Figure 13a 28 GHz horn MAXAMP=21.14 dB
09-15-1994 FREQ.=28GHZ

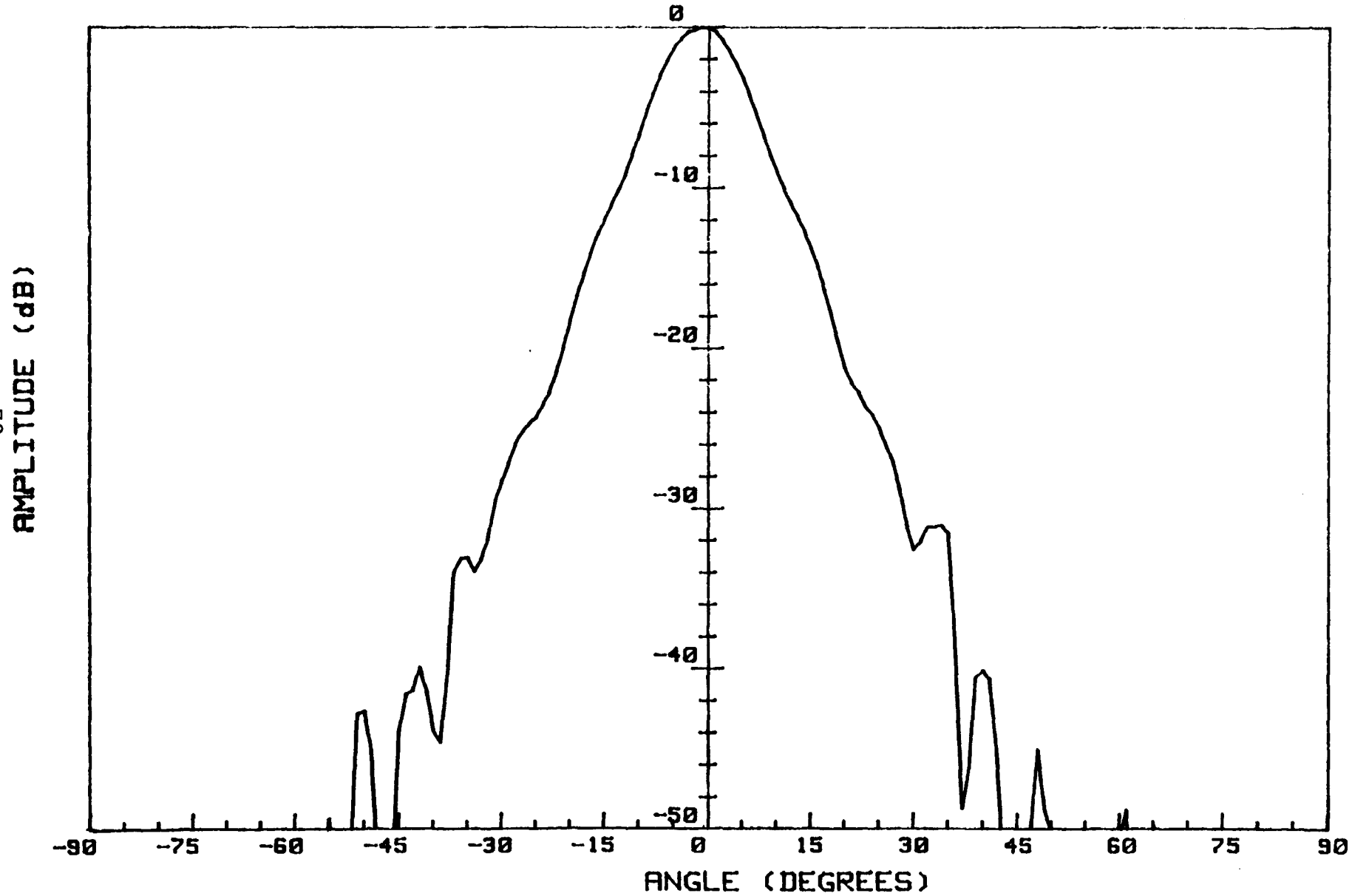


Table 2. Parameters and Antenna Pattern Model for ACTS LBR-2 2.44 meter Terminal

Frequency : 29.25 GHz

Antenna diameter: 2.44 m (8 ft)

Peak antenna gain (dBi): 55.23

Uplink transmit Power (dBW): 16.02 (40 W)

Uplink transmit EIRP (dBW): 68.52 (includes 2.73 dB feed loss)

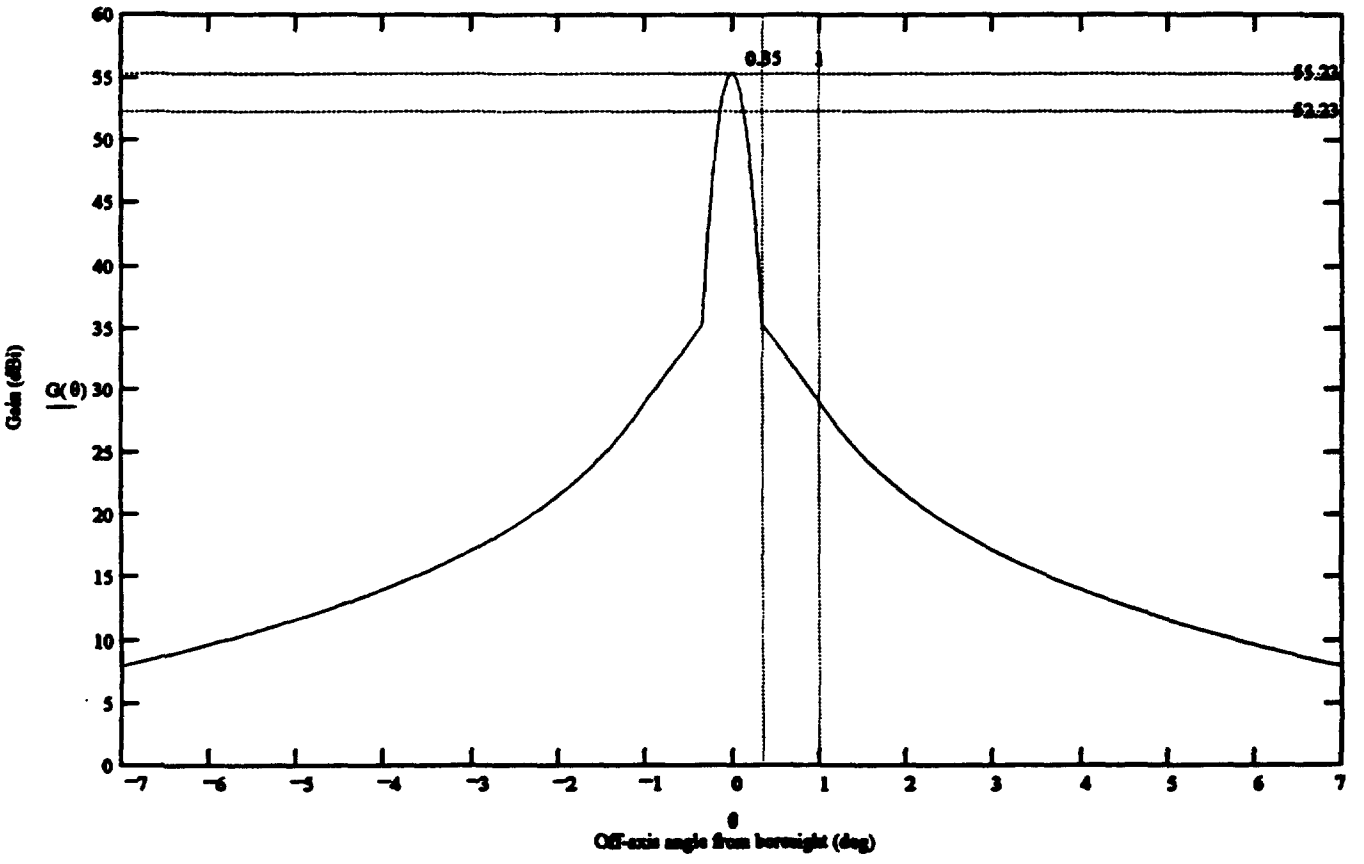
Data rate : 220 Mbps (SMSK modulation)

Channel Bandwidth: 330 MHz

Linear polarization

Approximation to ACTS LBR-2 2.44 meter Terminal Transmit Antenna Pattern

(Pattern over ± 7° Off-axis Angle Range)



$f = 29.25$ GHz

$G_{max} = 55.23$ dBi

$\theta_{3dB} = 0.3°$

$\theta_{10dB} = 0.5°$

$\theta_{20dB} = 0.7°$

for $0° <= \theta <= .35°$, the gain is $G_{max} - 12(\theta/\theta_{3dB})^2$ dBi

for $.35° < \theta <= 1°$, the gain is $-9.5846*\theta + 38.5846$ dBi

for $1° < \theta <= 7°$, the gain is $29 - 25 \log(\theta)$ dBi

for $7° < \theta <= 9.2°$, the gain is 8 dBi

for $9.2° < \theta <= 48°$, the gain is $32 - 25 \log(\theta)$ dBi

for $48° < \theta <= 75°$, the gain is -10 dBi

for $75° < \theta <= 100°$, the gain is -6 dBi

for $100° < \theta <= 180°$, the gain is -15 dBi

Figure 13b **Antenna Pattern model for the 2.44 meter antenna**

FIGURE 13 c EndGate NBA#4 28 GHz MAXAMP=18.9 dB
09-15-1994 FREQ.=28GHZ

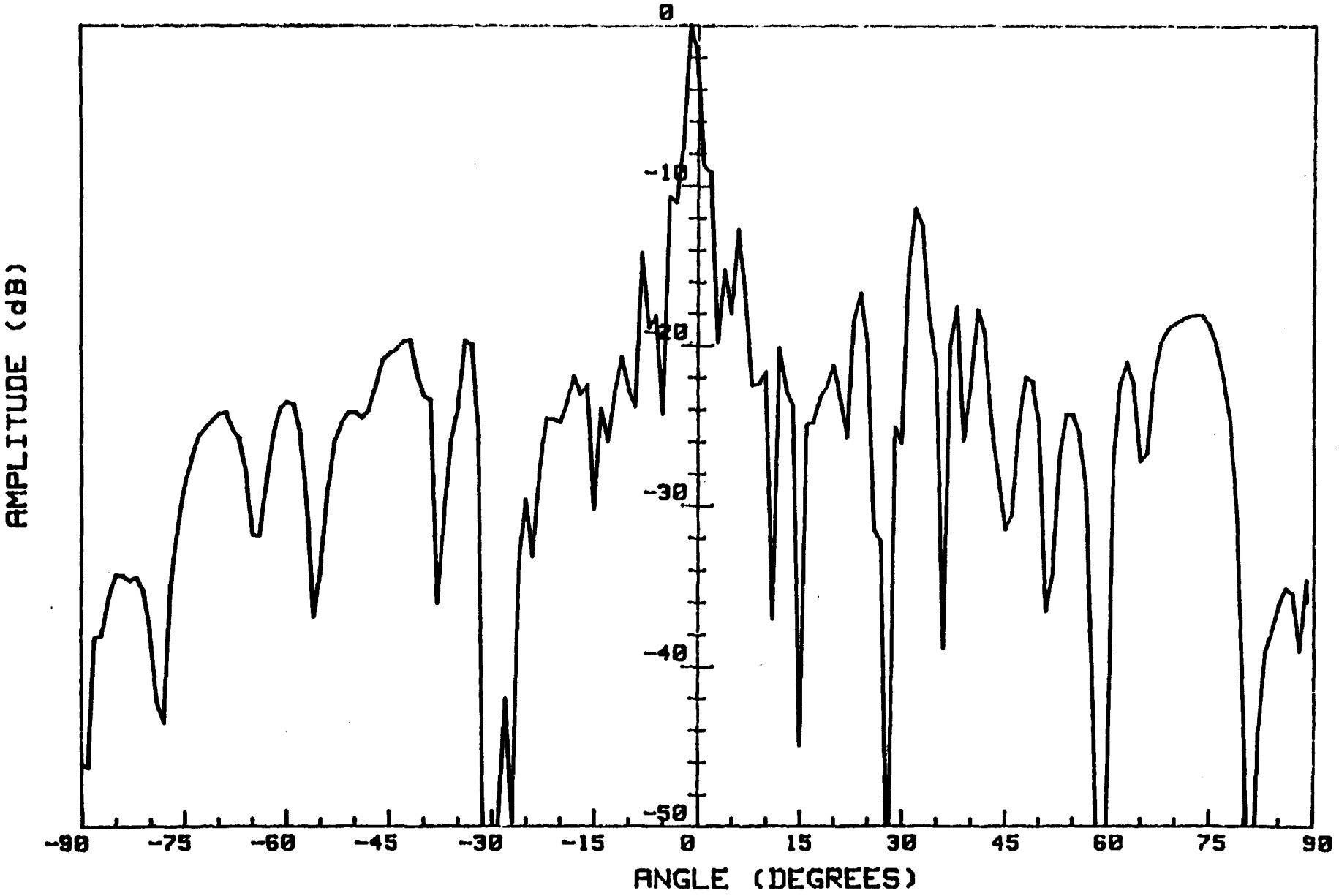


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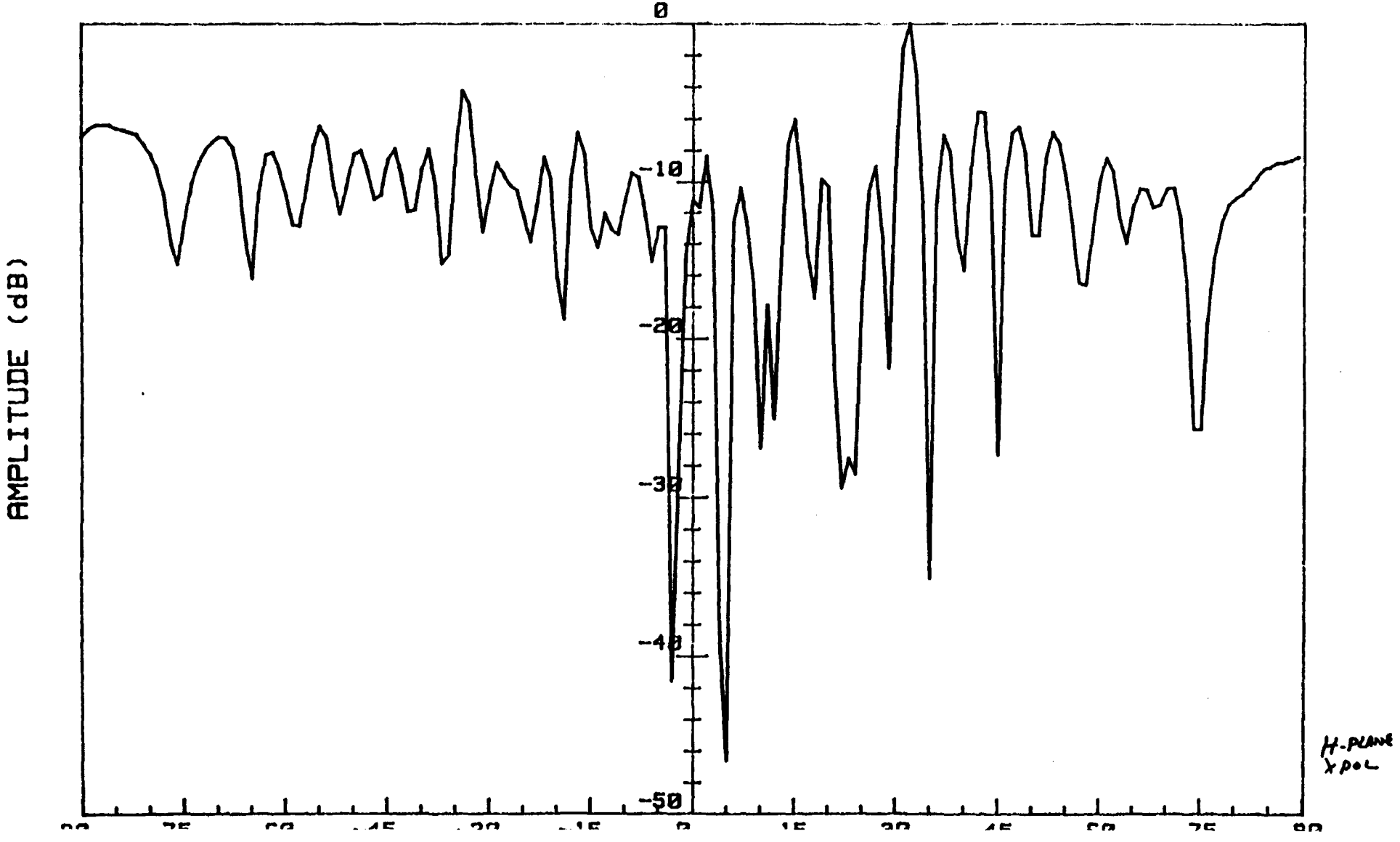
Figure 13d EndGate NBA#4 28 GHz MAXAMP=8.47 dB
09-15-1994 FREQ.=28GHZ



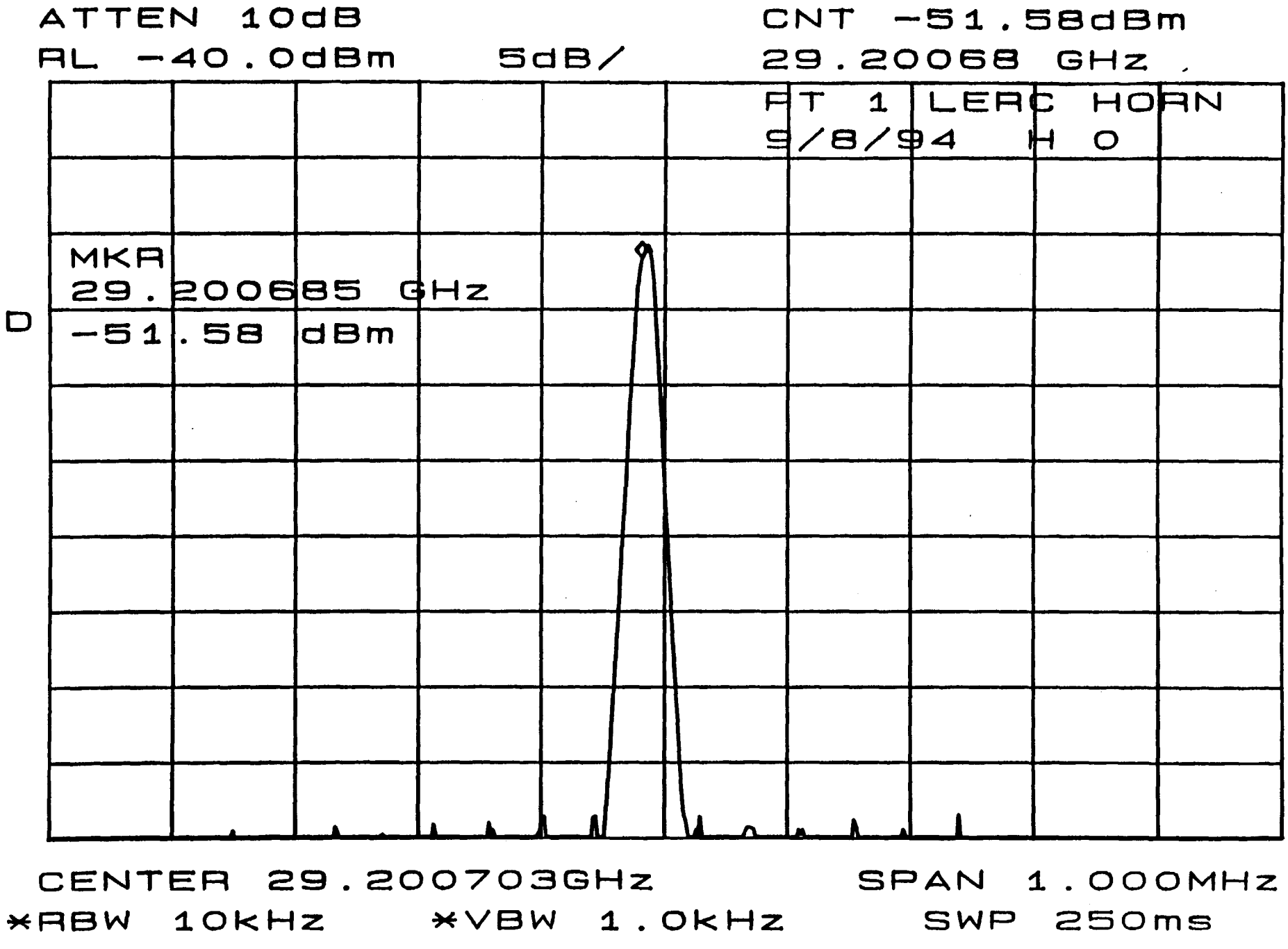


Figure 14 Field measurement at point 2 (200 ft, on INTEX boresight) for Lewis horn, horizontal polarization

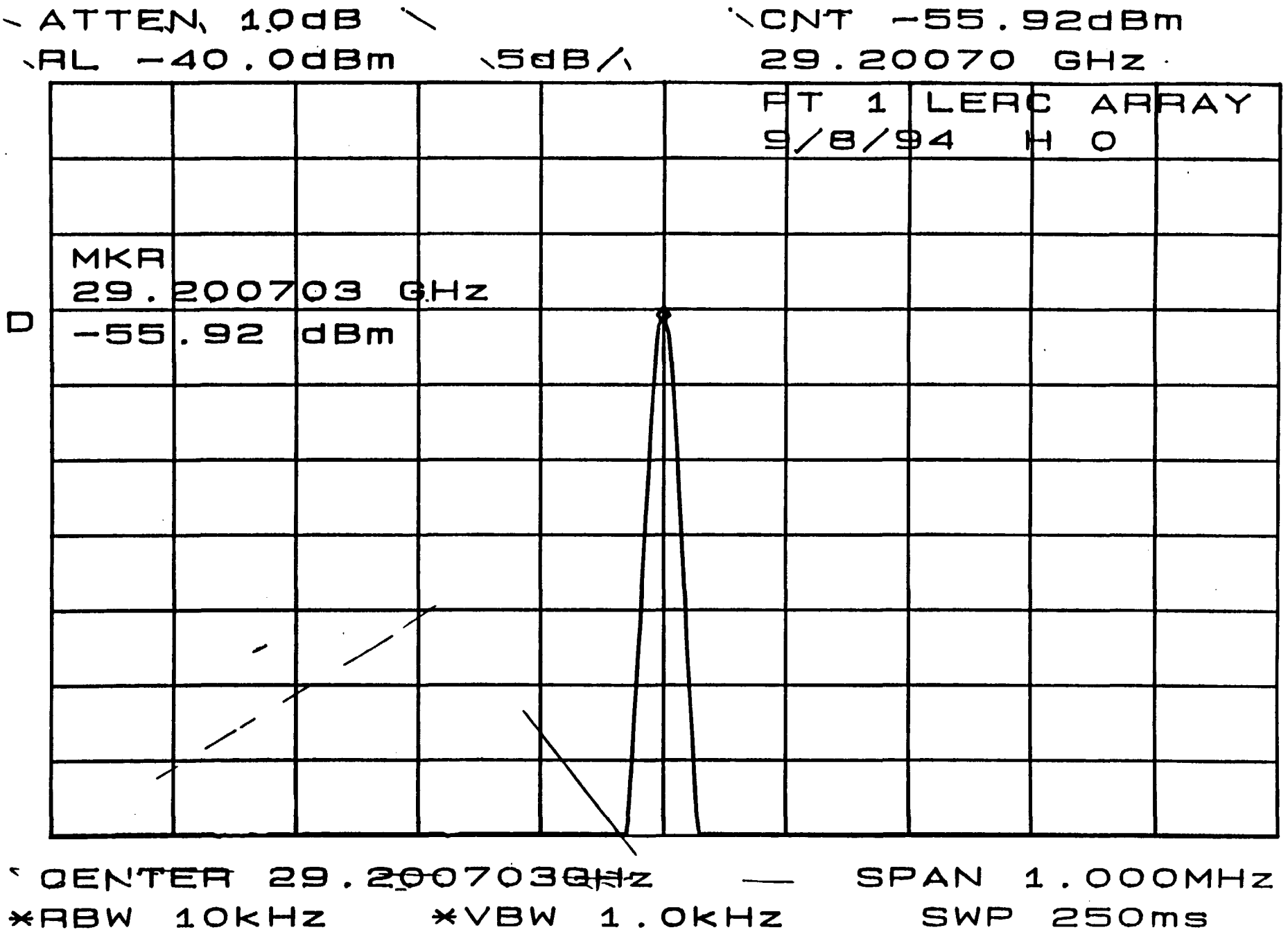


Figure 15 Field measurement at point 2 (200 ft, on INTEX boresight) for Lewis array, horizontal polarization

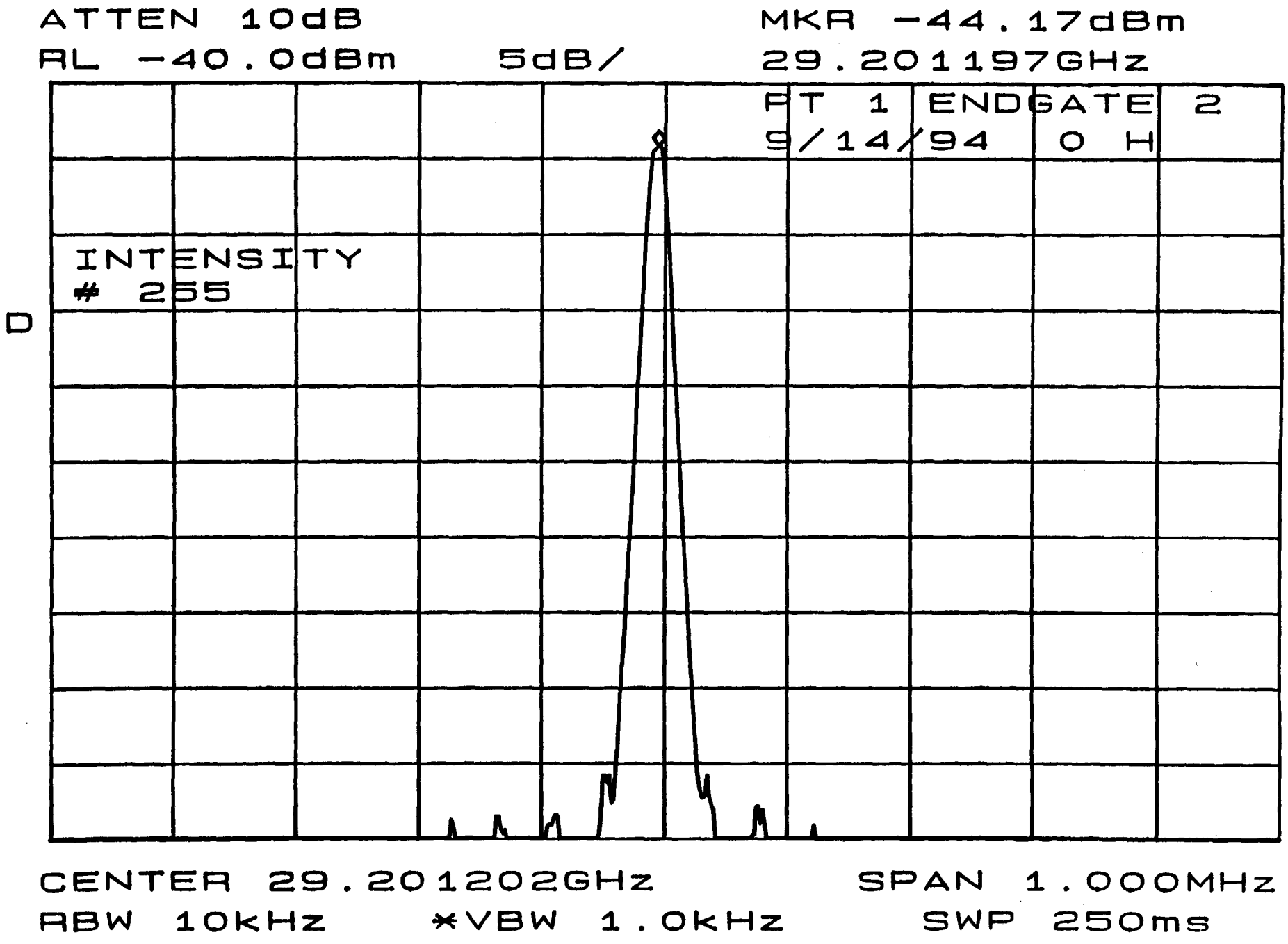


Figure 16 Field measurement at point 2 (200 ft, on INTEX boresight) for Endgate array, horizontal polarization

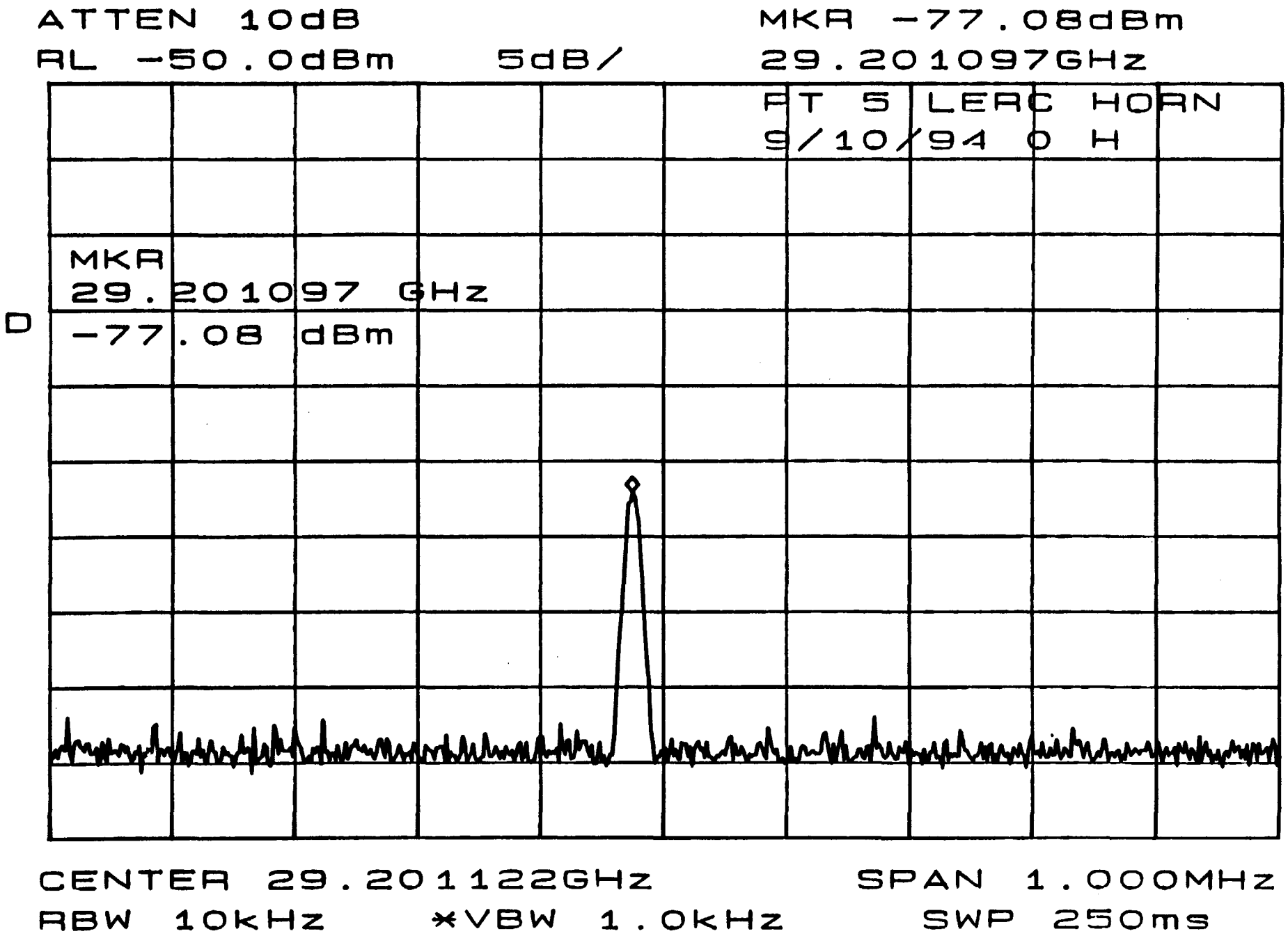


Figure 17 Field measurement at point 5 (1500 ft, on INTEX boresight) for Lewis horn, horizontal polarization

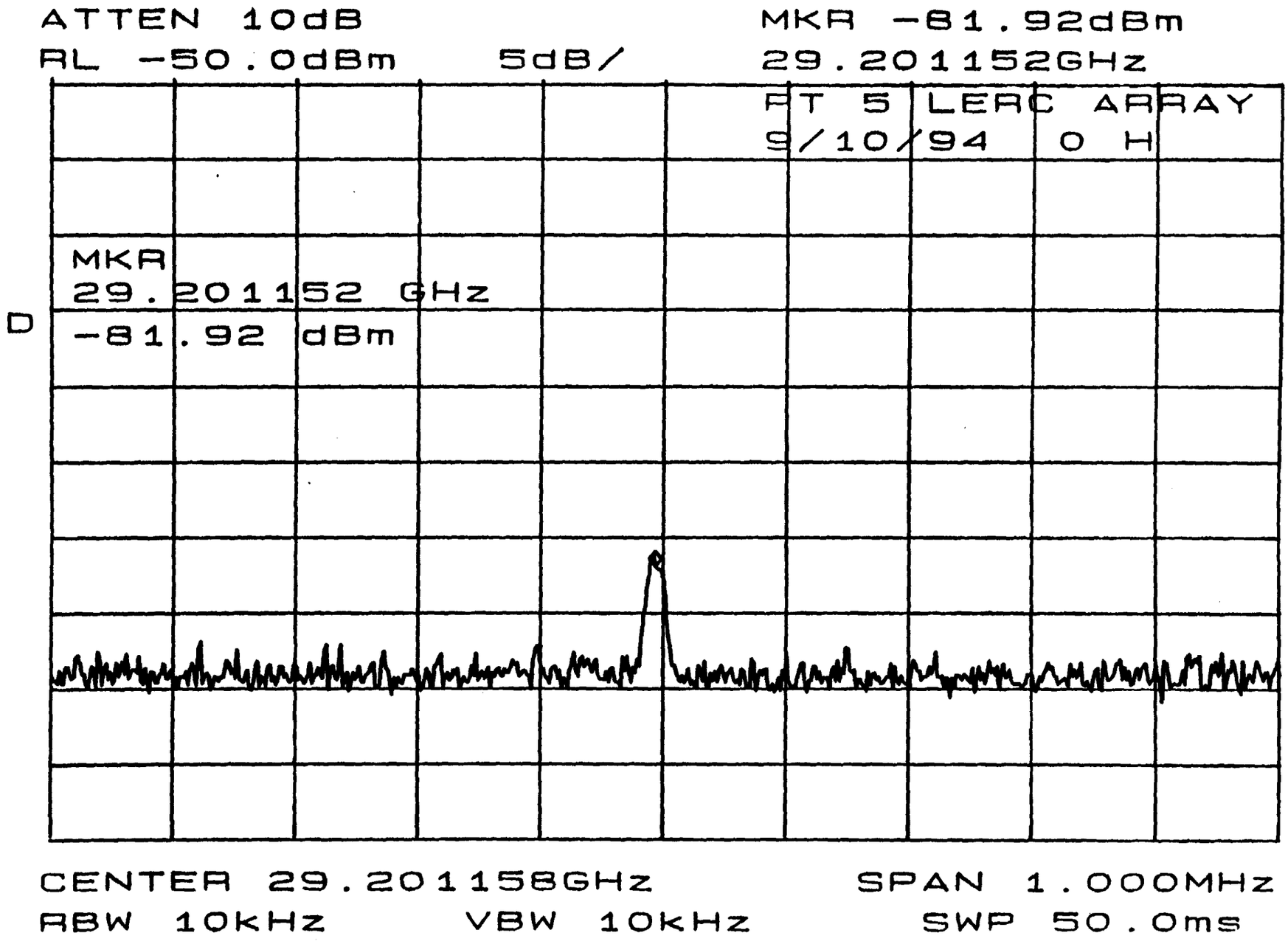
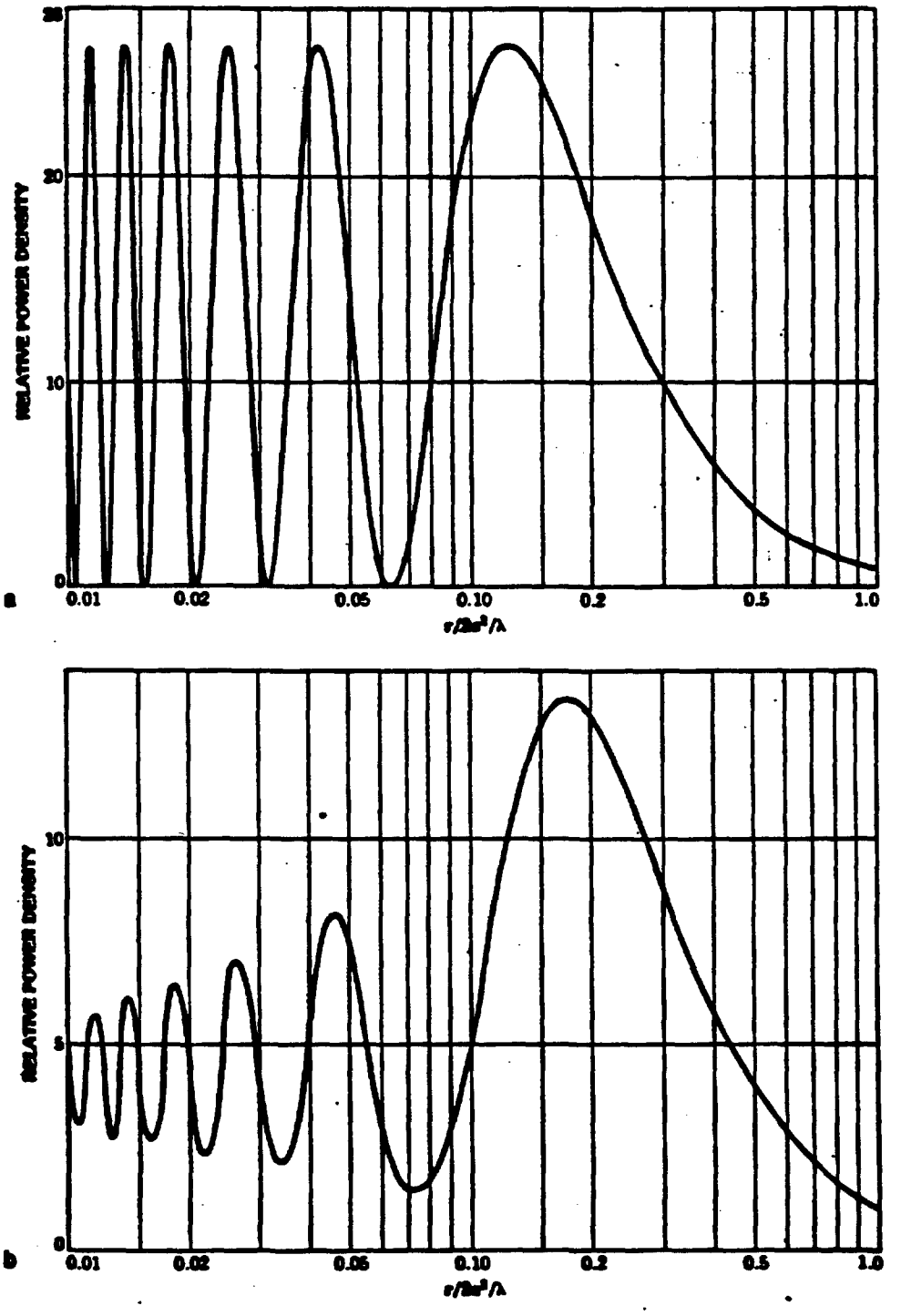


Figure 18 Field measurement at point 5 (1500 ft, on INTEX boresight) for Lewis array, horizontal polarization



Axial power density in the near field of uniform distributions. (*a*) Circular aperture of diameter *a*; (*b*) Square aperture of side *a*.(*After Jull [5], © 1981 Peter Peregrinus Ltd.*)

Figure 19 Near-field power distributions for circular and square apertures, from Lee and Lo, Antenna Handbook, Van Nostrand Reinhold, 1988.

Table 1 : ALONG INTEX Boresight

All Readings in dBm

Distance, Ft		200		400		500		1000		1500	
$r / 2D^2/\lambda$		0.05 FF		0.10 FF		0.13 FF		0.26 FF		0.39 FF	
PT.In Map		1		2		3		4		5	
		V	H	V	H	V	H	V	H	V	H
0°	Lewis Array	-58.08	-55.92	-55.08	-48.33	-61.50	-49.80	-68.25	-64.92	-88.50	-81.92
	Horn	-59.42	-51.58	-50.17	-40.17	-58.83	-47.33	-65.25	-55.00	-78.58	-77.08
	Endgate Array	-44.14	-63.50	-54.75	-48.17	-62.58	-52.50				
180°	Lewis Array	-76.17	-68.00	-78.25	-77.67	-77.58	-80.92	-86.92	-76.08	-91.25	-88.67
	Horn	-50.00	-68.08	-79.92	-80.33	-91.25	-84.92	-90.83	-82.58	-89.33	-86.67
	Endgate Array	-74.58	-77.67	-71.25	-70.92	-79.25	-74.58				
45°W	Lewis Array	-63.08	-52.08	-64.33	-61.00	-65.42	-49.17	-71.25	-63.83	-89.33	-89.58
	Horn	-84.42	-73.58	-74.33	-66.42	-86.67	-73.75	-91.33	-75.75	-93.00	-88.42
	Endgate Array	-60.92	-66.25	-57.67	-59.67	-60.92	-65.58				
45°E	Lewis Array	-65.58	-65.75	-67.08	-66.67	-67.67	-62.67	-71.42	-70.75	-88.58	-88.08
	Horn	-74.75	-63.75	-78.25	-59.33	-81.75	-67.58	-89.92	-74.08	-95.17	-91.75
	Endgate Array	-68.67	-57.17	-58.50	-65.58	-68.25	-74.58				
90°W	Lewis Array	-67.83	-61.25	-67.17	-65.67	-71.83	-70.67	-76.00	-69.25	-90.00	-85.17
	Horn	-81.67	-80.58	-79.67	-69.75	-88.25	-75.67	-94.42	-83.25	-90.83	-85.42
	Endgate Array	-62.75	-61.17	63.75	-62.08	-68.25	-67.67				
90°E	Lewis Array	-69.92	-56.08	-66.92	-57.25	-69.67	-59.75	-72.08	-62.83	-89.25	-89.08
	Horn	-82.08	-66.58	-82.00	-69.83	-85.08	-73.42	-94.83	-81.25	-92.25	-93.00
	Endgate Array	-58.17	-63.83	-63.92	-60.75	-69.75	-65.83				

Table 2: 30 DEGREES OFF INTEX Boresight

All Readings in dBm

Distance, Ft $r / 2D^2/\lambda$ PT.in Map		200 0.05 FF 6		400 0.10 FF 7		500 0.13 FF 8		1000 0.26 FF 9		1500 0.39 FF	
		V	H	V	H	V	H	V	H	V	H
0°	Array	-55.00	-45.17	-61.17	-66.75	-79.83	-77.17				
	Horn	-53.58	-43.67	-52.33	-45.58	-83.67	-69.58				
180°	Array	-76.58	-76.33	-75.25	-81.25	-81.58	-76.75				
	Horn	-80.50	-72.92	-72.00	-77.92	-79.50	-74.42				
45°W	Array	-64.58	-65.67	-69.58	-70.50	-80.00	-79.25				
	Horn	-83.25	-67.32	-84.00	-71.17	-73.33	-77.5				
45°E	Array	-64.75	-62.00	-69.50	-66.50	-82.42	-79.42				
	Horn	-77.92	-64.92	-73.67	-69.25	-86.33	-75.75				
90°W	Array	-67.42	-66.67	-71.92	-71.75	-85.08	-77.08				
	Horn	-76.5	-70.17	-89.17	-75.83	-90.42	-86.83				
90°E	Array	-72.33	-69.42	-76.08	-70.83	-85.75	-83.58				
	Horn	-82.25	-74.50	-83.33	-76.33	-87.50	-83.83				

All Readings in dBm

Table 3 : 45 DEGREES OFF INTEX Boresight

Distance, Ft $r / 2D^2/\lambda$ PT.in Map		200 0.05 FF 10 V	 H	400 0.10 FF 11 V	 H	500 0.13 FF 12 V	 H	1000 0.26 FF 13 V	 H	1500 0.39 FF V	 H
0°	Array	-50.58	-46.58	-69.42	-70.50	-86.67	-87.25	NOISE	NOISE		
	Horn	-48.42	-45.33	-63.83	-63.67	-86.42	-81.42	NOISE	NOISE		
180°	Array	-76.42	-76.92	-83.25	-82.25	-90.25	-91.17	NOISE	NOISE		
	Horn	-76.50	-78.50	-81.92	-78.92	-93.17	-93.17	NOISE	NOISE		
45°W	Array	-62.83	-56.92	-79.50	-78.33	-91.17	-83.42	NOISE	NOISE		
	Horn	-70.92	-68.83	-78.33	-76.50	-91.75	-89.75	NOISE	NOISE		
45°E	Array	-66.33	-65.83	-77.75	-80.33	-88.42	-85.00	NOISE	NOISE		
	Horn	-80.42	-70.08	-79.33	-75.92	-86.92	-81.67	NOISE	NOISE		
90°W	Array	-73.83	-62.00	-78.58	-81.25	-90.83	-89.25	NOISE	NOISE		
	Horn	-73.83	-69.92	-75.67	-79.00	-93.17	-91.58	NOISE	NOISE		
90°E	Array	-67.58	-60.75	-81.08	-78.00	-89.17	-88.75	NOISE	NOISE		
	Horn	-76.00	-75.00	-88.50	-81.42	-84.58	-84.42	NOISE	NOISE		

Table 4 : 90 DEGREES OFF INTEX Boresight

All Readings in dBm

Distance, Ft $r / 2D^2/\lambda$ PT.In Map		200 0.05 FF 14		400 0.10 FF 15		500 0.13 FF		1000 0.26 FF		1500 0.39 FF	
		V	H	V	H	V	H	V	H	V	H
0°	Array	-63.33	-60.33								
	Horn	-56.67	-55.42								
180°	Array	-82.50	-81.17								
	Horn	-68.67	-74.75								
45°W	Array	-83.00	-70.50								
	Horn	-74.58	-72.83								
45°E	Array	-78.42	-79.00								
	Horn	-80.67	-81.67								
90°W	Array	-75.50	-76.33								
	Horn	-77.83	-77.25								
90°E	Array	-79.83	-74.33								
	Horn	-87.42	-84.33								

IV. CONCLUSIONS

Conclusion 1.

1. Concerning FSS Earth station transmitters interfering into LMDS receivers, the Committee did not find a technical solution, based on the system characteristics and methodologies considered, for co-frequency sharing between FSS and LMDS services that was deemed feasible by any combination of LMDS and FSS proponents.

2. Sharing problems, in large part, are due to the proposed widespread distribution of both FSS Earth stations and LMDS receivers throughout the same geographic areas, and the desire to impose minimal restrictions on the siting and operation of both.

3. The Committee considered all proposed solutions presented to it by the participants; however, none were deemed feasible by any combination of LMDS and FSS proponents.

4. In addition, a number of operational and interference mitigation techniques to assist sharing were identified. Modeling methods could not be developed, within the time frame allowed by this Committee's charter, to statistically assess the full impact of mitigating techniques and factors. Similarly, modeling methods to statistically and analytically assess the impact of environmental factors, and diffuse and specular scattering could not be developed in the time allowed.

Conclusion 2.

1. Concerning LMDS transmitters interfering with FSS satellite receivers, and based on the system characteristics and methodologies considered, analyses have shown that in most cases, interferences from hub-to-subscriber transmissions for present LMDS and FSS system designs provide positive margins. One (AM video) out of 25 cases analyzed, had a negative margin in clear air. For one additional case, a slight negative margin existed under intense rain conditions. In such cases of negative margin, mitigating factors or techniques need to be applied; however, they were not analyzed.

2. Based on the system characteristics and methodologies considered, subscriber-to-hub transmissions as modeled have five out of 25 cases with negative margins in clear air, but these margins are of smaller magnitude than those for hub-to-subscriber transmissions. For one additional case, a slight negative margin existed under intense rain conditions. In such cases of negative margin, mitigating factors or techniques need to be applied; however, they were not analyzed.

3. Based on the system characteristics and methodologies considered, aggregate limits on the power spectral density (dBW/Hz/km^2) can preclude interference to satellite receivers. Although discussions occurred concerning the form and content of compliance provisions, agreement could not be reached on the feasibility of enforcement.

Conclusion 3.

There is currently only one potential non-geostationary MSS operator proposing to use spectrum in the 27.5 - 29.5 GHz band for feeder link transmissions. Three other potential non-geostationary MSS operators have requested feeder link spectrum at or below 15 GHz, and one has requested feeder link spectrum at 29.5 - 30.0 GHz. The Committee recognized that the Commission has indicated that it may attempt to accommodate feeder link requirements of all five (5) non-geostationary MSS applicants in the 27.5 - 30.0 GHz band. (See FCC CC Docket No. 92-166 and CC Docket No. 92-297.) Accommodating all of these non-geostationary MSS operator feeder link requirements in the 27.5 - 29.5 GHz band would greatly complicate the sharing environment between non-geostationary MSS feeder links as well as between non-geostationary MSS feeder links and the LMDS service. Accordingly, the Committee recommends that the Commission designate spectrum outside of the 27.5 - 29.5 GHz band to accommodate the feeder link requirements of the four (4) non-geostationary MSS operators that have not previously applied to use spectrum in the 27.5 - 29.5 GHz band.

Conclusion 4.

The Committee concluded that unrestricted sharing of the band (27.5 - 29.5 GHz) is not possible due to the interference level anticipated from LMDS backbone and subscriber transmitters into non-geostationary MSS feeder link receivers and due to the interference level anticipated from non-geostationary MSS feeder link transmitters into LMDS receivers. The orbital design of the satellites associated with these feeder links results in LMDS subscriber transmitter antenna 'look angles' being on-boresight with the satellite receivers. To minimize the potential interference problem, the Committee recommends that an EIRP limit be placed on LMDS backbone point-to-point microwave links, and that the power spectral density radiated toward the horizon by LMDS hubs not exceed the level which would result in unacceptable interference into a non-geostationary MSS satellite receiver. This Committee also recognized that interference from LMDS subscriber terminals to non-geostationary MSS feeder links is a significant issue which may require mitigation measures. One option discussed was that LMDS subscriber transmitters be precluded from operating in a prescribed portion of the band.

Conclusion 5.

The Committee believed that a coordination procedure is required to preclude unacceptable interference from non-geostationary MSS feeder link systems to LMDS receivers. One option discussed was a rule to require that non-geostationary MSS feeder link Earth stations be located at an appropriate distance from the boundary of certain metropolitan statistical areas. However, there remains the need for all potentially affected parties to have access to coordination information to enable them to maximize their use of the spectrum.

Conclusion 6.

The Committee concluded that Table 4-1, entitled "Clear Air Earth-to-Space Atmospheric Loss vs. Elevation Angle," contained in the Working Group 2 report (Document NRMC-82), should be used as the basis for determining atmospheric attenuation of low elevation Earth-to-space signals in the 27.5 - 29.5 GHz band. (See page 87, infra.) This Table is modeled in accordance with CCIR Report 719, "Attenuation by Atmospheric Gases" and is displayed

Table 4-1: Clear Air Earth-to-Space Atmospheric Loss vs. Elevation Angle

Rain-Climatic Zone 1		Rain-Climatic Zone 2		Rain-Climatic Zone 3-5	
El. Angle	Atmos.Attn.	El. Angle	Atmos.Attn.	El. Angle	Atmos.Attn.
deg.	dB	deg.	dB	deg.	dB
0.0	19.1	0.0	11.0	0.0	6.8
0.5	13.5	0.5	8.0	0.5	5.1
1.5	8.2	1.5	5.0	1.5	3.3
2.6	5.6	2.6	3.5	2.6	2.4
3.7	4.2	3.7	2.6	3.7	1.8
4.9	3.2	4.9	2.1	4.9	1.4
6.1	2.7	6.1	1.7	6.1	1.2
7.4	2.2	7.4	1.4	7.4	1.0
8.8	1.9	8.8	1.2	8.8	0.8
10.2	1.6	10.2	1.1	10.2	0.7
11.8	1.4	11.8	0.9	11.8	0.6
13.4	1.3	13.4	0.8	13.4	0.6
25.0	0.7	25.0	0.4	25.0	0.3
30.0	0.6	30.0	0.4	30.0	0.3
45.0	0.4	45.0	0.3	45.0	0.2
60.0	0.3	60.0	0.2	60.0	0.2
75.0	0.3	75.0	0.2	75.0	0.1
90.0	0.3	90.0	0.2	90.0	0.1

This table is based on information developed in CCIR Report 719.

below. The specific section of the CCIR Report that deals with this type of atmospheric attenuation is Section 3.2.2., "Elevation angle between 0 and 10 degrees."

According to CCIR Report 719, atmospheric attenuation is due to molecular absorption of radio waves by oxygen and atmospheric water vapor. Oxygen absorption is fairly uniform over the frequency band from 27.5 - 29.5 GHz. However, the absorption due to atmospheric water vapor varies significantly within the five rain climatic zones across the contiguous United States (CONUS). For this reason, it is further recommended that the atmospheric attenuation be calculated with the specific water vapor values (in g/m^3) identified in Appendix 28 of the ITU Radio Regulations and Section 25.254 of the Commission's Rules.

Conclusion 7.

Scattering effects - - The Committee examined various models that could be employed to determine scattered energy. The Committee concluded that there currently are no satisfactory models of the scattering effects for an urban or suburban environment.

Conclusion 8.

Polarization discrimination - - The Committee concluded that where non-geostationary MSS satellite feeder link polarization is circular and the LMDS system polarization is linear, then the polarization discrimination of the satellite receiver antenna against LMDS interference is 3 dB in the satellite main beam. This should not be construed as a recommendation that the Federal Communications Commission should impose any particular polarization scheme for non-geostationary MSS feeder links, FSS uplinks, or the LMDS. There is an advantage to LMDS system designers if non-geostationary MSS satellite feeder link receivers use circular polarization.

Conclusion 9.

Aggregate interference power - The Committee examined simulation results of simultaneous co-frequency emitters using a wide variety of different modulations that suggest that when the number of interfering sources exceeds five and are non-coherent, their effect on the receiver is the same as additive white Gaussian noise (AWGN) - - no matter what the relative modulation formats or bandwidths.

Conclusion 10.

Single source interference power - The Committee concluded that interference from a non-geostationary feeder link Earth station into an LMDS receiver is from a single source, and it may not have the same effect as AWGN. Relative modulation bandwidths and modulation types should be considered.

Conclusion 11.

Aggregate uplink interference from subscriber units - To model the aggregate interference from LMDS subscriber transmitters into non-geostationary MSS feeder link satellite receivers,

one would have to make assumptions about:

- subscriber transmitter elevation angle
- antenna heights
- non-geostationary MSS feeder link Earth station distance from hub(s)
- EIRP vs. distance from hub for various climatic zones
- statistical geographic distribution in azimuth from hubs
- statistical geographic distribution in distance from hubs
- number of co-frequency subscribers per hub
- spectral power density of return links vs. different modulation
- maximum duty factor of traffic

This large number of assumptions would make a valid model complex.

Conclusion 12.

Uplink interference from single high power emitter - The Committee concluded that it is statistically likely that no more than one high power LMDS backbone station at a time would be pointing its antenna above the horizon on an azimuth towards the Earth station at the proper separation distance from the station to intercept a receive spot beam from the non-geostationary MSS feeder link satellite antenna such as used in an Iridium-type system.

V. RECOMMENDATIONS

Recommendation 1.

Whereas the Committee recognized that there is currently only one potential non-geostationary MSS operator proposing to use 200 MHz of spectrum in the 27.5 - 29.5 GHz band for feeder link transmissions, and that three other potential non-geostationary MSS operators have requested feeder link spectrum at or below 15 GHz, while one has requested feeder link spectrum at 29.5 - 30.0 GHz;

Whereas the FCC has indicated that it may attempt to accommodate the feeder link requirements of all five (5) non-geostationary MSS applicants in the band 27.5 - 30.0 GHz;

Whereas the Committee has recognized that accommodating the five potential non-geostationary MSS operators' feeder link requirements in the 27.5 - 29.5 GHz band would greatly complicate sharing between non-geostationary MSS feeder links as well as between non-geostationary MSS feeder links and the LMDS;

The Committee strongly recommends that: In order to maximize the opportunities for co-frequency sharing between non-geostationary MSS feeder links and LMDS, and in order to minimize the interference to which both services will be subject, the Commission should identify spectrum in frequency bands other than the 27.5 - 29.5 GHz band - - bands suitable to satisfy their respective requirements - - for use for feeder links for the four (4) non-geostationary MSS applicants that have not previously applied to use spectrum in the 27.5 - 29.5 Ghz band.

Recommendation 2.

The FCC should encourage industry commitment to further exploring mitigation techniques and more extensive statistical modeling to more completely understand the issues related to sharing in the 28 GHz band.

Recommendation 3.

The following is a non-exhaustive list of parameters that should be considered in the event that interference/sharing scenarios are developed, or that interference calculations are made to determine the interference between LMDS and MSS feeder link systems.

LMDS System Parameters:

modulation
spectral peaking factor over an appropriate bandwidth
duty cycle
channel bandwidth
channel spacing

transmitter and receiver antenna pattern including maximum gain and sidelobe discrimination function
antenna polarization
transmitter power (clear sky)
maximum power control
power control algorithm
receiver noise figure
minimum required C/(N+I) in clear sky and rain-faded conditions
nominal distance to cell edge
density of hubs over a given area

Non-geostationary MSS Feeder Link System Parameters:

modulation
spectral peaking factor over an appropriate bandwidth
duty cycle
channel bandwidth
channel spacing
transmitter and receiver antenna pattern including maximum gain and sidelobe discrimination function
antenna polarization
transmitter power (clear sky)
maximum power control
power control algorithm
range of possible Earth station antenna elevation angles
link budget for a nominal elevation angle and variation in link parameters as a function of elevation angle

Propagation Path Loss Factors:

free space path loss
atmospheric loss as a function of climatic zone
rain model including expected rain rate, rain attenuation, and maximum rain cell size

Other Factors:

interference from LMDS into MSS satellite receivers and interference from MSS feeder links into LMDS receivers (hub, subscriber, and backbone)
LMDS system link (hub-to-subscriber and subscriber-to-hub)
effect of interference (validity of the AWGN assumption)

MSS Feeder Uplinks into LMDS Receivers:

geometry of MSS feeder link angle (relative to boresight)

towards LMDS receiver and LMDS receiver antenna angle relative to the location of the MSS feeder link Earth station

relative height above ground of MSS feeder link Earth station and LMDS receiver

clear sky and rain conditions on the three possible propagation paths - -

- desired LMDS signal path
- desired MSS feeder link signal path
- interference path between MSS feeder link Earth station and LMDS receiver

LMDS Into MSS Satellite Receivers:

proportion of LMDS transmitters operating under power control at any given time

sub-division of satellite footprint due to unequal amounts of interference power arriving from different portions of the footprint

maximum number of simultaneous subscriber transmissions

main beam coupling of directional transmitter antennas - -

- statistical frequency of occurrence of main beam coupling
- length of time of coupling when it occurs

Recommendation 4.

Working Group 2 calculations were performed with atmospheric attenuation values of 0.1 dB/km. When interference is received through main beam coupling of the LMDS receiver, required separation distances can be on the order of 100 km. In these cases, the climatic zone where the terminals are located may impact the clear sky attenuation rate. The Committee recommends that the clear sky attenuation rate given in CCIR Report 719 for different climatic zones be used in the calculations. (See ITU Radio Regulations Appendix 28 and Table below.)

Atmospheric Attenuation vs Terrestrial Distances at Ka Band

CCIR Report 719-3

NRMC-

Sep. 23, 1994

G	0.363	km	Ground elevation wrt sea level						
H	6	km	Oxygen absorption height (wrt sea level)						
f	29.2	GHz	Frequency of interest						
rad	57.30	deg/rad							
Re	6370	km	Radius of Earth (6370 actual, 8500 four-thirds)						
	Zone 1			Zone 2			Zones 3-5		
hwo	1.6	km		1.6	km		1.6	km	Water vapor equiv. height (1.6 clear weather; 2.1 rain)
ho	5.637	km		5.637	km		5.637	km	Oxygen absorption height
hw	1.69	km		1.69	km		1.69	km	Water vapor height, clear weather
rho	10	g/m^3		5	g/m^3		2	g/m^3	Water vapor density
go	0.02	dB/km		0.02	dB/km		0.02	dB/km	Dry air attenuation rate *
gw	0.11	dB/km		0.05	dB/km		0.02	dB/km	Water vapor attenuation rate
									* pressure = 1013 mb & T = 15 C

distance	Zone 1	Zone 2	Zones 3-5
1	0.13	0.07	0.04
2	0.26	0.14	0.08
3	0.40	0.21	0.11
4	0.53	0.28	0.15
5	0.66	0.36	0.19
6	0.79	0.43	0.23
7	0.92	0.50	0.26
8	1.06	0.57	0.30
9	1.19	0.64	0.34
10	1.32	0.71	0.38
11	1.45	0.78	0.41
12	1.58	0.85	0.45
13	1.71	0.93	0.49
14	1.85	1.00	0.53
15	1.98	1.07	0.56
16	2.11	1.14	0.60
17	2.24	1.21	0.64
18	2.37	1.28	0.68
19	2.51	1.35	0.71
20	2.64	1.42	0.75
21	2.77	1.50	0.79
22	2.90	1.57	0.83
23	3.03	1.64	0.86
24	3.17	1.71	0.90
25	3.30	1.78	0.94
26	3.43	1.85	0.98
27	3.56	1.92	1.01
28	3.69	1.99	1.05
29	3.83	2.06	1.09
30	3.96	2.14	1.13
31	4.09	2.21	1.16
32	4.22	2.28	1.20
33	4.35	2.35	1.24