TEST PROCEDURE AND REPORT

CONDUCTED AND RADIATED EMISSIONS

UNLICENSED INTENTIONAL RADIATOR

SOUTHWEST MICROWAVE MODEL 380

31 MARCH 2003

INTRODUCTION

This procedure and report was prepared to insure compliance with the requirements of part 15.245 of the Federal Communications Rules and Regulations regarding unlicensed intentional radiators. The procedures outlined herein are based on the October 1, 2001 revision of the Federal Communications Commission Rules and Regulations, Parts 2 and 15. The measurements made herein were performed on a preproduction model of the equipment specified and is considered representative of all production units of this series.

The product referenced in this document is a microwave transceiver operating within the frequency band of 24.075 to 24.175 GHz. It is a shorter-range version of the Southwest Microwave Model 385 that was certified under file number 31010/EQU 4-3-3 dated August 13, 1991**.** All aspects of the two sensors are electrically identical except that model 380 has a lower gain antenna. The Doppler sensor is intended to operate as an outdoor security system and therefore must be certified as an intentional radiator. Because of the low powers involved, RF harmonic measurements were performed directly on the transmitter using a waveguide test set-up and then repeated with an antenna installed on the 3-meter test site.

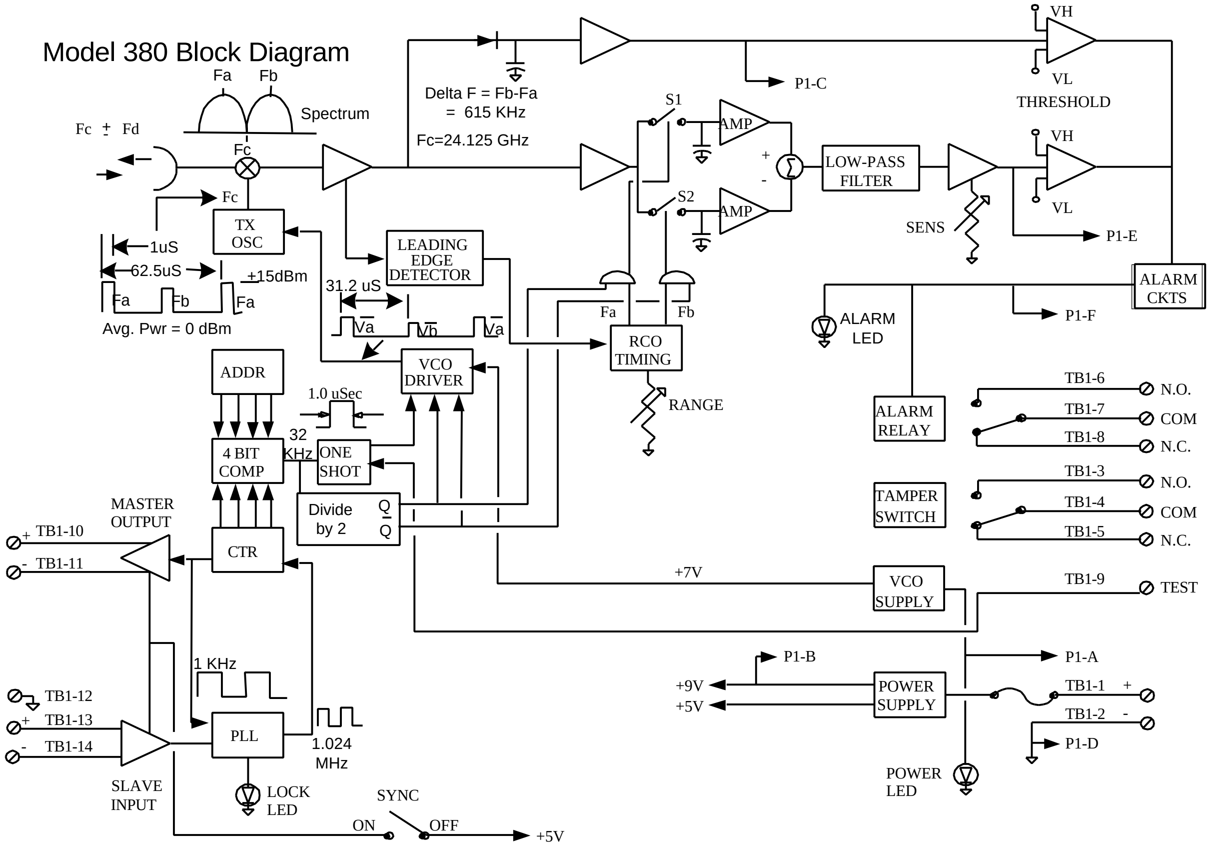
All microwave testing was performed at the Southwest Microwave test site, documentation for which has been filed with the Federal Communications Commission. M. Flom and Associates, Chandler, AZ performed radiation tests per part 15.209 of the commission's rules.

This product utilizes a 4.2-inch diameter parabolic antenna, having a gain of approximately 22.4 dB and a beamwidth of 8.0 degrees (-3 dB) at 24.125 GHz. The modulation signal is comprised of a one-microsecond pulse train operating at a 32-kilohertz repetition rate resulting in a 3.2 percent duty cycle. Alternate pulses are shifted in frequency by approximately 615 kilohertz.

BLOCK DIAGRAM

Referring to the block diagram shown below, all timing functions are derived from the master clock which is contained within the phase locked loop and is operating at a frequency of 1.024 MHz. The clock is divided down to 1 kHz and coupled to the phase comparator of the phase locked loop. If the system is operated in the master mode the oscillator is free running and provides a 1 kHz clock at the master output terminals. This RS 422 master output can be used to sync up to 16 other units together, providing a unique address to each so that interference between sensors is eliminated. The address is selected by means of a binary switch located in each sensor. The phase-lock loop output is connected to a binary ripple counter which provides a 1 microsecond pulse at a 32 kHz repetition rate and a 32 kHz square wave which is connected to a divide by 2 circuit resulting in two channels at 16 kHz of opposite phase.

Model 380 Block Diagram



The one-microsecond pulse is connected to oscillator drive circuit, which provides a minimal voltage change resulting in a small frequency shift on alternate pulses (approximately 615 kHz). The transmitted signal is therefore a continuous pulse train of 1-microsecond pulses at a 32 kHz repetition frequency with alternate pulses shifted by 615 kHz.

A certain portion of the transmitted signal is coupled to a detector diode where the pulse envelope is detected, amplified and connected to a leading edge detector circuit. The output of this circuit is a narrow sampling pulse that is positioned from the leading edge in time by means of a user accessible range-cutoff potentiometer. The range cutoff feature prevents signals from being processed beyond the time it takes the RF pulses to intercept the target and return.

The receiver channels are alternately switched at a 16 kHz rate coincident with the Fa and Fb frequencies. The two-frequency approach provides Doppler signals whose phase is proportional to range. The sampled Doppler output of each channel is then connected to a difference amplifier, the output of which provides a signal whose amplitude is proportional to the phase difference between the two Doppler signals. The purpose of this circuit is to cancel the effects of rain on the radome. Rain running down the radome causes Doppler signals that are in phase because of the close proximity to the transmitter and are essentially cancelled.

The Doppler output of the difference amplifier is amplified after filtering and then connected to a comparator circuit that provides an alarm if the signal amplitude exceeds either threshold.

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1.0 GENERAL

The purpose of this test procedure and report is to specify the measurement technique to be used in determining compliance with Federal Communications Commission (FCC) regulations applying to an unlicensed intentional radiator for purpose of certification.

2.0 SPECIFICATIONS

2.1 Commission Rules & Regulations, Title 47, Parts 15, dated October 1, 2001.

3.0 PERTINENT SPECIFICATIONS

3.1 **Intentional Radiator (Transmitter)**

3.11 Transmitter Frequency: 24. 075 to 24.175 GHz (Part 15.245).

3.12 Fundamental Field Strength: 2500 mV/m at three meters (Part 15.245).

3.13 Harmonic Emissions: Not in excess of 7.5 mV/m at three meters (Part 15.245) unless in a restricted band, in which case the limit is 500 µv/m.

3.14 Spurious Emissions: Minimum of 50 dB below level of fundamental (Part 15.245).

3.15 Conducted Limits: 250 µv maximum from 450 kHz to 30 MHz (Part 15.207).

3.16 Radiated Emission Limits: (Part 15.209)

Frequency MHz	Field Strength µV/m	Measurement Distance Meters
.009-0.490	2400/F(KHz)	300
0.490 - 1.705	24000/F(KHz)	30
1.705-30	30	30
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

3.2 **Unintentional Radiator (Receiver)**

3.21 Conducted Limits:	0.45-1.705 MHz	1000 µv
(Part 15.107 (b))	1.705-30 MHz	3000 µv

3.22 Radiated Limits:	30 - 88 MHz	100µv/m	@ 3m
(Part 15.109 (b))	88-216 MHz	150µv/m	@ 3m
	216-960 MHz	200µv/m	@ 3m
	Above 960 MHz	500µv/m	@ 3m

4.0 EQUATIONS AND CALCULATIONS

Relationships required converting measured data to specification limits.

4.1 Field Strength to Receiver Power

The electric field strength, E, in volts/meter and power density, P, in Watts/meter^2 at any point are related by

$$(1) \quad P = \frac{E^2}{120\pi}$$

Where 120π is known as the resistance of free space. To determine power intercepted by a receiving antenna, multiply power density by receiving area.

$$(2) \quad \text{Area} = \frac{G_R \lambda^2}{4\pi}$$

where G_R = gain of receiving antenna λ = wavelength in meters.

Combining equations (1) and (2), field strength is converted to received power thus,

$$(3) \quad P_{R_{WATTS}} = \frac{E^2}{120\pi} \frac{G_R \lambda^2}{4\pi}$$

therefore, knowing the receiving antenna gain, the field strength can be obtained by measuring the received power at three meters.

4.2 Conversion Calculations: Specifically, for the fundamental

$$P_R = \frac{(2.5)^2 G_R \left[\frac{0.3}{(24.125)}\right]^2}{480p^2} \text{watts}$$

$$= 2.04 \times 10^{-4} G_R \text{ mW}$$

The receiving antenna gain (G_R) at K-Band is 16.0 dB (40), so that the maximum average received power at three meters is:

$$P_R = 8.16 \times 10^{-3}\, mW (-21 dBm)$$

For the second harmonic:

$$P_R = \frac{\left(7.5x10^{-3}\ \mathrm{V}/\mathrm{m}\right)^2 G_{R2}\left[\frac{0.3}{2(24.125)}\right]^2}{480p^2}\ \text{watts}$$
$$= 4.59\times10^{-10}\ G_{R2}\ \text{mW}$$

The receiving antenna gain (G_{R2}) at the second harmonic is 20 dB (100), so that the maximum average received power at three meters is:

$$P_{R2} = 4.59\times10^{-8}\ mW(-73.4dBm)$$

Applying the same technique to the other harmonics,

For the third harmonic:
The receiving antenna gain (G_{R3}) at the third harmonic is 20 dB (100), so that the maximum averaged received power at three meters is:

$$P_{R3} = 2.04\times10^{-8}\ mW(-76.9dBm)$$

For the fourth harmonic:
The receiving antenna gain (G_{R4}) at the fourth harmonic is 23 dB (200), so that the maximum averaged received power at three meters is:

$$P_{R4} = 2.3\times10^{-8}\ mW(-76.4dBm)$$

Therefore, to meet the FCC field strength requirements the average received power for the fundamental cannot exceed -21.0 dBm at three meters, the second harmonic cannot exceed –73.4dBm, the third harmonic –76.9 dBm and the fourth –76.4 dBm at three meters.

For measurements from 1 to 40 GHz the recommended bandwidth per ANSI 63.4-1992 is 1 MHz. At this bandwidth, the noise floor of the HP8563E is –64 dBm well above the maximum allowed received harmonic power levels. Even at lower bandwidths, the received power is below the noise floor. In order to insure compliance, the harmonic measurements will be made on a waveguide setup measuring the harmonic content directly at the transmitter.

It can be shown that the field strength is related to the transmit power by the following relationship:

$P_t = E^2\ R^2\ /\ 30\ G_t$ (Watts)

where, E = Field Strength in V/M
R = Distance from antenna in meters
G_t = Transmitting Antenna Gain at frequency of interest.

From the preceding equation, the following table can be configured:

Table 1

Harmonic Number	Frequency GHz	Transmitting Antenna Gain dB	Field Strength V/M	Maximum Allowable Avg.Power at Transmitter dBm
1	24.125	22.4	2.5	10.33
2	48.25	22.8	7.5E-03	-40.5
3	72.375	24.5	7.5E-03	-42.2
4	96.5	25.8	7.5E-03	-43.5

Therefore, in the wave-guide tests, the average power levels of the harmonics cannot equal the power levels shown in the table.

Spurious Measurements:

Since the system is always operated in the modulated mode, the fundamental is assumed to be the maximum average power occurring in the vicinity of 24.125 GHz therefore, all spurious emissions must be 50 dB below the peak value at 3 meters, (-11 dBm -50 dBm = -61 dBm).

Emissions:

The transceiver was tested for compliance to 15.209 for the transmitter section and receiver section. The measurements were conducted at an independent recognized test facility located in Chandler, Arizona (M Flom and Associates).

Conducted Emissions

Since the Model 380 is typically operated from a 12-v battery, with a customer-supplied charger, the conducted emissions requirement is not applicable.

5.0 TEST PROCEDURE FOR FIELD STRENGTH CONFORMANCE

5.1 The following methods and procedures are used to verify conformance to FCC regulations. The test site documentation has been submitted to the FCC.

5.2 Test Equipment

1 each HP Spectrum Analyzer - Model 8563E
1 each Narda 638 K-Band Standard Gain Horn (G = 16 dB)
1 each Dorado GH-22 Q-Band Standard Gain Horn (G = 20 dB)
1 each Dorado GH-15 V-Band Standard Gain Horn (G = 22 dB)
1 each Dorado GH-10 W-Band standard Gain Horn (G = 23 dB)
1 each HP11970Q Harmonic Mixer (33-50 GHz)
1 each HP11970V Harmonic Mixer (50-75 GHz)
1 each HP11970W Harmonic Mixer (75-110 GHz)
1 each K-K_A Band Waveguide Transition
1 each K_A-V Band Waveguide Transition
1 each K_A-W Band Waveguide Transition
2 each SMI Waveguide to Coax Adapters
1 each Graphics Plotter, HP7550A
1 each Amplifier, Kalmus 704 FC
1 each Antenna, Electrometrics EM 6917 (30-1000 MHz)
1 each 10 dB attenuator, Minicircuits CAT-10
2 each 3 dB attenuators, Minicircuits CAT-3
1 each 6 dB attenuator, Minicircuits CAT-6
1 each 15 VDC Power Supply, SMI PS-45
1 each Agilent E7402A EMC Analyzer (9 kHz-3.0 GHz)
1 each ARA ALA-130RS Loop Antenna (1kHz – 30 MHz)

5.3 Fundamental and Harmonic measurements

5.3.1 Insure test equipment is calibrated to manufacturer specifications before beginning tests.

5.3.2 Remove the antenna from the UUT and replace it with the circular to rectangular waveguide transition. Connect the waveguide test set up as shown in Fig.1.

5.3.3 Set the HP 8563E analyzer to the following:

Resolution Bandwidth	1.0 MHz
Video Bandwidth	Auto
Averaging	Off
Amplitude Reference Level	0 dBm
Span	100 MHz
Center Frequency	24.125 GHz
Peak Search	On
Detector	Peak Positive
Sweep	50ms

5.3.4 Turn on the modulation to the transmitter and measure the fundamental power at the output of the circular to rectangular waveguide transition and record the **peak** power level and frequency in the appropriate portion of the Certification Test Report.

5.3.5 Connect the equipment as shown in Fig. 2 for harmonic measurements.

5.3.6 Connect the K-K_A waveguide transition between the circular to rectangular transition and the HP 11970Q (33-50 GHz) harmonic mixer. Set the analyzer to Q band and the center frequency to twice the value found in 3.5.4. Set the span to 100 MHz and the bandwidth to 1 MHz. Record the **peak** power of the second harmonic in the appropriate portion of the certification test report.

5.3.7 Connect the K_A-V waveguide transition between the K-K_A transition and the HP 11970V (50-75 GHz) harmonic mixer. Set the analyzer to V band and the center frequency to three times the value found in 3.5.4. Set the span to 100 MHz and the bandwidth to 1 MHz. Record the **peak** power of the third harmonic in the appropriate portion of the Certification.

5.3.8 Connect the K_A-W waveguide transition between the K-K_A circular to rectangular transition and the HP 11970W (75-110 GHz) harmonic mixer. Set the analyzer to W band and the center frequency to four times the value found in 3.5.4. Set the span to 100 MHz and the bandwidth to 1 MHz. Record the **peak** power of the fourth harmonic in the appropriate portion of the Certification.

5.3.9 Calculate the average power of the signal by adding the duty cycle of the modulated waveform (10 log (.032) = -15 dB) to each of the **peak** powers found in 5.3.4-7. Insure that the calculated value does not exceed the values shown in Table 1.

5.3.10 Connect the antenna to the UUT and set up the outdoor 3-meter test area as shown in Fig 3. Before recording the data in each case, peak both the transmitting and receiving antennas for maximum signal.

5.3.11 Set up the spectrum analyzer to the same conditions as shown in 5.3.3. attach the K-Band receiving antenna.

5.3.12 Turn on the modulation to the transmitter and measure the peak fundamental power and frequency. Record in the appropriate section of the test report. Plot the fundamental spectrum and attach to the report.

5.3.13 Subtract 50 dB from the peak power found in 5.3.7, reduce the noise floor of the analyzer by changing the bandwidth to 100 kHz. Note the upper and lower frequencies at which the spectrum equals this value and enter in the appropriate portion of the test report. Reset the bandwidth to 1.0 MHz.

5.3.14 Attach the HP 11970Q mixer and the Q- Band antenna, set the spectrum analyzer to twice the frequency found in 5.3.11 and measure the second harmonic peak power. Record in the appropriate section of the test report. Plot the second harmonic spectrum and attach to the test report.

5.3.15 Turn on the modulation and insure that the peak spectrum power does not exceed the level found in 5.3.10. Calculate the average power by adding the duty cycle factor and enter in the appropriate section of the Certification test report. Plot the second harmonic spectrum and attach to the test report.

5.3.16 Attach the HP 11970V mixer and the V- Band antenna, set the spectrum analyzer to three times the frequency found in 5.3.11 and measure the third harmonic peak power. Record in the appropriate section of the test report.

5.3.17 Turn on the modulation and insure that the peak spectrum power does not exceed the level found in 5.3.10. Calculate the average power by adding the duty cycle factor and enter in the appropriate section of the Certification test report. Plot the third harmonic spectrum and attach to the test report.

5.3.18 Attach the HP 11970W mixer and the W- Band antenna, set the spectrum analyzer to four times the frequency found in 5.3.11 and measure the fourth harmonic peak power. Record in the appropriate section of the test report.

5.3.19 Turn on the modulation and insure that the peak spectrum power does not exceed the level found in 5.3.10. Calculate the average power by adding the duty cycle factor and enter in the appropriate section of the Certification test report. Plot the fourth harmonic spectrum and attach to the test report.

5.4 Spurious

5.4.4 Reconnect the K band antenna and turn on the modulation to the transmitter. Note the upper and lower frequencies on the test report, which are 50 dB below the peak signal. Slowly sweep the analyzer between 18 and 24.075 GHz and insure that no signal exceeds a level 50 dB below the peak. Repeat the same process between 24.075 and 26.5 GHz.

5.5 Radiated Emissions

5.5.1 See attached data from the independent test laboratory.

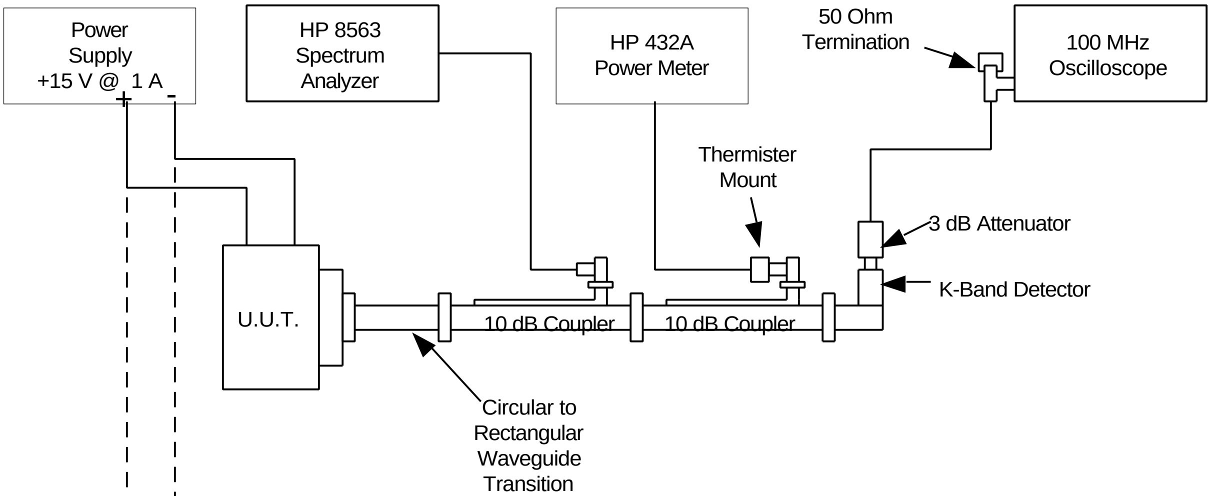


Fig 1. Fundamental Waveguide Setup

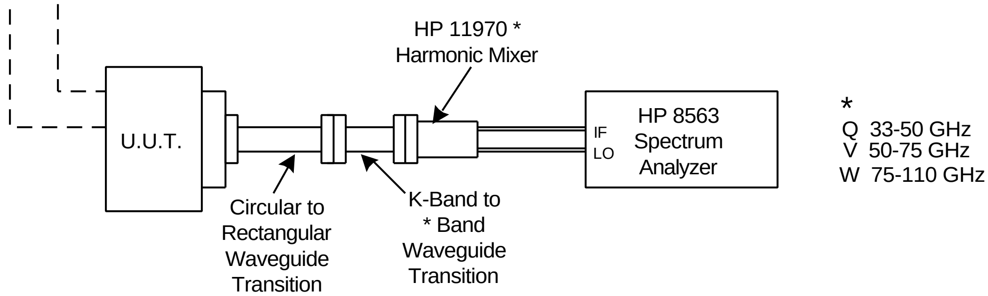


Fig. 2 Harmonic Waveguide Setup

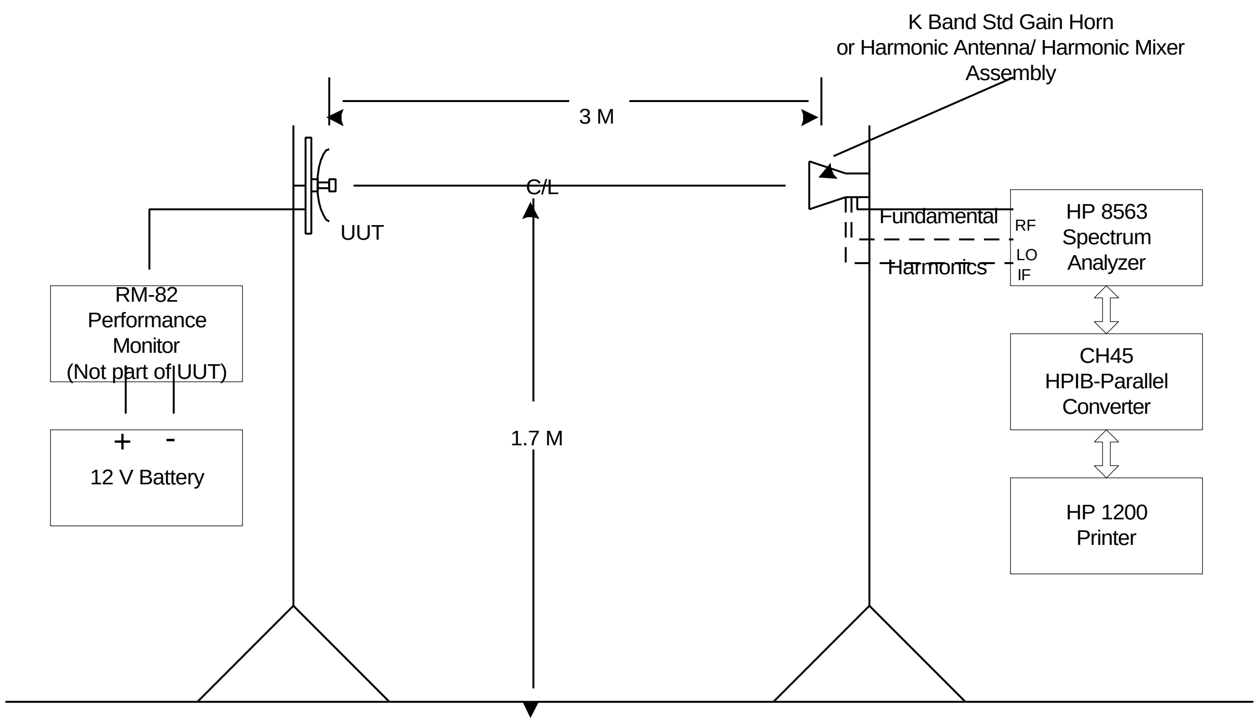


Fig 3
3-Meter Antenna Test
Configuration

CERTIFICATION TEST REPORT

Model 320
Serial Number 673045
Tested by: Mauricio Flores

DATE 4-8-03

FUNDAMENTAL AND HARMONIC MEASUREMENTS (WAVEGUIDE)

		Frequency GHz	Pk Power dBm	Avg.Power dBm	Spec. dBm
5.3.4	Fundamental	24.125	12.67	-2.33	10.3
5.3.5	Second Harmonic	48.216	-42.69	-57.6	-40.5
5.3.6	Third Harmonic	72.374	-51.43	-66.43	-42.2
5.3.7	Fourth Harmonic	96.500	-52.47	-67.47	-43.5

FUNDAMENTAL AND HARMONIC MEASUREMENTS (3 METER TEST RANGE)

		Frequency GHz		Pk Power dBm	Avg.Power dBm	Spec.
5.3.11	Fundamental	24.125	PLOT	-18.00	-33	-21 dBm

5.3.12	Bandwidth 100 kHz	F High	24146.7	GHz	
		F Low	24105.0	GHz	
		Fh-Fl	41.7	MHz	100 MHz

		Frequency GHz		Pk Power dBm	Avg.Power dBm	Spec.
5.3.14	Second Harmonic	48.255	PLOT	-60.93	-75.93	-73.4dBm
5.3.16	Third Harmonic	72.375	PLOT	-62.60	-77.6	-76.9dBm
5.3.18	Fourth Harmonic	96.500	PLOT	-66.63	-81.63	-76.4dBm

5.4.1	Spurious	18-24.075 GHz	N/V	-50 dBc
		24.175-26.5 GHz	N/V	-50 dBc

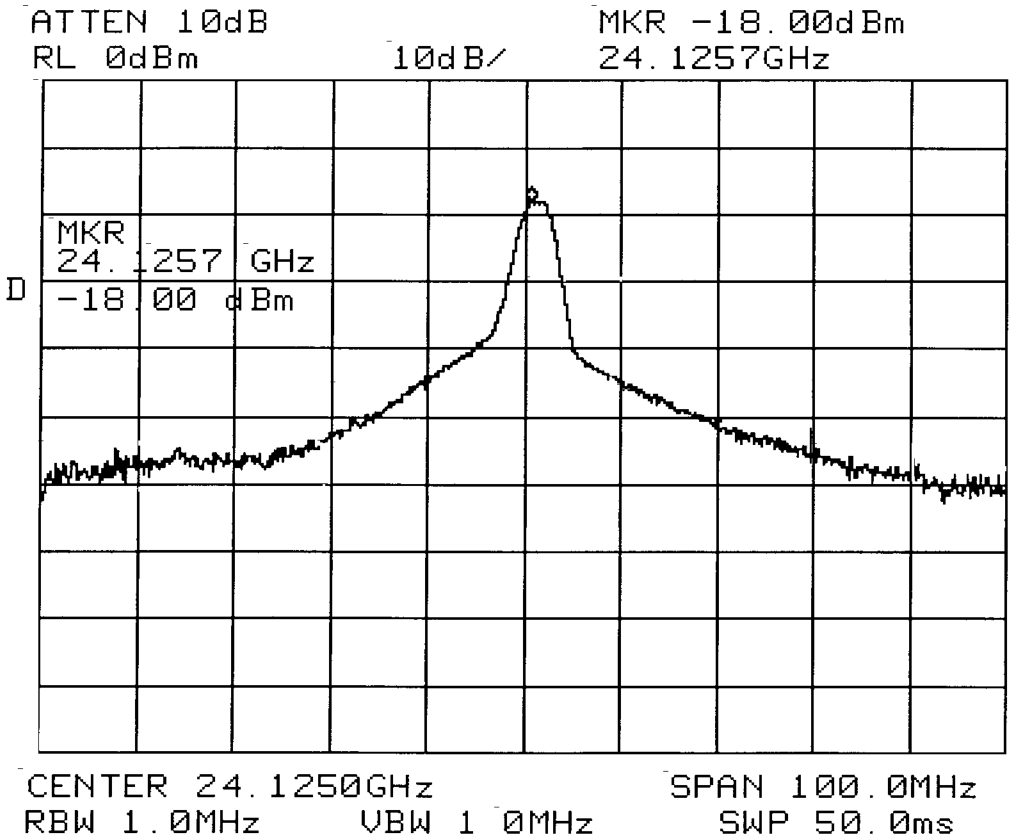
5.5.3 Radiated Emissions

Indicate largest signal and frequency attributable to unit under test. See attached Low Frequency Emission Test Report

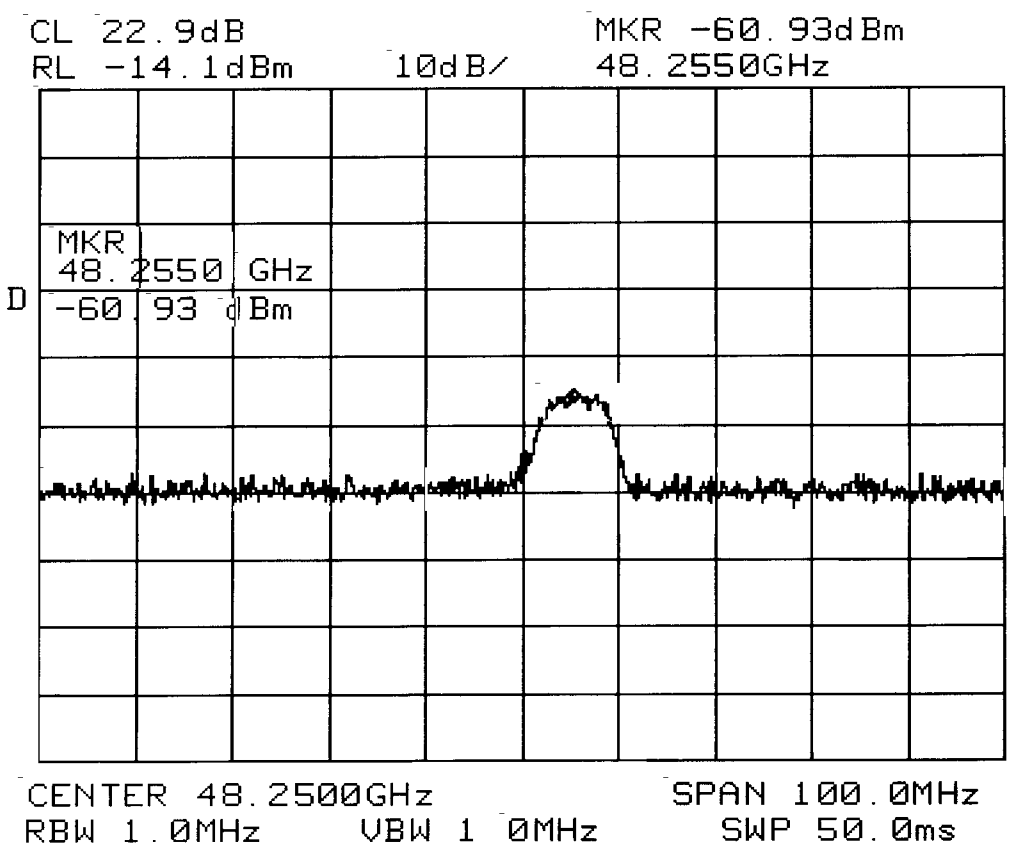
	Frequency Range		Frequency	Level @ 3.0 M	Spec
5.5.3	1-30	MHz	2.048	27.43	30 uV/M
5.5.4	30-88	MHz	83.963	28.38	100uV/M
	88-216	MHz	98.304	45.39	150uV/M
	216-960	MHz	880.640	76.21	200uV/M
	960-1000	MHz	991.420	96.61	500uV/M

To the best of my knowledge, this device meets the requirements of parts 15.245,15.209, 15.207 of the FCC code of federal regulations.

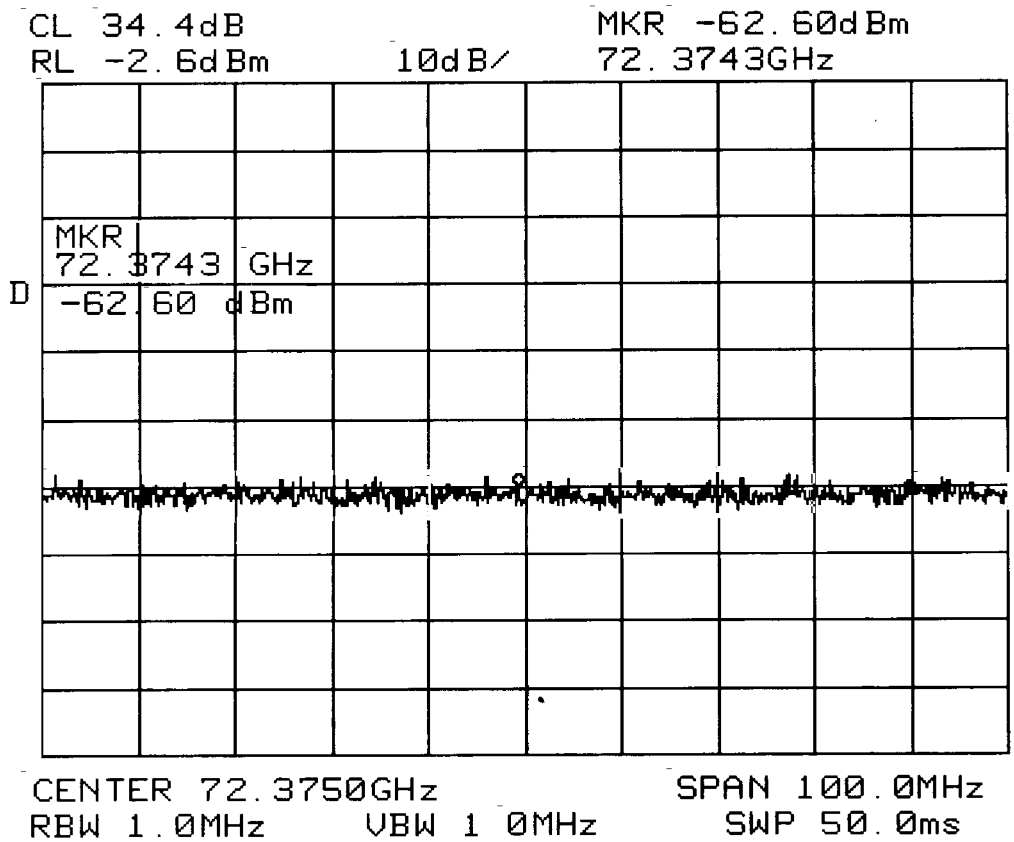
Approved by: E Foley Date APRIL 8, 2003
Title VP ENGINEERING



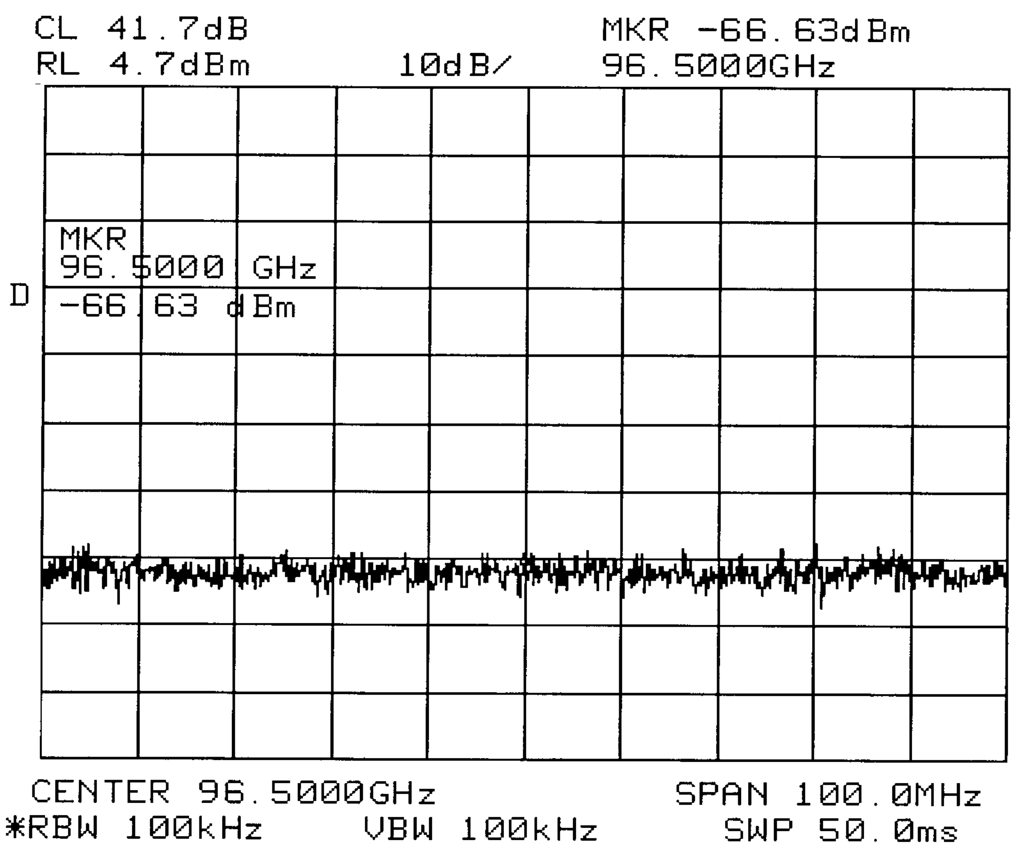
ATTEN 10dB
RL 0dBm
10dB/
MKR -18.00dBm
24.1257GHz
MKR
24.1257 GHz
-18.00 dBm
D
CENTER 24.1250GHz
SPAN 100.0MHz
RBW 1.0MHz
VBW 1 0MHz
SWP 50.0ms



CL 22.9dB
RL -14.1dBm
10dB/
MKR -60.93dBm
48.2550GHz
MKR
48.2550 GHz
-60.93 dBm
D
CENTER 48.2500GHz
SPAN 100.0MHz
RBW 1.0MHz
VBW 1 0MHz
SWP 50.0ms



CL 34.4dB
RL -2.6dBm
10dB/
MKR -62.60dBm
72.3743GHz
MKR
72.3743 GHz
-62.60 dBm
D
CENTER 72.3750GHz
SPAN 100.0MHz
RBW 1.0MHz
VBW 1 0MHz
SWP 50.0ms



CL 41.7dB
RL 4.7dBm
10dB/
MKR -66.63dBm
96.5000GHz
MKR
96.5000 GHz
-66.63 dBm
D
CENTER 96.5000GHz
SPAN 100.0MHz
*RBW 100kHz
VBW 100kHz
SWP 50.0ms