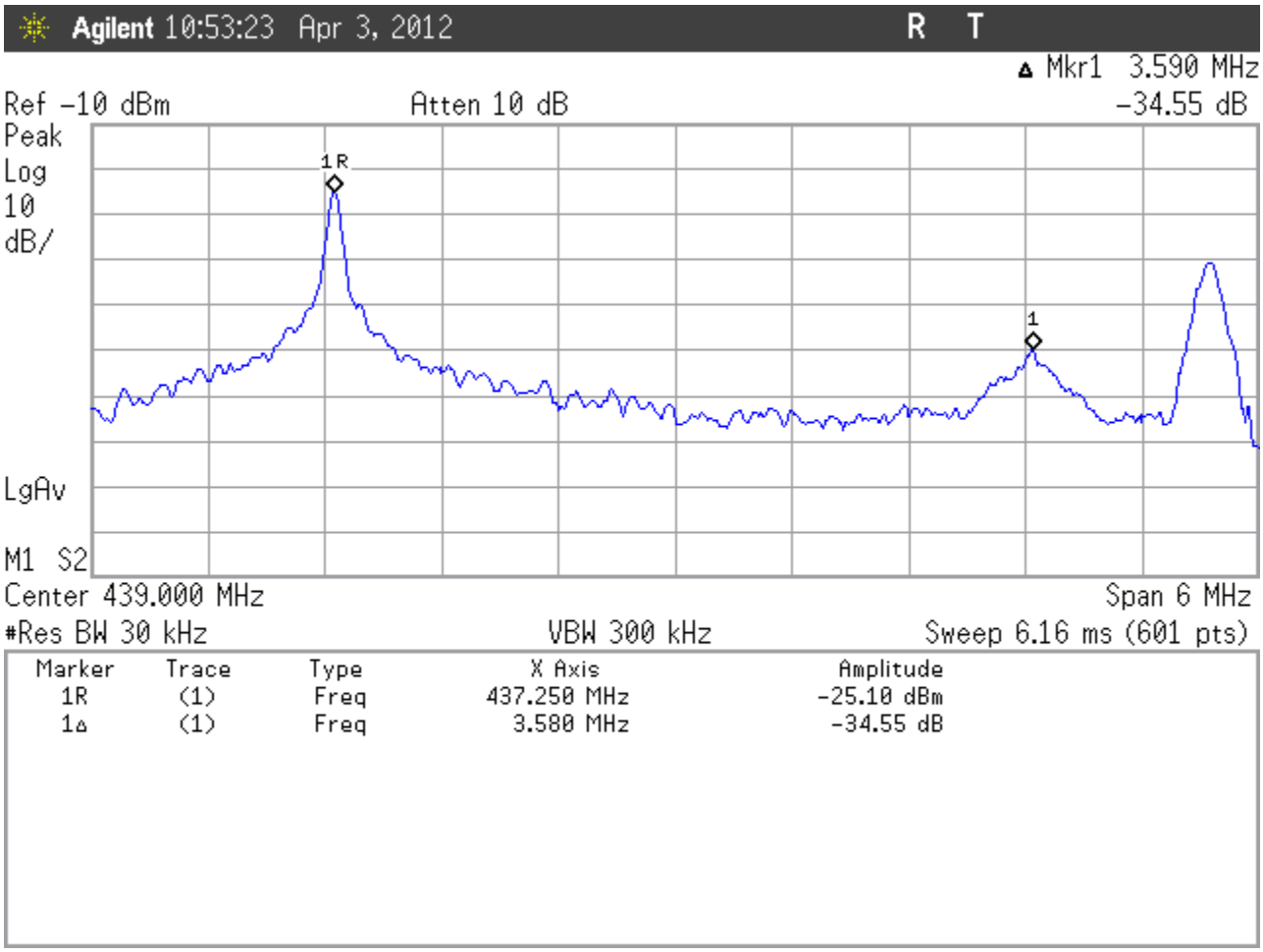


Figure 8: NTSC Signal Parameters, Unit C

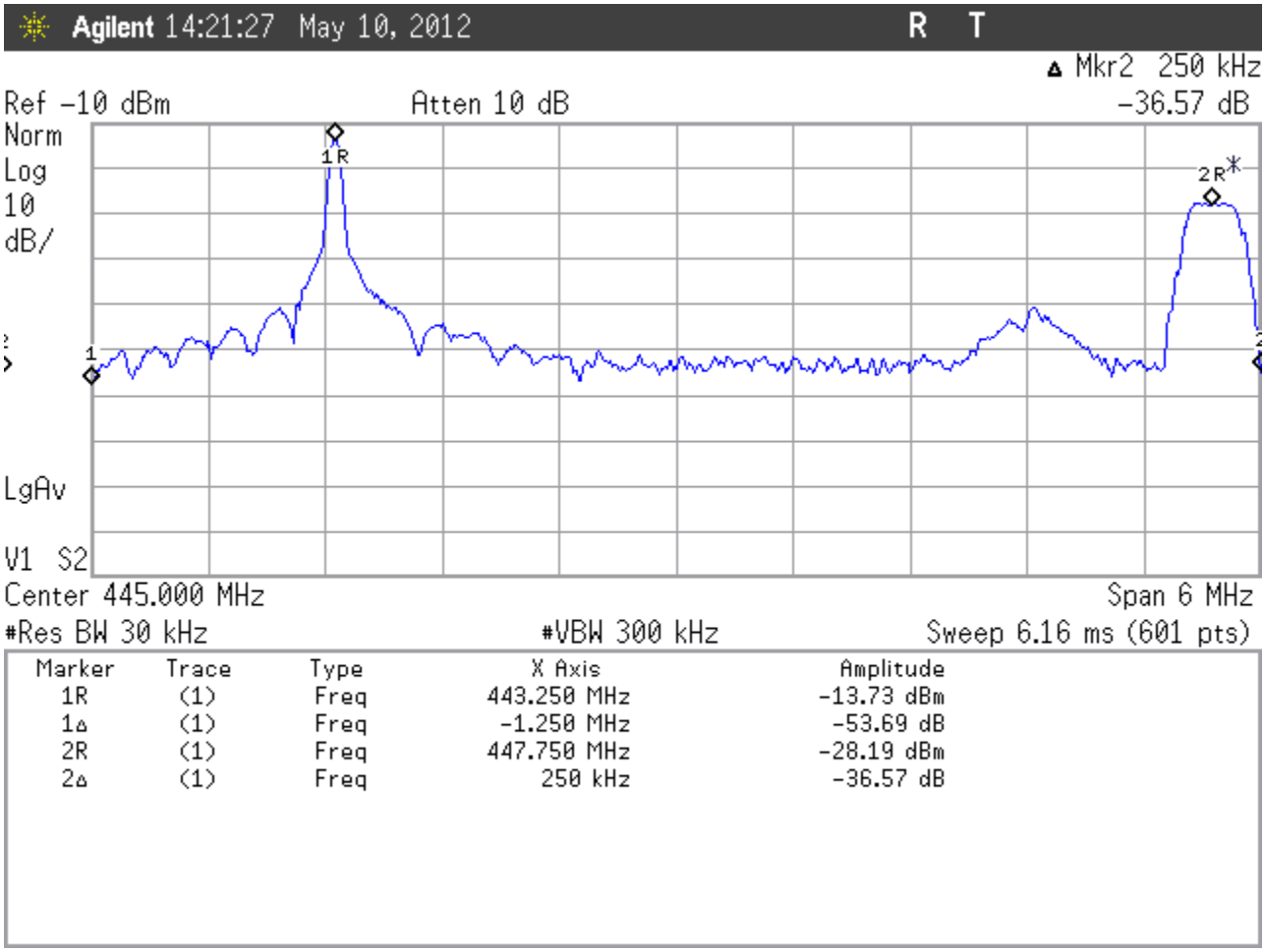


Figure 9: NTSC Signal Parameters, Unit A

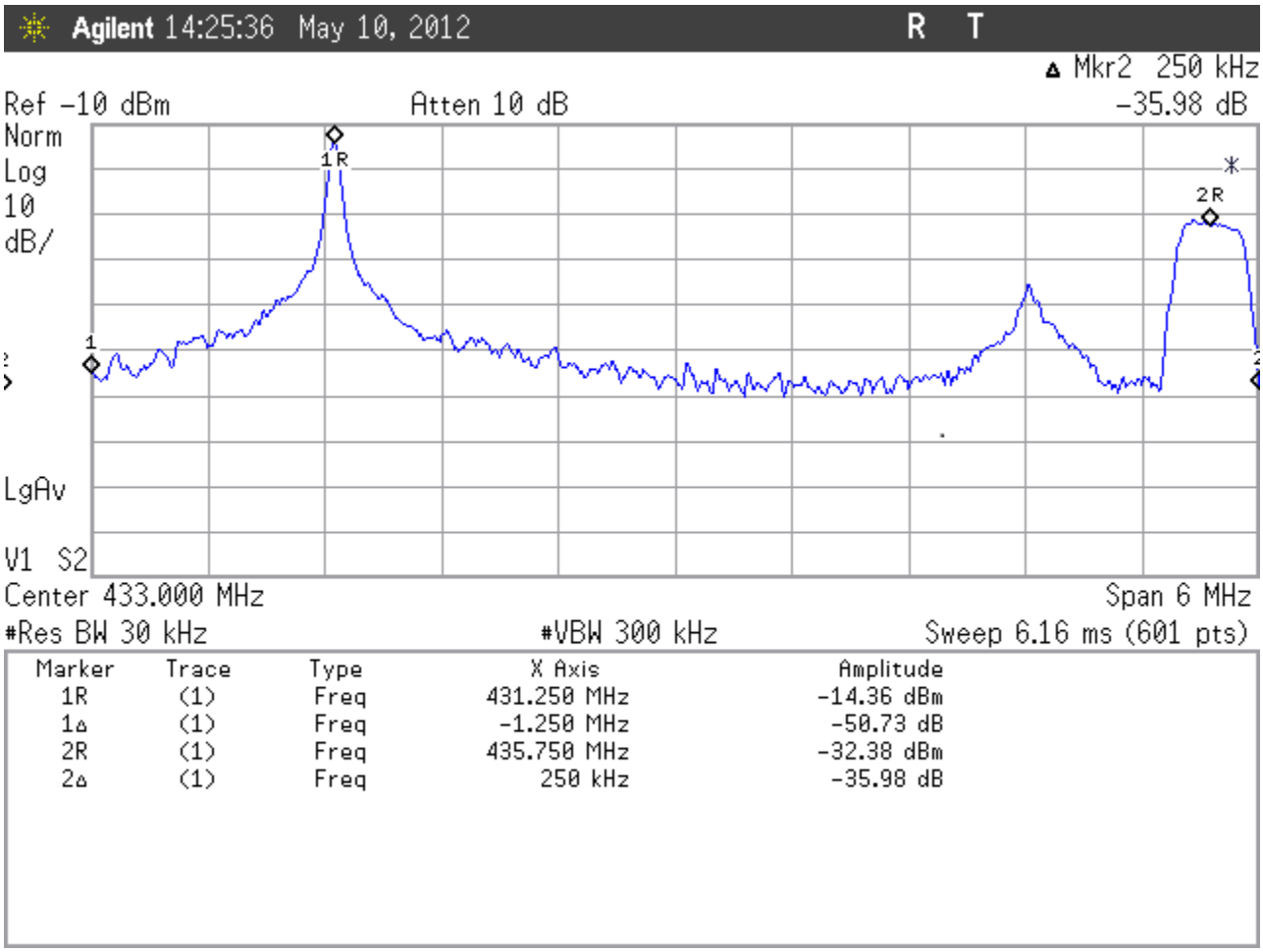


Figure 10: NTSC Signal Parameters, Unit B

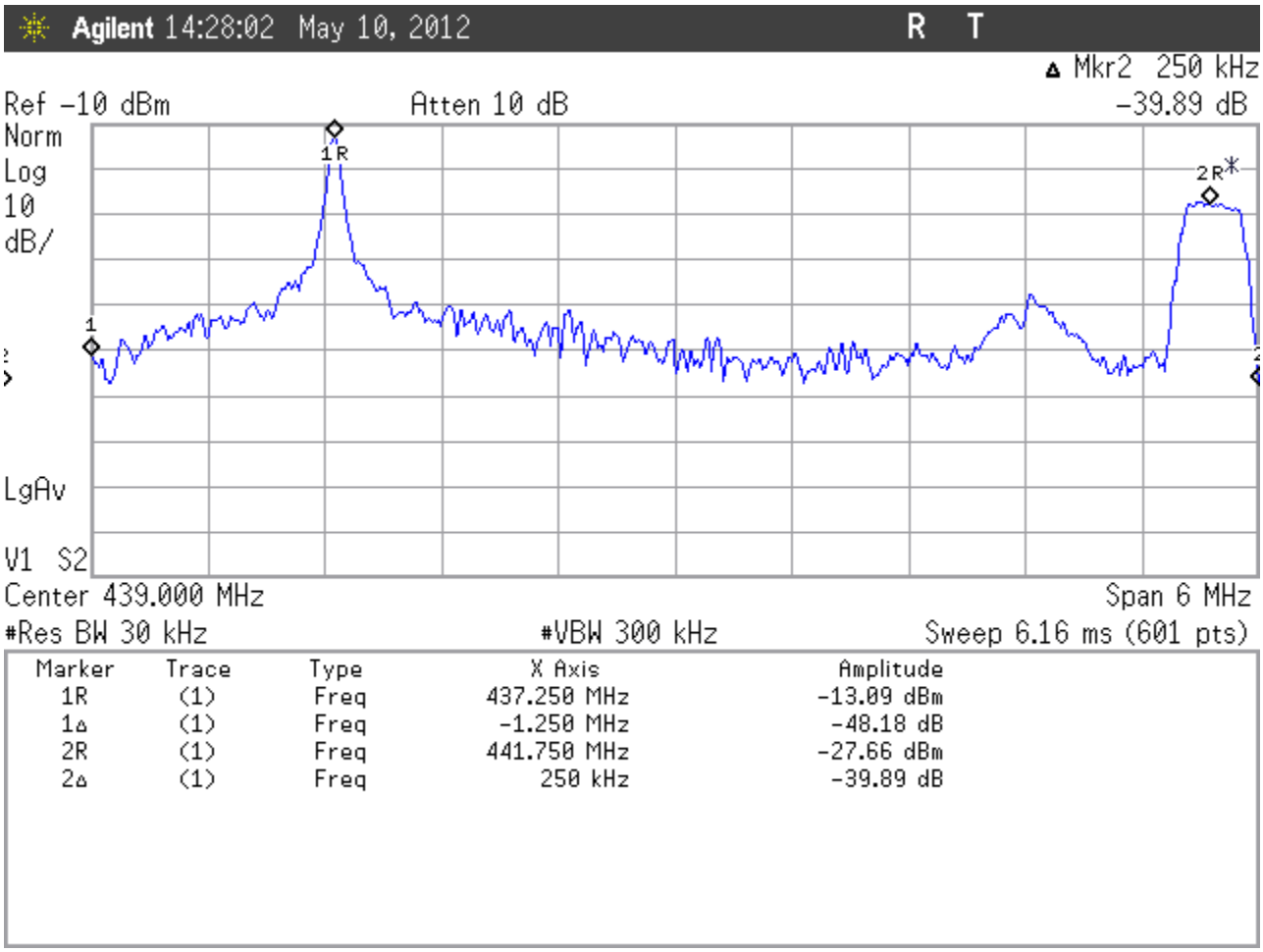


Figure 11: NTSC Signal Parameters, Unit C

Table 9: Unwanted Radiated Emissions <1GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
113.76	V	90.0	1.0	18.8	-63.2	-65.4	10.8	0.5	-64.8	-13	-51.8
116.25	V	90.0	1.0	13.2	-67.1	-69.3	10.9	0.6	-68.7	-13	-55.7
118.72	V	90.0	1.0	11.6	-68.7	-70.9	11.1	0.6	-70.2	-13	-57.2
121.24	V	90.0	1.0	9.6	-70.9	-73.1	11.1	0.8	-72.3	-13	-59.3
133.72	V	180.0	1.0	23.4	-57.4	-59.6	9.8	2.9	-56.7	-13	-43.7
136.24	V	180.0	1.0	22.9	-58.9	-61.1	9.4	3.5	-57.5	-13	-44.5
138.72	V	180.0	1.0	20.0	-62.7	-64.9	9.0	4.1	-60.8	-13	-47.8
225.00	V	135.0	1.0	11.1	-67.1	-69.3	12.5	4.8	-64.5	-13	-51.5
315.00	V	180.0	1.4	9.9	-71.0	-73.2	13.9	6.3	-66.9	-13	-53.9
343.73	V	135.0	1.4	5.7	-73.9	-79.6	14.3	6.7	-72.9	-13	-59.9
374.98	V	225.0	1.8	20.8	-58.3	-64.2	16.2	5.5	-58.8	-13	-45.8
399.97	V	180.0	1.8	18.8	-59.7	-65.8	16.4	5.9	-59.9	-13	-46.9
419.98	V	180.0	1.8	18.6	-59.4	-65.6	16.9	5.8	-59.9	-13	-46.9
499.99	V	180.0	1.8	14.0	-54.1	-60.9	17.4	6.8	-54.2	-13	-41.2
624.98	V	225.0	1.8	16.2	-59.6	-67.3	19.3	6.8	-60.5	-13	-47.5
699.99	V	45.0	1.5	13.3	-58.9	-67.2	20.1	7.0	-60.2	-13	-47.2
113.76	H	180.0	2.0	15.0	-67.9	-70.1	10.8	0.5	-69.5	-13	-56.5
116.25	H	180.0	3.5	16.1	-65.2	-67.4	10.9	0.6	-66.8	-13	-53.8
118.72	H	180.0	3.5	14.2	-67.3	-69.5	11.1	0.6	-68.8	-13	-55.8
121.24	H	180.0	3.5	13.4	-68.5	-70.7	11.1	0.8	-69.9	-13	-56.9
133.72	H	90.0	3.5	21.4	-61.6	-63.8	9.8	2.9	-60.9	-13	-47.9
136.24	H	90.0	3.5	22.1	-62.6	-64.8	9.4	3.5	-61.2	-13	-48.2
138.72	H	90.0	3.5	19.5	-65.8	-68.0	9.0	4.1	-63.9	-13	-50.9
225.00	H	90.0	3.0	10.5	-72.1	-74.3	12.5	4.8	-69.5	-13	-56.5
315.00	H	90.0	2.3	12.5	-65.8	-71.2	14.8	5.4	-65.8	-13	-52.8
343.73	H	180.0	2.3	12.0	-60.7	-66.4	14.3	6.7	-59.7	-13	-46.7
374.98	H	180.0	1.5	26.2	-41.2	-47.1	16.2	5.5	-41.7	-13	-28.7
399.97	H	180.0	1.5	23.2	-49.1	-55.2	16.4	5.9	-49.3	-13	-36.3
419.98	H	180.0	1.5	23.8	-50.8	-57.0	16.9	5.8	-51.3	-13	-38.3
499.99	H	135.0	1.0	19.0	-59.0	-65.8	17.4	6.8	-59.1	-13	-46.1
624.98	H	225.0	1.0	20.7	-52.0	-59.7	19.3	6.8	-52.9	-13	-39.9
699.99	H	135.0	1.2	16.7	-50.3	-58.6	20.1	7.0	-51.6	-13	-38.6

Table 10: Unwanted Radiated Emissions >1GHz

Frequency (MHz)	Polarity	Azimuth	Ant. Height (m)	Spurious Level (dBuV)	Sub. Sig. Gen. Level (dBm)	Sub. Power Level (dBm)	Sub. Ant. Factor (dB)	Sub. Ant. Gain (dB)	EIRP Level (dBm)	Limit (dBm)	Margin (dB)
1200.00	V	180.0	2.3	52.8	-39.3	-41.5	27.0	4.8	-36.7	-13	-23.7
1600.00	V	180.0	2.3	46.7	-40.1	-42.7	29.2	5.1	-37.6	-13	-24.6
	H										
1200.00	H	180.0	2.6	44.4	-48.0	-50.2	27.0	4.8	-45.4	-13	-32.4
1400.00	H	180.0	2.6	42.7	-45.2	-47.6	26.9	6.2	-41.4	-13	-28.4
1600.00	H	180.0	2.6	42.3	-43.1	-45.7	29.2	5.1	-40.6	-13	-27.6

Table 11: Band Edge Measurements

Frequency (MHz)	Polarity (H/V)	Azimuth (Degree)	Ant. Height (m)	SA Level (dBuV)	Corr Factors (dB)	Corr. Level (dBuV/m)	EIRP Calc (dBm)	Limit (dBm)	Margin (dB)	Peak or Average	Comments
Unit A											
442.00	V	90.0	1.2	28.5	20.7	49.2	-46.1	-13.0	-33.1	Peak	
448.00	V	90.0	1.2	26.1	21.2	47.2	-48.0	-13.0	-35.0	Peak	
Unit B											
430.00	V	90.0	1.2	31.7	19.9	51.6	-43.6	-13.0	-30.6	Peak	
436.00	V	90.0	1.2	30.3	20.3	50.6	-44.7	-13.0	-31.7	Peak	
Unit C										Peak	
436.00	V	90.0	1.2	38.7	20.3	59.0	-36.3	-13.0	-23.3	Peak	
442.00	V	90.0	1.2	27.5	20.7	48.2	-47.1	-13.0	-34.1	Peak	
Unit A											
442.00	H	225.0	1.9	34.8	20.7	55.5	-39.8	-13.0	-26.8	Peak	
448.00	H	225.0	1.9	34.3	21.2	55.5	-39.8	-13.0	-26.8	Peak	
Unit B											
430.00	H	180.0	1.9	30.3	19.9	50.2	-45.1	-13.0	-32.1	Peak	
436.00	H	180.0	1.9	29.3	20.3	49.5	-45.7	-13.0	-32.7	Peak	
Unit C											
436.00	H	180.0	1.9	37.0	20.3	57.2	-38.0	-13.0	-25.0	Peak	
442.00	H	180.0	1.9	28.7	20.7	49.4	-45.8	-13.0	-32.8	Peak	

5.4 Voice Scrambling [FCC Part 90.212]

Voice scrambling is not permitted and therefore not applicable to this device.

5.5 Frequency Tolerance [FCC Part 90.213(a)]

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 set to transmit at 439 MHz where the video carrier was located at 437.25MHz and the audio carrier was located at 441.75MHz. The video carrier was selected as the measurement point (437.25MHz). A frequency reading was taken with the temperature at ambient (22C). 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 in Table 11 and Table 12.

5.5.4 Test Summary

The EUT complied with the requirements of Part 90.213(a).

Table 12: Frequency Tolerance vs. Temperature

Unit A

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	443.250591	0.0	0
-30	443.251649	1058.0	0.00024
-20	443.252564	1973.0	0.00045
-10	443.252132	1541.0	0.00035
0	443.251895	1304.0	0.00029
10	443.250960	369.0	0.00008
20	443.250591	0.0	0.00000
30	443.249947	-644.0	0.00015
40	443.248658	-1933.0	0.00044
50	443.248365	-2226.0	0.00050

Unit B

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	431.248276	0.0	0.00000
-30	431.248997	721.0	0.00017
-20	431.249747	1471.0	0.00034
-10	431.249521	1245.0	0.00029
0	431.250007	1731.0	0.00040
10	431.249932	1656.0	0.00038
20	431.248276	0.0	0.00000
30	431.247329	-947.0	0.00022
40	431.246156	-2120.0	0.00049
50	431.246108	-2168.0	0.00050

Unit C

Temperature (Centigrade)	Frequency (MHz)	Difference (Hz)	Deviation (%)
Ambient	437.249892	0.0	0
-30	437.249852	-40.0	0.000009
-20	437.249940	48.0	0.000011
-10	437.250347	455.0	0.000104
0	437.250628	736.0	0.000168
10	437.249755	-137.0	0.000031
20	437.249892	0.0	0.000000
30	437.248437	-1455.0	0.000333
40	437.247968	-1924.0	0.000440
50	437.247727	-2165.0	0.000495

Table 13: Frequency Tolerance vs. Battery Voltage

Unit C

Voltage (Volts)	Frequency (MHz)	Difference (Hz)	Deviation (%)	Voltage (Volts)
At rated	437.249892	0	0.0	12.8
At 85%	437.250113	-221	0.000051	10.9VDC
At 115%	437.250098	-206	0.000047	14.7

5.6 Transient Frequency Behavior [FCC Part 90.214]

Measurement of the Recon Robotics Throwbot XT transient frequency response was completed under the guidance of TIA-603-C as specified by the FCC for a licensed product. The transmitter output power was monitored by coupling the radiated signal to an adjacent antenna and then amplifying the signal to the maximum allowable measurement equipment specifications. The Throwbot XT has no keyed functionality for transmission of the audio signal. The EUT is on continuously, therefore to make these measurements, the transmitter was enabled and an o-scope was triggered via a crystal diode detector from the output signal. The transmitter off signal was triggered via the 1kHz tone when the transmitter was disabled.

5.6.1 Test Limit

Since no limit exists for this transmitter bandwidth the largest bandwidth timing available was chosen. This channel spacing was 25 kHz.

5.6.2 Test Results

The test results are shown below in Figure 13 thru Figure 18. A diagram of the representative set-up is shown in Figure 12.

5.6.3 Test Summary

The EUT complied with the requirements of Part 90.214 for equipment operating in the 421 to 521MHz frequency range and the largest available channel of 25kHz.

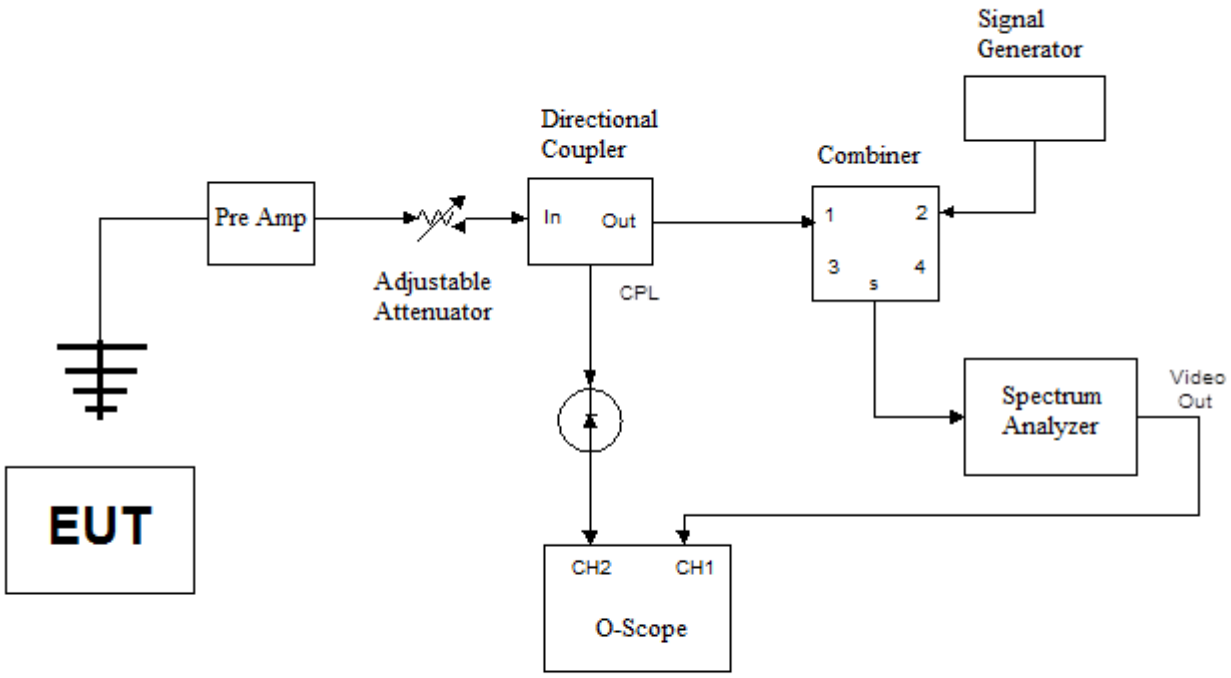


Figure 12: Test Set-up Diagram

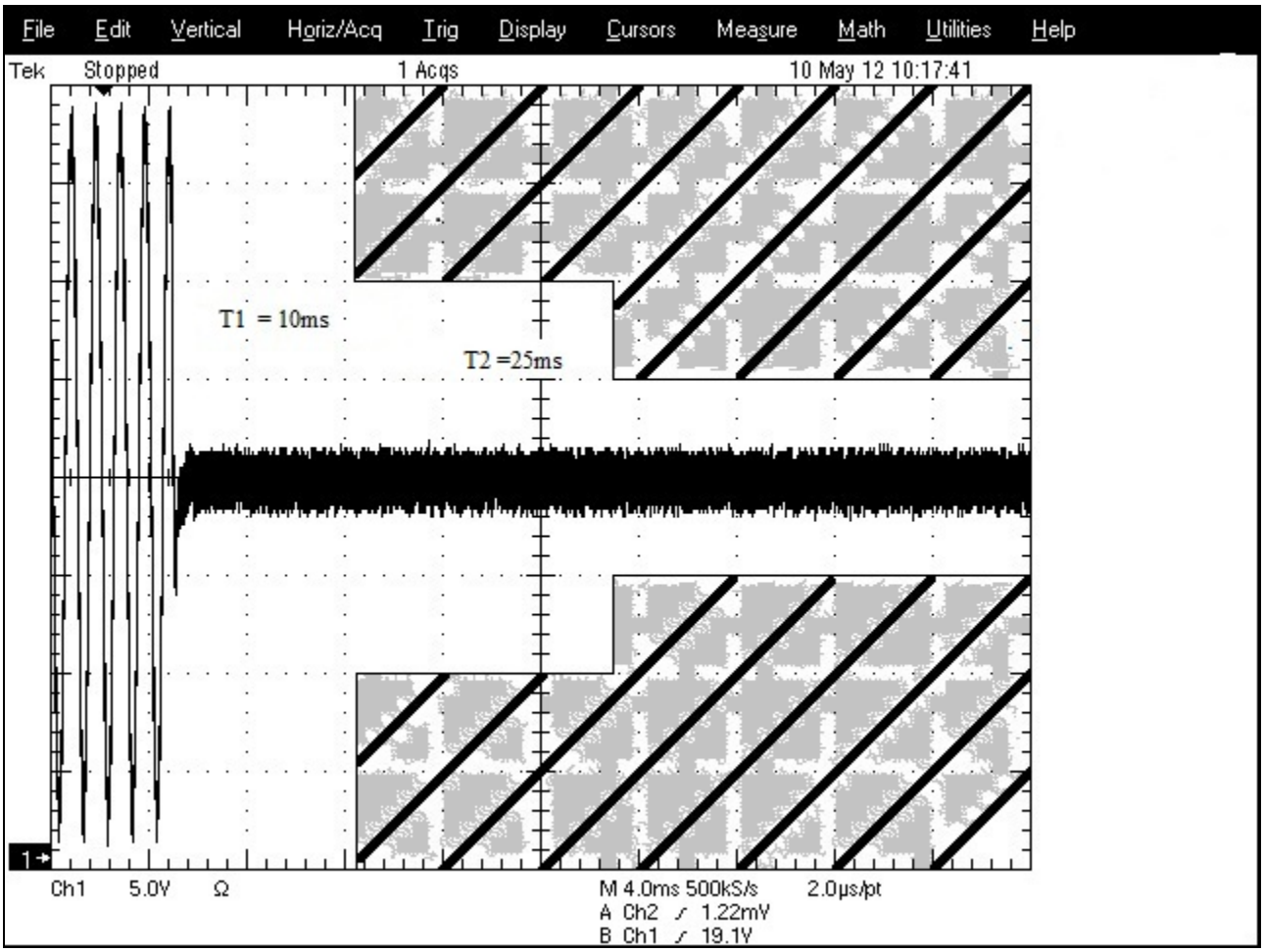


Figure 13: Unit A, T_{on} Timing

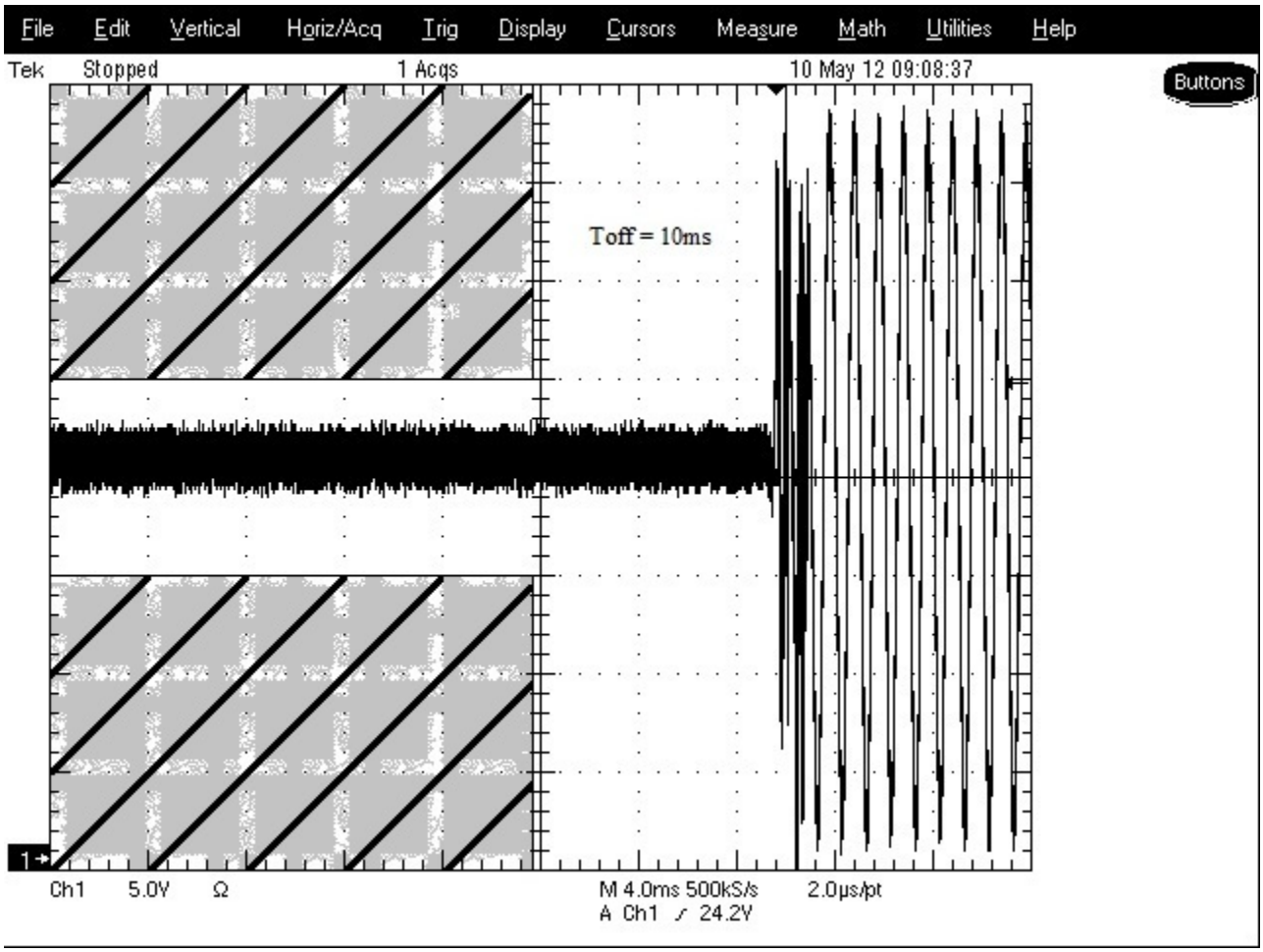


Figure 14: Unit A, To_{ff} Timing

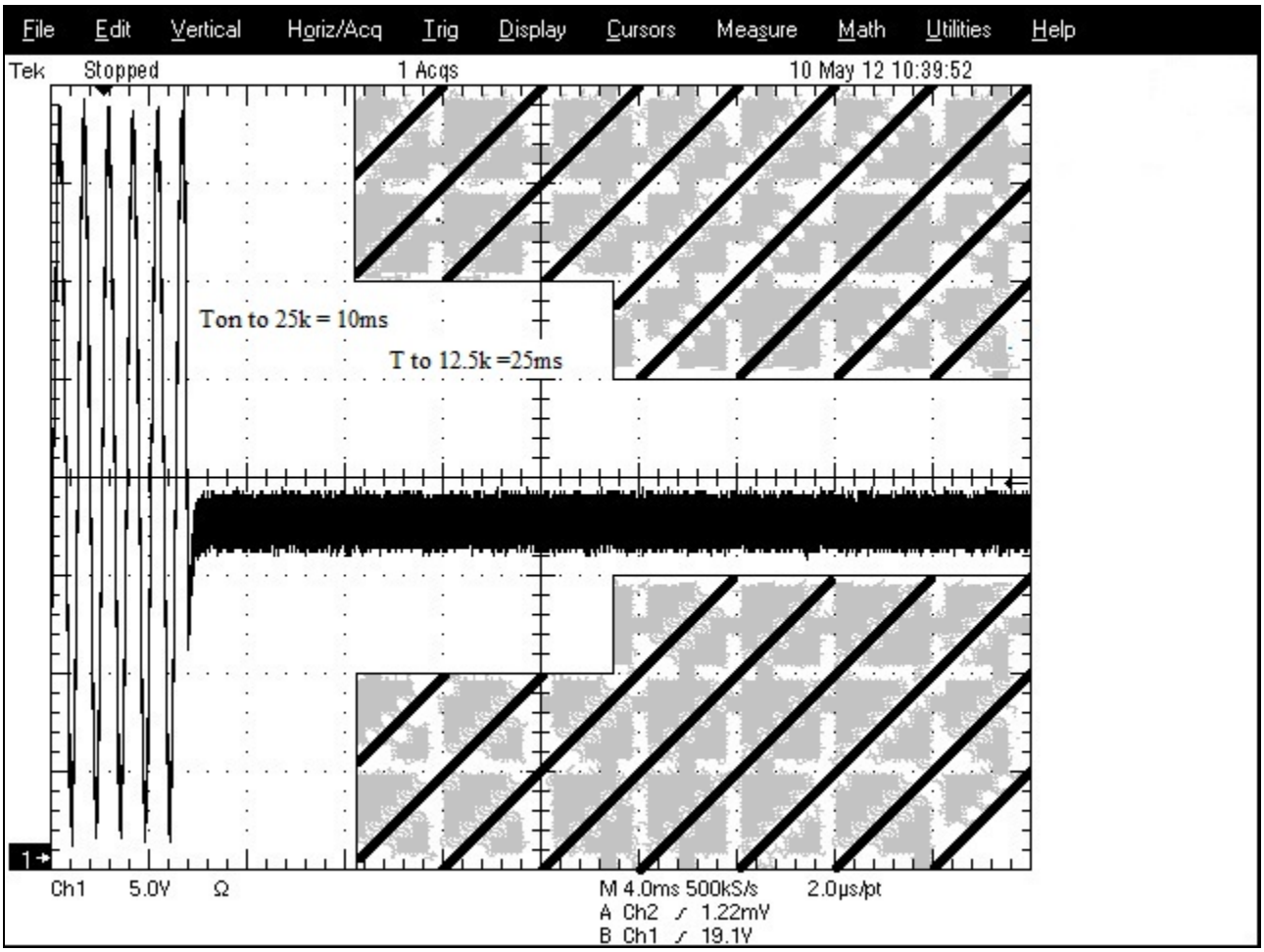


Figure 15: Unit B, T_{on} Timing

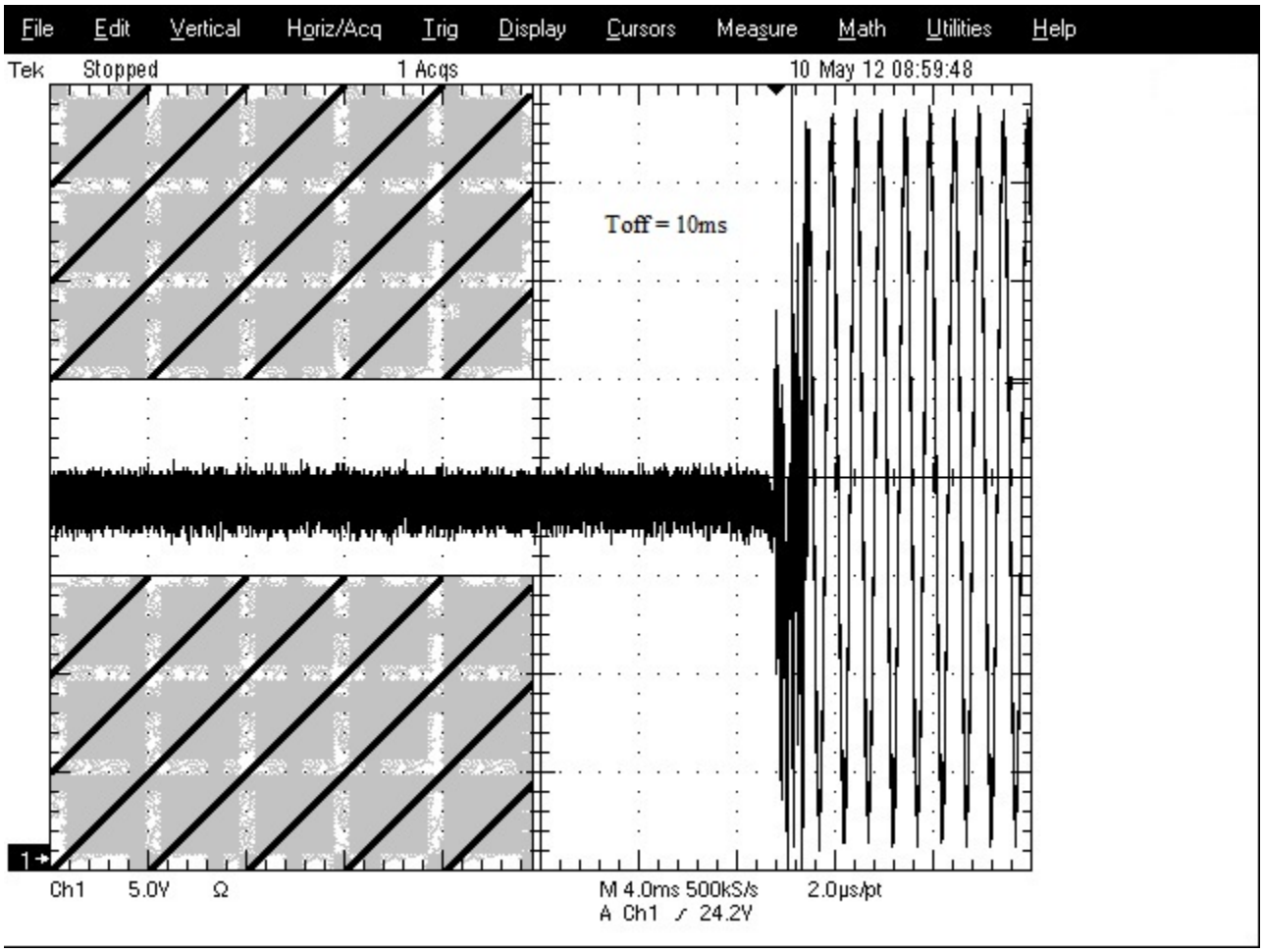


Figure 16: Unit B, To_{ff} Timing

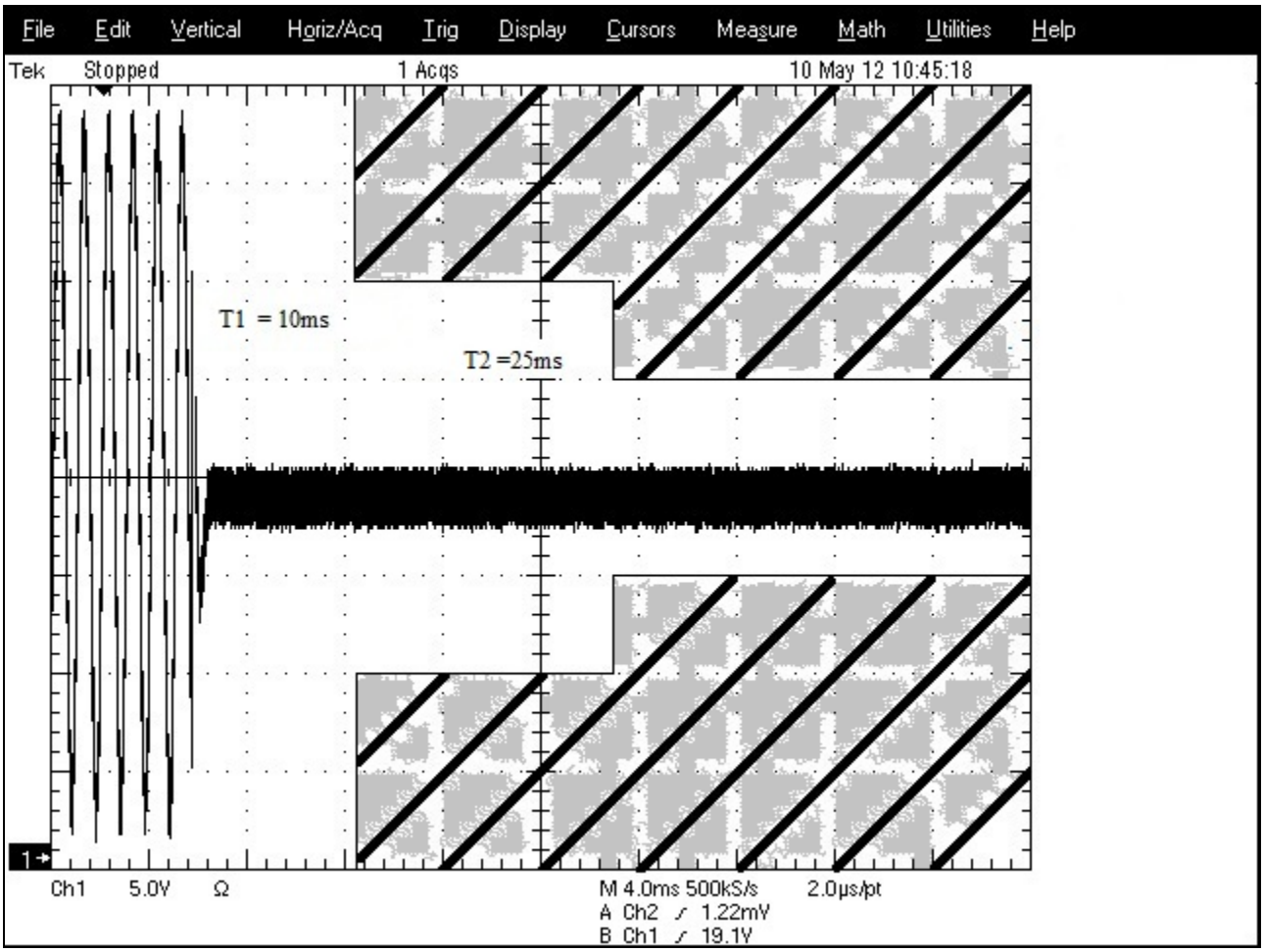


Figure 17: Unit C, T_{on} Timing

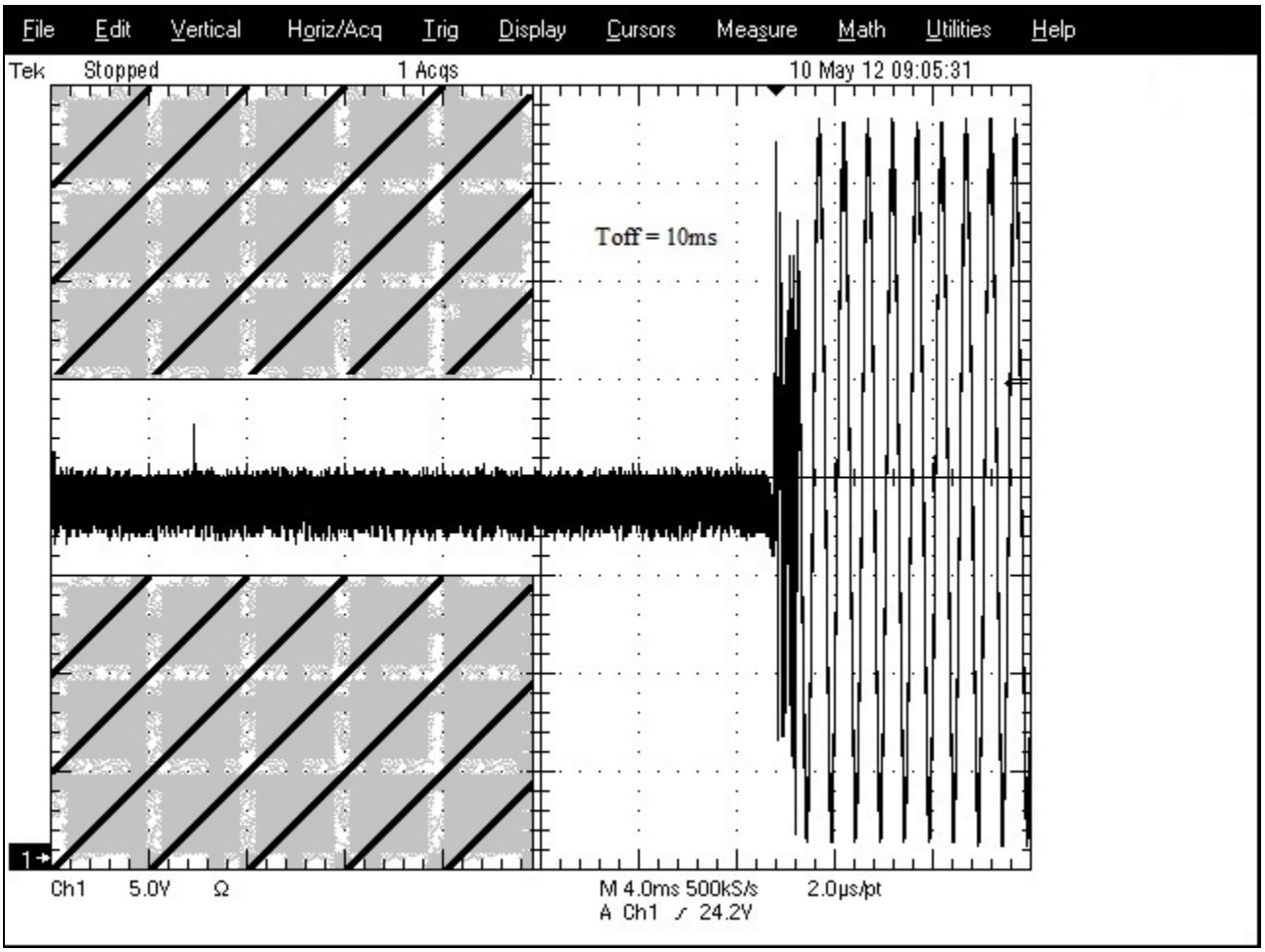


Figure 18: Unit C, To_{ff} Timing

5.7 Modulation Characteristics 2.1047 & 2.1049

The audio frequency response was measured in accordance with TIA/EIA-603. The audio signal was fed directly into the microphone circuit with the microphone removed. The audio low pass filter testing was performed per the method given in TIA-603.

It should be noted that this device has no modulation limiting characteristics and does not incorporate an audio low pas filter.

5.7.1 Test Limit

There are no applicable limits associated with these measurements. The only consideration is maintaining the modulation of the signal within the band edge and meeting the -13dBm limit at 250% of the center frequency.

5.7.2 Test Results

The test results are shown below in Figure 20 thru Figure 22. The test set-up diagram is shown in Figure 19.

5.7.3 Test Summary

The furthest peak from the audio carrier that rose above the non-modulated waveform was less than 240 kHz from the center of the audio carrier and at least 40dB below the luminance carrier peak.

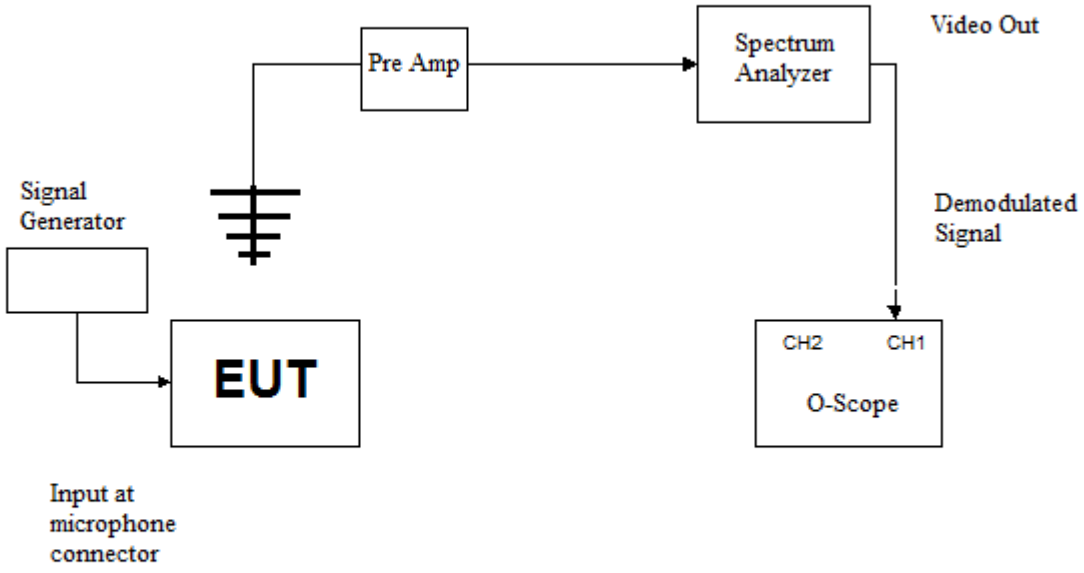


Figure 19: Test Set-up Diagram

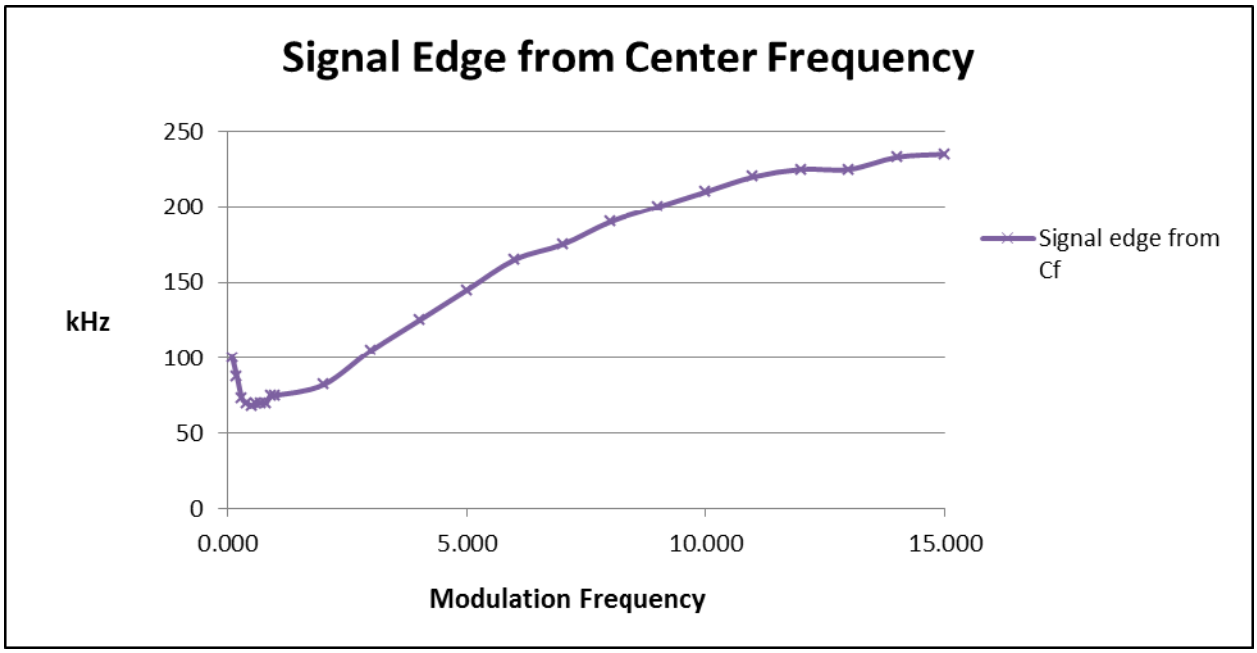


Figure 20: Signal Edge from Center Frequency

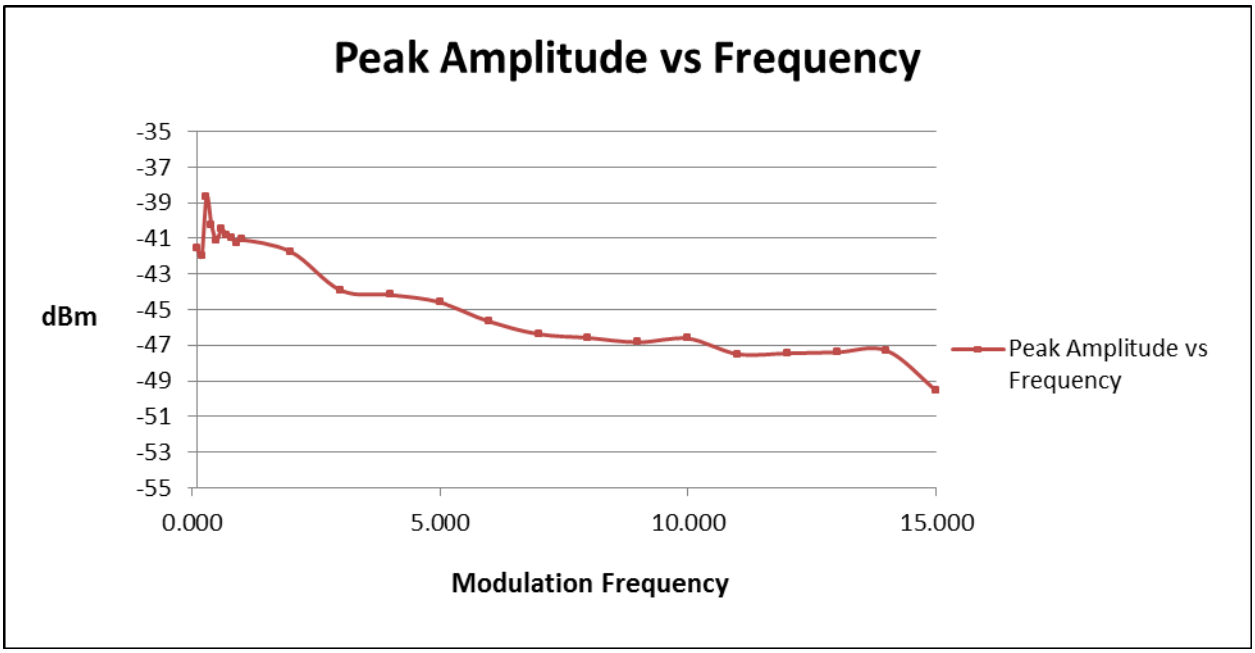


Figure 21: Peak Signal Amplitude vs Modulation Frequency

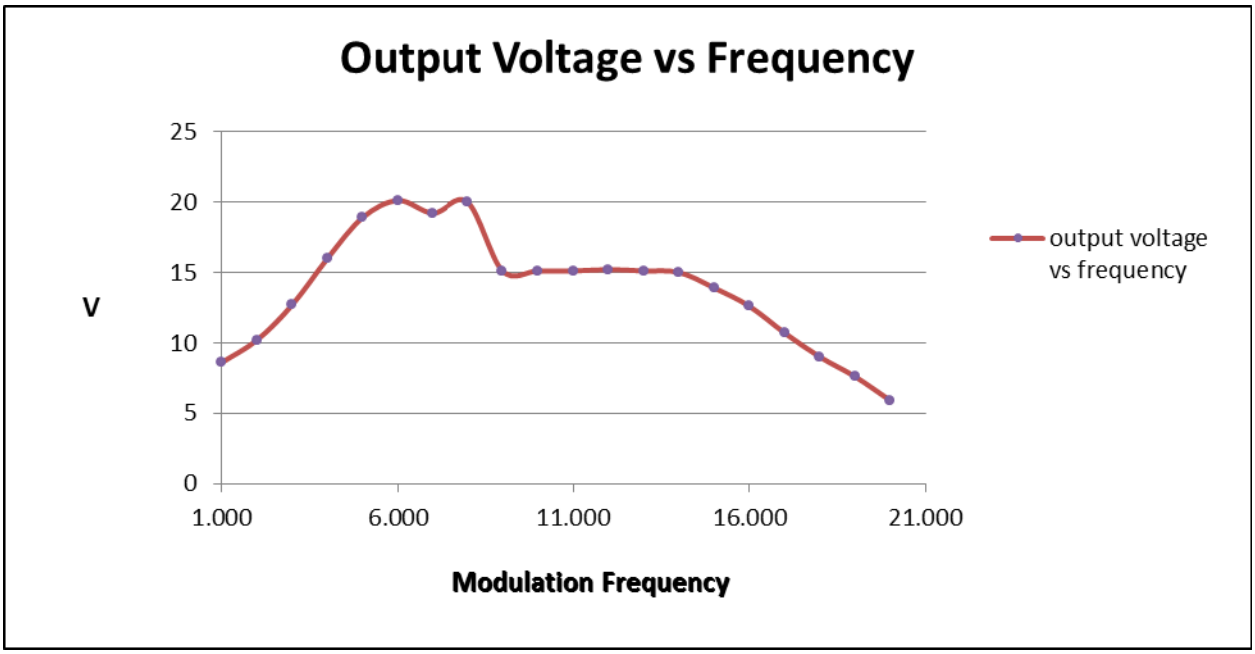


Figure 22: Measured Output Voltage vs Modulation Frequency