SMITH ELECTRONICS, INC.
ELECTROMAGNETIC COMPATIBILITY LABORATORIES

Radio Frequency Emissions Report
FCC Certification Data
on the
Audiopack Technologies, Inc.
Draeger HUD Transmitter

December 20, 2002
Revised table 1 February 5, 2003

Prepared by: James R. Pollock

Prepared for: Audiopack Technologies, Inc.
4933 Neo Parkway
Garfield Heights, OH 44128

Smith Electronics, Inc.
8200 Snowville Road
Brecksville, OH 44141
Phone: (440) 526-4386
Fax: (440) 526-9205

CERTIFICATE OF COMPLIANCE

1.	Applicant:	Audiopack Technologies, Inc. 4933 New Parkway Garfield Heights, OH 44128
2.	Manufacturer:	Same
3.	Contact:	Joe Birli, Audiopack, 216/332-7040
4.	Regulation	CFR47-Part 15B - C 15.109, 15.201, 15.209
5.	Measurement Method:	ANSI C63.4-1992
6.	Type:	Transmitter to transmit tank air pressure data to mask mounted receiver/indicator
7.	Frequency:	37.0 kHz
8.	Dates of Tests:	December 10 – 12, 2002
9.	Place of Tests:	Smith Electronics, Inc., Test Lab 8200 Snowville Road Brecksville, OH 44141 OATS located at same address

10. Statement of Compliance:

I hereby certify that the measurements of radio frequency emissions from the Audiopack HUD transmitter were performed by me between December 10 and 12, 2002, and that the results of the measurements confirmed that the prototype unit tested is capable of compliance with the above regulations for an intentional radiator and for a Class A digital device.

December 20, 2002
Date

James R. Pollock
President

INTRODUCTION:

The device tested is designed to be connected in line with an emergency worker's air or oxygen supply line and to transmit rough air pressure values to a companion receiver located in the individuals field of view where colored lights indicate air status. The battery operated transmitter's frequency of operation is 37.0 kHz and a ferrite core loop antenna is totally contained within the housing and is not accessible to the user. The ±1.8 kHz FSK modulation produces a dual peak on the spectrum analyzer at 37 ±1.8 kHz as the fundamental frequency. The transmitter has no operator controls but does contain a microprocessor running at 4 MHz.

EMISSIONS MEASUREMENTS:

The emissions from the transmitter portion of the device were investigated from the lowest frequency of operation (35.2 kHz), to 30 MHz (¶15.33). The emissions from the digital device portion of the device were examined from 30 MHz – 1000 MHz. As the device is battery powered, no conducted emissions measurements were performed.

RADIATED EMISSIONS, TRANSMITTER:

The emissions from the transmitter were first examined in the shielded room using a shielded loop antenna at close range. Using the information from this test, the test equipment was moved to an open area in which measurements could be made with little or no effect from reflecting objects. Even at a distance of 2 m, only the first frequency pair could be detected. Measured values of these two frequencies were made using the loop antenna, rotating the transmitter to maximize the measured value and also orienting the transmitter along each of three orthogonal axes. The maximum values obtained using a 3 kHz bandwidth were recorded.

The peak values of these emissions, along with appropriate correction factors are shown in Table 1 below.

Table 1
Transmitter Fundamental

Freq. (MHz)	Value (dBuV) @2 m	Ant. Fact (dB)	dBuV/m @2 m	dBuV/m @ 300 m*	uV/m @ 300 m	Limit (uV/m) @300 m	Diff. (dB)
35.2	33.7	58	91.7	4.7	1.7	68.2	-32.1
38.8	32.7	57	89.7	2.7	1.4	61.9	-32.9
	Value (dBuV) @1m		**dBuV/m @1 m**				
68.9	20.6	56	76.6	-22.4	0.07	34.8	-53.9
76.8	24.7	56	80.7	-18.3	0.12	31.3	-48.2
103.4	22.8	54	76.8	-22.2	0.078	23.2	-49.5
115.4	21.5	54	75.5	-23.5	0.067	20.8	-49.9
137.8	13.5	54	67.5	-31.5	0.027	17.4	-56.3
172.2	11.1	54	65.1	-33.9	0.020	13.9	-56.8
192.6	9.4	54	63.4	-35.6	0.014	12.5	-57.5
203.8	12.1	54	66.1	-32.9	0.023	11.6	-54.2
241.4	14.1	54	68.1	-30.9	0.029	9.9	-50.7
				dBuV/m @ 30 m*	**uV/m @ 30 m**	**Limit (uV/m) @30 m**	
980	12.0	43	55.0	-4.0	0.63	24.5	-36.7
2250	8	35	43.0	-16.0	0.16	30.0	-45.5

Notes:

2 meter measurements converted to 300 m by subtracting 87 dB. (Inverse distance squared)

1 meter measurements converted to 300 m by subtracting 99 dB. (Inverse distance squared)

1 meter measurements converted to 30 m by subtracting 59 dB. (Inverse distance squared)

Reading at 2250 kHz has 26 dB amplifier gain subtracted to arrive at 8 dB.

* Inverse distance squared from 2m to 300m is an 87 dB reduction.

As none of the harmonics were measurable at the two meter distance, the information obtained in the shielded room at a distance of about 1 meter was used to show that all the harmonics are lower in magnitude than the fundamental. This information is seen in Figs. 1 & 2. In both figures, the red trace is the ambient level and the black trace is the measured level. The bandwidth is set so that the peak level of the transmission is recorded.

Figure 1 covers the range between 30 kHz and 500 kHz, while Fig. 2 covers from 500 kHz to 30 MHz. The calculated limit adjusted to 1 meter is also shown on each plot. As can be seen from the table and the plots, all peak emissions from the transmitter are more than 30 dB below the limits of 15.209.

RADIATED EMISSIONS, DIGITAL DEVICE:

As the transmitter does contain a microprocessor, it qualifies as a Class A digital device. The emissions of this part of the system were first examined in the shielded room where the lower ambient level makes determining the presence of emissions easier. These emissions were measured at a distance of one-meter using linearly polarized antennas in both horizontal and vertical modes. Figures 3 & 4 show the data obtained and a comparison to the Class A limit. At approximately 48 MHz, the indicated emission is about 20 dB below the Class A limit. Experience with in-room measurements indicates that readings in this area of the spectrum typically read significantly higher in the room than on the open area test site (OATS). This was borne out again as the transmitter was taken to the OATS and examined for emissions.

On the OATS, even at a distance of 1.3 m, no good measurement of an emission from the transmitter could be made. At about 46 MHz, the modulation of the transmitter could be detected aurally but the RF level was unchanged with the transmitter on or off. This, and another frequency at 72 MHz with the same conditions are indicated in Table 2.

Table 2
Open Area Emissions

Freq. MHz	Signal dBuV	Antenna Factor	Coax Factor	E UV/m	dB vs. FCC A	Antenna Type
46.0	19	10.4	0.6	31.6	-19.5*	BICON V
72.0	12	8.0	0.8	11.0	-28.7*	BICON H

*FCC limit adjusts to 300 uV/m at 3m. Measurements made at 1.3m but assumed to be at 3m. Further adjustment to the 1.3m would result in another 7 dB of clearance from the limit.

No emissions were observed within 19.5 dB of the Class A limit. The transmitter as a digital device is capable of compliance with the requirements of a Class A digital device as found in 15.109.

Sample Calculations:

1. Field Strength In order to calculate field strength from an antenna voltage reading, the antenna factor, any coax loss or amplifier gain must be accounted for as shown in Eq. 1.

$$FS = V + AF + CL - A \qquad \text{Eq. 1}$$

where: FS = field strength dBuv/m)
V = measured value of antenna output voltage (dBuV)
AF = antenna factor (dB)
C = coax losss (dB)
A = amplifier gain, if used (dB)

From Table 2, the measured value at 46 MHz was 19 dBuV, the antenna factor is 10.4 dB and the coax loss is 0.6 dB. No amplifier was used for this measurement. Replacing these values into Eq. 1 gives:

$$19 + 10.4 + 0.6 - 0 = 30 \text{ dBuV/m}$$

To convert dBuV/m to uV/m, the following equation is used:

$$E = \text{antilog}(FS/20)$$

or $10^{(30/20)}$ = 31.6 uV/m.

2. Adjusted limits. Instead of adding and subtracting factors to the measured values to determine field strengths in relation to limits, the limits can be adjusted by using the same factors. This is useful for a non-computerized spectrum analyzer as it allows the limits to be placed on the plot without changing the indicated signal levels. When adjusting the limit instead of the measured values, the correction factors are applied using the opposite functions. Equation 2 would be used to adjust a limit for a system that does not allow adjusting the measured values.

$$CL = L - AF - CL + A \ (+/-)\ D \qquad \text{EQ. 2}$$

where: CL = calculated limit (dBuV/m)
L = specification limit (dBuV/m)
AF = antenna factor (dB)
CL = coax loss (dB)
A = amplifier gain (dB)
D = distance correction factor (dB)

The distance correction factor can be positive or negative depending on whether the measurement distance is more or less than the specification distance. In the case of the transmitter fundamental measurement, the measurement distance was 2 m and the specification distance was 300 m. The distance correction factor would be based on the ratio of the two distances, (2/300) and since the frequency is below 30 MHz the correction factor would be:

$$40 \log (2/300) \text{ or } -87 \text{ dB}$$

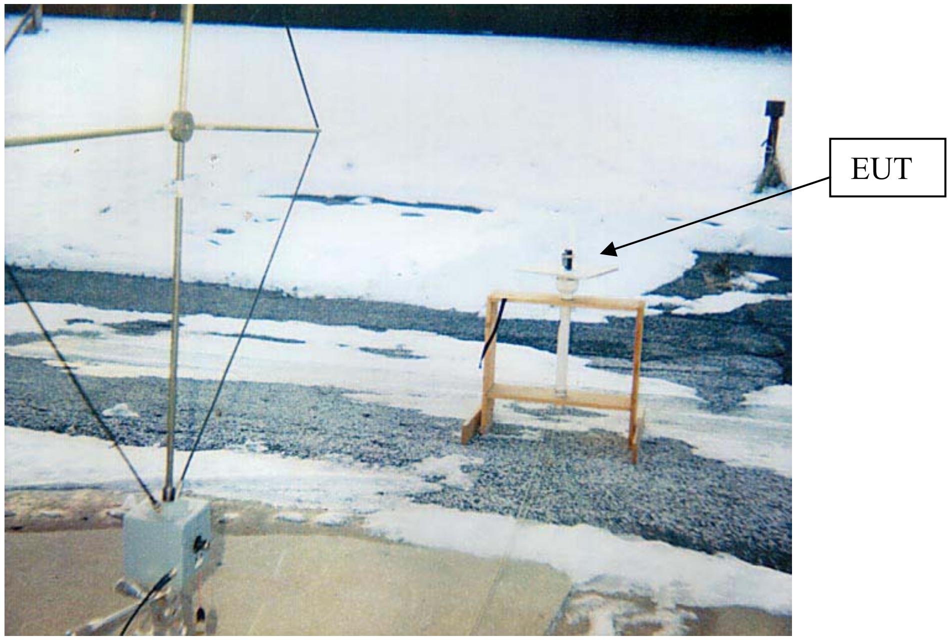
If the field strength were being adjusted to the greater distance, the 87 dB would be subtracted from the field strength value. If the limit were being adjusted to the nearer distance, the 87 dB would be added to the specification limit. For frequencies above 30 MHz, the distance correction factor would be :

$$20 \log (d_1/d_2)$$

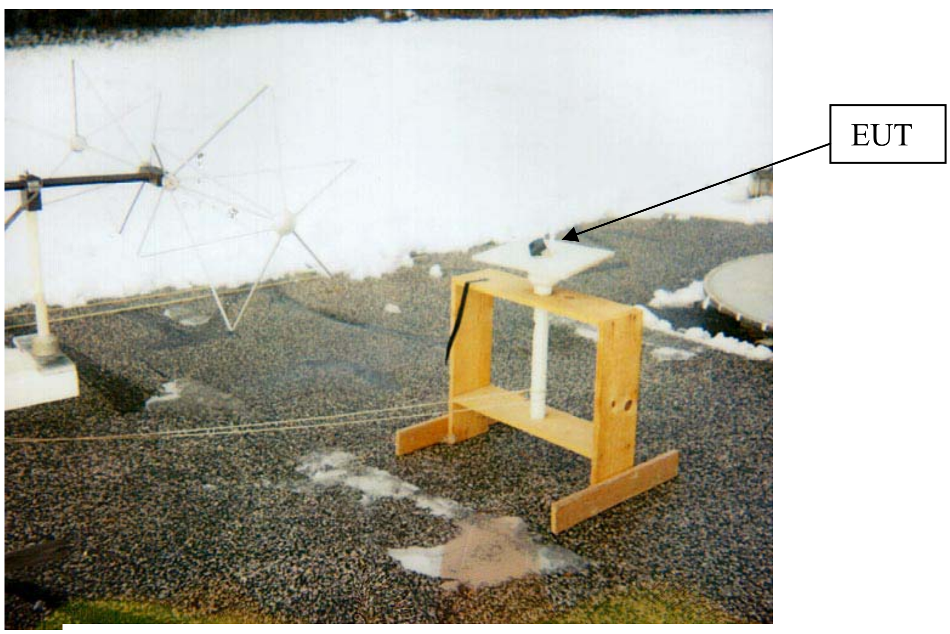
where d_1 and d_2 are the distances involved.

Conclusion:

Based on the measurements of the transmitter's RF output signal, the transmitter does meet the requirements for an intentional radiator operating at about 37 kHz. Based on the measurements of the emissions from the digital device portion of the transmitter, it meets the requirements for an unintentional radiator and the device as a whole is capable of compliance with the appropriate FCC Rules and Regulations for a certified device.

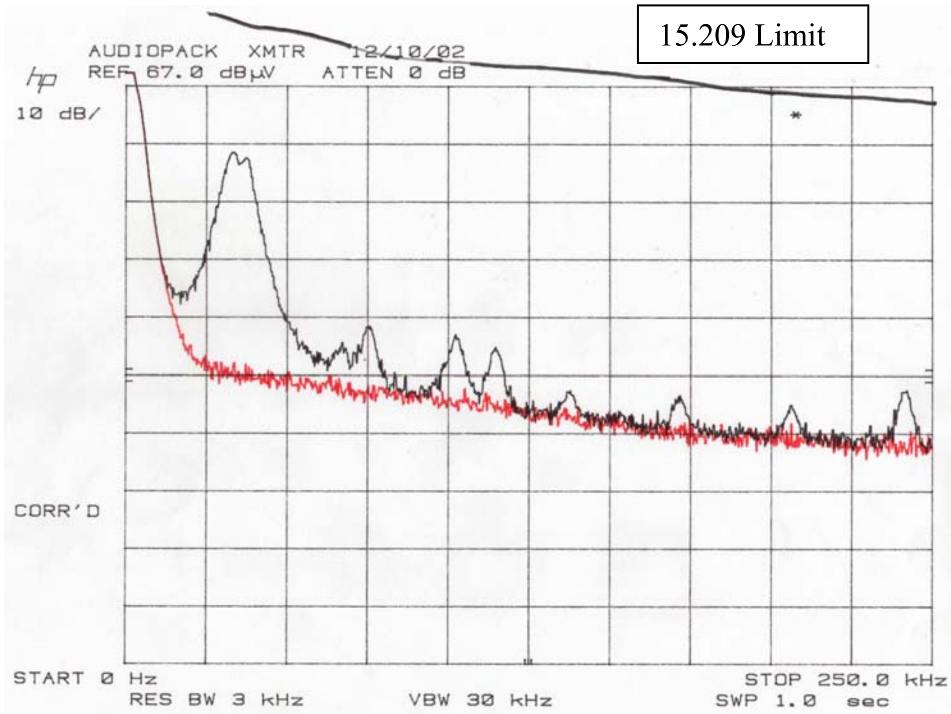


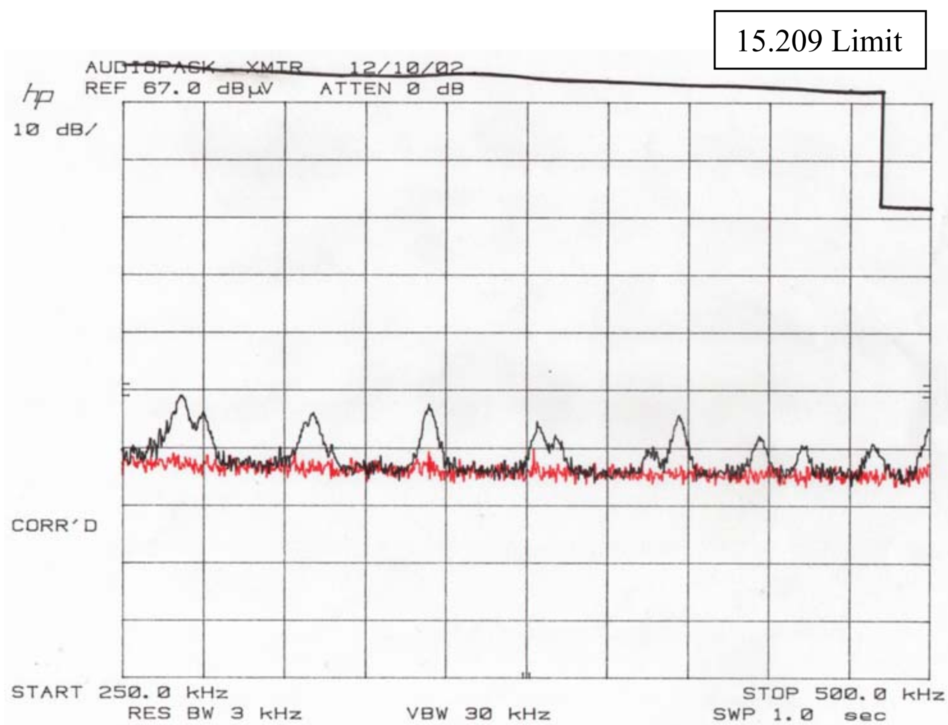
TEST SET UP FOR TRANSMITTER EMISSIONS
AUDIOPACK HUD TRANSMITTER



TEST SET UP FOR DIGITAL DEVICE EMISSIONS
AUDIOPACK HUD TRANSMITTER

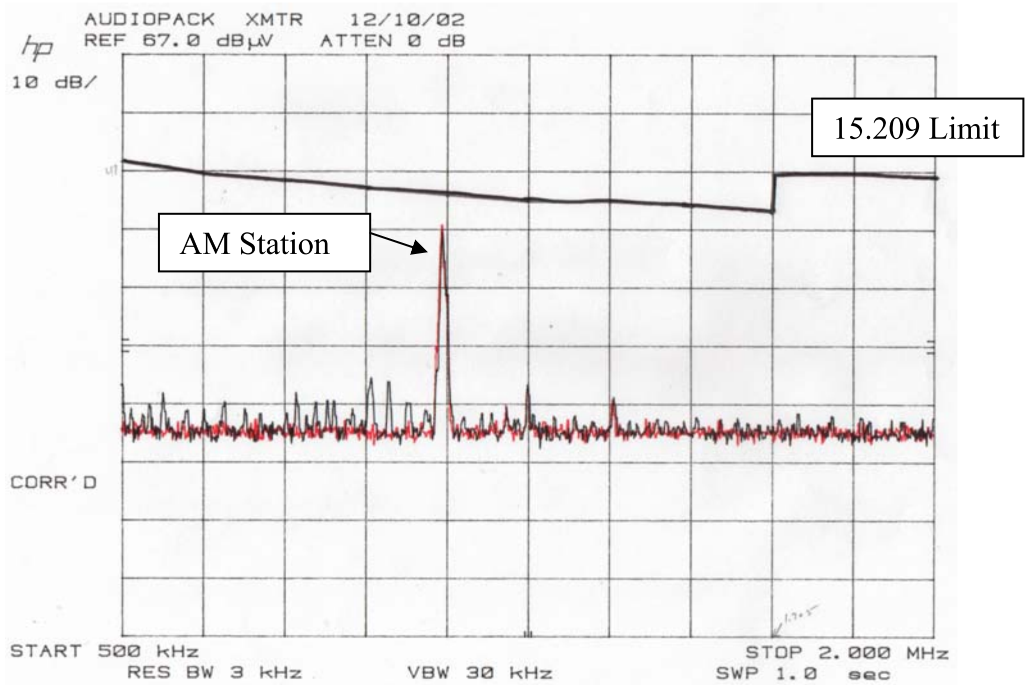
PICTORIAL 1
AUDIOPACK TRANSMITTER
TEST SET UPS

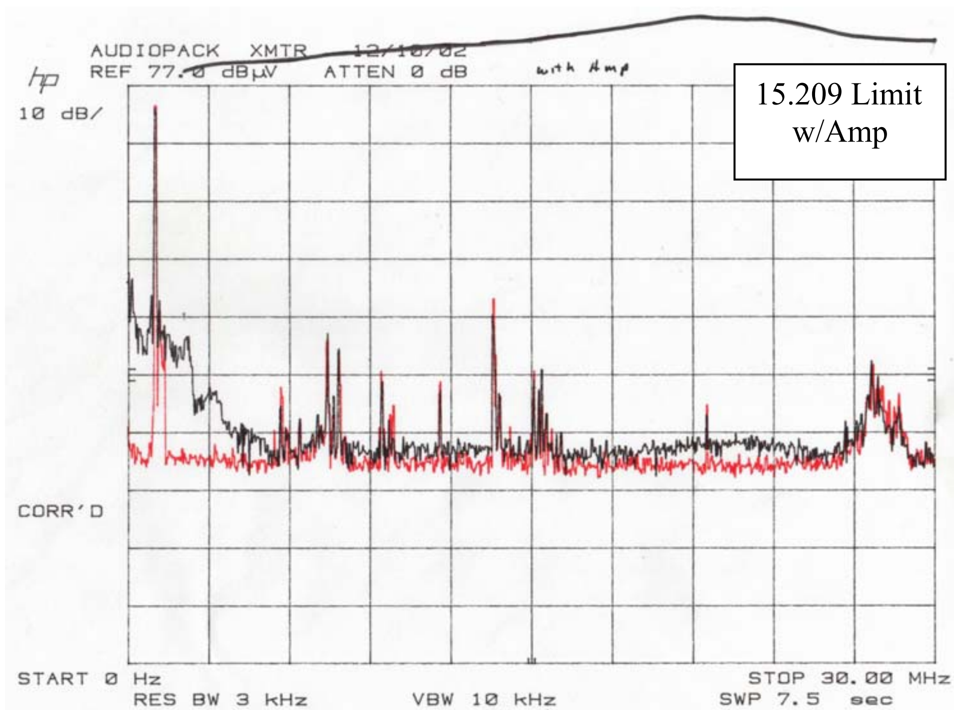




Black = Transmitter on
Red = Ambient

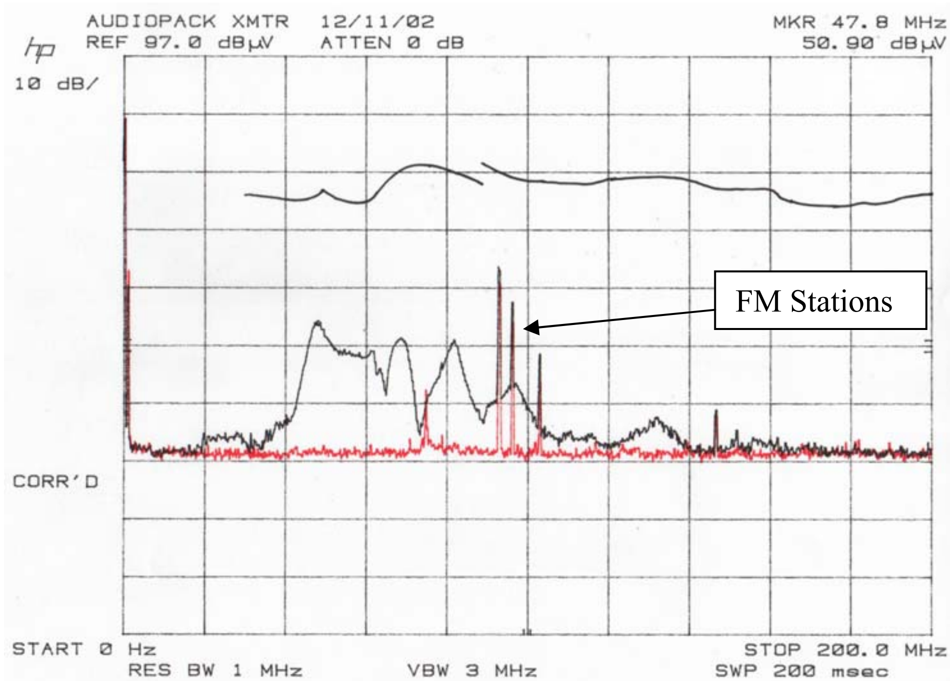
Fig. 1
TRANSMITTER EMISSIONS
AUDIOPACK HUD TRANSMITTER
30 kHz – 500 kHz



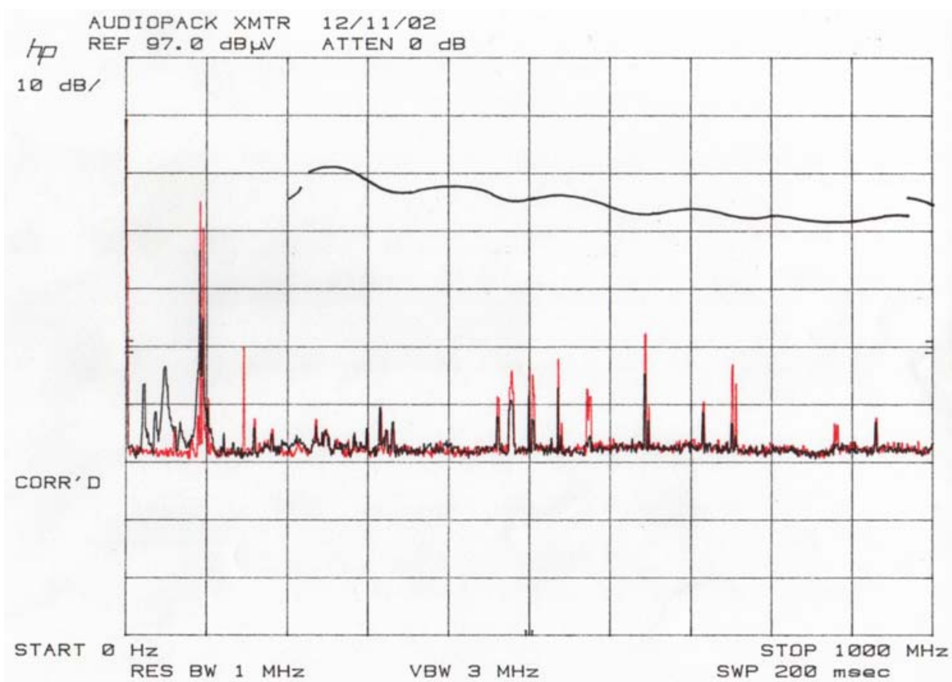


Black = Transmitter on
Red = Ambient

Fig. 2
AUDIOPACK HUD TRANSMITTER
0.5 MHz - 30 MHz



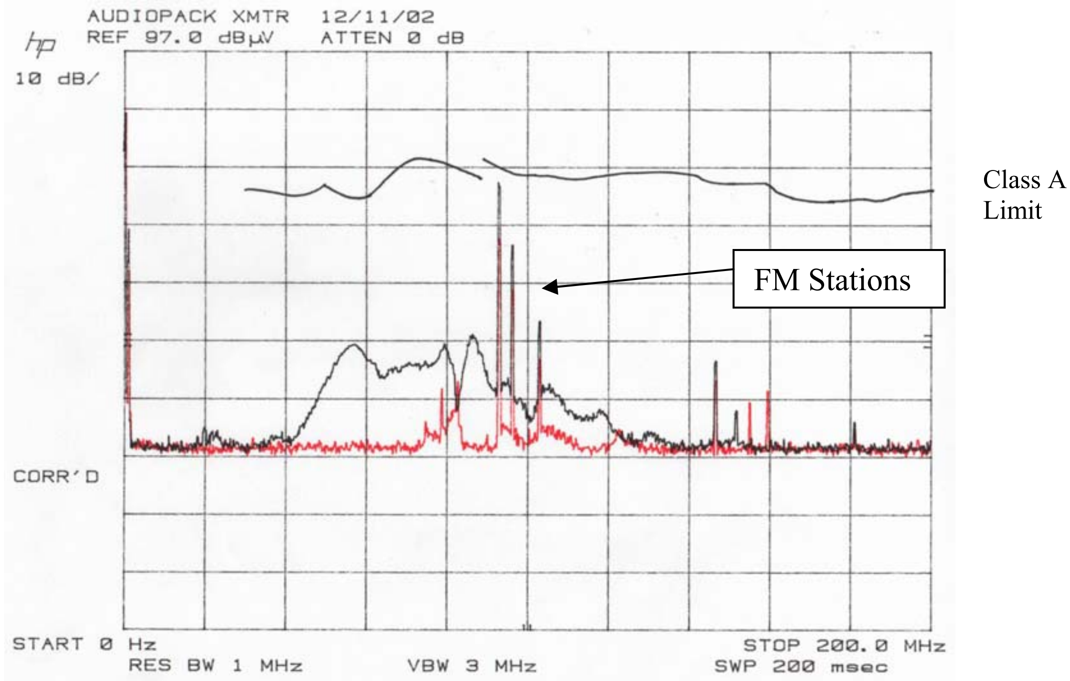
Class A
Limit

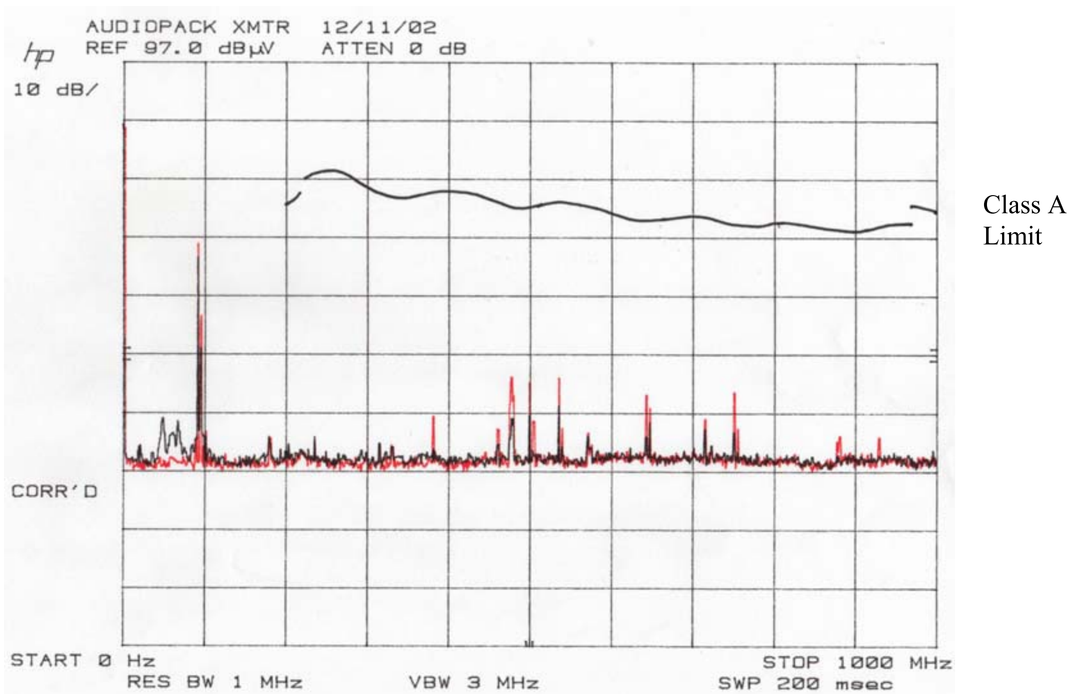


Class A
Limit

Black = Device on
Red = Ambient

Fig. 3
AUDIOPACK HUD DIGITAL DEVICE
30 MHz – 1000 MHz
Vertical Polarization





Black = Device on
Red = Ambient

Fig. 4
AUDIOPACK DIGITAL DEVICE
30 MHz – 1000 MHz
Horizontal Polarization

MEASUREMENT EQUIPMENT

Spectrum Analyzers	Hewlett Packard Type 8568B with 85680A RF Spectrum Analyzer section SN: 2216A02120 85662A display section SN: 2152A03683 Calibrated 6/02 Hewlett-Packard Model 8593EM Calibrated 6/00
Quasi-Peak Adapter	Hewlett Packard Model: 85650A SN: 2043A00350 Calibrated: 6/02
Interference Receiver	Singer Instrumentation Model: NM-37/57 SN: 0366-06168 Calibrated: 6/02
Preamplifier	Hewlett Packard Type 8447D SN: 1726A01282 Gain: 26 dB
Vector Plotter	Hewlett Packard Type 7407A SN: 2308A39494
LISN's	50 uH LISN's per ANSI C63.4-1992
Loop Antenna	Stoddart Model 94593-1 Frequency Range: 10 kHz – 30 MHz
Biconical Antenna	EMCO Model: 3104 Frequency Range: 30-200 MHz
Log Periodic Antenna	EMCO Model: 3146 Frequency Range: 200-1000 MHz
Coaxial Cable	Type RG-214/U 8 m length (shielded room) 12.2 m length (open field)

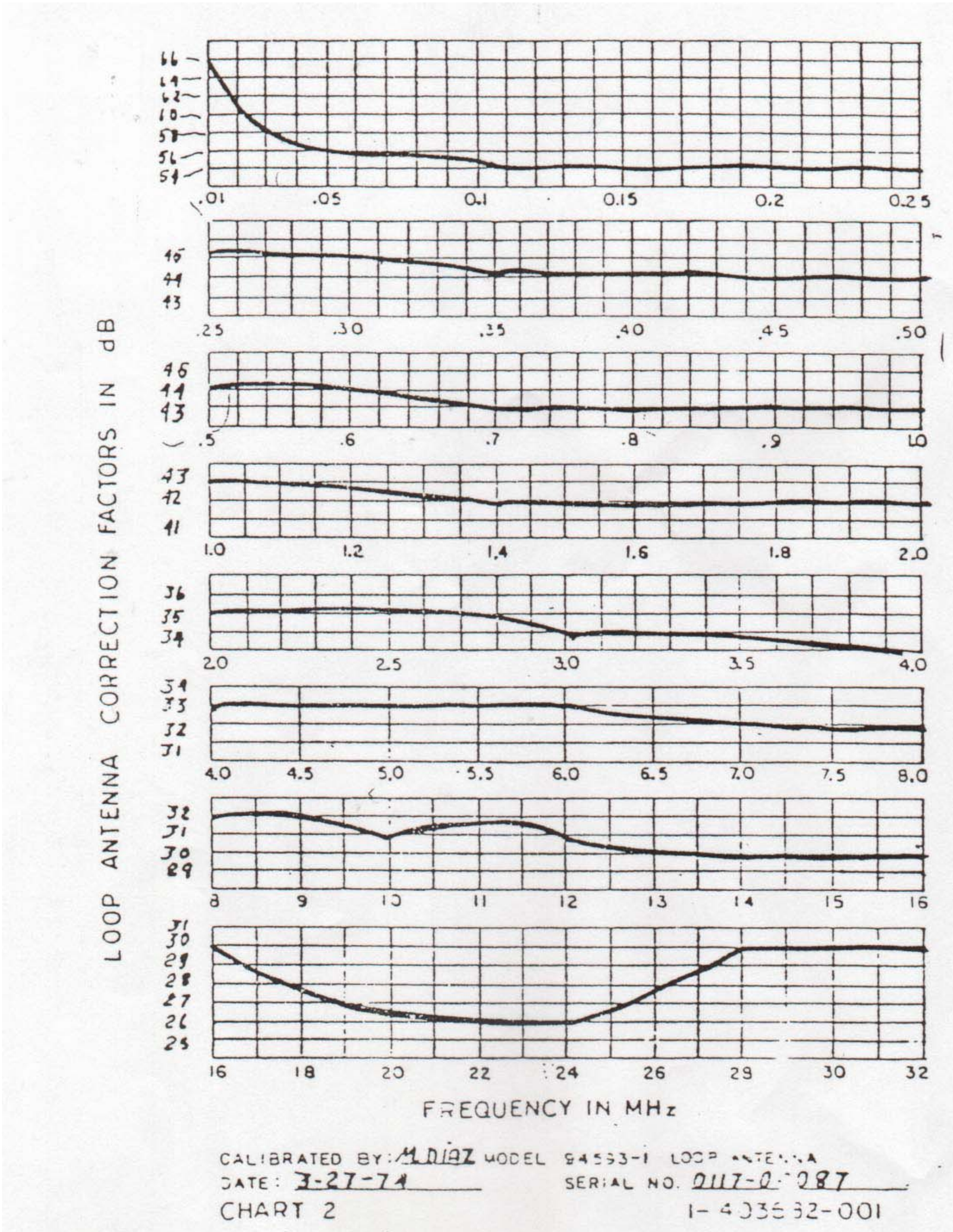
Appendix

Antenna Factors, Loop Antenna

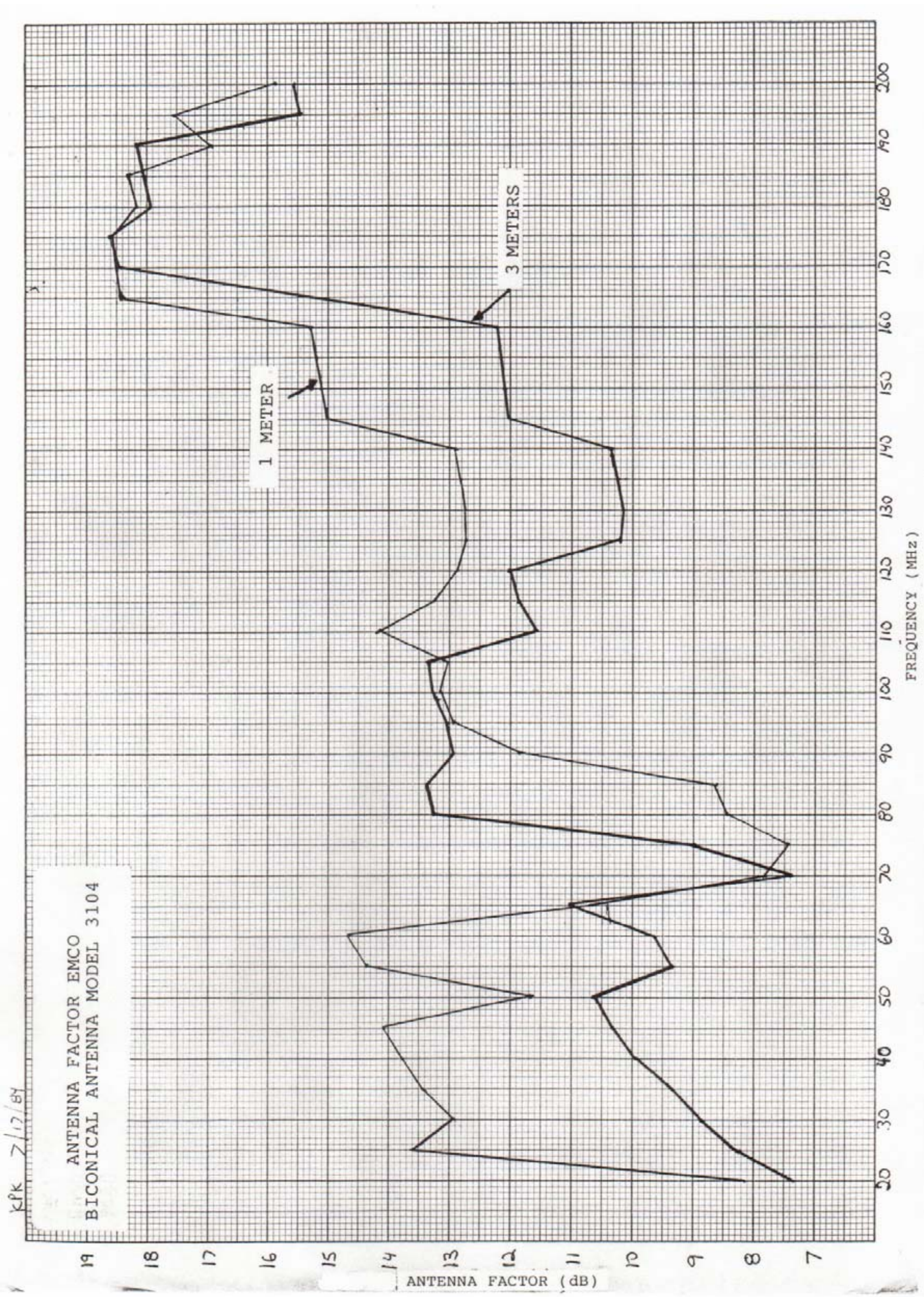
Antenna Factors, Biconical Antenna

Antenna Factors, Log-Periodic Antenna

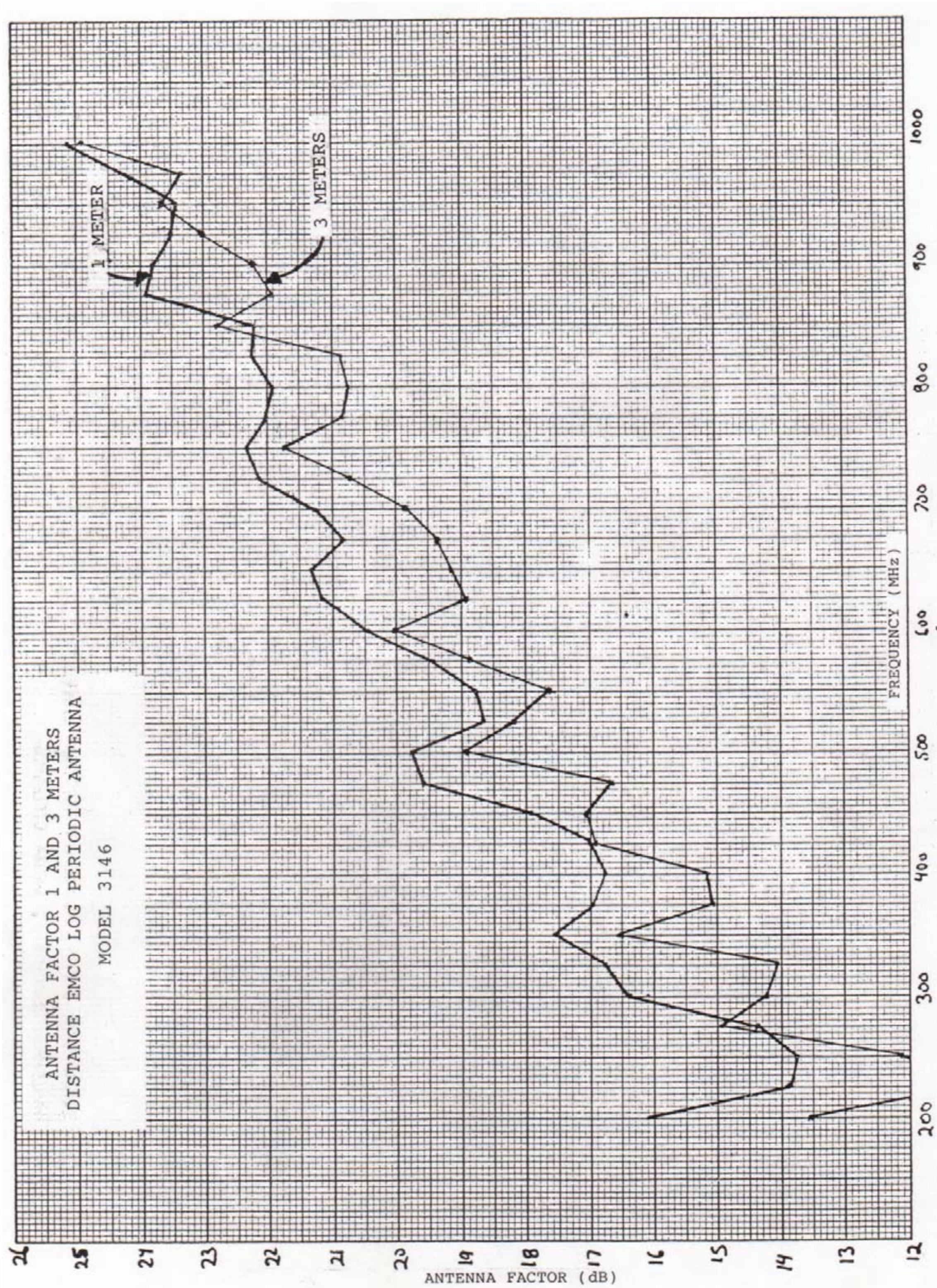
Coax Loss, RG-214/U



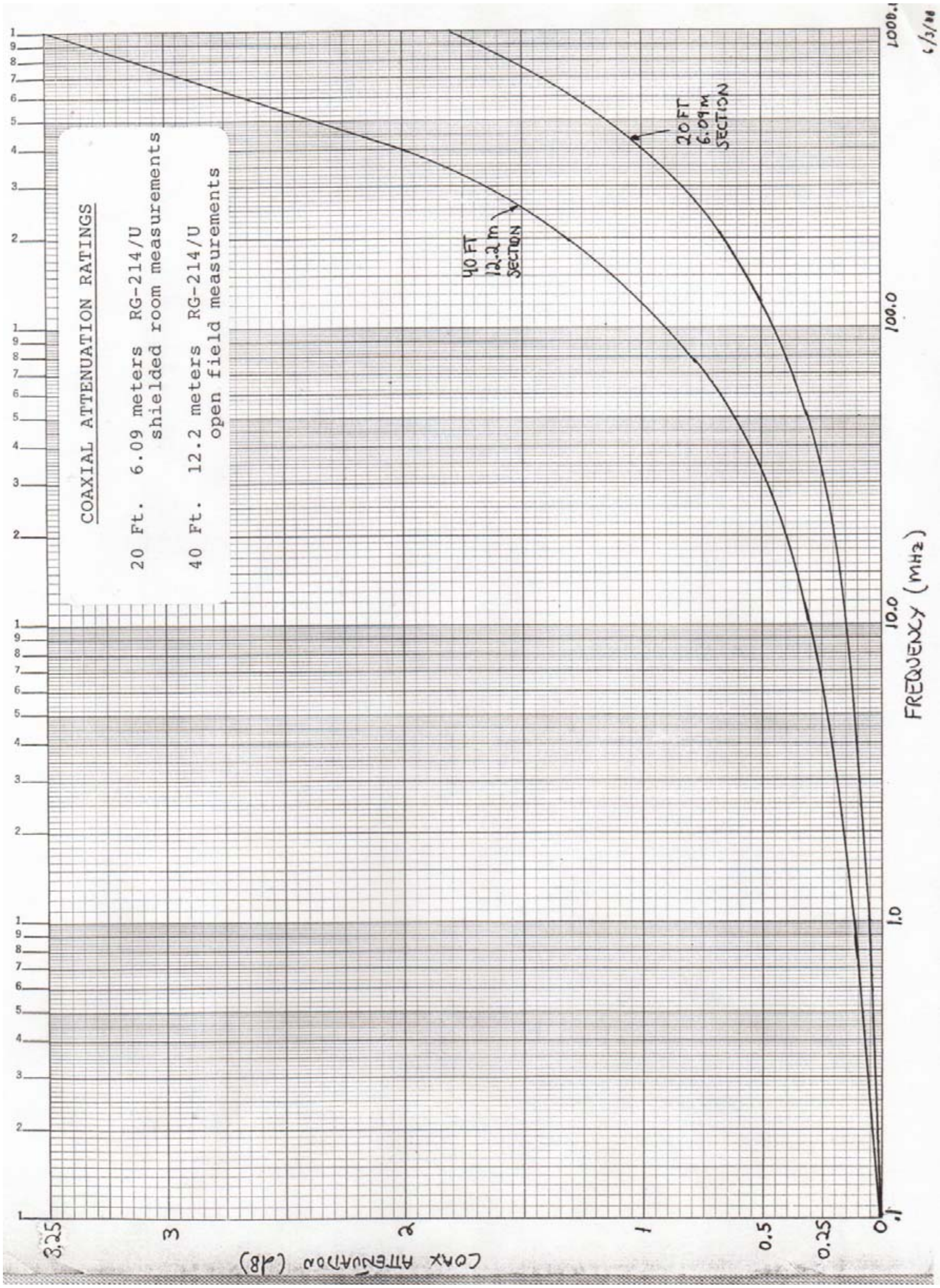
ANTENNA FACTORS
STODDART 94593-1 LOOP



ANTENNA FACTORS
EMCO MODEL 3104 BICONICAL



ANTENNA FACTORS
EMCO MODEL 3146 LOG-PERIODIC



COAX LOSS FACTORS
RG-214/U