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Analysis of a Generalized Dual Reflector Antenna System Using Physical Optics

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ANALYSIS OF A GENERALIZED DUAL REFLECTOR ANTENNA SYSTEM USING PHYSICAL OPTICS

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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 obtained 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 method that can be used for predicting antenna performance characteristics. The method assumes that the complex currents in both reflectors are known. This, currents satisfies Maxwell's equations and are use 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):

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

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).

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

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,

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

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

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).

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

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

$\mathbf{J} = 2(\mathbf{n} \times \mathbf{H}^{inc})$	illuminated region
$\mathbf{J} = 0$	otherwise

where **n** is the unit normal to the surface and **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 (xs,ys,zs) and the feed located at (xf,yf,zf) the incident fields on the sub-reflector are given

$$\mathbf{E} = \frac{e^{-jkr}}{r} \; F(xs,ys,zs) \tag{5a}$$

where F(xs,ys,zs) 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

$$\mathbf{H} = (\mathbf{r} \times \mathbf{E})/Z_0 \tag{5b}$$

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

$$\mathbf{H}(xm,ym,zm) = jk \iint (\mathbf{J} \times \mathbf{r1}) \; \frac{e^{-jkr1}}{4\pi r1} \; ds \tag{6a}$$

$$\mathbf{E}(xm,ym,zm) = -jkZ_0 \iint (\mathbf{J}-(\mathbf{J} \cdot \mathbf{r1})\mathbf{r1}) \; \frac{e^{-jkr1}}{4\pi r1} \; ds \tag{6b}$$

Where **J** is the induced current on the sub-reflector, r1 is the distance from any point in the sub-reflector to the observation point (xm,ym,zm). **r1** is a unit vector in the direction from any point in the sub-reflector to any observation point on the main reflector (xm,ym,zm).

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.

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

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

Where **J** is the induced current in the main reflector, **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

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

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

if the secondary pattern can be expressed as

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

The reference-polarization expression is

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

and the cross-polarization expression is

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

The directivity for the reference polarization is defined by

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

similarly the directivity for the cross polarization is defined by

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

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

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

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

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

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
rtempl (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
rtempl (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
```

```
************************************************************************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                                                   DRS01210
      PARAMETER (ETA    = 4.0*PI*C*(1.E-7)    )                         DRS01220
******************************************************************     DRS01230
******INPUT : FREQUENCY*******************************************     DRS01240
******************************************************************     DRS01250
      REAL        FREQQ                                                 DRS01260
      PARAMETER (FREQQ  = 19.45*(1.E+9)        )                        DRS01270
*****************************************************************      DRS01280
      REAL        LAMBDA                                                DRS01290
      PARAMETER (LAMBDA =(C/FREQQ)*1.000      )                         DRS01300
      REAL        LAMBSQ                                                DRS01310
      PARAMETER (LAMBSQ = LAMBDA*LAMBDA       )                         DRS01320
*****************************************************************      DRS01330
******INPUT : QQ:EXPONED EXPONENT********************************      DRS01340
******************************************************************     DRS01350
      REAL        QQ                                                    DRS01360
      PARAMETER (QQ     = 62.000              )                         DRS01370
******************************************************************     DRS01380
      INTEGER     MXYZ                                                  DRS01390
      PARAMETER (MXYZ   = 4                   )                         DRS01400
      INTEGER     DXYZ                                                  DRS01410
      PARAMETER (DXYZ   = 3                   )                         DRS01420
      INTEGER     LNRY                                                  DRS01430
      PARAMETER (LNRY   = 1                   )                         DRS01440
      INTEGER     VDTX                                                  DRS01450
      PARAMETER (VDTX   = 4                   )                         DRS01460
      INTEGER     MDTX                                                  DRS01470
      PARAMETER (MDTX   = 10                  )                         DRS01480
      INTEGER     IDXZ                                                  DRS01490
      INTEGER     IDXZX                                                 DRS01500
      INTEGER     IDXZY                                                 DRS01510
      INTEGER     IDXMSK                                                DRS01520
      INTEGER     MXMX,MXMY,TMXMX,TMXMY                                 DRS01530
      INTEGER     MXSX,MXSY,TMXSX,TMXSY                                 DRS01540
      PARAMETER (IDXZ   =  1                  )                         DRS01550
      PARAMETER (IDXZX  =  2                  )                         DRS01560
      PARAMETER (IDXZY  =  3                  )                         DRS01570
      PARAMETER (IDXMSK =  4                  )                         DRS01580
******************************************************************     DRS01590
******INPUT : NUMBER OF POINTS (-1) MAIN AND SUB REFLECTOR GRIDS***     DRS01600
******************************************************************     DRS01610
      PARAMETER (MXMX   = 101                 )                         DRS01620
      PARAMETER (MXMY   = 101                 )                         DRS01630
      PARAMETER (MXSX   = 61                  )                         DRS01640
      PARAMETER (MXSY   = 61                  )                         DRS01650
******************************************************************     DRS01660
      PARAMETER (TMXMX  = MXMX + 1            )                         DRS01670
      PARAMETER (TMXMY  = MXMY + 1            )                         DRS01680
      PARAMETER (TMXSX  = MXSX + 1            )                         DRS01690
      PARAMETER (TMXSY  = MXSY + 1            )                         DRS01700
************************************************************************DRS01710
************************************************************************DRS01720
      REAL        MAIARY(4,TMXMY,TMXMX)                                 DRS01730
      REAL        SUBARY(4,TMXSY,TMXSX)                                 DRS01740
      REAL        XYZARY(DXYZ,MXYZ)                                     DRS01750
      REAL        MRXYZ0(DXYZ),XM0,YM0,ZM0                              DRS01760
      REAL        SRXYZ0(DXYZ),XS0,YS0,ZS0                              DRS01770
      REAL        FEDXYZ(DXYZ),XF ,YF ,ZF                               DRS01780
      REAL        REFXYZ(DXYZ),XR ,YR ,ZR                               DRS01790
      REAL        DMX,DMY                                               DRS01800
```

```
      REAL      INCMX,INCMY
      REAL      DSX,DSY
      REAL      INCSX,INCSY
      REAL      FREQ
      REAL      Q
************************************************************************
** EQUIVALENCE
************************************************************************
      EQUIVALENCE (XYZARY(1,1),MRXYZO(1))
      EQUIVALENCE (XYZARY(1,2),SRXYZO(1))
      EQUIVALENCE (XYZARY(1,3),FEDXYZ(1))
      EQUIVALENCE (XYZARY(1,4),REFXYZ(1))
      EQUIVALENCE (MRXYZO(1),XMO   )
      EQUIVALENCE (MRXYZO(2),YMO   )
      EQUIVALENCE (MRXYZO(3),ZMO   )
      EQUIVALENCE (SRXYZO(1),XSO   )
      EQUIVALENCE (SRXYZO(2),YSO   )
      EQUIVALENCE (SRXYZO(3),ZSO   )
      EQUIVALENCE (FEDXYZ(1),XF    )
      EQUIVALENCE (FEDXYZ(2),YF    )
      EQUIVALENCE (FEDXYZ(3),ZF    )
      EQUIVALENCE (REFXYZ(1),XR    )
      EQUIVALENCE (REFXYZ(2),YR    )
      EQUIVALENCE (REFXYZ(3),ZR    )
************************************************************************
************************************************************************
      REAL      MAIXYZ(3),XM, YM, ZM
      REAL      SUBXYZ(3),XS, YS, ZS
      REAL      GENXYZ(3),XI, YJ, ZIJ
      REAL      RADSQ,XSQ
      REAL      CNTRX
      REAL      CNTRY
      REAL      RTEMP0
      REAL      RTEMP1
      REAL      RTEMP2
      REAL      RTEMP3
      REAL      RTEMP4
      REAL      RTEMP5
      REAL      RTEMP6
      INTEGER   I,J,V,W
************************************************************************
** EQUIVALENCE
************************************************************************
      EQUIVALENCE (SUBXYZ(1),XS   )
      EQUIVALENCE (SUBXYZ(2),YS   )
      EQUIVALENCE (SUBXYZ(3),ZS   )
      EQUIVALENCE (MAIXYZ(1),XM   )
      EQUIVALENCE (MAIXYZ(2),YM   )
      EQUIVALENCE (MAIXYZ(3),ZM   )
      EQUIVALENCE (GENXYZ(1),XI   )
      EQUIVALENCE (GENXYZ(2),YJ   )
      EQUIVALENCE (GENXYZ(3),ZIJ  )
************************************************************************
** Initialize Arrays
** MAIFIL <== MAIARY()
** SUBFIL <== SUBARY()
** XYZFIL <== XYZARY() <== MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ()
** DTAFIL <== DTAARX() <== DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ,
************************************************************************
      DO 20200 I = 1,TMXMX,1
```

```
      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************************
************************************************************************
      XM0 = (-110.00000000    *LAMBDA)
      YM0 = (  79.65000000    *LAMBDA)
      ZM0 = (  1.000000000    *LAMBDA)
************************************************************************
******INPUT:LOWER LEFT CORNER OF SUB REFLECTOR GRID*********************
*****************************************************************
      XS0 = ( -41.25000000    *LAMBDA)
      YS0 = (  000.00000000    *LAMBDA)
      ZS0 = (    1.00000000   *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)
*****SEATLE 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)
```

```
      INCMY     = DTAARX( 4)
      DSX       = DTAARX( 5)
      DSY       = DTAARX( 6)
      INCSX     = DTAARX( 7)
      INCSY     = DTAARX( 8)
      FREQ      = DTAARX( 9)
      Q         = DTAARX(10)
*****************************************************************
*******TO GENEARATE 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,TMXSY,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))
```

```
      RTEMP5 = ((RTEMP1*RTEMP2)/RTEMP4)

*     +===========================================================
*
*     | SubReflector: Hyperbola
*
*     |                            +-----------------
*
*     |                           /       2   2
*
*     |  Z    = 18.97*LAMBDA X   / 1 + (X + Y) )     +160.85*LAMBDA
*
*     |                         /     ---------------
*
*     |                       \/      (    0.6829    )
*
*     |
*
*     |
*
*     |                                     +-----------------
*
*     |                                    /       2   2
*
*     |                    X              /      X + Y
*
*     |  ZX   = 18.97 (-----------)  /   / 1+(-------------)
*
*     |              150.XLAMBDA    \/          0.6829
*
*     |
*
*     |                                     +---------------
*
*     |                                    /       2   2
*
*     |                    Y              /     X + Y
*
*     |  ZY   = 18.97 (-----------)  /   / 1+(-------------)
*
*     |              150.XLAMBDA    \/         0.6829
*
*     |
*
*     +===========================================================
*


*-----------------------------------------------------------------
      SUBARY(IDXZ  ,J,I) = ((RTEMP6)+RTEMP1*RTEMP4)
      SUBARY(IDXZX ,J,I) = (XS*RTEMP5                        )
      SUBARY(IDXZY ,J,I) = (YS*RTEMP5                        )
      SUBARY(IDXMSK,J,I) = 1.
*-----------------------------------------------------------------
20520 FORMAT (5X,4(E15.8,2X))
 309        WRITE(17,20520)  SUBARY(IDXZ  ,J,I),SUBARY(IDXZX ,J,I),
     1                       SUBARY(IDXZY ,J,I),SUBARY(IDXMSK,J,I)
20600    CONTINUE
20700 CONTINUE

******************************************************************
```

```
** 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
************************************************************************
      RTEMP0=LAMBDA
      XM    = XM0 - INCMX
*********************************************************************
*****INPUT: RADIUS OF CYLINDER MAIN REFLECTOR************************
*********************************************************************
*     RADSQ  = (107.2*RTEMP0)**2
      RADSQ  = (108.2*RTEMP0)**2
*********************************************************************
****INPUT: CENTER OF COORDINATES OF CYLINDER*************************
*********************************************************************
      CNTRX  = 0.0
      CNTRY  = 189.7*RTEMP0
*********************************************************************
*****INPUT : 1/4F PARAMETER FOCAL LENGTH*****************************
*********************************************************************
      RTEMP1 = (1./(870.00*RTEMP0))
      RTEMP2 = 2*RTEMP1
      DO 20900   I = 1,TMXMX,1
         XM     = XM + INCMX
         XSQ    = XM*XM
         YM  = YM0 - INCMY
         DO 20800   J = 1,TMXMY,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)
*
```

```
*          |                                                           DRS04610
*                                                                      DRS04620
*          +==========================================================DRS04630
*                                                                      DRS04640
                                                                       DRS04650
              MAIARY(IDXZ  ,J,I)  = ((XM*XM)+(YM*YM))*RTEMP1           DRS04660
              MAIARY(IDXZX ,J,I)  =  (XM*RTEMP2)                       DRS04670
              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    IDXRMJ
      INTEGER    IDXIMJ
      INTEGER    IDXUNM
      INTEGER    IDXJVX
      INTEGER    IDXNRM
      INTEGER    IDXDTX
      INTEGER    IDXMNM
      INTEGER    IDXMSI
      INTEGER    IDXAOT
      INTEGER    IDXPWR
      INTEGER    IDXADB
      INTEGER    IDXRDB
      INTEGER    MXMX,MXMY,TMXMX,TMXMY
      INTEGER    MXSX,MXSY,TMXSX,TMXSY
      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 (IDXRMJ = 1                    )
      PARAMETER (IDXIMJ = 2                    )
      PARAMETER (IDXUNM = 3                    )
      PARAMETER (IDXJVX = 1                    )
```

```
      PARAMETER (IDXNRM = 2                     )                         DUA00610
      PARAMETER (IDXDTX = 3                     )                         DUA00620
      PARAMETER (IDXMNM = 1                     )                         DUA00630
      PARAMETER (IDXMSI = 2                     )                         DUA00640
      PARAMETER (IDXAOT = 3                     )                         DUA00650
      PARAMETER (IDXPWR = 1                     )                         DUA00660
      PARAMETER (IDXADB = 2                     )                         DUA00670
      PARAMETER (IDXRDB = 3                     )                         DUA00680
*******************************************************************     DUA00690
*****INPUT : NUMBER OF POINTS IN X AND Y MAIN REF. GRID.***********     DUA00700
*******************************************************************     DUA00710
      PARAMETER (MXMX   = 101                  )                          DUA00720
      PARAMETER (MXMY   = 101                  )                          DUA00730
**********************************************************************  DUA00740
******INPUT : NUMBER OF POINTS IN X AND Y SUB REF. GRID***************  DUA00750
**********************************************************************  DUA00760
      PARAMETER (MXSX   = 61                    )                         DUA00770
      PARAMETER (MXSY   = 61                    )                         DUA00780
**********************************************************************  DUA00790
      PARAMETER (TMXMX  = MXMX + 1              )                         DUA00800
      PARAMETER (TMXMY  = MXMY + 1              )                         DUA00810
      PARAMETER (TMXSX  = MXSX + 1              )                         DUA00820
      PARAMETER (TMXSY  = MXSY + 1              )                         DUA00830
**********************************************************************  DUA00840
******INPUT : NUMBER OF FAR-FIELD GRID POINTS*************************  DUA00850
**********************************************************************  DUA00860
      PARAMETER (MXTHE  = 50                    )                         DUA00870
      PARAMETER (MXPHI  = 360                   )                         DUA00880
**********************************************************************  DUA00890
      PARAMETER (MXYZ   = 4                     )                         DUA00900
      PARAMETER (DXYZ   = 3                     )                         DUA00910
      PARAMETER (LNRY   = 1                     )                         DUA00920
      PARAMETER (VDTX   = 4                     )                         DUA00930
      PARAMETER (NDTX   = 3                     )                         DUA00940
      PARAMETER (MDTX   = 10                    )                         DUA00950
      PARAMETER (KDTX   = 18                    )                         DUA00960
************************************************************************DUA00970
** INTRINSIC FUNCTIONS                                                  DUA00980
************************************************************************DUA00990
      INTRINSIC SQRT                                                    DUA01000
      INTRINSIC SIN                                                     DUA01010
      INTRINSIC COS                                                     DUA01020
      INTRINSIC ACOS                                                    DUA01030
      INTRINSIC NINT                                                    DUA01040
************************************************************************DUA01050
** EXTERNAL FUNCTIONS                                                   DUA01060
************************************************************************DUA01070
      REAL      DOT                                                     DUA01080
      EXTERNAL  DOT                                                     DUA01090
      REAL      FDPTRN                                                  DUA01100
      EXTERNAL  FDPTRN                                                  DUA01110
************************************************************************DUA01120
** EXTERNAL SUBROUTINES                                                 DUA01130
************************************************************************DUA01140
      EXTERNAL  CROSS                                                   DUA01150
      EXTERNAL  SCALER                                                  DUA01160
      EXTERNAL  VECADD                                                  DUA01170
      EXTERNAL  VECSUB                                                  DUA01180
************************************************************************DUA01190
** RUN     TIME CONSTANTS                                               DUA01200
```

```
************************************************************************
      REAL        DTAARY(MDTX)
      REAL        DMX,DMY
      REAL        INCMX,INCMY
      REAL        DSX,DSY
      REAL        INCSX,INCSY
      INTEGER     MAXMX,MAXMY
      INTEGER     MAXSX,MAXSY
      REAL        FREQ
      REAL        Q
************************************************************************
** EQUIVALENCE
************************************************************************
      EQUIVALENCE (DTAARY( 1),DMX  )
      EQUIVALENCE (DTAARY( 2),DMY  )
      EQUIVALENCE (DTAARY( 3),INCMX)
      EQUIVALENCE (DTAARY( 4),INCMY)
      EQUIVALENCE (DTAARY( 5),DSX  )
      EQUIVALENCE (DTAARY( 6),DSY  )
      EQUIVALENCE (DTAARY( 7),INCSX)
      EQUIVALENCE (DTAARY( 8),INCSY)
      EQUIVALENCE (DTAARY( 9),FREQ )
      EQUIVALENCE (DTAARY(10),Q    )
************************************************************************
** RUN     TIME VARIABLES
************************************************************************
      REAL        LAMBDA
      REAL        K
************************************************************************
** EQUIVALENCE
************************************************************************
** Input Arrays
** MAIFIL  ==> MAIARY()
** SUBFIL  ==> SUBARY()
** XYZFIL  ==> XYZARY() ==> MRXYZ0(),SRXYZ0(),FEDXYZ(),REFXYZ()
** DTAFIL  ==> DTAARY() ==> DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ
************************************************************************
******READ IN THE XYZARY AND DTAARY FROM FILE GENERATOR*****************
************************************************************************
        DO 10 I=1,10
        READ(15,805) DTAARY(I)
805     FORMAT(5X,E15.8)
10      CONTINUE
*******************************************************************
*********************************************************************
** Initial Calculations
********************************************************************
      LAMBDA = C/FREQ
      K      = 2*PI/LAMBDA
      MAXMX = (NINT(DMX/INCMX) + 1)
      MAXMY = (NINT(DMY/INCMY) + 1)
      MAXSX = (NINT(DSX/INCSX) + 1)
      MAXSY = (NINT(DSY/INCSY) + 1)
      CALL SUBMAI(MAXMX,MAXMY,MAXSX,MAXSY,MDTX,DTAARY)
      END
*********************************************************************
***********MAIN PROGRAM**********************************************
*********************************************************************
      SUBROUTINE SUBMAI(PMXMX,PMXMY,PMXSX,PMXSY,PDTX,DTXARX)
      INTEGER     PMXMX
```

```
      INTEGER    PMXMY
      INTEGER    PMXSX
      INTEGER    PMXSY
      INTEGER    PDTX
      REAL       DTXARX(PDTX)
************************************************************************
** 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    IDXRMJ
      INTEGER    IDXIMJ
      INTEGER    IDXUNM
      INTEGER    IDXJVX
      INTEGER    IDXNRM
      INTEGER    IDXDTX
      INTEGER    IDXMNM
      INTEGER    IDXMSI
      INTEGER    IDXAOT
      INTEGER    IDXPWR
      INTEGER    IDXADB
      INTEGER    IDXRDB
      INTEGER    MXMX,MXMY,TMXMX,TMXMY
      INTEGER    MXSX,MXSY,TMXSX,TMXSY
      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 (IDXRMJ = 1                    )
      PARAMETER (IDXIMJ = 2                    )
      PARAMETER (IDXUNM = 3                    )
      PARAMETER (IDXJVX = 1                    )
      PARAMETER (IDXNRM = 2                    )
      PARAMETER (IDXDTX = 3                    )
```

```
      PARAMETER (IDXMNM = 1                     )                       DUA02410
      PARAMETER (IDXMSI = 2                     )                       DUA02420
      PARAMETER (IDXAOT = 3                     )                       DUA02430
      PARAMETER (IDXPWR = 1                     )                       DUA02440
      PARAMETER (IDXADB = 2                     )                       DUA02450
      PARAMETER (IDXRDB = 3                     )                       DUA02460
*********************************************************************   DUA02470
******INPUT : NUMBER OF POINTS IN X AND Y MAIN REF. GRID*************   DUA02480
*********************************************************************   DUA02490
      PARAMETER (MXMX   = 101                  )                        DUA02500
      PARAMETER (MXMY   = 101                  )                        DUA02510
*********************************************************************   DUA02520
******INPUT : NUMBER OF POINTS IN X AND Y SUB REF. GRID**************   DUA02530
*********************************************************************   DUA02540
      PARAMETER (MXSX   = 61                    )                       DUA02550
      PARAMETER (MXSY   = 61                    )                       DUA02560
*********************************************************************   DUA02570
      PARAMETER (TMXMX    = MXMX + 1            )                       DUA02580
      PARAMETER (TMXMY    = MXMY + 1            )                       DUA02590
      PARAMETER (TMXSX    = MXSX + 1            )                       DUA02600
      PARAMETER (TMXSY    = MXSY + 1            )                       DUA02610
********************************************************************    DUA02620
******* INPUT : FAR-FIELD GRID POINTS THETA AND PHI*****************    DUA02630
**********************************************************************  DUA02640
      PARAMETER (MXTHE  = 50                    )                       DUA02650
      PARAMETER (MXPHI  = 360                   )                       DUA02660
*******************************************************************     DUA02670
      PARAMETER (MXYZ   = 4                     )                       DUA02680
      PARAMETER (DXYZ   = 3                     )                       DUA02690
      PARAMETER (LNRY   = 1                     )                       DUA02700
      PARAMETER (VDTX   = 4                     )                       DUA02710
      PARAMETER (NDTX   = 3                     )                       DUA02720
      PARAMETER (MDTX   = 10                    )                       DUA02730
      PARAMETER (KDTX   = 18                    )                       DUA02740
************************************************************************DUA02750
** INTRINSIC FUNCTIONS                                                  DUA02760
************************************************************************DUA02770
      INTRINSIC SQRT                                                    DUA02780
      INTRINSIC SIN                                                     DUA02790
      INTRINSIC COS                                                     DUA02800
      INTRINSIC ACOS                                                    DUA02810
      INTRINSIC NINT                                                    DUA02820
************************************************************************DUA02830
** EXTERNAL FUNCTIONS                                                   DUA02840
************************************************************************DUA02850
      REAL      DOT                                                     DUA02860
      EXTERNAL  DOT                                                     DUA02870
      REAL      FDPTRN                                                  DUA02880
      EXTERNAL  FDPTRN                                                  DUA02890
************************************************************************DUA02900
** EXTERNAL SUBROUTINES                                                 DUA02910
************************************************************************DUA02920
      EXTERNAL  CROSS                                                   DUA02930
      EXTERNAL  SCALER                                                  DUA02940
      EXTERNAL  VECADD                                                  DUA02950
      EXTERNAL  VECSUB                                                  DUA02960
************************************************************************DUA02970
** RUN     TIME CONSTANTS                                               DUA02980
************************************************************************DUA02990
      REAL       MAIARY(VDTX,TMXMY,TMXMX)                               DUA03000
```

```
      REAL        SUBARY(VDTX,TMXSY,TMXSX)
      REAL        XYZARY(DXYZ,MXYZ)
      REAL        SRXYZ0(DXYZ),XS0,YS0,ZS0
      REAL        MRXYZ0(DXYZ),XM0,YM0,ZM0
      REAL        FEDXYZ(DXYZ),XF ,YF ,ZF
      REAL        REFXYZ(DXYZ),XR ,YR ,ZR
      REAL        SR(DXYZ),     SRX ,SRY ,SRZ
      REAL        USR(DXYZ),    USRX,USRY,USRZ
      REAL        MAGSR
      REAL        DTAARY(MDTX)
      REAL        DMX,DMY
      REAL        INCMX,INCMY
      REAL        DSX,DSY
      REAL        INCSX,INCSY
      REAL        FREQ
      REAL        Q
      REAL        DTXARY(KDTX)
      REAL        BEGPHX
      REAL        ENDPHX
      REAL        IDXPHX
      REAL        STPPHX
      REAL        INCPHX
      REAL        BEGTHX
      REAL        ENDTHX
      REAL        IDXTHX
      REAL        STPTHX
      REAL        INCTHX
      REAL        PTTMNX
      REAL        PTTMXX
      REAL        ADBMNX
      REAL        ADBMXX
      REAL        RDBMNX
      REAL        PRAD
      REAL        RINTNS
      REAL        RIFCTR
      REAL        DIRCTV
************************************************************************
** EQUIVALENCE
************************************************************************
      EQUIVALENCE (XYZARY(1,1),MRXYZ0(1))
      EQUIVALENCE (XYZARY(1,2),SRXYZ0(1))
      EQUIVALENCE (XYZARY(1,3),FEDXYZ(1))
      EQUIVALENCE (XYZARY(1,4),REFXYZ(1))
      EQUIVALENCE (MRXYZ0( 1),XM0   )
      EQUIVALENCE (MRXYZ0( 2),YM0   )
      EQUIVALENCE (MRXYZ0( 3),ZM0   )
      EQUIVALENCE (SRXYZ0( 1),XS0   )
      EQUIVALENCE (SRXYZ0( 2),YS0   )
      EQUIVALENCE (SRXYZ0( 3),ZS0   )
      EQUIVALENCE (FEDXYZ( 1),XF    )
      EQUIVALENCE (FEDXYZ( 2),YF    )
      EQUIVALENCE (FEDXYZ( 3),ZF    )
      EQUIVALENCE (REFXYZ( 1),XR    )
      EQUIVALENCE (REFXYZ( 2),YR    )
      EQUIVALENCE (REFXYZ( 3),ZR    )
      EQUIVALENCE (SR    ( 1),SRX   )
      EQUIVALENCE (SR    ( 2),SRY   )
      EQUIVALENCE (SR    ( 3),SRZ   )
      EQUIVALENCE (USR   ( 1),USRX  )
      EQUIVALENCE (USR   ( 2),USRY  )
```

```
      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),ADBMNX)                                   DUA03840
      EQUIVALENCE (DTXARY(14),ADBMXX)                                   DUA03850
      EQUIVALENCE (DTXARY(15),RDBMNX)                                   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,TMXMY,TMXMX)                         DUA03930
      REAL        SCDARY(DXYZ,DXYZ,TMXSY,TMXSX)                         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,UHVY,UHVZ                             DUA04190
      REAL        MAGHV                                                 DUA04200
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      REAL       JV (DXYZ),JVX ,JVY ,JVZ                                  DUA04210
      REAL       UJV(DXYZ),UJVX,UJVY,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),TMRY  )                                    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),HVRY )                                    DUA05270
      EQUIVALENCE (HVR    (3),HVRZ )                                    DUA05280
      EQUIVALENCE (HVI    (1),HVIX )                                    DUA05290
      EQUIVALENCE (HVI    (2),HVIY )                                    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
```

```
      EQUIVALENCE (JVR   (2),JVRY )
      EQUIVALENCE (JVR   (3),JVRZ )
      EQUIVALENCE (JVI   (1),JVIX )
      EQUIVALENCE (JVI   (2),JVIY )
      EQUIVALENCE (JVI   (3),JVIZ )
      EQUIVALENCE (JV    (1),JVX  )
      EQUIVALENCE (JV    (2),JVY  )
      EQUIVALENCE (JV    (3),JVZ  )
      EQUIVALENCE (UJV   (1),UJVX )
      EQUIVALENCE (UJV   (2),UJVY )
      EQUIVALENCE (UJV   (3),UJVZ )
      EQUIVALENCE (R1    (1),R1X  )
      EQUIVALENCE (R1    (2),R1Y  )
      EQUIVALENCE (R1    (3),R1Z  )
      EQUIVALENCE (UR1   (1),UR1X )
      EQUIVALENCE (UR1   (2),UR1Y )
      EQUIVALENCE (UR1   (3),UR1Z )
      EQUIVALENCE (INTG  (1),INTX )
      EQUIVALENCE (INTG  (2),INTY )
      EQUIVALENCE (INTG  (3),INTZ )
      EQUIVALENCE (RFF   (1),RFFX )
      EQUIVALENCE (RFF   (2),RFFY )
      EQUIVALENCE (RFF   (3),RFFZ )
      EQUIVALENCE (PSI   (1),COSKR)
      EQUIVALENCE (PSI   (2),SINKR)
      EQUIVALENCE (CMPTMP(1),CMPTMR)
      EQUIVALENCE (CMPTMP(2),CMPTMI)
************************************************************************
** INITIALIZE INPUT ARRAYS
** MAIFIL ==> MAIARY()
** SUBFIL ==> SUBARY()
** XYZFIL ==> XYZARY() ==> MRXYZO(),SRXYZO(),FEDXYZ(),REFXYZ()
** DTAFIL ==> DTAARY() ==> DMX,DMY,INCMX,INCMY,DSX,DSY,INCSX,INCSY,FREQ,
************************************************************************
** GENERATE   OUTPUT ARRRAYS
** MCDFIL <== MCDARY()
** SCDFIL <== SCDARY()
** RFXFIL <== PTTRN ()
** DTXFIL <== DTXARY() <==  BEG,END,IDX,STP,INC * THE,PHI , PTT * ADR *
************************************************************************
******READ IN THE XYZARY,SUBARY,MAIARY ARRAYS FROM FILE GEN.************
************************************************************************
          DO 11 II=1,4
          DO 12 JJ=1,3
          READ(16,806)XYZARY(JJ,II)
806       FORMAT(5X,E15.8)
12        CONTINUE
11        CONTINUE
************************************************************************
****************************************************************
          DO 13 III=1,TMXSX,1
          DO 14 JJJ=1,TMXSY,1
          READ(17,807)SUBARY(IDXZ,JJJ,III),
     1                SUBARY(IDXZX,JJJ,III),
     2                SUBARY(IDXZY,JJJ,III),
     3                SUBARY(IDXMSK,JJJ,III)
807       FORMAT(5X,4(E15.8,2X))
14        CONTINUE
13        CONTINUE
          DO 15 IIII=1,TMXMX,1
```

```
         DO 16 JJJJ=1,TMXMY,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,PDTX,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
```

```
            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)
```

```
                 JFLD(IDXVCX,IDXIMJ) = -(SCALE*UJV(IDXVCX)*SINKR)
                 JFLD(IDXVCY,IDXIMJ) = -(SCALE*UJV(IDXVCY)*SINKR)
                 JFLD(IDXVCZ,IDXIMJ) = -(SCALE*UJV(IDXVCZ)*SINKR)
               ELSE
             ENDIF
00599        CONTINUE
00600        CONTINUE
00700    CONTINUE
***********************************************************************
** Calculate Induced Magnetic Field on Main_Reflector by Sub_Reflector.
***********************************************************************
         INCMXY = INCMX*INCMY
         XM     = XM0 - INCMX
         DO 01900   IP = 1,MAXMX,1
           XM = XM + INCMX
           YM     = YM0 - INCMY
           DO 01800   JP = 1,MAXMY,1
             YM   = YM + INCMY
             ZM   = MAIARY(IDXZ,JP,IP)
             MSKFAC    = MAIARY(IDXMSK,JP,IP)
             IF (MSKFAC .EQ. 1.) THEN
               NX = -(MAIARY(IDXZX,JP,IP))
               NY = -(MAIARY(IDXZY,JP,IP))
               NZ = +1.
               MAGNRM = SQRT(NX*NX + NY*NY +1.)
               DO 01100   V = 1,3,1
                 NORM(V) = NORM(V)/MAGNRM
                 DO   01000 W = 1,2,1
                   HFLD(V,W) = 0.
01000            CONTINUE
01100          CONTINUE
               XS     = XS0 - INCSX
               DO 01700   I = 1,MAXSX,1
                 XS = XS + INCSX
                 YS     = YS0 - INCSY
                 DO 01600   J = 1,MAXSY,1
                   YS   = YS + INCSY
                   ZS   = SUBARY(IDXZ,J,I)
                   MSKFAC = SUBARY(IDXMSK,J,I)
                   IF (MSKFAC .EQ. 1.) THEN
                     DS      = SCDARY(IDXMNM,IDXDTX,J,I)*INCSXY
                     MAGSI   = SCDARY(IDXMSI,IDXDTX,J,I)
                     SCALE   = SCDARY(IDXAOT,IDXDTX,J,I)
                     MAGR1 = 0.
                     DO 01200   V = 1,3,1
                       R1TMP   = (MAIXYZ(V) - SUBXYZ(V))
                       R1(V)   = R1TMP
                       MAGR1   = MAGR1 + R1TMP*R1TMP
01200                CONTINUE
                     MAGR1 = SQRT(MAGR1)
                     DO 01300   V = 1,3,1
                       UR1(V)  = R1(V)/MAGR1
                       UHV(V)  = SCDARY(V,IDXJVX,J,I)
01300                CONTINUE
                     KR =(K*(MAGR1 + MAGSI))
                     RR = MAGR1*MAGSI
                     COSKR = +COS(KR)/RR
                     SINKR = -SIN(KR)/RR
*                    CALL CROSS(INTG,SCDARY(IDXVCX,IDXJVX,J,I),UR1)
                     CALL CROSS(INTG,UHV,UR1)
```

```
                        MAGINT = 1.
*     0                 MAGINT = SQRT(( (INTX*INTX)
*     1                                +(INTY*INTY)
*     2                                +(INTZ*INTZ)))
                        INTX = INTX/MAGINT
                        INTY = INTY/MAGINT
                        INTZ = INTZ/MAGINT
                        DO 01500   V = 1,3,1
                           DO 01400   W = 1,2,1
      0                       HFLD(V,W) = HFLD(V,W)
      1                         +SCALE*PSI(W)*INTG(V)*DS
01400                      CONTINUE
01500                   CONTINUE
                     ENDIF
01599             CONTINUE
01600             CONTINUE
01700          CONTINUE
               MCDARY(IDXVCX,IDXUNM,JP,IP) = NX
               MCDARY(IDXVCY,IDXUNM,JP,IP) = NY
               MCDARY(IDXVCZ,IDXUNM,JP,IP) = NZ
               CALL SCALER(NORM,NORM,2.)
               CALL CROSS (JFLD(IDXVCX,IDXRMJ),NORM,HFLD(IDXVCX,IDXRMJ))
               CALL CROSS (JFLD(IDXVCX,IDXIMJ),NORM,HFLD(IDXVCX,IDXIMJ))
               DO 01720   V = 1,3,1
                  DO 01710   W = 1,2,1
                     MCDARY(V,W,JP,IP) = JFLD(V,W)
01710             CONTINUE
01720          CONTINUE
************************************************************************
            ELSE
               JFLD(IDXVCX,IDXRMJ) = 0.
               JFLD(IDXVCY,IDXRMJ) = 0.
               JFLD(IDXVCZ,IDXRMJ) = 0.
               JFLD(IDXVCX,IDXIMJ) = 0.
               JFLD(IDXVCY,IDXIMJ) = 0.
               JFLD(IDXVCZ,IDXIMJ) = 0.
               MAGJV               = 0.
            ENDIF
************************************************************************
01799    CONTINUE
01800    CONTINUE
01900 CONTINUE
************************************************************************
*** FAR FIELD ANTENNA PATTERN COMPUTATION
************************************************************************
      PTTMIN    = +1.E+38
      PTTMAX    = -1.E+38
      ANGPHI = BEGPHI - INCPHI
      DO 02600   ANGPHX = 0,IDXPHI,STPPHI
         ANGPHI = ANGPHI + INCPHI
         SINPHI = SIN(ANGPHI)
         COSPHI = COS(ANGPHI)
         ANGTHE = BEGTHE - INCTHE
         DO 02500   ANGTHX = 0,IDXTHE,STPTHE
            ANGTHE = ANGTHE + INCTHE
            SINTHE = SIN(ANGTHE)
            COSTHE = COS(ANGTHE)
            RFFX = SINTHE*COSPHI
            RFFY = SINTHE*SINPHI
            RFFZ = COSTHE
```

```
             SUM(1,1) = 0.
             SUM(1,2) = 0.
             SUM(2,1) = 0.
             SUM(2,2) = 0.
             SUM(3,1) = 0.
             SUM(3,2) = 0.
      XM    = XMO - INCMX
       DO 02400  IP = 1,MAXMX,1
          XM = XM + INCMX
          YM    = YMO - INCMY
          DO 02300  JP = 1,MAXMY,1
             YM = YM + INCMY
             ZM  = MAIARY(IDXZ,JP,IP)
             KR =(K*((RFFX*XM)+(RFFY*YM)+(RFFZ*ZM)))
             COSKR = COS(KR)
             SINKR = SIN(KR)
             MSKFAC = MAIARY(IDXMSK,JP,IP)
             IF(MSKFAC.EQ.0)GO TO 2300
                NORM(IDXVCX) = -MAIARY(IDXZX,JP,IP)
                NORM(IDXVCY) = -MAIARY(IDXZY,JP,IP)
                NORM(IDXVCZ) = +1.
     0 DS = INCMXY*SQRT(NORM(IDXVCX)*NORM(IDXVCX)
     2                 +NORM(IDXVCY)*NORM(IDXVCY)
     3                 +NORM(IDXVCZ)*NORM(IDXVCZ))
                CMPTMP (IDXRMJ) =
     1                      RFFX*MCDARY(IDXVCX,IDXRMJ,JP,IP)
     2                    + RFFY*MCDARY(IDXVCY,IDXRMJ,JP,IP)
     3                    + RFFZ*MCDARY(IDXVCZ,IDXRMJ,JP,IP)
                   CMPTMP(IDXIMJ) =
     1                      RFFX*MCDARY(IDXVCX,IDXIMJ,JP,IP)
     2                    + RFFY*MCDARY(IDXVCY,IDXIMJ,JP,IP)
     3                    + RFFZ*MCDARY(IDXVCZ,IDXIMJ,JP,IP)
                  TMRX = CMPTMP(IDXRMJ)*RFFX
                  TMRY = CMPTMP(IDXRMJ)*RFFY
                  TMRZ = CMPTMP(IDXRMJ)*RFFZ
                  TMIX = CMPTMP(IDXIMJ)*RFFX
                  TMIY = CMPTMP(IDXIMJ)*RFFY
                  TMIZ = CMPTMP(IDXIMJ)*RFFZ
                 TMRX = MCDARY(IDXVCX,IDXRMJ,JP,IP) - TMRX
                 TMRY = MCDARY(IDXVCY,IDXRMJ,JP,IP) - TMRY
                 TMRZ = MCDARY(IDXVCZ,IDXRMJ,JP,IP) - TMRZ
                 TMIX = MCDARY(IDXVCX,IDXIMJ,JP,IP) - TMIX
                 TMIY = MCDARY(IDXVCY,IDXIMJ,JP,IP) - TMIY
                 TMIZ = MCDARY(IDXVCZ,IDXIMJ,JP,IP) - TMIZ
                  TTMRX = ((TMRX*COSKR)-(TMIX*SINKR))
                  TTMRY = ((TMRY*COSKR)-(TMIY*SINKR))
                  TTMRZ = ((TMRZ*COSKR)-(TMIZ*SINKR))
                  TTMIX = ((TMRX*SINKR)+(TMIX*COSKR))
                  TTMIY = ((TMRY*SINKR)+(TMIY*COSKR))
                  TTMIZ = ((TMRZ*SINKR)+(TMIZ*COSKR))
                   JVRX = TTMRX*DS
                   JVRY = TTMRY*DS
                   JVRZ = TTMRZ*DS
                   JVIX = TTMIX*DS
                   JVIY = TTMIY*DS
                   JVIZ = TTMIZ*DS
                   SUMRX = SUMRX + JVRX
                   SUMRY = SUMRY + JVRY
                   SUMRZ = SUMRZ + JVRZ
                   SUMIX = SUMIX + JVIX
```

```
                    SUMIY = SUMIY + JVIY
                    SUMIZ = SUMIZ + JVIZ
02299          CONTINUE
02300          CONTINUE
02400       CONTINUE
    0             ETHRE =   SUMRX*COSTHE*COSPHI
    1                     + SUMRY*COSTHE*SINPHI
    2                     - SUMRZ*SINTHE
    0             ETHIM =   SUMIX*COSTHE*COSPHI
    1                     + SUMIY*COSTHE*SINPHI
    2                     - SUMIZ*SINTHE
    0             EPHRE = - SUMRX*SINPHI
    1                     + SUMRY*COSPHI
    0             EPHIM = - SUMIX*SINPHI
    1                     + SUMIY*COSPHI
************************************************************************
**********ETHETA AND EPHI COMPUTED *************************************
**********TRANSFORM TO CO AND CO-POL LUDWIG'S DEFINITION***************
************************************************************************
        AREFR=SINPHI*ETHRE+COSPHI*EPHRE
        AREFI=SINPHI*ETHIM+COSPHI*EPHIM
        ACRPR=-COSPHI*ETHRE+SINPHI*EPHRE
        ACRPI=-COSPHI*ETHIM+SINPHI*EPHIM
**********************************************************************
          AMGREF=AREFR**2+AREFI**2
          AMGCRP=ACRPR**2+ACRPI**2
**********CO AND CROSS POL FIELDS ARE COMPLETED***********************
**********************************************************************
*******************************TOTAL FIELD****************************
*    0            R1TMP =   ETHRE*ETHRE + ETHIM*ETHIM
*    1                    + EPHRE*EPHRE + EPHIM*EPHIM
***************PLOT THE CO POL FIELDS*********************************
                  R1TMP = AMGREF
***************PLOT THE CROSS POL FIELDS******************************
*                 R1TMP = AMGCRP
**********************************************************************
                  PTTRN(IDXPWR,ANGTHX,ANGPHX) = R1TMP
                  IF (R1TMP .LT. PTTMIN) THEN
                     PTTMIN = R1TMP
                  ENDIF
                  IF (R1TMP .GT. PTTMAX) THEN
                     PTTMAX = R1TMP
                  ENDIF
02500    CONTINUE
02600 CONTINUE
      PRAD   = ((2.*PI)/(ETA*((2.*Q)+1)))
      RIFCTR = (((K*K*K*K)*ETA)/(256.*(PI*PI*PI*PI)))
      RINTNS = (RIFCTR*PTTMAX)
      DIRCTV = ((4.*PI*RINTNS)/(PRAD))
      DIRCTV = (10*ALOG10(DIRCTV))
**********************************************************************
      WRITE(19,897)DIRCTV
897   FORMAT(5X,F15.5)
**********************************************************************
      ADBMNX = 10.*ALOG10(PTTMIN)
      ADBMXX = 10.*ALOG10(PTTMAX)
      RDBMNX = (ADBMNX - ADBMXX)
      ANGPHI = BEGPHI - INCPHI
      DO 02800   ANGPHX = 0,IDXPHI,STPPHI
         ANGPHI = ANGPHI + INCPHI
```

```
         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
```

```
         REAL      SUM
         SUM = 0.
         DO 00100 I = 1,N,1
            SUM = SUM + A(I)*B(I)
00100    CONTINUE
         DOT = SUM
      RETURN
      END
**********************************************************************
** SUBROUTINE CROSS       ! Performs C = AxB
**********************************************************************
      SUBROUTINE CROSS(C,A,B)
      REAL    C(3)
      REAL    A(3)
      REAL    B(3)
         C(1) = +((A(2)*B(3))-(A(3)*B(2)))
         C(2) = -((A(1)*B(3))-(A(3)*B(1)))
         C(3) = +((A(1)*B(2))-(A(2)*B(1)))
      END
**********************************************************************
** SUBROUTINE SCALER      ! Performs C = A*<SCALER>
**********************************************************************
      SUBROUTINE SCALER(C,A,SCALEX)
      REAL    C(3)
      REAL    A(3)
      REAL    SCALEX
         C(1) = SCALEX*(A(1))
         C(2) = SCALEX*(A(2))
         C(3) = SCALEX*(A(3))
      RETURN
      END
**********************************************************************
** SUBROUTINE VECADD      ! Performs C = A+B
**********************************************************************
      SUBROUTINE VECADD(C,A,B)
      REAL    C(3)
      REAL    A(3)
      REAL    B(3)
         C(1) = (A(1)+B(1))
         C(2) = (A(2)+B(2))
         C(3) = (A(3)+B(3))
      RETURN
      END
**********************************************************************
** SUBROUTINE VECSUB      ! Performs C = A-B
**********************************************************************
      SUBROUTINE VECSUB(C,A,B)
      REAL    C(3)
      REAL    A(3)
      REAL    B(3)
         C(1) = (A(1)-B(1))
         C(2) = (A(2)-B(2))
         C(3) = (A(3)-B(3))
      RETURN
      END
```

```
      PROGRAM FFPLOT
      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 GPLOT3
      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.
```

```
      VARS(8)=1.
      VARS(9)=10.
      VARS(10)=1.
      VARS(11)=4.
      VARS(12)=11.
      VARS(13)=20.
      VARS(14)=211.
      VARS(15)=0.
      CALL XAXIS3(VARS)
C*****VARS : 2 3 4 =X1 Y1 Z1 ; 5 6 7=X2 Y2 Z2 ; 8=USER UNIT ; 9=NO. OF
C*****INTERVALS ; 10=GRID OPTION ; 11=DRAW PARALLEL TO X-AXIS ; 12=
C*****VARS(9)+1 ; 13=SIZE OF LABEL ; 14=DIR. OF X-AXIS ; 15=AXIS SETTING
C*****COMPLETE.
      VARS(2)=-ZM
      VARS(3)=-54.
      VARS(4)=0.
      VARS(5)=-ZM
      VARS(6)=0.
      VARS(7)=0.
      VARS(8)=1.
      VARS(9)=9.
      VARS(10)=1.
      VARS(11)=3.
      VARS(12)=10.
      VARS(13)=20.
      VARS(14)=212.
      VARS(15)=1.
      CALL YAXIS3(VARS)
C*****TITLE3 : GRAPH3D ROUTINE ; PRINTS TITLE OF X-AXIS
C***** 4=X-AXIS ; 20=X-ALPHANUMERIC DIMENSION ; 15=CHARACTER SIZE
      CALL TITLE3(4,20,15,XTITLE,0.,1.,0.)
C*****TITLE3 : GRAPH3D ROUTINE ; PRINTS Y-AXIS TITLE
C***** 3=Y-AXIS ; 18=Y-ALPHANUMERIC DIMENSION ; 15=CHARACTER SIZE
      CALL TITLE3(3,24,15,YTITLE,-1.,0.,0.)
C*****GPLOT3 : GRAPH3D ROUTINE ; TO PLOT A CURVE WITH POINT OR VECTOR
C*****IVARS : 1=DIMENSION OF IVARS ; 2=NO. OF POINTS,EXACT ; 3=NO Z-AXIS
C***** 4=DO NOT CALL AXIS ROUTINES ; 5=POINT PLOT ; 6=SYMBOL FREQUENCY
C***** 7=SIZE OF SYMBOL ; 8=EXACT MIN-MAX INTERVAL
      IVARS(1)=8
      IVARS(2)=NP
      IVARS(3)=0
      IVARS(4)=0
      IVARS(5)=0
      IVARS(6)=1
      IVARS(7)=15
      IVARS(8)=1
      CALL GPLOT3(IVARS,X,Y)
      CALL CHARS3(13,CH,3.,10.5,0.,25,1.)
      CALL NUMBER(4,DDIR,5,2,DIR)
      CALL CHARS3(5,DIR,7.,10.5,0.,25,1.)
      CALL CHARS3(2,ADB,9.,10.5,0.,25,1.)
C*****GVIEW : GRAPH3D ROUTINE ; IDENTIFIES VIEWING ENVIRONMENT
C***** 1=DEFAULT VALUES FOR THREE REMAINING VARIABLES
      CALL GVIEW(1)
C*****WINDW : GRAPH3D ROUTINE ; SPECIFY DIMENSION OF VIEW WINDOW
C***** 6=TOTAL NO OF VARIABLES ; 0=LOWEST OF THE PARAMETER RANGE
C*****UMIN=MIN. VALUE OF NO. OF RELATIVE UNITS FROM VIEW REFERENCE
C*****UMAX=MAX. VALUE OF NO.OF RELATIVE UNITS FROM VIEW REFERENCE
C*****VMIN= "    "    " " "    "    "    "    "    "
C*****VMAX= "    "    " " "    "    "    "    "    "
```

```
      CALL WINDW(6,0,-6.5,6.5,-6.5,6.5)                          FFP01200
C*****DISPLA : GRAPH3D ROUTINE ; DISPLAYS INTERNAL BUFFER        FFP01210
C***** 1=OPTION TO CLEAR BUFFER                                  FFP01220
      CALL DISPLA(1)                                             FFP01230
C*****TERM : GRAPH3D ROUTINE ; REQUIRED TO CLOSE THE GRAPHICS    FFP01240
      CALL TERM                                                  FFP01250
      STOP                                                       FFP01260
      END                                                        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 FFPLOT(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.

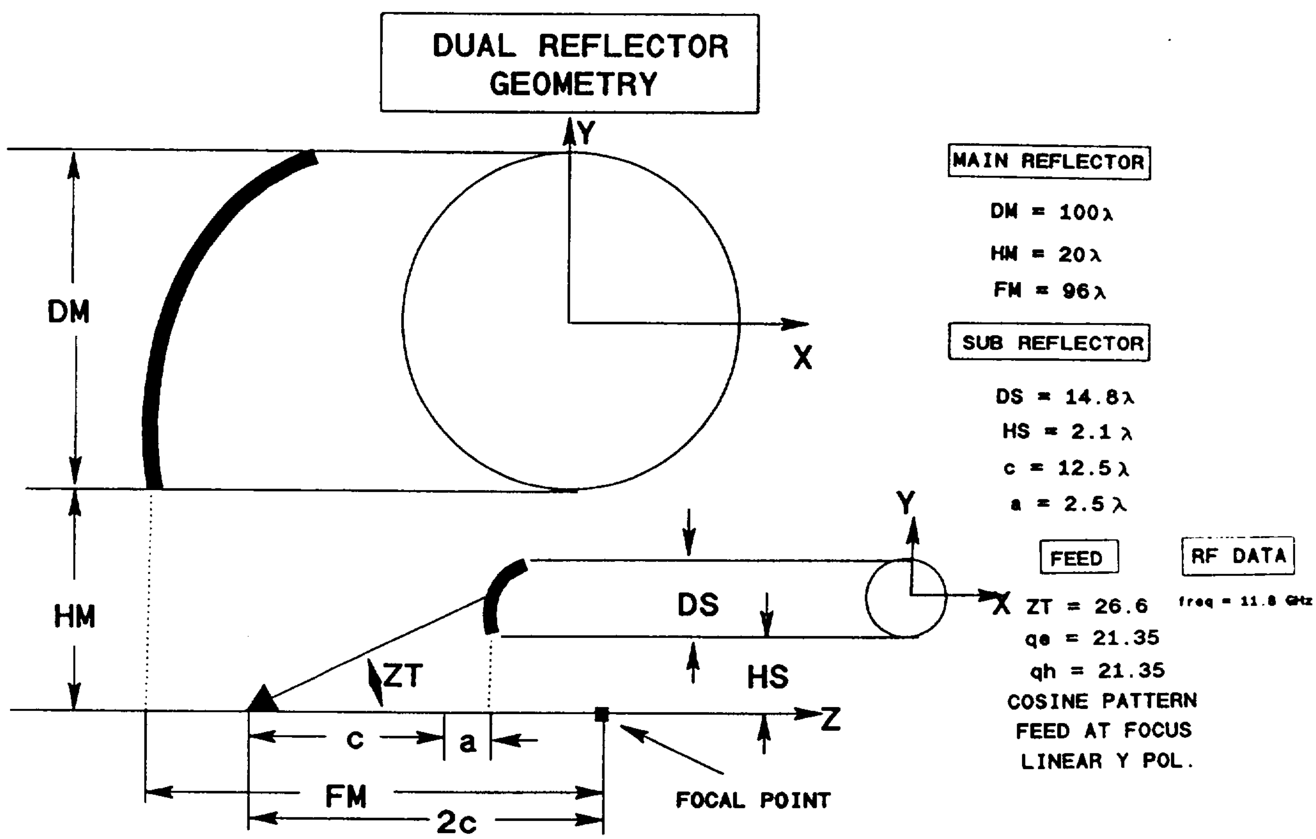

Figure 1, Dual reflector configuration

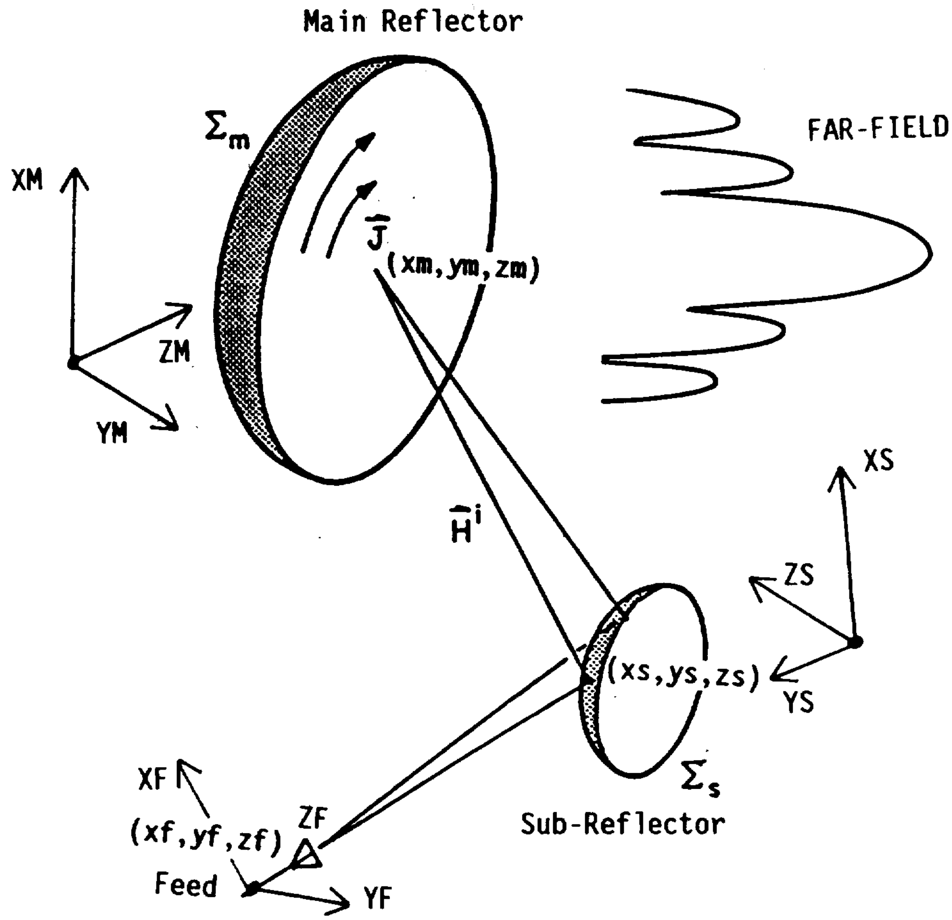

Figure 2, Generalized dual reflector geometry

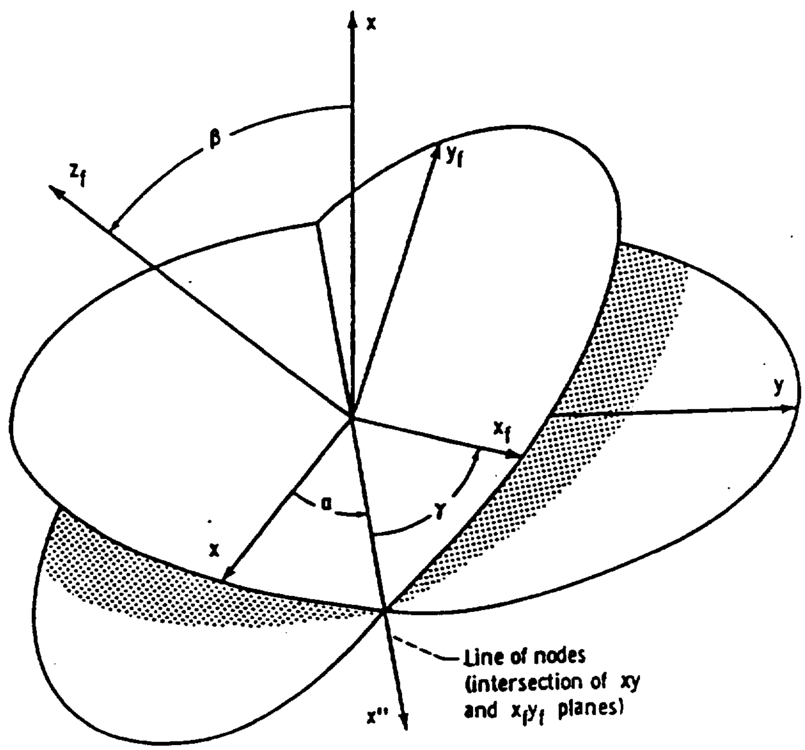

Figure 3, Eulerian angles

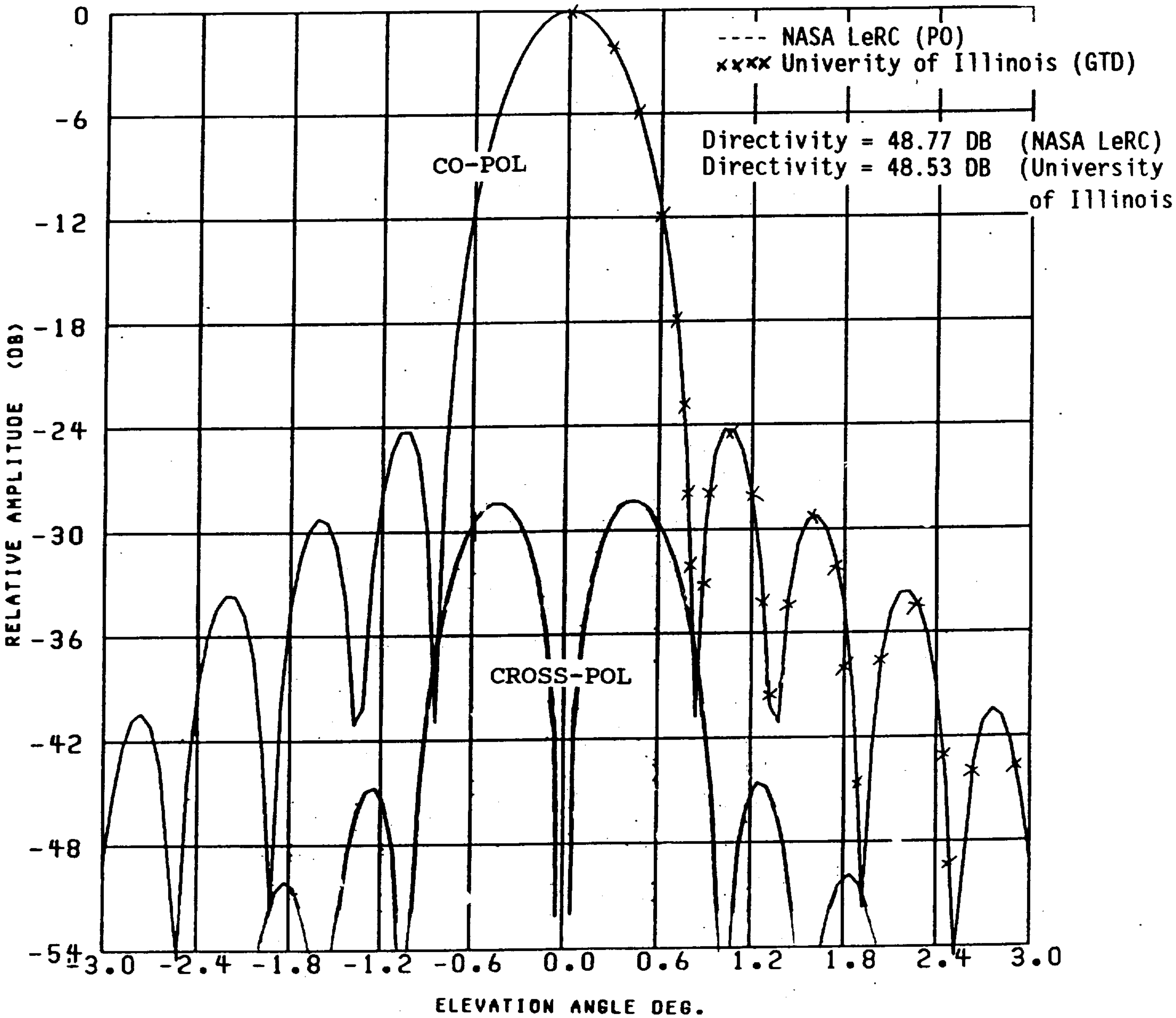

Figure 4a, H-plane far-field antenna pattern

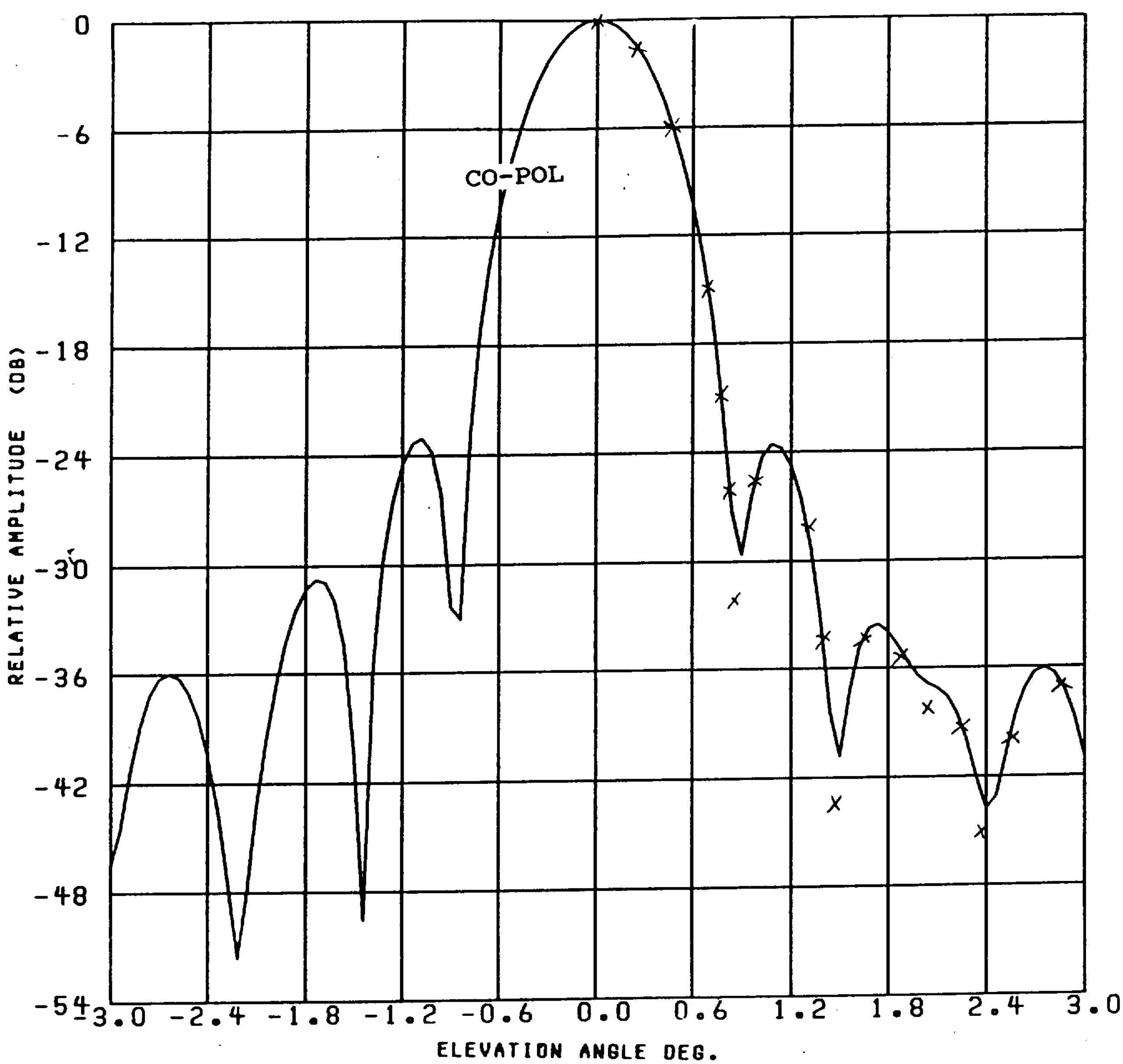

Figure 4b, E-plane far-field antenna pattern

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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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