FCC Certification Test Report

FCC Certification Test Report

for

Terabeam Wireless, a Division of YDI Wireless, Inc.

Marquee P2P Bridge

FCC ID: NM5-MB-49-HP

Prepared for:

Terabeam Wireless
A Division of YDI Wireless, Inc.
8000 Lee Highway
Falls Church, VA 22042

Prepared By:

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

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for the
Terabeam Wireless, a Division of YDI Wireless, Inc.
Marquee P2P Bridge
Mxx49HEXN

WLL JOB# 8441

Prepared by: _____
Michael Violette
President

Reviewed by: _____
Gregory M. Snyder
Chief EMC Engineer

Abstract

This report has been prepared on behalf of Terabeam Wireless, a Division of YDI Wireless, 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 90 of the FCC Rules and Regulations. This Federal Communication Commission (FCC) Certification Test Report documents the test configuration and test results for a Terabeam Wireless, a Division of YDI Wireless, Inc. Marquee Radio operating at 4.9GHz.

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 Terabeam Wireless, a Division of YDI Wireless, Inc. complies with the limits for a licensed transmitter under Part 90 of the FCC Rules and Regulations.

SPECIAL NOTE

This version, Document 8441-02 updates the previous test report (Document 8441-01) with finalized version of the circuit board and the final channel bandwidth desired for this Certification.

1. This report details a single 20 MHz channel for this device.
2. A discrete filter in the previous version has been replaced with a filter that has been integrated into the radio circuit board.
3. The rest of the radio and its supporting electronics remain unchanged.

In addition, the latest Rulemaking and masks are represented in this Test Report. Notably, FCC 04-265, Released November 12, 2004 contains the requirements for masks “L” and “M” with the M mask required for products with a channel bandwidth power of greater than 20 dBm.

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1 Introduction

1.1 Compliance Statement

The Terabeam Wireless, a Division of YDI Wireless, Inc. Marquee P2P Bridge complies with the limits of Part 90 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:	Terabeam Wireless A Division of YDI Wireless, Inc. 8000 Lee Highway Falls Church, VA 22042
Customer P.O. Number:	P04011590
Quotation Number:	62007
Test Dates:	Testing was performed on February 26 and March 8, 2005.

1.4 Test and Support Personnel

Washington Laboratories, LTD: Mike Violette

1.5 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 Marquee 4.9 Bridge is a wireless network bridge transmitting at 4.965 GHz. Power is supplied via an Ethernet DC injector.

The Marquee 4.9 Bridge uses an OFDM radio card with a digital interface. The system does nothing to change the modulation, duty cycle, or timing of the signal. The system has one input port for DC and Ethernet data, and one output port for an OFDM 4.9 GHz signal to an antenna.

The radio is configured using the Ethernet port of the radio.

The unit is available in the following operational offering.

1) Unit capable of single channel at 4965 MHz with 20 MHz Channel Bandwidth

The 4.9 GHz OFDM radio operates as follows: The radio card consists of a chipset that handles the MAC, the decoding/encoding, and baseband filtering. The companion chip takes the encoded digital data and modulates it using OFDM to 4.9GHz signal. Internal to this chip is also amplification. The same chipset also does the receiving LNA and demodulation.

The radio card is controlled by a digital interface card that allows for Ethernet connectivity for both configuration and monitoring of the link. This device can be configured as a point-to-point or point-to-multipoint system to bridge two Ethernet LANs. The product is professionally installed and is used for outdoor installations only.

The EUT uses the TERABEAM WIRELESS-Fi software which supports VLAN bridging (802.1q protocol).

Following is the section of FCC Part 90 that addresses allowable frequencies. The EUT utilizes a single 20 MHz band by aggregating the four 5 MHz channels 8-11 as allowed in Part 90.1213.

§ 90.1213 Band plan.

The following channel center frequencies are permitted to be aggregated for channel bandwidths of 5, 10, 15 or 20 MHz. Channel numbers 1 through 5 and 15 through 18 are 1 MHz channels and channels numbers 6 through 14 are 5 MHz channels.

Center frequency (MHz)	Channel Nos.
4940.5	1
4941.5	2
4942.5	3
4943.5	4
4944.5	5
4947.5	6
4952.5	7
4957.5	8
4962.5	9
4967.5	10
4972.5	11
4977.5	12
4982.5	13
4985.5	14
4986.5	15
4987.5	16
4988.5	17
4989.5	18

Table 1. Device Summary

ITEM	DESCRIPTION
Manufacturer:	Terabeam Wireless, a Division of YDI Wireless, Inc.
FCC ID Number	NM5-MB-49-HP
EUT Name:	Marquee P2P Bridge
Model:	Mxx49HEXN
FCC Rule Parts:	§90
Frequency Range:	4940-4990 MHz
Modulation:	OFDM
Authorized Bandwidth:	50MHz
Occupied Bandwidth:	22.8 MHz
Keying:	Continuous
Type of Information:	Data
Number of Channels:	One 20 MHz Channel @ 4965 MHz
Average Power Over the Band	10.8 dBm
Peak Power Spectral Density	-1.7 dBm/MHz
Antenna Type	N-Connector
Frequency Tolerance:	<0.01%
Emission Type(s):	OFDM
Interface Cables:	Ethernet/DC input port
Power Source & Voltage:	120VAC/DC Adapter
Emissions Designator 20MHz Channel Configuration	 22M8X1D

2.2 Test Configuration

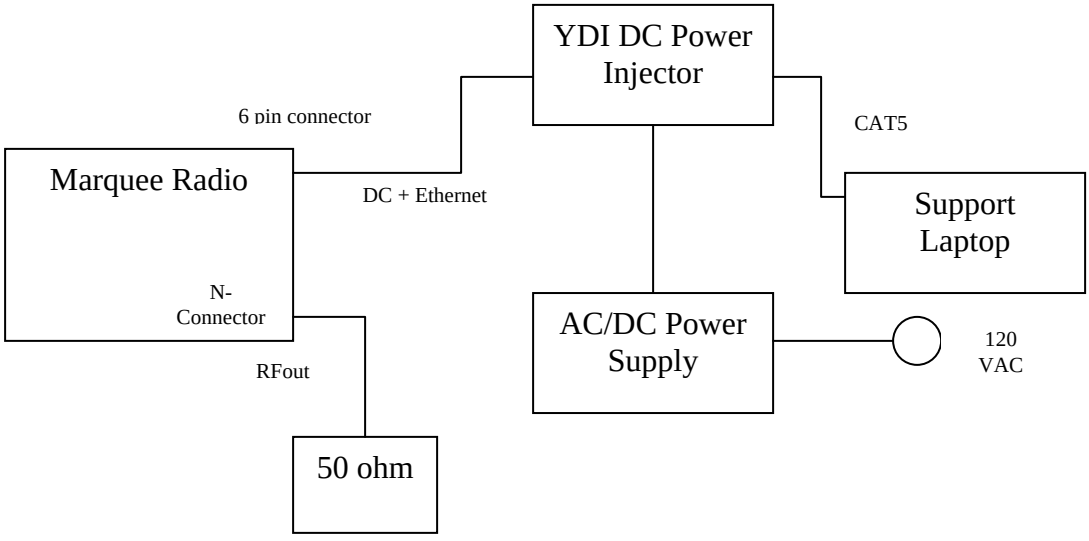

Figure 2-1. EUT Testing Configuration

3 Support Equipment

Item	Model
Computer	Hewlett Packard Onmibook 900 S/N: TW94090069
Ethernet Card	D-Link Model DFE-690TXD Ethenet Card S/N: 004005335BA8
Power Supply	Phihong Model PSA31U-480 AC Adapter
DC Power Injector	TERABEAM WIRELESS "DC Power Injector" (No other identifiers)

3.1 Testing Algorithm

The EUT was configured with "TERABEAM Configurator" software connected via an Ethernet cable that commanded the EUT to modulate at a maximum data rate.

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

3.2 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.

3.3 Measurements

3.3.1 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

3.4 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.

4 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/Asset Number	Calibration Due
HP 8564E Spectrum Analyzer (Radiated and conducted emissions)	67	1/31/2005
DRG-118 Double Ridge Waveguide Antenna	425	4/17/2005
Narda 638 Standard Gain Horn Antenna 18-26.5 GHz	210	10/1/2005
Narda 638 Standard Gain Horn Antenna 26.5-40 GHz	209	10/1/2005
Hewlett-Packard Microwave Preamp: 8449B 1-18 GHz	3008A00729	2/11/2005
A.H. Systems Preamplifier PAM-1840 18GHz-40 GHz	453	1/6/2005
HP 11970U Harmonic Mixer w/SGH-19 Horn 40-60GHz	83	10/1/2005
HP 11970V Harmonic Mixer w/SGH-15 Horn 60-75 GHz	54	10/1/2005
HP 11970W Harmonic Mixer w/SGH-10 Horn 75-110 GHz	53	10/1/2005

5 Test Results

5.1 RF Power Output: (FCC Part §2.1046)

Power measurements are performed using the HP8564E Power Measurement Functions.

5.1.1 Channel Power Measurement

The RF output power was measured over the channel bandwidth using the algorithm provided in the HP 8564E spectrum analyzer. The channel power is measured over the 6dB bandwidth of the device. The 6 dB bandwidth is specified as 16.8 MHz, measured at 16.8 MHz as shown in Figure 5-1.

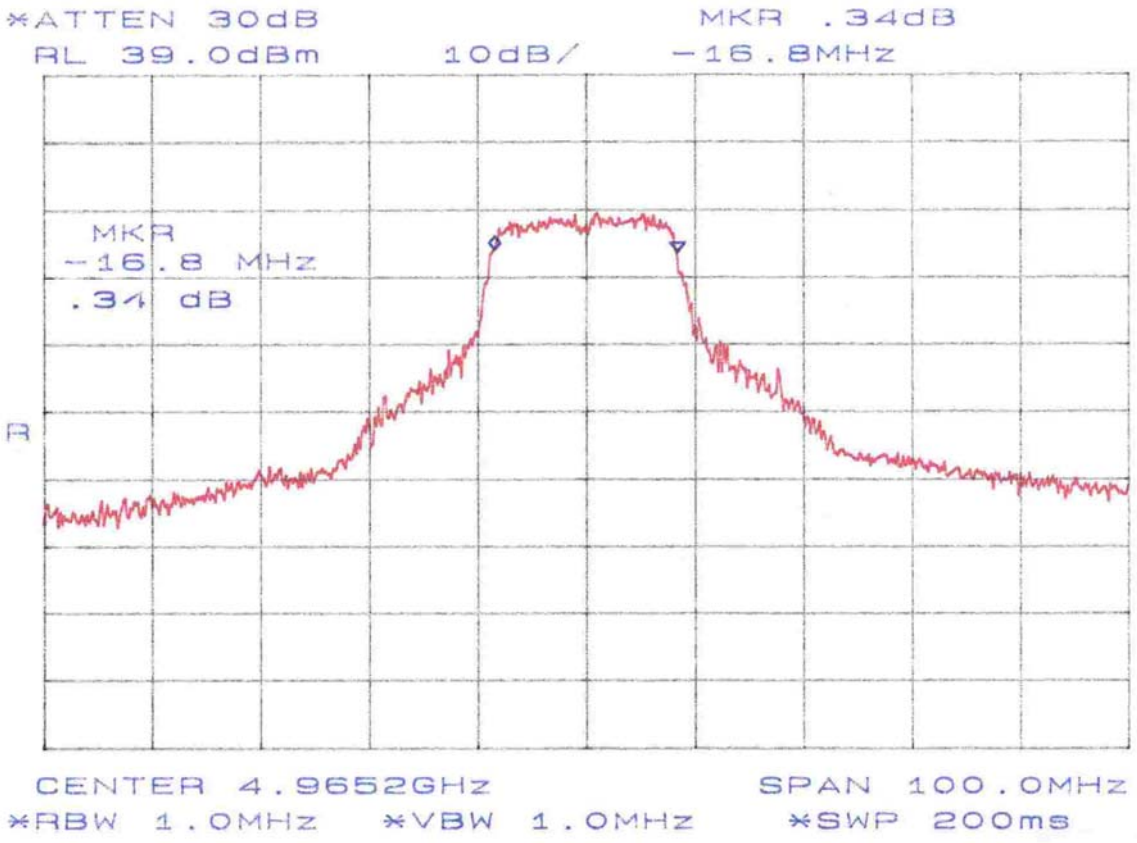

Figure 5-1. 6 dB Bandwidth

From the HP 8564E user's manual, this guidance is provided for making power measurements.

Using Power Measurement Functions

RMS Detection

For most power measurements, it is desireable to respond to signals in an RMS fasion. This means that the power measured is accurately reported, whether the signal contains tones, noise, or other signals. If the spectrum analyzer is not configured for RMS detection (also known as power detection), CW-like signals (tones) will be measured correctly, but noise-like signals (including most digitally-modulated signals) will not be correctly measured.

The power measurement functions compute the RMS of all the applicable measurement cells (display buckets). If the data in these cells is unbiased, RMS detection occurs. To keep the data unbiased requires:

- The detection mode must be SAMPLE. Other modes, such as POSitive PEAK, are biased differently for noise-like signals than for CW-like signals.
- The video bandwidth (VBW) should be at least 10 times the resolution bandwidth (RBW). If it is not, video filtering of a noise-like signal on a logarithmic (dB) display scale biases the measurement.

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The Spectrum Analyzer was configured for SAMPLE detection. The channel power is shown below and is 10.8dBm.

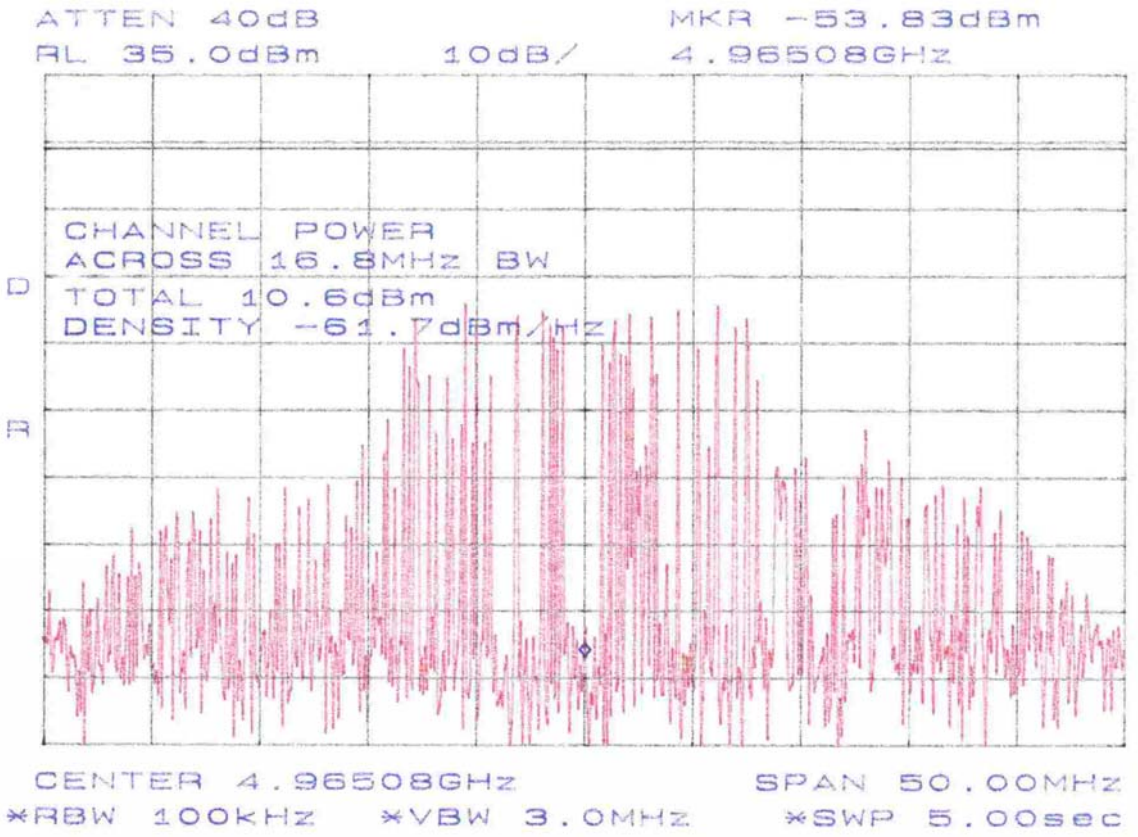

Figure 5-2. Channel Power

The channel power is then used as the zero dB reference for the Mask comparisons as referenced by FCC04-265: "The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz."

Table 3. RF Output Power Results

Frequency MHz	Channel Power	Limit
4965 MHz	10.8 dBm	33dBm

5.1.2 Power Spectral Density Measurements

3. Section 90.1215 is amended to read as follows:

§ 90.1215 Power limits.

The transmitting power of stations operating in the 4940-4990 MHz band must not exceed the maximum limits in this section.

(a) The peak transmit power should not exceed:

Channel Bandwidth (MHz)	Low power peak transmitter power (dBm)	High power peak transmitter power (dBm)
1	7	20
5	14	27
10	17	30
15	18.8	31.8
20	20	33

(a) High power devices are also limited to a peak power spectral density of 21 dBm per one MHz. High power devices using channel bandwidths other than those listed above are permitted; however, they are limited to a peak power spectral density of 21 dBm/MHz. If transmitting antennas of directional gain greater than 9 dBi are used, both the peak transmit power and the peak power spectral density should be reduced by the amount in decibels that the directional gain of the antenna exceeds 9 dBi. However, high power point-to-point or point-to-multipoint operation (both fixed and temporary-fixed rapid deployment) may employ transmitting antennas with directional gain up to 26 dBi without any corresponding reduction in the transmitter power or spectral density. Corresponding reduction in the peak transmit power and peak power spectral density should be the amount in decibels that the directional gain of the antenna exceeds 26 dBi.

Table 4. Peak Power Spectral Density

Frequency MHz	Power Density	Limit
4965 MHz	-1.7 dBm/MHz	30dBm/MHz

5.2 Occupied Bandwidth (FCC Part §2.1049)

Occupied bandwidth was performed by coupling the output of the radio to the input of a spectrum analyzer via an attenuator.

Table 5 provides a summary of the Occupied Bandwidth Results. Maximum authorized bandwidth is 50 MHz.

Table 5. Occupied Bandwidth Results

Frequency MHz	Bandwidth MHz
4965 MHz	22.8 MHz

At full modulation, the occupied bandwidth was measured as shown in Figure 5-3:

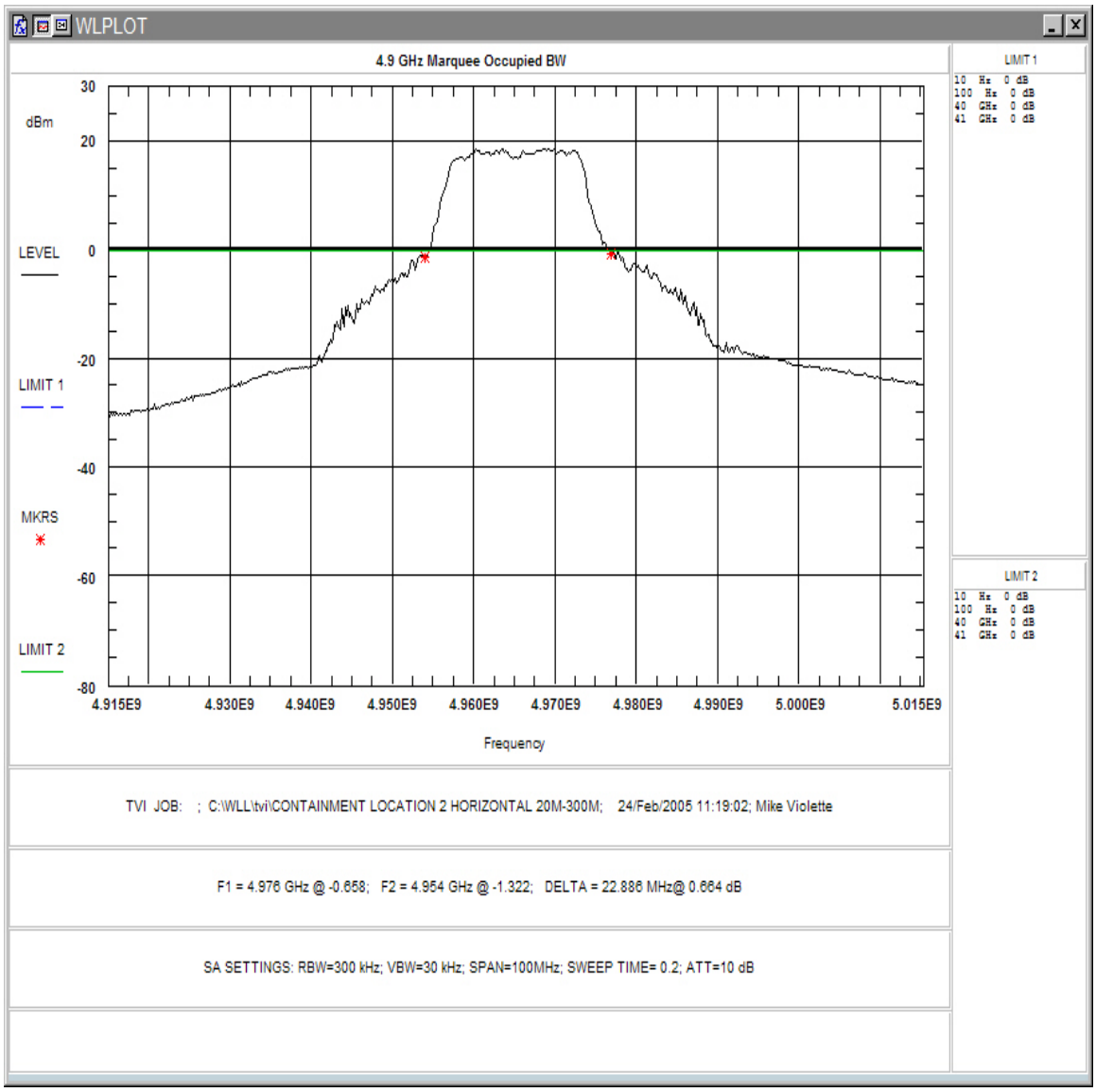

Figure 5-3. Occupied Bandwidth

5.3 Emissions and emission limitations to §90.210

Emissions limitations are specified in §90.210. The output of the transmitter was connected to the input of the spectrum analyzer and the transmitter modulated with data. Conducted emissions from the antenna port were measured from 30 MHz to 40GHz.

The following selection is from FCC 04-265, dated November 12, 2004:

(m) *Emission Mask M.* For high power transmitters (greater that 20 dBm) operating in the 4940-4990 MHz frequency band, the power spectral density of the emissions must be attenuated below the output power of the transmitter as follows:

(1) On any frequency removed from the assigned frequency between 0 - 45 % of the authorized bandwidth (BW): 0 dB.

(2) On any frequency removed from the assigned frequency between 45 – 50 % of the authorized bandwidth: 568 log (% of (BW) / 45) dB.

(3) On any frequency removed from the assigned frequency between 50 - 55 % of the authorized bandwidth: 26 + 145 log (% of BW / 50) dB.

(4) On any frequency removed from the assigned frequency between 55 – 100 % of the authorized bandwidth: 32 + 31 log (% of (BW) / 55) dB.

(5) On any frequency removed from the assigned frequency between 100 – 150 % of the authorized bandwidth: 40 + 57 log (% of (BW) / 100) dB.

(6) On any frequency removed from the assigned frequency between above 150 % of the authorized bandwidth: 50 dB or 55 + 10 log (P) dB, whichever is the lesser attenuation.

(7) The zero dB reference is measured relative to the highest average power of the fundamental emission measured across the designated channel bandwidth using a resolution bandwidth of at least one percent of the occupied bandwidth of the fundamental emission and a video bandwidth of 30 kHz. The power spectral density is the power measured within the resolution bandwidth of the measurement device divided by the resolution bandwidth of the measurement device. Emission levels are also based on the use of measurement instrumentation employing a resolution bandwidth of at least one percent of the occupied bandwidth.

(Note: Low power devices may as an option, comply with paragraph (m).)

Data are supplied in the following figures.

5.3.1 Spurious Emissions

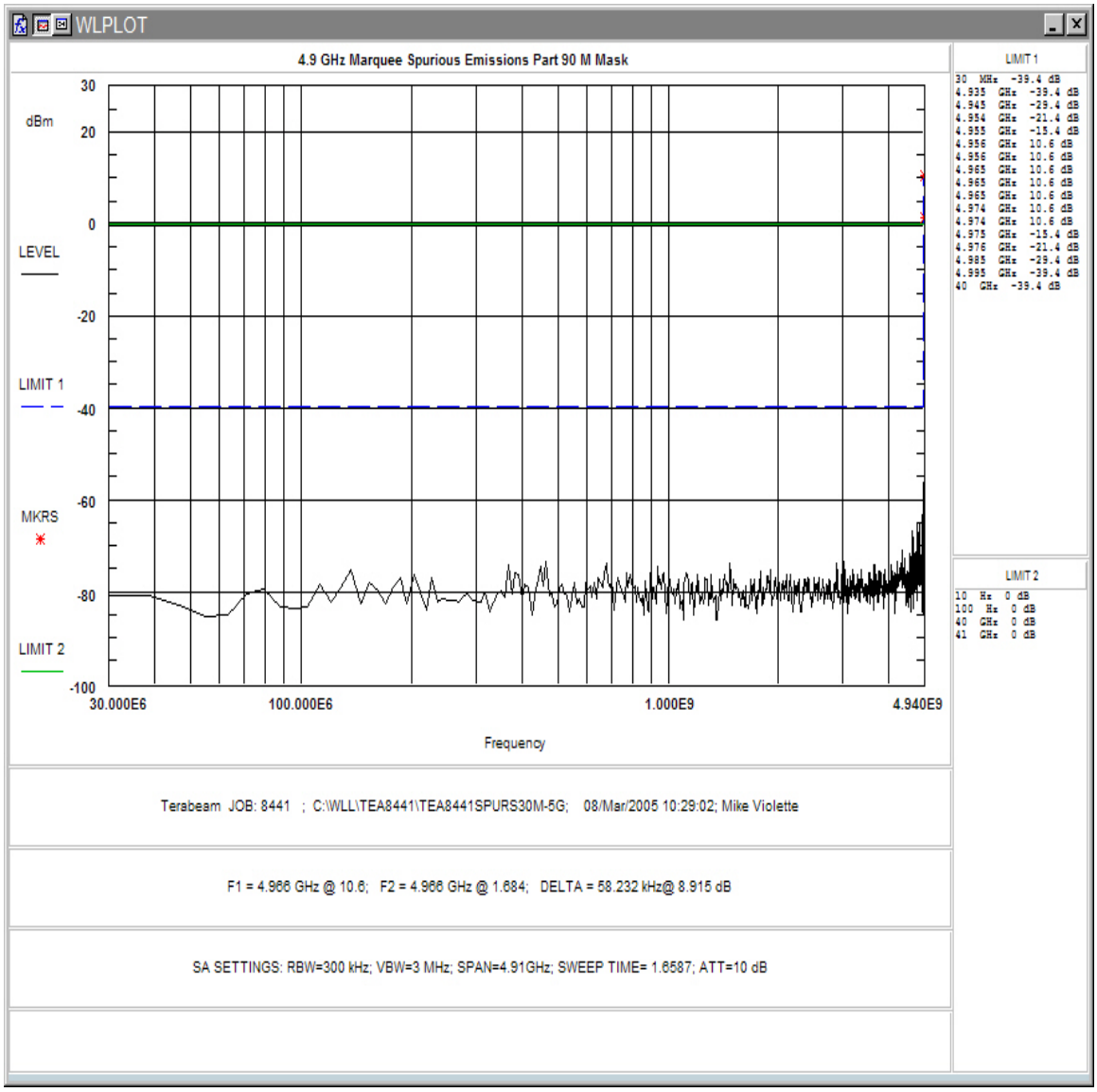

Figure 5-4. Spurious Emissions, 30M – 5GHz

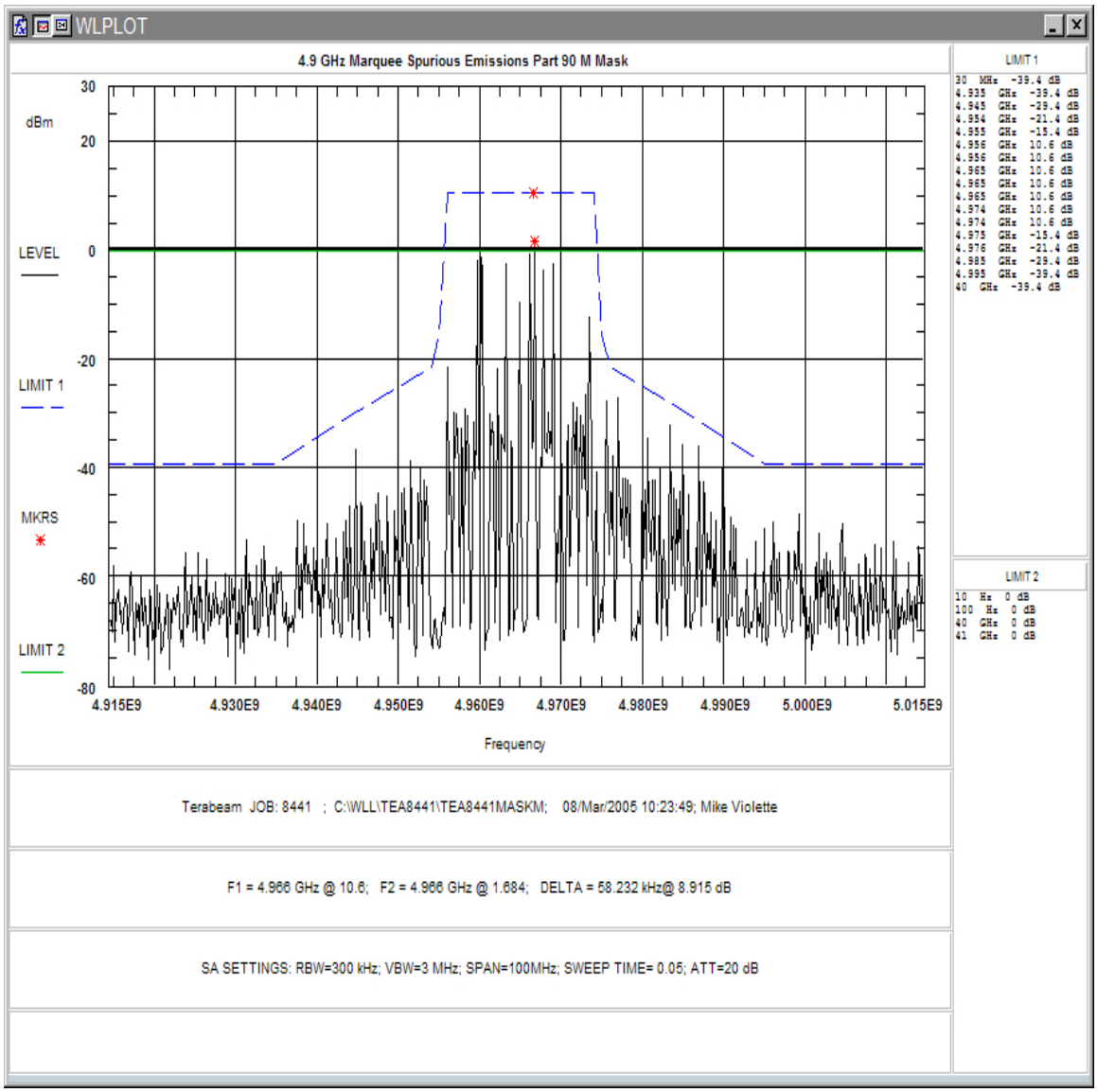

Figure 5-5. Spurious Emissions: Mask M at Fundamental

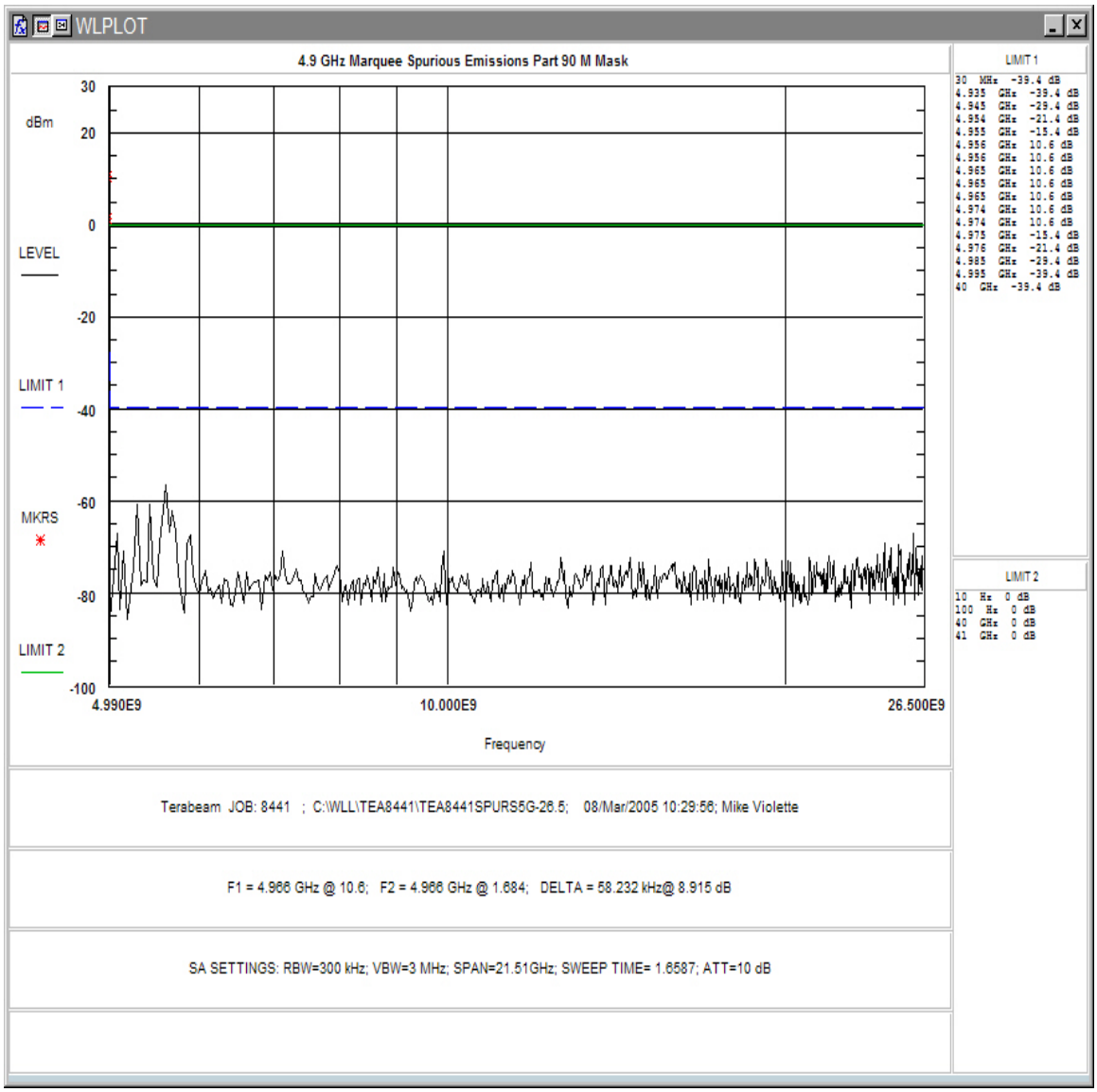

Figure 5-6. Spurious Emissions. 5GHz-26.5GHz

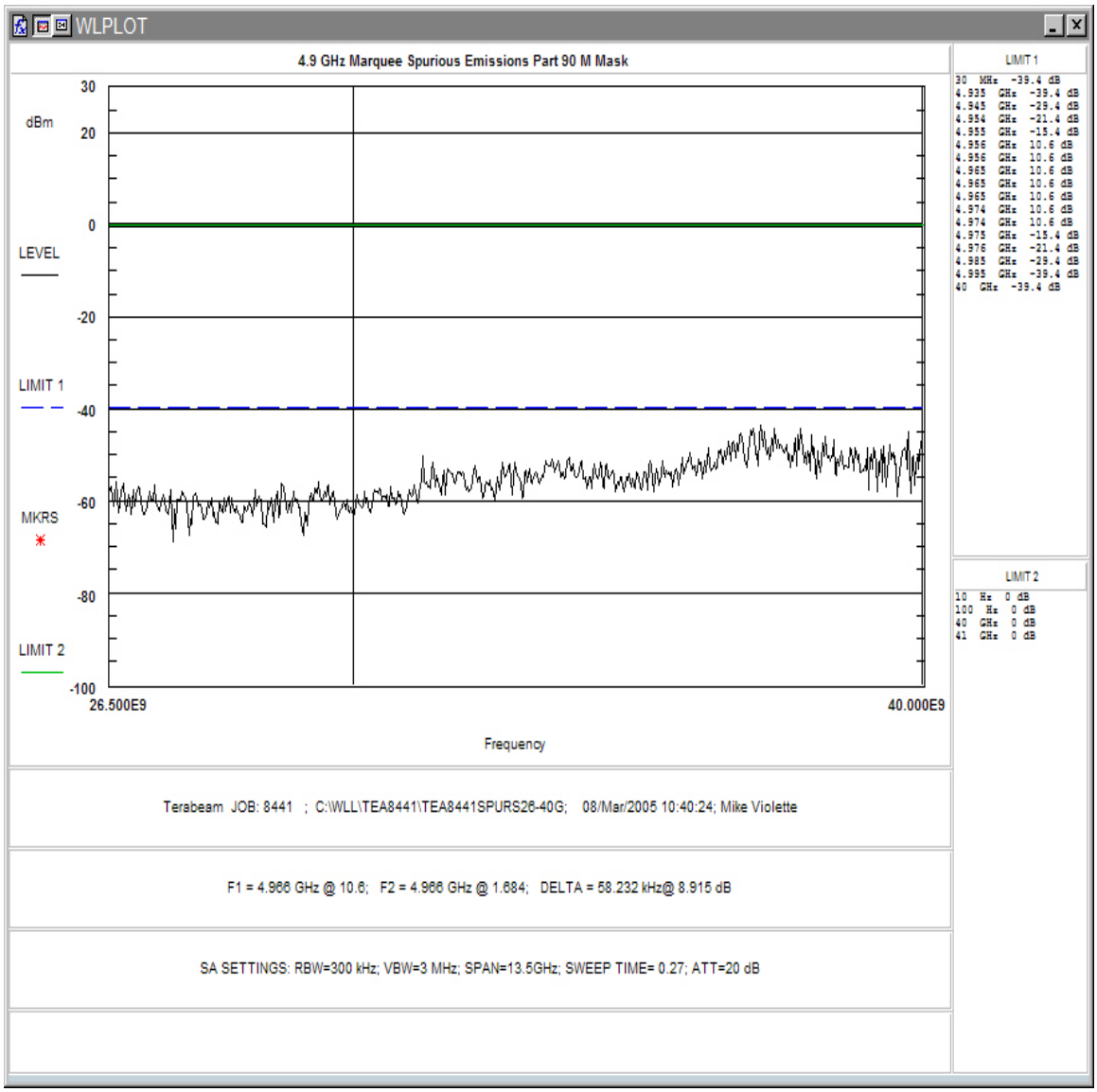

Figure 5-7. Spurious Emissions. 26.5GHz-40GHz

5.4 Radiated Spurious Emissions: (FCC Part §2.1053)

he EUT must comply with requirements for radiated spurious emissions. The limits are based on the emissions mask of §90.210(l) and are as shown in the following table.

5.4.1 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.

Where emissions were detected, the EIRP levels were determined using the method of signal substitution.

The frequency range of 30 MHz to 40 GHz was measured. All emissions detected are recorded in Table 5.

Table 7 provides levels measured during a re-scan of the device after integration of the filter into the unit. The levels are at or below the spurious transmitter fundamental harmonics previously measured. The filter improved or did not worsen the levels of spurious emissions.

Table 6: Spurious Radiated Emissions, EIRP Levels

CLIENT:	TERABEAM WIRELESS	DATE:	November 18, 2004
TESTER:	James Ritter	JOB #:	8441
EUT Information:		**Test Requirements:**	
EUT:	Marquee Bridge 4.9 GHz	TEST STANDARD:	FCC 90
CONFIGURATION:	In full speed mode	DISTANCE:	3m
S/N:	N/A		

ORIGINAL DATA BEFORE INTEGRATION OF FILTER TO TX BOARD

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Height (m)	SA Level (dBµV)	Ant. Gain dBi	Sig. Gen. Level dBm	EIRP Level dBm	Limit (dBm)	Margin dB
109.98	H	270.0	3.0	4.7	-3.6	-72.0	-75.6	-37.7	-37.9
319.99	H	90.0	1.4	5.2	6.7	-77.7	-71.0	-37.7	-33.3
330.21	H	90.0	1.2	8.0	6.9	-74.5	-67.6	-37.7	-29.9
1162.00	H	180.0	1.0	48.6	5.3	-64.1	-58.8	-37.7	-21.1
1200.00	H	45.0	1.0	42.6	5.6	-67.5	-61.9	-37.7	-24.2
1558.33	H	180.0	1.0	40.5	6.4	-78.3	-71.9	-37.7	-34.2
1726.50	H	90.0	1.0	50.5	6.9	-65.6	-58.7	-37.7	-21.0
4953.92	H	100.0	1.0	80.2	10.5	-26.2	-15.7	15.3	-31.0
9907.84	H	0.0	1.0	37.5	10.2	-58.7	-48.5	-37.7	-10.8
14861.76	H	0.0	1.0	33.2	12.0	-57.9	-45.9	-37.7	-8.2
109.98	V	0.0	1.0	8.5	-3.6	-70.0	-73.6	-37.7	-35.9
319.99	V	45.0	2.0	3.5	6.7	-78.1	-71.4	-37.7	-33.7
330.21	V	0.0	2.5	5.0	6.9	-76.4	-69.5	-37.7	-31.8
1162.000	V	190.0	1.0	37.2	5.3	-79.1	-73.8	-37.7	-36.1
1200.000	V	200.0	1.0	39.2	5.6	-77.5	-71.9	-37.7	-34.2
1558.33	V	90.0	1.0	36.2	6.4	-76.3	-69.9	-37.7	-32.2
1726.50	V	180.0	1.0	43.2	6.9	-68.5	-61.6	-37.7	-23.9
4953.92	V	45.0	1.0	82.3	10.5	-25.2	-14.7	15.3	-30.0
9907.84	V	180.0	1.0	40.2	10.2	-55.2	-45.0	-37.7	-7.3
14861.76	V	0.0	1.0	33.2	12.0	-55.9	-43.9	-37.7	-6.2

No emissions were detected above 14.861GHz.

Table 7: Spurious Radiated Emissions, EIRP Levels

CLIENT:	TERABEAM WIRELESS	DATE:	March 9, 2005
TESTER:	Mike Violette	JOB #:	8441
EUT Information:		**Test Requirements:**	
EUT:	Marquee Bridge 4.9 GHz	TEST STANDARD:	FCC 90
CONFIGURATION:	In full speed mode	DISTANCE:	3m
S/N:	N/A		

FINAL DATA AFTER INTEGRATION OF FILTER TO TX BOARD

Frequency (MHz)	Polarity H/V	Azimuth Degree	Ant. Height (m)	ORIGINAL SA Level (dBµV)	AFTER FILTER SA Level (dBuV)
4965.0	H	100.0	1.0	80.2	52.1
9930.1	H	0.0	1.0	37.5	30.3a
14895.2	H	0.0	1.0	33.2	32.0a
4965.0	V	45.0	1.0	82.3	78.0
9930.1	V	180.0	1.0	40.2	30.5a
14895.2	V	0.0	1.0	33.2	30a

a=Ambient Levels

No emissions were detected above 14.861GHz.

5.5 Emission Designator

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

For the subject unit, the following Emission Designator has been determined according to Section 2.201 of the FCC Rules.

- First Symbol, type of modulation of the main carrier: X-Other Modulation
- Second Symbol, nature of signal(s) modulating the main carrier: 1
- Third Symbol, type of information to be transmitted: D-Digital

The necessary bandwidth, Bn, is taken to be the occupied bandwidth of the signal: 22.8MHz

Hence, the emission designator for the 20MHz (4965MHz channel) is: **22M8X1D**

5.6 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 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.

The EUT is powered by 120VAC adapter providing 24VDC via an Ethernet injector.

Table 8. Frequency Deviation

CLIENT: TERABEAM WIRELESS
MODEL NO: Mxx49HEXN
DATE: November 18, 2004
JOB #: 8441
BY: James Ritter
Limit: Specified by station authorization

Center Of Channel

Temperature Degrees C	Frequency MHz	Difference Hz	Deviation (%)
Ambient	4965.000000	0.0	0
-30	4965.000000	0.0	0.000000
-20	4965.010000	10000.0	0.000201
-10	4964.980000	-20000.0	0.000403
0	4965.000000	0.0	0.000000
10	4964.990000	-10000.0	0.000201
20	4965.000000	0.0	0.000000
30	4964.930000	-70000.0	0.001410
40	4964.850000	-150000.0	0.003021
50	4964.900000	-100000.0	0.002014

Upper Edge

Temperature Degrees C	Frequency MHz	Difference Hz	Deviation (%)
Ambient	4973.320000	0.0	0
-30	4973.320000	0.0	0.000000
-20	4973.330000	10000.0	0.000201
-10	4973.300000	-20000.0	0.000402
0	4973.320000	0.0	0.000000
10	4973.310000	-10000.0	0.000201
20	4973.320000	0.0	0.000000
30	4973.250000	-70000.0	0.001408
40	4973.170000	-150000.0	0.003016
50	4973.220000	-100000.0	0.002011

Frequency variation as function of voltage

Voltage Volts	Frequency MHz	Difference Hz	Deviation (%)	Voltage Volts
At rated	4965.000000	0	0.0	120 VAC
At 85%	4965.007000	-7000	0.000141	102VAC
At 115%	4965.002000	-2000	0.000040	138VAC

Notes: Measured in Peak mode