AHD
EMC Laboratory
92723 M-152, Dowagiac, MI 49047 USA
Phone: (616) 424-7014
www.ahde.com

EMC Test Report

#0100460F80
Issued 09/12/01

REGARDING THE FCC PART 15.231(E)

TRANSMITTER MODEL: VER-1780

Prepared for: Mr. Bob Wiser
VERSUS Technology
2600 Miller Creek Rd.
Traverse City, MI 49684

Test Date(s): September 7, 2001

data recorded by

Gordon Helm, PE
Ted Chaffee, NCE

witnessed by

Bob Wiser

This report prepared by:

Ted Chaffee, NCE
Lab Manager/Test Engineer, AHD

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STATEMENTS CONCERNING THIS REPORT

Test Traceability:
The calibration of all measuring and test equipment and the measured data using this equipment are traceable to the National Institute for Standards and Technology (NIST).

Limitations on results:
The test results contained in this report relate only to the Item(s) tested. Any electrical or mechanical modification made to the test item subsequent to the test date shall invalidate the data presented in this report. Any electrical or mechanical modification made to the test item subsequent to this test date shall require an evaluation to verify continued compliance.

Limitations on copying:
This report shall not be reproduced, except in full, without the written approval of AHD.

Limitations of the report:
This report shall not be used to claim product endorsement by NVLAP, FCC, or any agency of the US Government.

Statement of Test Results Uncertainty: Following the guidelines of NAMAS publication NIS81 and NIST Technical Note 1297, the Measurement Uncertainty at a 95% confidence level is determined to be: ±3.6 dB

Retention of Records:
For equipment verified to comply with FCC regulations, the manufacturer is obliged to retain the following records for two years following the manufacture of the equipment model tested.

1. This test report.
2. Design drawings/schematics of the equipment.
3. Record of design changes that may impact the compliance of the equipment.
4. A record of the procedures used to assure production compliance [audits].

MEASUREMENT/TEST SITE FACILITY & EQUIPMENT

Test Site [2.948, 2.1033(b6)]

The AHD test facility is centered on 9 acres of rural property near Sister Lakes, Michigan. The mailing address is 92723 M-152, Dowagiac, Michigan 49047. This test facility is NVLAP accredited (LabCode 200129-0). It has been fully described in a report filed with the FCC and Industry Canada. The original report filed with the FCC is, dated November 5, 1996, was accepted by the FCC in a letter dated January 15, 1997 and reconfirmed July 14, 2000, (31040/SIT 1300F2). The original report filed with Industry Canada, dated August 11, 1998, was accepted via a letter dated September 1, 1998, (file:IC3161).

Measurement Equipment Used [2.947(d), 15.31(b)]

Equipment	Model	S/N	Last Cal Date	Calibration Interval
HP EMI Receiver system	HP 8546A			
RF Filter Section	HP-85460A	3448A00283	22-Aug-01	12 month
RF Receiver Section	HP-85462A	3625A00342	22-Aug-01	12 month
EMCO BiconiLog Antenna	3142	1077	24-Aug-01	12 months
(3-M) Type 129FF Ultra Flex LowLoss	RG58/U	9910-12	08-Jun-01	6 months
(3-M) LMR-400 Ultra Flex	LMR400	9812-11	08-Jun-01	6 months
(10-M) Amelco 50ohm Coax	RG213/U	9903-10ab	08-Jun-01	6 months
Double Ridged Horn	ONO91202-2	A00329	17-Apr-01	12 months

Measurement Environment

The tests were performed with the equipment under test, and measurement equipment inside the all-weather enclosure. Ambient temperature was 22deg.C., the relative humidity 40%.

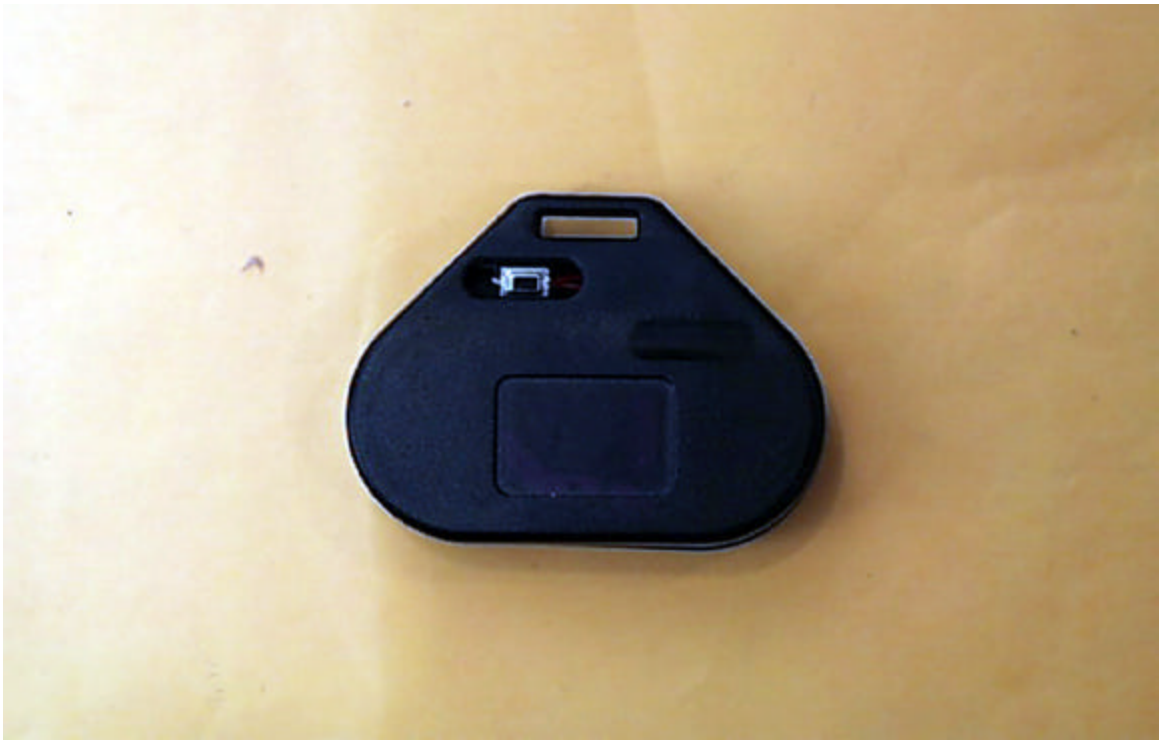
EUT DESCRIPTION

Description: 434MHz low power transmitter. Personal Badge.
Model: VER-1780
Serial/ID No.: ---
Manufacturer: VERSUS Technology

Details: A pre-production unit
Plastic chassis
2-layer printed circuit board
Oscillator:
3.58 MHz
13.56 MHz
operating frequency is 434MHz
3-volt Lithium battery is power source

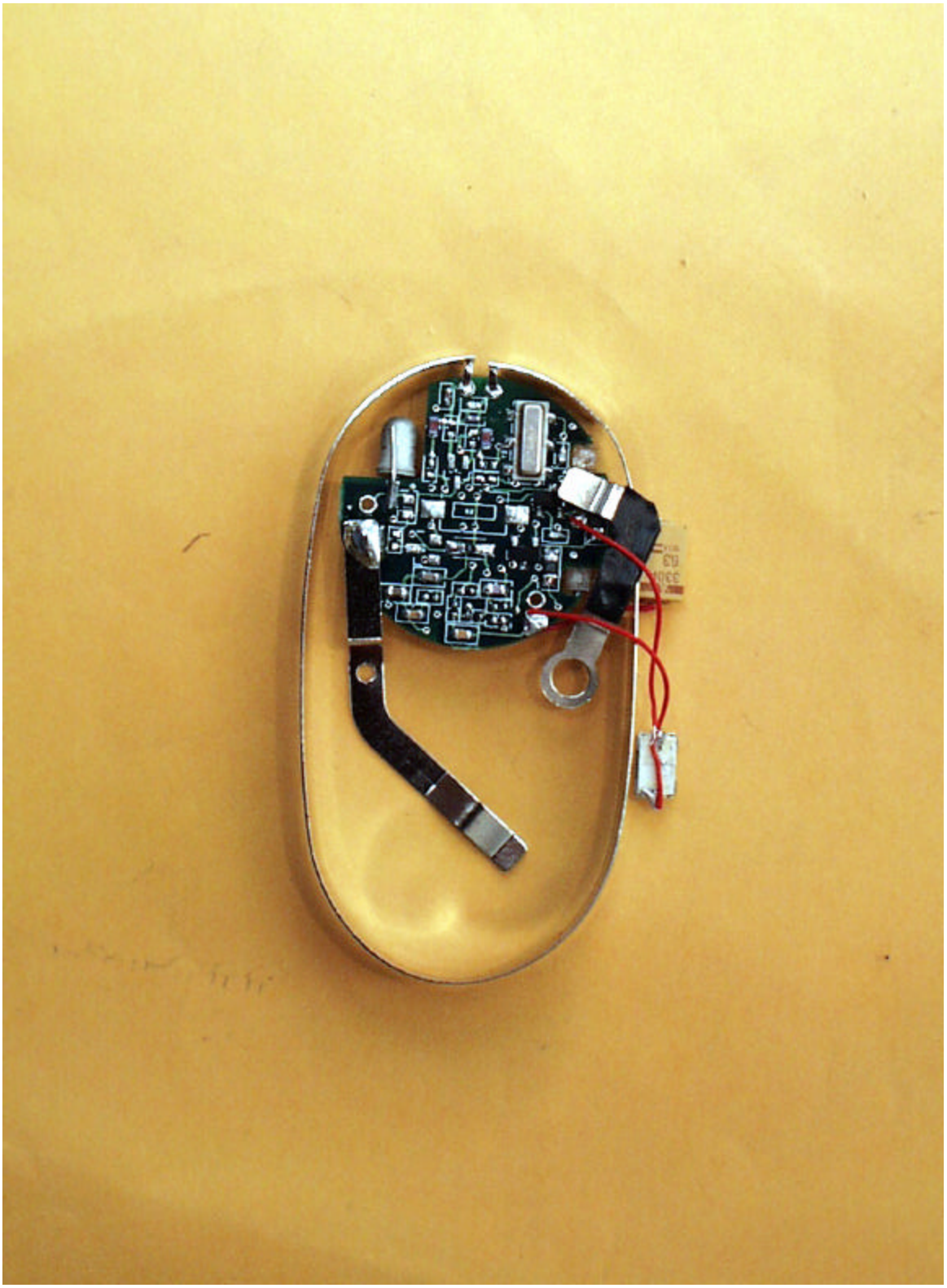
EUT Pictures

VER-1780 – TOP VIEW



VER-1780 PCB – TOP VIEW

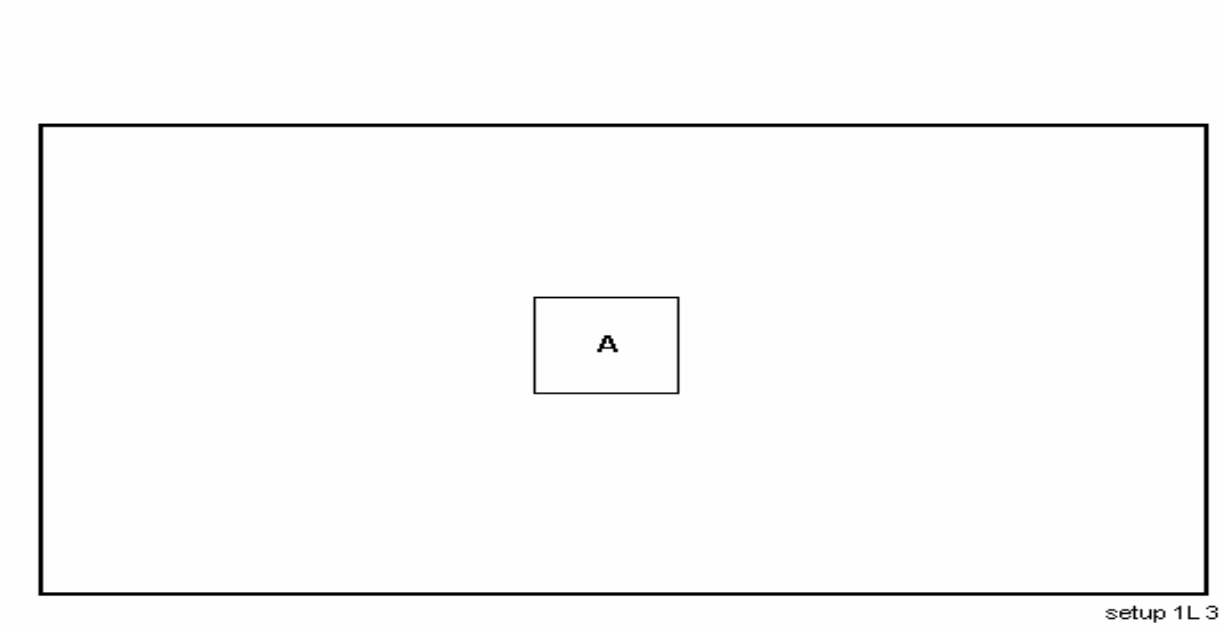
VER-1780 PCB – BOTTOM VIEW



TESTED CONFIGURATION /SETUP: [2.1033(B8)]

Support Equipment & Cabling

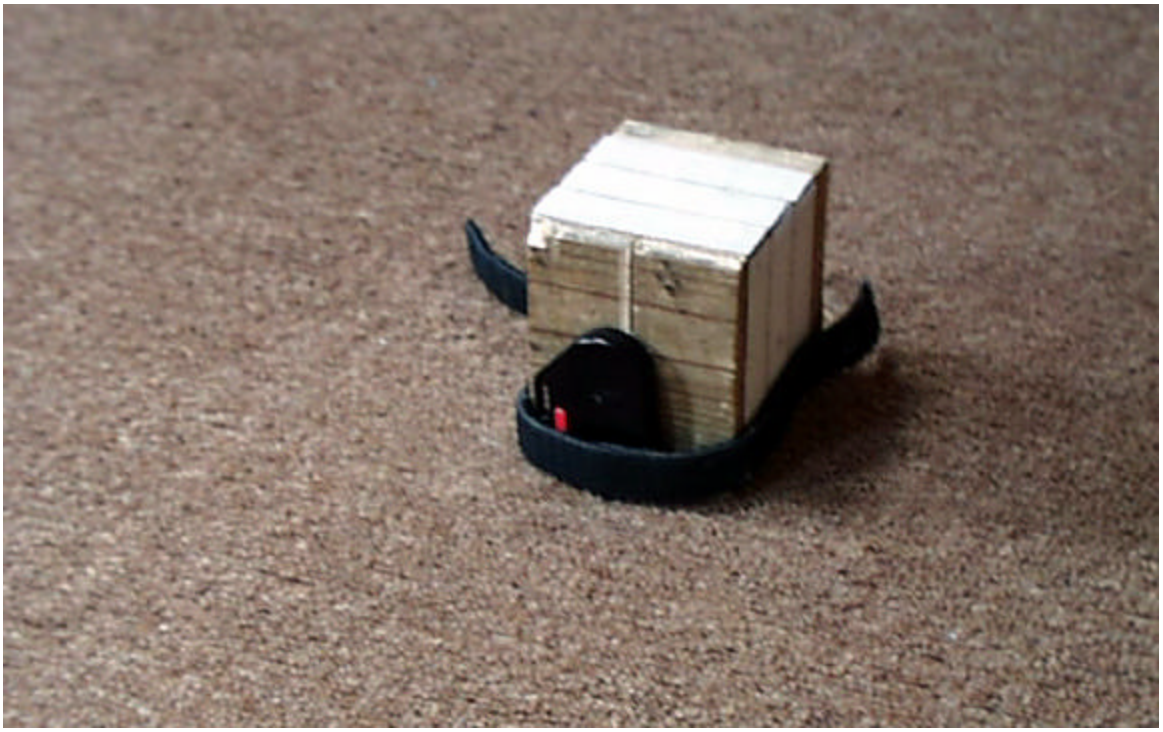
Setup Diagram Legend	Description	Model	Serial No. / Part No.	EMC Consideration
A	EUT personal badge	VER-1780	preproduction	



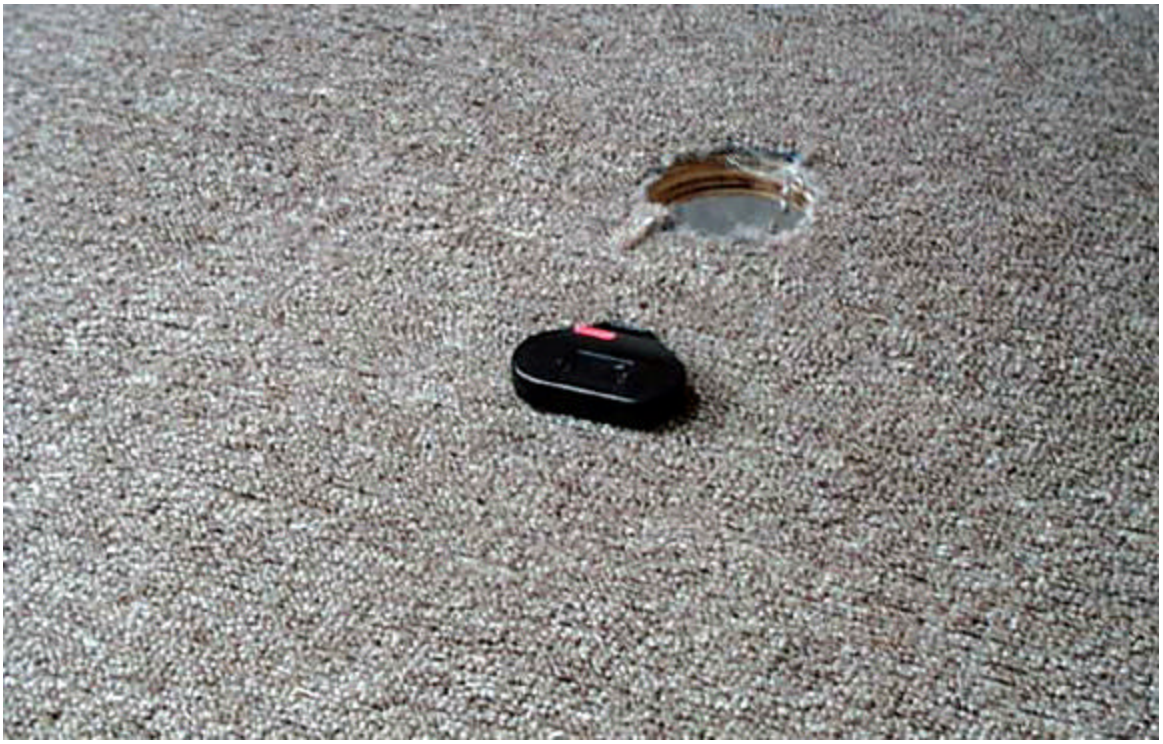
BASIC EUT SETUP
(Legend designation is above)

Setup Pictures

RADIATED SETUP
END POSITION



FLAT POSITION



SIDE POSITION

TEST METHODOLOGY: [2.1033(B6)]

Standards Applied to Test: [2.1033(b6)]

ANSI C63.4 - 1992, Appendix I
CFR47 FCC Part 2, Part 15, SubPart C, 15.231(e) Intentional Radiator;
SubPart B, Digital Device

Methodology

The pictures in this report, showing test setups, indicate the agreed upon configuration of testing for this product-type.

For the testing, the EUT was placed at the center of the table 80cm above the ground plane pursuant to ANSI C63.4 for stand-alone equipment.

The internal lithium battery was replaced periodically throughout the testing to ensure that the greatest available battery power was available to the transmitter.

The line conducted emission testing was not performed on this product. In its final configuration the product is powered from an internal lithium battery only.

Radiated

The system was placed upon a 1 x 1.5 meter non-metallic table 80cm above the open field site ground plane in the prescribed setup per ANSI C63.4, Figure 9(c).

The table sits upon a remote controlled turntable. The receiving antenna, located at the appropriate standards distance of 3 or 10 meters from the table center, is also remote controlled.
The principle settings of the EMI Receiver for radiated testing include:

IF Bandwidth: 120KHz for frequencies less than 1GHz.
1 MHz for frequencies greater than 1GHz.
Detector Function: Peak Mode
The Average levels were determined mathematically based upon the worst case 'on time' of the transmitted pulses over one complete pulse train period. The calculations for this averaging is found in Appendix A of this document.

At frequencies up to 1000MHz a BiconiLog broadband antenna was used for measurements.

At frequencies above 1000MHz a double-ridge Horn broadband antenna was used for measurements.

During the evaluation the EUT was transmitting continuously.

The turntable was rotated 360 degrees and the receiving antenna height varied from 1 to 4 meters to search out the highest emissions.

The EUT was placed in three orthogonal positions. At each position measurements were taken with the receive antenna in vertical and horizontal positions. Refer to photographs on preceding pages to view these three positions.

The EUT was tested with the transmitter in CW mode to determine the azimuth and antenna height to maximize the signal.

The unit was evaluated up to the tenth harmonic of the fundamental as an intentional radiator, and up to 1000MHz as a digital device.

FORMULAS AND SAMPLE CALCULATIONS:

THE HP8546A EMI Receiver has stored in memory the antenna and coax correction factors used in this test. The resultant Field Strength (FS) in dBuV/m presented by the HP8546A is the summation in decibels (dB) of the Received Level (RF), the Antenna Correction Factor (AF), and the Cable Loss Factor (CF).

Formula 1: FS(dBuV/m) = RF(dBuV) + AF(dB/m) +CF(dB)

The resultant Field Strength measurement is recorded using the peak hold detector of the HP8546A.

The allowed occupied bandwidth of the fundamental is calculated as

Formula 2: $BW(KHz) = F_o(KHz) * .0025$
$BW = 434000*.0025 = 1085KHz$

Calculation of FCC limits Part 15.231e

For the frequency range 260MHz - 470MHz, the limit is a linear interpolation between 1500uV/m and 5000uV/m where the limit at 260MHz is 1500uV/m and the limit at 470MHz is 5000uV/m.

A formula to calculate the limit is established with a ratio linearly equating the frequency range to the limit range.

$$(F_0 - F_L) / (F_H - F_L) = (L_0 - L_L) / (L_H - L_L)$$

where F_0 and L_0 represent the frequency in question and its limit
where F_L and L_L represent the lower frequency (260MHz) and its limit (1500uV/m).
Where F_H and L_H represent the higher frequency (470MHz) and its limit (5000uV/m).

The calculations for the frequencies included in the application are:

434MHz $(434 - 260) / (470 - 260) = (L_0 - 1500) / (5000 - 1500)$
$(174 / 210) * (3500) = L_0 - 1500$
$L_0 = 2900 + 1500$
$L_0 = 4400$ uV/m is LIMIT at 434MHz

The limit in dB terms is calculated as the result of 20 times the log of the uV/m limit.

434MHz dB limit is 20 * LOG(4400 uV/m) = 72.9 dBuV/m

The average level is calculated using information of the pulse 'on time' during one complete pulse train. Refer to Appendix A for the discussion of this calculation.

MEASUREMENT RESULTS

Summary:

1. This test series evaluated the Equipment Under Test to FCC Part 15, SubPart C.
2. The system tested is compliant to the requirement of CFR 47, FCC Part 15.231(e) for Low Power Transmitters.
3. The equipment under test was received on September 7, 2001 and this test series commenced on September 7, 2001.
4. The line conducted emission testing does not apply to this product. The device is powered from a 3 volt Lithium battery.
5. The preliminary scan for spurious emissions conducted in a shielded room indicated low level broadband noise between 460 and 480MHz. The measured level in this area was 23dB below the limit of 46dBuV/m.
6. The average field strength level of the fundamental was calculated to be 9.8dB below the limit of 72.9dBuV/m (4400uV/m).
7. The evaluation of the field strength levels of the harmonics showed the emission nearest the limit occurred at 868MHz. This average field strength level was calculated to be 4.7dB below the limit of 52.9dBuV/m (440uV/m
8. Occupied BandWidth: Refer to Test Report #0100446F82 for additional information of this product. In that report it was shown that the bandwidth of the transmitted signal, at the 20dB point, was measured to be 510KHz. This measurement is within the allowed 1085KHz bandwidth.

Changes made to achieve compliance

1. Remove R12.

Test Data [2.1033(b6)]

Restricted Bands: [15.205]

The following frequency bands are restricted. Only spurious emissions are permitted at levels limited by 15.209:

MHz	MHz	MHz	GHz
0.090-0.110	16.42-16.423	399.9-410	4.5-5.25
0.490-0.510	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	Above 38.6
13.36-13.41			

GENERAL LIMIT @ 3meter: [15.209(a)]

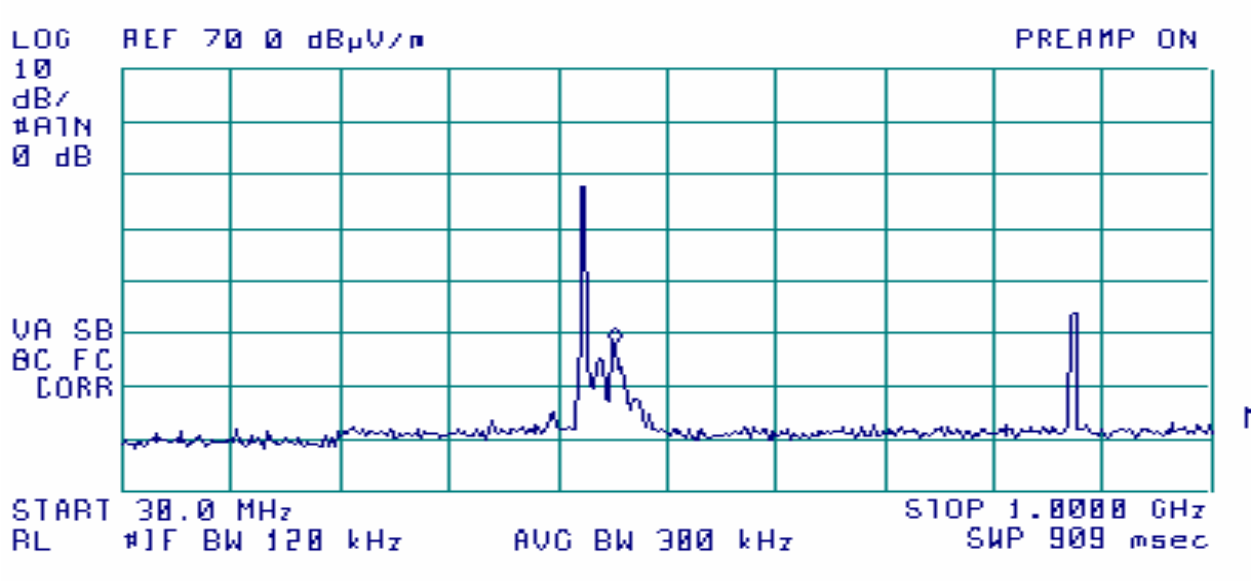
30-88MHz	100uV/m	40dBuV/m
88-216MHz	150uV/m	43.5dBuV/m
216-960MHz	200uV/m	46dBuV/m
above 960MHz	500uV/m	54dBuV/m

Radiated Field Strength Measurements: [15.231(b), 15.205]

A scan of the VER-1780 was made in a shielded room to study the emission profile of the EUT.

These scans indicate a band of emissions between 460 and 480MHz.
The two major emissions shown are the fundamental and first harmonic.

The chart shows the spectrum pattern of the EUT emissions. Note, the levels indicated are not calibrated levels.



Frequency MHz	Polarity	Quasi Peak Measurement dBuV/m	FCC Class B Limit dBuV/m	Margin dB		Included Cable + Antenna Factors dB/m
464.6	V	22.92	46.00	-23.08		19.33

The frequencies for measurements were determined by the suspect list generated from the shielded room prescan.
**These suspect signal levels were measured to be at or below the background noise and ambient.

Field Strength Measurements

MEASUREMENT PROCEDURE:

1. The EUT was setup to one of the three orthogonal positions.
2. The measurement antenna was positioned in vertical and horizontal polarities.
3. Steps 1-2 were repeated to cover all positions, and polarities.

DUT transmitting at 434MHz,

Freq. MHz	DUT position	Ant. Pol.	Corrected Data Peak Detector dBuV/m	**Duty Cycle Factor dB	Calculated Average Level dBuV/m	FCC Limit 15.231e dBuV/m	Margin dB	Cable +Ant. Factor dB+dB/m
434	side	V	79.9	16.8	**63.1**	72.9	**9.8**	18.7
868	end	V	65.0	16.8	**48.2**	52.9	**4.7**	25.4
1302	side	V	58.7	16.8	**41.9**	54.0	**12.1**	27.3
1736	end	V	54.9	16.8	**38.1**	54.0	**15.9**	31.0
2170	side	V	58.5	16.8	**41.7**	54.0	**12.3**	33.6
2604	end	V	53.3	16.8	**36.7**	54.0	**17.3**	33.3
3038	end	V	52.3	16.8	**35.5**	54.0	**18.5**	34.8
3472	side	V	43.4	16.8	**26.6**	54.0	**27.4**	35.9
3906	-	-	42 in noise floor	16.8	**<25.2**	54.0	**>28.8**	36.9
4340	-	-	42 in noise floor	16.8	**<25.2**	54.0	**>28.8**	36.8

**Duty Cycle factor can vary from approximately 16.8dB to 19.6dB and is the dB term derived on page 20. 16.8dB is used in the table above because it determines the highest possible calculated level of the RF emission from the unit under test.

APPENDIX A

Modulation Characteristics and Duty Cycle Calculations

An encoded transmission consists of defined train of Forty-Six 225uSec pulses.
The encoding of the logical 1's and 0's is determined by the space (off time) between the pulses.

The off time of approximately 1.2mSec determines the logical "0"(zero).
The off time of approximately 1.9mSec determines the logical "1"(one).

The pulse train consists of
1. Four Preamble (0.225mS) pulses separated by approximately 1.24mSec off time
2. An 'off' time of approximately 6.75mSec.
3. Forty-Two (0.225mS) pulses separated by 'off' time of either 1.24mSec or 1.91mS.

If all forty-two encoding pulses are separated by 1.24mS, then the average value of the emission is calculated as follows:

Pulse on time:

1. Total pulses on time 46x0.225mS		10.35 mS

Pulse train length:

1. Preamble on time 4x.225mS	0.90 mS	
2. Preamble off time 3x1.24mS	3.72 mS	
3. Preamble space time 6.75mS		6.75 mS
4. Encoded pulses 42x0.225mS		9.45 mS
5. Encoded off time 41x1.24mS		50.84 mS
TOTAL pulse train length		71.66 mS

Duty cycle factor (average time on) is:

1. Numeric factor: (10.35mS / 71.66mS)	=	0.144
2. dB factor: 20 * LOG(0.144)	=	**-16.8dB**

If all forty-two encoding pulses are separated by 1.91mS, then the average value of the emission is calculated as follows:

Pulse on time:

1. Total pulses on time 46x0.225mS		10.35 mS

Pulse train length:

1. Preamble on time 4x.225mS	0.90 mS	
2. Preamble off time 3x1.24mS	3.72 mS	
3. Preamble space time 6.75mS		6.75 mS
4. Encoded pulses 42x0.225mS		9.45 mS
5. Encoded off time 41x1.91mS		78.31 mS
TOTAL pulse train length		99.13 mS

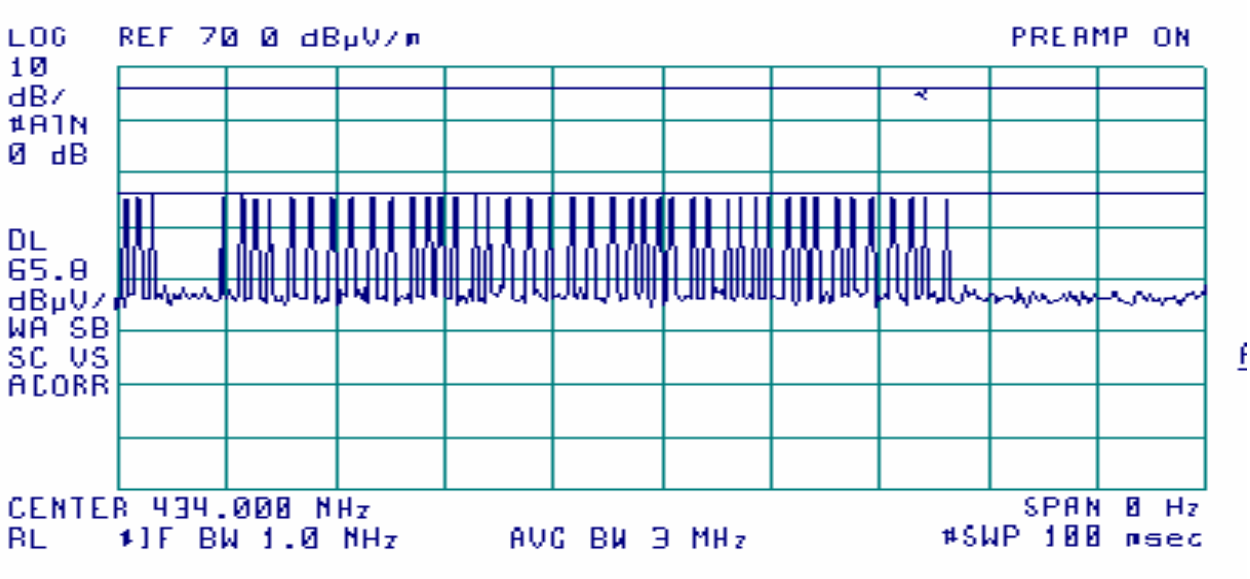
Duty cycle factor (average time on) is:

1. Numeric factor: (10.35mS / 99.13mS)	=	0.104
2. dB factor: 20 * LOG(0.104)	=	**-19.6dB**

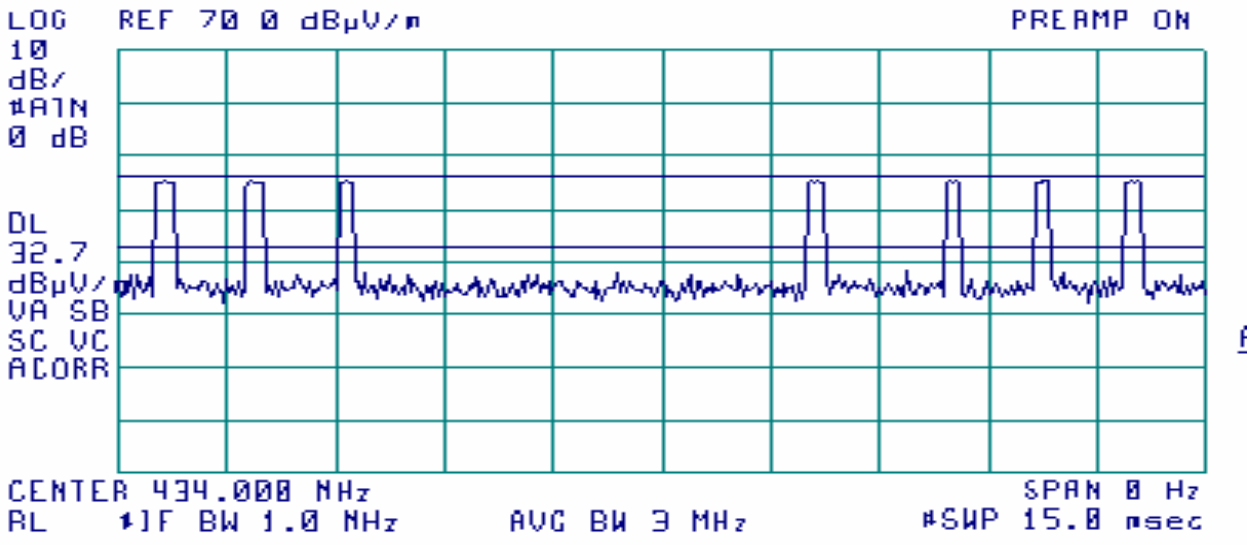
The following page shows captures views of typical encoded transmissions.

APPENDIX A

Typical encoding packet:



Typical encoding showing spaces between the pulses:



Test Data from test 0100446F82 issued 08/15/01

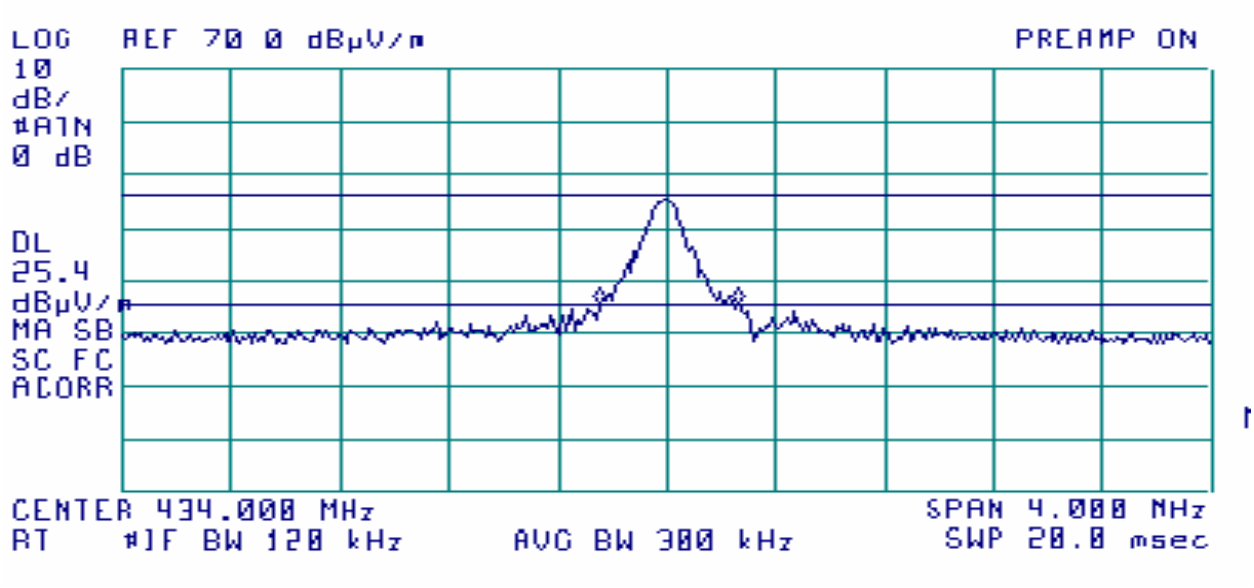
Occupied Bandwidth [15.231(c)]

The maximum allowed 20dB bandwidth is determined pursuant to 15.23(c). For fundamental signals between 70MHz and 900MHz the bandwidth allowed is 0.25% of the fundamental.

Formula 2: Allowed bandwidth = [Fundamental] x [.0025]

Fundamental (MHz)	Measured 20dB Bandwidth	LIMIT Fundamental * .0025
434	510 KHz	1085 KHz

This chart shows the measured bandwidth signal.



APPENDIX B

General Measurement Procedures

Line Conducted

The system was placed upon a 1 x 1.5 meter non-metallic table 80cm from the ground floor and 40cm from the vertical conducting plane in the prescribed setup per ANSI C63.4, Figure 9(a). This table is housed in a shielded enclosure to prevent the detection of unwanted ambients.

The host computer housing the EUT was connected to the LISN being monitored by the EMI Receiver. The remaining support devices requiring 115Vac power were connected to a second LISN.

The EUT was continuously exercised by methods (i.e. software) supplied by the manufacturer.

While monitoring the display of the EMI Receiver, via remote video monitor, the cables were manipulated to determine a position that maximized the emissions being observed. Once the highest amplitude relative to the limit was determined for the Phase current carrying line the procedure was repeated for the Neutral current carrying line.

The configuration that created an emission closest to the limit was used during the course of taking final measurements. Pictures of this final configuration are recorded in this report.

The principal settings of the EMI Receiver for line conducted testing include:

Bandwidth = 9KHz

Detector Function: scanning and signal search = Peak Detection Mode
measurements = Quasi Peak Detection

The cable losses of the coax used in line conducted testing is charted in this appendix.

Radiated

The system was placed upon a 1 x 1.5 meter non-metallic table 80cm from the open field site ground plane in the prescribed setup per ANSI C63.4, Figure 9(c).

The table sits upon a remote controlled turntable. The receiving antenna, located at the appropriate standards distance of 3 or 10 meters from the table center, is also remote controlled.

The EUT was continuously exercised by methods (i.e. software) supplied by the manufacturer.

Preliminary tests were done at the 3 meter open field test site. The final tests are done at the appropriate standards distance of 3 or 10 meters. The "Biconical/Log Periodic" broadband antenna connected to an EMI Receiver, meeting CISPR 16, is used throughout the testing.

During the preliminary scans and while monitoring the display of the EMI Receiver, the turntable was rotated 360 degrees and the receiving antenna height varied from 1 to 4 meters to search out the highest emissions. At the significant emissions, the cables were manipulated to determine a position that maximized the emissions being observed. Once the cable position was determined that presented the highest amplitude relative to the limit for Vertical polarized emissions the procedure was repeated for the Horizontal polarization.

The configuration that created an emission closest to the limit was used during the course of taking final measurements. Pictures of this final configuration are recorded in this report.

The principal settings of the EMI Receiver for radiated testing include:

Bandwidth:	120KHz
Detector Function:	scanning and signal search = Peak Mode
	measurements = Quasi Peak Mode.
Search Range:	30MHz to 1000MHz or 2000MHz

The cable loss of the coax used in radiated scanning is charted in this appendix.

The antenna factors, for the test distance used, are charted in this appendix.

The resultant Field Strength (FS) is a summation in decibels (dB) of the Indicated Receiver Level (RF), the Antenna Correction Factor (AF), and the Cable Loss Factor (CF). If a PreAmplifier (PA) is used, its gain (dB) is subtracted from the above sum.

Formula 1: $FS(dBuV/m) = RF(dBuV) + AF(dB/m) + CF(dB) - PA(dB)$

To convert the Field Strength dBuV/m term to uV/m, the dBuV/m is first divided by 20. The Base 10 AntiLog is taken of this quotient. The result is the Field Strength value in uV/m terms.

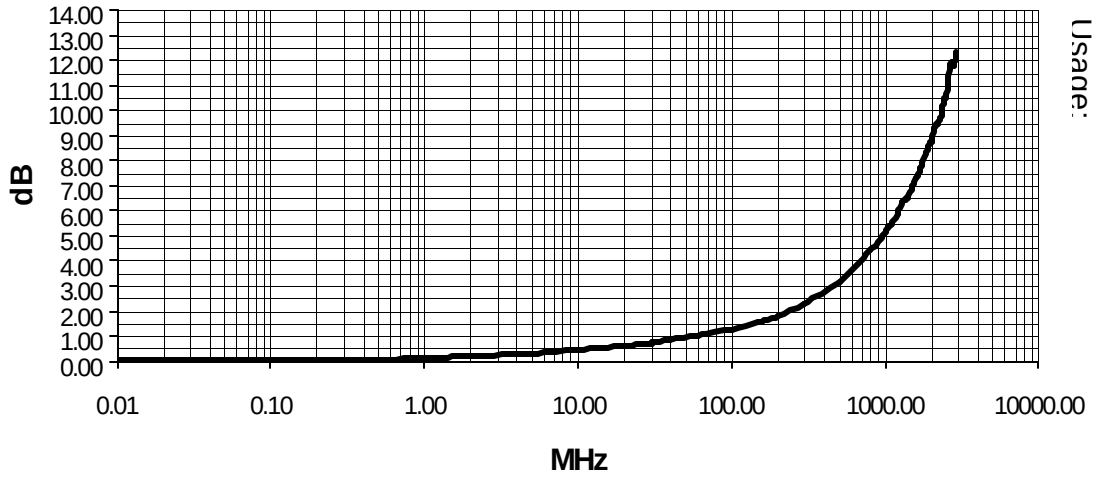
Formula 2: $FS(uV/m) = AntiLog[(FS(dBuV/m))/20]$

APPENDIX B

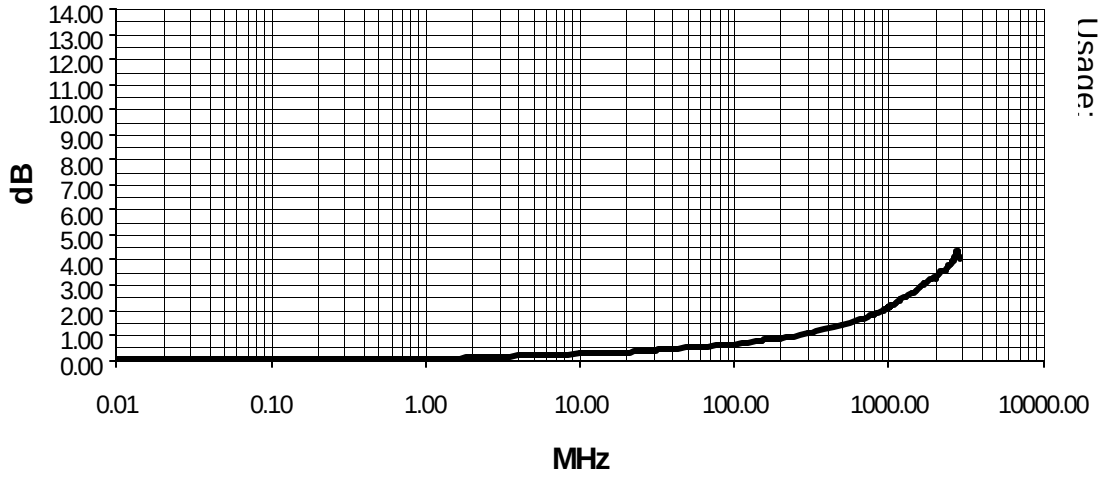
Cable Loss

Attenuation of coax cables used during this test.

Line Conducted 150KHz through 30MHz
Coax #920809
between LISN and EMI Receiver
Last Calibration date: June 11, 2001



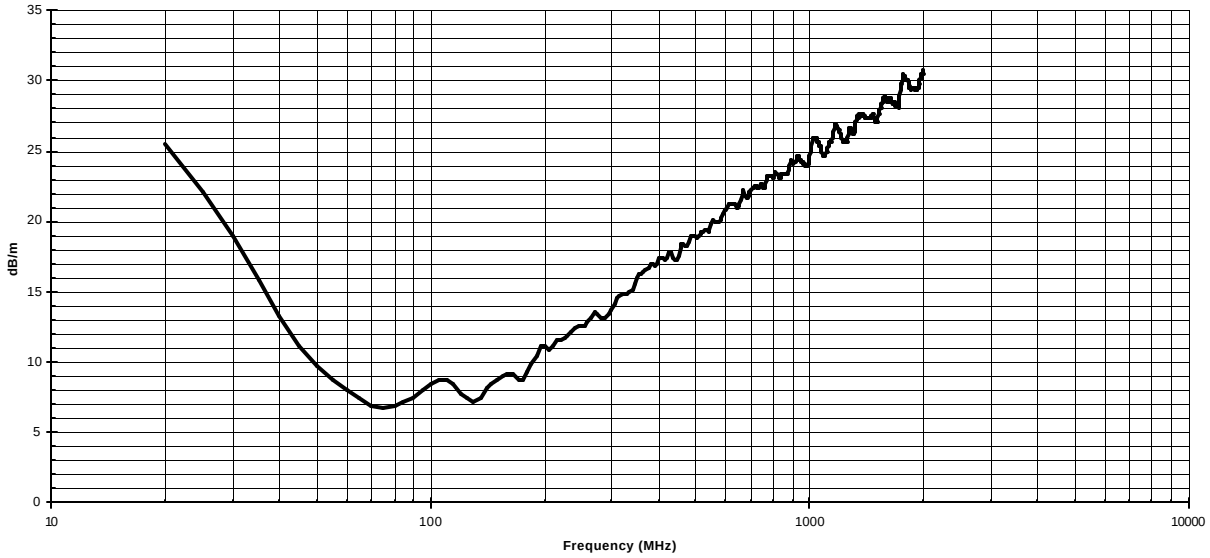
Radiated at 3 meters; 30MHz through 2000MHz
Coax #9812_11
between Antenna and EMI Receiver
Last Calibration date: June 08, 2001



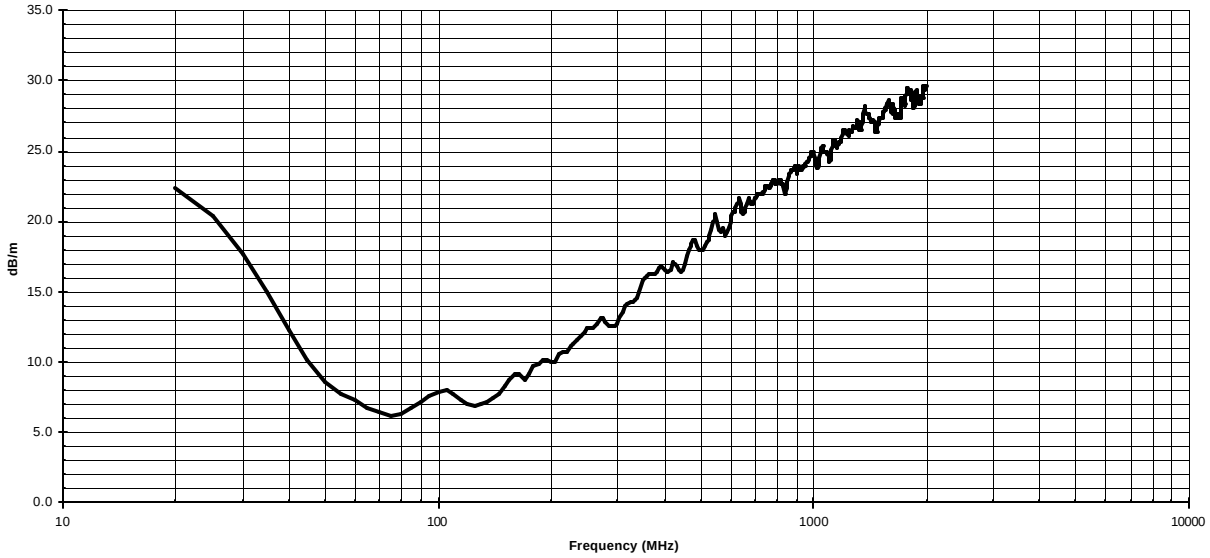
Antenna Factors

EMCO Model 3142 Antenna #9608-1077
Last Calibration Date; August 24, 2001

3 Meter Distance Factors

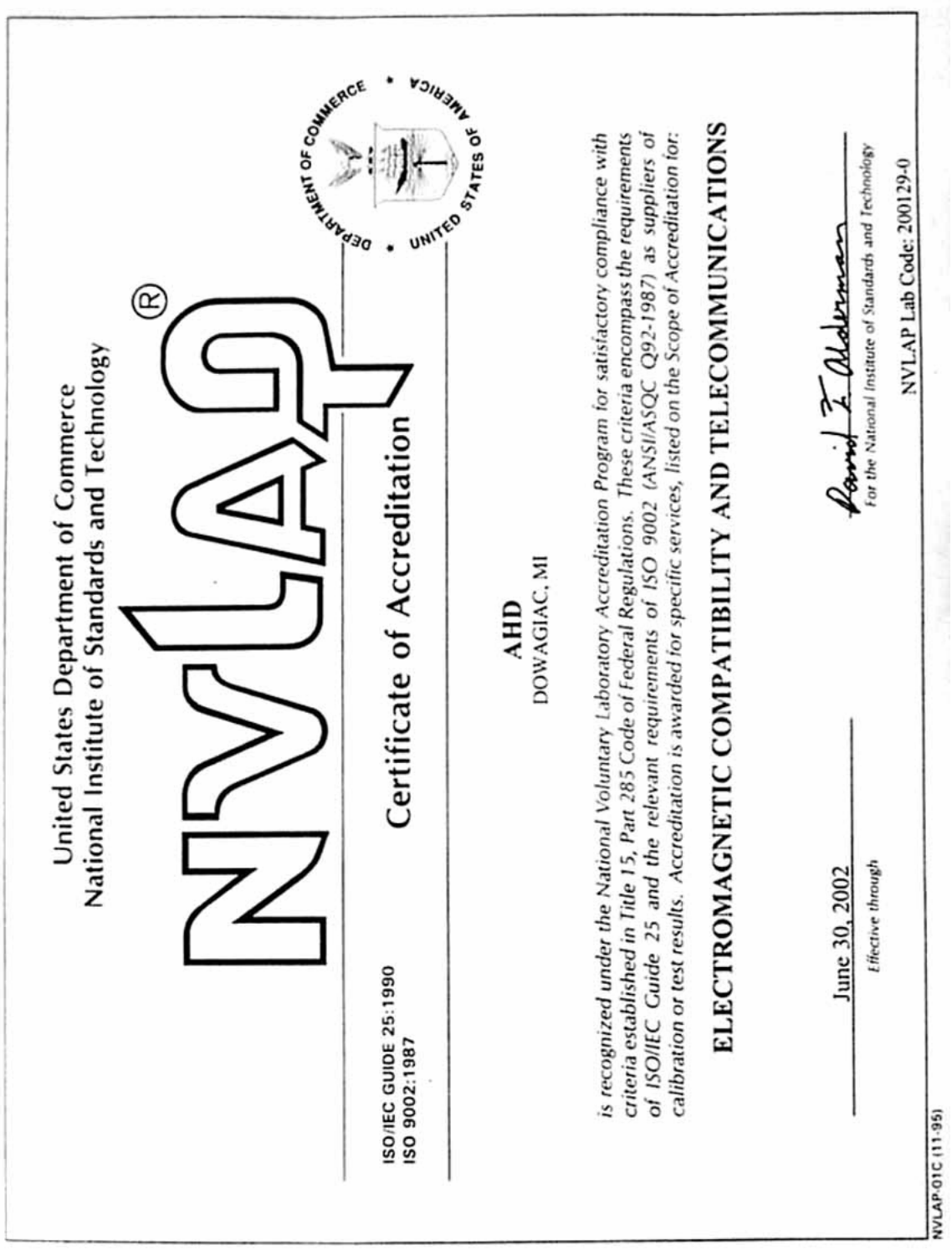


10 Meter Distance Factors



APPENDIX B

AHD Accreditation



United States Department of Commerce
National Institute of Standards and Technology

NVLAP®

DEPARTMENT OF COMMERCE • UNITED STATES OF AMERICA

Certificate of Accreditation

ISO/IEC GUIDE 25:1990
ISO 9002:1987

AHD
DOWAGIAC, MI

is recognized under the National Voluntary Laboratory Accreditation Program for satisfactory compliance with criteria established in Title 15, Part 285 Code of Federal Regulations. These criteria encompass the requirements of ISO/IEC Guide 25 and the relevant requirements of ISO 9002 (ANSI/ASQC Q92-1987) as suppliers of calibration or test results. Accreditation is awarded for specific services, listed on the Scope of Accreditation for:

ELECTROMAGNETIC COMPATIBILITY AND TELECOMMUNICATIONS

June 30, 2002
Effective through

For the National Institute of Standards and Technology

NVLAP Lab Code: 200129-0

NVLAP-01C (11-95)

FEDERAL COMMUNICATIONS COMMISSION
Laboratory Division
7435 Oakland Mills Road
Columbia, MD. 21046

July 14, 2000

Registration Number: 90413

AHD EMC Laboratory
92723 M-152
Dowagiac, MI 49047

Attention: Ted Chaffee

Re: Measurement facility located at Sister Lakes
3 & 10 meter site
Date of Listing: February 02, 2000

Gentlemen:

Your submission of the description of the subject measurement facility has been reviewed and found to be in compliance with the requirements of Section 2.948 of the FCC Rules. The description has, therefore, been placed on file and the name of your organization added to the Commission's list of facilities whose measurement data will be accepted in conjunction with applications for Certification under Parts 15 or 18 of the Commission's Rules. Please note that this filing must be updated for any changes made to the facility, and at least every three years from the date of listing the data on file must be certified as current.

If requested, the above mentioned facility has been added to our list of those who perform these measurement services for the public on a fee basis. An up-to-date list of such public test facilities is available on the Internet on the FCC Website at WWW.FCC.GOV, E-Filing, OET Equipment Authorization Electronic Filing.

Sincerely,

Thomas W. Phillips

Thomas W Phillips
Electronics Engineer