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ABSTRACT

The theoretical performance of the antenna element for the 96-element receiving array of MITRE's High-Frequency, High-Resolution Experimental Site is analyzed. The antenna element consists of a monopole tower with a buried radial-wire ground screen of modest diameter. Each element is connected by a long buried coaxial cable to an associated receiver in one of three electronics shelters within the array. The analysis forms the basis for selecting the final design configuration of the monopole antenna element, its associated ground screen, and the buried feed cable. System internal noise figure and antenna directivity serve as the principal measures of performance. The contributions of antenna efficiency, cable mismatch loss, cable attenuation loss, and receiver noise figure to system internal noise figure are treated.

The monopole antenna element and an alternative dipole antenna element are modeled and analyzed using the Numerical Electromagnetics Code-Ground Screen (NEC-GS) version of the NEC Method-of-Moments software. NEC-GS, which is particularly well-suited for modeling azimuthally symmetric structures, is used to calculate the antenna input impedance, efficiency, and power gain pattern. The antenna efficiency, cable mismatch loss, and antenna directivity pattern are determined as a function of frequency, earth electrical properties, and antenna element/ground-screen geometry. Asymmetric radiation pattern effects caused by a long, buried or unburied, coaxial feed cable, and by a nearby electronics shelter, are also evaluated. This is accomplished by using NEC software versions NEC-3I and NEC-3 to model the monopole with ground screen in the presence of a jacketed feed cable and a shelter, respectively. Included are brief descriptions of NEC-GS, NEC-3, and NEC-3I versions of NEC, and some associated modeling constraints.

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M. K. Eggimann and L. Giandomenico executed a large number of NEC computer runs during the course of this work.

S. Zamosciany generated the performance plots from Numerical Electromagnetic Code (NEC) computer output files.

M. H. Weeden and C. S. E. Sherman prepared the balance of the graphics and tables.

J. K. Viveiros prepared the typed manuscript.

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SECTION A1

OVERVIEW

Volume 2—Appendices presents a more comprehensive reference set of theoretical performance results, in tabular and graphical form, for the symmetrical "fat" monopole antenna configuration. The results were obtained from computations using the Numerical Electromagnetics Code—Ground Screen option (NEC-GS). The objective was to provide a more complete reference for investigators interested in a more extensive set of results than was supplied in Volume 1. The results are suitably identified, but presented without elaboration, to serve as an archival reference.

The measures of performance include antenna input impedance, magnitude of the reflection coefficient, cable mismatch loss, antenna efficiency, ohmic loss (noise figure), and directivity. These were examined as a function of monopole antenna dimensions (height and feed height), number, length, and depth of ground screen radial wires, electrical properties (conductivity and relative dielectric constant) of the surrounding earth, and operating frequency across the HF band. The remainder of Volume 2 is organized as follows:

SECTION A2 — 5.4 METER MONOPOLE CONFIGURATION RESULTS

- Antenna input impedance
- Antenna reflection coefficient and cable mismatch loss
- Antenna efficiency and noise figure (ohmic loss)
- Cable attenuation loss
- System internal noise figure
- Directivity

SECTION A3 — 6.3 METER MONOPOLE CONFIGURATION RESULTS

- Antenna input impedance
- Antenna reflection coefficient and cable mismatch loss
- Antenna efficiency and noise figure (ohmic loss)
- Cable attenuation loss
- System internal noise figure
- Directivity

SECTION A4 — 6.0, 6.5, 7.0 METER MONOPOLE RESULTS

- Antenna input impedance
- Antenna efficiency and noise figure (ohmic loss)
- Directivity

SECTION A2

5.4 METER MONOPOLE CONFIGURATION RESULTS

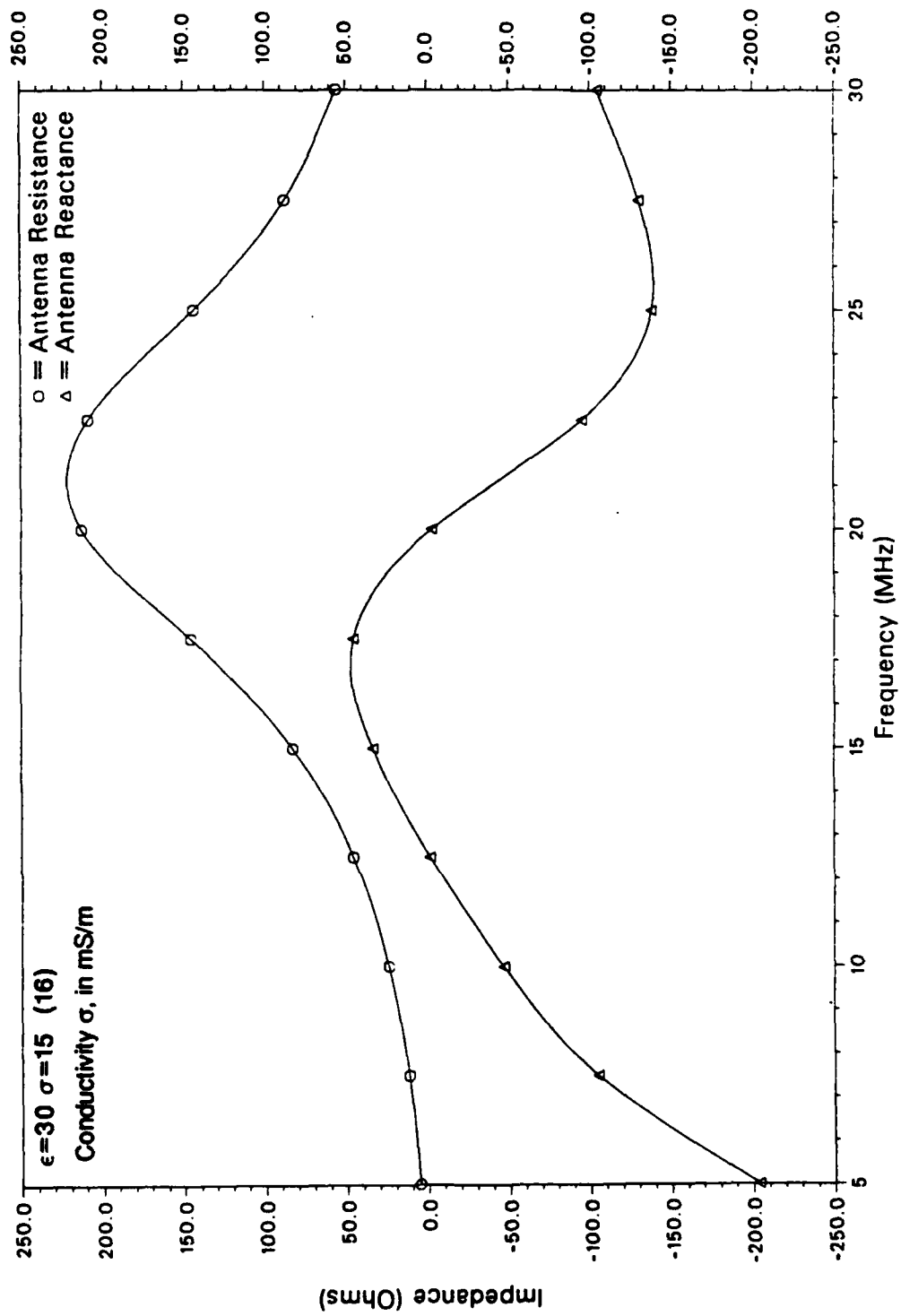


Figure A-1. Antenna Input Resistance and Reactance versus Frequency in Wet Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

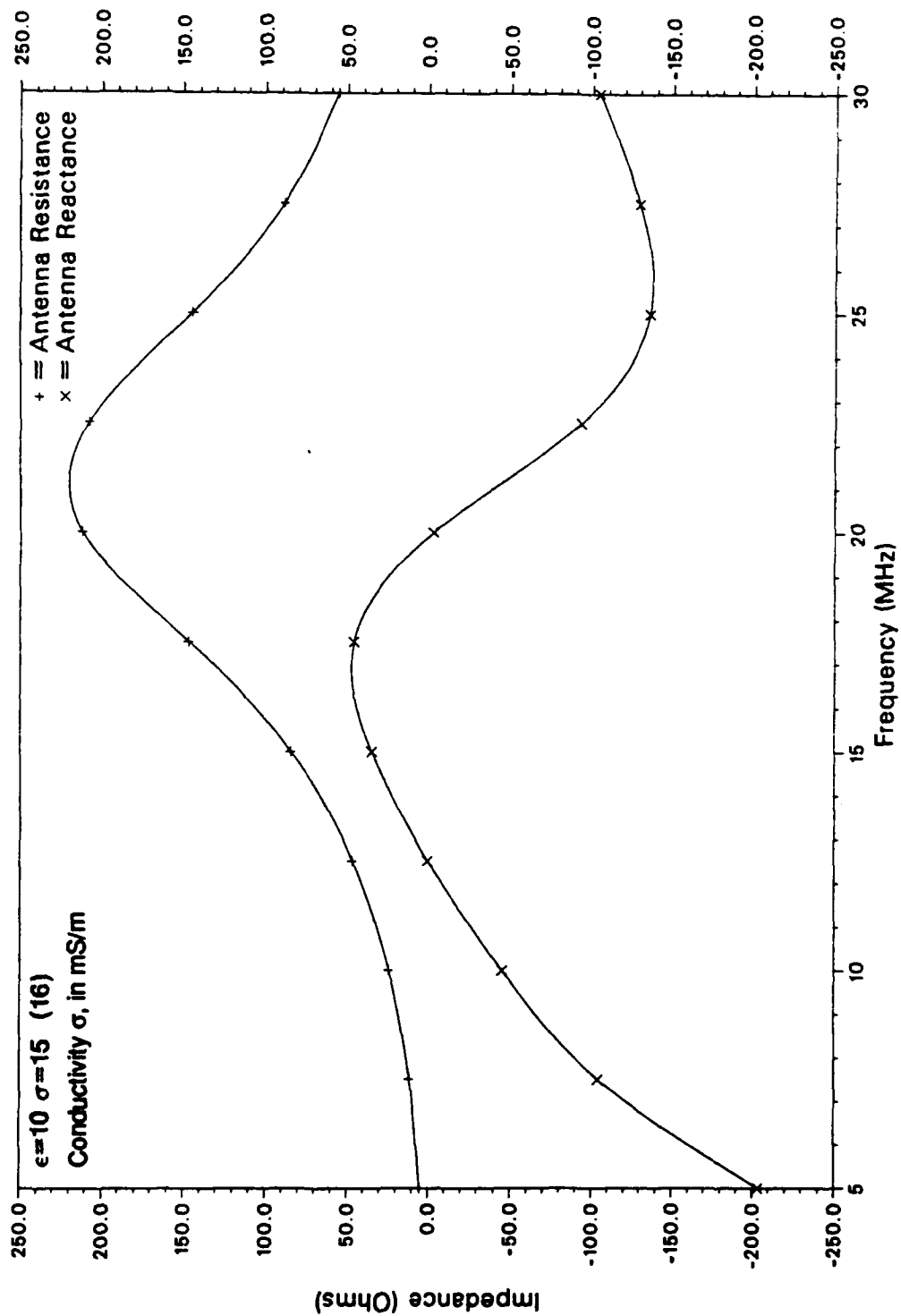


Figure A-2. Antenna Input Resistance and Reactance versus Frequency in Moist Clay for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

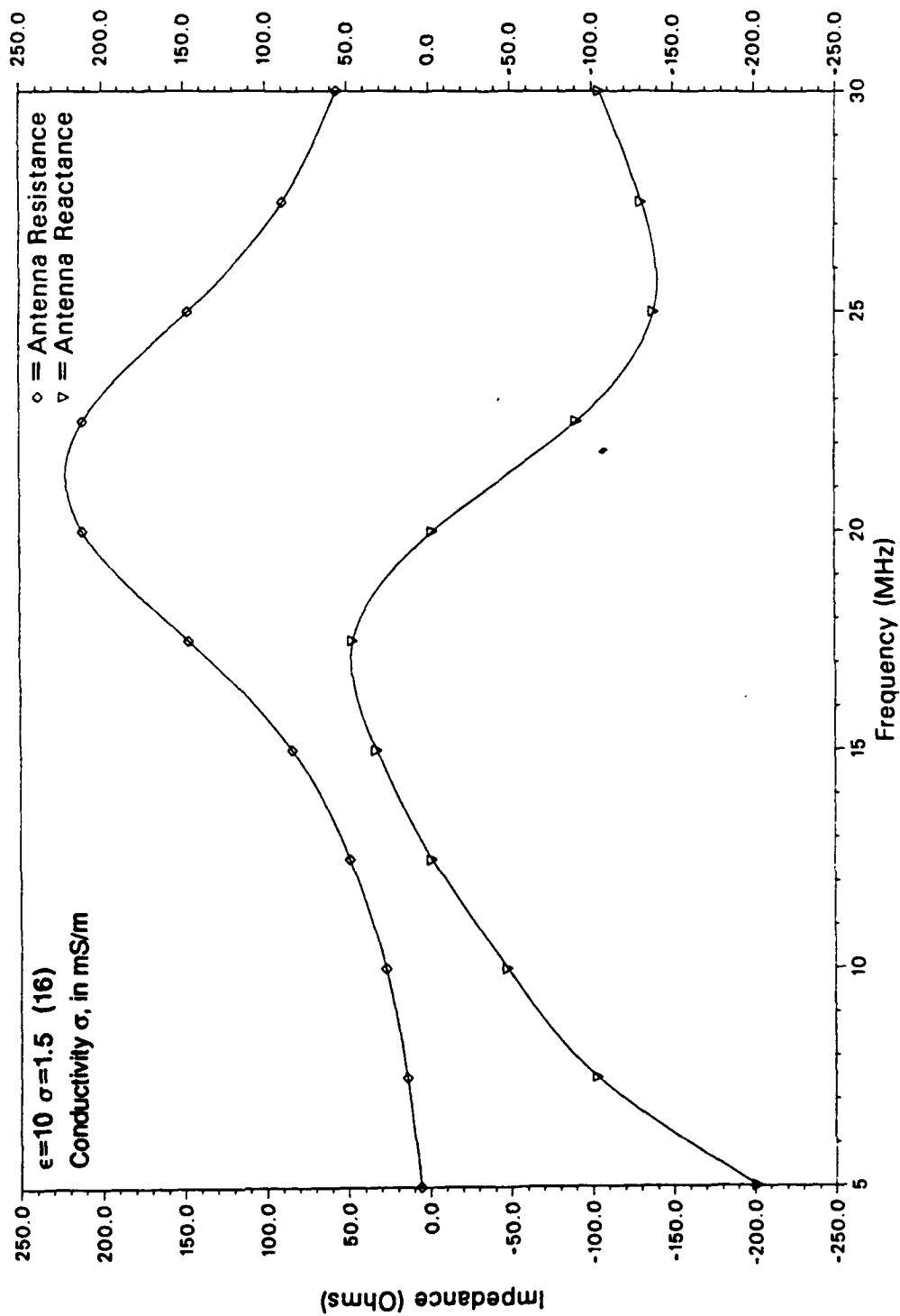


Figure A-3. Antenna Input Resistance and Reactance versus Frequency in Medium Dry Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

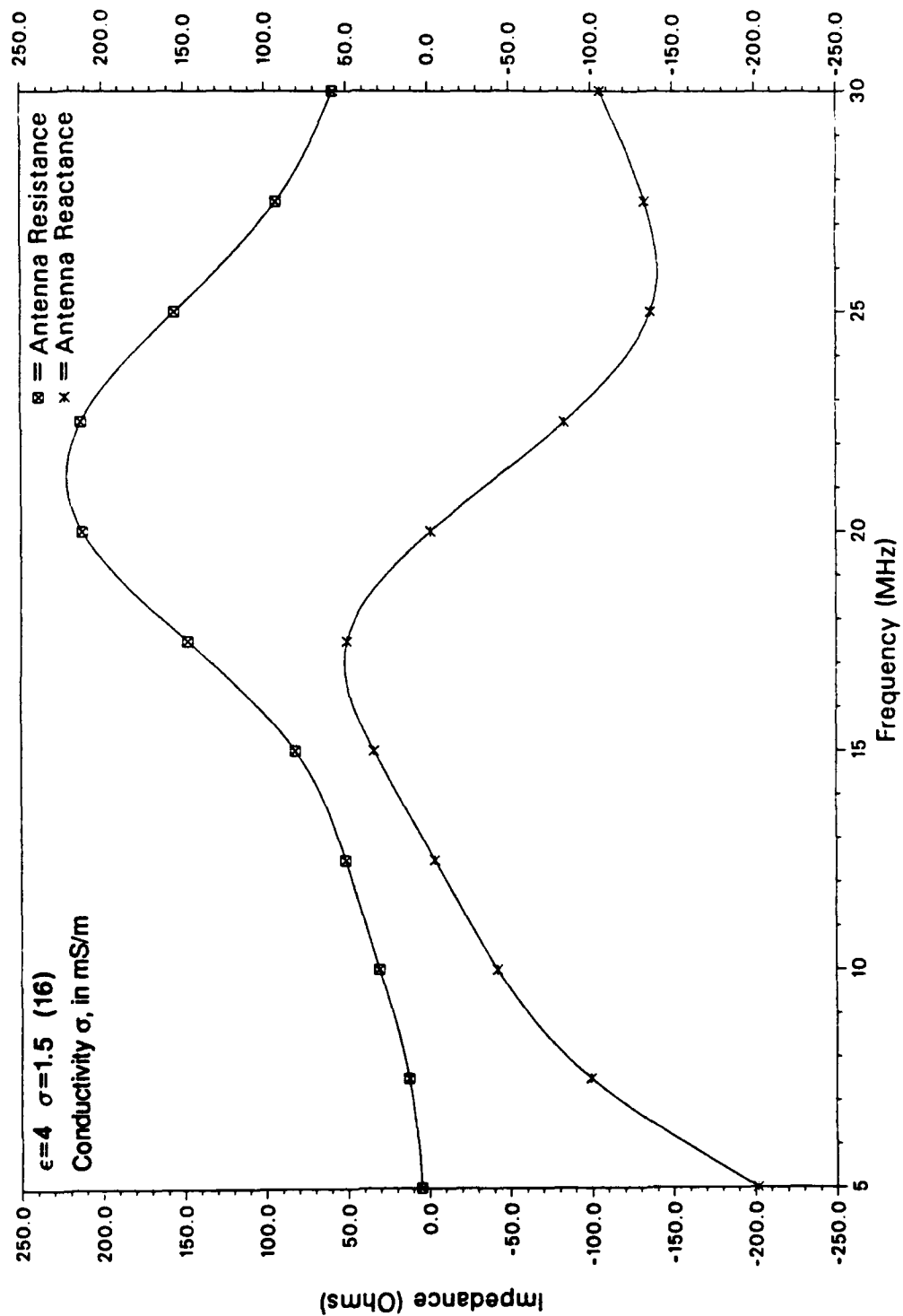


Figure A-4. Antenna Input Resistance and Reactance versus Frequency in Sandy Soil for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

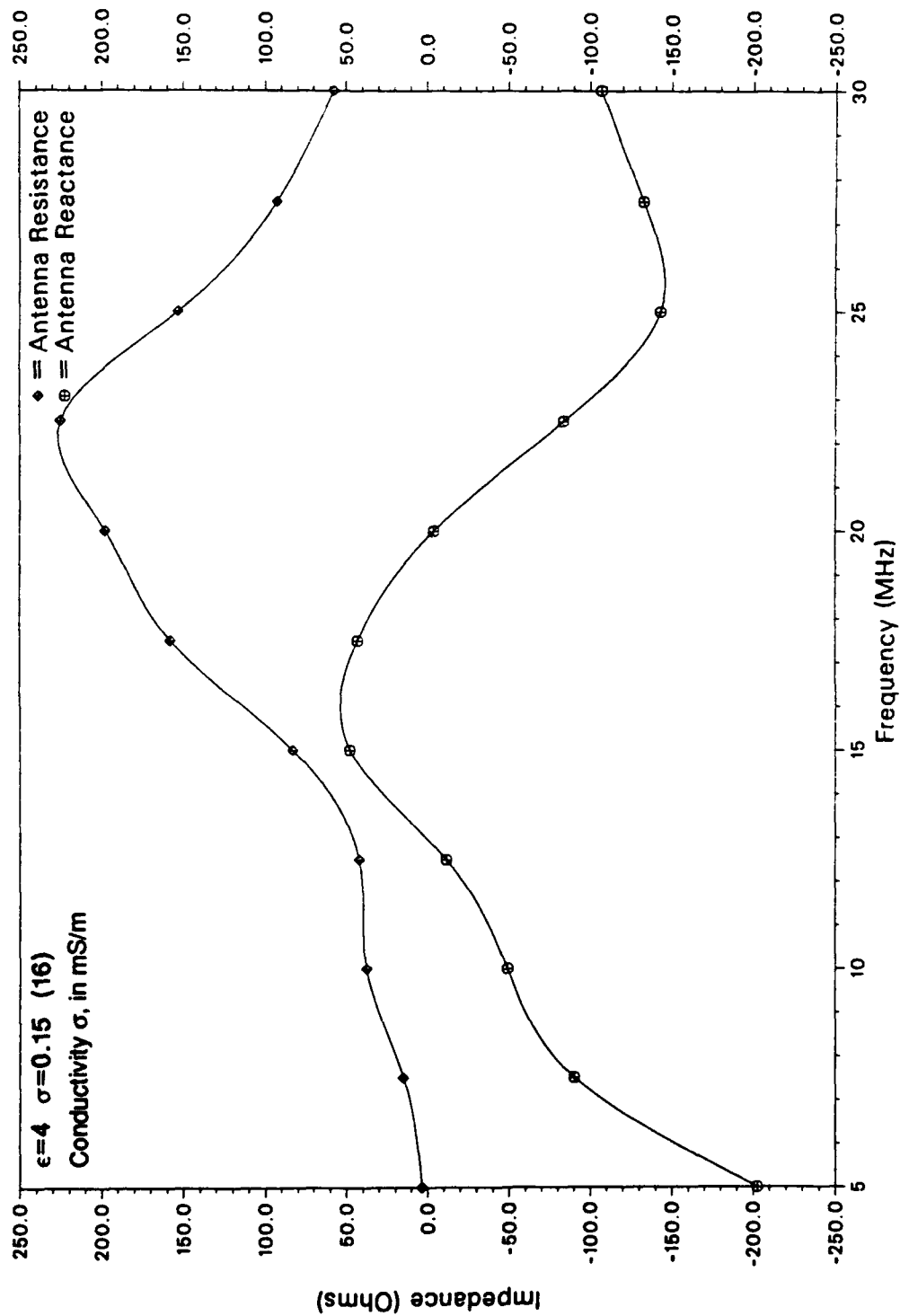


Figure A-5. Antenna Input Resistance and Reactance versus Frequency in Very Dry Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

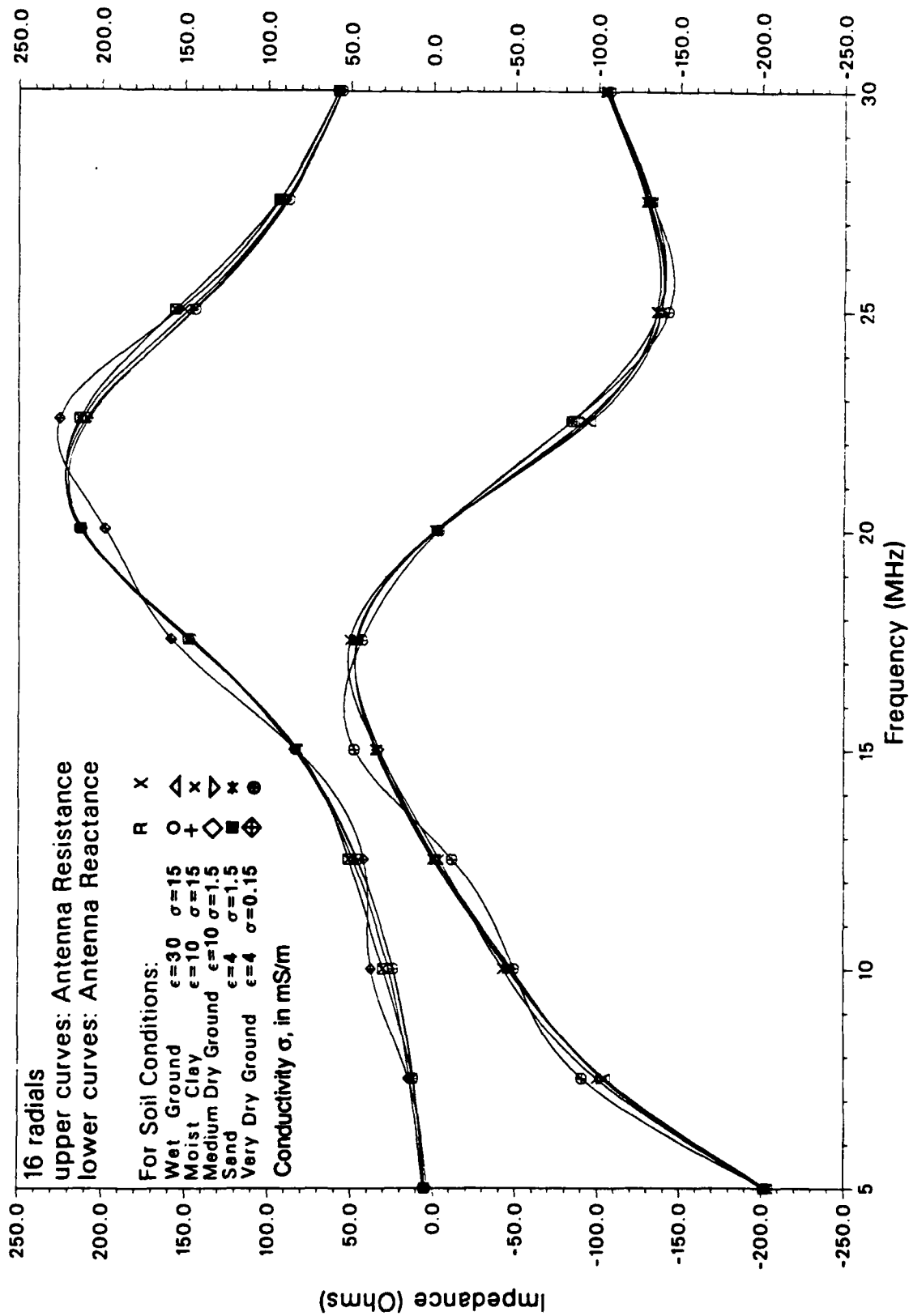


Figure A-6. Antenna Input Resistance and Reactance versus Frequency and Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

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Table A-1. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 5, 6, 7, 8, 9, 10, & 12)

Frequency (MHz)	Soil Characteristics				
	Very Good (Wet Ground)	Good (Moist Clay)	Average (Medium Dry Ground)	Fair (Sand)	Poor (Very Dry Ground)
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
5.0	5.26 - j203.9	5.01 - j203.7	5.73 - j201.7	4.79 - j201.7	3.35 - j202.6
7.5	12.2 - j104.6	11.7 - j104.1	14.3 - j102.9	12.4 - j99.5	14.9 - j90.5
10.0	24.6 + j46.3	24.3 - j45.2	27.2 - j47.7	30.6 - j42.2	37.9 - j49.0
12.5	46.1 - j1.19	46.6 + j0.25	49.0 - j1.69	51.4 - j3.62	42.3 - j11.4
15.0	83.3 + j34.1	84.4 + j34.9	84.2 + j32.6	82.0 + j33.8	83.2 + j47.9
17.5	146.0 + j46.1	146.8 + j45.8	145.9 + j46.6	148.1 + j50.4	158.3 + j43.3
20.0	213.4 - j2.56	207.7 - j93.0	211.9 - j2.62	212.5 - j1.49	198.0 - j3.67
22.5	209.3 - j95.1	212.3 - j93.0	211.8 - j91.0	213.2 - j83.6	225.3 - j83.9
25.0	143.7 - j138.4	144.5 - j135.9	147.3 - j138.4	155.6 - j136.6	153.3 - j143.0
27.5	87.5 - j130.3	88.7 - j129.4	89.2 - j131.2	93.1 - j133.1	92.8 - j132.7
30.0	55.7 - j104.9	55.8 - j104.3	56.1 - j105.1	57.8 - j105.8	57.5 - j106.8

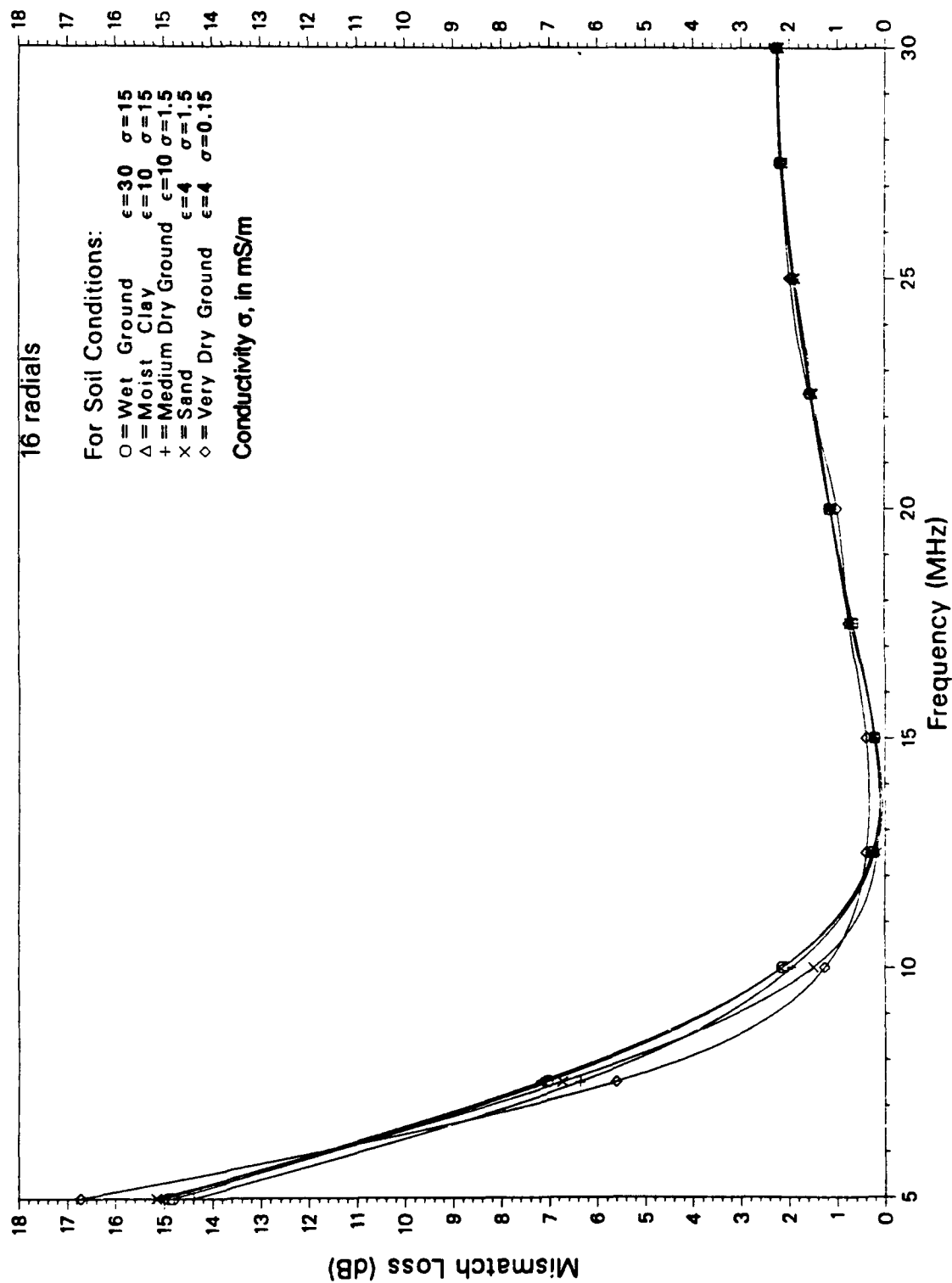


Figure A-7. Cable Mismatch Loss versus Frequency and Five Soil Conditions for 75 ohm Coaxial Cable Feeding 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

Table A-2. Antenna Input Resistance (ohms), Reactance (ohms), Magnitude Squared of Reflection Coefficient and Mismatch Loss (dB) versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole and 12 Meter Radius Ground Screen of 16 Radials and a 75 ohm Feed Cable

(Supports Vol. 1, Tables 5, 6, 7, 8, 9, 10 & 12)

FREQ	R	X	GAMMA SQ	dB
5.0	5.26	-203.90	9.67137E-01	14.83
7.5	12.20	-104.60	8.02642E-01	7.05
10.0	24.60	-46.30	3.88255E-01	2.13
12.5	46.10	-1.19	5.70429E-02	0.26
15.0	83.30	34.10	4.69725E-02	0.21
17.5	146.00	46.10	1.40607E-01	0.66
20.0	213.40	-2.56	2.30354E-01	1.14
22.5	209.30	-95.10	3.01328E-01	1.56
25.0	143.70	-138.40	3.56416E-01	1.91
27.5	87.50	-130.30	3.94943E-01	2.18
30.0	55.70	-104.90	4.05052E-01	2.26
5.0	5.01	-203.70	9.68619E-01	15.03
7.5	11.70	-104.10	8.08758E-01	7.18
10.0	24.30	-45.20	3.87577E-01	2.13
12.5	46.60	0.25	5.45508E-02	0.24
15.0	84.40	34.90	4.90630E-02	0.22
17.5	146.80	45.80	1.41401E-01	0.66
20.0	212.30	-2.99	2.28470E-01	1.13
22.5	207.70	-93.00	2.96475E-01	1.53
25.0	144.50	-135.90	3.49578E-01	1.87
27.5	88.70	-129.40	3.88867E-01	2.14
30.0	55.80	-104.30	4.01868E-01	2.23
5.0	5.73	-201.70	9.63581E-01	14.39
7.5	14.30	-102.90	7.68894E-01	6.36
10.0	27.20	-47.70	3.58497E-01	1.93
12.5	49.00	-1.69	4.41422E-02	0.20
15.0	84.20	32.60	4.34499E-02	0.19
17.5	146.90	46.60	1.42793E-01	0.67
20.0	211.90	-2.62	2.27755E-01	1.12
22.5	211.80	-91.00	2.98174E-01	1.54
25.0	147.30	-138.40	3.55566E-01	1.91
27.5	89.20	-131.20	3.94229E-01	2.18
30.0	56.10	-105.10	4.03894E-01	2.25
5.0	4.79	-201.70	9.69458E-01	15.15
7.5	12.40	-99.50	7.87901E-01	6.73
10.0	30.60	-42.20	2.90144E-01	1.49
12.5	51.40	-3.62	3.56512E-02	0.16
15.0	82.00	33.80	4.61952E-02	0.21
17.5	148.10	50.40	1.50702E-01	0.71
20.0	212.50	-1.49	2.28754E-01	1.13
22.5	213.20	-83.60	2.89714E-01	1.49
25.0	155.60	-136.60	3.50186E-01	1.87
27.5	93.10	-133.10	3.92472E-01	2.16
30.0	57.80	-105.80	3.98532E-01	2.21
5.0	3.35	-202.60	9.78701E-01	16.72
7.5	14.90	-90.50	7.25299E-01	5.61
10.0	37.90	-49.00	2.49377E-01	1.25
12.5	42.30	-11.40	8.63438E-02	0.39
15.0	83.20	47.90	8.64388E-02	0.39
17.5	158.30	43.30	1.56540E-01	0.74
20.0	198.00	-3.67	2.03139E-01	0.99
22.5	225.30	-83.90	3.04768E-01	1.58
25.0	153.30	-143.00	3.66266E-01	1.98
27.5	92.80	-132.70	3.91690E-01	2.16
30.0	57.50	-106.80	4.04402E-01	2.25

Wet Ground
 $\epsilon_r = 30, \sigma = 15 \text{ mS/m}$

Moist Clay
 $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

Medium Dry Ground
 $\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$

Sandy Soil
 $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

Very Dry Ground
 $\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$

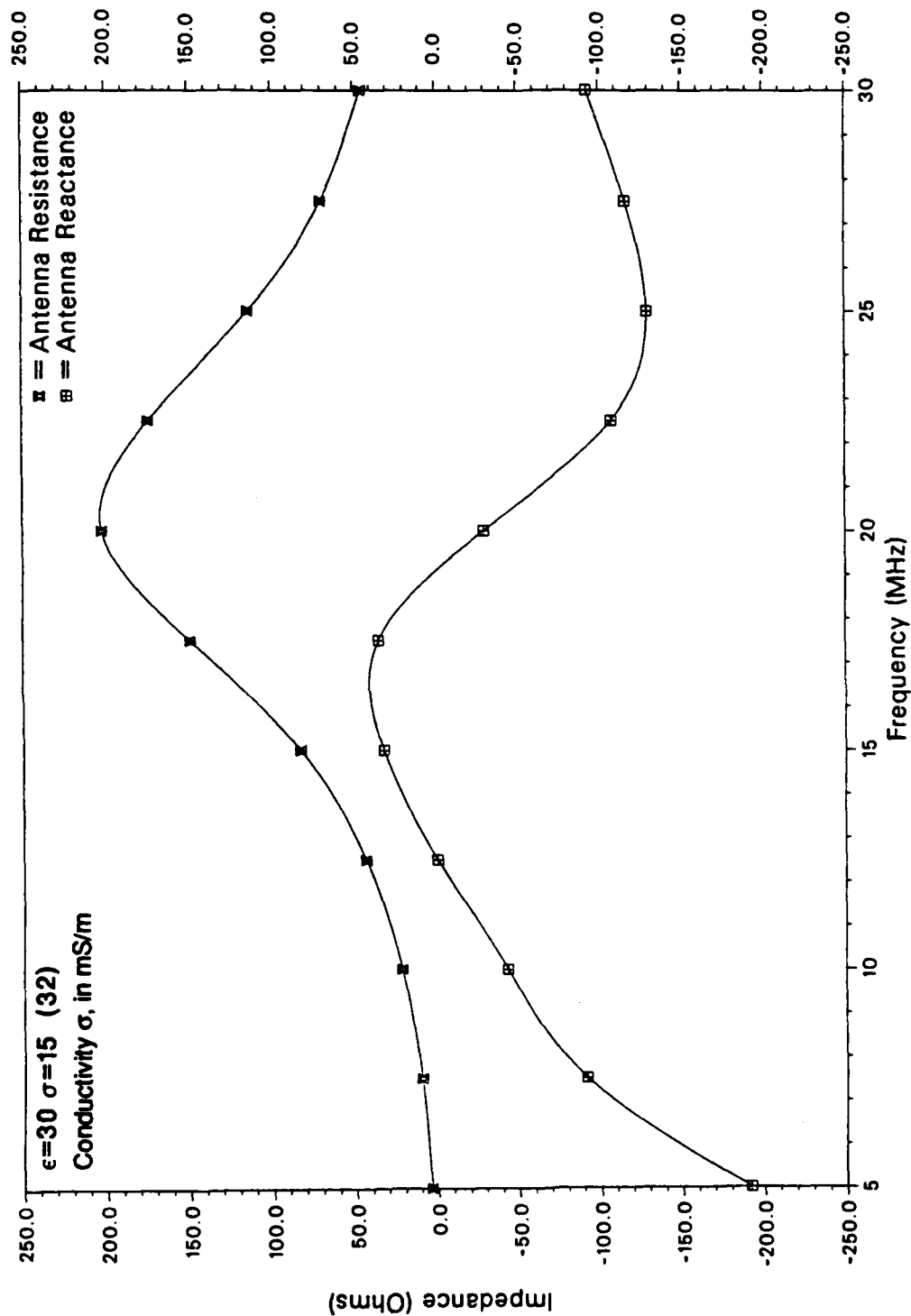


Figure A-8. Antenna Input Resistance and Reactance versus Frequency in Wet Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

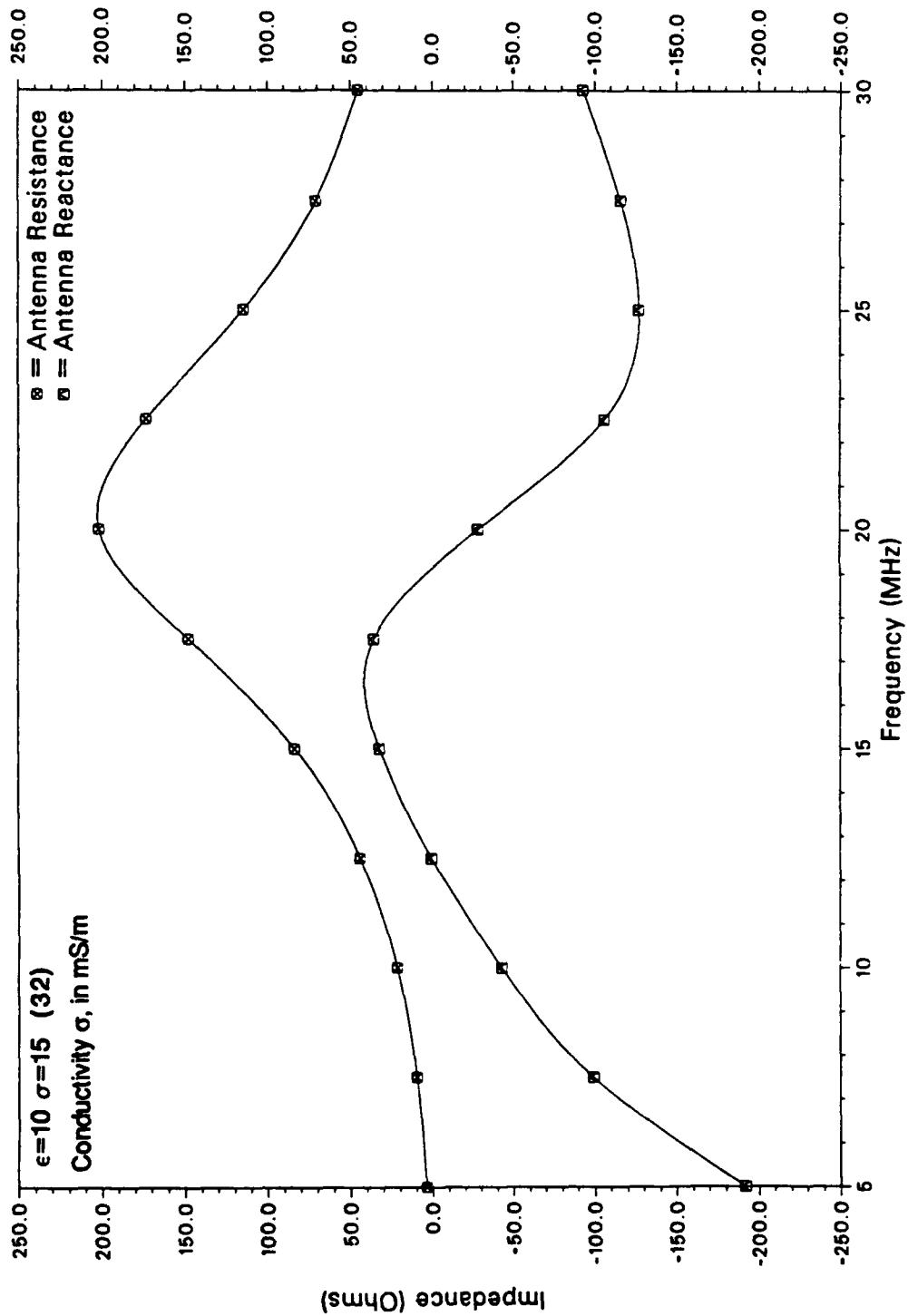


Figure A-9. Antenna Input Resistance and Reactance versus Frequency in Moist Clay for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

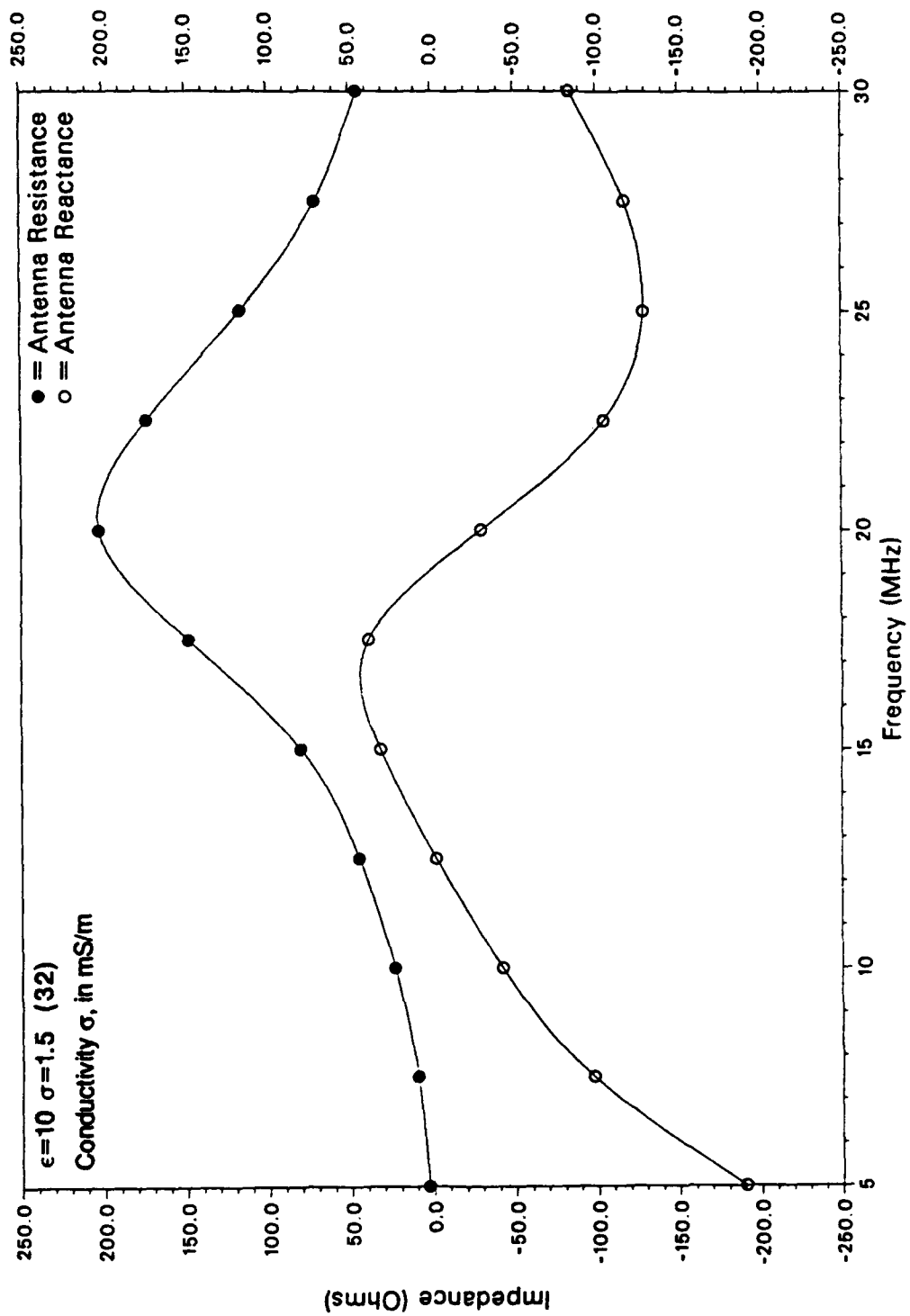


Figure A-10. Antenna Input Resistance and Reactance versus Frequency in Medium Dry Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

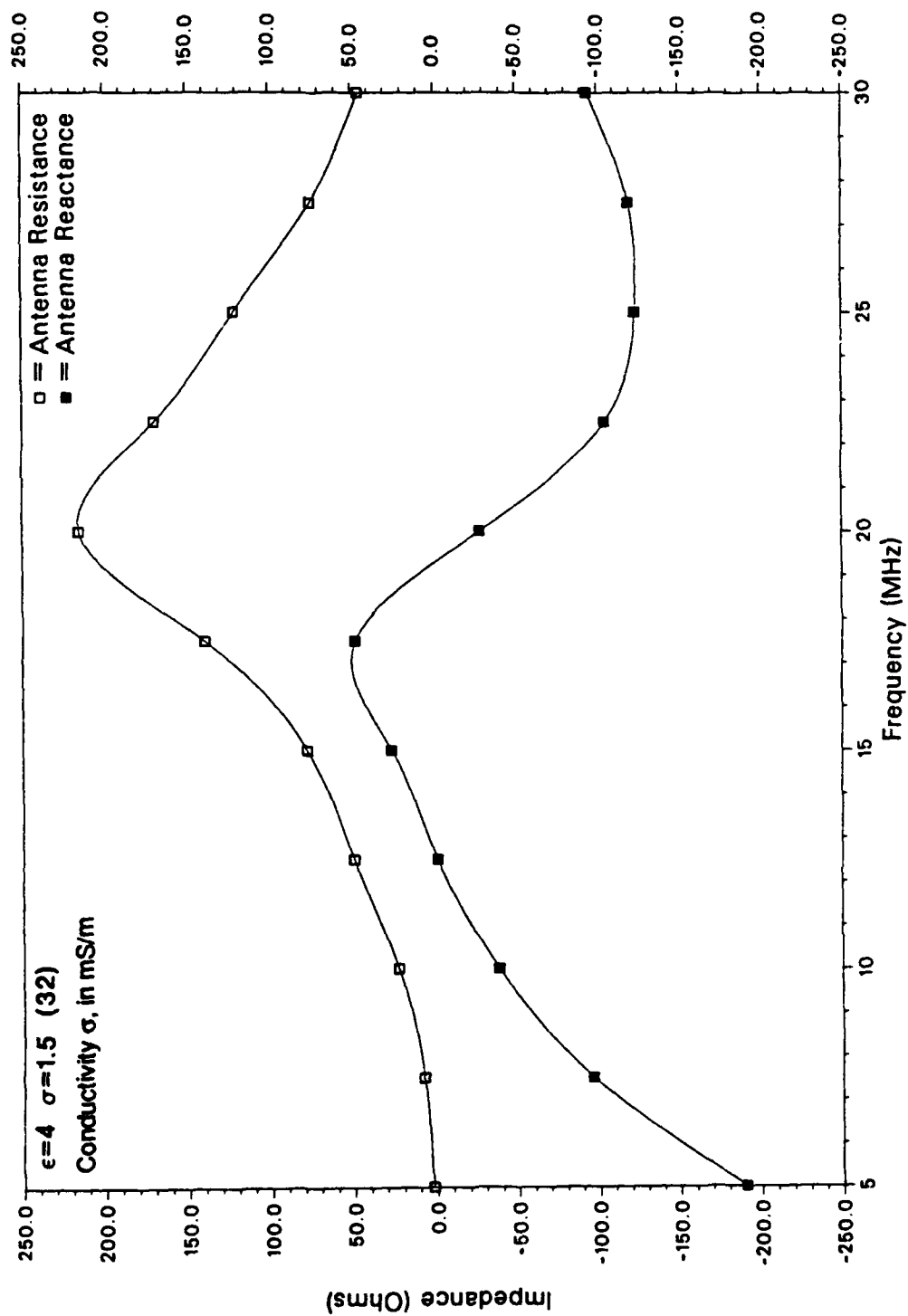


Figure A-11. Antenna Input Resistance and Reactance versus Frequency in Sandy Soil for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

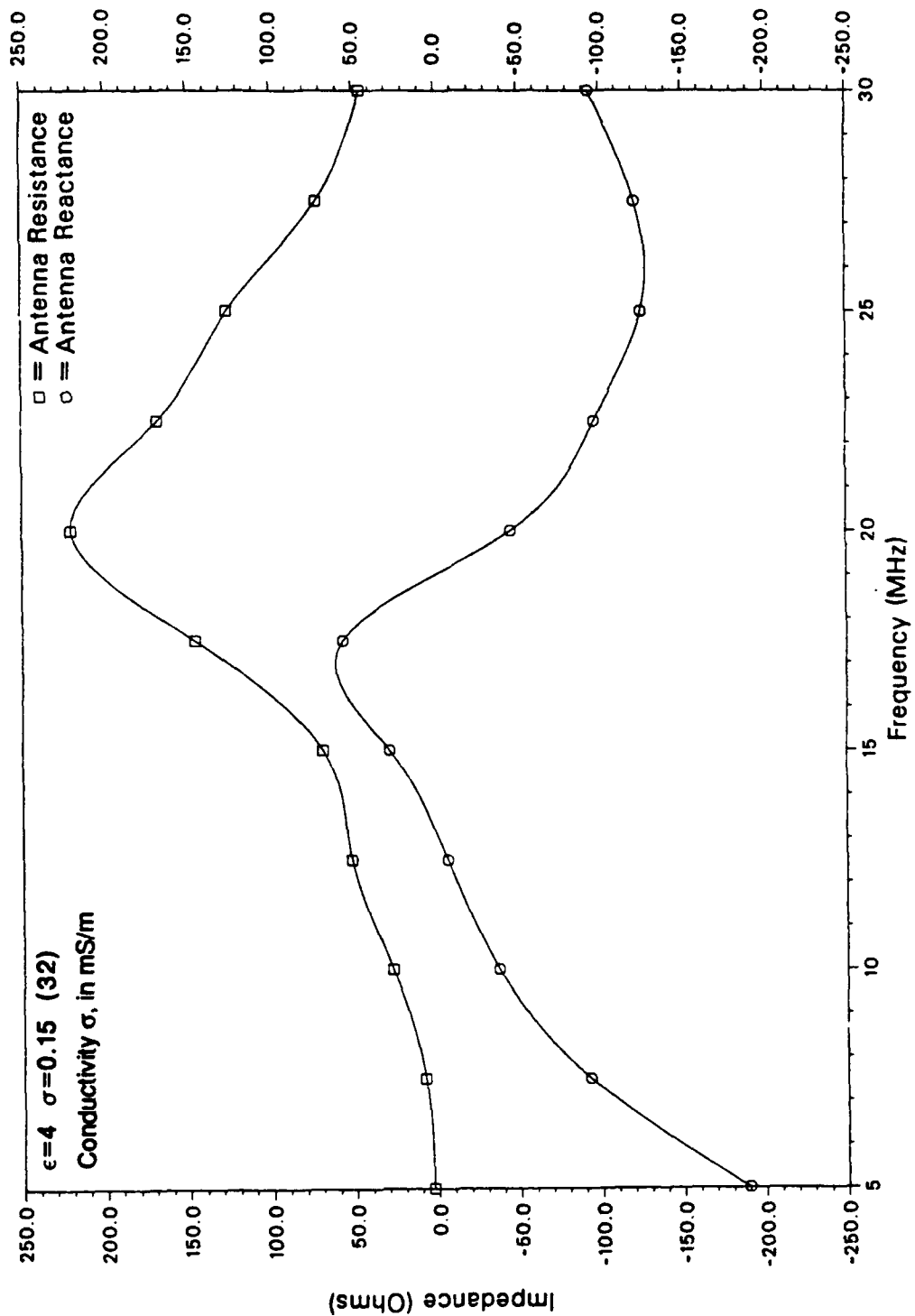


Figure A-12. Antenna Input Resistance and Reactance versus Frequency in Very Dry Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

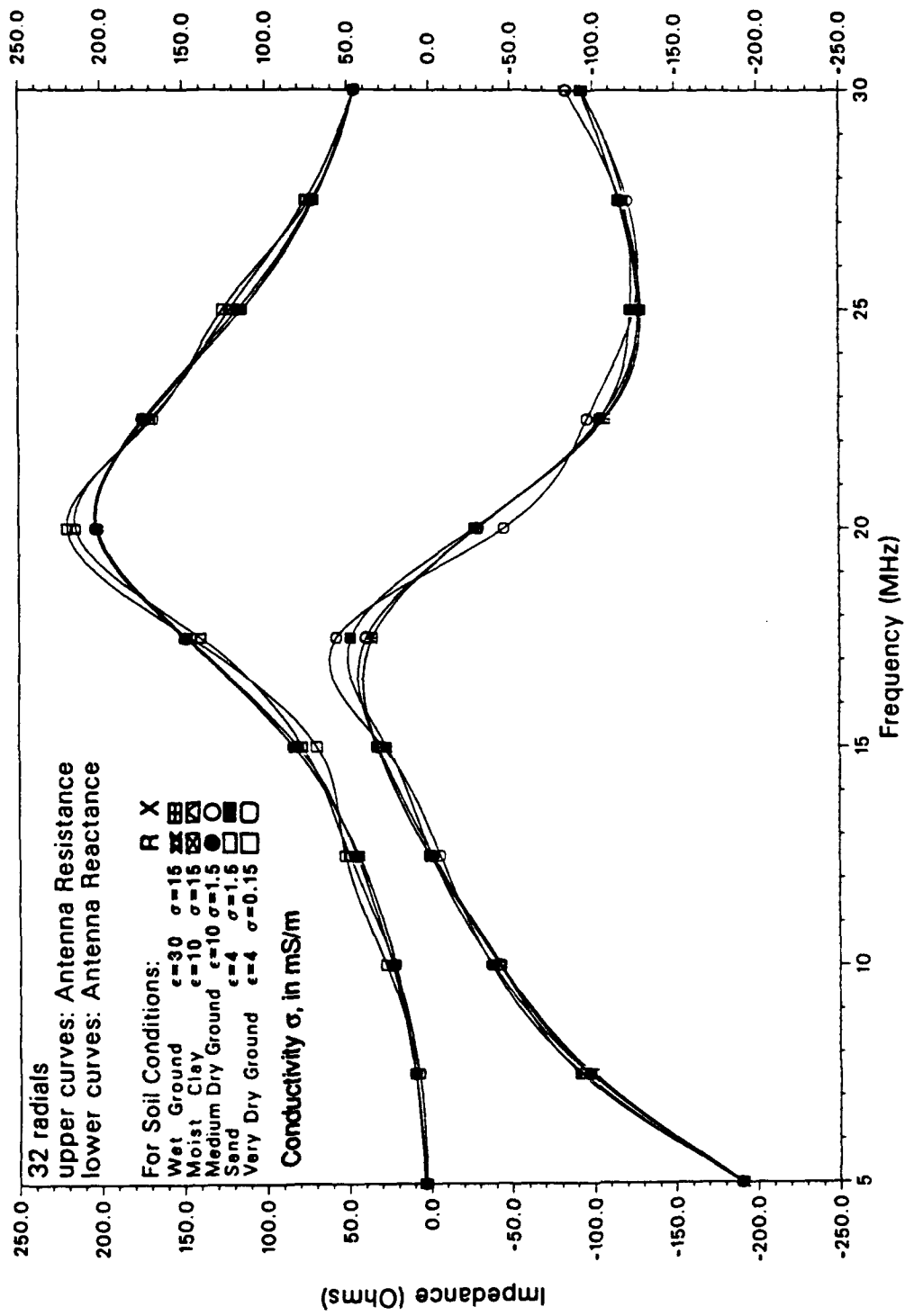


Figure A-13. Antenna Input Resistance and Reactance versus Frequency and Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

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Table A-3. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials, 2 mm in Diameter and Buried 0.178 Deep

(Supports Vol. 1, Tables 5, 7, & 8)

Frequency (MHz)	Soil Characteristics				
	Very Good (Wet Ground)	Good (Moist Clay)	Average (Medium Dry Ground)	Fair (Sand)	Poor (Very Dry Ground)
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
5.0	3.80 - j192.0	3.66 - j191.9	3.08 - j190.6	2.30 - j190.5	2.85 - j189.7
7.5	10.0 - j91.1	9.64 - j99.2	9.74 - j97.3	7.42 - j96.4	7.79 - j92.8
10.0	22.0 - j43.2	21.6 - j42.8	23.7 - j41.9	22.8 - j38.2	27.5 - j37.2
12.5	43.9 - j0.1	44.1 + j0.51	45.3 - j1.66	49.7 - j0.83	52.3 - j6.05
15.0	83.4 + j32.8	83.4 + j32.3	80.7 + j32.1	77.9 + j26.6	69.4 + j29.0
17.5	149.5 + j35.7	147.8 + j35.6	149.1 + j39.4	139.9 + 48.8	146.3 + j57.6
20.0	202.5 - j29.3	201.8 - j28.4	203.2 - j24.5	215.5 - j27.2	220.5 - j45.4
22.5	174.3 - j107.4	172.9 - j106.3	174.3 - j104.2	169.9 - j104.2	168.3 - j96.4
25.0	114.0 - j129.5	114.1 - j127.7	116.8 - j128.7	126.6 - j123.0	126.0 - j125.3
27.5	69.9 - j116.5	70.6 - j116.1	71.0 - j117.4	75.0 - j119.4	72.2 - j121.7
30.0	45.3 - j93.0	45.2 - j93.1	45.2 - j83.9	45.4 - j94.2	45.3 - j93.8

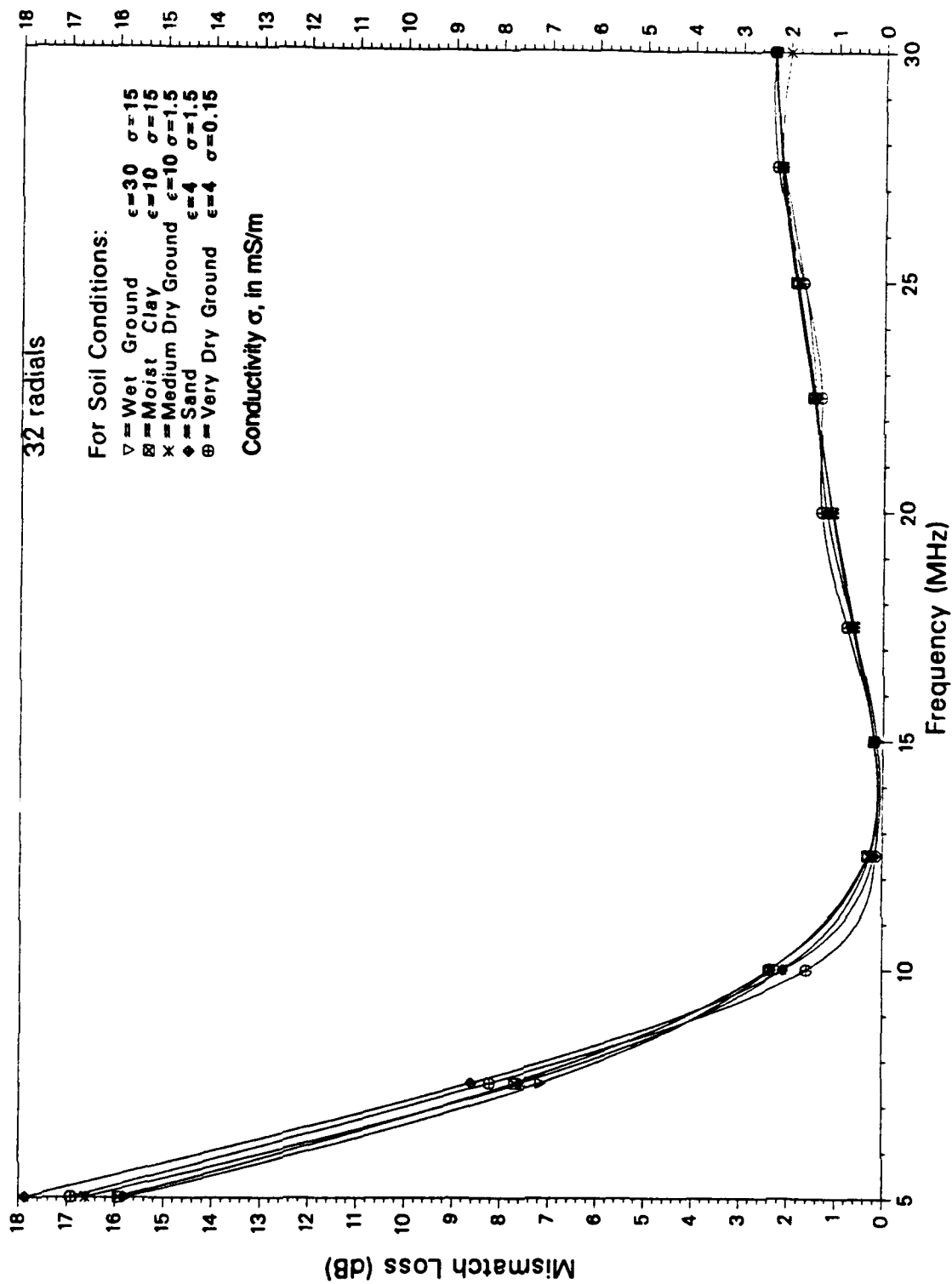


Figure A-14. Cable Mismatch Loss versus Frequency and Five Soil Conditions for 75 ohm Coaxial Cable Feeding 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

Table A-4. Antenna Input Resistance (ohms), Reactance (ohms), Magnitude Squared of Reflection Coefficient and Mismatch Loss (dB) versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole and 12 Meter Radius Ground Screen of 32 Radials and a 75 ohm Feed Cable

(Supports Vol. 1, Tables 5, 7 & 8)

FREQ	R	X	GAMMA SQ	dB
5.0	3.80	-192.00	9.73534E-01	15.77
7.5	10.00	-91.10	8.06753E-01	7.14
10.0	22.00	-43.20	4.14647E-01	2.33
12.5	43.90	-0.10	6.84166E-02	0.31
15.0	83.40	32.80	4.38119E-02	0.19
17.5	149.50	35.70	1.32071E-01	0.62
20.0	202.50	-29.30	2.19801E-01	1.08
22.5	174.30	-107.40	2.90360E-01	1.49
25.0	114.00	-129.50	3.48463E-01	1.86
27.5	69.90	-116.50	3.93374E-01	2.17
30.0	45.30	-93.00	4.12225E-01	2.31
5.0	3.66	-191.90	9.74473E-01	15.93
7.5	9.64	-99.20	8.29928E-01	7.69
10.0	21.60	-42.80	4.19532E-01	2.36
12.5	44.10	0.51	6.73293E-02	0.30
15.0	83.40	32.30	4.26210E-02	0.19
17.5	147.80	35.60	1.29003E-01	0.60
20.0	201.80	-28.40	2.18080E-01	1.07
22.5	172.90	-106.30	2.87051E-01	1.47
25.0	114.10	-127.70	3.42566E-01	1.82
27.5	70.60	-116.10	3.89248E-01	2.14
30.0	45.20	-93.10	4.13384E-01	2.32
5.0	3.08	-190.60	9.78220E-01	16.62
7.5	9.79	-97.30	8.23674E-01	7.54
10.0	23.70	-41.90	3.81594E-01	2.09
12.5	45.30	-1.66	6.11299E-02	0.27
15.0	80.70	32.10	4.20569E-02	0.19
17.5	149.10	39.40	1.36039E-01	0.64
20.0	203.20	-29.50	2.21113E-01	1.09
22.5	174.30	-104.20	2.83778E-01	1.45
25.0	116.80	-128.70	3.43217E-01	1.83
27.5	71.00	-117.40	3.93141E-01	2.17
30.0	45.20	-83.90	3.68928E-01	2.00
5.0	2.30	-190.50	9.83675E-01	17.87
7.5	7.42	-96.40	8.61619E-01	8.59
10.0	22.80	-38.20	3.79540E-01	2.07
12.5	49.70	-0.83	4.12056E-02	0.18
15.0	77.90	26.60	2.97256E-02	0.13
17.5	139.90	48.80	1.35770E-01	0.63
20.0	215.50	-27.20	2.40574E-01	1.20
22.5	169.90	-104.20	2.80427E-01	1.43
25.0	121.60	-123.00	3.21688E-01	1.69
27.5	75.00	-119.40	3.87861E-01	2.13
30.0	45.40	-94.20	4.17197E-01	2.34
5.0	2.85	-189.70	9.79665E-01	16.92
7.5	7.79	-92.80	8.48895E-01	8.21
10.0	27.50	-37.20	3.06145E-01	1.59
12.5	52.30	-6.05	3.39796E-02	0.15
15.0	69.40	29.00	4.02151E-02	0.18
17.5	146.30	57.60	1.60666E-01	0.76
20.0	220.50	-45.40	2.59913E-01	1.31
22.5	168.30	-96.40	2.62789E-01	1.32
25.0	126.00	-125.30	3.26216E-01	1.71
27.5	72.20	-121.70	4.06229E-01	2.26
30.0	45.30	-93.80	4.16000E-01	2.34

Wet Ground
 $\epsilon_r = 30, \sigma = 15 \text{ mS/m}$

Moist Clay
 $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

Medium Dry Ground
 $\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$

Sandy Soil
 $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

Very Dry Ground
 $\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$

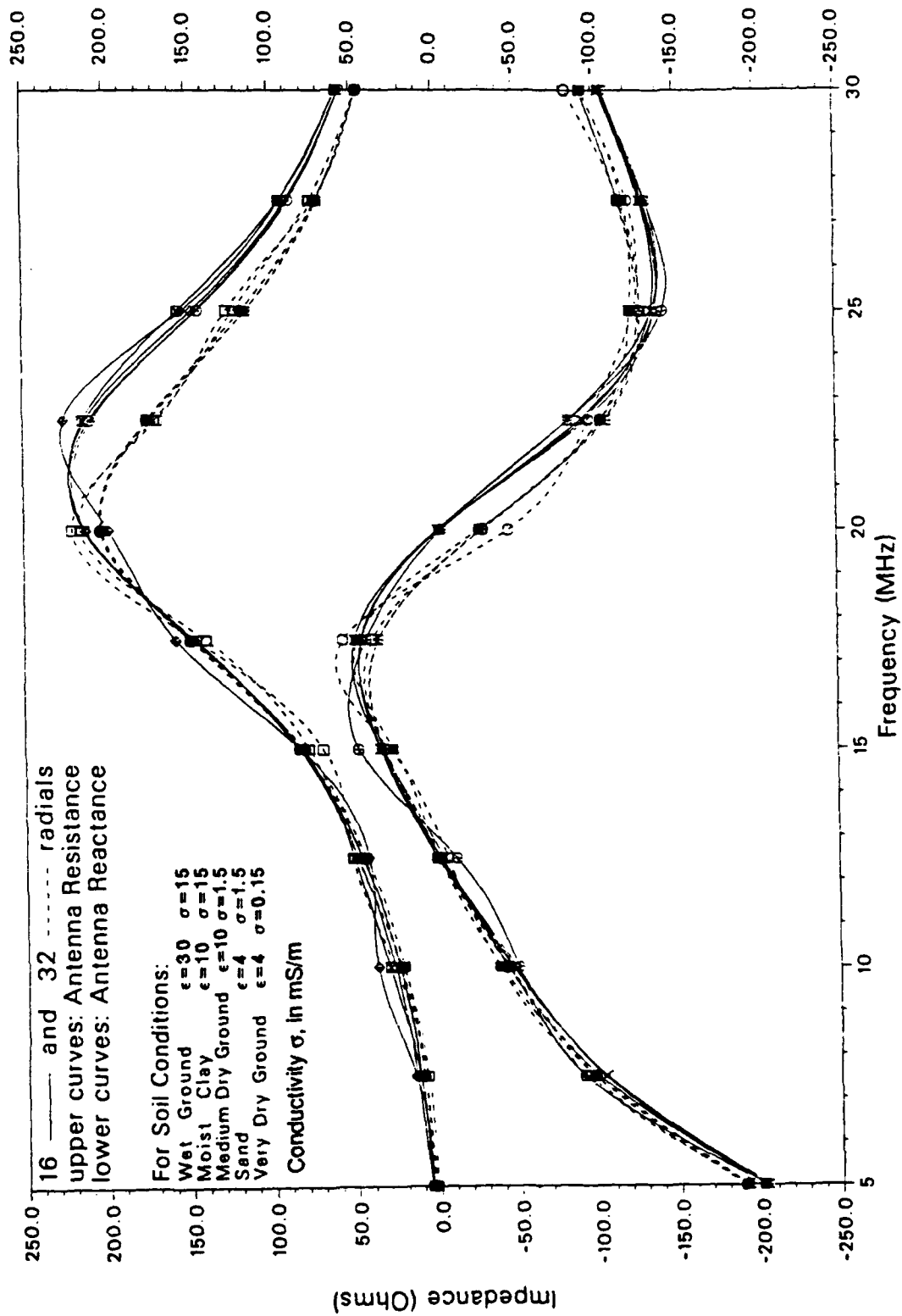


Figure A-15. Antenna Input Resistance and Reactance versus Frequency and Five Ground Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of Either 16 or 32 Radials

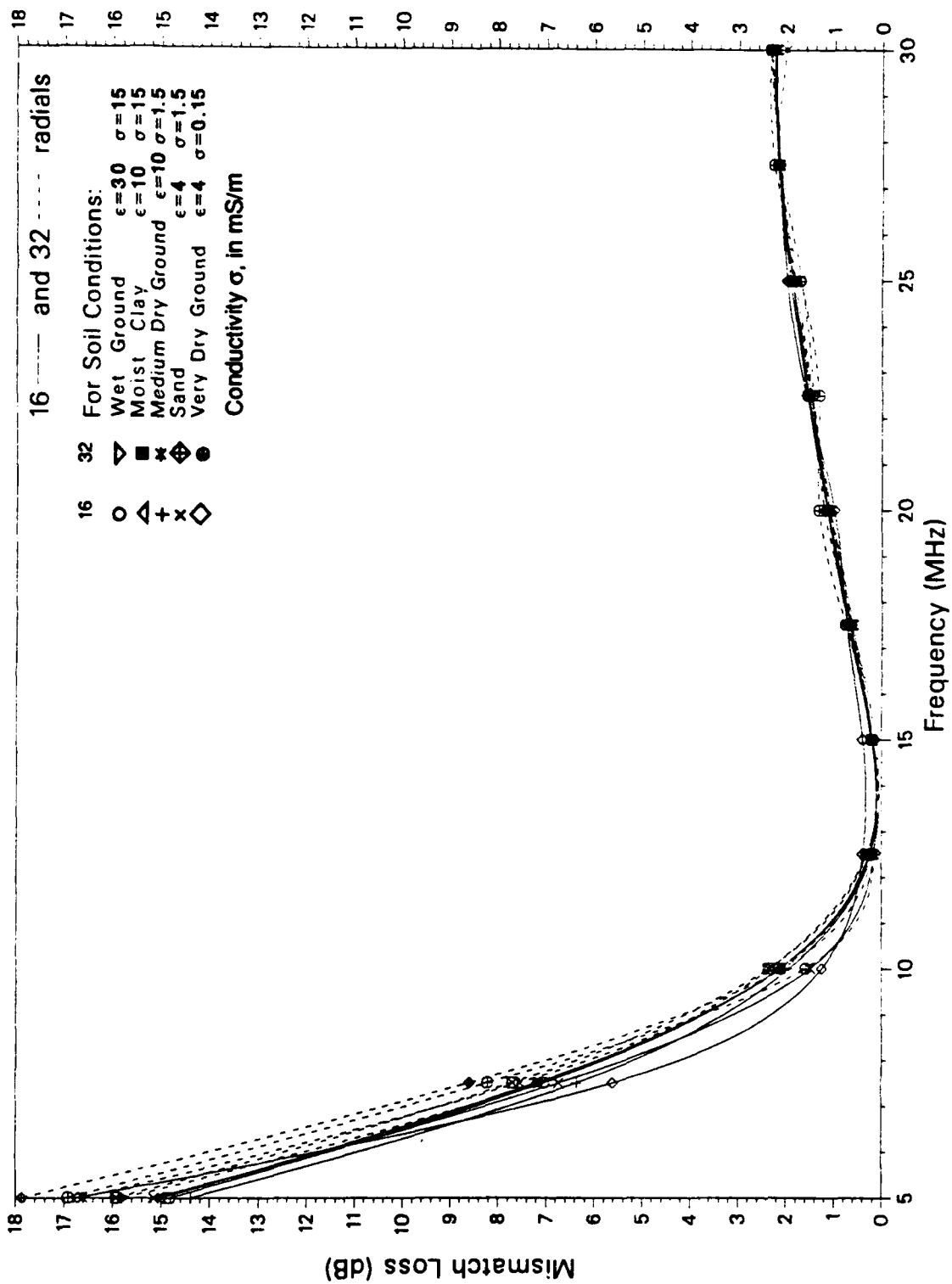


Figure A-16. Cable Mismatch Loss versus Frequency and Five Soil Conditions for 75 ohm Coaxial Cable Feeding
5.4 Meter High Monopole with 12 Meter Radius Ground Screen Having Either 16 or 32 Radials

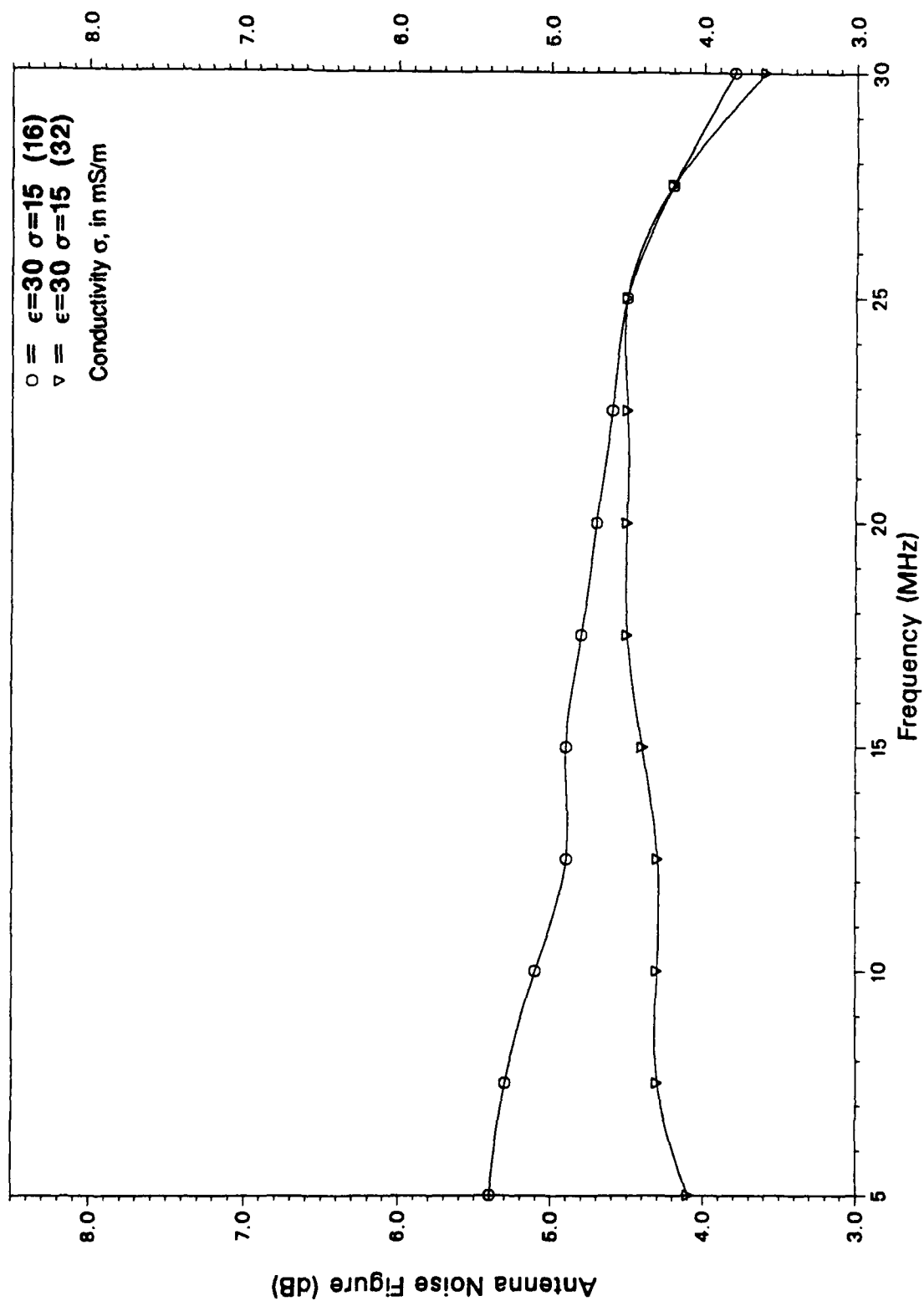


Figure A-17. Antenna Noise Figure (Ohmic Loss) versus Frequency and Number of Radials (16 or 32) in Wet Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen

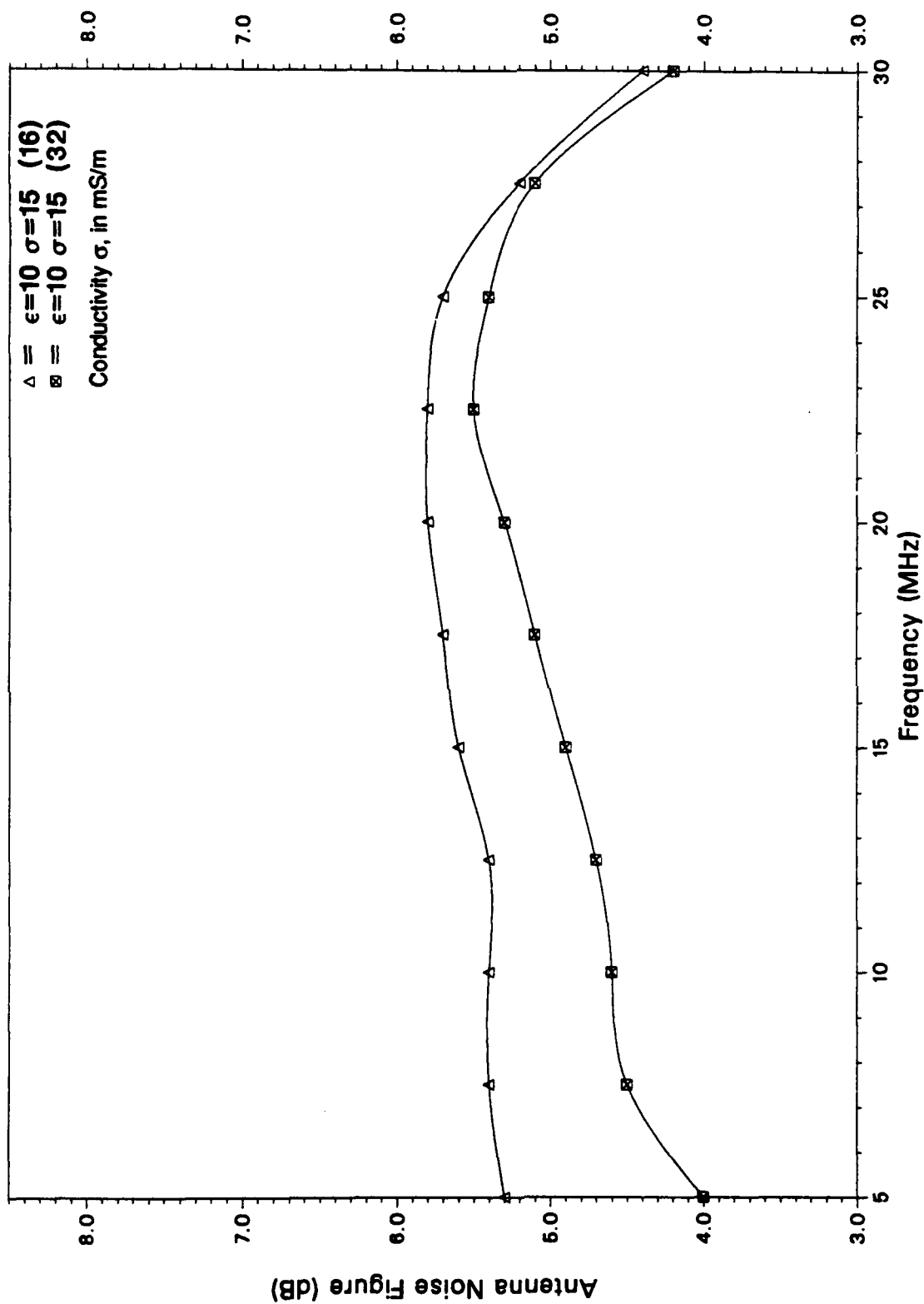


Figure A-18. Antenna Noise Figure (Ohmic Loss) versus Frequency and Number of Radials (16 or 32) in Moist Clay for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen

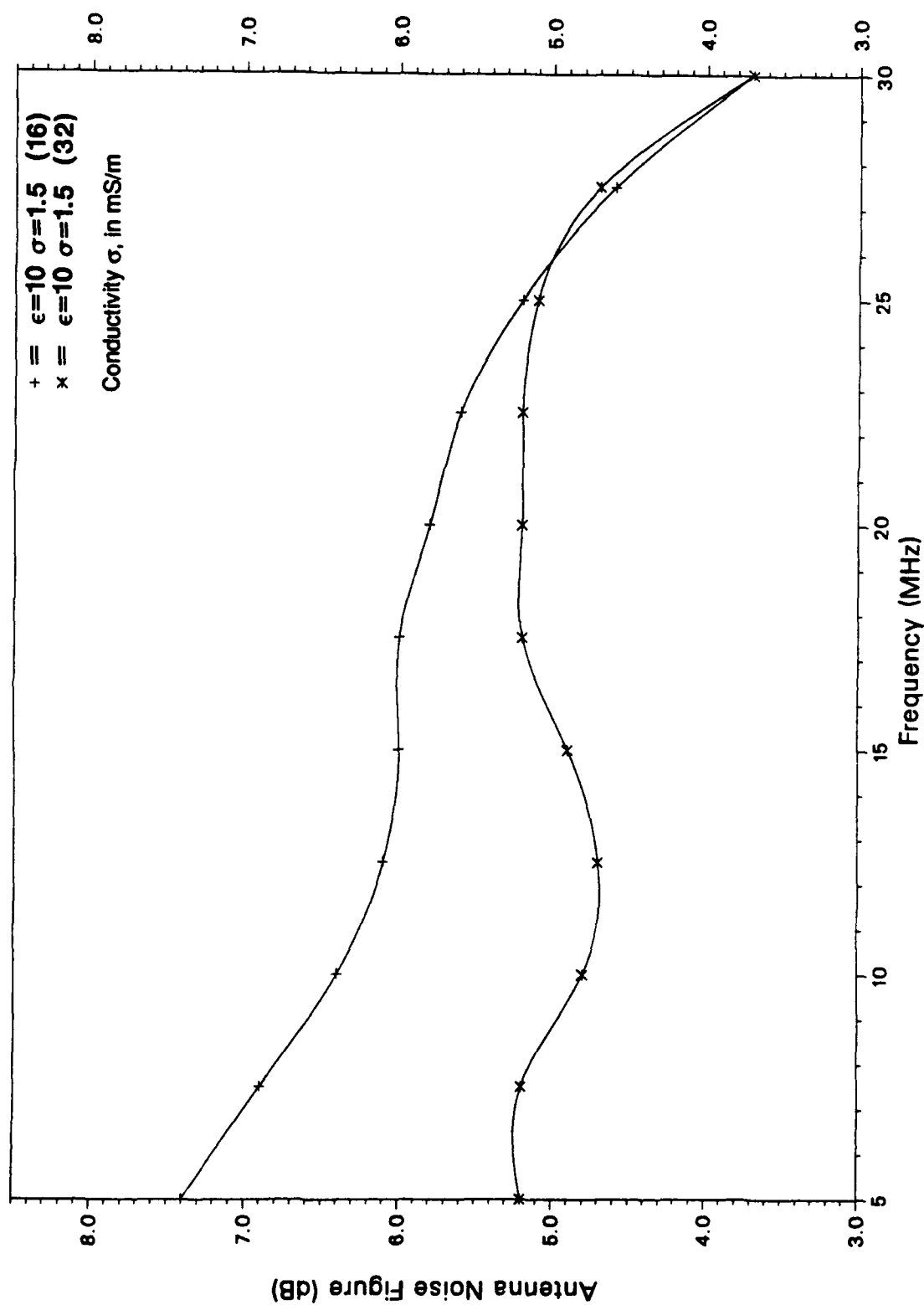


Figure A-19. Antenna Noise Figure (Ohmic Loss) versus Frequency and Number of Radials (16 or 32) in Medium Dry Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen

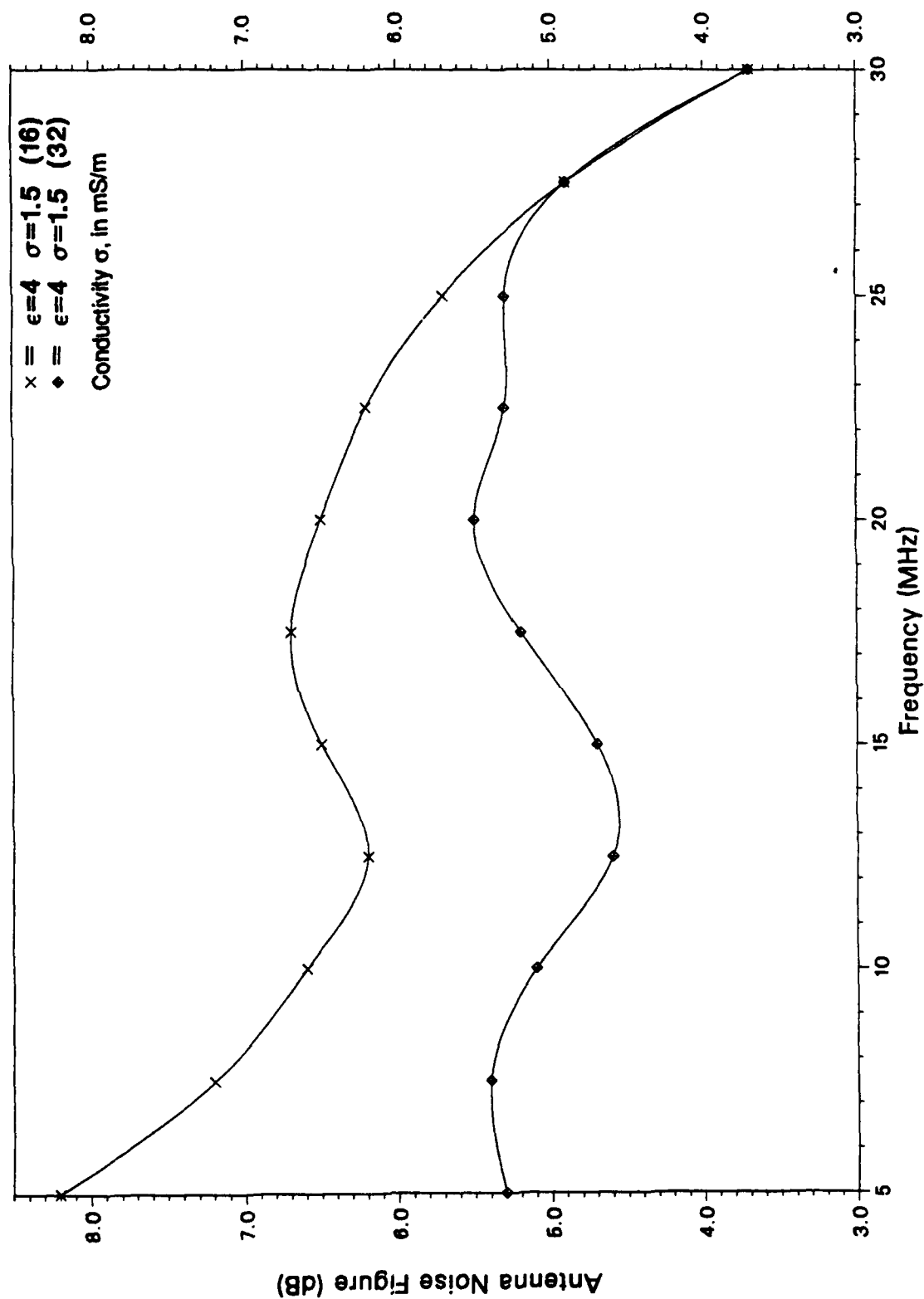


Figure A-20. Antenna Noise Figure (Ohmic Loss) versus Frequency and Number of Radials (16 or 32) in Sandy Soil for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen

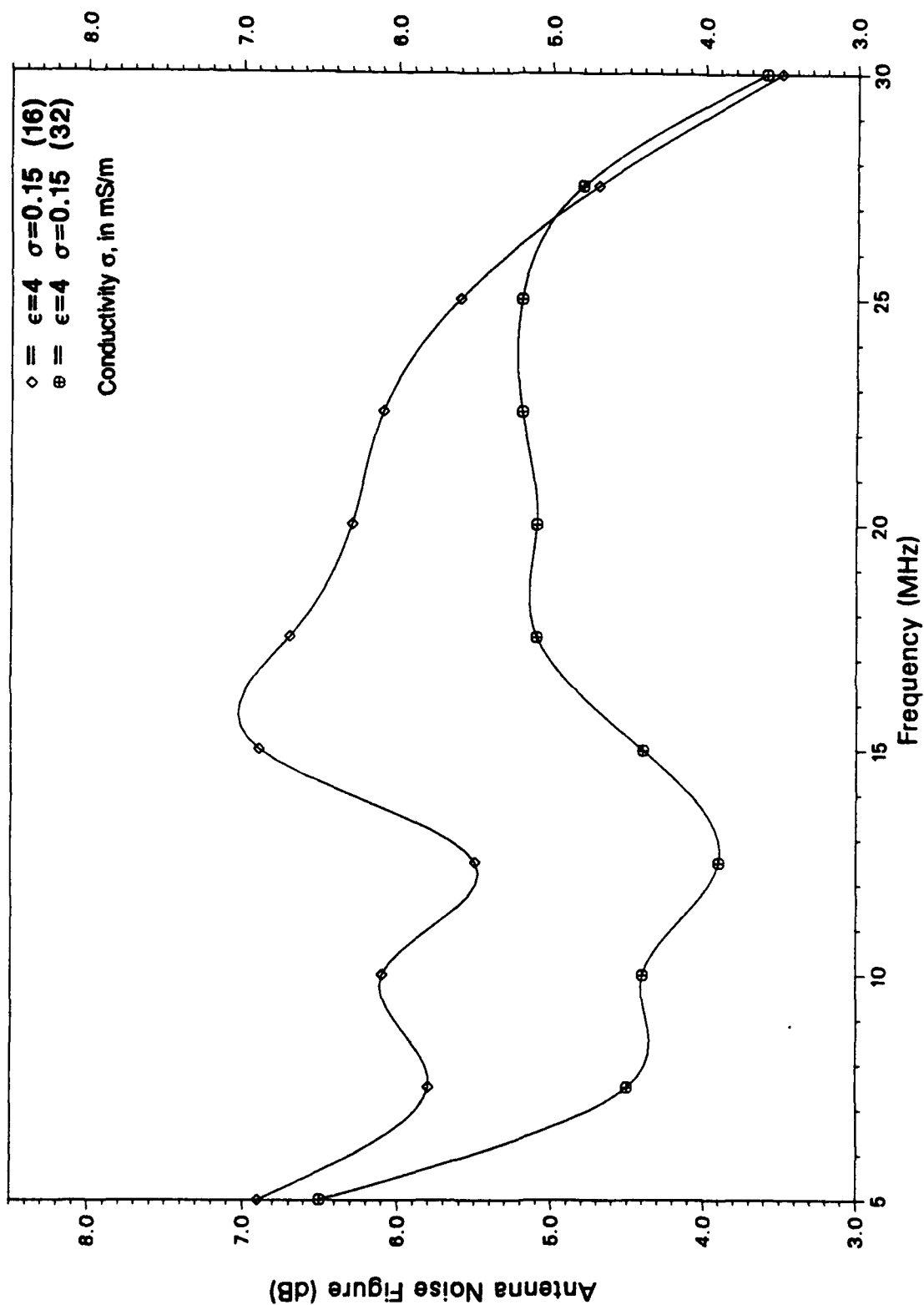


Figure A-21. Antenna Noise Figure (Ohmic Loss) versus Frequency and Number of Radials (16 or 32) in Very Dry Ground for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen

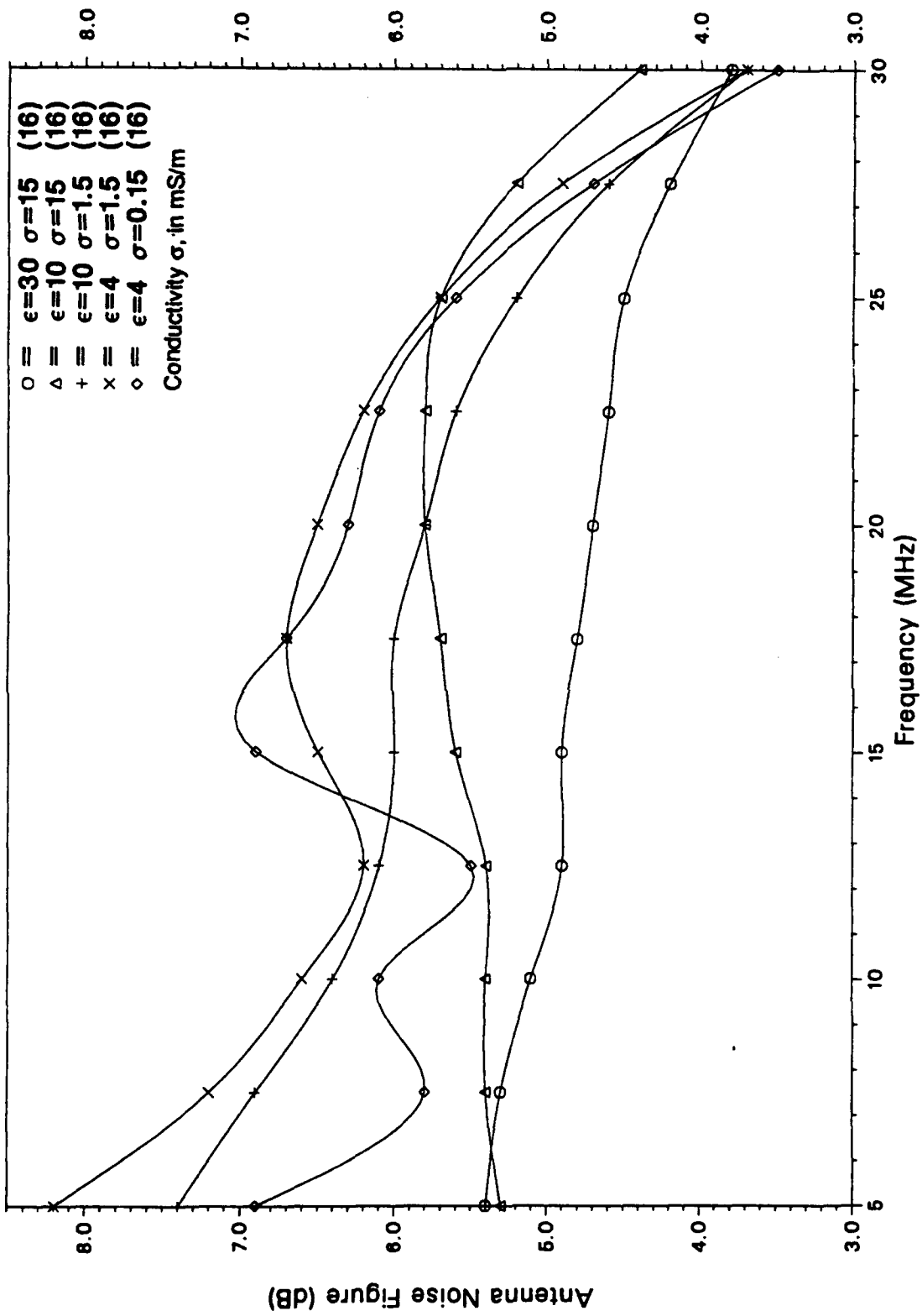


Figure A-22. Antenna Noise Figure (Ohmic Loss) versus Frequency and Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

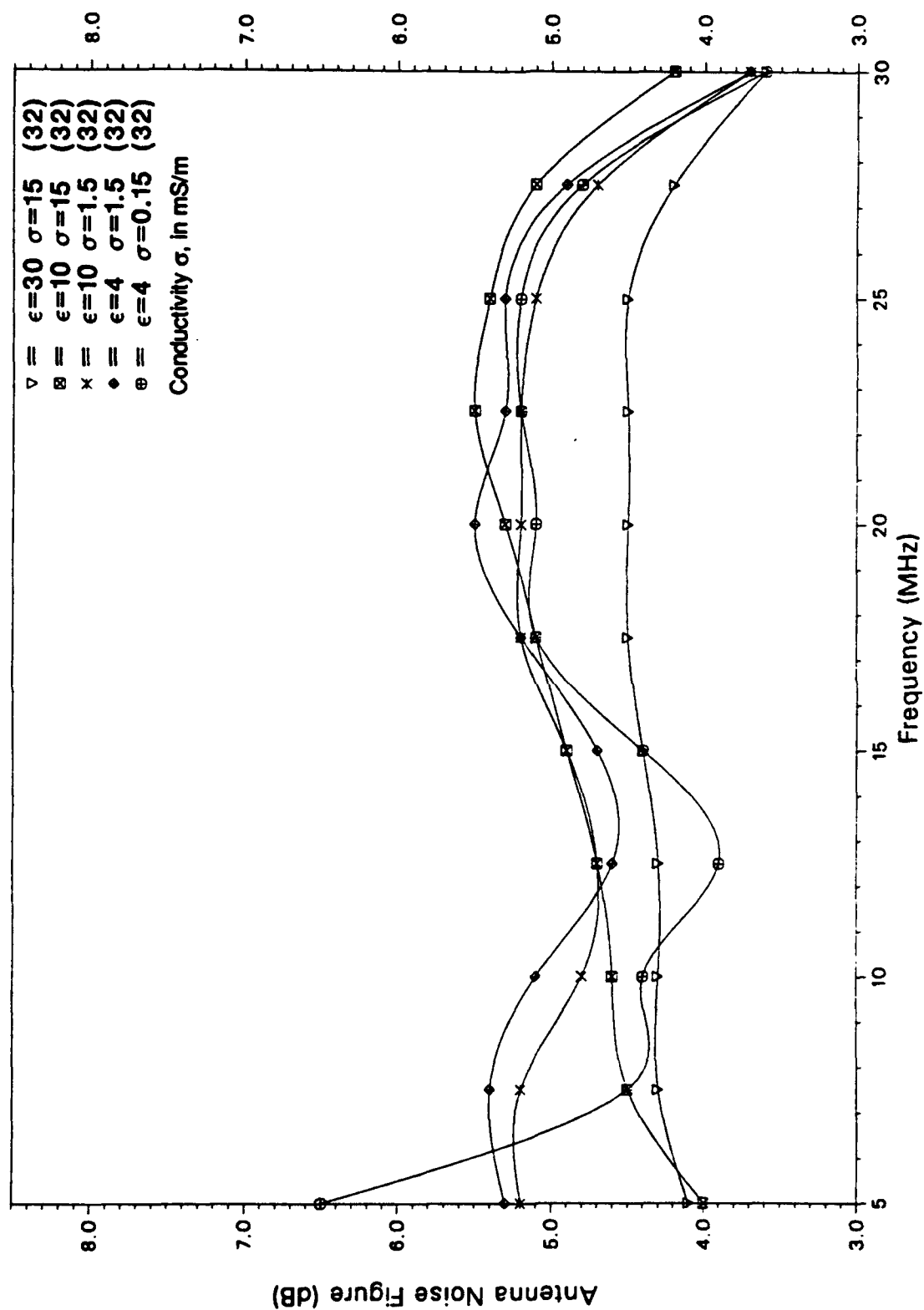


Figure A-23. Antenna Noise Figure (Ohmic Loss) versus Frequency and Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

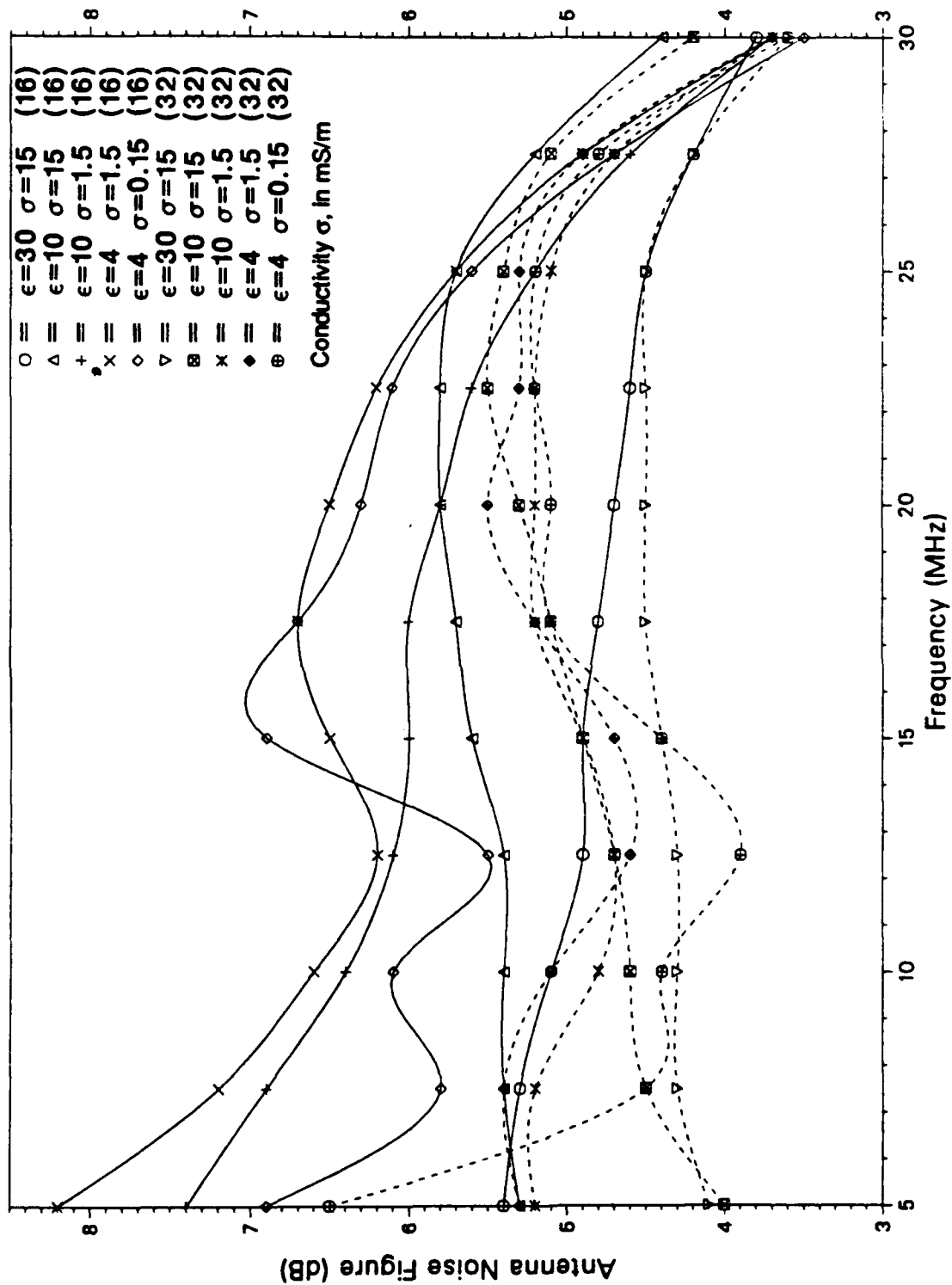


Figure A-24. Antenna Noise (Ohmic Loss) versus Frequency and Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 or 32 Radials

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Table A-5. Antenna Efficiency and Noise Figure versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 5, 6, 7, 8, 9, 10 & 12)

Frequency (MHz)	Soil Characteristics									
	Very Good (Wet Ground)		Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	28.9	5.4	29.7	5.3	18.2	7.4	15.3	8.2	20.2	6.9
7.5	29.3	5.3	28.5	5.4	20.5	6.9	19.1	7.2	26.6	5.8
10.0	31.0	5.1	28.7	5.4	22.9	6.4	21.9	6.6	24.7	6.1
12.5	32.1	4.9	28.6	5.4	24.4	6.1	23.8	6.2	28.1	5.5
15.0	32.6	4.9	27.8	5.6	25.0	6.0	22.4	6.5	20.2	6.9
17.5	33.2	4.8	27.0	5.7	25.3	6.0	21.6	6.7	21.3	6.7
20.0	33.7	4.7	26.3	5.8	26.4	5.8	22.5	6.5	23.4	6.3
22.5	34.5	4.6	26.3	5.8	27.8	5.6	24.2	6.2	24.4	6.1
25.0	35.8	4.5	27.1	5.7	30.2	5.2	26.8	5.7	27.7	5.6
27.5	38.1	4.2	29.9	5.2	34.8	4.6	32.4	4.9	33.6	4.7
30.0	42.1	3.8	36.6	4.4	42.4	3.7	42.9	3.7	45.0	3.5

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Table A-6. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 5, 7, & 8)

Frequency (MHz)	Soil Characteristics									
	Very Good (Wet Ground)		Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	39.0	4.1	39.5	4.0	30.1	5.2	29.4	5.3	22.4	6.5
7.5	36.8	4.3	35.1	4.5	30.1	5.2	28.7	5.4	35.7	4.5
10.0	37.3	4.3	34.3	4.6	33.3	4.8	31.1	5.1	36.6	4.4
12.5	37.4	4.3	33.7	4.7	33.9	4.7	34.6	4.6	40.8	3.9
15.0	36.7	4.4	32.4	4.9	32.2	4.9	33.7	4.7	36.5	4.4
17.5	35.9	4.5	30.8	5.1	30.4	5.2	30.0	5.2	30.6	5.1
20.0	35.3	4.5	29.2	5.3	29.9	5.2	28.5	5.4	31.0	5.1
22.5	35.2	4.5	28.4	5.5	29.9	5.2	29.4	5.3	30.4	5.2
25.0	35.8	4.5	28.6	5.4	30.7	5.1	29.8	5.3	30.3	5.2
27.5	38.2	4.2	30.7	5.1	34.1	4.7	32.2	4.9	32.8	4.8
30.0	44.1	3.6	38.0	4.2	43.0	3.7	42.7	3.7	43.9	3.6

Table A-7. Antenna Input Resistance and Reactance versus Frequency for Four Soil Conditions for 5.4 Meter High Monopole with 24 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 6 and 8)

Frequency (MHz)	Soil Characteristics			
	Good (Moist Clay)	Average (Medium Dry Ground)	Fair (Sand)	Poor (Very Dry Ground)
	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
5.0	5.02 - j203.5	6.50 - j202.1	6.21 - j200.5	10.8 - j202.7
10.0	24.2 - j45.2	26.9 - j45.5	27.8 - j43.2	28.5 - j45.1
15.0	84.5 + j35.7	85.3 + j33.6	86.6 + j34.4	86.5 + j32.5
20.0	212.3 - j1.87	211.4 - j1.25	210.4 + j5.58	216.3 + j11.2
25.0	145.8 - j136.5	148.7 - j137.4	154.6 - j136.6	153.1 - j140.1
30.0	56.7 - j104.5	58.4 - j103.8	58.4 - j105.1	58.3 - j106.5

Table A-8. Antenna Efficiency and Noise Figure versus Frequency for Four Soil Conditions for 5.4 Meter High Monopole with 24 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 6 and 8)

Frequency (MHz)	Soil Characteristics							
	Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	30.7	5.1	18.4	7.3	18.3	7.4	19.3	7.2
10.0	29.0	5.4	21.7	6.6	19.2	7.2	18.4	7.3
15.0	27.6	5.6	24.0	6.2	20.3	6.9	20.4	6.9
20.0	26.2	5.8	25.9	5.9	21.6	6.7	22.0	6.6
25.0	26.8	5.7	29.8	5.3	26.1	5.8	27.3	5.6
30.0	36.1	4.4	41.4	3.8	42.5	3.7	44.1	3.6

Table A-9. Antenna Input Resistance and Reactance versus Frequency for Four Soil Conditions for 5.4 Meter High Monopole with 24 Meter Radius Ground Screen of 32 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 7 and 8)

Frequency (MHz)	Soil Characteristics			
	Good (Moist Clay)	Average (Medium Dry Ground)	Fair (Sand)	Poor (Very Dry Ground)
	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
5.0	3.68 - j191.7	3.95 - j190.1	2.84 - j188.9	5.85 - j187.1
10.0	21.4 - j43.1	22.4 - j42.5	21.7 - j40.7	23.9 - j39.9
15.0	83.5 + j33.5	83.5 + j33.4	82.4 + j35.1	83.7 + j35.5
20.0	200.3 - j26.7	201.0 - j24.3	201.0 - j18.1	204.6 - j17.1
25.0	115.2 - j128.1	116.5 - j128.5	120.5 - j128.1	120.7 - j130.4
30.0	46.0 - j92.9	46.3 - j92.2	46.7 - j93.1	46.4 - j93.5

Table A-10. Antenna Efficiency and Noise Figure versus Frequency for Four Soil Conditions, for 5.4 Meter High Monopole with 24 Meter Radius Ground Screen of 32 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Tables 7 and 8)

Frequency (MHz)	Soil Characteristics							
	Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	41.8	3.8	33.9	4.7	39.5	4.0	32.3	4.9
10.0	35.3	4.5	30.3	5.2	29.6	5.3	29.3	5.3
15.0	32.0	5.0	29.5	5.3	27.7	5.6	27.6	5.6
20.0	28.9	5.4	28.4	5.5	25.8	5.9	26.0	5.9
25.0	27.7	5.6	29.4	5.3	26.6	5.8	27.1	5.7
30.0	37.4	4.3	41.8	3.8	41.5	3.8	42.8	3.7

Table A-11. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.305m Deep

(Supports Vol. 1, Table 9)

Frequency (MHz)	Soil Characteristics				
	Very Good (Wet Ground)	Good (Moist Clay)	Average (Medium Dry Ground)	Fair (Sand)	Poor (Very Dry Ground)
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
5.0	5.63 - j202.8	5.31 - j202.8	5.97 - j200.3	4.76 - j200.5	3.45 - j200.8
10.0	26.4 - j44.4	25.8 - j43.3	28.8 - j43.2	32.1 - j40.0	39.4 - j47.4
15.0	88.0 + j35.1	88.5 + j36.4	88.9 + j34.8	86.4 + j37.4	91.4 + j53.1
20.0	214.4 - j5.81	214.4 - j5.78	214.2 - j5.28	213.9 - j2.69	197.3 + j1.88
25.0	144.8 - j138.9	146.2 - j136.1	149.2 - j139.0	157.8 - j137.7	154.1 - j143.3
30.0	57.2 - j105.2	57.4 - j103.5	58.0 - j104.1	59.3 - j104.6	58.8 - j105.8

Table A-12. Antenna Efficiency and Noise Figure versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.305m Deep

(Supports Vol. 1, Table 9)

Frequency (MHz)	Soil Characteristics									
	Very Good (Wet Ground)		Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	27.2	5.7	28.3	5.5	17.9	7.5	15.8	8.0	20.4	6.9
10.0	28.8	5.4	27.2	5.7	21.5	6.7	21.3	6.7	24.1	6.2
15.0	29.9	5.2	25.9	5.9	22.8	6.4	20.6	6.9	18.1	7.4
20.0	31.4	5.0	24.5	6.1	24.1	6.2	20.8	6.8	21.5	6.7
25.0	34.6	4.6	25.9	5.9	28.7	5.4	25.5	5.9	26.3	5.8
30.0	40.6	3.9	36.1	4.4	42.4	3.7	43.9	3.6	46.6	3.3

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Table A-13. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with Feed Point Raised 0.2m and with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol.1, Table 10)

Frequency (MHz)	Soil Characteristics				
	Very Good (Wet Ground)	Good (Moist Clay)	Average (Medium Dry Ground)	Fair (Sand)	Poor (Very Dry Ground)
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$	$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$	$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
5.0	6.26 - j218.2	6.05 - j218.0	7.12 - j217.2	7.21 - j217.9	4.06 - j220.0
10.0	26.5 - j48.2	26.3 - j47.0	29.5 - j47.9	33.5 - j44.3	41.3 - j51.7
15.0	79.6 + j39.2	80.6 + j40.5	81.7 + j38.0	80.8 + j39.6	81.1 + j52.4
20.0	206.7 + j47.9	207.5 + j48.3	208.0 + j45.3	213.7 + j44.5	200.3 + j35.9
25.0	217.8 - j121.5	218.4 - j119.1	220.9 - j121.6	228.1 - j119.9	227.2 - j127.3
30.0	86.7 - j125.3	87.0 - j125.1	87.0 - j126.1	88.0 - j127.6	87.7 - j128.2

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Table A-14. Antenna Efficiency and Noise Figure versus Frequency for Five Soil Conditions for 5.4 Meter High Monopole with Feed Point Raised 0.2m and with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep

(Supports Vol. 1, Table 10)

Frequency (MHz)	Soil Characteristics									
	Very Good (Wet Ground)		Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	27.6	5.6	28.0	5.5	16.5	7.8	11.5	9.4	18.6	7.3
10.0	31.1	5.1	28.8	5.4	22.8	6.4	21.5	6.7	24.3	6.2
15.0	32.5	4.9	27.8	5.6	24.7	6.1	22.0	6.6	19.6	7.1
20.0	33.5	4.7	26.3	5.8	25.9	5.9	22.1	6.6	22.7	6.4
25.0	35.5	4.5	27.1	5.7	29.7	5.3	26.1	5.8	26.6	5.8
30.0	42.2	3.7	36.3	4.4	41.8	3.8	41.7	3.8	43.4	3.6

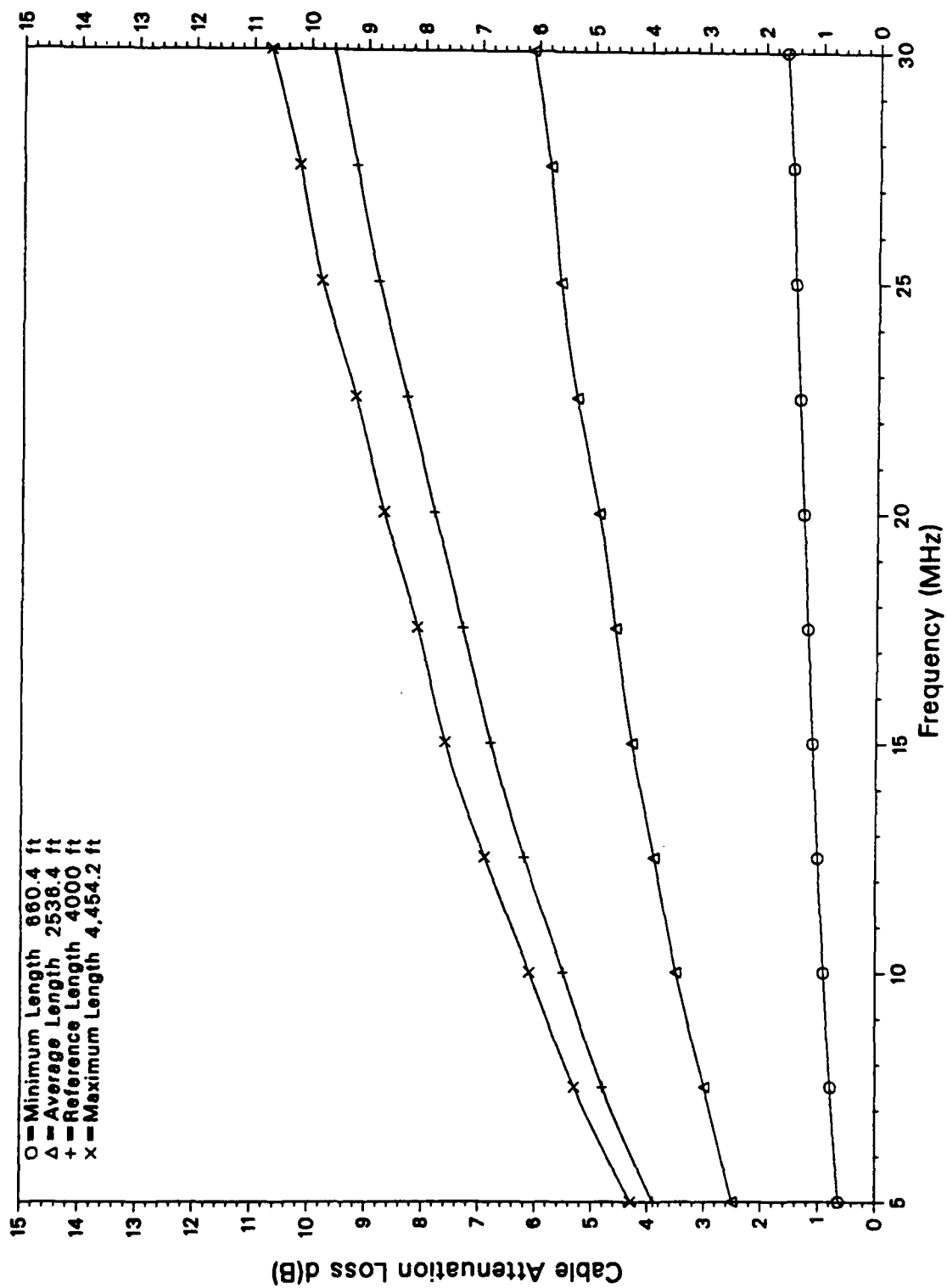


Figure A-25. Cable Attenuation Loss versus Frequency for Four Cable Lengths

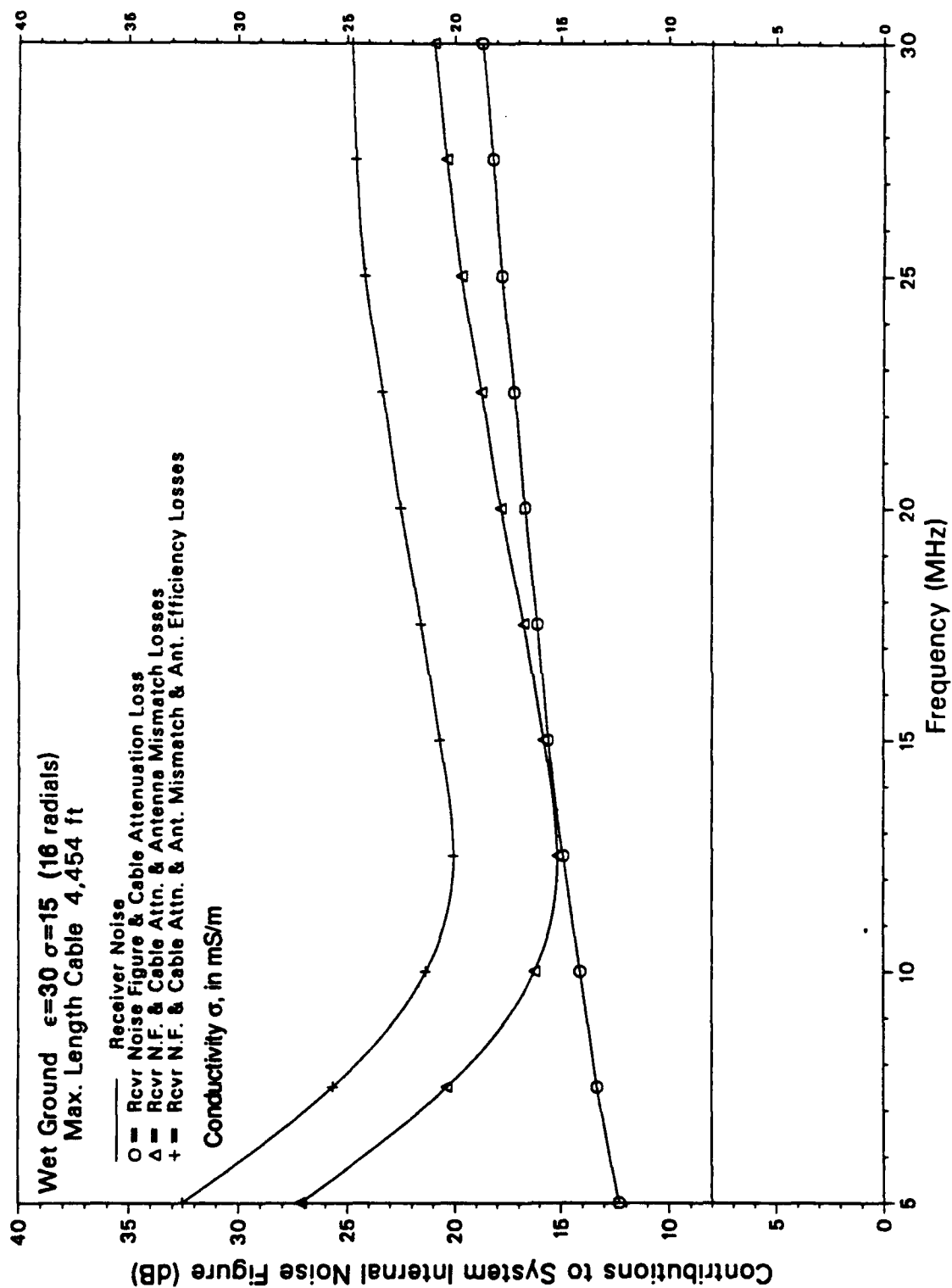


Figure A-26. System Internal Noise Figure Cumulative Contributions for Case of Wet Ground and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

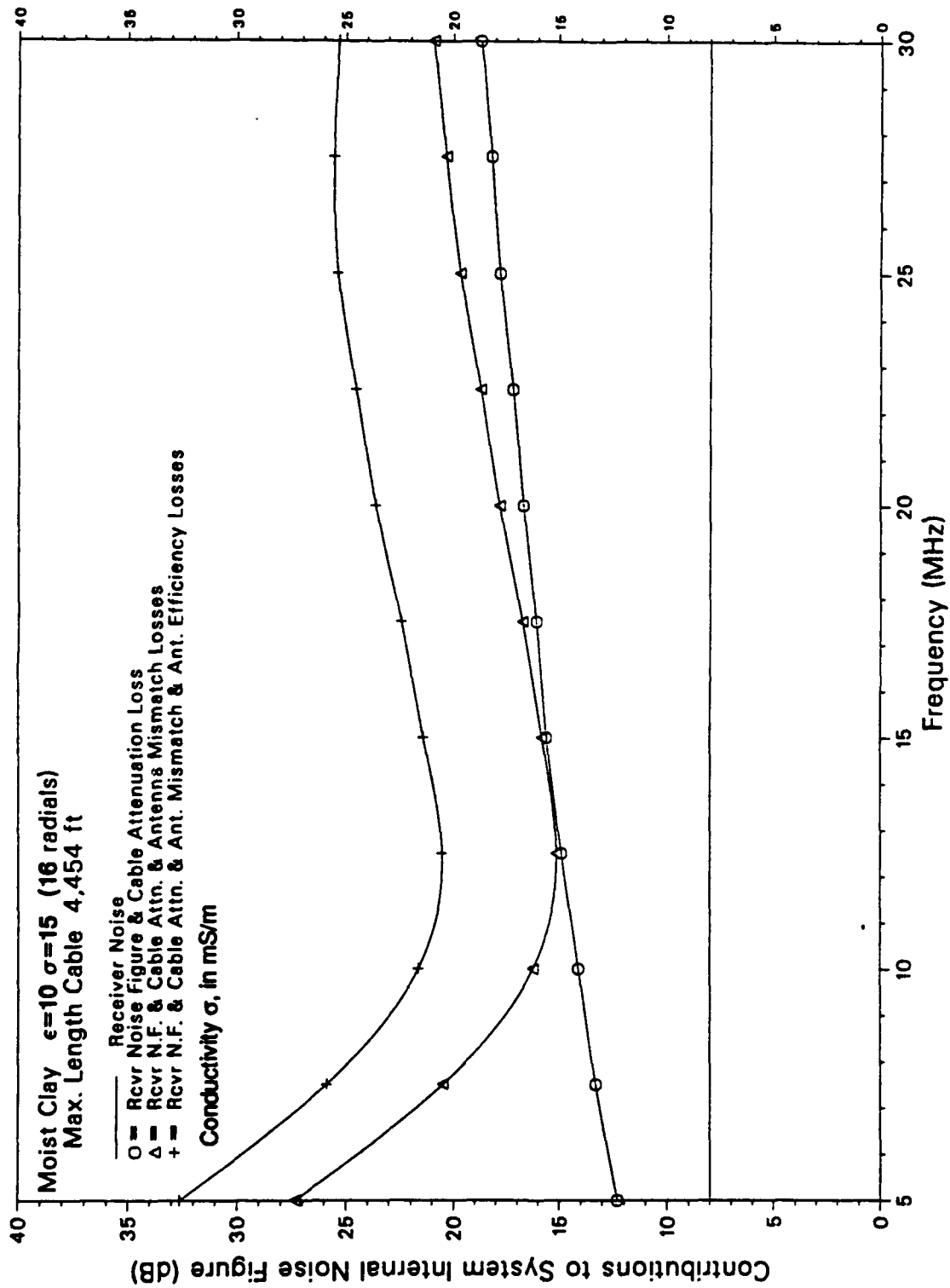


Figure A-27. System Internal Noise Figure Cumulative Contributions for Case of Moist Clay and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

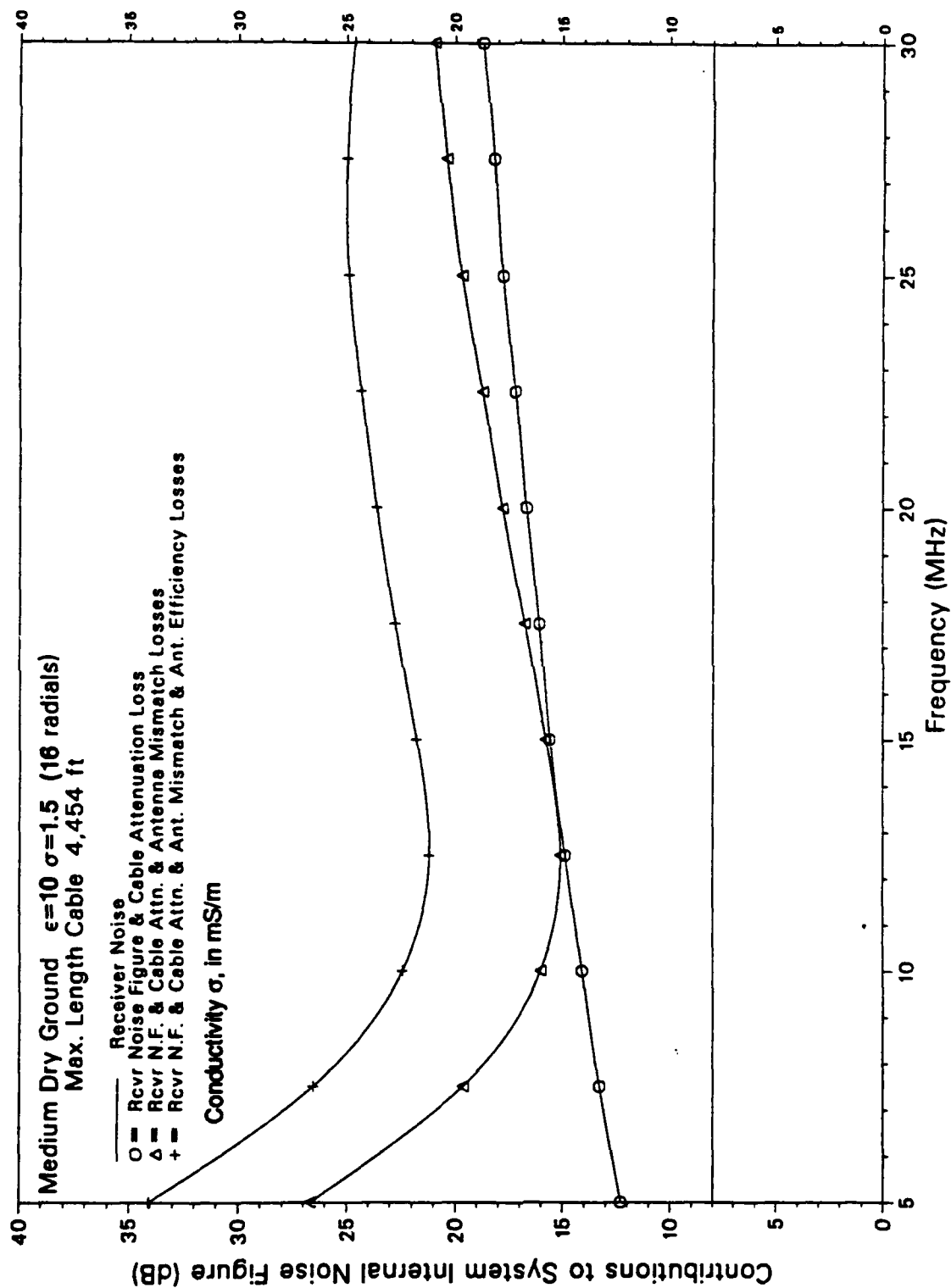


Figure A-28. System Internal Noise Figure Cumulative Contributions for Case of Medium Dry Ground and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

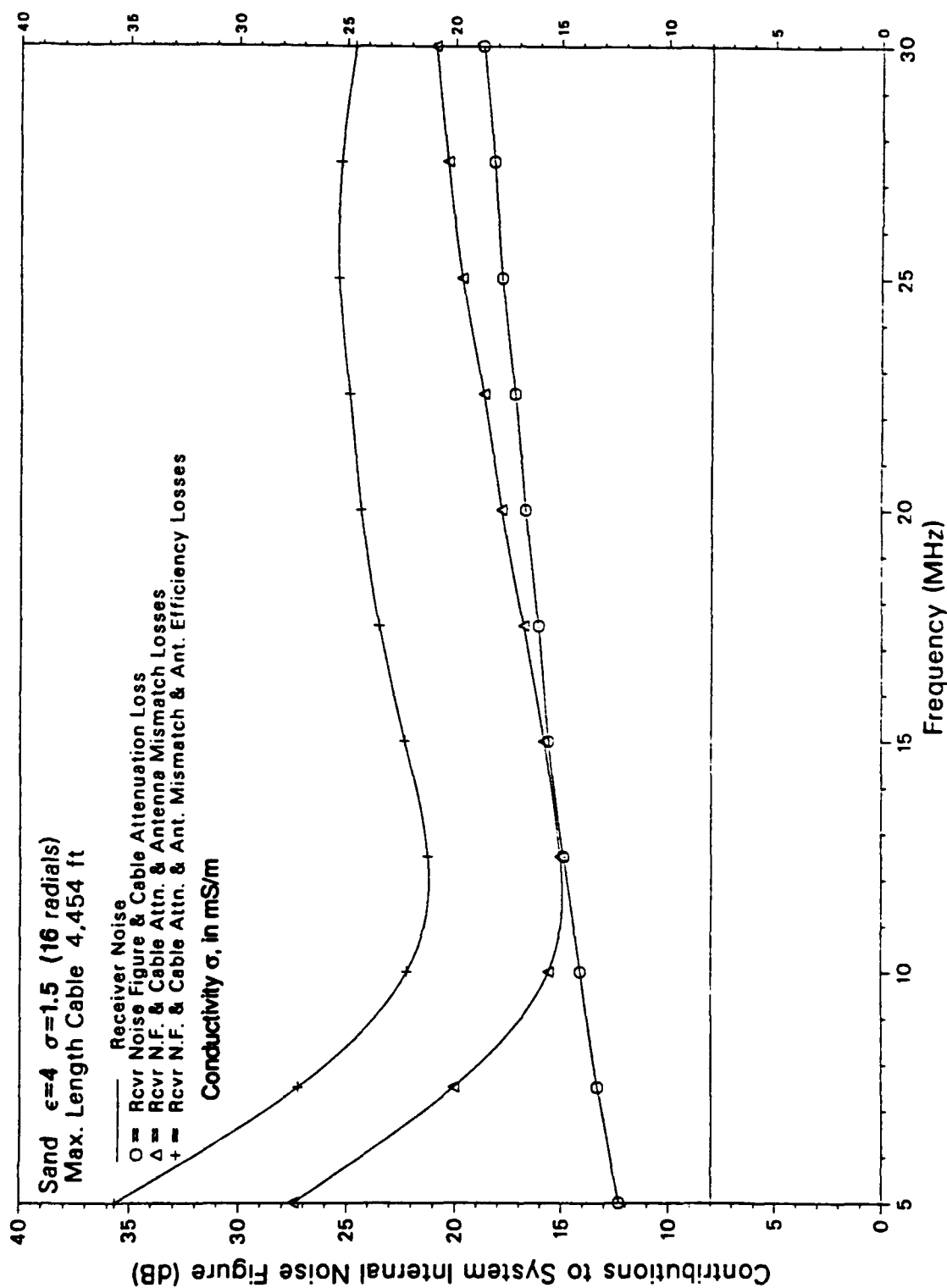


Figure A-29. System Internal Noise Figure Cumulative Contributions for Case of Sandy Soil and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

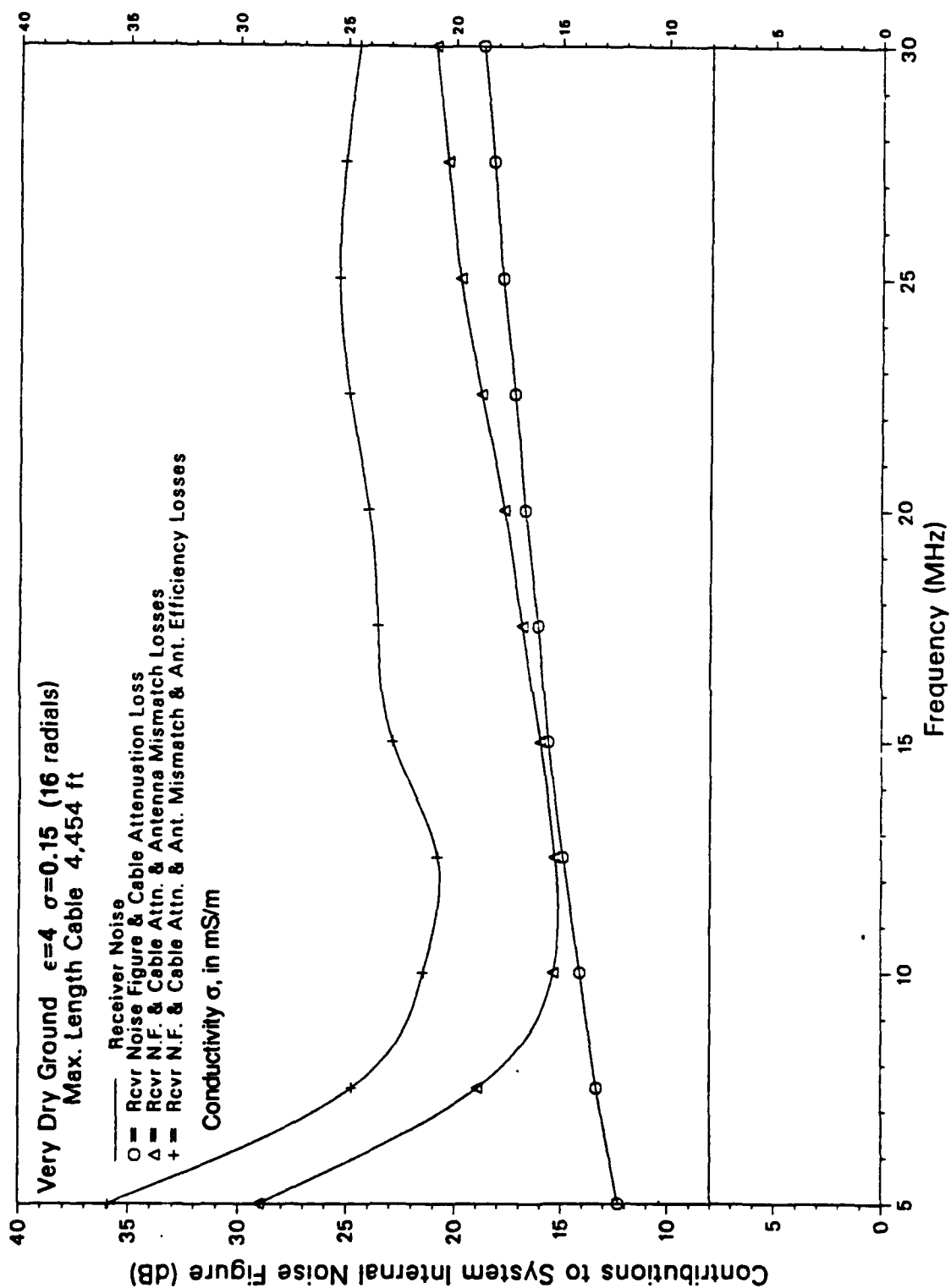


Figure A-30. System Internal Noise Figure Cumulative Contributions for Case of Very Dry Ground and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

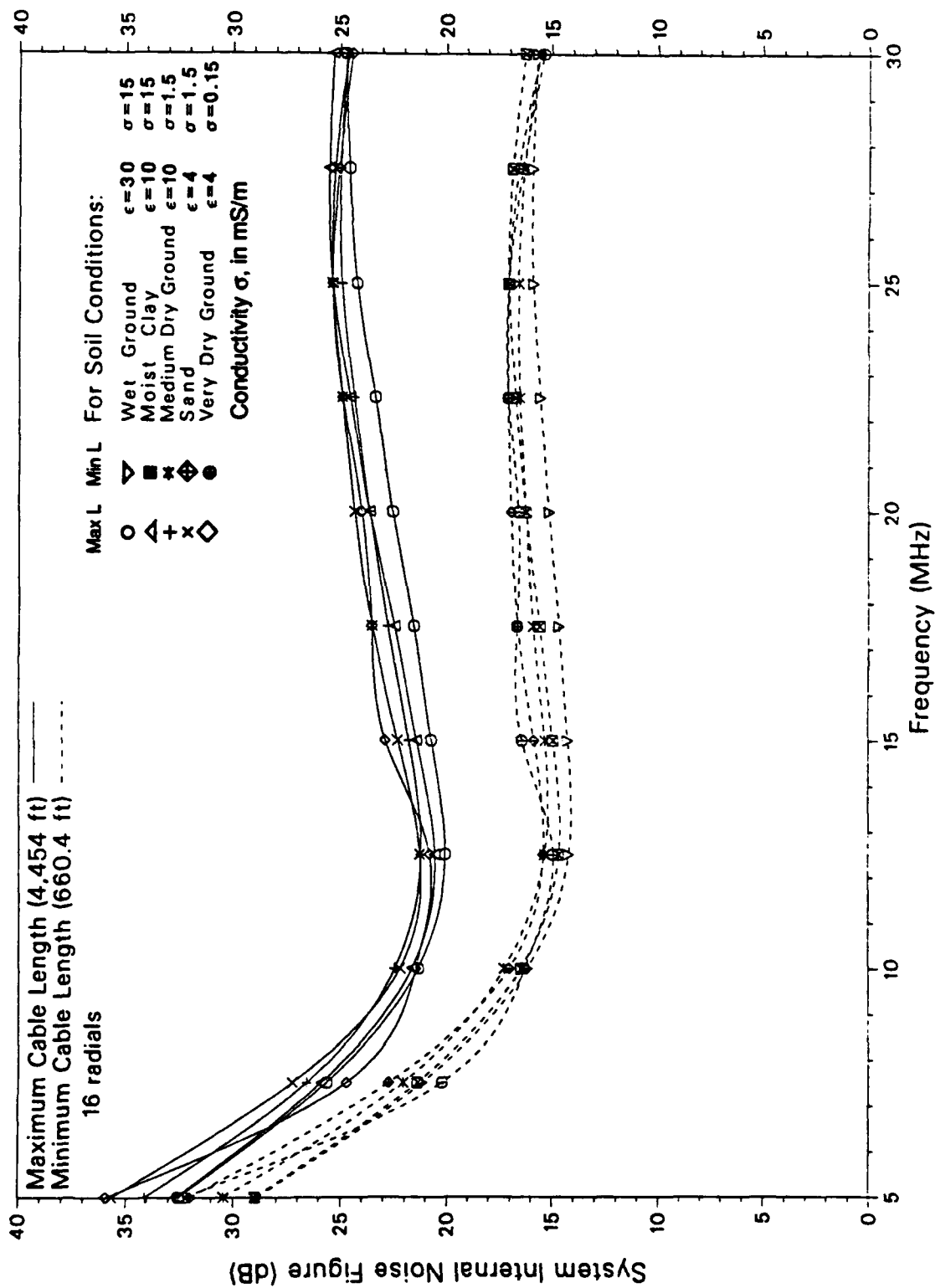


Figure A-31. System Internal Noise Figure versus Frequency, Soil Condition, and Maximum and Minimum Cable Lengths for 5.4 Meter High Monopole with 12 Meter Ground Screen of 16 Radials

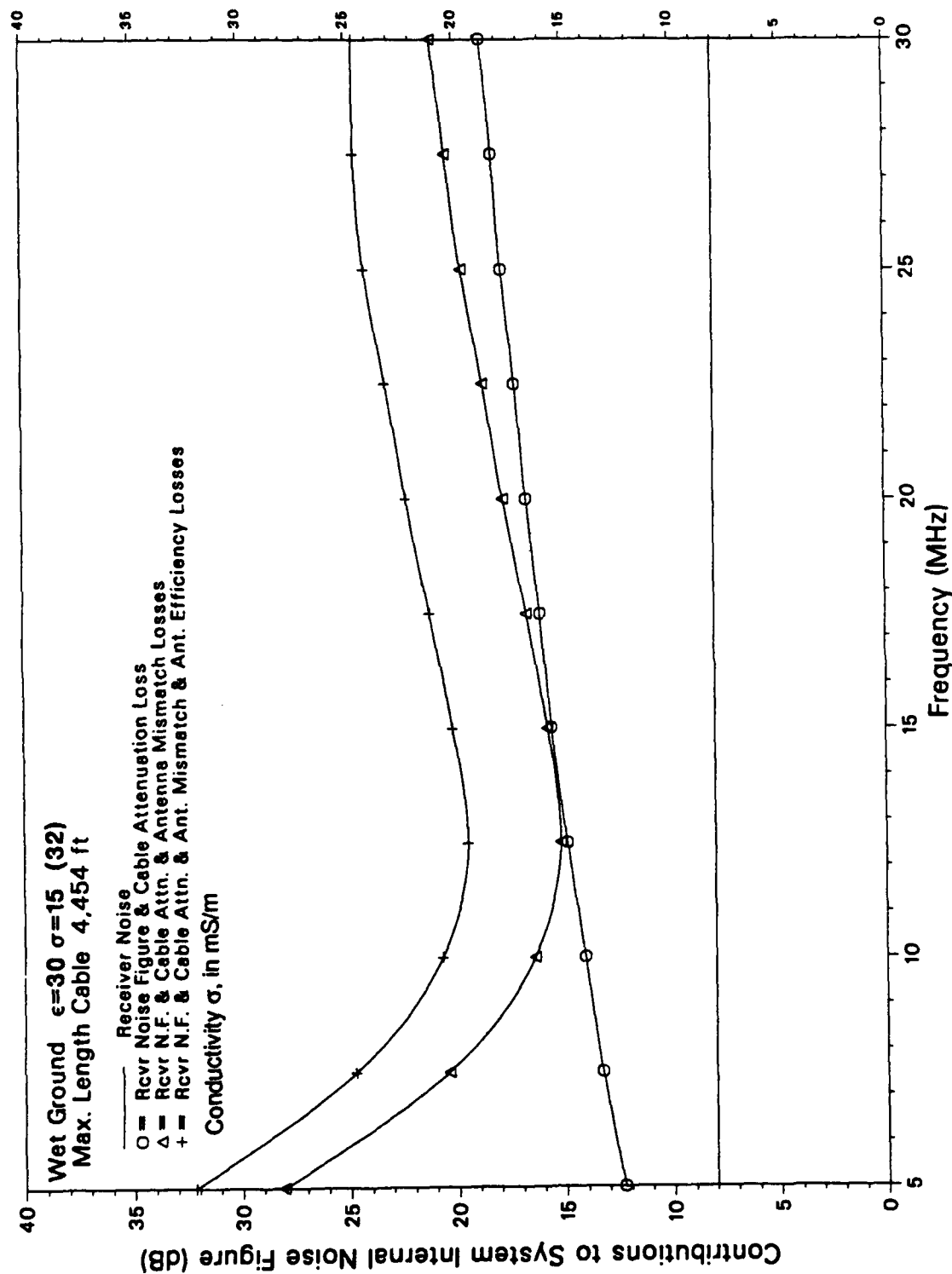


Figure A-32. System Internal Noise Figure Cumulative Contributions for Case of Wet Ground and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

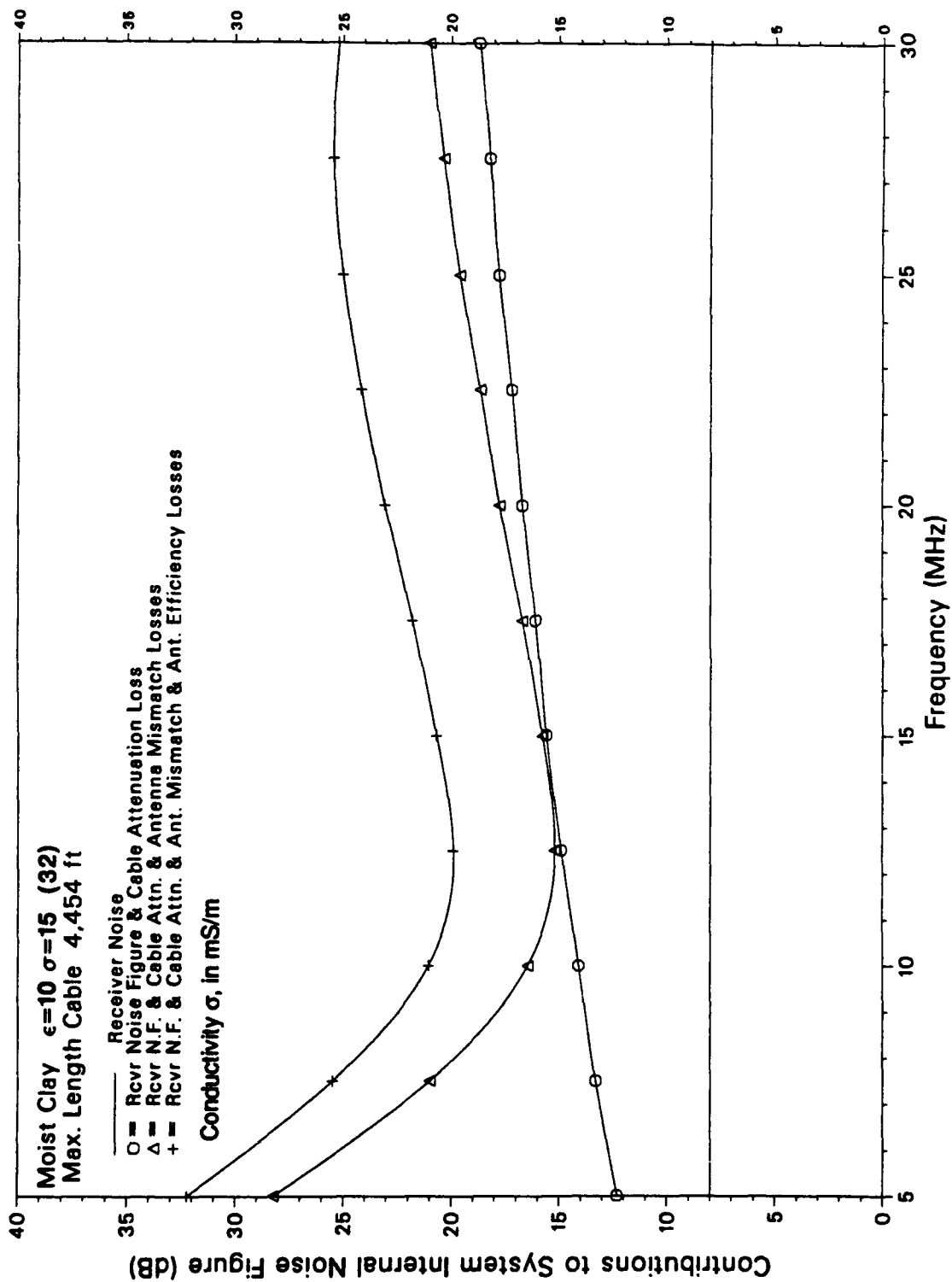


Figure A-33. System Internal Noise Figure Cumulative Contributions for Case of Moist Clay and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

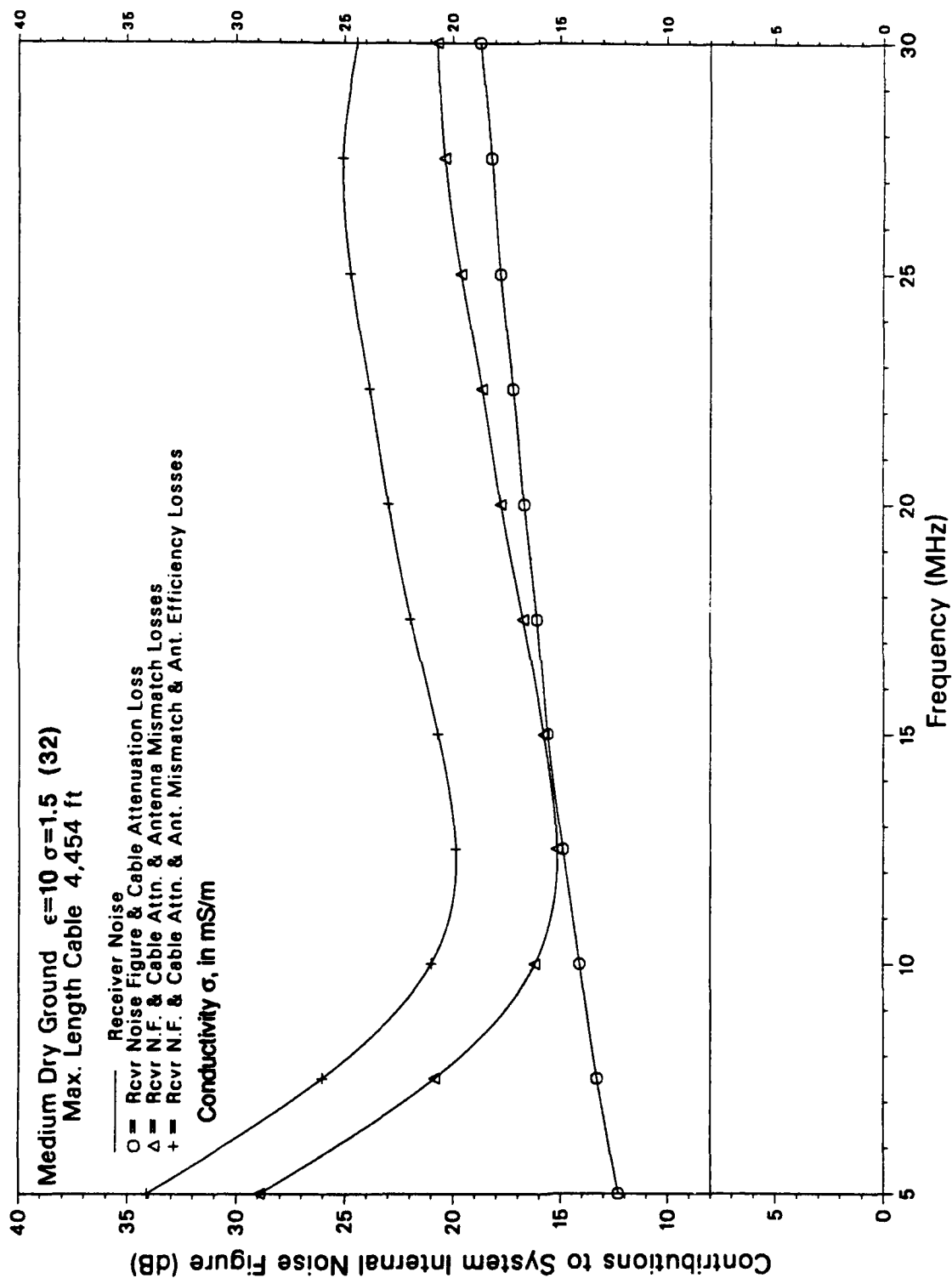


Figure A-34. System Internal Noise Figure Cumulative Contributions for Case of *Medium Dry Ground* and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

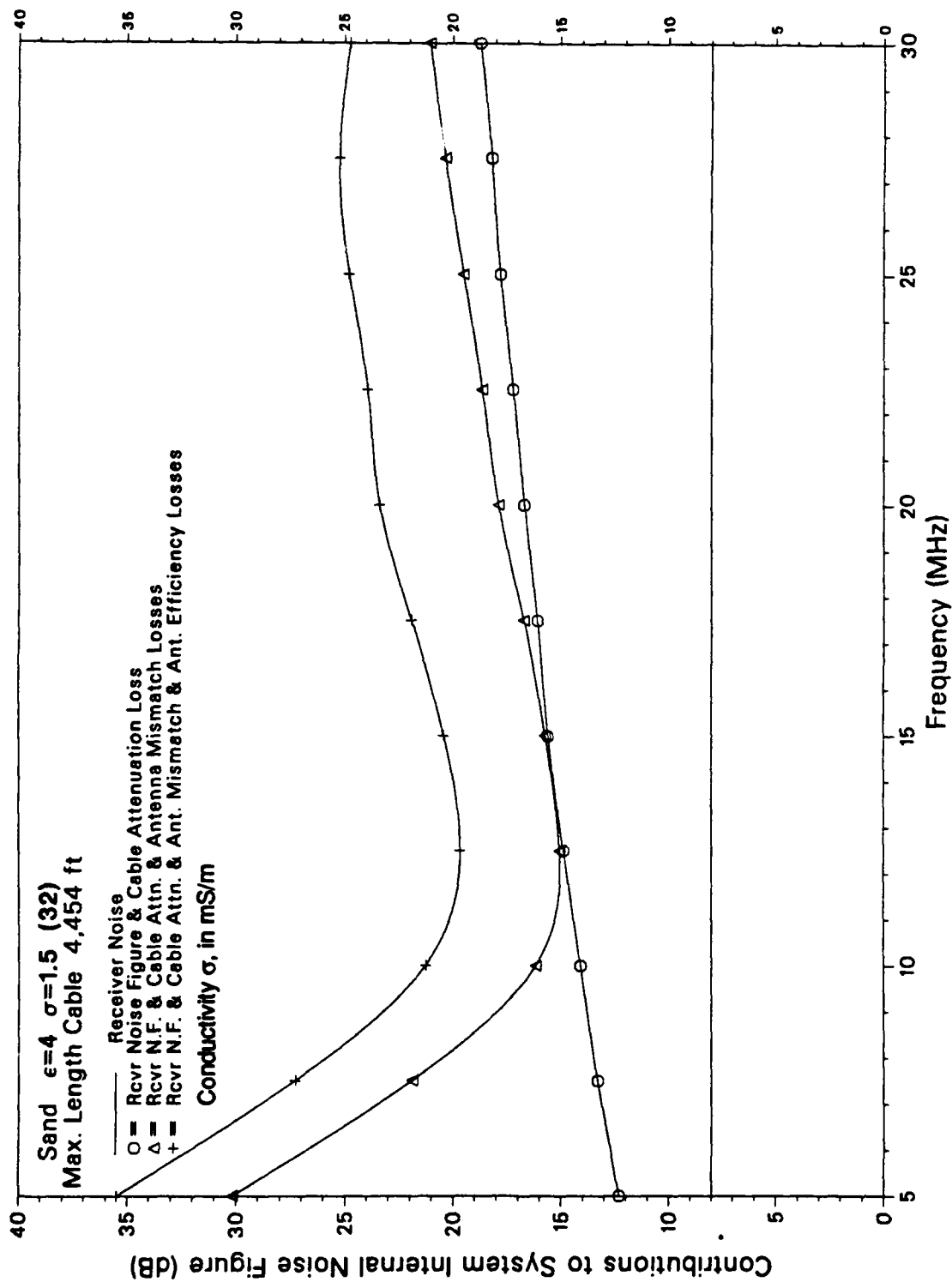


Figure A-35. System Internal Noise Figure Cumulative Contributions for Case of Sandy Soil and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

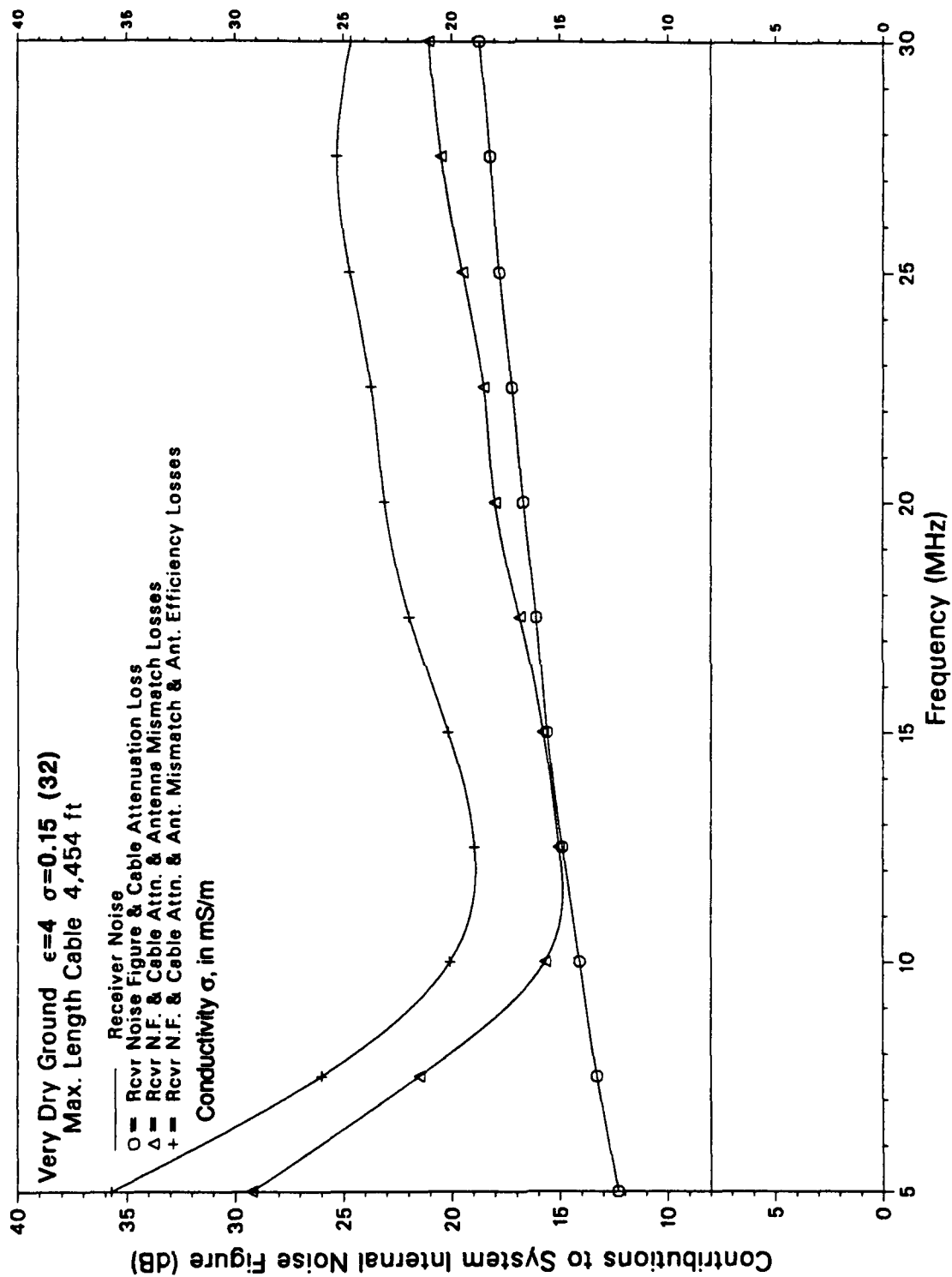


Figure A-36. System Internal Noise Figure Cumulative Contributions for Case of Very Dry Ground and Maximum Length Cable, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

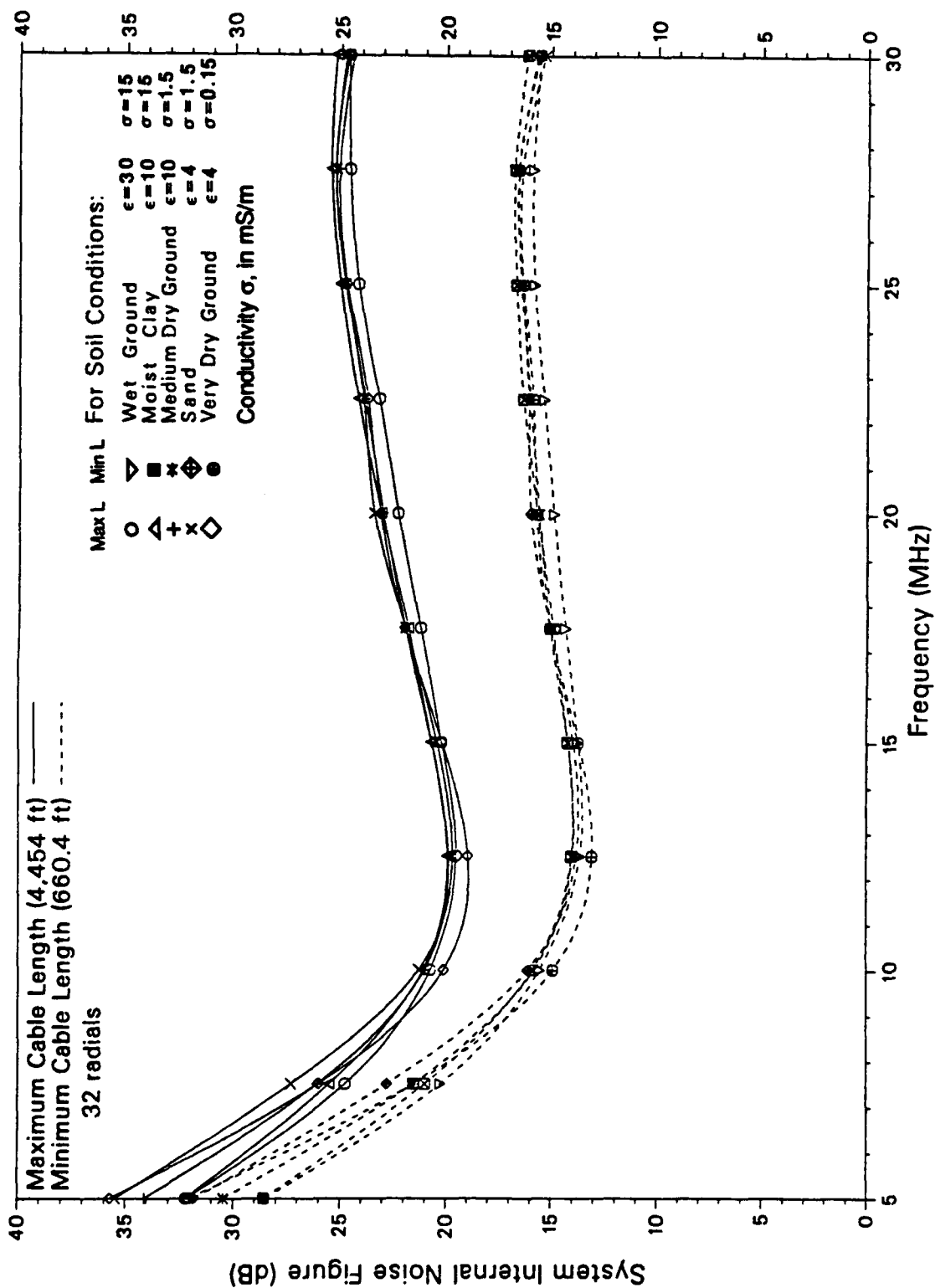


Figure A-37. System Internal Noise Figure versus Frequency, Soil Condition, and Maximum and Minimum Cable Lengths for 5.4 Meter High Monopole with 12 Meter High Radius Ground Screen of 32 Radials

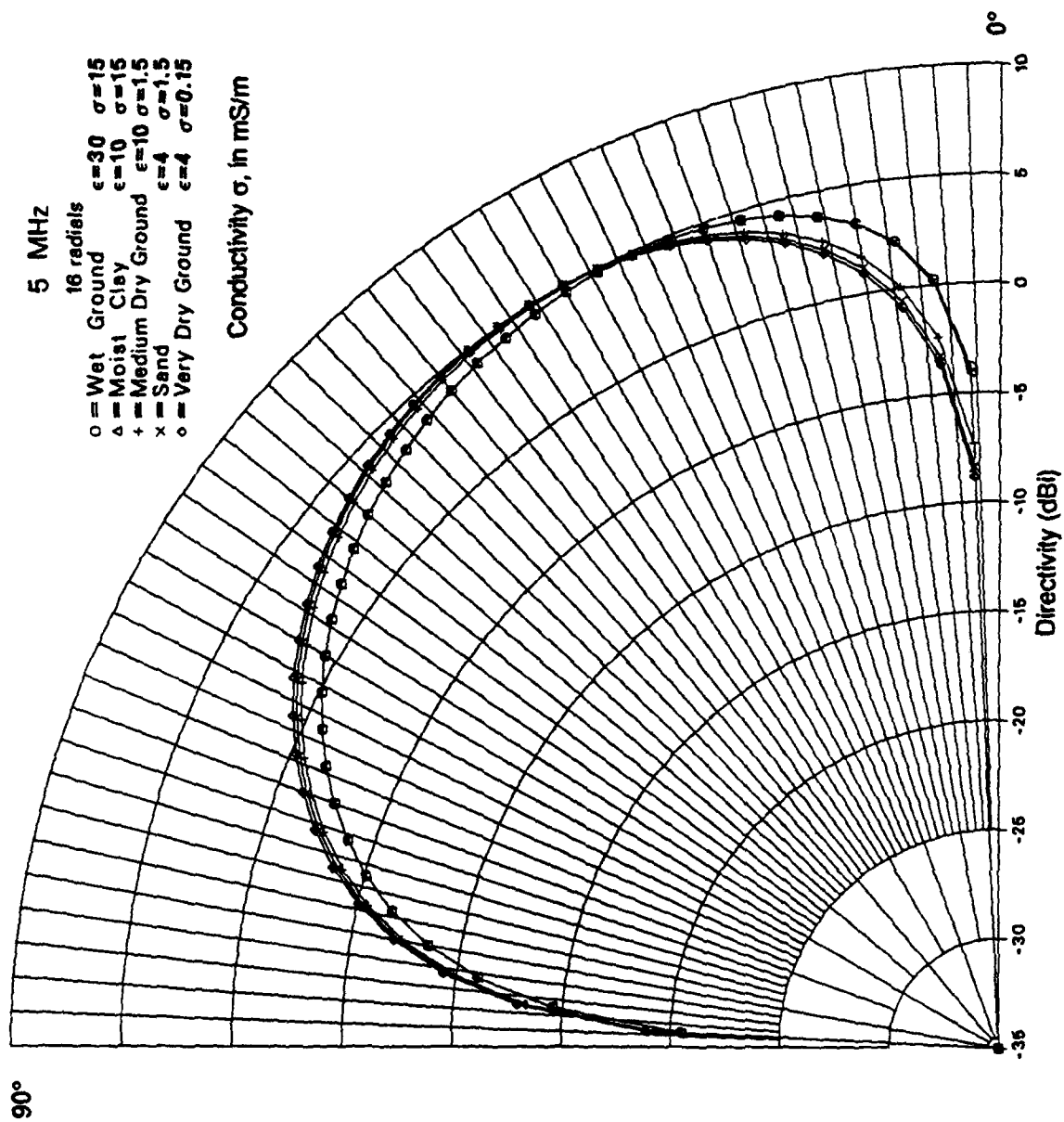


Figure A-38. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 5 MHz, for 5.4 MeV High Monopole with 12 Meter Radius Ground Screen of 16 Radials

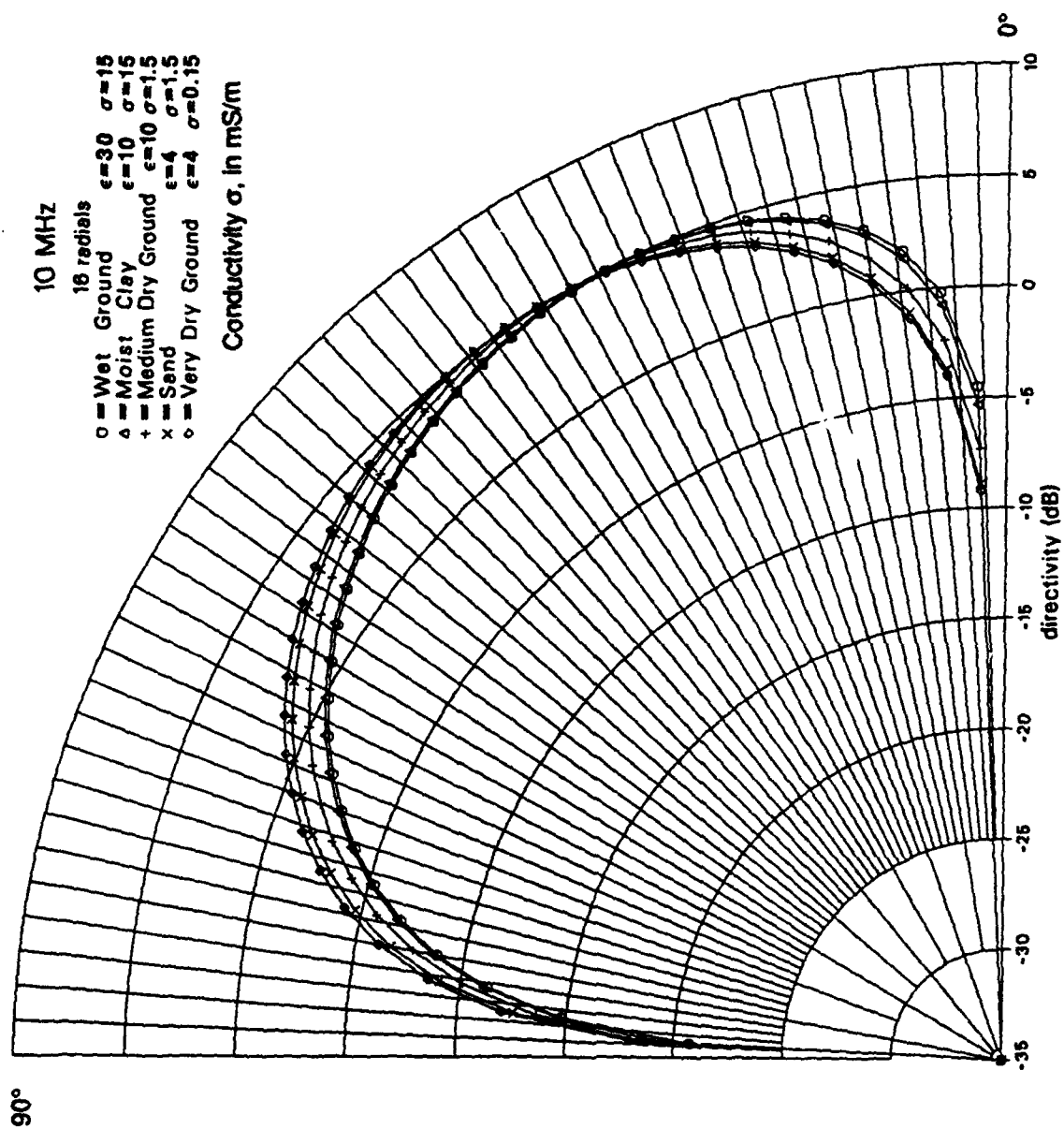


Figure A-39. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 10 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

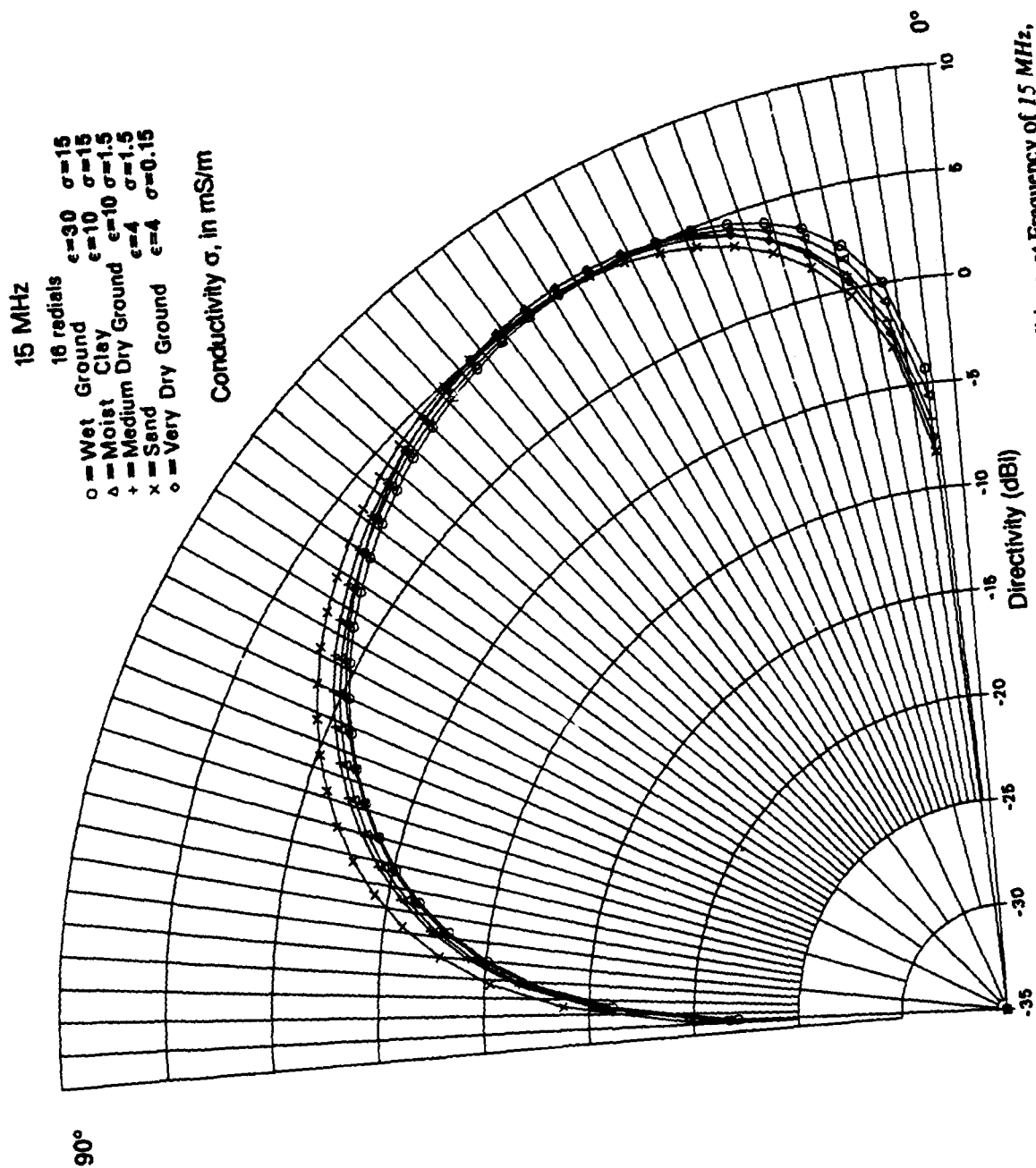


Figure A-40. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 15 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

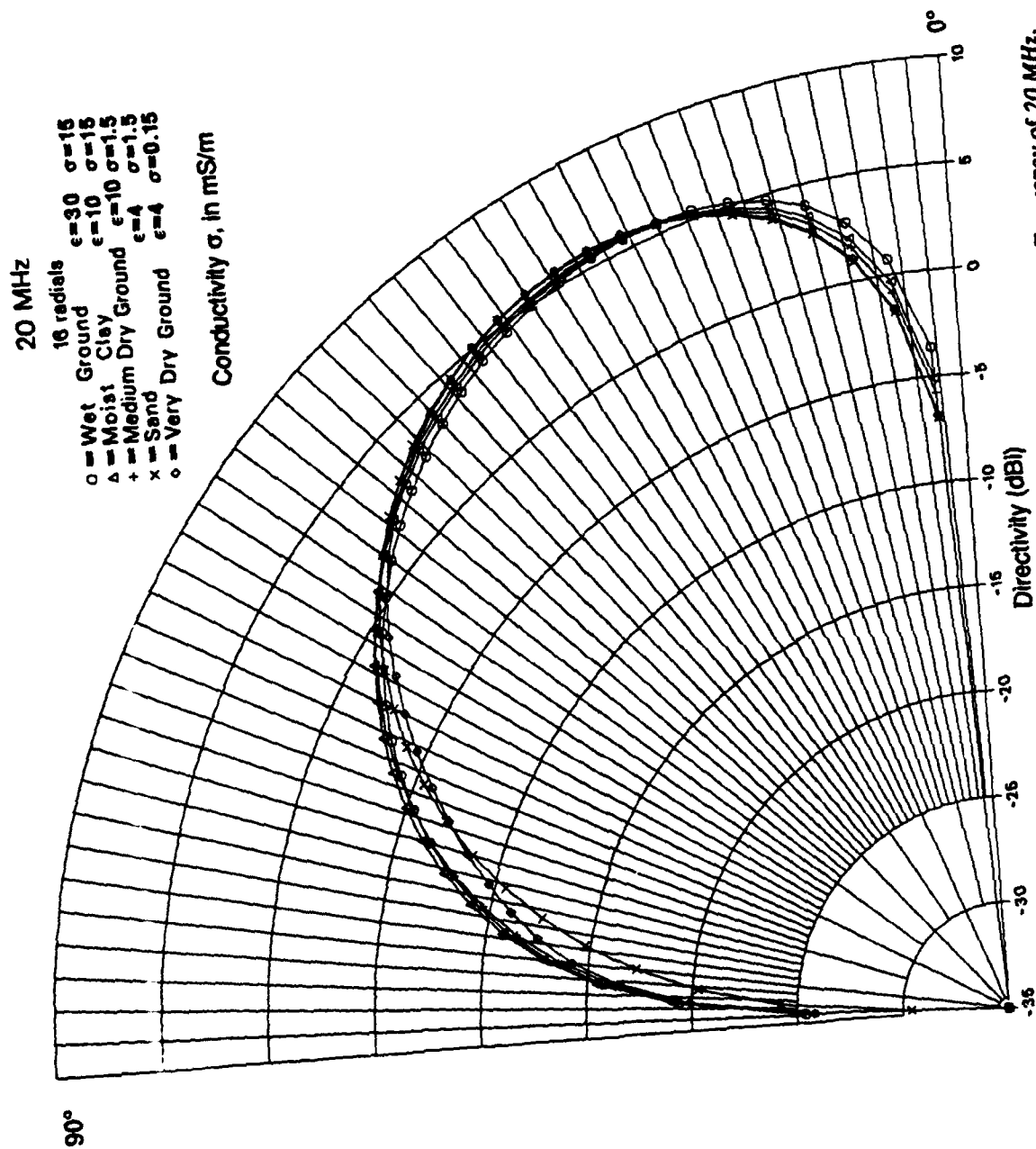


Figure A-41. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 20 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

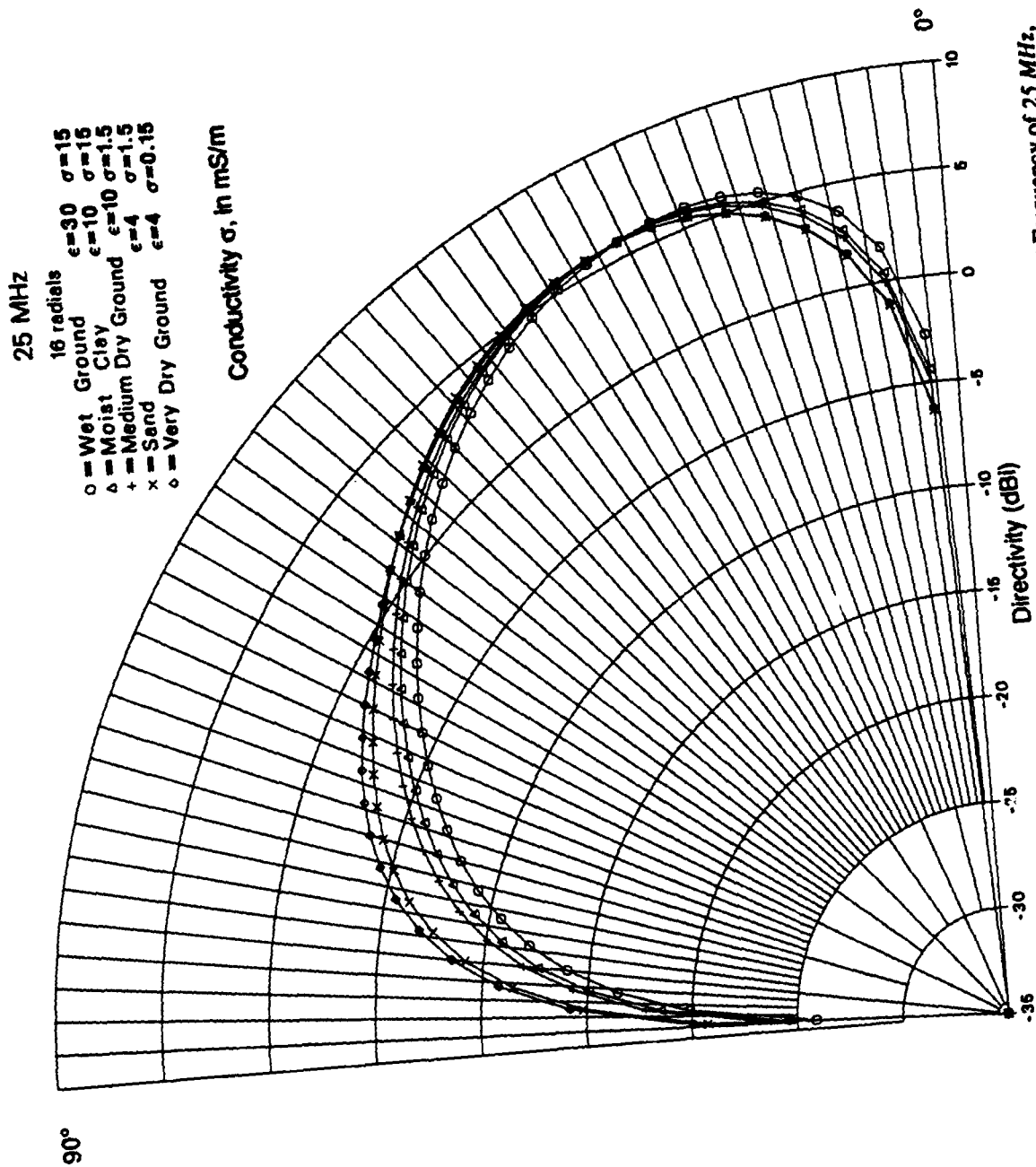


Figure A-42. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 25 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

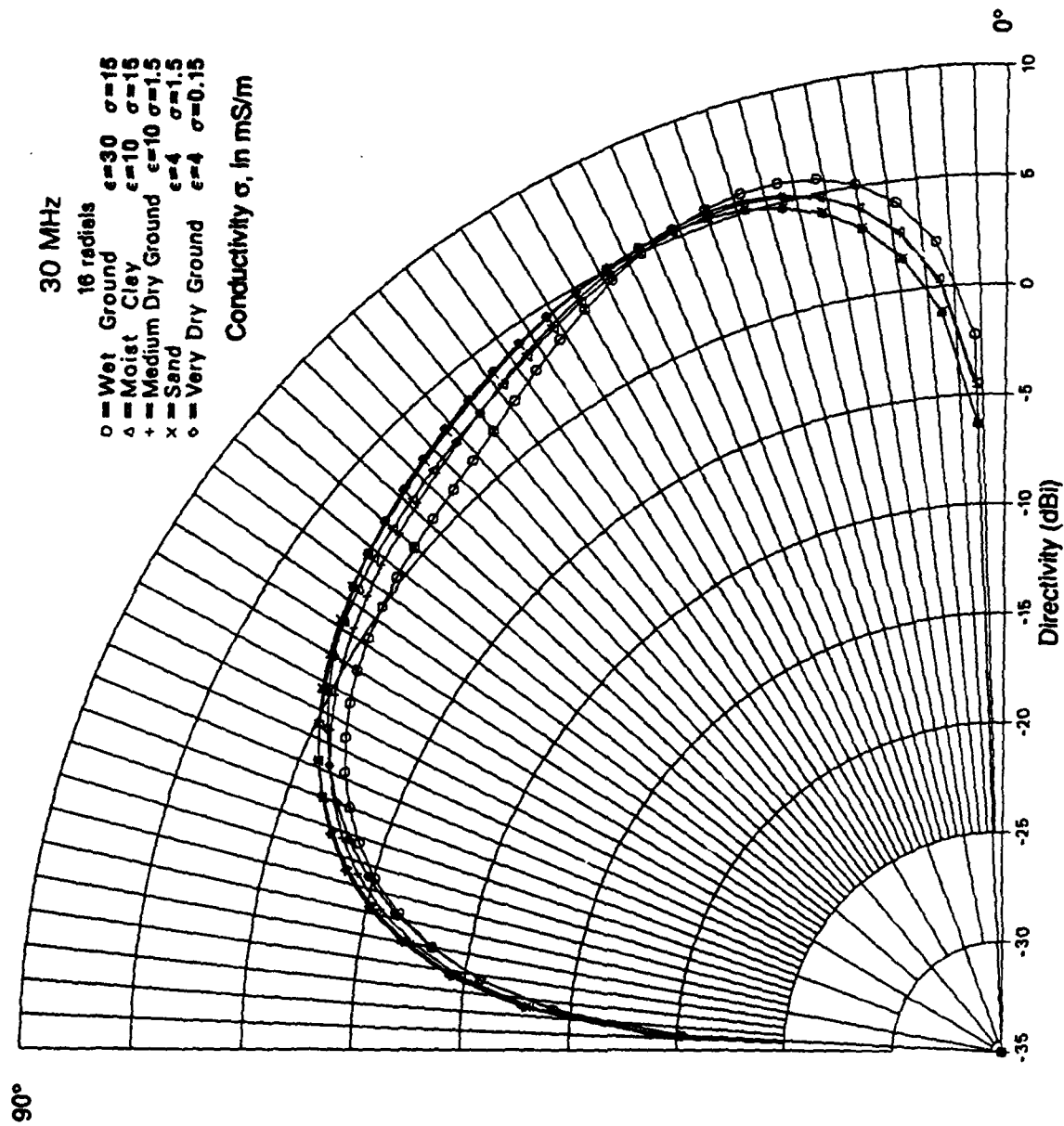


Figure A-43. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 30 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

Wet Ground $\epsilon=30$ $\sigma=15$

16 radials
 $\circ$ = 5 MHz
 Δ = 10 MHz
 $+$ = 15 MHz
 $\times$ = 20 MHz
 $\diamond$ = 25 MHz
 ∇ = 30 MHz

Conductivity σ , in mS/m

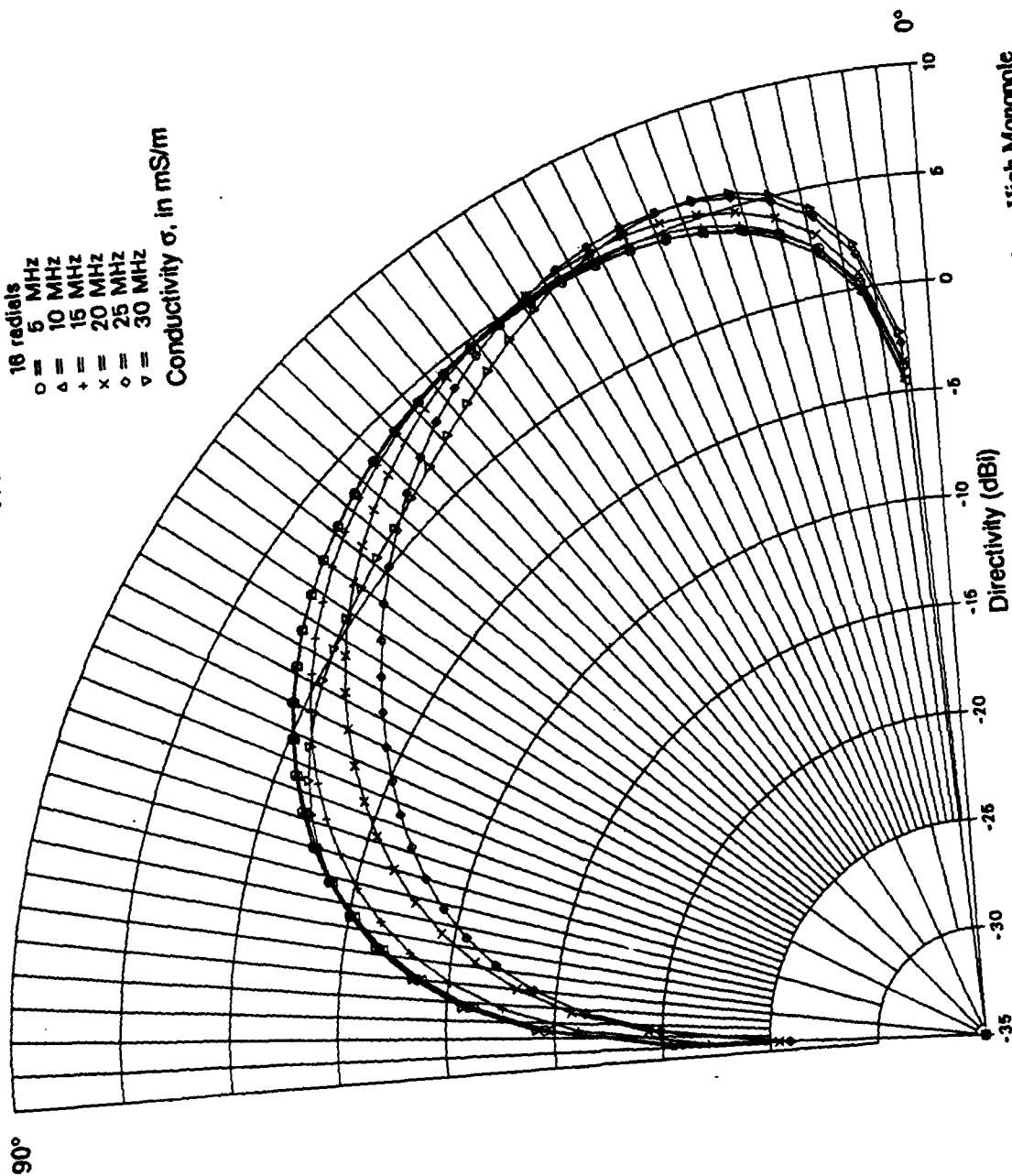


Figure A-44. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials for a Wet Ground Condition

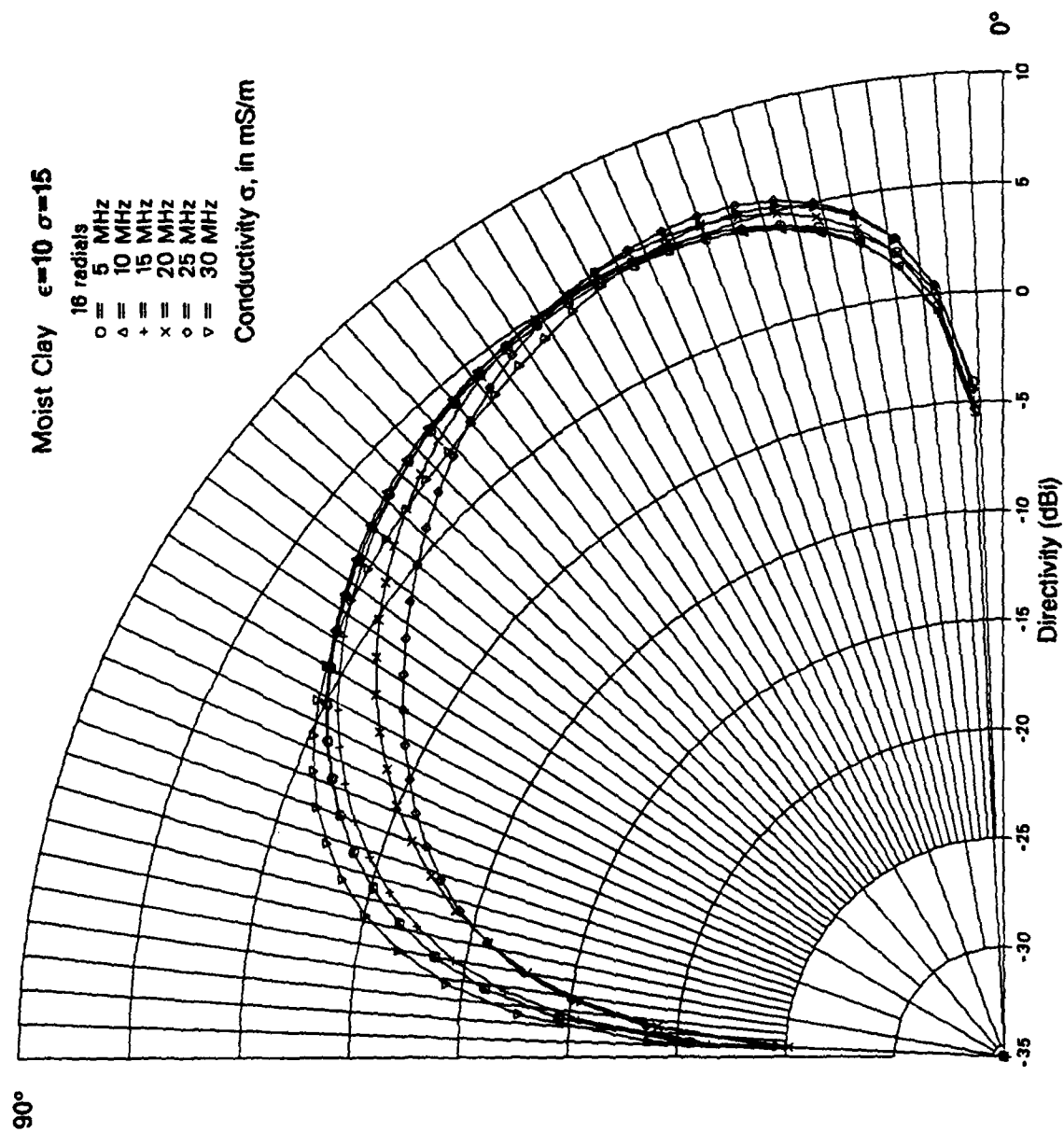


Figure A-45. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials for a Moist Clay Condition

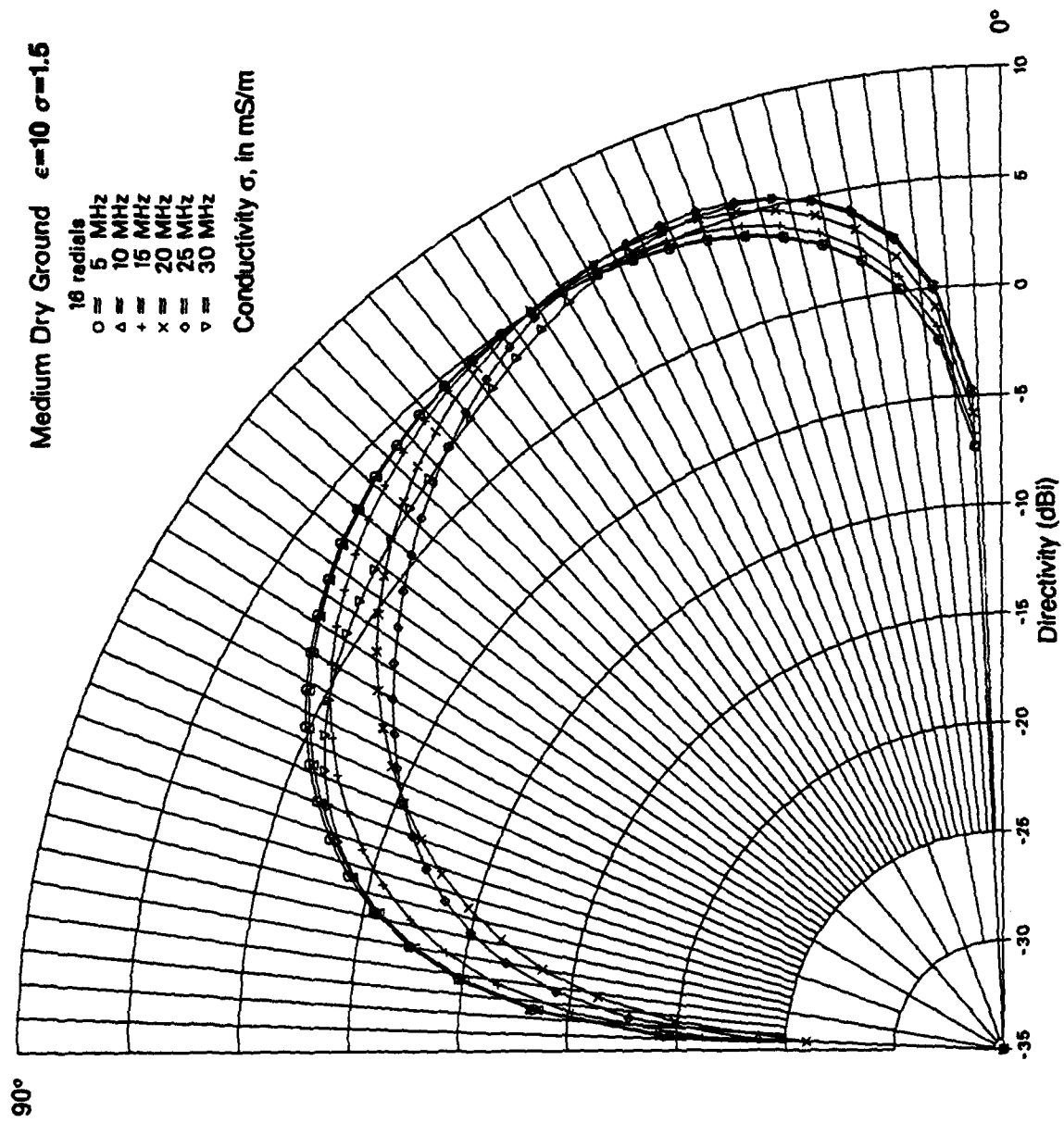


Figure A-46. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials for a Medium Dry Ground Condition

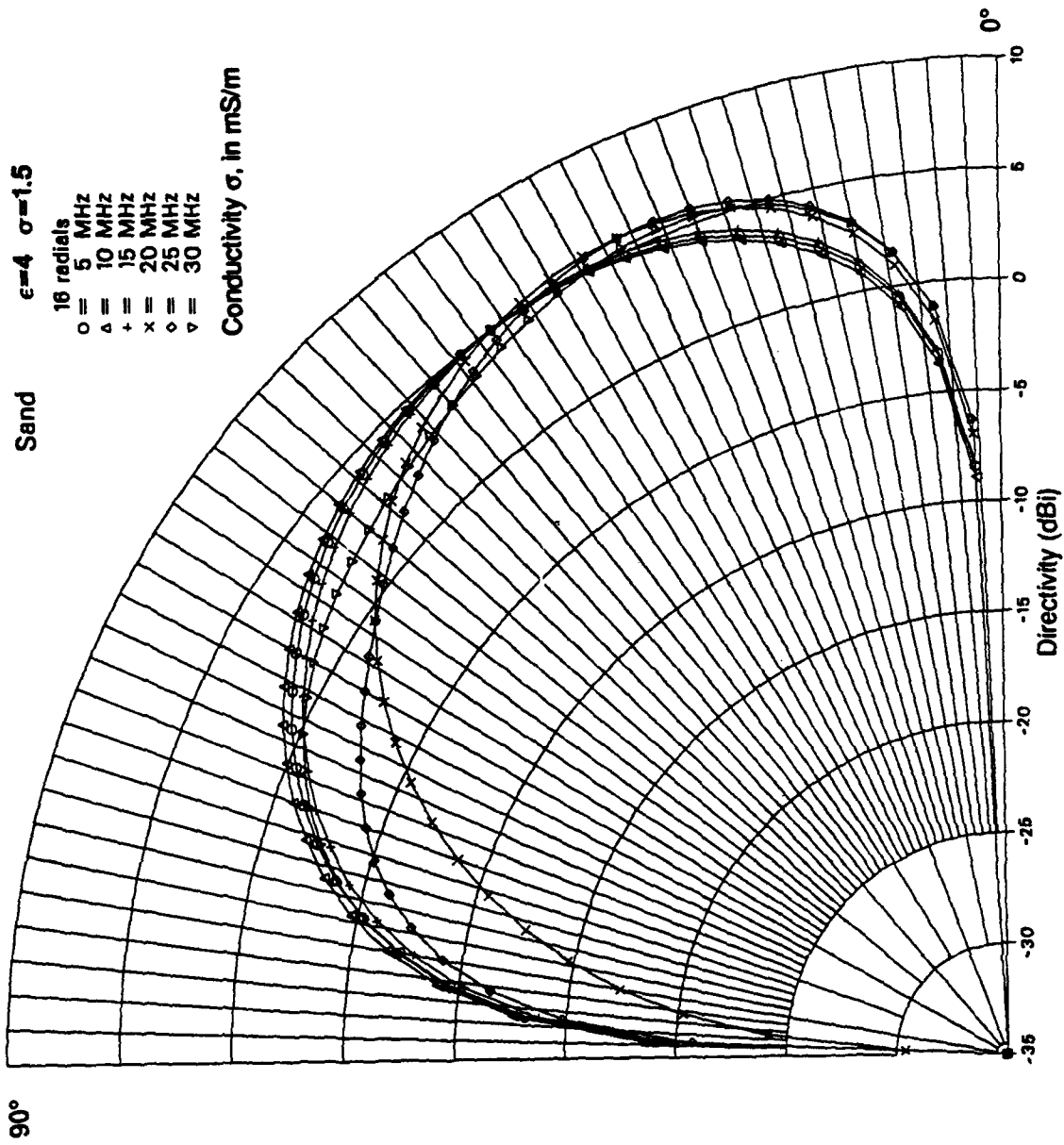


Figure A-47. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials for a Sandy Soil Condition

Very Dry Ground $\epsilon=4$ $\sigma=0.15$

16 radials

$\circ$ = 5 MHz
 Δ = 10 MHz
 $+$ = 15 MHz
 $\times$ = 20 MHz
 $\diamond$ = 25 MHz
 ∇ = 30 MHz

Conductivity σ , in mS/m

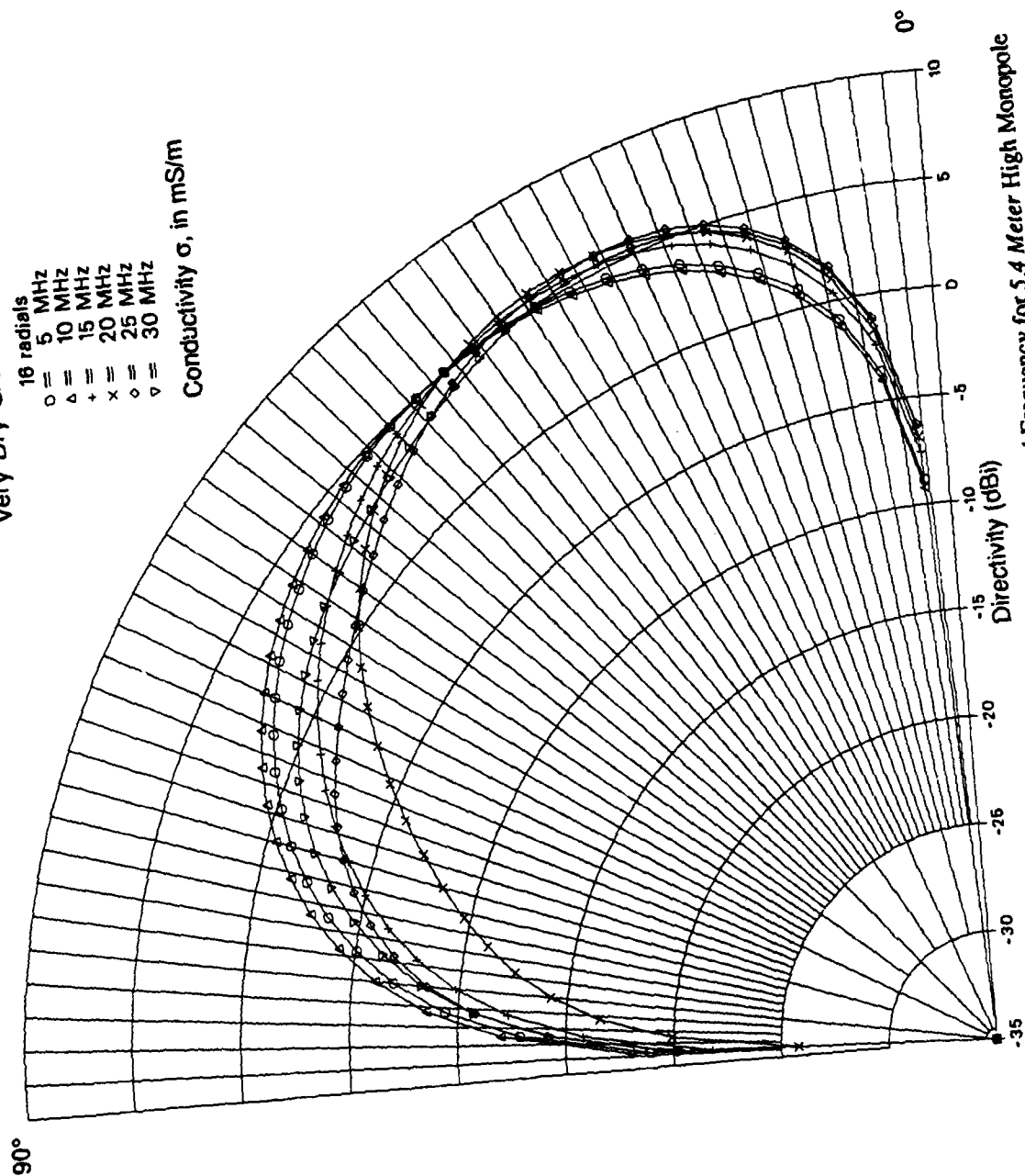


Figure A-48. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials for a Very Dry Ground Condition

Table A-15. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Six Frequencies and Five Soil Conditions, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

		[Elevation Angle $\psi = 90^\circ - \theta$]									
		Wet Ground $\epsilon_r = 30, \sigma = 15 \text{ mS/m}$									
THETA		5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz				
0.0	0.0	-86.64	-86.95	-87.18	-87.32	-87.58	-88.29	THETA	5 MHz	10 MHz	15 MHz
2.5	2.5	-20.54	-20.76	-22.13	-25.41	-25.92	-20.17	2.5	-20.55	-20.57	-21.48
5.0	5.0	-14.53	-14.75	-16.11	-19.35	-19.92	-14.18	5.0	-14.53	-14.55	-15.46
7.5	7.5	-11.03	-11.24	-12.57	-15.76	-16.43	-10.72	7.5	-11.03	-11.04	-11.94
10.0	10.0	-8.55	-8.75	-10.06	-13.17	-13.97	-8.31	10.0	-8.55	-8.56	-9.43
12.5	12.5	-6.64	-6.83	-8.10	-11.11	-12.08	-6.49	12.5	-6.64	-6.64	-7.49
15.0	15.0	-5.09	-5.27	-6.50	-9.39	-10.54	-5.05	15.0	-5.09	-5.08	-5.90
17.5	17.5	-3.80	-3.96	-5.14	-7.90	-9.23	-3.89	17.5	-3.80	-3.78	-4.56
20.0	20.0	-2.68	-2.84	-3.96	-6.57	-8.08	-2.94	20.0	-2.68	-2.65	-3.39
22.5	22.5	-1.72	-1.85	-2.91	-5.37	-7.04	-2.16	22.5	-1.72	-1.67	-2.37
25.0	25.0	-0.87	-0.98	-1.98	-4.27	-6.07	-1.52	25.0	-0.87	-0.81	-1.46
27.5	27.5	-0.11	-0.21	-1.13	-3.24	-5.14	-1.00	27.5	-0.11	-0.03	-0.63
30.0	30.0	0.57	0.49	-0.36	-2.29	-4.25	-0.58	30.0	0.57	0.66	0.11
32.5	32.5	1.17	1.12	0.35	-1.41	-3.37	-0.24	32.5	1.18	1.28	0.79
35.0	35.0	1.72	1.68	1.00	-0.57	-2.50	0.03	35.0	1.72	1.84	1.41
37.5	37.5	2.21	2.20	1.59	0.20	-1.64	0.27	37.5	2.22	2.35	1.98
40.0	40.0	2.66	2.66	2.14	0.93	-0.79	0.48	40.0	2.66	2.81	2.50
42.5	42.5	3.06	3.08	2.64	1.61	0.04	0.71	42.5	3.06	3.22	2.97
45.0	45.0	3.41	3.46	3.09	2.24	0.84	0.98	45.0	3.42	3.59	3.40
47.5	47.5	3.73	3.79	3.51	2.82	1.61	1.31	47.5	3.74	3.92	3.78
50.0	50.0	4.01	4.09	3.88	3.35	2.34	1.72	50.0	4.02	4.20	4.12
52.5	52.5	4.25	4.34	4.21	3.84	3.03	2.20	52.5	4.26	4.45	4.42
55.0	55.0	4.45	4.55	4.49	4.27	3.66	2.74	55.0	4.46	4.65	4.67
57.5	57.5	4.62	4.73	4.73	4.64	4.23	3.32	57.5	4.63	4.81	4.88
60.0	60.0	4.75	4.85	4.92	4.96	4.74	3.01	60.0	4.75	4.92	5.03
62.5	62.5	4.83	4.93	5.06	5.21	5.17	4.47	62.5	4.84	4.98	5.12
65.0	65.0	4.86	4.96	5.13	5.40	5.52	4.97	65.0	4.87	4.98	5.15
67.5	67.5	4.84	4.92	5.14	5.50	5.78	5.40	67.5	4.85	4.92	5.10
70.0	70.0	4.76	4.81	5.06	5.51	5.93	5.71	70.0	4.76	4.78	5.45
72.5	72.5	4.59	4.60	4.89	5.41	5.94	5.89	72.5	4.59	4.54	5.26
75.0	75.0	4.31	4.27	4.58	5.16	5.80	5.89	75.0	4.30	4.16	4.32
77.5	77.5	3.88	3.77	4.08	4.72	5.45	5.66	77.5	3.86	3.60	3.72
80.0	80.0	3.22	3.01	3.32	3.99	4.79	5.10	80.0	3.18	2.76	2.82
82.5	82.5	2.15	1.82	2.11	2.80	3.65	4.04	82.5	2.08	1.45	1.43
85.0	85.0	0.28	-0.22	0.03	0.73	1.61	2.06	85.0	0.14	-0.77	-0.89
87.5	87.5	-3.79	-4.52	-4.32	-3.64	-2.74	-2.27	87.5	-4.07	-5.34	-5.60
90.0	90.0	-86.64	-86.95	-87.18	-87.32	-87.58	-88.29	90.0	-86.78	-86.62	-86.48

[Elevation Angle $\psi = 90^\circ - \theta$]

Moist Clay $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

THETA		5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz
0.0	0.0	-86.78	-86.62	-86.48	-86.25	-86.38	-87.67
2.5	2.5	-20.55	-20.57	-21.48	-25.15	-24.49	-18.70
5.0	5.0	-14.53	-14.55	-15.46	-19.08	-18.51	-12.72
7.5	7.5	-11.03	-11.04	-11.94	-15.47	-15.04	-9.28
10.0	10.0	-8.55	-8.56	-9.43	-12.87	-12.62	-6.88
12.5	12.5	-6.64	-6.64	-7.49	-10.79	-10.76	-5.07
15.0	15.0	-5.09	-5.08	-5.90	-9.05	-9.26	-3.65
17.5	17.5	-3.80	-3.78	-4.56	-7.54	-8.00	-2.51
20.0	20.0	-2.68	-2.65	-3.39	-6.19	-6.90	-1.57
22.5	22.5	-1.72	-1.67	-2.37	-4.97	-5.91	-0.81
25.0	25.0	-0.87	-0.81	-1.46	-3.85	-5.00	-0.18
27.5	27.5	-0.11	-0.03	-0.63	-2.82	-4.12	0.34
30.0	30.0	0.57	0.66	0.11	-1.86	-3.28	0.76
32.5	32.5	1.18	1.28	0.79	-0.97	-2.45	1.10
35.0	35.0	1.72	1.84	1.41	-0.14	-1.63	1.38
37.5	37.5	2.22	2.35	1.98	0.63	-0.82	1.62
40.0	40.0	2.66	2.81	2.50	1.35	-0.02	1.82
42.5	42.5	3.06	3.22	2.97	2.02	0.75	2.03
45.0	45.0	3.42	3.59	3.40	2.63	1.50	2.25
47.5	47.5	3.74	3.92	3.78	3.19	2.22	2.49
50.0	50.0	4.02	4.20	4.12	3.69	2.89	2.79
52.5	52.5	4.26	4.45	4.42	4.15	3.52	3.12
55.0	55.0	4.46	4.65	4.67	4.54	4.09	3.50
57.5	57.5	4.63	4.81	4.88	4.88	4.59	3.90
60.0	60.0	4.75	4.92	5.03	5.15	5.03	4.31
62.5	62.5	4.84	4.98	5.12	5.36	5.39	4.69
65.0	65.0	4.87	4.98	5.15	5.48	5.66	5.02
67.5	67.5	4.85	4.92	5.10	5.52	5.82	5.27
70.0	70.0	4.76	4.78	5.45	5.87	5.82	5.42
72.5	72.5	4.59	4.54	5.26	5.78	5.78	5.42
75.0	75.0	4.30	4.16	4.32	4.90	5.50	5.24
77.5	77.5	3.86	3.60	3.72	4.33	4.99	4.81
80.0	80.0	3.18	2.76	2.82	3.44	4.14	4.03
82.5	82.5	2.08	1.45	1.43	2.03	2.76	2.69
85.0	85.0	0.14	-0.77	-0.89	-0.33	0.40	0.36
87.5	87.5	-4.07	-5.34	-5.60	-5.10	-4.39	-4.43
90.0	90.0	-86.78	-86.62	-86.48	-86.25	-86.38	-87.67

Table A-15. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Six Frequencies and Five Soil Conditions, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

[Elevation Angle $\psi = 90^\circ - \theta$]													
Sand $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$													
THETA	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	THETA	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz
0.0	-83.88	-85.45	-85.55	-85.57	-86.32	-88.36	0.0	-83.88	-85.45	-85.55	-85.57	-86.32	-88.36
2.5	-19.13	-18.54	-19.77	-30.41	-20.75	-18.93	2.5	-19.13	-18.54	-19.77	-30.41	-20.75	-18.93
5.0	-13.12	-12.54	-13.76	-24.16	-14.82	-12.95	5.0	-13.12	-12.54	-13.76	-24.16	-14.82	-12.95
7.5	-9.62	-9.04	-10.26	-20.26	-11.45	-9.48	7.5	-9.62	-9.04	-10.26	-20.26	-11.45	-9.48
10.0	-7.15	-6.59	-7.79	-17.27	-9.15	-7.07	10.0	-7.15	-6.59	-7.79	-17.27	-9.15	-7.07
12.5	-5.25	-4.70	-5.89	-14.75	-7.46	-5.24	12.5	-5.25	-4.70	-5.89	-14.75	-7.46	-5.24
15.0	-3.72	-3.19	-4.35	-12.52	-6.16	-3.79	15.0	-3.72	-3.19	-4.35	-12.52	-6.16	-3.79
17.5	-2.43	-1.93	-3.06	-10.51	-5.13	-2.61	17.5	-2.43	-1.93	-3.06	-10.51	-5.13	-2.61
20.0	-1.34	-0.86	-1.95	-8.67	-4.28	-1.63	20.0	-1.34	-0.86	-1.95	-8.67	-4.28	-1.63
22.5	-0.40	0.06	-0.99	-6.99	-3.56	-0.82	22.5	-0.40	0.06	-0.99	-6.99	-3.56	-0.82
25.0	0.43	0.86	-0.15	-5.43	-2.92	-0.14	25.0	0.43	0.86	-0.15	-5.43	-2.92	-0.14
27.5	1.16	1.56	0.61	-4.01	-2.31	0.42	27.5	1.16	1.56	0.61	-4.01	-2.31	0.42
30.0	1.80	2.17	1.28	-2.70	-1.71	0.90	30.0	1.80	2.17	1.28	-2.70	-1.71	0.90
32.5	2.38	2.71	1.89	-1.51	-1.09	1.29	32.5	2.38	2.71	1.89	-1.51	-1.09	1.29
35.0	2.88	3.18	2.44	-0.42	-0.46	1.64	35.0	2.88	3.18	2.44	-0.42	-0.46	1.64
37.5	3.33	3.59	2.93	0.57	0.20	1.94	37.5	3.33	3.59	2.93	0.57	0.20	1.94
40.0	3.72	3.95	3.38	1.46	0.88	2.22	40.0	3.72	3.95	3.38	1.46	0.88	2.22
42.5	4.06	4.26	3.77	2.26	1.55	2.50	42.5	4.06	4.26	3.77	2.26	1.55	2.50
45.0	4.35	4.51	4.12	2.98	2.22	2.79	45.0	4.35	4.51	4.12	2.98	2.22	2.79
47.5	4.60	4.72	4.42	3.61	2.87	3.09	47.5	4.60	4.72	4.42	3.61	2.87	3.09
50.0	4.79	4.88	4.67	4.16	3.47	3.42	50.0	4.79	4.88	4.67	4.16	3.47	3.42
52.5	4.94	5.00	4.88	4.63	4.03	3.76	52.5	4.94	5.00	4.88	4.63	4.03	3.76
55.0	5.04	5.06	5.03	5.02	4.53	4.11	55.0	5.04	5.06	5.03	5.02	4.53	4.11
57.5	5.08	5.07	5.13	5.33	4.95	4.46	57.5	5.08	5.07	5.13	5.33	4.95	4.46
60.0	5.07	5.02	5.17	5.56	5.30	4.77	60.0	5.07	5.02	5.17	5.56	5.30	4.77
62.5	4.99	4.91	5.14	5.69	5.56	5.04	62.5	4.99	4.91	5.14	5.69	5.56	5.04
65.0	4.84	4.73	5.03	5.73	5.72	5.24	65.0	4.84	4.73	5.03	5.73	5.72	5.24
67.5	4.61	4.46	4.83	5.65	5.77	5.34	67.5	4.61	4.46	4.83	5.65	5.77	5.34
70.0	4.28	4.09	4.52	5.46	5.68	5.32	70.0	4.28	4.09	4.52	5.46	5.68	5.32
72.5	3.81	3.60	4.08	5.11	5.43	5.14	72.5	3.81	3.60	4.08	5.11	5.43	5.14
75.0	3.19	2.93	3.46	4.57	4.98	4.76	75.0	3.19	2.93	3.46	4.57	4.98	4.76
77.5	2.34	2.04	2.61	3.78	4.27	4.11	77.5	2.34	2.04	2.61	3.78	4.27	4.11
80.0	1.15	0.81	1.41	2.64	3.19	3.09	80.0	1.15	0.81	1.41	2.64	3.19	3.09
82.5	-0.56	-0.95	-0.33	0.94	1.54	1.49	82.5	-0.56	-0.95	-0.33	0.94	1.54	1.49
85.0	-3.26	-3.71	-3.07	-1.77	-1.14	-1.16	85.0	-3.26	-3.71	-3.07	-1.77	-1.14	-1.16
87.5	-8.42	-8.92	-8.28	-6.96	-6.31	-6.31	87.5	-8.42	-8.92	-8.28	-6.96	-6.31	-6.31
90.0	-83.88	-85.45	-85.55	-85.57	-86.32	-88.36	90.0	-83.88	-85.45	-85.55	-85.57	-86.32	-88.36

[Elevation Angle $\psi = 90^\circ - \theta$]													
Medium Dry Ground $\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$													
THETA	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	THETA	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz
0.0	-84.63	-85.63	-86.02	-86.25	-86.85	-88.31	0.0	-84.63	-85.63	-86.02	-86.25	-86.85	-88.31
2.5	-19.38	-19.62	-21.19	-25.98	-23.75	-19.24	2.5	-19.38	-19.62	-21.19	-25.98	-23.75	-19.24
5.0	-13.37	-13.61	-15.17	-19.88	-17.77	-13.27	5.0	-13.37	-13.61	-15.17	-19.88	-17.77	-13.27
7.5	-9.87	-10.11	-11.64	-16.25	-14.31	-9.83	7.5	-9.87	-10.11	-11.64	-16.25	-14.31	-9.83
10.0	-7.40	-7.64	-9.13	-13.60	-11.89	-7.44	10.0	-7.40	-7.64	-9.13	-13.60	-11.89	-7.44
12.5	-5.50	-5.73	-7.19	-11.47	-10.04	-5.64	12.5	-5.50	-5.73	-7.19	-11.47	-10.04	-5.64
15.0	-3.97	-4.19	-5.60	-9.66	-8.55	-4.23	15.0	-3.97	-4.19	-5.60	-9.66	-8.55	-4.23
17.5	-2.68	-2.90	-4.25	-8.07	-7.31	-3.09	17.5	-2.68	-2.90	-4.25	-8.07	-7.31	-3.09
20.0	-1.59	-1.79	-3.08	-6.65	-6.24	-2.16	20.0	-1.59	-1.79	-3.08	-6.65	-6.24	-2.16
22.5	-0.64	-0.84	-2.05	-5.34	-5.28	-1.40	22.5	-0.64	-0.84	-2.05	-5.34	-5.28	-1.40
25.0	0.19	0.01	-1.14	-4.14	-4.41	-0.76	25.0	0.19	0.01	-1.14	-4.14	-4.41	-0.76
27.5	0.92	0.75	-0.31	-3.03	-3.58	-0.24	27.5	0.92	0.75	-0.31	-3.03	-3.58	-0.24
30.0	1.57	1.41	0.44	-2.00	-2.78	0.19	30.0	1.57	1.41	0.44	-2.00	-2.78	0.19
32.5	2.14	2.00	1.12	-1.04	-2.00	0.56	32.5	2.14	2.00	1.12	-1.04	-2.00	0.56
35.0	2.65	2.53	1.73	-0.15	-1.23	0.87	35.0	2.65	2.53	1.73	-0.15	-1.23	0.87
37.5	3.11	3.00	2.30	0.67	-0.46	1.16	37.5	3.11	3.00	2.30	0.67	-0.46	1.16
40.0	3.51	3.41	2.81	1.44	0.29	1.43	40.0	3.51	3.41	2.81	1.44	0.29	1.43
42.5	3.86	3.78	3.27	2.14	1.04	1.72	42.5	3.86	3.78	3.27	2.14	1.04	1.72
45.0	4.16	4.10	3.69	2.78	1.75	2.02	45.0	4.16	4.10	3.69	2.78	1.75	2.02
47.5	4.42	4.37	4.06	3.36	2.44	2.37	47.5	4.42	4.37	4.06	3.36	2.44	2.37
50.0	4.63	4.60	4.38	3.87	3.09	2.76	50.0	4.63	4.60	4.38	3.87	3.09	2.76
52.5	4.80	4.79	4.65	4.33	3.69	3.18	52.5	4.80	4.79	4.65	4.33	3.69	3.18
55.0	4.92	4.92	4.87	4.72	4.23	3.63	55.0	4.92	4.92	4.87	4.72	4.23	3.63
57.5	4.99	5.01	5.04	5.05	4.71	4.08	57.5	4.99	5.01	5.04	5.05	4.71	4.08
60.0	5.01	5.04	5.15	5.30	5.12	4.51	60.0	5.01	5.04	5.15	5.30	5.12	4.51
62.5	4.97	5.01	5.19	5.48	5.45	4.90	62.5	4.97	5.01	5.19	5.48	5.45	4.90
65.0	4.86	4.91	5.17	5.57	5.68	5.23	65.0	4.86	4.91	5.17	5.57	5.68	5.23
67.5	4.68	4.74	5.05	5.57	5.81	5.16	67.5	4.68	4.74	5.05	5.57	5.81	5.16
70.0	4.41	4.47	4.84	5.45	5.82	5.18	70.0	4.41	4.47	4.84	5.45	5.82	5.18
72.5	4.02	4.09	4.51	5.20	5.68	5.54	72.5	4.02	4.09	4.51	5.20	5.68	5.54
75.0	3.48	3.54	4.01	4.77	5.35	5.32	75.0	3.48	3.54	4.01	4.77	5.35	5.32
77.5	2.73	2.79	3.29	4.11	4.77	4.83	77.5	2.73	2.79	3.29	4.11	4.77	4.83
80.0	1.67	1.72	2.25	3.13	3.85	3.99	80.0	1.67	1.72	2.25	3.13	3.85	3.99
82.5	0.10	0.15	0.70	1.61	2.39	2.59	82.5	0.10	0.15	0.70	1.61	2.39	2.59
85.0	-2.41	-2.38	-1.81	-0.88	-0.06	0.19	85.0	-2.41	-2.38	-1.81	-0.88	-0.06	0.19
87.5	-7.33	-7.32	-6.74	-5.79	-4.95	-4.68	87.5	-7.33	-7.32	-6.74	-5.79	-4.95	-4.68
90.0	-84.63	-85.63	-86.02	-86.25	-86.85	-88.31	90.0	-84.63	-85.63	-86.02	-86.25	-86.85	-88.31

[Elevation Angle $\psi = 90^\circ - \theta$]

Sand $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

Table A-15. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Six Frequencies and Five Soil Conditions, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Concluded)

THETA	[Elevation Angle $\psi = 90^\circ - \theta$]									
	Very Dry Ground $\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$									
	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	35 MHz	40 MHz	45 MHz	50 MHz
0.0	-85.09	-85.96	-85.09	-85.73	-86.46	-88.58	-88.58	-88.58	-88.58	-88.58
2.5	-18.90	-17.99	-21.80	-25.84	-20.11	-20.31	-20.31	-20.31	-20.31	-20.31
5.0	-12.90	-11.99	-15.80	-19.92	-14.18	-14.28	-14.28	-14.28	-14.28	-14.28
7.5	-9.40	-8.51	-12.29	-16.55	-10.80	-10.75	-10.75	-10.75	-10.75	-10.75
10.0	-6.93	-6.07	-9.82	-14.24	-8.50	-8.24	-8.24	-8.24	-8.24	-8.24
12.5	-5.04	-4.20	-7.90	-12.47	-6.80	-6.30	-6.30	-6.30	-6.30	-6.30
15.0	-3.51	-2.70	-6.34	-11.00	-5.50	-4.73	-4.73	-4.73	-4.73	-4.73
17.5	-2.23	-1.46	-5.01	-9.68	-4.47	-3.42	-3.42	-3.42	-3.42	-3.42
20.0	-1.14	-0.41	-3.86	-8.41	-3.63	-2.31	-2.31	-2.31	-2.31	-2.31
22.5	-0.21	0.48	-2.82	-7.13	-2.94	-1.38	-1.38	-1.38	-1.38	-1.38
25.0	0.61	1.26	-1.88	-5.84	-2.33	-0.58	-0.58	-0.58	-0.58	-0.58
27.5	1.33	1.93	-1.02	-4.55	-1.79	0.10	0.10	0.10	0.10	0.10
30.0	1.97	2.51	-0.21	-3.28	-1.27	0.68	0.68	0.68	0.68	0.68
32.5	2.53	3.02	0.54	-2.07	-0.75	1.18	1.18	1.18	1.18	1.18
35.0	3.03	3.45	1.24	-0.92	-0.22	1.60	1.60	1.60	1.60	1.60
37.5	3.46	3.83	1.89	0.14	0.34	1.97	1.97	1.97	1.97	1.97
40.0	3.84	4.16	2.50	1.11	0.93	2.30	2.30	2.30	2.30	2.30
42.5	4.17	4.43	3.05	1.99	1.53	2.62	2.62	2.62	2.62	2.62
45.0	4.45	4.65	3.56	2.78	2.15	2.92	2.92	2.92	2.92	2.92
47.5	4.68	4.82	4.01	3.47	2.76	3.23	3.23	3.23	3.23	3.23
50.0	4.86	4.95	4.41	4.08	3.35	3.55	3.55	3.55	3.55	3.55
52.5	4.99	5.03	4.75	4.59	3.90	3.87	3.87	3.87	3.87	3.87
55.0	5.07	5.06	5.02	5.02	4.41	4.20	4.20	4.20	4.20	4.20
57.5	5.10	5.03	5.23	5.35	4.85	4.52	4.52	4.52	4.52	4.52
60.0	5.07	4.96	5.37	5.60	5.22	4.81	4.81	4.81	4.81	4.81
62.5	4.97	4.82	5.43	5.75	5.50	5.06	5.06	5.06	5.06	5.06
65.0	4.80	4.60	5.40	5.80	5.68	5.24	5.24	5.24	5.24	5.24
67.5	4.54	4.31	5.28	5.74	5.75	5.33	5.33	5.33	5.33	5.33
70.0	4.18	3.91	5.03	5.55	5.68	5.29	5.29	5.29	5.29	5.29
72.5	3.68	3.39	4.64	5.21	5.45	5.11	5.11	5.11	5.11	5.11
75.0	3.02	2.70	4.06	4.67	5.01	4.72	4.72	4.72	4.72	4.72
77.5	2.13	1.79	3.24	3.88	4.31	4.07	4.07	4.07	4.07	4.07
80.0	0.90	0.54	2.07	2.74	3.24	3.04	3.04	3.04	3.04	3.04
82.5	-0.87	-1.24	0.35	1.04	1.60	1.43	1.43	1.43	1.43	1.43
85.0	-3.63	-4.01	-2.38	-1.67	-1.07	-1.21	-1.21	-1.21	-1.21	-1.21
87.5	-8.85	-9.24	-7.58	-6.87	-6.24	-6.36	-6.36	-6.36	-6.36	-6.36
90.0	-85.09	-85.96	-85.09	-85.73	-86.46	-88.58	-88.58	-88.58	-88.58	-88.58

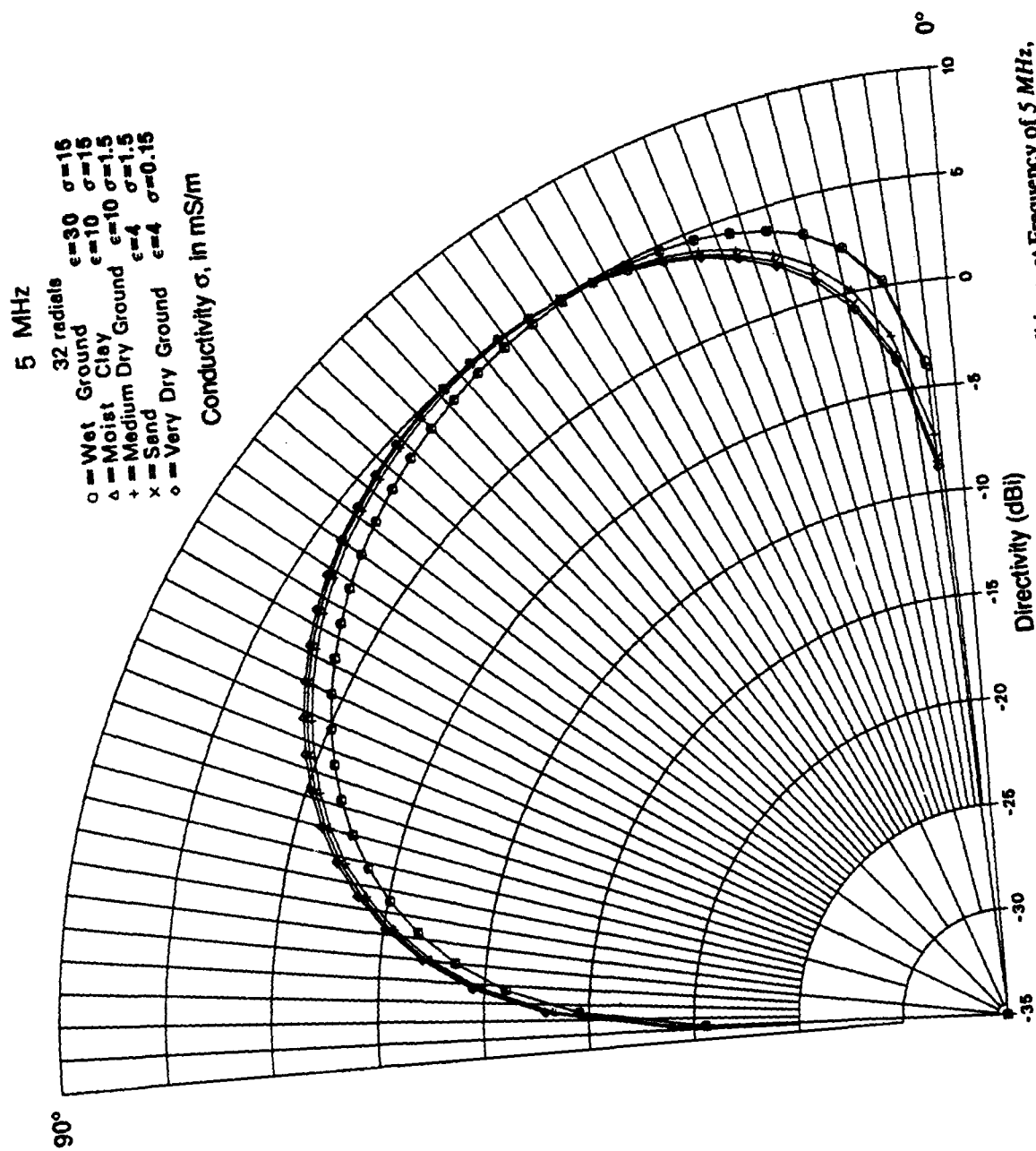


Figure A-49. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 5 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

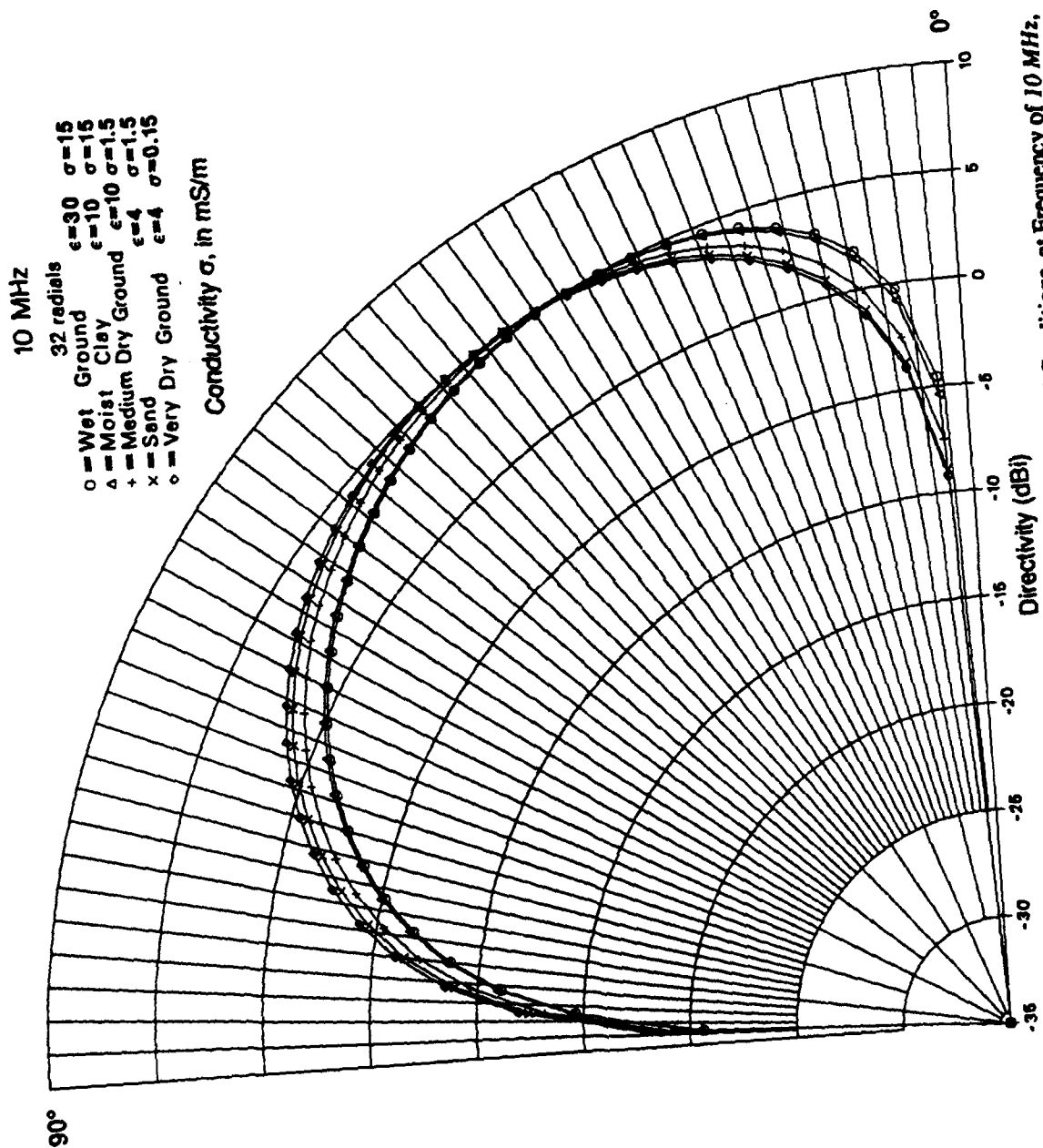


Figure A-50. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 10 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

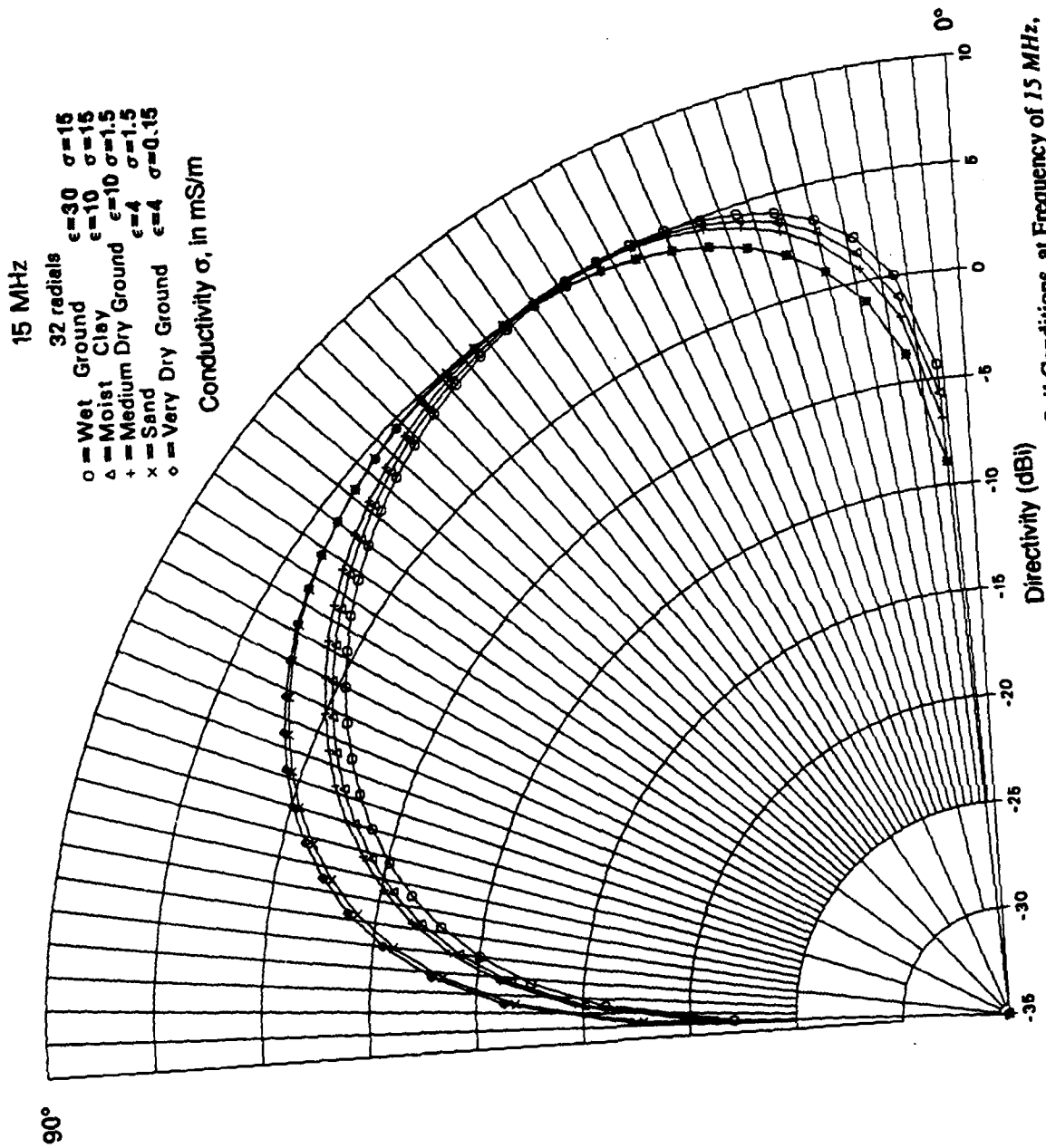


Figure A-51. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 15 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

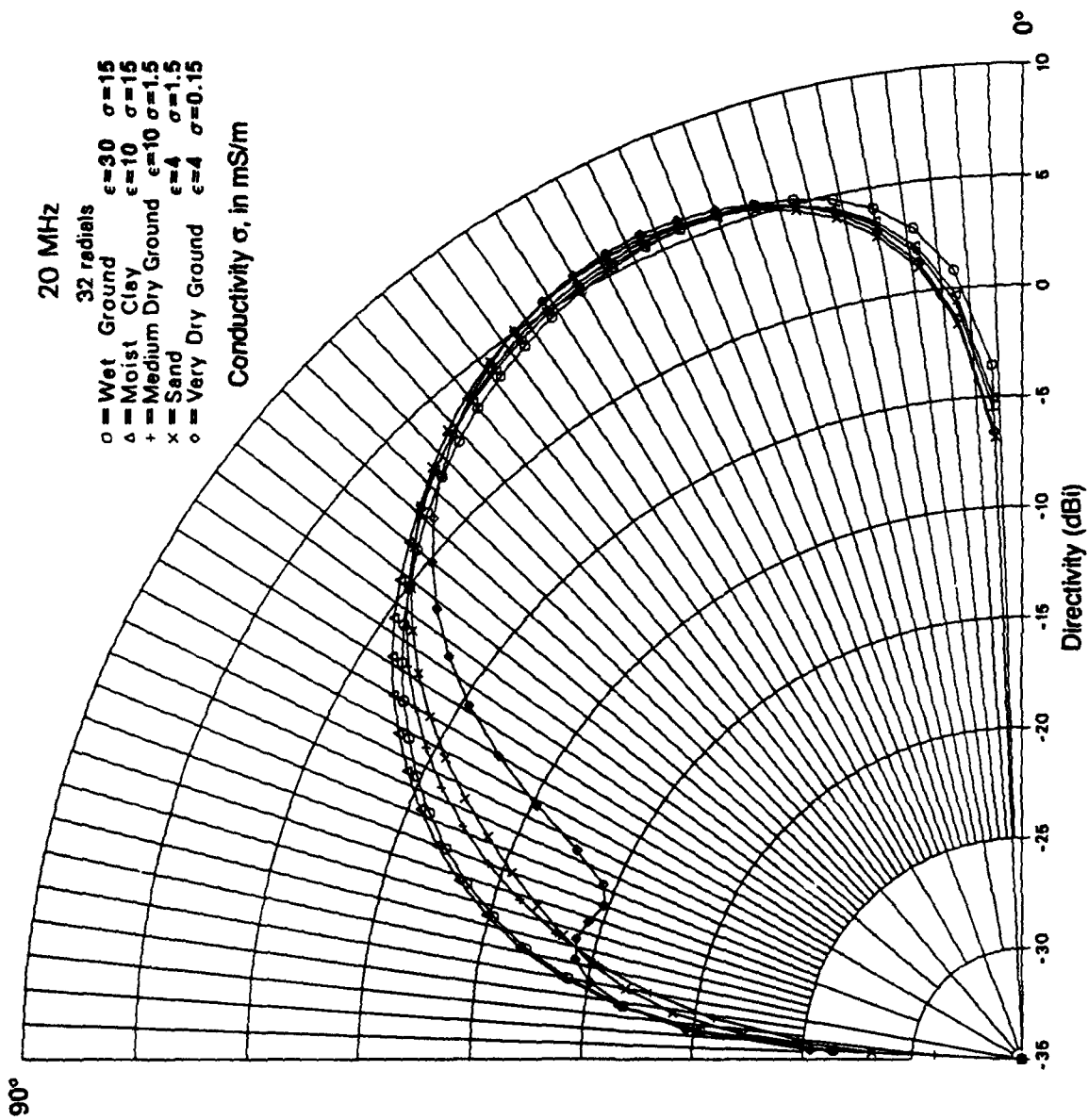


Figure A-52. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 20 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

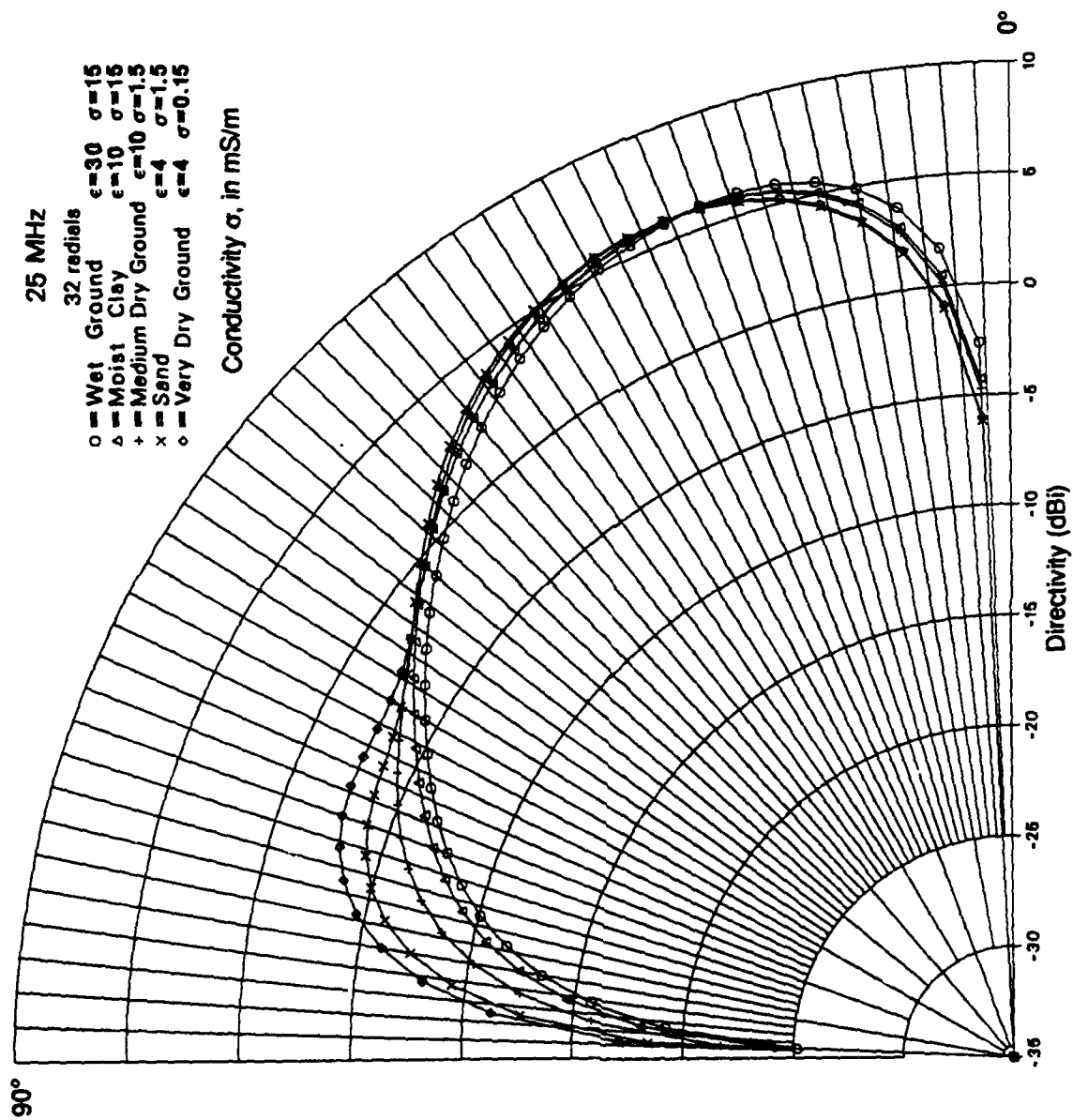


Figure A-53. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 25 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

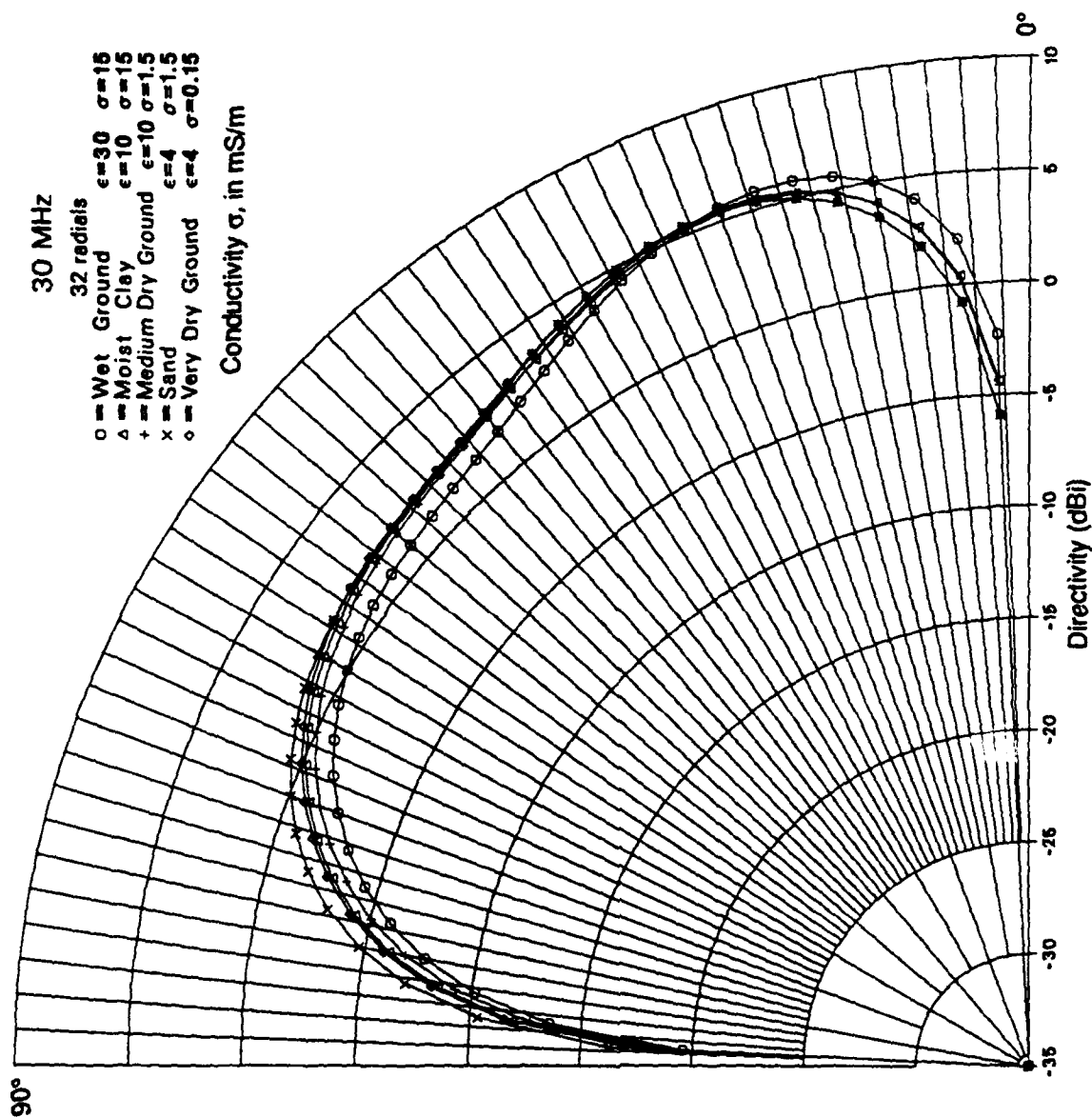


Figure A-54. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 30 MHz, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

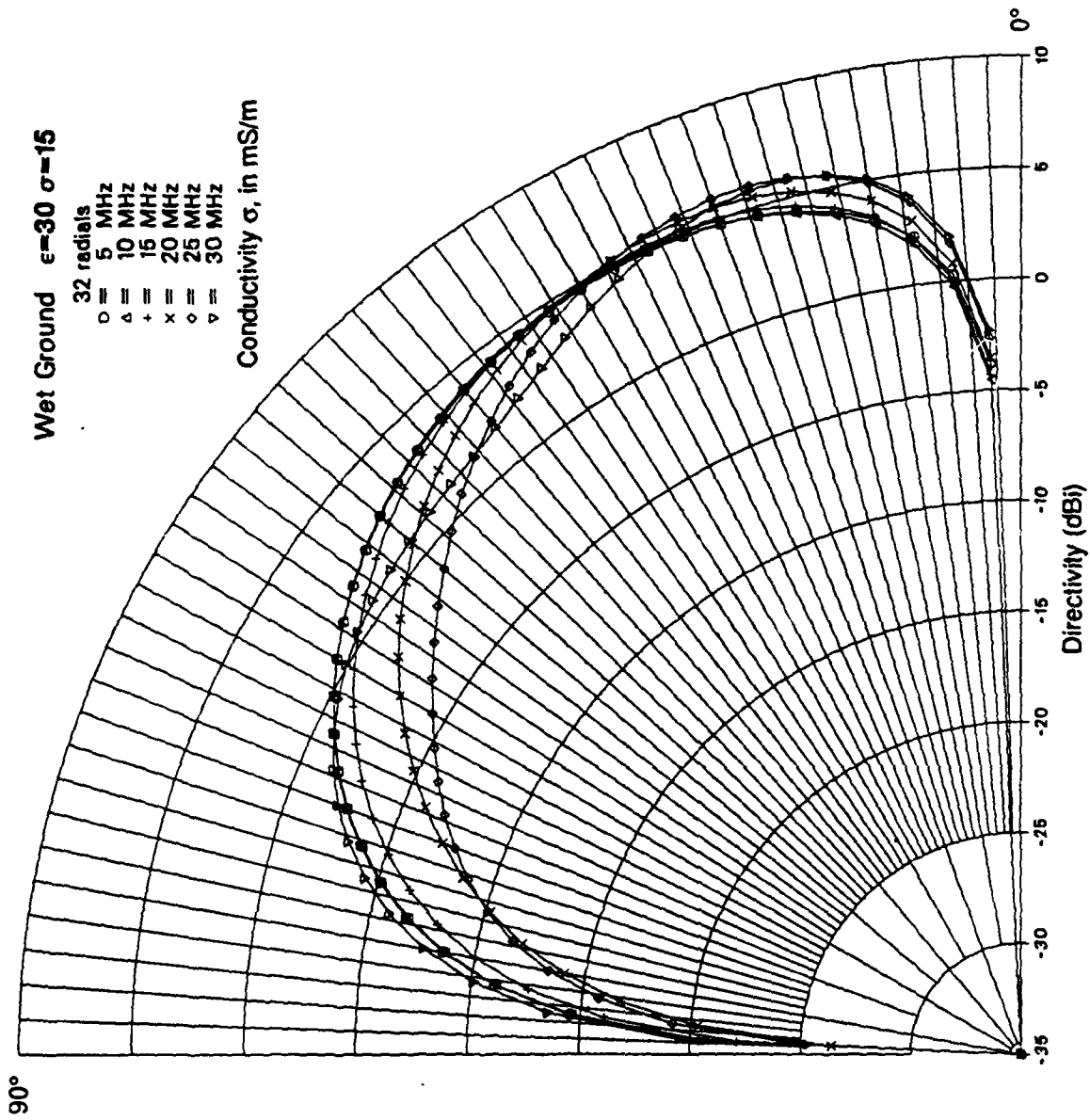


Figure A-55. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials for a Wet Ground Condition

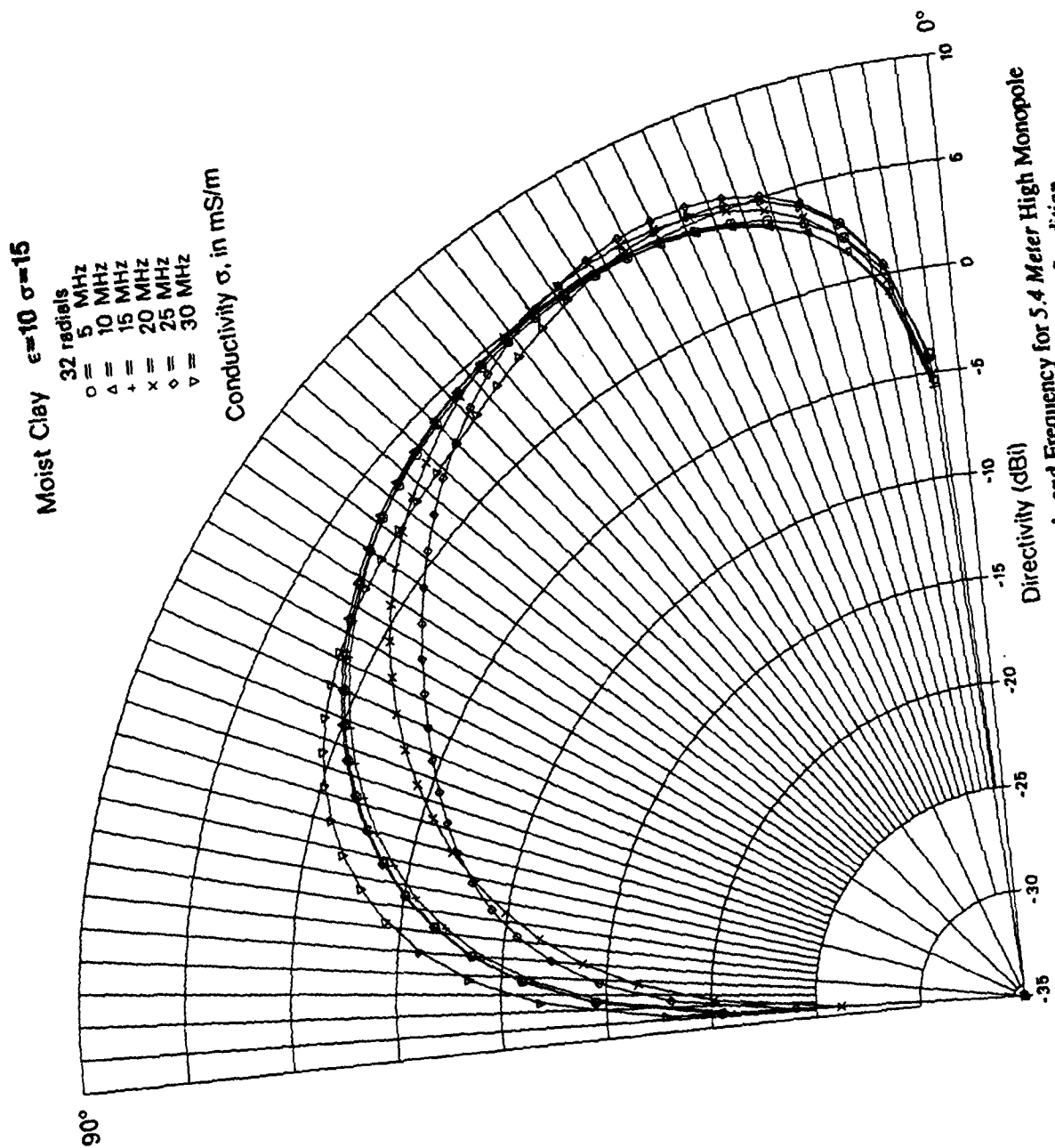


Figure A-56. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials for a Moist Clay Condition

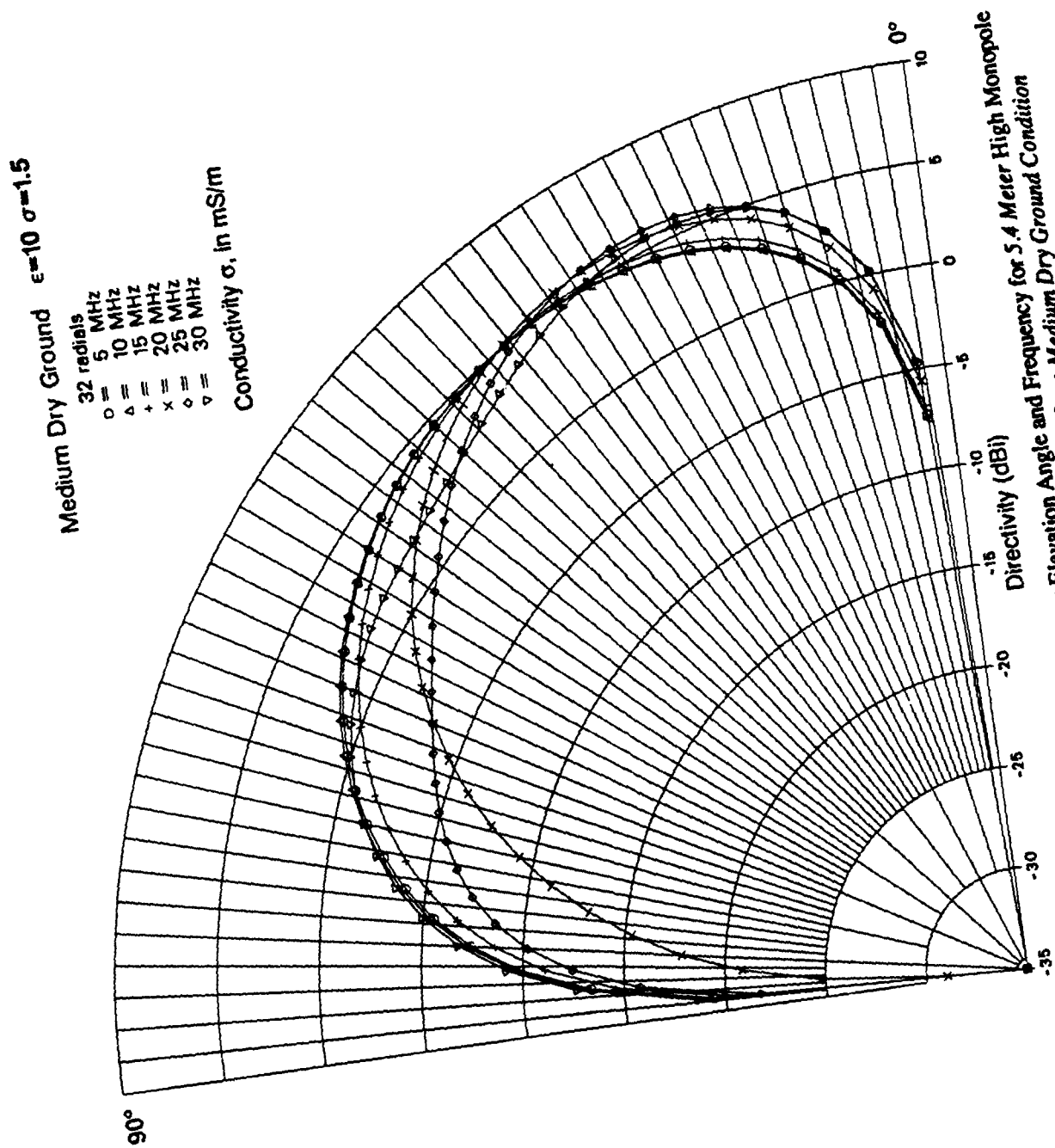


Figure A-57. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials for a Medium Dry Ground Condition

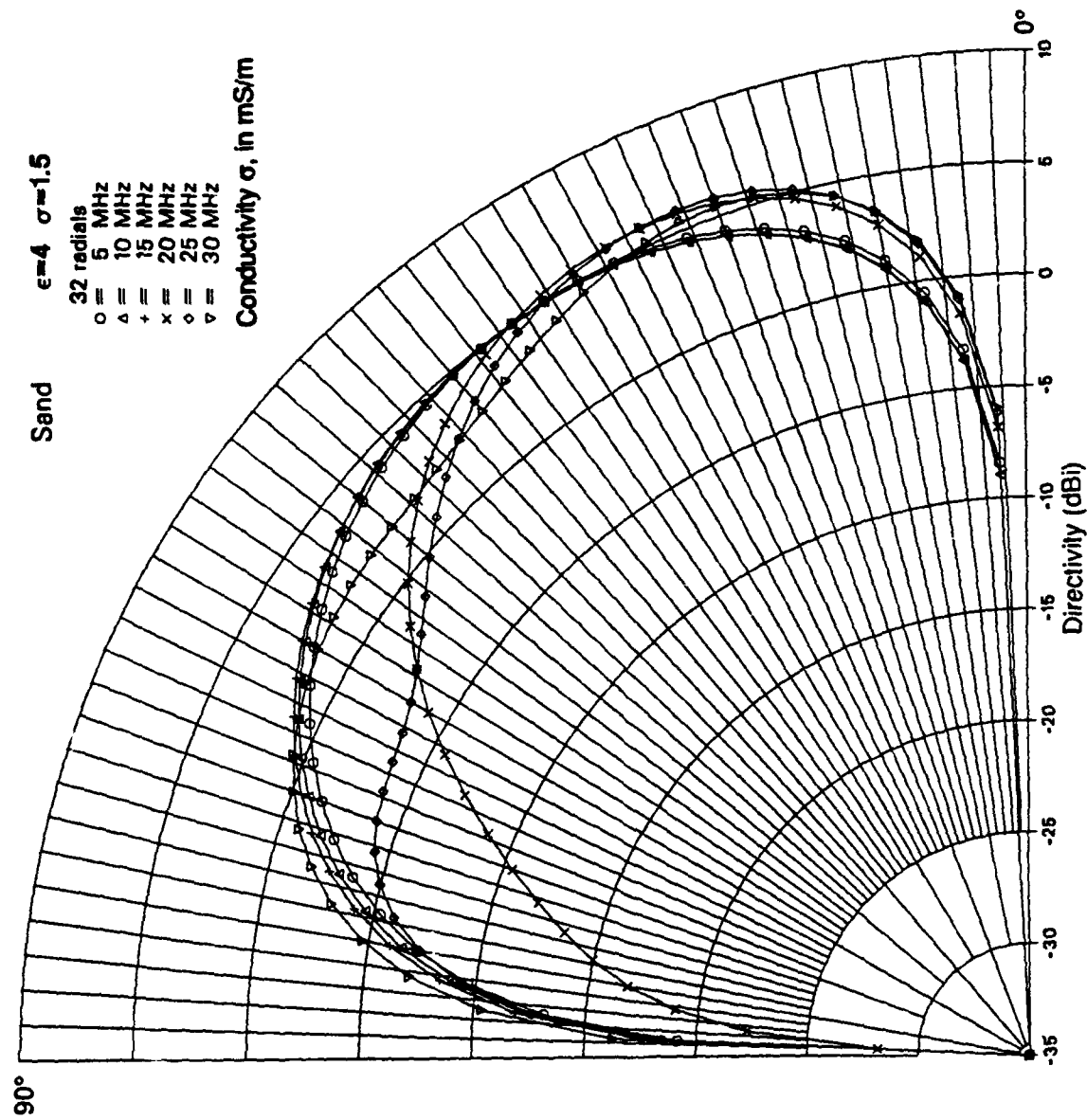


Figure A-58. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials for a Sandy Soil Condition

Very Dry Ground $\epsilon=4$ $\sigma=0.15$

32 radials
 0 = 5 MHz
 4 = 10 MHz
 + = 15 MHz
 x = 20 MHz
 o = 25 MHz
 v = 30 MHz

Conductivity σ , in mS/m

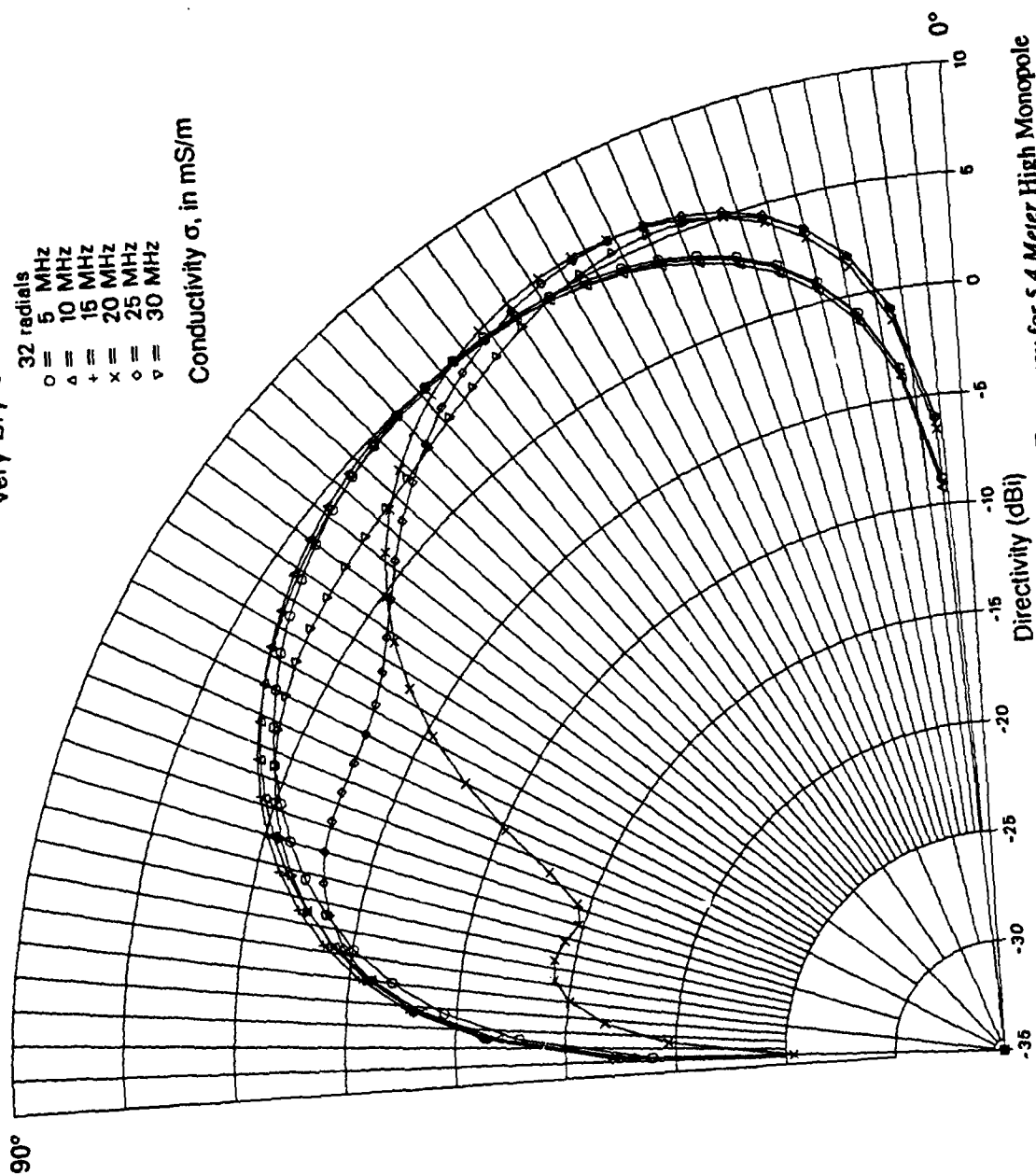


Figure A-59. Antenna Directivity versus Elevation Angle and Frequency for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials for a Very Dry Ground Condition

Table A-16. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Six Frequencies and Five Soil Conditions, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

[Elevation Angle $\psi = 90^\circ - \theta$]													
Moist Clay $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$													
	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz		5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz
THETA	0.0	-91.01	-90.41	-90.16	-89.71	-89.61	0.0	-91.01	-90.41	-90.16	-89.71	-89.61	-90.85
	2.5	-20.54	-20.47	-21.11	-26.24	-24.02	2.5	-20.54	-20.47	-21.11	-26.24	-24.02	-17.87
	5.0	-14.53	-14.46	-15.09	-20.15	-18.08	5.0	-14.53	-14.46	-15.09	-20.15	-18.08	-11.90
	7.5	-11.03	-10.95	-11.57	-16.50	-14.68	7.5	-11.03	-10.95	-11.57	-16.50	-14.68	-8.47
	10.0	-8.55	-8.47	-9.08	-13.83	-12.34	10.0	-8.55	-8.47	-9.08	-13.83	-12.34	-6.09
	12.5	-6.64	-6.55	-7.15	-11.69	-10.60	12.5	-6.64	-6.55	-7.15	-11.69	-10.60	-4.31
	15.0	-5.09	-5.00	-5.57	-9.87	-9.22	15.0	-5.09	-5.00	-5.57	-9.87	-9.22	-2.92
	17.5	-3.79	-3.70	-4.25	-8.27	-8.09	17.5	-3.79	-3.70	-4.25	-8.27	-8.09	-1.81
	20.0	-2.68	-2.58	-3.10	-6.84	-7.12	20.0	-2.68	-2.58	-3.10	-6.84	-7.12	-0.91
	22.5	-1.71	-1.60	-2.10	-5.53	-6.25	22.5	-1.71	-1.60	-2.10	-5.53	-6.25	-0.18
	25.0	-0.86	-0.74	-1.20	-4.33	-5.43	25.0	-0.86	-0.74	-1.20	-4.33	-5.43	0.40
	27.5	-0.10	0.03	-0.40	-3.22	-4.62	27.5	-0.10	0.03	-0.40	-3.22	-4.62	0.86
	30.0	0.57	0.71	0.32	-2.19	-3.81	30.0	0.57	0.71	0.32	-2.19	-3.81	1.22
	32.5	1.18	1.33	0.98	-1.24	-2.97	32.5	1.18	1.33	0.98	-1.24	-2.97	1.50
	35.0	1.73	1.89	1.58	-0.35	-2.12	35.0	1.73	1.89	1.58	-0.35	-2.12	1.70
	37.5	2.22	2.39	2.12	0.47	-1.26	37.5	2.22	2.39	2.12	0.47	-1.26	1.86
	40.0	2.67	2.84	2.62	1.23	-0.40	40.0	2.67	2.84	2.62	1.23	-0.40	1.98
	42.5	3.07	3.25	3.07	1.93	0.45	42.5	3.07	3.25	3.07	1.93	0.45	2.10
	45.0	3.43	3.61	3.48	2.57	1.26	45.0	3.43	3.61	3.48	2.57	1.26	2.24
	47.5	3.74	3.93	3.85	3.16	2.04	47.5	3.74	3.93	3.85	3.16	2.04	2.43
	50.0	4.02	4.21	4.17	3.69	2.77	50.0	4.02	4.21	4.17	3.69	2.77	2.67
	52.5	4.27	4.45	4.45	4.15	3.44	52.5	4.27	4.45	4.45	4.15	3.44	2.97
	55.0	4.47	4.64	4.68	4.56	4.05	55.0	4.47	4.64	4.68	4.56	4.05	3.34
	57.5	4.64	4.80	4.87	4.91	4.59	57.5	4.64	4.80	4.87	4.91	4.59	3.74
	60.0	4.76	4.91	5.01	5.19	5.05	60.0	4.76	4.91	5.01	5.19	5.05	4.16
	62.5	4.84	4.96	5.09	5.39	5.42	62.5	4.84	4.96	5.09	5.39	5.42	4.56
	65.0	4.88	4.96	5.11	5.52	5.71	65.0	4.88	4.96	5.11	5.52	5.71	4.92
	67.5	4.86	4.90	5.05	5.56	5.89	67.5	4.86	4.90	5.05	5.56	5.89	5.20
	70.0	4.77	4.75	4.91	5.50	5.94	70.0	4.77	4.75	4.91	5.50	5.94	5.37
	72.5	4.60	4.51	4.65	5.30	5.85	72.5	4.60	4.51	4.65	5.30	5.85	5.39
	75.0	4.31	4.13	4.25	4.94	5.58	75.0	4.31	4.13	4.25	4.94	5.58	5.23
	77.5	3.87	3.56	3.64	4.37	5.08	77.5	3.87	3.56	3.64	4.37	5.08	4.82
	80.0	3.19	2.72	2.74	3.47	4.23	80.0	3.19	2.72	2.74	3.47	4.23	4.04
	82.5	2.09	1.41	1.35	2.07	2.85	82.5	2.09	1.41	1.35	2.07	2.85	2.72
	85.0	0.15	-0.81	-0.98	-0.29	0.49	85.0	0.15	-0.81	-0.98	-0.29	0.49	0.39
	87.5	-4.06	-5.38	-5.69	-5.06	-4.30	87.5	-4.06	-5.38	-5.69	-5.06	-4.30	-4.39
	90.0	-91.01	-90.41	-90.16	-89.71	-89.61	90.0	-91.01	-90.41	-90.16	-89.71	-89.61	-90.85

[Elevation Angle $\psi = 90^\circ - \theta$]													
Wet Ground $\epsilon_r = 30, \sigma = 15 \text{ mS/m}$													
	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz		5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz
THETA	0.0	-90.96	-90.77	-90.69	-90.53	-91.49	0.0	-90.96	-90.77	-90.69	-90.53	-90.59	-91.49
	2.5	-20.55	-20.65	-22.10	-26.41	-25.18	2.5	-20.55	-20.65	-22.10	-26.41	-25.18	-19.57
	5.0	-14.54	-14.63	-16.07	-20.33	-19.20	5.0	-14.54	-14.63	-16.07	-20.33	-19.20	-13.58
	7.5	-11.03	-11.12	-12.54	-16.71	-15.76	7.5	-11.03	-11.12	-12.54	-16.71	-15.76	-10.12
	10.0	-8.55	-8.64	-10.03	-14.08	-13.36	10.0	-8.55	-8.64	-10.03	-14.08	-13.36	-7.70
	12.5	-6.64	-6.73	-8.07	-11.97	-11.54	12.5	-6.64	-6.73	-8.07	-11.97	-11.54	-5.87
	15.0	-5.09	-5.17	-6.47	-10.20	-10.08	15.0	-5.09	-5.17	-6.47	-10.20	-10.08	-4.42
	17.5	-3.80	-3.86	-5.11	-8.64	-8.87	17.5	-3.80	-3.86	-5.11	-8.64	-8.87	-3.25
	20.0	-2.69	-2.74	-3.93	-7.24	-7.83	20.0	-2.69	-2.74	-3.93	-7.24	-7.83	-2.29
	22.5	-1.72	-1.76	-2.88	-5.97	-6.89	22.5	-1.72	-1.76	-2.88	-5.97	-6.89	-1.50
	25.0	-0.87	-0.90	-1.95	-4.80	-6.03	25.0	-0.87	-0.90	-1.95	-4.80	-6.03	-0.86
	27.5	-0.11	-0.13	-1.10	-3.71	-5.20	27.5	-0.11	-0.13	-1.10	-3.71	-5.20	-0.35
	30.0	0.57	0.56	-0.33	-2.70	-4.38	30.0	0.57	0.56	-0.33	-2.70	-4.38	0.06
	32.5	1.17	1.18	0.37	-1.75	-3.56	32.5	1.17	1.18	0.37	-1.75	-3.56	0.37
	35.0	1.72	1.74	1.02	-0.86	-2.72	35.0	1.72	1.74	1.02	-0.86	-2.72	0.61
	37.5	2.21	2.25	1.61	-0.04	-1.88	37.5	2.21	2.25	1.61	-0.04	-1.88	0.79
	40.0	2.66	2.71	2.16	0.74	-1.04	40.0	2.66	2.71	2.16	0.74	-1.04	0.94
	42.5	3.06	3.12	2.66	1.46	-0.20	42.5	3.06	3.12	2.66	1.46	-0.20	1.09
	45.0	3.41	3.49	3.11	2.12	0.63	45.0	3.41	3.49	3.11	2.12	0.63	1.27
	47.5	3.73	3.82	3.52	2.74	1.43	47.5	3.73	3.82	3.52	2.74	1.43	1.50
	50.0	4.01	4.11	3.89	3.30	2.19	50.0	4.01	4.11	3.89	3.30	2.19	1.81
	52.5	4.25	4.35	4.22	3.80	2.91	52.5	4.25	4.35	4.22	3.80	2.91	2.21
	55.0	4.45	4.56	4.50	4.25	3.58	55.0	4.45	4.56	4.50	4.25	3.58	2.69
	57.5	4.62	4.73	4.74	4.65	4.18	57.5	4.62	4.73	4.74	4.65	4.18	3.23
	60.0	4.75	4.85	4.93	4.98	4.71	60.0	4.75	4.85	4.93	4.98	4.71	3.79
	62.5	4.83	4.92	5.06	5.24	5.17	62.5	4.83	4.92	5.06	5.24	5.17	4.34
	65.0	4.86	4.94	5.14	5.44	5.54	65.0	4.86	4.94	5.14	5.44	5.54	4.85
	67.5	4.84	4.90	5.14	5.55	5.81	67.5	4.84	4.90	5.14	5.55	5.81	5.28
	70.0	4.76	4.79	5.06	5.57	5.98	70.0	4.76	4.79	5.06	5.57	5.98	5.60
	72.5	4.59	4.58	4.88	5.47	6.01	72.5	4.59	4.58	4.88	5.47	6.01	5.79
	75.0	4.31	4.25	4.57	5.23	5.88	75.0	4.31	4.25	4.57	5.23	5.88	5.80
	77.5	3.88	3.74	4.08	4.79	5.53	77.5	3.88	3.74	4.08	4.79	5.53	5.58
	80.0	3.22	2.98	3.32	4.06	4.88	80.0	3.22	2.98	3.32	4.06	4.88	5.04
	82.5	2.15	1.79	2.11	2.88	3.75	82.5	2.15	1.79	2.11	2.88	3.75	3.99
	85.0	0.28	-0.25	0.03	0.81	1.71	85.0	0.28	-0.25	0.03	0.81	1.71	2.01
	87.5	-3.79	-4.55	-4.33	-3.56	-2.64	87.5	-3.79	-4.55	-4.33	-3.56	-2.64	-2.32
	90.0	-90.96	-90.77	-90.69	-90.53	-91.49	90.0	-90.96	-90.77	-90.69	-90.53	-90.59	-91.49

[Elevation Angle $\psi = 90^\circ - \theta$]

Moist Clay $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

Table A-16. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Six Frequencies and Five Soil Conditions, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials (Continued)

		[Elevation Angle $\psi = 90^\circ - \theta$]												
		Sand $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$												
THETA		Medium Dry Ground $\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$												
		5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	THETA	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz
0.0	0.0	-89.83	-90.28	-90.13	-89.81	-89.93	-91.38	0.0	-89.74	-89.98	-90.33	-89.60	-89.80	-91.35
2.5	2.5	-19.42	-19.17	-20.62	-31.03	-21.73	-18.68	2.5	-19.16	-18.42	-17.84	-28.17	-18.45	-16.28
5.0	5.0	-13.41	-13.17	-14.61	-24.76	-15.82	-12.70	5.0	-13.15	-12.42	-11.85	-22.29	-12.61	-10.36
7.5	7.5	-9.91	-9.67	-11.10	-20.86	-12.47	-9.24	7.5	-9.65	-8.93	-8.38	-18.98	-9.39	-7.01
10.0	10.0	-7.44	-7.20	-8.61	-17.86	-10.21	-6.83	10.0	-7.18	-6.48	-5.96	-16.72	-7.32	-4.73
12.5	12.5	-5.54	-5.31	-6.69	-15.34	-8.57	-5.00	12.5	-5.28	-4.60	-4.11	-14.96	-5.91	-3.07
15.0	15.0	-4.00	-3.78	-5.13	-13.12	-7.32	-3.56	15.0	-3.74	-3.08	-2.64	-13.44	-4.97	-1.82
17.5	17.5	-2.72	-2.51	-3.81	-11.11	-6.36	-2.40	17.5	-2.46	-1.83	-1.43	-11.96	-4.36	-0.84
20.0	20.0	-1.62	-1.43	-2.68	-9.28	-5.58	-1.44	20.0	-1.37	-0.77	-0.42	-10.42	-4.00	-0.08
22.5	22.5	-0.67	-0.49	-1.68	-7.59	-4.93	-0.66	22.5	-0.42	0.15	0.44	-8.82	-3.79	0.51
25.0	25.0	0.16	0.33	-0.80	-6.04	-4.35	-0.03	25.0	0.41	0.94	1.18	-7.19	-3.65	0.96
27.5	27.5	0.89	1.05	-0.01	-4.61	-3.79	0.48	27.5	1.14	1.63	1.82	-5.59	-3.47	1.31
30.0	30.0	1.54	1.68	0.70	-3.30	-3.21	0.88	30.0	1.78	2.24	2.38	-4.06	-3.15	1.55
32.5	32.5	2.12	2.25	1.35	-2.09	-2.58	1.19	32.5	2.36	2.77	2.87	-2.64	-2.65	1.72
35.0	35.0	2.63	2.74	1.93	-0.99	-1.90	1.43	35.0	2.86	3.23	3.29	-1.33	-1.94	1.83
37.5	37.5	3.09	3.19	2.47	0.02	-1.15	1.61	37.5	3.31	3.64	3.66	-0.14	-1.09	1.90
40.0	40.0	3.49	3.57	2.95	0.94	-0.37	1.76	40.0	3.71	3.99	3.98	0.92	-0.16	1.97
42.5	42.5	3.85	3.91	3.38	1.77	0.44	1.90	42.5	4.05	4.29	4.25	1.87	0.78	2.06
45.0	45.0	4.15	4.21	3.77	2.52	1.24	2.08	45.0	4.34	4.54	4.48	2.71	1.69	2.21
47.5	47.5	4.41	4.45	4.12	3.19	2.03	2.30	47.5	4.59	4.74	4.67	3.44	2.53	2.44
50.0	50.0	4.63	4.65	4.42	3.78	2.77	2.59	50.0	4.79	4.89	4.82	4.07	3.30	2.75
52.5	52.5	4.80	4.81	4.67	4.29	3.46	2.95	52.5	4.94	5.00	4.93	4.61	3.97	3.14
55.0	55.0	4.92	4.92	4.87	4.73	4.08	3.37	55.0	5.03	5.06	4.99	5.05	4.56	3.58
57.5	57.5	4.99	4.98	5.02	5.10	4.63	3.82	57.5	5.08	5.06	5.00	5.39	5.05	4.04
60.0	60.0	5.01	4.99	5.12	5.38	5.10	4.28	60.0	5.07	5.01	4.95	5.65	5.43	4.48
62.5	62.5	4.98	4.94	5.15	5.58	5.48	4.71	62.5	4.99	4.89	4.85	5.80	5.72	4.87
65.0	65.0	4.87	4.83	5.11	5.69	5.75	5.08	65.0	4.85	4.71	4.68	5.85	5.89	5.18
67.5	67.5	4.69	4.64	4.98	5.70	5.92	5.35	67.5	4.62	4.43	4.42	5.79	5.94	5.38
70.0	70.0	4.42	4.35	4.76	5.60	5.95	5.51	70.0	4.28	4.06	4.06	5.60	5.85	5.44
72.5	72.5	4.03	3.95	4.42	5.35	5.83	5.51	72.5	3.82	3.56	3.57	5.25	5.60	5.33
75.0	75.0	3.49	3.40	3.91	4.93	5.52	5.32	75.0	3.20	2.89	2.92	4.71	5.14	5.00
77.5	77.5	2.74	2.63	3.19	4.28	4.96	4.86	77.5	2.35	1.99	2.03	3.93	4.42	4.40
80.0	80.0	1.68	1.56	2.14	3.29	4.05	4.04	80.0	1.16	0.76	0.81	2.78	3.34	3.41
82.5	82.5	0.12	-0.02	0.59	1.78	2.60	2.65	82.5	-0.55	-1.00	-0.95	1.08	1.68	1.83
85.0	85.0	-2.39	-2.56	-1.93	-0.71	0.15	0.26	85.0	-3.25	-3.75	-3.71	-1.63	-1.00	-0.80
87.5	87.5	-7.31	-7.50	-6.86	-5.62	-4.74	-4.60	87.5	-8.41	-8.97	-8.92	-6.82	-6.17	-5.94
90.0	90.0	-89.83	-90.28	-90.13	-89.81	-89.93	-91.38	90.0	-89.74	-89.98	-90.33	-89.60	-89.80	-91.35

Table A-16. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Six Frequencies and Five Soil Conditions, for 5.4 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials (Concluded)

THETA	[Elevation Angle $\psi = 90^\circ - \theta$]									
	Very Dry Ground $\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$									
	5 MHz	10 MHz	15 MHz	20 MHz	25 MHz	30 MHz	30 MHz	30 MHz	30 MHz	30 MHz
0.0	-88.55	-90.69	-90.68	-89.97	-89.97	-89.86	-91.48			
2.5	-18.93	-17.96	-17.30	-25.36	-17.11	-17.56				
5.0	-12.92	-11.96	-11.32	-19.68	-11.28	-11.60				
7.5	-9.43	-8.48	-7.87	-16.74	-8.06	-8.19				
10.0	-6.96	-6.03	-5.47	-15.08	-5.99	-5.84				
12.5	-5.06	-4.17	-3.66	-14.26	-4.60	-4.09				
15.0	-3.53	-2.67	-2.23	-14.08	-3.68	-2.71				
17.5	-2.25	-1.43	-1.06	-14.39	-3.10	-1.61				
20.0	-1.17	-0.38	-0.09	-14.78	-2.79	-0.72				
22.5	-0.23	0.51	0.73	-14.44	-2.67	0.01				
25.0	0.60	1.28	1.42	-12.74	-2.66	0.60				
27.5	1.32	1.95	2.01	-10.21	-2.68	1.07				
30.0	1.95	2.53	2.52	-7.65	-2.61	1.42				
32.5	2.52	3.03	2.96	-5.34	-2.37	1.69				
35.0	3.02	3.47	3.35	-3.34	-1.90	1.88				
37.5	3.45	3.85	3.68	-1.62	-1.21	2.01				
40.0	3.84	4.17	3.98	-0.15	-0.38	2.11				
42.5	4.17	4.44	4.23	1.10	0.52	2.21				
45.0	4.45	4.66	4.44	2.18	1.42	2.35				
47.5	4.68	4.83	4.62	3.10	2.29	2.56				
50.0	4.86	4.95	4.76	3.88	3.08	2.84				
52.5	5.00	5.03	4.86	4.52	3.79	3.20				
55.0	5.08	5.05	4.93	5.05	4.41	3.61				
57.5	5.11	5.03	4.94	5.46	4.94	4.05				
60.0	5.08	4.95	4.91	5.76	5.36	4.48				
62.5	4.98	4.81	4.81	5.96	5.68	4.87				
65.0	4.81	4.59	4.65	6.04	5.88	5.17				
67.5	4.55	4.30	4.40	6.00	5.95	5.37				
70.0	4.19	3.90	4.05	5.82	5.89	5.44				
72.5	3.70	3.37	3.57	5.48	5.65	5.33				
75.0	3.04	2.69	2.92	4.95	5.21	5.01				
77.5	2.14	1.77	2.04	4.17	4.51	4.41				
80.0	0.91	0.52	0.82	3.03	3.43	3.42				
82.5	-0.85	-1.26	-0.94	1.33	1.78	1.84				
85.0	-3.61	-4.03	-3.69	-1.39	-0.89	-0.79				
87.5	-8.83	-9.26	-8.91	-6.58	-6.06	-5.93				
90.0	-88.55	-90.69	-90.68	-89.97	-89.86	-91.48				

SECTION A3

6.3 METER MONOPOLE CONFIGURATION RESULTS

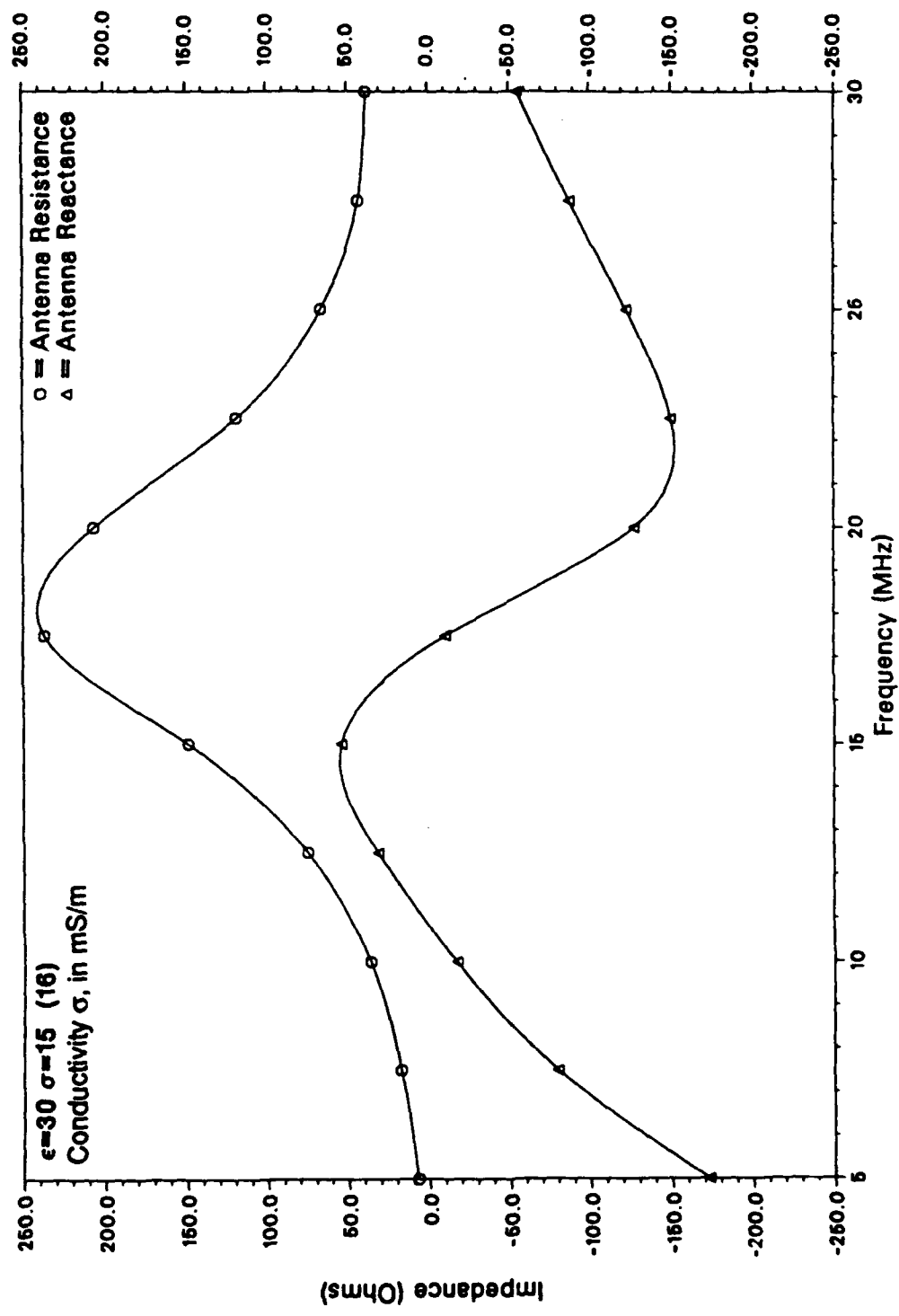


Figure A-60. Antenna Input Impedance (Resistance and Reactance) versus Frequency in Wet Ground for 6.3 Mc. *er* High Monopole with 12 Meter Radius Ground Screen of 16 Radials

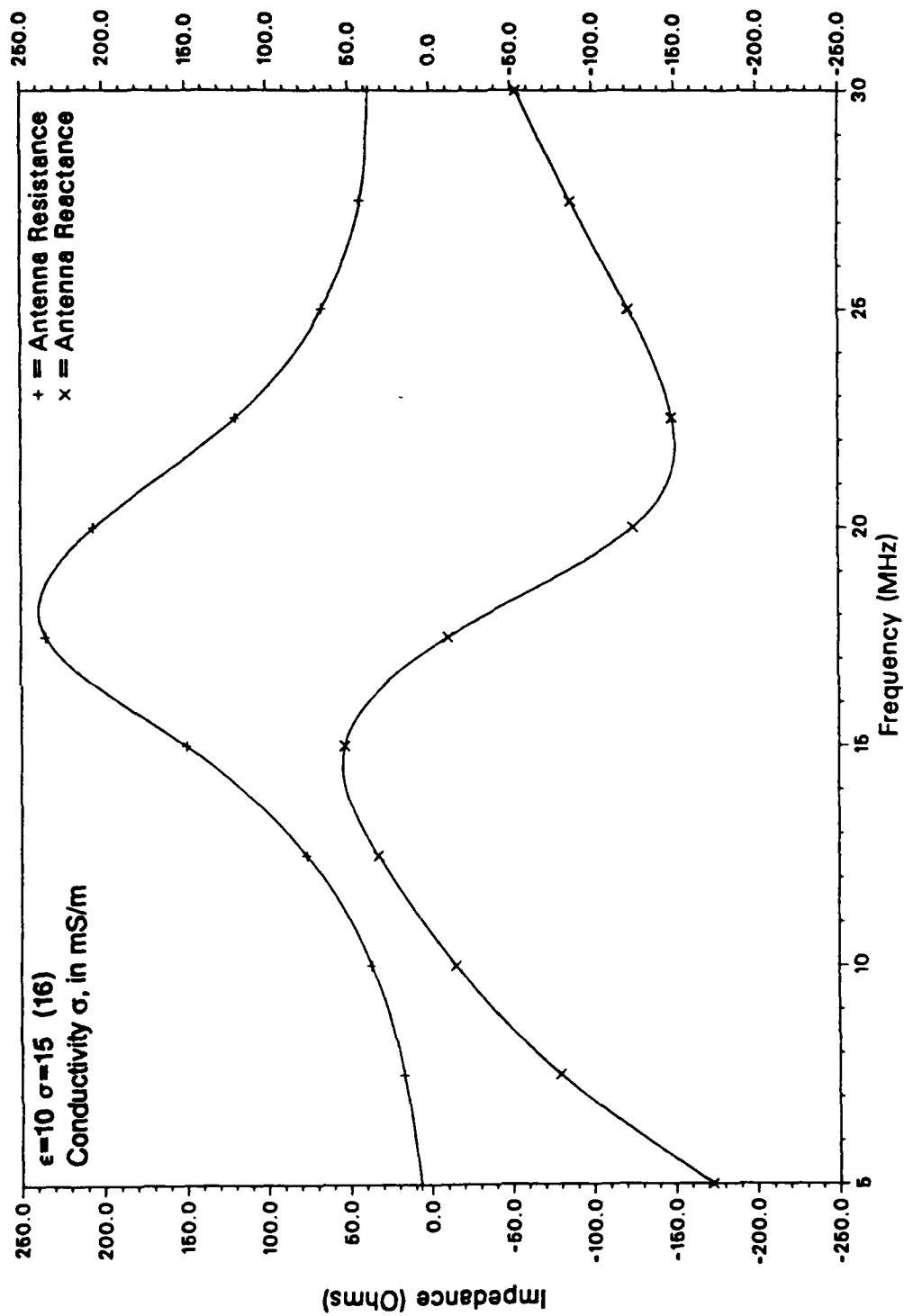


Figure A-61. Antenna Input Impedance (Resistance and Reactance) versus Frequency in Moist Clay for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

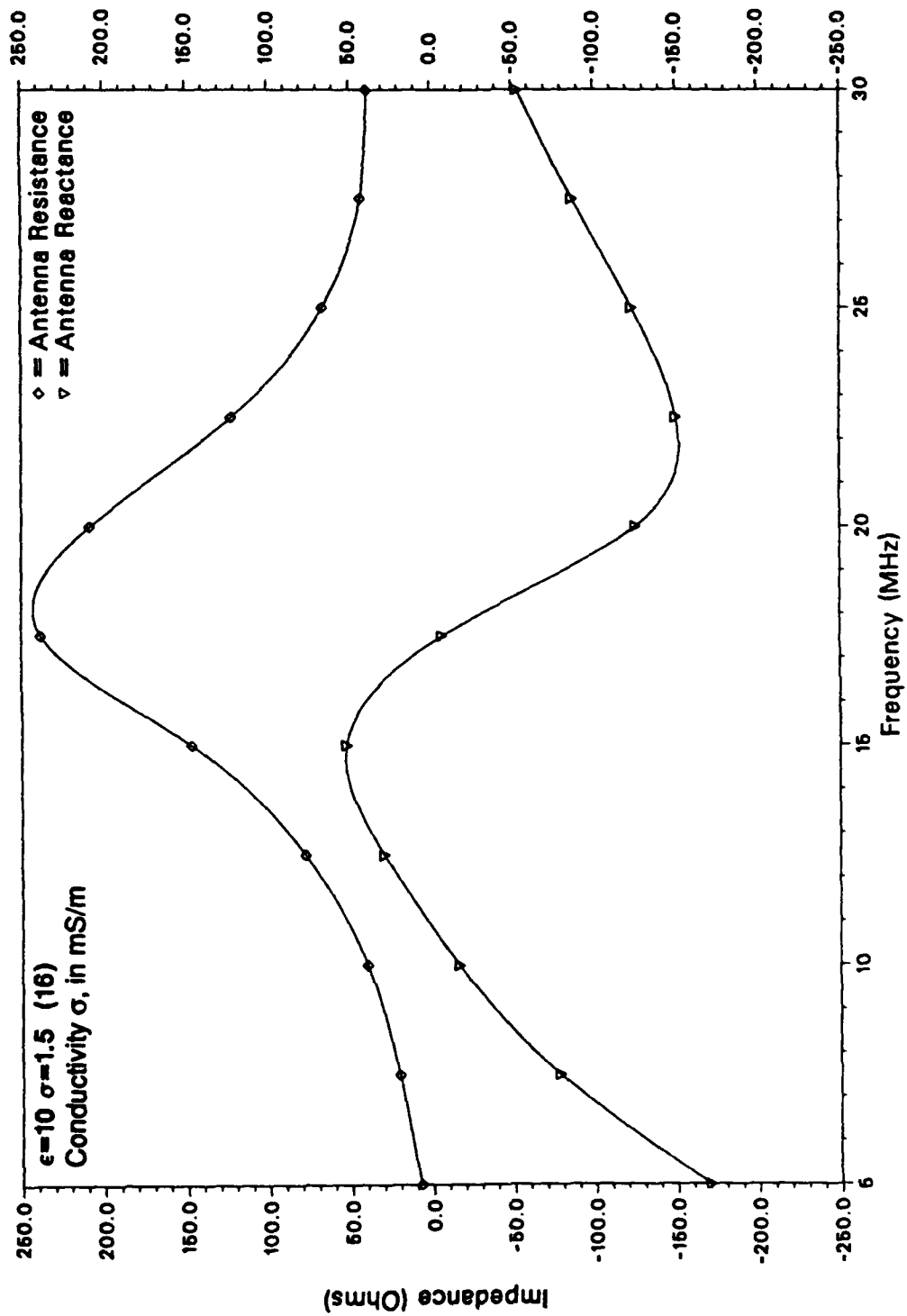


Figure A-62. Antenna Input Impedance (Resistance and Reactance) versus Frequency in Medium Dry Ground for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

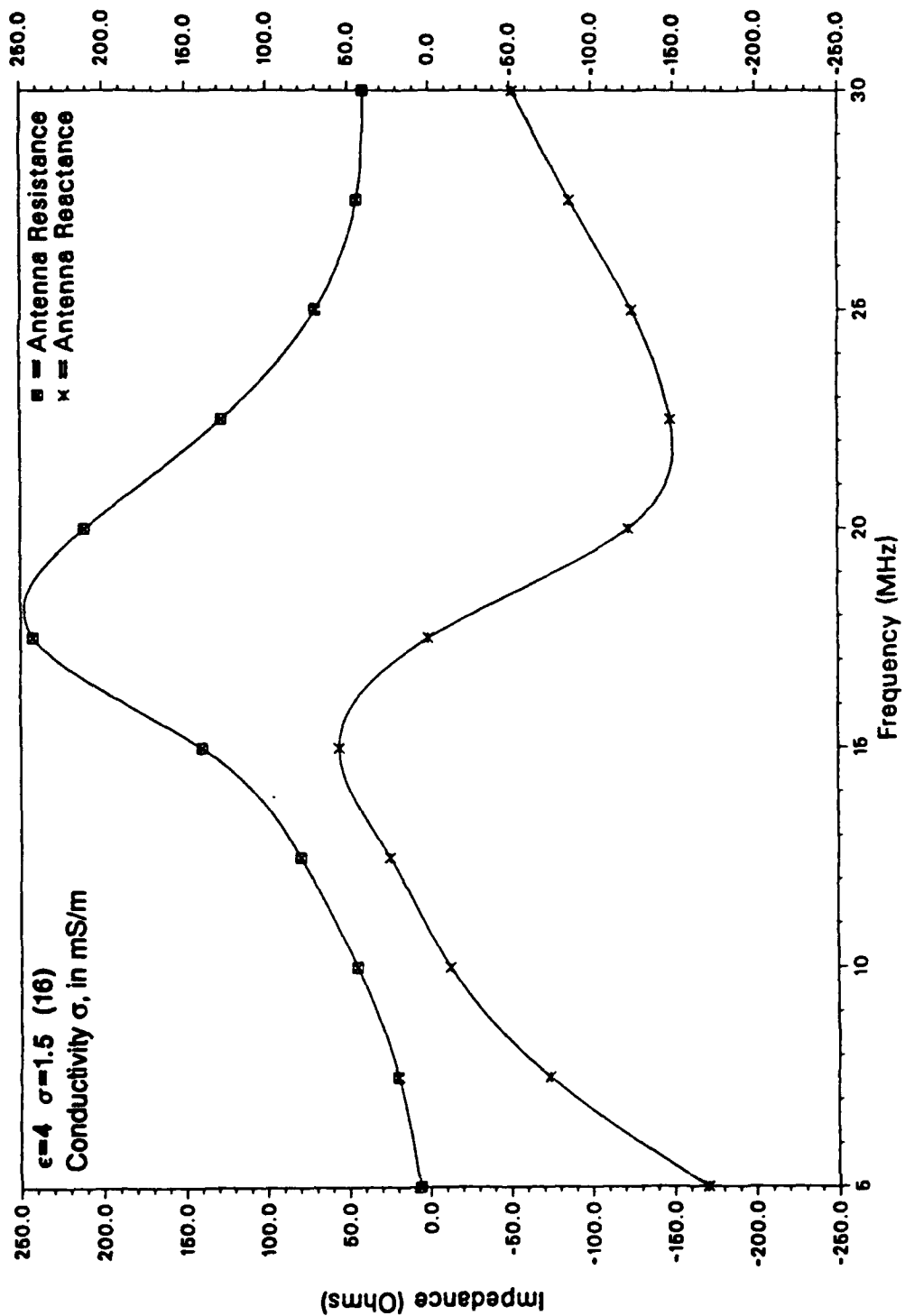


Figure A-63. Antenna Input Impedance (Resistance and Reactance) versus Frequency in Sand for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

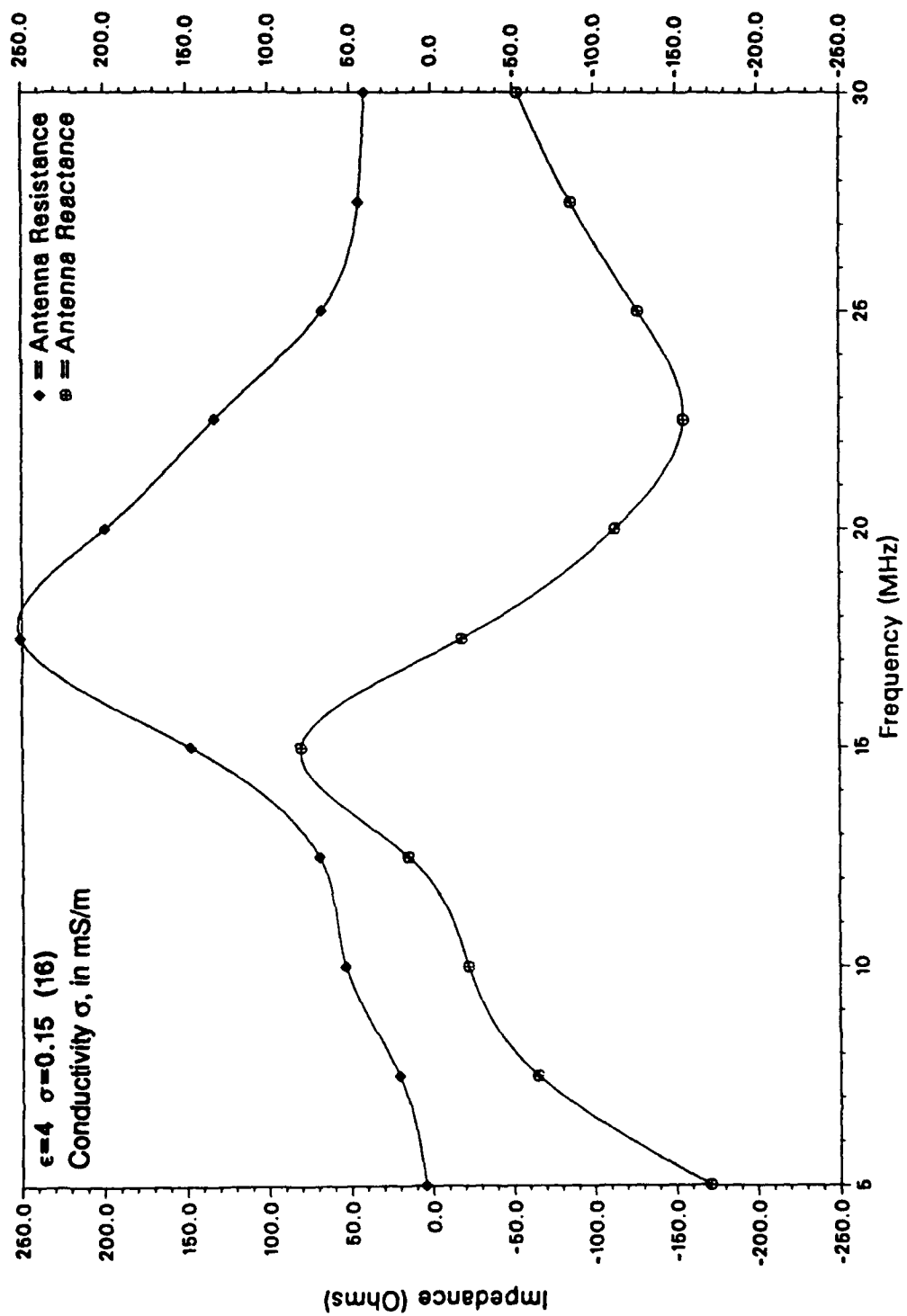


Figure A-64. Antenna Input Impedance (Resistance and Reactance) versus Frequency in Very Dry Ground for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

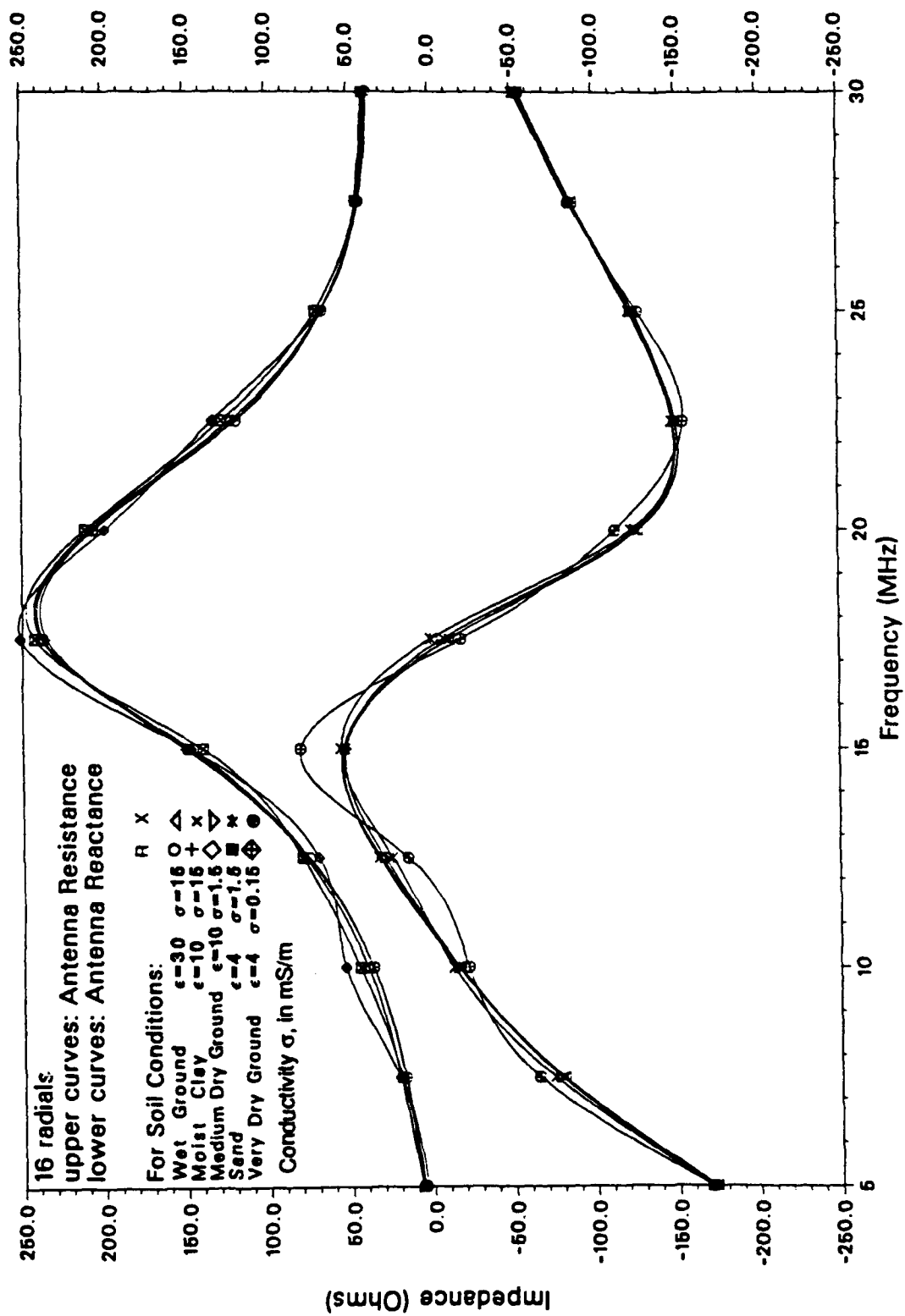


Figure A-65. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

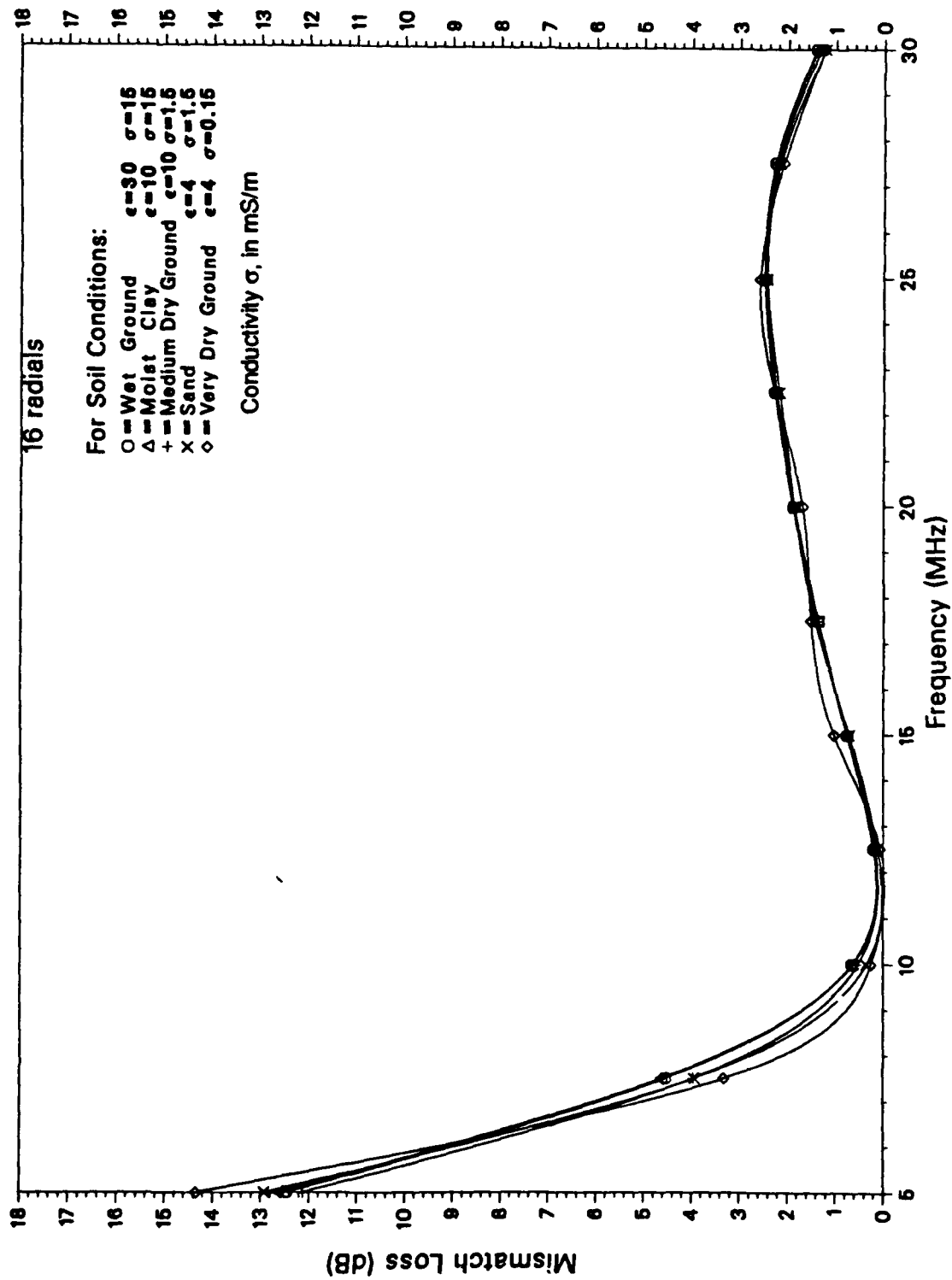


Figure A-66. Cable Mismatch Loss versus Frequency and Five Soil Conditions for 75 ohm Coaxial Cable Feeding 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

Table A-17. Antenna Input Resistance (ohms), Reactance (ohms), Magnitude Squared of Reflection Coefficient ($|\Gamma|^2$), and Mismatch Loss (dB) versus Frequency for Five Soil Conditions for 6.3 Meter High Monopole and 12 Meter Radius Ground Screen of 16 Radials and a 75 ohm Feed Cable
(Supports Vol. 1, Table 12)

Freq	R	X	$ \Gamma ^2$	MML (dB)	
5.0	6.92	-172.89	9.43279E-01	12.46	Wet Ground $\epsilon_r = 30, \sigma = 15 \text{ mS/m}$
7.5	17.53	-79.74	6.47576E-01	4.53	
10.0	36.65	-16.76	1.37452E-01	0.64	
12.5	75.25	31.55	4.22240E-02	0.19	
15.0	149.16	54.33	1.58850E-01	0.75	
17.5	237.06	-10.45	2.70509E-01	1.37	
20.0	206.71	-127.21	3.50947E-01	1.88	
22.5	118.69	-150.02	4.06758E-01	2.27	
25.0	65.97	-122.78	4.33678E-01	2.47	
27.5	42.88	-87.91	4.05114E-01	2.26	
30.0	38.10	-55.10	2.77810E-01	1.41	
5.0	6.63	-172.69	9.45454E-01	12.63	Moist Clay $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$
7.5	17.05	-79.41	6.53930E-01	4.61	
10.0	36.61	-15.39	1.34749E-01	0.63	
12.5	76.56	32.69	4.45537E-02	0.20	
15.0	150.32	53.25	1.58732E-01	0.75	
17.5	234.92	-10.82	2.67152E-01	1.35	
20.0	206.01	-124.88	3.46426E-01	1.85	
22.5	119.46	-148.51	4.01414E-01	2.23	
25.0	66.36	-122.15	4.29614E-01	2.44	
27.5	42.49	-87.04	4.03754E-01	2.25	
30.0	37.59	-53.31	2.73339E-01	1.39	
5.0	7.32	-170.16	9.38583E-01	12.12	Medium Dry Ground $\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$
7.5	20.47	-78.25	5.96928E-01	3.95	
10.0	39.84	-16.60	1.12305E-01	0.52	
12.5	77.74	29.43	3.61164E-02	0.16	
15.0	146.94	52.57	1.52604E-01	0.72	
17.5	238.04	-6.57	2.71588E-01	1.38	
20.0	208.52	-125.39	3.49090E-01	1.86	
22.5	122.11	-150.37	4.03981E-01	2.25	
25.0	66.69	-123.39	4.33273E-01	2.47	
27.5	43.22	-87.13	3.98831E-01	2.21	
30.0	39.07	-53.49	2.61620E-01	1.32	
5.0	6.06	-170.45	9.48993E-01	12.92	Sandy Soil $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$
7.5	19.42	-74.15	5.95821E-01	3.93	
10.0	44.60	-12.81	7.52202E-02	0.34	
12.5	79.59	24.55	2.54591E-02	0.11	
15.0	139.99	55.74	1.48610E-01	0.70	
17.5	242.38	0.61	2.78125E-01	1.42	
20.0	211.20	-122.75	3.46656E-01	1.85	
22.5	127.47	-148.26	3.92769E-01	2.17	
25.0	69.91	-124.82	4.26671E-01	2.42	
27.5	44.07	-87.06	3.92344E-01	2.16	
30.0	40.17	-52.06	2.45597E-01	1.22	
5.0	4.36	-171.01	9.63191E-01	14.34	Very Dry Ground $\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$
7.5	20.82	-64.70	5.32818E-01	3.31	
10.0	53.49	-21.92	5.55211E-02	0.25	
12.5	69.53	15.05	1.21466E-02	0.05	
15.0	147.79	80.64	2.10215E-01	1.02	
17.5	250.99	-18.09	2.93623E-01	1.51	
20.0	199.32	-112.90	3.20483E-01	1.68	
22.5	132.91	-155.00	4.07110E-01	2.27	
25.0	67.02	-127.27	4.47141E-01	2.57	
27.5	44.67	-85.92	3.82508E-01	2.09	
30.0	40.71	-53.19	2.46922E-01	1.23	

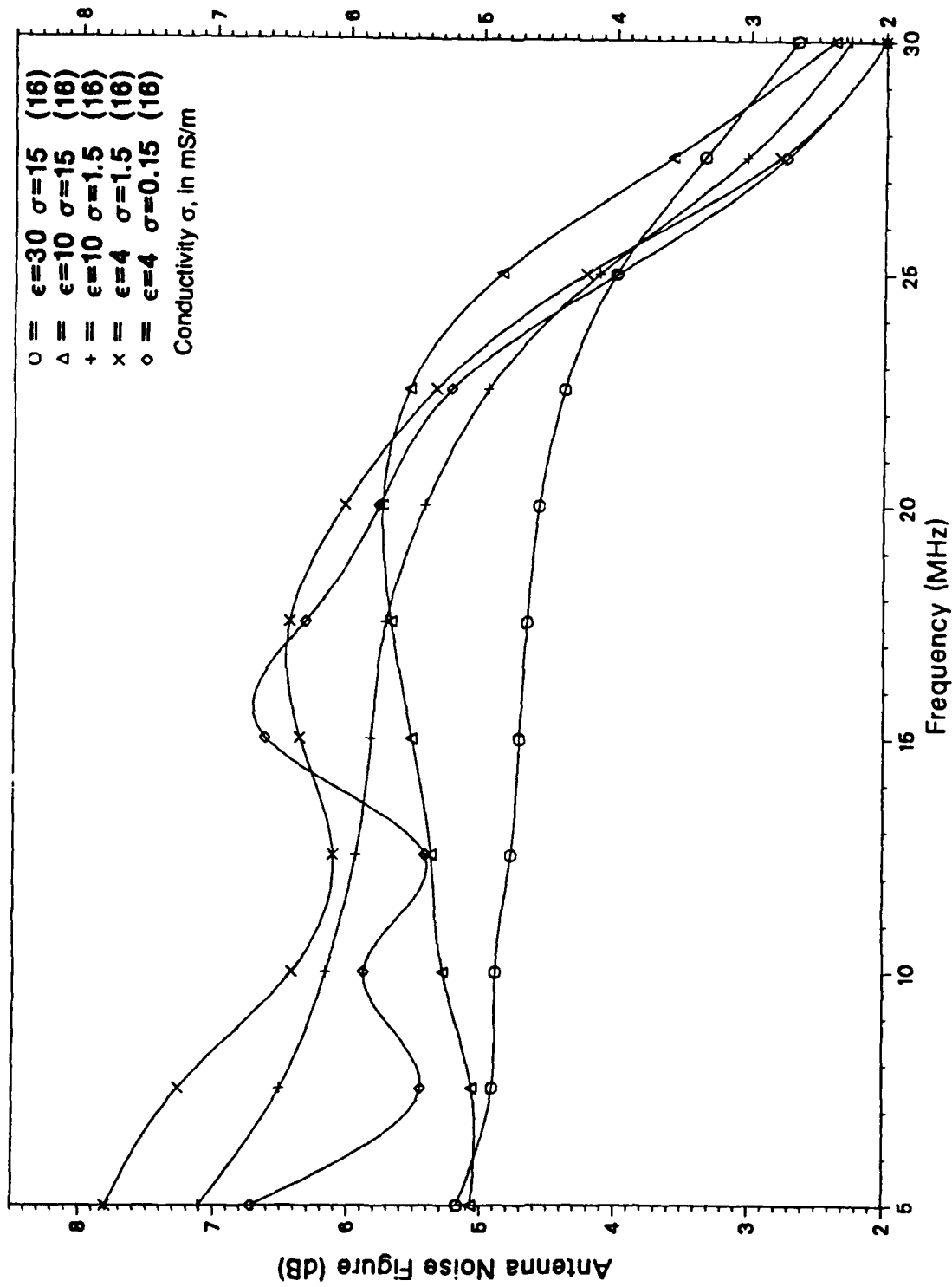


Figure A-67. Antenna Noise (Ohmic Loss) versus Frequency and Five Soil Conditions for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 32 Radials

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Table A-18. 6.3 Meter High Monopole Antenna: Efficiency and Noise Figure versus Frequency for Five Soil Conditions for 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178 Deep

(Supports Vol. 1, Table 12)

Frequency (MHz)	Soil Characteristics									
	Very Good (Wet Ground)		Good (Moist Clay)		Average (Medium Dry Ground)		Fair (Sand)		Poor (Very Dry Ground)	
	$\epsilon_r = 30, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$		$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$	
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)
5.0	9.7	5.2	10.0	5.1	6.2	7.1	5.3	7.8	6.8	6.7
7.5	10.3	4.9	10.0	5.1	7.1	6.5	6.0	7.3	9.1	5.4
10.0	10.4	4.9	9.5	5.3	7.7	6.2	7.3	6.4	8.3	5.9
12.5	10.7	4.8	9.3	5.4	8.1	5.9	7.8	6.1	9.2	5.4
15.0	10.8	4.7	9.0	5.5	8.4	5.8	7.4	6.4	7.0	6.6
17.5	10.9	4.7	8.6	5.7	8.6	5.7	7.3	6.4	7.5	6.3
20.0	11.2	4.6	8.5	5.8	9.2	5.4	8.0	6.0	8.5	5.8
22.5	11.7	4.4	8.9	5.5	10.2	5.0	9.3	5.3	9.6	5.2
25.0	12.7	4.0	10.5	4.9	12.4	4.1	12.1	4.2	12.8	4.0
27.5	14.8	3.3	14.0	3.6	15.9	3.0	16.8	2.8	17.0	2.7
30.0	17.4	2.7	18.5	2.4	19.0	2.3	20.8	2.0	21.0	2.0

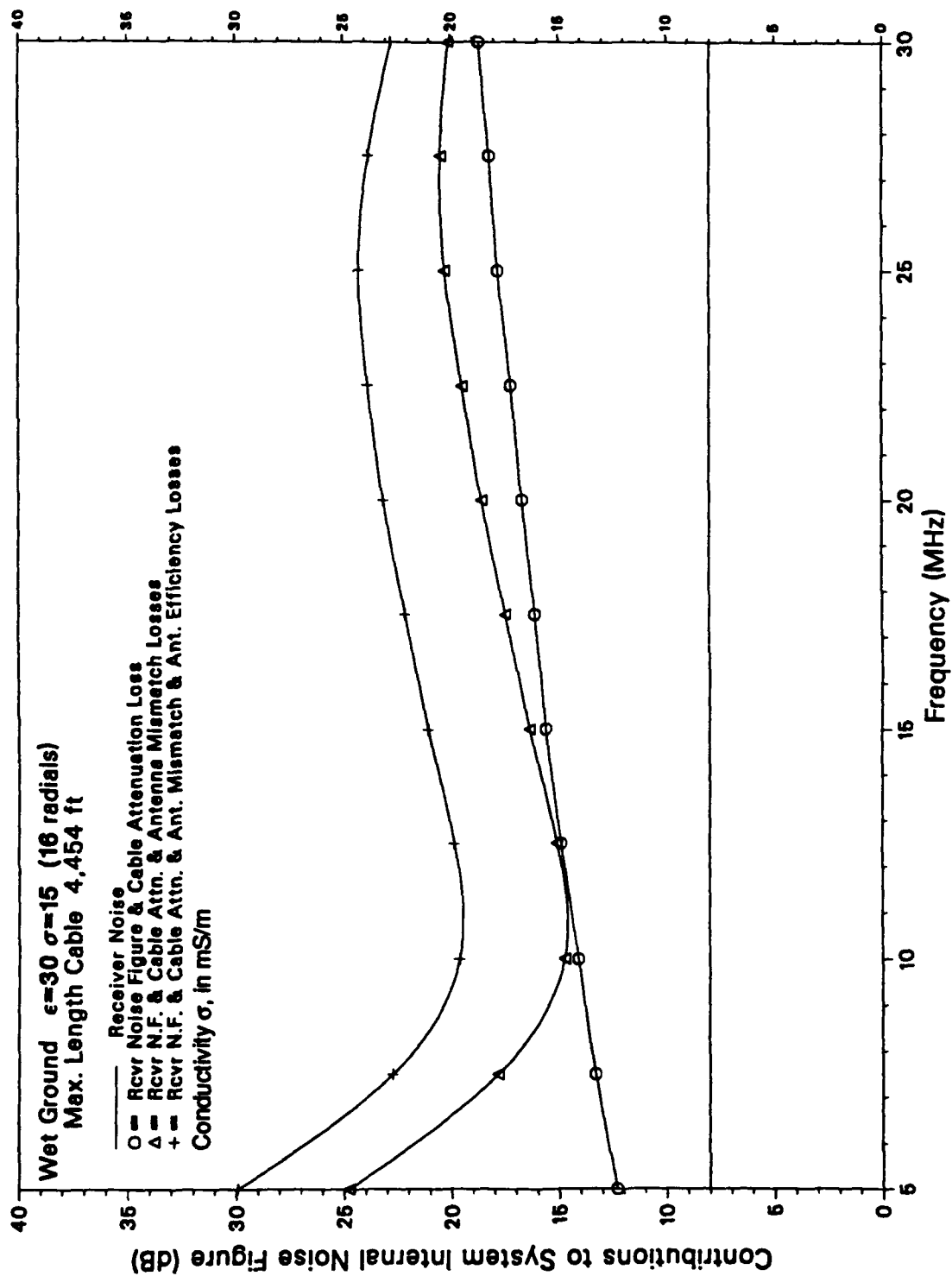


Figure A-68. System Internal Noise Figure Cumulative Contributions for Case of Wet Ground and Maximum Length Cable for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

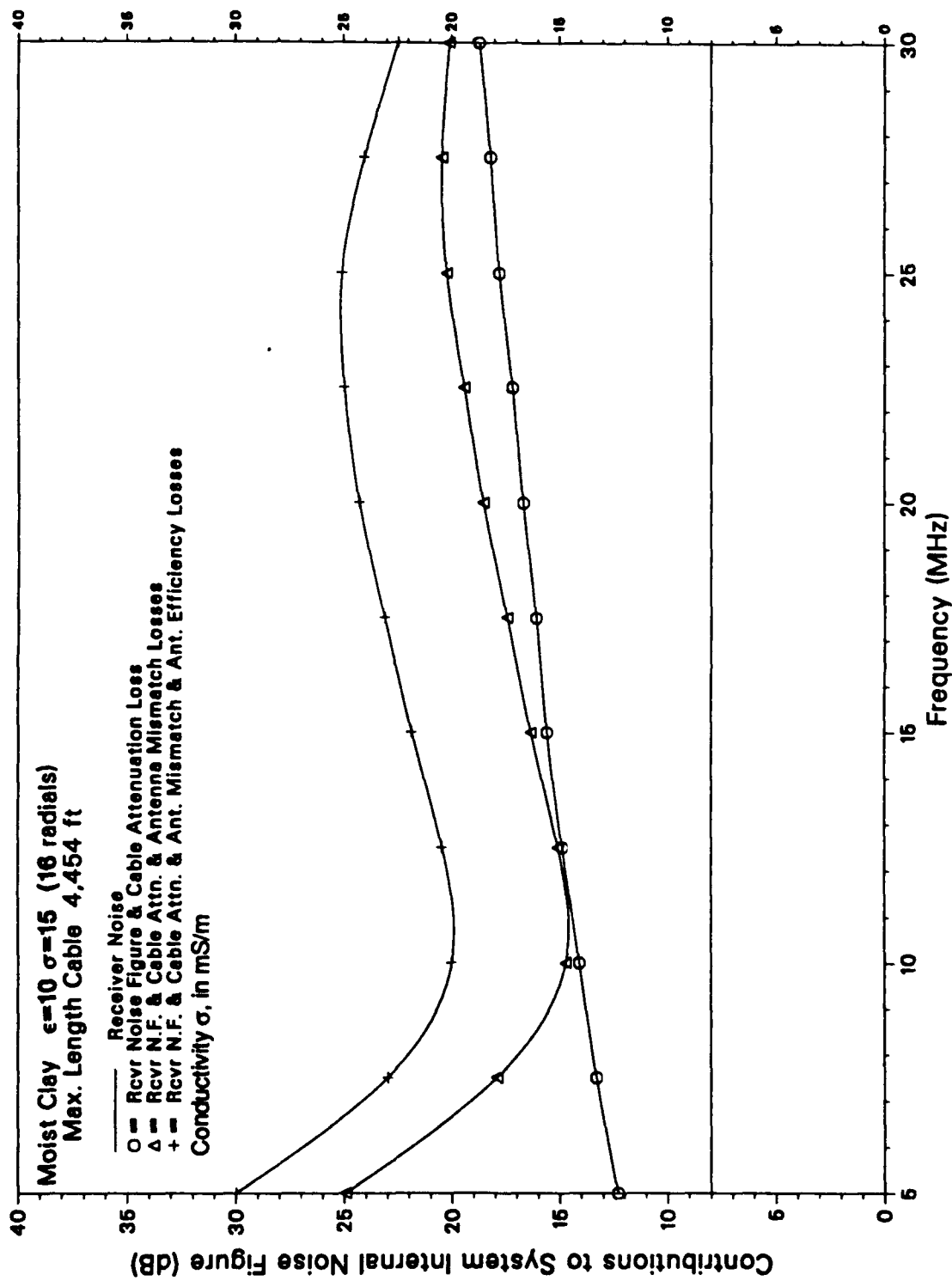


Figure A-69. System Internal Noise Figure Cumulative Contributions for Case of Moist Clay and Maximum Length Cable for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

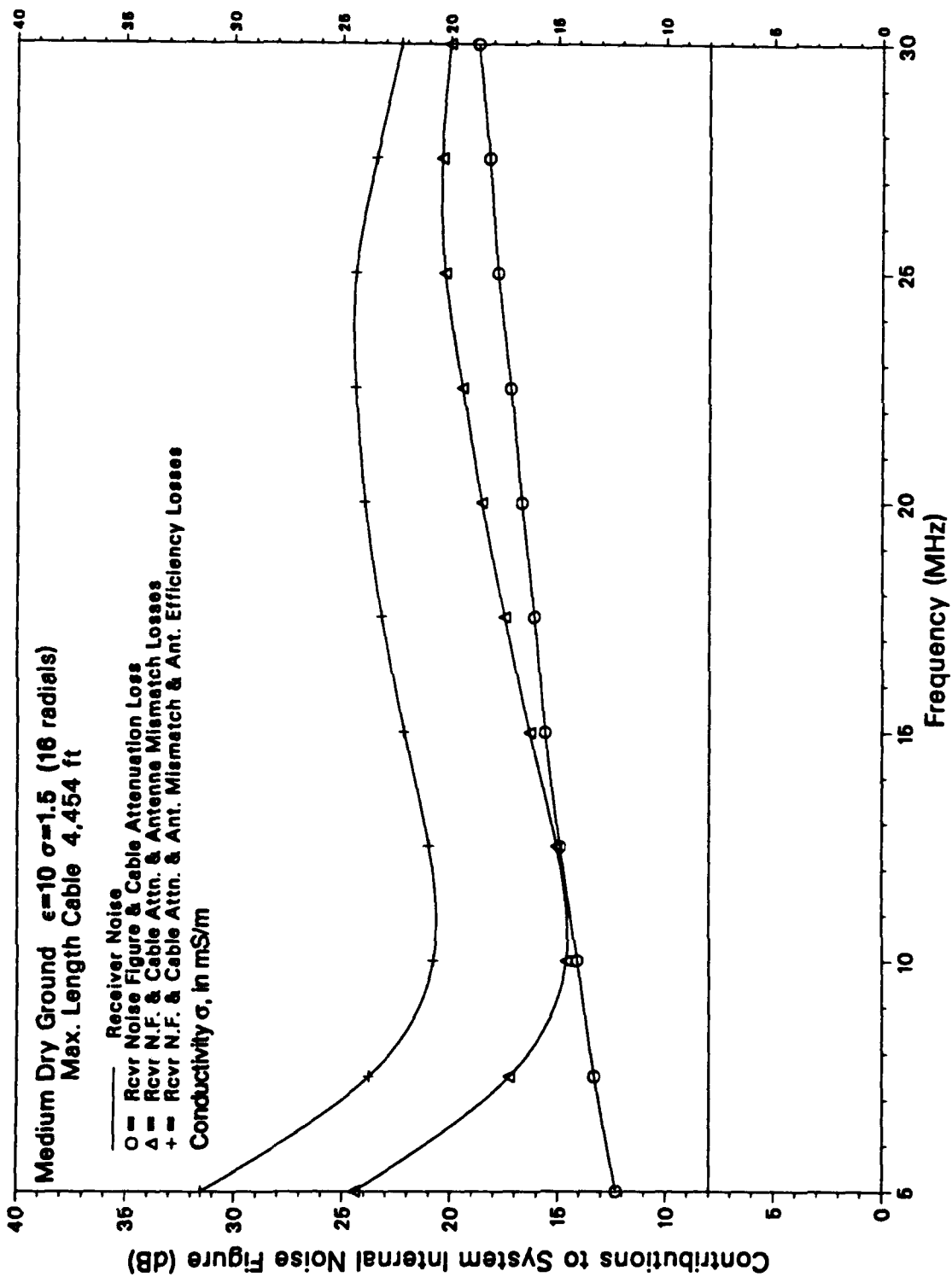


Figure A-70. System Internal Noise Figure Cumulative Contributions for Case of Medium Dry Ground and Maximum Length Cable for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

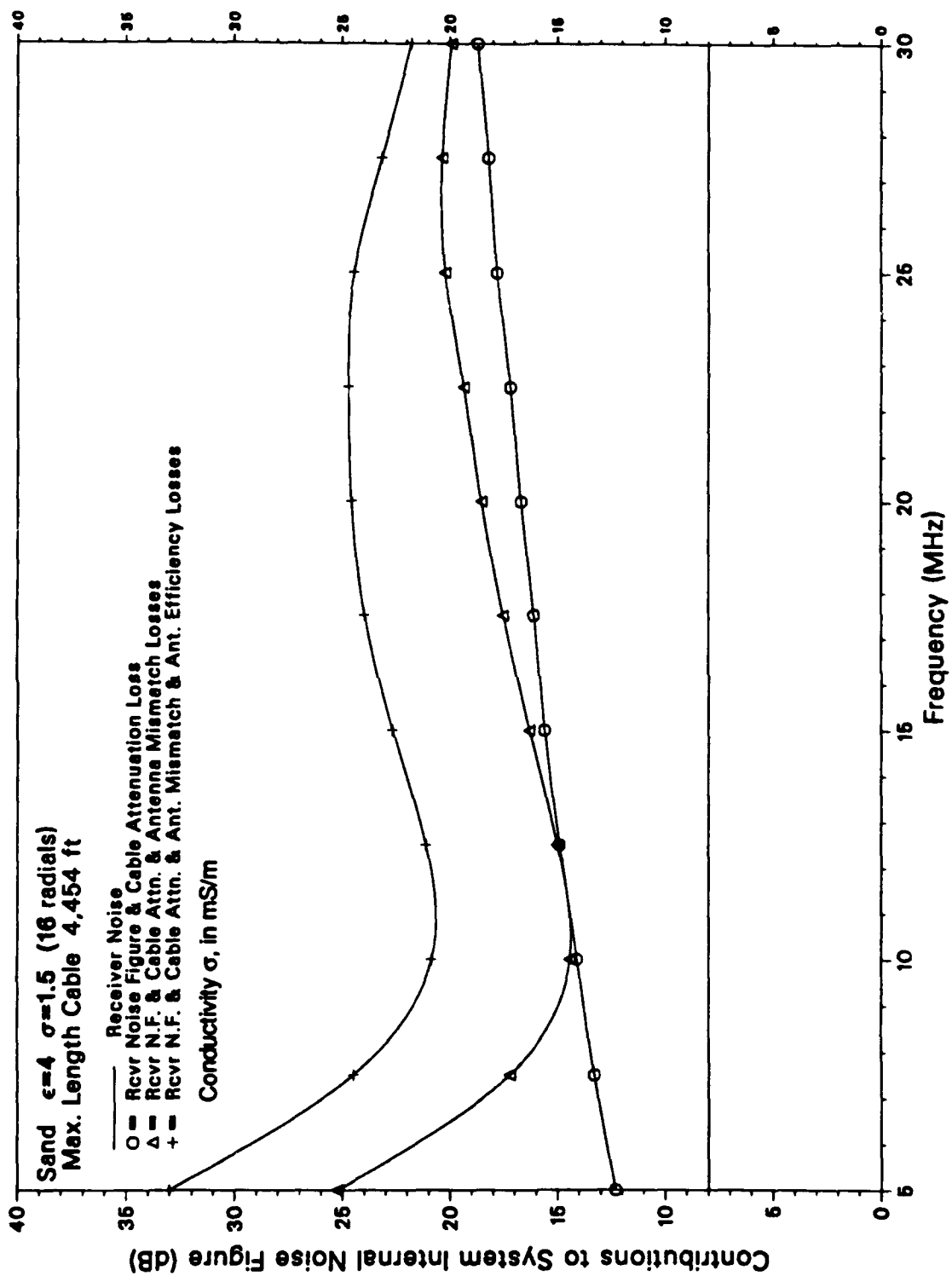


Figure A-71. System Internal Noise Figure Cumulative Contributions for Case of Sandy Soil and Maximum Length Cable for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

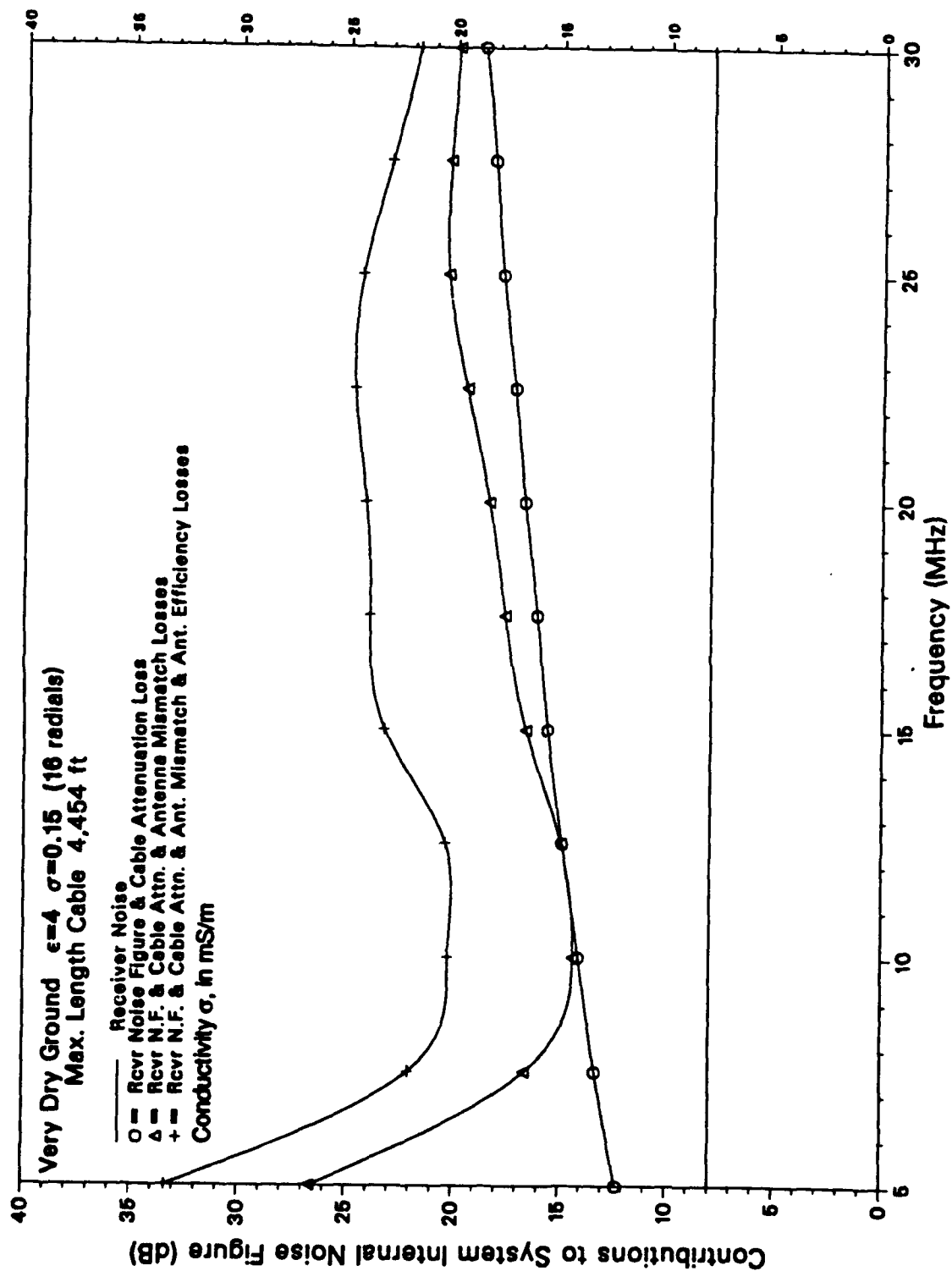


Figure A-72. System Internal Noise Figure Cumulative Contributions for Case of Very Dry Ground and Maximum Length Cable for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

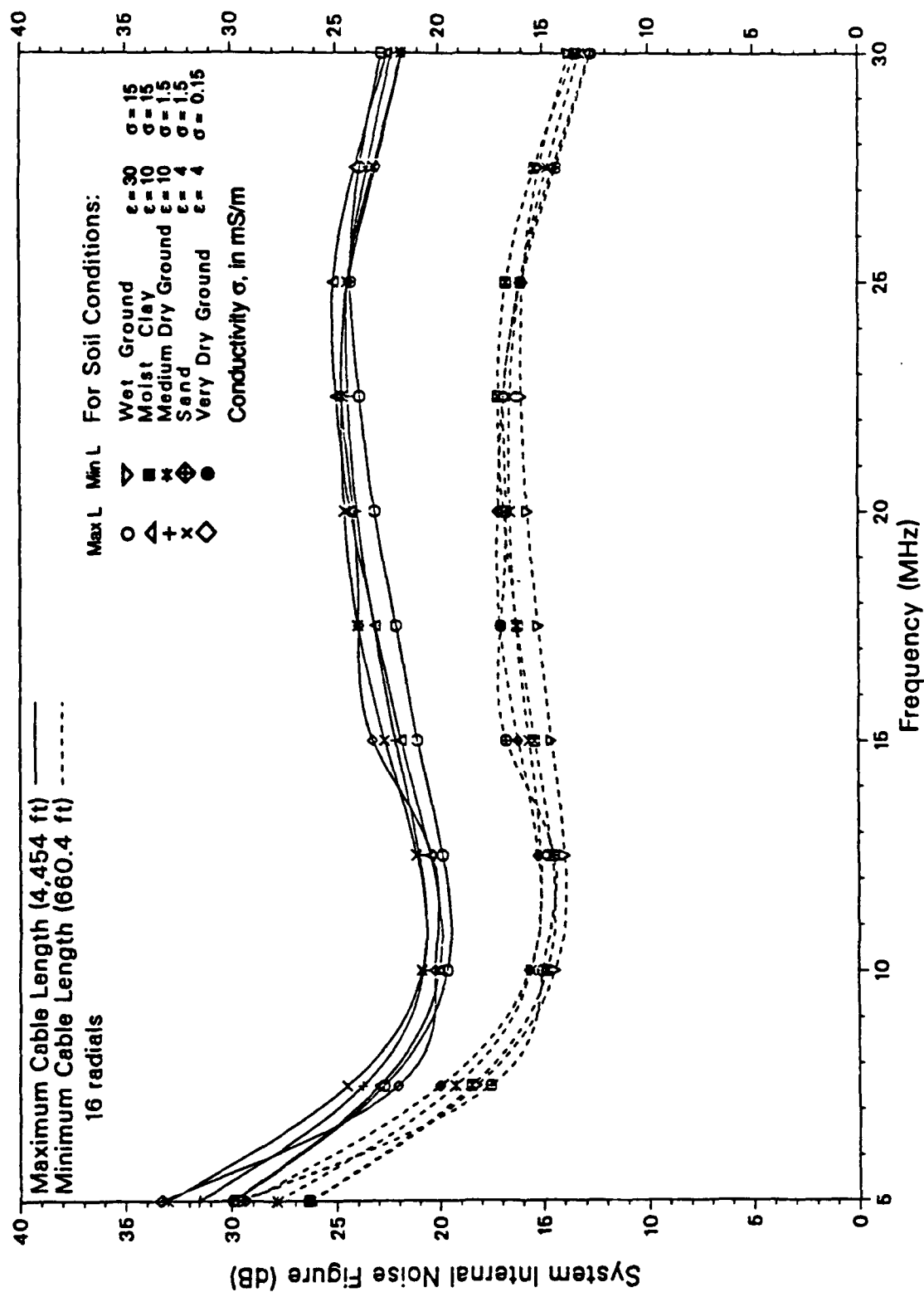


Figure A-73. System Internal Noise Figures versus Frequency, Soil Condition, and Maximum and Minimum Cable Lengths for 6.3 Meter High Monopole Antenna with 12 Meter Radius Ground Screen of 16 Radial Wires

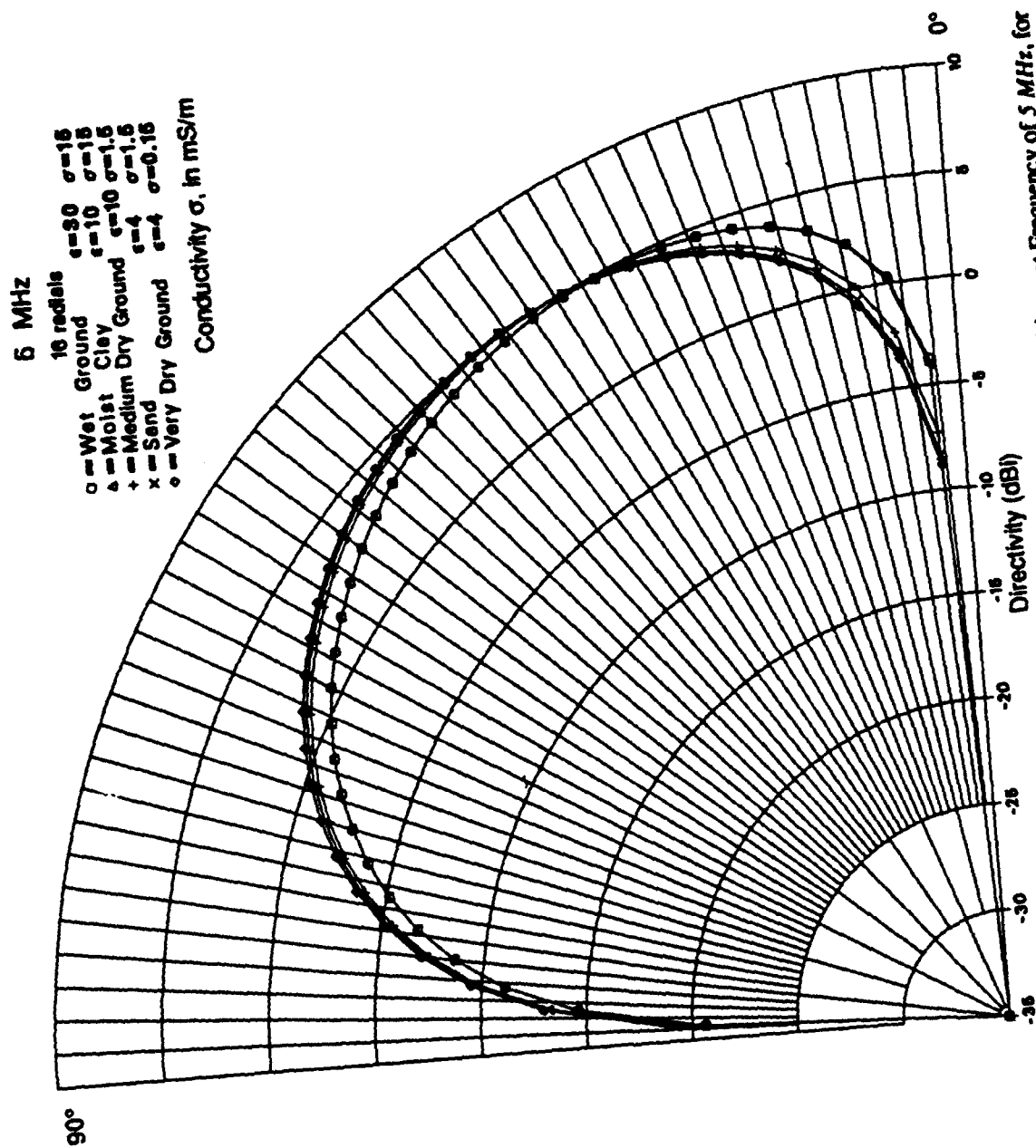


Figure A-74. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 5 MHz, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

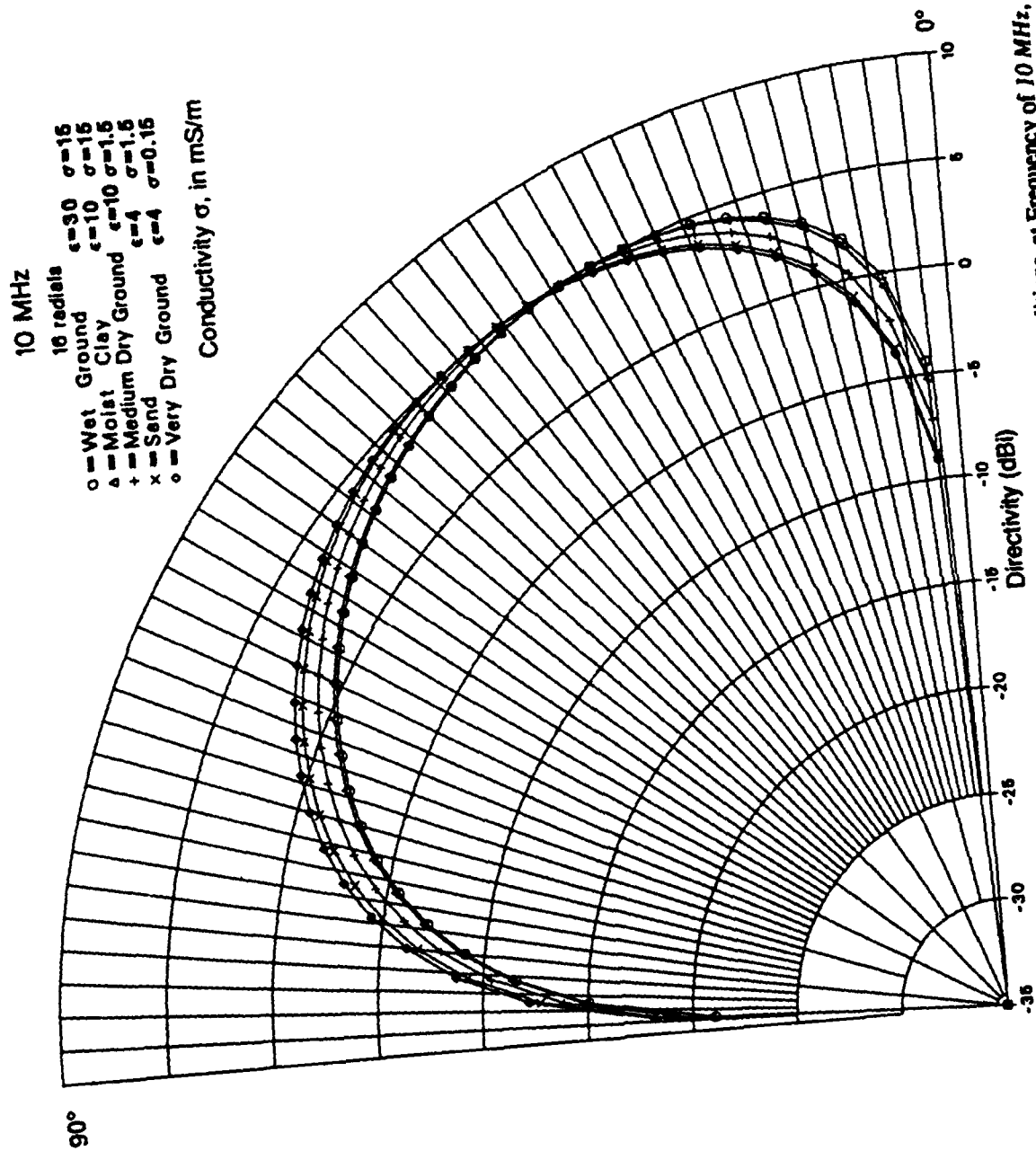


Figure A-75. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 10 MHz, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

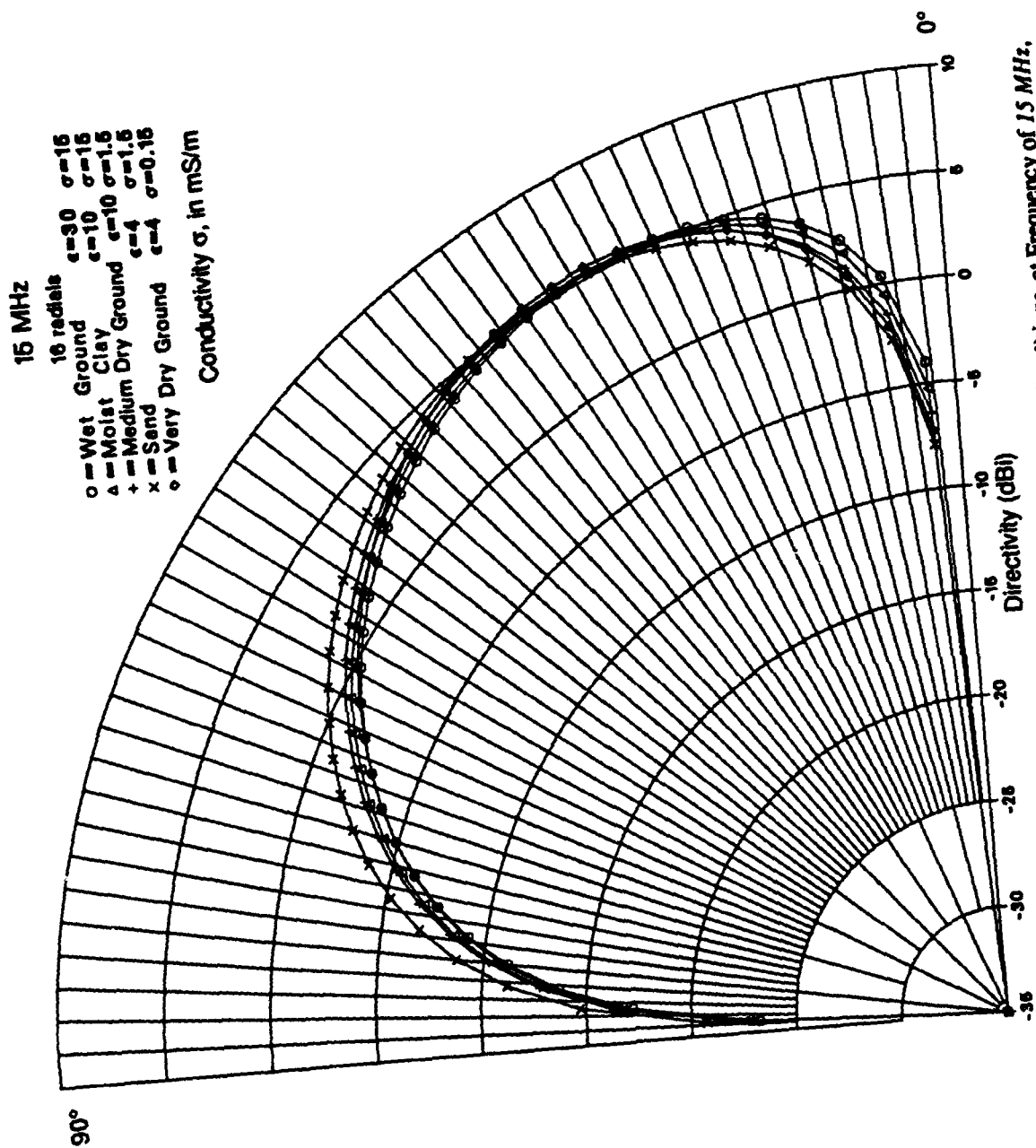


Figure A-76. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 15 MHz, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

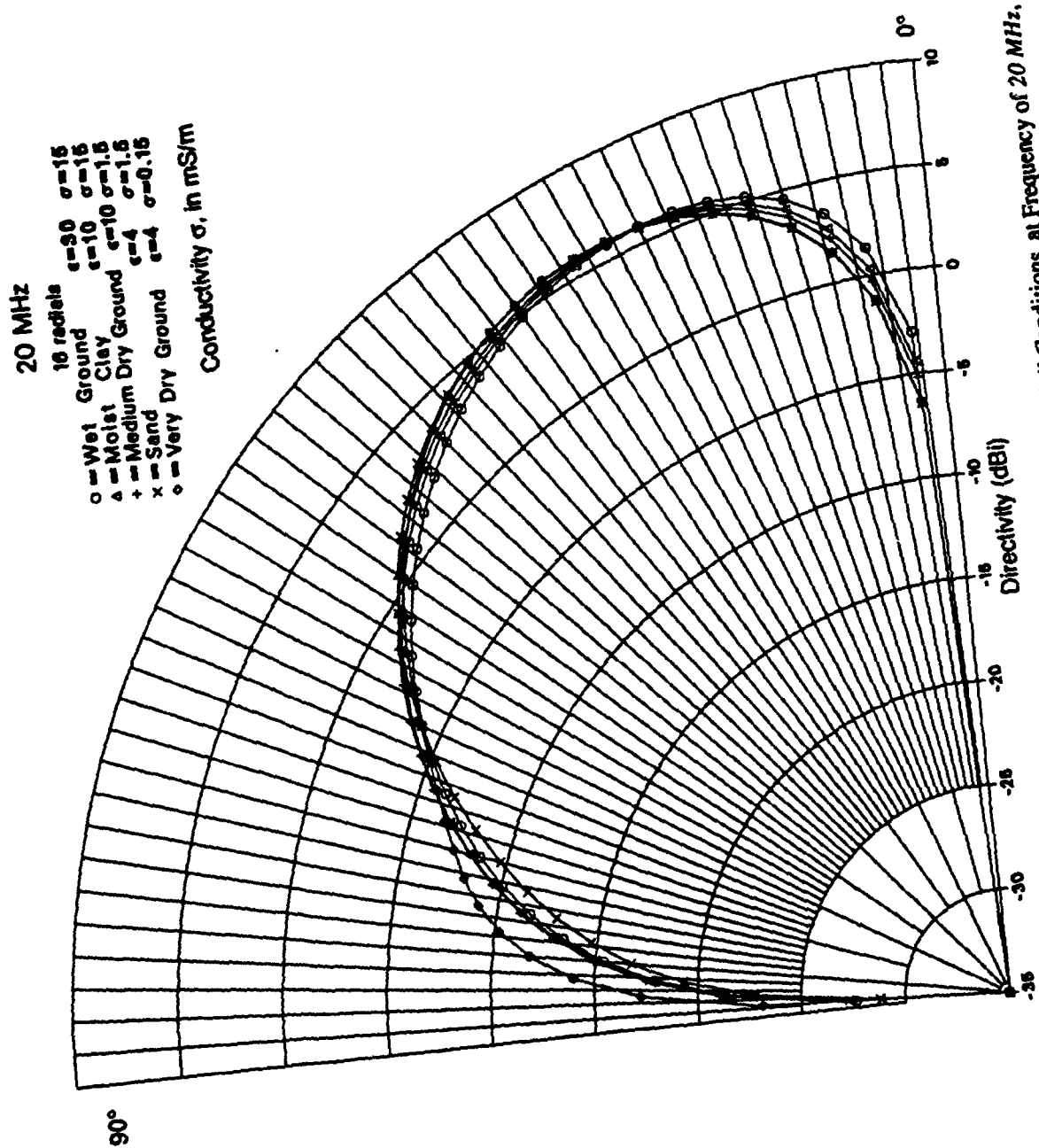


Figure A-77. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 20 MHz, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

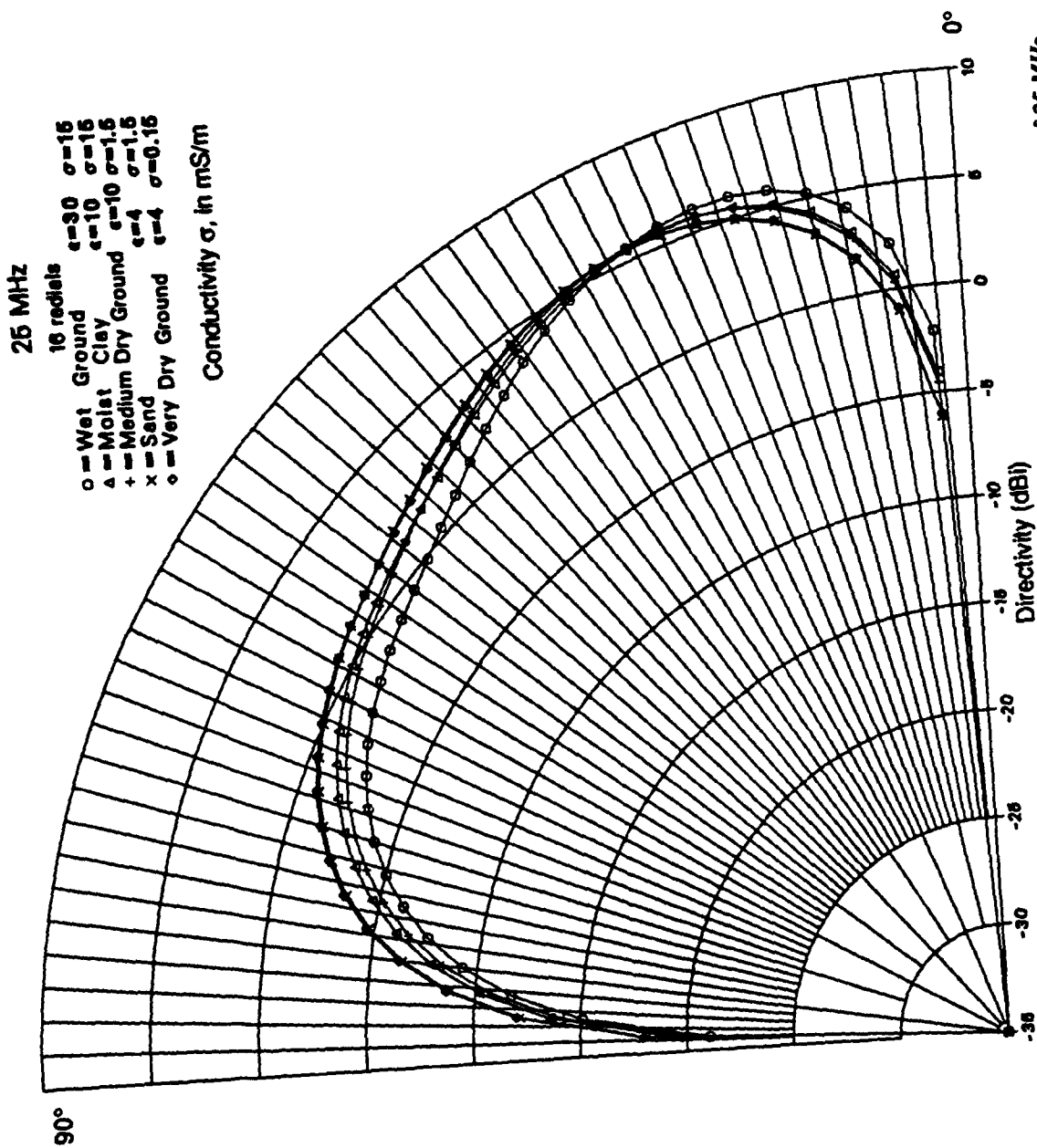


Figure A-78. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 25 MHz, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

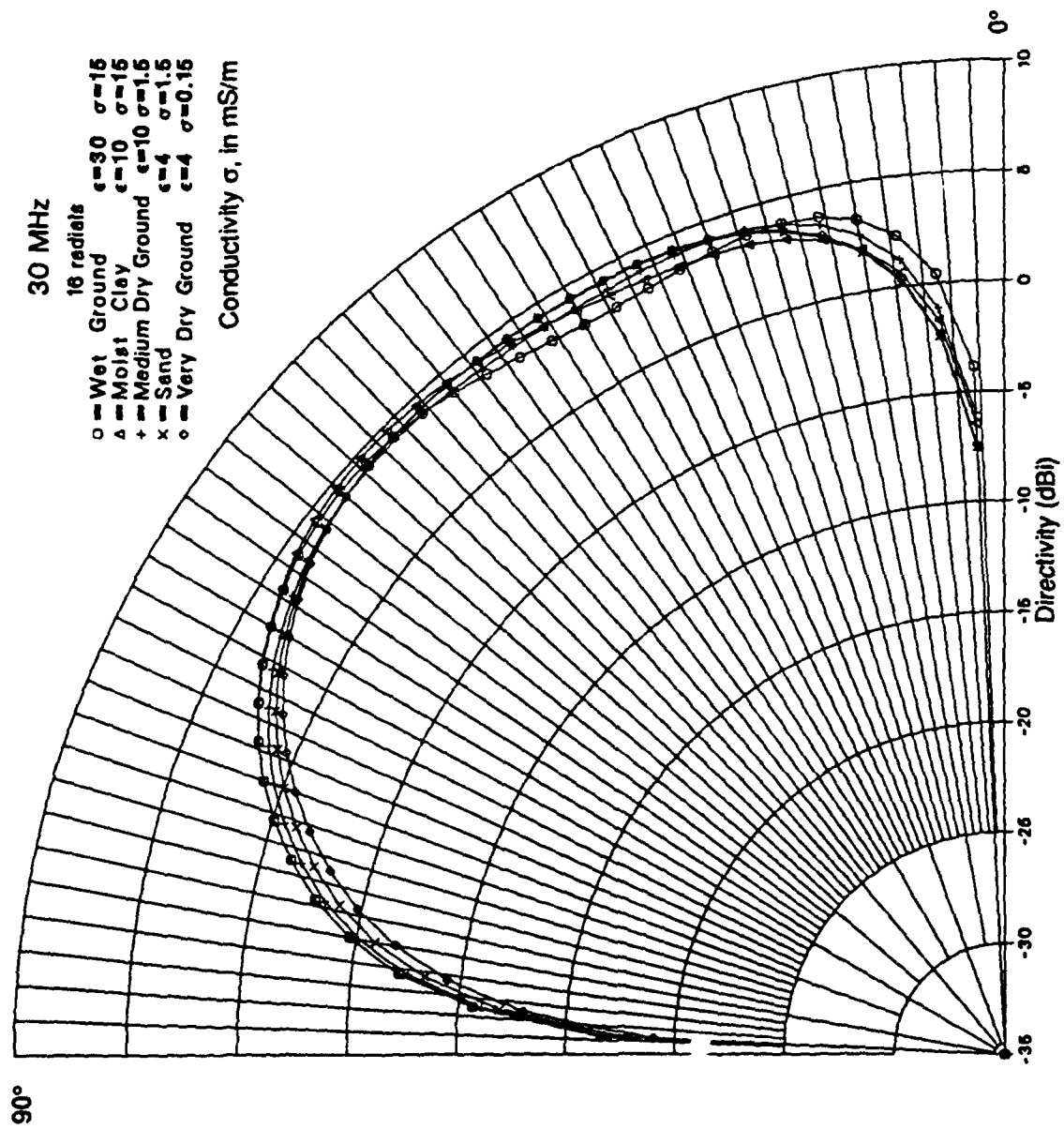


Figure A-79. Antenna Directivity versus Elevation Angle and Five Soil Conditions, at Frequency of 30 MHz, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

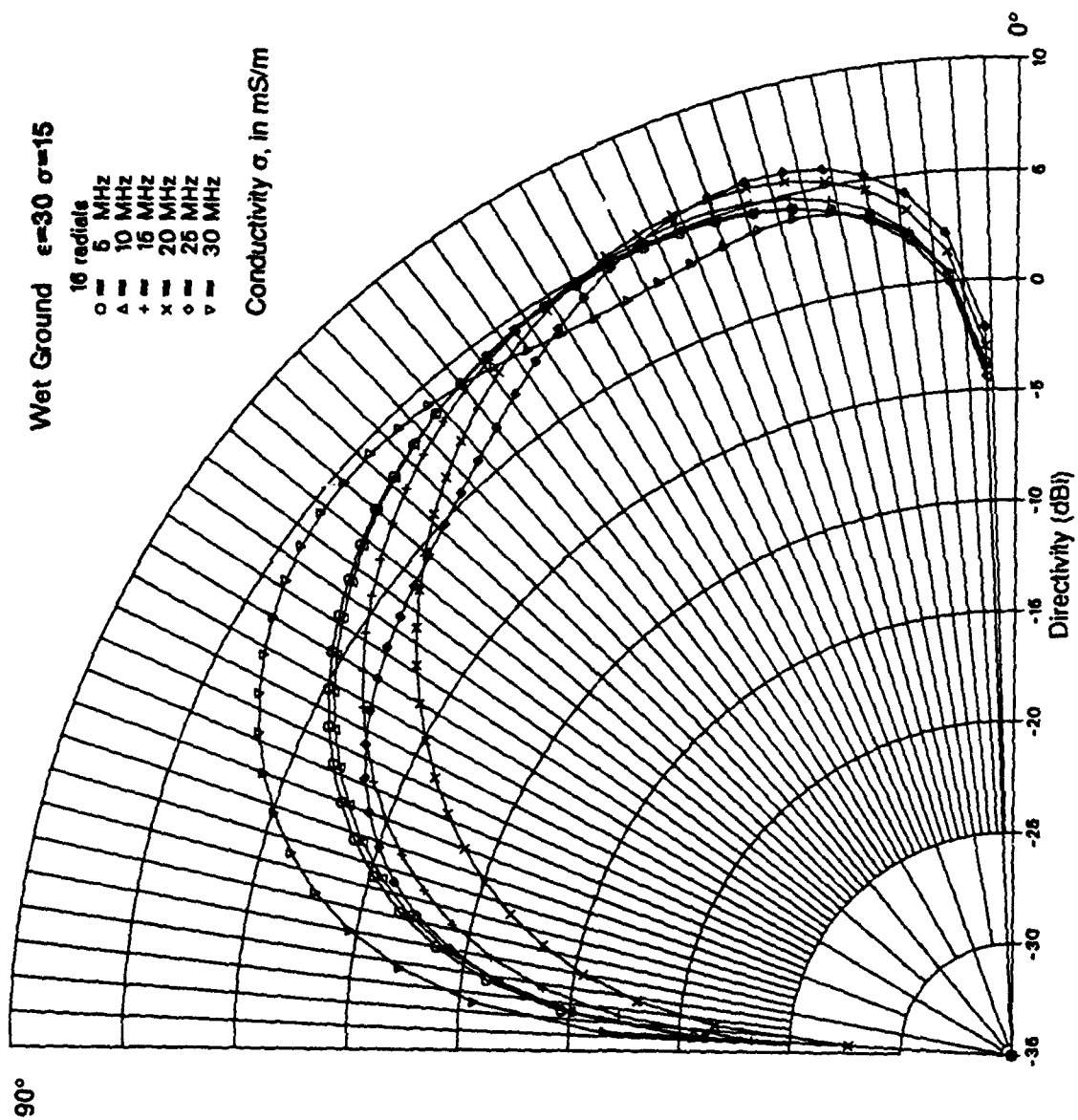


Figure A-80. Antenna Directivity versus Elevation Angle and Frequency, for 6.3 Meter High Monopole Antenna with 12 Meter Radius Ground Screen of 16 Radials, for a Wet Ground Condition

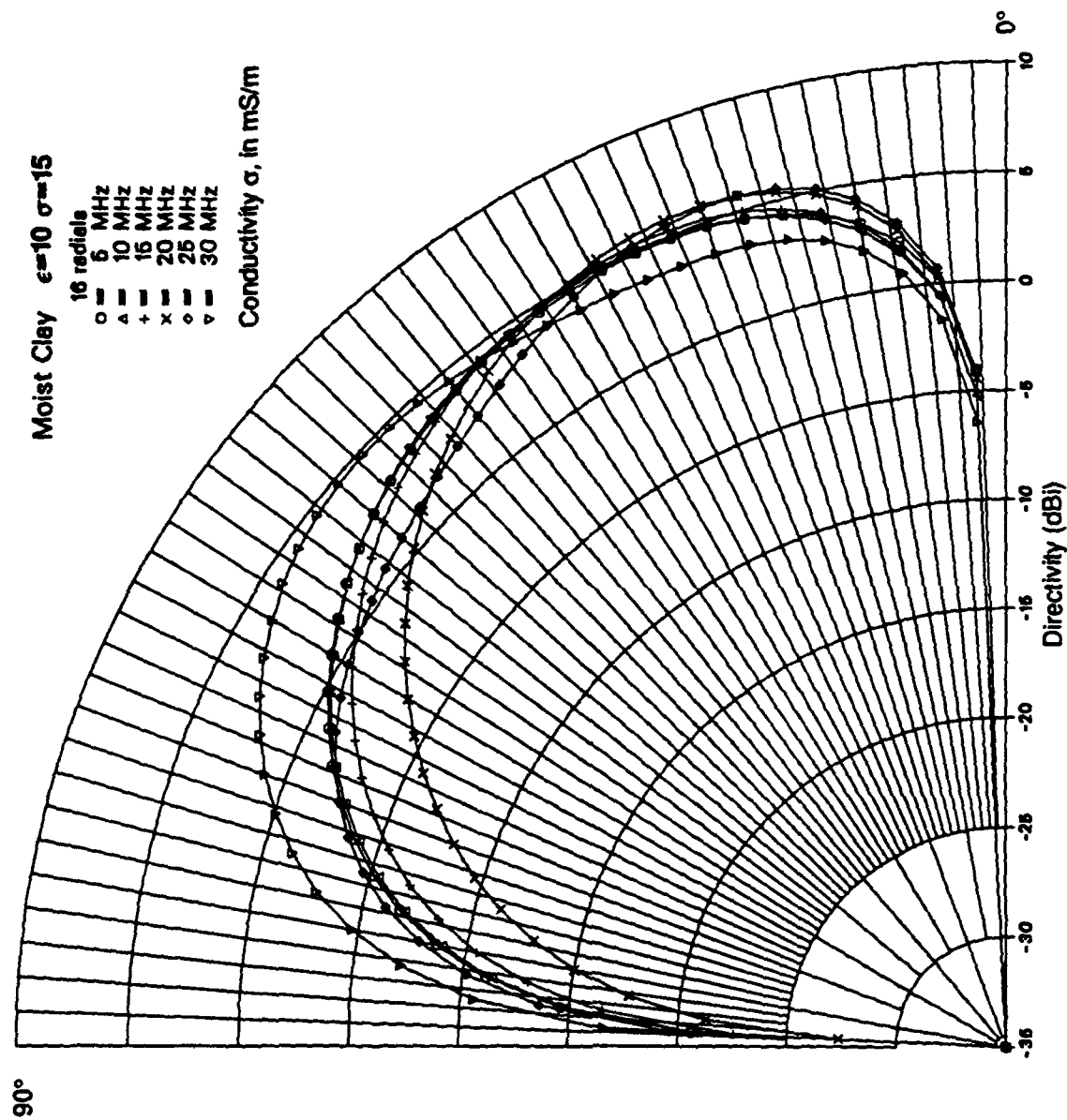


Figure A-81. Antenna Directivity versus Elevation Angle and Frequency, for 6.3 Meter High Monopole Antenna with 12 Meter Radius Ground Screen of 16 Radials, for a Moist Clay Condition

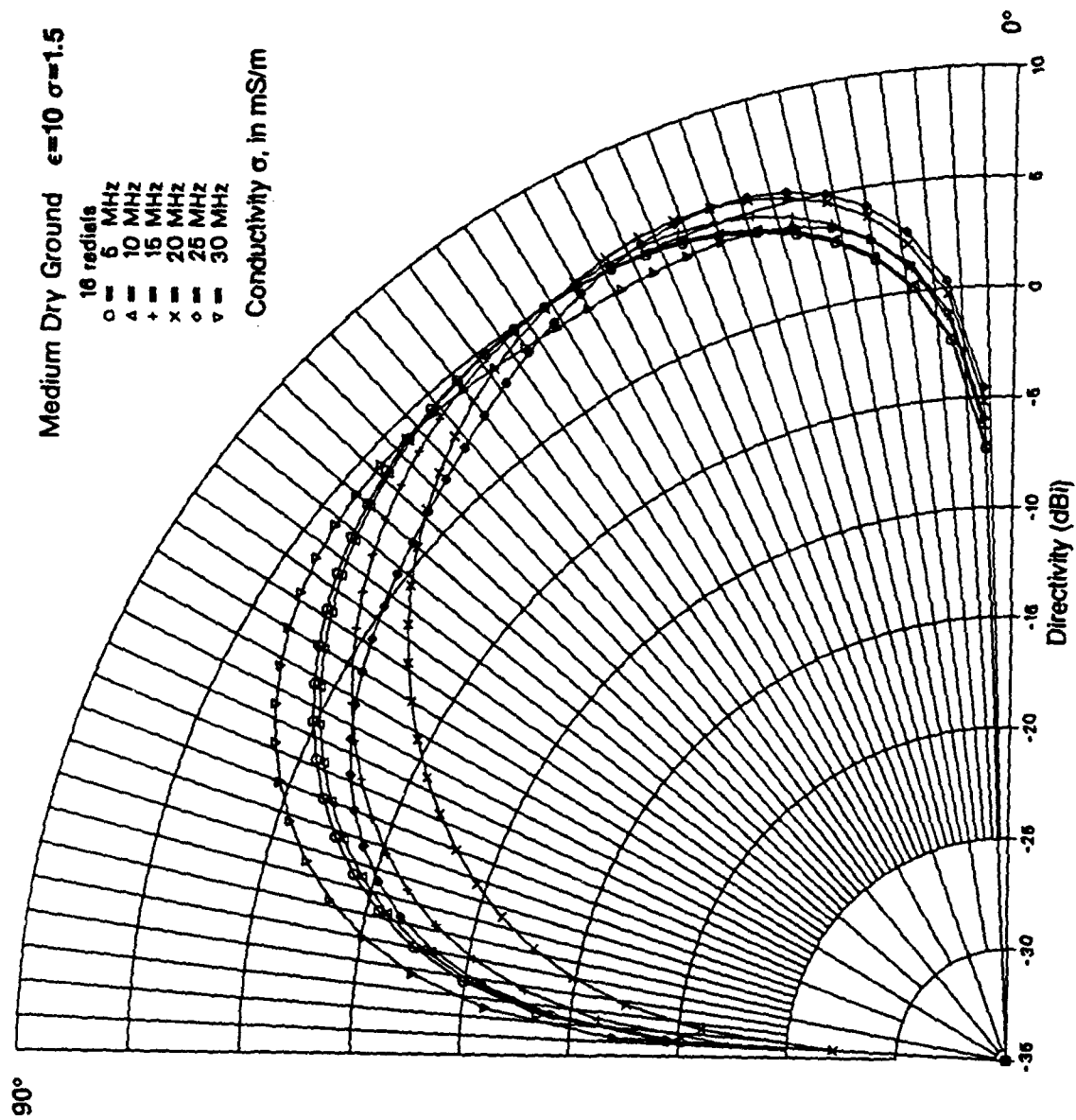


Figure A-82. Antenna Directivity versus Elevation Angle and Frequency, for 6.3 Meter High Monopole Antenna with 12 Meter Radius Ground Screen of 16 Radials, for a Medium Dry Ground Condition

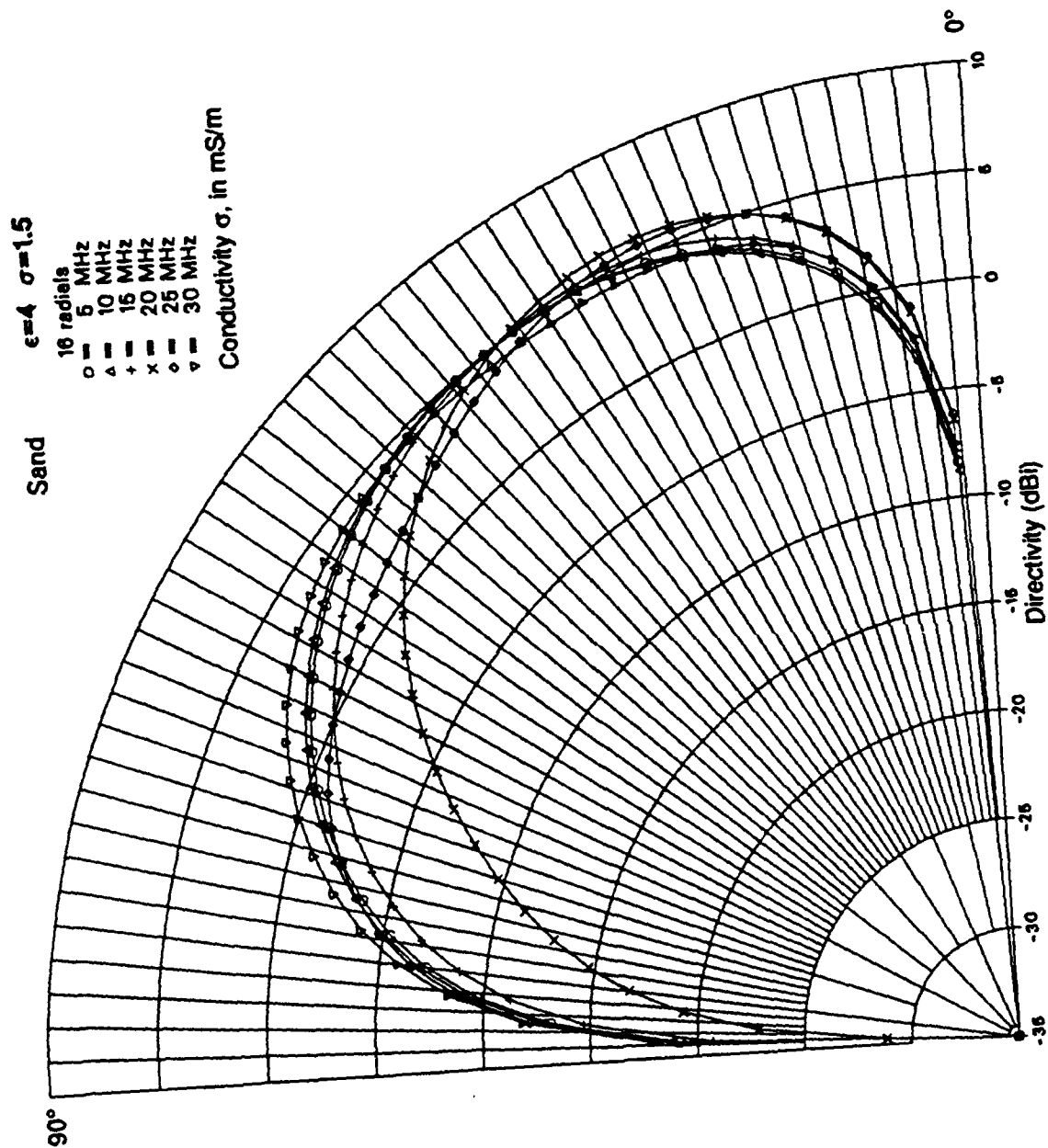


Figure A-83. Antenna Directivity versus Elevation Angle and Frequency, for 6.3 Meter High Monopole Antenna with 12 Meter Radius Ground Screen of 16 Radials, for a Sandy Soil Condition

Very Dry Ground $\epsilon=4$ $\sigma=0.15$

16 radials

- o = 5 MHz
- Δ = 10 MHz
- + = 15 MHz
- x = 20 MHz
- = 25 MHz
- ▽ = 30 MHz

Conductivity σ , in mS/m

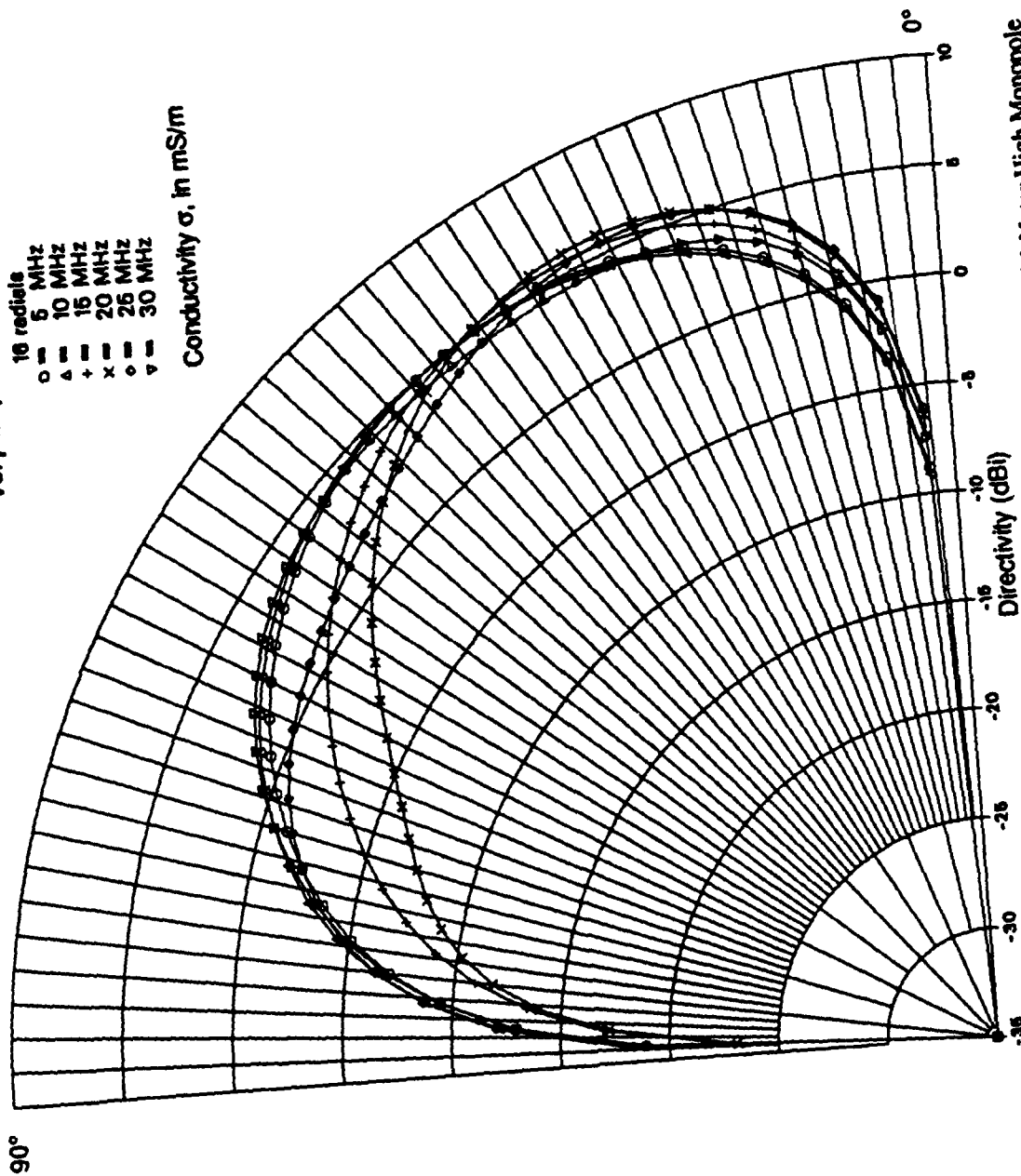


Figure A-84. Antenna Directivity versus Elevation Angle and Frequency, for 6.3 Meter High Monopole Antenna with 12 Meter Radius Ground Screen of 16 Radials, for a Very Dry Ground Condition

Table A-19. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Eleven Frequencies and Five Soil Conditions, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radiats

(Elevation Angle $\psi = 90^\circ - \theta$)

Wet Ground

$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$

Directivity in dBi

θ	F = 5 MHz	7.5 MHz	10	12.5	15	17.5	20	22.5	25	27.5	30
0.0	-86.87	-87.13	-87.15	-87.27	-87.33	-87.38	-87.47	-87.66	-88.04	-88.70	-89.39
2.5	-20.62	-20.73	-21.10	-21.86	-23.27	-25.55	-27.65	-25.38	-21.10	-18.03	-16.64
5.0	-14.61	-14.72	-15.08	-15.84	-17.23	-19.48	-21.59	-19.40	-15.13	-12.04	-10.64
7.5	-11.10	-11.21	-11.57	-12.31	-13.68	-15.89	-18.00	-15.94	-11.70	-8.58	-7.15
10.0	-8.62	-8.72	-9.07	-9.80	-11.15	-13.30	-15.40	-13.52	-9.32	-6.17	-4.69
12.5	-6.71	-6.81	-7.15	-7.86	-9.16	-11.25	-13.34	-11.68	-7.53	-4.34	-2.82
15.0	-5.16	-5.25	-5.58	-6.27	-7.52	-9.53	-11.59	-10.21	-6.14	-2.90	-1.32
17.5	-3.86	-3.94	-4.26	-4.92	-6.12	-8.04	-10.07	-8.98	-5.02	-1.73	-0.09
20.0	-2.75	-2.82	-3.12	-3.75	-4.89	-6.71	-8.69	-7.92	-4.11	-0.78	0.94
22.5	-1.78	-1.84	-2.12	-2.72	-3.80	-5.50	-7.42	-6.98	-3.37	0.01	1.80
25.0	-0.92	-0.98	-1.24	-1.80	-2.81	-4.40	-6.24	-6.11	-2.76	0.64	2.52
27.5	-0.16	-0.20	-0.44	-0.97	-1.91	-3.37	-5.12	-5.29	-2.26	1.15	3.12
30.0	0.52	0.49	0.27	-0.21	-1.08	-2.42	-4.06	-4.50	-1.85	1.55	3.60
32.5	1.13	1.11	0.91	0.48	-0.31	-1.52	-3.04	-3.70	-1.49	1.84	3.97
35.0	1.68	1.67	1.50	1.11	0.40	-0.69	-2.08	-2.89	-1.16	2.04	4.24
37.5	2.18	2.18	2.03	1.69	1.06	0.10	-1.16	-2.08	-0.84	2.17	4.41
40.0	2.63	2.64	2.52	2.22	1.67	0.83	-0.29	-1.25	-0.50	2.22	4.49
42.5	3.03	3.06	2.96	2.70	2.24	1.52	0.54	-0.42	-0.11	2.23	4.47
45.0	3.39	3.43	3.35	3.14	2.76	2.16	1.32	0.41	0.35	2.22	4.37
47.5	3.71	3.76	3.71	3.54	3.23	2.75	2.05	1.21	0.88	2.21	4.19
50.0	3.99	4.05	4.02	3.90	3.67	3.30	2.73	1.99	1.48	2.25	3.95
52.5	4.24	4.30	4.30	4.22	4.06	3.79	3.36	2.73	2.12	2.37	3.68
55.0	4.45	4.52	4.53	4.49	4.40	4.23	3.92	3.42	2.79	2.60	3.40
57.5	4.62	4.69	4.72	4.72	4.69	4.62	4.43	4.06	3.46	2.93	3.18
60.0	4.74	4.82	4.86	4.90	4.93	4.95	4.87	4.62	4.10	3.36	3.04
62.5	4.83	4.90	4.96	5.03	5.12	5.21	5.24	5.11	4.68	3.84	3.03
65.0	4.87	4.93	5.00	5.10	5.24	5.40	5.52	5.51	5.19	4.33	3.15
67.5	4.85	4.90	4.97	5.10	5.29	5.52	5.72	5.82	5.61	4.78	3.36
70.0	4.77	4.80	4.88	5.02	5.25	5.54	5.82	6.01	5.91	5.14	3.60
72.5	4.60	4.61	4.68	4.84	5.10	5.45	5.79	6.07	6.07	5.38	3.80
75.0	4.33	4.30	4.36	4.54	4.82	5.21	5.61	5.96	6.05	5.45	3.88
77.5	3.90	3.82	3.87	4.05	4.36	4.78	5.23	5.64	5.81	5.28	3.76
80.0	3.24	3.10	3.12	3.30	3.62	4.06	4.55	5.01	5.24	4.78	3.31
82.5	2.18	1.95	1.94	2.10	2.42	2.88	3.40	3.90	4.17	3.77	2.35
85.0	0.31	-0.03	-0.10	0.04	0.36	0.82	1.35	1.87	2.18	1.82	0.43
87.5	-3.77	-4.26	-4.40	-4.30	-3.99	-3.53	-3.00	-2.47	-2.14	-2.48	-3.85
90.0	-86.87	-87.13	-87.15	-87.27	-87.33	-87.38	-87.47	-87.66	-88.04	-88.70	-89.39

Table A-19. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Eleven Frequencies and Five Soil Conditions, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

(Elevation Angle $\psi = 90^\circ - \theta$)

Moist Clay											
$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$											
Directivity in dBi											
	F = 5 MHz	7.5 MHz	10	12.5	15	17.5	20	22.5	25	27.5	30
0.0	-86.97	-86.98	-86.75	-86.66	-86.52	-86.36	-86.29	-86.49	-87.19	-88.46	-89.66
2.5	-20.61	-20.67	-20.90	-21.42	-22.56	-24.84	-27.35	-24.09	-19.59	-17.19	-16.64
5.0	-14.60	-14.65	-14.88	-15.39	-16.53	-18.79	-21.28	-18.10	-13.62	-11.21	-10.63
7.5	-11.09	-11.14	-11.37	-11.87	-12.99	-15.20	-17.67	-14.65	-10.19	-7.75	-7.15
10.0	-8.61	-8.66	-8.88	-9.37	-10.47	-12.62	-15.04	-12.23	-7.82	-5.35	-4.69
12.5	-6.70	-6.74	-6.95	-7.43	-8.50	-10.57	-12.95	-10.40	-6.04	-3.53	-2.82
15.0	-5.15	-5.19	-5.39	-5.85	-6.87	-8.87	-11.17	-8.93	-4.65	-2.10	-1.32
17.5	-3.85	-3.88	-4.07	-4.51	-5.49	-7.39	-9.61	-7.70	-3.54	-0.94	-0.09
20.0	-2.73	-2.76	-2.93	-3.35	-4.29	-6.07	-8.21	-6.65	-2.63	0.01	0.95
22.5	-1.76	-1.78	-1.94	-2.33	-3.22	-4.88	-6.91	-5.73	-1.89	0.80	1.81
25.0	-0.91	-0.91	-1.06	-1.43	-2.25	-3.80	-5.70	-4.88	-1.28	1.44	2.55
27.5	-0.15	-0.14	-0.27	-0.61	-1.38	-2.80	-4.57	-4.09	-0.77	1.96	3.16
30.0	0.53	0.55	0.44	0.13	-0.57	-1.86	-3.50	-3.33	-0.35	2.38	3.66
32.5	1.14	1.17	1.08	0.80	0.16	-1.00	-2.49	-2.58	0.01	2.70	4.06
35.0	1.69	1.74	1.66	1.42	0.85	-0.18	-1.53	-1.83	0.33	2.94	4.37
37.5	2.19	2.24	2.19	1.98	1.47	0.57	-0.62	-1.07	0.64	3.11	4.59
40.0	2.64	2.70	2.67	2.49	2.06	1.28	0.24	-0.32	0.94	3.21	4.72
42.5	3.04	3.12	3.10	2.96	2.59	1.94	1.04	0.44	1.27	3.27	4.78
45.0	3.41	3.49	3.49	3.38	3.08	2.55	1.80	1.18	1.63	3.30	4.76
47.5	3.73	3.82	3.84	3.76	3.53	3.11	2.50	1.91	2.03	3.32	4.67
50.0	4.01	4.11	4.14	4.10	3.93	3.62	3.14	2.61	2.48	3.35	4.53
52.5	4.26	4.36	4.40	4.39	4.28	4.07	3.73	3.27	2.96	3.41	4.35
55.0	4.47	4.56	4.63	4.64	4.59	4.48	4.25	3.88	3.46	3.52	4.15
57.5	4.64	4.73	4.80	4.84	4.85	4.83	4.71	4.43	3.96	3.69	3.95
60.0	4.77	4.86	4.93	5.00	5.05	5.11	5.10	4.92	4.44	3.90	3.78
62.5	4.85	4.93	5.01	5.09	5.19	5.33	5.42	5.32	4.88	4.15	3.66
65.0	4.89	4.95	5.03	5.13	5.27	5.47	5.65	5.64	5.24	4.40	3.57
67.5	4.87	4.91	4.98	5.09	5.26	5.52	5.78	5.86	5.52	4.61	3.52
70.0	4.78	4.79	4.85	4.97	5.16	5.47	5.79	5.95	5.68	4.75	3.47
72.5	4.61	4.58	4.62	4.73	4.95	5.30	5.68	5.90	5.69	4.78	3.36
75.0	4.33	4.25	4.26	4.36	4.58	4.96	5.38	5.67	5.52	4.63	3.13
77.5	3.89	3.74	3.70	3.78	4.01	4.41	4.86	5.19	5.10	4.23	2.70
80.0	3.21	2.96	2.87	2.92	3.13	3.54	4.02	4.38	4.32	3.49	1.93
82.5	2.11	1.74	1.57	1.57	1.76	2.16	2.65	3.03	3.00	2.19	0.63
85.0	0.17	-0.37	-0.64	-0.71	-0.55	-0.17	0.31	0.70	0.68	-0.11	-1.68
87.5	-4.03	-4.81	-5.21	-5.36	-5.25	-4.90	-4.44	-4.06	-4.08	-4.88	-6.45
90.0	-86.97	-86.98	-86.75	-86.66	-86.52	-86.36	-86.29	-86.49	-87.19	-88.46	-89.66

Table A-19. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Eleven Frequencies and Five Soil Conditions, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

(Elevation Angle $\psi = 90^\circ - \theta$)												
Medium Dry Ground												
$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$												
θ	Directivity in dBi											
	F = 5 MHz	7.5 MHz	10	12.5	15	17.5	20	22.5	25	27.5	30	
0.0	-84.93	-85.53	-85.87	-86.10	-86.21	-86.32	-86.61	-87.09	-87.92	-89.01	-89.78	
2.5	-19.44	-19.52	-19.89	-20.63	-22.33	-26.03	-27.11	-22.99	-20.19	-18.15	-17.05	
5.0	-13.44	-13.51	-13.88	-14.61	-16.29	-19.94	-21.05	-17.02	-14.22	-12.17	-11.06	
7.5	-9.93	-10.01	-10.37	-11.09	-12.75	-16.30	-17.47	-13.59	-10.78	-8.70	-7.58	
10.0	-7.46	-7.53	-7.89	-8.60	-10.22	-13.64	-14.89	-11.22	-8.40	-6.29	-5.14	
12.5	-5.56	-5.63	-5.98	-6.67	-8.24	-11.51	-12.83	-9.43	-6.61	-4.46	-3.28	
15.0	-4.02	-4.09	-4.43	-5.10	-6.61	-9.70	-11.09	-8.01	-5.21	-3.01	-1.80	
17.5	-2.74	-2.80	-3.13	-3.78	-5.22	-8.11	-9.55	-6.85	-4.08	-1.83	-0.58	
20.0	-1.64	-1.70	-2.02	-2.63	-4.00	-6.68	-8.16	-5.86	-3.16	-0.86	0.44	
22.5	-0.69	-0.75	-1.05	-1.63	-2.92	-5.38	-6.86	-5.01	-2.40	-0.05	1.29	
25.0	0.14	0.09	-0.19	-0.75	-1.94	-4.19	-5.64	-4.23	-1.76	0.61	2.00	
27.5	0.87	0.82	0.56	0.05	-1.06	-3.08	-4.49	-3.50	-1.22	1.15	2.59	
30.0	1.53	1.48	1.24	0.76	-0.25	-2.05	-3.39	-2.80	-0.76	1.60	3.08	
32.5	2.11	2.06	1.84	1.41	0.50	-1.10	-2.35	-2.10	-0.35	1.95	3.47	
35.0	2.62	2.59	2.39	1.99	1.18	-0.21	-1.36	-1.39	0.02	2.22	3.77	
37.5	3.08	3.05	2.87	2.52	1.81	0.61	-0.42	-0.68	0.39	2.44	3.99	
40.0	3.48	3.46	3.30	3.00	2.39	1.38	0.46	0.05	0.77	2.60	4.13	
42.5	3.84	3.82	3.69	3.43	2.92	2.08	1.29	0.78	1.18	2.74	4.20	
45.0	4.15	4.13	4.02	3.81	3.40	2.72	2.05	1.50	1.62	2.86	4.21	
47.5	4.41	4.40	4.32	4.15	3.83	3.31	2.76	2.20	2.10	2.99	4.17	
50.0	4.62	4.62	4.56	4.44	4.21	3.83	3.40	2.88	2.61	3.15	4.10	
52.5	4.80	4.80	4.76	4.68	4.54	4.29	3.97	3.51	3.14	3.35	4.01	
55.0	4.92	4.92	4.91	4.88	4.82	4.69	4.48	4.09	3.67	3.59	3.94	
57.5	4.99	5.00	5.01	5.02	5.04	5.03	4.91	4.61	4.19	3.88	3.90	
60.0	5.02	5.03	5.06	5.11	5.20	5.29	5.27	5.05	4.66	4.19	3.90	
62.5	4.98	5.00	5.05	5.13	5.29	5.48	5.55	5.42	5.08	4.50	3.94	
65.0	4.88	4.90	4.97	5.09	5.31	5.58	5.73	5.69	5.41	4.79	4.01	
67.5	4.70	4.72	4.80	4.96	5.24	5.58	5.81	5.85	5.65	5.01	4.08	
70.0	4.43	4.45	4.55	4.73	5.06	5.47	5.76	5.89	5.76	5.13	4.12	
72.5	4.04	4.06	4.17	4.38	4.76	5.23	5.58	5.77	5.71	5.12	4.06	
75.0	3.50	3.51	3.64	3.87	4.29	4.81	5.21	5.47	5.47	4.92	3.84	
77.5	2.75	2.76	2.89	3.15	3.59	4.16	4.60	4.92	4.98	4.46	3.39	
80.0	1.70	1.69	1.83	2.10	2.58	3.18	3.66	4.01	4.12	3.65	2.59	
82.5	0.13	0.12	0.27	0.55	1.04	1.67	2.17	2.57	2.72	2.27	1.24	
85.0	-2.38	-2.40	-2.26	-1.97	-1.46	-0.82	-0.29	0.13	0.30	-0.11	-1.13	
87.5	-7.30	-7.34	-7.19	-6.90	-6.39	-5.73	-5.19	-4.76	-4.57	-4.97	-5.98	
90.0	-84.93	-85.53	-85.87	-86.10	-86.21	-86.32	-86.61	-87.09	-87.92	-89.01	-89.78	

Table A-19. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Eleven Frequencies and Five Soil Conditions, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

(Elevation Angle $\psi = 90^\circ - \theta$)

Sandy Soil

$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

Directivity in dBi

θ	F = 5 MHz	7.5 MHz	10	12.5	15	17.5	20	22.5	25	27.5	30
0.0	-84.24	-84.77	-85.62	-85.92	-85.67	-85.60	-86.01	-86.70	-87.82	-89.25	-90.17
2.5	-19.20	-19.05	-18.78	-18.89	-20.74	-27.15	-28.85	-20.99	-18.13	-17.59	-17.90
5.0	-13.19	-13.04	-12.77	-12.88	-14.72	-21.02	-22.83	-15.06	-12.19	-11.61	-11.88
7.5	-9.69	-9.55	-9.28	-9.39	-11.21	-17.34	-19.30	-11.68	-8.80	-8.16	-8.36
10.0	-7.22	-7.08	-6.82	-6.93	-8.72	-14.61	-16.75	-9.39	-6.48	-5.76	-5.88
12.5	-5.32	-5.18	-4.93	-5.05	-6.80	-12.39	-14.70	-7.70	-4.77	-3.95	-3.96
15.0	-3.78	-3.65	-3.41	-3.53	-5.23	-10.49	-12.91	-6.39	-3.46	-2.53	-2.42
17.5	-2.50	-2.37	-2.14	-2.26	-3.91	-8.79	-11.26	-5.36	-2.43	-1.37	-1.14
20.0	-1.40	-1.28	-1.06	-1.19	-2.77	-7.25	-9.69	-4.52	-1.62	-0.43	-0.05
22.5	-0.45	-0.33	-0.13	-0.26	-1.76	-5.83	-8.18	-3.79	-0.96	0.35	0.86
25.0	0.38	0.49	0.67	0.55	-0.87	-4.52	-6.71	-3.15	-0.44	1.00	1.64
27.5	1.11	1.22	1.38	1.26	-0.06	-3.30	-5.30	-2.54	-0.01	1.53	2.30
30.0	1.76	1.86	2.01	1.89	0.67	-2.16	-3.96	-1.94	0.35	1.97	2.85
32.5	2.33	2.43	2.56	2.44	1.33	-1.12	-2.69	-1.31	0.67	2.33	3.30
35.0	2.84	2.93	3.05	2.93	1.94	-0.14	-1.51	-0.67	0.97	2.61	3.66
37.5	3.29	3.38	3.48	3.37	2.50	0.75	-0.42	0.01	1.26	2.84	3.94
40.0	3.69	3.77	3.85	3.75	3.00	1.57	0.59	0.70	1.58	3.03	4.15
42.5	4.04	4.10	4.17	4.08	3.46	2.31	1.51	1.40	1.93	3.20	4.29
45.0	4.33	4.39	4.44	4.37	3.87	2.99	2.34	2.09	2.32	3.35	4.37
47.5	4.58	4.63	4.67	4.61	4.23	3.59	3.09	2.76	2.74	3.50	4.41
50.0	4.78	4.83	4.84	4.80	4.54	4.12	3.75	3.38	3.19	3.67	4.42
52.5	4.93	4.97	4.97	4.95	4.80	4.58	4.32	3.96	3.64	3.86	4.41
55.0	5.03	5.06	5.05	5.04	5.01	4.96	4.82	4.48	4.09	4.07	4.39
57.5	5.08	5.10	5.08	5.09	5.16	5.27	5.22	4.92	4.51	4.30	4.38
60.0	5.07	5.08	5.05	5.07	5.25	5.49	5.53	5.29	4.88	4.52	4.37
62.5	5.00	4.99	4.95	4.99	5.27	5.63	5.75	5.56	5.19	4.72	4.36
65.0	4.85	4.83	4.78	4.84	5.20	5.68	5.87	5.74	5.41	4.87	4.33
67.5	4.62	4.59	4.53	4.60	5.04	5.61	5.87	5.80	5.52	4.95	4.27
70.0	4.29	4.24	4.17	4.26	4.77	5.42	5.74	5.73	5.50	4.93	4.14
72.5	3.83	3.76	3.68	3.79	4.36	5.08	5.45	5.49	5.33	4.75	3.90
75.0	3.21	3.12	3.02	3.14	3.77	4.56	4.96	5.05	4.94	4.38	3.49
77.5	2.36	2.24	2.14	2.27	2.94	3.78	4.22	4.35	4.29	3.75	2.83
80.0	1.18	1.03	0.92	1.05	1.76	2.64	3.11	3.28	3.26	2.74	1.81
82.5	-0.53	-0.71	-0.84	-0.70	0.03	0.94	1.44	1.64	1.65	1.15	0.22
85.0	-3.23	-3.45	-3.59	-3.45	-2.70	-1.76	-1.26	-1.04	-1.00	-1.48	-2.41
87.5	-8.39	-8.64	-8.80	-8.66	-7.90	-6.95	-6.44	-6.20	-6.15	-6.62	-7.55
90.0	-84.24	-84.77	-85.62	-85.92	-85.67	-85.60	-86.01	-86.70	-87.82	-89.25	-90.17

Table A-19. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Eleven Frequencies and Five Soil Conditions, for 6.3 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Concluded)

(Elevation Angle $\psi = 90^\circ - \theta$)												
Very Dry Ground												
$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$												
Directivity in dBi												
θ	F = 5 MHz	7.5 MHz	10	12.5	15	17.5	20	22.5	25	27.5	30	
0.0	-85.32	-86.59	-86.15	-86.62	-85.41	-85.72	-86.27	-86.81	-88.05	-89.31	-90.22	
2.5	-18.96	-18.37	-18.21	-18.15	-22.94	-34.78	-23.13	-19.18	-17.97	-20.02	-19.03	
5.0	-12.96	-12.36	-12.21	-12.15	-16.93	-28.30	-17.25	-13.25	-12.03	-13.97	-12.97	
7.5	-9.46	-8.87	-8.72	-8.67	-13.42	-24.08	-13.97	-9.89	-8.64	-10.40	-9.40	
10.0	-6.99	-6.42	-6.27	-6.24	-10.94	-20.70	-11.79	-7.61	-6.33	-7.84	-6.83	
12.5	-5.09	-4.54	-4.40	-4.37	-9.01	-17.78	-10.23	-5.94	-4.62	-5.84	-4.82	
15.0	-3.56	-3.03	-2.89	-2.88	-7.42	-15.17	-9.07	-4.68	-3.31	-4.20	-3.18	
17.5	-2.28	-1.77	-1.65	-1.65	-6.06	-12.81	-8.16	-3.70	-2.29	-2.82	-1.79	
20.0	-1.19	-0.71	-0.59	-0.61	-4.86	-10.65	-7.37	-2.93	-1.48	-1.65	-0.60	
22.5	-0.25	0.21	0.31	0.27	-3.78	-8.68	-6.62	-2.31	-0.83	-0.64	0.41	
25.0	0.57	1.00	1.09	1.04	-2.78	-6.89	-5.82	-1.79	-0.32	0.22	1.28	
27.5	1.29	1.69	1.77	1.71	-1.85	-5.26	-4.93	-1.34	0.10	0.95	2.02	
30.0	1.93	2.30	2.37	2.29	-0.97	-3.77	-3.95	-0.92	0.44	1.56	2.64	
32.5	2.50	2.82	2.89	2.80	-0.15	-2.41	-2.90	-0.50	0.74	2.07	3.16	
35.0	3.00	3.29	3.34	3.24	0.63	-1.18	-1.82	-0.06	1.00	2.48	3.57	
37.5	3.44	3.69	3.73	3.63	1.37	-0.07	-0.75	0.42	1.27	2.81	3.88	
40.0	3.82	4.04	4.07	3.96	2.05	0.93	0.28	0.95	1.55	3.07	4.12	
42.5	4.16	4.33	4.35	4.25	2.68	1.84	1.24	1.51	1.87	3.28	4.28	
45.0	4.44	4.58	4.59	4.49	3.26	2.64	2.12	2.09	2.23	3.45	4.38	
47.5	4.67	4.77	4.78	4.69	3.78	3.35	2.92	2.68	2.63	3.62	4.43	
50.0	4.86	4.92	4.92	4.85	4.24	3.98	3.63	3.27	3.07	3.78	4.44	
52.5	4.99	5.02	5.02	4.95	4.64	4.51	4.25	3.82	3.53	3.95	4.43	
55.0	5.08	5.07	5.06	5.02	4.97	4.96	4.77	4.33	3.99	4.15	4.42	
57.5	5.11	5.07	5.05	5.03	5.24	5.32	5.21	4.78	4.43	4.36	4.40	
60.0	5.08	5.01	4.99	4.99	5.42	5.59	5.54	5.16	4.82	4.57	4.40	
62.5	4.99	4.88	4.86	4.88	5.53	5.76	5.78	5.45	5.15	4.76	4.40	
65.0	4.82	4.69	4.66	4.70	5.54	5.83	5.90	5.65	5.40	4.92	4.38	
67.5	4.56	4.40	4.38	4.44	5.45	5.79	5.91	5.73	5.54	5.00	4.33	
70.0	4.20	4.02	4.00	4.08	5.23	5.62	5.78	5.67	5.54	4.97	4.21	
72.5	3.71	3.51	3.49	3.59	4.87	5.30	5.50	5.45	5.38	4.80	3.98	
75.0	3.05	2.83	2.81	2.93	4.32	4.78	5.01	5.03	5.01	4.44	3.57	
77.5	2.16	1.92	1.90	2.04	3.52	4.01	4.27	3.28	3.35	3.81	2.92	
80.0	0.93	0.68	0.66	0.81	2.37	2.88	3.16	1.64	1.75	2.80	1.90	
82.5	-0.84	-1.09	-1.12	-0.95	0.66	1.18	1.48	-1.02	-0.90	-1.41	-2.32	
85.0	-3.60	-3.86	-3.88	-3.71	-2.06	-1.52	-1.21	-6.39	-6.05	-6.55	-7.46	
87.5	-8.82	-9.08	-9.11	-8.93	-7.25	-6.71	-6.39	-86.27	-88.05	-89.31	-90.22	
90.0	-85.32	-86.59	-86.15	-86.62	-85.41	-85.72	-86.27	-86.81	-88.05	-89.31	-90.22	

SECTION A4

6.0, 6.5, 7.0 METER MONOPOLE RESULTS

TA1788

Table A-20. Antenna Input Resistance and Reactance versus Frequency for Five Soil Conditions, for 6.0, 6.5 and 7.0 Meter High Monopoles with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep
(Supports Vol. 1, Table 12)

Soil Characteristics				
Frequency (MHz)	Very Good	Good	Medium	Poor
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$ $\epsilon_r = 10, \sigma = 15 \text{ mS/m}$ $\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$ $\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$ $\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$			
Height = 6.0m				
5.0	6.26 – j182.6	5.99 – j182.1	6.65 – j179.3	5.36 – j179.8
17.5	210.3 + j19.8	209.3 + j18.7	210.4 + j22.3	212.6 + j28.5
30.0	38.6 – j71.4	38.0 – j70.1	39.1 – j70.2	40.0 – j69.3
Height = 6.5m				
5.0	7.32 – j167.3	7.04 – j167.5	7.70 – j164.8	6.44 – j165.0
17.5	247.9 – j37.1	245.4 – j36.7	250.2 – j32.7	256.4 – j25.5
30.0	40.0 – j44.3	39.7 – j42.3	41.3 – j42.6	42.6 – j41.0
Height = 7.0m				
5.0	8.44 – j153.1	8.41 – j152.5	8.83 – j149.7	7.42 – j151.2
17.5	241.2 – j110.1	239.4 – j107.6	246.9 – j106.9	257.3 – j103.4
30.0	53.4 – j19.4	53.8 – j17.3	55.5 – j18.1	57.2 – j16.4
				58.0 – j18.0

TA1780

Table A-21. Antenna Efficiency and Noise versus Frequency for Five Soil Conditions, for 6.0, 6.5 and 7.0 Meter High Monopoles with 12 Meter Radius Ground Screen of 16 Radials, 2 mm in Diameter and Buried 0.178m Deep
(Supports Vol. 1, Table 12)

Frequency (MHz)	Soil Characteristics														
	Very Good			Good			Medium			Fair			Poor		
	$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$			$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$			$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$			$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$			$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$		
	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	η (%)	NF (dB)	
Height = 6.0m															
5.0	30.1	5.2	30.9	5.1	19.3	7.1	16.8	7.7	21.2	6.7					
17.5	33.9	4.7	27.0	5.7	26.3	5.8	22.3	6.5	22.6	6.5					
30.0	50.0	3.0	50.7	2.9	54.9	2.6	59.6	2.2	61.1	2.1					
Height = 6.5m															
5.0	30.7	5.1	31.3	5.0	19.7	7.1	16.6	7.8	21.4	6.7					
17.5	34.4	4.6	27.0	5.7	27.1	5.6	23.0	6.4	23.8	6.2					
30.0	56.6	2.5	61.2	2.1	61.0	2.1	66.5	1.8	66.7	1.8					
Height = 7.0m															
5.0	30.4	5.0	31.9	5.0	20.2	7.0	16.9	7.7	21.7	6.6					
17.5	34.8	4.6	27.0	5.7	28.1	5.5	24.0	6.2	25.5	5.9					
30.0	60.2	2.2	64.3	1.9	60.8	2.2	64.5	1.9	64.2	1.9					

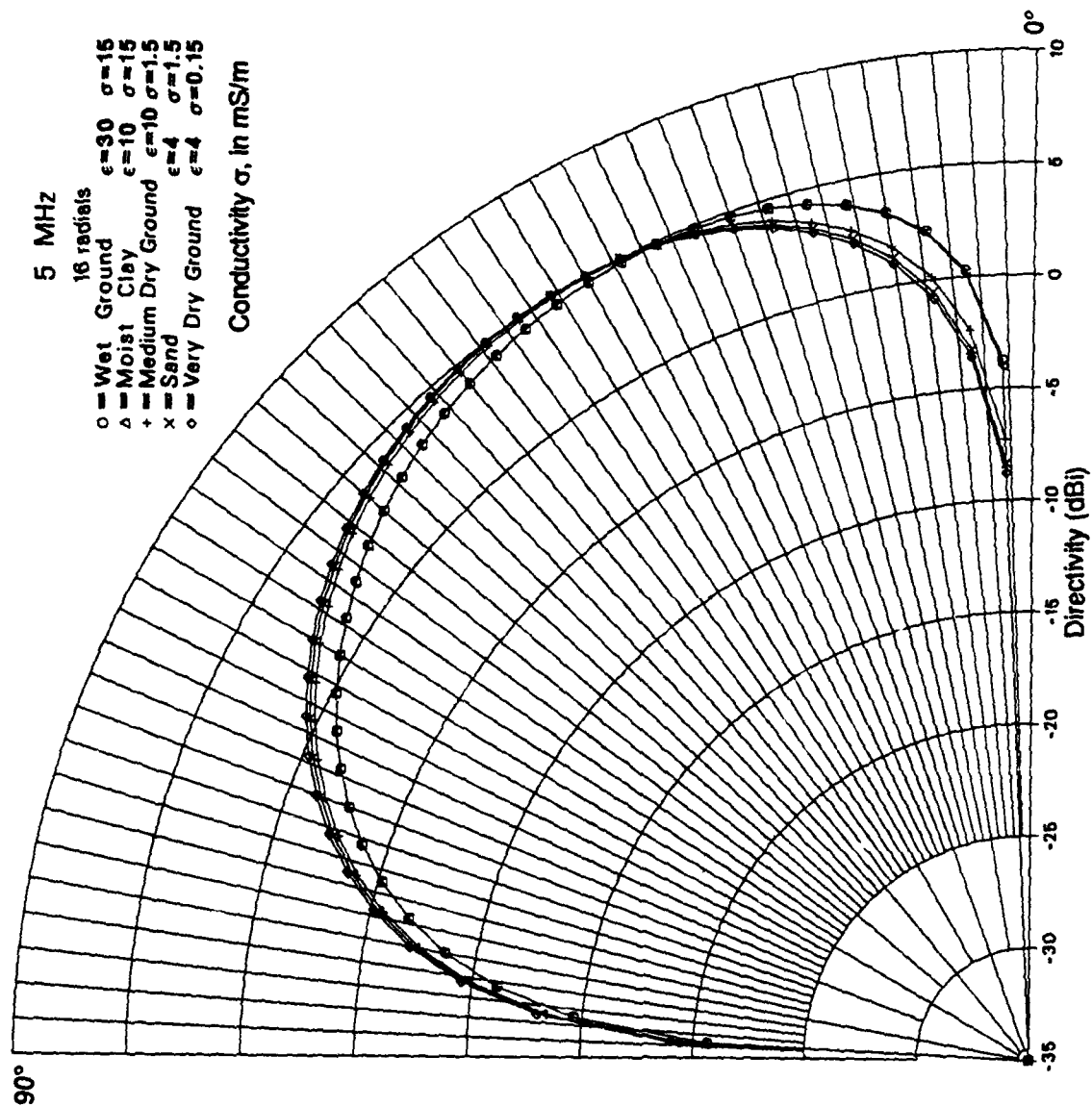


Figure A-85. Antenna Directivity versus Elevation Angle and Five Soil Conditions for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials at Frequency of 5 MHz

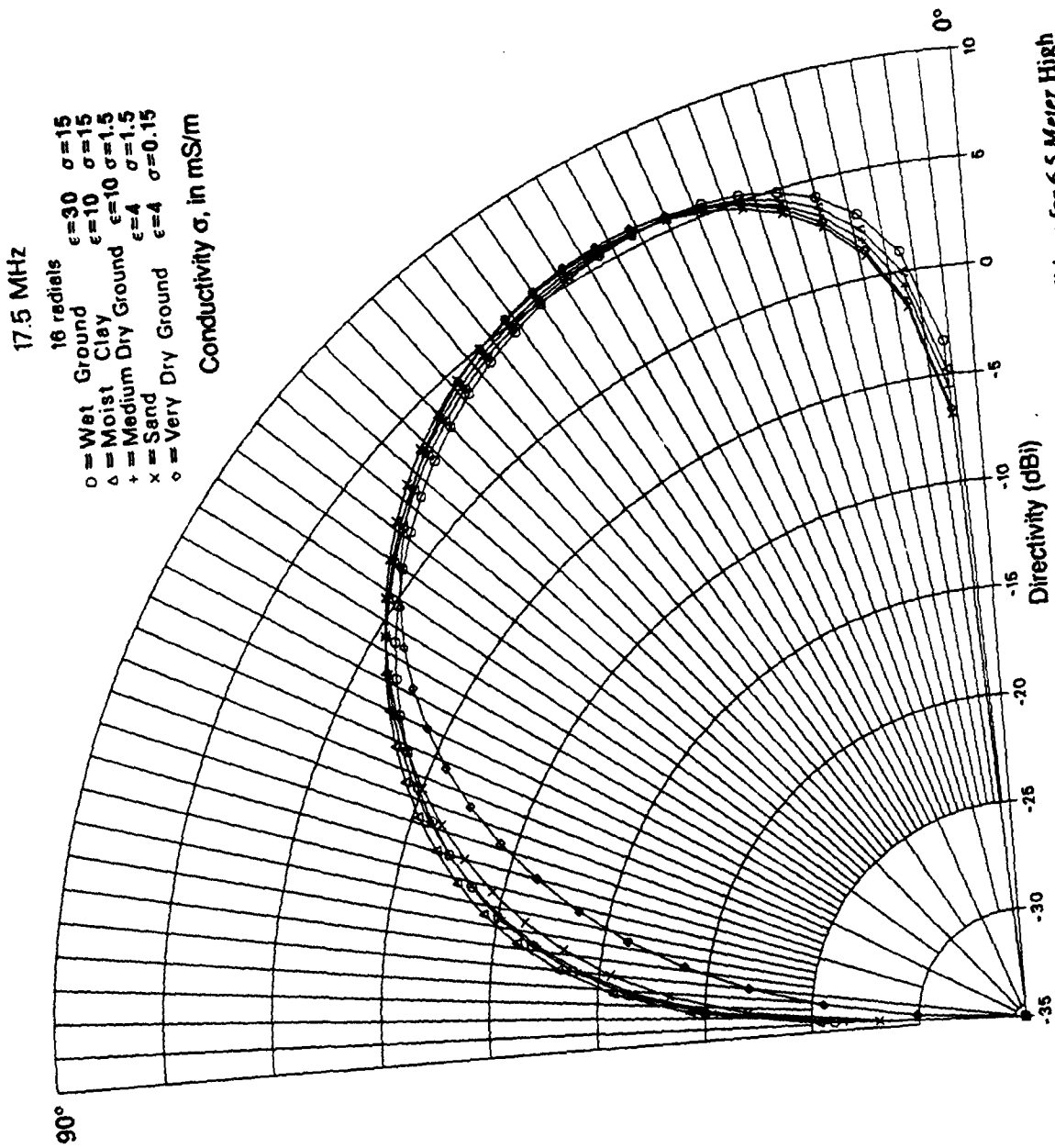


Figure A-86. Antenna Directivity versus Elevation Angle and Five Soil Conditions for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials at Frequency of 17.5 MHz

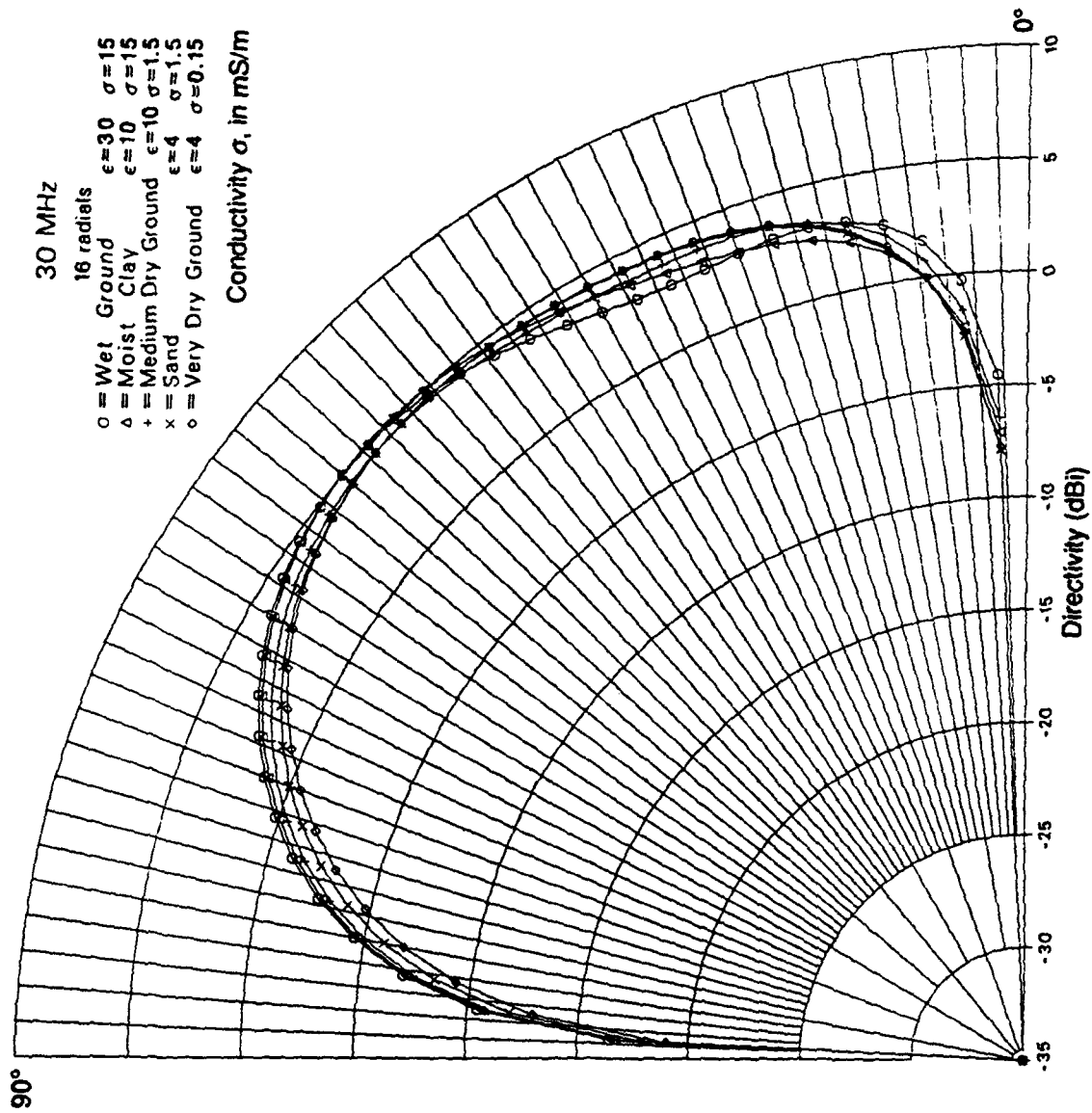


Figure A-87. Antenna Directivity versus Elevation Angle and Five Soil Conditions for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials at Frequency of 30 MHz

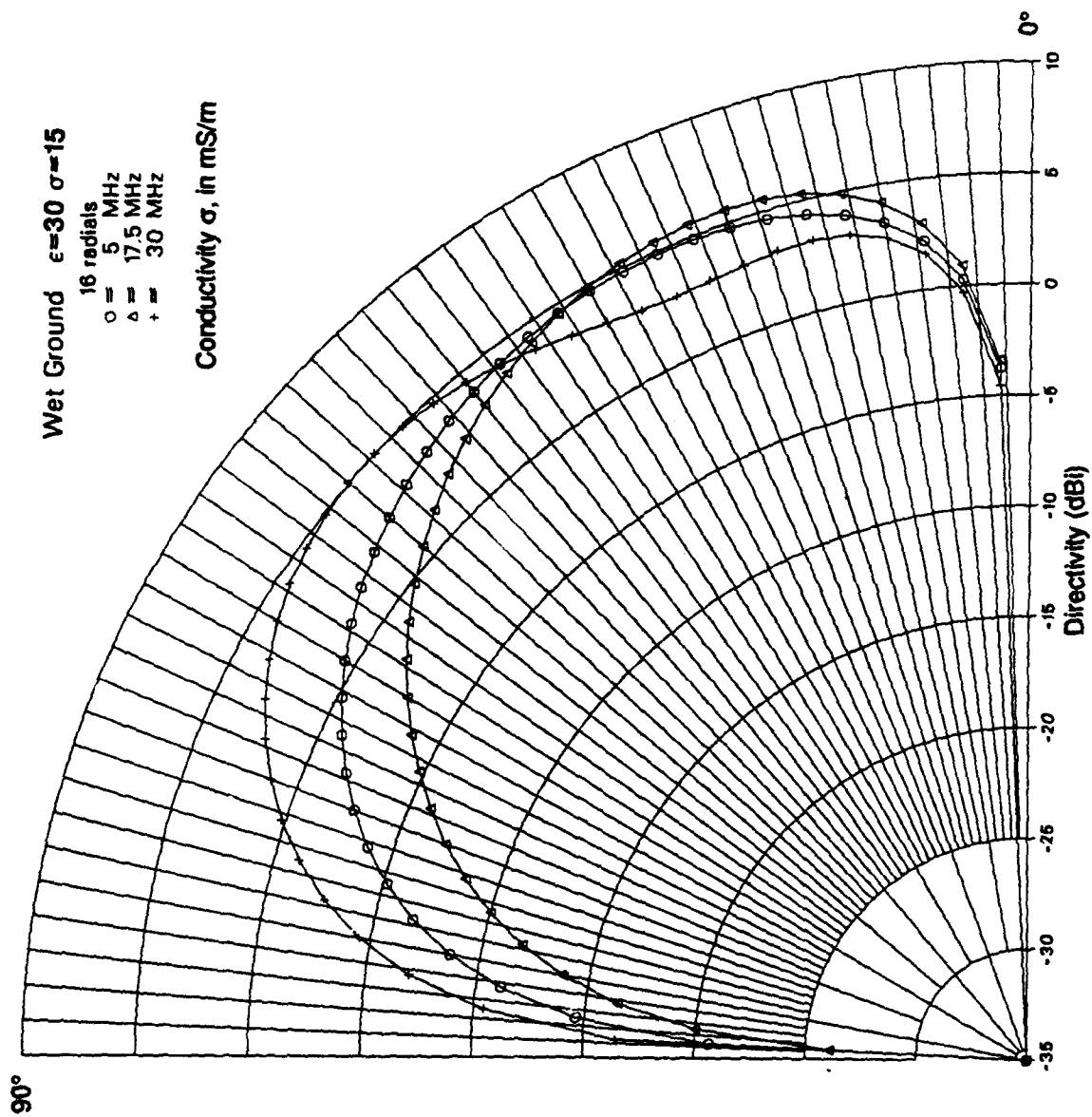


Figure A-88. Antenna Directivity versus Elevation Angle and Frequency, for 6.5 Meter High Monopole with 16 Radials, for a Wet Ground Condition

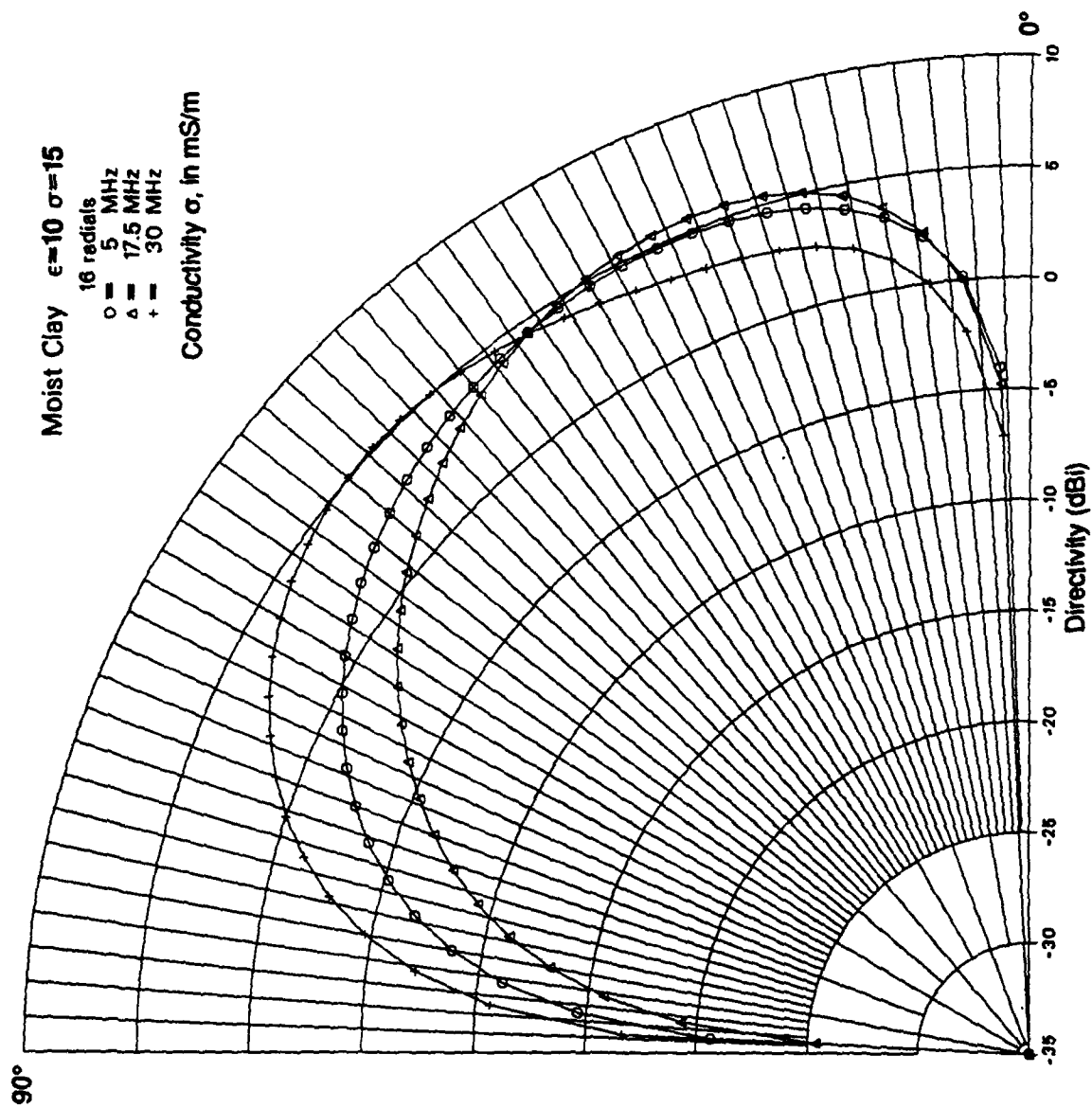


Figure A-89. Antenna Directivity versus Elevation Angle and Frequency, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, for a Moist Clay Condition

Medium Dry Ground $\epsilon=10$ $\sigma=1.5$

16 radials
 o = 5 MHz
 Δ = 17.5 MHz
 + = 30 MHz

Conductivity σ , in mS/m

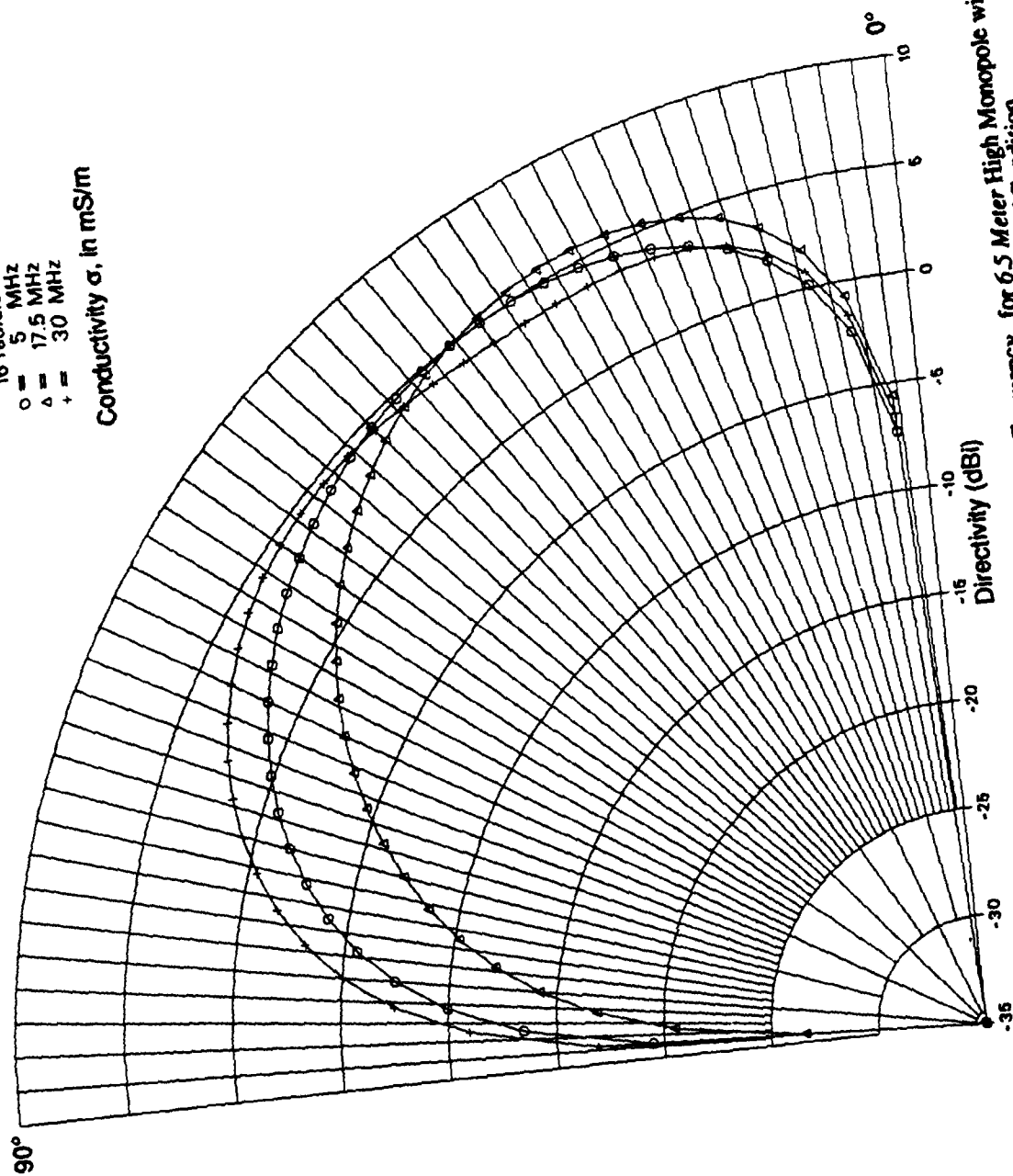


Figure A-90. Antenna Directivity versus Elevation Angle and Frequency, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, for a Medium Dry Ground Condition

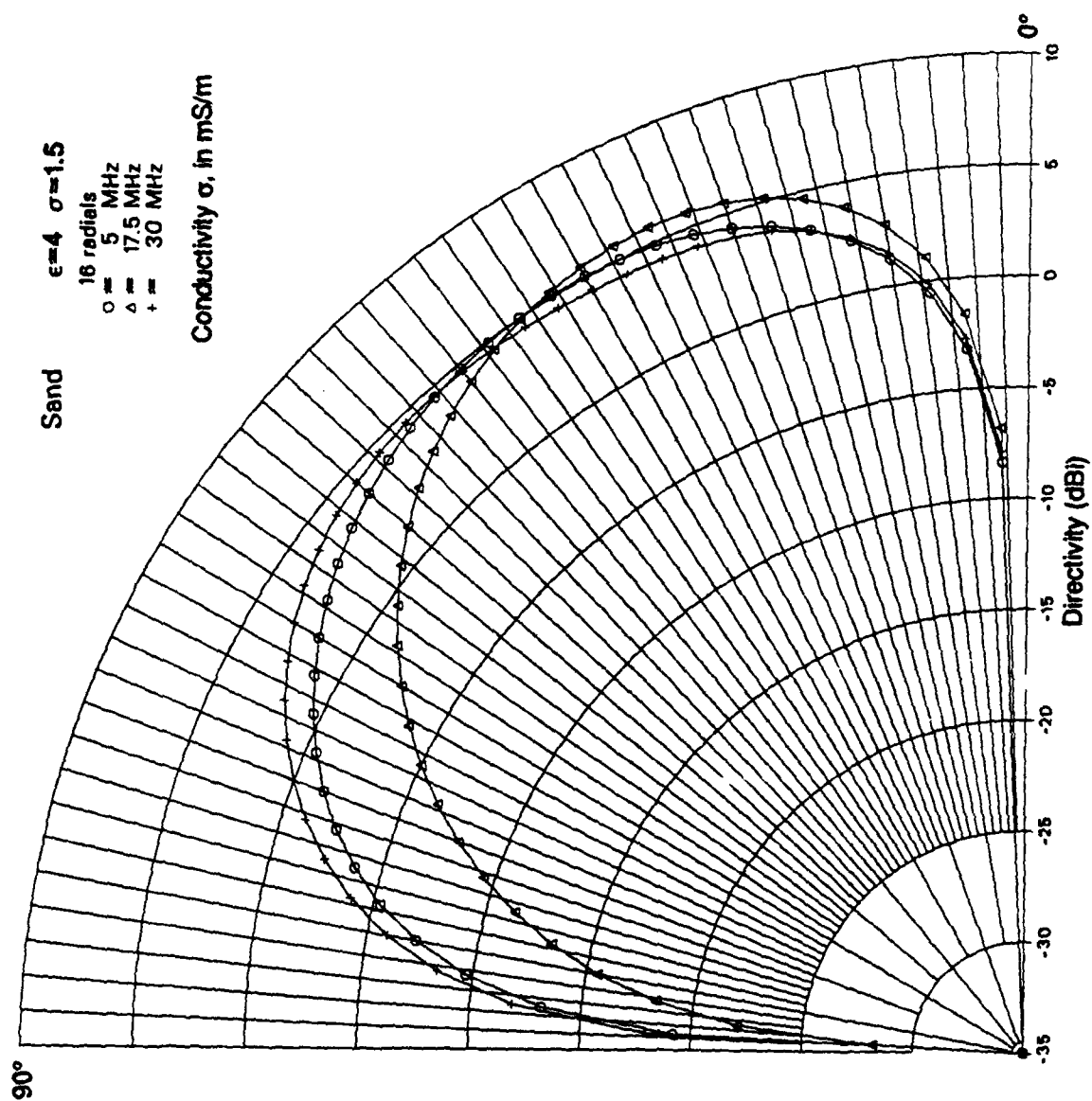


Figure A-91. Antenna Directivity versus Elevation Angle and Frequency, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, for a Sandy Soil Condition

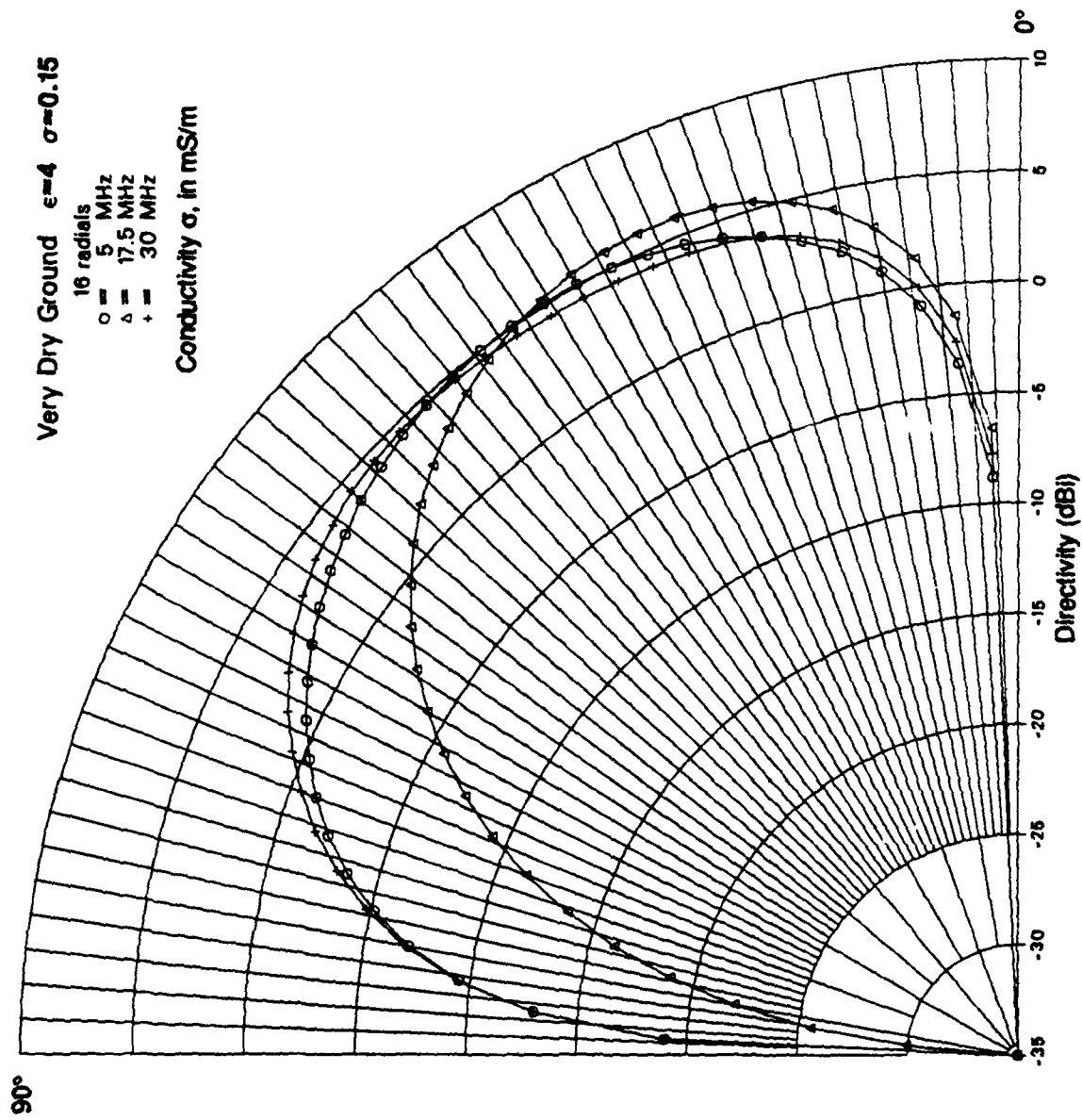


Figure A-92. Antenna Directivity versus Elevation Angle and Frequency, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials, for a Very Dry Ground Condition

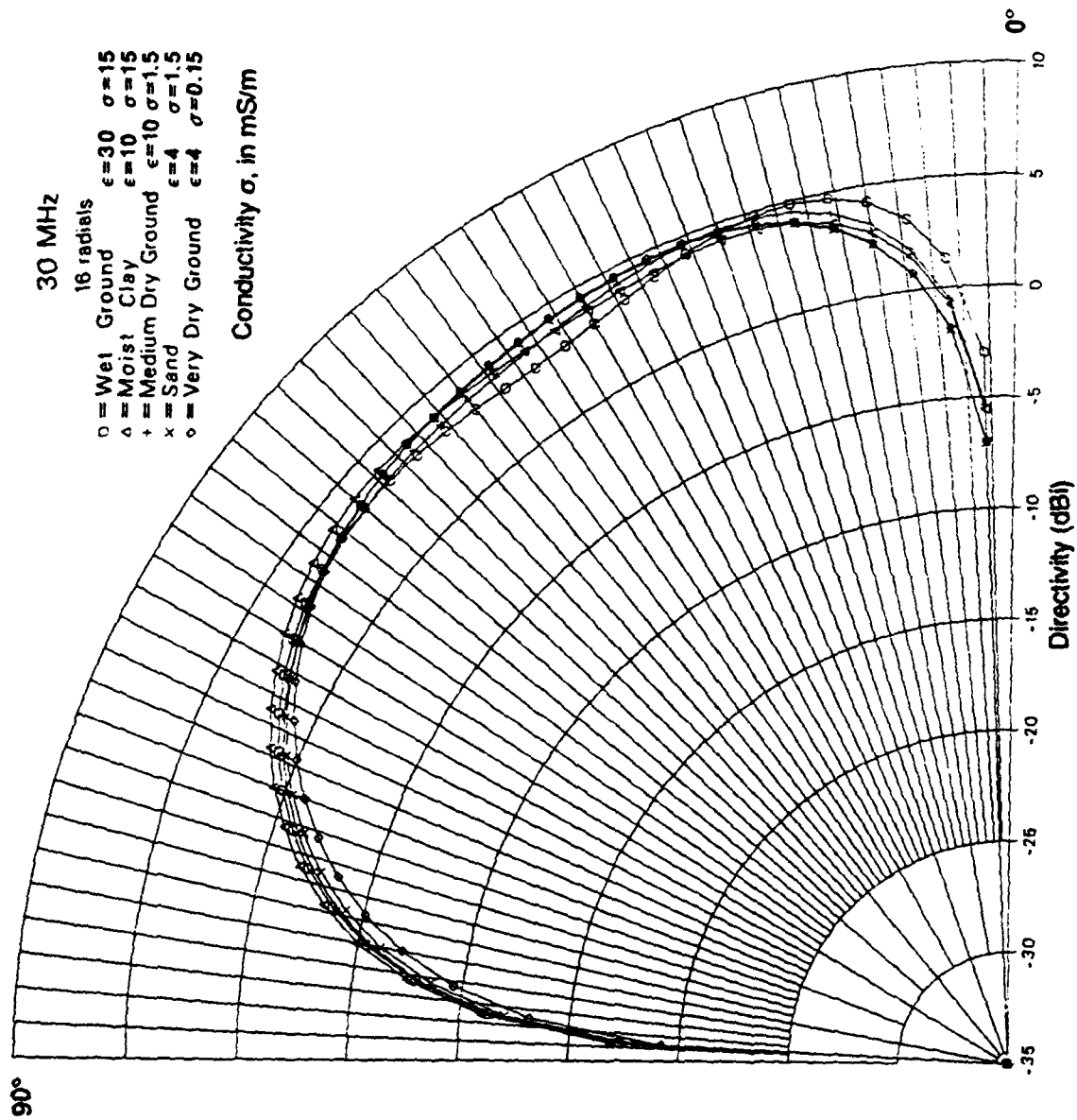


Figure A-93. Antenna Directivity versus Elevation Angle and Five Soil Conditions for 6.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials at Frequency of 30 MHz

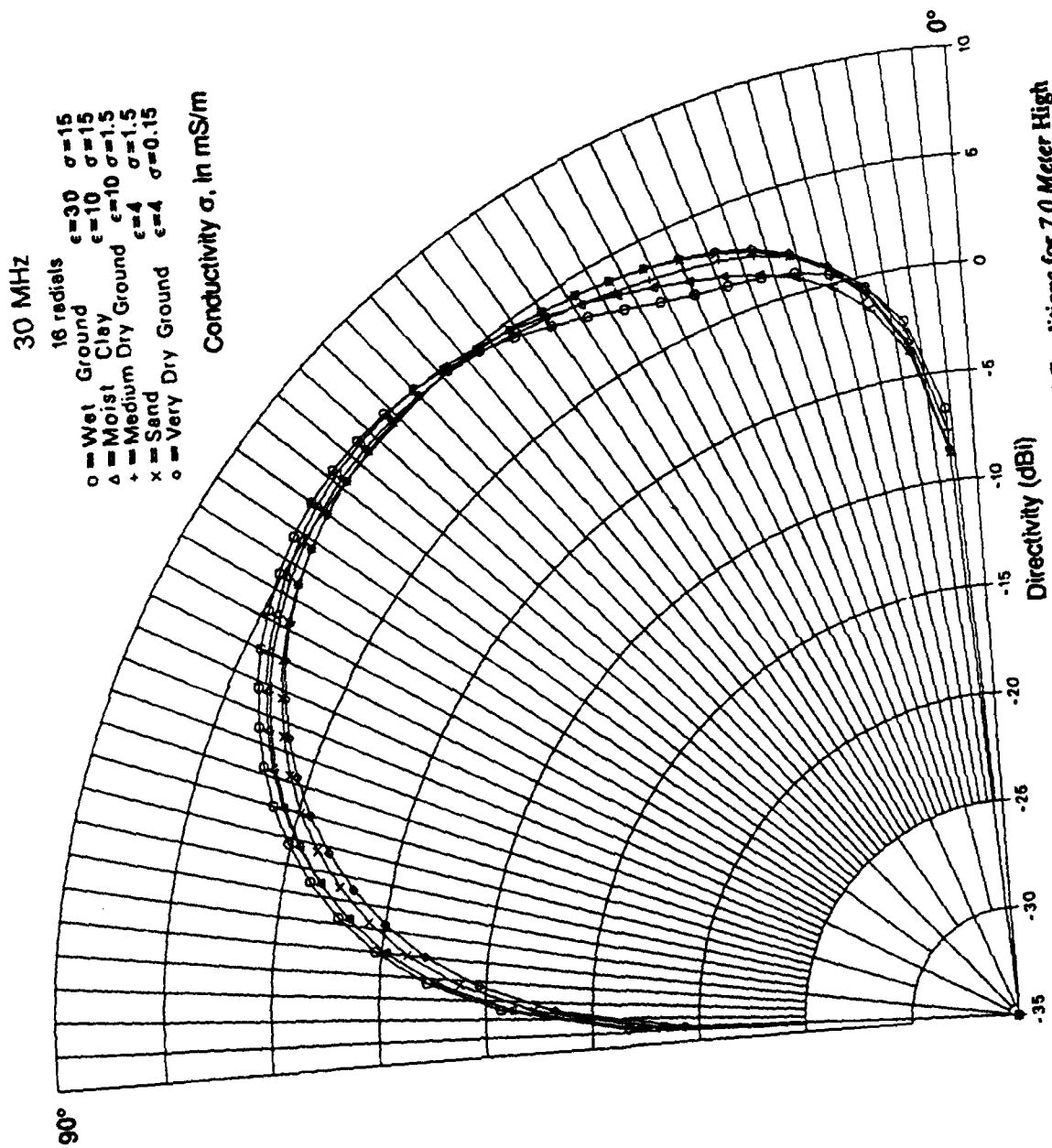


Figure A-94. Antenna Directivity versus Elevation Angle and Five Soil Conditions for 7.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials at Frequency of 30 MHz

Table A-22. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$

WET GROUND			
THETA	5 MHz	17.5 MHz	30 MHz
0.0	-86.91	-87.40	-89.57
2.5	-20.63	-26.08	-16.45
5.0	-14.62	-20.01	-10.45
7.5	-11.11	-16.42	-6.95
10.0	-8.64	-13.81	-4.49
12.5	-6.72	-11.75	-2.60
15.0	-5.17	-10.01	-1.08
17.5	-3.87	-8.50	0.17
20.0	-2.76	-7.15	1.22
22.5	-1.79	-5.92	2.11
25.0	-0.93	-4.79	2.86
27.5	-0.17	-3.73	3.48
30.0	0.51	-2.75	4.00
32.5	1.12	-1.83	4.40
35.0	1.67	-0.96	4.71
37.5	2.17	-0.15	4.91
40.0	2.62	0.61	5.02
42.5	3.02	1.33	5.03
45.0	3.39	2.00	4.94
47.5	3.71	2.62	4.76
50.0	3.99	3.19	4.50
52.5	4.24	3.71	4.18
55.0	4.45	4.17	3.81
57.5	4.62	4.58	3.44
60.0	4.75	4.93	3.12
62.5	4.83	5.22	2.90
65.0	4.87	5.43	2.80
67.5	4.85	5.56	2.83
70.0	4.77	5.60	2.95
72.5	4.61	5.52	3.08
75.0	4.33	5.30	3.13
77.5	3.91	4.87	3.00
80.0	3.25	4.17	2.56
82.5	2.18	2.99	1.61
85.0	0.31	0.94	-0.29
87.5	-3.76	-3.42	-4.56
90.0	-86.91	-87.40	-89.57

$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

MOIST CLAY			
THETA	5 MHz	17.5 MHz	30 MHz
0.0	-87.00	-86.35	-89.91
2.5	-20.63	-25.37	-16.66
5.0	-14.62	-19.31	-10.65
7.5	-11.11	-15.71	-7.16
10.0	-8.63	-13.12	-4.69
12.5	-6.72	-11.06	-2.80
15.0	-5.17	-9.33	-1.28
17.5	-3.87	-7.83	-0.03
20.0	-2.75	-6.50	1.03
22.5	-1.78	-5.28	1.93
25.0	-0.93	-4.17	2.69
27.5	-0.17	-3.14	3.33
30.0	0.52	-2.18	3.86
32.5	1.13	-1.28	4.29
35.0	1.68	-0.44	4.63
37.5	2.18	0.34	4.88
40.0	2.63	1.08	5.04
42.5	3.03	1.76	5.12
45.0	3.40	2.40	5.11
47.5	3.72	2.99	5.03
50.0	4.00	3.52	4.87
52.5	4.25	4.01	4.66
55.0	4.46	4.43	4.40
57.5	4.63	4.80	4.12
60.0	4.76	5.11	3.85
62.5	4.85	5.35	3.59
65.0	4.88	5.51	3.37
67.5	4.87	5.58	3.19
70.0	4.78	5.54	3.03
72.5	4.61	5.38	2.84
75.0	4.33	5.06	2.55
77.5	3.89	4.52	2.08
80.0	3.21	3.66	1.30
82.5	2.11	2.28	-0.02
85.0	0.17	-0.04	-2.33
87.5	-4.03	-4.77	-7.10
90.0	-87.00	-86.35	-89.91

Table A-22. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$

$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

MEDIUM DRY GROUND			
THETA	5 MHz	17.5 MHz	30 MHz
0.0	-84.98	-86.37	-89.90
2.5	-19.47	-26.61	-16.96
5.0	-13.46	-20.51	-10.96
7.5	-9.96	-16.86	-7.47
10.0	-7.48	-14.18	-5.02
12.5	-5.58	-12.02	-3.15
15.0	-4.04	-10.19	-1.65
17.5	-2.76	-8.57	-0.41
20.0	-1.66	-7.12	0.63
22.5	-0.71	-5.79	1.50
25.0	0.12	-4.56	2.24
27.5	0.86	-3.42	2.86
30.0	1.51	-2.36	3.38
32.5	2.09	-1.38	3.79
35.0	2.61	-0.46	4.12
37.5	3.07	0.40	4.36
40.0	3.47	1.19	4.51
42.5	3.83	1.92	4.59
45.0	4.14	2.59	4.60
47.5	4.40	3.20	4.54
50.0	4.62	3.75	4.43
52.5	4.79	4.24	4.29
55.0	4.91	4.66	4.14
57.5	4.99	5.01	3.99
60.0	5.01	5.29	3.88
62.5	4.98	5.50	3.80
65.0	4.88	5.62	3.77
67.5	4.70	5.64	3.75
70.0	4.43	5.54	3.72
72.5	4.04	5.31	3.61
75.0	3.50	4.90	3.37
77.5	2.76	4.26	2.91
80.0	1.70	3.28	2.11
82.5	0.14	1.78	0.76
85.0	-2.38	-0.70	-1.61
87.5	-7.30	-5.61	-6.45
90.0	-84.98	-86.37	-89.90

SAND			
THETA	5 MHz	17.5 MHz	30 MHz
0.0	-84.25	-85.65	-90.27
2.5	-19.22	-28.19	-17.93
5.0	-13.21	-22.04	-11.90
7.5	-9.71	-18.31	-8.38
10.0	-7.24	-15.53	-5.88
12.5	-5.33	-13.24	-3.95
15.0	-3.80	-11.27	-2.39
17.5	-2.51	-9.49	-1.08
20.0	-1.42	-7.88	0.02
22.5	-0.47	-6.39	0.96
25.0	0.36	-5.01	1.77
27.5	1.10	-3.73	2.45
30.0	1.75	-2.54	3.03
32.5	2.32	-1.44	3.50
35.0	2.83	-0.42	3.89
37.5	3.29	0.52	4.18
40.0	3.68	1.37	4.40
42.5	4.03	2.15	4.55
45.0	4.33	2.86	4.63
47.5	4.58	3.49	4.66
50.0	4.78	4.05	4.64
52.5	4.93	4.53	4.59
55.0	5.03	4.94	4.52
57.5	5.08	5.26	4.44
60.0	5.07	5.51	4.35
62.5	5.00	5.67	4.27
65.0	4.86	5.73	4.18
67.5	4.63	5.68	4.06
70.0	4.30	5.50	3.88
72.5	3.84	5.17	3.61
75.0	3.22	4.65	3.17
77.5	2.37	3.88	2.50
80.0	1.19	2.75	1.47
82.5	-0.53	1.06	-0.13
85.0	-3.23	-1.64	-2.76
87.5	-8.38	-6.83	-7.90
90.0	-84.25	-85.65	-90.27

Table A-22. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 6.5 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Concluded)

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$

THETA	VERY DRY GROUND		
	5 MHz	17.5 MHz	30 MHz
0.0	-85.34	-85.81	-90.28
2.5	-18.98	-36.54	-19.01
5.0	-12.98	-29.95	-12.95
7.5	-9.48	-25.56	-9.37
10.0	-7.01	-22.00	-6.79
12.5	-5.11	-18.90	-4.77
15.0	-3.58	-16.13	-3.10
17.5	-2.30	-13.62	-1.69
20.0	-1.21	-11.34	-0.49
22.5	-0.27	-9.27	0.55
25.0	0.56	-7.39	1.45
27.5	1.28	-5.68	2.21
30.0	1.92	-4.13	2.85
32.5	2.49	-2.72	3.38
35.0	2.99	-1.44	3.81
37.5	3.43	-0.29	4.14
40.0	3.81	0.75	4.39
42.5	4.15	1.69	4.55
45.0	4.43	2.52	4.64
47.5	4.67	3.26	4.67
50.0	4.85	3.90	4.66
52.5	4.99	4.46	4.61
55.0	5.08	4.93	4.54
57.5	5.11	5.31	4.46
60.0	5.08	5.59	4.39
62.5	4.99	5.79	4.31
65.0	4.82	5.87	4.24
67.5	4.56	5.85	4.13
70.0	4.20	5.69	3.97
72.5	3.71	5.37	3.70
75.0	3.05	4.86	3.28
77.5	2.16	4.10	2.61
80.0	0.93	2.97	1.59
82.5	-0.83	1.29	0.00
85.0	-3.59	-1.42	-2.63
87.5	-8.81	-6.60	-7.77
90.0	-85.34	-85.81	-90.28

Table A-23. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 6.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$

$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

THETA	WET GROUND		
	5 MHz	17.5 MHz	30 MHz
0.0	-86.83	-87.34	-89.03
2.5	-20.59	-24.80	-17.30
5.0	-14.58	-18.75	-11.30
7.5	-11.08	-15.17	-7.83
10.0	-8.60	-12.59	-5.39
12.5	-6.69	-10.56	-3.54
15.0	-5.14	-8.87	-2.06
17.5	-3.84	-7.40	-0.86
20.0	-2.73	-6.10	0.14
22.5	-1.76	-4.93	0.96
25.0	-0.90	-3.86	1.64
27.5	-0.15	-2.87	2.20
30.0	0.53	-1.96	2.63
32.5	1.14	-1.11	2.96
35.0	1.69	-0.31	3.19
37.5	2.19	0.43	3.33
40.0	2.63	1.13	3.38
42.5	3.04	1.78	3.36
45.0	3.40	2.38	3.28
47.5	3.72	2.93	3.16
50.0	4.00	3.44	3.03
52.5	4.24	3.89	2.93
55.0	4.45	4.30	2.90
57.5	4.62	4.66	2.97
60.0	4.74	4.95	3.16
62.5	4.83	5.19	3.46
65.0	4.86	5.36	3.82
67.5	4.84	5.45	4.20
70.0	4.76	5.45	4.54
72.5	4.59	5.33	4.78
75.0	4.32	5.08	4.86
77.5	3.89	4.63	4.71
80.0	3.23	3.91	4.24
82.5	2.17	2.72	3.25
85.0	0.29	0.65	1.31
87.5	-3.78	-3.71	-2.99
90.0	-86.83	-87.34	-89.03

THETA	MOIST CLAY		
	5 MHz	17.5 MHz	30 MHz
0.0	-86.94	-86.36	-89.09
2.5	-20.59	-24.11	-16.89
5.0	-14.58	-18.06	-10.90
7.5	-11.07	-14.48	-7.42
10.0	-8.59	-11.92	-4.99
12.5	-6.68	-9.90	-3.14
15.0	-5.13	-8.21	-1.67
17.5	-3.83	-6.76	-0.47
20.0	-2.72	-5.48	0.53
22.5	-1.75	-4.33	1.36
25.0	-0.90	-3.28	2.05
27.5	-0.14	-2.31	2.62
30.0	0.54	-1.42	3.08
32.5	1.15	-0.59	3.44
35.0	1.70	0.18	3.71
37.5	2.20	0.90	3.90
40.0	2.65	1.56	4.01
42.5	3.05	2.18	4.05
45.0	3.41	2.75	4.04
47.5	3.73	3.27	3.99
50.0	4.01	3.75	3.92
52.5	4.26	4.17	3.85
55.0	4.46	4.54	3.79
57.5	4.63	4.85	3.78
60.0	4.76	5.11	3.82
62.5	4.84	5.30	3.90
65.0	4.88	5.41	4.02
67.5	4.86	5.44	4.13
70.0	4.77	5.37	4.20
72.5	4.60	5.18	4.18
75.0	4.32	4.83	4.00
77.5	3.88	4.26	3.59
80.0	3.20	3.38	2.84
82.5	2.09	1.99	1.53
85.0	0.16	-0.35	-0.78
87.5	-4.05	-5.09	-5.55
90.0	-86.94	-86.36	-89.09

Table A-23. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 6.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$

$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

THETA	MEDIUM DRY GROUND		
	5 MHz	17.5 MHz	30 MHz
0.0	-84.89	-86.24	-89.43
2.5	-19.42	-25.22	-17.46
5.0	-13.41	-19.14	-11.47
7.5	-9.91	-15.52	-8.00
10.0	-7.44	-12.88	-5.58
12.5	-5.54	-10.78	-3.74
15.0	-4.00	-9.01	-2.28
17.5	-2.72	-7.46	-1.09
20.0	-1.63	-6.08	-0.11
22.5	-0.68	-4.82	0.71
25.0	0.16	-3.67	1.38
27.5	0.89	-2.61	1.94
30.0	1.54	-1.62	2.40
32.5	2.12	-0.71	2.75
35.0	2.63	0.13	3.03
37.5	3.09	0.91	3.23
40.0	3.49	1.64	3.36
42.5	3.84	2.30	3.45
45.0	4.15	2.91	3.50
47.5	4.41	3.45	3.53
50.0	4.63	3.94	3.56
52.5	4.80	4.37	3.61
55.0	4.92	4.74	3.71
57.5	4.99	5.05	3.84
60.0	5.01	5.28	4.03
62.5	4.98	5.44	4.23
65.0	4.87	5.52	4.44
67.5	4.69	5.50	4.61
70.0	4.42	5.38	4.71
72.5	4.03	5.11	4.69
75.0	3.49	4.68	4.49
77.5	2.74	4.02	4.04
80.0	1.68	3.02	3.23
82.5	0.12	1.50	1.87
85.0	-2.39	-0.99	-0.51
87.5	-7.31	-5.90	-5.36
90.0	-84.89	-86.24	-89.43

THETA	SAND		
	5 MHz	17.5 MHz	30 MHz
0.0	-84.30	-85.52	-89.80
2.5	-19.17	-25.84	-18.03
5.0	-13.16	-19.74	-12.02
7.5	-9.66	-16.10	-8.52
10.0	-7.19	-13.44	-6.06
12.5	-5.29	-11.29	-4.17
15.0	-3.75	-9.47	-2.65
17.5	-2.47	-7.85	-1.40
20.0	-1.38	-6.40	-0.35
22.5	-0.43	-5.07	0.53
25.0	0.40	-3.84	1.27
27.5	1.13	-2.70	1.89
30.0	1.78	-1.64	2.41
32.5	2.35	-0.66	2.83
35.0	2.86	0.25	3.17
37.5	3.31	1.08	3.43
40.0	3.71	1.85	3.63
42.5	4.05	2.54	3.78
45.0	4.34	3.17	3.89
47.5	4.59	3.73	3.98
50.0	4.79	4.22	4.05
52.5	4.94	4.65	4.13
55.0	5.04	5.00	4.22
57.5	5.09	5.27	4.33
60.0	5.07	5.47	4.44
62.5	5.00	5.59	4.54
65.0	4.85	5.61	4.61
67.5	4.62	5.53	4.63
70.0	4.29	5.32	4.56
72.5	3.83	4.96	4.36
75.0	3.21	4.42	3.97
77.5	2.36	3.63	3.33
80.0	1.18	2.48	2.31
82.5	-0.54	0.78	0.72
85.0	-3.24	-1.93	-1.91
87.5	-8.40	-7.13	-7.05
90.0	-84.30	-85.52	-89.80

Table A-23. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 6.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Concluded)

(Elevation Angle $\psi = 90^\circ - \theta$)

$$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$$

THETA	VERY DRY GROUND		
	5 MHz	17.5 MHz	30 MHz
0.0	-85.30	-85.58	-89.90
2.5	-18.95	-32.45	-19.21
5.0	-12.94	-26.11	-13.17
7.5	-9.44	-22.07	-9.61
10.0	-6.98	-18.92	-7.06
12.5	-5.08	-16.22	-5.08
15.0	-3.55	-13.82	-3.45
17.5	-2.27	-11.65	-2.10
20.0	-1.18	-9.66	-0.94
22.5	-0.24	-7.84	0.04
25.0	0.58	-6.17	0.88
27.5	1.30	-4.64	1.59
30.0	1.94	-3.24	2.19
32.5	2.50	-1.96	2.68
35.0	3.00	-0.80	3.07
37.5	3.44	0.26	3.38
40.0	3.83	1.21	3.62
42.5	4.16	2.06	3.79
45.0	4.44	2.82	3.92
47.5	4.67	3.50	4.02
50.0	4.85	4.08	4.11
52.5	4.99	4.59	4.19
55.0	5.07	5.00	4.28
57.5	5.10	5.34	4.38
60.0	5.07	5.58	4.49
62.5	4.97	5.73	4.59
65.0	4.80	5.79	4.66
67.5	4.55	5.73	4.68
70.0	4.19	5.54	4.61
72.5	3.69	5.20	4.41
75.0	3.03	4.67	4.02
77.5	2.14	3.88	3.38
80.0	0.91	2.74	2.36
82.5	-0.85	1.05	0.77
85.0	-3.61	-1.66	-1.86
87.5	-8.83	-6.86	-7.00
90.0	-85.30	-85.58	-89.90

Table A-24. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 7.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 30, \sigma = 15 \text{ mS/m}$

THETA	WET GROUND		
	5 MHz	17.5 MHz	30 MHz
0.0	-87.01	-87.46	-89.83
2.5	-20.68	-27.43	-16.74
5.0	-14.66	-21.36	-10.72
7.5	-11.16	-17.75	-7.20
10.0	-8.68	-15.13	-4.70
12.5	-6.77	-13.04	-2.78
15.0	-5.21	-11.27	-1.21
17.5	-3.91	-9.72	0.10
20.0	-2.80	-8.33	1.21
22.5	-1.82	-7.04	2.17
25.0	-0.97	-5.85	2.99
27.5	-0.20	-4.74	3.70
30.0	0.48	-3.69	4.30
32.5	1.09	-2.69	4.79
35.0	1.65	-1.75	5.19
37.5	2.15	-0.86	5.50
40.0	2.60	-0.01	5.70
42.5	3.01	0.78	5.80
45.0	3.37	1.53	5.80
47.5	3.70	2.23	5.69
50.0	3.98	2.87	5.48
52.5	4.23	3.46	5.16
55.0	4.44	4.00	4.74
57.5	4.62	4.47	4.23
60.0	4.75	4.89	3.66
62.5	4.84	5.23	3.05
65.0	4.88	5.49	2.48
67.5	4.86	5.67	1.99
70.0	4.78	5.75	1.63
72.5	4.62	5.71	1.38
75.0	4.35	5.52	1.19
77.5	3.92	5.13	0.93
80.0	3.26	4.44	0.44
82.5	2.20	3.29	-0.52
85.0	0.33	1.25	-2.41
87.5	-3.74	-3.10	-6.67
90.0	-87.01	-87.46	-89.83

$\epsilon_r = 10, \sigma = 15 \text{ mS/m}$

THETA	MOIST CLAY		
	5 MHz	17.5 MHz	30 MHz
0.0	-87.08	-86.35	-90.13
2.5	-20.68	-26.68	-17.24
5.0	-14.67	-20.61	-11.22
7.5	-11.16	-17.00	-7.70
10.0	-8.68	-14.38	-5.20
12.5	-6.77	-12.30	-3.27
15.0	-5.21	-10.53	-1.70
17.5	-3.91	-8.99	-0.38
20.0	-2.79	-7.61	0.74
22.5	-1.82	-6.34	1.71
25.0	-0.96	-5.17	2.55
27.5	-0.20	-4.08	3.27
30.0	0.48	-3.05	3.89
32.5	1.10	-2.09	4.41
35.0	1.65	-1.18	4.83
37.5	2.15	-0.31	5.17
40.0	2.61	0.50	5.41
42.5	3.01	1.26	5.57
45.0	3.38	1.97	5.63
47.5	3.71	2.63	5.60
50.0	3.99	3.24	5.48
52.5	4.24	3.79	5.27
55.0	4.45	4.28	4.97
57.5	4.63	4.72	4.61
60.0	4.76	5.08	4.18
62.5	4.85	5.38	3.71
65.0	4.89	5.59	3.23
67.5	4.87	5.71	2.76
70.0	4.79	5.71	2.30
72.5	4.62	5.59	1.84
75.0	4.34	5.30	1.34
77.5	3.91	4.78	0.71
80.0	3.22	3.95	-0.18
82.5	2.12	2.59	-1.56
85.0	0.19	0.28	-3.91
87.5	-4.02	-4.44	-8.69
90.0	-87.08	-86.35	-90.13

Table A-24. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 7.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Continued)

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 10, \sigma = 1.5 \text{ mS/m}$

$\epsilon_r = 4, \sigma = 1.5 \text{ mS/m}$

MEDIUM DRY GROUND			
THETA	5 MHz	17.5 MHz	30 MHz
0.0	-85.09	-86.53	-89.88
2.5	-19.51	-27.99	-17.19
5.0	-13.50	-21.87	-11.18
7.5	-10.00	-18.20	-7.67
10.0	-7.53	-15.49	-5.19
12.5	-5.63	-13.29	-3.28
15.0	-4.09	-11.41	-1.74
17.5	-2.80	-9.74	-0.45
20.0	-1.70	-8.22	0.65
22.5	-0.75	-6.83	1.58
25.0	0.09	-5.53	2.39
27.5	0.83	-4.32	3.09
30.0	1.48	-3.18	3.68
32.5	2.06	-2.12	4.17
35.0	2.58	-1.13	4.58
37.5	3.04	-0.20	4.89
40.0	3.45	0.67	5.11
42.5	3.81	1.47	5.25
45.0	4.12	2.21	5.30
47.5	4.39	2.89	5.26
50.0	4.61	3.51	5.14
52.5	4.78	4.06	4.94
55.0	4.91	4.54	4.69
57.5	4.99	4.95	4.38
60.0	5.01	5.28	4.05
62.5	4.98	5.54	3.73
65.0	4.88	5.70	3.42
67.5	4.71	5.76	3.14
70.0	4.44	5.70	2.88
72.5	4.05	5.50	2.61
75.0	3.52	5.12	2.25
77.5	2.77	4.51	1.72
80.0	1.71	3.55	0.89
82.5	0.15	2.06	-0.48
85.0	-2.36	-0.41	-2.85
87.5	-7.28	-5.31	-7.69
90.0	-85.09	-86.53	-89.88

SAND			
THETA	5 MHz	17.5 MHz	30 MHz
0.0	-84.33	-85.83	-90.14
2.5	-19.26	-31.45	-18.31
5.0	-13.25	-25.19	-12.27
7.5	-9.75	-21.28	-8.73
10.0	-7.28	-18.28	-6.20
12.5	-5.37	-15.75	-4.23
15.0	-3.83	-13.51	-2.63
17.5	-2.55	-11.49	-1.27
20.0	-1.45	-9.64	-0.11
22.5	-0.50	-7.93	0.89
25.0	0.33	-6.35	1.76
27.5	1.07	-4.89	2.51
30.0	1.72	-3.54	3.16
32.5	2.30	-2.30	3.70
35.0	2.81	-1.16	4.16
37.5	3.27	-0.11	4.52
40.0	3.67	0.85	4.79
42.5	4.02	1.72	4.99
45.0	4.32	2.51	5.10
47.5	4.57	3.21	5.13
50.0	4.77	3.84	5.10
52.5	4.93	4.39	5.00
55.0	5.03	4.85	4.86
57.5	5.08	5.23	4.67
60.0	5.08	5.53	4.45
62.5	5.01	5.73	4.21
65.0	4.87	5.83	3.96
67.5	4.64	5.82	3.69
70.0	4.31	5.68	3.38
72.5	3.86	5.38	2.99
75.0	3.23	4.89	2.48
77.5	2.39	4.14	1.75
80.0	1.21	3.03	0.69
82.5	-0.51	1.36	-0.93
85.0	-3.21	-1.34	-3.57
87.5	-8.36	-6.52	-8.72
90.0	-84.33	-85.83	-90.14

Table A-24. Antenna Directivity in dBi versus Polar Angle Theta (θ) for Three Frequencies and Five Soil Conditions, for 7.0 Meter High Monopole with 12 Meter Radius Ground Screen of 16 Radials (Concluded)

(Elevation Angle $\psi = 90^\circ - \theta$)

$\epsilon_r = 4, \sigma = 0.15 \text{ mS/m}$

THETA	VERY DRY GROUND		
	5 MHz	17.5 MHz	30 MHz
0.0	-85.40	-86.10	-90.12
2.5	-19.02	-37.48	-19.35
5.0	-13.01	-31.14	-13.28
7.5	-9.51	-27.05	-9.67
10.0	-7.04	-23.71	-7.06
12.5	-5.15	-20.69	-5.00
15.0	-3.61	-17.89	-3.28
17.5	-2.33	-15.27	-1.82
20.0	-1.24	-12.85	-0.56
22.5	-0.30	-10.62	0.54
25.0	0.53	-8.58	1.50
27.5	1.26	-6.72	2.33
30.0	1.90	-5.04	3.03
32.5	2.47	-3.51	3.63
35.0	2.97	-2.12	4.12
37.5	3.41	-0.87	4.51
40.0	3.80	0.26	4.80
42.5	4.14	1.27	5.00
45.0	4.43	2.18	5.11
47.5	4.66	2.99	5.14
50.0	4.85	3.70	5.10
52.5	4.99	4.31	5.00
55.0	5.08	4.83	4.84
57.5	5.11	5.26	4.65
60.0	5.09	5.59	4.44
62.5	5.00	5.82	4.21
65.0	4.83	5.95	3.98
67.5	4.58	5.96	3.73
70.0	4.22	5.83	3.44
72.5	3.73	5.54	3.08
75.0	3.07	5.06	2.59
77.5	2.18	4.31	1.88
80.0	0.96	3.20	0.83
82.5	-0.81	1.53	-0.77
85.0	-3.57	-1.16	-3.41
87.5	-8.79	-6.34	-8.55
90.0	-85.40	-86.10	-90.12