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GBS IOTE Feed Measurements

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23 May 2001

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LEXINGTON, MASSACHUSETTS

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Group 63

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ABSTRACT

The Ka-Band (30/20 GHz) terminal was used to conduct I, O, T, and E of the Global Broadcast System (GBS) package on UHF Follow-on (UFO) satellites, flights 8, 9, and 10. This terminal has been transferred to Lincoln Laboratory through the Milsatcom Joint Program Office at the USAF Space and Missile Center (AFSMC). At Lincoln Laboratory, the terminal is to be evaluated for possible use in on-orbit checkout/experimentation with the Ka-band portion of the Wideband Gap Filler Satellites (expected to launch in 2004). These satellites use the government 20.2–21.2 GHz (downlink) and 30–31 GHz (uplink) frequency allocations. This report describes the test and evaluation of the Ka-Band Terminal dual frequency feed at Lincoln Laboratory's Antenna Test Range and identifies some deficiencies that will need to be addressed prior to use with the Wideband Gapfiller system.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

The Ka-band dual frequency feed (Figure 1) was tested and evaluated at the MIT Lincoln Laboratory Antenna Test Range. Originally specified to operate from 20.25–20.75 GHz (downlink) and 30–30.5 GHz (uplink), measurements were made from 20.2–21.2 GHz and 29–31 GHz in an attempt to determine if the feed could operate in the 20.2–21.2 GHz and the 30–31 GHz Wideband Gapfiller bands.

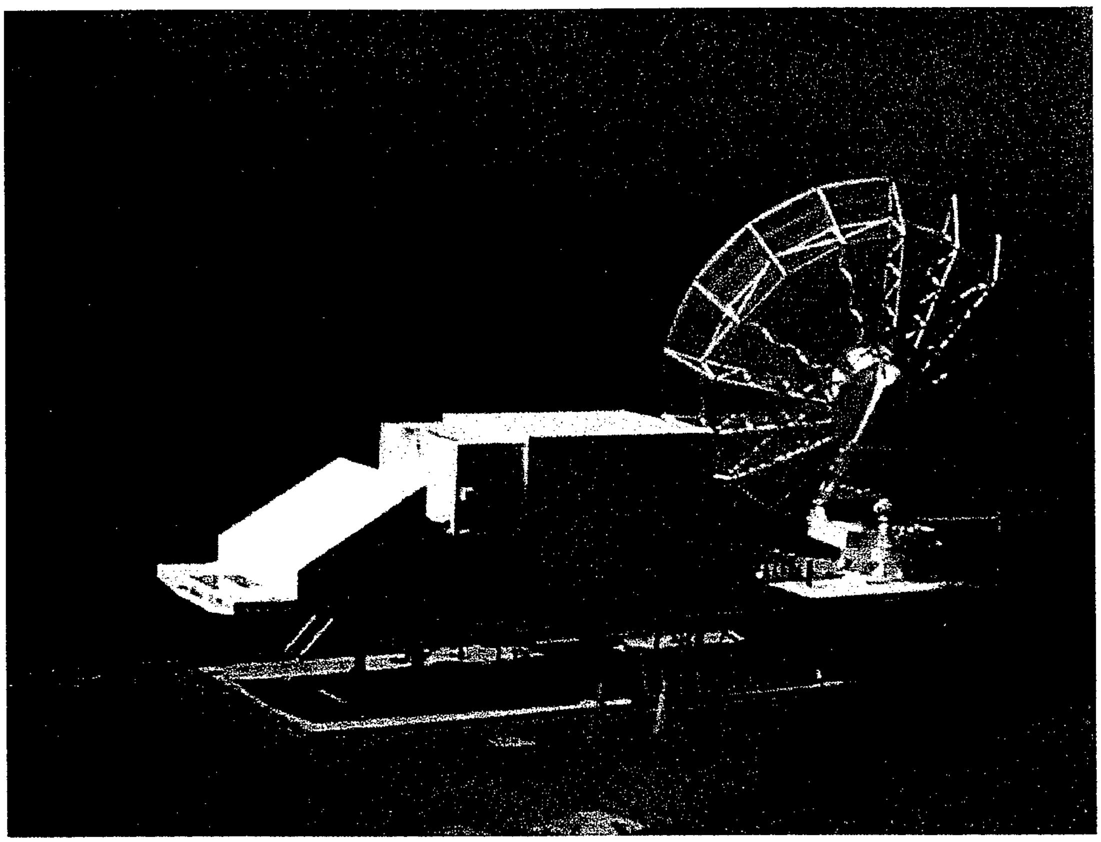

Figure 1. GBS-IOTE Ka-Band Terminal

2.0 MEASUREMENT SYSTEM

Measurements were performed in anechoic chamber #2 using the Hewlett Packard 8530 receiver and the Antenna Measurement Program (AMP) software developed by Dave Besse of Lincoln Laboratory. Return loss measurements were conducted on the Hewlett Packard 8510C network analyzer at both frequency bands. Figure 2 shows the GBS IOTE feed on an elevation /azimuth positioner in the anechoic chamber.

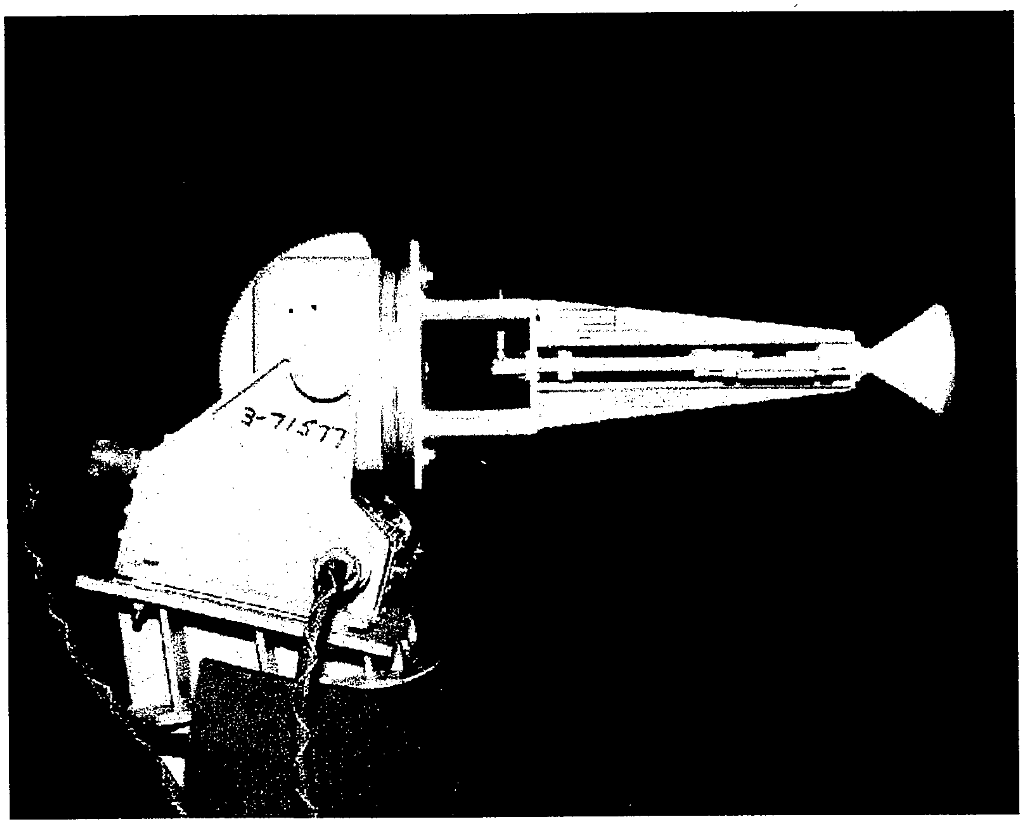

Figure 2. GBS-IOTE Antenna Feed in Anechoic Chamber

3.0 MEASUREMENT RESULTS

Azimuth radiation patterns from –90 to 90 degrees, swept frequency gain, and axial ratio measurements were performed. Table 1 shows the Ka-Band (transmit) axial ratio, gain, return loss, VSWR, beam widths and cross-polar data for frequencies in the 29–31 GHz range. Data results indicate that performance of the feed rapidly deteriorates in both axial ratio and gain above 30.6 GHz. For a 1 GHz bandwidth between 29.6–30.6 GHz, data results demonstrate a <2.1 db axial ratio, nominal gain of 15.1 dbi, return loss <13.3 db, and a 1.55 maximum VSWR. Figures 3 and 4 depict the Ka-Band return loss and the corresponding VSWR graphs. Figures 5 and 6 show the Ka-Band swept gain (for RHCP) and axial ratio plots. The Ka-Band co-polar (RHCP) and cross-polar (LHCP) azimuth patterns are indicated in Figures 7–15, note the asymmetry in the patterns at 30.75 and 31 GHz figures (Figure 14 and 15). Table 2 lists the K-Band (Receive) axial ratio, gain, return loss, VSWR, beam widths, and cross-polar data for frequencies between 20.2-21.2 GHz. Data results indicate <1.7 db axial ratios, nominal gain of 15.5 dbi, return loss <16.6 db, and a maximum VSWR of 1.35. Also presented are the beam widths and cross-polar data. Figures 16 and 17 represent the Ka-band return loss and the corresponding VSWR graphs. The K-Band swept gain (for LHCP) and axial ratio plots are shown in Figures 18 and 19. Figures 20–24 depict the K-band co-polar (LHCP) and cross-polar (RHCP) azimuth radiation patterns.

Table 1. Ka-Band Antenna Feed Tabular Data

Freq (GHz)	Axial Ratio (dB)	Gain (dbi)	Return Loss (dB)	VSWR
29.00	3.05	15.41	-17.63	1.30
29.10	2.83	15.53	-24.66	1.12
29.20	2.80	14.92	-17.33	1.31
29.30	2.62	15.40	-16.19	1.37
29.40	2.55	15.64	-30.78	1.06
29.50	2.30	15.16	-14.00	1.50
29.60	2.10	15.10	-17.66	1.30
29.70	1.85	14.64	-18.73	1.26
29.80	1.80	14.93	-13.29	1.55
29.90	1.53	15.27	-24.93	1.12
30.00	1.30	14.85	-15.14	1.42
30.10	1.15	15.36	-18.33	1.28
30.20	0.76	15.48	-20.95	1.20
30.30	0.81	15.52	-16.62	1.35
30.40	0.89	15.56	-22.44	1.16
30.50	1.27	15.15	-16.83	1.34
30.60	1.90	14.72	-16.38	1.36
30.70	2.85	14.45	-16.56	1.35
30.80	3.95	13.70	-21.97	1.17
30.90	4.60	13.33	-11.03	1.78
31.00	6.55	12.42	-14.61	1.46
Freq (GHz)	**BeamWidth (3dB)°**	**BeamWidth (10dB)°**	**X-pol (dB)**	
29.00	32.09	51.27	-14.77	
29.25	33.02	53.23	-18.37	
29.50	33.70	53.77	-15.75	
29.75	33.62	53.26	-14.58	
30.00	34.16	53.41	-15.51	
30.25	34.05	53.23	-15.09	
30.50	34.43	54.16	-13.29	
30.75	35.57	55.77	-9.48	
31.00	33.20	53.80	-3.96	

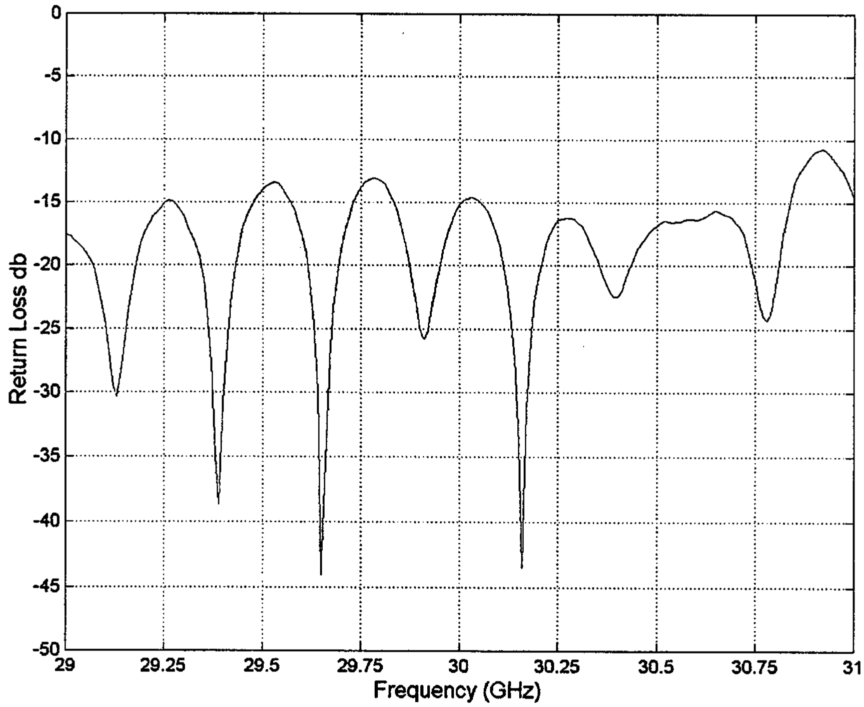

Figure 3. Ka-Band Return Loss Graph

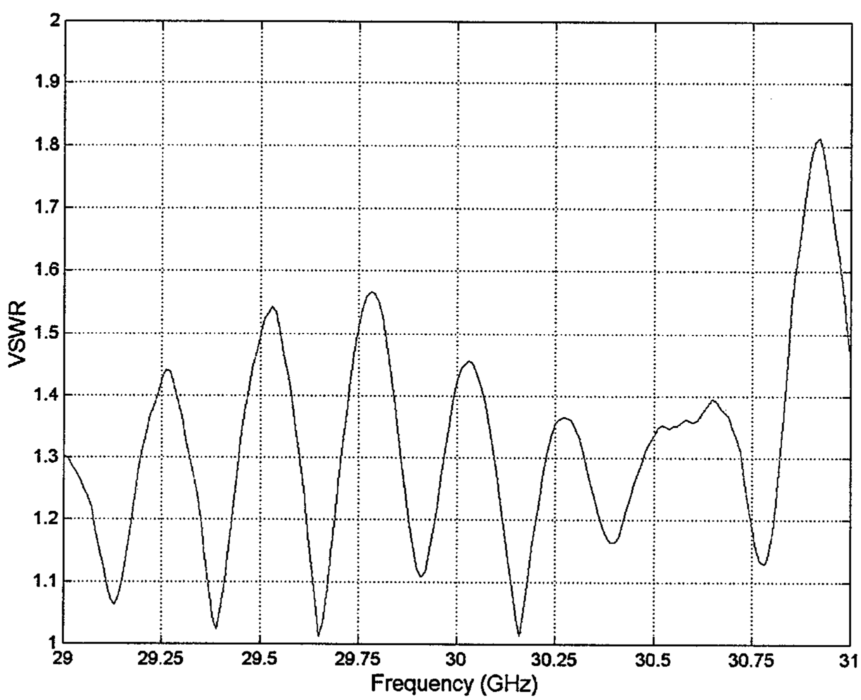

Figure 4. Ka-Band VSWR Graph

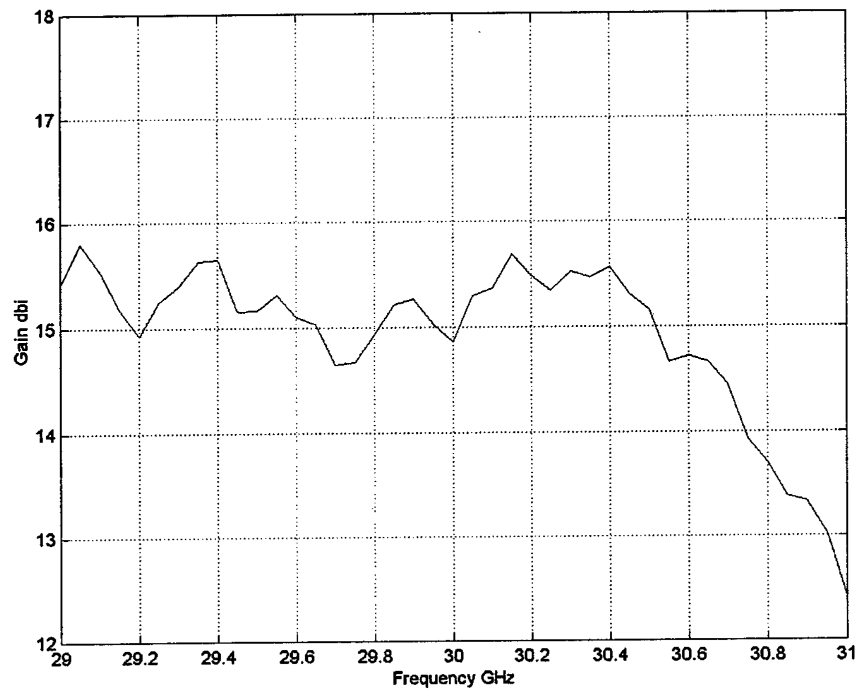

Figure 5. Ka-Band RHCP Swept Frequency Gain Graph

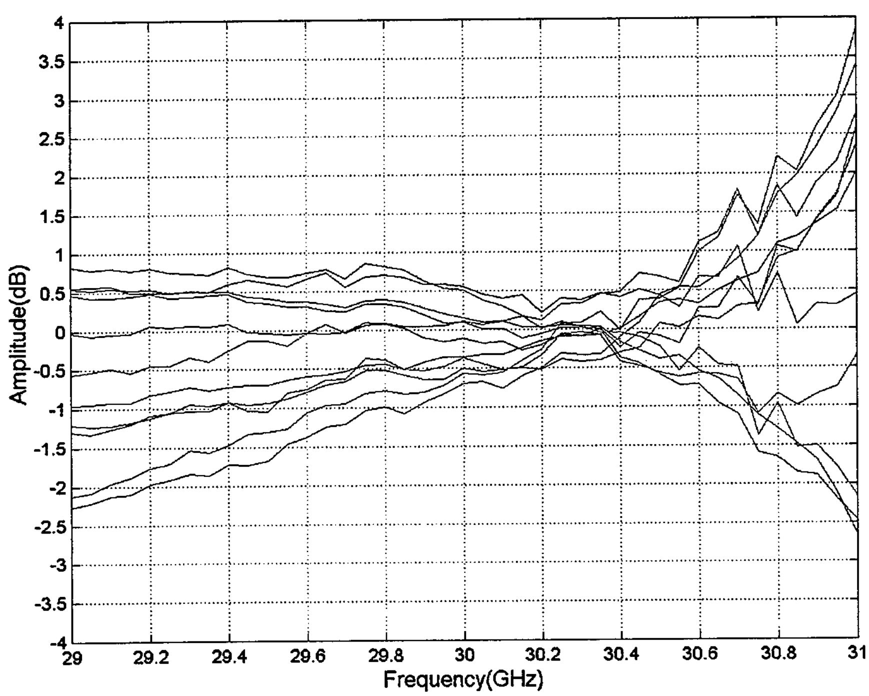

Figure 6. Ka-Band Axial Ratio Graph

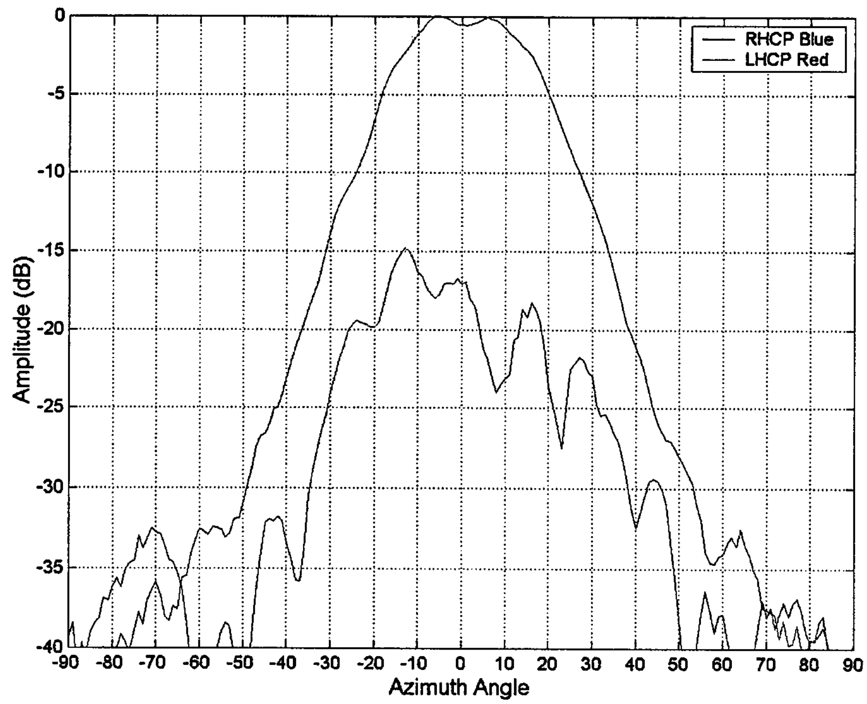

Figure 7. 29 GHz Co-Polar (RHCP) and Cross Polar (LHCP) Azimuth Radiation Pattern

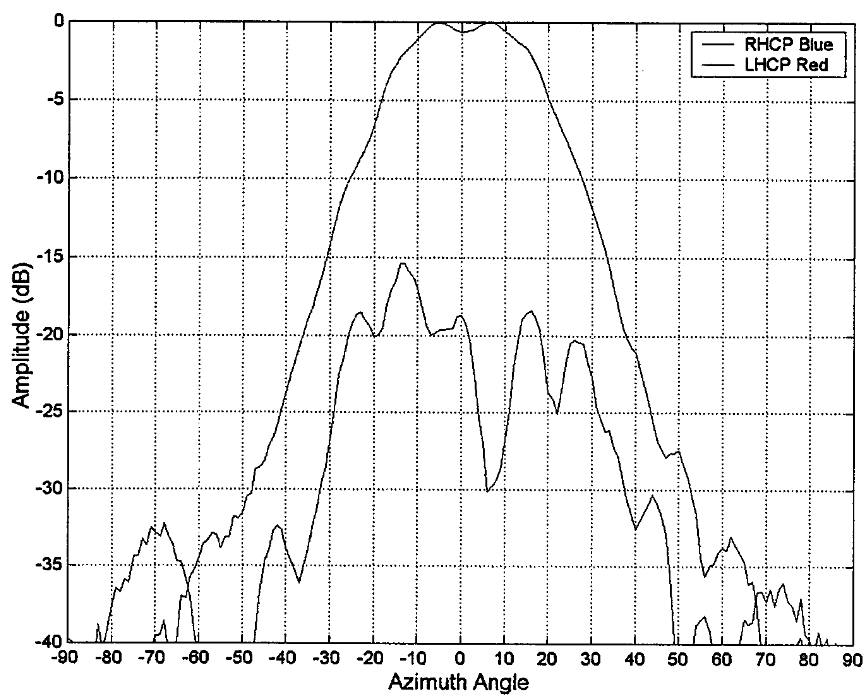

Figure 8. 29.25 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

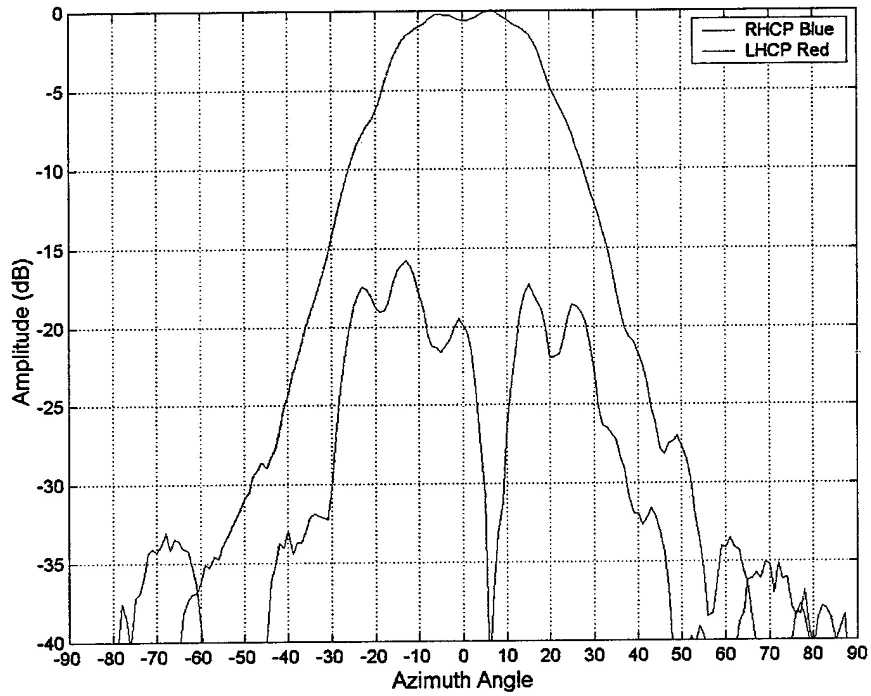

Figure 9. 29.5 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

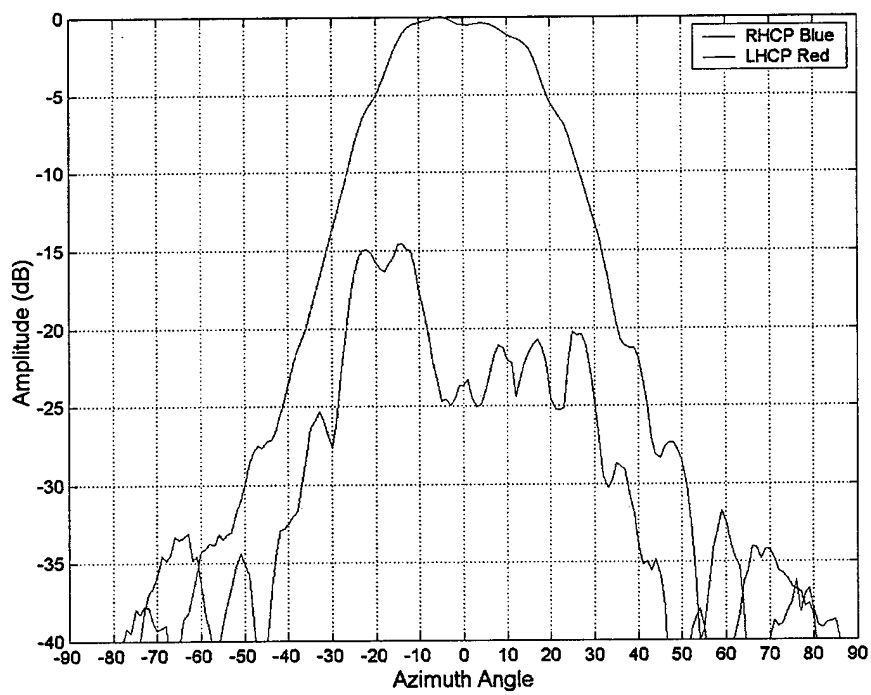

Figure 10. 29.75 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

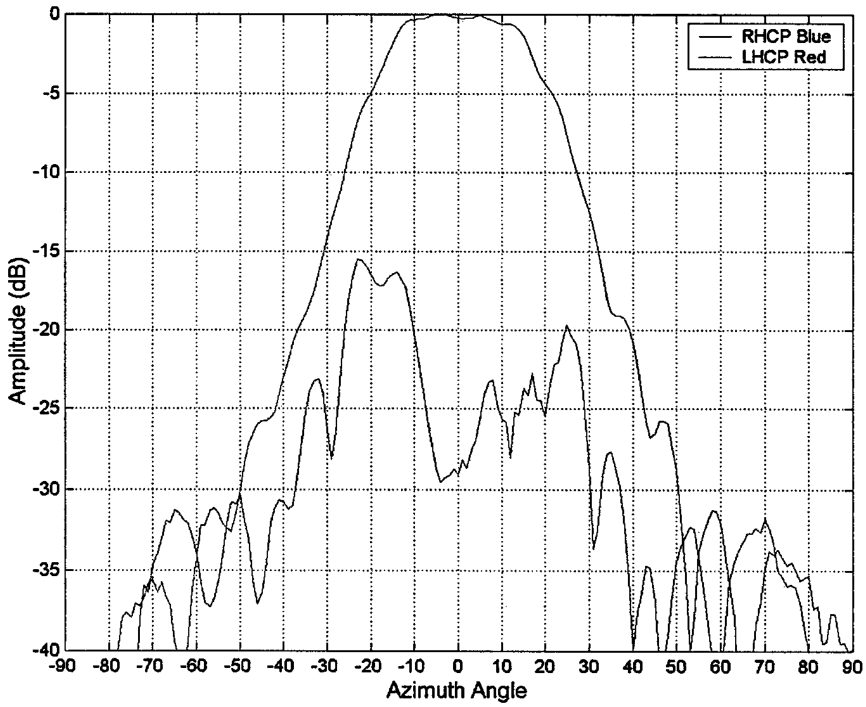

Figure 11. 30.0 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

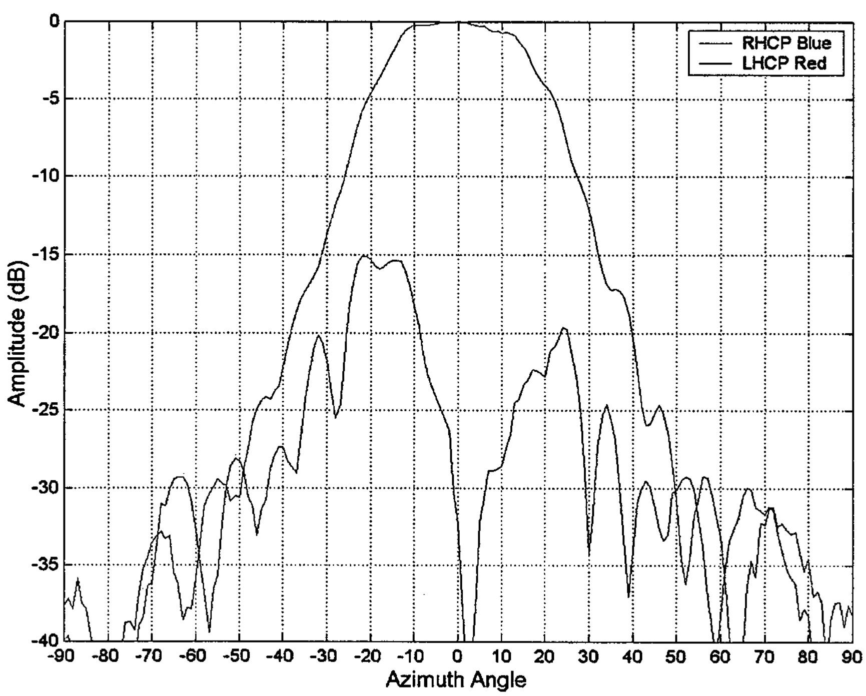

Figure 12. 30.25 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

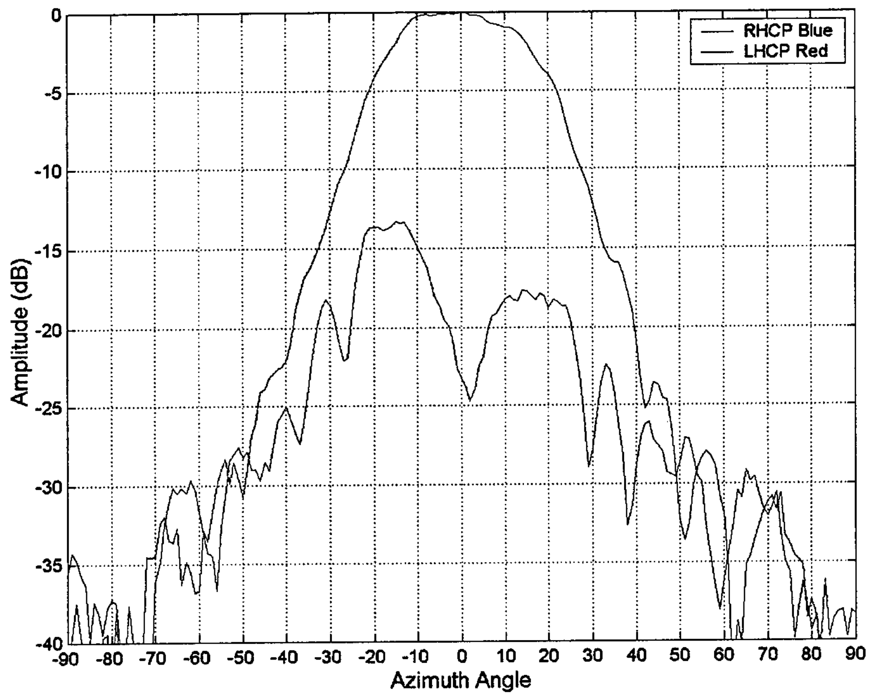

Figure 13. 30.5 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

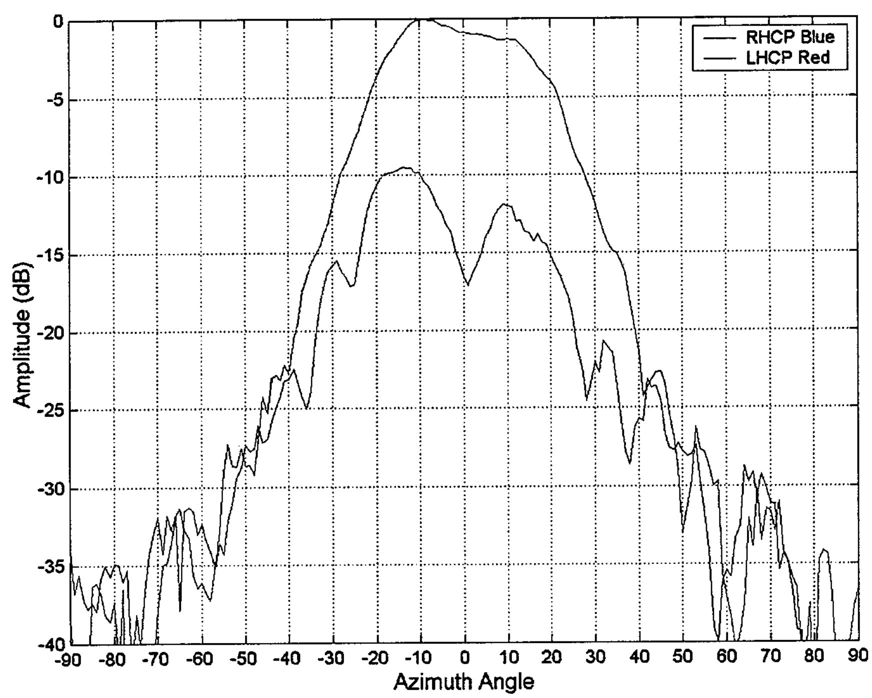

Figure 14. 30.75 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

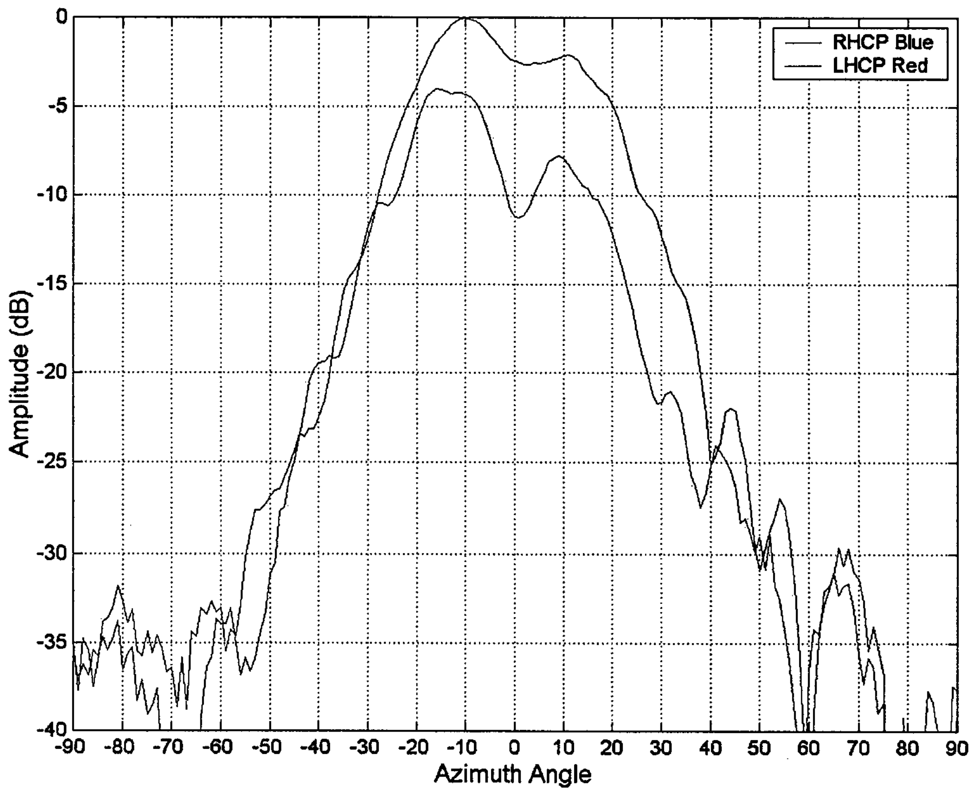

Figure 15. 31.0 GHz Co-Polar (RHCP) and Cross-Polar (LHCP) Azimuth Radiation Pattern

Table 2. K-Band Tabular Data

Freq(GHz)	Axial Ratio(dB)	Gain(dBi)	Return Loss (dB)	VSWR
20.20	0.70	15.66	-25.05	1.12
20.25	0.45	15.72	-16.79	1.34
20.30	0.90	15.57	-17.56	1.31
20.35	0.60	15.49	-25.89	1.11
20.40	0.70	15.51	-26.21	1.10
20.45	0.90	15.49	-21.67	1.18
20.50	0.95	15.51	-25.33	1.11
20.55	0.50	15.45	-23.29	1.15
20.60	0.75	15.54	-19.89	1.23
20.65	1.05	15.69	-23.38	1.15
20.70	1.03	15.45	-28.99	1.07
20.75	1.00	15.47	-21.01	1.20
20.80	1.17	15.67	-21.75	1.18
20.85	1.10	15.53	-26.13	1.10
20.90	1.25	15.54	-19.14	1.25
20.95	1.00	15.54	-16.60	1.35
21.00	1.37	15.48	-18.47	1.27
21.05	1.40	15.46	-25.64	1.11
21.10	1.25	15.24	-20.45	1.21
21.15	1.45	15.20	-18.96	1.25
21.20	1.68	15.18	-19.37	1.24
Freq(GHz)	**BeamWidth(3dB)°**	**BeamWidth(10dB)°**	**x-pol(dB)**	
20.20	30.53	53.13	-19.88	
20.45	30.87	53.48	-17.80	
20.70	31.20	53.10	-17.03	
20.95	31.71	52.78	-17.24	
21.20	32.83	53.32	-15.06	

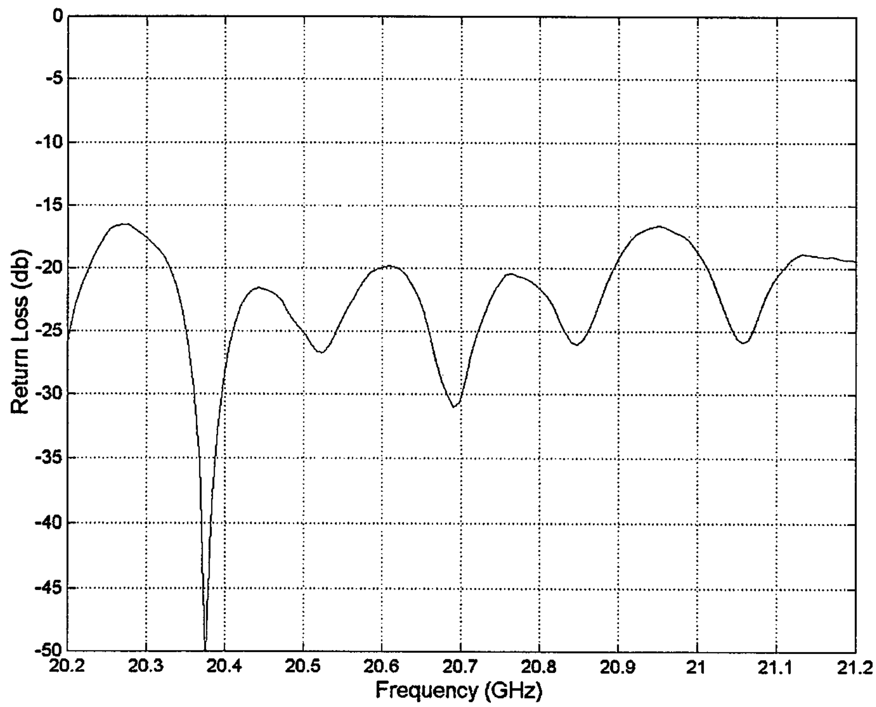

Figure 16. K-Band Return Loss Graph

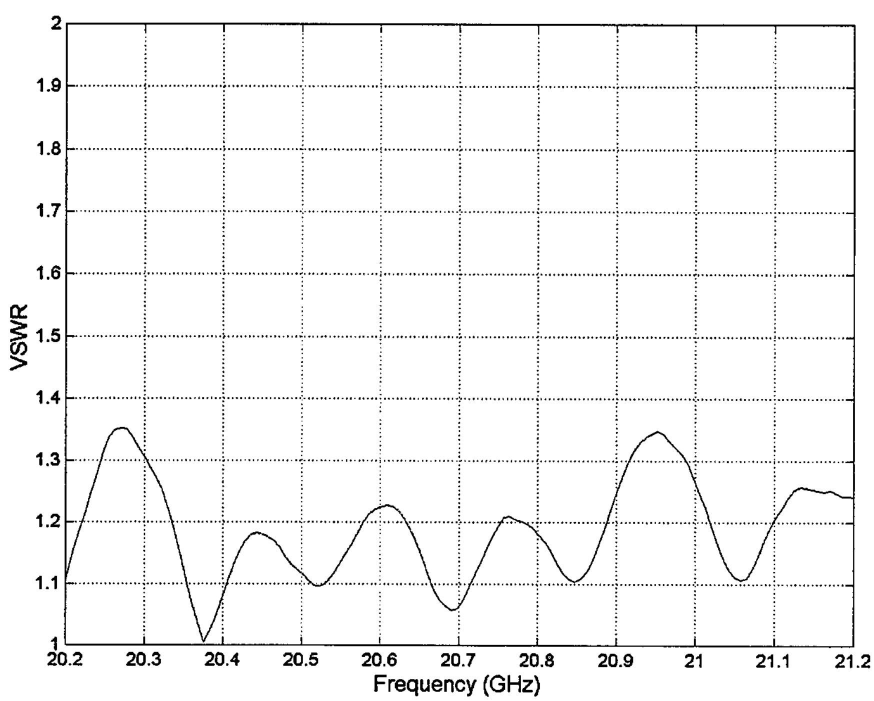

Figure 17. K-Band VSWR Graph

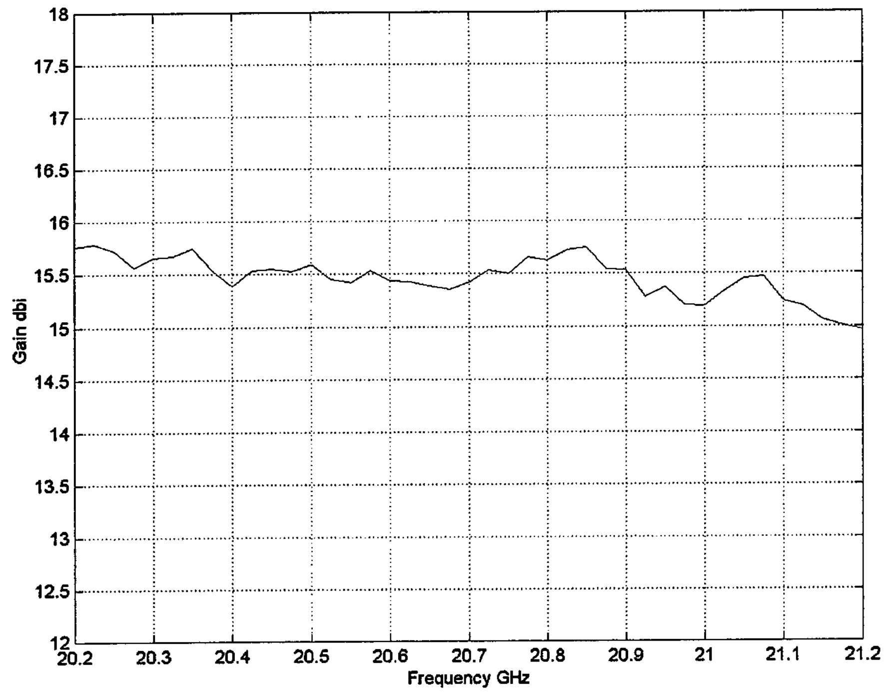

Figure 18. K-Band LHCP Swept Frequency Gain Graph

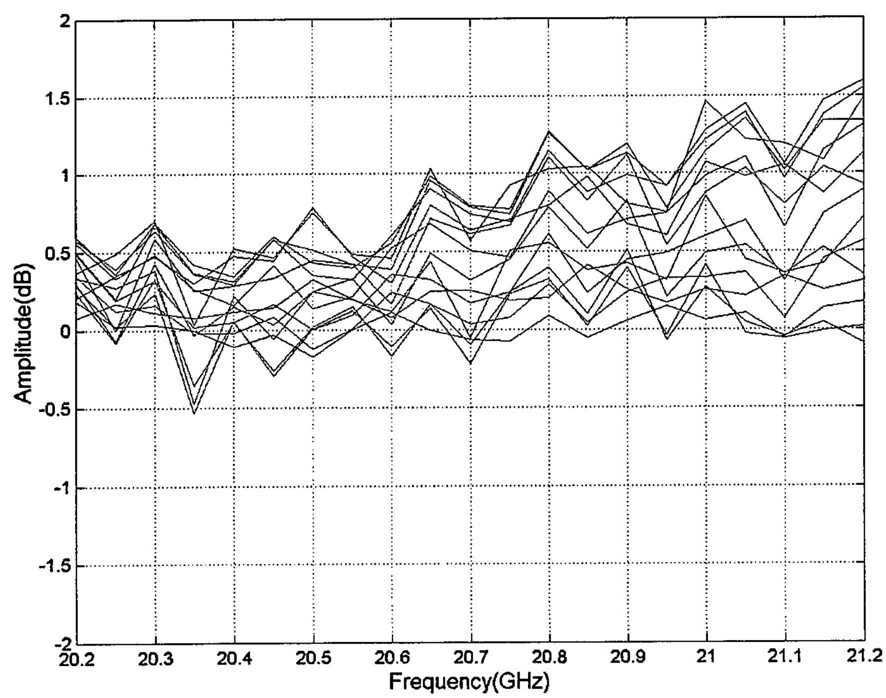

Figure 19. K-Band Axial Ratio Graph

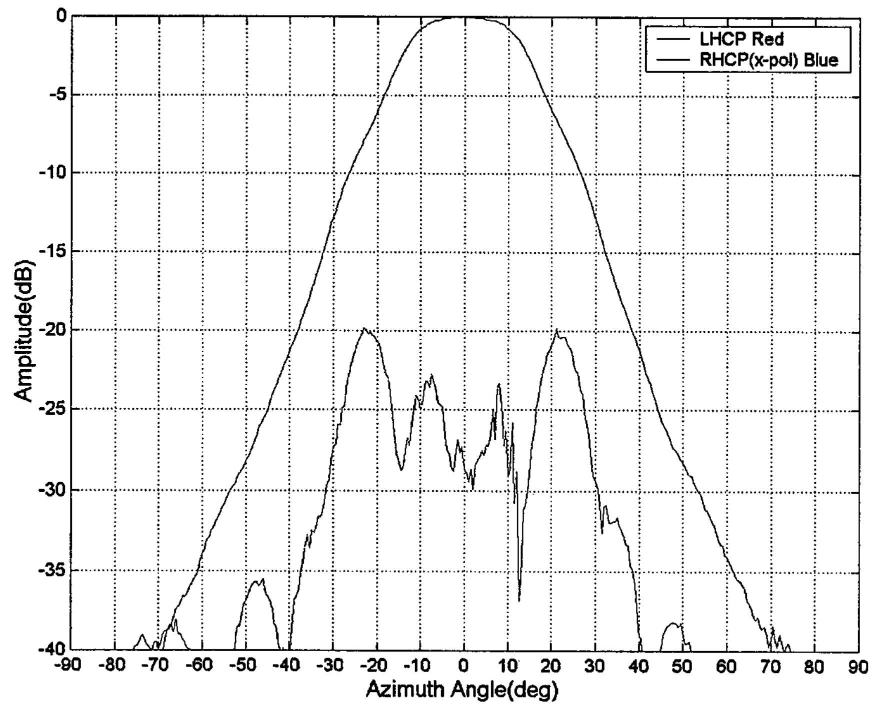

Figure 20. 20.2 GHz Co-Polar (LHCP) and Cross-Polar (RHCP) Azimuth Radiation Patterns

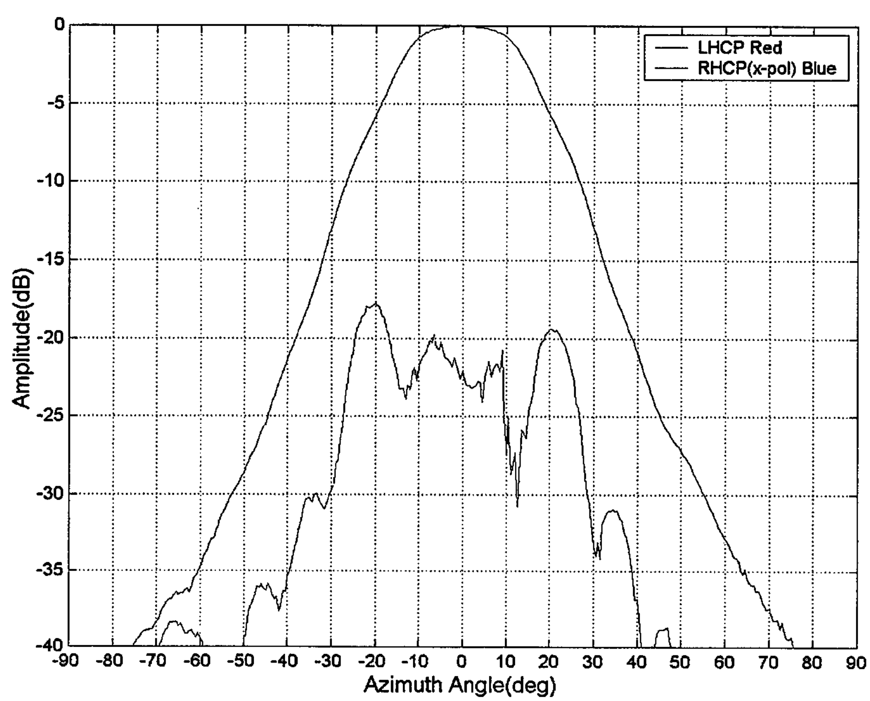

Figure 21. 20.45 GHz Co-Polar (LHCP) and Cross-Polar (RHCP) Azimuth Radiation Patterns

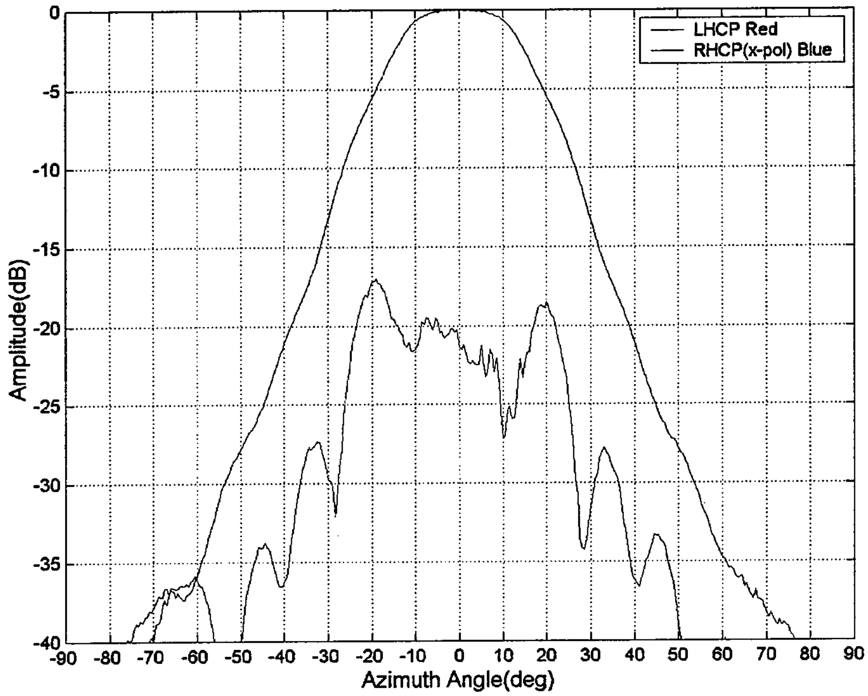

Figure 22. 20.7 GHz Co-Polar (LHCP) and Cross-Polar (RHCP) Azimuth Radiation Patterns

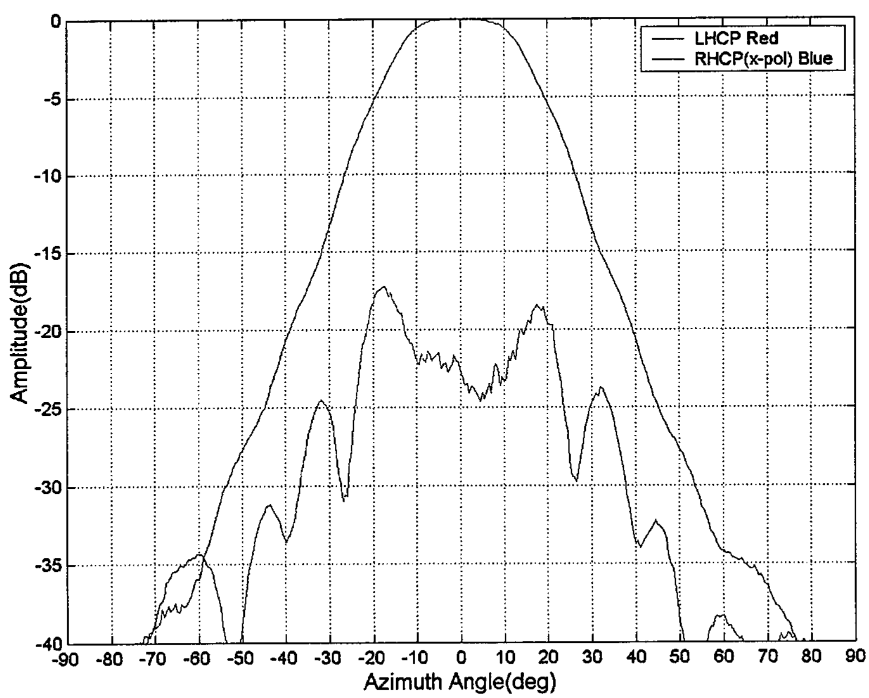

Figure 23. 20.95 GHz Co-Polar (LHCP) and Cross-Polar (RHCP) Azimuth Radiation Patterns

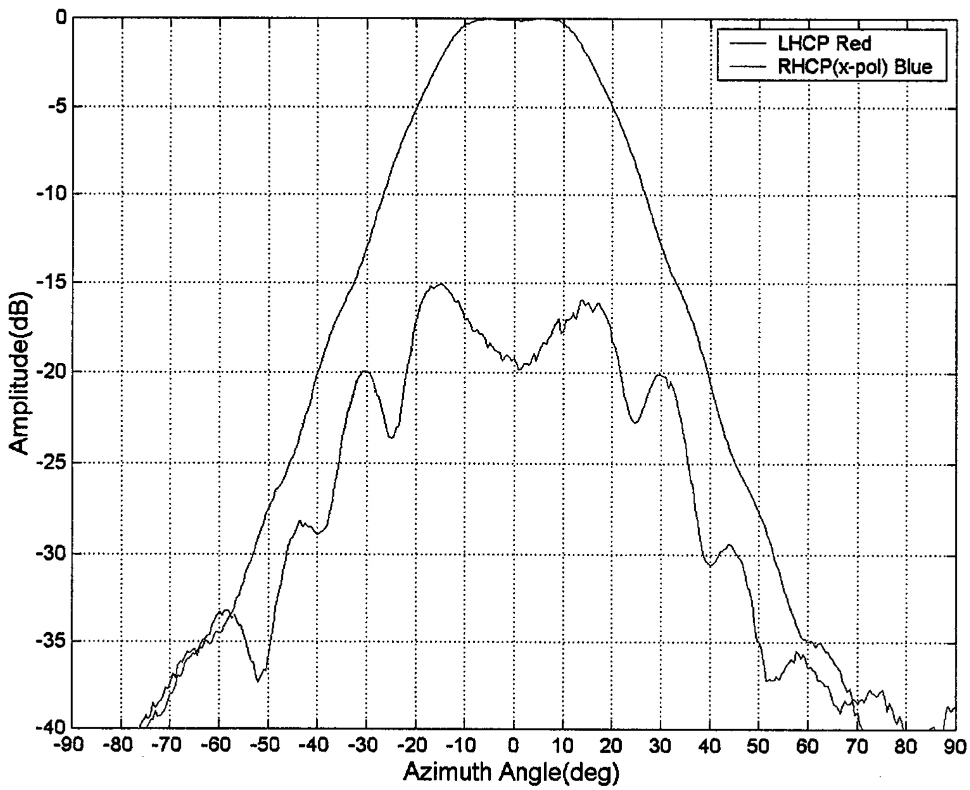

Figure 24. 21.2 GHz Co-Polar (LHCP) and Cross-Polar (RHCP) Azimuth Radiation Patterns

4.0 CONCLUSION

Measurements have shown the Ka-band Terminal feed to exhibit reasonable performance over a 1 GHz bandwidth at K-Band. Within the K-band 1 GHz bandwidth (20.2–21.2 GHz), an axial ratio <1.68 db, nominal gain of 15.5 dbi, return loss <16.6 db, and a maximum cross polarization level of 15 db is achieved. At Ka-band, a 1 GHz bandwidth from 30–31 GHz shows that the feed has seriously degraded performance above 30.6 GHz, with 3 db less gain at 31 GHz than at 30.5 GHz and an axial ratio of 6.5 db at 31 GHz. The radiation patterns also demonstrate deterioration from 30.75 to 31 GHz. However, since good performance can be achieved from 29.6–30.6 GHz, it may be possible to retune the feed. Thus major modification and retuning of the feed will be necessary to achieve good performance in the Ka-band uplink (30-31 GHz) band for the Wideband Gapfiller System.

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13. ABSTRACT (*Maximum 200 words*)

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