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# RF Performance of a Proposed L-Band Antenna System

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*Scale model work to determine efficiencies and bandwidth were made on a smooth wall dual mode feedhorn to study the feasibility of its use at L-Band for the Venus Balloon Project. Measured feedhorn patterns were made and scattered from a symmetrical subreflector. A perturbation technique was then used to predict efficiencies due to scanning effects. A correction for the asymmetrical subreflector was also made. Tables of results and patterns are included.*

A series of antenna range experiments and computer predictions were performed to estimate efficiency and bandwidth performance of a proposed L-band (nominally 1668 MHz) feed for the DSN 64 meter antennas. In order to provide for a maximum of future users, it was desired to know overall antenna performance over the widest possible frequency band, limited primarily by a constraint to use simple smooth-walled dual mode ($TE_{11}$ + $TM_{11}$) feedhorns. This constraint arose in order to take advantage of existing S-band feedhorns (3 units), which are modifiable to the L-band missions, and because of the short project time available for implementation at all three 64 meter stations. It had long been suspected that such smooth walled horns of requisite dimensions provided only about 5 percent bandwidth (at roughly -0.5 dB performance degradation). Therefore, some care in evaluating expected performance and in selecting the center frequency of operation was indicated and accomplished. This article details the work, gives final performance estimates, and provides archival data.

An X-band horn model having the approximate correct scale factor was available and radiation patterns were obtained, taped and filed for the next evaluation step. Using a symmetric equivalent computer model of the 64 meter asymmetric (Tricone) subreflector, we were able to efficiently scatter the ten experimental horn pattern sets from this analytic subreflector and then evaluate those patterns for spillover, illumination efficiency and other factors.

Two additional losses were also considered. First, the gain is affected by slight higher order mode generation by the asymmetrical subreflector. Past experience has shown this to be less than 0.05 dB. And secondly, a computed scanning loss of less than 0.05 dB occurs due to the unfortunate but necessary placement of the L-band feedhorn slightly off the focal "ring" of the 64 meter antenna.

The results of the first step in this procedure are given in Table 1. Table 1 contains those factors of interest to the feed designers and contains useful information to determine a judgement on bandwidth, as various factors deteriorate in different ways. (Table 2 provides final predicted *system* efficiencies.) In Table 1 it can be seen that maximum gain is achieved with an antenna having a main reflector edge angle of about 55°. When designing a Cassegrain antenna for an optimum $G/T$ ratio experience has shown that the best illumination angle is somewhat less than the main reflector edge angle; in effect a low noise design requires some main reflector peripheral "shielding." For the 64 m antenna with an edge angle of 61.4°, this angle is about 55° at mid-band making the L-band feed very close to the optimum. Here we sacrifice about 7 percent gain (0.77 → 0.71) to achieve low spillover, but obtain a better final *G/T* ratio. Table 1 also shows the feed cross polarization behavior in the diagonal (45°) plane, as yet another bandwidth indicator. From Table 1 we select 8650 MHz as the best band center and this performance is scaled to 1690 (not 1668) MHz. This was to extend the radio science upper band to 1740 MHz to accommodate their bandwidth requirements. Effectively then, the horn performance available at 8537 MHz will scale to 1668 MHz. Resulting bandwidth, for high performance use (-0.3 dB gain reduction from center frequency) is 1640-1740 MHz; a 6% band. Within this band, no problems are anticipated.

Figure 2, parts a and b, shows the 64 m subreflector (symmetric equivalent) scattering patterns at 1661 MHz (from the available horn pattern at the 8500 MHz frequency). From these amplitude and phase patterns one can observe the E- and H-plane beamwidth equality across the aperture (±61.4°), the very low rear spillover (±61.4 to ±90°) and quite acceptable forward spillover (±90 to ±180°). Figures 1 and 3 show the scattered patterns at 1563 and 1758 MHz (from 8000 and 9000 MHz available horn patterns). At the lower frequency, the rather extreme spillovers are obvious and at the upper frequency, the lack of beamwidth equality with higher than desired forward spillover can be seen. It is instructive to observe all 3 scattered patterns with reference to Table 1 efficiency listings.

Table 2 builds upon Table 1, by including quadripod blocking and feed dissipation loss factors, taken as constant over such a bandwidth. Also shown in Table 2 are the spillovers and zenith noise due to rear spillover. Over the bandwidth studied, rear spillover noise is not a problem, but forward spillover is one of the primary bandwidth determinants, with illumination and cross polarization playing a further role.

In Table 2, we can estimate the L-band system overall efficiency as close to 60 percent at 1668 MHz with, as mentioned, a -0.3 dB bandwidth of 1640-1740 MHz. Operation beyond this band is possible but with reduced performance both in the efficiency and overall reflector system radiation pattern dimensions.

Finally, Fig. 4 is included, again for archival reasons, to enable possible future expansion of this system for other frequencies in the 1400-1800 MHz region. For example, it may be possible to add an aperture extension to obtain good performance at the hydrogen line (~ 1420 MHz). However associated feed parts (not addressed in this analysis such as the circular polarizer and waveguide transitions) would also most likely require modifications to reach that band.

## Acknowledgments

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**Table 1. Symmetric equivalent subreflector scattering-efficiency analysis**

| X-band horn freq., MHz | L-band operational freq., MHz[a] | Reflector Aperture angle (deg) for maximum efficiency, Θ | Available maximum efficiency, % | Reflector available efficiencies at Θ = 61.4° | | | | | Feed cross polarization, dB from peak (Reference) | Note |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Spillover | Illumination | Phase | Central blocking | Total | | |
| 8,000 | 1563 | – | – | – | – | – | – | – | – | See Fig. 1 |
| 8,100 | 1583 | 54.3 | 61 | 0.778 | 0.85 | 0.87 | 0.94 | 0.54 | −17 | |
| 8,200 | 1602 | 54.8 | 66 | 0.829 | 0.85 | 0.90 | 0.94 | 0.60 | −20 | |
| 8,300 | 1622 | 54.9 | 68 | 0.849 | 0.85 | 0.91 | 0.94 | 0.62 | −21 | |
| 8,400 | 1641 | 55.3 | 73 | 0.889 | 0.85 | 0.94 | 0.95 | 0.67 | −26 | |
| 8,500 | 1661 | 55.3 | 77 | 0.913 | 0.84 | 0.96 | 0.94 | 0.69 | −32 | See Fig. 2 |
| 8,600 | 1680 | 55.4 | 77 | 0.933 | 0.84 | 0.97 | 0.94 | 0.71 | −33 | |
| 8,700 | 1700 | 55.2 | 77 | 0.941 | 0.82 | 0.98 | 0.94 | 0.71 | −28 | |
| 8,800 | 1719 | 55.0 | 76 | 0.942 | 0.81 | 0.97 | 0.94 | 0.70 | −24 | |
| 8,900 | 1739 | 54.3 | 73 | 0.931 | 0.80 | 0.96 | 0.93 | 0.66 | −21 | |
| 9,000 | 1758 | 53.8 | 71 | 0.918 | 0.79 | 0.95 | 0.93 | 0.63 | −19 | See Fig. 3 |

[a]Recommended scale factor

**Table 2. L-Band system overall efficiency and spillover noise**

| L-band operational Freq., MHz | Overall efficiency, %[a] | Forward spillover, % | Zenith rear spillover, % | Zenith spillover noise, K |
|---|---|---|---|---|
| 1583 | 45 | 21.7 | 0.5 | 1.2 |
| 1602 | 51 | 16.6 | 0.5 | 1.2 |
| 1622 | 52 | 14.7 | 0.4 | 1.0 |
| 1641 | 57 | 10.6 | 0.5 | 1.2 |
| 1661 | 58 | 8.3 | 0.4 | 1.0 |
| 1680 | 60 | 6.4 | 0.3 | 0.7 |
| 1700 | 60 | 5.5 | 0.4 | 1.0 |
| 1719 | 59 | 5.5 | 0.3 | 0.7 |
| 1739 | 56 | 6.6 | 0.3 | 0.7 |
| 1758 | 53 | 7.9 | 0.3 | 0.7 |

[a]Total from Table 1, times 0.88 quadripod blocking, times 0.98 feed dissipation factors times 0.98 mode and scan factor.

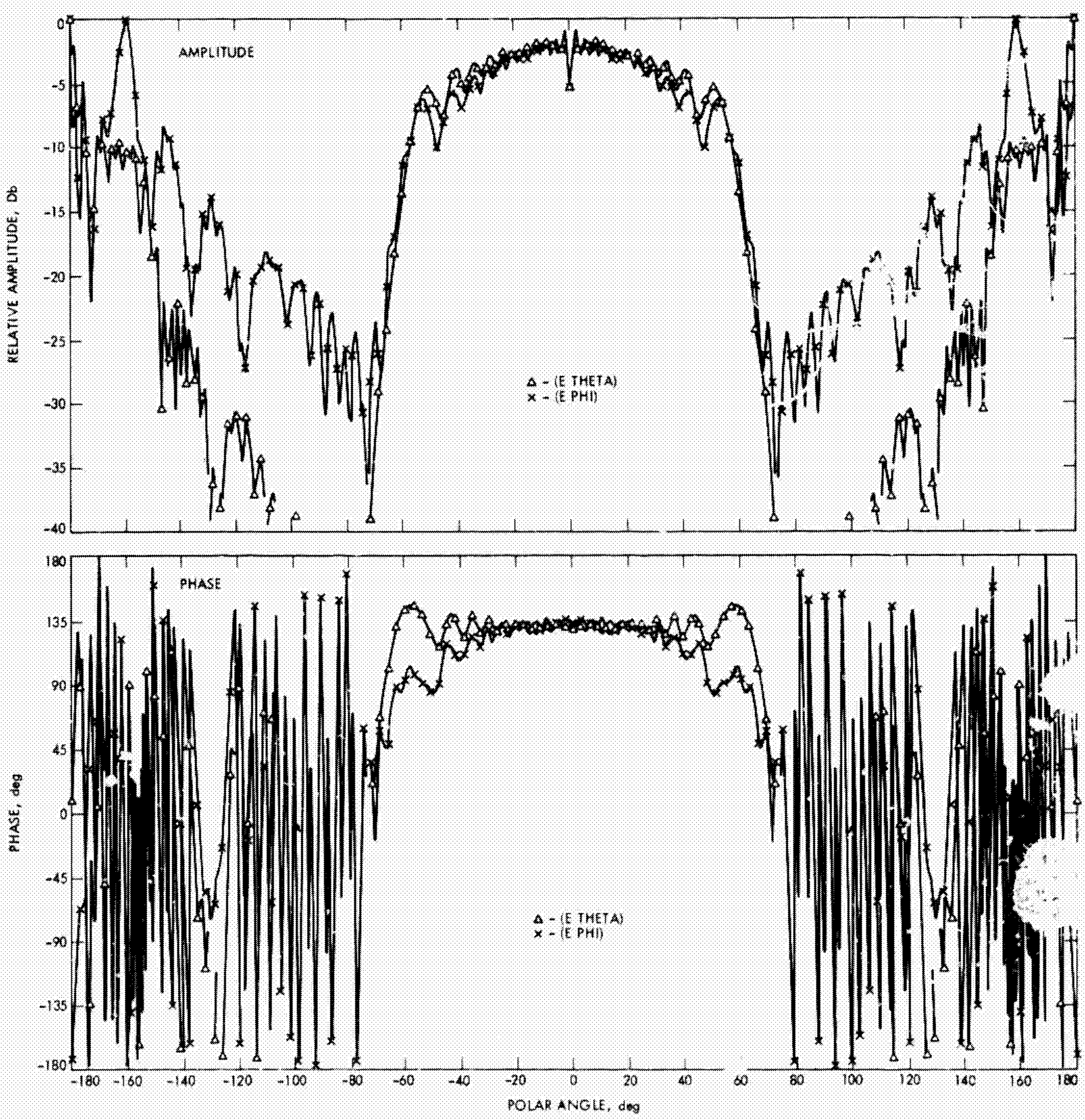


**Fig. 1. L-band scattered patterns from an equivalent 64-m symmetrical subreflector, frequency = 1.563 GHz**

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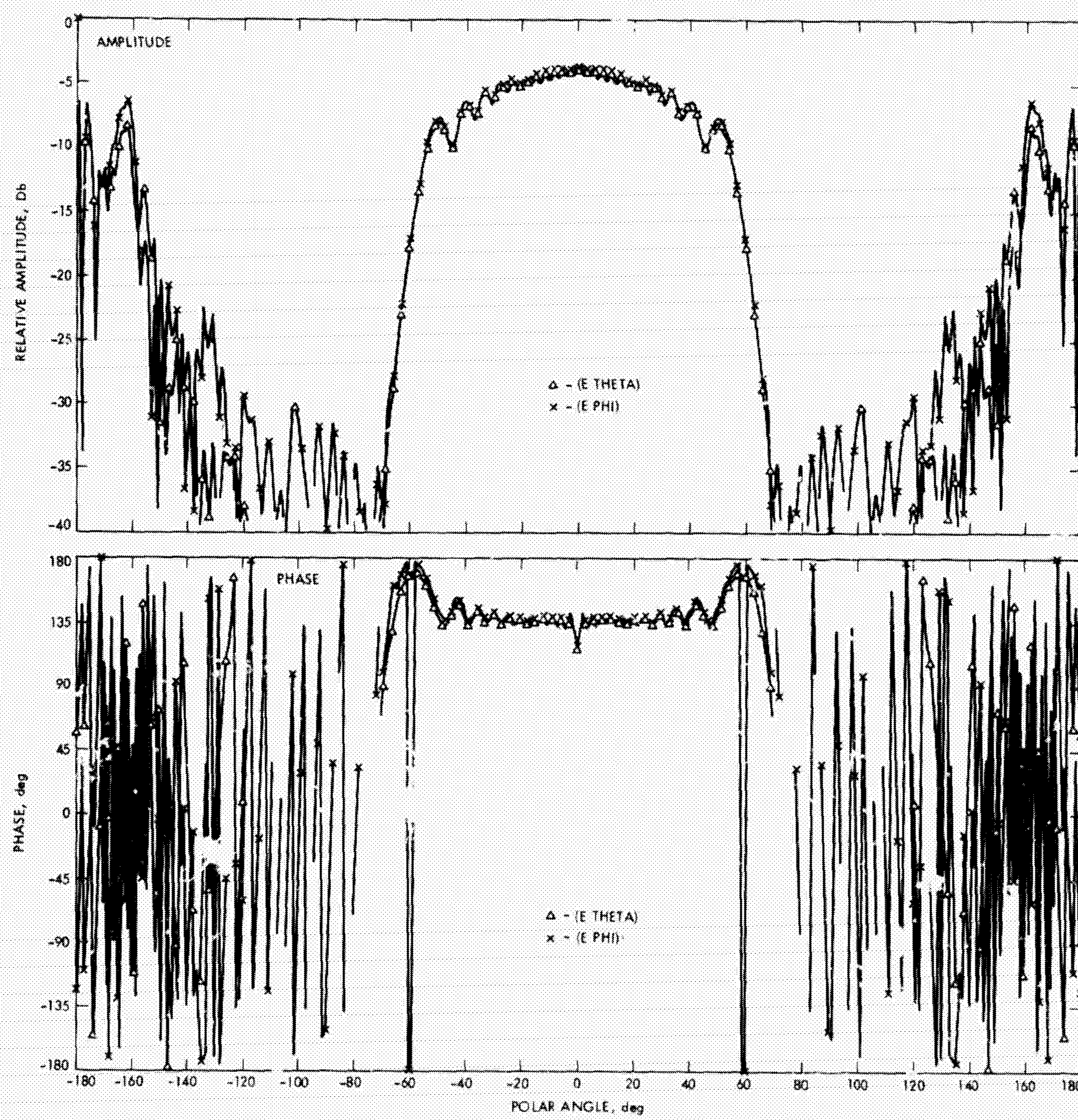


Fig. 2. L-band scattered patterns from an equivalent 64-m symmetrical subreflector, frequency = 1.661 GHz

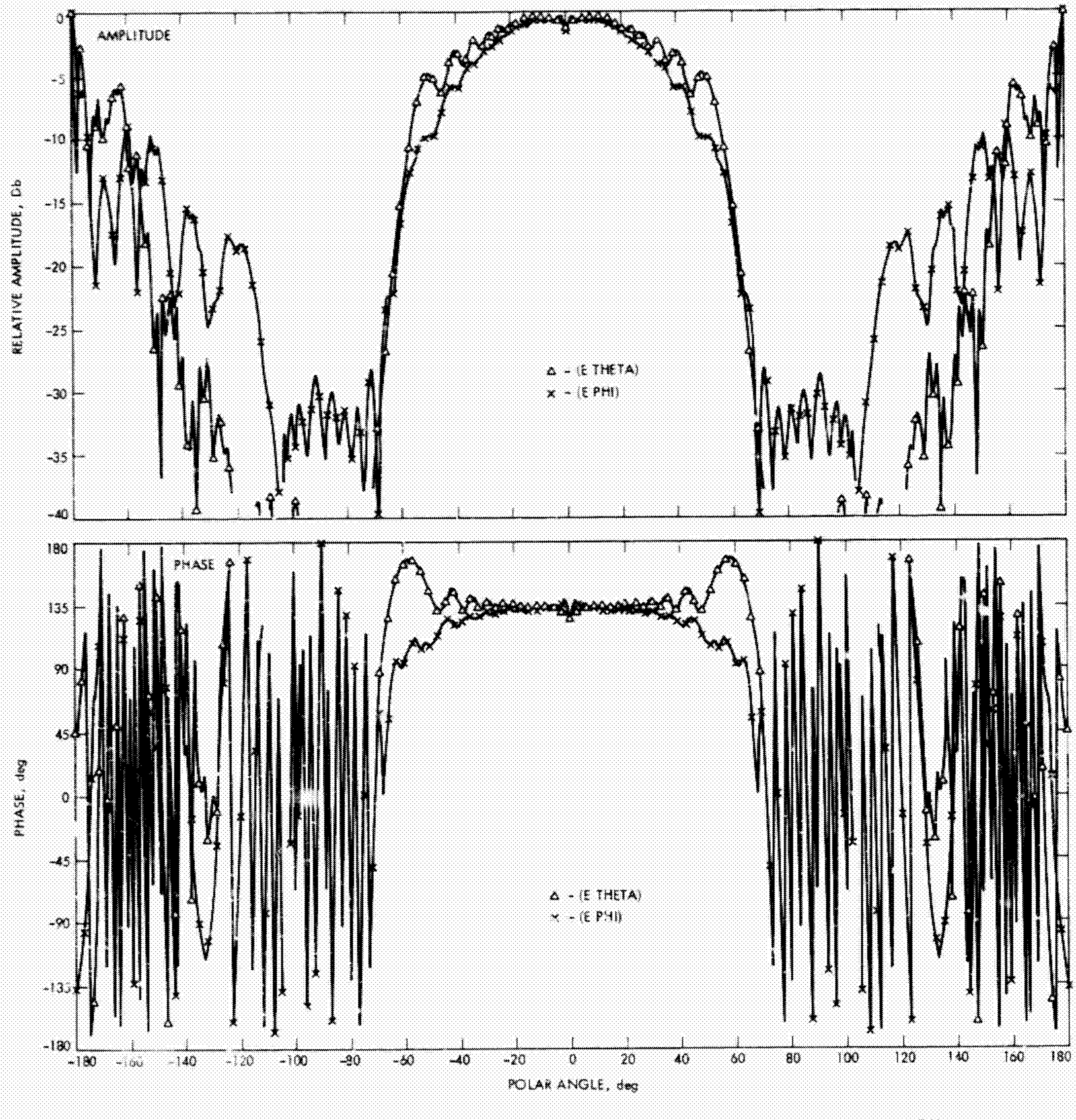


Fig. 3. L-band scattered patterns from an equivalent 64-m symmetrical subreflector, frequency = 1. [illegible] GHz

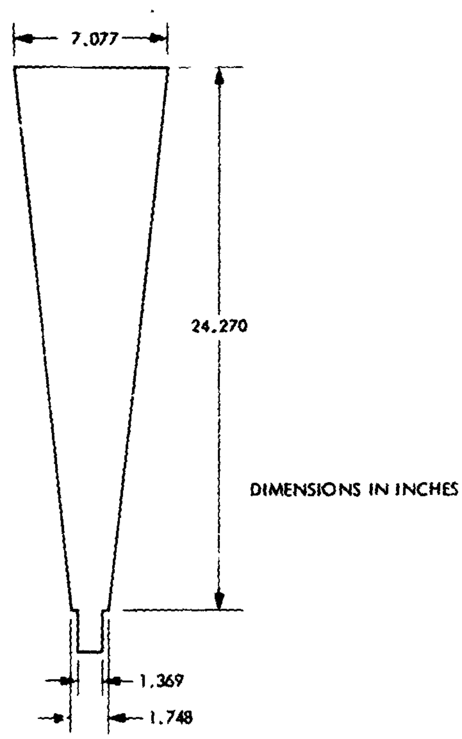


**Fig. 4. X-band model horn evaluated for L-band application**