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Analysis of a Generalized Dual Reflector Antenna System Using Physical Optics

Roberto J. Acosta and Alan R. Lagin
*Lewis Research Center
Cleveland, Ohio*

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ANALYSIS OF A GENERALIZED DUAL REFLECTOR ANTENNA SYSTEM USING PHYSICAL OPTICS

Roberto J. Acosta and Alan R. Lagin
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

ABSTRACT

Reflector antennas are widely used in communication satellite systems because they provide high gain at low cost. Offset-fed single paraboloids and dual reflector offset Cassegrain and Gregorian antennas with multiple focal region feeds provide a simple, blockage-free means of forming multiple, shaped and isolated beams with low sidelobes. Such antennas are applicable to communications satellite frequency reuse systems and earth stations requiring access to several satellites. While the single offset paraboloid has been the most extensively used configuration for the satellite multiple-beam antenna, the trend toward large apertures requiring minimum scanned beam degradation over the field of view 18 degrees for full earth coverage from geostationary orbit may lead to impractically long focal length and large feed arrays. Dual reflector antennas offer packaging advantages and more degrees of design freedom to improve beam scanning and cross-polarization properties. The Cassegrain and Gregorian antennas are the most commonly used dual reflector antennas.

A computer program for calculating the secondary pattern and directivity of a generalized dual reflector antenna system has been developed and implemented at the NASA Lewis Research Center. The theoretical foundation for this program is based on the use of physical optics methodology for describing the induced currents on the sub-reflector and main reflector. The resulting induced currents on the main reflector are integrated to obtain the antenna far-zone electric fields. The computer program is verified with other physical optics programs and with measured antenna patterns. The comparison shows good agreement in far-field sidelobe reproduction and directivity.

INTRODUCTION

The accurate prediction of radiation characteristics for a microwave antenna is essential in designing antenna systems. Antenna radiation characteristics such as beamwidth, gain, aperture efficiency, side-lobe level, and cross polarization are used in analyzing and designing advanced antenna systems. The physical optics-current integration approach (ref. 1) described in this report is one of several methods that can be used for predicting antenna performance characteristics. The method assumes that the complex currents in both reflectors are known. These currents satisfy Maxwell's equations and are used to solve the complex-vector wave equation at any arbitrary observation location. The computation of the induced currents on the main and sub-

reflector are briefly described. A dual reflector configuration (figure 1.) is analyzed, and the results compared with other dual reflector computer programs. A description of the input parameters (user guide) and a copy of the program are included in Appendixes A,B and C.

PHYSICAL OPTICS-CURRENT INTEGRATION APPROACH

DESCRIPTION OF PROBLEM

The geometry of a dual-reflector with a feed at an arbitrary position is shown in Figure 2. Three coordinate systems are shown to define the main reflector, the sub-reflector, and the feed position (or array of feeds). The position and field vectors of these coordinate system can be interrelated by using the Eulerian angles (Figure 3) construction (ref. 2). For instance, the fields of the feed can be expressed in feed coordinates (xf,yf,zf) and then transformed into sub-reflector coordinates (xs,ys,zs) to determine the scattered field from the sub-reflector and then transformed again into main reflector coordinates (xm,ym,zm) to finally obtain the radiated field of the main reflector.

INCIDENT ELECTRIC FIELD ON SUB-REFLECTOR

The radiated electric field from the feed antenna has the asymptotic form given by equation (1):

$$E(\theta, \phi) = \frac{e^{-jkr}}{r} F(\theta, \phi) \quad (1)$$

where $F(\theta, \phi)$ is the element pattern, $k=2\pi/\lambda$ is the wavenumber, and r is the distance from the source (feed) to the sub-reflector point. The vector function in equation (1) can be approximated (ref. 3) by equation (2).

$$F(\theta, \phi) = \theta UE(\theta)(a e^{jp} \cos \phi + b \sin \phi) + \phi UH(\theta)(b \cos \phi + a e^{jp} \sin \phi) \quad (2)$$

where $UE(\theta)$ is the E-plane pattern, $UH(\theta)$ is the H-plane pattern, and $a, b,$ and p are polarization parameters. The various feed polarization parameters are described in the following table:

TABLE I : Polarization Parameters

	a	b	p
Linear x	1	0	0
Linear y	0	1	0
Right-hand circular	0.707	0.7007	+90
Left-hand circular	0.707	0.707	-90

Typically these elements patterns can be approximated by a cosine to a power function, that is,

$$UE(\theta) = \cos^{qe}(\theta) \quad (3a)$$

$$UH(\theta) = \cos^{qh}(\theta) \quad (3b)$$

If equations (3a) and (3b) are used to represent the element pattern, the power radiated (ref 3.) by this source is given by equation (4).

$$P_{rad} = \frac{(qe+qh+1)}{60(2qe+1)(2qh+1)} \quad (4)$$

SURFACE CURRENT APPROXIMATION

The foundations of physical optics (PO), rests on the assumption that the induced current on the reflector surface is given (for a perfect conductor) by

$$\begin{aligned} \mathbf{J} &= 2(\mathbf{n} \times \mathbf{H}^{inc}) && \text{illuminated region} \\ \mathbf{J} &= 0 && \text{otherwise} \end{aligned}$$

where \mathbf{n} is the unit normal to the surface and \mathbf{H} is the incident magnetic field. This incident field may emanate directly from the source or be scattered from the sub-reflector. Although the PO current is an approximation for the true current on the reflector surface, it nevertheless gives very accurate results for predicting far-field patterns of reflectors.

SCATTERED FIELDS FROM SUB-REFLECTOR

For a given point on the sub-reflector (x_s, y_s, z_s) and the feed located at (x_f, y_f, z_f) the incident fields on the sub-reflector are given

$$E = \frac{e^{-jkr}}{r} F(x_s, y_s, z_s) \quad (5a)$$

where $F(x_s, y_s, z_s)$ is the feed pattern, k the wavenumber and r the distance from the feed to sub-reflector point. The magnetic field incident on the sub-reflector is given by

$$H = (r \times E)/Z_0 \quad (5b)$$

The scattered fields from the sub-reflector are given by (ref.4)

$$H(x_m, y_m, z_m) = jk \iint (J \times r_1) \frac{e^{-jkr_1}}{4\pi r_1} ds \quad (6a)$$

$$E(x_m, y_m, z_m) = -jkZ_0 \iint (J - (J \cdot r_1)r_1) \frac{e^{-jkr_1}}{4\pi r_1} ds \quad (6b)$$

Where J is the induced current on the sub-reflector, r_1 is the distance from any point in the sub-reflector to the observation point (x_m, y_m, z_m) . r_1 is a unit vector in the direction from any point in the sub-reflector to any observation point on the main reflector (x_m, y_m, z_m) .

MAIN REFLECTOR FAR-FIELDS

The resulting induced currents produced by the sub-reflector scattering the main reflector are integrated to obtain the far-zone electric fields.

$$E(\theta, \phi) = -jkZ_0 e^{-jkr} \iint (\mathbf{J} - (\mathbf{J} \cdot \mathbf{R})\mathbf{R}) \frac{e^{jkr}}{4\pi R} ds \quad (7a)$$

$$\mathbf{H}(\theta, \phi) = (\mathbf{R} \times \mathbf{E})/Z_0 \quad (7b)$$

Where \mathbf{J} is the induced current in the main reflector, \mathbf{R} is a unit vector from any point in the main reflector to the far-field observation point. r is the distance from the origin of the main reflector coordinate system to any point in the main reflector.

This method of calculating secondary pattern is accurate in cases where the antenna diameter is of the order greater than 50 to 100 wavelength. If the antenna diameter is of the order less than 50 wavelength, the accuracy is reduced, specifically in the sidelobe region. The reflector configuration described in figure 1 was analyzed by using various methods and computer codes. The calculated E- and H- plane far-field antenna pattern and directivities are shown in figures 4a and 4b respectively. The directivity and the far-field pattern are in a very good agreement among computer programs. The computer program given in appendix C was used to analyze the configuration.

DIRECTIVITY

The far zone electric field is usually divided into two orthogonal polarizations. Following Ludwig's definition 3 (ref. 4) the following unitary polarization vectors are introduced

$$\mathbf{R} = \theta (a e^{jp} \cos \phi + b \sin \phi) + \phi (-a e^{jp} \sin \phi + b \cos \phi) \quad (8a)$$

$$\mathbf{C} = \theta (a e^{jp} \sin \phi - b \cos \phi) + \phi (a e^{jp} \cos \phi + b \sin \phi) \quad (8b)$$

if the secondary pattern can be expressed as

$$\mathbf{E} = \frac{e^{-jkr}}{r} (E_\theta(\theta, \phi) + E_\phi(\theta, \phi)) \quad (9)$$

The reference-polarization expression is

$$E_{\text{ref}} = E \cdot (R^*)^* \quad (10a)$$

and the cross-polarization expression is

$$C_{\text{cross}} = E \cdot (C^*)^* \quad (10b)$$

The directivity for the reference polarization is defined by

$$DR(\theta, \phi) = \frac{4\pi (E_{\text{ref}} \cdot E_{\text{ref}}^*) / Z_0}{P_{\text{rad}}} \quad (11a)$$

similarly the directivity for the cross polarization is defined by

$$DC(\theta, \phi) = \frac{4\pi (E_{\text{cross}} \cdot E_{\text{cross}}^*) / Z_0}{P_{\text{rad}}} \quad (12b)$$

CONCLUDING REMARKS

A computer program using physical optics-current integration method, has been developed for calculating the far-field antenna pattern of dual reflector antennas illuminated by a feed with arbitrary polarization. The program utilizes a 3th order polynomial spline or nth order polynomial interpolation algorithms for cases in which the reflectors are numerically specified. The results for the far-field sidelobes and directivity are in good agreement with those obtained by other well-known techniques.

The computer program based on physical optics-current integration techniques is one of the main system engineering tools used at NASA Lewis Research Center for analyzing advanced antenna systems.

APPENDIX A

IDEAL REFLECTOR CONFIGURATIONS

Offset dual-reflectors are carved-out of portions of surfaces of revolutions (paraboloids, ellipsoids, hyperboloids, etc.) resulting from the intersection with cylinders or cones. The cylinders have their axes parallel to the axes of the parent reflector surfaces and the cones have their tips at one of the foci of the reflectors. In this appendix the geometrical characteristic of offset conic sections are presented.

The following are the analytical equations describing parabolic, hyperbolic and elliptical surfaces of revolution all are shown in main reflector coordinate system.

A: Parabolic reflector : The geometry associated with a parabolic reflector is shown in figure A-1

Parameters : F focal length

$$\text{Equation : } z = \frac{x^2 + y^2}{4F}$$

B: Hyperbolic Sub-reflector : The geometry associated with a hyperbolic sub-reflector is shown in figure A-2.

Parameters : z_0 offset distance
a vertex distance

$$b = \sqrt{c^2 - a^2}$$

2c foci distance

$$\text{Equation : } z = z_0 + a \sqrt{1 + \frac{x^2 + y^2}{b^2}}$$

C: Elliptical sub-reflector : The geometry associated with an elliptical sub-reflector is shown in figure A-3.

Parameters : z_0 offset distance
 a vertex distance

$$b = \sqrt{a^2 - c^2}$$

$2c$ foci distance

Equation : $z = z_0 + a \sqrt{1 - \frac{x^2 + y^2}{b^2}}$

APPENDIX B

PROGRAM INPUT USER GUIDE

A computer program was designed to calculate the antenna performance characteristics. The method of analysis is physical optics. The program runs in an IBM370 using VM operating system. All the inputs are put into the program DRSG FORTRAN and are describe as follows:

FFREQ	frequency GHz
QQ	feed pattern exponent
DMX,DMY	x and y length in wavelength main reflector rectangle
DSX,DSY	x and y length in wavelength sub-reflector rectangle
MAXMX,MAXSY	number of points in the x and y direction
xm0,ym0,zm0	lower left corner of main reflector rectangle
xs0,ys0,zs0	lower left corner of sub-reflector rectangle
xf,yf,zf	feed location in wavelength
xr,yr,zr	feed boresight point on sub-reflector
rtemp1 (sub)	parameter a in wavelength
rtemp2	parameter $b=\sqrt{a^2-c^2}$
rtemp6	offset distance in wavelength
fradsq	radius square of cylinder sub-reflector
FCENX,FCENY	center of sub-reflector cylinder
radsq	radius of cylinder of main reflector
CNTRX,CNTRY	center of cylinder of main reflector
rtemp1 (main)	1/4F, F is focal length in wavelength

APPENDIX C
COMPUTER PROGRAM

```

PROGRAM DRSG
*****
* NASA LEWIS RESEARCH CENTER
* AUTHOR : R. ACOSTA AND A. LAGIN IBM 370 VM VERSION
* DATE : 7/14/91
* PURPOSE : TO SIMULATE GENERALIZED SURFACES OF REVOLUTION
* FOR THE GENERALIZED DUAL REFLECTOR ANALYSIS PROGRAM
*****
** COMPILE CONSTANTS
*****
REAL C
PARAMETER (C = 2.99792458E+08 )
REAL PI
PARAMETER (PI = 3.141592653589793238)
REAL ETA
PARAMETER (ETA = 4.0*PI*C*(1.E-7) )
*****
*****INPUT : FREQUENCY (HZ)*****
*****
REAL FREQQ
PARAMETER (FREQQ = 19.45*(1.E+9) )
*****
REAL LAMBDA
PARAMETER (LAMBDA =(C/FREQQ)*1.000 )
REAL LAMBSQ
PARAMETER (LAMBSQ = LAMBDA*LAMBDA )
*****
*****INPUT : QQ : FEED PATTERN EXPONENT*****
*****
REAL QQ
PARAMETER (QQ = 62.00 )
*****
INTEGER MXYZ
PARAMETER (MXYZ = 4 )
INTEGER DXYZ
PARAMETER (DXYZ = 3 )
INTEGER LNRY
PARAMETER (LNRY = 1 )
INTEGER MDTX
PARAMETER (MDTX = 10 )
*****
** INTRINSIC FUNCTIONS
*****
INTRINSIC SQRT
INTRINSIC INT
INTRINSIC NINT
*****
** EXTERNAL SUBROUTINES
*****
EXTERNAL SUBMAI
*****
REAL DATARY (MDTX)
REAL DMX, DMY
REAL INCMX, INCMY
REAL DSX, DSY
REAL INCSX, INCSY
REAL FREQ
REAL Q
*****
** EQUIVALENCE

```

DRS00010
DRS00020
DRS00030
DRS00040
DRS00050
DRS00060
DRS00070
DRS00080
DRS00090
DRS00100
DRS00110
DRS00120
DRS00130
DRS00140
DRS00150
DRS00160
DRS00170
DRS00180
DRS00190
DRS00200
DRS00210
DRS00220
DRS00230
DRS00240
DRS00250
DRS00260
DRS00270
DRS00280
DRS00290
DRS00300
DRS00310
DRS00320
DRS00330
DRS00340
DRS00350
DRS00360
DRS00370
DRS00380
DRS00390
DRS00400
DRS00410
DRS00420
DRS00430
DRS00440
DRS00450
DRS00460
DRS00470
DRS00480
DRS00490
DRS00500
DRS00510
DRS00520
DRS00530
DRS00540
DRS00550
DRS00560
DRS00570
DRS00580
DRS00590
DRS00600

```

*****DRS00610
EQUIVALENCE (DATARY( 1),DMX ) DRS00620
EQUIVALENCE (DATARY( 2),DMY ) DRS00630
EQUIVALENCE (DATARY( 3),INCMX) DRS00640
EQUIVALENCE (DATARY( 4),INCMY) DRS00650
EQUIVALENCE (DATARY( 5),DSX ) DRS00660
EQUIVALENCE (DATARY( 6),DSY ) DRS00670
EQUIVALENCE (DATARY( 7),INCSX) DRS00680
EQUIVALENCE (DATARY( 8),INCSY) DRS00690
EQUIVALENCE (DATARY( 9),FREQ ) DRS00700
EQUIVALENCE (DATARY(10),Q ) DRS00710
INTEGER MAXMX,MAXMY DRS00720
INTEGER MAXSX,MAXSY DRS00730
*****DRS00740
** INITIAL CALCUALTIONS DRS00750
*****DRS00760
*INPUT: LENGTH OF MAIN REF. RECTANGLE GRID DRS00770
*****DRS00780
DMX = (220.0 *LAMBDA) DRS00790
DMY = (220.0 *LAMBDA) DRS00800
*****DRS00810
*****INPUT : NUMBER POINTS IN X AND Y MAIN REF. RECTANGLE GRID***** DRS00820
*****DRS00830
MAXMX = 101 DRS00840
MAXMY = 101 DRS00850
*****DRS00860
INCMX = DMX/(REAL((MAXMX-1))) DRS00870
INCMY = DMY/(REAL((MAXMY-1))) DRS00880
*****DRS00890
*****INPUT : LENGHT OF SUB REF. RECTANGLE GRID ***** DRS00900
*****DRS00910
DSX = ( 82.50 *LAMBDA) DRS00920
DSY = ( 82.50 *LAMBDA) DRS00930
*****DRS00940
*****INPUT : NUMBER OF POINTS IN X AND Y IN THE SUB REFLECTOR GRID* DRS00950
*****DRS00960
MAXSX = 61 DRS00970
MAXSY = 61 DRS00980
*****DRS00990
INCSX = (DSX/REAL(MAXSX-1)) DRS01000
INCSY = (DSY/REAL(MAXSY-1)) DRS01010
*****DRS01020
FREQ = FREQQ DRS01030
Q = QQ DRS01040
CALL SUBMAI(MAXMY,MAXMX,MAXSY,MAXSX,MDTX,DATARY) DRS01050
END DRS01060
*****DRS01070
*****SUBROUTINE SUBMAI***** DRS01080
*****DRS01090
SUBROUTINE SUBMAI(PMXMY,PMXMX,PMXSY,PMXSX,PDTX,DTAARX) DRS01100
INTEGER PMXMY DRS01110
INTEGER PMXMX DRS01120
INTEGER PMXSY DRS01130
INTEGER PMXSX DRS01140
INTEGER PDTX DRS01150
REAL DTAARX(PDTX) DRS01160
REAL C DRS01170
PARAMETER (C = 2.99792458E+08 ) DRS01180
REAL PI DRS01190
PARAMETER (PI = 3.141592653589793238) DRS01200

```

```

REAL      ETA
PARAMETER (ETA      = 4.0*PI*C*(1.E-7)      )
*****
*****INPUT : FREQUENCY*****
*****
REAL      FREQQ
PARAMETER (FREQQ    = 19.45*(1.E+9)      )
*****
REAL      LAMBDA
PARAMETER (LAMBDA  = (C/FREQQ)*1.000      )
REAL      LAMBSQ
PARAMETER (LAMBSQ  = LAMBDA*LAMBDA      )
*****
*****INPUT : QQ:EXPONED EXPONENT*****
*****
REAL      QQ
PARAMETER (QQ      = 62.000      )
*****
INTEGER   MXYZ
PARAMETER (MXYZ   = 4      )
INTEGER   DXYZ
PARAMETER (DXYZ   = 3      )
INTEGER   LNRY
PARAMETER (LNRY   = 1      )
INTEGER   VDTX
PARAMETER (VDTX   = 4      )
INTEGER   MDTX
PARAMETER (MDTX   = 10     )
INTEGER   IDXZ
INTEGER   IDXZX
INTEGER   IDXZY
INTEGER   IDXMSK
INTEGER   MXMX, MXMY, TMXMX, TMXMY
INTEGER   MXSX, MXSY, TMXSX, TMXSY
PARAMETER (IDXZ   = 1      )
PARAMETER (IDXZX = 2      )
PARAMETER (IDXZY = 3      )
PARAMETER (IDXMSK = 4     )
*****
*****INPUT : NUMBER OF POINTS (-1) MAIN AND SUB REFLECTOR GRIDS***
*****
PARAMETER (MXMX   = 101     )
PARAMETER (MXMY   = 101     )
PARAMETER (MXSX   = 61      )
PARAMETER (MXSY   = 61      )
*****
PARAMETER (TMXMX  = MXMX + 1 )
PARAMETER (TMXMY  = MXMY + 1 )
PARAMETER (TMXSX  = MXSX + 1 )
PARAMETER (TMXSY  = MXSY + 1 )
*****
*****
REAL      MAIARY(4, TMXMY, TMXMX)
REAL      SUBARY(4, TMXSY, TMXSX)
REAL      XYZARY(DXYZ, MXYZ)
REAL      MRXYZO(DXYZ), XMO, YMO, ZMO
REAL      SRXYZO(DXYZ), XSO, YSO, ZSO
REAL      FEDXYZ(DXYZ), XF, YF, ZF
REAL      REFXYZ(DXYZ), XR, YR, ZR
REAL      DMX, DMY

```

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DRS01210
DRS01220
DRS01230
DRS01240
DRS01250
DRS01260
DRS01270
DRS01280
DRS01290
DRS01300
DRS01310
DRS01320
DRS01330
DRS01340
DRS01350
DRS01360
DRS01370
DRS01380
DRS01390
DRS01400
DRS01410
DRS01420
DRS01430
DRS01440
DRS01450
DRS01460
DRS01470
DRS01480
DRS01490
DRS01500
DRS01510
DRS01520
DRS01530
DRS01540
DRS01550
DRS01560
DRS01570
DRS01580
DRS01590
DRS01600
DRS01610
DRS01620
DRS01630
DRS01640
DRS01650
DRS01660
DRS01670
DRS01680
DRS01690
DRS01700
DRS01710
DRS01720
DRS01730
DRS01740
DRS01750
DRS01760
DRS01770
DRS01780
DRS01790
DRS01800

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REAL      INCMX, INCMY                                DRS01810
REAL      DSX, DSY                                    DRS01820
REAL      INCSX, INCSY                               DRS01830
REAL      FREQ                                        DRS01840
REAL      Q                                           DRS01850
***** DRS01860
** EQUIVALENCE                                       DRS01870
***** DRS01880
EQUIVALENCE (XYZARY(1,1),MRXYZO(1))                DRS01890
EQUIVALENCE (XYZARY(1,2),SRXYZO(1))                DRS01900
EQUIVALENCE (XYZARY(1,3),FEDXYZ(1))                DRS01910
EQUIVALENCE (XYZARY(1,4),REFXYZ(1))                DRS01920
EQUIVALENCE (MRXYZO(1),XMO )                       DRS01930
EQUIVALENCE (MRXYZO(2),YMO )                       DRS01940
EQUIVALENCE (MRXYZO(3),ZMO )                       DRS01950
EQUIVALENCE (SRXYZO(1),XSO )                       DRS01960
EQUIVALENCE (SRXYZO(2),YSO )                       DRS01970
EQUIVALENCE (SRXYZO(3),ZSO )                       DRS01980
EQUIVALENCE (FEDXYZ(1),XF )                        DRS01990
EQUIVALENCE (FEDXYZ(2),YF )                        DRS02000
EQUIVALENCE (FEDXYZ(3),ZF )                        DRS02010
EQUIVALENCE (REFXYZ(1),XR )                        DRS02020
EQUIVALENCE (REFXYZ(2),YR )                        DRS02030
EQUIVALENCE (REFXYZ(3),ZR )                        DRS02040
***** DRS02050
***** DRS02060
REAL      MAIXYZ(3),XM, YM, ZM                       DRS02070
REAL      SUBXYZ(3),XS, YS, ZS                       DRS02080
REAL      GENXYZ(3),XI, YJ, ZIJ                      DRS02090
REAL      RADSQ,XSQ                                  DRS02100
REAL      CNTRX                                       DRS02110
REAL      CNTRY                                       DRS02120
REAL      RTEMPO                                       DRS02130
REAL      RTEMP1                                       DRS02140
REAL      RTEMP2                                       DRS02150
REAL      RTEMP3                                       DRS02160
REAL      RTEMP4                                       DRS02170
REAL      RTEMP5                                       DRS02180
REAL      RTEMP6                                       DRS02190
INTEGER   I, J, V, W                                  DRS02200
***** DRS02210
** EQUIVALENCE                                       DRS02220
***** DRS02230
EQUIVALENCE (SUBXYZ(1),XS )                          DRS02240
EQUIVALENCE (SUBXYZ(2),YS )                          DRS02250
EQUIVALENCE (SUBXYZ(3),ZS )                          DRS02260
EQUIVALENCE (MAIXYZ(1),XM )                          DRS02270
EQUIVALENCE (MAIXYZ(2),YM )                          DRS02280
EQUIVALENCE (MAIXYZ(3),ZM )                          DRS02290
EQUIVALENCE (GENXYZ(1),XI )                          DRS02300
EQUIVALENCE (GENXYZ(2),YJ )                          DRS02310
EQUIVALENCE (GENXYZ(3),ZIJ )                         DRS02320
***** DRS02330
** Initialize Arrays                                  DRS02340
** MAIFIL <= MAIARY()                                DRS02350
** SUBFIL <= SUBARY()                                DRS02360
** XYZFIL <= XYZARY() <= MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ() DRS02370
** DTAFIL <= DTAARX() <= DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ, DRS02380
***** DRS02390
DO 20200 I = 1, TMXMX, 1                             DRS02400

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DO 20100 J = 1, TMXMY, 1
DO 20000 W = 1, 4, 1
MAIARY(W, J, I) = 0.
20000 CONTINUE
20100 CONTINUE
20200 CONTINUE
DO 20500 I = 1, TMXSX, 1
DO 20400 J = 1, TMXSY, 1
DO 20300 W = 1, 4, 1
SUBARY(W, J, I) = 0.
20300 CONTINUE
20400 CONTINUE
20500 CONTINUE
*****
*****INPUT : LOWER LEFT CORNER OF MAIN REF GRID*****
*****
XMO = ( -110.00000000 *LAMBDA)
YMO = ( 79.65000000 *LAMBDA)
ZMO = ( 1.000000000 *LAMBDA)
*****
*****INPUT: LOWER LEFT CORNER OF SUB REFLECTOR GRID*****
*****
XSO = ( -41.25000000 *LAMBDA)
YSO = ( 000.00000000 *LAMBDA)
ZSO = ( 1.000000000 *LAMBDA)
*****
*****INPUT : FEED COORDINATES*****
*****
*****BORSIGHT BEAM FEED COORDINATES:
XF = ( 0.000000000 *LAMBDA)
* YF = ( 0.000000000 *LAMBDA)
* ZF = ( 103.93560000 *LAMBDA)
*****CLEVELAND BEAM FEED COORDINATES:
YF = ( 5.629 * LAMBDA)
ZF = ( 101.067 * LAMBDA)
*****MIAMI BEAM FEED COORDINATES:
* XF = ( -16.4 * LAMBDA)
* YF = ( 9.62287 * LAMBDA)
* ZF = ( 99.0325 * LAMBDA)
*****LOS ANGELES BEAM FEED COORDINATES:
* XF = (-7.996 *LAMBDA)
* YF = (-30.52 *LAMBDA)
* ZF = ( 119.49 *LAMBDA)
*****SEATTLE BEAM FEED COORDINATES:
* XF = ( 3.4579 *LAMBDA)
* YF = (-30.2 *LAMBDA)
* ZF = (119.32 *LAMBDA)
*****
*****INPUT : REFERENCE RAY LOCATION COORDINATES *****
*****
XR = ( 0.000000000 *LAMBDA)
YR = ( 41.25000000 *LAMBDA)
* YR = ( 30.00000000 *LAMBDA)
Y = YR*39.36
ZR = ( 11.5*SQRT(1+(XR**2+Y**2)/1058)+97.5)
ZR=ZR/39.36
*****
DMX = DTAARX( 1)
DMY = DTAARX( 2)
INCMX = DTAARX( 3)

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DRS02410
DRS02420
DRS02430
DRS02440
DRS02450
DRS02460
DRS02470
DRS02480
DRS02490
DRS02500
DRS02510
DRS02520
DRS02530
DRS02540
DRS02550
DRS02560
DRS02570
DRS02580
DRS02590
DRS02600
DRS02610
DRS02620
DRS02630
DRS02640
DRS02650
DRS02660
DRS02670
DRS02680
DRS02690
DRS02700
DRS02710
DRS02720
DRS02730
DRS02740
DRS02750
DRS02760
DRS02770
DRS02780
DRS02790
DRS02800
DRS02810

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      INCMY      = DTAARX( 4)
      DSX       = DTAARX( 5)
      DSY       = DTAARX( 6)
      INCSX     = DTAARX( 7)
      INCSY     = DTAARX( 8)
      FREQ      = DTAARX( 9)
      Q         = DTAARX(10)
*****
*****TO GENERATE THE INPUT ARRAYS*****
*****
      DO 10 I=1,10
      WRITE(15,805)DTAARX(I)
805   FORMAT(5X,E15.8)
10    CONTINUE
      DO 11 I=1,4
      DO 12 J=1,3
      WRITE(16,806)XYZARY(J,I)
806   FORMAT(5X,E15.8)
12    CONTINUE
11    CONTINUE
*****
** Calculate Z, Zx, Zy, Usage for SubReflector.
****Z = SUBARY(IDXZ,... SURFACE Z
****DX= SUBARY(IDXZX... DERIVATIVE WITH RESP. TO X
****DY= SUBARY(IDXZY... DERIVATIVE WITH RESP. TO Y
*****
      RTEMP0 = ( LAMBDA)
*****
*****INPUT : A :PARAMETER OF SURFACE OF REVOLUTION*****
*****
      RTEMP1 = (18.97*RTEMP0)
*****
*****INPUT : 1/B**2 PARAMETER OF SURFACE OF REVOLUTION*****
*****
      RTEMP2 = (1./(.6829) )
*****
*****INPUT : Z0 OFFSET OF THE CENTER OF THE SURFACE OFF REV.**
*****
      RTEMP6 = 160.85*RTEMP0
*****
*****INPUT: RADIUS OF CYLINDER OF SUB-REFLECTOR*****
*****
      FRADSQ=(19.0*RTEMP0)**2
*****
*****INPUT: CENTER OF COORDINATES OF CYLINDER*****
*****
      FCENX=0.0
      FCENY=31.8*RTEMP0
*****
      XS      = XS0 - INCSX
      DO 20700 I = 1, TMXSX, 1
      XS      = XS + INCSX
      XSQ     = XS*XS
      YS      = YS0 - INCSY
      DO 20600 J = 1, TMYSY, 1
      YS      = YS + INCSY
      FTEMP=(XS-FCENX)**2+(YS-FCENY)**2
*      IF(FTEMP.GT.FRADSQ) GO TO 309
      RTEMP3 = ((XSQ) + (YS*YS))
      RTEMP4 = (SQRT(1+ RTEMP3*RTEMP2))

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DRS02820
DRS02830
DRS02840
DRS02850
DRS02860
DRS02870
DRS02880
DRS02890
DRS02900
DRS02910
DRS02920
DRS02930
DRS02940
DRS02950
DRS02960
DRS02970
DRS02980
DRS02990
DRS03000
DRS03010
DRS03020
DRS03030
DRS03040
DRS03050
DRS03060
DRS03070
DRS03080
DRS03090
DRS03100
DRS03110
DRS03120
DRS03130
DRS03140
DRS03150
DRS03160
DRS03170
DRS03180
DRS03190
DRS03200
DRS03210
DRS03220
DRS03230
DRS03240
DRS03250
DRS03260
DRS03270
DRS03280
DRS03290
DRS03300
DRS03310
DRS03320
DRS03330
DRS03340
DRS03350
DRS03360
DRS03370
DRS03380
DRS03390
DRS03400
DRS03410

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```

RTEMP5 = ((RTEMP1*RTEMP2)/RTEMP4)
DRS03420
DRS03430
*
* +=====DRS03440
*
* | SubReflector: Hyperbola DRS03450
* | DRS03460
* | +----- DRS03470
* | / 2 2 DRS03480
* | DRS03490
* | Z = 18.97*LAMBDA X / 1 + (X + Y) +160.85*LAMBDA DRS03500
* | DRS03510
* | / ----- DRS03520
* | \ / ( 0.6829 ) DRS03530
* | DRS03540
* | DRS03550
* | DRS03560
* | DRS03570
* | DRS03580
* | DRS03590
* | DRS03600
* | DRS03610
* | +----- DRS03620
* | / 2 2 DRS03630
* | X / X + Y DRS03640
* | DRS03650
* | ZX = 18.97 (-----) / / 1+(-----) DRS03660
* | DRS03670
* | 150.XLAMBDA \ / 0.6829 DRS03680
* | DRS03690
* | DRS03700
* | DRS03710
* | DRS03720
* | DRS03730
* | +----- DRS03740
* | / 2 2 DRS03750
* | Y / X + Y DRS03760
* | DRS03770
* | ZY = 18.97 (-----) / / 1+(-----) DRS03780
* | DRS03790
* | 150.XLAMBDA \ / 0.6829 DRS03800
* | DRS03810
* | DRS03820
* | DRS03830
* | DRS03840
* | DRS03850
* +=====DRS03860
*
* DRS03870
* DRS03880
*-----DRS03890
SUBARY(IDXZ ,J,I) = ((RTEMP6)+RTEMP1*RTEMP4) DRS03900
SUBARY(IDXZX ,J,I) = (XS*RTEMP5 ) DRS03910
SUBARY(IDXZY ,J,I) = (YS*RTEMP5 ) DRS03920
SUBARY(IDXMSK,J,I) = 1. DRS03930
*-----DRS03940
20520 FORMAT (5X,4(E15.8,2X)) DRS03950
309 WRITE(17,20520) SUBARY(IDXZ ,J,I),SUBARY(IDXZX ,J,I), DRS03960
1 SUBARY(IDXZY ,J,I),SUBARY(IDXMSK,J,I) DRS03970
20600 CONTINUE DRS03980
20700 CONTINUE DRS03990
DRS04000
*****DRS04010

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```

** Calculate Z, Zx, Zy, Usage for MainReflector.
****Z = MAIARY(IDXZ,... SURFACE FUNCTION
****Z = MAIARY(IDXZX,... DERIVATIVE WITH RESP. X
****Z = MAIARY(IDXZY,... DERIVATIVE WITH RESP. Y
*****
RTEMPO=LAMBDA
XM = XMO - INCMX
*****
*****INPUT: RADIUS OF CYLINDER MAIN REFLECTOR*****
*****
* RADSQ = (107.2*RTEMPO)**2
RADSQ = (108.2*RTEMPO)**2
*****
****INPUT: CENTER OF COORDINATES OF CYLINDER*****
*****
CNTRX = 0.0
CNTRY = 189.7*RTEMPO
*****
*****INPUT : 1/4F PARAMETER FOCAL LENGTH*****
*****
RTEMP1 = (1./(870.00*RTEMPO))
RTEMP2 = 2*RTEMP1
DO 20900 I = 1, TMXX, 1
XM = XM + INCMX
XSQ = XM*XM
YM = YMO - INCMY
DO 20800 J = 1, TMY, 1
YM=YM+INCMY
RTEMP4 = (((XM-CNTRX)*(XM-CNTRX))+((YM-CNTRY)*(YM-CNTRY)))
IF (RTEMP4 .GT. RADSQ) GO TO 450
*
*
* | MaiReflector: Parabola
* |
* |
* | 2 2
* | ( X + Y )
* |
* | Z = -----
* | (870. X LAMBDA)
* |
* |
* | X
* |
* | Zx = -----
* | (435. X LAMBDA)
* |
* |
* | Y
* |
* | Zy = -----
* | (435. X LAMBDA)
*

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DRS04020
DRS04030
DRS04040
DRS04050
DRS04060
DRS04070
DRS04080
DRS04090
DRS04100
DRS04110
DRS04120

DRS04130
DRS04140
DRS04150
DRS04160
DRS04170
DRS04180
DRS04190
DRS04200
DRS04210
DRS04220
DRS04230
DRS04240
DRS04250
DRS04260
DRS04270
DRS04280
DRS04290
DRS04300
DRS04310
DRS04320
DRS04330
DRS04340
DRS04350
DRS04360
DRS04370
DRS04380
DRS04390
DRS04400
DRS04410
DRS04420
DRS04430
DRS04440
DRS04450
DRS04460
DRS04470
DRS04480
DRS04490
DRS04500
DRS04510
DRS04520
DRS04530
DRS04540
DRS04550
DRS04560
DRS04570
DRS04580
DRS04590
DRS04600

*		DRS04610
*		DRS04620
*	+=====	DRS04630
*		DRS04640
	MAIARY(IDXZ ,J,I) = ((XM*XM)+(YM*YM))*RTEMP1	DRS04650
	MAIARY(IDXZX ,J,I) = (XM*RTEMP2)	DRS04660
	MAIARY(IDXZY ,J,I) = (YM*RTEMP2)	DRS04680
	MAIARY(IDXMSK,J,I) = 1.	DRS04690
450	WRITE(18,20520) MAIARY(IDXZ ,J,I),MAIARY(IDXZX ,J,I)	DRS04700
1	,MAIARY(IDXZY ,J,I),MAIARY(IDXMSK ,J,I)	DRS04710
20800	CONTINUE	DRS04720
20900	CONTINUE	DRS04730
	END	DRS04740

```

PROGRAM DUALREF
*****
* AUTHOR : R. ACOSTA AND A. LAGIN  VM VERSION
* DATE   : 7/15/91
* PURPOSE : TO COMPUTE FAR FIELD CO-POL AND CROSS POL OF A
*          GENERALIZED DUAL REFLECTOR SYSTEM
*          GENERALIZED DUAL REFLECTOR ANALYSIS PROGRAM
*****
** COMPILE CONSTANTS
*****
REAL      C
PARAMETER (C      = 2.99792458E+08      )
REAL      PI
PARAMETER (PI     = 3.141592653589793238)
REAL      ETA
PARAMETER (ETA    = 4.0*PI*C*(1.E-7)   )
REAL      R2DEG
PARAMETER (R2DEG  = 180./PI            )
REAL      D2RAD
PARAMETER (D2RAD  = PI/180.            )
INTEGER   IDXZ
INTEGER   IDXZX
INTEGER   IDXZY
INTEGER   IDXMSK
INTEGER   IDXVCX
INTEGER   IDXVCY
INTEGER   IDXVCZ
INTEGER   IDXR MJ
INTEGER   IDXIMJ
INTEGER   IDXUNM
INTEGER   IDXJVX
INTEGER   IDXNRM
INTEGER   IDXDTX
INTEGER   IDXMMN
INTEGER   IDXMSI
INTEGER   IDXAOT
INTEGER   IDXPWR
INTEGER   IDXADB
INTEGER   IDXRDB
INTEGER   MXMX, MXMY, TMXMX, TMXMY
INTEGER   MXSX, MXSY, TMSX, TMSY
INTEGER   MXTHE, MXPHI
INTEGER   MXYZ
INTEGER   DXYZ
INTEGER   LNRY
INTEGER   VDTX
INTEGER   NDTX
INTEGER   MDTX
INTEGER   KDTX
PARAMETER (IDXZ   = 1
PARAMETER (IDXZX = 2
PARAMETER (IDXZY = 3
PARAMETER (IDXMSK = 4
PARAMETER (IDXVCX = 1
PARAMETER (IDXVCY = 2
PARAMETER (IDXVCZ = 3
PARAMETER (IDXR MJ = 1
PARAMETER (IDXIMJ = 2
PARAMETER (IDXUNM = 3
PARAMETER (IDXJVX = 1
DUA00010
DUA00020
DUA00030
DUA00040
DUA00050
DUA00060
DUA00070
*****DUA00080
DUA00090
DUA00100
DUA00110
DUA00120
DUA00130
DUA00140
DUA00150
DUA00160
DUA00170
DUA00180
DUA00190
DUA00200
DUA00210
DUA00220
DUA00230
DUA00240
DUA00250
DUA00260
DUA00270
DUA00280
DUA00290
DUA00300
DUA00310
DUA00320
DUA00330
DUA00340
DUA00350
DUA00360
DUA00370
DUA00380
DUA00390
DUA00400
DUA00410
DUA00420
DUA00430
DUA00440
DUA00450
DUA00460
DUA00470
DUA00480
DUA00490
DUA00500
DUA00510
DUA00520
DUA00530
DUA00540
DUA00550
DUA00560
DUA00570
DUA00580
DUA00590
DUA00600

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PARAMETER (IDXNRM = 2 ) DUA00610
PARAMETER (IDXDTX = 3 ) DUA00620
PARAMETER (IDXNMN = 1 ) DUA00630
PARAMETER (IDXMSI = 2 ) DUA00640
PARAMETER (IDXAOT = 3 ) DUA00650
PARAMETER (IDXPWR = 1 ) DUA00660
PARAMETER (IDXADB = 2 ) DUA00670
PARAMETER (IDXRDB = 3 ) DUA00680
*****
*****INPUT : NUMBER OF POINTS IN X AND Y MAIN REF. GRID.*****
*****
PARAMETER (MXMX = 101 ) DUA00690
PARAMETER (MXMY = 101 ) DUA00700
*****
*****INPUT : NUMBER OF POINTS IN X AND Y SUB REF. GRID*****
*****
PARAMETER (MXSX = 61 ) DUA00710
PARAMETER (MXSY = 61 ) DUA00720
*****
PARAMETER (TMXMX = MXMX + 1 ) DUA00730
PARAMETER (TMXMY = MXMY + 1 ) DUA00740
PARAMETER (TMXSX = MXSX + 1 ) DUA00750
PARAMETER (TMXSY = MXSY + 1 ) DUA00760
*****
*****INPUT : NUMBER OF FAR-FIELD GRID POINTS*****
*****
PARAMETER (MXTHE = 50 ) DUA00770
PARAMETER (MXPHI = 360 ) DUA00780
*****
PARAMETER (MXYZ = 4 ) DUA00790
PARAMETER (DXYZ = 3 ) DUA00800
PARAMETER (LNRY = 1 ) DUA00810
PARAMETER (VDTX = 4 ) DUA00820
PARAMETER (NDTX = 3 ) DUA00830
PARAMETER (MDTX = 10 ) DUA00840
PARAMETER (KDTX = 18 ) DUA00850
*****
** INTRINSIC FUNCTIONS DUA00860
*****
INTRINSIC SQRT DUA01000
INTRINSIC SIN DUA01010
INTRINSIC COS DUA01020
INTRINSIC ACOS DUA01030
INTRINSIC NINT DUA01040
*****
** EXTERNAL FUNCTIONS DUA01050
*****
REAL DOT DUA01060
EXTERNAL DOT DUA01070
REAL FDPTRN DUA01080
EXTERNAL FDPTRN DUA01090
*****
** EXTERNAL SUBROUTINES DUA01100
*****
EXTERNAL CROSS DUA01110
EXTERNAL SCALER DUA01120
EXTERNAL VECADD DUA01130
EXTERNAL VECSUB DUA01140
*****
** RUN TIME CONSTANTS DUA01150
DUA01160
DUA01170
DUA01180
DUA01190
DUA01200

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*****DUA01210
      REAL      DTAARY(MDTX)          DUA01220
      REAL      DMX,DMY              DUA01230
      REAL      INCMX,INCMY         DUA01240
      REAL      DSX,DSY             DUA01250
      REAL      INCSX,INCSY        DUA01260
      INTEGER   MAXMX,MAXMY        DUA01270
      INTEGER   MAXSX,MAXSY        DUA01280
      REAL      FREQ                DUA01290
      REAL      Q                   DUA01300
*****DUA01310
** EQUIVALENCE                      DUA01320
*****DUA01330
      EQUIVALENCE (DTAARY( 1),DMX  ) DUA01340
      EQUIVALENCE (DTAARY( 2),DMY  ) DUA01350
      EQUIVALENCE (DTAARY( 3),INCMX) DUA01360
      EQUIVALENCE (DTAARY( 4),INCMY) DUA01370
      EQUIVALENCE (DTAARY( 5),DSX  ) DUA01380
      EQUIVALENCE (DTAARY( 6),DSY  ) DUA01390
      EQUIVALENCE (DTAARY( 7),INCSX) DUA01400
      EQUIVALENCE (DTAARY( 8),INCSY) DUA01410
      EQUIVALENCE (DTAARY( 9),FREQ ) DUA01420
      EQUIVALENCE (DTAARY(10),Q    ) DUA01430
*****DUA01440
** RUN      TIME VARIABLES          DUA01450
*****DUA01460
      REAL      LAMBDA              DUA01470
      REAL      K                   DUA01480
*****DUA01490
** EQUIVALENCE                      DUA01500
*****DUA01510
** Input Arrays                     DUA01520
** MAIFIL ==> MAIARY()             DUA01530
** SUBFIL  ==> SUBARY()            DUA01540
** XYZFIL  ==> XYZARY() ==> MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ() DUA01550
** DTAFIL  ==> DTAARY() ==> DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ DUA01560
*****DUA01570
*****READ IN THE XYZARY AND DTAARY FROM FILE GENERATOR*****DUA01580
*****DUA01590
      DO 10 I=1,10                 DUA01600
      READ(15,805) DTAARY(I)       DUA01610
805  FORMAT(5X,E15.8)              DUA01620
10   CONTINUE                     DUA01630
*****DUA01640
*****DUA01650
** Initial Calculations             DUA01660
*****DUA01670
      LAMBDA = C/FREQ              DUA01680
      K      = 2*PI/LAMBDA         DUA01690
      MAXMX = (NINT(DMX/INCMX) + 1) DUA01700
      MAXMY = (NINT(DMY/INCMY) + 1) DUA01710
      MAXSX = (NINT(DSX/INCSX) + 1) DUA01720
      MAXSY = (NINT(DSY/INCSY) + 1) DUA01730
      CALL SUBMAI(MAXMX,MAXMY,MAXSX,MAXSY,MDTX,DTAARY) DUA01740
      END                          DUA01750
*****DUA01760
*****MAIN PROGRAM*****DUA01770
*****DUA01780
      SUBROUTINE SUBMAI(PMXMX,PMXMY,PMXSX,PMXSY,PDTX,DTXARX) DUA01790
      INTEGER      PMXMX           DUA01800

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INTEGER	PMXMY		DUA01810
INTEGER	PMXSX		DUA01820
INTEGER	PMXSY		DUA01830
INTEGER	PDTX		DUA01840
REAL	DTXARX(PDTX)		DUA01850
*****			DUA01860
** COMPILE CONSTANTS			DUA01870
*****			DUA01880
REAL	C		DUA01890
PARAMETER	(C = 2.99792458E+08)		DUA01900
REAL	PI		DUA01910
PARAMETER	(PI = 3.141592653589793238)		DUA01920
REAL	ETA		DUA01930
PARAMETER	(ETA = 4.0*PI*C*(1.E-7))		DUA01940
REAL	R2DEG		DUA01950
PARAMETER	(R2DEG = 180./PI)		DUA01960
REAL	D2RAD		DUA01970
PARAMETER	(D2RAD = PI/180.)		DUA01980
INTEGER	IDXZ		DUA01990
INTEGER	IDXZX		DUA02000
INTEGER	IDXZY		DUA02010
INTEGER	IDXMSK		DUA02020
INTEGER	IDXVCX		DUA02030
INTEGER	IDXVCY		DUA02040
INTEGER	IDXVCZ		DUA02050
INTEGER	IDXRMJ		DUA02060
INTEGER	IDXIMJ		DUA02070
INTEGER	IDXUNM		DUA02080
INTEGER	IDXJVX		DUA02090
INTEGER	IDXNRM		DUA02100
INTEGER	IDXDTX		DUA02110
INTEGER	IDXMNM		DUA02120
INTEGER	IDXMSI		DUA02130
INTEGER	IDXAOT		DUA02140
INTEGER	IDXPWR		DUA02150
INTEGER	IDXADB		DUA02160
INTEGER	IDXRDB		DUA02170
INTEGER	MXMX, MXMY, TMXMX, TMXMY		DUA02180
INTEGER	MXSX, MXSX, TMXSX, TMXSY		DUA02190
INTEGER	MXTHE, MXPFI		DUA02200
INTEGER	MXYZ		DUA02210
INTEGER	DXYZ		DUA02220
INTEGER	LNRY		DUA02230
INTEGER	VDTX		DUA02240
INTEGER	NDTX		DUA02250
INTEGER	MDTX		DUA02260
INTEGER	KDTX		DUA02270
PARAMETER	(IDXZ = 1)		DUA02280
PARAMETER	(IDXZX = 2)		DUA02290
PARAMETER	(IDXZY = 3)		DUA02300
PARAMETER	(IDXMSK = 4)		DUA02310
PARAMETER	(IDXVCX = 1)		DUA02320
PARAMETER	(IDXVCY = 2)		DUA02330
PARAMETER	(IDXVCZ = 3)		DUA02340
PARAMETER	(IDXRMJ = 1)		DUA02350
PARAMETER	(IDXIMJ = 2)		DUA02360
PARAMETER	(IDXUNM = 3)		DUA02370
PARAMETER	(IDXJVX = 1)		DUA02380
PARAMETER	(IDXNRM = 2)		DUA02390
PARAMETER	(IDXDTX = 3)		DUA02400


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PARAMETER (IDXMMN = 1 )
PARAMETER (IDXMSI = 2 )
PARAMETER (IDXAOT = 3 )
PARAMETER (IDXPWR = 1 )
PARAMETER (IDXADB = 2 )
PARAMETER (IDXRDB = 3 )
*****
*****INPUT : NUMBER OF POINTS IN X AND Y MAIN REF. GRID*****
*****
PARAMETER (MXMX = 101 )
PARAMETER (MXMY = 101 )
*****
*****INPUT : NUMBER OF POINTS IN X AND Y SUB REF. GRID*****
*****
PARAMETER (MXSX = 61 )
PARAMETER (MXSY = 61 )
*****
PARAMETER (TMXMX = MXMX + 1 )
PARAMETER (TMXMY = MXMY + 1 )
PARAMETER (TMXSX = MXSX + 1 )
PARAMETER (TMXSY = MXSY + 1 )
*****
***** INPUT : FAR-FIELD GRID POINTS THETA AND PHI*****
*****
PARAMETER (MXTHE = 50 )
PARAMETER (MXPHI = 360 )
*****
PARAMETER (MXYZ = 4 )
PARAMETER (DXYZ = 3 )
PARAMETER (LNRY = 1 )
PARAMETER (VDTX = 4 )
PARAMETER (NDTX = 3 )
PARAMETER (MDTX = 10 )
PARAMETER (KDTX = 18 )
*****
** INTRINSIC FUNCTIONS
*****
INTRINSIC SQRT
INTRINSIC SIN
INTRINSIC COS
INTRINSIC ACOS
INTRINSIC NINT
*****
** EXTERNAL FUNCTIONS
*****
REAL DOT
EXTERNAL DOT
REAL FDPTRN
EXTERNAL FDPTRN
*****
** EXTERNAL SUBROUTINES
*****
EXTERNAL CROSS
EXTERNAL SCALER
EXTERNAL VECADD
EXTERNAL VECSUB
*****
** RUN TIME CONSTANTS
*****
REAL MAIARY (VDTX, TMXMY, TMXMX)

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```

DUA02410
DUA02420
DUA02430
DUA02440
DUA02450
DUA02460
DUA02470
DUA02480
DUA02490
DUA02500
DUA02510
DUA02520
DUA02530
DUA02540
DUA02550
DUA02560
DUA02570
DUA02580
DUA02590
DUA02600
DUA02610
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DUA02690
DUA02700
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DUA02740
DUA02750
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DUA02780
DUA02790
DUA02800
DUA02810
DUA02820
DUA02830
DUA02840
DUA02850
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DUA02870
DUA02880
DUA02890
DUA02900
DUA02910
DUA02920
DUA02930
DUA02940
DUA02950
DUA02960
DUA02970
DUA02980
DUA02990
DUA03000

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REAL	SUBARY (VDTX, TMXSY, TMXSX)	DUA03010
REAL	XYZARY (DXYZ, MXYZ)	DUA03020
REAL	SRXYZO (DXYZ), XSO, YSO, ZSO	DUA03030
REAL	MRXYZO (DXYZ), XMO, YMO, ZMO	DUA03040
REAL	FEDXYZ (DXYZ), XF, YF, ZF	DUA03050
REAL	REFXYZ (DXYZ), XR, YR, ZR	DUA03060
REAL	SR (DXYZ), SRX, SRY, SRZ	DUA03070
REAL	USR (DXYZ), USRX, USRY, USRZ	DUA03080
REAL	MAGSR	DUA03090
REAL	DTAARY (MDTX)	DUA03100
REAL	DMX, DMY	DUA03110
REAL	INCMX, INCMY	DUA03120
REAL	DSX, DSY	DUA03130
REAL	INCSX, INCSY	DUA03140
REAL	FREQ	DUA03150
REAL	Q	DUA03160
REAL	DTXARY (KDTX)	DUA03170
REAL	BEGPHX	DUA03180
REAL	ENDPHX	DUA03190
REAL	IDXPHX	DUA03200
REAL	STPPHX	DUA03210
REAL	INCPHX	DUA03220
REAL	BEGTHX	DUA03230
REAL	ENDTHX	DUA03240
REAL	IDXTHX	DUA03250
REAL	STPTHX	DUA03260
REAL	INCTHX	DUA03270
REAL	PTTMNX	DUA03280
REAL	PTTMXX	DUA03290
REAL	ADBMNX	DUA03300
REAL	ADBMX	DUA03310
REAL	RDBMNX	DUA03320
REAL	PRAD	DUA03330
REAL	RINTNS	DUA03340
REAL	RIFCTR	DUA03350
REAL	DIRCTV	DUA03360

** EQUIVALENCE

EQUIVALENCE	(XYZARY (1,1), MRXYZO (1))	DUA03370
EQUIVALENCE	(XYZARY (1,2), SRXYZO (1))	DUA03380
EQUIVALENCE	(XYZARY (1,3), FEDXYZ (1))	DUA03390
EQUIVALENCE	(XYZARY (1,4), REFXYZ (1))	DUA03400
EQUIVALENCE	(MRXYZO (1), XMO)	DUA03410
EQUIVALENCE	(MRXYZO (2), YMO)	DUA03420
EQUIVALENCE	(MRXYZO (3), ZMO)	DUA03430
EQUIVALENCE	(SRXYZO (1), XSO)	DUA03440
EQUIVALENCE	(SRXYZO (2), YSO)	DUA03450
EQUIVALENCE	(SRXYZO (3), ZSO)	DUA03460
EQUIVALENCE	(FEDXYZ (1), XF)	DUA03470
EQUIVALENCE	(FEDXYZ (2), YF)	DUA03480
EQUIVALENCE	(FEDXYZ (3), ZF)	DUA03490
EQUIVALENCE	(REFXYZ (1), XR)	DUA03500
EQUIVALENCE	(REFXYZ (2), YR)	DUA03510
EQUIVALENCE	(REFXYZ (3), ZR)	DUA03520
EQUIVALENCE	(SR (1), SRX)	DUA03530
EQUIVALENCE	(SR (2), SRY)	DUA03540
EQUIVALENCE	(SR (3), SRZ)	DUA03550
EQUIVALENCE	(USR (1), USRX)	DUA03560
EQUIVALENCE	(USR (2), USRY)	DUA03570
EQUIVALENCE	(USR (3), USRZ)	DUA03580
EQUIVALENCE	(USR (1), USRX)	DUA03590
EQUIVALENCE	(USR (2), USRY)	DUA03600

EQUIVALENCE (USR (3),USRZ)	DUA03610
EQUIVALENCE (DTAARY(1),DMX)	DUA03620
EQUIVALENCE (DTAARY(2),DMY)	DUA03630
EQUIVALENCE (DTAARY(3),INCMX)	DUA03640
EQUIVALENCE (DTAARY(4),INCMY)	DUA03650
EQUIVALENCE (DTAARY(5),DSX)	DUA03660
EQUIVALENCE (DTAARY(6),DSY)	DUA03670
EQUIVALENCE (DTAARY(7),INCSX)	DUA03680
EQUIVALENCE (DTAARY(8),INCSY)	DUA03690
EQUIVALENCE (DTAARY(9),FREQ)	DUA03700
EQUIVALENCE (DTAARY(10),Q)	DUA03710
EQUIVALENCE (DTXARY(1),BEGPHX)	DUA03720
EQUIVALENCE (DTXARY(2),ENDPHX)	DUA03730
EQUIVALENCE (DTXARY(3),IDXPHX)	DUA03740
EQUIVALENCE (DTXARY(4),STPPHX)	DUA03750
EQUIVALENCE (DTXARY(5),INCPHX)	DUA03760
EQUIVALENCE (DTXARY(6),BEGTHX)	DUA03770
EQUIVALENCE (DTXARY(7),ENDTHX)	DUA03780
EQUIVALENCE (DTXARY(8),IDXTHX)	DUA03790
EQUIVALENCE (DTXARY(9),STPTHX)	DUA03800
EQUIVALENCE (DTXARY(10),INCTHX)	DUA03810
EQUIVALENCE (DTXARY(11),PTTMNX)	DUA03820
EQUIVALENCE (DTXARY(12),PTTMXX)	DUA03830
EQUIVALENCE (DTXARY(13),ADB MNX)	DUA03840
EQUIVALENCE (DTXARY(14),ADB MXX)	DUA03850
EQUIVALENCE (DTXARY(15),RDB MNX)	DUA03860
EQUIVALENCE (DTXARY(16),PRAD)	DUA03870
EQUIVALENCE (DTXARY(17),RINTNS)	DUA03880
EQUIVALENCE (DTXARY(18),DIRCTV)	DUA03890
*****	DUA03900
** RUN TIME VARIABLES	DUA03910
*****	DUA03920
REAL MCDARY(DXYZ,DXYZ,TMXYM,TMXXM)	DUA03930
REAL SCDARY(DXYZ,DXYZ,TMXXSY,TMXXSX)	DUA03940
REAL MAIXYZ(DXYZ),XM, YM, ZM	DUA03950
REAL SUBXYZ(DXYZ),XS, YS, ZS	DUA03960
REAL GENXYZ(DXYZ),XI, YJ, ZIJ	DUA03970
REAL TMPXYZ(DXYZ,2)	DUA03980
REAL TMRXYZ(DXYZ),TMRX,TMRY,TMRZ	DUA03990
REAL TMIXYZ(DXYZ),TMIX,TMIY,TMIZ	DUA04000
REAL HFLD(DXYZ,2)	DUA04010
REAL HVR (DXYZ),HVRX,HVRY,HVRZ	DUA04020
REAL HVI (DXYZ),HVIX,HVIY,HVIZ	DUA04030
REAL JFLD(DXYZ,2)	DUA04040
REAL JVR (DXYZ),JVRX,JVRY,JVRZ	DUA04050
REAL JVI (DXYZ),JVIX,JVIY,JVIZ	DUA04060
REAL SUM (DXYZ,2)	DUA04070
REAL SUMR(DXYZ),SUMRX,SUMRY,SUMRZ	DUA04080
REAL SUMI(DXYZ),SUMIX,SUMIY,SUMIZ	DUA04090
REAL NORM(DXYZ),NX ,NY ,NZ	DUA04100
REAL MAGNRM	DUA04110
REAL SI (DXYZ),SIX ,SIY ,SIZ	DUA04120
REAL USI (DXYZ),USIX,USIY,USIZ	DUA04130
REAL MAGSI	DUA04140
REAL PV (DXYZ),PVX ,PVY ,PVZ	DUA04150
REAL UPV (DXYZ),UPVX,UPVY,UPVZ	DUA04160
REAL MAGPV	DUA04170
REAL HV (DXYZ),HVX ,HVY ,HVZ	DUA04180
REAL UHV (DXYZ),UHVX,UHVIY,UHVZ	DUA04190
REAL MAGHV	DUA04200

REAL	JV (DXYZ),JVX ,JVY ,JVZ	DUA04210
REAL	UJV(DXYZ),UJVX,UJVV,UJVZ	DUA04220
REAL	MAGJV	DUA04230
REAL	R1 (DXYZ),R1X ,R1Y ,R1Z	DUA04240
REAL	UR1(DXYZ),UR1X,UR1Y,UR1Z	DUA04250
REAL	MAGR1	DUA04260
REAL	INTG(DXYZ),INTX,INTY,INTZ	DUA04270
REAL	MAGINT	DUA04280
REAL	RFF (DXYZ),RFFX,RFFY,RFFZ	DUA04290
REAL	PTTRN(NDTX,0:MXTHE,0:MXPHI)	DUA04300
REAL	PTTMIN	DUA04310
REAL	PTTMAX	DUA04320
REAL	LAMBDA	DUA04330
REAL	K	DUA04340
REAL	KR	DUA04350
REAL	RR	DUA04360
REAL	PSI(2),COSKR,SINKR	DUA04370
REAL	MIN	DUA04380
REAL	MAX	DUA04390
REAL	R1TMP	DUA04400
REAL	R2TMP	DUA04410
REAL	CMPTMP(2),CMPTMR,CMPTMI	DUA04420
REAL	SCALE	DUA04430
REAL	ANGLE	DUA04440
INTEGER	ANGPHX	DUA04450
REAL	ANGPHI	DUA04460
REAL	BEGPHI	DUA04470
REAL	ENDPHI	DUA04480
INTEGER	IDXPHI	DUA04490
INTEGER	STPPHI	DUA04500
REAL	INCPHI	DUA04510
REAL	SINPHI	DUA04520
REAL	COSPHI	DUA04530
INTEGER	ANGTHX	DUA04540
REAL	ANGTHE	DUA04550
REAL	BEGTHE	DUA04560
REAL	ENDTHE	DUA04570
INTEGER	IDXTHE	DUA04580
INTEGER	STPTHE	DUA04590
REAL	INCTHE	DUA04600
REAL	SINTHE	DUA04610
REAL	COSTHE	DUA04620
REAL	EPHRE	DUA04630
REAL	EPHIM	DUA04640
REAL	ETHRE	DUA04650
REAL	ETHIM	DUA04660
REAL	COZ	DUA04670
REAL	MSKFAC	DUA04680
INTEGER	MAXMX,MAXMY	DUA04690
INTEGER	MAXSX,MAXSY	DUA04700
REAL	DS	DUA04710
REAL	INCMXY	DUA04720
REAL	INCSXY	DUA04730
INTEGER	I,J,IP,JP,V,W	DUA04740
INTEGER	IOS	DUA04750
INTEGER	FLG	DUA04760
INTEGER	ITMP	DUA04770
CHARACTER	TIME*8	DUA04780
REAL	AAAKR	DUA04790
INTEGER	IIIKR	DUA04800

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*****DUA04810
** EQUIVALENCE DUA04820
*****DUA04830
EQUIVALENCE (SUBXYZ(1),XS ) DUA04840
EQUIVALENCE (SUBXYZ(2),YS ) DUA04850
EQUIVALENCE (SUBXYZ(3),ZS ) DUA04860
EQUIVALENCE (MAIXYZ(1),XM ) DUA04870
EQUIVALENCE (MAIXYZ(2),YM ) DUA04880
EQUIVALENCE (MAIXYZ(3),ZM ) DUA04890
EQUIVALENCE (GENXYZ(1),XI ) DUA04900
EQUIVALENCE (GENXYZ(2),YJ ) DUA04910
EQUIVALENCE (GENXYZ(3),ZIJ ) DUA04920
EQUIVALENCE (TMPXYZ(1,1),TMRXYZ(1)) DUA04930
EQUIVALENCE (TMPXYZ(1,2),TMIXYZ(1)) DUA04940
EQUIVALENCE (TMRXYZ(1),TMRX ) DUA04950
EQUIVALENCE (TMRXYZ(2),TMRX ) DUA04960
EQUIVALENCE (TMRXYZ(3),TMRZ ) DUA04970
EQUIVALENCE (TMIXYZ(1),TMIX ) DUA04980
EQUIVALENCE (TMIXYZ(2),TMIY ) DUA04990
EQUIVALENCE (TMIXYZ(3),TMIZ ) DUA05000
EQUIVALENCE (SUM(1,1),SUMR(1)) DUA05010
EQUIVALENCE (SUM(1,2),SUMI(1)) DUA05020
EQUIVALENCE (SUMR(1),SUMRX ) DUA05030
EQUIVALENCE (SUMR(2),SUMRY ) DUA05040
EQUIVALENCE (SUMR(3),SUMRZ ) DUA05050
EQUIVALENCE (SUMI(1),SUMIX ) DUA05060
EQUIVALENCE (SUMI(2),SUMIY ) DUA05070
EQUIVALENCE (SUMI(3),SUMIZ ) DUA05080
EQUIVALENCE (NORM(1),NX ) DUA05090
EQUIVALENCE (NORM(2),NY ) DUA05100
EQUIVALENCE (NORM(3),NZ ) DUA05110
EQUIVALENCE (SI(1),SIX ) DUA05120
EQUIVALENCE (SI(2),SIY ) DUA05130
EQUIVALENCE (SI(3),SIZ ) DUA05140
EQUIVALENCE (USI(1),USIX ) DUA05150
EQUIVALENCE (USI(2),USIY ) DUA05160
EQUIVALENCE (USI(3),USIZ ) DUA05170
EQUIVALENCE (PV(1),PVX ) DUA05180
EQUIVALENCE (PV(2),PVY ) DUA05190
EQUIVALENCE (PV(3),PVZ ) DUA05200
EQUIVALENCE (UPV(1),UPVX ) DUA05210
EQUIVALENCE (UPV(2),UPVY ) DUA05220
EQUIVALENCE (UPV(3),UPVZ ) DUA05230
EQUIVALENCE (HFLD(1,1),HVR(1)) DUA05240
EQUIVALENCE (HFLD(1,2),HVI(1)) DUA05250
EQUIVALENCE (HVR(1),HVRX ) DUA05260
EQUIVALENCE (HVR(2),HVRX ) DUA05270
EQUIVALENCE (HVR(3),HVRZ ) DUA05280
EQUIVALENCE (HVI(1),HVIX ) DUA05290
EQUIVALENCE (HVI(2),HVIX ) DUA05300
EQUIVALENCE (HVI(3),HVIZ ) DUA05310
EQUIVALENCE (HV(1),HVX ) DUA05320
EQUIVALENCE (HV(2),HVY ) DUA05330
EQUIVALENCE (HV(3),HVZ ) DUA05340
EQUIVALENCE (UHV(1),UHVX ) DUA05350
EQUIVALENCE (UHV(2),UHVY ) DUA05360
EQUIVALENCE (UHV(3),UHVZ ) DUA05370
EQUIVALENCE (JFLD(1,1),JVR(1)) DUA05380
EQUIVALENCE (JFLD(1,2),JVI(1)) DUA05390
EQUIVALENCE (JVR(1),JVRX ) DUA05400

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EQUIVALENCE (JVR (2),JVRY ) DUA05410
EQUIVALENCE (JVR (3),JVRZ ) DUA05420
EQUIVALENCE (JVI (1),JVIX ) DUA05430
EQUIVALENCE (JVI (2),JVII ) DUA05440
EQUIVALENCE (JVI (3),JVIZ ) DUA05450
EQUIVALENCE (JV (1),JVX ) DUA05460
EQUIVALENCE (JV (2),JVY ) DUA05470
EQUIVALENCE (JV (3),JVZ ) DUA05480
EQUIVALENCE (UJV (1),UJVX ) DUA05490
EQUIVALENCE (UJV (2),UJVY ) DUA05500
EQUIVALENCE (UJV (3),UJVZ ) DUA05510
EQUIVALENCE (R1 (1),R1X ) DUA05520
EQUIVALENCE (R1 (2),R1Y ) DUA05530
EQUIVALENCE (R1 (3),R1Z ) DUA05540
EQUIVALENCE (UR1 (1),UR1X ) DUA05550
EQUIVALENCE (UR1 (2),UR1Y ) DUA05560
EQUIVALENCE (UR1 (3),UR1Z ) DUA05570
EQUIVALENCE (INTG (1),INTX ) DUA05580
EQUIVALENCE (INTG (2),INTY ) DUA05590
EQUIVALENCE (INTG (3),INTZ ) DUA05600
EQUIVALENCE (RFF (1),RFFX ) DUA05610
EQUIVALENCE (RFF (2),RFFY ) DUA05620
EQUIVALENCE (RFF (3),RFFZ ) DUA05630
EQUIVALENCE (PSI (1),COSKR) DUA05640
EQUIVALENCE (PSI (2),SINKR) DUA05650
EQUIVALENCE (CMPTMP(1),CMPTMR) DUA05660
EQUIVALENCE (CMPTMP(2),CMPTMI) DUA05670
*****DUA05680
** INITIALIZE INPUT ARRAYS DUA05690
** MAIFIL ==> MAIARY() DUA05700
** SUBFIL ==> SUBARY() DUA05710
** XYZFIL ==> XYZARY() ==> MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ() DUA05720
** DTAFIL ==> DTAARY() ==> DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ, DUA05730
*****DUA05740
** GENERATE OUTPUT ARRAYS DUA05750
** MCDFIL <== MCDARY() DUA05760
** SCDFIL <== SCDARY() DUA05770
** RFXFIL <== PTTRN () DUA05780
** DTXFIL <== DTXARY() <== BEG,END,IDX,STP,INC * THE,PHI , PTT * ADR * DUA05790
*****DUA05800
*****READ IN THE XYZARY,SUBARY,MAIARY ARRAYS FROM FILE GEN.*****DUA05810
*****DUA05820
DO 11 II=1,4 DUA05830
DO 12 JJ=1,3 DUA05840
READ(16,806)XYZARY(JJ,II) DUA05850
806 FORMAT(5X,E15.8) DUA05860
12 CONTINUE DUA05870
11 CONTINUE DUA05880
*****DUA05890
*****DUA05900
DO 13 III=1,TMXSX,1 DUA05910
DO 14 JJJ=1,TMXSY,1 DUA05920
READ(17,807)SUBARY(IDXZ,JJJ,III), DUA05930
1 SUBARY(IDXZX,JJJ,III), DUA05940
2 SUBARY(IDXZY,JJJ,III), DUA05950
3 SUBARY(IDXMSK,JJJ,III) DUA05960
807 FORMAT(5X,4(E15.8,2X)) DUA05970
14 CONTINUE DUA05980
13 CONTINUE DUA05990
DO 15 IIII=1,TMXMX,1 DUA06000

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DO 16 JJJJ=1,TXMY,1
READ(18,807)MAIARY(IDXZ,JJJJ,IIII),
1 MAIARY(IDXZX,JJJJ,IIII),
2 MAIARY(IDXZY,JJJJ,IIII),
3 MAIARY(IDXMSK,JJJJ,IIII)
16 CONTINUE
15 CONTINUE
*****
** INITIAL CALCULATIONS
*****
DO 00100 I = 1,PDX,1
DTAARY(I) = DTXARX(I)
00100 CONTINUE
LAMBDA = C/FREQ
K = 2*PI/LAMBDA
MAXMX = PMXMX
MAXMY = PMXMY
MAXSX = PMXSX
MAXSY = PMXSY
MAGSR = 0
DO 00200 V = 1,3,1
R1TMP = REFXYZ(V) - FEDXYZ(V)
SR(V) = R1TMP
MAGSR = MAGSR + R1TMP*R1TMP
00200 CONTINUE
MAGSR=SQRT(MAGSR)
DO 00300 V = 1,3,1
USR(V) = SR(V)/MAGSR
00300 CONTINUE
*****
*****INPUT : FAR-FIELD LIMIT POINTS*****
***** E-PLANE : 90 - 270 PHI CUTS
***** H-PLANE : 0 - 180 PHI CUTS
***** 45-PLANE: 45 - 225 PHI CUTS
*****
BEGPHI = 74.99858*pi/180.
ENDPHI = 254.99858*pi/180.
IDXPHI = 1
STPPHI = 1
INCPHI = (ENDPHI-BEGPHI)/IDXPHI
* INCPHI = 0
*****
BEGTHE = 0.
ENDTHE = 5.*PI/180
IDXTHE = 50
STPTHE = 1
INCTHE = (ENDTHE-BEGTHE)/IDXTHE
*****
** Calculate Current Densities on the SubReflector Resulting from Source
*****
INCSXY = INCSX*INCSY
XS = XS0 - INCSX
DO 00700 I = 1,MAXSX,1
XS = XS + INCSX
YS = YS0 - INCSY
DO 00600 J = 1,MAXSY,1
YS = YS + INCSY
ZS = SUBARY(IDXZ,J,I)
MSKFAC = SUBARY(IDXMSK,J,I)
IF (MSKFAC .EQ. 1.) THEN

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MAGSI = 0.
DO 00500 V = 1,3,1
  R1TMP = SUBXYZ(V) - FEDXYZ(V)
  SI(V) = R1TMP
  MAGSI = MAGSI + R1TMP*R1TMP
00500 CONTINUE
  MAGSI=SQRT(MAGSI)
  IF (MAGSI .EQ. 0.) THEN
    STOP
  ENDIF

DO 00510 V = 1,3,1
  USI(V) = SI(V)/MAGSI
00510 CONTINUE
  PVX = (-USIX*USIY)
  PVY = ( USIX*USIX + USIZ*USIZ)
  PVZ = (-USIY*USIZ)
  MAGPV = SQRT(PVX*PVX + PVY*PVY + PVZ*PVZ)
DO 00520 V = 1,3,1
  UPV(V) = PV(V)/MAGPV
00520 CONTINUE
* COSTHE = DOT(USR,UPV,3)
  SCALE = FDPTRN(USR,USI,Q,COZ,FLG)/ETA
  IF ( (FLG .EQ. 1)
1 .OR.(SCALE .EQ. 0.)) THEN
  STOP
ENDIF
CALL CROSS(HV,USI,UPV)
MAGHV = SQRT(HVX*HVX + HVY*HVY + HVZ*HVZ)
DO 00530 V = 1,3,1
  UHV(V) = HV(V)/MAGHV
00530 CONTINUE
  NX = SUBARY(IDXZX,J,I)
  NY = SUBARY(IDXZY,J,I)
  NZ = -1
  MAGNRM = SQRT(NX*NX + NY*NY +1)
DO 00540 V = 1,3,1
  R1TMP = NORM(V)/MAGNRM
  NORM(V) = R1TMP
  SCDARY(V,IDXNRM,J,I) = R1TMP
00540 CONTINUE
* CALL CROSS(JV,NORM,UHV)
  MAGJV = SQRT(JVX*JVX + JVY*JVY + JVZ*JVZ)
  MAGJV = 1.
DO 00550 V = 1,3,1
  R1TMP = JV(V)/MAGJV
  UJV(V) = R1TMP
  SCDARY(V,IDXJVX,J,I) = R1TMP
00550 CONTINUE
  IF (MAGSI .EQ. 0.) THEN
    STOP
  ENDIF

  SCDARY(IDXMNM,IDXDTX,J,I) = MAGNRM
  SCDARY(IDXMSI,IDXDTX,J,I) = MAGSI
  SCDARY(IDXAOT,IDXDTX,J,I) = (2.*SCALE)
  SCALE = 2.*SCALE/MAGSI
  COSKR = COS(K*MAGSI)
  SINKR = SIN(K*MAGSI)
  JFLD(IDXVCX,IDXRMJ) = (SCALE*UJV(IDXVCX)*COSKR)
  JFLD(IDXVCY,IDXRMJ) = (SCALE*UJV(IDXVCY)*COSKR)
  JFLD(IDXVCZ,IDXRMJ) = (SCALE*UJV(IDXVCZ)*COSKR)

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DUA06610
DUA06620
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DUA07140
DUA07150
DUA07160
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DUA07180
DUA07190
DUA07200

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                JFLD(IDXVCX,IDXIMJ) = -(SCALE*UJV(IDXVCX)*SINKR)          DUA07210
                JFLD(IDXVCY,IDXIMJ) = -(SCALE*UJV(IDXVCY)*SINKR)          DUA07220
                JFLD(IDXVCZ,IDXIMJ) = -(SCALE*UJV(IDXVCZ)*SINKR)          DUA07230
    ELSE                                                DUA07240
    ENDIF                                              DUA07250
00599  CONTINUE                                       DUA07260
00600  CONTINUE                                       DUA07270
00700  CONTINUE                                       DUA07280
*****DUA07290
** Calculate Induced Magnetic Field on Main Reflector by Sub Reflector. DUA07300
*****DUA07310
    INCMXY = INCMX*INCMY          DUA07320
    XM      = XMO - INCMX         DUA07330
    DO 01900  IP = 1,MAXMX,1      DUA07340
        XM = XM + INCMX          DUA07350
        YM      = YMO - INCMY     DUA07360
        DO 01800  JP = 1,MAXMY,1  DUA07370
            YM = YM + INCMY       DUA07380
            ZM = MAIARY(IDXZ,JP,IP) DUA07390
            MSKFAC = MAIARY(IDXMSK,JP,IP) DUA07400
            IF (MSKFAC .EQ. 1.) THEN DUA07410
                NX = -(MAIARY(IDXZX,JP,IP)) DUA07420
                NY = -(MAIARY(IDXZY,JP,IP)) DUA07430
                NZ = +1.          DUA07440
                MAGNRM = SQRT(NX*NX + NY*NY +1.) DUA07450
                DO 01100  V = 1,3,1 DUA07460
                    NORM(V) = NORM(V)/MAGNRM DUA07470
                    DO 01000 W = 1,2,1 DUA07480
                        HFLD(V,W) = 0. DUA07490
                    CONTINUE DUA07500
                CONTINUE DUA07510
            XS      = XS0 - INCSX   DUA07520
            DO 01700  I = 1,MAXSX,1 DUA07530
                XS = XS + INCSX   DUA07540
                YS      = YS0 - INCSY DUA07550
                DO 01600  J = 1,MAXSY,1 DUA07560
                    YS = YS + INCSY DUA07570
                    ZS = SUBARY(IDXZ,J,I) DUA07580
                    MSKFAC = SUBARY(IDXMSK,J,I) DUA07590
                    IF (MSKFAC .EQ. 1.) THEN DUA07600
                        DS      = SCDARY(IDXMNM,IDXDTX,J,I)*INCSXY DUA07610
                        MAGSI = SCDARY(IDXMSI,IDXDTX,J,I) DUA07620
                        SCALE = SCDARY(IDXAOT,IDXDTX,J,I) DUA07630
                        MAGR1 = 0. DUA07640
                        DO 01200  V = 1,3,1 DUA07650
                            R1TMP = (MAIXYZ(V) - SUBXYZ(V)) DUA07660
                            R1(V) = R1TMP DUA07670
                            MAGR1 = MAGR1 + R1TMP*R1TMP DUA07680
                        CONTINUE DUA07690
                        MAGR1 = SQRT(MAGR1) DUA07700
                        DO 01300  V = 1,3,1 DUA07710
                            UR1(V) = R1(V)/MAGR1 DUA07720
                            UHV(V) = SCDARY(V,IDXJVX,J,I) DUA07730
                        CONTINUE DUA07740
                    KR = (K*(MAGR1 + MAGSI)) DUA07750
                    RR = MAGR1*MAGSI DUA07760
                    COSKR = +COS(KR)/RR DUA07770
                    SINKR = -SIN(KR)/RR DUA07780
                    * CALL CROSS(INTG,SCDARY(IDXVCX,IDXJVX,J,I),UR1) DUA07790
                    CALL CROSS(INTG,UHV,UR1) DUA07800

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MAGINT = 1. DUA07810
* 0 MAGINT = SQRT(( (INTX*INTX) DUA07820
* 1 + (INTY*INTY) DUA07830
* 2 + (INTZ*INTZ))) DUA07840
INTX = INTX/MAGINT DUA07850
INTY = INTY/MAGINT DUA07860
INTZ = INTZ/MAGINT DUA07870
DO 01500 V = 1,3,1 DUA07880
DO 01400 W = 1,2,1 DUA07890
0 HFLD(V,W) = HFLD(V,W) DUA07900
1 +SCALE*PSI(W)*INTG(V)*DS DUA07910
01400 CONTINUE DUA07920
01500 CONTINUE DUA07930
ENDIF DUA07940
01599 CONTINUE DUA07950
01600 CONTINUE DUA07960
01700 CONTINUE DUA07970
MCDARY(IDXVCX,IDXUNM,JP,IP) = NX DUA07980
MCDARY(IDXVCY,IDXUNM,JP,IP) = NY DUA07990
MCDARY(IDXVCZ,IDXUNM,JP,IP) = NZ DUA08000
CALL SCALER(NORM,NORM,2.) DUA08010
CALL CROSS (JFLD(IDXVCX,IDXRMJ),NORM,HFLD(IDXVCX,IDXRMJ)) DUA08020
CALL CROSS (JFLD(IDXVCX,IDXIMJ),NORM,HFLD(IDXVCX,IDXIMJ)) DUA08030
DO 01720 V = 1,3,1 DUA08040
DO 01710 W = 1,2,1 DUA08050
MCDARY(V,W,JP,IP) = JFLD(V,W) DUA08060
01710 CONTINUE DUA08070
01720 CONTINUE DUA08080
*****DUA08090
ELSE DUA08100
JFLD(IDXVCX,IDXRMJ) = 0. DUA08110
JFLD(IDXVCY,IDXRMJ) = 0. DUA08120
JFLD(IDXVCZ,IDXRMJ) = 0. DUA08130
JFLD(IDXVCX,IDXIMJ) = 0. DUA08140
JFLD(IDXVCY,IDXIMJ) = 0. DUA08150
JFLD(IDXVCZ,IDXIMJ) = 0. DUA08160
MAGJV = 0. DUA08170
ENDIF DUA08180
*****DUA08190
01799 CONTINUE DUA08200
01800 CONTINUE DUA08210
01900 CONTINUE DUA08220
*****DUA08230
*** FAR FIELD ANTENNA PATTERN COMPUTATION DUA08240
*****DUA08250
PTTMIN = +1.E+38 DUA08260
PTTMAX = -1.E+38 DUA08270
ANGPHI = BEGPHI - INCPHI DUA08280
DO 02600 ANGPHX = 0,IDXPHI,STPPHI DUA08290
ANGPHI = ANGPHI + INCPHI DUA08300
SINPHI = SIN(ANGPHI) DUA08310
COSPHI = COS(ANGPHI) DUA08320
ANGTHE = BEGTHE - INCTHE DUA08330
DO 02500 ANGTHX = 0,IDXTHE,STPTHE DUA08340
ANGTHE = ANGTHE + INCTHE DUA08350
SINTHE = SIN(ANGTHE) DUA08360
COSTHE = COS(ANGTHE) DUA08370
RFFX = SINTHE*COSPHI DUA08380
RFFY = SINTHE*SINPHI DUA08390
RFFZ = COSTHE DUA08400

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	SUM(1,1) = 0.	DUA08410
	SUM(1,2) = 0.	DUA08420
	SUM(2,1) = 0.	DUA08430
	SUM(2,2) = 0.	DUA08440
	SUM(3,1) = 0.	DUA08450
	SUM(3,2) = 0.	DUA08460
	XM = XM0 - INCMX	DUA08470
	DO 02400 IP = 1,MAXMX,1	DUA08480
	XM = XM + INCMX	DUA08490
	YM = YM0 - INCMY	DUA08500
	DO 02300 JP = 1,MAXMY,1	DUA08510
	YM = YM + INCMY	DUA08520
	ZM = MAIARY(IDXZ,JP,IP)	DUA08530
	KR = (K*((RFFX*XM)+(RFFY*YM)+(RFFZ*ZM)))	DUA08540
	COSKR = COS(KR)	DUA08550
	SINKR = SIN(KR)	DUA08560
	MSKFAC = MAIARY(IDXMSK,JP,IP)	DUA08570
	IF(MSKFAC.EQ.0)GO TO 2300	DUA08580
	NORM(IDXVCX) = -MAIARY(IDXZX,JP,IP)	DUA08590
	NORM(IDXVCY) = -MAIARY(IDXZY,JP,IP)	DUA08600
	NORM(IDXVCZ) = +1.	DUA08610
0	DS = INCMXY*SQRT(NORM(IDXVCX)*NORM(IDXVCX)	DUA08620
2	+NORM(IDXVCY)*NORM(IDXVCY)	DUA08630
3	+NORM(IDXVCZ)*NORM(IDXVCZ))	DUA08640
	CMPTMP (IDXRMJ) =	DUA08650
1	RFFX*MCDARY (IDXVCX,IDXRMJ,JP,IP)	DUA08660
2	+ RFFY*MCDARY (IDXVCY,IDXRMJ,JP,IP)	DUA08670
3	+ RFFZ*MCDARY (IDXVCZ,IDXRMJ,JP,IP)	DUA08680
	CMPTMP (IDXIMJ) =	DUA08690
1	RFFX*MCDARY (IDXVCX,IDXIMJ,JP,IP)	DUA08700
2	+ RFFY*MCDARY (IDXVCY,IDXIMJ,JP,IP)	DUA08710
3	+ RFFZ*MCDARY (IDXVCZ,IDXIMJ,JP,IP)	DUA08720
	TMRX = CMPTMP (IDXRMJ)*RFFX	DUA08730
	TMRY = CMPTMP (IDXRMJ)*RFFY	DUA08740
	TMRZ = CMPTMP (IDXRMJ)*RFFZ	DUA08750
	TMIX = CMPTMP (IDXIMJ)*RFFX	DUA08760
	TMIY = CMPTMP (IDXIMJ)*RFFY	DUA08770
	TMIZ = CMPTMP (IDXIMJ)*RFFZ	DUA08780
	TMRX = MCDARY (IDXVCX,IDXRMJ,JP,IP) - TMRX	DUA08790
	TMRY = MCDARY (IDXVCY,IDXRMJ,JP,IP) - TMRY	DUA08800
	TMRZ = MCDARY (IDXVCZ,IDXRMJ,JP,IP) - TMRZ	DUA08810
	TMIX = MCDARY (IDXVCX,IDXIMJ,JP,IP) - TMIX	DUA08820
	TMIY = MCDARY (IDXVCY,IDXIMJ,JP,IP) - TMIY	DUA08830
	TMIZ = MCDARY (IDXVCZ,IDXIMJ,JP,IP) - TMIZ	DUA08840
	TTMRX = ((TMRX*COSKR)-(TMIX*SINKR))	DUA08850
	TTMRY = ((TMRY*COSKR)-(TMIY*SINKR))	DUA08860
	TTMRZ = ((TMRZ*COSKR)-(TMIZ*SINKR))	DUA08870
	TTMIX = ((TMRX*SINKR)+(TMIX*COSKR))	DUA08880
	TTMIY = ((TMRY*SINKR)+(TMIY*COSKR))	DUA08890
	TTMIZ = ((TMRZ*SINKR)+(TMIZ*COSKR))	DUA08900
	JVRX = TTMRX*DS	DUA08910
	JVRY = TTMRY*DS	DUA08920
	JVRZ = TTMRZ*DS	DUA08930
	JVIX = TTMIX*DS	DUA08940
	JVIY = TTMIY*DS	DUA08950
	JVIZ = TTMIZ*DS	DUA08960
	SUMRX = SUMRX + JVRX	DUA08970
	SUMRY = SUMRY + JVRY	DUA08980
	SUMRZ = SUMRZ + JVRZ	DUA08990
	SUMIX = SUMIX + JVIX	DUA09000

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SUMIY = SUMIY + JVIY
SUMIZ = SUMIZ + JVIZ
DUA09010
02299 CONTINUE DUA09020
02300 CONTINUE DUA09030
02400 CONTINUE DUA09040
0 ETHRE = SUMRX*COSTHE*COSPHI DUA09050
1 + SUMRY*COSTHE*SINPHI DUA09060
2 - SUMRZ*SIN THE DUA09070
0 ETHIM = SUMIX*COSTHE*COSPHI DUA09080
1 + SUMIY*COSTHE*SINPHI DUA09090
2 - SUMIZ*SIN THE DUA09100
0 EPHRE = - SUMRX*SINPHI DUA09110
1 + SUMRY*COSPHI DUA09120
0 EPHIM = - SUMIX*SINPHI DUA09130
1 + SUMIY*COSPHI DUA09140
***** DUA09150
*****ETHETA AND EPHI COMPUTED ***** DUA09160
*****TRANSFORM TO CO AND CO-POL LUDWIG'S DEFINITION***** DUA09170
***** DUA09180
AREFR=SINPHI*ETHRE+COSPHI*EPHRE DUA09190
AREFI=SINPHI*ETHIM+COSPHI*EPHIM DUA09200
ACRPR=-COSPHI*ETHRE+SINPHI*EPHRE DUA09210
ACRPI=-COSPHI*ETHIM+SINPHI*EPHIM DUA09220
***** DUA09230
AMGREF=AREFR**2+AREFI**2 DUA09240
AMGCRP=ACRPR**2+ACRPI**2 DUA09250
*****CO AND CROSS POL FIELDS ARE COMPLETED***** DUA09260
***** DUA09270
*****TOTAL FIELD***** DUA09280
* 0 R1TMP = ETHRE*ETHRE + ETHIM*ETHIM DUA09290
* 1 + EPHRE*EPHRE + EPHIM*EPHIM DUA09300
*****PLOT THE CO POL FIELDS***** DUA09310
R1TMP = AMGREF DUA09320
*****PLOT THE CROSS POL FIELDS***** DUA09330
* R1TMP = AMGCRP DUA09340
***** DUA09350
PTTRN(IDXPWR,ANGTHX,ANGPHX) = R1TMP DUA09360
IF (R1TMP .LT. PTTMIN) THEN DUA09370
PTTMIN = R1TMP DUA09380
ENDIF DUA09390
IF (R1TMP .GT. PTTMAX) THEN DUA09400
PTTMAX = R1TMP DUA09410
ENDIF DUA09420
02500 CONTINUE DUA09430
02600 CONTINUE DUA09440
PRAD = ((2.*PI)/(ETA*((2.*Q)+1))) DUA09450
RIFCTR = (((K*K*K*K)*ETA)/(256.*(PI*PI*PI*PI))) DUA09460
RINTNS = (RIFCTR*PTTMAX) DUA09470
DIRCTV = ((4.*PI*RINTNS)/(PRAD)) DUA09480
DIRCTV = (10*ALOG10(DIRCTV)) DUA09490
***** DUA09500
WRITE(19,897)DIRCTV DUA09510
897 FORMAT(5X,F15.5) DUA09520
***** DUA09530
ADBMNX = 10.*ALOG10(PTTMIN) DUA09540
ADBMXX = 10.*ALOG10(PTTMAX) DUA09550
RDBMNX = (ADBMNX - ADBMXX) DUA09560
ANGPHI = BEGPHI - INCPHI DUA09570
DO 02800 ANGPHX = 0,IDXPHI,STPPHI DUA09580
ANGPHI = ANGPHI + INCPHI DUA09590
DUA09600

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      ANGTHE = BEGTHE - INCTHE
      DO 02700  ANGTHX = 0,IDXTHE,STPTHE
      ANGTHE = ANGTHE + INCTHE
      R1TMP = 10.*ALOG10((PTTRN(IDXPWR,ANGTHX,ANGPHX)))
      PTTRN(IDXADB,ANGTHX,ANGPHX) = (R1TMP
      PTTRN(IDXRDB,ANGTHX,ANGPHX) = (R1TMP - ADBMXX)
*****
*****GENERATE THE OUTPUT ARRAYS*****
*****
      ZETA=ANGTHE*180/PI
      APhi=ANGPHI*180/PI
      WRITE(19,895)PTTRN(IDXRDB,ANGTHX,ANGPHX),ZETA,APHI
895      FORMAT(5X,F15.8,3X,2(F15.8,3X))
02700      CONTINUE
02800 CONTINUE
      DTXARY( 2) = ENDPHI
      DTXARY( 3) = REAL(IDXPHI)
      DTXARY( 4) = REAL(STPPHI)
      DTXARY( 5) = INCPHI
      DTXARY( 6) = BEGTHE
      DTXARY( 7) = ENDTHE
      DTXARY( 8) = REAL(IDXTHE)
      DTXARY( 9) = REAL(STPTHE)
      DTXARY(10) = INCTHE
      DTXARY(11) = PTTMIN
      DTXARY(12) = PTTMAX
      END
*****
*****REAL FUNCTION FDPTRN RETURN FEED PATTERN*****
*****
      REAL FUNCTION FDPTRN(THETA,PHI,RHO,COZ,ERR)
      REAL THETA(3)
      REAL PHI(3)
      REAL RHO
      REAL COZ
      INTEGER ERR
      REAL DOT
      EXTERNAL DOT
      REAL DOTVAL
      DOTVAL = DOT(THETA,PHI,3)
      IF (DOTVAL .LT. 0.) THEN
          ERR = 1
          ERR = 1
          COZ = 0.
          FDPTRN = 0.
      ELSE
          ERR = 0
          COZ = DOTVAL
          FDPTRN = (DOTVAL)**RHO
      ENDIF
      RETURN
      END
*****
** REAL FUNCTION DOT() ! Returns Real Value of DOT PRODUCT A and B
*****
      REAL FUNCTION DOT(A,B,N)
      INTEGER N
      REAL A(N)
      REAL B(N)
      INTEGER I

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REAL      SUM                                DUA10210
SUM = 0.                                       DUA10220
DO 00100 I = 1,N,1                             DUA10230
    SUM = SUM + A(I)*B(I)                       DUA10240
00100 CONTINUE                                 DUA10250
    DOT = SUM                                   DUA10260
RETURN                                          DUA10270
END                                              DUA10280
*****DUA10290
** SUBROUTINE CROSS      ! Performs C = AxB      DUA10300
*****DUA10310
SUBROUTINE CROSS(C,A,B)                       DUA10320
REAL      C(3)                                 DUA10330
REAL      A(3)                                 DUA10340
REAL      B(3)                                 DUA10350
    C(1) = +((A(2)*B(3))-(A(3)*B(2)))          DUA10360
    C(2) = -((A(1)*B(3))-(A(3)*B(1)))          DUA10370
    C(3) = +((A(1)*B(2))-(A(2)*B(1)))          DUA10380
END                                              DUA10390
*****DUA10400
** SUBROUTINE SCALER     ! Performs C = A*⟨SCALER⟩ DUA10410
*****DUA10420
SUBROUTINE SCALER(C,A,SCALEX)                 DUA10430
REAL      C(3)                                 DUA10440
REAL      A(3)                                 DUA10450
REAL      SCALEX                               DUA10460
    C(1) = SCALEX*(A(1))                       DUA10470
    C(2) = SCALEX*(A(2))                       DUA10480
    C(3) = SCALEX*(A(3))                       DUA10490
RETURN                                          DUA10500
END                                              DUA10510
*****DUA10520
** SUBROUTINE VECADD     ! Performs C = A+B      DUA10530
*****DUA10540
SUBROUTINE VECADD(C,A,B)                      DUA10550
REAL      C(3)                                 DUA10560
REAL      A(3)                                 DUA10570
REAL      B(3)                                 DUA10580
    C(1) = (A(1)+B(1))                         DUA10590
    C(2) = (A(2)+B(2))                         DUA10600
    C(3) = (A(3)+B(3))                         DUA10610
RETURN                                          DUA10620
END                                              DUA10630
*****DUA10640
** SUBROUTINE VECSUB     ! Performs C = A-B      DUA10650
*****DUA10660
SUBROUTINE VECSUB(C,A,B)                     DUA10670
REAL      C(3)                                 DUA10680
REAL      A(3)                                 DUA10690
REAL      B(3)                                 DUA10700
    C(1) = (A(1)-B(1))                         DUA10710
    C(2) = (A(2)-B(2))                         DUA10720
    C(3) = (A(3)-B(3))                         DUA10730
RETURN                                          DUA10740
END                                              DUA10750

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PROGRAM FFPL0T
DIMENSION X(10000),Y(10000),VARS(20)
DIMENSION XPL(1000),YPL(1000)
CHARACTER*13 CH/'DIRECTIVITY ='/
CHARACTER*2 ADB/'DB'/
CHARACTER*5 DIR(1)
C*****THIS PROGRAM CAN BE USED TO PLOT THE ANTENNA FAR-FIELD PATTERN
C***** (E-PLANE OR H-PLANE CUTS)
C***** IAXIS, NUM, Y, RTNARR: PARAMETERS IN SCLBK2
C***** IVAR: PARAMETERS IN GLOT3
      INTEGER * 4 IAXIS /0/
      INTEGER * 4 IVARS(20)
      INTEGER * 4 NUM/10000/
      CHARACTER*4 XTITLE(5) /'ELEV', 'ATIO', 'N AN', 'GLE ', 'DEG.' /
      CHARACTER*4 YTITLE(6) /'RELA', 'TIVE', ' AMP', 'LITU', 'DE ', '(DB)' /
C***** NP : TOTAL NO. OF POINTS ; ZM: MAXM. VIEWING ANGLE(DEG.)

      READ(19,756)DDIR
756      FORMAT(5X,F15.5)
*****2(NFF+1)
      NP=102
      ZM=2.

      DO 15 J=1,NP
C*****X : ANGLE POSITIONS(DEG.) ; Y: RELATIVE FAR FLD. AMPLITUDES(DB)
      READ(19,300)YPL(J),XPL(J),DUM1
300      FORMAT(5X,F15.8,3X,2(F15.8,3X))
15      CONTINUE
      DO 98 J=1,51
      Y(J)=(YPL(103-J))
      X(J)=-XPL(103-J)
      Y(J+51)=(YPL(J))
      X(J+51)=XPL(J)
98      CONTINUE

C*****SCLKK2:GRAPH3D ROUTINE TO FIND MIN,MAX IN DATA
C***** 0 : Y-COORDINATE ; NUM : DIMENSION OF Y-ARRAY ; Y : Y-ARRAY
C*****RTNARR(2) : DIMENSION TO STORE Y(MIN),Y(MAX) VALUES
C*****REARRANGE THE FAR FIELD VALUES*****
C*****UXTRM :GRAPH3D ROUTINE; DEFINES EXTREME POSITIONS OF A 3D PLOT
C*****8 :TOTAL NO. OF VARIABLES ; 0 :CARTESIAN ; (-ZM,ZM) :(XMIN,XMAX)
C*****(-80.,0) :(YMIN,YMAX) ; (0.,0.) :(ZMIN,ZMAX)
      CALL UXTRM(8,0,-ZM,ZM,-54.,0.,0.0,0.)
C*****UMAPF :GRAPH3D ROUTINE , DEFINE MAPPING TO TRANSFORM FROM USER
C*****TO RELATIVE UNITS.
C***** 0 :CARTESIAN ; 1. :ONE VARS,DEFAULT ; 0 :NO LOG SCALE
      CALL UMAPF(0,1.,0)
C*****XAXIS3 : GRAPH3D ROUTINE , DEFINES X-AXIX COORDINATE
C***** VARS: 1=TOTAL NO OF VARS ; 2 3 4=X1 Y1 Z1 ; 5 6 7=X2 Y2 Z2
C***** 8=USER UNIT(1.) ; 9=NO. OF INTERVALS ; 10=GRID OPTION(1.)
C***** 11=DRAW PARALLEL TO Y-AXIS ; 12=VARS(9)+1 ; 13=SIZE OF LABEL
C***** 14=(DIR.OF X AXIS)(CENTERED AT GRID)(CLOCKWISE TO AXIS)
C***** 15=AXIS SETTING IS NOT COMPLETE
      VARS(1)=15
      VARS(2)=-ZM
      VARS(3)=-54.
      VARS(4)=0.0
      VARS(5)=ZM
      VARS(6)=-54.
      VARS(7)=0.

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VARS(8)=1. FFP00600
VARS(9)=10. FFP00610
VARS(10)=1. FFP00620
VARS(11)=4. FFP00630
VARS(12)=11. FFP00640
VARS(13)=20. FFP00650
VARS(14)=211. FFP00660
VARS(15)=0. FFP00670
CALL XAXIS3(VARS) FFP00680
C*****VARS : 2 3 4 =X1 Y1 Z1 ; 5 6 7=X2 Y2 Z2 ; 8=USER UNIT ; 9=NO. OF FFP00690
C*****INTERVALS ; 10=GRID OPTION ; 11=DRAW PARALLEL TO X-AXIS ; 12= FFP00700
C*****VARS(9)+1 ; 13=SIZE OF LABEL ; 14=DIR. OF X-AXIS ; 15=AXIS SETTING FFP00710
C*****COMPLETE. FFP00720
VARS(2)=-ZM FFP00730
VARS(3)=-54. FFP00740
VARS(4)=0. FFP00750
VARS(5)=-ZM FFP00760
VARS(6)=0. FFP00770
VARS(7)=0. FFP00780
VARS(8)=1. FFP00790
VARS(9)=9. FFP00800
VARS(10)=1. FFP00810
VARS(11)=3. FFP00820
VARS(12)=10. FFP00830
VARS(13)=20. FFP00840
VARS(14)=212. FFP00850
VARS(15)=1. FFP00860
CALL YAXIS3(VARS) FFP00870
C*****TITLE3 : GRAPH3D ROUTINE ; PRINTS TITLE OF X-AXIS FFP00880
C***** 4=X-AXIS ; 20=X-ALPHANUMERIC DIMENSION ; 15=CHARACTER SIZE FFP00890
CALL TITLE3(4,20,15,XTITLE,0.,1.,0.) FFP00900
C*****TITLE3 : GRAPH3D ROUTINE ; PRINTS Y-AXIS TITLE FFP00910
C***** 3=Y-AXIS ; 18=Y-ALPHANUMERIC DIMENSION ; 15=CHARACTER SIZE FFP00920
CALL TITLE3(3,24,15,YTITLE,-1.,0.,0.) FFP00930
C*****GLOT3 : GRAPH3D ROUTINE ; TO PLOT A CURVE WITH POINT OR VECTOR FFP00940
C*****IVARS : 1=DIMENSION OF IVARS ; 2=NO. OF POINTS,EXACT ; 3=NO Z-AXIS FFP00950
C***** 4=DO NOT CALL AXIS ROUTINES ; 5=POINT PLOT ; 6=SYMBOL FREQUENCY FFP00960
C***** 7=SIZE OF SYMBOL ; 8=EXACT MIN-MAX INTERVAL FFP00970
IVARS(1)=8 FFP00980
IVARS(2)=NP FFP00990
IVARS(3)=0 FFP01000
IVARS(4)=0 FFP01010
IVARS(5)=0 FFP01020
IVARS(6)=1 FFP01030
IVARS(7)=15 FFP01040
IVARS(8)=1 FFP01050
CALL GLOT3(IVARS,X,Y) FFP01060
CALL CHARS3(13,CH,3.,10.5,0.,25,1.) FFP01070
CALL NUMBER(4,DDIR,5,2,DIR) FFP01080
CALL CHARS3(5,DIR,7.,10.5,0.,25,1.) FFP01090
CALL CHARS3(2,ADB,9.,10.5,0.,25,1.) FFP01100
C*****GVIEW : GRAPH3D ROUTINE ; IDENTIFIES VIEWING ENVIRONMENT FFP01110
C***** 1=DEFAULT VALUES FOR THREE REMAINING VARIABLES FFP01120
CALL GVIEW(1) FFP01130
C*****WINDW : GRAPH3D ROUTINE ; SPECIFY DIMENSION OF VIEW WINDOW FFP01140
C***** 6=TOTAL NO OF VARIABLES ; 0=LOWEST OF THE PARAMETER RANGE FFP01150
C*****UMIN=MIN. VALUE OF NO. OF RELATIVE UNITS FROM VIEW REFERENCE FFP01160
C*****UMAX=MAX. VALUE OF NO.OF RELATIVE UNITS FROM VIEW REFERENCE FFP01170
C*****VMIN= " " " " " " " " " " " " FFP01180
C*****VMAX= " " " " " " " " " " " " FFP01190

```



```
CALL WINDW(6,0,-6.5,6.5,-6.5,6.5)
C*****DISPLA : GRAPH3D ROUTINE ; DISPLAYS INTERNAL BUFFER
C***** 1=OPTION TO CLEAR BUFFER
CALL DISPLA(1)
C*****TERM : GRAPH3D ROUTINE ; REQUIRED TO CLOSE THE GRAPHICS
CALL TERM
STOP
END
```

```
FFP01200
FFP01210
FFP01220
FFP01230
FFP01240
FFP01250
FFP01260
FFP01270
```

```
/* EXEC DUAL REFLECTOR */  
"GRAPH3D"  
SETUP FTN  
"FI 19 DISK DUALREF OUT19 A1"  
"FI 15 DISK DUALREF OUT15 A1"  
"FI 16 DISK DUALREF OUT16 A1"  
"FI 17 DISK DUALREF OUT17 A1"  
"FI 18 DISK DUALREF OUT18 A1"  
"LOAD DRSG(CLEAR START"  
"LOAD DUALREF(CLEAR START"  
"LOAD FFLOT(CLEAR START"
```

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4. Lam, Peter T.; Lee, Shung-Wu and Acosta, Roberto: Secondary Pattern Computation of Arbitrarily Shaped Main Reflector. Electromagnetic Laboratory, University of Illinois Scientific Report 84-7; April 1984.

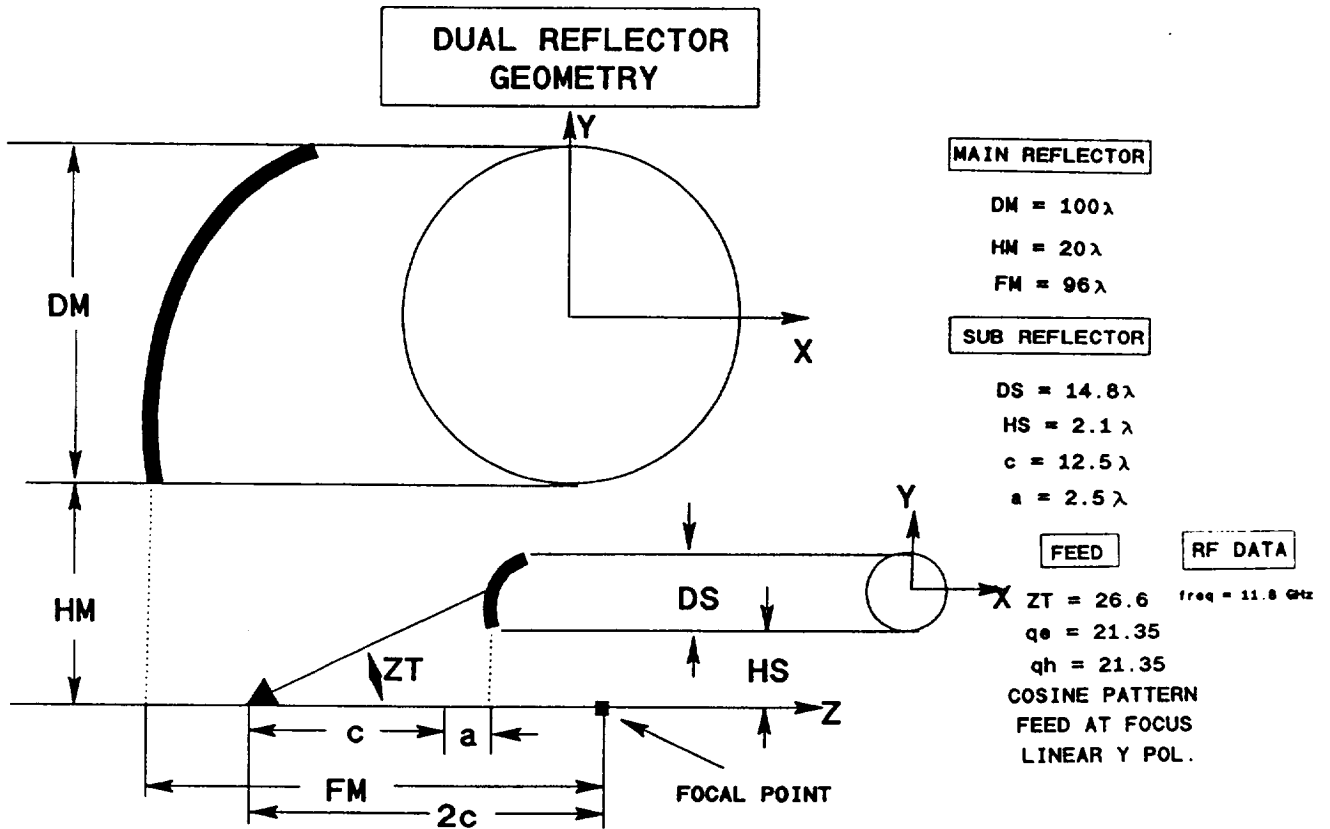


Figure 1, Dual reflector configuration

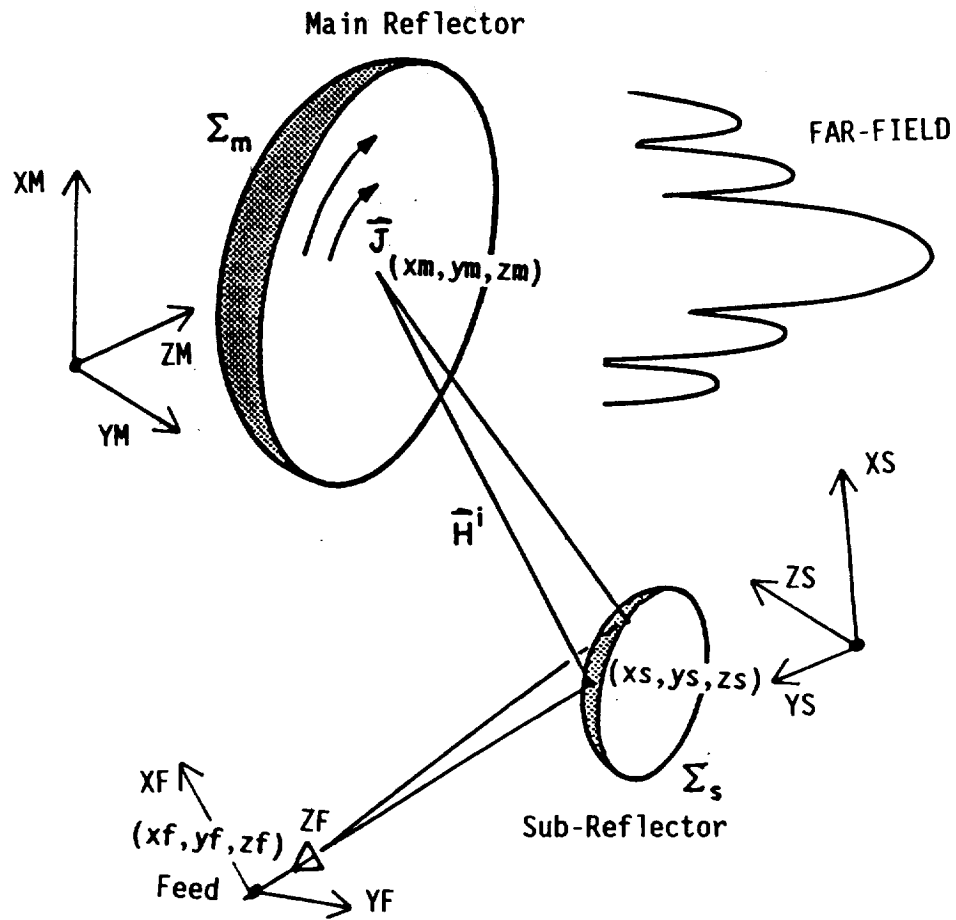


Figure 2, Generalized dual reflector geometry

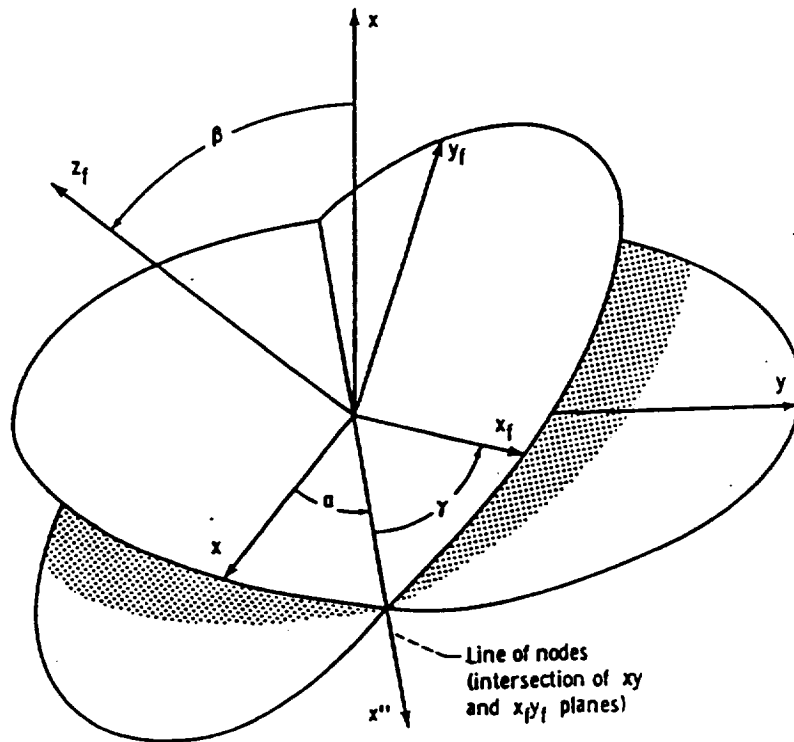


Figure 3, Eulerian angles

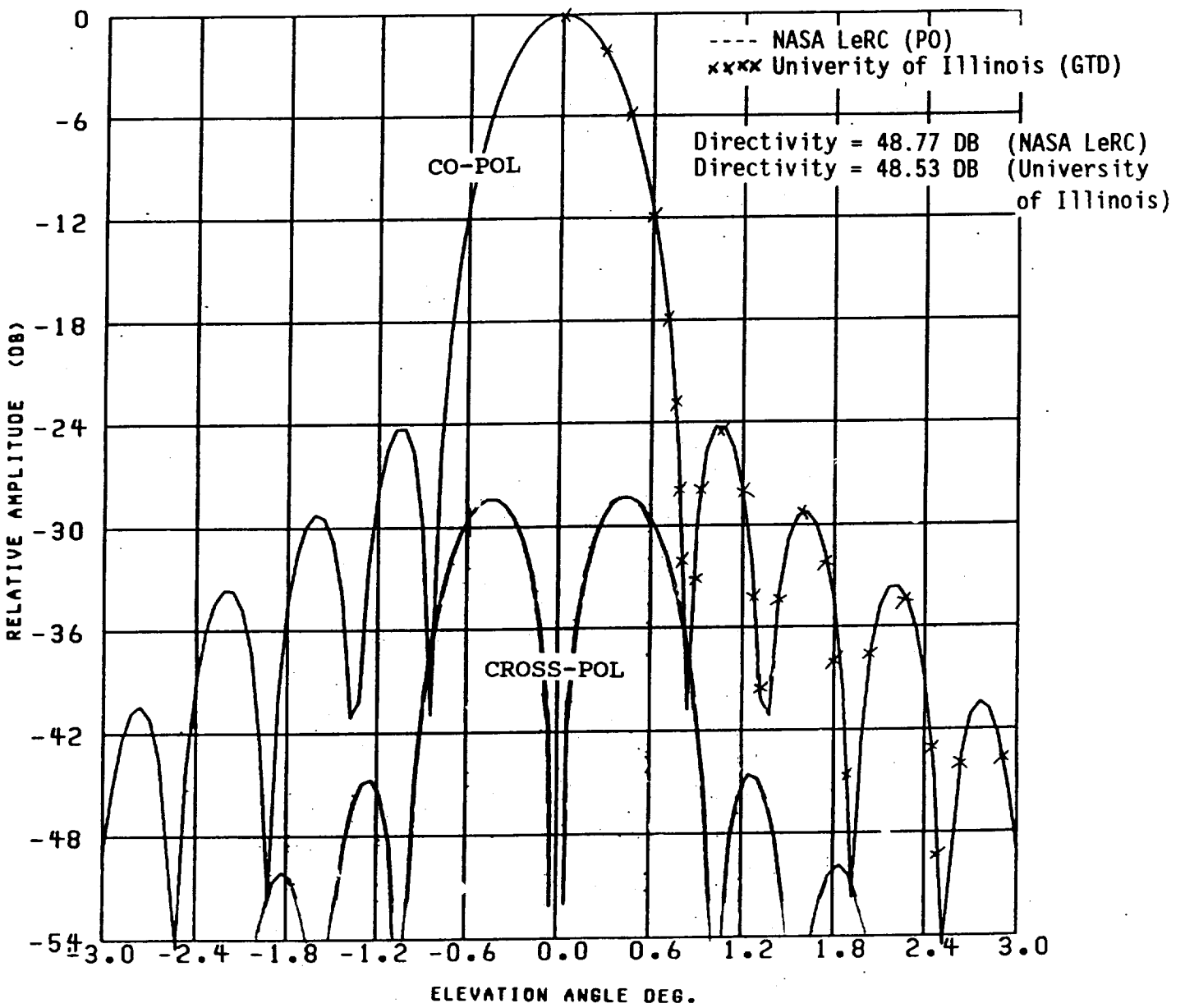


Figure 4a, H-plane far-field antenna pattern

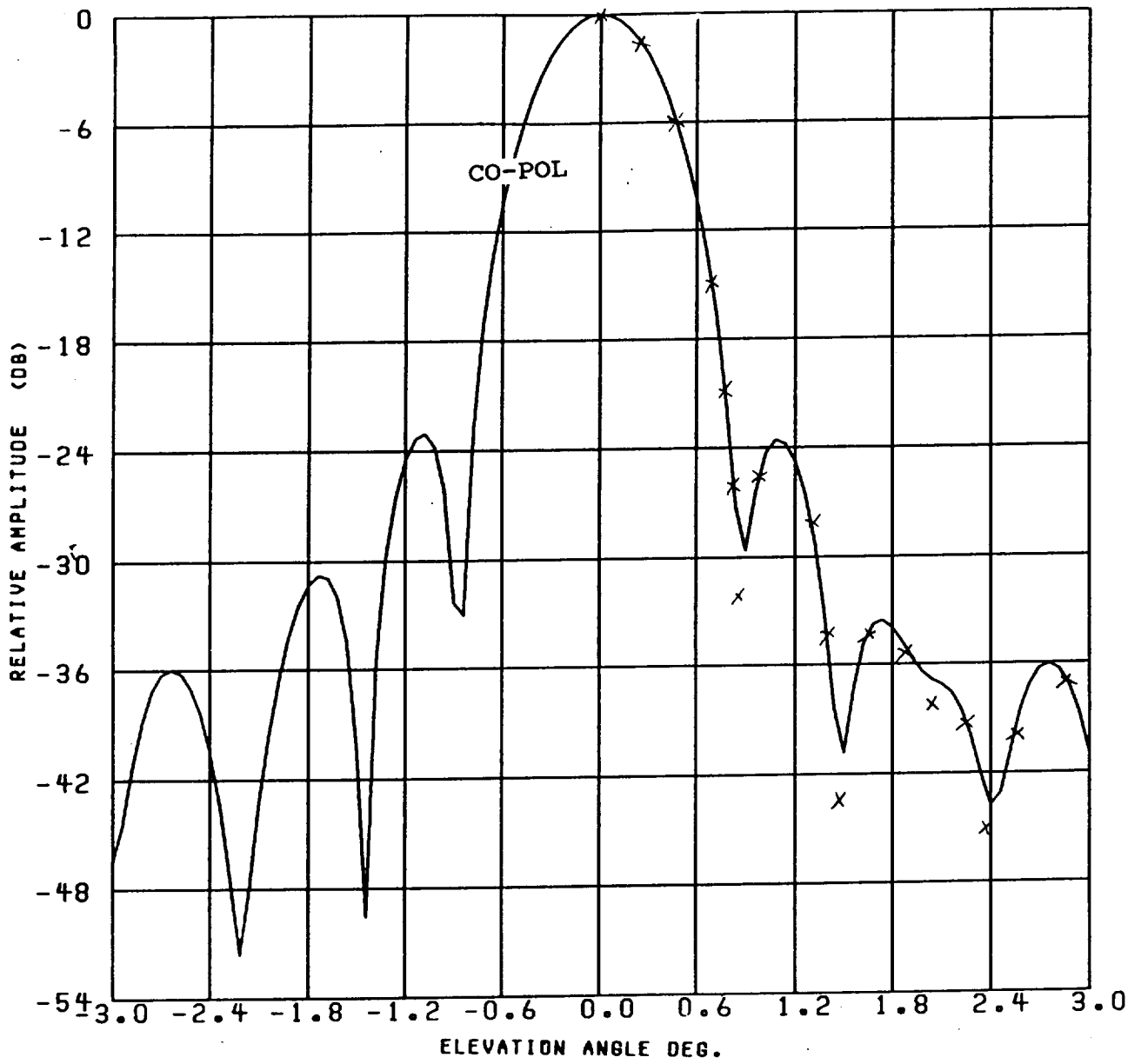


Figure 4b, E-plane far-field antenna pattern

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13. ABSTRACT (Maximum 200 words) Reflector antennas are widely used in communication satellite systems because they provide high gain at low cost. Offset-fed single paraboloids and dual reflector offset Cassegrain and Gregorian antennas with multiple focal region feeds provide a simple, blockage-free means of forming multiple, shaped and isolated beams with low sidelobes. Such antennas are applicable to communications satellite frequency reuse systems and earth stations requiring access to several satellites. While the single offset paraboloid has been the most extensively used configuration for the satellite multiple-beam antenna, the trend toward large apertures requiring minimum scanned beam degradation over the field of view 18 degrees for full earth coverage from geostationary orbit may lead to impractically long focal length and large feed arrays. Dual reflector antennas offer packaging advantages and more degrees of design freedom to improve beam scanning and cross-polarization properties. The Cassegrain and Gregorian antennas are the most commonly used dual reflector antennas. A computer program for calculating the secondary pattern and directivity of a generalized dual reflector antenna system has been developed and implemented at the NASA Lewis Research Center. The theoretical foundation for this program is based on the use of physical optics methodology for describing the induced currents on the sub-reflector and main reflector. The resulting induced currents on the main reflector are integrated to obtain the antenna far-zone electric fields. The computer program is verified with other physical optics programs and with measured antenna patterns. The comparison shows good agreement in far-field sidelobe reproduction and directivity.			
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