FCC Certification Test Report

FCC Certification Test Report
for
Broadcast Sports, Inc.
FCC ID: KTB-HUB97

May 6, 2004

(Revision 1, June 21, 2004)

Prepared for:

Broadcast Sports, Inc.
1360 Blair Drive
Odenton, MD 21113

Prepared By:

Washington Laboratories, Ltd.
7560 Lindbergh Drive
Gaithersburg, Maryland 20879

FCC Certification Test Program

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for the
Broadcast Sports, Inc.
Hub Video Transmitter
FCC ID: KTB-HUB97

May 6, 2004

WLL JOB# 7960

Prepared by: Michael Violette
President

Reviewed by: Greg Snyder.
Chief EMC Engineer

Abstract

This report has been prepared on behalf of Broadcast Sports, Inc. to support the attached Application for Equipment Authorization. The test report and application are submitted for a Licensed Non-Broadcast Station Transmitter under Part 74 F of the FCC Rules and Regulations. This Federal Communication Commission (FCC) Certification Test Report documents the test configuration and test results for a Broadcast Sports, Inc. Hub Video Transmitter.

Testing was performed on an Open Area Test Site (OATS) of Washington Laboratories, Ltd, 7560 Lindbergh Drive, Gaithersburg, MD 20879. 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. Washington Laboratories, Ltd. has been accepted by the FCC and approved by NIST NVLAP (NVLAP Lab Code: 200066-0) as an independent FCC test laboratory.

The Broadcast Sports, Inc. Hub Video Transmitter complies with the limits for a Licensed Non-Broadcast Station Transmitter device under Part 74 F of the FCC Rules and Regulations.

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1 Introduction

1.1 Compliance Statement

The Broadcast Sports, Inc. Hub Video Transmitter complies with the limits for a Licensed Non-Broadcast Station Transmitter device under Part 74F of the FCC Rules and Regulations.

1.2 Test Scope

Tests for radiated and conducted emissions were performed. All measurements were performed according to the 2001 version of ANSI C63.4 and EIA/TIA 603. The measurement equipment conforms to ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation.

1.3 Contract Information

Customer:	Broadcast Sports, Inc. 1360 Blair Drive Odenton, MD 21113
Purchase Order Number:	4472DW
Quotation Number:	60412-A

1.4 Test Dates

Testing was performed from February 9 to February 24, 2004.

1.5 Test and Support Personnel

Washington Laboratories, LTD	Greg Snyder, Chad Beattie, James Ritter

1.6 Abbreviations

A	Ampere
Ac	alternating current
AM	Amplitude Modulation
Amps	Amperes
b/s	bits per second
BW	Bandwidth
CE	Conducted Emission
cm	centimeter
CW	Continuous Wave
dB	decibel
dc	direct current
EMI	Electromagnetic Interference
EUT	Equipment Under Test
FM	Frequency Modulation
G	giga - prefix for 10^9 multiplier
Hz	Hertz
IF	Intermediate Frequency
k	kilo - prefix for 10^3 multiplier
M	Mega - prefix for 10^6 multiplier
m	Meter
μ	micro - prefix for 10^{-6} multiplier
NB	Narrowband
LISN	Line Impedance Stabilization Network
RE	Radiated Emissions
RF	Radio Frequency
rms	root-mean-square
SN	Serial Number
S/A	Spectrum Analyzer
V	Volt

2 Equipment Under Test

2.1 EUT Identification & Description

The HUB97 is a portable video transmitter specifically designed to meet the growing needs of the mobile television broadcast industry. The unit is designed to be Certificated per CFR 47, Part 74, Subpart F and functions as a stand alone transmitter for a TV ENG station. The transmitter has 16 preset channels including those in the RF ENG 2.0 GHz. and 2.5 GHz. bands as well as 2 channels in the 2.3 GHz. band. Optionally, the device can be factory tuned to any frequency between 1999 to 2500 Mhz in 250 kHz steps in accordance with FCC specifications.

The HUB97 features several capabilities that make it an ideal building block for a modular system requiring high density packaging. Four NTSC video inputs allow the user to easily switch between four video sources with no transmission delays. Additionally, a programmable audio sub carrier provides for the transmission of voice or telemetry. An RS-422 interface enables the unit to be remotely operated and provides control of all internal functions and status monitoring. The unit's small size and functional interface make it readily chassis mountable.

HUB97 FRONT VIEW

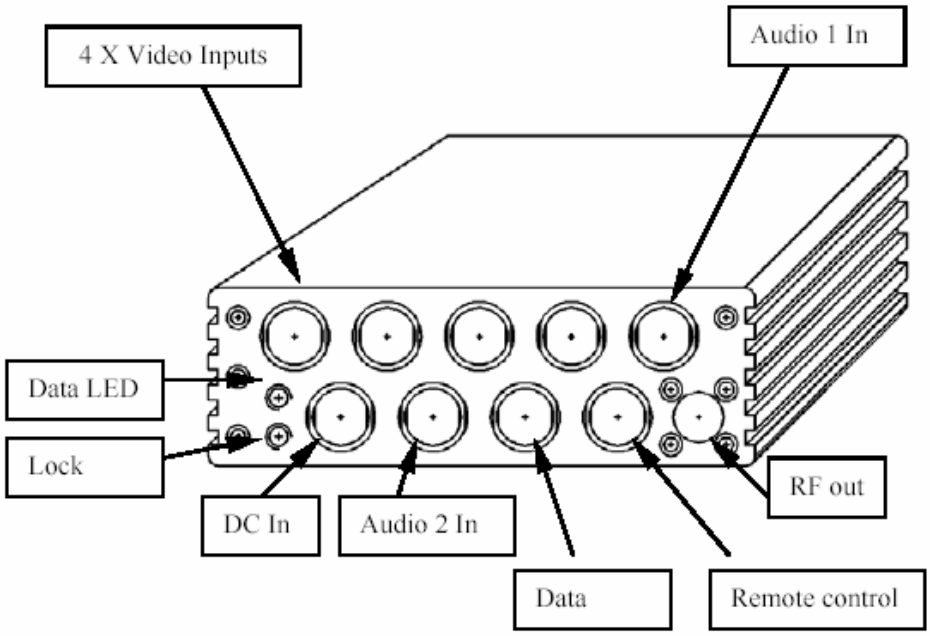

Table 1. Device Summary

ITEM	DESCRIPTION
Manufacturer:	Broadcast Sports, Inc.
FCC ID Number	KTB-HUB97
EUT Name:	Video Transmitter
Model:	Hub
FCC Rule Parts:	§74 F
Frequency Range:	1999MHz – 2496MHz
Maximum Output Power:	1.5W
Modulation:	FM
Necessary Bandwidth:	8.724MHz
Keying:	Continuous
Type of Information:	Video & Audio
Number of Channels:	16 (0-15)
Power Output Level	Fixed
Antenna Type	Connector
Frequency Tolerance:	>0.005%
Emission Type(s):	FM
Interface Cables:	4 Video Inputs 2 Audio DC in Remote control RF out
Power Source & Voltage:	12Vdc from vehicle
Emissions Designator	8M72F3W

2.2 Test Configuration

The Hub was configured with the required cables, power supply, and a Tektronix NTSC Pathfinder™ Signal Generator.

2.3 Testing Algorithm

The Hub was operated continuously by supplying an NTSC signal to the input, adjusted for peak signal, which modulated the carrier.

Worst-case emission levels are provided in the test results data.

2.4 Test Location

All measurements herein were performed at Washington Laboratories, Ltd. test center in Gaithersburg, 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. Washington Laboratories, Ltd. has been accepted by the FCC and approved by NIST NVLAP (NVLAP Lab Code: 200066-0) as an independent FCC test laboratory.

2.5 Measurements

2.5.1 References

ANSI C63.2 Specifications for Electromagnetic Noise and Field Strength Instrumentation

ANSI C63.4 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

Land Mobile FM or PM Communications Equipment Measurement and Performance Standards (ANSI/TIA/EIA-603-93)

2.6 Measurement Uncertainty

All results reported herein relate only to the equipment tested. For the purposes of the measurements performed by Washington Laboratories, the measurement uncertainty is ±2.3 dB. This has been calculated for a *worst-case situation* (radiated emissions measurements performed on an open area test site).

The following measurement uncertainty calculation is provided:

$$\text{Total Uncertainty} = (A^2 + B^2 + C^2)^{1/2}/(n-1)$$

where:

A = Antenna calibration uncertainty, in dB = 2 dB

B = Spectrum Analyzer uncertainty, in dB = 1 dB

C = Site uncertainty, in dB = 4 dB

n = number of factors in uncertainty calculation = 3

Thus, Total Uncertainty = $0.5\ (2^2 + 1^2 + 4^2)^{1/2} = \pm 2.3$ dB.

3 Test Equipment

Table 2 shows a list of the test equipment used for measurements along with the calibration information.

Table 2: Test Equipment List

Equipment	Serial Number	Calibration Due
Sunol JB1 Biconilog Antenna	A090501	10/21/04
ARA DRG118/A Microwave Horn Antenna	1010	2/17/06
ARA Biconilog Antenna	1044	6/20/2004
A.H. Systems Log Periodic Antenna: SAS-200/518	117	3/11/2006
Narda Standard Gain Horn Antenna: V638	- -	7/22/2004
Hewlett-Packard Spectrum Analyzer: HP 8568B (Site 1)	2928A04750	7/02/04
Hewlett-Packard Quasi-Peak Adapter: HP 85650A (Site 1)	3303A01786	7/08/04
Hewlett-Packard RF Preselector: HP 85685A (Site 1)	3146A01296	7/02/04
Hewlett-Packard Spectrum Analyzer: HP 8593A	3009A00739	6/25/04
Hewlett-Packard Spectrum Analyzer: HP 8563A	500	4/04/04
Hewlett-Packard Microwave Preamp: 8449B	3008A00729	2/11/05
A.H. Systems Pre-Amplifier 18GHz-40 GHz	126	1/6/2005
Hewlett-Packard Synth. Signal Generator: 8672A	2311A03131	3/23/2005
Hewlett-Packard Power Meter: 438A	3048U02786	3/10/2005
Hewlett-Packard 30dB Attenuator: 8481B	331BA04749	3/10/2005
Hewlett-Packard Power Head: 8481B	331BA04749	3/10/2005
Solar Electronics LISN 8012-50-R-24-BNC	8379493	6/30/04

4 Test Results

4.1 RF Power Output: (FCC Part §2.1046)

The output from the transmitter was connected to a power meter and the output power measured.

Table 3. RF Power Output

Channel and/or Frequency	Measured Level (dBm)	Measured Level (Watts)	Rated (Watts)	Limit (Watts)
Channel 1: 1999 MHz	30.04	1.008	1.5	12
Channel 8: 2454 MHz	29.80	0.954	1.5	12
Channel 11: 2316 MHz	30.92	1.24	1.5	12

4.2 Modulation Characteristics (FCC Part §2.201)

To determine the deviation frequency, an RF signal generator was input to the modulation input of the transmitter. The transmitter output was connected to a spectrum analyzer. The 1Vp-p sinewave modulating frequency was increased and the carrier observed on the spectrum analyzer.

As the modulation frequency is increased, the fundamental signal was observed for nulls. At the null the side lobes were measured and compared to the Bessel Function chart for a modulation index of 2.4. Only one null was located as the modulation frequency was scanned up through 15MHz.

The spectrum was plotted at each of the three carrier frequencies measured and the first four Bessel terms measured. Adjusting the modulation frequency for a null in carrier and where the Bessel functions yield:

Jc1 = -5.8 dB

Jc2 = -7.3 dB

Jc3 = -14.1 dB

Jc4 = -23.9 dB

Deviations for each channel are recorded in Table 4.

Table 4. Deviation Measurements

Frequency	Deviation Frequency (MHz)
Channel 1: 1999 MHz	1.22
Channel 8: 2454 MHz	1.283
Channel 11: 2316 MHz	1.269

Modulation Index: 2.4

The data are as follows:

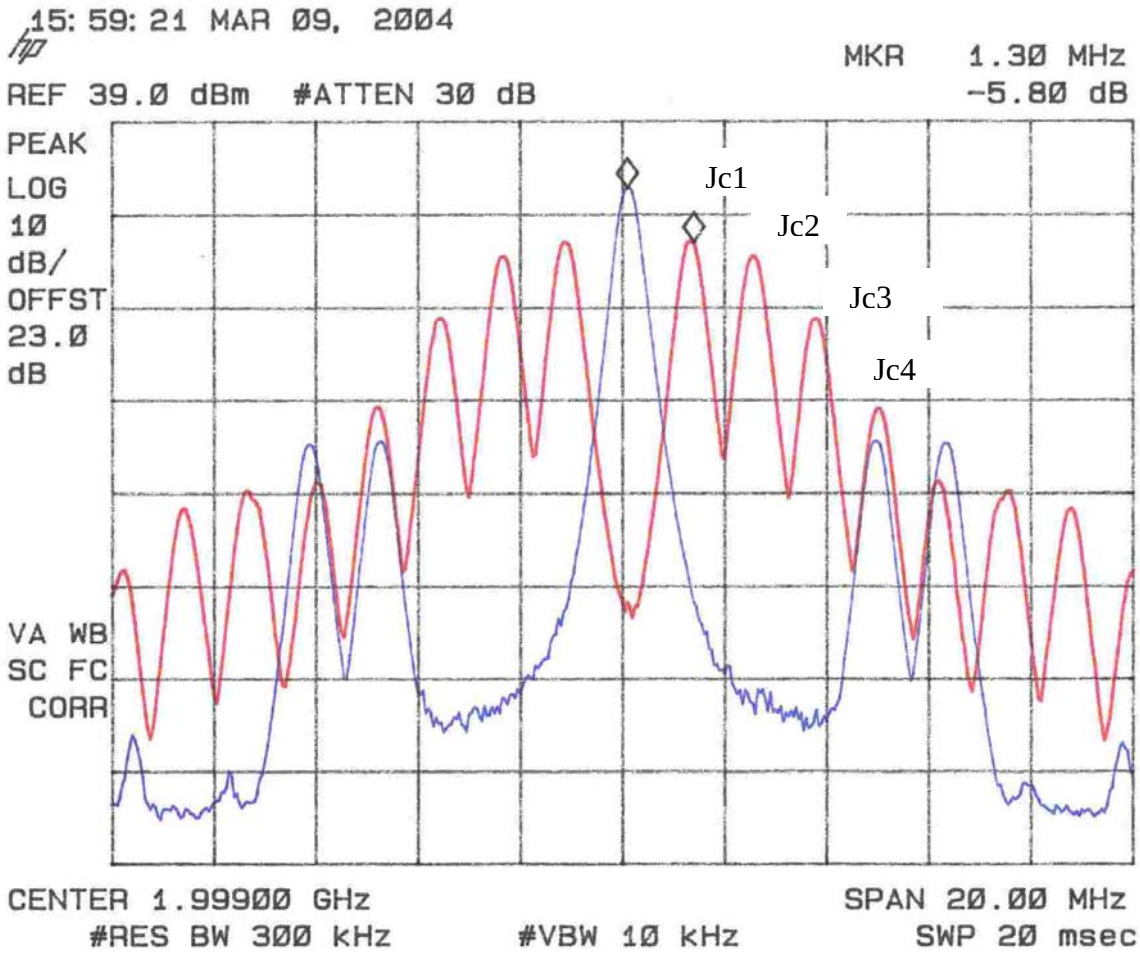

Figure 1. Modulated Carrier, Channel 1

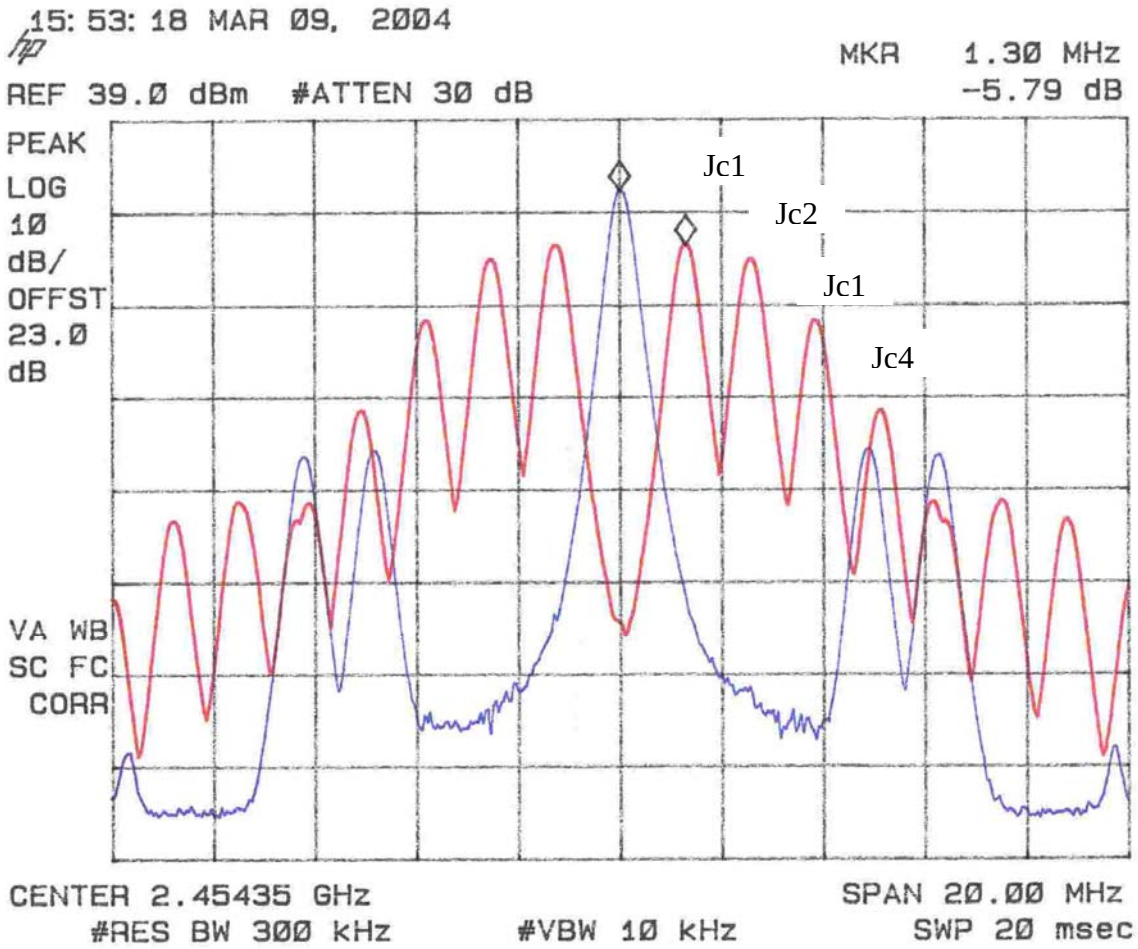

Figure 2. Modulated Carrier, Channel 8

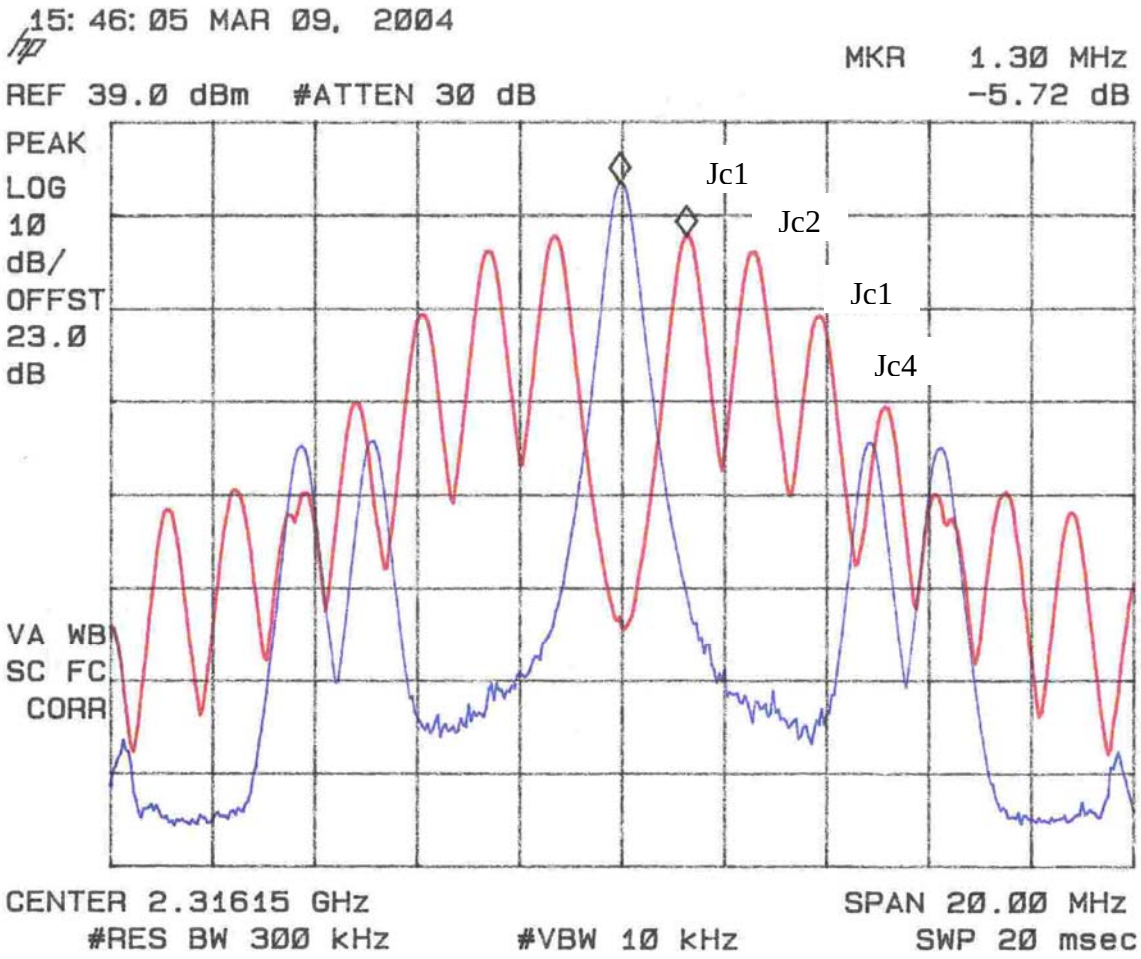

Figure 3. Modulated Carrier, Channel 11

4.3 Emission Designator

The emission designator is determined from the necessary bandwidth, the type of modulation and the information conveyed in the signal.

Necessary bandwidth is determined from:

Bn = 2M + 2 DK

Where,

M = Deviation = 1.283

D = Deviation X Modulation Index = 1.283 MHz X 2.4 = 3.079 MHz

And K=1

Table 5. Modulation Parameters

Parameter	Result
Modulation Index (from Bessel function plot)	2.4
M Deviation	1.283 MHz
Deviation = 2.4M	3.079 MHz

Thus,

Bn = 2M + 2DK = (2 X 1.283) + (2 X 3.079) = 8.724 MHz

First Symbol: F (Frequency Modulation)

Second Symbol: 3 (Single channel carrying analogue information)

Third Symbol: W (video and audio)

Emission Designator: 8M72F3W

4.4 Occupied Bandwidth: (FCC Part §2.1049)

Occupied bandwidth was performed by coupling the output of the EUT to the input of a spectrum analyzer.

At full modulation, the occupied bandwidth was measured as shown:

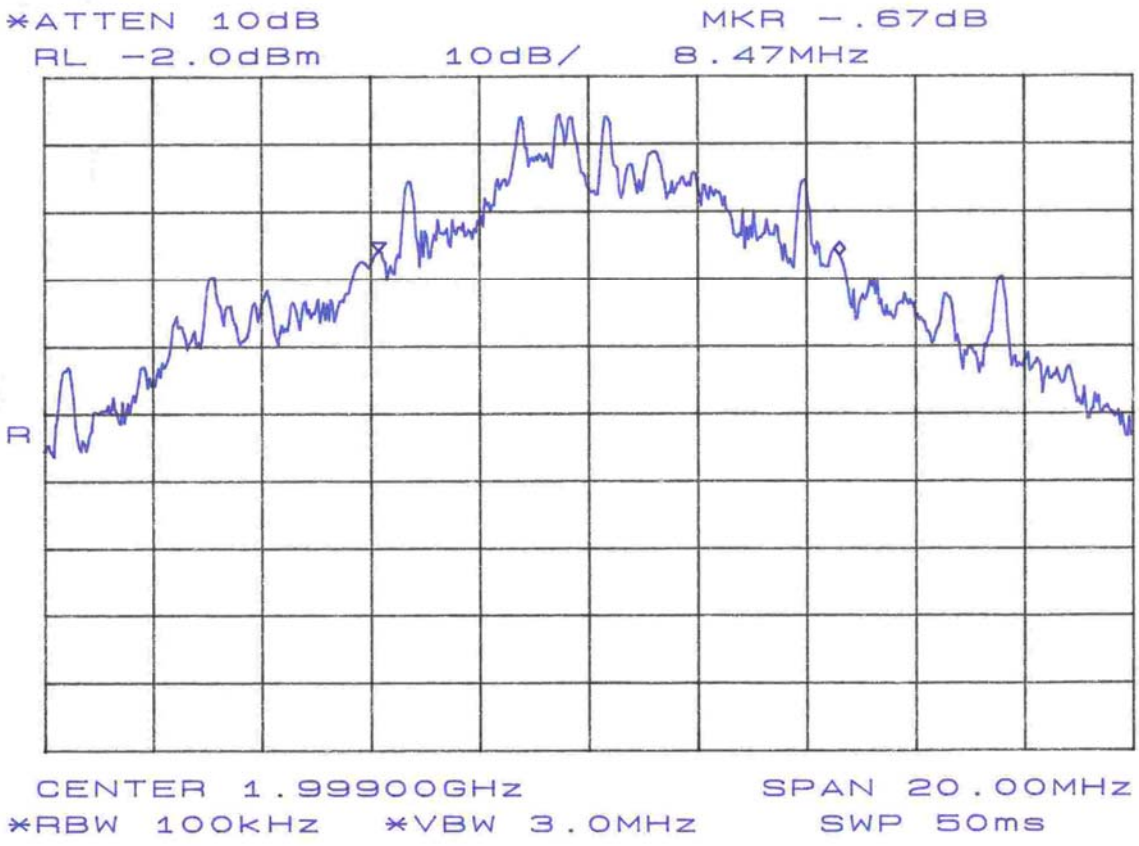

Figure 4. Occupied Bandwidth, Channel 1

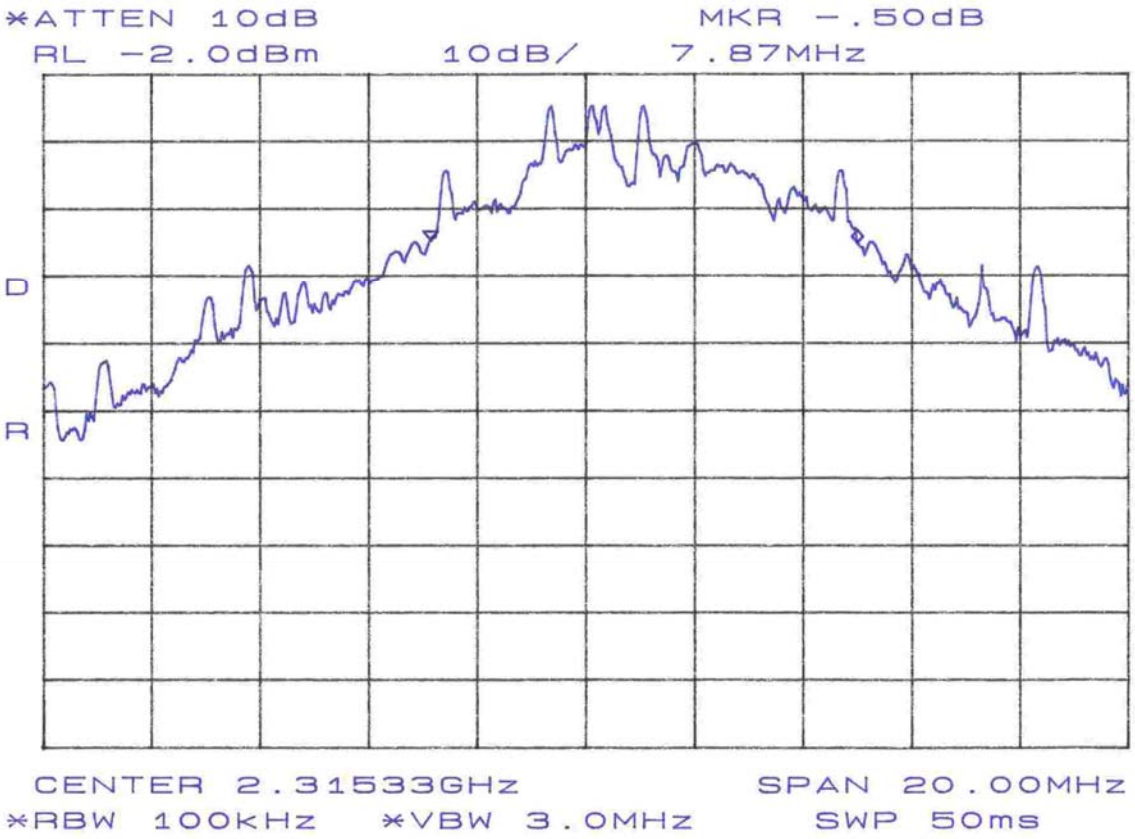

Figure 5. Occupied Bandwidth, Channel 8

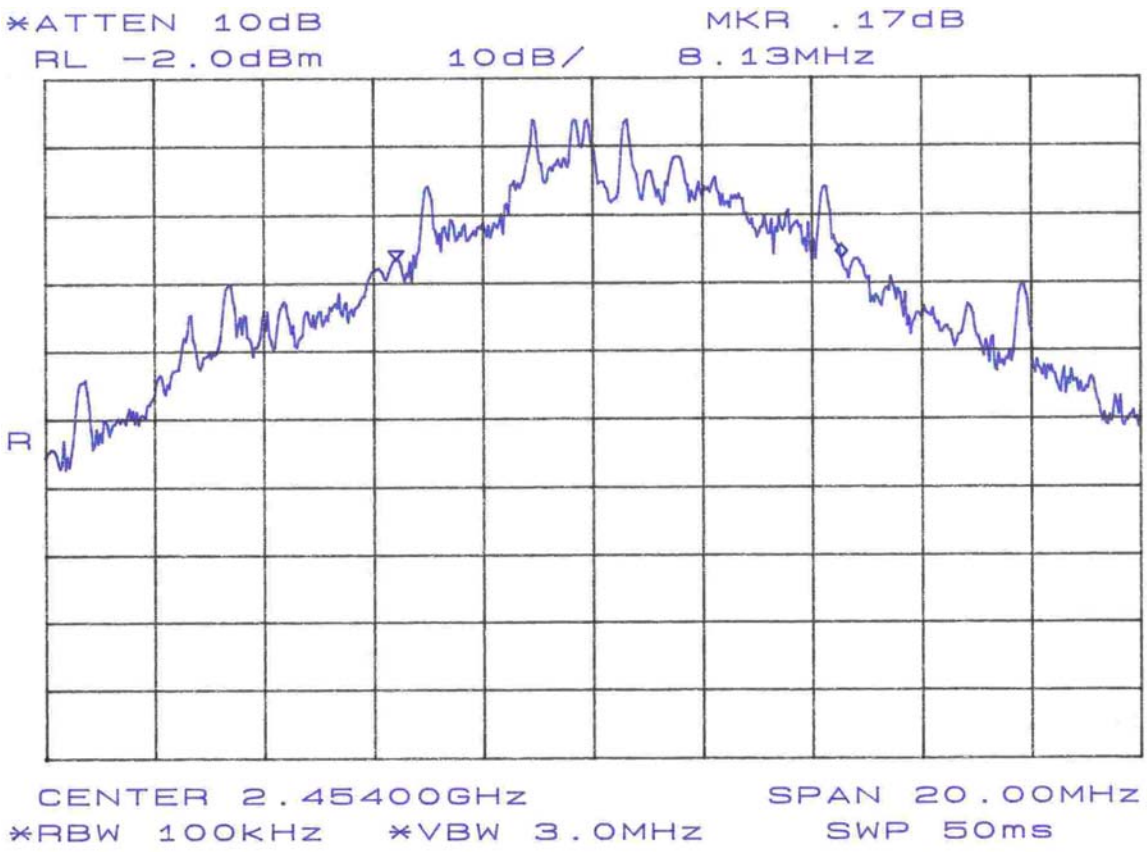

Figure 6. Occupied Bandwidth, Channel 11

Table 6 provides a summary of the Occupied Bandwidth Results.

Table 6. Occupied Bandwidth Results

Frequency	Bandwidth
Low Channel: 1999MHz	8.47MHz
Mid Channel: 2315.3MHz	7.87MHz
High Channel: 2454MHz	8.13MHz

4.5 Emissions and emission limitations to § 74.637

Emissions limitations are specified in § 74.637. The output of the transmitter was connected to the input of the spectrum analyzer and the transmitter modulated. The emissions from 30 MHz to the tenth harmonic of the operating frequency were measured and provided in the following figures.

The masks are based on 74.637(a)(1) with an authorized bandwidth of 18 MHz. Note that the tighter limit specified for emissions removed from the carrier by more than 250% of the authorized bandwidth was inadvertently applied starting at 150% of the authorized bandwidth.

For the emission mask measurements the resolution bandwidth was set to 100kHz and the video bandwidth was set to 3MHz.

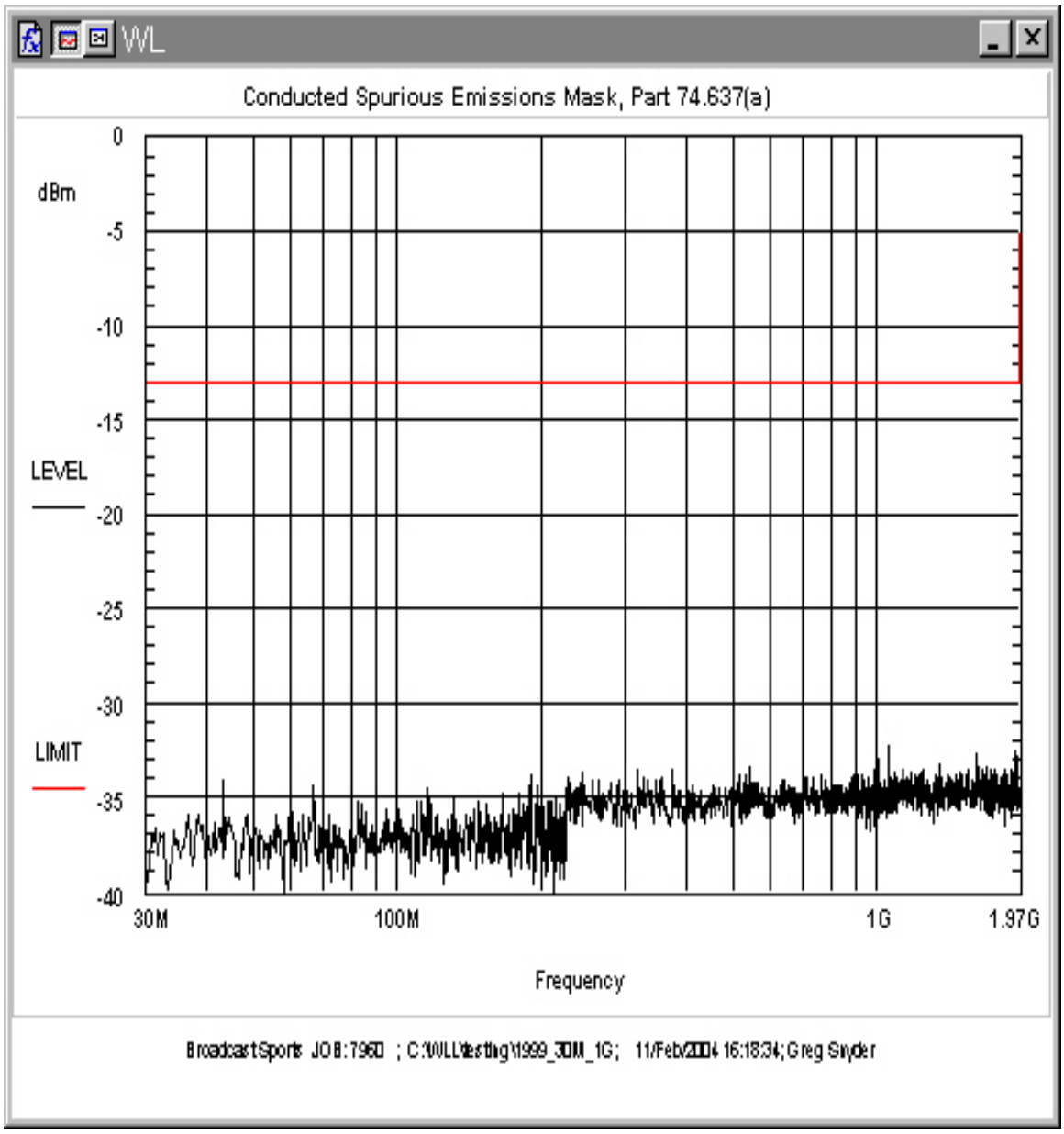

Figure 7. Emissions Mask, Channel 1

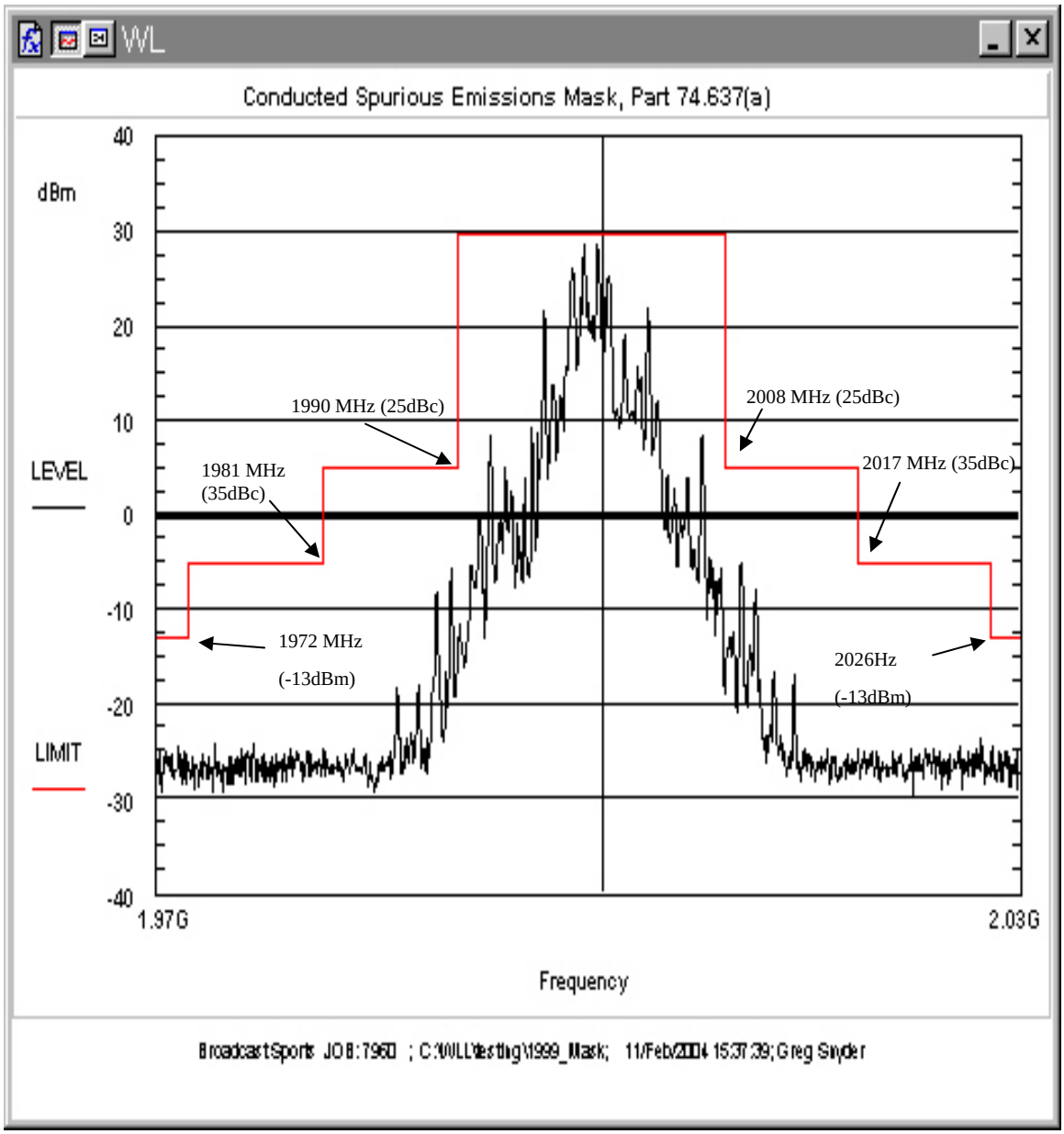

Figure 8. Emissions Mask, Channel 1

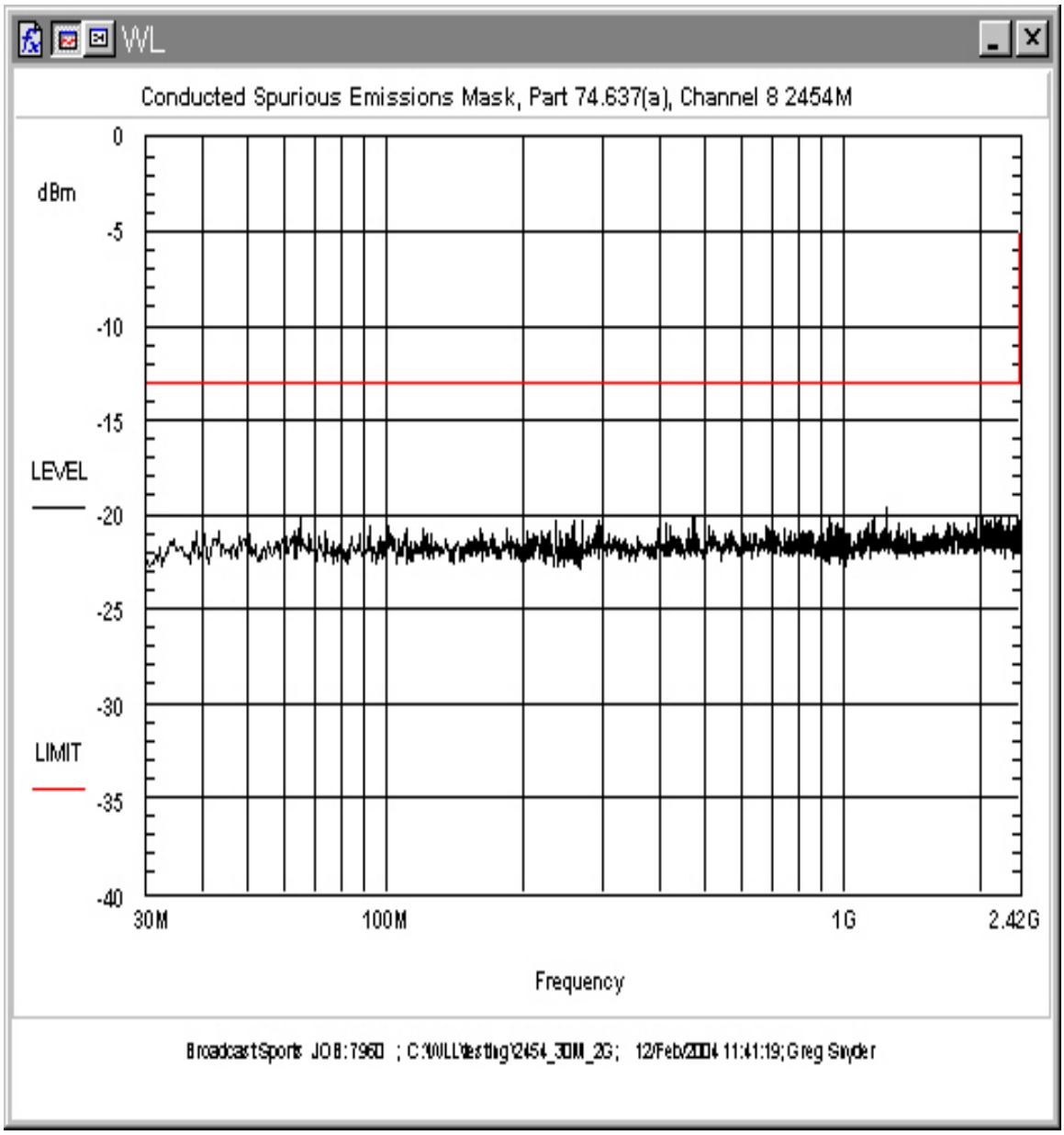

Figure 9. Emissions Mask, Channel 8

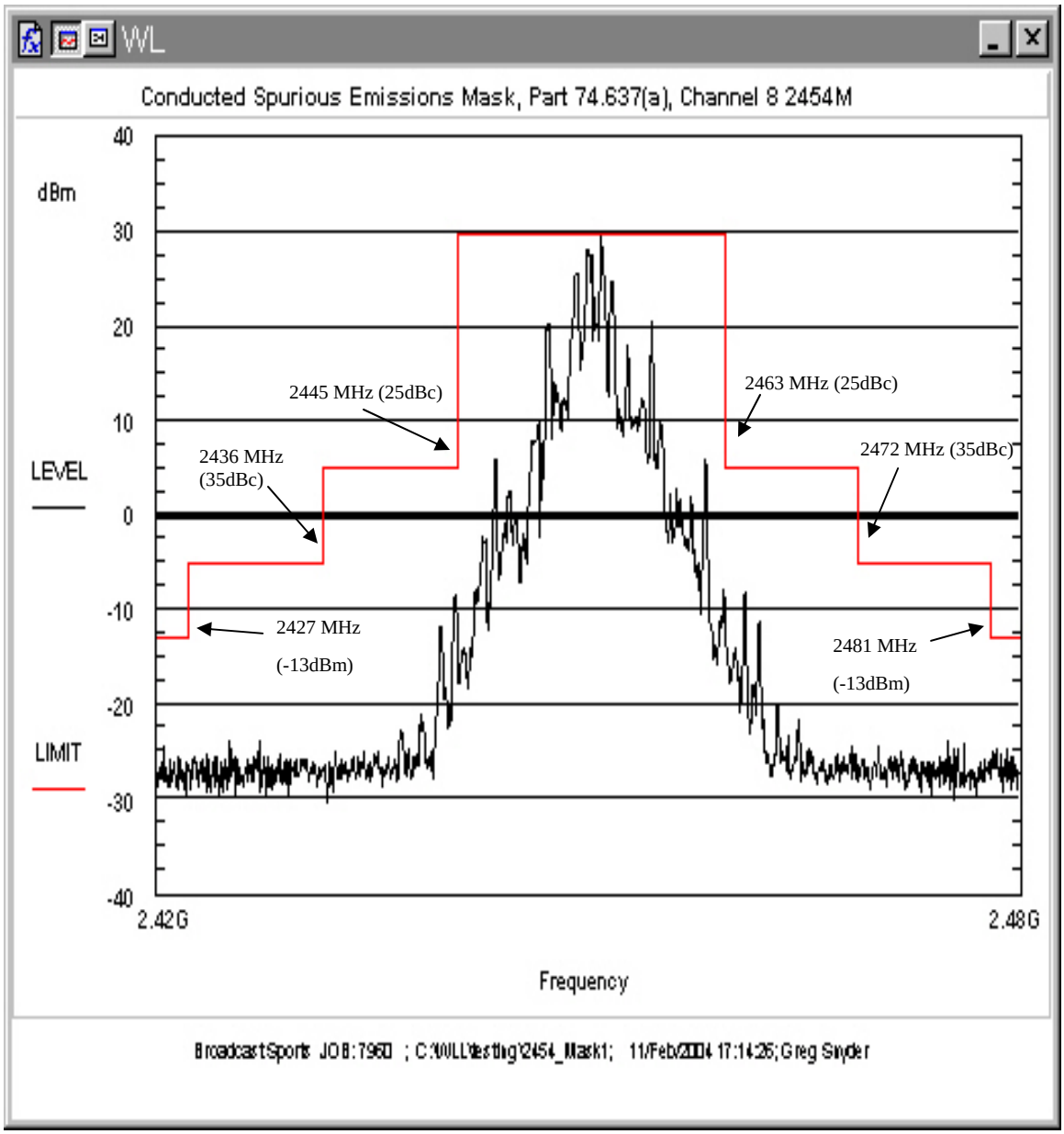

Figure 10. Emissions Mask, Channel 8

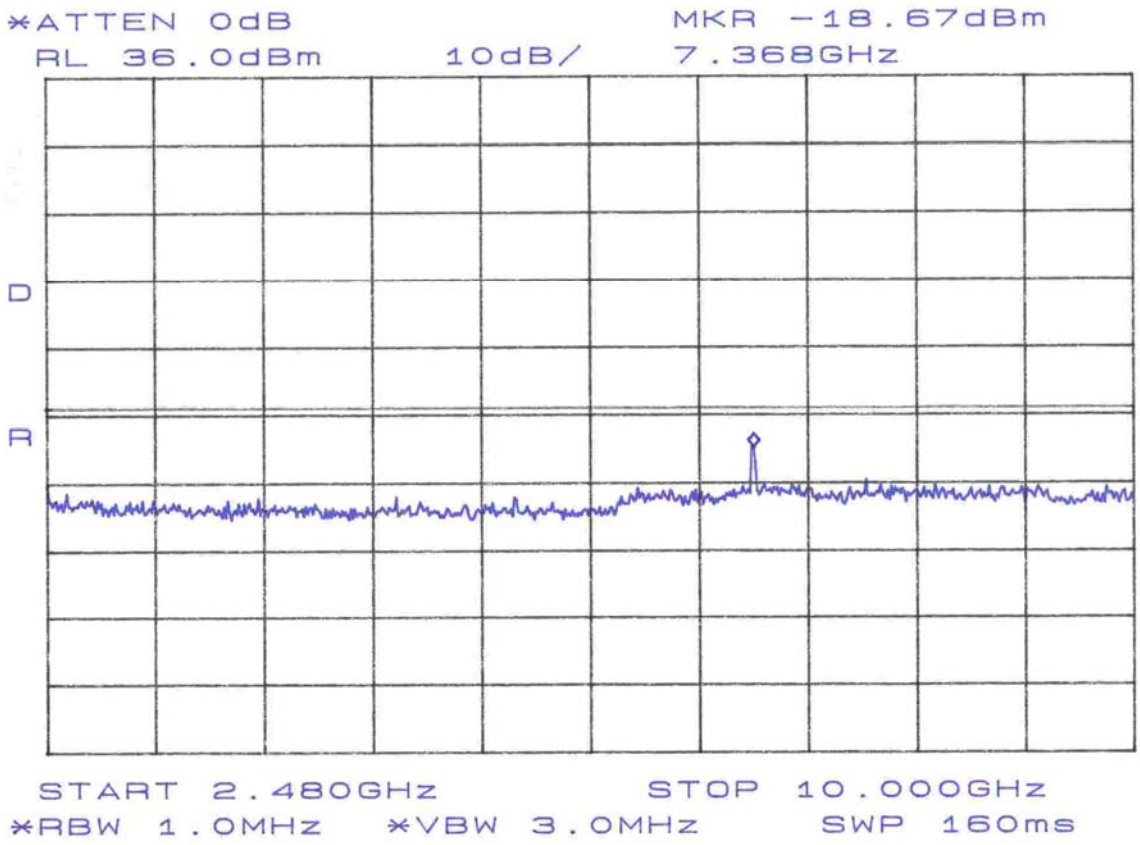

Figure 11. Emissions Mask, Channel 8

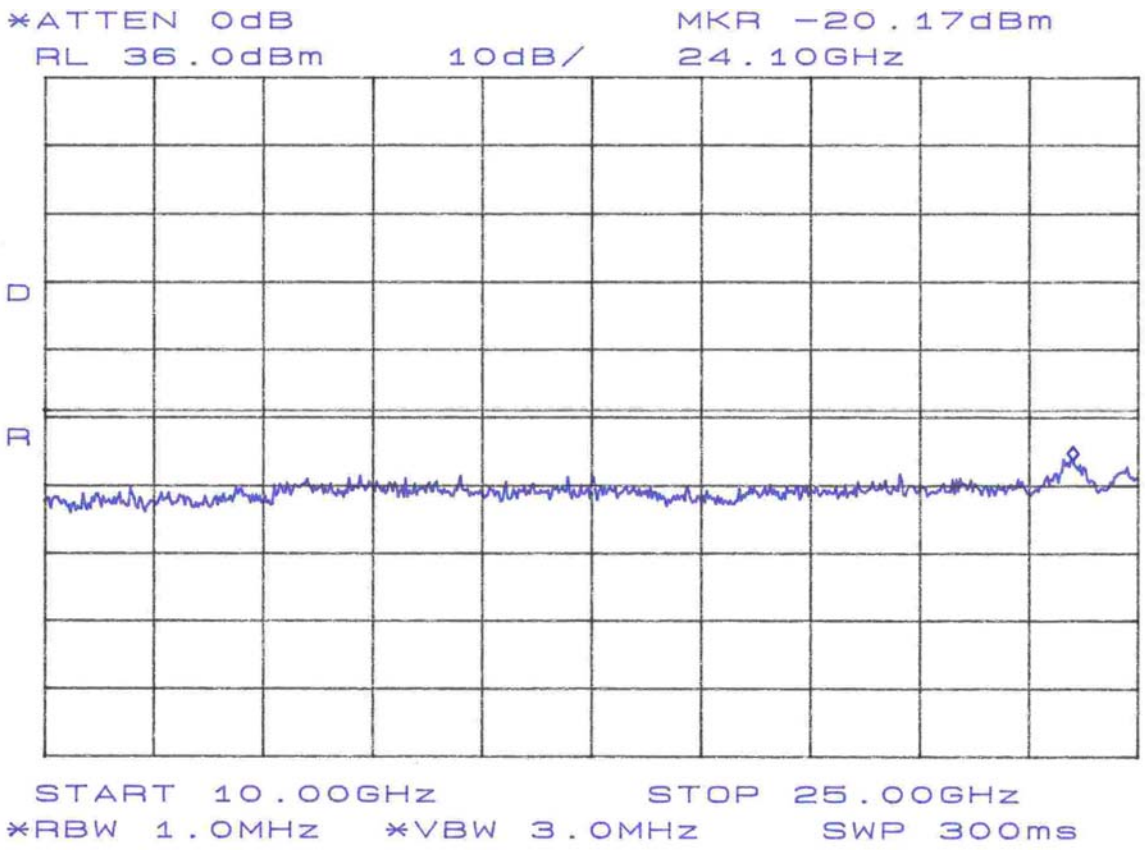

Figure 12. Emissions Mask, Channel 8

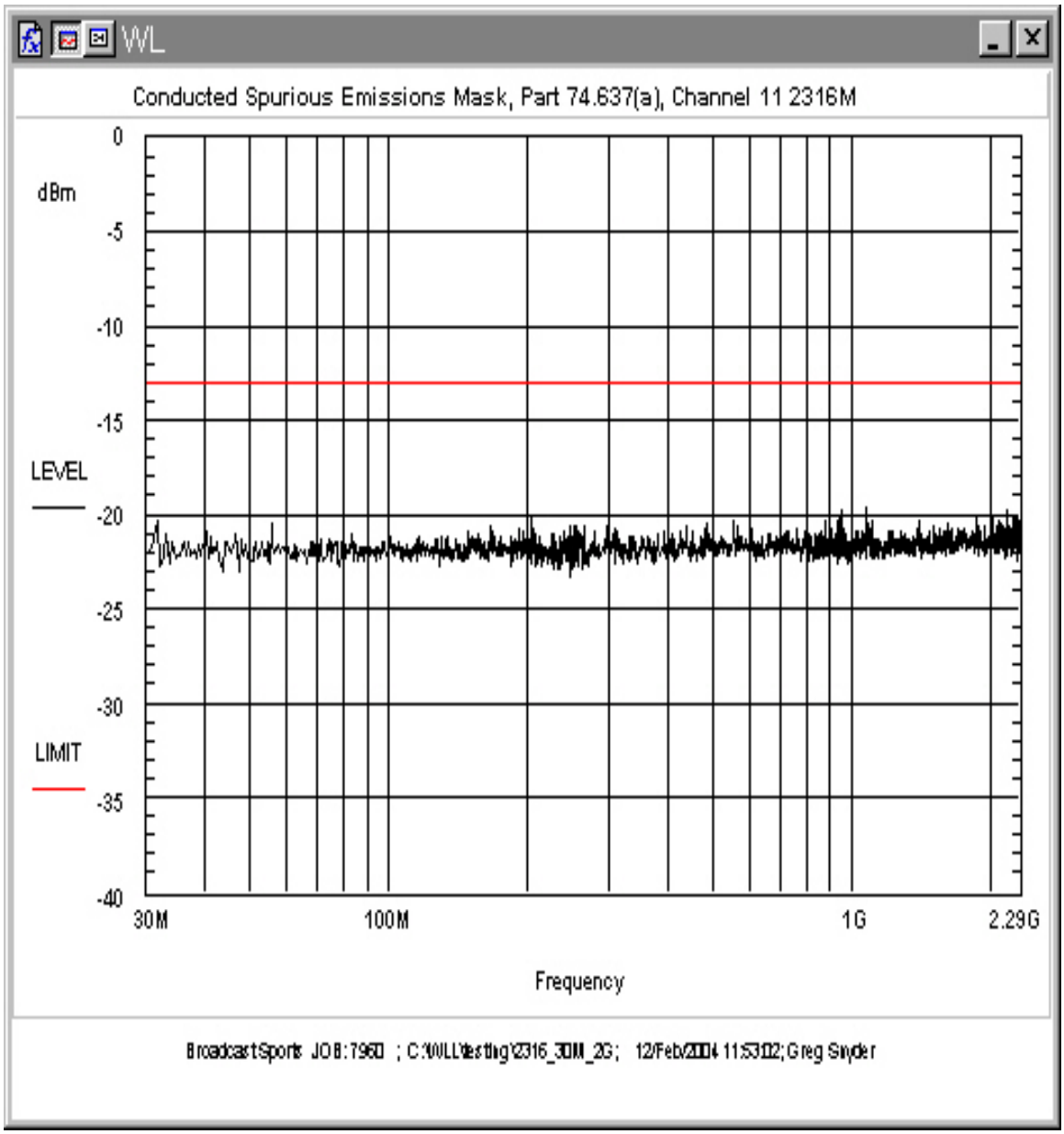

Figure 13. Emissions Mask, Channel 11

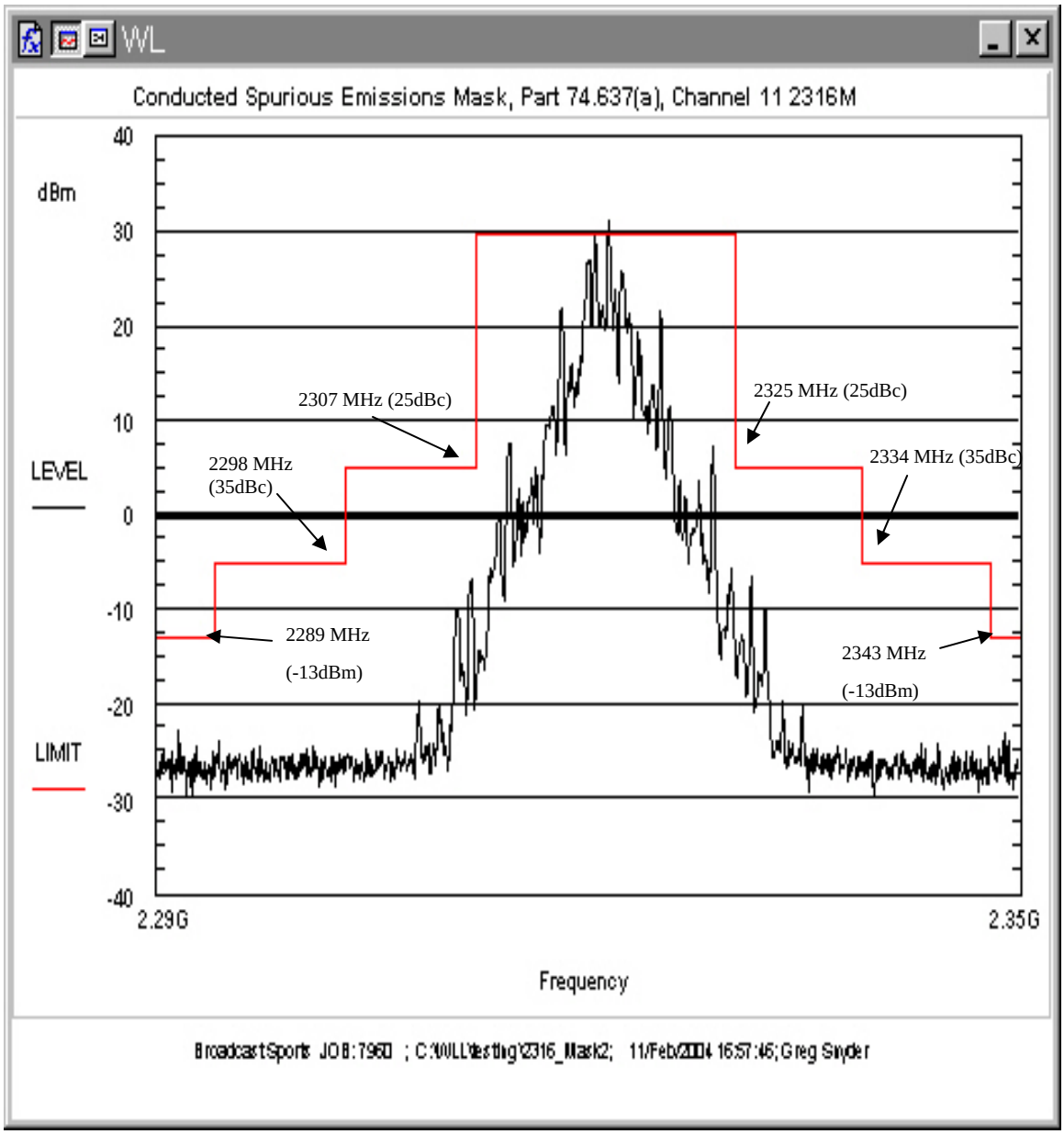

Figure 14. Emissions Mask, Channel 11

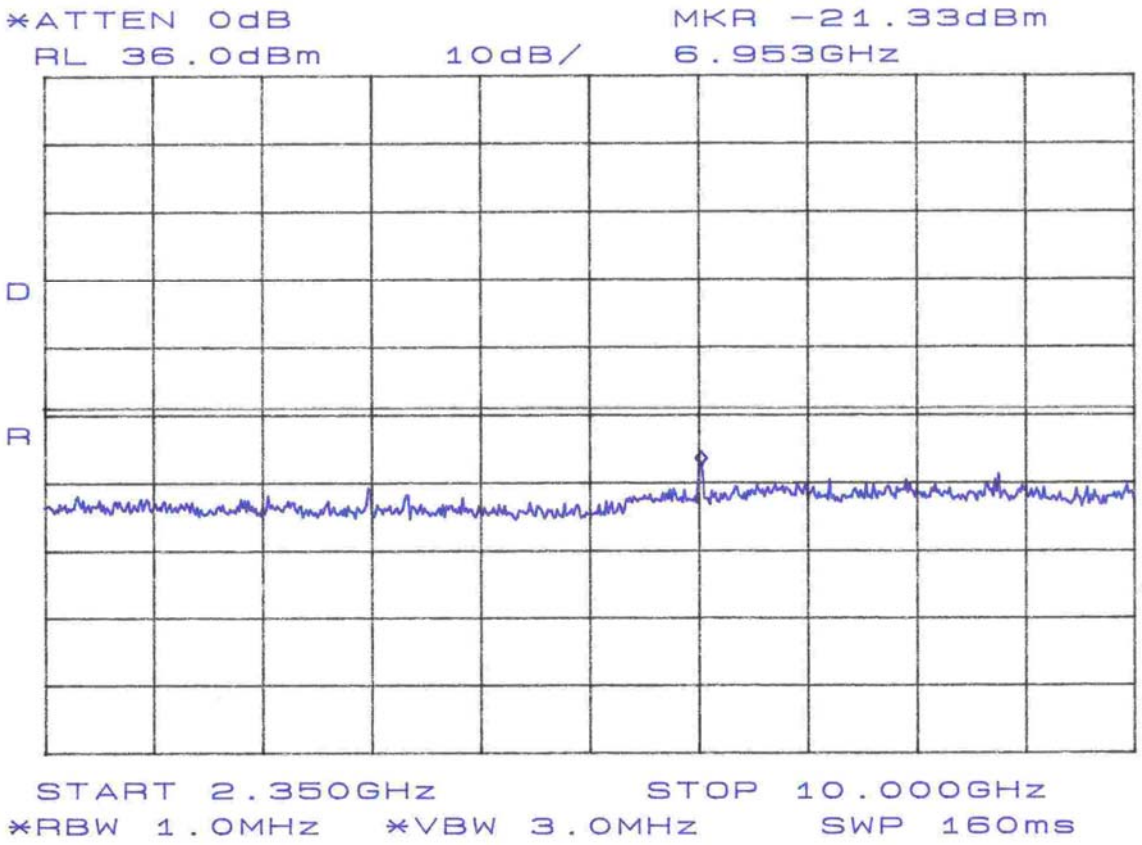

Figure 15. Emissions Mask, Channel 11

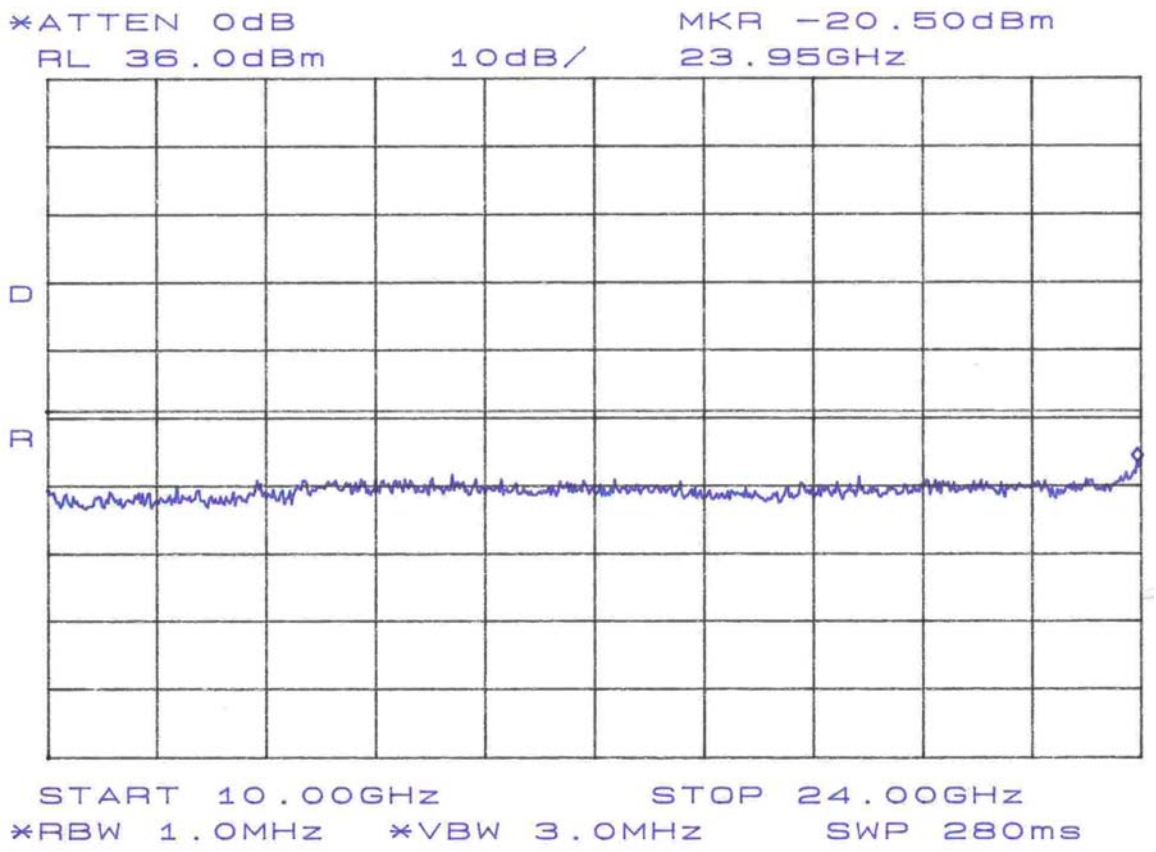

Figure 16. Emissions Mask, Channel 11

4.6 Radiated Spurious Emissions: (FCC Part §2.1053)

The EUT must comply with requirements for radiated spurious emissions.

4.6.1 Test Procedure

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 height of the antenna was varied between 1 and 4 meters. The peripherals were placed on the table in accordance with ANSI C63.4-2001. Cables were varied in position to produce maximum emissions. Both the horizontal and vertical field components were measured.

The Effective Isotropic Radiated Power (EIRP) levels were measured and compared with the limit of –13 dBm per FCC Part 74. The limit of -13dB is derived from the formula of 43+10LOG(P) dB per §74.637(a)(1)(iii).

Emissions were measured for Channel 1, Channel 8 and Channel 11 and are reported in the following tables. Emissions were scanned up to the 10^{th} harmonic of the fundamental. Worst case measurements are reported. The signal substitution method was used to obtain EIRP levels.

Table 7: EIRP Radiated Emissions Test Data: Channel 1

CLIENT:	Broadcast Sports	DATE:	02.10.04
TESTER:	Chad M. Beattie/James Ritter	JOB #:	7960
EUT Information:		**Test Requirements:**	
EUT:	HUB	TEST STANDARD:	Part 74
CONFIGURATION:	CH1 (1999MHZ TX)	DISTANCE:	3m
CLOCKS:	Modulated with NTSC video/audio	CLASS:	B
Test Equipment/Limit:			
ANTENNA:	A_00425	LIMIT:	EIRP
CABLE:	CSITE1_HF	AMPLIFIER (dB)	A_00066

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Hght (m)	SA Level (QP) (dBµV)	Sub. Ant. Gain dBi	Sig. Gen. Level dBm	EIRP Level dBm	Limit (dBm)	Margin dB
CH1									
1999.00	V	157.5	1.0	67.1	4.1	-35.5	-31.4	-13.0	-18.4
3998.00	V	157.5	1.0	57.2	4.9	-46.8	-41.9	-13.0	-28.9
5997.00	V	157.5	1.0	57.2	5.2	-40.3	-35.1	-13.0	-22.1
7996.00	V	157.5	1.0	48.3	5.6	-47.5	-41.9	-13.0	-28.9
9995.00	V	135.0	1.0	47.5	4.1	-44.5	-40.4	-13.0	-27.4
11994.00	V	0.0	1.0	45.3	2.3	-42.5	-40.2	-13.0	-27.2
13993.00	V	0.0	1.0	45.2	3.6	-34.0	-30.4	-13.0	-17.4
15992.00	V	0.0	1.0	45.5	-1.0	-33.3	-34.3	-13.0	-21.3
1999.00	H	225.0	1.0	65.7	4.1	-39.8	-35.7	-13.0	-22.7
3998.00	H	135.0	1.0	52.8	4.9	-49.0	-44.1	-13.0	-31.1
5997.00	H	157.5	1.0	51.0	5.2	-47.8	-42.6	-13.0	-29.6
7996.00	H	0.0	1.0	44.8	5.6	-50.5	-44.9	-13.0	-31.9
9995.00	H	0.0	1.0	44.7	4.1	-47.8	-43.7	-13.0	-30.7
11994.00	H	0.0	1.0	47.2	2.3	-37.0	-34.7	-13.0	-21.7
13993.00	H	0.0	1.0	45.2	3.6	-33.8	-30.2	-12.0	-18.2
15992.00	H	0.0	1.0	46.5	-1.0	-29.3	-30.3	-13.0	-17.3

Table 8: EIRP Radiated Emissions Test Data: Channel 8

CLIENT:	Broadcast Sports	DATE:	02.10.04
TESTER:	Chad M. Beattie/James Ritter	JOB #:	7960
EUT Information:		**Test Requirements:**	
EUT:	HUB	TEST STANDARD:	Part 74
CONFIGURATION:	CH8 (2454MHZ TX)	DISTANCE:	3m
CLOCKS:	Modulated with NTSC video/audio	CLASS:	B
Test Equipment/Limit:			
ANTENNA:	A_00425	LIMIT:	EIRP
CABLE:	CSITE1_HF	AMPLIFIER (dB)	A_00066

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Hght (m)	SA Level (QP) (dBµV)	Sub. Ant. Gain dBi	Sig. Gen. Level dBm	EIRP Level dBm	Limit (dBm)	Margin dB
CH8									
2454.00	V	0.0	1.0	69.7	3.9	-30.5	-26.6	-13.0	-13.6
4908.00	V	225.0	1.0	63.7	6.1	-34.0	-27.9	-13.0	-14.9
7362.00	V	180.0	1.0	51.3	5.7	-39.1	-33.4	-13.0	-20.4
9816.00	V	0.0	1.0	47.3	4.0	-46.5	-42.5	-13.0	-29.5
12270.00	V	0.0	1.0	44.5	2.2	-43.1	-40.9	-13.0	-27.9
14724.00	V	0.0	1.0	45.2	1.2	-38.0	-36.8	-13.0	-23.8
2454.00	H	225.0	1.0	70.0	3.9	-29.0	-25.1	-14.0	-11.1
4908.00	H	292.5	1.0	59.5	6.1	-37.5	-31.4	-13.0	-18.4
7362.00	H	180.0	1.0	47.8	5.7	-45.8	-40.1	-13.0	-27.1
9816.00	H	0.0	1.0	46.5	4.0	-47.3	-43.3	-13.0	-30.3
12270.00	H	0.0	1.0	44.3	2.2	-45.5	-43.3	-13.0	-30.3
14724.00	H	0.0	1.0	44.7	1.2	-39.0	-37.8	-13.0	-24.8

Table 9: EIRP Radiated Emissions Test Data: Channel 11

CLIENT:	Broadcast Sports	DATE:	02.10.04
TESTER:	Chad M. Beattie/James Ritter	JOB #:	7960
EUT Information:		**Test Requirements:**	
EUT:	HUB	TEST STANDARD:	Part 74
CONFIGURATION:	CH11 (2316MHZ TX)	DISTANCE:	3m
CLOCKS:	Modulated with NTSC video/audio	CLASS:	B
Test Equipment/Limit:			
ANTENNA:	A_00425	LIMIT:	EIRP
CABLE:	CSITE1_HF	AMPLIFIER (dB)	A_00066

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Hght (m)	SA Level (QP) (dBµV)	Sub. Ant. Gain dBi	Sig. Gen. Level dBm	EIRP Level dBm	Limit (dBm)	Margin dB
CH11									
2316.00	V	225.0	1.0	70.3	3.9	-32.5	-28.6	-13.0	-15.6
4632.00	V	180.0	1.0	66.8	6.0	-31.7	-25.7	-13.0	-12.7
6948.00	V	157.5	1.0	64.7	5.3	-29.7	-24.4	-13.0	-11.4
9264.00	V	0.0	1.0	46.0	3.4	-43.5	-40.1	-13.0	-27.1
11580.00	V	0.0	1.0	44.0	3.6	-41.0	-37.4	-13.0	-24.4
13896.00	V	0.0	1.0	44.7	3.7	-41.5	-37.8	-13.0	-24.8
2316.00	H	225.0	1.0	67.2	3.9	-35.5	-31.6	-15.0	-16.6
4632.00	H	157.5	1.0	63.7	6.0	-36.6	-30.6	-14.0	-16.6
6948.00	H	157.5	1.0	60.2	5.3	-28.5	-23.2	-13.0	-10.2
9264.00	H	0.0	1.0	45.7	3.4	-43.5	-40.1	-13.0	-27.1
11580.00	H	0.0	1.0	45.8	3.6	-36.8	-33.2	-13.0	-20.2
13896.00	H	0.0	1.0	44.0	3.7	-38.3	-34.6	-13.0	-21.6

4.7 Frequency Stability: (FCC Part §2.1055)

Frequency as a function of temperature and voltage variation shall be maintained within the FCC-prescribed tolerances.

The temperature stability was measured with the unit in an environmental chamber used to vary the temperature of the sample. The sample was held at each temperature step to allow the temperature of the sample to stabilize.

The EUT is powered by DC voltage supplied externally. The manufacturer's power requirements for the EUT include the following:

Low DC Voltage of 10 VDC (manufacturer's specification)

High DC Voltage of 13.8VDC (manufacturer's specifications)

The frequency stability of the transmitter was examined at the voltage extremes and for the temperature range of -30°C to +50°C. The carrier frequency was measured while the EUT was in the temperature chamber. The reference frequency of the EUT was measured at the ambient room temperature with the frequency counter.

Table 10. Frequency Deviation as a Function of Temperature

CLIENT: Broadcast Sports
MODEL NO: Hub Video Transmitter
DATE: 3/11/2004
JOB #: 7960
BY: Chad Beattie
Limit: .005%

Temperature Degrees C	Frequency MHz	Difference Hz	Deviation (%)
-30	2454.28892	64190	12.27
-20	2454.29262	67890	12.27
-10	2454.29023	65500	12.27
0	2454.28153	56800	12.27
10	2454.27635	51620	12.27
20	2454.25635	31620	12.27
30	2454.25508	30350	12.27
40	2454.23878	14050	12.27
50	2454.22985	5120	12.27

Table 11. Frequency Deviation as a Function of Voltage

Voltage Volts	Frequency MHz	Difference Hz	Deviation (%)	Voltage Volts
At rated	2316.125000	0	0.0	12VDC
At 85%	2316.124100	900	0.000039	10.9VDC
At 115%	2316.124900	100	0.000004	13.8VDC

Transmit turns off below 10.9VDC