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Television Field Strength and Home Receiving System Gain Measurements in Northern Illinois

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U.S. DEPARTMENT OF COMMERCE
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TELEVISION FIELD STRENGTH AND HOME RECEIVING SYSTEM GAIN MEASUREMENTS IN NORTHERN ILLINOIS

R. D. Jennings*

Throughout an area between Chicago and Peoria, Illinois, approximately 50 measurement locations were selected. At each location measurements were made, typically, for two VHF television broadcasts from Chicago and three UHF television broadcasts from either Chicago or Peoria.

Measurements were made using a standard antenna erected on the measurement van to the same height as the home antenna. Cumulative distributions of these measurements were produced from which the median electric field strengths were computed and plotted at each measured Chicago broadcast frequency, as a function of distance from the broadcast (transmitting) antenna. The least squares, linear regression line for each set of data is shown. Also shown are field strengths required by FCC Regulations for Grades A and B Service and the coverage ranges at which each Grade of Service is realized scaled from contours published in the Television Factbook and as computed using an automated model named COVERAGE which uses a modified version of the FCC propagation loss curves (discussed in Appendix B).

Measurements of received signal level also were made using each home antenna system. Using the two types of measured data, cumulative distributions of sample home antenna system gain are presented for each measurement frequency and location in Appendix A. Median values from these cumulative distributions have been chosen as estimates of gain for the home antenna systems.

It is concluded that systems using single-function antennas typically have significantly higher system gain than systems incorporating VHF/UHF combination antennas. Statistical results (median and interdecile values) from the measured data provide the basis for a generalized model for VHF and UHF television receiving antenna system gain. Though home antenna systems can be installed to provide excellent performance, the measurements show that in-service antenna system performance is 0.4 dB to 12.5 dB less than has been assumed.

All the measured data were obtained and are retained in digital form on magnetic tape.

Key words: antenna system gain; electric field strength; gain model; grade of service; measurements; statistical analyses; UHF television; VHF television

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1. INTRODUCTION

The broad concern of comparability between VHF and UHF television arises from a number of competitive and technical impairments that have been termed the "UHF handicap." These impairments have been defined and examined in an FCC staff report (Gieseler et al., 1979). That report classifies the impairments into three areas as follows:

- the channel selection mechanism,
- picture quality, and
- programming.

A number of technical factors that contribute to the picture quality handicap for UHF television are defined in the FCC report. These factors include ghosting, color and sound degradation, and "snow" (a consequence of low signal-to-noise ratio). The level of the received (desired) signal depends upon the effective radiated power of the broadcast transmitter, the propagation medium, and the receiving system which includes the receiving antenna, the transmission line connecting the antenna to the receiver, other components such as impedance matching transformers commonly known as baluns, and signal splitters. Picture quality ultimately is determined by the TV receiver and the received signal-to-noise ratio.

Measurements of received signal levels from television broadcasts were conducted during September 10-21, 1979, at approximately 50 locations throughout an area between Chicago and Peoria, Illinois. At each location, measurements were made, typically at two VHF and three UHF frequencies, using a standard antenna for which gain vs. frequency characteristics were known. From these measurements the electric field strengths subsequently were computed. Received signal levels also were measured at each location using the home antenna system. Gain vs. frequency was computed for the homeowner's antenna system using these two sets of received signal level measurements.

2. APPROACH

The area between Chicago and Peoria, Illinois, in which measurements were made is shown by Figure 1. Along an imaginary line between the cities, measurements were made at approximately 50 locations which were selected to provide roughly equivalent numbers of measurement sites within the distance intervals defined by the arcs shown in

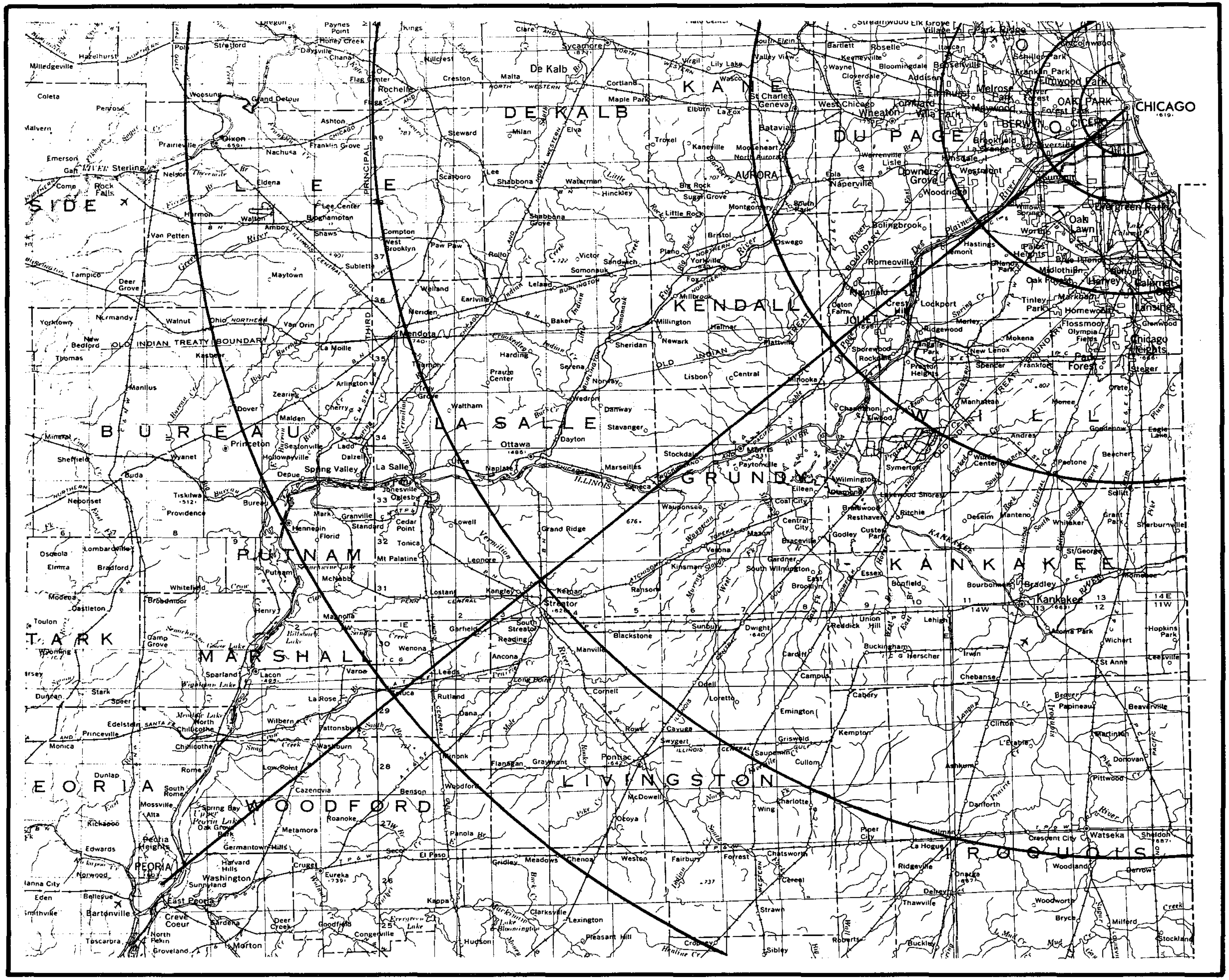

Figure 1. The Chicago-Peoria, Illinois, area where TV broadcast electric field strength and home receiving antenna performance measurements were made.

Figure 1. These arcs are drawn at distances of 5, 10, 20, 40, 80, and 100 mi (8, 16, 32, 64, 129, and 161 km) from the Hancock Building in downtown Chicago. The locations at which measurements were made are listed in Table 1.

The primary objective of these measurements and analyses was to determine home antenna system gain at many locations. To determine gain directly, the electric field incident on the antenna must be known, the received signal level delivered by the antenna must be measured, then the gain can be computed. The fields incident on the antenna, of course, were not known. Instead, the electric field near the (home) antenna was sampled using a standard antenna. This sampling produced sets of data from which the incident fields, varying in time and space, were calculated. The median values were selected as estimates of the fields incident on the home antenna.

The measurements at each location were made using our mobile receiving system depicted in the block diagram of Figure 2. This system is designed to make sequential measurements of two separate signal levels at a rapid rate; thus it provides comparative measurements of a test signal level with respect to some reference signal level. A spectrum analyzer serves as the receiver. The maximum signal amplitude during each scan of the spectrum analyzer is digitized and recorded on magnetic tape. Data management and system housekeeping functions are provided by a minicomputer which also provides real-time analysis of data which are displayed on the CRT terminal. Permanent records of data displayed by the CRT are obtained using the hard copy unit. "Test" signals for the field strength measurements were provided by the standard VHF and UHF receiving antenna for which gain versus frequency characteristics had been measured at our Table Mountain antenna test range north of Boulder, Colorado. The homeowner's TV antenna system provided "test" signals for the home antenna system gain measurements. For all measurements, the reference signal levels were provided by a high-quality, signal generator.

The frequencies at which measurements were made are listed in Table 2. At each location, measurements were attempted on five frequencies from Chicago or two VHF frequencies from Chicago and three UHF frequencies from Peoria. We would select a location adjacent to the house, usually the street in front of or beside the house, erect

Table 1. Measurement Locations, Distances to TV Transmitters, and Antenna System Definition

Location	Distance to Chicago Xmtrs, mi (km)	Distance to Peoria Xmtrs, mi (km)	*Type Antenna	Type Transmission Line
1. 2931 S. Parnell Ave., Chicago	2.4 (3.9)	-	1	?
2. 4053 S. Campbell Ave., Chicago	4.8 (7.7)	-	1	300 ohm
3. 4052 S. Maplewood Ave., Chicago	4.9 (7.9)	-	4,5	300 ohm
4. 4104 S. Campbell Ave., Chicago	5.0 (8.0)	-	1(in attic)	300 ohm
5. 4141 S. Campbell Ave., Chicago	5.1 (8.2)	-	1	75 ohm
6. 4405 S. Maplewood Ave., Chicago	5.2 (8.4)	-	4(in attic),11	300 ohm
7. 3855 W. 61st Pl., Chicago	7.3 (11.7)	-	2(backwards)	75 ohm
8. 3833 56th St., Chicago	7.4 (11.9)	-	1	75 ohm
9. 5800 S. Kolmar Ave., Chicago	8.2 (13.2)	-	2	75 ohm
10. 5955 S. Kostner Ave., Chicago	8.3 (13.4)	-	1	300 ohm
11. 7800 Archer Rd., Justice (FS)	13.9 (22.4)	-	10	300 ohm
12. 7800 Archer Rd., Justice (PS)	13.9 (22.4)	-	2	75 ohm
13. 8611 S. Roberts Rd., Roberts Park	14.3 (23.0)	-	2	75 ohm
14. 9334 S. 81st Ave., Hickory Hills	15.0 (24.1)	-	1	300 ohm
15. 9352 S. 81st Ave., Hickory Hills	15.0 (24.1)	-	1	300 ohm
16. 514 Porter St., Lemont	24.4 (39.3)	-	1	300 ohm
17. Lockport & Main St., Lemont (FS)	24.5 (39.4)	-	2	300 ohm
18. Highway 7 & 7th St., Lockport (FS)	29.6 (47.6)	-	2	300 ohm
19. Weber & Root St., Lockport	30.6 (49.2)	-	2	75 ohm
20. 868 Draper St., Joliet	32.7 (52.6)	-	2	75 ohm
21. 1019 Wabash St., Joliet	32.8 (52.8)	-	8,9	75 ohm
22. 1100 Wabash St., Joliet	32.8 (52.8)	-	2	300 ohm

Table 1. Measurement Locations, Distances to TV Transmitters, and Antenna System Definition (continued)

Location	Distance to Chicago Xmtrs, mi (km)	Distance to Peoria Xmtrs, mi (km)	*Type Antenna	Type Transmission Line
23. 1703 E. Washington St., Joliet	33.8 (54.4)	-	2	300 ohm
24. 319 Grove St., Joliet	34.4 (55.4)	-	2	75 ohm
25. 1830 Coventry Rd., Joliet	35.1 (56.5)	-	2	300 ohm
26. 1900 Coventry Rd., Joliet	35.1 (56.5)	-	1	300 ohm
27. 2323 Essington Rd., Joliet	35.8 (57.8)	-	2	75 ohm
28. 215 S. May St., Joliet	35.8 (57.8)	-	2	300 ohm
29. 3410 Regan Rd., Joliet	35.8 (57.8)	-	1	300 ohm
30. 155 Houbolt Ave., Joliet	38.2 (61.5)	-	2	75 ohm
31. 1260 E. Southmoor Rd., Morris	55.2 (88.8)	-	2	300 ohm
32. 1290 E. Southmoor Rd., Morris	55.2 (88.8)	-	2	300 ohm
33. 3590 School Dr., Morris	55.2 (88.8)	-	2	75 ohm
34. 1685 North St., Morris	55.2 (88.8)	-	4,7	300 ohm
35. Residence, Kinsman (RM)	68.4(110.1)	-	8,7	300 ohm
36. Residence, Kinsman (D)	68.4(110.1)	-	3	300 ohm
37. Residence, Kinsman (H)	68.4(110.1)	-	8,7	300 ohm
38. 2 1/2 mi E. of Grand Ridge	74.5(119.9)	-	8,7	75 ohm
39. 425 Poundstone St., Grand Ridge	75.6(121.7)	-	8,9	?
40. Highway 18, 4 1/2 mi W. of Streator	84.9(136.6)	48.0(77.2)	8,7	300 ohm
41. HWY 17, 3/4 mi E. of HWY 23, Streator	85.2(137.1)	48.0(77.2)	6,7	300 ohm
42. HWY 18, 5 mi W. of Streator	85.2(137.1)	47.4(76.3)	6,7	300 ohm
43. HWY 18, 5 1/2 mi W. of Streator	85.5(137.1)	47.4(76.3)	8,7	300 ohm
44. HWY 18, 8 1/2 mi W. of Streator	87.6(141.0)	45.0(72.4)	8,9	300 ohm

Table 1. Measurement Locations, Distances to TV Transmitters, and Antenna System Definition (continued)

Location	Distance to Chicago Xmtrs, mi (km)	Distance to Peoria Xmtrs, mi (km)	*Type Antenna	Type Transmission Line
45. HWY 17, 5 mi E. of Wenona	90.0(144.8)	42.0(67.6)	No VHF, 7	300 ohm
46. HWY 17, 2 1/4 mi E. of Wenona	92.4(148.7)	39.6(63.7)	8,9	300 ohm
47. 6 blocks E. of HWY 116A, Toluca	99.6(160.3)	32.4(52.1)	3	300 ohm
48. 203 E. 2nd St., Toluca	99.6(160.3)	32.4(52.1)	6,7	300 ohm
49. 309 N. Olive St., Toluca	99.6(160.3)	32.4(52.1)	8,7	300 ohm
50. 815 N. Nile St., Metamore	118.8(191.2)	14.4(23.2)	1	300 ohm
51. 820 N. Nile St., Metamore	118.8(191.2)	14.4(23.2)	2	300 ohm

*Code for Type of Antenna

1. Urban, outdoor, VHF/UHF combination.
2. Suburban, outdoor, VHF/UHF combination.
3. Fringe/deep fringe area, outdoor, VHF/UHF combination.
4. Urban, outdoor VHF.
5. Urban, outdoor UHF.
6. Suburban, outdoor VHF.
7. Suburban, outdoor UHF.
8. Fringe/deep fringe area VHF.
9. Fringe/deep fringe area UHF.
10. Indoor VHF/UHF combination.
11. Indoor UHF loop.

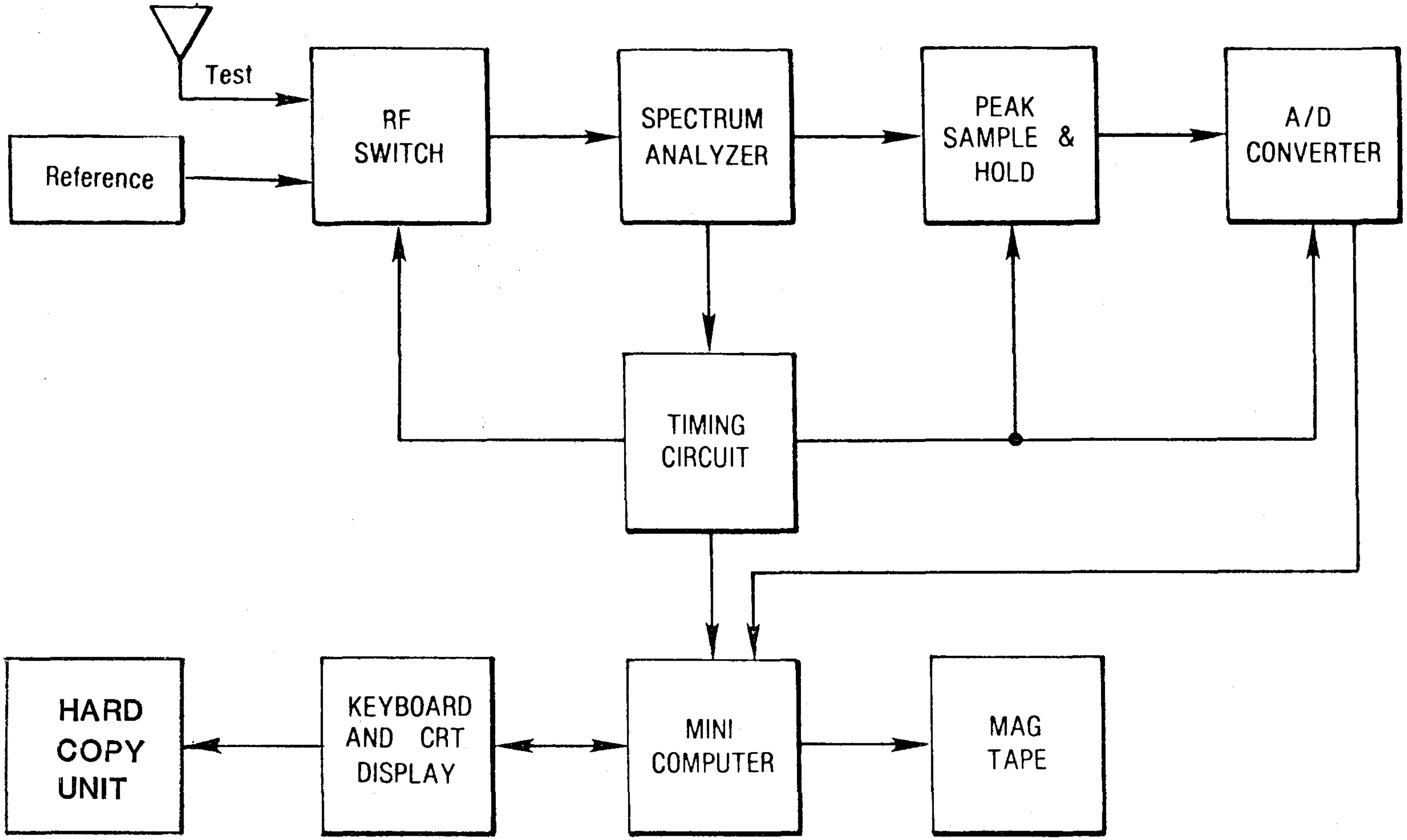

Figure 2. Simplified block diagram of the receiving system.

Table 2. Measurement Frequencies and Transmitter Locations

			Transmitter Location*		
Channel No.	Frequency, MHz	Call Letters	Address	Latitude	Longitude
5 (NBC)	77.25	WMAQ-TV	Hancock Bldg, Chicago	41°53'55.5"	87°37'23.0"
9 (Independent)	187.26	WGN-TV	Hancock Bldg, Chicago	41°53'55.5"	87°37'23.0"
19 (ABC)	501.25	WRAU-TV	500 N. Stewart St. Creve Coeur, Illinois	40°39'11.0"	89°35'13.0"
25 (NBC)	537.26	WEEK-TV	2907 Springfield Hill Rd. Peoria, Illinois	40°37'42.0"	89°32'51.2"
26 (Spanish Lang.)	543.25	WCIU-TV	Board of Trade Bldg, Chicago	41°52'39.0"	87°38'02.0"
31 (CBS)	573.26	WMBD-TV	Fahey Hollow Rd. E. Peoria, Illinois	40°38'06.8"	89°32'18.5"
32 (Independent)	579.25	WFLD-TV	Hancock Bldg, Chicago	41°53'55.5"	87°37'23.0"
44 (Independent)	651.25	WSNS-TV	Hancock Bldg, Chicago	41°53'55.5"	87°37'23.0"

*Television Factbook No. 47 (1978 Edition) and properly orient the standard receiving antenna, then probe the electric field for a distance of 100-200 ft (30.5-61 m) at each of the five test frequencies. In that distance, 500 test-reference signal level samples were obtained. We were sampling at a rate to provide 10 samples per second, so we obtained five test signal levels and five reference signal level measurements each second. The difference in received signal level with respect to the reference level was computed, recorded on magnetic tape, and plotted on the CRT terminal. Figures 3 and 4 show two typical records of this type of measurement. If possible, the standard antenna was at the same height as the homeowner's antenna for these measurements.

Following these measurements of received signal levels from the standard antenna, the receiving system was connected to the homeowner's transmission line removed from his TV receiver. Measurements of received signals from the homeowner's antenna system then were made at the same frequencies used for the field strength measurements. Forty measurements of test signal level difference, with respect to the reference signal level, were made; an average power value for the 40 measurements was computed and printed on the CRT screen. That average power value was recorded manually on the appropriate copy of plotted field strength measurements (see the bottom line of the printed legends on Figures 3 and 4).

The information provided in the legends on Figures 3 and 4 now will be explained. The first line of that legend reports the reference signal level used for the measurements. The second line shows the frequency at which the measurements were made. The third line contains two items of information derived from the real-time data analysis. First, an average relative power for the 500 measurements is shown. The value shown is $10 \log_{10} \bar{x}$, where $\bar{x}$ is the average relative power. The second item of information termed variability is $10 \log_{10} V(x)$, where $V(x)$ is variability in the relative power measurements normalized to the average relative power.

All analyses performed since the field measurements were completed have been done working with cumulative distributions of the data and median and decile values obtained from these distributions. Median values were used instead of average values because some sets of data contained values with large deviations (usually only a small portion of the data set). Median values, as measures of central tendency in

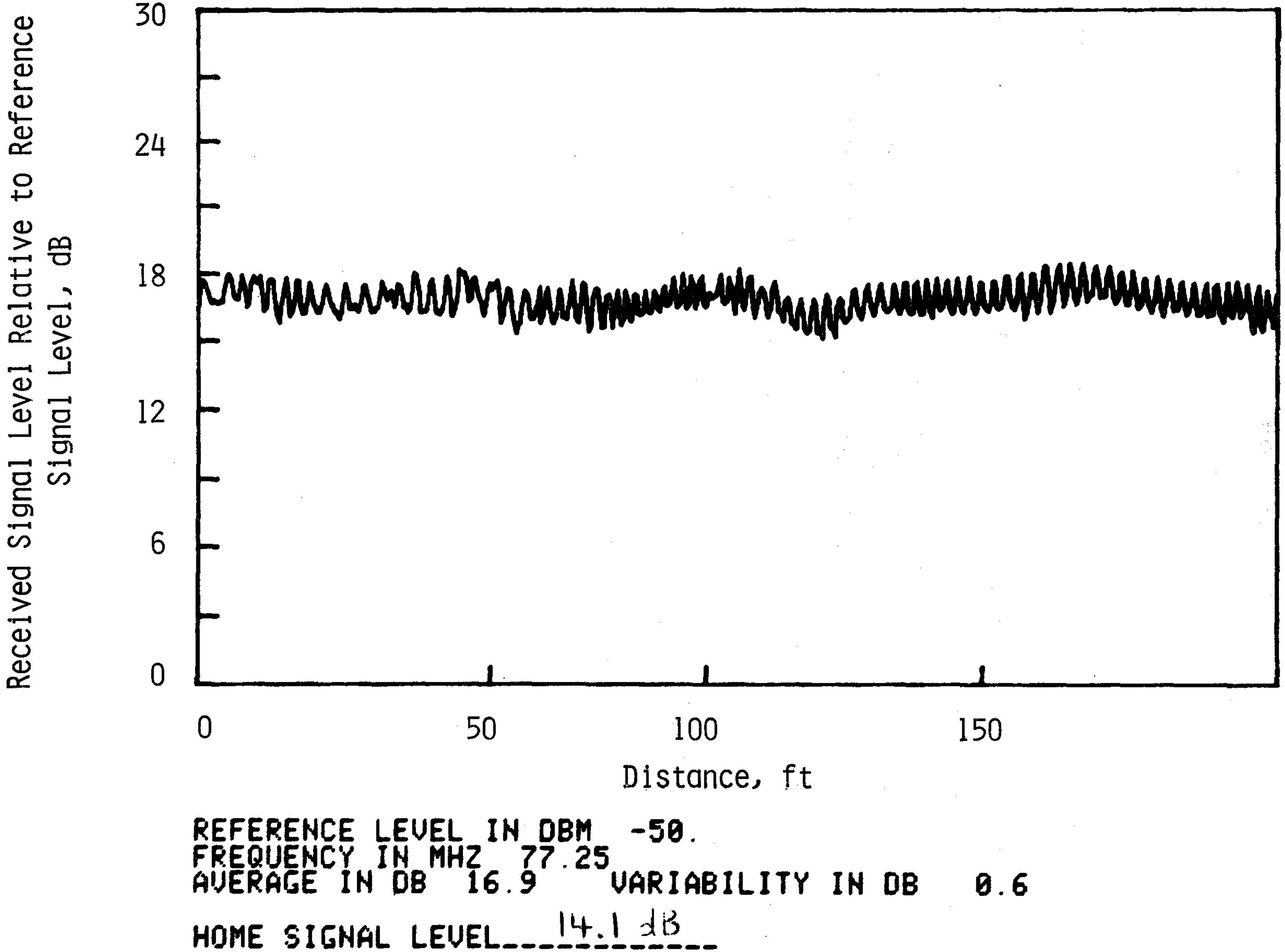

Figure 3. Plot showing small variability in the measured electric field produced by station WMAQ-TV, channel 5.

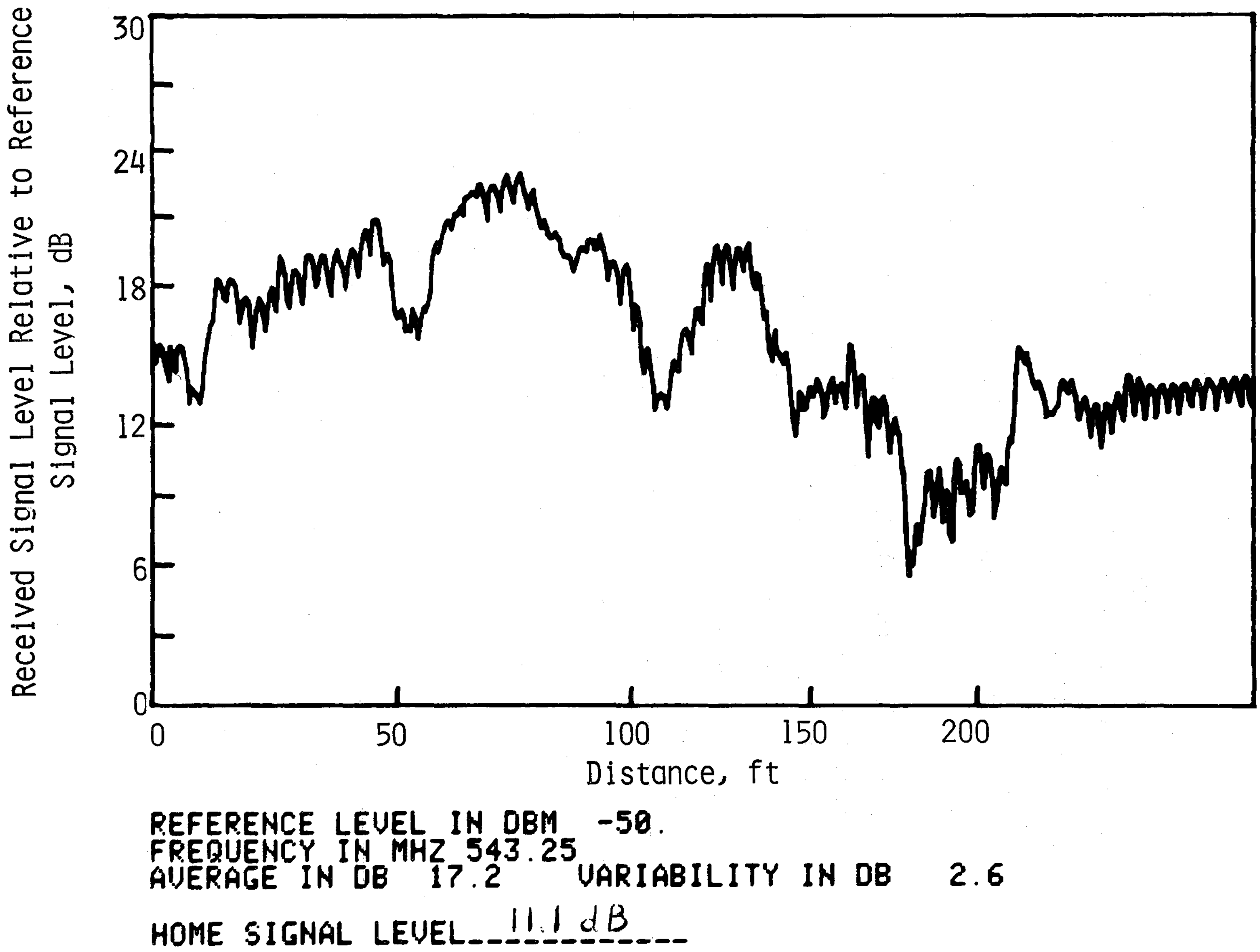

Figure 4. Plot showing considerable variability in the measured electric field produced by station WCIU-TV, channel 26.

the data, are insensitive to these large deviations in a small fraction of the data; average values are not, unless some culling of extreme-valued data is performed.

The field data were reduced for analysis using relationships between incident field strength, power delivered by an antenna system, and antenna system gain which now will be defined. In the report by FitzGerrell et al. (1979), a free-space power budget equation is defined for power, P, in decibels referenced to 1 W, dBW, at the terminals of a TV receiver as

$$P = C + 10 \log_{10} p + G - L_{TL} \quad , \tag{1}$$

where

- p is the power flow in watts/meter^2 produced by an electric field,
- G is gain in decibels of the receiving antenna with respect to the gain of a tuned half-wavelength dipole antenna, and
- L_{TL} is loss in decibels for attenuation of the transmission line used to connect the secondary standard antenna to the receiving system during electric field measurements.

The antenna constant, expressed in decibels, is calculated using the following expression:

$$C = 10 \log_{10} \left. \frac{\lambda^2 g}{4\pi} \right|_{g=1.64} \quad , \tag{2}$$

where

- λ is wavelength in meters of the energy in the electric field, E, and
- g is gain of the receiving antenna relative to a half-wavelength dipole antenna.

A half-wavelength dipole antenna has g=1.64 with respect to isotropic. The relationship between field strength, E, in volts/meter and power flow, p, in watts/meter^2 is

$$p = E^2/120\,\pi \quad . \tag{3}$$

This relationship is substituted into the power budget equation which then is solved for electric field strength,

$$E = \left[120\ \pi\ \log_{10}^{-1}\left((P_{STD} - C - G_{STD} + L_{TL})/10\right)\right]^{\frac{1}{2}} \quad . \qquad (4)$$

Gains of the homeowner's antenna systems were computed using the relationship

$$G_{HS} = G_{STD} + P_{HS} - P_{STD} + L_{bal} \quad , \qquad (5)$$

where

HS as a subscript indicates that the parameter pertains to the home antenna system,

STD as a subscript indicates that the parameter pertains to the standard antenna used for the electric field measurements, and

L_{bal} is loss in decibels resulting from balun mismatch and insertion loss for a balun used during the home antenna system measurements to match the impedance of our coaxial cable to the impedance of the signal splitter used in the homeowner's antenna system.

It should be recognized that we have assumed a uniform electric field creates the signals measured from our standard antenna and the homeowner's antenna system. Figure 3 depicts a situation where the assumption probably is very good. Figure 4 depicts a situation where the assumption likely is not as good. The cumulative distributions of measured field strength data provide an indication of the uncertainity associated with selecting median values as estimates of the fields incident on the home antennas. More specifically, the decile values and interdecile ranges obtained from the distributions provide statistical measures of the uncertainity.

3. RESULTS

As stated earlier, the primary objective of these measurements was to determine the in-service antenna system gain versus frequency at about 50 homes. The electric fields incident on each antenna must be known and the powers delivered by the antenna systems must be measured to compute the gain of each system. The fields incident upon the home antennas were not known; neither was it possible to erect the standard antenna to exactly the same locations in space as each home antenna and measure the fields.

The electric fields were sampled horizontally (in time and space) as near as possible to each home antenna, as a practical and reasonable compromise, using a standard antenna erected to the same height as each home antenna. These field sampling (probing) measurements produced sets of measured data which were plotted as cumulative distributions. Median values from these distributions were selected as estimates of the electric fields incident on the home antennas, and interdecile ranges provide statistical measures of the uncertainty in each estimate.

Home antenna system gains versus frequency were computed from the sets of received signal level measurements made using the standard antenna and the average received signal levels measured from the home antenna systems, as outlined in Section 2. In making these computations, one assumes that uniform electric fields produced the signals measured from our standard antenna and the homeowner's antenna system. In fact, there were variations in the electric field--both time and spatial variations. These variations were caused by atmospheric influences upon propagation and the reality of signal reflectors along the propagation path. Cumulative distributions of these data for each measurement frequency and location are included as Appendix A. These distributions of sample home antenna system gain show this variation--very dramatically at times. For the 500-sample sets of data, these variations were as small as 3.2 dB (77.25 MHz at location 27) and as large as 32.7 dB (651.25 MHz at location 18).

A specific example is shown in Figure 5 for the same set of data shown by Figure 4. Let us review the information presented by Figure 5 for that set of data. First, we can deduce that the 500 samples comprising the measured data set have a range of 17.5 dB and an interdecile range of 9.4 dB. When the data are converted to sample home antenna system gain as described earlier, the median gain, selected as estimated home antenna system gain, is 4.8 dB with respect to a half-wavelength dipole. (Note in Figure 5, and in other figures and tables, that gain with respect to a half-wavelength dipole is denoted by dBd.) We see that 90% of the data set would convert to home antenna system gain of -0.5 dB or greater, whereas a gain of 8.9 dB or greater would be obtained from only 10% of the data set. These results are for measurements of the broadcast signal from WCIU-TV, channel 26, at

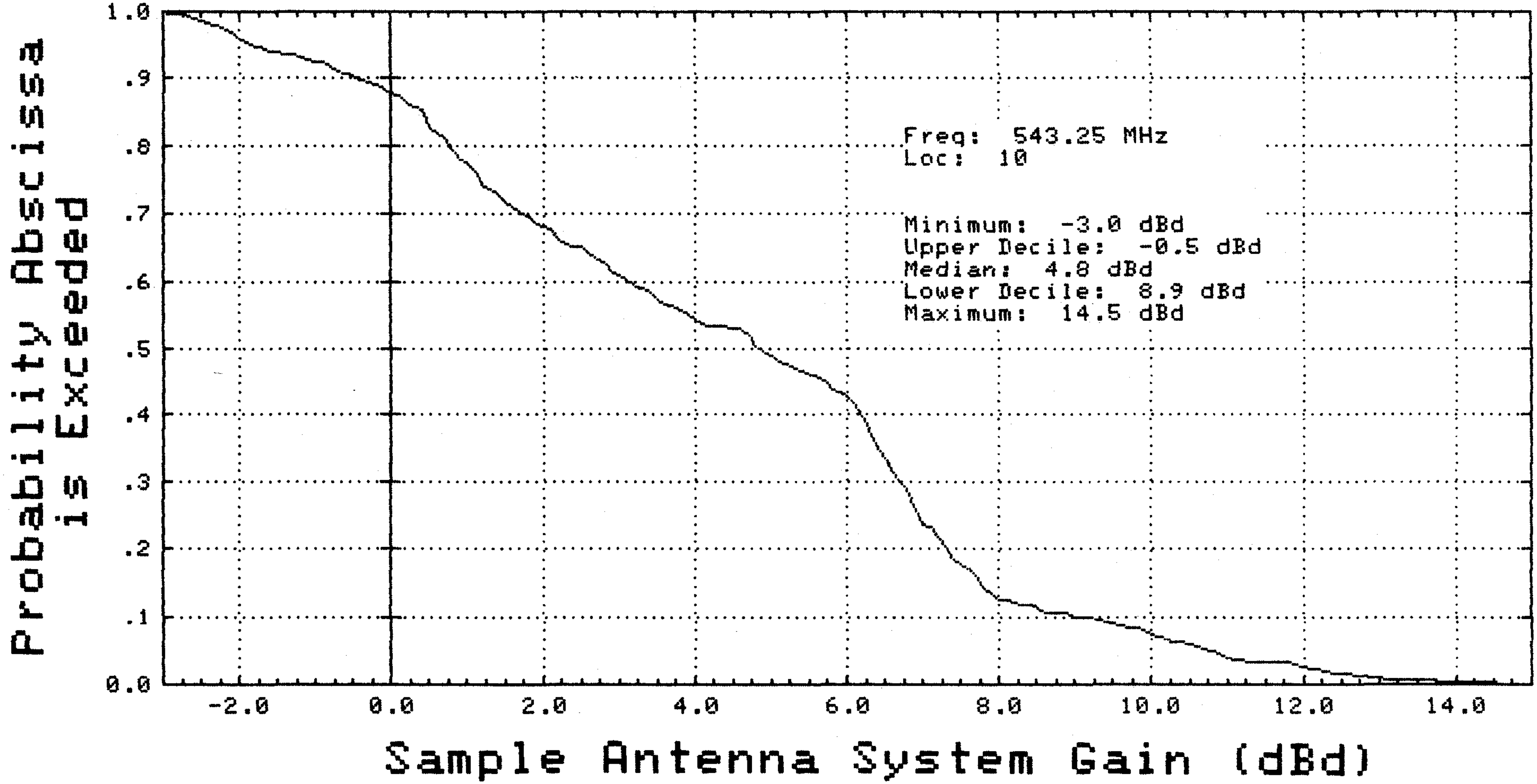

Figure 5. Cumulative distribution of sample home antenna system gain for location 10 at 543.25 MHz. Figure 4 shows the set of electric field probing measurements used to produce this plot.

543.25 MHz at location 10, which was 8.3 mi (13.4 km) from the broadcast antenna.

Many types of analyses of combined sets of data can be conceived. We have chosen to group measured data sets according to type of antenna and type of transmission line used to connect the antenna to the TV receiver. Several other system variations simply have been ignored. These variations include length of transmission line, antenna height above ground, and use of signal splitters and multicoupling devices.

Figures 6 through 13 are cumulative distributions of sample home antenna system gain for aggregated sets of measured data grouped according to type of antenna (all outdoor antennas) and type of transmission line. The only indoor antennas for which we have data are one combination antenna at location 11 and one UHF loop at location 6. Figures 14 and 15 are cumulative distributions of the combined data sets for these indoor VHF and UHF antennas. Table 3 is a summary of the estimated home antenna system gain data grouped according to type of antenna and type of transmission line. The upper section of the table shows data summarized from Figures 6 through 15. The lower section of the table shows data summarized from the individual cumulative distributions in Appendix A.

The upper section of Table 3 shows the median sample gains and interdecile ranges in the data for all measurements grouped according to type of antenna and transmission line. For example, all data for VHF performance of VHF/UHF combination antennas where 300-ohm transmission line was used produce a median sample gain, or estimated home antenna system gain, of -0.8 dB (with respect to a tuned half-wavelength dipole). Measurements from 17 locations, with 34 sets of data, are combined to produce that estimate. The interdecile range in the aggregate data is 24.2 dB. Considering the same sets of data for VHF performance of VHF/UHF combination antennas with 300-ohm transmission line, we find from the cumulative distributions in Appendix A that the median estimated gain is also -0.8 dB and the interdecile range in the estimated gains for the 34 sets of data is 3.6 dB. The maximum estimated gain is 8.2 dB (at location 18) and the minimum estimated gain is -22.3 dB (at location 29). The lower section of Table 3 shows this information.

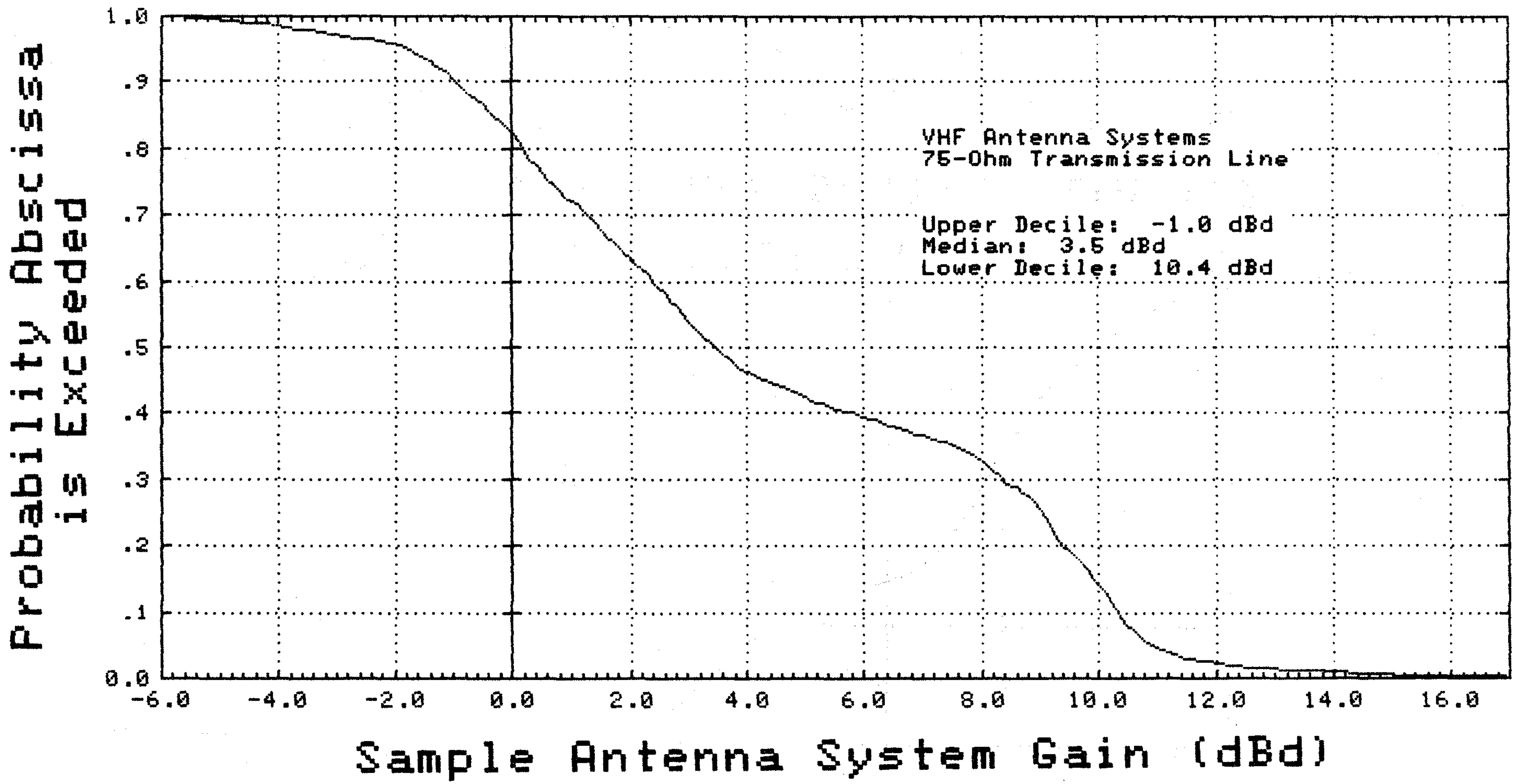

Figure 6. Cumulative distribution of sample home antenna system gain for all electric field probing data at VHF test frequencies at two locations (21 and 38) using VHF-only antennas and 75-ohm transmission line.

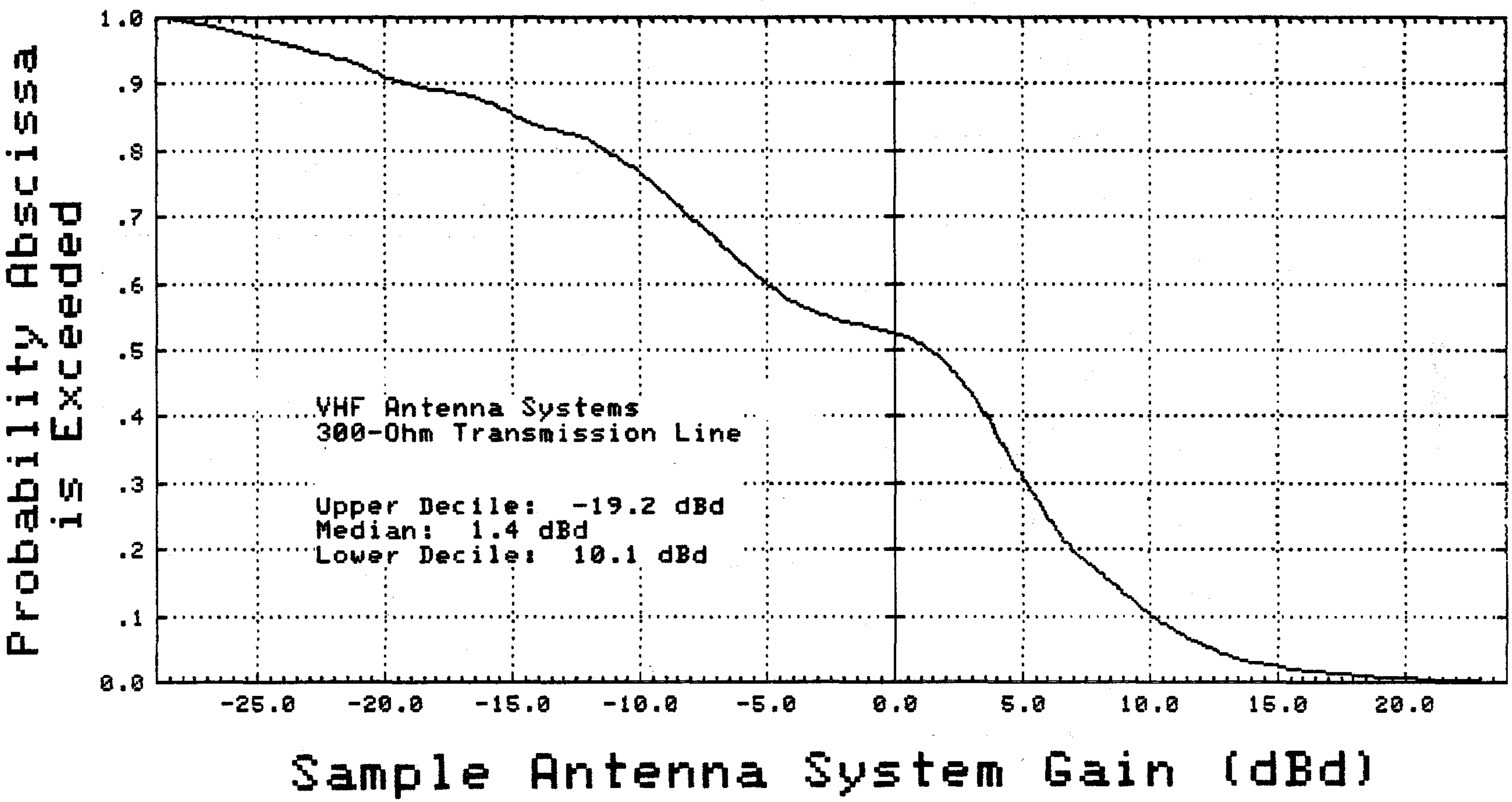

Figure 7. Cumulative distribution of sample home antenna system gain for all electric field probing data at VHF test frequencies at 13 locations using VHF-only antennas and 300-ohm transmission line. The locations were 3, 6, 34, 35, 37, 40, 41, 42, 43, 44, 46, 48, and 49.

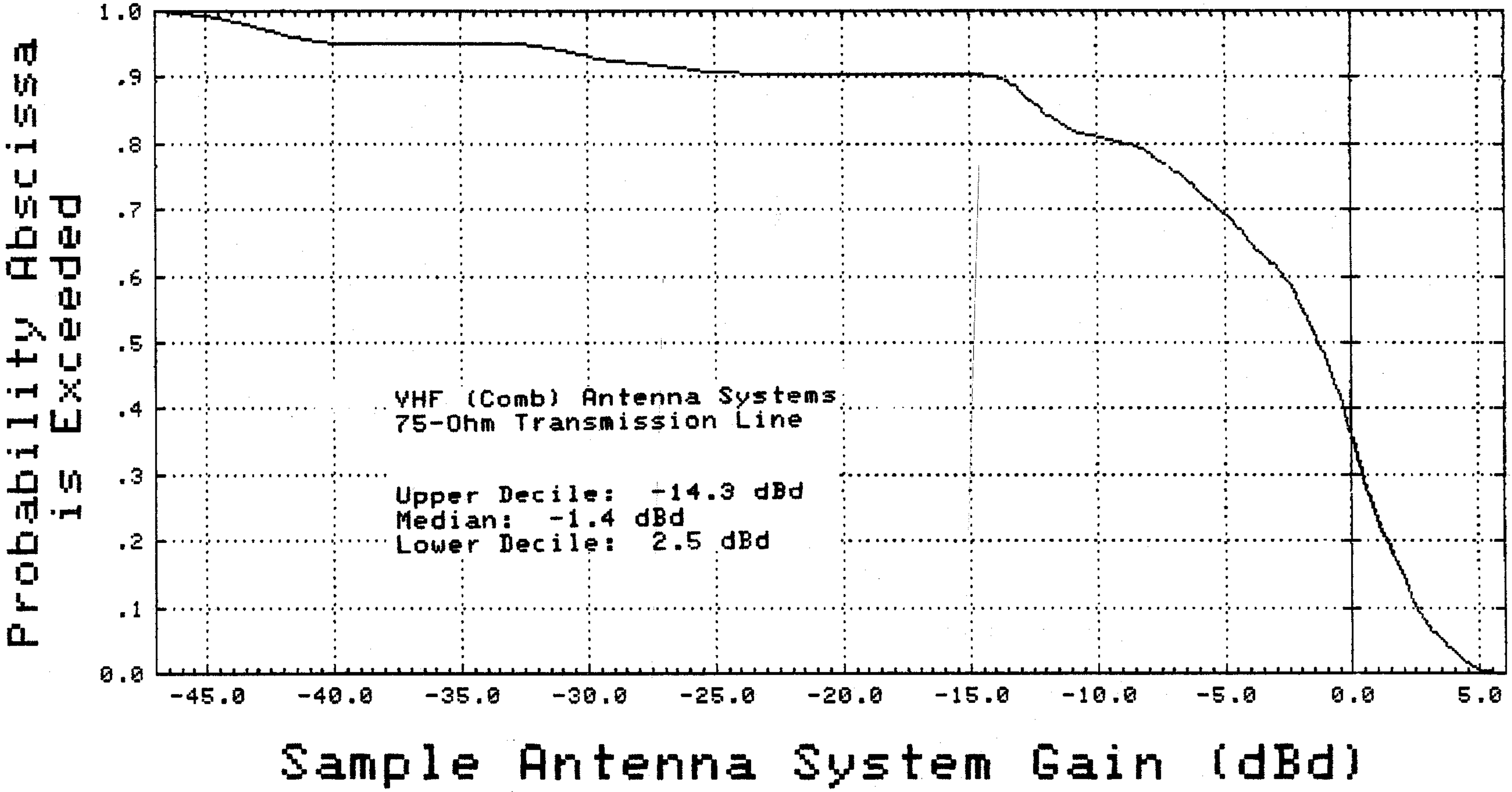

Figure 8. Cumulative distribution of sample home antenna system gain for all electric field probing data at VHF test frequencies at 11 locations using VHF/UHF combination antennas and 75-ohm transmission line. The locations were 5, 7, 9, 12, 13, 19, 20, 24, 27, 30, and 33.

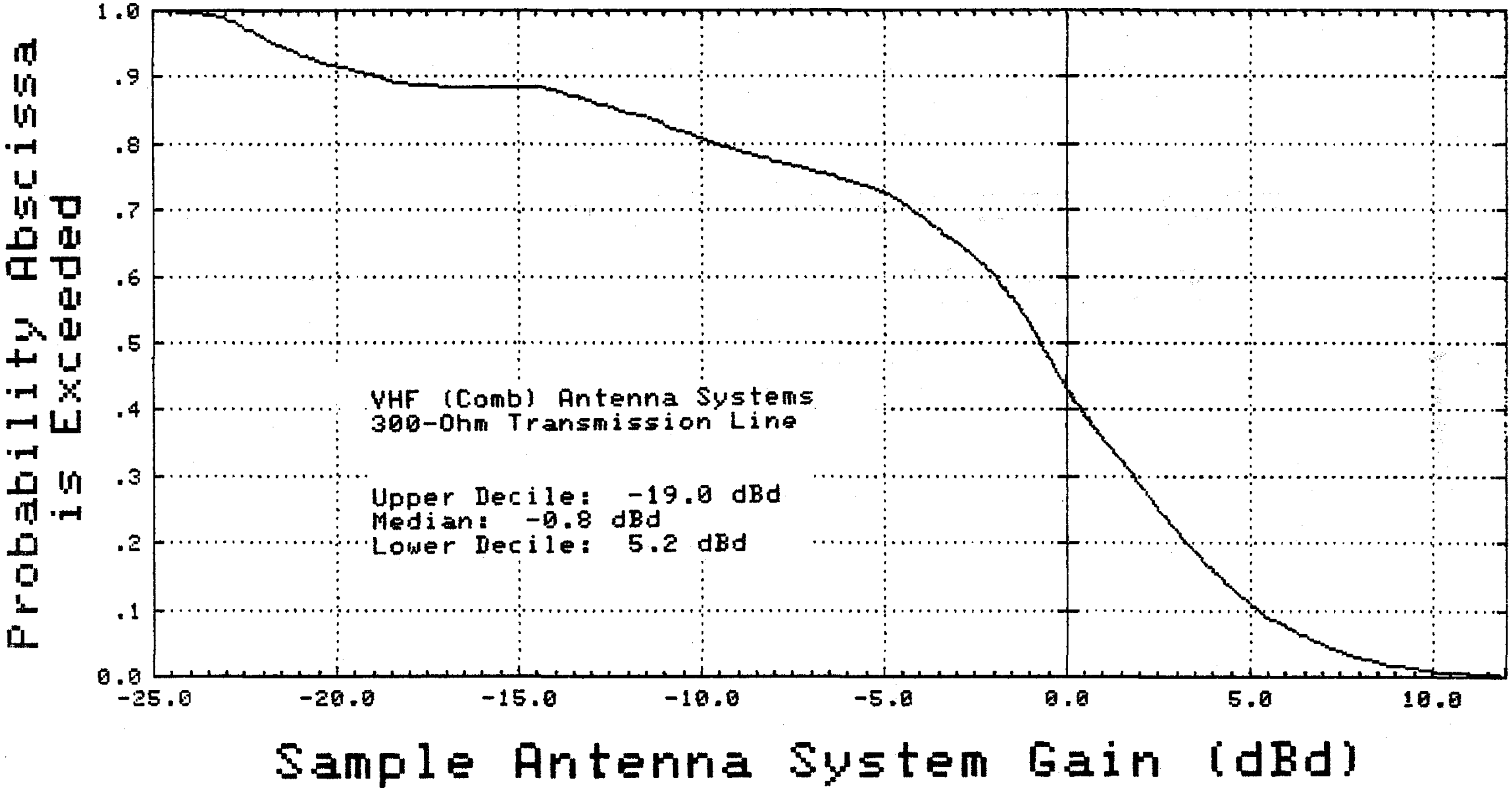

Figure 9. Cumulative distribution of sample home antenna system gain for all electric field probing data at VHF test frequencies at 17 locations using VHF/UHF combination antennas and 300-ohm transmission line. The locations were 2, 4, 10, 14, 15, 16, 17, 18, 22, 23, 25, 26, 28, 29, 31, 36, and 47.

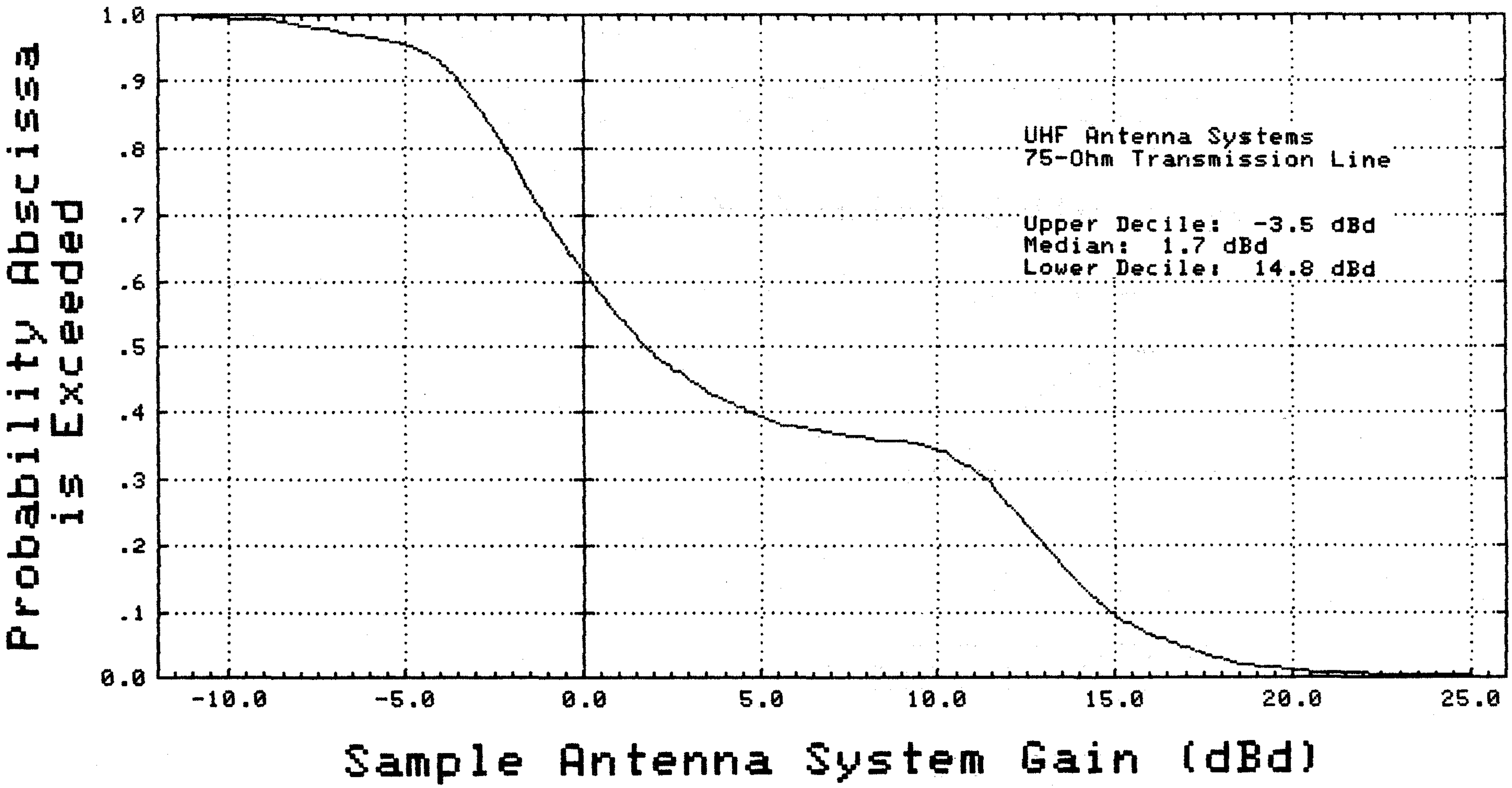

Figure 10. Cumulative distribution of sample home antenna system gain for all electric field probing data at UHF test frequencies at two locations (21 and 38) using UHF-only antennas and 75-ohm transmission line.

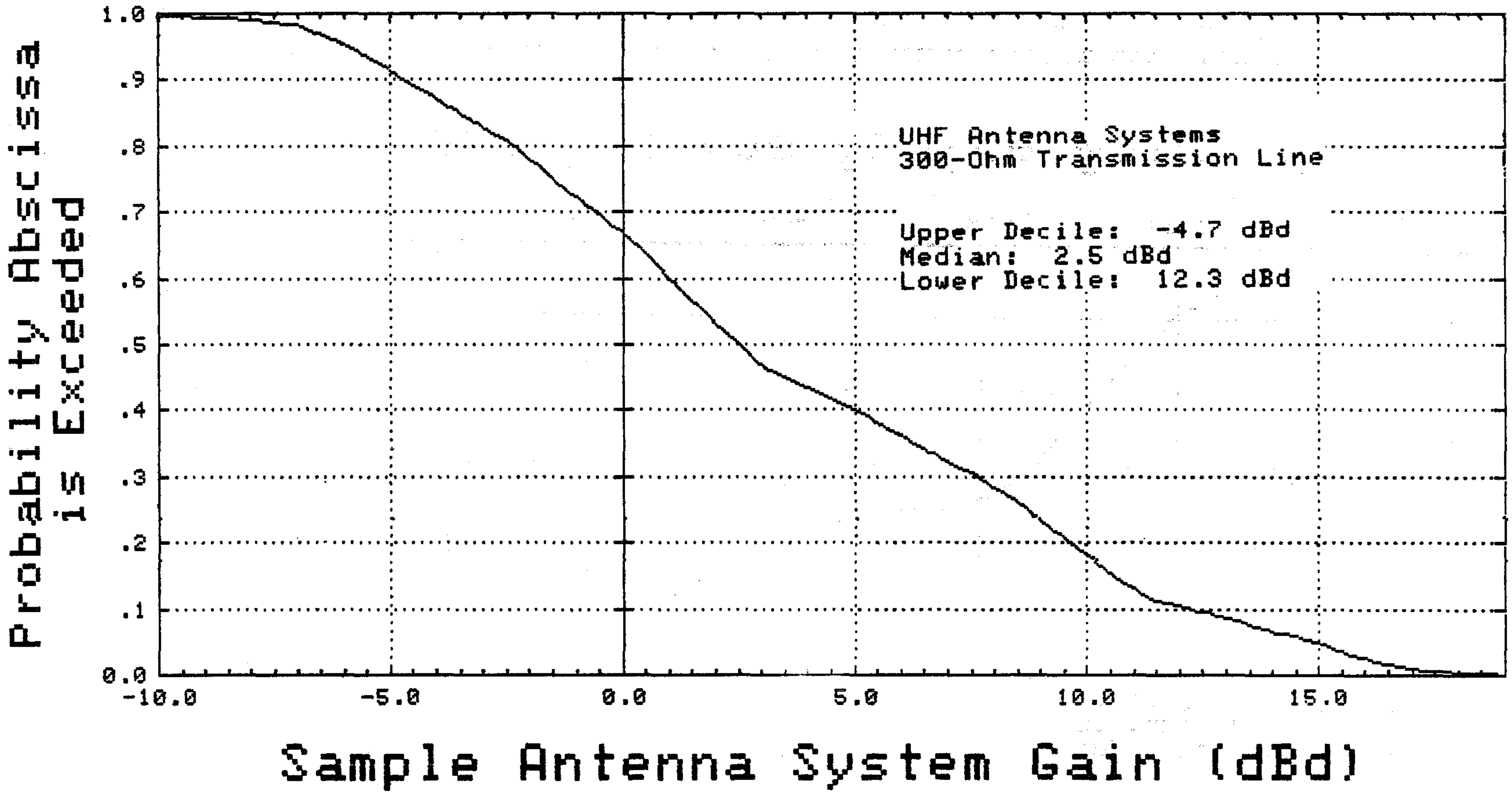

Figure 11. Cumulative distribution of sample home antenna system gain for all electric field probing data at UHF test frequencies at 13 locations using UHF-only antennas and 300-ohm transmission line. The locations were 3, 34, 35, 37, 40, 41, 42, 43, 44, 45, 46, 48, and 49.

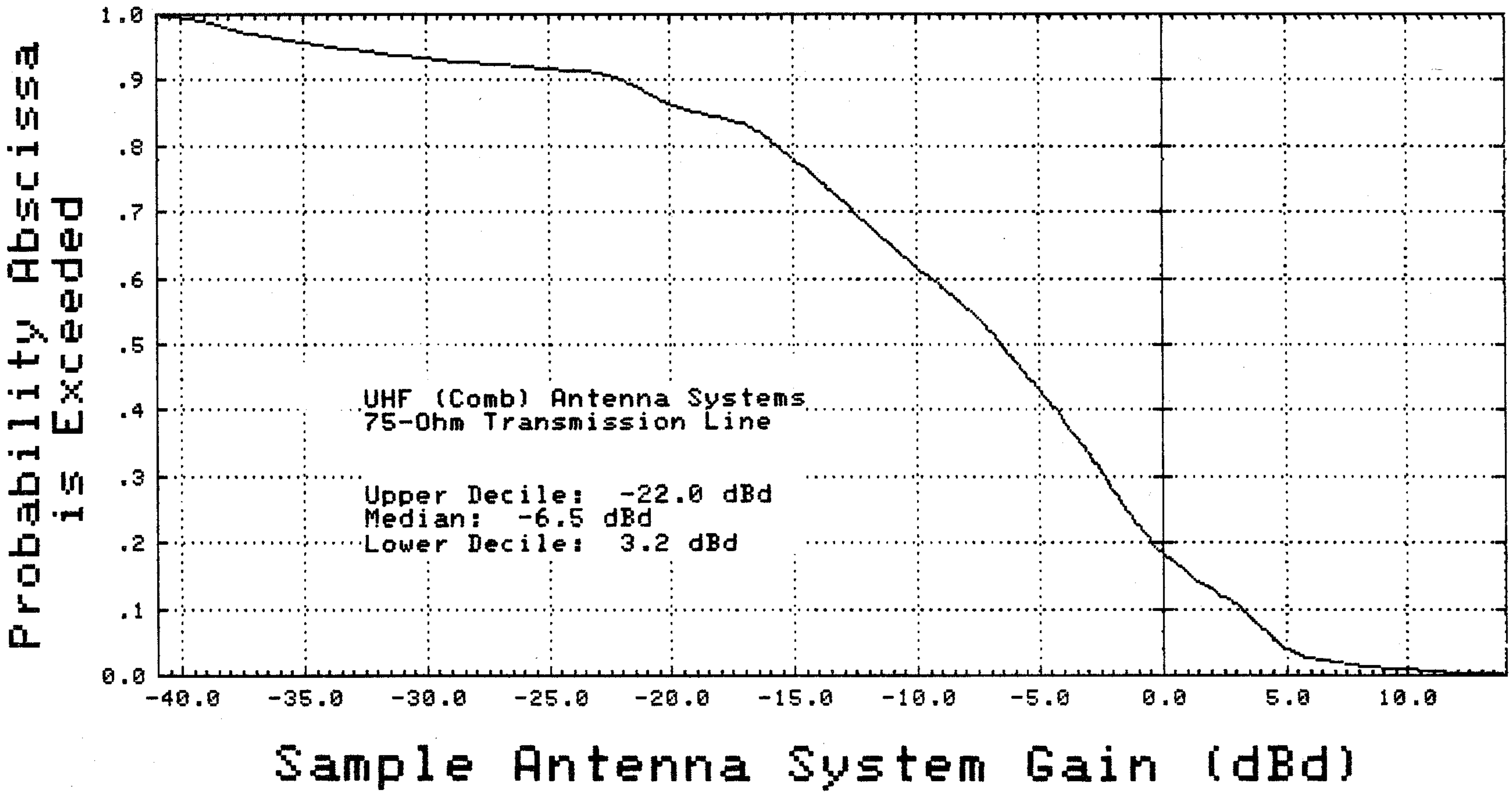

Figure 12. Cumulative distribution of sample home antenna system gain for all electric field probing data at UHF test frequencies at 11 locations using VHF/UHF combination antennas and 75-ohm transmission line. The locations were 5, 7, 8, 9, 12, 13, 19, 20, 24, 27, 30, and 33.

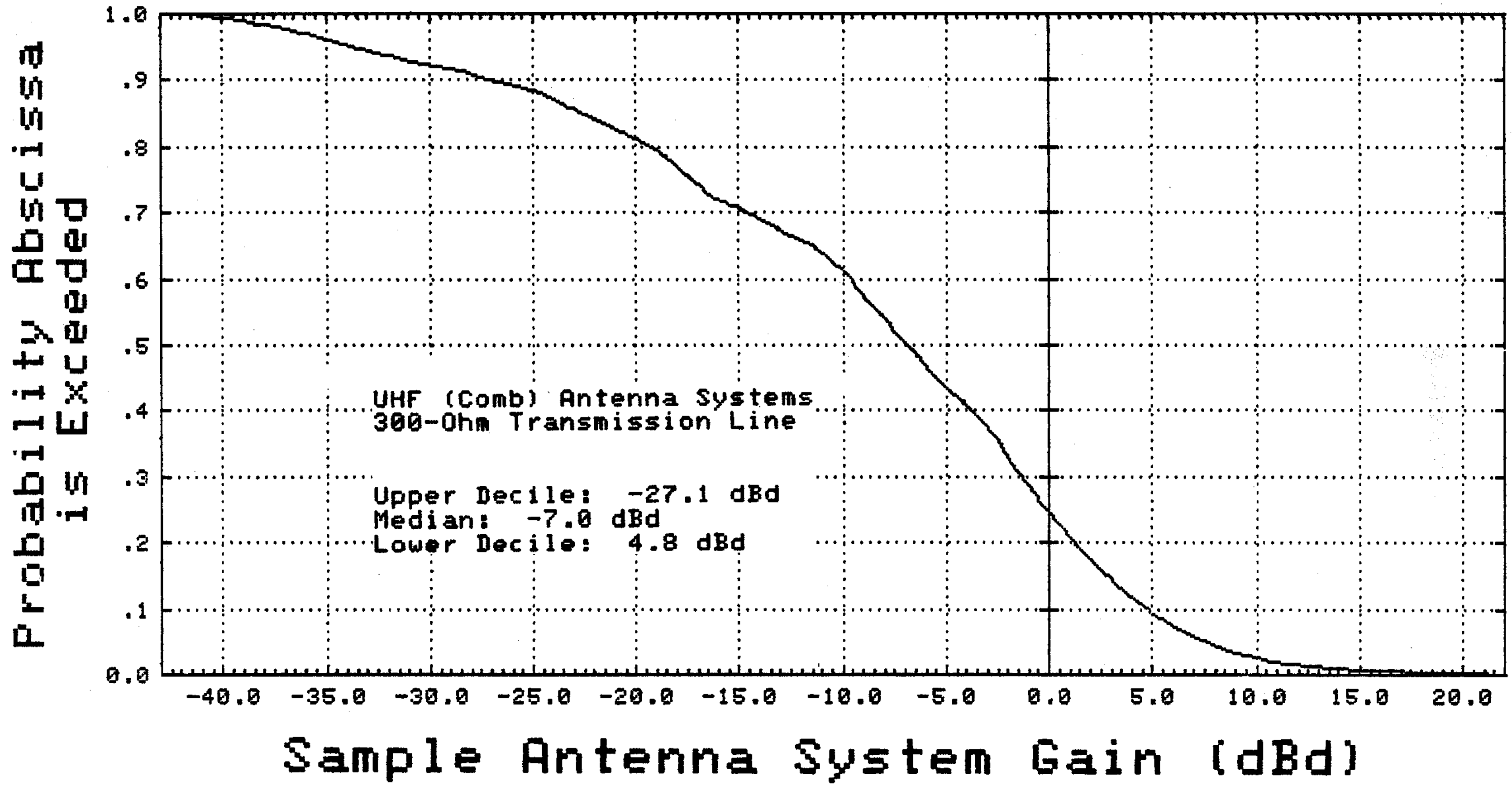

Figure 13. Cumulative distribution of sample home antenna system gain for all electric field probing data at UHF test frequencies at 19 locations using VHF/UHF combination antennas and 300-ohm transmission line. The locations were 2, 4, 10, 14, 15, 16, 17, 18, 22, 23, 25, 26, 28, 29, 31, 36, 47, 50, and 51.

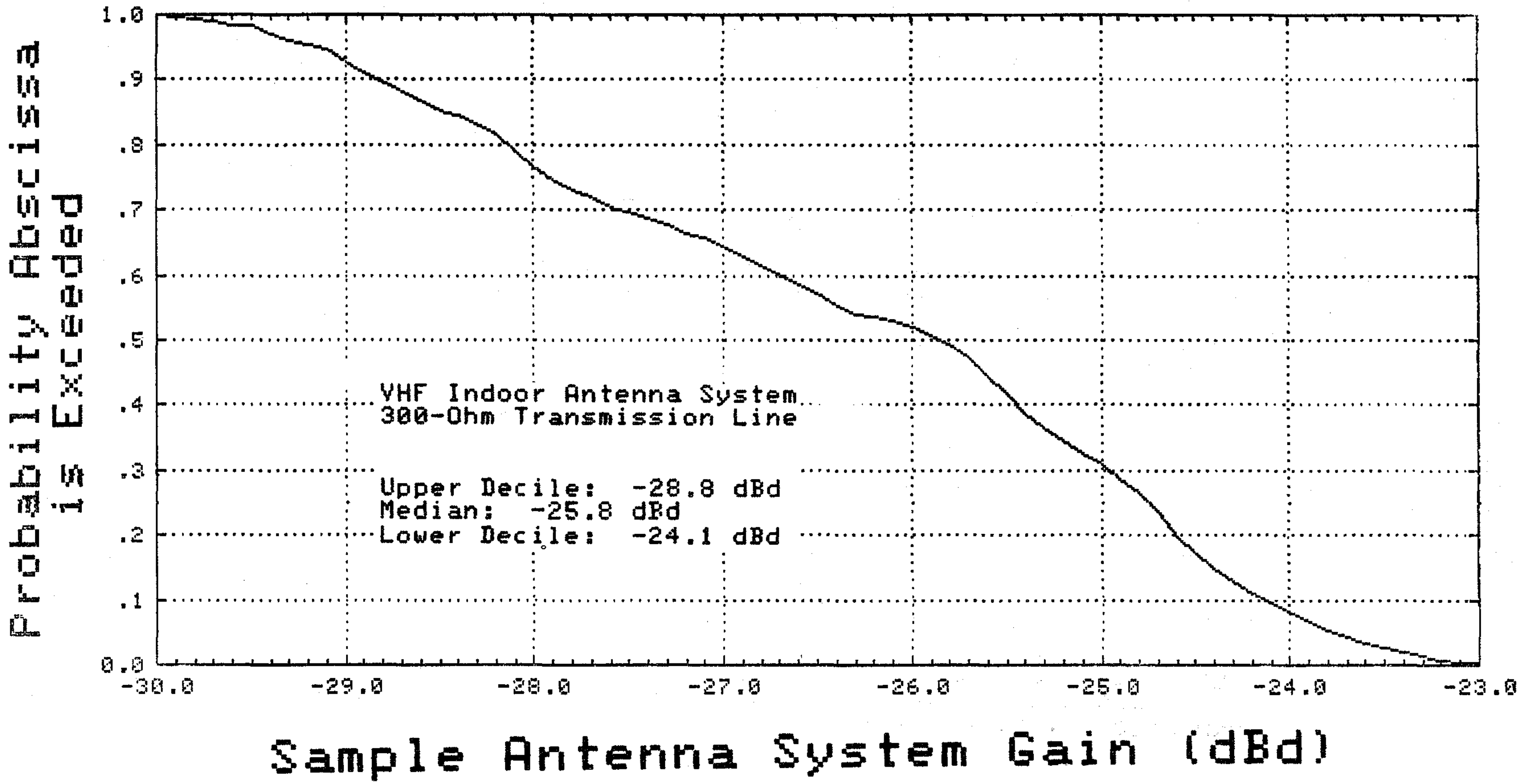

Figure 14. Cumulative distribution of sample home antenna system gain for electric field probing data at VHF test frequencies at location 11, where an indoor VHF/UHF combination antenna was used.

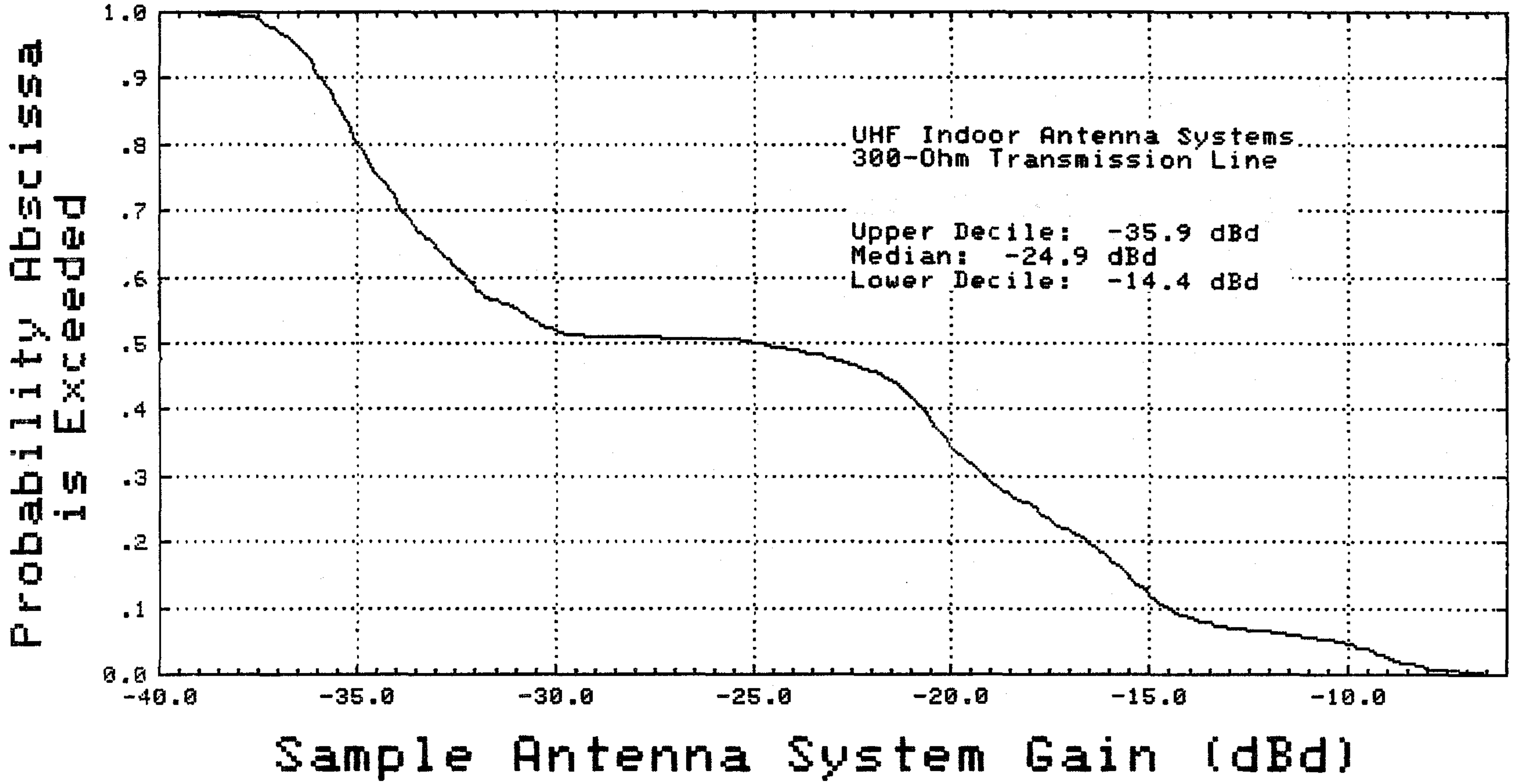

Figure 15. Cumulative distribution of sample home antenna system gain for all electric field probing data at UHF test frequencies at two locations (6 and 11). An indoor UHF loop was used at location 6, and an indoor VHF/UHF combination antenna was used at location 11. The distribution clearly suggests the data came from locations which produced data with little overlap. Data at location 6 ranged from -25 dB to -6 dB while data at location 11 ranged from -40 dB to -28 dB.

Table 3. Summary of Estimated Home Antenna System Gain Data from Aggregated-Data Cumulative Distributions (Figures 6-15) and Cumulative Distributions of Individual Data Sets (Appendix A) Grouped According to Type of Antenna and Impedance of the Transmission Line

Data Descriptor	VHF Antenna Systems		Combination Antenna Systems, VHF Performance		UHF Antenna Systems		Combination Antenna Systems, UHF Performance		Indoor Antenna Systems	
	75 ohm	300 ohm	75 ohm	300 ohm	75 ohm	300 ohm	75 ohm	300 ohm	VHF	UHF
From Aggregated-Data Cumulative Distributions, Figures 6-15										
Median Sample Gain, dBd	3.5	1.4	-1.4	-0.8	1.7	2.5	-6.5	-7.0	-25.8	-24.9
Intercile Range, dB	11.4	29.3	16.8	24.2	18.3	17.0	25.2	31.9	4.7	21.5
Number of Measurement Locations	2	13	11	17	2	13	11	19	1	2
Number of Data Sets	4	26	21	34	6	39	33	57	2	6
From Cumulative Distributions of Individual Data Sets, Appendix A										
Median Estimated Gain, dBd	3.3	1.7	-2.2	-0.8	0.1	1.1	-6.6	-7.7	-26.4	-27.0
Interdecile Range of Estimated Gains, dB	5.2	7.2	3.4	3.6	6.9	3.5	4.8	7.1	4.3	5.4
Max. Estimated Gain, dBd (Location)	9.4 (21)	12.3 (40)	3.3 (20)	8.2 (18)	12.9 (38)	15.2 (46)	4.6 (33)	8.4 (22)	-25.5 (11)	-14.2 (6)
Min. Estimated Gain, dBd (Location)	0.1 (21)	-24.3 (42)	-43.2 (7)	-22.3 (29)	-2.9 (38)	-38.3 (3)	-37.4 (7)	-39.0 (17)	-27.2 (11)	-35.4 (11)

Some of the categories defined in Table 3 contain data from only a few locations; these results must be recognized as derived from small samples. However, there are very interesting characteristics to be observed in the Table 3 data. For example, the median gains for systems using VHF/UHF combination antennas are consistently lower than median gains for systems using VHF-only and UHF-only antennas. We also note that median estimated gains usually are very similar to median sample gains obtained from the aggregated-data distributions. However, the interdecile ranges in estimated gains are much smaller than the interdecile ranges from the aggregated-data distributions. The interdecile range data are not entirely consistent, but there is the tendency for interdecile ranges to be smaller in VHF performance data than for the comparable conditions in UHF performance data. As examples for aggregated data, the interdecile range in performance for systems using VHF-only antennas with 75-ohm transmission line is 6.9 dB smaller than the interdecile range in performance for systems using UHF-only antennas with 75-ohm transmission line. And, the interdecile range in estimated gains for VHF performance of combination antennas using 300-ohm transmission line is 3.5 dB smaller than the interdecile range in estimated gains for UHF performance of combination antennas using 300-ohm transmission line.

We further observe that for VHF-only systems and UHF performance of combination antenna systems, the median gains for systems using 300-ohm transmission line are poorer than for systems using 75-ohm transmission line. Conversely, for UHF-only systems and VHF performance of combination antenna systems, the median gains for systems using 75-ohm transmission line are poorer than for systems using 300-ohm transmission line. We believe these results are consequences of the following factors:

(1) Measurements were made at only two locations with VHF-only and UHF-only antenna systems which used 75-ohm transmission line. These measurements provided small samples.

(2) Performance of UHF-only systems which used 300-ohm transmission line was measured at 13 locations, and 9 of these locations were Peoria-reception locations. Since Peoria is a UHF-only market area, there may

be more incentive to install and maintain "good" UHF antenna systems than at locations within the Chicago VHF/UHF market area.

(3) Combination antenna systems typically were used at locations within the Chicago television market area for which many of our measurements were at short-to-intermediate ranges from the transmitters. These circumstances combine to allow adequate reception without demanding high quality installations and/or maintenance of the antenna systems. Differences in median gains that are shown for combination antenna systems with 75-ohm transmission compared to systems with 300-ohm transmission line are not considered to be significant.

In an earlier report (FitzGerrell et al., 1979) on television receiving antenna system component measurements, we show that attenuation for good, 300-ohm transmission line is less than for good, 75-ohm transmission line. This fact suggests that, all other factors being equivalent, we should have seen better performance for systems using 300-ohm transmission line compared with systems using 75-ohm transmission line. Notice in the lower section of Table 3 that, indeed, the highest estimated values (best performance) for home antenna system gain always were for systems using 300-ohm transmission line. However, the poorest performing systems usually used 300-ohm transmission line too. We believe the factors discussed in the preceding paragraph explain these performance extremes.

In a paper written (O'Connor, 1968) to help develop a common understanding of the assumptions behind and meaning of the Grade A and Grade B Service contours, the author shows the antenna system gains that have been assumed in establishing the Grade of Service field strength requirements. He shows that for Grade A Service the antenna system gain is assumed to be -1 dB for VHF reception and 3 dB for UHF reception. For Grade B Service the antenna system gain is assumed to be 5 dB for VHF reception and 8 dB for UHF reception.

We have analyzed our data to determine the total numbers of antenna system gain values within the Grade A Service contour and in the area beyond the Grade A Service contour (Grade B Service area and beyond). We have tabulated system gain values for systems within those areas and compared the values with the assumed gains detailed above. A summary of this tabulation is shown in Table 4. We see that within the Grade A Service contours 51.2% of the VHF data were less than the assumed value and 95.1% of the UHF data were less than the assumed value. Data for the region beyond the Grade A Service contour show 77.3% of the VHF data were less than the assumed values and 78.3% of the UHF data were less than the assumed value.

The measured, estimated home antenna system gains (shown in Appendix A) also have been examined to determine median estimated gain as a function of frequency for the Grade of Service areas. These data show the median estimated home antenna system gains for VHF reception to be -1.4 dB within the Grade A Service contour and 0.7 dB beyond the Grade A Service contour. The median estimated home antenna system gain for all VHF data is 0.5 dB. Median estimated gains for UHF reception are -9.5 dB within the Grade A Service contours and 0.9 dB beyond the Grade A Service contours. For all UHF data the median estimated gain is -3.6 dB. These data, and some decile values and interdecile range data which will be discussed shortly, are shown in Table 5.

Figures 16 and 17 are plots of the estimated home antenna system gains as a function of distance from the broadcast (transmitting) antenna locations for VHF and UHF respectively. Though the data are rather widely scattered, one does observe the tendency for higher gains at locations more distant from the transmitters. The least squares linear regression lines fit to the data for each figure confirm this observation, as shown in each figure. As one would expect, the increase in antenna system gain as a function of distance from the transmitters is more pronounced for UHF performance than for VHF performance.

An examination of the data in Appendix A shows the lowest estimated system gain was at 77.25 MHz (Figure 13b in Appendix A, for location 7). The highest estimated system gain was at 501.25 MHz (Figure 103a in Appendix A, for location 46). The backgrounds of these measured data are very interesting.

First, let's consider the very low, estimated antenna system gain reported at 77.25 MHz. This measurement was at a home which was 7.3 mi (11.7 km) from the transmitting antenna in Chicago. The antenna system installation had been done by the homeowner. The antenna was a

Table 4. Summary Tabulation Comparing Measured Estimated Antenna System Gain Data with Assumed Values (O'Connor, 1968)

Frequency	Service Area	Assumed Antenna System Gain Values* (dB)	Total No. of Data	Percent of Estimated Gain Values Less Than Assumed Value	Percent of Estimated Gain Values Equal to or Greater Than Assumed Value
VHF	Within Grade A contour	-1	43	51.2% (22)	48.8% (21)
	Beyond Grade A contour (Grade B area and beyond)	5	44	77.3% (34)	22.7% (10)
UHF (all data)	Within Grade A contour	3	81	95.1% (77)	4.9% (4)
	Beyond Grade A contour (Grade B area and beyond)	8	60	78.3% (47)	21.7% (13)
UHF (Peoria data)	Within Grade A contour	3	9	88.9% (8)	11.1% (1)
	Beyond Grade A contour (Grade B area and beyond)	8	27	74.1% (20)	25.9% (7)

*The values shown here are the difference between antenna gain and transmission line loss reported by O'Connor (1968).

Table 5. Tabulation of Median Estimated Gain and Interdecile Ranges in the Estimated Gain Data by Location Classifications

Frequency Range	Data Location Classification	Median Estimated Gain,[1] dB	Decile Values of Estimated Gains,[2] dB		Median Interdecile Range,[3] dB	Decile Values of Interdecile Range,[4] dB	
			Lower	Upper		Lower	Upper
VHF	Within Grade A contours	-1.4	-23.6	3.8	3.8	2.3	6.2
	Beyond Grade A contours (Grade B area and beyond)	0.7	-18.3	8.3	4.9	2.5	12.5
	All VHF data	0.5	-19.9	5.9	3.9	2.4	8.2
UHF (all data)	Within Grade A contours	-9.5	-34.4	1.3	5.6	3.6	9.3
	Beyond Grade A contours (Grade B area and beyond)	0.9	- 6.1	10.7	4.2	2.7	9.8
	All UHF data	-3.6	-24.2	7.7	5.3	3.0	9.3
UHF	Chicago data	-6.3	-30.7	3.7	5.5	3.3	9.7
	Peoria data	0.6	- 8.8	10.4	3.6	2.7	9.1

[1]The median value of estimated home antenna system gains for frequencies and locations as defined.

[2]The decile values of estimated home antenna system gains for frequencies and locations as defined.

[3]The median interdecile range in estimated home antenna system gain for frequencies and locations as defined.

[4]The decile values of interdecile ranges in estimated home antenna system gain for frequencies and locations as defined.

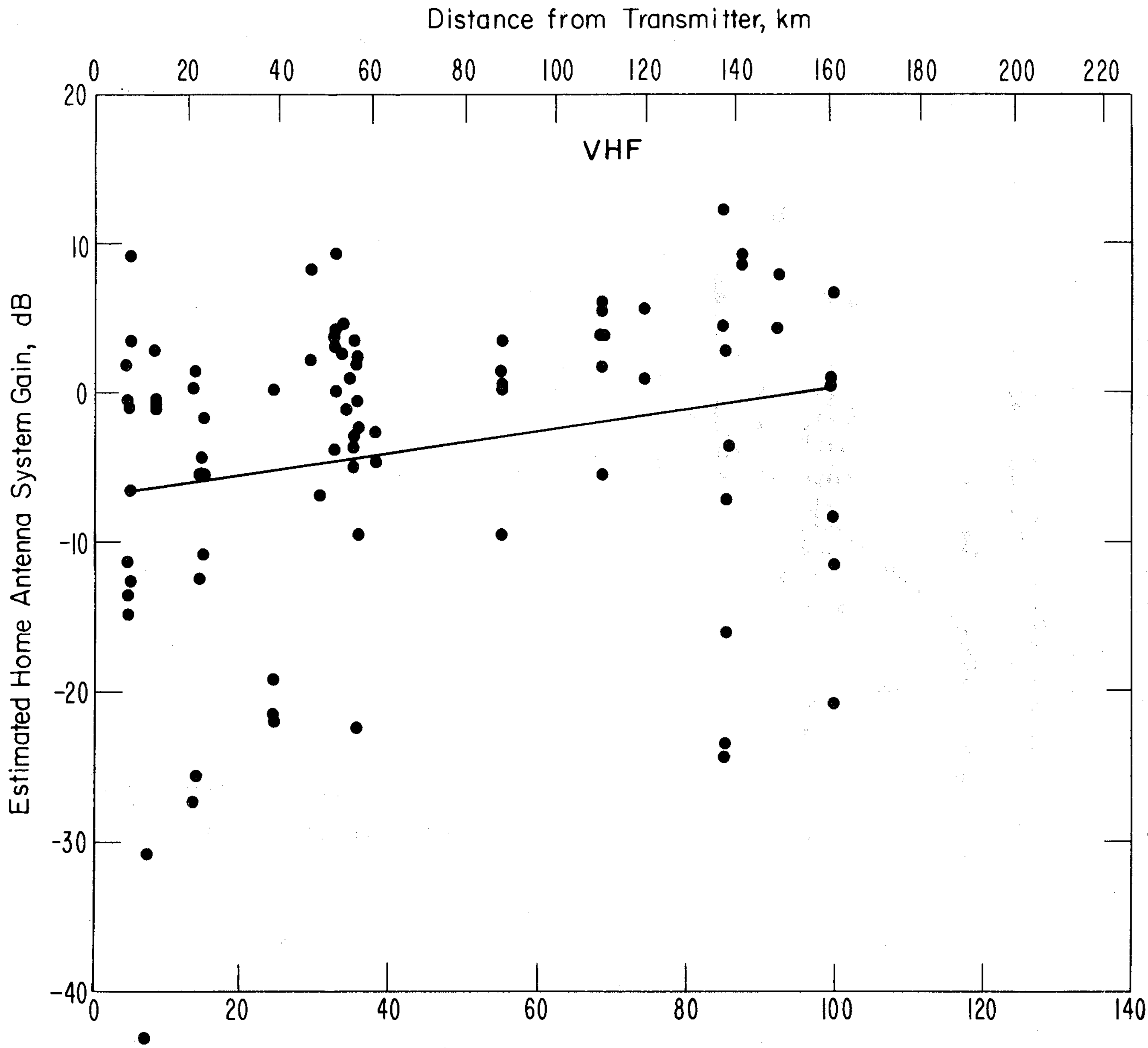

Figure 16. Estimated home antenna system gain at VHF as a function of distance from the transmitter. The least squares, linear regression line fit to these data also is shown.

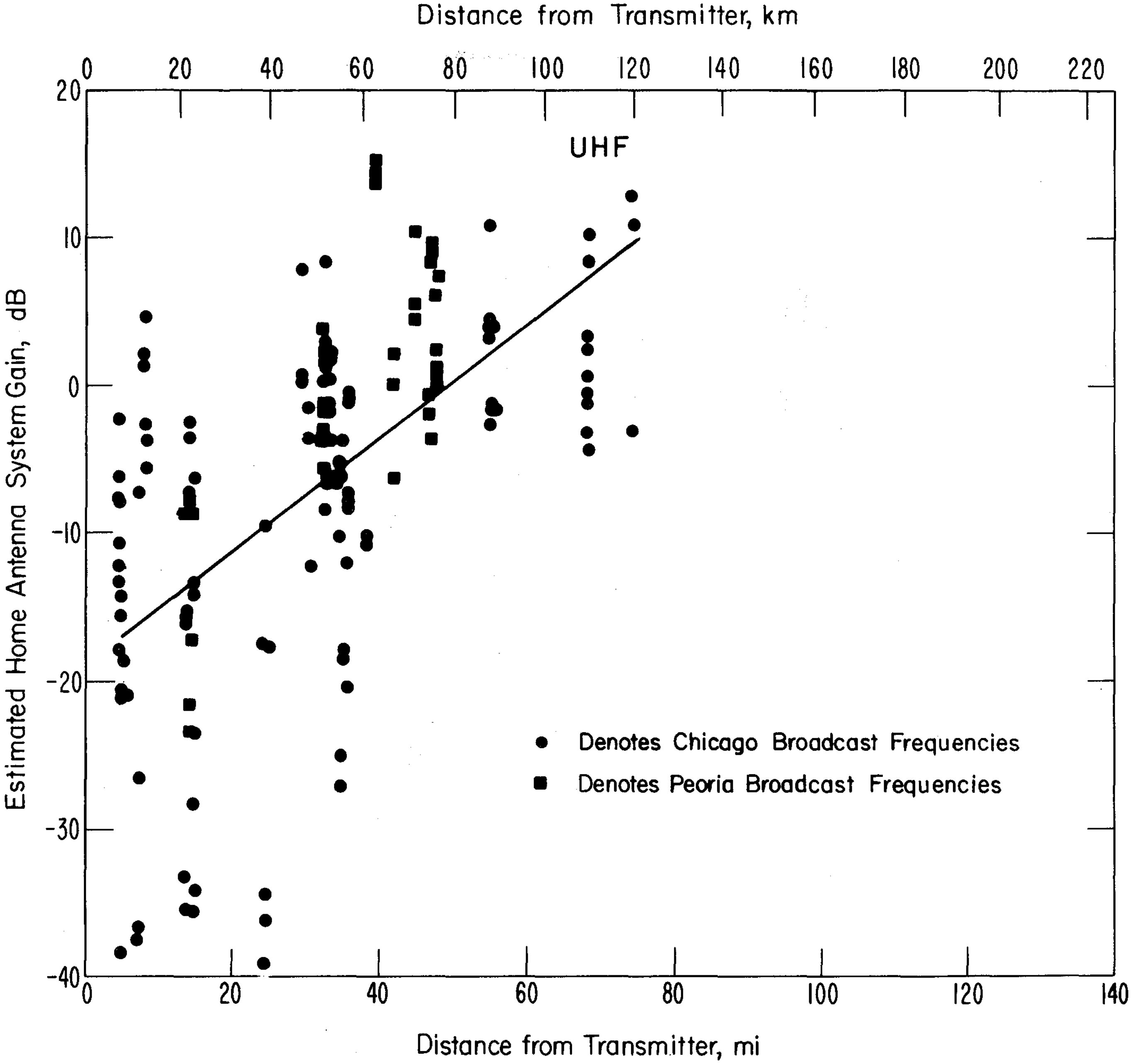

Figure 17. Estimated home antenna system gain at UHF as a function of distance from the transmitter. The least squares, linear regression line fit to these data also is shown.

good quality, VHF/UHF combination antenna designed for suburban service, and it was only about 3 years old. The VHF elements of the antenna extended to form an angle of about 60 deg with the support boom (rather than being perpendicular to the boom). Such design is quite common for VHF antennas. The antenna was erected about 35 ft (10.7 m) above ground on a mast which was strapped to the chimney. The homeowner reported that at the time he purchased the antenna he had been instructed to "install the antenna so that it points at the TV station." He thought he had followed that instruction. However, because of the design of the VHF portion of the antenna and his unfamiliarity with TV antenna designs, he had interpreted that instruction in a way which resulted in the antenna being installed to point exactly backward.

About 50 ft (15.3 m) of good quality, 75-ohm coaxial transmission line had been used in the installation. At the time we made our measurements, the transmission line was connected (at the TV set) to a VHF/UHF signal splitter designed for use with 300-ohm transmission line. This connection had been accomplished by cutting off the type F connector, fraying a length of the braided shield which had been twisted and attached to one input terminal of the signal splitter, and stripping a length of the center conductor which had been attached to the other input terminal on the signal splitter. The homeowner said his original installation had included a signal splitter designed for use with 75-ohm cable and a type F connector. However, that signal splitter had been broken, and he was told by a salesperson that the signal splitter we observed in his system "would be just as good."

The highest system gain, measured at 501.25 MHz, was at a farm home which was 39.6 mi (63.7 km) from the transmitting antenna in Peoria, Illinois. The antenna was a 7-ft (2.1-m), parabolic dish about 70 ft (21.3 m) above ground on a tower adjacent to the house. The system, reported to be about 6 years old, had been installed by the homeowner, who was an amateur radio operator. He had used 300-ohm transmission line that was shielded and featured polyethylene foam insulation between the conductors. This type transmission line probably provides the lowest attenuation to TV signals of any transmission line available to consumers today. Since this installation was a UHF-only antenna, there was no signal splitter in the system.

These contrasting examples illustrate that technical information (gain/attenuation versus frequency, insertion loss versus frequency, etc.) for all components of the antenna system and instructions (or knowledge) with which to apply that information can result in excellent installations. Conversely, lack of information and/or technical skills can result in very poor installations, even though a conscientious effort is made to realize a good installation.

We are not suggesting that technical information and instruction provided with each antenna system component to the consumer will guarantee consistent installations as good as the best we observed. But, we do believe it is possible to provide information and instruction for use with antenna system components offered the consumer so that system quality can be improved significantly with respect to the quality of systems we typically tested during the field work being reported.

Often the antenna systems for which we measured performance were very similar in design within a community. This similarity suggested to us that many of the systems had been installed by the same service technician. This deduction was verified several times in conversations with the homeowners. It appeared to us that a combination of system components which seemed to provide adequate service had been defined somehow by the service technician and regularly used thereafter with little additional consideration applied to custom designing a system to unique circumstances. Tables 4 and 5 show for every frequency and location classification that more than 50% of the estimated system gains were less than the values reported by O'Connor (1968). Median estimated values ranged from 0.4 dB to 12.5 dB lower. Our point is not to criticize the service technicians but rather to suggest that technical information defining performance capabilities of antenna system components is not available readily even to these service technicians, and they, too, could provide better service if better technical information were available to them.

In earlier sections of this report, variability in the measured data has been discussed. However, there are at least three aspects of this variability that should be discussed in more detail. First, there is the localized propagation variability which affects each set of measured data. Because of this localized variability, one is concerned about error in the measured results. Or one may ask, "How good is the assumption that each set of measurements with the standard antenna and the measurements from the home antenna system were obtained while sampling from a uniform electric field?"

A second consideration is that of location-to-location differences in propagation. For example, the propagation over two seemingly similar, but different, paths may be very different due to the differences in terrain and/or man-made structures along the path. These and other factors contribute to what is termed location variability.

Finally, there is the variability in the home antenna systems. This variability arises from many factors such as the size of the antenna, length and type of transmission line connecting the antenna to the TV receiver, other components such as baluns, signal splitters, or multi-coupling devices which may be a part of the antenna system, age and condition of the antenna system components, and workmanship quality for the installation. Unfortunately, these measurements are not amenable to the development of separate statistical results for each variability contribution.

The information provided by Table 5, as it relates to variability, now will be discussed. The median estimated gain data in the first column were discussed earlier in this section as being obtained from an examination of the estimated gain values tabulated from the cumulative distributions in Appendix A.

The lower and upper decile values for each set of estimated gain data, according to location classifications, are shown in the second column of Table 5. For example, the median estimated gain for UHF antenna systems at locations within the Grade A Service contours was -9.5 dB. There were 10% of the systems with estimated gains poorer than -34.4 dB, and 10% of the systems had estimated gains of 1.3 dB or higher. Systems for UHF reception at locations beyond the Grade A Service contours exhibited the best performance. That is, the median estimated gain was the highest--0.9 dB, and variability was the smallest--an interdecile range in estimated gain of 16.8 dB (6.1 dB + 10.7 dB).

Each cumulative distribution in Appendix A provides lower and upper decile values, as well as the median. The difference between each pair of decile values has been tabulated to form sets of interdecile range data according to the defined data location classifications. These sets of interdecile range data then were examined to determine the median and decile values which are shown in the third and fourth columns of Table 5.

These interdecile range data are important as a measure of the localized variability discussed earlier in this section. For example, median uncertainty in the measurements of VHF antenna system performance at locations within the Grade A Service contour is about ±1.9 dB. It should be recognized that this estimate of uncertainty is half the median interdecile range shown in the third column of Table 5. Such an estimate assumes a symmetric distribution of the interdecile range data. That is not necessarily a particularly good assumption. However, separate tabulation of lower and upper decile ranges creates considerable difficulty in understanding the data. We believe discussion of interdecile range is a reasonable compromise to reduce that difficulty.) The fourth column of data shows that uncertainty in the measurements may be estimated to not exceed ±1.2 dB at 10% of the locations nor ±3.1 dB at 90% of the locations. One should be careful to recognize that the variabilities shown in the third and fourth columns of Table 5 are included (implicitly) in the variabilities shown in the second column. The data reported in the second column show total variability. As discussed earlier in this section, total variability includes, in concept, localized variability, location variability, and variability due to home antenna system differences.

One more comment should be made about variability to avoid possible confusion to the reader. In Section 2 we defined a quantity termed "variability" as V(x). That quantity was calculated as part of the field analysis of measured data for each frequency and location. Figures 4 and 5 show that calculated variability in the legends for each set of data. We believe, however, that the decile values and interdecile ranges of data shown by the figures in Appendix A provide a more useful measure of variability, since extreme values with low frequency of occurrence are eliminated from the variability measures.

We have discussed how the sets of measured electric field probing data that were recorded during the field measurements have been used to produce cumulative distributions of the recorded data, scaled to sample home antenna system gain using (5). The data, just as well, could have been scaled for electric field strength. Each distribution, of course, would have the same shape as those distributions shown in

Appendix A. The abscissa scale simply would be different. That scale translation can be made using information contained in Tables 6 and 7 and the following expression for electric field strength. The relationship is developed by solving (5) for received power from the standard antenna, P_{STD}, and substituting that expression into (4) to produce

$$E = \left[120\pi \log_{10}^{-1} \left((P_{HS} - C - G_{HS} + L_{bal} + L_{TL})/10 \right) \right]^{\frac{1}{2}} \quad . \quad (6)$$

The terms of this expression are defined in Section 2 of this report, as well as in Section 6, Glossary of Terms.

Consider, for example, the measurements at location 10 for 543.25 MHz (channel 26) shown in Figure 4. The median received signal level using the standard antenna was -33.5 dBm. Using that value and appropriate data from Tables 6 and 7, we calculate, with (5), the median sample home antenna system gain to be 4.8 dB (as shown by the cumulative distribution in Figure 5 for that set of measurements). A calculation using (4) shows the median electric field strength to be about 39,000 μV/m (91.8 dBμ). The same result is obtained using (6) and the appropriate data from Tables 6 and 7. Therefore, (6) provides scale translation for the cumulative distributions in sample home antenna system gain to sample electric field strength.

The median electric field strength for each set of measured data for the five frequencies broadcast from Chicago has been plotted as a function of distance from the transmitter. These data are shown in the plots of Figures 18 through 22. Each plot has constant field strength lines drawn which indicate field strengths required for Grade A and Grade B service, as defined in the FCC Rules and Regulations, Part 73.683(a). Lines at fixed distances also are drawn on each plot. The solid lines correspond to distances scaled from the contours for Grades A and B Service published for each station in the Television Factbook. Presumably these contours were computed using the FCC F(50,50) curves without terrain roughness correction for determining the field strengths. The dashed lines correspond to distances scaled from contours for Grades A and B Service determined by using an automated model named COVERAGE. The COVERAGE model used an automated and modified version of the FCC F(50,50) curves for the radio propagation model in determining these contours. Modifications included (1)

Table 6. Data Required to Calculate Home Antenna System Gain and Electric Field Strength from Received Signal Level Measurements

Channel	Freq, MHz	C, dB	G_{STD}, dB	L_{bal}, dB	L_{TL}, dB
5	77.25	2.94	3.1	0.37	1.1
9	187.25	-4.75	5.8	0.91	1.8
19	501.25	-13.30	7.2	0.90	3.3
20*	507.25	-13.41	7.3	0.92	3.3
25	537.25	-13.90	7.7	1.10	3.4
26	543.25	-14.00	7.8	1.15	3.4
31	573.25	-14.47	8.0	1.32	3.5
32	579.25	-14.56	8.1	1.35	3.5
44	651.25	-15.58	9.0	1.72	3.9

*Measurements were attempted on this channel, but there was insufficient signal.

Table 7. Measured Received Signal Level (dBm) Versus Frequency for Home Antenna Systems (Average for 40 Measurements at Each Frequency)

Location	Channel 5 77.25 MHz	Channel 9 187.25 MHz	Channel 19 501.25 MHz	Channel 20* 507.25 MHz	Channel 25 537.25 MHz	Channel 26 543.25 MHz	Channel 31 573.25 MHz	Channel 32 579.25 MHz	Channel 44 651.25 MHz
1	-	-	-	-	-	-	-	-	-
2	-23.4	-22.7	-	-	-	-43.2	-	-44.1	-60.3
3	-34.2	-39.4	-	-	-	-70.7	-	-52.0	-54.5
4	-36.4	-25.5	-	-	-	-40.2	-	-42.5	-44.5
5	-35.5	-30.9	-	-	-	-45.5	-	-57.2	-63.4
6	-30.7	-33.1	-	-	-	-64.3	-	-61.0	-63.1
7	-79.4	-65.9	-	-	-	-70.6	-	-76.1	-82.0
8	-33.9	-31.0	-	-	-	-43.7	-	-53.8	-51.1
9	-34.0	-28.3	-	-	-	-32.9	-	-40.1	-44.5
10	-33.5	-35.8	-	-	-	-37.7	-	-36.5	-51.2
11	-63.9	-59.9	-	-	-	-71.0	-	-66.4	-69.3
12	-34.8	-33.1	-	-	-	-50.3	-	-47.2	-47.3
13	-46.5	-41.4	-	-	-	-41.4	-	-45.5	-45.6
14	-46.4	-39.5	-	-	-	-53.6	-	-71.5	-68.5
15	-39.8	-43.3	-	-	-	-46.6	-	-61.0	-54.4
16	-62.0	-64.2	-	-	-	-63.1	-	-47.5	-56.2
17	-48.4	-71.2	-	-	-	-87.7	-	-83.1	-76.4
18	-59.0	-54.2	-	-	-	-64.9	-	-63.8	-64.1
19	-66.6	-50.5	-	-	-	-71.7	-	-47.6	-47.5
20	-61.6	-57.7	-	-	-	-81.5	-	-71.5	-70.0
21	-51.5	-64.2	-	-	-	-81.4	-	-70.4	-72.4
22	-56.9	-60.2	-	-	-	-82.3	-	-65.6	-62.8
23	-57.9	-58.7	-	-	-	-80.5	-	-64.2	-66.3
24	-60.1	-57.4	-	-	-	-72.4	-	-64.9	-58.4

Table 7. Measured Received Signal Level (dBm) Versus Frequency for Home Antenna Systems (Average for 40 Measurements at Each Frequency) (continued)

Location	Channel 5 77.25 MHz	Channel 9 187.25 MHz	Channel 19 501.25 MHz	Channel 20* 507.25 MHz	Channel 25 537.25 MHz	Channel 26 543.25 MHz	Channel 31 573.25 MHz	Channel 32 579.25 MHz	Channel 44 651.25 MHz
25	-59.1	-58.8	-	-	-	-84.2	-	-76.8	-71.5
26	-60.4	-57.4	-	-	-	-71.8	-	-55.5	-79.7
27	-52.2	-49.4	-	-	-	-	-	-51.9	-50.0
28	-60.4	-56.3	-	-	-	-65.6	-	-71.0	-66.7
29	-78.9	-65.4	-	-	-	-79.4	-	-71.8	-58.1
30	-57.9	-60.9	-	-93.8	-	-	-	-65.7	-65.0
31	-64.0	-61.4	-	-	-	-78.8	-	-66.2	-65.4
32	-66.6	-66.5	-	-	-	-88.2	-	-67.0	-66.6
33	-65.3	-60.4	-	-	-	-70.1	-	-55.8	-50.7
34	-78.4	-71.6	-	-	-	-72.0	-	-63.5	-61.9
35	-69.1	-65.3	-	-	-	-79.7	-	-58.8	-54.3
36	-68.8	-71.3	-	-	-	-88.7	-	-67.7	-68.8
37	-70.8	-67.5	-	-	-	-90.0	-	-75.1	-70.0
38	-73.1	-70.5	-	-106.7	-	-	-	-66.5	-64.1
39	-	-	-	-	-	-	-	-	-
40	-72.8	-79.6	-73.3	-	-64.1	-	-69.8	-	-
41	-91.5	-89.8	-73.0	-	-65.6	-	-68.7	-	-
42	-108.6	-108.3	-76.9	-	-72.0	-	-78.0	-	-
43	-101.0	-87.4	-63.5	-	-62.3	-	-67.6	-	-
44	-78.2	-85.5	-59.3	-	-54.4	-	-62.8	-	-
45	-	-	-68.5	-	-64.6	-	-74.1	-	-
46	-83.8	-86.0	-52.2	-	-49.8	-	-50.6	-	-
47	-90.4	-92.9	-63.8	-	-64.8	-	-67.8	-	-
48	-94.7	-97.0	-68.8	-	-62.7	-	-70.3	-	-

Table 7. Measured Received Signal Level (dBm) Versus Frequency for Home Antenna Systems (Average for 40 Measurements at Each Frequency) (continued)

Location	Channel 5 77.25 MHz	Channel 9 187.25 MHz	Channel 19 501.25 MHz	Channel 20* 507.25 MHz	Channel 25 537.25 MHz	Channel 26 543.25 MHz	Channel 31 573.25 MHz	Channel 32 579.25 MHz	Channel 44 651.25 MHz
49	-107.2	-90.5	-61.3	-	-64.6	-	-62.6	-	-
50	-	-	-53.4	-	-48.5	-	-51.9	-	-
51	-	-	-62.8	-	-62.8	-	-64.9	-	-

*Measurements were attempted on this channel, but there was insufficient signal.

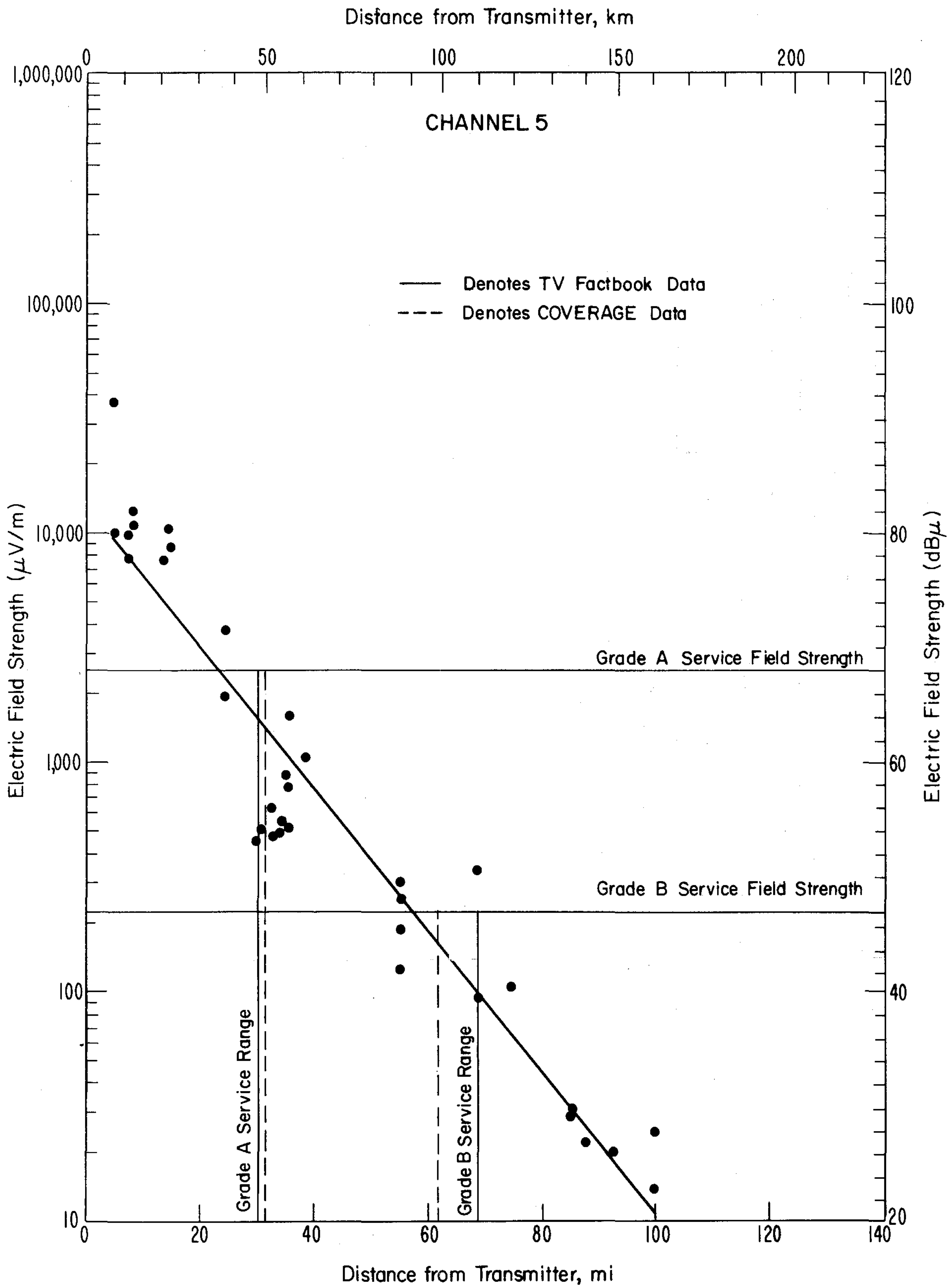

Figure 18. Median electric field strength as a function of distance from the transmitter for WMAQ-TV, channel 5, 77.25 MHz. The least squares, linear regression line fit to the measured data also is shown.

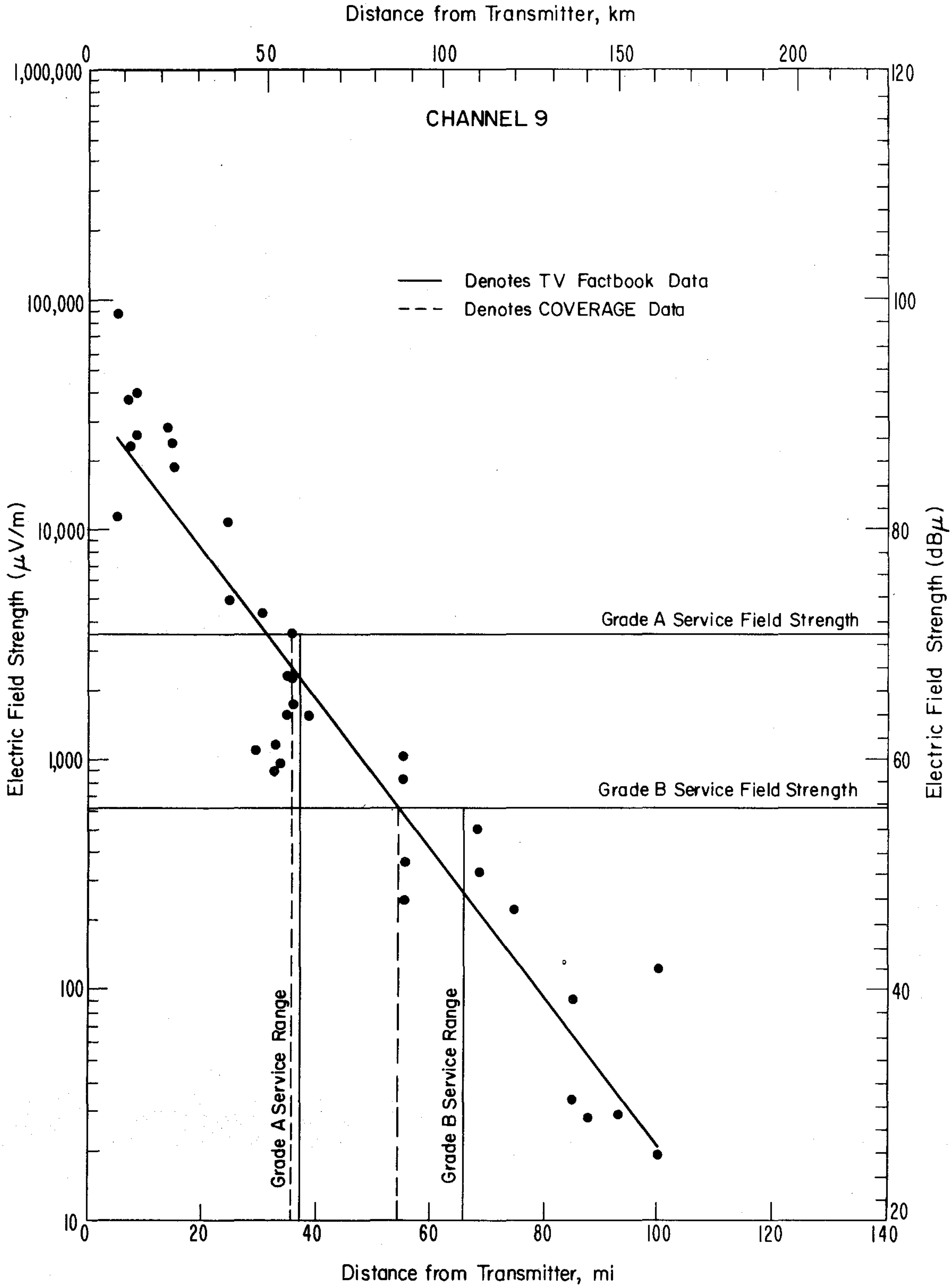

Figure 19. Median electric field strength as a function of distance from the transmitter for WGN-TV, channel 9, 187.26 MHz. The least squares, linear regression line fit to the measured data also is shown.

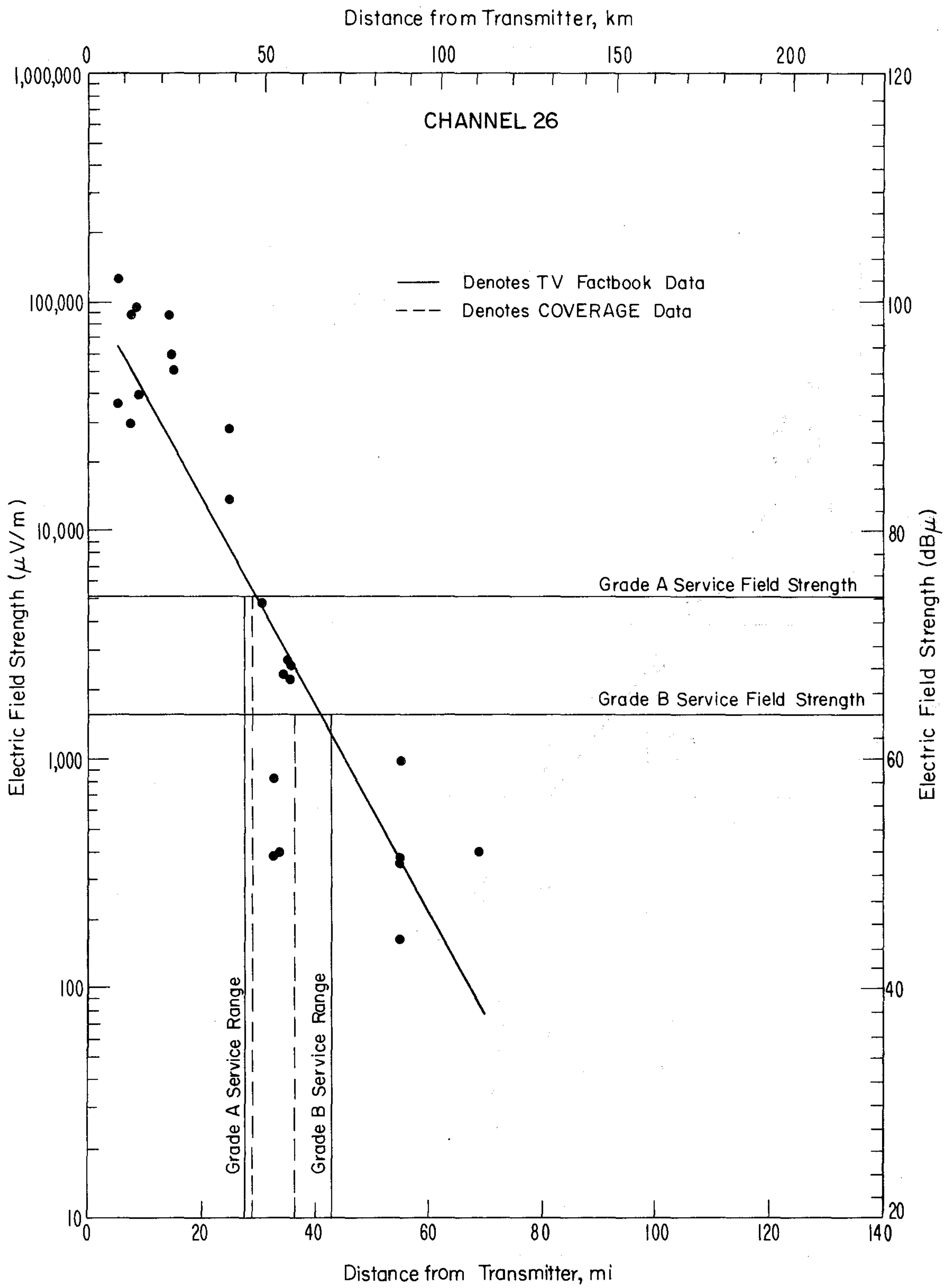

Figure 20. Median electric field strength as a function of distance from the transmitter for WCIU-TV, channel 26, 543.25 MHz. The least squares, linear regression line fit to the measured data also is shown.

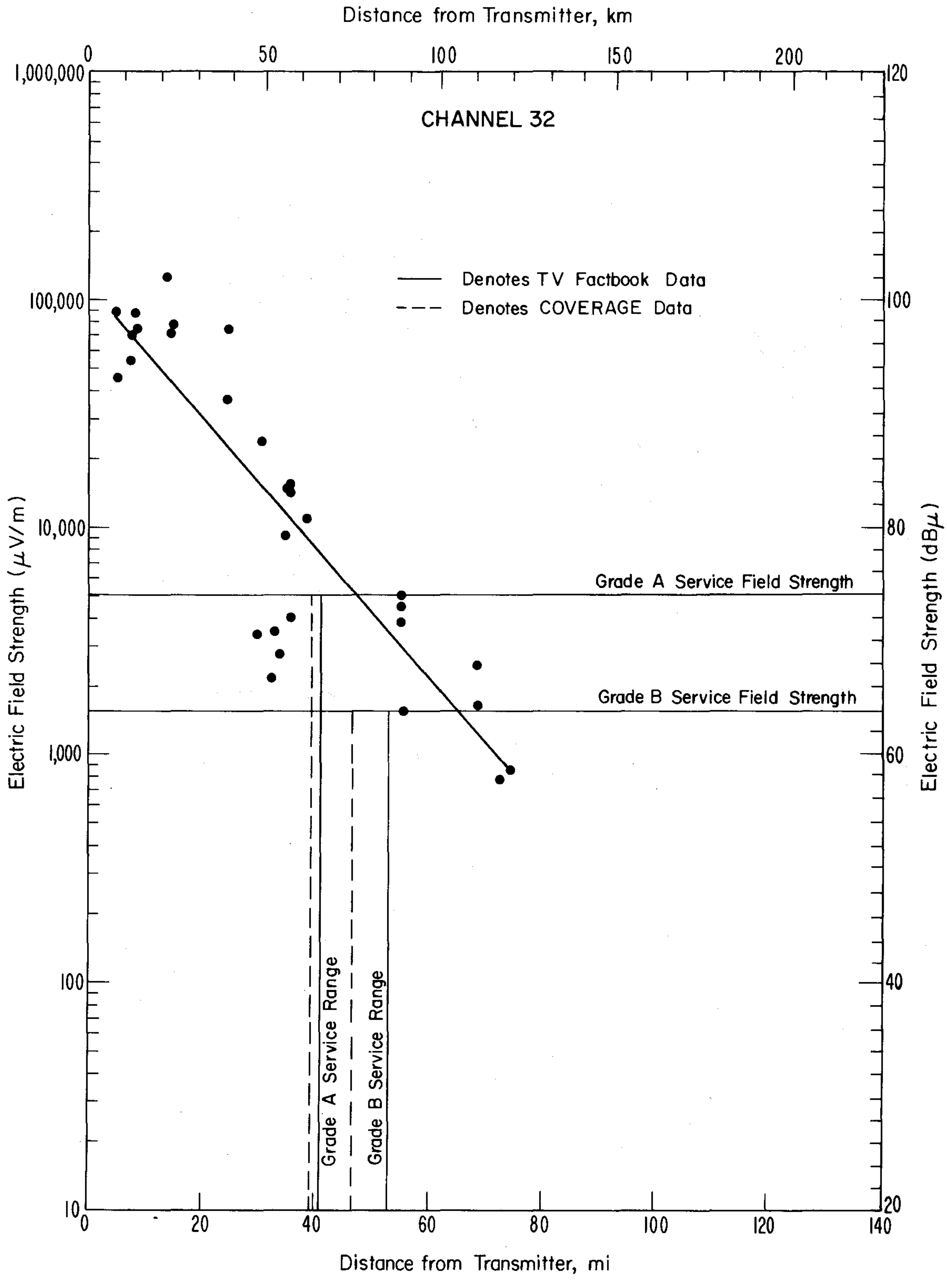

Figure 21. Median electric field strength as a function of distance from the transmitter for WFLD-TV, channel 32, 579.25 MHz. The least squares, linear regression line fit to the measured data also is shown.

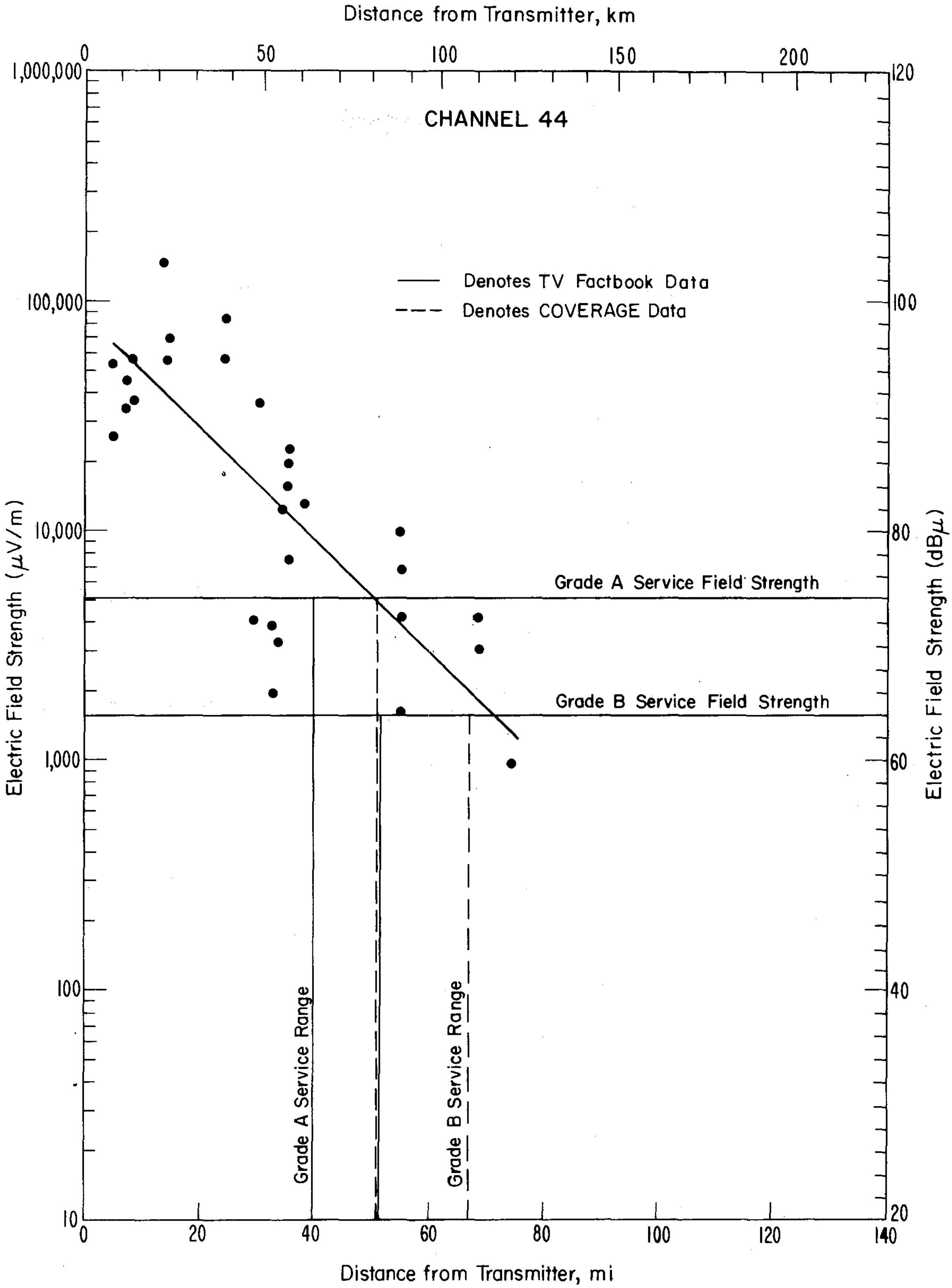

Figure 22. Median electric field strength as a function of distance from the transmitter for WSNS-TV, channel 44, 651.25 MHz. The least squares, linear regression line fit to the measured data also is shown.

elimination of isolated topographic features which would produce extremes in the computed terrain roughness factor; (2) limitation to the computed roughness correction factor for attenuation, and (3) incorporation of double knife-edge diffraction, as appropriate, in the computation of attenuation relative to free space. The COVERAGE model is described and contour plots from which distances were scaled are included as Appendix B. The modifications applied to the FCC F(50,50) curves are discussed in detail in a report by Hufford (1977).

Several interesting observations can be drawn from the data presented in Figures 18 through 22. On each figure there are a small number of data (median values) which were measured at locations in and near Joliet (about 30-35 miles (48-56 km) from the transmitters) which are unusually low. Other data measured in that area are very near the regression line. All these data were measured on two different days, September 11 and 14, and we believe the data are valid. However, we do not offer an explanation for these clusters of unusually low, median values.

Comparing the Grade of Service ranges (scaled from contours in the Television Factbook and contours produced with the COVERAGE model), generally, there is less difference for Grade A Service predictions compared with Grade B Service predictions. There also is less difference between types of coverage predictions at the lower frequencies than at the higher frequencies, although the results for channel 9, Grade B Service violate this tendency. Intersections of Grade of Service range lines with Grade of Service required field strength lines show three instances when the intersections for ranges from the COVERAGE model coincide with the regression lines fit to the measured data. And, in general, the intersections for ranges determined with the COVERAGE model provide better correspondence with the median measured data. Results for channel 32 are the principal exception.

The data for channels 26, 32, and 44 show considerable variations in computed field strength versus distance from the transmitter. This observation is not particularly surprising, since the UHF signals are more strongly affected by many propagation and terrain influences than are the VHF signals. Our measurements do not provide sufficient information, however, for thorough analysis of these propagation and terrain-dependent influences.

4. SUMMARY AND CONCLUSIONS

Measurements were made at 51 locations of received signal levels from selected television broadcasts from Chicago (two VHF and three UHF stations) and Peoria (three UHF stations). The locations provided propagation paths of 2.4 - 99.6 mi (3.9 - 160.3 km) for VHF broadcasts (from Chicago), 2.4 - 74.5 mi (3.9 - 119.9 km) for UHF broadcasts from Chicago, and 14.4 - 48.0 mi (23.2 - 77.2 km) for UHF broadcasts from Peoria. These measurements were made using a standard antenna which allowed calculation of electric field strengths. Measurements also were made using the home antennas at these locations, and with these two types of data, the home antenna system gains were computed.

Combination VHF/UHF antennas were used at 34 locations. One combination antenna was an indoor type; the remaining 33 antennas were outdoor types. Twelve of the outdoor combination antenna systems used coaxial, 75-ohm transmission line; 300-ohm transmission line was used for 20 systems; and the type of transmission line was not determined for one system. Outdoor antennas for only VHF reception were used at 16 locations (there was no antenna for VHF reception at one location). Two of these systems used 75-ohm transmission line, 13 systems used 300-ohm transmission line, and one system was undetermined. Antennas for only UHF reception were used at 17 locations--16 outdoor types and 1 indoor type. Two of the outdoor systems used 75-ohm transmission line, 13 systems used 300-ohm transmission line, and the type of transmission line was not determined for one system.

Unexpected circumstances prevented complete measurements at two locations. In one case, it was determined that a signal amplifier was being used on the home antenna system. This amplifier was installed, ahead of the transmission line, at the top of a 50 ft (15 m) tower. In the second situation, the homeowner, who had initially agreed to cooperate, subsequently would not respond to our request to enter his home; therefore, his antenna system could be connected to our measurement system.

The measurements at each frequency and location have been converted and plotted as cumulative distributions of sample home antenna system gain, included in Appendix A. Median values for these sample home antenna system gain distributions have been selected as estimates of the home antenna system gains vs. frequency. Information is presented in this report which allows conversion of the antenna system gain units to field strength units. The results computed from our field measurements and presented in this report support a number of interesting conclusions relevant to the question of comparability for UHF television.

The required field strengths and assumed home antenna system gains used in establishing Grade A and Grade B Service are clearly defined and discussed in the paper by O'Connor (1968). The Grade of Service field strengths, required by FCC regulation, and the assumed values for home antenna system gains have been used as bases of comparison for our data.

In Figures 18 through 22 we have shown plots of median electric field strengths with the required levels and computed Grade of Service distances in the direction of Peoria from Chicago, also shown. In general, the measured, median field strengths seem reasonable, judged by intersections of the Grade of Service range (distance) lines with the Grade of Service required field strength lines. The Grade of Service ranges were determined in two ways: (1) distances were scaled from the coverage contours published in the Television Factbook, presumably determined using the standard FCC F(50,50) curves for propagation loss determinations (no correction for terrain roughness), and (2) distances were scaled from coverage contours which we produced (shown in Appendix B) using a modified and automated version of the FCC curves in a computer-based model named COVERAGE. Modification included (1) discarding out-of-range values for terrain roughness, (2) limiting attenuation correction factors due to terrain roughness, and (3) incorporating, as appropriate, ridge attenuation in the computation of attenuation relative to free space. The least squares, linear regression lines fit to each set of data are shown.

Each set of data has a subset of 4 to 7 samples at locations in and near Joliet, about 30-35 mi (48-56 km) southwest of the broadcast antennas, which are well below the regression line. These data were measured on two different days which were two days apart; therefore, we believe the data are valid. However, we cannot offer a reasonable explanation for these low, median field strengths.

Grade A Service predictions using the COVERAGE model usually are not very different from those in the Television Factbook. Coverage from the channel 44 broadcast is an exception for which the COVERAGE model prediction agrees with the measured, median field strength results much better than the Television Factbook coverage prediction. Grade B Service predictions using the COVERAGE model generally are more conservative than those in the Television Factbook. Again, channel 44 is an exception. Our measured field strength data suggest, however, that estimates using either COVERAGE or the FCC procedures are somewhat pessimistic for the UHF broadcasts, at least along the radial from Chicago to Peoria.

Comparing estimated values of home antenna system gains with the values assumed in O'Connor's (1968) paper, we see that the estimated performance of a majority of systems is less than those assumed values (see Tables 4 and 5). As a subgroup, the (all data) UHF antenna systems (without regard to type of transmission line) at locations beyond the Grade A contours had the best performance. Median estimated gain was 0.9 dB, and the interdecile range in estimated gain was smaller than for other subgroups of data. However, the median estimated gain of 0.9 dB was much less than the 8 dB assumed for Grade B, UHF performance. The median gain for VHF antenna systems within the Grade A contours deviated from the assumed gain by the least amount---1.4 dB compared to -1 dB assumed.

The data shown in Table 5 for UHF antenna system performance are derived from 141 samples of estimated home antenna system gain. Thirty-six of these samples were from systems receiving Peoria broadcasts, while 105 samples were from systems receiving Chicago broadcasts. Despite the difference in sample sizes, we believe the 6.9 dB difference in median estimated gain is significant. This difference suggests that UHF antenna systems in the Peoria, UHF-only market area may be designed, installed, and maintained to provide better performance than the UHF antenna systems used in the combined VHF/UHF market area for Chicago.

Analyses of the data in subsets grouped according to type of antenna and impedance of the transmission line used for the system show several things:

(1) Single-function antennas provide higher gain for the system than do combination antennas (regardless of the type of transmission line that is used in the system).

(2) Antenna system performance as a function of the type of transmission line used in the system is somewhat inconclusive from these measurements. For example, the median gain for systems with UHF-only antennas and 300-ohm transmission line was about 1.0 dB higher than the median gain for systems with UHF-only antennas and 75-ohm transmission line. However, the number of samples for systems with 75-ohm transmission line was very small. Then, we note that the UHF performance, median gain for systems with combination antennas and 300-ohm transmission line was about 1.0 dB lower than the UHF performance, median gain for systems with combination antennas and 75-ohm transmission line. Similar inconsistencies are shown for VHF system performance.

One would expect, all other factors being equal, that systems with "good" 300-ohm transmission line would provide better performance than systems with "good" 75-ohm transmission line (see FitzGerrell et al., 1979). In fact, the best system performances measured--i.e., VHF performance at locations 40, 44, and 46 and UHF performance at location 46--were for systems which used 300-ohm transmission lines.

We attribute much of the measured low system gain performance to age of the systems and quality of transmission lines used. Many of the systems using 300-ohm transmission line were more than 5 years old, thus suffering degradation in performance due to aging and weathering. By contrast most of the systems installed with 75-ohm, coaxial transmission line were less than 3 years old. Also, improper installations were observed where 300-ohm transmission line recommended only for interior use had been used for exterior application. One would expect such installations to suffer premature aging and weathering degradations.

The data in Table 5 define a model of home antenna system gain for in-service antenna systems. The model will provide conservative estimates using upper decile, estimated gain values, typical estimates using median, estimated gain values, or liberal estimates using lower decile, estimated gain values of measured antenna system gain results. These estimates are without regard to the type of transmission line or other devices (such as baluns, signal splitters, and/or multicouplers) that may be used in the system. Further refinement of such a model can be realized by incorporating a quantitative factor for error in the measured data, but no methodology is recommended in this report for that refinement. An estimate of this measurement error is provided in Table 5 as median and decile values for interdecile range in the individual sets of measured data. Based upon the median interdecile range data, we estimate median error depending upon the data location classification, to range from ±1.8 dB (for the Peoria UHF data) to ±2.8 dB (for the UHF data from locations within the Grade A contours). Again, one can use the lower or upper decile data, if desired, for conservative or liberal estimates of error.

With regard to our measurements of home antenna system gain, we conclude the following:

(1) Installations can be made using antenna system components commonly available which will provide very good gain versus frequency performance.

(2) Median estimated home antenna system gains classified by frequency and service area always were less than system gain assumed (O'Connor, 1968) in defining required field strengths. Differences ranged from 0.4 dB to 12.5 dB. At Grade A service locations, 51.2% of the VHF values and 95.1% of the UHF values were less than the assumed values. At locations beyond the Grade A service contours, 77.3% of the VHF values and 78.3% of the UHF values were lower than assumed values. Such performance is attributed to a combination of inadequate system design, installation, and maintenance. To some degree, we attribute this condition to a lack of adequate design, installation, and service information for the consumer.

(3) The quality of UHF television reception is impacted more than VHF television reception quality by the factors detailed in the preceding conclusion.

(4) Our measured data may contain bias, although we have no way in which to quantify such bias if it is there, due to our suspicion that homeowners who felt they might have an antenna system problem were more cooperative with our field measurement program than

were homeowners who apparently recognized no deficiency in their TV reception.

Based upon our reported results and conclusions, we also offer the following recommendation: A study should be initiated to define the performance of television antenna system components using parameters that (a) are easy to understand by the average layman and (b) can and will be utilized by the manufacturers of antenna system components. Such a study also should consider the needs for consumer education to use the technical information and methods by which such education could be accomplished.

5. ACKNOWLEDGMENTS

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7. GLOSSARY OF SYMBOLS

In Sections 2 and 3 of this report, the following symbols are used in discussing the measurements that were made and the results that were developed from the measured data. Symbols using the English alphabet precede symbols using the Greek alphabet. Generally, upper-case letters are used for quantities expressed in decibels.

C is the ratio of power, in decibels, at the terminals of any half-wavelength dipole antenna to the power at the terminals of a half-wavelength dipole antenna for 108.38 MHz in plane-wave fields with equal power density.

E is the electric field strength in volts/meter.

g is the gain of the receiving antenna relative to a half-wavelength dipole antenna. A half-wavelength dipole antenna has g=1.64 with respect to isotropic.

G is the gain in decibels of the receiving antenna with respect to the gain of a tuned half-wavelength dipole antenna. Numerical quantities are expressed using dBd.

HS as a subscript indicates that the parameter pertains to the home antenna system.

L_{bal} is loss in decibels resulting from balun mismatch and insertion loss for a balun used during the home antenna system measurements to match the impedance of our coaxial cable to the impedance of the signal splitter used in the homeowner's antenna system.

L_{TL} is loss in decibels for attenuation of the transmission line used to connect the secondary standard antenna to the receiving system during electric field measurements.

p is the power flow in watts/meter^2 produced by an electric field.

P is the power in decibels referenced to 1 W at the terminals of a receiver.

STD as a subscript indicates that the parameter pertains to the standard antennas used for the electric field measurements.

x_i denotes a set of measured signal amplitude data which are differences with respect to a reference signal amplitude.

$\overline{x}$ is the mean value of the x_i set of measured data.

V(x) is the variability of the x_i set of measured data normalized to the mean value, $\overline{x}$, of the x_i set of measured data.

λ is wavelength in meters of the energy in the electric field, E.

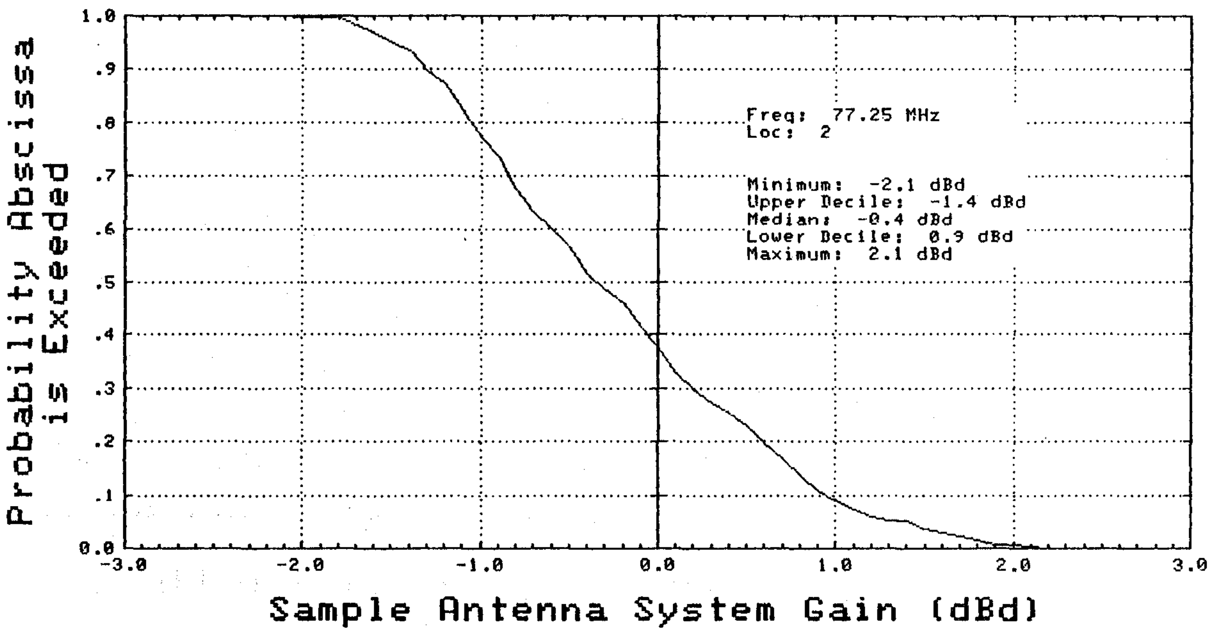
APPENDIX A. CUMULATIVE DISTRIBUTIONS OF HOME ANTENNA SYSTEM GAINS

This Appendix contains cumulative distributions of the measured data at each location and frequency. The figures are arranged first by location, then by frequency at a given location. There are no data for location 1 because the homeowner refused to allow a measurement team member to enter the house and connect the home antenna system to the measurement system. There are no data for location 39 because it was determined that a signal amplifier was installed on the antenna tower about 50 ft (15 m) above ground. Data for locations 8 and 32 were recorded, but these data were destroyed accidently while attempting to transfer the data from temporary storage on a diskette to permanent storage on magnetic tape. At location 45 only an antenna for UHF reception was in service. Finally, at locations 50 and 51 the antennas were directed toward Peoria; therefore, the orientation was incorrect for reception of VHF broadcasts from Chicago.

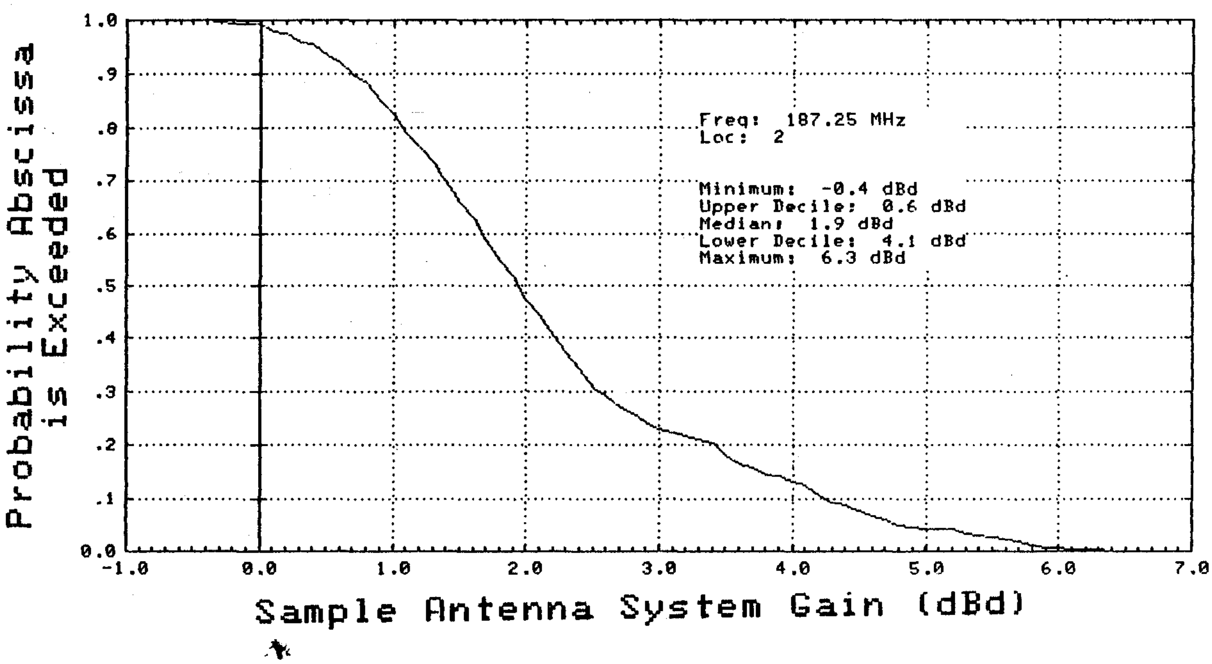
Each cumulative distribution is scaled to show sample antenna system gain. A translation to sample electric field strength can be made using the expression

$$E = \left[120\pi \log_{10}^{-1} \left((P_{HS} - C - G_{HS} + L_{bal} + L_{TL})/10\right)\right]^{\frac{1}{2}}$$

The above expression provides electric field strength in volts per meter. Other terms in the expression are defined in Section 7 of the report, and values for these terms are shown in Section 3, Tables 6 and 7.

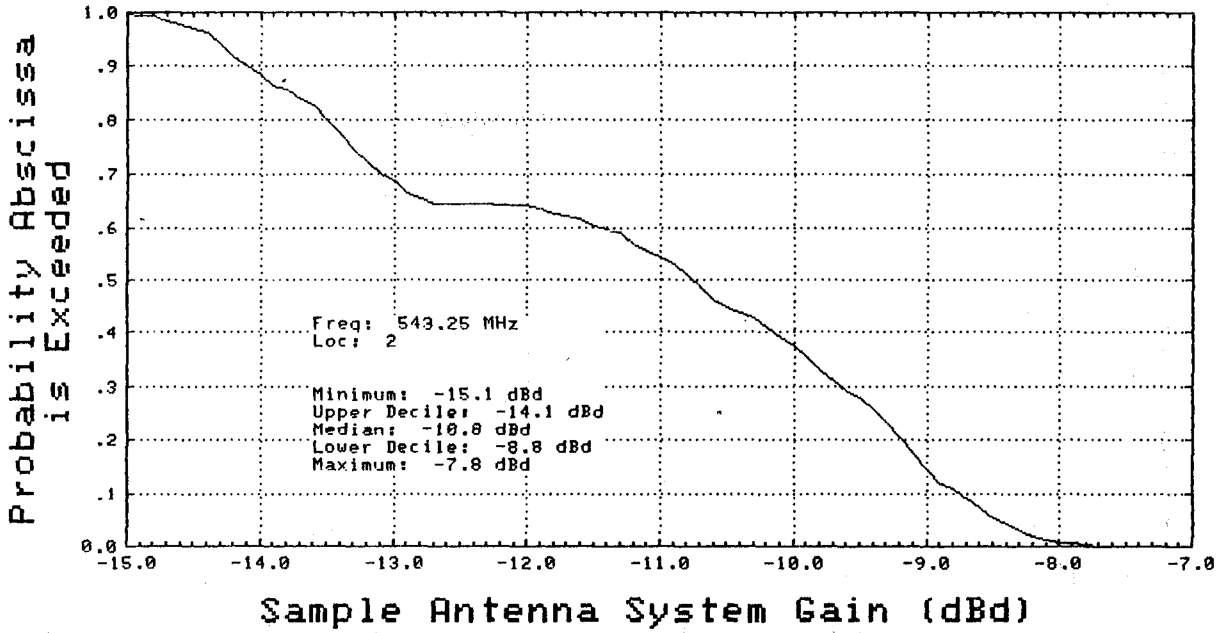


(a)

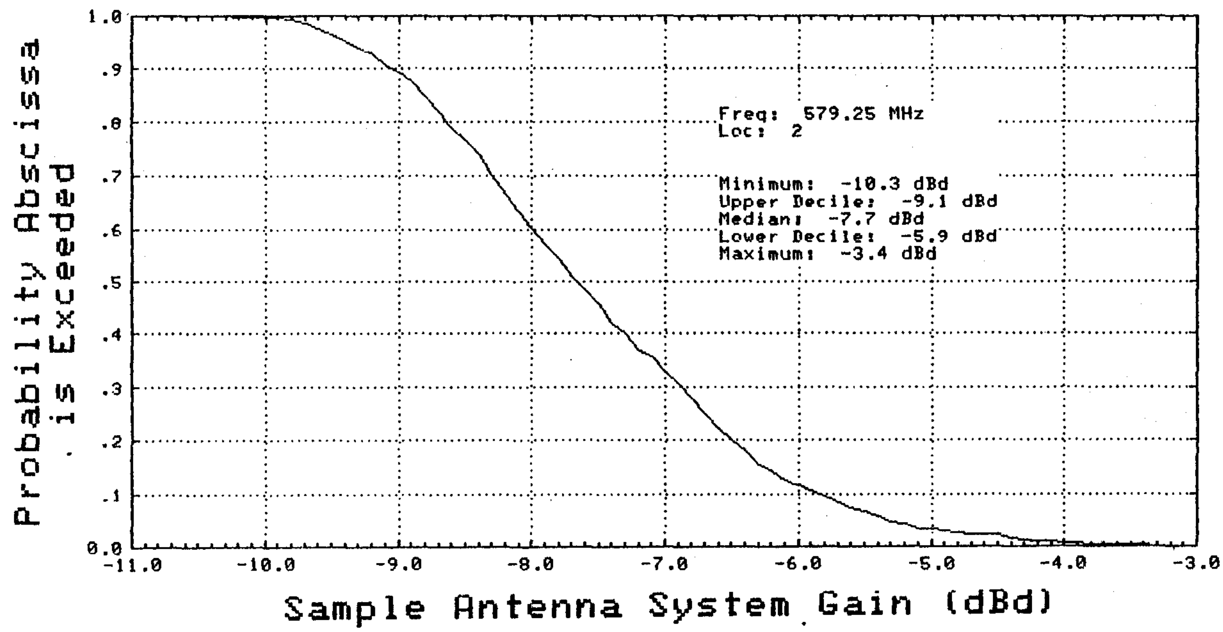


(b)

Figure A-1. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 2 at 77.25 MHz(a) and 187.25 MHz(b).

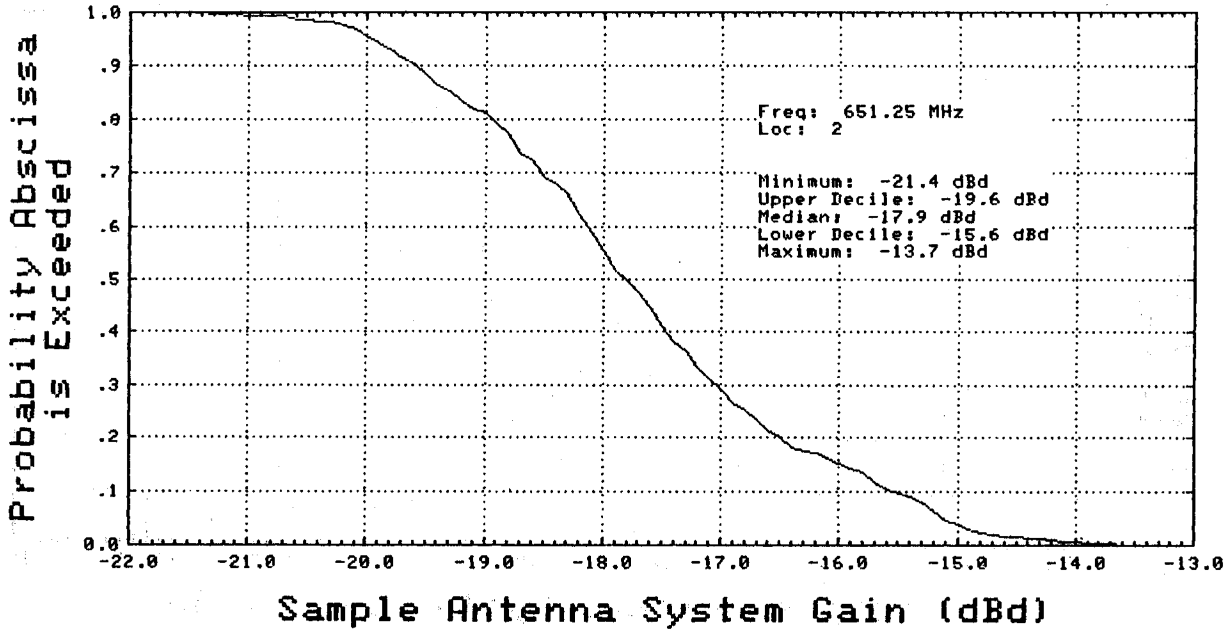


(a)

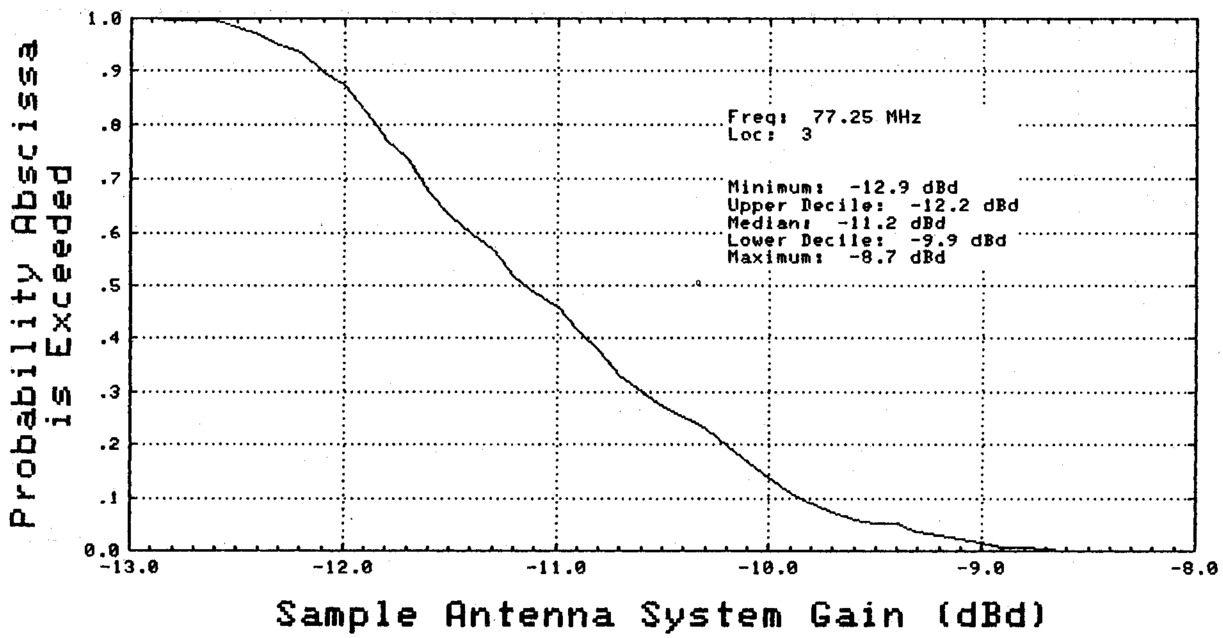


(b)

Figure A-2. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 2 at 543.25 MHz (a) and 579.25 MHz (b).

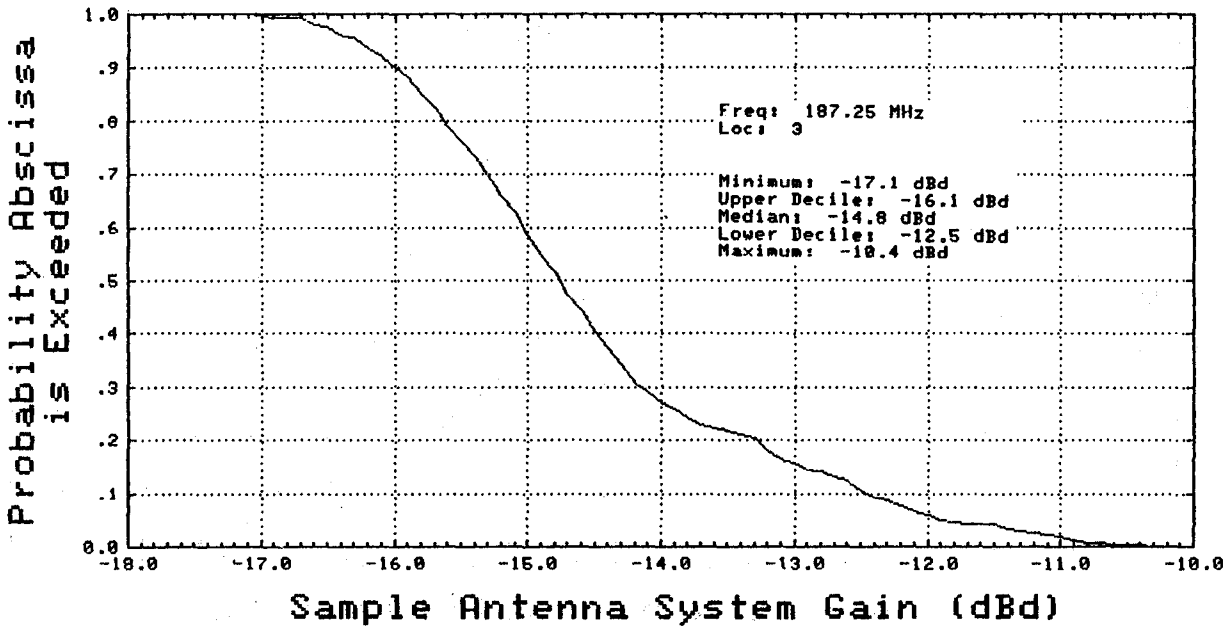


(a)

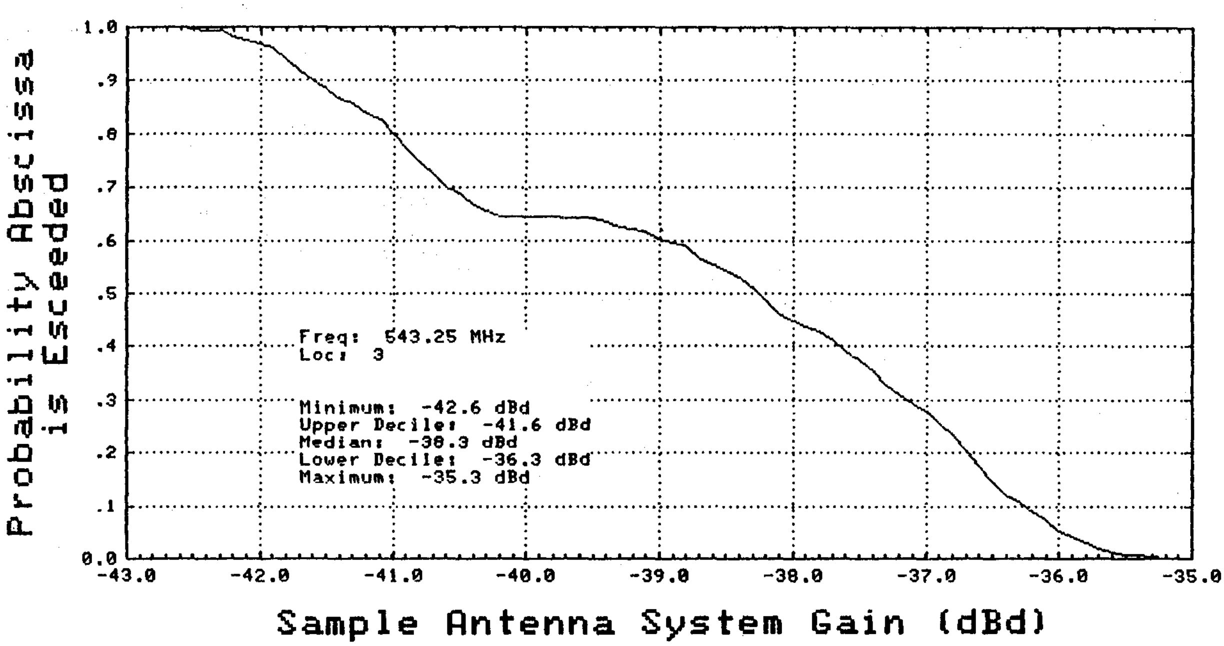


(b)

Figure A-3. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 2 at 651.25 MHz (a) and location 3 at 77.25 MHz (b).

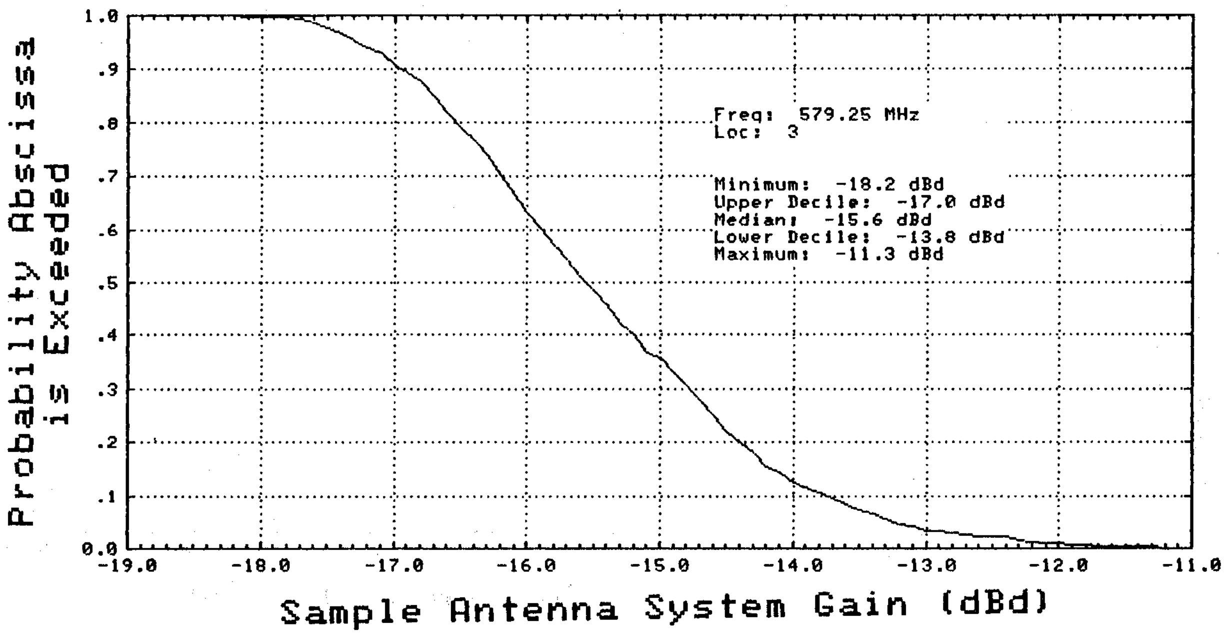


(a)

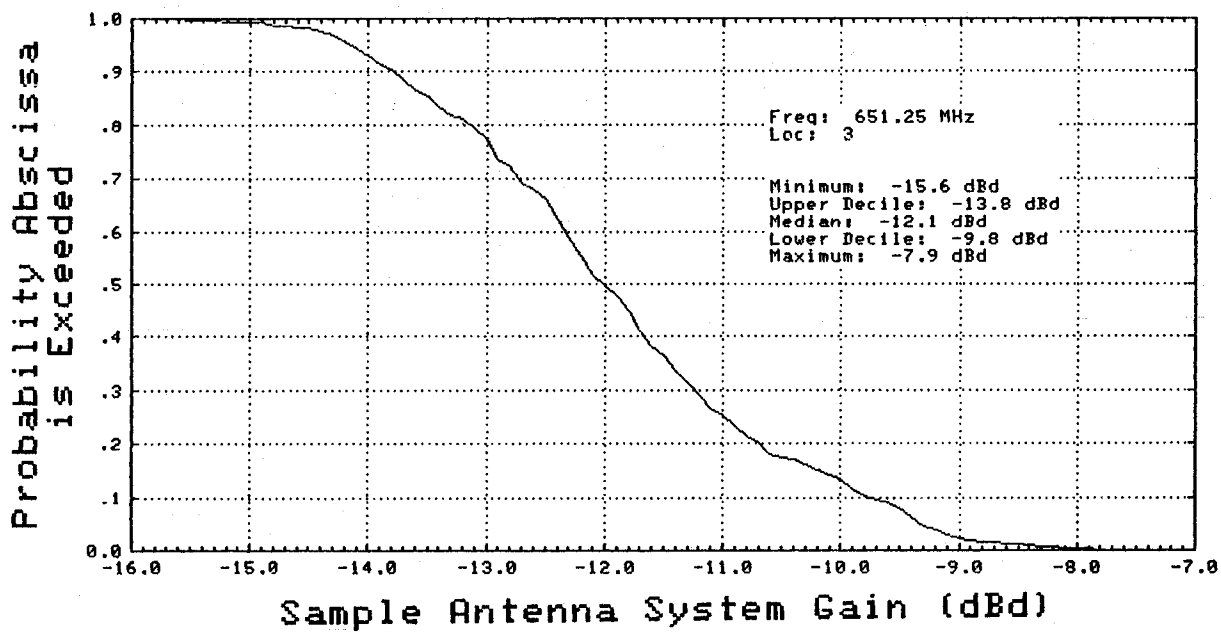


(b)

Figure A-4. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 3 at 187.25 MHz (a) and 543.25 MHz (b).

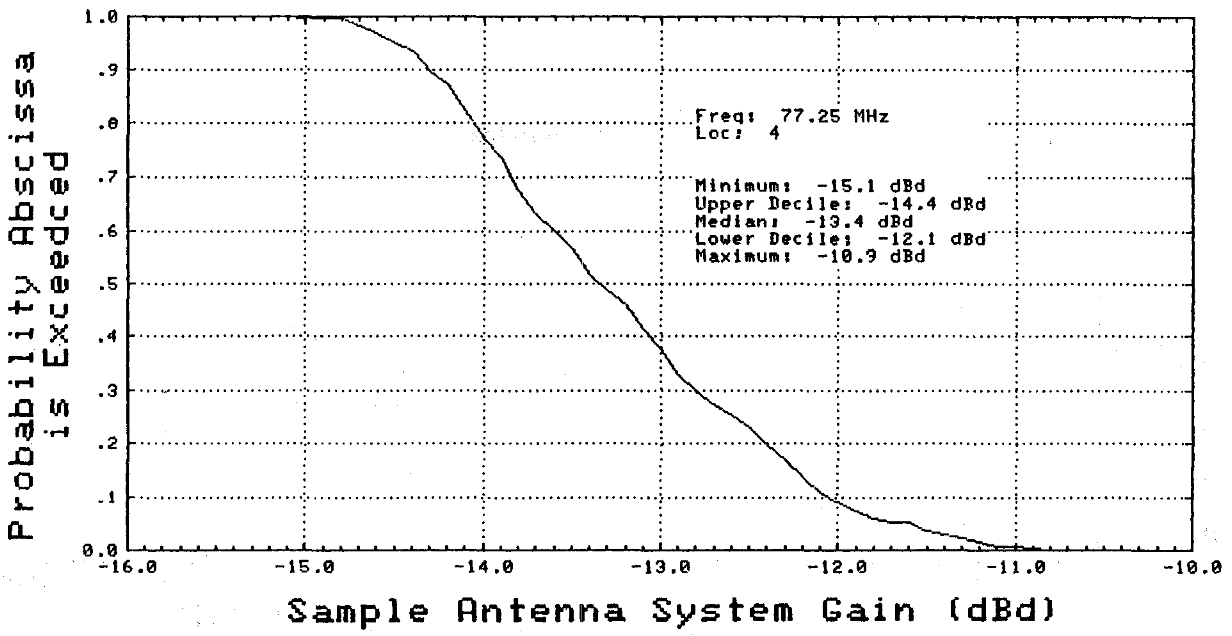


(a)

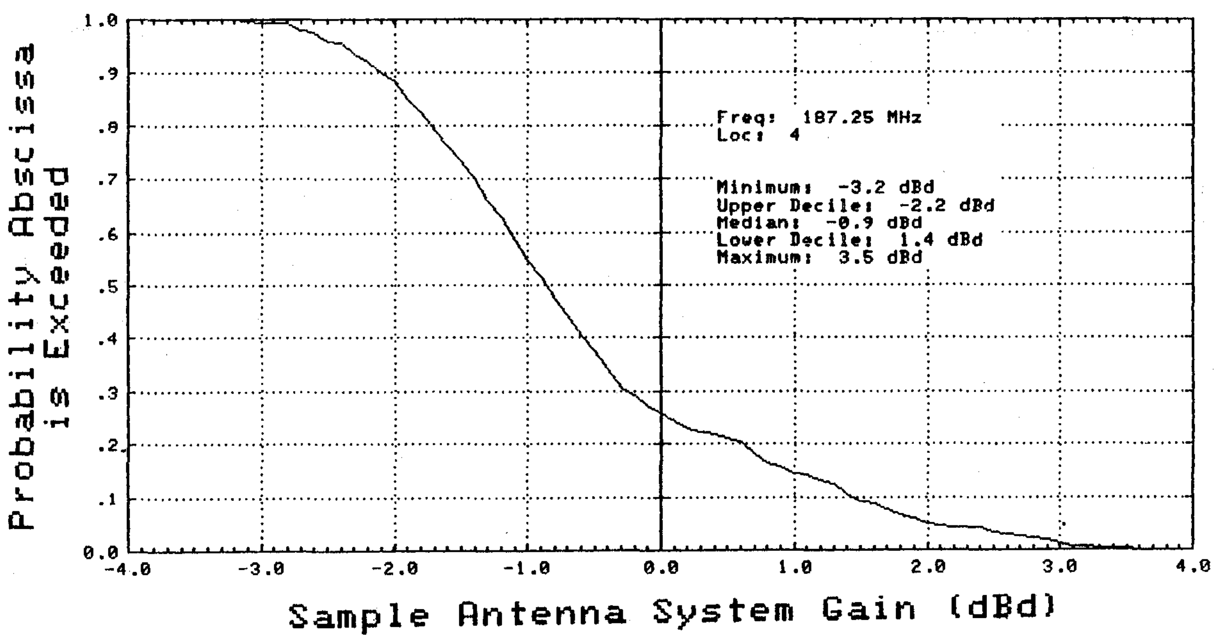


(b)

Figure A-5. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 3 at 579.25 MHz (a) and 651.25 MHz (b).

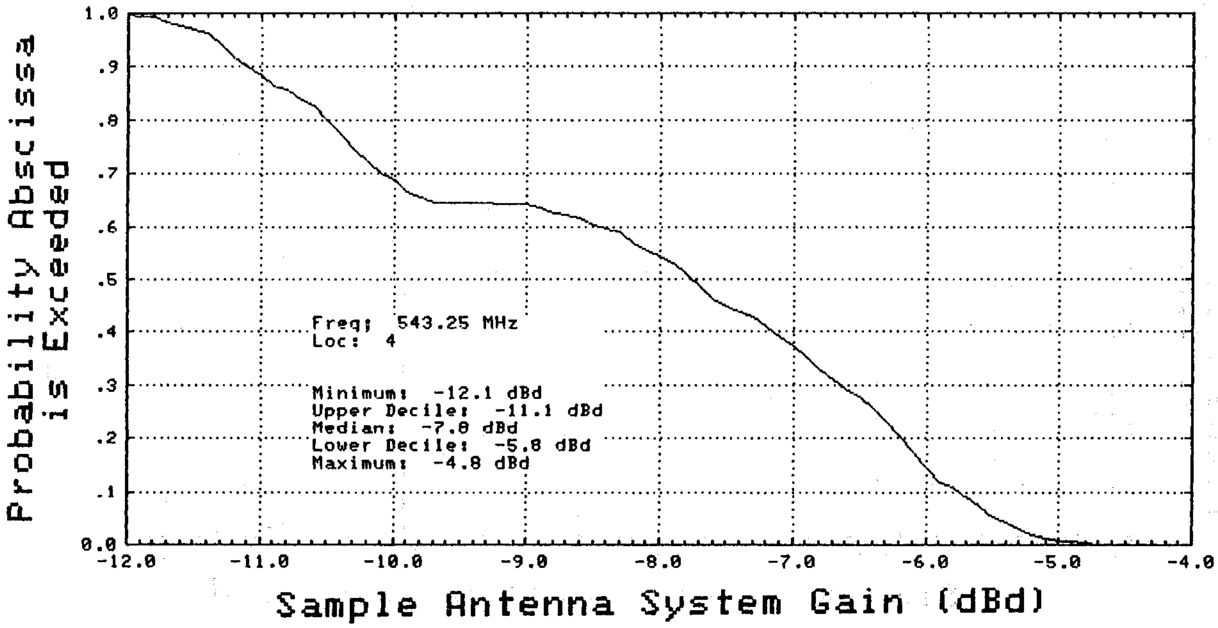


(a)



(b)

Figure A-6. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 4 at 77.25 MHz (a) and 187.25 MHz (b).



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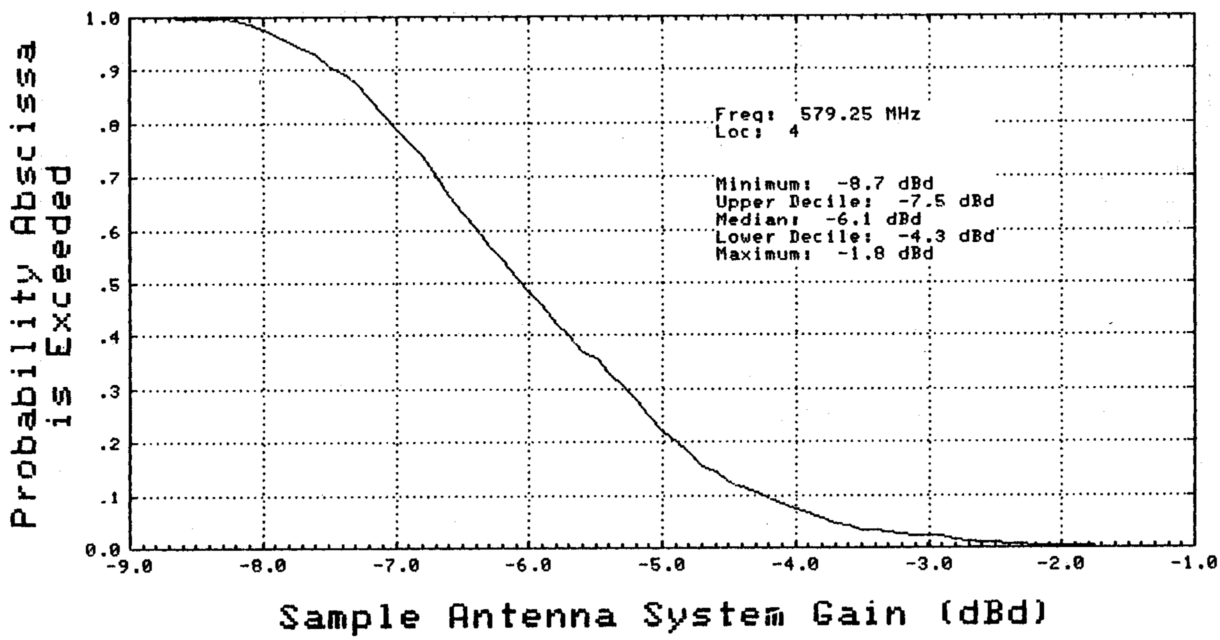
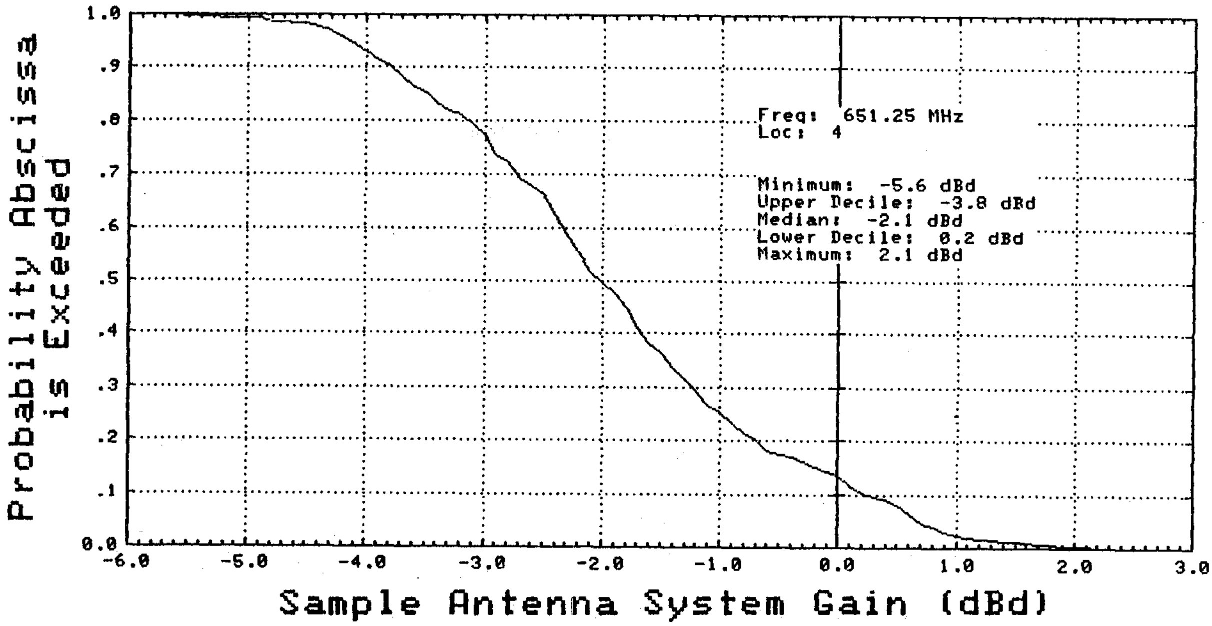
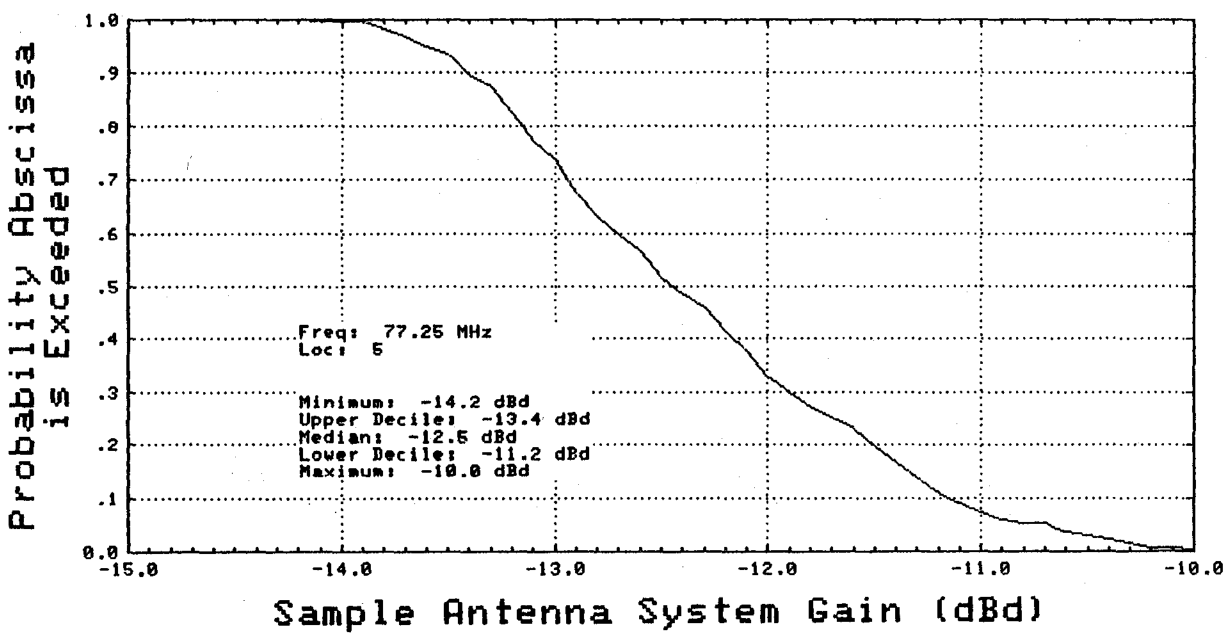


(b)

Figure A-7. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 4 at 543.25 MHz (a) and 579.25 MHz (b).

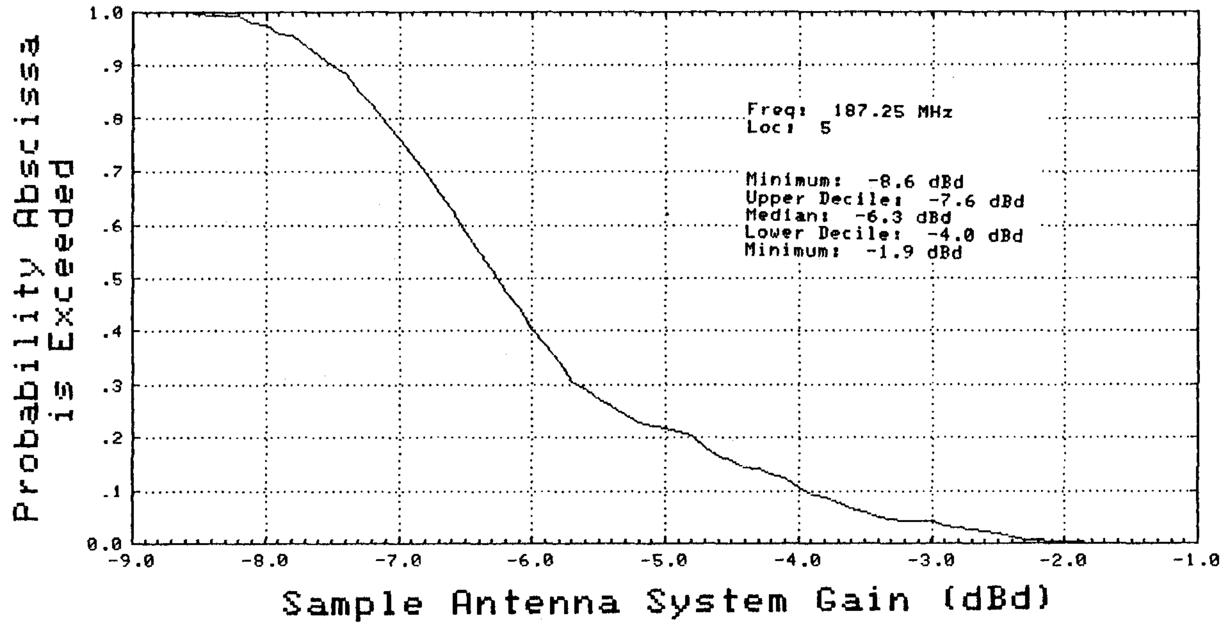


(a)

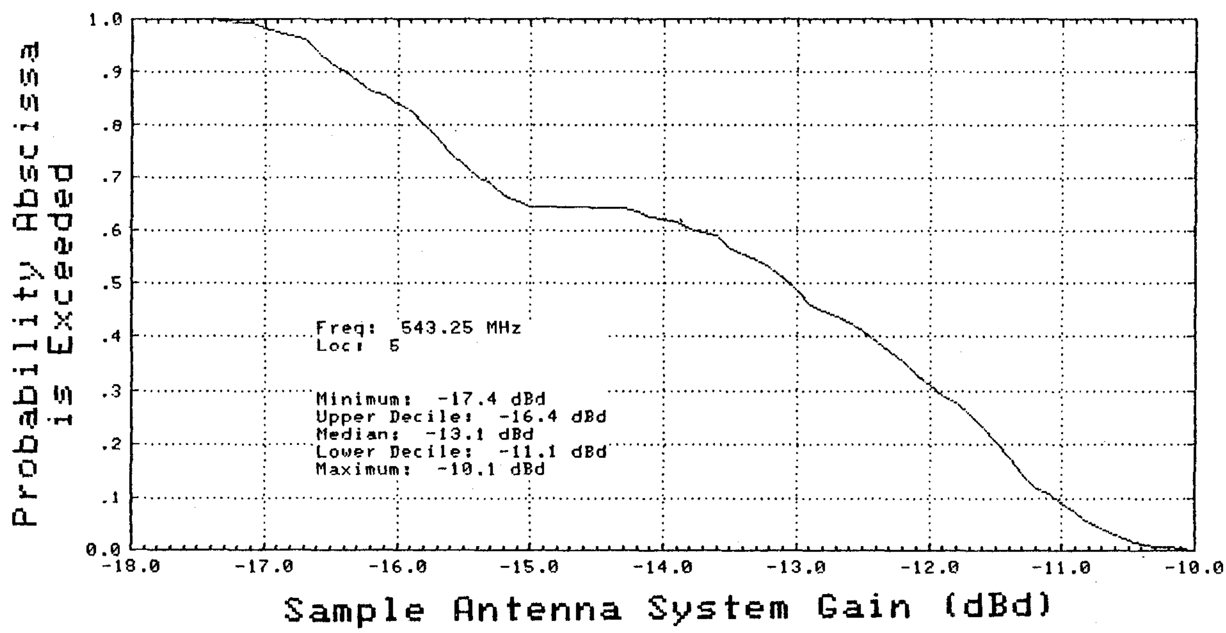


(b)

Figure A-8. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 4 at 651.25 MHz (a) and location 5 at 77.25 MHz (b).

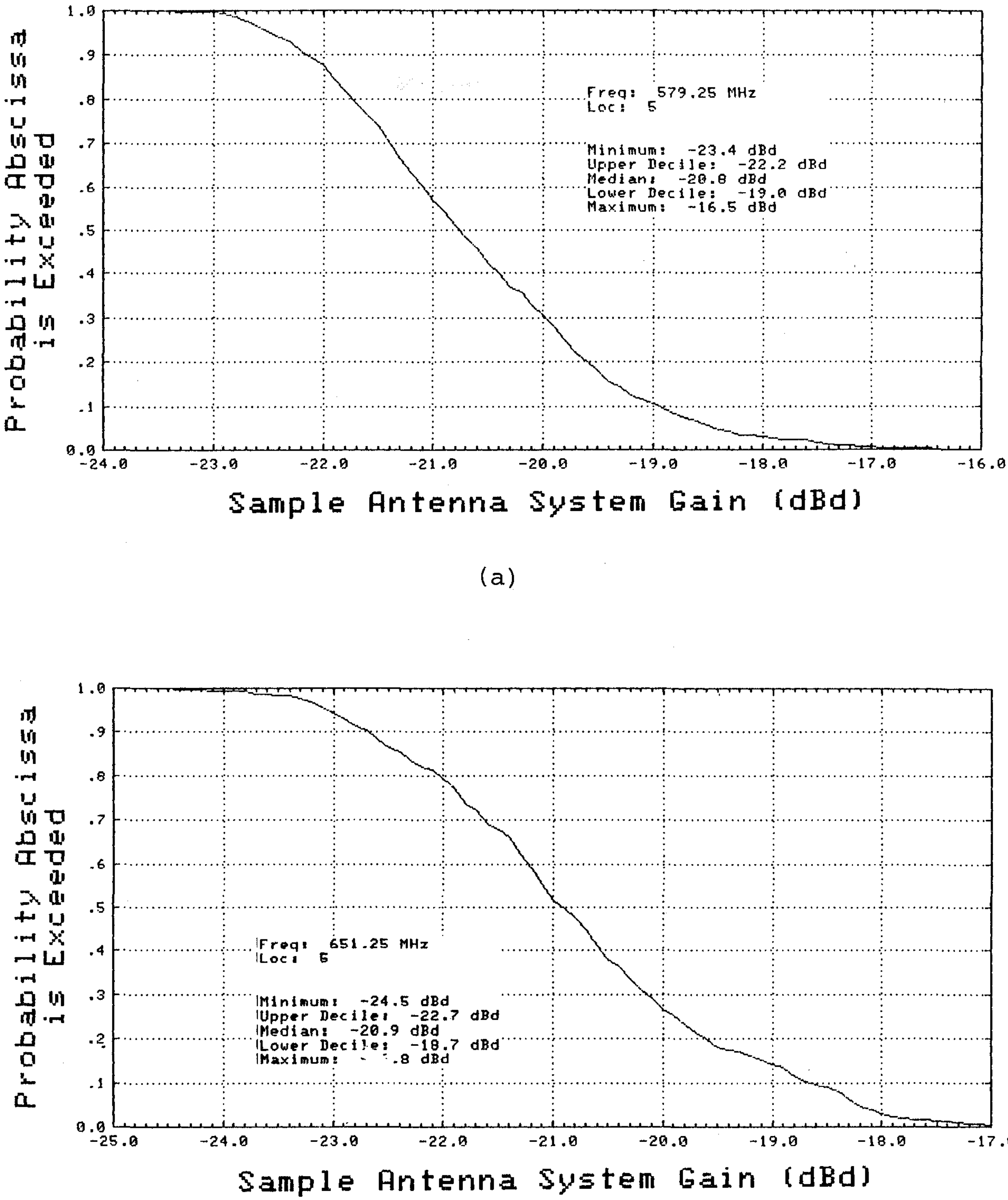


(a)



(b)

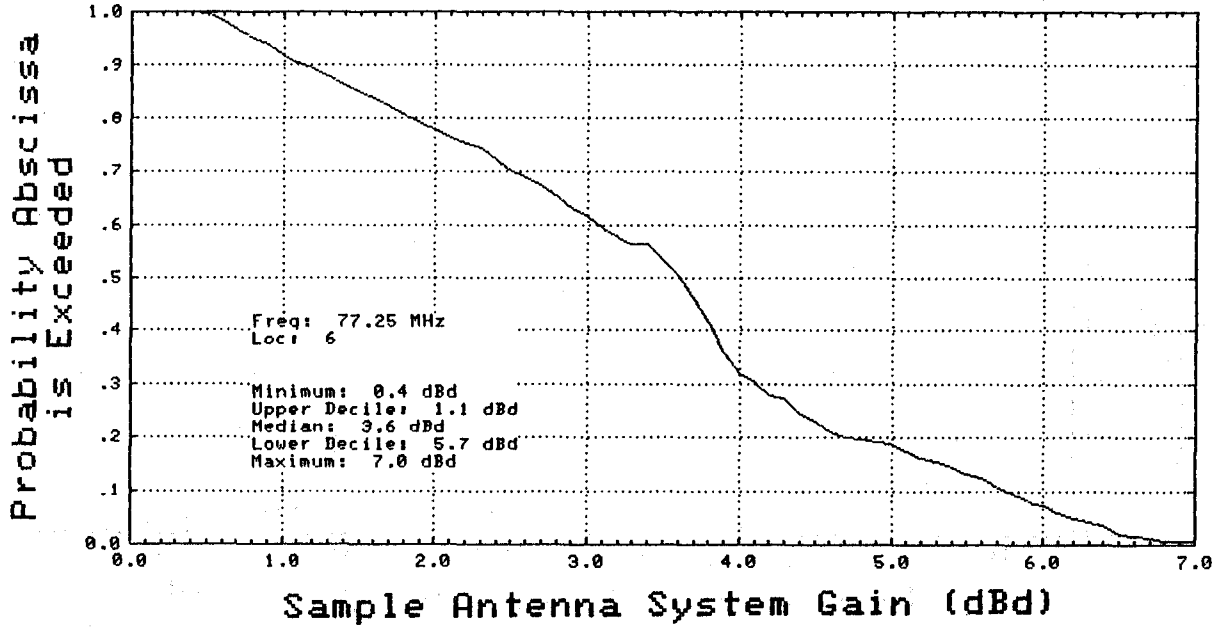
Figure A-9. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 5 at 187.25 MHz (a) and 543.25 MHz (b).



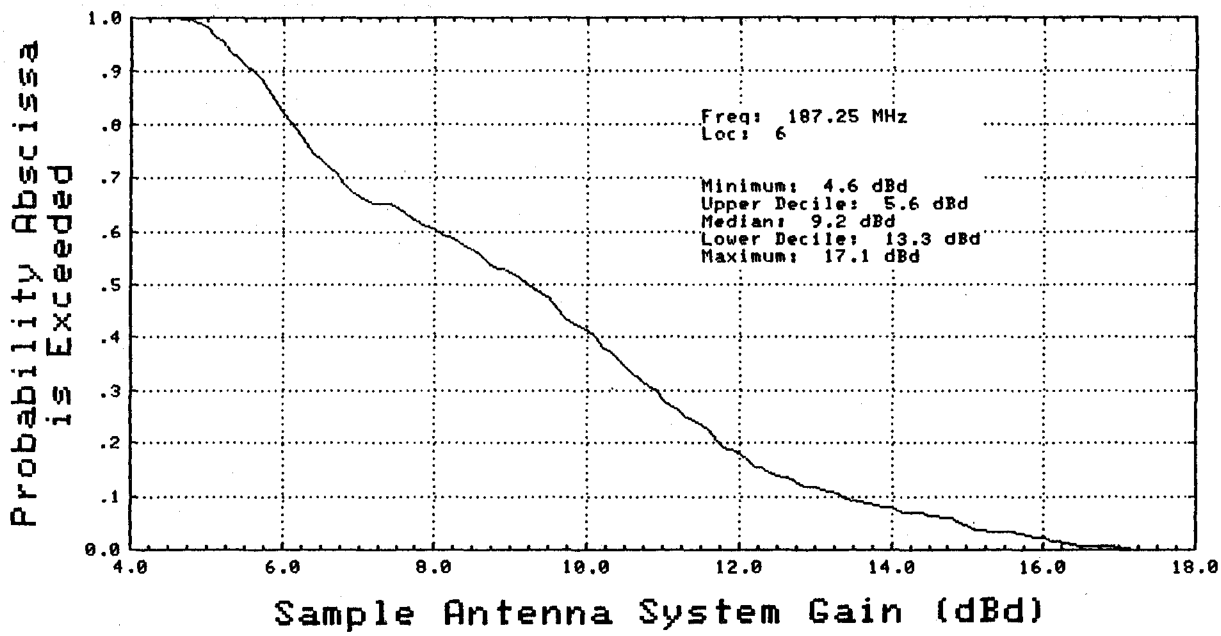
(a)

(b)

Figure A-10. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 5 at 579.25 MHz (a) and 651.25 MHz (b).

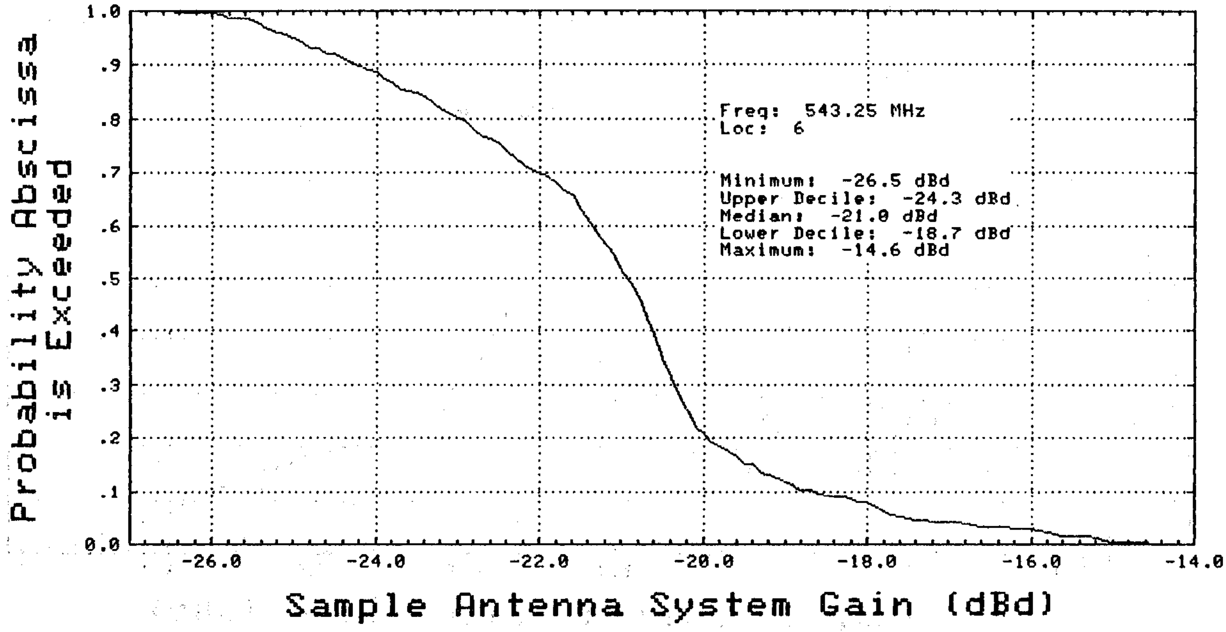


(a)

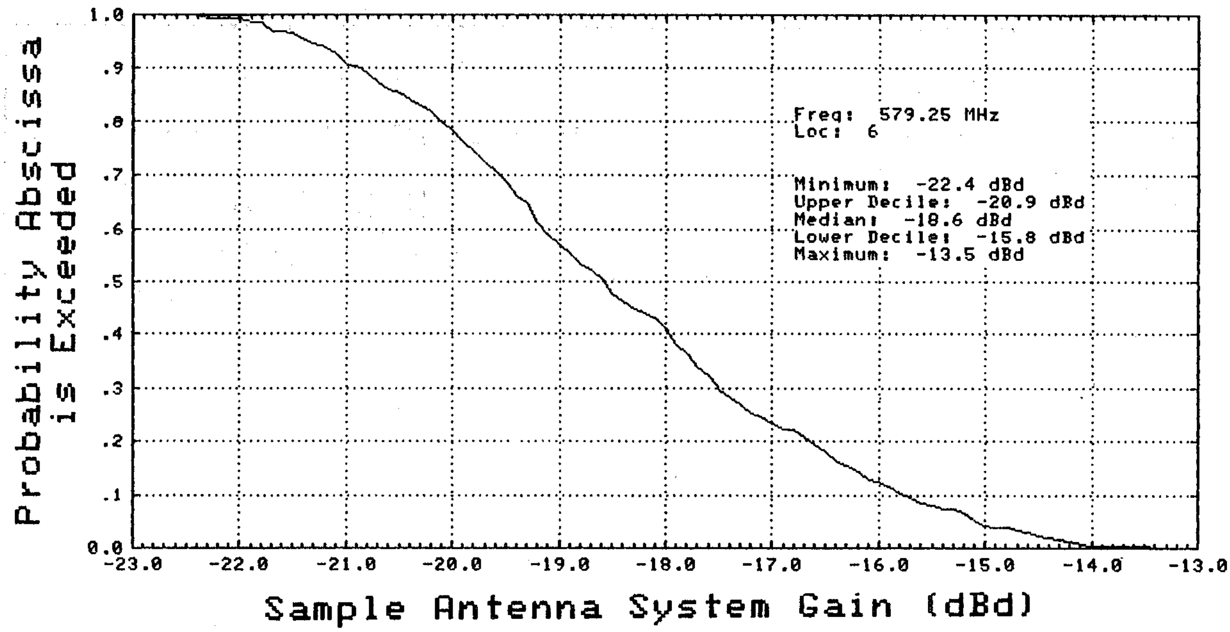


(b)

Figure A-11. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 6 at 77.25 MHz (a) and 187.25 MHz (b).

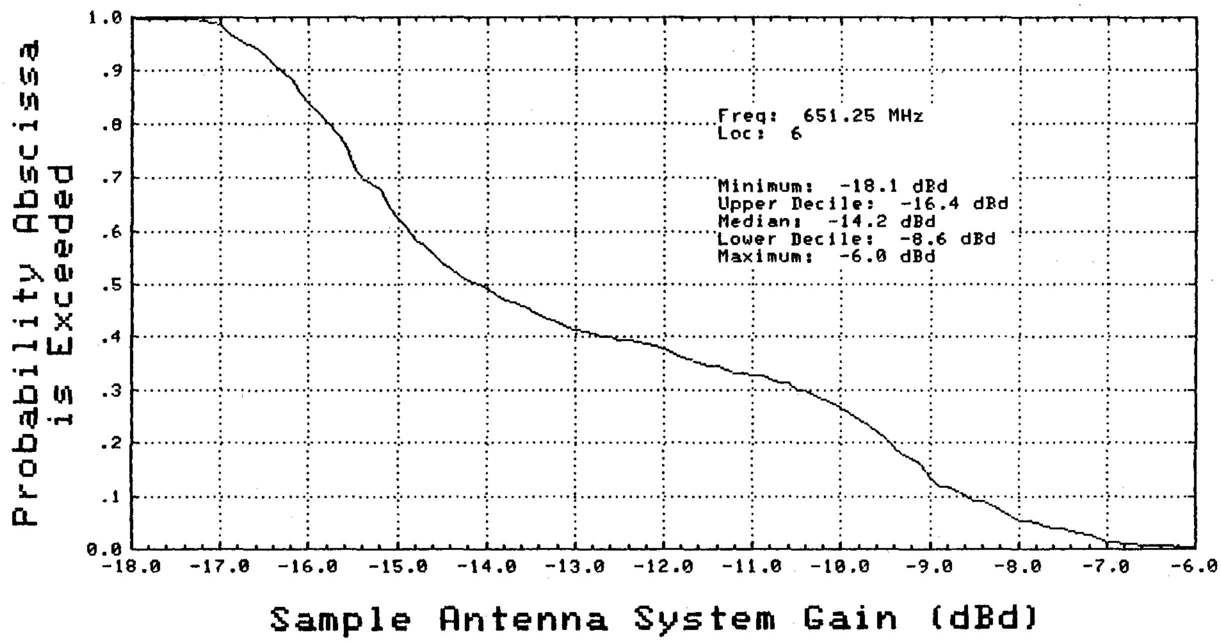


(a)

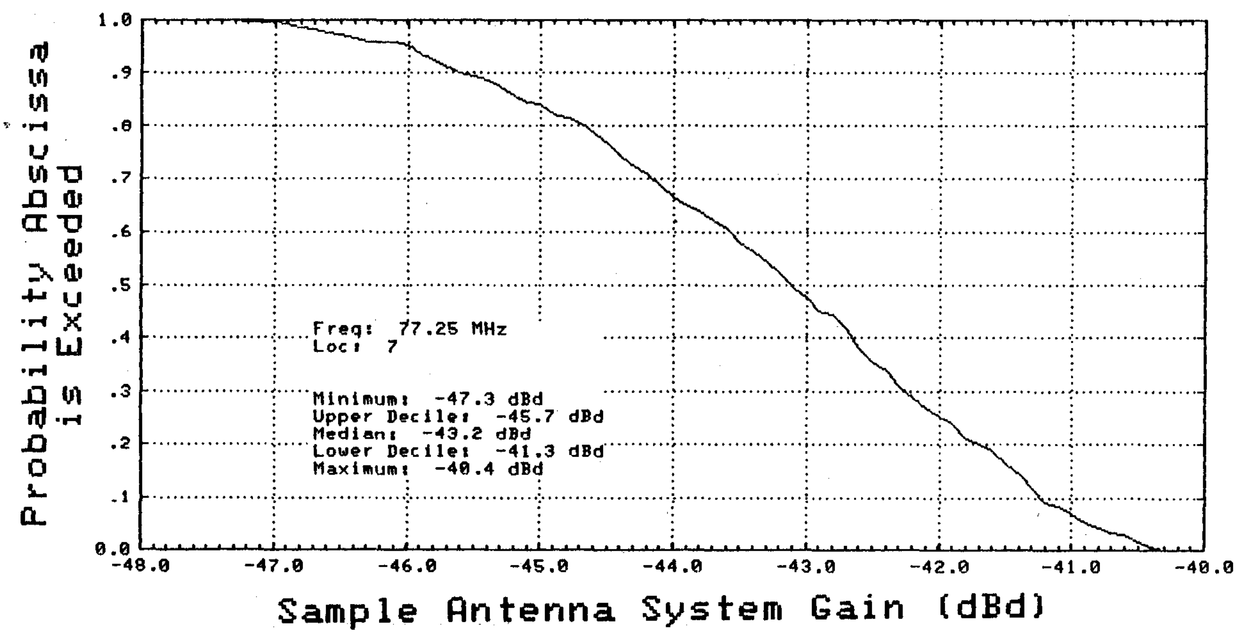


(b)

Figure A-12. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 6 at 543.25 MHz (a) and 579.25 MHz (b).

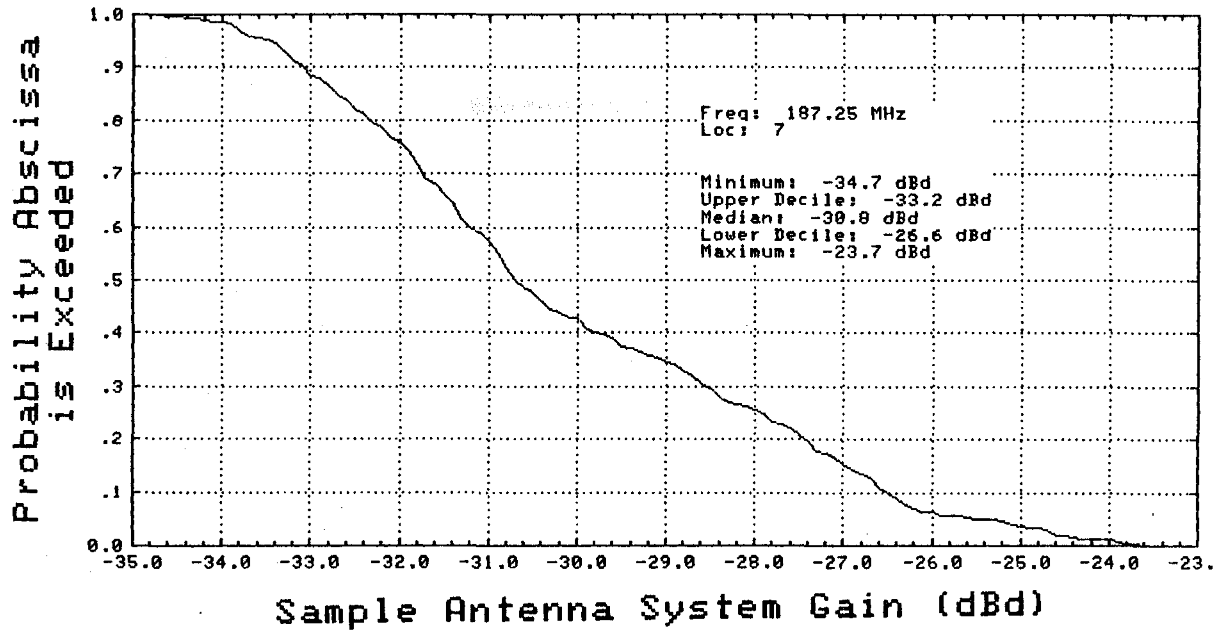


(a)

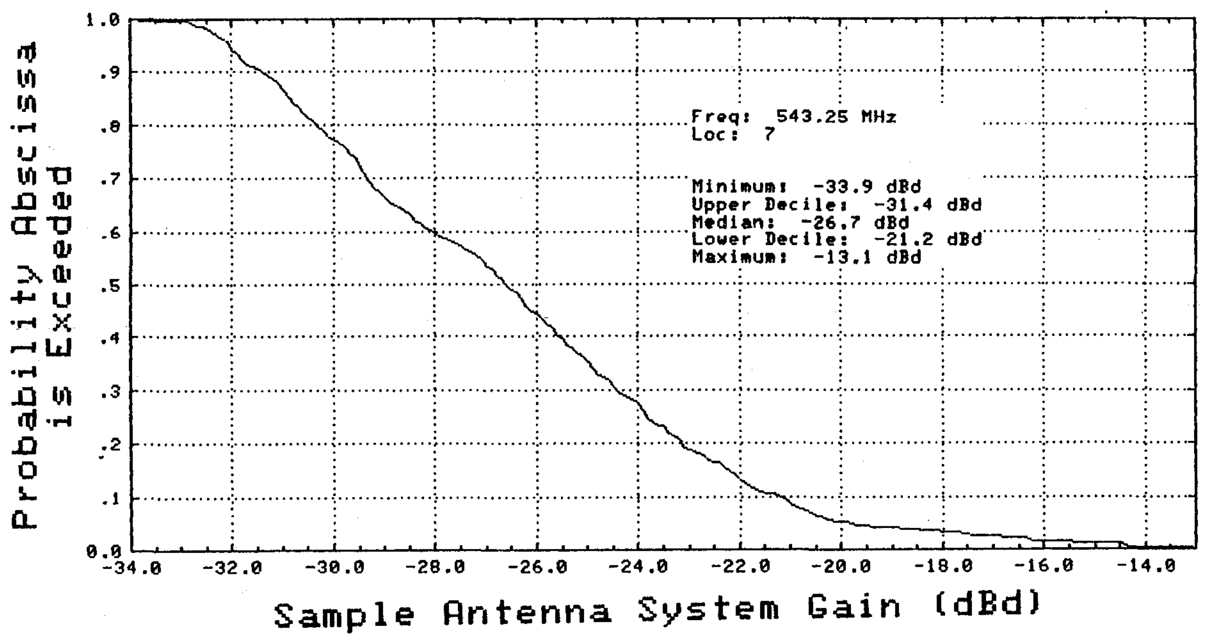


(b)

Figure A-13. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 6 at 651.25 MHz (a) and location 7 at 77.25 MHz (b).

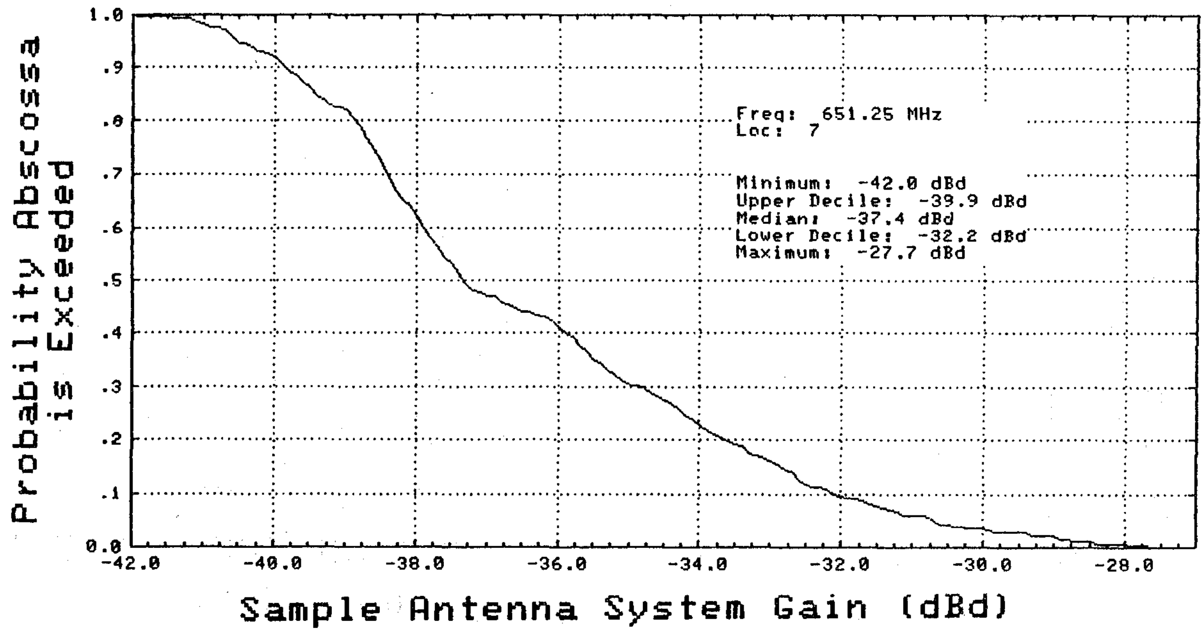


(a)

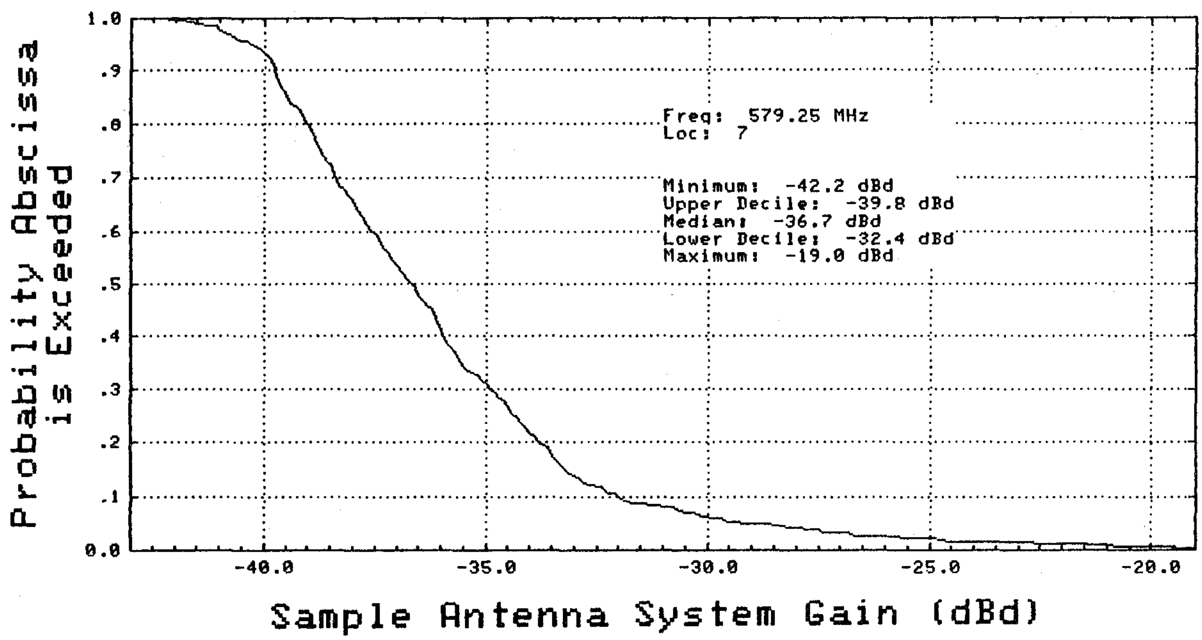


(b)

Figure A-14. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 7 at 187.25 MHz (a) and 543.25 MHz (b).

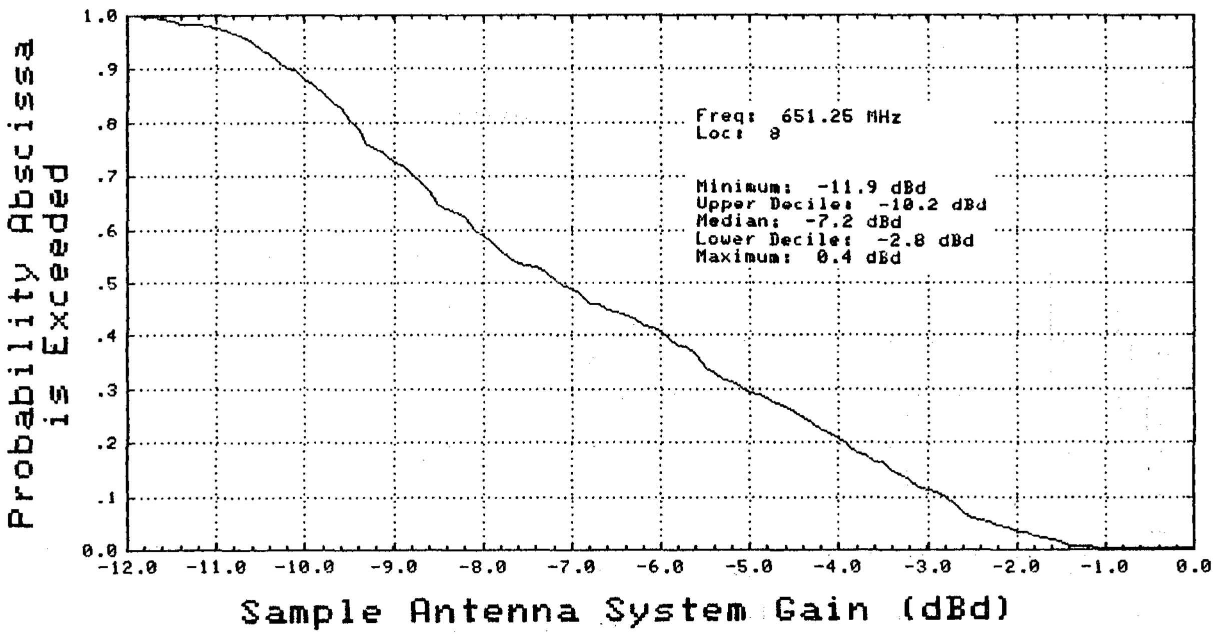


(a)

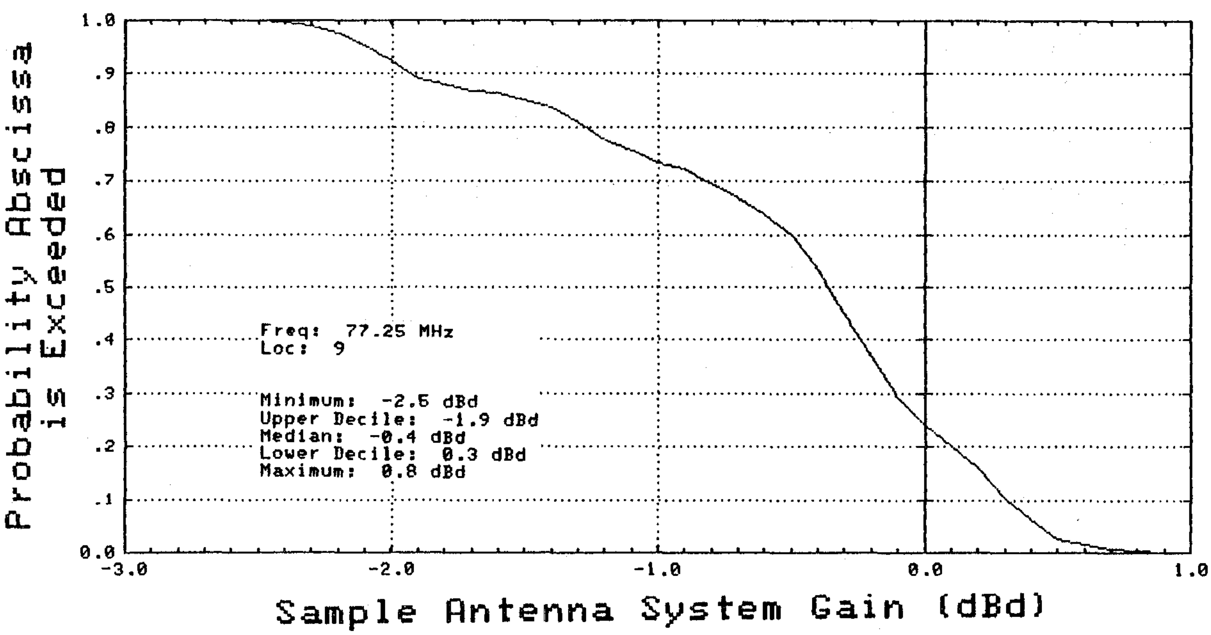


(b)

Figure A-15. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 7 at 651.25 MHz (a) and 579.25 MHz (b).

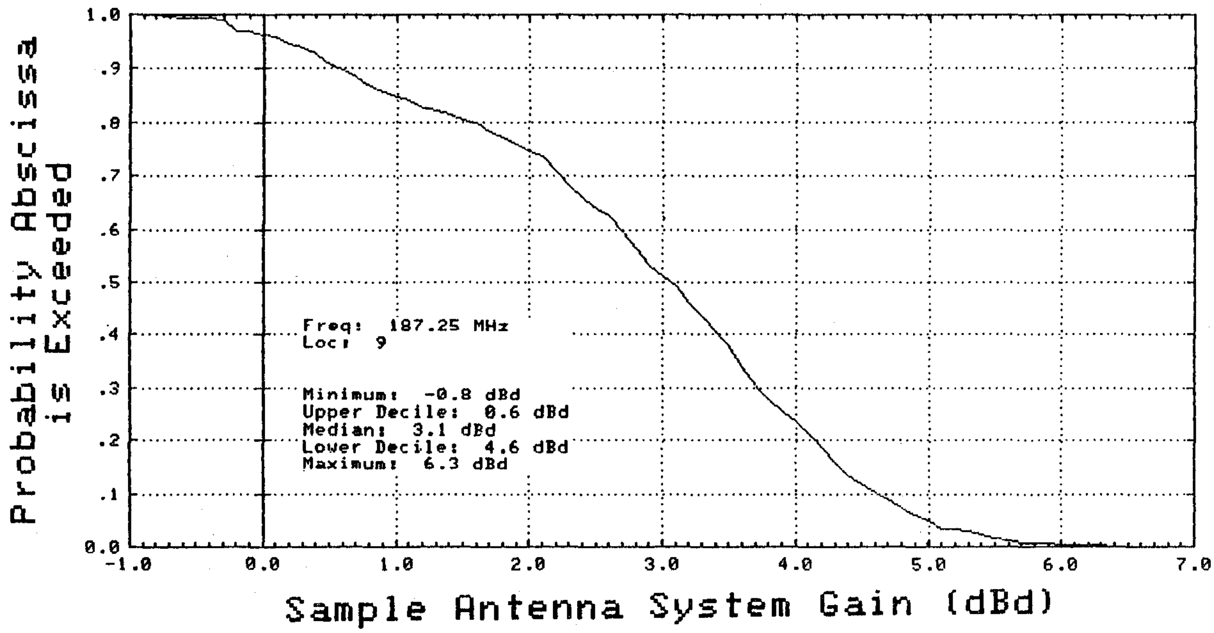


(a)

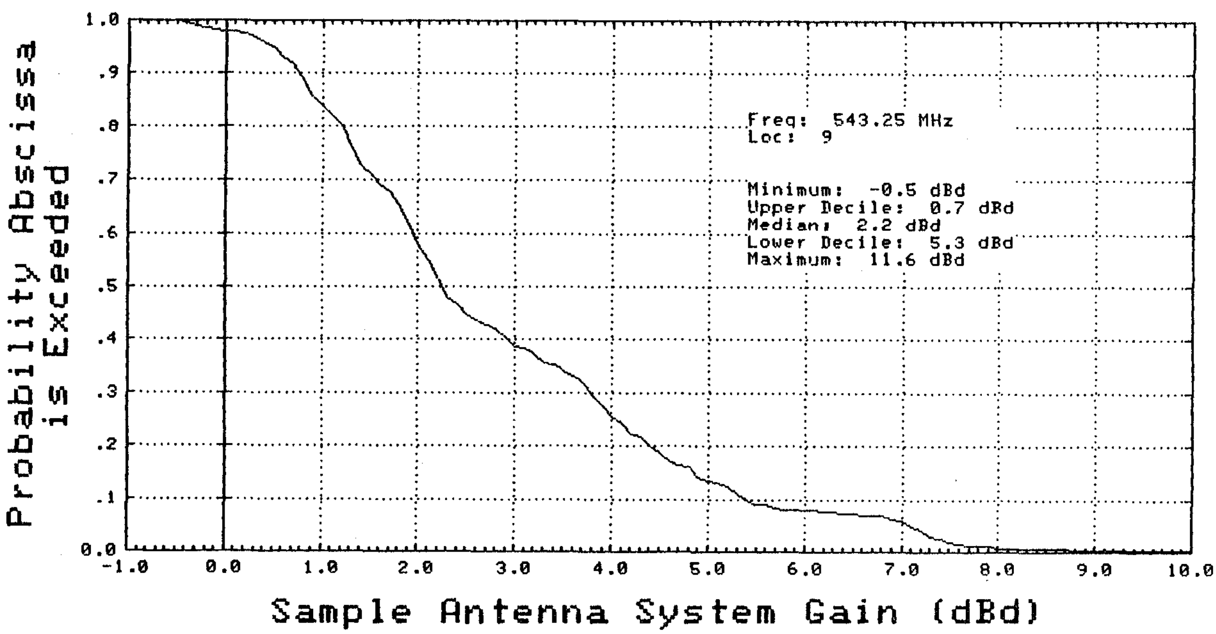


(b)

Figure A-16. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 8 at 651.25 MHz (a) and location 9 at 77.25 MHz (b).

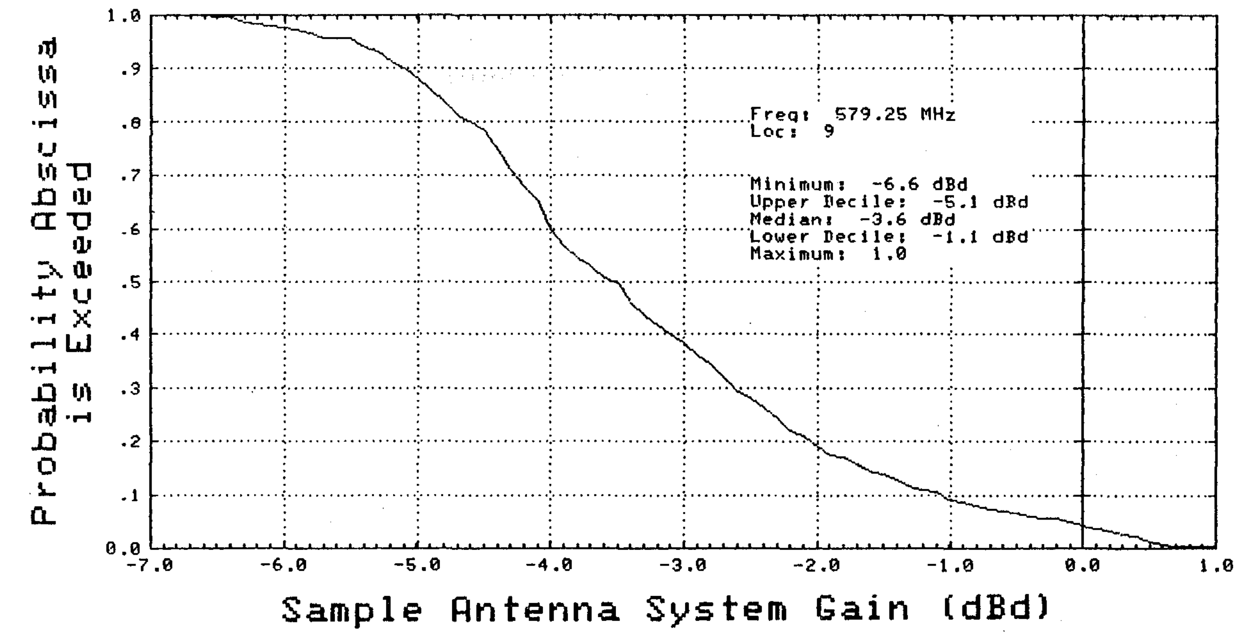


(a)

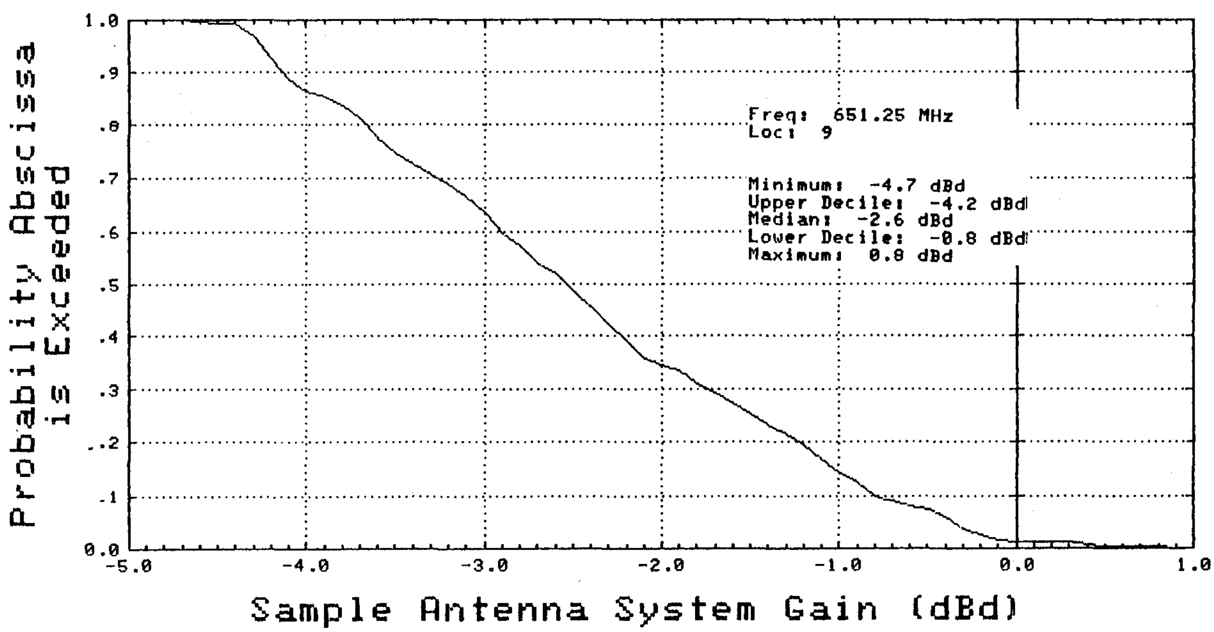


(b)

Figure A-17. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 9 at 187.25 MHz (a) and 543.25 MHz (b).

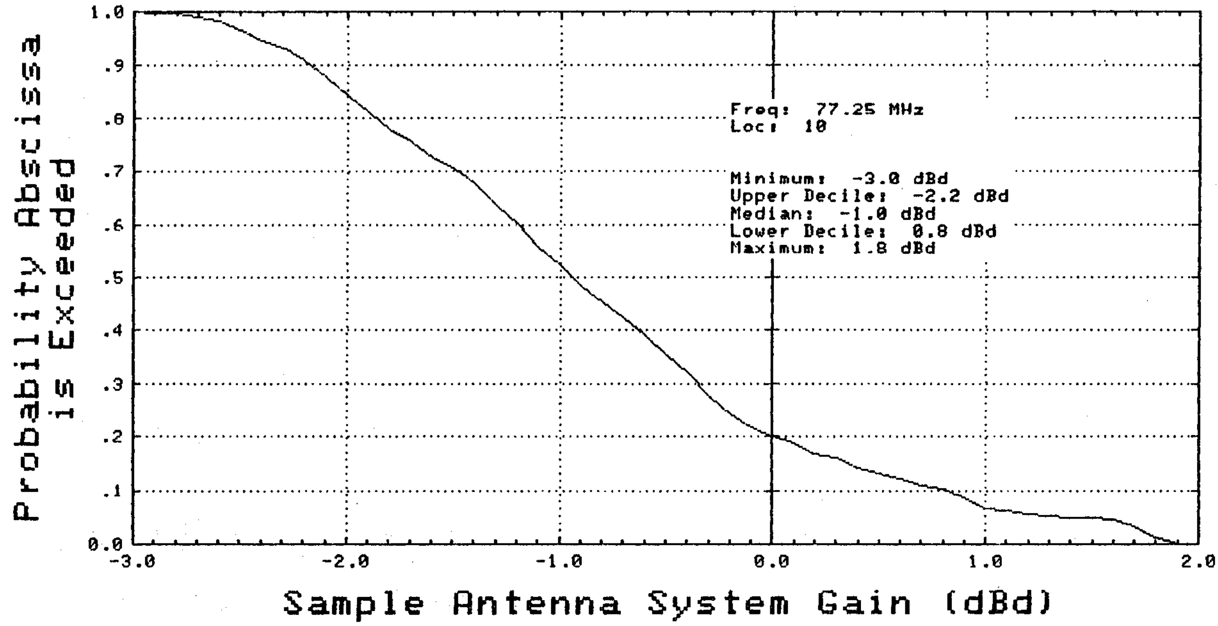


(a)

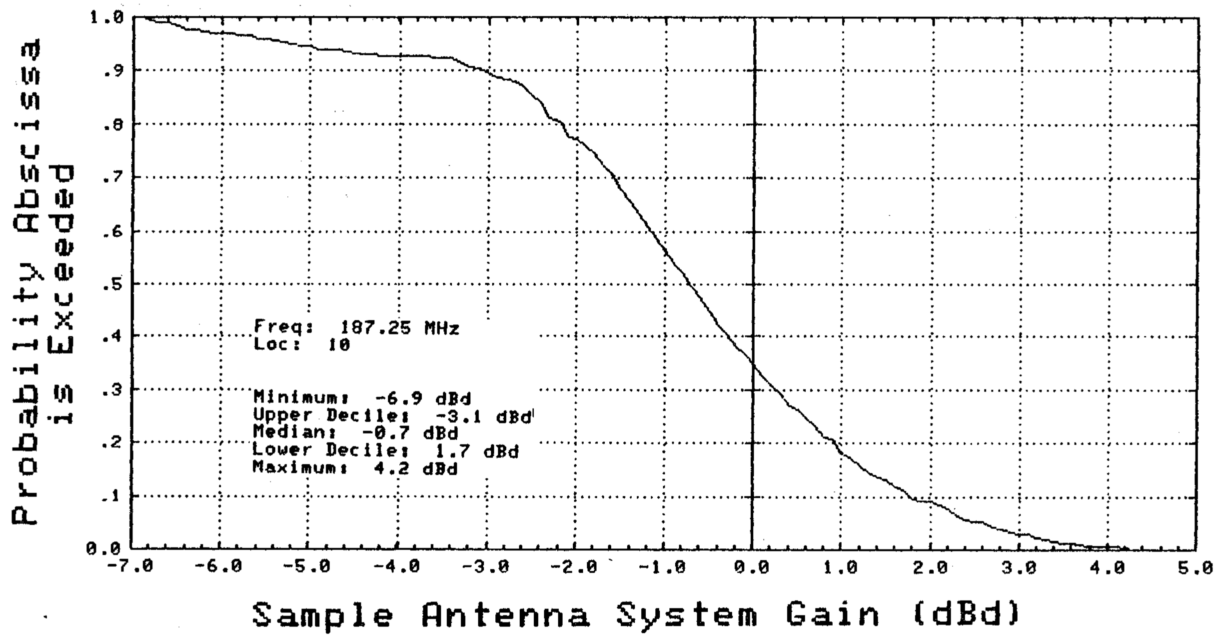


(b)

Figure A-18. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 9 at 579.25 MHz (a) and 651.25 MHz (b).

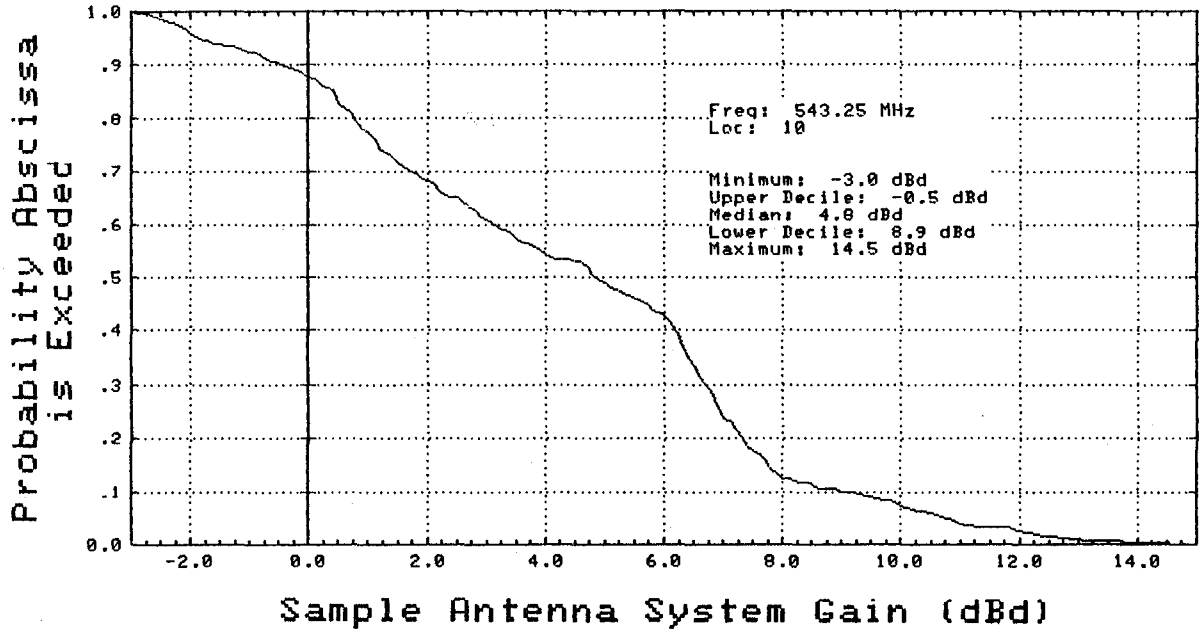


(a)

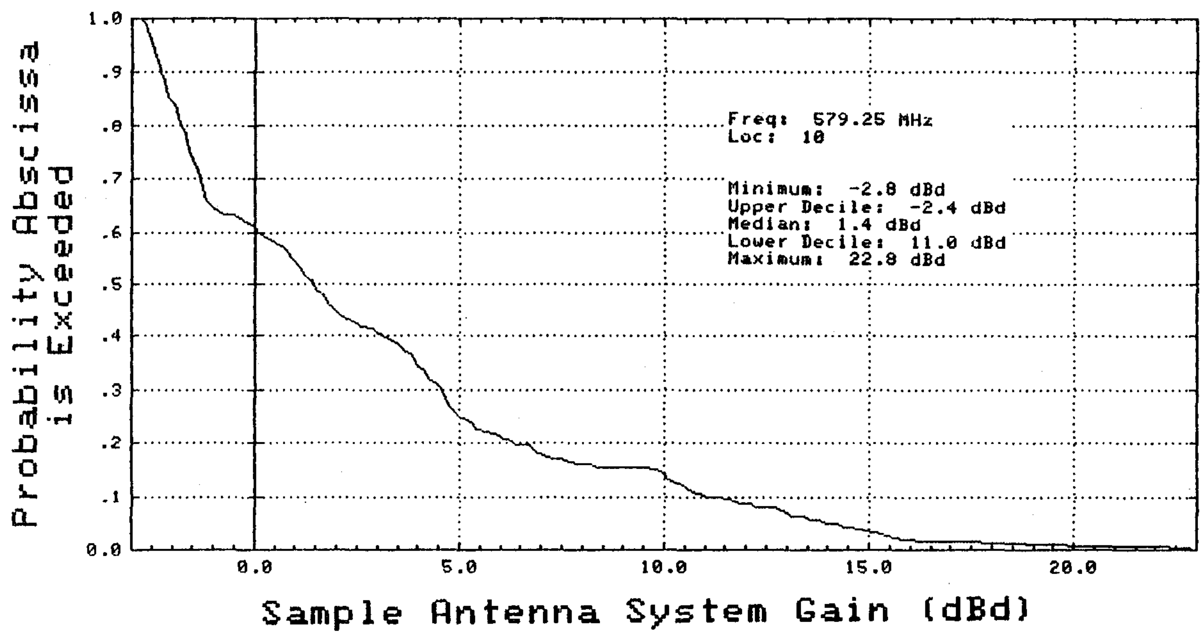


(b)

Figure A-19. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 10 at 77.25 MHz (a) and 187.25 MHz (b).

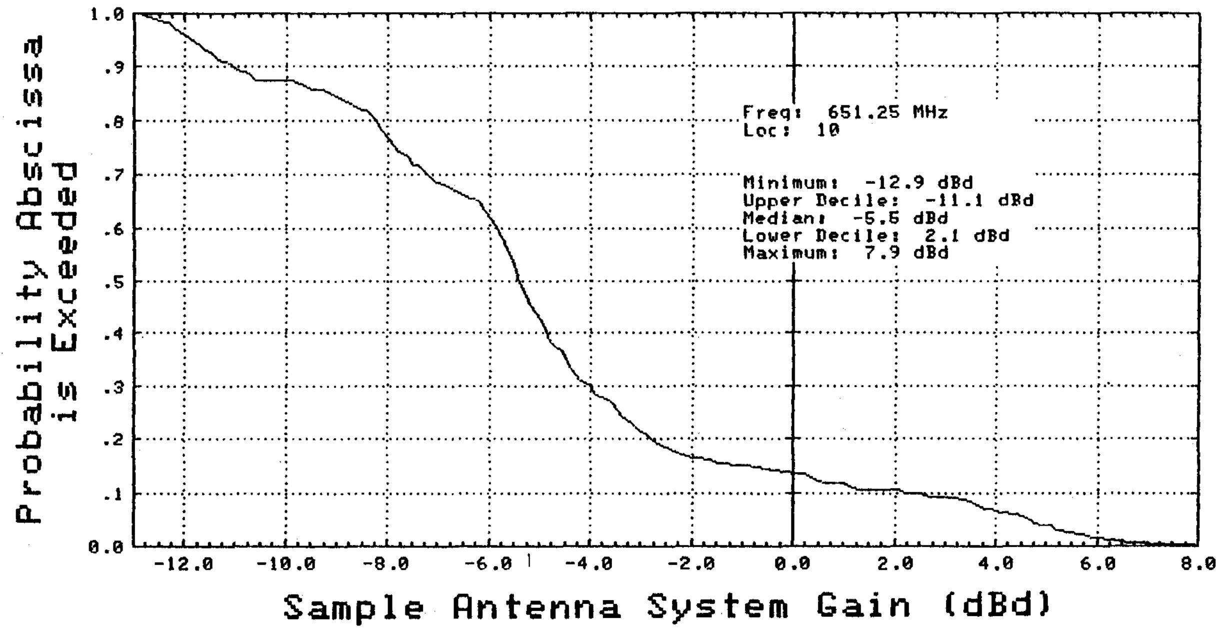


(a)

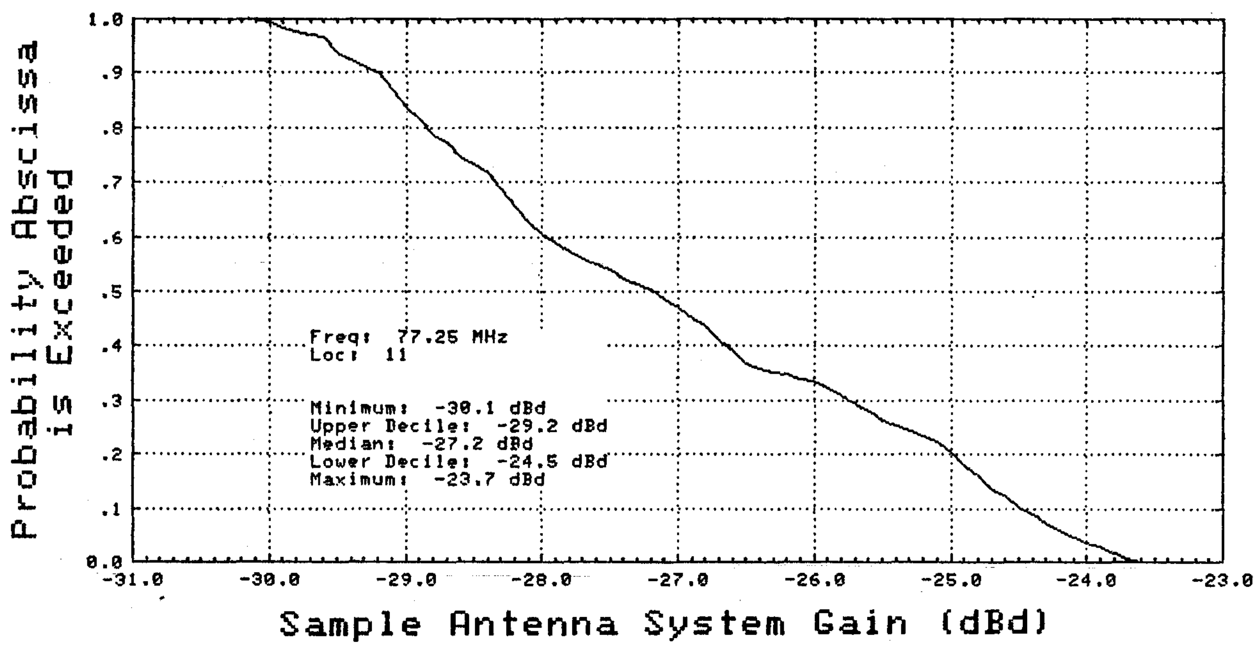


(b)

Figure A-20. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 10 at 543.25 MHz (a) and 579.25 MHz (b).

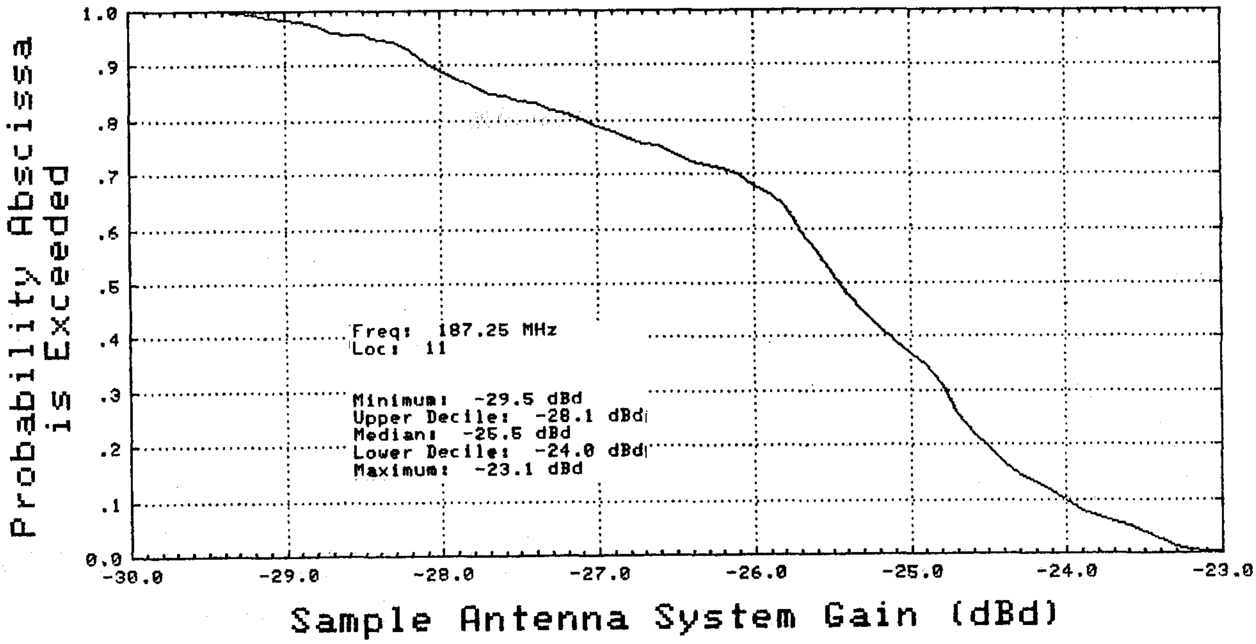


(a)

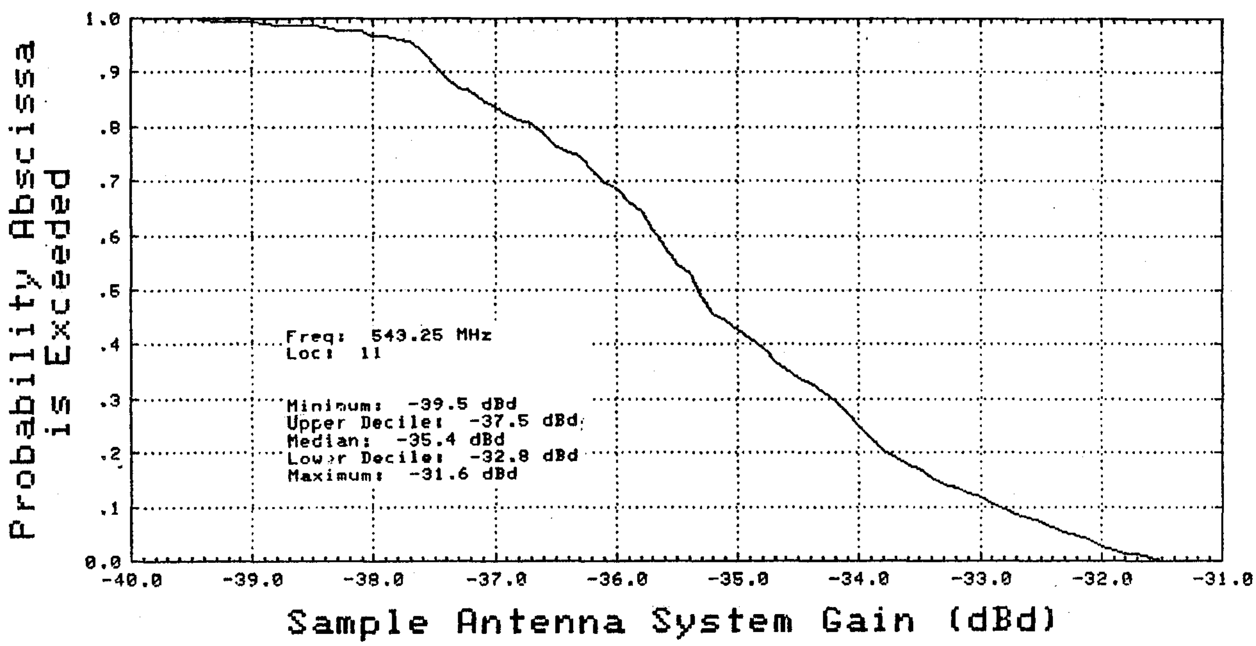


(b)

Figure A-21. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 10 at 651.25 MHz (a) and location 11 at 77.25 MHz (b).

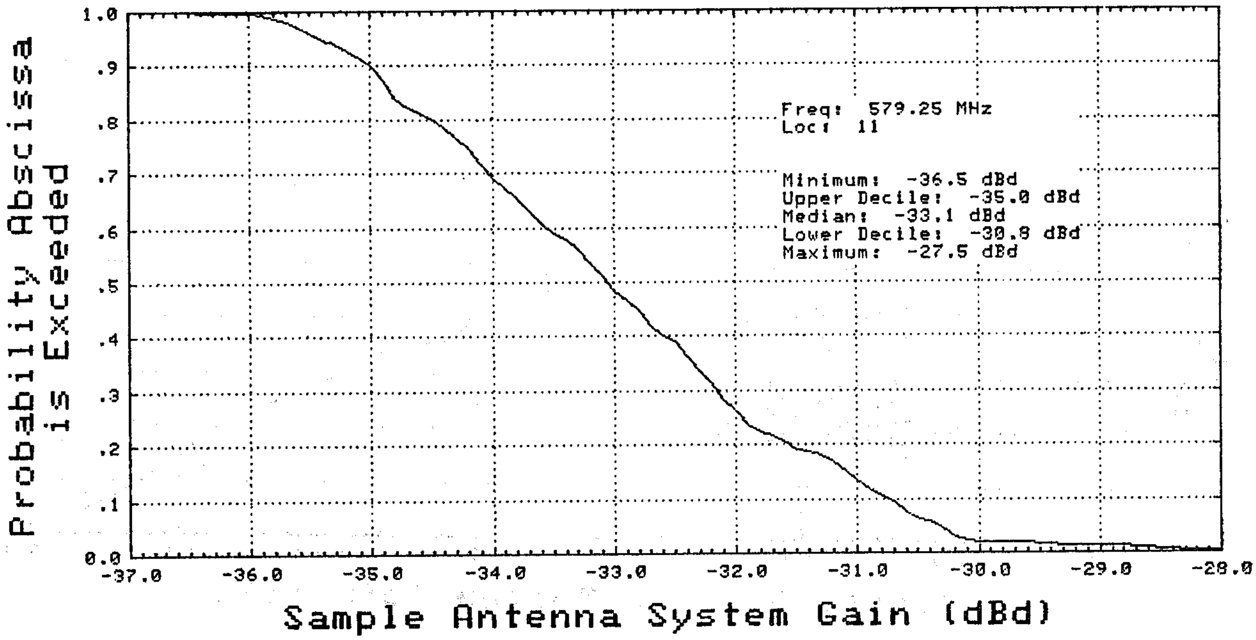


(a)

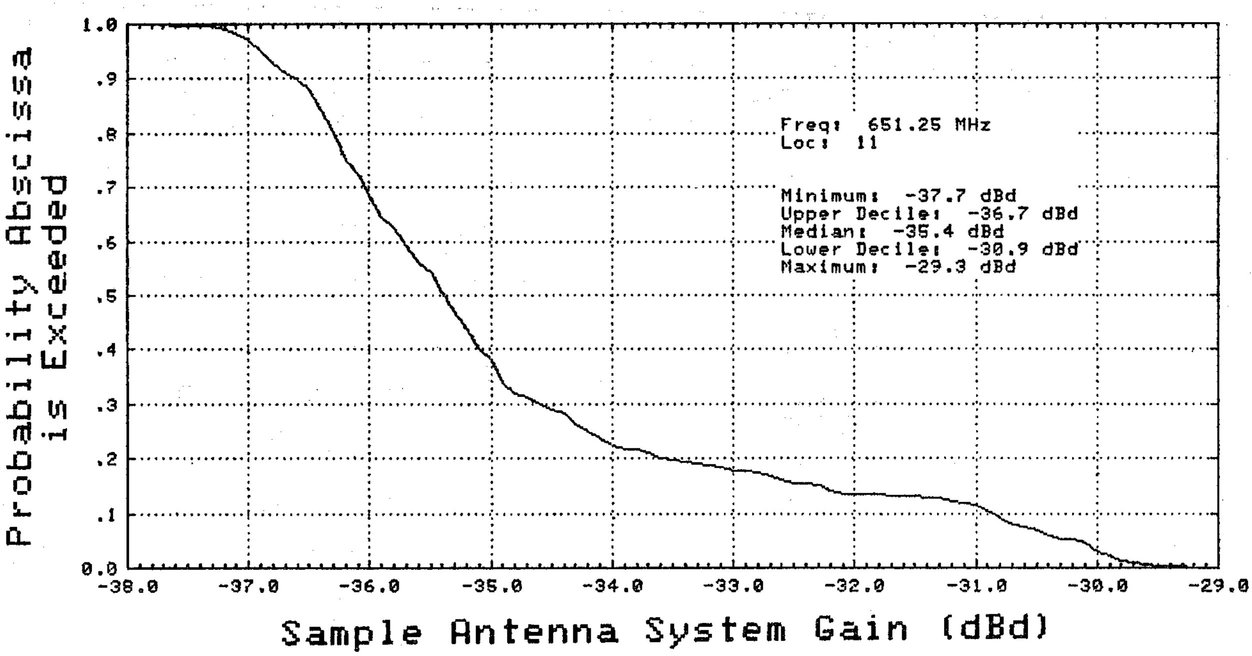


(b)

Figure A-22. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 11 at 187.25 MHz (a) and 543.25 MHz (b).

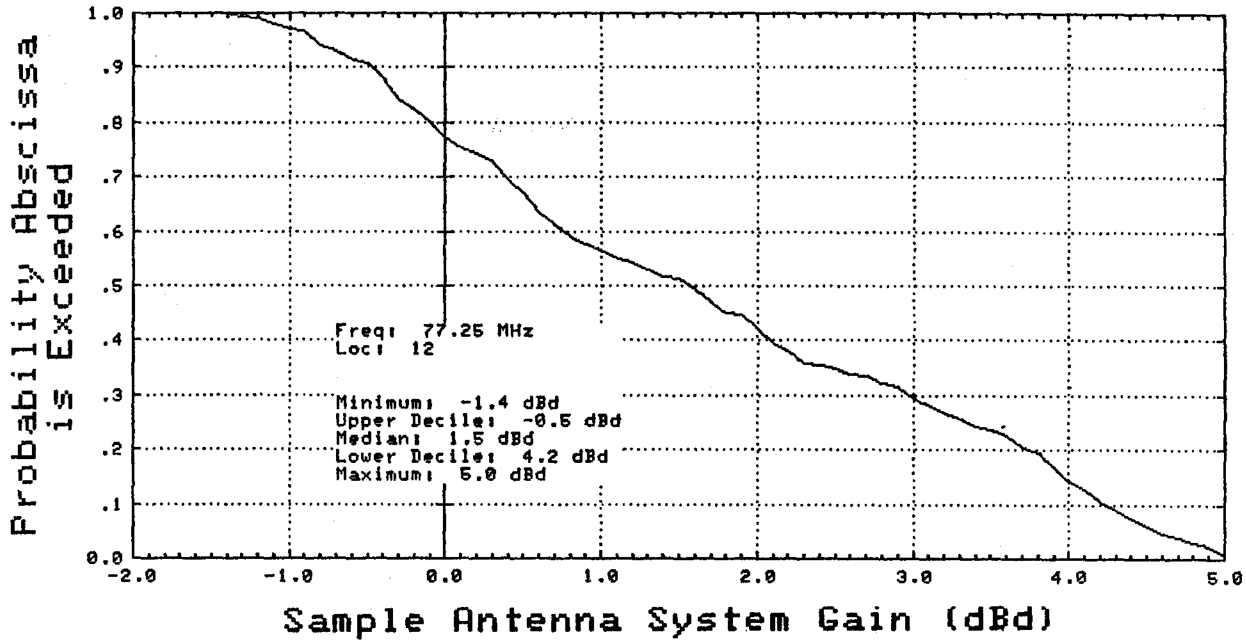


(a)

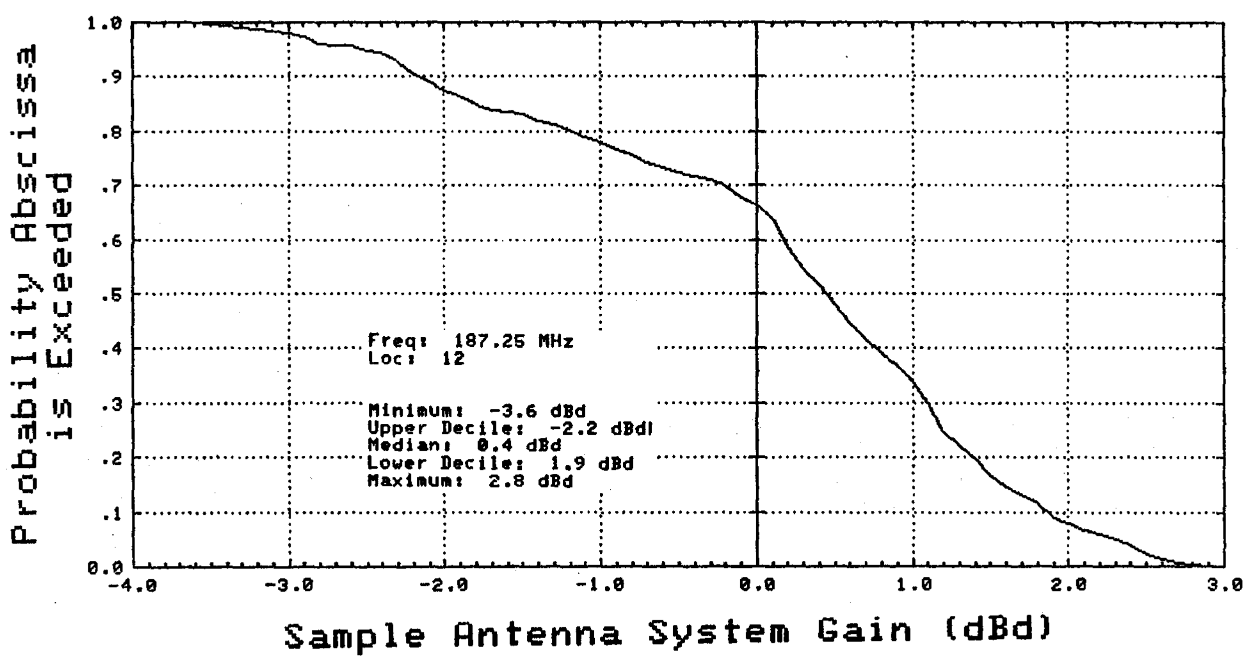


(b)

Figure A-23. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 11 at 579.25 MHz (a) and 651.25 MHz (b).

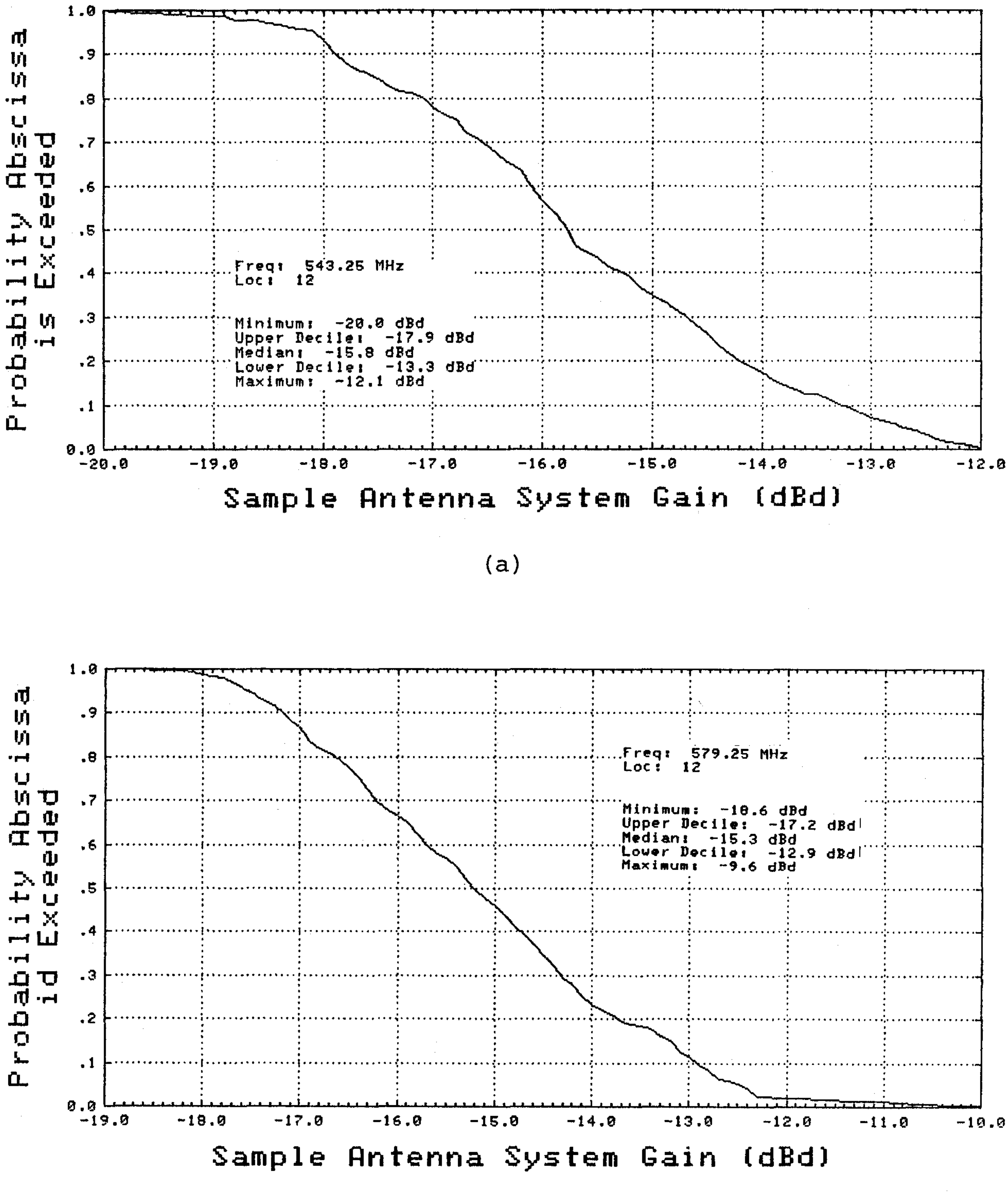


(a)



(b)

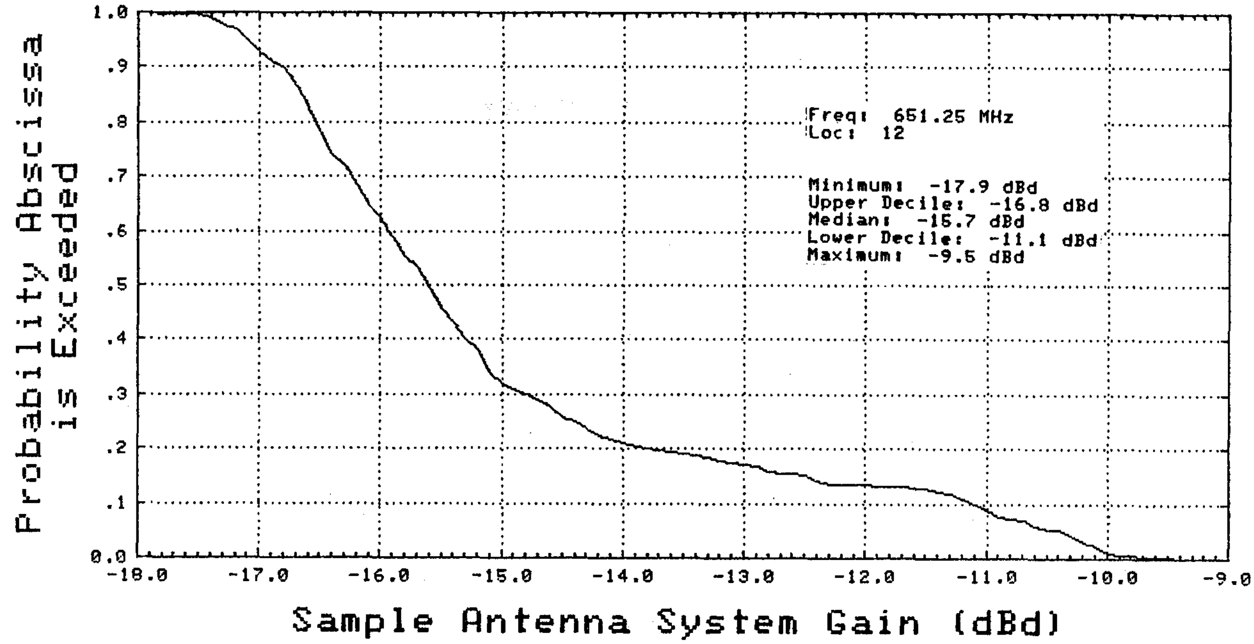
Figure A-24. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 12 at 77.25 MHz (a) and 187.25 MHz (b).



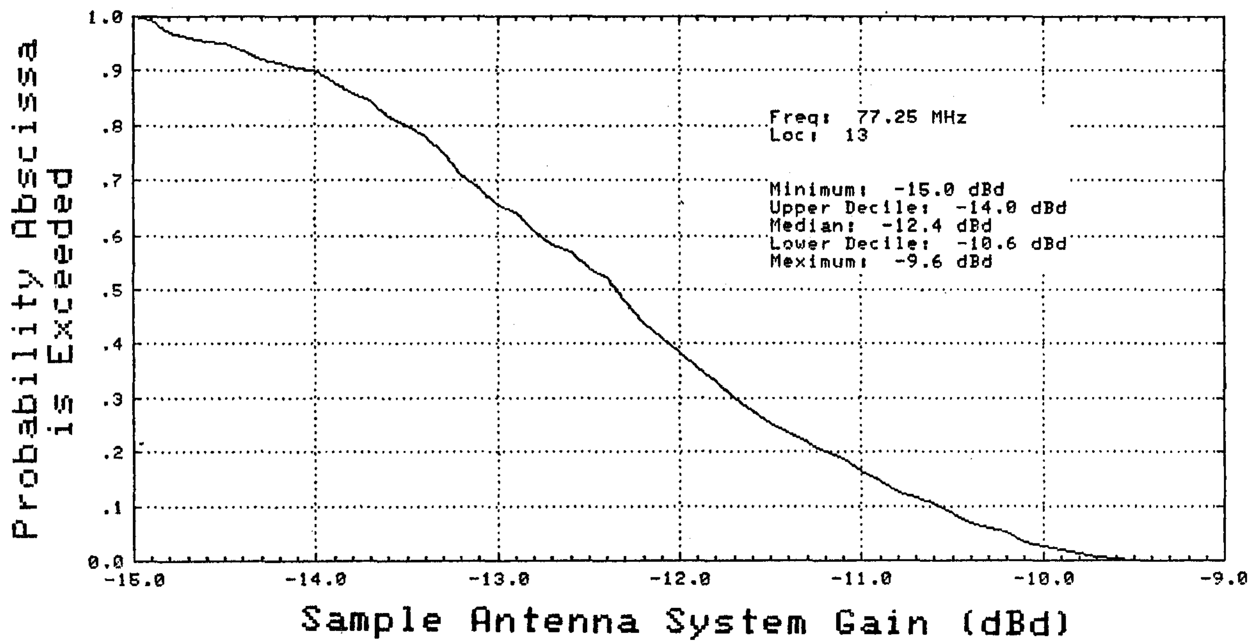
(a)

(b)

Figure A-25. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 12 at 543.25 MHz (a) and 579.25 MHz (b).

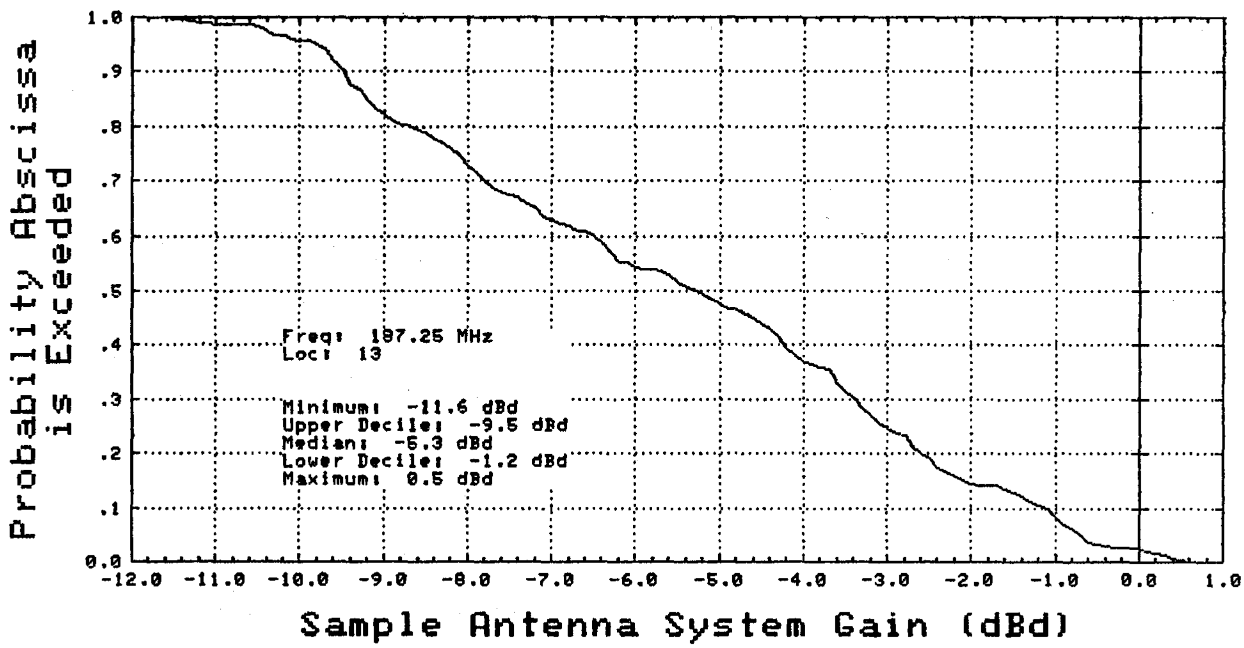


(a)

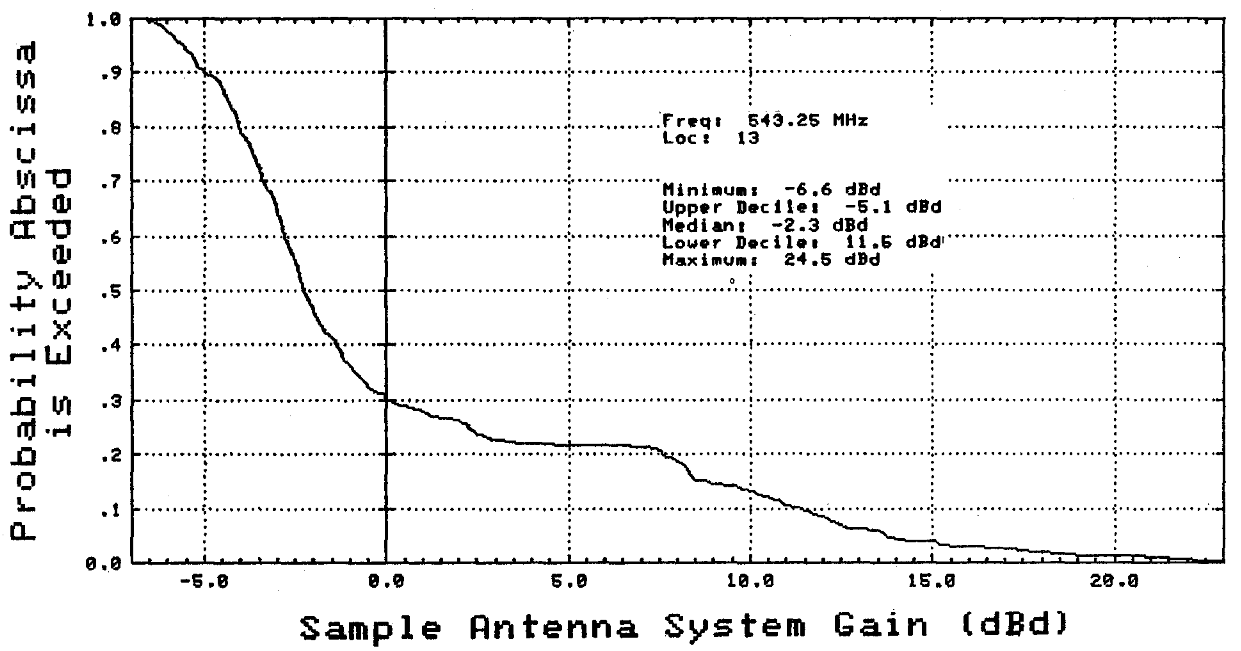


(b)

Figure A-26. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 12 at 651.25 MHz (a) and location 13 at 77.25 MHz (b).

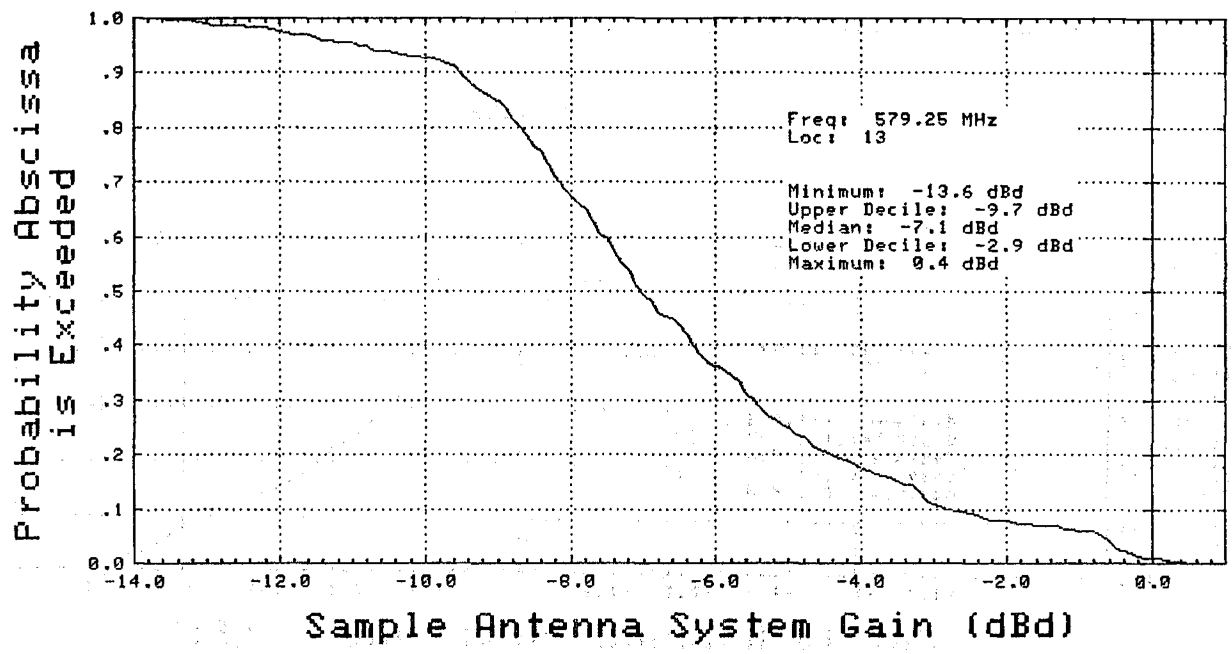


(a)

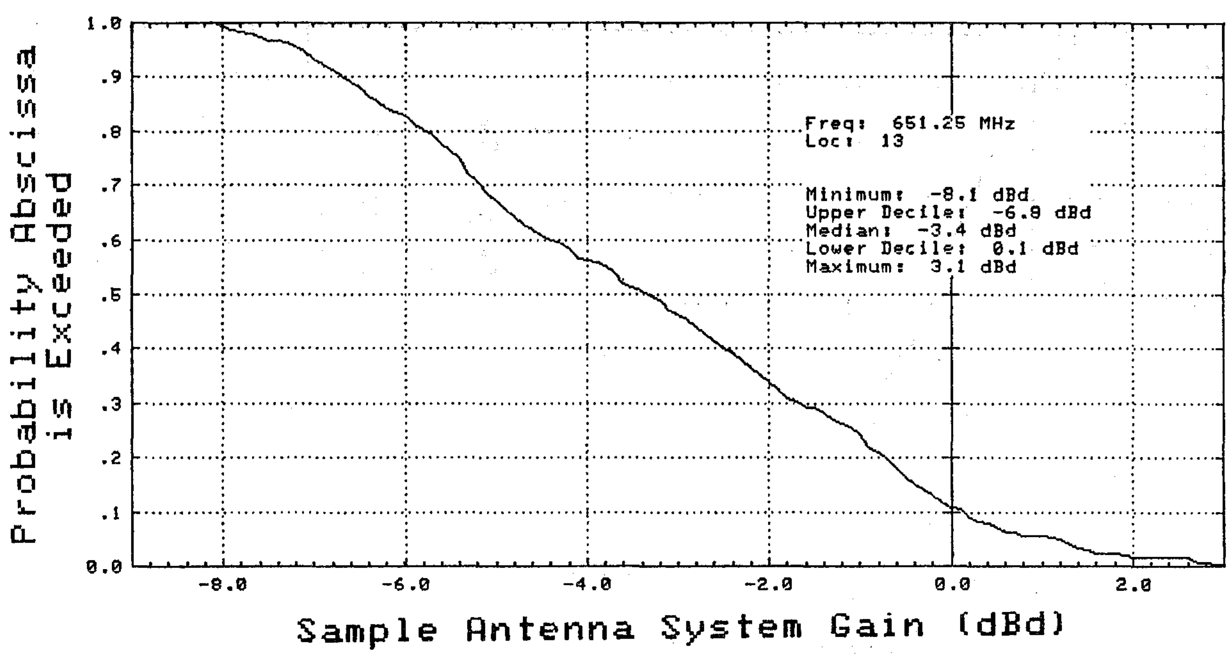


(b)

Figure A-27. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 13 at 187.25 MHz (a) and 543.25 MHz (b).

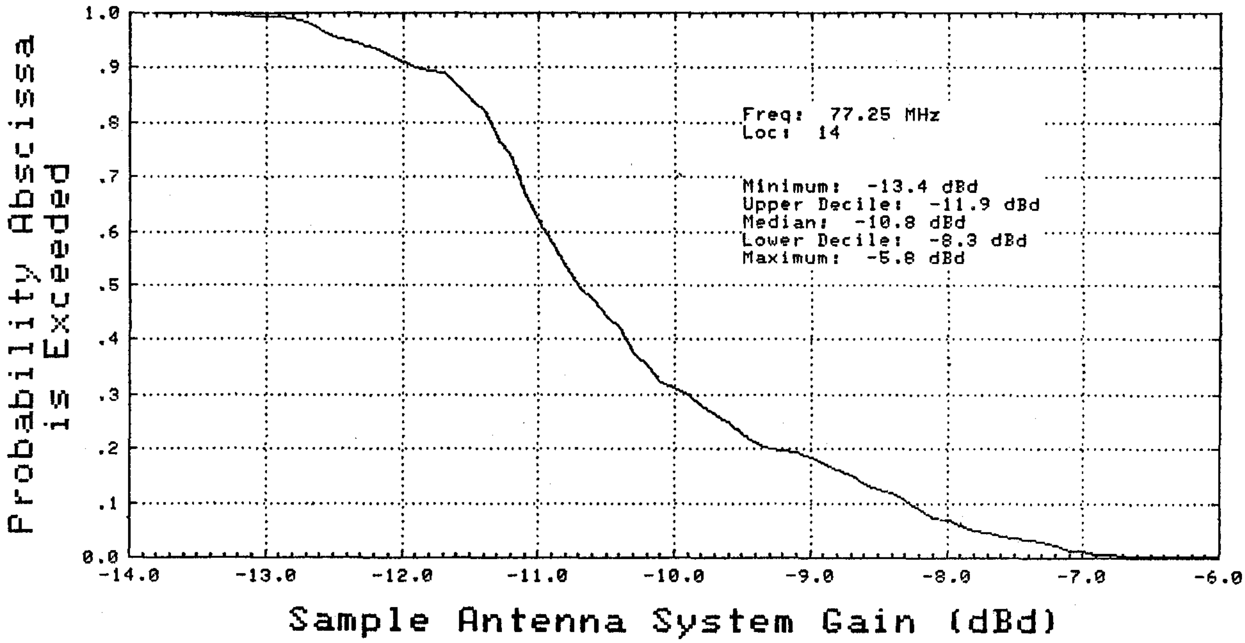


(a)

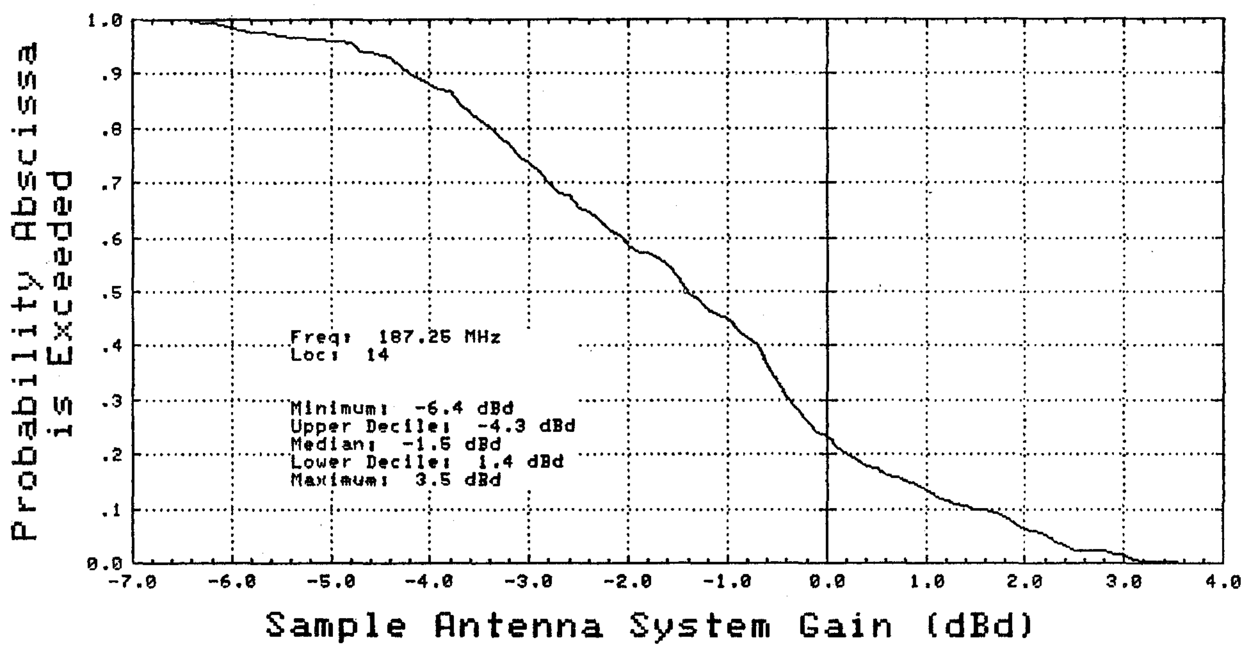


(b)

Figure A-28. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 13 at 579.25 MHz (a) and 651.25 MHz (b).

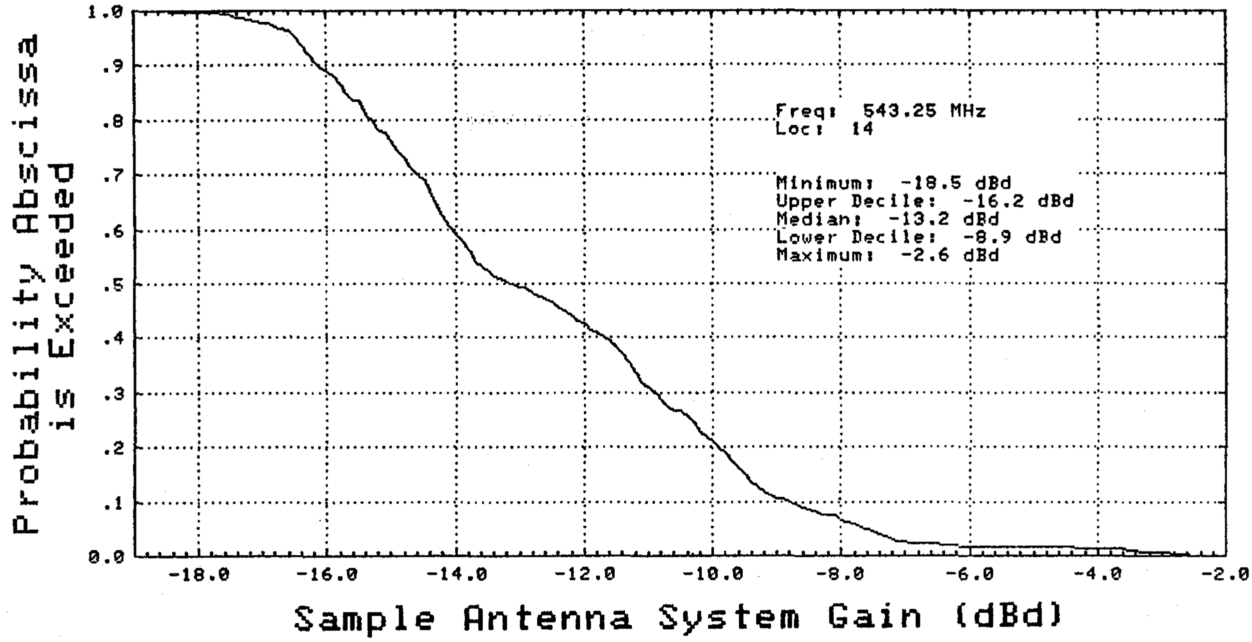


(a)

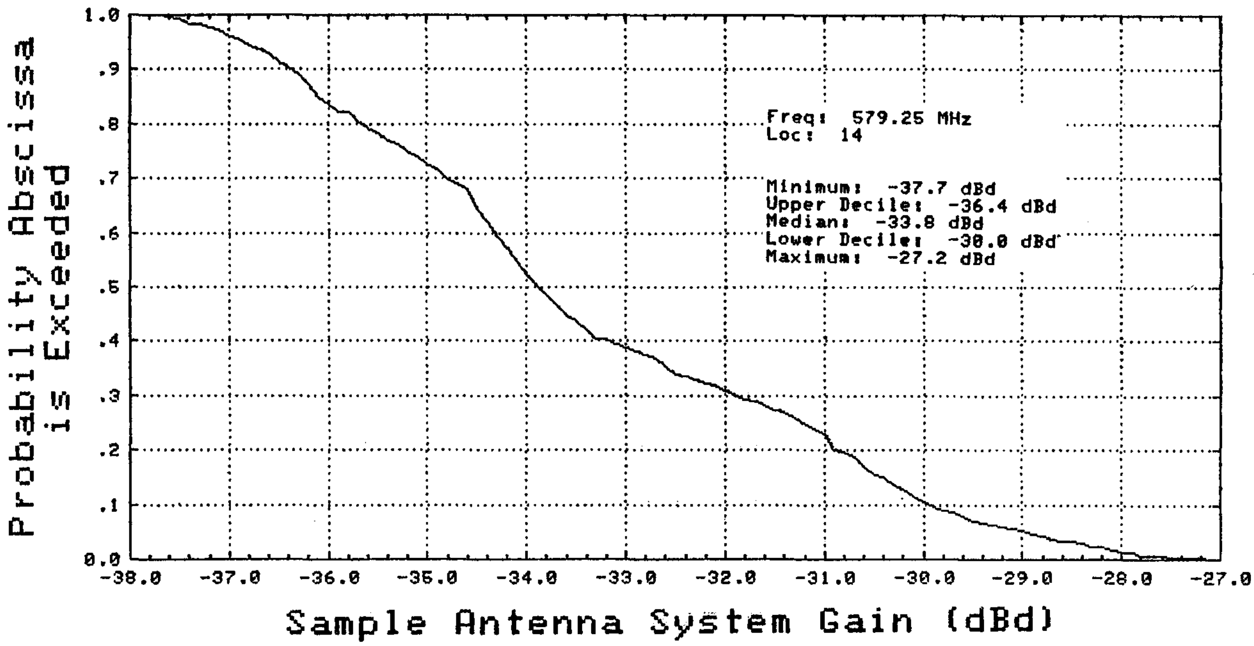


(b)

Figure A-29. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 14 at 77.25 MHz (a) and 187.25 MHz (b).

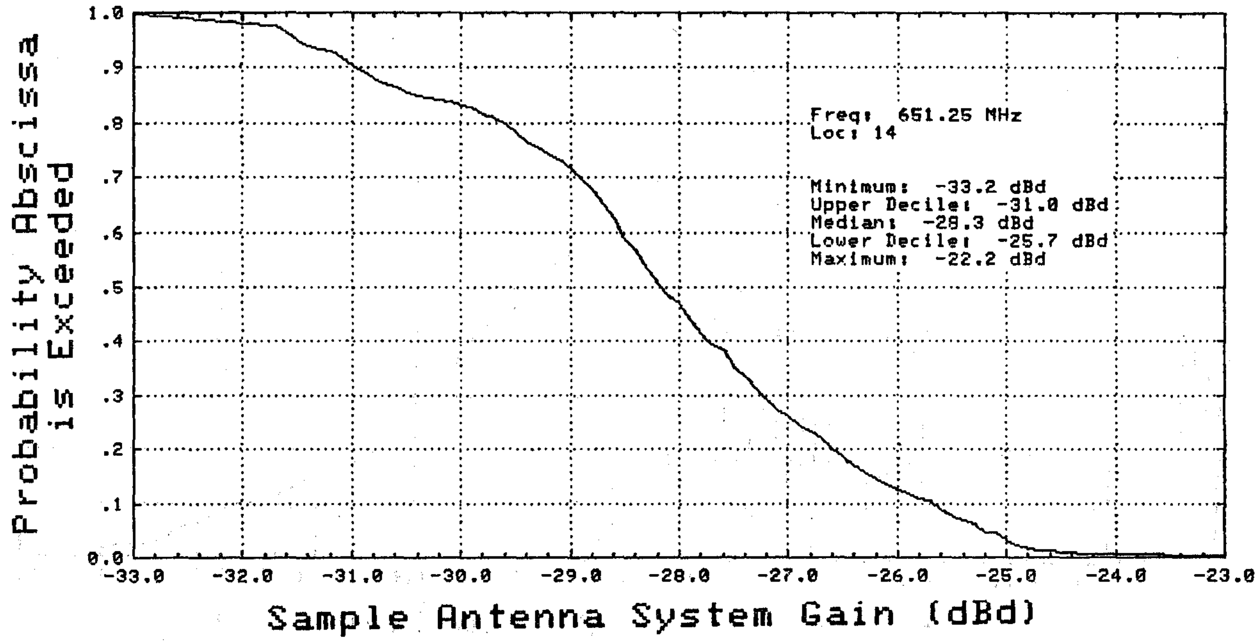


(a)

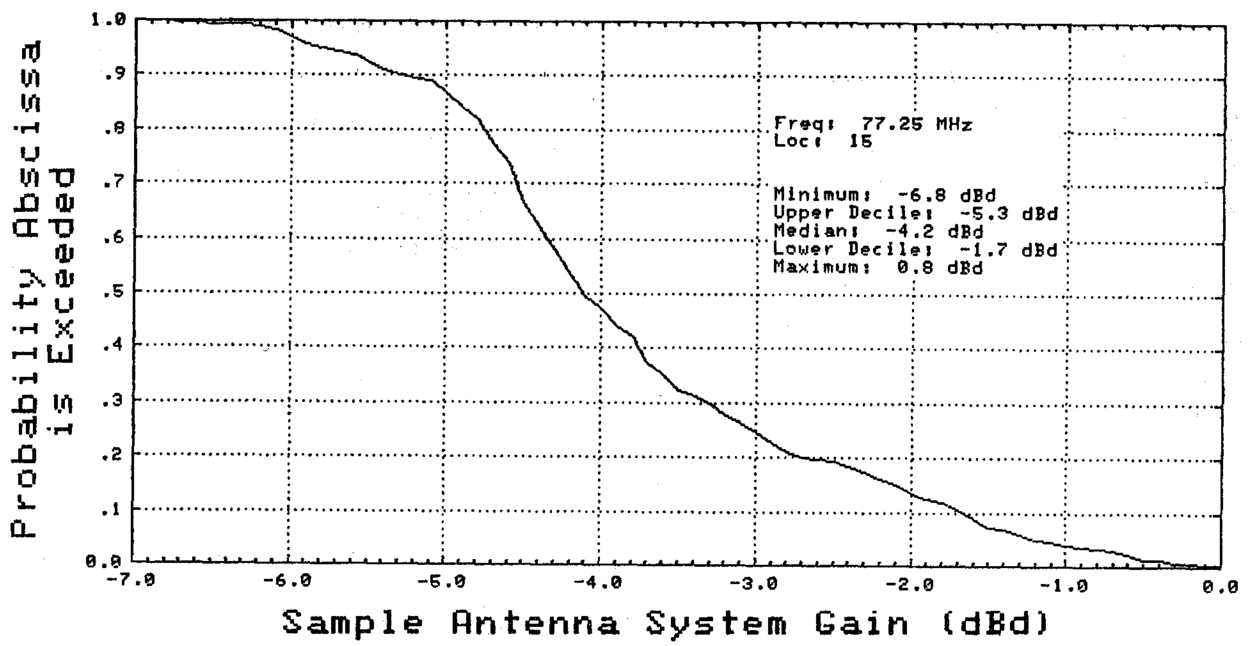


(b)

Figure A-30. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 14 at 543.25 MHz (a) and 579.25 MHz (b).

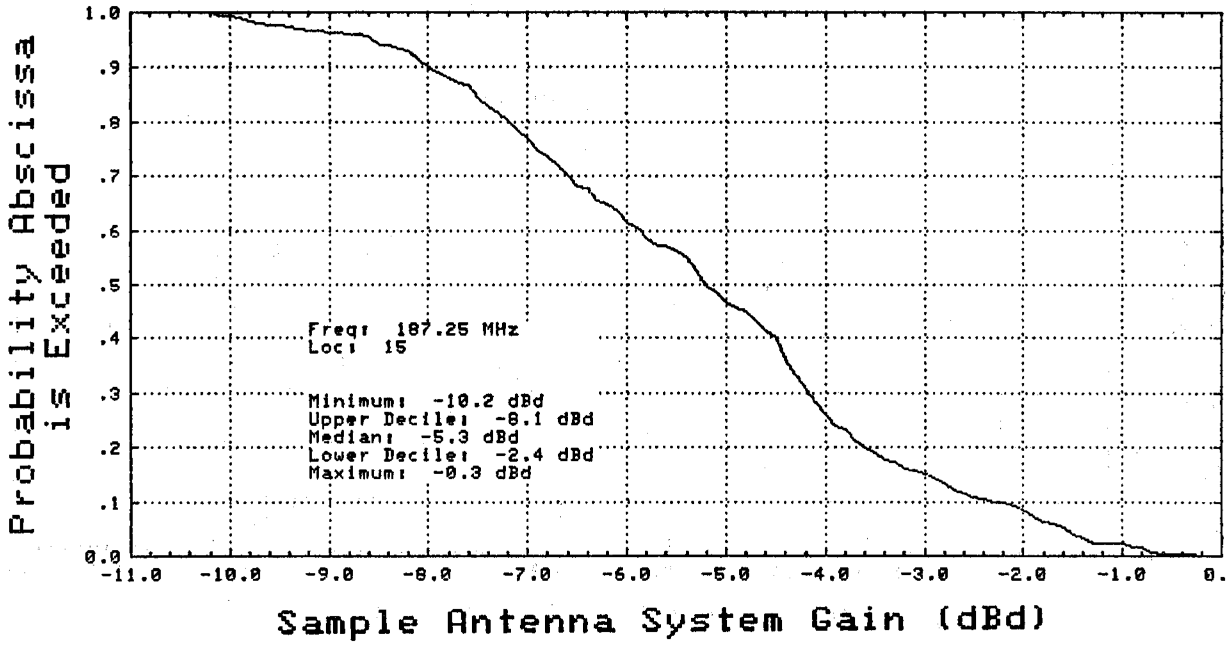


(a)

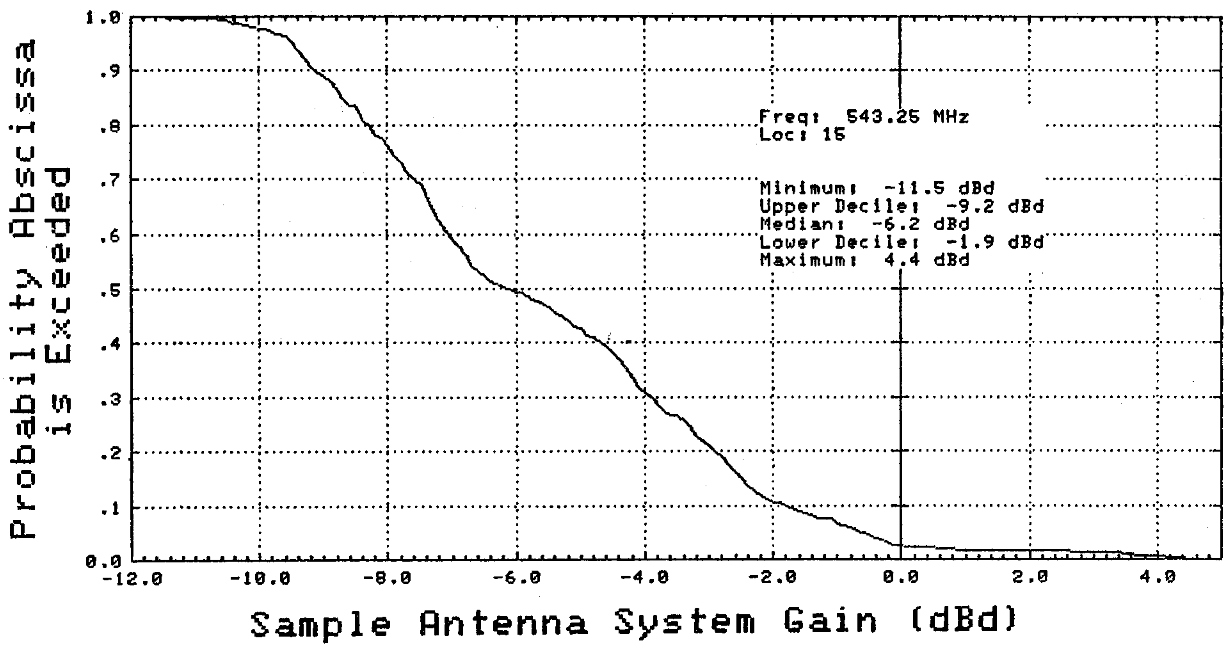


(b)

Figure A-31. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 14 at 651.25 MHz (a) and location 15 at 77.25 MHz (b).

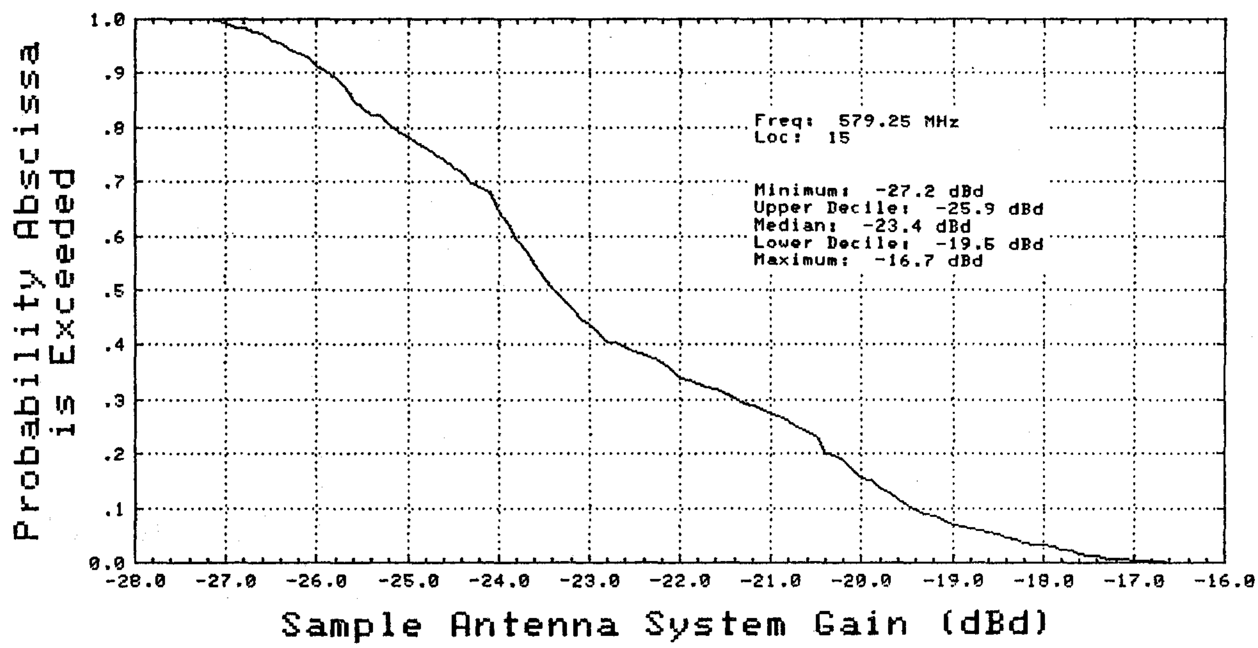


(a)

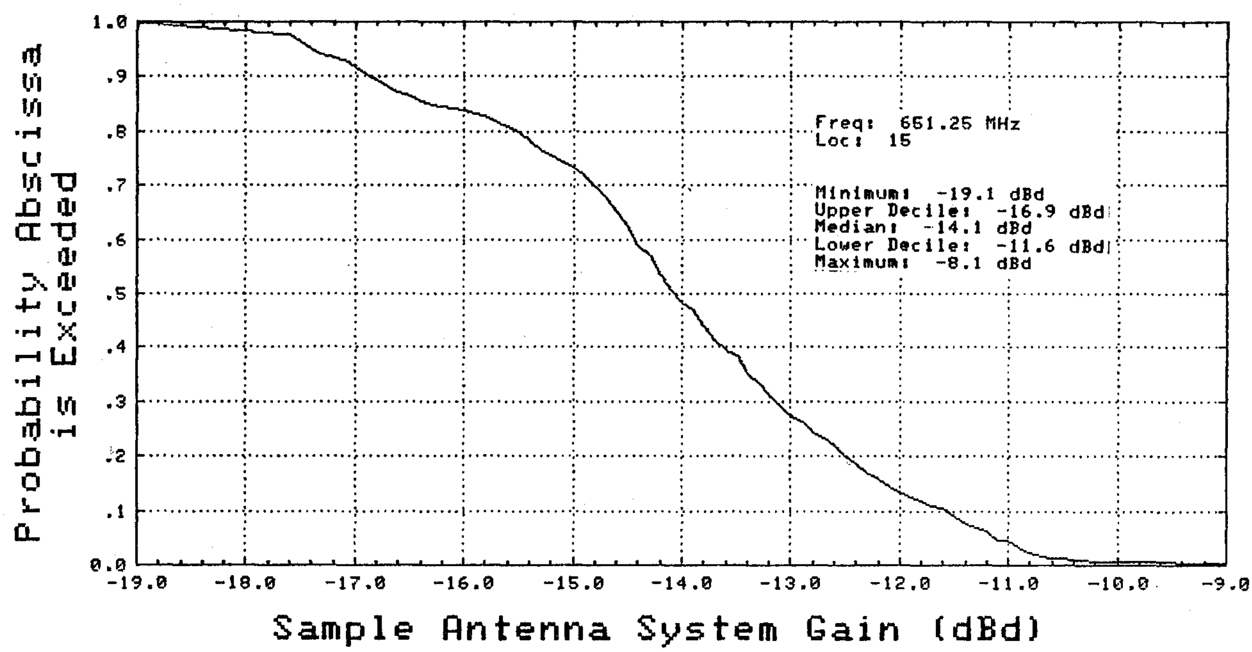


(b)

Figure A-32. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 15 at 187.25 MHz (a) and 543.25 MHz (b).

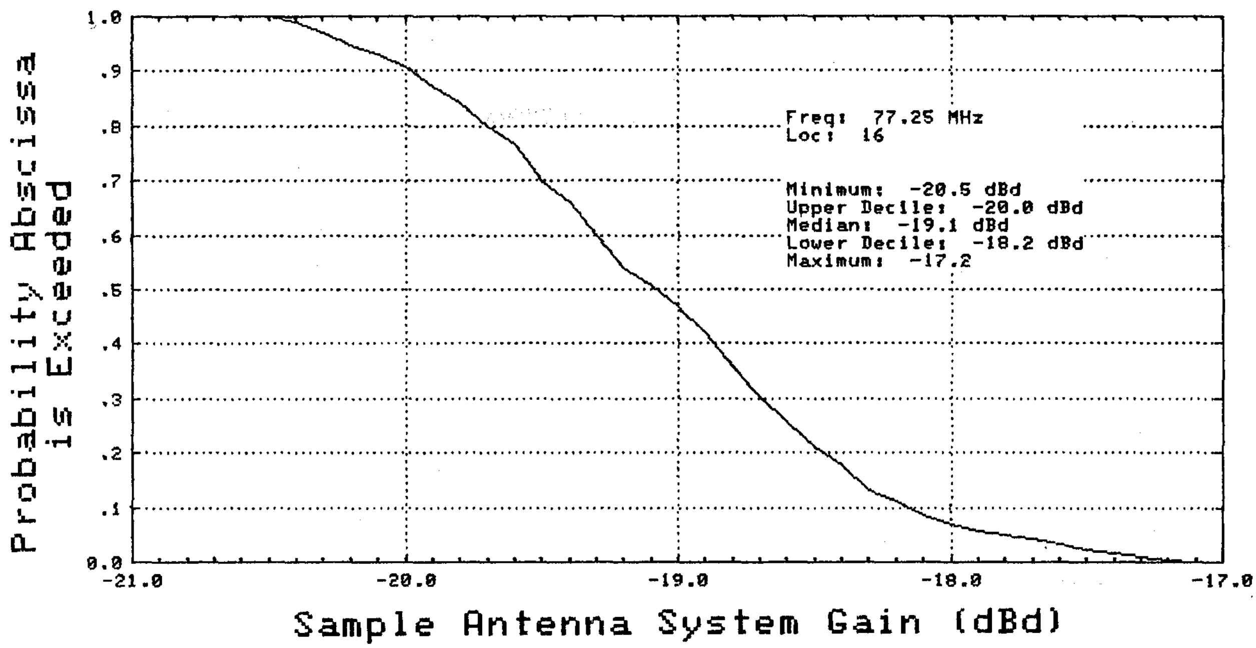


(a)

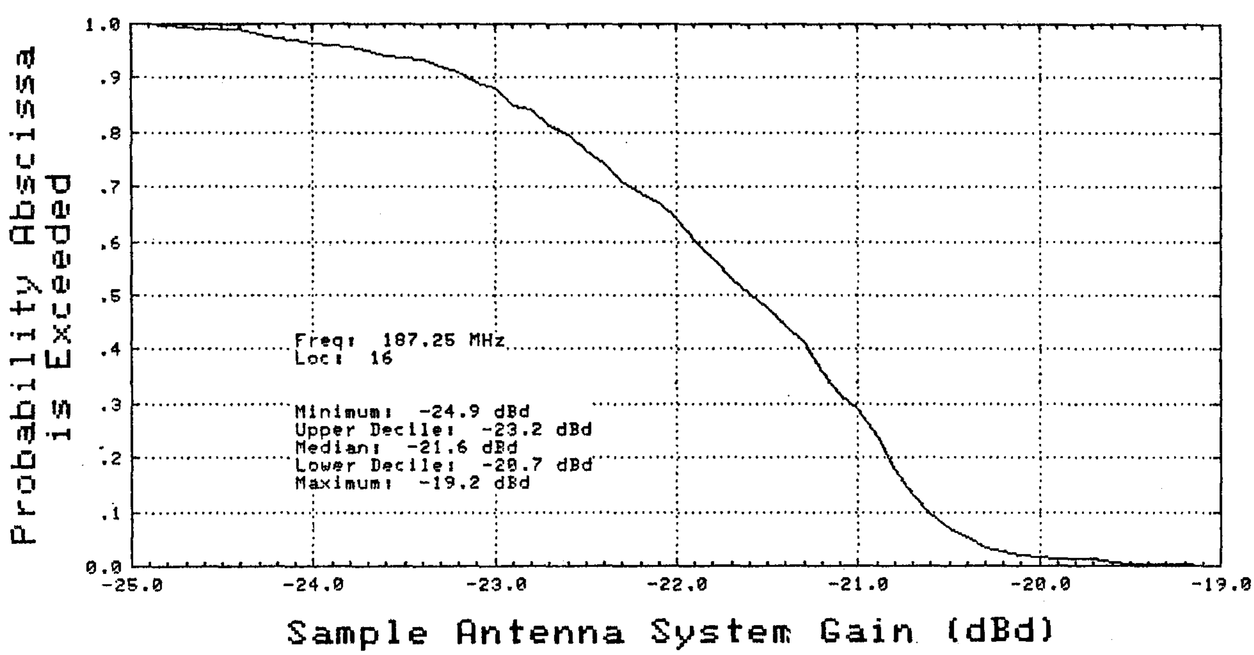


(b)

Figure A-33. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 15 at 579.25 MHz (a) and 651.25 MHz (b).

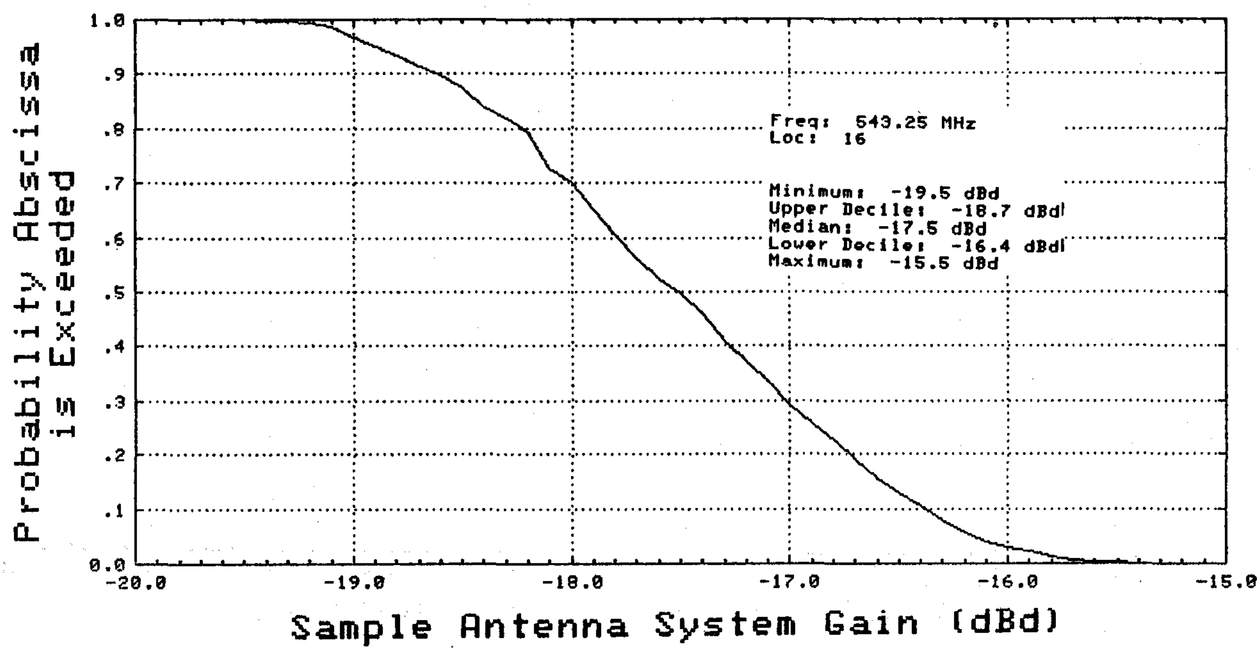


(a)

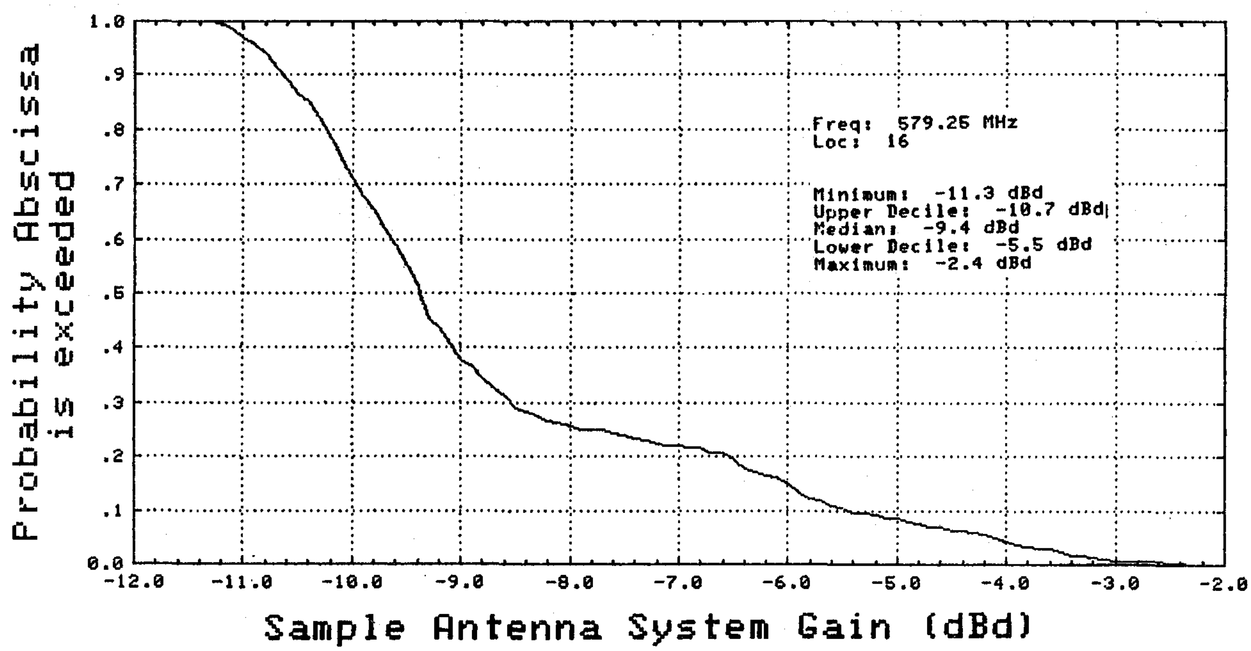


(b)

Figure A-34. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 16 at 77.25 MHz (a) and 187.25 MHz (b).

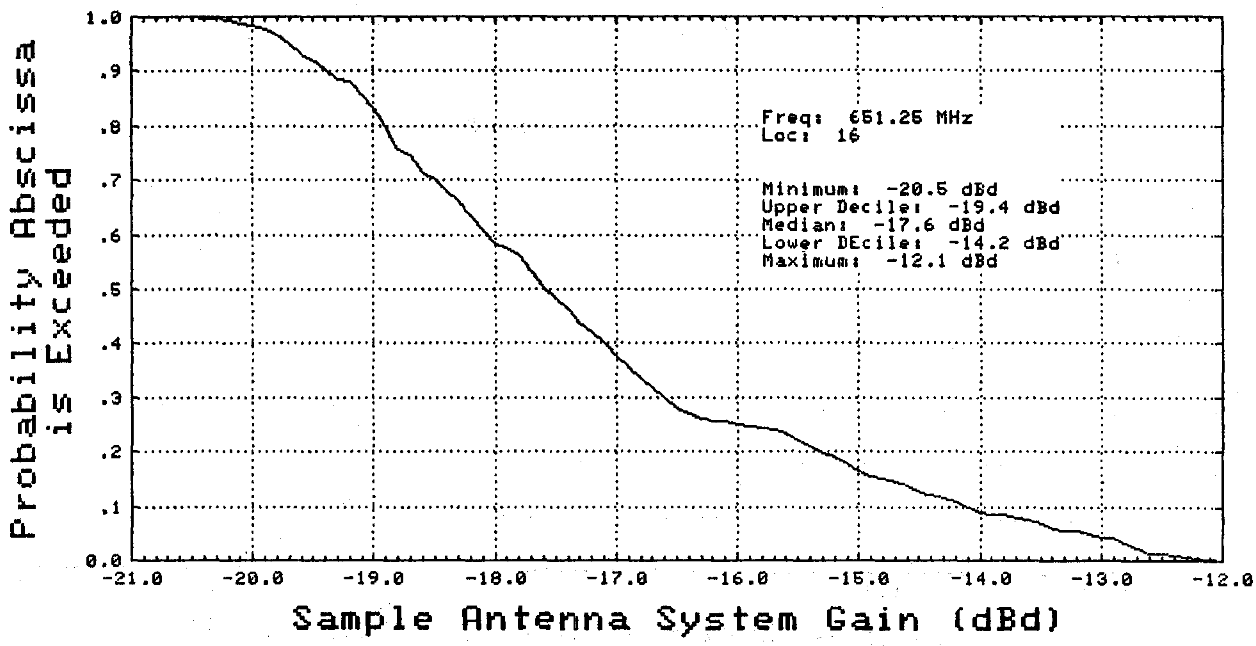


(a)

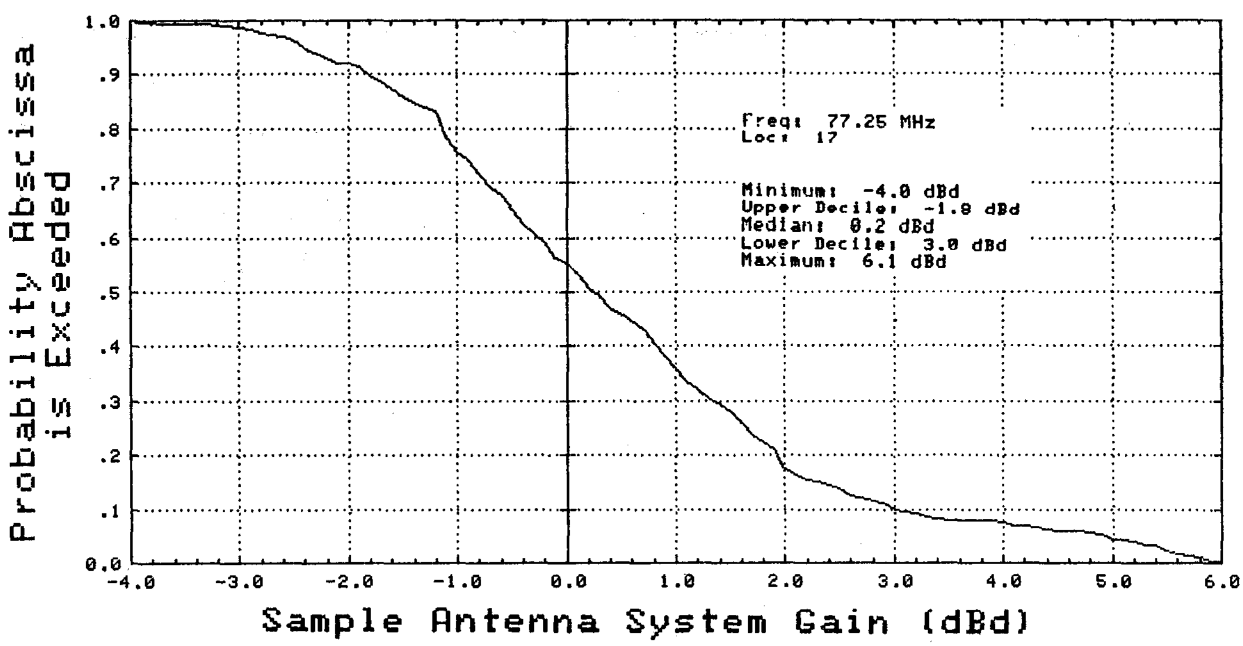


(b)

Figure A-35. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 16 at 543.25 MHz (a) and 579.25 MHz (b).

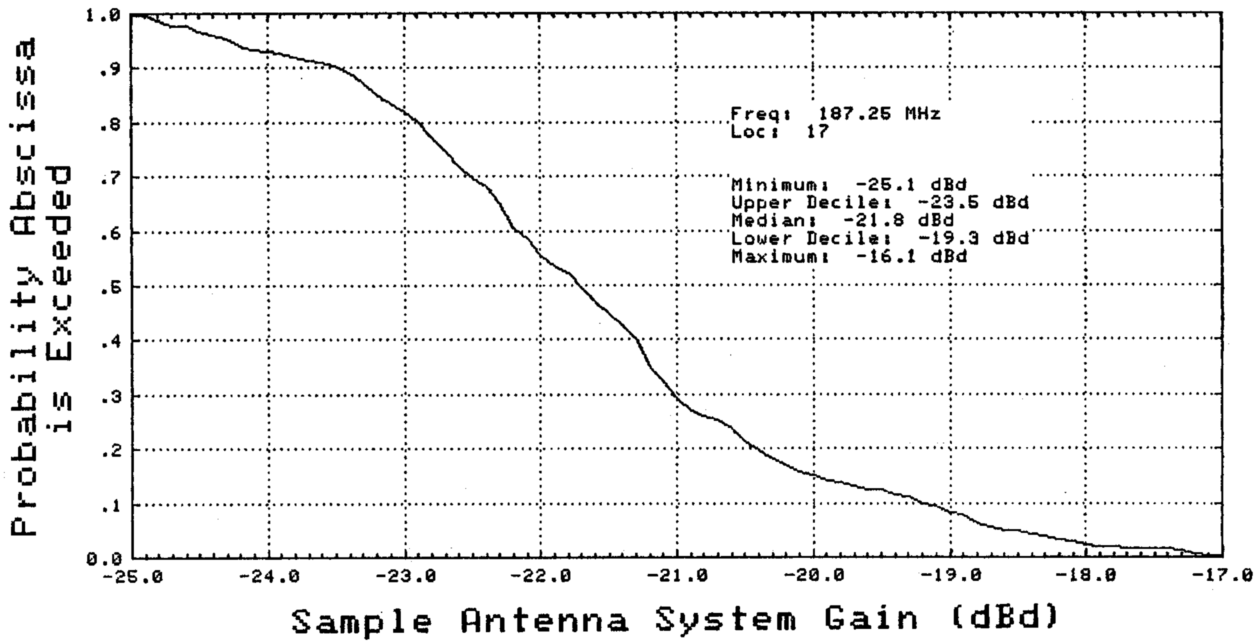


(a)

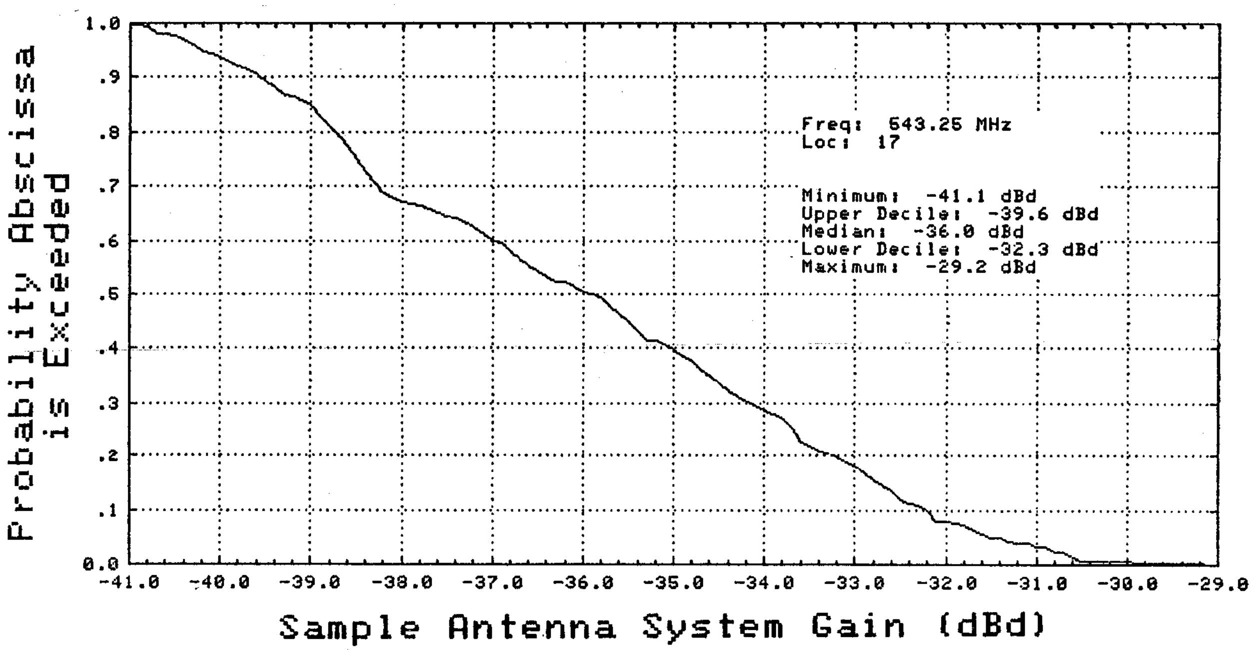


(b)

Figure A-36. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 16 at 651.25 MHz (a) and location 17 at 77.25 MHz (b).

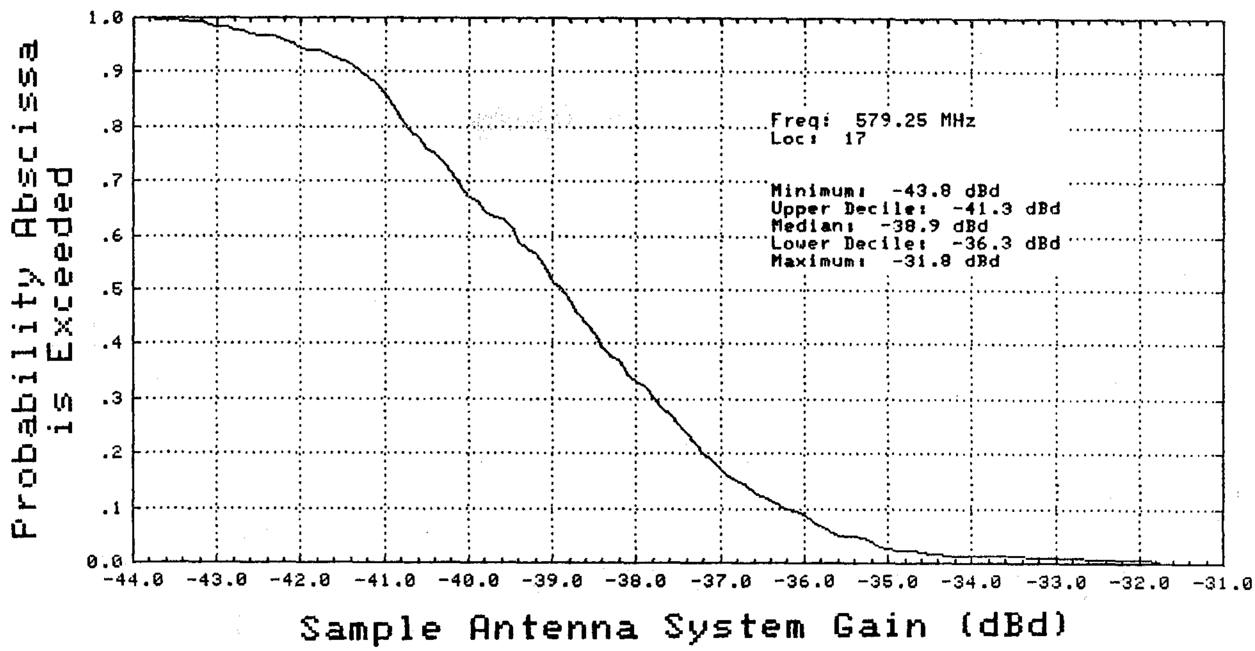


(a)

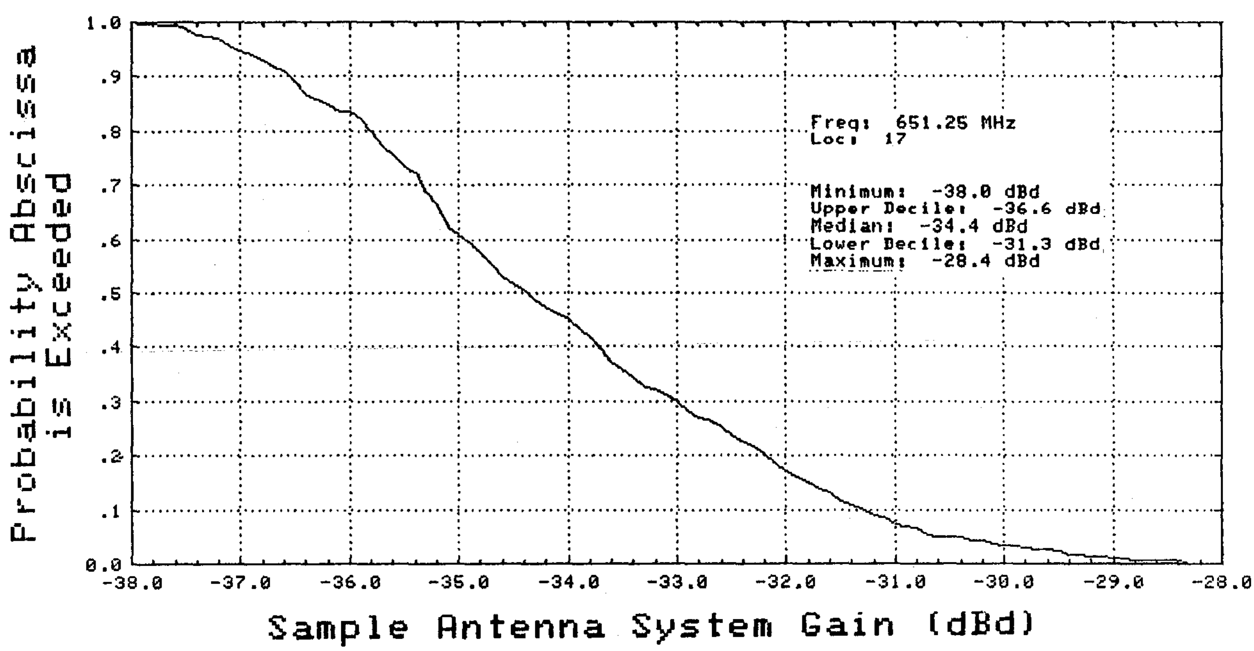


(b)

Figure A-37. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 17 at 187.25 MHz (a) and 543.25 MHz (b).

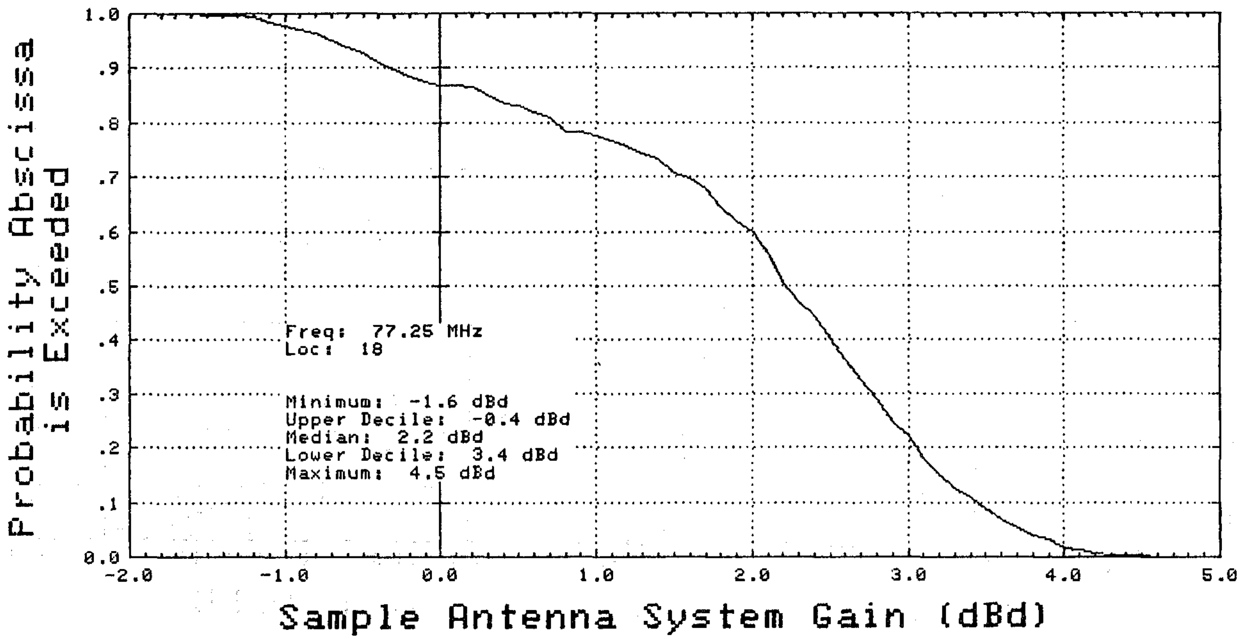


(a)

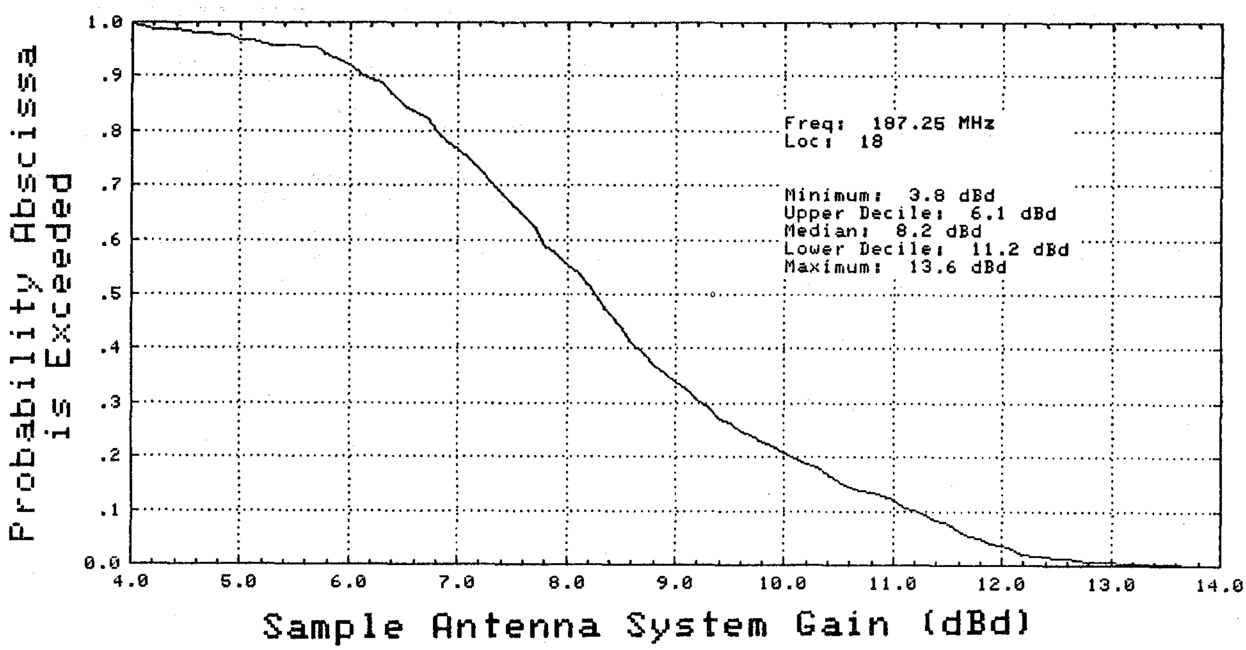


(b)

Figure A-38. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 17 at 579.25 MHz (a) and 651.25 MHz (b).

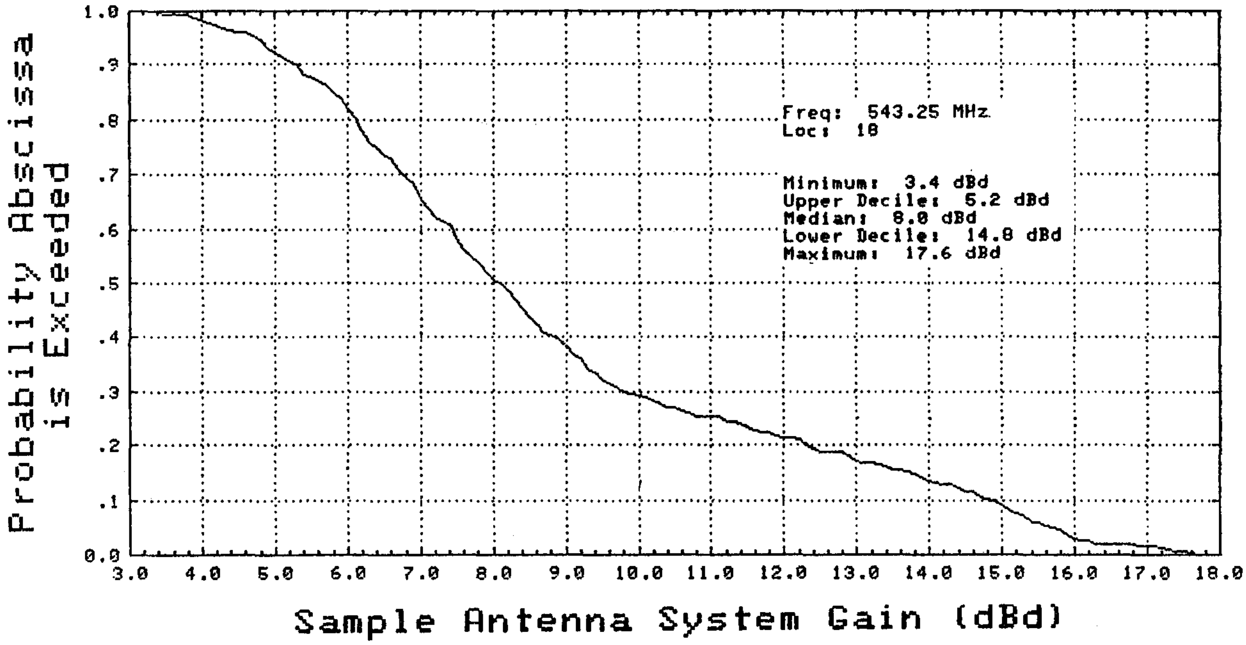


(a)

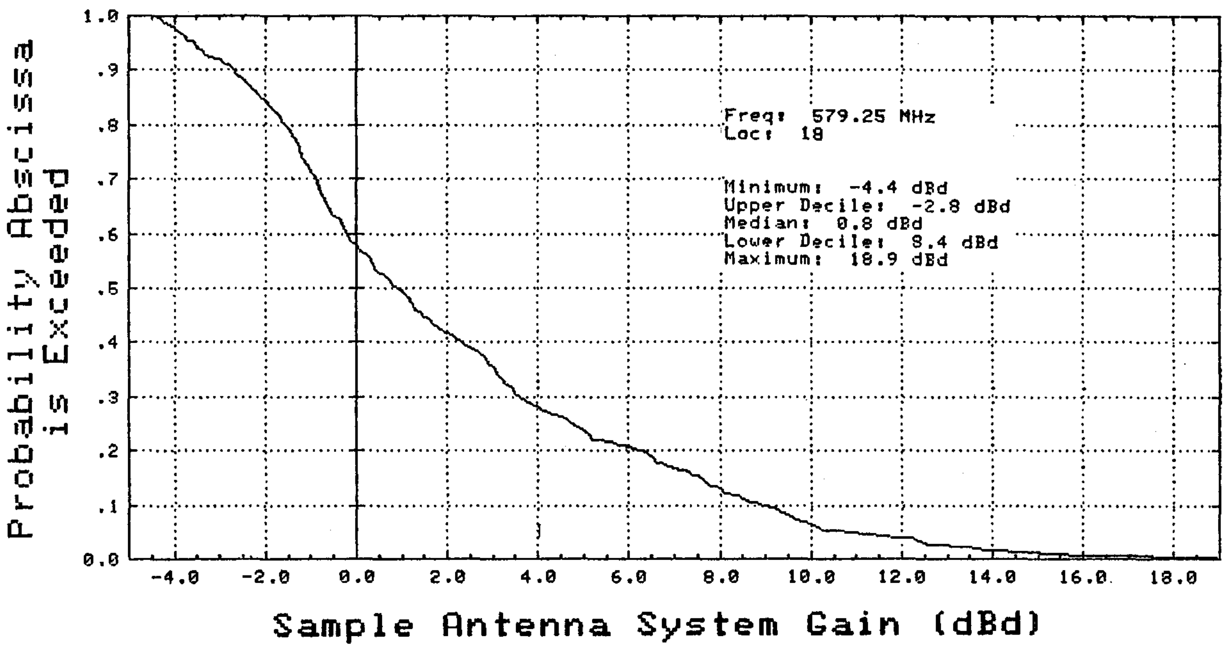


(b)

Figure A-39. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 18 at 77.25 MHz (a) and 187.25 MHz (b).

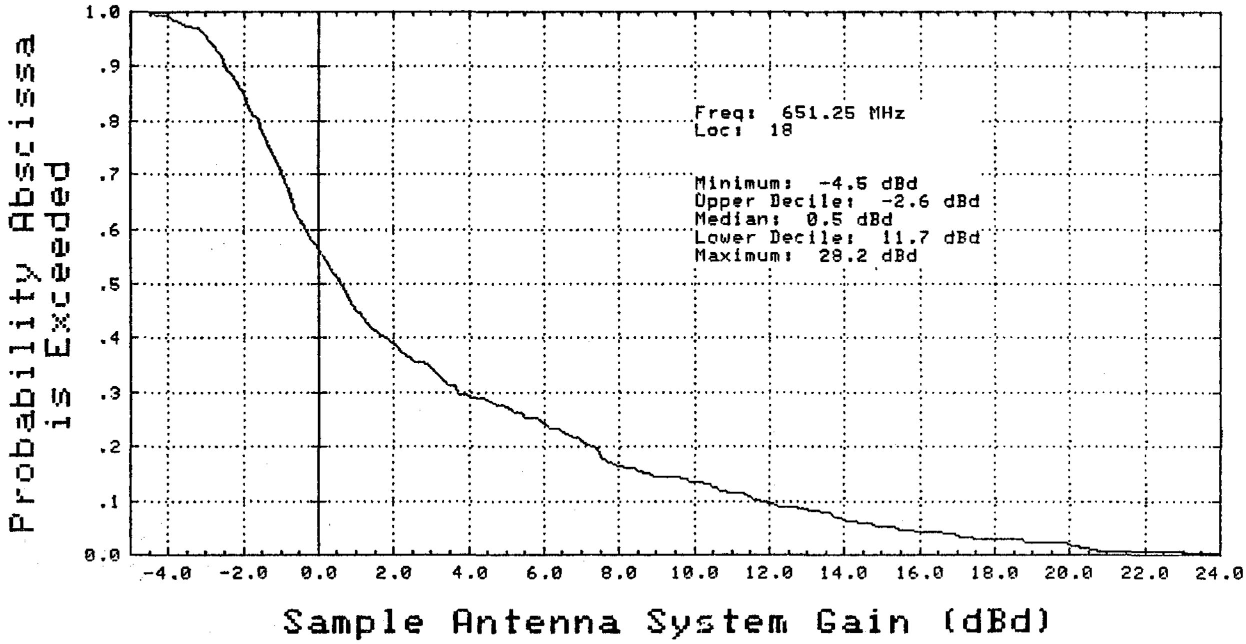


(a)

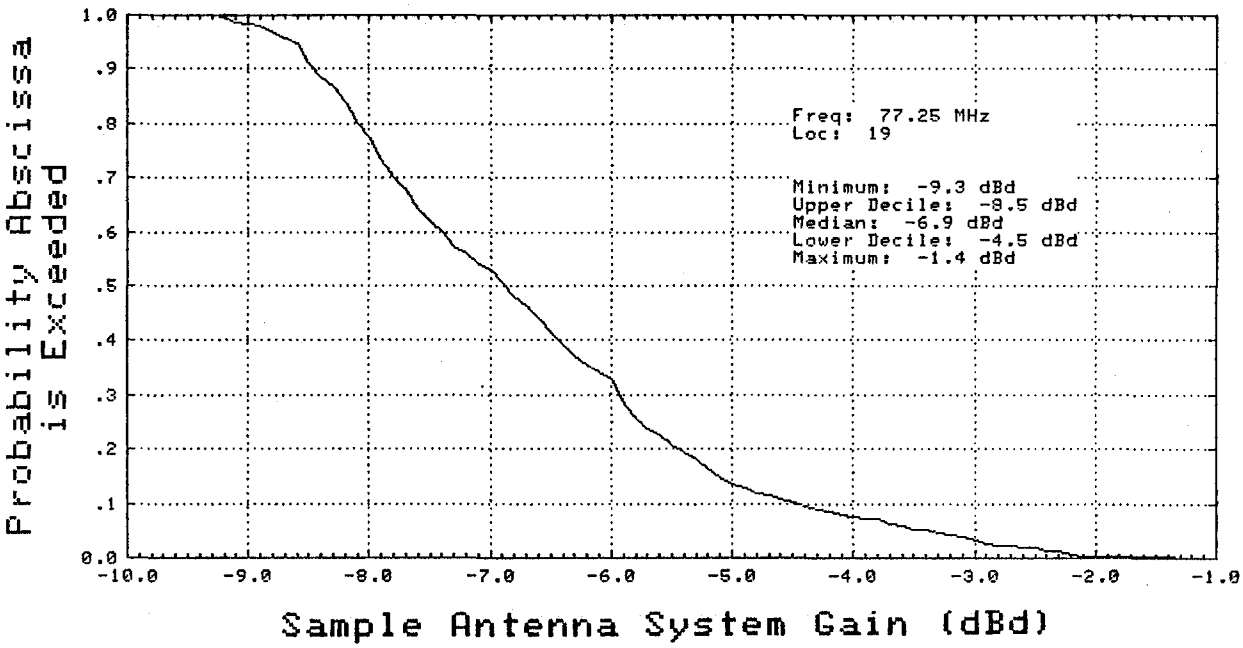


(b)

Figure A-40. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 18 at 543.25 MHz (a) and 579.25 MHz (b).

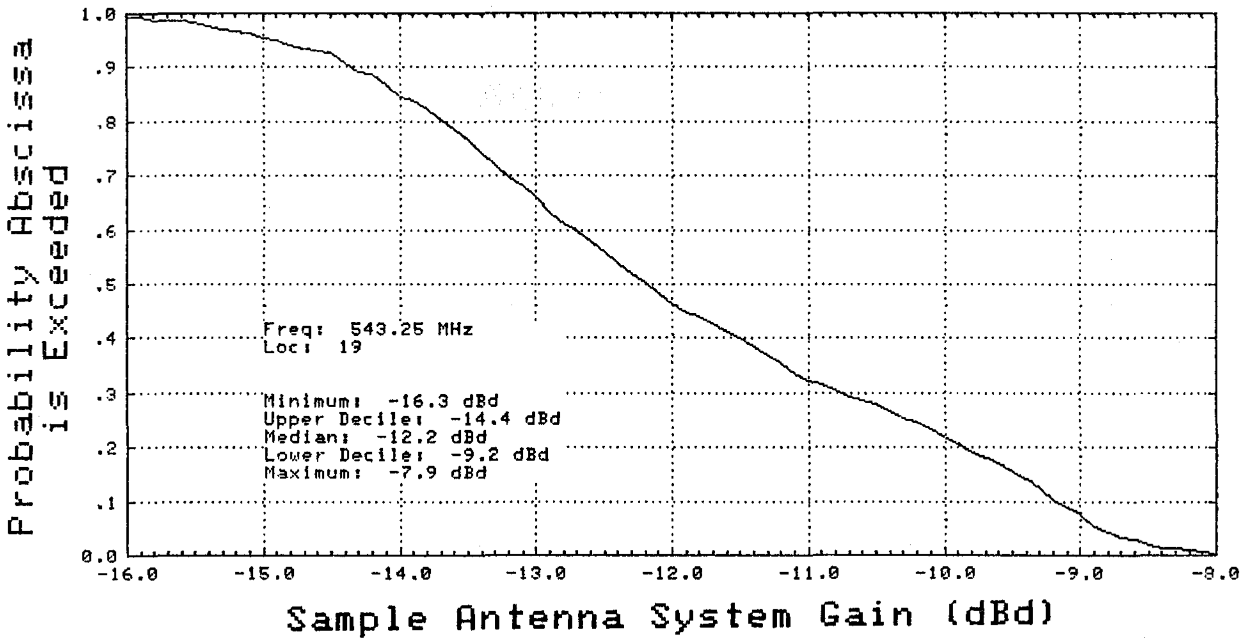


(a)

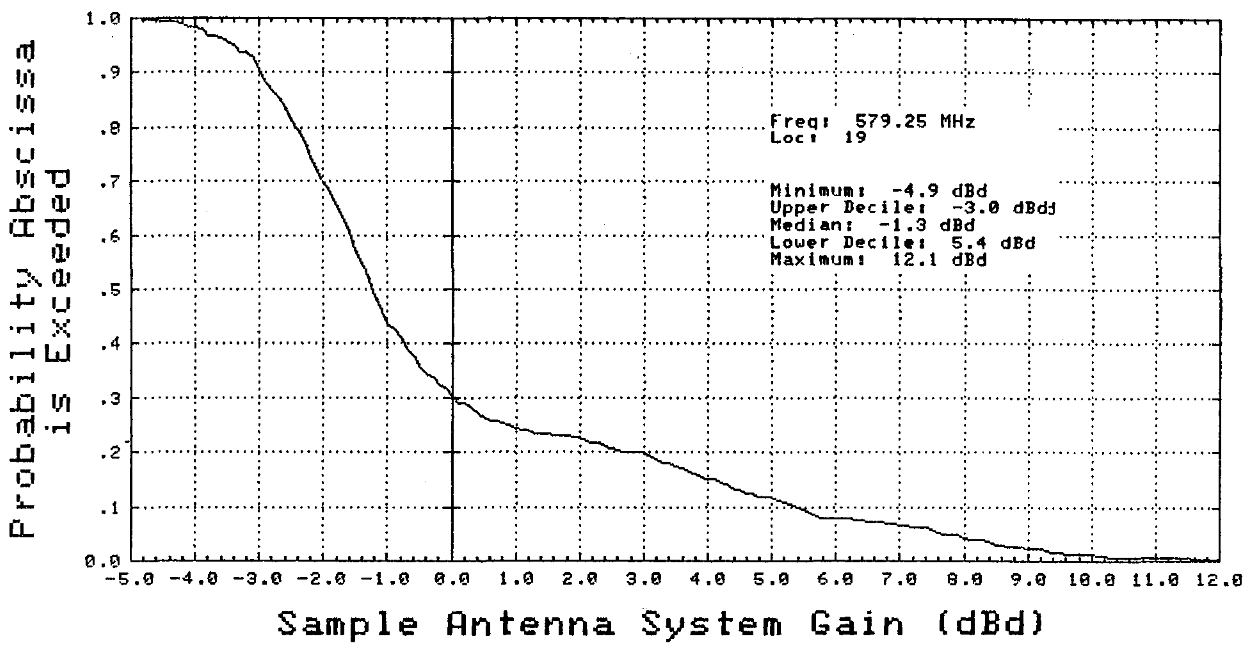


(b)

Figure A-41. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 18 at 651.25 MHz (a) and location 19 at 77.25 MHz (b).

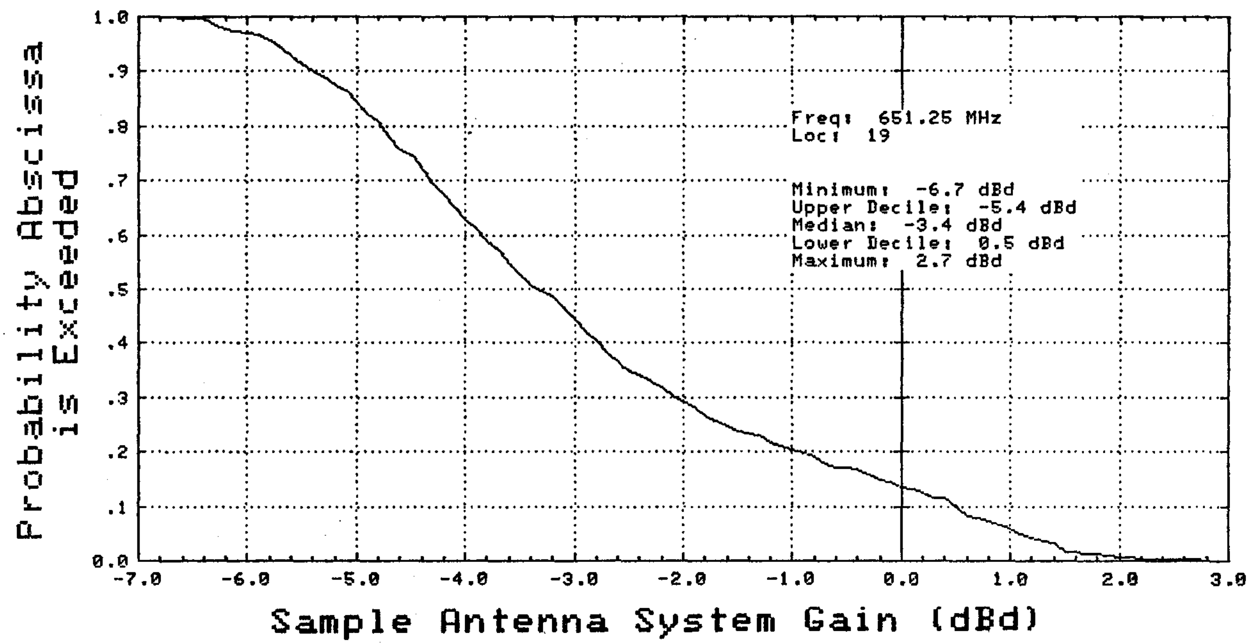


(a)

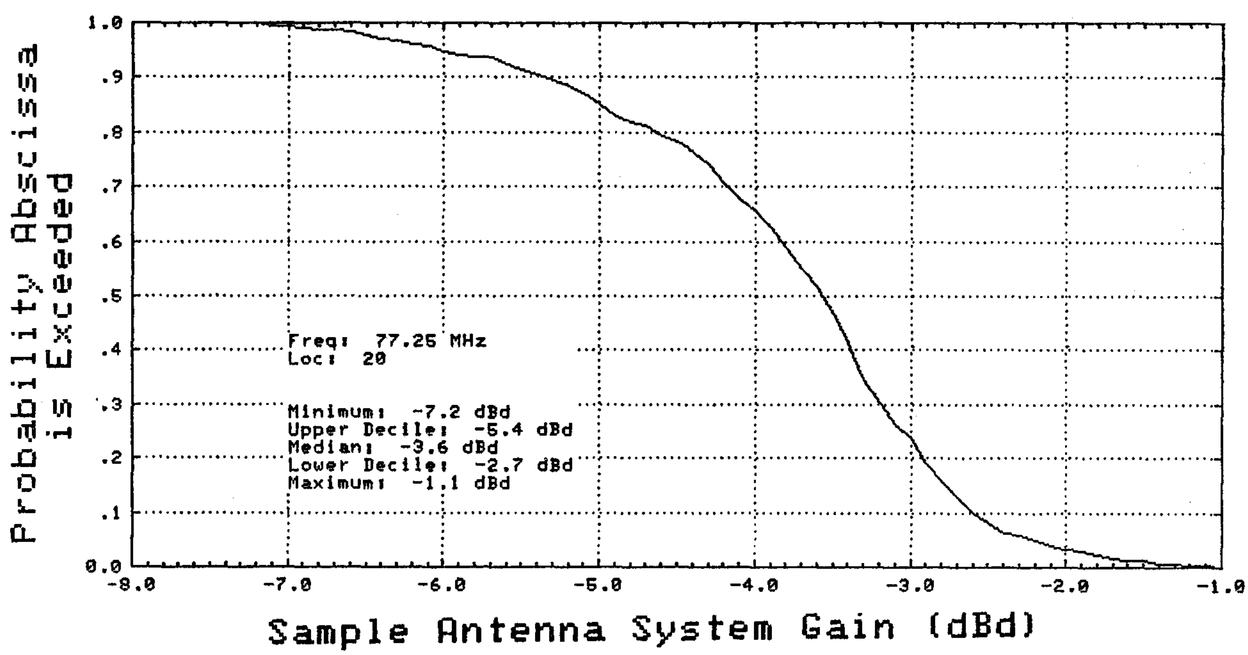


(b)

Figure A-42. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 19 at 543.25 MHz (a) and 579.25 MHz (b).

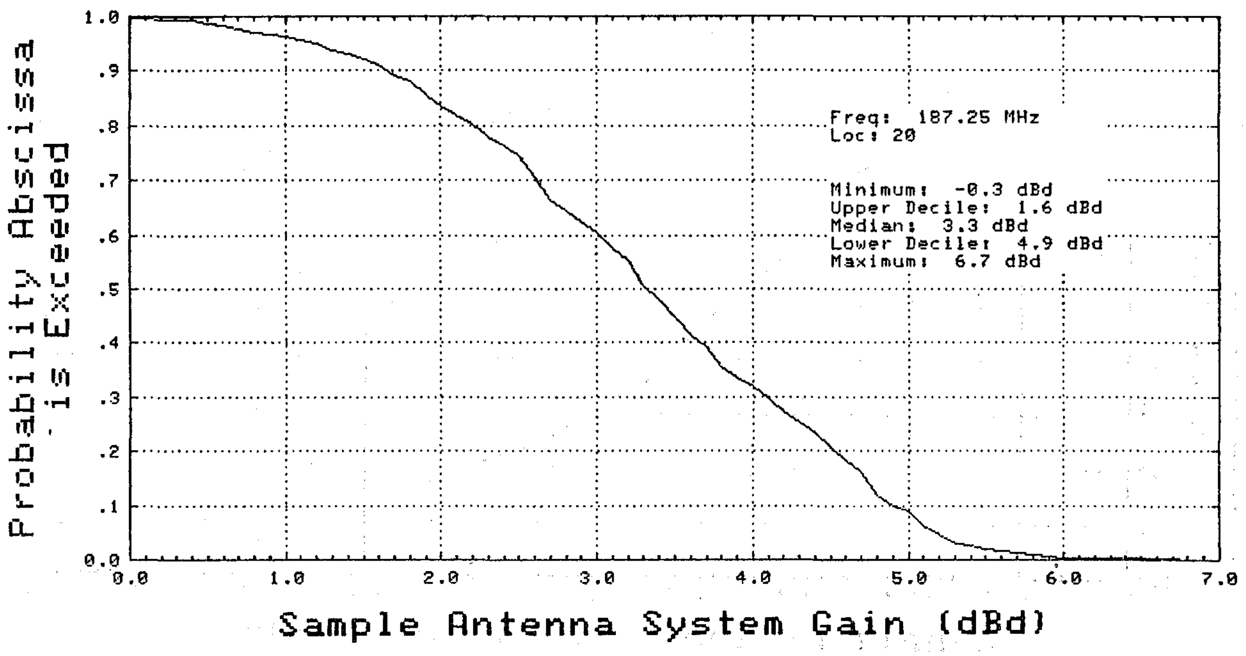


(a)

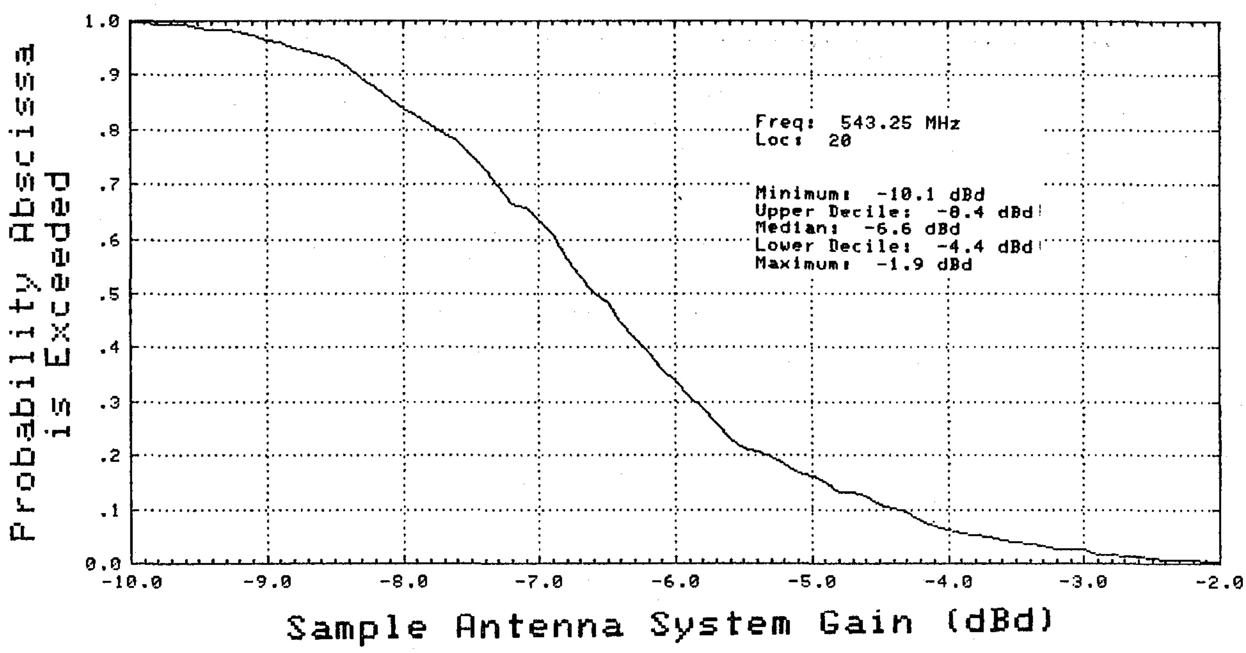


(b)

Figure A-43. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 19 at 651.25 MHz (a) and location 20 at 77.25 MHz (b).

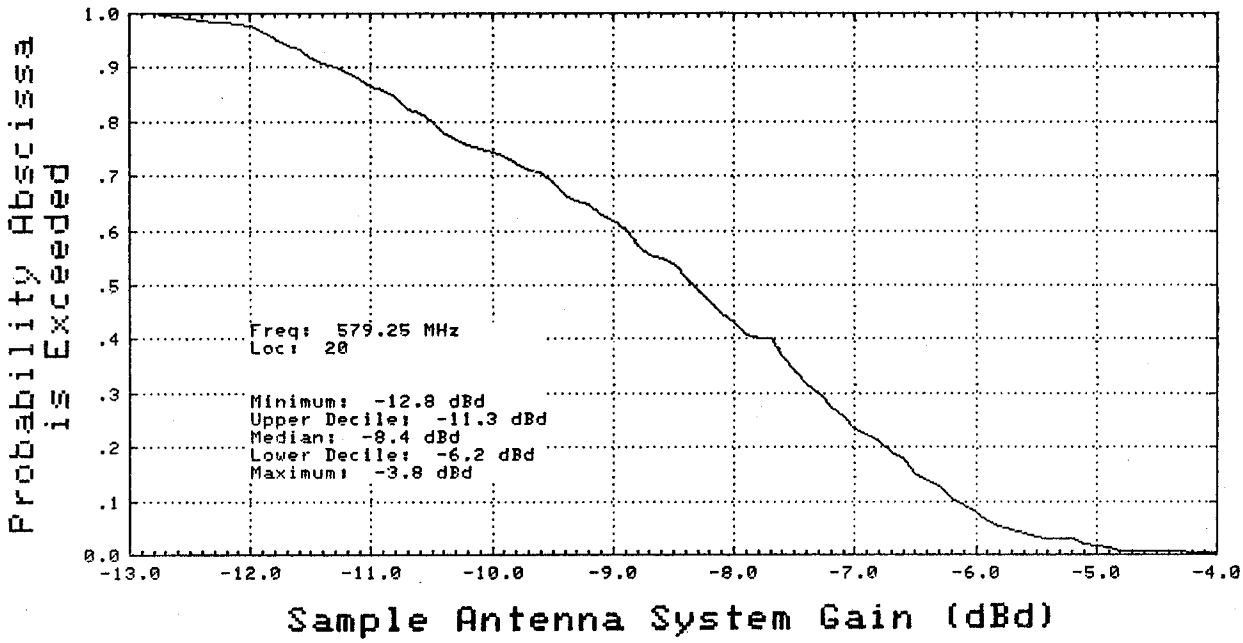


(a)

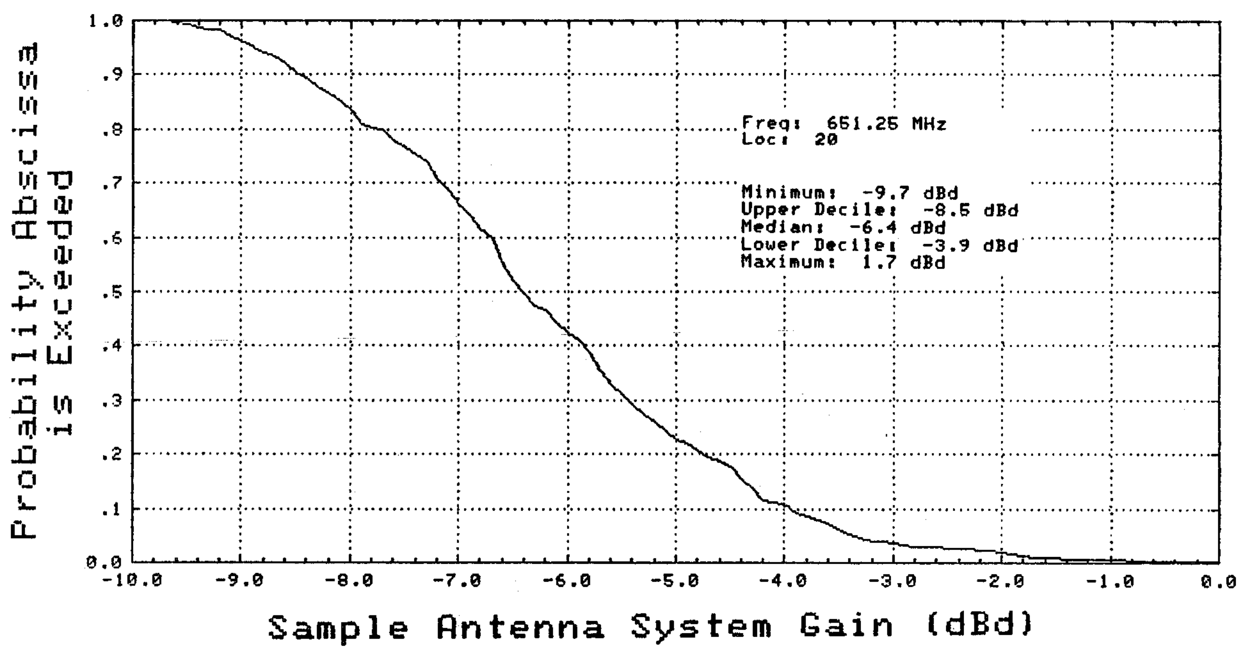


(b)

Figure A-44. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 20 at 187.25 MHz (a) and 543.25 MHz (b).

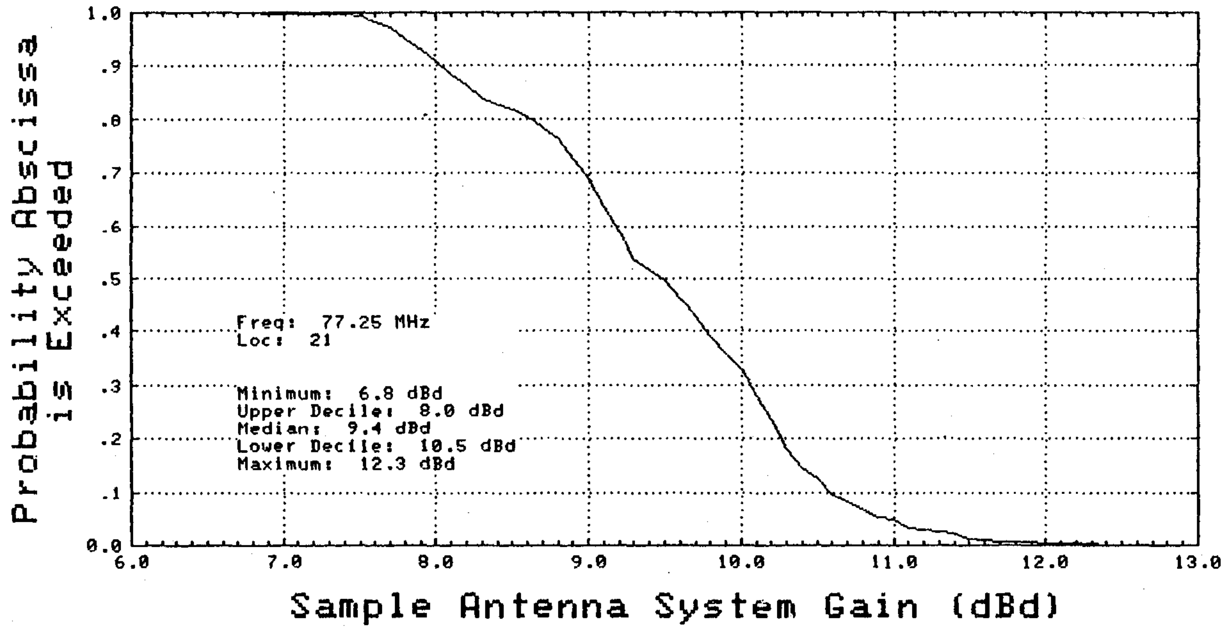


(a)

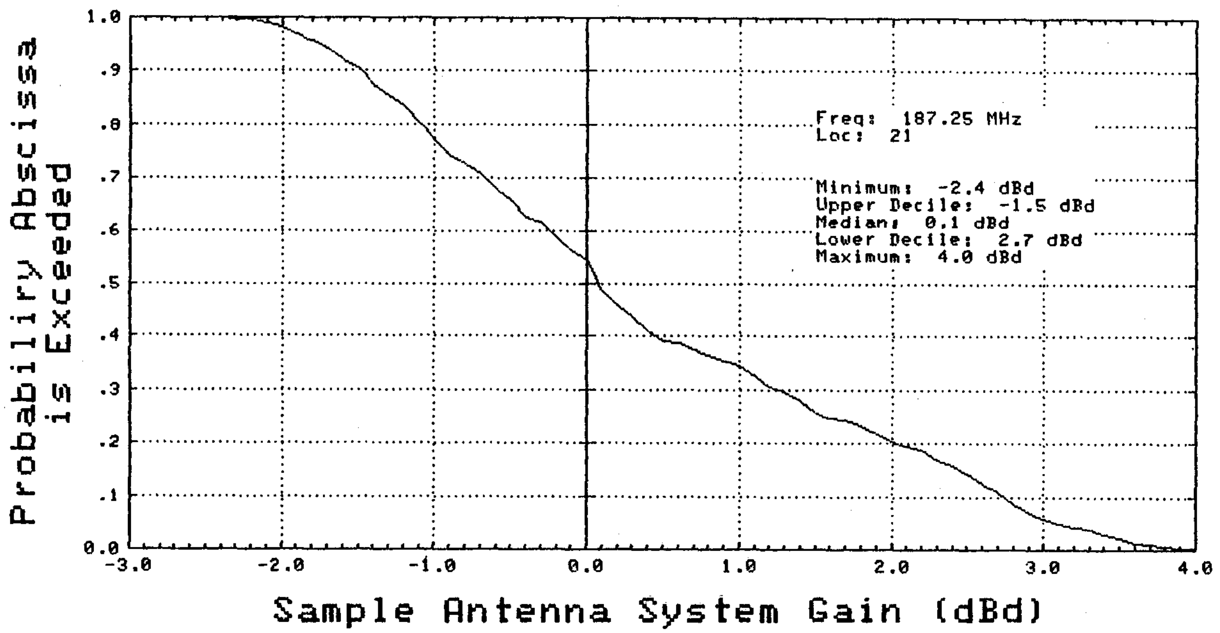


(b)

Figure A-45. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 20 at 579.25 MHz (a) and 651.25 MHz (b).

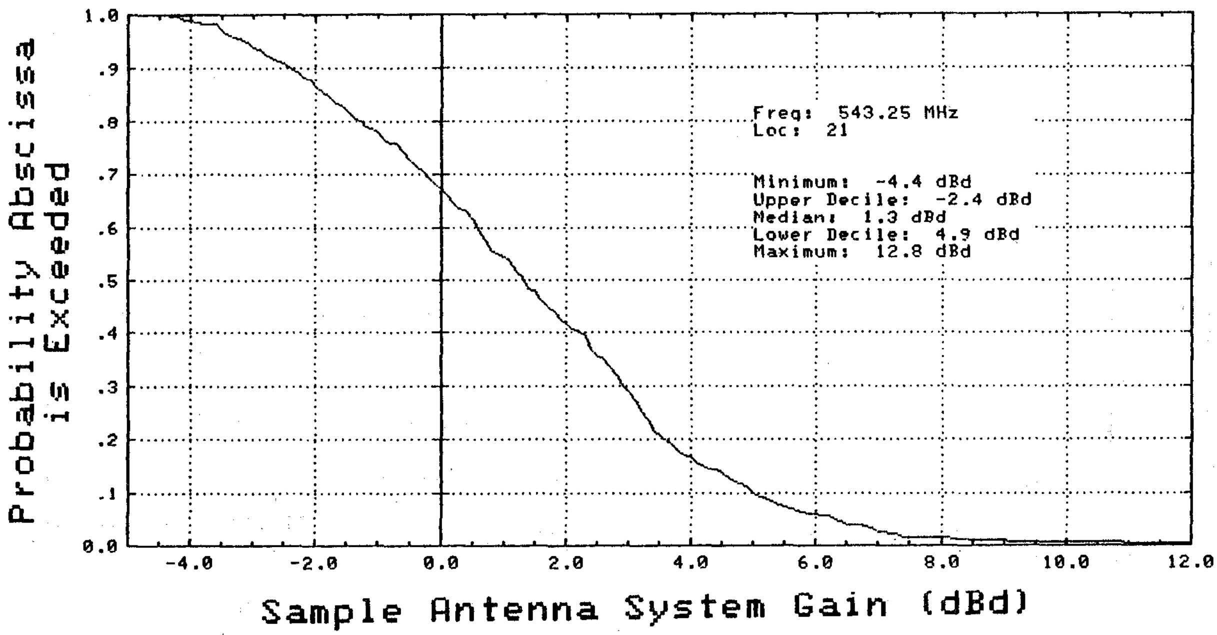


(a)

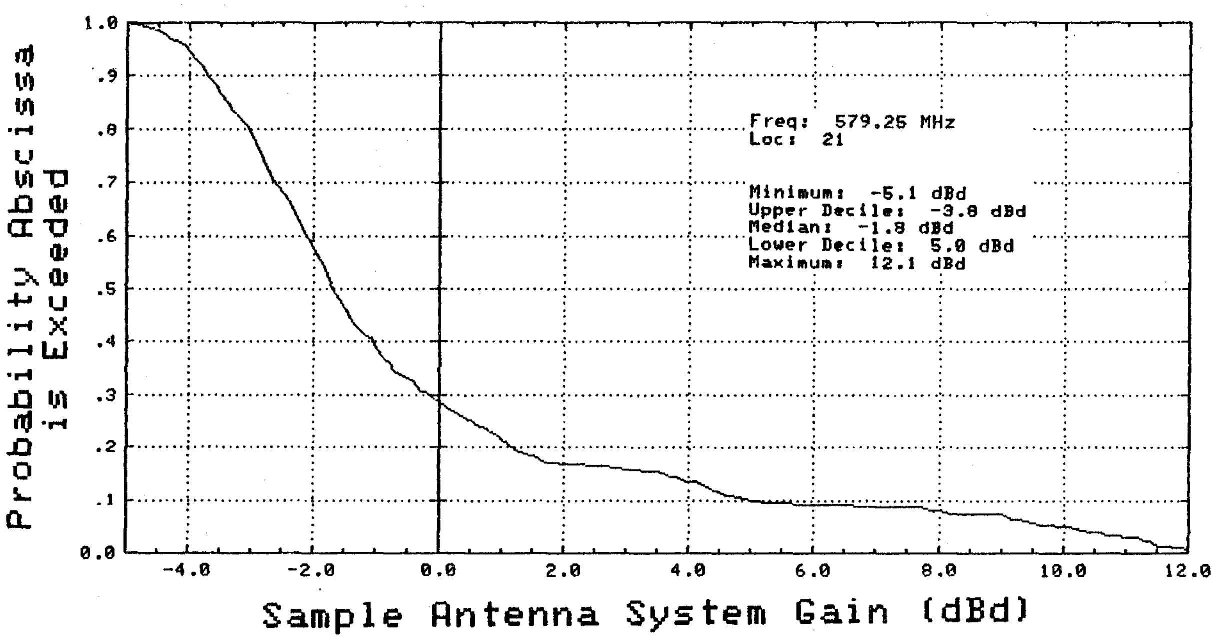


(b)

Figure A-46. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 21 at 77.25 MHz (a) and 187.25 MHz (b).

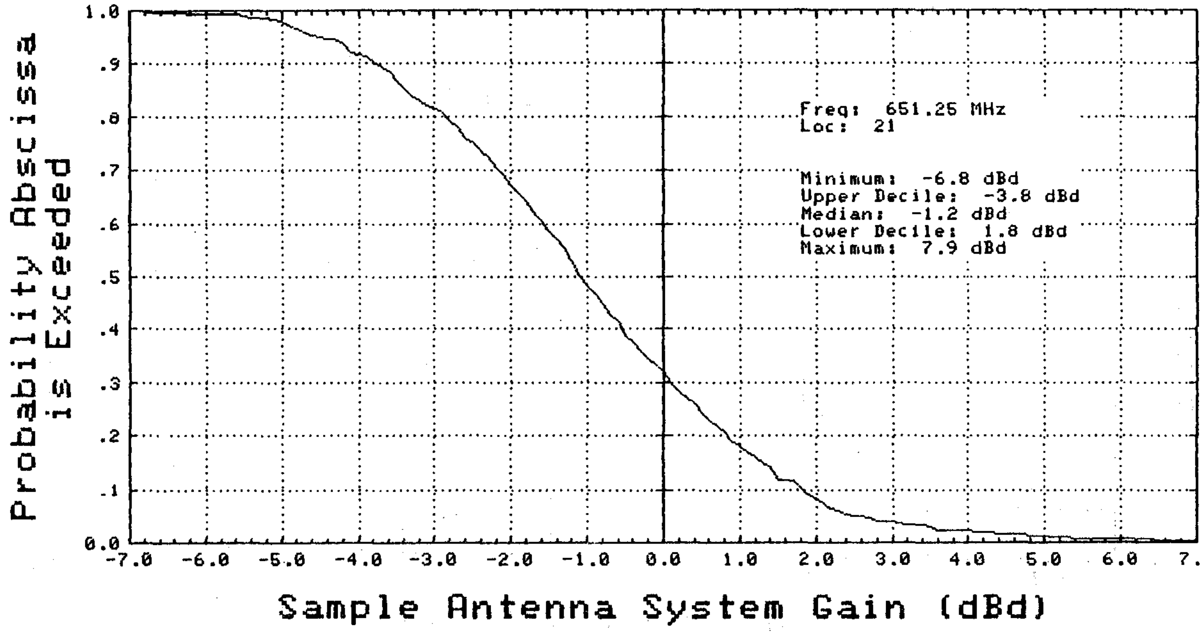


(a)

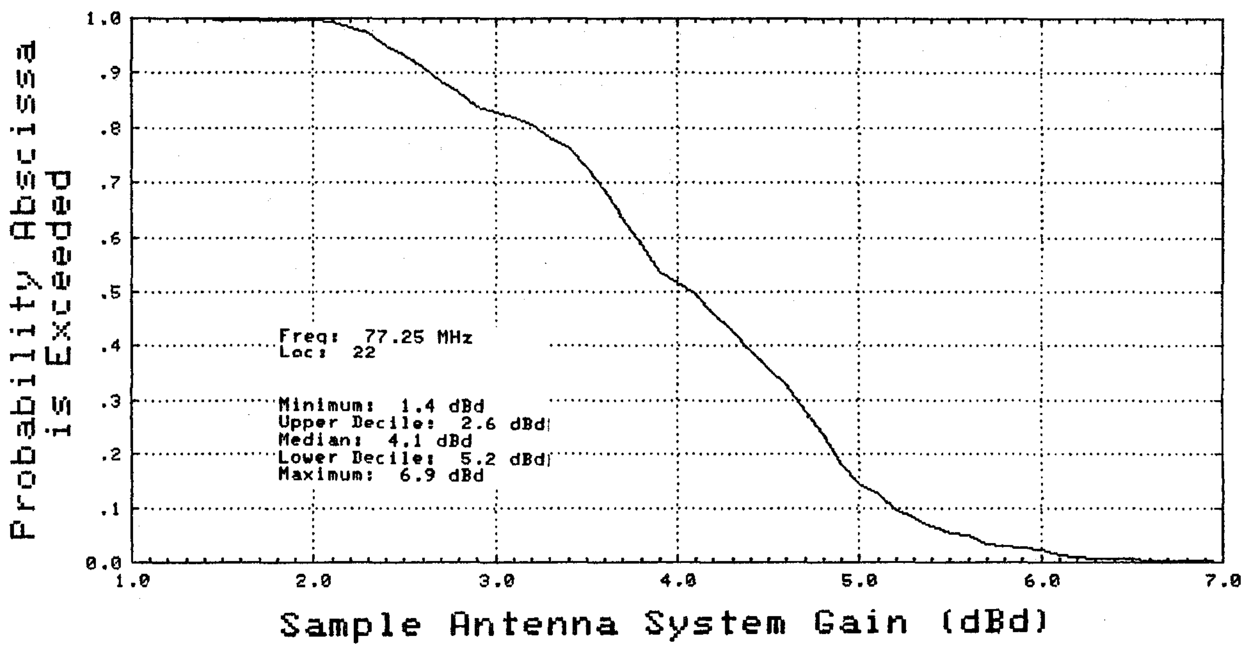


(b)

Figure A-47. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 21 at 543.25 MHz (a) and 579.25 MHz (b).

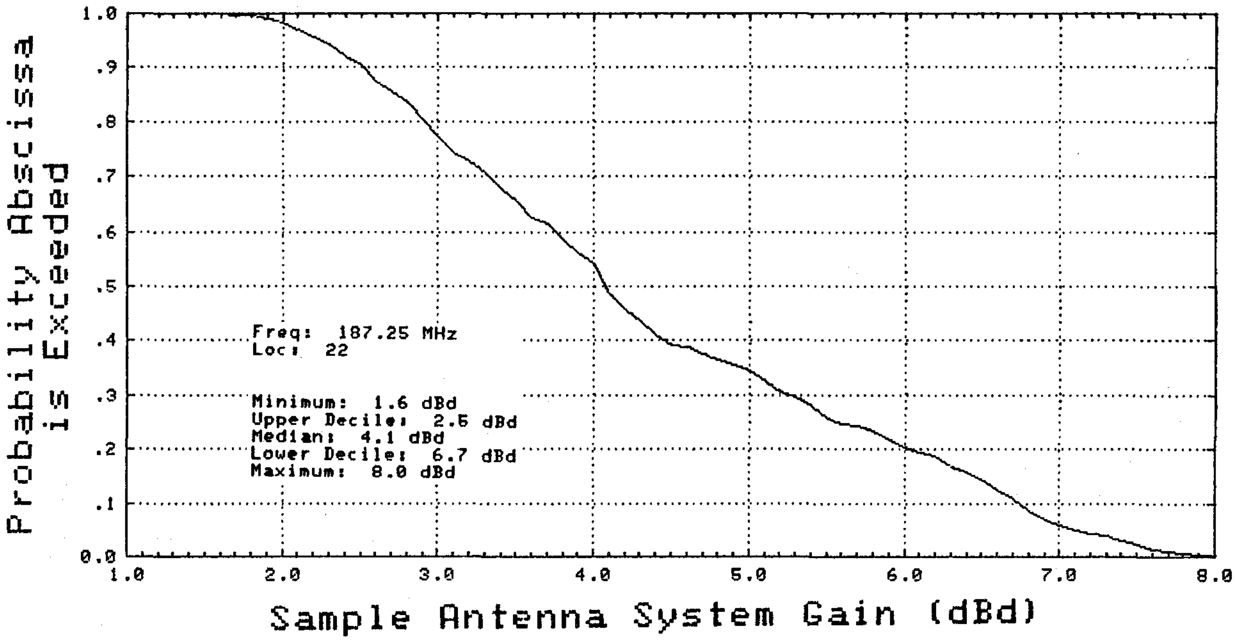


(a)

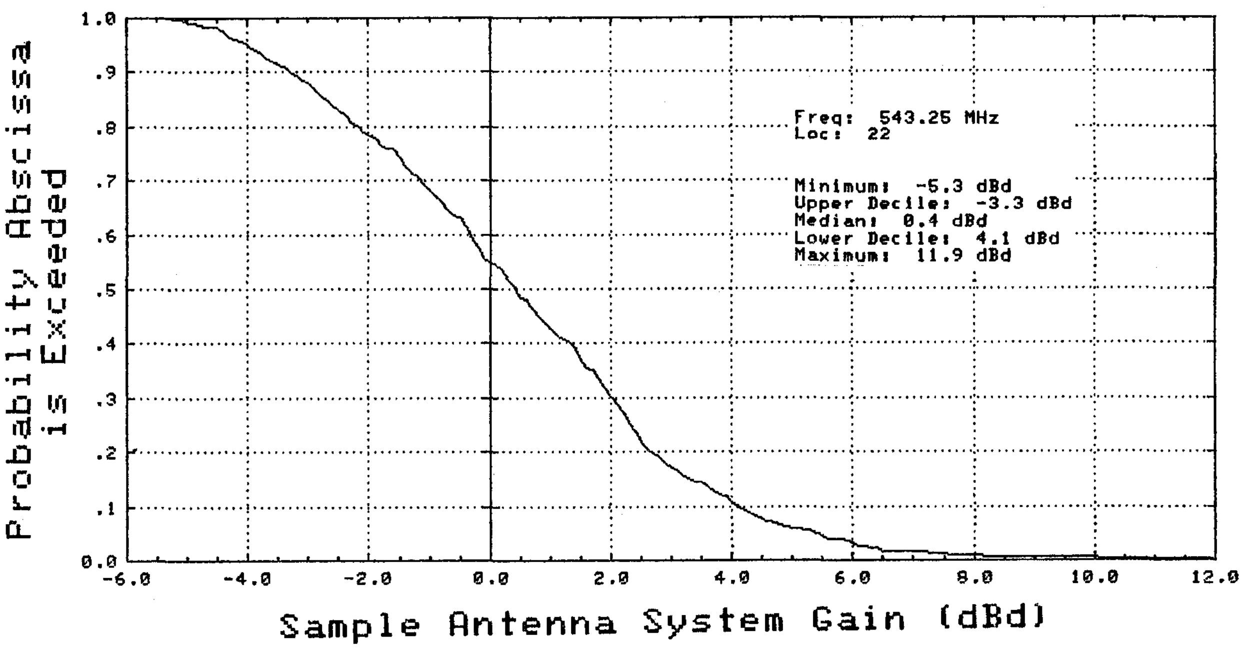


(b)

Figure A-48. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 21 at 651.25 MHz (a) and location 22 at 77.25 MHz (b).

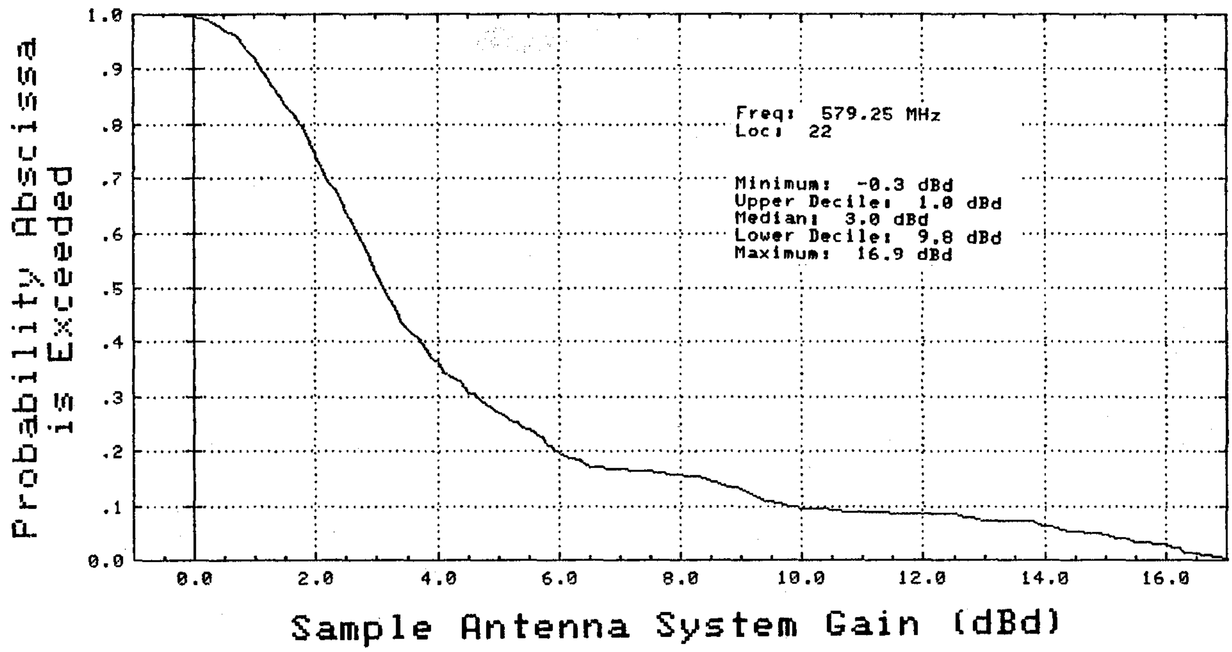


(a)

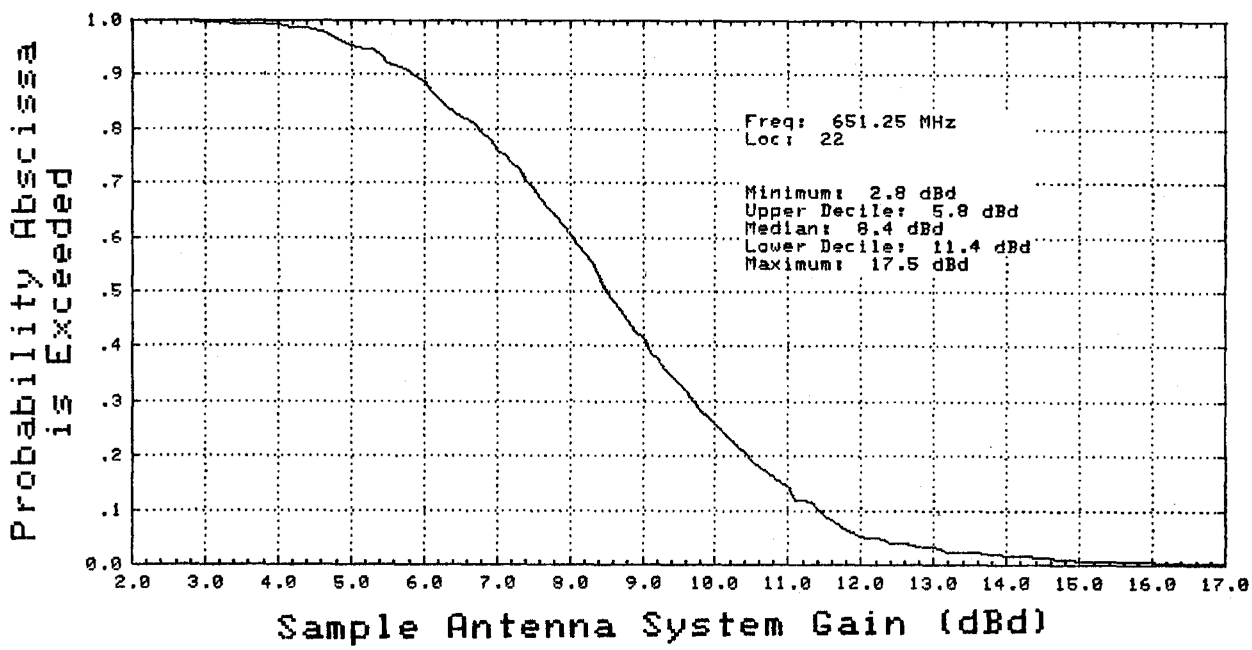


(b)

Figure A-49. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 22 at 187.25 MHz (a) and 543.25 MHz (b).

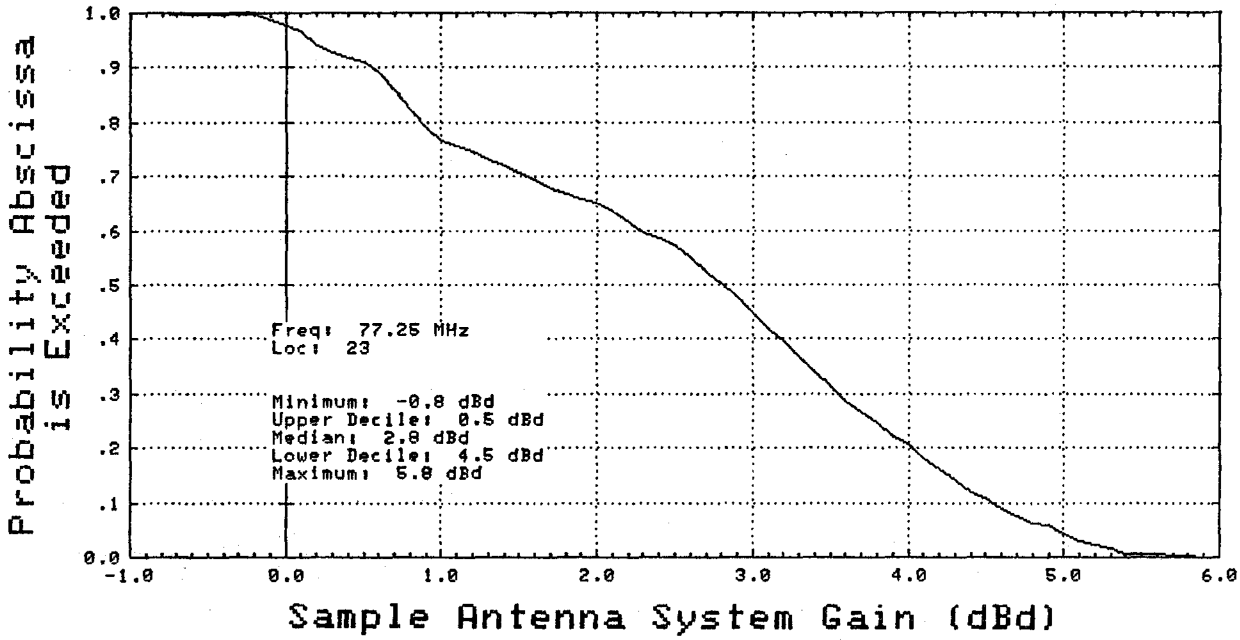


(a)

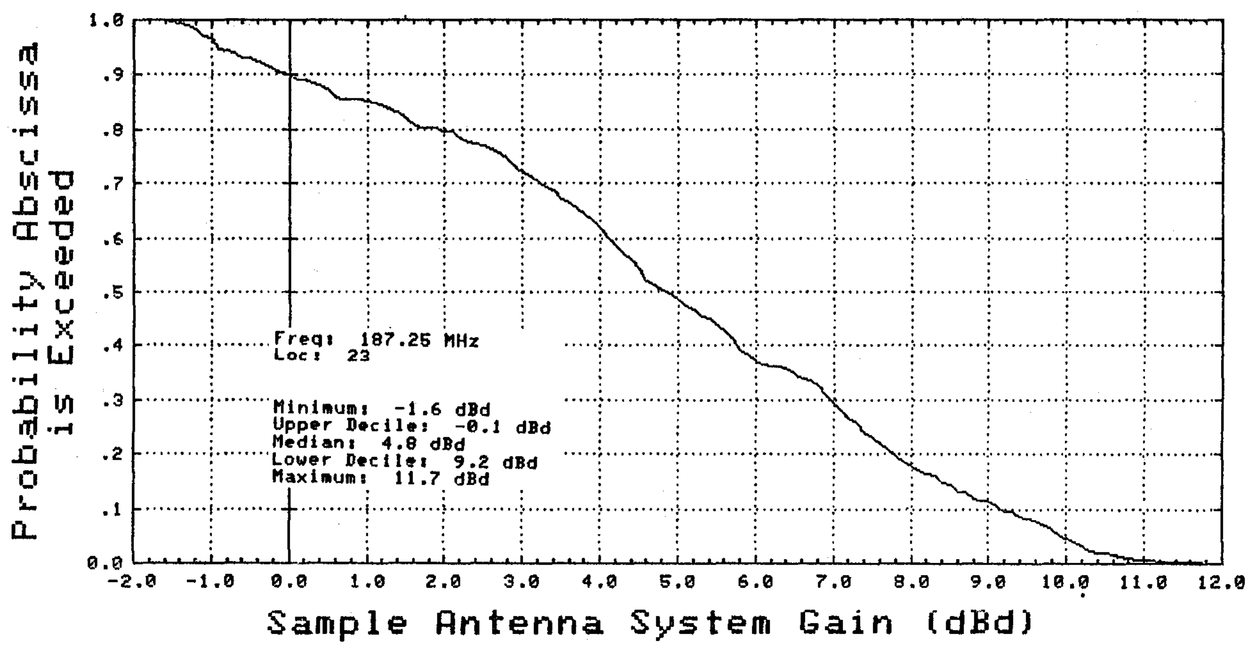


(b)

Figure A-50. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 22 at 579.25 MHz (a) and 651.25 MHz (b).

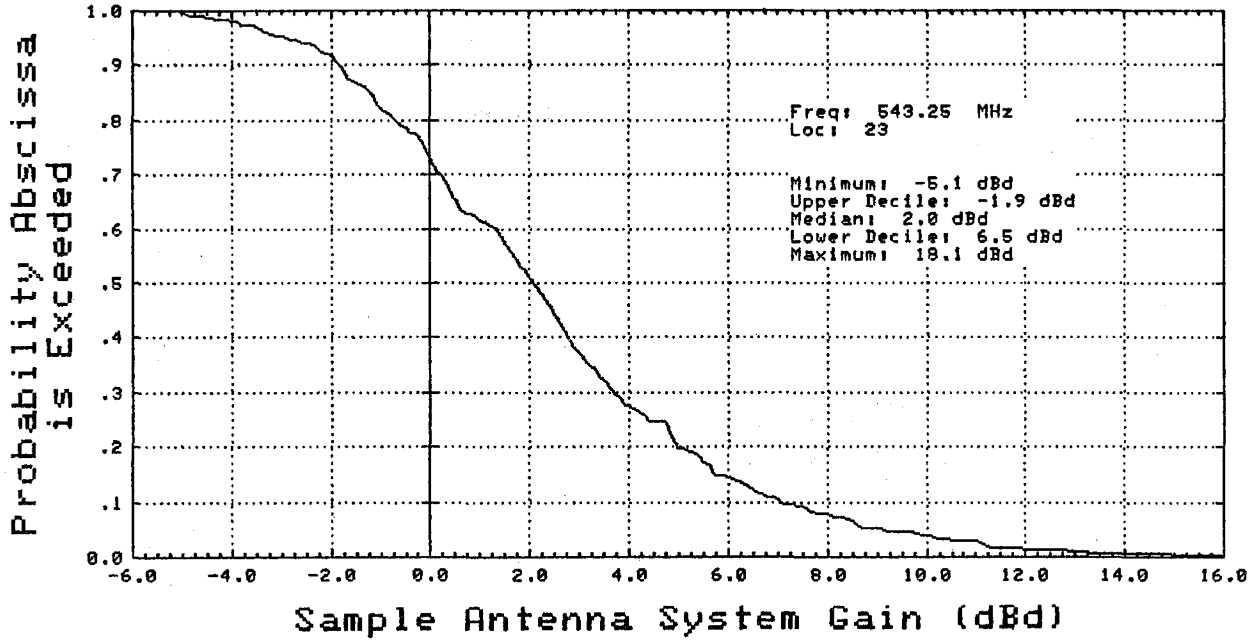


(a)

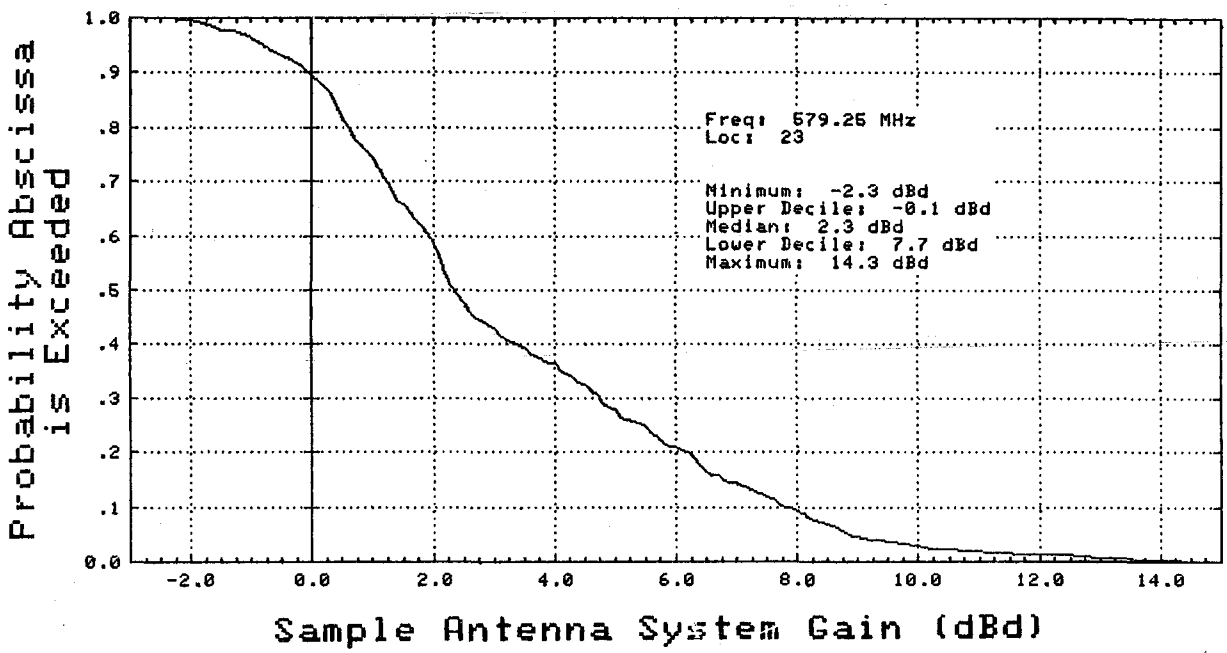


(b)

Figure A-51. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 23 at 77.25 MHz (a) and 187.25 MHz (b).

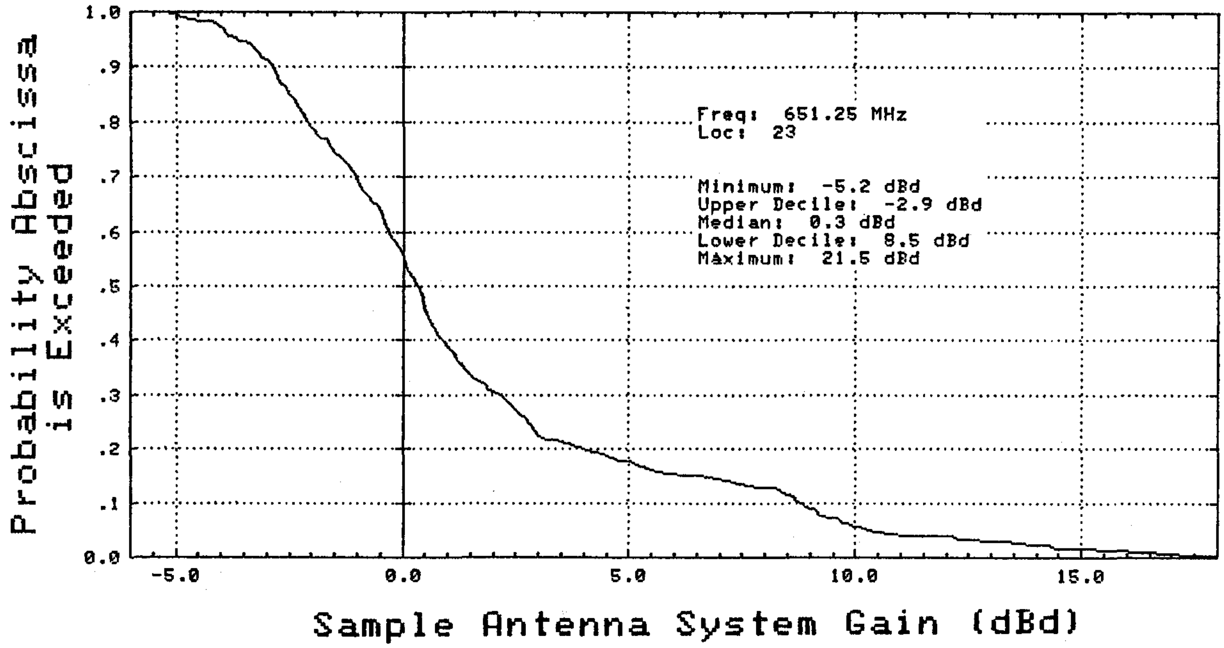


(a)

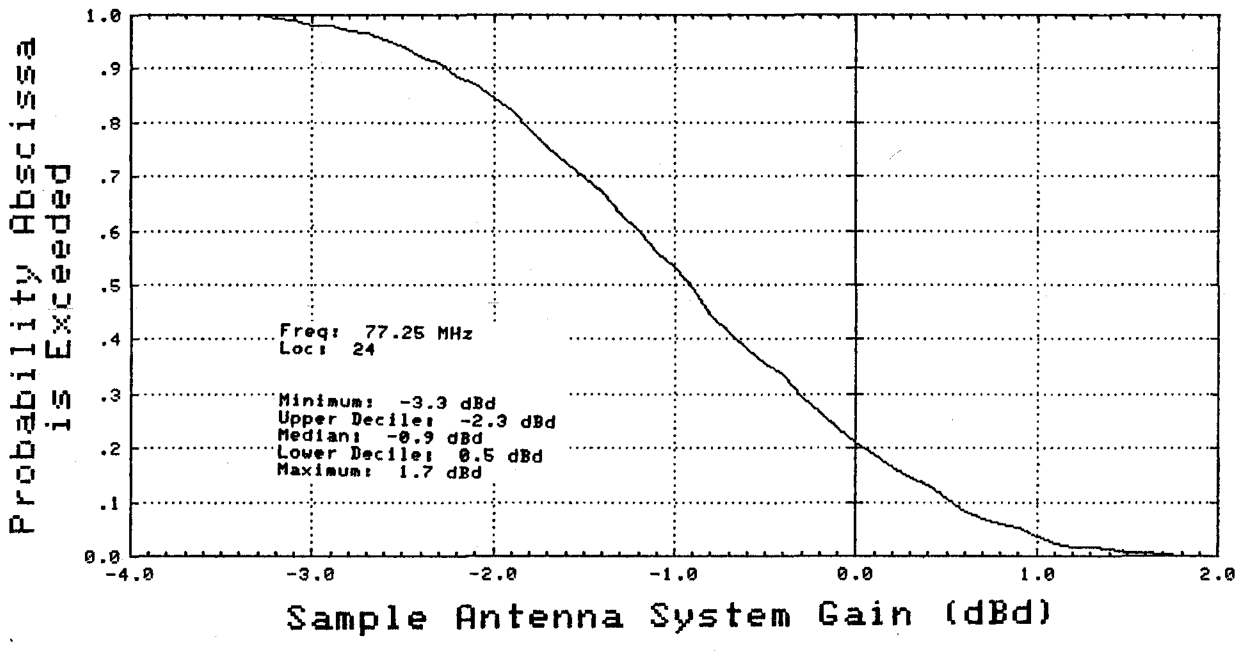


(b)

Figure A-52. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 23 at 543.25 MHz (a) and 579.25 MHz (b).

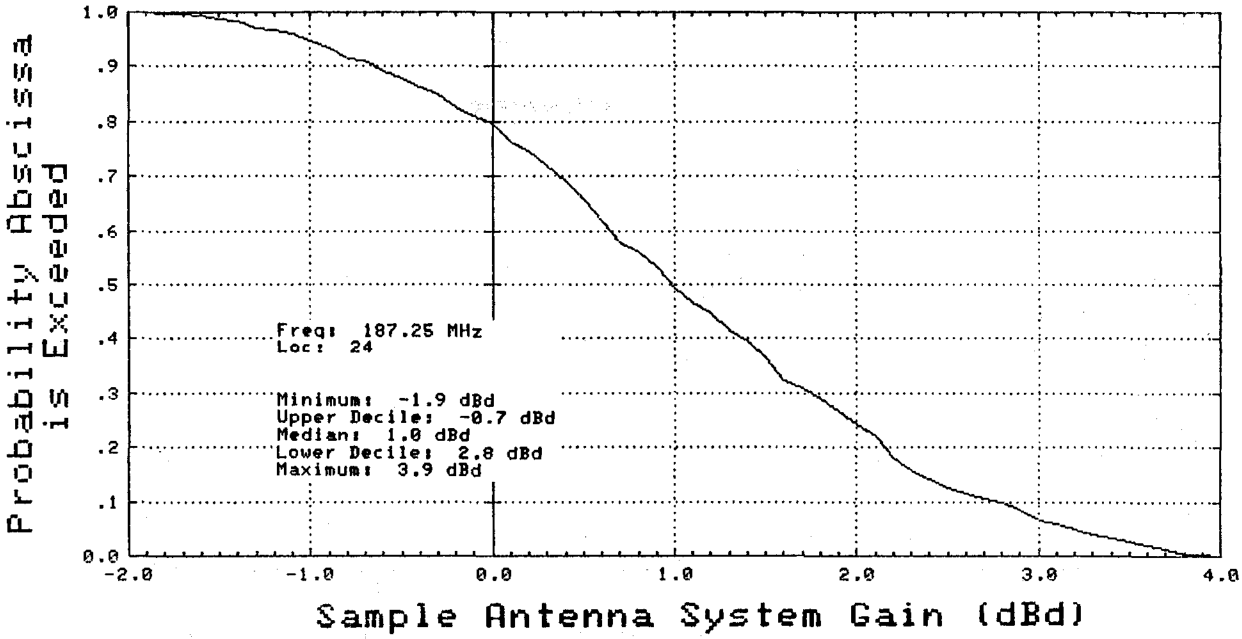


(a)

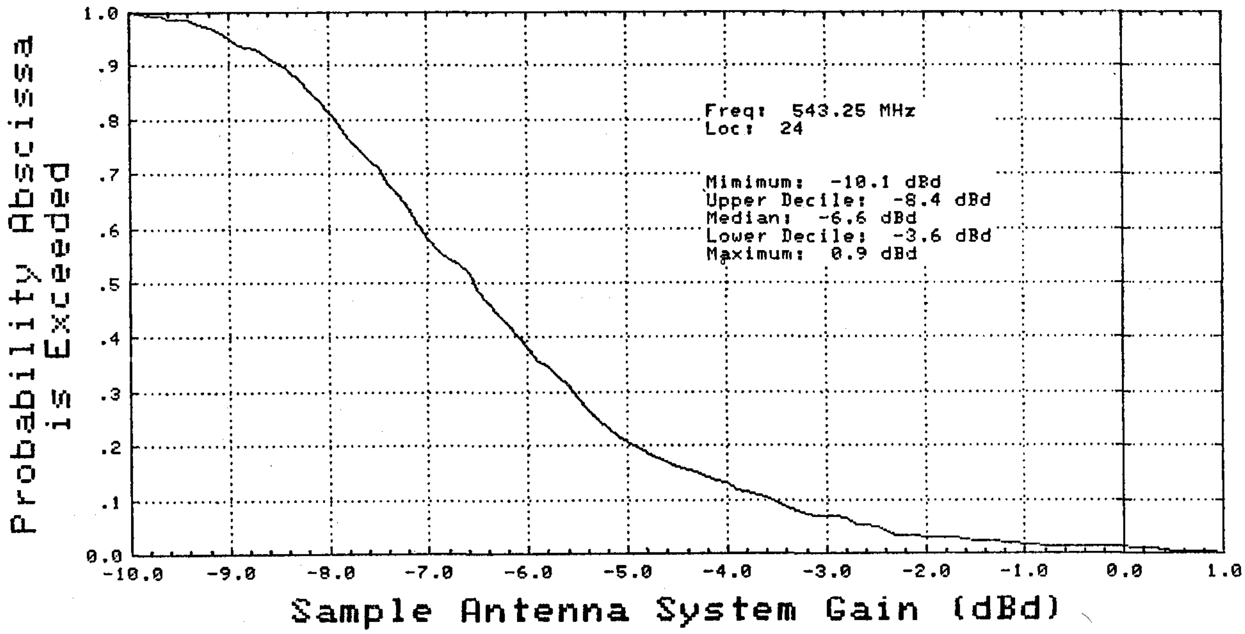


(b)

Figure A-53. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 23 at 651.25 MHz (a) and location 24 at 77.25 MHz.

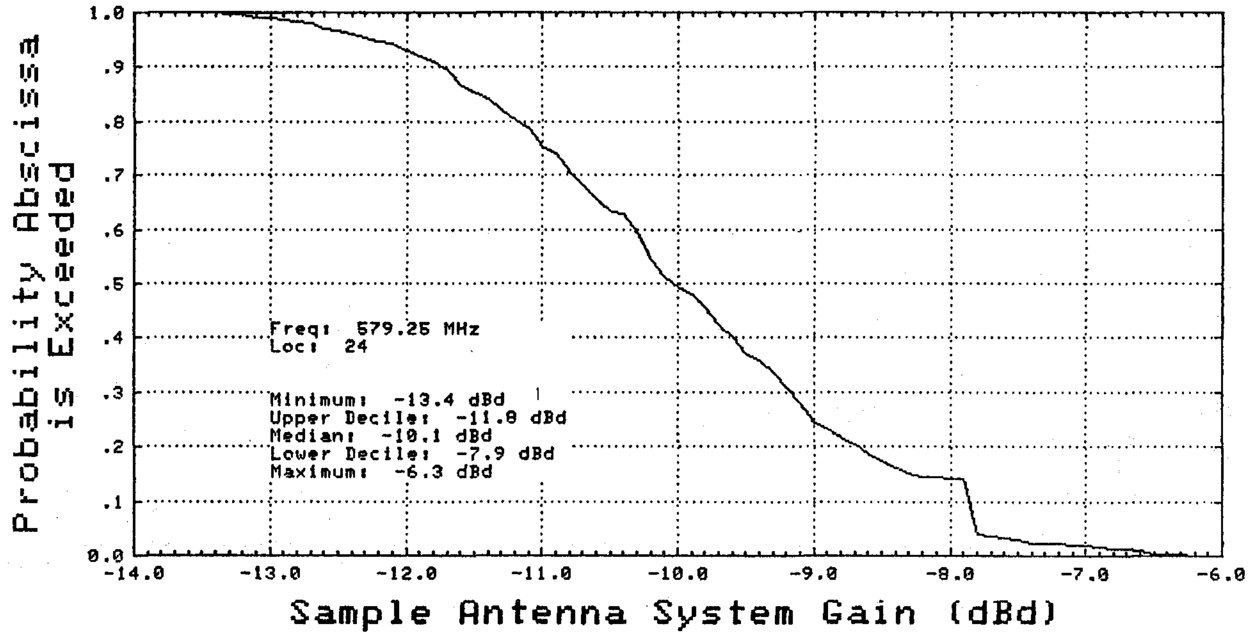


(a)

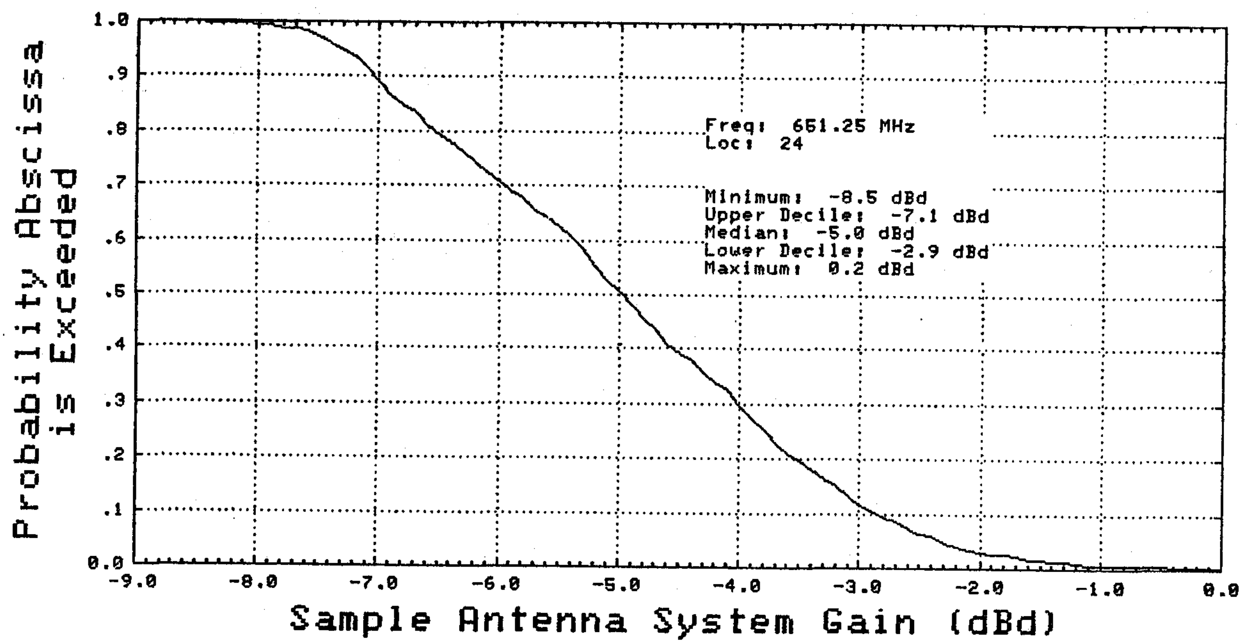


(b)

Figure A-54. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 24 at 187.25 MHz (a) and 543.25 MHz (b).

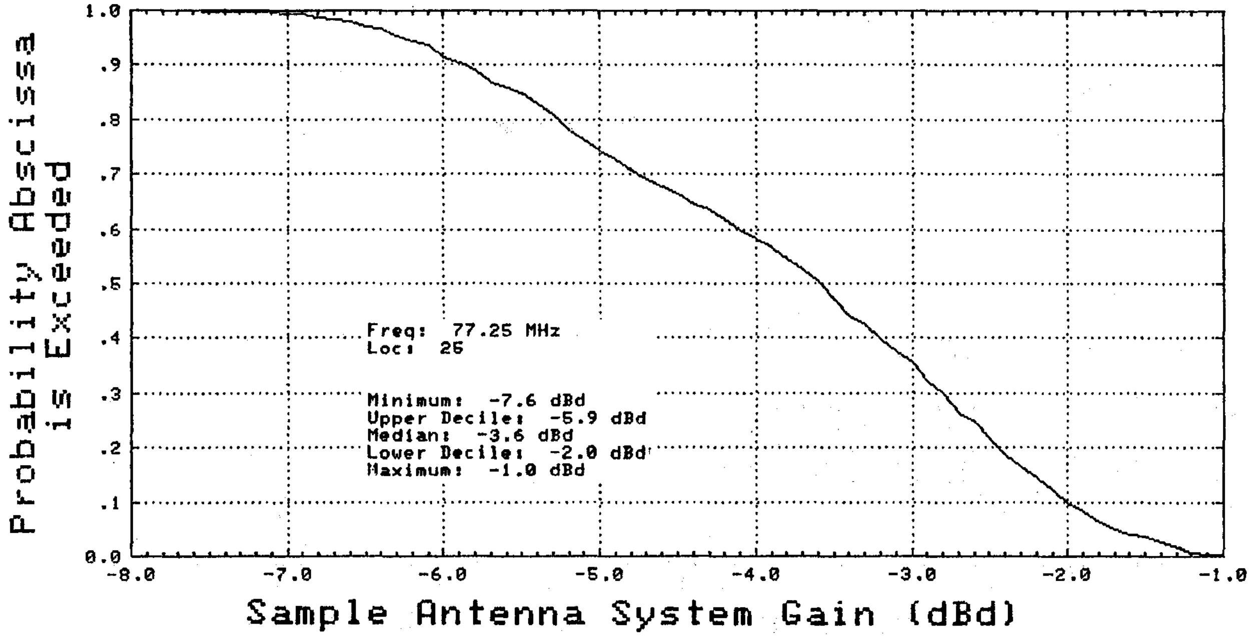


(a)

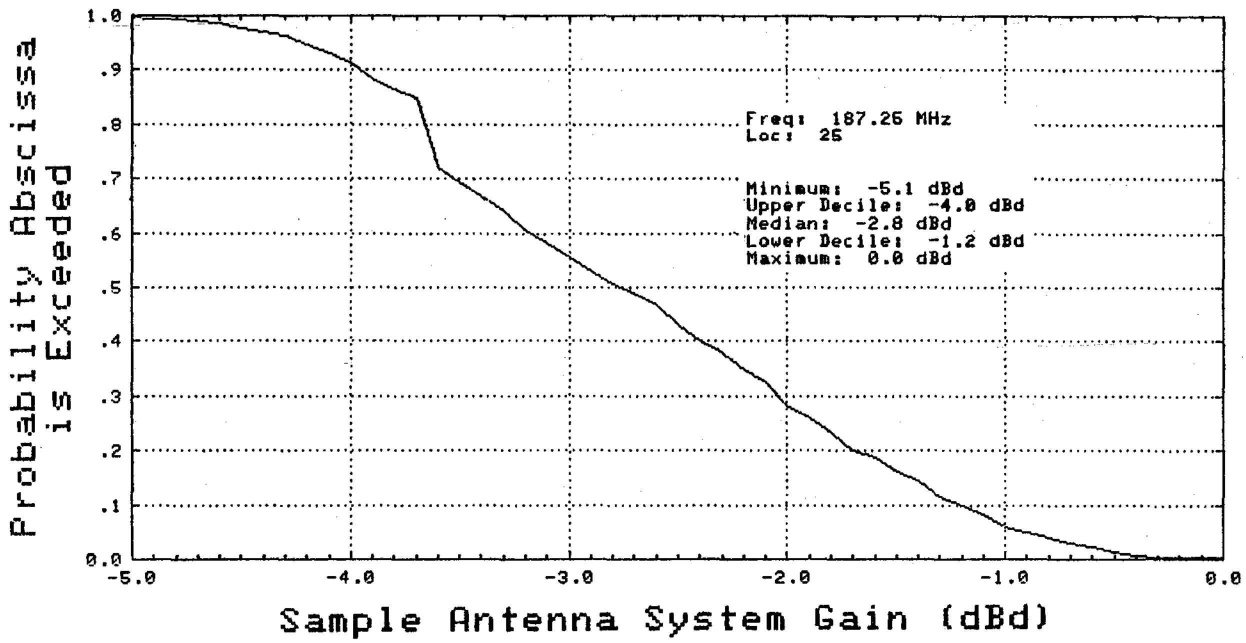


(b)

Figure A-55. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 24 at 579.25 MHz (a) and 651.25 MHz (b).

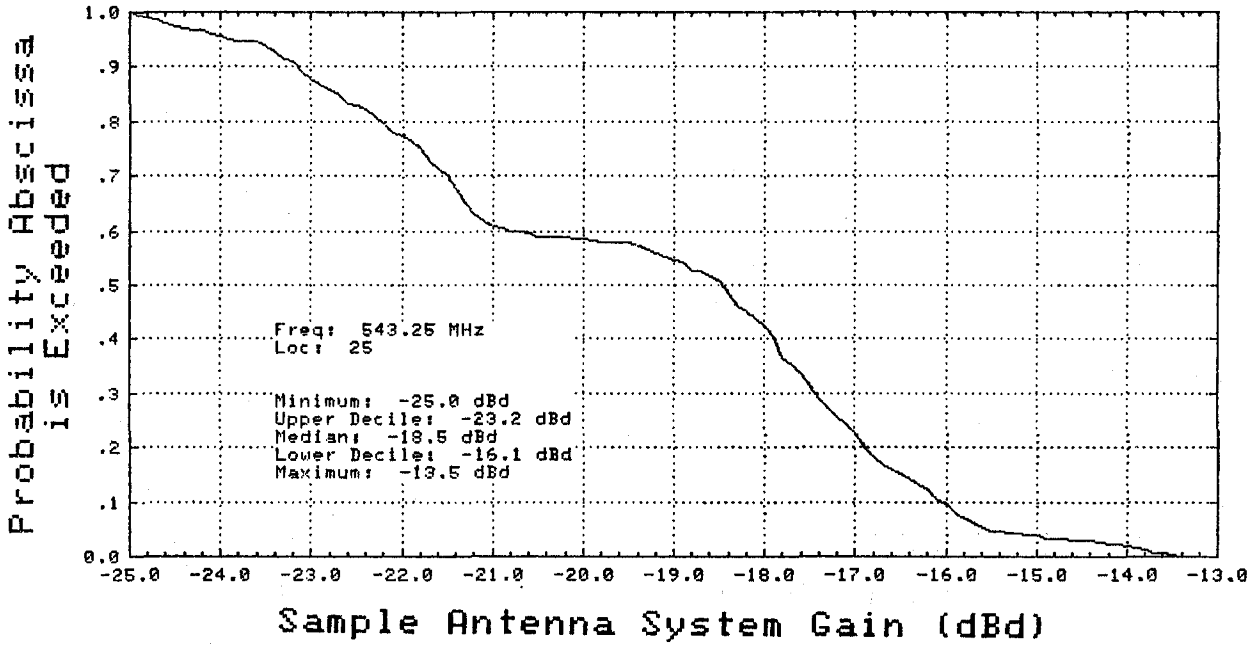


(a)

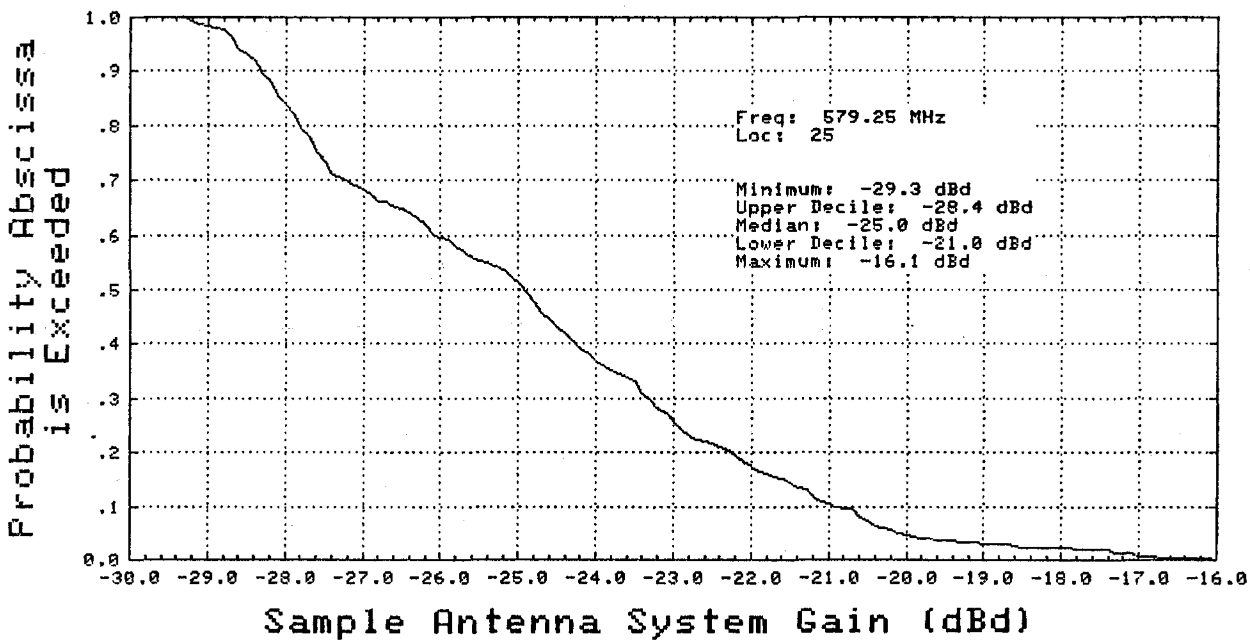


(b)

Figure A-56. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 25 at 77.25 MHz (a) and 187.25 MHz (b).

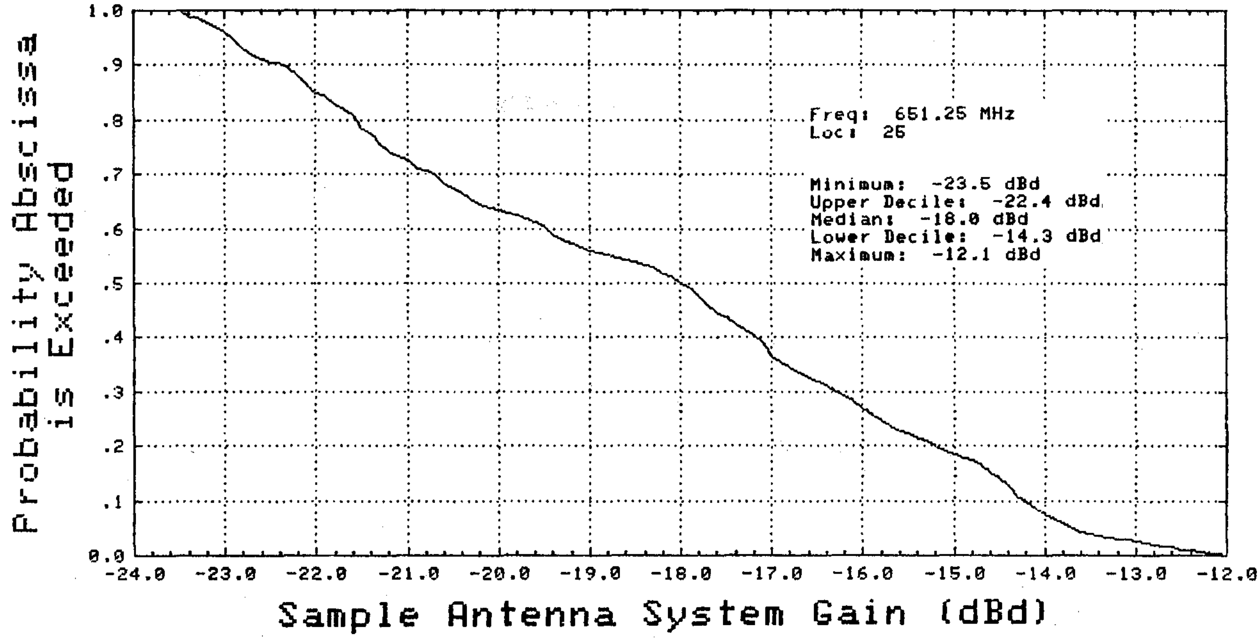


(a)

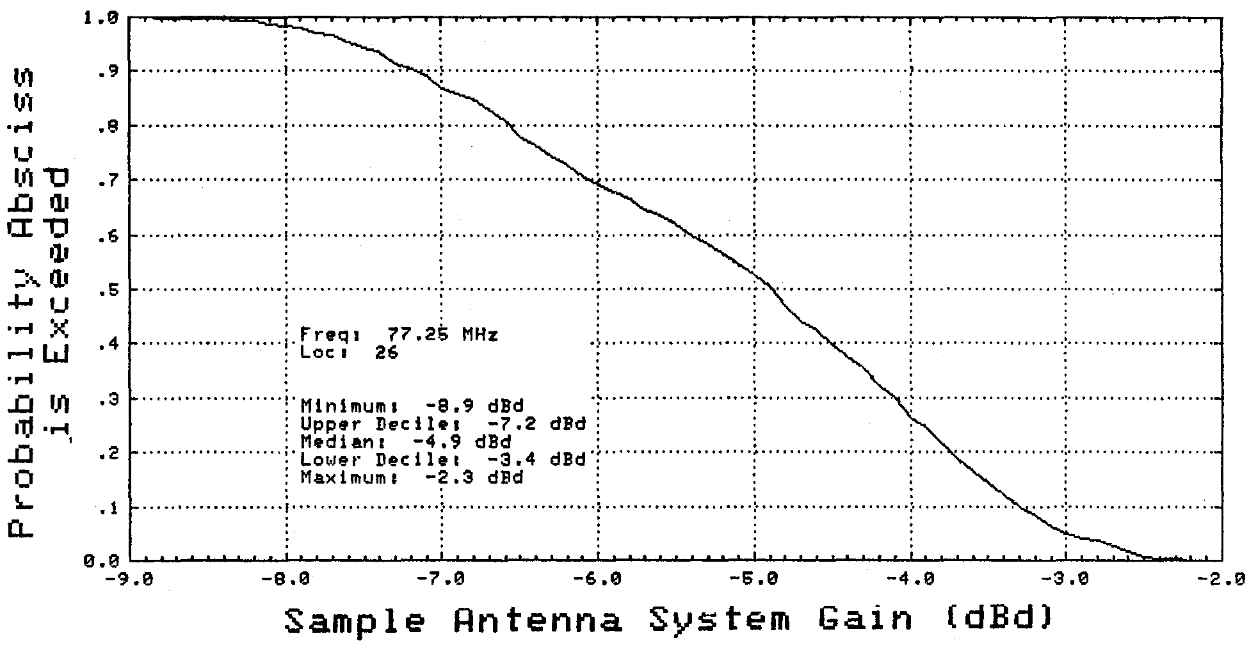


(b)

Figure A-57. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 25 at 543.25 MHz (a) and 579.25 MHz (b).

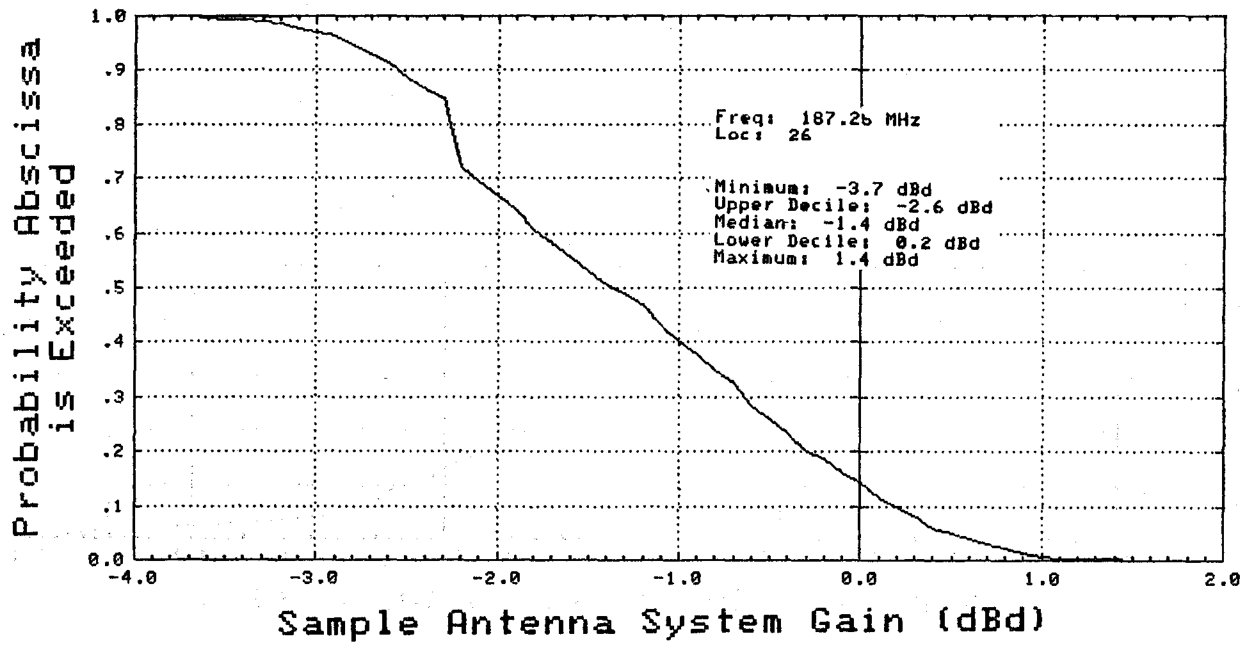


(a)

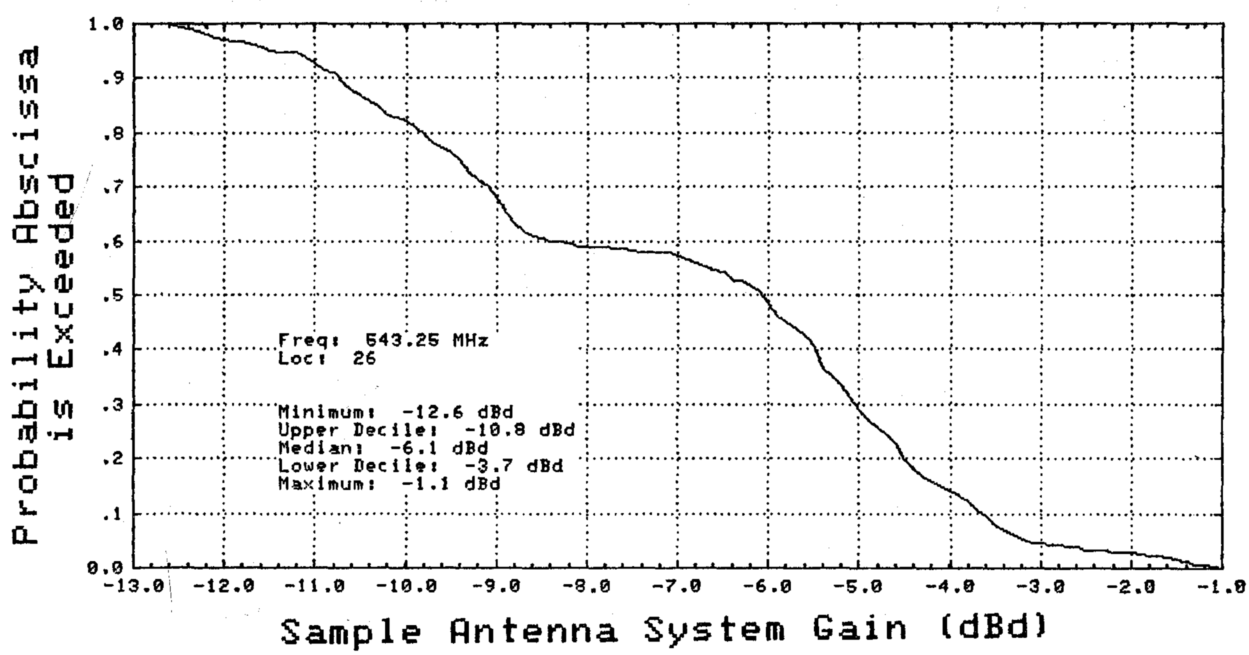


(b)

Figure A-58. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 25 at 651.25 MHz (a) and location 26 at 77.25 MHz (b).

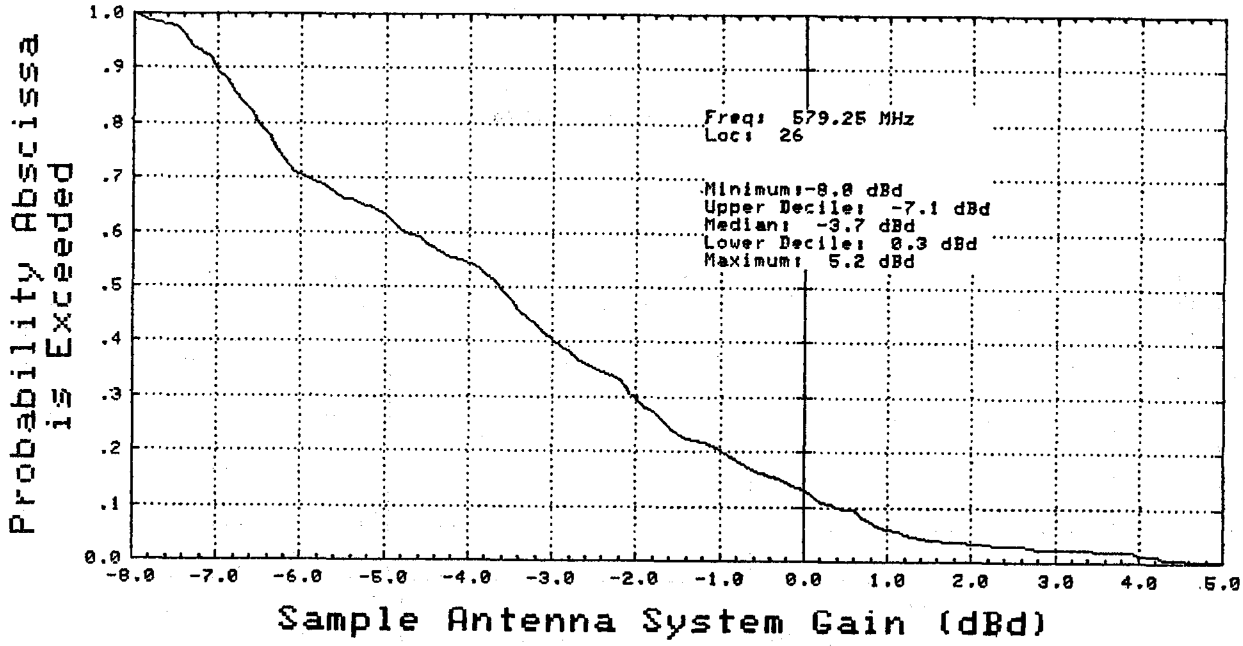


(a)

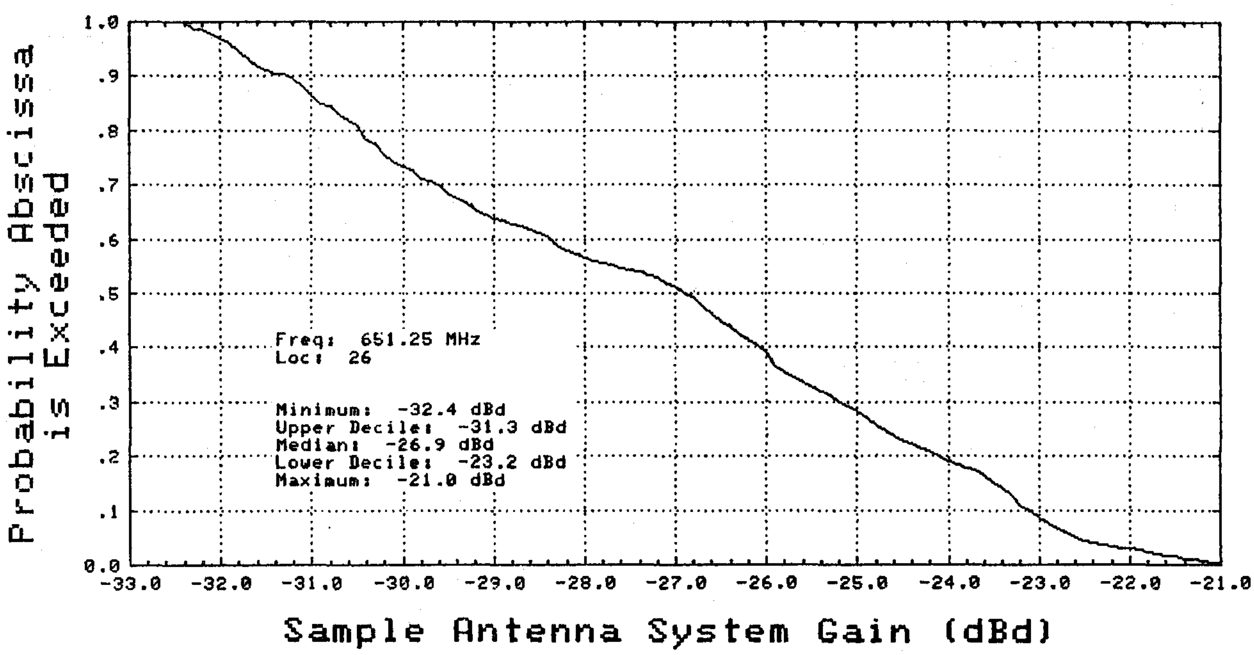


(b)

Figure A-59. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 26 at 187.25 MHz (a) and 543.25 MHz (b).

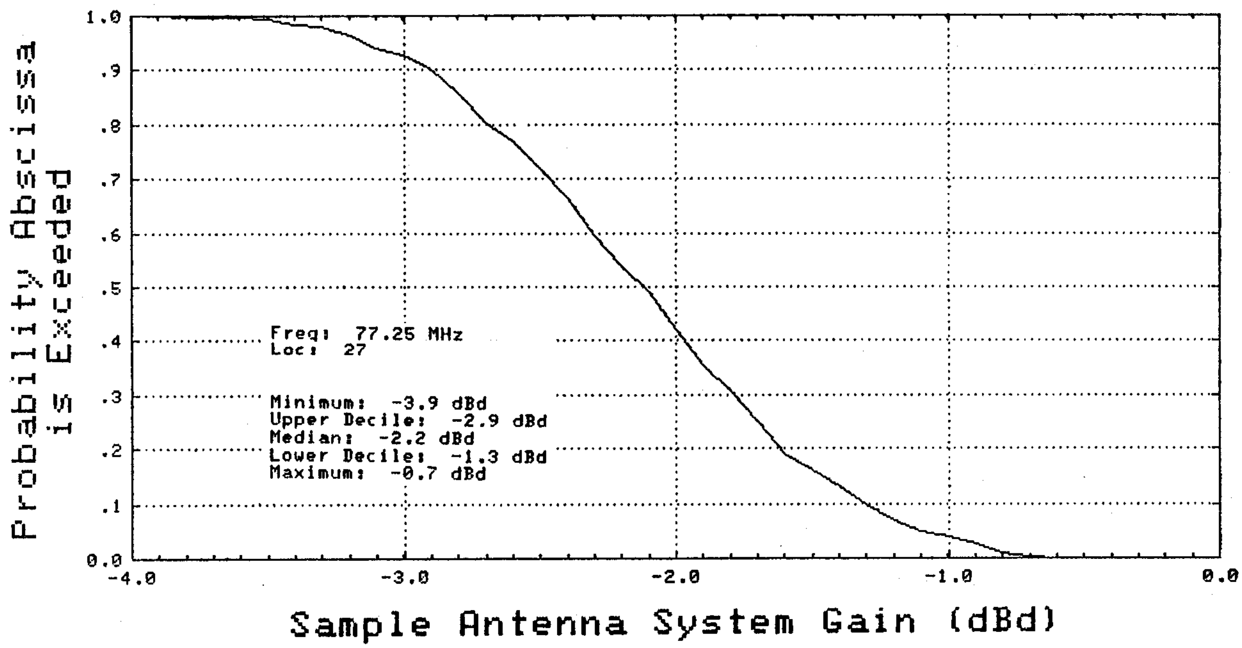


(a)

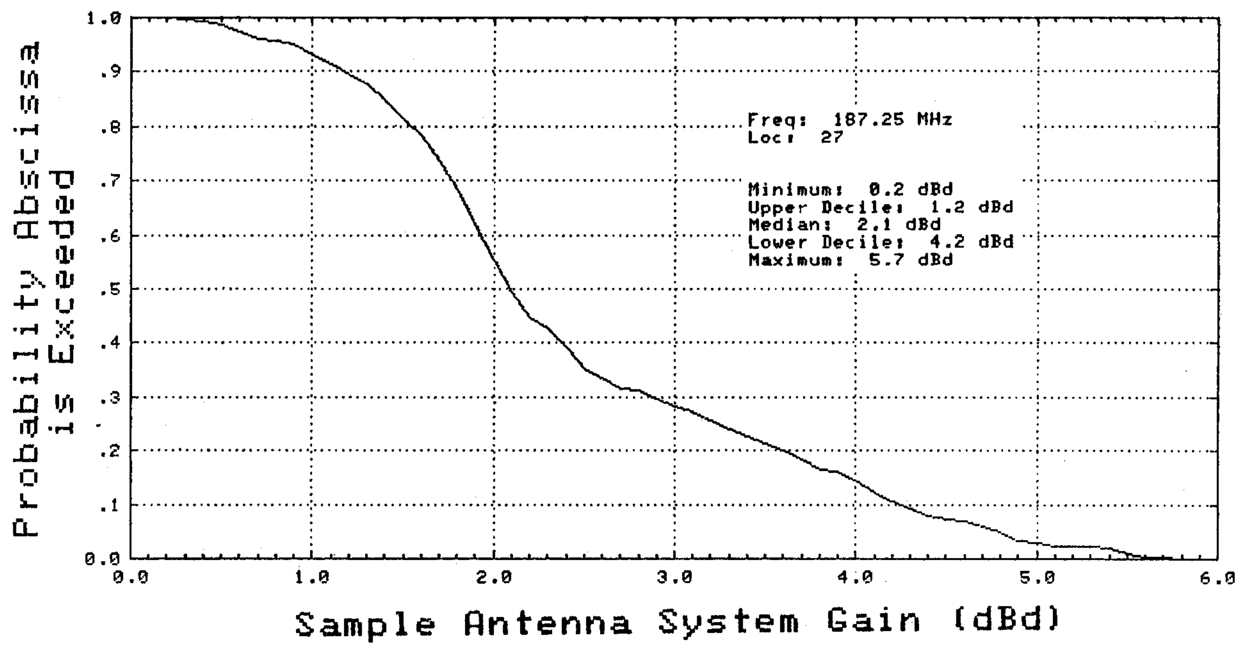


(b)

Figure A-60. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 26 at 579.25 MHz (a) and 651.25 MHz (b).

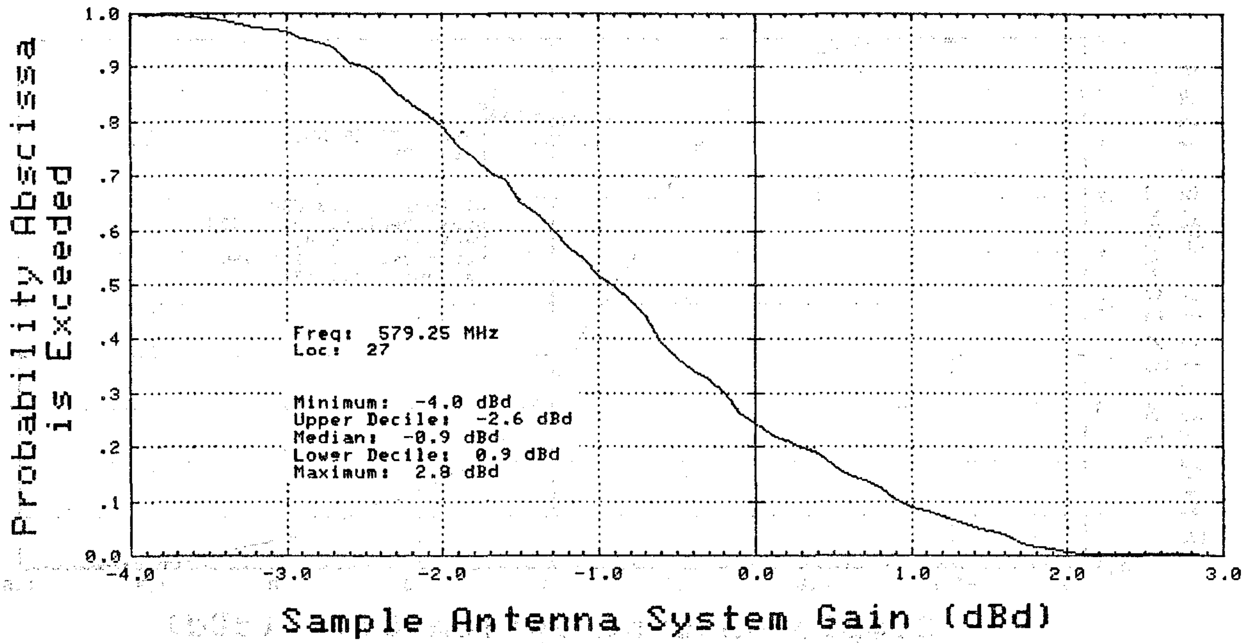


(a)

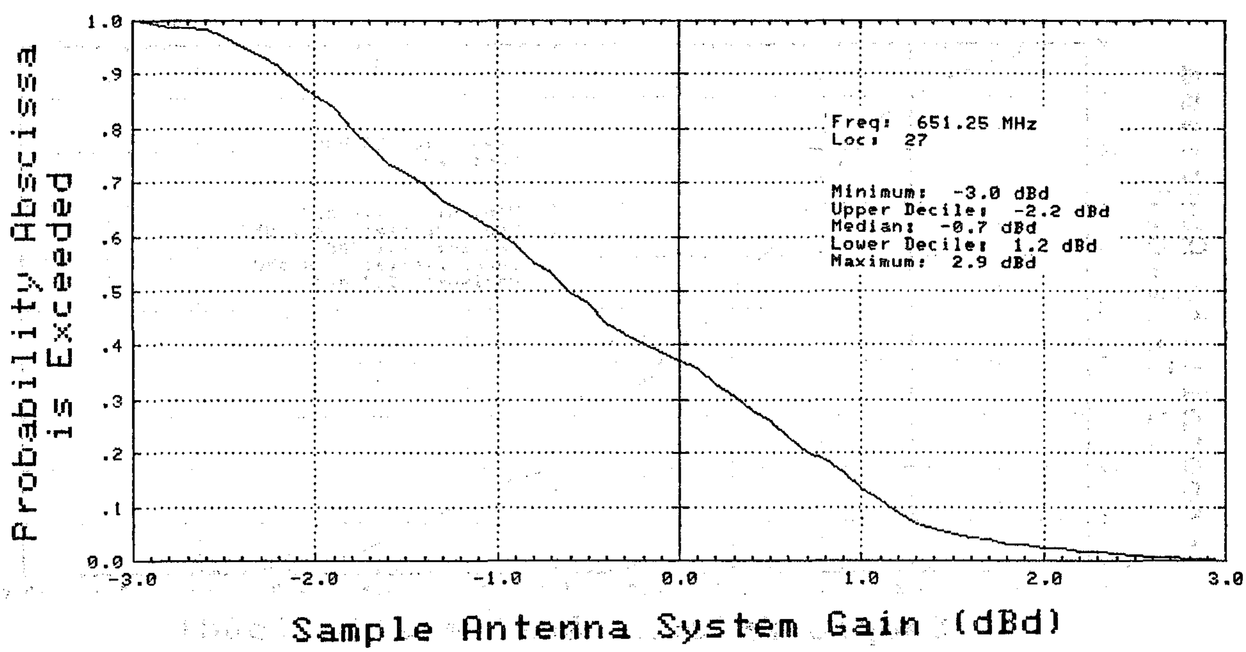


(b)

Figure A-61. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 27 at 77.25 MHz (a) and 187.25 MHz (b).

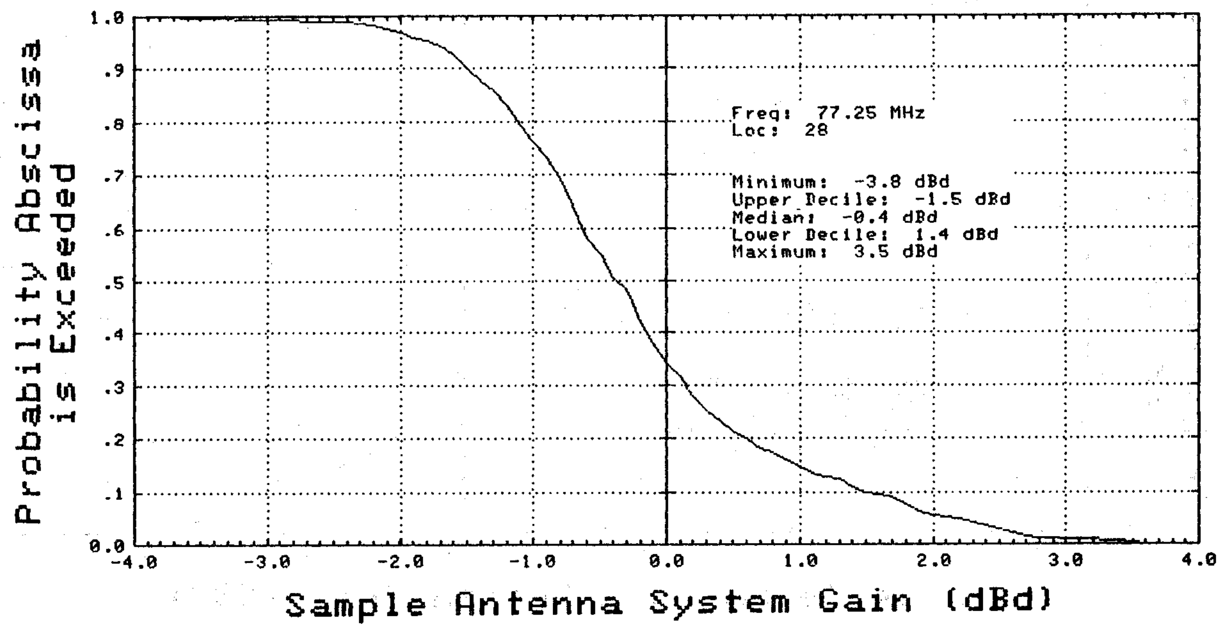


(a)

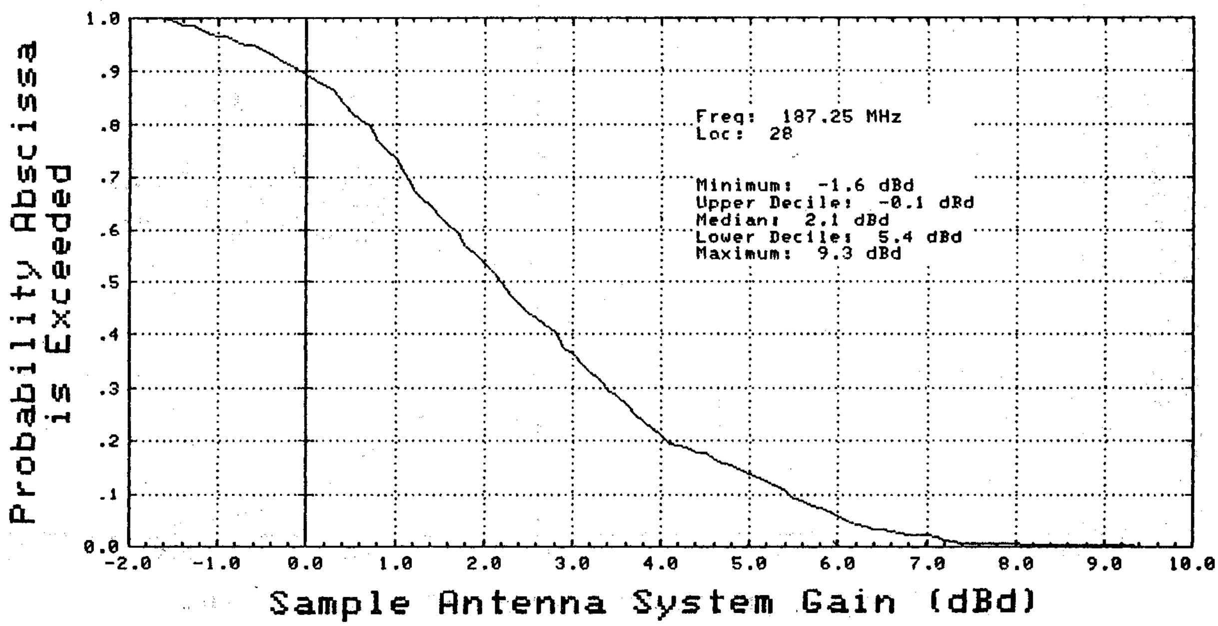


(b)

Figure A-62. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 27 at 579.25 MHz (a) and 651.25 MHz (b).

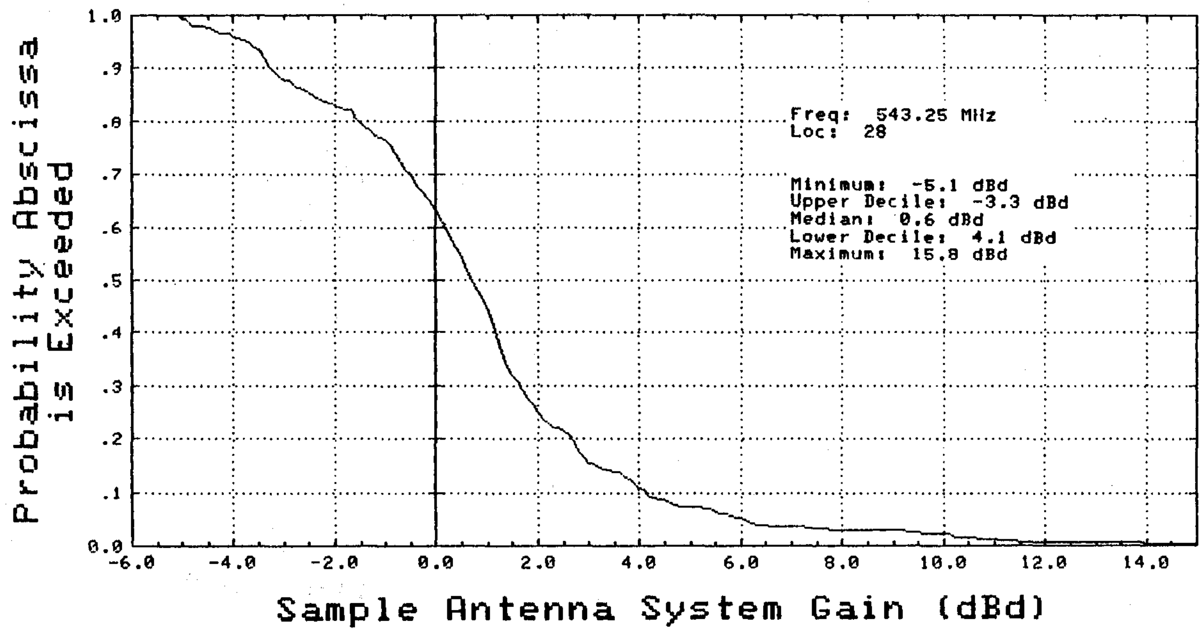


(a)

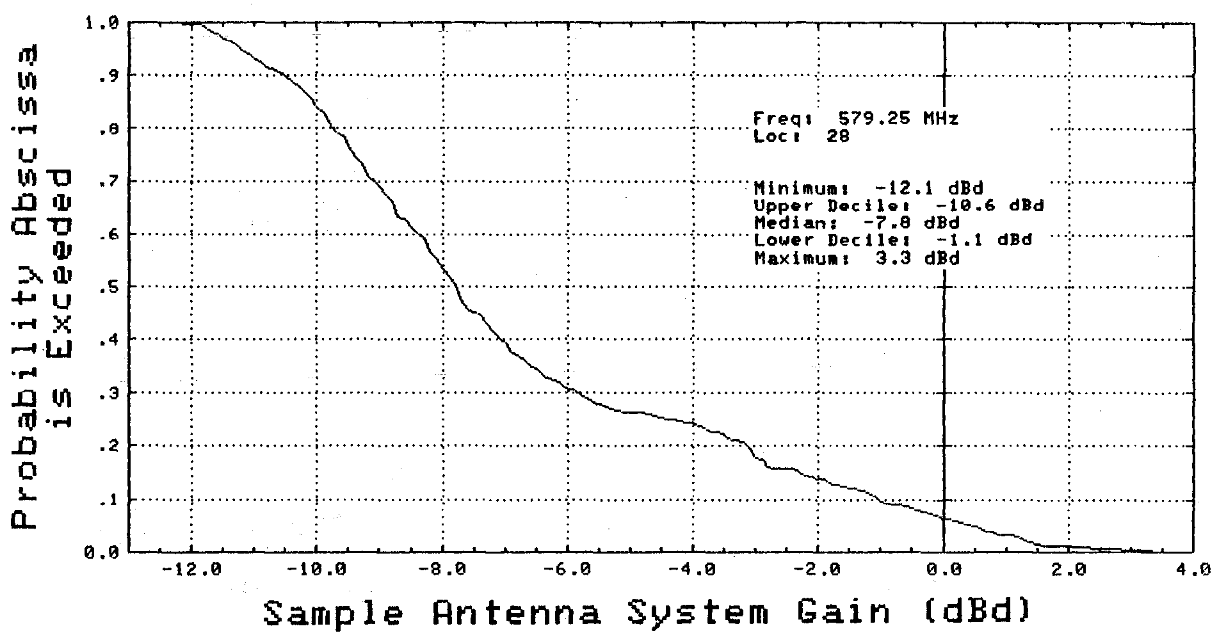


(b)

Figure A-63. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 28 at 77.25 MHz (a) and 187.25 MHz (b).

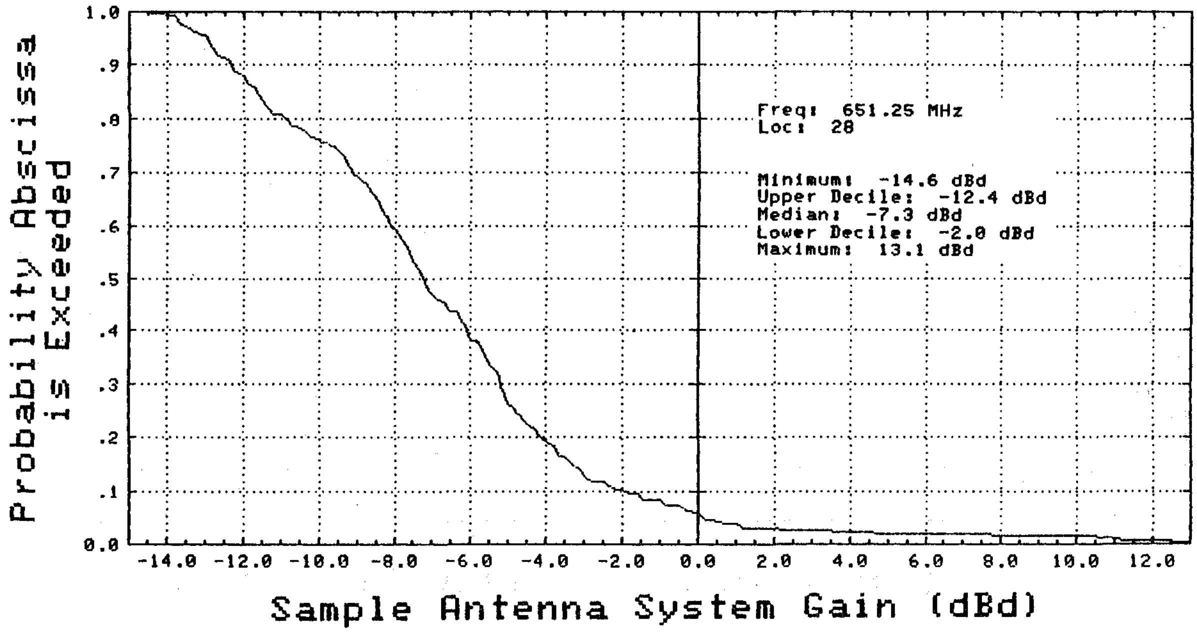


(a)

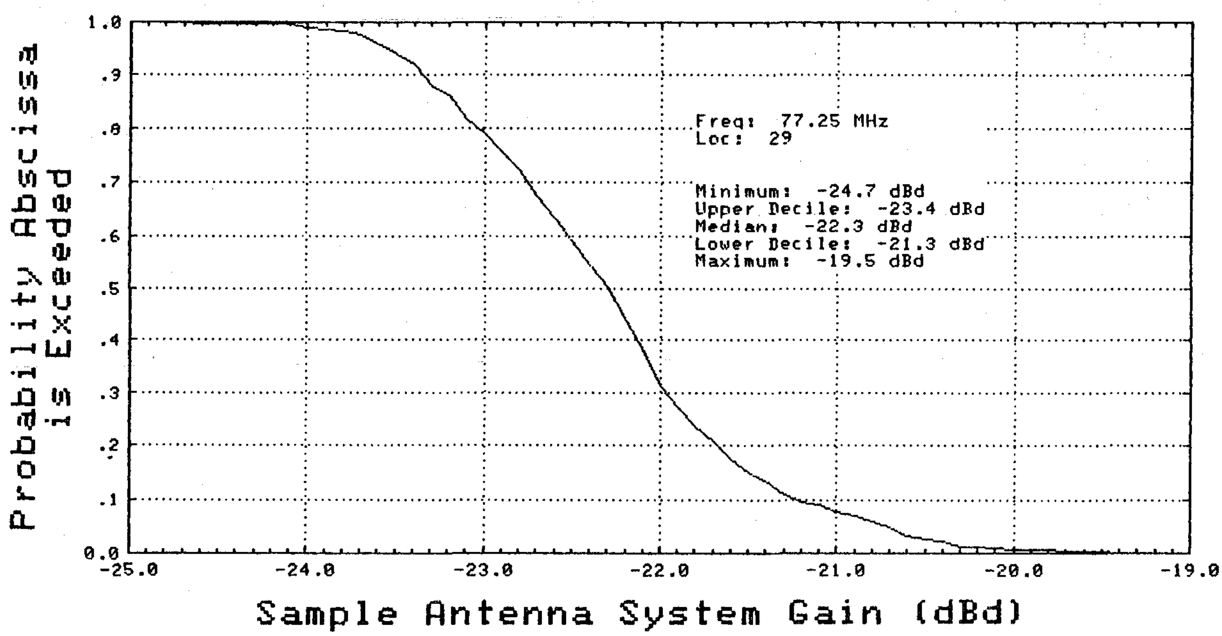


(b)

Figure A-64. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 28 at 543.25 MHz (a) and 579.25 MHz (b).

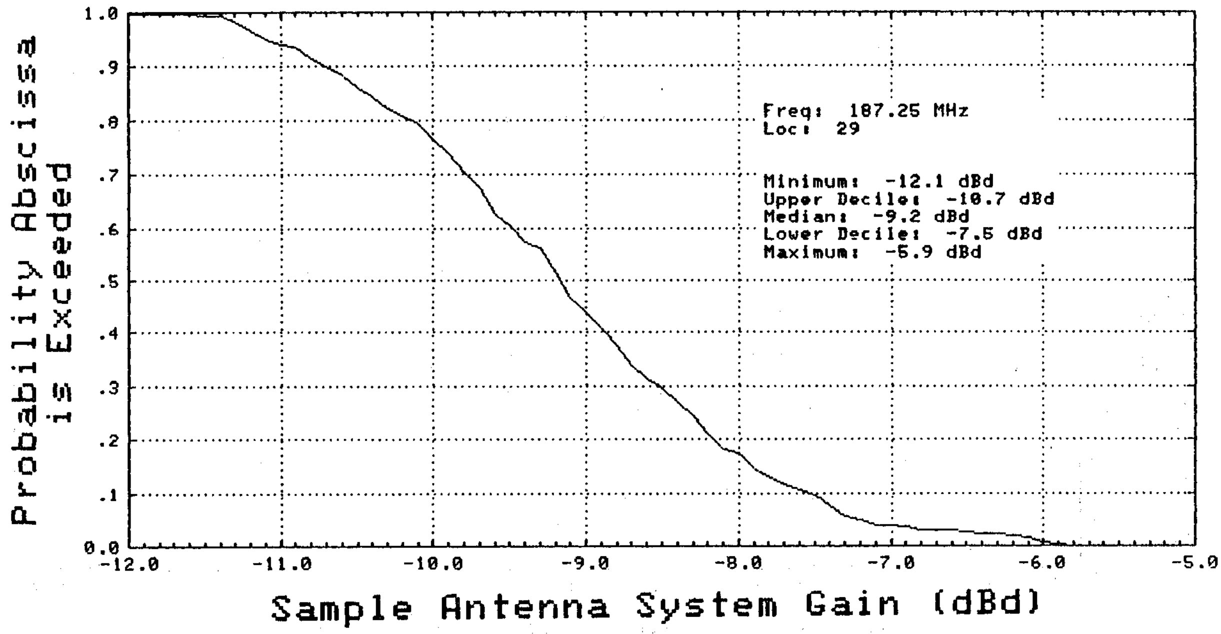


(a)

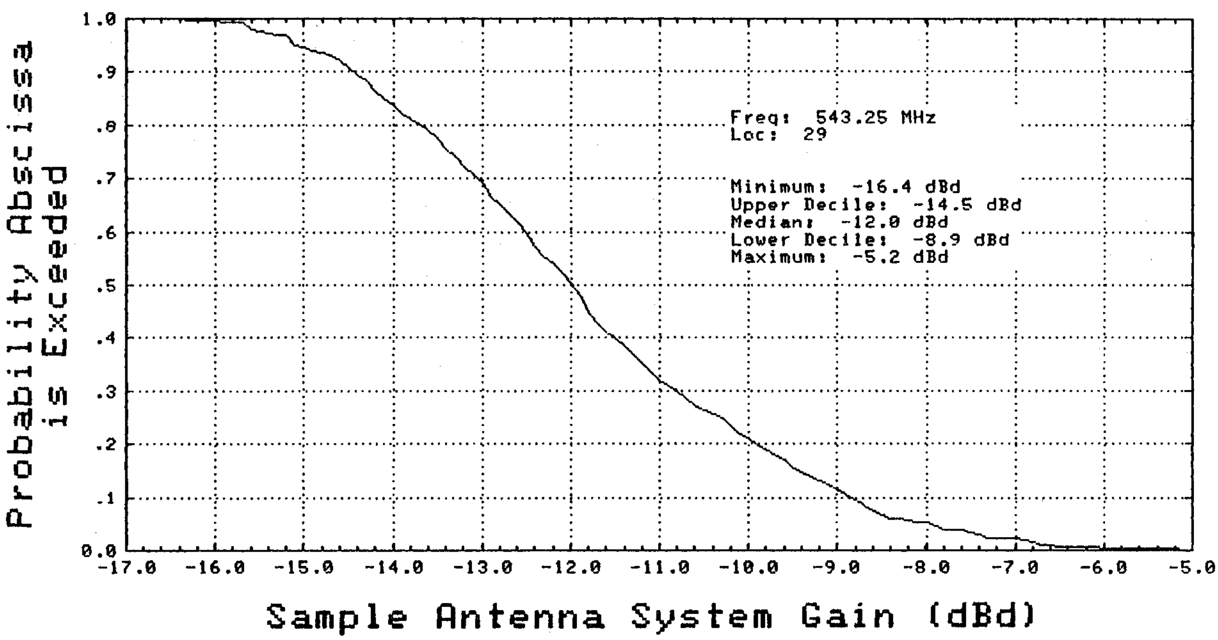


(b)

Figure A-65. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 28 at 651.25 MHz (a) and location 29 at 77.25 MHz (b).

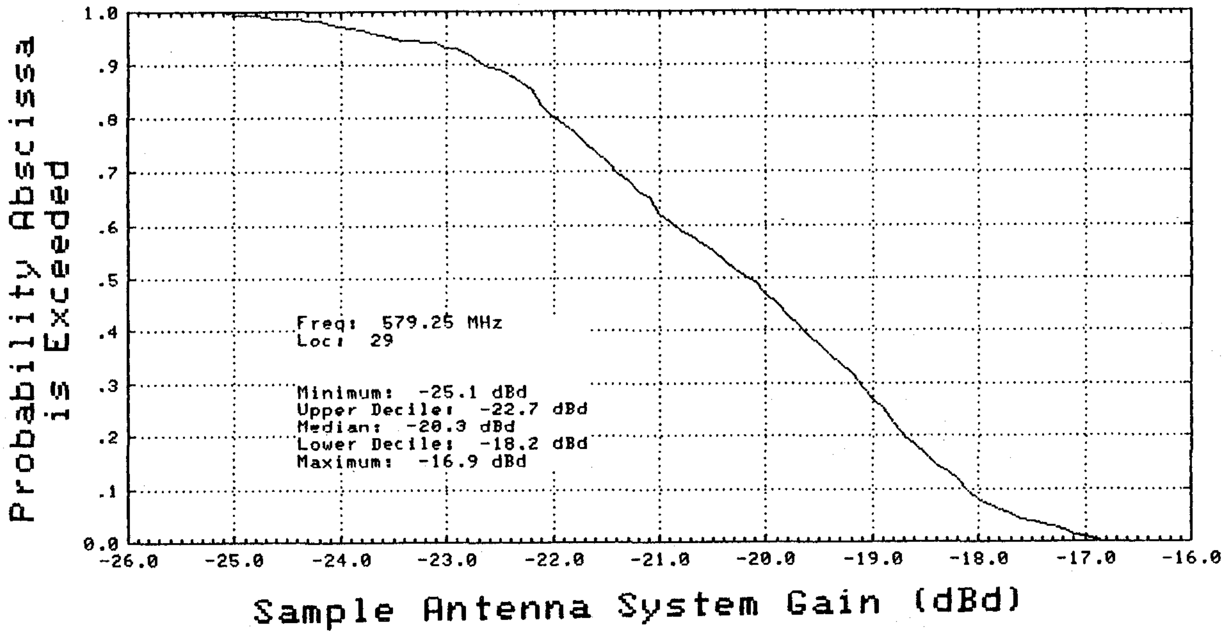


(a)

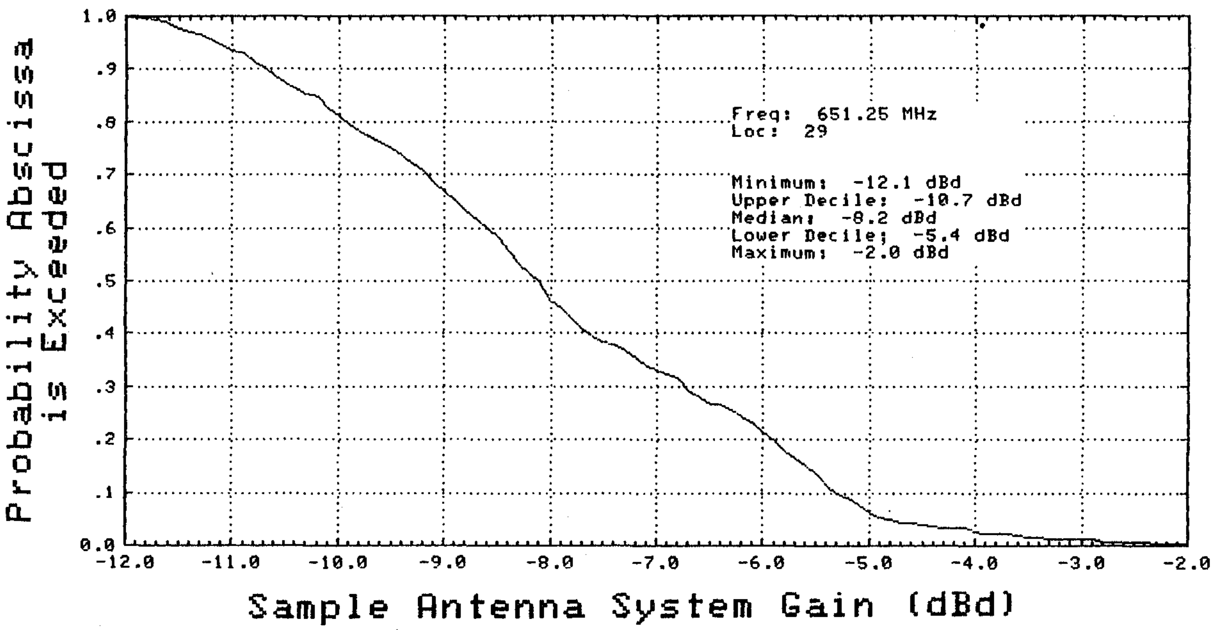


(b)

Figure A-66. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 29 at 187.25 MHz (a) and 543.25 MHz (b).

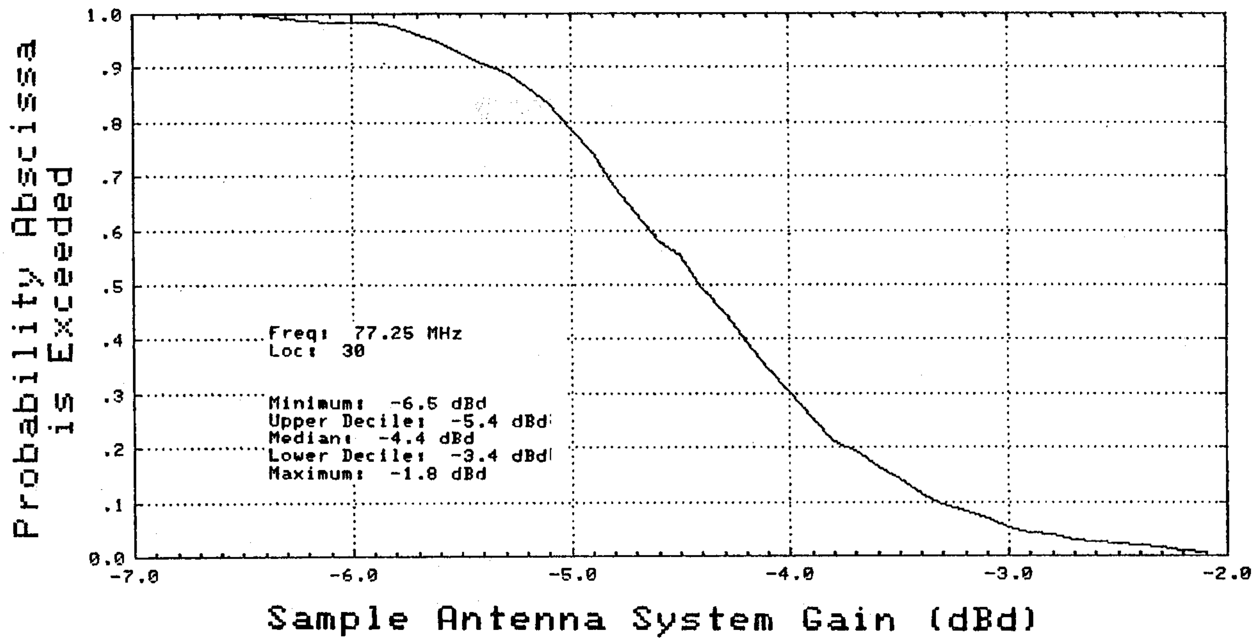


(a)

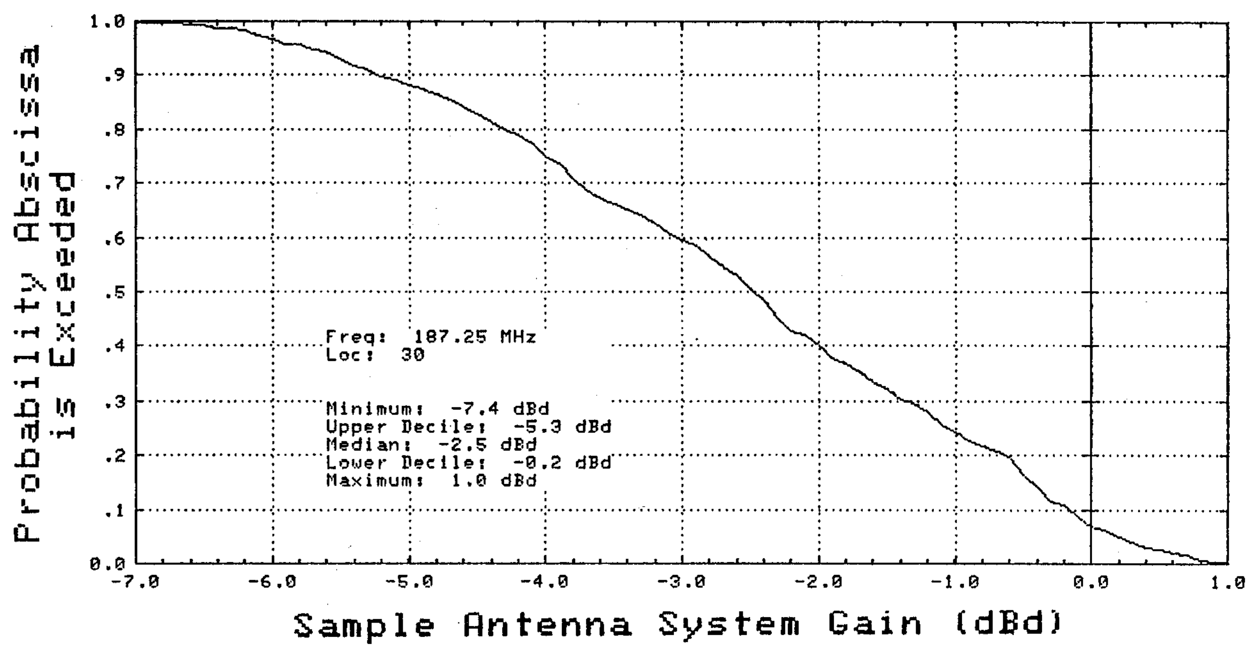


(b)

Figure A-67. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 29 at 579.25 MHz (a) and 651.25 MHz (b).

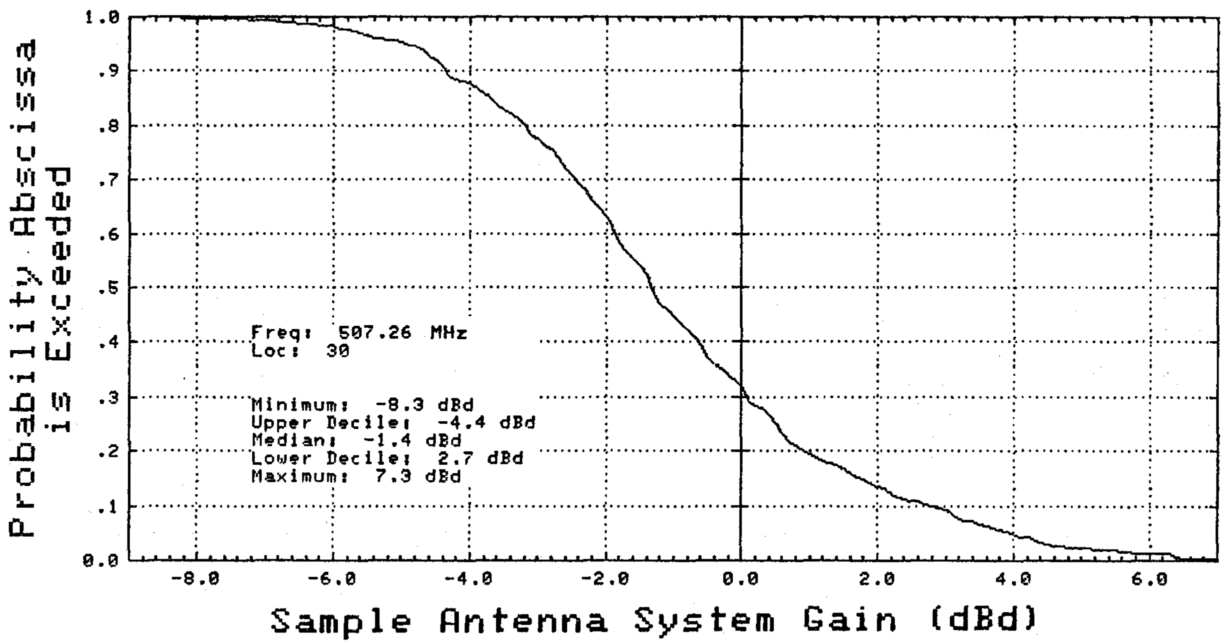


(a)

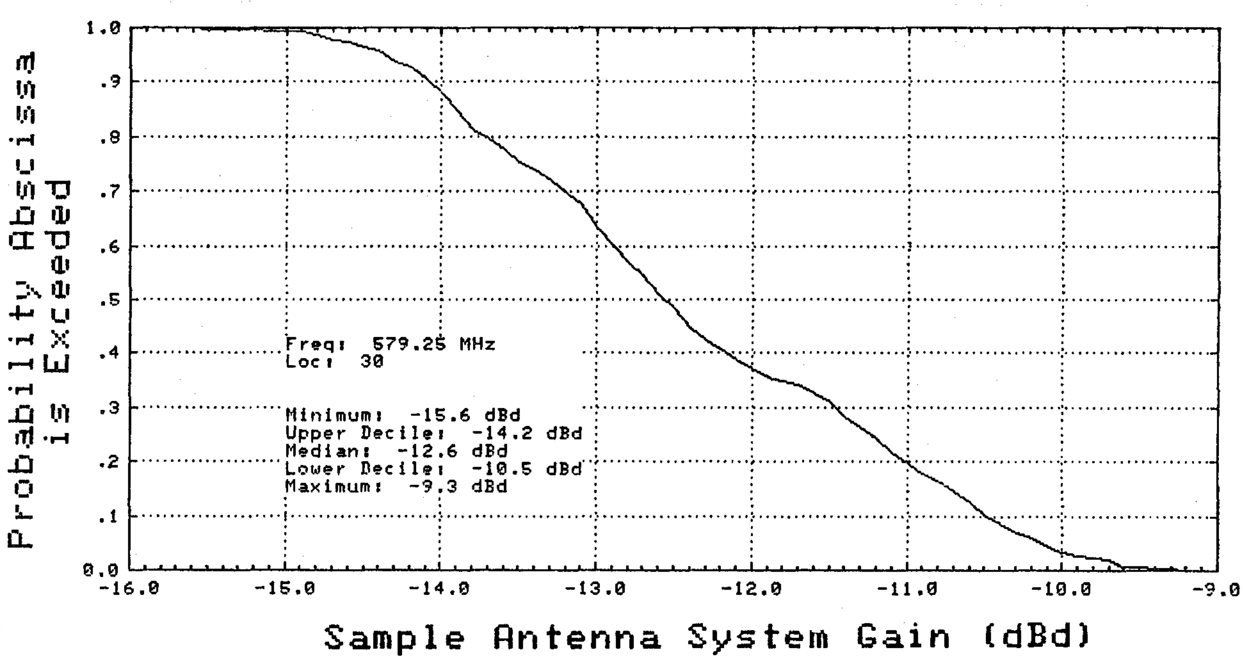


(b)

Figure A-68. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 30 at 77.25 MHz (a) and 187.25 MHz (b).

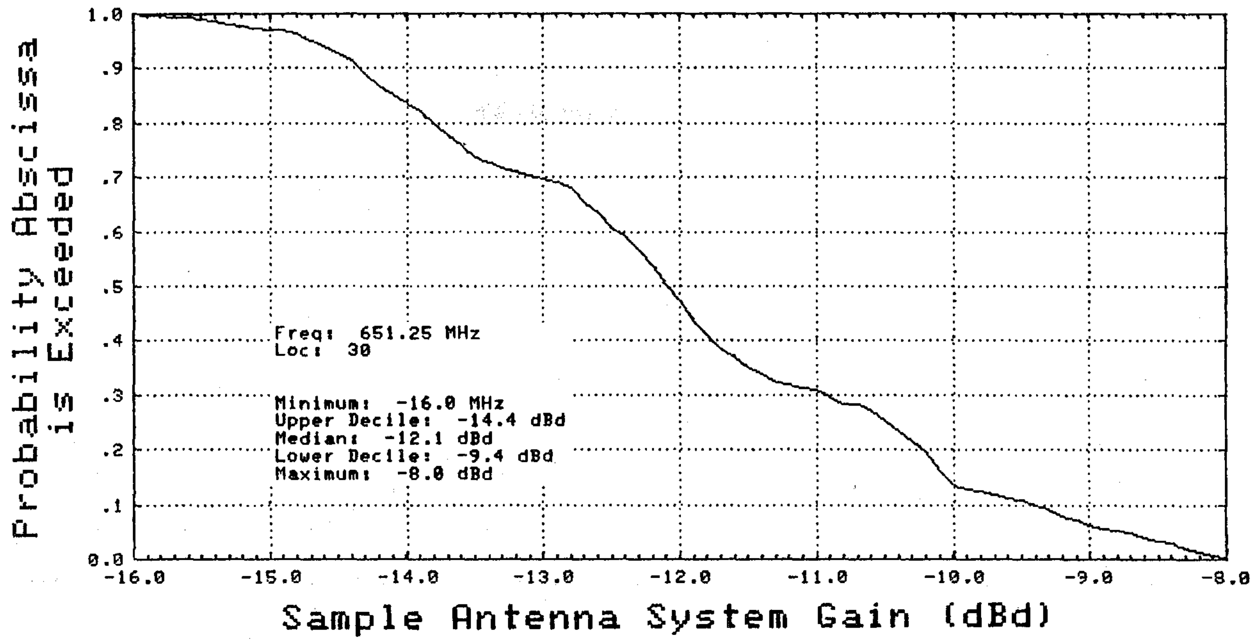


(a)

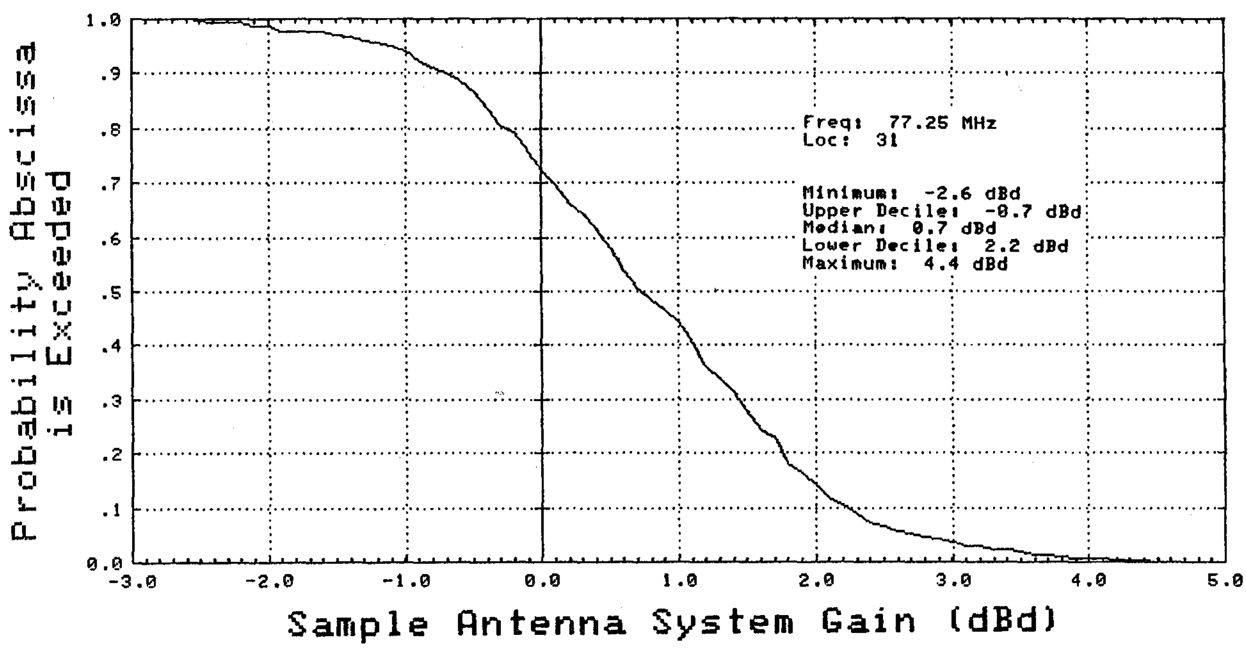


(b)

Figure A-69. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 30 at 507.26 MHz (a) and 579.25 MHz (b).

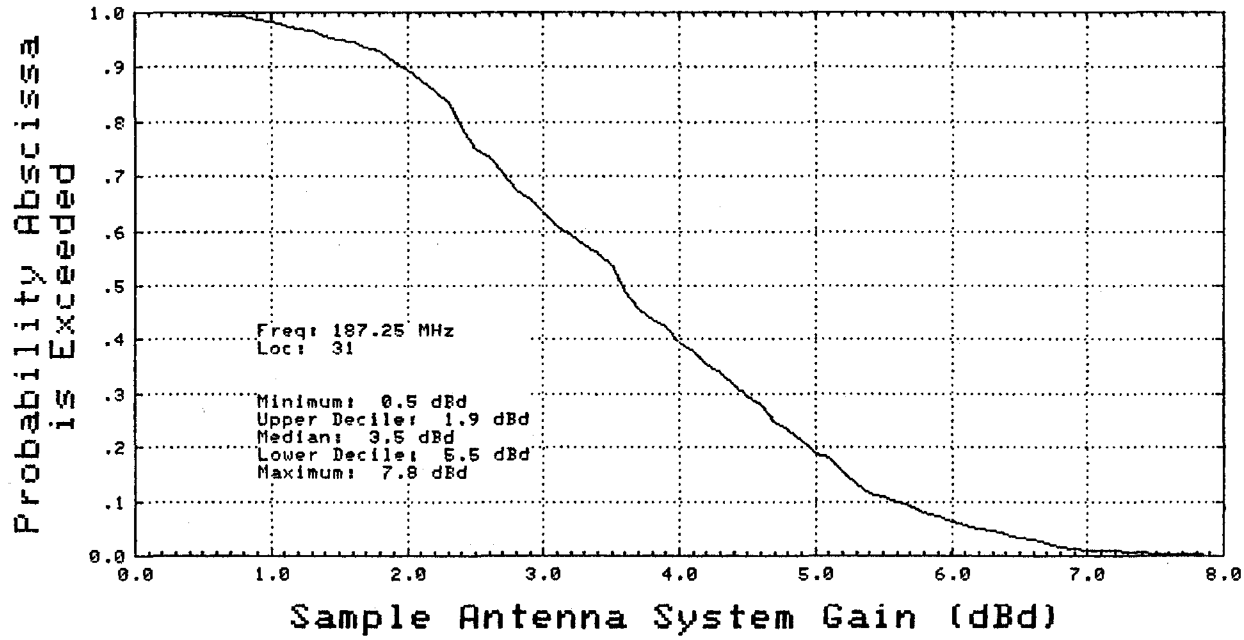


(a)

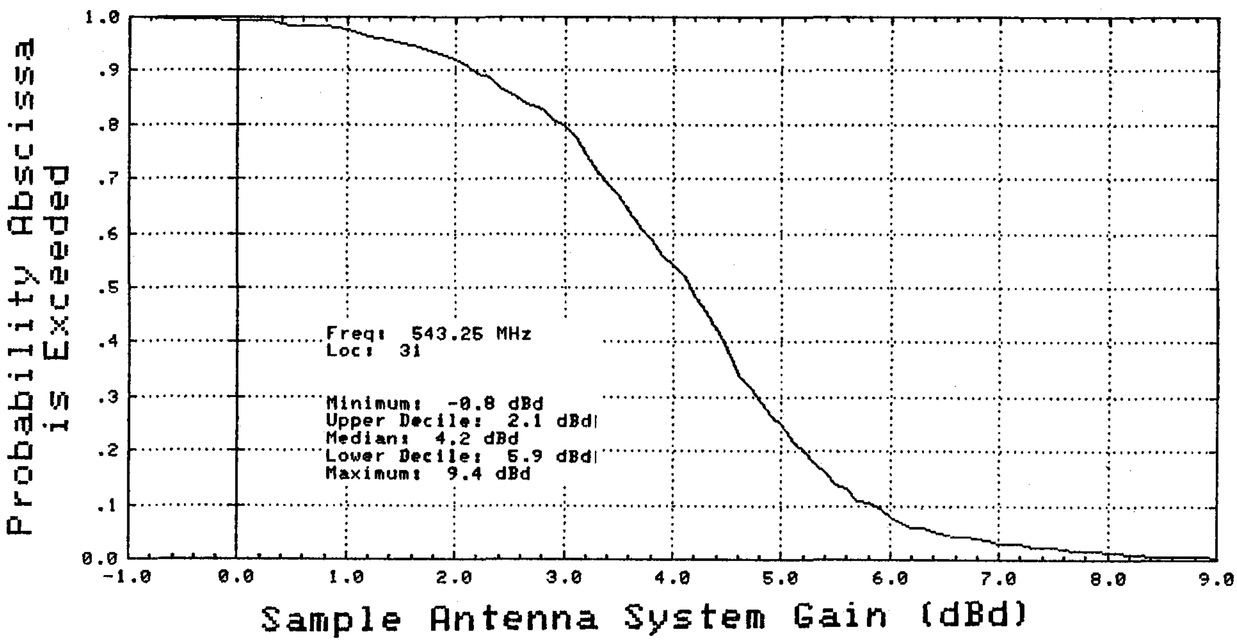


(b)

Figure A-70. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 30 at 651.25 MHz (a) and location 31 at 77.25 MHz (b).

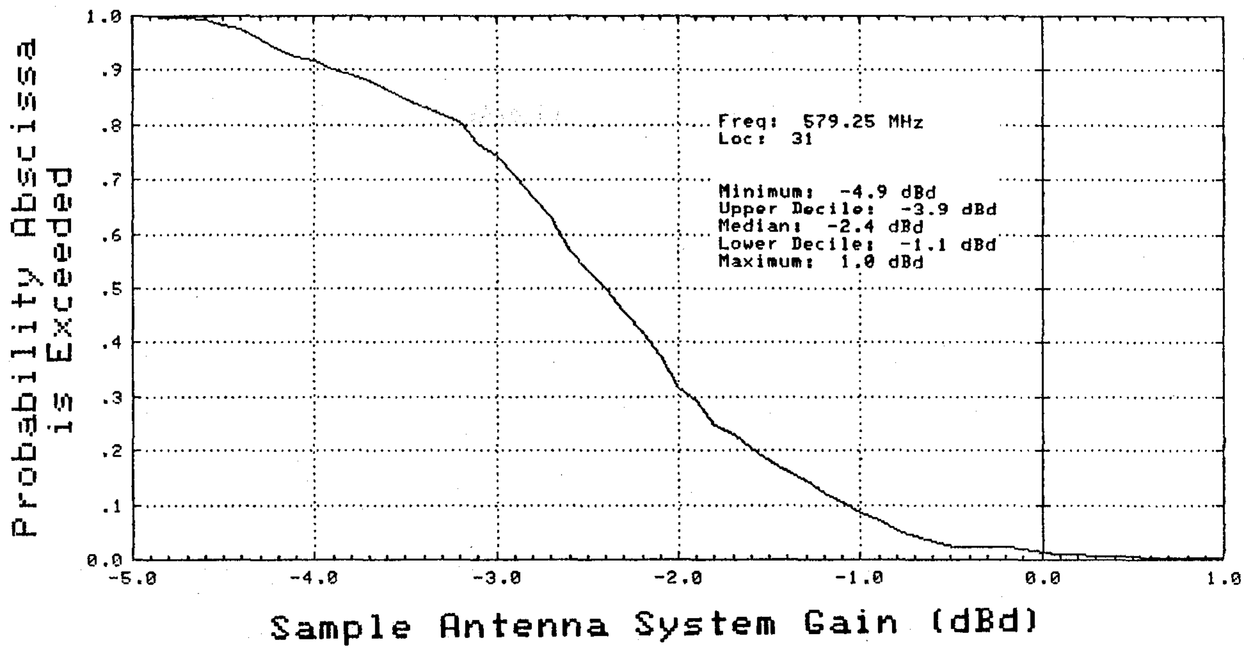


(a)

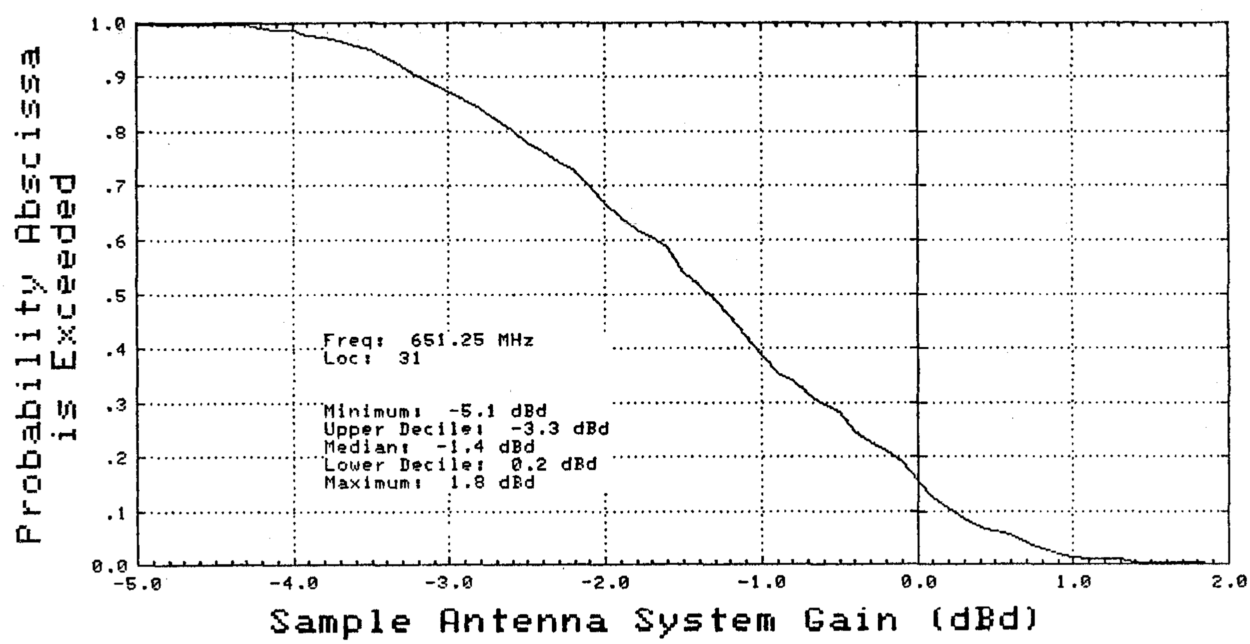


(b)

Figure A-71. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 31 at 187.25 MHz (a) and 543.25 MHz (b).

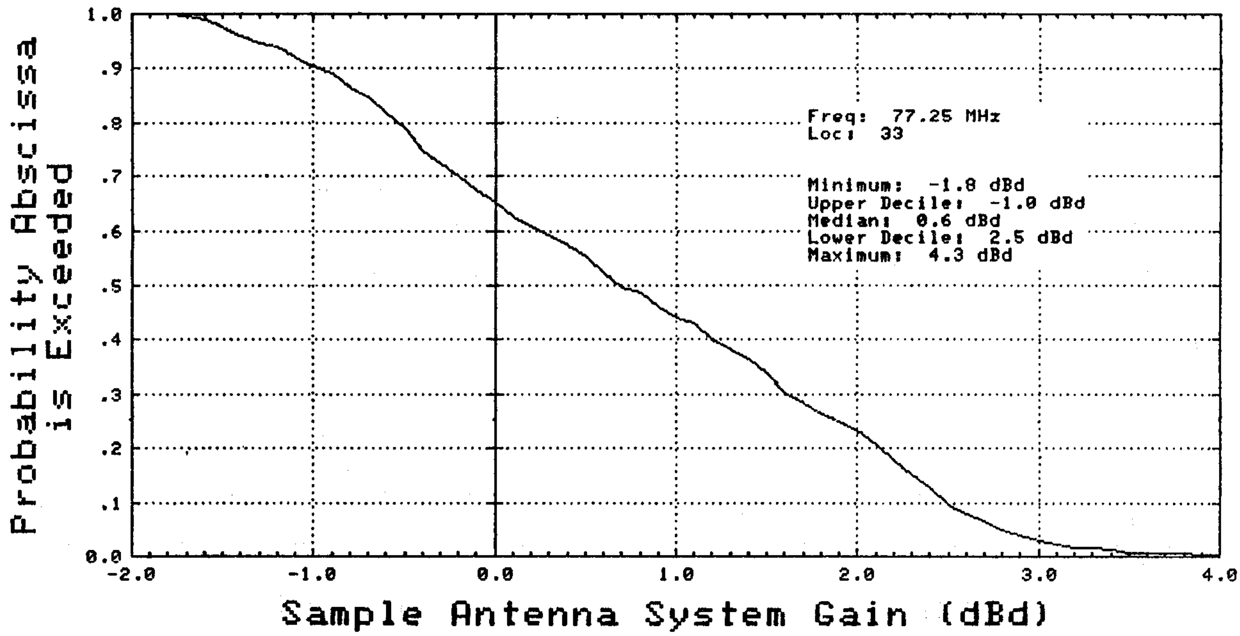


(a)

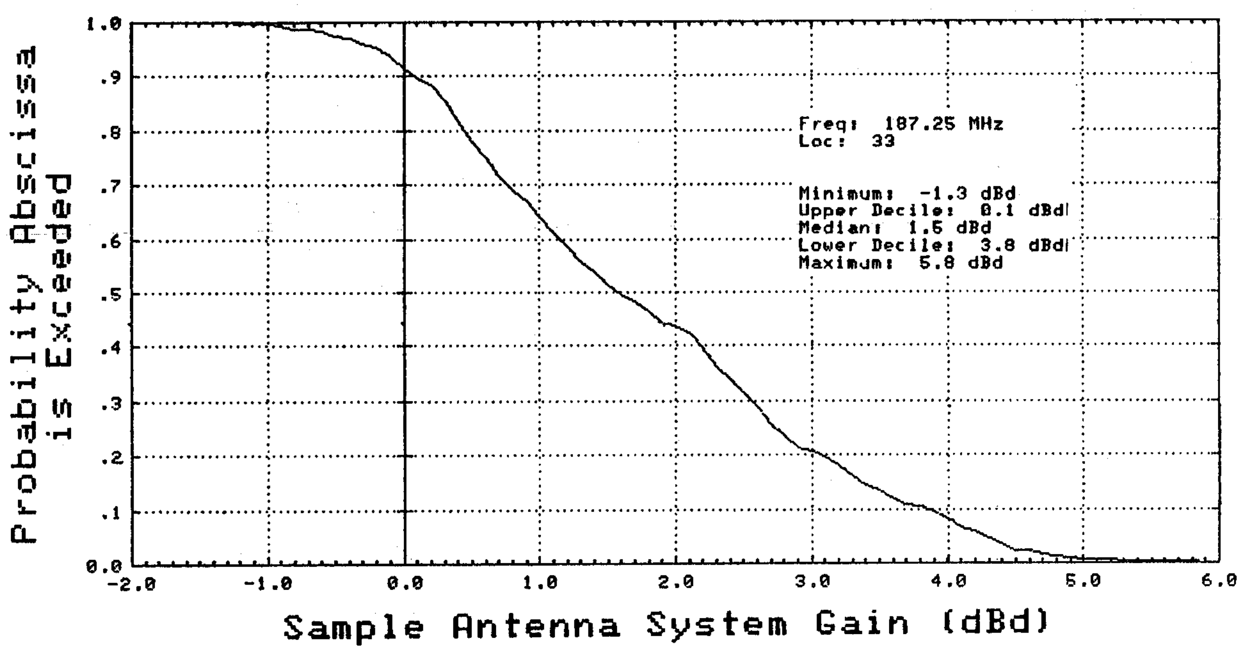


(b)

Figure A-72. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 31 at 579.25 MHz (a) and 651.25 MHz (b).

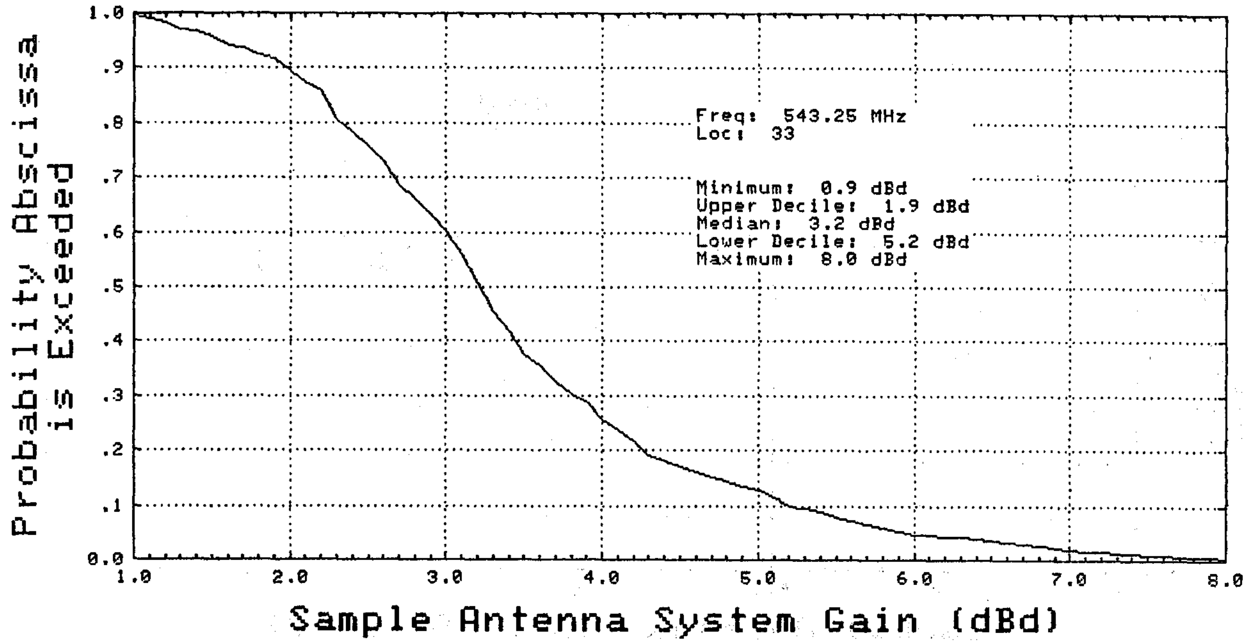


(a)

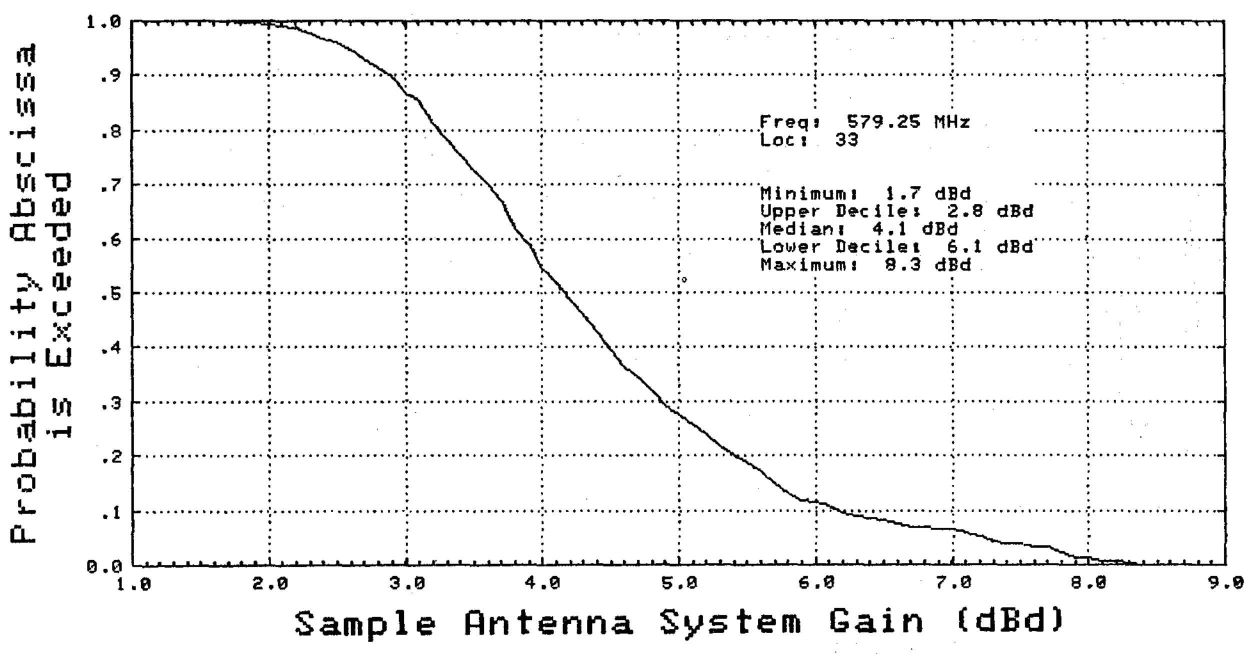


(b)

Figure A-73. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 33 at 77.25 MHz (a) and 187.25 MHz (b).

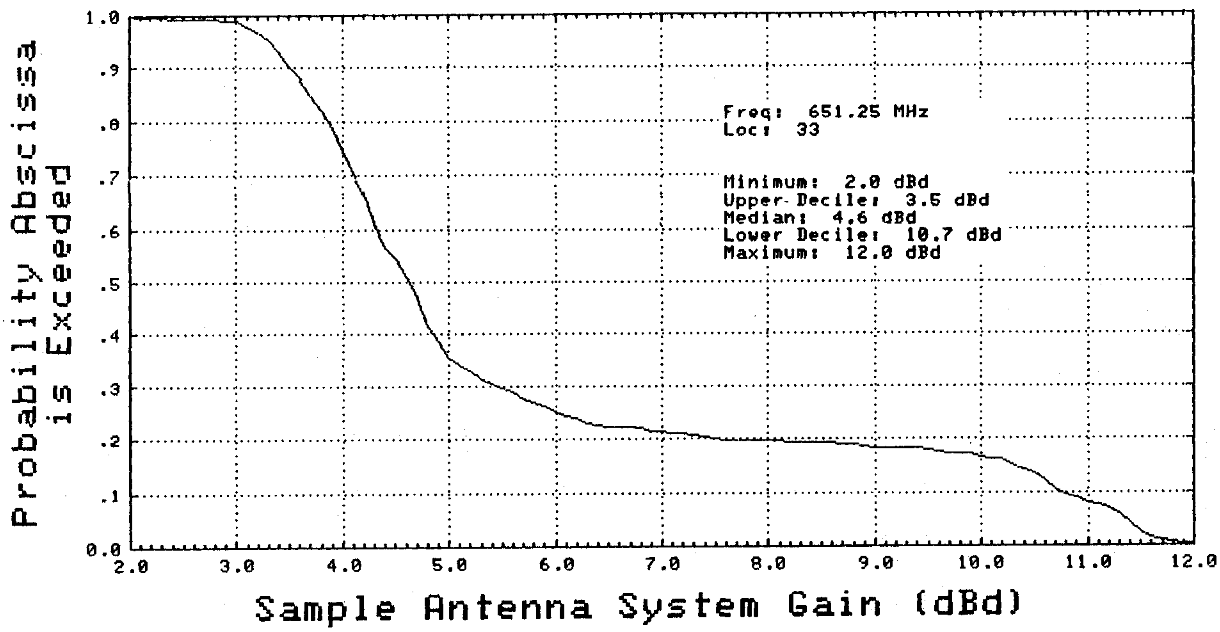


(a)

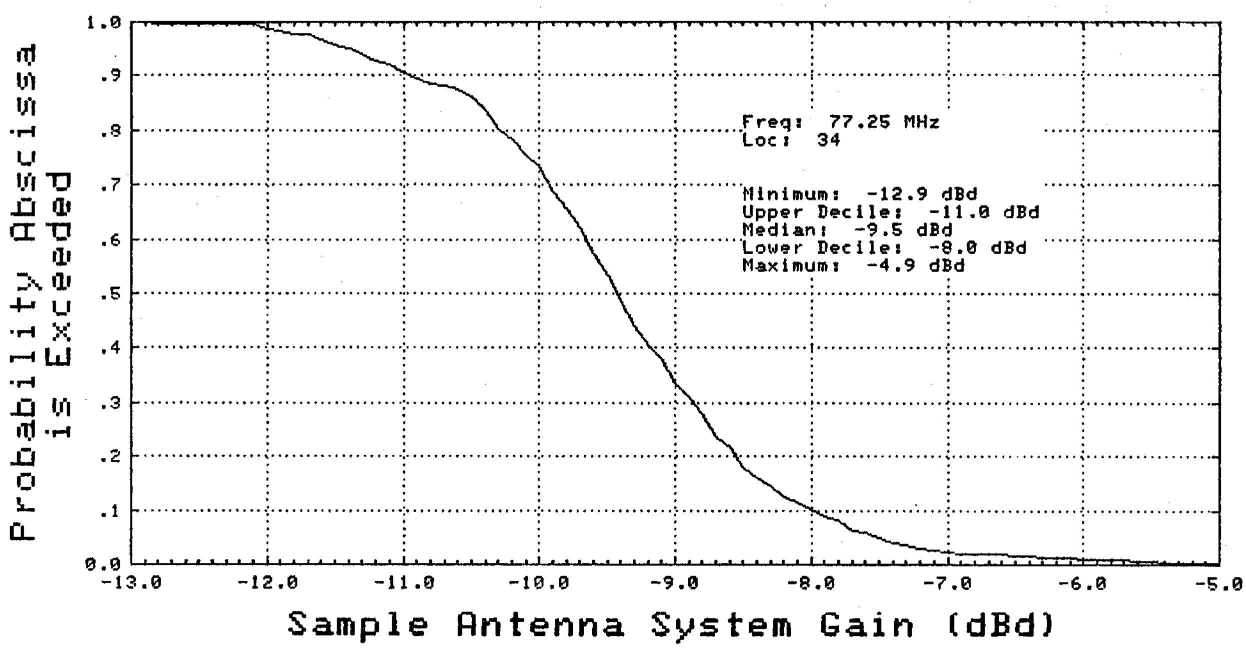


(b)

Figure A-74. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 33 at 543.25 MHz (a) and 579.25 MHz (b).

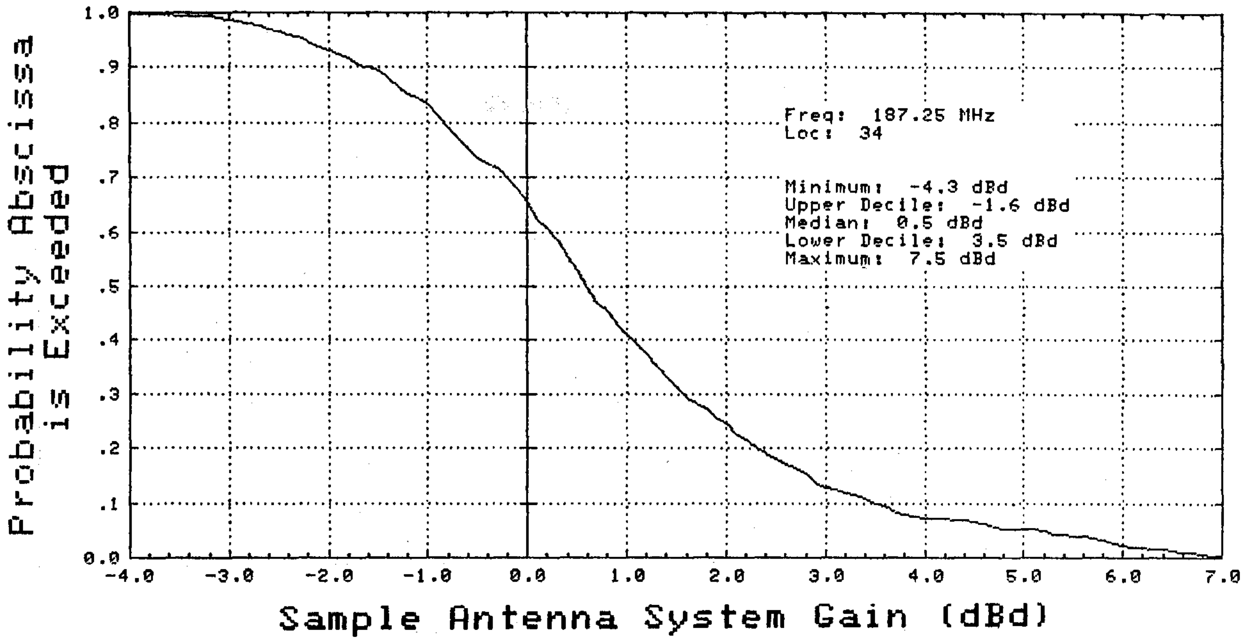


(a)

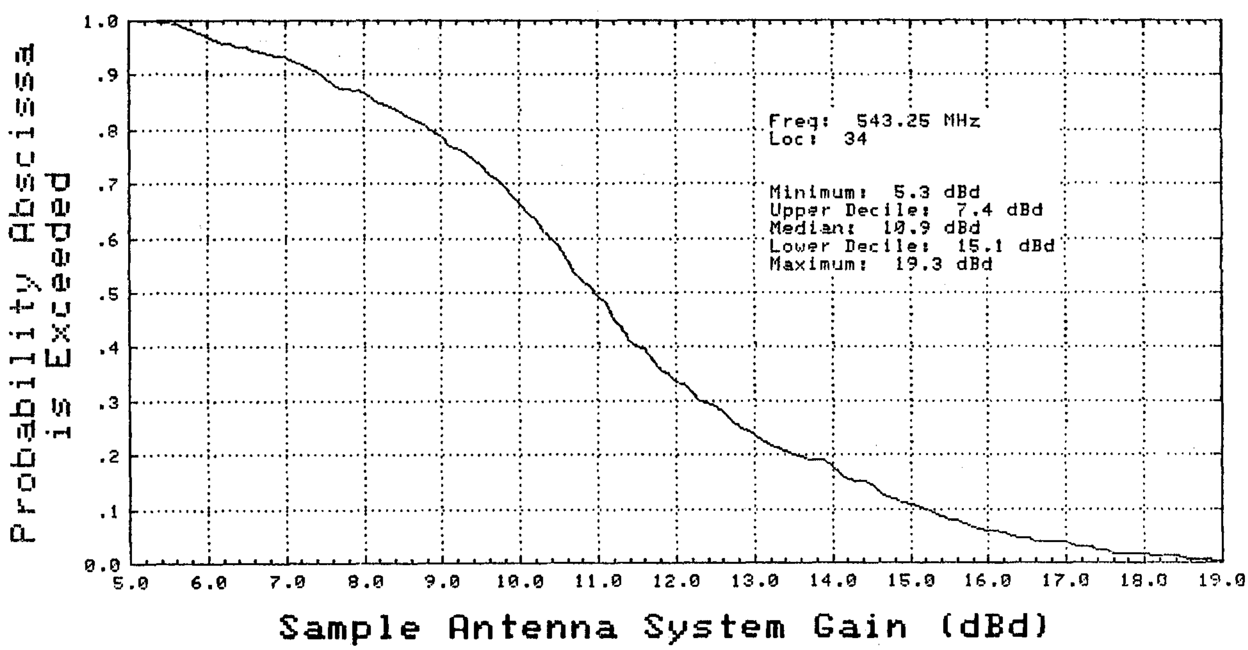


(b)

Figure A-75. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 33 at 651.25 MHz (a) and location 34 at 77.25 MHz (b).

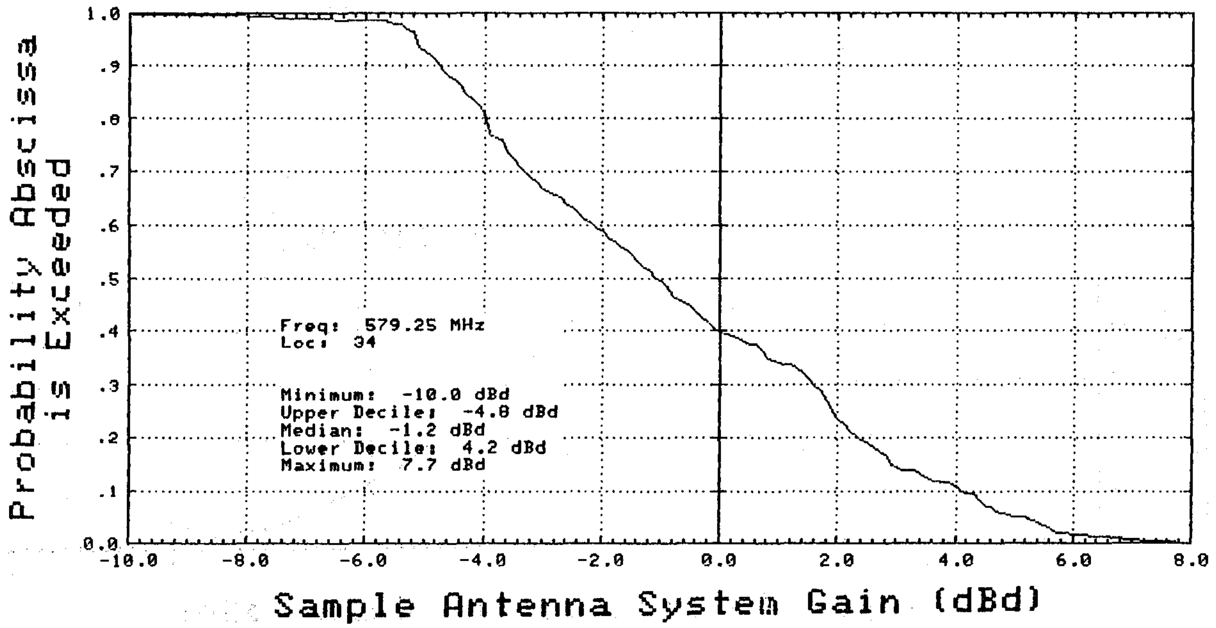


(a)

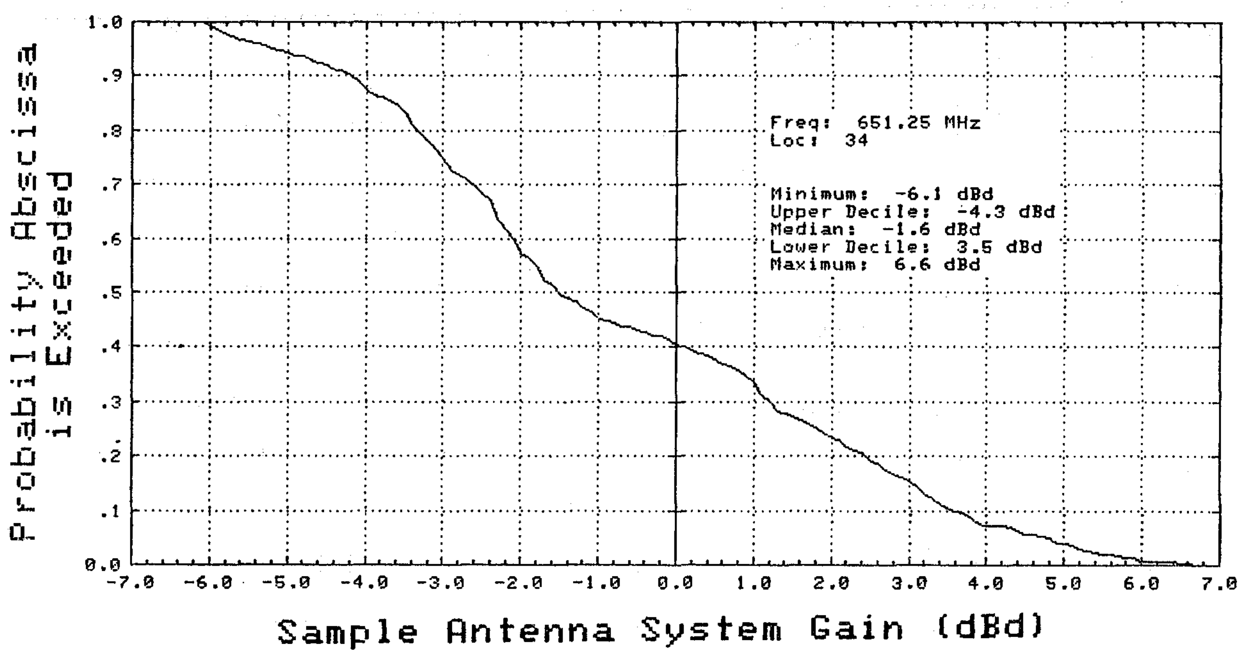


(b)

Figure A-76. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 34 at 187.25 MHz (a) and 543.25 MHz (b).

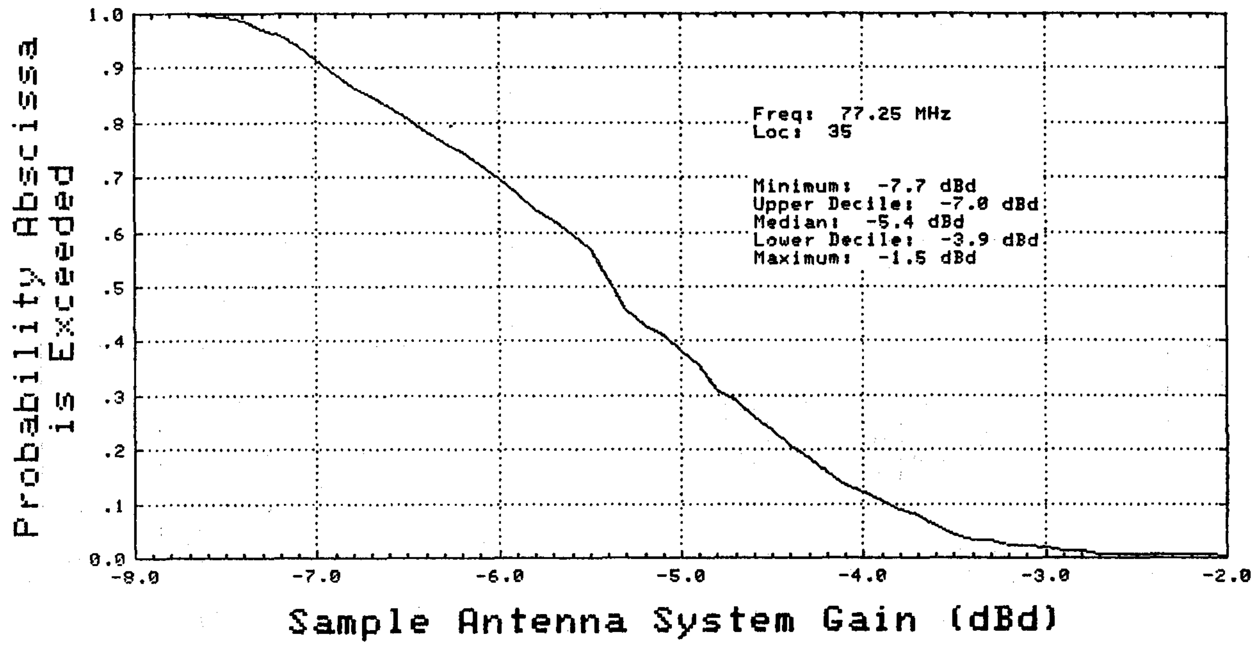


(a)

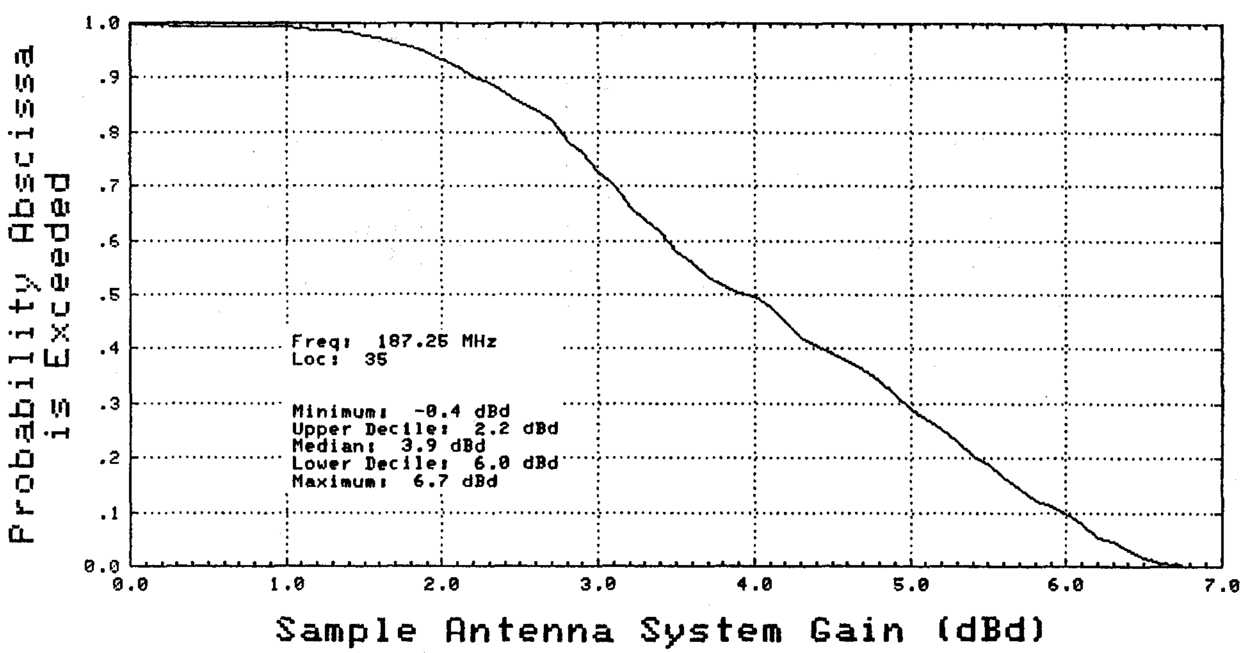


(b)

Figure A-77. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 34 at 579.25 MHz (a) and 651.25 MHz (b).

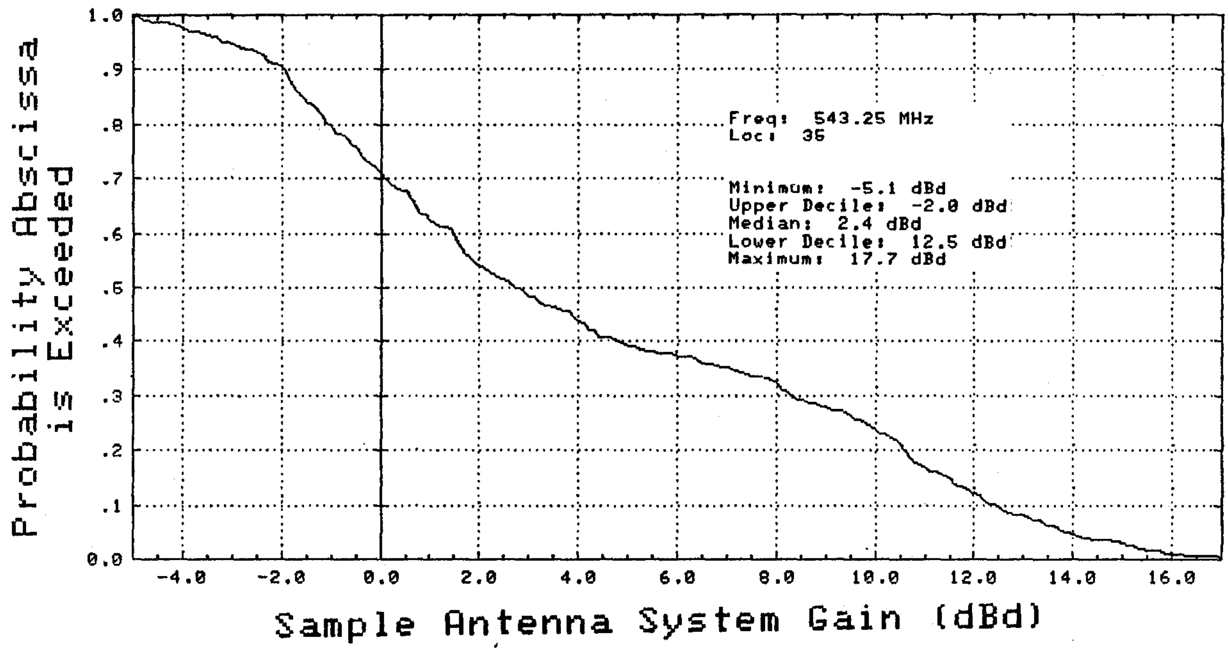


(a)

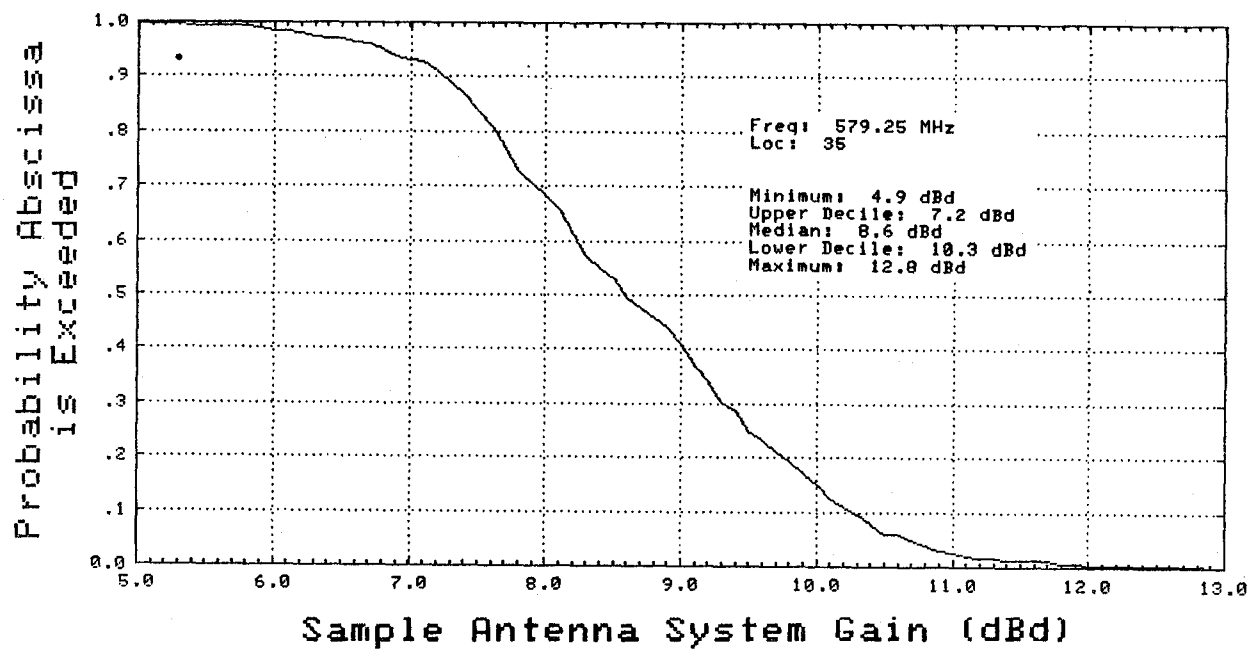


(b)

Figure A-78. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 35 at 77.25 MHz (a) and 187.25 MHz (b).

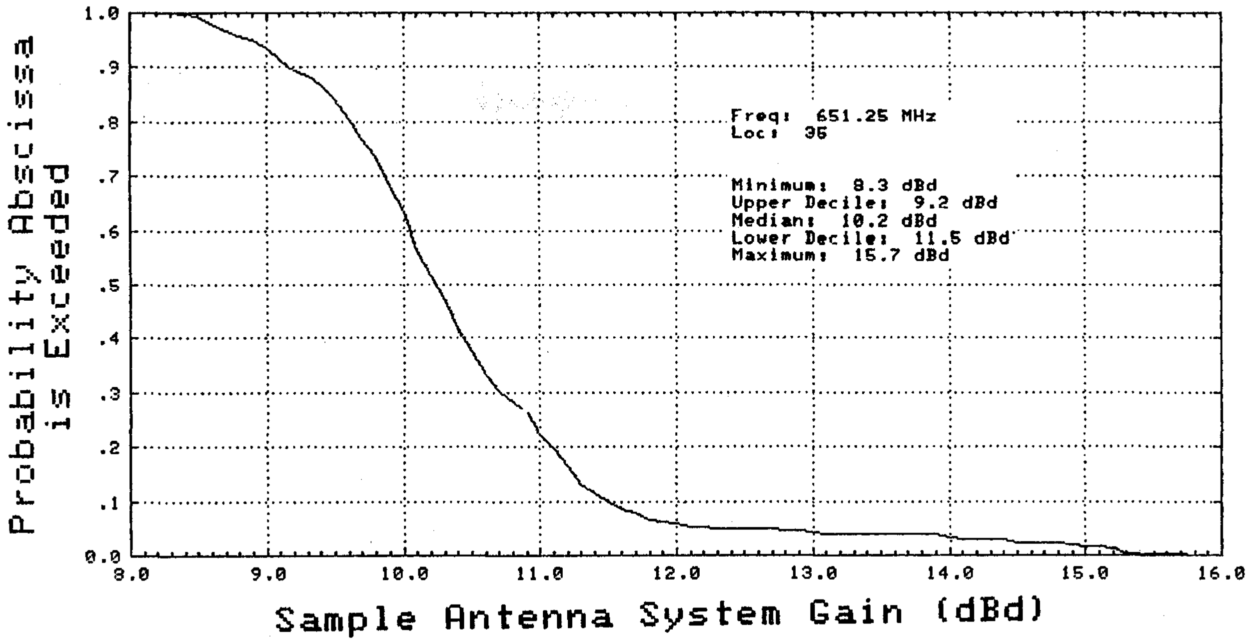


(a)

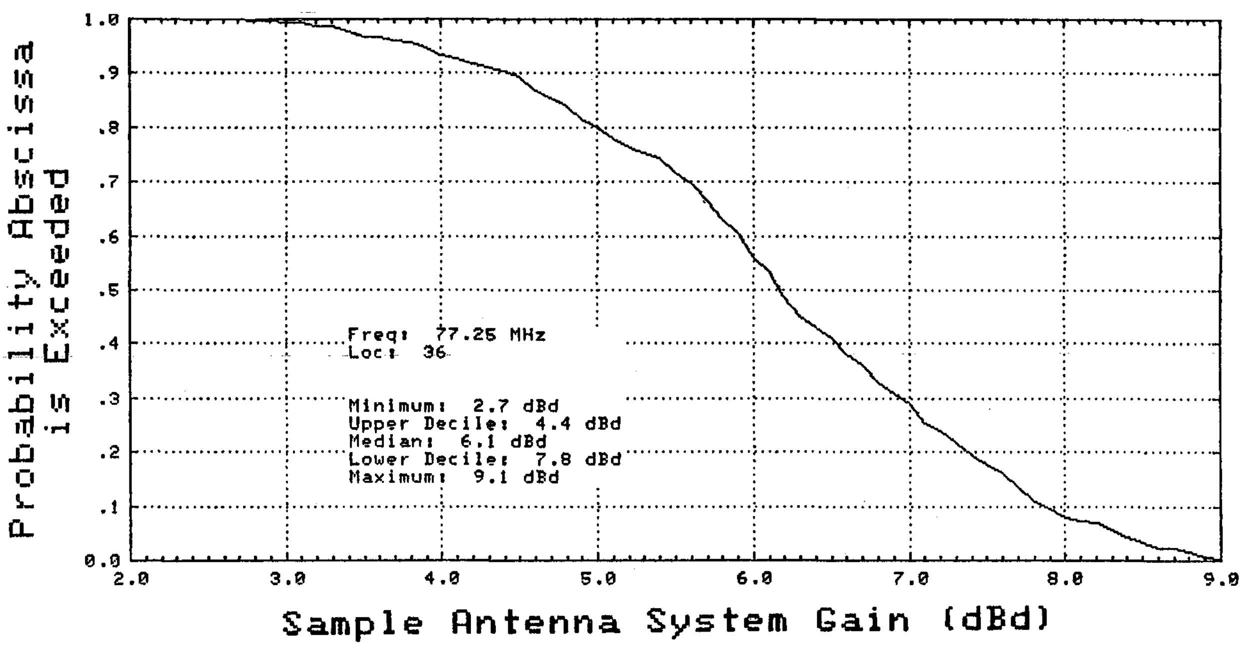


(b)

Figure A-79. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 35 at 543.25 MHz (a) and 579.25 MHz (b).

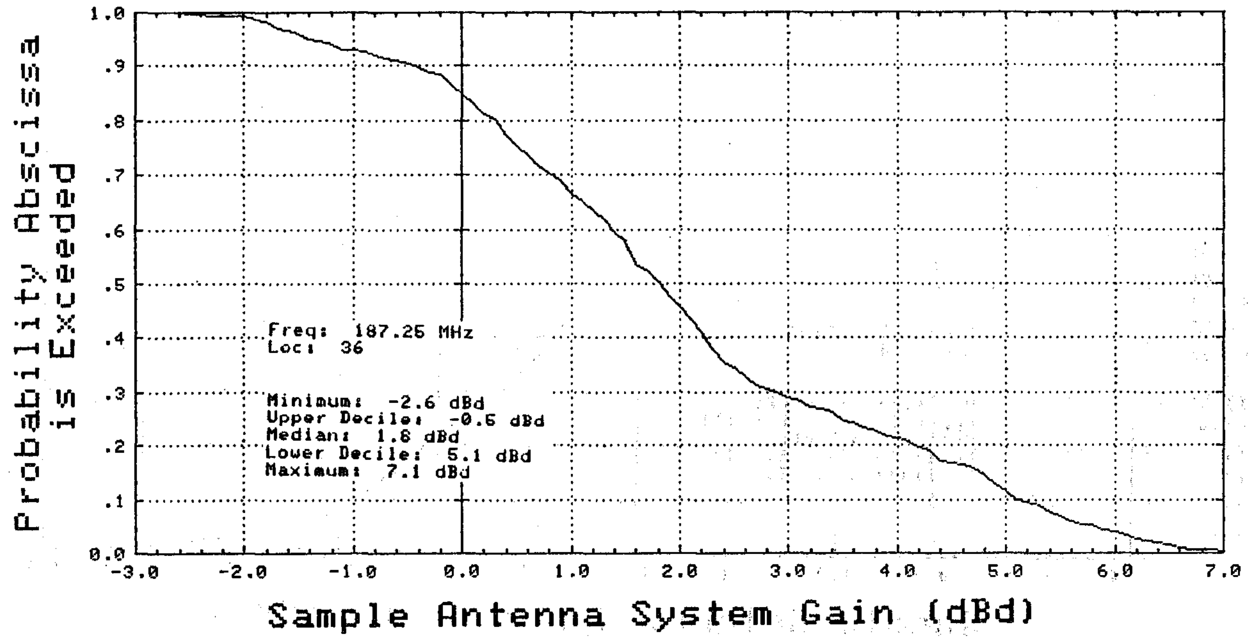


(a)

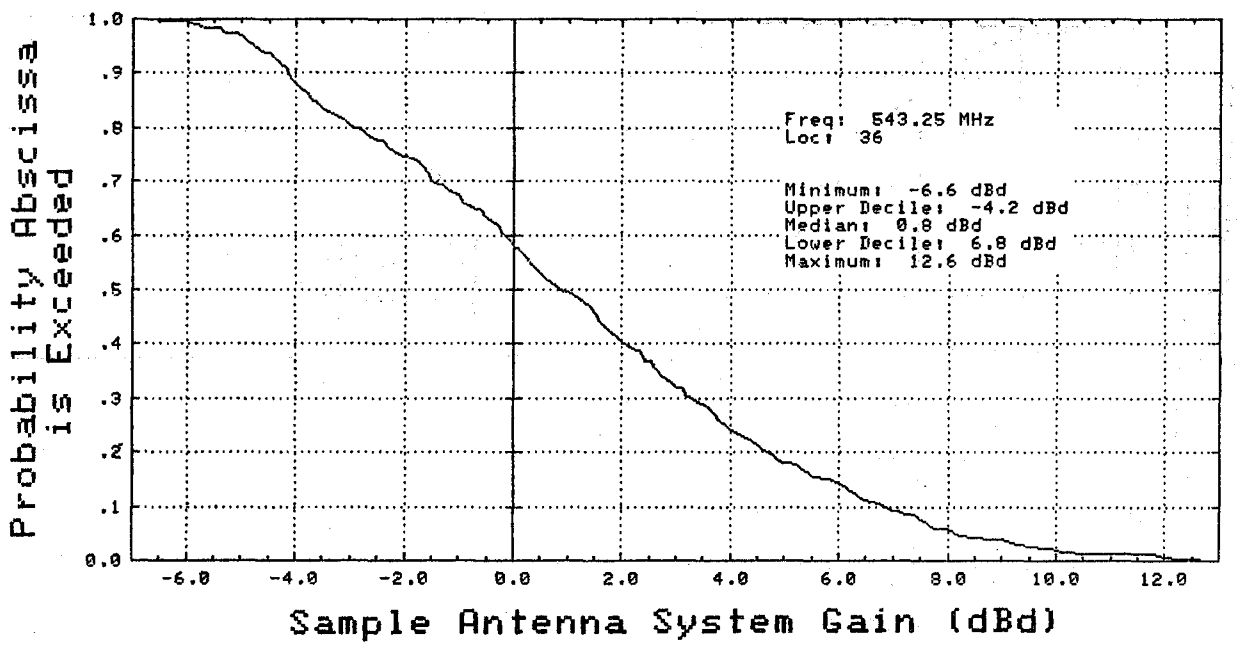


(b)

Figure A-80. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 35 at 651.25 MHz (a) and location 36 at 77.25 MHz (b).

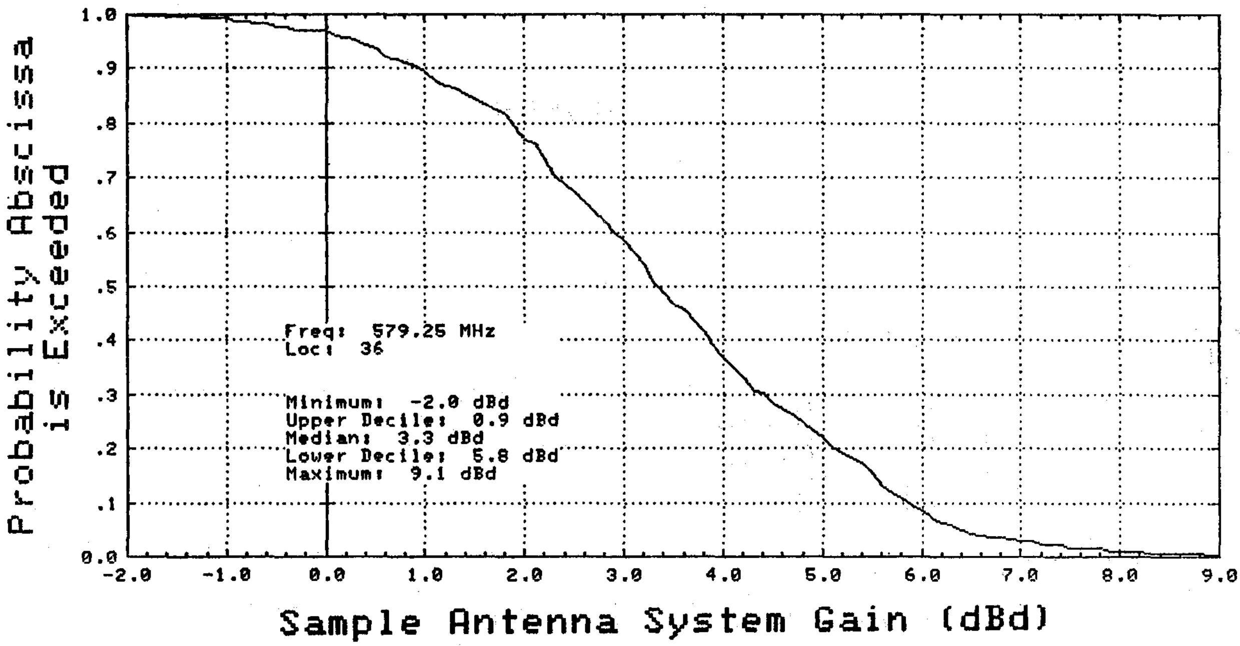


(a)

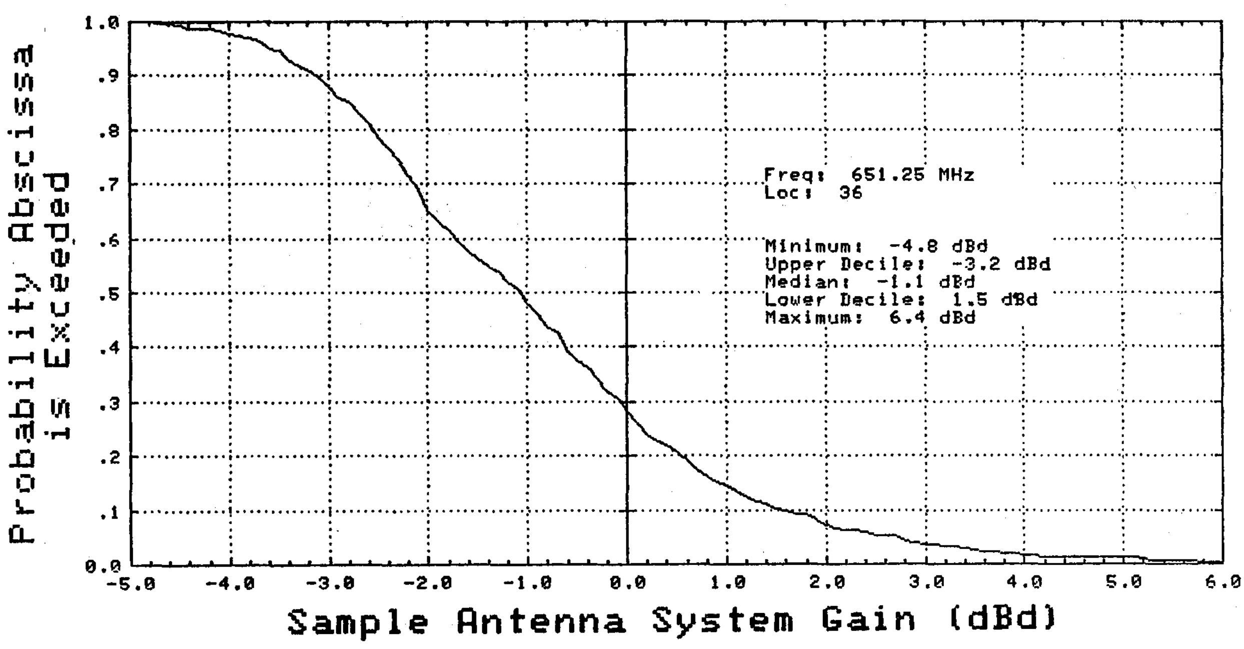


(b)

Figure A-81. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 36 at 187.25 MHz (a) and 543.25 MHz (b).

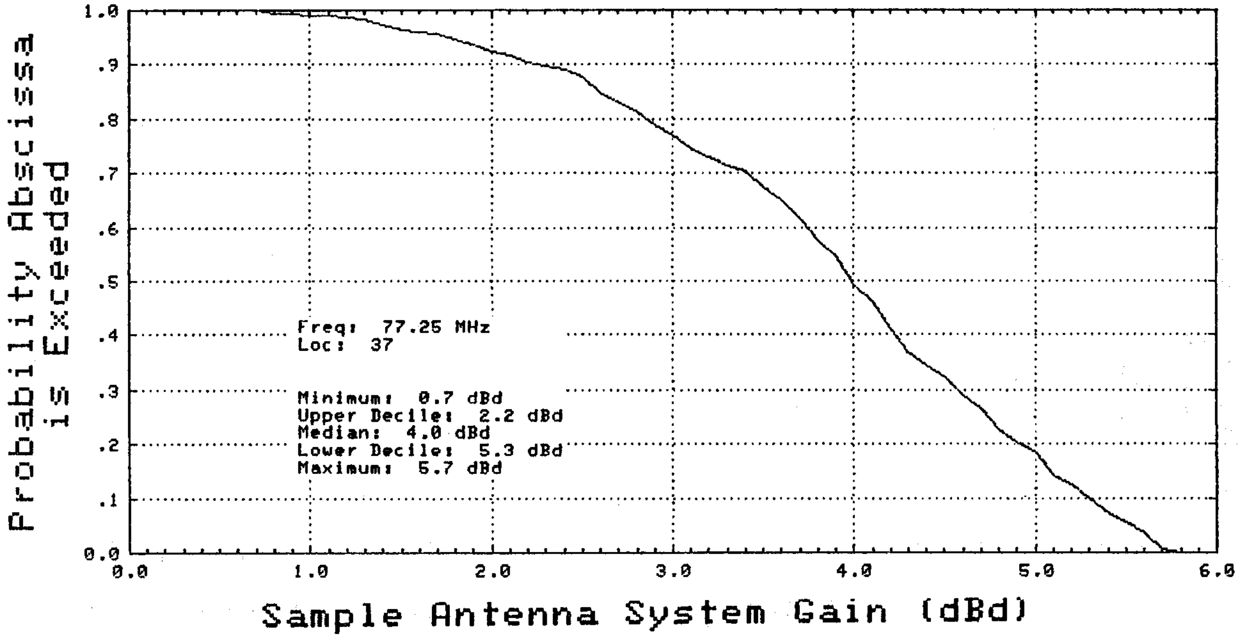


(a)

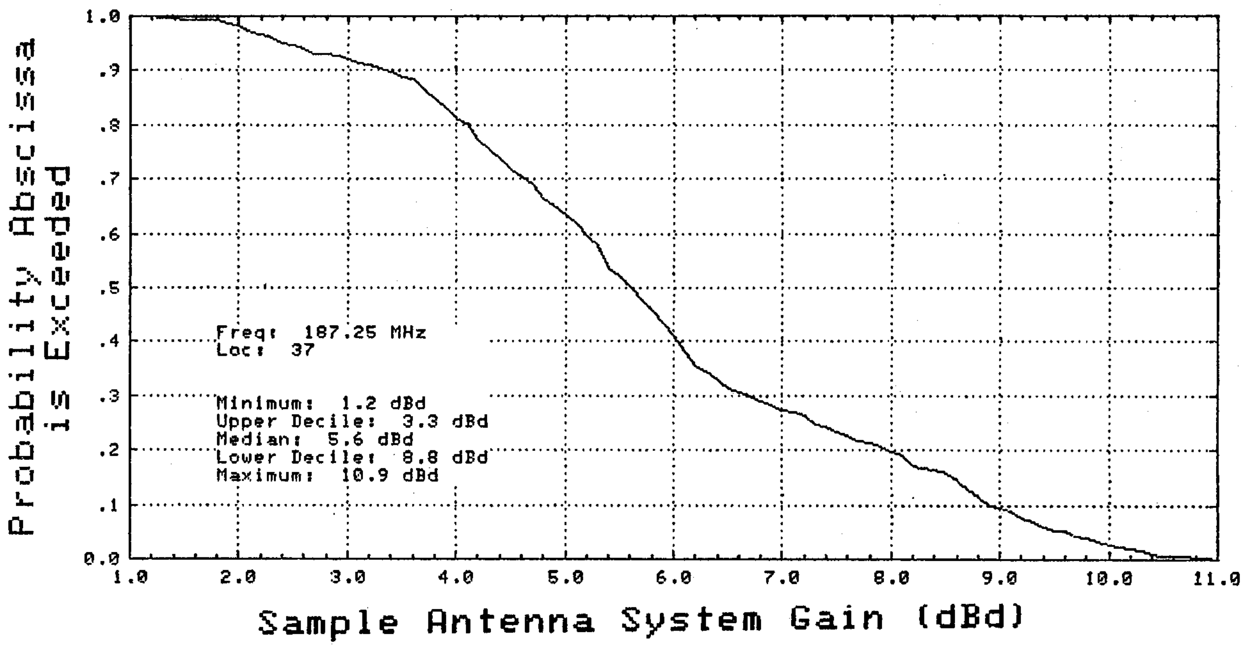


(b)

Figure A-82. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 36 at 579.25 MHz (a) and 651.25 MHz (b).

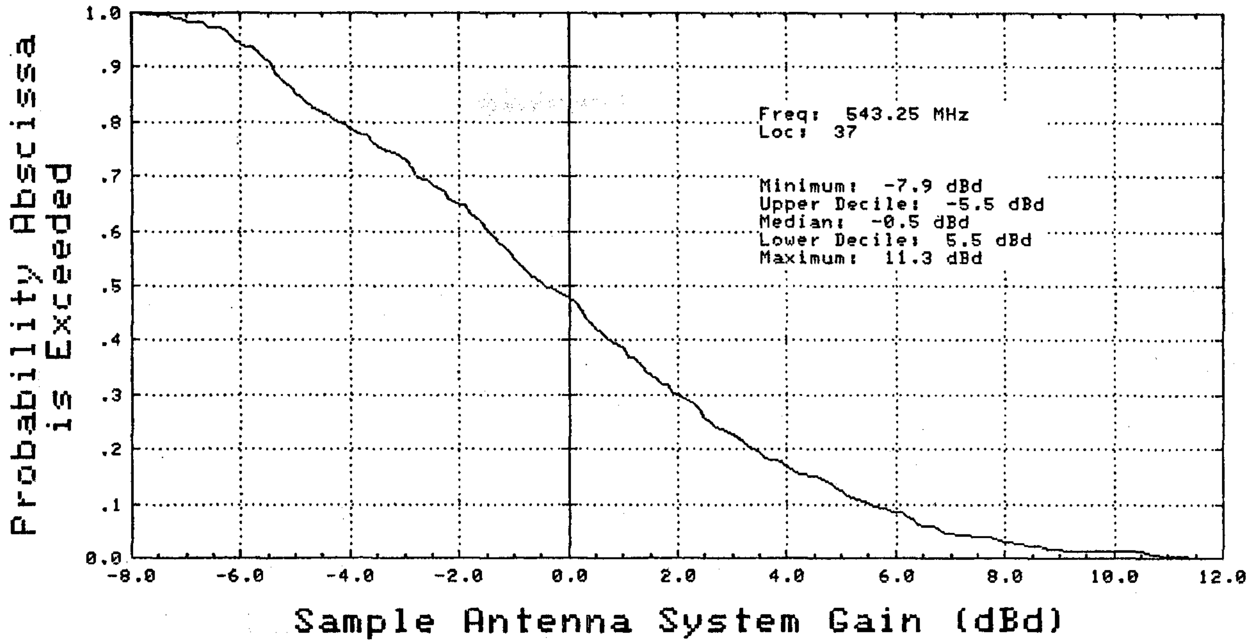


(a)

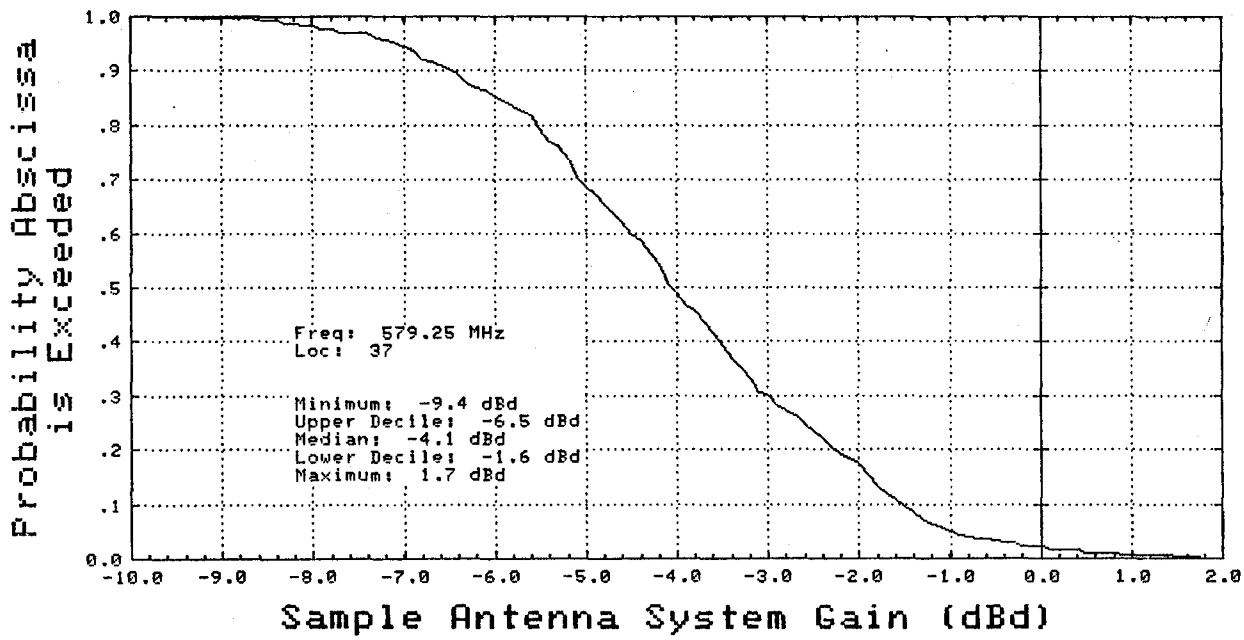


(b)

Figure A-83. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 37 at 77.25 MHz (a) and 187.25 MHz (b).

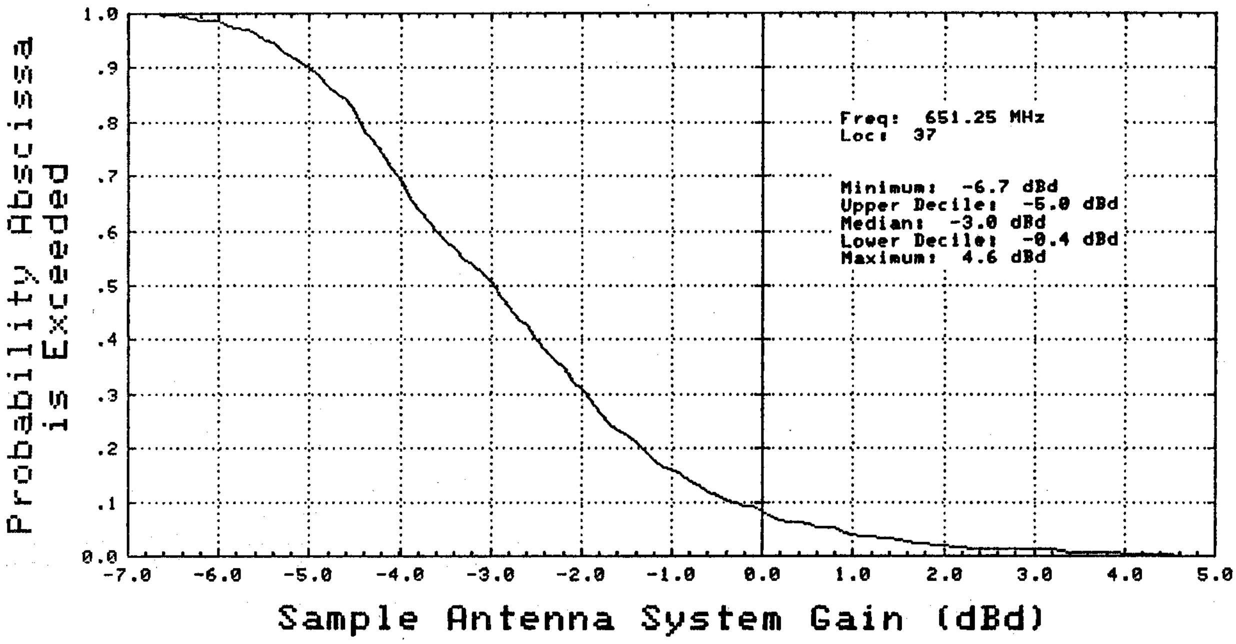


(a)

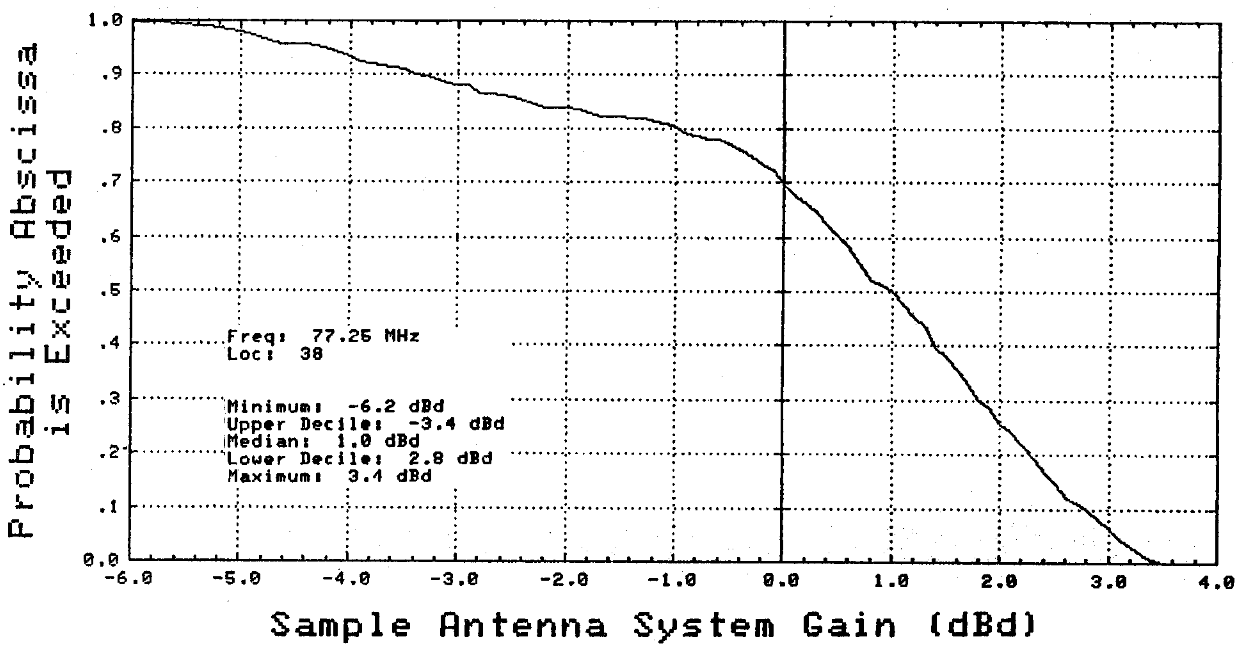


(b)

Figure A-84. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 37 at 543.25 MHz (a) and 579.25 MHz (b).

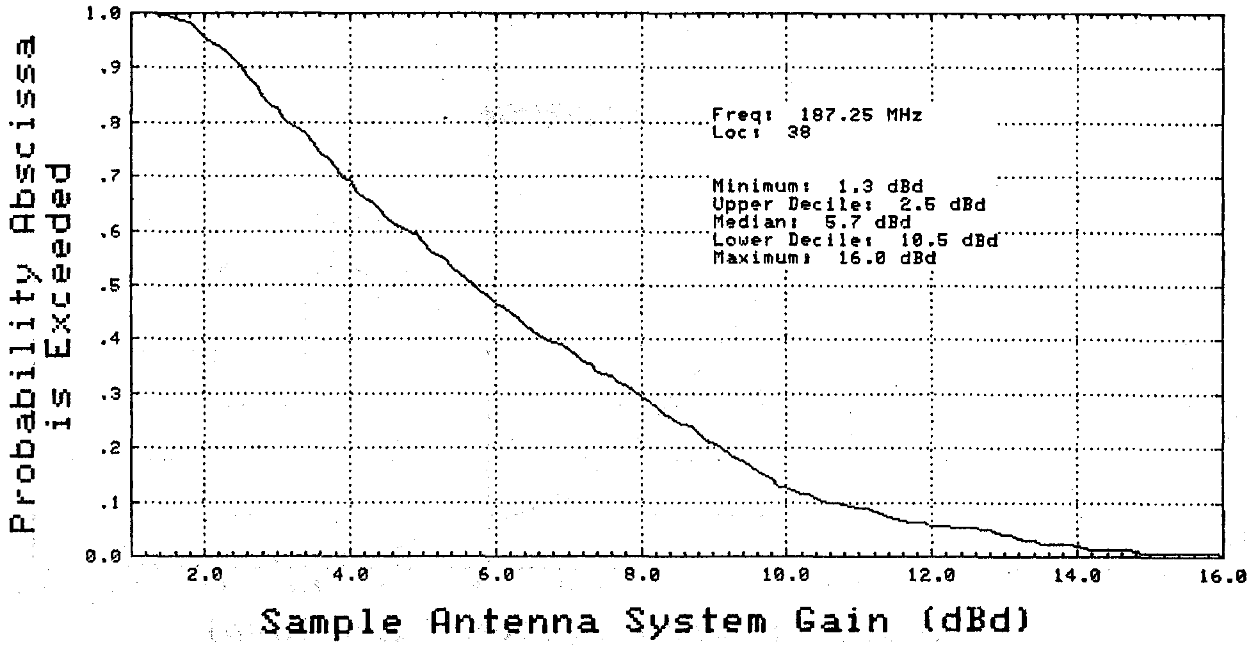


(a)

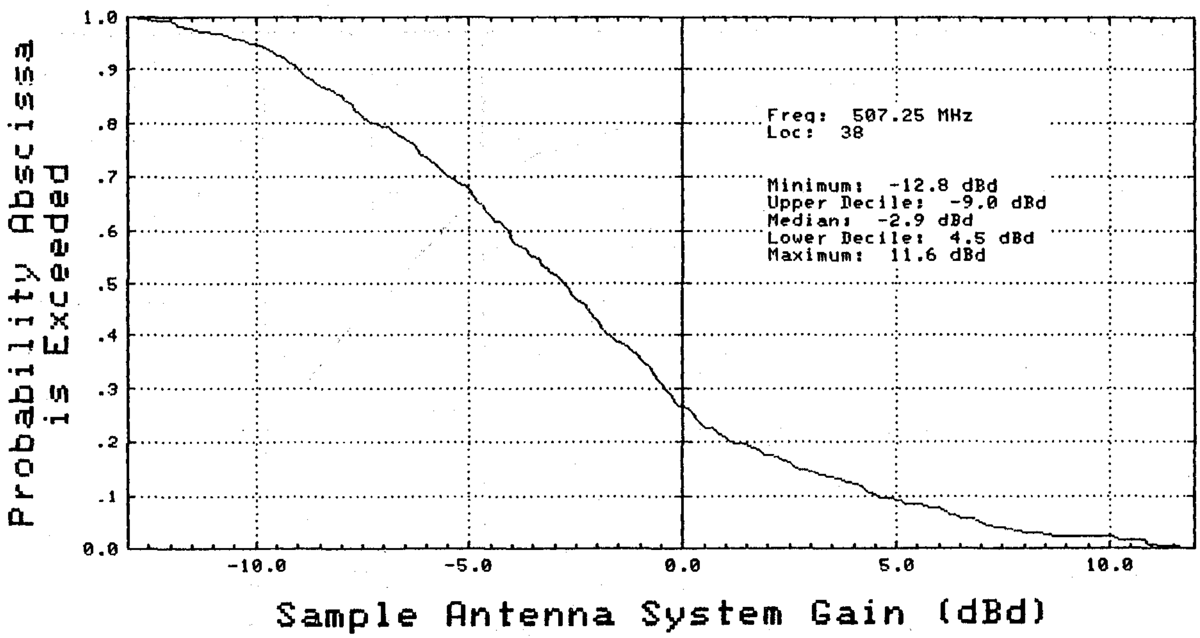


(b)

Figure A-85. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 37 at 651.25 MHz (a) and location 38 at 77.25 MHz (b).

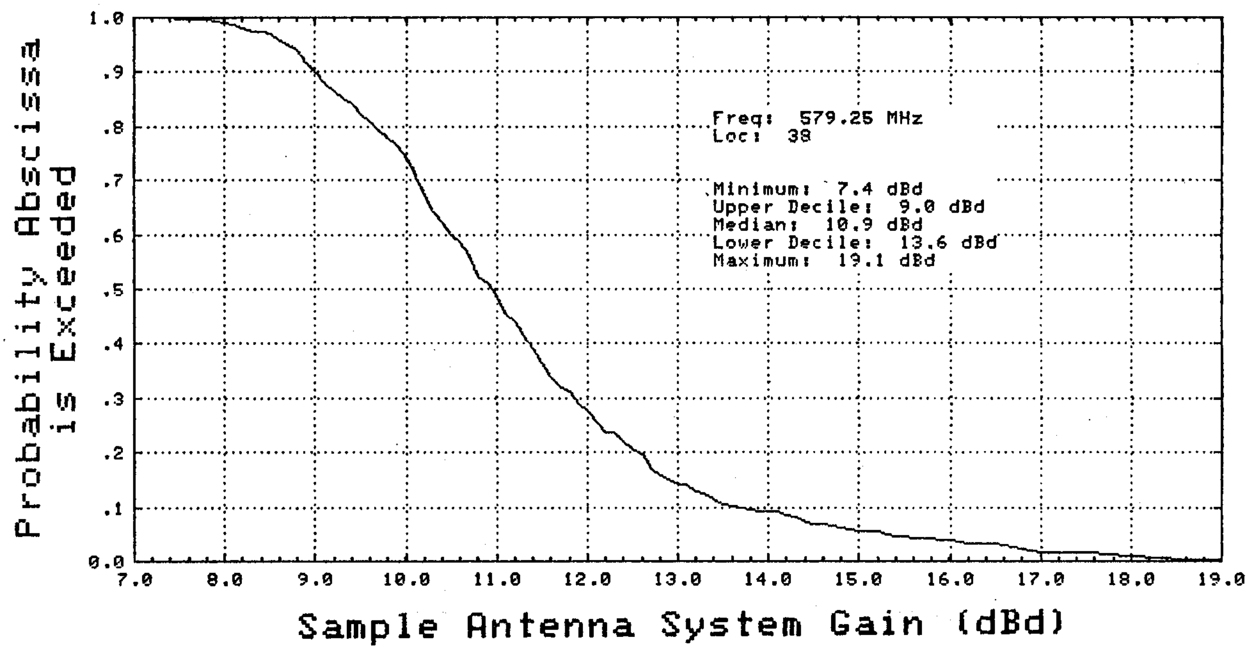


(a)

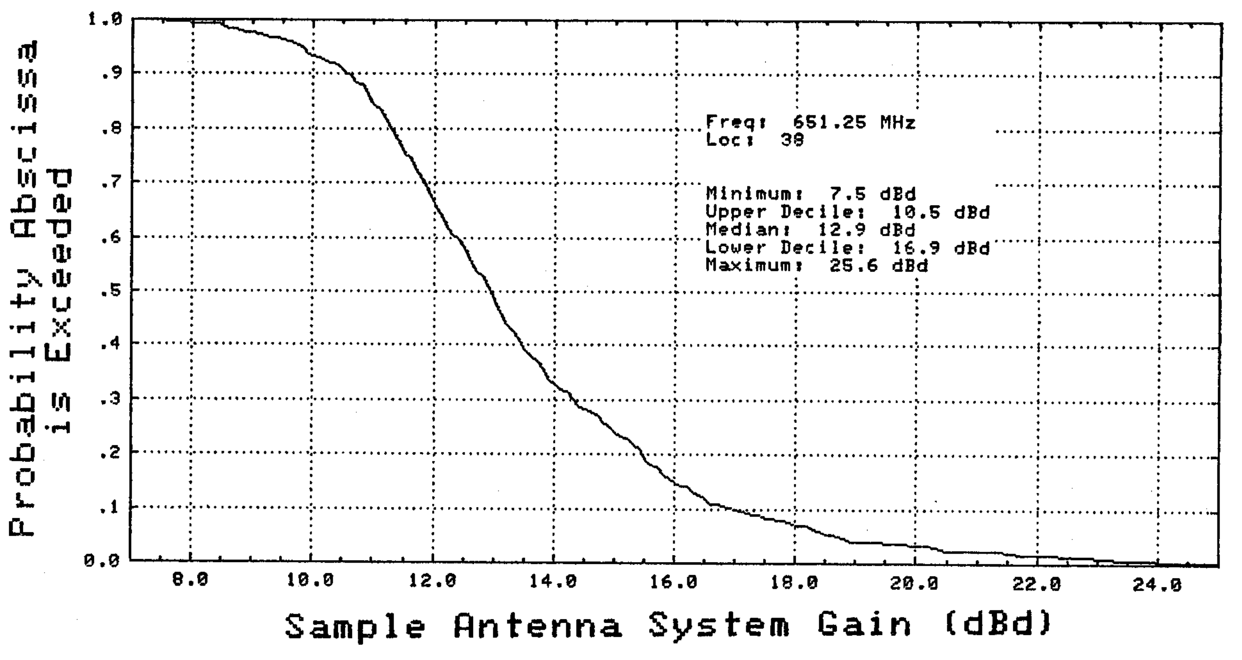


(b)

Figure A-86. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 38 at 187.25 MHz (a) and 507.25 MHz (b).

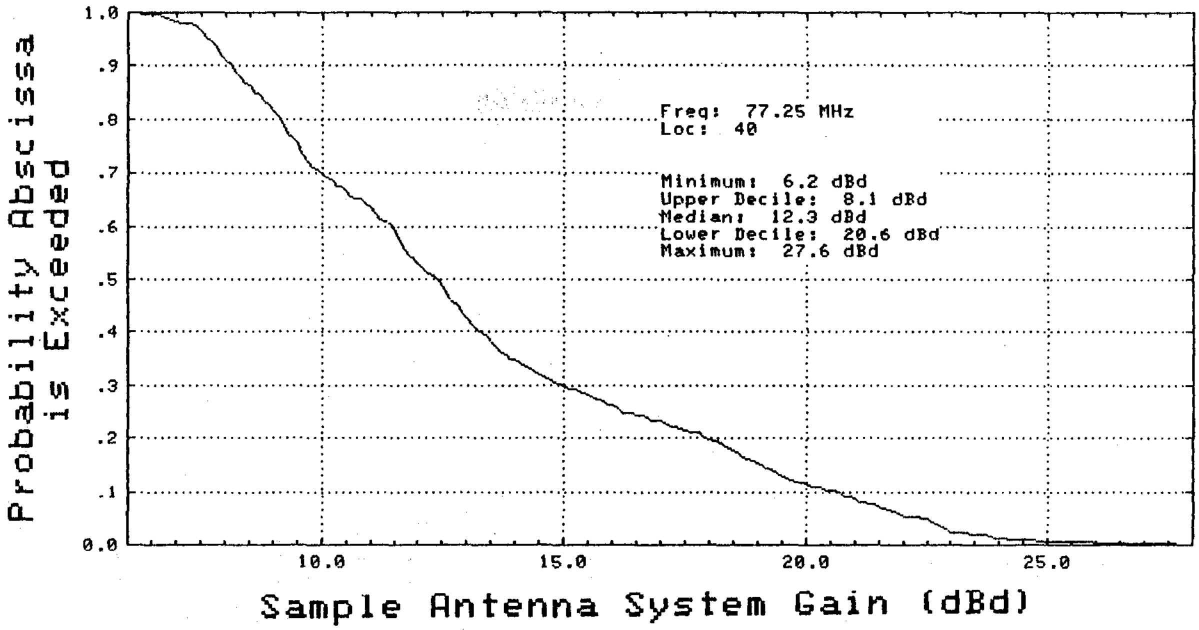


(a)

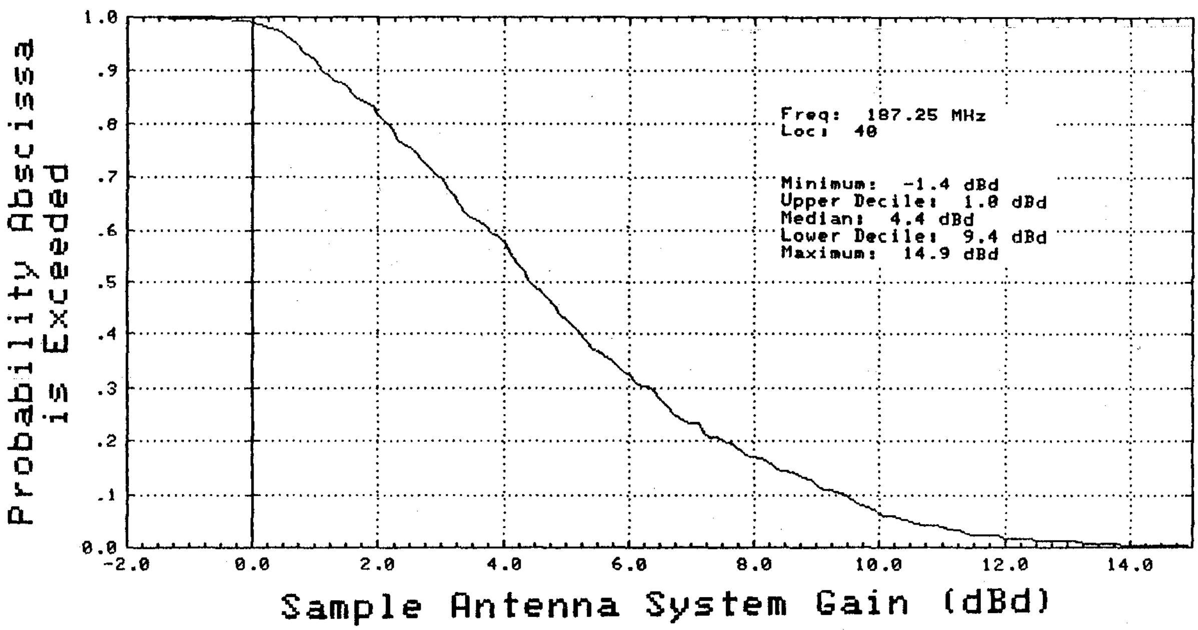


(b)

Figure A-87. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 38 at 579.25 MHz (a) and 651.25 MHz (b).

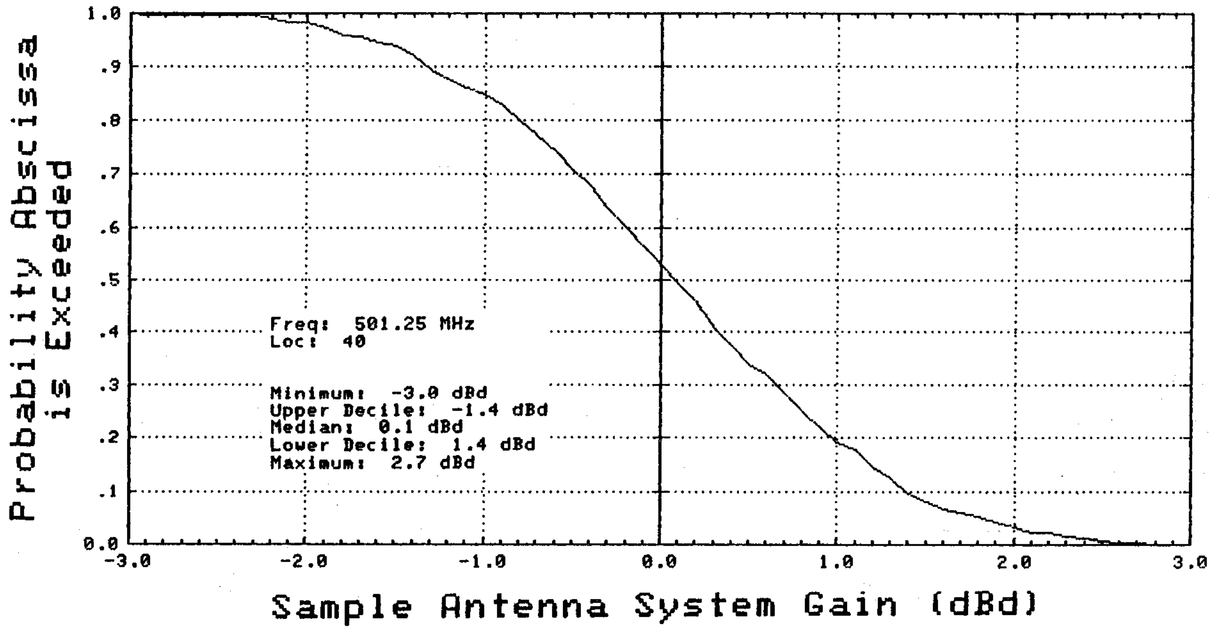


(a)

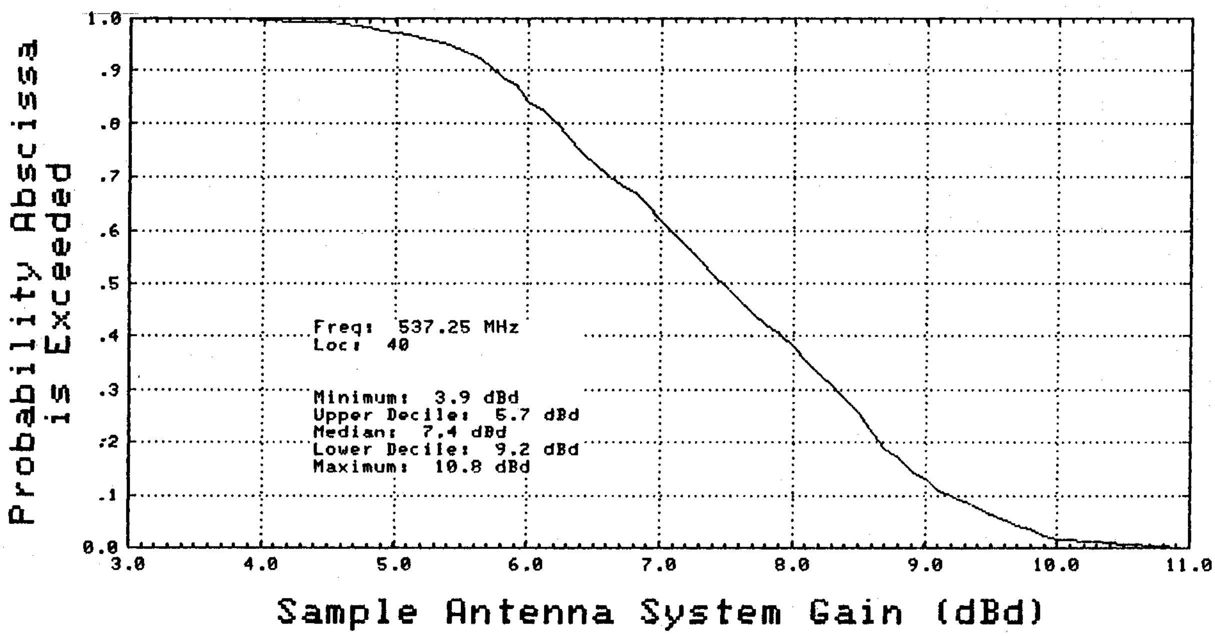


(b)

Figure A-88. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 40 at 77.25 MHz (a) and 187.25 MHz (b).

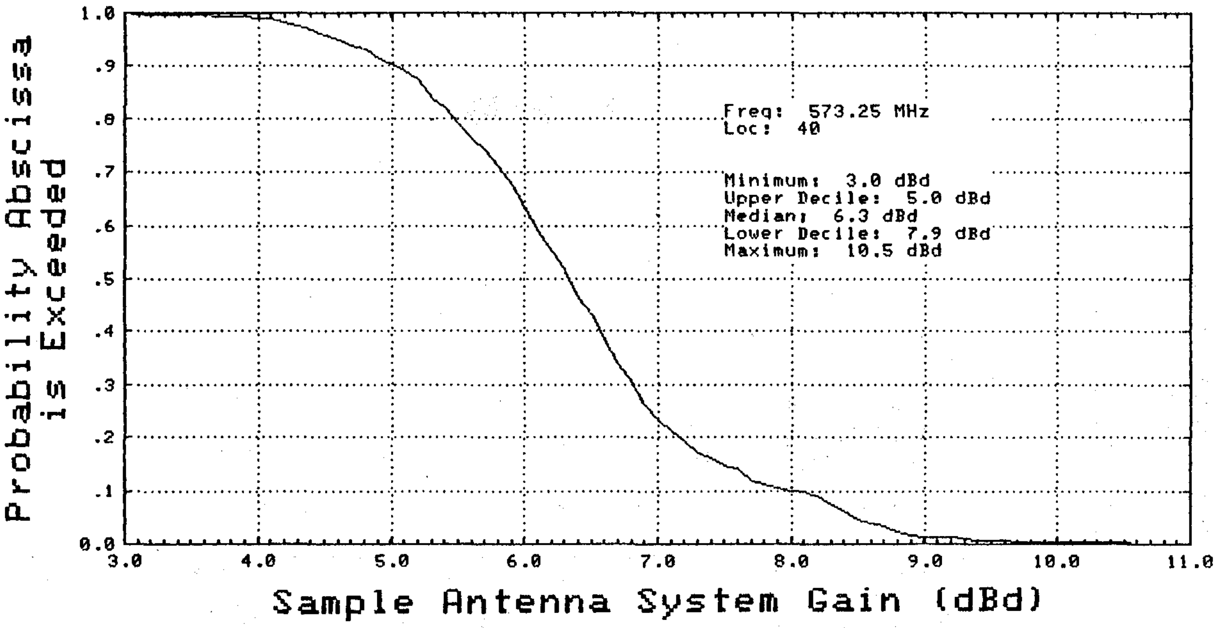


(a)

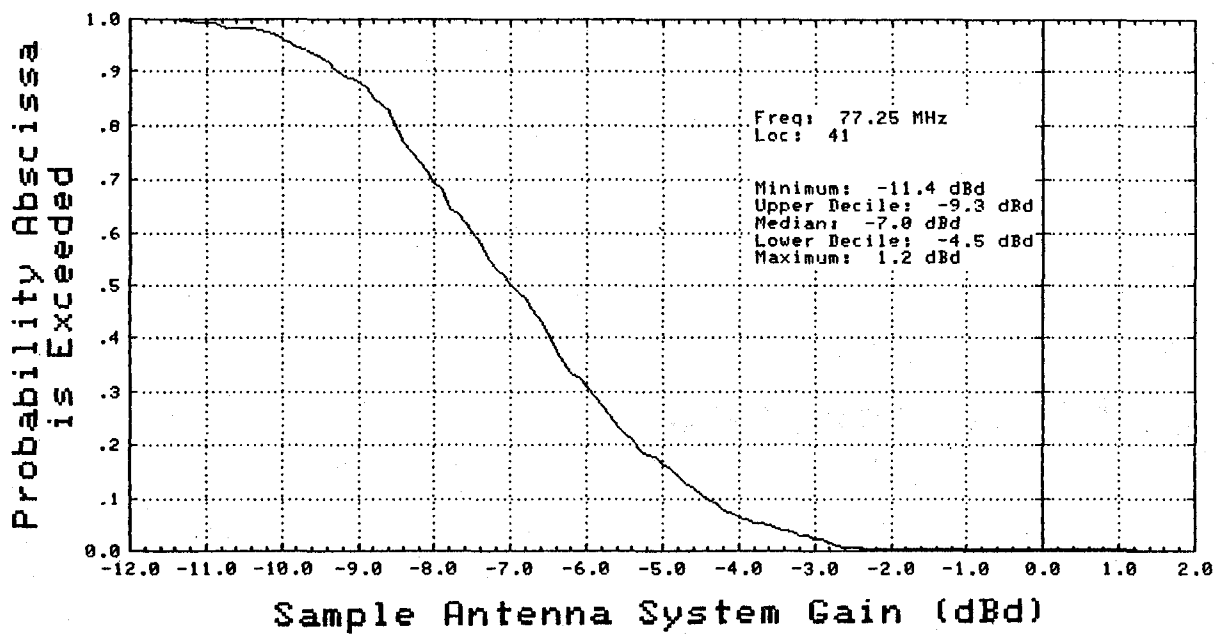


(b)

Figure A-89. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 40 at 501.25 MHz (a) and 537.25 MHz (b).

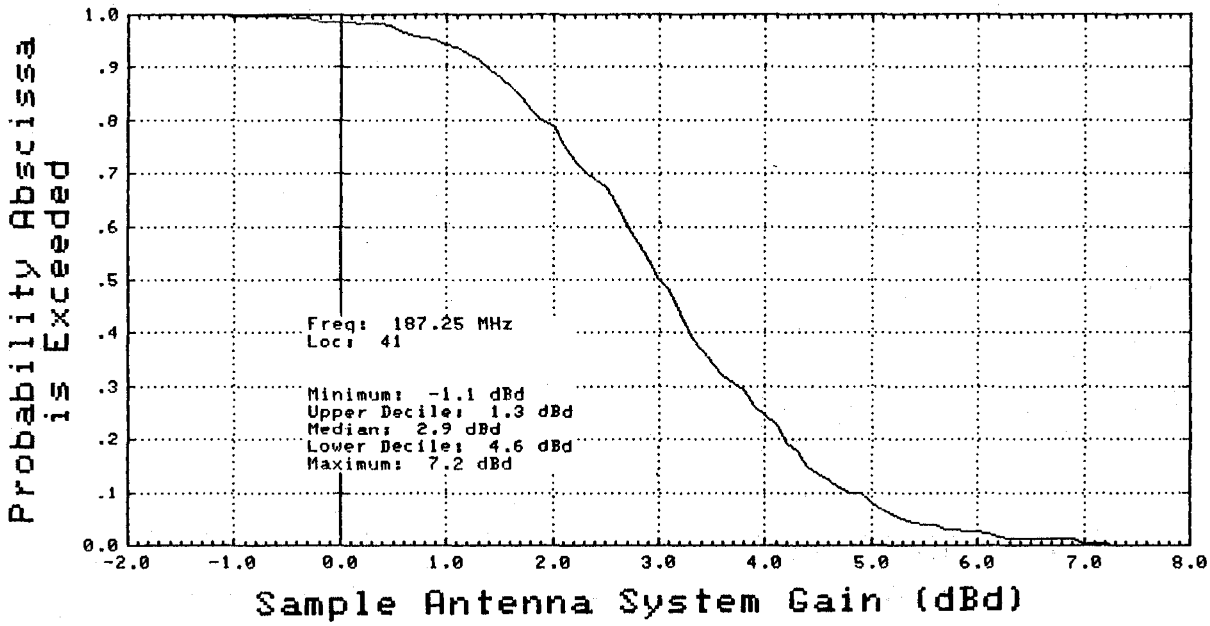


(a)

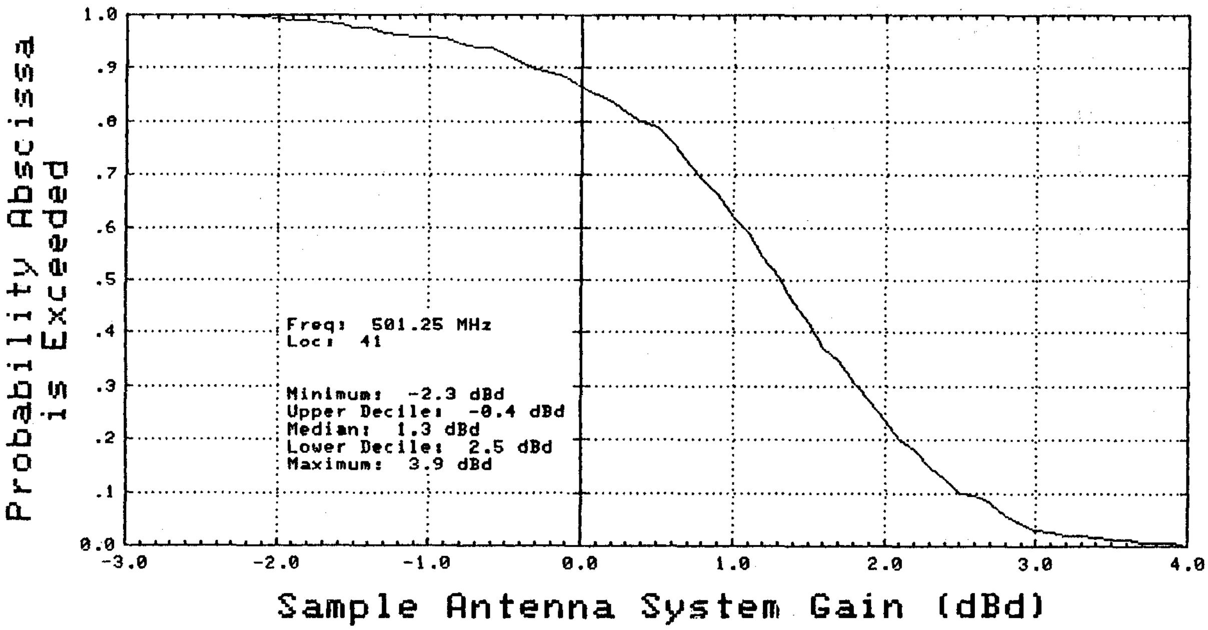


(b)

Figure A-90. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 40 at 573.25 MHz (a) and location 41 at 77.25 MHz (b).

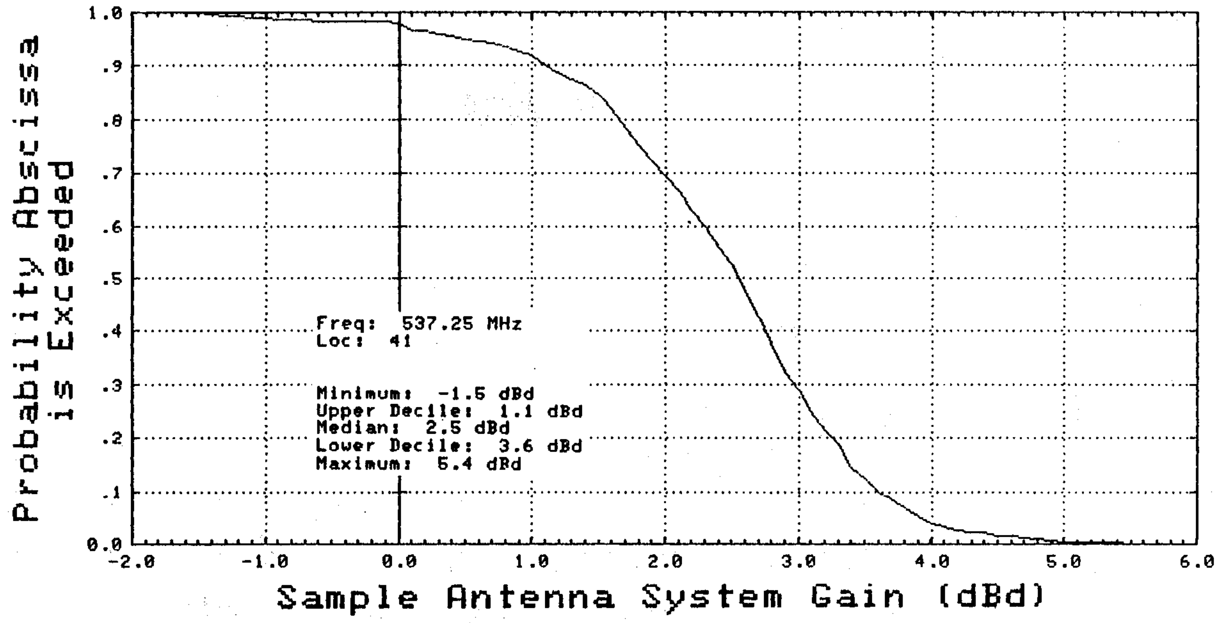


(a)

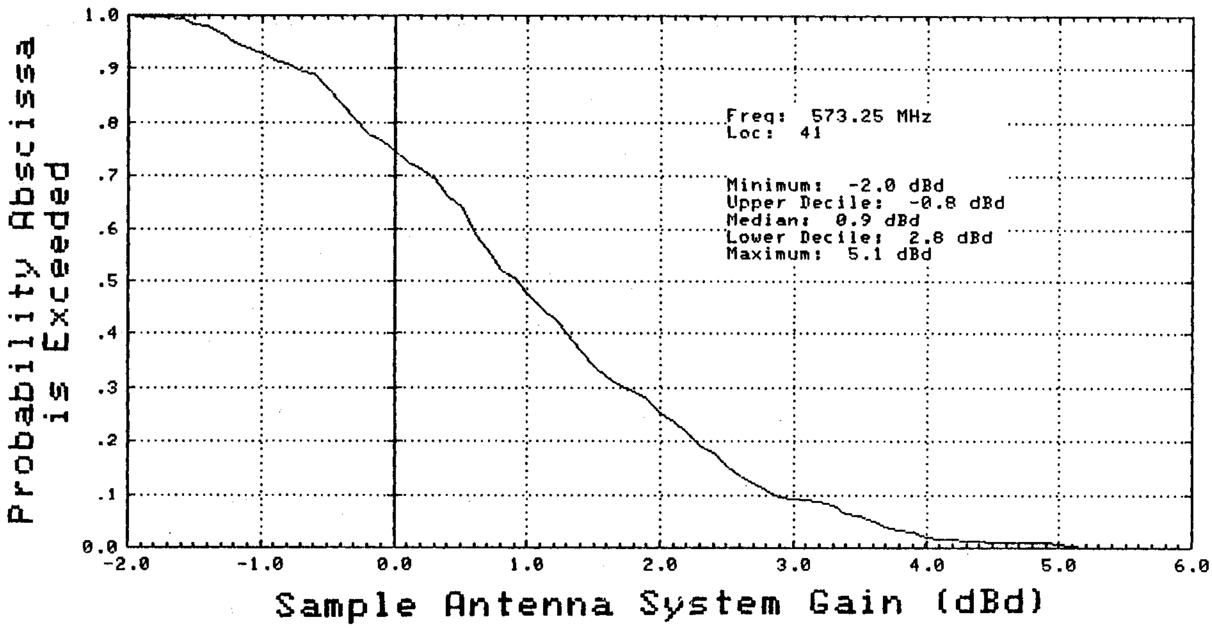


(b)

Figure A-91. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 41 at 187.25 MHz (a) and 501.25 MHz (b).

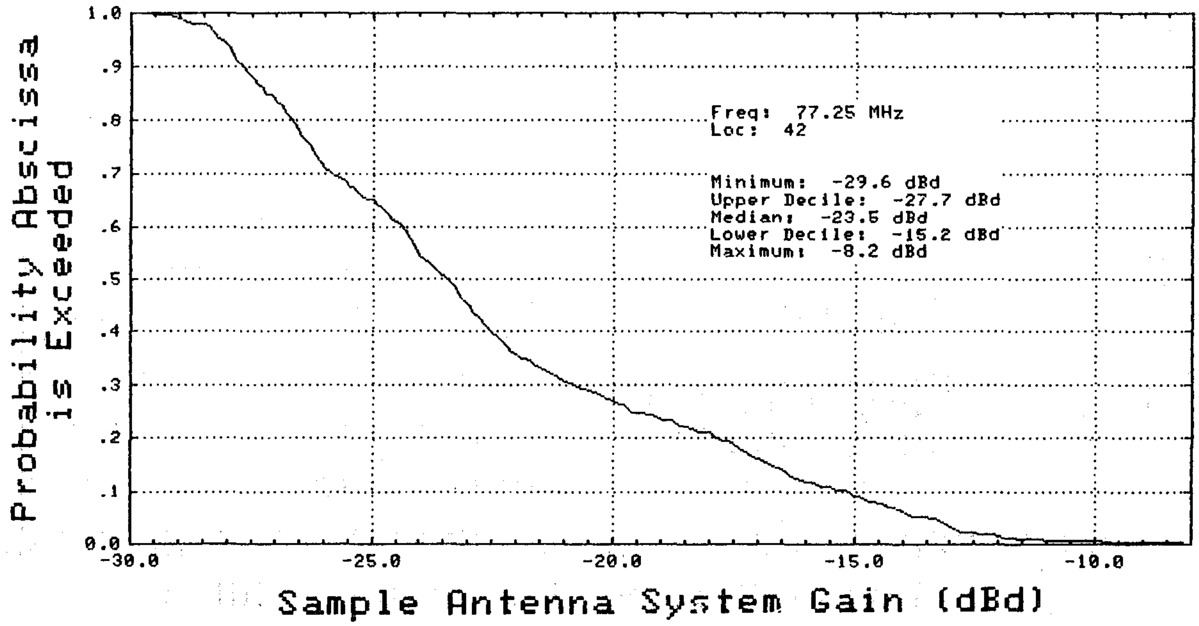


(a)

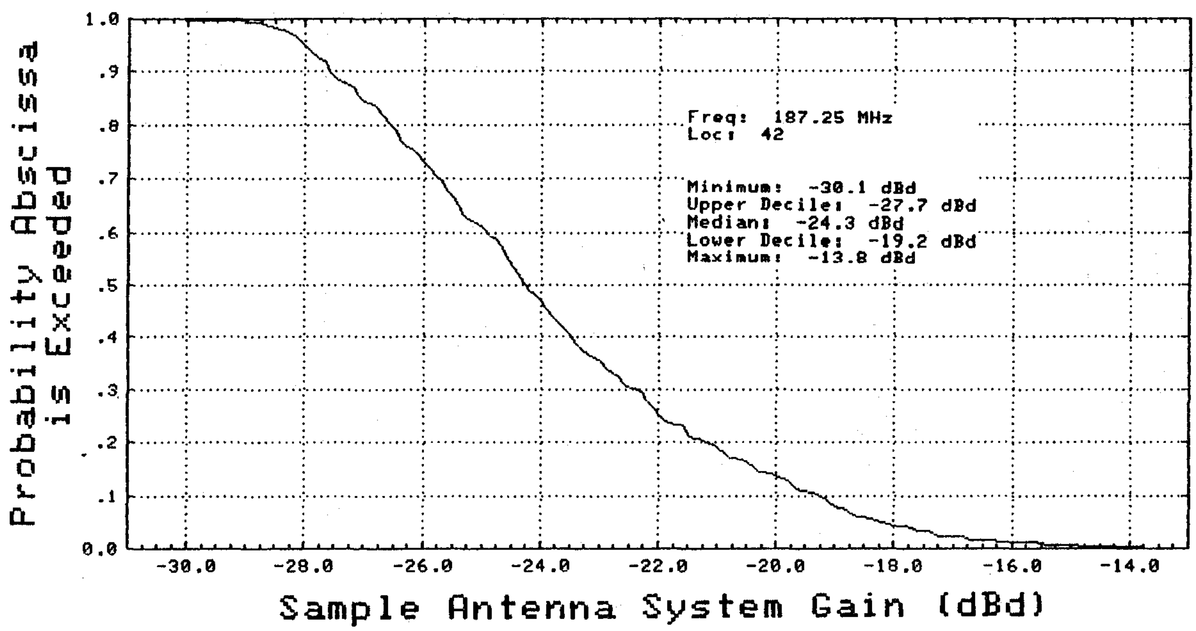


(b)

Figure A-92. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 41 at 537.25 MHz (a) and 573.25 MHz (b).

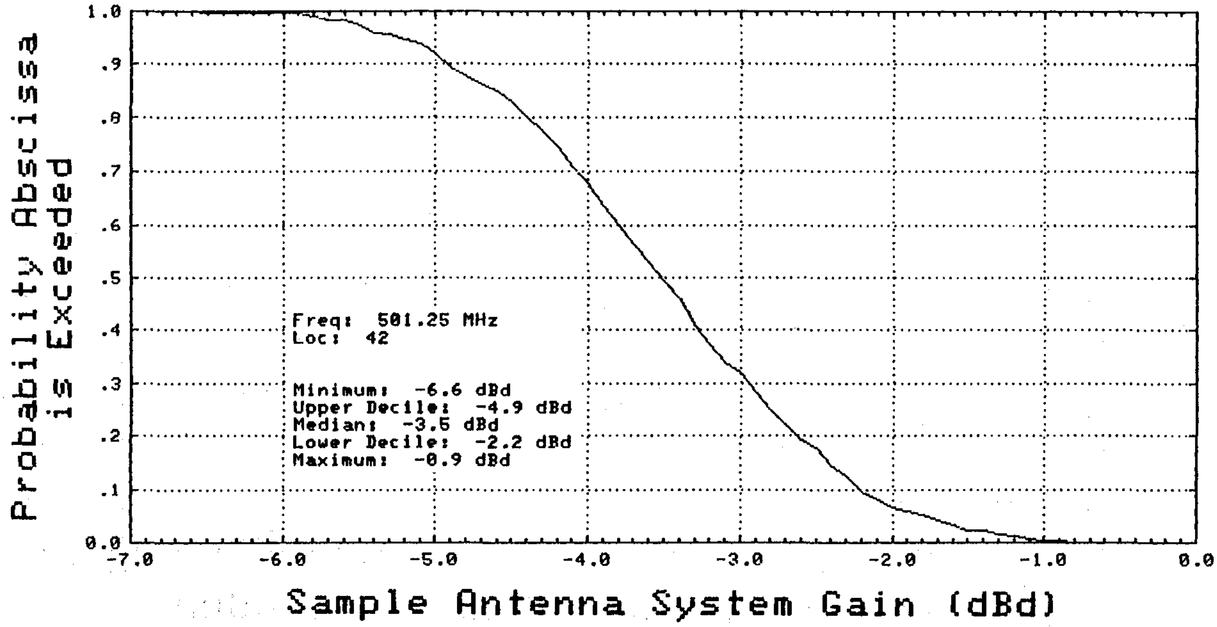


(a)

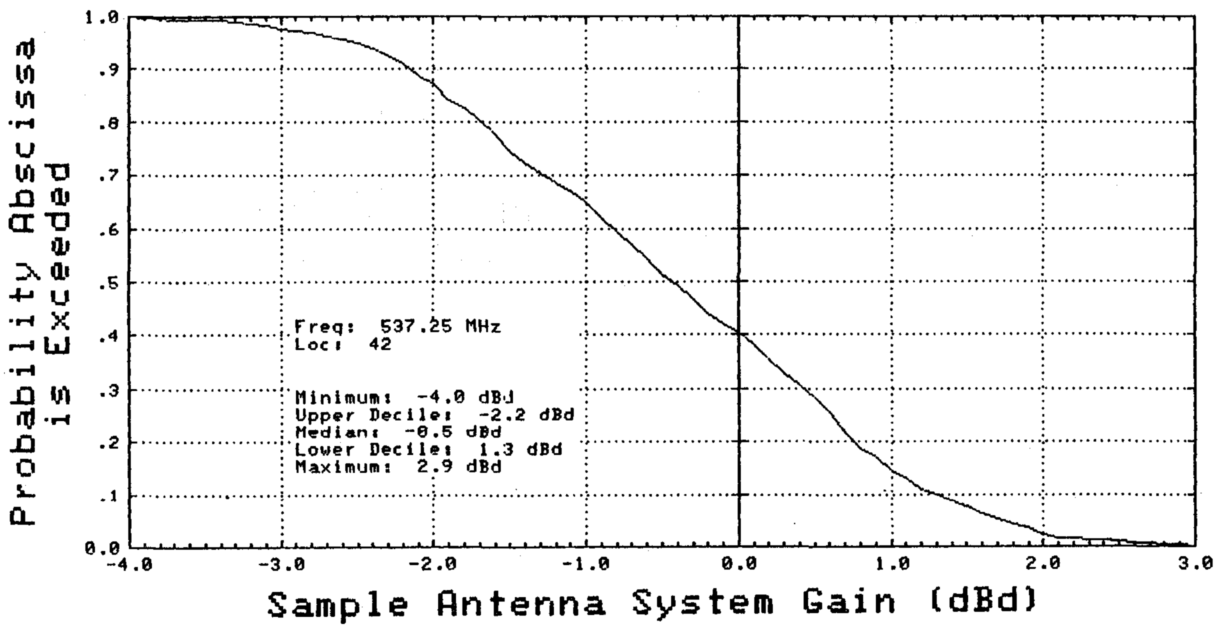


(b)

Figure A-93. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 42 at 77.25 MHz (a) and 187.25 MHz (b).

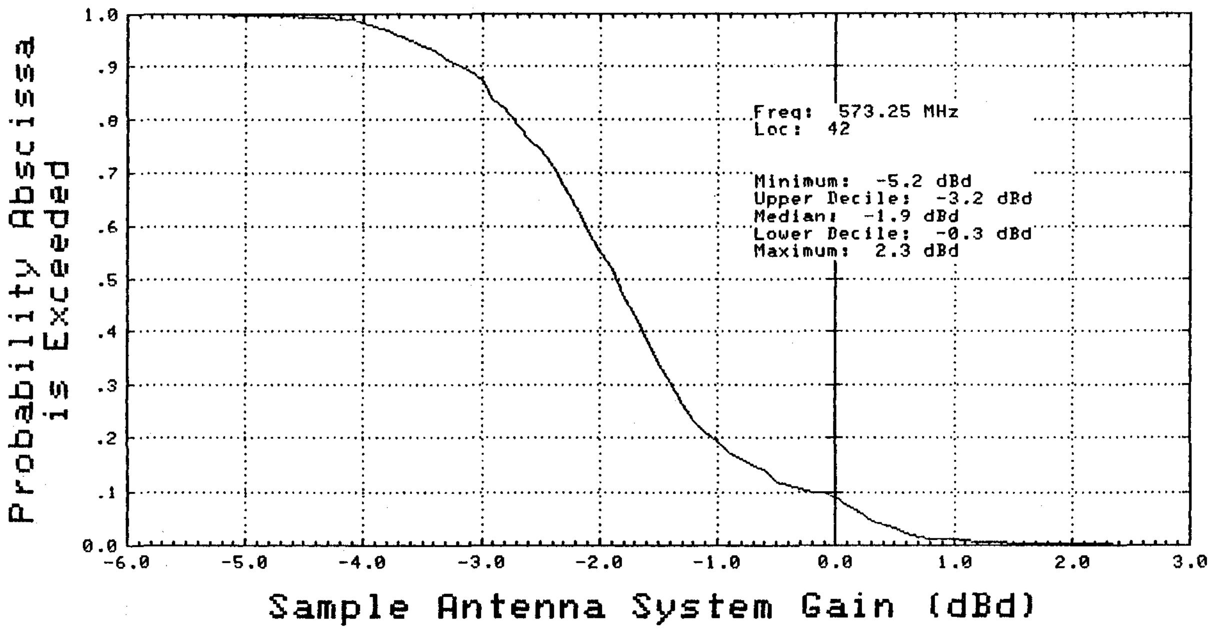


(a)

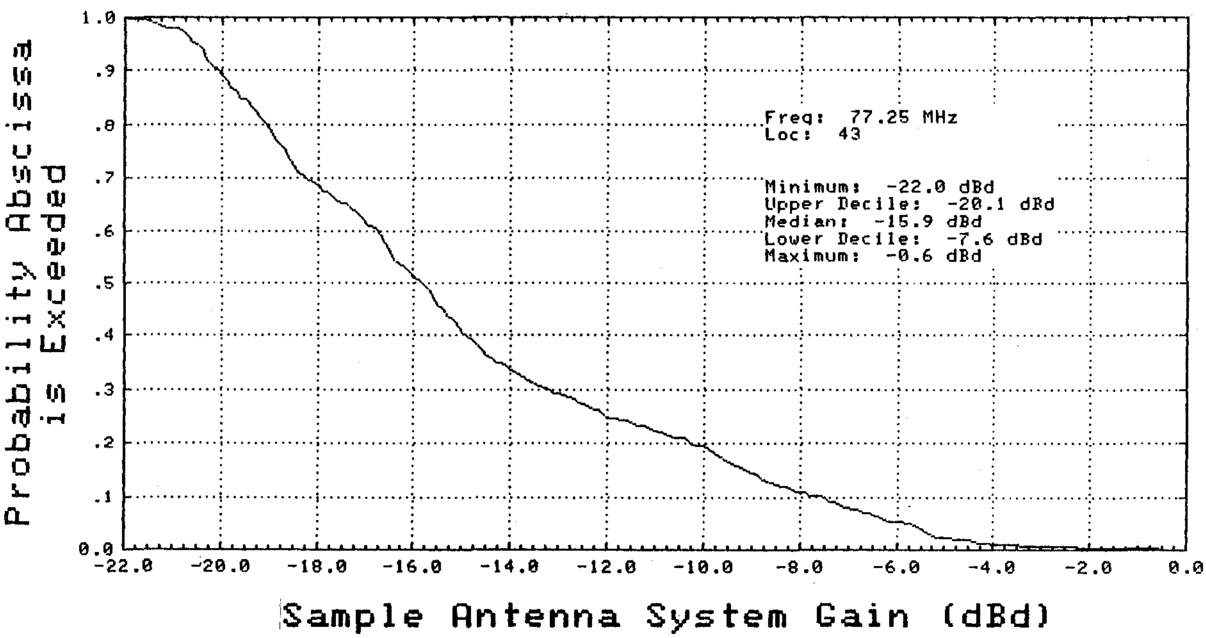


(b)

Figure A-94. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 42 at 501.25 MHz (a) and 537.25 MHz (b).

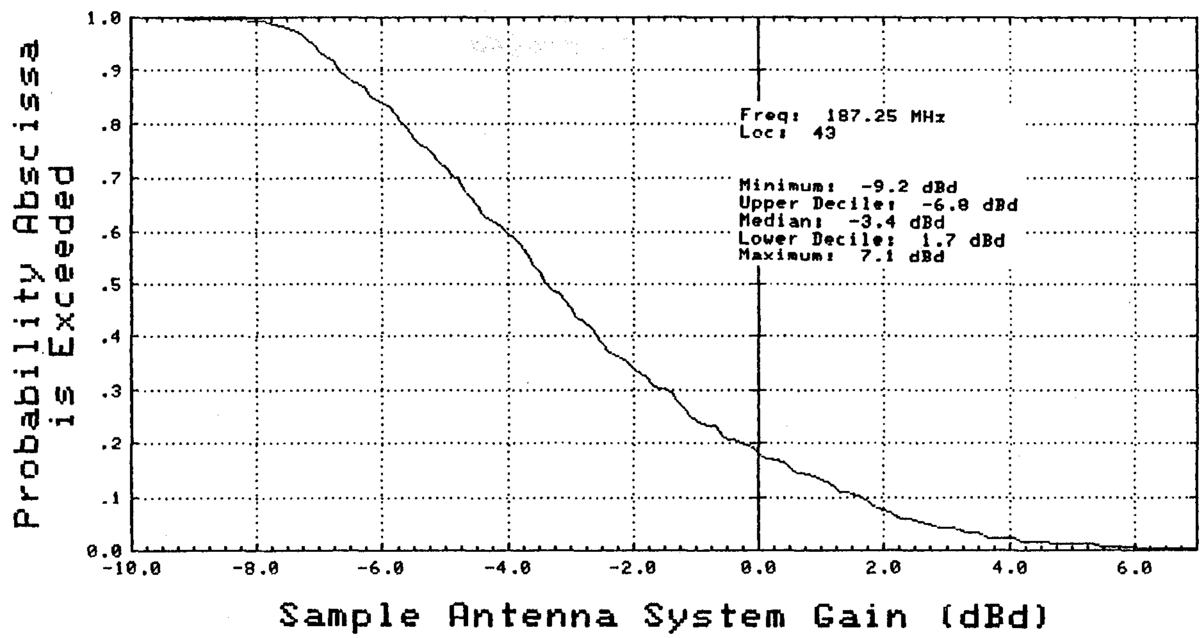


(a)

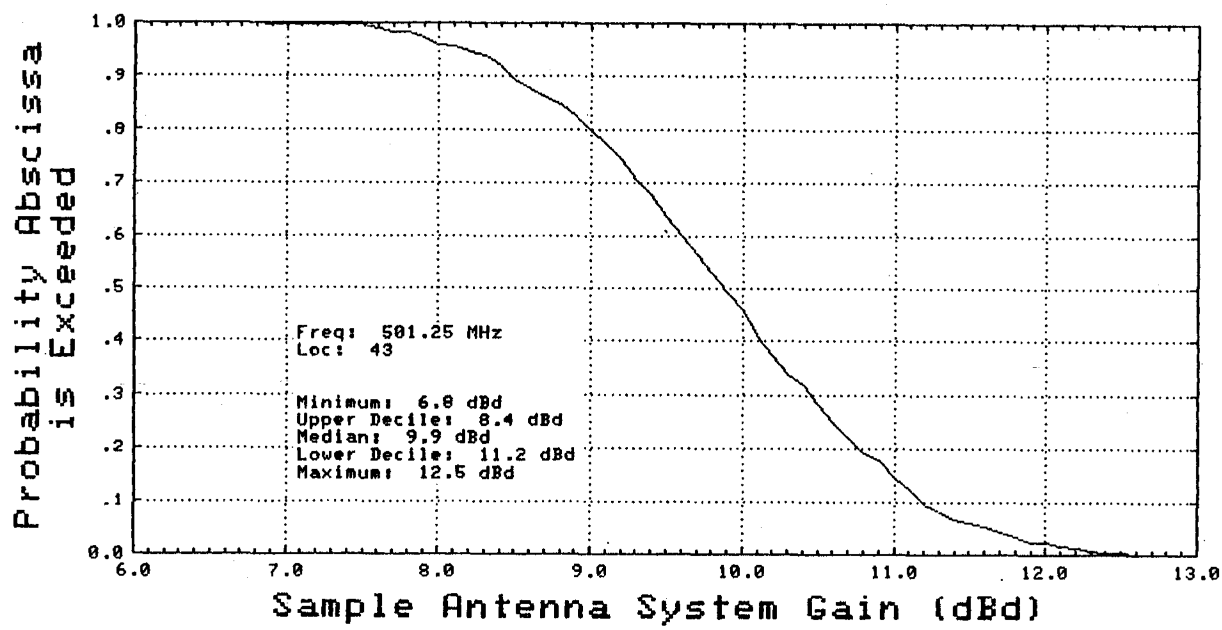


(b)

Figure A-95. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 42 at 573.25 MHz (a) and locaion 43 at 77.25 MHz (b).

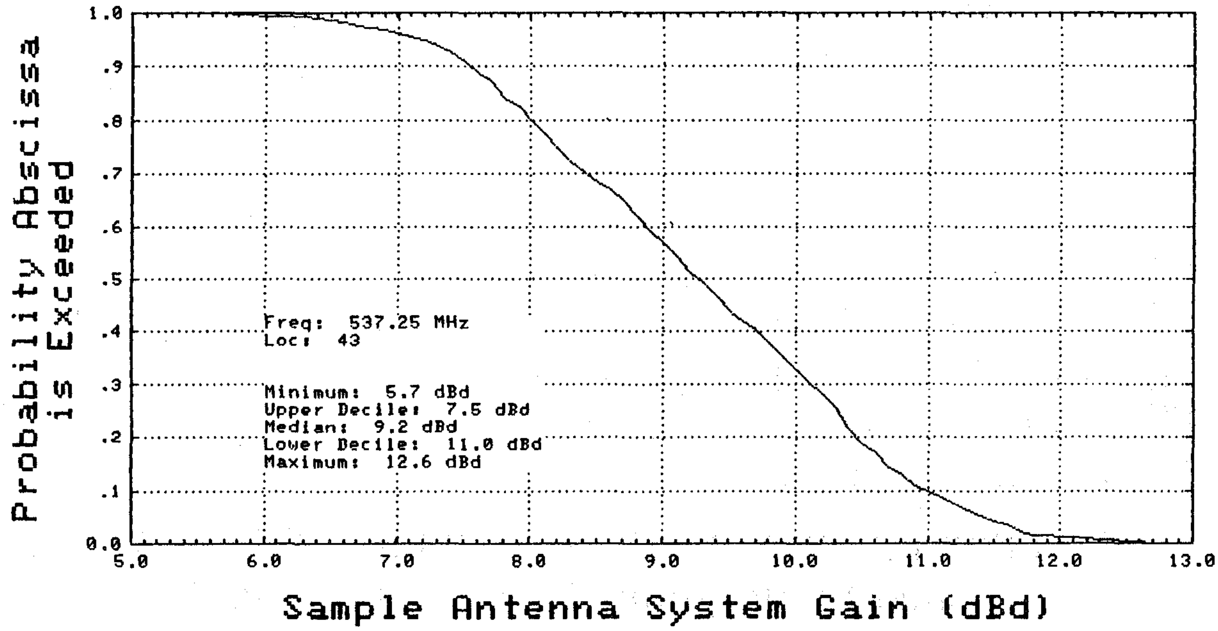


(a)

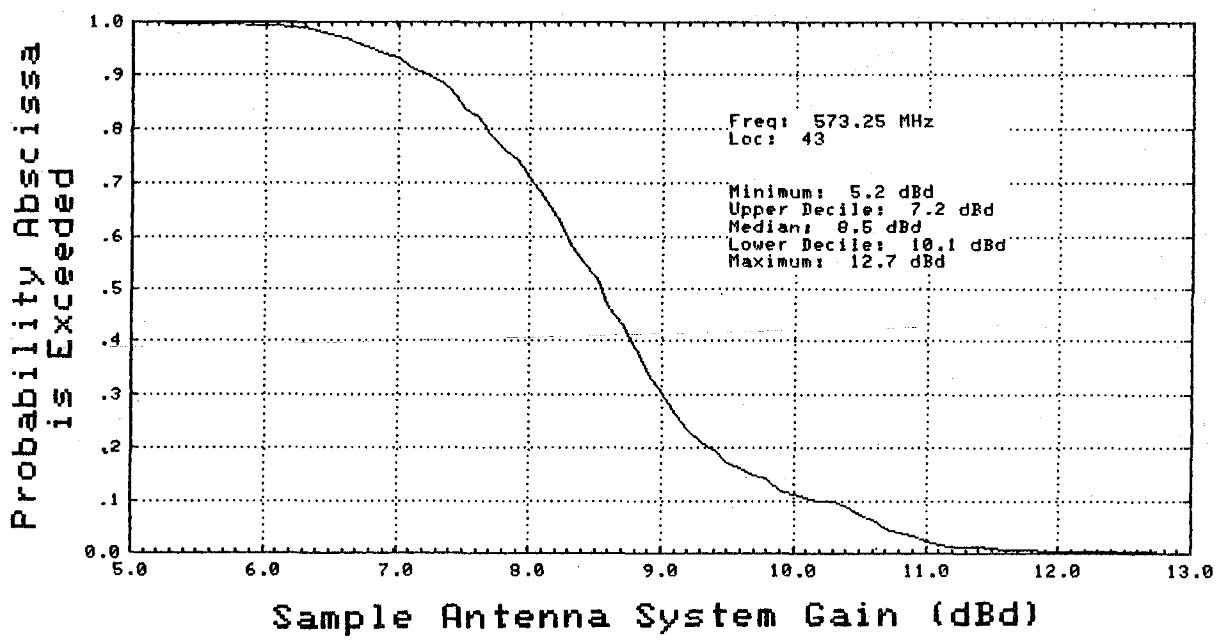


(b)

Figure A-96. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 43 at 187.25 MHz (a) and 501.25 MHz (b).

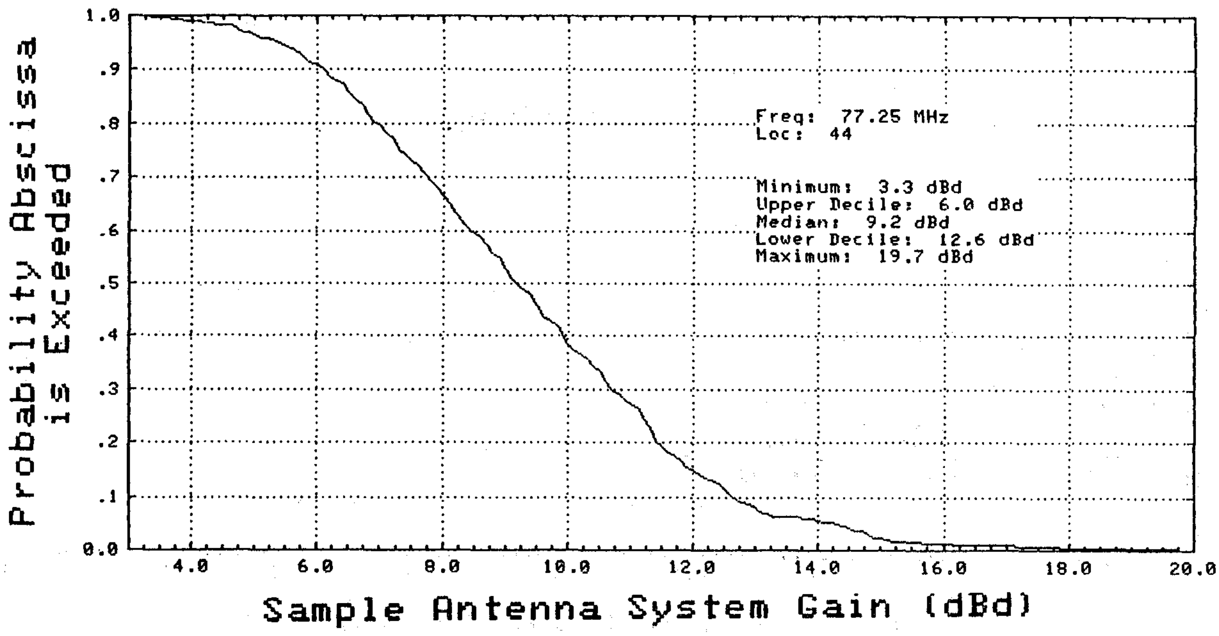


(a)

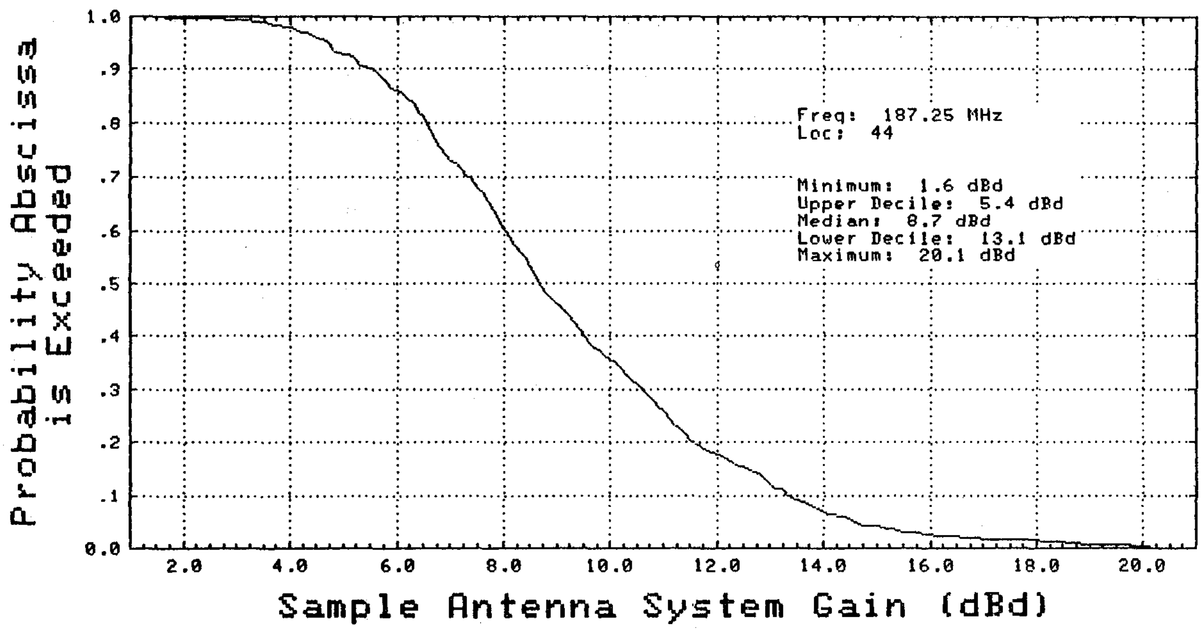


(b)

Figure A-97. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 43 at 537.25 MHz (a) and 573.25 MHz (b).

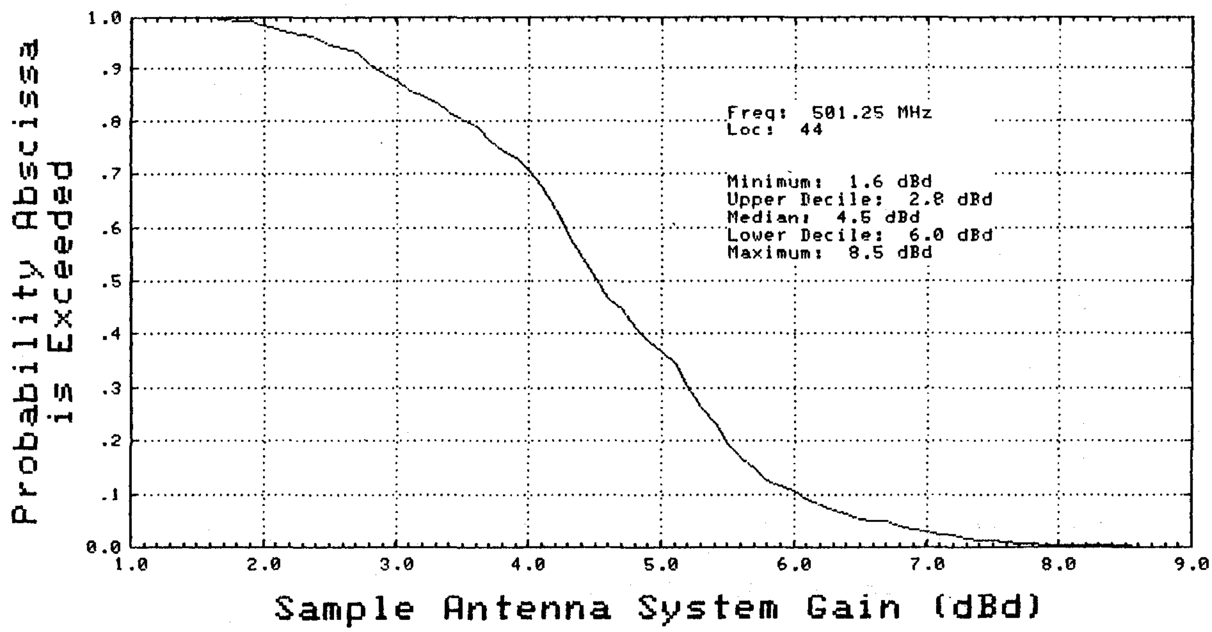


(a)

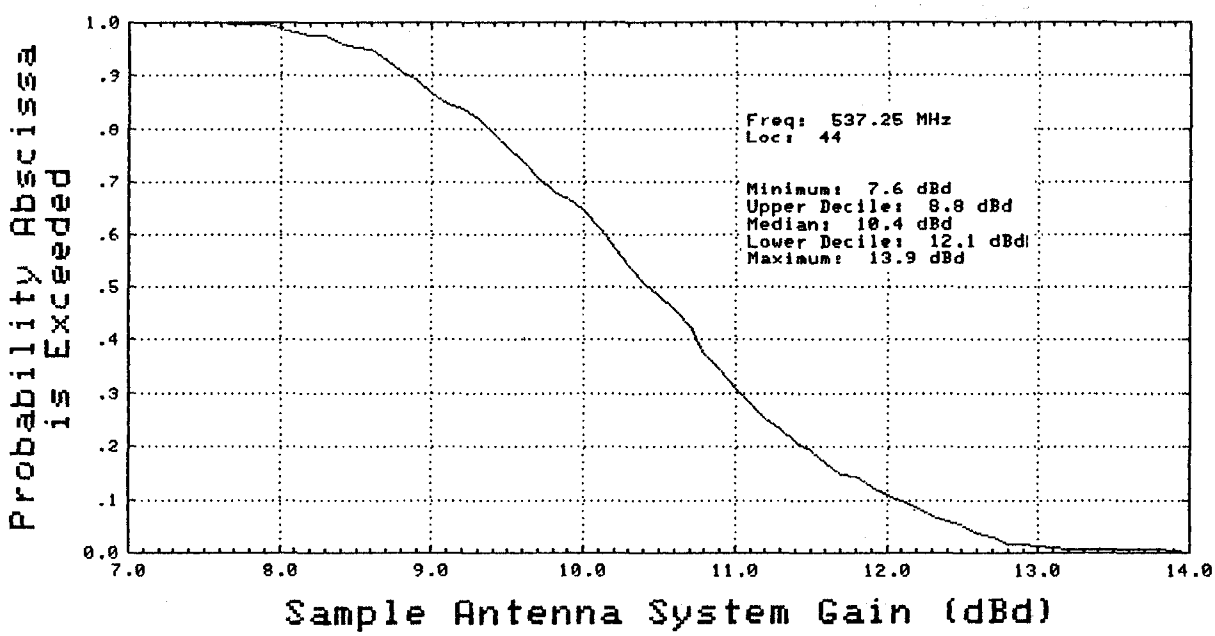


(b)

Figure A-98. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 44 at 77.25 MHz (a) and 187.25 MHz (b).

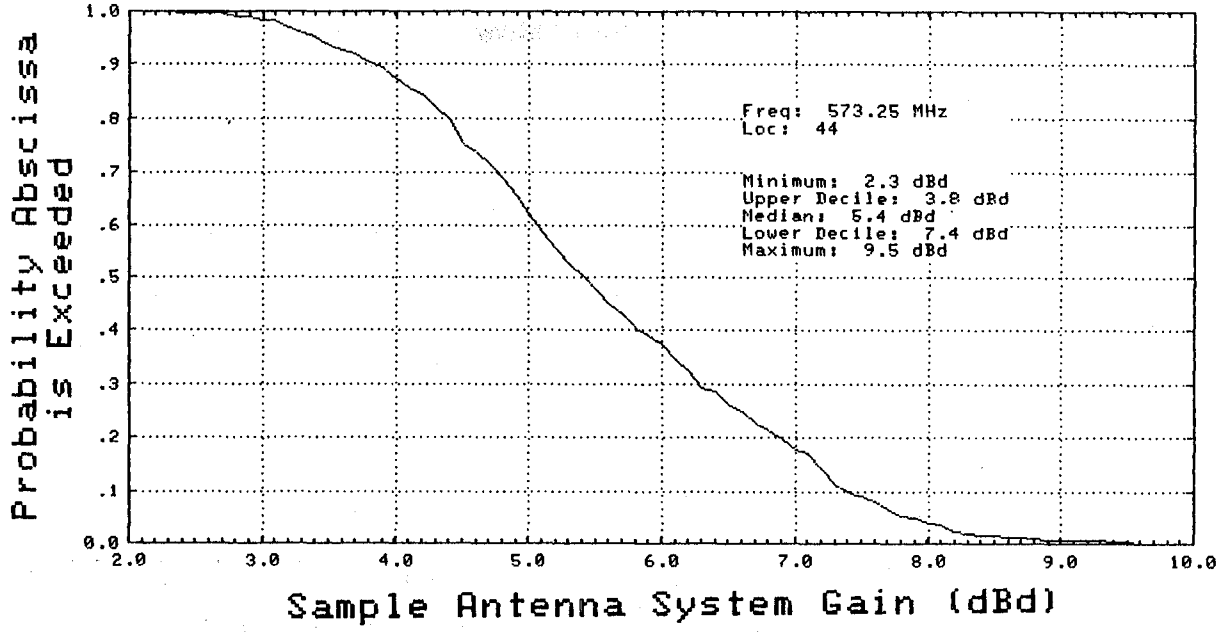


(a)

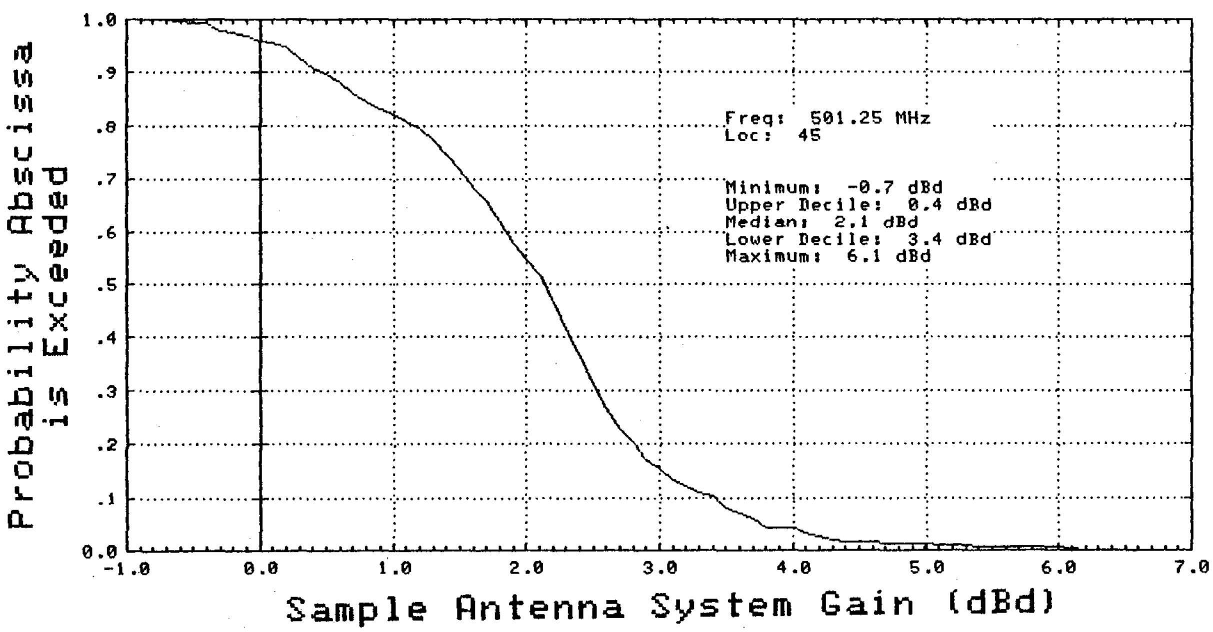


(b)

Figure A-99. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 44 at 501.25 MHz (a) and 537.25 MHz (b).

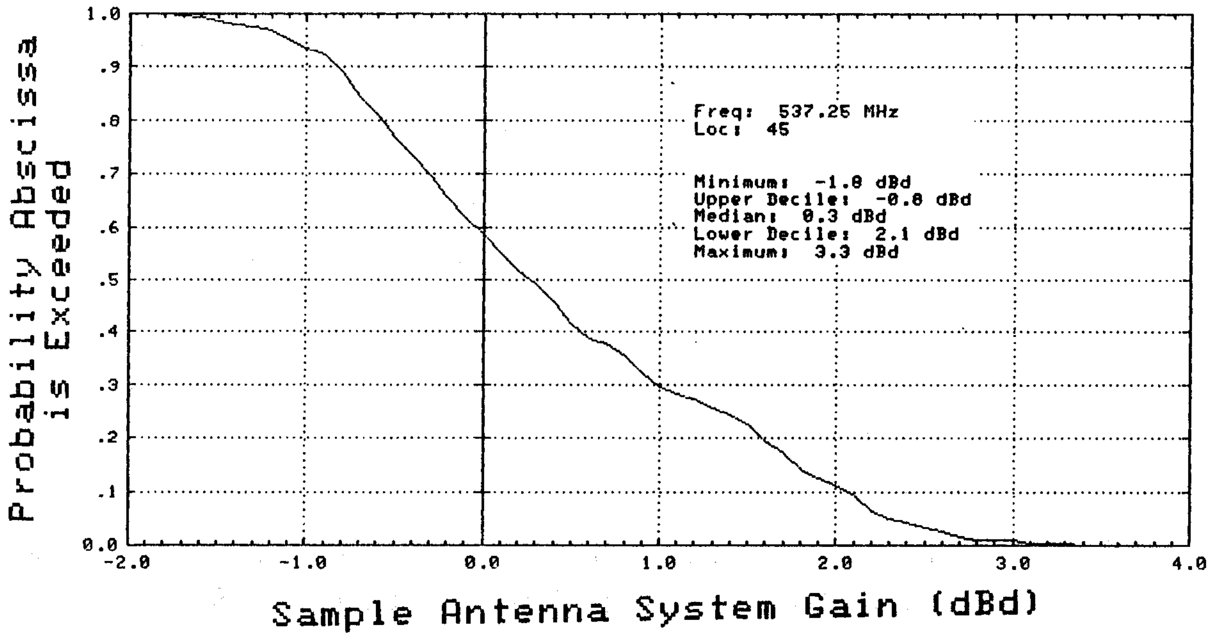


(a)

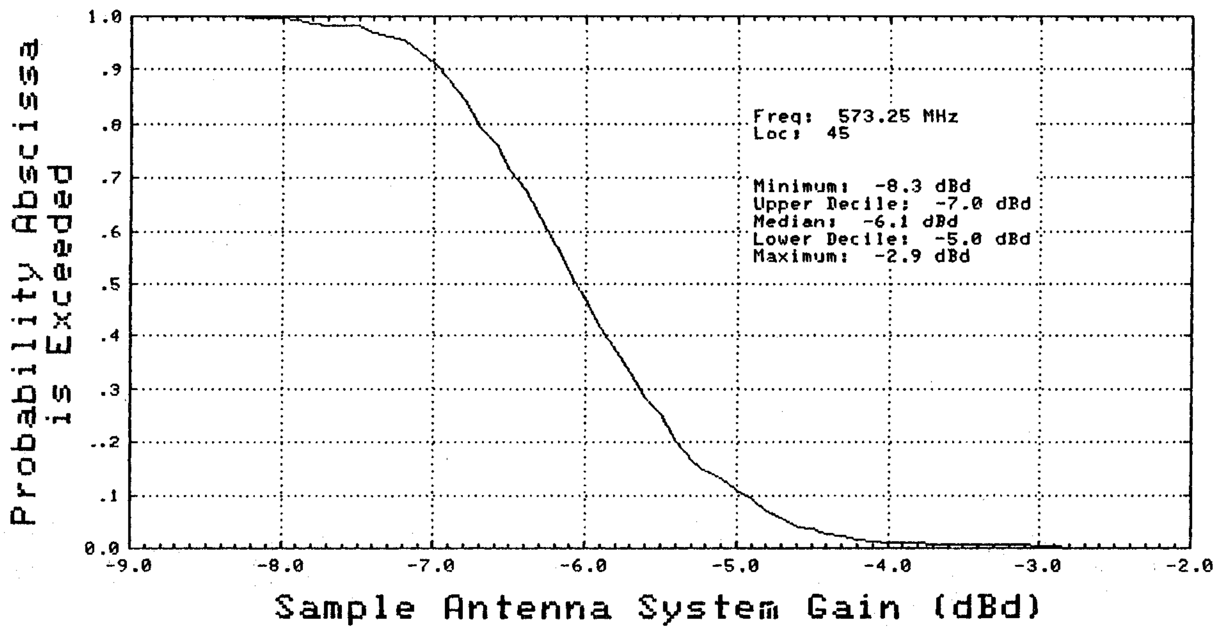


(b)

Figure A-100. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 44 at 573.25 MHz (a) and location 45 at 501.25 MHz (b).

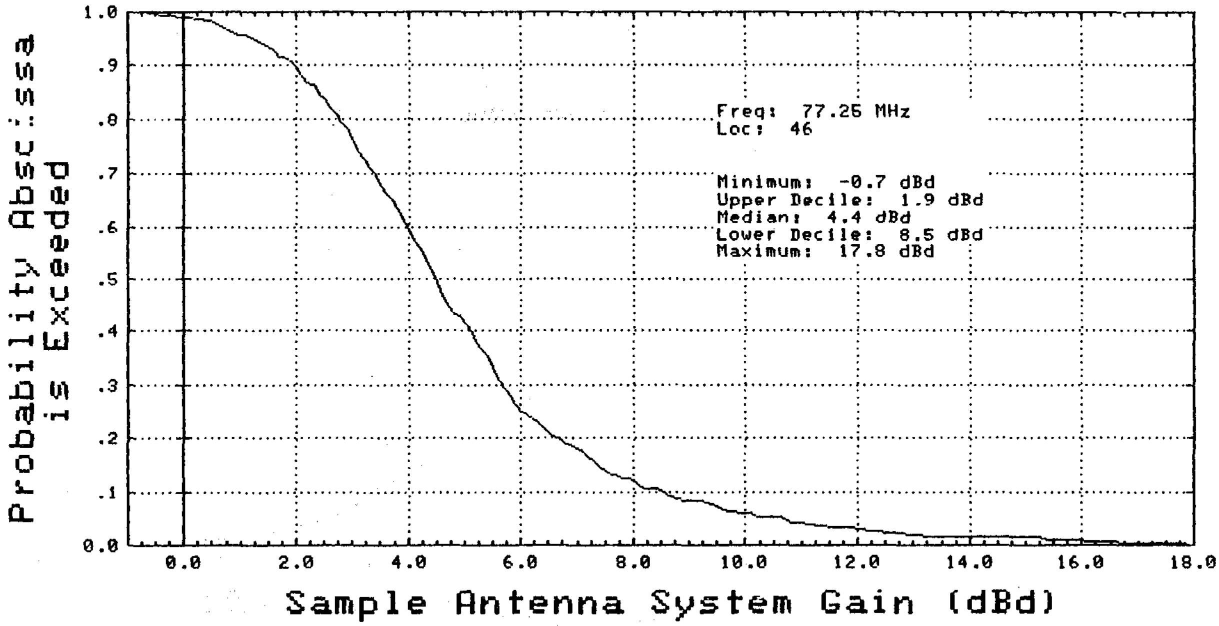


(a)

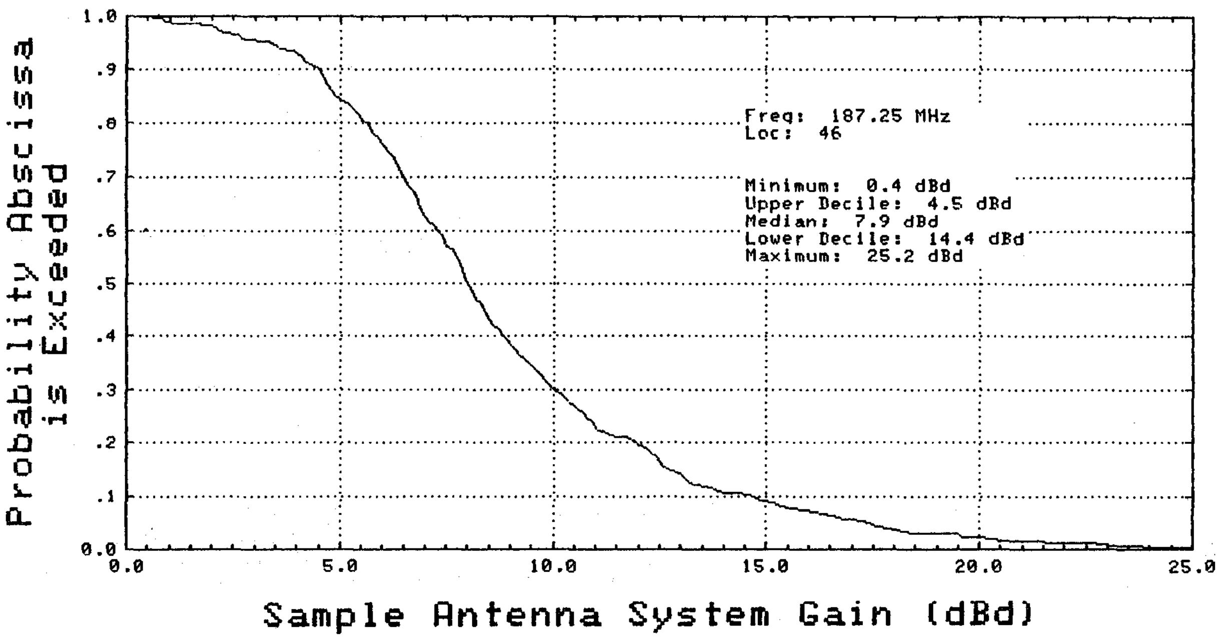


(b)

Figure A-101. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 45 at 537.25 MHz (a) and 573.25 MHz (b).

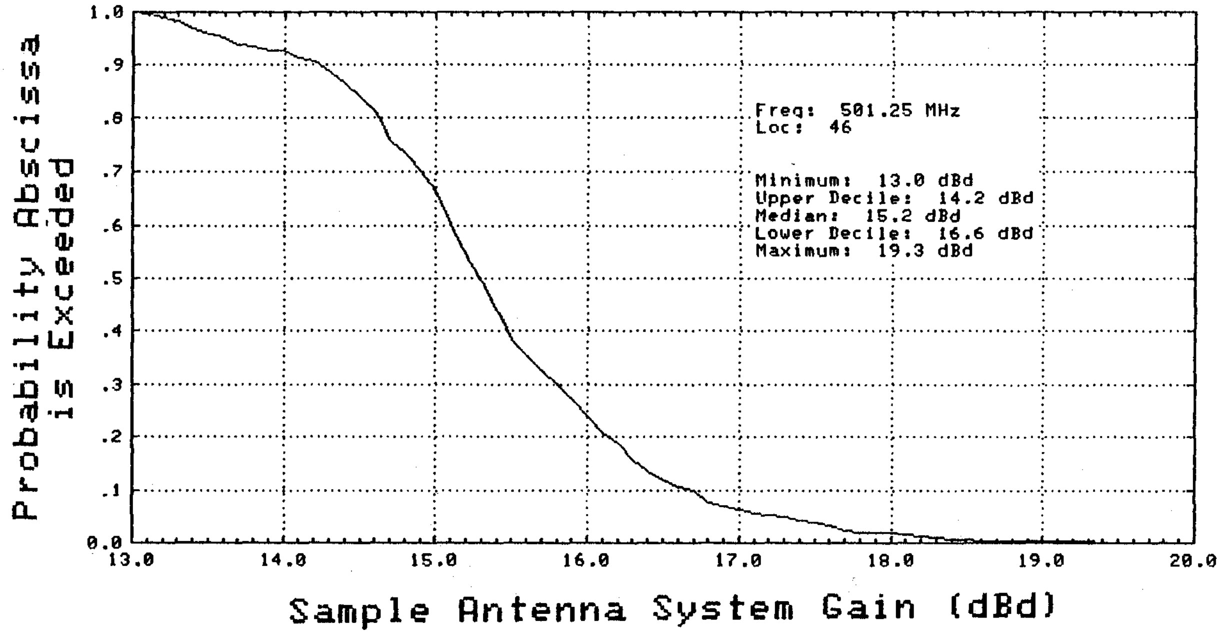


(a)

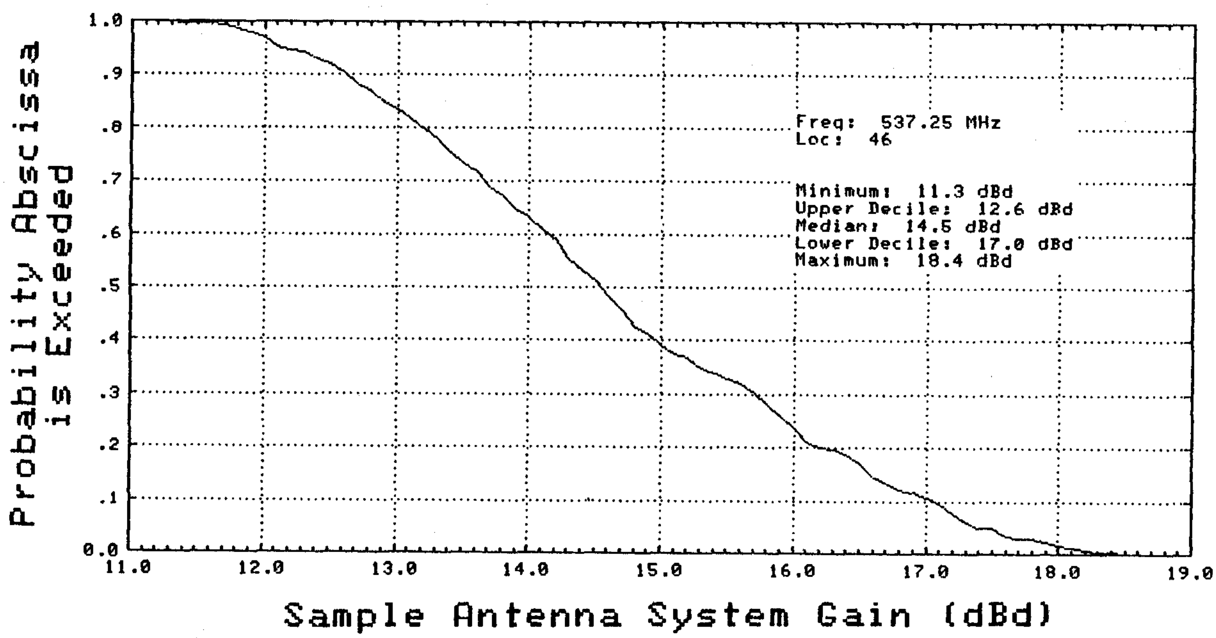


(b)

Figure A-102. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 46 at 77.25 MHz (a) and 187.25 MHz (b).

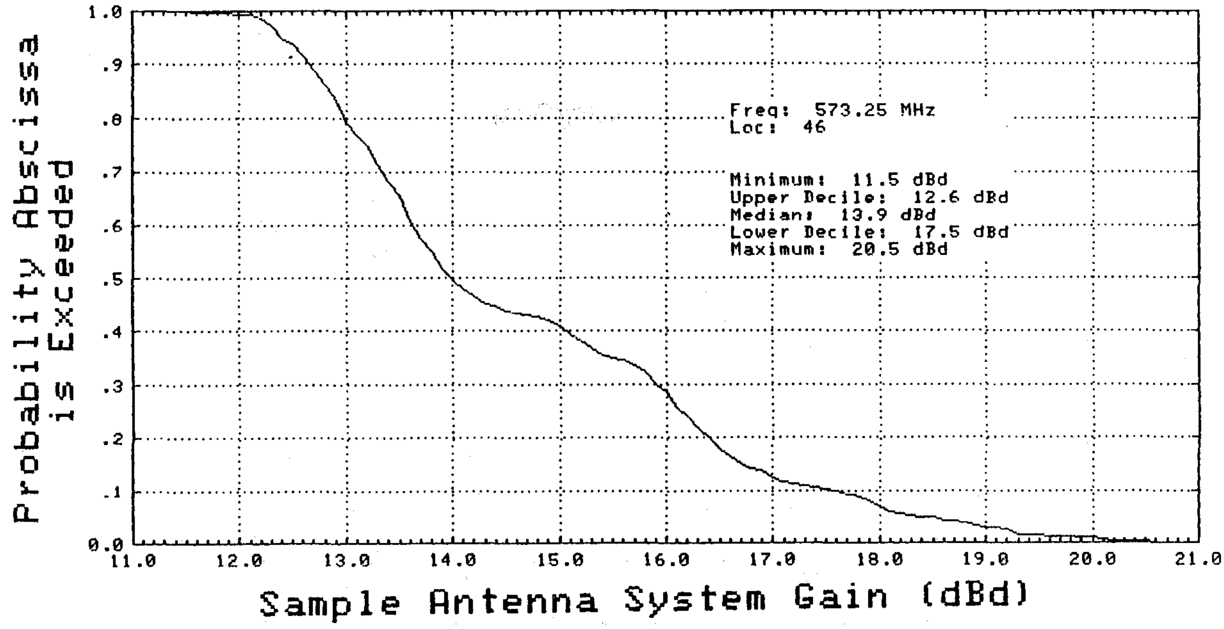


(a)

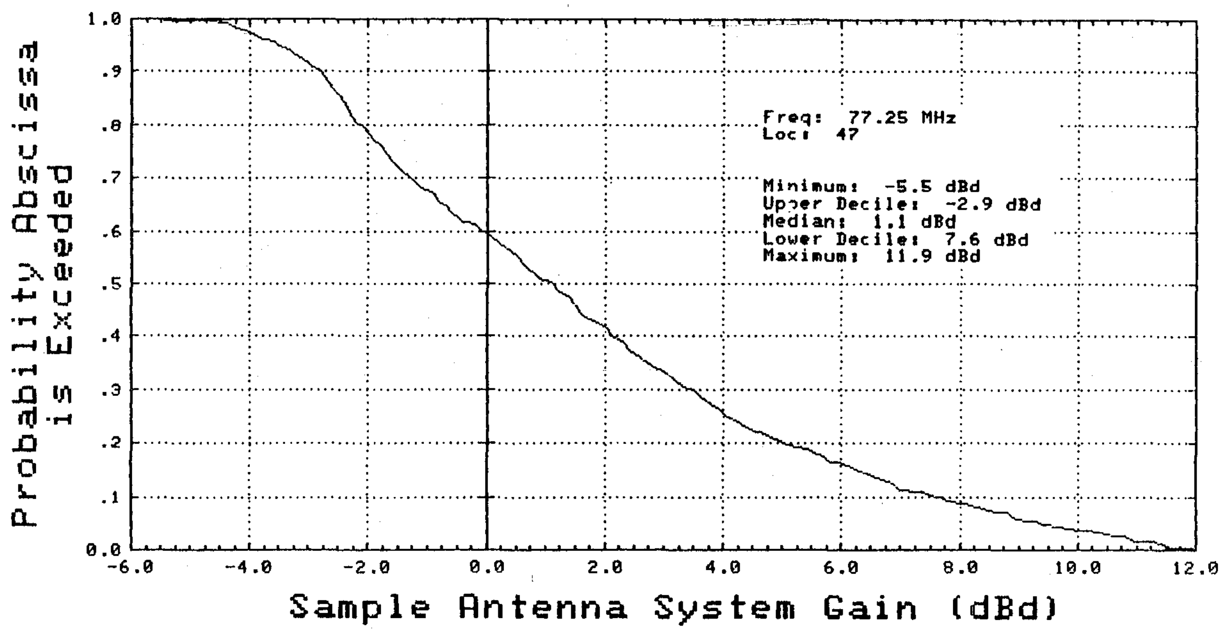


(b)

Figure A-103. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 46 at 501.25 MHz (a) and 537.25 MHz (b).

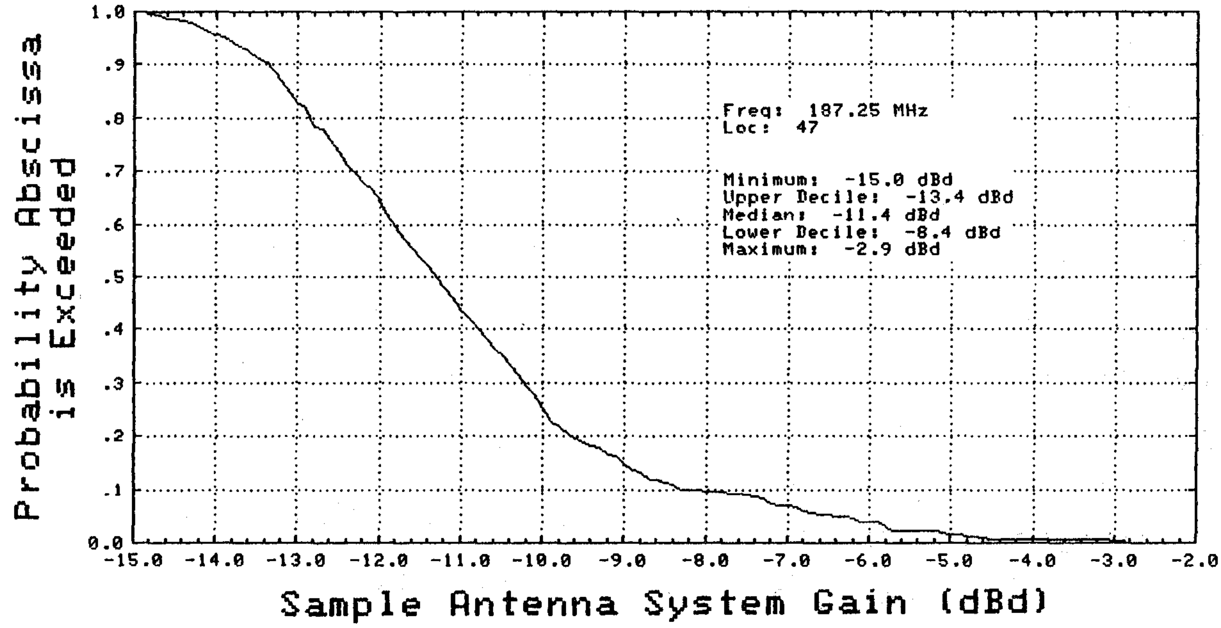


(a)

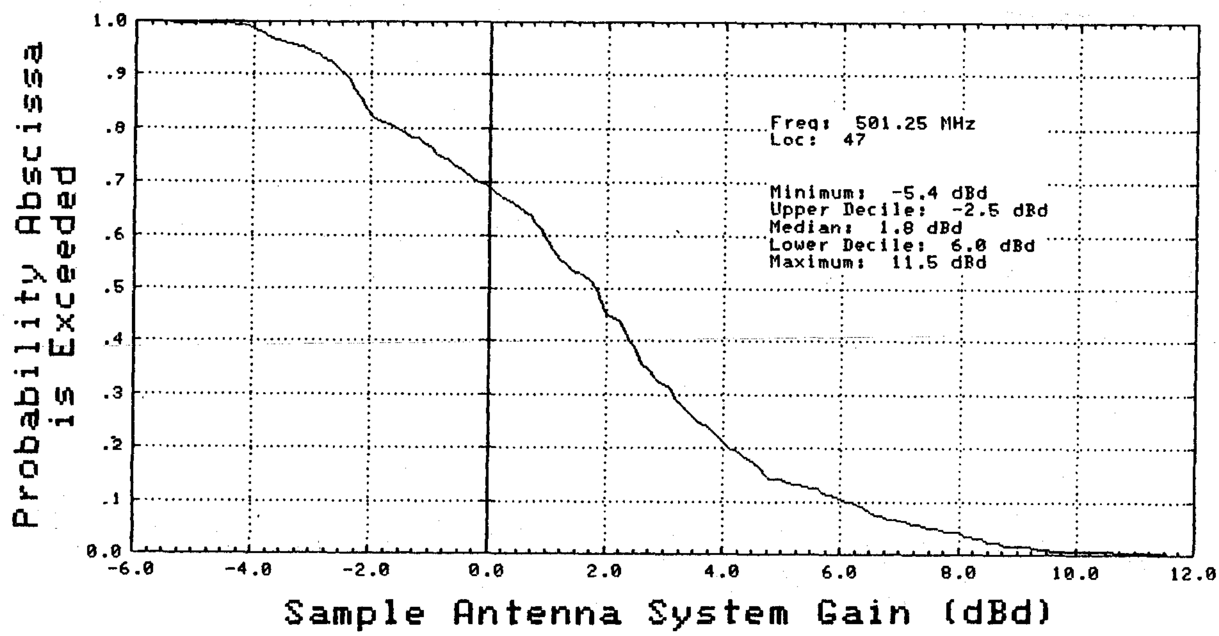


(b)

Figure A-104. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 46 at 573.25 MHz (a) and location 47 at 77.25 MHz (b).

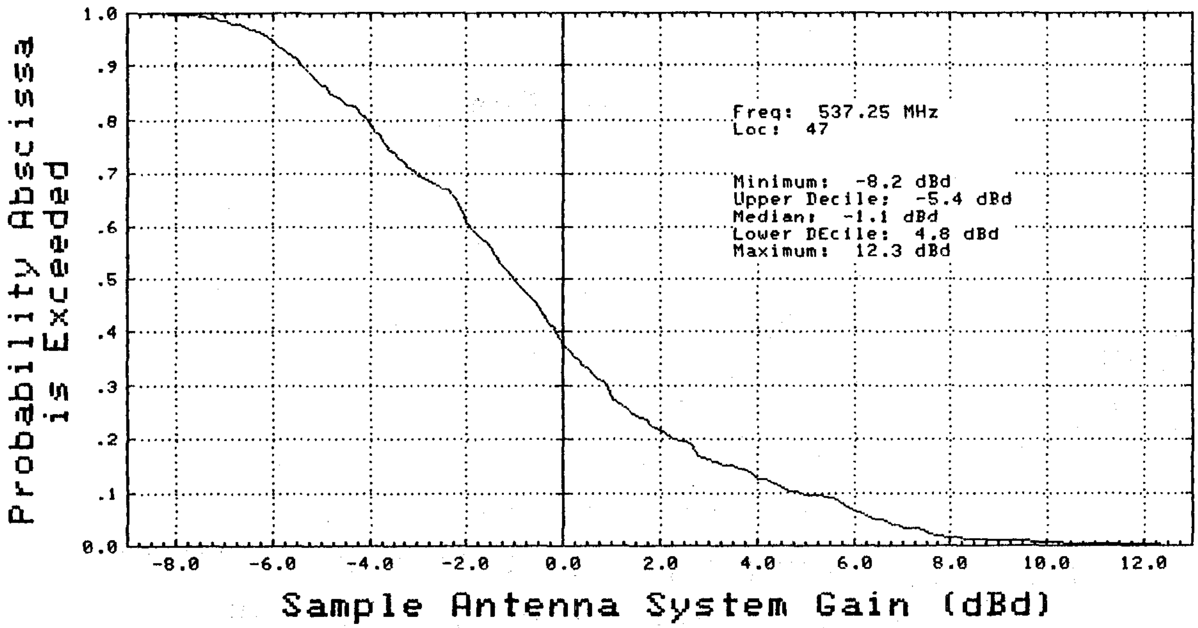


(a)

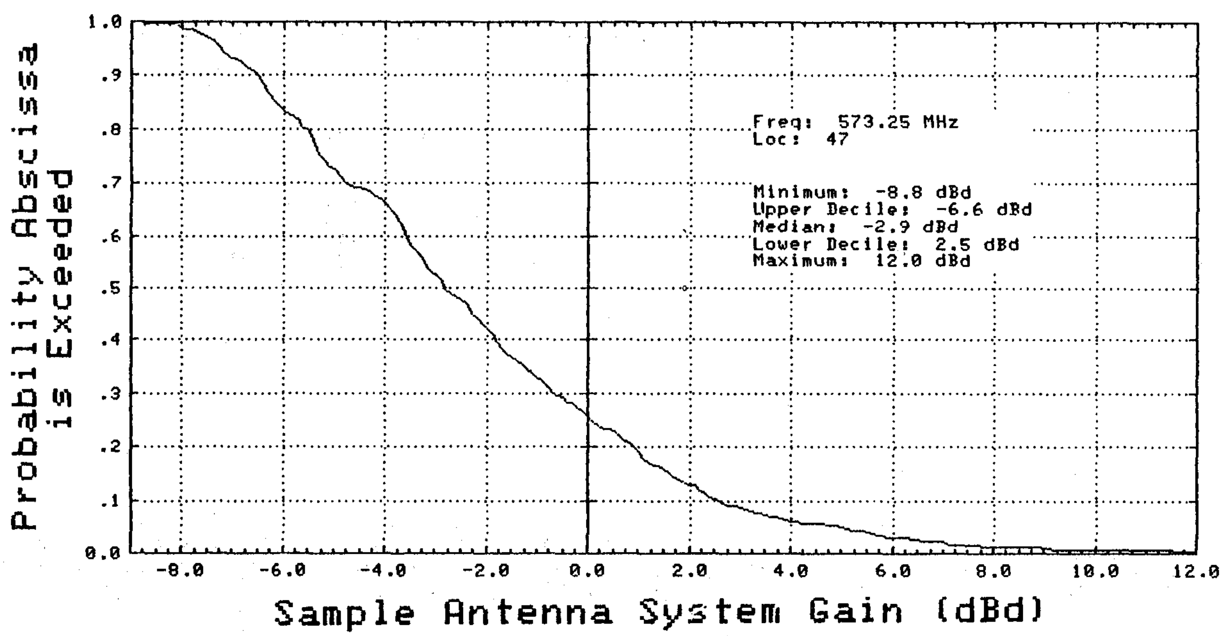


(b)

Figure A-105. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 47 at 187.25 MHz (a) and 501.25 MHz (b).

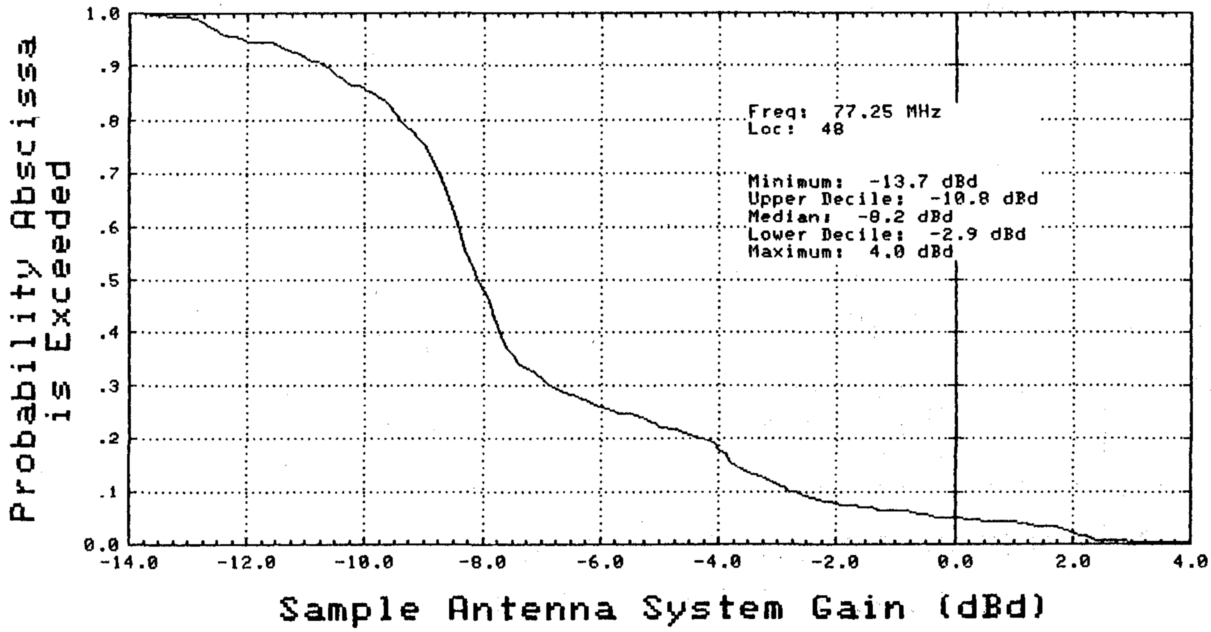


(a)

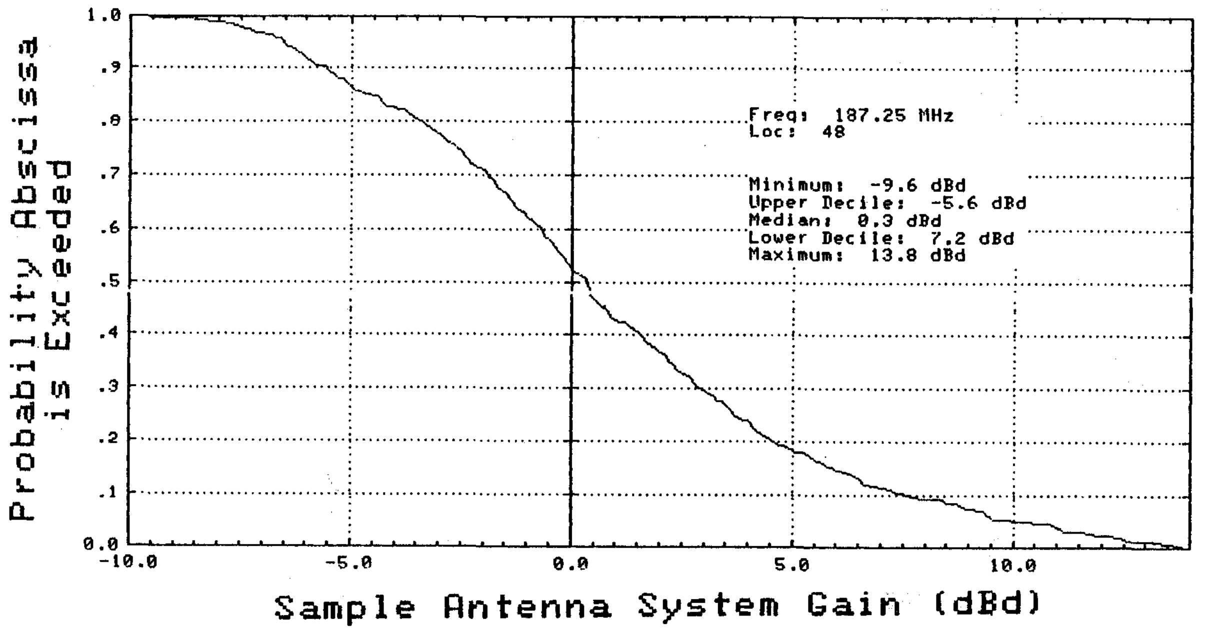


(b)

Figure A-106. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 47 at 537.25 MHz (a) and 573.25 MHz (b).

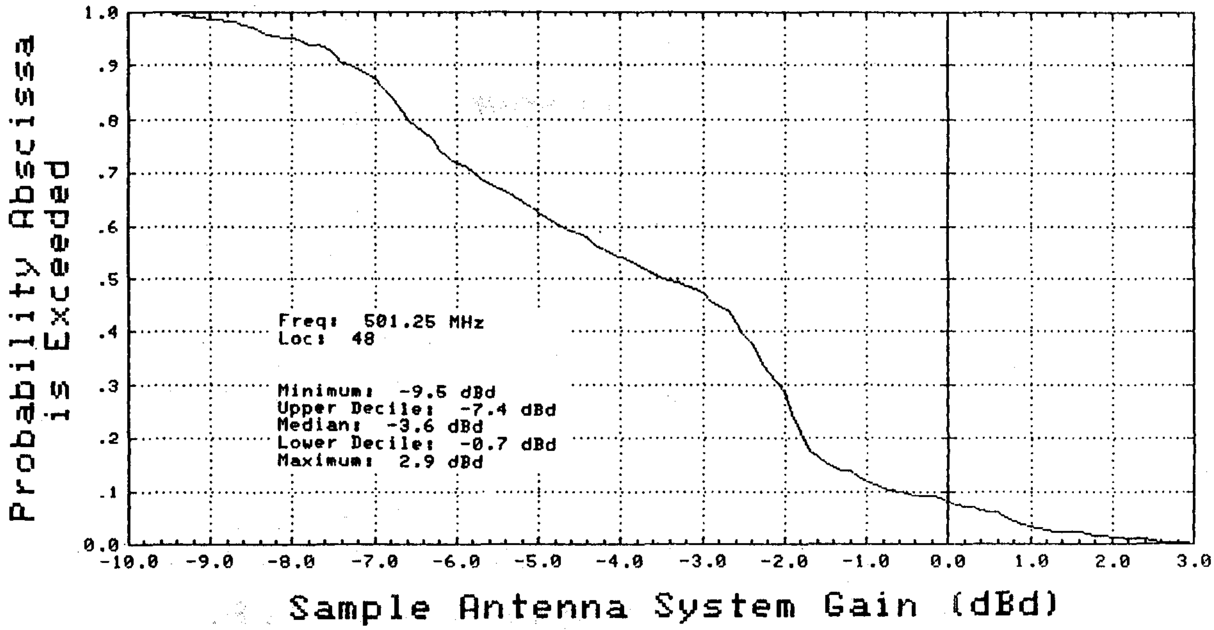


(a)

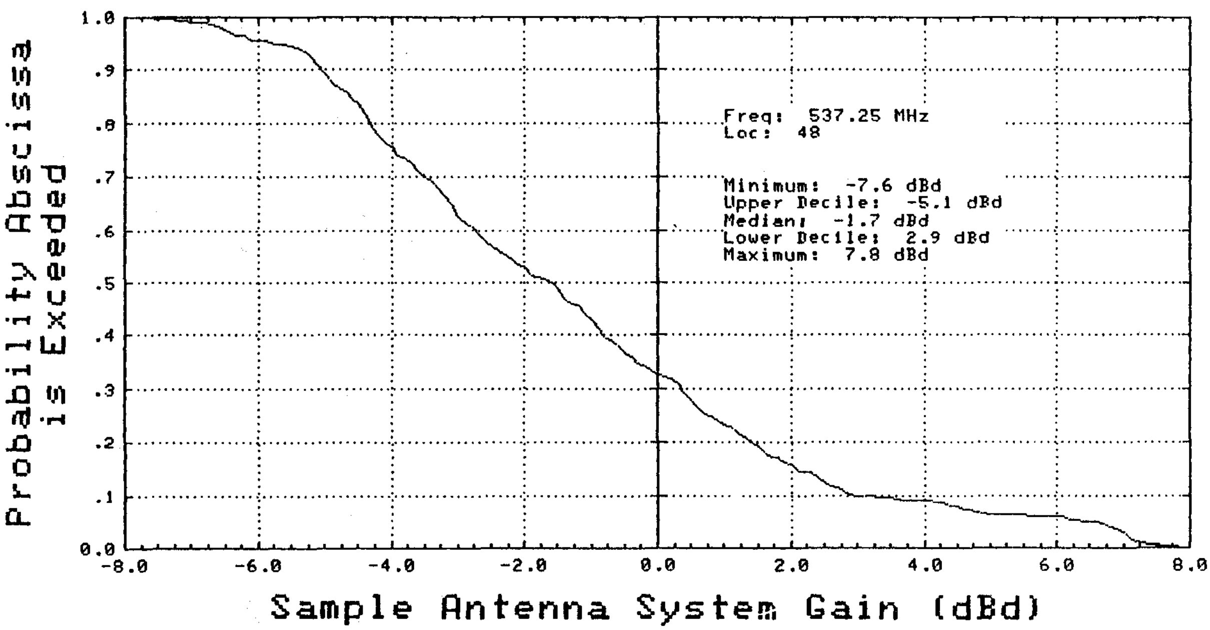


(b)

Figure A-107. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 48 at 77.25 MHz (a) and 187.25 MHz (b).

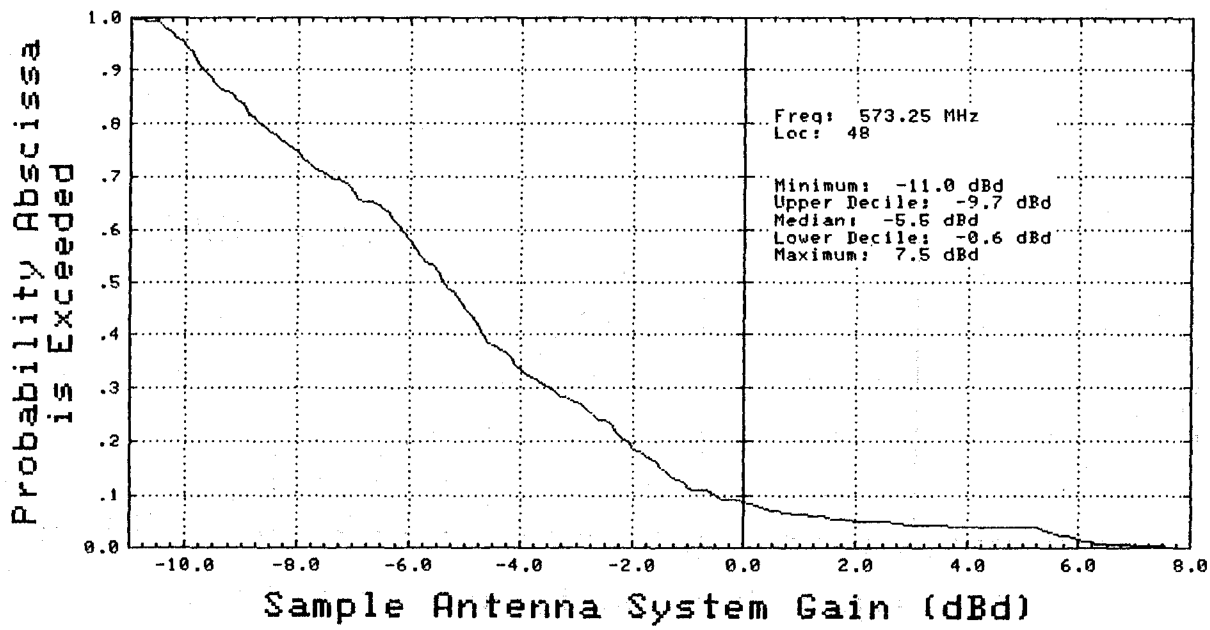


(a)

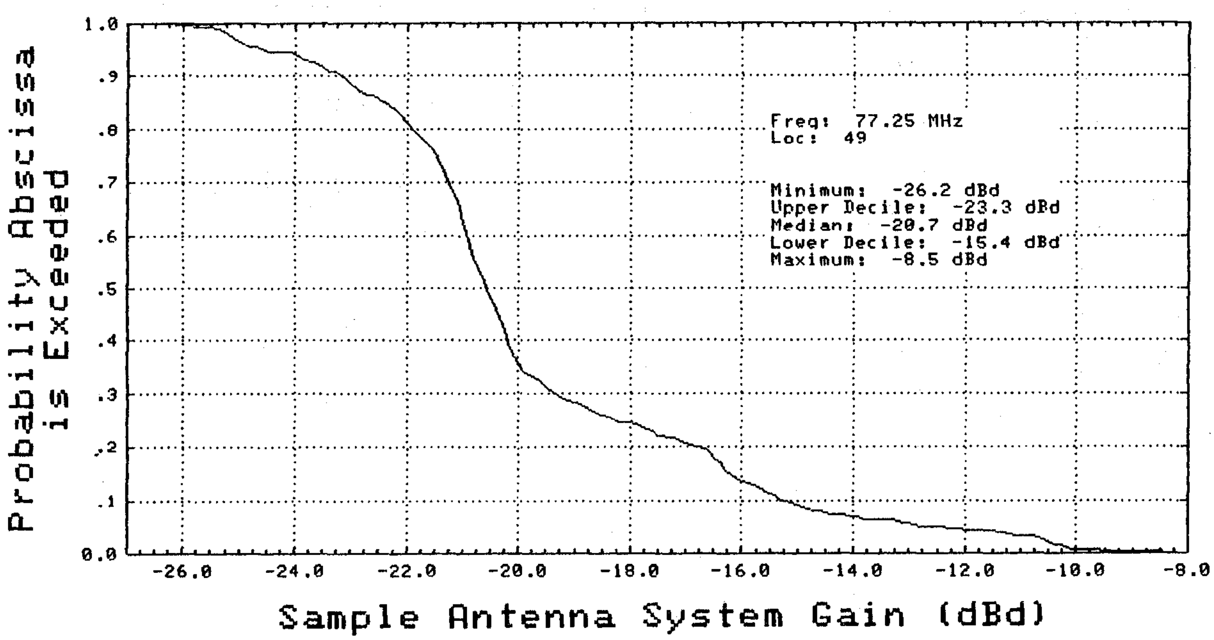


(b)

Figure A-108. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 48 at 501.25 MHz (a) and 537.25 MHz (b).

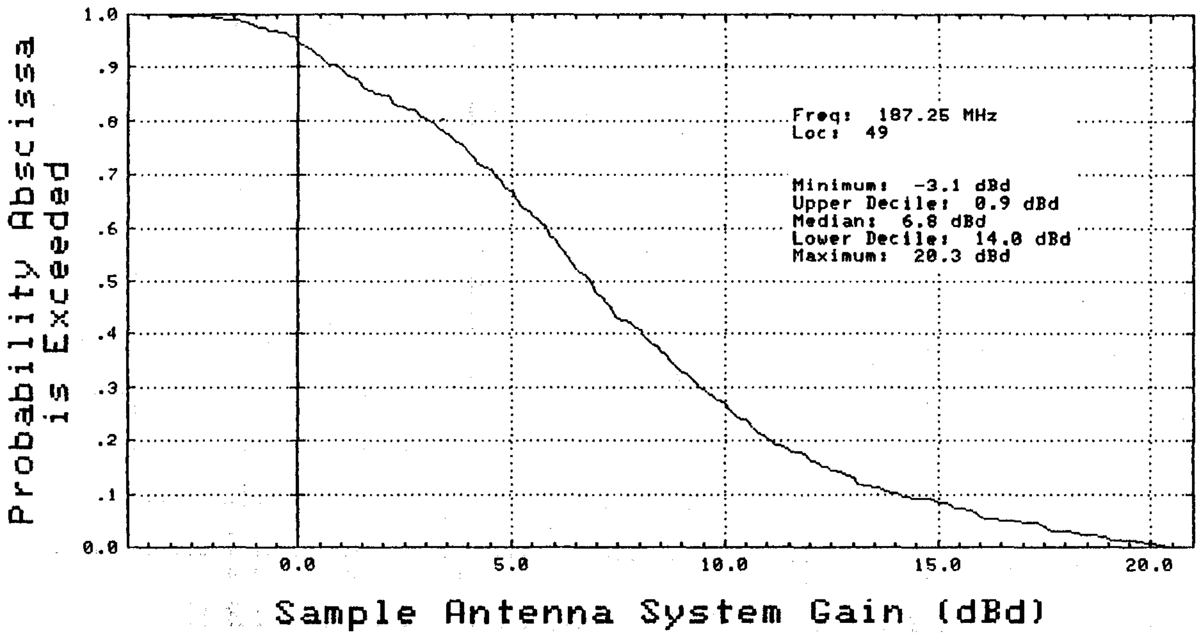


(a)

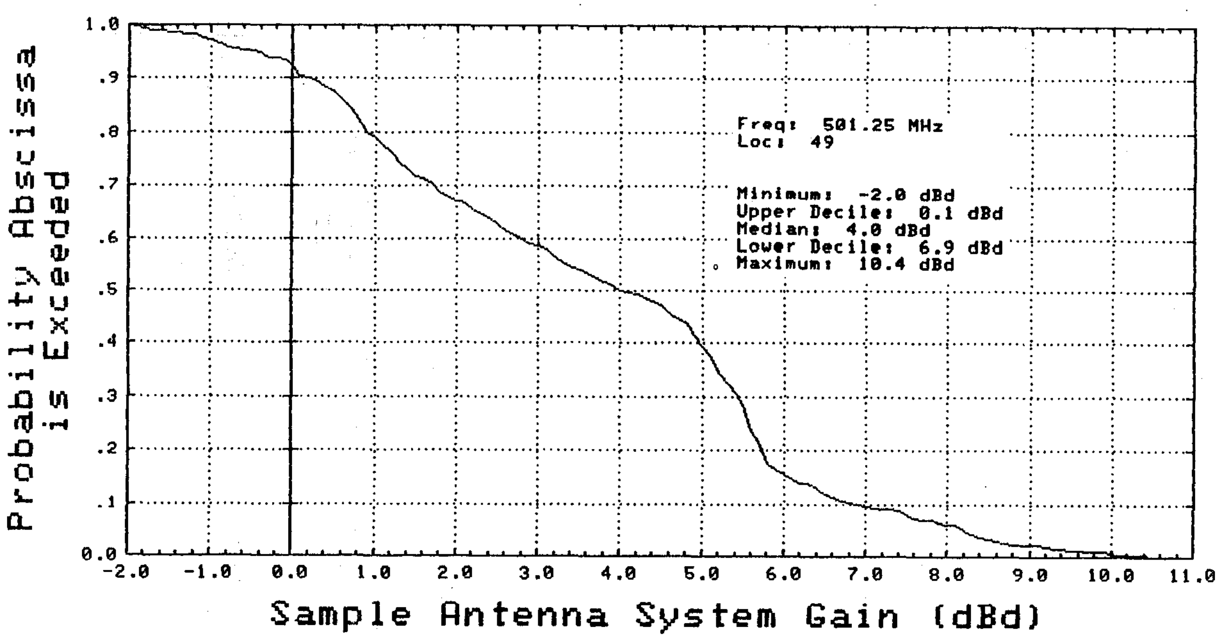


(b)

Figure A-109. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 48 at 573.25 MHz (a) and location 49 at 77.25 MHz (b).

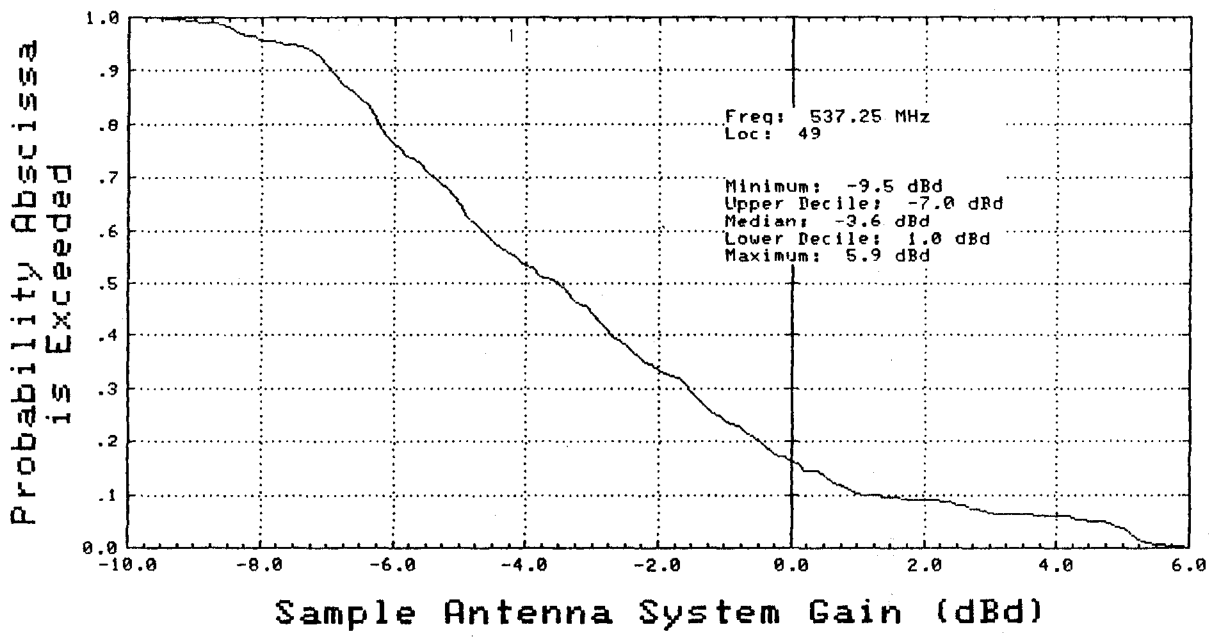


(a)

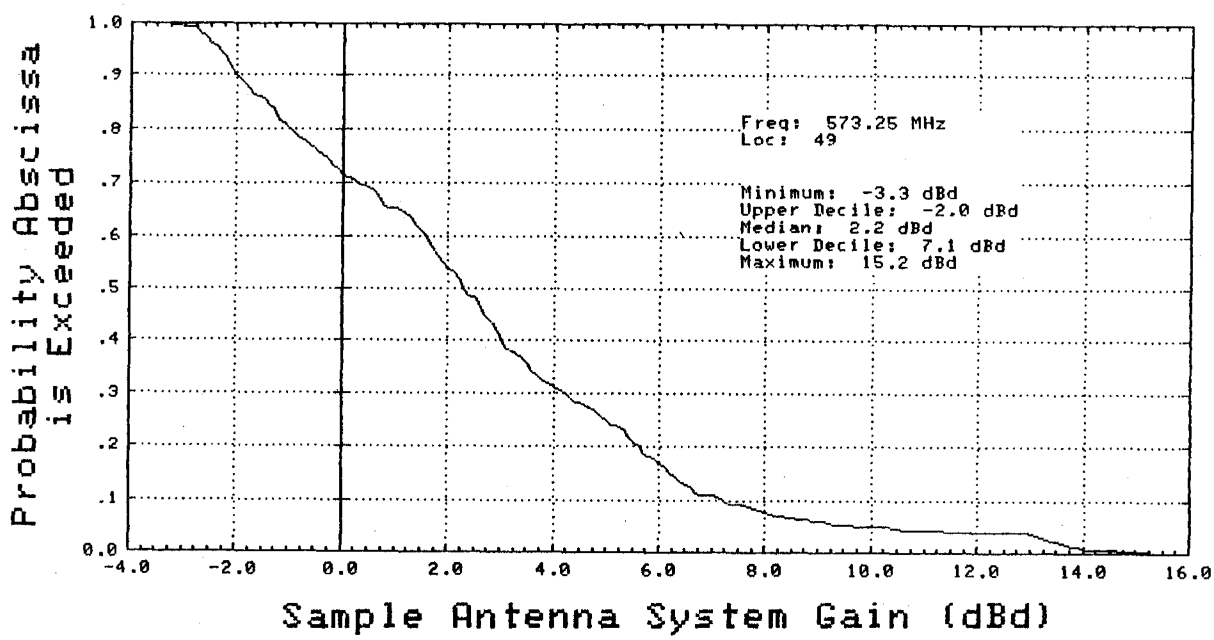


(b)

Figure A-110. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 49 at 187.25 MHz (a) and 501.25 MHz (b).

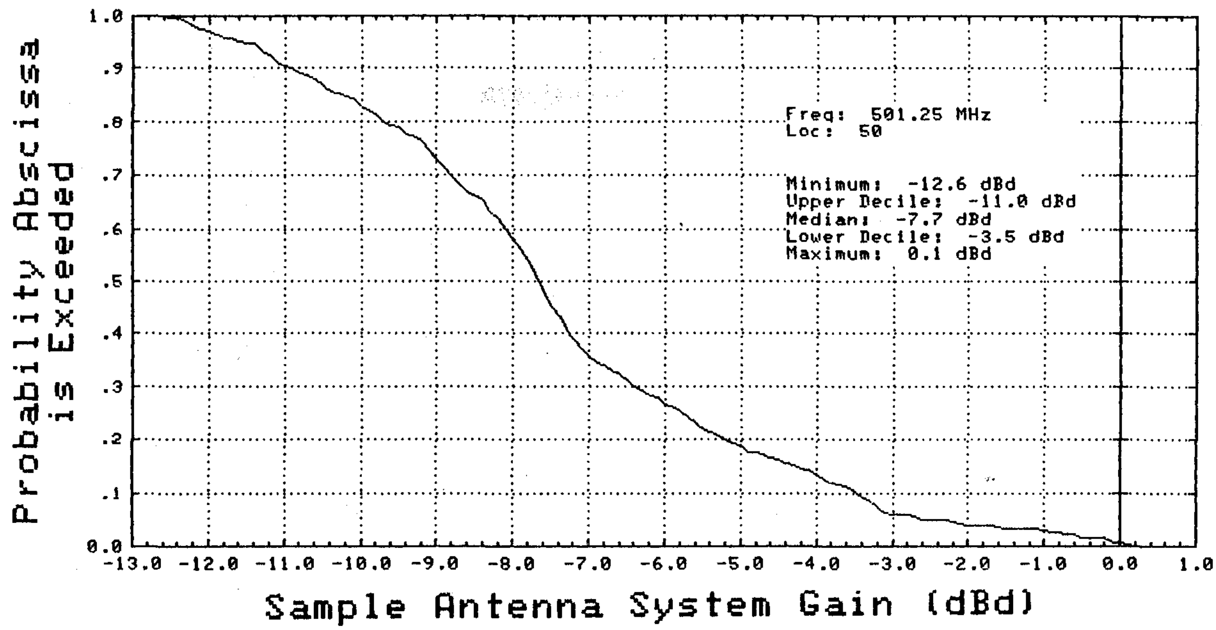


(a)

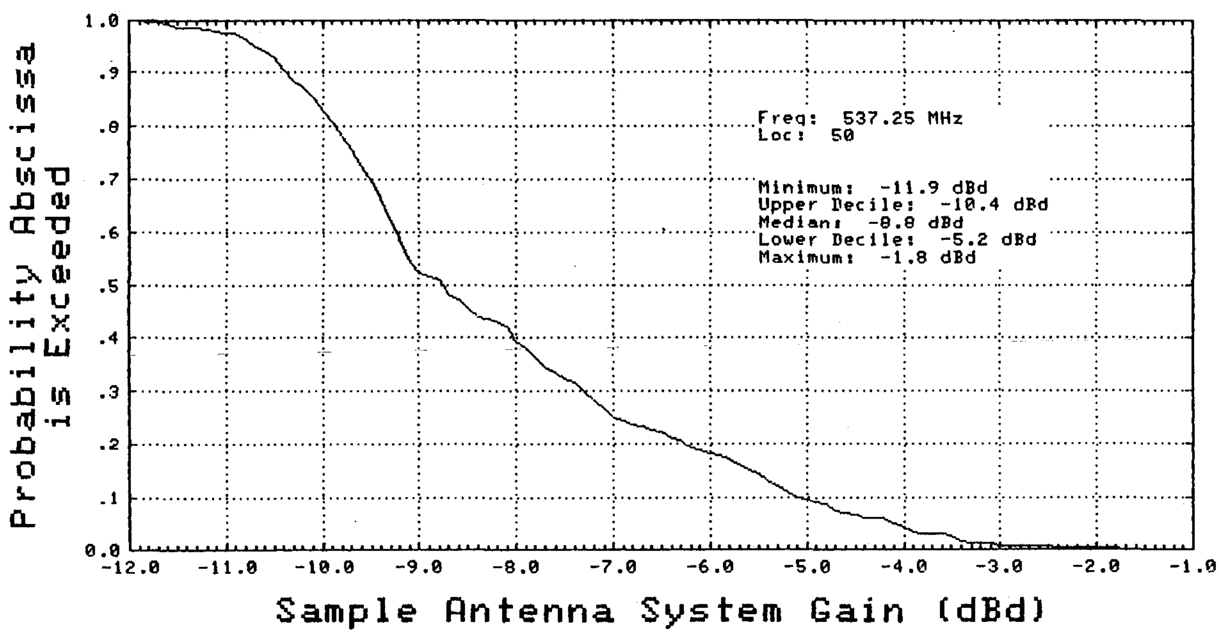


(b)

Figure A-111. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 49 at 537.25 MHz (a) and 573.25 MHz (b).

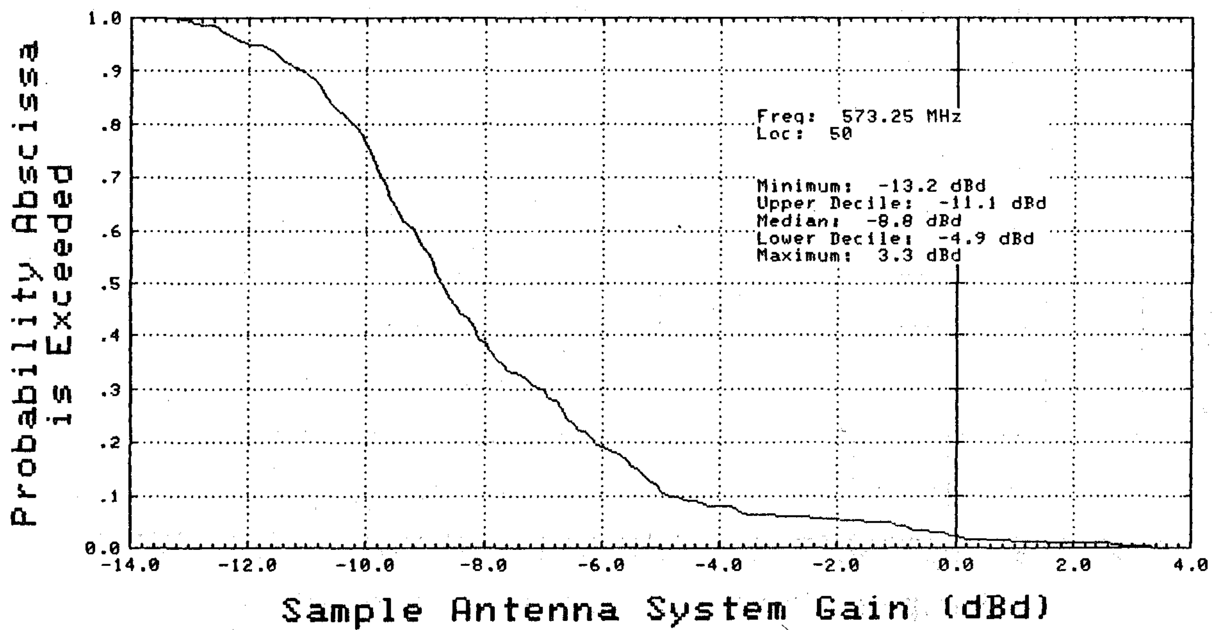


(a)

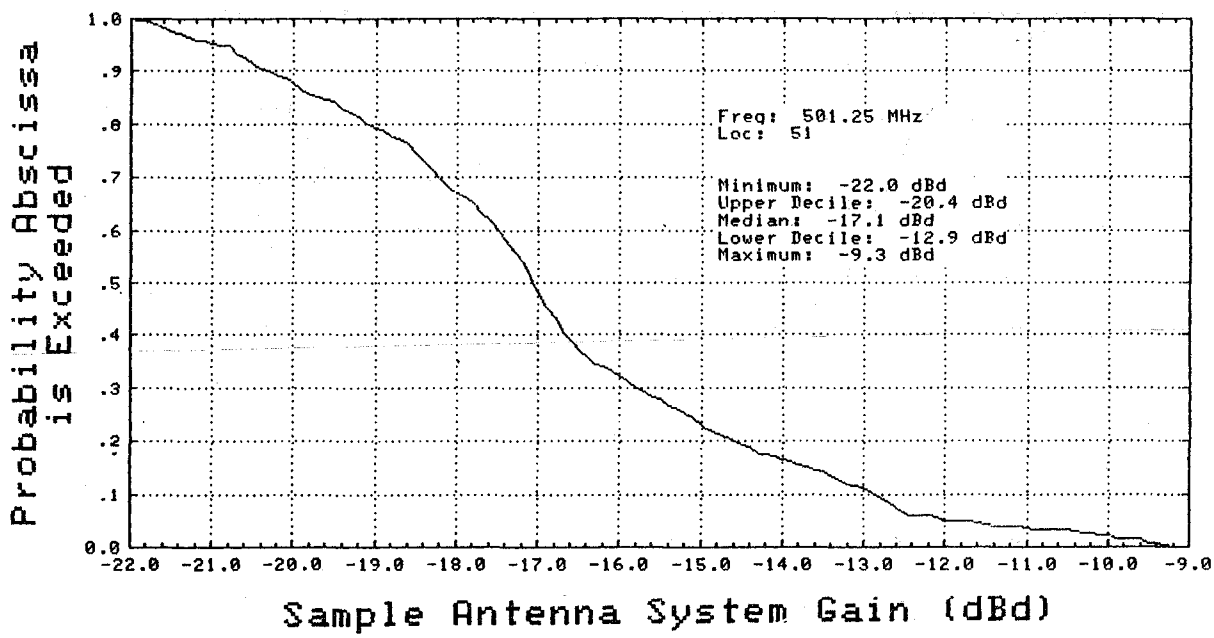


(b)

Figure A-112. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 50 at 501.25 MHz (a) and 537.25 MHz (b).

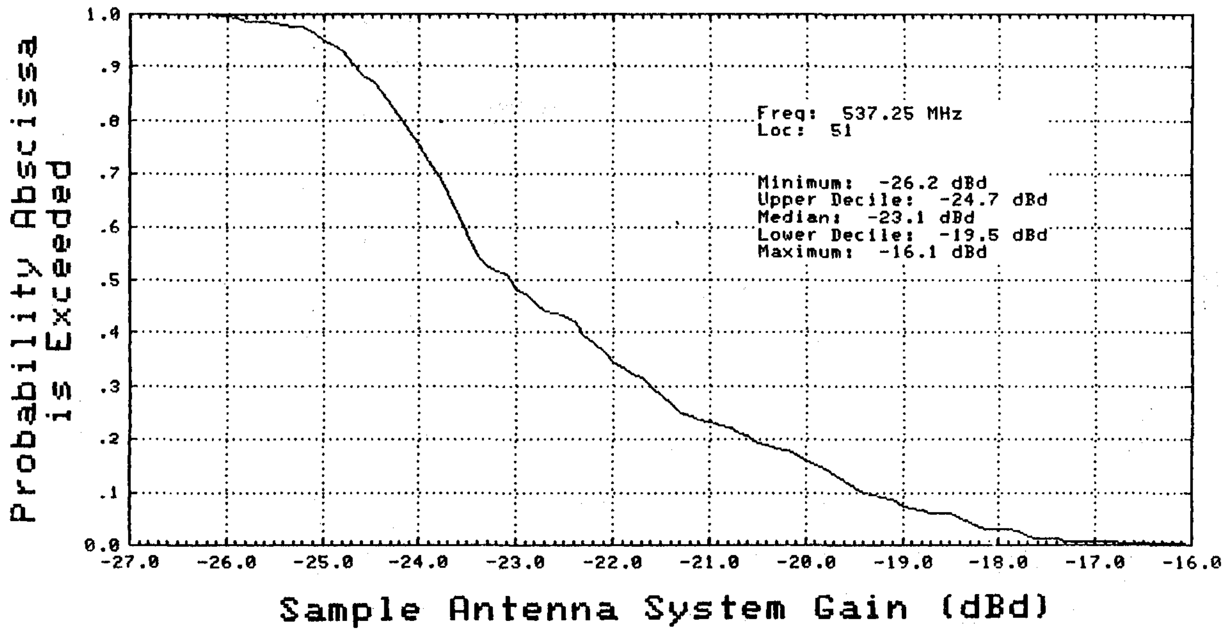


(a)

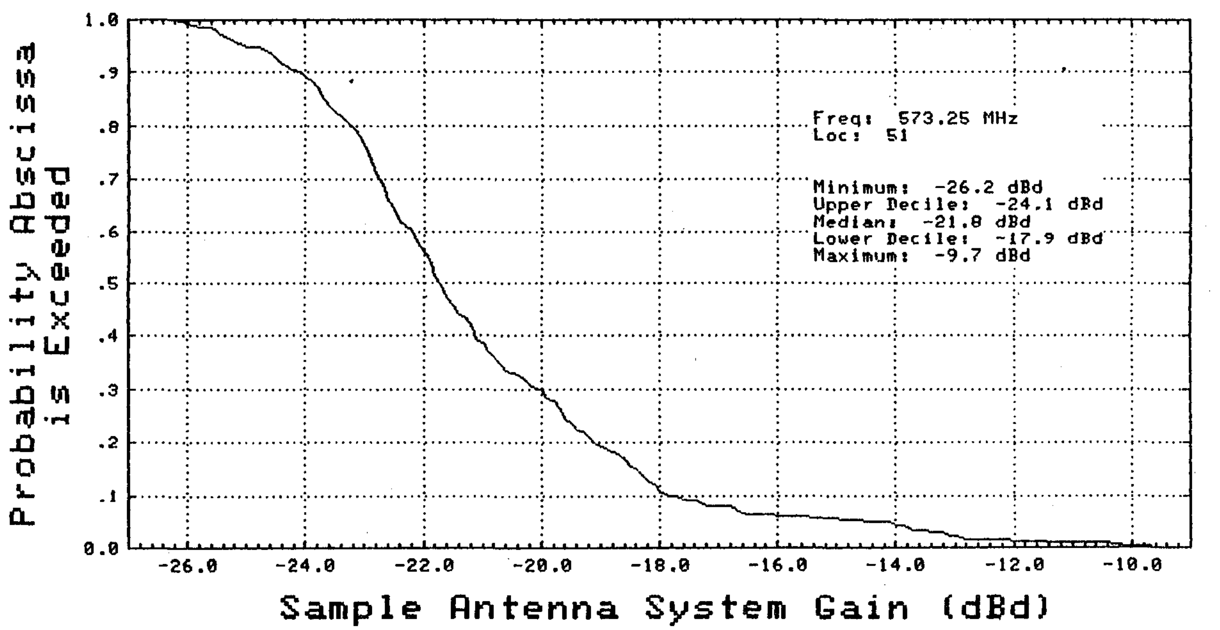


(b)

Figure A-113. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 50 at 573.25 MHz (a) and location 51 at 501.25 MHz (b).



(a)



(b)

Figure A-114. Cumulative distributions of electric field probing measurements, scaled for sample home antenna system gain, for location 51 at 537.25 MHz (a) and 573.25 MHz (b).

APPENDIX B. DESCRIPTION OF AND RESULTS FROM THE MODEL COVERAGE

COVERAGE is an automated program which predicts and plots contours of equal field strength for TV and FM broadcast stations. The program has been developed by Dr. G. A. Hufford (1977). Conditions for which results are valid and a complete description of the program are detailed in the referenced document. Capabilities of the COVERAGE model include:

(a) Computation and plotting (or listing) of constant field strength contours for up to five user-specified contours (Grades of Service). Options are offered for the propagation loss model to be used in computing the field strengths.

(b) Computation and listing of populations and area within the specified contours.

(c) State boundaries and, optionally, county boundaries and user specified landmarks can be plotted with the signal strength contours.

Program COVERAGE allows user-selection for the propagation model. Choices are (1) the Longley-Rice model developed at the ITS or (2) an automated version of the FCC F(50,50) curves. When the FCC F(50,50) propagation model is used, there are several options which may be selected. These options include:

(a) Use of the F(50,50) curves, as presently approved by the FCC, without modification.

(b) A modification which takes into consideration the effects of terrain, in addition to height above average terrain (HAAT). Corrections to the F(50,50) curves are computed along each of the 24 radial directions from the transmitter location. This modification of the terrain roughness factor (Δh) eliminates isolated topographic features that would otherwise destroy statistical homogeneity. The effect of this modification can be only a reduction in the magnitude of the terrain roughness factor.

(c) A modification that limits the maximum attenuation associated with the terrain roughness factor (Δh) to 35 dB.

(d) A modification that causes "holes" in service coverage (areas behind small hills and ridges where additional attenuation occurs due to Fresnel diffraction) to be ignored.

The program can be directed to assume omni-directional radiation, or directional antenna pattern data may be supplied, if desired.

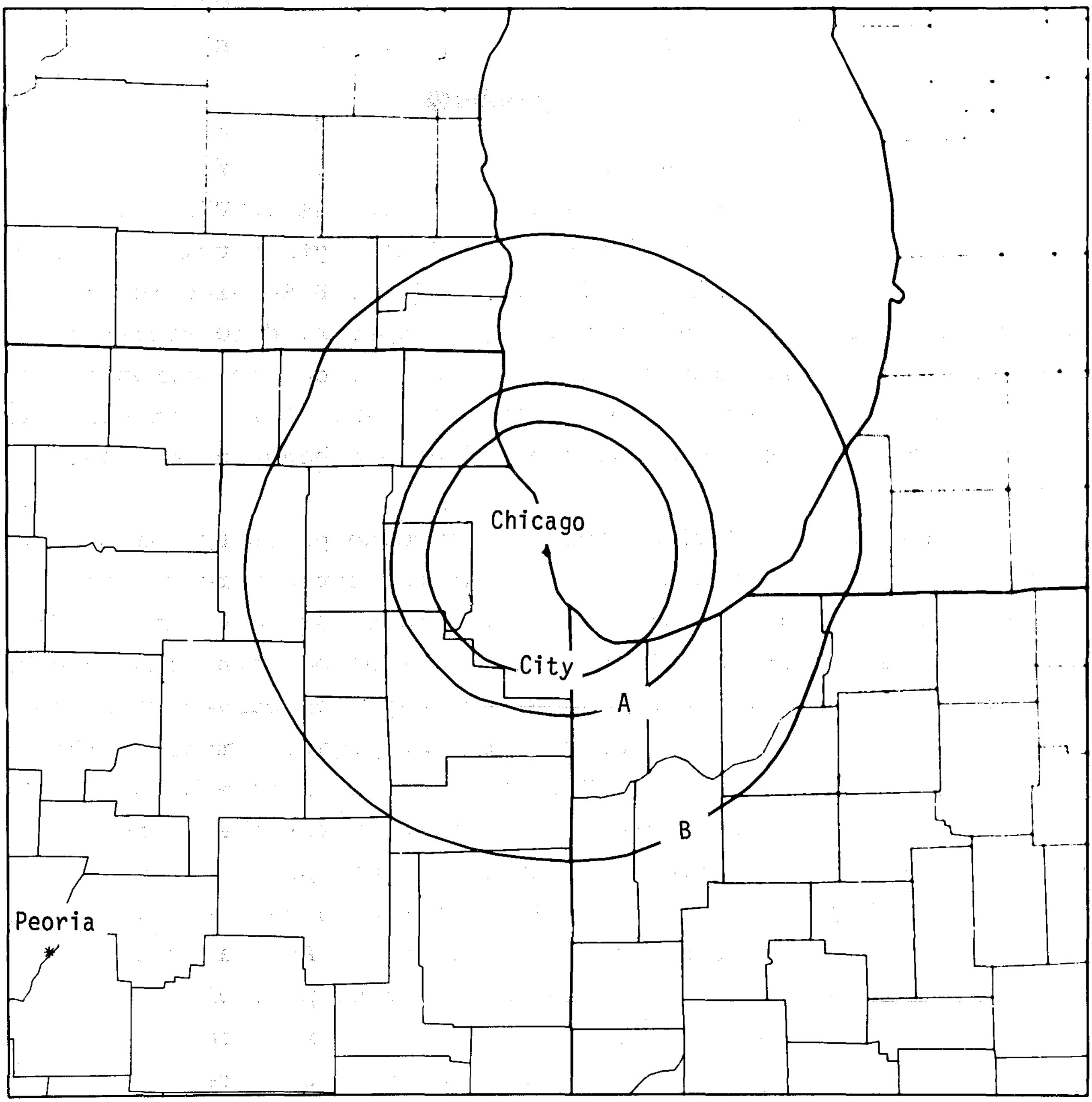
Extensive plot formatting is available in the COVERAGE model. The five (maximum) contours of equal field strength usually include the contours for City Grade, Grade A, and Grade B Service for TV broadcasting. The remaining values may be specified to arbitrary values or ignored. Landmarks, plot origin, and county boundaries may be specified/selected at the option of the user. Also, contour data for one contour may be saved and plotted with subsequent contours, if desired.

We have used the COVERAGE model to produce plots for each of the TV broadcast stations used as a signal source for our measurements. The appropriate field strengths for City Grade, Grade A, and Grade B Service have been plotted. Directional antenna pattern data have been used when available. The FCC F(50,50) propagation curves with modifications b, c, and d have been used as the propagation model. The John Hancock Building in Chicago and Peoria city center have been specified as landmarks. Each plot origin is the location for the transmitting antenna for the station being considered. These plots are included as Figures B-1 through B-8. A common scale has been used for all plots.

Along a line connecting the plot origin and Peoria or Chicago, as the case may be, distances have been scaled from plot origin to the intersection of the radial line and the contours for Grade A and Grade B Service. These data are used in the report to compare with similar data scaled from contour plots published in the Television Factbook and developed using the F(50,50) curves without modification and to compare with our computed median electric field strength data to which least squares, linear regression lines have been fit.

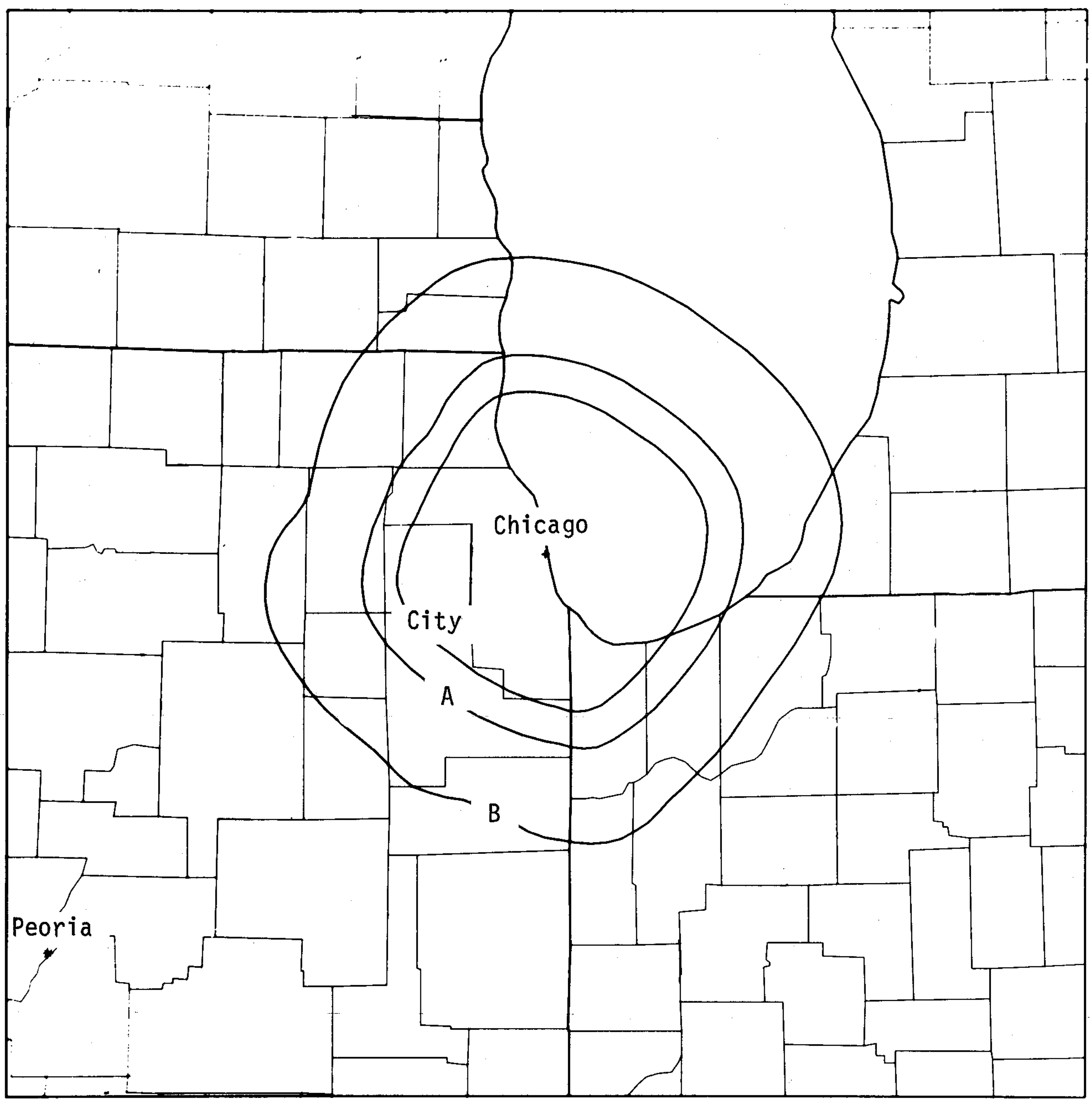
REFERENCE

Hufford, G. A. (1977), Techniques for the evaluation of proposed VHF TV drop-ins, OT Report 77-112, July (NTIS Access. No. PB 271 212/ AS).



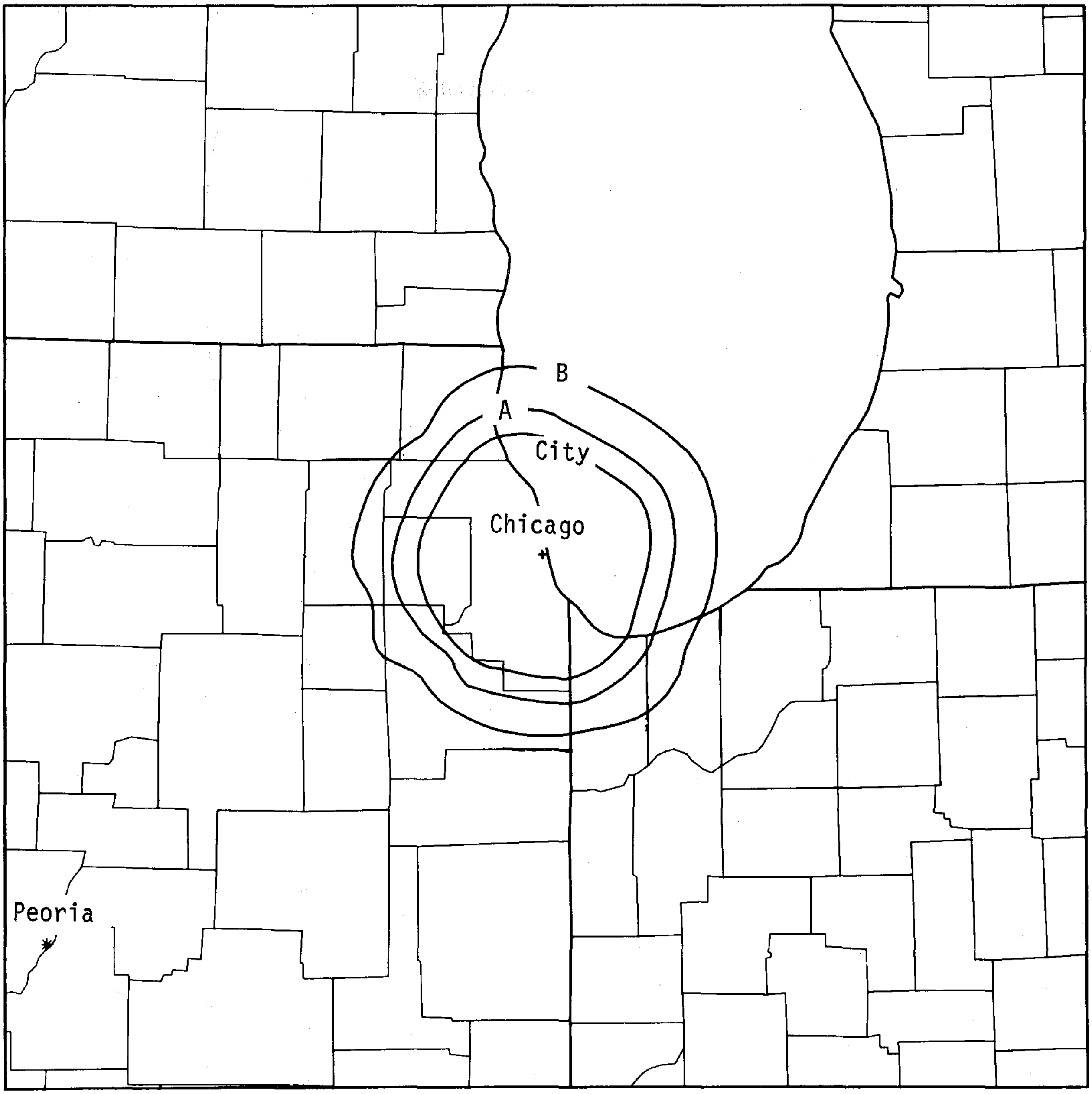
WMAQ-TV, CHAN 5, CHICAGO

Figure B-1. Equal field strength contours for channel 5 (77.25 MHz), WMAQ-TV, broadcast from the John Hancock Building in Chicago. City Grade Service = 74 dBμ, Grade A Service = 68 dBμ, and Grade B Service = 47 dBμ. Distance toward Peoria to Grade A contour is 31.4 mi (50.5 km); to Grade B contour is 61.8 mi (99.5 km).



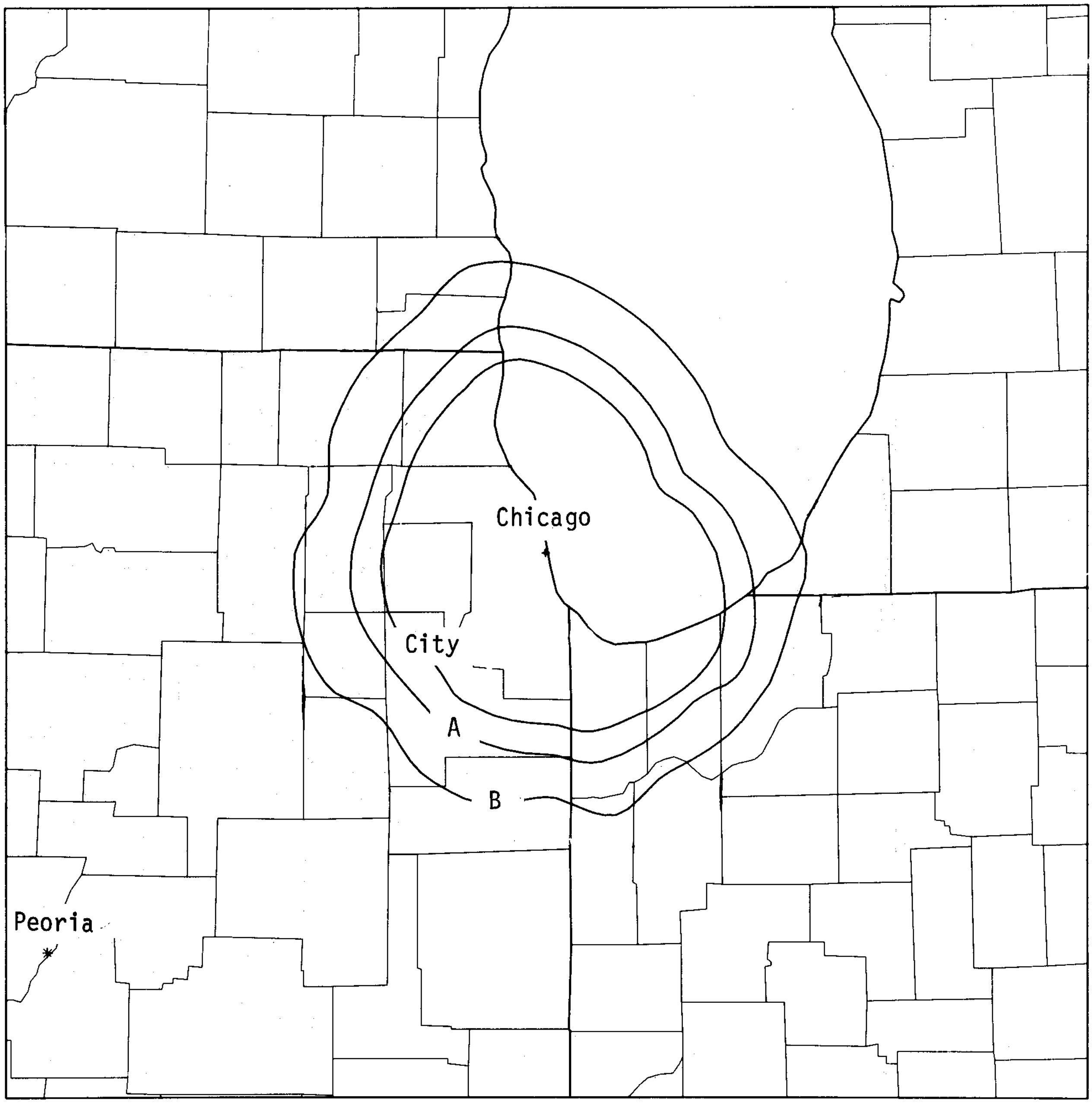
WGN-TV, CHAN 9, CHICAGO

Figure B-2. Equal field strength contours for channel 9 (187.26 MHz), WGN-TV, broadcast from the John Hancock Building in Chicago. City Grade Service = 77 dBμ, Grade A Service = 71 dBμ, and Grade B Service = 56 dBμ. Distance toward Peoria to Grade A contour is 35.8 mi (57.6 km); to Grade B contour is 54.0 mi (86.9 km).



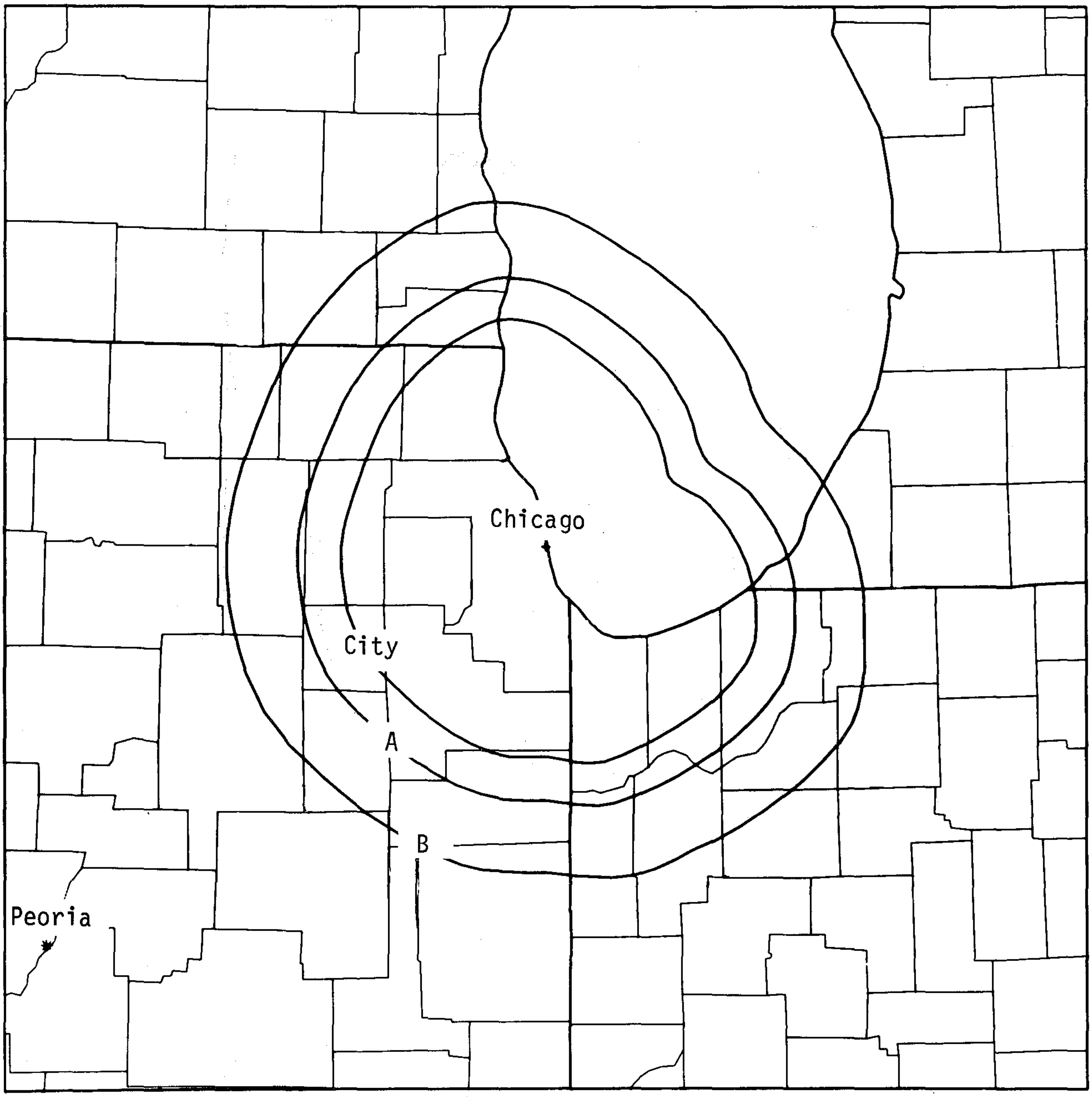
WCIU-TV CHAN 26, CHICAGO

Figure B-3. Equal field strength contours for channel 26 (543.25 MHz), WCIU-TV, broadcast from the Board of Trade Building in Chicago. City Grade Service = 80 dBμ, Grade A Service = 74 dBμ, and Grade B Service = 64 dBμ. Distance toward Peoria to Grade A contour is 28.5 mi (45.9 km); to Grade B contour is 36.5 mi (58.7 km).



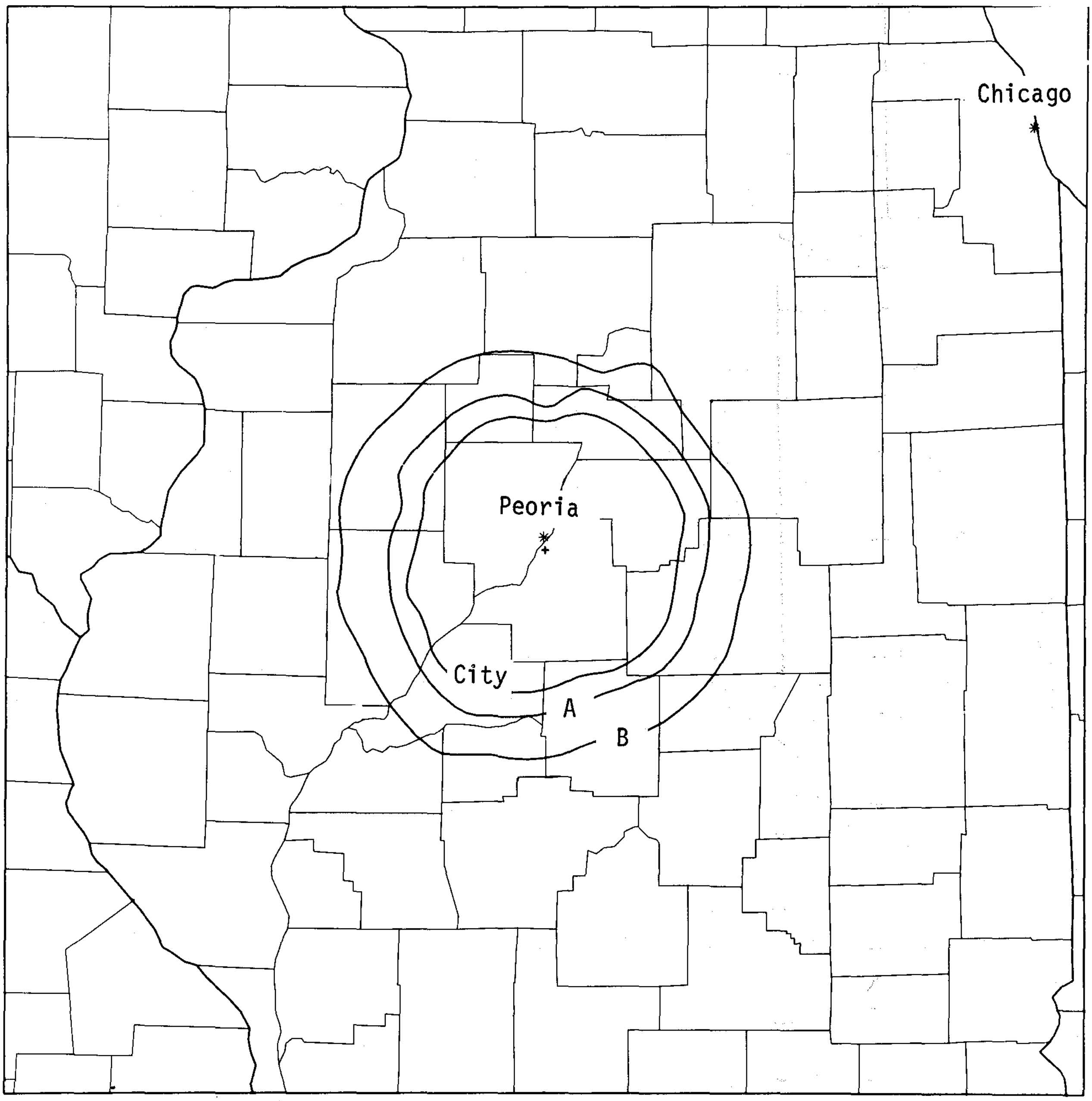
WFLD-TV, CHAN 32, CHICAGO

Figure B-4. Equal field strength contours for channel 32 (579.25 MHz), WFLD-TV, broadcast from the John Hancock Building in Chicago. City Grade Service = 80 dBμ, Grade A Service = 74 dBμ, and Grade B Service = 64 dBμ. Distance toward Peoria to Grade A contour is 39.0 mi (62.7 km); to Grade B contour is 46.8 mi (75.3 km).



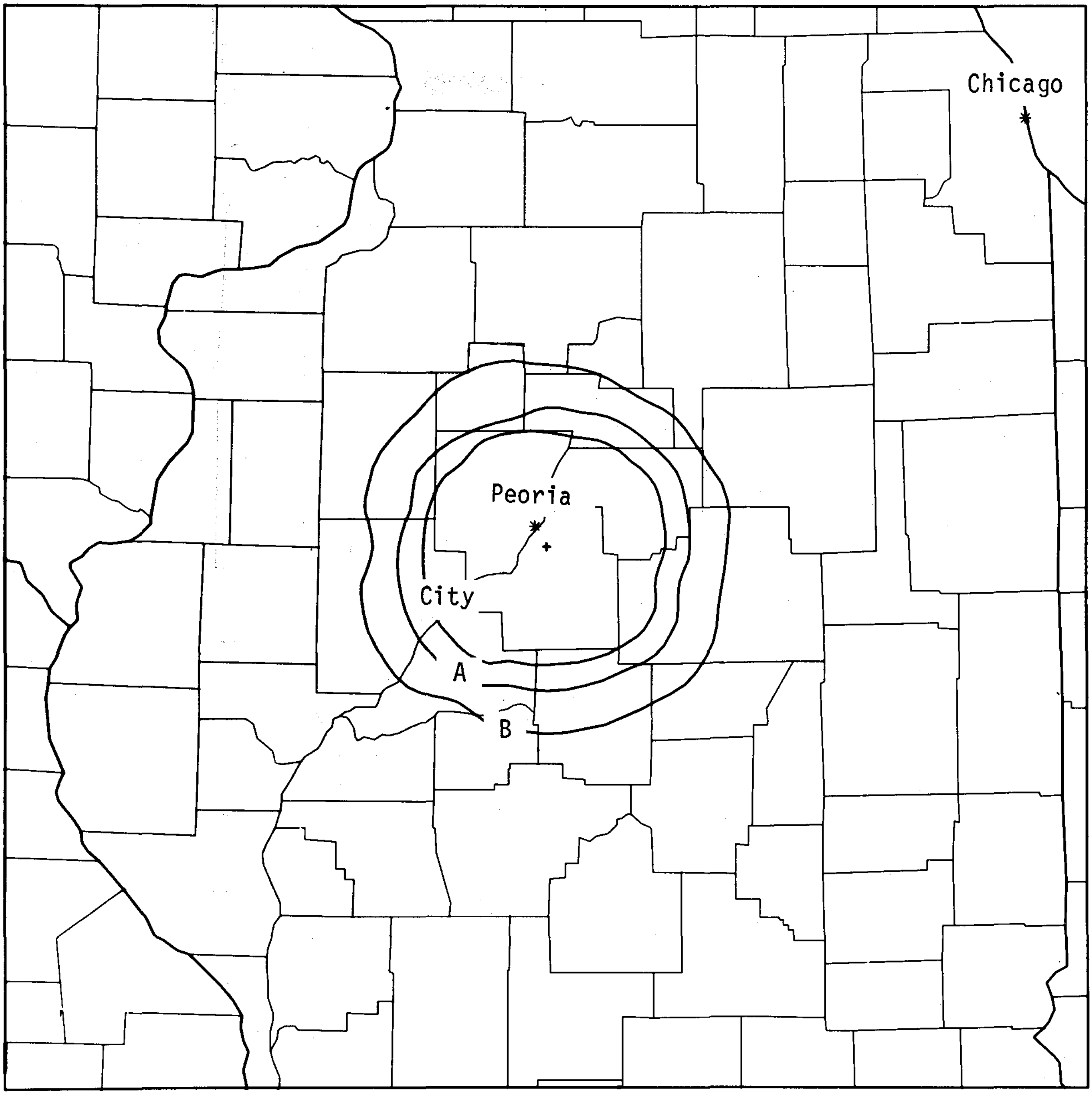
WSNS-TV CHAN 44, CHICAGO

Figure B-5. Equal field strength contours for channel 44 (651.25 MHz), WSNS-TV, broadcast from the John Hancock Building in Chicago. City Grade Service = 80 dBμ, Grade A Service = 74 dBμ, and Grade B Service = 64 dBμ. Distance toward Peoria to Grade A contour is 51.5 mi (82.9 km); to Grade B contour is 66.3 mi (106.7 km).



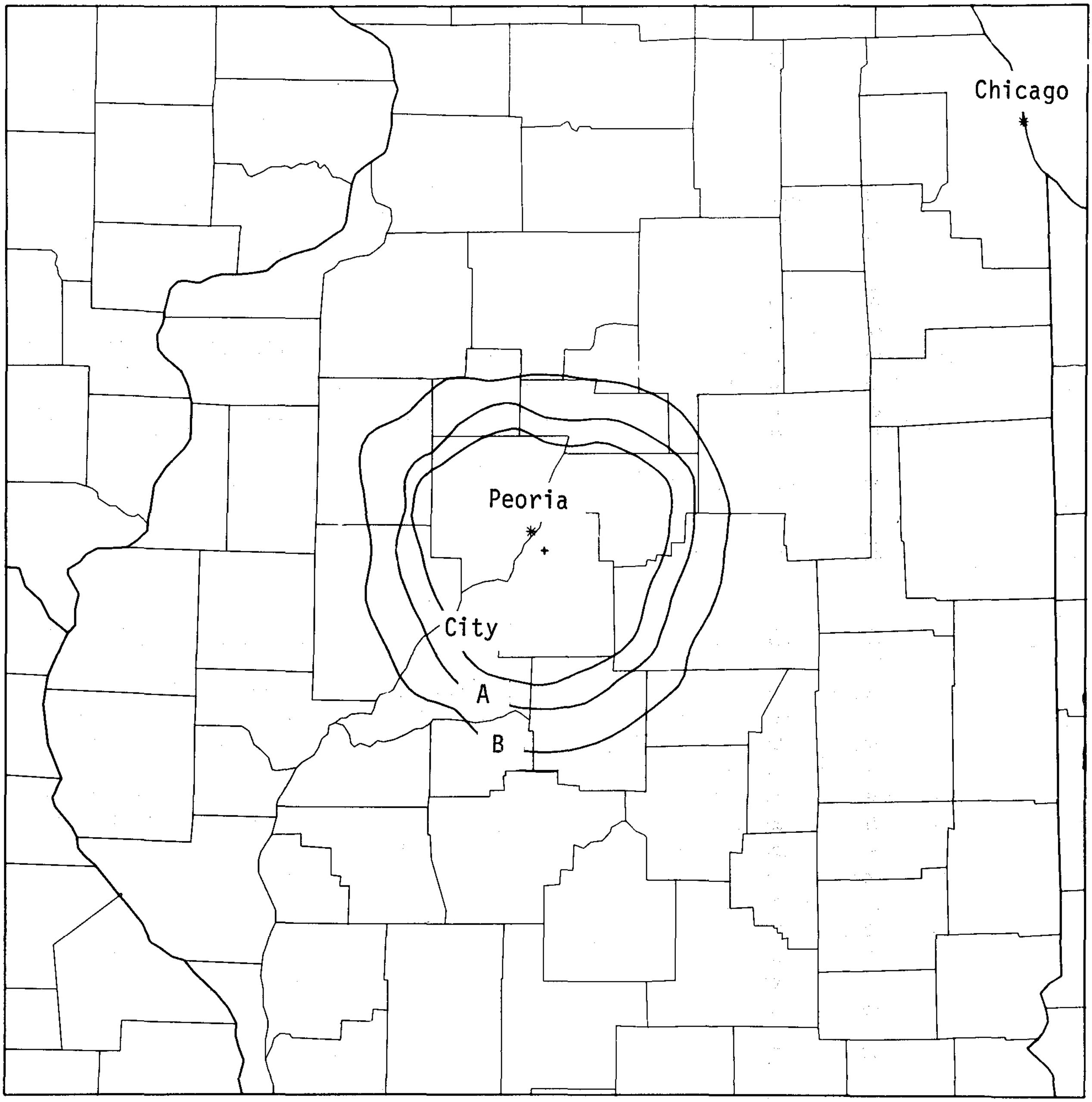
WRAU-TV, CHAN 19, PEORIA

Figure B-6. Equal field strength contours for channel 19 (501.25 MHz), WRAU-TV, broadcast from location near Peoria. City Grade Service = 80 dBμ, Grade A Service = 74 dBμ, and Grade B Service = 64 dBμ. Distance toward Chicago to Grade A contour is 33.6 mi (54.1 km); to Grade B contour is 39.4 mi (63.4 km).



WEEK-TV CHAN 25, PEORIA

Figure B-7. Equal field strength contours for channel 25 (537.26 MHz), WEEK-TV, broadcast from location near Peoria. City Grade Service = 80 dBμ, Grade A Service = 74 dBμ, and Grade B Service = 64 dBμ. Distance toward Chicago to Grade A contour is 29.6 mi (47.6 km); to Grade B contour is 37.2 mi (59.9 km).



WMBD-TV, CHAN 31, PEORIA

Figure B-8. Equal field strength contours for channel 31 (573.26 MHz), WMBD-TV, broadcast from location near Peoria. City Grade Service = 80 dBμ, Grade A Service = 74 dBμ, and Grade B Service = 64 dBμ. Distance toward Chicago to Grade A contour is 32.0 mi (51.5 km); to Grade B contour is 39.2 mi (63.1 km).

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14. SUPPLEMENTARY NOTES

15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

Throughout an area between Chicago and Peoria, Illinois, approximately 50 measurement locations were selected. At each location measurements were made, typically, for two VHF television broadcasts from Chicago and three UHF television broadcasts from either Chicago or Peoria.

Measurements were made using a standard antenna erected on the measurement van to the same height as the home antenna. Cumulative distributions of these measurements were produced from which the median electric field strengths were computed and plotted at each measured Chicago broadcast frequency, as a function of distance from the broadcast (transmitting) antenna. The least squares, linear regression line for each set of data is shown. Also shown are field strengths required by FCC Regulations for Grades A and B Service and the coverage ranges at which each Grade of Service is realized scaled from contours published in the Television Factbook and as computed using an automated model named COVERAGE which

(continued on next page)

16. Key Words *(Alphabetical order, separated by semicolons)*

Antenna system gain; electric field strength; gain model; grade of service; measurements; statistical analyses; UHF television; VHF television

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uses a modified version of the FCC propagation loss curves (discussed in Appendix B).

Measurements of received signal level also were made using each home antenna system. Using the two types of measured data, cumulative distributions of sample home antenna system gain are presented for each measurement frequency and location in Appendix A. Median values from these cumulative distributions have been chosen as estimates of gain for the home antenna systems.

It is concluded that systems using single-function antennas typically have significantly higher system gain than systems incorporating VHF/UHF combination antennas. Statistical results (median and interdecile values) from the measured data provide the basis for a generalized model for VHF and UHF television receiving antenna system gain. Though home antenna systems can be installed to provide excellent performance, the measurements show that in-service antenna system performance is 0.4 dB to 12.5 dB less than has been assumed.

All the measured data were obtained and are retained in digital form on magnetic tape.

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