FCC CFR47 PART 15 SUBPART C CERTIFICATION

CLASS II PERMISSIVE CHANGE TEST REPORT

FOR

MICROWAVE LINK, HIGH & LOW BAND

MODEL NUMBER: GE60

FCC ID: RWM-GE60

REPORT NUMBER: 05U3500-1 Revision B

ISSUE DATE: JUNE 29, 2005

Prepared for
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Revision History

Rev.	Revisions	Revised By
A	Initial Issue	MH
B	Corrected table error in PDF conversion, and typo in RF Exposure Calculation	MH

TABLE OF CONTENTS

1. ATTESTATION OF TEST RESULTS

COMPANY NAME: BRIDGEWAVE COMMUNICATIONS
3350 THOMAS ROAD
SANTA CLARA, CA 95054

EUT DESCRIPTION: MICROWAVE LINK , HIGH & LOW BAND

MODEL: GE60

DATE TESTED: JUNE 13, 2005

APPLICABLE STANDARDS	
STANDARD	**TEST RESULTS**
FCC PART 15 SUBPART C	NO NON-COMPLIANCE NOTED

Compliance Certification Services, Inc. tested the above equipment in accordance with the requirements set forth in the above standards. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: This document reports conditions under which testing was conducted and results of tests performed. This document may not be altered or revised in any way unless done so by Compliance Certification Services and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by Compliance Certification Services will constitute fraud and shall nullify the document.

Approved & Released For CCS By:

MIKE HECKROTTE
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COMPLIANCE CERTIFICATION SERVICES

Tested By:

T.N. COKENIAS
DIRECTOR OF ENGINEERING
COMPLIANCE CERTIFICATION SERVICES

2. TEST METHODOLOGY

The tests documented in this report were performed in accordance with ANSI C63.4-2003, FCC CFR 47 Part 2 and FCC CFR 47 Part 15.

3. FACILITIES AND ACCREDITATION

The test sites and measurement facilities used to collect data are located at 561F Monterey Road, Morgan Hill, California, USA. The sites are constructed in conformance with the requirements of ANSI C63.4, ANSI C63.7 and CISPR Publication 22. All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

CCS is accredited by NVLAP, Laboratory Code 200065-0. The full scope of accreditation can be viewed at http://www.ccsemc.com.

4. CALIBRATION AND UNCERTAINTY

4.1. MEASURING INSTRUMENT CALIBRATION

The measuring equipment utilized to perform the tests documented in this report has been calibrated in accordance with the manufacturer's recommendations, and is traceable to recognized national standards.

4.2. MEASUREMENT UNCERTAINTY

Where relevant, the following measurement uncertainty levels have been estimated for tests performed on the apparatus:

PARAMETER	UNCERTAINTY
Radiated Emission, 30 to 200 MHz	+/- 3.3 dB
Radiated Emission, 200 to 1000 MHz	+4.5 / -2.9 dB
Radiated Emission, 1000 to 2000 MHz	+4.5 / -2.9 dB
Power Line Conducted Emission	+/- 2.9 dB

Uncertainty figures are valid to a confidence level of 95%.

5. EQUIPMENT UNDER TEST

5.1. DESCRIPTION OF EUT

The EUT is a 60 GHz transceiver operating under section 15.255 of the Rules.

5.2. DESCRIPTION OF CLASS II PERMISSIVE CHANGE

The radio is equipped with an Integral Directional Cassegrain Antenna with a gain of 46 dBi.

5.3. DESCRIPTION OF TEST SETUP

SUPPORT EQUIPMENT

PERIPHERAL SUPPORT EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Serial Number**	**FCC ID**
AC ADAPTER	CINCO ELECTRONICS CO.,LTD	TR70A24-01A03	70240-0048908	N/A

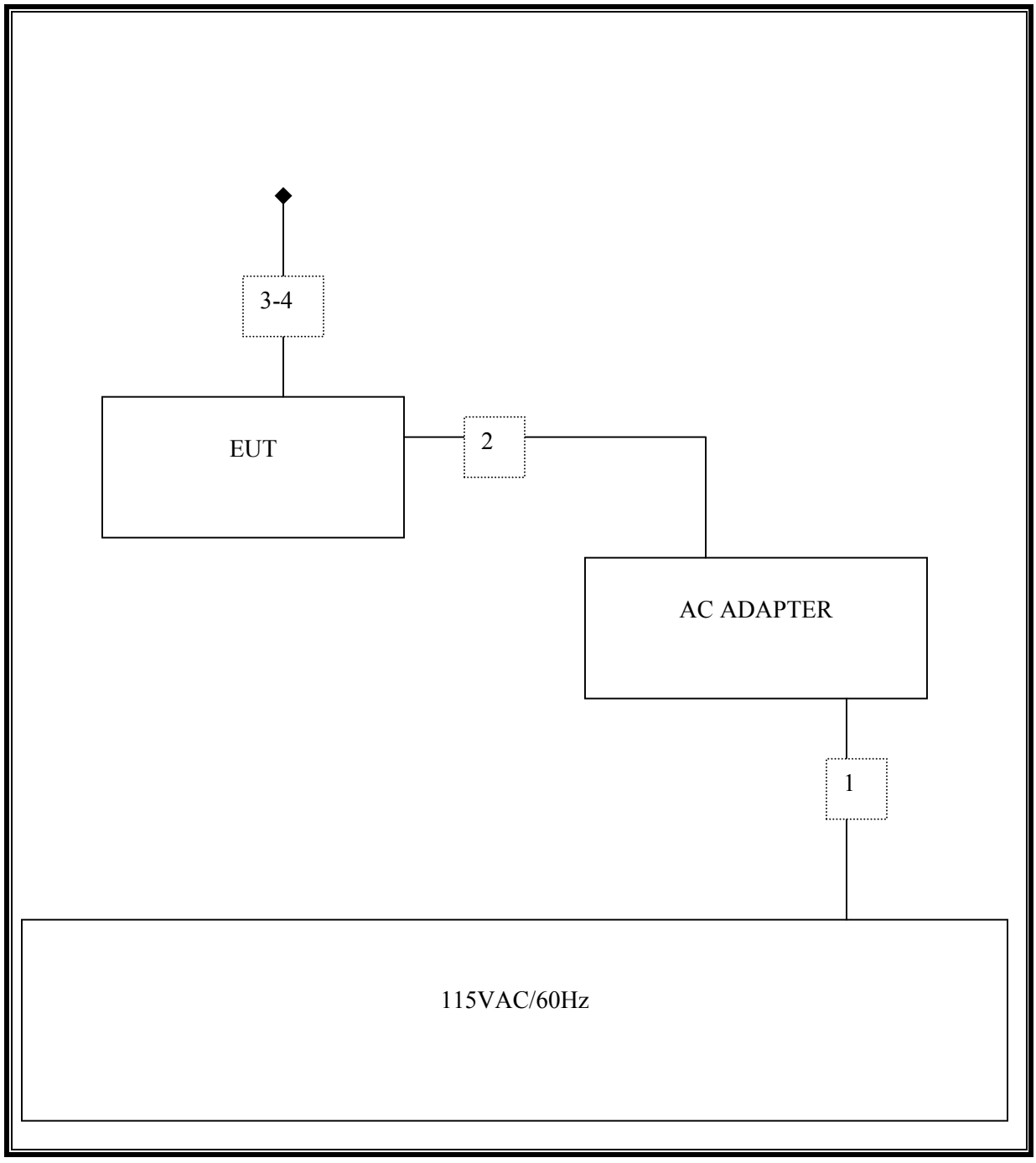
I/O CABLES

I/O CABLE LIST						
Cable No.	**Port**	**# of Identical Ports**	**Connector Type**	**Cable Type**	**Cable Length**	**Remarks**
1	AC PWR	1	AC PWR	UNSHIELDED	1.86M	US (3 PRONG)
2	DC PWR	1	TERMINAL	UNSHIELDED	1.86M	N/A
3&4	FIBEROPTIC	2	FIBEROPTIC	UNSHIELDED	15M	UNTERMINATED

TEST SETUP

During the testing process the EUT was in continuous transmit mode.

SETUP DIAGRAM FOR TESTS



6. TEST AND MEASUREMENT EQUIPMENT

The following test and measurement equipment was utilized for the tests documented in this report:

TEST EQUIPMENT LIST				
Description	**Manufacturer**	**Model**	**Serial Number**	**Cal Due**
Spectrum Analyzer, 40 GHz	HP	8564E	3943A01643	3/16/2006
Harmonic Mixer, 75 ~ 110 GHz	HP	11970W	2521A01314	10/25/2005
Harmonic Mixer, 50 ~ 75 GHz	HP	11970V	2521A01163	10/22/2005
Harmonic Mixer, 26.5 ~ 40 GHz	HP	11970A	3008A04190	10/14/2005
Harmonic Mixer, 33 ~ 50 GHz	HP	11970Q	3003A03363	10/18/2005
Harmonic Mixer, 90 ~ 140 GHz	OML	M08HWA	F90519-2	CNR
Harmonic Mixer, 140 ~ 220 GHz	OML	M05HWA	G90519-1	CNR
Mixer Diplexer for HP	OML	DPL.313B	0	CNR
Power Meter	Agilent	E4419B	GB40202203	CNR
Power Sensor	Agilent	V8486A	170891	CNR

7. APPLICABLE LIMITS AND TEST RESULTS

7.1. MEASUREMENT FUNDAMENTALS

TEST PROCEDURE

The EUT was placed on a non-conductive table, measurements were made at the far field boundary. The far field distance was determined from calculations described below.

The EUT antenna and measurement antennas were brought into alignment. The measurement antenna/mixer assembly was hand held and was very slowly moved with small horizontal and vertical motions to capture the maximum signal level from the EUT.

NEAR FIELD BOUNDARY CALCULATIONS

For the high-gain antenna used with the EUT, the 3m distance is within the antenna's near field or Fresnel region. This is confirmed from the equation for near-field boundary given in OET 65 (p. 27):

(12) R(near field) = (D^2) / (4 * λ)

where
D = Largest Antenna Dimension, including the reflector, in meters
λ = wavelength in meters

For a parabolic reflector antenna with D = 0.6096 m and λ = 300 / f (MHz) equation (12) predicts a near-field boundary of

R (near field) = 17.992 m at 58.1 GHz, and 19.479 m at 62.9 GHz.

FAR FIELD BOUNDARY CALCULATIONS

The far-field boundary is given in OET 65 (page 29) as:

(16) R(far field) = (0.6 * D^2) / λ

where
D = Largest Antenna Dimension, including the reflector, in meters
λ = wavelength in meters

For a parabolic reflector antenna with D = 0.275 m and λ = 300 / f (MHz) equation (16) predicts a far-field boundary of

R (far field) = 43.181 m at 58.1 GHz, and 46.749 m at 62.9 GHz.

POWER DENSITY AS A FUNCTION OF DISTANCE FROM ANTENNA

The equations are given in OET 65 pages 27 – 29 as follows:

(5) at the surface of the antenna with aperture area A:
S(surface) = 4P/A

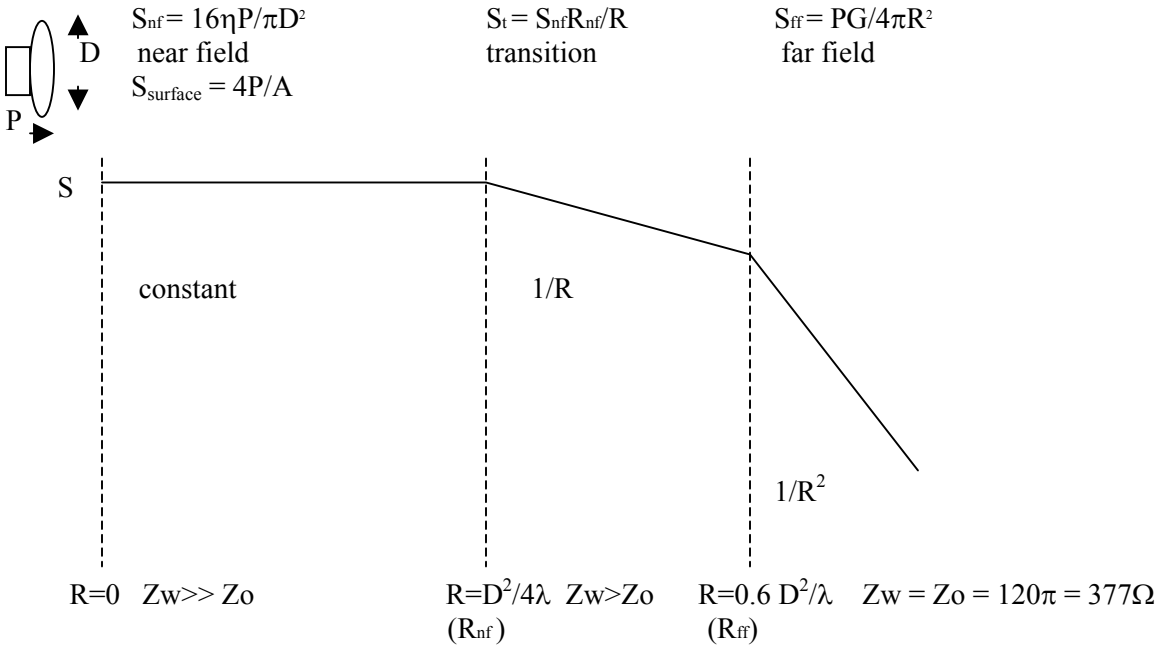
(6) in the near field, with antenna maximum dimension D:
S(near field) = 16ηP/πD^2
where η = aperture efficiency

(7) in the transition region R (near field) < R < R (far field) at distance R:
S(transition) = (S(near field) * R(near field)) / R

(8) in the far field or Fraunhofer region:
S(far field) = PG/4πR^2
where G = transmitter antenna gain

The equations (5) – (8) indicate that the variation of power density with distance R from the Cassegrain antenna is:

a) constant from the antenna surface to the near-field boundary R_{nf};
b) decreases as 1/R in the transition region $R_{nf} < R < R_{ff}$;
c) decreases as $1/R^2$ in the far field, for $R > R_{ff}$.



When the near field boundary is greater than 3m, as it is for this EUT, the power density can be calculated from far field measurements according to the following relationship:

S(at 3m) = S(at measurement distance) + 20log(R/R(far field)) + 10log (R(far field) / R(near field))

where S = Power Density in $dBuW/cm^2$
R = measurement distance in far field
R(far field) = from equation (16) and
R(near field) = from equation (12) above

Correction Factor from far field boundary to near field region = 10 * log (R(far field) / R(near field))

Correction Factor from far field boundary to near field region (the near field region includes 3 meters) = 3.8 dB at 58.1 GHz and 62.9 GHz.

POWER DENSITY AND FIELD STRENGTH RELATIONSHIP

From OET 40, the relationship between field strength, power at the spectrum analyzer input, and test antenna gain is given by

$E = (2\pi/\lambda)* (120Prx/Grx)^{1/2}$

where

Prx = power at receiver input, watts
Grx = antenna gain with impedance matching receiver, numeric

λ = wavelength, meters

Power density in the far field is related to field strength:

S = (E^2) / 120 π = (E^2) / 377
where
S is the Power Density in W/m^2
and
E is the Field Strength in V/m

POWER DENSITY LIMITS EXPRESSED AS FIELD STRENGTH

Rearranging terms from above,

E = Sqrt (377 * S)

where E is the field strength in V/m and S is the power density in W/m^2

For S = 18 uW/cm^2,
S = 0.18 W/m^2 and E = 8.24 V/m or 138 dBuV/m

For S = 9 uW/cm^2,
S = 0.09 W/m^2 and E = 5.82 V/m or 135 dBuV/m

For S = 90 pW/cm^2,
S = 9 * 10 ^ (-11) W/m^2 and E = 0.000184 V/m or 45.3 dBuV/m

7.2. POWER DENSITY

LIMIT

§15.255 (b) Within the 57-64 GHz band, emission levels shall not exceed the following:
(1) For products other than fixed field disturbance sensors, the average power density of any emission, measured during the transmit interval, shall not exceed 9 uW/cm^2, as measured 3 meters from the radiating structure, and the peak power density of any emission shall not exceed 18 uW/cm^2, as measured 3 meters from the radiating structure.

(4) Peak power density shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-64 GHz band and has a video bandwidth of at least 10 MHz, or using an equivalent measurement method.

(5) The average emission limits shall be calculated, based on the measured peak levels, over the actual time period during which transmission occurs.

TEST PROCEDURE

Refer to the Measurement Fundamentals section of this report for the derivation of equations and calculations.

The power meter mount and corresponding horn antenna are set up in the far field to measure the radiated output of the transmitter. The frequency range of each device is 50 to 75 GHz, which encompasses the authorized band of 57 to 64 GHz. No video filtering is used.

The measured power level at the far field distance is converted to field strength using:

Power (dBuV) = Power (dBm) + 107
and
Field strength = Power (dBuV) + Antenna Factor (dB/m).

For the measurement distance of 50 m, the correction factor for extrapolation of this data to the field strength at 3 meters using the equations derived in the Measurement Fundamentals section of this report is 3.8 + 20 log (50 / 43.181) = 5.07 dB at 58.1 GHz
and 3.8 + 20 log (50 / 46.749) = 4.38 dB at 62.9 GHz.

The 3 meter field strength is then compared to the field strength corresponding to the 3 meter power density limit.

Result

No non-compliance noted:

Freqeuncy (GHz)	Measured Power (dBm)	Antenna Factor (dB/m)	Far Field Strength (dBuV/m)	3 m Field Strength (dBuV/m)	3 m Average F.S. Limit (dBuV/m)	Margin (dB)
58.1	-23.7	45.50	128.8	133.9	135	-1.1
62.9	-23.5	46.20	129.7	134.1	135	-0.9

For reference, the measured field strength is also converted to power density for direct comparison to the power density limit:

Freqeuncy (GHz)	3 m Field Strength (dBuV/m)	Peak Power Density (uW/cm^2)	Power Density Peak Limit (uW/cm^2)	Power Density Avg Limit (uW/cm^2)
58.1	133.9	6.5	18.0	9.0
62.9	134.1	6.8	18.0	9.0

The Peak Power Density is less than both the Peak and Average Power Density limits.

7.3. PEAK POWER

LIMIT

15.255(e) Except as specified below, the total peak transmit output power shall not exceed 500 mW.

(2) Peak transmit output power shall be measured with an RF detector that has a detection bandwidth that encompasses the 57-64 GHz band and has a video bandwidth of at least 10 MHz, or using an equivalent measurement method.

(3) For the purpose of demonstrating compliance with this paragraph, corrections to the transmitter output power may be made due to the antenna and circuit loss.

PROCEDURE

The 3 meter field strengths from the peak power density measurements are converted to EIRP and peak output power using the following formulas:

EIRP (dBm) = field strength (dBuV) – 95.2

Output Power (dBm) = EIRP - Antenna Gain (dBi)

RESULT

No non-compliance noted:

Freqeuncy (GHz)	3 m Field Strength (dBuV/m)	Measured EIRP (dBm)	Antenna Gain (dBi)	Output Power (dBm)	Output Power (mW)	Power Limit (mW)
58.1	133.9	38.7	46.00	-7.3	0.186	500.0
62.9	134.1	38.9	46.00	-7.1	0.195	500.0

7.4. RF EXPOSURE

LIMITS

§1.1310 The criteria listed in Table 1 shall be used to evaluate the environmental impact of human exposure to radio-frequency (RF) radiation as specified in §1.1307(b), except in the case of portable devices which shall be evaluated according to the provisions of §2.1093 of this chapter.

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposures				
0.3–3.0	614	1.63	*(100)	6
3.0–30	1842/f	4.89/f	*($900/f^2$)	6
30–300	61.4	0.163	1.0	6
300–1500			f/300	6
1500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*(100)	30
1.34–30	824/f	2.19/f	*($180/f^2$)	30

TABLE 1—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)—Continued

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
30–300	27.5	0.073	0.2	30
300–1500			f/1500	30
1500–100,000			1.0	30

f = frequency in MHz
* = Plane-wave equivalent power density
NOTE 1 TO TABLE 1: Occupational/controlled limits apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. Limits for occupational/controlled exposure also apply in situations when an individual is transient through a location where occupational/controlled limits apply provided he or she is made aware of the potential for exposure.
NOTE 2 TO TABLE 1: General population/uncontrolled exposures apply in situations in which the general public may be exposed, or in which persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or can not exercise control over their exposure.

CALCULATIONS

From §1.1310 Table 1 (B), S = 1.0 mW/cm^2

The maximum allowed exposure for uncontrolled exposure is 1 mW/cm^2.

RESULTS

No non-compliance noted:

Maximum power density at 3m is 6.8 uW/cm2 at 62.9 GHz.

S = 6.8 uW/cm^2 = 0.0068 mW/cm^2

This is constant from the antenna surface to the near field boundary (18 m at 58.1 GHz, and 19.5 m at 62.9 GHz.)

NOTE: For mobile or fixed location transmitters, the minimum separation distance is 20 cm, even if calculations indicate that the MPE distance would be less.

7.5. FIELD STRENGTH

7.5.1. APPLICABLE RULES

§15.255 Operation within the band 57-64 GHz.

(c) Limits on spurious emissions:
(1) The power density of any emissions outside the 57-64 GHz band shall consist solely of spurious emissions.
(2) Radiated emissions below 40 GHz shall not exceed the general limits in Section 15.209 of this part.
(3) Between 40 GHz and 200 GHz, the level of these emissions shall not exceed 90 pW/cm2 at a distance of 3 meters.
(4) The levels of the spurious emissions shall not exceed the level of the fundamental emission.

§15.205 (a) Except as shown in paragraph (d) of this section, only spurious emissions are permitted in any of the frequency bands listed below:

MHz	MHz	MHz	GHz
0.090 - 0.110	16.42 - 16.423	399.9 - 410	4.5 - 5.15
[1]0.495 - 0.505	16.69475 - 16.69525	608 - 614	5.35 - 5.46
2.1735 - 2.1905	16.80425 - 16.80475	960 - 1240	7.25 - 7.75
4.125 - 4.128	25.5 - 25.67	1300 - 1427	8.025 - 8.5
4.17725 - 4.17775	37.5 - 38.25	1435 - 1626.5	9.0 - 9.2
4.20725 - 4.20775	73 - 74.6	1645.5 - 1646.5	9.3 - 9.5
6.215 - 6.218	74.8 - 75.2	1660 - 1710	10.6 - 12.7
6.26775 - 6.26825	108 - 121.94	1718.8 - 1722.2	13.25 - 13.4
6.31175 - 6.31225	123 - 138	2200 - 2300	14.47 - 14.5
8.291 - 8.294	149.9 - 150.05	2310 - 2390	15.35 - 16.2
8.362 - 8.366	156.52475 - 156.52525	2483.5 - 2500	17.7 - 21.4
8.37625 - 8.38675	156.7 - 156.9	2655 - 2900	22.01 - 23.12
8.41425 - 8.41475	162.0125 - 167.17	3260 - 3267	23.6 - 24.0
12.29 - 12.293	167.72 - 173.2	3332 - 3339	31.2 - 31.8
12.51975 - 12.52025	240 - 285	3345.8 - 3358	36.43 - 36.5
12.57675 - 12.57725	322 - 335.4	3600 - 4400	([2])
13.36 - 13.41			

[1] Until February 1, 1999, this restricted band shall be 0.490-0.510 MHz.
[2] Above 38.6

§15.205 (b) Except as provided in paragraphs (d) and (e), the field strength of emissions appearing within these frequency bands shall not exceed the limits shown in Section 15.209. At frequencies equal to or less than 1000 MHz, compliance with the limits in Section 15.209 shall be demonstrated using measurement instrumentation employing a CISPR quasi-peak detector. Above 1000 MHz, compliance with the emission limits in Section 15.209 shall be demonstrated based on the average value of the measured emissions. The provisions in Section 15.35 apply to these measurements.

§15.209 (a) Except as provided elsewhere in this Subpart, the emissions from an intentional radiator shall not exceed the field strength levels specified in the following table:

Frequency (MHz)	Field Strength (microvolts/meter)	Measurement Distance (meters)
30 - 88	100 **	3
88 - 216	150 **	3
216 - 960	200 **	3
Above 960	500	3

** Except as provided in paragraph (g), fundamental emissions from intentional radiators operating under this Section shall not be located in the frequency bands 54-72 MHz, 76-88 MHz, 174-216 MHz or 470-806 MHz. However, operation within these frequency bands is permitted under other sections of this Part, e.g., Sections 15.231 and 15.241.

§15.209 (b) In the emission table above, the tighter limit applies at the band edges.

7.5.2. TEST PROCEDURE

The EUT is placed on the 0.8 m high non-conducting tabletop. The EUT is continuously transmitting.

For spurious measurements above 26.5 GHz, the maximum distance from the EUT that yields a minimum system noise floor at least 6 dB below the 15.209 limit is calculated for each separate harmonic mixer band. This distance is shown in the noise floor calculations below. The antenna is scanned around the entire perimeter surface of the EUT, in both horizontal and vertical polarizations. During this perimeter scan, the antenna is kept no further from the EUT than the maximum distance calculated for each mixer band.

For harmonic measurements above 26.5 GHz, the above scanning procedure is used to detect harmonic emissions. For all emissions detected, the antenna is moved away from the EUT in a 1/3/10 sequence, as far as possible to maintain a 10 dB signal to noise ratio. Each emission is then maximized by rotating the EUT and varying the antenna height.

7.5.3. SYSTEM NOISE FLOOR ABOVE 1 GHZ

SYSTEM NOISE FLOOR FROM 1 TO 40 GHz

Compliance Certification Services									
Worst Case Radiated Emissions System Noise Floor									
Each band below corresponds to each horn antenna band									
Uses the lowest gain preamplifier; actual preamp used may have higher gain									
Uses the longest typical cable configuration; actual cables used may have less loss									
Noise floor field strength results are compared to the FCC 15.205 Restricted Band limit									
Specification Distance:			3	meters					
Freq	**SA**	**AF**	**Distance**	**Distance**	**Preamp**	**Cable**	**Field**	**Limit**	**Margin**
GHz	**dBuV**	**dB/m**	**m**	**dB**	**dB**	**dB**	**dBuV/m**	**dBuV/m**	**dB**
1 to 18 GHz band									
RBW = 1 MHz, peak detection									
18	41.9	47.8	1	-9.5	32.6	13.5	61.06	74	-12.94
RBW = 1 MHz, average detection									
18	28.7	47.8	1	-9.5	32.6	13.5	47.86	54	-6.14
18 to 26 GHz band									
RBW = 1 MHz, peak detection									
26	44.6	33.4	1	-9.5	35.0	19.5	52.96	74	-21.04
RBW = 1 MHz, average detection									
26	32.4	33.4	1	-9.5	35.0	19.5	40.76	54	-13.24
26 to 40 GHz band									
External mixer is used for this band									
Preamplifier is internal to Spectrum Analyzer, with gain factor built into firmware									
Antenna is mounted directly on external mixer, therefore cable = 0 dB									
RBW = 1 MHz, peak detection									
40	39.2	44.5	0.1	-29.5	0.0	0	54.16	74	-19.84
RBW = 1 MHz, average detection									
40	27.2	44.5	0.1	-29.5	0.0	0	42.16	54	-11.84

SYSTEM NOISE FLOOR FROM 40 TO 200 GHz

Compliance Certification Services							
Worst Case Radiated Emissions System Noise Floor, 40 to 200 GHz							
External Harmonic Mixers are used for this frequency range							
The preamplifier is internal to Spectrum Analyzer, with the gain factor built into firmware							
The antenna is mounted directly on the harmonic mixer, therefore there is no cable loss							
Each band below corresponds to each harmonic mixer band							
Noise floor field strength results are compared to the applicable FCC 15.255 limit							
Specification Distance:		3	meters				
Freq	**SA**	**AF**	**Distance**	**Distance**	**Field**	**Limit**	**Margin**
GHz	**dBuV**	**dB/m**	**m**	**dB**	**dBuV/m**	**dBuV/m**	**dB**
33 to 50 GHz							
RBW = 1 MHz, average detection							
50	27.2	44.2	0.03	-40.0	31.40	45.3	-13.90
50 to 75 GHz							
RBW = 1 MHz, average detection							
75	35.4	47.7	0.01	-49.5	33.56	45.3	-11.74
75 to 100 GHz							
RBW = 1 MHz, average detection							
100	42.5	50.2	0.003	-60.0	32.70	45.3	-12.60
100 to 200 GHz							
RBW = 1 MHz, average detection							
200	39	53.3	0.003	-60.0	32.30	45.3	-13.00

7.5.4. TEST RESULTS

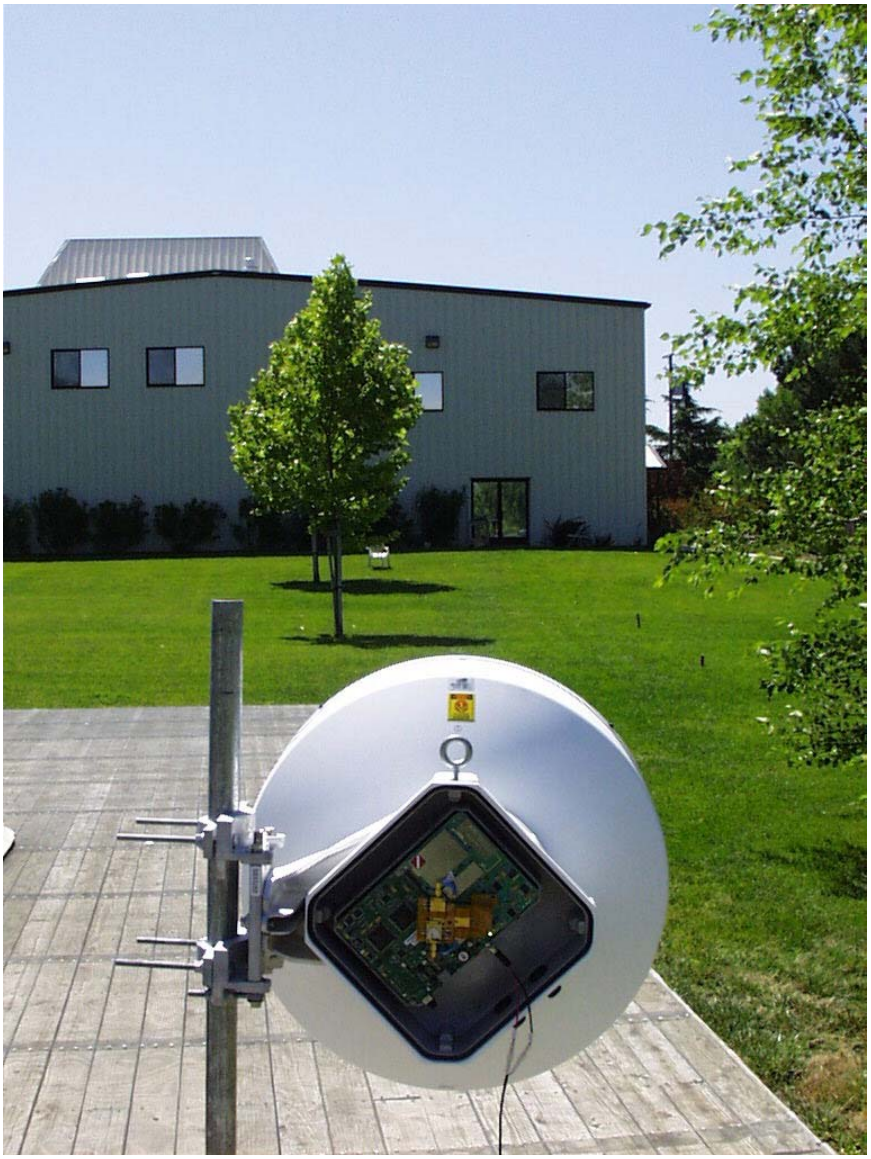
No emissions were detected above noise floor 26.5 to 57 GHz or 64 to 200 GHz.

8. SETUP PHOTOS

IN-BAND RADIATED RF MEASUREMENT SETUP

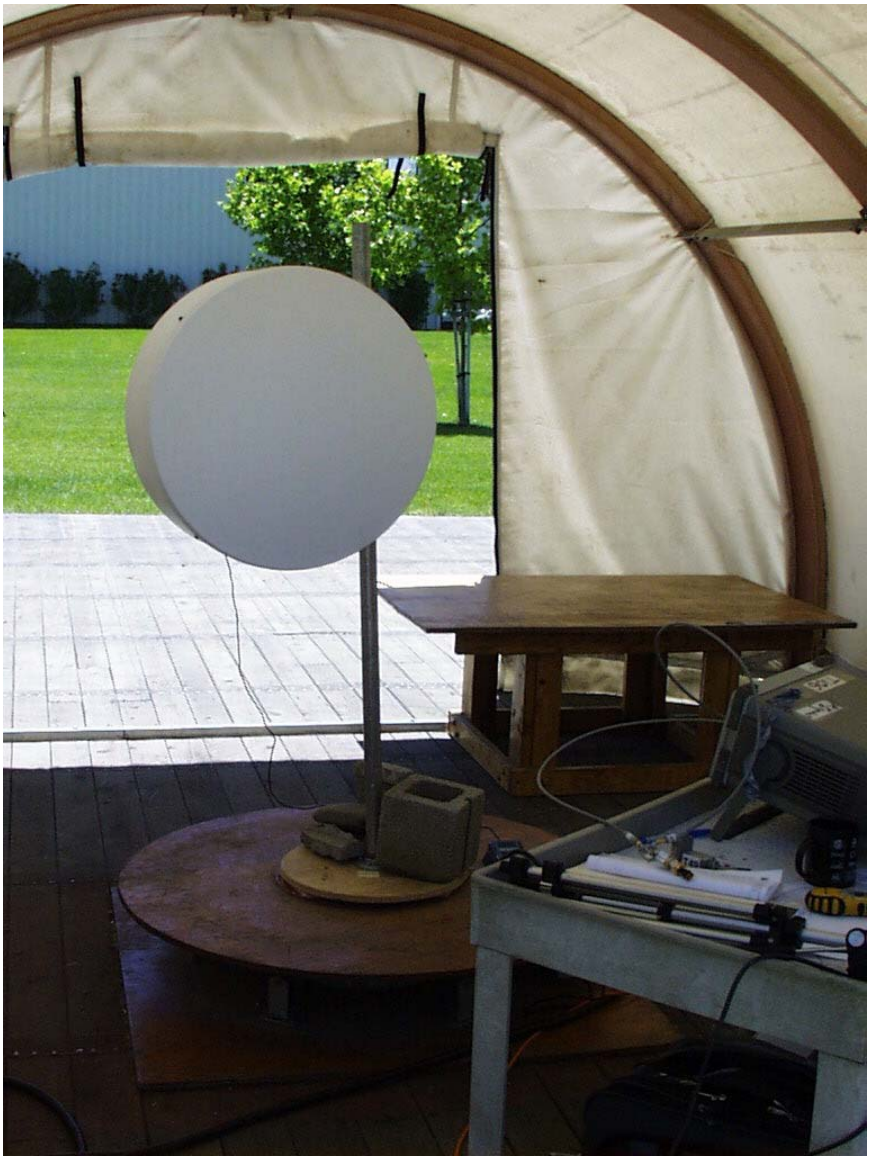
VIEW FROM MEASUREMENT ANTENNA TO EUT

VIEW FROM EUT TO MEASUREMENT ANTENNA



OUT-OF-BAND RADIATED RF MEASUREMENT SETUP

HARMONIC AND SPURIOUS TEST SETUP



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