GBT Memo No. 47

NATIONAL RADIO ASTRONOMY OBSERVATORY
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Electromagnetic Analysis of the GBT

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Electromagnetic analysis of the Green Bank Telescope (unshaped) has been completed and presented hereunder. Spillover noise computations and scanning properties will be presented in separate memos. In the frequency range of 300 MHz to 1.00 GHz, analysis has been done at prime focus. Two different size subreflectors have been used to analyze the gregorian geometry in the 600 MHz to 100 GHz range.

Prime focus computations are done using the NEC Reflector Antenna Code of The Ohio State University. In this code, far fields are computed using a combination of Aperture Integration and Geometric Theory of Diffraction techniques. For the gregorian system of reflectors, a dual reflector analysis program provided by JPL has been used. In this program the subreflector scattered fields are computed by the Uniform Geometric Theory of Diffraction (UTD) which includes geometric optics fields, edge diffracted and slope diffracted fields. The main reflector analysis uses the Jacobi Bessel series expansion technique to evaluate the physical optics radiation integral.

Table 1 gives the prime focus results. The input feed pattern has a taper of -12 dB at the edge of the main reflector in the plane of asymmetry. Table 2 lists the results of a gregorian geometry for a 7.55m x 7.95m subreflector, while Table 3 provides the results for a 4.07m x 4.33m subreflector. The feed taper is again -12 dB at the edge of the subreflector. All computations are done for linear polarization. The efficiency in the tables is the product of illumination, spillover and diffraction terms. The half-power beam width (HPBW) as computed in the software is listed in the tables. The factor that multiplies the ratio of wavelength to diameter of the projected aperture (λ/D) to give the HPBW is also provided. The UTD technique used in the dual reflector analysis is not accurate enough in predicting the cross-polarized fields. Hence, a correction factor has been applied to the cross-polarized fields presented in Tables 2 and 3. The cross-polarized terms will be checked with a more accurate induced current technique.

The attached telescope beam patterns compare the main beam and near-in sidelobes of pairs of geometries (prime focus and gregorian with 7.5m subreflector or gregorian with 7.5m and 4m subreflectors) at common frequencies. Figures 1 and 2 show the far-field patterns at 800 MHz and 1.00 GHz, respectively, at prime focus and gregorian geometry. Figures 3 and 4 show the patterns at 5 GHz and 8 GHz, respectively, for the cases of 7.5m and 4m subreflectors. These are patterns in the symmetric plane or the plane of offset. Diffraction in the small subreflector case has moved the first sidelobe closer to the main beam.

Attachments

TABLE 1. Prime Focus Geometry

Freq. (GHz)	Peak Gain (dB)	Efficiency %	Peak Xpol. Below Peak Gain (dB)	HPBW	$\frac{\text{HPBW}}{(\lambda/D)}$	First Sidelobe	
						Level Below Peak Gain (dB)	No. of HPBW's Off Beam Max.
0.300	48.27	68.02	-21.42	43.9′	1.28	-28.21	1.85
0.600	54.29	68.02	-21.42	21.8′	1.27	-28.26	1.93
0.800	56.79	68.04	-21.54	16.3′	1.26	-28.25	1.84
1.000	58.73	68.07	-21.42	13.0′	1.26	-28.25	1.85

TABLE 2. Gregorian Geometry (7.5-m Subreflector)

Freq. (GHz)	d_1/λ	Peak Gain (dB)	Efficiency %	Peak Cross-Polarization Below Peak Gain (dB)	HPBW	$\frac{\text{HPBW}}{(\lambda/D)}$	First Sidelobe	
							Level Below Peak Gain (dB)	No. of HPBW's Off Beam Max.
0.600	15.10	54.492	71.26	-36.9	20.9′	1.21	-27.72	2.43
0.800	20.13	57.002	71.44	-40.7	15.6′	1.21	-27.41	2.40
1.000	25.17	58.954	71.67	-44.9	12.4′	1.20	-27.36	2.38
1.420	35.74	62.013	71.89	-47.8	8.7′	1.20	-27.23	2.37
5.000	125.83	72.980	72.44	-54.6	2.5′	1.19	-27.22	2.34
8.000	201.33	77.069	72.55	-59.6	1.5′	1.19	-27.01	2.31

Notes:

1) 7.55m x 7.95m subreflector (d_1 x d_2).

2) Eccentricity 0.528.

3) Ellipsoidal focal length 11.00 m.

TABLE 3. Gregorian Geometry (4-m Subreflector)

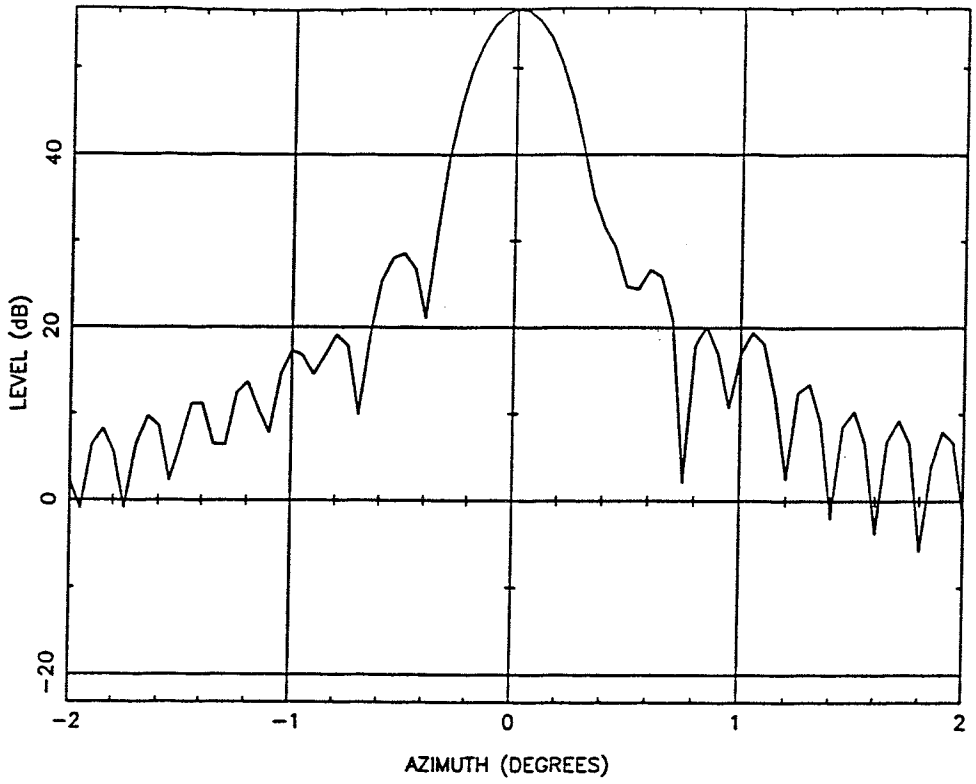
Freq. (GHz)	d_1/λ	Peak Gain (dB)	Efficiency %	Peak Cross-Polarization Below Peak Gain (dB)	HPBW	$\frac{\text{HPBW}}{(\lambda/D)}$	First Sidelobe	
							Level Below Peak Gain (dB)	No. of HPBW's Off Beam Max.
5.000	67.88	73.134	75.06	-53.1	2.4′	1.16	-26.24	1.62
8.000	108.61	77.249	75.63	-55.8	1.5′	1.19	-26.17	1.57
20.000	271.53	85.260	76.54	-63.8	36.7"	1.19	-26.04	1.57
40.000	543.06	91.293	76.76	-66.9	18.3"	1.18	-26.28	1.57
100.000	1357.67	99.255	76.81	-74.3	7.3"	1.18	-26.84	1.57

Notes:

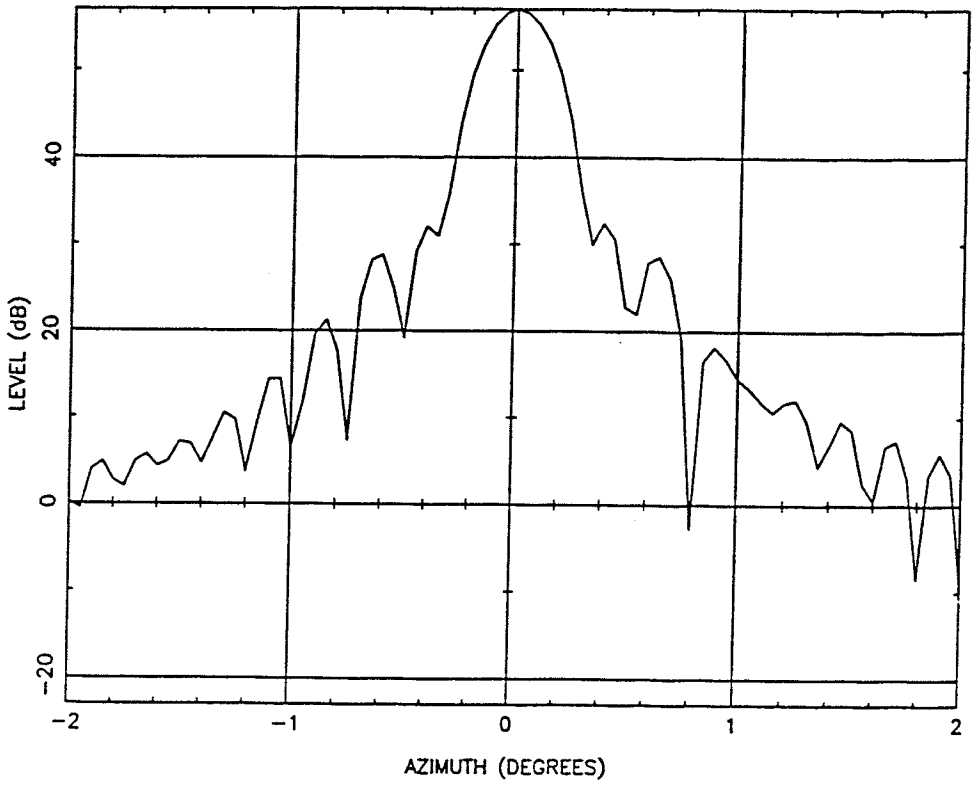
1) 4.07m x 4.33m subreflector (d_1 x d_2).

2) Eccentricity 0.680.

3) Ellipsoidal focal length 11.00 m.

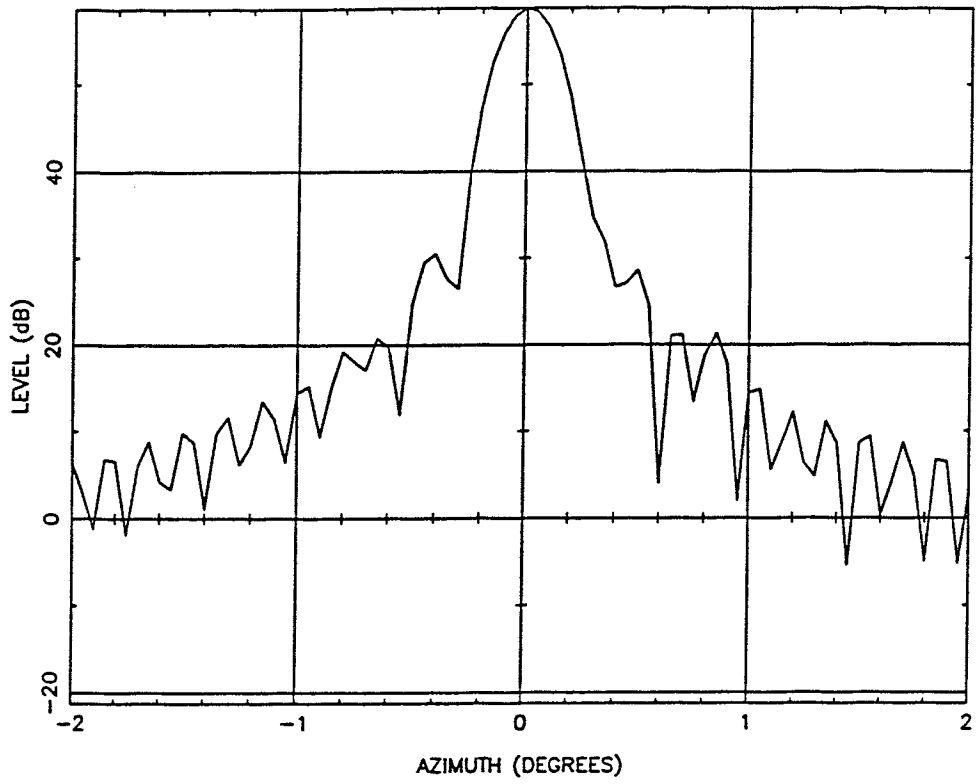


(a) Prime focus

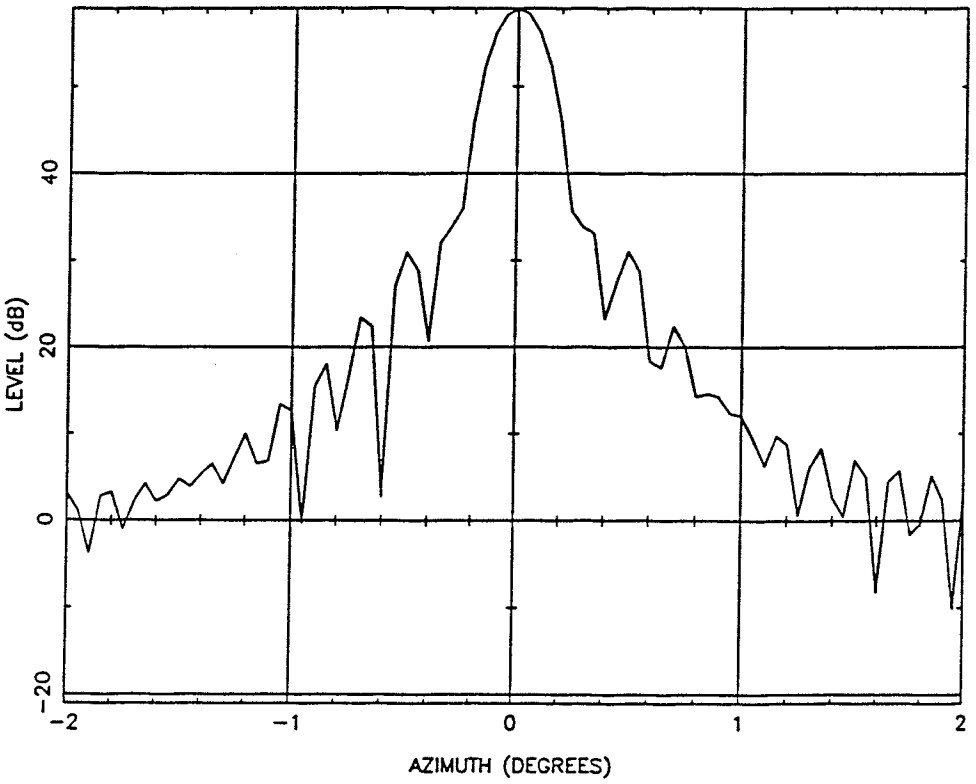


(b) Gregorian - 7.5m

Fig. 1. Far-field pattern at 800 MHz.

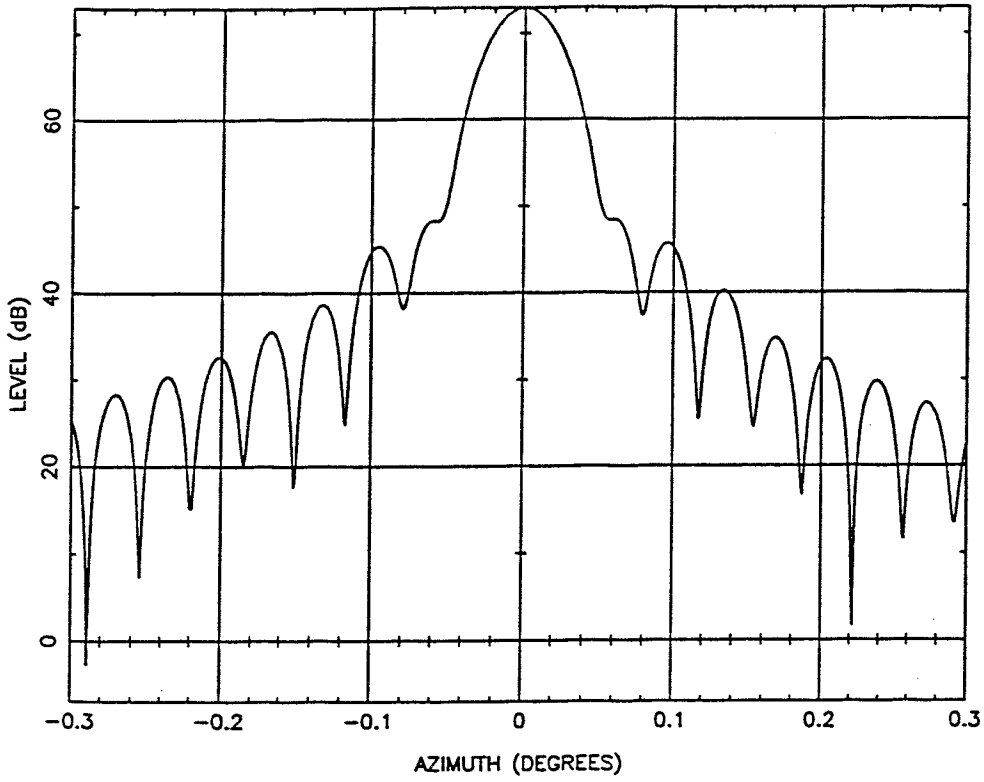


(a) Prime focus

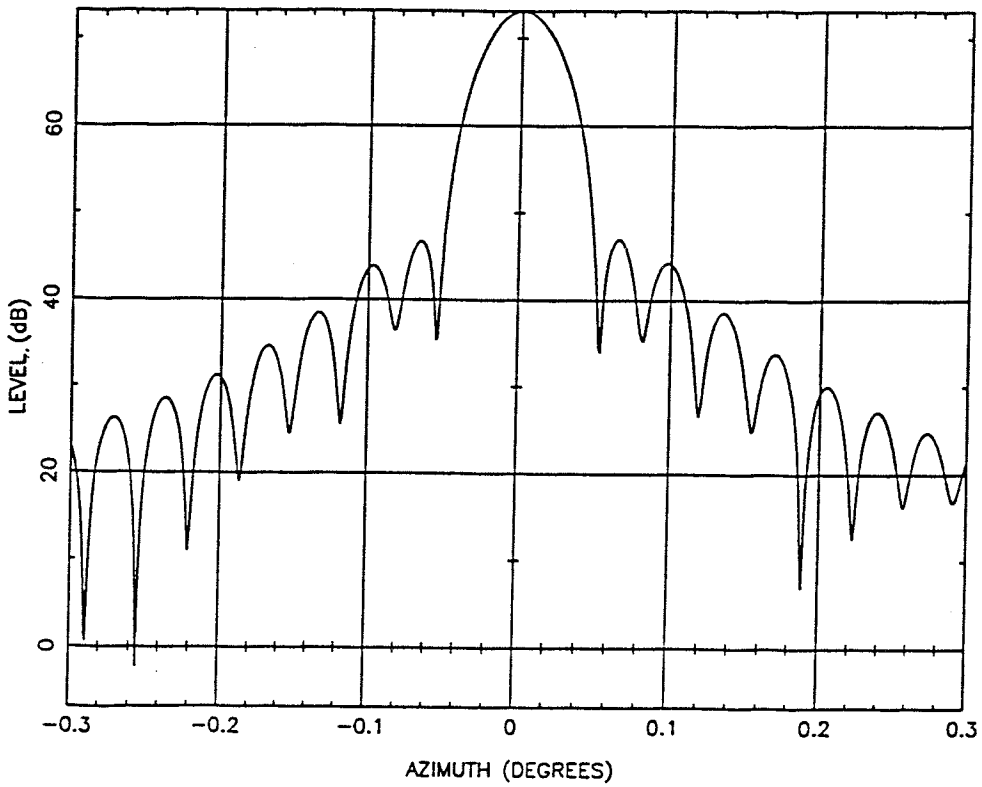


(b) Gregorian - 7.5m

Fig. 2. Far-field pattern at 1 GHz.

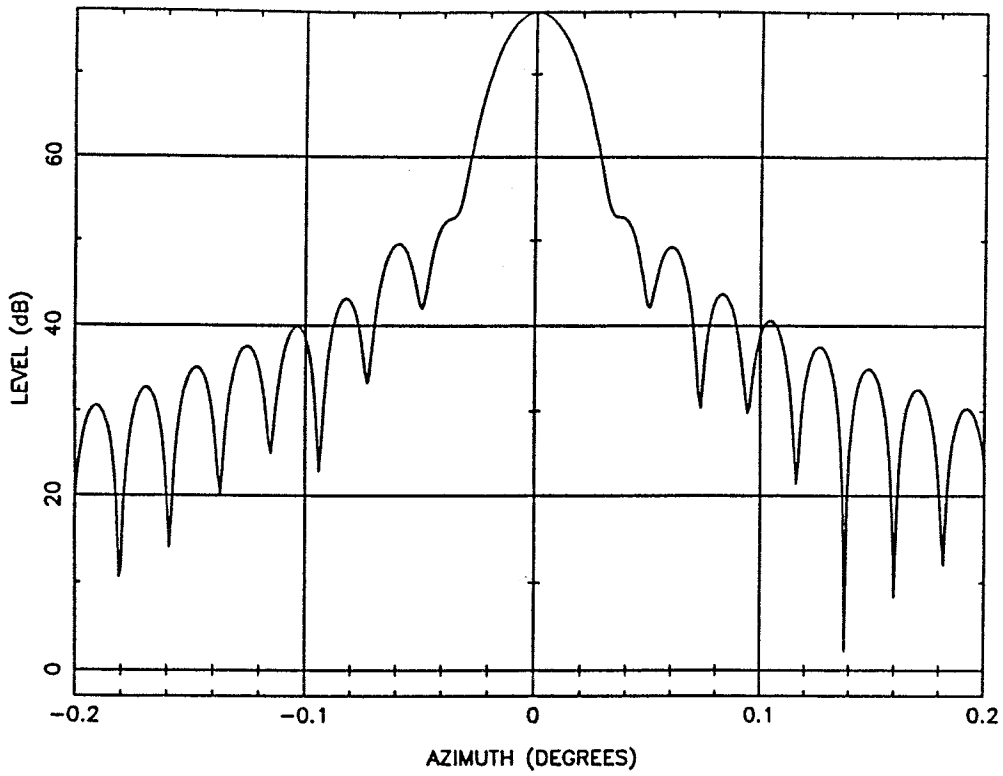


(a) Gregorian - 7.5m

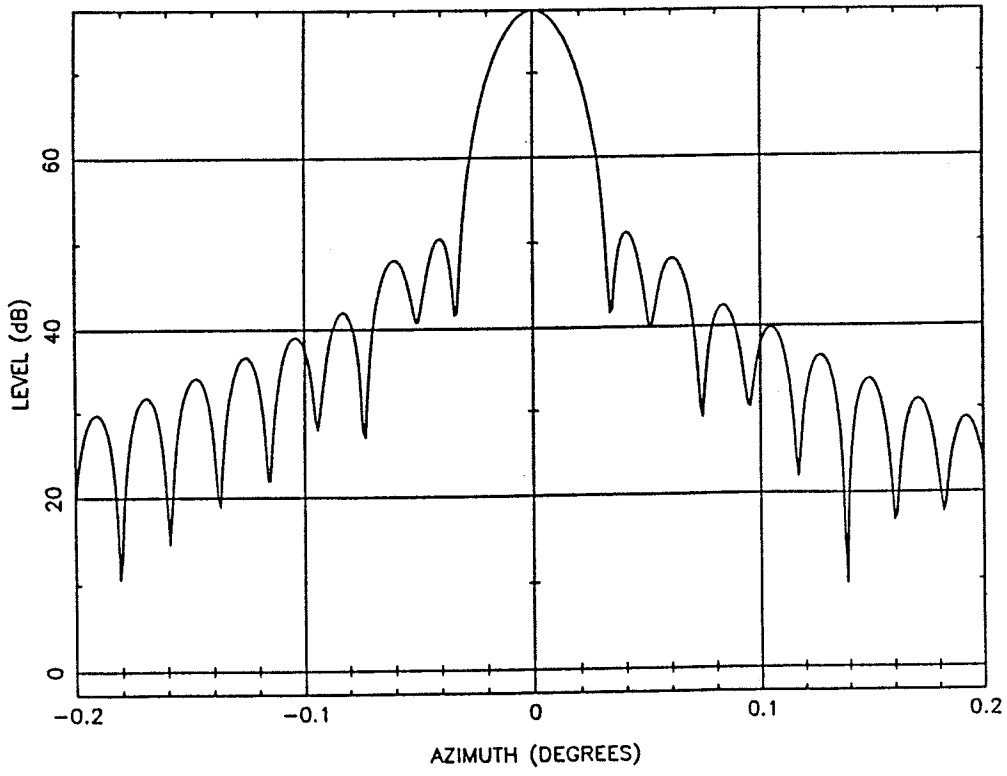


(b) Gregorian - 4.0m

Fig. 3. Far-field pattern at 5 GHz.



(a) Gregorian - 7.5m



(b) Gregorian - 4.0m

Fig. 4. Far-field pattern at 8 GHz.