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ANTENNA SIDELOBE PATTERN INTERPOLATION SOFTWARE
FINAL REPORT

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ABSTRACT

A software package for fast computation of radiation patterns from reflector antennas has been developed. A sampling technique is used for pattern reconstruction so that only slightly more than one sample per sidelobe is needed. A finite double sinc series then gives the field values at the in-between points from the minimum data set. The set of sample values are calculated using an efficient surface currents integration technique.

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ANTENNA SIDELOBE PATTERN INTERPOLATION SOFTWARE

1.0 INTRODUCTION

The computational effort required to reconstruct the radiation patterns from antennas is directly proportional to the number of discrete data points used. If one is interested only in the main beam which is slowly varying, a small number of data points may be used in conjunction with quadratic or cubic interpolation to represent the pattern. However, in the sidelobe region which is fast varying, at least four to five points per lobe are needed with polynomial interpolation to give a good approximation of the peak. More points are required if accurate null prediction is attempted. The amount of work can be drastically reduced by resorting to sampling theory to reconstruct the pattern. A sampling criterion is presented in the following which gives the minimum number of points required to ensure that the pattern is completely specified. It amounts to slightly over one sample per lobe. A considerable saving in effort is thus realised. After the minimum data set point is calculated using a suitably modified existing antenna program, an efficient Fourier interpolation technique is used to compute any desired number of far field points. This interpolation scheme is implemented in a separate program where one may use to generate points either on a one- or two-dimensional observation grid.

2.0 SAMPLING THEORY APPLIED TO ANTENNA PROBLEMS

Consider the planar aperture of Figure 1, which has X- and Y-dimension of $2a$ and $2b$ respectively. The far-field electric field, \bar{E} in the direction (θ, ϕ) is proportional to the Fourier Transform (FT) of the aperture distribution $\bar{J}(x, y)$:

$$\begin{aligned} \bar{E}(u, v) &= \alpha \int_{-\infty}^{+\infty} \int_{-\infty}^{+\infty} \bar{J}(x, y) e^{+jk(ux + vy)} dy dx \\ &= \alpha \int_{-a}^{+a} \int_{-b}^{+b} \bar{J}(x, y) e^{+jk(ux + vy)} dy dx \end{aligned} \quad (1)$$

where

$$u = \sin \theta \cos \phi$$

$$v = \sin \theta \sin \phi$$

The field outside the aperture is assumed to be zero. Let us expand the aperture distribution in a Fourier series on the fundamental period $-a \leq x \leq a, -b \leq y \leq b$.

$$\bar{J}(x, y) = \sum_{n=-\infty}^{+\infty} \sum_{m=-\infty}^{+\infty} \bar{J}_{mn} e^{-j n \pi x / a} e^{-j m \pi y / b} \quad (2)$$

Multiplying both sides of eqn. (2) by $\exp[+j(nx/a + my/b)\pi]$ and integrating, one finds that the complex constants, \bar{J}_{mn} , are given by

$$\begin{aligned} \bar{J}_{mn} &= \frac{1}{4ab} \int_{-a}^{+a} \int_{-b}^{+b} \bar{J}(x, y) e^{+j n \pi x / a} e^{+j m \pi y / b} dy dx \\ &= \frac{1}{4ab} \bar{E}\left(\frac{n\pi}{ka}, \frac{m\pi}{kb}\right) \end{aligned} \quad (3)$$

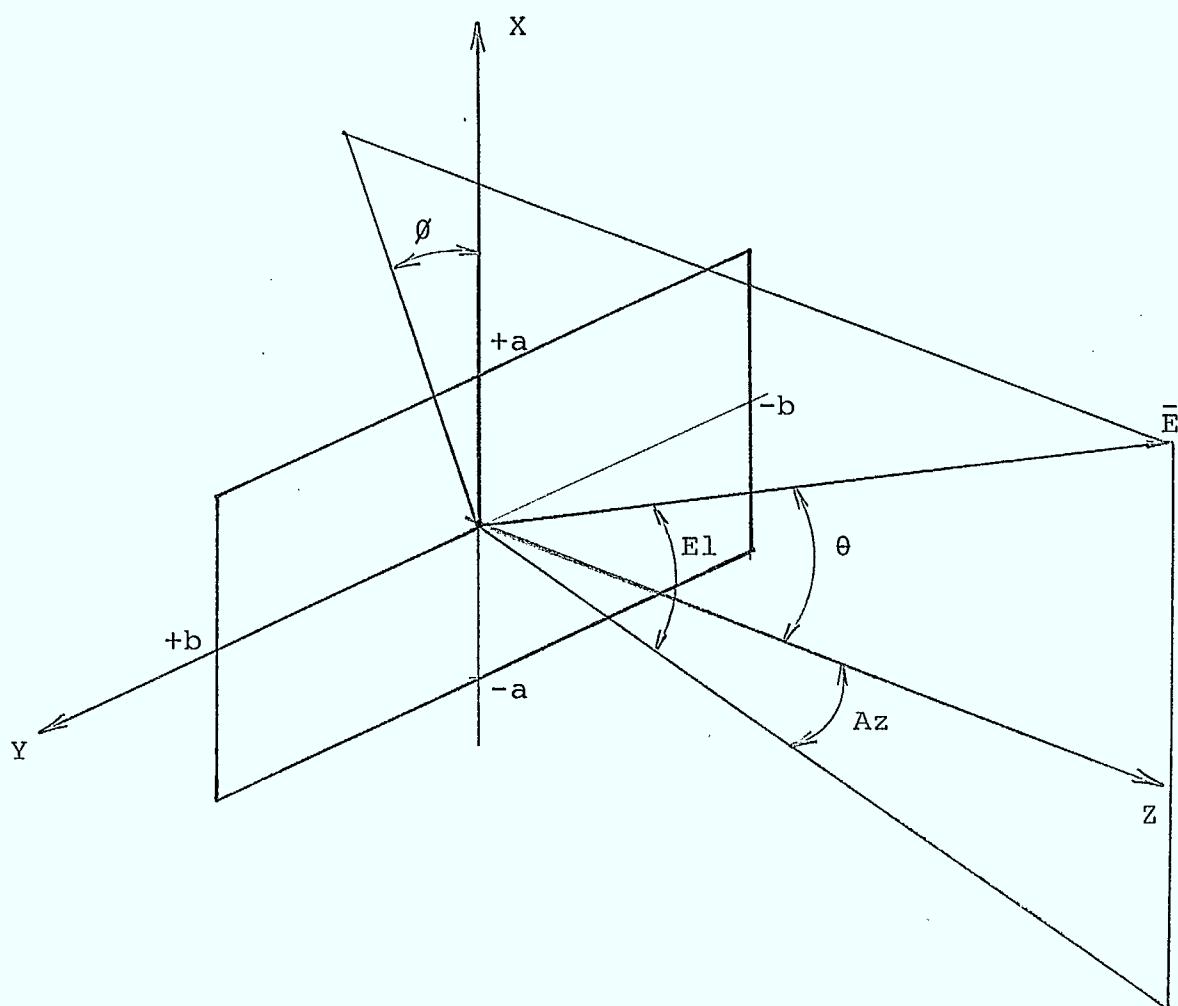


Figure 1 Planar Aperture and Co-ordinate Systems

Thus \tilde{J}_{mn} is a sample of the far-field pattern $\tilde{E}(u,v)$ at $u = n\pi/ka$, $v = m\pi/kb$. Substituting eqn. (2) into (1), exchanging integration and summation, and using eqn. (3), one gets

$$\tilde{E}(u,v) = \sum_{n=-\infty}^{+\infty} \sum_{m=-\infty}^{+\infty} E\left(\frac{n\pi}{ka}, \frac{m\pi}{kb}\right) \frac{\sin(kau - n\pi)}{(kau - n\pi)} \frac{\sin(kbv - m\pi)}{(kbv - m\pi)}$$
(4)

From eqn. (4), one can see that the far-field pattern is completely described by knowing its values at a series of points with spacing of π/ka in U-space and π/kb in V-space. Both amplitude and phase are required for the description. The point separations may be written as

$$\begin{aligned} \Delta u &= \lambda/2a \\ \Delta v &= \lambda/2b \end{aligned} \tag{5}$$

These separations are approximately the 3-dB beamwidths of an uniformly illuminated aperture or the null-to-null width of a sidelobe. The minimum number of samples is thus about one per sidelobe.

We will now apply this sampling theory to the reflector antenna. The far-field of the reflector is unfortunately not the FT of the induced surface currents. This problem can be circumvented by placing an arbitrary plane in front of the aperture. If this aperture is sufficiently large so that all scattered fields from the reflector pass through it, then the far-field can be obtained from the FT of the aperture distribution. Enlarging the aperture by a factor χ is equivalent to increasing the sampling rate. From numerical experiments on pattern reconstruction for communication satellite antennas, which tend to be electrically large, the appropriate

value for χ is found to be $1.2 \sim 1.3$.

In the case of an offset-fed reflector shown in Figure 2, the aperture of the reflector is inclined at angles ξ_x and ξ_y with respect to the X- and Y-axis. The inclined aperture dimensions, needed to determine the sampling points, are expressed as

$$\begin{aligned} a_i &= a/\cos \xi_x \\ b_i &= b/\cos \xi_y \end{aligned} \quad (6)$$

where

$$\begin{aligned} \tan \xi_x &= \frac{\Delta x}{2f} \\ \tan \xi_y &= \frac{\Delta y}{2f} \\ f &= \text{focal length} \end{aligned} \quad (7)$$

Substituting a_i for a in eqn. (4) and using the enlargement factor, we find that the electric field becomes

$$\bar{E}(\theta, \phi) = \sum_{n=-\infty}^{+\infty} \sum_{m=-\infty}^{+\infty} \bar{E}(\theta_{nm}, \phi_{nm}) \frac{\sin(u' - n\pi)}{(u' - n\pi)} \frac{\sin(v' - m\pi)}{(v' - m\pi)} \quad (8)$$

where

$$u' = \frac{k\chi a}{\cos \xi_x} \sin \theta \cos \phi$$

$$v' = \frac{k\chi b}{\cos \xi_y} \sin \theta \sin \phi$$

$$\sin^2 \theta_{nm} = \left(\frac{n\pi}{k\chi a} \right)^2 \cos^2 \xi_x + \left(\frac{m\pi}{k\chi b} \right)^2 \cos^2 \xi_y$$

$$\tan \phi_{nm} = \frac{ma \cos \xi_y}{nb \cos \xi_x}$$

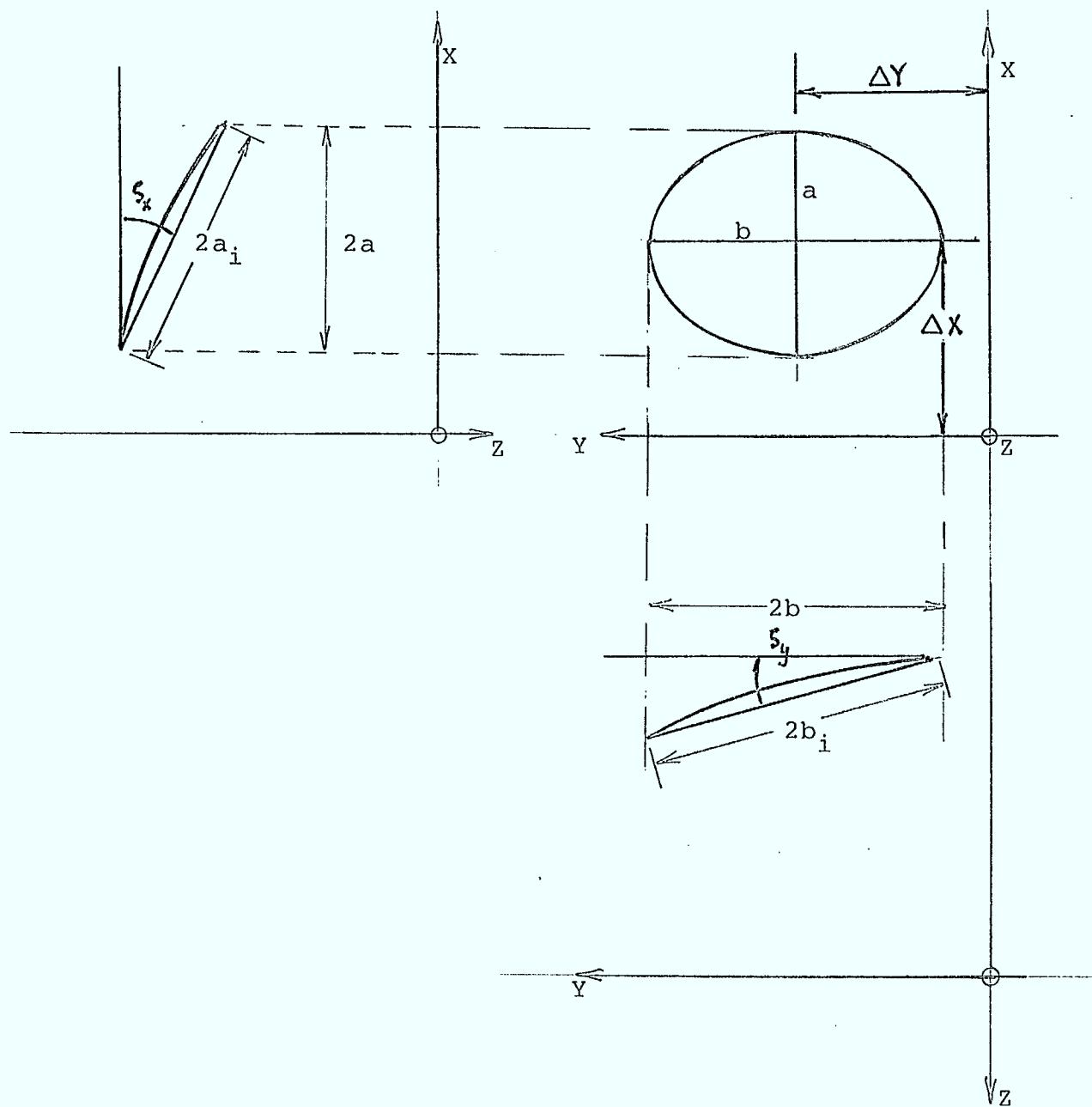


Figure 2 Projected and Inclined Apertures of Offset Reflector

3.0 CO-ORDINATE SYSTEM FOR FIELD OBSERVATION AND SAMPLING

The co-ordinate system of choice for communication satellite antennas is the rectangular elevation - azimuth grid of Figure 3. Their relationship with the spherical co-ordinates are shown in Figure 1, and defined as follows:

$$\sin^2 \theta = \sin^2 El + \cos^2 El \sin^2 Az \quad (9)$$

$$\tan \phi = \sin Az / \tan El$$

Given the co-ordinates (El , Az) of the field point, the spherical co-ordinates are determined from eqn. (9) and used in (8) to give the electric field. A two-dimensional gain matrix for points with arbitrary spacing in the El - Az plane can be readily generated. A contour plot with fine resolution may in turn be produced.

The alternative method of displaying data is to make pseudo-phi cuts, $\overline{\phi}$, in the El - Az plane as shown in Figure 3. The length of the radial vector from the origin is the pseudo-theta angle, (H) . These pseudo-angles are defined using (El , Az) co-ordinates as

$$(H) = \sqrt{El^2 + Az^2} \quad (10)$$

$$\tan \overline{\phi} = Az/El$$

For small elevation and azimuth angles, often encountered in satellite antennas, the spherical angular co-ordinates (θ, ϕ) may be written, from eqn. (9), as

$$\theta \approx \sqrt{El^2 + Az^2} = (H) \quad (11)$$

$$\tan \phi \approx Az/El = \tan \overline{\phi}$$

By comparing eqns. (10) and (11), one can see that the spherical co-ordinates are approximately equal to the pseudo-angles in the El - Az plane. Thus making a $\bar{\phi}$ -cut, where $\bar{\phi}$ is measured from the El-axis, is equivalent to that of a spherical ϕ -cut with (H) equal to θ .

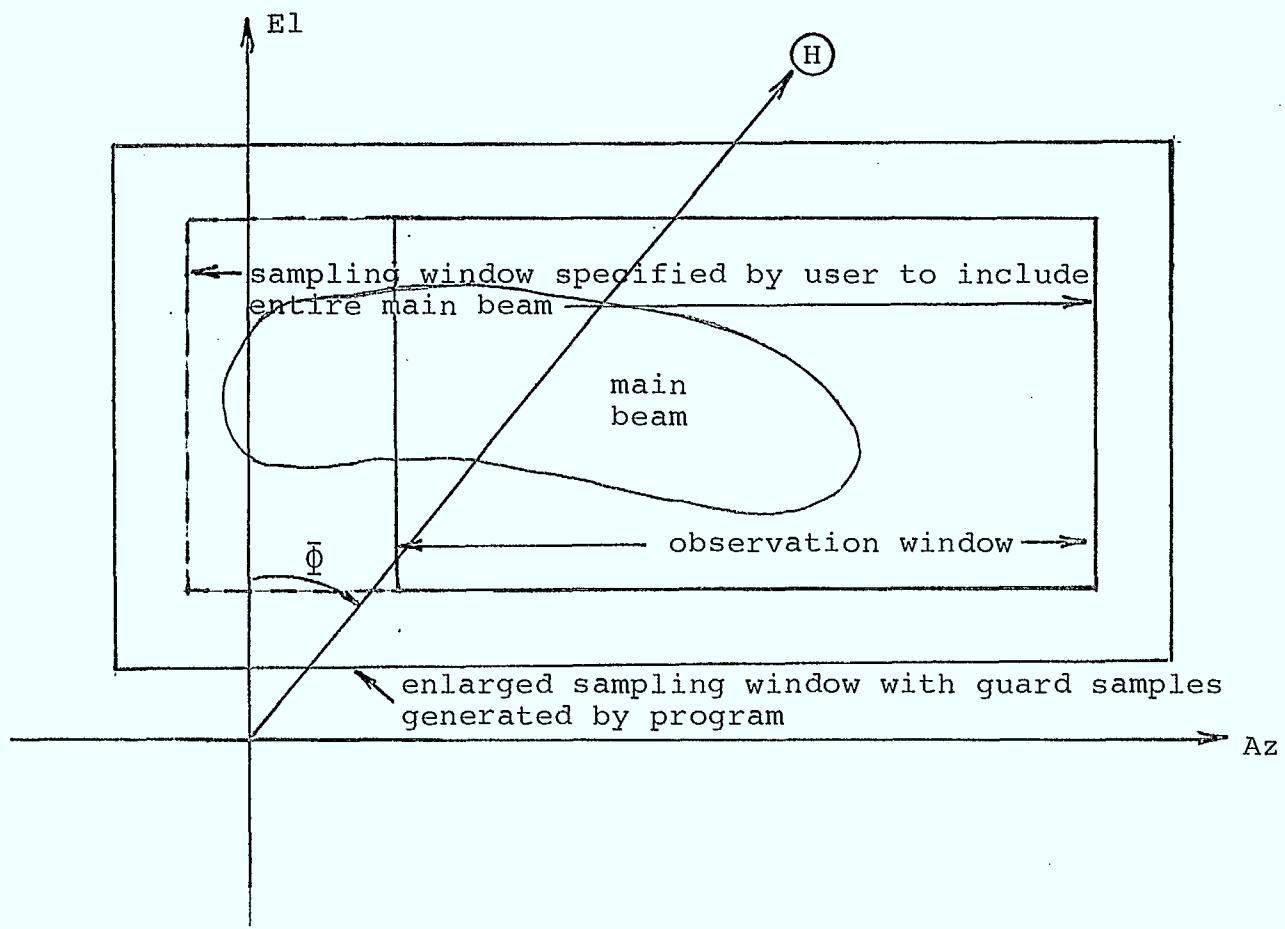


Figure 3 Sampling Windows and Observation Grid for Pattern Reconstruction.

4.0 SAMPLING WINDOW

The double infinite series of eqn. (8) has to be truncated for computation purpose. The number of terms to be retained depends on the sampling window which in turn is determined by the observation window. The sampling window is larger than the observation window by one or two guard samples at the periphery. The sampling window must include the entire main beam in addition to the area of interest so that all the high energy samples are taken into account. Thus even if the observation window is centred in the sidelobe region or includes part of the main beam, the sampling window must be enlarged accordingly.

If the observation window already includes the main beam, the sampling window can be defined to be the same when using the pattern reconstruction program. The program internally enlarges the sampling window to include the guard samples. As a result, the limits of the N-summation may be given by

$$\text{lower limit, } N_1 = \frac{k\chi a}{\cos \xi_x} (\sin El)_{\min} / \pi - 2 \quad (12)$$

$$\text{upper limit, } N_u = \frac{k\chi a}{\cos \xi_x} (\sin El)_{\max} / \pi + 2$$

while the limits for the M-summation are

$$\text{lower limit, } M_1 = \frac{k\chi b}{\cos \xi_y} (\cos El \sin Az)_{\min} / \pi - 2 \quad (13)$$

$$\text{upper limit, } M_u = \frac{k\chi b}{\cos \xi_y} (\cos El \sin Az)_{\max} / \pi + 2$$

The subscripts min and max denote the smallest and largest value of the expression enclosed in brackets and evaluated for the window. Two guard samples are used in the above equations.

A substantial saving in computational effort is realised through the sampling approach because a much smaller number of simpler function evaluations need be carried out to obtain the field pattern. The total number of samples is

$$(M_u - M_l + 1) \cdot (N_u - N_l + 1)$$

In defining the sampling window and observation grid for the program, the user must ensure that the entire main beam is bounded by the sampling window. The observation grid must be equal to or less than the size of the sampling window. Accurate reconstruction of the pattern within the observation grid is then assured.

5.0 SOFTWARE IMPLEMENTATION AND USAGE

An existing reflector program was modified to accomodate an observation grid in U - V space as well as a procedure for internal generation of the number and positions of the sample points, given the sampling window. Also the automatic selection of quadrature formula for the reflector currents is made less conservative to speed up the computation. The modified program is renamed REFC_SIF. A program listing, program description and examples of its input and output files can be found in Appendix A. The input to the program is through file REFC_DAT. The output is dumped into file REFC_DUM. The reflector program has the option of computing gain on a rectangular El-Az grid. In which case, the gain matrix is written to file GNMAT. For the purpose of pattern reconstruction, the program can also compute field points on a U-V grid. In this case, the complex co-polar and cross-polar fields are written to file SAME_DAT together with the sampling information.

The pattern reconstruction method is implemented in a separate program RECON_SIF whose listing and program description are included in Appendix B. Part of the data input is through file RECON_DAT. The rest of the data concerning sampled fields are read from file SAME_DAT. The output is directed to the user's terminal, if requested, while the co-polar and cross-polar reconstructed gain matrices are written to files CGNMAT and XGNMAT respectively if the rectangular observation grid is chosen. If the pseudo-phi cut option is chosen instead, the gain values are written to CGNSEC and XGNSEC. Both options may of course be exercised, one after the other.

The procedure to follow for a fast and accurate reconstruction of the pattern is summarised in the following steps.

- (i) Define reflector and feed configuration. Build data file REFC_DAT.
- (ii) Using the rectangular El-Az grid option and automatic quadrature selection, compute gain with REFC_SIF at the four corners of the observation window. Then recompute using lower number of quadrature points and manual selection. Compare gain values. Repeat, if necessary, to obtain the minimum number of integration points on the reflector for an acceptable level of gain error.
- (iii) Compute fields on the U-V grid spanning the sampling window which must include the main beam.
- (iv) Reconstruct pattern from samples by running program RECON_SIF.
Steps (i) and (ii) need be carried out only once for a particular class of problem.

6.0 RESULTS

The example chosen to test the program was the design for CAN504 DBS beam because it embodies a number of worst case features. The reflector is electrically large, 111.8λ . It has twenty-four horn feeds/component beams forming a shaped beam with a null region directed towards Iceland. This antenna configuration is defined in the output data of Appendix A.

The observation window chosen is from 0° to 4° in azimuth while the elevation window extends from -1.25° to $+1.25^\circ$. The sampling window has to be enlarged in azimuth, covering -1.5° to $+4^\circ$ to include the remainder of the main beam. Total number of samples used is 209. The reconstructed pattern on a rectangular El-Az grid is given in Table 1. To check the accuracy of the reconstruction, the "exact" values based on direct computation with the reflector program are shown in Table 2. Good agreement can be seen. With 209 samples, a very dense set of points with accurate gain values can be generated, if required, for contour plotting.

Next, two pseudo-phi cuts are computed with $\bar{\varphi} = 83.25^\circ$ and 90° . The former cut goes through Iceland. The gain values are tabulated in Table 3, and plotted in Figures 4 and 5. As can be observed, slightly over one sample per lobe is used to recreate accurately the sidelobe structure. Quite clearly, polynomial interpolation of the sample points would not have reproduced the same pattern.

Table 1 Reconstructed Gain Values for CAN504 Beam

RECONSTRUCTION OF DBS BEAM CANADA 504

RKA = 451,7521

RKB = 439,0844

NO. OF SAMPLE PTS. IN U-SPACE = 11

NO. OF SAMPLE PTS. IN V-SPACE = 19

TOTAL NO. OF SAMPLES IN U-V SPACE = 209

RECONSTRUCTED CO-POLAR GAIN PATTERN

Table 1 cont'd

RECONSTRUCTED X-POLAR GAIN PATTERN

Table 1 cont'd

EL (DEG) = 1.000															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-32.70	.250	-28.38	.500	-29.48	.750	-36.21	1.000	-43.70	1.250	-44.53	1.500	-47.99	1.750	-52.58
2.000	-46.09	2.250	-42.75	2.500	-43.91	2.750	-52.58	3.000	-41.18	3.250	-50.28	3.500	-42.87	3.750	-47.29
4.000	-45.77														
EL (DEG) = .750															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-23.35	.250	-30.85	.500	-29.48	.750	-27.24	1.000	-29.39	1.250	-33.44	1.500	-39.25	1.750	-43.43
2.000	-46.16	2.250	-50.68	2.500	-41.15	2.750	-49.83	3.000	-43.65	3.250	-45.79	3.500	-47.87	3.750	-46.08
4.000	-52.95														
EL (DEG) = .500															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-19.95	.250	-24.08	.500	-30.94	.750	-26.64	1.000	-25.87	1.250	-28.16	1.500	-33.25	1.750	-41.04
2.000	-41.54	2.250	-47.32	2.500	-46.26	2.750	-45.51	3.000	-51.61	3.250	-46.36	3.500	-59.24	3.750	-47.80
4.000	-64.56														
EL (DEG) = .250															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-27.08	.250	-26.06	.500	-27.51	.750	-32.10	1.000	-31.41	1.250	-28.08	1.500	-27.94	1.750	-30.86
2.000	-35.93	2.250	-41.27	2.500	-48.18	2.750	-47.39	3.000	-56.98	3.250	-50.75	3.500	-57.18	3.750	-55.00
4.000	-55.30														
EL (DEG) = .000															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-29.67	.250	-38.11	.500	-25.40	.750	-24.52	1.000	-30.72	1.250	-33.91	1.500	-27.20	1.750	-27.40
2.000	-31.76	2.250	-39.81	2.500	-44.57	2.750	-51.94	3.000	-50.27	3.250	-59.45	3.500	-50.37	3.750	-75.24
4.000	-52.13														
EL (DEG) = -.250															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-26.90	.250	-31.80	.500	-29.32	.750	-24.37	1.000	-27.27	1.250	-49.50	1.500	-27.55	1.750	-25.62
2.000	-29.63	2.250	-39.26	2.500	-44.75	2.750	-51.62	3.000	-47.06	3.250	-63.44	3.500	-48.08	3.750	-58.92
4.000	-48.33														
EL (DEG) = -.500															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-26.16	.250	-22.78	.500	-26.59	.750	-52.47	1.000	-32.14	1.250	-41.76	1.500	-26.41	1.750	-23.99
2.000	-28.17	2.250	-37.93	2.500	-44.30	2.750	-47.55	3.000	-47.44	3.250	-52.39	3.500	-48.41	3.750	-52.05
4.000	-47.71														
EL (DEG) = -.750															
AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)	AZ(DEG)	GN (DB)
.000	-24.47	.250	-20.19	.500	-20.49	.750	-23.35	1.000	-24.81	1.250	-34.53	1.500	-28.10	1.750	-24.33

Table 1 cont'd

2,000	-28.73	2,250	-39.30	2,500	-42.90	2,750	-41.94	3,000	-51.22	3,250	-45.28	3,500	-47.98	3,750	-49.12
4,000	-47.78														

EL (DEG) = -1,000

AZ(DEG)	GN (DB)														
,000	-39.82	,250	-25.12	,500	-22.63	,750	-23.76	1,000	-25.59	1,250	-32.09	1,500	-27.28	1,750	-25.54
2,000	-31.64	2,250	-38.74	2,500	-37.78	2,750	-40.02	3,000	-50.21	3,250	-42.13	3,500	-52.60	3,750	-45.14
4,000	-48.97														

EL (DEG) = -1,250

AZ(DEG)	GN (DB)														
,000	-23.37	,250	-25.05	,500	-27.05	,750	-34.28	1,000	-42.66	1,250	-30.71	1,500	-27.09	1,750	-29.41
2,000	-39.69	2,250	-35.52	2,500	-37.25	2,750	-40.98	3,000	-41.16	3,250	-41.93	3,500	-48.74	3,750	-42.60
4,000	-57.16														

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Table 2 "Exact" Gain Values for CAN504 Beam

CO-POLAR GAIN IN DB

ELEV *	AZIMUTH (DEG)																
(DEG) *	.00	.25	.50	.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75	4.00
* 1,250*	23.90	5.64	15.94	13.86	-4.59	9.89	4.40	-1.09	6.48	4.86	,04	-3.55	-2.40	,23	-10.42	-2.48	-5.79
* 1,000*	32.25	26.59	13.01	10.22	7.78	4.82	10.49	8.88	,08	-1.34	3.11	3.24	-7.91	-,51	-2.91	-8.82	-3.93
* ,750*	36.50	34.29	30.36	23.95	12.30	-,37	,01	8.76	10.86	7.60-12.28	2.85	,19	-9.58	-2.07	-19.21	-6.27	
* ,500*	37.89	37.47	36.06	32.89	26.72	15.15	8.81	-,72	7.90	10.63	5.24	-9.60	,04	-11.26	-6.56	-9.34	-14.64
* ,250*	37.67	37.88	37.80	36.54	33.18	26.93	15.88	-1.36	3.15	4.91	4.83	-2.94	-8.39	-5.27	-25.29	-7.95	-18.83
* ,000*	37.45	37.37	37.69	37.99	37.07	34.31	29.08	19.44	-2.96	6.55-10.81	,04	-9.24	-4.16	-8.66	-7.10	-9.34	
* -,250*	37.65	37.58	37.81	38.76	39.31	38.22	34.63	27.18	9.03	10.52	2.18	1.79	-1.74	-2.13	-4.07	-4.91	-6.04
* -,500*	38.59	38.58	38.78	39.22	39.79	39.11	35.87	28.64	10.63	9.98	3.56	4.98	,17	,49	-2.35	-2.66	-4.51
* -,750*	39.09	39.04	39.04	38.57	38.09	36.92	33.23	24.76	9.23	8.94	3.94	6.22	,30	2.25	-2.06	-1.02	-4.04
* -,1000*	36.79	36.88	36.77	35.56	33.42	30.80	25.35	13.62	14.74	4.79	7.06	3.84	2.11	2.04	-1.61	-,46	-3.99
* -,1250*	29.23	29.74	30.08	28.41	23.74	16.56	2.71	14.09	11.30	-,57	7.90	-7.63	4.25	-2.15	,43	-2.06	-2.90

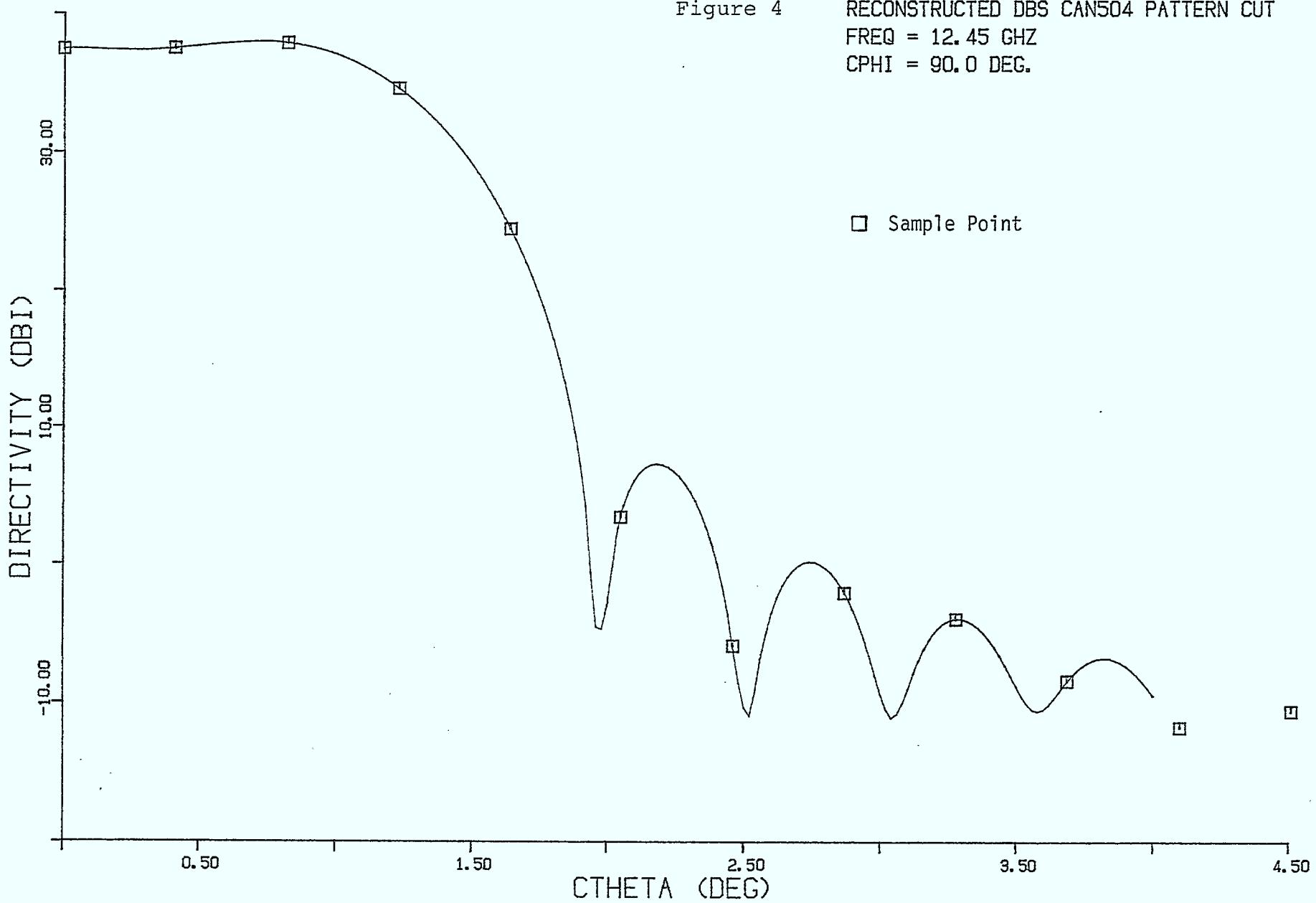
Table 2 cont'd

X-POLAR GAIN IN DB

ELEV *	AZIMUTH (DEG)
(DEG) *	,00 ,25 ,50 ,75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00
* * * * *	* * * * *
1.250*	-23.0 -24.9 -32.3 -39.7 -45.4 -39.8 -37.5 -42.1 -42.1 -50.1 -52.8 -44.9 -46.4 -50.5 -42.9 -53.8 -43.7
*	
1.000*	-32.9 -28.6 -29.5 -36.3 -43.6 -45.1 -47.5 -56.0 -45.9 -42.7 -44.6 -52.0 -42.0 -52.9 -43.8 -46.8 -46.9
*	
,750*	-23.4 -30.9 -29.3 -27.2 -29.4 -33.5 -39.5 -43.0 -46.4 -49.1 -41.4 -51.3 -44.2 -45.9 -49.1 -45.6 -54.7
*	
,500*	-20.1 -24.1 -30.3 -26.6 -25.8 -28.2 -33.4 -40.2 -41.5 -48.6 -46.4 -46.0 -53.0 -46.6 -62.0 -47.7 -64.7
*	
,250*	-27.1 -26.2 -27.6 -32.1 -31.1 -28.0 -28.0 -30.9 -36.1 -41.5 -50.4 -48.1 -58.7 -51.0 -57.7 -54.2 -55.7
*	
,000*	-29.7 -38.2 -25.4 -24.5 -30.7 -33.9 -27.2 -27.4 -31.8 -39.7 -44.7 -51.9 -51.0 -59.3 -51.3 -70.3 -53.1
*	
-,250*	-27.0 -32.3 -29.2 -24.4 -27.5 -48.3 -27.3 -25.6 -29.6 -39.1 -43.9 -53.2 -47.1 -70.4 -49.4 -56.0 -49.4
*	
-,500*	-25.9 -22.6 -26.3 -51.7 -32.5 -41.1 -26.4 -24.0 -28.2 -38.0 -44.2 -46.4 -46.9 -52.2 -47.4 -52.4 -47.7
*	
-,750*	-24.4 -20.2 -20.5 -23.3 -24.8 -34.5 -28.2 -24.3 -28.7 -39.2 -42.5 -41.7 -50.6 -45.1 -47.7 -48.4 -47.9
*	
-1.000*	-41.2 -25.9 -23.0 -23.9 -25.5 -31.9 -27.3 -25.7 -32.0 -39.5 -38.2 -40.4 -48.7 -42.3 -58.3 -44.2 -50.2
*	
-1.250*	-23.6 -25.4 -27.0 -33.9 -41.9 -30.7 -27.0 -29.4 -39.3 -35.9 -37.2 -41.9 -41.4 -42.3 -49.6 -42.8 -61.3

CD-POLAR PHASE IN DEG

ELEV *	AZIMUTH (DEG)
(DEG) *	,00 ,25 ,50 ,75 1.00 1.25 1.50 1.75 2.00 2.25 2.50 2.75 3.00 3.25 3.50 3.75 4.00
* * * * *	* * * * *



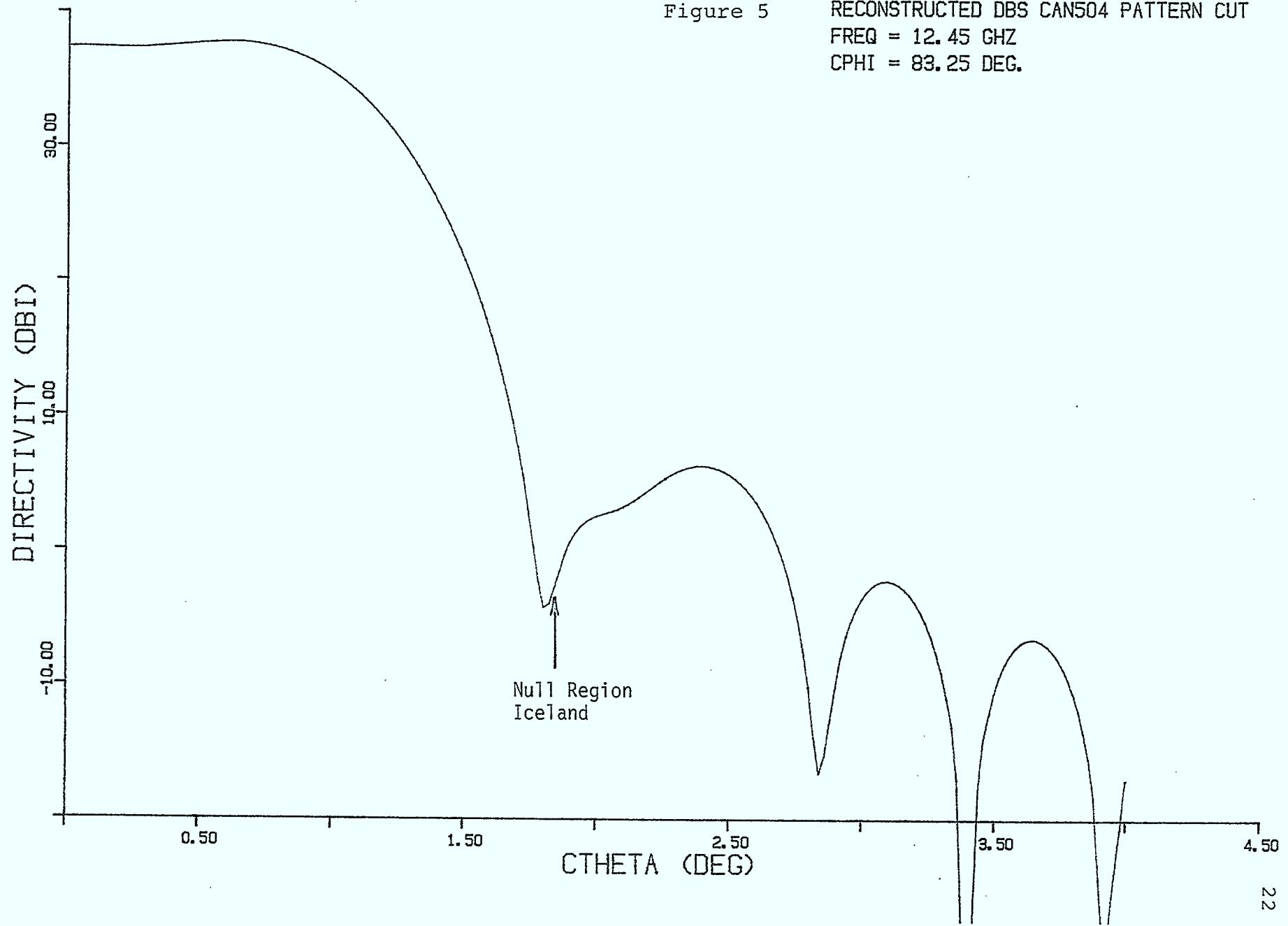


Table 3 Reconstructed $\bar{\Phi}$ - Cuts for CAN504 Beam

RECONSTRUCTION OF DEG BEAM CANADA 504

RKA = 451.7521

RKB = 439.0844

NO. OF SAMPLE PTS. IN U-SPACE = 11

NO. OF SAMPLE PTS. IN V-SPACE = 19

TOTAL NO. OF SAMPLES IN U-V SPACE = 209

RECONSTRUCTED CO-POLAR GAIN PATTERN

PHI (DEG) = 93.25

THETA (D)	GAIN (DB)										
,000	37.45	,040	37.45	,080	37.44	,120	37.42	,160	37.41	,200	37.40
,240	37.40	,280	37.42	,320	37.46	,360	37.51	,400	37.57	,440	37.64
,480	37.71	,520	37.78	,560	37.82	,600	37.85	,640	37.84	,680	37.80
,720	37.71	,760	37.57	,800	37.38	,840	37.14	,880	36.83	,920	36.47
,960	36.03	1.000	35.53	1.040	34.96	1.080	34.31	1.120	33.59	1.160	32.79
1.200	31.89	1.240	30.89	1.280	29.81	1.320	28.61	1.360	27.30	1.400	25.97
1.440	24.28	1.480	22.53	1.520	20.59	1.560	18.41	1.600	15.95	1.640	13.10
1.680	9.73	1.720	5.59	1.760	,40	1.800	-4.19	1.840	-2.82	1.880	-,25
1.920	1.31	1.960	2.14	2.000	2.56	2.040	2.81	2.080	3.07	2.120	3.45
2.160	3.96	2.200	4.54	2.240	5.11	2.280	5.62	2.320	6.01	2.360	6.25
2.400	6.33	2.440	6.22	2.480	5.92	2.520	5.40	2.560	4.65	2.600	3.63
2.640	2.28	2.680	,51	2.720	-1.85	2.760	-5.12	2.800	-10.03	2.840	-16.50
2.880	-12.37	2.920	-7.94	2.960	-5.18	3.000	-3.53	3.040	-2.59	3.080	-2.19
3.120	-2.25	3.160	-2.75	3.200	-3.71	3.240	-5.21	3.280	-7.44	3.320	-10.85
3.360	-16.83	3.400	-36.36	3.440	-17.67	3.480	-12.16	3.520	-9.32	3.560	-7.69
3.600	-6.81	3.640	-6.51	3.680	-6.70	3.720	-7.39	3.760	-8.52	3.800	-10.53
3.840	-13.45	3.880	-18.28	3.920	-29.21	3.960	-23.93	4.000	-17.03		

PHI (DEG) = 90.00

THETA (D)	GAIN (DB)										
,000	37.45	,040	37.45	,080	37.44	,120	37.42	,160	37.40	,200	37.38
,240	37.37	,280	37.38	,320	37.40	,360	37.44	,400	37.49	,440	37.56
,480	37.64	,520	37.73	,560	37.81	,600	37.88	,640	37.94	,680	37.98
,720	39.00	,760	37.98	,800	37.93	,840	37.84	,880	37.71	,920	37.54
,960	37.33	1.000	37.07	1.040	36.77	1.080	36.41	1.120	36.00	1.160	35.55
1.200	35.03	1.240	34.46	1.280	33.83	1.320	33.13	1.360	32.37	1.400	31.53
1.440	30.62	1.480	29.61	1.520	28.52	1.560	27.31	1.600	25.98	1.640	24.50
1.680	22.86	1.720	21.01	1.760	18.89	1.800	16.41	1.840	13.43	1.880	9.62
1.920	4.25	1.960	-4.54	2.000	-3.05	2.040	2.54	2.080	5.24	2.120	6.61
2.160	7.20	2.200	7.23	2.240	6.79	2.280	5.92	2.320	4.59	2.360	2.72
2.400	,15	2.440	-3.47	2.480	-8.53	2.520	-10.94	2.560	-6.84	2.600	-3.59
2.640	-1.60	2.680	-4.46	2.720	,08	2.760	,13	2.800	-27	2.840	-1.10
2.880	-2.39	2.920	-4.21	2.960	-6.60	3.000	-9.37	3.040	-11.10	3.080	-10.08
3.120	-7.94	3.160	-6.15	3.200	-4.92	3.240	-4.21	3.280	-3.94	3.320	-4.06
3.360	-4.55	3.400	-5.40	3.440	-6.58	3.480	-8.02	3.520	-9.49	3.560	-10.49
3.600	-10.53	3.640	-9.74	3.680	-8.70	3.720	-7.80	3.760	-7.17	3.800	-6.84
3.840	-6.82	3.880	-7.09	3.920	-7.64	3.960	-8.44	4.000	-9.44		

Table 3 cont'd

RECONSTRUCTED X-POLAR GAIN PATTERN

PHI (DEG) = 83.25

THETA (D)	GAIN (DB)										
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.000	-29.67	.040	-31.66	.080	-34.57	.120	-39.40	.160	-51.95	.200	-44.17
.240	-36.76	.280	-32.93	.320	-30.43	.360	-28.66	.400	-27.37	.440	-26.42
.480	-25.76	.520	-25.34	.560	-25.12	.600	-25.10	.640	-25.27	.680	-25.62
.720	-26.16	.760	-26.90	.800	-27.87	.840	-29.08	.880	-30.58	.920	-32.40
.960	-34.47	1.000	-36.43	1.040	-37.26	1.080	-36.32	1.120	-34.53	1.160	-32.78
1.200	-31.30	1.240	-30.11	1.280	-29.18	1.320	-28.47	1.360	-27.95	1.400	-27.59
1.440	-27.37	1.480	-27.29	1.520	-27.33	1.560	-27.49	1.600	-27.76	1.640	-28.13
1.680	-28.61	1.720	-29.19	1.760	-29.86	1.800	-30.63	1.840	-31.47	1.880	-32.38
1.920	-33.34	1.960	-34.31	2.000	-35.27	2.040	-36.21	2.080	-37.10	2.120	-37.96
2.160	-38.81	2.200	-39.72	2.240	-40.73	2.280	-41.91	2.320	-43.32	2.360	-45.00
2.400	-46.94	2.440	-48.88	2.480	-50.11	2.520	-49.96	2.560	-48.87	2.600	-47.68
2.640	-46.79	2.680	-46.30	2.720	-46.22	2.760	-46.59	2.800	-47.42	2.840	-48.83
2.880	-50.98	2.920	-54.24	2.960	-58.99	3.000	-60.75	3.040	-56.15	3.080	-52.58
3.120	-50.31	3.160	-48.89	3.200	-48.11	3.240	-47.84	3.280	-48.06	3.320	-48.74
3.360	-50.04	3.400	-52.06	3.440	-55.22	3.480	-60.45	3.520	-65.41	3.560	-59.15
3.600	-54.67	3.640	-51.98	3.680	-50.29	3.720	-49.29	3.760	-48.82	3.800	-48.82
3.840	-49.29	3.880	-50.26	3.920	-51.84	3.960	-54.27	4.000	-58.09		

PHI (DEG) = 90.00

THETA (D)	GAIN (DB)										
-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------	-----------

.000	-29.67	.040	-31.38	.080	-33.81	.120	-37.53	.160	-44.68	.200	-50.83
.240	-39.61	.280	-34.72	.320	-31.49	.360	-29.53	.400	-27.92	.440	-26.70
.480	-25.77	.520	-25.08	.560	-24.59	.600	-24.27	.640	-24.12	.680	-24.13
.720	-24.30	.760	-24.62	.800	-25.10	.840	-25.76	.880	-26.62	.920	-27.70
.960	-29.05	1.000	-30.72	1.040	-32.79	1.080	-35.26	1.120	-37.69	1.160	-39.43
1.200	-36.76	1.240	-34.45	1.280	-32.45	1.320	-30.86	1.360	-29.62	1.400	-28.66
1.440	-27.93	1.480	-27.40	1.520	-27.03	1.560	-26.81	1.600	-26.72	1.640	-26.75
1.680	-26.89	1.720	-27.14	1.760	-27.50	1.800	-27.95	1.840	-28.51	1.880	-29.17
1.920	-29.93	1.960	-30.79	2.000	-31.76	2.040	-32.84	2.080	-34.03	2.120	-35.31
2.160	-36.68	2.200	-38.09	2.240	-39.48	2.280	-40.76	2.320	-41.84	2.360	-42.68
2.400	-43.30	2.440	-43.79	2.480	-44.29	2.520	-44.88	2.560	-45.66	2.600	-46.66
2.640	-47.92	2.680	-49.40	2.720	-50.95	2.760	-52.18	2.800	-52.60	2.840	-52.17
2.880	-51.38	2.920	-50.68	2.960	-50.29	3.000	-50.27	3.040	-50.69	3.080	-51.60
3.120	-53.09	3.160	-55.25	3.200	-57.93	3.240	-59.57	3.280	-57.97	3.320	-55.28
3.360	-53.13	3.400	-51.64	3.440	-50.75	3.480	-50.37	3.520	-50.49	3.560	-51.11
3.600	-52.33	3.640	-54.32	3.680	-57.56	3.720	-63.56	3.760	-79.44	3.800	-63.02
3.840	-57.67	3.880	-54.83	3.920	-53.20	3.960	-52.35	4.000	-52.13		

STOP

!

APPENDIX A

PROGRAM REF C_SIF

APPENDIX AA.1-Description of Computer Program : REFC_SIF

IDENTIFICATION: REFC_SIF

PURPOSE:

The program calculates the field radiated by a parabolic reflector antenna with projected elliptical aperture using the method of physical optics (surface currents). Various feed models, single or dual-mode pyramidal or conical horns, may be used to illuminate the reflector. Either linearly or circularly polarized secondary beam may be specified.

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DESCRIPTION:

The geometry of a general reflector antenna system is shown in Figure A1. A global co-ordinate system, XYZ, is defined at the focal point, 0, of the reflector. All input quantities are referred to this co-ordinate system. Besides this global system, three other local co-ordinate systems are also used. The first, $X_1Y_1Z_1$, is for the inte-

gration of currents over the reflector surface and has its origin located at the centre of the projected aperture in the focal plane. The second, $X_r Y_r Z_r$, is used to describe the feed while the third, $X_q Y_q Z_q$, is the far field observation co-ordinate system.

The reflector is a parabola with focal length F and its projected aperture can be off-set in the X- and Y-direction. The offset distances of the centre of the projected aperture from the focal axis are ΔX and ΔY as shown in Figure A2. The projected aperture is assumed to be elliptical with major X- and Y-axes equal to $SX2$ and $SY2$ respectively.

There are two ways of specifying the position and orientation of the feed in the program. The most frequently used approach, especially when a horn array is involved, is to position first the horn feeds on the X-Y plane (focal plane). The entire horn array is then rotated about the global X- and Y-axes as shown in Figure A3. The rotation, α , about the X-axis is carried out first, followed by rotation, β , about the rotated Y-axis. If required, one can further rotate each feed about its own local Z_r -axis by γ . Hence if this approach is selected, the X-, Y- and Z- displace-

ments given by (δx_r , δy_r , $\delta z_r = 0$) on the focal plane have to be specified together with the rotations. This ensures that the apertures of the feeds lie on the same plane without any obscuration.

The other approach is to position and orientate each feed individually. The feed is first translated from the global system by (δx_r , δy_r , δz_r) and then rotated about the translated x_t -, y_t - and z_t - axes in turn by α_r , β_r , and γ_r respectively as shown in Figure A1.

This method allows for complete freedom in locating the feed.

The far-field observation system may be displaced from the global system by (X_{dq} , Y_{dq} , Z_{dq}) when one is interested in phase parallax correction.

If one is only interested in co- and cross-polarized gain, the displacement may be set to zero. Location of the far-field point is defined by its elevation and azimuth co-ordinates as shown in Figure A4. Elevation angle is positive when measured upwards from the Y_q - Z_q plane while the azimuth angle in the Y_q - Z_q plane is positive when measured from the Z_q -axis towards the Y_q -axis.

Far-field computations are carried out as follows.

A suitable Gaussian integration formula is first obtained by taking into account the reflector size in wavelength, furthest observation angle and extreme feed position. This formula determines the locations (r_1 , ϕ_1) of the surface integration points. At each point, the incident fields from the feeds are found, summed and stored. Next, the field at each of the observation point is obtained by adding the contribution from all the integration points. Knowing the field intensity and the total power radiated by the feeds, the co- and cross-polarized gain may be calculated for the observation point.

The built-in feed models are:

- conical horn excited in the fundamental TE_{11} mode.
- conical horn excited with TE_{11} and TM_{11} modes.
- pyramidal horn excited in the fundamental TE_{10} mode.
- pyramidal horn excited with TE_{10} and TE/TM_{12} modes

These horns may be excited either with linear polarization or circular polarization. To visualise the excitation arrangement, consider the feed of Figure A5, which has a X_r -axis and a Y_r -axis directed probe. For VP, only the X_r -probe is

excited. Similarly, for HP, only the Y_r -probe is excited. To produce a RHCP (LHCP) secondary beam, the excitation of the X_r -probe is $C_x \angle 0^\circ$ and the excitation of the Y_r -probe is $C_y \angle 90^\circ + \psi$ ($C_y \angle -90^\circ + \psi$). For perfect CP, $C_x = C_y = 1.0$ and $\psi = 0^\circ$. To simulate realistic condition, the amplitude imbalance ratio, C_y/C_x , and the departure from phase quadrature, ψ , may be specified.

REMARKS:

The dimensions of the horns are checked to ensure that the fundamental and/or higher order modes could propagate. Execution is terminated if the modes are below cut-off. Program does not check for overlapping of feeds. User must ensure that this does not occur.

The output gain matrices are with respect to an elevation-azimuth co-ordinate system whose boresight axis is parallel to the RF-axis of the reflector. This means that the user has to position the gain contours over the coverage area to obtain the best possible boresight direction.

In order to speed up the computation of the feed illumination, two computations saving features are incorporated. The first involves a search through the list of entered horns and separates them into different groups. Within each group, the horns have the same dimensions. Hence patterns need to

be computed only for one horn from each group. The second time saving feature is obtained by computing only the E-plane and H-plane patterns of the designated horn at 46 points equally spaced between $\theta = 0^\circ$ and 90° . Any in-between points within a phi-plane are obtained by quadratic interpolation while points between phi-planes are found by $\cos \phi - \sin \phi$ interpolation. Because of this azimuthal interpolation, the ratio of the H-plane dimension to the E-plane dimension of a pyramidal horn should be greater than 0.7 but less than 2.8 i.e. $0.7 < a/b < 2.80$. Such a restriction is necessary to prevent interpolation errors which will occur when the beamwidths are too different in the principal planes.

USAGE (INPUT):

The input data required by the program are to be supplied in a file named REFC_DAT. Data may be written in free format and follow the sequence laid out below. Data input is list directed.

IHEAD(I)- Header describing the particular run. Maximum of 60 characters. Limitation due to array size.

FREQ- Frequency in GHz.

NHORN- Number of horns in feed array. See Restriction.

ITYPE- Type of built-in feed. All horns must either be pyramidal or conical. A mixture is not allowed.
= 0, pyramidal horn.
= 1, conical horn.

AM- Amplitude ratio of the higher order mode relative to the fundamental mode.
= 0.0, for basic mode operation.
= 0.100 ~ 0.125, for small dual mode conical horns..
= 0.670, for small multi-mode pyramidal horns.
These are only suggested values for mode content and are found to equalise the beamwidths down to the -10 dB point.

PM- Relative phase in radians of the higher order mode.
= 0.0, normally.

B(I)- E-plane horn aperture dimension in inches. Pyramidal horn option only. An entry must be provided for each feed. B(I) should not exceed 7.5λ .

A(I)- H-plane horn aperture dimension in inches.
Pyramidal horn option only. An entry must be provided for each feed. $A(I) \leq 7.5\lambda$.

WGB(I)- E-plane dimension of input rectangular waveguide in inches. Pyramidal horn option only. An entry must be provided for each feed. $WGB(I) \leq B(I)$

WGA(I)- H-plane dimension of input rectangular waveguide in inches. Pyramidal horn option only. An entry must be provided for each feed. $WGA(I) \leq A(I)$.

AR(I)- Radius of circular horn aperture in inches.
Conical horn option only. An entry must be provided for each feed. $AR(I) \leq 8\lambda$.

WGR(I)- Radius of input waveguide in inches. Conical horn option only. An entry must be provided for each feed. $WGR(I) \leq AR(I)$.

HRNLTH(I)- Horn length between input guide and aperture in inches. An entry must be provided by each feed.

MODH- Choice of aperture field model for horn pattern.
= 0, Electric field model. Good approximation to measured results for horn sizes between 0.95λ and 1.30λ .
= 1, Chu model. Conservative model that can be used for all horn sizes.

OPTH- Option for specifying feed positions and rotations.
= 0, Collective movement and rotation of feed array.
= 1, Individual movement and rotation of feed horn.

DX(I), } Displacements of component feeds in inches from
DY(I), } focal point. A set of values must be provided
DZ(I) - for each feed.

ALPHA(I), - Rotations about X-, Y- and Z- axes in degrees.

BETA(I), See text for definition. If the option of

GAMMA(I) collective movement is chosen, only one set of
values need be provided. Otherwise, a set must
be provided for each feed.

IPOLA - Polarization of secondary beam.
= 1, Vertical polarization. (VP).
= 2, Horizontal polarization. (HP).
= 3, Right hand circular polarization. (RHCP).
= 4, Left hand circular polarization. (LHCP).

CXY(I) - Amplitude imbalance of Y_r -port relative to X_r -
port. CP only. An entry must be provided for
each feed.

PSI(I) - Departure from phase quadrature of the Y_r -port
in degrees. CP only. An entry must be provided
for each feed.

HPWR(I) - Power input to each feed in watts.

HPHASE(I) - Relative phase excitation of each feed in degrees.

F - Focal length of parabolic reflector in inches.

SX2 - X-dimension of elliptical reflector aperture in
inches.

SY2 - Y-dimension of elliptical reflector aperture in
inches.

DELTAX - X-offset of aperture centre in inches.

DELTAY - Y-offset of aperture centre in inches.

OPTB - Option for specifying limits of integration.
This feature may be used to simulate aperture blockage.
= 0, Limits are generated by program. No blockage
is assumed.
= 1, Limit. are specified by user.

NREG - Number of regions of ϕ_1 - integration. In the program
this number is set equal to 4.

PHL (I), Lower and upper limits of ϕ_1 - integration for

PHU (I) - the I th region in radians.

BX2, BY2 - X- and Y-dimension of central elliptical blockage in
inches.

OPTQ - Option of specifying number of integration points.
= 0, Determined by program.
= 1, Specified by user.

NQR - No. of integration points in the radial-direction
(r_1). Choose from: 3, 4, 6, 8, 10, 12, 14, 16, 20, 24, 28, 34, 40.

NQP - No. of integration points in the phi-direction.
(ϕ_1). Choose from: 3, 4, 6, 8, 10, 12, 14, 16, 20, 24, 28, 34, 40.

IGRD - Choice of far field observation grid.
= 0, Rectangular elevation-azimuth grid
= 1, U - V grid. Required for pattern reconstruction.

For U - V grid:

ELS, ELE - Elevation start and stop angles in degrees defining
the elevation width of the sampling window.

AZS, AZE - Azimuth start and stop angles in degrees defining
the azimuth width of the sampling window.

CHI - Aperture or sampling rate enlargement factor.
Typical value is around 1.25.

For El-Az grid:

AZS - Start of azimuth cut in degrees.
AZE - End of azimuth cut in degrees.
NAZ - Number of azimuth points. See restriction.
ELS - Start of elevation cut in degrees.
ELE - End of elevation cut in degrees.
NEL - Number of elevation points. See Restriction.
PVR - Angular rotation about z-axis of field polarization vector in degrees. It is used to rotate the linear polarization vector in cases where minimising rain attenuation is important. For CP application, it has the effect of rotating the polarization ellipse.
In most situations, it is set equal to GAMMA.

In the above input list, all variables beginning with the letter I through N as well as OPTH, OPTB and OPTQ, are integer variables. The flow chart for the data input section is shown in Figure A6.

OUTPUT:

All input data are printed out for the purpose of verification and run identification. The spillover efficiency of the reflector is displayed next, followed by the co-polar component gain, cross-polar component gain, and co-polar component phase. All this output is directed to file REFC_DUM. If the U-V grid option is chosen, the complex co-polar and cross-polar fields at the sample points are written into a file named SAME_DAT together

with the sampling information. For the El-Az grid option, the co-polar gain matrix together with the header and angular information on the observation frame (AZS, AZE, NAZ, ELS, ELE, NEL) are written into a file named GNMAT. This gain file can be assessed later for contour plotting purposes.

CODING INFORMATION:

Program is written in FORTRAN 77 for use on the Honeywell CP-6 computer system.

Restriction:

The restriction on the antenna configuration that can be analysed is solely due to array dimensions. In order to minimise the demand on computer resources, the arrays have been dimensioned to cover many of the cases usually encountered. In certain situations such as DBS application where the number of feeds required or the number of integration points needed or the field of view exceeded those envisaged, the pertinent arrays must be changed according to the following prescription.

To Increase the Number of Horn Feeds

The program has been set to allow a maximum of 50 feeds. To increase the number of feeds, the following changes have to be made.

MAIN PROGRAM: (i) Change the dimensions of the following arrays to the value of NHORN -

A, B, WGA, WGB, AR, WGR, HRNLTH, DX, DY, DZ,
GAMMA, BETA, ALPHA, HPWR, HPHASE, AN, CX, CY,
PSI, PWRL, W11, W12, W13, W21, W22, W23, W31,
W32, W33, CX, CY, IND, IGP.

(ii) Change the value of MAXHRN in the data statement to the value of NHORN.

SUBROUTINE SOURCE:

Change the dimensions of the following arrays to NHORN - AN, HPHASE, CX, CY, PSI, IGP.

To Increase the Number of Horn Groups

Eventhough the number of horn feeds is set by MAXHRN, the number of different horn sizes within the array must not be more than MAXHGP which, at present, has a value of 10.

MAIN PROGRAM: Change the value of MAXHGP in the data statement to reflect the new value.

SUBROUTINE PAT: Change the second dimensions of arrays EPA, EPP, HPA and HPP to MAXHGP.

SUBROUTINE PYRHRN: Change the second dimensions of arrays EPA, EPP, HPA, HPP to MAXHGP.

SUBROUTINE CONHRN: Change the second dimensions of arrays EPA, EPP, HPA, HPP to MAXHGP.

SUBROUTINE PTNORM: Change the second dimensions of arrays EPA, EPP, HPA, HPP to MAXHGP.

To Increase Array Sizes to Accommodate Larger Number of Integ. Points.

The maximum number of integration points allowable in the radial or phi-direction is given by the variable MAXQ. MAXQ is set equal to the larger of the two numbers, NQR and NQP, which determines the dimension requirement. At present, the value of MAXQ is 28.

- MAIN PROGRAM:
- (i) Change the value of MAXQ in the data statement to reflect the new value.
 - (ii) Change the first dimensions of arrays RDL and RDU to the value of MAXQ.
 - (iii) Change the dimensions of the following arrays to $4 * \text{MAXQ} * \text{MAXQ}$ -
XG, YG, ZG, RJX, RJY, RJZ.

SUBROUTINE FIELD: (i) Change the dimensions of the following arrays to $4 * \text{MAXQ} * \text{MAXQ}$ -
X, Y, Z, RJX, RYJ, RJZ.

To Increase Frame of Observation

The field of observation is defined by a rectangular grid of elevation and azimuth cuts. The number of grid points in the elevation direction is given by NEL and its maximum is set by MAXEL. Similarly, the number of grid points in the azimuth direction is given by NAZ and its maximum is set by MAXAZ. At present the values of MAXEL and MAXAZ are 49 and 49 respectively.

MAIN PROGRAM: (i) Change the values of MAXEL and MAXAZ in the data statement.

(ii) Change the dimension of array EL and AZ to MAXEL and MAXAZ respectively.

(iii) Change the dimensions of arrays CGN, CPH and XGN to the value given by MAXEL*MAXAZ.

For the U-V grid, the maximum number of samples in U- and V-space is governed by MAXU and MAXV respectively. The required numbers of samples for the user defined window, are determined by the program. If an error message appeared regarding the number of samples, then carried out the following changes.

Main Program: (i) Change the values of MAXU and MAXV in data statement to new limits, $\text{MAXU} \leq \text{MAXEL}$, $\text{MAXV} \leq \text{MAXAZ}$

(ii) Redimension arrays, CPEF(MAXV, MAXU), XPEF(MAXV, MAXU)

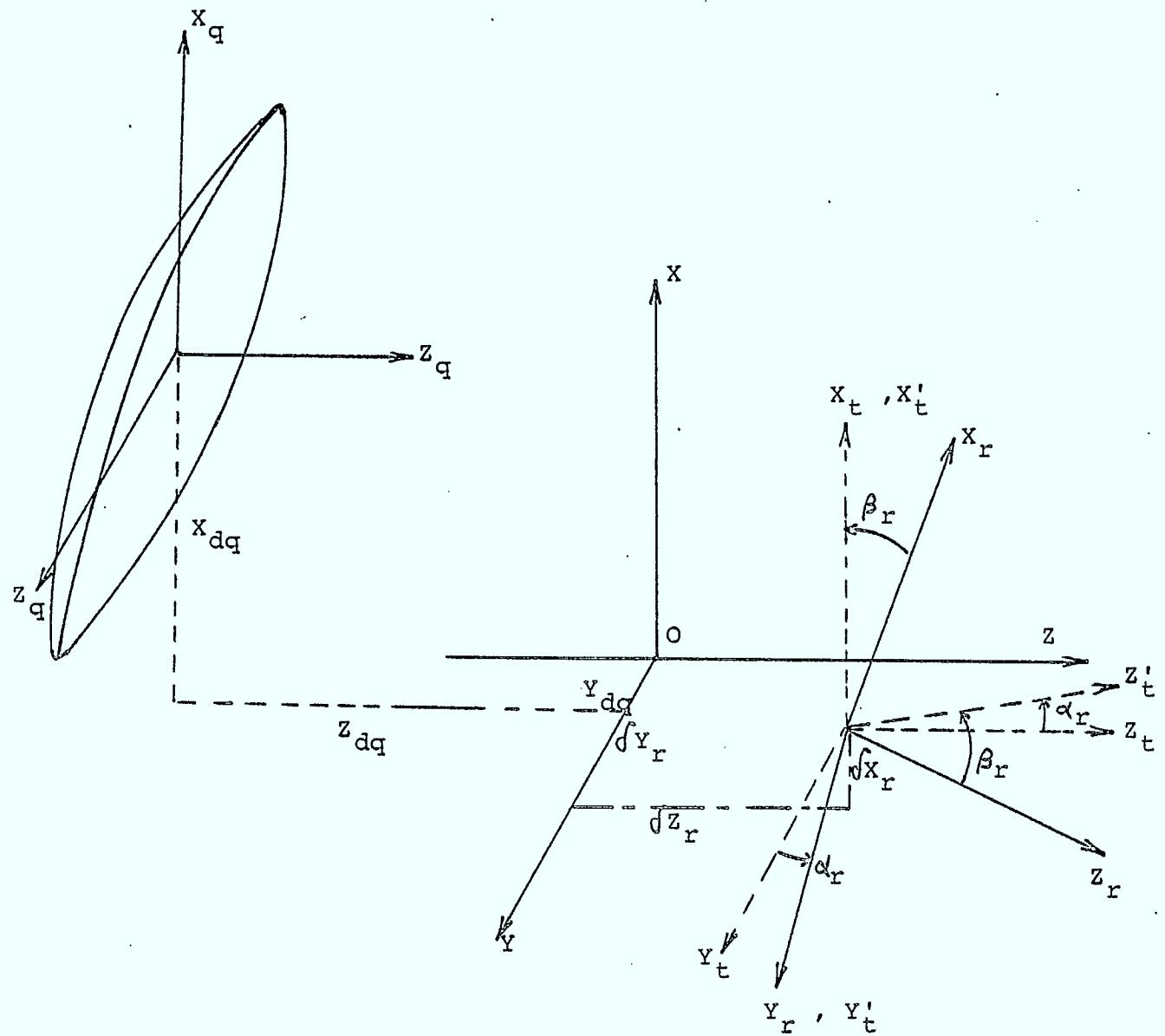


Figure A1. Geometry of Reflector Antenna System.

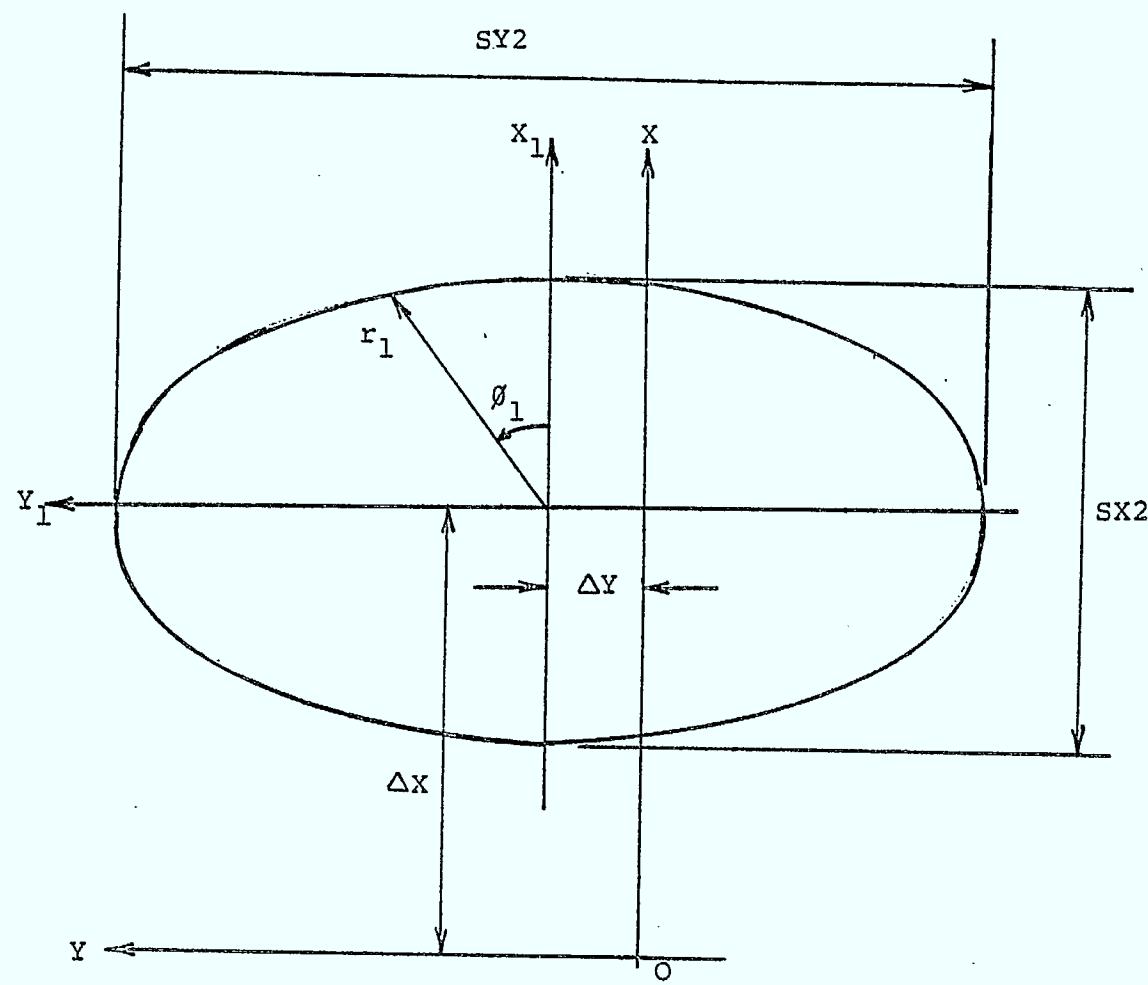


Figure A2. Projected Aperture in the Focal Plane.

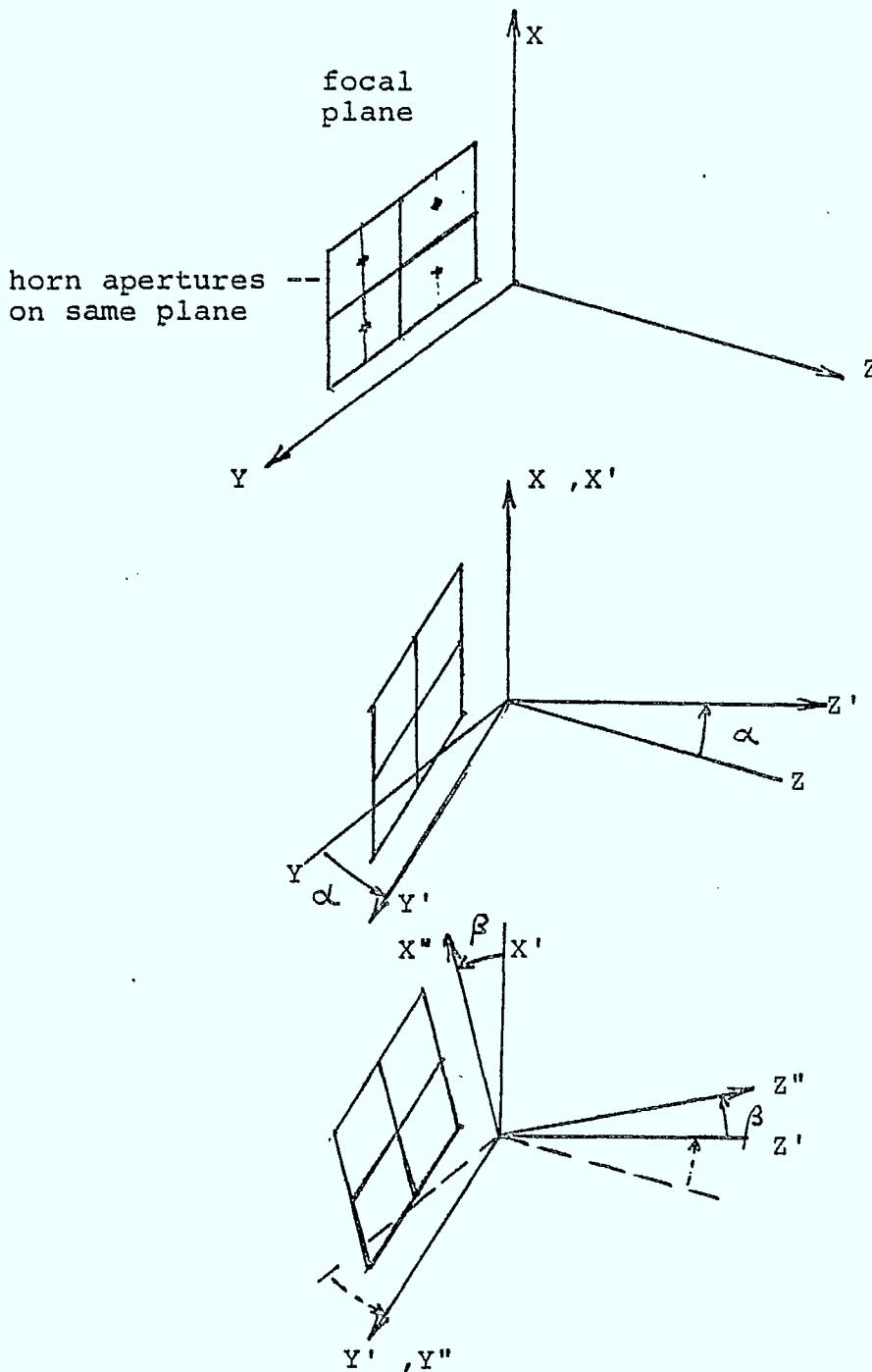


Figure A3. Collective Translation and Rotation of Feed Array.

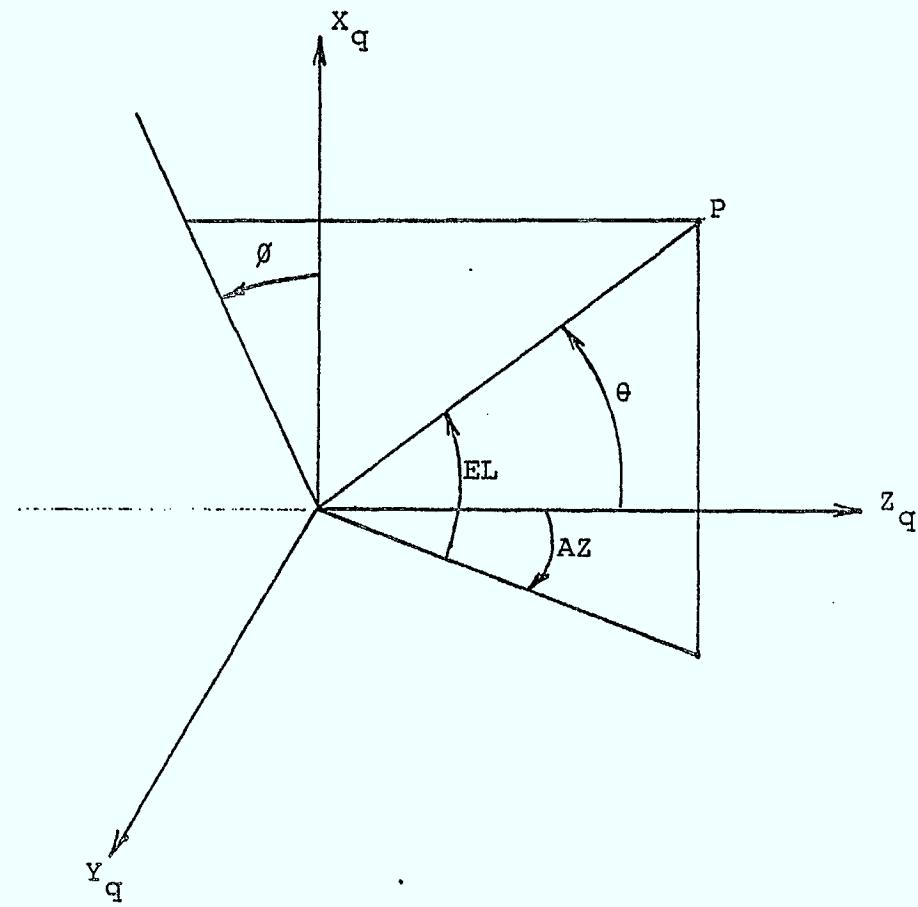


Figure A4. Elevation and Azimuth Co-ordinates of Observation Point.

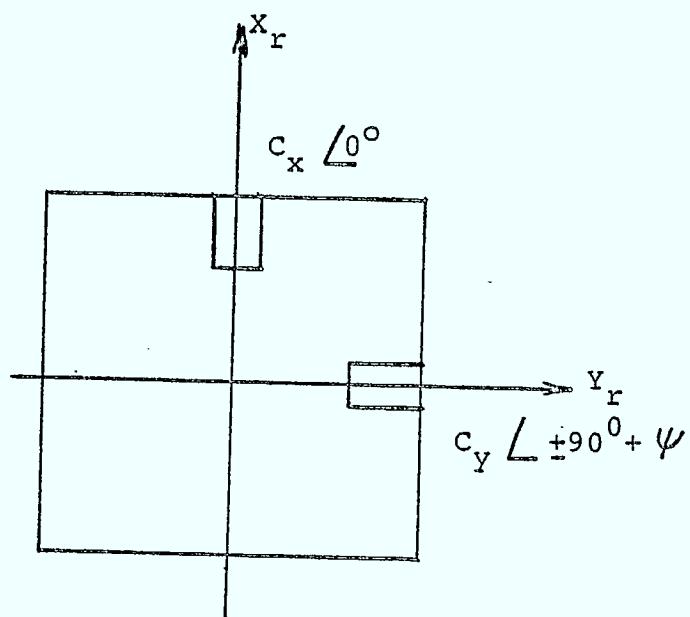
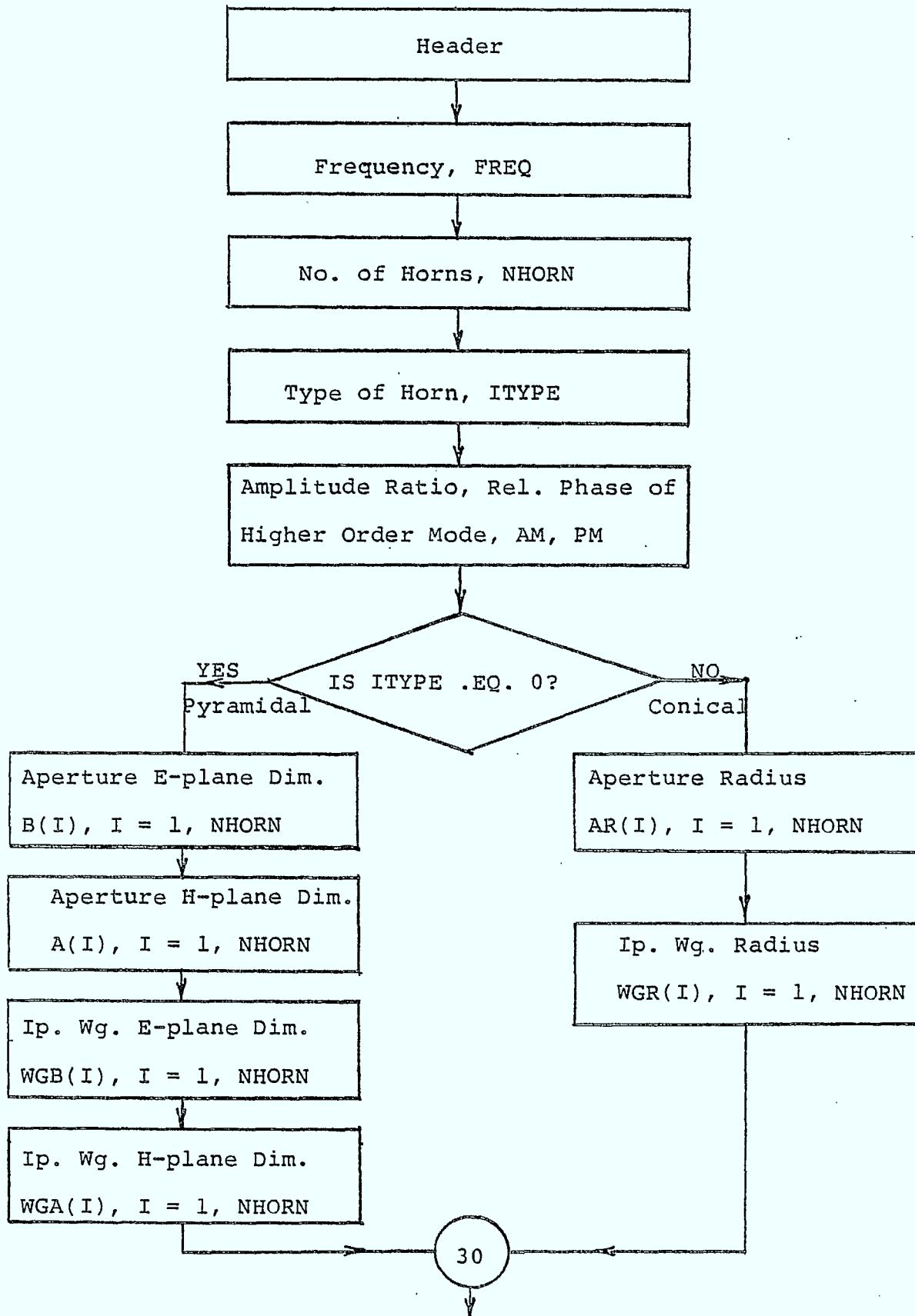
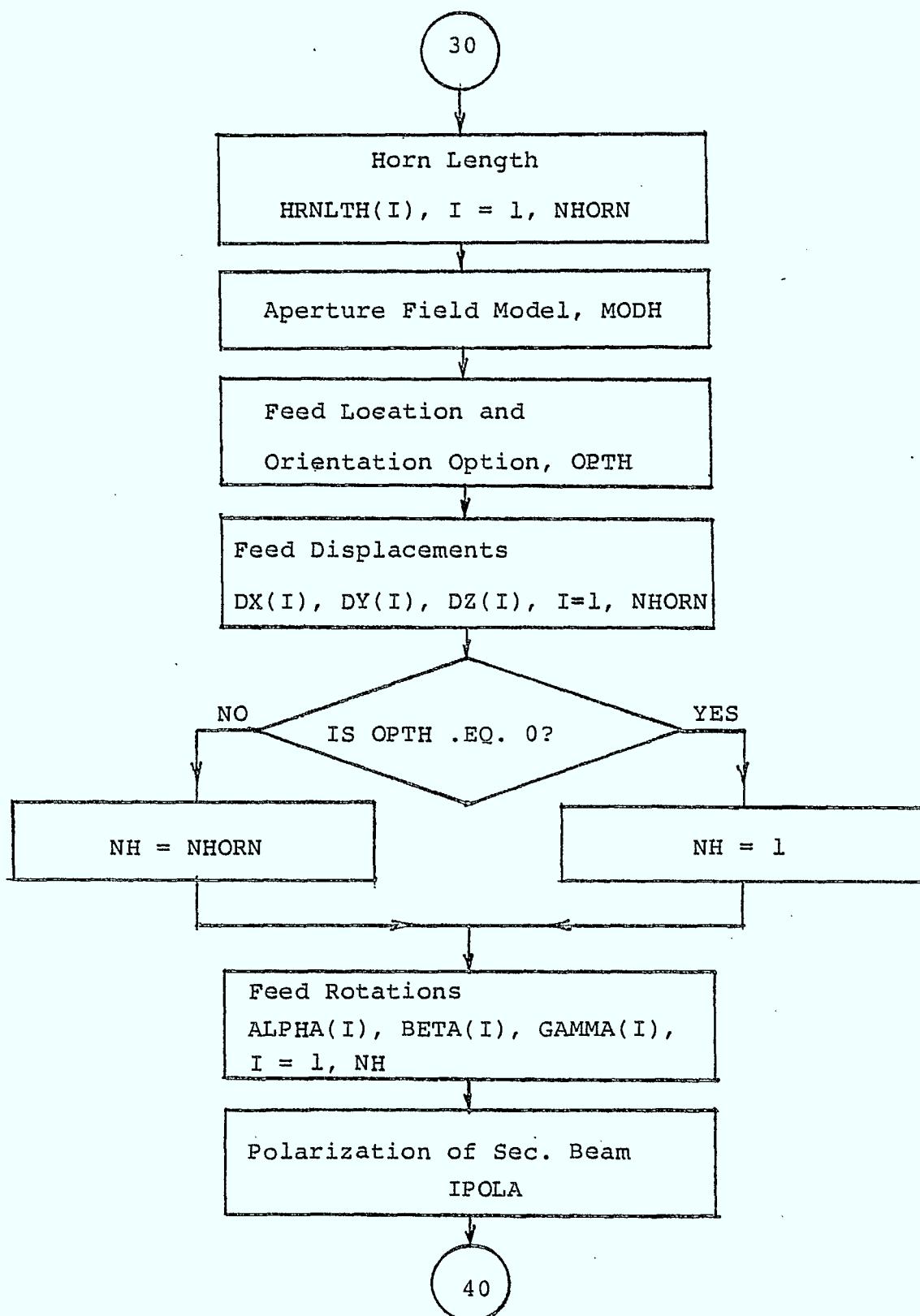
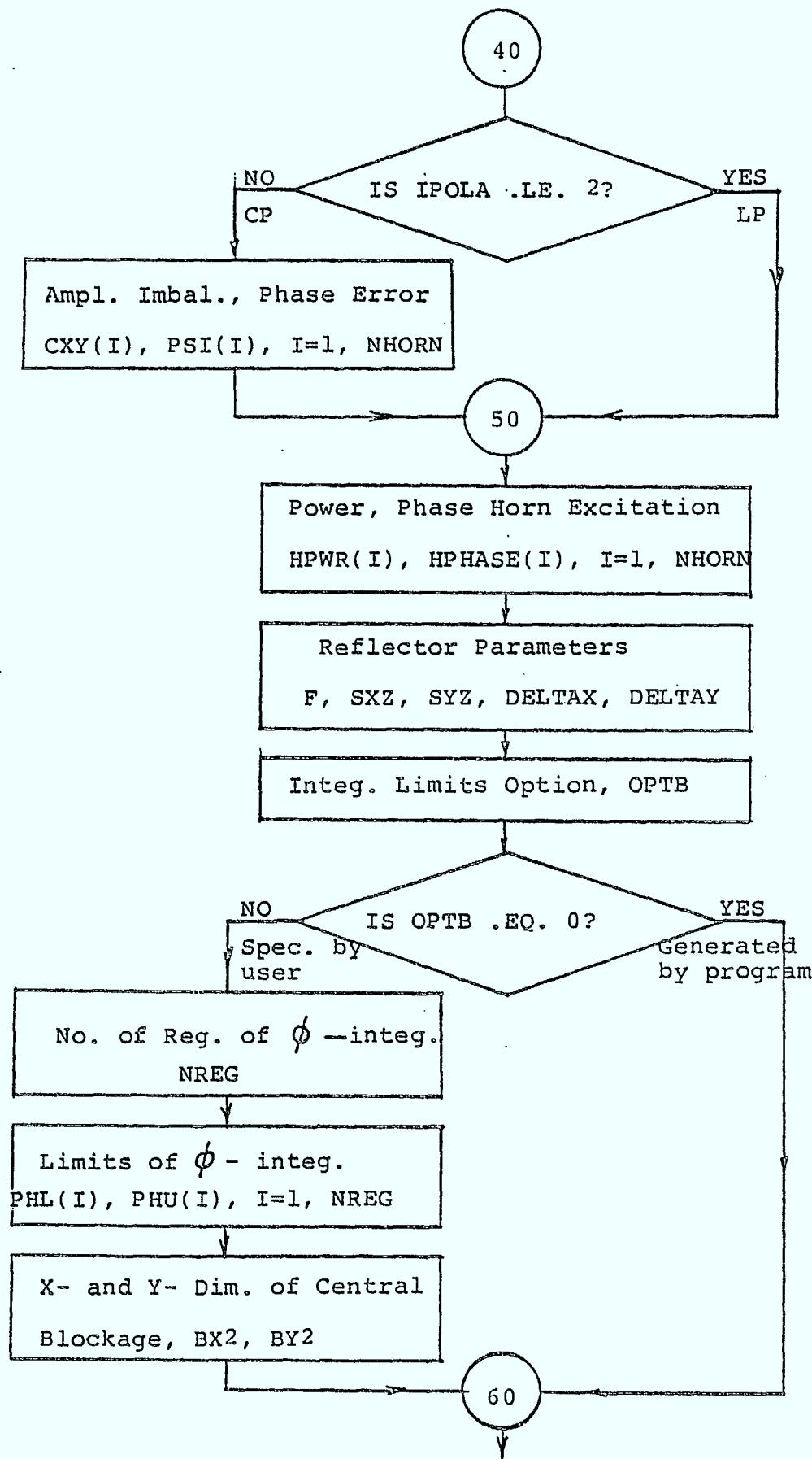


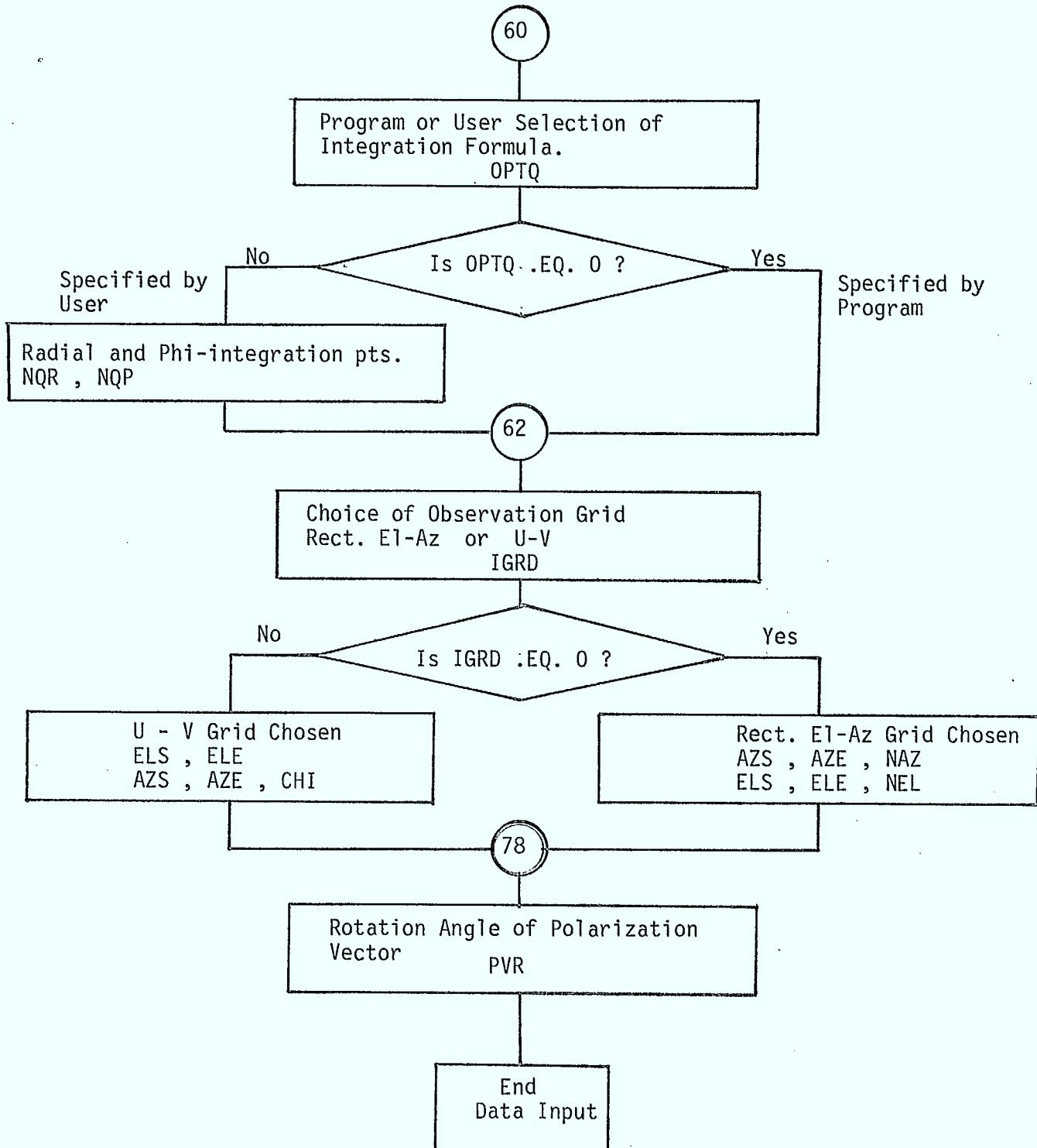
Figure A5. Excitation of Horn Feed.

Figure A6. Flow Chart of Input Data File.









A.2 PROGRAM LISTING

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1.000      PROGRAM REF.C
2.000 *
3.000 * PHYSICAL OPTICS ANALYSIS OF A PARABOLIC REFLECTOR FED BY A
4.000 * MULTI-HORN ARRAY.
5.000 * THE REFLECTOR HAS AN ELLIPTICAL APERTURE AND IS OFF-SET IN THE
6.000 * X- AND Y- DIRECTION. FAR FIELD CO-POLARISED AND CROSS-POLARISED
7.000 * GAIN MATRICES ARE COMPUTED OVER A RECTANGULAR ELEVATION - AZIMUTH
8.000 * GRID. IT MAY ALSO BE COMPUTED OVER A U - V GRID FOR THE PURPOSE
9.000 * OF FIELD RECONSTRUCTION.
10.000 * MAIN FEATURES OF THE PROGRAM ARE THE FOLLOWING -
11.000 * MULTIPLE HORN CAPABILITY.
12.000 * CHOICE OF HORN TYPE , CONICAL OR PYRAMIDAL.
13.000 * HORNS MAY BE EXCITED WITH A COMBINATION OF BASIC AND HIGHER ORDER
14.000 * MODES. PYRAMIDAL HORN MAY CONTAIN TE10 AND TE/TM12 MODES.
15.000 * CONICAL HORN MAY CONTAIN TE11 AND TM11 MODES.
16.000 * CHOICE OF HORN APERTURE FIELD MODEL.
17.000 * MODELING OF APERTURE BLOCKAGE BY FEED AND STRUTS.
18.000 * AUTOMATIC SELECTION OF INTEGRATION LIMITS AND FORMULAS.
19.000 * CHOICE OF CIRCULAR OR ROTATABLE LINEAR POLARISATION.
20.000 * FOR CIRCULAR POL. ,ABILITY TO SPECIFY AMPL. AND PHASE IMBALANCE
21.000 * IN THE EXCITATION OF THE ORTHOGONAL PORTS.
22.000 *
23.000 * WRITTEN BY CHAN TECHNOLOGIES INC.
24.000 * REVISION 0 , MARCH 1986.
25.000 *
26.000      CHARACTER*4 IHEAD(15)
27.000      DIMENSION A(50),B(50),WGA(50),WGB(50),AR(50),WGR(50),HRNLTH(50)
28.000      DIMENSION DX(50),DY(50),DZ(50),GAMMA(50),BETA(50),ALPHA(50)
29.000      DIMENSION HPWR(50),HPHASE(50),AN(50),CX(50),PSI(50),PWR1(50)
30.000      DIMENSION W11(50),W12(50),W13(50),W21(50),W22(50),W23(50)
31.000      DIMENSION W31(50),W32(50),W33(50),CX(50),CY(50)
32.000      DIMENSION PHL(4),PHU(4),RDL(28,4),RDU(28,4)
33.000      DIMENSION XG(3136),YG(3136),ZG(3136)
34.000      DIMENSION CGN(2401),CPH(2401),XGN(2401),EL(49),AZ(49),TETA(46)
35.000      COMPLEX EX,EY,EZ,EXPX,ETHETA,EPHI,FTX,FTY,FTZ,HX,HY,HZ
36.000      COMPLEX COPOL,XPOL,CPEF(34,34),XPEF(34,34)
37.000      COMPLEX RJX(3136),RJY(3136),RJZ(3136)
38.000      INTEGER OPTB,OPTH,OPTQ,IND(50),IGP(50)
39.000      COMMON/VAL1/PI,RAD,ZETA
40.000      COMMON/VAL2/AN,HPHASE,CX,CY,PSI,IPOLA,IGP
41.000      COMMON/BLOCK/RX(219),QW(219)
42.000      COMMON/CURRENT/RJX,RJY,RJZ,XG,YG,ZG
43.000      COMMON/VAL3/NREG,NQR,NQP,PT,XDQ,YDQ,ZDQ,CPVR,SPVR
44.000      COMMON/PATPAR/NPF,PAI,TETA
45.000      COMMON/EFC/COPOL,XPOL
46.000      DATA PI,RAD,ZETA/3.14159265,57.2957795,376.99111/
47.000 *
48.000 * THE FOLLOWING ARE PRESET LIMITS DUE TO ARRAY DIMENSIONS.
49.000 * MAXQ - MAX. NO. OF INTEGRATION PTS. PERMITTED
50.000 * MAXHRN - MAX. NO. OF HORNS PERMITTED
51.000 * MAXHGP - MAX. NO. OF HORN GROUPS PERMITTED
52.000 * MAXEL - MAX. NO. OF EL GRID PTS.

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53.000 * MAXAZ - MAX. NO. OF AZ GRID PTS. PERMITTED
54.000 * MAXU = MAX. NO. OF SAMPLED FIELD PTS. IN U-SPACE, MUST BE .LE. MAXEL
55.000 * MAXV = MAX. NO. OF SAMPLED FIELD PTS. IN V-SPACE, MUST BE .LE. MAXAZ
56.000 *
57.000      DATA MAXQ,MAXHRN,MAXHGP,MAXEL,MAXAZ,MAXU,MAXV/28,50,10,49,49,34,
58.000      + 34/
59.000 *
60.000 * START OF DATA INPUT
61.000 *
62.000 * INPUT DATA ARE READ FROM FILE PAREFC_DAT
63.000      OPEN(UNIT=5,NAME='REFC_DAT',STATUS='OLD',USAGE='INPUT')
64.000 * OUTPUT DATA ARE WRITTEN INTO FILE REFC_DUM
65.000      OPEN(UNIT=6,NAME='REFC_DUM',STATUS='OLD',USAGE='OUTPUT')
66.000 *
67.000 * IHEAD - HEADING FOR COMPUTER RUN. MAX. OF 60 CHARACTERS.
68.000 *
69.000      READ(5,10) (IHEAD(I),I=1,15)
70.000 10      FORMAT(15A4)
71.000 *
72.000 * DATA DESCRIBING HORN ARRAY
73.000 *
74.000 * FREQ - FREQUENCY IN GHZ
75.000 *
76.000      READ(5,*) FREQ
77.000 *
78.000 * NHORN - NO. OF HORNS. MAX. NO. IS 10 DUE TO DIMENSION RESTR.
79.000 *
80.000      READ(5,*) NHORN
81.000      IF (NHORN.LE.MAXHRN) GO TO 14
82.000      WRITE(6,12) MAXHRN
83.000 12      FORMAT(1X,'EXECUTION TERMINATED. NO. OF HORNS EXCEEDED MAX. OF'
84.000      +,13)
85.000      STOP
86.000 14      CONTINUE
87.000 *
88.000 * ITYPE - TYPE OF HORN
89.000      = 0, PYRAMIDAL
90.000      = 1, CONICAL
91.000 *
92.000 * IT IS ASSUMED THAT ALL HORNS IN THE ARRAY ARE OF THE SAME TYPE.
93.000 *
94.000      READ(5,*) ITYPE
95.000 *
96.000 * SPEC. OF HIGHER ORDER MODE CONTENT OF HORN.
97.000 * FOR CONICAL HORN, THE HIGHER ORDER MODE IS TM11.
98.000 * FOR PYRAMIDAL HORN THE HIGHER ORDER MODE PAIR IS THE TE/TM12.
99.000 * AM = AMPLITUDE RATIO OF THE HIGHER ORDER MODE.
100.000 * PM = REL. PHASE (RAD) OF THE HIGHER ORDER MODE.
101.000 *
102.000      READ(5,*) AM , PM
103.000      IF (ITYPE.EQ.1) GO TO 20
104.000 *
105.000 * IF CIRCULAR POLARIZATION IS SPEC. BOTH E- AND H-PLANE DIM. OF THE
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106.000 * PYRAMIDAL HORN MUST BE THE SAME I.E. SQUARE HORN ONLY.  
107.000 * B - E-PLANE DIMENSION OF HORN APERTURE IN INS.  
108.000 *  
109.000      READ(5,*) (B(I),I=1,NHORN)  
110.000 *  
111.000 * A - H-PLANE DIM. OF HORN APERTURE IN INS.  
112.000 *  
113.000      READ(5,*) (A(I),I=1,NHORN)  
114.000 *  
115.000 * WGB - E-PLANE DIM. OF INPUT WAVEGUIDE IN INS.  
116.000 *  
117.000      READ(5,*) (WGB(I),I=1,NHORN)  
118.000 *  
119.000 * WGA - H-PLANE DIM. OF INPUT WAVEGUIDE IN INS.  
120.000 *  
121.000      READ(5,*) (WGA(I),I=1,NHORN)  
122.000      GO TO 30  
123.000 *  
124.000 * AR - CIRCULAR HORN APERTURE RADIUS IN INS.  
125.000 *  
126.000 20    READ(5,*) (AR(I),I=1,NHORN)  
127.000 *  
128.000 * WGR - INPUT WAVEGUIDE RADIUS IN INS.  
129.000 *  
130.000      READ(5,*) (WGR(I),I=1,NHORN)  
131.000 *  
132.000 * HRNLTH - HORN LENGTH IN INS.  
133.000 *  
134.000 30    READ(5,*) (HRNLTH(I),I=1,NHORN)  
135.000 *  
136.000 * MODH - CHOICE OF APERTURE FIELD MODEL  
137.000 *      = 0 , ELECTRIC FIELD MODEL  
138.000 *      = 1 , CHU MODEL  
139.000 *  
140.000      READ(5,*) MODH  
141.000 *  
142.000 * OPTH - OPTION FOR SPECIFYING FEED POSITIONS AND ROTATIONS.  
143.000 *      = 0, FEED POSITIONS ARE SPECIFIED BEFORE ROTATION. THE WHOLE  
144.000 *          FEED ARRAY IS ROTATED ABOUT THE GLOBAL X-AXIS BY ANGLE  
145.000 *          ALPHA FOLLOWED BY ROTATION ABOUT THE NEW Y-AXIS BY ANGLE  
146.000 *          BETA,FINALLY EACH FEED IS ROTATED ABOUT ITS OWN LOCAL Z-  
147.000 *          AXIS BY ANGLE GAMMA.THIS OPTION ALLOWS FOR THE COLLECTIVE  
148.000 *          MOVEMENT OF THE ARRAY,ONLY THREE VALUES NEED TO BE SPECI-  
149.000 *          FIED FOR THE ROTATIONS.  
150.000 *      = 1, FEED DISPLACEMENTS SPECIFIED ARE THE FINAL POSITIONS,THE  
151.000 *          ROTATIONS TO FOLLOW ARE ABOUT THE INDIVIDUAL FEED LOCAL  
152.000 *          X,Y AND Z-AXES.THIS OPTION ALLOWS FOR INDEPENDENT ROTATION  
153.000 *          AND POSITIONING OF THE FEEDS.THREE ROTATION ANGLES MUST BE  
154.000 *          ENTERED FOR EACH FEED.  
155.000 *  
156.000      READ(5,*) OPTH  
157.000 *  
158.000 * DISPLACEMENTS OF COMPONENT FEEDS IN INCHES FROM FOCAL POINT
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159.000 *
160.000      READ(5,*)(DX(I),DY(I),DZ(I),I=1,NHORN)
161.000 *
162.000 * ALPHA - ROTATION ABOUT EITHER THE GLOBAL OR LOCAL X-AXIS IN DEG,
163.000 * BETA - ROTATION ABOUT EITHER THE GLOBAL OR LOCAL Y-AXIS IN DEG,
164.000 * GAMMA - ROTATION ABOUT LOCAL Z-AXIS IN DEG.
165.000 *
166.000      NH = 1
167.000      IF (OPTH.NE.0) NH = NHORN
168.000      READ(5,*)(ALPHA(I),BETA(I),GAMMA(I),I=1,NH)
169.000 *
170.000 * IPOLA - POLARISATION OF SECONDARY BEAM FROM REFLECTOR SYSTEM.
171.000 *      - VP=1 , HP=2 , RHCP=3 , LHCP=4
172.000 *
173.000      READ(5,*) IPOLA
174.000      IF (IPOLA.LE.2) GO TO 50
175.000 *
176.000 * FOR NON-IDEAL CP FEEDS, AN IMBALANCE EXISTS IN THE AMPLITUDE
177.000 * EXCITATIONS OF THE ORTHOGONAL PORTS AS WELL AS DEVIATION FROM THE
178.000 * PHASE QUADRATURE CONDITION. PORT 1 IS ASSOCIATED WITH THE X-PORT
179.000 * AND PORT 2 WITH THE Y-PORT.
180.000 *
181.000 * CX(Y(I)) = AMPLITUDE IMBALANCE OF Y-PORT RELATIVE TO X-PORT.
182.000 * PSI(I) = DEPARTURE FROM PHASE QUADRATURE IN DEG OF THE Y-PORT.
183.000 *
184.000      READ(5,*)(CX(Y(I)),I=1,NHORN)
185.000      READ(5,*)(PSI(I),I=1,NHORN)
186.000 *
187.000 * HFWR - POWER INPUT TO EACH FEED IN WATTS.
188.000 * HPHASE - RELATIVE PHASE EXCITATION OF EACH FEED IN DEG.
189.000 *
190.000 50    READ(5,*)(HFWR(I),HPHASE(I),I=1,NHORN)
191.000 *
192.000 * DATA DESCRIBING PARABOLIC REFLECTOR CONFIGURATION.
193.000 *
194.000 * F - FOCAL LENGTH OF PARABOLIC REFLECTOR IN INCHES.
195.000 * SX2 - X-DIMENSION OF ELLIPTICAL REFLECTOR APERTURE IN INCHES
196.000 * SY2 - Y-DIMENSION OF ELLIPTICAL REFLECTOR APERTURE IN INCHES
197.000 * DELTAX - X-OFFSET OF APERTURE CENTRE IN INCHES
198.000 * DELTAY - Y-OFFSET OF APERTURE CENTRE IN INCHES.
199.000 *
200.000      READ(5,*) F, SX2, SY2, DELTAX, DELTAY
201.000 *
202.000 * OPTB - OPTION FOR SPECIFYING LIMITS OF INTEGRATION TO SIMULATE BLOCKAGE.
203.000 *      = 0, LIMITS ARE GENERATED BY PROGRAM FROM INPUT REFLECTOR
204.000 *      DATA. NO APERTURE BLOCKAGE IS ASSUMED.
205.000 *      = 1, LIMITS ARE DERIVED BY THE USER AND READ INTO THE PROGRAM.
206.000 *
207.000      READ(5,*) OPTB
208.000      IF (OPTB.EQ.0) GO TO 60
209.000 *
210.000 * NREG - NUMBER OF REGIONS OF PHI-INTEGRATION.
211.000 *
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212.000      READ(5,*) NREG
213.000 *
214.000 * PHL(I) - LOWER LIMIT OF PHI-INTEG FOR THE I TH REGION IN RADIANS.
215.000 * PHU(I) - UPPER LIMIT OF PHI-INTEG FOR THE I TH REGION IN RADIANS.
216.000 *
217.000      READ(5,*) (PHL(I),PHU(I),I=1,NREG)
218.000 *
219.000 * BX2 - X-AXIS DIMENSION OF CENTRAL ELLIPTICAL BLOCKAGE IN INS.
220.000 * BY2 - Y-AXIS DIMENSION OF CENTRAL ELLIPTICAL BLOCKAGE IN INS.
221.000 *
222.000      READ(5,*) BX2, BY2
223.000 *
224.000 * OPTQ - OPTION FOR SPECIFYING NO. OF INTEGRATION POINTS.
225.000 *      = 0, NO. OF INTEGRATION POINTS IS DETERMINED BY PROGRAM,
226.000 *      = 1, SPECIFIED BY USER.
227.000 *
228.000 60    READ(5,*) OPTQ
229.000      IF (OPTQ,EQ,0) GO TO 62
230.000 *
231.000 * DATA FOR SURFACE INTEGRATION.
232.000 * NQR - NO. OF INTEGRATION POINTS IN THE RADIAL-DIRECTION.
233.000 * NQP - NO. OF INTEGRATION POINTS IN THE PHI-DIRECTION.
234.000 * CHOOSE FROM THE FOLLOWING LIST - 3,4,6,8,10,12,14,16,20,24,28,34,40 PTS
235.000 *
236.000      READ(5,*) NQR,NQP
237.000 *
238.000 * DETERMINE LOCATION OF THESE INTEGRATION FORMULAS.
239.000 *
240.000      CALL APQUAD(NQR,I,LQR)
241.000      NQR = I
242.000      CALL APQUAD(NQP,I,LQP)
243.000      NQP = I
244.000 *
245.000 * READ IN DATA FOR FAR FIELD OBSERVATION
246.000 *
247.000 * IGRD = CHOICE OF OBSERVATION GRID
248.000 *      = 0 , RECT. EL - AZ GRID
249.000 *      = 1 , U - V GRID (REQUIRED FOR FIELD RECONSTRUCTION)
250.000 *
251.000 62    READ(5,*) IGRD
252.000      IF (IGRD,EQ,0) GO TO 70
253.000 *
254.000 * DATA OF U - V WINDOW FOR FIELD SAMPLING
255.000 * ELS , ELE = ELEVATION START AND STOP ANGLES (DEG) DEFINING ELEV.
256.000 *          WIDTH OF WINDOW.
257.000 * AZS , AZE = AZIMUTH START AND STOP ANGLES (DEG) DEFINING AZ. WIDTH
258.000 *          OF WINDOW.
259.000 *
260.000      READ(5,*) AZS , AZE
261.000      READ(5,*) ELS , ELE
262.000 *
263.000 * CHI = APERTURE OR SAMPLING RATE ENLARGEMENT FACTOR
264.000 *      RECOMMENDED VALUE OF CHI IS AROUND 1.20
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265.000 *
266.000      READ(5,*), CHI
267.000      GO TO 78
268.000 *
269.000 * DATA FOR RECT. EL - AZ OBSERVATION GRID
270.000 * ELS - START OF ELEV CUT IN DEG
271.000 * ELE - END OF ELEV CUT IN DEG
272.000 * NEL - NO. OF ELEVATION GRID POINTS, (NO. OF AZ CUTS)
273.000 * AZS - START OF AZIMUTH CUT IN DEG
274.000 * AZE - END OF AZIMUTH CUT IN DEG
275.000 * NAZ - NO. OF AZIMUTH GRID POINTS, (NO. OF ELEV CUTS)
276.000 *
277.000 70    READ(5,*), AZS, AZE, NAZ, ELS, ELE, NEL
278.000      IF (NEL, LE, MAXEL) GO TO 74
279.000      WRITE(6,72), MAXEL
280.000 72    FORMAT(1X, 'EXECUTION TERMINATED. NO. OF ELEV PTS EXCEEDED MAX. OF'
281.000      +, I3)
282.000      STOP
283.000 74    IF (NAZ, LE, MAXAZ) GO TO 78
284.000      WRITE(6,76), MAXAZ
285.000 76    FORMAT(1X, 'EXECUTION TERMINATED. NO. OF AZ PTS EXCEEDED MAX. OF'
286.000      +, I3)
287.000      STOP
288.000 78    CONTINUE
289.000 *
290.000 *
291.000 * PVR - ANGULAR ROTATION OF FIELD POLARISATION VECTOR IN DEGREES.
292.000 *
293.000      READ(5,*), PVR
294.000 *
295.000 * DATA INPUT COMPLETED
296.000 *
297.000 80    FORMAT(12I5)
298.000 90    FORMAT(12F10.4)
299.000 95    FORMAT(1X, 15A4)
300.000      WRITE(6,95), (IHEAD(I), I=1,15)
301.000      WRITE(6,100)
302.000 100   FORMAT(1X, 'FREQUENCY IN GHZ')
303.000      WRITE(6,90), FREQ
304.000      WRITE(6,110)
305.000 110   FORMAT(1X, 'NO OF FEED HORNS')
306.000      WRITE(6,80), NHORN
307.000      WRITE(6,115)
308.000 115   FORMAT(1X, 'HORN TYPE - 0=PYRAMIDAL, 1=CONICAL')
309.000      WRITE(6,80), ITYPE
310.000      WRITE(6,120)
311.000 120   FORMAT(1X, 'AMPL. AND PHASE (RAD) OF HIGHER ORDER MODE')
312.000      WRITE(6,90), AM, PM
313.000      IF (ITYPE, EQ, 1) GO TO 145
314.000      WRITE(6,125)
315.000 125   FORMAT(1X, 'E-PLANE DIM. OF HORN APERTURE IN INS.')
316.000      WRITE(6,90), (B(I), I=1, NHORN)
317.000      WRITE(6,130)
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318.000 130 FORMAT(1X,'H-PLANE DIM. OF HORN APERTURE IN INS.')
319.000 WRITE(6,90) (A(I),I=1,NHORN)
320.000 WRITE(6,135)
321.000 135 FORMAT(1X,'E-PLANE DIM. OF INPUT WAVEGUIDE IN INS.')
322.000 WRITE(6,90) (WGB(I),I=1,NHORN)
323.000 WRITE(6,140)
324.000 140 FORMAT(1X,'H-PLANE DIM. OF INPUT WAVEGUIDE IN INS.')
325.000 WRITE(6,90) (WGA(I),I=1,NHORN)
326.000 GO TO 160
327.000 145 WRITE(6,150)
328.000 150 FORMAT(1X,'APERTURE RADIUS OF HORN APERTURE IN INS.')
329.000 WRITE(6,90) (AR(I),I=1,NHORN)
330.000 WRITE(6,155)
331.000 155 FORMAT(1X,'RADIUS OF INPUT WAVEGUIDE IN INS.')
332.000 WRITE(6,90) (WBR(I),I=1,NHORN)
333.000 160 WRITE(6,165)
334.000 165 FORMAT(1X,'HORN LENGTH IN INS')
335.000 WRITE(6,90) (HRNLTH(I),I=1,NHORN)
336.000 WRITE(6,170)
337.000 170 FORMAT(1X,'HORN APERTURE FIELD MODEL - 0=E-FIELD , 1=CHU')
338.000 WRITE(6,80) MODH
339.000 IF (OPTH.EQ.1) THEN
340.000   WRITE(6,175)
341.000 175 FORMAT(1X,'OPT. CHOSEN - INDIVIDUAL DISPLACEMENT AND ROTATION',
342.000 +' OF HORNS')
343.000 ELSE
344.000   WRITE(6,180)
345.000 180 FORMAT(1X,'OPT. CHOSEN - COLLECTIVE MOVEMENT AND ROTATION OF',
346.000 +' HORN ARRAY')
347.000 END IF
348.000 WRITE(6,80) OPTH
349.000 WRITE(6,185)
350.000 185 FORMAT(1X,'DISPLACEMENTS OF FEEDS IN INS.')
351.000 WRITE(6,90) (DX(I),DY(I),DZ(I),I=1,NHORN)
352.000 WRITE(6,190)
353.000 190 FORMAT(1X,'ROT. OF FEEDS ABOUT X-,Y-,AND Z-AXIS IN DEG.')
354.000 WRITE(6,90) (ALPHA(I),BETA(I),GAMMA(I),I=1,NH)
355.000 WRITE(6,195)
356.000 195 FORMAT(1X,'POLAR. OF SECON. BEAM - VP=1,HP=2,RHCP=3,LHCP=4')
357.000 WRITE(6,80) IPOLA
358.000 IF (IPOLA.LE.2) GO TO 210
359.000 WRITE(6,200)
360.000 200 FORMAT(1X,'AMPL IMBALANCE OF Y-PORT REL. TO X-PORT')
361.000 WRITE(6,90) (CXY(I),I=1,NHORN)
362.000 WRITE(6,205)
363.000 205 FORMAT(1X,'PHASE DEPARTURE OF Y-PORT FROM QUADRATURE IN DEG.')
364.000 WRITE(6,90) (PSI(I),I=1,NHORN)
365.000 210 WRITE(6,215)
366.000 215 FORMAT(1X,'POWER(W) AND PHASE(DEG) OF FEED EXCITATIONS')
367.000 WRITE(6,90) (HPWR(I),HPHASE(I),I=1,NHORN)
368.000 WRITE(6,220)
369.000 220 FORMAT(1X,'FOC LTH.,AFER, X-DIM,Y-DIM AND X-, Y-OFFSET IN INS.')
370.000 WRITE(6,90) F,SX2,SY2,DELTAX,DELTAY
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371.000 IF (OPTB,LE,0) GO TO 260
372.000 WRITE(6,230)
373.000 230 FORMAT(1X,'NO. OF REGIONS OF PHI-INTEG = ',I2)
374.000 WRITE(6,80) NREG
375.000 WRITE(6,240)
376.000 240 FORMAT(1X,'LOWER AND UPPER LIMITS OF PHI-INTEG IN RADIANS')
377.000 WRITE(6,90) (PHL(I),PHU(I),I=1,NREG)
378.000 WRITE(6,250)
379.000 250 FORMAT(1X,'X-AND Y-DIM. OF CENTRAL ELLIPTICAL BLOCKAGE IN INS')
380.000 WRITE(6,90) BX2,BY2
381.000 260 IF (OPTQ,LE,0) GO TO 271
382.000 WRITE(6,270)
383.000 270 FORMAT(1X,'INTEG. PTS. SPEC. BY USER FOR RADIAL AND PHI-VAR.')
384.000 WRITE(6,80) NQR, NQP
385.000 271 IF (IGRD,EQ,0) GO TO 275
386.000 WRITE(6,272)
387.000 272 FORMAT(1X,'AZ START,STOP AND EL START,STOP ANGLES (DEG) OF ')
388.000 +' SAMPLING WINDOW.')
389.000 WRITE(6,90) AZS,AZE,ELS,ELE
390.000 WRITE(6,273)
391.000 273 FORMAT(1X,'APERTURE OR SAMPLING RATE ENLARGEMENT FACTOR.')
392.000 WRITE(6,90) CHI
393.000 GO TO 295
394.000 275 WRITE(6,280)
395.000 280 FORMAT(1X,'START,STOP AND NO. OF PTS. FOR AZ,EL SCAN')
396.000 WRITE(6,290) AZS,AZE,NAZ,ELS,ELE,NEL
397.000 290 FORMAT(2(2F10.5,15))
398.000 295 WRITE(6,310)
399.000 310 FORMAT(1X,'ROTATION OF FIELD POLARISATION VECTOR IN DEGREES')
400.000 WRITE(6,90) PVR
401.000 *
402.000 * COMPUTE WAVELENGTH
403.000 *
404.000 WAVE = 29.97925/(2.54*FREQ)
405.000 RK = 2.0*PI/WAVE
406.000 *
407.000 * MOVE ORIGIN OF OBSERVATION FIELD CO-ORDINATE SYSTEM TO CENTRE OF
408.000 * REFLECTING SURFACE. XDQ, YDQ, AND ZDQ ARE THE TRANSLATIONS FROM
409.000 * THE ORIGIN OF THE GLOBAL SYSTEM LOCATED AT THE FOCAL POINT.
410.000 *
411.000 XDQ = DELTAX
412.000 YDQ = DELTAY
413.000 ZDQ = (DELTAX*DELTAX + DELTAY*DELTAY)*0.25/F - F
414.000 *
415.000 IF (IGRD ,EQ, 0) GO TO 314
416.000 *
417.000 * DETERMINE SAMPLE POINTS IN U-V SPACE
418.000 *
419.000 ZETAX = ATAN(0.50*DELTAX/F)
420.000 ZETAY = ATAN(0.50*DELTAY/F)
421.000 RKA = RK*CHI*0.50*SX2/COS(ZETAX)
422.000 RKB = RK*CHI*0.50*SY2/COS(ZETAY)
423.000 ARG1 = RKA*SIN(ELS/RAD)/PI
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424.000      ARG2 = RKA*SIN(ELE/RAD)/PI
425.000      ARG = AMINI(ARG1,ARG2)
426.000      NL = SIGN(1.0,ARG)*(ABS(ARG) + 0.50)
427.000 * INCREASE RANGE OF SUMMATION AT THE LOWER LIMIT BY INCLUDING TWO
428.000 * EXTRA GUARD SAMPLES.
429.000      NL = NL - 2
430.000      ARG = AMAX1(ARG1,ARG2)
431.000      NU = SIGN(1.0,ARG)*(ABS(ARG) + 0.50)
432.000 * INCREASE RANGE OF SUMMATION AT THE UPPER LIMIT BY INCLUDING TWO
433.000 * EXTRA GUARD SAMPLES.
434.000      NU = NU + 2
435.000      ARG1 = RKB*COS(ELS/RAD)*SIN(AZS/RAD)/PI
436.000      ARG2 = RKB*COS(ELS/RAD)*SIN(AZE/RAD)/PI
437.000      ARG3 = RKB*COS(ELE/RAD)*SIN(AZS/RAD)/PI
438.000      ARG4 = RKB*COS(ELE/RAD)*SIN(AZE/RAD)/PI
439.000      ARG = AMIN1(ARG1,ARG2,ARG3,ARG4)
440.000      ML = SIGN(1.0,ARG)*(ABS(ARG) + 0.50)
441.000      ML = ML - 2
442.000      ARG = AMAX1(ARG1,ARG2,ARG3,ARG4)
443.000      MU = SIGN(1.0,ARG)*(ABS(ARG) + 0.50)
444.000      MU = MU + 2
445.000      NS = NU - NL + 1
446.000      MS = MU - ML + 1
447.000      IF (NS.GT.MAXU) THEN
448.000      WRITE(6,312) NS
449.000 312  FORMAT(1X,'NO. OF SAMPLING PTS. IN U-SPACE ,GT. MAX. LIMIT. NS ='/
450.000      +,14)
451.000      STOP
452.000      ELSE IF (MS .GT. MAXV) THEN
453.000      WRITE(6,313) MS
454.000 313  FORMAT(1X,'NO. OF SAMPLING PTS. IN V-SPACE ,GT. MAX. LIMIT. MS ='/
455.000      +,14)
456.000      STOP
457.000      END IF
458.000 314  IF (OPTH.NE.0) GO TO 325
459.000 *
460.000 * COMPUTE FINAL LOCATIONS OF HORNS AFTER COLLECTIVE ALPHA AND BETA ROTATIONS.
461.000 *
462.000      SA = SIN(ALPHA(1)/RAD)
463.000      CA = COS(ALPHA(1)/RAD)
464.000      SB = SIN(BETA(1)/RAD)
465.000      CB = COS(BETA(1)/RAD)
466.000      SG = SIN(GAMMA(1)/RAD)
467.000      CG = COS(GAMMA(1)/RAD)
468.000      DO 315 I = 1,NHORN
469.000      ARG1 = DX(I)
470.000      ARG2 = DY(I)
471.000      ARG3 = DZ(I)
472.000      DX(I) = ARG1*CB + ARG3*SB
473.000      DY(I) = ARG1*SA*SB + ARG2*CA - ARG3*SA*CB
474.000      DZ(I) = -ARG1*SB*CA + ARG2*SA + ARG3*CA*CB
475.000 315  CONTINUE
476.000 *

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477,000 * COMPUTE TRANSFORMATION FUNCTIONS OF COLLECTIVE HORN ROTATIONS
478,000 *
479,000      W11(1) = CB*CG
480,000      W12(1) = SA*SB*CG + CA*SG
481,000      W13(1) = -CA*SB*CG + SA*SG
482,000      W21(1) = -CB*SG
483,000      W22(1) = -SA*SB*SG + CA*CG
484,000      W23(1) = CA*SB*SG + SA*CG
485,000      W31(1) = SB
486,000      W32(1) = -SA*CB
487,000      W33(1) = CA*CB
488,000      IF (NHORN,EQ,1) GO TO 335
489,000      DO 320 I = 2,NHORN
490,000      W11(I) = W11(1)
491,000      W12(I) = W12(1)
492,000      W13(I) = W13(1)
493,000      W21(I) = W21(1)
494,000      W22(I) = W22(1)
495,000      W23(I) = W23(1)
496,000      W31(I) = W31(1)
497,000      W32(I) = W32(1)
498,000      W33(I) = W33(1)
499,000 320  CONTINUE
500,000      GO TO 335
501,000 *
502,000 * COMPUTE TRANSFORMATION FUNCTIONS OF INDIVIDUAL HORN ROTATIONS.
503,000 *
504,000 325  DO 330 I = 1,NHORN
505,000      SB = SIN(BETA(I)/RAD)
506,000      CB = COS(BETA(I)/RAD)
507,000      SA = SIN(ALPHA(I)/RAD)
508,000      CA = COS(ALPHA(I)/RAD)
509,000      SG = SIN(GAMMA(I)/RAD)
510,000      CG = COS(GAMMA(I)/RAD)
511,000      W11(I) = CB*CG
512,000      W12(I) = SA*SB*CG + CA*SG
513,000      W13(I) = -CA*SB*CG + SA*SG
514,000      W21(I) = -CB*SG
515,000      W22(I) = -SA*SB*SG + CA*CG
516,000      W23(I) = CA*SB*SG + SA*CG
517,000      W31(I) = SB
518,000      W32(I) = -SA*CB
519,000      W33(I) = CA*CB
520,000 330  CONTINUE
521,000 *
522,000 * CONVERT DEGREES INTO RADIANS AND DB INTO VOLTAGE.
523,000 *
524,000 335  DO 340 I = 1,NHORN
525,000      HPHASE(I) = HPHASE(I)/RAD
526,000 340  CONTINUE
527,000 *
528,000 * SORT HORNS INTO DIFFERENT GROUPS ACCORDING TO SIZES
529,000 *
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530.000 * NGP = TOTAL NO. OF GROUPS
531.000 * IND(N) = INDEX OF HORN THAT IS REPRESENTATIVE OF THE N TH GROUP.
532.000 * IGP(I) = INDEX OF GROUP TO WHICH THE I TH HORN BELONGS.
533.000 *
534.000 IND(1) = 1
535.000 IGP(1) = 1
536.000 NGP = 1
537.000 IF (NHORN.EQ.1) GO TO 354
538.000 DO 352 I = 2,NHORN
539.000 IF (ITYPE.EQ.1) GO TO 344
540.000 * RECTANGULAR APERTURE
541.000 DO 342 J = 1,NGP
542.000 IF (ABS(A(I) - A(IND(J))),LT,0.001,AND,ABS(B(I)-B(IND(J))),LT,
543.000 +0.001) GO TO 350
544.000 342 CONTINUE
545.000 GO TO 348
546.000 * CIRCULAR APERTURE
547.000 344 DO 346 J = 1,NGP
548.000 IF (ABS(AR(I) - AR(IND(J))),LT,0.001) GO TO 350
549.000 346 CONTINUE
550.000 348 NGP = NGP + 1
551.000 IND(NGP) = I
552.000 IGP(I) = NGP
553.000 GO TO 352
554.000 350 IGP(I) = J
555.000 352 CONTINUE
556.000 *
557.000 * MAXIMUM ALLOWABLE NUMBER OF DIFFERENT HORN GROUPS IS DEFINED BY MAXHGP.
558.000 IF (NGP.LE.MAXHGP) GO TO 354
559.000 WRITE(6,353) NGP, MAXHGP
560.000 353 FORMAT(1X,'EXECUTION TERMINATED. NO. OF HORN GROUPS IS ',I2,
561.000 +', MAXIMUM ALLOWABLE IS ',I2)
562.000 STOP
563.000 *
564.000 * COMPUTE E- AND H-PLANE PATTERNS OF EACH HORN GROUP
565.000 *
566.000 * NPP = NO. OF OBSERVATION POINTS SPANNING 0 TO 90 DEG.
567.000 * THIS HAS BEEN ARBITRARILY SET TO 46.
568.000 * PAI = EQUAL SPACING OF OBSERVATION POINTS.
569.000 *
570.000 354 CONTINUE
571.000 NPP = 46
572.000 PAI = 1.570/(NPP - 1)
573.000 DO 356 I = 1,NPP
574.000 TETA(I) = PAI*(I-1)
575.000 356 CONTINUE
576.000 IF (ITYPE.EQ.1) GO TO 360
577.000 DO 358 J = 1,NGP
578.000 I = IND(J)
579.000 CALL PYRHRN(A(I),B(I),WGA(I),WGB(I),HRNLTH(I),AM,PM,MODH,RK,J)
580.000 358 CONTINUE
581.000 GO TO 365
582.000 360 DO 362 J = 1,NGP

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583.000      I = IND(J)
584.000      CALL CONHRN(AR(I),WGR(I),HRNLTH(I),AM,PM,MODH,RK,J)
585.000 362  CONTINUE
586.000 *
587.000 * SPECIFY EXCITATIONS OF ORTHOGONAL PORTS OF EACH HORN.
588.000 *
589.000 365  DO 390 I = 1,NHORN
590.000      GO TO (370,375,380,385), IPOLA
591.000 *
592.000 * VERTICAL POLARIZATION
593.000 *
594.000 370  CX(I) = 1.0
595.000      CY(I) = 0.0
596.000      PSI(I) = 0.0
597.000      GO TO 390
598.000 *
599.000 * HORIZONTAL POLARIZATION
600.000 *
601.000 375  CX(I) = 0.0
602.000      CY(I) = 1.0
603.000      PSI(I) = 0.0
604.000      GO TO 390
605.000 *
606.000 * RIGHT HANDED CIRCULAR POLARIZATION
607.000 *
608.000 380  CX(I) = 1.0
609.000      CY(I) = CXY(I)*CX(I)
610.000      PSI(I) = PSI(I)/RAD + 1.5707963
611.000      GO TO 390
612.000 *
613.000 * LEFT HANDED CIRCULAR POLARIZATION
614.000 *
615.000 385  CX(I) = 1.0
616.000      CY(I) = CXY(I)*CX(I)
617.000      PSI(I) = PSI(I)/RAD - 1.5707963
618.000 390  CONTINUE
619.000 *
620.000 * COMPUTE VOLTAGE NORMALISATION CONSTANT , AN , FOR EACH FEED.
621.000 *
622.000      DO 395 J = 1,NGP
623.000      CALL PWRFED(J,PWR1(J))
624.000 395  CONTINUE
625.000      DO 400 I = 1,NHORN
626.000      AN(I) = (CX(I)*CX(I) + CY(I)*CY(I))*PWR1(IGP(I))
627.000 400  CONTINUE
628.000      DO 415 J = 1,NHORN
629.000      AN(J) = SQRT(HPWR(J)/AN(J))
630.000 415  CONTINUE
631.000 *
632.000 * TAKE SINE AND COSINE OF FIELD VECTOR ROTATION ANGLE.
633.000 *
634.000      CPVR = COS(PVR/RAD)
635.000      SPVR = SIN(PVR/RAD)
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636.000      IF (OPTB.GT.0) GO TO 425
637.000 *
638.000 * INTERNAL DEFAULT INTEGRATION LIMITS.
639.000 * APERTURE IS DIVIDED INTO FOUR REGIONS FOR PHI-INTEG.
640.000 * LIMITS OF THESE REGIONS ARE SET BELOW.
641.000 *
642.000      NREG = 4
643.000      PHL(1) = 0.0
644.000      PHU(1) = 1.570796327
645.000      DO 420 I = 2,NREG
646.000      PHL(I) = PHL(I-1) + 1.570796327
647.000      PHU(I) = PHU(I-1) + 1.570796327
648.000 420  CONTINUE
649.000 *
650.000 * THERE IS NO CENTRAL BLOCKAGE.
651.000 *
652.000      BX2 = 0.0
653.000      BY2 = 0.0
654.000 425  IF (OPTQ.GT.0) GO TO 455
655.000 *
656.000 * SELECTION OF THE APPROPRIATE QUADRATURE FORMULA
657.000 *
658.000      XMAX = -99999.0
659.000      XMIN = +99999.0
660.000      YMAX = -99999.0
661.000      YMIN = +99999.0
662.000      DO 430 I = 1,NHORN
663.000      IF (DX(I).GT.XMAX) XMAX = DX(I)
664.000      IF (DX(I).LT.XMIN) XMIN = DX(I)
665.000      IF (DY(I).GT.YMAX) YMAX = DY(I)
666.000      IF (DY(I).LT.YMIN) YMIN = DY(I)
667.000 430  CONTINUE
668.000 * FIND THE LARGEST ANGLE BETWEEN COMPONENT BEAMS AND FIELD
669.000 * OBSERVATION POINTS. THIS ANGLE TOGETHER WITH THE APERTURE SIZE WILL
670.000 * DETERMINE THE NUMBER OF INTEGRATION POINTS, TO CALCULATE BEAM
671.000 * DISPLACEMENT, A BDF FACTOR OF 0.90 IS USED.
672.000 *
673.000      ARG1 = ABS(ELE/RAD + 0.90*ATAN(XMAX/F))
674.000      ARG2 = ABS(0.90*ATAN(XMIN/F) + ELS/RAD)
675.000      ARG3 = ABS(AZE/RAD + 0.90*ATAN(YMAX/F))
676.000      ARG4 = ABS(0.90*ATAN(YMIN/F) + AZS/RAD)
677.000      ARG1 = AMAX1(ARG1,ARG2)
678.000      ARG3 = AMAX1(ARG3,ARG4)
679.000      NQR = (SIN(ARG1)*SX2/WAVE + 0.666)*1.50
680.000      NQP = (SIN(ARG3)*SY2/WAVE + 0.666)*1.50
681.000      NQR = MAX0(NQR,NQP)
682.000 *
683.000      CALL AFQUAD(NQR,NQP,LQP)
684.000      NQR = NQP
685.000      LQR = LQP
686.000      WRITE(6,450)
687.000 450  FORMAT(1X,'NO. OF INTEG. PTS. SELECTED FOR RADIAL AND PHI-VAR.')
688.000      WRITE(6,80) NQR,NQP
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689,000 455 IF (NQR,LE,MAXQ,ANI,NQP,LE,MAXQ) GO TO 459
690,000 WRITE(6,457) NQR,NQP
691,000 457 FORMAT(1X,'EXECUTION TERMINATED. INCREASE ARRAYS SIZE TO',
692,000 +' ACCOMODATE FOLLOWING RADIAL AND PHI INTEG. PTS,-',2I3)
693,000 STOP
694,000 459 CONTINUE
695,000 *
696,000 * COMPUTE SEMI-AXES DIMENSIONS FOR REFLECTOR AND BLOCKAGE APERTURES.
697,000 *
698,000 SX2 = SX2*0.50
699,000 SY2 = SY2*0.50
700,000 BX2 = BX2*0.50
701,000 BY2 = BY2*0.50
702,000 *
703,000 * INITIALISE CURRENT MATRIX RJX,RJY,RJZ
704,000 *
705,000 KOUNT = 0
706,000 DO 470 L = 1,NREG
707,000 DO 465 J = 1,NQR
708,000 DO 460 I = 1,NQP
709,000 KOUNT = KOUNT + 1
710,000 RJX(KOUNT) = (0.0,0.0)
711,000 RJY(KOUNT) = (0.0,0.0)
712,000 RJZ(KOUNT) = (0.0,0.0)
713,000 460 CONTINUE
714,000 465 CONTINUE
715,000 470 CONTINUE
716,000 *
717,000 * COMPUTE CURRENT MATRIX
718,000 * AT THE SAME TIME COMPUTE POWER INTERCEPTED BY REFL
719,000 *
720,000 PWR = 0.0
721,000 *
722,000 * L = INDEX FOR REGION OF PHI- INTEGRATION.
723,000 *
724,000 KOUNT = 0
725,000 DO 520 L = 1,NREG
726,000 *
727,000 * I = INDEX FOR PHI-INTEG
728,000 *
729,000 DO 510 I = 1,NQP
730,000 PHII = (PHL(L)+PHU(L))*0.50+(PHU(L)-PHL(L))*0.50*X(I+LQ)
731,000 CPI = COS(PHII)
732,000 SPI = SIN(PHII)
733,000 *
734,000 * FIND THE LIMITS OF RADIAL-INTEGRATION GIVEN PHII
735,000 *
736,000 CALL RADLIM(CPI,SPI,SX2,SY2,BX2,BY2,RDL(I,L),RDU(I,L))
737,000 FAC = (PHU(L)-PHL(L))*(RDU(I,L)-RDL(I,L))*0.25
738,000 *
739,000 * J = INDEX FOR RHO-INTEG.
740,000 *
741,000 DO 500 J = 1,NQR
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742,000      RDJ = (RDL(I,L)+RDU(I,L))*0.50+(RDU(I,L)-RDL(I,L))*0.50*
743,000      + QX(J+LQR)
744,000      KOUNT = KOUNT + 1
745,000 *
746,000 * STORE REFLECTOR SURFACE POINTS
747,000 *
748,000      XG(KOUNT) = RDJ*CPI + DELTAX
749,000      YG(KOUNT) = RDJ*SPI + DELTAY
750,000      ZG(KOUNT) = (XG(KOUNT)**2 + YG(KOUNT)**2)*0.25/F - F
751,000 *
752,000 * COMPUTE COMPONENTS OF SURFACE NORMAL
753,000 *
754,000      RNX = -XG(KOUNT)*0.50/F
755,000      RNY = -YG(KOUNT)*0.50/F
756,000 *
757,000 * K = INDEX FOR FEED HORN
758,000      EX = (0.0,0.0)
759,000      EY = (0.0,0.0)
760,000      EZ = (0.0,0.0)
761,000      HX = (0.0,0.0)
762,000      HY = (0.0,0.0)
763,000      HZ = (0.0,0.0)
764,000      DO 490 K = 1,NHORN
765,000 * THE FOLLOWING TRANSFORMATIONS CONVERT SURFACE POINT
766,000 * COORDINATES TO HORN COORDINATES.
767,000 * TRANSFORM (RHO,THETA,PHI) TO (RHOT,THETAT,PHIT)
768,000      RHOT = SQRT((XG(KOUNT) - DX(K))**2 + (YG(KOUNT) - DY(K))**2
769,000      + + (ZG(KOUNT) - DZ(K))**2)
770,000      CTT = (ZG(KOUNT)-DZ(K))/RHOT
771,000      STT = ACOS(CTT)
772,000      STT = SIN(STT)
773,000      SPT = ATAN2((YG(KOUNT)-DY(K)),(XG(KOUNT)-DX(K)))
774,000      CPT = COS(SPT)
775,000      SPT = SIN(SPT)
776,000 *
777,000 * TRANSFORM (RHOT,THETAT,PHIT) TO (RHOR,THETAR,PHIR)
778,000      STSP = STT*SPT
779,000      STCP = STT*CPT
780,000      CTR = STCP*W31(K) + STSP*W32(K) + CTT*W33(K)
781,000      THETAR = ACOS(CTR)
782,000      STR = SIN(THETAR)
783,000      SPR = STCP*W21(K) + W22(K)*STSP + W23(K)*CTT
784,000      CPR = STCP*W11(K) + STSP*W12(K) + CTT*W13(K)
785,000      SPR = ATAN2(SPR,CPR)
786,000      CPR = COS(SPR)
787,000      SPR = SIN(SPR)
788,000      CTCP = CTR*CPR
789,000      CTSP = CTR*SPR
790,000 *
791,000      TXT = CTCP*W11(K) + CTSP*W21(K) - STR*W31(K)
792,000      TYT = CTCP*W12(K) - STR*W32(K) + CTSP*W22(K)
793,000      TZT = CTCP*W13(K) + CTSP*W23(K) - STR*W33(K)
794,000      TXP = -SPR*W11(K) + CPR*W21(K)
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795,000      TYP = -SPR*W12(K) + CPR*W22(K)
796,000      TZP = -SPR*W13(K) + CPR*W23(K)
797,000 *
798,000      PT = RK*RHOT
799,000      EXPN = CMPLX(COS(PT),-SIN(PT))/RHOT
800,000 * COMPUTE FEED ARRAY FIELDS AT (RHOT,THETAR,PHIR)
801,000      CALL SOURCE(THETAR,SPR,CPR,ETHETA,EPHI,K)
802,000      ETHETA = ETHETA*EXPN
803,000      EPHI = EPHI*EXPN
804,000      FTX = ETHETA*TYP - EPHI*TXT
805,000      FTY = ETHETA*TZP - EPHI*TYT
806,000      FTZ = ETHETA*TZP - EPHI*TZT
807,000      RJX(KOUNT) = RJX(KOUNT) + FTZ*RNY - FTY
808,000      RJY(KOUNT) = RJY(KOUNT) + FTX - FTZ*RNX
809,000      RJZ(KOUNT) = RJZ(KOUNT) + FTY*RNX - FTX*RNY
810,000 *
811,000 * COMPUTE COMBINED FEED PATTERN FOR SPILL-OVER CALCULATION
812,000 *
813,000      EX = EX + ETHETA*TXT + EPHI*TXF
814,000      EY = EY + ETHETA*TYT + EPHI*TYP
815,000      EZ = EZ + ETHETA*TZT + EPHI*TZP
816,000      HX = HX + FTX
817,000      HY = HY + FTY
818,000      HZ = HZ + FTZ
819,000 490  CONTINUE
820,000      FACW = FAC*RDJ*QW(I+LQP)*QW(J+LQR)
821,000      RJX(KOUNT) = RJX(KOUNT)*FACW
822,000      RJY(KOUNT) = RJY(KOUNT)*FACW
823,000      RJZ(KOUNT) = RJZ(KOUNT)*FACW
824,000      PWR = PWR - (REAL(EY*CONJG(HZ)) - EZ*CONJG(HY))*RNX +
825,000      +           REAL(EZ*CONJG(HX)) - EX*CONJG(HZ))*RNY +
826,000      +           REAL(EX*CONJG(HY)) - EY*CONJG(HX)))*FACW
827,000 500  CONTINUE
828,000 510  CONTINUE
829,000 520  CONTINUE
830,000 * COMPUTATION OF CURRENT MATRIX COMPLETED
831,000 *
832,000 * COMPUTE SPILL-OVER EFFICIENCY - ETAS
833,000 * PWR = POWER CAPTURED BY REFLECTOR
834,000 *
835,000      PWR = PWR*0.50/ZETA
836,000 * PT = TOTAL POWER RADIATED
837,000      PT = 0.0
838,000      DO 530 K = 1,NHORN
839,000 530  PT = PT + HPWR(K)
840,000      ETAS = PWR/PT
841,000      WRITE(6,540) ETAS
842,000 540  FORMAT(///,1X,'SPILL-OVER EFFICIENCY =',F7.3,/)
843,000      PT = PT*60.0*WAVE*WAVE
844,000      IF (IGRD.EQ.1) GO TO 810
845,000 *
846,000 * COMPUTE GAIN AND PHASE OF CO-POLAR AND X-POLAR COMPONENTS
847,000 * IN RECTANGULAR EL - AZ GRID.

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848.000 *
849.000      ELIN = ELE - ELS
850.000      IF (NEL.GT.1) ELIN = ELIN/FLOAT(NEL - 1)
851.000      AZIN = AZE - AZS
852.000      IF (NAZ.GT.1) AZIN = AZIN/FLOAT(NAZ - 1)
853.000      DO 550 I = 1,NEL
854.000 550   EL(I) = ELE - ELIN*(I-1)
855.000      DO 560 I = 1,NAZ
856.000 560   AZ(I) = AZS + AZIN*(I-1)
857.000      KOUNT = 0
858.000      DO 580 I = 1,NEL
859.000      DO 570 J = 1,NAZ
860.000      KOUNT = KOUNT + 1
861.000      CALL CONV(EL(I),AZ(J),STQ,CTQ,SPQ,CPQ)
862.000      CALL FIELD(STQ,CTQ,SPQ,CPQ,IPOLA,CGNO,XGNO,CPHO)
863.000      CGN(KOUNT) = CGNO
864.000      XGN(KOUNT) = XGNO
865.000      CPH(KOUNT) = CPHO
866.000 570   CONTINUE
867.000 580   CONTINUE
868.000 * OUTPUT FAR FIELD AT OBSERVATION GRID.
869.000 *
870.000      WRITE(6,710)
871.000 710   FORMAT(//,50X,'CO-POLAR GAIN IN DB')
872.000      WRITE(6,720)
873.000 720   FORMAT(48X,23(1H-))
874.000      WRITE(6,730) (AZ(I),I=1,NAZ)
875.000 730   FORMAT(//,1X,' ELEV *',50X,'AZIMUTH (DEG)',/,1X,', (DEG) *',
876.000      +20F6.2)
877.000      WRITE(6,735)
878.000 735   FORMAT(1X,65(2H *))
879.000      DO 740 I = 1,NEL
880.000      KOUNT = (I-1)*NAZ + 1
881.000      KOUNT1 = KOUNT + NAZ - 1
882.000 740   WRITE(6,750) EL(I),(CGN(J),J=KOUNT,KOUNT1)
883.000 750   FORMAT(//,8X,1H*,/,1X,F7.3,1H*,20F6.2,/,8X,1H*)
884.000      WRITE(6,760)
885.000 760   FORMAT(//,50X,'X-POLAR GAIN IN DB')
886.000      WRITE(6,720)
887.000      WRITE(6,730) (AZ(I),I=1,NAZ)
888.000      WRITE(6,735)
889.000      DO 770 I = 1,NEL
890.000      KOUNT = (I-1)*NAZ + 1
891.000      KOUNT1 = KOUNT + NAZ - 1
892.000 770   WRITE(6,765) EL(I),(XGN(J),J=KOUNT,KOUNT1)
893.000 765   FORMAT(//,8X,1H*,/,1X,F7.3,1H*,20F6.1,/,8X,1H*)
894.000      WRITE(6,775)
895.000 775   FORMAT(//,49X,'CO-POLAR PHASE IN DEG')
896.000      WRITE(6,720)
897.000      WRITE(6,730) (AZ(I),I=1,NAZ)
898.000      WRITE(6,735)
899.000      DO 780 I = 1,NEL
900.000      KOUNT = (I-1)*NAZ + 1
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901.000      KOUNT1 = KOUNT + NAZ - 1
902.000 780  WRITE(6,765) EL(I),(CPH(J),J=KOUNT,KOUNT1)
903.000      OPEN(UNIT=7,FILE='GNMAT',STATUS='OLD',USAGE='OUTPUT')
904.000      WRITE(7,10) (IHEAD(I),I=1,15)
905.000      WRITE(7,290) AZS,AZE,NAZ,ELS,ELE,NEL
906.000      DO 790 I = 1,NEL
907.000      KOUNT = (I-1)*NAZ + 1
908.000      KOUNT1= KOUNT + NAZ - 1
909.000 790  WRITE(7,800) (CGN(J),J=KOUNT,KOUNT1)
910.000 800  FORMAT(10F8.2)
911.000      STOP
912.000 *
913.000 * COMPUTE GAIN AND PHASE OF CO-POLAR AND X-POLAR COMPONENTS ON U-V GRID.
914.000 *
915.000 * LOOP THROUGH ALL U-COMPONENTS,
916.000 *
917.000 810  KOUNT = 0
918.000      DO 830 NP = 1,NS
919.000      N = NL + NP - 1
920.000      EL(NP) = N
921.000 *
922.000 * LOOP THROUGH ALL V-COMPONENTS
923.000 *
924.000      DO 820 MP = 1,MS
925.000      M = ML + MP - 1
926.000      AZ(MP) = M
927.000      IF (M,EQ.0 .AND. N,EQ.0) THEN
928.000      STQ = 0.0
929.000      CTQ = 1.0
930.000      SPQ = 0.0
931.000      CPQ = 1.0
932.000      ELSE
933.000      SPQ = M*PI/RKB
934.000      CPQ = N*PI/RKA
935.000      STQ = SQRT(SPQ*SPQ + CPQ*CPQ)
936.000      CTQ = SQRT(1.0 - STQ*STQ)
937.000      SPQ = SPQ/STQ
938.000      CPQ = CPQ/STQ
939.000      END IF
940.000      CALL FIELD(STQ,CTQ,SPQ,CPQ,IPOLA,CGNO,XGNO,CPHO)
941.000      KOUNT = KOUNT + 1
942.000      CGN(KOUNT) = CGNO
943.000      XGN(KOUNT) = XGNO
944.000      CPH(KOUNT) = CPH0
945.000      CPEF(MP,NP) = COPOL
946.000      XPEF(MP,NP) = XPOL
947.000 820  CONTINUE
948.000 830  CONTINUE
949.000 *
950.000 * OUTPUT GAIN VALUES AT SAMPLING POINTS
951.000 *
952.000      WRITE(6,840)
953.000 840  FORMAT(///,40X,'CO-POLAR GAIN (DB) OF SAMPLING POINTS,')
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```
954,000      WRITE(6,950)
955,000 850  FORMAT(40X,36(1H-))
956,000      WRITE(6,960) RKA,RKB
957,000 860  FORMAT(//,40X,'RKA = ',F10.4,5X,'RKB = ',F10.4)
958,000      DO 910 NP = 1,NS
959,000      KOUNT = (NP -1)*MS
960,000      WRITE(6,870) EL(NP)
961,000 870  FORMAT(//,47X,'U/PI = ',F6.1)
962,000      WRITE(6,880)
963,000 880  FORMAT(8(1X,' V/PI ',2X,'GN(DB)' ))
964,000      WRITE(6,890)
965,000 890  FORMAT(8(1X,6H-----,2X,6H-----))
966,000      WRITE(6,900) (AZ(MP),CGN(KOUNT+MP),MP=1,MS)
967,000 900  FORMAT(8(1X,F6.1,1X,F7.2))
968,000 910  CONTINUE
969,000      WRITE(6,920)
970,000 920  FORMAT(///,40X,'X-POLAR GAIN (DB) OF SAMPLING POINTS.')
971,000      WRITE(6,850)
972,000      WRITE(6,860) RKA, RKB
973,000      DO 930 NP = 1,NS
974,000      KOUNT = (NP -1)*MS
975,000      WRITE(6,870) EL(NP)
976,000      WRITE(6,880)
977,000      WRITE(6,890)
978,000      WRITE(6,900) (AZ(MP),XGN(KOUNT+MP),MP=1,MS)
979,000 930  CONTINUE
980,000 * WRITE SAMPLED DATA INTO FILE SAME_DAT
981,000      OPEN (UNIT=7,FILE='SAME_DAT',STATUS='OLD',USAGE='OUTPUT')
982,000      WRITE(7,90) RKA, RKB
983,000      WRITE(7,80) NL,NU,NS,ML,MU,MS
984,000      WRITE(7,940) ((CPEF(MP,NP),MP=1,MS),NP=1,NS)
985,000      WRITE(7,940) ((XPEF(MP,NP),MP=1,MS),NP=1,NS)
986,000 940  FORMAT(10F12.6)
987,000      STOP
988,000      END
989,000      SUBROUTINE RADLIM(CP,SP,A1,B1,A2,B2,RL,RU)
990,000 *
991,000 * COMPUTES LOWER AND UPPER LIMITS OF RADIAL VAR. INTEG. FOR A GIVEN
992,000 * PHI.
993,000 *
994,000      RU = A1*B1/SQRT(A1*A1*SP*SP + B1*B1*CP*CP)
995,000      RL = 0.0
996,000      IF (A2.LT.1.0E-04.OR.B2.LT.1.0E-04) RETURN
997,000      RL = A2*B2/SQRT(A2*A2*SP*SP + B2*B2*CP*CP)
998,000      RETURN
999,000      END
1000,000      SUBROUTINE SOURCE(THETAR,SP,CP,ETHETA,EPHI,K)
1001,000 *
1002,000 * COMPUTES ETHETA AND EPHI COMPONENTS OF FEED HORN
1003,000 *
1004,000      COMPLEX ETHETA,EPHI,CONSTX,CONSTY,EXT,EXP
1005,000      COMMON/VAL2/AN(50),HPHASE(50),CX(50),CY(50),PSI(50),IFOLA,IGP(50)
1006,000 *
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```
1060.000      ETHP = EPP(N1,J)
1061.000      EPHA = HPA(N1,J)
1062.000      EPHP = HPP(N1,J)
1063.000      RETURN
1064.000 10   WRITE(6,20)
1065.000 20   FORMAT(1X,'PATTERN INTERPOLATION IS OUT OF RANGE OF DATA')
1066.000      STOP
1067.000      END
1068.000      SUBROUTINE PWRFED(K,PWR)
1069.000 *
1070.000 * INTEGRATES POYNTING'S VECTOR TO OBTAIN POWER RADIATED BY THE K TH
1071.000 * HORN.
1072.000 *
1073.000      DIMENSION THL(2),THU(2),POW(2)
1074.000      COMMON/VAL1/PI,RAD,RK,ZETA
1075.000      COMMON/PATPAR/NPP,PAI,TETA(46)
1076.000      COMMON/BLOCK/QX(219),QW(219)
1077.000 *
1078.000 * RANGE OF THETA-INTEGRATION IS DIVIDED INTO TWO REGIONS. 20-PT
1079.000 * GAUSS-LEGENDRE FORMULA IS USED FOR EACH REGION.
1080.000 *
1081.000 * LOC = LOCATION OF FORMULA
1082.000 *
1083.000      LOC = 73
1084.000      TINC = (NPP - 1)*PAI*0.50
1085.000      PWR = 0.0
1086.000      DO 20 N = 1,2
1087.000      POW(N) = 0.0
1088.000      THL(N) = (N-1)*TINC
1089.000      THU(N) = THL(N) + TINC
1090.000      DO 10 I = 1,20
1091.000      THETA = (THL(N) + THU(N))*0.50 + (THU(N) - THL(N))*0.50*QX(I+LOC)
1092.000      CALL PAT(THETA,ETHA,EPHP,EPHA,K)
1093.000      POW(N) = POW(N) + (ETHA**2 + EPHA**2)*SIN(THETA)*QW(I+LOC)
1094.000 10   CONTINUE
1095.000      PWR = POW(N)*(THU(N) - THL(N)) + PWR
1096.000 20   CONTINUE
1097.000      PWR = PWR*0.25*PI/ZETA
1098.000      RETURN
1099.000      END
1100.000      SUBROUTINE CONV(EL,AZ,ST,CT,SP,CP)
1101.000 *
1102.000 * CONVERTS (EL,AZ) TO (THETA,PHI) CO-ORD.
1103.000 *
1104.000 * ST = SIN(THETA)
1105.000 * CT = COS(THETA)
1106.000 * SP = SIN(PHI)
1107.000 * CP = COS(PHI)
1108.000 *
1109.000      COMMON/VAL1/PI,RAD,RK,ZETA
1110.000 *
1111.000      CT = COS(EL/RAD)*COS(AZ/RAD)
1112.000      ST = SQRT(1.0 - CT*CT)
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1007.000 CONSTX = AN(K)*CMPLX(COS(HPHASE(K)), SIN(HPHASE(K)))
1008.000 CONSTY = CONSTX*CY(K)*CMPLX(COS(PSI(K)), SIN(PSI(K)))
1009.000 CONSTX = CONSTX*CX(K)
1010.000 THETA = 3.14159265 - THETAR
1011.000 KK = IGP(K)
1012.000 CALL PAT(THETA,ETHA,ETHP,EPHA,EPHP,KK)
1013.000 EXT = ETHA*CMPLX(COS(ETHP), SIN(ETHP))
1014.000 EXP = EPHA*CMPLX(COS(EPHP), SIN(EPHP))
1015.000 ETHETA = -CONSTX*EXT*CP + CONSTY*EXT*SP
1016.000 EPHI = -CONSTY*EXP*CP - CONSTX*EXP*SP
1017.000 RETURN
1018.000 END
1019.000 SUBROUTINE PAT(THETA,ETHA,ETHP,EPHA,EPHP,J)
1020.000 *
1021.000 * INTERPOLATES INPUT PATTERN DATA.
1022.000 *
1023.000 COMMON/PATERN/EPA(46,10),EPP(46,10),HPA(46,10),HPP(46,10)
1024.000 COMMON/PATPAR/NPP,PAI,TETA(46)
1025.000 *
1026.000 * STATEMENT FUNCTION DEFINING SECOND ORDER LAGRANGIAN INTERPOLATION.
1027.000 *
1028.000 FX(X1,X2,X3,Y1,Y2,Y3,X) = Y1*(X-X2)*(X-X3)/((X1-X2)*(X1-X3))
1029.000 + + Y2*(X-X1)*(X-X3)/((X2-X1)*(X2-X3)) +
1030.000 + Y3*(X-X1)*(X-X2)/((X3-X1)*(X3-X2))
1031.000 *
1032.000 X = THETA
1033.000 N = X/PAI
1034.000 N1 = N + 1
1035.000 IF (N1 = NPP) 1,5,10
1036.000 1 IF (N1 .EQ. (NPP-1)) N1 = N1 - 1
1037.000 X1 = (N1 - 1)*PAI
1038.000 X2 = N1*PAI
1039.000 X3 = (N1 + 1)*PAI
1040.000 N2 = N1 + 1
1041.000 N3 = N1 + 2
1042.000 Y1 = EPA(N1,J)
1043.000 Y2 = EPA(N2,J)
1044.000 Y3 = EPA(N3,J)
1045.000 ETHA = FX(X1,X2,X3,Y1,Y2,Y3,X)
1046.000 Y1 = EPP(N1,J)
1047.000 Y2 = EPP(N2,J)
1048.000 Y3 = EPP(N3,J)
1049.000 ETHP = FX(X1,X2,X3,Y1,Y2,Y3,X)
1050.000 Y1 = HPA(N1,J)
1051.000 Y2 = HPA(N2,J)
1052.000 Y3 = HPA(N3,J)
1053.000 EPHA = FX(X1,X2,X3,Y1,Y2,Y3,X)
1054.000 Y1 = HPP(N1,J)
1055.000 Y2 = HPP(N2,J)
1056.000 Y3 = HPP(N3,J)
1057.000 EPHP = FX(X1,X2,X3,Y1,Y2,Y3,X)
1058.000 RETURN
1059.000 5 ETHA = EPA(N1,J)

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1113.000      IF (ABS(EL),LT,1.0E-07) GO TO 10
1114.000      SP = COS(EL/RAD)*SIN(AZ/RAD)/ST
1115.000      CP = SIN(EL/RAD)/ST
1116.000      RETURN
1117.000 10   IF(AZ) 20,30,40
1118.000 20   SP = -1.0
1119.000      CP = 0.0
1120.000      RETURN
1121.000 30   SP = 0.0
1122.000      CP = 1.0
1123.000      RETURN
1124.000 40   SP = 1.0
1125.000      CP = 0.0
1126.000      RETURN
1127.000      END
1128.000      SUBROUTINE FIELD(STQ,CTQ,SPQ,CPQ,IPOLA,CGN,XGN,CPH)
1129.000 *
1130.000 * COMPUTE FIELD COMPONENTS OF REFLECTOR AT (THETAQ,PHIQ)
1131.000 *
1132.000      DIMENSION X(3136),Y(3136),Z(3136)
1133.000      COMPLEX FTX,FTY,FTZ,RJX(3136),RJY(3136),RJZ(3136)
1134.000      COMPLEX EXPN,POL1,POL2,COPOL,XPOL
1135.000      COMMON/CURENT/RJX,RJY,RJZ,X,Y,Z
1136.000      COMMON/VAL3/NREG,NQR,NQP,FT,XDQ,YDQ,ZDQ,CPVR,SPVR
1137.000      COMMON/VAL1/PI,RAD,RK,ZETA
1138.000      COMMON/EFC/COPOL,XPOL
1139.000 *
1140.000 * SUM UP CONTRIBUTIONS FROM ALL PANEL CURRENTS.
1141.000 *
1142.000      FTX = (0.0,0.0)
1143.000      FTY = (0.0,0.0)
1144.000      FTZ = (0.0,0.0)
1145.000      STCP = STQ*CPQ
1146.000      STSP = STQ*SPQ
1147.000      KOUNT = 0
1148.000      DO 30 L = 1,NREG
1149.000      DO 20 J = 1,NQP
1150.000      DO 10 I = 1,NQR
1151.000      KOUNT = KOUNT + 1
1152.000      ARG = (X(KOUNT)*STCP + Y(KOUNT)*STSP + Z(KOUNT)*CTQ)*RK
1153.000      EXPN = CMPLX(COS(ARG),SIN(ARG))
1154.000      FTX = FTX + RJX(KOUNT)*EXPN
1155.000      FTY = FTY + RJY(KOUNT)*EXPN
1156.000      FTZ = FTZ + RJZ(KOUNT)*EXPN
1157.000 10   CONTINUE
1158.000 20   CONTINUE
1159.000 30   CONTINUE
1160.000      POL1 = (1.0 - (1.0 - CTQ)*CPQ*CPQ)*FTX - (1.0 - CTQ)*SPQ*CPQ*FTY
1161.000      + - STCP*FTZ
1162.000      POL2 = -(1.0 - CTQ)*SPQ*CPQ*FTX + (1.0 - SPQ*SPQ*(1.0 - CTQ))*FTY
1163.000      + - STSP*FTZ
1164.000 *
1165.000 * SHIFT REFERENCE TO FIELD CO-ORDINATE SYSTEM

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1166.000 *
1167.000      ARG = (STCP*X0Q + STSP*Y0Q + CTQ*Z0Q)*RK
1168.000      EXPN = CMPLX(COS(ARG),-SIN(ARG))
1169.000      FTX = (POL1*CPVR + POL2*SPVR)*EXPN/SQRT(PT)
1170.000      FTY = (POL2*CPVR - POL1*SPVR)*EXPN/SQRT(PT)
1171.000      GO TO (40,50,60,70), IPOLA
1172.000 40    COPOL = FTX
1173.000      XPOL = FTY
1174.000      GO TO 80
1175.000 50    COPOL = FTY
1176.000      XPOL = FTX
1177.000      GO TO 80
1178.000 60    COPOL = 0.70710678*(FTX + CMPLX(0,0,1,0)*FTY)
1179.000      XPOL = 0.70710678*(FTX - CMPLX(0,0,1,0)*FTY)
1180.000      GO TO 80
1181.000 70    COPOL = 0.70710678*(FTX - CMPLX(0,0,1,0)*FTY)
1182.000      XPOL = 0.70710678*(FTX + CMPLX(0,0,1,0)*FTY)
1183.000 80    CGN = 20.0*ALOG10(CABS(COPOL))
1184.000      XGN = 20.0*ALOG10(CABS(XPOL))
1185.000      CPH = ATAN2(AIMAG(COPOL),REAL(COPOL))*RAD
1186.000      RETURN
1187.000      END
1188.000      SUBROUTINE PYRHRN(A,B,WGA,WGB,HRNLTH,AM,PM,MODH,RK,IG)
1189.000 *
1190.000 * COMPUTES PATTERNS OF SINGLE MODE OR MULTIMODE PYRAMIDAL HORNS.
1191.000 *
1192.000      DIMENSION EPA(46,10),EPP(46,10),HPA(46,10),HPP(46,10),THETA(46)
1193.000      COMPLEX HAR(24),EAR(24),A12,HSUM,ESUM,CSUM,EF
1194.000      COMMON/PATERN/EPA,EPP,HPA,HPP
1195.000      COMMON/PATPAR/NFT,PAI,THETA
1196.000      COMMON/BLOCK/QX(219),QW(219)
1197.000 *
1198.000 * TE10 MODE CUT-OFF CHECK
1199.000 *
1200.000      IF (RK.LE.(3.14159/A)) GO TO 90
1201.000      IF (AM.LT.1.0E-02) GO TO 5
1202.000 *
1203.000 * TE/TM21 MODE CUT-OFF CHECK
1204.000 *
1205.000      IF (RK.LE.(6.28318*SQRT(1.0 + (.50*A/B)**2)/A)) GO TO 100
1206.000 *
1207.000 * COMPUTE HORN AXIAL LENGTHS
1208.000 *
1209.000 5     ALE = 999.0
1210.000      ALH = 999.0
1211.000      IF (B.GT.WGB) ALE = HRNLTH*B/(B - WGB)
1212.000      IF (A.GT.WGA) ALH = HRNLTH*A/(A - WGA)
1213.000 *
1214.000 * COMPUTE MODE COEFFICIENTS
1215.000 *
1216.000      A12 = AM*CMPLX(COS(PM),SIN(PM))
1217.000 *
1218.000 * SELECTION OF APPROPRIATE QUADRATURE FORMULA

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1219.000 * ARRAYS HAR AND EAR ARE DIMENSIONED TO ACCOMODATE HORN SIZES LESS
1220.000 * THAN OR EQUAL TO 7.5 WAVELENGTHS.
1221.000 *
1222.000     ARG = AMAX1(A,B)
1223.000     IQ = RK*ARG/3.141592 + 1.0
1224.000     IQ = (IQ+1)*1,40
1225.000     IF (IQ.GT.24) GO TO 70
1226.000     CALL APQUAD(IQ,NQ,LOC)
1227.000 *
1228.000 * COMPUTE INTEGRAL INVARIANT WITH OBSERVATION ANGLE
1229.000 *
1230.000     HSUM = (0,0,0,0)
1231.000     ESUM = (0,0,0,0)
1232.000     DO 10 I = 1,NQ
1233.000     ARG = RK*((QX(I+LOC)*A*0.50)**2)*0.50/ALH
1234.000     HAR(I) = COS(1.5707963*QX(I+LOC))*CMPLX(COS(ARG),-SIN(ARG))*+
1235.000     +QW(I+LOC)
1236.000     HSUM = HSUM + HAR(I)
1237.000     ARG = RK*((QX(I+LOC)*B*0.50)**2)*0.50/ALE
1238.000     EAR(I) = (1.0 + A12*COS(3.1415926*QX(I+LOC)))*
1239.000     +CMPLX(COS(ARG),-SIN(ARG))*QW(I+LOC)
1240.000     ESUM = ESUM + EAR(I)
1241.000 10    CONTINUE
1242.000 *
1243.000 * COMPUTE E-PLANE PATTERN
1244.000 *
1245.000     DO 40 I = 1,NPT
1246.000     ST = RK*B*0.50*SIN(THETA(I))
1247.000     CSUM = (0,0,0,0)
1248.000     DO 30 J = 1,NQ
1249.000     ARG = ST*QX(J+LOC)
1250.000     CSUM = CSUM + EAR(J)*CMPLX(COS(ARG),SIN(ARG))
1251.000 30    CONTINUE
1252.000     EF = HSUM*CSUM
1253.000     IF (MODH,EQ,1) EF = EF*(1.0 + COS(THETA(I)))
1254.000     EPA(I,IG) = CABS(EF)
1255.000     EPP(I,IG) = ATAN2(AIMAG(EF),REAL(EF))
1256.000 40    CONTINUE
1257.000 *
1258.000 * COMPUTE H-PLANE PATTERN
1259.000 *
1260.000     DO 60 I = 1,NPT
1261.000     ST = RK*A*0.50*SIN(THETA(I))
1262.000     CSUM = (0,0,0,0)
1263.000     DO 50 J = 1,NQ
1264.000     ARG = ST*QX(J+LOC)
1265.000     CSUM = CSUM + HAR(J)*CMPLX(COS(ARG),SIN(ARG))
1266.000 50    CONTINUE
1267.000     CSUM = CSUM*ESUM
1268.000     EF = COS(THETA(I))*CSUM
1269.000     IF (MODH,EQ,1) EF = EF + CSUM
1270.000     HPA(I,IG) = CABS(EF)
1271.000     HPP(I,IG) = ATAN2(AIMAG(EF),REAL(EF))
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1272,000 60      CONTINUE
1273,000 *
1274,000 * NORMALISE PATTERNS
1275,000 *
1276,000      CALL PTNORM(IG,NPT)
1277,000      RETURN
1278,000 * ERROR DIAGNOSTICS
1279,000 70      WRITE(6,80)
1280,000 80      FORMAT(1X,'HORN APER. DIM. IS TOO LARGE. EXECUTION TERMINATED.')
1281,000      STOP
1282,000 90      WRITE(6,95)
1283,000 95      FORMAT(1X,'PYRAMIDAL HORN DIM. IS BELOW TE10 MODE CUT-OFF.',,
1284,000      +' EXECUTION IS TERMINATED.')
1285,000      STOP
1286,000 100     WRITE(6,105)
1287,000 105     FORMAT(1X,'MULTI MODE PYRAMIDAL RN DIM. IS BELOW TE/TM21 ',,
1288,000      +'MODE CUT-OFF. STOP.')
1289,000      STOP
1290,000      END
1291,000      SUBROUTINE CONHRN(AR,WGR,HRNLTH,AM,PM,MODH,RK,IG)
1292,000 *
1293,000 * COMPUTES PATTERNS OF CONICAL HORNS.
1294,000 * E- AND H-PLANE NORM. AMP. ARE STORED IN ARRAYS EPA AND HPA RESP.
1295,000 * E- AND H-PLANE NORM. PHASES ARE STORED IN ARRAYS EPP AND HPP RESP.
1296,000 *
1297,000      DIMENSION EPA(46,10),EPP(46,10),HPA(46,10),HPP(46,10),THETA(46)
1298,000      COMPLEX HJ0(14),HJ2(14),EJ0(14),EJ2(14),ESUMT,ESUMP,HSUMT,
1299,000      +HSUMP,B11,EF
1300,000      COMMON/BLOCK/QX(219),QW(219)
1301,000      COMMON/PATERN/EPA,EPP,HPA,HPP
1302,000      COMMON/PATPAR/NPT,FAI,THETA
1303,000 *
1304,000 * TE11 MODE CUT-OFF CHECK
1305,000 *
1306,000      IF (RK.LE.1.94118/AR) GO TO 80
1307,000      IF (AM.LT.1.0E-02) GO TO 5
1308,000 *
1309,000 * TM11 MODE CUT-OFF CHECK
1310,000 *
1311,000      IF (RK.LE.3.83171/AR) GO TO 90
1312,000 *
1313,000 * COMPUTE AXIAL LENGTH
1314,000 *
1315,000 5      AL = 999.0
1316,000      IF (AR.GT.WGR) AL = HRNLTH*AR/(AR - WGR)
1317,000 *
1318,000 * COMPUTE MODE COEFFICIENT
1319,000 *
1320,000      B11 = 2.08116*AM*CMPLX(COS(PM),SIN(PM))
1321,000 *
1322,000 * SELECTION OF APPROPRIATE QUADRATURE FORMULA
1323,000 * ARRAYS HJ0,HJ2,EJ0 AND EJ2 ARE DIMENSIONED TO ACCOMODATE HORN
1324,000 * DIAMETERS LESS THAN 8 WAVELENGTHS.
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1325.000 *
1326.000     IQ = RK*AR/3.141592 + 1.0
1327.000     IQ = (IQ+1)*1.40
1328.000     IF (IQ.GT.14) GO TO 50
1329.000     CALL AFQUAD(IQ,NQ,LOC)
1330.000 *
1331.000 * COMPUTE INTEGRAND INVARIANT WITH OBSERVATION POINTS.
1332.000 *
1333.000     DO 10 I = 1,NQ
1334.000     RHO = 0.50*(1.0 + QX(I+LOC))
1335.000     ARG1 = RK*RHO*RHO*AR*AR*0.50/AL
1336.000     ARG2 = 1.84118*RHO
1337.000     CALL BESEL(ARG2,BJ0,BJ2)
1338.000     ESUMT = CMPLX(COS(ARG1),-SIN(ARG1))
1339.000     HJ2(I) = BJ2*RHO*ESUMT*QW(I+LOC)
1340.000     HJ0(I) = BJ0*ESUMT*QW(I+LOC)*RHO
1341.000     IF (MODE.EQ.1) GO TO 10
1342.000     ARG2 = 3.83171*RHO
1343.000     CALL BESEL(ARG2,BJ0,BJ2)
1344.000     EJ0(I) = BJ0*ESUMT*QW(I+LOC)*RHO
1345.000     EJ2(I) = BJ2*ESUMT*QW(I+LOC)*RHO
1346.000 10   CONTINUE
1347.000 *
1348.000 * COMPUTES E- AND H-PLANE PATTERNS
1349.000 *
1350.000     DO 40 I = 1,NPT
1351.000     ST = RK*AR*SIN(THETA(I))
1352.000     HSUMT = (0.0,0.0)
1353.000     HSUMP = (0.0,0.0)
1354.000     ESUMT = (0.0,0.0)
1355.000     ESUMP = (0.0,0.0)
1356.000     DO 20 J = 1,NQ
1357.000     ARG = ST*0.50*(1.0 + QX(J+LOC))
1358.000     CALL BESEL(ARG,BJ0,BJ2)
1359.000     HSUMP = HSUMP - HJ2(J)*BJ2 - HJ0(J)*BJ0
1360.000     HSUMT = HSUMT + HJ2(J)*BJ2 - HJ0(J)*BJ0
1361.000     IF (AM.LT.1.0E-02) GO TO 20
1362.000     ESUMP = ESUMP - EJ2(J)*BJ2 + EJ0(J)*BJ0
1363.000     ESUMT = ESUMT + EJ0(J)*BJ0 + EJ2(J)*BJ2
1364.000 20   CONTINUE
1365.000     BKH = 0.0
1366.000     BKE = 0.0
1367.000     IF (MODH.EQ.0) GO TO 30
1368.000     BKH = SQRT(RK**2 - (1.84118/AR)**2)/RK
1369.000     IF (AM.LT.1.0E-02) GO TO 30
1370.000     BKE = RK/SQRT(RK**2 - (3.83171/AR)**2)
1371.000 30   CT = COS(THETA(I))
1372.000     EF = (1.0 + BKH*CT)*HSUMT - (1.0+BKE*CT)*B11*ESUMT
1373.000     EPA(I,IG) = CABS(EF)
1374.000     EPP(I,IG) = ATAN2(AIMAG(EF),REAL(EF))
1375.000     EF = (CT + BKH)*HSUMP - (CT+BKE)*B11*ESUMP
1376.000     HPA(I,IG) = CABS(EF)
1377.000     HPP(I,IG) = ATAN2(AIMAG(EF),REAL(EF))

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1378.000 40    CONTINUE
1379.000 *
1380.000 * NORMALISE PATTERNS
1381.000 *
1382.000      CALL PTNORM(IG,NPT)
1383.000      RETURN
1384.000 * ERROR DIAGNOSTICS
1385.000 50    WRITE(6,60)
1386.000 60    FORMAT(1X,'CONICAL HORN APER. RAD. IS TOO LARGE. EXECUTION TERM.')
1387.000      STOP
1388.000 80    WRITE(6,85)
1389.000 85    FORMAT(1X,'CONICAL HORN DIM. IS BELOW TE11 MODE CUT-OFF.',,
1390.000      +' EXECUTION IS TERMINATED.')
1391.000      STOP
1392.000 90    WRITE(6,95)
1393.000 95    FORMAT(1X,'DUAL MODE CONICAL HORN DIM. IS BELOW TM11 MODE ',,
1394.000      +'CUT-OFF. STOP.')
1395.000      STOP
1396.000      END
1397.000      SUBROUTINE PTNORM(IG,NPT)
1398.000 *
1399.000 * NORMALISES AMPLITUDE AND PHASE PATTERNS.
1400.000 *
1401.000      DIMENSION EPA(46,10),EPP(46,10),HPA(46,10),HPP(46,10)
1402.000      COMMON/PATERN/EPA,EPP,HPA,HPP
1403.000 *
1404.000      ANORM = EPA(1,IG)
1405.000      PNORM = EPP(1,IG)
1406.000      EPA(1,IG) = EPA(1,IG)/ANORM
1407.000      EPP(1,IG) = EPP(1,IG) - PNORM
1408.000      HPA(1,IG) = HPA(1,IG)/ANORM
1409.000      HPP(1,IG) = HPP(1,IG) - PNORM
1410.000      IF (NPT.EQ.1) RETURN
1411.000      DO 10 I = 2,NPT
1412.000      EPA(I,IG) = EPA(I,IG)/ANORM
1413.000      HPA(I,IG) = HPA(I,IG)/ANORM
1414.000      EPP(I,IG) = EPP(I,IG) - PNORM
1415.000      PDIF = EPP(I,IG) - EPP(I-1,IG)
1416.000      IF (PDIF.GE.3.141592) EPP(I,IG) = EPP(I,IG) - 6.283185
1417.000      IF (PDIF.LE.-3.141592) EPP(I,IG) = EPP(I,IG) + 6.283185
1418.000      HPP(I,IG) = HPP(I,IG) - PNORM
1419.000      PDIF = HPP(I,IG) - HPP(I-1,IG)
1420.000      IF (PDIF.GE.3.141592) HPP(I,IG) = HPP(I,IG) - 6.283185
1421.000      IF (PDIF.LE.-3.141592) HPP(I,IG) = HPP(I,IG) + 6.283185
1422.000 10    CONTINUE
1423.000      RETURN
1424.000      END
1425.000      SUBROUTINE BESEL(ARG,BJ0,BJ2)
1426.000 *
1427.000 * COMPUTES BESEL FUNCTION OF THE FIRST KIND , ZERO(BJ0) AND
1428.000 * SECOND(BJ2) ORDER. ARG IS THE INPUT ARGUMENT.
1429.000 *
1430.000      IF (ARG.GE.3.0) GO TO 10
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1431.000 *
1432.000 * 0 < ARG < 3
1433.000 *
1434.000      X2 = (ARG/3.0)**2
1435.000      X4 = X2*X2
1436.000      X6 = X4*X2
1437.000      X8 = X6*X2
1438.000      X10 = X8*X2
1439.000      X12 = X10*X2
1440.000      BJ0 = 1.0 - 2.2499997*X2 + 1.2656208*X4 - .3163866*X6
1441.000      + .0444479*X8 - .0039444*X10 + .0002100*X12
1442.000      BJ2 = 0.5 - .56249985*X2 + .21093573*X4 - .03954289*X6
1443.000      + .00443319*X8 - .00031761*X10 + .00001109*X12
1444.000      BJ2 = 2.0*BJ2 - BJ0
1445.000      RETURN
1446.000 *
1447.000 * ARG > 3
1448.000 *
1449.000 10    X = 3.0/ARG
1450.000      X2 = X*X
1451.000      X3 = X2*X
1452.000      X4 = X3*X
1453.000      X5 = X4*X
1454.000      X6 = X5*X
1455.000      THETA = ARG - .78539816 - .04166397*X - .00003954*X2
1456.000      + .00262573*X3 - .00054125*X4 - .00029333*X5 + .00013558*X6
1457.000      F = .79788456 - .00000077*X - .00552740*X2 - .00009512*X3
1458.000      + .00137237*X4 - .00072805*X5 + .00014476*X6
1459.000      BJ0 = F*COS(THETA)/SQRT(ARG)
1460.000      THETA = ARG - 2.35619449 + .12499612*X + .0000565*X2
1461.000      + -.00637879*X3 + .00074348*X4 + .00079824*X5 - .00029166*X6
1462.000      BJ2 = F*COS(THETA)/(ARG*SQRT(ARG))
1463.000      BJ2 = 2.0*BJ2 - BJ0
1464.000      RETURN
1465.000      END
1466.000      SUBROUTINE AFQUAD(IQ,NQ,LOC)
1467.000 *
1468.000 * FINDS THE NEAREST QUAD. FORMULA TO THAT REQUIRED.
1469.000 * THE AVAILABLE FORMULAS ARE STORED IN ASCENDING ORDER IN ARRAY
1470.000 * IQF. NQF IS THE NUMBER OF FORMULAS STORED IN THE BLOCK DATA.
1471.000 * BOTH IQF AND NQF ARE DEFINED IN THE DATA STATEMENT BELOW.
1472.000 * IQ = IQ POINT FORM. REQ.
1473.000 * NQ = NEAREST AVAIL. IS NQ POINT FORM.
1474.000 * LOC = LOCATION OF FORM.
1475.000 *
1476.000      INTEGER IQF(13)
1477.000      DATA NQF,IQF/13,3,4,6,8,10,12,14,16,20,24,28,34,40/
1478.000 *
1479.000      DO 10 I = 1,NQF
1480.000      IF (IQ.LE.IQF(I)) GO TO 30
1481.000 10    CONTINUE
1482.000      WRITE(6,20)
1483.000 20    FORMAT(1X,'QUADRATURE FORMULA REQUIRED IS LARGER THAN THAT ')

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1484.000      +'AVAILABLE IN THE BLOCK DATA. SEE DOCUMENTATION. EXECUTION',
1485.000      +' TERMINATED')
1486.000      STOP
1487.000 30   IF (I.EQ.1) THEN
1488.000      NQ = IQF(I)
1489.000      ELSE IF ((IQ - IQF(I-1)),LE,(IQF(I) - IQ)) THEN
1490.000      NQ = IQF(I-1)
1491.000      ELSE
1492.000      NQ = IQF(I)
1493.000      END IF
1494.000      CALL QRLOC(NQ,LOC)
1495.000      RETURN
1496.000      END
1497.000      SUBROUTINE QRLOC(NQ,LOC)
1498.000      *
1499.000      * PURPOSE - DETERMINE LOCATION OF INTEGRATION FORMULA IN BLOCK DATA
1500.000      * BLOCK DATA IS ASSUMED TO CONTAIN THE FOLLOWING FORMULAE,
1501.000      * 3,4,6,8,10,12,14,16,20,24,28,34,40 PTS.
1502.000      *
1503.000      IF (NQ - 34) 10,170,180
1504.000 10   IF (NQ - 24) 20,150,160
1505.000 20   IF (NQ - 16) 30,130,140
1506.000 30   IF (NQ - 12) 40,110,120
1507.000 40   IF (NQ - 8) 50,90,100
1508.000 50   IF (NQ - 4) 60,70,80
1509.000 60   LOC = 0
1510.000      RETURN
1511.000 70   LOC = 3
1512.000      RETURN
1513.000 80   LOC = 7
1514.000      RETURN
1515.000 90   LOC = 13
1516.000      RETURN
1517.000 100  LOC = 21
1518.000      RETURN
1519.000 110  LOC = 31
1520.000      RETURN
1521.000 120  LOC = 43
1522.000      RETURN
1523.000 130  LOC = 57
1524.000      RETURN
1525.000 140  LOC = 73
1526.000      RETURN
1527.000 150  LOC = 93
1528.000      RETURN
1529.000 160  LOC = 117
1530.000      RETURN
1531.000 170  LOC = 145
1532.000      RETURN
1533.000 180  LOC = 179
1534.000      RETURN
1535.000      END
1536.000      BLOCK DATA
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1537.000 COMMON/BLOCK/QX(219),QW(219)
 1538.000 * 3 PTS
 1539.000 DATA (QX(I),I=1,3)/-.774596669241,0.00000000,+.774596669241/
 1540.000 DATA (QW(I),I=1,3)/,.5555555555,.888888888888,.555555555555/
 1541.000 * 4 PTS
 1542.000 DATA (QX(I),I=4,7)/-,861136311594,-.3399810435848,.3399810435848,
 1543.000 +.861136311594/
 1544.000 DATA (QW(I),I=4,7)/.347854845137,.652145154862,.652145154862,
 1545.000 +.347854845137/
 1546.000 * 6 PTS.
 1547.000 DATA (QX(I),I=8,13)/.93246951420315,.66120938646626,
 1548.000 +.23861918608319,
 1549.000 +-,.23861918608319,-.66120938646626,-.93246951420315/
 1550.000 DATA (QW(I),I=8,13)/.17132449237917,.36076157304814,
 1551.000 +.46791393457269,
 1552.000 +.46791393457269,.36076157304814,.17132449237917/
 1553.000 * 8 PTS.
 1554.000 DATA (QX(I),I=14,21)/-,9602898564,-.7966664774,-.5255324099,
 1555.000 +-,.1834346424,.1834346424,.5255324099,.7966664774,.9602898564/
 1556.000 DATA (QW(I),I=14,21)/.1012285362,.2223810344,.3137066458,
 1557.000 +.3626837833,.3626837833,.3137066458,.2223810344,.1012285362/
 1558.000 * 10 PTS.
 1559.000 DATA (QX(I),I=22,31)/-,9739065285,-.8650633666,-.6794095682,
 1560.000 +-,.4333953941,-.1488743389,
 1561.000 +.1488743389,.4333953941,.6794095682,.8650633666,.9739065285/
 1562.000 DATA (QW(I),I=22,31)/.0666713443,.1494513491,.2190863625,
 1563.000 +.2692667193,.2955242247,
 1564.000 +.2955242247,.2692667193,.2190863625,.1494513491,.0666713443/
 1565.000 * 12 PTS.
 1566.000 DATA (QX(I),I=32,43)/-,981560634246,-.90411725637,-.769902674194,
 1567.000 +-,.587317954286,-.367831498998,-.125233408511,.125233408511,
 1568.000 +.367831498998,.587317954286,.769902674194,.904117256370,
 1569.000 +.981560634246/
 1570.000 DATA (QW(I),I=32,43)/.047175336386,.106939325995,.160078328543,
 1571.000 +.203167426723,.233492536538,.249147045813,.249147045813,
 1572.000 +.233492536538,.203167426723,.160078328543,.106939325995,
 1573.000 +.047175336386/
 1574.000 * 14 PTS.
 1575.000 DATA (QX(I),I=44,57)/-,986283808696,-.928434883663,-.82720131507,
 1576.000 +-,.687292904811,-.515248636358,-.319112368927,-.108054948707,
 1577.000 +.108054948707,.319112368927,.515248636358,.687292904811,
 1578.000 +.827201315069,.928434883663,.986283808696/
 1579.000 DATA (QW(I),I=44,57)/.035119460331,.080158087159,.121518570687,
 1580.000 +.157203167158,.185538397477,.205198463721,.215263853463,
 1581.000 +.215263853463,.205198463721,.185538397477,.157203167158,
 1582.000 +.121518570687,.080158087159,.035119460331/
 1583.000 * 16 PTS.
 1584.000 DATA (QX(I),I=58,73)/-,989400934991,-.944575023073,-.865631202388,
 1585.000 +-,.755404408355,-.617876244403,-.458016777657,-.281603550779,
 1586.000 +-,.095012509837,.095012509837,.281603550779,.458016777657,
 1587.000 +.617876244403,.755404408355,.865631202387,.944575023073,
 1588.000 +.989400934992/
 1589.000 DATA (QW(I),I=58,73)/.027152459412,.062253523938,.095158511682,

1590.000 +.124628971255,,149595988816,,169156519395,,182603415045,
 1591.000 +-189450610455,,189450610455,,182603415045,,169156519395,
 1592.000 +-149595988816,,124628971255,,095158511682,,062253523938,
 1593.000 +.0271524594117/
 1594.000 * 20 PTS.
 1595.000 DATA (QX(I),I=74,93)/-,9931285991,-,9639719272,-,9122344282,
 1596.000 +-8391169718,
 1597.000 +-,7463319064,-,6360536807,-,5108670019,-,3737060887,-,2277958511,
 1598.000 +-,07652652113,,07652652113,,2277858511,,3737060887,,5108670019,
 1599.000 +.6360536807,
 1600.000 +-,7463319064,,8391169718,,9122344282,,9639719272,,9931285991/
 1601.000 DATA (QW(I),I=74,93)/,01761400713,,04060142980,,06267204833,
 1602.000 +.08327674157,
 1603.000 +-1019301198,,1181945319,,1316886384,,1420961093,,1491729864,
 1604.000 +.1527533871,
 1605.000 +-1527533871,,1491729864,,1420961093,,1316886384,,1181945319,
 1606.000 +.1019301198,
 1607.000 +-08327674157,,06267204833,,04060142980,,01761400713/
 1608.000 * 24 PTS.
 1609.000 DATA (QX(I),I=94,117)/-,9951872199,-,9747285559,-,9382745520,
 1610.000 +-8864155270,-,8200019859,-,7401241915,-,6480936519,
 1611.000 +-,5454214713,-,4337935076,-,3150426796,-,1911188674,
 1612.000 +-,06405689286,,06405689286,,1911188674,,3150426796,,4337935076,
 1613.000 +.5454214713,,6480936519,,7401241915,,8200019859,,8864155270,
 1614.000 +.9382745520,,9747285559,,9951872199/
 1615.000 DATA (QW(I),I=94,117)/,01234122979,,02853138862,,04427743881,
 1616.000 +-05929858491,,07334648141,,08619016153,,09761865210,,1074442701,
 1617.000 +-1155056680,,1216704729,,1258374563,,1279381953,,1279381953,
 1618.000 +-1258374563,,1216704729,,1155056680,,1074442701,,0976186521,
 1619.000 +-08619016153,,07334648141,,05929858491,,04427743881,
 1620.000 +-02853138862,,01234122979/
 1621.000 * 28 PTS.
 1622.000 DATA (QX(I),I=118,145)/-,9964424975,-,9813031653,-,9542592906,
 1623.000 +-,9156330263,-,8658925225,-,8056413709,-,7356108780,
 1624.000 +-,6566510940,-,5697204718,-,4758742249,-,3762515160,
 1625.000 +-,2720616276,-,1645692821,-,05507928988,,05507928988,
 1626.000 +-1645692821,,2720616276,,3762515160,,4758742249,,5697204718,
 1627.000 +-6566510940,,7356108780,,8056413709,,8658925225,,9156330263,
 1628.000 +-,9542592806,,9813031653,,9964424975/
 1629.000 DATA (QW(I),I=118,145)/,009124282593,,02113211259,,03290142778,
 1630.000 +-04427293475,,05510734567,,06527292396,,07464621423,
 1631.000 +-08311341722,,09057174439,,09693065799,,1021129675,,1060557659,
 1632.000 +-1087111922,,1100470130,,1100470130,,1087111922,,1060557659,
 1633.000 +-1021129675,,09693065799,,09057174439,,08311341722,,07464621423,
 1634.000 +-06527292396,,05510734567,,04427293475,,03290142778,
 1635.000 +-02113211259,,009124282593/
 1636.000 * 34 PTS.
 1637.000 DATA (QX(I),I=146,179)/-,9975717537,-,9872278164,-,9687082625,
 1638.000 +-,9421623974,-,9078096777,-,8659346383,-,8168842279,
 1639.000 +-,7610648766,-,6989391132,-,6310217270,-,5578755006,
 1640.000 +-,4801065451,-,3983592777,-,3133110813,-,2256666916,
 1641.000 +-,1361523572,-,04550982195,,04550982195,,1361523572,
 1642.000 +-2256666916,,3133110813,,3983592777,,4801065451,,5578755006,

1643.000 +.6310217270,.6989391132,.7610648766,.8168842279,.8659346383,
1644.000 +.9078096777,.9421623974,.9687082625,.9872278164,.9975717537/
1645.000 DATA (QW(I),I=146,179)/,.006229140555,.01445016274,.02256372198,
1646.000 +.03049138063,.03816659379,.04552561152,.05250741457,.05905413582,
1647.000 +.06511152155,.07062937581,.07556198466,.07986844433,.08351309969,
1648.000 +.08646573974,.08870189783,.09020304437,.09095674033,.09095674033,
1649.000 +.09020304437,.08870189783,.08646573974,.08351309969,.07986844433,
1650.000 +.07556197466,.07062937581,.06511152155,.05905413582,.05250741457,
1651.000 +.04552561152,.03816659379,.03049138063,.02256372198,.01445016274,
1652.000 +.006229140555/
1653.000 * 40 PTS.
1654.000 DATA (QX(I),I=180,219)/-.9982377097,-.9907262386,-.9772599499,
1655.000 +-9579168192,-.9328128082,-.9020988069,-.8659595032,-.8246122308,
1656.000 +-7783056514,-.7273182551,-.6719566846,-.6125538896,-.549467125,
1657.000 +-4830758016,-.4137792043,-.3419940908,-.268152185,-.1926975807,
1658.000 +-1160840706,-.0387724175,.0387724175,.1160840706,.1926975807,
1659.000 +.268152185,.3419940908,.4137792043,.4830758016,.549467125,
1660.000 +.6125538896,.6719566846,.7273182551,.7783056514,.8246122308,
1661.000 +.8659595032,.9020988069,.9328128082,.9579168192,.9772599499,
1662.000 +.9907262386,.9982377097/
1663.000 DATA (QW(I),I=180,219)/.00452127709,.0104982845,.0164210583,
1664.000 +.0222458491,.0279370069,.0334601952,.0387821679,.0438709081,
1665.000 +.0486958076,.0532278469,.0574397690,.0613062424,.0648040134,
1666.000 +.0679120458,.0706116473,.0728865823,.0747231690,.0761103619,
1667.000 +.0770398181,.0775059479,.0775059479,.0770398181,.0761103619,
1668.000 +.0747231690,.0728865823,.0706116473,.0679120458,.0648040134,
1669.000 +.0613062424,.0574397690,.0532278469,.0486958076,.0438709081,
1670.000 +.0387821679,.0334601952,.0279370069,.0222458491,.0164210583,
1671.000 +.0104982845,.00452127709/
1672.000 END

A.3 INPUT DATA FILE REFC_DAT

DBS BEAM CANADA 504 (POTTER HORNS)

12,450

24

1

,100 0,0

,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62 ,62

,62 ,62 ,62 ,62 ,62 ,62

,36 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35 ,35

,35 ,35 ,35 ,35 ,35 ,35

5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0 5.0

5.0 5.0 5.0 5.0 5.0 5.0

0

0

2.16 ,96 ,0 2.16 -,28 ,0 2.16 -1.52 ,0 2.16 -2.76 ,0

1.08 1.58 ,0 1.08 ,34 ,0 1.08 -,90 ,0 1.08 -2.14 ,0 1.08 -3.38 ,0

,0 2.2 ,0 ,0 ,96 ,0 ,0 -,28 ,0 ,0 -1.52 ,0 ,0 -2.76 ,0

-1.08 2.82 ,0 -1.08 1.58 ,0 -1.08 ,34 ,0 -1.08 -,90 ,0 -1.08 -2.14 ,0

-2.16 3.44 ,0 -2.16 2.20 ,0 -2.16 ,96 ,0 -2.16 -,28 ,0

-,54 -4.30 ,0

0.0 -26.6 0,0

3

1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0 1.0

1.0 1.0 1.0 1.0 1.0 1.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0 0.0

0.0 0.0 0.0 0.0 0.0 0.0 0.0

,0388 -11.8 ,0512 0.0 ,0699 20.9 ,0145 -22.0 ,0442 -9.0 ,0537 2.9

,0546 20.2 ,0611 -17.3 ,0610 -21.6 ,0446 -9.0 ,0491 11.2 ,0508 37.5

,0568 -9.0 ,0245 -22.0 ,0423 0.4 ,0467 -11.3 ,0456 9.6 ,0452 -7.3

,0072 7.9 ,0397 5.9 ,0384 -5.3 ,0489 -5.3 ,0109 1.5 ,0006 47.6

124.0 106.0 106.0 60.0 0.0

0

0

1

-1.50 4.0

-1.25 +1.25

1.25

0.0

!

A.4 OUTPUT FILE REF C DUM

DBS BEAM CANADA 504 (POTTER HORNS)

FREQUENCY IN GHZ

12.4500

NO OF FEED HORNS

24

HORN TYPE - 0=PYRAMIDAL , 1=CONICAL

1

AMPL. AND PHASE (RAD) OF HIGHER ORDER MODE

.1000 .0000

APERTURE RADIUS OF HORN APERTURE IN INS.

.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200
.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200	.6200

RADIUS OF INPUT WAVEGUIDE IN INS.

.3600	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500
.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500	.3500

HORN LENGTH IN INS

5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000
5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000	5.0000

HORN APERTURE FIELD MODEL - 0=E-FIELD , 1=CHU

0

OPT. CHOSEN - COLLECTIVE MOVEMENT AND ROTATION OF HORN ARRAY

0

DISPLACEMENTS OF FEEDS IN INS.

2.1600	.9600	.0000	2.1600	-.2800	.0000	2.1600	-1.5200	.0000	2.1600	-2.7600	.0000	.0000
1.0800	1.5800	.0000	1.0800	.3400	.0000	1.0800	-.9000	.0000	1.0800	-2.1400	.0000	.0000
1.0800	-3.3800	.0000	.0000	2.2000	.0000	.0000	.9600	.0000	.0000	-.2800	.0000	.0000
.0000	-1.5200	.0000	.0000	-2.7600	.0000	-1.0800	2.8200	.0000	-1.0800	1.5800	.0000	.0000
-1.0800	.3400	.0000	-1.0800	-.9000	.0000	-1.0800	-2.1400	.0000	-2.1600	3.4400	.0000	.0000
-2.1600	2.2000	.0000	-2.1600	.9600	.0000	-2.1600	-.2800	.0000	-.5400	-4.3000	.0000	.0000

ROT. OF FEEDS ABOUT X-,Y-,AND Z-AXIS IN DEG.

.0000 -26.6000 .0000

POLAR. OF SECON. BEAM - VP=1,HP=2,RHCP=3,LHCP=4

3

AMPL IMBALANCE OF Y-PORT REL. TO X-PORT

1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

PHASE DEPARTURE OF Y-PORT FROM QUADRATURE IN DEG.

.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000
.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000

POWER(W) AND PHASE(DEG) OF FEED EXCITATIONS

.0388	-11.8000	.0512	.0000	.0699	20.9000	.0145	-22.0000	.0442	-9.0000	.0537	2.9000	.0000
.0546	20.2000	.0611	-17.3000	.0610	-21.6000	.0446	-9.0000	.0491	11.2000	.0508	37.5000	.0000
.0568	-9.0000	.0245	-22.0000	.0423	.4000	.0467	-11.3000	.0456	8.6000	.0452	-7.3000	.0000
.0072	7.9000	.0397	5.9000	.0384	-5.3000	.0489	-5.3000	.0109	1.5000	.0006	47.6000	.0000

FOC LTH., APER, X-DIM,Y-DIM AND X-, Y-OFFSET IN INS.

124.0000 106.0000 106.0000 60.0000 .0000

AZ START,STOP AND EL START,STOP ANGLES (DEG) OF SAMPLING WINDOW.

-1.5000 4.0000 -1.2500 1.2500

APERTURE OR SAMPLING RATE ENLARGEMENT FACTOR.

1.2500

ROTATION OF FIELD POLARISATION VECTOR IN DEGREES

1000

NO. OF INTEG. PTS. SELECTED FOR RADIAL AND PHT-VAR.

20 20

SPILL-OVER EFFICIENCY = .713

CO-POLAR GAIN (DB) OF SAMPLING POINTS.

RKA = 451,7521 RKB = 439,0844

X-POLAR GAIN (DB) OF SAMPLING POINTS.

RKA = 451,7521 RKB = 439,0844

U/PI = -5.0

-6.0 -49.65 -5.0 -39.84 -4.0 -43.35 -3.0 -32.95 -2.0 -30.71 -1.0 -29.93 .0 -32.12 1.0 -33.91
 2.0 -35.89 3.0 -40.66 4.0 -42.67 5.0 -43.90 6.0 -38.04 7.0 -41.09 8.0 -40.01 9.0 -44.71
 10.0 -45.19 11.0 -42.73 12.0 -47.39

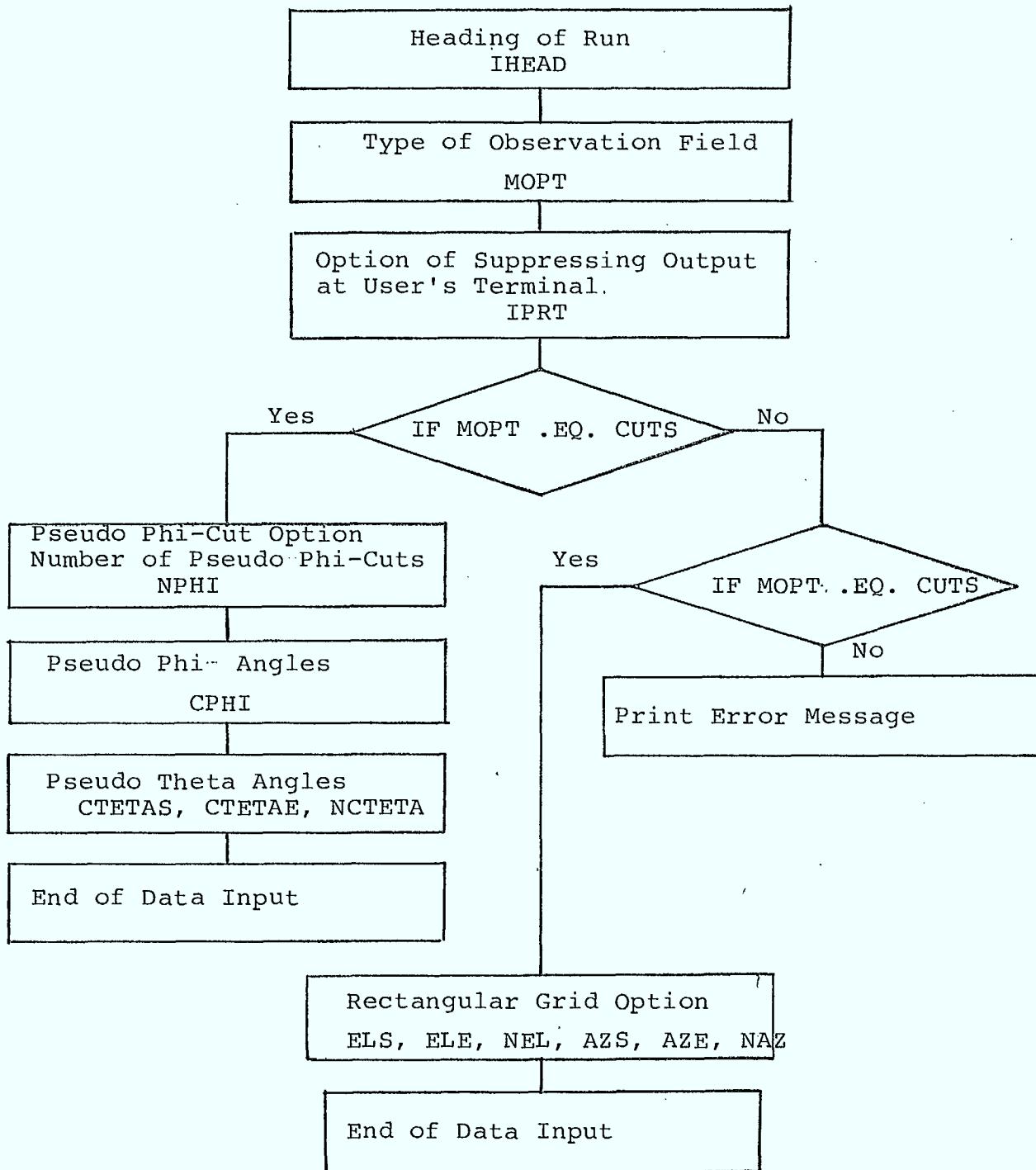
A.5 OUTPUT FILE SAME DAT

-,007132	-,012724	-,002861	,005475	,006719	,002444	-,006109	-,003759	,003345	,000497
-,000181	,002499	-,003021	-,003426	,004569	-,024162	,007310	,007756	,004153	,021036
,010041	-,048046	,000112	-,007226	-,009113	,047844	-,054817	-,003625	-,084793	-,056459
-,001667	-,070332	,016076	-,018877	-,038250	,041925	-,009476	,026811	,006521	-,005357
-,005043	-,004734	,003621	,005300	-,002990	-,001012	,001638	-,002210	,000874	,004246
-,002773	-,003285	-,003002	-,009721	-,003594	,023435	-,006780	-,021184	-,019720	-,054560
-,017521	,046412	-,001792	,057409	-,021496	-,035503	-,034906	-,014389	,011843	,029998
,001760	-,002177	-,055581	-,020183	-,030978	,001821	,002716	,006555	,000375	-,005074
,000999	,001823	-,001793	,000740	,001531	-,003302	,000041	,003420	-,002029	-,002719
-,005364	,022187	,008406	-,000991	-,001940	-,037361	-,007926	,004561	,044355	,034310
,053766	-,019458	,012130	-,030543	,000165	,041738	,007269	,053160	,012090	-,012983
,001543	-,045943	-,011718	-,018671	-,003947	,004888	,002404	-,001095	-,001269	,000135
-,000666	,000912	,001137	-,001528	-,000934	,002531	-,000105	-,001869	,004558	,013333
,007928	-,047230	-,012969	-,016633	-,020814	,053955	,009682	,003162	-,042569	-,019349
-,073412	,044635	,003944	,039905	,032311	-,024349	,016864	-,039499	,008625	-,019864
-,006686	-,007243	,000809	,001427	,002361	,000403	-,003722	-,000992	,002945	,000420
-,000488	-,000334	-,001196	,000440	,001840	-,000946	-,008434	-,003126	-,040063	-,028093
-,032649	,023035	-,023049	,025315	-,025277	-,045451	-,058217	-,015886	-,041296	,033069
,027097	,002741	,025271	-,026551	-,001648	-,018477	-,005795	-,003654	-,002273	,001599
,008277	,002757	-,003021	-,000691	-,003210	-,002044	,005712	,001736	-,004556	,000034
,000777	-,000965	,002270	,000881	-,005349	,003579	-,034663	,028829	,013510	,057551
,038838	,014284	,023996	-,015641	,044979	,001221	,061056	-,027167	,022796	-,031204
-,009925	,000129	,006594	-,000880	,009081	,001828	,000797	,007336	,001499	-,000384
-,005937	-,003314	,003121	,000125	,003239	,002636	-,006407	-,001754	,005006	-,000797
-,000531	,002186	,012561	-,002293	,003670	,010965	,029898	,016357	,033990	,000306
,008222	,016383	,020963	,018673	,021827	-,014796	-,007671	-,006354	-,000735	,002224
,013402	-,004144	-,006272	,007639	-,009005	-,001749	,001557	-,009763	,000538	,002509
,003769	,002476	-,003328	-,000497	-,002186	-,002069	,006103	,001225	-,005059	,001472
,003535	-,001857	,002656	-,011230	-,006606	-,015956	-,003672	-,012546	,001089	-,007619
-,005602	-,010079	-,016776	,003648	-,004107	,015918	,009761	-,002158	-,007934	-,000614
-,012970	,002593	,008520	-,012223	,007624	,003464	-,003184	,009508	-,001427	-,005272
-,001926	-,001308	,003295	,001268	,000943	,000934	-,005234	-,000519		

APPENDIX B

PROGRAM RECON_SIF

Figure B.1 Flow Chart for Creating Input Data File RECON_DAT



B.2 PROGRAM LISTING

```
1.000      PROGRAM RECON
2.000 *
3.000 * THIS PROGRAM RECONSTRUCTS THE RADIATION PATTERN FROM SAMPLED FIELD
4.000 * POINTS TAKEN IN PRESCRIBED DIRECTIONS. A DOUBLE SERIES OF SINC
5.000 * FUNCTIONS IN U - V SPACE IS USED. THE PROGRAM READS IN THE GAIN
6.000 * MATRIX OF SAMPLE POINTS AND THEN RECONSTRUCTS THE RADIATED FIELD
7.000 * EITHER ON A RECTANGULAR EL-AZ GRID OR ALONG PSEUDO-PHI CUTS. THE
8.000 * PATTERN NEEDS TO BE COMPUTED AT ONLY A SMALL NUMBER OF SAMPLE POINTS,
9.000 * IT CAN THEN BE EXPANDED OVER A MUCH LARGER GRID WITH THIS FAST,
10.000 * ACCURATE AND YET SIMPLE ALGORITHM. A SAVING IN COMPUTATIONAL EFFORT
11.000 * IS THUS ACHIEVED.
12.000 * DATA INPUT ARE FROM TWO DATA FILES , SAME_DAT AND RECON_DAT
13.000 * THE DATA FOR FILE SAME_DAT MAY BE GENERATED USING COMPANION
14.000 * REFLECTOR PROGRAMS.
15.000 * OUTPUT DATA ARE DIRECTED TO THE USER'S TERMINAL (OPTIONAL) AND
16.000 * EITHER TO FILE CGNMAT AND XGNMAT OR CGNSEC AND XGNSEC.
17.000 *
18.000 * WRITTEN BY CHAN TECHNOLOGIES INC.
19.000 * REVISION 0      MARCH 1986
20.000 *
21.000      DIMENSION EL(61),AZ(61),CPHI(3),CTHETA(101),CGNCUT(101,3),
22.000      + XGNCUT(101,3),CGNGRD(61,61),XGNGRD(61,61)
23.000      INTEGER GRID,CUTS,IHEAD(18)
24.000      COMPLEX CPEF(34,34),XPEF(34,34)
25.000      EQUIVALENCE (CGNCUT,CGNGRD) , (XGNCUT,XGNGRD)
26.000 *
27.000 * RESTRICTIONS ON INPUT PARAMETERS DUE TO DIMENSIONS OF ARRAYS.
28.000 * MAXEL = MAXIMUM NUMBER OF ELEVATION GRID POINTS.
29.000 * MAXAZ = MAXIMUM NUMBER OF AZIMUTH GRID POINTS.
30.000 * MAXPHI = MAXIMUM NUMBER OF PSEUDO-PHI CUTS.
31.000 * MAXTET = MAXIMUM NUMBER OF PSEUDO-THETA PTS. FOR EA. PHI-CUT.
32.000 * MAXU = MAXIMUM NUMBER OF SAMPLED FIELD POINTS IN U SPACE.
33.000 * MAXV = MAXIMUM NUMBER OF SAMPLED FIELD POINTS IN V SPACE.
34.000 * DIMENSIONS OF ARRAYS - CGNGRD(MAXEL,MAXAZ) , EL(MAXEL) , AZ(MAXAZ)
35.000 * CPHI(MAXPHI) , CTHETA(MAXTET) , CGNCUT(MAXTET,MAXPHI) , CPEF(MAXV,MAXU)
36.000 * XGNGRD(MAXEL,MAXAZ) , XGNCUT(MAXTET,MAXPHI) , XPEF(MAXV,MAXU)
37.000 *
38.000      DATA MAXEL,MAXAZ,MAXPHI,MAXTET,MAXU,MAXV/61,61,3,101,34,34/
39.000      DATA GRID,CUTS/4HGRID,4HCUTS/
40.000 *
41.000 * READ IN SAMPLED FIELD DATA FROM FILE SAME_DAT
42.000 *
43.000      OPEN(UNIT=4,FILE='SAME_DAT',STATUS='OLD')
44.000 *
45.000 * RKA = WAVENUMBER * PROJECTED APERTURE X-RADIUS * ENLARGEMENT FACTOR
46.000 *           / COS(APERTURE INCLINATION ANGLE W.R.T. X-AXIS)
47.000 * RKB = WAVENUMBER * PROJECTED APERTURE Y-RADIUS * ENLARGEMENT FACTOR
48.000 *           / COS(APERTURE INCLINATION ANGLE W.R.T. Y-AXIS)
49.000 * NL = LOWER LIMIT OF N - SUMMATION,
50.000 * NU = UPPER LIMIT OF N - SUMMATION,
```

```
51.000 * NS = NUMBER OF N-SUMMATION TERMS.  
52.000 * ML = LOWER LIMIT OF M - SUMMATION.  
53.000 * MU = UPPER LIMIT OF M - SUMMATION.  
54.000 * MS = NUMBER OF M - SUMMATION TERMS.  
55.000 * CPEF(M,N) = ARRAY OF SAMPLED NORMALISED FIELD STRENGTH IN U - V SPACE,  
56.000 * SQUARED OF THE ABSOLUTE VALUE OF FIELD GIVES THE GAIN  
57.000 * AT THAT POINT W.R.T. ISOTROPIC.  
58.000 * XPEF(M,N) = ARRAY OF NORMALISED X-POLAR FIELD STRENGTH WHOSE MAGNITUDE  
59.000 * SQUARED GIVES THE GAIN W.R.T. ISOTROPIC.  
60.000 * M INDEX CORRESPONDS TO V-CO-ORDINATE  
61.000 * N INDEX CORRESPONDS TO U-CO-ORDINATE.  
62.000 *  
63.000 READ(4,*),RKA,RKB  
64.000 READ(4,*),NL,NU,NS,ML,MU,MS  
65.000 *  
66.000 NMS = NS * MS  
67.000 IF (NS.GT.MAXU) THEN  
68.000 PRINT 10, MAXU  
69.000 10 FORMAT(1X,'NO. OF SAMPLE POINTS IN U-SPACE ,GT. MAX. LIMIT OF',  
70.000 + I4)  
71.000 STOP  
72.000 ELSE IF (MS.GT.MAXV) THEN  
73.000 PRINT 20, MAXV  
74.000 20 FORMAT(1X,'NO. OF SAMPLE POINTS IN V-SPACE ,GT. MAX. LIMIT OF',  
75.000 + I4)  
76.000 STOP  
77.000 END IF  
78.000 *  
79.000 READ(4,25)((CPEF(M,N),N=1,MS),N=1,NS)  
80.000 READ(4,25)((XPEF(M,N),M=1,MS),N=1,NS)  
81.000 25 FORMAT(10F12.6)  
82.000 *  
83.000 * READ IN OBSERVATION FIELD DATA FROM FILE RECON.DAT  
84.000 *  
85.000 OPEN (UNIT=5,FILE='RECON.DAT',STATUS='OLD')  
86.000 *  
87.000 * IHEAD = HEADING DESCRIBING RUN.  
88.000 *  
89.000 READ(5,30)(IHEAD(I),I=1,18)  
90.000 30 FORMAT(18A4)  
91.000 *  
92.000 * MOPT = TYPE OF OBSERVATION FIELD  
93.000 * = GRID , GENERATES A RECTANGULAR EL-AZ OBSERVATION GRID.  
94.000 * = CUTS , GENERATES PSEUDO-PHI CUTS (CUTS IN THE EL-AZ GRID).  
95.000 *  
96.000 READ(5,40) MOPT  
97.000 40 FORMAT(A4)  
98.000 *  
99.000 * IPRT = OPTION FOR SUPPRESSING PRINTING OF RESULTS AT USER'S TERMINAL.  
100.000 * = 0 , NO OUTPUT TO TERMINAL.  
101.000 * = 1 , OUTPUT DIRECTED ALSO TO TERMINAL.  
102.000 * IN ANY EVENT RECONSTRUCTED FIELDS ARE ALWAYS WRITTEN TO OUTPUT FILE  
103.000 * GNMAT OR GNSEC.
```

```
104.000 *
105.000      READ(5,*) IPRT
106.000 *
107.000      IF (MOFT .EQ. CUTS) GO TO 70
108.000      IF (MOFT .EQ. GRID) GO TO 45
109.000      PRINT 42
110.000 42    FORMAT(1X,'ERROR IN SPECIFYING OBSERVATION FIELD TYPE.')
111.000      STOP
112.000 *
113.000 * RECTANGULAR GRID OPTION CHOSEN.
114.000 * ELS = ELEV. CUT START ANGLE (DEG).
115.000 * ELE = ELEV. CUT STOP ANGLE (DEG).
116.000 * NEL = NO. OF POINTS IN EACH ELEV. CUT.
117.000 * AZS = AZIM. CUT START ANGLE (DEG).
118.000 * AZE = AZIM. CUT STOP ANGLE (DEG).
119.000 * NAZ = NO. OF POINTS IN EACH AZIM. CUT.
120.000 *
121.000 45    READ(5,*) AZS,AZE,NAZ
122.000      READ(5,*) ELS,ELE,NEL
123.000 *
124.000      IF (NEL.GT.MAXEL) THEN
125.000      PRINT 50 , MAXEL
126.000 50    FORMAT(1X,'NO. OF ELEV. PTS. ,GT. MAX. LIMIT OF',I4)
127.000      STOP
128.000      ELSE IF (NAZ .GT. MAXAZ) THEN
129.000      PRINT 60 , MAXAZ
130.000 60    FORMAT(1X,'NO. OF AZ. PTS ,GT. MAX. LIMIT OF',I4)
131.000      END IF
132.000      GO TO 300
133.000 *
134.000 * PHI-CUT OPTION CHOSEN.
135.000 * NPHI = NUMBER OF PSEUDO PHI-CUTS.
136.000 * CPHI = PSEUDO-PHI CUT ANGLE (DEG).
137.000 *          CPHI IS MEASURED FROM THE EL -AXIS ON THE TWO-DIMENSIONAL
138.000 *          EL-AZ PLOT. IT IS APPROXIMATELY EQUAL TO THE PHI-ANGLE OF THE
139.000 *          SPHERICAL CO-ORDINATE SYSTEM OF THE ANTENNA FOR CPHI SMALL.
140.000 * CTETAS = PSEUDO-THETA SCAN START ANGLE (DEG)
141.000 * CTETAE = PSEUDO-THETA SCAN STOP ANGLE (DEG).
142.000 *          CTETA IS THE LENGTH OF THE RADIAL VECTOR IN THE PLANE OF
143.000 *          THE EL-AZ PLOT. IT IS APPROXIMATELY EQUAL TO THE THETA
144.000 *          ANGLE OF THE SPHERICAL CO-ORDINATE SYSTEM FOR CTETA SMALL.
145.000 * NCTETA = NUMBER OF PSEUDO-THETA SCAN POINTS.
146.000 *
147.000 70    READ(5,*) NPHI
148.000 *
149.000      IF (NPHI.GT.MAXPHI) THEN
150.000      PRINT 80 , MAXPHI
151.000 80    FORMAT(1X,'NO. OF PSEUDO PHI-CUTS ,GT. MAX. LIMIT OF',I4)
152.000      STOP
153.000      END IF
154.000 *
155.000      READ(5,*) (CPHI(I),I=1,NPHI)
156.000      READ(5,*) CTETAS,CTETAE,NCTETA
```

```
157.000 *
158.000      IF (NCTETA.GT.MAXTET) THEN
159.000      PRINT 90 , MAXTET
160.000 90    FORMAT(1X,'NO. OF PSEUDO-THETA SCAN PTS. ,GT. MAX. LIMIT OF',I4)
161.000      STOP
162.000      END IF
163.000 *
164.000 * PSEUDO-PHI CUT OPTION
165.000 *
166.000      CTINC = CTETAE - CTETAS
167.000      IF (NCTETA .GT. 2) CTINC = CTINC/(NCTETA -1)
168.000      DO 100 J = 1,NCTETA
169.000      CTHETA(J) = CTETAS + (J-1)*CTINC
170.000 100    CONTINUE
171.000 *
172.000 * LOOP THROUGH ALL PSEUDO PHI-CUTS.
173.000 *
174.000      DO 120 I = 1,NPHI
175.000      FI = CPHI(I)/57.29578
176.000 *
177.000 * LOOP THROUGH ALL PSEUDO-THETA PTS.
178.000      DO 110 J = 1,NCTETA
179.000      TETA = CTHETA(J)/57.29578
180.000 *
181.000 * CONVERT PSEUDO-THETA AND -PHI COORD. TO EL AND AZ CO-ORD.
182.000 *
183.000      ELA = TETA*COS(FI)
184.000      AZA = TETA*SIN(FI)
185.000 *
186.000 * CONVERT EL-AZ COORD. TO U - V COORD.
187.000 *
188.000      U = SIN(ELA)*RKA
189.000      IU = U/3.1415926
190.000      V = COS(ELA)*SIN(AZA)*RKB
191.000      IV = V/3.1415926
192.000 *
193.000 * CHECK IF FIELD POINT IS WITHIN SAMPLED FIELD WINDOW.
194.000 *
195.000      IF (IU.LT.(NL+1) ,OR, IU.GT.(NU-1)) GO TO 420
196.000      IF (IV.LT.(ML+1) ,OR, IV.GT.(MU-1)) GO TO 440
197.000 *
198.000 * RECONSTRUCT E-FIELD AT (THETA,PHI)
199.000 *
200.000      CALL SERIES(U,V,NL,NS,ML,MS,CPEF,XPEF,MAXU,MAXV,EC,EX)
201.000      CGNCUT(J,I) = 20.0*ALOG10(EC)
202.000      XGNCUT(J,I) = 20.0*ALOG10(EX)
203.000 110    CONTINUE
204.000 120    CONTINUE
205.000 *
206.000      IF (IPRT.EQ.0) GO TO 250
207.000      PRINT 30 , (IHEAD(I),I=1,18)
208.000      PRINT 140 , RKA
209.000 140    FORMAT(1X,'RKA = ',F10.4)
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210.000 PRINT 150 , RKB
211.000 150 FORMAT(1X,'RKB = ',F10.4)
212.000 PRINT 160 , NS
213.000 160 FORMAT(1X,'NO. OF SAMPLE PTS. IN U-SPACE = ',I3)
214.000 PRINT 170 , MS
215.000 170 FORMAT(1X,'NO. OF SAMPLE PTS. IN V-SPACE = ',I3)
216.000 PRINT 175 , NMS
217.000 175 FORMAT(1X,'TOTAL NO. OF SAMPLES IN U-V SPACE = ',I4)
218.000 PRINT 180
219.000 180 FORMAT(//,40X,'RECONSTRUCTED CO-POLAR GAIN PATTERN')
220.000 PRINT 190
221.000 190 FORMAT(40X,35(1H-))
222.000 DO 240 I = 1,NPHI
223.000 PRINT 200, CPHI(I)
224.000 200 FORMAT(//,50X,'PHI (DEG) = ',FB.2)
225.000 PRINT 210
226.000 210 FORMAT(6(1X,'THETA (D)',1X,'GAIN (DB)'))
227.000 PRINT 220
228.000 220 FORMAT(6(1X,9H-----,1X,9H-----))
229.000 PRINT 230 , (CTHETA(J),CGNCUT(J,I),J=1,NCTETA)
230.000 230 FORMAT(6(2X,F7.3,3X,F7.2,1X))
231.000 240 CONTINUE
232.000 PRINT 242
233.000 242 FORMAT(//,40X,'RECONSTRUCTED X-POLAR GAIN PATTERN')
234.000 PRINT 190
235.000 DO 245 I = 1,NPHI
236.000 PRINT 200, CPHI(I)
237.000 PRINT 210
238.000 PRINT 220
239.000 PRINT 230 , (CTHETA(J),XGNSEC(J,I),J=1,NCTETA)
240.000 245 CONTINUE
241.000 *
242.000 * OUTPUT RESULTS TO DATA FILE GNSEC
243.000 *
244.000 250 OPEN(UNIT=6,FILE='CGNSEC',STATUS='OLD',USAGE='OUTPUT')
245.000 WRITE(6,30) (IHEAD(I),I=1,18)
246.000 DO 290 I = 1,NPHI
247.000 WRITE(6,260) CPHI(I)
248.000 260 FORMAT(FB.3)
249.000 WRITE(6,270) CTETAS,CTETAE,NCTETA
250.000 270 FORMAT(2(2F10.5,I5))
251.000 WRITE(6,280) (CTHETA(J),CGNCUT(J,I),J=1,NCTETA)
252.000 280 FORMAT(10FB.2)
253.000 290 CONTINUE
254.000 OPEN (UNIT=7,FILE='XGNSEC',STATUS='OLD',USAGE='OUTPUT')
255.000 WRITE(7,30) (IHEAD(I),I=1,18)
256.000 DO 295 I = 1,NPHI
257.000 WRITE(7,260) CPHI(I)
258.000 WRITE(7,270) CTETAS,CTETAE,NCTETA
259.000 WRITE(7,280) (CTHETA(J),XGNSEC(J,I),J=1,NCTETA)
260.000 295 CONTINUE
261.000 STOP
262.000 *
```

```
263.000 * RECTANGULAR EL - AZ GRID OPTION
264.000 *
265.000 300  ELIN = ELE - ELS
266.000  IF (NEL.GT.2) ELIN = ELIN/(NEL -1)
267.000  AZIN = AZE - AZS
268.000  IF (NAZ.GT.2) AZIN = AZIN/(NAZ -1)
269.000  DO 310 I = 1,NEL
270.000  EL(I) = ELE - ELIN*(I-1)
271.000 310  CONTINUE
272.000  DO 320 I = 1,NAZ
273.000  AZ(I) = AZS + AZIN*(I-1)
274.000 320  CONTINUE
275.000  DO 340 I = 1,NEL
276.000  U = SIN(EL(I)/57.29578)*RKA
277.000  IU = U/3.1415926
278.000  IF (IU.LT.(NL+1) ,OR, IU.GT.(NU-1)) GO TO 420
279.000  DO 330 J = 1,NAZ
280.000  V = COS(EL(I)/57.29578)*SIN(AZ(J)/57.29578)*RKB
281.000  IV = V/3.1415926
282.000  IF (IV.LT.(ML+1) ,OR, IV.GT.(MU-1)) GO TO 440
283.000  CALL SERIES(U,V,NL,NS,ML,MS,CPEF,XPEF,MAXU,MAXV,EC,EX)
284.000  CGNGRD(I,J) = 20.0*ALOG10(EC)
285.000  XGNGRD(I,J) = 20.0*ALOG10(EX)
286.000 330  CONTINUE
287.000 340  CONTINUE
288.000 *
289.000  IF (IPRT.EQ.0) GO TO 400
290.000  PRINT 30 , (IHEAD(I),I=1,18)
291.000  PRINT 140 , RKA
292.000  PRINT 150 , RKB
293.000  PRINT 160 , NS
294.000  PRINT 170 , MS
295.000  PRINT 175 , NMS
296.000  PRINT 180
297.000  PRINT 190
298.000  DO 390 I = 1,NEL
299.000  PRINT 350 , EL(I)
300.000 350  FORMAT(//,50X,'EL (DEG) = ',F8.3)
301.000  PRINT 360
302.000 360  FORMAT(8(1X,'AZ(DEG)',1X,'GN (BB)' ))
303.000  PRINT 370
304.000 370  FORMAT(8(1X,7H-----,1X,7H-----))
305.000  PRINT 380 , (AZ(J),CGNGRD(I,J),J=1,NAZ)
306.000 380  FORMAT(8(1X,F7.3,1X,F7.2))
307.000 390  CONTINUE
308.000  PRINT 242
309.000  PRINT 190
310.000  DO 405 I = 1,NEL
311.000  PRINT 350 , EL(I)
312.000  PRINT 360
313.000  PRINT 370
314.000  PRINT 380 , (AZ(J),XGNGRD(I,J),J=1,NAZ)
315.000 405  CONTINUE
```

```
316.000 *
317.000 * WRITE RESULTS INTO FILE GNMAT
318.000 *
319.000 400 OPEN(UNIT=6,FILE='CGNMAT',STATUS='OLD',USAGE='OUTPUT')
320.000 WRITE(6,30) (IHEAD(I),I=1,18)
321.000 WRITE(6,270) AZS,AZE,NAZ,ELS,ELE,NEL
322.000 DO 410 I = 1,NEL
323.000 410 WRITE(6,280) (CGNGrid(I,J),J=1,NAZ)
324.000 OPEN (UNIT=7,FILE='XGNMAT',STATUS='OLD',USAGE='OUTPUT')
325.000 WRITE(7,30) (IHEAD(I),I=1,18)
326.000 WRITE(7,270) AZS,AZE,NAZ,ELS,ELE,NEL
327.000 DO 415 I = 1,NEL
328.000 415 WRITE(7,280) (XGNGrid(I,J),J=1,NAZ)
329.000 STOP
330.000 *
331.000 * DIAGNOSTICS
332.000 *
333.000 420 PRINT 430 , IU,NL,NU
334.000 430 FORMAT(1X,'SAMPLE POINT (U/PI) = ',I3,' IS OUT OF RANGE DEFINED'
335.000 +' BY NL = ',I3,' AND NU = ',I3)
336.000 STOP
337.000 440 PRINT 450 , IV,ML,MU
338.000 450 FORMAT(1X,'SAMPLE POINT (V/PI) = ',I3,' IS OUT OF RANGE DEFINED'
339.000 +' BY ML = ',I3,' AND MU = ',I3)
340.000 STOP
341.000 END
342.000 SUBROUTINE SERIES(U,V,NL,NS,ML,MS,CREF,XPEF,MAXU,MAXV,EC,EX)
343.000 *
344.000 * PERFORMS SUMMATION OF DOUBLE SERIES TO RECONSTRUCT FIELD
345.000 *
346.000 COMPLEX CREF(MAXV,MAXU) , XPEF(MAXV,MAXU) , SUM1 , SUM2
347.000 *
348.000 SUM1 = (0.0,0.0)
349.000 SUM2 = (0.0,0.0)
350.000 DO 20 NP = 1,NS
351.000 N = NL + NP -1
352.000 X = U - N*3.1415926
353.000 IF (ABS(X).GT.1.0E-06) THEN
354.000 SINCX = SIN(X)/X
355.000 ELSE
356.000 SINCX = 1.0
357.000 END IF
358.000 DO 10 MP = 1,MS
359.000 M = ML + MP - 1
360.000 Y = V - M*3.1415926
361.000 IF (ABS(Y).GT.1.0E-06) THEN
362.000 SINCY = SIN(Y)/Y
363.000 ELSE
364.000 SINCY = 1.0
365.000 END IF
366.000 SUM1 = SUM1 + CREF(MP,NP)*SINCX*SINCY
367.000 SUM2 = SUM2 + XPEF(MP,NP)*SINCX*SINCY
368.000 10 CONTINUE
```

369,000 20 CONTINUE
370,000 EC = CABS(SUM1)
371,000 EX = CABS(SUM2)
372,000 RETURN
373,000 END

B.3 DATA FILE RECON.DAT

RECONSTRUCTION OF DBS BEAM CANADA 504
CUTS

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